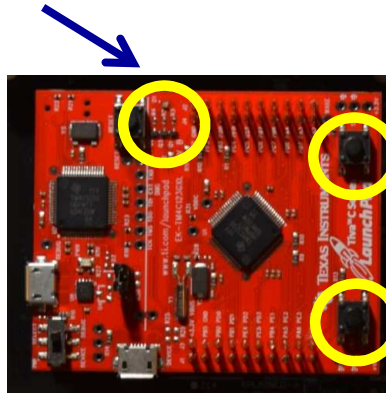


CSE 379

General Purpose Input/Output with the ARM Processor

General Purpose Input/Output (GPIO) Highlights – Tiva

RGB LED



SW2

Push
Buttons

SW1

- General Purpose I/O Details

- ☞ Two User Momentary Push Buttons

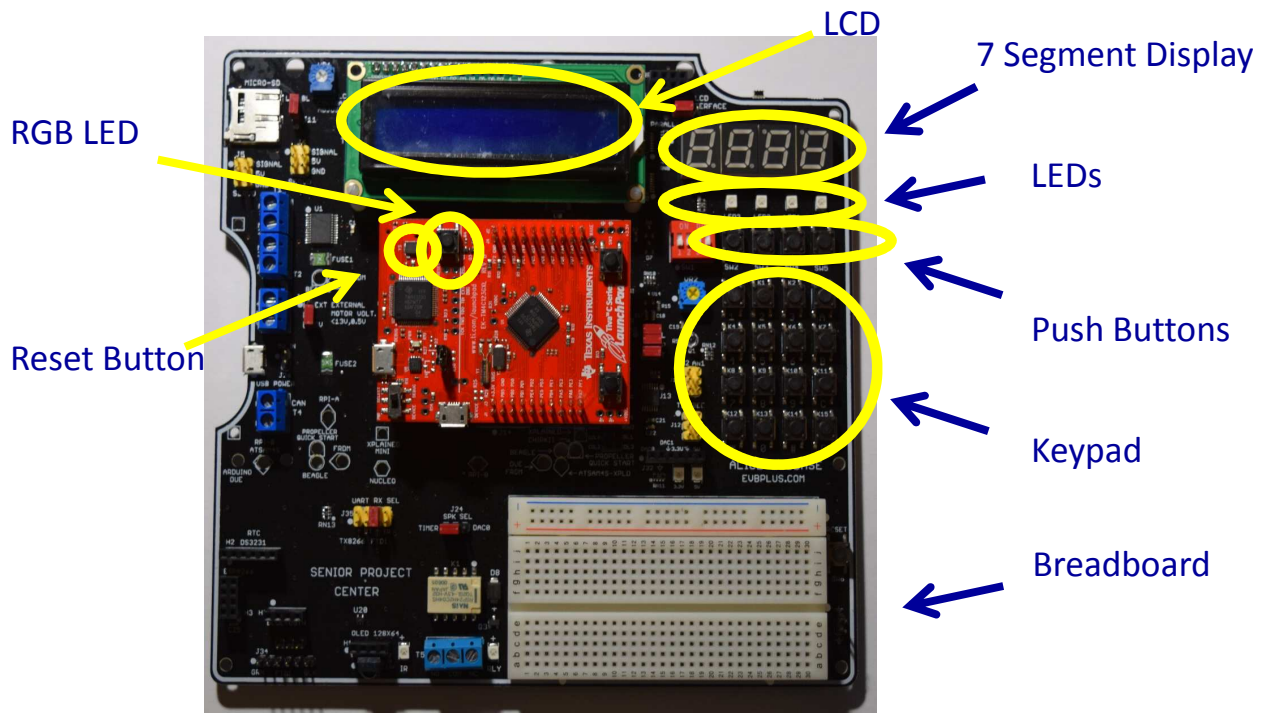
- ☞ SW1

- ☞ SW2

- ☞ RGB LED

- ☞ Individual control of red, blue, green LEDs

General Purpose Input/Output (GPIO) Highlights – Alice EduBase Board



LCD

7 Segment Display

RGB LED

LEDs

Reset Button

Push Buttons

Keypad

Breadboard

- **General Purpose I/O Details**

- ☞ Eight Momentary Push Buttons
- ☞ Four LEDs
- ☞ RGB LED
 - ↳ Controlled by pulse width modulated signals
- ☞ Keypad
 - ↳ 4x4 matrix
- ☞ 16x2 LCD Display
- ☞ Four Digit Seven Segment Display
- ☞ Speaker
- ☞ Breadboard
 - ↳ Allows for connection to other components, such as
 - ✓ Additional Seven-Segment Displays
 - ✓ Additional Switches
 - ✓ Temperature Sensors

GPIO Overview

- **GPIO Organized into Ports (A-F)**

- ☞ Each port has 8 I/O pins
- ☞ A pin can be input or output
 - ↳ Senses or drives a one or a zero

Procedure for Using GPIO

- **Enable a Clock for GPIO Port**

- ☞ Each GPIO Port Needs Clock to Read/Write Data

- **Set Direction for Each Pin Configured for GPIO**

- ☞ Configured by GPIO Direction Register

- **Set Each GPIO Configured Pin as Digital**

- ☞ Configured by GPIO Digital Enable Register

- **Using GPIO**

- ☞ **Output**

- ↳ **To Set GPIO Output High**

- ✓ Write 1 to GPIO Data Register Pin

- ↳ **To Set GPIO Output Low**

- ✓ Write 0 to GPIO Data Register Pin

- ☞ **Input**

- ↳ **Reading GPIO Value**

- ✓ Read from GPIO Data Register Pin

Details

