



# **EK-TM4C123GXL-BOOSTXL-KENTEC-S1 Firmware Development Package**

**USER'S GUIDE**

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## Revision Information

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# Table of Contents

<b>Copyright</b>	<b>2</b>
<b>Revision Information</b>	<b>2</b>
<b>1 Introduction</b>	<b>5</b>
<b>2 Example Applications</b>	<b>7</b>
2.1 Font Viewer (fontview)	7
2.2 Graphics Library Demonstration (glib_demo)	7
2.3 Graphics Library String Table Demonstration (lang_demo)	8
2.4 Scribble Pad (scribble)	9
<b>3 Kentec 320x240x16 Display Driver</b>	<b>11</b>
3.1 Introduction	11
3.2 API Functions	11
3.3 Programming Example	11
<b>4 Frame Module</b>	<b>13</b>
4.1 Introduction	13
4.2 API Functions	13
4.3 Programming Example	14
<b>5 Touch Screen Driver</b>	<b>15</b>
5.1 Introduction	15
5.2 API Functions	16
5.3 Programming Example	17
<b>IMPORTANT NOTICE</b>	<b>20</b>



# 1 Introduction

The Texas Instruments® Tiva™ C Series EK-TM4C123GXL-BOOSTXL-KENTEC-S1 evaluation board (Tiva C Series TM4C123G LaunchPad) is a low cost platform that can be used for software development and to prototype a hardware design. A variety of BoosterPacks are available to quickly extend the LaunchPad's features.

This document describes the example applications that are provided for the EK-TM4C123GXL when paired with the BOOSTXL-K350QVG-S1 BoosterPack. This BoosterPack provides a QVGA (320 x 240) display. These examples utilize the TivaWare™ for C Series Graphics Library to create a rich graphical user interface with widgets and multi-language support.



## 2 Example Applications

The example applications show how to use features of the Cortex-M4F microprocessor, the peripherals on the Tiva C Series microcontroller, and the drivers provided by the peripheral driver library. These applications are intended for demonstration and as a starting point for new applications.

There is an IAR workspace file (`ek-tm4c123gx1-boostxl-kentec-s1.eww`) that contains the peripheral driver library project, USB library project, and all of the board example projects, in a single, easy to use workspace for use with Embedded Workbench version 6.

There is a Keil multi-project workspace file (`ek-tm4c123gx1-boostxl-kentec-s1.mpw`) that contains the peripheral driver library project, USB library project, and all of the board example projects, in a single, easy to use workspace for use with uVision.

All of these examples reside in the `examples/boards/ek-tm4c123gx1-boostxl-kentec-s1` subdirectory of the firmware development package source distribution.

### 2.1 Font Viewer (fontview)

This example displays the contents of a TivaWare Graphics Library font on the DK board's LCD touchscreen. By default, the application shows a test font containing ASCII, the Japanese Hiragana and Katakana alphabets, and a group of Korean Hangul characters.

TODO: The use of LCD BoosterPack (BOOSTXL-K350QVG-S1) requires resistors R9 and R10 to be removed from the EK-TM4C123GXL Launchpad.

### 2.2 Graphics Library Demonstration (glib\_demo)

This application provides a demonstration of the capabilities of the TivaWare Graphics Library. A series of panels show different features of the library. For each panel, the bottom provides a forward and back button (when appropriate), `aint32_t` with a brief description of the contents of the panel.

The first panel provides some introductory text and basic instructions for operation of the application.

The second panel shows the available drawing primitives: lines, circles, rectangles, strings, and images.

The third panel shows the canvas widget, which provides a general drawing surface within the widget hierarchy. A text, image, and application-drawn canvas are displayed.

The fourth panel shows the check box widget, which provides a means of toggling the state of an item. Four check boxes are provided, with each having a red "LED" to the right. The state of the LED tracks the state of the check box via an application callback.

The fifth panel shows the container widget, which provides a grouping construct typically used for radio buttons. Containers with a title, a centered title, and no title are displayed.

The sixth panel shows the push button widget. Two columns of push buttons are provided; the appearance of each column is the same but the left column does not utilize auto-repeat while the right column does. Each push button has a red "LED" to its left, which is toggled via an application callback each time the push button is pressed.

The seventh panel shows the radio button widget. Two groups of radio buttons are displayed, the first using text and the second using images for the selection value. Each radio button has a red “LED” to its right, which tracks the selection state of the radio buttons via an application callback. Only one radio button from each group can be selected at a time, though the radio buttons in each group operate independently.

