Micriµm

Empowering Embedded Systems

µC/LIB

V1.24

User's Manual

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Manual versions

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Table Of Contents

	Introduction	6
I.1	Portable	6
I.2	Configurable	6
I.3	Coding Standards	6
I.4	MISRA C	6
I.5	Safety Critical Certification	7
I.6	µC/LIB Limitations	7
	Getting Started with µC/LIB	8
1.00	Installing µC/LIB	8
	µC/LIB Constant and Macro Library	11
2.00.01	Boolean Constants	11
2.00.02	Bit Constants	11
2.00.03	Octet Constants	11
2.00.04	Integer Constants	11
2.00.05	Time Constants	12
2.10	Macros	13
2.10.01.01	DEF_BIT()	13
2.10.01.02	DEF_BIT_MASK()	14
2.10.01.03	DEF_BIT_FIELD()	15
2.10.01.04	DEF_BIT_SET()	16
2.10.01.05	DEF_BIT_CLR()	17
2.10.01.06	DEF_BIT_IS_SET()	18
2.10.01.07	DEF_BIT_IS_CLR()	19
2.10.01.08	DEF_BIT_IS_SET_ANY()	20
2.10.01.09	DEF_BIT_IS_CLR_ANY()	21
2.10.02.01	DEF_MIN()	22
2.10.02.02	DEF_MAX()	23
2.10.02.03	DEF_ABS()	24

µC/LIB Memory Library 25
3.00 µC/LIB Memory Library Configuration 25
3.10.01 MEM_VAL_GET_xxx() 26
3.10.02 MEM_VAL_SET_xxx() 28
3.10.03 MEM_VAL_COPY_GET_xxx() 30
3.10.04 MEM_VAL_COPY_SET_xxx() 32
3.10.05 MEM_VAL_COPY_xxx() 34
3.20.01 Mem_Clr() 35
3.20.02 Mem_Set() 36
3.20.03 Mem_Copy() 37
3.20.04 Mem_Cmp() 38
3.30 µC/LIB Memory Library Optimization 39
3.30.01 Mem_Copy() Optimization 39

µC/LIB String Library 40
4.00 µC/LIB String Library Configuration 40
4.10.01 Str_Len() 41
4.10.02.01 Str_Copy() 42
4.10.02.02 Str_Copy_N() 43
4.10.03.01 Str_Cat() 44
4.10.03.02 Str_Cat_N() 45
4.10.04.01 Str_Cmp() 46
4.10.04.02 Str_Cmp_N() 47
4.10.05.01 Str_Char() 48
4.10.05.02 Str_Char_N() 49
4.10.05.03 Str_Char_Last() 50
4.10.06 Str_Str() 51
4.10.07 Str_FmtNbr_32() 52

A µC/LIB Licensing Policy 54

Introduction

Designed with Micrium's renowned quality, scalability and reliability, the purpose of µC/LIB is to provide a clean, organized ANSI C implementation of the most common standard library functions, macros, and constants.

I.1 Portable

µC/LIB was designed for the vast variety of embedded applications. The source code for µC/LIB is designed to be independent of and used with any processor (CPU) and compiler.

I.2 Configurable

The memory footprint of µC/LIB can be adjusted at compile time based on the features you need and the desired level of run-time performance.

I.3 Coding Standards

Coding standards have been established early in the design of µC/LIB and include the following:

- C coding style
- Naming convention for `#define` constants, macros, variables and functions
- Commenting
- Directory structure

I.4 MISRA C

The source code for µC/LIB follows the Motor Industry Software Reliability Association (MISRA) C Coding Standards. These standards were created by MISRA to improve the reliability and predictability of C programs in critical automotive systems. Members of the MISRA consortium include Delco Electronics, Ford Motor Company, Jaguar Cars Ltd., Lotus Engineering, Lucas Electronics, Rolls-Royce, Rover Group Ltd., and other firms and universities dedicated to improving safety and reliability in automotive electronics. Full details of this standard can be obtained directly from the MISRA web site, **http://www.misra.org.uk**.

I.5 Safety Critical Certification

µC/LIB has been designed and implemented with safety critical certification in mind. µC/LIB is intended for use in any high-reliability, safety-critical systems including avionics RTCA DO-178B and EUROCAE ED-12B, medical FDA 510(k), and IEC 61058 transportation and nuclear systems.

For example, the FAA (Federal Aviation Administration) requires that ALL the source code for an application be available in source form and conforming to specific software standards in order to be certified for avionics systems. Since most standard library functions are provided by compiler vendors in uncertifiable binary format, µC/LIB provides its library functions in certifiable source-code format.

If your product is NOT safety critical, you should view the software and safety-critical standards as proof that µC/LIB is a very robust and highly-reliable software module.

I.6 µC/LIB Limitations

By design, we have limited some of the feature of µC/LIB. Table I-1 describes those limitations.

Does not support variable argument library functions

Table I-1, µC/LIB limitations for current software version

Chapter 1

Getting Started with µC/LIB

This chapter provides information on the distribution and installation of µC/LIB.

1.00 Installing µC/LIB

The distribution of µC/LIB is typically included in a ZIP file called: `uC-LIB-Vxyy.zip`. µC/LIB could also have been included in the distribution of another Micrium ZIP file (µC/OS-II, µC/TCP-IP, µC/FS). The ZIP file contains all the source code and documentation for µC/LIB as well as all other required software modules. All modules are placed in their respective directories as shown in Figure 1-1.

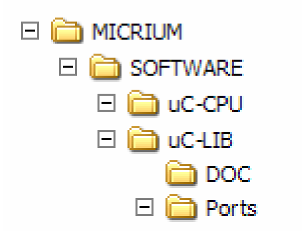


Figure 1-1, µC/LIB Module Directories

`\uC-CPU` This directory contains CPU-specific code which depends on the processor and compiler used. The directory contains additional sub-directories specific for each processor/compiler combination organized as follows :

```
\MICRIUM\SOFTWARE\uC-CPU\<CPU Type>\<Compiler>
```

The µC/CPU directory contains one master CPU file :

```
\MICRIUM\SOFTWARE\uC-CPU\cpu_def.h
```

`cpu_def.h`
This file declares `#define` constants for CPU word sizes, endianess, critical section methods, and other processor configuration.

