

fI AVR - Funkenstein Little AVR Virtual Runtime

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Chapter 3

Data Structure Documentation

3.1 `_BreakPoint` Struct Reference

Node-structure for a linked-list of breakpoint addresses.

```
#include <breakpoint.h>
```

Data Fields

- struct `_BreakPoint` * `next`
Pointer to next breakpoint.
- struct `_BreakPoint` * `prev`
Pointer to previous breakpoint.
- uint16_t `u16Addr`
Address of the breakpoint.

3.1.1 Detailed Description

Node-structure for a linked-list of breakpoint addresses.

Definition at line 33 of file [breakpoint.h](#).

The documentation for this struct was generated from the following file:

- [src/debug/breakpoint.h](#)

3.2 `_IOClockList` Struct Reference

Data Fields

- struct `_IOClockList` * `next`
- void * `pvContext`
- PeriphClock `pfClock`

3.2.1 Detailed Description

Definition at line 44 of file [avr_io.h](#).

The documentation for this struct was generated from the following file:

- [src/avr_cpu/avr_io.h](#)

3.3 _IOReaderList Struct Reference

Data Fields

- struct [_IOReaderList](#) * **next**
- void * **pvContext**
- PeriphRead **pfReader**

3.3.1 Detailed Description

Definition at line 28 of file [avr_io.h](#).

The documentation for this struct was generated from the following file:

- [src/avr_cpu/avr_io.h](#)

3.4 _IOWriterList Struct Reference

Data Fields

- struct [_IOWriterList](#) * **next**
- void * **pvContext**
- PeriphWrite **pfWriter**

3.4.1 Detailed Description

Definition at line 36 of file [avr_io.h](#).

The documentation for this struct was generated from the following file:

- [src/avr_cpu/avr_io.h](#)

3.5 _WatchPoint Struct Reference

Data Fields

- struct [_WatchPoint](#) * **next**
Pointer to next watchpoint.
- struct [_WatchPoint](#) * **prev**
Pointer to previous watchpoint.
- uint16_t **u16Addr**
Address (in RAM) to watch on.

3.5.1 Detailed Description

Definition at line 31 of file [watchpoint.h](#).

3.5.2 Field Documentation

3.5.2.1 uint16_t WatchPoint::u16Addr

Address (in RAM) to watch on.

Definition at line 36 of file [watchpoint.h](#).

The documentation for this struct was generated from the following file:

- [src/debug/watchpoint.h](#)

3.6 AddressCoverageTLV_t Struct Reference

Data Fields

- uint32_t **u32CodeAddress**
- uint64_t **u64Hits**
- char [szDisasmLine](#) [256]
Disassembly for the address in question.

3.6.1 Detailed Description

Definition at line 55 of file [code_profile.c](#).

The documentation for this struct was generated from the following file:

- [src/debug/code_profile.c](#)

3.7 AVR_CoreRegisters Struct Reference

This is a bit of overkill, but there are reasons why the struct is presented as more than just a single array of 32 8-bit uints.

```
#include <avr_coreregs.h>
```

Data Fields

3.7.1 Detailed Description

This is a bit of overkill, but there are reasons why the struct is presented as more than just a single array of 32 8-bit uints.

Here, we create anonymous unions between the following core registers representations: 1) 32, 8-bit registers, as an array (r[0] through r[31]) 2) 16, 16-bit register-pairs, as an array (r_word[0] through r_word[15]) 3) 32, 8-bit registers, as named registers (r0 through r31) 4) 16, 16-bit register-pairs, as named registers (r1_0, through r31_30) 5) X, Y and Z registers map to r27_26, r29_28, and r31_30

Definition at line 38 of file [avr_coreregs.h](#).

The documentation for this struct was generated from the following file:

- [src/avr_cpu/avr_coreregs.h](#)

3.8 AVR_CPU Struct Reference

This structure effectively represents an entire simulated AVR CPU - all memories, registers (memory-mapped or internal), peripherals and housekeeping information.

```
#include <avr_cpu.h>
```

Data Fields

- [IOReaderList](#) * **apstPeriphReadTable** [CONFIG_IO_ADDRESS_BYTES]
 - [IOWriterList](#) * **apstPeriphWriteTable** [CONFIG_IO_ADDRESS_BYTES]
 - [IOClockList](#) * **pstClockList**
 - struct [_WatchPoint](#) * **pstWatchPoints**
 - struct [_BreakPoint](#) * **pstBreakPoints**
 - uint16_t **u16PC**
 - uint64_t **u64InstructionCount**
 - uint64_t **u64CycleCount**
 - uint32_t **u32CoreFreq**
 - uint32_t **u32WDTCount**
 - uint16_t **u16ExtraPC**
 - uint16_t **u16ExtraCycles**
 - bool **bAsleep**
 - uint16_t * **Rd16**
 - uint8_t * **Rd**
 - uint16_t * **Rr16**
 - uint8_t * **Rr**
 - uint16_t **K**
-
- uint8_t **A**
 - uint8_t **b**
 - uint8_t **s**
 - uint8_t **q**
 - uint16_t * **pu16ROM**
 - uint8_t * **pu8EEPROM**
 - [AVR_RAM_t](#) * **pstRAM**
 - uint32_t **u32ROMSize**
 - uint32_t **u32EEPROMSize**
 - uint32_t **u32RAMSize**
 - uint8_t **u8IntPriority**
 - uint32_t **u32IntFlags**
 - InterruptAck **apfInterruptCallbacks** [32]
 - bool **bExitOnReset**
 - bool **bProfile**

3.8.1 Detailed Description

This structure effectively represents an entire simulated AVR CPU - all memories, registers (memory-mapped or internal), peripherals and housekeeping information.

All new CPU functionality added to the emulator eventually winds up tied to this structure.

Definition at line 63 of file [avr_cpu.h](#).

The documentation for this struct was generated from the following file:

- [src/avr_cpu/avr_cpu.h](#)

3.9 AVR_CPU_Config_t Struct Reference

Struct defining parameters used to initialize the AVR CPU structure on startup.

```
#include <avr_cpu.h>
```

Data Fields

- `uint32_t u32ROMSize`
- `uint32_t u32RAMSize`
- `uint32_t u32EESize`
- `bool bExitOnReset`

3.9.1 Detailed Description

Struct defining parameters used to initialize the AVR CPU structure on startup.

Definition at line 146 of file [avr_cpu.h](#).

The documentation for this struct was generated from the following file:

- [src/avr_cpu/avr_cpu.h](#)

3.10 AVR_RAM_t Struct Reference

union structure mapping the first 256 bytes of IO address space to an array of bytes used to represent CPU RAM.

```
#include <avr_cpu.h>
```

Data Fields

3.10.1 Detailed Description

union structure mapping the first 256 bytes of IO address space to an array of bytes used to represent CPU RAM.

Note that based on the runtime configuration, we'll purposefully `malloc()` a block of memory larger than the size of this struct to extend the `au8RAM[]` array to the appropriate size for the CPU target.

Definition at line 47 of file [avr_cpu.h](#).

The documentation for this struct was generated from the following file:

- [src/avr_cpu/avr_cpu.h](#)

3.11 AVR_Variant_t Struct Reference

This struct contains the information necessary to effectively describe an AVR Microcontroller variant among the rest of the code.

```
#include <variant.h>
```

Data Fields

- const char * [szName](#)
Name for the variant, used for identification (i.e.
- uint32_t [u32RAMSize](#)
RAM size for this variant.
- uint32_t [u32ROMSize](#)
ROM size (in bytes) for this variant.
- uint32_t [u32EESize](#)
EEPROM size of this variant.
- const uint8_t * [u8Descriptors](#)
A bytestream composed of feature descriptors.

3.11.1 Detailed Description

This struct contains the information necessary to effectively describe an AVR Microcontroller variant among the rest of the code.

Definition at line 29 of file [variant.h](#).

3.11.2 Field Documentation

3.11.2.1 const char* AVR_Variant_t::szName

Name for the variant, used for identification (i.e.

"atmega328p")

Definition at line 31 of file [variant.h](#).

The documentation for this struct was generated from the following file:

- src/config/[variant.h](#)

3.12 AVRPeripheral Struct Reference

Data Fields

- PeriphInit **pflnit**
- PeriphRead **pfRead**
- PeriphWrite **pfWrite**
- PeriphClock **pfClock**
- void * **pvContext**
- uint8_t **u8AddrStart**
- uint8_t **u8AddrEnd**

3.12.1 Detailed Description

Definition at line 41 of file [avr_peripheral.h](#).

The documentation for this struct was generated from the following file:

- [src/peripheral/avr_peripheral.h](#)

3.13 AVRRegisterFile Struct Reference

The first 256 bytes of the AVR memory space is composed of the core 32 general-purpose registers (R0-R31), and 224 bytes for the remaining I/O registers (used by peripherals).

```
#include <avr_registerfile.h>
```

Data Fields

- [AVR_CoreRegisters](#) **CORE_REGISTERS**
- AVR_PIN **PINA**
- AVR_DDR **DDRA**
- AVR_PORT **PORTA**
- AVR_PIN **PINB**
- AVR_DDR **DDRB**
- AVR_PORT **PORTB**
- AVR_PIN **PINC**
- AVR_DDR **DDRC**
- AVR_PORT **PORTC**
- AVR_PIN **PIND**
- AVR_DDR **DDRD**
- AVR_PORT **PORTD**
- uint8_t **RESERVED_0x2C**
- uint8_t **RESERVED_0x2D**
- uint8_t **RESERVED_0x2E**
- uint8_t **RESERVED_0x2F**
- uint8_t **RESERVED_0x30**
- uint8_t **RESERVED_0x31**
- uint8_t **RESERVED_0x32**
- uint8_t **RESERVED_0x33**
- uint8_t **RESERVED_0x34**
- AVR_TIFR0 **TIFR0**
- AVR_TIFR1 **TIFR1**
- AVR_TIFR2 **TIFR2**
- uint8_t **RESERVED_0x38**
- uint8_t **RESERVED_0x39**
- uint8_t **RESERVED_0x3A**
- AVR_PCIFR **PCIFR**
- AVR_EIFR **EIFR**
- AVR_EIMSK **EIMSK**
- uint8_t **GPOR0**
- AVR_EECR **EECR**
- uint8_t **EEDR**
- uint8_t **EEARL**
- uint8_t **EEARH**
- AVR_GTCCR **GTCCR**

- AVR_TCCR0A **TCCR0A**
- AVR_TCCR0B **TCCR0B**
- uint8_t **TCNT0**
- uint8_t **OCR0A**
- uint8_t **OCR0B**
- uint8_t **RESERVED_0x49**
- uint8_t **GPIOR1**
- uint8_t **GPIOR2**
- AVR_SPCR **SPCR**
- AVR_SPSR **SPSR**
- uint8_t **SPDR**
- uint8_t **RESERVED_0x4F**
- AVR_ACSR **ACSR**
- uint8_t **RESERVED_0x51**
- uint8_t **RESERVED_0x52**
- AVR_SMCR **SMCR**
- AVR_MCUSR **MCUSR**
- AVR_MCUCR **MCUCR**
- uint8_t **RESERVED_0x56**
- AVR_SPMCSR **SPMCSR**
- uint8_t **RESERVED_0x58**
- uint8_t **RESERVED_0x59**
- uint8_t **RESERVED_0x5A**
- uint8_t **RESERVED_0x5B**
- uint8_t **RESERVED_0x5C**
- AVR_SPL **SPL**
- AVR_SPH **SPH**
- AVR_SREG **SREG**
- AVR_WDTCSR **WDTCR**
- AVR_CLKPR **CLKPR**
- uint8_t **RESERVED_0x62**
- uint8_t **RESERVED_0x63**
- AVR_PRR **PRR**
- uint8_t **RESERVED_0x65**
- uint8_t **OSCCAL**
- uint8_t **RESERVED_0x67**
- AVR_PCICR **PCICR**
- AVR_EICRA **EICRA**
- uint8_t **RESERVED_0x6A**
- AVR_PCMSK0 **PCMSK0**
- AVR_PCMSK1 **PCMSK1**
- AVR_PCMSK2 **PCMSK2**
- AVR_TIMSK0 **TIMSK0**
- AVR_TIMSK1 **TIMSK1**
- AVR_TIMSK2 **TIMSK2**
- uint8_t **RESERVED_0x71**
- uint8_t **RESERVED_0x72**
- uint8_t **RESERVED_0x73**
- uint8_t **RESERVED_0x74**
- uint8_t **RESERVED_0x75**
- uint8_t **RESERVED_0x76**
- uint8_t **RESERVED_0x77**
- uint8_t **ADCL**
- uint8_t **ADCH**
- AVR_ADCSRA **ADCSRA**

- AVR_ADCSR **ADSRB**
- AVR_ADMUX **ADMUX**
- uint8_t **RESERVED_0x7F**
- AVR_DIDR0 **DIDR0**
- AVR_DIDR1 **DIDR1**
- AVR_TCCR1A **TCCR1A**
- AVR_TCCR1B **TCCR1B**
- AVR_TCCR1C **TCCR1C**
- uint8_t **RESERVED_0x83**
- uint8_t **TCNT1L**
- uint8_t **TCNT1H**
- uint8_t **ICR1L**
- uint8_t **ICR1H**
- uint8_t **OCR1AL**
- uint8_t **OCR1AH**
- uint8_t **OCR1BL**
- uint8_t **OCR1BH**
- uint8_t **RESERVED_0x8C**
- uint8_t **RESERVED_0x8D**
- uint8_t **RESERVED_0x8E**
- uint8_t **RESERVED_0x8F**
- uint8_t **RESERVED_0x90**
- uint8_t **RESERVED_0x91**
- uint8_t **RESERVED_0x92**
- uint8_t **RESERVED_0x93**
- uint8_t **RESERVED_0x94**
- uint8_t **RESERVED_0x95**
- uint8_t **RESERVED_0x96**
- uint8_t **RESERVED_0x97**
- uint8_t **RESERVED_0x98**
- uint8_t **RESERVED_0x99**
- uint8_t **RESERVED_0x9A**
- uint8_t **RESERVED_0x9B**
- uint8_t **RESERVED_0x9C**
- uint8_t **RESERVED_0x9D**
- uint8_t **RESERVED_0x9E**
- uint8_t **RESERVED_0x9F**
- uint8_t **RESERVED_0xA0**
- uint8_t **RESERVED_0xA1**
- uint8_t **RESERVED_0xA2**
- uint8_t **RESERVED_0xA3**
- uint8_t **RESERVED_0xA4**
- uint8_t **RESERVED_0xA5**
- uint8_t **RESERVED_0xA6**
- uint8_t **RESERVED_0xA7**
- uint8_t **RESERVED_0xA8**
- uint8_t **RESERVED_0xA9**
- uint8_t **RESERVED_0xAA**
- uint8_t **RESERVED_0xAB**
- uint8_t **RESERVED_0xAC**
- uint8_t **RESERVED_0xAD**
- uint8_t **RESERVED_0xAE**
- uint8_t **RESERVED_0xAF**
- AVR_TCCR2A **TCCR2A**
- AVR_TCCR2B **TCCR2B**

- uint8_t **TCNT2**
- uint8_t **OCR2A**
- uint8_t **OCR2B**
- uint8_t **RESERVED_0xB5**
- AVR_ASSR **ASSR**
- uint8_t **RESERVED_0xB7**
- uint8_t **TWBR**
- AVR_TWSR **TWSR**
- AVR_TWAR **TWAR**
- uint8_t **TWDR**
- AVR_TWCR **TWCR**
- AVR_TWAMR **TWAMR**
- uint8_t **RESERVED_0xBE**
- uint8_t **RESERVED_0xBF**
- AVR_UCSR0A **UCSR0A**
- AVR_UCSR0B **UCSR0B**
- AVR_UCSR0C **UCSR0C**
- uint8_t **RESERVED_0xC3**
- uint8_t **UBRR0L**
- uint8_t **UBRR0H**
- uint8_t **UDR0**
- uint8_t **RESERVED_0xC7**
- uint8_t **RESERVED_0xC8**
- uint8_t **RESERVED_0xC9**
- uint8_t **RESERVED_0xCA**
- uint8_t **RESERVED_0xCB**
- uint8_t **RESERVED_0xCC**
- uint8_t **RESERVED_0xCD**
- uint8_t **RESERVED_0xCE**
- uint8_t **RESERVED_0xCF**
- uint8_t **RESERVED_0xD0**
- uint8_t **RESERVED_0xD1**
- uint8_t **RESERVED_0xD2**
- uint8_t **RESERVED_0xD3**
- uint8_t **RESERVED_0xD4**
- uint8_t **RESERVED_0xD5**
- uint8_t **RESERVED_0xD6**
- uint8_t **RESERVED_0xD7**
- uint8_t **RESERVED_0xD8**
- uint8_t **RESERVED_0xD9**
- uint8_t **RESERVED_0xDA**
- uint8_t **RESERVED_0xDB**
- uint8_t **RESERVED_0xDC**
- uint8_t **RESERVED_0xDD**
- uint8_t **RESERVED_0xDE**
- uint8_t **RESERVED_0xDF**
- uint8_t **RESERVED_0xE0**
- uint8_t **RESERVED_0xE1**
- uint8_t **RESERVED_0xE2**
- uint8_t **RESERVED_0xE3**
- uint8_t **RESERVED_0xE4**
- uint8_t **RESERVED_0xE5**
- uint8_t **RESERVED_0xE6**
- uint8_t **RESERVED_0xE7**
- uint8_t **RESERVED_0xE8**

- uint8_t **RESERVED_0xE9**
- uint8_t **RESERVED_0xEA**
- uint8_t **RESERVED_0xEB**
- uint8_t **RESERVED_0xEC**
- uint8_t **RESERVED_0xED**
- uint8_t **RESERVED_0xEE**
- uint8_t **RESERVED_0xEF**
- uint8_t **RESERVED_0xF0**
- uint8_t **RESERVED_0xF1**
- uint8_t **RESERVED_0xF2**
- uint8_t **RESERVED_0xF3**
- uint8_t **RESERVED_0xF4**
- uint8_t **RESERVED_0xF5**
- uint8_t **RESERVED_0xF6**
- uint8_t **RESERVED_0xF7**
- uint8_t **RESERVED_0xF8**
- uint8_t **RESERVED_0xF9**
- uint8_t **RESERVED_0xFA**
- uint8_t **RESERVED_0xFB**
- uint8_t **RESERVED_0xFC**
- uint8_t **RESERVED_0xFD**
- uint8_t **RESERVED_0xFE**
- uint8_t **RESERVED_0xFF**

3.13.1 Detailed Description

The first 256 bytes of the AVR memory space is composed of the core 32 general-purpose registers (R0-R31), and 224 bytes for the remaining I/O registers (used by peripherals).

This data structure maps these 256 bytes to their function. Note that each AVR variant has its own set of peripherals, so this struct definition may change as support for new targets is added. The original mapping is based off the peripherals found on the atmega328p.

Definition at line 38 of file [avr_registerfile.h](#).

The documentation for this struct was generated from the following file:

- [src/avr_cpu/avr_registerfile.h](#)

3.14 Debug_Symbol_t Struct Reference

Data Fields

- Debug_t [eType](#)
Debug symbol type.
- uint32_t [u32StartAddr](#)
Start of the address range held by the symbol.
- uint32_t [u32EndAddr](#)
Last address held by the symbol.
- const char * [szName](#)
Name of the debug symbol.
- uint64_t [u64TotalRefs](#)
Total reference count, used in code profiling.
- uint64_t [u64EpochRefs](#)
Current reference count, used in code profiling.

3.14.1 Detailed Description

Definition at line 36 of file [debug_sym.h](#).

The documentation for this struct was generated from the following file:

- [src/debug/debug_sym.h](#)

3.15 DrawPoint_t Struct Reference

Data Fields

- `uint16_t usX`
X coordinate of the pixel.
- `uint16_t usY`
Y coordinate of the pixel.
- `uint32_t uColor`
Color of the pixel in 5:6:5 format.

3.15.1 Detailed Description

Definition at line 39 of file [ka_graphics.c](#).

The documentation for this struct was generated from the following file:

- [src/kernel_aware/ka_graphics.c](#)

3.16 ElfHeader_t Struct Reference

Data Fields

- `uint32_t u32IdentMagicNumber`
- `uint8_t u8IdentFormat`
- `uint8_t u8IdentEndianness`
- `uint8_t u8IdentVersion`
- `uint8_t u8IdentABI`
- `uint8_t u8IdentABIVersion`
- `uint8_t u8Pad1 [7]`
- `uint16_t u16Type`
- `uint16_t u16Machine`
- `uint32_t u32Version`
- `uint32_t u32EntryPoint`
- `uint32_t u32PHOffset`
- `uint32_t u32SHOffset`
- `uint32_t u32Flags`
- `uint16_t u16EHSize`
- `uint16_t u16PHSize`
- `uint16_t u16PHNum`
- `uint16_t u16SHSize`
- `uint16_t u16SHNum`
- `uint16_t u16SHIndex`

3.16.1 Detailed Description

Definition at line 72 of file [elf_types.h](#).

The documentation for this struct was generated from the following file:

- [src/debug/elf_types.h](#)

3.17 ElfProgramHeader_t Struct Reference

Data Fields

- `uint32_t u32Type`
- `uint32_t u32Offset`
- `uint32_t u32VirtualAddress`
- `uint32_t u32PhysicalAddress`
- `uint32_t u32FileSize`
- `uint32_t u32MemSize`
- `uint32_t u32Flags`
- `uint32_t u32Alignment`

3.17.1 Detailed Description

Definition at line 122 of file [elf_types.h](#).

The documentation for this struct was generated from the following file:

- [src/debug/elf_types.h](#)

3.18 ElfSectionHeader_t Struct Reference

Data Fields

- `uint32_t u32Name`
- `uint32_t u32Type`
- `uint32_t u32Flags`
- `uint32_t u32Address`
- `uint32_t u32Offset`
- `uint32_t u32Size`
- `uint32_t u32Link`
- `uint32_t u32Info`
- `uint32_t u32Alignment`
- `uint32_t u32EntrySize`

3.18.1 Detailed Description

Definition at line 135 of file [elf_types.h](#).

The documentation for this struct was generated from the following file:

- [src/debug/elf_types.h](#)

3.19 ElfSymbol_t Struct Reference

Data Fields

- uint32_t **u32Name**
- uint32_t **u32Value**
- uint32_t **u32Size**
- uint8_t **u8Info**
- uint8_t **u8Other**
- uint16_t **u16SHIndex**

3.19.1 Detailed Description

Definition at line 150 of file [elf_types.h](#).

The documentation for this struct was generated from the following file:

- [src/debug/elf_types.h](#)

3.20 FunctionCoverageTLV_t Struct Reference

Data Fields

- uint32_t **u32FunctionSize**
- uint32_t **u32AddressesHit**
- char **szSymName** [256]

3.20.1 Detailed Description

Definition at line 47 of file [code_profile.c](#).

The documentation for this struct was generated from the following file:

- [src/debug/code_profile.c](#)

3.21 FunctionProfileTLV_t Struct Reference

Data Fields

- uint64_t **u64CyclesTotal**
- uint64_t **u64CPUCycles**
- char **szSymName** [256]

3.21.1 Detailed Description

Definition at line 39 of file [code_profile.c](#).

The documentation for this struct was generated from the following file:

- [src/debug/code_profile.c](#)

3.22 GDBCommandMap_t Struct Reference

Data Fields

- GDBCommandType_t **eCmd**
- const char * **szToken**
- GDBCommandHandler_t **pfHandler**

3.22.1 Detailed Description

Definition at line 63 of file [gdb_rsp.c](#).

The documentation for this struct was generated from the following file:

- [src/debug/gdb_rsp.c](#)

3.23 HEX_Record_t Struct Reference

Data type used to represent a single Intel Hex Record.

```
#include <intel_hex.h>
```

Data Fields

- uint8_t [u8ByteCount](#)
Number of bytes in this record.
- uint8_t [u8RecordType](#)
Record type stored in this record.
- uint16_t [u16Address](#)
16-bit address/offset in this record
- uint8_t [u8Data](#) [MAX_HEX_DATA_BYTES]
Record data bytes.
- uint8_t [u8Checksum](#)
8-bit Checksum for the record
- uint32_t [u32Line](#)
Current line number in the file.

3.23.1 Detailed Description

Data type used to represent a single Intel Hex Record.

Definition at line 57 of file [intel_hex.h](#).

The documentation for this struct was generated from the following file:

- [src/loader/intel_hex.h](#)

3.24 Interactive_Command_t Struct Reference

Struct type used to map debugger command-line inputs to command handlers.

Data Fields

- const char * [szCommand](#)
Command string, as input by the user.
- const char * [szDescription](#)
Command description, printed by "help".
- [Interactive_Handler](#) pfHandler
Pointer to handler function.

3.24.1 Detailed Description

Struct type used to map debugger command-line inputs to command handlers.

Definition at line 52 of file [interactive.c](#).

The documentation for this struct was generated from the following file:

- src/debug/[interactive.c](#)

3.25 Interrupt_Callout_ Struct Reference

Data Fields

- struct [Interrupt_Callout_](#) * [pstNext](#)
Next interrupt callout.
- [InterruptCalloutFunc](#) pfCallout
Callout function.

3.25.1 Detailed Description

Definition at line 29 of file [interrupt_callout.c](#).

The documentation for this struct was generated from the following file:

- src/avr_cpu/[interrupt_callout.c](#)

3.26 KernelAwareTrace_t Struct Reference

Data Fields

- uint16_t [u16File](#)
- uint16_t [u16Line](#)
- uint16_t [u16Code](#)
- uint16_t [u16Arg1](#)
- uint16_t [u16Arg2](#)

3.26.1 Detailed Description

Definition at line 34 of file [ka_trace.c](#).

The documentation for this struct was generated from the following file:

- src/kernel_aware/[ka_trace.c](#)

3.27 Mark3_Context_t Struct Reference

Data Fields

- uint8_t **SPH**
- uint8_t **SPL**
- uint8_t **r** [32]
- uint8_t **SREG**
- uint16_t **PC**

3.27.1 Detailed Description

Definition at line 26 of file [ka_thread.h](#).

The documentation for this struct was generated from the following file:

- [src/kernel_aware/ka_thread.h](#)

3.28 Mark3_Thread_Info_t Struct Reference

Data Fields

- [Mark3_Thread_t](#) * **pstThread**
- uint8_t **u8ThreadID**
- uint64_t **u64TotalCycles**
- uint64_t **u64EpockCycles**
- bool **bActive**

3.28.1 Detailed Description

Definition at line 84 of file [ka_thread.c](#).

The documentation for this struct was generated from the following file:

- [src/kernel_aware/ka_thread.c](#)

3.29 Mark3_Thread_t Struct Reference

Data Fields

- uint16_t [u16NextPtr](#)
Link list pointers.
- uint16_t **u16PrevPtr**
- uint16_t [u16StackTopPtr](#)
Pointer to the top of the thread's stack.
- uint16_t [u16StackPtr](#)
Pointer to the thread's stack.
- uint8_t [u8ThreadID](#)
Thread ID.
- uint8_t [u8Priority](#)
Default priority of the thread.

- `uint8_t u8CurPriority`
Current priority of the thread (priority inheritance)
- `uint8_t u8ThreadState`
Thread's current state (ready, blocking, etc)
- `uint16_t u16StackSize`
Size of the stack (in bytes)
- `uint16_t u16CurrentThreadList`
Threadlists.
- `uint16_t u16OwnerThreadList`
- `uint16_t u16EntryPoint`
The entry-point function called when the thread starts.
- `void * m_pvArg`
Pointer to the argument passed into the thread's entrypt.
- `uint16_t u16Quantum`
Thread quantum (in milliseconds)

3.29.1 Detailed Description

Definition at line 41 of file [ka_thread.c](#).

The documentation for this struct was generated from the following file:

- [src/kernel_aware/ka_thread.c](#)

3.30 Mark3ContextSwitch_TLV_t Struct Reference

Data Fields

- `uint64_t u64Timestamp`
- `uint16_t u16StackMargin`
- `uint8_t u8ThreadID`
- `uint8_t u8ThreadPri`

3.30.1 Detailed Description

Definition at line 94 of file [ka_thread.c](#).

The documentation for this struct was generated from the following file:

- [src/kernel_aware/ka_thread.c](#)

3.31 Mark3Interrupt_TLV_t Struct Reference

Data Fields

- `uint64_t u64TimeStamp`
- `uint8_t u8Vector`
- `bool bEntry`

3.31.1 Detailed Description

Definition at line 38 of file [ka_interrupt.c](#).

The documentation for this struct was generated from the following file:

- [src/kernel_aware/ka_interrupt.c](#)

3.32 Mark3Profile_TLV_t Struct Reference

Data Fields

- `uint64_t` [u64Timestamp](#)
Timestamp when the profiling print was made.
- `uint64_t` [u64ProfileCount](#)
Count of profiling events.
- `uint64_t` [u64ProfileTotalCycles](#)
Total cycles (sum from all profiling events).
- `char` [szName](#) [32]
Profiling name.

3.32.1 Detailed Description

Definition at line 44 of file [ka_profile.c](#).

The documentation for this struct was generated from the following file:

- [src/kernel_aware/ka_profile.c](#)

3.33 Option_t Struct Reference

Local data structure used to define a command-line option.

Data Fields

- `const char *` [szAttribute](#)
Name of the attribute (i.e.
- `const char *` [szDescription](#)
Description string, used for printing valid options.
- `char *` [szParameter](#)
Parameter string associated with the option.
- `bool` [bStandalone](#)
Attribute is standalone (no parameter value expected)

3.33.1 Detailed Description

Local data structure used to define a command-line option.

Definition at line 31 of file [options.c](#).

3.33.2 Field Documentation

3.33.2.1 `const char* Option_t::szAttribute`

Name of the attribute (i.e.

what's parsed from the commandline)

Definition at line 33 of file [options.c](#).

The documentation for this struct was generated from the following file:

- [src/config/options.c](#)

3.34 Profile_t Struct Reference

Data Fields

- [Debug_Symbol_t * pstSym](#)
Pointer to the debug symbol being profiled at this address.
- [uint64_t u64TotalHit](#)
Total count of hits at this address.
- [uint64_t u64EpochHit](#)
Count of hits at this address in the current epoch.

3.34.1 Detailed Description

Definition at line 31 of file [code_profile.c](#).

The documentation for this struct was generated from the following file:

- [src/debug/code_profile.c](#)

3.35 TLV_t Struct Reference

Data Fields

- [FlavrTag_t eTag](#)
Tag for the object.
- [uint16_t u16Len](#)
Number of bytes that follow in this entry.
- [uint8_t au8Data \[1\]](#)
Data array (1 or more bytes)

3.35.1 Detailed Description

Definition at line 53 of file [tlv_file.h](#).

The documentation for this struct was generated from the following file:

- [src/kernel_aware/tlv_file.h](#)

3.36 TraceBuffer_t Struct Reference

Implements a circular buffer of trace elements, sized according to the compile-time configuration.

```
#include <trace_buffer.h>
```

Data Fields

- [TraceElement_t astTraceStep](#) [[CONFIG_TRACEBUFFER_SIZE](#)]
Array of trace samples.
- [uint32_t u32Index](#)
Current sample index.

3.36.1 Detailed Description

Implements a circular buffer of trace elements, sized according to the compile-time configuration.

Definition at line 53 of file [trace_buffer.h](#).

The documentation for this struct was generated from the following file:

- [src/debug/trace_buffer.h](#)

3.37 TraceElement_t Struct Reference

Struct defining the CPU's running state at each tracebuffer sample point.

```
#include <trace_buffer.h>
```

Data Fields

- [uint64_t u64Counter](#)
Instruction counter.
- [uint64_t u64CycleCount](#)
CPU Cycle counter.
- [uint16_t u16OpCode](#)
opcode @ trace sample
- [uint16_t u16PC](#)
program counter @ trace sample
- [uint16_t u16SP](#)
stack pointer @ trace sample
- [uint8_t u8SR](#)
status register @ trace sample
- [AVR_CoreRegisters stCoreRegs](#)
core CPU registers @ trace sample

3.37.1 Detailed Description

Struct defining the CPU's running state at each tracebuffer sample point.

Definition at line 35 of file [trace_buffer.h](#).

The documentation for this struct was generated from the following file:

- [src/debug/trace_buffer.h](#)

3.38 Write_Callout_ Struct Reference

Data Fields

- struct [Write_Callout_](#) * [pstNext](#)
Pointer to the next callout.
- uint16_t [u16Addr](#)
Address in RAM to monitor.
- [WriteCalloutFunc](#) [pfCallout](#)
Function to call on write.

3.38.1 Detailed Description

Definition at line 31 of file [write_callout.c](#).

The documentation for this struct was generated from the following file:

- [src/avr_cpu/write_callout.c](#)

Chapter 4

File Documentation

4.1 src/avr_cpu/avr_coreregs.h File Reference

Module containing struct definition for the core AVR registers.

```
#include <stdint.h>
```

Data Structures

- struct [AVR_CoreRegisters](#)

This is a bit of overkill, but there are reasons why the struct is presented as more than just a single array of 32 8-bit uints.

4.1.1 Detailed Description

Module containing struct definition for the core AVR registers.

Definition in file [avr_coreregs.h](#).

4.2 avr_coreregs.h

```
00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ((/( ((/(      \      ( ((/(  | -- [ Funkenstein ] -----
00005 *      /( )  /( )  ((( ( ( )\ )\  /( )  | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ( ( )  | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ ( ) \ \ / / | _ \  | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ / / | _ /  | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \ \ \ / / | _ \  |
00010 *      | _ | | _      / _ \ \ \ / / | _ \  | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __AVR_COREREG_H__
00022 #define __AVR_COREREG_H__
00023
00024 #include <stdint.h>
00025
00038 typedef struct
00039 {
00040     union
00041     {
00042         uint8_t r[32];
00043         uint16_t r_word[16];
00044     }
00045 }
```

```

00046         uint16_t r1_0;
00047         uint16_t r3_2;
00048         uint16_t r5_4;
00049         uint16_t r7_6;
00050         uint16_t r9_8;
00051         uint16_t r11_10;
00052         uint16_t r13_12;
00053         uint16_t r15_14;
00054         uint16_t r17_16;
00055         uint16_t r19_18;
00056         uint16_t r21_20;
00057         uint16_t r23_22;
00058         uint16_t r25_24;
00059         uint16_t r27_26;
00060         uint16_t r29_28;
00061         uint16_t r31_30;
00062     };
00063     struct
00064     {
00065         uint8_t r0;
00066         uint8_t r1;
00067         uint8_t r2;
00068         uint8_t r3;
00069         uint8_t r4;
00070         uint8_t r5;
00071         uint8_t r6;
00072         uint8_t r7;
00073         uint8_t r8;
00074         uint8_t r9;
00075         uint8_t r10;
00076         uint8_t r11;
00077         uint8_t r12;
00078         uint8_t r13;
00079         uint8_t r14;
00080         uint8_t r15;
00081         uint8_t r16;
00082         uint8_t r17;
00083         uint8_t r18;
00084         uint8_t r19;
00085         uint8_t r20;
00086         uint8_t r21;
00087         uint8_t r22;
00088         uint8_t r23;
00089         uint8_t r24;
00090         uint8_t r25;
00091         union
00092         {
00093             uint16_t X;
00094             struct
00095             {
00096                 uint8_t r26;
00097                 uint8_t r27;
00098             };
00099         };
00100         union
00101         {
00102             uint16_t Y;
00103             struct
00104             {
00105                 uint8_t r28;
00106                 uint8_t r29;
00107             };
00108         };
00109         union
00110         {
00111             uint16_t Z;
00112             struct
00113             {
00114                 uint8_t r30;
00115                 uint8_t r31;
00116             };
00117         };
00118     };
00119 };
00120 } AVR_CoreRegisters;
00121
00122 #endif

```

4.3 src/avr_cpu/avr_cpu.c File Reference

AVR CPU emulator logic - this module contains the entrypoints required to implement CPU instruction fetch/decode/execute operations, using either lookup tables or direct-decoding logic.

```
#include <stdint.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include "emu_config.h"
#include "avr_cpu.h"
#include "avr_peripheral.h"
#include "avr_interrupt.h"
#include "avr_io.h"
#include "avr_op_decode.h"
#include "avr_op_size.h"
#include "avr_opcodes.h"
#include "avr_op_cycles.h"
#include "trace_buffer.h"
```

Functions

- static void **CPU_Decode** (uint16_t OP_)
- static void **CPU_Execute** (uint16_t OP_)
- uint16_t **CPU_Fetch** (void)
 - CPU_Fetch Fetch the next opcode for the CPU object.*
- static void **CPU_GetOpCycles** (uint16_t OP_)
- static void **CPU_GetOpSize** (uint16_t OP_)
- static void **CPU_PeripheralCycle** (void)
- void **CPU_RunCycle** (void)
 - CPU_RunCycle Run a CPU instruction cycle.*
- void **CPU_Init** (AVR_CPU_Config_t *pstConfig_)
 - CPU_Init Initialize the CPU object and its associated data.*
- void **CPU_AddPeriph** (AVRPeripheral *pstPeriph_)
 - CPU_AddPeriph Add a new I/O Peripheral to the CPU.*
- void **CPU_RegisterInterruptCallback** (InterruptAck pfIntAck_, uint8_t ucVector_)
 - CPU_RegisterInterruptCallback.*

Variables

- **AVR_CPU stCPU**

4.3.1 Detailed Description

AVR CPU emulator logic - this module contains the entrypoints required to implement CPU instruction fetch/decode/execute operations, using either lookup tables or direct-decoding logic.

Definition in file [avr_cpu.c](#).

4.3.2 Function Documentation

4.3.2.1 void CPU_AddPeriph (AVRPeripheral * pstPeriph_)

CPU_AddPeriph Add a new I/O Peripheral to the CPU.

Parameters

<i>pstPeriph_</i>	Pointer to an initialized AVR Peripheral object to be associated with this CPU.
-------------------	---

Definition at line 264 of file [avr_cpu.c](#).

4.3.2.2 uint16_t CPU_Fetch (void)

CPU_Fetch Fetch the next opcode for the CPU object.

Returns

First word of the next opcode

Definition at line 87 of file [avr_cpu.c](#).

4.3.2.3 void CPU_Init (AVR_CPU_Config_t * pstConfig)

CPU_Init Initialize the CPU object and its associated data.

Parameters

<i>pstConfig_</i>	Pointer to an initialized AVR_CPU_Config_t struct
-------------------	---

Definition at line 227 of file [avr_cpu.c](#).

4.3.2.4 void CPU_RegisterInterruptCallback (InterruptAck pfIntAck_, uint8_t ucVector_)

CPU_RegisterInterruptCallback.

Install a function callback to be run whenever a specific interrupt vector is run. This is useful for resetting peripheral registers once a specific type of interrupt has been acknowledged.

Parameters

<i>pfIntAck_</i>	Callback function to register
<i>ucVector_</i>	Interrupt vector index to install handler at

Definition at line 282 of file [avr_cpu.c](#).

4.3.2.5 void CPU_RunCycle (void)

CPU_RunCycle Run a CPU instruction cycle.

This performs Fetch, Decode, Execute, Clock updates, and Interrupt handling.

Definition at line 124 of file [avr_cpu.c](#).

4.4 avr_cpu.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/ ( ((/ (      (      | -- [ Funkenstein ] -----
00005 *      / ( ) / ( ) ((( ( ( )\ )\ / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ( ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ ( ) \ \ / / | _ \ |      | -- [ Virtual ] -----
00008 *      | _ | | _ |      / _ \ \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ \ / | _ \ |      |
00010 *      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 *      See license.txt for details

```

```

00014  *****/
00023 #include <stdint.h>
00024 #include <stdio.h>
00025 #include <string.h>
00026 #include <stdlib.h>
00027
00028 #include "emu_config.h"
00029
00030 #include "avr_cpu.h"
00031 #include "avr_peripheral.h"
00032 #include "avr_interrupt.h"
00033 #include "avr_io.h"
00034 #include "avr_op_decode.h"
00035 #include "avr_op_size.h"
00036 #include "avr_opcodes.h"
00037 #include "avr_op_cycles.h"
00038
00039 #include "trace_buffer.h"
00040
00041 AVR_CPU stCPU;
00042
00043 #if FEATURE_USE_JUMPTABLES
00044 //-----
00055 //-----
00056
00057 static AVR_Decoder astDecoders[65536] = { 0 };
00058 static AVR_Opcode astOpcodes[65536] = { 0 };
00059 static uint8_t au8OpSizes[65536] = { 0 };
00060 static uint8_t au8OpCycles[65536] = { 0 };
00061
00062 #endif
00063
00064 //-----
00065 static void CPU_Decode( uint16_t OP_ )
00066 {
00067     #if FEATURE_USE_JUMPTABLES
00068         astDecoders[OP_] ( OP_ );
00069     #else
00070         AVR_Decoder pfOp = AVR_Decoder_Function( OP_ );
00071         pfOP( OP_ );
00072     #endif
00073 }
00074
00075 //-----
00076 static void CPU_Execute( uint16_t OP_ )
00077 {
00078     #if FEATURE_USE_JUMPTABLES
00079         astOpcodes[OP_] ();
00080     #else
00081         AVR_Opcode pfOp = AVR_Opcode_Function(OP_);
00082         pfOP( OP_ );
00083     #endif
00084 }
00085
00086 //-----
00087 uint16_t CPU_Fetch( void )
00088 {
00089     uint16_t PC = stCPU.ul6PC;
00090     if (PC >= 16384)
00091     {
00092         return 0xFFFF;
00093     }
00094     return stCPU.pu16ROM[ stCPU.ul6PC ];
00095 }
00096
00097 //-----
00098 static void CPU_GetOpCycles( uint16_t OP_ )
00099 {
00100     #if FEATURE_USE_JUMPTABLES
00101         stCPU.ul6ExtraCycles = au8OpCycles[ OP_ ];
00102     #else
00103         stCPU.ul6ExtraCycles = AVR_Opcode_Cycles( OP_ );
00104     #endif
00105 }
00106
00107 //-----
00108 static void CPU_GetOpSize( uint16_t OP_ )
00109 {
00110     #if FEATURE_USE_JUMPTABLES
00111         stCPU.ul6ExtraPC = au8OpSizes[ OP_ ];
00112     #else
00113         stCPU.ul6ExtraPC = AVR_Opcode_Size( OP_ );
00114     #endif
00115 }
00116
00117 //-----
00118 static void CPU_PeripheralCycle( void )

```

```

00119 {
00120     IO_Clock();
00121 }
00122
00123 //-----
00124 void CPU_RunCycle( void )
00125 {
00126     uint16_t OP;
00127
00128     if (!stCPU.bAsleep)
00129     {
00130
00131         OP = CPU_Fetch();
00132
00133         // From the first word fetched, figure out how big this opcode is
00134         // (either 16 or 32-bit)
00135         CPU_GetOpSize( OP );
00136
00137         // Based on the first word fetched, figure out the minimum number of
00138         // CPU cycles required to execute the instruction fetched.
00139         CPU_GetOpCycles( OP );
00140
00141         // Decode the instruction, load internal registers with appropriate
00142         // values.
00143         CPU_Decode( OP );
00144
00145         // Execute the instruction that was just decoded
00146         CPU_Execute( OP );
00147
00148         // Update the PC based on the size of the instruction + whatever
00149         // modifications occurred during the execution cycle.
00150         stCPU.ul6PC += stCPU.ul6ExtraPC;
00151
00152         // Add CPU clock cycles to the global cycle counter based on
00153         // the minimum instruction time, plus whatever modifiers are applied
00154         // during execution of the instruction.
00155         stCPU.u64CycleCount += stCPU.ul6ExtraCycles;
00156
00157         // Cycle-accurate peripheral clocking -- one iteration for each
00158         // peripheral for each CPU cycle of the instruction.
00159         // Note that CPU Interrupts are generated in the peripheral
00160         // phase of the instruction cycle.
00161         while (stCPU.ul6ExtraCycles--)
00162         {
00163             CPU_PeripheralCycle();
00164         }
00165
00166         // Increment the "total executed instruction counter"
00167         stCPU.u64InstructionCount++;
00168     }
00169     else
00170     {
00171         // CPU is asleep, just NOP and wait until we hit an interrupt.
00172         stCPU.u64CycleCount++;
00173         CPU_PeripheralCycle();
00174     }
00175
00176     // Check to see if there are any pending interrupts - if so, vector
00177     // to the appropriate location. This has no effect if no interrupts
00178     // are pending
00179     AVR_Interrupt();
00180 }
00181
00182
00183
00184 #if FEATURE_USE_JUMPTABLES
00185 //-----
00186 static void CPU_BuildDecodeTable(void)
00187 {
00188     uint32_t i;
00189     for (i = 0; i < 65536; i++)
00190     {
00191         astDecoders[i] = AVR_Decoder_Function(i);
00192     }
00193 }
00194
00195 //-----
00196 static void CPU_BuildOpcodeTable(void)
00197 {
00198     uint32_t i;
00199     for (i = 0; i < 65536; i++)
00200     {
00201         astOpcodes[i] = AVR_Opcode_Function(i);
00202     }
00203 }
00204
00205 //-----

```

```

00206 static void CPU_BuildSizeTable(void)
00207 {
00208     uint32_t i;
00209     for (i = 0; i < 65536; i++)
00210     {
00211         au8OpSizes[i] = AVR_Opcode_Size(i);
00212     }
00213 }
00214
00215 //-----
00216 static void CPU_BuildCycleTable(void)
00217 {
00218     uint32_t i;
00219     for (i = 0; i < 65536; i++)
00220     {
00221         au8OpCycles[i] = AVR_Opcode_Cycles(i);
00222     }
00223 }
00224 #endif
00225
00226 //-----
00227 void CPU_Init( AVR_CPU_Config_t *pstConfig_ )
00228 {
00229     memset( &stCPU, 0, sizeof(stCPU));
00230     pstConfig_>u32RAMSize += 256;
00231
00232     stCPU.bExitOnReset = pstConfig_>bExitOnReset;
00233
00234     // Dynamically allocate memory for RAM, ROM, and EEPROM buffers
00235     stCPU.pu8EEPROM = (uint8_t*)malloc( pstConfig_>u32EESize );
00236     stCPU.pu16ROM    = (uint16_t*)malloc( pstConfig_>u32ROMSize );
00237     stCPU.pstRAM     = (AVR_RAM_t*)malloc( pstConfig_>u32RAMSize );
00238
00239     stCPU.u32ROMSize = pstConfig_>u32ROMSize;
00240     stCPU.u32RAMSize = pstConfig_>u32RAMSize;
00241     stCPU.u32EEPROMSize = pstConfig_>u32EESize;
00242
00243     memset( stCPU.pu8EEPROM, 0, pstConfig_>u32EESize );
00244     memset( stCPU.pu16ROM, 0, pstConfig_>u32ROMSize );
00245     memset( stCPU.pstRAM, 0, pstConfig_>u32RAMSize );
00246
00247     // Set the base stack pointer to top-of-ram.
00248     uint16_t ul6InitialStack = 256 + pstConfig_>u32RAMSize - 1;
00249     stCPU.pstRAM->stRegisters.SPH.r = (uint8_t)(ul6InitialStack >> 8);
00250     stCPU.pstRAM->stRegisters.SPL.r = (uint8_t)(ul6InitialStack & 0xFF);
00251
00252     // Reset the interrupt priority register
00253     stCPU.u8IntPriority = 255;
00254
00255     #if FEATURE_USE_JUMPTABLES
00256     CPU_BuildCycleTable();
00257     CPU_BuildSizeTable();
00258     CPU_BuildOpcodeTable();
00259     CPU_BuildDecodeTable();
00260     #endif
00261 }
00262
00263 //-----
00264 void CPU_AddPeriph( AVRPeripheral *pstPeriph_ )
00265 {
00266     IO_AddClocker( pstPeriph_ );
00267
00268     uint8_t i;
00269     for (i = pstPeriph_>u8AddrStart; i <= pstPeriph_>u8AddrEnd; i++)
00270     {
00271         IO_AddReader( pstPeriph_, i );
00272         IO_AddWriter( pstPeriph_, i );
00273     }
00274
00275     if (pstPeriph_>pfInit)
00276     {
00277         pstPeriph_>pfInit( pstPeriph_>pvContext );
00278     }
00279 }
00280
00281 //-----
00282 void CPU_RegisterInterruptCallback( InterruptAck pfIntAck_, uint8_t ucVector_ )
00283 {
00284     if (ucVector_ >= 32)
00285     {
00286         return;
00287     }
00288
00289     stCPU.apfInterruptCallbacks[ ucVector_ ] = pfIntAck_;
00290 }

```

4.5 src/avr_cpu/avr_cpu.h File Reference

AVR CPU Emulator - virtual AVR structure declarations and functions used to drive the emulator (fetch/decode/execute).

```
#include <stdint.h>
#include <stdbool.h>
#include "emu_config.h"
#include "avr_peripheral.h"
#include "avr_periphregs.h"
#include "avr_coreregs.h"
#include "avr_registerfile.h"
#include "avr_io.h"
#include "watchpoint.h"
#include "breakpoint.h"
```

Data Structures

- struct [AVR_RAM_t](#)
union structure mapping the first 256 bytes of IO address space to an array of bytes used to represent CPU RAM.
- struct [AVR_CPU](#)
This structure effectively represents an entire simulated AVR CPU - all memories, registers (memory-mapped or internal), peripherals and housekeeping information.
- struct [AVR_CPU_Config_t](#)
Struct defining parameters used to initialize the AVR CPU structure on startup.

Functions

- void [CPU_Init](#) ([AVR_CPU_Config_t](#) *pstConfig_)
CPU_Init Initialize the CPU object and its associated data.
- uint16_t [CPU_Fetch](#) (void)
CPU_Fetch Fetch the next opcode for the CPU object.
- void [CPU_RunCycle](#) (void)
CPU_RunCycle Run a CPU instruction cycle.
- void [CPU_AddPeriph](#) ([AVRPeripheral](#) *pstPeriph_)
CPU_AddPeriph Add a new I/O Peripheral to the CPU.
- void [CPU_RegisterInterruptCallback](#) (InterruptAck pflntAck_, uint8_t ucVector_)
CPU_RegisterInterruptCallback.

Variables

- [AVR_CPU](#) **stCPU**

4.5.1 Detailed Description

AVR CPU Emulator - virtual AVR structure declarations and functions used to drive the emulator (fetch/decode/execute).

Definition in file [avr_cpu.h](#).

4.5.2 Function Documentation

4.5.2.1 void CPU_AddPeriph (AVRPeripheral * pstPeriph_)

[CPU_AddPeriph](#) Add a new I/O Peripheral to the CPU.


```

00014  *****/
00022 #ifndef __AVR_CPU_H__
00023 #define __AVR_CPU_H__
00024
00025 #include <stdint.h>
00026 #include <stdbool.h>
00027
00028 #include "emu_config.h"
00029
00030 #include "avr_peripheral.h"
00031 #include "avr_periphregs.h"
00032 #include "avr_coreregs.h"
00033 #include "avr_registerfile.h"
00034 #include "avr_io.h"
00035
00036 #include "watchpoint.h"
00037 #include "breakpoint.h"
00038
00039 //-----
00047 typedef struct
00048 {
00049     union
00050     {
00051         AVRRegisterFile stRegisters;
00052         uint8_t au8RAM[ sizeof(AVRRegisterFile) ];
00053     };
00054 } AVR_RAM_t;
00055
00056 //-----
00063 typedef struct
00064 {
00065     //-----
00066     // Jump tables for peripheral read/write functions. This implementation uses
00067     // a table with function pointer arrays, enabling multiple peripherals to
00068     // monitor reads/writes at particular addresses efficiently.
00069     //-----
00070     IOReaderList *apstPeriphReadTable[CONFIG_IO_ADDRESS_BYTES];
00071     IOWriterList *apstPeriphWriteTable[CONFIG_IO_ADDRESS_BYTES];
00072     IOClockList *pstClockList;
00073
00074     //-----
00075     // List of data watchpoints
00076     struct _WatchPoint *pstWatchPoints;
00077
00078     //-----
00079     // List of instruction breakpoints
00080     struct _BreakPoint *pstBreakPoints;
00081
00082     //-----
00083     // Internal CPU Registers (not exposed via IO space)
00084     uint16_t u16PC; // Program counter is not memory mapped, unlike all others
00085
00086     //-----
00087     // Emulator variables
00088     uint64_t u64InstructionCount; // Total Executed instructions
00089     uint64_t u64CycleCount; // Cycle Counter
00090     uint32_t u32CoreFreq; // CPU Frequency (Hz)
00091     uint32_t u32WDTCnt; // Current watchdog timer count
00092     uint16_t u16ExtraPC; // Offset to add to the PC after executing an instruction
00093     uint16_t u16ExtraCycles; // CPU Cycles to add for the current instruction
00094
00095     bool bAsleep; // Whether or not the CPU is sleeping (wake by interrupt)
00096     //-----
00097     // Temporary registers used for optimizing opcodes - for various addressing modes
00098     uint16_t *Rd16;
00099     uint8_t *Rd; // Destination register (in some cases, also source)
00100
00101     uint16_t *Rr16;
00102     uint8_t *Rr; // Source register
00103
00104     uint16_t K; // Constant data
00105     union
00106     {
00107         uint32_t k; // Constant address
00108         int32_t k_s; // Signed, constant address
00109     };
00110
00111     uint8_t A; // IO location address
00112     uint8_t b; // Bit in a register file (3-bits wide)
00113     uint8_t s; // Bit in the status register (3-bits wide)
00114     uint8_t q; // Displacement for direct addressing (6-bits)
00115
00116     //-----
00117     // Setting up regions of memory for general-purpose RAM (shared with the
00118     // IO space from 0-0xFF), ROM/FLASH, and EEPROM.
00119     //-----
00120     uint16_t *pu16ROM;

```

```

00121     uint8_t      *pu8EEPROM;
00122     AVR_RAM_t    *pstRAM;
00123
00124     uint32_t     u32ROMSize;
00125     uint32_t     u32EEPROMSize;
00126     uint32_t     u32RAMSize;
00127
00128     //-----
00129     uint8_t      u8IntPriority; // Priority of pending interrupts this cycle
00130     uint32_t     u32IntFlags;   // Bitmask for the 32 interrupts
00131
00132     //-----
00133     InterruptAck apfInterruptCallbacks[32]; // Interrupt callbacks
00134
00135     //-----
00136     bool         bExitOnReset; // Flag indicating behavior when we jump to 0. true == exit emulator
00137     bool         bProfile;     // Flag indicating that CPU is running with active code profiling
00138 } AVR_CPU;
00139
00140
00141 //-----
00142 typedef struct
00143 {
00144     uint32_t u32ROMSize;
00145     uint32_t u32RAMSize;
00146     uint32_t u32EESize;
00147     bool     bExitOnReset;
00148 } AVR_CPU_Config_t;
00149
00150 //-----
00151 void CPU_Init( AVR_CPU_Config_t *pstConfig_ );
00152
00153 //-----
00154 uint16_t CPU_Fetch( void );
00155
00156 //-----
00157 void CPU_RunCycle( void );
00158
00159 //-----
00160 void CPU_AddPeriph( AVRPeripheral *pstPeriph_ );
00161
00162 //-----
00163 void CPU_RegisterInterruptCallback( InterruptAck pfIntAck_, uint8_t ucVector_
00164 );
00165
00166
00167 extern AVR_CPU stCPU;
00168
00169 #endif

```

4.7 src/avr_cpu/avr_cpu_print.c File Reference

Helper module used to print the contents of a virtual AVR's internal registers and memory.

```

#include "avr_cpu.h"
#include "emu_config.h"
#include <stdio.h>
#include <stdlib.h>
#include <stdint.h>

```

Macros

- #define **PRINT_FUNC** printf
- #define **RAM_DISPLAY_SPAN** (16)
Number of RAM values per line.
- #define **ROM_DISPLAY_SPAN** (8)
Number of ROM values per line.

Functions

- void [print_core_regs](#) (void)
print_core_regs
- void [print_io_reg](#) (uint8_t u8Addr_)
print_io_reg
- void [print_io_reg_with_name](#) (uint8_t u8Addr_, const char *szName_)
print_io_reg_with_name
- void [print_ram](#) (uint16_t u16Start_, uint16_t u16Span_)
print_ram
- void [print_rom](#) (uint16_t u16Start_, uint16_t u16Span_)
print_rom

4.7.1 Detailed Description

Helper module used to print the contents of a virtual AVR's internal registers and memory.

Definition in file [avr_cpu_print.c](#).

4.7.2 Function Documentation

4.7.2.1 void print_core_regs (void)

print_core_regs

Display the contents of the CPU's core registers to the console

Definition at line 37 of file [avr_cpu_print.c](#).

4.7.2.2 void print_io_reg (uint8_t u8Addr_)

print_io_reg

Display a single IO register (addresses 0-255) to the console.

Parameters

<i>u8Addr_</i>	Address of the IO register to display
----------------	---------------------------------------

Definition at line 116 of file [avr_cpu_print.c](#).

4.7.2.3 void print_io_reg_with_name (uint8_t u8Addr_, const char * szName_)

print_io_reg_with_name

Print an IO register to the console, with a "friendly" name attached.

Parameters

<i>u8Addr_</i>	Address of the IO register to display
<i>szName_</i>	"Friendly name" of the register.

Definition at line 122 of file [avr_cpu_print.c](#).

4.7.2.4 void print_ram (uint16_t u16Start_, uint16_t u16Span_)

print_ram

Display a block of RAM on the console.

Parameters

<i>u16Start_</i>	Start address
<i>u16Span_</i>	Number of bytes to display

Definition at line 128 of file [avr_cpu_print.c](#).

4.7.2.5 void print_rom (uint16_t u16Start_, uint16_t u16Span_)

print_rom

Display a block of ROM to the console

Parameters

<i>u16Start_</i>	Start address
<i>u16Span_</i>	Number of instruction words (16-bit) to display

Definition at line 185 of file [avr_cpu_print.c](#).

4.8 avr_cpu_print.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      |
00004 *      ((/( ((/(      )\      | -- [ Funkenstein ] -----
00005 *      /( )  /( )  ((( ( )\   )\ /( )      | -- [ Little ] -----
00006 *      ( )_ | ( )      )\ _ )\ (( ( ( ) ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ \ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | | _ | | _      / _ \ \ V / | _ /      | -- [ Runtime ] -----
00009 *      | | _ | | _      / _ \ \ V / | _ /      |
00010 *                                          | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00022 #include "avr_cpu.h"
00023
00024 #include "emu_config.h"
00025
00026 #include <stdio.h>
00027 #include <stdlib.h>
00028 #include <stdint.h>
00029
00030 //-----
00031 #define PRINT_FUNC      printf
00032
00033 #define RAM_DISPLAY_SPAN      (16)
00034 #define ROM_DISPLAY_SPAN      (8)
00035
00036 //-----
00037 void print_core_regs( void )
00038 {
00039     uint8_t i;
00040     for (i = 0; i < 32; i++)
00041     {
00042         PRINT_FUNC( "[R%02d] = 0x%02X\n", i, stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[i] );
00043     }
00044     PRINT_FUNC( "[SP] = 0x%02X%02X\n", (uint8_t)stCPU.pstRAM->stRegisters.SPH.r, (uint8_t)stCPU.pstRAM->
stRegisters.SPL.r );
00045     PRINT_FUNC( "[PC] = 0x%04X\n", (uint16_t)stCPU.u16PC );
00046     PRINT_FUNC( "[SREG]= 0x%02X    ", stCPU.pstRAM->stRegisters.SREG.r );
00047
00048     if (1 == stCPU.pstRAM->stRegisters.SREG.I)
00049     {
00050         PRINT_FUNC( "I" );
00051     }
00052     else
00053     {
00054         PRINT_FUNC( "-" );
00055     }
00056     if (1 == stCPU.pstRAM->stRegisters.SREG.T)
00057     {
00058         PRINT_FUNC( "T" );
00059     }
00060     else
00061     {

```

```

00062     PRINT_FUNC("-");
00063 }
00064 if (1 == stCPU.pstRAM->stRegisters.SREG.H)
00065 {
00066     PRINT_FUNC("H");
00067 }
00068 else
00069 {
00070     PRINT_FUNC("-");
00071 }
00072 if (1 == stCPU.pstRAM->stRegisters.SREG.S)
00073 {
00074     PRINT_FUNC("S");
00075 }
00076 else
00077 {
00078     PRINT_FUNC("-");
00079 }
00080 if (1 == stCPU.pstRAM->stRegisters.SREG.V)
00081 {
00082     PRINT_FUNC("V");
00083 }
00084 else
00085 {
00086     PRINT_FUNC("-");
00087 }
00088 if (1 == stCPU.pstRAM->stRegisters.SREG.N)
00089 {
00090     PRINT_FUNC("N");
00091 }
00092 else
00093 {
00094     PRINT_FUNC("-");
00095 }
00096 if (1 == stCPU.pstRAM->stRegisters.SREG.Z)
00097 {
00098     PRINT_FUNC("Z");
00099 }
00100 else
00101 {
00102     PRINT_FUNC("-");
00103 }
00104 if (1 == stCPU.pstRAM->stRegisters.SREG.C)
00105 {
00106     PRINT_FUNC("C");
00107 }
00108 else
00109 {
00110     PRINT_FUNC("-");
00111 }
00112 PRINT_FUNC("]\n");
00113 }
00114
00115 //-----
00116 void print_io_reg( uint8_t u8Addr_ )
00117 {
00118     PRINT_FUNC( "[IO%02X]= 0x%02X\n", u8Addr_, stCPU.pstRAM->au8RAM[u8Addr_] );
00119 }
00120
00121 //-----
00122 void print_io_reg_with_name( uint8_t u8Addr_, const char *szName_ )
00123 {
00124     PRINT_FUNC( "[%s]= 0x%02X\n", szName_, stCPU.pstRAM->au8RAM[u8Addr_] );
00125 }
00126
00127 //-----
00128 void print_ram( uint16_t u16Start_, uint16_t u16Span_ )
00129 {
00130     uint16_t i, j;
00131
00132     while (u16Span_)
00133     {
00134         // Print the current memory address
00135         PRINT_FUNC( "[0x%04X]", u16Start_ );
00136         if (u16Span_ < RAM_DISPLAY_SPAN)
00137         {
00138             j = u16Span_;
00139         }
00140         else
00141         {
00142             j = RAM_DISPLAY_SPAN;
00143         }
00144
00145         // Print a divider, followed by the ASCII codes for each char
00146         PRINT_FUNC( "|" );
00147         for (i = 0; i < j; i++)
00148         {

```

```

00149         uint8_t u8Char = stCPU.pstRAM->au8RAM[u16Start_ + i];
00150         if (u8Char < 32)
00151         {
00152             u8Char = '.';
00153         }
00154
00155         PRINT_FUNC( " %c", u8Char );
00156     }
00157     i = j;
00158     while (i < RAM_DISPLAY_SPAN)
00159     {
00160         PRINT_FUNC(" ");
00161         i++;
00162     }
00163
00164     // Print a divider, followed by the HEX code for each char
00165     PRINT_FUNC( "|" );
00166     for (i = 0; i < j; i++)
00167     {
00168         PRINT_FUNC( " %02X", stCPU.pstRAM->au8RAM[u16Start_ + i]);
00169     }
00170
00171     if (u16Span_ < RAM_DISPLAY_SPAN)
00172     {
00173         u16Span_ = 0;
00174     }
00175     else
00176     {
00177         u16Span_ -= RAM_DISPLAY_SPAN;
00178     }
00179     u16Start_ += RAM_DISPLAY_SPAN;
00180     PRINT_FUNC( "\n" );
00181 }
00182 }
00183
00184 //-----
00185 void print_rom( uint16_t u16Start_, uint16_t u16Span_ )
00186 {
00187     uint16_t i, j;
00188
00189     while (u16Span_)
00190     {
00191         // Print the current memory address
00192         PRINT_FUNC( "[0x%04X]", u16Start_ );
00193         if (u16Span_ < ROM_DISPLAY_SPAN)
00194         {
00195             j = u16Span_;
00196         }
00197         else
00198         {
00199             j = ROM_DISPLAY_SPAN;
00200         }
00201
00202         // Print a divider, followed by the ASCII codes for each char
00203         PRINT_FUNC( "|" );
00204         for (i = 0; i < j; i++)
00205         {
00206             uint16_t u16Val = stCPU.pu16ROM[u16Start_ + i];
00207             uint8_t u8High = u16Val >> 8;
00208             uint8_t u8Low = u16Val & 0x00FF;
00209
00210             if (u8High < 32)
00211             {
00212                 u8High = '.';
00213             }
00214             if (u8Low < 32)
00215             {
00216                 u8Low = '.';
00217             }
00218
00219             PRINT_FUNC( " %c%c", u8High, u8Low );
00220         }
00221         i = j;
00222         while (i < ROM_DISPLAY_SPAN)
00223         {
00224             PRINT_FUNC(" ");
00225             i++;
00226         }
00227
00228         // Print a divider, followed by the HEX code for each char
00229         PRINT_FUNC( "|" );
00230         for (i = 0; i < j; i++)
00231         {
00232             PRINT_FUNC( " %04X", stCPU.pu16ROM[u16Start_ + i]);
00233         }
00234
00235         if (u16Span_ < ROM_DISPLAY_SPAN)

```

```

00236     {
00237         u16Span_ = 0;
00238     }
00239     else
00240     {
00241         u16Span_ -= ROM_DISPLAY_SPAN;
00242     }
00243     u16Start_ += ROM_DISPLAY_SPAN;
00244     PRINT_FUNC( "\n" );
00245 }
00246 }

```

4.9 src/avr_cpu/avr_cpu_print.h File Reference

Helper module used to print the contents of a virtual AVR's internal registers and memory.

```

#include <stdint.h>
#include "avr_cpu.h"

```

Functions

- void [print_core_regs](#) (void)
print_core_regs
- void [print_io_reg](#) (uint8_t u8Addr_)
print_io_reg
- void [print_io_reg_with_name](#) (uint8_t u8Addr_, const char *szName_)
print_io_reg_with_name
- void [print_ram](#) (uint16_t u16Start_, uint16_t u16Span_)
print_ram
- void [print_rom](#) (uint16_t u16Start_, uint16_t u16Span_)
print_rom

4.9.1 Detailed Description

Helper module used to print the contents of a virtual AVR's internal registers and memory.

Definition in file [avr_cpu_print.h](#).

4.9.2 Function Documentation

4.9.2.1 void print_core_regs (void)

[print_core_regs](#)

Display the contents of the CPU's core registers to the console

Definition at line 37 of file [avr_cpu_print.c](#).

4.9.2.2 void print_io_reg (uint8_t u8Addr_)

[print_io_reg](#)

Display a single IO register (addresses 0-255) to the console.

Parameters

<i>u8Addr_</i>	Address of the IO register to display
----------------	---------------------------------------

Definition at line 116 of file [avr_cpu_print.c](#).

4.9.2.3 void print_io_reg_with_name (uint8_t u8Addr_, const char * szName_)

print_io_reg_with_name

Print an IO register to the console, with a "friendly" name attached.

Parameters

<i>u8Addr_</i>	Address of the IO register to display
<i>szName_</i>	"Friendly name" of the register.

Definition at line 122 of file [avr_cpu_print.c](#).

4.9.2.4 void print_ram (uint16_t u16Start_, uint16_t u16Span_)

print_ram

Display a block of RAM on the console.

Parameters

<i>u16Start_</i>	Start address
<i>u16Span_</i>	Number of bytes to display

Definition at line 128 of file [avr_cpu_print.c](#).

4.9.2.5 void print_rom (uint16_t u16Start_, uint16_t u16Span_)

print_rom

Display a block of ROM to the console

Parameters

<i>u16Start_</i>	Start address
<i>u16Span_</i>	Number of instruction words (16-bit) to display

Definition at line 185 of file [avr_cpu_print.c](#).

4.10 avr_cpu_print.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ((/( ((/(      \      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( ) \ ) \ / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      ) \ _ \ ( ( ( ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ \ ( ) \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _ | / _ \ \ / \ / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ / \ / | _ \      |
00010 *      | _ | | _ | / _ \ \ / \ / | _ \      | "Yeah, it does Arduino..."
00011 *      | _ | | _ | / _ \ \ / \ / | _ \      |
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00023 #ifndef __AVR_CPU_PRINT_H__
00024 #define __AVR_CPU_PRINT_H__
00025
00026 #include <stdint.h>
00027 #include "avr_cpu.h"
00028

```

```

00029 //-----
00035 void print_core_regs( void );
00036
00037 //-----
00045 void print_io_reg( uint8_t u8Addr_ );
00046
00047 //-----
00057 void print_io_reg_with_name( uint8_t u8Addr_, const char *szName_ );
00058
00059 //-----
00068 void print_ram( uint16_t u16Start_, uint16_t u16Span_ );
00069
00070 //-----
00079 void print_rom( uint16_t u16Start_, uint16_t u16Span_ );
00080
00081 #endif

```

4.11 src/avr_cpu/avr_disasm.c File Reference

AVR Disassembler Implementation.

```

#include <stdint.h>
#include <stdio.h>
#include "emu_config.h"
#include "avr_disasm.h"
#include "avr_op_decode.h"
#include "avr_opcodes.h"
#include "avr_op_size.h"
#include "avr_cpu.h"
#include "avr_cpu_print.h"
#include "avr_loader.h"

```

Functions

- int8_t **Signed_From_Unsigned_6** (uint8_t u8Signed_)
- uint8_t **Register_From_Rd** (void)
- uint8_t **Register_From_Rr** (void)
- uint8_t **Register_From_Rd16** (void)
- uint8_t **Register_From_Rr16** (void)
- static void **AVR_Disasm_ADD** (char *szOutput_)
- static void **AVR_Disasm_ADC** (char *szOutput_)
- static void **AVR_Disasm_ADIW** (char *szOutput_)
- static void **AVR_Disasm_SUB** (char *szOutput_)
- static void **AVR_Disasm_SUBI** (char *szOutput_)
- static void **AVR_Disasm_SBC** (char *szOutput_)
- static void **AVR_Disasm_SBCI** (char *szOutput_)
- static void **AVR_Disasm_SBIW** (char *szOutput_)
- static void **AVR_Disasm_AND** (char *szOutput_)
- static void **AVR_Disasm_ANDI** (char *szOutput_)
- static void **AVR_Disasm_OR** (char *szOutput_)
- static void **AVR_Disasm_ORI** (char *szOutput_)
- static void **AVR_Disasm_EOR** (char *szOutput_)
- static void **AVR_Disasm_COM** (char *szOutput_)
- static void **AVR_Disasm_NEG** (char *szOutput_)
- static void **AVR_Disasm_SBR** (char *szOutput_)
- static void **AVR_Disasm_CBR** (char *szOutput_)
- static void **AVR_Disasm_INC** (char *szOutput_)
- static void **AVR_Disasm_DEC** (char *szOutput_)
- static void **AVR_Disasm_TST** (char *szOutput_)

- static void **AVR_Disasm_CLR** (char *szOutput_)
- static void **AVR_Disasm_SER** (char *szOutput_)
- static void **AVR_Disasm_MUL** (char *szOutput_)
- static void **AVR_Disasm_MULS** (char *szOutput_)
- static void **AVR_Disasm_MULSU** (char *szOutput_)
- static void **AVR_Disasm_FMUL** (char *szOutput_)
- static void **AVR_Disasm_FMULS** (char *szOutput_)
- static void **AVR_Disasm_FMULSU** (char *szOutput_)
- static void **AVR_Disasm_DES** (char *szOutput_)
- static void **AVR_Disasm_RJMP** (char *szOutput_)
- static void **AVR_Disasm_IJMP** (char *szOutput_)
- static void **AVR_Disasm_EIJMP** (char *szOutput_)
- static void **AVR_Disasm_JMP** (char *szOutput_)
- static void **AVR_Disasm_RCALL** (char *szOutput_)
- static void **AVR_Disasm_ICALL** (char *szOutput_)
- static void **AVR_Disasm_EICALL** (char *szOutput_)
- static void **AVR_Disasm_CALL** (char *szOutput_)
- static void **AVR_Disasm_RET** (char *szOutput_)
- static void **AVR_Disasm_RETI** (char *szOutput_)
- static void **AVR_Disasm_CPSE** (char *szOutput_)
- static void **AVR_Disasm_CP** (char *szOutput_)
- static void **AVR_Disasm_CPC** (char *szOutput_)
- static void **AVR_Disasm_CPI** (char *szOutput_)
- static void **AVR_Disasm_SBRC** (char *szOutput_)
- static void **AVR_Disasm_SBRB** (char *szOutput_)
- static void **AVR_Disasm_SBI** (char *szOutput_)
- static void **AVR_Disasm_SBIS** (char *szOutput_)
- static void **AVR_Disasm_BRBS** (char *szOutput_)
- static void **AVR_Disasm_BRBC** (char *szOutput_)
- static void **AVR_Disasm_BREQ** (char *szOutput_)
- static void **AVR_Disasm_BRNE** (char *szOutput_)
- static void **AVR_Disasm_BRCS** (char *szOutput_)
- static void **AVR_Disasm_BRCC** (char *szOutput_)
- static void **AVR_Disasm_BRSH** (char *szOutput_)
- static void **AVR_Disasm_BRLO** (char *szOutput_)
- static void **AVR_Disasm_BRMI** (char *szOutput_)
- static void **AVR_Disasm_BRPL** (char *szOutput_)
- static void **AVR_Disasm_BRGE** (char *szOutput_)
- static void **AVR_Disasm_BRLT** (char *szOutput_)
- static void **AVR_Disasm_BRHS** (char *szOutput_)
- static void **AVR_Disasm_BRHC** (char *szOutput_)
- static void **AVR_Disasm_BRTS** (char *szOutput_)
- static void **AVR_Disasm_BRTC** (char *szOutput_)
- static void **AVR_Disasm_BRVS** (char *szOutput_)
- static void **AVR_Disasm_BRVC** (char *szOutput_)
- static void **AVR_Disasm_BRIE** (char *szOutput_)
- static void **AVR_Disasm_BRID** (char *szOutput_)
- static void **AVR_Disasm_MOV** (char *szOutput_)
- static void **AVR_Disasm_MOVW** (char *szOutput_)
- static void **AVR_Disasm_LDI** (char *szOutput_)
- static void **AVR_Disasm_LDS** (char *szOutput_)
- static void **AVR_Disasm_LD_X_Indirect** (char *szOutput_)
- static void **AVR_Disasm_LD_X_Indirect_Postinc** (char *szOutput_)
- static void **AVR_Disasm_LD_X_Indirect_Predec** (char *szOutput_)
- static void **AVR_Disasm_LD_Y_Indirect** (char *szOutput_)

- static void **AVR_Disasm_LD_Y_Indirect_Postinc** (char *szOutput_)
- static void **AVR_Disasm_LD_Y_Indirect_Predec** (char *szOutput_)
- static void **AVR_Disasm_LDD_Y** (char *szOutput_)
- static void **AVR_Disasm_LD_Z_Indirect** (char *szOutput_)
- static void **AVR_Disasm_LD_Z_Indirect_Postinc** (char *szOutput_)
- static void **AVR_Disasm_LD_Z_Indirect_Predec** (char *szOutput_)
- static void **AVR_Disasm_LDD_Z** (char *szOutput_)
- static void **AVR_Disasm_STS** (char *szOutput_)
- static void **AVR_Disasm_ST_X_Indirect** (char *szOutput_)
- static void **AVR_Disasm_ST_X_Indirect_Postinc** (char *szOutput_)
- static void **AVR_Disasm_ST_X_Indirect_Predec** (char *szOutput_)
- static void **AVR_Disasm_ST_Y_Indirect** (char *szOutput_)
- static void **AVR_Disasm_ST_Y_Indirect_Postinc** (char *szOutput_)
- static void **AVR_Disasm_ST_Y_Indirect_Predec** (char *szOutput_)
- static void **AVR_Disasm_STD_Y** (char *szOutput_)
- static void **AVR_Disasm_ST_Z_Indirect** (char *szOutput_)
- static void **AVR_Disasm_ST_Z_Indirect_Postinc** (char *szOutput_)
- static void **AVR_Disasm_ST_Z_Indirect_Predec** (char *szOutput_)
- static void **AVR_Disasm_STD_Z** (char *szOutput_)
- static void **AVR_Disasm_LPM** (char *szOutput_)
- static void **AVR_Disasm_LPM_Z** (char *szOutput_)
- static void **AVR_Disasm_LPM_Z_Postinc** (char *szOutput_)
- static void **AVR_Disasm_ELPM** (char *szOutput_)
- static void **AVR_Disasm_ELPM_Z** (char *szOutput_)
- static void **AVR_Disasm_ELPM_Z_Postinc** (char *szOutput_)
- static void **AVR_Disasm_SPM** (char *szOutput_)
- static void **AVR_Disasm_SPM_Z_Postinc2** (char *szOutput_)
- static void **AVR_Disasm_IN** (char *szOutput_)
- static void **AVR_Disasm_OUT** (char *szOutput_)
- static void **AVR_Disasm_LAC** (char *szOutput_)
- static void **AVR_Disasm_LAS** (char *szOutput_)
- static void **AVR_Disasm_LAT** (char *szOutput_)
- static void **AVR_Disasm_LSL** (char *szOutput_)
- static void **AVR_Disasm_LSR** (char *szOutput_)
- static void **AVR_Disasm_POP** (char *szOutput_)
- static void **AVR_Disasm_PUSH** (char *szOutput_)
- static void **AVR_Disasm_ROL** (char *szOutput_)
- static void **AVR_Disasm_ROR** (char *szOutput_)
- static void **AVR_Disasm_ASR** (char *szOutput_)
- static void **AVR_Disasm_SWAP** (char *szOutput_)
- static void **AVR_Disasm_BSET** (char *szOutput_)
- static void **AVR_Disasm_BCLR** (char *szOutput_)
- static void **AVR_Disasm_SBI** (char *szOutput_)
- static void **AVR_Disasm_CBI** (char *szOutput_)
- static void **AVR_Disasm_BST** (char *szOutput_)
- static void **AVR_Disasm_BLD** (char *szOutput_)
- static void **AVR_Disasm_SEC** (char *szOutput_)
- static void **AVR_Disasm_CLC** (char *szOutput_)
- static void **AVR_Disasm_SEN** (char *szOutput_)
- static void **AVR_Disasm_CLN** (char *szOutput_)
- static void **AVR_Disasm_SEZ** (char *szOutput_)
- static void **AVR_Disasm_CLZ** (char *szOutput_)
- static void **AVR_Disasm_SEI** (char *szOutput_)
- static void **AVR_Disasm_CLI** (char *szOutput_)
- static void **AVR_Disasm_SES** (char *szOutput_)

- static void **AVR_Disasm_CLS** (char *szOutput_)
 - static void **AVR_Disasm_SEV** (char *szOutput_)
 - static void **AVR_Disasm_CLV** (char *szOutput_)
 - static void **AVR_Disasm_SET** (char *szOutput_)
 - static void **AVR_Disasm_CLT** (char *szOutput_)
 - static void **AVR_Disasm_SEH** (char *szOutput_)
 - static void **AVR_Disasm_CLH** (char *szOutput_)
 - static void **AVR_Disasm_BREAK** (char *szOutput_)
 - static void **AVR_Disasm_NOP** (char *szOutput_)
 - static void **AVR_Disasm_SLEEP** (char *szOutput_)
 - static void **AVR_Disasm_WDR** (char *szOutput_)
 - static void **AVR_Disasm_XCH** (char *szOutput_)
 - static void **AVR_Disasm_Unimplemented** (char *szOutput_)
 - AVR_Disasm [AVR_Disasm_Function](#) (uint16_t OP_)
- AVR_Disasm_Function.*

4.11.1 Detailed Description

AVR Disassembler Implementation.

Definition in file [avr_disasm.c](#).

4.11.2 Function Documentation

4.11.2.1 AVR_Disasm AVR_Disasm_Function (uint16_t OP_)

AVR_Disasm_Function.

Return a function pointer to a disassembly routine corresponding to a given opcode.

Parameters

<i>OP_</i>	Opcode to disassemble
------------	-----------------------

Returns

Function pointer that, when called with a valid CPU object and opcode, will produce a valid disassembly statement to standard output.

Definition at line 1637 of file [avr_disasm.c](#).

4.12 avr_disasm.c

```

00001 /*****
00002 *      ( )      ( )      ( )      |
00003 *      )\ ) )\ )      (      )\ ) |
00004 *      (( / ( ( / (      )\      ( ( ( / ( | -- [ Funkenstein ] -----
00005 *      / ( ) / ( ) ((( ( ( ) )\ )\ / ( ) | -- [ Little ] -----
00006 *      ( ) _ ( ) )\ _ )\ ( ( ) ( ) ( ) | -- [ AVR ] -----
00007 *      | _ | | ( ) _ ( ) \ \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ V / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _ / _ \ \ / | _ \ |
00010 *      | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdint.h>
00022 #include <stdio.h>
00023
00024 #include "emu_config.h"
```

```

00025
00026 #include "avr_disasm.h"
00027 #include "avr_op_decode.h"
00028 #include "avr_opcodes.h"
00029 #include "avr_op_size.h"
00030 #include "avr_cpu.h"
00031 #include "avr_cpu_print.h"
00032 #include "avr_loader.h"
00033
00034 //-----
00035 inline int8_t Signed_From_Unsigned_6( uint8_t u8Signed_ )
00036 {
00037     int8_t i8Ret = 0;
00038     if( u8Signed_ & 0x20 )
00039     {
00040         //Sign extend...
00041         i8Ret = (int8_t)(u8Signed_ | 0xC0);
00042     }
00043     else
00044     {
00045         i8Ret = (int8_t)u8Signed_;
00046     }
00047     return i8Ret;
00048 }
00049
00050 //-----
00051 inline uint8_t Register_From_Rd( void )
00052 {
00053     return stCPU.Rd - &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r0);
00054 }
00055 //-----
00056 inline uint8_t Register_From_Rr( void )
00057 {
00058     return stCPU.Rr - &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r0);
00059 }
00060
00061 //-----
00062 inline uint8_t Register_From_Rd16( void )
00063 {
00064     return (uint8_t*)(stCPU.Rd16) - &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r0);
00065 }
00066
00067 //-----
00068 inline uint8_t Register_From_Rr16( void )
00069 {
00070     return (uint8_t*)(stCPU.Rr16) - &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r0);
00071 }
00072
00073 //-----
00074 static void AVR_Disasm_ADD( char *szOutput_ )
00075 {
00076     uint8_t u8Rd = Register_From_Rd();
00077     uint8_t u8Rr = Register_From_Rr();
00078
00079     //ruler: 0---5---10---15---20---25---30---35---40" );
00080     sprintf( szOutput_, "add r%d, r%d\t ; Add: r%d = r%d + r%d\n",
00081             u8Rd, u8Rr,
00082             u8Rd, u8Rd, u8Rr );
00083 }
00084
00085 //-----
00086 static void AVR_Disasm_ADC( char *szOutput_ )
00087 {
00088     uint8_t u8Rd = Register_From_Rd();
00089     uint8_t u8Rr = Register_From_Rr();
00090
00091     //ruler: 0---5---10---15---20---25---30---35---40" );
00092     sprintf( szOutput_, "adc r%d, r%d\t ; Add with carry: r%d = r%d + r%d + C\n",
00093             u8Rd, u8Rr,
00094             u8Rd, u8Rd, u8Rr );
00095 }
00096
00097 //-----
00098 static void AVR_Disasm_ADIW( char *szOutput_ )
00099 {
00100     uint8_t u8Rd = Register_From_Rd16();
00101     uint8_t u8K = stCPU.K;
00102
00103     //ruler: 0---5---10---15---20---25---30---35---40" );
00104     sprintf( szOutput_, "adiw r%d:%d, %d\t ; Add immediate to word: r%d:%d = r%d:%d + %d\n",
00105             u8Rd + 1, u8Rd, u8K,
00106             u8Rd + 1, u8Rd, u8Rd + 1, u8Rd, u8K
00107             );
00108 }
00109
00110 //-----
00111

```

```

00112 static void AVR_Disasm_SUB( char *szOutput_ )
00113 {
00114     uint8_t u8Rd = Register_From_Rd();
00115     uint8_t u8Rr = Register_From_Rr();
00116
00117     //ruler: 0----5----10----15----20----25----30----35----40" );
00118     sprintf( szOutput_, "sub r%d, r%d                \t ; Subtract: r%d = r%d - r%d \n",
00119             u8Rd, u8Rr,
00120             u8Rd, u8Rd, u8Rr
00121         );
00122 }
00123
00124 //-----
00125 static void AVR_Disasm_SUBI( char *szOutput_ )
00126 {
00127     uint8_t u8Rd = Register_From_Rd();
00128     uint8_t u8K = stCPU.K;
00129
00130     //ruler: 0----5----10----15----20----25----30----35----40" );
00131     sprintf( szOutput_, "subi r%d, %d                \t ; Subtract immediate: r%d = r%d - %d \n",
00132             u8Rd, u8K,
00133             u8Rd, u8Rd, u8K
00134         );
00135 }
00136
00137 //-----
00138 static void AVR_Disasm_SBC( char *szOutput_ )
00139 {
00140     uint8_t u8Rd = Register_From_Rd();
00141     uint8_t u8Rr = Register_From_Rr();
00142
00143     //ruler: 0----5----10----15----20----25----30----35----40" );
00144     sprintf( szOutput_, "sbc r%d, r%d                \t ; Subtract with carry: r%d = r%d - r%d - C \n",
00145             u8Rd, u8Rr,
00146             u8Rd, u8Rd, u8Rr
00147         );
00148 }
00149
00150 //-----
00151 static void AVR_Disasm_SBCI( char *szOutput_ )
00152 {
00153     uint8_t u8Rd = Register_From_Rd();
00154     uint8_t u8K = stCPU.K;
00155
00156     //ruler: 0----5----10----15----20----25----30----35----40" );
00157     sprintf( szOutput_, "sbci r%d, %d                \t ; Subtract immediate with carry: r%d = r%d - %d - C\n",
00158             u8Rd, u8K,
00159             u8Rd, u8Rd, u8K
00160         );
00161 }
00162
00163 //-----
00164 static void AVR_Disasm_SBIW( char *szOutput_ )
00165 {
00166     uint8_t u8Rd = Register_From_Rd16();
00167     uint8_t u8K = stCPU.K;
00168
00169     //ruler: 0----5----10----15----20----25----30----35----40" );
00170     sprintf( szOutput_, "sbw r%d:%d, %d                \t ; Subtract immediate from word: r%d:%d = r%d:%d + %d\n",
00171             u8Rd + 1, u8Rd, u8K,
00172             u8Rd + 1, u8Rd, u8Rd + 1, u8Rd, u8K
00173         );
00174 }
00175
00176 //-----
00177 static void AVR_Disasm_AND( char *szOutput_ )
00178 {
00179     uint8_t u8Rd = Register_From_Rd();
00180     uint8_t u8Rr = Register_From_Rr();
00181
00182     //ruler: 0----5----10----15----20----25----30----35----40" );
00183     sprintf( szOutput_, "and r%d, r%d                \t ; Logical AND: r%d = r%d & r%d \n",
00184             u8Rd, u8Rr,
00185             u8Rd, u8Rd, u8Rr
00186         );
00187 }
00188
00189 //-----
00190 static void AVR_Disasm_ANDI( char *szOutput_ )
00191 {
00192     uint8_t u8Rd = Register_From_Rd();
00193     uint8_t u8K = stCPU.K;
00194
00195     //ruler: 0----5----10----15----20----25----30----35----40" );
00196     sprintf( szOutput_, "andi r%d, %d                \t ; Logical AND with Immediate: r%d = r%d & %d\n",

```

```

00197         u8Rd, u8K,
00198         u8Rd, u8Rd, u8K
00199     );
00200 }
00201
00202 //-----
00203 static void AVR_Disasm_OR( char *szOutput_ )
00204 {
00205     uint8_t u8Rd = Register_From_Rd();
00206     uint8_t u8Rr = Register_From_Rr();
00207
00208     //ruler: 0----5----10----15----20----25----30----35----40" );
00209     sprintf( szOutput_, "or r%d, r%d          \t ; Logical OR: r%d = r%d | r%d \n",
00210             u8Rd, u8Rr,
00211             u8Rd, u8Rd, u8Rr
00212         );
00213 }
00214
00215 //-----
00216 static void AVR_Disasm_ORI( char *szOutput_ )
00217 {
00218     uint8_t u8Rd = Register_From_Rd();
00219     uint8_t u8K = stCPU.K;
00220
00221     //ruler: 0----5----10----15----20----25----30----35----40" );
00222     sprintf( szOutput_, "ori r%d, %d          \t ; Logical OR with Immediate: r%d = r%d | %d\n",
00223             u8Rd, u8K,
00224             u8Rd, u8Rd, u8K
00225         );
00226 }
00227
00228 //-----
00229 static void AVR_Disasm_EOR( char *szOutput_ )
00230 {
00231     uint8_t u8Rd = Register_From_Rd();
00232     uint8_t u8Rr = Register_From_Rr();
00233
00234     //ruler: 0----5----10----15----20----25----30----35----40" );
00235     sprintf( szOutput_, "eor r%d, r%d          \t ; Exclusive OR: r%d = r%d ^ r%d \n",
00236             u8Rd, u8Rr,
00237             u8Rd, u8Rd, u8Rr
00238         );
00239 }
00240
00241 //-----
00242 static void AVR_Disasm_COM( char *szOutput_ )
00243 {
00244     uint8_t u8Rd = Register_From_Rd();
00245
00246     //ruler: 0----5----10----15----20----25----30----35----40" );
00247     sprintf( szOutput_, "com r%d          \t ; One's complement (bitwise inverse): r%d = 0xFF -
00248         r%d\n",
00249             u8Rd,
00250             u8Rd, u8Rd
00251         );
00252 }
00253 //-----
00254 static void AVR_Disasm_NEG( char *szOutput_ )
00255 {
00256     uint8_t u8Rd = Register_From_Rd();
00257
00258     //ruler: 0----5----10----15----20----25----30----35----40" );
00259     sprintf( szOutput_, "neg r%d          \t ; Two's complement (sign swap): r%d = 0x00 - r%d\n",
00260             u8Rd,
00261             u8Rd, u8Rd
00262         );
00263 }
00264
00265 //-----
00266 static void AVR_Disasm_SBR( char *szOutput_ )
00267 {
00268     uint8_t u8Rd = Register_From_Rd();
00269     uint8_t u8K = stCPU.K;
00270
00271     //ruler: 0----5----10----15----20----25----30----35----40" );
00272     sprintf( szOutput_, "sbr r%d, %d          \t ; Set Bits in Register: r%d = r%d | %d\n",
00273             u8Rd, u8K,
00274             u8Rd, u8Rd, u8K
00275         );
00276 }
00277
00278 //-----
00279 static void AVR_Disasm_CBR( char *szOutput_ )
00280 {
00281     uint8_t u8Rd = Register_From_Rd();
00282     uint8_t u8K = stCPU.K;

```



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00283
00284 //ruler: 0----5----10---15---20---25---30---35---40" );
00285 sprintf( szOutput_, "cbr r%d, %d          \t ; Clear Bits in Register: r%d = r%d & (0xFF - %d)\n",
00286          u8Rd, u8K,
00287          u8Rd, u8Rd, u8K
00288          );
00289 }
00290
00291 //-----
00292 static void AVR_Disasm_INC( char *szOutput_ )
00293 {
00294     uint8_t u8Rd = Register_From_Rd();
00295
00296     //ruler: 0----5----10---15---20---25---30---35---40" );
00297     sprintf( szOutput_, "inc r%d          \t ; Increment Register: r%d = r%d + 1\n",
00298             u8Rd,
00299             u8Rd, u8Rd
00300             );
00301 }
00302
00303 //-----
00304 static void AVR_Disasm_DEC( char *szOutput_ )
00305 {
00306     uint8_t u8Rd = Register_From_Rd();
00307
00308     //ruler: 0----5----10---15---20---25---30---35---40" );
00309     sprintf( szOutput_, "dec r%d          \t ; Decrement Register: r%d = r%d - 1\n",
00310             u8Rd,
00311             u8Rd, u8Rd
00312             );
00313 }
00314
00315 //-----
00316 static void AVR_Disasm_TST( char *szOutput_ )
00317 {
00318     uint8_t u8Rd = Register_From_Rd();
00319
00320     //ruler: 0----5----10---15---20---25---30---35---40" );
00321     sprintf( szOutput_, "tst r%d          \t ; Test Register for Zero or Negative\n",
00322             u8Rd
00323             );
00324 }
00325
00326 //-----
00327 static void AVR_Disasm_CLR( char *szOutput_ )
00328 {
00329     uint8_t u8Rd = Register_From_Rd();
00330
00331     //ruler: 0----5----10---15---20---25---30---35---40" );
00332     sprintf( szOutput_, "clr r%d          \t ; Clear Register\n",
00333             u8Rd
00334             );
00335 }
00336
00337 //-----
00338 static void AVR_Disasm_SER( char *szOutput_ )
00339 {
00340     uint8_t u8Rd = Register_From_Rd();
00341
00342     //ruler: 0----5----10---15---20---25---30---35---40" );
00343     sprintf( szOutput_, "ser r%d          \t ; Set All Bits in Register\n",
00344             u8Rd
00345             );
00346 }
00347
00348 //-----
00349 static void AVR_Disasm_MUL( char *szOutput_ )
00350 {
00351     uint8_t u8Rd = Register_From_Rd();
00352     uint8_t u8Rr = Register_From_Rr();
00353
00354     //ruler: 0----5----10---15---20---25---30---35---40" );
00355     sprintf( szOutput_, "mul r%d, r%d          \t ; Unsigned Multiply: r1:0 = r%d * r%d\n",
00356             u8Rd, u8Rr,
00357             u8Rd, u8Rr );
00358 }
00359
00360 //-----
00361 static void AVR_Disasm_MULS( char *szOutput_ )
00362 {
00363     uint8_t u8Rd = Register_From_Rd();
00364     uint8_t u8Rr = Register_From_Rr();
00365
00366     //ruler: 0----5----10---15---20---25---30---35---40" );
00367     sprintf( szOutput_, "muls r%d, r%d          \t ; Signed Multiply: r1:0 = r%d * r%d\n",
00368             u8Rd, u8Rr,
00369             u8Rd, u8Rr );

```

```

00370 }
00371
00372 //-----
00373 static void AVR_Disasm_MULSU( char *szOutput_ )
00374 {
00375     uint8_t u8Rd = Register_From_Rd();
00376     uint8_t u8Rr = Register_From_Rr();
00377
00378     //ruler: 0---5---10---15---20---25---30---35---40" );
00379     sprintf( szOutput_, "mulsu r%d, r%d          \t ; Signed * Unsigned Multiply: r1:0 = r%d * r%d\n",
00380             u8Rd, u8Rr,
00381             u8Rd, u8Rr );
00382 }
00383
00384 //-----
00385 static void AVR_Disasm_Fmul( char *szOutput_ )
00386 {
00387     uint8_t u8Rd = Register_From_Rd();
00388     uint8_t u8Rr = Register_From_Rr();
00389
00390     //ruler: 0---5---10---15---20---25---30---35---40" );
00391     sprintf( szOutput_, "fmul r%d, r%d          \t ; Fractional Multiply: r1:0 = r%d * r%d\n",
00392             u8Rd, u8Rr,
00393             u8Rd, u8Rr );
00394 }
00395
00396 //-----
00397 static void AVR_Disasm_FmulS( char *szOutput_ )
00398 {
00399     uint8_t u8Rd = Register_From_Rd();
00400     uint8_t u8Rr = Register_From_Rr();
00401
00402     //ruler: 0---5---10---15---20---25---30---35---40" );
00403     sprintf( szOutput_, "fmuls r%d, r%d          \t ; Signed Fractional Multiply: r1:0 = r%d * r%d\n",
00404             u8Rd, u8Rr,
00405             u8Rd, u8Rr );
00406 }
00407 }
00408
00409 //-----
00410 static void AVR_Disasm_FmulSU( char *szOutput_ )
00411 {
00412     uint8_t u8Rd = Register_From_Rd();
00413     uint8_t u8Rr = Register_From_Rr();
00414
00415     //ruler: 0---5---10---15---20---25---30---35---40" );
00416     sprintf( szOutput_, "fmulsu r%d, r%d          \t ; Signed * Unsigned Fractional Multiply: r1:0 = r%d *
00417             r%d\n",
00418             u8Rd, u8Rr,
00419             u8Rd, u8Rr );
00420 }
00421 //-----
00422 static void AVR_Disasm_DES( char *szOutput_ )
00423 {
00424     uint8_t u8K = stCPU.K;
00425
00426     //ruler: 0---5---10---15---20---25---30---35---40" );
00427     sprintf( szOutput_, "des %d          \t ; DES Encrypt/Decrypt\n",
00428             u8K );
00429 }
00430
00431 //-----
00432 static void AVR_Disasm_RJMP( char *szOutput_ )
00433 {
00434     int16_t i16k = stCPU.k_s;
00435
00436     //ruler: 0---5---10---15---20---25---30---35---40" );
00437     sprintf( szOutput_, "rjmp %d          \t ; Relative Jump: PC = PC + %d + 1\n",
00438             i16k, i16k );
00439 }
00440
00441 //-----
00442 static void AVR_Disasm_IJMP( char *szOutput_ )
00443 {
00444     //ruler: 0---5---10---15---20---25---30---35---40" );
00445     sprintf( szOutput_, "ijmp          \t ; Indirect Jump: PC = Z\n");
00446 }
00447
00448 //-----
00449 static void AVR_Disasm_EIJMP( char *szOutput_ )
00450 {
00451     //ruler: 0---5---10---15---20---25---30---35---40" );
00452     sprintf( szOutput_, "eijmp          \t ; Extended Indirect Jump: PC(15:0) = Z(15:0),
00453             PC(21:16) = EIND\n" );
00454 }

