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S5U13781R01C100 Shield Graphics Library Users Guide

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SEIKO EPSON CORPORATION

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1 Introduction

This document introduces the user to the S5U13781R01C100 Shield Graphics Library. The S5U13781R01C100 Shield Graphics Library is a software library designed to simplify the process of displaying graphics and text to a panel connected to a S5U13781R01C100 Shield.

The S5U13781R01C100 Shield is designed to be used with the Arduino Due microcontroller board. For details on the Arduino Due, refer to the Arduino website at www.arduino.cc/. For further details on the S1D13781, or the S5U13781R01C100 Shield, visit our Website at vdc.epson.com.

Note:
The S5U13781R01C100 Shield TFT Board can also be used to evaluate the low cost S1D13L01 LCD Controller which provides a similar feature set as the S1D13781. The S1D13L01 is designed as a lower cost option with a streamlined feature set. The following table shows the main differences between the S1D13781 and S1D13L01. For a complete feature list for each LCD controller, refer to the S1D13781 Hardware Functional Specification and S1D13L01 Hardware Functional Specification available at vdc.epson.com.

Feature Differences	S1D13L01	S1D13781
Display Interfaces	Active TFT Displays only	Passive STN and Active TFT Displays
BitBLT Support	SW BitBLT	Hardware BitBLT Engine with: - Move BitBLT - Solid Fill BitBLT
Temperature Range	-40 to 85° C	-40 to 85° C or -40 to 105° C
Package	QFP15 128-pin	QFP15 100-pin

Please visit our Youtube channel, EEAVDC Productions, where we offer videos which demonstrate the installation and use of our products.

We appreciate your comments on our documentation. Please contact us via email at vdc-documentation@ea.epson.com.

2 Requirements

The S5U13781R01C100 Shield Graphics Library is designed to simplify the process of displaying graphics and text to a panel connected to a S5U13781R01C100 Shield TFT board that is connected to a Arduino Due Controller board.

Before installing the S5U13781R01C100 Shield Graphics Library, ensure that you have the following available:

- S5U13781R01C100 Shield TFT board
- Arduino Due Controller board
- LCD panel (default configuration is 480x272 @ 24bpp)
- Arduino Sketch IDE software v1.6.2 or greater (see Note)
- S5U13781R01C100 Graphics Library package
- Micro USB cable (to power the Due and optionally use the Serial Monitor)

Note:
The Arduino Sketch IDE software requires a platform running Windows, Mac OS X, or Linux. For specific requirements and installation instructions, refer to the Arduino website at www.arduino.cc/en/Main/Software.

This user manual is updated as appropriate. Please check for the latest revision of this document at vdc.epson.com before beginning any development.

3 Installation

Installing the S5U13781R01C100 Shield Graphics Library requires two steps:

- connecting the hardware components
- installing the software

3.1 Hardware Installation

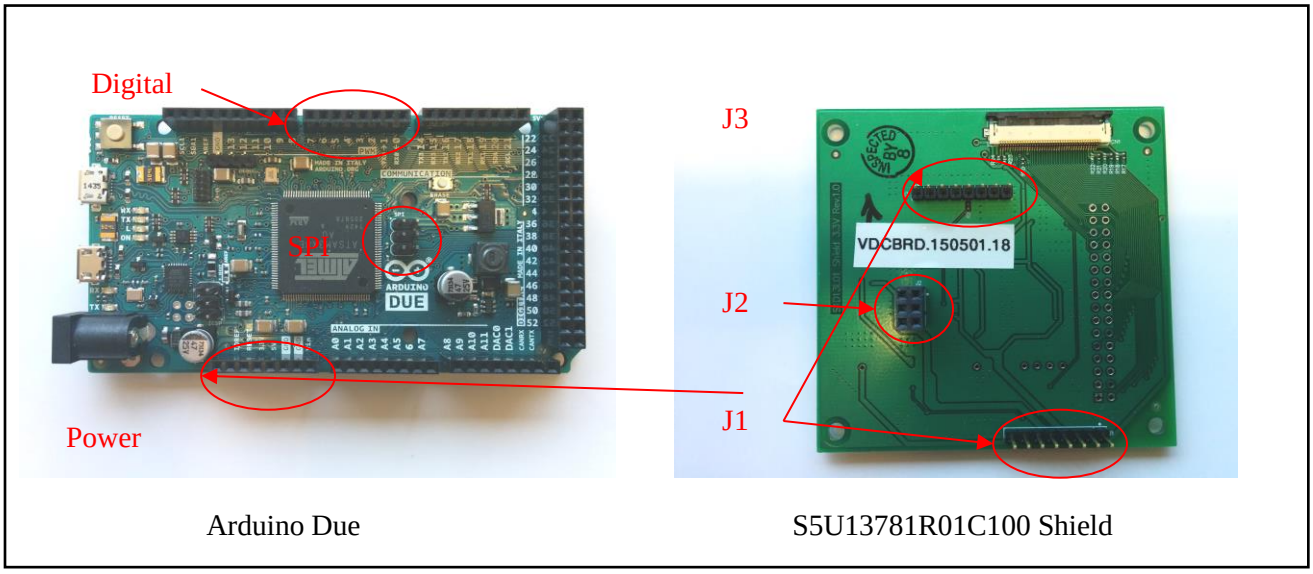
Before installing the S5U13781R01C100 Shield Graphics Library software package, connect your hardware components as shown in the following instructions.

3.1.1 Connecting S5U13781R01C100 Shield to Arduino Due

To properly connect the S5U13781R01C100 Shield to the Arduino Due, the following headers from each board must be connected together.

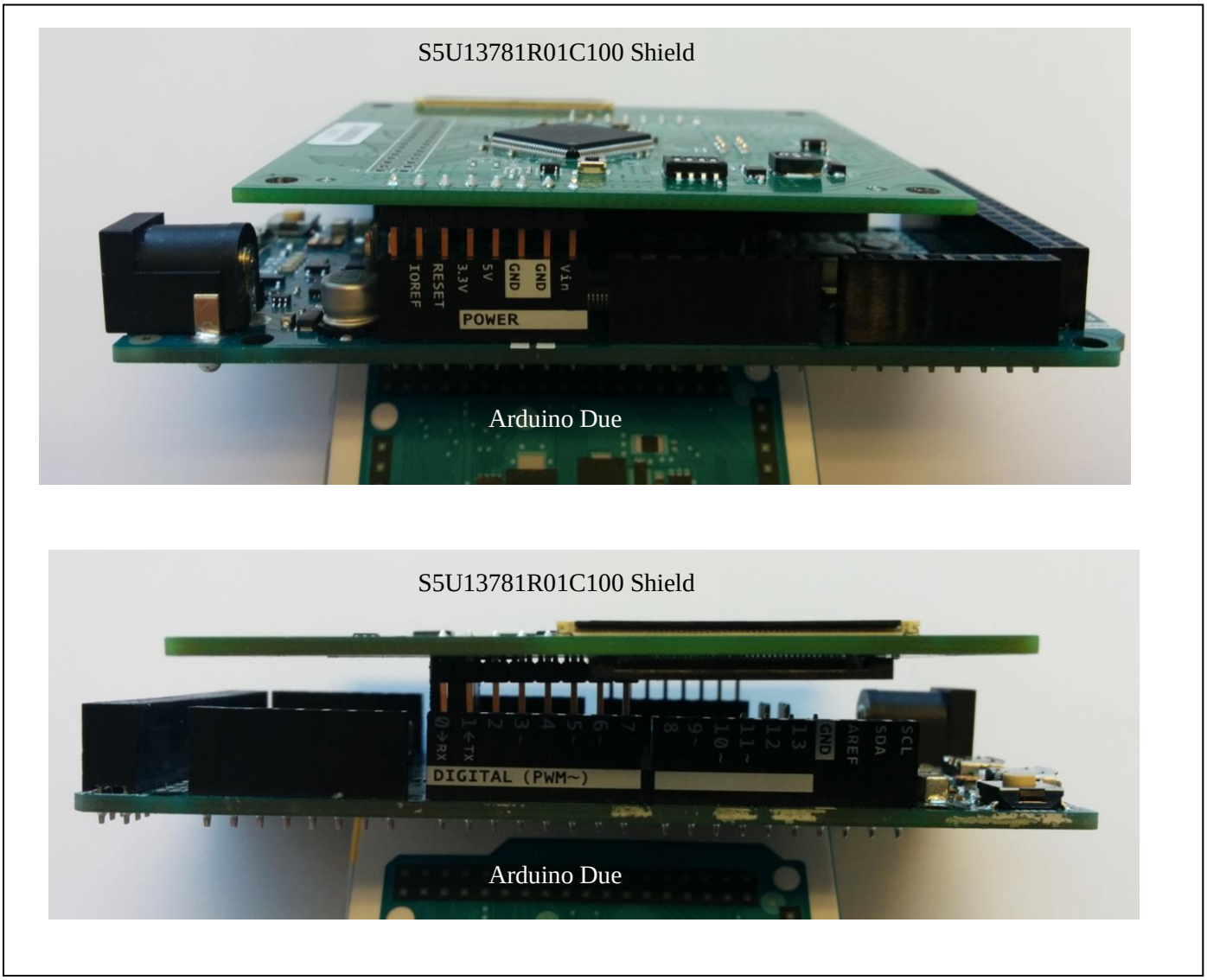
S5U13781R01C100 Shield		**Arduino Due**
J1 Header	←→	"Power" Socket
J2 Header	←→	SPI Socket
J3 Header	←→	"Digital" (PWML) Socket

The headers and sockets for each board are identified in the following image.



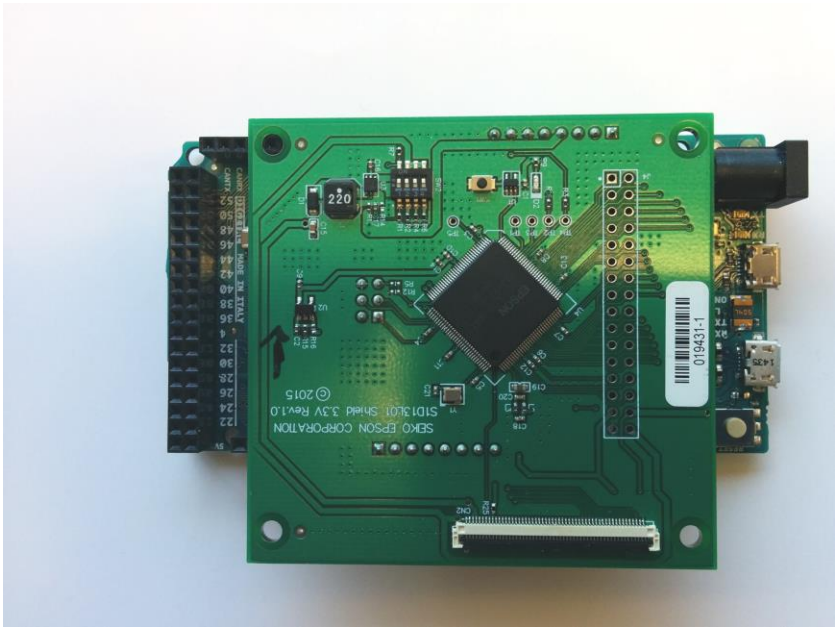
Hardware Connector Locations

To connect the boards, align the boards as shown in the following image, and then gently press the boards together. If the boards are aligned correctly, they should slide together smoothly until the header pins are completely in the corresponding socket.



Mounting the S5U13781R01C100 Shield and Arduino Due

Once the boards are connected, they should look similar to the image below.



