

Foenix Toolbox Programmer's Guide

Firmware functions for the Foenix Retro System F256 computers

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October 18, 2024

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Chapter 1

Introduction

The Foenix Toolbox is simple firmware package for the Foenix Retro Systems F256 computers, when they are fitted with the 65816 CPU and the chipset for the flat memory model. It can be thought of being similar to a BIOS or like the Macintosh Toolbox from the original 68000 based Macintoshes. It has three main purposes:

- Boot up the computer from a cold boot, initializing all devices
- Look for, load, and start whatever program the user wants to run. Such a program may be on the internal SD card, the external SD card, the flash memory of the F256, or a flash cartridge plugged into the expansion port. For the purposes of code development and testing, the program can be loaded into RAM under certain conditions.
- Provide a standard collection of functions to make it easier for users to write programs to run on the F256s. The functions mainly cover those areas of programming for the machine that would otherwise require a lot of uninteresting re-work or are particularly complicated.

What the Foenix Toolbox is not is a complete operating system. This is on purpose. The Toolbox is meant to help the user get a programming running, but it tries to stay out of the user's way as much as possible. What this means is:

- The Toolbox uses an absolute minimum of interrupts and hardware timers
- Although the Toolbox provides an interrupt dispatch system for the user program, user programs may take complete control over for the interrupt system and just call into the Toolbox if it needs those services affected
- There is no memory protection or really any memory management set by the Toolbox
- The Toolbox does not provide a command line interface (CLI). Although a separate project may provide a simple one, if the user wants one.
- The Toolbox does not provide a graphical user interface (GUI). If a user wants to create their own, of course they are welcome to it.

The philosophy of the Toolbox is that the owner of a Foenix computer has bought the machine to tinker with and make it do what they want it to do. The Toolbox should be there to help the user but not hinder them or restrict their freedom to do what they want with the machine.

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Chapter 2

Devices

Devices on the Foenix computers fall into one of three main categories: channel devices, block devices, and files (which are really special purpose channel devices).

Channel Devices

Channel devices are predominantly sequential, byte oriented devices. They are essentially byte streams. A program can read or write a series of bytes from or to the device. A channel can have the notion of a “cursor” which represents the point where a read or write will happen. Examples of channel devices include the console, the serial ports, and files.

Currently, the only fully supported channel devices are open files, the keyboard, and the screen. In the future, there should be full support for the serial ports, the parallel port, and the MIDI ports. Channel devices are assigned as shown in table 2.1:

By default, channel 0 is open automatically to device 0 (the console) at boot time.

Block Devices

Block devices organize their data into blocks of bytes. A block may be read from or written to a block device, and blocks maybe accessed in any order desired. The F256K2e comes with two block devices: the internal and external SD cards (see table 2.2).

File Channels

Files represent a special channel pseudo-device. Although files are stored on block devices, they may be open as file channels, which may be accessed like a channel device. There is a special file channel driver, which

| Number | Device |
|--------|---|
| 0 | Main console (keyboard and main screen) |
| 1 | Reserved |
| 2 | Serial Port 1 |
| 3 | Reserved |
| 5 | MIDI Ports |
| 6 | Files |

Table 2.1: Channel devices

| Number | Device |
|--------|----------------------|
| 0 | sd0—External SD card |
| 1 | sd1—Internal SD card |

Table 2.2: Channel devices

converts channel reads and writes on a file to the appropriate block calls. Access to these file channels is managed in part through the file system calls listed below.

Paths

File and directory names follow the Unix style path conventions. That is, the forward slash (/) is used as a separator, and drives are treated as directories (“/sd”, “/hd”, *etc.*). FAT32 long file names are supported, but not Unicode characters. Special path names “.” and “..” are supported to specify a path relative to the current path. Example paths are:

```
/sd0/hello.txt
/sd1/system/format.elf
../games/HauntedCastle/start
```


Chapter 3

Toolbox Functions

3.1 Calling Convention

All Toolbox functions are long call functions (*i.e.* using the **JSL** and **RTL** instructions) using the Calypsi “simple call” calling convention:

- left-most parameter is placed in the accumulator for 8 and 16-bit types, and the X register and the accumulator for 24 and 32 bit types (X taking the most significant bits).
- remaining parameters are pushed on to the stack in right to left order (that is, the second parameter in a call is at the top of the stack just before the **JSL**).
- 8-bit types are pushed as 16-bit values to avoid switching register sizes mid-call
- 24-bit types are pushed as 32-bit values for the same reason
- the return value is placed in the accumulator for 8 and 16-bit types, or in the X register and accumulator for 24 and 32 bit types (most significant bits in the X register).
- The caller is responsible for removing the parameters from the stack (if any) after the call returns.

Furthermore, Toolbox functions are written so as to save the direct page and data bank registers of the caller and to restore them before returning to the caller. This means that a user program can do whatever it likes with the direct page and data bank registers, and the Toolbox will not interfere with those settings. The Toolbox does use those registers itself, but so long as the user program does not alter the Toolbox’s RAM blocks (see the memory maps), there should be no interference between the two.

The Toolbox functions are accessed through a jumptable located in the F256’s flash memory, starting at 0xFFE000. Each entry is four bytes long, and the address of each function is called out in their detailed descriptions below.

NOTE: Calypsi’s “simple call” convention is not the fastest way to pass parameters to functions, and it is not Calypsi’s only calling convention. There is also a calling convention that uses pseudo-registers in the direct page to pass parameters. Unfortunately, the rules for which parameter goes where in direct page are rather involved. While that convention is preferable when Calypsi is the only compiler involved, the Toolbox needs to allow for other development tools to be used. The stack based convention is more likely to be supported by other compilers. So speed was traded for broader compatibility.

3.2 General Functions

sys_proc_exit – 0xFFE000

This function ends the currently running program and returns control to the kernel. It takes a single short argument, which is the result code that should be passed back to the kernel. This function does not return.

| void sys_proc_exit(short result) | |
|----------------------------------|----------------------------------|
| result | the code to return to the kernel |

Example: C

```
sys_proc_exit(0); // Quit the program with a result code of 0
```

Example: Assembler

```
lda #0                ; Return code of 0
jsl sys_proc_exit     ; Quit the program
```

sys_proc_run – 0xFFE0DC

Load and run an executable binary file. This function will not return on success, since Foenix Toolbox is single tasking. Any return value will be an error condition.

| Prototype | short sys_proc_run(const char * path, int argc, char * argv[]) |
|-----------|--|
| path | the path to the executable file |
| argc | the number of arguments passed |
| argv | the array of string arguments |
| Returns | the return result of the program |

Example: C

```
// Attempt to load and run /sd0/hello.pgx
// Pass the command name and "test" as the arguments

int argc = 2;
char * argv[] = {
    "hello.pgx",
    "test"
};
short result = sys_proc_run("/sd0/hello.pgx", argc, argv);
```

Example: Assembler

```
pei #'argv            ; Push pointer to the arguments
pei #<>argv
pei #2                ; Push the argument count
ldx #'path            ; Point to the path to load
lda #<>path
jsl sys_proc_run      ; Try to load and run the file

ply                  ; Clean up the stack
```

```

ply
ply

; If we get here, there was an error loading or running
; the file. Error number is in the accumulator

...

path:
.nulll "/sd0/hello.pgx"

argv:
.nulll "hello.pgx"
.nulll "test"

```

sys_get_info – 0xFFE020

Fill out a structure with information about the computer. This information includes the model, the CPU, the amount of memory, versions of the board and FPGAs, and what optional equipment is installed. . There is no return value.

| | |
|-----------|---|
| Prototype | void sys_get_info(p_sys_info info) |
| info | pointer to a s_sys_info structure to fill out |

Example: C

```

struct s_sys_info info;
sys_get_info(&info);
printf("Machine: %s\n", info.model_name);

```

Example: Assembler

```

ldx #'info    ; Point to the info structure
lda #<>info
jsl sys_get_info

; The structure at info now has data in it

```

sys_mem_get_ramtop – 0xFFE0BC

Return the limit of accessible system RAM. The address returned is the first byte of memory that user programs may not access. User programs may use any byte from the bottom of system RAM to RAMTOP - 1.

| | |
|-----------|--|
| Prototype | uint32_t sys_mem_get_ramtop() |
| Returns | the address of the first byte of reserved system RAM |

sys_mem_reserve – 0xFFE0C0

Reserve a block of memory from the top of system RAM. This call will reduce the value returned by sys_get_ramtop and will create a block of memory that user programs and the kernel will not change. The current user program can load into that memory any code or data it needs to protect after it has quit (for

instance, a terminate-stay-resident code block). `sys_mem_reserve` returns the address of the first byte of the block reserved.

NOTE: a reserved block cannot be returned to general use except by restarting the system.

| | |
|-----------|---|
| Prototype | <code>uint32_t sys_mem_reserve(uint32_t bytes)</code> |
| bytes | the number of bytes to reserve |
| Returns | address of the first byte of the reserved block |

Example: C

```
// Reserve a block of 256 bytes...
uint32_t my_block = sys_mem_reserve(256);
```

Example: Assembler

```
ldx #0                ; Push the amount requested (256 bytes)
lda #256
jsl sys_mem_reserve    ; Attempt to reserve the block
stx my_block+2         ; Save the address of the block reserved
sta my_block
```

`sys_time_jiffies` – 0xFFE0C4

Returns the number of “jiffies” since system startup.

A jiffy is 1/60 second. This clock counts the number of jiffies since the last system startup, but it is not terribly precise. This counter should be sufficient for providing timeouts and wait delays on a fairly coarse level, but it should not be used when precision is required.

| | |
|-----------|--|
| Prototype | <code>uint32_t sys_time_jiffies()</code> |
| Returns | the number of jiffies since the last reset |

Example: C

```
long jiffies = sys_time_jiffies();
```

Example: Assembler

```
jsl sys_time_jiffies    ; Get the time

; Jiffy count is now in X:A
```

`sys_rtc_set_time` – 0xFFE0C8

Sets the date and time in the real time clock. The date and time information is provided in an `s_time` structure (see below).

| | |
|-----------|---|
| Prototype | <code>void sys_rtc_set_time(p_time time)</code> |
| time | pointer to a <code>t_time</code> record containing the correct time |

Example: C

```
struct s_time time;

// time structure is filled in with the current time

// Set the time in the RTC
sys_rtc_set_time(&time);
```

Example: Assembler

```
; time structure is filled in with the current time

...

ldx #'time          ; Point to the time structure
lda #<>time
jsl sys_rtc_set_time ; Set the time in the RTC
```

sys_rtc_get_time – 0xFFE0CC

Gets the date and time in the real time clock. The date and time information is provided in an **s_time** structure (see below).

| | |
|-----------|---|
| Prototype | void sys_rtc_get_time(p_time time) |
| time | pointer to a t_time record in which to put the current time |

Example: C

```
struct s_time time;
// ...
sys_rtc_get_time(&time);
```

Example: Assembler

```
ldx #'time          ; Point to the time structure
lda #<>time
jsl sys_rtc_get_time ; Get the time from the RTC
```

sys_kbd_scancode – 0xFFE0D0

Returns the next keyboard scan code (0 if none are available). Note that reading a scan code directly removes it from being used by the regular console code and may cause some surprising behavior if you combine the two.

