Application Note

AN_320

FT800 Example with PIC

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The FTDI FT800 video controller offers a low cost solution for embedded graphics requirements. In addition to the graphics, resistive touch inputs and an audio output provide a complete human machine interface to the outside world.

This application note will provide a simple example of developing an 8bit PIC MicroController code to control the FT800 over SPI. The principles demonstrated can then be used to produce more complex applications.

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Table of Contents

1 Introduction 2
2 Software Architecture 3
3 User Application 4
3.1 FT800 Graphics Rendering 4
3.1.1 Display List 4
3.1.2 Co-Processor 4
3.2 Microchip PIC code 5
3.2.1 setup() 5
3.2.2 loop() 6
3.2.3 Other functions 7
4 Hardware 8
5 Conclusion 9
6 Contact Information 10
Appendix A – References 11
Document References 11
Acronyms and Abbreviations 11
Appendix B – List of Tables & Figures 12
List of Tables 12
List of Figures 12
Appendix C – Revision History 13

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1 Introduction

The FT800 is a peripheral to a main system processor which provides a low-cost, yet complete, human interface experience by the incorporation of graphics rendering, touch screen sensing and audio capabilities. It is controlled over a low-bandwidth SPI or I^2C interface allowing practically any microcontroller to be used.

For this application, a PIC 16F886 microcontroller chip is used in the PICKit 28pin Demo board which is coupled with the VM800C43A-D, FT800 development kit and the MPLAB X IDE v1.95 development environment. The target application demonstrates the initialization and display of different elements on the LCD of the VM800C. The design flow follows concepts introduced in application note AN_240 FT800 From the Ground Up.

Once these concepts are mastered, this example can be used as a basis for larger and more complex applications that the FT800 has to offer: graphics primitives (e.g. lines, shapes, text), inbuilt widgets (e.g. sliders, switches, dials), touch events and audio output.

Note: It is recommended to view the code while reading this application note, available here.

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2 Software Architecture

This project consists of two files:

- FT800.h – a header file containing all of the FT800-specific values for memory locations, command values, etc.
- main.c – the main program file

An "abstraction layer" concept was explicitly avoided in this example.

Source code for the Microchip PIC 16F886 used in this application note can be found here: http://www.ftdichip.com/Support/SoftwareExamples/EVE/AN320.zip

FT800.h

This header file contains all of the information that is specific to the FT800 and assigns meaningful names to each value or address. The file is separated into the following sections:

- Memory Map – base addresses of the sections of memory within the FT800
  - RAM_CMD = 4KB ring buffer to place Co-Processor commands
  - RAM_DL = 8KB buffer to place display lists
  - RAM_G = 256KB general element memory for images, fonts and audio data
  - RAM_PAL = 1KB color palette
  - RAM_REG = FT800 registers
- Register Addresses
  - Each of the FT800 registers is named and associated with its address. Refer to the FT800 Datasheet for register sizes.
- Graphic Engine Commands
  - Each command associated with the FT800 graphics engine is assigned a value according to the FT800 Programmers Guide. Many of the Co-Processor commands require additional arguments.
- Display List Commands
  - Each display list command is assigned a value according to the FT800 Programmers Guide. All display list commands are 4-bytes in length. The first byte is the actual command. The remaining three bytes contain the necessary arguments.
- Command and register value options
  - Assorted named values useful for the main program.
- Useful Macros
  - Assorted macros to perform basic calculations.

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3 User Application

The intent of the user application is to render a circle on the LCD. The initial circle is white, then each time through the loop, the color toggles between red and white. Touch and audio are not covered.

3.1 FT800 Graphics Rendering

There are two methods available for rendering graphics elements, playing audio and sensing touch events.

- The first method is to write display list commands directly to the RAM_DL (Display List RAM). Note: This method is illustrated when blanking the screen as part of the initialization of the FT800.

- The second method is to write a series of Co-Processor commands or display list commands to the RAM_CMD (Command FIFO). The Co-Processor then creates the display list in RAM_DL based on the commands which it is given in the RAM_CMD FIFO. This method makes it easier to combine the drawing of graphics objects (lines etc.) and Widgets (slider etc.) on the same screen.
  Note: This method is illustrated when creating the main screen.

Although it is in theory possible to mix both methods when creating a new display list (screen) it is recommended that only one of the two methods is used in any given screen. This is because the RAM_DL would be written by both the MCU and the Co-Processor within the FT800.