The eighth and final panel shows the slider widget. Six sliders constructed using the various supported style options are shown. The slider value callback is used to update two widgets to reflect the values reported by sliders. A canvas widget near the top right of the display tracks the value of the red and green image-based slider to its left and the text of the grey slider on the left side of the panel is update to show its own value. The slider on the right is configured as an indicator which tracks the state of the upper slider and ignores user input.

## 2.3 Graphics Library String Table Demonstration (lang\_demo)

This application provides a demonstration of the capabilities of the TivaWare Graphics Library's string table functions. Two panels show different implementations of features of the string table functions. For each panel, the bottom provides a forward and back button (when appropriate).

The first panel provides a large string with introductory text and basic instructions for operation of the application.

The second panel shows the available languages and allows them to be switched between English, German, Spanish and Italian.

The string table and custom fonts used by this application can be found under `/third_party/fonts/lang_demo`. The original strings that the application intends displaying are found in the `language.csv` file (encoded in UTF8 format to allow accented characters and Asian language ideographs to be included). The `mkstringtable` tool is used to generate two versions of the string table, one which remains encoded in UTF8 format and the other which has been remapped to a custom codepage allowing the table to be reduced in size compared to the original UTF8 text. The tool also produces character map files listing each character used in the string table. These are then provided as input to the `ftrasterize` tool which generates two custom fonts for the application, one indexed using Unicode and a smaller one indexed using the custom codepage generated for this string table.

The command line parameters required for `mkstringtable` and `ftrasterize` can be found in the make-file in `third_party/fonts/lang_demo`.

By default, the application builds to use the custom codepage version of the string table and its matching custom font. To build using the UTF8 string table and Unicode-indexed custom font, ensure that the definition of **USE\_REMAPPED\_STRINGS** at the top of the `lang_demo.c` source file is commented out.

TODO: The use of LCD BoosterPack (BOOSTXL-K350QVG-S1) requires resistors R9 and R10 to be removed from the EK-TM4C123GXL Launchpad.



## 2.4 Scribble Pad (scribble)

The scribble pad provides a drawing area on the screen. Touching the screen will draw onto the drawing area using a selection of fundamental colors (in other words, the seven colors produced by the three color channels being either fully on or fully off). Each time the screen is touched to start a new drawing, the drawing area is erased and the next color is selected.

TODO: The use of LCD BoosterPack (BOOSTXL-K350QVG-S1) requires resistors R9 and R10 to be removed from the EK-TM4C123GXL Launchpad.



## 3 Kentec 320x240x16 Display Driver

Introduction .....	11
API Functions .....	11
Programming Example .....	11

### 3.1 Introduction

The display driver offers a standard interface to access display functions on the Kentec K350QVG-V2-F 320x240 16-bit color TFT display and is used by the TivaWare Graphics Library and widget manager. The display is controlled by the embedded SSD2119 display controller, which provides the frame buffer for the display. In addition to providing the `tDisplay` structure required by the graphics library, the display driver also provides an API for initializing the display.

The display driver can be built to operate in one of four orientations:

- **LANDSCAPE** - In this orientation, the screen is wider than it is tall; this is the normal orientation for a television or a computer monitor, and is the normal orientation for photographs of the outdoors (hence the name). For the K350QVG-V2-F, the flex connector is on the bottom side of the screen when viewed in **LANDSCAPE** orientation.
- **PORTRAIT** - In this orientation, the screen is taller than it is wide; this is the normal orientation of photographs of people (hence the name). For the K350QVG-V2-F, the flex connector is on the left side of the screen when viewed in **PORTRAIT** orientation.
- **LANDSCAPE\_FLIP** - **LANDSCAPE** mode rotated 180 degrees (in other words, the flex connector is on the top side of the screen).
- **PORTRAIT\_FLIP** - **PORTRAIT** mode rotated 180 degrees (in other words, the flex connector is on the right side of the screen).

One of the above highlighted defines selects the orientation that the display driver will use. If none is defined, the default orientation is **LANDSCAPE** (which corresponds to how the display is mounted to the BOOSTXL-K350QVG-S1 BoosterPack).

This driver is located in `examples/boards/ek-tm4c123gx1-boostxl-kentec-s1/drivers`, with `kentec320x240x16_ssd2119_spi.c` containing the source code and `kentec320x240x16_ssd2119_spi.h` containing the API declarations for use by applications.