See below for details about Foenix scan codes.

| | |
|-----------|--|
| Prototype | uint16_t sys_kbd_scancode() |
| Returns | the next scan code from the keyboard... 0 if nothing pending |

Example: C

```
// Wait for a keypress
uint16_t scan_code = 0;
do {
    // Get the Foenix scan code from the keyboard
    scan_code = sys_kbd.scancode();
} while (scan_code == 0);
```

Example: Assembler

```
wait:
    jsl sys_kbd_scancode    ; Get the scan code from the keyboard
    cmp #0                 ; Keep checking until we get a keypress
    beq wait
```

sys_kbd_layout – 0xFFE0D8

Sets the keyboard translation tables converting from scan codes to 8-bit character codes. The table provided is copied by the kernel into its own area of memory, so the memory used in the calling program's memory space may be reused after this call.

Takes a pointer to the new translation tables (see below for details). If this pointer is 0, Foenix Toolbox will reset its translation tables to their defaults.

Returns 0 on success, or a negative number on failure.

| | |
|-----------|--|
| Prototype | short sys_kbd_layout(const char * tables) |
| tables | pointer to the keyboard translation tables |
| Returns | 0 on success, negative number on error |

3.3 Channel Functions

The channel functions provide support for channel or stream based I/O devices. Any time a device or program wants to work with data as a sequential stream of bytes or characters, that device should be a channel device. Examples of channel devices that the Toolbox supports are the console (screen and keyboard), the serial port, MIDI devices, and files open on SD cards. In the future, there may be other channel devices as well (*e.g.* network streams). Some channel devices can provide support for higher level functionality. As an example, the console channel device provides support for printing ANSI terminal codes to the screen and for reading certain keypresses back as ANSI escape sequences (for instance, function key presses).

sys_chan_read_b – 0xFFE028

Read a single character from the channel. Returns the character, or 0 if none are available.

| | |
|-----------|---|
| Prototype | short sys_chan_read_b(short channel) |
| channel | the number of the channel |
| Returns | the value read (if negative, error) |

Example: C

```
// Read a byte from channel #0 (keyboard)
short b = sys_chan_read_b(0);
if (b >= 0) {
```

```

    } // We have valid data from 0–255 in b
}

```

Example: Assembler

```

lda #0                ; Select channel #0
jsl sys_chan_read_b   ; Read from the channel
bit #$ffff            ; If negative...
bmi error             ; Process an error

; We have valid data in A

```

sys_chan_read – 0xFFE02C

Read bytes from a channel and fill a buffer with them, given the number of the channel and the size of the buffer. Returns the number of bytes read.

| | |
|-----------|---|
| Prototype | short sys_chan_read(short channel, unsigned char * buffer, short size) |
| channel | the number of the channel |
| buffer | the buffer into which to copy the channel data |
| size | the size of the buffer. |
| Returns | number of bytes read, any negative number is an error code |

Example: C

```

char buffer[80];
short n = sys_chan_read(0, buffer, 80);
if (n >= 0) {
    // We correctly read n bytes into the buffer
} else {
    // We have an error
}

```

Example: Assembler

```

pei #80                ; Push the size of the buffer

pei #'buffer           ; Push the address of the buffer
pei #<>buffer

lda #0                ; Select channel #0

jsl sys_chan_read     ; Try to read the bytes from the channel

ply                   ; Clean up the stack
ply
ply

bit #$ffff            ; If result is negative...
bmi error             ; Go to process the error

sta n                 ; Otherwise: save the number of bytes read

```

sys_chan_readline – 0xFFE030

Read a line of text from a channel (terminated by a newline character or by the end of the buffer). Returns the number of bytes read.

| | |
|-----------|---|
| Prototype | short sys_chan_readline(short channel, unsigned char * buffer, short size) |
| channel | the number of the channel |
| buffer | the buffer into which to copy the channel data |
| size | the size of the buffer |
| Returns | number of bytes read, any negative number is an error code |

Example: C

```
short c = ...; // The channel number
unsigned char buffer[128];
short n = sys_chan_read_line(c, buffer, 128);
```

Example: Assembler

```
pei #128                ; Push the size of the buffer
pei #'buffer            ; Push the pointer to the buffer
pei #<>buffer
lda c                   ; Set the channel number to read from
jsl sys_chan_read_line  ; Attempt to read a line from the console

ply                     ; Clean up the stack
ply
ply

sta n                   ; Save the number of bytes read
```

sys_chan_write_b – 0xFFE034

Write a single byte to the channel.

| | |
|-----------|--|
| Prototype | short sys_chan_write_b(short channel, uint8_t b) |
| channel | the number of the channel |
| b | the byte to write |
| Returns | 0 on success, a negative value on error |

Example: C

```
// Write 'a' to the console
short result = sys_chan_write_b(0, 'a');
```

Example: Assembler

```
pei #'a'                ; Push 'a' as the b parameter
lda #0                  ; Select the console (channel #0)
jsl sys_chan_write_b    ; Write the character to the console
ply                     ; Clean up the stack
```


sys_chan_write – 0xFFE038

Write bytes from a buffer to a channel, given the number of the channel and the size of the buffer. Returns the number of bytes written.

| | |
|-----------|--|
| Prototype | short sys_chan_write(short channel, const uint8_t * buffer, short size) |
| channel | the number of the channel |
| buffer | |
| size | |
| Returns | number of bytes written, any negative number is an error code |

Example: C

```
char * message = 'Hello, world!\n';
short n = sys_chan_write(0, message, strlen(message));
```

Example: Assembler

```
pei #15                ; Push the size of the buffer
pei #'message          ; Push the pointer to the message
pei #<>message
lda #0                 ; Select the console (channel #0)
jsl sys_chan_write     ; Write the buffer to the console

ply                    ; Clean up the stack
ply
ply

; ...
message:
.null "Hello, world!", 13, 10
```

sys_chan_status – 0xFFE03C

Gets the status of the channel. The meaning of the status bits is channel-specific, but four bits are recommended as standard:

- 0x01: The channel has reached the end of its data
- 0x02: The channel has encountered an error
- 0x04: The channel has data that can be read
- 0x08: The channel can accept data

| | |
|-----------|---|
| Prototype | short sys_chan_status(short channel) |
| channel | the number of the channel |
| Returns | the status of the device |

Example: C

```
// Check the status of the file_in channel
short status = sys_chan_status(file_in);
if (status & 0x01) {
    // We have reached end of file
}
```

Example: Assembler

```
lda file_in
jsl sys_chan_status
and #$01
beq have_data
; We have reached end of file
```

sys_chan_flush – 0xFFE040

Ensure any pending writes to a channel are completed.

| | |
|-----------|--|
| Prototype | short sys_chan_flush(short channel) |
| channel | the number of the channel |
| Returns | 0 on success, any negative number is an error code |

Example: C

```
short file_out = ...; // Channel number
sys_chan_flush(file_out); // Flush the channel
```

Example: Assembler

```
lda file_out          ; Channel number
jsl sys_chan_flush     ; Flush the channel
```

sys_chan_seek – 0xFFE044

Set the position of the input/output cursor. This function may not be honored by a given channel as not all channels are “seekable.” In addition to the usual channel parameter, the function takes two other parameters:

- position: the new position for the cursor
- base: whether the position is absolute (0), or relative to the current position (1).

| | |
|-----------|--|
| Prototype | short sys_chan_seek(short channel, long position, short base) |
| channel | the number of the channel |
| position | the position of the cursor |
| base | whether the position is absolute or relative to the current position |
| Returns | 0 = success, a negative number is an error. |

Example: C

```
short c = ...; // The channel number
sys_chan_seek(c, -10, 1); // Move the point back 10 bytes
```

Example: Assembler

```
pei #1          ; Move is relative
pei #-10        ; Move back by 10 bytes
lda c           ; Select the channel
jsl sys_chan_seek ; Move the channel cursor

ply            ; Clean up the stack
ply
```

sys_chan_ioctl – 0xFFE048

Send a command to a channel. The mapping of commands and their actions are channel-specific. The return value is also channel and command-specific. The **buffer** and **size** parameters provide additional data to the commands, what exactly needs to go in them (if anything) is command-specific. Some commands require data in the buffer, and others do not.

| | |
|-----------|---|
| Prototype | short sys_chan_ioctl(short channel, short command, uint8_t * buffer, short size) |
| channel | the number of the channel |
| command | the number of the command to send |
| buffer | pointer to bytes of additional data for the command |
| size | the size of the buffer |
| Returns | 0 on success, any negative number is an error code |

Example: C

```
short c = ...; // The channel number
short cmd = ...; // The command
short r = sys_chan_ioctl(c, cmd, 0, 0); // Send simple command
```

Example: Assembler

```
pei #0          ; Push 0 for the size
pei #0          ; Push the null pointer for the buffer
pei #0
lda cmd         ; Push the command
pha
lda c
jsl sys_chan_ioctl ; Issue the command

ply            ; Clean up the stack
ply
ply
ply
```

sys_chan_open – 0xFFE04C

Open a channel device for reading or writing given: the number of the device, the path to the resource on the device (if any), and the access mode. The access mode is a bitfield:

- 0x01: Open for reading
- 0x02: Open for writing

- 0x03: Open for reading and writing

| | |
|-----------|--|
| Prototype | short sys_chan_open(short dev, const char * path, short mode) |
| dev | the device number to have a channel opened |
| path | a "path" describing how the device is to be open |
| mode | s the device to be read, written, both |
| Returns | the number of the channel opened, negative number on error |

Example: C

```
// Serial port: 9600bps, 8-data bits, 1 stop bit, no parity
short chan = sys_chan_open(2, "9600,8,1,N", 3);
```

Example: Assembler

```
pei #3                ; Mode: Read & Write
pei #'path            ; Pointer to the path
pei #<>path
lda #2                ; Device #2 (UART)
jsl sys_chan_open     ; Open the channel to the UART

ply                  ; Clean up the stack
ply
ply

; ...

path:
    .null "9600,8,1,N"
```

sys_chan_close – 0xFFE050

Close a channel that was previously open by sys_chan_open.

| | |
|-----------|---|
| Prototype | short sys_chan_close(short chan) |
| chan | the number of the channel to close |
| Returns | nothing useful |

Example: C

```
short c = ...; // The channel number
sys_chan_close(c); // Close the channel
```

Example: Assembler

```
lda c                ; Get the channel number
jsl sys_chan_close   ; Close the channel
```

sys_chan_swap – 0xFFE054

Swaps two channels, given their IDs. If before the call, channel ID `channel1` refers to the file “hello.txt”, and channel ID `channel2` is the console, then after the call, `channel1` is the console, and `channel2` is the open file “hello.txt”. Any context for the channels is preserved (for instance, the position of the file cursor in an open file).

| | |
|-----------|---|
| Prototype | short sys_chan_swap(short channel1, short channel2) |
| channel1 | the ID of one of the channels |
| channel2 | the ID of the other channel |
| Returns | 0 on success, any other number is an error |

sys_chan_device – 0xFFE058

Given a channel ID (the only parameter), return the ID of the device associated with the channel. The channel must be open.

| | |
|-----------|---|
| Prototype | short sys_chan_device(short channel) |
| channel | the ID of the channel to query |
| Returns | the ID of the device associated with the channel, negative number for error |

3.4 Block Device Functions

The block device functions provide low-level support for access to block-based storage devices. The main operations on block devices are reading a block of data from a device (given the device number and the address of the block to read), and writing a block of data to the device. These functions are used by the driver to the FatFS library to provide FAT32 file based access to those block devices. Currently, for the F256, this support is limited to SD cards. The F256jr and F256K have just the one SD card, but the F256K2e has an internal and an external SD card. Future machines might provide additional block devices (*e.g.* floppy drives or hard drives), and if someone wanted to build some sort of block device for the F256, a driver to support it could be added to the Toolbox to add those devices to the FAT32 file support.

sys_bdev_register – 0xFFE060

Register a device driver for a block device. A device driver consists of a structure that specifies the name and number of the device as well as the various handler functions that implement the block device calls for that device.