```

```

00455 //-----
00456 static void AVR_Disasm_JMP( char *szOutput_ )
00457 {
00458     uint32_t u32k = stCPU.k;
00459
00460     //ruler: 0----5----10----15----20----25----30----35----40" );
00461     sprintf( szOutput_, "jmp 0x%X          \t ; Jump to 0x%X \n",
00462             u32k, u32k );
00463 }
00464
00465 //-----
00466 static void AVR_Disasm_RCALL( char *szOutput_ )
00467 {
00468     int16_t i16k = stCPU.k_s;
00469
00470     //ruler: 0----5----10----15----20----25----30----35----40" );
00471     sprintf( szOutput_, "rcall %d          \t ; Relative call to Subroutine: PC = PC +%d + 1\n",
00472             i16k, i16k
00473             );
00474 }
00475
00476 //-----
00477 static void AVR_Disasm_ICALL( char *szOutput_ )
00478 {
00479     //ruler: 0----5----10----15----20----25----30----35----40" );
00480     sprintf( szOutput_, "icall          \t ; Indirect Jump: PC = Z\n");
00481 }
00482
00483 //-----
00484 static void AVR_Disasm_EICALL( char *szOutput_ )
00485 {
00486     //ruler: 0----5----10----15----20----25----30----35----40" );
00487     sprintf( szOutput_, "eicall          \t ; Extended Indirect Jump: PC(15:0) = Z(15:0),
00488             PC(21:16) = EIND\n" );
00489 }
00490 //-----
00491 static void AVR_Disasm_CALL( char *szOutput_ )
00492 {
00493     uint32_t u32k = stCPU.k;
00494
00495     //ruler: 0----5----10----15----20----25----30----35----40" );
00496     sprintf( szOutput_, "call 0x%X          \t ; Long Call to Subroutine: PC = 0x%X \n",
00497             u32k, u32k
00498             );
00499 }
00500 //-----
00501 static void AVR_Disasm_RET( char *szOutput_ )
00502 {
00503     //ruler: 0----5----10----15----20----25----30----35----40" );
00504     sprintf( szOutput_, "ret          \t ; Return from subroutine\n" );
00505 }
00506
00507 //-----
00508 static void AVR_Disasm_RETI( char *szOutput_ )
00509 {
00510     //ruler: 0----5----10----15----20----25----30----35----40" );
00511     sprintf( szOutput_, "reti          \t ; Return from interrupt\n" );
00512 }
00513
00514 //-----
00515 static void AVR_Disasm_CPSE( char *szOutput_ )
00516 {
00517     uint8_t u8Rd = Register_From_Rd();
00518     uint8_t u8Rr = Register_From_Rr();
00519
00520     //ruler: 0----5----10----15----20----25----30----35----40" );
00521     sprintf( szOutput_, "cpse r%d, r%d          \t ; Compare, Skip Next If r%d = r%d\n",
00522             u8Rd, u8Rr,
00523             u8Rd, u8Rr
00524             );
00525 }
00526
00527 //-----
00528 static void AVR_Disasm_CP( char *szOutput_ )
00529 {
00530     uint8_t u8Rd = Register_From_Rd();
00531     uint8_t u8Rr = Register_From_Rr();
00532
00533     //ruler: 0----5----10----15----20----25----30----35----40" );
00534     sprintf( szOutput_, "cp r%d, r%d          \t ; Compare: r%d == r%d\n",
00535             u8Rd, u8Rr,
00536             u8Rd, u8Rr
00537             );
00538 }
00539
00540 //-----

```

```

00541 static void AVR_Disasm_CPC( char *szOutput_ )
00542 {
00543     uint8_t u8Rd = Register_From_Rd();
00544     uint8_t u8Rr = Register_From_Rr();
00545
00546     //ruler: 0----5----10----15----20----25----30----35----40" );
00547     sprintf( szOutput_, "cpc r%d, r%d          \t ; Compare with carry: r%d == r%d + C\n",
00548             u8Rd, u8Rr,
00549             u8Rd, u8Rr
00550         );
00551 }
00552
00553 //-----
00554 static void AVR_Disasm_CPI( char *szOutput_ )
00555 {
00556     uint8_t u8Rd = Register_From_Rd();
00557     uint8_t u8K = stCPU.K;
00558
00559     //ruler: 0----5----10----15----20----25----30----35----40" );
00560     sprintf( szOutput_, "cpi r%d, %d          \t ; Compare with Immediate: r%d == %d\n",
00561             u8Rd, u8K,
00562             u8Rd, u8K
00563         );
00564 }
00565
00566 //-----
00567 static void AVR_Disasm_SBRC( char *szOutput_ )
00568 {
00569     uint8_t u8Rd = Register_From_Rd();
00570     uint8_t u8b = stCPU.b;
00571
00572     //ruler: 0----5----10----15----20----25----30----35----40" );
00573     sprintf( szOutput_, "sbrc r%d, %d          \t ; Skip if Bit (%d) in Register (r%d) Cleared \n",
00574             u8Rd, u8b,
00575             u8Rd, u8b
00576         );
00577 }
00578
00579 //-----
00580 static void AVR_Disasm_SBRS( char *szOutput_ )
00581 {
00582     uint8_t u8Rd = Register_From_Rd();
00583     uint8_t u8b = stCPU.b;
00584
00585     //ruler: 0----5----10----15----20----25----30----35----40" );
00586     sprintf( szOutput_, "sbrs r%d, %d          \t ; Skip if Bit (%d) in Register (r%d) Set \n",
00587             u8Rd, u8b,
00588             u8Rd, u8b
00589         );
00590 }
00591 }
00592
00593 //-----
00594 static void AVR_Disasm_SBIC( char *szOutput_ )
00595 {
00596     uint8_t u8A = stCPU.A;
00597     uint8_t u8b = stCPU.b;
00598
00599     //ruler: 0----5----10----15----20----25----30----35----40" );
00600     sprintf( szOutput_, "sbic %d, %d          \t ; Skip if Bit (%d) in IO Register (r%d) Cleared \n",
00601             u8A, u8b,
00602             u8A, u8b
00603         );
00604 }
00605
00606 //-----
00607 static void AVR_Disasm_SBI( char *szOutput_ )
00608 {
00609     uint8_t u8A = stCPU.A;
00610     uint8_t u8b = stCPU.b;
00611
00612     //ruler: 0----5----10----15----20----25----30----35----40" );
00613     sprintf( szOutput_, "sbi %d, %d          \t ; Skip if Bit (%d) in IO Register (r%d) Set \n",
00614             u8A, u8b,
00615             u8A, u8b
00616         );
00617 }
00618
00619 //-----
00620 static void AVR_Disasm_BRBS( char *szOutput_ )
00621 {
00622     uint8_t u8s = stCPU.s;
00623     int8_t s8k = stCPU.k_s;
00624
00625     //ruler: 0----5----10----15----20----25----30----35----40" );
00626     sprintf( szOutput_, "brbs %d, %d          \t ; Branch if Bit (%d) in SR set: PC = PC + %d + 1\n",
00627             u8s, s8k,

```

```

00628         u8s, s8k
00629     );
00630 }
00631
00632 //-----
00633 static void AVR_Disasm_BRBC( char *szOutput_ )
00634 {
00635     uint8_t u8s = stCPU.s;
00636     int8_t s8k = stCPU.k_s;
00637
00638     //ruler: 0----5----10---15---20---25---30---35---40" );
00639     sprintf( szOutput_, "brbc %d", %d          \t ; Branch if Bit (%d) in SR clear: PC = PC + %d + 1\n"
,
00640         u8s, s8k,
00641         u8s, s8k
00642     );
00643 }
00644
00645 //-----
00646 static void AVR_Disasm_BREQ( char *szOutput_ )
00647 {
00648     int8_t s8k = stCPU.k_s;
00649
00650     //ruler: 0----5----10---15---20---25---30---35---40" );
00651     sprintf( szOutput_, "breq %d", s8k, s8k          \t ; Branch if zero flag set: PC = PC + %d + 1\n",
00652         s8k,
00653         s8k
00654     );
00655 }
00656
00657 //-----
00658 static void AVR_Disasm_BRNE( char *szOutput_ )
00659 {
00660     int8_t s8k = stCPU.k_s;
00661
00662     //ruler: 0----5----10---15---20---25---30---35---40" );
00663     sprintf( szOutput_, "brne %d", s8k, s8k          \t ; Branch if zero flag clear: PC = PC + %d + 1\n",
00664         s8k,
00665         s8k
00666     );
00667 }
00668
00669 //-----
00670 static void AVR_Disasm_BRCS( char *szOutput_ )
00671 {
00672     int8_t s8k = stCPU.k_s;
00673
00674     //ruler: 0----5----10---15---20---25---30---35---40" );
00675     sprintf( szOutput_, "brcs %d", s8k, s8k          \t ; Branch if carry flag set: PC = PC + %d + 1\n",
00676         s8k,
00677         s8k
00678     );
00679 }
00680
00681 //-----
00682 static void AVR_Disasm_BRCC( char *szOutput_ )
00683 {
00684     int8_t s8k = stCPU.k_s;
00685
00686     //ruler: 0----5----10---15---20---25---30---35---40" );
00687     sprintf( szOutput_, "brcc %d", s8k, s8k          \t ; Branch if carry flag clear: PC = PC + %d + 1\n",
00688         s8k,
00689         s8k
00690     );
00691 }
00692 }
00693
00694 //-----
00695 static void AVR_Disasm_BRSH( char *szOutput_ )
00696 {
00697     int8_t s8k = stCPU.k_s;
00698
00699     //ruler: 0----5----10---15---20---25---30---35---40" );
00700     sprintf( szOutput_, "brsh %d", s8k, s8k          \t ; Branch if same or higher: PC = PC + %d + 1\n",
00701         s8k,
00702         s8k
00703     );
00704 }
00705
00706 //-----
00707 static void AVR_Disasm_BRLO( char *szOutput_ )
00708 {
00709     int8_t s8k = stCPU.k_s;
00710
00711     //ruler: 0----5----10---15---20---25---30---35---40" );
00712     sprintf( szOutput_, "brlo %d", s8k, s8k          \t ; Branch if lower: PC = PC + %d + 1\n",
00713         s8k,

```

```

00714             s8k
00715             );
00716 }
00717
00718 //-----
00719 static void AVR_Disasm_BRMI( char *szOutput_ )
00720 {
00721     int8_t  s8k = stCPU.k_s;
00722
00723     //ruler: 0---5---10---15---20---25---30---35---40" );
00724     sprintf( szOutput_, "brmi %d                \t ; Branch if minus: PC = PC + %d + 1\n",
00725             s8k,
00726             s8k
00727             );
00728 }
00729
00730 //-----
00731 static void AVR_Disasm_BRPL( char *szOutput_ )
00732 {
00733     int8_t  s8k = stCPU.k_s;
00734
00735     //ruler: 0---5---10---15---20---25---30---35---40" );
00736     sprintf( szOutput_, "brpl %d                \t ; Branch if plus: PC = PC + %d + 1\n",
00737             s8k,
00738             s8k
00739             );
00740 }
00741
00742 //-----
00743 static void AVR_Disasm_BRGE( char *szOutput_ )
00744 {
00745     int8_t  s8k = stCPU.k_s;
00746
00747     //ruler: 0---5---10---15---20---25---30---35---40" );
00748     sprintf( szOutput_, "brge %d                \t ; Branch if greater-or-equal (signed): PC = PC + %d +
00749 1\n",
00750             s8k,
00751             s8k
00752             );
00753 }
00754 //-----
00755 static void AVR_Disasm_BRLT( char *szOutput_ )
00756 {
00757     int8_t  s8k = stCPU.k_s;
00758
00759     //ruler: 0---5---10---15---20---25---30---35---40" );
00760     sprintf( szOutput_, "brlt %d                \t ; Branch if less-than (signed): PC = PC + %d + 1\n",
00761             s8k,
00762             s8k
00763             );
00764 }
00765
00766 //-----
00767 static void AVR_Disasm_BRHS( char *szOutput_ )
00768 {
00769     int8_t  s8k = stCPU.k_s;
00770
00771     //ruler: 0---5---10---15---20---25---30---35---40" );
00772     sprintf( szOutput_, "brlt %d                \t ; Branch if half-carry set: PC = PC + %d + 1\n",
00773             s8k,
00774             s8k
00775             );
00776 }
00777
00778 //-----
00779 static void AVR_Disasm_BRHC( char *szOutput_ )
00780 {
00781     int8_t  s8k = stCPU.k_s;
00782
00783     //ruler: 0---5---10---15---20---25---30---35---40" );
00784     sprintf( szOutput_, "brhc %d                \t ; Branch if half-carry clear: PC = PC + %d + 1\n",
00785             s8k,
00786             s8k
00787             );
00788 }
00789 }
00790
00791 //-----
00792 static void AVR_Disasm_BRTS( char *szOutput_ )
00793 {
00794     int8_t  s8k = stCPU.k_s;
00795
00796     //ruler: 0---5---10---15---20---25---30---35---40" );
00797     sprintf( szOutput_, "brts %d                \t ; Branch if T-flag set: PC = PC + %d + 1\n",
00798             s8k,
00799             s8k

```

```

00800             );
00801 }
00802
00803 //-----
00804 static void AVR_Disasm_BRTC( char *szOutput_ )
00805 {
00806     int8_t  s8k = stCPU.k_s;
00807
00808     //ruler: 0---5---10---15---20---25---30---35---40" );
00809     sprintf( szOutput_, "brtc %d          \t ; Branch if T-flag clear: PC = PC + %d + 1\n",
00810             s8k,
00811             s8k
00812             );
00813 }
00814
00815 //-----
00816 static void AVR_Disasm_BRVS( char *szOutput_ )
00817 {
00818     int8_t  s8k = stCPU.k_s;
00819
00820     //ruler: 0---5---10---15---20---25---30---35---40" );
00821     sprintf( szOutput_, "brvs %d          \t ; Branch if Overflow set: PC = PC + %d + 1\n",
00822             s8k,
00823             s8k
00824             );
00825 }
00826
00827 //-----
00828 static void AVR_Disasm_BRVC( char *szOutput_ )
00829 {
00830     int8_t  s8k = stCPU.k_s;
00831
00832     //ruler: 0---5---10---15---20---25---30---35---40" );
00833     sprintf( szOutput_, "brvc %d          \t ; Branch if Overflow clear: PC = PC + %d + 1\n",
00834             s8k,
00835             s8k
00836             );
00837 }
00838
00839 //-----
00840 static void AVR_Disasm_BRIE( char *szOutput_ )
00841 {
00842     int8_t  s8k = stCPU.k_s;
00843
00844     //ruler: 0---5---10---15---20---25---30---35---40" );
00845     sprintf( szOutput_, "brie %d          \t ; Branch if Interrupt Enabled: PC = PC + %d + 1\n",
00846             s8k,
00847             s8k
00848             );
00849 }
00850
00851 //-----
00852 static void AVR_Disasm_BRID( char *szOutput_ )
00853 {
00854     int8_t  s8k = stCPU.k_s;
00855
00856     //ruler: 0---5---10---15---20---25---30---35---40" );
00857     sprintf( szOutput_, "brid %d          \t ; Branch if Interrupt Disabled: PC = PC + %d + 1\n",
00858             s8k,
00859             s8k
00860             );
00861 }
00862 }
00863
00864 //-----
00865 static void AVR_Disasm_MOV( char *szOutput_ )
00866 {
00867     uint8_t u8Rd = Register_From_Rd();
00868     uint8_t u8Rr = Register_From_Rr();
00869
00870     //ruler: 0---5---10---15---20---25---30---35---40" );
00871     sprintf( szOutput_, "mov r%d, r%d          \t ; Copy Register: r%d = r%d\n",
00872             u8Rd, u8Rr,
00873             u8Rd, u8Rr
00874             );
00875 }
00876
00877 //-----
00878 static void AVR_Disasm_MOVW( char *szOutput_ )
00879 {
00880     uint16_t u16Rd = Register_From_Rd16();
00881     uint16_t u16Rr = Register_From_Rr16();
00882
00883     //ruler: 0---5---10---15---20---25---30---35---40" );
00884     sprintf( szOutput_, "movw r%d:r%d, r%d:r%d          \t ; Copy Register (Word): r%d:r%d = r%d:r%d\n",
00885             u16Rd+1, u16Rd, u16Rr+1, u16Rr,
00886             u16Rd+1, u16Rd, u16Rr+1, u16Rr

```

```

00887         );
00888     }
00889
00890 //-----
00891 static void AVR_Disasm_LDI( char *szOutput_ )
00892 {
00893     uint8_t u8Rd = Register_From_Rd();
00894     uint8_t u8K = stCPU.K;
00895
00896     //ruler: 0---5---10---15---20---25---30---35---40" );
00897     sprintf( szOutput_, "ldi r%d, %d          \t ; Load Immediate: r%d = %d\n",
00898             u8Rd, u8K,
00899             u8Rd, u8K
00900             );
00901 }
00902
00903 //-----
00904 static void AVR_Disasm_LDS( char *szOutput_ )
00905 {
00906     uint8_t u8Rd = Register_From_Rd();
00907     uint16_t u16k = stCPU.k;
00908
00909     //ruler: 0---5---10---15---20---25---30---35---40" );
00910     sprintf( szOutput_, "lds r%d, %d          \t ; Load Direct from Data Space: r%d = (%d)\n",
00911             u8Rd, u16k,
00912             u8Rd, u16k
00913             );
00914 }
00915
00916 //-----
00917 static void AVR_Disasm_LD_X_Indirect( char *szOutput_ )
00918 {
00919     uint8_t u8Rd = Register_From_Rd();
00920
00921     //ruler: 0---5---10---15---20---25---30---35---40" );
00922     sprintf( szOutput_, "ld r%d, X          \t ; Load Indirect from Data Space\n",
00923             u8Rd
00924             );
00925 }
00926
00927 //-----
00928 static void AVR_Disasm_LD_X_Indirect_Postinc( char *szOutput_ )
00929 {
00930     uint8_t u8Rd = Register_From_Rd();
00931
00932     //ruler: 0---5---10---15---20---25---30---35---40" );
00933     sprintf( szOutput_, "ld r%d, X+        \t ; Load Indirect from Data Space w/Postincrement\n",
00934             u8Rd
00935             );
00936 }
00937
00938 //-----
00939 static void AVR_Disasm_LD_X_Indirect_Preddec( char *szOutput_ )
00940 {
00941     uint8_t u8Rd = Register_From_Rd();
00942
00943     //ruler: 0---5---10---15---20---25---30---35---40" );
00944     sprintf( szOutput_, "ld r%d, -X        \t ; Load Indirect from Data Space w/Preddecrement\n",
00945             u8Rd
00946             );
00947 }
00948
00949 //-----
00950 static void AVR_Disasm_LD_Y_Indirect( char *szOutput_ )
00951 {
00952     uint8_t u8Rd = Register_From_Rd();
00953
00954     //ruler: 0---5---10---15---20---25---30---35---40" );
00955     sprintf( szOutput_, "ld r%d, Y          \t ; Load Indirect from Data Space\n",
00956             u8Rd
00957             );
00958 }
00959
00960 //-----
00961 static void AVR_Disasm_LD_Y_Indirect_Postinc( char *szOutput_ )
00962 {
00963     uint8_t u8Rd = Register_From_Rd();
00964
00965     //ruler: 0---5---10---15---20---25---30---35---40" );
00966     sprintf( szOutput_, "ld r%d, Y+        \t ; Load Indirect from Data Space w/Postincrement\n",
00967             u8Rd
00968             );
00969 }
00970
00971 //-----
00972 static void AVR_Disasm_LD_Y_Indirect_Preddec( char *szOutput_ )
00973 {

```



```

00974     uint8_t u8Rd = Register_From_Rd();
00975
00976     //ruler: 0----5----10----15----20----25----30----35----40" );
00977     sprintf( szOutput_, "ld r%d, -Y          \t ; Load Indirect from Data Space w/Predecrement\n",
00978             u8Rd
00979             );
00980 }
00981
00982 //-----
00983 static void AVR_Disasm_LDD_Y( char *szOutput_ )
00984 {
00985     uint8_t u8Rd = Register_From_Rd();
00986     uint8_t u8q = stCPU.q;
00987
00988     //ruler: 0----5----10----15----20----25----30----35----40" );
00989     sprintf( szOutput_, "ldd r%d, Y+%d          \t ; Load Indirect from Data Space (with Displacement)\n",
00990             u8Rd, u8q
00991             );
00992 }
00993
00994 //-----
00995 static void AVR_Disasm_LD_Z_Indirect( char *szOutput_ )
00996 {
00997     uint8_t u8Rd = Register_From_Rd();
00998
00999     //ruler: 0----5----10----15----20----25----30----35----40" );
01000     sprintf( szOutput_, "ld r%d, Z          \t ; Load Indirect from Data Space\n",
01001             u8Rd
01002             );
01003 }
01004
01005 //-----
01006 static void AVR_Disasm_LD_Z_Indirect_Postinc( char *szOutput_ )
01007 {
01008     uint8_t u8Rd = Register_From_Rd();
01009
01010     //ruler: 0----5----10----15----20----25----30----35----40" );
01011     sprintf( szOutput_, "ld r%d, Z+          \t ; Load Indirect from Data Space w/Postincrement\n",
01012             u8Rd
01013             );
01014 }
01015
01016 //-----
01017 static void AVR_Disasm_LD_Z_Indirect_Preddec( char *szOutput_ )
01018 {
01019     uint8_t u8Rd = Register_From_Rd();
01020
01021     //ruler: 0----5----10----15----20----25----30----35----40" );
01022     sprintf( szOutput_, "ld r%d, -Z          \t ; Load Indirect from Data Space w/Predecrement\n",
01023             u8Rd
01024             );
01025 }
01026
01027 //-----
01028 static void AVR_Disasm_LDD_Z( char *szOutput_ )
01029 {
01030     uint8_t u8Rd = Register_From_Rd();
01031     uint8_t u8q = stCPU.q;
01032
01033     //ruler: 0----5----10----15----20----25----30----35----40" );
01034     sprintf( szOutput_, "ldd r%d, Z+%d          \t ; Load Indirect from Data Space (with Displacement)\n",
01035             u8Rd, u8q
01036             );
01037 }
01038
01039 //-----
01040 static void AVR_Disasm_STS( char *szOutput_ )
01041 {
01042     uint8_t u8Rd = Register_From_Rd();
01043     uint16_t ul6k = stCPU.k;
01044
01045     //ruler: 0----5----10----15----20----25----30----35----40" );
01046     sprintf( szOutput_, "sts %d, r%d          \t ; Store Direct to Data Space: (%d) = r%d\n",
01047             ul6k, u8Rd,
01048             ul6k, u8Rd
01049             );
01050 }
01051
01052 //-----
01053 static void AVR_Disasm_ST_X_Indirect( char *szOutput_ )
01054 {
01055     uint8_t u8Rd = Register_From_Rd();
01056
01057     //ruler: 0----5----10----15----20----25----30----35----40" );
01058     sprintf( szOutput_, "st X, r%d          \t ; Store Indirect\n",

```

```

01059             u8Rd
01060             );
01061     }
01062
01063     //-----
01064     static void AVR_Disasm_ST_X_Indirect_Postinc( char *szOutput_ )
01065     {
01066         uint8_t u8Rd = Register_From_Rd();
01067
01068         //ruler: 0---5---10---15---20---25---30---35---40" );
01069         sprintf( szOutput_, "st X+, r%d          \t ; Store Indirect w/Postincrement \n",
01070                 u8Rd
01071                 );
01072     }
01073
01074     //-----
01075     static void AVR_Disasm_ST_X_Indirect_Preddec( char *szOutput_ )
01076     {
01077         uint8_t u8Rd = Register_From_Rd();
01078
01079         //ruler: 0---5---10---15---20---25---30---35---40" );
01080         sprintf( szOutput_, "st -X, r%d          \t ; Store Indirect w/Pred decrement\n",
01081                 u8Rd
01082                 );
01083     }
01084
01085     //-----
01086     static void AVR_Disasm_ST_Y_Indirect( char *szOutput_ )
01087     {
01088         uint8_t u8Rd = Register_From_Rd();
01089
01090         //ruler: 0---5---10---15---20---25---30---35---40" );
01091         sprintf( szOutput_, "st Y, r%d          \t ; Store Indirect\n",
01092                 u8Rd
01093                 );
01094     }
01095
01096     //-----
01097     static void AVR_Disasm_ST_Y_Indirect_Postinc( char *szOutput_ )
01098     {
01099         uint8_t u8Rd = Register_From_Rd();
01100
01101         //ruler: 0---5---10---15---20---25---30---35---40" );
01102         sprintf( szOutput_, "st Y+, r%d          \t ; Store Indirect w/Postincrement \n",
01103                 u8Rd
01104                 );
01105     }
01106
01107     //-----
01108     static void AVR_Disasm_ST_Y_Indirect_Preddec( char *szOutput_ )
01109     {
01110         uint8_t u8Rd = Register_From_Rd();
01111
01112         //ruler: 0---5---10---15---20---25---30---35---40" );
01113         sprintf( szOutput_, "st -Y, r%d          \t ; Store Indirect w/Pred decrement\n",
01114                 u8Rd
01115                 );
01116     }
01117
01118     //-----
01119     static void AVR_Disasm_STD_Y( char *szOutput_ )
01120     {
01121         uint8_t u8Rd = Register_From_Rd();
01122         uint8_t u8q = stCPU.q;
01123
01124         //ruler: 0---5---10---15---20---25---30---35---40" );
01125         sprintf( szOutput_, "std Y+%d, r%d          \t ; Store Indirect from Data Space (with Displacement)
01126         \n",
01127                 u8q, u8Rd
01128                 );
01129     }
01130
01131     //-----
01132     static void AVR_Disasm_ST_Z_Indirect( char *szOutput_ )
01133     {
01134         uint8_t u8Rd = Register_From_Rd();
01135
01136         //ruler: 0---5---10---15---20---25---30---35---40" );
01137         sprintf( szOutput_, "st Z, r%d          \t ; Store Indirect\n",
01138                 u8Rd
01139                 );
01140     }
01141
01142     //-----
01143     static void AVR_Disasm_ST_Z_Indirect_Postinc( char *szOutput_ )
01144     {
01145         uint8_t u8Rd = Register_From_Rd();

```

```

01145
01146 //ruler: 0----5----10---15---20---25---30---35---40" );
01147 sprintf( szOutput_, "st Z+, r%d          \t ; Store Indirect w/Postincrement \n",
01148          u8Rd
01149          );
01150 }
01151
01152 //-----
01153 static void AVR_Disasm_ST_Z_Indirect_Predc( char *szOutput_ )
01154 {
01155     uint8_t u8Rd = Register_From_Rd();
01156
01157     //ruler: 0----5----10---15---20---25---30---35---40" );
01158     sprintf( szOutput_, "st -Z, r%d          \t ; Store Indirect w/Predcrement\n",
01159             u8Rd
01160             );
01161 }
01162
01163 //-----
01164 static void AVR_Disasm_STD_Z( char *szOutput_ )
01165 {
01166     uint8_t u8Rd = Register_From_Rd();
01167     uint8_t u8q = stCPU.q;
01168
01169     //ruler: 0----5----10---15---20---25---30---35---40" );
01170     sprintf( szOutput_, "std Z+%d, r%d          \t ; Store Indirect from Data Space (with Displacement)
01171 \n",
01172             u8q, u8Rd
01173             );
01174 }
01175 //-----
01176 static void AVR_Disasm_LPM( char *szOutput_ )
01177 {
01178     //ruler: 0----5----10---15---20---25---30---35---40" );
01179     sprintf( szOutput_, "lpm          \t ; Load Program Memory: r0 = (Z)\n" );
01180 }
01181
01182 //-----
01183 static void AVR_Disasm_LPM_Z( char *szOutput_ )
01184 {
01185     uint8_t u8Rd = Register_From_Rd();
01186
01187     //ruler: 0----5----10---15---20---25---30---35---40" );
01188     sprintf( szOutput_, "lpm r%d, Z          \t ; Load Program Memory: r%d = (Z)\n",
01189             u8Rd,
01190             u8Rd
01191             );
01192 }
01193
01194 //-----
01195 static void AVR_Disasm_LPM_Z_Postinc( char *szOutput_ )
01196 {
01197     uint8_t u8Rd = Register_From_Rd();
01198
01199     //ruler: 0----5----10---15---20---25---30---35---40" );
01200     sprintf( szOutput_, "lpm r%d, Z+          \t ; Load Program Memory with Postincrement: r%d = (Z),
01201 Z = Z + 1\n",
01202             u8Rd,
01203             u8Rd
01204             );
01205 }
01206 //-----
01207 static void AVR_Disasm_ELPM( char *szOutput_ )
01208 {
01209     //ruler: 0----5----10---15---20---25---30---35---40" );
01210     sprintf( szOutput_, "elpm          \t ; (Extended) Load Program Memory: r0 = (Z)\n" );
01211 }
01212
01213 //-----
01214 static void AVR_Disasm_ELPM_Z( char *szOutput_ )
01215 {
01216     uint8_t u8Rd = Register_From_Rd();
01217
01218     //ruler: 0----5----10---15---20---25---30---35---40" );
01219     sprintf( szOutput_, "elpm r%d, Z          \t ; (Extended) Load Program Memory: r%d = (Z)\n",
01220             u8Rd,
01221             u8Rd
01222             );
01223 }
01224
01225 //-----
01226 static void AVR_Disasm_ELPM_Z_Postinc( char *szOutput_ )
01227 {
01228     uint8_t u8Rd = Register_From_Rd();
01229

```

```

01230     //ruler: 0----5----10---15---20---25---30---35---40" );
01231     sprintf( szOutput_, "elpm r%d, Z+                \t ; (Extended) Load Program Memory w/Postincrement: r%d
= (Z), Z = Z + 1\n",
01232             u8Rd,
01233             u8Rd
01234             );
01235 }
01236
01237 //-----
01238 static void AVR_Disasm_SPM( char *szOutput_ )
01239 {
01240     //ruler: 0----5----10---15---20---25---30---35---40" );
01241     sprintf( szOutput_, "spm                \t ; Store Program Memory\n" );
01242 }
01243
01244 //-----
01245 static void AVR_Disasm_SPM_Z_Postinc2( char *szOutput_ )
01246 {
01247     //ruler: 0----5----10---15---20---25---30---35---40" );
01248     sprintf( szOutput_, "spm Z+                \t ; Store Program Memory Z = Z + 2 \n" );
01249 }
01250
01251 //-----
01252 static void AVR_Disasm_IN( char *szOutput_ )
01253 {
01254     uint8_t u8Rd = Register_From_Rd();
01255     uint8_t u8A = stCPU.A;
01256
01257     //ruler: 0----5----10---15---20---25---30---35---40" );
01258     sprintf( szOutput_, "in r%d, %d                \t ; Load an I/O location to register\n",
01259             u8Rd,
01260             u8A
01261             );
01262 }
01263
01264 //-----
01265 static void AVR_Disasm_OUT( char *szOutput_ )
01266 {
01267     uint8_t u8Rd = Register_From_Rd();
01268     uint8_t u8A = stCPU.A;
01269
01270     //ruler: 0----5----10---15---20---25---30---35---40" );
01271     sprintf( szOutput_, "out %d, r%d                \t ; Load an I/O location to register\n",
01272             u8A,
01273             u8Rd
01274             );
01275 }
01276
01277 //-----
01278 static void AVR_Disasm_LAC( char *szOutput_ )
01279 {
01280     uint8_t u8Rd = Register_From_Rd();
01281
01282     //ruler: 0----5----10---15---20---25---30---35---40" );
01283     sprintf( szOutput_, "lac Z, r%d                \t ; Load And Clear\n",
01284             u8Rd
01285             );
01286 }
01287
01288 //-----
01289 static void AVR_Disasm_LAS( char *szOutput_ )
01290 {
01291     uint8_t u8Rd = Register_From_Rd();
01292
01293     //ruler: 0----5----10---15---20---25---30---35---40" );
01294     sprintf( szOutput_, "las Z, r%d                \t ; Load And Set\n",
01295             u8Rd
01296             );
01297 }
01298
01299 //-----
01300 static void AVR_Disasm_LAT( char *szOutput_ )
01301 {
01302     uint8_t u8Rd = Register_From_Rd();
01303
01304     //ruler: 0----5----10---15---20---25---30---35---40" );
01305     sprintf( szOutput_, "lat Z, r%d                \t ; Load And Toggle\n",
01306             u8Rd
01307             );
01308 }
01309
01310 //-----
01311 static void AVR_Disasm_LSL( char *szOutput_ )
01312 {
01313     uint8_t u8Rd = Register_From_Rd();
01314 }
01315

```

```

01316 //ruler: 0----5----10---15---20---25---30---35---40" );
01317 sprintf( szOutput_, "lsl r%d\t ; Logical shift left r%d by 1 bit\n",
01318         u8Rd,
01319         u8Rd
01320         );
01321 }
01322
01323 //-----
01324 static void AVR_Disasm_LSR( char *szOutput_ )
01325 {
01326     uint8_t u8Rd = Register_From_Rd();
01327
01328     //ruler: 0----5----10---15---20---25---30---35---40" );
01329     sprintf( szOutput_, "lsr r%d\t ; Logical shift right r%d by 1 bit\n",
01330             u8Rd,
01331             u8Rd
01332             );
01333 }
01334
01335 //-----
01336 static void AVR_Disasm_POP( char *szOutput_ )
01337 {
01338     uint8_t u8Rd = Register_From_Rd();
01339
01340     //ruler: 0----5----10---15---20---25---30---35---40" );
01341     sprintf( szOutput_, "pop r%d\t ; Pop byte from stack into r%d\n",
01342             u8Rd,
01343             u8Rd
01344             );
01345 }
01346
01347 //-----
01348 static void AVR_Disasm_PUSH( char *szOutput_ )
01349 {
01350     uint8_t u8Rd = Register_From_Rd();
01351
01352     //ruler: 0----5----10---15---20---25---30---35---40" );
01353     sprintf( szOutput_, "push r%d\t ; Push register r%d to stack\n",
01354             u8Rd,
01355             u8Rd
01356             );
01357 }
01358
01359 //-----
01360 static void AVR_Disasm_ROL( char *szOutput_ )
01361 {
01362     uint8_t u8Rd = Register_From_Rd();
01363
01364     //ruler: 0----5----10---15---20---25---30---35---40" );
01365     sprintf( szOutput_, "rol r%d\t ; Rotate Left through Carry\n",
01366             u8Rd,
01367             );
01368 }
01369
01370 //-----
01371 static void AVR_Disasm_ROR( char *szOutput_ )
01372 {
01373     uint8_t u8Rd = Register_From_Rd();
01374
01375     //ruler: 0----5----10---15---20---25---30---35---40" );
01376     sprintf( szOutput_, "ror r%d\t ; Rotate Right through Carry\n",
01377             u8Rd,
01378             );
01379 }
01380
01381 //-----
01382 static void AVR_Disasm_ASR( char *szOutput_ )
01383 {
01384     uint8_t u8Rd = Register_From_Rd();
01385
01386     //ruler: 0----5----10---15---20---25---30---35---40" );
01387     sprintf( szOutput_, "asr r%d\t ; Arithmetic Shift Right\n",
01388             u8Rd,
01389             );
01390 }
01391
01392 //-----
01393 static void AVR_Disasm_SWAP( char *szOutput_ )
01394 {
01395     uint8_t u8Rd = Register_From_Rd();
01396
01397     //ruler: 0----5----10---15---20---25---30---35---40" );
01398     sprintf( szOutput_, "swap r%d\t ; Swap high/low Nibbles in Register\n",
01399             u8Rd,
01400             );
01401 }
01402

```

```

01403 //-----
01404 static void AVR_Disasm_BSET( char *szOutput_ )
01405 {
01406     uint8_t u8s = stCPU.s;
01407
01408     //ruler: 0---5---10---15---20---25---30---35---40" );
01409     sprintf( szOutput_, "bset %d                \t ; Set bit %d in status register\n",
01410             u8s,
01411             u8s
01412             );
01413 }
01414
01415 //-----
01416 static void AVR_Disasm_BCLR( char *szOutput_ )
01417 {
01418     uint8_t u8s = stCPU.s;
01419
01420     //ruler: 0---5---10---15---20---25---30---35---40" );
01421     sprintf( szOutput_, "bclr %d                \t ; Clear bit %d in status register\n",
01422             u8s,
01423             u8s
01424             );
01425 }
01426
01427 //-----
01428 static void AVR_Disasm_SBI( char *szOutput_ )
01429 {
01430     uint8_t u8b = stCPU.b;
01431     uint8_t u8A = stCPU.A;
01432
01433     //ruler: 0---5---10---15---20---25---30---35---40" );
01434     sprintf( szOutput_, "sbi %d, %d                \t ; Set bit in I/O register\n",
01435             u8A,
01436             u8b
01437             );
01438 }
01439
01440 //-----
01441 static void AVR_Disasm_CBI( char *szOutput_ )
01442 {
01443     uint8_t u8s = stCPU.b;
01444     uint8_t u8A = stCPU.A;
01445
01446     //ruler: 0---5---10---15---20---25---30---35---40" );
01447     sprintf( szOutput_, "cbi %d, %d                \t ; Clear bit in I/O register\n",
01448             u8A,
01449             u8s
01450             );
01451 }
01452
01453 //-----
01454 static void AVR_Disasm_BST( char *szOutput_ )
01455 {
01456     uint8_t u8Rd = Register_From_Rd();
01457     uint8_t u8b = stCPU.b;
01458
01459     //ruler: 0---5---10---15---20---25---30---35---40" );
01460     sprintf( szOutput_, "bst r%d, %d                \t ; Store Bit %d of r%d in the T register\n",
01461             u8Rd, u8b,
01462             u8b, u8Rd
01463             );
01464 }
01465
01466 //-----
01467 static void AVR_Disasm_BLD( char *szOutput_ )
01468 {
01469     uint8_t u8Rd = Register_From_Rd();
01470     uint8_t u8b = stCPU.b;
01471
01472     //ruler: 0---5---10---15---20---25---30---35---40" );
01473     sprintf( szOutput_, "bld r%d, %d                \t ; Load the T register into Bit %d of r%d\n",
01474             u8Rd, u8b,
01475             u8b, u8Rd
01476             );
01477 }
01478
01479 //-----
01480 static void AVR_Disasm_SEC( char *szOutput_ )
01481 {
01482     //ruler: 0---5---10---15---20---25---30---35---40" );
01483     sprintf( szOutput_, "sec                \t ; Set the carry flag in the SR\n" );
01484 }
01485
01486 //-----
01487 static void AVR_Disasm_CLC( char *szOutput_ )
01488 {
01489     //ruler: 0---5---10---15---20---25---30---35---40" );

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```

01490     sprintf( szOutput_, "clc                                \t ; Clear the carry flag in the SR\n" );
01491 }
01492
01493 //-----
01494 static void AVR_Disasm_SEN( char *szOutput_ )
01495 {
01496     //ruler: 0---5---10---15---20---25---30---35---40" );
01497     sprintf( szOutput_, "sen                                \t ; Set the negative flag in the SR\n" );
01498 }
01499
01500 //-----
01501 static void AVR_Disasm_CLN( char *szOutput_ )
01502 {
01503     //ruler: 0---5---10---15---20---25---30---35---40" );
01504     sprintf( szOutput_, "cln                                \t ; Clear the negative flag in the SR\n" );
01505 }
01506
01507 //-----
01508 static void AVR_Disasm_SEZ( char *szOutput_ )
01509 {
01510     //ruler: 0---5---10---15---20---25---30---35---40" );
01511     sprintf( szOutput_, "sez                                \t ; Set the zero flag in the SR\n" );
01512 }
01513
01514 //-----
01515 static void AVR_Disasm_CLZ( char *szOutput_ )
01516 {
01517     //ruler: 0---5---10---15---20---25---30---35---40" );
01518     sprintf( szOutput_, "clz                                \t ; Clear the zero flag in the SR\n" );
01519 }
01520
01521 //-----
01522 static void AVR_Disasm_SEI( char *szOutput_ )
01523 {
01524     //ruler: 0---5---10---15---20---25---30---35---40" );
01525     sprintf( szOutput_, "sei                                \t ; Enable MCU interrupts\n" );
01526 }
01527
01528 //-----
01529 static void AVR_Disasm_CLI( char *szOutput_ )
01530 {
01531     //ruler: 0---5---10---15---20---25---30---35---40" );
01532     sprintf( szOutput_, "cli                                \t ; Disable MCU interrupts\n" );
01533 }
01534
01535 //-----
01536 static void AVR_Disasm_SES( char *szOutput_ )
01537 {
01538     //ruler: 0---5---10---15---20---25---30---35---40" );
01539     sprintf( szOutput_, "ses                                \t ; Set the sign flag in the SR\n" );
01540 }
01541
01542 //-----
01543 static void AVR_Disasm_CLS( char *szOutput_ )
01544 {
01545     //ruler: 0---5---10---15---20---25---30---35---40" );
01546     sprintf( szOutput_, "cls                                \t ; Clear the sign flag in the SR\n" );
01547 }
01548
01549 //-----
01550 static void AVR_Disasm_SEV( char *szOutput_ )
01551 {
01552     //ruler: 0---5---10---15---20---25---30---35---40" );
01553     sprintf( szOutput_, "sev                                \t ; Set the overflow flag in the SR\n" );
01554 }
01555
01556 //-----
01557 static void AVR_Disasm_CLV( char *szOutput_ )
01558 {
01559     //ruler: 0---5---10---15---20---25---30---35---40" );
01560     sprintf( szOutput_, "clv                                \t ; Clear the overflow flag in the SR\n" );
01561 }
01562
01563 //-----
01564 static void AVR_Disasm_SET( char *szOutput_ )
01565 {
01566     //ruler: 0---5---10---15---20---25---30---35---40" );
01567     sprintf( szOutput_, "set                                \t ; Set the T-flag in the SR\n" );
01568 }
01569
01570 //-----
01571 static void AVR_Disasm_CLT( char *szOutput_ )
01572 {
01573     //ruler: 0---5---10---15---20---25---30---35---40" );
01574     sprintf( szOutput_, "clt                                \t ; Clear the T-flag in the SR\n" );
01575 }
01576

```

```

01577 //-----
01578 static void AVR_Disasm_SEH( char *szOutput_ )
01579 {
01580     //ruler: 0---5---10---15---20---25---30---35---40" );
01581     sprintf( szOutput_, "seh                \t ; Set half-carry flag in SR\n" );
01582 }
01583
01584 //-----
01585 static void AVR_Disasm_CLH( char *szOutput_ )
01586 {
01587     //ruler: 0---5---10---15---20---25---30---35---40" );
01588     sprintf( szOutput_, "clh                \t ; Clear half-carry flag in SR\n" );
01589 }
01590
01591 //-----
01592 static void AVR_Disasm_BREAK( char *szOutput_ )
01593 {
01594     //ruler: 0---5---10---15---20---25---30---35---40" );
01595     sprintf( szOutput_, "break                \t ; Halt for debugger\n" );
01596 }
01597
01598 //-----
01599 static void AVR_Disasm_NOP( char *szOutput_ )
01600 {
01601     //ruler: 0---5---10---15---20---25---30---35---40" );
01602     sprintf( szOutput_, "nop                \t ; Do nothing\n" );
01603 }
01604
01605 //-----
01606 static void AVR_Disasm_SLEEP( char *szOutput_ )
01607 {
01608     //ruler: 0---5---10---15---20---25---30---35---40" );
01609     sprintf( szOutput_, "sleep                \t ; Put MCU into sleep mode\n" );
01610 }
01611
01612 //-----
01613 static void AVR_Disasm_WDR( char *szOutput_ )
01614 {
01615     //ruler: 0---5---10---15---20---25---30---35---40" );
01616     sprintf( szOutput_, "wdr                \t ; Reset Watchdog Timer\n" );
01617 }
01618
01619 //-----
01620 static void AVR_Disasm_XCH( char *szOutput_ )
01621 {
01622     uint8_t u8Rd = Register_From_Rd();
01623
01624     //ruler: 0---5---10---15---20---25---30---35---40" );
01625     sprintf( szOutput_, "xch Z, r%d                \t ; Exchange registers w/memory\n",
01626             u8Rd
01627     );
01628 }
01629
01630 //-----
01631 static void AVR_Disasm_Unimplemented( char *szOutput_ )
01632 {
01633     sprintf( szOutput_, ".db 0x%04X ; Data (not an opcode)\n", stCPU.pu16ROM[ stCPU.u16PC ] );
01634 }
01635
01636 //-----
01637 AVR_Disasm AVR_Disasm_Function( uint16_t OP_ )
01638 {
01639     // Special instructions - "static" encoding
01640     switch (OP_)
01641     {
01642     case 0x0000: return AVR_Disasm_NOP;
01643
01644     case 0x9408: return AVR_Disasm_SEC;
01645     case 0x9409: return AVR_Disasm_IJMP;
01646     case 0x9418: return AVR_Disasm_SEZ;
01647     case 0x9419: return AVR_Disasm_EIJMP;
01648     case 0x9428: return AVR_Disasm_SEN;
01649     case 0x9438: return AVR_Disasm_SEV;
01650     case 0x9448: return AVR_Disasm_SES;
01651     case 0x9458: return AVR_Disasm_SEH;
01652     case 0x9468: return AVR_Disasm_SET;
01653     case 0x9478: return AVR_Disasm_SEI;
01654
01655     case 0x9488: return AVR_Disasm_CLC;
01656     case 0x9498: return AVR_Disasm_CLZ;
01657     case 0x94A8: return AVR_Disasm_CLN;
01658     case 0x94B8: return AVR_Disasm_CLV;
01659     case 0x94C8: return AVR_Disasm_CLS;
01660     case 0x94D8: return AVR_Disasm_CLH;
01661     case 0x94E8: return AVR_Disasm_CLT;
01662     case 0x94F8: return AVR_Disasm_CLI;
01663

```



```

01664     case 0x9508: return AVR_Disasm_RET;
01665     case 0x9509: return AVR_Disasm_ICALL;
01666     case 0x9518: return AVR_Disasm_RETI;
01667     case 0x9519: return AVR_Disasm_EICALL;
01668     case 0x9588: return AVR_Disasm_SLEEP;
01669     case 0x9598: return AVR_Disasm_BREAK;
01670     case 0x95A8: return AVR_Disasm_WDR;
01671     case 0x95C8: return AVR_Disasm_LPM;
01672     case 0x95D8: return AVR_Disasm_ELPM;
01673     case 0x95E8: return AVR_Disasm_SPM;
01674     case 0x95F8: return AVR_Disasm_SPM_Z_Postinc2;
01675     }
01676
01677 #if 0
01678     // Note: These disasm handlers are generalized versions of specific mnemonics in the above list.
01679     // For disassembly, it's probably easier to read the output from the more "specific" mnemonics, so
01680     // those are used. For emulation, using the generalized functions may be more desirable.
01681     switch( OP_ & 0xFF8F)
01682     {
01683     case 0x9408: return AVR_Disasm_BSET;
01684     case 0x9488: return AVR_Disasm_BCLR;
01685     }
01686 #endif
01687
01688     switch( OP_ & 0xFF88)
01689     {
01690     case 0x0300: return AVR_Disasm_MULSU;
01691     case 0x0308: return AVR_Disasm_FMUL;
01692     case 0x0380: return AVR_Disasm_FMULS;
01693     case 0x0388: return AVR_Disasm_FMULSU;
01694     }
01695
01696     switch( OP_ & 0xFF0F)
01697     {
01698     case 0x940B: return AVR_Disasm_DES;
01699     case 0xEF0F: return AVR_Disasm_SER;
01700     }
01701
01702     switch( OP_ & 0xFF00)
01703     {
01704     case 0x0100: return AVR_Disasm_MOVW;
01705     case 0x9600: return AVR_Disasm_ADIW;
01706     case 0x9700: return AVR_Disasm_SBIW;
01707
01708     case 0x9800: return AVR_Disasm_CBI;
01709     case 0x9900: return AVR_Disasm_SBIC;
01710     case 0x9A00: return AVR_Disasm_SBI;
01711     case 0x9B00: return AVR_Disasm_SBIS;
01712     }
01713
01714     switch( OP_ & 0xFE0F)
01715     {
01716     case 0x8008: return AVR_Disasm_LD_Y_Indirect;
01717     case 0x8000: return AVR_Disasm_LD_Z_Indirect;
01718     case 0x8200: return AVR_Disasm_ST_Z_Indirect;
01719     case 0x8208: return AVR_Disasm_ST_Y_Indirect;
01720
01721     // -- Single 5-bit register...
01722     case 0x9000: return AVR_Disasm_LDS;
01723     case 0x9001: return AVR_Disasm_LD_Z_Indirect_Postinc;
01724     case 0x9002: return AVR_Disasm_LD_Z_Indirect_Predec;
01725     case 0x9004: return AVR_Disasm_LPM_Z;
01726     case 0x9005: return AVR_Disasm_LPM_Z_Postinc;
01727     case 0x9006: return AVR_Disasm_ELPM_Z;
01728     case 0x9007: return AVR_Disasm_ELPM_Z_Postinc;
01729     case 0x9009: return AVR_Disasm_LD_Y_Indirect_Postinc;
01730     case 0x900A: return AVR_Disasm_LD_Y_Indirect_Predec;
01731     case 0x900C: return AVR_Disasm_LD_X_Indirect;
01732     case 0x900D: return AVR_Disasm_LD_X_Indirect_Postinc;
01733     case 0x900E: return AVR_Disasm_LD_X_Indirect_Predec;
01734     case 0x900F: return AVR_Disasm_POP;
01735
01736     case 0x9200: return AVR_Disasm_STS;
01737     case 0x9201: return AVR_Disasm_ST_Z_Indirect_Postinc;
01738     case 0x9202: return AVR_Disasm_ST_Z_Indirect_Predec;
01739     case 0x9204: return AVR_Disasm_XCH;
01740     case 0x9205: return AVR_Disasm_LAS;
01741     case 0x9206: return AVR_Disasm_LAC;
01742     case 0x9207: return AVR_Disasm_LAT;
01743     case 0x9209: return AVR_Disasm_ST_Y_Indirect_Postinc;
01744     case 0x920A: return AVR_Disasm_ST_Y_Indirect_Predec;
01745     case 0x920C: return AVR_Disasm_ST_X_Indirect;
01746     case 0x920D: return AVR_Disasm_ST_X_Indirect_Postinc;
01747     case 0x920E: return AVR_Disasm_ST_X_Indirect_Predec;
01748     case 0x920F: return AVR_Disasm_PUSH;
01749
01750     // -- One-operand instructions

```

```

01751     case 0x9400: return AVR_Disasm_COM;
01752     case 0x9401: return AVR_Disasm_NEG;
01753     case 0x9402: return AVR_Disasm_SWAP;
01754     case 0x9403: return AVR_Disasm_INC;
01755     case 0x9405: return AVR_Disasm_ASR;
01756     case 0x9406: return AVR_Disasm_LSR;
01757     case 0x9407: return AVR_Disasm_ROR;
01758     case 0x940A: return AVR_Disasm_DEC;
01759
01760     }
01761     switch (OP_ & 0xFE0E)
01762     {
01763     case 0x940C: return AVR_Disasm_JMP;
01764     case 0x940E: return AVR_Disasm_CALL;
01765     }
01766
01767     switch (OP_ & 0xFE08)
01768     {
01769
01770     // -- BLD/BST Encoding
01771     case 0xF800: return AVR_Disasm_BLD;
01772     case 0xFA00: return AVR_Disasm_BST;
01773     // -- SBRC/SBRS Encoding
01774     case 0xFC00: return AVR_Disasm_SBRC;
01775     case 0xFE00: return AVR_Disasm_SBRS;
01776     }
01777
01778     switch (OP_ & 0xFC07)
01779     {
01780     // -- Conditional branches
01781     case 0xF000: return AVR_Disasm_BRCS;
01782     // case 0xF000: return AVR_Disasm_BRLO; // AKA AVR_Disasm_BRCS;
01783     case 0xF001: return AVR_Disasm_BREQ;
01784     case 0xF002: return AVR_Disasm_BRMI;
01785     case 0xF003: return AVR_Disasm_BRVS;
01786     case 0xF004: return AVR_Disasm_BRLT;
01787     case 0xF006: return AVR_Disasm_BRTS;
01788     case 0xF007: return AVR_Disasm_BRIE;
01789     case 0xF400: return AVR_Disasm_BRCC;
01790     // case 0xF400: return AVR_Disasm_BRSH; // AKA AVR_Disasm_BRCC;
01791     case 0xF401: return AVR_Disasm_BRNE;
01792     case 0xF402: return AVR_Disasm_BRPL;
01793     case 0xF403: return AVR_Disasm_BRVC;
01794     case 0xF404: return AVR_Disasm_BRGE;
01795     case 0xF405: return AVR_Disasm_BRHC;
01796     case 0xF406: return AVR_Disasm_BRTC;
01797     case 0xF407: return AVR_Disasm_BRID;
01798     }
01799
01800     switch (OP_ & 0xFC00)
01801     {
01802     // -- 4-bit register pair
01803     case 0x0200: return AVR_Disasm_MULS;
01804
01805     // -- 5-bit register pairs --
01806     case 0x0400: return AVR_Disasm_CPC;
01807     case 0x0800: return AVR_Disasm_SBC;
01808     case 0x0C00: return AVR_Disasm_ADD;
01809     // case 0x0C00: return AVR_Disasm_LSL; (!! Implemented with: " add rd, rd"
01810     case 0x1000: return AVR_Disasm_CPSE;
01811     case 0x1300: return AVR_Disasm_ROL;
01812     case 0x1400: return AVR_Disasm_CP;
01813     case 0x1C00: return AVR_Disasm_ADC;
01814     case 0x1800: return AVR_Disasm_SUB;
01815     case 0x2000: return AVR_Disasm_AND;
01816     // case 0x2000: return AVR_Disasm_TST; (!! Implemented with: " and rd, rd"
01817     case 0x2400: return AVR_Disasm_EOR;
01818     case 0x2C00: return AVR_Disasm_MOV;
01819     case 0x2800: return AVR_Disasm_OR;
01820
01821     // -- 5-bit register pairs -- Destination = R1:R0
01822     case 0x9C00: return AVR_Disasm_MUL;
01823     }
01824
01825     switch (OP_ & 0xF800)
01826     {
01827     case 0xB800: return AVR_Disasm_OUT;
01828     case 0xB000: return AVR_Disasm_IN;
01829     }
01830
01831     switch (OP_ & 0xF000)
01832     {
01833     // -- Register immediate --
01834     case 0x3000: return AVR_Disasm_CPI;
01835     case 0x4000: return AVR_Disasm_SBCI;
01836     case 0x5000: return AVR_Disasm_SUBI;
01837     case 0x6000: return AVR_Disasm_ORI; // return AVR_Disasm_SBR;

```

```

01838     case 0x7000: return AVR_Disasm_ANDI;
01839
01840     //-- 12-bit immediate
01841     case 0xC000: return AVR_Disasm_RJMP;
01842     case 0xD000: return AVR_Disasm_RCALL;
01843
01844     // -- Register immediate
01845     case 0xE000: return AVR_Disasm_LDI;
01846     }
01847
01848     switch (OP_ & 0xD208)
01849     {
01850     // -- 7-bit signed offset
01851     case 0x8000: return AVR_Disasm_LDD_Z;
01852     case 0x8008: return AVR_Disasm_LDD_Y;
01853     case 0x8200: return AVR_Disasm_STD_Z;
01854     case 0x8208: return AVR_Disasm_STD_Y;
01855     }
01856
01857     return AVR_Disasm_Unimplemented;
01858 }
01859

```

4.13 src/avr_cpu/avr_disasm.h File Reference

AVR Disassembler Implementation.

```
#include "avr_opcodes.h"
```

Typedefs

- typedef void(* **AVR_Disasm**)(char *szOutput_)

Functions

- AVR_Disasm [AVR_Disasm_Function](#) (uint16_t OP_)
AVR_Disasm_Function.

4.13.1 Detailed Description

AVR Disassembler Implementation.

Definition in file [avr_disasm.h](#).

4.13.2 Function Documentation

4.13.2.1 AVR_Disasm AVR_Disasm_Function (uint16_t OP_)

AVR_Disasm_Function.

Return a function pointer to a disassembly routine corresponding to a given opcode.

Parameters

<i>OP_</i>	Opcode to disassemble
------------	-----------------------

Returns

Function pointer that, when called with a valid CPU object and opcode, will produce a valid disassembly statement to standard output.

Definition at line 1637 of file [avr_disasm.c](#).

4.14 avr_disasm.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      )\ ) |
00004 *      ((/( ((/(      )\      ( ((/( | -- [ Funkenstein ] -----
00005 *      /( ) )/( )((( ( )\ )\ /( ) | -- [ Little ] -----
00006 *      ( )_( )      )\ _ )\ ( ( ( ( ) | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ \ ( ) \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ v / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \ \ \ / | _ \ |
00010 *      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __AVR_DISASM_H__
00022 #define __AVR_DISASM_H__
00023
00024 #include "avr_opcodes.h"
00025
00026 //-----
00027 // Format opcode function for disassembly
00028 typedef void (*AVR_Disasm)( char *szOutput_ );
00029
00030 //-----
00042 AVR_Disasm AVR_Disasm_Function( uint16_t OP_ );
00043
00044
00045 #endif

```

4.15 src/avr_cpu/avr_interrupt.c File Reference

CPU Interrupt management.

```

#include <stdint.h>
#include "emu_config.h"
#include "avr_cpu.h"
#include "interrupt_callout.h"

```

Functions

- static void **AVR_NextInterrupt** (void)
- void **AVR_InterruptCandidate** (uint8_t u8Vector_)
AVR_InterruptCandidate.
- void **AVR_ClearCandidate** (uint8_t u8Vector_)
AVR_ClearCandidate.
- void **AVR_Interrupt** (void)
AVR_Interrupt.

4.15.1 Detailed Description

CPU Interrupt management.

Definition in file [avr_interrupt.c](#).

4.15.2 Function Documentation

4.15.2.1 void AVR_ClearCandidate (uint8_t u8Vector_)

AVR_ClearCandidate.

Parameters

<code>u8Vector_</code>	Vector to clear pending interrupt for.
------------------------	--

Definition at line 59 of file [avr_interrupt.c](#).

4.15.2.2 void AVR_Interrupt (void)

AVR_Interrupt.

Entrypoint for CPU interrupts. Stop executing the currently-executing code, push the current PC to the stack, disable interrupts, and resume execution at the new location specified in the vector table.

Definition at line 67 of file [avr_interrupt.c](#).

4.15.2.3 void AVR_InterruptCandidate (uint8_t u8Vector_)

AVR_InterruptCandidate.

Given an existing interrupt candidate, determine if the selected interrupt vector is of higher priority. If higher priority, update the candidate.

Parameters

<code>u8Vector_</code>	- Candidate interrupt vector.
------------------------	-------------------------------

Definition at line 47 of file [avr_interrupt.c](#).

4.16 avr_interrupt.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( (/( ( \      ( ( (/( | -- [ Funkenstein ] -----
00005 *      /( ) )/( ) ((( ( ) \ \ /( ) | -- [ Little ] -----
00006 *      ( ) _ ( ) ) \ _ \ ( ( ( ( ) | -- [ AVR ] -----
00007 *      | _ | | ( ) _ \ ( ) \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ | / _ \ \ V / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ \ / | _ \ |
00010 *      | "Yeah, it does Arduino..."
00011 *      -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdint.h>
00022 #include "emu_config.h"
00023 #include "avr_cpu.h"
00024 #include "interrupt_callout.h"
00025
00026 //-----
00027 static void AVR_NextInterrupt(void)
00028 {
00029     uint32_t i = 0x80000000;
00030     uint32_t j = 31;
00031     while (i)
00032     {
00033         if ((stCPU.u32IntFlags & i) == i)
00034         {
00035             stCPU.u8IntPriority = j;
00036             return;
00037         }
00038         i >>= 1;
00039         j--;
00040     }
00041     stCPU.u8IntPriority = 255;
00042     stCPU.u32IntFlags = 0;
00043 }
00044
00045 //-----
00047 void AVR_InterruptCandidate( uint8_t u8Vector_ )
00048 {
00049     // Interrupts are prioritized by index -- lower == higher priority.

```

```

00050 // Candidate is the lowest
00051 if (u8Vector_ < stCPU.u8IntPriority)
00052 {
00053     stCPU.u8IntPriority = u8Vector_;
00054 }
00055 stCPU.u32IntFlags |= (1 << u8Vector_);
00056 }
00057
00058 //-----
00059 void AVR_ClearCandidate( uint8_t u8Vector_ )
00060 {
00061     stCPU.u32IntFlags &= ~(1 << u8Vector_ );
00062     AVR_NextInterrupt();
00063 }
00064
00065 //-----
00067 void AVR_Interrupt( void )
00068 {
00069     // First - check to see if there's an interrupt pending.
00070     if (stCPU.u8IntPriority == 255 || stCPU.pstRAM->stRegisters.SREG.I == 0)
00071     {
00072         return; // no interrupt pending
00073     }
00074
00075     // Push the current PC to stack.
00076     uint16_t ul6SP = (((uint16_t)stCPU.pstRAM->stRegisters.SPH.r) << 8) |
00077                     (((uint16_t)stCPU.pstRAM->stRegisters.SPL.r));
00078
00079     uint16_t ul6StoredPC = stCPU.ul6PC;
00080
00081     stCPU.pstRAM->au8RAM[ ul6SP ] = (uint8_t)(ul6StoredPC & 0x00FF);
00082     stCPU.pstRAM->au8RAM[ ul6SP - 1 ] = (uint8_t)(ul6StoredPC >> 8);
00083
00084     // Stack is post-decremented
00085     ul6SP -= 2;
00086
00087     // Store the new SP.
00088     stCPU.pstRAM->stRegisters.SPH.r = (ul6SP >> 8);
00089     stCPU.pstRAM->stRegisters.SPL.r = (ul6SP & 0x00FF);
00090
00091     // Read the new PC from the vector table
00092     uint16_t ul6NewPC = (uint16_t)(stCPU.u8IntPriority * 2);
00093
00094     // Set the new PC
00095     stCPU.ul6PC = ul6NewPC;
00096     stCPU.ul6ExtraPC = 0;
00097
00098     // Clear the "I" (global interrupt enabled) register in the SR
00099     stCPU.pstRAM->stRegisters.SREG.I = 0;
00100
00101     // Run the interrupt-acknowledge callback associated with this vector
00102     uint8_t u8Pri = stCPU.u8IntPriority;
00103     if (u8Pri < 32 && stCPU.apfInterruptCallbacks[ u8Pri ])
00104     {
00105         stCPU.apfInterruptCallbacks[ u8Pri ]( u8Pri );
00106     }
00107
00108     // Reset the CPU interrupt priority
00109     stCPU.u32IntFlags &= ~(1 << u8Pri);
00110     AVR_NextInterrupt();
00111
00112     // Run the generic interrupt callout routine
00113     InterruptCallout_Run( true, u8Pri );
00114
00115     // Clear any sleep-mode flags currently set
00116     stCPU.bAsleep = false;
00117 }

```

4.17 src/avr_cpu/avr_interrupt.h File Reference

AVR CPU Interrupt management - functionality responsible for arming/ disarming/processing CPU interrupts generated during the course of normal operation.

```

#include <stdint.h>
#include "emu_config.h"
#include "avr_cpu.h"

```

Functions

- void [AVR_InterruptCandidate](#) (uint8_t u8Vector_)
AVR_InterruptCandidate.
- void [AVR_ClearCandidate](#) (uint8_t u8Vector_)
AVR_ClearCandidate.
- void [AVR_Interrupt](#) (void)
AVR_Interrupt.

4.17.1 Detailed Description

AVR CPU Interrupt management - functionality responsible for arming/ disarming/processing CPU interrupts generated during the course of normal operation.

Definition in file [avr_interrupt.h](#).

4.17.2 Function Documentation

4.17.2.1 void AVR_ClearCandidate (uint8_t u8Vector_)

AVR_ClearCandidate.

Parameters

<i>u8Vector_</i>	Vector to clear pending interrupt for.
------------------	--

Definition at line 59 of file [avr_interrupt.c](#).

4.17.2.2 void AVR_Interrupt (void)

AVR_Interrupt.

Entrypoint for CPU interrupts. Stop executing the currently-executing code, push the current PC to the stack, disable interrupts, and resume execution at the new location specified in the vector table.

Definition at line 67 of file [avr_interrupt.c](#).

4.17.2.3 void AVR_InterruptCandidate (uint8_t u8Vector_)

AVR_InterruptCandidate.

Given an existing interrupt candidate, determine if the selected interrupt vector is of higher priority. If higher priority, update the candidate.

Parameters

<i>u8Vector_</i>	- Candidate interrupt vector.
------------------	-------------------------------

Definition at line 47 of file [avr_interrupt.c](#).

4.18 avr_interrupt.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )  (      )\ ) |
00004 *      ((/( ((/(      )\      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /( ) ) /( ) ) ((( ( )\ )\ /( ) )      | -- [ Little ] -----
00006 *      ( ) _| ( )      )\ _ )\ ( ( ( ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ ( ) \ / / | _ \      | -- [ Virtual ] -----

```

```

00008 * | _ | | _ / _ \ \ V / | / | -- [ Runtime ] -----
00009 * | _ | | _ / _ \ \ V / | _ \ |
00010 * | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00023 #ifndef __AVR_INTERRUPT_H__
00024 #define __AVR_INTERRUPT_H__
00025
00026 #include <stdint.h>
00027 #include "emu_config.h"
00028 #include "avr_cpu.h"
00029
00030 //-----
00039 void AVR_InterruptCandidate( uint8_t u8Vector_ );
00040
00041 //-----
00047 void AVR_ClearCandidate( uint8_t u8Vector_ );
00048
00049 //-----
00058 void AVR_Interrupt( void );
00059
00060 #endif //__AVR_INTERRUPT_H__

```

4.19 src/avr_cpu/avr_io.c File Reference

Interface to connect I/O register updates to their corresponding peripheral plugins.

```

#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include "emu_config.h"
#include "avr_peripheral.h"
#include "avr_cpu.h"
#include "avr_io.h"

```

Functions

- void [IO_AddReader](#) ([AVRPeripheral](#) *pstPeriph_, uint8_t addr_)
IO_AddReader.
- void [IO_AddWriter](#) ([AVRPeripheral](#) *pstPeriph_, uint8_t addr_)
IO_AddWriter.
- void [IO_AddClocker](#) ([AVRPeripheral](#) *pstPeriph_)
IO_AddClocker.
- void [IO_Write](#) (uint8_t addr_, uint8_t value_)
IO_Write.
- void [IO_Read](#) (uint8_t addr_, uint8_t *value_)
IO_Read.
- void [IO_Clock](#) (void)
IO_Clock.

4.19.1 Detailed Description

Interface to connect I/O register updates to their corresponding peripheral plugins.

Definition in file [avr_io.c](#).

4.19.2 Function Documentation

4.19.2.1 void IO_AddClocker (AVRPeripheral * *pstPeriph_*)

IO_AddClocker.

Parameters

<i>pstPeriph_</i>	
-------------------	--

Definition at line 69 of file [avr_io.c](#).

4.19.2.2 void IO_AddReader (AVRPeripheral * *pstPeriph_*, uint8_t *addr_*)

IO_AddReader.

Parameters

<i>pstPeriph_</i>	
<i>addr_</i>	

Definition at line 33 of file [avr_io.c](#).

4.19.2.3 void IO_AddWriter (AVRPeripheral * *pstPeriph_*, uint8_t *addr_*)

IO_AddWriter.

Parameters

<i>pstPeriph_</i>	
<i>addr_</i>	

Definition at line 51 of file [avr_io.c](#).

4.19.2.4 void IO_Clock (void)

IO_Clock.

Definition at line 115 of file [avr_io.c](#).

4.19.2.5 void IO_Read (uint8_t *addr_*, uint8_t * *value_*)

IO_Read.

Parameters

<i>addr_</i>	
<i>value_</i>	

Definition at line 101 of file [avr_io.c](#).

4.19.2.6 void IO_Write (uint8_t *addr_*, uint8_t *value_*)

IO_Write.

Parameters

<i>addr_</i>	
<i>value_</i>	

Definition at line 87 of file [avr_io.c](#).

4.20 avr_io.c

00001 /*****

```

00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( ((/(      (      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( ) \ ) \ / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      ) \ _ ) \ ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _ | / _ \ \ \ \ / | _ \      |
00010 *      |                                     | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00022 #include <stdint.h>
00023 #include <stdio.h>
00024 #include <stdlib.h>
00025
00026 #include "emu_config.h"
00027
00028 #include "avr_peripheral.h"
00029 #include "avr_cpu.h"
00030 #include "avr_io.h"
00031
00032 //-----
00033 void IO_AddReader( AVRPeripheral *pstPeriph_, uint8_t addr_)
00034 {
00035     IOReaderList *node = NULL;
00036
00037     node = (IOReaderList*)malloc(sizeof(*node));
00038     if (!node)
00039     {
00040         return;
00041     }
00042
00043     node->next = stCPU.apstPeriphReadTable[addr_];
00044     node->pfReader = pstPeriph_>pfRead;
00045     node->pvContext = pstPeriph_>pvContext;
00046
00047     stCPU.apstPeriphReadTable[addr_] = node;
00048 }
00049
00050 //-----
00051 void IO_AddWriter( AVRPeripheral *pstPeriph_, uint8_t addr_)
00052 {
00053     IOWriterList *node = NULL;
00054
00055     node = (IOWriterList*)malloc(sizeof(*node));
00056     if (!node)
00057     {
00058         return;
00059     }
00060
00061     node->next = stCPU.apstPeriphWriteTable[addr_];
00062     node->pfWriter = pstPeriph_>pfWrite;
00063     node->pvContext = pstPeriph_>pvContext;
00064
00065     stCPU.apstPeriphWriteTable[addr_] = node;
00066 }
00067
00068 //-----
00069 void IO_AddClocker( AVRPeripheral *pstPeriph_ )
00070 {
00071     IOClockList *node = NULL;
00072
00073     node = (IOClockList*)malloc(sizeof(*node));
00074     if (!node)
00075     {
00076         return;
00077     }
00078
00079     node->next = stCPU.pstClockList;
00080     node->pfClock = pstPeriph_>pfClock;
00081     node->pvContext = pstPeriph_>pvContext;
00082
00083     stCPU.pstClockList = node;
00084 }
00085
00086 //-----
00087 void IO_Write( uint8_t addr_, uint8_t value_ )
00088 {
00089     IOWriterList *node = stCPU.apstPeriphWriteTable[addr_];
00090     while (node)
00091     {
00092         if (node->pfWriter)
00093         {
00094             node->pfWriter( node->pvContext, addr_, value_ );
00095         }

```

```

00096         node = node->next;
00097     }
00098 }
00099
00100 //-----
00101 void IO_Read( uint8_t addr_, uint8_t *value_ )
00102 {
00103     IOReaderList *node = stCPU.apstPeriphReadTable[addr_];
00104     while (node)
00105     {
00106         if (node->pfReader)
00107         {
00108             node->pfReader( node->pvContext, addr_, value_ );
00109         }
00110         node = node->next;
00111     }
00112 }
00113
00114 //-----
00115 void IO_Clock( void )
00116 {
00117     IOClockList *node = stCPU.pstClockList;
00118     while (node)
00119     {
00120         if (node->pfClock)
00121         {
00122             node->pfClock( node->pvContext );
00123         }
00124         node = node->next;
00125     }
00126 }

```

4.21 src/avr_cpu/avr_io.h File Reference

Interface to connect I/O register updates to their corresponding peripheral plugins.

```
#include "avr_peripheral.h"
```

Data Structures

- struct [_IOReaderList](#)
- struct [_IOWriterList](#)
- struct [_IOClockList](#)

Typedefs

- typedef struct [_IOReaderList](#) **IOReaderList**
- typedef struct [_IOWriterList](#) **IOWriterList**
- typedef struct [_IOClockList](#) **IOClockList**

Functions

- void [IO_AddReader](#) ([AVRPeripheral](#) *pstPeriph_, uint8_t addr_)
IO_AddReader.
- void [IO_AddWriter](#) ([AVRPeripheral](#) *pstPeriph_, uint8_t addr_)
IO_AddWriter.
- void [IO_AddClocker](#) ([AVRPeripheral](#) *pstPeriph_)
IO_AddClocker.
- void [IO_Write](#) (uint8_t addr_, uint8_t value_)
IO_Write.
- void [IO_Read](#) (uint8_t addr_, uint8_t *value_)
IO_Read.

- void [IO_Clock](#) (void)
IO_Clock.

4.21.1 Detailed Description

Interface to connect I/O register updates to their corresponding peripheral plugins.

Definition in file [avr_io.h](#).

4.21.2 Function Documentation

4.21.2.1 void [IO_AddClocker](#) (AVRPeripheral * *pstPeriph_*)

[IO_AddClocker.](#)

Parameters

<i>pstPeriph_</i>	
-------------------	--

Definition at line 69 of file [avr_io.c](#).

4.21.2.2 void [IO_AddReader](#) (AVRPeripheral * *pstPeriph_*, uint8_t *addr_*)

[IO_AddReader.](#)

Parameters

<i>pstPeriph_</i>	
<i>addr_</i>	

Definition at line 33 of file [avr_io.c](#).

4.21.2.3 void [IO_AddWriter](#) (AVRPeripheral * *pstPeriph_*, uint8_t *addr_*)

[IO_AddWriter.](#)

Parameters

<i>pstPeriph_</i>	
<i>addr_</i>	

Definition at line 51 of file [avr_io.c](#).

4.21.2.4 void [IO_Clock](#) (void)

[IO_Clock.](#)

Definition at line 115 of file [avr_io.c](#).

4.21.2.5 void [IO_Read](#) (uint8_t *addr_*, uint8_t * *value_*)

[IO_Read.](#)

Parameters


```
00100 void IO_Clock( void );
00101
00102 #endif
```

4.23 src/avr_cpu/avr_op_cycles.c File Reference

Opcode cycle counting functions.

```
#include <stdint.h>
#include <stdio.h>
#include "emu_config.h"
#include "avr_op_decode.h"
#include "avr_opcodes.h"
#include "avr_op_size.h"
#include "avr_cpu.h"
#include "avr_cpu_print.h"
#include "avr_loader.h"
```

Functions

- static uint8_t AVR_Opcode_Cycles_ADD ()
- static uint8_t AVR_Opcode_Cycles_ADC ()
- static uint8_t AVR_Opcode_Cycles_ADIW ()
- static uint8_t AVR_Opcode_Cycles_SUB ()
- static uint8_t AVR_Opcode_Cycles_SUBI ()
- static uint8_t AVR_Opcode_Cycles_SBC ()
- static uint8_t AVR_Opcode_Cycles_SBCI ()
- static uint8_t AVR_Opcode_Cycles_SBIW ()
- static uint8_t AVR_Opcode_Cycles_AND ()
- static uint8_t AVR_Opcode_Cycles_ANDI ()
- static uint8_t AVR_Opcode_Cycles_OR ()
- static uint8_t AVR_Opcode_Cycles_ORI ()
- static uint8_t AVR_Opcode_Cycles_EOR ()
- static uint8_t AVR_Opcode_Cycles_COM ()
- static uint8_t AVR_Opcode_Cycles_NEG ()
- static uint8_t AVR_Opcode_Cycles_SBR ()
- static uint8_t AVR_Opcode_Cycles_CBR ()
- static uint8_t AVR_Opcode_Cycles_INC ()
- static uint8_t AVR_Opcode_Cycles_DEC ()
- static uint8_t AVR_Opcode_Cycles_TST ()
- static uint8_t AVR_Opcode_Cycles_CLR ()
- static uint8_t AVR_Opcode_Cycles_SER ()
- static uint8_t AVR_Opcode_Cycles_MUL ()
- static uint8_t AVR_Opcode_Cycles_MULS ()
- static uint8_t AVR_Opcode_Cycles_MULSU ()
- static uint8_t AVR_Opcode_Cycles_FMUL ()
- static uint8_t AVR_Opcode_Cycles_FMULS ()
- static uint8_t AVR_Opcode_Cycles_FMULSU ()
- static uint8_t AVR_Opcode_Cycles_DES ()
- static uint8_t AVR_Opcode_Cycles_RJMP ()
- static uint8_t AVR_Opcode_Cycles_IJMP ()
- static uint8_t AVR_Opcode_Cycles_EIJMP ()
- static uint8_t AVR_Opcode_Cycles_JMP ()
- static uint8_t AVR_Opcode_Cycles_RCALL ()

- static uint8_t [AVR_Opcode_Cycles_STD_Y](#) ()
- static uint8_t [AVR_Opcode_Cycles_ST_Z_Indirect](#) ()
- static uint8_t [AVR_Opcode_Cycles_ST_Z_Indirect_Postinc](#) ()
- static uint8_t [AVR_Opcode_Cycles_ST_Z_Indirect_Predec](#) ()
- static uint8_t [AVR_Opcode_Cycles_STD_Z](#) ()
- static uint8_t [AVR_Opcode_Cycles_LPM](#) ()
- static uint8_t [AVR_Opcode_Cycles_LPM_Z](#) ()
- static uint8_t [AVR_Opcode_Cycles_LPM_Z_Postinc](#) ()
- static uint8_t [AVR_Opcode_Cycles_ELPM](#) ()
- static uint8_t [AVR_Opcode_Cycles_ELPM_Z](#) ()
- static uint8_t [AVR_Opcode_Cycles_ELPM_Z_Postinc](#) ()
- static uint8_t [AVR_Opcode_Cycles_SPM](#) ()
- static uint8_t [AVR_Opcode_Cycles_SPM_Z_Postinc2](#) ()
- static uint8_t [AVR_Opcode_Cycles_IN](#) ()
- static uint8_t [AVR_Opcode_Cycles_OUT](#) ()
- static uint8_t [AVR_Opcode_Cycles_LAC](#) ()
- static uint8_t [AVR_Opcode_Cycles_LAS](#) ()
- static uint8_t [AVR_Opcode_Cycles_LAT](#) ()
- static uint8_t [AVR_Opcode_Cycles_LSL](#) ()
- static uint8_t [AVR_Opcode_Cycles_LSR](#) ()
- static uint8_t [AVR_Opcode_Cycles_POP](#) ()
- static uint8_t [AVR_Opcode_Cycles_PUSH](#) ()
- static uint8_t [AVR_Opcode_Cycles_ROL](#) ()
- static uint8_t [AVR_Opcode_Cycles_ROR](#) ()
- static uint8_t [AVR_Opcode_Cycles_ASR](#) ()
- static uint8_t [AVR_Opcode_Cycles_SWAP](#) ()
- static uint8_t [AVR_Opcode_Cycles_BSET](#) ()
- static uint8_t [AVR_Opcode_Cycles_BCLR](#) ()
- static uint8_t [AVR_Opcode_Cycles_SBI](#) ()
- static uint8_t [AVR_Opcode_Cycles_CBI](#) ()
- static uint8_t [AVR_Opcode_Cycles_BST](#) ()
- static uint8_t [AVR_Opcode_Cycles_BLD](#) ()
- static uint8_t [AVR_Opcode_Cycles_SEC](#) ()
- static uint8_t [AVR_Opcode_Cycles_CLC](#) ()
- static uint8_t [AVR_Opcode_Cycles_SEN](#) ()
- static uint8_t [AVR_Opcode_Cycles_CLN](#) ()
- static uint8_t [AVR_Opcode_Cycles_SEZ](#) ()
- static uint8_t [AVR_Opcode_Cycles_CLZ](#) ()
- static uint8_t [AVR_Opcode_Cycles_SEI](#) ()
- static uint8_t [AVR_Opcode_Cycles_CLI](#) ()
- static uint8_t [AVR_Opcode_Cycles_SES](#) ()
- static uint8_t [AVR_Opcode_Cycles_CLS](#) ()
- static uint8_t [AVR_Opcode_Cycles_SEV](#) ()
- static uint8_t [AVR_Opcode_Cycles_CLV](#) ()
- static uint8_t [AVR_Opcode_Cycles_SET](#) ()
- static uint8_t [AVR_Opcode_Cycles_CLT](#) ()
- static uint8_t [AVR_Opcode_Cycles_SEH](#) ()
- static uint8_t [AVR_Opcode_Cycles_CLH](#) ()
- static uint8_t [AVR_Opcode_Cycles_BREAK](#) ()
- static uint8_t [AVR_Opcode_Cycles_NOP](#) ()
- static uint8_t [AVR_Opcode_Cycles_SLEEP](#) ()
- static uint8_t [AVR_Opcode_Cycles_WDR](#) ()
- static uint8_t [AVR_Opcode_Cycles_XCH](#) ()
- static uint8_t [AVR_Opcode_Cycles_Unimplemented](#) ()
- uint8_t [AVR_Opcode_Cycles](#) (uint16_t OP_)

AVR_Opcode_Cycles.

4.23.1 Detailed Description

Opcode cycle counting functions.

Definition in file [avr_op_cycles.c](#).

4.23.2 Function Documentation

4.23.2.1 `uint8_t AVR_Opcode_Cycles (uint16_t OP_)`

AVR_Opocde_Cycles.

Parameters

<code>OP_</code>	Opcode to compute the minimum cycles to execute for
------------------	---

Returns

The minimum number of cycles it will take to execute an opcode

Definition at line [892](#) of file [avr_op_cycles.c](#).

4.23.2.2 `static uint8_t AVR_Opcode_Cycles_CALL () [static]`

! ToDo – 5 cycles on devices w/22-bit PC

Definition at line [250](#) of file [avr_op_cycles.c](#).

4.23.2.3 `static uint8_t AVR_Opcode_Cycles_CBI () [static]`

! ToDo - take into account XMEGA/tinyAVR timing

Definition at line [742](#) of file [avr_op_cycles.c](#).

4.23.2.4 `static uint8_t AVR_Opcode_Cycles_ICALL () [static]`

! ToDo – n cycles on devices w/22-bit PC

Definition at line [238](#) of file [avr_op_cycles.c](#).

4.23.2.5 `static uint8_t AVR_Opcode_Cycles_LD_Z_Indirect_Postinc () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line [508](#) of file [avr_op_cycles.c](#).

4.23.2.6 `static uint8_t AVR_Opcode_Cycles_LD_Z_Indirect_Preddec () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line [514](#) of file [avr_op_cycles.c](#).

4.23.2.7 `static uint8_t AVR_Opcode_Cycles_RCALL () [static]`

! ToDo – n cycles on devices w/22-bit PC

Definition at line [232](#) of file [avr_op_cycles.c](#).

4.23.2.8 `static uint8_t AVR_Opcode_Cycles_RET () [static]`

! ToDo – 5 cycles on devices w/22-bit PC

Definition at line 256 of file [avr_op_cycles.c](#).

4.23.2.9 `static uint8_t AVR_Opcode_Cycles_RETI () [static]`

! ToDo – 5 cycles on devices w/22-bit PC

Definition at line 262 of file [avr_op_cycles.c](#).

4.23.2.10 `static uint8_t AVR_Opcode_Cycles_SBI () [static]`

! ToDo - take into account XMEGA/tinyAVR timing

Definition at line 736 of file [avr_op_cycles.c](#).

4.23.2.11 `static uint8_t AVR_Opcode_Cycles_SPM () [static]`

!ToDo - Datasheet says "Depends on the operation"...

Definition at line 634 of file [avr_op_cycles.c](#).

4.23.2.12 `static uint8_t AVR_Opcode_Cycles_SPM_Z_Postinc2 () [static]`

!ToDo - Datasheet says "Depends on the operation"...

Definition at line 640 of file [avr_op_cycles.c](#).

4.23.2.13 `static uint8_t AVR_Opcode_Cycles_ST_X_Indirect () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line 532 of file [avr_op_cycles.c](#).

4.23.2.14 `static uint8_t AVR_Opcode_Cycles_ST_X_Indirect_Postinc () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line 538 of file [avr_op_cycles.c](#).

4.23.2.15 `static uint8_t AVR_Opcode_Cycles_ST_X_Indirect_Preddec () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line 544 of file [avr_op_cycles.c](#).

4.23.2.16 `static uint8_t AVR_Opcode_Cycles_ST_Y_Indirect () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line 550 of file [avr_op_cycles.c](#).

4.23.2.17 `static uint8_t AVR_Opcode_Cycles_ST_Y_Indirect_Postinc () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line 556 of file [avr_op_cycles.c](#).

4.23.2.18 `static uint8_t AVR_Opcode_Cycles_ST_Y_Indirect_Preddec () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line 562 of file [avr_op_cycles.c](#).

4.23.2.19 `static uint8_t AVR_Opcode_Cycles_ST_Z_Indirect () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line 574 of file [avr_op_cycles.c](#).

4.23.2.20 `static uint8_t AVR_Opcode_Cycles_ST_Z_Indirect_Postinc () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line 580 of file [avr_op_cycles.c](#).

4.23.2.21 `static uint8_t AVR_Opcode_Cycles_ST_Z_Indirect_Preddec () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line 586 of file [avr_op_cycles.c](#).

4.23.2.22 `static uint8_t AVR_Opcode_Cycles_STD_Y () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line 568 of file [avr_op_cycles.c](#).

4.23.2.23 `static uint8_t AVR_Opcode_Cycles_STD_Z () [static]`

! ToDo - Cycles on XMEGA/tinyAVR

Definition at line 592 of file [avr_op_cycles.c](#).

4.24 `avr_op_cycles.c`

```
00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      )\ ) |
00004 *      ( ) / ( ( ) / (      \      ( ( ) / (      | -- [ Funkenstein ] -----
00005 *      / ( ) / ( ) ) ( ( ( ) )\      )\      / ( ) | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _      \      ( ) ( ( ) ( ) | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \      \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _      / _ \      \ /      | _ \      |
00010 *      | _ | | _ _ _      / _ \      \ /      | _ \      |
00011 *      -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdint.h>
00022 #include <stdio.h>
00023
```

```
00024 #include "emu_config.h"
00025
00026 #include "avr_op_decode.h"
00027 #include "avr_opcodes.h"
00028 #include "avr_op_size.h"
00029 #include "avr_cpu.h"
00030 #include "avr_cpu_print.h"
00031 #include "avr_loader.h"
00032
00033 //-----
00034 static uint8_t AVR_Opcode_Cycles_ADD()
00035 {
00036     return 1;
00037 }
00038
00039 //-----
00040 static uint8_t AVR_Opcode_Cycles_ADC()
00041 {
00042     return 1;
00043 }
00044
00045 //-----
00046 static uint8_t AVR_Opcode_Cycles_ADIIW()
00047 {
00048     return 2;
00049 }
00050
00051 //-----
00052 static uint8_t AVR_Opcode_Cycles_SUB()
00053 {
00054     return 1;
00055 }
00056
00057 //-----
00058 static uint8_t AVR_Opcode_Cycles_SUBI()
00059 {
00060     return 1;
00061 }
00062
00063 //-----
00064 static uint8_t AVR_Opcode_Cycles_SBC()
00065 {
00066     return 1;
00067 }
00068
00069 //-----
00070 static uint8_t AVR_Opcode_Cycles_SBCI()
00071 {
00072     return 1;
00073 }
00074
00075 //-----
00076 static uint8_t AVR_Opcode_Cycles_SBIW()
00077 {
00078     return 2;
00079 }
00080
00081 //-----
00082 static uint8_t AVR_Opcode_Cycles_AND()
00083 {
00084     return 1;
00085 }
00086
00087 //-----
00088 static uint8_t AVR_Opcode_Cycles_ANDI()
00089 {
00090     return 1;
00091 }
00092
00093 //-----
00094 static uint8_t AVR_Opcode_Cycles_OR()
00095 {
00096     return 1;
00097 }
00098
00099 //-----
00100 static uint8_t AVR_Opcode_Cycles_ORI()
00101 {
00102     return 1;
00103 }
00104
00105 //-----
00106 static uint8_t AVR_Opcode_Cycles_EOR()
00107 {
00108     return 1;
00109 }
00110
```

```
00111 //-----
00112 static uint8_t AVR_Opcode_Cycles_COM()
00113 {
00114     return 1;
00115 }
00116
00117 //-----
00118 static uint8_t AVR_Opcode_Cycles_NEG()
00119 {
00120     return 1;
00121 }
00122
00123 //-----
00124 static uint8_t AVR_Opcode_Cycles_SBR()
00125 {
00126     return 1;
00127 }
00128
00129 //-----
00130 static uint8_t AVR_Opcode_Cycles_CBR()
00131 {
00132     return 1;
00133 }
00134
00135 //-----
00136 static uint8_t AVR_Opcode_Cycles_INC()
00137 {
00138     return 1;
00139 }
00140
00141 //-----
00142 static uint8_t AVR_Opcode_Cycles_DEC()
00143 {
00144     return 1;
00145 }
00146
00147 //-----
00148 static uint8_t AVR_Opcode_Cycles_TST()
00149 {
00150     return 1;
00151 }
00152
00153 //-----
00154 static uint8_t AVR_Opcode_Cycles_CLR()
00155 {
00156     return 1;
00157 }
00158
00159 //-----
00160 static uint8_t AVR_Opcode_Cycles_SER()
00161 {
00162     return 1;
00163 }
00164
00165 //-----
00166 static uint8_t AVR_Opcode_Cycles_MUL()
00167 {
00168     return 2;
00169 }
00170
00171 //-----
00172 static uint8_t AVR_Opcode_Cycles_MULS()
00173 {
00174     return 2;
00175 }
00176
00177 //-----
00178 static uint8_t AVR_Opcode_Cycles_MULSU()
00179 {
00180     return 2;
00181 }
00182
00183 //-----
00184 static uint8_t AVR_Opcode_Cycles_FMUL()
00185 {
00186     return 2;
00187 }
00188
00189 //-----
00190 static uint8_t AVR_Opcode_Cycles_FMULS()
00191 {
00192     return 2;
00193 }
00194
00195 //-----
00196 static uint8_t AVR_Opcode_Cycles_FMULSU()
00197 {
```

```

00198     return 2;
00199 }
00200
00201 //-----
00202 static uint8_t AVR_Opcode_Cycles_DES()
00203 {
00204     return 1;
00205 }
00206
00207 //-----
00208 static uint8_t AVR_Opcode_Cycles_RJMP()
00209 {
00210     return 2;
00211 }
00212
00213 //-----
00214 static uint8_t AVR_Opcode_Cycles_IJMP()
00215 {
00216     return 2;
00217 }
00218
00219 //-----
00220 static uint8_t AVR_Opcode_Cycles_EIJMP()
00221 {
00222     return 2;
00223 }
00224
00225 //-----
00226 static uint8_t AVR_Opcode_Cycles_JMP()
00227 {
00228     return 2;
00229 }
00230
00231 //-----
00232 static uint8_t AVR_Opcode_Cycles_RCALL()
00233 {
00234     return 3;
00235 }
00236
00237 //-----
00238 static uint8_t AVR_Opcode_Cycles_ICALL()
00239 {
00240     return 3;
00241 }
00242
00243 //-----
00244 static uint8_t AVR_Opcode_Cycles_EICALL()
00245 {
00246     return 4;
00247 }
00248
00249 //-----
00250 static uint8_t AVR_Opcode_Cycles_CALL()
00251 {
00252     return 4;
00253 }
00254
00255 //-----
00256 static uint8_t AVR_Opcode_Cycles_RET()
00257 {
00258     return 4;
00259 }
00260
00261 //-----
00262 static uint8_t AVR_Opcode_Cycles_RETI()
00263 {
00264     return 4;
00265 }
00266
00267 //-----
00268 static uint8_t AVR_Opcode_Cycles_CPSE()
00269 {
00270     return 1;
00271 }
00272
00273 //-----
00274 static uint8_t AVR_Opcode_Cycles_CP()
00275 {
00276     return 1;
00277 }
00278
00279 //-----
00280 static uint8_t AVR_Opcode_Cycles_CPC()
00281 {
00282     return 1;
00283 }
00284

```

```
00285 //-----
00286 static uint8_t AVR_Opcode_Cycles_CPI()
00287 {
00288     return 1;
00289 }
00290
00291 //-----
00292 static uint8_t AVR_Opcode_Cycles_SBRC()
00293 {
00294     return 1;
00295 }
00296
00297 //-----
00298 static uint8_t AVR_Opcode_Cycles_SBRSC()
00299 {
00300     return 1;
00301 }
00302
00303 //-----
00304 static uint8_t AVR_Opcode_Cycles_SBIC()
00305 {
00306     return 1;
00307 }
00308
00309 //-----
00310 static uint8_t AVR_Opcode_Cycles_SBIS()
00311 {
00312     return 1;
00313 }
00314
00315 //-----
00316 static uint8_t AVR_Opcode_Cycles_BRBS()
00317 {
00318     return 1;
00319 }
00320
00321 //-----
00322 static uint8_t AVR_Opcode_Cycles_BRBC()
00323 {
00324     return 1;
00325 }
00326
00327 //-----
00328 static uint8_t AVR_Opcode_Cycles_BREQ()
00329 {
00330     return 1;
00331 }
00332
00333 //-----
00334 static uint8_t AVR_Opcode_Cycles_BRNE()
00335 {
00336     return 1;
00337 }
00338
00339 //-----
00340 static uint8_t AVR_Opcode_Cycles_BRCS()
00341 {
00342     return 1;
00343 }
00344
00345 //-----
00346 static uint8_t AVR_Opcode_Cycles_BRCC()
00347 {
00348     return 1;
00349 }
00350
00351 //-----
00352 static uint8_t AVR_Opcode_Cycles_BRSH()
00353 {
00354     return 1;
00355 }
00356
00357 //-----
00358 static uint8_t AVR_Opcode_Cycles_BRLO()
00359 {
00360     return 1;
00361 }
00362
00363 //-----
00364 static uint8_t AVR_Opcode_Cycles_BRMI()
00365 {
00366     return 1;
00367 }
00368
00369 //-----
00370 static uint8_t AVR_Opcode_Cycles_BRPL()
00371 {
```