S5U13781R01C100 Shield and Arduino Due Connected

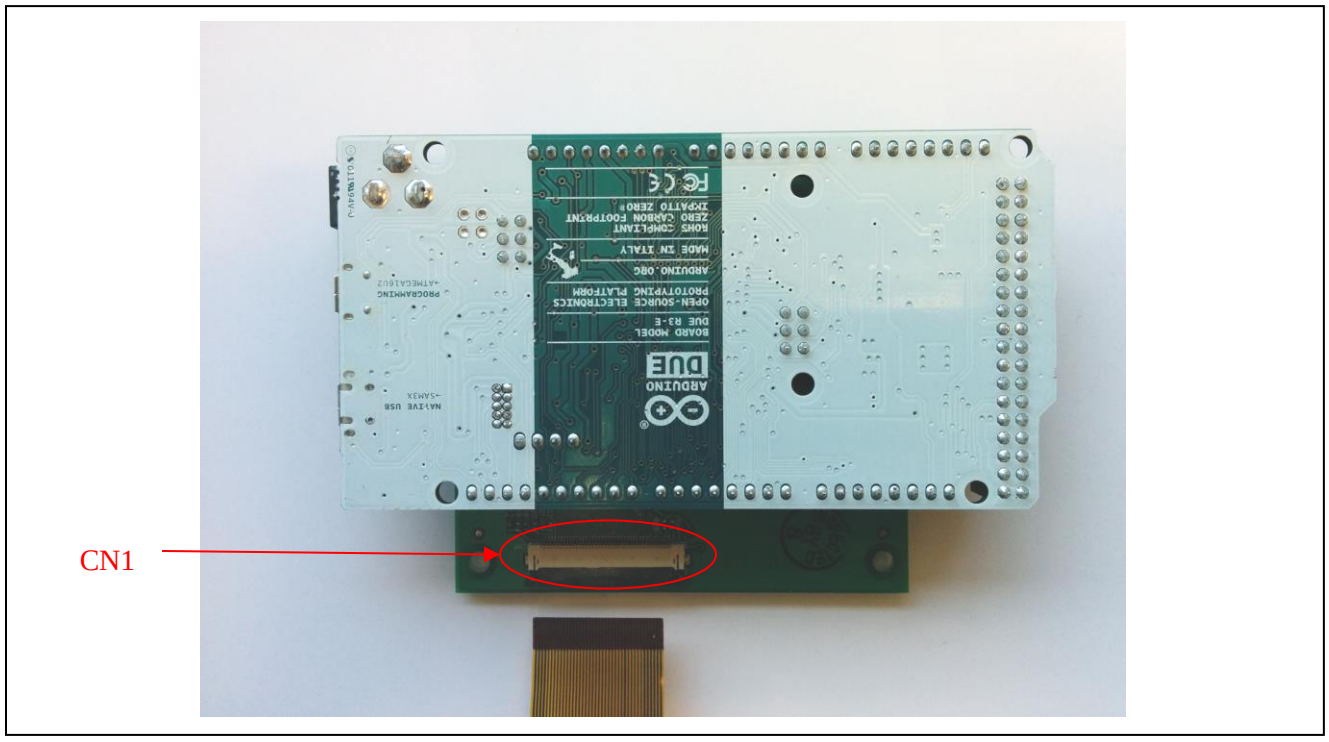
3.1.2 Connecting the LCD Panel

Once the two boards are connected, the LCD Panel can be connected to the S5U13781R01C100 Shield board. The default configuration of the S5U13781R01C100 Shield Graphics Library provides support for a Newhaven Display 480x272 LCD panel (NHD-4.3-480272EF-ATXL#).

The connector for the LCD panel is located on the side of the S5U13781R01C100 Shield board that connects to the Arduino Due. The connector is FPC connector CN1.

To connect the LCD panel:

1. Open connector CN1 by gently pulling the dark colored tabs towards the edge of the board.
2. Slide the flat panel cable into connector CN1.
3. Close connector CN1 by pushing the dark colored tabs back into place.



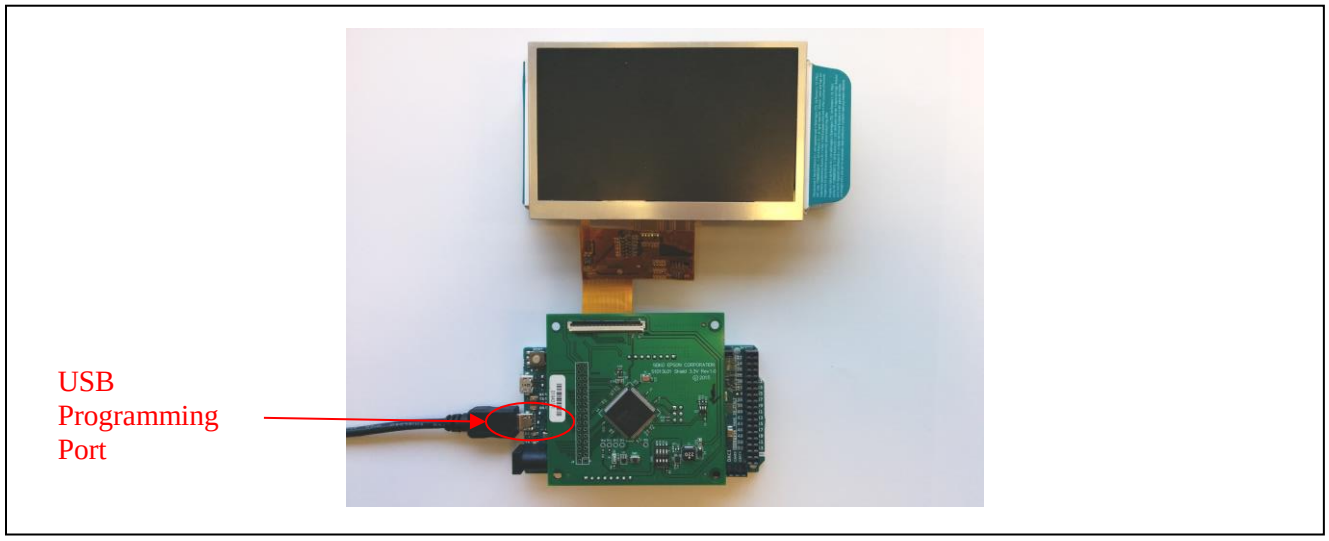
S5U13781R01C100 Shield LCD Connector

Once the panel cable is secure, carefully turn the board and panel over so that the panel is facing up.

3.1.3 Connecting the Arduino Due to Development Platform

Once all the hardware components are connected, plug a Micro USB cable between your development platform and the Programming Port on the Arduino Due.

This will provide power for the Arduino Due and optionally provide a serial monitor feature for debugging purposes.



Finished Hardware Installation

3.2 Software Installation

In order to prepare the development platform for use with the S5U13781R01C100 Shield Graphics Library, the following steps are required.

1. Install Arduino Sketch IDE
2. Install the Arduino SAM boards (includes the Due)
3. Install S5U13781R01C100 Graphics Library and example sketches
4. Use the Sketch IDE to compile example sketches and upload to the Arduino Due

3.2.1 Installing Arduino Sketch IDE

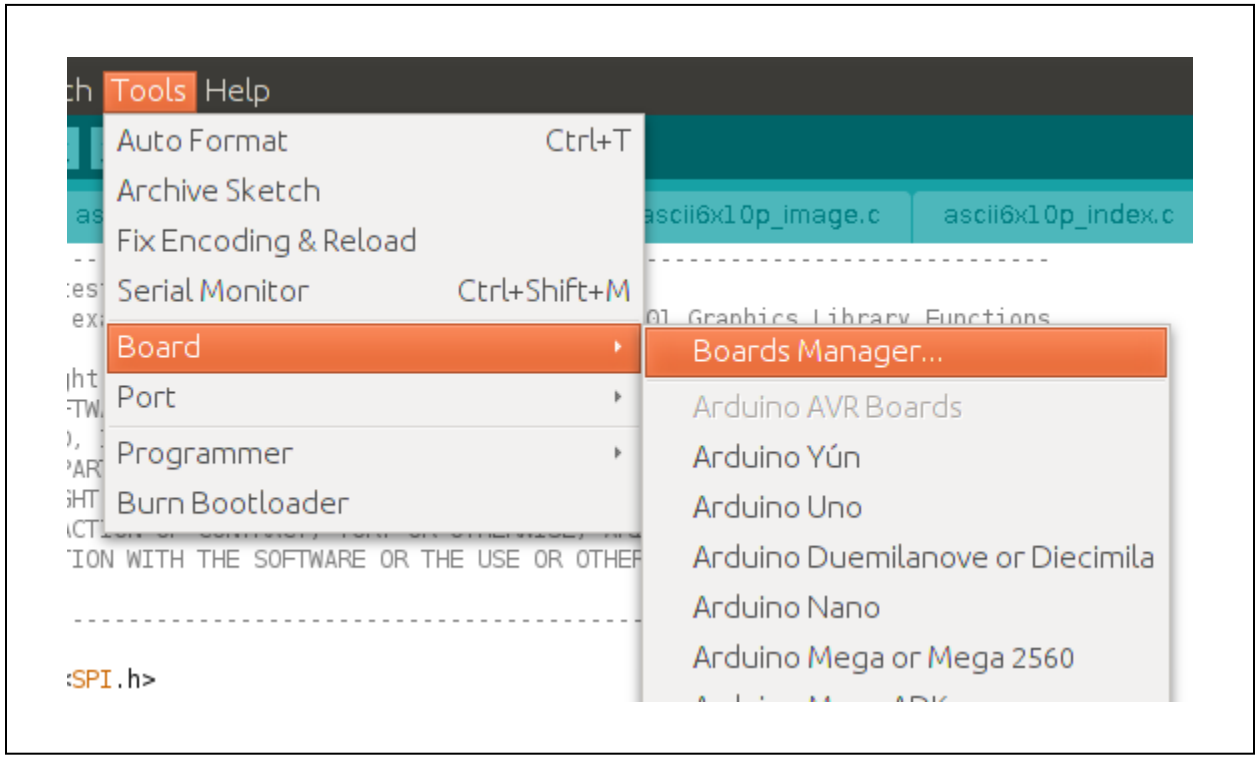
The S5U13781R01C100 Shield Graphics Library is designed to work with the Arduino Sketch IDE. It was developed and tested using Sketch v1.6.2.

Sketch requires a platform running Windows, Mac OS X, or Linux. If you do not have Sketch installed on your development platform, please visit the Arduino website and download the version of Sketch compatible with your operating system. Once Sketch is installed on your development platform, proceed to the next step.

For specific requirements and installation instructions, refer to the Arduino website at www.arduino.cc/en/Main/Software.

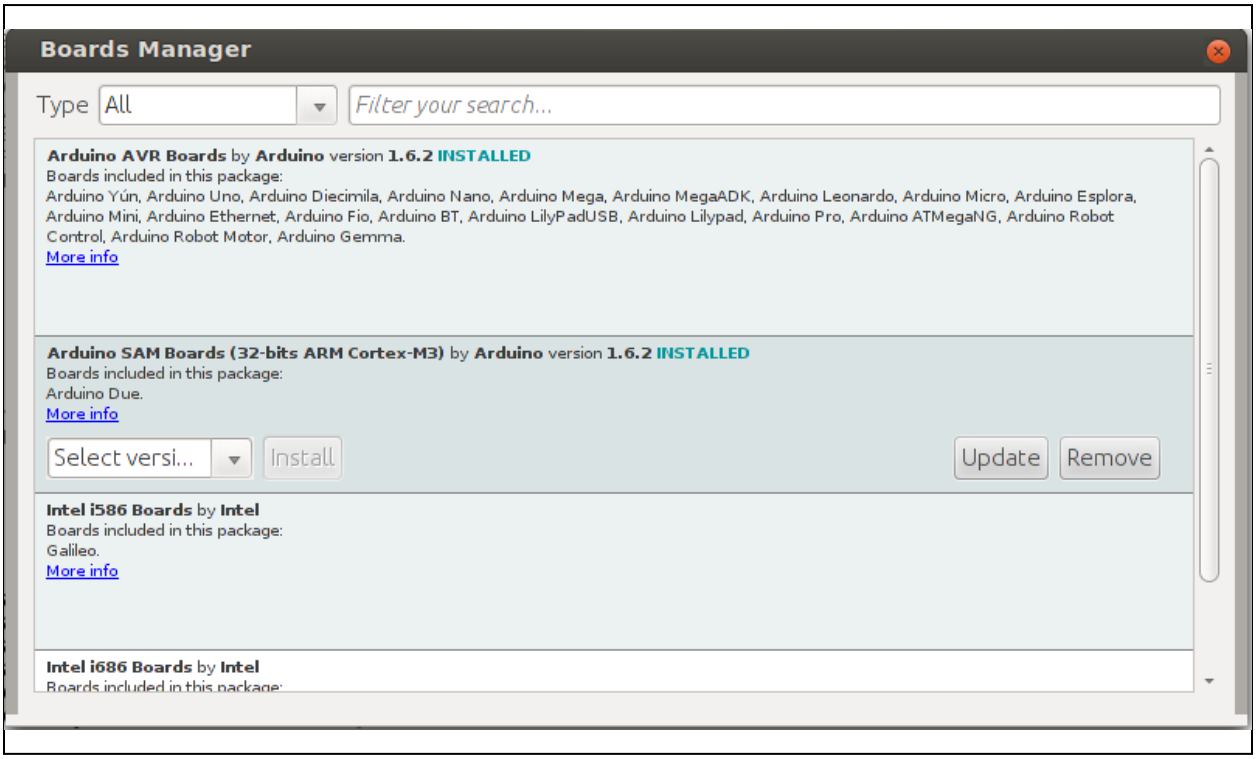
3.2.2 Installing the Arduino SAM Boards

The default installation of Arduino Sketch may not include support for the Arduino Due. To confirm whether Due support is installed click on "Tools->Board->Boards Manager..." on the Sketch menu.



Arduino Sketch: Loading Boards Manager

This will display the Boards Manager window as shown below.