Each sub-directory contains source files specific for each processor/compiler combination :

```
\MICRIUM\SOFTWARE\uC-CPU\<CPU Type>\<Compiler>\cpu.h
\MICRIUM\SOFTWARE\uC-CPU\<CPU Type>\<Compiler>\cpu_a.asm
```

`cpu.h`
This file contains configuration specific to the processor, such as data type definitions, processor address and data word sizes, endianess, and critical section implementation. The data type definitions are declared so as to be independent of processor and compiler word sizes.

`cpu_a.asm`
This file contains assembly code to enable/disable interrupts, implement critical section methods, and any other code specific to the processor.

`\uC-LIB` This directory contains the µC/LIB library source files common to many Micrium products and is shown in Figure 1-2.

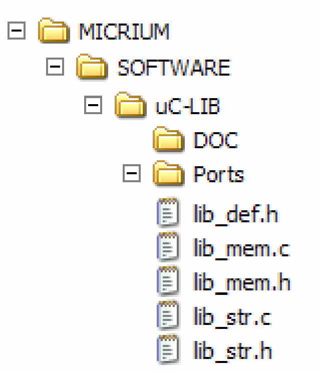


Figure 1-2, µC/LIB Library Files

`lib_def.h`
This file declares `#define` constants for many common values such as `TRUE/FALSE`, `YES/NO`, `ENABLED/DISABLED`, as well as for integer, octet, and bit values. This file also contains macros for common mathematical operations like `min()/max()`, `abs()`, `bit_set()/bit_clr()`. See Chapter 2 for more details.

`lib_mem.c` and **`lib_mem.h`**
These files contain source code to replace standard library functions `memclr()`, `memset()`, `memcpy()`, `memcmp()`, etc. These functions are replaced with `Mem_Clr()`, `Mem_Set()`, `Mem_Copy()`, and `Mem_Cmp()`, respectively. See Chapter 3 for more details.

`lib_str.c` and **`lib_str.h`**
These files contain source code to replace standard library functions `strlen()`, `strcpy()`, `strcmp()`, etc. These functions are replaced with `Str_Len()`, `Str_Copy()`, and `Str_Cmp()`, respectively. See Chapter 4 for more details.

\Application

This directory represents the application's directory or directory tree. Application files which intend to make use of µC/LIB constants, macros, or functions should #include the desired µC/LIB header files.

app_cfg.h

This application-specific configuration file declares `#define` constants used to configure Micrium products and/or non-Micrium-related application files. This file is required by µC/LIB to `#define` its configuration constants.

Chapter 2

µC/LIB Constant and Macro Library

µC/LIB contains many standard constants and macros. Common constants include Boolean, bit-mask, and integer values; common macros include minimum, maximum, and absolute value operations. All µC/LIB constants and macros are prefixed with `DEF_` to provide a consistent naming convention and to avoid namespace conflicts with other constants and macros in your application. These constants and macros are defined in `lib_def.h`.

2.00.01 Boolean Constants

µC/LIB contains many Boolean constants such as `DEF_TRUE/DEF_FALSE`, `DEF_YES/DEF_NO`, `DEF_ON/DEF_OFF`, and `DEF_ENABLED/DEF_DISABLED`. These constants should be used to configure, assign, and test Boolean values or variables.

2.00.02 Bit Constants

µC/LIB contains bit constants such as `DEF_BIT_00`, `DEF_BIT_07`, and `DEF_BIT_15`, which define values corresponding to specific bit positions. Currently, µC/LIB supports bit constants up to 32-bits (`DEF_BIT_31`). These constants should be used to configure, assign, and test appropriately-sized bit-field or integer values or variables.

2.00.03 Octet Constants

µC/LIB contains octet constants such as `DEF_OCTET_NBR_BITS` and `DEF_OCTET_MASK` which define octet or octet-related values. These constants should be used to configure, assign, and test appropriately-sized, octet-related integer values or variables.

2.00.04 Integer Constants

µC/LIB contains octet constants such as `DEF_INT_08_MASK`, `DEF_INT_16U_MAX_VAL`, and `DEF_INT_32S_MIN_VAL` which define integer-related values. These constants should be used to configure, assign, and test appropriately-sized, octet-related integer values or variables.

2.00.05 Time Constants

µC/LIB contains time constants such as `DEF_TIME_NBR_HR_PER_DAY`, `DEF_TIME_NBR_SEC_PER_MIN`, and `DEF_TIME_NBR_mS_PER_SEC` which define time or time-related values. These constants should be used to configure, assign, and test time-related values or variables.

2.10 Macros

µC/LIB contains many common bit and arithmetic macros. Bit macros modify or test values based on bit masks. Arithmetic macros perform simple mathematical operations or tests.

2.10.01.01 DEF_BIT()

This macro is called to create a bit mask based on a single bit-number position.

Prototype

`DEF_BIT``(bit)`

Arguments

`bit`	This is the bit number of the bit mask to set.

Returned Value

Bit mask with the single `bit` number position set.

Notes / Warnings

1) `bit` values that overflow the target CPU &/or compiler environment (e.g. negative or greater-than-CPU-data-size values) MAY generate compiler warnings &/or errors.

Example

```
void AppFnct (void)
{
    CPU_INT16U  mask;
    :
    :
    mask = DEF_BIT(12);
    :
    :
}
```

2.10.01.02 DEF_BIT_MASK()

This macro is called to shift a bit mask.

Prototype

`DEF_BIT_MASK``(bit_mask, bit_shift)`

Arguments

`bit_mask`	This is the bit mask to shift.
`bit_shift`	This is the number of bit positions to left-shift the bit mask.

Returned Value

`bit_mask` left-shifted by `bit_shift` number of bits.

Notes / Warnings

1) `bit_shift` values that overflow the target CPU &/or compiler environment (e.g. negative or greater-than-CPU-data-size values) MAY generate compiler warnings &/or errors.