See the section “Extending the System” below for more information.

| | |
|-----------|--|
| Prototype | short sys_bdev_register(p_dev_block device) |
| device | pointer to the description of the device to register |
| Returns | 0 on succes, negative number on error |

sys_bdev_read – 0xFFE064

Read a block from a block device. Returns the number of bytes read.

| | |
|-----------|---|
| Prototype | short sys_bdev_read(short dev, long lba, uint8_t * buffer, short size) |
| dev | the number of the device |
| lba | the logical block address of the block to read |
| buffer | the buffer into which to copy the block data |
| size | the size of the buffer. |
| Returns | number of bytes read, any negative number is an error code |

Example: C

```
unsigned char buffer[512];

// Read the MBR of the internal SD card
short n = sys_bdev_read(BDEV_SD1, 0, buffer, 512);
```

Example: Assembler

```
pei #512    ; Push the size of the buffer
pei #'buffer ; Push the pointer to the read buffer
pei #<>buffer
pei #0      ; Push LBA = 0
pei #0
lda #1      ; The device number for the internal SD

jsl sys_bdev_read ; Read sector 0

ply        ; Clean up the stack
ply
ply
ply
ply
```

sys_bdev_write – 0xFFE068

Write a block from a block device. Returns the number of bytes written.

| | |
|-----------|---|
| Prototype | short sys_bdev_write(short dev, long lba, const uint8_t * buffer, short size) |
| dev | the number of the device |
| lba | the logical block address of the block to write |
| buffer | the buffer containing the data to write |
| size | the size of the buffer. |
| Returns | number of bytes written, any negative number is an error code |

Example: C

```
unsigned char buffer[512];

// Fill in the buffer with data...

// Write the MBR of the internal SD card
short n = sys_bdev_write(BDEV_SD1, 0, buffer, 512);
```

Example: Assembler

```
pei #512    ; Push the size of the buffer
pei #'buffer ; Push the pointer to the read buffer
pei #<>buffer
pei #0      ; Push LBA = 0
pei #0
lda #1      ; The device number for the internal SD
```

```

jsl sys_bdev_write ; Write sector 0

ply      ; Clean up the stack
ply
ply
ply
ply

```

sys_bdev_status – 0xFFE06C

Gets the status of a block device. The meaning of the status bits is device specific, but there are two bits that are required in order to support the file system:

- 0x01: Device has not been initialized yet
- 0x02: Device is present

| | |
|-----------|---|
| Prototype | short sys_bdev_status(short dev) |
| dev | the number of the device |
| Returns | the status of the device |

Example: C

```

short bdev = ...; // The device number
short status = sys_bdev_status(bdev);

```

Example: Assembler

```

lda bdev      ; Load the device number
jsl sys_bdev_flush ; Attempt to flush pending writes

; Status is in the accumulator

```

sys_bdev_flush – 0xFFE070

Ensure any pending writes to a block device are completed.

| | |
|-----------|--|
| Prototype | short sys_bdev_flush(short dev) |
| dev | the number of the device |
| Returns | 0 on success, any negative number is an error code |

Example: C

```

short bdev = ...; // The device number
sys_bdev_flush(bdev);

```

Example: Assembler

```

lda bdev      ; Load the device number
jsl sys_bdev_flush ; Attempt to flush pending writes

```

sys_bdev_ioctl – 0xFFE074

Send a command to a block device. The mapping of commands and their actions are device-specific. The return value is also device and command-specific.

Four commands should be supported by all devices:

- GET_SECTOR_COUNT (1): Returns the number of physical sectors on the device
- GET_SECTOR_SIZE (2): Returns the size of a physical sector in bytes
- GET_BLOCK_SIZE (3): Returns the block size of the device. Really only relevant for flash devices and only needed by FatFS
- GET_DRIVE_INFO (4): Returns the identification of the drive

| | |
|-----------|---|
| Prototype | short sys_bdev_ioctl(short dev, short command, uint8_t * buffer, short size) |
| dev | the number of the device |
| command | the number of the command to send |
| buffer | pointer to bytes of additional data for the command |
| size | the size of the buffer |
| Returns | 0 on success, any negative number is an error code |

Example: C

```
short dev = ...; // The device number
short cmd = ...; // The command
short r = sys_bdev_ioctl(dev, cmd, 0, 0); // Send simple command
```

Example: Assembler

```
pei #0                ; Push buffer size of 0
pei #0                ; Push null pointer for buffer
pei #0
lda cmd               ; Push the command number
pha
lda bdev              ; Select the block device

jsl sys_bdev_ioctl    ; Send the command

ply                  ; Clean up the stack
ply
ply
```

3.5 File System Functions

sys_fsopen – 0xFFE078

Attempt to open a file in the file system for reading or writing. Returns a channel number associated with the file. If the returned number is negative, there was an error opening the file.

The mode parameter indicates how the file should be open and is a bitfield, where each bit has a separate meaning:

- 0x01: Read

- 0x02: Write
- 0x04: Create if new
- 0x08: Always create
- 0x10: Open file if it exists, otherwise create
- 0x20: Open file for appending

| | |
|-----------|--|
| Prototype | short sys_fsys_open(const char * path, short mode) |
| path | the ASCIIZ string containing the path to the file. |
| mode | the mode (e.g. r/w/create) |
| Returns | the channel ID for the open file (negative if error) |

Example: C

```

short chan = sys_fsys_open("hello.txt", 0x01);
if (chan > 0) {
    // File is open for reading
} else {
    // File was not open... chan has the error number
}

```

Example: Assembler

```

pei #1                ; Push

ldx #'path            ; Point to the path
lda #<>path

jsl sys_fsys_open     ; Try to open the file

ply                  ; Clean up the stack

bit #$ffff           ; Check to see if we opened the file
bmi error

; File is open for reading

error:

; There was an error
; The error number is in the accumulator

path:
.null "hello.txt"

```

sys_fsys_close – 0xFFE07C

Close a file that was previously opened, given its channel number. If there were writes done on the channel, those writes will be committed to the block device holding the file.

| | |
|-----------|---|
| Prototype | short sys_fsyclose(short fd) |
| fd | the channel ID for the file |
| Returns | 0 on success, negative number on failure |

Example: C

```

short chan = sys_fsyclose(...);
// ...
sys_fsyclose(chan);

```

Example: Assembler

```

lda chan
jsl sys_fsyclose

```

sys_fsycendir – 0xFFE080

Open a directory on a volume for reading, given its path. Returns a directory handle number on success, or a negative number on failure.

| | |
|-----------|--|
| Prototype | short sys_fsycendir(const char * path) |
| path | the path to the directory to open |
| Returns | the handle to the directory if $\neq 0$. An error if $\neq 0$ |

Example: C

```

short dir = sys_fsycendir("/sd0/System");
if (dir > 0) {
    // dir can be used for reading the directory entries
} else {
    // There was an error... error number in dir
}

```

Example: Assembler

```

ldx #'path                ; Point to the path
lda #<>path

jsl sys_fsycendir          ; Try to open the directory

bit #$ffff                ; Check to see if we opened the directory
bmi error

    ; Directory is open for reading

error:

    ; There was an error
    ; The error number is in the accumulator

path:
    .null "/sd0/System"

```

sys_fs_sys_closedir – 0xFFE084

Close a previously open directory, given its number.

| | |
|-----------|---|
| Prototype | short sys_fs_sys_closedir(short dir) |
| dir | the directory handle to close |
| Returns | 0 on success, negative number on error |

Example: C

```
short dir = ... // Number of the directory to close
sys_fs_sys_closedir(dir);
```

Example: Assembler

```
lda dir                ; Get the number of the directory to close
jsl sys_fs_sys_closedir ; Close the directory
```

sys_fs_sys_readdir – 0xFFE088

Given the number of an open directory, and a buffer in which to place the data, fetch the file information of the next directory entry. (See below for details on the `file_info` structure.)

Returns 0 on success, a negative number on failure.

| | |
|-----------|--|
| Prototype | short sys_fs_sys_readdir(short dir, p_file_info file) |
| dir | the handle of the open directory |
| file | pointer to the t_file_info structure to fill out. |
| Returns | 0 on success, negative number on failure |

Example: C

```
short dir = sys_fs_sys_opendir("/sd0/System");
if (dir > 0) {
    // dir can be used for reading the directory entries
    struct s_file_info file;
    if (sys_fs_sys_readdir(dir, &file_info) == 0) {
        // file_info contains information...
    } else {
        // Could not read the file entry...
    }
} else {
    // There was an error... error number in dir
}
```

Example: Assembler

```
ldx #'path                ; Point to the path
lda #<>path

jsl sys_fs_sys_opendir     ; Try to open the directory

bit #$ffff                ; Check to see if we opened the directory
bmi error
```

```

; Directory is open for reading

sta dir                ; Save the directory number

pei #'file_info        ; Set the pointer to the file info
pei #<>file_info

; Directory number is already in A

jsl sys_fsys_readdir   ; Try to read from the directory

ply                    ; Clean up the stack
ply

bit #$ffff             ; If result is <0, there is an error
bmi error

; Entry is loaded into structure at file_info

error:

; There was an error
; The error number is in the accumulator

path:
.null "/sd0/System"
file_info:
.dstruct s_file_info

```

sys_fsys_findfirst – 0xFFE08C

Given the path to a directory to search, a search pattern, and a pointer to a **file_info** structure, return the first entry in the directory that matches the pattern.

Returns a directory handle on success, a negative number if there is an error

| | |
|-----------|---|
| Prototype | short sys_fsys_findfirst(const char * path, const char * pattern, p_file_info file) |
| path | the path to the directory to search |
| pattern | the file name pattern to search for |
| file | pointer to the t_file_info structure to fill out |
| Returns | error if negative, otherwise the directory handle to use for subsequent calls |

Example: C

```

struct s_file_info file;
short dir = sys_fsys_findfirst("/hd0/System/", "*.pgx", &file.info);
if (dir == 0) {
    // file_info contains information...
} else {
    // Could not read the file entry...
}

```

Example: Assembler

```
pei #'file_info          ; Point to the file_info
pei #<>file_info

pei #'pattern            ; Point to the search pattern
pei #<>pattern

ldx #'path               ; Point to the directory to search
lda #<>path

jsl sys_fsys_findfirst   ; Try to find the first match

ply                      ; Clean up the stack
ply
ply
ply

bit #$ffff               ; Check to see if error (negative)
bmi error

; File info should contain the first match

error:

; There was an error

file_info:
.dstruct s_file_info
pattern:
.null "*.pgx"
path:
.null "/sd0/System"
```

sys_fsys_findnext – 0xFFE090

Given the directory handle for a previously open search (from `sys_fsys_findfirst`), and a `file_info` structure, fill out the structure with the file information of the next file to match the original search pattern.