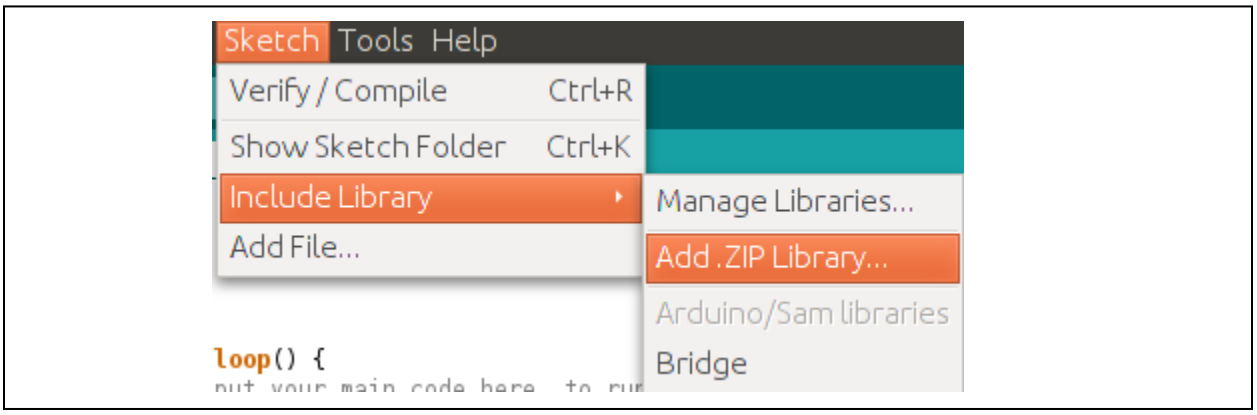
Arduino Sketch: Installing SAM Boards Package

Confirm whether the “Arduino SAM Boards (32-bits ARM Cortex-M3)” board package is installed. If the package is not installed, install the version that matches your version of the Sketch IDE. Once the SAM Boards package is installed, proceed to the next step.

3.2.3 Installing the S5U13781R01C100 Shield Graphics Library

The S5U13781R01C100 Shield Graphics Library is available as a .zip archive that includes the Graphics Library in another .zip file and a folder of example sketches. Unzip the files to a temporary location on your development platform.

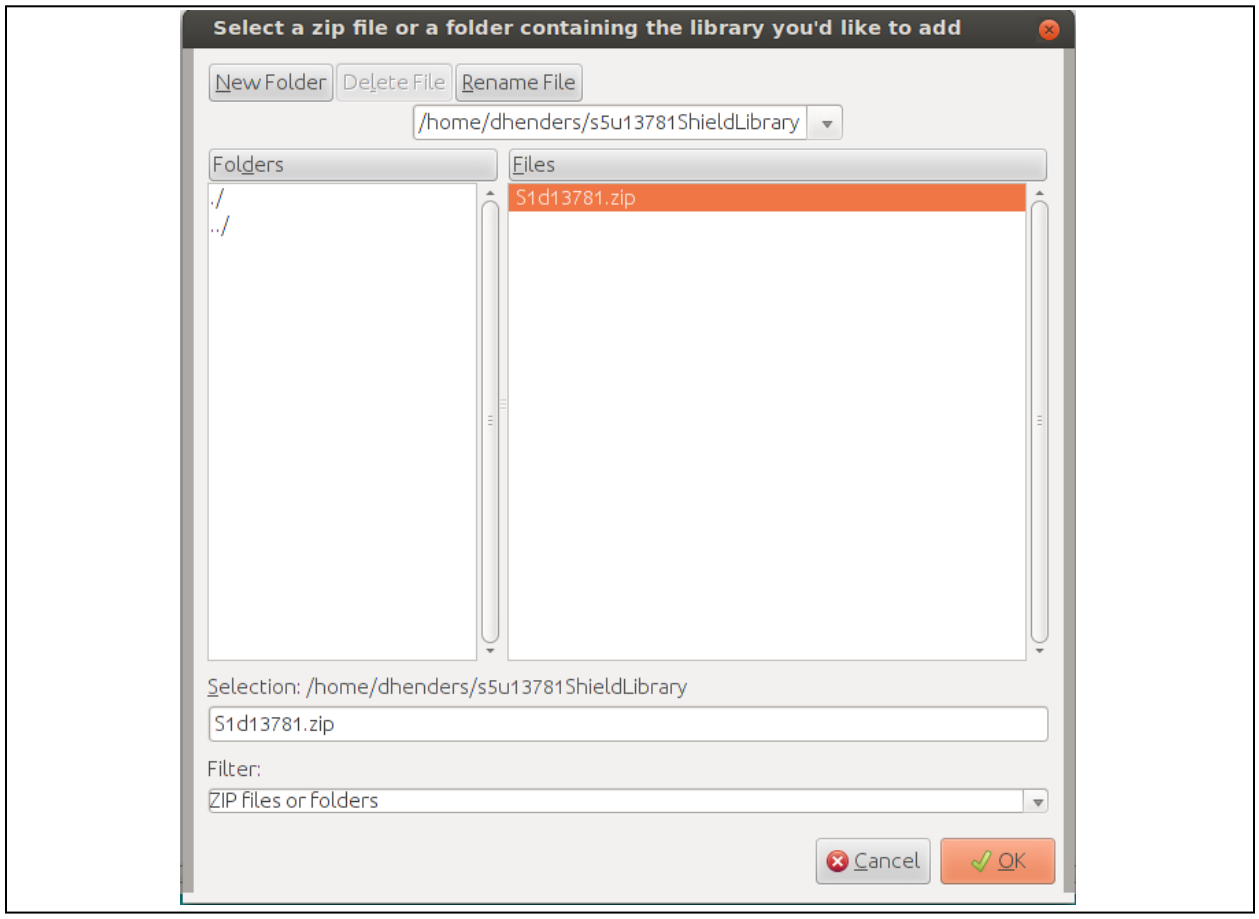
The Sketch IDE can directly import the S5U13781R01C100 Shield Graphics Library, so click on "Sketch->Include Library->Add .ZIP Library..." on the Sketch menu.



Arduino Sketch: Add .ZIP Library

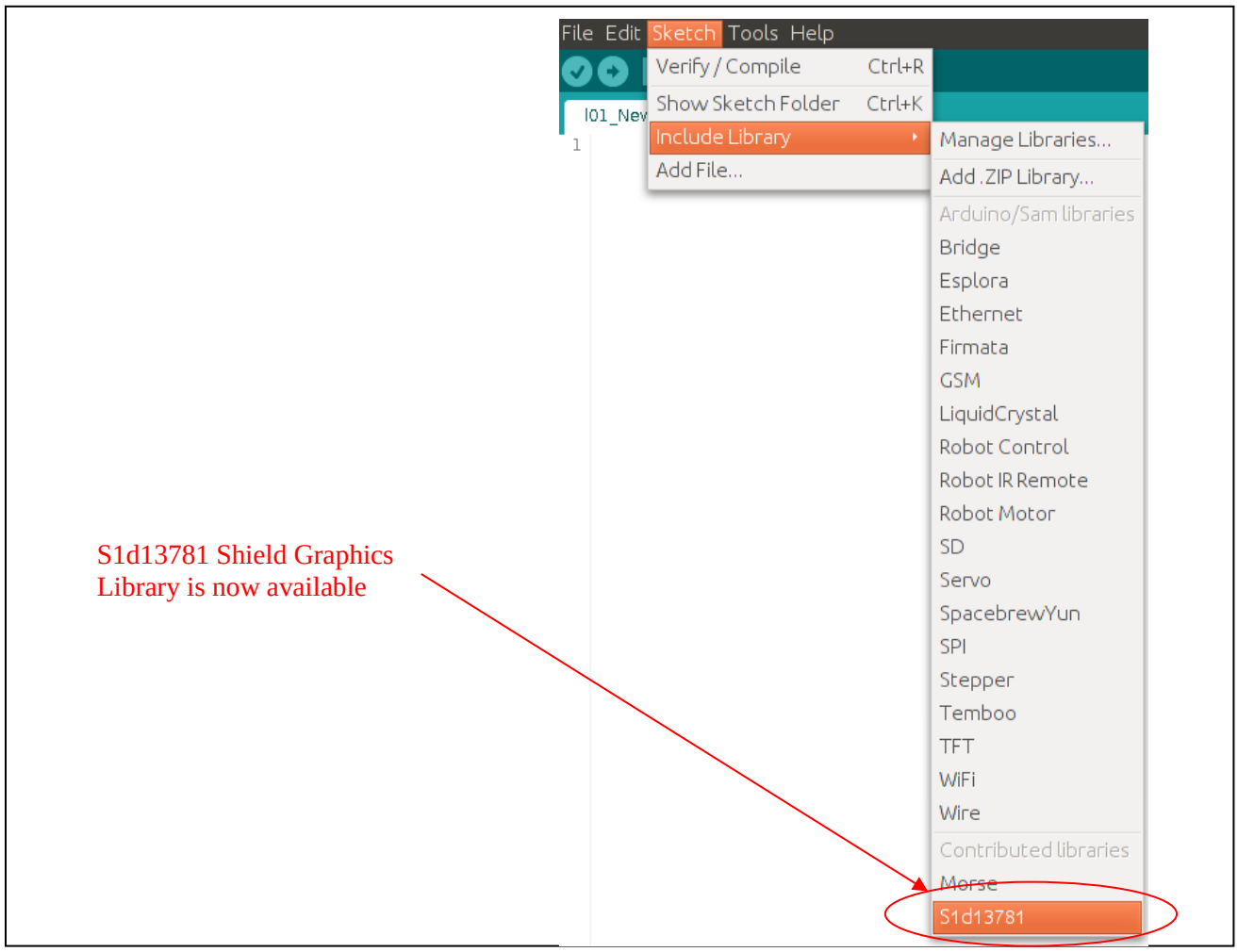
This will display the section window. Navigate to the location where the “S1d13781.zip” file was unzipped, select it, and click OK. This will install the Graphics Library into the Sketch IDE.

Note
If re-installing a modified or updated version of an existing library, the folder containing the existing library files must be removed from the “Arduino/libraries” folder before re-installing the new library.



Arduino Sketch: Loading S5U13781R01C100 Shield Graphics Library

To confirm that the S5U13781R01C100 Shield Graphics Library is installed, click on “Sketch->Include Library” and look for the “S1d13781” entry at the bottom of the list of available libraries.

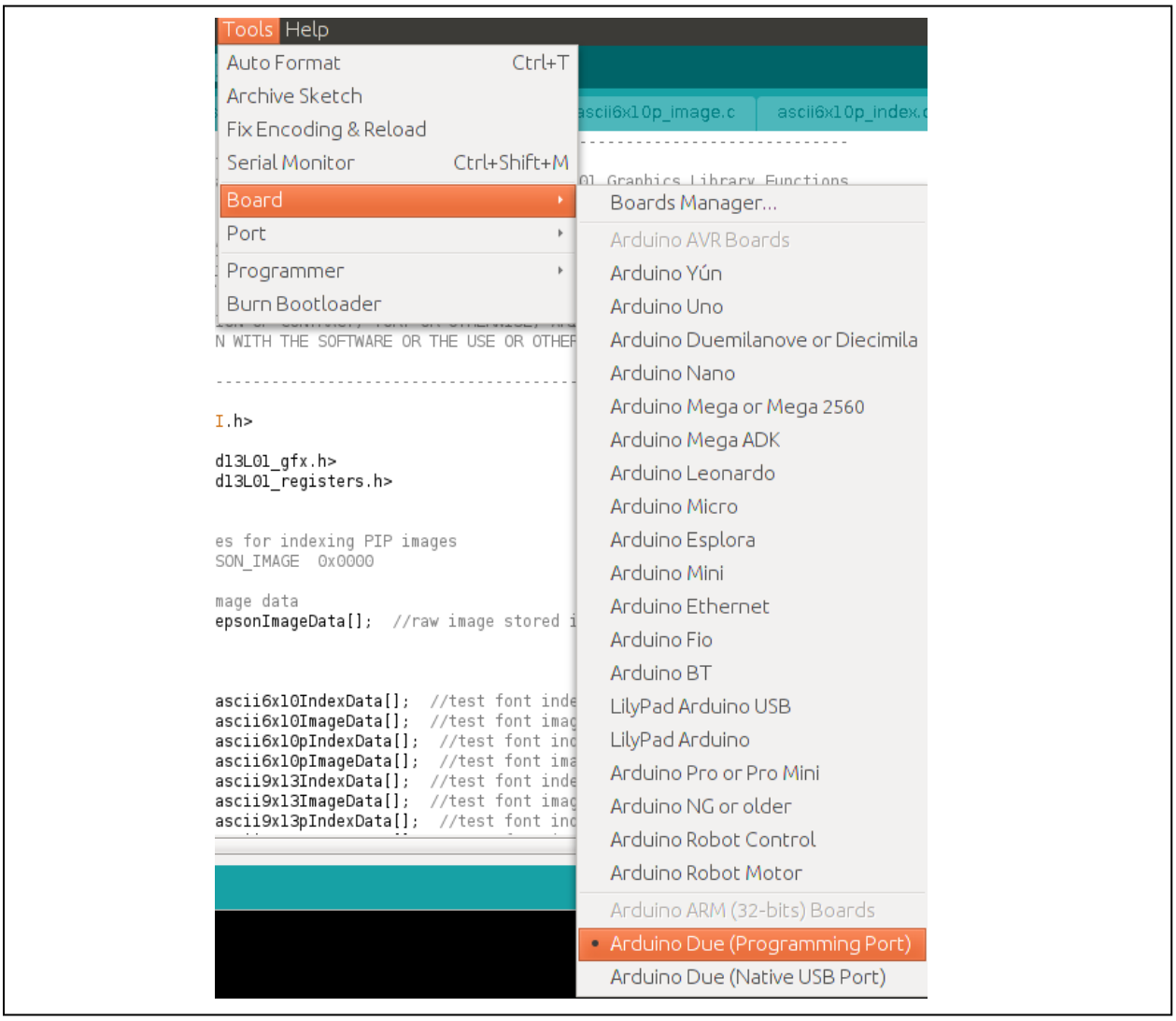


Arduino Sketch: Confirm S1d13781 Shield Graphics Library

3.2.4 Compiling and Running Example Sketch

Before we run one of the example sketches, we need to set the Board and Port settings in the Sketch IDE. The Board and Port settings tell the Sketch IDE which Arduino product is being used and how to communicate with it.