3.1.1 Display List

With the Display List, the FT800 can draw several primitives (points, lines, edge and line strips, rectangles and images), manipulate the screen LCD parameters, read and write registers, etc. It can also play synthesized sounds and audio files and work with the raw touch screen activity (X-Y coordinates, touch pressure).

There is an 8K Display List buffer. All display list commands are 4-bytes in length, allowing for up to 2K commands. A display list command is constructed by logically combining the command byte with the necessary parameters. For example, this application uses the POINTS primitive. A BEGIN command is used coupled with the type of object associated with following commands - in this case, POINTS. The value for BEGIN is 0x1F, located in bits 31 through 24 of the command. Bits 23 through 4 are not used (reserved). Bits 3 through 0 indicate the primitive type. POINTS is type 2. The full command is then 0x1F000002.

Each display list command is constructed in a similar fashion. When sending these values to the FT800, they are sent in "little-endian" format, or least significant byte first: 0x02, 0x00, 0x00, 0x1F.

Commands are sent to successive locations in the RAM_DL (0x100000) memory of the FT800. The last Display List command of every list is "DISPLAY" to instruct the FT800 to process the commands and draw the screen. Processing is started when the register REG_DLSWAP is written with a value of 1 (swap after the current line) or 2 (swap after the current screen).

At this point, the list is made "active", and a new list can now be written starting at RAM_DL again.

3.1.2 Co-Processor

While the Display List covers basic screen manipulation, the Co-Processor allows more advanced rendering using inbuilt widgets, memory management and touch tags. The command memory for the Co-Processor is located at RAM_CMD (0x108000). While the display list always starts at the beginning of RAM_DL, the Co-Processor uses a 4K FIFO ring buffer.

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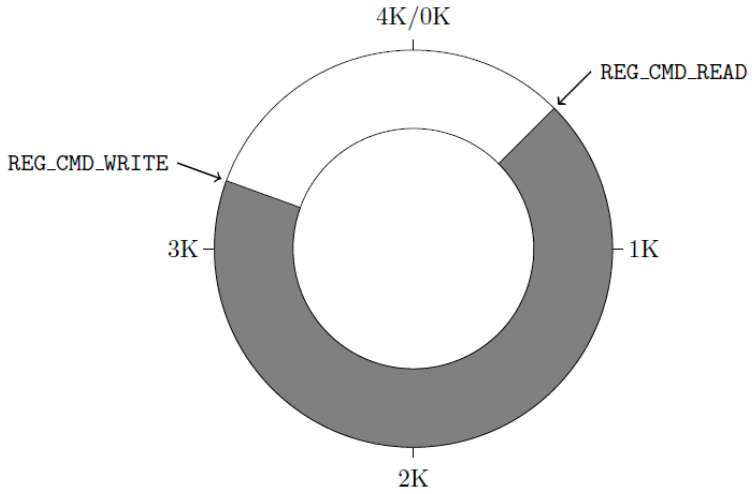


Note: This FIFO is mapped at FT800 memory addresses 108000h (RAM_CMD) to 108FFFh (RAM_CMD + 4095)

Figure 3.1 - Co-Processor Ring Buffer

The index of the last command executed is held in the register REG_CMD_READ, while the index ofthe last command written is in REG_CMD_WRITE. The process for adding commands is:

1) Read REG_CMD_READ and REG_CMD_WRITE. Loop here until they're equal.
2) Write new commands starting at REG_CMD_WRITE.
3) Update REG_CMD_WRITE with the next address following the last command in the list (4-byte aligned).
4) With the new value in REG_CMD_WRITE, the Co-Processor will start executing each command and updating REG_CMD_READ until it reaches REG_CMD_WRITE.

While only one type of rendering is recommended; display list commands can be embedded into the command list. This allows mixing of the primitive graphics elements with widgets allowing the full capabilities of the FT800 to be utilized. The loop() function utilizes this method of embedding display list commands into the command list.

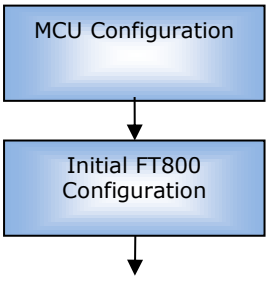
3.2 Microchip PIC code

This application consists of the following methods : init_spi(), setup() and loop().

- `void` **`setup`**`(void)`
  - This code is executed once after power on or reset.
- `void` **`loop`**`(void)`
  - This code is continually executed after setup() completes.