Returns 0 on success, a negative number if there is an error

| | |
|-----------|--|
| Prototype | short sys_fsys_findnext(short dir, p_file_info file) |
| dir | the handle to the directory (returned by <code>fsys_findfirst</code>) to search |
| file | pointer to the <code>t_file_info</code> structure to fill out |
| Returns | 0 on success, error if negative |

Example: C

```
struct s_file_info file;
short dir = sys_fsys_findfirst("/hd0/System/", "*.pgx", &file_info);
if (dir == 0) {
    // file_info contains information...

    // Look for the next...
```

```

    short result = sys_fsys_findnext(dir, &file.info);

} else {
    // Could not read the file entry...
}

```

Example: Assembler

```

    pei #'file_info          ; Point to the file_info
    pei #<>file_info

    pei #'pattern           ; Point to the search pattern
    pei #<>pattern

    ldx #'path              ; Point to the directory to search
    lda #<>path

    jsl sys_fsys_findfirst  ; Try to find the first match

    ply                    ; Clean up the stack
    ply
    ply
    ply

    bit #$ffff             ; Check to see if error (negative)
    bmi error

    sta dir                ; Save the open directory number

    ; File info should contain the first match

    ; ...

    ; Find the next

    pei #'file_info          ; Point to the file_info
    pei #<>file_info

    lda dir                ; Get the directory number

    jsl sys_fsys_findnext   ; Try to find the next match

    ply                    ; Clean up the stack
    ply

    bit #$ffff             ; Check to see if error
    bmi error

    ; File info should contain next match

error:

```

```

        ; There was an error

file_info:
    .dstruct s_file_info
pattern:
    .null "*.pgx"
path:
    .null "/sd0/System"

```

sys_fsys_get_label – 0xFFE094

Get the label of a volume.

| | |
|-----------|---|
| Prototype | short sys_fsys_get_label(const char * path, char * label) |
| path | path to the drive |
| label | buffer that will hold the label... should be at least 35 bytes |
| Returns | 0 on success, error if negative |

Example: C

```

char label[64];
short result = sys_fsys_get_label("/sd0", label);

```

Example: Assembler

```

pei #'label                ; Point to the label buffer
pei #<>label

ldx #'path                 ; Point to the path of the drive
lda #<>path

jsl sys_fsys_get_label     ; Attempt to get the label

ply                        ; Clean the stack
ply

bit #$ffff                ; Check for an error
bmi error

        ; We should have the label filled

error:

        ; There was an error

path:
    .null "/sd0"
label:
    .fill 64

```

sys_fsys_set_label – 0xFFE098

Set the label of a volume.

| | |
|-----------|---|
| Prototype | short sys_fsys_set_label(short drive, const char * label) |
| drive | drive number |
| label | buffer that holds the label |
| Returns | 0 on success, error if negative |

Example: C

```
short result = sys_fsys_set_label(0, "FNXSD0");
```

Example: Assembler

```
pei #'label          ; Point to the label
pei #<>label

lda #0                ; Set the volume number

jsl sys_fsys_set_label ; Attempt to set the label

ply                   ; Clean the stack
ply

bit #$ffff            ; Check for an error
bmi error

; We should have the label updated

error:

; There was an error

label:
.null "FNXSD0"
```

sys_fsys_mkdir – 0xFFE09C

Create a directory.

| | |
|-----------|--|
| Prototype | short sys_fsys_mkdir(const char * path) |
| path | the path of the directory to create. |
| Returns | 0 on success, negative number on failure. |

Example: C

```
short result = sys_fsys_mkdir("/sd0/Samples");
```


Example: Assembler

```
ldx #'path
lda #<>path

jsl sys_fsys_mkdir ; Attempt to create the directory

bit #$ffff ; Check for an error
bmi error

; Directory should be created

error:

; There was an error

path:
.null "/sd0/Samples"
```

sys_fsys_delete – 0xFFE0A0

Delete a file or directory, given its path. Returns 0 on success, a negative number if there is an error

| | |
|-----------|---|
| Prototype | short sys_fsys_delete(const char * path) |
| path | the path of the file or directory to delete. |
| Returns | 0 on success, negative number on failure. |

Example: C

```
short result = sys_fsys_delete("/sd0/test.txt");
```

Example: Assembler

```
ldx #'path ; Point to the path to delete
lda #<>path

jsl sys_fsys_delete ; Try to delete the file
bit #$ffff
bmi error

; File was deleted...

error:

; There was an error

path:
.null "/sd0/test.txt"
```

sys_fsys_rename – 0xFFE0A4

Rename a file or directory. Returns 0 on success, a negative number if there is an error

| | |
|-----------|---|
| Prototype | short sys_fsys_rename(const char * old_path, const char * new_path) |
| old_path | the current path to the file |
| new_path | the new path for the file |
| Returns | 0 on success, negative number on failure. |

Example: C

```
short result = sys_fsys_rename("/sd0/test.txt", "doc.txt");
```

Example: Assembler

```
pei #'new_path      ; Push the pointer to the new name
pei #<>new_path

ldx #'old_path      ; Point to the original file name
lda #<>old_path

jsl sys_fsys_rename ; Try to rename the file the file

ply                ; Clean up the stack
ply

bit #$ffff         ; Check for an error
bmi error

; File was named...

error:

; There was an error

old_path:
.null "/sd0/test.txt"
new_path:
.null "doc.txt"
```

sys_fsys_load – 0xFFE0B0

Load a file into memory. This function can either load a file into a specific address provided by the caller, or to the loading address specified in the file (for executable files). For executable files, the function will also return the starting address specified in the file.

| | |
|-------------|---|
| Prototype | short sys_fsys_load(const char * path, uint32_t destination, uint32_t * start) |
| path | the path to the file to load |
| destination | the destination address (0 for use file's address) |
| start | pointer to the long variable to fill with the starting address |
| Returns | 0 on success, negative number on error |

Example: C

```
uint32_t start;
short result = sys_fsys_load("hello.pgx", 0, &start);
```

Example: Assembler

```
pei #'start          ; Push the pointer to the start variable
pei #<>start

pei #0               ; Push 0 to leave a load address unspecified
pei #0

ldx #'path           ; Point to the file name
lda #<>path

jsl sys_fsys_load    ; Try to rename the file the file

ply                  ; Clean up the stack
ply
ply
ply

bit #$ffff           ; Check for an error
bmi error

; File was loaded

error:

; There was an error

path:
.null "hello.pgx"
start:
.dword ?
```

sys_fsys_register_loader – 0xFFE0B4

Register a file loader for a binary file type. A file loader is a function that takes a channel number for a file to load, a long representing the destination address, and a pointer to a long for the start address of the program. These last two parameters are the same as are provided the `sys_fsys_load`.

On success, returns 0. If there is an error in registering the loader, returns a negative number.

| | |
|-----------|---|
| Prototype | short sys_fsys_register_loader(const char * extension, p_file_loader loader) |
| extension | the file extension to map to |
| loader | pointer to the file load routine to add |
| Returns | 0 on success, negative number on error |

Example: C

```
short foo_loader(short chan, uint32_t destination, uint32_t * start) {
    // Load file to destination (if provided)
    // If executable, set start to address to run
    return 0; // If successful
};
// ...
short result = sys_fsys_register_loader("F00", foo_loader);
```

sys_fsstat – 0xFFE0B8

Check to see if a file is present. The `s_file_info` structure will be populated if the file is found. Returns 0 on success or a negative number on an error.

| | |
|-----------|--|
| Prototype | <code>short sys_fsstat(const char * path, p_file_info file)</code> |
| path | the path to the file to check |
| file | pointer to a file info record to fill in, if the file is found. |
| Returns | 0 on success, negative number on error |

Example: C

```
s_file_info file_info;
short result = sys_fsstat("/sd0/fnxboot.pgx", &file_info);
```

3.6 Text System Functions

Many programs will likely use the console channel device and the `sys_chan_write` call to print most things to the screen, but there are certain operations that a program might need to carry out that do not fit well with the channel device. Also, programs may want lower level control over the text screen. These functions are part of the text block of functions.

Functions in this block allow a program to find out what kinds of text modes the screen is capable of, change the size of the display text, manipulate the cursor and the border of the screen, and even change the font and display colors. Additionally, the text functions also provide for “regions” which may be used to create simple text windows—smaller rectangles on the screen where printing will go, leaving other portions of the text screen unchanged.

The F256 supports only the one screen, but the text system functions were written with support for multiple screens in mind. All text functions take a screen number. For the F256 as of the time of this writing, that number will always be 0. If at some point, an F256 with multi-screen support is created or a graphics expansion card is produced, that additional screen could be supported by the Toolbox with the addition of a text mode driver.

sys_txt_get_capabilities – 0xFFE0E4

Gets the description of a screen’s capabilities. The capabilities are returned as a pointer to a structure that provides a bitfield of the various modes supported, a listing of different font sizes that are supported (the F256 currently supports only 8 by 8 fonts), and a listing of different screen resolutions supported by the screen.

```
struct s_txt_capabilities {
    short number; /* The unique ID of the screen */
    short supported_modes; /* The display modes supported on this screen */
    short font_size_count; /* The number of supported font sizes */
    p_extent font_sizes; /* Pointer to a list of t_extent listing all supported font sizes */
    short resolution_count; /* The number of supported display resolutions */
    p_extent resolutions; /* Pointer to a list of t_extent for supported resolutions (in pixels) */
}
```

| | |
|-----------|--|
| Prototype | <code>const p_txt_capabilities sys_txt_get_capabilities(short screen)</code> |
| screen | the number of the text device |
| Returns | a pointer to the read-only description (0 on error) |

sys_txt_set_mode – 0xFFE0E4

Set the display mode of the screen. There are five basic modes supported which are indicated by the five flags:

- `TXT_MODE_TEXT`—Render base text
- `TXT_MODE_BITMAP`—Render bitmap graphics
- `TXT_MODE_TILE`—Render tilesets
- `TXT_MODE_SPRITE`—Render sprites
- `TXT_MODE_SLEEP`—Puts the monitor in power-saving mode by turning off the sync signals

These flags are returned in the `supported_modes` field of the `t_txt_capabilities` structure returned by `sys_txt_get_caps`, and they may be combined to mix the different rendering engines if supported by the hardware (for instance, `TXT_MODE_TEXT | TXT_MODE_SPRITE` would combine text and sprites). `TXT_MODE_SLEEP` will over-ride all the other modes.

The result of turning off all the mode flags is system dependent, but should result in a blank screen without putting the monitor into sleep mode.

