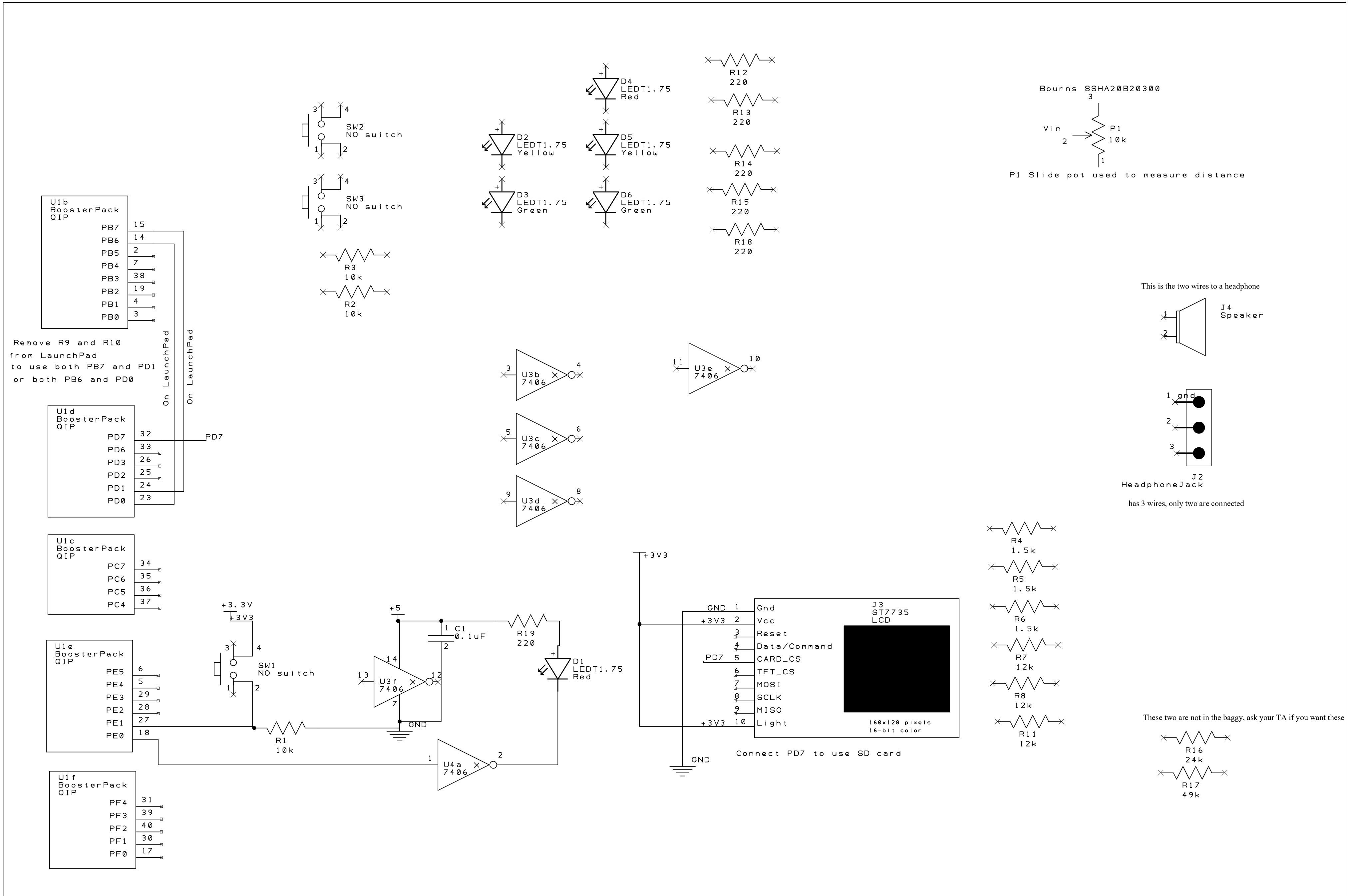

All resistors are 1/4 watt 5% carbon composition
C1 is ceramic Z5U
Switches are www.BGMicro.com SWT1043
Red LEDs. T1 3/4. 20mA Digikey 160-1087-ND
Yellow LEDs. T1 3/4. 20mA Digikey 160-1088-ND
Green LEDs. T1 3/4. 20mA Digikey 160-1089-ND
Slide pot. Bourns SSHA20B20300 www.AllElectronics.comSP-20K

University Of Texas At Austin	
Schematic Name: Lab 3 Schematic for EE319K	
Name(s): HYDER SHAD (UT EID: hs25796)	
Date: Febuary 21, 2016	**Semester:** Spring 2016

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Parameter	Value	Units	Conditions
Resistance of the 10kΩ resistor, R1	9.98 kΩ	ohms	with power off and disconnected from circuit (measured with ohmmeter)
Supply Voltage, $V_{+3.3}$	3.30 V	volts	Powered (measured with voltmeter)
Input Voltage, V_{PE1}	0.00 V	volts	Powered, but with switch not pressed (measured with voltmeter)
Resistor current	0.00A	mA	Powered, but switch not pressed $I=V_{PE1}/R1$ (calculated and measured with an ammeter)
Input Voltage, V_{PE1}	3.21 V	volts	Powered and with switch pressed (measured with voltmeter)
Resistor current	75.7mA	mA	Powered and switch pressed $I=V_{PE1}/R1$ (calculated and measured with an ammeter)

Table 3.1. Switch measurements.