3.2.1 setup()

All FT800 and PIC SPI initialization and configuration requirements are handled in setup():



Configures the PIC I/O Ports and SPI Interface.

Powers up the FT800 and then sends commands over SPI to configure the FT800's oscillator settings and reset the FT800. This is followed by reading the FT800's ID register – reading the expected value of 0x7C confirms that the FT800 is ready and responding correctly.

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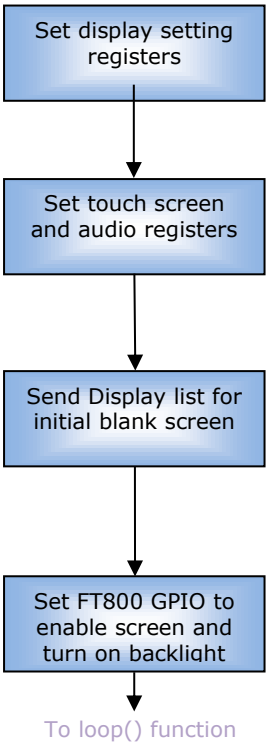

Write the display registers of the FT800 to configure it for the particular display which is attached. Each register is configured with a write of a 16-bit value to its address.

The touch screen threshold is set here. The touch screen and audio functionality is not used in this application note but some of the later code examples will use these features.

Create an initial display list which simply blanks the screen. This code writes three 4-byte commands to successive locations in the Display list RAM.

- [RAM_DL + 0] Specify the colour which will be used when the screen is cleared
- [RAM_DL + 4] Specify that the Colour, Stencil and Tag buffers should be cleared
- [RAM_DL + 8] Display command which signifies the end of the Display List
- Writing to the DL_Swap register then tells the FT800 to render the above display

The FT800 has its own GPIO port which can be controlled by writing to the FT800's GPIO_DIR and GPIO registers over SPI. This part of the code writes to these registers to assert the display's enable pin which is connected to the FT800 GPIO. The FT800 backlight PWM is also ramped up to turn on the LCD panel's LED backlight.

3.2.2 loop()

The generated images are shown while executing loop().

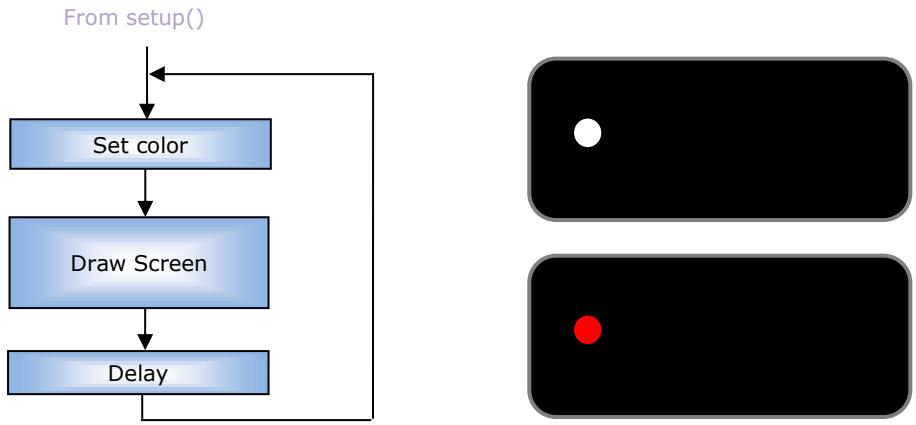

Figure 3.2 - Program Output

The Draw Screen block above performs the following steps:

1. Check the Co-Processor command buffer pointers. Wait until they're equal.
2. Alternate active colors between white and red (start with white).
3. Start the display list.
4. Clear the screen to black to eliminate any artifacts from the previous screen.
5. Clear the color, stencil and tag buffers.
6. Set the active color.
7. Define a point location and size.
8. Display the screen.
9. Swap display lists.