Example

```
void AppFnct (void)
{
    CPU_INT16U  mask;
    CPU_INT16U  mask_hi;
    :
    :
    mask    = 0x0064;
    mask_hi = DEF_BIT_MASK(mask, 8);
    :
    :
}
```

2.10.01.03 DEF_BIT_FIELD()

This macro is called to create a contiguous, multi-bit bit field.

Prototype

`DEF_BIT_FIELD``(bit_field, bit_shift)`

Arguments

`bit_field`	This is the number of contiguous bits to set in the bit field.
`bit_shift`	This is the number of bit positions to left-shift the bit field.

Returned Value

Contiguous bit field of `bit_field` number of bits left-shifted by `bit_shift` number of bits.

Notes / Warnings

1) `bit_field/bit_shift` values that overflow the target CPU &/or compiler environment (e.g. negative or greater-than-CPU-data-size values) MAY generate compiler warnings &/or errors.

Example

```
void AppFnct (void)
{
    CPU_INT08U  upper_nibble;
    :
    :
    upper_nibble = DEF_BIT_FIELD(4, 4);
    :
    :
}
```

2.10.01.04 DEF_BIT_SET()

This macro is called to set the appropriate bits in a value according to a specified bit mask.

Prototype

`DEF_BIT_SET``(val, mask)`

Arguments

`val`	This is the value to modify by setting the specified bits.
`mask`	This is the mask of bits to set in the value.

Returned Value

Modified value with specified bits set.

Notes / Warnings

None

Example

```
void AppFnct (void)
{
    CPU_INT16U  flags;
    CPU_INT16U  flags_alarm;
    :
    :
    flags       = 0x0000;
    flags_alarm = DEF_BIT_00 | DEF_BIT_03;
    DEF_BIT_SET(flags, flags_alarm);
    :
    :
}
```

2.10.01.05 DEF_BIT_CLR()

This macro is called to clear the appropriate bits in a value according to a specified bit mask.

Prototype

`DEF_BIT_CLR``(val, mask)`

Arguments

`val`	This is the value to modify by clearing the specified bits.
`mask`	This is the mask of bits to clear in the value.

Returned Value

Modified value with specified bits clear.

Notes / Warnings

None

Example

```
void AppFnct (void)
{
    CPU_INT16U  flags;
    CPU_INT16U  flags_alarm;
    :
    :
    flags       = 0x0FFF;
    flags_alarm = DEF_BIT_00 | DEF_BIT_03;
    DEF_BIT_CLR(flags, flags_alarm);
    :
    :
}
```

2.10.01.06 DEF_BIT_IS_SET()

This macro is called to determine if all the specified bits in a value are set according to a specified bit mask.

Prototype

`DEF_BIT_IS_SET``(val, mask)`

Arguments

`val`	This is the value to test if the specified bits are set.
`mask`	This is the mask of bits to check if set in the value.

Returned Value

`DEF_YES`, if ALL the bits in the bit `mask` are set in `val`.

`DEF_NO`, if ALL the bits in the bit `mask` are NOT set in `val`.

Notes / Warnings

None

Example

```
void AppFnct (void)
{
    CPU_INT16U   flags;
    CPU_INT16U   flags_mask;
    CPU_BOOLEAN  flags_set;
    :
    :
    flags      = 0x0369;
    flags_mask = DEF_BIT_08 | DEF_BIT_09;
    flags_set  = DEF_BIT_IS_SET(flags, flags_mask);
    :
    :
}
```

2.10.01.07 DEF_BIT_IS_CLR()

This macro is called to determine if all the specified bits in a value are clear according to a specified bit mask.

Prototype

`DEF_BIT_IS_CLR``(val, mask)`

Arguments

`val`	This is the value to test if the specified bits are clear.
`mask`	This is the mask of bits to check if clear in the value.

Returned Value

`DEF_YES`, if ALL the bits in the bit `mask` are clear in `val`.

`DEF_NO`, if ALL the bits in the bit `mask` are NOT clear in `val`.

Notes / Warnings

None

Example

```
void AppFnct (void)
{
    CPU_INT16U   alarms;
    CPU_INT16U   alarms_mask;
    CPU_BOOLEAN  alarms_clr;
    :
    :
    alarms      = 0x07F0;
    alarms_mask = DEF_BIT_04 | DEF_BIT_03;
    alarms_clr  = DEF_BIT_IS_CLR(alarms, alarms_mask);
    :
    :
}
```

2.10.01.08 DEF_BIT_IS_SET_ANY()

This macro is called to determine if any of the specified bits in a value are set according to a specified bit mask.

Prototype

DEF_BIT_IS_SET_ANY(val, mask)

Arguments

val	This is the value to test if any of the specified bits are set.
mask	This is the mask of bits to check if set in the value.

Returned Value

DEF_YES, if ANY of the bits in the bit mask are set in val.

DEF_NO, if ALL the bits in the bit mask are NOT set in val.

Notes / Warnings

None

Example

```
void AppFnct (void)
{
    CPU_INT16U   flags;
    CPU_INT16U   flags_mask;
    CPU_BOOLEAN  flags_set;
    :
    :
    flags      = 0x0369;
    flags_mask = DEF_BIT_08 | DEF_BIT_09;
    flags_set  = DEF_BIT_IS_SET_ANY(flags, flag_mask);
    :
    :
}
```

2.10.01.09 DEF_BIT_IS_CLR_ANY()

This macro is called to determine if any of the specified bits in a value are clear according to a specified bit mask.

Prototype

DEF_BIT_IS_CLR_ANY(val, mask)

Arguments

val	This is the value to test if any of the specified bits are clear.
mask	This is the mask of bits to check if clear in the value.

Returned Value

DEF_YES,	if ANY of the bits in the bit mask are clear in val.
DEF_NO,	if ALL the bits in the bit mask are NOT clear in val.