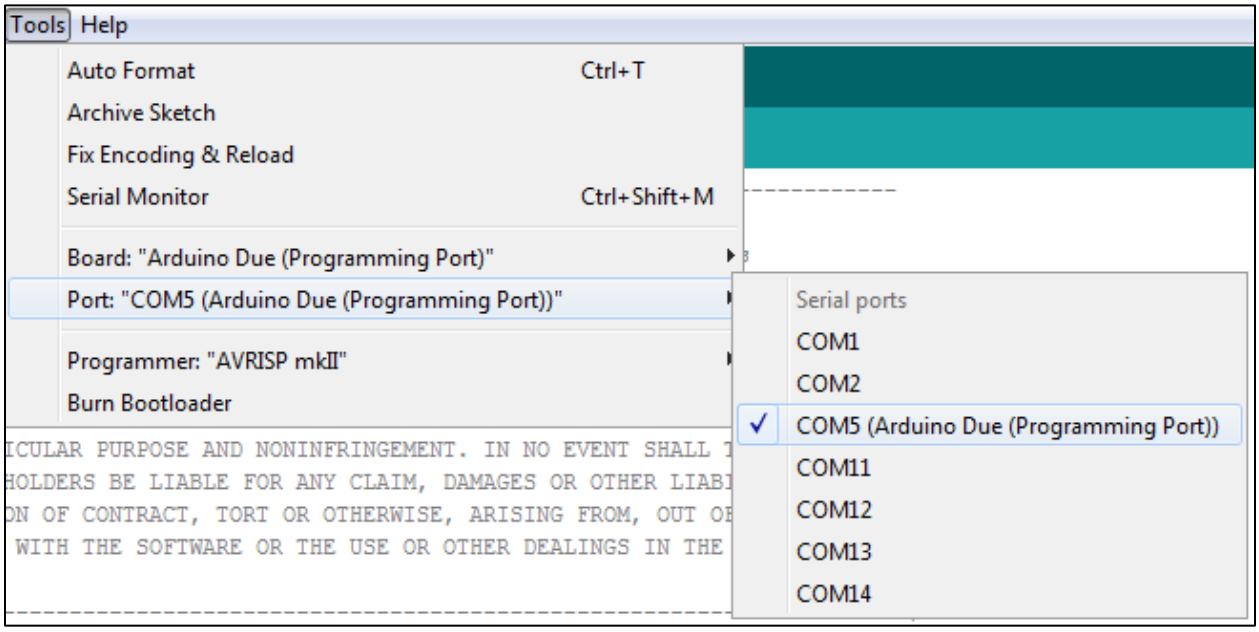
To set the Board for the Arduino Due, click "Tools->Board->Arduino Due (Programming Port)" as shown in the following image.



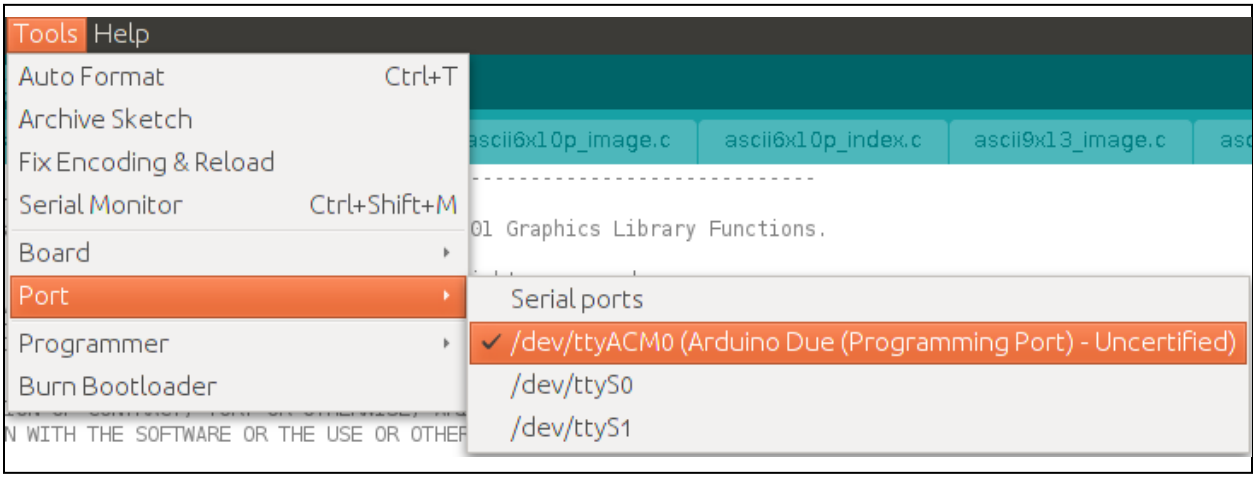
Arduino Sketch: Setting the Board

To set the Port for the Arduino Due, click “Tools->Port->Arduino Due (Programming Port)” as shown in the following image.

The port that the Arduino Due is located on may differ according to the operating system of the development system. For issues regarding USB port connections, please refer to the Arduino website at www.arduino.cc/.



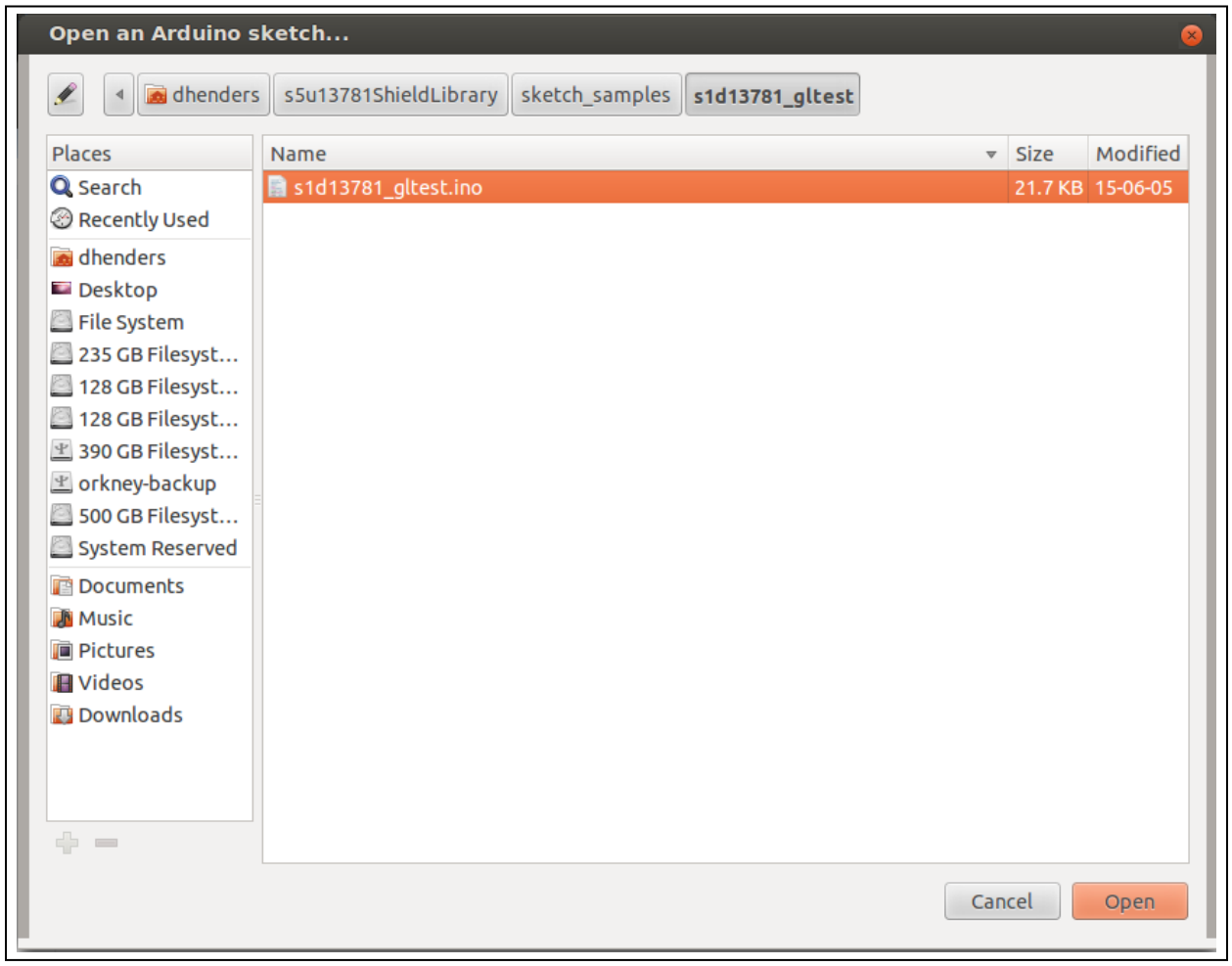
Arduino Sketch: Setting the Port (Windows Example)



Arduino Sketch: Setting the Port (Linux Example)

Now that the S5U13781R01C100 Shield Graphics Library is installed, we can run one of the example sketches. To open the “781_gltest” example sketch, click on “File->Open…”, navigate to the folder where the example sketches were unzipped, select the “781_gltest.ino” sketch file, and click Open. This will open an example sketch that demonstrates some of the capabilities of the S1D13781 LCD controller and the S5U13781R01C100 Shield Graphics Library.

Note:
The default configuration assumes that a Newhaven Display 480x272 LCD panel is connected to the S5U13781R01C100 Shield.

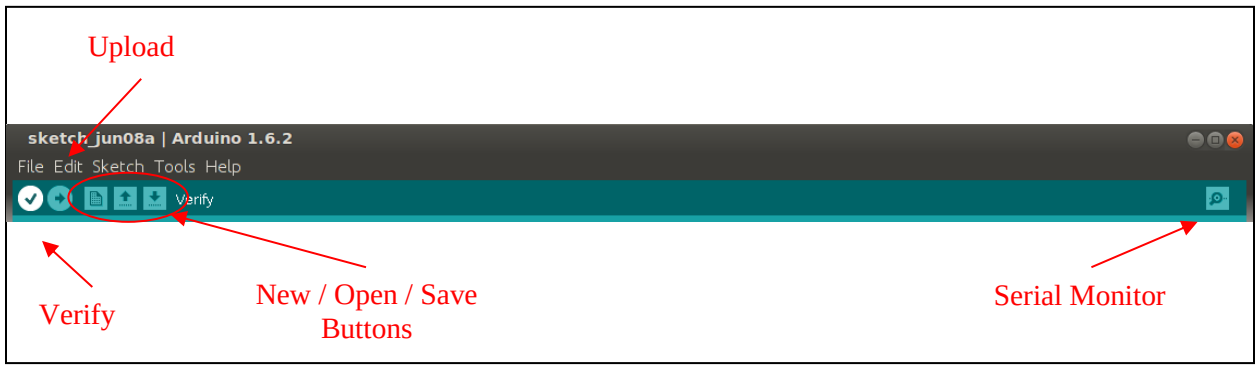


Arduino Sketch: Loading an Example Sketch

Once the example sketch is loaded, it can be compiled and uploaded to the Arduino Due. If you simply want to check modifications or new code for errors, click the "Verify" button on the Sketch Toolbar. If you want to upload the application to the Arduino Due and run it, click the "Upload" button. Upload will verify the application code and then upload the required binary images to the Arduino Due.

Note:
The Upload stage will fail if the Sketch "Board" and "Port" settings are not configured correctly. For these settings, see the instructions earlier in this section.

The following image identifies the buttons that on the Sketch toolbar.



Arduino Sketch: Important Toolbar Functions

For both the "Verify" and "Upload" options, results and errors messages are shown in the message window of the Sketch IDE. If the upload to the Arduino Due completes successfully, the 781_gltest demo should start and provide examples of the drawing functions available in the S5U13781R01C100 Shield Graphics Library.