### 3.2 API Functions

### 3.3 Programming Example

The following example shows how to initialize the display and prepare to draw on it using the graphics library.

```
extern const tDisplay g_sKentec320x240x16_SSD2119;

//
// The Kentec 320x240x16 SSD2119 example.
//
void
Kentec320x240x16_SSD2119Example(void)
{
    uint32_t ui32SysClock;
    tContext sContext;

    //
    // Initialize the display. This code assumes that ui32SysClock has been
    // set to the clock frequency of the device (for example, the value
    // returned by SysCtlClockFreqSet).
    //
    Kentec320x240x16_SSD2119Init(ui32SysClock);

    //
    // Initialize a graphics library drawing context.
    //
    GrContextInit(&sContext, &g_sKentec320x240x16_SSD2119);
}
```

## 4 Frame Module

Introduction .....	13
API Functions .....	13
Programming Example .....	14

### 4.1 Introduction

The frame module is a common function for drawing an application frame on the display. This is used by the example applications to provide a uniform appearance.

This driver is located in `examples/boards/ek-tm4c123gxl-boostxl-kentec-s1/drivers`, with `frame.c` containing the source code and `frame.h` containing the API declarations for use by applications.

### 4.2 API Functions

#### Functions

- void `FrameDraw` (tContext \*psContext, const char \*pcAppName)

#### 4.2.1 Function Documentation

##### 4.2.1.1 FrameDraw

Draws a frame on the LCD with the application name in the title bar.

#### Prototype:

```
void
FrameDraw(tContext *psContext,
          const char *pcAppName)
```

#### Parameters:

**psContext** is a pointer to the graphics library context used to draw the application frame.  
**pcAppName** is a pointer to a string that contains the name of the application.

#### Description:

This function draws an application frame onto the LCD, using the supplied graphics library context to access the LCD and the given name in the title bar of the application frame.

#### Returns:

None.

## 4.3 Programming Example

The following example shows how to draw the application frame.

```
//  
// The frame example.  
//  
void  
FrameExample(void)  
{  
    tContext sContext;  
  
    //  
    // Draw the application frame. This code assumes the the graphics library  
    // context has already been initialized.  
    //  
    FrameDraw(&sContext, "example");  
}
```

## 5 Touch Screen Driver

Introduction .....	15
API Functions .....	16
Programming Example .....	17

### 5.1 Introduction

The touch screen is a pair of resistive layers on the surface of the display. One layer has connection points at the top and bottom of the screen, and the other layer has connection points at the left and right of the screen. When the screen is touched, the two layers make contact and electricity can flow between them.

The horizontal position of a touch can be found by applying positive voltage to the right side of the horizontal layer and negative voltage to the left side. When not driving the top and bottom of the vertical layer, the voltage potential on that layer will be proportional to the horizontal distance across the screen of the press, which can be measured with an ADC channel. By reversing these connections, the vertical position can also be measured. When the screen is not being touched, there will be no voltage on the non-powered layer.

By monitoring the voltage on each layer when the other layer is appropriately driven, touches and releases on the screen, as well as movements of the touch, can be detected and reported.

In order to read the current voltage on the two layers and also drive the appropriate voltages onto the layers, each side of each layer is connected to both a GPIO and an ADC channel. The GPIO is used to drive the node to a particular voltage, and when the GPIO is configured as an input, the corresponding ADC channel can be used to read the layer's voltage.

The touch screen is sampled every 2.5 ms, with four samples required to properly read both the X and Y position. Therefore, 100 X/Y sample pairs are captured every second.

Like the display driver, the touch screen driver operates in the same four orientations (selected in the same manner). Default calibrations are provided for using the touch screen in each orientation; the calibrate application can be used to determine new calibration values if necessary.

The touch screen driver utilizes sample sequence 3 of ADC0 and timer 1 subtimer A. The interrupt from the ADC0 sample sequence 3 is used to process the touch screen readings; the [TouchScreenIntHandler\(\)](#) function should be called when this interrupt occurs (which is typically accomplished by placing it in the vector table in the startup code for the application).

The touch screen driver makes use of calibration parameters determined using the “calibrate” example application. The theory behind these parameters is explained by Carlos E. Videles in the June 2002 issue of Embedded Systems Design. It can be found online at <http://www.embedded.com/story/OEG20020529S0046>.

This driver is located in `examples/boards/ek-tm4c123gx1-boostx1-kentec-s1-kentec/drivers`, with `touch.c` containing the source code and `touch.h` containing the API declarations for use by applications.