- Details for each of the aforementioned steps in the procedure will be outlined

Enabling the Clock

- Controlled via System Run Mode Clock Gating Control Register (SYSCTL_RCGC)

- ☞ Controls & Enables a Clock for Various Components

- ☞ Was Used in UART0 Setup

- ☞ SYSCTL_RCGC_UARG Register

- ✓ Offset: 0x618

- ☞ Write 1 to enable clock for UART0

- SYSCTL_RCGC_GPIO Details

- ☞ Base Value: 0x400FE000

- ☞ Offset: 0x608

- ☞ Effective Address: 0x400FE608

- ☞ Description

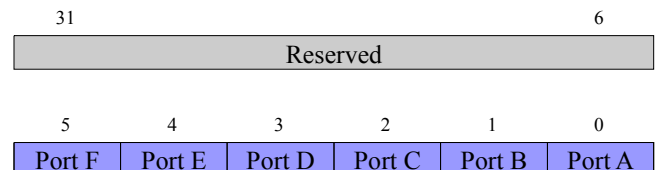
- ☞ Enables Clock for GPIO Ports

- ✓ Disable Clock

- Write 0

- ✓ Enable Clock

- Write 1



GPIO Base Addresses

- Each port has its own region mapped in memory

- Each port can support up to 8 inputs & outputs

- Base Addresses

- ☞ GPIO Port A

- ☞ Address: 0x40004000

- ☞ GPIO Port B

- ☞ Address: 0x40005000

- ☞ GPIO Port C

- ☞ Address: 0x40006000

- ☞ GPIO Port D

- ☞ Address: 0x40007000

- ☞ GPIO Port E

- ☞ Address: 0x40024000

- ☞ GPIO Port F

- ☞ Address: 0x40025000

Using Base Addresses to Access a GPIO Control Register for a Port

- ☞ Accessing a GPIO Register for a Specific Port

- ☞ Add the Port Base to the Offset Value for a Register to Obtain Effective Address

- ☞ Example

- ✓ Port C Data Direction Register Address

- 0x40006400

✓ To derive that address:

- Add base address (0x40006000) to offset (0x400)

✓ To write to Port C Data Direction Register

```
mov r0, #0xC000      ; Base Address Stored in r0
movt r0, #0x4000
strb r1, [r0, #0x400]
```

✓ Alternative method of writing to the data direction register using constants to make code more readable

```
DIR: .equ 0x400
mov r0, #0x6000      ; Base Address Stored in
r0
movt r0, #0x4000
strb r1, [r0, #DIR]
```