Notes / Warnings

None

Example

```
void AppFnct (void)
{
    CPU_INT16U   alarms;
    CPU_INT16U   alarms_mask;
    CPU_BOOLEAN  alarms_clr;
    :
    :
    alarms      = 0x07F0;
    alarms_mask = DEF_BIT_04 | DEF_BIT_03;
    alarms_clr  = DEF_BIT_IS_CLR_ANY(alarms, alarms_mask);
    :
    :
}
```

2.10.02.01 DEF_MIN()

This macro is called to determine the minimum of two values.

Prototype

DEF_MIN(a, b)

Arguments

a	First value in minimum comparison.
b	Second value in minimum comparison.

Returned Value

The lesser of the two values, a or b.

Notes / Warnings

None

Example

```
void AppFnct (void)
{
    CPU_INT16S  x;
    CPU_INT16S  y;
    CPU_INT16S  z;
    :
    :
    x =  100;
    y = -101;
    z =  DEF_MIN(x, y);
    :
    :
}
```

2.10.02.02 DEF_MAX()

This macro is called to determine the maximum of two values.

Prototype

DEF_MAX(a, b)

Arguments

a	First value in maximum comparison.
b	Second value in maximum comparison.

Returned Value

The greater of the two values, a or b.

Notes / Warnings

None

Example

```
void AppFnct (void)
{
    CPU_INT16S  x;
    CPU_INT16S  y;
    CPU_INT16S  z;
    :
    :
    x =  100;
    y = -101;
    z =  DEF_MAX(x, y);
    :
    :
}
```

2.10.02.03 DEF_ABS()

This macro is called to determine the absolute value of a value.

Prototype

DEF_ABS(a)

Arguments

a	Value to calculate absolute value.

Returned Value

The absolute value of a.

Notes / Warnings

None

Example

```
void AppFnct (void)
{
    CPU_INT16S  y;
    CPU_INT16S  z;
    :
    :
    y = -101;
    z =  DEF_ABS(y);
    :
    :
}
```

Chapter 3

µC/LIB Memory Library

µC/LIB contains library functions that replace standard library memory functions such as `memclr()`, `memset()`, `memcpy()`, `memcmp()`, etc. These functions are defined in `lib_mem.c`.

3.00 µC/LIB Memory Library Configuration

The following µC/LIB memory library configuration may be optionally configured in `app_cfg.h` :

`uC_CFG_OPTIMIZE_ASM_EN`	Implement certain functionality in assembly-optimized files (see Section 3.30).

3.10.01 MEM_VAL_GET_xxx()

These macro's are called to decode data values from any CPU memory address.

Prototype

```
MEM_VAL_GET_xxx(addr)
```

Arguments

`addr`	This is the lowest CPU memory address of the data value to decode.

Returned Value

Decoded data value from CPU memory address.

Notes / Warnings

1) Decode data values based on the values' data-word order in CPU memory :

`MEM_VAL_GET_xxx_BIG()`	Decode big- endian data values -- data words' most significant octet @ lowest memory address
`MEM_VAL_GET_xxx_LITTLE()`	Decode little-endian data values -- data words' least significant octet @ lowest memory address
`MEM_VAL_GET_xxx()`	Decode data values using CPU's native or configured data-word order

2) CPU memory addresses/pointers NOT checked for NULL.

3) a) **`MEM_VAL_GET_xxx()`** macro's decode data values without regard to CPU word-aligned addresses. Thus for processors that require data word alignment, data words can be decoded from any CPU address, word-aligned or not, without generating data-word-alignment exceptions/faults.

   b) However, any variable to receive the returned data value MUST start on an appropriate CPU word-aligned address.

4) **`MEM_VAL_COPY_GET_xxx()`** macro's are more efficient than **`MEM_VAL_GET_xxx()`** macro's & are also independent of CPU data-word-alignment & SHOULD be used whenever possible.

   See also Section 3.10.03 Note #4.

Example

```
void AppFnct (void)
{
    CPU_INT08U  *pval;
    CPU_INT16U   val;
    :
    :
    pval = &SomeAddr;                      /* Any CPU Address */
     val =  MEM_VAL_GET_INT16U(pval);
    :
    :
}
```

3.10.02 MEM_VAL_SET_xxx()

These macro's are called to encode data values to any CPU memory address.

Prototype

`MEM_VAL_SET_xxx(addr, val)`

Arguments

`addr`	This is the lowest CPU memory address to encode the data value.
`val`	This is the data value to encode.

Returned Value

None

Notes / Warnings

1) Encode data values based on the values' data-word order in CPU memory :

`MEM_VAL_SET_xxx_BIG()`	Encode big- endian data values -- data words' most significant octet @ lowest memory address
`MEM_VAL_SET_xxx_LITTLE()`	Encode little-endian data values -- data words' least significant octet @ lowest memory address
`MEM_VAL_SET_xxx()`	Encode data values using CPU's native or configured data-word order

2) CPU memory addresses/pointers NOT checked for NULL.

3) a) **`MEM_VAL_SET_xxx()`** macro's encode data values without regard to CPU word-aligned addresses. Thus for processors that require data word alignment, data words can be encoded to any CPU address, word-aligned or not, without generating data-word-alignment exceptions/faults.

   b) However, `val` data value to encode MUST start on appropriate CPU word-aligned address.

4) **`MEM_VAL_COPY_SET_xxx()`** macro's are more efficient than **`MEM_VAL_SET_xxx()`** macro's & are also independent of CPU data-word-alignment & SHOULD be used whenever possible.

   See also Section 3.10.04 Note #4.

Example

```
void AppFnct (void)
{
    CPU_INT08U  *pval;
    CPU_INT16U   val;
    :
    :
    pval = &SomeAddr;                      /* Any CPU Address */
     val =  0xABCD;
    MEM_VAL_SET_INT16U(pval, val);
    :
    :
}
```

3.10.03 MEM_VAL_COPY_GET_xxx()

These macro’s are called to copy & decode data values from any CPU memory address to any other memory address.

Prototype

```
MEM_VAL_COPY_GET_xxx(addr_dest, addr_src)
```

Arguments

`addr_dest`	This is the lowest CPU memory address to copy/decode source address’s data value.
`addr_src`	This is the lowest CPU memory address of the data value to copy/decode.

