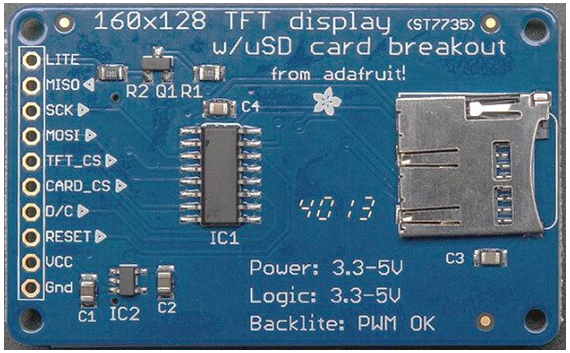
LCD Driver & Display

SPI Interface

TFT LCD Display

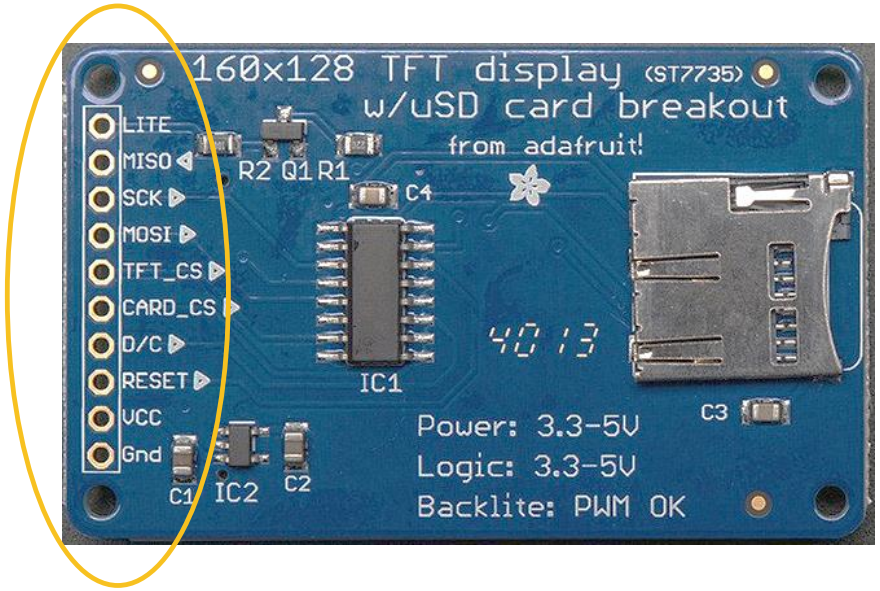
- 1.8" LCD TFT display.
- 128 x160 pixel resolution, 18-bit (262,144) colors.
- **SPI** Serial interface.
- Use with 3.3V or 5V logic
- On-board 3.3V @ 150mA LDO regulator.
- White LED backlight supporting PWM dimming control.
- 1 x10 header for connections to microcontroller.
- *Support for SD card interface (not used in ECE300).*



SPI: **S**erial **P**eripheral **I**nterface, is a synchronous serial interface (requires a clock).

TFT LCD Connections to LaunchPad

LCD Pin	LaunchPad GPIO Pins
MOSI	PA5
D/C	PA6
RESET	PA7
LITE	PB1
TFT_CS	PA3
SCK	PA2
VCC	+3.3V
Gnd	GND