```
00372     return 1;
00373 }
00374
00375 //-----
00376 static uint8_t AVR_Opcode_Cycles_BRGE()
00377 {
00378     return 1;
00379 }
00380
00381 //-----
00382 static uint8_t AVR_Opcode_Cycles_BRLT()
00383 {
00384     return 1;
00385 }
00386
00387 //-----
00388 static uint8_t AVR_Opcode_Cycles_BRHS()
00389 {
00390     return 1;
00391 }
00392
00393 //-----
00394 static uint8_t AVR_Opcode_Cycles_BRHC()
00395 {
00396     return 1;
00397 }
00398
00399 //-----
00400 static uint8_t AVR_Opcode_Cycles_BRTS()
00401 {
00402     return 1;
00403 }
00404
00405 //-----
00406 static uint8_t AVR_Opcode_Cycles_BRTC()
00407 {
00408     return 1;
00409 }
00410
00411 //-----
00412 static uint8_t AVR_Opcode_Cycles_BRVS()
00413 {
00414     return 1;
00415 }
00416
00417 //-----
00418 static uint8_t AVR_Opcode_Cycles_BRVC()
00419 {
00420     return 1;
00421 }
00422
00423 //-----
00424 static uint8_t AVR_Opcode_Cycles_BRIE()
00425 {
00426     return 1;
00427 }
00428
00429 //-----
00430 static uint8_t AVR_Opcode_Cycles_BRID()
00431 {
00432     return 1;
00433 }
00434
00435 //-----
00436 static uint8_t AVR_Opcode_Cycles_MOV()
00437 {
00438     return 1;
00439 }
00440
00441 //-----
00442 static uint8_t AVR_Opcode_Cycles_MOVW()
00443 {
00444     return 1;
00445 }
00446
00447 //-----
00448 static uint8_t AVR_Opcode_Cycles_LDI()
00449 {
00450     return 1;
00451 }
00452
00453 //-----
00454 static uint8_t AVR_Opcode_Cycles_LDS()
00455 {
00456     return 2;
00457 }
00458
```

```

00459 //-----
00460 static uint8_t AVR_Opcode_Cycles_LD_X_Indirect()
00461 {
00462     return 1;
00463 }
00464
00465 //-----
00466 static uint8_t AVR_Opcode_Cycles_LD_X_Indirect_Postinc()
00467 {
00468     return 2;
00469 }
00470
00471 //-----
00472 static uint8_t AVR_Opcode_Cycles_LD_X_Indirect_Predec()
00473 {
00474     return 3;
00475 }
00476
00477 //-----
00478 static uint8_t AVR_Opcode_Cycles_LD_Y_Indirect()
00479 {
00480     return 1;
00481 }
00482
00483 //-----
00484 static uint8_t AVR_Opcode_Cycles_LD_Y_Indirect_Postinc()
00485 {
00486     return 2;
00487 }
00488
00489 //-----
00490 static uint8_t AVR_Opcode_Cycles_LD_Y_Indirect_Predec()
00491 {
00492     return 3;
00493 }
00494
00495 //-----
00496 static uint8_t AVR_Opcode_Cycles_LDD_Y()
00497 {
00498     return 2;
00499 }
00500
00501 //-----
00502 static uint8_t AVR_Opcode_Cycles_LD_Z_Indirect()
00503 {
00504     return 1;
00505 }
00506
00507 //-----
00508 static uint8_t AVR_Opcode_Cycles_LD_Z_Indirect_Postinc()
00509 {
00510     return 2;
00511 }
00512
00513 //-----
00514 static uint8_t AVR_Opcode_Cycles_LD_Z_Indirect_Predec()
00515 {
00516     return 3;
00517 }
00518
00519 //-----
00520 static uint8_t AVR_Opcode_Cycles_LDD_Z()
00521 {
00522     return 2;
00523 }
00524
00525 //-----
00526 static uint8_t AVR_Opcode_Cycles_STS()
00527 {
00528     return 2;
00529 }
00530
00531 //-----
00532 static uint8_t AVR_Opcode_Cycles_ST_X_Indirect()
00533 {
00534     return 2;
00535 }
00536
00537 //-----
00538 static uint8_t AVR_Opcode_Cycles_ST_X_Indirect_Postinc()
00539 {
00540     return 2;
00541 }
00542
00543 //-----
00544 static uint8_t AVR_Opcode_Cycles_ST_X_Indirect_Predec()
00545 {

```

```

00546     return 2;
00547 }
00548
00549 //-----
00550 static uint8_t AVR_Opcode_Cycles_ST_Y_Indirect()
00551 {
00552     return 2;
00553 }
00554
00555 //-----
00556 static uint8_t AVR_Opcode_Cycles_ST_Y_Indirect_Postinc()
00557 {
00558     return 2;
00559 }
00560
00561 //-----
00562 static uint8_t AVR_Opcode_Cycles_ST_Y_Indirect_Predec()
00563 {
00564     return 2;
00565 }
00566
00567 //-----
00568 static uint8_t AVR_Opcode_Cycles_STD_Y()
00569 {
00570     return 2;
00571 }
00572
00573 //-----
00574 static uint8_t AVR_Opcode_Cycles_ST_Z_Indirect()
00575 {
00576     return 2;
00577 }
00578
00579 //-----
00580 static uint8_t AVR_Opcode_Cycles_ST_Z_Indirect_Postinc()
00581 {
00582     return 2;
00583 }
00584
00585 //-----
00586 static uint8_t AVR_Opcode_Cycles_ST_Z_Indirect_Predec()
00587 {
00588     return 2;
00589 }
00590
00591 //-----
00592 static uint8_t AVR_Opcode_Cycles_STD_Z()
00593 {
00594     return 2;
00595 }
00596
00597 //-----
00598 static uint8_t AVR_Opcode_Cycles_LPM()
00599 {
00600     return 3;
00601 }
00602
00603 //-----
00604 static uint8_t AVR_Opcode_Cycles_LPM_Z()
00605 {
00606     return 3;
00607 }
00608
00609 //-----
00610 static uint8_t AVR_Opcode_Cycles_LPM_Z_Postinc()
00611 {
00612     return 3;
00613 }
00614
00615 //-----
00616 static uint8_t AVR_Opcode_Cycles_ELPM()
00617 {
00618     return 3;
00619 }
00620
00621 //-----
00622 static uint8_t AVR_Opcode_Cycles_ELPM_Z()
00623 {
00624     return 3;
00625 }
00626
00627 //-----
00628 static uint8_t AVR_Opcode_Cycles_ELPM_Z_Postinc()
00629 {
00630     return 3;
00631 }
00632

```

```

00633 //-----
00634 static uint8_t AVR_Opcode_Cycles_SPM()
00635 {
00636     return 2;
00637 }
00638
00639 //-----
00640 static uint8_t AVR_Opcode_Cycles_SPM_Z_Postinc2()
00641 {
00642     return 2;
00643 }
00644
00645 //-----
00646 static uint8_t AVR_Opcode_Cycles_IN()
00647 {
00648     return 1;
00649 }
00650
00651 //-----
00652 static uint8_t AVR_Opcode_Cycles_OUT()
00653 {
00654     return 1;
00655 }
00656
00657 //-----
00658 static uint8_t AVR_Opcode_Cycles_LAC()
00659 {
00660     return 1;
00661 }
00662
00663 //-----
00664 static uint8_t AVR_Opcode_Cycles_LAS()
00665 {
00666     return 1;
00667 }
00668
00669 //-----
00670 static uint8_t AVR_Opcode_Cycles_LAT()
00671 {
00672     return 1;
00673 }
00674
00675 //-----
00676 static uint8_t AVR_Opcode_Cycles_LSL()
00677 {
00678     return 1;
00679 }
00680
00681 //-----
00682 static uint8_t AVR_Opcode_Cycles_LSR()
00683 {
00684     return 1;
00685 }
00686
00687 //-----
00688 static uint8_t AVR_Opcode_Cycles_POP()
00689 {
00690     return 2;
00691 }
00692
00693 //-----
00694 static uint8_t AVR_Opcode_Cycles_PUSH()
00695 {
00696     return 2;
00697 }
00698
00699 //-----
00700 static uint8_t AVR_Opcode_Cycles_ROL()
00701 {
00702     return 1;
00703 }
00704
00705 //-----
00706 static uint8_t AVR_Opcode_Cycles_ROR()
00707 {
00708     return 1;
00709 }
00710
00711 //-----
00712 static uint8_t AVR_Opcode_Cycles_ASR()
00713 {
00714     return 1;
00715 }
00716
00717 //-----
00718 static uint8_t AVR_Opcode_Cycles_SWAP()
00719 {

```

```
00720     return 1;
00721 }
00722
00723 //-----
00724 static uint8_t AVR_Opcode_Cycles_BSET()
00725 {
00726     return 1;
00727 }
00728
00729 //-----
00730 static uint8_t AVR_Opcode_Cycles_BCLR()
00731 {
00732     return 1;
00733 }
00734
00735 //-----
00736 static uint8_t AVR_Opcode_Cycles_SBI()
00737 {
00738     return 2;
00739 }
00740
00741 //-----
00742 static uint8_t AVR_Opcode_Cycles_CBI()
00743 {
00744     return 2;
00745 }
00746
00747 //-----
00748 static uint8_t AVR_Opcode_Cycles_BST()
00749 {
00750     return 1;
00751 }
00752
00753 //-----
00754 static uint8_t AVR_Opcode_Cycles_BLD()
00755 {
00756     return 1;
00757 }
00758
00759 //-----
00760 static uint8_t AVR_Opcode_Cycles_SEC()
00761 {
00762     return 1;
00763 }
00764
00765 //-----
00766 static uint8_t AVR_Opcode_Cycles_CLC()
00767 {
00768     return 1;
00769 }
00770
00771 //-----
00772 static uint8_t AVR_Opcode_Cycles_SEN()
00773 {
00774     return 1;
00775 }
00776
00777 //-----
00778 static uint8_t AVR_Opcode_Cycles_CLN()
00779 {
00780     return 1;
00781 }
00782
00783 //-----
00784 static uint8_t AVR_Opcode_Cycles_SEZ()
00785 {
00786     return 1;
00787 }
00788
00789 //-----
00790 static uint8_t AVR_Opcode_Cycles_CLZ()
00791 {
00792     return 1;
00793 }
00794
00795 //-----
00796 static uint8_t AVR_Opcode_Cycles_SEI()
00797 {
00798     return 1;
00799 }
00800
00801 //-----
00802 static uint8_t AVR_Opcode_Cycles_CLI()
00803 {
00804     return 1;
00805 }
00806
```

```

00807 //-----
00808 static uint8_t AVR_Opcode_Cycles_SES()
00809 {
00810     return 1;
00811 }
00812
00813 //-----
00814 static uint8_t AVR_Opcode_Cycles_CLS()
00815 {
00816     return 1;
00817 }
00818
00819 //-----
00820 static uint8_t AVR_Opcode_Cycles_SEV()
00821 {
00822     return 1;
00823 }
00824
00825 //-----
00826 static uint8_t AVR_Opcode_Cycles_CLV()
00827 {
00828     return 1;
00829 }
00830
00831 //-----
00832 static uint8_t AVR_Opcode_Cycles_SET()
00833 {
00834     return 1;
00835 }
00836
00837 //-----
00838 static uint8_t AVR_Opcode_Cycles_CLT()
00839 {
00840     return 1;
00841 }
00842
00843 //-----
00844 static uint8_t AVR_Opcode_Cycles_SEH()
00845 {
00846     return 1;
00847 }
00848
00849 //-----
00850 static uint8_t AVR_Opcode_Cycles_CLH()
00851 {
00852     return 1;
00853 }
00854
00855 //-----
00856 static uint8_t AVR_Opcode_Cycles_BREAK()
00857 {
00858     return 1;
00859 }
00860
00861 //-----
00862 static uint8_t AVR_Opcode_Cycles_NOP()
00863 {
00864     return 1;
00865 }
00866
00867 //-----
00868 static uint8_t AVR_Opcode_Cycles_SLEEP()
00869 {
00870     return 1;
00871 }
00872
00873 //-----
00874 static uint8_t AVR_Opcode_Cycles_WDR()
00875 {
00876     return 1;
00877 }
00878
00879 //-----
00880 static uint8_t AVR_Opcode_Cycles_XCH()
00881 {
00882     return 1;
00883 }
00884
00885 //-----
00886 static uint8_t AVR_Opcode_Cycles_Unimplemented()
00887 {
00888     return 1;
00889 }
00890
00891 //-----
00892 uint8_t AVR_Opcode_Cycles( uint16_t OP_ )
00893 {

```

```

00894 // Special instructions - "static" encoding
00895 switch (OP_)
00896 {
00897     case 0x0000: return AVR_Opcode_Cycles_NOP();
00898
00899     case 0x9408: return AVR_Opcode_Cycles_SEC();
00900     case 0x9409: return AVR_Opcode_Cycles_IJMP();
00901     case 0x9418: return AVR_Opcode_Cycles_SEZ();
00902     case 0x9419: return AVR_Opcode_Cycles_EIJMP();
00903     case 0x9428: return AVR_Opcode_Cycles_SEN();
00904     case 0x9438: return AVR_Opcode_Cycles_SEV();
00905     case 0x9448: return AVR_Opcode_Cycles_SES();
00906     case 0x9458: return AVR_Opcode_Cycles_SEH();
00907     case 0x9468: return AVR_Opcode_Cycles_SET();
00908     case 0x9478: return AVR_Opcode_Cycles_SEI();
00909
00910     case 0x9488: return AVR_Opcode_Cycles_CLC();
00911     case 0x9498: return AVR_Opcode_Cycles_CLZ();
00912     case 0x94A8: return AVR_Opcode_Cycles_CLN();
00913     case 0x94B8: return AVR_Opcode_Cycles_CLV();
00914     case 0x94C8: return AVR_Opcode_Cycles_CLS();
00915     case 0x94D8: return AVR_Opcode_Cycles_CLH();
00916     case 0x94E8: return AVR_Opcode_Cycles_CLT();
00917     case 0x94F8: return AVR_Opcode_Cycles_CLI();
00918
00919     case 0x9508: return AVR_Opcode_Cycles_RET();
00920     case 0x9509: return AVR_Opcode_Cycles_ICALL();
00921     case 0x9518: return AVR_Opcode_Cycles_RETI();
00922     case 0x9519: return AVR_Opcode_Cycles_EICALL();
00923     case 0x9588: return AVR_Opcode_Cycles_SLEEP();
00924     case 0x9598: return AVR_Opcode_Cycles_BREAK();
00925     case 0x95A8: return AVR_Opcode_Cycles_WDR();
00926     case 0x95C8: return AVR_Opcode_Cycles_LPM();
00927     case 0x95D8: return AVR_Opcode_Cycles_ELPM();
00928     case 0x95E8: return AVR_Opcode_Cycles_SPM();
00929     case 0x95F8: return AVR_Opcode_Cycles_SPM_Z_Postinc2();
00930 }
00931
00932 #if 0
00933 // Note: These disasm handlers are generalized versions of specific mnemonics in the above list.
00934 // For disassembly, it's probably easier to read the output from the more "specific" mnemonics, so
00935 // those are used. For emulation, using the generalized functions may be more desirable.
00936 switch (OP_ & 0xFF8F)
00937 {
00938     case 0x9408: return AVR_Opcode_Cycles_BSET();
00939     case 0x9488: return AVR_Opcode_Cycles_BCLR();
00940 }
00941 #endif
00942
00943 switch (OP_ & 0xFF88)
00944 {
00945     case 0x0300: return AVR_Opcode_Cycles_MULSU();
00946     case 0x0308: return AVR_Opcode_Cycles_FIMUL();
00947     case 0x0380: return AVR_Opcode_Cycles_FIMULS();
00948     case 0x0388: return AVR_Opcode_Cycles_FIMULSU();
00949 }
00950
00951 switch (OP_ & 0xFF0F)
00952 {
00953     case 0x940B: return AVR_Opcode_Cycles_DES();
00954     case 0xEF0F: return AVR_Opcode_Cycles_SER();
00955 }
00956
00957 switch (OP_ & 0xFF00)
00958 {
00959     case 0x0100: return AVR_Opcode_Cycles_MOVW();
00960     case 0x9600: return AVR_Opcode_Cycles_ADIW();
00961     case 0x9700: return AVR_Opcode_Cycles_SBIW();
00962
00963     case 0x9800: return AVR_Opcode_Cycles_CBI();
00964     case 0x9900: return AVR_Opcode_Cycles_SBIC();
00965     case 0x9A00: return AVR_Opcode_Cycles_SBI();
00966     case 0x9B00: return AVR_Opcode_Cycles_SBIS();
00967 }
00968
00969 switch (OP_ & 0xFE0F)
00970 {
00971     case 0x8008: return AVR_Opcode_Cycles_LD_Y_Indirect();
00972     case 0x8000: return AVR_Opcode_Cycles_LD_Z_Indirect();
00973     case 0x8200: return AVR_Opcode_Cycles_ST_Z_Indirect();
00974     case 0x8208: return AVR_Opcode_Cycles_ST_Y_Indirect();
00975
00976     // -- Single 5-bit register...
00977     case 0x9000: return AVR_Opcode_Cycles_LDS();
00978     case 0x9001: return AVR_Opcode_Cycles_LD_Z_Indirect_Postinc();
00979     case 0x9002: return AVR_Opcode_Cycles_LD_Z_Indirect_Preddec();
00980     case 0x9004: return AVR_Opcode_Cycles_LPM_Z();

```

```

00981     case 0x9005: return AVR_Opcode_Cycles_LPM_Z_Postinc();
00982     case 0x9006: return AVR_Opcode_Cycles_ELPM_Z();
00983     case 0x9007: return AVR_Opcode_Cycles_ELPM_Z_Postinc();
00984     case 0x9009: return AVR_Opcode_Cycles_LD_Y_Indirect_Postinc();
00985     case 0x900A: return AVR_Opcode_Cycles_LD_Y_Indirect_Predec();
00986     case 0x900C: return AVR_Opcode_Cycles_LD_X_Indirect();
00987     case 0x900D: return AVR_Opcode_Cycles_LD_X_Indirect_Postinc();
00988     case 0x900E: return AVR_Opcode_Cycles_LD_X_Indirect_Predec();
00989     case 0x900F: return AVR_Opcode_Cycles_POP();
00990
00991     case 0x9200: return AVR_Opcode_Cycles_STS();
00992     case 0x9201: return AVR_Opcode_Cycles_ST_Z_Indirect_Postinc();
00993     case 0x9202: return AVR_Opcode_Cycles_ST_Z_Indirect_Predec();
00994     case 0x9204: return AVR_Opcode_Cycles_XCH();
00995     case 0x9205: return AVR_Opcode_Cycles_LAS();
00996     case 0x9206: return AVR_Opcode_Cycles_LAC();
00997     case 0x9207: return AVR_Opcode_Cycles_LAT();
00998     case 0x9209: return AVR_Opcode_Cycles_ST_Y_Indirect_Postinc();
00999     case 0x920A: return AVR_Opcode_Cycles_ST_Y_Indirect_Predec();
01000     case 0x920C: return AVR_Opcode_Cycles_ST_X_Indirect();
01001     case 0x920D: return AVR_Opcode_Cycles_ST_X_Indirect_Postinc();
01002     case 0x920E: return AVR_Opcode_Cycles_ST_X_Indirect_Predec();
01003     case 0x920F: return AVR_Opcode_Cycles_PUSH();
01004
01005     // -- One-operand instructions
01006     case 0x9400: return AVR_Opcode_Cycles_COM();
01007     case 0x9401: return AVR_Opcode_Cycles_NEG();
01008     case 0x9402: return AVR_Opcode_Cycles_SWAP();
01009     case 0x9403: return AVR_Opcode_Cycles_INC();
01010     case 0x9405: return AVR_Opcode_Cycles_ASR();
01011     case 0x9406: return AVR_Opcode_Cycles_LSR();
01012     case 0x9407: return AVR_Opcode_Cycles_ROR();
01013     case 0x940A: return AVR_Opcode_Cycles_DEC();
01014
01015     }
01016     switch (OP_ & 0xFE0E)
01017     {
01018     case 0x940C: return AVR_Opcode_Cycles_JMP();
01019     case 0x940E: return AVR_Opcode_Cycles_CALL();
01020     }
01021
01022     switch (OP_ & 0xFE08)
01023     {
01024
01025     // -- BLD/BST Encoding
01026     case 0xF800: return AVR_Opcode_Cycles_BLD();
01027     case 0xFA00: return AVR_Opcode_Cycles_BST();
01028     // -- SBRC/SBRS Encoding
01029     case 0xFC00: return AVR_Opcode_Cycles_SBRC();
01030     case 0xFE00: return AVR_Opcode_Cycles_SBRS();
01031     }
01032
01033     switch (OP_ & 0xFC07)
01034     {
01035     // -- Conditional branches
01036     case 0xF000: return AVR_Opcode_Cycles_BRCS();
01037     // case 0xF000: return AVR_Opcode_Cycles_BRLO(); // AKA AVR_Opcode_Cycles_BRCS();
01038     case 0xF001: return AVR_Opcode_Cycles_BREQ();
01039     case 0xF002: return AVR_Opcode_Cycles_BRMI();
01040     case 0xF003: return AVR_Opcode_Cycles_BRVS();
01041     case 0xF004: return AVR_Opcode_Cycles_BRLT();
01042     case 0xF006: return AVR_Opcode_Cycles_BRTS();
01043     case 0xF007: return AVR_Opcode_Cycles_BRIE();
01044     case 0xF400: return AVR_Opcode_Cycles_BRCC();
01045     // case 0xF400: return AVR_Opcode_Cycles_BRSH(); // AKA AVR_Opcode_Cycles_BRCC();
01046     case 0xF401: return AVR_Opcode_Cycles_BRNE();
01047     case 0xF402: return AVR_Opcode_Cycles_BRPL();
01048     case 0xF403: return AVR_Opcode_Cycles_BRVC();
01049     case 0xF404: return AVR_Opcode_Cycles_BRGE();
01050     case 0xF405: return AVR_Opcode_Cycles_BRHC();
01051     case 0xF406: return AVR_Opcode_Cycles_BRTC();
01052     case 0xF407: return AVR_Opcode_Cycles_BRID();
01053     }
01054
01055     switch (OP_ & 0xFC00)
01056     {
01057     // -- 4-bit register pair
01058     case 0x0200: return AVR_Opcode_Cycles_MULS();
01059
01060     // -- 5-bit register pairs --
01061     case 0x0400: return AVR_Opcode_Cycles_CPC();
01062     case 0x0800: return AVR_Opcode_Cycles_SBC();
01063     case 0x0C00: return AVR_Opcode_Cycles_ADD();
01064     // case 0x0C00: return AVR_Opcode_Cycles_LSL(); (!! Implemented with: " add rd, rd")
01065     case 0x1000: return AVR_Opcode_Cycles_CPSE();
01066     case 0x1300: return AVR_Opcode_Cycles_ROL();
01067     case 0x1400: return AVR_Opcode_Cycles_CP();

```



```

01068     case 0x1C00: return AVR_Opcode_Cycles_ADC();
01069     case 0x1800: return AVR_Opcode_Cycles_SUB();
01070     case 0x2000: return AVR_Opcode_Cycles_AND();
01071     // case 0x2000: return AVR_Opcode_Cycles_TST(); (!! Implemented with: " and rd, rd"
01072     case 0x2400: return AVR_Opcode_Cycles_EOR();
01073     case 0x2C00: return AVR_Opcode_Cycles_MOV();
01074     case 0x2800: return AVR_Opcode_Cycles_OR();
01075
01076     // -- 5-bit register pairs -- Destination = R1:R0
01077     case 0x9C00: return AVR_Opcode_Cycles_MUL();
01078     }
01079
01080     switch (OP_ & 0xF800)
01081     {
01082     case 0xB800: return AVR_Opcode_Cycles_OUT();
01083     case 0xB000: return AVR_Opcode_Cycles_IN();
01084     }
01085
01086     switch (OP_ & 0xF000)
01087     {
01088     // -- Register immediate --
01089     case 0x3000: return AVR_Opcode_Cycles_CPI();
01090     case 0x4000: return AVR_Opcode_Cycles_SBCI();
01091     case 0x5000: return AVR_Opcode_Cycles_SUBI();
01092     case 0x6000: return AVR_Opcode_Cycles_ORI();
01093     case 0x7000: return AVR_Opcode_Cycles_ANDI();
01094
01095     //-- 12-bit immediate
01096     case 0xC000: return AVR_Opcode_Cycles_RJMP();
01097     case 0xD000: return AVR_Opcode_Cycles_RCALL();
01098
01099     // -- Register immediate
01100     case 0xE000: return AVR_Opcode_Cycles_LDI();
01101     }
01102
01103     switch (OP_ & 0xD208)
01104     {
01105     // -- 7-bit signed offset
01106     case 0x8000: return AVR_Opcode_Cycles_LDD_Z();
01107     case 0x8008: return AVR_Opcode_Cycles_LDD_Y();
01108     case 0x8200: return AVR_Opcode_Cycles_STD_Z();
01109     case 0x8208: return AVR_Opcode_Cycles_STD_Y();
01110     }
01111
01112     return AVR_Opcode_Cycles_Unimplemented();
01113 }
01114

```

4.25 src/avr_cpu/avr_op_cycles.h File Reference

Opcode cycle counting functions.

```
#include <stdint.h>
```

Functions

- `uint8_t AVR_Opcode_Cycles(uint16_t OP_)`
AVR_Opcode_Cycles.

4.25.1 Detailed Description

Opcode cycle counting functions.

Definition in file [avr_op_cycles.h](#).

4.25.2 Function Documentation

4.25.2.1 `uint8_t AVR_Opcode_Cycles (uint16_t OP_)`

`AVR_Opocde_Cycles.`

Parameters

<i>OP_</i>	Opcode to compute the minimum cycles to execute for
------------	---

Returns

The minimum number of cycles it will take to execute an opcode

Definition at line 892 of file [avr_op_cycles.c](#).

4.26 avr_op_cycles.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      |
00004 *      ((/( ((/(      (      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( ) \      | -- [ Little ] -----
00006 *      ( ) _ ( )      ) \      | -- [ AVR ] -----
00007 *      | _ | _ |      ( ) \      | -- [ Virtual ] -----
00008 *      | _ | _ |      / _ \      | -- [ Runtime ] -----
00009 *      | _ | _ |      / _ \      |
00010 *      | _ | _ |      / _ \      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 *      See license.txt for details
00014 *****/
00021 #ifndef __AVR_OP_CYCLES_H__
00022 #define __AVR_OP_CYCLES_H__
00023
00024 #include <stdint.h>
00025
00026 //-----
00032 uint8_t AVR_Opcode_Cycles( uint16_t OP_ );
00033
00034 #endif

```

4.27 src/avr_cpu/avr_op_decode.c File Reference

Module providing logic to decode AVR CPU Opcodes.

```

#include <stdint.h>
#include "emu_config.h"
#include "avr_op_decode.h"

```

Functions

- static void **AVR_Decoder_NOP** (uint16_t OP_)
- static void **AVR_Decoder_Register_Pair_4bit** (uint16_t OP_)
- static void **AVR_Decoder_Register_Pair_3bit** (uint16_t OP_)
- static void **AVR_Decoder_Register_Pair_5bit** (uint16_t OP_)
- static void **AVR_Decoder_Register_Immediate** (uint16_t OP_)
- static void **AVR_Decoder_LDST_YZ_k** (uint16_t OP_)
- static void **AVR_Decoder_LDST** (uint16_t OP_)
- static void **AVR_Decoder_LDS_STS** (uint16_t OP_)
- static void **AVR_Decoder_Register_Single** (uint16_t OP_)
- static void **AVR_Decoder_Register_SC** (uint16_t OP_)
- static void **AVR_Decoder_Misc** (uint16_t OP_)
- static void **AVR_Decoder_Indirect_Jump** (uint16_t OP_)
- static void **AVR_Decoder_DEC_Rd** (uint16_t OP_)
- static void **AVR_Decoder_DES_round_4** (uint16_t OP_)

- static void **AVR_Decoder_JMP_CALL_22** (uint16_t OP_)
 - static void **AVR_Decoder_ADIW_SBIW_6** (uint16_t OP_)
 - static void **AVR_Decoder_IO_Bit** (uint16_t OP_)
 - static void **AVR_Decoder_MUL** (uint16_t OP_)
 - static void **AVR_Decoder_IO_In_Out** (uint16_t OP_)
 - static void **AVR_Decoder_Relative_Jump** (uint16_t OP_)
 - static void **AVR_Decoder_LDI** (uint16_t OP_)
 - static void **AVR_Decoder_Conditional_Branch** (uint16_t OP_)
 - static void **AVR_Decoder_BLD_BST** (uint16_t OP_)
 - static void **AVR_Decoder_SBRC_SBRB** (uint16_t OP_)
 - AVR_Decoder [AVR_Decoder_Function](#) (uint16_t OP_)
- AVR_Decoder_Function.*
- void [AVR_Decode](#) (uint16_t OP_)
- AVR_Decode.*

4.27.1 Detailed Description

Module providing logic to decode AVR CPU Opcodes.

Implemented based on descriptions provided in Atmel document doc0856

Definition in file [avr_op_decode.c](#).

4.27.2 Function Documentation

4.27.2.1 void AVR_Decode (uint16_t OP_)

AVR_Decode.

Decode a specified instruction into the internal registers of the CPU object. Opcodes must be decoded before they can be executed.

Parameters

<i>OP_</i>	Opcode to decode
------------	------------------

Definition at line 400 of file [avr_op_decode.c](#).

4.27.2.2 AVR_Decoder AVR_Decoder_Function (uint16_t OP_)

AVR_Decoder_Function.

Returns an "instruction decode" function pointer to the caller for a given opcode.

Parameters

<i>OP_</i>	Opcode to return the instruction decode function for
------------	--

Returns

Pointer to an opcode/instruction decoder routine

! MOS Verified

! MOS Verified

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! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

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! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

!MOS Verified

Definition at line 251 of file avr_op_decode.c.

4.28 avr_op_decode.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      )\ ) |
00004 *      ()/( ()/( )\      ( ( ()/( | -- [ Funkenstein ] -----
00005 *      /( ) )/( ) ((( ( )\ )\ /( ) | -- [ Little ] -----
00006 *      ( )|( ) )\ _ ) ( ( ( ( ) | -- [ AVR ] -----
00007 *      | _ | | ( )\ ( )\ \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ v / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _ | / \ \ \ \ | _ | _ |
00010 *
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00024 #include <stdint.h>
00025
00026 #include "emu_config.h"
00027
00028 #include "avr_op_decode.h"
00029
00030 //-----
00031 static void AVR_Decoder_NOP( uint16_t OP_ )
00032 {
00033     // Nothing to do here...
00034 }
00035 //-----
00036 static void AVR_Decoder_Register_Pair_4bit( uint16_t OP_ )
00037 {
00038     uint8_t Rr = (OP_ & 0x000F);
00039     uint8_t Rd = ((OP_ & 0x00F0) >> 4);
00040
00041     stCPU.Rr16 = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r_word[Rr]);
00042     stCPU.Rd16 = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r_word[Rd]);
00043 }
00044 //-----
00045 static void AVR_Decoder_Register_Pair_3bit( uint16_t OP_ )
00046 {
00047     uint8_t Rr = (OP_ & 0x0007) + 16;
00048     uint8_t Rd = ((OP_ & 0x0070) >> 4) + 16;

```

```

00049
00050     stCPU.Rr = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rr]);
00051     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00052 }
00053 //-----
00054 static void AVR_Decoder_Register_Pair_5bit( uint16_t OP_)
00055 {
00056     uint8_t Rr = (OP_ & 0x000F) | ((OP_ & 0x0200) >> 5);
00057     uint8_t Rd = (OP_ & 0x01F0) >> 4;
00058
00059     stCPU.Rr = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rr]);
00060     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00061 }
00062 //-----
00063 static void AVR_Decoder_Register_Immediate( uint16_t OP_)
00064 {
00065     uint8_t K = (OP_ & 0x000F) | ((OP_ & 0x0F00) >> 4);
00066     uint8_t Rd = ((OP_ & 0x00F0) >> 4) + 16;
00067
00068     stCPU.K = K;
00069     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00070 }
00071 //-----
00072 static void AVR_Decoder_LDST_YZ_k( uint16_t OP_)
00073 {
00074     uint8_t q = (OP_ & 0x0007) | // Awkward encoding... see manual for details.
00075                 ((OP_ & 0x0C00) >> (7)) |
00076                 ((OP_ & 0x2000) >> (8));
00077
00078     uint8_t Rd = (OP_ & 0x01F0) >> 4;
00079
00080     stCPU.q = q;
00081     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00082 }
00083 //-----
00084 static void AVR_Decoder_LDST( uint16_t OP_)
00085 {
00086     uint8_t Rd = (OP_ & 0x01F0) >> 4;
00087
00088     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00089 }
00090 //-----
00091 static void AVR_Decoder_LDS_STS( uint16_t OP_)
00092 {
00093     uint8_t Rd = (OP_ & 0x01F0) >> 4;
00094
00095     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00096     stCPU.K = stCPU.pu16ROM[ stCPU.u16PC + 1 ];
00097 }
00098 //-----
00099 static void AVR_Decoder_Register_Single( uint16_t OP_)
00100 {
00101     uint8_t Rd = (OP_ & 0x01F0) >> 4;
00102
00103     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00104 }
00105 //-----
00106 static void AVR_Decoder_Register_SC( uint16_t OP_)
00107 {
00108     uint8_t b = (OP_ & 0x0070) >> 4;
00109
00110     stCPU.b = b;
00111 }
00112 //-----
00113 static void AVR_Decoder_Misc( uint16_t OP_)
00114 {
00115     // Nothing to do here.
00116 }
00117 //-----
00118 static void AVR_Decoder_Indirect_Jump( uint16_t OP_)
00119 {
00120     // Nothing to do here.
00121 }
00122 //-----
00123 static void AVR_Decoder_DEC_Rd( uint16_t OP_)
00124 {
00125     uint8_t Rd = (OP_ & 0x01F0) >> 4;
00126
00127     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00128 }
00129 //-----
00130 static void AVR_Decoder_DES_round_4( uint16_t OP_)
00131 {
00132     uint8_t K = (OP_ & 0x00F0) >> 4;
00133     stCPU.K = K;
00134 }
00135 //-----

```

```

00136 static void AVR_Decoder_JMP_CALL_22( uint16_t OP_)
00137 {
00138     uint16_t op = stCPU.pu16ROM[ stCPU.u16PC + 1 ];
00139     uint32_t k = op;
00140     k |= ((OP_ & 0x0001) | (OP_ & 0x01F0) >> 3) << 16);
00141
00142     stCPU.k = k;
00143
00144     // These are 2-cycle instructions. Clock the CPU here, since we're fetching
00145     // the second word of data for this opcode here.
00146     IQ_Clock();
00147 }
00148 //-----
00149 static void AVR_Decoder_ADIW_SBIW_6( uint16_t OP_)
00150 {
00151     uint8_t K = (OP_ & 0x000F) | ((OP_ & 0x00C0) >> 2);
00152     uint8_t Rd16 = ((OP_ & 0x0030) >> 4) * 2 + 24;
00153
00154     stCPU.K = K;
00155     stCPU.Rd16 = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r_word[Rd16 >> 1]);
00156 }
00157 //-----
00158 static void AVR_Decoder_IO_Bit( uint16_t OP_)
00159 {
00160     uint8_t b = (OP_ & 0x0007);
00161     uint8_t A = (OP_ & 0x00F8) >> 3;
00162
00163     stCPU.b = b;
00164     stCPU.A = A;
00165 }
00166 //-----
00167 static void AVR_Decoder_MUL( uint16_t OP_)
00168 {
00169     uint8_t Rr = (OP_ & 0x000F) | ((OP_ & 0x0200) >> 5);
00170     uint8_t Rd = (OP_ & 0x01F0) >> 4;
00171
00172     stCPU.Rr = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rr]);
00173     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00174 }
00175 //-----
00176 static void AVR_Decoder_IO_In_Out( uint16_t OP_)
00177 {
00178     uint8_t A = (OP_ & 0x000F) | ((OP_ & 0x0600) >> 5);
00179     uint8_t Rd = (OP_ & 0x01F0) >> 4;
00180
00181     stCPU.A = A;
00182     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00183 }
00184 //-----
00185 static void AVR_Decoder_Relative_Jump( uint16_t OP_)
00186 {
00187     // NB: -2K <= k <= 2K
00188     uint16_t k = (OP_ & 0xFFFF);
00189
00190     // Check for sign bit in 12-bit value...
00191     if (k & 0x0800)
00192     {
00193         stCPU.k_s = (int32_t)((~k & 0x07FF) + 1) * -1;
00194     }
00195     else
00196     {
00197         stCPU.k_s = (int32_t)k;
00198     }
00199 }
00200 //-----
00201 static void AVR_Decoder_LDI( uint16_t OP_)
00202 {
00203     uint8_t K = (OP_ & 0x000F) | ((OP_ & 0x0F00) >> 4);
00204     uint8_t Rd = ((OP_ & 0x00F0) >> 4) + 16;
00205
00206     stCPU.K = K;
00207     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00208 }
00209 //-----
00210 static void AVR_Decoder_Conditional_Branch( uint16_t OP_)
00211 {
00212     // NB: -64 <= k <= 63
00213     uint8_t b = (OP_ & 0x0007);
00214     uint8_t k = ((OP_ & 0x03F8) >> 3);
00215
00216     stCPU.b = b;
00217
00218     // Check for sign bit in 7-bit value...
00219     if (k & 0x40)
00220     {
00221         // Convert to signed 32-bit integer... probably a cleaner way
00222         // of doing this, but I'm tired.

```

```

00223         stCPU.k_s = (int32_t)((~k & 0x3F) + 1) * -1;
00224     }
00225     else
00226     {
00227         stCPU.k_s = (int32_t)k;
00228     }
00229 }
00230 //-----
00231 static void AVR_Decoder_BLD_BST( uint16_t OP_)
00232 {
00233     uint8_t b = (OP_ & 0x0007);
00234     uint8_t Rd = ((OP_ & 0x01F0) >> 4);
00235
00236     stCPU.b = b;
00237     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00238 }
00239
00240 //-----
00241 static void AVR_Decoder_SBRC_SBRS( uint16_t OP_)
00242 {
00243     uint8_t b = (OP_ & 0x0007);
00244     uint8_t Rd = ((OP_ & 0x01F0) >> 4);
00245
00246     stCPU.b = b;
00247     stCPU.Rd = &(stCPU.pstRAM->stRegisters.CORE_REGISTERS.r[Rd]);
00248 }
00249
00250 //-----
00251 AVR_Decoder AVR_Decoder_Function( uint16_t OP_ )
00252 {
00253     if (( OP_ & 0xFF0F) == 0x9408 )
00254     {
00255         // SEx/CLx status register clear/set bit.
00256         return AVR_Decoder_Register_SC;
00257     }
00258     else if (( OP_ & 0xFF0F) == 0x9508 )
00259     {
00260         // Miscellaneous instruction
00261         return AVR_Decoder_Misc;
00262     }
00263     else if (( OP_ & 0xFF0F) == 0x940B )
00264     {
00265         // Des round k
00266         return AVR_Decoder_DES_round_4;
00267     }
00268     else if ( (( OP_ & 0xFF00 ) == 0x0100 ) ||
00269              (( OP_ & 0xFF00 ) == 0x0200 ) )
00270     {
00271         // Register pair 4bit (MOVW, MULS)
00272         return AVR_Decoder_Register_Pair_4bit;
00273     }
00274     else if (( OP_ & 0xFF00 ) == 0x0300 )
00275     {
00276         // 3-bit register pair (R16->R23) - (FMUL, FMULS, FMULSU, MULSU)
00277         return AVR_Decoder_Register_Pair_3bit;
00278     }
00279     else if (( OP_ & 0xFF00 ) <= 0x2F00 )
00280     {
00281         // Register pair 5bit
00282         return AVR_Decoder_Register_Pair_5bit;
00283     }
00284     else if (( OP_ & 0xFF00 ) <= 0x7F00 )
00285     {
00286         // Register immediate
00287         return AVR_Decoder_Register_Immediate;
00288     }
00289     else if (( OP_ & 0xFEEF) == 0x9409 )
00290     {
00291         // Indirect Jump/call
00292         return AVR_Decoder_Indirect_Jump;
00293     }
00294     else if (( OP_ & 0xFE08) == 0x9400 )
00295     {
00296         // 1-operand instructions.
00297         return AVR_Decoder_Register_Single;
00298     }
00299     else if (( OP_ & 0xFE0F) == 0x940A )
00300     {
00301         // Dec Rd
00302         return AVR_Decoder_DEC_Rd;
00303     }
00304     else if (( OP_ & 0xFE0C) == 0x940C )
00305     {
00306         // Jmp/call abs22
00307         return AVR_Decoder_JMP_CALL_22;
00308     }
00309     else if (( OP_ & 0xFE00) == 0x9600 )

```



```

00320     {
00322         // ADIW/SBIW Rp
00323         return AVR_Decoder_ADIW_SBIW_6;
00324     }
00325     else if (( OP_ & 0xFC0F) == 0x9000 )
00326     {
00328         // LDS/STS
00329         return AVR_Decoder_LDS_STS;
00330     }
00331     else if (( OP_ & 0xFC00) == 0x9000 )
00332     {
00334         // LD/ST other
00335         return AVR_Decoder_LDST;
00336     }
00337     else if (( OP_ & 0xFC00) == 0x9800 )
00338     {
00340         // IO Space bit operations
00341         return AVR_Decoder_IO_Bit;
00342     }
00343     else if (( OP_ & 0xFC00) == 0x9C00 )
00344     {
00346         // MUL unsigned Rl:R0 = Rr x Rd
00347         return AVR_Decoder_MUL;
00348     }
00349     else if (( OP_ & 0xFC00) == 0xF800 )
00350     {
00352         // BLD/BST register bit to STATUS.T
00353         return AVR_Decoder_BLD_BST;
00354     }
00355     else if (( OP_ & 0xFC00) == 0xFC00 )
00356     {
00358         // SBRC/SBRS
00359         return AVR_Decoder_SBRC_SBRS;
00360     }
00361     else if (( OP_ & 0xF800) == 0xF000 )
00362     {
00364         // Conditional branch
00365         return AVR_Decoder_Conditional_Branch;
00366     }
00367     else if (( OP_ & 0xF000) == 0xE000 )
00368     {
00370         // LDI Rh, K
00371         return AVR_Decoder_LDI;
00372     }
00373     else if (( OP_ & 0xF000) == 0xB000 )
00374     {
00376         // IO space IN/OUT operations
00377         return AVR_Decoder_IO_In_Out;
00378     }
00379     else if (( OP_ & 0xE000) == 0xC000 )
00380     {
00382         // RRelative Jump/Call
00383         return AVR_Decoder_Relative_Jump;
00384     }
00385     else if (( OP_ & 0xD000) == 0x8000 )
00386     {
00388         // LDD/STD to Z+kY+k
00389         return AVR_Decoder_LDST_YZ_k;
00390     }
00391     else if ( OP_ == 0 )
00392     {
00394         return AVR_Decoder_NOP;
00395     }
00396     return AVR_Decoder_NOP;
00397 }
00398
00399 //-----
00400 void AVR_Decode( uint16_t OP_ )
00401 {
00402     AVR_Decoder myDecoder;
00403     myDecoder = AVR_Decoder_Function(OP_);
00404     myDecoder( OP_ );
00405 }

```

4.29 src/avr_cpu/avr_op_decode.h File Reference

Module providing logic to decode AVR CPU Opcodes.

```

#include <stdint.h>
#include "avr_cpu.h"

```

Typedefs

- typedef void(* **AVR_Decoder**)(uint16_t OP_)

Functions

- AVR_Decoder [AVR_Decoder_Function](#) (uint16_t OP_)
AVR_Decoder_Function.
- void [AVR_Decode](#) (uint16_t OP_)
AVR_Decode.

4.29.1 Detailed Description

Module providing logic to decode AVR CPU Opcodes.

Definition in file [avr_op_decode.h](#).

4.29.2 Function Documentation

4.29.2.1 void AVR_Decode (uint16_t OP_)

AVR_Decode.

Decode a specified instruction into the internal registers of the CPU object. Opcodes must be decoded before they can be executed.

Parameters

<i>OP_</i>	Opcode to decode
------------	------------------

Definition at line 400 of file [avr_op_decode.c](#).

4.29.2.2 AVR_Decoder AVR_Decoder_Function (uint16_t OP_)

AVR_Decoder_Function.

Returns an "instruction decode" function pointer to the caller for a given opcode.

Parameters

<i>OP_</i>	Opcode to return the instruction decode function for
------------	--

Returns

Pointer to an opcode/instruction decoder routine

! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

! MOS Verified

[illegible]

Definition at line 251 of file avr_op_decode.c.

4.30 avr_op_decode.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )      |
00004 *      ()/( ()/(      )\      (      ()/(      | -- [ Funkenstein ] -----
00005 *      /( )  /( )  ((( )\ )\  /( )      | -- [ Little ] -----
00006 *      ( )_ ( )      )\ _ )\ ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( )_ \ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \      \ v / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _ | / \ \      \ /      | _ \      |
00010 *      +-----+-----+-----+-----+-----+-----+-----+-----+
00011 *
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 *      See license.txt for details
00014 *****/
00021 #ifndef __AVR_OP_DECODE_H__
00022 #define __AVR_OP_DECODE_H__
00023
00024 #include <stdint.h>
00025 #include "avr_cpu.h"
00026
00027 //-----
00028 // Format decoder function jump table
00029 typedef void (*AVR_Decoder)( uint16_t OP_ );
00030
00031 //-----
00041 AVR_Decoder AVR_Decoder_Function( uint16_t OP_ );
00042
00043 //-----
00052 void AVR_Decode( uint16_t OP_ );
00053
00054 #endif
00055

```

4.31 src/avr_cpu/avr_op_size.c File Reference

Module providing opcode sizes.

```
#include <stdint.h>
#include "emu_config.h"
#include "avr_op_size.h"
```

Functions

- static uint8_t **AVR_Opcode_Size_NOP** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_Register_Pair_4bit** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_Register_Pair_3bit** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_Register_Pair_5bit** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_Register_Immediate** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_LDST_YZ_k** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_LDST** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_LDS_STS** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_Register_Single** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_Register_SC** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_Misc** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_Indirect_Jump** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_DEC_Rd** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_DES_round_4** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_JMP_CALL_22** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_ADIW_SBIW_6** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_IO_Bit** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_MUL** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_IO_In_Out** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_Relative_Jump** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_LDI** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_Conditional_Branch** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_BLD_BST** (uint16_t OP_)
- static uint8_t **AVR_Opcode_Size_SBRC_SBRB** (uint16_t OP_)
- uint8_t **AVR_Opcode_Size** (uint16_t OP_)

AVR_Opcode_Size.

4.31.1 Detailed Description

Module providing opcode sizes.

Definition in file [avr_op_size.c](#).

4.31.2 Function Documentation

4.31.2.1 uint8_t AVR_Opcode_Size (uint16_t OP_)

AVR_Opcode_Size.

Return the number of bytes are in a specific opcode based on a 16-bit first opcode word.

Parameters

<i>OP_</i>	Opcode word to determine instruction size for
------------	---

Returns

The number of words in an instruction

Definition at line 150 of file [avr_op_size.c](#).

4.32 avr_op_size.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( (/(      (      | -- [ Funkenstein ] -----
00005 *      /( ) )/( )((( ( )\ )\ /( )      | -- [ Little ] -----
00006 *      ( )_ ( )      ) _ )\ ( ( ( )      | -- [ AVR ] -----
00007 *      | _ | _      ( )_ \ ( )\ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ / / | _ \      | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \ \ \ / / | _ \      |
00010 *      | _ | | _      / _ \ \ \ / / | _ \      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdint.h>
00022
00023 #include "emu_config.h"
00024
00025 #include "avr_op_size.h"
00026
00027 //-----
00028 static uint8_t AVR_Opcode_Size_NOP( uint16_t OP_)
00029 {
00030     return 1;
00031 }
00032 //-----
00033 static uint8_t AVR_Opcode_Size_Register_Pair_4bit( uint16_t OP_)
00034 {
00035     return 1;
00036 }
00037 //-----
00038 static uint8_t AVR_Opcode_Size_Register_Pair_3bit( uint16_t OP_)
00039 {
00040     return 1;
00041 }
00042 //-----
00043 static uint8_t AVR_Opcode_Size_Register_Pair_5bit( uint16_t OP_)
00044 {
00045     return 1;
00046 }
00047 //-----
00048 static uint8_t AVR_Opcode_Size_Register_Immediate( uint16_t OP_)
00049 {
00050     return 1;
00051 }
00052 //-----
00053 static uint8_t AVR_Opcode_Size_LDST_YZ_k( uint16_t OP_)
00054 {
00055     return 1;
00056 }
00057 //-----
00058 static uint8_t AVR_Opcode_Size_LDST( uint16_t OP_)
00059 {
00060     return 1;
00061 }
00062 //-----
00063 static uint8_t AVR_Opcode_Size_LDS_STS( uint16_t OP_)
00064 {
00065     return 2;
00066 }
00067 //-----
00068 static uint8_t AVR_Opcode_Size_Register_Single( uint16_t OP_)
00069 {
00070     return 1;
00071 }
00072 //-----
00073 static uint8_t AVR_Opcode_Size_Register_SC( uint16_t OP_)
00074 {
00075     return 1;
00076 }
00077 //-----
00078 static uint8_t AVR_Opcode_Size_Misc( uint16_t OP_)
00079 {
00080     return 1;
00081 }
00082 //-----
00083 static uint8_t AVR_Opcode_Size_Indirect_Jump( uint16_t OP_)
00084 {
00085     return 1;
00086 }
00087 //-----
00088 static uint8_t AVR_Opcode_Size_DEC_Rd( uint16_t OP_)
00089 {
00090     return 1;

```

```

00091 }
00092 //-----
00093 static uint8_t AVR_Opcode_Size_DES_round_4( uint16_t OP_ )
00094 {
00095     return 1;
00096 }
00097 //-----
00098 static uint8_t AVR_Opcode_Size_JMP_CALL_22( uint16_t OP_ )
00099 {
00100     return 2;
00101 }
00102 //-----
00103 static uint8_t AVR_Opcode_Size_ADIW_SBIW_6( uint16_t OP_ )
00104 {
00105     return 1;
00106 }
00107 //-----
00108 static uint8_t AVR_Opcode_Size_IO_Bit( uint16_t OP_ )
00109 {
00110     return 1;
00111 }
00112 //-----
00113 static uint8_t AVR_Opcode_Size_MUL( uint16_t OP_ )
00114 {
00115     return 1;
00116 }
00117 //-----
00118 static uint8_t AVR_Opcode_Size_IO_In_Out( uint16_t OP_ )
00119 {
00120     return 1;
00121 }
00122 //-----
00123 static uint8_t AVR_Opcode_Size_Relative_Jump( uint16_t OP_ )
00124 {
00125     return 1;
00126 }
00127 //-----
00128 static uint8_t AVR_Opcode_Size_LDI( uint16_t OP_ )
00129 {
00130     return 1;
00131 }
00132 //-----
00133 static uint8_t AVR_Opcode_Size_Conditional_Branch( uint16_t OP_ )
00134 {
00135     return 1;
00136 }
00137 //-----
00138 static uint8_t AVR_Opcode_Size_BLD_BST( uint16_t OP_ )
00139 {
00140     return 1;
00141 }
00142 //-----
00143 static uint8_t AVR_Opcode_Size_SBRC_SBRSC( uint16_t OP_ )
00144 {
00145     return 1;
00146 }
00147 }
00148 //-----
00149 //-----
00150 uint8_t AVR_Opcode_Size( uint16_t OP_ )
00151 {
00152     if (( OP_ & 0xFF0F) == 0x9408 )
00153     {
00154         // SEx/CLx status register clear/set bit.
00155         return AVR_Opcode_Size_Register_SC( OP_ );
00156     }
00157     else if (( OP_ & 0xFF0F) == 0x9508 )
00158     {
00159         // Miscellaneous instruction
00160         return AVR_Opcode_Size_Misc( OP_ );
00161     }
00162     else if (( OP_ & 0xFF0F) == 0x940B )
00163     {
00164         // Des round k
00165         return AVR_Opcode_Size_DES_round_4( OP_ );
00166     }
00167     else if ( (( OP_ & 0xFF00 ) == 0x0100 ) ||
00168              (( OP_ & 0xFF00 ) == 0x0200 ) )
00169     {
00170         // Register pair 4bit (MOVW, MULS)
00171         return AVR_Opcode_Size_Register_Pair_4bit( OP_ );
00172     }
00173     else if (( OP_ & 0xFF00 ) == 0x0300 )
00174     {
00175         // 3-bit register pair (R16->R23) - (FMUL, FMULS, FMULSU, MULSU)
00176         return AVR_Opcode_Size_Register_Pair_3bit( OP_ );
00177     }

```

```

00178     else if (( OP_ & 0xFF00 ) <= 0x4F00 )
00179     {
00180         // Register pair 5bit
00181         return AVR_Opcode_Size_Register_Pair_5bit( OP_ );
00182     }
00183     else if (( OP_ & 0xFF00 ) <= 0x7F00 )
00184     {
00185         // Register immediate
00186         return AVR_Opcode_Size_Register_Immediate( OP_ );
00187     }
00188     else if (( OP_ & 0xFEEF ) == 0x9409 )
00189     {
00190         // Indirect Jump/call
00191         return AVR_Opcode_Size_Indirect_Jump( OP_ );
00192     }
00193     else if (( OP_ & 0xFE08 ) == 0x9400 )
00194     {
00195         // 1-operand instructions.
00196         return AVR_Opcode_Size_Register_Single( OP_ );
00197     }
00198     else if (( OP_ & 0xFE0F ) == 0x940A )
00199     {
00200         // Dec Rd
00201         return AVR_Opcode_Size_DEC_Rd( OP_ );
00202     }
00203     else if (( OP_ & 0xFE0C ) == 0x940C )
00204     {
00205         // Jmp/call abs22
00206         return AVR_Opcode_Size_JMP_CALL_22( OP_ );
00207     }
00208     else if (( OP_ & 0xFE00 ) == 0x9600 )
00209     {
00210         // ADIW/SBIW Rp
00211         return AVR_Opcode_Size_ADIW_SBIW_6( OP_ );
00212     }
00213     else if (( OP_ & 0xFC0F ) == 0x9000 )
00214     {
00215         // LDS/STS
00216         return AVR_Opcode_Size_LDS_STS( OP_ );
00217     }
00218     else if (( OP_ & 0xFC00 ) == 0x9000 )
00219     {
00220         // LD/ST other
00221         return AVR_Opcode_Size_LDST( OP_ );
00222     }
00223     else if (( OP_ & 0xFC00 ) == 0x9800 )
00224     {
00225         // IO Space bit operations
00226         return AVR_Opcode_Size_IO_Bit( OP_ );
00227     }
00228     else if (( OP_ & 0xFC00 ) == 0x9C00 )
00229     {
00230         // MUL unsigned Rl:R0 = Rr x Rd
00231         return AVR_Opcode_Size_MUL( OP_ );
00232     }
00233     else if (( OP_ & 0xFC00 ) == 0xF800 )
00234     {
00235         // BLD/BST register bit to STATUS.T
00236         return AVR_Opcode_Size_BLD_BST( OP_ );
00237     }
00238     else if (( OP_ & 0xFC00 ) == 0xFC00 )
00239     {
00240         // SBRC/SBRS
00241         return AVR_Opcode_Size_SBRC_SBRS( OP_ );
00242     }
00243     else if (( OP_ & 0xF800 ) == 0xF000 )
00244     {
00245         // Conditional branch
00246         return AVR_Opcode_Size_Conditional_Branch( OP_ );
00247     }
00248     else if (( OP_ & 0xF000 ) == 0xE000 )
00249     {
00250         // LDI Rh, K
00251         return AVR_Opcode_Size_LDI( OP_ );
00252     }
00253     else if (( OP_ & 0xF000 ) == 0xB000 )
00254     {
00255         // IO space IN/OUT operations
00256         return AVR_Opcode_Size_IO_In_Out( OP_ );
00257     }
00258     else if (( OP_ & 0xE000 ) == 0xC000 )
00259     {
00260         // Relative Jump/Call
00261         return AVR_Opcode_Size_Relative_Jump( OP_ );
00262     }
00263     else if (( OP_ & 0xD000 ) == 0x8000 )
00264     {

```

```

00265         // LDD/STD to Z+kY+k
00266         return AVR_Opcode_Size_LDST_YZ_k( OP_ );
00267     }
00268     else if ( OP_ == 0 )
00269     {
00270         return AVR_Opcode_Size_NOP( OP_ );
00271     }
00272     return AVR_Opcode_Size_NOP( OP_ );
00273 }

```

4.33 src/avr_cpu/avr_op_size.h File Reference

Module providing an interface to lookup the size of an opcode.

```
#include <stdint.h>
```

Functions

- `uint8_t AVR_Opcode_Size (uint16_t OP_)`
AVR_Opcode_Size.

4.33.1 Detailed Description

Module providing an interface to lookup the size of an opcode.

Definition in file [avr_op_size.h](#).

4.33.2 Function Documentation

4.33.2.1 `uint8_t AVR_Opcode_Size (uint16_t OP_)`

AVR_Opcode_Size.

Return the number of bytes are in a specific opcode based on a 16-bit first opcode word.

Parameters

<i>OP_</i>	Opcode word to determine instruction size for
------------	---

Returns

The number of words in an instruction

Definition at line 150 of file [avr_op_size.c](#).

4.34 avr_op_size.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      |
00004 *      ((/( ((/(      )\      | -- [ Funkenstein ] -----
00005 *      /( )  /( ) )(( ( )\  )\  / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | | |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ / / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _ / _ \ \ \ / / | _ \      |
00010 *      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 *      See license.txt for details

```



```

00014  *****/
00021 #ifndef __AVR_OP_SIZE__
00022 #define __AVR_OP_SIZE__
00023
00024 #include <stdint.h>
00025
00026 //-----
00037 uint8_t AVR_Opcode_Size( uint16_t OP_ );
00038
00039 #endif

```

4.35 src/avr_cpu/avr_opcodes.c File Reference

AVR CPU - Opcode implementation.

```

#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include "avr_cpu_print.h"
#include "emu_config.h"
#include "avr_opcodes.h"
#include "interactive.h"
#include "write_callout.h"
#include "interrupt_callout.h"

```

Macros

- #define **DEBUG_PRINT**(...)

Functions

- static void **AVR_Abort** (void)
- static void **Data_Write** (uint16_t u16Addr_, uint8_t u8Val_)
- static uint8_t **Data_Read** (uint16_t u16Addr_)
- static void **AVR_Opcode_NOP** (void)
- void **ADD_Half_Carry** (uint8_t Rd_, uint8_t Rr_, uint8_t Result_)
- void **ADD_Full_Carry** (uint8_t Rd_, uint8_t Rr_, uint8_t Result_)
- void **ADD_Overflow_Flag** (uint8_t Rd_, uint8_t Rr_, uint8_t Result_)
- void **Signed_Flag** (void)
- void **R8_Zero_Flag** (uint8_t R_)
- void **R8_CPC_Zero_Flag** (uint8_t R_)
- void **R8_Negative_Flag** (uint8_t R_)
- static void **AVR_Opcode_ADD** (void)
- static void **AVR_Opcode_ADC** (void)
- void **R16_Negative_Flag** (uint16_t Result_)
- void **R16_Zero_Flag** (uint16_t Result_)
- void **ADIW_Overflow_Flag** (uint16_t Rd_, uint16_t Result_)
- void **ADIW_Carry_Flag** (uint16_t Rd_, uint16_t Result_)
- static void **AVR_Opcode_ADIW** (void)
- void **SUB_Overflow_Flag** (uint8_t Rd_, uint8_t Rr_, uint8_t Result_)
- void **SUB_Half_Carry** (uint8_t Rd_, uint8_t Rr_, uint8_t Result_)
- void **SUB_Full_Carry** (uint8_t Rd_, uint8_t Rr_, uint8_t Result_)
- static void **AVR_Opcode_SUB** (void)
- static void **AVR_Opcode_SUBI** (void)
- static void **AVR_Opcode_SBC** (void)
- static void **AVR_Opcode_SBCI** (void)

- void **SBIW_Overflow_Flag** (uint16_t Rd_, uint16_t Result_)
- void **SBIW_Full_Carry** (uint16_t Rd_, uint16_t Result_)
- static void **AVR_Opcode_SBIW** (void)
- static void **AVR_Opcode_AND** (void)
- static void **AVR_Opcode_ANDI** (void)
- static void **AVR_Opcode_OR** (void)
- static void **AVR_Opcode_ORI** (void)
- static void **AVR_Opcode_EOR** (void)
- static void **AVR_Opcode_COM** (void)
- void **NEG_Overflow_Flag** (uint8_t u8Result_)
- void **NEG_Carry_Flag** (uint8_t u8Result_)
- static void **AVR_Opcode_NEG** (void)
- static void **AVR_Opcode_SBR** (void)
- static void **AVR_Opcode_CBR** (void)
- void **INC_Overflow_Flag** (uint8_t u8Result_)
- static void **AVR_Opcode_INC** (void)
- void **DEC_Overflow_Flag** (uint8_t u8Result_)
- static void **AVR_Opcode_DEC** (void)
- static void **AVR_Opcode_SER** (void)
- void **Mul_Carry_Flag** (uint16_t R_)
- void **Mul_Zero_Flag** (uint16_t R_)
- static void **AVR_Opcode_MUL** (void)
- static void **AVR_Opcode_MULS** (void)
- static void **AVR_Opcode_MULSU** (void)
- static void **AVR_Opcode_Fmul** (void)
- static void **AVR_Opcode_Fmuls** (void)
- static void **AVR_Opcode_FmulSU** (void)
- static void **AVR_Opcode_DES** (void)
- static **Unconditional_Jump** (uint16_t u16Addr_)
- static **Relative_Jump** (uint16_t u16Offset_)
- static void **AVR_Opcode_RJMP** (void)
- static void **AVR_Opcode_IJMP** (void)
- static void **AVR_Opcode_EIJMP** (void)
- static void **AVR_Opcode_JMP** (void)
- static void **AVR_Opcode_RCALL** (void)
- static void **AVR_Opcode_ICALL** (void)
- static void **AVR_Opcode_EICALL** (void)
- static void **AVR_Opcode_CALL** (void)
- static void **AVR_Opcode_RET** (void)
- static void **AVR_Opcode_RETI** (void)
- static void **AVR_Opcode_CPSE** (void)
- void **CP_Half_Carry** (uint8_t Rd_, uint8_t Rr_, uint8_t Result_)
- void **CP_Full_Carry** (uint8_t Rd_, uint8_t Rr_, uint8_t Result_)
- void **CP_Overflow_Flag** (uint8_t Rd_, uint8_t Rr_, uint8_t Result_)
- static void **AVR_Opcode_CP** (void)
- static void **AVR_Opcode_CPC** (void)
- static void **AVR_Opcode_CPI** (void)
- static void **AVR_Opcode_SBRC** (void)
- static void **AVR_Opcode_SBRs** (void)
- static void **AVR_Opcode_SBIC** (void)
- static void **AVR_Opcode_SBIs** (void)
- static **Conditional_Branch** (void)
- static void **AVR_Opcode_BRBS** (void)
- static void **AVR_Opcode_BRBC** (void)
- static void **AVR_Opcode_BREQ** (void)

- static void **AVR_Opcode_BRNE** (void)
- static void **AVR_Opcode_BRCS** (void)
- static void **AVR_Opcode_BRCC** (void)
- static void **AVR_Opcode_BRSH** (void)
- static void **AVR_Opcode_BRLO** (void)
- static void **AVR_Opcode_BRMI** (void)
- static void **AVR_Opcode_BRPL** (void)
- static void **AVR_Opcode_BRGE** (void)
- static void **AVR_Opcode_BRLT** (void)
- static void **AVR_Opcode_BRHS** (void)
- static void **AVR_Opcode_BRHC** (void)
- static void **AVR_Opcode_BRTS** (void)
- static void **AVR_Opcode_BRTC** (void)
- static void **AVR_Opcode_BRVS** (void)
- static void **AVR_Opcode_BRVC** (void)
- static void **AVR_Opcode_BRIE** (void)
- static void **AVR_Opcode_BRID** (void)
- static void **AVR_Opcode_MOV** (void)
- static void **AVR_Opcode_MOVW** (void)
- static void **AVR_Opcode_LDI** (void)
- static void **AVR_Opcode_LDS** (void)
- static void **AVR_Opcode_LD_X_Indirect** (void)
- static void **AVR_Opcode_LD_X_Indirect_Postinc** (void)
- static void **AVR_Opcode_LD_X_Indirect_Preddec** (void)
- static void **AVR_Opcode_LD_Y_Indirect** (void)
- static void **AVR_Opcode_LD_Y_Indirect_Postinc** (void)
- static void **AVR_Opcode_LD_Y_Indirect_Preddec** (void)
- static void **AVR_Opcode_LDD_Y** (void)
- static void **AVR_Opcode_LD_Z_Indirect** (void)
- static void **AVR_Opcode_LD_Z_Indirect_Postinc** (void)
- static void **AVR_Opcode_LD_Z_Indirect_Preddec** (void)
- static void **AVR_Opcode_LDD_Z** (void)
- static void **AVR_Opcode_STS** (void)
- static void **AVR_Opcode_ST_X_Indirect** (void)
- static void **AVR_Opcode_ST_X_Indirect_Postinc** (void)
- static void **AVR_Opcode_ST_X_Indirect_Preddec** (void)
- static void **AVR_Opcode_ST_Y_Indirect** (void)
- static void **AVR_Opcode_ST_Y_Indirect_Postinc** (void)
- static void **AVR_Opcode_ST_Y_Indirect_Preddec** (void)
- static void **AVR_Opcode_STD_Y** (void)
- static void **AVR_Opcode_ST_Z_Indirect** (void)
- static void **AVR_Opcode_ST_Z_Indirect_Postinc** (void)
- static void **AVR_Opcode_ST_Z_Indirect_Preddec** (void)
- static void **AVR_Opcode_STD_Z** (void)
- static void **AVR_Opcode_LPM** (void)
- static void **AVR_Opcode_LPM_Z** (void)
- static void **AVR_Opcode_LPM_Z_Postinc** (void)
- static void **AVR_Opcode_ELPM** (void)
- static void **AVR_Opcode_ELPM_Z** (void)
- static void **AVR_Opcode_ELPM_Z_Postinc** (void)
- static void **AVR_Opcode_SPM** (void)
- static void **AVR_Opcode_SPM_Z_Postinc2** (void)
- static void **AVR_Opcode_IN** (void)
- static void **AVR_Opcode_OUT** (void)
- static void **AVR_Opcode_PUSH** (void)

- static void **AVR_Opcode_POP** (void)
- static void **AVR_Opcode_XCH** (void)
- static void **AVR_Opcode_LAS** (void)
- static void **AVR_Opcode_LAC** (void)
- static void **AVR_Opcode_LAT** (void)
- void **LSL_HalfCarry_Flag** (uint8_t R_)
- void **Left_Carry_Flag** (uint8_t R_)
- void **Rotate_Overflow_Flag** ()
- static void **AVR_Opcode_LSL** (void)
- void **Right_Carry_Flag** (uint8_t R_)
- static void **AVR_Opcode_LSR** (void)
- static void **AVR_Opcode_ROL** (void)
- static void **AVR_Opcode_ROR** (void)
- static void **AVR_Opcode_ASR** (void)
- static void **AVR_Opcode_SWAP** (void)
- static void **AVR_Opcode_BSET** (void)
- static void **AVR_Opcode_BCLR** (void)
- static void **AVR_Opcode_SBI** (void)
- static void **AVR_Opcode_CBI** (void)
- static void **AVR_Opcode_BST** (void)
- static void **AVR_Opcode_BLD** (void)
- static void **AVR_Opcode_BREAK** (void)
- static void **AVR_Opcode_SLEEP** (void)
- static void **AVR_Opcode_WDR** (void)
- AVR_Opcode [AVR_Opcode_Function](#) (uint16_t OP_)
AVR_Opcode_Function.
- void [AVR_RunOpcode](#) (uint16_t OP_)
AVR_RunOpcode.

4.35.1 Detailed Description

AVR CPU - Opcode implementation.

Definition in file [avr_opcodes.c](#).

4.35.2 Function Documentation

4.35.2.1 static void AVR_Opcode_DES (void) [static]

ToDo - Implement DES

Definition at line 749 of file [avr_opcodes.c](#).

4.35.2.2 static void AVR_Opcode_EICALL (void) [static]

! ToDo - Implement EIND calling!

Definition at line 858 of file [avr_opcodes.c](#).

4.35.2.3 static void AVR_Opcode_EIJMP (void) [static]

ToDo - implement EIND instructions

Definition at line 793 of file [avr_opcodes.c](#).

4.35.2.4 static void AVR_Opcode_ELPM(void) [static]

! ToDo - Add in RAMPZ register.

Definition at line 1484 of file [avr_opcodes.c](#).

4.35.2.5 AVR_Opcode AVR_Opcode_Function(uint16_t OP_)

AVR_Opcode_Function.

Return a function pointer corresponding to the CPU logic for a given opcode.

Parameters

OP_	Opcode to return an "opcode execution" function pointer for
-----	---

Returns

Opcode execution function pointer corresponding to the given opcode.

Definition at line 1856 of file [avr_opcodes.c](#).

4.35.2.6 static void AVR_Opcode_SPM(void) [static]

! Implement later...

Definition at line 1535 of file [avr_opcodes.c](#).

4.35.2.7 static void AVR_Opcode_SPM_Z_Postinc2(void) [static]

! Implement later...

Definition at line 1541 of file [avr_opcodes.c](#).

4.35.2.8 void AVR_RunOpcode(uint16_t OP_)

AVR_RunOpcode.

Execute the instruction corresponding to the provided opcode, on the provided CPU object. Note that the opcode must have just been decoded on the given CPU object before calling this function.

Parameters

OP_	Opcode to execute
-----	-------------------

Definition at line 2057 of file [avr_opcodes.c](#).

4.36 avr_opcodes.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( (/( (      (      | -- [ Funkenstein ] -----
00005 *      /( ) )/( ) ((( ( ) )\ )/( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | | |      ( ) \ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ / / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _ | / _ \ \ \ / / | _ \      |
00010 *      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 *      See license.txt for details

```

```

00014  *****/
00022 #include <stdint.h>
00023 #include <stdio.h>
00024 #include <stdlib.h>
00025
00026 #include "avr_cpu_print.h"
00027 #include "emu_config.h"
00028 #include "avr_opcodes.h"
00029 #include "interactive.h"
00030 #include "write_callout.h"
00031 #include "interrupt_callout.h"
00032
00033 //-----
00034 #define DEBUG_PRINT(...)
00035
00036 //-----
00037 static void AVR_Abort(void)
00038 {
00039     print_core_regs();
00040     exit(-1);
00041 }
00042
00043 //-----
00044 static void Data_Write( uint16_t ul6Addr_, uint8_t u8Val_ )
00045 {
00046     // Writing to RAM can be a tricky deal, because the address space is shared
00047     // between RAM, the core registers, and a bunch of peripheral I/O registers.
00048     DEBUG_PRINT("Write: 0x%04X=%02X\n", ul6Addr_, u8Val_ );
00049     if (!WriteCallout_Run( ul6Addr_, u8Val_ ))
00050     {
00051         return;
00052     }
00053
00054     // Check to see if the write operation falls within the peripheral I/O range
00055     if (ul6Addr_ >= 32 && ul6Addr_ <= 255)
00056     {
00057         // I/O range - check to see if there's a peripheral installed at this address
00058         IOWriterList *pstIOWrite = stCPU.apstPeriphWriteTable[ ul6Addr_ ];
00059
00060         // If there is a peripheral or peripherals
00061         if (pstIOWrite)
00062         {
00063             // Iterate through the list of installed peripherals at this address, and
00064             // call their write handler
00065             while (pstIOWrite)
00066             {
00067                 pstIOWrite->pfWriter( pstIOWrite->pvContext, (uint8_t)ul6Addr_, u8Val_ );
00068                 pstIOWrite = pstIOWrite->next;
00069             }
00070         }
00071         // Otherwise, there is no peripheral -- just assume we can treat this as normal RAM.
00072         else
00073         {
00074             stCPU.pstRAM->au8RAM[ ul6Addr_ ] = u8Val_;
00075         }
00076     }
00077     else if (ul6Addr_ >= (stCPU.u32RAMSize + 256))
00078     {
00079         fprintf( stderr, "[Write Abort] RAM Address 0x%04X is out of range!\n", ul6Addr_ );
00080         AVR_Abort();
00081     }
00082     // RAM address range - direct write-through.
00083     else
00084     {
00085         stCPU.pstRAM->au8RAM[ ul6Addr_ ] = u8Val_;
00086     }
00087 }
00088
00089 //-----
00090 static uint8_t Data_Read( uint16_t ul6Addr_ )
00091 {
00092     // Writing to RAM can be a tricky deal, because the address space is shared
00093     // between RAM, the core registers, and a bunch of peripheral I/O registers.
00094
00095     // Check to see if the write operation falls within the peripheral I/O range
00096     DEBUG_PRINT("Data Read: %04X\n", ul6Addr_ );
00097     if (ul6Addr_ >= 32 && ul6Addr_ <= 255)
00098     {
00099         // I/O range - check to see if there's a peripheral installed at this address
00100         IOReaderList *pstIORead = stCPU.apstPeriphReadTable[ ul6Addr_ ];
00101         DEBUG_PRINT("Peripheral Read: 0x%04X\n", ul6Addr_ );
00102         // If there is a peripheral or peripherals
00103         if (pstIORead)
00104         {
00105             DEBUG_PRINT(" Found peripheral\n");
00106             // Iterate through the list of installed peripherals at this address, and

```

```

00108         // call their read handler
00109         uint8_t u8Val;
00110         while (pstIORead)
00111         {
00112             pstIORead->pfReader( pstIORead->pvContext,  (uint8_t)u16Addr_, &u8Val);
00113             pstIORead = pstIORead->next;
00114         }
00115         return u8Val;
00116     }
00117     // Otherwise, there is no peripheral -- just assume we can treat this as normal RAM.
00118     else
00119     {
00120         DEBUG_PRINT(" No peripheral\n");
00121         return stCPU.pstRAM->au8RAM[ u16Addr_ ];
00122     }
00123 }
00124 else if (u16Addr_ >= (stCPU.u32RAMSize + 256))
00125 {
00126     fprintf( stderr, "[Read Abort] RAM Address 0x%04X is out of range!\n", u16Addr_ );
00127     AVR_Abort();
00128 }
00129 // RAM address range - direct read
00130 else
00131 {
00132     return stCPU.pstRAM->au8RAM[ u16Addr_ ];
00133 }
00134 }
00135 }
00136 //-----
00137 static void AVR_Opcode_NOP( void )
00138 {
00139     // Nop - do nothing.
00140 }
00141 }
00142 //-----
00143 inline void ADD_Half_Carry( uint8_t Rd_, uint8_t Rr_, uint8_t Result_ )
00144 {
00145     stCPU.pstRAM->stRegisters.SREG.H =
00146         ( ((Rd_ & Rr_) & 0x08 )
00147         | ((Rr_ & (~Result_)) & 0x08 )
00148         | (((~Result_) & Rd_) & 0x08) ) != false;
00149 }
00150 }
00151 //-----
00152 inline void ADD_Full_Carry( uint8_t Rd_, uint8_t Rr_, uint8_t Result_ )
00153 {
00154     stCPU.pstRAM->stRegisters.SREG.C =
00155         ( ((Rd_ & Rr_) & 0x80 )
00156         | ((Rr_ & (~Result_)) & 0x80 )
00157         | (((~Result_) & Rd_) & 0x80) ) != false;
00158 }
00159 }
00160 //-----
00161 inline void ADD_Overflow_Flag( uint8_t Rd_, uint8_t Rr_, uint8_t Result_ )
00162 {
00163     stCPU.pstRAM->stRegisters.SREG.V =
00164         ( ((Rd_ & Rr_ & ~Result_) & 0x80 )
00165         | ((~Rd_ & ~Rr_ & Result_) & 0x80 ) ) != 0;
00166 }
00167 }
00168 //-----
00169 inline void Signed_Flag( void )
00170 {
00171     unsigned int N = stCPU.pstRAM->stRegisters.SREG.N;
00172     unsigned int V = stCPU.pstRAM->stRegisters.SREG.V;
00173     stCPU.pstRAM->stRegisters.SREG.S = N ^ V;
00174 }
00175 }
00176 }
00177 //-----
00178 inline void R8_Zero_Flag( uint8_t R_ )
00179 {
00180     stCPU.pstRAM->stRegisters.SREG.Z = (R_ == 0);
00181 }
00182 }
00183 //-----
00184 inline void R8_CPC_Zero_Flag( uint8_t R_ )
00185 {
00186     stCPU.pstRAM->stRegisters.SREG.Z = (stCPU.pstRAM->stRegisters.SREG.Z && (R_ == 0));
00187 }
00188 }
00189 //-----
00190 inline void R8_Negative_Flag( uint8_t R_ )
00191 {
00192     stCPU.pstRAM->stRegisters.SREG.N = ((R_ & 0x80) == 0x80);
00193 }
00194 }

```

```

00195 //-----
00196 static void AVR_Opcode_ADD( void )
00197 {
00198     uint8_t u8Result;
00199     uint8_t u8Rd = *(stCPU.Rd);
00200     uint8_t u8Rr = *(stCPU.Rr);
00201
00202     u8Result = u8Rd + u8Rr;
00203     *(stCPU.Rd) = u8Result;
00204
00205     // ---- Update flags ----
00206     ADD_Half_Carry( u8Rd, u8Rr, u8Result );
00207     ADD_Full_Carry( u8Rd, u8Rr, u8Result );
00208     ADD_Overflow_Flag( u8Rd, u8Rr, u8Result );
00209     R8_Negative_Flag( u8Result );
00210     R8_Zero_Flag( u8Result );
00211     Signed_Flag();
00212 }
00213
00214 //-----
00215 static void AVR_Opcode_ADC( void )
00216 {
00217     uint8_t u8Result;
00218     uint8_t u8Rd = *(stCPU.Rd);
00219     uint8_t u8Rr = *(stCPU.Rr);
00220     uint8_t u8Carry = (stCPU.pstRAM->stRegisters.SREG.C);
00221
00222     u8Result = u8Rd + u8Rr + u8Carry;
00223     *(stCPU.Rd) = u8Result;
00224
00225     // ---- Update flags ----
00226     ADD_Half_Carry( u8Rd, u8Rr, u8Result );
00227     ADD_Full_Carry( u8Rd, u8Rr, u8Result );
00228     ADD_Overflow_Flag( u8Rd, u8Rr, u8Result );
00229     R8_Negative_Flag( u8Result );
00230     R8_Zero_Flag( u8Result );
00231     Signed_Flag();
00232 }
00233
00234 //-----
00235 inline void R16_Negative_Flag( uint16_t Result_ )
00236 {
00237     stCPU.pstRAM->stRegisters.SREG.N =
00238         ((Result_ & 0x8000) != 0);
00239 }
00240
00241 //-----
00242 inline void R16_Zero_Flag( uint16_t Result_ )
00243 {
00244     stCPU.pstRAM->stRegisters.SREG.Z =
00245         (Result_ == 0);
00246 }
00247
00248 //-----
00249 inline void ADIW_Overflow_Flag( uint16_t Rd_, uint16_t Result_ )
00250 {
00251     stCPU.pstRAM->stRegisters.SREG.V =
00252         (((Rd_ & 0x8000) == 0) && ((Result_ & 0x8000) == 0x8000));
00253 }
00254
00255 //-----
00256 inline void ADIW_Carry_Flag( uint16_t Rd_, uint16_t Result_ )
00257 {
00258     stCPU.pstRAM->stRegisters.SREG.C =
00259         (((Rd_ & 0x8000) == 0x8000) && ((Result_ & 0x8000) == 0));
00260 }
00261
00262 //-----
00263 static void AVR_Opcode_ADIW( void )
00264 {
00265     uint16_t ul6K = (stCPU.K);
00266     uint16_t ul6Rd = *(stCPU.Rd16);
00267     uint16_t ul6Result;
00268
00269     ul6Result = ul6Rd + ul6K;
00270     *(stCPU.Rd16) = ul6Result;
00271
00272     // ---- Update Flags ----
00273     ADIW_Carry_Flag( ul6Rd, ul6Result );
00274     ADIW_Overflow_Flag( ul6Rd, ul6Result );
00275     R16_Negative_Flag( ul6Result );
00276     R16_Zero_Flag( ul6Result );
00277     Signed_Flag();
00278 }
00279
00280 //-----
00281 inline void SUB_Overflow_Flag( uint8_t Rd_, uint8_t Rr_, uint8_t Result_ )

```



```

00282 {
00283     stCPU.pstRAM->stRegisters.SREG.V =
00284         ( ((Rd_ & ~Rr_ & ~Result_) & 0x80 )
00285         | ((~Rd_ & Rr_ & Result_) & 0x80 ) ) != 0;
00286 }
00287 //-----
00288 inline void SUB_Half_Carry( uint8_t Rd_, uint8_t Rr_, uint8_t Result_)
00289 {
00290     stCPU.pstRAM->stRegisters.SREG.H =
00291         ( ((~Rd_ & Rr_) & 0x08 )
00292         | ((Rr_ & Result_) & 0x08 )
00293         | ((Result_ & ~Rd_) & 0x08 ) ) == 0x08;
00294 }
00295 //-----
00296 inline void SUB_Full_Carry( uint8_t Rd_, uint8_t Rr_, uint8_t Result_)
00297 {
00298     stCPU.pstRAM->stRegisters.SREG.C =
00299         ( ((~Rd_ & Rr_) & 0x80 )
00300         | ((Rr_ & Result_) & 0x80 )
00301         | ((Result_ & ~Rd_) & 0x80 ) ) == 0x80;
00302 }
00303
00304 //-----
00305 static void AVR_Opcode_SUB( void )
00306 {
00307     uint8_t u8Rd = *stCPU.Rd;
00308     uint8_t u8Rr = *stCPU.Rr;
00309     uint8_t u8Result = u8Rd - u8Rr;
00310
00311     *stCPU.Rd = u8Result;
00312
00313     //--Flags
00314     SUB_Half_Carry( u8Rd, u8Rr, u8Result);
00315     SUB_Full_Carry( u8Rd, u8Rr, u8Result);
00316     SUB_Overflow_Flag( u8Rd, u8Rr, u8Result);
00317     R8_Negative_Flag( u8Result);
00318     R8_Zero_Flag( u8Result);
00319     Signed_Flag();
00320 }
00321
00322 //-----
00323 static void AVR_Opcode_SUBI( void )
00324 {
00325     uint8_t u8Rd = *stCPU.Rd;
00326     uint8_t u8K = (uint8_t)stCPU.K;
00327     uint8_t u8Result = u8Rd - u8K;
00328
00329     *stCPU.Rd = u8Result;
00330
00331     //--Flags
00332     SUB_Half_Carry( u8Rd, u8K, u8Result);
00333     SUB_Full_Carry( u8Rd, u8K, u8Result);
00334     SUB_Overflow_Flag( u8Rd, u8K, u8Result);
00335     R8_Negative_Flag( u8Result);
00336     R8_Zero_Flag( u8Result);
00337     Signed_Flag();
00338 }
00339
00340 //-----
00341 static void AVR_Opcode_SBC( void )
00342 {
00343     uint8_t u8Rd = *stCPU.Rd;
00344     uint8_t u8Rr = *stCPU.Rr;
00345     uint8_t u8C = stCPU.pstRAM->stRegisters.SREG.C;
00346     uint8_t u8Result = u8Rd - u8Rr - u8C;
00347
00348     *stCPU.Rd = u8Result;
00349
00350     //--Flags
00351     SUB_Half_Carry( u8Rd, u8Rr, u8Result);
00352     SUB_Full_Carry( u8Rd, u8Rr, u8Result);
00353     SUB_Overflow_Flag( u8Rd, u8Rr, u8Result);
00354     R8_Negative_Flag( u8Result);
00355     if (u8Result)
00356     {
00357         stCPU.pstRAM->stRegisters.SREG.Z = 0;
00358     }
00359     Signed_Flag();
00360 }
00361
00362 //-----
00363 static void AVR_Opcode_SBCI( void )
00364 {
00365     uint8_t u8Rd = *stCPU.Rd;
00366     uint8_t u8K = (uint8_t)stCPU.K;
00367     uint8_t u8C = stCPU.pstRAM->stRegisters.SREG.C;
00368     uint8_t u8Result = u8Rd - u8K - u8C;

```

```

00369
00370     *stCPU.Rd = u8Result;
00371
00372     //--Flags
00373     SUB_Half_Carry( u8Rd, u8K, u8Result);
00374     SUB_Full_Carry( u8Rd, u8K, u8Result);
00375     SUB_Overflow_Flag( u8Rd, u8K, u8Result);
00376     R8_Negative_Flag( u8Result);
00377     if (u8Result)
00378     {
00379         stCPU.pstRAM->stRegisters.SREG.Z = 0;
00380     }
00381     Signed_Flag();
00382 }
00383
00384
00385 //-----
00386 inline void SBIW_Overflow_Flag( uint16_t Rd_, uint16_t Result_)
00387 {
00388     stCPU.pstRAM->stRegisters.SREG.V =
00389         ((Rd_ & 0x8000) == 0x8000) && ((Result_ & 0x8000) == 0);
00390 }
00391
00392
00393 //-----
00394 inline void SBIW_Full_Carry( uint16_t Rd_, uint16_t Result_)
00395 {
00396     stCPU.pstRAM->stRegisters.SREG.C =
00397         ((Rd_ & 0x8000) == 0) && ((Result_ & 0x8000) == 0x8000);
00398 }
00399
00400 //-----
00401 static void AVR_Opcode_SBIW( void )
00402 {
00403     uint16_t u16Rd = *stCPU.Rd16;
00404     uint16_t u16Result;
00405
00406     //fprintf( stderr, "SBIW: RD=[%4X], K=[%2X]\n", u16Rd, stCPU.K );
00407     u16Result = u16Rd - stCPU.K;
00408
00409     *stCPU.Rd16 = u16Result;
00410     //fprintf( stderr, "    Result=[%4X]\n", u16Result );
00411
00412     SBIW_Full_Carry( u16Rd, u16Result);
00413     SBIW_Overflow_Flag( u16Rd, u16Result);
00414     R16_Negative_Flag( u16Result);
00415     R16_Zero_Flag( u16Result);
00416     Signed_Flag();
00417 }
00418
00419
00420 //-----
00421 static void AVR_Opcode_AND( void )
00422 {
00423     uint8_t u8Rd = *stCPU.Rd;
00424     uint8_t u8Rr = *stCPU.Rr;
00425     uint8_t u8Result = u8Rd & u8Rr;
00426
00427     *stCPU.Rd = u8Result;
00428
00429     //--Update Status registers;
00430     stCPU.pstRAM->stRegisters.SREG.V = 0;
00431     R8_Negative_Flag( u8Result );
00432     R8_Zero_Flag( u8Result );
00433     Signed_Flag();
00434 }
00435
00436 //-----
00437 static void AVR_Opcode_ANDI( void )
00438 {
00439     uint8_t u8Rd = *stCPU.Rd;
00440     uint8_t u8Result = u8Rd & (uint8_t)stCPU.K;
00441
00442     *stCPU.Rd = u8Result;
00443
00444     //--Update Status registers;
00445     stCPU.pstRAM->stRegisters.SREG.V = 0;
00446     R8_Negative_Flag( u8Result );
00447     R8_Zero_Flag( u8Result );
00448     Signed_Flag();
00449 }
00450
00451 //-----
00452 static void AVR_Opcode_OR( void )
00453 {
00454     uint8_t u8Rd = *stCPU.Rd;
00455     uint8_t u8Rr = *stCPU.Rr;

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```

00456     uint8_t u8Result = u8Rd | u8Rr;
00457
00458     *stCPU.Rd = u8Result;
00459
00460     //--Update Status registers;
00461     stCPU.pstRAM->stRegisters.SREG.V = 0;
00462     R8_Negative_Flag( u8Result );
00463     R8_Zero_Flag( u8Result );
00464     Signed_Flag();
00465 }
00466
00467 //-----
00468 static void AVR_Opcode_ORI( void )
00469 {
00470     uint8_t u8Rd = *stCPU.Rd;
00471     uint8_t u8Result = u8Rd | (uint8_t)stCPU.K;
00472
00473     *stCPU.Rd = u8Result;
00474
00475     //--Update Status registers;
00476     stCPU.pstRAM->stRegisters.SREG.V = 0;
00477     R8_Negative_Flag( u8Result );
00478     R8_Zero_Flag( u8Result );
00479     Signed_Flag();
00480 }
00481
00482 //-----
00483 static void AVR_Opcode_EOR( void )
00484 {
00485     uint8_t u8Rd = *stCPU.Rd;
00486     uint8_t u8Rr = *stCPU.Rr;
00487     uint8_t u8Result = u8Rd ^ u8Rr;
00488
00489     *stCPU.Rd = u8Result;
00490
00491     //--Update Status registers;
00492     stCPU.pstRAM->stRegisters.SREG.V = 0;
00493     R8_Negative_Flag( u8Result );
00494     R8_Zero_Flag( u8Result );
00495     Signed_Flag();
00496 }
00497
00498 //-----
00499 static void AVR_Opcode_COM( void )
00500 {
00501     // 1's complement.
00502     uint8_t u8Result = *stCPU.Rd;
00503     u8Result = (0xFF - u8Result);
00504
00505     *stCPU.Rd = u8Result;
00506
00507     //--Update Status registers;
00508     stCPU.pstRAM->stRegisters.SREG.V = 0;
00509     stCPU.pstRAM->stRegisters.SREG.C = 1;
00510     R8_Negative_Flag( u8Result );
00511     R8_Zero_Flag( u8Result );
00512     Signed_Flag();
00513 }
00514
00515 //-----
00516 inline void NEG_Overflow_Flag( uint8_t u8Result_ )
00517 {
00518     stCPU.pstRAM->stRegisters.SREG.V = (u8Result_ == 0x80);
00519 }
00520
00521 //-----
00522 inline void NEG_Carry_Flag( uint8_t u8Result_ )
00523 {
00524     stCPU.pstRAM->stRegisters.SREG.C = (u8Result_ != 0x00);
00525 }
00526
00527 //-----
00528 static void AVR_Opcode_NEG( void )
00529 {
00530     // 2's complement.
00531     uint8_t u8Result = *stCPU.Rd;
00532     u8Result = (0 - u8Result);
00533
00534     *stCPU.Rd = u8Result;
00535
00536     //--Update Status registers;
00537     NEG_Overflow_Flag( u8Result );
00538     NEG_Carry_Flag( u8Result );
00539     R8_Negative_Flag( u8Result );
00540     R8_Zero_Flag( u8Result );
00541     Signed_Flag();
00542 }

```

```

00543
00544 //-----
00545 static void AVR_Opcode_SBR( void )
00546 {
00547     // Set Bits in Register
00548     uint8_t u8Result = *stCPU.Rd;
00549     u8Result |= ((uint8_t)stCPU.K);
00550
00551     *stCPU.Rd = u8Result;
00552
00553     //--Update Status registers;
00554     stCPU.pstRAM->stRegisters.SREG.V = 0;
00555     R8_Negative_Flag( u8Result );
00556     R8_Zero_Flag( u8Result );
00557     Signed_Flag();
00558 }
00559
00560 //-----
00561 static void AVR_Opcode_CBR( void )
00562 {
00563     // Clear Bits in Register
00564     uint8_t u8Result = *stCPU.Rd;
00565     u8Result &= ~((uint8_t)stCPU.K);
00566
00567     *stCPU.Rd = u8Result;
00568
00569     //--Update Status registers;
00570     stCPU.pstRAM->stRegisters.SREG.V = 0;
00571     R8_Negative_Flag( u8Result );
00572     R8_Zero_Flag( u8Result );
00573     Signed_Flag();
00574 }
00575
00576 //-----
00577 inline void INC_Overflow_Flag( uint8_t u8Result_ )
00578 {
00579     stCPU.pstRAM->stRegisters.SREG.V = (u8Result_ == 0x80);
00580 }
00581
00582 //-----
00583 static void AVR_Opcode_INC( void )
00584 {
00585     uint8_t u8Result;
00586     u8Result = *stCPU.Rd + 1;
00587
00588     *stCPU.Rd = u8Result;
00589
00590     //--Update Status registers;
00591     INC_Overflow_Flag( u8Result );
00592     R8_Negative_Flag( u8Result );
00593     R8_Zero_Flag( u8Result );
00594     Signed_Flag();
00595 }
00596 //-----
00597 inline void DEC_Overflow_Flag( uint8_t u8Result_ )
00598 {
00599     stCPU.pstRAM->stRegisters.SREG.V = (u8Result_ == 0x7F);
00600 }
00601 //-----
00602 static void AVR_Opcode_DEC( void )
00603 {
00604     uint8_t u8Result;
00605     u8Result = *stCPU.Rd - 1;
00606
00607     *stCPU.Rd = u8Result;
00608
00609     //--Update Status registers;
00610     DEC_Overflow_Flag( u8Result );
00611     R8_Negative_Flag( u8Result );
00612     R8_Zero_Flag( u8Result );
00613     Signed_Flag();
00614 }
00615
00616 //-----
00617 static void AVR_Opcode_SER( void )
00618 {
00619     *stCPU.Rd = 0xFF;
00620 }
00621
00622 //-----
00623 inline void Mul_Carry_Flag( uint16_t R_ )
00624 {
00625     stCPU.pstRAM->stRegisters.SREG.C = ((R_ & 0x8000) == 0x8000);
00626 }
00627
00628 //-----
00629 inline void Mul_Zero_Flag( uint16_t R_ )

```

```

00630 {
00631     stCPU.pstRAM->stRegisters.SREG.Z = (R_ == 0);
00632 }
00633
00634 //-----
00635 static void AVR_Opcode_MUL( void )
00636 {
00637     uint16_t u16Product;
00638     uint16_t u16R1;
00639     uint16_t u16R2;
00640
00641     u16R1 = *stCPU.Rd;
00642     u16R2 = *stCPU.Rr;
00643
00644     u16Product = u16R1 * u16R2;
00645
00646     stCPU.pstRAM->stRegisters.CORE_REGISTERS.r1_0 = u16Product;
00647
00648     //-- Update Flags --
00649     Mul_Zero_Flag( u16Product);
00650     Mul_Carry_Flag( u16Product);
00651 }
00652
00653 //-----
00654 static void AVR_Opcode_MULS( void )
00655 {
00656     int16_t s16Product;
00657     int16_t s16R1;
00658     int16_t s16R2;
00659
00660     s16R1 = (int8_t)*stCPU.Rd;
00661     s16R2 = (int8_t)*stCPU.Rr;
00662
00663     s16Product = s16R1 * s16R2;
00664
00665     stCPU.pstRAM->stRegisters.CORE_REGISTERS.r1_0 = (uint16_t)s16Product;
00666
00667     //-- Update Flags --
00668     Mul_Zero_Flag( (uint16_t)s16Product);
00669     Mul_Carry_Flag( (uint16_t)s16Product);
00670 }
00671
00672 //-----
00673 static void AVR_Opcode_MULSU( void )
00674 {
00675     int16_t s16Product;
00676     int16_t s16R1;
00677     uint16_t u16R2;
00678
00679     s16R1 = (int8_t)*stCPU.Rd;
00680     u16R2 = *stCPU.Rr;
00681
00682     s16Product = s16R1 * u16R2;
00683
00684     stCPU.pstRAM->stRegisters.CORE_REGISTERS.r1_0 = (uint16_t)s16Product;
00685
00686     //-- Update Flags --
00687     Mul_Zero_Flag( (uint16_t)s16Product);
00688     Mul_Carry_Flag( (uint16_t)s16Product);
00689 }
00690
00691 //-----
00692 static void AVR_Opcode_FMUL( void )
00693 {
00694     uint16_t u16Product;
00695     uint16_t u16R1;
00696     uint16_t u16R2;
00697
00698     u16R1 = *stCPU.Rd;
00699     u16R2 = *stCPU.Rr;
00700
00701     u16Product = u16R1 * u16R2;
00702
00703     stCPU.pstRAM->stRegisters.CORE_REGISTERS.r1_0 = u16Product << 1;
00704
00705     //-- Update Flags --
00706     Mul_Zero_Flag( u16Product);
00707     Mul_Carry_Flag( u16Product);
00708 }
00709
00710 //-----
00711 static void AVR_Opcode_FMULS( void )
00712 {
00713     int16_t s16Product;
00714     int16_t s16R1;
00715     int16_t s16R2;
00716

```