Returns 0 on success, any other number means the mode was invalid for the screen or the screen was invalid.

| | |
|-----------|---|
| Prototype | short sys_txt_set_mode(short screen, short mode) |
| screen | the number of the text device |
| mode | a bitfield of desired display mode options |
| Returns | 0 on success, any other number means the mode is invalid for the screen |

Example: C

```
// Set screen 0 to text and tiles
short result = sys_txt_set_mode(0, TXT_MODE_TEXT | TXT_MODE_TILE);
if (result) {
    // Handle the error
}
```

Example: Assembler

```
pei #(TXT_MODE_TEXT | TXT_MODE_TILE)    ; Turn on text and tile modes
lda #0                                  ; On screen 0

jsl sys_txt_set_mode

ply                                     ; Clean up the stack
```

sys_txt_set_resolution – 0xFFE0E8

Set the display resolution of the screen. The width and height must match one of the resolutions listed in the screen's capabilities.

| | |
|-----------|--|
| Prototype | short sys_txt_set_resolution(short screen, short width, short height) |
| screen | the number of the text device |
| width | the desired horizontal resolution in pixels |
| height | the desired veritical resolution in pixels |
| Returns | 0 on success, any other number means the mode is invalid for the screen |

Example: C

```
// Set screen 0 resolution to (320, 240)
short result = sys_txt_set_resolution(0, 320, 240);
```

Example: Assembler

```
pei #240          ; Resolution: 320 by 240
pei #320
lda #0            ; On screen 0

jsl sys_txt_set_mode

ply              ; Clean up the stack
ply
```

sys_txt_set_xy – 0xFFE0F0

Sets the position of the cursor on the screen.

The call takes the number of the screen and the character row (y) and column (x) of the cursor. The cursor positions are specified relative to the origin of the current region set on the screen, so (0, 0) will be the origin of the region, (0, 1) will be the character position right below the origin, and so on.

| | |
|-----------|--|
| Prototype | void sys_txt_set_xy(short screen, short x, short y) |
| screen | the number of the text device |
| x | the column for the cursor |
| y | the row for the cursor |

Example: C

```
// Move the cursor to the home position in the current region
sys_txt_set_xy(0, 0, 0);
```

Example: Assembler

```
pei #0          ; Set y = 0
pei #0          ; Set x = 0
lda #0          ; Screen 0

jsl sys_txt_set_xy ; Set the position

ply          ; Clean up the stack
ply
```

sys_txt_get_xy – 0xFFE0F4

Gets the position of the text cursor, given two parameters: the screen number, and the pointer to a **t_point**. The cursor position will be copied into the **t_point** object.

| | |
|-----------|--|
| Prototype | void sys_txt_get_xy(short screen, p_point position) |
| screen | the number of the text device |
| position | pointer to a t_point record to fill out |

Example: C

```
// Get the cursor position
t_point position;
sys_txt_get_xy(0, &position);
```

Example: Assembler

```
pei #'position      ; Pointer to the position object
pei #<>position

lda #0              ; Screen 0

jsl sys_txt_get_xy  ; Get the cursor position

ply                ; Clean up the stack
ply
```

```
position:
    .dstruct s_position
```

sys_txt_get_region – 0xFFE0F8

Gets the origin and size of the rectangle describing the current region.

The call takes a screen number and a pointer to a **t_rect** structure to fill out with the current information. Returns 0 on success, any other number is an error.

| | |
|-----------|---|
| Prototype | short sys_txt_get_region(short screen, p_rect region) |
| screen | the number of the text device |
| region | pointer to a t_rect describing the rectangular region (using character cells for size and size) |
| Returns | 0 on success, any other number means the region was invalid |

Example: C

```
// Get the current region
t_rect region;
sys_txt_get_region(0, &region);
```

Example: Assembler

```
pei #'region        ; Pointer to the position object
pei #<>region

lda #0              ; Screen 0

jsl sys_txt_get_region ; Get the current region

ply                ; Clean up the stack
ply
```

```
region:
    .dstruct s_rect
```

sys_txt_set_region – 0xFFE0FC

Sets the rectangular region of the screen that will be used for all subsequent printing, scrolling, and filling. This call takes the screen number and a pointer to a `t_rect` structure containing the origin (upper-left corner) and the size (width and height) of the region. These values are specified in character cells, with (0, 0) being the upper-left corner of the screen. If the size of the rectangle is 0 (width = height = 0), then the region will be the full screen.

Returns 0 on success, any other number is an error.

| | |
|-----------|--|
| Prototype | short sys_txt_set_region(short screen, p_rect region) |
| screen | the number of the text device |
| region | pointer to a <code>t_rect</code> describing the rectangular region (using character cells for size and size) |
| Returns | 0 on success, any other number means the region was invalid |

Example: C

```
// Set the region to a 5x5 panel in the upper left
t_rect region;
region.origin.x = 0;
region.origin.y = 0;
region.size.width = 5;
region.size.height = 5;
short result = sys_txt_set_region(0, &region);
if (result) {
    // Handle the error
}
```

Example: Assembler

```
pei #'region          ; Pointer to the position object
pei #<>region

lda #0                ; Screen 0

jsl sys_txt_set_region ; Set the new region

ply                  ; Clean up the stack
ply

region:
    .word 0, 0, 5, 5
```

sys_txt_set_color – 0xFFE100

Set the foreground and background color to use for subsequent prints to the screen. Takes the screen number and the color indexes for foreground and background colors (0 – 15). Returns 0 on success, any other number is an error.

| | |
|------------|---|
| Prototype | void sys_txt_set_color(short screen, unsigned char foreground, unsigned char background) |
| screen | the number of the text device |
| foreground | the Text LUT index of the new current foreground color (0 - 15) |
| background | the Text LUT index of the new current background color (0 - 15) |

Example: C

```
// Set the text color to cyan on black (in standard colors)
sys_txt_set_color(0, 6, 0);
```

Example: Assembler

```
pei #0                ; Background to black
pei #6                ; Foreground to cyan

lda #0                ; Screen 0

jsl sys_txt_set_color ; Set the text color

ply                  ; Clean up the stack
ply
```

sys_txt_get_color – 0xFFE104

Gets the current foreground and background color settings. Takes the screen number and two pointers: one for the foreground color value, and one for the background color value. Returns 0 on success, any other number is an error.

| | |
|------------|---|
| Prototype | void sys_txt_get_color(short screen, unsigned char * foreground, unsigned char * background) |
| screen | the number of the text device |
| foreground | the Text LUT index of the new current foreground color (0 - 15) |
| background | the Text LUT index of the new current background color (0 - 15) |

Example: C

```
// Gets the text color for the screen
short foreground = 0;
short background = 0;
if (sys_txt_get_color(0, &foreground, &background)) {
    // Handle error
}
```

Example: Assembler

```
pei #'background      ; Push address of background variable
pei #<>background

pei #'foreground      ; Push address of foreground variable
pei #<>foreground

lda #0                ; Screen 0

jsl sys_txt_get_color ; Get the color

ply                  ; Clean up the stack
ply
ply
```

```

ply
; ...

foreground:
.word ?
background:
.word ?

```

sys_txt_set_cursor – 0xFFE108

Set the appearance of the text mode cursor.

| | |
|-----------|---|
| Prototype | void sys_txt_set_cursor(short screen, short enable, short rate, char c) |
| screen | the screen number |
| enable | 0 to hide, any other number to make visible |
| rate | the blink rate for the cursor (0=1s, 1=0.5s, 2=0.25s, 3=1/5s) |
| char | the character in the current font to use as a cursor |

Example: C

```

// Set the cursor on screen 0
// Visible, blink period 0.25s, character @
sys_txt_set_cursor(0, 1, 2, '@');

```

Example: Assembler

```

pei #'@' ; Cursor character @
pei #2   ; Blink period 0.25s
pei #1   ; Show the cursor
lda #0   ; Screen 0

jsl sys_txt_set_cursor

ply      ; Clean the stack
ply
ply

```

sys_txt_set_cursor_visible – 0xFFE10C

Sets the visibility of the text cursor.

| | |
|------------|---|
| Prototype | void sys_txt_set_cursor_visible(short screen, short is_visible) |
| screen | the screen number |
| is_visible | TRUE if the cursor should be visible, FALSE (0) otherwise |

Example: C

```

// Hide the cursor on screen 0
sys_txt_set_cursor_visible(0, 0);

```

Example: Assembler

```
pei #0      ; Hide the cursor
lda #0      ; Screen 0

jsl sys_txt_set_cursor_visible

ply        ; Clean the stack
```

sys_txt_set_font – 0xFFE110

Set the font to be used in text mode on the screen. Takes the screen number, the width and height of the characters (in pixels), and a pointer to the actual font data. Returns 0 on success, any other number means the screen is invalid, or the font size is invalid.

NOTE: the font size must be listed in the `font_sizes` field of the `t_txt_capabilities` structure returned by `sys_txt_get_caps`.

| Prototype | short sys_txt_set_font(short screen, short width, short height, unsigned char * data) |
|-----------|---|
| screen | the number of the text device |
| width | width of a character in pixels |
| height | of a character in pixels |
| data | pointer to the raw font data to be loaded |

Example: C

```
// Set the font of screen 0 to an 8x8 font
unsigned char * font_data;
font_data = ...;
short result = sys_txt_set_font(0, 8, 8, font_data);
if (result) {
    // Handle error
}
```

Example: Assembler

```
pei #'font_data      ; Push pointer to the font data
pei #<>font_data

pei #8               ; Push size of 8x8
pei #8

lda #0              ; Screen 0

jsl sys_txt_set_font ; Set the font

ply                ; Clean up the stack
ply
ply
ply
```

sys_txt_setsizes – 0xFFE0EC

Sets the text screen device driver to the current screen geometry, based on the display resolution and border size. If a program changes the border or display resolution on its own but still needs to use the Toolbox console or text routines to display text, it should call this function to have the Toolbox recalculate the screen geometry.

| | |
|-----------|--|
| Prototype | void sys_txt_setsizes(short screen) |
| screen | the number of the text device |

Example: C

```
// Recalculate geometry of screen 0
sys_txt_setsizes(0);
```

Example: Assembler

```
lda #0
jsl sys_txt_setsizes
```

sys_txt_get_sizes – 0xFFE114

Gets the size of the screen in total pixels (not taking the border into consideration) and visible characters (taking the border into account).

NOTE: **text_size** and **pixel_size** can be null (0), in which case that structure will not be filled out, so you do not have to provide a **t_extent** for a measurement you do not need.

| | |
|------------|--|
| Prototype | void sys_txt_get_sizes(short screen, p_extent text_size, p_extent pixel_size) |
| screen | the screen number |
| text_size | the size of the screen in visible characters (may be null) |
| pixel_size | the size of the screen in pixels (may be null) |

Example: C

```
// Hide the cursor on screen 0
t_rect text_matrix;
t_rect pixel_matrix;
sys_txt_get_sizes(0, &text_matrix, &pixel_matrix);
```

Example: Assembler

```
pei #'pixel_matrix      ; Push pointer to pixel extent
pei #<>pixel_matrix

pei #'text_matrix       ; Push pointer to text extent
pei #<>text_matrix

lda #0

jsl sys_txt_get_sizes   ; Get the sizes

ply                     ; Clean up the stack
ply
```

```

ply
ply

; ...

pixel_matrix:          ; Holds size of screen in pixels
    .dstruct s_extent
text_matrix:          ; Holds size of screen in characters
    .dstruct s_extent

```

sys_txt_set_border – 0xFFE118

Sets the size of the border around the screen. Takes the number of the screen and the size of the border width and height. In this context, width is the width of the left and right borders taken separately, and height is the height of the top and bottom borders. So if width is 8 and height is 16, 32 lines will be taken up by the top and bottom borders together, and 16 columns will be taken up by the left and right borders.