Setting GPIO Pin Direction

- Controlled via GPIO Direction Register (GPIODIR)

☞ Controls whether each GPIO pin is input or output

- GPIODIR Details

☞ Offset Value: 0x400

☞ Accessing a Port's Data Direction Register

☞ Description

- ✓ For each pin on the port, the pin can be configured as input or output
 - Configuring Pin as Input
 - Write 0
 - Configuring Pin as Output
 - Write 1



Configuring GPIO Pin as Digital

- Controlled via GPIO Digital Enable Register (GPIODEN)

☞ Controls whether each GPIO pin is enabled for digital I/O use

- GPIODEN Details

☞ Offset Value: 0x51C

☞ Description

- ☞ For each pin on the port, the pin can be enabled for digital I/O
- ☞ Initially all pins on each port are disabled
- ☞ Configuration
 - ✓ Disable Pin
 - Write 0
 - ✓ Digital Pin
 - Write 1



Using GPIO

- GPIO Data Register (GPIODATA)

- ☞ Offset Value: 0x3FC

- Description

- ☞ Allows data to be read or written for each pin on the port

- ☞ When Configured as Input

- ☞ Reading 0, Pin is Low

- ☞ Reading 1, Pin is High

- ☞ When Configured as Output

- ☞ Writing 0, Pin is Set Low

- ☞ Writing 1, Pin is Set High



Tiva GPIO

- Momentary Push Buttons

- ☞ Switches 1 & 2

- ☞ We'll use switch 1

- ☞ Labelled as SW1

- ✓ Port F, Pin 4

- RGB LED

- ☞ Port F

- ☞ The RGB LED consists of three LEDs:

- ☞ Red

- ✓ Pin 1

- ☞ Green

- ✓ Pin 3

- ☞ Blue

- ✓ Pin 2

- ☞ The three LEDs can be controlled independently

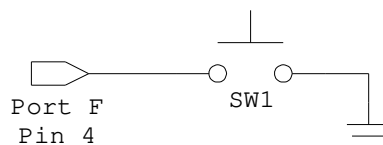
- ☞ Write a 1 to turn on

- ☞ Write a 0 to turn off

- Switch Configuration

- ☞ We'll use SW1

- ☞ SW1 Schematic

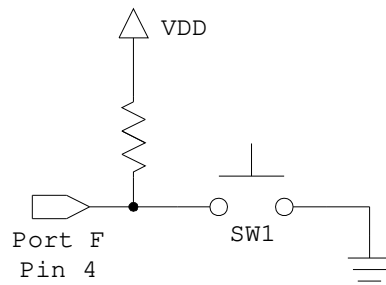


- ☞ When the switch is closed, what value is on Port F, Pin 4?

- ☞ How about when the switch is open?

Schematic derived from Texas Instruments Incorporated, *Tiva™ C Series TM4C123G Launch Pad Evaluation Board User's Guide*, SPMU296, April 2013, Texas Instruments

☞ A pull-up resistor is needed



☞ Port F, Pin 4

☞ 1 when SW1 is open

☞ 0 when SW1 is closed

● Configuring a Pull-Up Resistor

☞ Controlled via GPIO Pull-Up Select Register (GPIOPUR)