Returned Value

None

Notes / Warnings

1) Copy/decode data values based on the values' data-word order in CPU memory :

`MEM_VAL_COPY_GET_xxx_BIG``()`	Decode big- endian data values -- data words' most significant octet @ lowest memory address
`MEM_VAL_COPY_GET_xxx_LITTLE``()`	Decode little-endian data values -- data words' least significant octet @ lowest memory address
`MEM_VAL_COPY_GET_xxx``()`	Decode data values using CPU's native or configured data-word order

2) CPU memory addresses/pointers NOT checked for NULL.

3) **`MEM_VAL_COPY_GET_xxx`**`()` macro's copy/decode data values without regard to CPU word-aligned addresses. Thus for processors that require data word alignment, data words can be copied/decoded to/from any CPU addresses, word-aligned or not, without generating data-word-alignment exceptions/faults.

4) **`MEM_VAL_COPY_GET_xxx`**`()` macro's are more efficient than **`MEM_VAL_GET_xxx`**`()` macro's & are also independent of CPU data-word-alignment & SHOULD be used whenever possible.

Example

```
void AppFnct (void)
{
    CPU_INT08U  *pmem;
    CPU_INT08U  *pval;
    :
    :
    pmem = &SomeAddr;                       /* Any CPU Address */
    pval = &SomeVal;                        /* Any CPU Address */
    MEM_VAL_COPY_GET_INT16U(pmem, pval);
    :
    :
}
```

3.10.04 MEM_VAL_COPY_SET_xxx()

These macro’s are called to copy & encode data values from any CPU memory address to any other memory address.

Prototype

```
MEM_VAL_COPY_SET_xxx(addr_dest, addr_src)
```

Arguments

`addr_dest`	This is the lowest CPU memory address to copy/encode source address’s data value.
`addr_src`	This is the lowest CPU memory address of the data value to copy/encode.

Returned Value

None

Notes / Warnings

1) Copy/encode data values based on the values' data-word order in CPU memory :

`MEM_VAL_COPY_SET_xxx_BIG``()`	Encode big- endian data values -- data words' most significant octet @ lowest memory address
`MEM_VAL_COPY_SET_xxx_LITTLE``()`	Encode little-endian data values -- data words' least significant octet @ lowest memory address
`MEM_VAL_COPY_SET_xxx``()`	Encode data values using CPU's native or configured data-word order

2) CPU memory addresses/pointers NOT checked for NULL.

3) **`MEM_VAL_COPY_SET_xxx`**`()` macro's copy/encode data values without regard to CPU word-aligned addresses. Thus for processors that require data word alignment, data words can be copied/encoded to/from any CPU addresses, word-aligned or not, without generating data-word-alignment exceptions/faults.

4) **`MEM_VAL_COPY_SET_xxx`**`()` macro's are more efficient than **`MEM_VAL_SET_xxx`**`()` macro's & are also independent of CPU data-word-alignment & SHOULD be used whenever possible.

Example

```
void AppFnct (void)
{
    CPU_INT08U  *pmem;
    CPU_INT08U  *pval;
    :
    :
    pmem = &SomeAddr;                        /* Any CPU Address */
    pval = &SomeVal;                         /* Any CPU Address */
    MEM_VAL_COPY_SET_INT16U(pmem, pval);
    :
    :
}
```

3.10.05 MEM_VAL_COPY_xxx()

These macro's are called to copy data values from any CPU memory address to any other memory address.

Prototype

`MEM_VAL_COPY_xxx``(addr_dest, addr_src)`

Arguments

`addr_dest`	This is the lowest CPU memory address to copy source address's data value.
`addr_src`	This is the lowest CPU memory address of the data value to copy.

Returned Value

None

Notes / Warnings

2) **`MEM_VAL_COPY_xxx`**`()` macro's copy data values based on CPU's native data-word order.

3) CPU memory addresses/pointers NOT checked for NULL.

4) **`MEM_VAL_COPY_xxx`**`()` macro's copy data values without regard to CPU word-aligned addresses. Thus for processors that require data word alignment, data words can be copied to/from any CPU addresses, word-aligned or not, without generating data-word-alignment exceptions/faults.

Example

```
void AppFnct (void)
{
    CPU_INT08U  *pmem;
    CPU_INT08U  *pval;
    :
    :
    pmem = &SomeAddr;                       /* Any CPU Address */
    pval = &SomeVal;                        /* Any CPU Address */
    MEM_VAL_COPY_16(pmem, pval);
    :
    :
}
```

3.20.01 Mem_Clr()

This function is called to clear a memory buffer. In other words, set all octets in the memory buffer to a value of ‘0’.

Prototype

```
void  Mem_Clr (void        *pmem,
               CPU_SIZE_T   size);
```

Arguments

`pmem`	This is the pointer to the memory buffer to be clear.
`size`	This is the number of memory buffer octets to clear.

Returned Value

None

Notes / Warnings

1) Zero-sized clears allowed.

Example

```
void AppFnct (void)
{
    CPU_CHAR  AppBuf[10];
    :
    :
    Mem_Clr((void     *)&AppBuf[0],
            (CPU_SIZE_T) sizeof(AppBuf));
    :
    :
}
```

3.20.02 Mem_Set()

This function is called to fill a memory buffer with a specific value. In other words, set all octets in the memory buffer to the specific value.

Prototype

```
void  Mem_Set (void         *pmem,
               CPU_INT08U    data_val,
               CPU_SIZE_T    size);
```

Arguments

`pmem`	This is the pointer to the memory buffer to be set with a specific value.
`data_val`	This is the value to set.
`size`	This is the number of memory buffer octets to set.

Returned Value

None

Notes / Warnings

1) Zero-sized sets allowed.

Example

```
void AppFnct (void)
{
    CPU_CHAR  AppBuf[10];
    :
    :
    Mem_Set((void     *)&AppBuf[0],
            (CPU_INT08U) 0x64,
            (CPU_SIZE_T) sizeof(AppBuf));
    :
    :
}
```

3.20.03 Mem_Copy()

This function is called to copy values from one memory buffer to another memory buffer.