```

00717     s16R1 = (int8_t)*stCPU.Rd;
00718     s16R2 = (int8_t)*stCPU.Rr;
00719
00720     s16Product = s16R1 * s16R2;
00721
00722     stCPU.pstRAM->stRegisters.CORE_REGISTERS.r1_0 = ((uint16_t)s16Product) << 1;
00723
00724     //-- Update Flags --
00725     Mul_Zero_Flag( (uint16_t)s16Product);
00726     Mul_Carry_Flag( (uint16_t)s16Product);
00727 }
00728
00729 //-----
00730 static void AVR_Opcode_FMULSU( void )
00731 {
00732     int16_t s16Product;
00733     int16_t s16R1;
00734     uint16_t ul6R2;
00735
00736     s16R1 = (int8_t)*stCPU.Rd;
00737     ul6R2 = *stCPU.Rr;
00738
00739     s16Product = s16R1 * ul6R2;
00740
00741     stCPU.pstRAM->stRegisters.CORE_REGISTERS.r1_0 = ((uint16_t)s16Product) << 1;
00742
00743     //-- Update Flags --
00744     Mul_Zero_Flag( (uint16_t)s16Product);
00745     Mul_Carry_Flag( (uint16_t)s16Product);
00746 }
00747
00748 //-----
00749 static void AVR_Opcode_DES( void )
00750 {
00751 }
00752 }
00753
00754 //-----
00755 static inline Unconditional_Jump( uint16_t ul6Addr_ )
00756 {
00757     stCPU.ul6PC = ul6Addr_;
00758     stCPU.ul6ExtraPC = 0;
00759
00760     // Feature -- Terminate emulator if jump-to-zero encountered at runtime.
00761     if (stCPU.ul6PC == 0 && stCPU.bExitOnReset)
00762     {
00763         exit(0);
00764     }
00765 }
00766
00767 //-----
00768 static inline Relative_Jump( uint16_t ul6Offset_ )
00769 {
00770     // ul6Offset_ Will always be 1 or 2, based on the size of the next opcode
00771     // in a program
00772
00773     stCPU.ul6PC += ul6Offset_;
00774     stCPU.ul6ExtraPC = 0;
00775     stCPU.ul6ExtraCycles += ul6Offset_;
00776 }
00777
00778 //-----
00779 static void AVR_Opcode_RJMP( void )
00780 {
00781     int32_t s32NewPC = (int32_t)stCPU.ul6PC + (int32_t)stCPU.k_s + 1;
00782
00783     Unconditional_Jump( (uint16_t)s32NewPC );
00784 }
00785
00786 //-----
00787 static void AVR_Opcode_IJMP( void )
00788 {
00789     Unconditional_Jump( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z );
00790 }
00791
00792 //-----
00793 static void AVR_Opcode_EIJMP( void )
00794 {
00795 }
00796 }
00797
00798 //-----
00799 static void AVR_Opcode_JMP( void )
00800 {
00801     Unconditional_Jump( (uint16_t)stCPU.k );
00802 }
00803
00804 //-----
00805 static void AVR_Opcode_RCALL( void )

```

```

00806 {
00807     // Push the next instruction address onto the stack
00808     uint16_t ul6SP = (((uint16_t)stCPU.pstRAM->stRegisters.SPH.r) << 8) |
00809                     (((uint16_t)stCPU.pstRAM->stRegisters.SPL.r));
00810
00811     uint16_t ul6StoredPC = stCPU.ul6PC + 1;
00812
00813     Data_Write( ul6SP, (uint8_t)(ul6StoredPC & 0x00FF));
00814     Data_Write( ul6SP - 1, (uint8_t)(ul6StoredPC >> 8));
00815
00816     // Stack is post-decremented
00817     ul6SP -= 2;
00818
00819     // Set the new PC (relative call)
00820     int32_t s32NewPC = (int32_t)stCPU.ul6PC + (int32_t)stCPU.k_s + 1;
00821     uint16_t ul6NewPC = (uint16_t)s32NewPC;
00822
00823     // Store the new SP.
00824     stCPU.pstRAM->stRegisters.SPH.r = (ul6SP >> 8);
00825     stCPU.pstRAM->stRegisters.SPL.r = (ul6SP & 0x00FF);
00826
00827     // Set the new PC
00828     Unconditional_Jump( ul6NewPC );
00829 }
00830
00831 //-----
00832 static void AVR_Opcode_ICALL( void )
00833 {
00834     // Push the next instruction address onto the stack
00835     uint16_t ul6SP = (((uint16_t)stCPU.pstRAM->stRegisters.SPH.r) << 8) |
00836                     (((uint16_t)stCPU.pstRAM->stRegisters.SPL.r));
00837
00838     uint16_t ul6StoredPC = stCPU.ul6PC + 1;
00839
00840     Data_Write( ul6SP, (uint8_t)(ul6StoredPC & 0x00FF));
00841     Data_Write( ul6SP - 1, (uint8_t)(ul6StoredPC >> 8));
00842
00843     // Stack is post-decremented
00844     ul6SP -= 2;
00845
00846     // Set the new PC
00847     uint16_t ul6NewPC = stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z;
00848
00849     // Store the new SP.
00850     stCPU.pstRAM->stRegisters.SPH.r = (ul6SP >> 8);
00851     stCPU.pstRAM->stRegisters.SPL.r = (ul6SP & 0x00FF);
00852
00853     // Set the new PC
00854     Unconditional_Jump( ul6NewPC );
00855 }
00856
00857 //-----
00858 static void AVR_Opcode_EICALL( void )
00859 {
00860 }
00861 }
00862
00863 //-----
00864 static void AVR_Opcode_CALL( void )
00865 {
00866     // See ICALL for documentation
00867     uint16_t ul6SP = (((uint16_t)stCPU.pstRAM->stRegisters.SPH.r) << 8) |
00868                     (((uint16_t)stCPU.pstRAM->stRegisters.SPL.r));
00869
00870     uint16_t ul6StoredPC = stCPU.ul6PC + 2;
00871
00872     Data_Write( ul6SP, (uint8_t)(ul6StoredPC & 0x00FF));
00873     Data_Write( ul6SP - 1, (uint8_t)(ul6StoredPC >> 8));
00874
00875     ul6SP -= 2;
00876
00877     uint16_t ul6NewPC = stCPU.k;
00878
00879     stCPU.pstRAM->stRegisters.SPH.r = (ul6SP >> 8);
00880     stCPU.pstRAM->stRegisters.SPL.r = (ul6SP & 0x00FF);
00881
00882     Unconditional_Jump( ul6NewPC );
00883 }
00884
00885 //-----
00886 static void AVR_Opcode_RET( void )
00887 {
00888     // Pop the next instruction off of the stack, pre-incrementing
00889     uint16_t ul6SP = (((uint16_t)stCPU.pstRAM->stRegisters.SPH.r) << 8) |
00890                     (((uint16_t)stCPU.pstRAM->stRegisters.SPL.r));
00891     ul6SP += 2;
00892
00893     uint16_t ul6High = Data_Read( ul6SP - 1 );

```

```

00894     uint16_t u16Low = Data_Read( u16SP );
00895     uint16_t u16NewPC = (u16High << 8) | u16Low;
00896
00897     stCPU.pstRAM->stRegisters.SPH.r = (u16SP >> 8);
00898     stCPU.pstRAM->stRegisters.SPL.r = (u16SP & 0x00FF);
00899
00900     // Set new PC based on address read from stack
00901     Unconditional_Jump( u16NewPC );
00902 }
00903
00904 //-----
00905 static void AVR_Opcode_RETI( void )
00906 {
00907     uint16_t u16SP = (((uint16_t)stCPU.pstRAM->stRegisters.SPH.r) << 8) |
00908                     (((uint16_t)stCPU.pstRAM->stRegisters.SPL.r));
00909     u16SP += 2;
00910
00911     uint16_t u16High = Data_Read( u16SP - 1 );
00912     uint16_t u16Low = Data_Read( u16SP );
00913     uint16_t u16NewPC = (u16High << 8) | u16Low;
00914
00915     stCPU.pstRAM->stRegisters.SPH.r = (u16SP >> 8);
00916     stCPU.pstRAM->stRegisters.SPL.r = (u16SP & 0x00FF);
00917
00918     //-- Enable interrupts
00919     stCPU.pstRAM->stRegisters.SREG.I = 1;
00920     Unconditional_Jump( u16NewPC );
00921
00922     //-- Run callout functions registered when we return from interrupt.
00923     InterruptCallout_Run( false, 0 );
00924 }
00925
00926 //-----
00927 static void AVR_Opcode_CPSE( void )
00928 {
00929     if (*stCPU.Rr == *stCPU.Rd)
00930     {
00931         uint8_t u8NextOpSize = AVR_Opcode_Size( stCPU.pu16ROM[ stCPU.u16PC + 1 ] );
00932         Relative_Jump( u8NextOpSize + 1 );
00933     }
00934 }
00935
00936 //-----
00937 inline void CP_Half_Carry( uint8_t Rd_, uint8_t Rr_, uint8_t Result_ )
00938 {
00939     stCPU.pstRAM->stRegisters.SREG.H =
00940         ( ((~Rd_ & Rr_) & 0x08 )
00941         | ((Rr_ & (Result_)) & 0x08 )
00942         | (((Result_) & ~Rd_) & 0x08) ) != false;
00943 }
00944
00945 //-----
00946 inline void CP_Full_Carry( uint8_t Rd_, uint8_t Rr_, uint8_t Result_ )
00947 {
00948     stCPU.pstRAM->stRegisters.SREG.C =
00949         ( ((~Rd_ & Rr_) & 0x80 )
00950         | ((Rr_ & (Result_)) & 0x80 )
00951         | (((Result_) & ~Rd_) & 0x80) ) != false;
00952 }
00953
00954 //-----
00955 inline void CP_Overflow_Flag( uint8_t Rd_, uint8_t Rr_, uint8_t Result_ )
00956 {
00957     stCPU.pstRAM->stRegisters.SREG.V =
00958         ( ((Rd_ & ~Rr_ & ~Result_) & 0x80 )
00959         | ((~Rd_ & Rr_ & Result_) & 0x80 ) ) != 0;
00960 }
00961
00962 //-----
00963 static void AVR_Opcode_CP( void )
00964 {
00965     // Compare
00966     uint8_t u8Result;
00967     uint8_t u8Rd = *stCPU.Rd;
00968     uint8_t u8Rr = *stCPU.Rr;
00969
00970     u8Result = u8Rd - u8Rr;
00971
00972     //---
00973     CP_Half_Carry( u8Rd, u8Rr, u8Result );
00974     CP_Overflow_Flag( u8Rd, u8Rr, u8Result );
00975     CP_Full_Carry( u8Rd, u8Rr, u8Result );
00976
00977     R8_Zero_Flag( u8Result );
00978     R8_Negative_Flag( u8Result );
00979
00980     Signed_Flag();

```



```

00981 }
00982
00983 //-----
00984 static void AVR_Opcode_CPC( void )
00985 {
00986     // Compare with carry
00987     uint8_t u8Result;
00988     uint8_t u8Rd = *stCPU.Rd;
00989     uint8_t u8Rr = *stCPU.Rr;
00990     uint8_t u8C = (stCPU.pstRAM->stRegisters.SREG.C == 1);
00991
00992     u8Result = u8Rd - u8Rr - u8C;
00993
00994     //---
00995     CP_Half_Carry( u8Rd, u8Rr, u8Result );
00996     CP_Overflow_Flag( u8Rd, u8Rr, u8Result );
00997     CP_Full_Carry( u8Rd, u8Rr, u8Result );
00998
00999     R8_CPC_Zero_Flag( u8Result );
01000     R8_Negative_Flag( u8Result );
01001
01002     Signed_Flag();
01003 }
01004
01005 //-----
01006 static void AVR_Opcode_CPI( void )
01007 {
01008     // Compare with immediate
01009     uint8_t u8Result;
01010     uint8_t u8Rd = *stCPU.Rd;
01011     uint8_t u8K = stCPU.K;
01012
01013     u8Result = u8Rd - u8K;
01014
01015     //---
01016     CP_Half_Carry( u8Rd, u8K, u8Result );
01017     CP_Overflow_Flag( u8Rd, u8K, u8Result );
01018     CP_Full_Carry( u8Rd, u8K, u8Result );
01019
01020     R8_Zero_Flag( u8Result );
01021     R8_Negative_Flag( u8Result );
01022
01023     Signed_Flag();
01024 }
01025
01026 //-----
01027 static void AVR_Opcode_SBRC( void )
01028 {
01029     // Skip if Bit in IO register clear
01030     if ((*stCPU.Rd & (1 << stCPU.b)) == 0)
01031     {
01032         uint8_t u8NextOpSize = AVR_Opcode_Size( stCPU.pu16ROM[ stCPU.u16PC + 1 ] );
01033         Relative_Jump( u8NextOpSize + 1 );
01034     }
01035 }
01036
01037 //-----
01038 static void AVR_Opcode_SBRS( void )
01039 {
01040     // Skip if Bit in IO register set
01041     if ((*stCPU.Rd & (1 << stCPU.b)) != 0)
01042     {
01043         uint8_t u8NextOpSize = AVR_Opcode_Size( stCPU.pu16ROM[ stCPU.u16PC + 1 ] );
01044         Relative_Jump( u8NextOpSize + 1 );
01045     }
01046 }
01047
01048 //-----
01049 static void AVR_Opcode_SBI( void )
01050 {
01051     // Skip if Bit in IO register clear
01052     uint8_t u8IOVal = Data_Read( 32 + stCPU.A );
01053     if ((u8IOVal & (1 << stCPU.b)) == 0)
01054     {
01055         uint8_t u8NextOpSize = AVR_Opcode_Size( stCPU.pu16ROM[ stCPU.u16PC + 1 ] );
01056         Relative_Jump( u8NextOpSize + 1 );
01057     }
01058 }
01059
01060 //-----
01061 static void AVR_Opcode_SBIS( void )
01062 {
01063     // Skip if Bit in IO register set
01064     uint8_t u8IOVal = Data_Read( 32 + stCPU.A );
01065     if ((u8IOVal & (1 << stCPU.b)) != 0)
01066     {
01067         uint8_t u8NextOpSize = AVR_Opcode_Size( stCPU.pu16ROM[ stCPU.u16PC + 1 ] );

```

```

01068         Relative_Jump( u8NextOpSize + 1 );
01069     }
01070 }
01071
01072 //-----
01073 static inline Conditional_Branch( void )
01074 {
01075     stCPU.ul6PC = (uint16_t)((int16_t)stCPU.ul6PC + stCPU.k_s + 1);
01076     stCPU.ul6ExtraPC = 0;
01077     stCPU.ul6ExtraCycles++;
01078 }
01079
01080 //-----
01081 static void AVR_Opcode_BRBS( void )
01082 {
01083     if (0 != (stCPU.pstRAM->stRegisters.SREG.r & (1 << stCPU.b)))
01084     {
01085         Conditional_Branch();
01086     }
01087 }
01088
01089 //-----
01090 static void AVR_Opcode_BRBC( void )
01091 {
01092     if (0 == (stCPU.pstRAM->stRegisters.SREG.r & (1 << stCPU.b)))
01093     {
01094         Conditional_Branch();
01095     }
01096 }
01097
01098 //-----
01099 static void AVR_Opcode_BREQ( void )
01100 {
01101     if (1 == stCPU.pstRAM->stRegisters.SREG.Z)
01102     {
01103         Conditional_Branch();
01104     }
01105 }
01106
01107 //-----
01108 static void AVR_Opcode_BRNE( void )
01109 {
01110     if (0 == stCPU.pstRAM->stRegisters.SREG.Z)
01111     {
01112         Conditional_Branch();
01113     }
01114 }
01115
01116 //-----
01117 static void AVR_Opcode_BRCS( void )
01118 {
01119     if (1 == stCPU.pstRAM->stRegisters.SREG.C)
01120     {
01121         Conditional_Branch();
01122     }
01123 }
01124
01125 //-----
01126 static void AVR_Opcode_BRCC( void )
01127 {
01128     if (0 == stCPU.pstRAM->stRegisters.SREG.C)
01129     {
01130         Conditional_Branch();
01131     }
01132 }
01133
01134 //-----
01135 static void AVR_Opcode_BRSH( void )
01136 {
01137     if (0 == stCPU.pstRAM->stRegisters.SREG.C)
01138     {
01139         Conditional_Branch();
01140     }
01141 }
01142
01143 //-----
01144 static void AVR_Opcode_BRLO( void )
01145 {
01146     if (1 == stCPU.pstRAM->stRegisters.SREG.C)
01147     {
01148         Conditional_Branch();
01149     }
01150 }
01151
01152 //-----
01153 static void AVR_Opcode_BRMI( void )
01154 {

```

```

01155     if (1 == stCPU.pstRAM->stRegisters.SREG.N)
01156     {
01157         Conditional_Branch();
01158     }
01159 }
01160
01161 //-----
01162 static void AVR_Opcode_BRPL( void )
01163 {
01164     if (0 == stCPU.pstRAM->stRegisters.SREG.N)
01165     {
01166         Conditional_Branch();
01167     }
01168 }
01169
01170 //-----
01171 static void AVR_Opcode_BRGE( void )
01172 {
01173     if (0 == stCPU.pstRAM->stRegisters.SREG.S)
01174     {
01175         Conditional_Branch();
01176     }
01177 }
01178
01179 //-----
01180 static void AVR_Opcode_BRLT( void )
01181 {
01182     if (1 == stCPU.pstRAM->stRegisters.SREG.S)
01183     {
01184         Conditional_Branch();
01185     }
01186 }
01187
01188 //-----
01189 static void AVR_Opcode_BRHS( void )
01190 {
01191     if (1 == stCPU.pstRAM->stRegisters.SREG.H)
01192     {
01193         Conditional_Branch();
01194     }
01195 }
01196
01197 //-----
01198 static void AVR_Opcode_BRHC( void )
01199 {
01200     if (0 == stCPU.pstRAM->stRegisters.SREG.H)
01201     {
01202         Conditional_Branch();
01203     }
01204 }
01205
01206 //-----
01207 static void AVR_Opcode_BRTS( void )
01208 {
01209     if (1 == stCPU.pstRAM->stRegisters.SREG.T)
01210     {
01211         Conditional_Branch();
01212     }
01213 }
01214
01215 //-----
01216 static void AVR_Opcode_BRTC( void )
01217 {
01218     if (0 == stCPU.pstRAM->stRegisters.SREG.T)
01219     {
01220         Conditional_Branch();
01221     }
01222 }
01223
01224 //-----
01225 static void AVR_Opcode_BRVS( void )
01226 {
01227     if (1 == stCPU.pstRAM->stRegisters.SREG.V)
01228     {
01229         Conditional_Branch();
01230     }
01231 }
01232
01233 //-----
01234 static void AVR_Opcode_BRVC( void )
01235 {
01236     if (0 == stCPU.pstRAM->stRegisters.SREG.V)
01237     {
01238         Conditional_Branch();
01239     }
01240 }
01241

```

```

01242 //-----
01243 static void AVR_Opcode_BRIE( void )
01244 {
01245     if (1 == stCPU.pstRAM->stRegisters.SREG.I)
01246     {
01247         Conditional_Branch();
01248     }
01249 }
01250
01251 //-----
01252 static void AVR_Opcode_BRID( void )
01253 {
01254     if (0 == stCPU.pstRAM->stRegisters.SREG.I)
01255     {
01256         Conditional_Branch();
01257     }
01258 }
01259
01260 //-----
01261 static void AVR_Opcode_MOV( void )
01262 {
01263     *stCPU.Rd = *stCPU.Rr;
01264 }
01265
01266 //-----
01267 static void AVR_Opcode_MOVW( void )
01268 {
01269     *stCPU.Rd16 = *stCPU.Rr16;
01270 }
01271
01272 //-----
01273 static void AVR_Opcode_LDI( void )
01274 {
01275     *stCPU.Rd = stCPU.K;
01276 }
01277
01278 //-----
01279 static void AVR_Opcode_LDS( void )
01280 {
01281     *stCPU.Rd = Data_Read( stCPU.K );
01282 }
01283
01284 //-----
01285 static void AVR_Opcode_LD_X_Indirect( void )
01286 {
01287     *stCPU.Rd =
01288         Data_Read( stCPU.pstRAM->stRegisters.CORE_REGISTERS.X );
01289 }
01290
01291 //-----
01292 static void AVR_Opcode_LD_X_Indirect_Postinc( void )
01293 {
01294     *stCPU.Rd =
01295         Data_Read( stCPU.pstRAM->stRegisters.CORE_REGISTERS.X++ );
01296 }
01297
01298 //-----
01299 static void AVR_Opcode_LD_X_Indirect_Preddec( void )
01300 {
01301     *stCPU.Rd =
01302         Data_Read( --stCPU.pstRAM->stRegisters.CORE_REGISTERS.X );
01303 }
01304
01305 //-----
01306 static void AVR_Opcode_LD_Y_Indirect( void )
01307 {
01308     *stCPU.Rd =
01309         Data_Read( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Y );
01310 }
01311
01312 //-----
01313 static void AVR_Opcode_LD_Y_Indirect_Postinc( void )
01314 {
01315     *stCPU.Rd =
01316         Data_Read( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Y++ );
01317 }
01318
01319 //-----
01320 static void AVR_Opcode_LD_Y_Indirect_Preddec( void )
01321 {
01322     *stCPU.Rd =
01323         Data_Read( --stCPU.pstRAM->stRegisters.CORE_REGISTERS.Y );
01324 }
01325
01326 //-----
01327 static void AVR_Opcode_LDD_Y( void )
01328 {

```

```

01329     *stCPU.Rd =
01330         Data_Read( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Y + stCPU.q );
01331 }
01332
01333 //-----
01334 static void AVR_Opcode_LD_Z_Indirect( void )
01335 {
01336     *stCPU.Rd =
01337         Data_Read( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z );
01338 }
01339
01340 //-----
01341 static void AVR_Opcode_LD_Z_Indirect_Postinc( void )
01342 {
01343     *stCPU.Rd =
01344         Data_Read( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z++ );
01345 }
01346
01347 //-----
01348 static void AVR_Opcode_LD_Z_Indirect_Predec( void )
01349 {
01350     *stCPU.Rd =
01351         Data_Read( --stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z );
01352 }
01353
01354 //-----
01355 static void AVR_Opcode_LDD_Z( void )
01356 {
01357     *stCPU.Rd =
01358         Data_Read( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z + stCPU.q );
01359 }
01360
01361 //-----
01362 static void AVR_Opcode_STS( void )
01363 {
01364     Data_Write( stCPU.K, *stCPU.Rd );
01365 }
01366
01367 //-----
01368 static void AVR_Opcode_ST_X_Indirect( void )
01369 {
01370     Data_Write( stCPU.pstRAM->stRegisters.CORE_REGISTERS.X, *stCPU.Rd );
01371 }
01372
01373 //-----
01374 static void AVR_Opcode_ST_X_Indirect_Postinc( void )
01375 {
01376     Data_Write( stCPU.pstRAM->stRegisters.CORE_REGISTERS.X++, *stCPU.Rd );
01377 }
01378
01379 //-----
01380 static void AVR_Opcode_ST_X_Indirect_Predec( void )
01381 {
01382     Data_Write( --stCPU.pstRAM->stRegisters.CORE_REGISTERS.X, *stCPU.Rd );
01383 }
01384
01385 //-----
01386 static void AVR_Opcode_ST_Y_Indirect( void )
01387 {
01388     Data_Write( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Y, *stCPU.Rd );
01389 }
01390
01391 //-----
01392 static void AVR_Opcode_ST_Y_Indirect_Postinc( void )
01393 {
01394     Data_Write( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Y++, *stCPU.Rd );
01395 }
01396
01397 //-----
01398 static void AVR_Opcode_ST_Y_Indirect_Predec( void )
01399 {
01400     Data_Write( --stCPU.pstRAM->stRegisters.CORE_REGISTERS.Y, *stCPU.Rd );
01401 }
01402
01403 //-----
01404 static void AVR_Opcode_STD_Y( void )
01405 {
01406     Data_Write( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Y + stCPU.q, *stCPU.Rd );
01407 }
01408
01409 //-----
01410 static void AVR_Opcode_ST_Z_Indirect( void )
01411 {
01412     Data_Write( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z, *stCPU.Rd );
01413 }
01414
01415

```

```

01416 //-----
01417 static void AVR_Opcode_ST_Z_Indirect_Postinc( void )
01418 {
01419     Data_Write( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z++ , *stCPU.Rd );
01420 }
01421
01422 //-----
01423 static void AVR_Opcode_ST_Z_Indirect_Predc( void )
01424 {
01425     Data_Write( --stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z , *stCPU.Rd );
01426 }
01427
01428 //-----
01429 static void AVR_Opcode_STD_Z( void )
01430 {
01431     Data_Write( stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z + stCPU.q, *stCPU.Rd );
01432 }
01433
01434 //-----
01435 static void AVR_Opcode_LPM( void )
01436 {
01437     uint8_t u8Temp;
01438     if (stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z & 0x0001)
01439     {
01440         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] >> 8);
01441     }
01442     else
01443     {
01444         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] & 0x00FF);
01445     }
01446     stCPU.pstRAM->stRegisters.CORE_REGISTERS.r0 = u8Temp;
01447 }
01448
01449 //-----
01450 static void AVR_Opcode_LPM_Z( void )
01451 {
01452     uint8_t u8Temp;
01453     if (stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z & 0x0001)
01454     {
01455         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] >> 8);
01456     }
01457     else
01458     {
01459         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] & 0x00FF);
01460     }
01461     *stCPU.Rd = u8Temp;
01462 }
01463
01464 //-----
01465 static void AVR_Opcode_LPM_Z_Postinc( void )
01466 {
01467     uint8_t u8Temp;
01468     if (stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z & 0x0001)
01469     {
01470         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] >> 8);
01471     }
01472     else
01473     {
01474         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] & 0x00FF);
01475     }
01476     *stCPU.Rd = u8Temp;
01477     stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z++;
01478 }
01479
01480 //-----
01481 static void AVR_Opcode_ELPM( void )
01482 {
01483     uint8_t u8Temp;
01484     if (stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z & 0x0001)
01485     {
01486         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] >> 8);
01487     }
01488     else
01489     {
01490         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] & 0x00FF);
01491     }
01492     stCPU.pstRAM->stRegisters.CORE_REGISTERS.r0 = u8Temp;
01493 }
01494
01495 //-----
01496 static void AVR_Opcode_ELPM_Z( void )
01497 {
01498     uint8_t u8Temp;

```

```

01504     if (stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z & 0x0001)
01505     {
01506         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] >> 8);
01507     }
01508     else
01509     {
01510         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] & 0x00FF);
01511     }
01512
01513     *stCPU.Rd = u8Temp;
01514 }
01515
01516 //-----
01517 static void AVR_Opcode_ELPM_Z_Postinc( void )
01518 {
01519     uint8_t u8Temp;
01520     if (stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z & 0x0001)
01521     {
01522         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] >> 8);
01523     }
01524     else
01525     {
01526         u8Temp = (uint8_t)(stCPU.pul6ROM[ stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z >> 1 ] & 0x00FF);
01527     }
01528
01529     *stCPU.Rd = u8Temp;
01530
01531     stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z++;
01532 }
01533
01534 //-----
01535 static void AVR_Opcode_SPM( void )
01536 {
01537 }
01538 }
01539
01540 //-----
01541 static void AVR_Opcode_SPM_Z_Postinc2( void )
01542 {
01543 }
01544 }
01545
01546 //-----
01547 static void AVR_Opcode_IN( void )
01548 {
01549     *stCPU.Rd = Data_Read( 32 + stCPU.A );
01550 }
01551
01552 //-----
01553 static void AVR_Opcode_OUT( void )
01554 {
01555     Data_Write( 32 + stCPU.A , *stCPU.Rd );
01556 }
01557
01558 //-----
01559 static void AVR_Opcode_PUSH( void )
01560 {
01561     uint16_t ul6SP = (stCPU.pstRAM->stRegisters.SPL.r) |
01562                     ((uint16_t)(stCPU.pstRAM->stRegisters.SPH.r) << 8);
01563
01564     // Store contents from SP to destination register
01565     Data_Write( ul6SP, *stCPU.Rd );
01566
01567     // Postdecrement the SP
01568     ul6SP--;
01569
01570     // Update the SP registers
01571     stCPU.pstRAM->stRegisters.SPH.r = (uint8_t)(ul6SP >> 8);
01572     stCPU.pstRAM->stRegisters.SPL.r = (uint8_t)(ul6SP & 0x00FF);
01573 }
01574
01575 //-----
01576 static void AVR_Opcode_POP( void )
01577 {
01578     // Preincrement the SP
01579     uint16_t ul6SP = (stCPU.pstRAM->stRegisters.SPL.r) |
01580                     ((uint16_t)(stCPU.pstRAM->stRegisters.SPH.r) << 8);
01581     ul6SP++;
01582
01583     // Load contents from SP to destination register
01584     *stCPU.Rd = Data_Read( ul6SP );
01585
01586     // Update the SP registers
01587     stCPU.pstRAM->stRegisters.SPH.r = (uint8_t)(ul6SP >> 8);
01588     stCPU.pstRAM->stRegisters.SPL.r = (uint8_t)(ul6SP & 0x00FF);
01589 }
01590
01591 //-----
01592 static void AVR_Opcode_XCH( void )

```

```

01593 {
01594     uint8_t u8Z;
01595     uint8_t u8Temp;
01596     uint16_t ul6Addr = stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z;
01597
01598     u8Z = Data_Read( ul6Addr );
01599     u8Temp = *stCPU.Rd;
01600
01601     *stCPU.Rd = u8Z;
01602     Data_Write( ul6Addr, u8Temp );
01603 }
01604
01605 //-----
01606 static void AVR_Opcode_LAS( void )
01607 {
01608     uint8_t u8Z;
01609     uint8_t u8Temp;
01610
01611     uint16_t ul6Addr = stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z;
01612
01613     u8Z = Data_Read( ul6Addr );
01614     u8Temp = *stCPU.Rd | u8Z;
01615
01616     *stCPU.Rd = u8Z;
01617     Data_Write( ul6Addr, u8Temp );
01618 }
01619
01620 //-----
01621 static void AVR_Opcode_LAC( void )
01622 {
01623     uint8_t u8Z;
01624     uint8_t u8Temp;
01625
01626     uint16_t ul6Addr = stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z;
01627
01628     u8Z = Data_Read( ul6Addr );
01629     u8Temp = *stCPU.Rd & ~(u8Z);
01630     *stCPU.Rd = u8Z;
01631
01632     Data_Write( ul6Addr, u8Temp );
01633 }
01634
01635 //-----
01636 static void AVR_Opcode_LAT( void )
01637 {
01638     uint8_t u8Z;
01639     uint8_t u8Temp;
01640
01641     uint16_t ul6Addr = stCPU.pstRAM->stRegisters.CORE_REGISTERS.Z;
01642
01643     u8Z = Data_Read( ul6Addr );
01644     u8Temp = *stCPU.Rd ^ u8Z;
01645     *stCPU.Rd = u8Z;
01646
01647     Data_Write( ul6Addr, u8Temp );
01648 }
01649
01650 //-----
01651 inline void LSL_HalfCarry_Flag( uint8_t R_ )
01652 {
01653     stCPU.pstRAM->stRegisters.SREG.H = ((R_ & 0x08) == 0x08);
01654 }
01655
01656 //-----
01657 inline void Left_Carry_Flag( uint8_t R_ )
01658 {
01659     stCPU.pstRAM->stRegisters.SREG.C = ((R_ & 0x80) == 0x80);
01660 }
01661
01662 //-----
01663 inline void Rotate_Overflow_Flag()
01664 {
01665     stCPU.pstRAM->stRegisters.SREG.V = ( stCPU.pstRAM->stRegisters.SREG.N ^ stCPU.pstRAM->stRegisters.SREG.
01666 C );
01667 }
01668
01669 //-----
01669 static void AVR_Opcode_LSL( void )
01670 {
01671     // Logical shift left
01672     uint8_t u8Result = 0;
01673     uint8_t u8Temp = *stCPU.Rd;
01674
01675     u8Result = (u8Temp << 1);
01676     *stCPU.Rd = u8Result;
01677
01678     // ---- Update flags ----

```



```

01679     LSL_HalfCarry_Flag( u8Result);
01680     Left_Carry_Flag( u8Temp);
01681
01682     R8_Negative_Flag( u8Result );
01683     R8_Zero_Flag( u8Result );
01684     Rotate_Overflow_Flag();
01685     Signed_Flag();
01686 }
01687
01688 //-----
01689 inline void Right_Carry_Flag( uint8_t R_ )
01690 {
01691     stCPU.pstRAM->stRegisters.SREG.C = ((R_ & 0x01) == 0x01);
01692 }
01693
01694 //-----
01695 static void AVR_Opcode_LSR( void )
01696 {
01697     // Logical shift left
01698     uint8_t u8Result = 0;
01699     uint8_t u8Temp = *stCPU.Rd;
01700
01701     u8Result = (u8Temp >> 1);
01702     *stCPU.Rd = u8Result;
01703
01704     // ---- Update flags ----
01705     Right_Carry_Flag( u8Temp );
01706     stCPU.pstRAM->stRegisters.SREG.N = 0;
01707     R8_Zero_Flag( u8Result );
01708     Rotate_Overflow_Flag();
01709     Signed_Flag();
01710 }
01711
01712 //-----
01713 static void AVR_Opcode_ROL( void )
01714 {
01715     // Rotate left through carry
01716     uint8_t u8Result = 0;
01717     uint8_t u8Temp = *stCPU.Rd;
01718
01719     u8Result = (u8Temp << 1);
01720     if (stCPU.pstRAM->stRegisters.SREG.C)
01721     {
01722         u8Result |= 0x01;
01723     }
01724     *stCPU.Rd = u8Result;
01725
01726     // ---- Update flags ----
01727     Left_Carry_Flag( u8Temp );
01728     R8_Negative_Flag( u8Result );
01729     R8_Zero_Flag( u8Result );
01730     Rotate_Overflow_Flag();
01731     Signed_Flag();
01732 }
01733
01734 //-----
01735 static void AVR_Opcode_ROR( void )
01736 {
01737     // Rotate right through carry
01738     uint8_t u8Result = 0;
01739     uint8_t u8Temp = *stCPU.Rd;
01740
01741     u8Result = (u8Temp >> 1);
01742     if (stCPU.pstRAM->stRegisters.SREG.C)
01743     {
01744         u8Result |= 0x80;
01745     }
01746     *stCPU.Rd = u8Result;
01747
01748     // ---- Update flags ----
01749     Right_Carry_Flag( u8Temp );
01750     R8_Negative_Flag( u8Result );
01751     R8_Zero_Flag( u8Result );
01752     Rotate_Overflow_Flag();
01753     Signed_Flag();
01754 }
01755
01756 //-----
01757 static void AVR_Opcode_ASR( void )
01758 {
01759     // Shift all bits to the right, keeping sign bit intact
01760     uint8_t u8Result;
01761     uint8_t u8Temp = *stCPU.Rd;
01762     u8Result = (u8Temp & 0x80) | (u8Temp >> 1);
01763     *stCPU.Rd = u8Result;
01764
01765     // ---- Update flags ----

```

```

01766     Right_Carry_Flag( u8Temp );
01767     R8_Negative_Flag( u8Result );
01768     R8_Zero_Flag( u8Result );
01769     Rotate_Overflow_Flag();
01770     Signed_Flag();
01771 }
01772
01773 //-----
01774 static void AVR_Opcode_SWAP( void )
01775 {
01776     uint8_t u8temp;
01777     u8temp = ((*stCPU.Rd) >> 4) |
01778             ((*stCPU.Rd) << 4);
01779
01780     *stCPU.Rd = u8temp;
01781 }
01782
01783 //-----
01784 static void AVR_Opcode_BSET( void )
01785 {
01786     stCPU.pstRAM->stRegisters.SREG.r |= (1 << stCPU.b);
01787 }
01788
01789 //-----
01790 static void AVR_Opcode_BCLR( void )
01791 {
01792     stCPU.pstRAM->stRegisters.SREG.r &= ~(1 << stCPU.b);
01793 }
01794
01795 //-----
01796 static void AVR_Opcode_SBI( void )
01797 {
01798     uint8_t u8Temp = Data_Read( stCPU.A + 32 );
01799     u8Temp |= (1 << stCPU.b);
01800     Data_Write( stCPU.A + 32, u8Temp );
01801 }
01802
01803 //-----
01804 static void AVR_Opcode_CBI( void )
01805 {
01806     uint8_t u8Temp = Data_Read( stCPU.A + 32 );
01807     u8Temp &= ~(1 << stCPU.b);
01808     Data_Write( stCPU.A + 32, u8Temp );
01809 }
01810
01811 //-----
01812 static void AVR_Opcode_BST( void )
01813 {
01814     if ((*stCPU.Rd) & (1 << stCPU.b))
01815     {
01816         stCPU.pstRAM->stRegisters.SREG.T = 1;
01817     }
01818     else
01819     {
01820         stCPU.pstRAM->stRegisters.SREG.T = 0;
01821     }
01822 }
01823
01824 //-----
01825 static void AVR_Opcode_BLD( void )
01826 {
01827     if (stCPU.pstRAM->stRegisters.SREG.T)
01828     {
01829         *stCPU.Rd |= (1 << stCPU.b);
01830     }
01831     else
01832     {
01833         *stCPU.Rd &= ~(1 << stCPU.b);
01834     }
01835 }
01836
01837 //-----
01838 static void AVR_Opcode_BREAK( void )
01839 {
01840     // Unimplemented - since this requires debugging HW...
01841 }
01842
01843 //-----
01844 static void AVR_Opcode_SLEEP( void )
01845 {
01846     stCPU.bAsleep = true;
01847 }
01848
01849 //-----
01850 static void AVR_Opcode_WDR( void )
01851 {
01852     stCPU.u32WDTCount = 0; // Reset watchdog timer counter

```

```

01853 }
01854
01855 //-----
01856 AVR_Opcode AVR_Opcode_Function( uint16_t OP_ )
01857 {
01858     switch (OP_)
01859     {
01860         case 0x0000: return AVR_Opcode_NOP;
01861
01862         case 0x9409: return AVR_Opcode_IJMP;
01863         case 0x9419: return AVR_Opcode_EIJMP;
01864
01865         case 0x9508: return AVR_Opcode_RET;
01866         case 0x9509: return AVR_Opcode_ICALL;
01867         case 0x9518: return AVR_Opcode_RETI;
01868         case 0x9519: return AVR_Opcode_EICALL;
01869         case 0x9588: return AVR_Opcode_SLEEP;
01870         case 0x9598: return AVR_Opcode_BREAK;
01871         case 0x95A8: return AVR_Opcode_WDR;
01872         case 0x95C8: return AVR_Opcode_LPM;
01873         case 0x95D8: return AVR_Opcode_ELPM;
01874         case 0x95E8: return AVR_Opcode_SPM;
01875         case 0x95F8: return AVR_Opcode_SPM_Z_Postinc2;
01876     }
01877
01878     switch( OP_ & 0xFF8F)
01879     {
01880         case 0x9408: return AVR_Opcode_BSET;
01881         case 0x9488: return AVR_Opcode_BCLR;
01882     }
01883
01884     switch (OP_ & 0xFF88)
01885     {
01886         case 0x0300: return AVR_Opcode_MULSU;
01887         case 0x0308: return AVR_Opcode_FMUL;
01888         case 0x0380: return AVR_Opcode_FMULS;
01889         case 0x0388: return AVR_Opcode_FMULSU;
01890     }
01891
01892     switch (OP_ & 0xFF0F)
01893     {
01894         case 0x940B: return AVR_Opcode_DES;
01895         case 0xEF0F: return AVR_Opcode_SER;
01896     }
01897
01898     switch (OP_ & 0xFF00)
01899     {
01900         case 0x0100: return AVR_Opcode_MOVW;
01901         case 0x9600: return AVR_Opcode_ADIW;
01902         case 0x9700: return AVR_Opcode_SBIW;
01903
01904         case 0x9800: return AVR_Opcode_CBI;
01905         case 0x9900: return AVR_Opcode_SBIC;
01906         case 0x9A00: return AVR_Opcode_SBI;
01907         case 0x9B00: return AVR_Opcode_SBIS;
01908     }
01909
01910     switch (OP_ & 0xFE0F)
01911     {
01912         case 0x8008: return AVR_Opcode_LD_Y_Indirect;
01913         case 0x8000: return AVR_Opcode_LD_Z_Indirect;
01914         case 0x8200: return AVR_Opcode_ST_Z_Indirect;
01915         case 0x8208: return AVR_Opcode_ST_Y_Indirect;
01916
01917         // -- Single 5-bit register...
01918         case 0x9000: return AVR_Opcode_LDS;
01919         case 0x9001: return AVR_Opcode_LD_Z_Indirect_Postinc;
01920         case 0x9002: return AVR_Opcode_LD_Z_Indirect_Predec;
01921         case 0x9004: return AVR_Opcode_LPM_Z;
01922         case 0x9005: return AVR_Opcode_LPM_Z_Postinc;
01923         case 0x9006: return AVR_Opcode_ELPM_Z;
01924         case 0x9007: return AVR_Opcode_ELPM_Z_Postinc;
01925         case 0x9009: return AVR_Opcode_LD_Y_Indirect_Postinc;
01926         case 0x900A: return AVR_Opcode_LD_Y_Indirect_Predec;
01927         case 0x900C: return AVR_Opcode_LD_X_Indirect;
01928         case 0x900D: return AVR_Opcode_LD_X_Indirect_Postinc;
01929         case 0x900E: return AVR_Opcode_LD_X_Indirect_Predec;
01930         case 0x900F: return AVR_Opcode_POP;
01931
01932         case 0x9200: return AVR_Opcode_STS;
01933         case 0x9201: return AVR_Opcode_ST_Z_Indirect_Postinc;
01934         case 0x9202: return AVR_Opcode_ST_Z_Indirect_Predec;
01935         case 0x9204: return AVR_Opcode_XCH;
01936         case 0x9205: return AVR_Opcode_LAS;
01937         case 0x9206: return AVR_Opcode_LAC;
01938         case 0x9207: return AVR_Opcode_LAT;
01939         case 0x9209: return AVR_Opcode_ST_Y_Indirect_Postinc;

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01940     case 0x920A: return AVR_Opcode_ST_Y_Indirect_Predec;
01941     case 0x920C: return AVR_Opcode_ST_X_Indirect;
01942     case 0x920D: return AVR_Opcode_ST_X_Indirect_Postinc;
01943     case 0x920E: return AVR_Opcode_ST_X_Indirect_Predec;
01944     case 0x920F: return AVR_Opcode_PUSH;
01945
01946     // -- One-operand instructions
01947     case 0x9400: return AVR_Opcode_COM;
01948     case 0x9401: return AVR_Opcode_NEG;
01949     case 0x9402: return AVR_Opcode_SWAP;
01950     case 0x9403: return AVR_Opcode_INC;
01951     case 0x9405: return AVR_Opcode_ASR;
01952     case 0x9406: return AVR_Opcode_LSR;
01953     case 0x9407: return AVR_Opcode_ROR;
01954     case 0x940A: return AVR_Opcode_DEC;
01955
01956     }
01957     switch (OP_ & 0xFE0E)
01958     {
01959     case 0x940C: return AVR_Opcode_JMP;
01960     case 0x940E: return AVR_Opcode_CALL;
01961     }
01962
01963     switch (OP_ & 0xFE08)
01964     {
01965
01966     // -- BLD/BST Encoding
01967     case 0xF800: return AVR_Opcode_BLD;
01968     case 0xFA00: return AVR_Opcode_BST;
01969     // -- SBRC/SBRS Encoding
01970     case 0xFC00: return AVR_Opcode_SBRC;
01971     case 0xFE00: return AVR_Opcode_SBRS;
01972     }
01973
01974     switch (OP_ & 0xFC07)
01975     {
01976     // -- Conditional branches
01977     case 0xF000: return AVR_Opcode_BRCS;
01978     // case 0xF000: return AVR_Opcode_BRLO; // AKA AVR_Opcode_BRCS;
01979     case 0xF001: return AVR_Opcode_BREQ;
01980     case 0xF002: return AVR_Opcode_BRMI;
01981     case 0xF003: return AVR_Opcode_BRVS;
01982     case 0xF004: return AVR_Opcode_BRLT;
01983     case 0xF006: return AVR_Opcode_BRTS;
01984     case 0xF007: return AVR_Opcode_BRIE;
01985     case 0xF400: return AVR_Opcode_BRCC;
01986     // case 0xF400: return AVR_Opcode_BRSH; // AKA AVR_Opcode_BRCC;
01987     case 0xF401: return AVR_Opcode_BRNE;
01988     case 0xF402: return AVR_Opcode_BRPL;
01989     case 0xF403: return AVR_Opcode_BRVC;
01990     case 0xF404: return AVR_Opcode_BRGE;
01991     case 0xF405: return AVR_Opcode_BRHC;
01992     case 0xF406: return AVR_Opcode_BRTC;
01993     case 0xF407: return AVR_Opcode_BRID;
01994     }
01995
01996     switch (OP_ & 0xFC00)
01997     {
01998     // -- 4-bit register pair
01999     case 0x0200: return AVR_Opcode_MULS;
02000
02001     // -- 5-bit register pairs --
02002     case 0x0400: return AVR_Opcode_CPC;
02003     case 0x0800: return AVR_Opcode_SBC;
02004     case 0x0C00: return AVR_Opcode_ADD;
02005     // case 0x0C00: return AVR_Opcode_LSL; (!! Implemented with: " add rd, rd"
02006     case 0x1000: return AVR_Opcode_CPSE;
02007     case 0x1300: return AVR_Opcode_ROL;
02008     case 0x1400: return AVR_Opcode_CP;
02009     case 0x1C00: return AVR_Opcode_ADC;
02010     case 0x1800: return AVR_Opcode_SUB;
02011     case 0x2000: return AVR_Opcode_AND;
02012     // case 0x2000: return AVR_Opcode_TST; (!! Implemented with: " and rd, rd"
02013     case 0x2400: return AVR_Opcode_EOR;
02014     case 0x2C00: return AVR_Opcode_MOV;
02015     case 0x2800: return AVR_Opcode_OR;
02016
02017     // -- 5-bit register pairs -- Destination = R1:R0
02018     case 0x9C00: return AVR_Opcode_MUL;
02019     }
02020
02021     switch (OP_ & 0xF800)
02022     {
02023     case 0xB800: return AVR_Opcode_OUT;
02024     case 0xB000: return AVR_Opcode_IN;
02025     }
02026

```

```

02027     switch (OP_ & 0xF000)
02028     {
02029         // -- Register immediate --
02030         case 0x3000: return AVR_Opcode_CPI;
02031         case 0x4000: return AVR_Opcode_SBCI;
02032         case 0x5000: return AVR_Opcode_SUBI;
02033         case 0x6000: return AVR_Opcode_ORI; // return AVR_Opcode_SBR;
02034         case 0x7000: return AVR_Opcode_ANDI;
02035
02036         //-- 12-bit immediate
02037         case 0xC000: return AVR_Opcode_RJMP;
02038         case 0xD000: return AVR_Opcode_RCALL;
02039
02040         // -- Register immediate
02041         case 0xE000: return AVR_Opcode_LDI;
02042     }
02043
02044     switch (OP_ & 0xD208)
02045     {
02046         // -- 7-bit signed offset
02047         case 0x8000: return AVR_Opcode_LDD_Z;
02048         case 0x8008: return AVR_Opcode_LDD_Y;
02049         case 0x8200: return AVR_Opcode_STD_Z;
02050         case 0x8208: return AVR_Opcode_STD_Y;
02051     }
02052
02053     return AVR_Opcode_NOP;
02054 }
02055
02056 //-----
02057 void AVR_RunOpcode( uint16_t OP_ )
02058 {
02059     AVR_Opcode myOpcode = AVR_Opcode_Function( OP_ );
02060     myOpcode();
02061 }

```

4.37 src/avr_cpu/avr_opcodes.h File Reference

AVR CPU - Opcode interface.

```

#include <stdint.h>
#include "avr_cpu.h"

```

Typedefs

- typedef void(* **AVR_Opcode**)(void)

Functions

- AVR_Opcode [AVR_Opcode_Function](#) (uint16_t OP_)
AVR_Opcode_Function.
- void [AVR_RunOpcode](#) (uint16_t OP_)
AVR_RunOpcode.

4.37.1 Detailed Description

AVR CPU - Opcode interface.

Definition in file [avr_opcodes.h](#).

4.37.2 Function Documentation


```
#include "avr_coreregs.h"
#include "avr_periphregs.h"
```

Data Structures

- struct [AVRRegisterFile](#)

The first 256 bytes of the AVR memory space is composed of the core 32 general-purpose registers (R0-R31), and 224 bytes for the remaining I/O registers (used by peripherals).

4.39.1 Detailed Description

Module providing a mapping of IO memory to the AVR register file.

Definition in file [avr_registerfile.h](#).

4.40 avr_registerfile.h

```
00001 /*****
00002 *      (      )      (      )      |
00003 *      )\ )      )\ )      (      )\ )      |
00004 *      ((/( ((/(      )\      (      ((/(      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( ) ( ) )\      / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\      ( ( ) ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | _ |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \      \ v / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \      \ v / | _ \      |
00010 *      | _ | | _      / _ \      \ v / | _ \      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __AVR_REGISTERFILE_H__
00022 #define __AVR_REGISTERFILE_H__
00023
00024 //-----
00025 #include "avr_coreregs.h"
00026 #include "avr_periphregs.h"
00027
00028 //-----
00038 typedef struct
00039 {
00040     //-- 0x00
00041     AVR_CoreRegisters CORE_REGISTERS;
00042
00043     //-- 0x20
00044     AVR_PIN PINA;
00045     AVR_DDR DDRA;
00046     AVR_PORT PORTA;
00047
00048     //-- 0x23
00049     AVR_PIN PINB;
00050     AVR_DDR DDRB;
00051     AVR_PORT PORTB;
00052
00053     //-- 0x26
00054     AVR_PIN PINC;
00055     AVR_DDR DDRC;
00056     AVR_PORT PORTC;
00057
00058     //-- 0x29
00059     AVR_PIN PIND;
00060     AVR_DDR DDRD;
00061     AVR_PORT PORTD;
00062
00063     //-- 0x2C
00064     uint8_t RESERVED_0x2C;
00065     uint8_t RESERVED_0x2D;
00066     uint8_t RESERVED_0x2E;
00067     uint8_t RESERVED_0x2F;
00068     uint8_t RESERVED_0x30;
00069     uint8_t RESERVED_0x31;
00070     uint8_t RESERVED_0x32;
00071     uint8_t RESERVED_0x33;
```

```

00072     uint8_t      RESERVED_0x34;
00073
00074     //-- 0x35
00075     AVR_TIFR0      TIFR0;
00076     AVR_TIFR1      TIFR1;
00077     AVR_TIFR2      TIFR2;
00078
00079     //-- 0x38
00080     uint8_t      RESERVED_0x38;
00081     uint8_t      RESERVED_0x39;
00082     uint8_t      RESERVED_0x3A;
00083
00084     //-- 0x3B
00085     AVR_PCIFR      PCIFR;
00086     AVR_EIFR       EIFR;
00087     AVR_EIMSK      EIMSK;
00088
00089     //-- 0x3E
00090     uint8_t      GPIOR0;
00091
00092     //-- 0x3F
00093     AVR_EECR       EECR;
00094
00095     //-- 0x40
00096     uint8_t      EEDR;
00097     uint8_t      EEARL;
00098     uint8_t      EEARH;
00099
00100     //-- 0x43
00101     AVR_GTCCR      GTCCR;
00102     AVR_TCCR0A      TCCR0A;
00103     AVR_TCCR0B      TCCR0B;
00104     uint8_t      TCNT0;
00105     uint8_t      OCR0A;
00106     uint8_t      OCR0B;
00107
00108     //-- 0x49
00109     uint8_t      RESERVED_0x49;
00110     uint8_t      GPIOR1;
00111     uint8_t      GPIOR2;
00112
00113     AVR_SPCR        SPCR;
00114     AVR_SPSR        SPSR;
00115     uint8_t      SPDR;
00116
00117     uint8_t      RESERVED_0x4F;
00118     AVR_ACSR        ACSR;
00119
00120     uint8_t      RESERVED_0x51;
00121     uint8_t      RESERVED_0x52;
00122
00123     //-- 0x53
00124     AVR_SMCR        SMCR;
00125     AVR_MCUSR        MCUSR;
00126     AVR_MCUCR        MCUCR;
00127     uint8_t      RESERVED_0x56;
00128
00129     AVR_SPMCSR      SPMCSR;
00130     uint8_t      RESERVED_0x58;
00131     uint8_t      RESERVED_0x59;
00132     uint8_t      RESERVED_0x5A;
00133     uint8_t      RESERVED_0x5B;
00134     uint8_t      RESERVED_0x5C;
00135     AVR_SPL         SPL;
00136     AVR_SPH         SPH;
00137     AVR_SREG        SREG;
00138
00139     //-- 0x60
00140     AVR_WDTCSR      WDTCSR;
00141     AVR_CLKPR       CLKPR;
00142     uint8_t      RESERVED_0x62;
00143     uint8_t      RESERVED_0x63;
00144     AVR_PRR         PRR;
00145     uint8_t      RESERVED_0x65;
00146     uint8_t      OSCCAL;
00147     uint8_t      RESERVED_0x67;
00148
00149     AVR_PCICR        PCICR;
00150     AVR_EICRA        EICRA;
00151     uint8_t      RESERVED_0x6A;
00152
00153     AVR_PCMSK0       PCMSK0;
00154     AVR_PCMSK1       PCMSK1;
00155     AVR_PCMSK2       PCMSK2;
00156     AVR_TIMSK0       TIMSK0;
00157     AVR_TIMSK1       TIMSK1;
00158     AVR_TIMSK2       TIMSK2;

```



```

00159
00160     uint8_t      RESERVED_0x71;
00161     uint8_t      RESERVED_0x72;
00162     uint8_t      RESERVED_0x73;
00163     uint8_t      RESERVED_0x74;
00164     uint8_t      RESERVED_0x75;
00165     uint8_t      RESERVED_0x76;
00166     uint8_t      RESERVED_0x77;
00167
00168     uint8_t      ADCL;
00169     uint8_t      ADCH;
00170     AVR_ADCSRA   ADSRA;
00171     AVR_ADCSRB   ADSRB;
00172     AVR_ADMUX    ADMUX;
00173     uint8_t      RESERVED_0x7F;
00174
00175     AVR_DIDR0    DIDR0;
00176     AVR_DIDR1    DIDR1;
00177     AVR_TCCR1A   TCCR1A;
00178     AVR_TCCR1B   TCCR1B;
00179     AVR_TCCR1C   TCCR1C;
00180     uint8_t      RESERVED_0x83;
00181
00182     uint8_t      TCNT1L;
00183     uint8_t      TCNT1H;
00184     uint8_t      ICR1L;
00185     uint8_t      ICR1H;
00186     uint8_t      OCR1AL;
00187     uint8_t      OCR1AH;
00188     uint8_t      OCR1BL;
00189     uint8_t      OCR1BH;
00190
00191     uint8_t      RESERVED_0x8C;
00192     uint8_t      RESERVED_0x8D;
00193     uint8_t      RESERVED_0x8E;
00194     uint8_t      RESERVED_0x8F;
00195
00196     uint8_t      RESERVED_0x90;
00197     uint8_t      RESERVED_0x91;
00198     uint8_t      RESERVED_0x92;
00199     uint8_t      RESERVED_0x93;
00200     uint8_t      RESERVED_0x94;
00201     uint8_t      RESERVED_0x95;
00202     uint8_t      RESERVED_0x96;
00203     uint8_t      RESERVED_0x97;
00204     uint8_t      RESERVED_0x98;
00205     uint8_t      RESERVED_0x99;
00206     uint8_t      RESERVED_0x9A;
00207     uint8_t      RESERVED_0x9B;
00208     uint8_t      RESERVED_0x9C;
00209     uint8_t      RESERVED_0x9D;
00210     uint8_t      RESERVED_0x9E;
00211     uint8_t      RESERVED_0x9F;
00212
00213     uint8_t      RESERVED_0xA0;
00214     uint8_t      RESERVED_0xA1;
00215     uint8_t      RESERVED_0xA2;
00216     uint8_t      RESERVED_0xA3;
00217     uint8_t      RESERVED_0xA4;
00218     uint8_t      RESERVED_0xA5;
00219     uint8_t      RESERVED_0xA6;
00220     uint8_t      RESERVED_0xA7;
00221     uint8_t      RESERVED_0xA8;
00222     uint8_t      RESERVED_0xA9;
00223     uint8_t      RESERVED_0xAA;
00224     uint8_t      RESERVED_0xAB;
00225     uint8_t      RESERVED_0xAC;
00226     uint8_t      RESERVED_0xAD;
00227     uint8_t      RESERVED_0xAE;
00228     uint8_t      RESERVED_0xAF;
00229
00230     //--0xB0
00231     AVR_TCCR2A   TCCR2A;
00232     AVR_TCCR2B   TCCR2B;
00233     uint8_t      TCNT2;
00234     uint8_t      OCR2A;
00235     uint8_t      OCR2B;
00236
00237     uint8_t      RESERVED_0xB5;
00238     AVR_ASSR     ASSR;
00239     uint8_t      RESERVED_0xB7;
00240     uint8_t      TWBR;
00241     AVR_TWSR     TWSR;
00242     AVR_TWAR     TWAR;
00243     uint8_t      TWDR;
00244     AVR_TWCR     TWCR;
00245     AVR_TWAMR    TWAMR;

```

```

00246
00247     uint8_t      RESERVED_0xBE;
00248     uint8_t      RESERVED_0xBF;
00249
00250     //--0xC0
00251     AVR_UCSR0A    UCSR0A;
00252     AVR_UCSR0B    UCSR0B;
00253     AVR_UCSR0C    UCSR0C;
00254
00255     uint8_t      RESERVED_0xC3;
00256
00257     uint8_t      UBRR0L;
00258     uint8_t      UBRR0H;
00259     uint8_t      UDR0;
00260
00261     uint8_t      RESERVED_0xC7;
00262     uint8_t      RESERVED_0xC8;
00263     uint8_t      RESERVED_0xC9;
00264     uint8_t      RESERVED_0xCA;
00265     uint8_t      RESERVED_0xCB;
00266     uint8_t      RESERVED_0xCC;
00267     uint8_t      RESERVED_0xCD;
00268     uint8_t      RESERVED_0xCE;
00269     uint8_t      RESERVED_0xCF;
00270
00271     uint8_t      RESERVED_0xD0;
00272     uint8_t      RESERVED_0xD1;
00273     uint8_t      RESERVED_0xD2;
00274     uint8_t      RESERVED_0xD3;
00275     uint8_t      RESERVED_0xD4;
00276     uint8_t      RESERVED_0xD5;
00277     uint8_t      RESERVED_0xD6;
00278     uint8_t      RESERVED_0xD7;
00279     uint8_t      RESERVED_0xD8;
00280     uint8_t      RESERVED_0xD9;
00281     uint8_t      RESERVED_0xDA;
00282     uint8_t      RESERVED_0xDB;
00283     uint8_t      RESERVED_0xDC;
00284     uint8_t      RESERVED_0xDD;
00285     uint8_t      RESERVED_0xDE;
00286     uint8_t      RESERVED_0xDF;
00287
00288     uint8_t      RESERVED_0xE0;
00289     uint8_t      RESERVED_0xE1;
00290     uint8_t      RESERVED_0xE2;
00291     uint8_t      RESERVED_0xE3;
00292     uint8_t      RESERVED_0xE4;
00293     uint8_t      RESERVED_0xE5;
00294     uint8_t      RESERVED_0xE6;
00295     uint8_t      RESERVED_0xE7;
00296     uint8_t      RESERVED_0xE8;
00297     uint8_t      RESERVED_0xE9;
00298     uint8_t      RESERVED_0xEA;
00299     uint8_t      RESERVED_0xEB;
00300     uint8_t      RESERVED_0xEC;
00301     uint8_t      RESERVED_0xED;
00302     uint8_t      RESERVED_0xEE;
00303     uint8_t      RESERVED_0xEF;
00304
00305     uint8_t      RESERVED_0xF0;
00306     uint8_t      RESERVED_0xF1;
00307     uint8_t      RESERVED_0xF2;
00308     uint8_t      RESERVED_0xF3;
00309     uint8_t      RESERVED_0xF4;
00310     uint8_t      RESERVED_0xF5;
00311     uint8_t      RESERVED_0xF6;
00312     uint8_t      RESERVED_0xF7;
00313     uint8_t      RESERVED_0xF8;
00314     uint8_t      RESERVED_0xF9;
00315     uint8_t      RESERVED_0xFA;
00316     uint8_t      RESERVED_0xFB;
00317     uint8_t      RESERVED_0xFC;
00318     uint8_t      RESERVED_0xFD;
00319     uint8_t      RESERVED_0xFE;
00320     uint8_t      RESERVED_0xFF;
00321
00322 } AVRRegisterFile;
00323
00324
00325 #endif // __AVR_REGISTERFILE_H__

```

4.41 src/avr_cpu/interrupt_callout.c File Reference

Module providing functionality allowing emulator extensions to be triggered on interrupts.

```
#include "interrupt_callout.h"
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
```

Data Structures

- struct [Interrupt_Callout_](#)

Typedefs

- typedef struct [Interrupt_Callout_](#) [Interrupt_Callout_t](#)

Functions

- void [InterruptCallout_Add](#) ([InterruptCalloutFunc](#) pfCallout_)
InterruptCallout_Add.
- void [InterruptCallout_Run](#) (bool bEntry_, uint8_t u8Vector_)
InterruptCallout_Run.

Variables

- static [Interrupt_Callout_t](#) * **pstCallouts** = 0

4.41.1 Detailed Description

Module providing functionality allowing emulator extensions to be triggered on interrupts.

Definition in file [interrupt_callout.c](#).

4.41.2 Function Documentation

4.41.2.1 void InterruptCallout_Add (InterruptCalloutFunc pfCallout_)

[InterruptCallout_Add.](#)

Add a particular callout function to be executed whenever an interrupt is called (or returned-from).

Parameters

<i>pfCallout_</i>	Pointer to an interrupt callout function.
-------------------	---

Definition at line 39 of file [interrupt_callout.c](#).

4.41.2.2 void InterruptCallout_Run (bool bEntry_, uint8_t u8Vector_)

[InterruptCallout_Run.](#)

Run all interrupt callouts currently installed.

Parameters

<i>bEntry_</i>	true - interrupt entry, false - interrupt exit
<i>u8Vector_</i>	Interrupt vector # (undefined for interrupt-exit)

Definition at line 50 of file [interrupt_callout.c](#).

4.42 interrupt_callout.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( ((/(      \      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( ( ) \      / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ( ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ / / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \ \ \ / / | _ \      |
00010 *      |      |      | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00022 #include "interrupt_callout.h"
00023
00024 #include <stdint.h>
00025 #include <stdio.h>
00026 #include <stdlib.h>
00027 #include <string.h>
00028 //-----
00029 typedef struct Interrupt_Callout_
00030 {
00031     struct Interrupt_Callout_ *pstNext;
00032     InterruptCalloutFunc pfCallout;
00033 } Interrupt_Callout_t;
00034
00035 //-----
00036 static Interrupt_Callout_t *pstCallouts = 0;
00037
00038 //-----
00039 void InterruptCallout_Add( InterruptCalloutFunc pfCallout_ )
00040 {
00041     Interrupt_Callout_t *pstNewCallout = (Interrupt_Callout_t*) (
00042         malloc(sizeof(*pstNewCallout)));
00043     pstNewCallout->pstNext = pstCallouts;
00044     pstNewCallout->pfCallout = pfCallout_;
00045     pstCallouts = pstNewCallout;
00046 }
00047
00048 //-----
00049 void InterruptCallout_Run( bool bEntry_, uint8_t u8Vector_ )
00050 {
00051     Interrupt_Callout_t *pstCallout = pstCallouts;
00052     while (pstCallout)
00053     {
00054         pstCallout->pfCallout( bEntry_, u8Vector_ );
00055         pstCallout = pstCallout->pstNext;
00056     }
00057 }
00058

```

4.43 src/avr_cpu/interrupt_callout.h File Reference

Module providing functionality allowing emulator extensions to be triggered on interrupts.

```

#include <stdint.h>
#include <stdbool.h>

```

Typedefs

- typedef void(* [InterruptCalloutFunc](#))(bool bEntry_, uint8_t u8Vector_)

Function type used for interrupt callouts.

Functions

- void [InterruptCallout_Add](#) ([InterruptCalloutFunc](#) pfCallout_)
InterruptCallout_Add.
- void [InterruptCallout_Run](#) (bool bEntry_, uint8_t u8Vector_)
InterruptCallout_Run.

4.43.1 Detailed Description

Module providing functionality allowing emulator extensions to be triggered on interrupts.

Definition in file [interrupt_callout.h](#).

4.43.2 Function Documentation

4.43.2.1 void InterruptCallout_Add (InterruptCalloutFunc pfCallout_)

InterruptCallout_Add.

Add a particular callout function to be executed whenever an interrupt is called (or returned-from).

Parameters

<i>pfCallout_</i>	Pointer to an interrupt callout function.
-------------------	---

Definition at line 39 of file [interrupt_callout.c](#).

4.43.2.2 void InterruptCallout_Run (bool bEntry_, uint8_t u8Vector_)

InterruptCallout_Run.

Run all interrupt callouts currently installed.

Parameters

<i>bEntry_</i>	true - interrupt entry, false - interrupt exit
<i>u8Vector_</i>	Interrupt vector # (undefined for interrupt-exit)

Definition at line 50 of file [interrupt_callout.c](#).

4.44 interrupt_callout.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( ((/(      \      | -- [ Funkenstein ] -----
00005 *      /( ) )/( )((( ( )\ )/( )      | -- [ Little ] -----
00006 *      ( )_ ( )      )\ _ )\ ( ( ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( )_ \ ( ) \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ / / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \ \ / / | _ \      |
00010 *      | "Yeah, it does Arduino..."
00011 *      -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00022 #ifndef __INTERRUPT_CALLOUT_H__
00023 #define __INTERRUPT_CALLOUT_H__
00024
00025 #include <stdint.h>
00026 #include <stdbool.h>

```

```

00027
00028 //-----
00030 typedef void (*InterruptCalloutFunc)( bool bEntry_, uint8_t u8Vector_ );
00031
00032 //-----
00041 void InterruptCallout_Add( InterruptCalloutFunc pfCallout_ );
00042
00043 //-----
00052 void InterruptCallout_Run( bool bEntry_, uint8_t u8Vector_ );
00053
00054
00055 #endif
00056

```

4.45 src/avr_cpu/write_callout.h File Reference

Extended emulator functionality allowing for functions to be triggered based on RAM-write operations.

```

#include <stdint.h>
#include <stdbool.h>

```

Typedefs

- typedef bool(* [WriteCalloutFunc](#))(uint16_t u16Addr_, uint8_t u8Data_)
Function pointer type for memory-write callout handlers.

Functions

- void [WriteCallout_Add](#) ([WriteCalloutFunc](#) pfCallout_, uint16_t u16Addr_)
WriteCallout_Add.
- bool [WriteCallout_Run](#) (uint16_t u16Addr_, uint8_t u8Data_)
WriteCallout_Run.

4.45.1 Detailed Description

Extended emulator functionality allowing for functions to be triggered based on RAM-write operations.

Definition in file [write_callout.h](#).

4.45.2 Function Documentation

4.45.2.1 void WriteCallout_Add ([WriteCalloutFunc](#) *pfCallout_*, uint16_t *u16Addr_*)

[WriteCallout_Add](#).

Registers a specific function to be called whenever a specific address in memory is modified. Multiple functions can be registered at the same location in memory.

Parameters

<i>pfCallout_</i>	- Pointer to the callout function
<i>u16Addr_</i>	- Address in RAM that triggers the callout when written

Definition at line 60 of file [write_callout.c](#).

4.45.2.2 bool WriteCallout_Run (uint16_t u16Addr_, uint8_t u8Data_)

WriteCallout_Run.

Function called by the AVR CPU core whenever a word in memory is written. This searches the list of write callouts and executes any callouts registered at the specific address.

Parameters

<i>u16Addr_</i>	- Address in RAM currently being modified
<i>u8Data_</i>	- Data that will be written to the address

Returns

false - bypass CPU's own write function for this memory write.

Definition at line 77 of file write_callout.c.

4.46 write_callout.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      |
00004 *      ()/( ()/(      )\      ( ( ()/(      | -- [ Funkenstein ] -----
00005 *      /(_) )/(_) (((_) ()\      )\      /(_)      | -- [ Little ] -----
00006 *      (_)_(_)      )\ _ )\ ((_) ((_) ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ \ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \      \ v / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _ | / \ \ \      \ \ / | _ \      |
00010 *                                          | "Yeah, it does Arduino..."
00011 *                                          +-----+
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 *      See license.txt for details
00014 *****/
00022 #ifndef __WRITE_CALLOUT_H__
00023 #define __WRITE_CALLOUT_H__
00024
00025 #include <stdint.h>
00026 #include <stdbool.h>
00027
00028 //-----
00030 typedef bool (*WriteCalloutFunc)(uint16_t u16Addr_, uint8_t u8Data_);
00031
00032 //-----
00043 void WriteCallout_Add( WriteCalloutFunc pfCallout_, uint16_t u16Addr_ );
00044
00045 //-----
00058 bool WriteCallout_Run( uint16_t u16Addr_, uint8_t u8Data_ );
00059
00060
00061 #endif
00062

```

4.47 src/config/emu_config.h File Reference

configuration file - used to configure features used by the emulator at build-time.

```
#include <stdint.h>
#include <stdbool.h>
```

Macros

- #define **CONFIG_IO_ADDRESS_BYTES** (256)
- #define **FEATURE USE JUMPTABLES** (1)

Jump-tables can be used to optimize the execution of opcodes by building CPU instruction decode and execute jump tables at runtime.

4.49 src/config/options.c File Reference

Module for managing command-line options.

```
#include "emu_config.h"
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <stdint.h>
```

Data Structures

- struct [Option_t](#)
Local data structure used to define a command-line option.

Enumerations

- enum [OptionIndex_t](#) {
 [OPTION_VARIANT](#), [OPTION_FREQ](#), [OPTION_HEXFILE](#), [OPTION_ELFFILE](#),
 [OPTION_DEBUG](#), [OPTION_GDB](#), [OPTION_SILENT](#), [OPTION_DISASM](#),
 [OPTION_TRACE](#), [OPTION_MARK3](#), [OPTION_EXITRESET](#), [OPTION_PROFILE](#),
 [OPTION_NUM](#) }
Enumerated type specifying the known command-line options accepted by fIAVR.

Functions

- static void [Options_SetDefaults](#) (void)
Options_SetDefaults.
- const char * [Options_GetByName](#) (const char *szAttribute_)
Options_GetByName.
- static uint16_t [Options_ParseElement](#) (int start_, int argc_, char **argv_)
Options_ParseElement.
- static void [Options_Parse](#) (int argc_, char **argv_)
Options_Parse.
- void [Options_Init](#) (int argc_, char **argv_)
Options_Init.
- void [Options_PrintUsage](#) (void)
Options_PrintUsage.

Variables

- static [Option_t](#) astAttributes [[OPTION_NUM](#)]
Table of available commandline options.

4.49.1 Detailed Description

Module for managing command-line options.

Definition in file [options.c](#).

4.49.2 Enumeration Type Documentation

4.49.2.1 enum OptionIndex_t

Enumerated type specifying the known command-line options accepted by fIAVR.

Enumerator

OPTION_NUM Total count of command-line options supported.

Definition at line 44 of file [options.c](#).

4.49.3 Function Documentation

4.49.3.1 const char* Options_GetByName (const char * szAttribute_)

Options_GetByName.

Return the parameter value associated with an option attribute.

Parameters

<i>szAttribute_</i>	Name of the attribute to look up
---------------------	----------------------------------

Returns

Pointer to the attribute string, or NULL if attribute is invalid, or parameter has not been set.

Definition at line 97 of file [options.c](#).

4.49.3.2 void Options_Init (int argc_, char ** argv_)

Options_Init.

Initialize command-line options for the emulator based on argc/argv input.

Parameters

<i>argc_</i>	argc, passed in from main
<i>argv_</i>	argv, passed in from main

Definition at line 197 of file [options.c](#).

4.49.3.3 static void Options_Parse (int argc_, char ** argv_) [static]

Options_Parse.

Parse the commandline opts, seeding the array of known parameters with the values specified by the user on the commandline

Parameters

<i>argc_</i>	Number of arguments
<i>argv_</i>	Argument vector, passed from main().

Definition at line 186 of file [options.c](#).

4.49.3.4 static uint16_t Options_ParseElement (int start_, int argc_, char ** argv_) [static]

Options_ParseElement.

Parse out the next commandline option, starting with argv[start_]. Modifies the values stored in the local ast↔
Attributes table.

Parameters

<i>start_</i>	Starting index
<i>argc_</i>	Total number of arguments
<i>argv_</i>	Command-line argument vector

Returns

The next index to process

Definition at line 124 of file [options.c](#).

4.49.3.5 void Options_PrintUsage (void)

Options_PrintUsage.

Print a brief description of each command-line option and its usage.

Definition at line 204 of file [options.c](#).

4.49.3.6 static void Options_SetDefaults (void) [static]

Options_SetDefaults.

Set certain options to default implicit values, in case none are specific from the commandline.

Definition at line 91 of file [options.c](#).

4.49.4 Variable Documentation

4.49.4.1 Option_t astAttributes[OPTION_NUM] [static]

Initial value:

```
=
{
    {"--variant", "Specify the CPU variant by model name (default - atmega328p)", NULL, false },
    {"--freq", "Speed (in Hz) of the simulated CPU", NULL, false },
    {"--hexfile", "Programming file (intel HEX binary). Mutually exclusive with --elffile ", NULL, false },
    {"--elffile", "Programming file (ELF binary). Mutually exclusive with --hexfile", NULL, false },
    {"--debug", "Run simulator in interactive debug mode. Mutually exclusive with --gdb", NULL, true },
    {"--gdb", "Run simulator as a GDB remote, on the specified port.", NULL, false },
    {"--silent", "Start without the flavr-banner print", NULL, true },
    {"--disasm", "Disassemble programming file to standard output", NULL, true },
    {"--trace", "Enable tracebuffer support when used in conjunction with --debug", NULL, true },
    {"--mark3", "Enable Mark3 kernel-aware plugin", NULL, true },
    {"--exitreset", "Exit simulator if a jump-to-zero operation is encountered", NULL, true },
    {"--profile", "Run with code profile and code coverage enabled", NULL, true },
}
```

Table of available commandline options.

Order must match enumeration defined above.

Definition at line 67 of file [options.c](#).

4.50 options.c

```
00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )  (      )\ ) |
00004 *      ( ) / ( ( ) / (      )\ ( ( ( ) / (      | -- [ Funkenstein ] -----
```

```

00005 *      /(_) ) /(_) ) ((((_) () \ ) \ /(_) ) | -- [ Little ] -----
00006 *      ( ) | ( ) ) \ _ ) \ ( ( ( ) ( ) ) | -- [ AVR ] -----
00007 *      | _ | | _ | ( ) \ ( ) \ \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ | / _ \ \ V / | _ \ | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ V / | _ \ |
00010 *      | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include "emu_config.h"
00022 #include <stdio.h>
00023 #include <string.h>
00024 #include <stdlib.h>
00025 #include <stdint.h>
00026
00027 //-----
00031 typedef struct
00032 {
00033     const char *szAttribute;
00034     const char *szDescription;
00035     char *szParameter;
00036     bool bStandalone;
00037 } Option_t;
00038
00039 //-----
00044 typedef enum
00045 {
00046     OPTION_VARIANT,
00047     OPTION_FREQ,
00048     OPTION_HEXFILE,
00049     OPTION_ELFFILE,
00050     OPTION_DEBUG,
00051     OPTION_GDB,
00052     OPTION_SILENT,
00053     OPTION_DISASM,
00054     OPTION_TRACE,
00055     OPTION_MARK3,
00056     OPTION_EXITRESET,
00057     OPTION_PROFILE,
00058     //-- New options go here ^^^
00059     OPTION_NUM
00060 } OptionIndex_t;
00061
00062 //-----
00067 static Option_t astAttributes[OPTION_NUM] =
00068 {
00069     { "--variant", "Specify the CPU variant by model name (default - atmega328p)", NULL, false },
00070     { "--freq", "Speed (in Hz) of the simulated CPU", NULL, false },
00071     { "--hexfile", "Programming file (intel HEX binary). Mutually exclusive with --elffile ", NULL, false },
00072     { "--elffile", "Programming file (ELF binary). Mutually exclusive with --hexfile", NULL, false },
00073     { "--debug", "Run simulator in interactive debug mode. Mutually exclusive with --gdb", NULL, true },
00074     { "--gdb", "Run simulator as a GDB remote, on the specified port.", NULL, false },
00075     { "--silent", "Start without the flavr-banner print", NULL, true },
00076     { "--disasm", "Disassemble programming file to standard output", NULL, true },
00077     { "--trace", "Enable tracebuffer support when used in conjunction with --debug", NULL, true },
00078     { "--mark3", "Enable Mark3 kernel-aware plugin", NULL, true },
00079     { "--exitreset", "Exit simulator if a jump-to-zero operation is encountered", NULL, true },
00080     { "--profile", "Run with code profile and code coverage enabled", NULL, true },
00081 };
00082
00083 //-----
00091 static void Options_SetDefaults( void )
00092 {
00093     astAttributes[ OPTION_VARIANT ].szParameter = strdup( "atmega328p" );
00094     astAttributes[ OPTION_FREQ ].szParameter = strdup( "16000000" );
00095 }
00096 //-----
00097 const char *Options_GetByName (const char *szAttribute_)
00098 {
00099     uint16_t j;
00100
00101     // linear search for the correct option value.
00102     for (j = 0; j < OPTION_NUM; j++)
00103     {
00104         if (0 == strcmp(astAttributes[j].szAttribute, szAttribute_))
00105         {
00106             return (const char*)astAttributes[j].szParameter;
00107         }
00108     }
00109     return NULL;
00110 }
00111
00112 //-----
00124 static uint16_t Options_ParseElement( int start_, int argc_, char **argv_ )

```

```

00125 {
00126     // Parse out specific option parameter data for a given option attribute
00127     uint16_t i = start_;
00128     uint16_t j;
00129
00130     while (i < argc_)
00131     {
00132         // linear search for the correct option value.
00133         for (j = 0; j < OPTION_NUM; j++)
00134         {
00135             if (0 == strcmp(astAttributes[j].szAttribute, argv_[i]))
00136             {
00137                 // Match - is the option stand-alone, or does it take a parameter?
00138                 if (astAttributes[j].bStandalone)
00139                 {
00140                     // Standalone argument, auto-seed a "1" value for the parameter to
00141                     // indicate that the option was set on the commandline
00142                     astAttributes[j].szParameter = strdup("1");
00143                     return 1;
00144                 }
00145
00146                 // ensure the user provided a parameter for this attribute
00147                 if (i + 1 >= argc_)
00148                 {
00149                     fprintf( stderr, "Error: Paramter expected for attribute %s", argv_[i] );
00150                     exit(-1);
00151                 }
00152                 else if (*(char*)argv_[i+1] == '-')
00153                 {
00154                     fprintf( stderr, "Error: Paramter expected for attribute %s", argv_[i] );
00155                     exit(-1);
00156                 }
00157                 // Check to see if a parameter has already been set; if so, free the existing value
00158                 if (NULL != astAttributes[j].szParameter)
00159                 {
00160                     free(astAttributes[j].szParameter );
00161                 }
00162                 // fprintf( stderr, "Match: argv[i]=%s, argv[i+1]=%s\n", argv_[i], argv_[i+1] );
00163                 astAttributes[j].szParameter = strdup(argv_[i+1]);
00164             }
00165         }
00166         // Read attribute + parameter combo, 2 tokens
00167         return 2;
00168     }
00169
00170     // Unknown option - 1 token
00171     fprintf( stderr, "WARN: Invalid option \"%s\"", argv_[i] );
00172
00173     return 1;
00174 }
00175
00176 //-----
00186 static void Options_Parse(int argc_, char **argv_ )
00187 {
00188     uint16_t i = 1;
00189     while (i < argc_)
00190     {
00191         // Parse out token from the command line array.
00192         i += Options_ParseElement( i, argc_, argv_ );
00193     }
00194 }
00195
00196 //-----
00197 void Options_Init( int argc_, char **argv_ )
00198 {
00199     Options_SetDefaults();
00200     Options_Parse( argc_, argv_ );
00201 }
00202
00203 //-----
00204 void Options_PrintUsage(void)
00205 {
00206     int i;
00207     printf("\n Usage:\n\n"
00208           "      flavr <options>\n\n Where <options> include:\n");
00209     for (i = 0; i < OPTION_NUM; i++)
00210     {
00211         printf( " %14s: %s", astAttributes[i].szAttribute, astAttributes[i].szDescription );
00212         if (!astAttributes[i].bStandalone)
00213         {
00214             printf(" (takes an argument) " );
00215         }
00216         printf( "\n" );
00217     }
00218 }

```

4.51 src/config/variant.c File Reference

Module containing a table of device variants supported by flavr.

```
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "variant.h"
```

Macros

- `#define ADD_CAPABILITY 0xFE, 0xEF`
- `#define IO_REGISTER_RANGE 0xFD, 0xDF`
- `#define AVR_HAS_RAMP_Z 0x07`
- `#define AVR_HAS_EIND 0x08`
- `#define AVR_HAS_UART0 0x09`
- `#define AVR_HAS_UART1 0x0A`
- `#define AVR_HAS_TIMER0_8BIT 0x0B`
- `#define AVR_HAS_TIMER0_16BIT 0x0C`
- `#define AVR_HAS_TIMER1_8BIT 0x0D`
- `#define AVR_HAS_TIMER1_16BIT 0x0E`
- `#define AVR_HAS_TIMER2_8BIT 0x0F`
- `#define AVR_HAS_TIMER2_16BIT 0x10`
- `#define KB * (1024)`

Functions

- `const AVR_Variant_t * Variant_GetByName (const char *szName_)`
Variant_GetByName.

Variables

- `static AVR_Variant_t astVariants []`

4.51.1 Detailed Description

Module containing a table of device variants supported by flavr.

Definition in file [variant.c](#).

4.51.2 Function Documentation

4.51.2.1 `const AVR_Variant_t* Variant_GetByName (const char * szName_)`

Variant_GetByName.

Lookup a processor variant based on its name, and return a pointer to a matching variant string on successful match.

Parameters

<i>szName_</i>	String containing a variant name to check against (i.e. "atmega328p")
----------------	---

Returns

Pointer to a CPU Variant struct on successful match, NULL on failure.

Definition at line 66 of file [variant.c](#).

4.51.3 Variable Documentation

4.51.3.1 AVR_Variant_t astVariants[] [static]

Initial value:

```
=
{
  { "atmega328p", 2 KB, 32 KB, 1 KB, NULL },
  { "atmega328", 2 KB, 32 KB, 1 KB, NULL },
  { "atmega168pa", 1 KB, 16 KB, 0.5 KB, NULL },
  { "atmega168", 1 KB, 16 KB, 0.5 KB, NULL },
  { "atmega88pa", 1 KB, 8 KB, 0.5 KB, NULL },
  { "atmega88", 1 KB, 8 KB, 0.5 KB, NULL },
  { "atmega44pa", 0.5 KB, 4 KB, 0.25 KB, NULL },
  { "atmega44", 0.5 KB, 4 KB, 0.25 KB, NULL },
  { 0 }
}
```

Definition at line 52 of file [variant.c](#).

4.52 variant.c

```
00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/ ( ((/ (      \      | -- [ Funkenstein ] -----
00005 *      / ( ) / ( ) ((( ( ( ) \      )\ / ( )      | -- [ Little ] -----
00006 *      ( ) _ | ( )      ) \ _ )\ ( ( ( ( ) ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ \ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _ | / _ \ \ \ \ / | _ \      |
00010 *      |      |      | "Yeah, it does Arduino..."
00011 *      -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdint.h>
00022 #include <stdio.h>
00023 #include <stdlib.h>
00024 #include <string.h>
00025
00026 #include "variant.h"
00027
00028 //-----
00029 #define ADD_CAPABILITY          0xFE, 0xEF
00030
00031 #define IO_REGISTER_RANGE      0xFD, 0xDF
00032
00033 #define AVR_HAS_RAMP_Z          0x07
00034 #define AVR_HAS_EIND            0x08
00035
00036 #define AVR_HAS_UART0           0x09
00037 #define AVR_HAS_UART1           0x0A
00038
00039 #define AVR_HAS_TIMER0_8BIT      0x0B
00040 #define AVR_HAS_TIMER0_16BIT     0x0C
00041
00042 #define AVR_HAS_TIMER1_8BIT      0x0D
00043 #define AVR_HAS_TIMER1_16BIT     0x0E
00044
00045 #define AVR_HAS_TIMER2_8BIT      0x0F
00046 #define AVR_HAS_TIMER2_16BIT     0x10
```



```

00047
00048 //-----
00049 #define KB * (1024)
00050
00051 //-----
00052 static AVR_Variant_t astVariants[] =
00053 {
00054     { "atmega328p", 2 KB, 32 KB, 1 KB, NULL },
00055     { "atmega328", 2 KB, 32 KB, 1 KB, NULL },
00056     { "atmega168pa", 1 KB, 16 KB, 0.5 KB, NULL },
00057     { "atmega168", 1 KB, 16 KB, 0.5 KB, NULL },
00058     { "atmega88pa", 1 KB, 8 KB, 0.5 KB, NULL },
00059     { "atmega88", 1 KB, 8 KB, 0.5 KB, NULL },
00060     { "atmega44pa", 0.5 KB, 4 KB, 0.25 KB, NULL },
00061     { "atmega44", 0.5 KB, 4 KB, 0.25 KB, NULL },
00062     { 0 }
00063 };
00064
00065 //-----
00066 const AVR_Variant_t *Variant_GetByName( const char *szName_ )
00067 {
00068     AVR_Variant_t *pstVariant = astVariants;
00069     while (pstVariant->szName)
00070     {
00071         if (0 == strcmp(pstVariant->szName, szName_ ) )
00072         {
00073             return pstVariant;
00074         }
00075         pstVariant++;
00076     }
00077     return NULL;
00078 }
00079

```

4.53 src/config/variant.h File Reference

Module containing a lookup table of device variants supported by flavr.

Data Structures

- struct [AVR_Variant_t](#)

This struct contains the information necessary to effectively describe an AVR Microcontroller variant among the rest of the code.

Functions

- const [AVR_Variant_t](#) * [Variant_GetByName](#) (const char *szName_)
Variant_GetByName.

4.53.1 Detailed Description

Module containing a lookup table of device variants supported by flavr.

Definition in file [variant.h](#).

4.53.2 Function Documentation

4.53.2.1 const AVR_Variant_t* Variant_GetByName (const char * szName_)

[Variant_GetByName.](#)

Lookup a processor variant based on its name, and return a pointer to a matching variant string on successful match.

4.55.1 Detailed Description

Implements instruction breakpoints for debugging based on code path.

Definition in file [breakpoint.c](#).

4.55.2 Function Documentation

4.55.2.1 void BreakPoint_Delete (uint16_t u16Addr_)

BreakPoint_Delete.

Delete a breakpoint at a given address (if it exists). Has no effect if there isn't a breakpoint installed at the location

Parameters

<code>u16Addr_</code>	Address of the breakpoint to delete.
-----------------------	--------------------------------------

Definition at line 55 of file [breakpoint.c](#).

4.55.2.2 bool BreakPoint_EnabledAtAddress (uint16_t u16Addr_)

BreakPoint_EnabledAtAddress.

Check to see whether or not a CPU execution breakpoint has been installed at the given address.

Parameters

<code>u16Addr_</code>	Address (in flash) to check for breakpoint on.
-----------------------	--

Returns

true if a breakpoint has been set on the given address.

Definition at line 95 of file [breakpoint.c](#).

4.55.2.3 void BreakPoint_Insert (uint16_t u16Addr_)

BreakPoint_Insert.

Insert a CPU breakpoint at a given address. Has no effect if a breakpoint is already present at the given address.

Parameters

<code>u16Addr_</code>	Address of the breakpoint.
-----------------------	----------------------------

Definition at line 29 of file [breakpoint.c](#).

4.56 breakpoint.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      )\ ) |
00004 *      ((/( ((/(      \      ( ((/( | -- [ Funkenstein ] -----
00005 *      /( ) )/( )((( )\ )\ /( ) | -- [ Little ] -----
00006 *      ( ) ( )      )\ _ \ ( ( ( ) ( ) | -- [ AVR ] -----
00007 *      | | | |      ( ) \ ( ) \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ | / _ \ \ / / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ / / | _ / | _ \ |
00010 *      | _ | | _ | / _ \ \ / / | _ / | _ \ |
00011 *      -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/

```

```

00021 #include <stdint.h>
00022 #include <stdbool.h>
00023 #include <stdio.h>
00024 #include <stdlib.h>
00025
00026 #include "breakpoint.h"
00027
00028 //-----
00029 void BreakPoint_Insert( uint16_t ul6Addr_ )
00030 {
00031     // Don't add multiple breakpoints at the same address
00032     if (BreakPoint_EnabledAtAddress( ul6Addr_ ))
00033     {
00034         return;
00035     }
00036
00037     BreakPoint_t *pstNewBreak = NULL;
00038
00039     pstNewBreak = (BreakPoint_t*)malloc( sizeof(BreakPoint_t) );
00040
00041     pstNewBreak->next = stCPU.pstBreakPoints;
00042     pstNewBreak->prev = NULL;
00043
00044     pstNewBreak->ul6Addr = ul6Addr_;
00045
00046     if (stCPU.pstBreakPoints)
00047     {
00048         BreakPoint_t *pstTemp = stCPU.pstBreakPoints;
00049         pstTemp->prev = pstNewBreak;
00050     }
00051     stCPU.pstBreakPoints = pstNewBreak;
00052 }
00053
00054 //-----
00055 void BreakPoint_Delete( uint16_t ul6Addr_ )
00056 {
00057     BreakPoint_t *pstTemp = stCPU.pstBreakPoints;
00058
00059     while (pstTemp)
00060     {
00061         if (pstTemp->ul6Addr == ul6Addr_)
00062         {
00063             // Remove node -- reconnect surrounding elements
00064             BreakPoint_t *pstNext = pstTemp->next;
00065             if (pstNext)
00066             {
00067                 pstNext->prev = pstTemp->prev;
00068             }
00069
00070             BreakPoint_t *pstPrev = pstTemp->prev;
00071             if (pstPrev)
00072             {
00073                 pstPrev->next = pstTemp->next;
00074             }
00075
00076             // Adjust list-head if necessary
00077             if (pstTemp == stCPU.pstBreakPoints)
00078             {
00079                 stCPU.pstBreakPoints = pstNext;
00080             }
00081
00082             // Free the node/iterate to next node.
00083             pstPrev = pstTemp;
00084             pstTemp = pstTemp->next;
00085             free(pstPrev);
00086         }
00087         else
00088         {
00089             pstTemp = pstTemp->next;
00090         }
00091     }
00092 }
00093
00094 //-----
00095 bool BreakPoint_EnabledAtAddress( uint16_t ul6Addr_ )
00096 {
00097     BreakPoint_t *pstTemp = stCPU.pstBreakPoints;
00098
00099     while (pstTemp)
00100     {
00101         if (pstTemp->ul6Addr == ul6Addr_)
00102         {
00103             return true;
00104         }
00105         pstTemp = pstTemp->next;
00106     }
00107     return false;

```

```
00108 }
```

4.57 src/debug/breakpoint.h File Reference

Implements instruction breakpoints for debugging based on code path.

```
#include <stdint.h>
#include <stdbool.h>
#include "avr_cpu.h"
```

Data Structures

- struct [_BreakPoint](#)
Node-structure for a linked-list of breakpoint addresses.

Typedefs

- typedef struct [_BreakPoint](#) [BreakPoint_t](#)
Node-structure for a linked-list of breakpoint addresses.

Functions

- void [BreakPoint_Insert](#) (uint16_t u16Addr_)
BreakPoint_Insert.
- void [BreakPoint_Delete](#) (uint16_t u16Addr_)
BreakPoint_Delete.
- bool [BreakPoint_EnabledAtAddress](#) (uint16_t u16Addr_)
BreakPoint_EnabledAtAddress.

4.57.1 Detailed Description

Implements instruction breakpoints for debugging based on code path.

Definition in file [breakpoint.h](#).

4.57.2 Function Documentation

4.57.2.1 void BreakPoint_Delete (uint16_t u16Addr_)

[BreakPoint_Delete](#).

Delete a breakpoint at a given address (if it exists). Has no effect if there isn't a breakpoint installed at the location

Parameters

u16Addr_	Address of the breakpoint to delete.
--------------------------	--------------------------------------

Definition at line 55 of file [breakpoint.c](#).

4.57.2.2 `bool BreakPoint_EnabledAtAddress (uint16_t u16Addr_)`

`BreakPoint_EnabledAtAddress.`

Check to see whether or not a CPU execution breakpoint has been installed at the given address.

Parameters

<code>u16Addr_</code>	Address (in flash) to check for breakpoint on.
-----------------------	--

Returns

true if a breakpoint has been set on the given address.

Definition at line 95 of file [breakpoint.c](#).

4.57.2.3 void BreakPoint_Insert (uint16_t u16Addr_)

BreakPoint_Insert.

Insert a CPU breakpoint at a given address. Has no effect if a breakpoint is already present at the given address.

Parameters

<code>u16Addr_</code>	Address of the breakpoint.
-----------------------	----------------------------

Definition at line 29 of file [breakpoint.c](#).

4.58 breakpoint.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/ ( ((/ (      (      | -- [ Funkenstein ] -----
00005 *      / ( ) / ( ) ((( ( ) ( ) \ / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      ) \ _ ) \ ( ( ) ( ) ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ \ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ v / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _ | / _ \ \ \ \ / | _ \      |
00010 *      | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __BREAKPOINT_H__
00022 #define __BREAKPOINT_H__
00023
00024 #include <stdint.h>
00025 #include <stdbool.h>
00026
00027 #include "avr_cpu.h"
00028
00029 //-----
00033 typedef struct _BreakPoint
00034 {
00035     struct _BreakPoint *next;
00036     struct _BreakPoint *prev;
00037
00038     uint16_t    u16Addr;
00039 } BreakPoint_t;
00040
00041 //-----
00050 void BreakPoint_Insert( uint16_t u16Addr_ );
00051
00052 //-----
00061 void BreakPoint_Delete( uint16_t u16Addr_ );
00062
00063 //-----
00073 bool BreakPoint_EnabledAtAddress( uint16_t u16Addr_ );
00074
00075 #endif
00076

```

4.59 src/debug/code_profile.c File Reference

Code profiling (exeuction and coverage) functionality.

```
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "debug_sym.h"
#include "code_profile.h"
#include "avr_disasm.h"
#include "tlv_file.h"
```

Data Structures

- struct [Profile_t](#)
- struct [FunctionProfileTLV_t](#)
- struct [FunctionCoverageTLV_t](#)
- struct [AddressCoverageTLV_t](#)

Functions

- static void **Profile_TLVInit** (void)
- static void **Profile_FunctionCoverage** (const char *szFunc_, uint32_t u32FuncSize_, uint32_t u32HitSize_)
- static void **Profile_Function** (const char *szFunc_, uint64_t u64Cycles_, uint64_t u64CPUCycles_)
- static void **Profile_AddressCoverage** (const char *szDisasm_, uint32_t u32Addr_, uint64_t u64Hits_)
- void [Profile_Hit](#) (uint32_t u32Addr_)

Profile_Hit.
- void **Profile_ResetEpoch** (void)
- void **Profile_PrintCoverageDissassembly** (void)
- void [Profile_Print](#) (void)

Profile_Print.
- void [Profile_Init](#) (uint32_t u32ROMSize_)

Profile_Init.