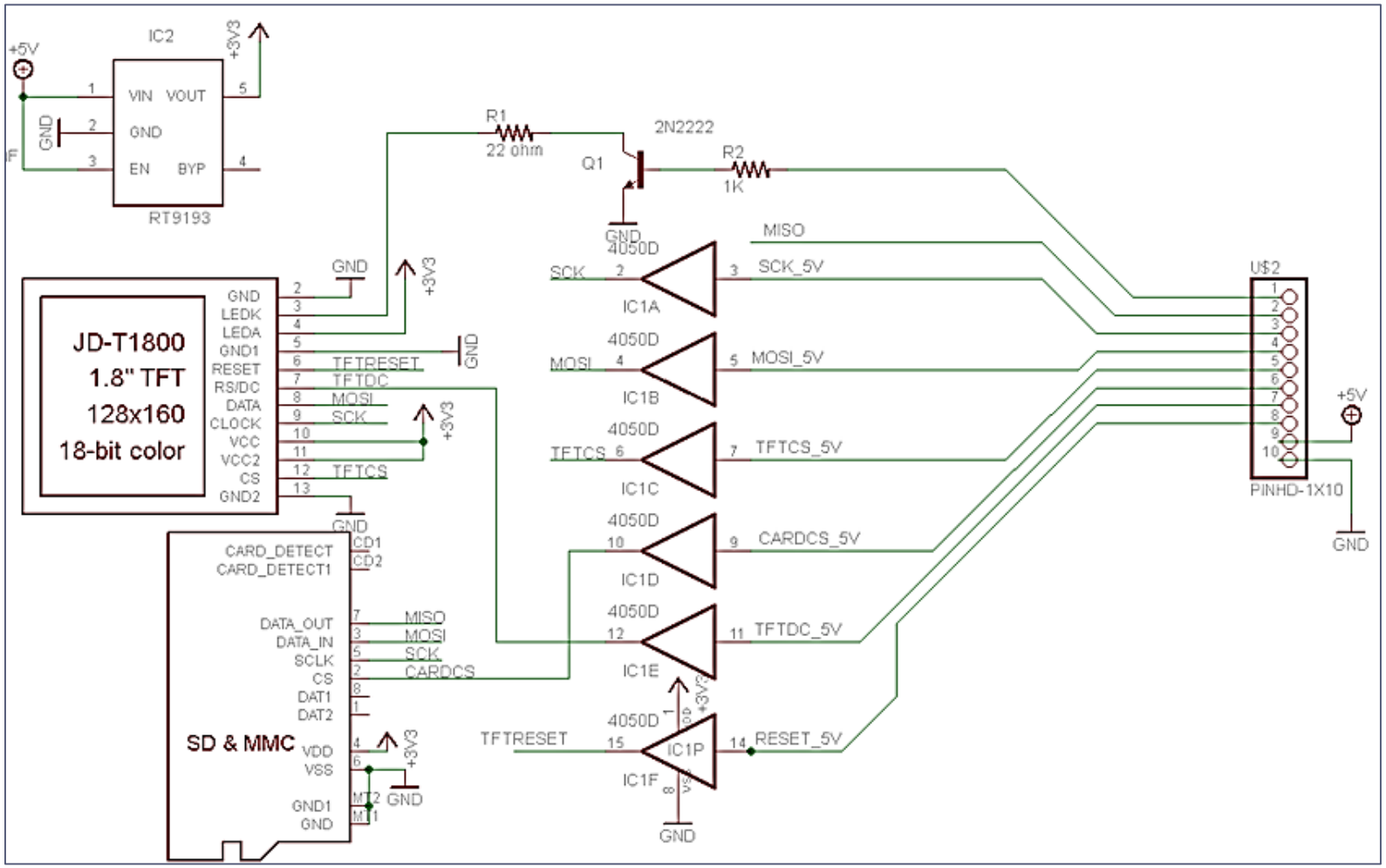


LCD TFT Display Interface Signals

- **LITE** - PWM input for LCD backlight control. Connect to 3-5VDC to turn on backlight or PWM control signal. [**PB1**]
- **MISO** - SPI Master In Slave Out pin (used for SD card). Not used for the TFT display which is write-only.
- **SCLK** - SPI clock input pin. [**PA2**]
- **MOSI** - SPI Master Out Slave In pin. To send data from LaunchPad to TFT. [**PA5**]
- **TFT_CS** - TFT SPI chip select pin. [**PA3**]
- **Card CS -** SD card chip select. To read from SD card.
- **D/C** - TFT SPI data or command selection pin. [**PA6**]
- **RESET** - TFT reset pin. Logic L to reset the TFT. [**PA7**]
- **VCC** - 3.3V - 5V DC.
- **GND** - Ground pin.

Signals greyed out are NOT USED in the ECE300 Lab.

TFT LCD Panel Schematics



TFT LCD Library & Functions

- LCD library & Initialization functions has been created with the basic functions.
  - **Src\App\LCD** folder:
    - LCD low-level functions : LCD_ST7735R.c
    - LCD low-level header file : LCD_ST7735R.h
    - LCD GUI library : DPGUI_KEIL_CM4_V11.lib
    - LCD GUI library header file : gui.h
    - Font file for LCD display : Fontarialbold12.c
    - Font file for LCD display : Fontarialbold16.c
    - Font file for LCD display : Fontarialbold24.c
  - **Src\BSP\SPI** folder:
    - SSI initialization : spim.c
    - SSI header file : spim.h

SSI: **S**ynchronous **S**erial **I**nterface module in LaunchPad. Used to implement the **SPI** interface for the LCD.

Program Structure: **main()**

```
int main()
{
      Port_Init();
      SystemCoreClockUpdate ();
      SysTick_Config( SystemCoreClock/1000 );

      /* SSI initialization */
      NVIC_SetPriority( SSI0_IRQn, 0 );

      SpimInit(
         &g_SpimHandle,
         0U,
         25000000U,
         SPI_CLK_INACT_LOW,
         SPI_CLK_RISING_EDGE,
         SPI_DATA_SIZE_8 );

      main_LcdInit();

      IRQ_Init();

       /** program continues in next slide  **/
```

Program Structure: `main()`

```
    for(;;)
    {
       /* LCD update */
       if( FALSE != g_bLCDUpdate )
       {
         if( 0 != g_bLcdFree )
         {
            g_bLCDUpdate = FALSE;
            g_bLcdFree = FALSE;
            GUI_Draw_Exe();
          }
       }
        /* other program codes  */        }
    }
  } /* end main */
```

`GUI_Draw_Exe()`: Call-back function to update TFT screen.

Program Structure: `SysTick_Handler()`

```
  void SysTick_Handler( void )
  {
     g_bSystemTick = TRUE;

     /** some program codes removed **/

     if( 0 != g_nLCD )
     {
        g_nLCD--;
        if( 0 == g_nLCD )
        {
          g_nLCD = LCD_UPDATE_MS;
          g_bLCDUpdate = TRUE;
        }
      }

}
```

- Frequency to update the TFT LCD screen is done through the SysTick timer.
- **`LCD_UPDATE_MS`** parameter controls the LCD display update frequency.