Prototype

```
void  Mem_Copy (void        *pdest,
                void        *psrc,
                CPU_SIZE_T   size);
```

Arguments

`pdest`	This is the pointer to the memory buffer to copy octets into.
`psrc`	This is the pointer to the memory buffer to copy octets from.
`size`	This is the number of memory buffer octets to copy.

Returned Value

None

Notes / Warnings

1) Zero-sized copies allowed.

2) Memory buffers NOT checked for overlapping.

3) This function can be configured to build an assembly-optimized version (see Sections 3.00 and 3.30.01).

Example

```
void AppFnct (void)
{
    CPU_CHAR  AppBuf[10];
    :
    :
    Mem_Copy((void     *)&AppBuf[0],
             (void     *)"ABCD",
             (CPU_SIZE_T) sizeof("ABCD"));
    :
    :
}
```

3.20.04 Mem_Cmp()

This function is called to compare values from two memory buffers.

Prototype

```
CPU_BOOLEAN  Mem_Copy (void         *p1_mem,
                       void         *p2_mem,
                       CPU_SIZE_T    size);
```

Arguments

`p1_mem`	This is the pointer to the first memory buffer to compare.
`p2_mem`	This is the pointer to the second memory buffer to compare.
`size`	This is the number of memory buffer octets to compare.

Returned Value

`DEF_YES`, if `size` number of octets are identical in both memory buffers.

`DEF_NO`, otherwise.

Notes / Warnings

1) Zero-sized compares allowed; `DEF_YES` returned for identical `NULL` compare.

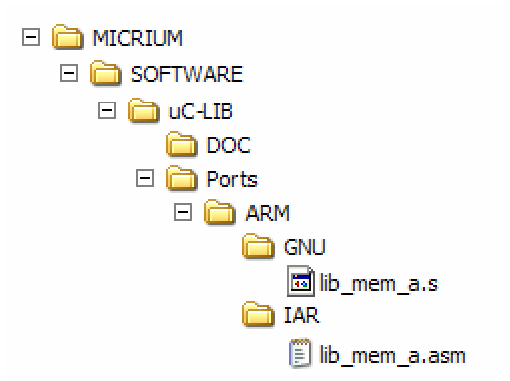
Example

```
void AppFnct (void)
{
    CPU_CHAR      AppBuf[10];
    CPU_BOOLEAN   cmp;
    :
    :
    Mem_Copy((void      *)&AppBuf[0],
             (void      *)"ABCD",
             (CPU_SIZE_T) sizeof("ABCD"));
    cmp = Mem_Cmp((void      *)&AppBuf[2],
                  (void      *)"CD",
                  (CPU_SIZE_T) sizeof("CD"));
    :
    :
}
```

3.30 µC/LIB Memory Library Optimization

All µC/LIB memory functions have been C-optimized for improved run-time performance, independent of processor or compiler optimizations. This is accomplished by performing memory operations on CPU-aligned word boundaries whenever possible.

In addition, some µC/LIB memory functions have been assembly-optimized for certain processors/compilers. If These optimizations are defined in assembly files found in appropriate port directories for each specific processor/compiler combination. See Figure 3-1 for an example port directory :



```
MICRIUM
  SOFTWARE
    uC-LIB
      DOC
      Ports
        ARM
          GNU
            lib_mem_a.s
          IAR
            lib_mem_a.asm
```

Figure 3-1, µC/LIB Example Port Directory

3.30.01 Mem_Copy() Optimization

Future Release

Chapter 4

µC/LIB String Library

µC/LIB contains library functions that replace standard library string functions such as `strlen()`, `strcpy()`, `strcmp()`, etc. These functions are defined in `lib_str.c`.

4.00 µC/LIB String Library Configuration

The following µC/LIB string library configuration may be optionally configured in `app_cfg.h` :

`LIB_STR_CFG_FP_EN`	Enable floating-point string conversion functions (see Section 4.10.09).

4.10.01 Str_Len()

This function is called to determine the length of a string.

Prototype

```
CPU_SIZE_T  Str_Len (CPU_CHAR  *pstr);
```

Arguments

`pstr`	This is the pointer to the string.

Returned Value

Length of string in number of characters in string before but NOT including the terminating `NULL` character.

Notes / Warnings

1) String buffer NOT modified.

2) String length calculation terminates if string pointer points to or overlaps the `NULL` address.

Example

```
void AppFnct (void)
{
    CPU_INT16U  len;
    :
    :
    len = (CPU_INT16U)Str_Len("Hello World.");
    :
    :
}
```

4.10.02.01 Str_Copy()

This function is called to copy string character values from one string memory buffer to another memory buffer.

Prototype

```
CPU_CHAR   *Str_Copy (CPU_CHAR  *pdest,
                      CPU_CHAR  *psrc);
```

Arguments

`pdest`	This is the pointer to the string memory buffer to copy string characters into.
`psrc`	This is the pointer to the string memory buffer to copy string characters from.

Returned Value

Pointer to copied destination string,	if NO errors.
Pointer to `NULL`,	otherwise.

Notes / Warnings

1) Destination buffer size NOT validated; buffer overruns MUST be prevented by caller.

    a) Destination buffer size MUST be large enough to accomodate the entire source string size including the terminating NULL character.

2) String copy terminates if either string pointer points to or overlaps the `NULL` address.

Example

```
void AppFnct (void)
{
    CPU_CHAR   AppBuf[20];
    CPU_CHAR  *pstr;
    :
    :
    pstr = Str_Copy(&AppBuf[0], "Hello World!");
    :
    :
}
```

4.10.02.02 Str_Copy_N()

This function is called to copy string character values from one string memory buffer to another memory buffer, up to a maximum number of characters.

Prototype

```
CPU_CHAR  *Str_Copy_N (CPU_CHAR    *pdest,
                       CPU_CHAR    *psrc,
                       CPU_SIZE_T   len_max);
```

Arguments

`pdest`	This is the pointer to the string memory buffer to copy string characters into.
`psrc`	This is the pointer to the string memory buffer to copy string characters from.
`len_max`	This is the maximum number of string characters to copy.