Variables

- static [Profile_t](#) * **pstProfile** = 0
- static uint32_t **u32ROMSize** = 0
- static [TLV_t](#) * **pstFunctionCoverageTLV** = NULL
- static [TLV_t](#) * **pstFunctionProfileTLV** = NULL
- static [TLV_t](#) * **pstAddressCoverageTLV** = NULL

4.59.1 Detailed Description

Code profiling (exeuction and coverage) functionality.

Definition in file [code_profile.c](#).

4.59.2 Function Documentation

4.59.2.1 void Profile_Hit (uint32_t u32Addr_)

Profile_Hit.

Add to profiling counters for the specified address. This should be called on each ROM/FLASH access (not per cycle)

Parameters

<code>u32Addr_</code>	- Address in ROM/FLASH being hit.
-----------------------	-----------------------------------

Definition at line 127 of file `code_profile.c`.

4.59.2.2 void Profile_Init (uint32_t u32ROMSize_)

Profile_Init.

Initialize the code profiling module

Parameters

<code>u32ROMSize_</code>	- Size of the CPU's ROM/FLASH
--------------------------	-------------------------------

Definition at line 280 of file `code_profile.c`.

4.59.2.3 void Profile_Print (void)

Profile_Print.

Display the cumulative profiling stats

Definition at line 214 of file `code_profile.c`.

4.60 code_profile.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ( ) / ( ( ) / (      | -- [ Funkenstein ] -----
00005 *      / ( ) / ( ) ) ( ( ( ( ) \      )\      / ( )      | -- [ Little ] -----
00006 *      ( ) _ | ( )      )\ _ )\ ( ( ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | _ |      ( ) _ \ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _ |      / _ \ \ \ / / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ |      / _ \ \ \ / / | _ \      |
00010 *      |      |      | "Yeah, it does Arduino..."
00011 *      +-----+
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdint.h>
00022 #include <stdio.h>
00023 #include <stdlib.h>
00024 #include <string.h>
00025 #include "debug_sym.h"
00026 #include "code_profile.h"
00027 #include "avr_disasm.h"
00028 #include "tlv_file.h"
00029
00030 //-----
00031 typedef struct
00032 {
00033     Debug_Symbol_t *pstSym;
00034     uint64_t u64TotalHit;
00035     uint64_t u64EpochHit;
00036 } Profile_t;
00037
00038 //-----
00039 typedef struct
00040 {
00041     uint64_t u64CyclesTotal;
00042     uint64_t u64CPUCycles;
00043     char szSymName[256];
00044 } FunctionProfileTLV_t;
00045
00046 //-----
00047 typedef struct
00048 {
00049     uint32_t u32FunctionSize;
00050     uint32_t u32AddressesHit;
00051     char szSymName[256];
00052 } FunctionCoverageTLV_t;

```

```

00053
00054 //-----
00055 typedef struct
00056 {
00057     uint32_t u32CodeAddress;
00058     uint64_t u64Hits;
00059     char      szDisasmLine[256];
00060 } AddressCoverageTLV_t;
00061
00062 //-----
00063 static Profile_t *pstProfile = 0;
00064 static uint32_t u32ROMSize = 0;
00065
00066 //-----
00067 static TLV_t *pstFunctionCoverageTLV = NULL;
00068 static TLV_t *pstFunctionProfileTLV = NULL;
00069 static TLV_t *pstAddressCoverageTLV = NULL;
00070
00071 //-----
00072 static void Profile_TLVInit(void)
00073 {
00074     pstFunctionProfileTLV = TLV_Alloc( sizeof(FunctionProfileTLV_t));
00075     pstFunctionProfileTLV->eTag = TAG_CODE_PROFILE_FUNCTION_GLOBAL;
00076
00077     pstFunctionCoverageTLV = TLV_Alloc( sizeof(FunctionCoverageTLV_t));
00078     pstFunctionCoverageTLV->eTag = TAG_CODE_COVERAGE_FUNCTION_GLOBAL;
00079
00080     pstAddressCoverageTLV = TLV_Alloc( sizeof(AddressCoverageTLV_t));
00081     pstAddressCoverageTLV->eTag = TAG_CODE_COVERAGE_ADDRESS;
00082 }
00083
00084 //-----
00085 static void Profile_FunctionCoverage( const char *szFunc_, uint32_t u32FuncSize_, uint32_t u32HitSize_ )
00086 {
00087     FunctionCoverageTLV_t *pstData = (FunctionCoverageTLV_t*) (&
00088 pstFunctionCoverageTLV->au8Data[0]);
00089
00090     strcpy(pstData->szSymName, szFunc_);
00091     pstData->u32FunctionSize = u32FuncSize_;
00092     pstData->u32AddressesHit = u32HitSize_;
00093     pstFunctionCoverageTLV->u16Len = strlen(szFunc_) + 8; // Size of the static + variable data
00094
00095     TLV_Write( pstFunctionCoverageTLV );
00096 }
00097 //-----
00098 static void Profile_Function( const char *szFunc_, uint64_t u64Cycles_, uint64_t u64CPUCycles_ )
00099 {
00100     FunctionProfileTLV_t *pstData = (FunctionProfileTLV_t*) (&
00101 pstFunctionProfileTLV->au8Data[0]);
00102
00103     strcpy(pstData->szSymName, szFunc_);
00104     pstData->u64CyclesTotal = u64Cycles_;
00105     pstData->u64CPUCycles = u64CPUCycles_;
00106
00107     pstFunctionProfileTLV->u16Len = strlen(szFunc_) + 16; // Size of the static + variable data
00108
00109     TLV_Write( pstFunctionProfileTLV );
00110 }
00111 //-----
00112 static void Profile_AddressCoverage( const char *szDisasm_, uint32_t u32Addr_, uint64_t u64Hits_ )
00113 {
00114     AddressCoverageTLV_t *pstData = (AddressCoverageTLV_t*) (&
00115 pstAddressCoverageTLV->au8Data[0]);
00116
00117     strcpy(pstData->szDisasmLine, szDisasm_);
00118
00119     pstData->u32CodeAddress = u32Addr_;
00120     pstData->u64Hits = u64Hits_;
00121
00122     pstAddressCoverageTLV->u16Len = strlen(szDisasm_) + 12;
00123
00124     TLV_Write( pstAddressCoverageTLV );
00125 }
00126 //-----
00127 void Profile_Hit( uint32_t u32Addr_ )
00128 {
00129     pstProfile[ u32Addr_ ].u64EpochHit++;
00130     pstProfile[ u32Addr_ ].u64TotalHit++;
00131
00132     Debug_Symbol_t *pstSym = pstProfile[ u32Addr_ ].pstSym;
00133     if (pstSym)
00134     {
00135         pstSym->u64EpochRefs++;
00136         pstSym->u64TotalRefs++;
00137     }
00138 }

```

```

00137     }
00138 }
00139
00140 //-----
00141 void Profile_ResetEpoch(void)
00142 {
00143     // Reset the epoch counters for all addresses
00144     int i;
00145     for (i = 0; i < u32ROMSize; i++)
00146     {
00147         pstProfile[i].u64EpochHit = 0;
00148     }
00149
00150     // Reset the per-symbol epoch counters
00151     Debug_Symbol_t *pstSym;
00152     int iSymCount = Symbol_Get_Func_Count();
00153     for (i = 0; i < iSymCount; i++)
00154     {
00155         pstSym = Symbol_Func_At_Index(i);
00156         pstSym->u64EpochRefs = 0;
00157     }
00158 }
00159
00160 //-----
00161 void Profile_PrintCoverageDisassembly(void)
00162 {
00163     Debug_Symbol_t *pstSym;
00164     int iSymCount = Symbol_Get_Func_Count();
00165     int i;
00166     int j;
00167
00168     printf( "=====\n");
00169     printf( "Detailed Code Coverage\n");
00170     printf( "=====\n");
00171     // Go through all of our symbols and show which instructions have actually
00172     // been hit.
00173     for (i = 0; i < iSymCount; i++)
00174     {
00175         pstSym = Symbol_Func_At_Index(i);
00176
00177         if (!pstSym)
00178         {
00179             break;
00180         }
00181
00182         printf("%s:\n", pstSym->szName);
00183         j = pstSym->u32StartAddr;
00184         while (j <= (int)pstSym->u32EndAddr)
00185         {
00186             uint16_t OP = stCPU.pu16ROM[j];
00187             stCPU.u16PC = (uint16_t)j;
00188
00189             if (pstProfile[j].u64TotalHit)
00190             {
00191                 printf( "[X] " );
00192             }
00193             else
00194             {
00195                 printf( "[ ] " );
00196             }
00197             printf(" 0x%04X: [0x%04X] ", stCPU.u16PC, OP);
00198
00199             AVR_Decode(OP);
00200
00201             char szBuf[256];
00202             AVR_Disasm_Function(OP)(szBuf);
00203             printf( " %s", szBuf );
00204
00205             Profile_AddressCoverage( szBuf, stCPU.u16PC, pstProfile[j].
u64TotalHit );
00206
00207             j += AVR_Opcode_Size(OP);
00208         }
00209         printf("\n");
00210     }
00211 }
00212
00213 //-----
00214 void Profile_Print(void)
00215 {
00216     uint64_t u64TotalCycles = 0;
00217
00218     Debug_Symbol_t *pstSym;
00219     int iSymCount = Symbol_Get_Func_Count();
00220     int i;
00221     for (i = 0; i < iSymCount; i++)
00222     {

```

```

00223     pstSym = Symbol_Func_At_Index(i);
00224     u64TotalCycles += pstSym->u64TotalRefs;
00225 }
00226 printf("\n\nTotal cycles spent in known functions: %llu\n\n", u64TotalCycles);
00227
00228 printf( "=====\n");
00229 printf( "%60s: CPU utilization(%%)\n", "Function");
00230 printf( "=====\n");
00231 for (i = 0; i < iSymCount; i++)
00232 {
00233     pstSym = Symbol_Func_At_Index(i);
00234     printf( "%60s: %0.3f\n",
00235         pstSym->szName,
00236         100.0 * (double) (pstSym->u64TotalRefs) / (double) (u64TotalCycles) );
00237     Profile_Function( pstSym->szName, pstSym->u64TotalRefs, u64TotalCycles );
00238 }
00239
00240 printf( "=====\n");
00241 printf( "Code coverage summary:\n");
00242 printf( "=====\n");
00243 int iGlobalHits = 0;
00244 int iGlobalMisses = 0;
00245 for (i = 0; i < iSymCount; i++)
00246 {
00247     pstSym = Symbol_Func_At_Index(i);
00248     int j;
00249     int iHits = 0;
00250     int iMisses = 0;
00251
00252     for (j = pstSym->u32StartAddr; j < pstSym->u32EndAddr; j++)
00253     {
00254         if (pstProfile[j].u64TotalHit)
00255         {
00256             iHits++;
00257             iGlobalHits++;
00258         }
00259         else
00260         {
00261             iMisses++;
00262             iGlobalMisses++;
00263         }
00264
00265         // If this is a 2-opcode instruction, skip the next word, as to not skew the results
00266         uint16_t OP = stCPU.pu16ROM[j];
00267         if (2 == AVR_Opcode_Size(OP))
00268         {
00269             j++;
00270         }
00271     }
00272     printf("%60s: %0.3f\n", pstSym->szName, 100.0 * (double)iHits/(double) (iHits + iMisses));
00273     Profile_FunctionCoverage(pstSym->szName, iHits + iMisses, iHits);
00274 }
00275 printf( "\n[Global Code Coverage] : %0.3f\n",
00276     100.0 * (double) iGlobalHits/(double) (iGlobalHits + iGlobalMisses));
00277
00278 }
00279 //-----
00280 void Profile_Init( uint32_t u32ROMSize_ )
00281 {
00282     // Allocate a lookup table, one entry per address in ROM to allow us to
00283     // gather code-coverage and code-profiling information.
00284     uint32_t u32BufSize = sizeof(Profile_t) * u32ROMSize_ ;
00285     u32ROMSize = u32ROMSize_;
00286     pstProfile = (Profile_t*)malloc( u32BufSize );
00287     memset( pstProfile, 0, u32BufSize );
00288
00289     // Go through the list of symbols, and associate each function with its
00290     // address range in the lookup table.
00291     int iFuncs = Symbol_Get_Func_Count();
00292     int i;
00293     for (i = 0; i < iFuncs; i++)
00294     {
00295         Debug_Symbol_t *pstSym = Symbol_Func_At_Index( i );
00296         int j;
00297         if (pstSym)
00298         {
00299             for (j = pstSym->u32StartAddr; j < pstSym->u32EndAddr; j++)
00300             {
00301                 pstProfile[j].pstSym = pstSym;
00302             }
00303         }
00304     }
00305
00306     Profile_TLVInit();
00307
00308     atexit( Profile_Print );
00309     atexit( Profile_PrintCoverageDisassembly );

```

```
00310 }
```

4.61 src/debug/code_profile.h File Reference

Code profiling (exeuction and coverage) functionality.

```
#include <stdint.h>
```

Functions

- void [Profile_Init](#) (uint32_t u32ROMSize_)
Profile_Init.
- void [Profile_Hit](#) (uint32_t u32Addr_)
Profile_Hit.
- void [Profile_Print](#) (void)
Profile_Print.

4.61.1 Detailed Description

Code profiling (exeuction and coverage) functionality.

Definition in file [code_profile.h](#).

4.61.2 Function Documentation

4.61.2.1 void Profile_Hit (uint32_t u32Addr_)

Profile_Hit.

Add to profiling counters for the specified address. This should be called on each ROM/FLASH access (not per cycle)

Parameters

<i>u32Addr_</i>	- Address in ROM/FLASH being hit.
-----------------	-----------------------------------

Definition at line 127 of file [code_profile.c](#).

4.61.2.2 void Profile_Init (uint32_t u32ROMSize_)

Profile_Init.

Initialize the code profiling module

Parameters

<i>u32ROMSize_</i>	- Size of the CPU's ROM/FLASH
--------------------	-------------------------------

Definition at line 280 of file [code_profile.c](#).

4.61.2.3 void Profile_Print (void)

Profile_Print.

Display the cumulative profiling stats

Definition at line 214 of file [code_profile.c](#).

4.62 code_profile.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )  (      )\ ) |
00004 *      ((/( ((/(      \      ( ((/( | -- [ Funkenstein ] -----
00005 *      /( )  /( )  ((( ( ) \  )\  /( ) | -- [ Little ] -----
00006 *      ( ) _ ( ) )  )\ _ )\  ( ( ) ( ( ) | -- [ AVR ] -----
00007 *      | _ | | |      ( ) _ ( ) \ \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ | / _ \ \ \ / / | _ \ | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ \ \ / / | _ \ |
00010 *      | _ | | _ | / _ \ \ \ \ / / | _ \ |
00011 *      | _ | | _ | / _ \ \ \ \ / / | _ \ | "Yeah, it does Arduino..."
00012 * -----+-----
00013 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00014 * See license.txt for details
00015 *****/
00021 #ifndef __CODE_PROFILE_H__
00022 #define __CODE_PROFILE_H__
00023
00024 #include <stdint.h>
00025
00026 //-----
00034 void Profile_Init( uint32_t u32ROMSize_ );
00035
00036 //-----
00045 void Profile_Hit( uint32_t u32Addr_ );
00046
00047 //-----
00054 void Profile_Print(void);
00055
00056
00057 #endif
00058

```

4.63 src/debug/debug_sym.c File Reference

Symbolic debugging support for data and functions.

```

#include "debug_sym.h"
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

```

Functions

- void [Symbol_Add_Func](#) (const char *szName_, const uint32_t u32Addr_, const uint32_t u32Len_)
Symbol_Add_Func.
- void [Symbol_Add_Obj](#) (const char *szName_, const uint32_t u32Addr_, const uint32_t u32Len_)
Symbol_Add_Obj.
- uint32_t [Symbol_Get_Obj_Count](#) (void)
Symbol_Get_Obj_Count.
- uint32_t [Symbol_Get_Func_Count](#) (void)
Symbol_Get_Func_Count.
- [Debug_Symbol_t](#) * [Symbol_Func_At_Index](#) (uint32_t u32Index_)
Symbol_Func_At_Index.
- [Debug_Symbol_t](#) * [Symbol_Obj_At_Index](#) (uint32_t u32Index_)
Symbol_Obj_At_Index.
- [Debug_Symbol_t](#) * [Symbol_Find_Func_By_Name](#) (const char *szName_)
Symbol_Find_Func_By_Name.
- [Debug_Symbol_t](#) * [Symbol_Find_Obj_By_Name](#) (const char *szName_)
Symbol_Find_Obj_By_Name.

Variables

- static [Debug_Symbol_t](#) * **pstFuncSymbols** = 0
- static uint32_t **u32FuncCount** = 0
- static [Debug_Symbol_t](#) * **pstObjSymbols** = 0
- static uint32_t **u32ObjCount** = 0

4.63.1 Detailed Description

Symbolic debugging support for data and functions.

Definition in file [debug_sym.c](#).

4.63.2 Function Documentation

4.63.2.1 void [Symbol_Add_Func](#) (const char * *szName_*, const uint32_t *u32Addr_*, const uint32_t *u32Len_*)

[Symbol_Add_Func](#).

Add a new function into the emulator's debug symbol table.

Parameters

<i>szName_</i>	- Name of the symbol (string)
<i>u32Addr_</i>	- Start address of the function
<i>u32Len_</i>	- Size of the function (in bytes)

Definition at line 36 of file [debug_sym.c](#).

4.63.2.2 void [Symbol_Add_Obj](#) (const char * *szName_*, const uint32_t *u32Addr_*, const uint32_t *u32Len_*)

[Symbol_Add_Obj](#).

Add a new object into the emulator's debug symbol table.

Parameters

<i>szName_</i>	- Name of the symbol (string)
<i>u32Addr_</i>	- Start address of the object
<i>u32Len_</i>	- Size of the object (in bytes)

Definition at line 51 of file [debug_sym.c](#).

4.63.2.3 [Debug_Symbol_t](#)* [Symbol_Find_Func_By_Name](#) (const char * *szName_*)

[Symbol_Find_Func_By_Name](#).

Search the local debug symbol table for a function specified by name.

Parameters

<i>szName_</i>	- Name of the object to look-up
----------------	---------------------------------

Returns

Pointer to the symbol retrieved, or NULL if index out-of-range.

Definition at line 98 of file [debug_sym.c](#).

4.63.2.4 **Debug_Symbol_t*** Symbol_Find_Obj_By_Name (const char * szName_)

Symbol_Find_Obj_By_Name.

Search the local debug symbol table for an object specified by name.

Parameters

<i>szName_</i>	- Name of the object to look up
----------------	---------------------------------

Returns

Pointer to the symbol retrieved, or NULL if index out-of-range.

Definition at line 112 of file [debug_sym.c](#).

4.63.2.5 **Debug_Symbol_t*** Symbol_Func_At_Index (uint32_t u32Index_)

Symbol_Func_At_Index.

Return a point to a debug symbol (function) stored in the table at a specific table index.

Parameters

<i>u32Index_</i>	- Table index to look up
------------------	--------------------------

Returns

Pointer to the symbol retrieved, or NULL if index out-of-range.

Definition at line 78 of file [debug_sym.c](#).

4.63.2.6 **uint32_t** Symbol_Get_Func_Count (void)

Symbol_Get_Func_Count.

Get the current count of the functions stored in the symbol table.

Returns

Number of functions in the symbol table

Definition at line 72 of file [debug_sym.c](#).

4.63.2.7 **uint32_t** Symbol_Get_Obj_Count (void)

Symbol_Get_Obj_Count.

Get the current count of the objects stored in the symbol table

Returns

Number of objects in the symbol table

Definition at line 66 of file [debug_sym.c](#).

4.63.2.8 **Debug_Symbol_t*** Symbol_Obj_At_Index (uint32_t u32Index_)

Symbol_Obj_At_Index.

Return a point to a debug symbol (object) stored in the table at a specific table index.

Parameters

<code>u32Index_</code>	- Table index to look up
------------------------	--------------------------

Returns

Pointer to the symbol retrieved, or NULL if index out-of-range.

Definition at line 88 of file [debug_sym.c](#).

4.64 debug_sym.c

```

00001  /*****
00002  *      (      (      (      (      |
00003  *      )\ )  )\ )      (      )\ )  |
00004  *      ((/( ((/(      )\      ( ((/( | -- [ Funkenstein ] -----
00005  *      /( )  /( )  ((( ( )\ )\  /( )  | -- [ Little ] -----
00006  *      ( )_ ( )      )\ _ )\ ( ( ) ( )  | -- [ AVR ] -----
00007  *      | | _ | |      ( )_ \ ( ) \ \ / / | _ \ | -- [ Virtual ] -----
00008  *      | _ | | _      / _ \ \ \ / / | _ / | -- [ Runtime ] -----
00009  *      | _ | | _      / _ \ \ \ / / | _ \ |
00010  *                                     | "Yeah, it does Arduino..."
00011  * -----+-----
00012  * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013  * See license.txt for details
00014  *****/
00022  #include "debug_sym.h"
00023  #include <stdint.h>
00024  #include <stdio.h>
00025  #include <stdlib.h>
00026  #include <string.h>
00027
00028  //-----
00029  static Debug_Symbol_t *pstFuncSymbols = 0;
00030  static uint32_t        u32FuncCount = 0;
00031
00032  static Debug_Symbol_t *pstObjSymbols = 0;
00033  static uint32_t        u32ObjCount = 0;
00034
00035  //-----
00036  void Symbol_Add_Func( const char *szName_, const uint32_t u32Addr_, const uint32_t u32Len_ )
00037  {
00038      pstFuncSymbols = (Debug_Symbol_t*)realloc( pstFuncSymbols, (u32FuncCount + 1) * sizeof(
00039      Debug_Symbol_t );
00040      Debug_Symbol_t *pstNew = &pstFuncSymbols[u32FuncCount];
00041
00042      pstNew->eType          = DBG_FUNC;
00043      pstNew->szName          = strdup( szName_ );
00044      pstNew->u32StartAddr    = u32Addr_;
00045      pstNew->u32EndAddr      = u32Addr_ + u32Len_ - 1;
00046      pstNew->u64EpochRefs   = 0;
00047      pstNew->u64TotalRefs    = 0;
00048      u32FuncCount++;
00049  }
00050  //-----
00051  void Symbol_Add_Obj( const char *szName_, const uint32_t u32Addr_, const uint32_t u32Len_ )
00052  {
00053      pstObjSymbols = (Debug_Symbol_t*)realloc( pstObjSymbols, (u32ObjCount + 1) * sizeof(
00054      Debug_Symbol_t );
00055      Debug_Symbol_t *pstNew = &pstObjSymbols[u32ObjCount];
00056
00057      pstNew->eType          = DBG_OBJ;
00058      pstNew->szName          = strdup( szName_ );
00059      pstNew->u32StartAddr    = u32Addr_;
00060      pstNew->u32EndAddr      = u32Addr_ + u32Len_ - 1;
00061      u32ObjCount++;
00062  }
00063
00064  //-----
00065  uint32_t Symbol_Get_Obj_Count( void )
00066  {
00067      return u32ObjCount;
00068  }
00069
00070  //-----
00071  uint32_t Symbol_Get_Func_Count( void )
00072  {

```

```

00074     return u32FuncCount;
00075 }
00076
00077 //-----
00078 Debug_Symbol_t *Symbol_Func_At_Index( uint32_t u32Index_ )
00079 {
00080     if (u32Index_ >= u32FuncCount)
00081     {
00082         return 0;
00083     }
00084     return &pstFuncSymbols[u32Index_];
00085 }
00086
00087 //-----
00088 Debug_Symbol_t *Symbol_Obj_At_Index( uint32_t u32Index_ )
00089 {
00090     if (u32Index_ >= u32ObjCount)
00091     {
00092         return 0;
00093     }
00094     return &pstObjSymbols[u32Index_];
00095 }
00096
00097 //-----
00098 Debug_Symbol_t *Symbol_Find_Func_By_Name( const char *szName_ )
00099 {
00100     uint32_t i = 0;
00101     for (i = 0; i < u32FuncCount; i++)
00102     {
00103         if (0 == strcmp(szName_, pstFuncSymbols[i].szName))
00104         {
00105             return &pstFuncSymbols[i];
00106         }
00107     }
00108     return 0;
00109 }
00110
00111 //-----
00112 Debug_Symbol_t *Symbol_Find_Obj_By_Name( const char *szName_ )
00113 {
00114     uint32_t i = 0;
00115     for (i = 0; i < u32ObjCount; i++)
00116     {
00117         if (0 == strcmp(szName_, pstObjSymbols[i].szName))
00118         {
00119             return &pstObjSymbols[i];
00120         }
00121     }
00122     return 0;
00123 }
00124
00125

```

4.65 src/debug/debug_sym.h File Reference

Symbolic debugging support for data and functions.

```
#include <stdint.h>
```

Data Structures

- struct [Debug_Symbol_t](#)

Enumerations

- enum [Debug_t](#) { **DBG_OBJ** = 0, **DBG_FUNC**, **DBG_COUNT** }

Functions

- void [Symbol_Add_Func](#) (const char *szName_, const uint32_t u32Addr_, const uint32_t u32Len_)
Symbol_Add_Func.

- void [Symbol_Add_Obj](#) (const char *szName_, const uint32_t u32Addr_, const uint32_t u32Len_)
Symbol_Add_Obj.
- uint32_t [Symbol_Get_Obj_Count](#) (void)
Symbol_Get_Obj_Count.
- uint32_t [Symbol_Get_Func_Count](#) (void)
Symbol_Get_Func_Count.
- [Debug_Symbol_t](#) * [Symbol_Func_At_Index](#) (uint32_t u32Index_)
Symbol_Func_At_Index.
- [Debug_Symbol_t](#) * [Symbol_Obj_At_Index](#) (uint32_t u32Index_)
Symbol_Obj_At_Index.
- [Debug_Symbol_t](#) * [Symbol_Find_Func_By_Name](#) (const char *szName_)
Symbol_Find_Func_By_Name.
- [Debug_Symbol_t](#) * [Symbol_Find_Obj_By_Name](#) (const char *szName_)
Symbol_Find_Obj_By_Name.

4.65.1 Detailed Description

Symbolic debugging support for data and functions.

Definition in file [debug_sym.h](#).

4.65.2 Function Documentation

4.65.2.1 void [Symbol_Add_Func](#) (const char * *szName_*, const uint32_t *u32Addr_*, const uint32_t *u32Len_*)

[Symbol_Add_Func](#).

Add a new function into the emulator's debug symbol table.

Parameters

<i>szName_</i>	- Name of the symbol (string)
<i>u32Addr_</i>	- Start address of the function
<i>u32Len_</i>	- Size of the function (in bytes)

Definition at line 36 of file [debug_sym.c](#).

4.65.2.2 void [Symbol_Add_Obj](#) (const char * *szName_*, const uint32_t *u32Addr_*, const uint32_t *u32Len_*)

[Symbol_Add_Obj](#).

Add a new object into the emulator's debug symbol table.

Parameters

<i>szName_</i>	- Name of the symbol (string)
<i>u32Addr_</i>	- Start address of the object
<i>u32Len_</i>	- Size of the object (in bytes)

Definition at line 51 of file [debug_sym.c](#).

4.65.2.3 [Debug_Symbol_t](#)* [Symbol_Find_Func_By_Name](#) (const char * *szName_*)

[Symbol_Find_Func_By_Name](#).

Search the local debug symbol table for a function specified by name.

Parameters

<i>szName_</i>	- Name of the object to look-up
----------------	---------------------------------

Returns

Pointer to the symbol retrieved, or NULL if index out-of-range.

Definition at line 98 of file [debug_sym.c](#).

4.65.2.4 Debug_Symbol_t* Symbol_Find_Obj_By_Name (const char * *szName_*)

Symbol_Find_Obj_By_Name.

Search the local debug symbol table for an object specified by name.

Parameters

<i>szName_</i>	- Name of the object to look up
----------------	---------------------------------

Returns

Pointer to the symbol retrieved, or NULL if index out-of-range.

Definition at line 112 of file [debug_sym.c](#).

4.65.2.5 Debug_Symbol_t* Symbol_Func_At_Index (uint32_t *u32Index_*)

Symbol_Func_At_Index.

Return a point to a debug symbol (function) stored in the table at a specific table index.

Parameters

<i>u32Index_</i>	- Table index to look up
------------------	--------------------------

Returns

Pointer to the symbol retrieved, or NULL if index out-of-range.

Definition at line 78 of file [debug_sym.c](#).

4.65.2.6 uint32_t Symbol_Get_Func_Count (void)

Symbol_Get_Func_Count.

Get the current count of the functions stored in the symbol table.

Returns

Number of functions in the symbol table

Definition at line 72 of file [debug_sym.c](#).

4.65.2.7 uint32_t Symbol_Get_Obj_Count (void)

Symbol_Get_Obj_Count.

Get the current count of the objects stored in the symbol table

Returns

Number of objects in the symbol table

Definition at line 66 of file [debug_sym.c](#).

4.65.2.8 Debug_Symbol_t* Symbol_Obj_At_Index (uint32_t u32Index_)

Symbol_Obj_At_Index.

Return a point to a debug symbol (object) stored in the table at a specific table index.

Parameters

<code>u32Index_</code>	- Table index to look up
------------------------	--------------------------

Returns

Pointer to the symbol retrieved, or NULL if index out-of-range.

Definition at line 88 of file [debug_sym.c](#).

4.66 debug_sym.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( ((/(      \      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( ) \      / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      ) \ _ \      ( ) ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \      \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _      / _ \      \ / | _ \      |
00010 *      | _ | | _ _ _      / _ \      \ / | _ \      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __DEBUG_SYM_H__
00022 #define __DEBUG_SYM_H__
00023
00024 #include <stdint.h>
00025
00026 //-----
00027 typedef enum
00028 {
00029     DBG_OBJ = 0,
00030     DBG_FUNC,
00031 } Debug_t;
00032
00033 //-----
00034
00035 typedef struct
00036 {
00037     Debug_t      eType;
00038     uint32_t      u32StartAddr;
00039     uint32_t      u32EndAddr;
00040     const char *szName;
00041     uint64_t      u64TotalRefs;
00042     uint64_t      u64EpochRefs;
00043 } Debug_Symbol_t;
00044
00045 //-----
00046
00047 void Symbol_Add_Func( const char *szName_, const uint32_t u32Addr_, const uint32_t u32Len_ )
00048 ;
00049
00050 void Symbol_Add_Obj( const char *szName_, const uint32_t u32Addr_, const uint32_t u32Len_ );
00051
00052 uint32_t Symbol_Get_Obj_Count( void );
00053
00054 //-----

```

```

00090 uint32_t Symbol_Get_Func_Count( void );
00091
00092 //-----
00102 Debug_Symbol_t *Symbol_Func_At_Index( uint32_t u32Index_ );
00103
00104 //-----
00114 Debug_Symbol_t *Symbol_Obj_At_Index( uint32_t u32Index_ );
00115
00116 //-----
00126 Debug_Symbol_t *Symbol_Find_Func_By_Name( const char *szName_ );
00127
00128 //-----
00137 Debug_Symbol_t *Symbol_Find_Obj_By_Name( const char *szName_ );
00138
00139 #endif

```

4.67 src/debug/elf_print.c File Reference

```

#include "elf_print.h"
#include "elf_types.h"
#include "elf_process.h"
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <unistd.h>

```

Functions

- void [ELF_PrintHeader](#) (const uint8_t *pau8Buffer_)
ELF_PrintHeader.
- void [ELF_PrintSections](#) (const uint8_t *pau8Buffer_)
ELF_PrintSections.
- void [ELF_PrintSymbols](#) (const uint8_t *pau8Buffer_)
ELF_PrintSymbols.
- void [ELF_PrintProgramHeaders](#) (const uint8_t *pau8Buffer_)
ELF_PrintProgramHeaders.

4.67.1 Function Documentation

4.67.1.1 void [ELF_PrintHeader](#) (const uint8_t * *pau8Buffer_*)

ELF_PrintHeader.

Print the contents of a loaded ELF file's header data to standard output.

Parameters

<i>pau8Buffer_</i>	Buffer containing the loaded ELF contents
--------------------	---

Definition at line 33 of file [elf_print.c](#).

4.67.1.2 void [ELF_PrintProgramHeaders](#) (const uint8_t * *pau8Buffer_*)

ELF_PrintProgramHeaders.

Print the list of program headers stored in the loaded ELF file .

Parameters

<i>pau8Buffer_</i>	Buffer containing the loaded ELF contents
--------------------	---

Definition at line 246 of file elf_print.c.

4.67.1.3 void ELF_PrintSections (const uint8_t * *pau8Buffer_*)

ELF_PrintSections.

Print a list of named sections contained in the loaded ELF file.

Parameters

<i>pau8Buffer_</i>	Buffer containing the loaded ELF contents
--------------------	---

Definition at line 147 of file elf_print.c.

4.67.1.4 void ELF_PrintSymbols (const uint8_t * *pau8Buffer_*)

ELF_PrintSymbols.

Print a list of ELF Symbols contained in the loaded ELF file.

Parameters

<i>pau8Buffer_</i>	Buffer containing the loaded ELF contents
--------------------	---

Definition at line 192 of file elf_print.c.

4.68 elf_print.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      )\ ) |
00004 *      ()/( ()/( )\      ( ( ()/( | -- [ Funkenstein ] -----
00005 *      /( ) )/( ) ((( ) )\ )\ /( ) | -- [ Little ] -----
00006 *      ( )_ ( ) )\ _ )\ ( ) ( ) | -- [ AVR ] -----
00007 *      | _ | |      ( )_ \ ( ) \ \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ v / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _ | / \ \ \ \ \ | _ \ |
00010 *
00011 *      | "Yeah, it does Arduino..."
00012 * -----+-----
00013 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00014 * See license.txt for details
00015 *****/
00021 #include "elf_print.h"
00022 #include "elf_types.h"
00023 #include "elf_process.h"
00024
00025 #include <stdint.h>
00026 #include <stdio.h>
00027 #include <stdlib.h>
00028 #include <sys/types.h>
00029 #include <sys/stat.h>
00030 #include <unistd.h>
00031
00032 //-----
00033 void ELF_PrintHeader( const uint8_t *pau8Buffer_ )
00034 {
00035     ElfHeader_t *pstHeader = (ElfHeader_t*)pau8Buffer_;
00036
00037     if (!pstHeader)
00038     {
00039         printf("NULL Header object\n");
00040         return;
00041     }
00042
00043     printf( "--[Magic Number:  " );
00044     if (pstHeader->u32IdentMagicNumber == ELF_MAGIC_NUMBER)
00045     {
00046         printf( "Valid]\n");
00047     }

```

```

00048     else
00049     {
00050         printf( "Invalid (%08X)\n", pstHeader->u32IdentMagicNumber);
00051         return;
00052     }
00053
00054     printf( "--[Format:  " );
00055     switch (pstHeader->u8IdentFormat)
00056     {
00057     case ELF_CLASS_32BIT:    printf( "32Bit]\n" ); break;
00058     case ELF_CLASS_64BIT:    printf( "64Bit]\n" ); break;
00059     default:
00060         printf( "Unknown (0x%02X)\n", pstHeader->u8IdentFormat );
00061         break;
00062     }
00063
00064     printf( "--[Endianness:  " );
00065     switch (pstHeader->u8IdentEndianness)
00066     {
00067     case ELF_ENDIAN_BIG:     printf( "Big]\n" ); break;
00068     case ELF_ENDIAN_LITTLE:  printf( "Little]\n" ); break;
00069     default:
00070         printf( "Unknown (0x%02X)\n", pstHeader->u8IdentEndianness );
00071         break;
00072     }
00073
00074     printf( "--[Version:  " );
00075     if (pstHeader->u8IdentVersion == ELF_IDENT_VERSION_ORIGINAL)
00076     {
00077         printf( "Original ELF]\n");
00078     }
00079     else
00080     {
00081         printf( "Unknown (0x%02X)\n", pstHeader->u8IdentVersion );
00082     }
00083
00084     printf( "--[ABI Format:  " );
00085     switch (pstHeader->u8IdentABI)
00086     {
00087     case ELF_OSABI_SYSV:     printf( "System V]\n" ); break;
00088     case ELF_OSABI_HPUX:     printf( "HP-UX]\n" ); break;
00089     case ELF_OSABI_NETBSD:   printf( "NetBSD]\n" ); break;
00090     case ELF_OSABI_LINUX:    printf( "Linux]\n" ); break;
00091     case ELF_OSABI_SOLARIS:   printf( "Solarix]\n" ); break;
00092     case ELF_OSABI_AIX:      printf( "AIX]\n" ); break;
00093     case ELF_OSABI_IRIX:     printf( "IRIX]\n" ); break;
00094     case ELF_OSABI_FREEBSD:   printf( "FreeBSD]\n" ); break;
00095     case ELF_OSABI_OPENBSD:  printf( "OpenBSD]\n" ); break;
00096     default:
00097         printf( "unknown (0x%02X)\n", pstHeader->u8IdentABI );
00098         break;
00099     }
00100
00101     printf( "--[ABI Version: 0x%02X]\n", pstHeader->u8IdentABIVersion );
00102
00103     printf( "--[Binary Type:  " );
00104     switch (pstHeader->u16Type)
00105     {
00106     case ELF_TYPE_RELOCATABLE: printf( "Relocatable]\n"); break;
00107     case ELF_TYPE_EXECUTABLE:  printf( "Executable]\n"); break;
00108     case ELF_TYPE_SHARED:      printf( "Shared]\n"); break;
00109     case ELF_TYPE_CORE:        printf( "Core]\n"); break;
00110     default:
00111         printf( "unknown (0x%04X)\n", pstHeader->u16Type );
00112         break;
00113     }
00114
00115     printf( "--[Machine Type:  " );
00116     switch (pstHeader->u16Machine)
00117     {
00118     case ELF_MACHINE_SPARC:    printf( "SPARC]\n" ); break;
00119     case ELF_MACHINE_X86:      printf( "x86]\n" ); break;
00120     case ELF_MACHINE_MIPS:     printf( "MIPS]\n" ); break;
00121     case ELF_MACHINE_POWERPC:  printf( "PowerPC]\n" ); break;
00122     case ELF_MACHINE_ARM:      printf( "ARM]\n" ); break;
00123     case ELF_MACHINE_SUPERH:   printf( "SuperH]\n" ); break;
00124     case ELF_MACHINE_IA64:     printf( "IA64]\n" ); break;
00125     case ELF_MACHINE_X86_64:   printf( "x86-64]\n" ); break;
00126     case ELF_MACHINE_AARCH64:  printf( "AArch64]\n" ); break;
00127     case ELF_MACHINE_AVR:      printf( "Atmel AVR]\n" ); break;
00128     default:
00129         printf( "unknown (0x%04X)\n", pstHeader->u16Machine );
00130         break;
00131     }
00132
00133     printf( "--[Version: 0x%08X]\n", pstHeader->u32Version );
00134     printf( "--[Entry Point: 0x%08X]\n", pstHeader->u32EntryPoint );

```



```

00135     printf( "--[Program Header Offset: 0x%08X]\n", pstHeader->u32PHOffset );
00136     printf( "--[Section Header Offset: 0x%08X]\n", pstHeader->u32SHOffset );
00137     printf( "--[Flags: 0x%08X]\n", pstHeader->u32Flags );
00138     printf( "--[Elf Header Size: %d]\n", pstHeader->u16EHSize );
00139     printf( "--[Program Header Size: %d]\n", pstHeader->u16PHSize );
00140     printf( "--[Program Header Count: %d]\n", pstHeader->u16PHNum );
00141     printf( "--[Section Header Size: %d]\n", pstHeader->u16SHSize );
00142     printf( "--[Section Header Count: %d]\n", pstHeader->u16SHNum );
00143     printf( "--[Section Header Index: %d]\n", pstHeader->u16SHIndex );
00144 }
00145
00146 //-----
00147 void ELF_PrintSections( const uint8_t *pau8Buffer_ )
00148 {
00149     ElfHeader_t *pstHeader = (ElfHeader_t*)pau8Buffer_;
00150     uint32_t u32StringOffset = ELF_GetHeaderStringTableOffset( pau8Buffer_ );
00151
00152     uint32_t u32Offset;
00153     uint16_t u16SHCount;
00154
00155     u32Offset = pstHeader->u32SHOffset;
00156     u16SHCount = pstHeader->u16SHNum;
00157
00158     while (u16SHCount)
00159     {
00160         ElfSectionHeader_t *pstSHeader = (ElfSectionHeader_t*)&
00161             pau8Buffer_[u32Offset];
00162         printf( "\n--[Section header @ 0x%08X]\n", u32Offset );
00163         printf( "--[Name %s]\n", &pau8Buffer_[u32StringOffset + pstSHeader->u32Name] );
00164
00165         printf( "--[Type " );
00166         switch (pstSHeader->u32Type)
00167         {
00168             case ELF_SECTION_TYPE_NULL: printf( "NULL]\n" ); break;
00169             case ELF_SECTION_TYPE_NOBITS: printf( "NOBITS]\n" ); break;
00170             case ELF_SECTION_TYPE_PROGBITS: printf( "PROGBITS]\n" ); break;
00171             case ELF_SECTION_TYPE_STRTAB: printf( "STRTAB]\n" ); break;
00172             case ELF_SECTION_TYPE_SYMTAB: printf( "SYMTAB]\n" ); break;
00173             default:
00174                 printf( "(unknown) 0x%08X]\n", pstSHeader->u32Type );
00175                 break;
00176         }
00177
00178         printf( "--[Flags @ 0x%08X]\n", pstSHeader->u32Flags );
00179         printf( "--[Address @ 0x%08X]\n", pstSHeader->u32Address );
00180         printf( "--[Offset @ 0x%08X]\n", pstSHeader->u32Offset );
00181         printf( "--[Size @ 0x%08X]\n", pstSHeader->u32Size );
00182         printf( "--[Link @ 0x%08X]\n", pstSHeader->u32Link );
00183         printf( "--[Info @ 0x%08X]\n", pstSHeader->u32Info );
00184         printf( "--[Alignment @ 0x%08X]\n", pstSHeader->u32Alignment );
00185         printf( "--[Entry Size @ 0x%08X]\n", pstSHeader->u32EntrySize );
00186         //--
00187         u16SHCount--;
00188         u32Offset += (pstHeader->u16SHSize);
00189     }
00190
00191 //-----
00192 void ELF_PrintSymbols( const uint8_t *pau8Buffer_ )
00193 {
00194     // Get a pointer to the section header for the symbol table
00195     uint32_t u32Offset = ELF_GetSymbolTableOffset( pau8Buffer_ );
00196     ElfSectionHeader_t *pstSymHeader = (ElfSectionHeader_t*)&
00197         pau8Buffer_[u32Offset];
00198
00199     // Get a pointer to the section header for the symbol table's strings
00200     u32Offset = ELF_GetSymbolStringTableOffset( pau8Buffer_ );
00201     ElfSectionHeader_t *pstStrHeader = (ElfSectionHeader_t*)&
00202         pau8Buffer_[u32Offset];
00203
00204     // Iterate through the symbol table section, printing out the details of each.
00205     uint32_t u32SymOffset = pstSymHeader->u32Offset;
00206     ElfSymbol_t *pstSymbol = (ElfSymbol_t*)&pau8Buffer_[u32SymOffset];
00207
00208     printf( "VALUE SIZE TYPE SCOPE ID NAME\n" );
00209     while (u32SymOffset < (pstSymHeader->u32Offset + pstSymHeader->u32Size))
00210     {
00211         printf( "%08X, ", pstSymbol->u32Value );
00212         printf( "%5d, ", pstSymbol->u32Size );
00213         uint8_t u8Type = pstSymbol->u8Info & 0x0F;
00214         switch (u8Type)
00215         {
00216             case 0: printf( "NOTYPE, " ); break;
00217             case 1: printf( "OBJECT, " ); break;
00218             case 2: printf( "FUNC, " ); break;
00219             case 3: printf( "SECTION, " ); break;
00220             case 4: printf( "FILE, " ); break;

```

```

00219         default:    printf( "Unknown (%02X), ", u8Type); break;
00220     }
00221     u8Type = (pstSymbol->u8Info >> 4) & 0x0F;
00222     switch (u8Type)
00223     {
00224         case 0:      printf( "LOCAL, " ); break;
00225         case 1:      printf( "GLOBAL " ); break;
00226         case 2:      printf( "WEAK, " ); break;
00227         default:     printf( "Unknown (%02X), ", u8Type); break;
00228     }
00229
00230     if (65521 == pstSymbol->u16SHIndex) // 65521 == special value "ABS"
00231     {
00232         printf("  ABS, ");
00233     }
00234     else
00235     {
00236         printf( "%5d, ", pstSymbol->u16SHIndex );
00237     }
00238     printf( "%s\n", &pau8Buffer_[pstSymbol->u32Name + pstStrHeader->u32Offset] );
00239
00240     u32SymOffset += pstSymHeader->u32EntrySize;
00241     pstSymbol = (ElfSymbol_t*)(&pau8Buffer_[u32SymOffset]);
00242 }
00243 }
00244
00245 //-----
00246 void ELF_PrintProgramHeaders( const uint8_t *pau8Buffer_ )
00247 {
00248     ElfHeader_t *pstHeader = (ElfHeader_t*)(pau8Buffer_);
00249     uint32_t u32Offset = pstHeader->u32PHOffset;
00250     uint32_t u16Count = pstHeader->u16PHNum;
00251
00252     while (u16Count)
00253     {
00254         ElfProgramHeader_t *pstProgHeader = (
00255             ElfProgramHeader_t*)(&pau8Buffer_[u32Offset]);
00256         printf( "Program Header:\n" );
00257         printf( "--[Type:      %08X]\n", pstProgHeader->u32Type );
00258         printf( "--[Offset:    %08X]\n", pstProgHeader->u32Offset );
00259         printf( "--[VAddr:     %08X]\n", pstProgHeader->u32VirtualAddress );
00260         printf( "--[PAddr:     %08X]\n", pstProgHeader->u32PhysicalAddress );
00261         printf( "--[FileSize:  %08X]\n", pstProgHeader->u32FileSize );
00262         printf( "--[MemSize:   %08X]\n", pstProgHeader->u32MemSize );
00263         printf( "--[Flags:     %08X]\n", pstProgHeader->u32Flags );
00264         printf( "--[Alignment: %08X]\n", pstProgHeader->u32Alignment );
00265
00266         u32Offset += pstHeader->u16PHSize;
00267         u16Count--;
00268     }
00269 }

```

4.69 src/debug/elf_print.h File Reference

Functions to print information from ELF files.

```

#include "elf_types.h"
#include <stdint.h>

```

Functions

- void [ELF_PrintHeader](#) (const uint8_t *pau8Buffer_)
ELF_PrintHeader.
- void [ELF_PrintSections](#) (const uint8_t *pau8Buffer_)
ELF_PrintSections.
- void [ELF_PrintSymbols](#) (const uint8_t *pau8Buffer_)
ELF_PrintSymbols.
- void [ELF_PrintProgramHeaders](#) (const uint8_t *pau8Buffer_)
ELF_PrintProgramHeaders.

4.69.1 Detailed Description

Functions to print information from ELF files.

Definition in file [elf_print.h](#).

4.69.2 Function Documentation

4.69.2.1 void ELF_PrintHeader (const uint8_t * *pau8Buffer_*)

ELF_PrintHeader.

Print the contents of a loaded ELF file's header data to standard output.

Parameters

<i>pau8Buffer_</i>	Buffer containing the loaded ELF contents
--------------------	---

Definition at line 33 of file [elf_print.c](#).

4.69.2.2 void ELF_PrintProgramHeaders (const uint8_t * *pau8Buffer_*)

ELF_PrintProgramHeaders.

Print the list of program headers stored in the loaded ELF file .

Parameters

<i>pau8Buffer_</i>	Buffer containing the loaded ELF contents
--------------------	---

Definition at line 246 of file [elf_print.c](#).

4.69.2.3 void ELF_PrintSections (const uint8_t * *pau8Buffer_*)

ELF_PrintSections.

Print a list of named sections contained in the loaded ELF file.

Parameters

<i>pau8Buffer_</i>	Buffer containing the loaded ELF contents
--------------------	---

Definition at line 147 of file [elf_print.c](#).

4.69.2.4 void ELF_PrintSymbols (const uint8_t * *pau8Buffer_*)

ELF_PrintSymbols.

Print a list of ELF Symbols contained in the loaded ELF file.

Parameters

<i>pau8Buffer_</i>	Buffer containing the loaded ELF contents
--------------------	---

Definition at line 192 of file [elf_print.c](#).

4.70 elf_print.h

```

00001  /*****
00002  *      (      (      (      |
00003  *      )\ )  )\ )  (      )\ )  |
00004  *      (( / ( (( / ( )\      ( ( (( / ( | -- [ Funkenstein ] -----

```

```

00005 *      /(_) ) /(_) ) ((((_) () \ ) \ /(_) )      | -- [ Little ] -----
00006 *      ( ) _ ( ) ) \ _ ) \ ( ) ( ) ( ) )      | -- [ AVR ] -----
00007 *      | _ | | | ( ) \ ( ) \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ V / | _ |      |
00010 *      * -----+ "Yeah, it does Arduino..."
00011 *
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 *      See license.txt for details
00014 * *****/
00021 #ifndef __ELF_PRINT_H__
00022 #define __ELF_PRINT_H__
00023
00024 #include "elf_types.h"
00025 #include <stdint.h>
00026
00027 //-----
00035 void ELF_PrintHeader( const uint8_t *pau8Buffer_ );
00036
00037 //-----
00045 void ELF_PrintSections( const uint8_t *pau8Buffer_ );
00046
00047 //-----
00055 void ELF_PrintSymbols( const uint8_t *pau8Buffer_ );
00056
00057 //-----
00065 void ELF_PrintProgramHeaders( const uint8_t *pau8Buffer_ );
00066
00067 #endif //__ELF_PRINT_H__

```

4.71 src/debug/elf_types.h File Reference

Defines and types used by ELF loader and supporting functionality.

```
#include <stdint.h>
```

Data Structures

- struct [ElfHeader_t](#)
- struct [ElfProgramHeader_t](#)
- struct [ElfSectionHeader_t](#)
- struct [ElfSymbol_t](#)

Macros

- #define **ELF_MAGIC_NUMBER** ((uint32_t)0x464C457F)
- #define **ELF_CLASS_32BIT** ((uint8_t)1)
- #define **ELF_CLASS_64BIT** ((uint8_t)2)
- #define **ELF_ENDIAN_LITTLE** ((uint8_t)1)
- #define **ELF_ENDIAN_BIG** ((uint8_t)2)
- #define **ELF_IDENT_VERSION_ORIGINAL** ((uint8_t)1)
- #define **ELF_OSABI_SYSV** ((uint8_t)0x00)
- #define **ELF_OSABI_HPUX** ((uint8_t)0x01)
- #define **ELF_OSABI_NETBSD** ((uint8_t)0x02)
- #define **ELF_OSABI_LINUX** ((uint8_t)0x03)
- #define **ELF_OSABI_SOLARIS** ((uint8_t)0x06)
- #define **ELF_OSABI_AIX** ((uint8_t)0x07)
- #define **ELF_OSABI_IRIX** ((uint8_t)0x08)
- #define **ELF_OSABI_FREEBSD** ((uint8_t)0x09)
- #define **ELF_OSABI_OPENBSD** ((uint8_t)0x0C)
- #define **ELF_TYPE_RELOCATABLE** ((uint8_t)0x01)
- #define **ELF_TYPE_EXECUTABLE** ((uint8_t)0x02)

- `#define ELF_TYPE_SHARED ((uint8_t)0x03)`
- `#define ELF_TYPE_CORE ((uint8_t)0x04)`
- `#define ELF_MACHINE_SPARC ((uint16_t)0x02)`
- `#define ELF_MACHINE_X86 ((uint16_t)0x03)`
- `#define ELF_MACHINE_MIPS ((uint16_t)0x08)`
- `#define ELF_MACHINE_POWERPC ((uint16_t)0x14)`
- `#define ELF_MACHINE_ARM ((uint16_t)0x28)`
- `#define ELF_MACHINE_SUPERH ((uint16_t)0x2A)`
- `#define ELF_MACHINE_IA64 ((uint16_t)0x32)`
- `#define ELF_MACHINE_X86_64 ((uint16_t)0x3E)`
- `#define ELF_MACHINE_AVR ((uint16_t)0x53)`
- `#define ELF_MACHINE_AARCH64 ((uint16_t)0xB7)`
- `#define ELF_VERSION_ORIGINAL ((uint32_t)1)`
- `#define ELF_SECTION_TYPE_NULL ((uint32_t)0)`
- `#define ELF_SECTION_TYPE_PROGBITS ((uint32_t)1)`
- `#define ELF_SECTION_TYPE_SYMTAB ((uint32_t)2)`
- `#define ELF_SECTION_TYPE_STRTAB ((uint32_t)3)`
- `#define ELF_SECTION_TYPE_NOBITS ((uint32_t)8)`

4.71.1 Detailed Description

Defines and types used by ELF loader and supporting functionality.

Definition in file [elf_types.h](#).

4.72 elf_types.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/ ( ( ( / (      \      (      ( ( / (      | -- [ Funkenstein ] -----
00005 *      / ( ) / ( ) ((( ( ( ) \      / ( )      | -- [ Little ] -----
00006 *      ( ) _ | ( )      ) \ _ ) \ ( ( ) ( ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ / / | _ \      | -- [ Runtime ] -----
00009 *      | _ | | _ _      / _ \ \ \ / / | _ \      |
00010 *                                          | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __ELF_TYPES_H__
00022 #define __ELF_TYPES_H__
00023
00024 #include <stdint.h>
00025
00026 //-----
00027 #define ELF_MAGIC_NUMBER          ((uint32_t)0x464C457F) // "~ELF"
00028
00029 #define ELF_CLASS_32BIT           ((uint8_t)1)
00030 #define ELF_CLASS_64BIT           ((uint8_t)2)
00031
00032 #define ELF_ENDIAN_LITTLE         ((uint8_t)1)
00033 #define ELF_ENDIAN_BIG            ((uint8_t)2)
00034
00035 #define ELF_IDENT_VERSION_ORIGINAL ((uint8_t)1)
00036
00037 #define ELF_OSABI_SYSV             ((uint8_t)0x00)
00038 #define ELF_OSABI_HPUX             ((uint8_t)0x01)
00039 #define ELF_OSABI_NETBSD           ((uint8_t)0x02)
00040 #define ELF_OSABI_LINUX            ((uint8_t)0x03)
00041 #define ELF_OSABI_SOLARIS          ((uint8_t)0x06)
00042 #define ELF_OSABI_AIX              ((uint8_t)0x07)
00043 #define ELF_OSABI_IRIX             ((uint8_t)0x08)
00044 #define ELF_OSABI_FREEBSD          ((uint8_t)0x09)
00045 #define ELF_OSABI_OPENBSD          ((uint8_t)0x0C)
00046
00047 #define ELF_TYPE_RELOCATABLE       ((uint8_t)0x01)
00048 #define ELF_TYPE_EXECUTABLE       ((uint8_t)0x02)

```

```

00049 #define ELF_TYPE_SHARED          ((uint8_t)0x03)
00050 #define ELF_TYPE_CORE              ((uint8_t)0x04)
00051
00052 #define ELF_MACHINE_SPARC          ((uint16_t)0x02)
00053 #define ELF_MACHINE_X86            ((uint16_t)0x03)
00054 #define ELF_MACHINE_MIPS           ((uint16_t)0x08)
00055 #define ELF_MACHINE_POWERPC        ((uint16_t)0x14)
00056 #define ELF_MACHINE_ARM             ((uint16_t)0x28)
00057 #define ELF_MACHINE_SUPERH         ((uint16_t)0x2A)
00058 #define ELF_MACHINE_IA64           ((uint16_t)0x32)
00059 #define ELF_MACHINE_X86_64         ((uint16_t)0x3E)
00060 #define ELF_MACHINE_AVR             ((uint16_t)0x53)
00061 #define ELF_MACHINE_AARCH64        ((uint16_t)0xB7)
00062
00063 #define ELF_VERSION_ORIGINAL        ((uint32_t)1)
00064
00065 #define ELF_SECTION_TYPE_NULL      ((uint32_t)0)
00066 #define ELF_SECTION_TYPE_PROGBITS  ((uint32_t)1)
00067 #define ELF_SECTION_TYPE_SYMTAB    ((uint32_t)2)
00068 #define ELF_SECTION_TYPE_STRTAB    ((uint32_t)3)
00069 #define ELF_SECTION_TYPE_NOBITS    ((uint32_t)8)
00070
00071 //-----
00072 typedef struct
00073 {
00074     // (Explicit line breaks to show 32-bit alignment)
00075     //---- 0x00
00076     uint32_t    u32IdentMagicNumber;
00077
00078     //---- 0x04
00079     uint8_t      u8IdentFormat;
00080     uint8_t      u8IdentEndianness;
00081     uint8_t      u8IdentVersion;
00082     uint8_t      u8IdentABI;
00083
00084     //---- 0x08
00085     uint8_t      u8IdentABIVersion;
00086     uint8_t      u8Pad1[7];
00087
00088     //---- 0x10
00089     uint16_t     u16Type;
00090     uint16_t     u16Machine;
00091
00092     //---- 0x14
00093     uint32_t     u32Version;
00094
00095     //---- 0x18
00096     uint32_t     u32EntryPoint;
00097
00098     //---- 0x1C
00099     uint32_t     u32PHOffset;
00100
00101     //---- 0x20
00102     uint32_t     u32SHOffset;
00103
00104     //---- 0x24
00105     uint32_t     u32Flags;
00106
00107     //---- 0x28
00108     uint16_t     u16EHSize;
00109     uint16_t     u16PHSize;
00110
00111     //---- 0x2C
00112     uint16_t     u16PHNum;
00113     uint16_t     u16SHSize;
00114
00115     //---- 0x30
00116     uint16_t     u16SHNum;
00117     uint16_t     u16SHIndex;
00118
00119 } ElfHeader_t;
00120
00121 //-----
00122 typedef struct
00123 {
00124     uint32_t     u32Type;
00125     uint32_t     u32Offset;
00126     uint32_t     u32VirtualAddress;
00127     uint32_t     u32PhysicalAddress;
00128     uint32_t     u32FileSize;
00129     uint32_t     u32MemSize;
00130     uint32_t     u32Flags;
00131     uint32_t     u32Alignment;
00132 } ElfProgramHeader_t;
00133
00134 //-----
00135 typedef struct

```

```

00136 {
00137     uint32_t    u32Name;
00138     uint32_t    u32Type;
00139     uint32_t    u32Flags;
00140     uint32_t    u32Address;
00141     uint32_t    u32Offset;
00142     uint32_t    u32Size;
00143     uint32_t    u32Link;
00144     uint32_t    u32Info;
00145     uint32_t    u32Alignment;
00146     uint32_t    u32EntrySize;
00147 } ElfSectionHeader_t;
00148
00149 //-----
00150 typedef struct
00151 {
00152     uint32_t    u32Name;
00153     uint32_t    u32Value;
00154     uint32_t    u32Size;
00155     uint8_t     u8Info;
00156     uint8_t     u8Other;
00157     uint16_t    u16SHIndex;
00158 } ElfSymbol_t;
00159
00160
00161 #endif /* __ELF_TYPES_H__

```

4.73 src/debug/interactive.c File Reference

Interactive debugging support.

```

#include "emu_config.h"
#include "avr_cpu.h"
#include "avr_cpu_print.h"
#include "watchpoint.h"
#include "breakpoint.h"
#include "avr_disasm.h"
#include "trace_buffer.h"
#include "debug_sym.h"
#include "write_callout.h"
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

```

Data Structures

- struct [Interactive_Command_t](#)
Struct type used to map debugger command-line inputs to command handlers.

Typedefs

- typedef bool(* [Interactive_Handler](#))(char *szCommand_)
Function pointer type used to implement interactive command handlers.

Functions

- static bool [Interactive_Continue](#)(char *szCommand_)
Interactive_Continue.
- static bool [Interactive_Step](#)(char *szCommand_)
Interactive_Step.

- static bool [Interactive_Break](#) (char *szCommand_)
Interactive_Break.
- static bool [Interactive_Watch](#) (char *szCommand_)
Interactive_Watch.
- static bool [Interactive_ROM](#) (char *szCommand_)
Interactive_ROM.
- static bool [Interactive_RAM](#) (char *szCommand_)
Interactive_RAM.
- static bool [Interactive_EE](#) (char *szCommand_)
Interactive_EE.
- static bool [Interactive_Registers](#) (char *szCommand_)
Interactive_Registers.
- static bool [Interactive_Quit](#) (char *szCommand_)
Interactive_Quit.
- static bool [Interactive_Help](#) (char *szCommand_)
Interactive_Help.
- static bool [Interactive_Disasm](#) (char *szCommand_)
Interactive_Disasm.
- static bool [Interactive_Trace](#) (char *szCommand_)
Interactive_Trace.
- static bool [Interactive_BreakFunc](#) (char *szCommand_)
Interactive_BreakFunc.
- static bool [Interactive_WatchObj](#) (char *szCommand_)
Interactive_WatchObj.
- static bool [Interactive_ListObj](#) (char *szCommand_)
Interactive_ListObj.
- static bool [Interactive_ListFunc](#) (char *szCommand_)
Interactive_ListFunc.
- static bool **Interactive_Execute_i** (void)
- void [Interactive_CheckAndExecute](#) (void)
Interactive_CheckAndExecute.
- void [Interactive_Set](#) (void)
Interactive_Set.
- bool **Interactive_WatchpointCallback** (uint16_t u16Addr_, uint8_t u8Val_)
- void [Interactive_Init](#) ([TraceBuffer_t](#) *pstTrace_)
Interactive_Init.
- static bool **Token_ScanNext** (char *szCommand_, int iStart_, int *piTokenStart_, int *piTokenLen_)
- static bool **Token_DiscardNext** (char *szCommand_, int iStart_, int *piNextTokenStart_)
- static bool **Token_ReadNextHex** (char *szCommand_, int iStart_, int *piNextTokenStart_, unsigned int *puiVal_)

Variables

- static bool [bIsInteractive](#)
"true" when interactive debugger is running
- static bool [bRetrigger](#)
"true" when the debugger needs to be enabled on the next cycle
- static [TraceBuffer_t](#) * [pstTrace](#) = 0
Pointer to a tracebuffer object used for printing CPU execution trace.
- static [Interactive_Command_t](#) **astCommands** []

4.73.1 Detailed Description

Interactive debugging support.

Provides mechanism for debugging a virtual AVR microcontroller with a variety of functionality common to external debuggers, such as GDB.

Definition in file [interactive.c](#).

4.73.2 Typedef Documentation

4.73.2.1 typedef bool(* Interactive_Handler)(char *szCommand_)

Function pointer type used to implement interactive command handlers.

szCommand_ is a pointer to a string of command-line data entered from the debug console. returns a boolean value of "true" if executing this command should cause the parser to exit interactive mode.

Definition at line 46 of file [interactive.c](#).

4.73.3 Function Documentation

4.73.3.1 static bool Interactive_Break (char * szCommand_) [static]

Interactive_Break.

Inserts a CPU breakpoint at a hex-address specified in the commandline

Parameters

szCommand_	command-line data passed in by the user.
------------	--

Returns

false - continue interactive debugging

Definition at line 478 of file [interactive.c](#).

4.73.3.2 static bool Interactive_BreakFunc (char * szCommand_) [static]

Interactive_BreakFunc.

Toggle a breakpoint at the beginning of a function referenced by name. Requires that the symbol name match a valid debug symbol loaded from an elf binary (i.e., not from a hex file).

Parameters

szCommand_	command-line data passed in by the user.
------------	--

Returns

false - continue interactive debugging

Definition at line 667 of file [interactive.c](#).

4.73.3.3 void Interactive_CheckAndExecute (void)

Interactive_CheckAndExecute.

Wait for feedback and execute if running interactive. Otherwise, continue execution without waiting.

Definition at line 341 of file [interactive.c](#).

4.73.3.4 static bool Interactive_Continue (char * *szCommand_*) [static]

Interactive_Continue.

Handler function used to implement the debugger's "continue" function, which exits interactive mode until the next breakpoint or watchpoint is hit.

Parameters

<i>szCommand_</i>	commnd-line data passed in by the user
-------------------	--

Returns

true - exit interactive debugging

Definition at line 470 of file [interactive.c](#).

4.73.3.5 static bool Interactive_Disasm (char * *szCommand_*) [static]

Interactive_Disasm.

Show the disassembly for the CPU's current opcode on the console.

Parameters

<i>szCommand_</i>	command-line data passed in by the user.
-------------------	--

Returns

false - continue interactive debugging

Definition at line 646 of file [interactive.c](#).

4.73.3.6 static bool Interactive_EE (char * *szCommand_*) [static]

Interactive_EE.

Display the contents of EEPROM (hex address, hex words) on the console

Parameters

<i>szCommand_</i>	command-line data passed in by the user.
-------------------	--

Returns

false - continue interactive debugging

Definition at line 586 of file [interactive.c](#).

4.73.3.7 static bool Interactive_Help (char * *szCommand_*) [static]

Interactive_Help.

Display the interactive help menu, listing available debugger commands on the console.

Parameters

<i>szCommand_</i>	command-line data passed in by the user.
-------------------	--

Returns

false - continue interactive debugging

Definition at line 633 of file [interactive.c](#).

4.73.3.8 void Interactive_Init (TraceBuffer_t * *pstTrace_*)

Interactive_Init.

Initialize the interactive debugger session for the given CPU struct and associated debug data

Parameters

<i>pstTrace_</i>	Pointer to the tracebuffer object
------------------	-----------------------------------

Definition at line 382 of file [interactive.c](#).

4.73.3.9 static bool Interactive_ListFunc (char * *szCommand_*) [static]

Interactive_ListFunc.

Display a list of functions in the symbol table, if the program was read from an ELF file, and contains debug symbols.

Parameters

<i>szCommand_</i>	command-line data passed in by the user.
-------------------	--

Returns

false - continue interactive debugging

Definition at line 783 of file [interactive.c](#).

4.73.3.10 static bool Interactive_ListObj (char * *szCommand_*) [static]

Interactive_ListObj.

Display a list of objects in the symbol table, if the program was read from an ELF file, and contains debug symbols.

Parameters

<i>szCommand_</i>	command-line data passed in by the user.
-------------------	--

Returns

false - continue interactive debugging

Definition at line 763 of file [interactive.c](#).

4.73.3.11 static bool Interactive_Quit (char * *szCommand_*) [static]

Interactive_Quit.

Stop debugging, and exit fIAVR.

Parameters

<i>szCommand_</i>	command-line data passed in by the user.
-------------------	--

Returns

N/A - does not return (program terminates)

Definition at line 620 of file [interactive.c](#).

4.73.3.12 `static bool Interactive_RAM (char * szCommand_) [static]`

Interactive_RAM.

Display the contents of RAM (hex address, hex words) on the console

Parameters

<i>szCommand_</i>	command-line data passed in by the user.
-------------------	--

Returns

false - continue interactive debugging

Definition at line 559 of file [interactive.c](#).

4.73.3.13 `static bool Interactive_Registers (char * szCommand_) [static]`

Interactive_Registers.

Display the contents of the core CPU registers on the console

Parameters

<i>szCommand_</i>	command-line data passed in by the user.
-------------------	--

Returns

false - continue interactive debugging

Definition at line 613 of file [interactive.c](#).

4.73.3.14 `static bool Interactive_ROM (char * szCommand_) [static]`

Interactive_ROM.

Display the contents of ROM (hex address, hex words) on the console

Parameters

<i>szCommand_</i>	command-line data passed in by the user.
-------------------	--

Returns

false - continue interactive debugging

Definition at line 532 of file [interactive.c](#).

4.73.3.15 void Interactive_Set (void)

Interactive_Set.

Enable interactive-debug mode on the next instruction cycle.

Definition at line 361 of file [interactive.c](#).

4.73.3.16 static bool Interactive_Step (char * szCommand_) [static]

Interactive_Step.

Cause the debugger to step to the next CPU instruction and return back to the debug console for further input.

Parameters

<i>szCommand_</i>	commnd-line data passed in by the user
-------------------	--

Returns

true - exit interactive debugging

Definition at line 626 of file [interactive.c](#).

4.73.3.17 static bool Interactive_Trace (char * szCommand_) [static]

Interactive_Trace.

Dump the contents of the simulator's tracebuffer to the command-line

Parameters

<i>szCommand_</i>	command-line data passed in by the user.
-------------------	--

Returns

false - continue interactive debugging

Definition at line 660 of file [interactive.c](#).

4.73.3.18 static bool Interactive_Watch (char * szCommand_) [static]

Interactive_Watch.

Insert a CPU data watchpoint at a hex-address specified in the commandline

Parameters

<i>szCommand_</i>	command-line data passed in by the user.
-------------------	--

Returns

false - continue interactive debugging

Definition at line 506 of file [interactive.c](#).

4.73.3.19 static bool Interactive_WatchObj (char * szCommand_) [static]

Interactive_WatchObj.

Toggle a watchpoint at the beginning of an object referenced by name. Requires that the symbol name match a valid debug symbol loaded from an elf binary (i.e., not from a hex file).

Parameters

<code>szCommand_</code>	command-line data passed in by the user.
-------------------------	--

Returns

false - continue interactive debugging

Definition at line 711 of file [interactive.c](#).

4.73.4 Variable Documentation

4.73.4.1 Interactive_Command_t astCommands[] [static]

Initial value:

```
=
{
    { "registers", "Dump registers to console", Interactive_Registers },
    { "continue", "continue execution", Interactive_Continue },
    { "disasm", "show disassembly", Interactive_Disasm },
    { "trace", "Dump tracebuffer to console", Interactive_Trace},
    { "break", "toggle breakpoint at address", Interactive_Break },
    { "watch", "toggle watchpoint at address", Interactive_Watch },
    { "lfunc", "List Functions", Interactive_ListFunc },
    { "help", "List commands", Interactive_Help },
    { "step", "Step to next instruction", Interactive_Step },
    { "quit", "Quit emulator", Interactive_Quit },
    { "lobj", "List Objects", Interactive_ListObj },
    { "bsym", "Toggle breakpoint at function referenced by symbol",
      Interactive_BreakFunc },
    { "wobj", "Toggle watchpoint on object referenced by symbol",
      Interactive_WatchObj },
    { "reg", "Dump registers to console", Interactive_Registers },
    { "rom", "Dump x bytes of ROM to console", Interactive_ROM },
    { "ram", "Dump x bytes of RAM to console", Interactive_RAM },
    { "ee", "Dump x bytes of RAM to console", Interactive_EE },
    { "b", "toggle breakpoint at address", Interactive_Break },
    { "c", "continue execution", Interactive_Continue },
    { "d", "show disassembly", Interactive_Disasm },
    { "w", "toggle watchpoint at address", Interactive_Watch },
    { "q", "Quit emulator", Interactive_Quit },
    { "s", "Step to next instruction", Interactive_Step },
    { "t", "Dump tracebuffer to console", Interactive_Trace},
    { "h", "List commands", Interactive_Help },
    { 0 }
}
```

Definition at line 252 of file [interactive.c](#).

4.74 interactive.c

```
00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( (/( (      ( (/( | -- [ Funkenstein ] -----
00005 *      /( ) /( ) ((( ( ) \ \ / ( ) | -- [ Little ] -----
00006 *      ( ) _ ( ) ) \ _ ) \ ( ( ( ) _ | -- [ AVR ] -----
00007 *      | _ | | ( ) _ \ ( ) \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ V / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _ / _ \ \ / | _ \ |
00010 *                                     | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00023 #include "emu_config.h"
00024 #include "avr_cpu.h"
00025 #include "avr_cpu_print.h"
00026 #include "watchpoint.h"
00027 #include "breakpoint.h"
00028 #include "avr_disasm.h"
00029 #include "trace_buffer.h"
```

```

00030 #include "debug_sym.h"
00031 #include "write_callout.h"
00032
00033 #include <stdint.h>
00034 #include <stdio.h>
00035 #include <stdlib.h>
00036 #include <string.h>
00037
00038 //-----
00046 typedef bool (*Interactive_Handler)( char *szCommand_ );
00047
00048 //-----
00052 typedef struct
00053 {
00054     const char *szCommand;
00055     const char *szDescription;
00056     Interactive_Handler pfHandler;
00057 } Interactive_Command_t;
00058
00059 //-----
00060 static bool bIsInteractive;
00061 static bool bRetrigger;
00062
00063 static TraceBuffer_t *pstTrace = 0;
00064
00065 //-----
00075 static bool Interactive_Continue( char *szCommand_ );
00076
00077 //-----
00087 static bool Interactive_Step( char *szCommand_ );
00088
00089 //-----
00098 static bool Interactive_Break( char *szCommand_ );
00099
00100 //-----
00109 static bool Interactive_Watch( char *szCommand_ );
00110
00111 //-----
00120 static bool Interactive_ROM( char *szCommand_ );
00121
00122 //-----
00131 static bool Interactive_RAM( char *szCommand_ );
00132
00133 //-----
00142 static bool Interactive_EE( char *szCommand_ );
00143
00144 //-----
00153 static bool Interactive_Registers( char *szCommand_ );
00154
00155 //-----
00164 static bool Interactive_Quit( char *szCommand_ );
00165
00166 //-----
00176 static bool Interactive_Help( char *szCommand_ );
00177
00178 //-----
00187 static bool Interactive_Disasm( char *szCommand_ );
00188
00189 //-----
00198 static bool Interactive_Trace( char *szCommand_ );
00199
00200 //-----
00211 static bool Interactive_BreakFunc( char *szCommand_ );
00212
00213 //-----
00224 static bool Interactive_WatchObj( char *szCommand_ );
00225
00226 //-----
00236 static bool Interactive_ListObj( char *szCommand_ );
00237
00238 //-----
00248 static bool Interactive_ListFunc( char *szCommand_ );
00249
00250 //-----
00251 // Command-handler table
00252 static Interactive_Command_t astCommands[] =
00253 {
00254     { "registers", "Dump registers to console", Interactive_Registers },
00255     { "continue", "continue execution", Interactive_Continue },
00256     { "disasm", "show disassembly", Interactive_Disasm },
00257     { "trace", "Dump tracebuffer to console", Interactive_Trace },
00258     { "break", "toggle breakpoint at address", Interactive_Break },
00259     { "watch", "toggle watchpoint at address", Interactive_Watch },
00260     { "lfunc", "List Functions", Interactive_ListFunc },
00261     { "help", "List commands", Interactive_Help },
00262     { "step", "Step to next instruction", Interactive_Step },
00263     { "quit", "Quit emulator", Interactive_Quit },

```

```

00264     { "lobj",      "List Objects", Interactive_ListObj },
00265     { "bsym",      "Toggle breakpoint at function referenced by symbol",
Interactive_BreakFunc },
00266     { "wobj",      "Toggle watchpoint on object referenced by symbol",
Interactive_WatchObj },
00267     { "reg",       "Dump registers to console", Interactive_Registers },
00268     { "rom",       "Dump x bytes of ROM to console", Interactive_ROM },
00269     { "ram",       "Dump x bytes of RAM to console", Interactive_RAM },
00270     { "ee",        "Dump x bytes of RAM to console", Interactive_EE },
00271     { "b",         "toggle breakpoint at address", Interactive_Break },
00272     { "c",         "continue execution", Interactive_Continue },
00273     { "d",         "show disassembly", Interactive_Disasm },
00274     { "w",         "toggle watchpoint at address", Interactive_Watch },
00275     { "q",         "Quit emulator", Interactive_Quit },
00276     { "s",         "Step to next instruction", Interactive_Step },
00277     { "t",         "Dump tracebuffer to console", Interactive_Trace},
00278     { "h",         "List commands", Interactive_Help },
00279     { 0 }
00280 };
00281
00282 //-----
00283 static bool Interactive_Execute_i( void )
00284 {
00285     // Interactive mode - grab a line from standard input.
00286     char szCmdBuf[256];
00287     int iCmd = 0;
00288
00289     printf( "> " );
00290
00291     // Bail if stdin reaches EOF...
00292     if (0 == fgets(szCmdBuf, 255, stdin))
00293     {
00294         printf("[EOF]\n");
00295         exit(0);
00296     }
00297
00298     iCmd = strlen(szCmdBuf);
00299     if ( iCmd <= 1 )
00300     {
00301         printf("\n");
00302         iCmd = 0;
00303     }
00304     else
00305     {
00306         szCmdBuf[ iCmd - 1 ] = 0;
00307     }
00308
00309     // Compare command w/elements in the command table
00310     Interactive_Command_t *pstCommand = astCommands;
00311     bool bFound = false;
00312     bool bContinue = false;
00313
00314     while (pstCommand->szCommand)
00315     {
00316         if ( (0 == strcmp(pstCommand->szCommand, szCmdBuf, strlen(pstCommand->
szCommand)))
00317             && ( szCmdBuf[ strlen(pstCommand->szCommand) ] == ' ' ||
szCmdBuf[ strlen(pstCommand->szCommand) ] == '\0' ||
00319             szCmdBuf[ strlen(pstCommand->szCommand) ] == '\n' ||
00320             szCmdBuf[ strlen(pstCommand->szCommand) ] == '\r' ) )
00321         {
00322             // printf( "Found match: %s\n", pstCommand->szCommand );
00323             bFound = true;
00324             bContinue = pstCommand->pfnHandler( szCmdBuf );
00325             break;
00326         }
00327         // Next command
00328         pstCommand++;
00329     }
00330
00331     if (!bFound)
00332     {
00333         printf( "Invalid Command\n");
00334     }
00335
00336     return bContinue;
00337 }
00338 }
00339
00340 //-----
00341 void Interactive_CheckAndExecute( void )
00342 {
00343     // If we're in non-interactive mode (i.e. native execution), then return
00344     // out instantly.
00345     if (false == bIsInteractive)
00346     {
00347         if (false == bRetrigger)

```



```

00348     {
00349         return;
00350     }
00351     bIsInteractive = true;
00352     bRetrigger = false;
00353 }
00354 printf( "Debugging @ Address [0x%X]\n", stCPU.ul6PC );
00355
00356 // Keep attempting to parse commands until a valid one was encountered
00357 while (!Interactive_Execute_i()) { /* Do Nothing */ }
00358 }
00359
00360 //-----
00361 void Interactive_Set( void )
00362 {
00363     bIsInteractive = true;
00364     bRetrigger = false;
00365 }
00366
00367 //-----
00368 bool Interactive_WatchpointCallback( uint16_t u16Addr_, uint8_t u8Val_ )
00369 {
00370     if (WatchPoint_EnabledAtAddress(u16Addr_))
00371     {
00372         Interactive_Set();
00373         printf( "Watchpoint @ 0x%04X hit. Old Value => %d, New Value => %d\n",
00374             u16Addr_,
00375             stCPU.pstRAM->au8RAM[ u16Addr_ ],
00376             u8Val_ );
00377     }
00378     return true;
00379 }
00380
00381 //-----
00382 void Interactive_Init( TraceBuffer_t *pstTrace_ )
00383 {
00384     pstTrace = pstTrace_;
00385     bIsInteractive = false;
00386     bRetrigger = false;
00387
00388     // Add the watchpoint handler as a wildcard callout (i.e. every write
00389     // triggers is, it's up to the callout to handle filtering on its own).
00390     WriteCallout_Add( Interactive_WatchpointCallback, 0 );
00391 }
00392 }
00393
00394 //-----
00395 static bool Token_ScanNext( char *szCommand_, int iStart_, int *piTokenStart_, int *piTokenLen_ )
00396 {
00397     int i = iStart_;
00398
00399     // Parse leading whitespace
00400     while ( (szCommand_[i] == ' ') ||
00401         (szCommand_[i] == '\t') ||
00402         (szCommand_[i] == '\r') ||
00403         (szCommand_[i] == '\n')
00404         ) { i++; }
00405
00406     // Check null termination
00407     if (szCommand_[i] == '\0' )
00408     {
00409         return false;
00410     }
00411
00412     // Parse token
00413     *piTokenStart_ = i;
00414     while ( (szCommand_[i] != ' ') &&
00415         (szCommand_[i] != '\t') &&
00416         (szCommand_[i] != '\r') &&
00417         (szCommand_[i] != '\n') &&
00418         (szCommand_[i] != '\0')
00419         ) { i++; }
00420     *piTokenLen_ = (i - *piTokenStart_);
00421
00422     // printf( "Start, Len: %d, %d\n", i, *piTokenLen_ );
00423     return true;
00424 }
00425
00426 //-----
00427 static bool Token_DiscardNext( char *szCommand_, int iStart_, int *piNextTokenStart_ )
00428 {
00429     int iTempStart;
00430     int iTempLen;
00431     if (!Token_ScanNext( szCommand_, iStart_, &iTempStart, &iTempLen ))
00432     {
00433         return false;
00434     }

```

```

00435     *piNextTokenStart_ = iTempStart + iTempLen + 1;
00436     return true;
00437 }
00438
00439 //-----
00440 static bool Token_ReadNextHex( char *szCommand_, int iStart_, int *piNextTokenStart_, unsigned int *puiVal_
    )
00441 {
00442     int iTempStart = iStart_;
00443     int iTempLen;
00444
00445     if (!Token_ScanNext( szCommand_, iStart_, &iTempStart, &iTempLen ))
00446     {
00447         return false;
00448     }
00449
00450     szCommand_[iTempStart + iTempLen] = 0;
00451
00452     if (0 == sscanf( &szCommand_[iTempStart], "%x", puiVal_ ))
00453     {
00454         if (0 == sscanf( &szCommand_[iTempStart], "x%x", puiVal_ ))
00455         {
00456             if (0 == sscanf( &szCommand_[iTempStart], "0x%x", puiVal_ ))
00457             {
00458                 printf( "Missing Argument\n" );
00459                 return false;
00460             }
00461         }
00462     }
00463
00464     *piNextTokenStart_ = iTempStart + iTempLen + 1;
00465     return true;
00466 }
00467
00468 //-----
00469 static bool Interactive_Continue( char *szCommand_ )
00470 {
00471     bIsInteractive = false;
00472     bRetrigger = false;
00473     return true;
00474 }
00475
00476 //-----
00477 static bool Interactive_Break( char *szCommand_ )
00478 {
00479     unsigned int uiAddr;
00480     int iTokenStart;
00481
00482     if (!Token_DiscardNext( szCommand_, 0, &iTokenStart))
00483     {
00484         return false;
00485     }
00486
00487     if (!Token_ReadNextHex( szCommand_, iTokenStart, &iTokenStart, &uiAddr))
00488     {
00489         return false;
00490     }
00491
00492     if (BreakPoint_EnabledAtAddress( (uint16_t)uiAddr))
00493     {
00494         BreakPoint_Delete( (uint16_t)uiAddr);
00495     }
00496     else
00497     {
00498         BreakPoint_Insert( (uint16_t)uiAddr);
00499     }
00500
00501     return false;
00502 }
00503
00504 //-----
00505 static bool Interactive_Watch( char *szCommand_ )
00506 {
00507     unsigned int uiAddr;
00508     int iTokenStart;
00509
00510     if (!Token_DiscardNext( szCommand_, 0, &iTokenStart))
00511     {
00512         return false;
00513     }
00514
00515     if (!Token_ReadNextHex( szCommand_, iTokenStart, &iTokenStart, &uiAddr))
00516     {
00517         return false;
00518     }
00519
00520

```

```

00521     if (WatchPoint_EnabledAtAddress((uint16_t)uiAddr))
00522     {
00523         WatchPoint_Delete( (uint16_t)uiAddr);
00524     }
00525     else
00526     {
00527         WatchPoint_Insert( (uint16_t)uiAddr);
00528     }
00529     return false;
00530 }
00531 //-----
00532 static bool Interactive_ROM( char *szCommand_ )
00533 {
00534     unsigned int uiAddr;
00535     unsigned int uiLen;
00536     int iTokenStart;
00537
00538     if (!Token_DiscardNext( szCommand_, 0, &iTokenStart))
00539     {
00540         return false;
00541     }
00542
00543     if (!Token_ReadNextHex( szCommand_, iTokenStart, &iTokenStart, &uiAddr))
00544     {
00545         return false;
00546     }
00547
00548     if (!Token_ReadNextHex( szCommand_, iTokenStart, &iTokenStart, &uiLen))
00549     {
00550         return false;
00551     }
00552
00553     print_rom( (uint16_t)uiAddr, (uint16_t)uiLen );
00554
00555     return false;
00556 }
00557 //-----
00558 static bool Interactive_RAM( char *szCommand_ )
00559 {
00560     unsigned int uiAddr;
00561     unsigned int uiLen;
00562     int iTokenStart;
00563
00564     if (!Token_DiscardNext( szCommand_, 0, &iTokenStart))
00565     {
00566         return false;
00567     }
00568
00569     if (!Token_ReadNextHex( szCommand_, iTokenStart, &iTokenStart, &uiAddr))
00570     {
00571         return false;
00572     }
00573
00574     if (!Token_ReadNextHex( szCommand_, iTokenStart, &iTokenStart, &uiLen))
00575     {
00576         return false;
00577     }
00578
00579     print_ram( (uint16_t)uiAddr, (uint16_t)uiLen );
00580
00581     return false;
00582 }
00583 //-----
00584 static bool Interactive_EE( char *szCommand_ )
00585 {
00586     unsigned int uiAddr;
00587     unsigned int uiLen;
00588     int iTokenStart;
00589
00590     if (!Token_DiscardNext( szCommand_, 0, &iTokenStart))
00591     {
00592         return false;
00593     }
00594
00595     if (!Token_ReadNextHex( szCommand_, iTokenStart, &iTokenStart, &uiAddr))
00596     {
00597         return false;
00598     }
00599
00600     if (!Token_ReadNextHex( szCommand_, iTokenStart, &iTokenStart, &uiLen))
00601     {
00602         return false;
00603     }
00604
00605     printf( "Dump EEPROM [%x:%x]\n", uiAddr, uiLen );
00606

```

```

00608
00609     return false;
00610 }
00611
00612 //-----
00613 static bool Interactive_Registers( char *szCommand_ )
00614 {
00615     print_core_regs();
00616     return false;
00617 }
00618
00619 //-----
00620 static bool Interactive_Quit( char *szCommand_ )
00621 {
00622     exit(0);
00623 }
00624
00625 //-----
00626 static bool Interactive_Step( char *szCommand_ )
00627 {
00628     bRetrigger = true; // retrigger debugging on next loop
00629     return true;
00630 }
00631
00632 //-----
00633 static bool Interactive_Help( char *szCommand_ )
00634 {
00635     Interactive_Command_t *pstCommand_ = astCommands;
00636     printf( "FLAVR interactive debugger commands:\n");
00637     while (pstCommand_->szCommand)
00638     {
00639         printf( "    %s: %s\n", pstCommand_->szCommand, pstCommand_->
szDescription );
00640         pstCommand_++;
00641     }
00642     return false;
00643 }
00644
00645 //-----
00646 static bool Interactive_Disasm( char *szCommand_ )
00647 {
00648     char szBuf[256];
00649     uint16_t OP = stCPU.pul6ROM[stCPU.ul6PC];
00650
00651     printf("0x%04X: [0x%04X] ", stCPU.ul6PC, OP);
00652     AVR_Decode(OP);
00653     AVR_Disasm_Function(OP)(szBuf);
00654     printf( "%s", szBuf );
00655
00656     return false;
00657 }
00658
00659 //-----
00660 static bool Interactive_Trace( char *szCommand_ )
00661 {
00662     TraceBuffer_Print( pstTrace, TRACE_PRINT_COMPACT | TRACE_PRINT_DISASSEMBLY );
00663     return false;
00664 }
00665
00666 //-----
00667 static bool Interactive_BreakFunc( char *szCommand_ )
00668 {
00669     unsigned int uiAddr;
00670     unsigned int uiLen;
00671     int iTokenStart;
00672     int iEnd;
00673
00674     if (!Token_DiscardNext( szCommand_, 0, &iTokenStart))
00675     {
00676         return false;
00677     }
00678
00679     if (!Token_ScanNext( szCommand_, iTokenStart, &iEnd, &uiLen ) )
00680     {
00681         return false;
00682     }
00683
00684     szCommand_[iTokenStart+uiLen] = 0;
00685
00686     char *szName = &szCommand_[iTokenStart];
00687     Debug_Symbol_t *pstSym = Symbol_Find_Func_By_Name( szName );
00688
00689     if (!pstSym)
00690     {
00691         printf( "Unknown function: %s", szName );
00692         return false;
00693     }

```

```

00694     printf( "Name: %s, Start Addr: %x, End Addr: %x\n", pstSym->szName, pstSym->
u32StartAddr, pstSym->u32EndAddr );
00695
00696     if (BreakPoint_EnabledAtAddress(pstSym->
u32StartAddr))
00697     {
00698         printf( "Removing breakpoint @ 0x%04X\n", pstSym->u32StartAddr );
00699         BreakPoint_Delete( pstSym->u32StartAddr );
00700     }
00701     else
00702     {
00703         printf( "Inserting breakpoint @ 0x%04X\n", pstSym->u32StartAddr );
00704         BreakPoint_Insert( pstSym->u32StartAddr );
00705     }
00706
00707     return false;
00708 }
00709
00710 //-----
00711 static bool Interactive_WatchObj( char *szCommand_ )
00712 {
00713     unsigned int uiAddr;
00714     unsigned int uiLen;
00715     int iTokenStart;
00716     int iEnd;
00717
00718     if (!Token_DiscardNext( szCommand_, 0, &iTokenStart))
00719     {
00720         return false;
00721     }
00722
00723     if (!Token_ScanNext( szCommand_, iTokenStart, &iEnd, &uiLen ) )
00724     {
00725         return false;
00726     }
00727
00728     szCommand_[iTokenStart+uiLen] = 0;
00729
00730     char *szName = &szCommand_[iTokenStart];
00731     Debug_Symbol_t *pstSym = Symbol_Find_Obj_By_Name( szName );
00732
00733     if (!pstSym)
00734     {
00735         printf( "Unknown object: %s", szName );
00736         return false;
00737     }
00738     printf( "Name: %s, Start Addr: %x, End Addr: %x\n", pstSym->szName, pstSym->
u32StartAddr, pstSym->u32EndAddr );
00739
00740     if (WatchPoint_EnabledAtAddress(pstSym->
u32StartAddr))
00741     {
00742         printf( "Removing watchpoint @ 0x%04X\n", pstSym->u32StartAddr );
00743         uint32_t i;
00744         for (i = pstSym->u32StartAddr; i <= pstSym->u32EndAddr; i++)
00745         {
00746             WatchPoint_Delete( i );
00747         }
00748     }
00749     else
00750     {
00751         printf( "Inserting watchpoint @ 0x%04X\n", pstSym->u32StartAddr );
00752         uint32_t i;
00753         for (i = pstSym->u32StartAddr; i <= pstSym->u32EndAddr; i++)
00754         {
00755             WatchPoint_Insert( i );
00756         }
00757     }
00758
00759     return false;
00760 }
00761
00762 //-----
00763 static bool Interactive_ListObj( char *szCommand_ )
00764 {
00765     uint32_t u32Count = Symbol_Get_Obj_Count();
00766     uint32_t i;
00767     printf( "Listing objects:\n" );
00768     for (i = 0; i < u32Count; i++)
00769     {
00770         Debug_Symbol_t *pstSymbol = Symbol_Obj_At_Index(i);
00771         if (!pstSymbol)
00772         {
00773             break;
00774         }
00775
00776         printf( "%d: %s\n", i, pstSymbol->szName );

```

```

00777     }
00778     printf( "   done\n" );
00779     return false;
00780 }
00781
00782 //-----
00783 static bool Interactive_ListFunc( char *szCommand_ )
00784 {
00785     uint32_t u32Count = Symbol_Get_Func_Count();
00786     uint32_t i;
00787     printf( "Listing functions:\n" );
00788     for (i = 0; i < u32Count; i++)
00789     {
00790         Debug_Symbol_t *pstSymbol = Symbol_Func_At_Index(i);
00791         if (!pstSymbol)
00792         {
00793             break;
00794         }
00795         printf( "%d: %s\n", i, pstSymbol->szName );
00796     }
00797     printf( "   done\n" );
00798     return false;
00799 }
00800 }

```

4.75 src/debug/interactive.h File Reference

Interactive debugging support.

```

#include "emu_config.h"
#include "avr_cpu.h"
#include "trace_buffer.h"

```

Functions

- void [Interactive_CheckAndExecute](#) (void)
Interactive_CheckAndExecute.
- void [Interactive_Set](#) (void)
Interactive_Set.
- void [Interactive_Init](#) ([TraceBuffer_t](#) *pstTrace_)
Interactive_Init.

4.75.1 Detailed Description

Interactive debugging support.

Provides mechanism for debugging a virtual AVR microcontroller with a variety of functionality common to external debuggers, such as GDB.

Definition in file [interactive.h](#).

4.75.2 Function Documentation

4.75.2.1 void Interactive_CheckAndExecute (void)

Interactive_CheckAndExecute.

Wait for feedback and execute if running interactive. Otherwise, continue execution without waiting.

Definition at line 341 of file [interactive.c](#).

4.75.2.2 void Interactive_Init (TraceBuffer_t * pstTrace_)

Interactive_Init.

Initialize the interactive debugger session for the given CPU struct and associated debug data

Parameters

<i>pstTrace_</i>	Pointer to the tracebuffer object
------------------	-----------------------------------

Definition at line 382 of file [interactive.c](#).

4.75.2.3 void Interactive_Set (void)

Interactive_Set.

Enable interactive-debug mode on the next instruction cycle.

Definition at line 361 of file [interactive.c](#).

4.76 interactive.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( (/(      (      | -- [ Funkenstein ] -----
00005 *      /( ) )/( ) )\      / ( ) | -- [ Little ] -----
00006 *      ( ) _ ( ) )\ _ )\ ( ) ( ) | -- [ AVR ] -----
00007 *      | | _ | | ( ) _ ( ) \ / | _ | | | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ V / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ \ / | _ | | |
00010 *      | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00023 #ifndef __INTERACTIVE_H__
00024 #define __INTERACTIVE_H__
00025
00026 #include "emu_config.h"
00027 #include "avr_cpu.h"
00028 #include "trace_buffer.h"
00029
00030 //-----
00037 void Interactive_CheckAndExecute( void );
00038
00039 //-----
00045 void Interactive_Set( void );
00046
00047 //-----
00056 void Interactive_Init( TraceBuffer_t *pstTrace_);
00057
00058 #endif

```

4.77 src/debug/trace_buffer.c File Reference

Implements a circular buffer containing a history of recently executed instructions, along with core register context for each.

```

#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "trace_buffer.h"
#include "emu_config.h"
#include "avr_disasm.h"
#include "avr_op_decode.h"

```

Functions

- void [TraceBuffer_Init](#) ([TraceBuffer_t](#) *pstTraceBuffer_)
TraceBuffer_Init Initialize a tracebuffer prior to use.
- void [TraceBuffer_StoreFromCPU](#) ([TraceBuffer_t](#) *pstTraceBuffer_)
TraceBuffer_StoreFromCPU Store a trace element in the tracebuffer at its current head index.
- void [TraceBuffer_LoadElement](#) ([TraceBuffer_t](#) *pstTraceBuffer_, [TraceElement_t](#) *pstElement_, [uint32_t](#) u32Element_)
TraceBuffer_LoadElement Load an element from the tracebuffer into a a specified output element.
- void [TraceBuffer_PrintElement](#) ([TraceElement_t](#) *pstElement_, [TracePrintFormat_t](#) eFormat_)
TraceBuffer_PrintElement Print a single element from a tracebuffer to standard output.
- void [TraceBuffer_Print](#) ([TraceBuffer_t](#) *pstTraceBuffer_, [TracePrintFormat_t](#) eFormat_)
TraceBuffer_Print Print the raw contents of a tracebuffer to standard output.