NOTE: if the width and height of the borders are 0, the border will be disabled.

| Prototype | void sys_txt_set_border(short screen, short width, short height) |
|-----------|---|
| screen | the number of the text device |
| width | the horizontal size of one side of the border (0 - 32 pixels) |
| height | the vertical size of one side of the border (0 - 32 pixels) |

Example: C

```

// Set the border on screen 0: width of 16, height of 8
sys_txt_set_border(0, 16, 8);

```

Example: Assembler

```

pei #8                ; 8 pixels vertically
pei #16               ; 16 pixels horizontally

lda #0                ; Screen 0

jsl sys_txt_set_border ; Set the border size

ply                  ; Clean up the stack
ply

```

sys_txt_set_border_color – 0xFFE11C

Set the color of the border, using red, green, and blue components (which may go from 0 to 255).

| Prototype | void sys_txt_set_border_color(short screen, unsigned char red, unsigned char green, unsigned char blue) |
|-----------|--|
| screen | the number of the text device |
| red | the red component of the color (0 - 255) |
| green | the green component of the color (0 - 255) |
| blue | the blue component of the color (0 - 255) |

Example: C

```
// Set the border of screen 0 to dark blue
sys_txt_set_border_color(0, 0, 0, 128);
```

Example: Assembler

```
pei #128          ; Push blue
pei #0            ; Push green
pei #0            ; Push red

lda #0            ; Screen 0

jsl sys_txt_set_border ; Set the border color

ply              ; Clean up the stack
ply
ply
```

sys_txt_put – 0xFFE120

Print a character to the screen.

NOTE: No this function does not interpret ANSI terminal codes and will display the characters corresponding to those bytes on the screen. To print with ANSI terminal code support, use the console channel device.

| | |
|-----------|---|
| Prototype | void sys_txt_put(short screen, char c) |
| screen | the number of the text device |
| c | the character to print |

Example: C

```
// Print 'A' to the screen
sys_txt_put(0, 'A');
```

Example: Assembler

```
pei #'A'          ; Push the character
lda #0            ; Screen 0

jsl sys_txt_put ; Print the character

ply              ; Clean up the stack
```

sys_txt_print – 0xFFE124

Print a null-terminated ASCII string to the screen.

NOTE: No this function does not interpret ANSI terminal codes and will display the characters corresponding to those bytes on the screen. To print with ANSI terminal code support, use the console channel device.

| | |
|-----------|---|
| Prototype | void sys_txt_print(short screen, const char * message) |
| screen | the number of the text device |
| message | the ASCII Z string to print |

Example: C

```
// Print a message to the screen
sys_txt_print(0, "Hello, Foenix!\n");
```

Example: Assembler

```
pei #'message      ; Push pointer to message
pei #<>message

lda #0             ; Screen 0

jsl sys_txt_print  ; Print the message

ply               ; Clean up the stack
ply

; ...

message:
    .null "Hello, Foenix!\n"
```

3.7 Interrupt Functions

Interrupts in the Toolbox are managed at a device level. The F256 includes an interrupt controller which assigns a different interrupt to each device that can raise an interrupt. The interrupt controller provides for separate masking and interrupt flags for each device interrupt. The Toolbox allows programs to register an interrupt handler for the specific device-level interrupt the program needs to handle. That handler is just a regular subroutine (it should not be coded so as to return with an RTI instruction). The Toolbox will take care of checking the various interrupt controller registers to determine which interrupts are currently pending and will call the associated interrupt handler automatically. The Toolbox will also take care to save register states to avoid interfering with the currently running program.

On the F256, interrupts are arranged into three groups, with each interrupt getting a bit within one of the groups in each of the control registers for that group. For instance, the start of frame interrupt (vertical blank interrupt) is the least significant bit of group 0. The Foenix Toolbox, on the other hand, assigns a single number to each interrupt and internally maps that number to the appropriate group and bit. When enabling or disabling an interrupt or when registering an interrupt handler, it is this internal interrupt number that is used.¹

In addition to controlling interrupts at a device level (*e.g.* the serial port interrupt), the Toolbox also has routines to allow a program to enable or disable IRQ processing at the CPU level. The `int_enable_all`, `int_disable_all`, and `int_restore_all` functions work at the CPU level and do not affect the mask bits in the F256's interrupt controller. The `int_enable` and `int_disable` functions work at the level of the individual device interrupt in the interrupt controller.

In some situations, the overhead required by the Toolbox to process interrupts may cause problems. If that is the case, there is a way to override the usual processing and hand control over to the interrupt handler earlier. There are two 32-bit vectors reserved:

```
uint32_t * irq_ram_vector = (uint32_t *)0x00fdec;
uint32_t * nmi_ram_vector = (uint32_t *)0x00fdf4;
```

¹The interrupt number assignments may seem arbitrary, but they are actually just inherited from Foenix MCP and the A2560s, where the interrupt number is essentially just the group and bit numbers packed into an 8-bit value.

| Hardware Group | Bit | Toolbox Number | Purpose |
|----------------|------|----------------|--------------------|
| 0 | 0x01 | 0x00 | Start of frame |
| | 0x02 | 0x01 | Start of line |
| | 0x04 | 0x10 | PS/2 Keyboard |
| | 0x08 | 0x12 | PS/2 Mouse |
| | 0x10 | 0x18 | Timer 0 |
| | 0x20 | 0x19 | Timer 1 |
| | 0x40 | — | Reserved |
| | 0x80 | 0x06 | External Expansion |
| 1 | 0x01 | 0x13 | Serial Port |
| | 0x02 | — | Reserved |
| | 0x04 | — | Reserved |
| | 0x08 | — | Reserved |
| | 0x10 | 0x1F | Real Time Clock |
| | 0x20 | 0x1D | VIA 0 |
| | 0x40 | 0x1E | VIA 1 (F256K) |
| | 0x80 | 0x22 | SD Card |
| 2 | 0x01 | — | Reserved |
| | 0x02 | — | Reserved |
| | 0x04 | — | Reserved |
| | 0x08 | — | Reserved |
| | 0x10 | — | Reserved |
| | 0x20 | — | Reserved |
| | 0x40 | — | Reserved |
| | 0x80 | 0x21 | SD Card Inserted |

Table 3.1: F256 Interrupt Assignments

By default, these vectors are set to 0, and they will be ignored by the Toolbox. If a program needs to take over the interrupt processing for either the IRQ or the NMI interrupt, it should set the appropriate vector to the address of a regular subroutine that will do its own determination of which interrupt needs to be processed. The Toolbox will check these vectors after saving all the registers that need to be restored after the interrupt is processed. If it sees a non-zero value in the vector, it will call the handler.

NOTE: both the low-level override handler and the standard interrupt handlers should be far call sub-routines that take no argument and returns no value.

sys_int_enable_all – 0xFFE004

This function enables all maskable interrupts at the CPU level. It returns a system-dependent code that represents the previous level of interrupt masking. Returns a machine dependent representation of the CPU interrupt mask state that can be used to restore the state later. Note: this does not change the mask status of interrupts in the machine's interrupt controller, it just changes if the CPU ignores IRQs or not.

| | |
|-----------|-----------------------------------|
| Prototype | short sys_int_enable_all() |
|-----------|-----------------------------------|

Example: C

```
// Enable processing of IRQs
short state = sys_int_enable_all();
```


Example: Assembler

```
; Enable processing of IRQs
jsl sys_int_enable_all
```

sys_int_disable_all – 0xFFE008

This function disables all maskable interrupts at the CPU level. It returns a system-dependent code that represents the previous level of interrupt masking. Returns a machine dependent representation of the CPU interrupt mask state that can be used to restore the state later. Note: this does not change the mask status of interrupts in the machine's interrupt controller, it just changes if the CPU ignores IRQs or not.

| | |
|-----------|------------------------------------|
| Prototype | short sys_int_disable_all() |
|-----------|------------------------------------|

Example: C

```
// Disable processing of IRQs
short state = sys_int_disable_all();
```

Example: Assembler

```
; Disable processing of IRQs
jsl sys_int_disable_all
```

sys_int_restore_all – 0xFFE00C

Restores

| | |
|-----------|--|
| Prototype | void sys_int_restore_all(short state) |
| state | the machine depended CPU interrupt state to restore |

Example: C

```
// Restore state of IRQ processing after enabling/disabling all
short state = ...;

sys_int_restore_all(state);
```

Example: Assembler

```
; Restore state of IRQ processing after enabling/disabling all
lda state
jsl sys_int_restore_all
```

sys_int_disable – 0xFFE010

This function disables a particular interrupt at the level of the interrupt controller. The argument passed is the number of the interrupt to disable.

| | |
|-----------|---|
| Prototype | void sys_int_disable(unsigned short n) |
| n | the number of the interrupt: n[7..4] = group number, n[3..0] = individual number. |

Example: C

```
// Disable the start-of-frame interrupt
sys_int_disable(INT_SOF_A);
```

Example: Assembler

```
lda #INT_SOF_A      ; Enable the start-of-frame interrupt
jsl sys_int_disable
```

sys_int_enable – 0xFFE014

This function enables a particular interrupt at the level of the interrupt controller. The argument passed is the number of the interrupt to enable. Note that interrupts that are enabled at this level will still be disabled, if interrupts are disabled globally by `sys_int_disable_all`.

| | |
|-----------|--|
| Prototype | void sys_int_enable(unsigned short n) |
| n | the number of the interrupt |

Example: C

```
// Enable the start-of-frame interrupt
sys_int_enable(INT_SOF_A);
```

Example: Assembler

```
lda #INT_SOF_A      ; Enable the start-of-frame interrupt
jsl sys_int_enable
```

sys_int_register – 0xFFE018

Registers a function as an interrupt handler. An interrupt handler is a function which takes and returns no arguments and will be run in at an elevated privilege level during the interrupt handling cycle.

The first argument is the number of the interrupt to handle, the second argument is a pointer to the interrupt handler to register. Registering a null pointer as an interrupt handler will “deregister” the old handler.