Returned Value

Pointer to copied destination string,	if NO errors.
Pointer to `NULL`,	otherwise.

Notes / Warnings

1) Destination buffer size NOT validated; buffer overruns MUST be prevented by caller.

   a) Destination buffer size MUST be large enough to accomodate the entire source string size including the terminating NULL character.

2) String copy terminates if either string pointer points to or overlaps the `NULL` address.

3) The maximum number of characters copied does NOT include the terminating NULL character.

Example

```
void AppFnct (void)
{
    CPU_CHAR   AppBuf[20];
    CPU_CHAR  *pstr;
    :
    :
    pstr = Str_Copy_N(&AppBuf[0], "Hello World!", 6);
    :
    :
}
```

4.10.03.01 Str_Cat()

This function is called to concatenate a string to the end of another string.

Prototype

```
CPU_CHAR   *Str_Cat (CPU_CHAR   *pdest,
                     CPU_CHAR   *pstr_cat);
```

Arguments

`pdest`	This is the pointer to the string memory buffer to append string characters into.
`pstr_cat`	This is the pointer to the string to concatenate onto the destination string.

Returned Value

Pointer to concatenated destination string,	if NO errors.
Pointer to `NULL`,	otherwise.

Notes / Warnings

1) Destination buffer size NOT validated; buffer overruns MUST be prevented by caller.

    a) Destination buffer size MUST be large enough to accomodate the entire source string size including the terminating NULL character.

2) String concatenation terminates if either string pointer points to or overlaps the `NULL` address.

Example

```
void AppFnct (void)
{
    CPU_CHAR   AppBuf[30];
    CPU_CHAR  *pstr;
    :
    :
    pstr = Str_Copy(&AppBuf[0], "Hello   World!");
    pstr = Str_Cat (&AppBuf[0], "Goodbye World!");
    :
    :
}
```

4.10.03.02 Str_Cat_N()

This function is called to concatenate a string to the end of another string, up to a maximum number of characters.

Prototype

```
CPU_CHAR  *Str_Cat_N (CPU_CHAR    *pdest,
                      CPU_CHAR    *pstr_cat,
                      CPU_SIZE_T   len_max);
```

Arguments

`pdest`	This is the pointer to the string memory buffer to append string characters into.
`pstr_cat`	This is the pointer to the string to concatenate onto the destination string.
`len_max`	This is the maximum number of string characters to concatenate.

Returned Value

Pointer to concatenated destination string,	if NO errors.
Pointer to `NULL`,	otherwise.

Notes / Warnings

1) Destination buffer size NOT validated; buffer overruns MUST be prevented by caller.

    a) Destination buffer size MUST be large enough to accomodate the entire source string size including the terminating NULL character.

2) String concatenation terminates if either string pointer points to or overlaps the `NULL` address.

3) The maximum number of characters concatenated does NOT include the terminating NULL character.

Example

```
void AppFnct (void)
{
    CPU_CHAR   AppBuf[30];
    CPU_CHAR  *pstr;
    :
    :
    pstr = Str_Copy (&AppBuf[0], "Hello   World!");
    pstr = Str_Cat_N(&AppBuf[0], "Goodbye World!", 5);
    :
    :
}
```

4.10.04.01 Str_Cmp()

This function is called to determine if two strings are identical.

Prototype

```
CPU_INT16S  Str_Cmp (CPU_CHAR  *p1_str,
                     CPU_CHAR  *p2_str);
```

Arguments

`p1_str`	This is the pointer to the first string.
`p2_str`	This is the pointer to the second string.

Returned Value

Zero value,	if strings are identical; i.e. both strings are identical in length and ALL characters.
Positive value,	if `p1_str` is greater than `p2_str`; i.e. `p1_str` points to a character of higher value than `p2_str` for the first non-matching character found.
Negative value,	if `p1_str` is less than `p2_str`; i.e. `p1_str` points to a character of lesser value than `p2_str` for the first non-matching character found.

Notes / Warnings

1) String buffers NOT modified.

2) String comparison terminates if either string pointer points to or overlaps the `NULL` address.

3) Since 16-bit signed arithmetic is performed to calculate a non-identical comparison return value, `CPU_CHAR` native data type size MUST be 8-bit.

Example

```
void AppFnct (void)
{
    CPU_INT16S  cmp;
    :
    :
    cmp = Str_Cmp("Hello World!", "Hello World.");
    :
    :
}
```

4.10.04.02 Str_Cmp_N()

This function is called to determine if two strings are identical for a specified length of characters.

Prototype

```
CPU_INT16S  Str_Cmp_N (CPU_CHAR    *p1_str,
                       CPU_CHAR    *p2_str,
                       CPU_SIZE_T   len_max);
```

Arguments

`p1_str`	This is the pointer to the first string.
`p2_str`	This is the pointer to the second string.
`len_max`	This is the maximum number of string characters to compare.

Returned Value

Zero value,	if strings are identical; i.e. both strings are identical for the specified length of characters.
Positive value,	if `p1_str` is greater than `p2_str`; i.e. `p1_str` points to a character of higher value than `p2_str` for the first non-matching character found.
Negative value,	if `p1_str` is less than `p2_str`; i.e. `p1_str` points to a character of lesser value than `p2_str` for the first non-matching character found.

Notes / Warnings

1) String buffers NOT modified.

2) String comparison terminates if either string pointer points to or overlaps the `NULL` address.

3) Since 16-bit signed arithmetic is performed to calculate a non-identical comparison return value, `CPU_CHAR` native data type size MUST be 8-bit.

Example

```
void AppFnct (void)
{
    CPU_INT16S  cmp;
    :
    :
    cmp = Str_Cmp_N("Hello World!", "Hello World.", 10);
    :
    :
}
```

4.10.05.01 Str_Char()

This function is called to find the first occurrence of a specific character in a string.

Prototype

```
CPU_CHAR  *Str_Char (CPU_CHAR  *pstr,
                     CPU_CHAR   srch_char);
```

Arguments

`pstr`	This is the pointer to the string to search for the specified character.
`srch_char`	This is the character to search for in the string.