## 5.2 API Functions

### Functions

- void [TouchScreenCallbackSet](#) (int32\_t (\*pfnCallback)(uint32\_t ui32Message, int32\_t i32X, int32\_t i32Y))
- void [TouchScreenInit](#) (uint32\_t ui32SysClock)
- void [TouchScreenIntHandler](#) (void)

### 5.2.1 Function Documentation

#### 5.2.1.1 TouchScreenCallbackSet

Sets the callback function for touch screen events.

**Prototype:**

```
void  
TouchScreenCallbackSet (int32_t (*ui32Message,) (uint32_t int32_t i32X,  
int32_t i32Y) pfnCallback)
```

**Parameters:**

***pfnCallback*** is a pointer to the function to be called when touch screen events occur.

**Description:**

This function sets the address of the function to be called when touch screen events occur. The events that are recognized are the screen being touched (“pen down”), the touch position moving while the screen is touched (“pen move”), and the screen no longer being touched (“pen up”).

**Returns:**

None.

#### 5.2.1.2 TouchScreenInit

Initializes the touch screen driver.

**Prototype:**

```
void  
TouchScreenInit (uint32_t ui32SysClock)
```

**Parameters:**

***ui32SysClock*** is the frequency of the system clock.

**Description:**

This function initializes the touch screen driver, beginning the process of reading from the touch screen. This driver uses the following hardware resources:

- ADC sample sequence 3
- Timer 1 subtimer A



**Returns:**

None.

### 5.2.1.3 TouchScreenIntHandler

Handles the ADC interrupt for the touch screen.

**Prototype:**

```
void  
TouchScreenIntHandler(void)
```

**Description:**

This function is called when the ADC sequence that samples the touch screen has completed its acquisition. The touch screen state machine is advanced and the acquired ADC sample is processed appropriately.

It is the responsibility of the application using the touch screen driver to ensure that this function is installed in the interrupt vector table for the ADC3 interrupt.

**Returns:**

None.

## 5.3 Programming Example

The following example shows how to initialize the touchscreen driver and the callback function which receives notifications of touch and release events in cases where the TivaWare Graphics Library widget manager is not being used by the application.

```
//  
// The touch screen driver calls this function to report all state changes.  
//  
static long  
TouchTestCallback(uint32_t ui32Message, int32_t i32X, int32_t i32Y)  
{  
    //  
    // Check the message to determine what to do.  
    //  
    switch(ui32Message)  
    {  
        //  
        // The screen is no longer being touched (in other words, pen/pointer  
        // up).  
        //  
        case WIDGET_MSG_PTR_UP:  
        {  
            //  
            // Handle the pointer up message if required.  
            //  
            break;  
        }  
        //  
        // The screen has just been touched (in other words, pen/pointer down).  
        //  
        case WIDGET_MSG_PTR_DOWN:
```

```
        {
            //
            // Handle the pointer down message if required.
            //
            break;
        }

        //
        // The location of the touch on the screen has moved (in other words,
        // the pen/pointer has moved).
        //
        case WIDGET_MSG_PTR_MOVE:
        {
            //
            // Handle the pointer move message if required.
            //
            break;
        }

        //
        // An unknown message was received.
        //
        default:
        {
            //
            // Ignore all unknown messages.
            //
            break;
        }
    }

    //
    // Success.
    //
    return(0);
}

//
// The first touch screen example.
//
void
TouchScreenExample1(void)
{
    uint32_t ui32SysClock;

    //
    // Initialize the touch screen driver. This code assumes that ui32SysClock
    // has been set to the clock frequency of the device (for example, the
    // value returned by SysCtlClockFreqSet).
    //
    TouchScreenInit(ui32SysClock);

    //
    // Register the application callback function that is to receive touch
    // screen messages.
    //
    TouchScreenCallbackSet(TouchTestCallback);
}
```

If using the TivaWare Graphics Library widget manager, touchscreen initialization code is as follows. In this case, the touchscreen callback is provided within the widget manager so no additional function is required in the application code.

```
//
```

```
// The second touch screen example.
//
void
TouchScreenExample2(void)
{
    uint32_t ui32SysClock;

    //
    // Initialize the touch screen driver. This code assumes that ui32SysClock
    // has been set to the clock frequency of the device (for example, the
    // value returned by SysCtlClockFreqSet).
    //
    TouchScreenInit(ui32SysClock);

    //
    // Register the graphics library pointer message callback function so that
    // it receives touch screen messages.
    //
    TouchScreenCallbackSet(WidgetPointerMessage);
}
```

---

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