The function returns the handler that was previously registered.

| | |
|-----------|---|
| Prototype | p_int_handler sys_int_register(unsigned short n, p_int_handler handler) |
| n | the number of the interrupt |
| handler | pointer to the interrupt handler to register |
| Returns | the pointer to the previous interrupt handler |

Example: C

```
// Handler for the start-of-frame interrupt
// Must be a far sub-routine (returns through RTL)
__attribute__((far)) void sof_handler() {
    // Interrupt handler code here...
}

// Register a handler for the start-of-frame interrupt
p_int_handler old = sys_int_register(INT_SOF_A, sof_handler);
```

Example: Assembler

```
; Handler for the start-of-frame interrupt
; Must be a far sub-routine (returns through RTL)
sof_handler:
    ; Handler code here...
    rtl

    ; Code to register the handler...
    pei #'sof_handler      ; push pointer to sof_handler
    pei #<>sof_handler

    lda #INT_SOF_A         ; A = the number for the SOF_A interrupt

    js1 sys_int_register

    ply                    ; Clean up the stack
    ply

    sta old                ; Save the pointer to the old handler
    stx old+2
```

sys_int_pending – 0xFFE01C

Query an interrupt to see if it is pending in the interrupt controller. NOTE: User programs will probably never need to use this call, since it is handled by the Toolbox itself.

| | |
|-----------|---|
| Prototype | short sys_int_pending(unsigned short n) |
| n | the number of the interrupt: n[7..4] = group number, n[3..0] = individual number. |
| Returns | non-zero if interrupt n is pending, 0 if not |

Example: C

```
// Check to see if start-of-frame interrupt is pending
short is_pending = sys_int_pending(INT_SOF_A);
if (is_pending) {
    // The interrupt has not yet been acknowledged
}
```

Example: Assembler

```
; Check to see if the start-of-frame interrupt is pending
lda #INT_SOF_A
js1 sys_int_pending
cmp #0
beq sof_not_pending

; Code for when start-of-frame is pending

sof_not_pending:
```

sys_int_clear – 0xFFE024

This function acknowledges the processing of an interrupt by clearing its pending flag in the interrupt controller. NOTE: User programs will probably never need to use this call, since it is handled by the Toolbox itself.

| | |
|-----------|---|
| Prototype | void sys_int_clear(unsigned short n) |
| n | the number of the interrupt: n[7..4] = group number, n[3..0] = individual number. |

Example: C

```
// Acknowledge the processing of the start-of-frame interrupt
sys_int_clear(INT_SOF_A);
```

Example: Assembler

```
; Acknowledge the processing of the start-of-frame interrupt
lda #INT_SOF_A
jsl sys_int_clear
```

Chapter 4

F256 Toolbox Boot Process

The Toolbox does not really “do” anything once it has finished initializing the hardware. There is no CLI to use to enter commands, no GUI to use, not even a machine language monitor to fall into. To actually do something, the user needs to have executable code somewhere on one of the SD cards or in the cartridge. When the Toolbox finishes initializing the system, it will look in memory and in the SD cards for executable code. If it finds it, it will load and run the code. The exact process is fairly involved.

To begin with, the Toolbox has the notion of a “boot source,” which is really just a storage device that can hold the executable code. There are several boot sources: the internal SD card, the external SD card, a flash cartridge inserted into the expansion port, the parts of flash memory the Toolbox does not occupy, and finally (under certain conditions) the system RAM. To include the system RAM as a boot source, DIP switch 1 must be in the “ON” position. The Toolbox will scan each of the boot sources in a priority order.

1. If DIP switch 1 is ON, the system RAM is checked first.
2. If a flash cartridge is present, it is checked next.
3. If an SD card is present in the external slot, it is checked next.
4. The internal SD card is checked next.
5. Finally, the flash memory is checked.

For the two SD cards, the Toolbox is looking for an executable file in the root directory of the card—either `fnxboot.pgx` or `fnxboot.pgz`. For RAM, flash memory, and the expansion cartridge, the Toolbox is looking for a special header that contains a signature and specifies the starting address to run. For RAM, the entire memory from 0x00:0000 to the top of system RAM will be checked on 8KB alignment boundaries (that is, the header should be at 0x00:0000, or 0x00:2000, or 0x00:4000, *etc.*). For the cartridge, it should be at the start of the cartridge’s memory (0xF4:0000). For the flash memory, it should be at the start of the flash memory (0xF8:0000)¹.

The header for the executable code can be describe with this C structure:

```
struct boot_record_s {  
    char signature1;    // Needs to be $f8  
    char signature2;    // Needs to be $16  
    uint8_t version;    // Currently $00  
    uint32_t start_address; // Address to start executing (in little-endian format of the 65816)  
    uint32_t icon_address;  // Address of an icon to show (32x32 sprite data, use 0 for no icon)  
    uint32_t clut_address;  // Address of the palette for the icon in Vicky format (0 to use the default)  
    const char * name;    // A display name/command word for the program (not currently used)  
}
```

¹This may change in future.

- The header starts with the hexadecimal value 0xF816 in big-endian format (for Foenix 65816).
- The third byte is the version number, which is currently 0.
- The next four bytes are the address of the code to start executing (really a 24-bit pointer packed into 32-bits for convenience).
- The next four bytes are a pointer to the raw Vicky sprite bitmap data for an icon to show in the boot screen. If no icon is needed, this should be 0.
- The next four bytes are a pointer to the Vicky graphics CLUT data for the icon, to be copied into graphics CLUT 2. Again, if no CLUT needs to be provided, this should be 0. An icon may be provided without a CLUT, in which case the default graphics CLUT will be used.²
- The last four bytes are a pointer to a null-terminated ASCII string providing the name of this code. Currently, this is not being used, but it is intended to be the equivalent of a file name in terms of readability and possibly being used to select from multiple options, in later versions of the Toolbox.

²The default CLUT is the “Google” color palette from the Aseprite package.

Chapter 5

Extending the System

Foenix Toolbox is designed to be somewhat extensible. Since it is meant to be small and stay as much out of the way of the user programs as possible, Foenix Toolbox does not have all of the features that absolutely everyone will want. Therefore, there are four main ways that the user can extend the capabilities of Foenix Toolbox: channel device drivers, block device drivers, keyboard translation tables, and file loaders.

5.1 Channel Device Drivers

Channel device drivers provide the functions needed by Foenix Toolbox to support a channel opened on a device. With some exceptions, each channel system call is routed through the channel to the correct channel driver function. Channel drivers can be added to the system using the `sys_chan_register` call, specifying all of the relevant information about the driver using a structure:

```
typedef struct s_dev_chan {
    short number; // The number of the device (assigned by registration)
    char * name; // The name of the device
    short (*init)(); // Initialize the device
    short (*open)(p_channel chan, const uint8_t * path, short mode); // -- open a channel for the device
    short (*close)(p_channel chan); // Called when a channel is closed
    short (*read)(p_channel chan, uint8_t * buf, short size); // Read a a buf from the device
    short (*readline)(p_channel chan, uint8_t * buf, short size); // Read a line of text from the device
    short (*read_b)(p_channel chan); // -- read a single uint8_t from the device
    short (*write)(p_channel chan, const uint8_t * buf, short size); // Write a buf to the device
    short (*write_b)(p_channel chan, const uint8_t b); // Write a single uint8_t to the device
    short (*status)(p_channel chan); // Get the status of the device
    short (*flush)(p_channel chan); // Ensure that any pending writes to teh device have been completed
    short (*seek)(p_channel chan, long position, short base); // Attempt to move the "cursor" in the channel
    short (*ioctl)(p_channel chan, short cmd, uint8_t * buf, short size); // Issue a command to the device
} t_dev_chan, *p_dev_chan;
```

Where `p_channel` is a pointer to a channel structure, which maps an open channel to its device and provides space for the channel driver to store data relevant to that particular channel. The channel device drivers are passed this structure directly by the channel system calls, rather than the channel number used by user programs.

```
struct s_channel {
    short number; // The number of the channel
    short dev; // The number of the channel's device
    uint8_t data[32]; // A block of state data that the channel code can use for its own purposes
};
```

To implement a driver for a new channel device, all of the functions should be implemented (if a function is not needed, it should still be implemented but return a 0). Then a `s_chan_dev` structure should be allocated and filled out, with the number being the number of the device to support, and name points to a suitable name for the device.

Most of the functions needed are directly mapped to the channel system calls of the same name, and they simply perform the operations needed for those calls. Three functions should be called out for special consideration:

The `init` function performs initialization functions. It is called once per device. This can be a place for setting up the device itself or installing interrupt handlers for the device.

The `open` function is called when the user program opens a channel, after a channel structure has been allocated for the channel. This is the correct place for setting up a connection for a specific transaction on the device. This is another point where interrupt handlers might be installed or turned on, or when specific connection settings are made in the device (like serial baud rate).

The `close` function is called when the user program closes a previously opened channel. This function should perform any house keeping functions needed before the channel is returned to the kernel's pool. In particular, if the device buffers writes, any writes that are still pending should be written to the device.

5.2 Block Device Drivers

Block device drivers are used by Foenix Toolbox to provide block level access to block devices like the SD card, floppy drive, and IDE/PATA hard drive. The main use of block device drivers is the FatFS file system, which is used to provide file channels. Block drivers can be added to the system in a similar way to channel device drivers by implementing the functions needed by Foenix Toolbox and registering them using the `sys_bdev_register` call. The information about the block device is provided through a `s_block_dev` structure:

```
struct s_dev_block {
    short number;           // The number of the device (assigned by registration)
    char * name;            // The name of the device
    void * data;            // Device-specific data block
    short (*init)(struct s_dev_block *); // Initialize the device
    short (*read)(struct s_dev_block *, long lba, uint8_t * buf, short size); // Read a block from the device
    short (*write)(struct s_dev_block *, long lba, const uint8_t * buf, short size); // Write a block to the device
    short (*status)(struct s_dev_block *); // Get the status of the device
    short (*flush)(struct s_dev_block *); // Completes any pending writes to the device
    // Issue a command to the device
    short (*ioctl)(struct s_dev_block *, short cmd, unsigned char * buf, short size);
}
```

One difference with the channel drivers is that a block driver is tied to its specific device, therefore the handler functions do not take a device number or other structure.

As before, when registering a driver, the device number is provided in the number field, and a useful name is provided in `name`. The `init` function will be called once to allow the driver to initialize the device, install interrupt handlers, or perform other functions.

Otherwise, `read` and `write` perform the `getblock` and `putblock` functions, and take a block address, a buffer of bytes, and a buffer size as arguments. The `status` and `flush` functions map to the `sys_bdev_status` and `sys_bdev_flush` calls. And finally, `ioctl` maps to the `sys_bdev_ioctl` function, and takes a command number, a buffer of bytes, and a size of the buffer as arguments.

5.3 Keyboard Translation Tables

By default, Foenix Toolbox supports the US standard QWERTY style keyboard, but other keyboards can be used by providing custom translation tables to map from Foenix scan codes to 8-bit character codes.

These tables can be activated in the kernel by calling the `sys_kbd_layout` system call, providing it with the appropriate translation tables. There are eight tables that are needed, each are 128 bytes long, and they are provided as consecutive tables in the following order:

1. **UNMODIFIED**: This table maps scan codes to characters when no modifier keys are pressed.
2. **SHIFT**: This table maps scan codes when either SHIFT key is pressed.
3. **CTRL**: This table maps scan codes when either CTRL key is pressed.
4. **CTRL_SHIFT**: This table maps scan codes when SHIFT and CTRL are both pressed.
5. **CAPS**: This table maps scan codes when CAPSLOCK is down but SHIFT is not pressed.
6. **CAPS_SHIFT**: This table maps scan codes when CAPSLOCK is down and SHIFT is pressed.
7. **ALT**: This table maps scan codes when either ALT is pressed.
8. **ALT_SHIFT**: This table maps scan codes when ALT is pressed and either SHIFT or CAPSLOCK are in effect (but not both).

For keys on the right side of the keyboard (cursor keys, number pad, INSERT, etc.), NUMLOCK being down causes the **CAPS** or **CAPS_SHIFT** tables to be used. For those keys, CTRL and ALT will have no effect when NUMLOCK is down.