4.77.1 Detailed Description

Implements a circular buffer containing a history of recently executed instructions, along with core register context for each.

Definition in file [trace_buffer.c](#).

4.77.2 Function Documentation

4.77.2.1 void [TraceBuffer_Init](#) ([TraceBuffer_t](#) * *pstTraceBuffer_*)

[TraceBuffer_Init](#) Initialize a tracebuffer prior to use.

Parameters

pstTraceBuffer_	Pointer to the tracebuffer to initialize
---------------------------------	--

Definition at line 35 of file [trace_buffer.c](#).

4.77.2.2 void [TraceBuffer_LoadElement](#) ([TraceBuffer_t](#) * *pstTraceBuffer_*, [TraceElement_t](#) * *pstElement_*, [uint32_t](#) *u32Element_*)

[TraceBuffer_LoadElement](#) Load an element from the tracebuffer into a a specified output element.

Parameters

pstTraceBuffer_	Pointer to a tracebuffer to load from
pstElement_	Pointer to a trace element structure to store data into
u32Element_	Index of the element in the tracebuffer to read

Definition at line 67 of file [trace_buffer.c](#).

4.77.2.3 void [TraceBuffer_Print](#) ([TraceBuffer_t](#) * *pstTraceBuffer_*, [TracePrintFormat_t](#) *eFormat_*)

[TraceBuffer_Print](#) Print the raw contents of a tracebuffer to standard output.

Parameters

<i>pstTraceBuffer_</i>	Pointer to the tracebuffer to print
<i>eFormat_</i>	Formatting type for the print

Definition at line 120 of file [trace_buffer.c](#).

4.77.2.4 void TraceBuffer_PrintElement (TraceElement_t * *pstElement_*, TracePrintFormat_t *eFormat_*)

TraceBuffer_PrintElement Print a single element from a tracebuffer to standard output.

This prints core registers and addresses.

Parameters

<i>pstElement_</i>	Pointer to the trace element to print
<i>eFormat_</i>	Formatting type for the print

Definition at line 75 of file [trace_buffer.c](#).

4.77.2.5 void TraceBuffer_StoreFromCPU (TraceBuffer_t * *pstTraceBuffer_*)

TraceBuffer_StoreFromCPU Store a trace element in the tracebuffer at its current head index.

Parameters

<i>pstTraceBuffer_</i>	Pointer to the tracebuffer to store into
------------------------	--

Definition at line 41 of file [trace_buffer.c](#).

4.78 trace_buffer.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( ((/(      )\      (      ((/(      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( )\ )\ / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ \ / / | _ \      | -- [ Runtime ] -----
00009 *      | _ | | _ / _ \ \ \ / / | _ \      |
00010 *      | _ | | _ / _ \ \ \ / / | _ \      | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00023 #include <stdint.h>
00024 #include <stdio.h>
00025 #include <stdlib.h>
00026 #include <string.h>
00027
00028 #include "trace_buffer.h"
00029 #include "emu_config.h"
00030
00031 #include "avr_disasm.h"
00032 #include "avr_op_decode.h"
00033
00034 //-----
00035 void TraceBuffer_Init( TraceBuffer_t *pstTraceBuffer_ )
00036 {
00037     memset( pstTraceBuffer_, 0, sizeof(*pstTraceBuffer_) );
00038 }
00039
00040 //-----
00041 void TraceBuffer_StoreFromCPU( TraceBuffer_t *pstTraceBuffer_ )

```

```

00042 {
00043     TraceElement_t *pstTraceElement = &pstTraceBuffer_>
astTraceStep[ pstTraceBuffer_>u32Index ];
00044
00045     // Manually copy over whatever elements we need to
00046     pstTraceElement->u64Counter      = stCPU.u64InstructionCount;
00047     pstTraceElement->u64CycleCount   = stCPU.u64CycleCount;
00048     pstTraceElement->u16PC           = stCPU.u16PC;
00049     pstTraceElement->u16SP           = ((uint16_t)(stCPU.pstRAM->stRegisters.SPH.r) << 8) |
(uint16_t)(stCPU.pstRAM->stRegisters.SPL.r);
00050
00051
00052     pstTraceElement->u16OpCode       = stCPU.pu16ROM[ stCPU.u16PC ];
00053     pstTraceElement->u8SR            = stCPU.pstRAM->stRegisters.SREG.r;
00054
00055     // Memcpy the core registers in one chunk
00056     memcpy(&(pstTraceElement->stCoreRegs), &(stCPU.pstRAM->stRegisters.CORE_REGISTERS), sizeof(
pstTraceElement->stCoreRegs));
00057
00058     // Update the index of the write buffer
00059     pstTraceBuffer_>u32Index++;
00060     if (pstTraceBuffer_>u32Index >= CONFIG_TRACEBUFFER_SIZE)
00061     {
00062         pstTraceBuffer_>u32Index = 0;
00063     }
00064 }
00065
00066 //-----
00067 void TraceBuffer_LoadElement( TraceBuffer_t *pstTraceBuffer_,
TraceElement_t *pstElement_, uint32_t u32Element_ )
00068 {
00069     TraceElement_t *pstSourceElement = &pstTraceBuffer_>
astTraceStep[ pstTraceBuffer_>u32Index ];
00070
00071     memcpy(pstElement_, pstSourceElement, sizeof(*pstElement_));
00072 }
00073
00074 //-----
00075 void TraceBuffer_PrintElement( TraceElement_t *pstElement_,
TracePrintFormat_t eFormat_ )
00076 {
00077     printf( "[%08d] 0x%04X:0x%04X: ",
00078         pstElement_>u64Counter, pstElement_>u16PC, pstElement_>
u16OpCode );
00079     if (eFormat_ & TRACE_PRINT_DISASSEMBLY)
00080     {
00081         uint16_t u16TempPC = stCPU.u16PC;
00082         stCPU.u16PC = pstElement_>u16PC;
00083
00084         AVR_Disasm pfOp = AVR_Disasm_Function( pstElement_>
u16OpCode );
00085
00086         char szBuf[256];
00087         AVR_Decode( pstElement_>u16OpCode );
00088         pfOp( szBuf );
00089         printf( "%s", szBuf );
00090
00091         stCPU.u16PC = u16TempPC;
00092     }
00093
00094     if (eFormat_ & TRACE_PRINT_COMPACT)
00095     {
00096         printf( "%04X ", pstElement_>u16SP );
00097
00098         int i;
00099         for (i = 0; i < 32; i++)
00100         {
00101             printf( "%02X ", pstElement_>stCoreRegs.r[i] );
00102         }
00103         printf( "\n" );
00104     }
00105     if (eFormat_ & TRACE_PRINT_REGISTERS)
00106     {
00107         uint8_t i;
00108         for (i = 0; i < 32; i++)
00109         {
00110             printf( "[R%02d] = 0x%02X\n", i, pstElement_>stCoreRegs.r[i] );
00111         }
00112         printf("[SP] = 0x%04X\n", pstElement_>u16SP );
00113         printf("[PC] = 0x%04X\n", (uint16_t)pstElement_>u16PC );
00114         printf("[SREG]= 0x%02X", pstElement_>u8SR );
00115         printf( "\n" );
00116     }
00117 }
00118
00119 //-----
00120 void TraceBuffer_Print( TraceBuffer_t *pstTraceBuffer_,
TracePrintFormat_t eFormat_ )

```

```

00121 {
00122     int i;
00123     for (i = pstTraceBuffer->u32Index; i < CONFIG_TRACEBUFFER_SIZE; i++)
00124     {
00125         TraceBuffer_PrintElement(&pstTraceBuffer->
astTraceStep[i], eFormat_ );
00126     }
00127     for (i = 0; i < pstTraceBuffer->u32Index; i++)
00128     {
00129         TraceBuffer_PrintElement(&pstTraceBuffer->
astTraceStep[i], eFormat_ );
00130     }
00131 }

```

4.79 src/debug/trace_buffer.h File Reference

Implements a circular buffer containing a history of recently executed instructions, along with core register context for each.

```

#include <stdint.h>
#include "emu_config.h"
#include "avr_cpu.h"

```

Data Structures

- struct [TraceElement_t](#)
Struct defining the CPU's running state at each tracebuffer sample point.
- struct [TraceBuffer_t](#)
Implements a circular buffer of trace elements, sized according to the compile-time configuration.

Enumerations

- enum [TracePrintFormat_t](#) { **TRACE_PRINT_COMPACT** = 1, **TRACE_PRINT_REGISTERS** = 2, **TRACE_↵**
PRINT_DISASSEMBLY = 4 }
- Enumerated values defining the various formats for printing/displaying tracebuffer information.*

Functions

- void [TraceBuffer_Init](#) ([TraceBuffer_t](#) *pstTraceBuffer_)
TraceBuffer_Init Initialize a tracebuffer prior to use.
- void [TraceBuffer_StoreFromCPU](#) ([TraceBuffer_t](#) *pstTraceBuffer_)
TraceBuffer_StoreFromCPU Store a trace element in the tracebuffer at its current head index.
- void [TraceBuffer_LoadElement](#) ([TraceBuffer_t](#) *pstTraceBuffer_, [TraceElement_t](#) *pstElement_, uint32_↵
t u32Element_)
TraceBuffer_LoadElement Load an element from the tracebuffer into a a specified output element.
- void [TraceBuffer_PrintElement](#) ([TraceElement_t](#) *pstElement_, [TracePrintFormat_t](#) eFormat_)
TraceBuffer_PrintElement Print a single element from a tracebuffer to standard output.
- void [TraceBuffer_Print](#) ([TraceBuffer_t](#) *pstTraceBuffer_, [TracePrintFormat_t](#) eFormat_)
TraceBuffer_Print Print the raw contents of a tracebuffer to standard output.

4.79.1 Detailed Description

Implements a circular buffer containing a history of recently executed instructions, along with core register context for each.

Definition in file [trace_buffer.h](#).

4.79.2 Function Documentation

4.79.2.1 void TraceBuffer_Init (TraceBuffer_t * *pstTraceBuffer_*)

TraceBuffer_Init Initialize a tracebuffer prior to use.

Parameters

<i>pstTraceBuffer_</i>	Pointer to the tracebuffer to initialize
------------------------	--

Definition at line 35 of file [trace_buffer.c](#).

4.79.2.2 void TraceBuffer_LoadElement (TraceBuffer_t * *pstTraceBuffer_*, TraceElement_t * *pstElement_*, uint32_t *u32Element_*)

TraceBuffer_LoadElement Load an element from the tracebuffer into a a specified output element.

Parameters

<i>pstTraceBuffer_</i>	Pointer to a tracebuffer to load from
<i>pstElement_</i>	Pointer to a trace element structure to store data into
<i>u32Element_</i>	Index of the element in the tracebuffer to read

Definition at line 67 of file [trace_buffer.c](#).

4.79.2.3 void TraceBuffer_Print (TraceBuffer_t * *pstTraceBuffer_*, TracePrintFormat_t *eFormat_*)

TraceBuffer_Print Print the raw contents of a tracebuffer to standard output.

Parameters

<i>pstTraceBuffer_</i>	Pointer to the tracebuffer to print
<i>eFormat_</i>	Formatting type for the print

Definition at line 120 of file [trace_buffer.c](#).

4.79.2.4 void TraceBuffer_PrintElement (TraceElement_t * *pstElement_*, TracePrintFormat_t *eFormat_*)

TraceBuffer_PrintElement Print a single element from a tracebuffer to standard output.

This prints core registers and addresses.

Parameters

<i>pstElement_</i>	Pointer to the trace element to print
<i>eFormat_</i>	Formatting type for the print

Definition at line 75 of file [trace_buffer.c](#).

4.79.2.5 void TraceBuffer_StoreFromCPU (TraceBuffer_t * *pstTraceBuffer_*)

TraceBuffer_StoreFromCPU Store a trace element in the tracebuffer at its current head index.

Parameters

<i>pstTraceBuffer</i> ↵	Pointer to the tracebuffer to store into
—	

Definition at line 41 of file [trace_buffer.c](#).

4.80 trace_buffer.h

```

00001 /*****
00002 *      (      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ((/( ((/(      )\      (  ((/( | -- [ Funkenstein ] -----
00005 *      /( )  /( )  ((( ( )\ )\  /( )  | -- [ Little ] -----
00006 *      ( )_ ( ) )\ _ )\ ( ( ) ( ) ( ) | -- [ AVR ] -----
00007 *      | | _ | | ( )_ ( ) \ \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ \ / / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _ | / / \ \ \ / / | _ \ |
00010 *                                     | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00023 #ifndef __TRACE_BUFFER_H__
00024 #define __TRACE_BUFFER_H__
00025
00026 #include <stdint.h>
00027
00028 #include "emu_config.h"
00029 #include "avr_cpu.h"
00030
00031 //-----
00032 typedef struct
00033 {
00034     uint64_t      u64Counter;
00035     uint64_t      u64CycleCount;
00036     uint16_t      u16OpCode;
00037     uint16_t      u16PC;
00038     uint16_t      u16SP;
00039     uint8_t       u8SR;
00040
00041     AVR_CoreRegisters stCoreRegs;
00042 } TraceElement_t;
00043
00044 //-----
00045 typedef struct
00046 {
00047     TraceElement_t  astTraceStep[ CONFIG_TRACEBUFFER_SIZE ];
00048     uint32_t        u32Index;
00049 } TraceBuffer_t;
00050
00051 //-----
00052 typedef enum
00053 {
00054     TRACE_PRINT_COMPACT      = 1,
00055     TRACE_PRINT_REGISTERS    = 2,
00056     TRACE_PRINT_DISASSEMBLY = 4
00057 } TracePrintFormat_t;
00058
00059 //-----
00060 void TraceBuffer_Init( TraceBuffer_t *pstTraceBuffer_ );
00061
00062 void TraceBuffer_StoreFromCPU( TraceBuffer_t *pstTraceBuffer_ );
00063
00064 void TraceBuffer_LoadElement( TraceBuffer_t *pstTraceBuffer_,
00065                               TraceElement_t *pstElement_, uint32_t u32Element_ );
00066
00067 void TraceBuffer_PrintElement( TraceElement_t *pstElement_,
00068                               TracePrintFormat_t eFormat_ );
00069
00070 void TraceBuffer_Print( TraceBuffer_t *pstTraceBuffer_,
00071                         TracePrintFormat_t eFormat_ );
00072 #endif

```

4.81 src/debug/watchpoint.c File Reference

Implements data watchpoints for debugging running programs based on reads/writes to a given memory address.

```
#include <stdint.h>
#include <stdbool.h>
#include <stdio.h>
#include <stdlib.h>
#include "watchpoint.h"
```

Functions

- void [WatchPoint_Insert](#) (uint16_t u16Addr_)
WatchPoint_Insert.
- void [WatchPoint_Delete](#) (uint16_t u16Addr_)
WatchPoint_Delete.
- bool [WatchPoint_EnabledAtAddress](#) (uint16_t u16Addr_)
WatchPoint_EnabledAtAddress.

4.81.1 Detailed Description

Implements data watchpoints for debugging running programs based on reads/writes to a given memory address.

Definition in file [watchpoint.c](#).

4.81.2 Function Documentation

4.81.2.1 void WatchPoint_Delete (uint16_t u16Addr_)

WatchPoint_Delete.

Remove a data watchpoint installed at a specific address. Has no effect if there isn't a watchpoint at the given address.

Parameters

<i>u16Addr_</i>	Address to remove data watchpoints from (if any)
-----------------	--

Definition at line 57 of file [watchpoint.c](#).

4.81.2.2 bool WatchPoint_EnabledAtAddress (uint16_t u16Addr_)

WatchPoint_EnabledAtAddress.

Check to see whether or not a watchpoint is installed at a given address

Parameters

<i>u16Addr_</i>	Address to check
-----------------	------------------

Returns

true if watchpoint is installed at the specified address

Definition at line 97 of file [watchpoint.c](#).

4.81.2.3 void WatchPoint_Insert (uint16_t u16Addr_)

WatchPoint_Insert.

Insert a data watchpoint for a given address. Has no effect if a watchpoint already exists at the specified address.

Parameters

<i>u16Addr_</i>	Address of the watchpoint.
-----------------	----------------------------

Definition at line 31 of file [watchpoint.c](#).

4.82 watchpoint.c

```

00001
00002 /*****
00003 *      (      (      (      |
00004 *      )\ ) )\ )      (      |
00005 *      ( ) / ( ) / (      (      | -- [ Funkenstein ] -----
00006 *      / ( ) / ( ) ( ( ( ) \ \ / ( )      | -- [ Little ] -----
00007 *      ( ) _ ( )      ) \ _ \ ( ( ( ) ( )      | -- [ AVR ] -----
00008 *      | _ | | |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00009 *      | _ | | |      / _ \ \ \ V / | _ /      | -- [ Runtime ] -----
00010 *      | _ | | _ | / _ \ \ \ \ / | _ \      |
00011 *      | _ | | _ | / _ \ \ \ \ / | _ \      | "Yeah, it does Arduino..."
00012 * -----+-----
00013 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00014 * See license.txt for details
00015 *****/
00023 #include <stdint.h>
00024 #include <stdbool.h>
00025 #include <stdio.h>
00026 #include <stdlib.h>
00027
00028 #include "watchpoint.h"
00029
00030 //-----
00031 void WatchPoint_Insert( uint16_t u16Addr_ )
00032 {
00033     // Don't add multiple watchpoints at the same address
00034     if (WatchPoint_EnabledAtAddress( u16Addr_ ))
00035     {
00036         return;
00037     }
00038
00039     WatchPoint_t *pstNewWatch = NULL;
00040
00041     pstNewWatch = (WatchPoint_t*)malloc( sizeof(WatchPoint_t) );
00042
00043     pstNewWatch->next = stCPU.pstWatchPoints;
00044     pstNewWatch->prev = NULL;
00045
00046     pstNewWatch->u16Addr = u16Addr_;
00047
00048     if (stCPU.pstWatchPoints)
00049     {
00050         WatchPoint_t *pstTemp = stCPU.pstWatchPoints;
00051         pstTemp->prev = pstNewWatch;
00052     }
00053     stCPU.pstWatchPoints = pstNewWatch;
00054 }
00055
00056 //-----
00057 void WatchPoint_Delete( uint16_t u16Addr_ )
00058 {
00059     WatchPoint_t *pstTemp = stCPU.pstWatchPoints;
00060
00061     while (pstTemp)
00062     {
00063         if (pstTemp->u16Addr == u16Addr_)
00064         {
00065             // Remove node -- reconnect surrounding elements
00066             WatchPoint_t *pstNext = pstTemp->next;
00067             if (pstNext)
00068             {
00069                 pstNext->prev = pstTemp->prev;
00070             }
00071
00072             WatchPoint_t *pstPrev = pstTemp->prev;
00073             if (pstPrev)
00074             {

```

```

00075         pstPrev->next = pstTemp->next;
00076     }
00077
00078     // Adjust list-head if necessary
00079     if (pstTemp == stCPU.pstWatchPoints)
00080     {
00081         stCPU.pstWatchPoints = pstNext;
00082     }
00083
00084     // Free the node/iterate to next node.
00085     pstPrev = pstTemp;
00086     pstTemp = pstTemp->next;
00087     free(pstPrev);
00088 }
00089 else
00090 {
00091     pstTemp = pstTemp->next;
00092 }
00093 }
00094 }
00095
00096 //-----
00097 bool WatchPoint_EnabledAtAddress( uint16_t u16Addr_ )
00098 {
00099     WatchPoint_t *pstTemp = stCPU.pstWatchPoints;
00100
00101     while (pstTemp)
00102     {
00103         if (pstTemp->u16Addr == u16Addr_)
00104         {
00105             return true;
00106         }
00107         pstTemp = pstTemp->next;
00108     }
00109     return false;
00110 }

```

4.83 src/debug/watchpoint.h File Reference

Implements data watchpoints for debugging running programs based on reads/writes to a given memory address.

```

#include <stdint.h>
#include <stdbool.h>
#include "avr_cpu.h"

```

Data Structures

- struct [_WatchPoint](#)

Typedefs

- typedef struct [_WatchPoint](#) **WatchPoint_t**

Functions

- void [WatchPoint_Insert](#) (uint16_t u16Addr_)
WatchPoint_Insert.
- void [WatchPoint_Delete](#) (uint16_t u16Addr_)
WatchPoint_Delete.
- bool [WatchPoint_EnabledAtAddress](#) (uint16_t u16Addr_)
WatchPoint_EnabledAtAddress.

4.83.1 Detailed Description

Implements data watchpoints for debugging running programs based on reads/writes to a given memory address.

Definition in file [watchpoint.h](#).

4.83.2 Function Documentation

4.83.2.1 void WatchPoint_Delete (uint16_t u16Addr_)

WatchPoint_Delete.

Remove a data watchpoint installed at a specific address. Has no effect if there isn't a watchpoint at the given address.

Parameters

<code>u16Addr_</code>	Address to remove data watchpoints from (if any)
-----------------------	--

Definition at line 57 of file [watchpoint.c](#).

4.83.2.2 bool WatchPoint_EnabledAtAddress (uint16_t u16Addr_)

WatchPoint_EnabledAtAddress.

Check to see whether or not a watchpoint is installed at a given address

Parameters

<code>u16Addr_</code>	Address to check
-----------------------	------------------

Returns

true if watchpoint is installed at the specified address

Definition at line 97 of file [watchpoint.c](#).

4.83.2.3 void WatchPoint_Insert (uint16_t u16Addr_)

WatchPoint_Insert.

Insert a data watchpoint for a given address. Has no effect if a watchpoint already exists at the specified address.

Parameters

<code>u16Addr_</code>	Address of the watchpoint.
-----------------------	----------------------------

Definition at line 31 of file [watchpoint.c](#).

4.84 watchpoint.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ((/( ((/(      )\      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /(_) /(_) ((((_( )\ )\ /(_)      | -- [ Little ] -----
00006 *      (_)_|(_)_ )\ _ )\ (_(_(_)_      | -- [ AVR ] -----
00007 *      | _ | | | (_)\(_)\ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ | / / \ \ \ / | _ \      |
00010 *      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 *      See license.txt for details

```

```

00014  *****/
00022 #ifndef __WATCHPOINT_H__
00023 #define __WATCHPOINT_H__
00024
00025 #include <stdint.h>
00026 #include <stdbool.h>
00027
00028 #include "avr_cpu.h"
00029
00030 //-----
00031 typedef struct _WatchPoint
00032 {
00033     struct _WatchPoint *next;
00034     struct _WatchPoint *prev;
00035
00036     uint16_t    u16Addr;
00037 } WatchPoint_t;
00038
00039 //-----
00048 void WatchPoint_Insert( uint16_t u16Addr_ );
00049
00050 //-----
00059 void WatchPoint_Delete( uint16_t u16Addr_ );
00060
00061 //-----
00070 bool WatchPoint_EnabledAtAddress( uint16_t u16Addr_ );
00071
00072 #endif
00073

```

4.85 src/flavr.c File Reference

Main AVR emulator entrypoint, commandline-use with built-in interactive debugger.

```

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <stdint.h>
#include "emu_config.h"
#include "variant.h"
#include "avr_coreregs.h"
#include "avr_periphregs.h"
#include "avr_op_cycles.h"
#include "avr_op_decode.h"
#include "avr_op_size.h"
#include "avr_cpu_print.h"
#include "avr_cpu.h"
#include "avr_loader.h"
#include "mega_uart.h"
#include "mega_eint.h"
#include "mega_timer16.h"
#include "mega_timer8.h"
#include "mega_eeprom.h"
#include "avr_disasm.h"
#include "trace_buffer.h"
#include "options.h"
#include "interactive.h"
#include "breakpoint.h"
#include "watchpoint.h"
#include "kernel_aware.h"
#include "code_profile.h"
#include "tlv_file.h"
#include "gdb_rsp.h"

```

Enumerations

- enum **ErrorReason_t** {
EEPROM_TOO_BIG, **RAM_TOO_BIG**, **RAM_TOO_SMALL**, **ROM_TOO_BIG**,
INVALID_HEX_FILE, **INVALID_VARIANT**, **INVALID_DEBUG_OPTIONS** }

Functions

- void **splash** (void)
- void **error_out** (ErrorReason_t eReason_)
- void **emulator_loop** (void)
- void **add_plugins** (void)
- void **flavr_disasm** (void)
- void **emulator_init** (void)
- int **main** (int argc, char **argv)

Variables

- static [TraceBuffer_t](#) **stTraceBuffer**

4.85.1 Detailed Description

Main AVR emulator entrypoint, commandline-use with built-in interactive debugger.

Definition in file [flavr.c](#).

4.86 flavr.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )  (      )\ )  |
00004 *      ((/( ((/(      \      ( ((/( | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( ) \ \ / ( ) | -- [ Little ] -----
00006 *      ( ) _ ( )      ) \ _ ) \ ( ( ( ) | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ \ ( ) \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ / / | _ \ | -- [ Runtime ] -----
00009 *      | _ | | _ / _ \ \ / / | _ \ |
00010 *      | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00022 #include <stdio.h>
00023 #include <stdlib.h>
00024 #include <string.h>
00025 #include <stdint.h>
00026
00027 #include "emu_config.h"
00028 #include "variant.h"
00029
00030 //-----
00031 #include "avr_coreregs.h"
00032 #include "avr_periphregs.h"
00033 #include "avr_op_cycles.h"
00034 #include "avr_op_decode.h"
00035 #include "avr_op_size.h"
00036 #include "avr_cpu_print.h"
00037 #include "avr_cpu.h"
00038 #include "avr_loader.h"
00039
00040 //-----
00041 #include "mega_uart.h"
00042 #include "mega_eint.h"
00043 #include "mega_timer16.h"
00044 #include "mega_timer8.h"
00045 #include "mega_eeprom.h"
00046

```

```

00047 //-----
00048 #include "avr_disasm.h"
00049 #include "trace_buffer.h"
00050 #include "options.h"
00051 #include "interactive.h"
00052 #include "breakpoint.h"
00053 #include "watchpoint.h"
00054 #include "kernel_aware.h"
00055 #include "code_profile.h"
00056 #include "tlv_file.h"
00057 #include "gdb_rsp.h"
00058
00059 //-----
00060 typedef enum
00061 {
00062     EEPROM_TOO_BIG,
00063     RAM_TOO_BIG,
00064     RAM_TOO_SMALL,
00065     ROM_TOO_BIG,
00066     INVALID_HEX_FILE,
00067     INVALID_VARIANT,
00068     INVALID_DEBUG_OPTIONS
00069 } ErrorReason_t;
00070
00071 //-----
00072 static TraceBuffer_t stTraceBuffer;
00073
00074 //-----
00075 void splash(void)
00076 {
00077     printf(
00078         "
00079         *      (      (      (      (      |
00080         *      )\\ ) )\\ )      (      )\\ )      |
00081         *      ((/( ((/(      )\\      ( ((/(      | -- [ Funkenstein ] -----
00082         *      /( ) /( ) ((( ( )\\ )\\      /( )      | -- [ Little ] -----
00083         *      ( )_ ( )      )\\ _ )\\      ( ( ( )_      | -- [ AVR ] -----
00084         *      | _ | |      ( )_\\ ( )\\ \\ / / | _ \\      | -- [ Virtual ] -----
00085         *      | _ | |      / _ \\ \\ \\ v / | /      | -- [ Runtime ] -----
00086         *      | _ | |      / _ \\ \\ \\ \\ / | _ \\      |
00087         *      | _ | |      / _ \\ \\ \\ \\ / | _ \\      | \\ "From the makers of Mark3!"
00088         *      | _ | |      / _ \\ \\ \\ \\ / | _ \\      |
00089         *      (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00090         *      See license.txt for details
00091     );
00092 }
00093
00094 //-----
00095 void error_out( ErrorReason_t eReason_ )
00096 {
00097     switch (eReason_)
00098     {
00099         case EEPROM_TOO_BIG:
00100             printf( "EEPROM Size specified is too large\n" );
00101             break;
00102         case RAM_TOO_BIG:
00103             printf( "RAM Size specified is too large\n" );
00104             break;
00105         case RAM_TOO_SMALL:
00106             printf( "RAM Size specified is too small\n" );
00107             break;
00108         case ROM_TOO_BIG:
00109             printf( "ROM Size specified is too large\n" );
00110             break;
00111         case INVALID_HEX_FILE:
00112             printf( "HEX Programming file cannot be loaded\n");
00113             break;
00114         case INVALID_VARIANT:
00115             printf( "Unknown variant not supported\n");
00116             break;
00117         case INVALID_DEBUG_OPTIONS:
00118             printf( "GDB and built-in interactive debugger are mutually exclusive\n");
00119         default:
00120             printf( "Some other reason\n" );
00121     }
00122
00123     Options_PrintUsage();
00124
00125     exit (-1);
00126 }
00127
00128 //-----
00129 void emulator_loop(void)
00130 {
00131     bool bUseTrace = false;
00132     bool bProfile = false;
00133     bool bUseGDB = false;

```

```

00134
00135     if ( Options_GetByName("--trace") && Options_GetByName("--debug") )
00136     {
00137         bUseTrace = true;
00138     }
00139
00140     if ( Options_GetByName("--profile"))
00141     {
00142         bProfile = true;
00143     }
00144
00145     if ( Options_GetByName("--gdb"))
00146     {
00147         bUseGDB = true;
00148     }
00149
00150     while (1)
00151     {
00152         // Check to see if we've hit a breakpoint
00153         if (BreakPoint_EnabledAtAddress(stCPU.u16PC))
00154         {
00155             if (bUseGDB)
00156             {
00157                 GDB_Set();
00158             }
00159             else
00160             {
00161                 Interactive_Set();
00162             }
00163         }
00164
00165         // Check to see if we're in interactive debug mode, and thus need to wait for input
00166         if (bUseGDB)
00167         {
00168             GDB_CheckAndExecute();
00169         }
00170         else
00171         {
00172             Interactive_CheckAndExecute();
00173         }
00174
00175         // Store the current CPU state into the tracebuffer
00176         if (bUseTrace)
00177         {
00178             TraceBuffer_StoreFromCPU(&stTraceBuffer);
00179         }
00180
00181         // Run code profiling logic
00182         if (bProfile)
00183         {
00184             Profile_Hit(stCPU.u16PC);
00185         }
00186
00187         // Execute a machine cycle
00188         CPU_RunCycle();
00189     }
00190     // doesn't return, except by quitting from debugger, or by signal.
00191 }
00192
00193 //-----
00194 void add_plugins(void)
00195 {
00196     CPU_AddPeriph(&stUART);
00197     CPU_AddPeriph(&stEINT_a);
00198     CPU_AddPeriph(&stEINT_b);
00199     CPU_AddPeriph(&stTimer16);
00200     CPU_AddPeriph(&stTimer16a);
00201     CPU_AddPeriph(&stTimer16b);
00202     CPU_AddPeriph(&stTimer8);
00203     CPU_AddPeriph(&stTimer8a);
00204     CPU_AddPeriph(&stTimer8b);
00205     CPU_AddPeriph(&stEEPROM);
00206 }
00207
00208 //-----
00209 void flavr_disasm(void)
00210 {
00211     uint32_t u32Size;
00212
00213     u32Size = stCPU.u32ROMSize / sizeof(uint16_t);
00214     stCPU.u16PC = 0;
00215
00216     while (stCPU.u16PC < u32Size)
00217     {
00218         uint16_t OP = stCPU.pu16ROM[stCPU.u16PC];
00219         char szBuf[256];
00220

```

```

00221         printf("0x%04X: [0x%04X] ", stCPU.u16PC, OP);
00222         AVR_Decode(OP);
00223         AVR_Disasm_Function(OP)(szBuf);
00224         printf( "%s", szBuf );
00225         stCPU.u16PC += AVR_Opcode_Size(OP);
00226     }
00227     exit(0);
00228 }
00229
00230 //-----
00231 void emulator_init(void)
00232 {
00233     AVR_CPU_Config_t stConfig;
00234
00235     // -- Initialize the emulator based on command-line args
00236     const AVR_Variant_t *pstVariant;
00237
00238     pstVariant = Variant_GetByName( Options_GetByName("--variant") );
00239     if (!pstVariant)
00240     {
00241         error_out( INVALID_VARIANT );
00242     }
00243
00244     if (Options_GetByName("--exitreset"))
00245     {
00246         stConfig.bExitOnReset = true;
00247     }
00248     else
00249     {
00250         stConfig.bExitOnReset = false;
00251     }
00252
00253     stConfig.u32EESize = pstVariant->u32EESize;
00254     stConfig.u32RAMSize = pstVariant->u32RAMSize;
00255     stConfig.u32ROMSize = pstVariant->u32ROMSize;
00256
00257     if (stConfig.u32EESize >= 32768)
00258     {
00259         error_out( EEPROM_TOO_BIG );
00260     }
00261
00262     if (stConfig.u32RAMSize >= 65535)
00263     {
00264         error_out( RAM_TOO_BIG );
00265     }
00266     else if (stConfig.u32RAMSize < 256)
00267     {
00268         error_out( RAM_TOO_SMALL );
00269     }
00270
00271     if (stConfig.u32ROMSize >= (256*1024))
00272     {
00273         error_out( ROM_TOO_BIG );
00274     }
00275
00276     CPU_Init(&stConfig);
00277
00278     TraceBuffer_Init( &stTraceBuffer );
00279
00280     if (Options_GetByName("--hexfile"))
00281     {
00282         if (!AVR_Load_HEX( Options_GetByName("--hexfile") ))
00283         {
00284             error_out( INVALID_HEX_FILE );
00285         }
00286     }
00287     else if (Options_GetByName("--elffile"))
00288     {
00289         if (!AVR_Load_ELF( Options_GetByName("--elffile") ))
00290         {
00291             error_out( INVALID_HEX_FILE );
00292         }
00293     }
00294     else
00295     {
00296         error_out( INVALID_HEX_FILE );
00297     }
00298
00299     if (Options_GetByName("--disasm"))
00300     {
00301         // terminates after disassembly is complete
00302         flavr_disasm();
00303     }
00304
00305     if (Options_GetByName("--debug"))
00306     {
00307         Interactive_Init( &stTraceBuffer );

```

```

00308     }
00309     if (Options_GetByName("--gdb"))
00310     {
00311         GDB_Init();
00312     }
00313
00314     // Only insert a breakpoint/enter interactive debugging mode if specified.
00315     // Otherwise, start with the emulator running.
00316     if (Options_GetByName("--debug") && Options_GetByName("--gdb"))
00317     {
00318         error_out( INVALID_DEBUG_OPTIONS );
00319     }
00320     if (Options_GetByName("--debug"))
00321     {
00322         BreakPoint_Insert( 0 );
00323     }
00324
00325     add_plugins();
00326
00327     if (Options_GetByName("--mark3") || Options_GetByName("--profile"))
00328     {
00329         // Initialize tag-length-value code if we're running with code
00330         // profiling or kernel-aware debugging, since they generate a
00331         // lot of data that's better stored in a binary format for
00332         // efficiency.
00333         TLV_WriteInit( "flavr.tlv" );
00334     }
00335
00336     if (Options_GetByName("--mark3"))
00337     {
00338         // Mark3 kernel-aware mode should only be enabled on-demand
00339         KernelAware_Init();
00340     }
00341
00342     if (Options_GetByName("--profile"))
00343     {
00344         Profile_Init( stConfig.u32ROMSize );
00345         atexit( Profile_Print );
00346     }
00347 }
00348
00349 //-----
00350 int main( int argc, char **argv )
00351 {
00352
00353     // Initialize all emulator data
00354     Options_Init(argc, argv);
00355
00356     if (!Options_GetByName("--silent"))
00357     {
00358         splash();
00359     }
00360
00361     emulator_init();
00362
00363     // Run the emulator/debugger loop.
00364     emulator_loop();
00365
00366     return 0;
00367 }
00368 }

```

4.87 src/kernel_aware/ka_graphics.c File Reference

Mark3 RTOS Kernel-Aware graphics library.

```

#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <stdint.h>
#include <SDL/SDL.h>
#include "kernel_aware.h"
#include "debug_sym.h"
#include "write_callout.h"
#include "interrupt_callout.h"

```

Data Structures

- struct [DrawPoint_t](#)

Macros

- `#define GFX_RES_X (128)`
- `#define GFX_RES_Y (160)`
- `#define GFX_SCALE (3)`

Functions

- void **KA_Graphics_Close** (void)
- void **KA_Graphics_ClearScreen** (void)
- void **KA_Graphics_DrawPoint** ([DrawPoint_t](#) *pstPoint_)
- void **KA_Graphics_Flip** (void)
- bool **KA_Graphics_Command** (uint16_t u16Addr_, uint8_t u8Data_)
- void **KA_Graphics_Init** (void)

Variables

- static SDL_Surface * **pstScreen** = 0

4.87.1 Detailed Description

Mark3 RTOS Kernel-Aware graphics library.

Definition in file [ka_graphics.c](#).

4.88 ka_graphics.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ((/( ((/(      \      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /( )  /( )  ((( ( ) \  )\  /( )  | -- [ Little ] -----
00006 *      ( ) _ ( )      ) _ )\ ( ( ( ) _ | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ ( ) \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ V / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \ \ V / | _ / |
00010 *      | "Yeah, it does Arduino..."
00011 *      -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdio.h>
00022 #include <string.h>
00023 #include <stdlib.h>
00024
00025 #include <stdint.h>
00026 #include <SDL/SDL.h>
00027
00028 #include "kernel_aware.h"
00029 #include "debug_sym.h"
00030 #include "write_callout.h"
00031 #include "interrupt_callout.h"
00032
00033 //-----
00034 #define GFX_RES_X      (128)
00035 #define GFX_RES_Y      (160)
00036 #define GFX_SCALE      (3)
00037
00038 //-----
00039 typedef struct
00040 {

```



```

00041     uint16_t usX;
00042     uint16_t usY;
00043     uint32_t uColor;
00044 } DrawPoint_t;
00045
00046 //-----
00047 static SDL_Surface *pstScreen = 0;
00048
00049 //-----
00050 void KA_Graphics_Close(void)
00051 {
00052     if (pstScreen)
00053     {
00054         SDL_FreeSurface(pstScreen);
00055     }
00056     SDL_Quit();
00057 }
00058
00059 //-----
00060 void KA_Graphics_ClearScreen(void)
00061 {
00062     memset( pstScreen->pixels, 0, sizeof(uint16_t) * (GFX_RES_X*GFX_SCALE) * (GFX_RES_Y*GFX_SCALE) );
00063 }
00064
00065 //-----
00066 void KA_Graphics_DrawPoint(DrawPoint_t *pstPoint_)
00067 {
00068     uint32_t *pixels = (uint32_t*)pstScreen->pixels;
00069
00070     // printf( "X:%d Y:%d C=%08X\n", pstPoint_>usX, pstPoint_>usY, pstPoint_>uColor );
00071     if ((pstPoint_>usX < GFX_RES_X ) && (pstPoint_>usY < GFX_RES_Y))
00072     {
00073         int i,j;
00074         for (i = 0; i < GFX_SCALE; i++)
00075         {
00076             for (j = 0; j < GFX_SCALE; j++)
00077             {
00078                 pixels[ ((uint32_t)((pstPoint_>usY*GFX_SCALE)+i) * (GFX_RES_X*GFX_SCALE) ) +
00079                     (uint32_t)((pstPoint_>usX*GFX_SCALE)+j) ] = (uint32_t)pstPoint_>
00080 uColor;
00081             }
00082         }
00083     }
00084
00085 //-----
00086 void KA_Graphics_Flip(void)
00087 {
00088     if (pstScreen)
00089     {
00090         SDL_Flip(pstScreen);
00091     }
00092 }
00093
00094 //-----
00095 bool KA_Graphics_Command( uint16_t u16Addr_, uint8_t u8Data_ )
00096 {
00097     Debug_Symbol_t *pstSymbol = Symbol_Find_Obj_By_Name( "g_pclPoint"
00098 );
00099
00100     switch( u8Data_ )
00101     {
00102         case 1:
00103             if (pstSymbol)
00104             {
00105                 uint16_t u16PointAddr = *(uint16_t*)(&stCPU.pstRAM->au8RAM[ pstSymbol->
00106 u32StartAddr ]));
00107                 DrawPoint_t *pstPoint = (DrawPoint_t*)(&stCPU.pstRAM->au8RAM[
00108 u16PointAddr ]));
00109                 KA_Graphics_DrawPoint( pstPoint );
00110             }
00111             break;
00112         case 2:
00113             KA_Graphics_Flip();
00114             break;
00115         case 0:
00116             default:
00117                 break;
00118     }
00119
00120     return true;
00121 }
00122
00123 //-----
00124 void KA_Graphics_Init(void)
00125 {
00126     Debug_Symbol_t *pstSymbol = 0;

```

```

00124     pstSymbol = Symbol_Find_Obj_By_Name( "g_u8GfxCommand" );
00125
00126     // Use pstSymbol's address to get a pointer to the current thread.
00127     if (!pstSymbol)
00128     {
00129         fprintf(stderr, "Kernel-aware graphics driver not found\n" );
00130         return;
00131     }
00132
00133     // Ensure that we actually have the information we need at a valid address
00134     uint16_t ul6CurrPtr = (uint16_t)(pstSymbol->u32StartAddr & 0x0000FFFF);
00135     if (!ul6CurrPtr)
00136     {
00137         fprintf(stderr, "Invalid address for graphics driver global\n" );
00138         return;
00139     }
00140
00141     // Add a callback so that when g_pstCurrent changes, we can update our
00142     // locally-tracked statistics.
00143     WriteCallout_Add( KA_Graphics_Command, ul6CurrPtr );
00144
00145     SDL_Init( SDL_INIT_EVERYTHING );
00146     pstScreen = SDL_SetVideoMode( GFX_RES_X * GFX_SCALE, GFX_RES_Y * GFX_SCALE, 32, SDL_SWSURFACE);
00147     fprintf(stderr, "Kernel-Aware Graphics Installed\n");
00148
00149     atexit( KA_Graphics_Close );
00150
00151 }

```

4.89 src/kernel_aware/ka_graphics.h File Reference

Mark3 RTOS Kernel-Aware graphics library.

```
#include "kernel_aware.h"
```

4.89.1 Detailed Description

Mark3 RTOS Kernel-Aware graphics library.

Definition in file [ka_graphics.h](#).

4.90 ka_graphics.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( ()/(      )\      ( ()/(      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( ) )\      / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ) ( ) ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ ( ) \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ / / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \ \ / / | _ \      |
00010 *      |      |      | "Yeah, it does Arduino..."
00011 *      -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __KA_TRACE__
00022 #define __KA_TRACE__
00023
00024 #include "kernel_aware.h"
00025 //-----
00026 //void KA_Graphics_Init( void );
00027
00028 #endif
00029

```

4.91 src/kernel_aware/ka_interrupt.c File Reference

Mark3 RTOS Kernel-Aware Interrupt Logging.

```
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <time.h>
#include "avr_cpu.h"
#include "kernel_aware.h"
#include "ka_interrupt.h"
#include "write_callout.h"
#include "interrupt_callout.h"
#include "tlv_file.h"
```

Data Structures

- struct [Mark3Interrupt_TLV_t](#)

Functions

- static void **KA_Interrupt** (bool bEntry_, uint8_t u8Vector_)
- void [KA_Interrupt_Init](#) (void)
KA_Interrupt_Init.

Variables

- static [TLV_t](#) * **pstTLV** = NULL

4.91.1 Detailed Description

Mark3 RTOS Kernel-Aware Interrupt Logging.

Definition in file [ka_interrupt.c](#).

4.91.2 Function Documentation

4.91.2.1 void KA_Interrupt_Init (void)

[KA_Interrupt_Init.](#)

Initialize the kernel-aware interrupt logging functionality in the emulator

Definition at line 59 of file [ka_interrupt.c](#).

4.92 ka_interrupt.c

```
00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      |
00004 *      ((/( ((/(      \      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( )\ )\ /( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( ) \ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
```

```

00008 * | _ | | _ / _ \ \ V / | _ / | -- [ Runtime ] -----
00009 * | _ | | _ / _ \ \ V / | _ \ |
00010 * | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdint.h>
00022 #include <stdio.h>
00023 #include <stdlib.h>
00024 #include <string.h>
00025 #include <time.h>
00026
00027 #include "avr_cpu.h"
00028 #include "kernel_aware.h"
00029 #include "ka_interrupt.h"
00030 #include "write_callout.h"
00031 #include "interrupt_callout.h"
00032 #include "tlv_file.h"
00033
00034 //-----
00035 static TLV_t *pstTLV = NULL;
00036
00037 //-----
00038 typedef struct
00039 {
00040     uint64_t    u64TimeStamp;
00041     uint8_t     u8Vector;
00042     bool        bEntry;
00043
00044 } Mark3Interrupt_TLV_t;
00045
00046 //-----
00047 static void KA_Interrupt( bool bEntry_, uint8_t u8Vector_ )
00048 {
00049     Mark3Interrupt_TLV_t stData;
00050     stData.u64TimeStamp = stCPU.u64CycleCount;
00051     stData.u8Vector = u8Vector_;
00052     stData.bEntry = bEntry_;
00053
00054     memcpy( &(pstTLV->au8Data[0]), &stData, sizeof(stData) );
00055     TLV_Write(pstTLV);
00056 }
00057
00058 //-----
00059 void KA_Interrupt_Init(void)
00060 {
00061     pstTLV = TLV_Alloc( sizeof(Mark3Interrupt_TLV_t) );
00062     if (!pstTLV)
00063     {
00064         return;
00065     }
00066
00067     pstTLV->eTag = TAG_KERNEL_AWARE_INTERRUPT;
00068     pstTLV->u16Len = sizeof(Mark3Interrupt_TLV_t);
00069
00070     InterruptCallout_Add( KA_Interrupt );
00071 }

```

4.93 src/kernel_aware/ka_interrupt.h File Reference

Mark3 RTOS Kernel-Aware Interrupt Logging.

Functions

- void [KA_Interrupt_Init](#) (void)
KA_Interrupt_Init.

4.93.1 Detailed Description

Mark3 RTOS Kernel-Aware Interrupt Logging.

Definition in file [ka_interrupt.h](#).

4.93.2 Function Documentation

4.93.2.1 void KA_Interrupt_Init (void)

KA_Interrupt_Init.

Initialize the kernel-aware interrupt logging functionality in the emulator

Definition at line 59 of file [ka_interrupt.c](#).

4.94 ka_interrupt.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      )\ ) |
00004 *      ((/( ((/(      \      (      ((/(      | -- [ Funkenstein ] -----
00005 *      /( ) )/( ) ((( ( )\ )\ /( ) | -- [ Little ] -----
00006 *      ( ) _ ( )      ) _ )\ ( ( ( ) ( ) | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ / / | _ \ | -- [ Runtime ] -----
00009 *      | _ | | _ _ / _ \ \ / \ | _ \ | |
00010 *      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 *      See license.txt for details
00014 *****/
00021 #ifndef __KA_INTERRUPT_H__
00022 #define __KA_INTERRUPT_H__
00023
00024 //-----
00030 void KA_Interrupt_Init(void);
00031
00032 #endif

```

4.95 src/kernel_aware/ka_joystick.c File Reference

Mark3 RTOS Kernel-Aware graphics library.

```

#include <stdio.h>
#include <stdint.h>
#include <stdlib.h>
#include <string.h>
#include <stdbool.h>
#include <SDL/SDL.h>
#include "ka_joystick.h"
#include "write_callout.h"
#include "debug_sym.h"
#include "avr_cpu.h"

```

Macros

- #define FLAVR_JOY_UP 0x01
- #define FLAVR_JOY_DOWN 0x02
- #define FLAVR_JOY_LEFT 0x04
- #define FLAVR_JOY_RIGHT 0x08
- #define FLAVR_JOY_FIRE 0x10

Functions

- static bool **KA_Scan_Joystick** (uint16_t u16Addr_, uint8_t u8Data_)
- void **KA_Joystick_Init** (void)

Variables

- static uint8_t u8Val = 0

4.95.1 Detailed Description

Mark3 RTOS Kernel-Aware graphics library.

Definition in file [ka_joystick.c](#).

4.96 ka_joystick.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ((/( ((/(      )\      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /( )  /( )  ((( ( )  )\  /( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ) ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | | |      ( ) _ ( ) \ \ / | _ |      | -- [ Virtual ] -----
00008 *      | _ | | _ |      / _ \ \ \ / | _ |      | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ \ / | _ |      |
00010 *                                          | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdio.h>
00022 #include <stdint.h>
00023 #include <stdlib.h>
00024 #include <string.h>
00025 #include <stdbool.h>
00026
00027 #include <SDL/SDL.h>
00028
00029 #include "ka_joystick.h"
00030 #include "write_callout.h"
00031 #include "debug_sym.h"
00032 #include "avr_cpu.h"
00033
00034 //-----
00035 #define FLAVR_JOY_UP      0x01
00036 #define FLAVR_JOY_DOWN    0x02
00037 #define FLAVR_JOY_LEFT    0x04
00038 #define FLAVR_JOY_RIGHT   0x08
00039 #define FLAVR_JOY_FIRE    0x10
00040
00041 //-----
00042 static uint8_t u8Val = 0;
00043
00044 //-----
00045 static bool KA_Scan_Joystick( uint16_t u16Addr_, uint8_t u8Data_ )
00046 {
00047     Debug_Symbol_t *pstSymbol = 0;
00048     pstSymbol = Symbol_Find_Obj_By_Name( "g_u8FlavrJoy" );
00049
00050     if (!pstSymbol)
00051     {
00052         fprintf(stderr, "Invalid joystick scan register\n");
00053         return true;
00054     }
00055
00056     uint16_t u16Addr = (uint16_t)(pstSymbol->u32StartAddr & 0x0000FFFF);
00057
00058     SDL_Event stEvent;
00059
00060     while (SDL_PollEvent(&stEvent))
00061     {
00062         switch (stEvent.type)
00063         {
00064             case SDL_KEYDOWN:
00065             {
00066                 switch( stEvent.key.keysym.sym )
00067                 {
00068                     case SDLK_UP:
00069                         u8Val |= FLAVR_JOY_UP;
00070                         break;
00071                     case SDLK_DOWN:
00072                         u8Val |= FLAVR_JOY_DOWN;
00073                         break;

```

```

00074         case SDLK_LEFT:
00075             u8Val |= FLAVR_JOY_LEFT;
00076             break;
00077         case SDLK_RIGHT:
00078             u8Val |= FLAVR_JOY_RIGHT;
00079             break;
00080         case SDLK_a:
00081             u8Val |= FLAVR_JOY_FIRE;
00082             break;
00083         case SDLK_ESCAPE:
00084             exit(0);
00085             break;
00086         default:
00087             break;
00088     }
00089 }
00090     break;
00091 case SDLK_KEYUP:
00092 {
00093     switch( stEvent.key.keysym.sym )
00094     {
00095         case SDLK_UP:
00096             u8Val &= ~FLAVR_JOY_UP;
00097             break;
00098         case SDLK_DOWN:
00099             u8Val &= ~FLAVR_JOY_DOWN;
00100             break;
00101         case SDLK_LEFT:
00102             u8Val &= ~FLAVR_JOY_LEFT;
00103             break;
00104         case SDLK_RIGHT:
00105             u8Val &= ~FLAVR_JOY_RIGHT;
00106             break;
00107         case SDLK_a:
00108             u8Val &= ~FLAVR_JOY_FIRE;
00109             break;
00110         default:
00111             break;
00112     }
00113 }
00114     break;
00115 default:
00116     break;
00117 }
00118 }
00119
00120 stCPU.pstRAM->au8RAM[ u16Addr ] = u8Val;
00121
00122 return true;
00123 }
00124
00125 //-----
00126 void KA_Joystick_Init( void )
00127 {
00128     Debug_Symbol_t *pstSymbol = 0;
00129     pstSymbol = Symbol_Find_Obj_By_Name( "g_u8FlavrJoyUp" );
00130
00131     if (!pstSymbol)
00132     {
00133         fprintf(stderr, "Kernel-aware joystick driver not found\n" );
00134         return;
00135     }
00136
00137     // Ensure that we actually have the information we need at a valid address
00138     uint16_t u16CurrPtr = (uint16_t)(pstSymbol->u32StartAddr & 0x0000FFFF);
00139     if (!u16CurrPtr)
00140     {
00141         fprintf(stderr, "Invalid address for joystick driver global\n" );
00142         return;
00143     }
00144
00145     // Add a callback so that when a joystick scan is requested, we parse keyboard input
00146     WriteCallout_Add( KA_Scan_Joystick, u16CurrPtr );
00147
00148 }

```

4.97 src/kernel_aware/ka_joystick.h File Reference

Mark3 RTOS Kernel-Aware graphics library.

```
#include "kernel_aware.h"
```


- void [KA_Command_Profile_Report](#) (void)
 KA_Command_Profile_Report.
- void [KA_Profile_Init](#) (void)
 KA_Profile_Init.

Variables

- static uint64_t [u64ProfileEpochStart](#) = 0
- static uint64_t [u64ProfileTotal](#) = 0
- static uint64_t [u64ProfileCount](#) = 0
- static char [szNameBuffer](#) [32] = {}
- static [TLV_t](#) * [pstTLV](#) = NULL

4.99.1 Detailed Description

Mark3 RTOS Kernel-Aware Profiling.

Definition in file [ka_profile.c](#).

4.99.2 Function Documentation

4.99.2.1 void KA_Profile_Init (void)

[KA_Profile_Init](#).

Initialize the kernel-aware profiling code.

Definition at line 120 of file [ka_profile.c](#).

4.99.3 Variable Documentation

4.99.3.1 uint64_t u64ProfileEpochStart = 0 [static]

! This is all singleton data... could be better hosted in a struct... ! Especially if Mark3 ever supports multiple concurrent Profilers

Definition at line 37 of file [ka_profile.c](#).

4.100 ka_profile.c

```

00001 /*****
00002 *      (      )      (      )      |
00003 *      )\ )      )\ )      (      )\ )      |
00004 *      ((/( ((/(      )\      (      ((/(      | -- [ Funkenstein ] -----
00005 *      /( )      /( )      ((( ( ( )\      )\      /( )      | -- [ Little ] -----
00006 *      ( )_ ( )      )\ _ )\      ( ( ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( )_ ( )\ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | |      / _ \      \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | |      / _ \      \ / | _ \      |
00010 *      | _ | |      / _ \      \ / | _ \      | "Yeah, it does Arduino..."
00011 *      -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include "kernel_aware.h"
00022 #include "debug_sym.h"
00023 #include "write_callout.h"
00024 #include "interrupt_callout.h"
00025 #include "ka_profile.h"
00026 #include "tlv_file.h"
00027

```

```

00028 #include <stdint.h>
00029 #include <stdio.h>
00030 #include <stdlib.h>
00031 #include <string.h>
00032 #include <time.h>
00033
00034 //-----
00037 static uint64_t u64ProfileEpochStart = 0;
00038 static uint64_t u64ProfileTotal = 0;
00039 static uint64_t u64ProfileCount = 0;
00040 static char szNameBuffer[32] = {};
00041 static TLV_t *pstTLV = NULL;
00042
00043 //-----
00044 typedef struct
00045 {
00046     uint64_t u64Timestamp;
00047     uint64_t u64ProfileCount;
00048     uint64_t u64ProfileTotalCycles;
00049     char      szName[32];
00050 } Mark3Profile_TLV_t;
00051
00052 //-----
00053 static void KA_PrintProfileResults(void)
00054 {
00055     Mark3Profile_TLV_t stTLV;
00056
00057     stTLV.u64ProfileCount      = u64ProfileCount;
00058     stTLV.u64ProfileTotalCycles = u64ProfileTotal;
00059     stTLV.u64Timestamp        = stCPU.u64CycleCount;
00060
00061     strcpy( stTLV.szName, szNameBuffer );
00062     memcpy( pstTLV->au8Data, &stTLV, sizeof(Mark3Profile_TLV_t) );
00063
00064     printf( "%s: %llu, %llu, %llu\n", stTLV.szName, stTLV.u64Timestamp, stTLV.
u64ProfileCount, stTLV.u64ProfileTotalCycles );
00065
00066     TLV_Write( pstTLV );
00067 }
00068
00069 //-----
00070 void KA_Command_Profile_Begin(void)
00071 {
00072     u64ProfileCount = 0;
00073     u64ProfileTotal = 0;
00074     u64ProfileEpochStart = 0;
00075
00076     Debug_Symbol_t *pstSymbol = Symbol_Find_Obj_By_Name( "g_stKADData"
);
00077     if (!pstSymbol)
00078     {
00079         return;
00080     }
00081
00082     uint16_t u16NamePtr = *((uint16_t*)&stCPU.pstRAM->au8RAM[ pstSymbol->
u32StartAddr ]);
00083     const char *szName = (const char*)&stCPU.pstRAM->au8RAM[ u16NamePtr ];
00084     if (szName)
00085     {
00086         strcpy( szNameBuffer, szName );
00087     }
00088     else
00089     {
00090         strcpy( szNameBuffer, "(NONE)" );
00091     }
00092 }
00093
00094
00095 //-----
00096 void KA_Command_Profile_Start(void)
00097 {
00098     // Profile stop or reset
00099     u64ProfileEpochStart = stCPU.u64CycleCount;
00100 }
00101
00102 //-----
00103 void KA_Command_Profile_Stop(void)
00104 {
00105     u64ProfileTotal += (stCPU.u64CycleCount - u64ProfileEpochStart);
00106     u64ProfileEpochStart = 0;
00107     u64ProfileCount++;
00108 }
00109
00110
00111 //-----
00112 void KA_Command_Profile_Report(void)
00113 {

```

```

00114     KA_PrintProfileResults();
00115     u64ProfileTotal = 0;
00116     u64ProfileEpochStart = 0;
00117 }
00118
00119 //-----
00120 void KA_Profile_Init(void)
00121 {
00122     pstTLV = TLV_Alloc(sizeof(Mark3Profile_TLV_t));
00123     pstTLV->eTag = TAG_KERNEL_AWARE_PROFILE;
00124     pstTLV->u16Len = sizeof(Mark3Profile_TLV_t);
00125 }

```

4.101 src/kernel_aware/ka_profile.h File Reference

Mark3 RTOS Kernel-Aware Profiling.

Functions

- void [KA_Profile_Init](#) (void)
KA_Profile_Init.
- void [KA_Command_Profile_Begin](#) (void)
KA_Command_Profile_Begin.
- void [KA_Command_Profile_Start](#) (void)
KA_Command_Profile_Start.
- void [KA_Command_Profile_Stop](#) (void)
KA_Command_Profile_Stop.
- void [KA_Command_Profile_Report](#) (void)
KA_Command_Profile_Report.

4.101.1 Detailed Description

Mark3 RTOS Kernel-Aware Profiling.

Definition in file [ka_profile.h](#).

4.101.2 Function Documentation

4.101.2.1 void KA_Profile_Init (void)

[KA_Profile_Init](#).

Initialize the kernel-aware profiling code.

Definition at line 120 of file [ka_profile.c](#).

4.102 ka_profile.h

```

00001  /*****
00002  *      (      (      (      |
00003  *      )\ )  )\ )      (      )\ )      |
00004  *      (( / ( (( / (      \      ( (( / (      | -- [ Funkenstein ] -----
00005  *      / ( )  / ( )  (( ( ( ( ( \      )\      / ( )      | -- [ Little ] -----
00006  *      ( ) _ ( )      )\ _ )\ ( ( ( ( ( )      | -- [ AVR ] -----
00007  *      | _ | |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008  *      | _ | | _      / _ \      \ V / | _ /      | -- [ Runtime ] -----
00009  *      | _ | | _      / _ \      \ V / | _ \      |
00010  *      | "Yeah, it does Arduino..."
00011  *      -----
00012  * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved

```

```

00013  *      See license.txt for details
00014  *****/
00021 #ifndef __KA_PROFILE_H__
00022 #define __KA_PROFILE_H__
00023
00024 //-----
00031 void KA_Profile_Init(void);
00032
00033 //-----
00037 void KA_Command_Profile_Begin(void);
00038
00039 //-----
00043 void KA_Command_Profile_Start(void);
00044
00045 //-----
00049 void KA_Command_Profile_Stop(void);
00050
00051 //-----
00055 void KA_Command_Profile_Report(void);
00056
00057 #endif

```

4.103 src/kernel_aware/ka_thread.c File Reference

Mark3 RTOS Kernel-Aware Thread Profiling.

```

#include "kernel_aware.h"
#include "debug_sym.h"
#include "write_callout.h"
#include "interrupt_callout.h"
#include "tlv_file.h"
#include "ka_thread.h"
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <time.h>

```

Data Structures

- struct [Mark3_Thread_t](#)
- struct [Mark3_Thread_Info_t](#)
- struct [Mark3ContextSwitch_TLV_t](#)

Macros

- #define **THREAD_STATE_EXIT** 0
- #define **THREAD_STATE_READY** 1
- #define **THREAD_STATE_BLOCKED** 2
- #define **THREAD_STATE_STOP** 3

Functions

- static void **Mark3KA_AddKnownThread** ([Mark3_Thread_t](#) *pstThread_)
- [Mark3_Thread_t](#) * **Mark3KA_GetCurrentThread** (void)
- static uint8_t **Mark3KA_GetCurrentPriority** (void)
- static uint16_t **Mark3KA_GetStackMargin** ([Mark3_Thread_t](#) *pstThread_)
- static uint16_t **Mark3KA_GetCurrentStackMargin** (void)
- static bool **KA_StackWarning** (uint16_t u16Addr_, uint8_t u8Data_)
- static bool **KA_ThreadChange** (uint16_t u16Addr_, uint8_t u8Data_)

- void **KA_PrintThreadInfo** (void)
- void **KA_Thread_Init** (void)
- char * **KA_Get_Thread_Info_XML** (uint8_t **thread_ids, uint16_t *thread_count)
- [Mark3_Context_t](#) * **KA_Get_Thread_Context** (uint8_t id_)
- int **KA_Get_Thread_ID** (void)
- int **KA_Get_Thread_Priority** (int id_)
- const char * **KA_Get_Thread_State** (int id_)

Variables

- static uint64_t **u64IdleTime** = 0
- static FILE * **fKernelState** = NULL
- static FILE * **fInterrupts** = NULL
- static [Mark3_Thread_Info_t](#) * **pstThreadInfo** = NULL
- static uint16_t **u16NumThreads** = 0
- static [Mark3_Thread_t](#) * **pstLastThread** = NULL
- static uint64_t **u64LastTime** = 0
- static uint8_t **u8LastPri** = 255
- static [TLV_t](#) * **pstTLV** = NULL

4.103.1 Detailed Description

Mark3 RTOS Kernel-Aware Thread Profiling.

Definition in file [ka_thread.c](#).

4.104 ka_thread.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      |
00004 *      ((/( ((/(      \      | -- [ Funkenstein ] -----
00005 *      /( )  /( )  ((( ( ( \  )\  /( )      | -- [ Little ] -----
00006 *      ( )_ | ( )      ) \_ )\ ( ( ( ( _ )      | -- [ AVR ] -----
00007 *      | | _ | |      ( )_ \ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | | _      / _ \ \ \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _ | / _ \ \ \ \ / | _ \      |
00010 *      |                                     | "Yeah, it does Arduino..."
00011 *      -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include "kernel_aware.h"
00022 #include "debug_sym.h"
00023 #include "write_callout.h"
00024 #include "interrupt_callout.h"
00025 #include "tlv_file.h"
00026 #include "ka_thread.h"
00027
00028 #include <stdint.h>
00029 #include <stdio.h>
00030 #include <stdlib.h>
00031 #include <string.h>
00032 #include <time.h>
00033
00034 #define THREAD_STATE_EXIT      0
00035 #define THREAD_STATE_READY    1
00036 #define THREAD_STATE_BLOCKED  2
00037 #define THREAD_STATE_STOP     3
00038
00039
00040 //-----
00041 typedef struct
00042 {
00043     uint16_t u16NextPtr;
00044     uint16_t u16PrevPtr;
00045
00046     uint16_t u16StackTopPtr;

```

```

00049
00051     uint16_t  u16StackPtr;
00052
00054     uint8_t   u8ThreadID;
00055
00057     uint8_t   u8Priority;
00058
00060     uint8_t   u8CurPriority;
00061
00063     uint8_t   u8ThreadState;
00064
00066     uint16_t  u16StackSize;
00067
00069     uint16_t  u16CurrentThreadList;
00070     uint16_t  u16OwnerThreadList;
00071
00073     uint16_t  u16EntryPoint;
00074
00076     void *m_pvArg;
00077
00079     uint16_t  u16Quantum;
00080
00081 } Mark3_Thread_t;
00082
00083 //-----
00084 typedef struct
00085 {
00086     Mark3_Thread_t *pstThread;
00087     uint8_t         u8ThreadID;
00088     uint64_t        u64TotalCycles;
00089     uint64_t        u64EpockCycles;
00090     bool            bActive;
00091 } Mark3_Thread_Info_t;
00092
00093 //-----
00094 typedef struct
00095 {
00096     uint64_t        u64Timestamp;
00097     uint16_t        u16StackMargin;
00098     uint8_t         u8ThreadID;
00099     uint8_t         u8ThreadPri;
00100 } Mark3ContextSwitch_TLV_t;
00101
00102 //-----
00103 static uint64_t u64IdleTime = 0;
00104 static FILE *fKernelState = NULL;
00105 static FILE *fInterrupts = NULL;
00106 static Mark3_Thread_Info_t *pstThreadInfo = NULL;
00107 static uint16_t u16NumThreads = 0;
00108
00109 static Mark3_Thread_t *pstLastThread = NULL;
00110 static uint64_t u64LastTime = 0;
00111 static uint8_t u8LastPri = 255;
00112 //-----
00113 static TLV_t *pstTLV = NULL;
00114
00115 //-----
00116 static void Mark3KA_AddKnownThread( Mark3_Thread_t *pstThread_ )
00117 {
00118     // Bail if the thread pointer is NULL
00119     if (!pstThread_ || ((uint32_t)pstThread_ == (uint32_t)stCPU.pstRAM->au8RAM))
00120     {
00121         return;
00122     }
00123
00124     // Check to see if a thread has already been tagged at this address
00125     bool bExists = false;
00126     if (pstThreadInfo)
00127     {
00128         int i;
00129         for (i = 0; i < u16NumThreads; i++)
00130         {
00131             Mark3_Thread_t *pstThread = pstThreadInfo[i].pstThread;
00132             // If there are other threads that exist at this address,
00133             if (pstThread == pstThread_)
00134             {
00135                 // If the stored thread's ID is different than the ID being presented here,
00136                 // then it's a dynamic thread involved. Create a new threadinfo object to track it.
00137                 if (pstThreadInfo[i].u8ThreadID != pstThread->u8ThreadID)
00138                 {
00139                     pstThreadInfo[i].bActive = false;
00140                 }
00141                 // Thread IDs are the same, thread has already been tracked, don't do anything.
00142             }
00143             else
00144             {
00145                 bExists = true;
00146             }
00147         }
00148     }

```

```

00146     }
00147     }
00148 }
00149
00150 // If not already known, add the thread to the list of known threads.
00151 if (!bExists)
00152 {
00153     u16NumThreads++;
00154     pstThreadInfo = (Mark3_Thread_Info_t*)realloc(pstThreadInfo, sizeof(
Mark3_Thread_Info_t) * u16NumThreads);
00155
00156     pstThreadInfo[u16NumThreads - 1].pstThread = pstThread_;
00157     pstThreadInfo[u16NumThreads - 1].u64EpockCycles = 0;
00158     pstThreadInfo[u16NumThreads - 1].u64TotalCycles = 0;
00159     pstThreadInfo[u16NumThreads - 1].u8ThreadID = pstThread_>u8ThreadID;
00160     pstThreadInfo[u16NumThreads - 1].bActive = true;
00161 }
00162 }
00163
00164 //-----
00165 Mark3_Thread_t *Mark3KA_GetCurrentThread(void)
00166 {
00167     Debug_Symbol_t *pstSymbol = 0;
00168
00169     pstSymbol = Symbol_Find_Obj_By_Name( "g_pclCurrent" );
00170
00171     // Use pstSymbol's address to get a pointer to the current thread.
00172     if (!pstSymbol)
00173     {
00174         return 0;
00175     }
00176
00177     uint16_t u16CurrPtr = (uint16_t)(pstSymbol->u32StartAddr & 0x0000FFFF);
00178     if (!u16CurrPtr)
00179     {
00180         return 0;
00181     }
00182
00183     // Now that we have the address of g_pstCurrent, dereference the pointer
00184     // to get the address of the current thread.
00185
00186     uint16_t u16CurrAddr = ((uint16_t)(stCPU.pstRAM->au8RAM[ u16CurrPtr + 1 ]) << 8) +
stCPU.pstRAM->au8RAM[ u16CurrPtr ];
00188
00189     // Return a pointer to the thread as it is in memory.
00190     return (Mark3_Thread_t*)(&stCPU.pstRAM->au8RAM[ u16CurrAddr ]);
00191 }
00192
00193 //-----
00194 static uint8_t Mark3KA_GetCurrentPriority(void)
00195 {
00196     Mark3_Thread_t *pstThread = Mark3KA_GetCurrentThread();
00197     if (!pstThread)
00198     {
00199         return 0;
00200     }
00201     uint8_t *pucData = (uint8_t*)pstThread;
00202
00203     // If the curpriority member is set, it means we're in the middle of
00204     // priority inheritance. If it's zero, return the normal priority
00205     if (0 == pstThread->u8CurPriority)
00206     {
00207         return pstThread->u8Priority;
00208     }
00209     return pstThread->u8CurPriority;
00210 }
00211
00212 //-----
00213 static uint16_t Mark3KA_GetStackMargin( Mark3_Thread_t *pstThread_ )
00214 {
00215     uint16_t u16StackBase = pstThread_>u16StackPtr;
00216     uint16_t u16StackSize = pstThread_>u16StackSize;
00217
00218     int i;
00219
00220     for (i = 0; i < u16StackSize; i++)
00221     {
00222         if (255 != stCPU.pstRAM->au8RAM[ u16StackBase + i ])
00223         {
00224             return (uint16_t)i;
00225         }
00226     }
00227
00228     return u16StackSize;
00229 }
00230
00231 //-----

```

```

00232 static uint16_t Mark3KA_GetCurrentStackMargin(void)
00233 {
00234     return Mark3KA_GetStackMargin( Mark3KA_GetCurrentThread() );
00235 }
00236
00237 //-----
00238 static bool KA_StackWarning( uint16_t u16Addr_, uint8_t u8Data_ )
00239 {
00240     if (u8Data_ != 0xFF && stCPU.pstRAM->au8RAM[ u16Addr_ ] == 0xFF )
00241     {
00242         fprintf( stderr, "[WARNING] Near stack-overflow detected - Thread %d, Stack Margin %d\n",
00243                 Mark3KA_GetCurrentThread()->u8ThreadID,
00244                 Mark3KA_GetCurrentStackMargin() );
00245     }
00246     return true;
00247 }
00248
00249 //-----
00250 static bool KA_ThreadChange( uint16_t u16Addr_, uint8_t u8Data_ )
00251 {
00252     uint8_t u8Pri = Mark3KA_GetCurrentPriority();
00253     uint8_t u8Thread = Mark3KA_GetCurrentThread()->u8ThreadID;
00254     uint16_t u16Margin = Mark3KA_GetCurrentStackMargin();
00255
00256     // -- Add context switch instrumentation to TLV
00257     Mark3ContextSwitch_TLV_t stData;
00258
00259     stData.u8ThreadID = u8Thread;
00260     stData.u8ThreadPri = u8Pri;
00261     stData.u16StackMargin = u16Margin;
00262     stData.u64Timestamp = stCPU.u64CycleCount;
00263
00264     memcpy( &(pstTLV->au8Data[0]), &stData, sizeof(stData) );
00265     TLV_Write( pstTLV );
00266
00267     if (u8LastPri == 0)
00268     {
00269         u64IdleTime += (stCPU.u64CycleCount - u64LastTime);
00270     }
00271
00272     // Track this as a known-thread internally for future reporting.
00273     Mark3KA_AddKnownThread( Mark3KA_GetCurrentThread() );
00274
00275     if (pstLastThread && u64LastTime)
00276     {
00277         Mark3_Thread_t *pstThread;
00278         int i;
00279         for ( i = 0; i < u16NumThreads; i++ )
00280         {
00281             if ( (pstLastThread == pstThreadInfo[i].pstThread) &&
00282                 (pstLastThread->u8ThreadID == pstThreadInfo[i].u8ThreadID) )
00283             {
00284                 pstThreadInfo[i].u64TotalCycles += stCPU.u64CycleCount - u64LastTime;
00285             }
00286         }
00287     }
00288
00289     u64LastTime = stCPU.u64CycleCount;
00290     u8LastPri = u8Pri;
00291
00292     // Add watchpoints on active thread stack at 32-bytes from the end
00293     // of the stack. That way, we can immediately detect stack smashing threats
00294     // without having to hunt.
00295
00296     uint16_t u16StackWarning = Mark3KA_GetCurrentThread()->u16StackPtr + 32;
00297     WriteCallout_Add( KA_StackWarning, u16StackWarning );
00298
00299     // Cache the current thread for use as the "last run" thread in
00300     // subsequent iterations
00301     pstLastThread = Mark3KA_GetCurrentThread();
00302
00303     return true;
00304 }
00305
00306 //-----
00307 void KA_PrintThreadInfo(void)
00308 {
00309     int i;
00310     uint64_t u64TrackedThreadTime = 0;
00311
00312     uint16_t u16LastThread = (uint16_t)((void*)Mark3KA_GetCurrentThread() - (void*)&stCPU.pstRAM->au8RAM[0]
00313 );
00314     KA_ThreadChange( u16LastThread, 0 );
00315
00316     for ( i = 0; i < u16NumThreads; i++ )
00317     {

```



```

00318         u64TrackedThreadTime += pstThreadInfo[i].u64TotalCycles;
00319     }
00320
00321     printf( "ThreadID, ThreadAddr, TotalCycles, PercentCPU, IsActive, Prio, StackMargin\n");
00322     for ( i = 0; i < u16NumThreads; i++ )
00323     {
00324         printf( "%d, %04X, %llu, %0.3f, %d, %d, %d\n",
00325             pstThreadInfo[i].u8ThreadID,
00326             (uint16_t)((void*)(pstThreadInfo[i].pstThread) - (void*)(&stCPU.pstRAM->au8RAM[0])),
00327             pstThreadInfo[i].u64TotalCycles,
00328             (double)pstThreadInfo[i].u64TotalCycles / u64TrackedThreadTime * 100.0f,
00329             pstThreadInfo[i].bActive,
00330             (pstThreadInfo[i].bActive ? pstThreadInfo[i].pstThread->
u8Priority : 0),
00331             (pstThreadInfo[i].bActive ? Mark3KA_GetStackMargin(pstThreadInfo[i].pstThread) : 0)
00332         );
00333     }
00334 }
00335
00336 //-----
00337 void KA_Thread_Init( void )
00338 {
00339     Debug_Symbol_t *pstSymbol = 0;
00340     pstSymbol = Symbol_Find_Obj_By_Name( "g_pclCurrent" );
00341
00342     // Use pstSymbol's address to get a pointer to the current thread.
00343     if (!pstSymbol)
00344     {
00345         return;
00346     }
00347
00348     // Ensure that we actually have the information we need at a valid address
00349     uint16_t u16CurrPtr = (uint16_t)(pstSymbol->u32StartAddr & 0x0000FFFF);
00350     if (!u16CurrPtr)
00351     {
00352         return;
00353     }
00354
00355     // Add a callback so that when g_pstCurrent changes, we can update our
00356     // locally-tracked statistics.
00357     WriteCallout_Add( KA_ThreadChange , u16CurrPtr + 1 );
00358
00359     pstTLV = TLV_Alloc( sizeof(Mark3ContextSwitch_TLV_t) );
00360     pstTLV->eTag = TAG_KERNEL_AWARE_CONTEXT_SWITCH;
00361     pstTLV->u16Len = sizeof(Mark3ContextSwitch_TLV_t);
00362
00363     atexit( KA_PrintThreadInfo );
00364 }
00365
00366 //-----
00367 char *KA_Get_Thread_Info_XML(uint8_t **thread_ids, uint16_t *thread_count)
00368 {
00369     char *ret = (char*)malloc(4096);
00370     char *writer = ret;
00371     uint8_t *new_ids;
00372
00373     if (u16NumThreads && thread_ids)
00374     {
00375         new_ids = (uint8_t*)malloc(u16NumThreads);
00376         *thread_ids = new_ids;
00377     }
00378
00379     writer += sprintf( writer,
00380         "<threads>" );
00381
00382     if (!u16NumThreads) {
00383         writer += sprintf( writer,
00384             " <thread id=\"0\" core=\"0\">"
00385             " System Thread - Priority N/A [Running] "
00386             "</thread>");
00387     }
00388
00389     int i;
00390     int count = 0;
00391     for (i = 0; i < u16NumThreads; i++)
00392     {
00393         if (pstThreadInfo[i].bActive)
00394         {
00395             if (pstThreadInfo[i].u8ThreadID == 255)
00396             {
00397                 writer += sprintf(writer,
00398                     " <thread id=\"255\" core=\"0\">"
00399                     " Mark3 Thread - Priority 0 [IDLE]");
00400             }
00401             else if (pstThreadInfo[i].u8ThreadID == Mark3KA_GetCurrentThread()->u8ThreadID)
00402             {
00403                 writer += sprintf(writer,

```

```

00404         " <thread id=\"%d\" core=\"%0\">"
00405         " Mark3 Thread - Priority %d [Running] " ,
00406         pstThreadInfo[i].u8ThreadID,
00407         pstThreadInfo[i].pstThread->u8CurPriority );
00408     }
00409     else
00410     {
00411         writer += sprintf(writer,
00412         " <thread id=\"%d\" core=\"%0\">"
00413         " Mark3 Thread - Priority %d" ,
00414         pstThreadInfo[i].u8ThreadID,
00415         pstThreadInfo[i].pstThread->u8CurPriority );
00416     }
00417     if (thread_ids)
00418     {
00419         new_ids[count++] = pstThreadInfo[i].u8ThreadID;
00420     }
00421 }
00422 writer += sprintf( writer, " </thread>");
00423 }
00424
00425 sprintf( writer, "</threads>" );
00426 if (thread_count)
00427 {
00428     *thread_count = count;
00429 }
00430 return ret;
00431 }
00432
00433 //-----
00434 Mark3_Context_t *KA_Get_Thread_Context(uint8_t id_)
00435 {
00436     int i;
00437     for (i = 0; i < ul6NumThreads; i++)
00438     {
00439         if (pstThreadInfo[i].bActive)
00440         {
00441             if (pstThreadInfo[i].u8ThreadID == id_)
00442             {
00443                 Mark3_Context_t *new_ctx = (Mark3_Context_t*)malloc(sizeof(
00444 Mark3_Context_t));
00445                 uint16_t context_addr = pstThreadInfo[i].pstThread->
00446 ul6StackTopPtr;
00447
00448                 new_ctx->SPH = stCPU.pstRAM->au8RAM[context_addr - 1];
00449                 new_ctx->SPL = stCPU.pstRAM->au8RAM[context_addr];
00450
00451                 int j = 0;
00452                 for (i = 31; i >= 0; i--)
00453                 {
00454                     new_ctx->r[i] = stCPU.pstRAM->au8RAM[context_addr + 1 + j];
00455                     j++;
00456                 }
00457                 new_ctx->SREG = stCPU.pstRAM->au8RAM[context_addr + 33];
00458                 uint16_t PC = *(uint16_t*)(stCPU.pstRAM->au8RAM[context_addr + 34]);
00459                 PC = ((PC & 0xFF00)>>8) | ((PC & 0x00FF) << 8);
00460                 new_ctx->PC = PC;
00461
00462                 return new_ctx;
00463             }
00464         }
00465     }
00466     return NULL;
00467 }
00468 //-----
00469 int KA_Get_Thread_ID(void)
00470 {
00471     return Mark3KA_GetCurrentThread()->u8ThreadID;
00472 }
00473 //-----
00474 int KA_Get_Thread_Priority( int id_ )
00475 {
00476     int i;
00477     for (i = 0; i < ul6NumThreads; i++)
00478     {
00479         if (pstThreadInfo[i].bActive)
00480         {
00481             if (pstThreadInfo[i].u8ThreadID == id_)
00482             {
00483                 return pstThreadInfo[i].pstThread->u8CurPriority;
00484             }
00485         }
00486     }
00487     return -1;
00488 }

```

```

00489
00490 //-----
00491 const char *KA_Get_Thread_State( int id_ )
00492 {
00493     int i;
00494     for (i = 0; i < ul6NumThreads; i++)
00495     {
00496         if (pstThreadInfo[i].bActive)
00497         {
00498             if (pstThreadInfo[i].u8ThreadID == id_)
00499             {
00500                 switch (pstThreadInfo[i].pstThread->u8ThreadState)
00501                 {
00502                     case THREAD_STATE_BLOCKED:
00503                         return "Blocked";
00504                     case THREAD_STATE_EXIT:
00505                         return "Exit";
00506                     case THREAD_STATE_READY:
00507                         if (id_ == Mark3KA_GetCurrentThread()->u8ThreadID)
00508                         {
00509                             return "Running";
00510                         }
00511                         return "Ready";
00512                     case THREAD_STATE_STOP:
00513                         return "Stopped";
00514                     default:
00515                         return "unknown";
00516                 }
00517             }
00518         }
00519     }
00520     return -1;
00521 }

```

4.105 src/kernel_aware/ka_thread.h File Reference

Mark3 RTOS Kernel-Aware Thread Profiling.

#include <stdint.h>

Data Structures

- struct [Mark3_Context_t](#)

Functions

- void **KA_Thread_Init** (void)
- int **KA_Get_Thread_Priority** (int id_)
- const char * **KA_Get_Thread_State** (int id_)

4.105.1 Detailed Description

Mark3 RTOS Kernel-Aware Thread Profiling.

Definition in file [ka_thread.h](#).

4.106 ka_thread.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )  (      )\ ) |
00004 *      ((/( ((/(      )\      ( ((/( | -- [ Funkenstein ] -----
00005 *      /(_ ) /(_ ) ((((_ ( )\  /(_ ) | -- [ Little ] -----
00006 *      (_ )_ | (_ )  )\ _ )\ ( (_ ) (_ ) | -- [ AVR ] -----
00007 *      | | _ | |      (_ )\ (_ )\ \ / / | _ \ | -- [ Virtual ] -----

```

```

00008 * | _ | | _ / _ \ \ V / | _ / | -- [ Runtime ] -----
00009 * | _ | | _ / _ \ \ V / | _ \ |
00010 * | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __KA_THREAD_H__
00022 #define __KA_THREAD_H__
00023
00024 #include <stdint.h>
00025
00026 typedef struct
00027 {
00028     uint8_t SPH;
00029     uint8_t SPL;
00030     uint8_t r[32];
00031     uint8_t SREG;
00032     uint16_t PC;
00033 } Mark3_Context_t;
00034
00035 //-----
00036 void KA_Thread_Init( void );
00037
00038 int KA_Get_Thread_Priority(int id_);
00039
00040 const char *KA_Get_Thread_State( int id_ );
00041
00042 #endif

```

4.107 src/kernel_aware/ka_trace.c File Reference

Mark3 RTOS Kernel-Aware Trace functionality.

```

#include "kernel_aware.h"
#include "debug_sym.h"
#include "ka_trace.h"
#include "tlv_file.h"
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <time.h>

```

Data Structures

- struct [KernelAwareTrace_t](#)

Functions

- void [KA_EmitTrace](#) (KernelAwareCommand_t eCmd_)
KA_EmitTrace.
- void [KA_Print](#) (void)
KA_Print.
- void [KA_Trace_Init](#) (void)
KA_Trace_Init.

Variables

- static [TLV_t](#) * **pstTLV** = NULL

4.107.1 Detailed Description

Mark3 RTOS Kernel-Aware Trace functionality.

Definition in file [ka_trace.c](#).

4.107.2 Function Documentation

4.107.2.1 void KA_EmitTrace (KernelAwareCommand_t eCmd_)

KA_EmitTrace.

Process a kernel trace event and emit the appropriate record into our TLV stream output

Parameters

eCmd_	Type of trace command being emitted.
-------	--------------------------------------

Definition at line 47 of file [ka_trace.c](#).

4.107.2.2 void KA_Print (void)

KA_Print.

Print a kernel string event to the console and TLV stream.

Definition at line 81 of file [ka_trace.c](#).

4.107.2.3 void KA_Trace_Init (void)

KA_Trace_Init.

Initialize the local TLV buffers, etc. Must be called prior to use

Definition at line 97 of file [ka_trace.c](#).

4.108 ka_trace.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ((/( ((/(      \      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /( )  /( )  ((( ( )\  )\  /( )      | -- [ Little ] -----
00006 *      ( )_ ( )      )\ _ )\  ( ( ) ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( )_ \ ( ) \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ / / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \ \ / / | _ \      |
00010 *      |      |      | "Yeah, it does Arduino..."
00011 *      -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include "kernel_aware.h"
00022 #include "debug_sym.h"
00023
00024 #include "ka_trace.h"
00025 #include "tlv_file.h"
00026
00027 #include <stdint.h>
00028 #include <stdio.h>
00029 #include <stdlib.h>
00030 #include <string.h>
00031 #include <time.h>
00032
00033 //-----
00034 typedef struct
00035 {
00036     uint16_t ul6File;
00037     uint16_t ul6Line;

```

```

00038     uint16_t u16Code;
00039     uint16_t u16Arg1;
00040     uint16_t u16Arg2;
00041 } KernelAwareTrace_t;
00042
00043 //-----
00044 static TLV_t *pstTLV = NULL;
00045
00046 //-----
00047 void KA_EmitTrace( KernelAwareCommand_t eCmd_ )
00048 {
00049     Debug_Symbol_t *pstSymbol = Symbol_Find_Obj_By_Name( "g_stKADData"
00050 );
00051     if (!pstSymbol)
00052     {
00053         return;
00054     }
00055     KernelAwareTrace_t *pstTrace = (KernelAwareTrace_t*)&stCPU.
00056 pstRAM->au8RAM[ pstSymbol->u32StartAddr ];
00057     switch (eCmd_)
00058     {
00059     case KA_COMMAND_TRACE_0:
00060         pstTLV->eTag = KA_COMMAND_TRACE_0;
00061         pstTLV->u16Len = 6;
00062         break;
00063     case KA_COMMAND_TRACE_1:
00064         pstTLV->eTag = KA_COMMAND_TRACE_1;
00065         pstTLV->u16Len = 8;
00066         break;
00067     case KA_COMMAND_TRACE_2:
00068         pstTLV->eTag = KA_COMMAND_TRACE_2;
00069         pstTLV->u16Len = 10;
00070         break;
00071     default:
00072         return;
00073     }
00074     fprintf(stderr, "Trace: %04X, %04X, %04X, %04X, %04x\n", pstTrace->u16File, pstTrace->u16Line,
00075 pstTrace->u16Code, pstTrace->u16Arg1, pstTrace->u16Arg2 );
00076     memcpy( pstTLV->au8Data, pstTrace, pstTLV->u16Len );
00077     TLV_Write( pstTLV );
00078 }
00079
00080 //-----
00081 void KA_Print( void )
00082 {
00083     Debug_Symbol_t *pstSymbol = Symbol_Find_Obj_By_Name( "g_stKADData"
00084 );
00085     if (!pstSymbol)
00086     {
00087         return;
00088     }
00089     uint16_t u16NamePtr = *((uint16_t*)&stCPU.pstRAM->au8RAM[ pstSymbol->
00090 u32StartAddr ]);
00091     const char *szString = (const char*)&stCPU.pstRAM->au8RAM[ u16NamePtr ];
00092     strcpy( pstTLV->au8Data, szString );
00093     fprintf( stderr, "%s", szString );
00094 }
00095
00096 //-----
00097 void KA_Trace_Init(void)
00098 {
00099     pstTLV = TLV_Alloc(64);
00100 }

```

4.109 src/kernel_aware/ka_trace.h File Reference

Mark3 RTOS Kernel-Aware Trace and Print Functionality.

```
#include "kernel_aware.h"
#include "debug_sym.h"
#include "ka_trace.h"
#include "tlv_file.h"
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <time.h>
```

Functions

- void [KA_EmitTrace](#) (KernelAwareCommand_t eCmd_)
KA_EmitTrace.
- void [KA_Print](#) (void)
KA_Print.
- void [KA_Trace_Init](#) (void)
KA_Trace_Init.

4.109.1 Detailed Description

Mark3 RTOS Kernel-Aware Trace and Print Functionality.

Definition in file [ka_trace.h](#).

4.109.2 Function Documentation

4.109.2.1 void [KA_EmitTrace](#) (KernelAwareCommand_t eCmd_)

KA_EmitTrace.

Process a kernel trace event and emit the appropriate record into our TLV stream output

Parameters

<i>eCmd_</i>	Type of trace command being emitted.
--------------	--------------------------------------

Definition at line 47 of file [ka_trace.c](#).

4.109.2.2 void [KA_Print](#) (void)

KA_Print.

Print a kernel string event to the console and TLV stream.

Definition at line 81 of file [ka_trace.c](#).

4.109.2.3 void [KA_Trace_Init](#) (void)

KA_Trace_Init.

Initialize the local TLV buffers, etc. Must be called prior to use

Definition at line 97 of file [ka_trace.c](#).

4.110 ka_trace.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      )\ ) |
00004 *      ((/( ((/(      \      ( ((/( | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( ) \ ) \ / ( ) | -- [ Little ] -----
00006 *      ( ) _ ( )      ) \ _ \ ( ( ) ( ( ) | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ \ ( ) \ \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ V / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _ _ / _ \ \ \ / | _ \ |
00010 *      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __KA_TRACE__
00022 #define __KA_TRACE__
00023
00024
00025 #include "kernel_aware.h"
00026 #include "debug_sym.h"
00027
00028 #include "ka_trace.h"
00029 #include "tlv_file.h"
00030
00031 #include <stdint.h>
00032 #include <stdio.h>
00033 #include <stdlib.h>
00034 #include <string.h>
00035 #include <time.h>
00036
00037 //-----
00046 void KA_EmitTrace( KernelAwareCommand_t eCmd_ );
00047
00048 //-----
00054 void KA_Print( void );
00055
00056 //-----
00062 void KA_Trace_Init( void );
00063
00064 #endif
00065

```

4.111 src/kernel_aware/kernel_aware.c File Reference

Mark3 RTOS Kernel-Aware debugger.

```

#include "kernel_aware.h"
#include "debug_sym.h"
#include "write_callout.h"
#include "interrupt_callout.h"
#include "ka_interrupt.h"
#include "ka_profile.h"
#include "ka_thread.h"
#include "ka_trace.h"
#include "ka_graphics.h"
#include "ka_joystick.h"
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <time.h>

```

Functions

- static bool **KA_Command** (uint16_t u16Addr_, uint8_t u8Data_)
- static bool **KA_Set** (uint16_t u16Addr_, uint8_t u8Data_)
- void **KernelAware_Init** (void)

KernelAware_Init.

4.111.1 Detailed Description

Mark3 RTOS Kernel-Aware debugger.

Definition in file [kernel_aware.c](#).

4.111.2 Function Documentation

4.111.2.1 void KernelAware_Init(void)

KernelAware_Init.

Initialize special RTOS kernel-aware debugger functionality when selected. Currently this is tied to Mark3 RTOS (see [kernel_aware.c](#) implementation), but can be abstracted using this simple interface to any other RTOS kernel or environment (but why would you – Mark3 is awesome!).

Definition at line 69 of file [kernel_aware.c](#).

4.112 kernel_aware.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/ ( ( ( / (      \      (      ( ( / (      | -- [ Funkenstein ] -----
00005 *      / ( ) / ( ) ((( ( ( ) \      / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      ) _ ) \ ( ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \      \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _      / _ \      \ / | _ \      |
00010 *                                  | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include "kernel_aware.h"
00022 #include "debug_sym.h"
00023 #include "write_callout.h"
00024 #include "interrupt_callout.h"
00025
00026 #include "ka_interrupt.h"
00027 #include "ka_profile.h"
00028 #include "ka_thread.h"
00029 #include "ka_trace.h"
00030 #include "ka_graphics.h"
00031 #include "ka_joystick.h"
00032
00033 #include <stdint.h>
00034 #include <stdio.h>
00035 #include <stdlib.h>
00036 #include <string.h>
00037 #include <time.h>
00038
00039
00040 //-----
00041 static bool KA_Command( uint16_t u16Addr_, uint8_t u8Data_ )
00042 {
00043     switch (u8Data_)
00044     {
00045     case KA_COMMAND_PROFILE_INIT:    KA_Command_Profile_Begin();    break;
00046     case KA_COMMAND_PROFILE_STOP:    KA_Command_Profile_Stop();    break;
00047     case KA_COMMAND_PROFILE_START:   KA_Command_Profile_Start();    break;
00048     case KA_COMMAND_PROFILE_REPORT:  KA_Command_Profile_Report();    break;
00049     case KA_COMMAND_TRACE_0:
00050     case KA_COMMAND_TRACE_1:
00051     case KA_COMMAND_TRACE_2:         KA_EmitTrace(u8Data_);        break;
00052     case KA_COMMAND_PRINT:           KA_Print();                    break;
00053     default:
00054         break;
00055     }
00056 }
00057 return true;

```

```

00058 }
00059
00060 //-----
00061 static bool KA_Set( uint16_t ul6Addr_, uint8_t u8Data_ )
00062 {
00063     fprintf(stderr, "ADDR: [%04X], Data: [%02X]\n", ul6Addr_, u8Data_ );
00064     stCPU.pstRAM->au8RAM[ ul6Addr_ & 0xFFFF ] = 1;
00065     return false;
00066 }
00067
00068 //-----
00069 void KernelAware_Init( void )
00070 {
00071     Debug_Symbol_t *pstSymbol = 0;
00072
00073     // Add a callout for profiling information (present in Mark3 Unit Tests)
00074     pstSymbol = Symbol_Find_Obj_By_Name( "g_u8KACommand" );
00075     if (pstSymbol)
00076     {
00077         // Ensure that we actually have the information we need at a valid address
00078         uint16_t ul6CurrPtr = (uint16_t)(pstSymbol->u32StartAddr & 0x0000FFFF);
00079         printf( "found kernel-aware command @ %04X\n", ul6CurrPtr );
00080         if (ul6CurrPtr)
00081         {
00082             // Add a callback so that when profiling state changes, we do something.
00083             WriteCallout_Add( KA_Command , ul6CurrPtr );
00084         }
00085     }
00086     else
00087     {
00088         printf( "Unable to find g_u8KACommand\n" );
00089     }
00090
00091     // Set the kernel's "simulator aware" flag, to let it know to configure itself
00092     // appropriately.
00093
00094     pstSymbol = Symbol_Find_Obj_By_Name( "g_bIsKernelAware" );
00095     if (pstSymbol)
00096     {
00097         fprintf( stderr, "Addr: %4X, Name: %s\n", pstSymbol->u32StartAddr, pstSymbol->
00098             szName );
00099         // Ensure that we actually have the information we need at a valid address
00100         uint16_t ul6CurrPtr = (uint16_t)(pstSymbol->u32StartAddr);
00101         if (ul6CurrPtr)
00102         {
00103             // Add a callout so that the kernel-aware flag is *always* set.
00104             fprintf( stderr, "Adding writeout\n" );
00105             WriteCallout_Add( KA_Set , ul6CurrPtr );
00106             fprintf( stderr, "done\n" );
00107         }
00108     }
00109     else
00110     {
00111         printf( "Unable to find g_bIsKernelAware" );
00112     }
00113
00114     KA_Interrupt_Init();
00115     KA_Thread_Init();
00116     KA_Profile_Init();
00117     KA_Trace_Init();
00118
00119     KA_Graphics_Init();
00120     KA_Joystick_Init();
00121
00122 }
00123
00124 }

```

4.113 src/kernel_aware/kernel_aware.h File Reference

Kernel-Aware debugger plugin interface.

```

#include "elf_process.h"
#include "debug_sym.h"
#include "avr_cpu.h"
#include <stdint.h>

```

Enumerations

- enum **KernelAwareCommand_t** {
KA_COMMAND_IDLE = 0, **KA_COMMAND_PROFILE_INIT**, **KA_COMMAND_PROFILE_START**, **KA_COMMAND_PROFILE_STOP**,
KA_COMMAND_PROFILE_REPORT, **KA_COMMAND_EXIT_SIMULATOR**, **KA_COMMAND_TRACE_0**, **KA_COMMAND_TRACE_1**,
KA_COMMAND_TRACE_2, **KA_COMMAND_PRINT** }

Functions

- void **KernelAware_Init** (void)
KernelAware_Init.
- void **KA_Graphics_Init** (void) __attribute__((weak))
- void **KA_Joystick_Init** (void) __attribute__((weak))

4.113.1 Detailed Description

Kernel-Aware debugger plugin interface.