4 Using the S5U13781R01C100 Shield Graphics Library with Sketch

4.1.1 Modifying an Existing Sketch

There are several example sketches included with the S5U13781R01C100 Shield Graphics Library which attempt to demonstrate different concepts. For example:

- 781_gltest.ino – demonstrates some of the graphics functions available in the Graphics Library
- 781_RegisterAccessExample – demonstrates how to read/write S1D13781 registers directly
- 781_MemoryAccessExample – demonstrates how to read/write S1D13781 memory directly

In order to modify a sketch and try out a new idea, simply add new line in the Sketch loop() function that calls one of the Graphics Library functions. For example, if we want to display a green line from position 20,20 to position 100,100 on the LCD panel display, we could add the following line(s).

```
result = lcdc.drawLine( S1d13781_gfx::window_Main,20,20,100,100,0x0000FF00 );
sleep(2000);
```

For the above example:

- result is the return value from the drawLine() function. Many Graphics Library functions return a value with either the requested value, or a value that can be tested for errors.
- lcdc is the instance of the S1d13781_gfx class that is used in the example sketches.
- drawLine is the method to be called.
- the parameters passed to drawLine determine the destination window, line end positions, and color of the line.
- sleep(2000) is added so that we will have a chance to see the effect of our function call before anything else happens

For details on the methods available as part of the S5U13781R01C100 Shield Graphics Library, refer to the Library Reference section.

4.1.2 Creating a New Sketch

When creating a New sketch certain elements must be added to the basic template. The following code shows the additions which are explained below.

```
/*-----------------------------------------------------------------
 * new_sketch.ino
 * Example of a new sketch using the S5U13781R01C100 Graphics
 * Library Functions.
 *-----------------------------------------------------------------*/

#include <SPI.h>

#include <S1d13781_gfx.h>
#include <S1d13781_registers.h>


//create an instance of S1d13781 for us to work with
S1d13781_gfx lcdc;

void setup() {
  //start serial for serial monitor
  Serial.begin(9600);
```

```
  //start the S1d13781 library
  lcdc.begin();

  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

A new sketch requires the following additions to work with the S5U13781R01C100 Shield Graphics Library.

- #include <SPI.h> - The SPI header is required because the S5U13781R01C100 Shield relies on SPI to interface with the Arduino Due.
- #include <S1d13781_gfx.h> - This header includes the S5U13781R01C100 Shield library classes.
- #include <S1d13781_registers.h> - This header includes the #defines for the S1D13781 registers. When accessing S1D13781 registers it is suggested that the defined constants are used to avoid unintended access attempts to un-defined registers.
- "S1d13781_gfx lcdc;" – This line creates an instance of the S1d13781_gfx class. lcdc is what is used for the example sketches, but this name can be anything that is appropriate for your application.
- "Serial.begin(9600);" – This line is optional, but provides useful debugging capabilities which allow messages to be sent from your application to the Serial Monitor (see Using the Serial Monitor).
- "lcdc.begin();" – This line starts the S5U13781R01C100 library and performs the following functions:
    1. Setup the SPI interface using by the S5U13781R01C100 Shield.
    2. Initializes the registers according to the settings in S1d13781_init.h.
    3. Leaves the S1D13781 in a powered on state (ready to go).

4.1.3 Using the Serial Monitor

When the Arduino Due is connected through the Programming Port, the Serial Monitor function is available. The Serial Monitor can be started using the "Serial Monitor" button on the Sketch toolbar, or by clicking "Tools->Serial Monitor" on the Sketch menu.

The Serial Monitor allows information and messages from the application running on the Arduino Due to be sent to and displayed by the Sketch IDE. This can be a helpful tool when debugging modified application code or creating new applications. The example sketches included in the S5U13781R01C100 Shield Graphics Library include examples of how to use the Serial class to output information to the Serial Monitor.

For more information on using the Serial Class and Serial Monitor, refer to the Arduino language reference at www.arduino.cc/en/Reference/.

4.1.4 Using Fonts with the S5U13781R01C100 Shield Graphics Library

The S5U13781R01C100 Shield Graphics Library supports text drawing using a programmable font. The font relies on two components:

- A 1 bpp image file stored as a .pbm graphics file (binary)
- A portable font index stored as a .pfi file (binary)

The Graphics Library package provides some sample fonts and includes both the .pbm image file and .pfi index file as binary files.

Note:
The .pfi files are also stored in a sub-folder as text files for reference. For more information on the font index files and information useful for creating custom fonts, refer to the Readme.txt in the sample font folder.

All the sample fonts included in the package are created by Epson and are free to modify and/or use.

- Ascii4x6
- Ascii4x6p (proportional font)
- Ascii6x10
- Ascii6x10p (proportional font)
- Ascii7x11
- Ascii7x11p (proportional font)
- Ascii9x13
- Ascii9x13p (proportional font)
- AsciiCaps4x6
- AsciiCaps4x6p (proportional font)
- Latin6x10
- Latin6x10p (proportional font)
- LineDraw6x10 (includes line draw graphics suitable for line art buttons)

When using a font within a Sketch application, a simple method to provide the desired font to the application is to convert the binary .pbm and binary .pfi files into a simple byte arrays. If the arrays are stored as "C" source, they can be copied into the Sketch application folder and referenced from the Sketch application to be passed to the S1d13781_gfx::createFont() method when necessary.

An example is included in the sample sketch "781_gltest.ino" which includes several of the sample fonts. To make use of the external byte arrays, the following lines could be added to the Sketch application.

```
//test fonts
extern byte ascii9x13IndexData[];  //test font index data
extern byte ascii9x13ImageData[];  //test font image data
```

Then to create the font, send the data and the number of bytes for each array.

```
testfont = lcdc.createFont(ascii9x13ImageData, 1453, ascii9x13IndexData, 498);
```

Once the font is created it can be used with methods such as drawText() and drawMultiLineText(). When the font is not required anymore, call the freeFont() method to free the font resources.

For further information on the Font methods, refer to the Library Reference section.

4.1.5 Displaying Images with the S5U13781R01C100 Shield Graphics Library

Due to the small amount of memory and storage on the Arduino boards, the S5U13781R01C100 Shield Graphics Library does not include a specific function set for bitmap image handling.

However, small bitmap images can be included as part of a sketch program and then displayed on the TFT panel. Note that the size and number of images is important as there may not be enough memory to store large images or a large number of small images. One method to do this is to include images as an external byte stream as follows. The example sketch s1d13781_gltest.ino demonstrates this method.

1. Prepare your image(s) using a graphics editor that can save the image as raw data. The open source graphics editor Gimp is one program that can do this (see www.gimp.org).
2. Save the image as "Raw Data" (Gimp does this using the "Export As…" command).
3. Convert the "Raw Data" files to a C-style byte stream. This can be done using the bin2c tool provided in the "extras" folder of the S5U13781R01C100 Shield Graphics Library. Source is provided for the bin2c tool, so compile for your OS and run the following command at the command line:

   bin2c file1 file2

   For example:

   bin2c imagefile.data imagefile.c

4. Using a text editor, add the variable type and name to the byte stream in your ".c" file. For example, add the lines highlighted in red.

```
unsigned char imageData[] = {
0xE6,0xE6,0xE9,0xE9,0xE9,0xFB,0xFB,0xFB,0xFB,0xFB,0xFB,0xFC,0xFC,0xFC,0xF5,0xF5,
    *
    *
    *
0xF5,0xFC,0xFC,0xFC,0xFC,0xFC,0xFC,0xF9,0xF9,0xF9,0xF5,0xF5,0xF5,0xFD,0xFD,0xFD,
};
```

5. Copy the imagefile.c file to the folder where your sketch is saved and add the data to your sketch as an external byte stream. For example:

```
//external image data
extern byte imageData[];  //raw image stored in imagefile.c
```

6. Add a function to send the data to the S1D13781. For example:

```
void drawImageAtXy( int x, int y, int width, int height)
{
  unsigned int vramAddress = lcdc.lcdGetStartAddress();  //video memory address
  word stride = lcdc.lcdGetStride();  //number of bytes in line
  word bytesPerPixel = lcdc.lcdGetBytesPerPixel();
  word imageStride;
  unsigned int offset;
  unsigned int i,j;  //loop vars

  //calculate starting offset
  offset = (y*stride) + (x*bytesPerPixel);

  //calculate image stride
  imageStride = (width * bytesPerPixel);

  //adjust address with offset
  vramAddress = vramAddress + offset;
```

```
  //write image to Main window
    for (i=0; i<height; i++){
      for (j=0; j<(width*bytesPerPixel); j+=3){
        lcdc.memWriteByte(vramAddress+j, imageData[(imageStride*i)+j+2]);
        lcdc.memWriteByte(vramAddress+j+1, imageData [(imageStride*i)+j+1]);
        lcdc.memWriteByte(vramAddress+j+2, imageData [(imageStride*i)+j]);
      }
      vramAddress = vramAddress + stride;
    }
}
```

7. Add the drawImageAtXy() function call to the loop() routine of your sketch which will send the image to S1D13781 memory.

For more details on the example, please refer to the source code for the s1d13781_gltest.ino example sketch.

5 Understanding the Graphics Library

The S5U13781R01C100 Shield Graphics Library is a collection of C++ methods organized into two classes: S1d13781 and S1d13781_gfx. When integrated into the Arduino Sketch IDE they provide hardware access and simple graphics routines which enable users to quickly display graphics and text to a LCD panel connected to the S5U13781R01C100 Shield.

5.1.1 Library Structure

The S5U13781R01C100 Shield Graphics Library is organized into the following files:

- S1d13781.h – The header file for the S1d13781 class. It is a good place to get an overview of hardware oriented functions of the Graphics Library. This file also includes some constants that configure the SPI interface used between the S5U13781R01C100 Shield and the Arduino Due.
- S1d13781.cpp – The source file for the S1d13781 class. It includes the source for the methods that allows access to the hardware level functions of the S1D13781 LCD controller. This includes functions such as direct register and memory access, initialization of the S1D13781, and setup of SPI used for the interface between the S5U13781R01C100 Shield and the Arduino Due.
- S1d13781_gfx.h – The header file for the S1d13781_gfx class. It provides an overview of the graphics and text methods implemented in the Graphics Library.
- S1d13781_gfx.cpp – The source file for the S1d13781_gfx class. It includes the source for the graphics and text display methods available in the Graphics Library.
- S1d13781_init.h – This header file includes a structure that contains the values used to initialize the S1D13781 hardware registers.
- S1d13781_registers.h – This header file includes #defines for the S1D13781 hardware registers. When accessing S1D13781 registers it is suggested that the defined constants are used to avoid unintended access attempts to un-defined registers.
- keywords.txt - A file required for Library support in the Arduino Sketch IDE. Any new classes and/or methods should be added to this file. For further information on keywords.txt, refer to the Library Tutorial at www.arduino.cc/.

5.1.2 Modifying the Graphics Library

Full source code is provided for the S5U13781R01C100 Shield Graphics Library allowing customization and modification by the user. The Graphics Library source is not intended to be modified from within the Sketch IDE, so an external code editing tool should be used.

Once the Graphics Library is installed in the Sketch IDE, it can be modified directly in the "Arduino/libraries/S1d13781" folder. Alternately, it can be modified "off-tree" and re-installed as a .ZIP Library. However, for the re-installation method, the existing S1d13781 library must be removed from the "Arduino/libraries" folder before re-installing the updated Graphics Library.

For full Sketch IDE support, if new Classes and/or methods are added to the Graphics Library they should be added to the keywords.txt file included in the Graphics Library package. For further information on keywords.txt, refer to the Library Tutorial at www.arduino.cc/.

5.1.3 Customizing S1D13781 Initialization Values

If the register initialization values for the S1D13781 LCD controller must be customized, such as in a situation where a non-default LCD panel is to be used, this is possible by updating the structure found in the S1d13781_init.h file. The S1d13781_init.h file contains the register values and sequence that will programmed into the S1D13781 at startup.

The new values can be generated using the S1d13781windows utility "781cfg.exe" which is available on the internet at vdc.epson.com. Using "781cfg" select the desired S1D13781 configuration and use the "Export…" option to generate a "C Header File for S1D13781 Generic Drivers". This will generate a file called S1D13781.h which contains the values used to update the S1d13781_init.h file.

Open the S1D13781.h file generated by "781cfg" and copy the Index / Value pairs from the variable_name[] array to the regInitValues[] array in the Graphics Library file S1d13781_init.h. For example:

From S1D13781.h generated by the "781cfg" application copy the values highlighted in red:

```
#define S1D_INSTANTIATE_REGISTERS(scope_prefix,variable_name)  \
  scope_prefix S1D_REGS variable_name[] =  \
  {  \
    { 0x06,             0x0100 },   /* Software Reset Register */  \
    { S1D_REGDELAYON,   0x2710 },   /* LCD Panel Power On Delay (in ms) */  \
    { 0x04,             0x0000 },   /* Power Save Register  */  \
      *
      *
      *
    { 0xD2,             0x0001 },   /* GPIO Status / Control Register */  \
    { 0xD4,             0x0000 }    /* GPIO Pull-Down Control Register */  \
  }
```

To the "regData regInitValues[] = {}" array in the Graphics Library file S1d13781_init.h. The Index / Value pairs should now be the updated register initialization values for the new configuration.

Note that if the new initialization values are not correct for your configuration, the S1D13781 may not initialize and/or the panel may not display correctly. If this happens, re-check the settings using the "781cfg" application. For detailed S1D13781 register information, refer to the S1D13781 Hardware Functional Specification, document number X94A-A-001-xx, which is available at vdc.epson.com.

6 Library Reference

The S5U13781R01C100 Shield Graphics Library is organized into two classes:

S1d13781 – The base class which provides hardware level support for the S5U13781R01C100 Shield board connected to the SPI interface of the Arduino Due.

S1d13781_gfx – The class that provides the graphics drawing and text display functions.

6.1 S1d13781 Class

The S1d13781 class provides the following public methods. Private methods are not described in this document, but are documented in the source code.

6.1.1 S1d13781()

This is the constructor for the class.

6.1.2 S1d13781::begin()

This method should be run once to setup the SPI interface used by the S5U13781R01C100 Shield board and configure the registers.

Params - none

Return:

- none

6.1.3 S1d13781::regWrite()

Method to write a word (16-bit unsigned int) to a S1D13781 register. The regIndex argument should use the predefined register names found in the S1d13781_registers.h file, so as to prevent reading misaligned or invalid (non-existent) registers.

Note:
NOT all registers can be written at any given time. Some registers cannot be written if the S1D13781 is in NMM (see the specification for more details).

Param - regIndex Register index to write.

Param - regValue Data to write to the register.

Return:

- none

6.1.4 S1d13781::regRead()

Method to read a word (16-bit unsigned int) from a S1D13781 register. The regIndex argument should use the predefined register names found in the S1d13781_registers.h file, so as to prevent reading misaligned or invalid (non-existent) registers.

Note:
NOT all registers can be read at any given time. Some registers cannot be read if the S1D13781 is in PSM0 (see specification for more details).

Param - regIndex Index (offset) of the register to read.

Return:

- Returns the contents of the specified S1D13781 register.

6.1.5 S1d13781::regModify()

Method to modify the contents of a S1D13781 register using bitmasks. The basic premise is:

1. read the current register value
2. clear the selected bits using the clearBits bitmask
3. set the selected bits using the setBits bitmask
4. write the value back to the register

This function should not be used on any register in which any bit in the register has a different effect for reading vs writing, such as a status register that requires a "1" to be written to clear the status state.

Normally, this function is used to set a new value for a bitfield in a register that contains other bits other than just the bitfield. If a register contains only one single bitfield, and all other bits are unused, then the regRead/regWrite() functions should be used as they are more efficient.

Param - regIndex Register index to modify.

Param - clearBits Bitmask of register bits to be cleared (set to '0'). Any bit positions set to '1' in this mask will be cleared in the register value.

Param setBits Bitmask of register bits to set (to '1').

Return:

- The return value is the value that was written to the register.

6.1.6 S1d13781::regSetBits()

Method to set specific bits in a S1D13781 register using a bitmask. The basic premise is:

1. read the current register value
2. set the selected bits using the setBits bitmask
3. write the value back to the register

Normally, this function is used to set a single bit in a register that contains other unrelated bits. This function should not be used to set an entire register to one, as regWrite() would be more efficient.

Param - regIndex Register index to clear bits in.

Param - setBits Bitmask of bits to be set to '1' in the register.

Return:

- Returns the updated contents of the register.

6.1.7 S1d13781::regClearBits()

Method to clear specific bits in a S1D13781 register using a bitmask. The basic premise is:

1. read the current register value
2. clear the selected bits using the clearBits bitmask
3. write the value back to the register

Normally, this function is used to clear a single bit in a register that contains other unrelated bits. This function should not be used to clear an entire register to 0, as regWrite() would be more efficient.

Param - regIndex Register index to clear bits in.

Param - clearBits Bitmask of bits to be set to '0' in the register. Any bit positions set to '1' in this mask will be cleared in the register.

Return:

- Returns the updated contents of the register.

6.1.8 S1d13781::memWriteByte()

Method to write a byte (8-bit) value to the specified address offset in S1D13781 video memory.

Note:
The memory address offset must be within valid memory space (0x00000000~0x0005FFFF).

Param - memAddress Memory offset into video memory starting from address 0x00000000.

Param - memValue Byte value (8-bit) to write to video memory.

Return:

- none

6.1.9 S1d13781::memReadByte()

Method to read a byte (8-bit) value from the specified address offset in S1D13781 video memory.

Note:
The memory address offset must be within valid memory space (0x00000000~0x0005FFFF).

Param - memAddress Memory offset into video memory starting from address 0x00000000.

Return:

- Returns the byte (8-bit) value from the specified address.

6.1.10 S1d13781::memWriteWord()

Method to write a word (16-bit) value to the specified address offset in S1D13781 video memory.

Notes:
1. The memory address offset must be within valid memory space (0x00000000~0x0005FFFF).
2. For word writes, the memory address offset must be evenly divisible by 2 to ensure proper memory alignment.

Param - memAddress Memory offset into video memory starting from address 0x00000000.

Param - memValue Word value (16-bit) to write to video memory.

Return:

- none

6.1.11 S1d13781::memReadWord()

Method to read a word (16-bit) value from the specified address offset in the S1D13781 video memory.

Notes:
1. The memory address offset must be within valid memory space (0x00000000~0x0005FFFF).
2. For word reads, the memory address offset must be evenly divisible by 2 to ensure proper memory alignment.

Param -	memAddress	Memory offset into video memory starting from address 0x00000000.

Return:

- Returns the word (16-bit) value from the specified address.

6.1.12 S1d13781::memBurstWriteBytes()

Method to burst write a specified number of byte (8-bit) values to the specified address offset in S1D13781 video memory.

Notes:
The memory address offset must be within valid memory space (0x00000000~0x0005FFFF).

Param -	memAddress	Memory offset into video memory starting from address 0x00000000.
Param -	memValues	A pointer to a buffer containing the byte values (8-bit) to write to video memory. If the pointer is NULL, then no write is performed.
Param -	count	The number of bytes to burst write. If count is 0, then no write is performed.

Return:

- none

6.1.13 S1d13781::memBurstReadBytes()

Method to burst read a specified number of bytes (8-bit) values from the specified address offset in S1D13781 video memory.

Note:
The memory address offset must be within valid memory space (0x00000000~0x0005FFFF).

Param -	memAddress	Memory offset into video memory starting from address 0x00000000.
Param-	memValues	A pointer to a buffer where the byte values (8-bit) read from video memory will be placed. If the pointer is NULL, then no reads are performed.
Param -	count	The number of bytes to burst read. If count is 0, then no reads are performed.

Return:

- none

6.1.14 S1d13781::memBurstWriteWords()

Method to burst write a specified number of words (16-bit) values to the specified address offset in S1D13781 video memory.

Notes:
1. The memory address offset must be within valid memory space (0x00000000~0x0005FFFF).

2. For word writes, the memory address offset must be evenly divisible by 2 to ensure proper memory alignment.

Param -	memAddress	Memory offset into video memory starting from address 0x00000000.
Param -	memValues	A pointer to a buffer containing the word values (16-bit) to write to video memory. If the pointer is NULL, then no writes are performed.
Param-	count	The number of words to burst write. If count is 0, then no writes are performed.

Return:

- none

6.1.15 S1d13781::memBurstReadWords()

Method to burst read a specified number of words (16-bit) values from the specified address offset in S1D13781 video memory.

Notes:
1. The memory address offset must be within valid memory space (0x00000000~0x0005FFFF).
2. For word writes, the memory address offset must be evenly divisible by 2 to ensure proper memory alignment.

Param -	memAddress	Memory offset into video memory starting from address 0x00000000.
Param -	memValues	A pointer to a buffer where the word values (16-bit) read from video memory will be placed. If the pointer is NULL, then no reads are performed.
Param -	count	The number of words to burst read. If count is 0, then no reads are performed.

Return:

- none

6.1.16 S1d13781::lcdSetRotation()

Method to set the rotation of the main layer.

Param -	rotationDegrees	Counter-clockwise rotation of the main layer in degrees. Acceptable values (0, 90, 180, 270)

Return:

- none

6.1.17 S1d13781::lcdGetRotation()

Method to return the current rotation of the main layer.

Param - none

Return:

- Current counter-clockwise rotation in degrees (0, 90, 180, 270).

6.1.18 S1d13781::lcdSetColorDepth()

Method to set the color depth of the main layer.

Param - colorDepth Color depth of the main layer according to enum S1d13781::imageDataFormat values:

- format_RGB_888
- format_RGB_565
- format_RGB_888LUT
- format_RGB_565LUT
- format_RGB_332LUT

Return:

- none

6.1.19 S1d13781::lcdGetColorDepth()

Method to return the current color depth of the main layer.

Param - none

Return:

- Current color depth (possible values):
  - format_RGB_888
  - format_RGB_565
  - format_RGB_888LUT
  - format_RGB_565LUT
  - format_RGB_332LUT

6.1.20 S1d13781::lcdGetBytesPerPixel()

Method to return the number of bytes used per pixel based on the main layer color depth.

Param - none

Return:

- Number of bytes per pixel (possible: 1, 2, or 3)

6.1.21 S1d13781::lcdSetStartAddress()

Method to set the memory start address for the Main Layer. The start address is the offset into display memory where the main layer image starts.

Note:
The start address must be 32-bit aligned (must be divisible by 4).

Param - lcdStartAddress Offset, in bytes, into display memory where the main layer image starts.

Return:

- none

6.1.22 S1d13781::lcdGetStartAddress()

Method to return the memory start address for the Main Layer. The start address is the offset into display memory where the main layer image starts.

Note:
The start address must be 32-bit aligned (must be divisible by 4).

Param - none

Return:

- The Main Layer image start address.

6.1.23 S1d13781::lcdSetWidth()

Method to set the width of the physical LCD, in pixels. This value is used to determine the Main Layer width/height depending on the selected rotation.

Note:
The width of the physical LCD must be a multiple of 8.

Param - lcdWidth Width of the physical LCD, in pixels.

Return:

- none

6.1.24 S1d13781::lcdGetWidth()

Method to return the width of the Main Layer (based on rotation).

Notes:
1. For 0 and 180 degree rotation, the width of the Main Layer is based on the width of the physical LCD.
2. For 90 and 270 degree rotation, the width of the Main Layer is based on the height of the physical LCD.

Param - none

Return:

- Width of the Main Layer, in pixels

6.1.25 S1d13781::lcdSetHeight()

Method to set the height of the physical LCD, in pixels. This value is used to determine the Main Layer width/height depending on the selected rotation.

Param - lcdHeight height of the physical LCD, in pixels

Return:

- none

6.1.26 S1d13781::lcdGetHeight()

Method to return the height of the Main Layer (based on rotation).

Notes:
1. For 0 and 180 degree rotation, the height of the Main Layer is based on the height of the physical LCD.

2. For 90 and 270 degree rotation, the height of the Main Layer is based on the width of the physical LCD.

Param - none

Return:

- Height of the Main Layer, in pixels

6.1.27 S1d13781::lcdGetStride()

Method to return the stride of the Main Layer, in bytes.

Stride is the number of bytes in one line (or row) of the image. It can be used as the number that must be added to the address of a pixel in display memory to obtain the address of the pixel directly below it.

Param - none

Return:

- Main Layer stride, in bytes

6.1.28 S1d13781::pipSetDisplayMode()

Method to set the effect (blink/fade) for the PIP window.

Param - newEffect PIP effect from one of the following enum S1d13781::pipEffect values:

- pipDisabled Stops the PIP from being displayed immediately
- pipNormal Causes the PIP to be displayed immediately. The PIP will be displayed with the currently set alpha blending mode. If the alpha blending ratio is changed while the PIP is displayed the effect will take place on the next frame.