Returned Value

Pointer to first occurrence of character in string,	if NO errors.
Pointer to `NULL`,	otherwise.

Notes / Warnings

1) String buffer NOT modified.
2) String search terminates if string pointer points to or overlaps the `NULL` address.

Example

```
void AppFnct (void)
{
    CPU_CHAR  *pstr;
    :
    :
    pstr = Str_Char("Hello World!", 'l');
    :
    :
}
```

4.10.05.02 Str_Char_N()

This function is called to find the first occurrence of a specific character in a string, up to a maximum number of characters.

Prototype

```
CPU_CHAR  *Str_Char_N (CPU_CHAR    *pstr,
                       CPU_SIZE_T   len_max,
                       CPU_CHAR     srch_char);
```

Arguments

`pstr`	This is the pointer to the string to search for the specified character.
`len_max`	This is the maximum number of string characters to search.
`srch_char`	This is the character to search for in the string.

Returned Value

Pointer to first occurrence of character in string,	if NO errors.
Pointer to `NULL`,	otherwise.

Notes / Warnings

1) String buffer NOT modified.

2) String search terminates if string pointer points to or overlaps the `NULL` address.

Example

```
void AppFnct (void)
{
    CPU_CHAR  *pstr;
    :
    :
    pstr = Str_Char_N("Hello World!", 'l', 5);
    :
    :
}
```

4.10.05.03 Str_Char_Last()

This function is called to find the last occurrence of a specific character in a string.

Prototype

```
CPU_CHAR  *Str_Char_Last (CPU_CHAR  *pstr,
                          CPU_CHAR   srch_char);
```

Arguments

`pstr`	This is the pointer to the string to search for the specified character.
`srch_char`	This is the character to search for in the string.

Returned Value

Pointer to first occurrence of character in string,	if NO errors.
Pointer to `NULL`,	otherwise.

Notes / Warnings

1) String buffer NOT modified.

2) String search terminates if string pointer points to or overlaps the `NULL` address.

Example

```
void AppFnct (void)
{
    CPU_CHAR  *pstr;
    :
    :
    pstr = Str_Char_Last("Hello World!", 'l');
    :
    :
}
```

4.10.06 Str_Str()

This function is called to find the first occurrence of a specific string within another string.

Prototype

```
CPU_CHAR   *Str_Str (CPU_CHAR  *pstr,
                     CPU_CHAR  *psrch_str);
```

Arguments

`pstr`	This is the pointer to the string to search for the specified string.
`psrch_str`	This is the pointer to the string to search for in the string.

Returned Value

Pointer to first occurrence of search string in string,	if NO errors.
Pointer to `NULL`,	otherwise.

Notes / Warnings

1) String buffers NOT modified.

2) String search terminates if string pointer points to or overlaps the `NULL` address.

Example

```
void AppFnct (void)
{
    CPU_CHAR  *pstr;
    :
    :
    pstr = Str_Str("Hello World!", "lo");
    :
    :
}
```

4.10.07 Str_FmtNbr_32()

This function is called to convert & format a 32-bit number into a string.

Prototype

```
CPU_CHAR  *Str_FmtNbr_32 (CPU_FP32       nbr,
                           CPU_INT08U     nbr_dig,
                           CPU_INT08U     nbr_dp,
                           CPU_BOOLEAN    lead_zeros,
                           CPU_BOOLEAN    nul,
                           CPU_CHAR      *pstr_fmt);
```

Arguments

`nbr`	This is the number to format into a string.
`nbr_dig`	This is the number of integer digits to format into the number string.
`nbr_dp`	This is the number of decimal digits to format into the number string.
`lead_zeros`	Option to prepend leading zeros into the formatted number string (see Note #2).
`nul`	Option to `NULL`-terminate the formatted number string (see Note #3).
`pstr_fmt`	This is the pointer to the string memory buffer to return the formatted number string (see Note #4).

Returned Value

Pointer to formatted number string,	if NO errors.
Pointer to `NULL`,	otherwise.

Notes / Warnings

1) This function enabled ONLY if `LIB_STR_CFG_FP_EN` enabled in `app_cfg.h` (see Section 4.00).

2) a) Leading zeros option prepends leading '0's prior to the first non-zero digit. The number of leading zeros is such that the total number integer digits is equal to the requested number of integer digits to format (`nbr_dig`).

   b) 1) If leading zeros option DISABLED,
      2) ... number of digits to format is non-zero,
      3) ... & the integer value of the number to format is zero;
      4) ... then one digit of '0' value is formatted.

      This is NOT a leading zero; but a single integer digit of '0' value.

3) a) `NULL`-character terminate option DISABLED prevents overwriting previous character array formatting.

b) **WARNING**: Unless `pstr_fmt` character array is pre-/post-terminated, `NULL`-character terminate option DISABLED will cause character string run-on.

4) a) Format buffer size NOT validated; buffer overruns MUST be prevented by caller.

b) To prevent character buffer overrun :

```
Character array size MUST be  >=  (nbr_dig          +
                                   nbr_dp           +
                                   1 negative sign  +
                                   1 decimal point  +
                                   1 NUL terminator)  characters
```

Example

```
void AppFnct (void)
{
    CPU_CHAR   AppBuf[20];
    CPU_CHAR  *pstr;
    :
    :
    pstr = Str_FmtNbr_32((CPU_FP32   )-1234.5678,
                         (CPU_INT08U ) 5,
                         (CPU_INT08U ) 2,
                         (CPU_BOOLEAN) DEF_YES,
                         (CPU_BOOLEAN) DEF_YES,
                         (CPU_CHAR  *)&AppBuf[0]);
    :
    :
}
```

Appendix A

µC/LIB Licensing Policy

You need to obtain an 'Object Code Distribution License' to embed µC/LIB in a product that is sold with the intent to make a profit. Each 'different' product (i.e. your product) requires its own license but, the license allows you to distribute an unlimited number of units for the life of your product. Please indicate the processor type(s) (i.e. ARM7, ARM9, MCF5272, MicroBlaze, Nios II, PPC,etc.) that you intend to use.

For licensing details, contact us at:

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