☞ Controls whether a pull-up resistor is connected to each GPIO pin

☞ GPIOPUR Details

☞ Offset Value: 0x510

☞ Description

✓ For each pin on the port, a pull-up resistor can be enabled or disabled

✓ Configuration

- Enable pull-up resistor

- Write 1

- Disable pull-up resistor

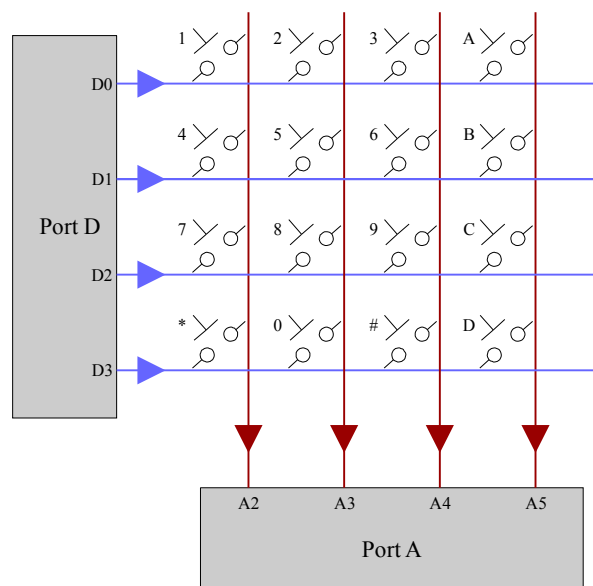
- Write 0



Alice EduBase Board GPIO

● Keypad

☞ Wiring



Derived from Figure 3-7, page 64, Muhammad Ali Mazidi, Shujen Chen, Sarmad Naimi, Sepehr Naimi, *Programming ARM Corect-M4 TM4C123G with C*, First Edition, MicroDigitalEd, 2014-2016

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☞ Details

☞ Keypad – 4x4 Matrix

☞ Rows

- ✓ Connected to Port D (Pins 0-3)

☞ Columns

- ✓ Connected to Port A (Pins 2-5)

☞ Momentary push button located at each intersection of row & column

- ✓ Blue & red wires are not connected unless button is pressed

☞ Operation

☞ Use GPIO to

✓ Drive line

- Output a 1 (5 V) or 0 (0 V)

✓ Sense lines

- Input
- What connections were made by the push buttons?

☞ Hint

- ✓ What happens when a button is pressed?
- ✓ How can this be observed by writing & reading from GPIO?

● LEDs

☞ Port B, Pins 0-3

☞ Pin Number Corresponds to LED Number

● Momentary Push Buttons

☞ Switches 2 – 5

☞ Port D, Pins 0 – 3

- ✓ Switch 2 is Pin 0
- ✓ Switch 5 is Pin 3

● RGB LED

☞ The RGB LED consists of three LEDs:

☞ Red

☞ Green

☞ Blue

☞ The three LEDs can be controlled independently

☞ The combination of red, blue, and green at varied intensities can be used to illuminate any color

✓ Example

- Purple is created by turning red and blue on (green off)

☞ Procedure for RGB LED Use

☞ Enable System Clock to Port F

☞ Set Direction (Output)

- ✓ Port F
 - Pins 1, 2, 3

☞ Set Type (Digital)

- ✓ Port F
 - Pins 1, 2, 3

☞ Controlling the RGB LED

☞ Red LED

- ✓ To Turn On
 - Data Register Port F, Pin 1 High
- ✓ To Turn Off
 - Data Register Port F, Pin 1 Low

☞ Blue LED

- ✓ To Turn On
 - Data Register Port F, Pin 2 High
- ✓ To Turn Off
 - Data Register Port F, Pin 2 Low

☞ Green LED

- ✓ To Turn On
 - Data Register Port F, Pin 3 High
- ✓ To Turn Off
 - Data Register Port F, Pin 3 Low

● Keypad

☞ Write a routine to return which key has been pressed

References

- Kris Schindler, *Introduction to Microprocessor Based Systems Using the ARM Microprocessor*, Second Edition, Pearson, 2013
- Muhammad Ali Mazidi, Shujen Chen, Sarmad Naimi, Sepehr Naimi, *Programming ARM Corect-M4 TM4C123G with C*, First Edition, MicroDigitalEd, 2014-2016
- Texas Instruments Incorporated, *Tiva™ TM4C123GH6PM Microcontroller Data Sheet*, June 12, 2014, Texas Instruments – Production Data, 2007-2014
- Texas Instruments Incorporated, *Tiva™ C Series TM4C123G Launch Pad Evaluation Board User's Guide*, SPMU296, April 2013, Texas Instruments
- *Alice EduBase for Tiva and MSP432 Launchpad User's Guide*, Version 1.21, EVB+, February 4, 2017