Definition in file [kernel_aware.h](#).

4.113.2 Function Documentation

4.113.2.1 void KernelAware_Init (void)

KernelAware_Init.

Initialize special RTOS kernel-aware debugger functionality when selected. Currently this is tied to Mark3 RTOS (see [kernel_aware.c](#) implementation), but can be abstracted using this simple interface to any other RTOS kernel or environment (but why would you – Mark3 is awesome!).

Definition at line 69 of file [kernel_aware.c](#).

4.114 kernel_aware.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      )\ ) |
00004 *      ((/( ((/(      )\      ( ((/( | -- [ Funkenstein ] -----
00005 *      /( ) / ) )((( ) )\ ) / ) | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ) ( ) | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ V / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ \ / | _ \ |
00010 *      | _ | | _ | / _ \ \ \ / | _ \ |
00011 *      | _ | | _ | / _ \ \ \ / | _ \ | "Yeah, it does Arduino..."
00012 *      +-----+
00013 *      (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00014 *      See license.txt for details
00015 *****/
00016 #ifndef __KERNEL_AWARE_H__
00017 #define __KERNEL_AWARE_H__
00018
00019 #include "elf_process.h"
00020 #include "debug_sym.h"
00021 #include "avr_cpu.h"
00022
00023 #include <stdint.h>
00024
00025 //-----
00026 typedef enum
00027 {
00028     KA_COMMAND_IDLE = 0,
00029     KA_COMMAND_PROFILE_INIT,
00030     KA_COMMAND_PROFILE_START,
00031     KA_COMMAND_PROFILE_STOP,
00032     KA_COMMAND_PROFILE_REPORT,
00033     KA_COMMAND_EXIT_SIMULATOR,
00034     KA_COMMAND_TRACE_0,
00035     KA_COMMAND_TRACE_1,
00036     KA_COMMAND_TRACE_2,
00037     KA_COMMAND_PRINT
00038 } KernelAwareCommand_t;

```

```

00036     KA_COMMAND_PROFILE_STOP,
00037     KA_COMMAND_PROFILE_REPORT,
00038     KA_COMMAND_EXIT_SIMULATOR,
00039     KA_COMMAND_TRACE_0,
00040     KA_COMMAND_TRACE_1,
00041     KA_COMMAND_TRACE_2,
00042     KA_COMMAND_PRINT
00043 } KernelAwareCommand_t;
00044
00045 //-----
00055 void KernelAware_Init(void);
00056
00057 void KA_Graphics_Init( void ) __attribute__((weak));
00058 void KA_Joystick_Init( void ) __attribute__((weak));
00059 #endif

```

4.115 src/kernel_aware/tlv_file.c File Reference

Tag-length-value file format used for encoding simulator run-time data (kernel-aware plugin data, code profiling statistics, etc.).

```

#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <sys/stat.h>
#include <sys/types.h>
#include "tlv_file.h"

```

Functions

- void [TLV_WriteInit](#) (const char *szPath_)
TLV_WriteInit.
- void [TLV_WriteFinish](#) (void)
- [TLV_t](#) * [TLV_Alloc](#) (uint16_t u16Len_)
TLV_Alloc.
- void [TLV_Free](#) ([TLV_t](#) *pstTLV_)
TLV_Free.
- int [TLV_Write](#) ([TLV_t](#) *pstData_)
TLV_Write.
- int [TLV_ReadInit](#) (const char *szPath_, uint8_t **pu8Buffer_)
TLV_ReadInit.
- int [TLV_Read](#) ([TLV_t](#) *pstTLV_, uint8_t *pu8Buffer_, int iIndex_)
TLV_Read.
- void [TLV_ReadFinish](#) (uint8_t *pu8Buffer_)
TLV_ReadFinish.

Variables

- static FILE * [fMyFile](#) = NULL

4.115.1 Detailed Description

Tag-length-value file format used for encoding simulator run-time data (kernel-aware plugin data, code profiling statistics, etc.).

Definition in file [tlv_file.c](#).

4.115.2 Function Documentation

4.115.2.1 TLV_t* TLV_Alloc (uint16_t u16Len_)

TLV_Alloc.

Dynamically allocate an appropriately-sized TLV buffer struct with a large enough data array to store u16Len_ bytes of data.

Parameters

<i>u16Len_</i>	Length of the data array to allocate
----------------	--------------------------------------

Returns

Pointer to a newly-allocated object, or NULL on error

Definition at line 55 of file [tlv_file.c](#).

4.115.2.2 void TLV_Free (TLV_t * pstTLV_)

TLV_Free.

Free a previously-allocated TLV object.

Parameters

<i>pstTLV_</i>	Pointer to a valid, previously-allocated TLV object
----------------	---

Definition at line 61 of file [tlv_file.c](#).

4.115.2.3 int TLV_Read (TLV_t * pstTLV_, uint8_t * pu8Buffer_, int iIndex_)

TLV_Read.

Read an entry from a local copy of the TLV buffer into a user-provided TLV pointer.

Parameters

<i>pstTLV_</i>	Pointer to a valid TLV object, with a buffer large enough to hold the largest data object we may encounter.
<i>pu8Buffer_</i>	Pointer to a buffer containing the contents of the TLV input file.
<i>iIndex_</i>	Byte index at which to start reading TLV data.

Returns

Number of bytes read into the TLV struct

! ToDo – add checks around buffer usage

Definition at line 102 of file [tlv_file.c](#).

4.115.2.4 void TLV_ReadFinish (uint8_t * pu8Buffer_)

TLV_ReadFinish.

Dispose of the in-ram copy of the TLV read buffer, allocated from TLV_ReadInit

Parameters

<i>pu8Buffer_</i>	Pointer to the previously allocated TLV ram buffer
-------------------	--

Definition at line 113 of file [tlv_file.c](#).

4.115.2.5 int TLV_ReadInit (const char * *szPath_*, uint8_t ** *pu8Buffer_*)

TLV_ReadInit.

Open the tlv-formatted binary specified in the *szPath_* argument, and read its contents into a newly-allocated buffer, which is passed back to the user by the double-pointer *pu8Buffer_* argument..

Parameters

<i>szPath_</i>	Path to the file to open
<i>pu8Buffer_</i>	Pointer which will be assigned to the newly-created buffer.

Returns

size of the newly-created buffer (in bytes), or 0 on error.

Definition at line 76 of file [tlv_file.c](#).

4.115.2.6 int TLV_Write (TLV_t * *pstData_*)

TLV_Write.

Write a TLV record to the active file stream.

Parameters

<i>pstData_</i>	Pointer to a valid TLV object to log
-----------------	--------------------------------------

Returns

-1 on error, number of bytes written on success.

Definition at line 67 of file [tlv_file.c](#).

4.115.2.7 void TLV_Writelnit (const char * *szPath_*)

TLV_Writelnit.

Initialize the TLV file used to store profiling and diagnostics information in an efficient binary format. Must be called before logging TLV data.

Parameters

<i>szPath_</i>	Name of the TLV output file to create
----------------	---------------------------------------

Definition at line 36 of file [tlv_file.c](#).

4.116 tlv_file.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      (( / ( (( / (      \      (      (( / (      | -- [ Funkenstein ] -----
00005 *      / ( )  / ( )  (( ( ( ( ) \      )\      / ( )      | -- [ Little ] -----
00006 *      ( ) _ | ( )      )\ _ )\ ( ( ( ( ( )      | -- [ AVR ] -----

```

```

00007 * | | | | | ( ) \ ( ) \ \ / / | - \ | -- [ Virtual ] -----
00008 * | | | | | / - \ \ \ v / | - \ | -- [ Runtime ] -----
00009 * | | | | | / \ \ \ \ \ / | - \ |
00010 * | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00022 #include <stdint.h>
00023 #include <stdio.h>
00024 #include <stdlib.h>
00025 #include <string.h>
00026 #include <unistd.h>
00027 #include <sys/stat.h>
00028 #include <sys/types.h>
00029
00030 #include "tlv_file.h"
00031
00032 //-----
00033 static FILE *fMyFile = NULL;
00034
00035 //-----
00036 void TLV_WriteInit( const char *szPath_ )
00037 {
00038     if (!fMyFile)
00039     {
00040         fMyFile = fopen( szPath_, "wb" );
00041     }
00042 }
00043
00044 //-----
00045 void TLV_WriteFinish( void )
00046 {
00047     if (fMyFile)
00048     {
00049         fclose(fMyFile);
00050     }
00051     fMyFile = NULL;
00052 }
00053
00054 //-----
00055 TLV_t *TLV_Alloc( uint16_t ul6Len_ )
00056 {
00057     return (TLV_t*)(malloc(sizeof(TLV_t) + ul6Len_ - 1));
00058 }
00059
00060 //-----
00061 void TLV_Free( TLV_t *pstTLV_ )
00062 {
00063     free( pstTLV_ );
00064 }
00065
00066 //-----
00067 int TLV_Write( TLV_t *pstData_ )
00068 {
00069     if (fMyFile)
00070     {
00071         return fwrite( (void*)pstData_, sizeof(uint8_t), sizeof(TLV_t) + pstData_>
00072             ul6Len - 1, fMyFile );
00073     }
00074     return -1;
00075 }
00076 //-----
00077 int TLV_ReadInit( const char *szPath_, uint8_t **pu8Buffer_ )
00078 {
00079     FILE *fReadFile = fopen( szPath_, "rb" );
00080     struct stat stStat;
00081
00082     if (!fReadFile)
00083     {
00084         fprintf(stderr, "Unable to open tlv for input!\n" );
00085         return 0;
00086     }
00087
00088     stat( szPath_, &stStat );
00089     *pu8Buffer_ = (uint8_t*)malloc( stStat.st_size );
00090     if (!pu8Buffer_)
00091     {
00092         fclose(fReadFile);
00093         fprintf(stderr, "Unable to allocate local tlv read buffer!\n" );
00094         return 0;
00095     }
00096     fread(*pu8Buffer_, 1, stStat.st_size, fReadFile );
00097     fclose(fReadFile);
00098     return stStat.st_size;
00099 }

```

```

00100
00101 //-----
00102 int TLV_Read( TLV_t *pstTLV_, uint8_t *pu8Buffer_, int iIndex_)
00103 {
00104     TLV_t *pstStreamTLV = (TLV_t*)&(pu8Buffer_[iIndex_]);
00105     pstTLV_>eTag = pstStreamTLV->eTag;
00106     pstTLV_>u16Len = pstStreamTLV->u16Len;
00107     memcpy( pstTLV_>au8Data, pstStreamTLV->au8Data, pstTLV_>
00108         u16Len );
00109     return (sizeof(TLV_t) + pstTLV_>u16Len - 1);
00110 }
00111
00112 //-----
00113 void TLV_ReadFinish ( uint8_t *pu8Buffer_ )
00114 {
00115     if (pu8Buffer_)
00116     {
00117         free( pu8Buffer_ );
00118     }
00119 }

```

4.117 src/kernel_aware/tlv_file.h File Reference

Tag-length-value file format used for encoding simulator run-time data (kernel-aware plugin data, code profiling statistics, etc.).

```

#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

```

Data Structures

- struct [TLV_t](#)

Enumerations

- enum [FlavrTag_t](#) {
[TAG_KERNEL_AWARE_INTERRUPT](#), [TAG_KERNEL_AWARE_CONTEXT_SWITCH](#), [TAG_KERNEL_AWARE_PRINT](#), [TAG_KERNEL_AWARE_TRACE_0](#),
[TAG_KERNEL_AWARE_TRACE_1](#), [TAG_KERNEL_AWARE_TRACE_2](#), [TAG_KERNEL_AWARE_PROFILE](#), [TAG_KERNEL_AWARE_THREAD_PROFILE_EPOCH](#),
[TAG_KERNEL_AWARE_THREAD_PROFILE_GLOBAL](#), [TAG_CODE_PROFILE_FUNCTION_EPOCH](#), [TAG_CODE_PROFILE_FUNCTION_GLOBAL](#), [TAG_CODE_COVERAGE_FUNCTION_EPOCH](#),
[TAG_CODE_COVERAGE_FUNCTION_GLOBAL](#), [TAG_CODE_COVERAGE_GLOBAL](#), [TAG_CODE_COVERAGE_ADDRESS](#), [TAG_COUNT](#) }

Functions

- void [TLV_WriteInit](#) (const char *szPath_)
[TLV_WriteInit.](#)
- void [TLV_WriteFinish](#) (void)
- [TLV_t](#) * [TLV_Alloc](#) (uint16_t u16Len_)
[TLV_Alloc.](#)
- void [TLV_Free](#) ([TLV_t](#) *pstTLV_)
[TLV_Free.](#)
- int [TLV_Write](#) ([TLV_t](#) *pstData_)
[TLV_Write.](#)
- int [TLV_ReadInit](#) (const char *szPath_, uint8_t **pu8Buffer_)

- TLV_ReadInit.*
- int [TLV_Read](#) ([TLV_t](#) *pstTLV_, uint8_t *pu8Buffer_, int iIndex_)
TLV_Read.
- void [TLV_ReadFinish](#) (uint8_t *pu8Buffer_)
TLV_ReadFinish.

4.117.1 Detailed Description

Tag-length-value file format used for encoding simulator run-time data (kernel-aware plugin data, code profiling statistics, etc.).

Definition in file [tlv_file.h](#).

4.117.2 Enumeration Type Documentation

4.117.2.1 enum FlavrTag_t

Enumerator

- TAG_KERNEL_AWARE_INTERRUPT*** Kernel-aware plugin generated interrupt events.
- TAG_KERNEL_AWARE_CONTEXT_SWITCH*** Kernel-aware plugin generated context switch events.
- TAG_KERNEL_AWARE_PRINT*** Prints generated from kernel-aware debugger.
- TAG_KERNEL_AWARE_TRACE_0*** Kernel trace events.
- TAG_KERNEL_AWARE_TRACE_1*** Kernel trace events, 1 argument.
- TAG_KERNEL_AWARE_TRACE_2*** Kernel trace events, 2 arguments.
- TAG_KERNEL_AWARE_PROFILE*** Kernel-aware profiling events.
- TAG_KERNEL_AWARE_THREAD_PROFILE_EPOCH*** Epoch-based thread profiling (i.e. CPU use per thread, per epoch)
- TAG_KERNEL_AWARE_THREAD_PROFILE_GLOBAL*** Global thread profiling (i.e. CPU use per thread, cumulative)
- TAG_CODE_PROFILE_FUNCTION_EPOCH*** CPU Profiling for a given function (per epoch)
- TAG_CODE_PROFILE_FUNCTION_GLOBAL*** CPU Profiling for a given function (cumulative)
- TAG_CODE_COVERAGE_FUNCTION_EPOCH*** Code coverage for a given function (per epoch)
- TAG_CODE_COVERAGE_FUNCTION_GLOBAL*** Code coverage for a given function (cumulative)
- TAG_CODE_COVERAGE_GLOBAL*** Global code coverage (cumulative)
- TAG_CODE_COVERAGE_ADDRESS*** Code coverage stats for a given address (cumulative)

Definition at line 31 of file [tlv_file.h](#).

4.117.3 Function Documentation

4.117.3.1 [TLV_t*](#) [TLV_Alloc](#) ([uint16_t](#) *u16Len_*)

[TLV_Alloc.](#)

Dynamically allocate an appropriately-sized TLV buffer struct with a large enough data array to store *u16Len_* bytes of data.

Parameters

<i>u16Len_</i>	Length of the data array to allocate
----------------	--------------------------------------

Returns

Pointer to a newly-allocated object, or NULL on error

Definition at line 55 of file [tlv_file.c](#).

4.117.3.2 void TLV_Free (TLV_t * *pstTLV_*)

TLV_Free.

Free a previously-allocated TLV object.

Parameters

<i>pstTLV_</i>	Pointer to a valid, previously-allocated TLV object
----------------	---

Definition at line 61 of file [tlv_file.c](#).

4.117.3.3 int TLV_Read (TLV_t * *pstTLV_*, uint8_t * *pu8Buffer_*, int *iIndex_*)

TLV_Read.

Read an entry from a local copy of the TLV buffer into a user-provided TLV pointer.

Parameters

<i>pstTLV_</i>	Pointer to a valid TLV object, with a buffer large enough to hold the largest data object we may encounter.
<i>pu8Buffer_</i>	Pointer to a buffer containing the contents of the TLV input file.
<i>iIndex_</i>	Byte index at which to start reading TLV data.

Returns

Number of bytes read into the TLV struct

! ToDo – add checks around buffer usage

Definition at line 102 of file [tlv_file.c](#).

4.117.3.4 void TLV_ReadFinish (uint8_t * *pu8Buffer_*)

TLV_ReadFinish.

Dispose of the in-ram copy of the TLV read buffer, allocated from TLV_ReadInit

Parameters

<i>pu8Buffer_</i>	Pointer to the previously allocated TLV ram buffer
-------------------	--

Definition at line 113 of file [tlv_file.c](#).

4.117.3.5 int TLV_ReadInit (const char * *szPath_*, uint8_t ** *pu8Buffer_*)

TLV_ReadInit.

Open the tlv-formatted binary specified in the *szPath_* argument, and read its contents into a newly-allocated buffer, which is passed back to the user by the double-pointer *pu8Buffer_* argument..

Parameters

<i>szPath</i>	Path to the file to open
<i>pu8Buffer</i>	Pointer which will be assigned to the newly-created buffer.

Returns

size of the newly-created buffer (in bytes), or 0 on error.

Definition at line 76 of file tlv_file.c.

4.117.3.6 int TLV_Write (TLV_t * pstData_)

TLV Write.

Write a TLV record to the active file stream.

Parameters

<i>pstData_</i>	Pointer to a valid TLV object to log
-----------------	--------------------------------------

Returns

-1 on error, number of bytes written on success.

Definition at line 67 of file tlv_file.c.

4.117.3.7 void TLV_WriteInit (const char * szPath_)

TLV_WriteInit.

Initialize the TLV file used to store profiling and diagnostics information in an efficient binary format. Must be called before logging TLV data.

Parameters

<i>szPath_</i>	Name of the TLV output file to create
----------------	---------------------------------------

Definition at line 36 of file tlv_file.c.

4.118 tlv_file.h

```
00001 /*****
00002 *      (      (      (      |
00003 *      )\ )   )\ )   (      )\ )   |
00004 *      ()/( ()/(      \    (    ()/( | -- [ Funkenstein ] -----
00005 *      /( )   /( )   ((( )\ )\   /( )   | -- [ Little ] -----
00006 *      ( )_ ( )   )\ _ \ ( ( ( )_ ( )   | -- [ AVR ] -----
00007 *      | |_ |   ( )_( ) \ \ / / | _ \   | -- [ Virtual ] -----
00008 *      | _| | |_ / _ \ \ v / | _ /       | -- [ Runtime ] -----
00009 *      |_| |__| /_ \ \ \ \ / |_|_| \     |
00010 *                                          | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00022 #ifndef __TLV_FILE_H__
00023 #define __TLV_FILE_H__
00024
00025 #include <stdint.h>
00026 #include <stdio.h>
00027 #include <stdlib.h>
00028 #include <string.h>
00029
00030 //-----
00031 typedef enum
00032 {
```

```

00033     TAG_KERNEL_AWARE_INTERRUPT,
00034     TAG_KERNEL_AWARE_CONTEXT_SWITCH,
00035     TAG_KERNEL_AWARE_PRINT,
00036     TAG_KERNEL_AWARE_TRACE_0,
00037     TAG_KERNEL_AWARE_TRACE_1,
00038     TAG_KERNEL_AWARE_TRACE_2,
00039     TAG_KERNEL_AWARE_PROFILE,
00040     TAG_KERNEL_AWARE_THREAD_PROFILE_EPOCH,
00041     TAG_KERNEL_AWARE_THREAD_PROFILE_GLOBAL,
00042     TAG_CODE_PROFILE_FUNCTION_EPOCH,
00043     TAG_CODE_PROFILE_FUNCTION_GLOBAL,
00044     TAG_CODE_COVERAGE_FUNCTION_EPOCH,
00045     TAG_CODE_COVERAGE_FUNCTION_GLOBAL,
00046     TAG_CODE_COVERAGE_GLOBAL,
00047     TAG_CODE_COVERAGE_ADDRESS,
00048 //---
00049     TAG_COUNT
00050 } FlavrTag_t;
00051
00052 //-----
00053 typedef struct
00054 {
00055     FlavrTag_t eTag;
00056     uint16_t ul6Len;
00057     uint8_t au8Data[1];
00058 } TLV_t;
00059
00060 //-----
00069 void TLV_WriteInit( const char *szPath_ );
00070
00071 void TLV_WriteFinish( void );
00072 //-----
00082 TLV_t *TLV_Alloc( uint16_t ul6Len_ );
00083
00084 //-----
00092 void TLV_Free( TLV_t *pstTLV_ );
00093
00094 //-----
00103 int TLV_Write( TLV_t *pstData_ );
00104
00105 //-----
00119 int TLV_ReadInit( const char *szPath_, uint8_t **pu8Buffer_ );
00120
00121 //-----
00138 int TLV_Read( TLV_t *pstTLV_, uint8_t *pu8Buffer_, int iIndex_ );
00139
00140 //-----
00149 void TLV_ReadFinish( uint8_t *pu8Buffer_ );
00150
00151 #endif

```

4.119 src/loader/avr_loader.c File Reference

Functions to load intel-formatted programming files into a virtual AVR.

```

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/stat.h>
#include <sys/fcntl.h>
#include "emu_config.h"
#include "avr_cpu.h"
#include "intel_hex.h"
#include "elf_types.h"
#include "elf_process.h"
#include "elf_print.h"
#include "debug_sym.h"

```

Functions

- static void **AVR_Copy_Record** ([HEX_Record_t](#) *pstHex_)
- bool **AVR_Load_HEX** (const char *szFilePath_)

AVR_Load_HEX Load a hex file, specified by path, into the flash memory of the CPU object.

- static void **AVR_Load_ELF_Symbols** (const uint8_t *pau8Buffer_)
- bool **AVR_Load_ELF** (const char *szFilePath_)

AVR_Load_ELF Load an elf file, specified by path, into the flash memory of the CPU object.

4.119.1 Detailed Description

Functions to load intel-formatted programming files into a virtual AVR.

Definition in file [avr_loader.c](#).

4.119.2 Function Documentation

4.119.2.1 bool AVR_Load_ELF (const char * szFilePath_)

AVR_Load_ELF Load an elf file, specified by path, into the flash memory of the CPU object.

Will also pre-seed RAM according to the contents of the ELF, if found.

Parameters

<i>szFilePath_</i>	Pointer to the elf-file path
--------------------	------------------------------

Returns

true if the elf file load operation succes

Definition at line 142 of file [avr_loader.c](#).

4.119.2.2 bool AVR_Load_HEX (const char * szFilePath_)

AVR_Load_HEX Load a hex file, specified by path, into the flash memory of the CPU object.

Parameters

<i>szFilePath_</i>	Pointer to the hexfile path
--------------------	-----------------------------

Returns

true if the hex file load operation succeeded, false otherwise

Definition at line 54 of file [avr_loader.c](#).

4.120 avr_loader.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( ((/(      \      | -- [ Funkenstein ] -----
00005 *      /( ) )/( ) ((( ( ) \      | -- [ Little ] -----
00006 *      ( ) _ ( )      ) \ _ \ ( ( ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( ) \ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _ |      / _ \ \ \ v / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ | / \ \ \ \ \ / | _ \      |
00010 *      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdio.h>
00022 #include <stdlib.h>

```

```

00023 #include <string.h>
00024 #include <sys/stat.h>
00025 #include <sys/fcntl.h>
00026
00027 #include "emu_config.h"
00028
00029 #include "avr_cpu.h"
00030 #include "intel_hex.h"
00031
00032 #include "elf_types.h"
00033 #include "elf_process.h"
00034 #include "elf_print.h"
00035
00036 #include "debug_sym.h"
00037
00038 //-----
00039 static void AVR_Copy_Record( HEX_Record_t *pstHex_)
00040 {
00041     uint16_t u16Data;
00042     uint16_t i;
00043     for (i = 0; i < pstHex_>u8ByteCount; i += 2)
00044     {
00045         u16Data = pstHex_>u8Data[i+1];
00046         u16Data <= 8;
00047         u16Data |= pstHex_>u8Data[i];
00048
00049         stCPU.pu16ROM[(pstHex_>u16Address + i) >> 1] = u16Data;
00050     }
00051 }
00052
00053 //-----
00054 bool AVR_Load_HEX( const char *szFilePath_)
00055 {
00056     HEX_Record_t stRecord;
00057     uint32_t u32Addr = 0;
00058     int fd = -1;
00059
00060     if (!szFilePath_)
00061     {
00062         fprintf(stderr, "No programming file specified\n");
00063         return false;
00064     }
00065
00066     fd = open(szFilePath_, O_RDONLY);
00067
00068     if (-1 == fd)
00069     {
00070         fprintf(stderr, "Unable to open file\n");
00071         return false;
00072     }
00073
00074     bool rc = true;
00075
00076     while (rc)
00077     {
00078         rc = HEX_Read_Record(fd, &stRecord);
00079         if (RECORD_EOF == stRecord.u8RecordType)
00080         {
00081             break;
00082         }
00083         if (RECORD_DATA == stRecord.u8RecordType)
00084         {
00085             AVR_Copy_Record(&stRecord);
00086         }
00087     }
00088
00089 cleanup:
00090     close(fd);
00091     return rc;
00092 }
00093
00094 //-----
00095 static void AVR_Load_ELF_Symbols( const uint8_t *pau8Buffer_ )
00096 {
00097     // Get a pointer to the section header for the symbol table
00098     uint32_t u32Offset = ELF_GetSymbolTableOffset( pau8Buffer_ );
00099     if (u32Offset == 0)
00100     {
00101         printf( "No debug symbol, bailing\n");
00102         return;
00103     }
00104     ElfSectionHeader_t *pstSymHeader = (ElfSectionHeader_t*)( &
pau8Buffer_[u32Offset]);
00105
00106     // Get a pointer to the section header for the symbol table's strings
00107     u32Offset = ELF_GetSymbolStringTableOffset( pau8Buffer_ );
00108     if (u32Offset == 0)

```

```

00109     {
00110         printf( "No debug symbol strings, bailing\n");
00111         return;
00112     }
00113     ElfSectionHeader_t *pstStrHeader = (ElfSectionHeader_t*) (&
pau8Buffer_[u32Offset]);
00114
00115     // Iterate through the symbol table section, printing out the details of each.
00116     uint32_t u32SymOffset = pstSymHeader->u32Offset;
00117     ElfSymbol_t *pstSymbol = (ElfSymbol_t*) (&pau8Buffer_[u32SymOffset]);
00118
00119     while (u32SymOffset < (pstSymHeader->u32Offset + pstSymHeader->u32Size))
00120     {
00121         uint8_t u8Type = pstSymbol->u8Info & 0x0F;
00122         if (u8Type == 2)
00123         {
00124             // Note that elf file uses byte addressing, and we use 16-bit word addressing
00125             Symbol_Add_Func( &pau8Buffer_[pstSymbol->u32Name + pstStrHeader->u32Offset],
00126                             pstSymbol->u32Value >> 1,
00127                             pstSymbol->u32Size >> 1);
00128         }
00129         else if (u8Type == 1)
00130         {
00131             // The elf files use 0x0080XXXX as an offset for dat objects. Mask here
00132             Symbol_Add_Obj( &pau8Buffer_[pstSymbol->u32Name + pstStrHeader->u32Offset],
00133                             pstSymbol->u32Value & 0x0000FFFF,
00134                             pstSymbol->u32Size );
00135         }
00136         u32SymOffset += pstSymHeader->u32EntrySize;
00137         pstSymbol = (ElfSymbol_t*) (&pau8Buffer_[u32SymOffset]);
00138     }
00139 }
00140
00141 //-----
00142 bool AVR_Load_ELF( const char *szFilePath_)
00143 {
00144     uint8_t *pu8Buffer;
00145
00146     // Load the ELF Binary from into a newly-created local buffer
00147     if (0 != ELF_LoadFromFile(&pu8Buffer, szFilePath_))
00148     {
00149         return false;
00150     }
00151
00152     // Loaded ELF successfully, load program sections into AVR memory.
00153     ElfHeader_t *pstHeader = (ElfHeader_t*) (pu8Buffer);
00154     uint32_t u32Offset = pstHeader->u32PHOffset;
00155     uint32_t u32MaxOffset = pstHeader->u32PHOffset
00156                             + (pstHeader->u16PHNum * pstHeader->u16PHSize);
00157
00158     // Iterate through every program header section in the elf-file
00159     while (u32Offset < u32MaxOffset)
00160     {
00161         ElfProgramHeader_t *pstPHeader = (ElfProgramHeader_t*) (&
pau8Buffer[u32Offset]);
00162
00163         // RAM encoded in ELF file using addresses >= 0x00800000
00164         if (pstPHeader->u32PhysicalAddress >= 0x00800000)
00165         {
00166             // Clear range in segment
00167             memset( &(stCPU.pstRAM->au8RAM[pstPHeader->u32PhysicalAddress & 0x0000FFFF]),
00168                    0,
00169                    pstPHeader->u32MemSize );
00170             // Copy program segment from ELF into CPU RAM
00171             memcpy( &(stCPU.pstRAM->au8RAM[pstPHeader->u32PhysicalAddress & 0x0000FFFF]),
00172                    &pu8Buffer[pstPHeader->u32Offset],
00173                    pstPHeader->u32FileSize );
00174         }
00175         else
00176         {
00177             // Clear range in segment
00178             memset( &(stCPU.pu16ROM[pstPHeader->u32PhysicalAddress >> 1]),
00179                    0,
00180                    pstPHeader->u32MemSize );
00181             // Copy program segment from ELF into CPU Flash
00182             memcpy( &(stCPU.pu16ROM[pstPHeader->u32PhysicalAddress >> 1]),
00183                    &pu8Buffer[pstPHeader->u32Offset],
00184                    pstPHeader->u32FileSize );
00185         }
00186
00187         // Next Section...
00188         u32Offset += pstHeader->u16PHSize;
00189     }
00190
00191     AVR_Load_ELF_Symbols( pu8Buffer );
00192
00193

```

```

00194     free( pu8Buffer );
00195     return true;
00196 }

```

4.121 src/loader/avr_loader.h File Reference

Functions to load intel hex or elf binaries into a virtual AVR.

```

#include <stdint.h>
#include "avr_cpu.h"

```

Functions

- bool [AVR_Load_HEX](#) (const char *szFilePath_)
AVR_Load_HEX Load a hex file, specified by path, into the flash memory of the CPU object.
- bool [AVR_Load_ELF](#) (const char *szFilePath_)
AVR_Load_ELF Load an elf file, specified by path, into the flash memory of the CPU object.

4.121.1 Detailed Description

Functions to load intel hex or elf binaries into a virtual AVR.

Definition in file [avr_loader.h](#).

4.121.2 Function Documentation

4.121.2.1 bool AVR_Load_ELF (const char * szFilePath_)

[AVR_Load_ELF](#) Load an elf file, specified by path, into the flash memory of the CPU object.

Will also pre-seed RAM according to the contents of the ELF, if found.

Parameters

<i>szFilePath_</i>	Pointer to the elf-file path
--------------------	------------------------------

Returns

true if the elf file load operation succes

Definition at line [142](#) of file [avr_loader.c](#).

4.121.2.2 bool AVR_Load_HEX (const char * szFilePath_)

[AVR_Load_HEX](#) Load a hex file, specified by path, into the flash memory of the CPU object.

Parameters

<i>szFilePath_</i>	Pointer to the hexfile path
--------------------	-----------------------------

Returns

true if the hex file load operation succeeded, false otherwise

Definition at line [54](#) of file [avr_loader.c](#).

4.122 avr_loader.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      )\ ) |
00004 *      ()/( ()/(      )\      ( ( ()/( | -- [ Funkenstein ] -----
00005 *      /( ) )/( ) ((( )\ )\ /( ) | -- [ Little ] -----
00006 *      ( )_ ( ) )\ _ ) ( ) ( ) | -- [ AVR ] -----
00007 *      | _ | | ( )_ ( ) \ / / | _ | | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ v / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _ | / / \ \ \ / | _ \ |
00010 *                                          | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __AVR_LOADER_H__
00022 #define __AVR_LOADER_H__
00023
00024 #include <stdint.h>
00025 #include "avr_cpu.h"
00026
00027 //-----
00035 bool AVR_Load_HEX( const char *szFilePath_);
00036
00037 //-----
00046 bool AVR_Load_ELF( const char *szFilePath_);
00047 #endif

```

4.123 src/loader/elf_process.c File Reference

Functions used to process ELF Binaries.

```
#include "elf_process.h"
#include "elf_types.h"
#include <stdint.h>
#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <unistd.h>
```

Macros

- #define **DEBUG_PRINT**(...)

Functions

- `uint32_t ELF_GetHeaderStringTableOffset` (`const uint8_t *pau8Buffer_`)
ELF_GetHeaderStringTableOffset.
- `uint32_t ELF_GetSymbolStringTableOffset` (`const uint8_t *pau8Buffer_`)
ELF_GetSymbolStringTableOffset.
- `uint32_t ELF_GetSymbolTableOffset` (`const uint8_t *pau8Buffer_`)
ELF_GetSymbolTableOffset.
- `int ELF_LoadFromFile` (`uint8_t **ppau8Buffer_`, `const char *szPath_`)
ELF_LoadFromFile.

4.123.1 Detailed Description

Functions used to process ELF Binaries.

Definition in file `elf` `process.c`.

4.123.2 Function Documentation

4.123.2.1 `uint32_t ELF_GetHeaderStringTableOffset (const uint8_t * pau8Buffer_)`

`ELF_GetHeaderStringTableOffset`.

Returns an offset (in bytes) from the beginning of a buffer containing an elf file, corresponding to the location of the header string table.

Parameters

<i>pau8Buffer_</i>	- Pointer to a buffer containing a loaded elf file
--------------------	--

Returns

Offset, or 0 if no table found

Definition at line 34 of file [elf_process.c](#).

4.123.2.2 `uint32_t ELF_GetSymbolStringTableOffset (const uint8_t * pau8Buffer_)`

`ELF_GetSymbolStringTableOffset`.

Returns an offset (in bytes) from the beginning of a buffer containing an elf file, corresponding to the location of the symbol-string table.

Parameters

<i>pau8Buffer_</i>	- Pointer to a buffer containing a loaded elf file
--------------------	--

Returns

Offset, or 0 if no table found

Definition at line 45 of file [elf_process.c](#).

4.123.2.3 `uint32_t ELF_GetSymbolTableOffset (const uint8_t * pau8Buffer_)`

`ELF_GetSymbolTableOffset`.

Returns an offset (in bytes) from the beginning of a buffer containing an elf file, corresponding to the location of the symbol table.

Parameters

<i>pau8Buffer_</i>	- Pointer to a buffer containing a loaded elf file
--------------------	--

Returns

Offset, or 0 if no symbol table

Definition at line 77 of file [elf_process.c](#).

4.123.2.4 `int ELF_LoadFromFile (uint8_t ** ppau8Buffer_, const char * szPath_)`

`ELF_LoadFromFile`.

Read the contents of a specific ELF file from disk into a buffer, allocated to a process-local RAM buffer.

Parameters

<i>ppau8Buffer_</i>	- Byte-array pointer, which will point to a newly-allocated buffer on successful read (or NULL) on error.
<i>szPath_</i>	- File path to load

Returns

0 on success, -1 on error.

Definition at line 104 of file [elf_process.c](#).

4.124 elf_process.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      )\ ) |
00004 *      ((/( ((/(      \      ( ((/( | -- [ Funkenstein ] -----
00005 *      /( )  /( ) ((( ( ) \      / ( ) | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ \      ( ( ( ( ) | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ ( ) \ \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \      \ V / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \      \ / | _ \ |
00010 *                                     | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include "elf_process.h"
00022 #include "elf_types.h"
00023
00024 #include <stdint.h>
00025 #include <stdio.h>
00026 #include <stdlib.h>
00027 #include <sys/types.h>
00028 #include <sys/stat.h>
00029 #include <unistd.h>
00030
00031 #define DEBUG_PRINT(...)
00032
00033 //-----
00034 uint32_t ELF_GetHeaderStringTableOffset( const uint8_t *pau8Buffer_ )
00035 {
00036     ElfHeader_t *pstHeader = (ElfHeader_t*)pau8Buffer_;
00037
00038     ElfSectionHeader_t *pstStringTable =
00039         (ElfSectionHeader_t*) (&pau8Buffer_[pstHeader->u32SHOffset + (pstHeader->
00040             ul6SHSize * pstHeader->ul6SHIndex)]);
00041     return pstStringTable->u32Offset;
00042 }
00043
00044 //-----
00045 uint32_t ELF_GetSymbolStringTableOffset( const uint8_t *pau8Buffer_ )
00046 {
00047     uint32_t u32Offset;
00048     uint16_t ul6SHCount;
00049
00050     ElfHeader_t *pstHeader = (ElfHeader_t*)pau8Buffer_;
00051     uint32_t u32StringOffset = ELF_GetHeaderStringTableOffset( pau8Buffer_ );
00052
00053     u32Offset = pstHeader->u32SHOffset;
00054     ul6SHCount = pstHeader->ul6SHNum;
00055
00056     while (ul6SHCount)
00057     {
00058         ElfSectionHeader_t *pstSHeader = (ElfSectionHeader_t*) (&
00059             pau8Buffer_[u32Offset]);
00060         if (
00061             (ELF_SECTION_TYPE_STRTAB == pstSHeader->u32Type) &&
00062             (0 == strcmp( ".strtab", &pau8Buffer_[u32StringOffset + pstSHeader->u32Name]))
00063         )
00064         {
00065             return u32Offset;
00066         }
00067
00068         //--
00069         ul6SHCount--;

```

```

00070         u32Offset += pstHeader->u16SHSize;
00071     }
00072
00073     return 0;
00074 }
00075
00076 //-----
00077 uint32_t ELF_GetSymbolTableOffset( const uint8_t *pau8Buffer_ )
00078 {
00079     uint32_t u32Offset;
00080     uint16_t u16SHCount;
00081
00082     ElfHeader_t *pstHeader = (ElfHeader_t*)pau8Buffer_;
00083
00084     u32Offset = pstHeader->u32SHOffset;
00085     u16SHCount = pstHeader->u16SHNum;
00086
00087     while (u16SHCount)
00088     {
00089         ElfSectionHeader_t *pstSHeader = (ElfSectionHeader_t*)&
00090         pau8Buffer_[u32Offset];
00091         if (ELF_SECTION_TYPE_SYMTAB == pstSHeader->u32Type)
00092         {
00093             return u32Offset;
00094         }
00095         //--
00096         u16SHCount--;
00097         u32Offset += pstHeader->u16SHSize;
00098     }
00099
00100     return 0;
00101 }
00102
00103 //-----
00104 int ELF_LoadFromFile( uint8_t **ppau8Buffer_, const char *szPath_ )
00105 {
00106     size_t      file_size;
00107     FILE        *my_file;
00108
00109     my_file = fopen( szPath_, "rb" );
00110     if (NULL == my_file)
00111     {
00112         DEBUG_PRINT( "Unable to read file @ %s\n", szPath_ );
00113         return -1;
00114     }
00115     fseek(my_file, 0, SEEK_END);
00116     file_size = ftell(my_file);
00117     fseek(my_file, 0, SEEK_SET);
00118
00119     uint8_t *bufptr = (uint8_t*)malloc(file_size);
00120     *ppau8Buffer_ = bufptr;
00121
00122     if (!bufptr)
00123     {
00124         DEBUG_PRINT( "Unable to malloc elf file buffer\n" );
00125         fclose( my_file );
00126         return -1;
00127     }
00128
00129     size_t bytes_read = 0;
00130     while (bytes_read < file_size)
00131     {
00132         size_t iter_read = fread( bufptr, 1, 4096, my_file );
00133         if( iter_read == 0 )
00134         {
00135             DEBUG_PRINT( "%d read total\n", bytes_read );
00136             break;
00137         }
00138         bytes_read += iter_read;
00139         bufptr += iter_read;
00140     }
00141
00142     DEBUG_PRINT( "Success reading %d bytes\n", file_size );
00143     fclose( my_file );
00144     return 0;
00145 }

```

4.125 src/loader/elf_process.h File Reference

Functions used to process ELF Binaries.

```
#include "elf_types.h"
#include <stdint.h>
```

Functions

- uint32_t [ELF_GetHeaderStringTableOffset](#) (const uint8_t *pau8Buffer_)
ELF_GetHeaderStringTableOffset.
- uint32_t [ELF_GetSymbolStringTableOffset](#) (const uint8_t *pau8Buffer_)
ELF_GetSymbolStringTableOffset.
- uint32_t [ELF_GetSymbolTableOffset](#) (const uint8_t *pau8Buffer_)
ELF_GetSymbolTableOffset.
- int [ELF_LoadFromFile](#) (uint8_t **ppau8Buffer_, const char *szPath_)
ELF_LoadFromFile.

4.125.1 Detailed Description

Functions used to process ELF Binaries.

Definition in file [elf_process.h](#).

4.125.2 Function Documentation

4.125.2.1 uint32_t ELF_GetHeaderStringTableOffset (const uint8_t * pau8Buffer_)

[ELF_GetHeaderStringTableOffset.](#)

Returns an offset (in bytes) from the beginning of a buffer containing an elf file, corresponding to the location of the header string table.

Parameters

<i>pau8Buffer_</i>	- Pointer to a buffer containing a loaded elf file
--------------------	--

Returns

Offset, or 0 if no table found

Definition at line 34 of file [elf_process.c](#).

4.125.2.2 uint32_t ELF_GetSymbolStringTableOffset (const uint8_t * pau8Buffer_)

[ELF_GetSymbolStringTableOffset.](#)

Returns an offset (in bytes) from the beginning of a buffer containing an elf file, corresponding to the location of the symbol-string table.

Parameters

<i>pau8Buffer_</i>	- Pointer to a buffer containing a loaded elf file
--------------------	--

Returns

Offset, or 0 if no table found

Definition at line 45 of file [elf_process.c](#).

4.125.2.3 uint32_t ELF_GetSymbolTableOffset (const uint8_t * *pau8Buffer_*)

ELF_GetSymbolTableOffset.

Returns an offset (in bytes) from the beginning of a buffer containing an elf file, corresponding to the location of the symbol table.

Parameters

<i>pau8Buffer_</i>	- Pointer to a buffer containing a loaded elf file
--------------------	--

Returns

Offset, or 0 if no symbol table

Definition at line 77 of file [elf_process.c](#).

4.125.2.4 int ELF_LoadFromFile (uint8_t ** *ppau8Buffer_*, const char * *szPath_*)

ELF_LoadFromFile.

Read the contents of a specific ELF file from disk into a buffer, allocated to a process-local RAM buffer.

Parameters

<i>ppau8Buffer_</i>	- Byte-array pointer, which will point to a newly-allocated buffer on successful read (or NULL) on error.
<i>szPath_</i>	- File path to load

Returns

0 on success, -1 on error.

Definition at line 104 of file [elf_process.c](#).

4.126 elf_process.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( ((/(      )\      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( )\ )\ / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( ) )\ _ )\ ( ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | | ( ) _ ( ) \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ / / | _ \      | -- [ Runtime ] -----
00009 *      | _ | | _ / _ \ \ / / | _ \      |
00010 *                                          | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __ELF_PROCESS_H__
00022 #define __ELF_PROCESS_H__
00023
00024 #include "elf_types.h"
00025 #include <stdint.h>
00026
00027 //-----
00037 uint32_t ELF_GetHeaderStringTableOffset( const uint8_t *pau8Buffer_ );
00038
00039 //-----
00049 uint32_t ELF_GetSymbolStringTableOffset( const uint8_t *pau8Buffer_ );
00050
00051 //-----
00061 uint32_t ELF_GetSymbolTableOffset( const uint8_t *pau8Buffer_ );
00062
00063 //-----
00075 int ELF_LoadFromFile( uint8_t **ppau8Buffer_, const char *szPath_ );
00076
00077 #endif //__ELF_PROCESS_H__

```

4.127 src/loader/intel_hex.c File Reference

Module for decoding Intel hex formatted programming files.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <stdint.h>
#include <sys/stat.h>
#include <sys/fcntl.h>
#include "emu_config.h"
#include "intel_hex.h"
```

Functions

- void [HEX_Print_Record](#) ([HEX_Record_t](#) *stRecord_)
HEX_Print_Record.
- static bool [HEX_Read_Header](#) (int fd_)
- static bool [HEX_Next_Line](#) (int fd_, [HEX_Record_t](#) *stRecord_)
- static bool [HEX_Read_Record_Type](#) (int fd_, [HEX_Record_t](#) *stRecord_)
- static bool [HEX_Read_Byte_Count](#) (int fd_, [HEX_Record_t](#) *stRecord_)
- static bool [HEX_Read_Address](#) (int fd_, [HEX_Record_t](#) *stRecord_)
- static bool [HEX_Read_Data](#) (int fd_, [HEX_Record_t](#) *stRecord_)
- static bool [HEX_Read_Checksum](#) (int fd_, [HEX_Record_t](#) *stRecord_)
- static bool [HEX_Line_Validate](#) ([HEX_Record_t](#) *stRecord_)
- bool [HEX_Read_Record](#) (int fd_, [HEX_Record_t](#) *stRecord_)
HEX_Read_Record.

4.127.1 Detailed Description

Module for decoding Intel hex formatted programming files.

Definition in file [intel_hex.c](#).

4.127.2 Function Documentation

4.127.2.1 void [HEX_Print_Record](#) ([HEX_Record_t](#) * *stRecord_*)

[HEX_Print_Record.](#)

Print the contents of a single Intel hex record to standard output.

Parameters

<i>stRecord_</i>	Pointer to a valid, initialized hex record
------------------	--

Definition at line 33 of file [intel_hex.c](#).

4.127.2.2 bool [HEX_Read_Record](#) (int *fd_*, [HEX_Record_t](#) * *stRecord_*)

[HEX_Read_Record.](#)

Read the next Intel Hex file record from an open Intel Hex programming file.

Parameters

<i>fd_</i>	[in] Open file handle corresponding to the hex file
<i>stRecord_</i>	[out] Pointer to a valid hex record struct

Returns

true - hex record read succeeded, false - failure or EOF.

Definition at line 216 of file [intel_hex.c](#).

4.128 intel_hex.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ( )/ ( )/ (      )\      | -- [ Funkenstein ] -----
00005 *      / ( ) / ( ) ( ( ( ) )\      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | | |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | |      / _ \ \ \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ \ \ / | _ \      |
00010 *      | _ | | _ | / _ \ \ \ \ / | _ \      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdio.h>
00022 #include <stdlib.h>
00023 #include <string.h>
00024 #include <stdint.h>
00025 #include <sys/stat.h>
00026 #include <sys/fcntl.h>
00027
00028 #include "emu_config.h"
00029
00030 #include "intel_hex.h"
00031
00032 //-----
00033 void HEX_Print_Record( HEX_Record_t *stRecord_ )
00034 {
00035     printf( "Line: %d\n"
00036            "ByteCount: %d\n"
00037            "RecordType: %d\n"
00038            "Address: %X\n"
00039            "Data:",
00040            stRecord_>u32Line,
00041            stRecord_>u8ByteCount,
00042            stRecord_>u8RecordType,
00043            stRecord_>u16Address );
00044     int i;
00045     for (i = 0; i < stRecord_>u8ByteCount; i++)
00046     {
00047         printf( " %02X", stRecord_>u8Data[i]);
00048     }
00049     printf( "\n" );
00050 }
00051
00052 //-----
00053 static bool HEX_Read_Header( int fd_ )
00054 {
00055     ssize_t bytes_read;
00056     char acBuf[2] = {0};
00057
00058     bytes_read = read(fd_, acBuf, 1);
00059     if (1 != bytes_read)
00060     {
00061         return false;
00062     }
00063     if (':' == acBuf[0])
00064     {
00065         return true;
00066     }
00067     return false;
00068 }
00069
00070 //-----
00071 static bool HEX_Next_Line( int fd_, HEX_Record_t *stRecord_ )
00072 {

```



```

00073     ssize_t bytes_read;
00074     char acBuf[2] = {0};
00075
00076     stRecord_>u32Line++;
00077     do
00078     {
00079         bytes_read = read(fd_, acBuf, 1);
00080         if (1 != bytes_read)
00081         {
00082             return false;
00083         }
00084     } while(acBuf[0] != '\n');
00085     return true;
00086 }
00087
00088
00089 //-----
00090 static bool HEX_Read_Record_Type( int fd_, HEX_Record_t *stRecord_ )
00091 {
00092     ssize_t bytes_read;
00093     uint32_t u32Hex;
00094     char acBuf[3] = {0};
00095
00096     bytes_read = read(fd_, acBuf, 2);
00097     if (2 != bytes_read)
00098     {
00099         return false;
00100     }
00101     sscanf(acBuf, "%02X", &u32Hex);
00102     stRecord_>u8RecordType = (uint8_t)u32Hex;
00103
00104     if (stRecord_>u8RecordType >= RECORD_TYPE_MAX)
00105     {
00106         return false;
00107     }
00108     return true;
00109 }
00110
00111 //-----
00112 static bool HEX_Read_Byte_Count( int fd_, HEX_Record_t *stRecord_ )
00113 {
00114     ssize_t bytes_read;
00115     uint32_t u32Hex;
00116     char acBuf[3] = {0};
00117
00118     bytes_read = read(fd_, acBuf, 2);
00119     if (2 != bytes_read)
00120     {
00121         return false;
00122     }
00123     sscanf(acBuf, "%02X", &u32Hex);
00124     stRecord_>u8ByteCount = (uint8_t)u32Hex;
00125     return true;
00126 }
00127
00128 //-----
00129 static bool HEX_Read_Address( int fd_, HEX_Record_t *stRecord_ )
00130 {
00131     ssize_t bytes_read;
00132     uint32_t u32Hex;
00133     char acBuf[5] = {0};
00134
00135     bytes_read = read(fd_, acBuf, 4);
00136     if (4 != bytes_read)
00137     {
00138         return false;
00139     }
00140     sscanf(acBuf, "%04X", &u32Hex);
00141     stRecord_>u16Address = (uint16_t)u32Hex;
00142     return true;
00143 }
00144
00145 //-----
00146 static bool HEX_Read_Data( int fd_, HEX_Record_t *stRecord_ )
00147 {
00148     ssize_t bytes_read;
00149     uint32_t u32Hex;
00150     char acBuf[MAX_HEX_DATA_BYTES * 2] = {0};
00151
00152     int i;
00153     for (i = 0; i < stRecord_>u8ByteCount; i++)
00154     {
00155         // printf("i:%d\n", i);
00156         bytes_read = read(fd_, acBuf, 2);

```

```

00160         if (2 != bytes_read)
00161         {
00162             return false;
00163         }
00164         sscanf(acBuf, "%02X", &u32Hex);
00165         stRecord->u8Data[i] = (uint8_t)u32Hex;
00166     }
00167
00168     return true;
00169 }
00170
00171 //-----
00172 static bool HEX_Read_Checksum( int fd_, HEX_Record_t *stRecord_ )
00173 {
00174     ssize_t bytes_read;
00175     uint32_t u32Hex;
00176     char acBuf[3] = {0,0,0};
00177
00178     bytes_read = read(fd_, acBuf, 2);
00179     if (2 != bytes_read)
00180     {
00181         return false;
00182     }
00183     sscanf(acBuf, "%02X", &u32Hex);
00184     stRecord->u8Checksum = (uint8_t)u32Hex;
00185
00186     return true;
00187 }
00188
00189 //-----
00190 static bool HEX_Line_Validate( HEX_Record_t *stRecord_ )
00191 {
00192     // Calculate the CRC for the fields in the struct and compare
00193     // against the value read from file...
00194     uint8_t u8CRC = 0;
00195     u8CRC += (uint8_t)(stRecord->u16Address >> 8);
00196     u8CRC += (uint8_t)(stRecord->u16Address & 0x00FF);
00197     u8CRC += stRecord->u8ByteCount;
00198     u8CRC += stRecord->u8RecordType;
00199
00200     uint8_t i;
00201     for (i = 0; i < stRecord->u8ByteCount; i++)
00202     {
00203         u8CRC += stRecord->u8Data[i];
00204     }
00205
00206     u8CRC = (~u8CRC) + 1; // Spec says to take the 2's complement
00207     if (u8CRC != stRecord->u8Checksum)
00208     {
00209         return false;
00210     }
00211
00212     return true;
00213 }
00214
00215 //-----
00216 bool HEX_Read_Record( int fd_, HEX_Record_t *stRecord_ )
00217 {
00218     bool rc = true;
00219     if (rc)
00220     {
00221         rc = HEX_Read_Header(fd_);
00222     }
00223     if (rc)
00224     {
00225         rc = HEX_Read_Byte_Count(fd_, stRecord_);
00226     }
00227     if (rc)
00228     {
00229         rc = HEX_Read_Address(fd_, stRecord_);
00230     }
00231     if (rc)
00232     {
00233         rc = HEX_Read_Record_Type(fd_, stRecord_);
00234     }
00235     if (rc)
00236     {
00237         rc = HEX_Read_Data(fd_, stRecord_);
00238     }
00239     if (rc)
00240     {
00241         rc = HEX_Read_Checksum(fd_, stRecord_);
00242     }
00243     if (rc)
00244     {
00245         rc = HEX_Line_Validate(stRecord_);
00246     }

```

```
00247
00248     HEX_Next_Line(fd_, stRecord_);
00249     return rc;
00250 }
```

4.129 src/loader/intel_hex.h File Reference

Module for decoding Intel hex formatted programming files.

```
#include <stdint.h>
#include <stdbool.h>
```

Data Structures

- struct [HEX_Record_t](#)
Data type used to represent a single Intel Hex Record.

Macros

- #define **MAX_HEX_DATA_BYTES** (255)
- #define **RECORD_DATA** (0)
- #define **RECORD_EOF** (1)
- #define **RECORD_EXTENDED_SEGMENT** (2)
- #define **RECORD_START_SEGMENT** (3)
- #define **RECORD_EXTENDED_LINEAR** (4)
- #define **RECORD_START_LINEAR** (5)
- #define **RECORD_TYPE_MAX** (5)

Functions

- void [HEX_Print_Record](#) ([HEX_Record_t](#) *stRecord_)
HEX_Print_Record.
- bool [HEX_Read_Record](#) (int fd_, [HEX_Record_t](#) *stRecord_)
HEX_Read_Record.

4.129.1 Detailed Description

Module for decoding Intel hex formatted programming files.

Definition in file [intel_hex.h](#).

4.129.2 Function Documentation

4.129.2.1 void HEX_Print_Record (HEX_Record_t * stRecord_)

HEX_Print_Record.

Print the contents of a single Intel hex record to standard output.

Parameters

<i>stRecord_</i>	Pointer to a valid, initialized hex record
------------------	--

Definition at line 33 of file [intel_hex.c](#).

4.129.2.2 bool HEX_Read_Record (int fd_, HEX_Record_t * stRecord_)

HEX_Read_Record.

Read the next Intel Hex file record from an open Intel Hex programming file.

Parameters

<i>fd_</i>	[in] Open file handle corresponding to the hex file
<i>stRecord_</i>	[out] Pointer to a valid hex record struct

Returns

true - hex record read succeeded, false - failure or EOF.

Definition at line 216 of file [intel_hex.c](#).

4.130 intel_hex.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( ((/(      )\      | -- [ Funkenstein ] -----
00005 *      /( ) )/( ) ((( ( )\ )\ /( )      | -- [ Little ] -----
00006 *      ( )_ ( )      )\ _ )\ (( ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( )_ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _ | / _ \ \ \ \ / | _ \      |
00010 *      |      |      | "Yeah, it does Arduino..."
00011 *      -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __INTEL_HEX_H__
00022 #define __INTEL_HEX_H__
00023
00024 #include <stdint.h>
00025 #include <stdbool.h>
00026
00027 //-----
00028 // Load a hex file into the ROM section of a virtual AVR.
00029 #define MAX_HEX_DATA_BYTES      (255)      // max data bytes per line in a record
00030
00031 //-----
00032 // Record types in the HEX specification
00033 #define RECORD_DATA      (0)
00034 #define RECORD_EOF      (1)
00035 #define RECORD_EXTENDED_SEGMENT      (2)
00036 #define RECORD_START_SEGMENT      (3)
00037 #define RECORD_EXTENDED_LINEAR      (4)
00038 #define RECORD_START_LINEAR      (5)
00039
00040 //-----
00041 #define RECORD_TYPE_MAX      (5)
00042
00043 //-----
00044 // For reference, this is the line format for an intel hex record.
00045 // :WWXXYYYYzz.....zzCC
00046 // Where : = the ":" start code
00047 // WW = the byte count in the data field
00048 // XX = the record type
00049 // YYYY = record address
00050 // zz = data bytes
00051 // CC = 2's complement checksum of all fields, excluding start code and checksum
00052
00053 //-----
00057 typedef struct
00058 {

```

```

00059     uint8_t    u8ByteCount;
00060     uint8_t    u8RecordType;
00061     uint16_t   u16Address;
00062     uint8_t    u8Data[MAX_HEX_DATA_BYTES];
00063     uint8_t    u8Checksum;
00064     uint32_t   u32Line;
00065 } HEX_Record_t;
00066
00067 //-----
00075 void HEX_Print_Record( HEX_Record_t *stRecord_ );
00076
00077 //-----
00090 bool HEX_Read_Record( int fd_, HEX_Record_t *stRecord_ );
00091
00092 #endif

```

4.131 src/peripheral/avr_peripheral.h File Reference

Interfaces for creating AVR peripheral plugins.

```
#include <stdint.h>
```

Data Structures

- struct [AVRPeripheral](#)

Typedefs

- typedef void(* **PeriphInit**)(void *context_)
- typedef void(* **PeriphRead**)(void *context_, uint8_t ucAddr_, uint8_t *pucValue_)
- typedef void(* **PeriphWrite**)(void *context_, uint8_t ucAddr_, uint8_t ucValue_)
- typedef void(* **PeriphClock**)(void *context_)
- typedef void(* **InterruptAck**)(uint8_t ucVector_)
- typedef struct [AVRPeripheral](#) **AVRPeripheral**

4.131.1 Detailed Description

Interfaces for creating AVR peripheral plugins.

Definition in file [avr_peripheral.h](#).

4.132 avr_peripheral.h

```

00001 /*****
00002 *      (      )      (      )      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ((/( ((/(      )\      ( ((/( | -- [ Funkenstein ] -----
00005 *      /( )  /( )  ((( ( ) )\ )\ /( )  | -- [ Little ] -----
00006 *      ( ) _ ( ) )\ _ )\ ( ( ) ( ) )\  | -- [ AVR ] -----
00007 *      | _ | | ( ) _ ( )\ \ / / | _ \  | -- [ Virtual ] -----
00008 *      | _ | | _ _ / _ \ \ / / | _ \  | -- [ Runtime ] -----
00009 *      | _ | | _ _ / _ \ \ / / | _ \  |
00010 *      | _ | | _ _ / _ \ \ / / | _ \  | "Yeah, it does Arduino..."
00011 *      -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __AVR_PERIPHERAL_H__
00022 #define __AVR_PERIPHERAL_H__
00023
00024 #include <stdint.h>
00025
00026 //-----
00027 // Peripheral callout functions - used to implement arbitrary peripherals

```

```

00028 // which are able to intercept/react to read/write operations to specific
00029 // I/O addresses.
00030 //-----
00031
00032 typedef void (*PeriphInit) (void *context_ );
00033 typedef void (*PeriphRead) (void *context_, uint8_t ucAddr_, uint8_t *pucValue_ );
00034 typedef void (*PeriphWrite)(void *context_, uint8_t ucAddr_, uint8_t ucValue_ );
00035 typedef void (*PeriphClock)(void *context_ );
00036
00037 //-----
00038 typedef void (*InterruptAck)( uint8_t ucVector_);
00039
00040 //-----
00041 typedef struct AVRPeripheral
00042 {
00043     PeriphInit      pfInit;
00044     PeriphRead      pfRead;
00045     PeriphWrite     pfWrite;
00046     PeriphClock     pfClock;
00047
00048     void            *pvContext;
00049
00050     uint8_t         u8AddrStart;
00051     uint8_t         u8AddrEnd;
00052 } AVRPeripheral;
00053
00054 #endif // __AVR_PERIPHERAL_H__

```

4.133 src/peripheral/avr_periphregs.h File Reference

Module defining bitfield/register definitions for memory-mapped peripherals located within IO memory space.

```
#include <stdint.h>
```

Functions

- struct **__attribute__** ((__packed__))

Variables

- **AVR_UCSR0A**
- **AVR_UCSR0B**
- **AVR_UCSR0C**
- **AVR_TWAMR**
- **AVR_TWCR**
- **AVR_TWAR**
- **AVR_TWSR**
- **AVR_ASSR**
- **AVR_TCCR2B**
- **AVR_TCCR2A**
- **AVR_TCCR1A**
- **AVR_TCCR1B**
- **AVR_TCCR1C**
- **AVR_DIDR1**
- **AVR_DIDR0**
- **AVR_ADMUX**
- **AVR_ADCSRA**
- **AVR_ADCSR**
- **AVR_TIMSK2**
- **AVR_TIMSK1**
- **AVR_TIMSK0**
- **AVR_PCMSK2**

- AVR_PCMSK1
- AVR_PCMSK0
- AVR_PCICR
- AVR_EICRA
- AVR_PRR
- AVR_CLKPR
- AVR_WDTCSR
- AVR_SREG
- AVR_SPL
- AVR_SPH
- AVR_SPMCSR
- AVR_MCUCR
- AVR_MCUSR
- AVR_SMCR
- AVR_ACSR
- AVR_SPCR
- AVR_SPSR
- AVR_GTCCR
- AVR_TCCR0A
- AVR_TCCR0B
- AVR_EECR
- AVR_EIFR
- AVR_EIMSK
- AVR_PIN
- AVR_DDR
- AVR_PORT
- AVR_TIFR0
- AVR_TIFR1
- AVR_TIFR2
- AVR_PCIFR

4.133.1 Detailed Description

Module defining bitfield/register definitions for memory-mapped peripherals located within IO memory space.

Definition in file [avr_periphregs.h](#).

4.134 avr_periphregs.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      )\ ) |
00004 *      ( )/( ( )/(      \      ( ( )/( | -- [ Funkenstein ] -----
00005 *      /( ) )/( ) )((( ( )\ )\ /( ) | -- [ Little ] -----
00006 *      ( )_ | ( )      )\ _ )\ ( ( ) ( ( ) | -- [ AVR ] -----
00007 *      | _ | |      ( )_ \ ( ) \ \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ / / | _ \ | -- [ Runtime ] -----
00009 *      | _ | | _ _      / _ \ \ \ / / | _ \ |
00010 *                                          | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00022 #ifndef __AVR_PERIPHREGS_H__
00023 #define __AVR_PERIPHREGS_H__
00024
00025 #include <stdint.h>
00026
00027 //-----
00028 // UART/USART register struct definitions.
00029 //-----
00030 typedef struct __attribute__((packed))

```

```

00031 {
00032     union __attribute__((packed))
00033     {
00034         uint8_t r;
00035         struct __attribute__((packed))
00036         {
00037             unsigned int MPCM0 : 1;
00038             unsigned int U2X0 : 1;
00039             unsigned int UPE0 : 1;
00040             unsigned int DOR0 : 1;
00041             unsigned int FE0 : 1;
00042             unsigned int UDRE0 : 1;
00043             unsigned int TXC0 : 1;
00044             unsigned int RXC0 : 1;
00045         };
00046     };
00047 } AVR_UCSR0A;
00048
00049 //-----
00050 typedef struct __attribute__((packed))
00051 {
00052     union __attribute__((packed))
00053     {
00054         uint8_t r;
00055         struct __attribute__((packed))
00056         {
00057             unsigned int TXB80 : 1;
00058             unsigned int RXB80 : 1;
00059             unsigned int UCSZ02 : 1;
00060             unsigned int TXEN0 : 1;
00061             unsigned int RXEN0 : 1;
00062             unsigned int UDRIE0 : 1;
00063             unsigned int TXCIE0 : 1;
00064             unsigned int RXCIE0 : 1;
00065         };
00066     };
00067 } AVR_UCSR0B;
00068
00069 //-----
00070 typedef struct __attribute__((packed))
00071 {
00072     union __attribute__((packed))
00073     {
00074         uint8_t r;
00075         struct __attribute__((packed))
00076         {
00077             unsigned int UCPOL0 : 1;
00078             unsigned int UCPHA0 : 1;
00079             unsigned int UDORD0 : 1;
00080             unsigned int USBS0 : 1;
00081             unsigned int UPM00 : 1;
00082             unsigned int UPM01 : 1;
00083             unsigned int UMSEL00 : 1;
00084             unsigned int UMSEL01 : 1;
00085         };
00086     };
00087 } AVR_UCSR0C;
00088
00089 //-----
00090 // TWI interface register struct definitions
00091 //-----
00092 typedef struct __attribute__((packed))
00093 {
00094     union __attribute__((packed))
00095     {
00096         uint8_t r;
00097         struct __attribute__((packed))
00098         {
00099             unsigned int reserved : 1;
00100             unsigned int TWAM0 : 1;
00101             unsigned int TWAM1 : 1;
00102             unsigned int TWAM2 : 1;
00103             unsigned int TWAM3 : 1;
00104             unsigned int TWAM4 : 1;
00105             unsigned int TWAM5 : 1;
00106             unsigned int TWAM6 : 1;
00107         };
00108     };
00109 } AVR_TWAMR;
00110
00111 //-----
00112 typedef struct __attribute__((packed))
00113 {
00114     union __attribute__((packed))
00115     {
00116         uint8_t r;
00117         struct __attribute__((packed))

```



```

00118     {
00119         unsigned int TWIE : 1;
00120         unsigned int reserved : 1;
00121         unsigned int TWEN : 1;
00122         unsigned int TWWC : 1;
00123         unsigned int TWSTO : 1;
00124         unsigned int TWSTA : 1;
00125         unsigned int TWEA : 1;
00126         unsigned int TWINT : 1;
00127     };
00128 };
00129 } AVR_TWCR;
00130
00131 //-----
00132 typedef struct __attribute__((__packed__))
00133 {
00134     union __attribute__((__packed__))
00135     {
00136         uint8_t r;
00137         struct __attribute__((__packed__))
00138         {
00139             unsigned int TWGCE: 1;
00140             unsigned int TWA0 : 1;
00141             unsigned int TWA1 : 1;
00142             unsigned int TWA2 : 1;
00143             unsigned int TWA3 : 1;
00144             unsigned int TWA4 : 1;
00145             unsigned int TWA5 : 1;
00146             unsigned int TWA6 : 1;
00147         };
00148     };
00149 } AVR_TWAR;
00150
00151 //-----
00152 typedef struct __attribute__((__packed__))
00153 {
00154     union __attribute__((__packed__))
00155     {
00156         uint8_t r;
00157         struct __attribute__((__packed__))
00158         {
00159             unsigned int TWPS0 : 1;
00160             unsigned int TWPS1 : 1;
00161             unsigned int reserved : 1;
00162             unsigned int TWPS3 : 1;
00163             unsigned int TWPS4 : 1;
00164             unsigned int TWPS5 : 1;
00165             unsigned int TWPS6 : 1;
00166             unsigned int TWPS7 : 1;
00167         };
00168     };
00169 } AVR_TWSR;
00170
00171 //-----
00172 // Timer 2 register struct __attribute__((__packed__)) definitins.
00173 //-----
00174 typedef struct __attribute__((__packed__))
00175 {
00176     union __attribute__((__packed__))
00177     {
00178         uint8_t r;
00179         struct __attribute__((__packed__))
00180         {
00181             unsigned int TCR2BUB : 1;
00182             unsigned int TCR2AUB : 1;
00183             unsigned int OCR2BUB : 1;
00184             unsigned int OCR2AUB : 1;
00185             unsigned int TCN2UB : 1;
00186             unsigned int AS2 : 1;
00187             unsigned int EXCLK : 1;
00188             unsigned int reserved : 1;
00189         };
00190     };
00191 } AVR_ASSR;
00192
00193 //-----
00194 typedef struct __attribute__((__packed__))
00195 {
00196     union __attribute__((__packed__))
00197     {
00198         uint8_t r;
00199         struct __attribute__((__packed__))
00200         {
00201             unsigned int CS20 : 1;
00202             unsigned int CS21 : 1;
00203             unsigned int CS22 : 1;
00204             unsigned int WGM22 : 1;

```

```

00205         unsigned int reserved : 2;
00206         unsigned int FOC2B : 1;
00207         unsigned int FOC2A : 1;
00208     };
00209 };
00210 } AVR_TCCR2B;
00211
00212 //-----
00213 typedef struct __attribute__((packed))
00214 {
00215     union __attribute__((packed))
00216     {
00217         uint8_t r;
00218         struct __attribute__((packed))
00219         {
00220             unsigned int WGM20 : 1;
00221             unsigned int WGM21 : 1;
00222             unsigned int reserved : 2;
00223             unsigned int COM2B0 : 1;
00224             unsigned int COM2B1 : 1;
00225             unsigned int COM2A0 : 1;
00226             unsigned int COM2A1 : 1;
00227         };
00228     };
00229 } AVR_TCCR2A;
00230
00231 //-----
00232 // Timer 1 Register struct __attribute__((packed)) definitions
00233 //-----
00234
00235 typedef struct __attribute__((packed))
00236 {
00237     union __attribute__((packed))
00238     {
00239         uint8_t r;
00240         struct __attribute__((packed))
00241         {
00242             unsigned int WGM10 : 1;
00243             unsigned int WGM11 : 1;
00244             unsigned int reserved : 2;
00245             unsigned int COM1B0 : 1;
00246             unsigned int COM1B1 : 1;
00247             unsigned int COM1A0 : 1;
00248             unsigned int COM1A1 : 1;
00249         };
00250     };
00251 } AVR_TCCR1A;
00252
00253 //-----
00254 typedef struct __attribute__((packed))
00255 {
00256     union __attribute__((packed))
00257     {
00258         uint8_t r;
00259         struct __attribute__((packed))
00260         {
00261             unsigned int CS10 : 1;
00262             unsigned int CS11 : 1;
00263             unsigned int CS12 : 1;
00264             unsigned int WGM12 : 1;
00265             unsigned int WGM13 : 1;
00266             unsigned int reserved : 1;
00267             unsigned int ICES1 : 1;
00268             unsigned int ICNC1 : 1;
00269         };
00270     };
00271 } AVR_TCCR1B;
00272
00273 //-----
00274 typedef struct __attribute__((packed))
00275 {
00276     union __attribute__((packed))
00277     {
00278         uint8_t r;
00279         struct __attribute__((packed))
00280         {
00281             unsigned int reserved : 6;
00282             unsigned int FOC1B : 1;
00283             unsigned int FOC1A : 1;
00284         };
00285     };
00286 } AVR_TCCR1C;
00287
00288 //-----
00289 // A2D converter register definitions
00290 //-----
00291 typedef struct __attribute__((packed))

```

```

00292 {
00293     union __attribute__((packed))
00294     {
00295         uint8_t r;
00296         struct __attribute__((packed))
00297         {
00298             unsigned int AIN0D : 1;
00299             unsigned int AIN1D : 1;
00300             unsigned int reserved : 6;
00301         };
00302     };
00303 } AVR_DIDR1;
00304
00305 //-----
00306 typedef struct __attribute__((packed))
00307 {
00308     union __attribute__((packed))
00309     {
00310         uint8_t r;
00311         struct __attribute__((packed))
00312         {
00313             unsigned int ADC0D : 1;
00314             unsigned int ADC1D : 1;
00315             unsigned int ADC2D : 1;
00316             unsigned int ADC3D : 1;
00317             unsigned int ADC4D : 1;
00318             unsigned int ADC5D : 1;
00319             unsigned int reserved : 2;
00320         };
00321     };
00322 } AVR_DIDR0;
00323
00324 //-----
00325 typedef struct __attribute__((packed))
00326 {
00327     union __attribute__((packed))
00328     {
00329         uint8_t r;
00330         struct __attribute__((packed))
00331         {
00332             unsigned int MUX0 : 1;
00333             unsigned int MUX1 : 1;
00334             unsigned int MUX2 : 1;
00335             unsigned int MUX3 : 1;
00336             unsigned int reserved : 1;
00337             unsigned int ADLAR : 1;
00338             unsigned int REFS0 : 1;
00339             unsigned int REFS1 : 1;
00340         };
00341     };
00342 } AVR_ADMUX;
00343
00344 //-----
00345 typedef struct __attribute__((packed))
00346 {
00347     union __attribute__((packed))
00348     {
00349         uint8_t r;
00350         struct __attribute__((packed))
00351         {
00352             unsigned int ADPS0 : 1;
00353             unsigned int ADPS1 : 1;
00354             unsigned int ADPS2 : 1;
00355             unsigned int ADIE : 1;
00356             unsigned int ADIF : 1;
00357             unsigned int ADATE : 1;
00358             unsigned int ADSC : 1;
00359             unsigned int ADEN : 1;
00360         };
00361     };
00362 } AVR_ADCSRA;
00363
00364 //-----
00365 typedef struct __attribute__((packed))
00366 {
00367     union __attribute__((packed))
00368     {
00369         uint8_t r;
00370         struct __attribute__((packed))
00371         {
00372             unsigned int ADTS0 : 1;
00373             unsigned int ADTS1 : 1;
00374             unsigned int ADTS2 : 1;
00375             unsigned int reserved : 3;
00376             unsigned int ACMD : 1;
00377             unsigned int reserved_ : 1;
00378         };
00379     };

```

```

00379     };
00380 } AVR_ADCSR;
00381
00382 //-----
00383 // Timer interrupt mask registers.
00384 //-----
00385 typedef struct __attribute__((packed))
00386 {
00387     union __attribute__((packed))
00388     {
00389         uint8_t r;
00390         struct __attribute__((packed))
00391         {
00392             unsigned int TOIE2 : 1;
00393             unsigned int OCIE2A : 1;
00394             unsigned int OCIE2B : 1;
00395             unsigned int reserved : 5;
00396         };
00397     };
00398 } AVR_TIMSK2;
00399
00400 //-----
00401 typedef struct __attribute__((packed))
00402 {
00403     union __attribute__((packed))
00404     {
00405         uint8_t r;
00406         struct __attribute__((packed))
00407         {
00408             unsigned int TOIE1 : 1;
00409             unsigned int OCIE1A : 1;
00410             unsigned int OCIE1B : 1;
00411             unsigned int reserved : 2;
00412             unsigned int ICIE1 : 1;
00413             unsigned int reserved_ : 2;
00414         };
00415     };
00416 } AVR_TIMSK1;
00417
00418 //-----
00419 typedef struct __attribute__((packed))
00420 {
00421     union __attribute__((packed))
00422     {
00423         uint8_t r;
00424         struct __attribute__((packed))
00425         {
00426             unsigned int TOIE0 : 1;
00427             unsigned int OCIE0A : 1;
00428             unsigned int OCIE0B : 1;
00429             unsigned int reserved : 5;
00430         };
00431     };
00432 } AVR_TIMSK0;
00433
00434 //-----
00435 // Pin change interrupt mask bit definitions
00436 //-----
00437 typedef struct __attribute__((packed))
00438 {
00439     union __attribute__((packed))
00440     {
00441         uint8_t r;
00442         struct __attribute__((packed))
00443         {
00444             unsigned int PCINT16 : 1;
00445             unsigned int PCINT17 : 1;
00446             unsigned int PCINT18 : 1;
00447             unsigned int PCINT19 : 1;
00448             unsigned int PCINT20 : 1;
00449             unsigned int PCINT21 : 1;
00450             unsigned int PCINT22 : 1;
00451             unsigned int PCINT23 : 1;
00452         };
00453     };
00454 } AVR_PCMSK2;
00455
00456 //-----
00457 typedef struct __attribute__((packed))
00458 {
00459     union __attribute__((packed))
00460     {
00461         uint8_t r;
00462         struct __attribute__((packed))
00463         {
00464             unsigned int PCINT8 : 1;
00465             unsigned int PCINT9 : 1;

```

```

00466         unsigned int PCINT10 : 1;
00467         unsigned int PCINT11 : 1;
00468         unsigned int PCINT12 : 1;
00469         unsigned int PCINT13 : 1;
00470         unsigned int PCINT14 : 1;
00471         unsigned int PCINT15 : 1;
00472     };
00473 };
00474 } AVR_PCMSK1;
00475
00476 //-----
00477 typedef struct __attribute__((packed))
00478 {
00479     union __attribute__((packed))
00480     {
00481         uint8_t r;
00482         struct __attribute__((packed))
00483         {
00484             unsigned int PCINT0 : 1;
00485             unsigned int PCINT1 : 1;
00486             unsigned int PCINT2 : 1;
00487             unsigned int PCINT3 : 1;
00488             unsigned int PCINT4 : 1;
00489             unsigned int PCINT5 : 1;
00490             unsigned int PCINT6 : 1;
00491             unsigned int PCINT7 : 1;
00492         };
00493     };
00494 } AVR_PCMSK0;
00495
00496 //-----
00497 typedef struct __attribute__((packed))
00498 {
00499     union __attribute__((packed))
00500     {
00501         uint8_t r;
00502         struct __attribute__((packed))
00503         {
00504             unsigned int PCIE0 : 1;
00505             unsigned int PCIE1 : 1;
00506             unsigned int PCIE2 : 1;
00507             unsigned int reserved : 5;
00508         };
00509     };
00510 } AVR_PCICR;
00511
00512 //-----
00513 typedef struct __attribute__((packed))
00514 {
00515     union __attribute__((packed))
00516     {
00517         uint8_t r;
00518         struct __attribute__((packed))
00519         {
00520             unsigned int ISC00 : 1;
00521             unsigned int ISC01 : 1;
00522             unsigned int ISC10 : 1;
00523             unsigned int ISC11 : 1;
00524             unsigned int reserved : 4;
00525         };
00526     };
00527 } AVR_EICRA;
00528
00529 //-----
00530 typedef struct __attribute__((packed))
00531 {
00532     union __attribute__((packed))
00533     {
00534         uint8_t r;
00535         struct __attribute__((packed))
00536         {
00537             unsigned int PRADC : 1;
00538             unsigned int PRUSART0 : 1;
00539             unsigned int PRSPI : 1;
00540             unsigned int PRTIM1 : 1;
00541             unsigned int reserved : 1;
00542             unsigned int PRTIM0 : 1;
00543             unsigned int PRTIM2 : 1;
00544             unsigned int PRTWI : 1;
00545         };
00546     };
00547 } AVR_PRR;
00548
00549 //-----
00550 typedef struct __attribute__((packed))
00551 {
00552     union __attribute__((packed))

```

```

00553     {
00554         uint8_t r;
00555         struct __attribute__((packed__))
00556         {
00557             unsigned int CLKPS0 : 1;
00558             unsigned int CLKPS1 : 1;
00559             unsigned int CLKPS2 : 1;
00560             unsigned int CLKPS3 : 1;
00561             unsigned int reserved : 3;
00562             unsigned int CLKPCE : 1;
00563         };
00564     };
00565 } AVR_CLKPR;
00566
00567 //-----
00568 typedef struct __attribute__((packed__))
00569 {
00570     union __attribute__((packed__))
00571     {
00572         uint8_t r;
00573         struct __attribute__((packed__))
00574         {
00575             unsigned int WDP0 : 1;
00576             unsigned int WDP1 : 1;
00577             unsigned int WDP2 : 1;
00578             unsigned int WDE : 1;
00579             unsigned int WDCE : 1;
00580             unsigned int WDP3 : 1;
00581             unsigned int WDIE : 1;
00582             unsigned int WDIF : 1;
00583         };
00584     };
00585 } AVR_WDTCSR;
00586
00587 //-----
00588 typedef struct __attribute__((packed__))
00589 {
00590     union __attribute__((packed__))
00591     {
00592         uint8_t r;
00593         struct __attribute__((packed__))
00594         {
00595             unsigned int C : 1;
00596             unsigned int Z : 1;
00597             unsigned int N : 1;
00598             unsigned int V : 1;
00599             unsigned int S : 1;
00600             unsigned int H : 1;
00601             unsigned int T : 1;
00602             unsigned int I : 1;
00603         };
00604     };
00605 } AVR_SREG;
00606
00607 //-----
00608 typedef struct __attribute__((packed__))
00609 {
00610     union __attribute__((packed__))
00611     {
00612         uint8_t r;
00613         struct __attribute__((packed__))
00614         {
00615             unsigned int SP0 : 1;
00616             unsigned int SP1 : 1;
00617             unsigned int SP2 : 1;
00618             unsigned int SP3 : 1;
00619             unsigned int SP4 : 1;
00620             unsigned int SP5 : 1;
00621             unsigned int SP6 : 1;
00622             unsigned int SP7 : 1;
00623         };
00624     };
00625 } AVR_SPL;
00626
00627 //-----
00628 typedef struct __attribute__((packed__))
00629 {
00630     union __attribute__((packed__))
00631     {
00632         uint8_t r;
00633         struct __attribute__((packed__))
00634         {
00635             unsigned int SP8 : 1;
00636             unsigned int SP9 : 1;
00637             unsigned int SP10 : 1;
00638             unsigned int reserved : 5;
00639         };

```

```

00640     };
00641 } AVR_SPH;
00642
00643 //-----
00644 typedef struct __attribute__((packed))
00645 {
00646     union __attribute__((packed))
00647     {
00648         uint8_t r;
00649         struct __attribute__((packed))
00650         {
00651             unsigned int SELFPRGEN : 1;
00652             unsigned int PGERS : 1;
00653             unsigned int PGWRT : 1;
00654             unsigned int BLBSET : 1;
00655             unsigned int RWWSRE : 1;
00656             unsigned int RWWSB : 1;
00657             unsigned int SPMIE : 1;
00658         };
00659     };
00660 } AVR_SPMCSR;
00661
00662 //-----
00663 typedef struct __attribute__((packed))
00664 {
00665     union __attribute__((packed))
00666     {
00667         uint8_t r;
00668         struct __attribute__((packed))
00669         {
00670             unsigned int IVCE : 1;
00671             unsigned int IVSEL : 1;
00672             unsigned int reserved : 2;
00673             unsigned int PUD : 1;
00674             unsigned int BODSE : 1;
00675             unsigned int BODS : 1;
00676             unsigned int reserved_ : 1;
00677         };
00678     };
00679 } AVR_MCUCR;
00680
00681 //-----
00682 typedef struct __attribute__((packed))
00683 {
00684     union __attribute__((packed))
00685     {
00686         uint8_t r;
00687         struct __attribute__((packed))
00688         {
00689             unsigned int PORF : 1;
00690             unsigned int EXTRF : 1;
00691             unsigned int BORF : 1;
00692             unsigned int WDRF : 1;
00693             unsigned int reserved : 4;
00694         };
00695     };
00696 } AVR_MCUSR;
00697
00698 //-----
00699 typedef struct __attribute__((packed))
00700 {
00701     union __attribute__((packed))
00702     {
00703         uint8_t r;
00704         struct __attribute__((packed))
00705         {
00706             unsigned int SE : 1;
00707             unsigned int SM0 : 1;
00708             unsigned int SM1 : 1;
00709             unsigned int SM2 : 1;
00710             unsigned int reserved : 4;
00711         };
00712     };
00713 } AVR_SMCR;
00714
00715 //-----
00716 typedef struct __attribute__((packed))
00717 {
00718     union __attribute__((packed))
00719     {
00720         uint8_t r;
00721         struct __attribute__((packed))
00722         {
00723             unsigned int ACIS0 : 1;
00724             unsigned int ACIS1 : 1;
00725             unsigned int ACIC : 1;
00726             unsigned int ACIE : 1;

```

```

00727         unsigned int ACI      : 1;
00728         unsigned int AC0      : 1;
00729         unsigned int ACBG     : 1;
00730         unsigned int ACD      : 1;
00731     };
00732 };
00733 } AVR_ACSR;
00734
00735 //-----
00736 typedef struct __attribute__((packed))
00737 {
00738     union __attribute__((packed))
00739     {
00740         uint8_t r;
00741         struct __attribute__((packed))
00742         {
00743             unsigned int SPRO : 1;
00744             unsigned int SPR1 : 1;
00745             unsigned int CPHA : 1;
00746             unsigned int CPOL : 1;
00747             unsigned int MSTR : 1;
00748             unsigned int DORD : 1;
00749             unsigned int SPE  : 1;
00750             unsigned int SPIE : 1;
00751         };
00752     };
00753 } AVR_SPCR;
00754
00755 //-----
00756 typedef struct __attribute__((packed))
00757 {
00758     union __attribute__((packed))
00759     {
00760         uint8_t r;
00761         struct __attribute__((packed))
00762         {
00763             unsigned int SPI2X : 1;
00764             unsigned int reserved : 5;
00765             unsigned int WCOL : 1;
00766             unsigned int SPIF : 1;
00767         };
00768     };
00769 } AVR_SPSR;
00770
00771 //-----
00772 typedef struct __attribute__((packed))
00773 {
00774     union __attribute__((packed))
00775     {
00776         uint8_t r;
00777         struct __attribute__((packed))
00778         {
00779             unsigned int PSRSYNC : 1;
00780             unsigned int PSRASY : 1;
00781             unsigned int reserved : 5;
00782             unsigned int TSM : 1;
00783         };
00784     };
00785 } AVR_GTCCR;
00786
00787 //-----
00788 typedef struct __attribute__((packed))
00789 {
00790     union __attribute__((packed))
00791     {
00792         uint8_t r;
00793         struct __attribute__((packed))
00794         {
00795             unsigned int WGM00 : 1;
00796             unsigned int WGM01 : 1;
00797             unsigned int reserved : 2;
00798             unsigned int COM0B0 : 1;
00799             unsigned int COM0B1 : 1;
00800             unsigned int COM0A0 : 1;
00801             unsigned int COM0A1 : 1;
00802         };
00803     };
00804 } AVR_TCCR0A;
00805
00806 //-----
00807 typedef struct __attribute__((packed))
00808 {
00809     union __attribute__((packed))
00810     {
00811         uint8_t r;
00812         struct __attribute__((packed))
00813         {

```



```

00814         unsigned int CS00      : 1;
00815         unsigned int CS01      : 1;
00816         unsigned int CS02      : 1;
00817         unsigned int WGM02      : 1;
00818         unsigned int reserved : 2;
00819         unsigned int FOC0B      : 1;
00820         unsigned int FOC0A      : 1;
00821     };
00822 };
00823 } AVR_TCCR0B;
00824
00825 //-----
00826 typedef struct __attribute__((packed))
00827 {
00828     union __attribute__((packed))
00829     {
00830         uint8_t r;
00831         struct __attribute__((packed))
00832         {
00833             unsigned int EERE      : 1;
00834             unsigned int EEPE      : 1;
00835             unsigned int EEMPE      : 1;
00836             unsigned int EERIE      : 1;
00837             unsigned int EEPM0      : 1;
00838             unsigned int EEPM1      : 1;
00839             unsigned int reserved : 2;
00840         };
00841     };
00842 } AVR_EECR;
00843
00844 //-----
00845 // External interrupt flag register definitions
00846 //-----
00847 typedef struct __attribute__((packed))
00848 {
00849     union __attribute__((packed))
00850     {
00851         uint8_t r;
00852         struct __attribute__((packed))
00853         {
00854             unsigned int INTF0      : 1;
00855             unsigned int INTF1      : 1;
00856             unsigned int reserved : 6;
00857         };
00858     };
00859 } AVR_EIFR;
00860
00861 //-----
00862 // External interrupt mask register definitions
00863 //-----
00864 typedef struct __attribute__((packed))
00865 {
00866     union __attribute__((packed))
00867     {
00868         uint8_t r;
00869         struct __attribute__((packed))
00870         {
00871             unsigned int INT0      : 1;
00872             unsigned int INT1      : 1;
00873             unsigned int reserved : 6;
00874         };
00875     };
00876 } AVR_EIMSK;
00877
00878 //-----
00879 // Pin (GPIO) register definitions
00880 //-----
00881 typedef struct __attribute__((packed))
00882 {
00883     union __attribute__((packed))
00884     {
00885         uint8_t r;
00886         struct __attribute__((packed))
00887         {
00888             unsigned int PIN0 : 1;
00889             unsigned int PIN1 : 1;
00890             unsigned int PIN2 : 1;
00891             unsigned int PIN3 : 1;
00892             unsigned int PIN4 : 1;
00893             unsigned int PIN5 : 1;
00894             unsigned int PIN6 : 1;
00895             unsigned int PIN7 : 1;
00896         };
00897     };
00898 } AVR_PIN;
00899
00900 //-----

```

```

00901 // Data-direction register (GPIO) definitions
00902 //-----
00903 typedef struct __attribute__((packed))
00904 {
00905     union __attribute__((packed))
00906     {
00907         uint8_t r;
00908         struct __attribute__((packed))
00909         {
00910             unsigned int DDR0 : 1;
00911             unsigned int DDR1 : 1;
00912             unsigned int DDR2 : 1;
00913             unsigned int DDR3 : 1;
00914             unsigned int DDR4 : 1;
00915             unsigned int DDR5 : 1;
00916             unsigned int DDR6 : 1;
00917             unsigned int DDR7 : 1;
00918         };
00919     };
00920 } AVR_DDR;
00921
00922 //-----
00923 // Port (GPIO) register definitions
00924 //-----
00925 typedef struct __attribute__((packed))
00926 {
00927     union __attribute__((packed))
00928     {
00929         uint8_t r;
00930         struct __attribute__((packed))
00931         {
00932             unsigned int PORT0 : 1;
00933             unsigned int PORT1 : 1;
00934             unsigned int PORT2 : 1;
00935             unsigned int PORT3 : 1;
00936             unsigned int PORT4 : 1;
00937             unsigned int PORT5 : 1;
00938             unsigned int PORT6 : 1;
00939             unsigned int PORT7 : 1;
00940         };
00941     };
00942 } AVR_PORT;
00943
00944 //-----
00945 // Timer interrupt flag register struct __attribute__((packed)) definitions
00946 //-----
00947 typedef struct __attribute__((packed))
00948 {
00949     union __attribute__((packed))
00950     {
00951         uint8_t r;
00952         struct __attribute__((packed))
00953         {
00954             unsigned int TOV0 : 1;
00955             unsigned int OCF0A : 1;
00956             unsigned int OCF0B : 1;
00957             unsigned int reserved : 5;
00958         };
00959     };
00960 } AVR_TIFR0;
00961
00962 //-----
00963 typedef struct __attribute__((packed))
00964 {
00965     union __attribute__((packed))
00966     {
00967         uint8_t r;
00968         struct __attribute__((packed))
00969         {
00970             unsigned int TOV1 : 1;
00971             unsigned int OCF1A : 1;
00972             unsigned int OCF1B : 1;
00973             unsigned int reserved : 2;
00974             unsigned int ICF1 : 1;
00975             unsigned int reserved_ : 2;
00976         };
00977     };
00978 } AVR_TIFR1;
00979
00980 //-----
00981 typedef struct __attribute__((packed))
00982 {
00983     union __attribute__((packed))
00984     {
00985         uint8_t r;
00986         struct __attribute__((packed))
00987         {

```

```

00988     {
00989         unsigned int TOV2      : 1;
00990         unsigned int OCF2A     : 1;
00991         unsigned int OCF2B     : 1;
00992         unsigned int reserved : 5;
00993     };
00994 };
00995 } AVR_TIFR2;
00996
00997 //-----
00998 // Pin-change interrupt flag bits
00999 //-----
01000 typedef struct __attribute__((__packed__))
01001 {
01002     union __attribute__((__packed__))
01003     {
01004         uint8_t r;
01005         struct __attribute__((__packed__))
01006         {
01007             unsigned int PCIF0 : 1;
01008             unsigned int PCIF1 : 1;
01009             unsigned int PCIF2 : 1;
01010             unsigned int reserved : 5;
01011         };
01012     };
01013 } AVR_PCIFR;
01014
01015 #endif // __AVR_PERIPHREGS_H__

```

4.135 src/peripheral/mega_eeprom.c File Reference

AVR atmega EEPROM plugin.

```

#include "mega_eeprom.h"
#include "avr_cpu.h"
#include <stdint.h>
#include <stdbool.h>
#include <stdlib.h>
#include <stdio.h>
#include <string.h>

```

Macros

- #define **DEBUG_PRINT**(...)

Enumerations

- enum **EEPROM_State_t** { **EEPROM_STATE_IDLE** = 0, **EEPROM_STATE_WRITE_ENABLE**, **EEPROM_STATE_READ**, **EEPROM_STATE_WRITE**, **EEPROM_STATES** }
- enum **EEPROM_Mode_t** { **EEPROM_MODE_ATOMIC** = 0, **EEPROM_MODE_ERASE**, **EEPROM_MODE_WRITE**, **EEPROM_MODES** }

Functions

- static void **EEARH_Write** (uint8_t u8Addr_)
- static void **EEARL_Write** (uint8_t u8Addr_)
- static uint16_t **EEAR_Read** (void)
- static void **EEPE_Clear** (void)
- static void **EEPE_Set** (void)
- static bool **EEPE_Read** (void)

- static void **EERE_Clear** (void)
- static void **EERE_Set** (void)
- static bool **EERE_Read** (void)
- static void **EEMPE_Clear** (void)
- static void **EEMPE_Set** (void)
- static bool **EEMPE_Read** (void)
- static void **EERIE_Clear** (void)
- static void **EERIE_Set** (void)
- static bool **EERIE_Read** (void)
- static [EEPROM_Mode_t](#) **EEPM_Read** (void)
- static uint8_t **EEDR_Read** (void)
- static void **EEPROM_Init** (void *context_)
- static void **EEPROM_Read** (void *context_, uint8_t ucAddr_, uint8_t *pucValue_)
- static void [EEPROM_Write](#) (void *context_, uint8_t ucAddr_, uint8_t ucValue_)
- static void **EEPROM_Clock** (void *context_)

Variables

- static [EEPROM_State_t](#) **eState** = [EEPROM_STATE_IDLE](#)
- static uint32_t **u32CountDown** = 0
- [AVRPeripheral](#) **stEEPROM**

4.135.1 Detailed Description

AVR atmega EEPROM plugin.

Definition in file [mega_eeprom.c](#).

4.135.2 Enumeration Type Documentation

4.135.2.1 enum EEPROM_Mode_t

Enumerator

EEPROM_MODE_ATOMIC Atomic Clear/Write operation.

EEPROM_MODE_ERASE Erase only.

EEPROM_MODE_WRITE Write only.

Definition at line 50 of file [mega_eeprom.c](#).

4.135.2.2 enum EEPROM_State_t

Enumerator

EEPROM_STATE_IDLE EEPROM is idle.

EEPROM_STATE_WRITE_ENABLE EEPROM write is enabled (for 4 cycles)

EEPROM_STATE_READ EEPROM is reading a byte.

EEPROM_STATE_WRITE EEPROM is writing a byte.

Definition at line 38 of file [mega_eeprom.c](#).

4.135.3 Function Documentation

4.135.3.1 static void EEPROM_Write (void * context_, uint8_t ucAddr_, uint8_t ucValue_) [static]

! ToDo - Fix the times to use RC-oscillator times, not CPU-clock times.

Definition at line 183 of file [mega_eeprom.c](#).