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3.2.3 Other functions

Several functions provide basic read and write capabilities for accessing the FT800:

- `void` **`ft800memWrite8`**`(unsigned long ftAddress, unsigned char ftData8)`
- `void` **`ft800memWrite16`**`(unsigned long ftAddress, unsigned int ftData16)`
- `void` **`ft800memWrite32`**`(unsigned long ftAddress, unsigned long ftData32)`
  - This function writes a value from the PIC through the SPI port to the FT800.
  - Available in three "sizes": 8-bits (unsigned char), 16-bits (unsigned int) and 32-bits (unsigned long).
  - The sequence of events is:
    - Set CS# active
    - Send the MEM_WRITE command combined with the 3-byte address
    - Send the data, least significant byte first
    - Set CS# inactive
- `unsigned char` **`ft800memRead8`**`(ftAddress)`
- `unsigned int` **`ft800memRead16`**`(ftAddress)`
- `unsigned long` **`ft800memRead32`**`(ftAddress)`
  - This function reads a value from the FT800 through the SPI port to the PIC.
  - Available in three "sizes": 8-bits (unsigned char), 16-bits (unsigned int) and 32-bits (unsigned long).
  - The sequence of events is:
    - Set CS# active
    - Send the MEM_READ command combined with the 3-byte address
    - Send one dummy byte
    - Read the data, least significant byte first and construct the return value
    - Set CS# inactive
    - Return the read data
- `void` **`ft800cmdWrite`**`(unsigned char ftCommand)`
  - This function sends specific commands from the PIC through the SPI port to the FT800.
  - A command is one of 8 3-byte values as noted in section 4 of the FT800 Datasheet. Since the second and third bytes are always zero, an 8-bit value is passed to the function.
  - The sequence of events is:
    - Set CS# active
    - Send the command byte
    - Send two bytes with the value 0x00
    - Set CS# inactive
- `void` **`incCMDOffset`**`(unsigned int currentOffset, unsigned char commandSize)`
  - This function ensures the command offset of the graphics processor command buffer rolls over within the 4KB ring buffer size.

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4 Hardware

Any of the FT800 LCD module kits can be used with this application.

Any currently available Microchip PIC with an SPI module can be used to interface with the FT800. The code has been tested with the PIC 16F886.

This application uses compiler directives to select the platform type and LCD size.

```
// Set LCD display resolution here
//#define LCD_QVGA  // QVGA  = 320 x 240 (VM800B/C 3.5")
#define LCD_WQVGA   // WQVGA = 480 x 272 (VM800B/C 4.3" and 5.0")
```

The connection between the PICkit board and either the VM800B or VM800C is made with seven wires:

Signal	PIC 16F886 (Digital I/O)	VM800B/ VM800C
SCLK	14	1 (SCLK)
MOSI	16	2 (MOSI)
MISO	15	3 (MISO)
CS#	17	4 (CS#)
INT#	NC	5 (INT#)
PD#	18	6 (PD#)
Ground	GND	7 (GND)

Table 4.1 – PIC 16F886 Pin Definitions

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5 Conclusion

This application note presented a simple example utilizing a Microchip PIC16F886 device on a PICkit 28 pin demo board with the standard MPLAB X IDE V1.95 to initialize the FT800. This was followed by the creation of different displays using the graphics processor commands. Low-level SPI function calls were created to allow convenient methods of sending and receiving data to the FT800.

Other display screens that contain other graphics objects, images and widgets, as well as audio output and touch events can be implemented through changing the code within the loop() function.

The SPI transfer calls could also be expanded to include more complex, multi-byte transfers useful for image and audio file transfers to and from the FT800 memory. Interrupts can also be enabled to indicate touch events, completion of display lists, etc.

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Appendix A – References

Document References

EVE Product Page

FT800 Datasheet

FT800 Programmers Guide

VM800C Datasheet – Credit Card sized development board with FT800

VM800B Datasheet – Bezel-mounted Display with FT800

AN_240 EVE From the Ground Up

AN_259 FT800 Example with 8-bit MCU

Microchip MPLAB X IDE

Pickit demo board for 16F886

Project source code

Acronyms and Abbreviations

Terms	Description
CS#	Chip Select
GND	Ground
HMI	Human-Machine Interface
I^2C	Inter-Integrated Circuit
INT#	Interrupt
LCD	Liquid Crystal Display
MISO	Master In / Slave Out
MOSI	Master Out / Slave In
PD#	Power Down
SCLK	Synchronous Clock
SPI	Synchronous Peripheral Interface

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Appendix B – List of Tables & Figures

List of Tables

Table 4.1 – Microchip PIC16F886 Pin Definitions 8
Table 4.2 - VM800P Pin Definitions ..... **Error! Bookmark not defined.**

List of Figures

Figure 3.1 - Co-Processor Ring Buffer 5
Figure 3.2 - Program Output 6

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Appendix C – Revision History

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