TFT LCD: `main_LcdInit()`

```
static void main_LcdInit( void )
{
  int screenx;
  int screeny;

  LcdInit( &g_SpimHandle, LCD_POTRAIT_180 );
  LCD_GetSize( &screenx, &screeny );

  GUI_Init(
    &g_MemDev,
    screenx, screeny, g_aBuf, sizeof(g_aBuf) );

    /* Switch to transfer word for faster performance */
    SpimSetDataSize( &g_SpimHandle, SPI_DATA_SIZE_16 );
    GUI_16BitPerPixel( TRUE );

    /* Clear LCD screen to Blue */
    GUI_Clear( ClrBlue );

    /* set font color background */
    GUI_SetFontBackColor( ClrBlue );

    /* Set font */
    GUI_SetFont( &g_sFontCalibri10 );
    LCD_AddCallback( main_cbLcdTransferDone );
    GUI_AddCbFrameEnd( main_cbGuiFrameEnd );

    LCD_BL_ON(); /* Backlight ON */
}
```

- Function initializes and setups the LCD screen for display.
- Utilizes the SPI interface.
- Do not modify this function unless necessary.

TFT LCD: `GUI_AppDraw()`

```
void GUI_AppDraw( BOOL bFrameStart )
{
  /* This function invokes from GUI library */
  char buf[128];
  GUI_Clear( ClrBlue ); /* Set background to blue.Refer to gui.h */
  GUI_SetFont( &FONT_Arialbold16 );
  GUI_SetFontBackColor( ClrBlue );
  GUI_PrintString( "SEM2306 FA21", ClrYellow , 8, 8 ); //col, row
  GUI_SetFont( &FONT_Arialbold12 );
  GUI_PrintString( "DigiPen-SiT", ClrWhite , 35, 28 );

  GUI_SetColor(ClrYellow);
  GUI_DrawFilledRect(0,55,127,115);
  GUI_SetFont( &FONT_Arialbold16 );
  GUI_PrintString( "Key Pressed", ClrBlack, 14, 62 );
  GUI_SetFont( &FONT_Arialbold24 );
  sprintf( buf, "%c", g_cKey);
  GUI_PrintString( buf, ClrBlack, 55, 88 );

  GUI_SetColor( ClrLightCyan );
  GUI_DrawFilledRect( 0, 140, 127, 159);
  GUI_SetFont( &FONT_Arialbold16 );
  GUI_SetFontBackColor( ClrLightCyan );
  sprintf( buf, "Time: %02u:%02u:%02u", (g_nTimeSec/3600)%24,
(g_nTimeSec/60)%60, g_nTimeSec%60 );
  GUI_PrintString( buf, ClrBlack, 12, 142 );
}
```

- Function in *main.c*.
- **`GUI_AppDraw()`** is a call-back function to refresh LCD screen with updated data.
- Use this function to design the look-and-feel of your LCD display.

Testing TFT LCD Display ….

- Try to add your own messages to the TFT display through editing function **`GUI_AppDraw()`.**
- You can choose different **font types** *(defined in gui.h)*:

```
/*  Fonts - List of selectable fonts  */
extern const GUI_FONT FONT_Arialbold12;
extern const GUI_FONT FONT_Arialbold16;
extern const GUI_FONT FONT_Arialbold24;
```

- You can change the LCD display **orientation** through the **`main_LcdInit()`** function *(in main.c)*. Options (below) are in file *LCD_ST7735R.h*.

```
typedef enum _tagLCD_ORIENTATION{
          LCD_POTRAIT,
          LCD_LANDSCAPE,
          LCD_POTRAIT_180,
          LCD_LANDSCAPE_180
}LCD_ORIENTATION;
```

Testing TFT LCD Display ....

- You can select different **color** combinations for fonts and backgrounds.


```
/* Color code */
#define ClrAliceBlue            0x00F0F8FF
#define ClrAntiqueWhite         0x00FAEBD7
#define ClrAqua                 0x0000FFFF
#define ClrAquamarine           0x007FFFD4
#define ClrAzure                0x00F0FFFF
#define ClrBeige                0x00F5F5DC
#define ClrBisque               0x00FFE4C4
#define ClrBlack                0x00000000
#define ClrBlanchedAlmond       0x00FFEBCD
#define ClrBlue                 0x000000FF
#define ClrBlueViolet           0x008A2BE2
#define ClrBrown                0x00A52A2A
#define ClrBurlyWood            0x00DEB887
#define ClrCadetBlue            0x005F9EA0
#define ClrChartreuse           0x007FFF00
#define ClrChocolate            0x00D2691E
#define ClrCoral                0x00FF7F50
#define ClrCornflowerBlue       0x006495ED
#define ClrCornsilk             0x00FFF8DC
#define ClrCrimson              0x00DC143C
#define ClrCyan                 0x0000FFFF

/** see complete list in gui.h     **/
```