4.135.4 Variable Documentation

4.135.4.1 AVRPeripheral stEEPROM

Initial value:

```
=
{
    EEPROM_Init,
    EEPROM_Read,
    EEPROM_Write,
    EEPROM_Clock,
    0,
    0x3F,
    0x3F
}
```

Definition at line 310 of file [mega_eeprom.c](#).

4.136 mega_eeprom.c

```
00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/ ( ( ) / (      \      (      ( ) / (      | -- [ Funkenstein ] -----
00005 *      / ( ) / ( ) ((( ( ) \      )\      / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ) ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ / \ | _ \      | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \ \ / \ | _ \      |
00010 *      | _ | | _      / _ \ \ / \ | _ \      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include "mega_eeprom.h"
00022
00023 #include "avr_cpu.h"
00024
00025 #include <stdint.h>
00026 #include <stdbool.h>
00027 #include <stdlib.h>
00028 #include <stdio.h>
00029 #include <string.h>
00030
00031 #if 1
00032     #define DEBUG_PRINT(...)
00033 #else
00034     #define DEBUG_PRINT    printf
00035 #endif
00036
00037 //-----
00038 typedef enum
00039 {
00040     EEPROM_STATE_IDLE = 0,
00041     EEPROM_STATE_WRITE_ENABLE,
00042     EEPROM_STATE_READ,
00043     EEPROM_STATE_WRITE,
00044     //--
00045     EEPROM_STATES
00046 } EEPROM_State_t;
00047
00048
00049 //-----
00050 typedef enum
00051 {
```

```

00052     EEPROM_MODE_ATOMIC = 0,
00053     EEPROM_MODE_ERASE,
00054     EEPROM_MODE_WRITE,
00055     //-----
00056     EEPROM_MODES
00057 } EEPROM_Mode_t;
00058
00059 //-----
00060 static EEPROM_State_t eState = EEPROM_STATE_IDLE;
00061 static uint32_t        u32CountDown = 0;
00062
00063 //-----
00064 static void EEARH_Write( uint8_t u8Addr_ )
00065 {
00066     stCPU.pstRAM->stRegisters.EEARH = (u8Addr_ & 0x03);
00067 }
00068
00069 //-----
00070 static void EEARL_Write( uint8_t u8Addr_ )
00071 {
00072     stCPU.pstRAM->stRegisters.EEARL = u8Addr_;
00073 }
00074
00075 //-----
00076 static uint16_t EEAR_Read( void )
00077 {
00078     uint16_t u16Addr;
00079     u16Addr = ((uint16_t) (stCPU.pstRAM->stRegisters.EEARH) << 8) |
00080              ((uint16_t) (stCPU.pstRAM->stRegisters.EEARL));
00081     return u16Addr;
00082 }
00083
00084 //-----
00085 static void EEPE_Clear(void)
00086 {
00087     stCPU.pstRAM->stRegisters.EECR.EEPE = 0;
00088 }
00089
00090 //-----
00091 static void EEPE_Set(void)
00092 {
00093     stCPU.pstRAM->stRegisters.EECR.EEPE = 1;
00094 }
00095
00096 //-----
00097 static bool EEPE_Read(void)
00098 {
00099     return (stCPU.pstRAM->stRegisters.EECR.EEPE == 1);
00100 }
00101
00102 //-----
00103 static void EERE_Clear(void)
00104 {
00105     stCPU.pstRAM->stRegisters.EECR.EERE = 0;
00106 }
00107
00108 //-----
00109 static void EERE_Set(void)
00110 {
00111     stCPU.pstRAM->stRegisters.EECR.EERE = 1;
00112 }
00113
00114 //-----
00115 static bool EERE_Read(void)
00116 {
00117     return (stCPU.pstRAM->stRegisters.EECR.EERE == 1);
00118 }
00119
00120 //-----
00121 static void EEMPE_Clear(void)
00122 {
00123     stCPU.pstRAM->stRegisters.EECR.EEMPE = 0;
00124 }
00125
00126 //-----
00127 static void EEMPE_Set(void)
00128 {
00129     stCPU.pstRAM->stRegisters.EECR.EEMPE = 1;
00130 }
00131
00132 //-----
00133 static bool EEMPE_Read(void)
00134 {
00135     return (stCPU.pstRAM->stRegisters.EECR.EEMPE == 1);
00136 }
00137
00138 //-----
00139 static void EERIE_Clear(void)
00140 {

```

```

00139     stCPU.pstRAM->stRegisters.EECR.EERIE = 0;
00140 }
00141
00142 //-----
00143 static void EERIE_Set(void)
00144 {
00145     stCPU.pstRAM->stRegisters.EECR.EERIE = 1;
00146 }
00147
00148 //-----
00149 static bool EERIE_Read(void)
00150 {
00151     return (stCPU.pstRAM->stRegisters.EECR.EERIE == 1);
00152 }
00153
00154 //-----
00155 static EEPROM_Mode_t EEPM_Read(void)
00156 {
00157     EEPROM_Mode_t eRet;
00158     eRet = (EEPROM_Mode_t) (stCPU.pstRAM->stRegisters.EECR.r & (0x30)) >> 4;
00159     return eRet;
00160 }
00161
00162 //-----
00163 static uint8_t EEDR_Read(void)
00164 {
00165     return stCPU.pstRAM->stRegisters.EEDR;
00166 }
00167
00168 //-----
00169 static void EEPROM_Init(void *context_)
00170 {
00171     eState = EEPROM_STATE_IDLE;
00172     u32CountDown = 0;
00173 }
00174
00175 //-----
00176 static void EEPROM_Read(void *context_, uint8_t ucAddr_, uint8_t *pucValue_)
00177 {
00178     DEBUG_PRINT( "EEPROM Read %2x\n", stCPU.pstRAM->stRegisters.EECR.r );
00179     *pucValue_ = stCPU.pstRAM->stRegisters.EECR.r;
00180 }
00181
00182 //-----
00183 static void EEPROM_Write(void *context_, uint8_t ucAddr_, uint8_t ucValue_)
00184 {
00185     // We're only interested in the EECR register. If we really want to be
00186     // 100% CPU-accurate, we'd take into account a ton of additional logic for
00187     // other peripherals (CPU SPM registers, etc.), but that's a lot of code
00188     // when pretty much everyone is going to be using the app note or the AVR
00189     // libc implementation, which is very much "sunny case" code. In short,
00190     // this will handle incorrectly-implemented code incorrectly.
00191
00192     stCPU.pstRAM->stRegisters.EECR.r |= (ucValue_ & 0x3F);
00193
00194     switch (eState)
00195     {
00196     case EEPROM_STATE_IDLE:
00197     {
00198         if ((ucValue_ & 0x01) == 0x01) // Read
00199         {
00200             // When the data is read, the data is available in the next instruction
00201             // but the CPU is halted for 4 cycles before it's executed.
00202             DEBUG_PRINT( "EEPROM Read\n" );
00203             eState = EEPROM_STATE_READ;
00204             u32CountDown = 4;
00205
00206             stCPU.u16ExtraCycles += u32CountDown;
00207             stCPU.u64CycleCount += u32CountDown;
00208
00209             // Read data at EEPROM address to EEPROM data register
00210             stCPU.pstRAM->stRegisters.EEDR = stCPU.pu8EEPROM[ EEAR_Read() ];
00211         }
00212         else if ((ucValue_ & 0x04) == 0x04) // Program Enable
00213         {
00214             // Must initiate a write within 4 cycles of enabling the EEPROM write bit
00215             DEBUG_PRINT( "EEPROM Write Enable \n" );
00216             eState = EEPROM_STATE_WRITE_ENABLE;
00217             u32CountDown = 4;
00218         }
00219     }
00220     break;
00221
00222     case EEPROM_STATE_WRITE_ENABLE:
00223     {
00224         if ((ucValue_ & 0x02) == 0x02) // Value has EEPE
00225         {

```

```

00226         eState = EEPROM_STATE_WRITE;
00227         DEBUG_PRINT( "EEPROM Write\n" );
00228         switch ( EEPM_Read() )
00229         {
00231             case EEPROM_MODE_ATOMIC:
00232             {
00233                 stCPU.pu8EEPROM[ EEAR_Read() ] = EEDR_Read();
00234                 u32CountDown = 48000;
00235             }
00236             break;
00237             case EEPROM_MODE_WRITE:
00238             {
00239                 // EEPROM works by setting individual bits -- once a bit is set, it must be
00240                 // cleared before it can be reset.
00241                 stCPU.pu8EEPROM[ EEAR_Read() ] |= EEDR_Read();
00242                 u32CountDown = 25000;
00243             }
00244             break;
00245             case EEPROM_MODE_ERASE:
00246             {
00247                 // EEPROM is 0 when cleared
00248                 stCPU.pu8EEPROM[ EEAR_Read() ] = 0x00;
00249                 u32CountDown = 25000;
00250             }
00251             break;
00252             default:
00253                 break;
00254         }
00255     }
00256 }
00257 break;
00258 default:
00259     break;
00260 }
00261 }
00262
00263 //-----
00264 static void EEPROM_Clock(void *context_)
00265 {
00266     if (u32CountDown)
00267     {
00268         // DEBUG_PRINT( "EEPROM Clock %d\n", u32CountDown );
00269
00270         u32CountDown--;
00271         if (!u32CountDown)
00272         {
00273             // We're only interested in the EECR register.
00274             switch (eState)
00275             {
00276                 case EEPROM_STATE_WRITE:
00277                 {
00278                     EEPE_Clear();
00279                     EERE_Clear();
00280                     EEMPE_Clear();
00281
00282                     eState = EEPROM_STATE_IDLE;
00283                 }
00284                 break;
00285                 case EEPROM_STATE_READ:
00286                 {
00287                     EEPE_Clear();
00288                     EERE_Clear();
00289                     EEMPE_Clear();
00290
00291                     eState = EEPROM_STATE_IDLE;
00292                 }
00293                 break;
00294                 case EEPROM_STATE_WRITE_ENABLE:
00295                 {
00296                     EEMPE_Clear();
00297                     EERE_Clear();
00298                     eState = EEPROM_STATE_IDLE;
00299                 }
00300                 break;
00301                 default:
00302                     break;
00303             }
00304         }
00305     }
00306 }
00307 }
00308
00309 //-----
00310 AVRPeripheral stEEPROM =
00311 {
00312     EEPROM_Init,
00313     EEPROM_Read,

```



```

00314     EEPROM_Write,
00315     EEPROM_Clock,
00316     0,
00317     0x3F,
00318     0x3F
00319 };
00320

```

4.137 src/peripheral/mega_eeprom.h File Reference

AVR atmega EEPROM plugin.

```
#include "avr_peripheral.h"
```

Variables

- [AVRPeripheral](#) `stEEPROM`

4.137.1 Detailed Description

AVR atmega EEPROM plugin.

Definition in file [mega_eeprom.h](#).

4.138 mega_eeprom.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ( ) / ( ( ) / (      (      ( ) / (      | -- [ Funkenstein ] -----
00005 *      / ( ) / ( ) ((( ( ) )\ )\ / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ) ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ / / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _ _      / _ \ \ \ / / | _ \      |
00010 *                                          | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __MEGA_EEPROM_H__
00022 #define __MEGA_EEPROM_H__
00023
00024 #include "avr_peripheral.h"
00025
00026
00027 extern AVRPeripheral stEEPROM;
00028
00029 #endif // __MEGA_EEPROM_H__

```

4.139 src/peripheral/mega_eint.c File Reference

ATMega External Interrupt Implementation.

```

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "avr_cpu.h"
#include "avr_peripheral.h"
#include "avr_periphregs.h"
#include "avr_interrupt.h"

```

Macros

- `#define DEBUG_PRINT(...)`

Enumerations

- enum `InterruptSense_t` { `INT_SENSE_LOW` = 0, `INT_SENSE_CHANGE`, `INT_SENSE_FALL`, `INT_SENSE_RISE` }

Functions

- static void `EINT_AckInt` (uint8_t ucVector_)
- static void `EINT_Init` (void *context_)
- static void `EINT_Read` (void *context_, uint8_t ucAddr_, uint8_t *pucValue_)
- static void `EICRA_Write` (uint8_t ucValue_)
- static void `EIFR_Write` (uint8_t ucValue_)
- static void `EIMSK_Write` (uint8_t ucValue_)
- static void `EINT_Write` (void *context_, uint8_t ucAddr_, uint8_t ucValue_)
- static void `EINT_Clock` (void *context_)

Variables

- static `InterruptSense_t` `eINT0Sense`
- static `InterruptSense_t` `eINT1Sense`
- static uint8_t `ucLastINT0`
- static uint8_t `ucLastINT1`
- `AVRPeripheral` `stEINT_a`
- `AVRPeripheral` `stEINT_b`

4.139.1 Detailed Description

ATMega External Interrupt Implementation.

Definition in file [mega_eint.c](#).

4.139.2 Enumeration Type Documentation

4.139.2.1 enum `InterruptSense_t`

Enumerator

- `INT_SENSE_LOW` Logic low triggers interrupt.
- `INT_SENSE_CHANGE` Change in state triggers interrupt.
- `INT_SENSE_FALL` Falling edge triggers interrupt.
- `INT_SENSE_RISE` Rising edge triggers interrupt.

Definition at line 32 of file [mega_eint.c](#).

4.139.3 Function Documentation

4.139.3.1 static void EINT_Clock (void * *context_*) [static]

! ToDo - Consider adding support for external stimulus (which would ! Invoke inputs on PIND as opposed to PORTD)... This will only work ! as software interrupts in its current state

Definition at line 169 of file [mega_eint.c](#).

4.139.4 Variable Documentation

4.139.4.1 AVRPeripheral stEINT_a

Initial value:

```
=
{
    EINT_Init,
    EINT_Read,
    EINT_Write,
    EINT_Clock,
    NULL,
    0x69,
    0x69
}
```

Definition at line 282 of file [mega_eint.c](#).

4.139.4.2 AVRPeripheral stEINT_b

Initial value:

```
=
{
    NULL,
    EINT_Read,
    EINT_Write,
    NULL,
    NULL,
    0x3C,
    0x3D
}
```

Definition at line 294 of file [mega_eint.c](#).

4.140 mega_eint.c

```
00001 /*****
00002 *      (      )      (      )      |
00003 *      )\ )      )\ )      (      )\ )      |
00004 *      ((/( ((/(      )\      (      ((/(      | -- [ Funkenstein ] -----
00005 *      /( )      /( )      ((( ( )      )\      /( )      | -- [ Little ] -----
00006 *      ( )_ ( )      )\ _ )\      ( ) ( )      ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( )_ ( )      \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | |      / _ \      \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | |      / _ \      \ / / | _ \      |
00010 *      | _ | |      / _ \      \ / / | _ \      | "Yeah, it does Arduino..."
00011 *      -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdio.h>
00022 #include <stdlib.h>
00023 #include <string.h>
00024 #include "avr_cpu.h"
00025 #include "avr_peripheral.h"
00026 #include "avr_periphregs.h"
00027 #include "avr_interrupt.h"
```

```

00028
00029 #define DEBUG_PRINT(...)
00030
00031 //-----
00032 typedef enum
00033 {
00034     INT_SENSE_LOW = 0,
00035     INT_SENSE_CHANGE,
00036     INT_SENSE_FALL,
00037     INT_SENSE_RISE
00038 } InterruptSense_t;
00039
00040
00041 //-----
00042 static InterruptSense_t eINT0Sense;
00043 static InterruptSense_t eINT1Sense;
00044 static uint8_t ucLastINT0;
00045 static uint8_t ucLastINT1;
00046
00047 //-----
00048 static void EINT_AckInt( uint8_t ucVector_);
00049
00050 //-----
00051 static void EINT_Init(void *context_ )
00052 {
00053     eINT0Sense = INT_SENSE_LOW;
00054     eINT1Sense = INT_SENSE_LOW;
00055     ucLastINT0 = 0;
00056     ucLastINT1 = 0;
00057
00058     // Register interrupt callback functions
00059     CPU_RegisterInterruptCallback(EINT_AckInt, 0x01);
00060     CPU_RegisterInterruptCallback(EINT_AckInt, 0x02);
00061 }
00062
00063 //-----
00064 static void EINT_Read(void *context_, uint8_t ucAddr_, uint8_t *pucValue_ )
00065 {
00066     *pucValue_ = stCPU.pstRAM->au8RAM[ucAddr_];
00067 }
00068
00069 //-----
00070 static void EICRA_Write( uint8_t ucValue_ )
00071 {
00072     DEBUG_PRINT("EICRA Clock\n");
00073     ucValue_ &= 0x0F; // Only the bottom 2 bits are valid.
00074     stCPU.pstRAM->stRegisters.EICRA.r = ucValue_;
00075
00076     // Change local interrupt sense value.
00077     if ((stCPU.pstRAM->stRegisters.EICRA.ISC00 == 0) &&
00078         (stCPU.pstRAM->stRegisters.EICRA.ISC01 == 0))
00079     {
00080         DEBUG_PRINT("I0-low\n");
00081         eINT0Sense = INT_SENSE_LOW;
00082     }
00083     else if ((stCPU.pstRAM->stRegisters.EICRA.ISC00 == 1) &&
00084             (stCPU.pstRAM->stRegisters.EICRA.ISC01 == 0))
00085     {
00086         DEBUG_PRINT("I0-change\n");
00087         eINT0Sense = INT_SENSE_CHANGE;
00088     }
00089     else if ((stCPU.pstRAM->stRegisters.EICRA.ISC00 == 0) &&
00090             (stCPU.pstRAM->stRegisters.EICRA.ISC01 == 1))
00091     {
00092         DEBUG_PRINT("I0-fall\n");
00093         eINT0Sense = INT_SENSE_FALL;
00094     }
00095     else if ((stCPU.pstRAM->stRegisters.EICRA.ISC00 == 1) &&
00096             (stCPU.pstRAM->stRegisters.EICRA.ISC01 == 1))
00097     {
00098         DEBUG_PRINT("I0-rise\n");
00099         eINT0Sense = INT_SENSE_RISE;
00100     }
00101
00102     if ((stCPU.pstRAM->stRegisters.EICRA.ISC10 == 0) &&
00103         (stCPU.pstRAM->stRegisters.EICRA.ISC11 == 0))
00104     {
00105         eINT1Sense = INT_SENSE_LOW;
00106     }
00107     else if ((stCPU.pstRAM->stRegisters.EICRA.ISC10 == 1) &&
00108             (stCPU.pstRAM->stRegisters.EICRA.ISC11 == 0))
00109     {
00110         eINT1Sense = INT_SENSE_CHANGE;
00111     }
00112     else if ((stCPU.pstRAM->stRegisters.EICRA.ISC10 == 0) &&
00113             (stCPU.pstRAM->stRegisters.EICRA.ISC11 == 1))
00114     {

```

```

00115     eINT1Sense = INT_SENSE_RISE;
00116 }
00117 else if ((stCPU.pstRAM->stRegisters.EICRA.ISC10 == 1) &&
00118         (stCPU.pstRAM->stRegisters.EICRA.ISC11 == 1))
00119 {
00120     eINT1Sense = INT_SENSE_FALL;
00121 }
00122 DEBUG_PRINT ("IntSense0,1: %d, %d\n", eINT0Sense, eINT1Sense);
00123 DEBUG_PRINT ("EICRA: %d, ISC00 : %d, ISC01 : %d, ISC10: %d, ISC11: %d\n",
00124             stCPU.pstRAM->stRegisters.EICRA.r,
00125             stCPU.pstRAM->stRegisters.EICRA.ISC00,
00126             stCPU.pstRAM->stRegisters.EICRA.ISC01,
00127             stCPU.pstRAM->stRegisters.EICRA.ISC10,
00128             stCPU.pstRAM->stRegisters.EICRA.ISC11
00129             );
00130 }
00131
00132 //-----
00133 static void EIFR_Write( uint8_t ucValue_ )
00134 {
00135     DEBUG_PRINT("EIFR Clock\n");
00136     ucValue_ &= 0x03;    // Only the bottom-2 bits are set
00137     stCPU.pstRAM->stRegisters.EIFR.r = ucValue_;
00138 }
00139
00140 //-----
00141 static void EIMSK_Write( uint8_t ucValue_ )
00142 {
00143     DEBUG_PRINT("EIMSK Write\n");
00144     ucValue_ &= 0x03;    // Only the bottom-2 bits are set
00145     stCPU.pstRAM->stRegisters.EIMSK.r = ucValue_;
00146 }
00147
00148 //-----
00149 static void EINT_Write(void *context_, uint8_t ucAddr_, uint8_t ucValue_ )
00150 {
00151     DEBUG_PRINT("EINT Write\n");
00152     switch (ucAddr_)
00153     {
00154     case 0x69: // EICRA
00155         EICRA_Write(ucValue_);
00156         break;
00157     case 0x3C: // EIFR
00158         EIFR_Write(ucValue_);
00159         break;
00160     case 0x3D: // EIMSK
00161         EIMSK_Write(ucValue_);
00162         break;
00163     default:
00164         break;
00165     }
00166 }
00167
00168 //-----
00169 static void EINT_Clock(void *context_ )
00170 {
00171     // Check to see if interrupts are enabled.  If so, check to see if the
00172     // interrupt mask is set, and then finally - whether or not an interrupt
00173     // condition has occurred based on the interrupt sense mode.
00174     bool bSetINT0 = false;
00175     bool bSetINT1 = false;
00176
00177     if (stCPU.pstRAM->stRegisters.EIMSK.INT0 == 1)
00178     {
00179         switch (eINT0Sense)
00180         {
00181         case INT_SENSE_LOW:
00182             if (stCPU.pstRAM->stRegisters.PORTD.PORT2 == 0)
00183             {
00184                 DEBUG_PRINT(" SET INT0\n");
00185                 bSetINT0 = true;
00186             }
00187             break;
00188         case INT_SENSE_CHANGE:
00189             if (stCPU.pstRAM->stRegisters.PORTD.PORT2 != ucLastINT0)
00190             {
00191                 DEBUG_PRINT(" SET INT0\n");
00192                 bSetINT0 = true;
00193             }
00194             break;
00195         case INT_SENSE_FALL:
00196             if ((stCPU.pstRAM->stRegisters.PORTD.PORT2 == 0) && (ucLastINT0 == 1))
00197             {
00198                 DEBUG_PRINT(" SET INT0\n");
00199                 bSetINT0 = true;
00200             }
00201         }
00202     }
00203 }

```

```

00205         break;
00206     case INT_SENSE_RISE:
00207         if ((stCPU.pstRAM->stRegisters.PORTD.PORT2 == 1) && (ucLastINT0 == 0))
00208         {
00209             DEBUG_PRINT(" SET INT0\n");
00210             bSetINT0 = true;
00211         }
00212         break;
00213     }
00214 }
00215 if (stCPU.pstRAM->stRegisters.EIMSK.INT1 == 1)
00216 {
00217     switch (eINT0Sense)
00218     {
00219     case INT_SENSE_LOW:
00220         if (stCPU.pstRAM->stRegisters.PORTD.PORT3 == 0)
00221         {
00222             bSetINT1 = true;
00223         }
00224         break;
00225     case INT_SENSE_CHANGE:
00226         if (stCPU.pstRAM->stRegisters.PORTD.PORT3 != ucLastINT1)
00227         {
00228             bSetINT1 = true;
00229         }
00230         break;
00231     case INT_SENSE_FALL:
00232         if ((stCPU.pstRAM->stRegisters.PORTD.PORT3 == 0) && (ucLastINT1 == 1))
00233         {
00234             bSetINT1 = true;
00235         }
00236         break;
00237     case INT_SENSE_RISE:
00238         if ((stCPU.pstRAM->stRegisters.PORTD.PORT3 == 1) && (ucLastINT1 == 0))
00239         {
00240             bSetINT1 = true;
00241         }
00242         break;
00243     }
00244 }
00245 // Trigger interrupts where necessary
00246 if (bSetINT0)
00247 {
00248     stCPU.pstRAM->stRegisters.EIFR.INTF0 = 1;
00249     AVR_InterruptCandidate(0x01);
00250 }
00251 if (bSetINT1)
00252 {
00253     stCPU.pstRAM->stRegisters.EIFR.INTF1 = 1;
00254     AVR_InterruptCandidate(0x02);
00255 }
00256 // Update locally-cached copy of previous INT0/INT1 pin status.
00257 ucLastINT0 = stCPU.pstRAM->stRegisters.PORTD.PORT2;
00258 ucLastINT1 = stCPU.pstRAM->stRegisters.PORTD.PORT3;
00259 }
00260 }
00261 }
00262 //-----
00263 static void EINT_AckInt( uint8_t ucVector_)
00264 {
00265     // We automatically clear the INTx flag as soon as the interrupt
00266     // is acknowledged.
00267     switch (ucVector_)
00268     {
00269     case 0x01:
00270         DEBUG_PRINT("INT0!\n");
00271         stCPU.pstRAM->stRegisters.EIFR.INTF0 = 0;
00272         break;
00273     case 0x02:
00274         DEBUG_PRINT("INT1!\n");
00275         stCPU.pstRAM->stRegisters.EIFR.INTF1 = 0;
00276         break;
00277     }
00278 }
00279 }
00280 //-----
00281 AVRPeripheral stEINT_a =
00282 {
00283     EINT_Init,
00284     EINT_Read,
00285     EINT_Write,
00286     EINT_Clock,
00287     NULL,
00288     0x69,
00289     0x69
00290 };
00291 };
```

```

00292
00293 //-----
00294 AVRPeripheral stEINT_b =
00295 {
00296     NULL,
00297     EINT_Read,
00298     EINT_Write,
00299     NULL,
00300     NULL,
00301     0x3C,
00302     0x3D
00303 };

```

4.141 src/peripheral/mega_eint.h File Reference

ATMega External Interrupt Implementation.

```
#include "avr_peripheral.h"
```

Variables

- [AVRPeripheral stEINT_a](#)
- [AVRPeripheral stEINT_b](#)

4.141.1 Detailed Description

ATMega External Interrupt Implementation.

Definition in file [mega_eint.h](#).

4.142 mega_eint.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      |
00004 *      ((/( ((/(      (      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( ) \  / ( ) | -- [ Little ] -----
00006 *      ( ) _ ( )      ) \ _ ) \ ( ( ( _ ( ) | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ ( ) \ \ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ \ v / | _ / | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \ \ \ v / | _ / |
00010 *      | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __MEGA_EINT_H__
00022 #define __MEGA_EINT_H__
00023
00024 #include "avr_peripheral.h"
00025
00026 extern AVRPeripheral stEINT_a;
00027 extern AVRPeripheral stEINT_b;
00028
00029 #endif //__MEGA_EINT_H__

```

4.143 src/peripheral/mega_timer16.c File Reference

ATMega 16-bit timer implementation.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "avr_cpu.h"
#include "avr_peripheral.h"
#include "avr_periphregs.h"
#include "avr_interrupt.h"
```

Macros

- `#define DEBUG_PRINT(...)`

Enumerations

- enum [ClockSource_t](#) {
CLK_SRC_OFF, **CLK_SRC_DIV_1**, **CLK_SRC_DIV_8**, **CLK_SRC_DIV_64**,
CLK_SRC_DIV_256, **CLK_SRC_DIV_1024**, **CLK_SRC_T1_FALL**, **CLK_SRC_T1_RISE**,
CLK_SRC_OFF, **CLK_SRC_DIV_1**, **CLK_SRC_DIV_8**, **CLK_SRC_DIV_64**,
CLK_SRC_DIV_256, **CLK_SRC_DIV_1024**, **CLK_SRC_T1_FALL**, **CLK_SRC_T1_RISE** }
- enum **WaveformGeneratorMode_t** {
WGM_NORMAL, **WGM_PWM_PC_8BIT**, **WGM_PWM_PC_9BIT**, **WGM_PWM_PC_10BIT**,
WGM CTC_OCR, **WGM_PWM_8BIT**, **WGM_PWM_9BIT**, **WGM_PWM_10BIT**,
WGM_PWM_PC_FC_ICR, **WGM_PWM_PC_FC_OCR**, **WGM_PWM_PC_ICR**, **WGM_PWM_PC_OCR**,
WGM CTC_ICR, **WGM_RESERVED**, **WGM_FAST_PWM_ICR**, **WGM_FAST_PWM_OCR**,
WGM_NORMAL, **WGM_PWM_PC_FF**, **WGM CTC_OCR**, **WGM_FAST_PWM_FF**,
WGM_RESERVED_1, **WGM_PWM_PC_OCR**, **WGM_RESERVED_2**, **WGM_FAST_PWM_OCR** }
- enum **CompareOutputMode_t** {
COM_NORMAL, **COM_TOGGLE_MATCH**, **COM_CLEAR_MATCH**, **COM_SET_MATCH**,
COM_NORMAL, **COM_TOGGLE_MATCH**, **COM_CLEAR_MATCH**, **COM_SET_MATCH** }

Functions

- static void **TCNT1_Increment** ()
- static uint16_t **TCNT1_Read** ()
- static void **TCNT1_Clear** ()
- static uint16_t **OCR1A_Read** ()
- static uint16_t **OCR1B_Read** ()
- static uint16_t **ICR1_Read** ()
- static bool **Timer16_Is_TOIE1_Enabled** ()
- static bool **Timer16_Is_OCIE1A_Enabled** ()
- static bool **Timer16_Is_OCIE1B_Enabled** ()
- static bool **Timer16_Is_ICIE1_Enabled** ()
- static void **OV1_Ack** (uint8_t ucVector_)
- static void **IC1_Ack** (uint8_t ucVector_)
- static void **COMP1A_Ack** (uint8_t ucVector_)
- static void **COMP1B_Ack** (uint8_t ucVector_)
- static void **Timer16_Init** (void *context_)
- static void **Timer16_Read** (void *context_, uint8_t ucAddr_, uint8_t *pucValue_)
- static void **TCCR1A_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **TCCR1B_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **TCCR1C_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **TCNT1L_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **TCNT1H_Write** (uint8_t ucAddr_, uint8_t ucValue_)

- static void **ICR1L_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **ICR1H_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **OCR1AL_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **OCR1AH_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **OCR1BL_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **OCR1BH_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **Timer16_IntFlagUpdate** (void)
- static void **Timer16b_Write** (void *context_, uint8_t ucAddr_, uint8_t ucValue_)
- static void **Timer16_Write** (void *context_, uint8_t ucAddr_, uint8_t ucValue_)
- static void [Timer16_Clock](#) (void *context_)

Variables

- static uint16_t **u16DivCycles** = 0
- static uint16_t **u16DivRemain** = 0
- static [ClockSource_t](#) **eClockSource** = CLK_SRC_OFF
- static WaveformGeneratorMode_t **eWGM** = WGM_NORMAL
- static CompareOutputMode_t **eCOM1A** = COM_NORMAL
- static CompareOutputMode_t **eCOM1B** = COM_NORMAL
- static uint8_t **u8Temp**
- static uint16_t **u8Count**
- [AVRPeripheral](#) **stTimer16**
- [AVRPeripheral](#) **stTimer16a**
- [AVRPeripheral](#) **stTimer16b**

4.143.1 Detailed Description

ATMega 16-bit timer implementation.

Definition in file [mega_timer16.c](#).

4.143.2 Enumeration Type Documentation

4.143.2.1 enum ClockSource_t

! This implementation only tracks the basic timer/capture/compare functionality of the peripheral, to match what's used in Mark3. Future considerations, TBD.

Definition at line 38 of file [mega_timer16.c](#).

4.143.3 Function Documentation

4.143.3.1 static void Timer16_Clock (void * context_) [static]

! ToDo - Handle external timer generated events.

Definition at line 448 of file [mega_timer16.c](#).

4.143.4 Variable Documentation

4.143.4.1 AVRPeripheral stTimer16

Initial value:

```
=
{
    Timer16_Init,
    Timer16_Read,
    Timer16_Write,
    Timer16_Clock,
    0,
    0x80,
    0x8B
}
```

Definition at line 580 of file [mega_timer16.c](#).

4.143.4.2 AVRPeripheral stTimer16a

Initial value:

```
=
{
    0,
    Timer16_Read,
    Timer16b_Write,
    0,
    0,
    0x36,
    0x36
}
```

Definition at line 592 of file [mega_timer16.c](#).

4.143.4.3 AVRPeripheral stTimer16b

Initial value:

```
=
{
    0,
    Timer16_Read,
    Timer16b_Write,
    0,
    0,
    0x6F,
    0x6F
}
```

Definition at line 604 of file [mega_timer16.c](#).

4.144 mega_timer16.c

```
00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ((/( ((/(      )\      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( )\ )\ / ( )      | -- [ Little ] -----
00006 *      ( ) _ ( )      )\ _ )\ ( ( ) ( )      | -- [ AVR ] -----
00007 *      | | _ | |      ( ) _ ( ) \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \ \ / / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \ \ / / | _ \      |
00010 *      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdio.h>
00022 #include <stdlib.h>
00023 #include <string.h>
00024 #include "avr_cpu.h"
00025 #include "avr_peripheral.h"
00026 #include "avr_periphregs.h"
00027 #include "avr_interrupt.h"
00028
```

```

00029 #define DEBUG_PRINT(...)
00030
00031 //-----
00035 //-----
00036
00037 //-----
00038 typedef enum
00039 {
00040     CLK_SRC_OFF,
00041     CLK_SRC_DIV_1,
00042     CLK_SRC_DIV_8,
00043     CLK_SRC_DIV_64,
00044     CLK_SRC_DIV_256,
00045     CLK_SRC_DIV_1024,
00046     CLK_SRC_T1_FALL,
00047     CLK_SRC_T1_RISE
00048 } ClockSource_t;
00049
00050 //-----
00051 typedef enum
00052 {
00053     WGM_NORMAL,
00054     WGM_PWM_PC_8BIT,
00055     WGM_PWM_PC_9BIT,
00056     WGM_PWM_PC_10BIT,
00057     WGM CTC_OCR,
00058     WGM_PWM_8BIT,
00059     WGM_PWM_9BIT,
00060     WGM_PWM_10BIT,
00061     WGM_PWM_PC_FC_ICR,
00062     WGM_PWM_PC_FC_OCR,
00063     WGM_PWM_PC_ICR,
00064     WGM_PWM_PC_OCR,
00065     WGM CTC_ICR,
00066     WGM_RESERVED,
00067     WGM_FAST_PWM_ICR,
00068     WGM_FAST_PWM_OCR
00069 } WaveformGeneratorMode_t;
00070
00071 //-----
00072 typedef enum
00073 {
00074     COM_NORMAL,           // OCA1/B disconnected
00075     COM_TOGGLE_MATCH,     // Toggle on match
00076     COM_CLEAR_MATCH,
00077     COM_SET_MATCH
00078 } CompareOutputMode_t;
00079
00080 //-----
00081 static uint16_t ul6DivCycles = 0;
00082 static uint16_t ul6DivRemain = 0;
00083 static ClockSource_t eClockSource = CLK_SRC_OFF;
00084 static WaveformGeneratorMode_t eWGM = WGM_NORMAL;
00085 static CompareOutputMode_t eCOM1A = COM_NORMAL;
00086 static CompareOutputMode_t eCOM1B = COM_NORMAL;
00087
00088 //-----
00089 static uint8_t u8Temp; // The 8-bit temporary register used in 16-bit register accesses
00090 static uint16_t u8Count; // Internal 16-bit count register
00091
00092 //-----
00093 static void TCNT1_Increment()
00094 {
00095     uint16_t ul6NewVal = 0;
00096
00097     ul6NewVal = (stCPU.pstRAM->stRegisters.TCNT1H << 8) |
00098                 stCPU.pstRAM->stRegisters.TCNT1L;
00099
00100     ul6NewVal++;
00101     stCPU.pstRAM->stRegisters.TCNT1L = (ul6NewVal & 0x00FF);
00102     stCPU.pstRAM->stRegisters.TCNT1H = (ul6NewVal >> 8);
00103 }
00104
00105 //-----
00106 static uint16_t TCNT1_Read()
00107 {
00108     uint16_t ul6Ret = 0;
00109
00110     ul6Ret = (stCPU.pstRAM->stRegisters.TCNT1H << 8) |
00111              stCPU.pstRAM->stRegisters.TCNT1L;
00112     return ul6Ret;
00113 }
00114
00115 //-----
00116 static void TCNT1_Clear()
00117 {
00118     stCPU.pstRAM->stRegisters.TCNT1H = 0;

```

```

00119     stCPU.pstRAM->stRegisters.TCNT1L = 0;
00120 }
00121
00122 //-----
00123 static uint16_t OCR1A_Read()
00124 {
00125     uint16_t u16Ret = 0;
00126
00127     u16Ret = (stCPU.pstRAM->stRegisters.OCR1AH << 8 ) |
00128             stCPU.pstRAM->stRegisters.OCR1AL;
00129     return u16Ret;
00130 }
00131
00132 //-----
00133 static uint16_t OCR1B_Read()
00134 {
00135     uint16_t u16Ret = 0;
00136
00137     u16Ret = (stCPU.pstRAM->stRegisters.OCR1BH << 8 ) |
00138             stCPU.pstRAM->stRegisters.OCR1BL;
00139     return u16Ret;
00140 }
00141
00142 //-----
00143 static uint16_t ICR1_Read()
00144 {
00145     uint16_t u16Ret = 0;
00146
00147     u16Ret = (stCPU.pstRAM->stRegisters.ICR1H << 8 ) |
00148             stCPU.pstRAM->stRegisters.ICR1L;
00149     return u16Ret;
00150 }
00151
00152 //-----
00153 static bool Timer16_Is_TOIE1_Enabled()
00154 {
00155     return (stCPU.pstRAM->stRegisters.TIMSK1.TOIE1 == 1);
00156 }
00157
00158 //-----
00159 static bool Timer16_Is_OCIE1A_Enabled()
00160 {
00161     return (stCPU.pstRAM->stRegisters.TIMSK1_OCIE1A == 1);
00162 }
00163
00164 //-----
00165 static bool Timer16_Is_OCIE1B_Enabled()
00166 {
00167     return (stCPU.pstRAM->stRegisters.TIMSK1_OCIE1B == 1);
00168 }
00169
00170 //-----
00171 static bool Timer16_Is_ICIE1_Enabled()
00172 {
00173     return (stCPU.pstRAM->stRegisters.TIMSK1_ICIE1 == 1);
00174 }
00175
00176 //-----
00177 static void OV1_Ack( uint8_t ucVector_)
00178 {
00179     stCPU.pstRAM->stRegisters.TIFR1.TOV1 = 0;
00180 }
00181
00182 //-----
00183 static void IC1_Ack( uint8_t ucVector_)
00184 {
00185     stCPU.pstRAM->stRegisters.TIFR1.ICF1 = 0;
00186 }
00187
00188 //-----
00189 static void COMPlA_Ack( uint8_t ucVector_)
00190 {
00191     static uint64_t lastcycles = 0;
00192     // printf("COMPlA - Ack'd: %d delta\n", stCPU.u64CycleCount - lastcycles);
00193     lastcycles = stCPU.u64CycleCount;
00194
00195     stCPU.pstRAM->stRegisters.TIFR1.OCF1A = 0;
00196 }
00197
00198 //-----
00199 static void COMPlB_Ack( uint8_t ucVector_)
00200 {
00201     stCPU.pstRAM->stRegisters.TIFR1.OCF1B = 0;
00202 }
00203
00204 //-----
00205 static void Timer16_Init(void *context_ )

```

```

00206 {
00207     DEBUG_PRINT(stderr, "Timer16 Init\n");
00208
00209     CPU_RegisterInterruptCallback( OV1_Ack, 0x0D);
00210     CPU_RegisterInterruptCallback( IC1_Ack, 0x0A);
00211     CPU_RegisterInterruptCallback( COMP1A_Ack, 0x0B);
00212     CPU_RegisterInterruptCallback( COMP1B_Ack, 0x0C);
00213 }
00214
00215 //-----
00216 static void Timer16_Read(void *context_, uint8_t ucAddr_, uint8_t *pucValue_)
00217 {
00218     DEBUG_PRINT(stderr, "Timer16 Read: 0x%02x\n", ucAddr_);
00219     *pucValue_ = stCPU.pstRAM->au8RAM[ ucAddr_ ];
00220 }
00221
00222 //-----
00223 static void TCCR1A_Write( uint8_t ucAddr_, uint8_t ucValue_)
00224 {
00225     // Update the waveform generator mode (WGM11:10) bits.
00226     uint8_t u8WGMBits = ucValue_ & 0x03; // WGM11 and 10 are in bits 0,1
00227     uint8_t u8WGMTemp = (uint8_t)eWGM;
00228     u8WGMTemp &= ~(0x03);
00229     u8WGMTemp |= u8WGMBits;
00230     eWGM = (WaveformGeneratorMode_t)u8WGMTemp;
00231
00232     // Update the memory-mapped register.
00233     stCPU.pstRAM->stRegisters.TCCR1A.r = ucValue_ & 0xF3;
00234 }
00235
00236 //-----
00237 static void TCCR1B_Write( uint8_t ucAddr_, uint8_t ucValue_)
00238 {
00239     // Update the waveform generator mode (WGM13:12) bits.
00240     uint8_t u8WGMBits = (ucValue_ >> 1) & 0x0C; // WGM13 and 12 are in register bits 3,4
00241     uint8_t u8WGMTemp = (uint8_t)eWGM;
00242     u8WGMTemp &= ~(0x0C);
00243     u8WGMTemp |= u8WGMBits;
00244     eWGM = (WaveformGeneratorMode_t)u8WGMTemp;
00245
00246     // Update the clock-select bits
00247     uint8_t u8ClockSource = ucValue_ & 0x07; // clock select is last 3 bits in reg
00248     eClockSource = (ClockSource_t)u8ClockSource;
00249     switch (eClockSource)
00250     {
00251     case CLK_SRC_DIV_1:
00252         u16DivCycles = 1;
00253         break;
00254     case CLK_SRC_DIV_8:
00255         u16DivCycles = 8;
00256         break;
00257     case CLK_SRC_DIV_64:
00258         u16DivCycles = 64;
00259         break;
00260     case CLK_SRC_DIV_256:
00261         u16DivCycles = 256;
00262         break;
00263     case CLK_SRC_DIV_1024:
00264         u16DivCycles = 1024;
00265         break;
00266     default:
00267         u16DivCycles = 0;
00268         break;
00269     }
00270
00271     // Update the memory-mapped register.
00272     stCPU.pstRAM->stRegisters.TCCR1B.r = ucValue_ & 0xDF; // Bit 5 is read-only
00273 }
00274
00275 //-----
00276 static void TCCR1C_Write( uint8_t ucAddr_, uint8_t ucValue_)
00277 {
00278     stCPU.pstRAM->stRegisters.TCCR1C.r = ucValue_;
00279 }
00280
00281 //-----
00282 static void TCNT1L_Write( uint8_t ucAddr_, uint8_t ucValue_)
00283 {
00284     // Writing the low-word forces the high-word to be stored from the internal
00285     // temp register... which is why the high byte must be written first.
00286     stCPU.pstRAM->stRegisters.TCNT1L = ucValue_;
00287     stCPU.pstRAM->stRegisters.TCNT1H = u8Temp;
00288 }
00289 //-----
00290 static void TCNT1H_Write( uint8_t ucAddr_, uint8_t ucValue_)
00291 {
00292     u8Temp = ucValue_;

```

```

00293 }
00294 //-----
00295 static void ICR1L_Write( uint8_t ucAddr_, uint8_t ucValue_)
00296 {
00297     // Writing the low-word forces the high-word to be stored from the internal
00298     // temp register... which is why the high byte must be written first.
00299     stCPU.pstRAM->stRegisters.ICR1L = ucValue_;
00300     stCPU.pstRAM->stRegisters.ICR1H = u8Temp;
00301 }
00302 //-----
00303 static void ICR1H_Write( uint8_t ucAddr_, uint8_t ucValue_)
00304 {
00305     u8Temp = ucValue_;
00306 }
00307
00308 //-----
00309 static void OCR1AL_Write( uint8_t ucAddr_, uint8_t ucValue_)
00310 {
00311     // Writing the low-word forces the high-word to be stored from the internal
00312     // temp register... which is why the high byte must be written first.
00313     stCPU.pstRAM->stRegisters.OCR1AL = ucValue_;
00314     stCPU.pstRAM->stRegisters.OCR1AH = u8Temp;
00315 }
00316
00317 //-----
00318 static void OCR1AH_Write( uint8_t ucAddr_, uint8_t ucValue_)
00319 {
00320     u8Temp = ucValue_;
00321 }
00322
00323 //-----
00324 static void OCR1BL_Write( uint8_t ucAddr_, uint8_t ucValue_)
00325 {
00326     // Writing the low-word forces the high-word to be stored from the internal
00327     // temp register... which is why the high byte must be written first.
00328     stCPU.pstRAM->stRegisters.OCR1BL = ucValue_;
00329     stCPU.pstRAM->stRegisters.OCR1BH = u8Temp;
00330 }
00331
00332 //-----
00333 static void OCR1BH_Write( uint8_t ucAddr_, uint8_t ucValue_)
00334 {
00335     u8Temp = ucValue_;
00336 }
00337
00338 //-----
00339 static void Timer16_IntFlagUpdate(void)
00340 {
00341     if (stCPU.pstRAM->stRegisters.TIMSK1.TOIE1 == 1)
00342     {
00343         if (stCPU.pstRAM->stRegisters.TIFR1.TOV1 == 1)
00344         {
00345             DEBUG_PRINT(" TOV1 Interrupt Candidate\n" );
00346             AVR_InterruptCandidate(0x0D);
00347         }
00348         else
00349         {
00350             AVR_ClearCandidate(0x0D);
00351         }
00352     }
00353
00354     if (stCPU.pstRAM->stRegisters.TIMSK1.OCF1A == 1)
00355     {
00356         if (stCPU.pstRAM->stRegisters.TIFR1.OCF1A == 1)
00357         {
00358             DEBUG_PRINT(" OCF1A Interrupt Candidate\n" );
00359             AVR_InterruptCandidate(0x0B);
00360         }
00361         else
00362         {
00363             AVR_ClearCandidate(0x0B);
00364         }
00365     }
00366
00367     if (stCPU.pstRAM->stRegisters.TIMSK1.OCF1B == 1)
00368     {
00369         if (stCPU.pstRAM->stRegisters.TIFR1.OCF1B == 1)
00370         {
00371             DEBUG_PRINT(" OCF1B Interrupt Candidate\n" );
00372             AVR_InterruptCandidate(0x0C);
00373         }
00374         else
00375         {
00376             AVR_ClearCandidate(0x0C);
00377         }
00378     }
00379 }

```

```

00380     if (stCPU.pstRAM->stRegisters.TIMSK1.ICIE1 == 1)
00381     {
00382         if (stCPU.pstRAM->stRegisters.TIFR1.ICF1 == 1)
00383         {
00384             DEBUG_PRINT(" ICF1 Interrupt Candidate\n" );
00385             AVR_InterruptCandidate(0x0A);
00386         }
00387         else
00388         {
00389             AVR_ClearCandidate(0x0A);
00390         }
00391     }
00392 }
00393
00394 //-----
00395 // TIFR & TMSK
00396 static void Timer16b_Write(void *context_, uint8_t ucAddr_, uint8_t ucValue_ )
00397 {
00398     stCPU.pstRAM->au8RAM[ucAddr_] = ucValue_;
00399     Timer16_IntFlagUpdate();
00400 }
00401
00402 //-----
00403 static void Timer16_Write(void *context_, uint8_t ucAddr_, uint8_t ucValue_ )
00404 {
00405     switch (ucAddr_)
00406     {
00407     case 0x80: //TCCR1A
00408         TCCR1A_Write(ucAddr_, ucValue_);
00409         break;
00410     case 0x81: //TCCR1B
00411         TCCR1B_Write(ucAddr_, ucValue_);
00412         break;
00413     case 0x82: //TCCR1C
00414         TCCR1C_Write(ucAddr_, ucValue_);
00415         break;
00416     case 0x83: // Reserved
00417         break;
00418     case 0x84: // TCNT1L
00419         TCNT1L_Write(ucAddr_, ucValue_);
00420         break;
00421     case 0x85: // TCNT1H
00422         TCNT1H_Write(ucAddr_, ucValue_);
00423         break;
00424     case 0x86: // ICR1L
00425         ICR1L_Write(ucAddr_, ucValue_);
00426         break;
00427     case 0x87: // ICR1H
00428         ICR1H_Write(ucAddr_, ucValue_);
00429         break;
00430     case 0x88: // OCR1AL
00431         OCR1AL_Write(ucAddr_, ucValue_);
00432         break;
00433     case 0x89: // OCR1AH
00434         OCR1AH_Write(ucAddr_, ucValue_);
00435         break;
00436     case 0x8A: // OCR1BL
00437         OCR1BL_Write(ucAddr_, ucValue_);
00438         break;
00439     case 0x8B: // OCR1BH
00440         OCR1BH_Write(ucAddr_, ucValue_);
00441         break;
00442     default:
00443         break;
00444     }
00445 }
00446
00447 //-----
00448 static void Timer16_Clock(void *context_ )
00449 {
00450     if (eClockSource == CLK_SRC_OFF)
00451     {
00452         return;
00453     }
00454     // Handle clock division logic
00455     bool bUpdateTimer = false;
00456     switch (eClockSource)
00457     {
00458     case CLK_SRC_DIV_1:
00459     case CLK_SRC_DIV_8:
00460     case CLK_SRC_DIV_64:
00461     case CLK_SRC_DIV_256:
00462     case CLK_SRC_DIV_1024:
00463     {
00464         // Decrement the clock-divide value
00465         if (u16DivRemain)

```

```

00467     {
00468         //DEBUG_PRINT(" %d ticks remain\n", ul6DivRemain);
00469         ul6DivRemain--;
00470     }
00471
00472     if (!ul6DivRemain)
00473     {
00474         // clock-divider count hits zero, reset and trigger an update.
00475         //DEBUG_PRINT(" expire and reset\n");
00476         if (ul6DivCycles)
00477         {
00478             ul6DivRemain = ul6DivCycles;
00479             bUpdateTimer = true;
00480         }
00481     }
00482 }
00483     break;
00484 default:
00485     break;
00486 }
00487
00488
00489
00490 if (bUpdateTimer)
00491 {
00492     // Handle event flags on timer updates
00493     bool bOVF = false;
00494     bool bCTCA = false;
00495     bool bCTCB = false;
00496     bool bICR = false;
00497     bool bIntr = false;
00498
00499     //DEBUG_PRINT( " WGM Mode %d\n", eWGM );
00500     switch (eWGM)
00501     {
00502     case WGM_NORMAL:
00503     {
00504         DEBUG_PRINT(" Update Normal\n");
00505         TCNT1_Increment();
00506         if (TCNT1_Read() == 0)
00507         {
00508             bOVF = true;
00509         }
00510     }
00511     break;
00512     case WGM CTC_OCR:
00513     {
00514         DEBUG_PRINT(" Update CTC\n");
00515         TCNT1_Increment();
00516         if (TCNT1_Read() == 0)
00517         {
00518             bOVF = true;
00519         }
00520         else
00521         {
00522             bool bClearTCNT1 = false;
00523             if (TCNT1_Read() == OCR1A_Read())
00524             {
00525                 DEBUG_PRINT(" CTC1A Match\n" );
00526                 bCTCA = true;
00527                 bClearTCNT1 = true;
00528             }
00529             if (TCNT1_Read() == ICR1_Read())
00530             {
00531                 DEBUG_PRINT(" ICR1 Match\n" );
00532                 bICR = true;
00533                 bClearTCNT1 = true;
00534             }
00535             if (bClearTCNT1)
00536             {
00537                 TCNT1_Clear();
00538             }
00539         }
00540     }
00541     break;
00542     default:
00543         break;
00544 }
00545
00546 // Set interrupt flags if an appropriate transition has taken place
00547 if (bOVF)
00548 {
00549     DEBUG_PRINT(" TOV1 Set\n" );
00550     stCPU.pstRAM->stRegisters.TIFR1.TOV1 = 1;
00551     bIntr = true;
00552 }
00553 if (bCTCA)
00554 {

```



```

00555         DEBUG_PRINT(" OCF1A Set\n" );
00556         stCPU.pstRAM->stRegisters.TIFR1.OCF1A = 1;
00557         bIntr = true;
00558     }
00559     if (bCTCB)
00560     {
00561         DEBUG_PRINT(" OCF1B Set\n" );
00562         stCPU.pstRAM->stRegisters.TIFR1.OCF1B = 1;
00563         bIntr = true;
00564     }
00565     if (bICR)
00566     {
00567         DEBUG_PRINT(" ICF1 Set\n" );
00568         stCPU.pstRAM->stRegisters.TIFR1.ICF1 = 1;
00569         bIntr = true;
00570     }
00571
00572     if (bIntr)
00573     {
00574         Timer16_IntFlagUpdate();
00575     }
00576 }
00577 }
00578
00579 //-----
00580 AVRPeripheral stTimer16 =
00581 {
00582     Timer16_Init,
00583     Timer16_Read,
00584     Timer16_Write,
00585     Timer16_Clock,
00586     0,
00587     0x80,
00588     0x8B
00589 };
00590
00591 //-----
00592 AVRPeripheral stTimer16a =
00593 {
00594     0,
00595     Timer16_Read,
00596     Timer16b_Write,
00597     0,
00598     0,
00599     0x36,
00600     0x36
00601 };
00602
00603 //-----
00604 AVRPeripheral stTimer16b =
00605 {
00606     0,
00607     Timer16_Read,
00608     Timer16b_Write,
00609     0,
00610     0,
00611     0x6F,
00612     0x6F
00613 };

```

4.145 src/peripheral/mega_timer16.h File Reference

ATMega 16-bit timer implementation.

```
#include "avr_peripheral.h"
```

Variables

- [AVRPeripheral stTimer16](#)
- [AVRPeripheral stTimer16a](#)
- [AVRPeripheral stTimer16b](#)

4.145.1 Detailed Description

ATMega 16-bit timer implementation.

Definition in file [mega_timer16.h](#).

4.146 mega_timer16.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      )\ ) |
00004 *      ((/(( (/((      \      ( (/(( | -- [ Funkenstein ] -----
00005 *      /(\) /(\) ((((\) ()\ )\ /(\) | -- [ Little ] -----
00006 *      (\)_| (\)_      )\ _ )\ ((\ ((\ (\)_ | -- [ AVR ] -----
00007 *      | | _ | | _      (\)_\ (\)_\ / / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ | / _ \ \ / \ / | _ \ | -- [ Runtime ] -----
00009 *      | _ | | _ | / _ \ \ / \ / | _ \ |
00010 *      | "Yeah, it does Arduino..."
00011 *      +-----+
00012 *      (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 *      See license.txt for details
00014 *****/
00021 #ifndef __MEGA_TIMER16_H__
00022 #define __MEGA_TIMER16_H__
00023
00024 #include "avr_peripheral.h"
00025
00026 extern AVRPeripheral stTimer16;
00027 extern AVRPeripheral stTimer16a;
00028 extern AVRPeripheral stTimer16b;
00029
00030 #endif //__MEGA_EINT_H__

```

4.147 src/peripheral/mega_timer8.c File Reference

ATMega 8-bit timer implementation.

```

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "avr_cpu.h"
#include "avr_peripheral.h"
#include "avr_periphregs.h"
#include "avr_interrupt.h"

```

Macros

- #define **DEBUG_PRINT**(...)

Enumerations

- enum [ClockSource_t](#) {
CLK_SRC_OFF, **CLK_SRC_DIV_1**, **CLK_SRC_DIV_8**, **CLK_SRC_DIV_64**,
CLK_SRC_DIV_256, **CLK_SRC_DIV_1024**, **CLK_SRC_T1_FALL**, **CLK_SRC_T1_RISE**,
CLK_SRC_OFF, **CLK_SRC_DIV_1**, **CLK_SRC_DIV_8**, **CLK_SRC_DIV_64**,
CLK_SRC_DIV_256, **CLK_SRC_DIV_1024**, **CLK_SRC_T1_FALL**, **CLK_SRC_T1_RISE** }
- enum **WaveformGeneratorMode_t** {
WGM_NORMAL, **WGM_PWM_PC_8BIT**, **WGM_PWM_PC_9BIT**, **WGM_PWM_PC_10BIT**,
WGM CTC_OCR, **WGM_PWM_8BIT**, **WGM_PWM_9BIT**, **WGM_PWM_10BIT**,
WGM_PWM_PC_FC_ICR, **WGM_PWM_PC_FC_OCR**, **WGM_PWM_PC_ICR**, **WGM_PWM_PC_OCR**,
WGM CTC_ICR, **WGM_RESERVED**, **WGM_FAST_PWM_ICR**, **WGM_FAST_PWM_OCR**,
WGM_NORMAL, **WGM_PWM_PC_FF**, **WGM CTC_OCR**, **WGM_FAST_PWM_FF**,

```

WGM_RESERVED_1, WGM_PWM_PC_OCR, WGM_RESERVED_2, WGM_FAST_PWM_OCR }
• enum CompareOutputMode_t {
    COM_NORMAL, COM_TOGGLE_MATCH, COM_CLEAR_MATCH, COM_SET_MATCH,
    COM_NORMAL, COM_TOGGLE_MATCH, COM_CLEAR_MATCH, COM_SET_MATCH }

```

Functions

- static void **TCNT0_Increment** ()
- static uint8_t **TCNT0_Read** ()
- static void **TCNT0_Clear** ()
- static uint8_t **OCR0A_Read** ()
- static uint8_t **OCR0B_Read** ()
- static bool **Timer8_Is_TOIE0_Enabled** ()
- static bool **Timer8_Is_OCIE0A_Enabled** ()
- static bool **Timer8_Is_OCIE1B_Enabled** ()
- static void **OV0_Ack** (uint8_t ucVector_)
- static void **COMP0A_Ack** (uint8_t ucVector_)
- static void **COMP0B_Ack** (uint8_t ucVector_)
- static void **Timer8_Init** (void *context_)
- static void **Timer8_Read** (void *context_, uint8_t ucAddr_, uint8_t *pucValue_)
- static void **TCCR0A_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **TCCR0B_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **TCNT0_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **OCR0A_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **OCR0B_Write** (uint8_t ucAddr_, uint8_t ucValue_)
- static void **Timer8_IntFlagUpdate** (void)
- static void **Timer8b_Write** (void *context_, uint8_t ucAddr_, uint8_t ucValue_)
- static void **Timer8_Write** (void *context_, uint8_t ucAddr_, uint8_t ucValue_)
- static void [Timer8_Clock](#) (void *context_)

Variables

- static uint16_t **u16DivCycles** = 0
- static uint16_t **u16DivRemain** = 0
- static [ClockSource_t](#) **eClockSource** = CLK_SRC_OFF
- static WaveformGeneratorMode_t **eWGM** = WGM_NORMAL
- static CompareOutputMode_t **eCOM1A** = COM_NORMAL
- static CompareOutputMode_t **eCOM1B** = COM_NORMAL
- static uint8_t **u8Temp**
- static uint16_t **u8Count**
- [AVRPeripheral](#) **stTimer8**
- [AVRPeripheral](#) **stTimer8a**
- [AVRPeripheral](#) **stTimer8b**

4.147.1 Detailed Description

ATMega 8-bit timer implementation.

Definition in file [mega_timer8.c](#).

4.147.2 Enumeration Type Documentation

4.147.2.1 enum ClockSource_t

! This implementation only tracks the basic timer/capture/compare functionality of the peripheral, to match what's used in Mark3. Future considerations, TBD.

Definition at line 38 of file [mega_timer8.c](#).

4.147.3 Function Documentation

4.147.3.1 static void Timer8_Clock (void * *context_*) [static]

! ToDo - Handle external timer generated events.

Definition at line 315 of file [mega_timer8.c](#).

4.147.4 Variable Documentation

4.147.4.1 AVRPeripheral stTimer8

Initial value:

```
=
{
    Timer8_Init,
    Timer8_Read,
    Timer8_Write,
    Timer8_Clock,
    0,
    0x44,
    0x48
}
```

Definition at line 428 of file [mega_timer8.c](#).

4.147.4.2 AVRPeripheral stTimer8a

Initial value:

```
=
{
    0,
    Timer8_Read,
    Timer8b_Write,
    0,
    0,
    0x35,
    0x35
}
```

Definition at line 441 of file [mega_timer8.c](#).

4.147.4.3 AVRPeripheral stTimer8b

Initial value:

```
=
{
    0,
    Timer8_Read,
    Timer8b_Write,
    0,

```

```

0,
0x6E,
0x6E
}

```

Definition at line 453 of file mega_timer8.c.

4.148 mega_timer8.c

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      |
00004 *      ((/( ((/(      \      (      ((/(      | -- [ Funkenstein ] -----
00005 *      /( ) / ( ) ((( ( ) \      )\      / ( )      | -- [ Little ] -----
00006 *      ( ) _ | ( )      )\ _ )\ ( ( ) ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | | |      ( ) _ \ ( ) \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \      \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \      \ /      | _ \      |
00010 *                                          | "Yeah, it does Arduino..."
00011 * -----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #include <stdio.h>
00022 #include <stdlib.h>
00023 #include <string.h>
00024 #include "avr_cpu.h"
00025 #include "avr_peripheral.h"
00026 #include "avr_periphregs.h"
00027 #include "avr_interrupt.h"
00028
00029 #define DEBUG_PRINT(...)
00030
00031 //-----
00035 //-----
00036
00037 //-----
00038 typedef enum
00039 {
00040     CLK_SRC_OFF,
00041     CLK_SRC_DIV_1,
00042     CLK_SRC_DIV_8,
00043     CLK_SRC_DIV_64,
00044     CLK_SRC_DIV_256,
00045     CLK_SRC_DIV_1024,
00046     CLK_SRC_T1_FALL,
00047     CLK_SRC_T1_RISE
00048 } ClockSource_t;
00049
00050 //-----
00051 typedef enum
00052 {
00053     WGM_NORMAL,
00054     WGM_PWM_PC_FF,
00055     WGM CTC_OCR,
00056     WGM_FAST_PWM_FF,
00057     WGM_RESERVED_1, // Not a valid mode
00058     WGM_PWM_PC_OCR,
00059     WGM_RESERVED_2, // Not a valid mode
00060     WGM_FAST_PWM_OCR
00061 } WaveformGeneratorMode_t;
00062
00063 //-----
00064 typedef enum
00065 {
00066     COM_NORMAL, // OCA
00067     COM_TOGGLE_MATCH, // Toggle on match
00068     COM_CLEAR_MATCH,
00069     COM_SET_MATCH
00070 } CompareOutputMode_t;
00071
00072 //-----
00073 static uint16_t u16DivCycles = 0;
00074 static uint16_t u16DivRemain = 0;
00075 static ClockSource_t eClockSource = CLK_SRC_OFF;
00076 static WaveformGeneratorMode_t eWGM = WGM_NORMAL;
00077 static CompareOutputMode_t eCOM1A = COM_NORMAL;
00078 static CompareOutputMode_t eCOM1B = COM_NORMAL;
00079
00080 //-----
00081 static uint8_t u8Temp; // The 8-bit temporary register used in 16-bit register accesses
00082 static uint16_t u8Count; // Internal 16-bit count register

```

```

00083
00084 //-----
00085 static void TCNT0_Increment()
00086 {
00087     stCPU.pstRAM->stRegisters.TCNT0++;
00088 }
00089
00090 //-----
00091 static uint8_t TCNT0_Read()
00092 {
00093     return stCPU.pstRAM->stRegisters.TCNT0;
00094 }
00095
00096 //-----
00097 static void TCNT0_Clear()
00098 {
00099     stCPU.pstRAM->stRegisters.TCNT0 = 0;
00100 }
00101
00102 //-----
00103 static uint8_t OCR0A_Read()
00104 {
00105     return stCPU.pstRAM->stRegisters.OCR0A;
00106 }
00107
00108 //-----
00109 static uint8_t OCR0B_Read()
00110 {
00111     return stCPU.pstRAM->stRegisters.OCR0B;
00112 }
00113
00114 //-----
00115 static bool Timer8_Is_TOIE0_Enabled()
00116 {
00117     return (stCPU.pstRAM->stRegisters.TIMSK0.TOIE0 == 1);
00118 }
00119
00120 //-----
00121 static bool Timer8_Is_OCIE0A_Enabled()
00122 {
00123     return (stCPU.pstRAM->stRegisters.TIMSK0_OCIE0A == 1);
00124 }
00125
00126 //-----
00127 static bool Timer8_Is_OCIE1B_Enabled()
00128 {
00129     return (stCPU.pstRAM->stRegisters.TIMSK0_OCIE0B == 1);
00130 }
00131
00132 //-----
00133 static void OV0_Ack( uint8_t ucVector_)
00134 {
00135     static uint64_t lastcycles = 0;
00136     stCPU.pstRAM->stRegisters.TIFR0.TOV0 = 0;
00137     // printf("OV0 - Ack'd: %d delta\n", stCPU.u64CycleCount - lastcycles);
00138     lastcycles = stCPU.u64CycleCount;
00139 }
00140
00141 //-----
00142 static void COMP0A_Ack( uint8_t ucVector_)
00143 {
00144     stCPU.pstRAM->stRegisters.TIFR0.OCF0A = 0;
00145 }
00146
00147 //-----
00148 static void COMP0B_Ack( uint8_t ucVector_)
00149 {
00150     stCPU.pstRAM->stRegisters.TIFR0.OCF0B = 0;
00151 }
00152
00153 //-----
00154 static void Timer8_Init(void *context_ )
00155 {
00156     DEBUG_PRINT( "Timer8 Init\n");
00157     CPU_RegisterInterruptCallback( OV0_Ack, 0x10);
00158     CPU_RegisterInterruptCallback( COMP0A_Ack, 0x0E);
00159     CPU_RegisterInterruptCallback( COMP0B_Ack, 0x0F);
00160 }
00161
00162 //-----
00163 static void Timer8_Read(void *context_, uint8_t ucAddr_, uint8_t *pucValue_ )
00164 {
00165     DEBUG_PRINT( "Timer8 Read: 0x%02x\n", ucAddr_);
00166     *pucValue_ = stCPU.pstRAM->au8RAM[ ucAddr_ ];
00167 }
00168
00169 //-----

```

```

00170 static void TCCR0A_Write( uint8_t ucAddr_, uint8_t ucValue_)
00171 {
00172     // Update the waveform generator mode (WGM1:0) bits.
00173     uint8_t u8WGMBits = ucValue_ & 0x03; // WGM1 and 0 are in bits 0,1
00174     uint8_t u8WGMTemp = (uint8_t)eWGM;
00175     u8WGMTemp &= ~(0x03);
00176     u8WGMTemp |= u8WGMBits;
00177     eWGM = (WaveformGeneratorMode_t)u8WGMTemp;
00178
00179     // Update the memory-mapped register.
00180     stCPU.pstRAM->stRegisters.TCCR0A.r = ucValue_ & 0xF3;
00181 }
00182
00183 //-----
00184 static void TCCR0B_Write( uint8_t ucAddr_, uint8_t ucValue_)
00185 {
00186     // Update the waveform generator mode (WGM2) bit
00187     uint8_t u8WGMBits = (ucValue_ >> 1) & 0x04; // WGM2 is in bit 3 of the register
00188     uint8_t u8WGMTemp = (uint8_t)eWGM;
00189     u8WGMTemp &= ~(0x04);
00190     u8WGMTemp |= u8WGMBits;
00191     eWGM = (WaveformGeneratorMode_t)u8WGMTemp;
00192
00193     // Update the clock-select bits
00194     uint8_t u8ClockSource = ucValue_ & 0x07; // clock select is last 3 bits in reg
00195     eClockSource = (ClockSource_t)u8ClockSource;
00196     switch (eClockSource)
00197     {
00198     case CLK_SRC_DIV_1:
00199         u16DivCycles = 1;
00200         break;
00201     case CLK_SRC_DIV_8:
00202         u16DivCycles = 8;
00203         break;
00204     case CLK_SRC_DIV_64:
00205         u16DivCycles = 64;
00206         break;
00207     case CLK_SRC_DIV_256:
00208         u16DivCycles = 256;
00209         break;
00210     case CLK_SRC_DIV_1024:
00211         u16DivCycles = 1024;
00212         break;
00213     default:
00214         u16DivCycles = 0;
00215         break;
00216     }
00217     DEBUG_PRINT(" ClockSource = %d, %d cycles\n", eClockSource, u16DivCycles);
00218     // Update the memory-mapped register.
00219     stCPU.pstRAM->stRegisters.TCCR0B.r = ucValue_ & 0xCF; // Bit 5&6 are read-only
00220 }
00221
00222 //-----
00223 static void TCNT0_Write( uint8_t ucAddr_, uint8_t ucValue_)
00224 {
00225     stCPU.pstRAM->stRegisters.TCNT0 = ucValue_;
00226 }
00227
00228 //-----
00229 static void OCR0A_Write( uint8_t ucAddr_, uint8_t ucValue_)
00230 {
00231     stCPU.pstRAM->stRegisters.OCR0A = ucValue_;
00232 }
00233
00234 //-----
00235 static void OCR0B_Write( uint8_t ucAddr_, uint8_t ucValue_)
00236 {
00237     stCPU.pstRAM->stRegisters.OCR0B = ucValue_;
00238 }
00239
00240 //-----
00241 static void Timer8_IntFlagUpdate(void)
00242 {
00243     if (stCPU.pstRAM->stRegisters.TIMSK0.TOIE0 == 1)
00244     {
00245         if (stCPU.pstRAM->stRegisters.TIFR0.TOV0 == 1)
00246         {
00247             DEBUG_PRINT(" TOV0 Interrupt Candidate\n" );
00248             AVR_InterruptCandidate(0x10);
00249         }
00250         else
00251         {
00252             AVR_ClearCandidate(0x10);
00253         }
00254     }
00255     if (stCPU.pstRAM->stRegisters.TIMSK0.OCIE0A == 1)
00256     {

```

```

00257         if (stCPU.pstRAM->stRegisters.TIFR0.OCF0A == 1)
00258         {
00259             DEBUG_PRINT(" OCF0A Interrupt Candidate\n" );
00260             AVR_InterruptCandidate(0x0E);
00261         }
00262         else
00263         {
00264             AVR_ClearCandidate(0x0E);
00265         }
00266     }
00267     if (stCPU.pstRAM->stRegisters.TIMSK0.OCF0B == 1)
00268     {
00269         if (stCPU.pstRAM->stRegisters.TIFR0.OCF0B == 1)
00270         {
00271             DEBUG_PRINT(" OCF0B Interrupt Candidate\n" );
00272             AVR_InterruptCandidate(0x0F);
00273         }
00274         else
00275         {
00276             AVR_ClearCandidate(0x0F);
00277         }
00278     }
00279 }
00280
00281 //-----
00282 static void Timer8_Write(void *context_, uint8_t ucAddr_, uint8_t ucValue_ )
00283 {
00284     stCPU.pstRAM->au8RAM[ucAddr_] = ucValue_;
00285     Timer8_IntFlagUpdate();
00286 }
00287
00288 //-----
00289 static void Timer8_Write(void *context_, uint8_t ucAddr_, uint8_t ucValue_ )
00290 {
00291     DEBUG_PRINT("Timer8_Write: %d=%d\n", ucAddr_, ucValue_);
00292     switch (ucAddr_)
00293     {
00294         case 0x44: //TCCR1A
00295             TCCR0A_Write(ucAddr_, ucValue_);
00296             break;
00297         case 0x45: //TCCR1B
00298             TCCR0B_Write(ucAddr_, ucValue_);
00299             break;
00300         case 0x46: // TCNT0
00301             TCNT0_Write(ucAddr_, ucValue_);
00302             break;
00303         case 0x47: // OCR0A
00304             OCR0A_Write(ucAddr_, ucValue_);
00305             break;
00306         case 0x48: // OCR0B
00307             OCR0B_Write(ucAddr_, ucValue_);
00308             break;
00309         default:
00310             break;
00311     }
00312 }
00313
00314 //-----
00315 static void Timer8_Clock(void *context_ )
00316 {
00317     if (eClockSource == CLK_SRC_OFF)
00318     {
00319         return;
00320     }
00321
00322     // Handle clock division logic
00323     bool bUpdateTimer = false;
00324     switch (eClockSource)
00325     {
00326         case CLK_SRC_DIV_1:
00327         case CLK_SRC_DIV_8:
00328         case CLK_SRC_DIV_64:
00329         case CLK_SRC_DIV_256:
00330         case CLK_SRC_DIV_1024:
00331         {
00332             // Decrement the clock-divide value
00333             if (u16DivRemain)
00334             {
00335                 //DEBUG_PRINT(" %d ticks remain\n", u16DivRemain);
00336                 u16DivRemain--;
00337             }
00338
00339             if (!u16DivRemain)
00340             {
00341                 // clock-divider count hits zero, reset and trigger an update.
00342                 DEBUG_PRINT(" expire and reset\n");
00343                 if (u16DivCycles)

```



```

00344         {
00345             ul6DivRemain = ul6DivCycles;
00346             bUpdateTimer = true;
00347         }
00348     }
00349 }
00350     break;
00351 default:
00352     break;
00353 }
00354 }
00355
00356
00357 if (bUpdateTimer)
00358 {
00359     // Handle event flags on timer updates
00360     bool bOVF = false;
00361     bool bCTCA = false;
00362     bool bCTCB = false;
00363     bool bIntr = false;
00364
00365     switch (eWGM)
00366     {
00367     case WGM_NORMAL:
00368     {
00369         DEBUG_PRINT(" Update Normal, TCNT = %d\n", TCNT0_Read());
00370         TCNT0_Increment();
00371         if (TCNT0_Read() == 0)
00372         {
00373             bOVF = true;
00374         }
00375     }
00376     break;
00377     case WGM_CTC_OCR:
00378     {
00379         DEBUG_PRINT(" Update CTC\n");
00380         TCNT0_Increment();
00381         if (TCNT0_Read() == 0)
00382         {
00383             bOVF = true;
00384         }
00385         else
00386         {
00387             if (TCNT0_Read() == OCR0A_Read())
00388             {
00389                 DEBUG_PRINT(" CTC0A Match\n" );
00390                 bCTCA = true;
00391                 TCNT0_Clear();
00392             }
00393         }
00394     }
00395     break;
00396     default:
00397     break;
00398 }
00399
00400 // Set interrupt flags if an appropriate transition has taken place
00401 if (bOVF)
00402 {
00403     DEBUG_PRINT(" TOV0 Set\n" );
00404     stCPU.pstRAM->stRegisters.TIFR0.TOV0 = 1;
00405     bIntr = true;
00406 }
00407 if (bCTCA)
00408 {
00409     DEBUG_PRINT(" OCF0A Set\n" );
00410     stCPU.pstRAM->stRegisters.TIFR0.OCF0A = 1;
00411     bIntr = true;
00412 }
00413 if (bCTCB)
00414 {
00415     DEBUG_PRINT(" OCF0B Set\n" );
00416     stCPU.pstRAM->stRegisters.TIFR0.OCF0B = 1;
00417     bIntr = true;
00418 }
00419 if (bIntr)
00420 {
00421     Timer8_IntFlagUpdate();
00422 }
00423 }
00424 }
00425 }
00426
00427 //-----
00428 AVRPeripheral stTimer8 =
00429 {
00430     Timer8_Init,
00431     Timer8_Read,

```

```

00432     Timer8_Write,
00433     Timer8_Clock,
00434     0,
00435     0x44,
00436     0x48
00437 };
00438
00439
00440 //-----
00441 AVRPeripheral stTimer8a =
00442 {
00443     0,
00444     Timer8_Read,
00445     Timer8b_Write,
00446     0,
00447     0,
00448     0x35,
00449     0x35
00450 };
00451
00452 //-----
00453 AVRPeripheral stTimer8b =
00454 {
00455     0,
00456     Timer8_Read,
00457     Timer8b_Write,
00458     0,
00459     0,
00460     0x6E,
00461     0x6E
00462 };

```

4.149 src/peripheral/mega_timer8.h File Reference

ATMega 8-bit timer implementation.

```
#include "avr_peripheral.h"
```

Variables

- AVRPeripheral stTimer8
- AVRPeripheral stTimer8a
- AVRPeripheral stTimer8b

4.149.1 Detailed Description

ATMega 8-bit timer implementation.

Definition in file [mega_timer8.h](#).

4.150 mega_timer8.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ ) )\ )      (      )\ ) |
00004 *      ((/( ((/(      \      ( ((/( | -- [ Funkenstein ] -----
00005 *      /( ) )/( )((( )\ )\ /( ) | -- [ Little ] -----
00006 *      ( )_ ( )      )\ _ )\ ( ) ( ) | -- [ AVR ] -----
00007 *      | | _ | |      ( )\ ( )\ \ / | _ \ | -- [ Virtual ] -----
00008 *      | _ | | _ / _ \ \ / | _ \ | -- [ Runtime ] -----
00009 *      | _ | | _ / _ \ \ / | _ \ |
00010 *      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __MEGA_TIMER8_H__
00022 #define __MEGA_TIMER8_H__
00023

```

```

00024 #include "avr_peripheral.h"
00025
00026 extern AVRPeripheral stTimer8;
00027 extern AVRPeripheral stTimer8a;
00028 extern AVRPeripheral stTimer8b;
00029
00030 #endif //__MEGA_EINT_H__

```

4.151 src/peripheral/mega_uart.c File Reference

Implements an atmega UART plugin.

```

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "avr_cpu.h"
#include "avr_peripheral.h"
#include "avr_periphregs.h"
#include "avr_interrupt.h"

```

Macros

- #define **DEBUG_PRINT**(...)

Plugin must interface with the following registers:

Functions

- static void **Echo_Tx** ()
- static void **Echo_Rx** ()
- static bool **UART_IsRxEnabled** (void)
- static bool **UART_IsTxEnabled** (void)
- static bool **UART_IsTxIntEnabled** (void)
- static bool **UART_IsDREIntEnabled** (void)
- static bool **UART_IsRxIntEnabled** (void)
- static bool **UART_IsDoubleSpeed** ()
- static void **UART_SetDoubleSpeed** ()
- static void **UART_SetEmpty** (void)
- static void **UART_ClearEmpty** (void)
- static bool **UART_IsEmpty** (void)
- static bool **UART_IsTxComplete** (void)
- static void **UART_TxComplete** (void)
- static bool **UART_IsRxComplete** (void)
- static void **UART_RxComplete** (void)
- static void **TXC0_Callback** (uint8_t ucVector_)
- static void **UART_Init** (void *context_)
- static void **UART_Read** (void *context_, uint8_t ucAddr_, uint8_t *pucValue_)
- static void **UART_WriteBaudReg** ()
- static void **UART_WriteDataReg** ()
- static void **UART_WriteUCSR0A** (uint8_t u8Value_)
- static void **UART_UpdateInterruptFlags** (void)
- static void **UART_WriteUCSR0B** (uint8_t u8Value_)
- static void **UART_WriteUCSR0C** (uint8_t u8Value_)
- static void **UART_Write** (void *context_, uint8_t ucAddr_, uint8_t ucValue_)
- static void **UART_TxClock** (void *context_)
- static void **UART_RxClock** (void *context_)
- static void **UART_Clock** (void *context_)

Variables

- static bool **bUDR_Empty** = true
- static bool **bTSR_Empty** = true
- static uint8_t **RXB** = 0
- static uint8_t **TXB** = 0
- static uint8_t **TSR** = 0
- static uint8_t **RSR** = 0
- static uint32_t **u32BaudTicks** = 0
- static uint32_t **u32TxTicksRemaining** = 0
- static uint32_t **u32RxTicksRemaining** = 0
- [AVRPeripheral](#) **stUART**

4.151.1 Detailed Description

Implements an atmega UART plugin.

Definition in file [mega_uart.c](#).

4.151.2 Macro Definition Documentation

4.151.2.1 #define DEBUG_PRINT(...)

Plugin must interface with the following registers:

UDRn UCSRnA UCSRnB UCSRnC UBRRnL UBRRnH

Definition at line 42 of file [mega_uart.c](#).

4.151.3 Variable Documentation

4.151.3.1 AVRPeripheral stUART

Initial value:

```
=
{
    UART_Init,
    UART_Read,
    UART_Write,
    UART_Clock,
    0,
    0xC0,
    0xC6
}
```

Definition at line 436 of file [mega_uart.c](#).

4.152 mega_uart.c

```
00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ((/( ((/(      \      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /( )  /( )  ((( ( )\      )\      | -- [ Little ] -----
00006 *      ( ) _ ( )      ) _ )  ( ( ( ) ( )      | -- [ AVR ] -----
00007 *      | _ | |      ( ) _ ( ) \ \ / | _ \      | -- [ Virtual ] -----
00008 *      | _ | |      / _ \ \ \ / | _ \      | -- [ Runtime ] -----
00009 *      | _ | |      / _ \ \ \ / | _ \      |
00010 *      | _ | |      / _ \ \ \ / | _ \      | "Yeah, it does Arduino..."
00011 * -----+-----
```

```

00012  * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013  *      See license.txt for details
00014  *****/
00033 #include <stdio.h>
00034 #include <stdlib.h>
00035 #include <string.h>
00036 #include "avr_cpu.h"
00037 #include "avr_peripheral.h"
00038 #include "avr_periphregs.h"
00039 #include "avr_interrupt.h"
00040
00041 #if 1
00042 #define DEBUG_PRINT(...)
00043 #else
00044 #define DEBUG_PRINT printf
00045 #endif
00046
00047 //-----
00048 static bool bUDR_Empty = true;
00049 static bool bTSR_Empty = true;
00050
00051 static uint8_t RXB = 0; // receive buffer
00052 static uint8_t TXB = 0; // transmit buffer
00053 static uint8_t TSR = 0; // transmit shift register.
00054 static uint8_t RSR = 0; // receive shift register.
00055
00056 static uint32_t u32BaudTicks = 0;
00057 static uint32_t u32TxTicksRemaining = 0;
00058 static uint32_t u32RxTicksRemaining = 0;
00059
00060 //-----
00061 static void Echo_Tx()
00062 {
00063     printf("%c", TSR);
00064 }
00065
00066 //-----
00067 static void Echo_Rx()
00068 {
00069     printf("%c", RSR);
00070 }
00071
00072 //-----
00073 static bool UART_IsRxEnabled( void )
00074 {
00075     //DEBUG_PRINT( "RxEnabled\n");
00076     return (stCPU.pstRAM->stRegisters.UCSR0B.RXEN0 == 1);
00077 }
00078
00079 //-----
00080 static bool UART_IsTxEnabled( void )
00081 {
00082     //DEBUG_PRINT( "TxEnabled\n");
00083     return (stCPU.pstRAM->stRegisters.UCSR0B.TXEN0 == 1);
00084 }
00085
00086 //-----
00087 static bool UART_IsTxIntEnabled( void )
00088 {
00089     return (stCPU.pstRAM->stRegisters.UCSR0B.TXCIE0 == 1);
00090 }
00091
00092 //-----
00093 static bool UART_IsDREIntEnabled( void )
00094 {
00095     return (stCPU.pstRAM->stRegisters.UCSR0B.UDRIE0 == 1);
00096 }
00097
00098 //-----
00099 static bool UART_IsRxIntEnabled( void )
00100 {
00101     return (stCPU.pstRAM->stRegisters.UCSR0B.RXCIE0 == 1);
00102 }
00103
00104 //-----
00105 static bool UART_IsDoubleSpeed()
00106 {
00107     return (stCPU.pstRAM->stRegisters.UCSR0A.U2X0 == 1);
00108 }
00109
00110 //-----
00111 static void UART_SetDoubleSpeed()
00112 {
00113     stCPU.pstRAM->stRegisters.UCSR0A.U2X0 = 1;
00114 }
00115
00116 //-----

```

```

00117 static void UART_SetEmpty( void )
00118 {
00119     stCPU.pstRAM->stRegisters.UCSR0A.UDRE0 = 1;
00120 }
00121
00122 //-----
00123 static void UART_ClearEmpty( void )
00124 {
00125     stCPU.pstRAM->stRegisters.UCSR0A.UDRE0 = 0;
00126 }
00127
00128 //-----
00129 static bool UART_IsEmpty( void )
00130 {
00131     return (stCPU.pstRAM->stRegisters.UCSR0A.UDRE0 == 1);
00132 }
00133
00134 //-----
00135 static bool UART_IsTxComplete( void )
00136 {
00137     return (stCPU.pstRAM->stRegisters.UCSR0A.TXC0 == 1);
00138 }
00139
00140 //-----
00141 static void UART_TxComplete( void )
00142 {
00143     stCPU.pstRAM->stRegisters.UCSR0A.TXC0 = 1;
00144 }
00145
00146 //-----
00147 static bool UART_IsRxComplete( void )
00148 {
00149     return (stCPU.pstRAM->stRegisters.UCSR0A.RXC0 == 1);
00150 }
00151
00152 //-----
00153 static void UART_RxComplete( void )
00154 {
00155     stCPU.pstRAM->stRegisters.UCSR0A.RXC0 = 1;
00156 }
00157
00158 //-----
00159 static void TXC0_Callback( uint8_t ucVector_ )
00160 {
00161     // On TX Complete interrupt, automatically clear the TXC0 flag.
00162     stCPU.pstRAM->stRegisters.UCSR0A.TXC0 = 0;
00163 }
00164
00165 //-----
00166 static void UART_Init(void *context_ )
00167 {
00168     DEBUG_PRINT("UART Init\n");
00169     stCPU.pstRAM->stRegisters.UCSR0A.UDRE0 = 1;
00170
00171     CPU_RegisterInterruptCallback( TXC0_Callback, 0x14); // TX Complete
00172 }
00173
00174 //-----
00175 static void UART_Read(void *context_, uint8_t ucAddr_, uint8_t *pucValue_ )
00176 {
00177     DEBUG_PRINT( "UART Read: 0x%02x == 0x%02X\n", ucAddr_, stCPU.pstRAM->au8RAM[ ucAddr_ ]);
00178     *pucValue_ = stCPU.pstRAM->au8RAM[ ucAddr_ ];
00179     switch (ucAddr_)
00180     {
00181         case 0xC6: // UDR0
00182             stCPU.pstRAM->stRegisters.UCSR0A.RXC0 = 0;
00183             break;
00184         default:
00185             break;
00186     }
00187 }
00188
00189 //-----
00190 static void UART_WriteBaudReg()
00191 {
00192     DEBUG_PRINT( "WriteBaud\n");
00193     uint16_t u16Baud = (uint16_t)(stCPU.pstRAM->stRegisters.UBRR0L) |
00194         ((uint16_t)(stCPU.pstRAM->stRegisters.UBRR0H) << 8);
00195
00196     u32BaudTicks = u16Baud;
00197 }
00198
00199 //-----
00200 static void UART_WriteDataReg()
00201 {
00202     DEBUG_PRINT("UART Write UDR...\n");
00203     if (UART_IsTxEnabled())

```

```

00204     {
00205         DEBUG_PRINT("Enabled...\n");
00206         // Only set the baud timer if the UART is idle
00207         if (!u32TxTicksRemaining)
00208         {
00209             u32TxTicksRemaining = u32BaudTicks;
00210             if (UART_IsDoubleSpeed())
00211             {
00212                 u32TxTicksRemaining >>= 1;
00213             }
00214         }
00215
00216         // If the shift register is empty, load it immediately
00217         if (bTSR_Empty)
00218         {
00219             TSR = stCPU.pstRAM->stRegisters.UDR0;
00220             TXB = 0;
00221             bTSR_Empty = false;
00222             bUDR_Empty = true;
00223             UART_SetEmpty();
00224
00225             if (UART_IsDREIntEnabled())
00226             {
00227                 DEBUG_PRINT("DRE Interrupt\n");
00228                 AVR_InterruptCandidate( 0x13 );
00229             }
00230         }
00231         else
00232         {
00233             TXB = stCPU.pstRAM->stRegisters.UDR0;
00234             bTSR_Empty = false;
00235             bUDR_Empty = false;
00236             UART_ClearEmpty();
00237         }
00238     }
00239     else
00240     {
00241         DEBUG_PRINT("Disabled...\n");
00242     }
00243 }
00244
00245 //-----
00246 static void UART_WriteUCSR0A( uint8_t u8Value_ )
00247 {
00248     DEBUG_PRINT("UART Write UCSR0A...\n");
00249     uint8_t u8Reg = stCPU.pstRAM->stRegisters.UCSR0A.r;
00250     if (u8Value_ & 0x40) // TXC was set explicitly -- clear it in the SR.
00251     {
00252         u8Reg &= ~0x40;
00253     }
00254     u8Reg &= ~(0xBC);
00255
00256     stCPU.pstRAM->stRegisters.UCSR0A.r |= u8Reg;
00257 }
00258
00259 //-----
00260 static void UART_UpdateInterruptFlags(void)
00261 {
00262     //DEBUG_PRINT("Check UART Interrupts\n");
00263     if (UART_IsTxIntEnabled())
00264     {
00265         if (UART_IsTxComplete())
00266         {
00267             DEBUG_PRINT("Enable TXC Interrupt\n");
00268             AVR_InterruptCandidate( 0x14 );
00269         }
00270         else
00271         {
00272             DEBUG_PRINT("Clear TXC Interrupt\n");
00273             AVR_ClearCandidate( 0x14 );
00274         }
00275     }
00276
00277     if (UART_IsDREIntEnabled())
00278     {
00279         if ( UART_IsEmpty() )
00280         {
00281             DEBUG_PRINT("Enable DRE Interrupt\n");
00282             AVR_InterruptCandidate( 0x13 );
00283         }
00284         else
00285         {
00286             DEBUG_PRINT("Clear DRE Interrupt\n");
00287             AVR_ClearCandidate( 0x13 );
00288         }
00289     }
00290     if (UART_IsRxIntEnabled())

```

```

00291     {
00292         if (UART_IsRxComplete())
00293         {
00294             DEBUG_PRINT("Enable RXC Interrupt\n");
00295             AVR_InterruptCandidate( 0x12 );
00296         }
00297         else
00298         {
00299             DEBUG_PRINT("Clear RXC Interrupt\n");
00300             AVR_ClearCandidate( 0x12 );
00301         }
00302     }
00303 }
00304
00305 //-----
00306 static void UART_WriteUCSR0B( uint8_t u8Value_ )
00307 {
00308     DEBUG_PRINT("Write UCSR0B = %02x\n", u8Value_);
00309     stCPU.pstRAM->stRegisters.UCSR0B.r = u8Value_;
00310     UART_UpdateInterruptFlags();
00311 }
00312
00313 //-----
00314 static void UART_WriteUCSR0C( uint8_t u8Value_ )
00315 {
00316     DEBUG_PRINT("Write UCSR0C\n");
00317     stCPU.pstRAM->stRegisters.UCSR0C.r == u8Value_;
00318 }
00319
00320 //-----
00321 static void UART_Write(void *context_, uint8_t ucAddr_, uint8_t ucValue_ )
00322 {
00323     DEBUG_PRINT("UART Write: %2X=%2X\n", ucAddr_, ucValue_ );
00324     switch (ucAddr_)
00325     {
00326     case 0xC0: //UCSR0A
00327         UART_WriteUCSR0A( ucValue_ );
00328         break;
00329     case 0xC1: //UCSR0B
00330         UART_WriteUCSR0B( ucValue_ );
00331         break;
00332     case 0xC2: //UCSR0C
00333         UART_WriteUCSR0C( ucValue_ );
00334         break;
00335     case 0xC3: // NA.
00336         break;
00337     case 0xC4: //UBRR0L
00338     case 0xC5: //UBRR0H
00339         DEBUG_PRINT("Write UBRR0x\n");
00340         stCPU.pstRAM->au8RAM[ ucAddr_ ] = ucValue_;
00341         UART_WriteBaudReg();
00342         break;
00343     case 0xC6: //UDR0
00344         DEBUG_PRINT("Write UDR0\n");
00345         stCPU.pstRAM->au8RAM[ ucAddr_ ] = ucValue_;
00346         UART_WriteDataReg();
00347         break;
00348     default:
00349         break;
00350     }
00351 }
00352
00353 //-----
00354 static void UART_TxClock(void *context_ )
00355 {
00356     //DEBUG_PRINT("TX clock...\n");
00357     if (UART_IsTxEnabled() && u32TxTicksRemaining)
00358     {
00359         DEBUG_PRINT("Countdown %d ticks remain\n", u32TxTicksRemaining);
00360         u32TxTicksRemaining--;
00361         if (!u32TxTicksRemaining)
00362         {
00363             // Local echo of the freshly "shifted out" data to the terminal
00364             Echo_Tx();
00365
00366             // If there's something queued in the TXB, reload the TSR
00367             // register, flag the UDR as empty, and TSR as full.
00368             if (!bUDR_Empty)
00369             {
00370                 TSR = TXB;
00371                 TXB = 0;
00372                 bUDR_Empty = true;
00373                 bTSR_Empty = false;
00374
00375                 UART_SetEmpty();
00376
00377                 if (UART_IsDREIntEnabled())

```



```

00378         {
00379             DEBUG_PRINT("DRE Interrupt\n");
00380             AVR_InterruptCandidate( 0x13 );
00381         }
00382     }
00383     // Nothing pending in the TXB? Flag the TSR as empty, and
00384     // set the "Transmit complete" flag in the register.
00385     else
00386     {
00387         TXB = 0;
00388         TSR = 0;
00389         bTSR_Empty = true;
00390
00391         UART_TxComplete();
00392         if (UART_IsTxIntEnabled())
00393         {
00394             DEBUG_PRINT("TXC Interrupt\n");
00395             AVR_InterruptCandidate( 0x14 );
00396         }
00397     }
00398 }
00399 }
00400 }
00401
00402 //-----
00403 static void UART_RxClock(void *context_ )
00404 {
00405     if (UART_IsRxEnabled() && u32RxTicksRemaining)
00406     {
00407         u32RxTicksRemaining--;
00408         if (!u32RxTicksRemaining)
00409         {
00410             // Local echo of the freshly "shifted in" data to the terminal
00411             Echo_Rx();
00412
00413             // Move data from receive shift register into the receive buffer
00414             RXB = RSR;
00415             RSR = 0;
00416
00417             // Set the RX Complete flag
00418             UART_RxComplete();
00419             if (UART_IsRxIntEnabled())
00420             {
00421                 DEBUG_PRINT("RXC Interrupt\n");
00422                 AVR_InterruptCandidate( 0x12 );
00423             }
00424         }
00425     }
00426 }
00427 //-----
00428 static void UART_Clock(void *context_ )
00429 {
00430     // Handle Rx and TX clocks.
00431     UART_TxClock(context_);
00432     UART_RxClock(context_);
00433 }
00434
00435 //-----
00436 AVRPeripheral stUART =
00437 {
00438     UART_Init,
00439     UART_Read,
00440     UART_Write,
00441     UART_Clock,
00442     0,
00443     0xC0,
00444     0xC6
00445 };

```

4.153 src/peripheral/mega_uart.h File Reference

ATMega UART implementation.

```
#include "avr_peripheral.h"
```

Variables

- [AVRPeripheral stUART](#)

4.153.1 Detailed Description

ATMega UART implementation.

Definition in file [mega_uart.h](#).

4.154 mega_uart.h

```

00001 /*****
00002 *      (      (      (      |
00003 *      )\ )  )\ )      (      )\ )  |
00004 *      ((/( ((/(      \      ( ((/(      | -- [ Funkenstein ] -----
00005 *      /(_ ) /(_ ) ((((_ )\ )\ /(_ )      | -- [ Little ] -----
00006 *      (_)_| (_ )      )\ _ )\ (( _ ) (_ )      | -- [ AVR ] -----
00007 *      | | _ | |      ( _ \ ( _ \ \ / / | _ \      | -- [ Virtual ] -----
00008 *      | _ | | _      / _ \      \ V / | _ /      | -- [ Runtime ] -----
00009 *      | _ | | _      / _ \      \ / | _ \      |
00010 *      | _ | | _      / _ \      \ / | _ \      | "Yeah, it does Arduino..."
00011 * -----+-----
00012 * (c) Copyright 2014-15, Funkenstein Software Consulting, All rights reserved
00013 * See license.txt for details
00014 *****/
00021 #ifndef __MEGA_UART_H__
00022 #define __MEGA_UART_H__
00023
00024 #include "avr_peripheral.h"
00025
00026 extern AVRPeripheral stUART;
00027
00028 #endif //__MEGA_UART_H__

```