In the current code, character codes 0x80 through 0x95 are reserved. These codes are used to designate special keys like function keys, cursor keys, *etc.* This means that Foenix Toolbox cannot directly map characters using those code points to key presses, but in the various ISO-8859 and related standards, those code points are reserved for control codes. Also, this design choice allows for maximum flexibility in keyboard layouts, since all these keys can be mapped to whatever scan codes the user desires. See table 5.1 for the detailed mapping.

5.4 File Loaders

Out of the box, Foenix Toolbox supports only two simple file formats executables: PGX, PGZ, and ELF. Others may be supported in the future. Since this may not meet the needs of a user, the loading and execution of files may be extended using the `sys_fsys_register_loader` system call. This call takes an extension to map to a loader, and a pointer to a loader routine.

A loader routine can be very simple: it takes a channel to read from, an address to use as an optional destination, and a pointer to a long variable in which to store any starting address specified by an executable file.

To actually load the file, the loader just has to read the data it needs from the already open file channel provided. If a destination address was provided by the caller (any value other than 0), the loader should use that as the destination address, otherwise it should determine from the file or its own algorithm a reasonable starting address.

Once it has finished loading the file, if it had determined that the file is executable and knows the starting address, it should store that at the location provided by the start pointer.

Finally, if all was successful, it should return a 0 to indicate success. Otherwise, it should return an appropriate error number.

Example File Loader

| Key | Code |
|--------------|------|
| Cursor UP | 0x86 |
| Cursor Down | 0x89 |
| Cursor Left | 0x87 |
| Cursor Right | 0x88 |
| HOME | 0x80 |
| INS | 0x81 |
| DELETE | 0x82 |
| END | 0x83 |
| PAGE UP | 0x84 |
| PAGE DOWN | 0x85 |
| F1 | 0x8A |
| F2 | 0x8B |
| F3 | 0x8C |
| F4 | 0x8D |
| F5 | 0x8E |
| F6 | 0x8F |
| F7 | 0x90 |
| F8 | 0x91 |
| F9 | 0x92 |
| F10 | 0x93 |
| F11 | 0x94 |
| F12 | 0x95 |

Table 5.1: Special Key Codes

```

short fsys_pgz_loader(short chan, long destination, long * start) {
    // Use the channel calls to read the input file and load into memory
    // ...

    // If sucessful and found a start address:
    *start = start_address;
    return 0;
}

```

Chapter 6

Appendix

6.1 Console IOCTL Commands

The console channel driver supports the following commands for `sys_chan_ioctl`. None of these IOCTL commands require a buffer, so passing NULL for the buffer and 0 for the size is recommended.

1. `CON_IOCTL_ANSI_ON`: Turn on ANSI escape sequence processing.¹
2. `CON_IOCTL_ANSI_OFF`: Turn off ANSI escape sequence processing.
3. `CON_IOCTL_ECHO_ON`: Turn on character echoing for `sys_chan_read_b`.²
4. `CON_IOCTL_ECHO_OFF`: Turn off character echoing for `sys_chan_read_b`.
5. `CON_IOCTL_BREAK`: Check to see if the user has pressed the BREAK key sequence.³
6. `CON_IOCTL_CURS_ON`: The text mode cursor should be visible.⁴
7. `CON_IOCTL_CURS_OFF`: The text mode cursor should be hidden

6.2 ANSI Terminal Codes

Foenix Toolbox supports a basic subset of the VT102 ANSI terminal codes. The following escape sequences are shown in table 6.1.

For the SGR sequence, a fairly limited set of codes are currently supported, mainly to do with the color and intensity of the text (see table: 6.2).

NOTE: If the program does not want the console to interpret ANSI codes, this feature can be turned off by calling `sys_chan_ioctl` on the console channel to be changed. A command of 0x01 will turn ANSI interpretation on, while a command of 0x02 will turn it off. When ANSI interpretation is turned off, only the core ASCII control characters will still be recognized: 0x08 (backspace), 0x09 (TAB), 0x0A (linefeed), and 0x13 (carriage return).

For key presses, escape codes (see table 6.3) are sent to the calling program, when one of the `sys_chan_read` functions is used on the channel. Note that this feature is always on in the current system. Also, in the following codes, there are no actual spaces.

¹ANSI processing is on by default.

²Echo is on by default.

³`sys_chan_ioctl` will return a non-zero value if the BREAK key was pressed, and 0 if not. On all Foenix machines, CTRL-C (code point 0x03) will be treated as the BREAK key. On the A2560K, the combination Foenix-ESC will also work as the BREAK key. On the F256K, the RUN/STOP key will be treated as the BREAK key.

⁴Cursor is on by default.

| Sequence | Name | Function |
|---------------|------|----------------------------|
| ESC [# @ | ICH | Insert characters |
| ESC [# A | CUU | Move the cursor up |
| ESC [# B | CUF | Move the cursor forward |
| ESC [# C | CUB | Move the cursor back |
| ESC [# D | CUD | Move the cursor down |
| ESC [# J | ED | Erase the screen |
| ESC [# K | EL | Erase the line |
| ESC [# P | DCH | Delete characters |
| ESC [# ; # H | CUP | Set the cursor position |
| ESC [# m | SGR | Set the graphics rendition |

Table 6.1: ANSI Terminal Codes

| Code | Function |
|-----------|-----------------------------|
| 0 | Reset to defaults |
| 1 | High intensity / Bold |
| 2 | Low intensity / Normal |
| 22 | Normal |
| 30 – 37 | Set foreground color |
| 40 – 47 | Set background color |
| 90 – 97 | Set bright foreground color |
| 100 – 107 | Set bright background color |

Table 6.2: ANSI SGR Codes

| Key | Code |
|--------------|----------------|
| ESC | ESC ESC |
| Cursor UP | ESC [# A |
| Cursor Down | ESC [# B |
| Cursor Left | ESC [# C |
| Cursor Right | ESC [# D |
| HOME | ESC [1 ; # ~ |
| INS | ESC [2 ; # ~ |
| DELETE | ESC [3 ; # ~ |
| END | ESC [4 ; # ~ |
| PAGE UP | ESC [5 ; # ~ |
| PAGE DOWN | ESC [8 ; # ~ |
| F1 | ESC [11 ; # ~ |
| F2 | ESC [12 ; # ~ |
| F3 | ESC [13 ; # ~ |
| F4 | ESC [14 ; # ~ |
| F5 | ESC [15 ; # ~ |
| F6 | ESC [17 ; # ~ |
| F7 | ESC [18 ; # ~ |
| F8 | ESC [19 ; # ~ |
| F9 | ESC [20 ; # ~ |
| F10 | ESC [21 ; # ~ |
| F11 | ESC [23 ; # ~ |
| F12 | ESC [24 ; # ~ |

Table 6.3: ANSI Key Codes

6.3 Keyboard Scancodes

Foenix Toolbox uses the same Foenix scan codes that the original 65816 Foenix kernel and Foenix/MCP used. These scan codes are derived from the standard “set 1” scan codes with modifications to get the scan codes to fit within a single byte. The base scan codes for a US QWERTY keyboard are listed below.

When a key is pressed or released, bits 0 – 6 are the same, and follow the table below. A “make” scan code is sent when the key is pressed. For make scan codes, bit 7 is clear (0). A “break” scan code is sent when a key is released. For break scan codes, bit 7 is set (1).

Example—the user presses and releases the space bar: Two scan codes will be sent. First, the make code 0x39 will be sent. Second, the break scan code of 0xB9 will be sent when the key is released.

| | 0x00 | 0x10 | 0x20 | 0x30 | 0x40 | 0x50 | 0x60 |
|------|------|--------|--------|--------|--------|--------|---------|
| 0x00 | | Q | D | B | F6 | KP2 | PRSN |
| 0x01 | ESC | W | F | N | F7 | KP3 | PAUSE |
| 0x02 | 1 | E | G | M | F8 | KP0 | INS |
| 0x03 | 2 | R | H | < | F9 | KP. | HOME |
| 0x04 | 3 | T | J | > | F10 | | PGUP |
| 0x05 | 4 | Y | K | / | NUMLCK | | DEL |
| 0x06 | 5 | U | L | R SHFT | SCRLCK | | END |
| 0x07 | 6 | I | ; | KP* | KP7 | F11 | PGDN |
| 0x08 | 7 | O | " | L ALT | KP8 | F12 | UP |
| 0x09 | 8 | P | ~ | SPACE | KP9 | | LEFT |
| 0x0A | 9 | [| L SHFT | CAPS | KP- | | DOWN |
| 0x0B | 0 |] | \ | F1 | KP4 | L FNX | RIGHT |
| 0x0C | - | ENTER | Z | F2 | KP5 | R ALT | KP/ |
| 0x0D | = | L CTRL | X | F3 | KP6 | R FNX | KPENTER |
| 0x0E | BKSP | A | C | F4 | KP+ | R CTRL | |
| 0x0F | TAB | S | V | F5 | KP1 | | |

Table 6.4: Keyboard Scancodes

6.4 Useful Data Structures

Time

```
// Structure used for real time clock functions
struct s_time {
    short year; // Year (0 – 9999)
    short month; // Month (1 = January through 12 = December)
    short day; // Day of month (1 – 31)
    short hour; // Hour (0 – 12 / 23)
    short minute; // Minute (0 – 59)
    short second; // Seconds (0 – 59)
    short is_pm; // For 12-hour clock, 1 = PM
    short is_24hours; // 1 = clock is 24-hours, 0 = clock is 12-hours
}
```

Directory Entries

```

// Structure used for directory entry information
struct s_file_info {
    long size; // Size of the file in bytes
    unsigned short date; // Creation date
    unsigned short time; // Creation time
    unsigned char attributes; // Attribute bits
    char name[MAX_PATH_LEN]; // Name of the file (256 bytes)
}

```

File attribute bits:

| | |
|------|-------------|
| 0x01 | Read only |
| 0x02 | Hidden file |
| 0x04 | System file |
| 0x10 | Directory |
| 0x20 | Archive |

System Information

```

/*
 * Structure to describe the hardware
 */
struct s_sys_info {
    uint16_t mcp_version; // Current version of the MCP kernel */
    uint16_t mcp_rev; // Current revision, or sub-version of the MCP kernel */
    uint16_t mcp_build; // Current build # of the MCP kernel */
    uint16_t model; // Code to say what model of machine this is */
    uint16_t sub_model; // 0x00 = PB, 0x01 = LB, 0x02 = CUBE */
    const char * model_name; // Human readable name of the model of the computer */
    uint16_t cpu; // Code to say which CPU is running */
    const char * cpu_name; // Human readable name for the CPU */
    uint32_t cpu_clock_khz; // Speed of the CPU clock in KHz */
    unsigned long fpga_date; // YYYYMMDD */
    uint16_t fpga_model; // FPGA model number */
    uint16_t fpga_version; // FPGA version */
    uint16_t fpga_subver; // FPGA sub-version */
    uint32_t system_ram_size; // The number of bytes of system RAM on the board */
    bool has_floppy; // TRUE if the board has a floppy drive installed */
    bool has_hard_drive; // TRUE if the board has a PATA device installed */
    bool has_expansion_card; // TRUE if an expansion card is installed on the device */
    bool has_ethernet; // TRUE if an ethernet port is present */
    uint16_t screens; // How many screens are on this computer */
};

```