- pipBlink1 PIP layer toggles between the set alpha blend mode and no PIP.
- pipBlink2 PIP layer toggles between normal and invert. Alpha blend ratio remains constant.
- pipFadeOut Causes the PIP to fade from the current alpha blend value to 0x0000 (blank)
- pipFadeIn Causes the PIP layer to fade from 0x0000 to the set alpha blend ratio
- pipContinous Cycles between alpha blend 0x0000 and the current set alpha blend value.

Return:

- none

6.1.29 S1d13781::pipGetDisplayMode()

Method to return the current effect (blink/fade) for the PIP window.

Param - none

Return:

- Current effect from the following S1d13781::pipEffect enum values.
    - pipDisabled Stops the PIP from being displayed immediately
    - pipNormal Causes the PIP to be displayed immediately. The PIP will be displayed with the currently set alpha blending mode. If the alpha blending ratio is changed while the PIP is displayed the effect will take place on the next frame.
    - pipBlink1 PIP layer toggles between the set alpha blend mode and no PIP.
    - pipBlink2 PIP layer toggles between normal and invert. Alpha blend ratio remains constant.
    - pipFadeOut Causes the PIP to fade from the current alpha blend value to 0x0000 (blank)
    - pipFadeIn Causes the PIP layer to fade from 0x0000 to the set alpha blend ratio
    - pipContinous Cycles between alpha blend 0x0000 and the current set alpha blend value.

6.1.30 S1d13781::pipSetRotation()

Method to set the rotation of the PIP layer.

Param - rotationDegrees Counter-clockwise rotation of the PIP layer in degrees. Acceptable values (0, 90, 180, 270)

Return:

- none

6.1.31 S1d13781::pipGetRotation()

Method to return the current rotation of the PIP layer

Param - none

Return:

- Current counter-clockwise rotation in degrees (0, 90, 180, 270)

6.1.32 S1d13781::pipIsOrthogonal()

Method to determine if the Main and PIP layers have the same rotation.

Param - none

Return:

- True if same rotation
- False if different rotation.

6.1.33 S1d13781::pipSetColorDepth()

Method to set the color depth of the PIP layer.

Param - colorDepth Color depth of the PIP layer according to enum S1d13781::imageDataFormat values:

- format_RGB_888
- format_RGB_565
- format_RGB_888LUT

- format_RGB_565LUT
- format_RGB_332LUT

Return:

- none

6.1.34 S1d13781::pipGetColorDepth()

Method to return the current color depth of the PIP layer.

Param - none

Return:

- Current color depth (possible values):
  - format_RGB_888
  - format_RGB_565
  - format_RGB_888LUT
  - format_RGB_565LUT
  - format_RGB_332LUT

6.1.35 S1d13781::pipGetBytesPerPixel()

Method to return the number of bytes used per pixel based on the PIP Layer color depth.

Param - none

Return:

- Number of bytes per pixel (possible: 1, 2, or 3)

6.1.36 S1d13781::pipSetStartAddress()

Method to set the memory start address for the PIP Layer. The start address is the offset into display memory where the PIP Layer image starts.

Note:
The start address must be 32-bit aligned (must be divisible by 4).

Param - pipStartAddress Offset, in bytes, into display memory where the PIP layer image starts.

Return:

- none

6.1.37 S1d13781::pipGetStartAddress()

Method to return the memory start address for the PIP Layer. The start address is the offset into display memory where the PIP Layer image starts.

Note:
The start address must be 32-bit aligned (must be divisible by 4).

Param - none

Return:

- The PIP Layer image start address.

6.1.38 S1d13781::pipSetWidth()

Method to set the width of the PIP window, in pixels.

Param - pipWidth Width of the PIP window, in pixels.

Return:

- none

6.1.39 S1d13781::pipGetWidth()

Method to return the width of the PIP window, in pixels.

Param - none

Return:

- Width of the PIP window, in pixels

6.1.40 S1d13781::pipSetHeight()

Method to set the height of the PIP window, in pixels.

Param - pipHeight Height of the PIP window, in pixels.

Return:

- none

6.1.41 S1d13781::pipGetHeight()

Method to return the height of the PIP window, in pixels.

Param - none

Return:

- Height of the PIP window, in pixels

6.1.42 S1d13781::pipGetStride()

Method to return the stride of the PIP window, in bytes.

Stride is the number of bytes in one line (or row) of the image. It can be used as the number that must be added to the address of a pixel in display memory to obtain the address of the pixel directly below it.

Param - none

Return:

- PIP Layer stride, in bytes

6.1.43 S1d13781::pipSetPosition()

Method to set the position of the top left corner of the PIP window relative to the top left corner of the lcd panel origin.

Note:
1. The PIP x,y coordinates must be set within the panel display area.
2. Main Layer rotation is not checked, so the PIP position is always relative to the top left corner of the panel.

Param - xPos new x PIP window coordinate, in pixels

Param - yPos new y PIP window coordinate, in pixels

Return:

- none

6.1.44 S1d13781::pipGetPosition()

Method to get the position of the PIP window (x,y in pixels) relative to the top left corner of the lcd panel (origin).

Param - xPos pointer to the x starting position value, in pixels

Param - yPos pointer to the y starting position value, in pixels

Return:

- none

6.1.45 S1d13781::pipSetFadeRate()

Method to set the Blink/Fade period (in frames) for the PIP window.

When the PIP layer is set to use Fade In, Fade Out, or continuous Fade In/Out, the fadeRate value is used to determine the number of frames to pause before setting the Alpha blend ratio to the next step.

Param - fadeRate number of frames to wait between automatic alpha blend ratio steps. Range is from 1 to 64.

Return:

- none

6.1.46 S1d13781::pipGetFadeRate()

Method to return the current Blink/Fade period (in frames) for the PIP window.

When the PIP layer is set to use Fade In, Fade Out, or continuous Fade In/Out, the fadeRate value is used to determine the number of frames to pause before setting the Alpha blend ratio to the next step.

Param - none

Return:

- Blink/fade period of PIP window, in frames

6.1.47 S1d13781::pipWaitForFade()

Method to wait for the current PIP Blink/Fade operation to complete.

This method is normally used for one-time Fade Out and Fade In PIP Effects to check when the fade-out or fade-in has finished. It is also used when transitioning from the Blink1, Blink2, and Fade In/Out Continuous effects to the Normal or Blank effects to check when the blinking or fading has finished.

Param - maxTime maximum time to wait (timeout value)

Return:

- True for fade has completed, False if maxTime reached

6.1.48 S1d13781::pipSetAlphaBlendStep()

Method to set the Alpha Blend step for the PIP window.

The alpha blend step determines the increment/decrement steps for the alpha blend value during fade in/ fade out effects. If the PIP window Alpha Blend Ratio is not set to "Full PIP" (100%), the blend step should be set such that the step value is evenly divisible into the Alpha Blending Ratio.

Param - step alpha blend step (acceptable values: 1, 2, 4, 8)

Return:

- none

6.1.49 S1d13781::pipGetAlphaBlendStep()

Method to return the Alpha Blend step for the PIP window.

The alpha blend step determines the increment/decrement steps for the alpha blend value during fade in/ fade out effects. If the PIP window Alpha Blend Ratio is not set to "Full PIP" (100%), the blend step should be set such that the step value is evenly divisible into the Alpha Blending Ratio.

Param - none

Return:

- Alpha blend step value (possible values: 1, 2, 4, 8)

6.1.50 S1d13781::pipSetAlphaBlendRatio()

Method to set the Alpha Blend ratio (in percent) for the PIP window.

The PIP layer can be alpha blended with the Main layer image. The S1D13781 supports 64 levels of blending, but this function simplifies by allowing the ratio to be specified as a percentage which is calculated to the nearest value.

Param - ratio percentage for the PIP layer alpha blend, ranging from 0% (PIP not visible) to 100% (only PIP visible)

Return:

- none

6.1.51 S1d13781::pipGetAlphaBlendRatio()

Method to return the Alpha Blend ratio (in percent) for the PIP window.

The PIP layer can be alpha blended with the Main layer image. The S1D13781 supports 64 levels of blending, but this function simplifies by allowing the ratio to be specified as a percentage which is calculated to the nearest value.

Param - none

Return:

- PIP layer alpha blend ratio to the nearest percent (%)

6.1.52 S1d13781::pipEnableTransparency()

Method to enable/disable the Transparency function for the PIP window.

Param - enable Set to True to enable transparency, False to disable transparency

Return:

- none

6.1.53 S1d13781::pipGetTransparency()

Method to return the current Transparency state for the PIP window.

Param - none

Return:

- True if transparency is enabled
- False if transparency is disabled

6.1.54 S1d13781::pipSetTransColor()

Method to set the Transparency Key Color for the PIP window.

When the PIP layer transparency is enabled, any pixels in the PIP layer that match the transparent color become transparent and the Main layer pixels are displayed instead.

The transparent color is defined as a 32-bit RGB8888 as follows:

- x (bits 31-24) = unused
- r (bits 23-16) = 8-bits of Red
- g (bits 15-8) = 8-bits of Green
- b (bits 7-0) = 8-bits of Blue

Note:
For modes other than RGB888, refer to the specification to see which bits are significant.

Param - xrgbColor transparent key color as described above

Return:

- none

6.1.55 S1d13781::pipGetTransColor()

Method to return the Transparency Key Color for the PIP window.

When the PIP layer transparency is enabled, any pixels in the PIP layer that match the transparent color become transparent and the Main layer pixels are displayed instead.

The transparent color is defined as a 32-bit RGB8888 as follows:

- x (bits 31-24) = unused
- r (bits 23-16) = 8-bits of Red
- g (bits 15-8) = 8-bits of Green
- b (bits 7-0) = 8-bits of Blue

Note:
For modes other than RGB888, refer to the specification to see which bits are significant.

Param - none

Return:

- Transparent key color as described above

6.1.56 S1d13781::pipSetupWindow()

Method to setup a PIP window with a single function call.

This function permits setting PIP x,y coordinates, width, height and stride with one function call. Use this function to initially setup PIP or any time several parameters need to be simultaneously updated.

Param -	xPos	new X position, in pixels, for the PIP window relative to the top left corner of the main window.
Param -	yPos	new Y position, in pixels, for the PIP window relative to the top left corner of the main window.
Param -	pipWidth	new width, in pixels, for the PIP window.
Param -	pipHeight	new height, in pixels, for the PIP window.

Return:

- none

6.1.57 S1d13781::lcdSetLutEntry()

Method to set a specific LUT entry. For details, refer to the specification on LUT Architecture.

The LUT xrgbData color is defined as a 32-bit RGB8888 as follows:

- x (bits 31-24) = unused
- r (bits 23-16) = 8-bits of Red
- g (bits 15-8) = 8-bits of Green
- b (bits 7-0) = 8-bits of Blue

Note:
For modes other than RGB888, refer to the specification to see which bits are significant.

Param -	index	LUT index to write the LUT data to
Param -	xrgbData	Data to write to the LUT index
Param -	window	LUT to access as determined by the window specified by the enum S1d13781::windowDestination: • window_Main uses LUT1 at address 0x00060000 • window_Pip uses LUT2 at address 0x00060400

Return:

- none

6.1.58 S1d13781::lcdGetLutEntry()

Method to return a specific LUT entry value. For details, refer to the specification on LUT Architecture.

The LUT xrgbData color is defined as a 32-bit RGB8888 as follows:

- x (bits 31-24) = unused
- r (bits 23-16) = 8-bits of Red
- g (bits 15-8) = 8-bits of Green
- b (bits 7-0) = 8-bits of Blue

Note:
For modes other than RGB888, refer to the specification to see which bits are significant.

Param - index — LUT index to read the LUT data to

Param - window — LUT to access as determined by the window specified by the enum S1d13781::windowDestination:

- window_Main uses LUT1 at address 0x00060000
- window_Pip uses LUT2 at address 0x00060400

Return:

- Data from the specified LUT entry as described above.

6.1.59 S1d13781::lcdSetLutDefault()

Method to set the LUTs with default values. For details, refer to the specification on LUT Architecture.

Param - window — LUT to access as determined by the window specified by the enum S1d13781::windowDestination:

- window_Main uses LUT1 at address 0x00060000
- window_Pip uses LUT2 at address 0x00060400

Return:

- none

6.2 S1d13781_gfx Class

The S1d13781_gfx class provides the following public methods. Private methods are not described in this document, but are documented in the source code.

6.2.1 S1d13781_gfx()

This is the constructor for the class.

6.2.2 S1d13781_gfx::fillWindow()

Method to fill the destination window with a specified color.

The color parameter is a 32-bit unsigned int used as follows:

- for RGB 8:8:8 modes (24 bpp):
  - bits 31-24 = unused

  - bits 23-16 = 8-bits of Red
  - bits 15-8 = 8-bits of Green
  - bits 7-0 = 8-bits of Blue
- for RGB 5:6:5 modes (16 bpp):
  - bits 31-16 = unused
  - bits 15-11 = 5-bits of Red
  - bits 10-5 = 6-bits of Green
  - bits 4-0 = 5-bits of Blue
- for 8 bpp modes:
  - bits 31-8 = unused
  - bits 7-0 = 8-bit color value

Note:

For details on the color formats supported by the S1D13781, refer to the Hardware Specification.

Param - window Destination window to be filled.

Param - color Color value as specified above.

Return:

- Zero (0) indicates no errors.
- 1 indicates invalid window error.
- 2 indicates invalid image format error.

6.2.3 S1d13781_gfx::clearWindow()

Method to clear the destination window to black. This function is essentially the same as fillWindow().

Param - window Destination window to be filled.

Return:

- Zero (0) indicates no errors.
- 1 indicates invalid window error.

6.2.4 S1d13781_gfx::drawPixel()

Method to draw a pixel at the specified x,y coordinate using the specified color.

The color parameter is a 32-bit unsigned int used as follows:

- for RGB 8:8:8 modes (24 bpp):
  - bits 31-24 = unused
  - bits 23-16 = 8-bits of Red
  - bits 15-8 = 8-bits of Green
  - bits 7-0 = 8-bits of Blue
- for RGB 5:6:5 modes (16 bpp):
  - bits 31-16 = unused
  - bits 15-11 = 5-bits of Red
  - bits 10-5 = 6-bits of Green
  - bits 4-0 = 5-bits of Blue
- for 8 bpp modes:
  - bits 31-8 = unused
  - bits 7-0 = 8-bit color value

Note:

For details on the color formats supported by the S1D13781, refer to the Hardware Specification.

Param -	window	Destination window for the pixel.
Param -	x	X coordinate of the pixel relative to 0,0 of the window.
Param -	y	Y coordinate of the pixel relative to 0,0 of the window.
Param -	color	Color value as specified above.

Return:

- Zero (0) indicates no errors.
- 1 indicates invalid window error.
- 2 indicates coordinate out of window error.

6.2.5 S1d13781_gfx::getPixel()

Method to return the color value of a pixel at the specified x,y coordinates.

The color parameter is a 32-bit unsigned int used as follows:

- for RGB 8:8:8 modes (24 bpp):
  - bits 31-24 = unused
  - bits 23-16 = 8-bits of Red
  - bits 15-8 = 8-bits of Green
  - bits 7-0 = 8-bits of Blue
- for RGB 5:6:5 modes (16 bpp):
  - bits 31-16 = unused
  - bits 15-11 = 5-bits of Red
  - bits 10-5 = 6-bits of Green
  - bits 4-0 = 5-bits of Blue
- for 8 bpp modes:
  - bits 31-8 = unused
  - bits 7-0 = 8-bit color value

Note:

For details on the color formats supported by the S1D13781, refer to the Hardware Specification.

Param -	window	Source window for the pixel.
Param -	x	X coordinate of the pixel relative to 0,0 of the window.
Param -	y	Y coordinate of the pixel relative to 0,0 of the window.

Return:

- 0x00000000 to 0x00FFFFFF - Color value of the pixel depending on color format.
- 0xFF000000 - indicates invalid window error.
- 0xFE000000 - indicates coordinate out of window error.
- 0xFD000000 - indicates invalid window image format error.

6.2.6 S1d13781_gfx::drawLine()

Method to draw a line between 2 specified x,y coordinates using the specified color.

The color parameter is a 32-bit unsigned int used as follows:

- for RGB 8:8:8 modes (24 bpp):
  - bits 31-24 = unused
  - bits 23-16 = 8-bits of Red
  - bits 15-8 = 8-bits of Green
  - bits 7-0 = 8-bits of Blue
- for RGB 5:6:5 modes (16 bpp):
  - bits 31-16 = unused
  - bits 15-11 = 5-bits of Red
  - bits 10-5 = 6-bits of Green
  - bits 4-0 = 5-bits of Blue
- for 8 bpp modes:
  - bits 31-8 = unused
  - bits 7-0 = 8-bit color value

Note:

For details on the color formats supported by the S1D13781, refer to the Hardware Specification.

Param -	window	Destination window for the line.
Param -	x1	X1 coordinate of the first endpoint for the line relative to 0,0 of the window.
Param - window.	y1	Y1 coordinate of the first endpoint for the line relative to 0,0 of the
Param - window.	x2	X2 coordinate of the second endpoint for the line relative to 0,0 of the
Param - window.	y2	Y2 coordinate of the second endpoint for the line relative to 0,0 of the
Param-	color	Color value as specified above.

Return:

- Zero (0) indicates no errors.
- 1 indicates invalid window error.
- 2 indicates coordinate out of window error.

6.2.7 S1d13781_gfx::drawRect()

Method to draw a rectangle of a specified width,height starting at pixel coordinate x,y using the specified color.

The color parameter is a 32-bit unsigned int used as follows:

- for RGB 8:8:8 modes (24 bpp):
  - bits 31-24 = unused
  - bits 23-16 = 8-bits of Red
  - bits 15-8 = 8-bits of Green

  - bits 7-0 = 8-bits of Blue
- for RGB 5:6:5 modes (16 bpp):
  - bits 31-16 = unused
  - bits 15-11 = 5-bits of Red
  - bits 10-5 = 6-bits of Green
  - bits 4-0 = 5-bits of Blue
- for 8 bpp modes:
  - bits 31-8 = unused
  - bits 7-0 = 8-bit color value

Note:

For details on the color formats supported by the S1D13781, refer to the Hardware Specification.

Param -	window	Destination window for the rectangle.
Param -	xStart	X coordinate of rectangle start point relative to 0,0 of the window.
Param -	yStart	Y coordinate of rectangle start point relative to 0,0 of the window.
Param -	width	Width of the rectangle.
Param -	height	Height of the rectangle.
Param -	color	Color value as specified above.

Return:

- Zero (0) indicates no errors.
- 1 indicates invalid window error.
- 2 indicates coordinate out of window error.

6.2.8 S1d13781_gfx::drawFilledRect()

Method to draw a filled rectangle of a specified width,height starting at pixel coordinate x,y using the specified color.

The color parameter is a 32-bit unsigned int used as follows:

- for RGB 8:8:8 modes (24 bpp):
  - bits 31-24 = unused
  - bits 23-16 = 8-bits of Red
  - bits 15-8 = 8-bits of Green
  - bits 7-0 = 8-bits of Blue
- for RGB 5:6:5 modes (16 bpp):
  - bits 31-16 = unused
  - bits 15-11 = 5-bits of Red
  - bits 10-5 = 6-bits of Green
  - bits 4-0 = 5-bits of Blue
- for 8 bpp modes:
  - bits 31-8 = unused
  - bits 7-0 = 8-bit color value

Note:

For details on the color formats supported by the S1D13781, refer to the Hardware Specification.

Param -	window	Destination window for the rectangle.
Param -	xStart	X coordinate of rectangle start point relative to 0,0 of the window.
Param -	yStart	Y coordinate of rectangle start point relative to 0,0 of the window.
Param -	width	Width of the rectangle.
Param -	height	Height of the rectangle.
Param -	color	Color value as specified above.

Return:

- Zero (0) indicates no errors.
- 1 indicates invalid window error.
- 2 indicates coordinate out of window error.

6.2.9 S1d13781_gfx::drawPattern()

Method to draw useful test patterns to the specified window.

Param -	window	Destination window for the rectangle.
Param -	pattern	Test pattern type:

- S1d13781_gfx::patternRgbHorizBars (solid horizontal RGB bars)
- S1d13781_gfx::patternRgbHorizGradient (gradient horizontal. RGB bars)
- S1d13781_gfx::patternVertBars (vertical TV style color bars)

Param -	colorStrength	Intensity of colors used for patternRgbHorizBars and patternVertBars as a percentage (0 = black, 100 = full intensity colors) Note: This setting is not used for patternRgbHorizGradient.

Return:

- Zero (0) indicates no errors.
- 1 indicates invalid window error.
- 2 indicates invalid image format error.
- 3 indicates invalid pattern error.

6.2.10 S1d13781_gfx::createFont()

Method to create the structures needed to draw a simple raster font from the contents of an image file and an index font file.

To reduce memory footprint, font routines will refer to the ImageData buffer when drawing text. This routine will not allocate and copy this buffer for future use, so do NOT free the buffer you passed in as ImageData. There is allocation made for the font index information, so be sure to call the freeFont() routine to free resources when you exit the application. You can free the IndexData buffer after calling this routine.

Param -	imageData	The contents of a font image file (.pbm). See NOTE below.
Param -	imageDataSize	Size of the contents in the image file.
Param -	indexData	The contents of a font index file (.pfi). See NOTE below.

Param - indexDataSize Size of the contents in the index file.

Return:

- Returns a handle to the font created.

NOTE:

ImageData must point to a Non-ASCII "P4" .pbm image file. It must be the P4 binary format as the font routine will directly refer to the ImageData buffer that you provided. The IndexData can be either ASCII (F1) or Binary (F4). For more information about the F1 and F4 formats, please refer to the README.txt file.

6.2.11 S1d13781_gfx::freeFont()

Method to invalidate the specified font and free the system resources associated with it.

Param - font The font to free.

Return:

- NULL

6.2.12 S1d13781_gfx::drawText() S1d13781_gfx::drawTextW()

Method to draw text containing "Chars"or “Wchars” to the specified window using the given font.

Param -	window	Destination window where the text is drawn.
Param -	font	The font that will be used for the text. The Font information must have been previously created with createFont().
Param -	text	The text to be drawn.
Param -	X,Y	X and Y position where the text will be drawn.
Param-	width	The cropping area width (in pixels). A value of 0 means to crop at window width.
Param -	fgColor	The color of the text.
Param -	bgColor	The background color behind the text. A NULL value specifies the background will be unchanged.
Param -	wordCrop	True if cropping should be done on word boundaries.
Param -	cropped	Returns True if text was cropped (can be set to NULL).

Return:

- The number of characters drawn (after cropping).

6.2.13 S1d13781_gfx::drawMultiLineText() S1d13781_gfx::drawMultiLineTextW()

Method to draw multiple lines of text containing "Chars" or “Wchars” to the specified window using the given font.

Param - window Destination window where the text is drawn.

Param -	font	The font that will be used for the text. The Font information must have been previously created with createFont().
Param -	text	The text to be drawn.
Param -	X,Y	X and Y position where the text will be drawn.
Param -	width	The cropping area width (in pixels). A value of 0 means to crop at window width.
Param -	fgColor	The color of the text.
Param -	bgColor	The background color behind the text. A NULL value specifies the background will be unchanged.
Param -	wordCrop	True if cropping should be done on word boundaries.
Param -	cropped	Returns True if text was cropped (can be set to NULL).
Param -	linesDrawn	Returns the number of lines it took to draw the text.

Return:

- The number of characters drawn (after cropping).

6.2.14 S1d13781_gfx::measureText() S1d13781_gfx::measureTextW()

Method to measure text containing "Chars" or “Wchars” in pixels, and returns the number of characters that can be shown in the given width.

Param -	font	The font that will be used for the text. The Font information must have been previously created with createFont().
Param -	text	The text to be measured.
Param -	width	The cropping area width (in pixels).
Param -	wordCrop	True if cropping should be done on word boundaries.
Param -	cropped	Returns True if text would be cropped (can be set to NULL).

Return:

- The number of characters that would be drawn.

6.2.15 S1d13781_gfx::getFontName()

Method to return the name of a given font.

Param -	font	The font that will be used for the text. The Font information must have been previously created with createFont().

Return:

- The name of the font.

6.2.16 S1d13781_gfx::getFontHeight(

Method to return the height of a given font, in pixels.

Param - font The font that will be used for the text. The Font information must have been previously created with createFont().

Return:

- The height of the font, in pixels.

6.2.17 S1d13781_gfx::getCharWidth() S1d13781_gfx::getCharWidthW()

Method to return the width of the specified "Char" or “Wchar” character for a given font, in pixels.

Note: For proportional fonts, the character width may not be the same for all characters.

Param - font The font that will be used for the text. The Font information must have been previously created with createFont().

Param - character The "Char" character to measure.

Return:

- The width of the character, in pixels.

6.2.18 S1d13781_gfx::getTextWidth() S1d13781_gfx::getTextWidthW()

Method to return the width of specified text consisting of "Char" or “Wchar” characters for a given font, in pixels.

Note: For proportional fonts, the character width may not be the same for all characters.

Param - font The font that will be used for the text. The Font information must have been previously created with createFont().

Param - text The text consisting of "Char" characters.

Param - textLen The number of characters in the text to be measured.

Return:

- The width of the text, in pixels.

6.2.19 S1d13781_gfx::captureFontIndexFile()

Method to generate the contents for a font index file from a given Font. This method is provided as a convenience to genereate binary versions of the index files (which are smaller than the ASCII versions).

Param - font The font that will be used for the text. The Font information must have been previously created with createFont().

Param - dFileBuffer The destination buffer that will receive the font index file contents.

Param - dFileBufferSize The allocation size of the destination buffer.

Param - binaryData Determines if the index data is written in binary or ASCII.

Return:

- The number of bytes written into dBuffer (will return 0 if operation failed)

6.2.20 S1d13781_gfx::copyArea()

Method to copy a rectangular area to another area.

Param -	srcWindow	Source window area for the copy.
Param -	destWindow	Destination window to copy the area to.
Param -	area	Source rectangle to be copied (x,y,w,h).
Param -	destX	Destination X coordinate.
Param -	destY	Destination Y coordinate.

Return:

- Returns 0 if successful.
- Returns 1 if invalid window error.
- Returns 2 if line buffer memory allocation error.
- Returns 3 if drawPixel error.

7 Change Record

X94A-B-001-01 Revision 1.02 - Issued: March 29, 2018

- Updated address/contact page
- Updated Epson web page and email address
- Minor formatting changes

X94A-B-001-01 Revision 1.01 - Issued: July 14, 2015

- Fixed miscellaneous typos
- Section 3.2.4, added example port setting screen capture for Windows OS
- Section 4.1.5, added section about displaying images

X94A-B-001-01 Revision 1.0 - Issued: July 02, 2015

- Removed Confidential Watermark
- Issued as Revision 1.0 document

X94A-B-001-00 Revision 0.1 - Issued: June 26, 2015

- Initial revision of document

8 Sales and Technical Support

For more information on Epson Display Controllers, visit the Epson Global website.

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