Next, you can connect the input voltage to **PE1** and use the debugger to observe the input pin to verify the proper operation of the switch interface. You will have to single step through the code that initializes Port E, and PE1. You then execute the **Peripherals->TEXaS Port E** command. As you single step you should see the actual input as controlled by the switch you have interfaced, see Figure 3.1.

The next step is to build the LED output circuit. LEDs emit light when an electric current passes through them, as shown in Figure 3.8. LEDs have polarity, meaning current must pass from anode to cathode to activate. The anode is labeled **a** or + , and cathode is labeled **k** or -. The cathode is the short lead and there may be a slight flat spot on the body of round LEDs. Thus, the anode is the longer lead. LEDs are not usually damaged by heat when soldering. Furthermore, LEDs will not be damaged if you plug it in backwards. However, LEDs won't work plugged in backwards. Look up the pin assignments in the 7406 data sheet. Be sure to connect +5V power to pin 14 and ground to pin 7. The 0.1 μF capacitor from +5V to ground filters the power line. Every digital chip (e.g., 7406) should have a filter capacitor from its power line (i.e., pin 14 V_{CC}) to ground. The capacitor in your kit is ceramic, which is not polarized, meaning it can be connected in either direction.

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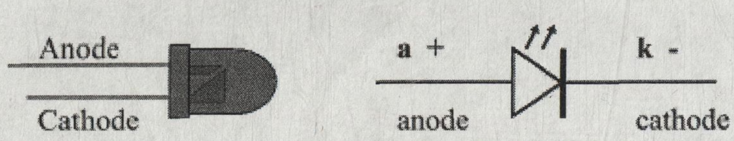

Figure 3.8. Left: a side view of an LED with leads labeled; Right: the corresponding circuit diagram

The circuit in Figures 3.2 and 3.3 used R10 as the 220Ω resistor. There are six 220Ω resistors R10 – R15 in the PCB artist starter file, any one of which could have been used.

Take the measurements as described in Table 3.2. The R10 measurement occurs before R10 is inserted into the circuit. Single step your software to make **PE0** to output. Initially **PE0** will be low. So take four measurements with **PE0** low, rows 2,3,4,5 in Table 3.2. Then, single step some more until **PE0** is high and measure the three voltages (rows 8,9,10 in Table 3.2). When active, the LED voltage should be about 2 V, and the LED current should be about 10 mA. The remaining rows are calculated values, based on these 8 measurements. The LED current (row 12) can be determined by calculation or by direct measurement using the ammeter function. You should perform both ways to get LED current.

Warning: NEVER INSERT/REMOVE WIRES/CHIPS WHEN THE POWER IS ON.

Row	Parameter	Value	Units	Conditions
1	Resistance of the 220Ω resistor, R10	217Ω	ohms	with power off and disconnected from circuit (measured with ohmmeter)
2	+5 V power supply V_{+5}	4.84V	volts	(measured with voltmeter, *notice that the +5V power is not exactly +5 volts*)
3	TM4C123 Output, ~~V_{PE}~~ PEO input to 7406	50 mV	volts	with **PE0** = 0 (measured with voltmeter)
4	7406 Output, V_{k-} LED k-	3.54V	volts	with **PE0** = 0 (measured with voltmeter)
5	LED a+, V_{a+} Bottom side of R~~10~~ 220	4.8 V	volts	with **PE0** = 0 (measured with voltmeter)
6	LED voltage	-0.541	volts	calculated as $V_{a+} - V_{k-}$
		0		calculated as $(V_{+5} - V_{a+})$/R10

$$\frac{4.84 - 4.86}{217} \approx 0$$

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7	LED current	0	mA	and measured with an ammeter
8	TM4C123 Output, V_{PE0} input to 7406	3.25 V	volts	with **PE0** = 1 (measured with voltmeter)
9	7406 Output, V_{k-} LED k-	133.8 mV	volts	with **PE0** = 1 (measured with voltmeter)
10	LED a+, V_{a+} Bottom side of R10	2.06 V	volts	with **PE0** = 1 (measured with voltmeter)
11	LED voltage	1.93	volts	calculated as V_{a+} - V_{k-}
12	LED current	12.81 mA 12.11 mA	mA	calculated as $(V_{+5} - V_{a+})$/R10 and measured with an ammeter

Table 3.2. LED measurements (assuming the 220 Ω resistor is labeled R10).

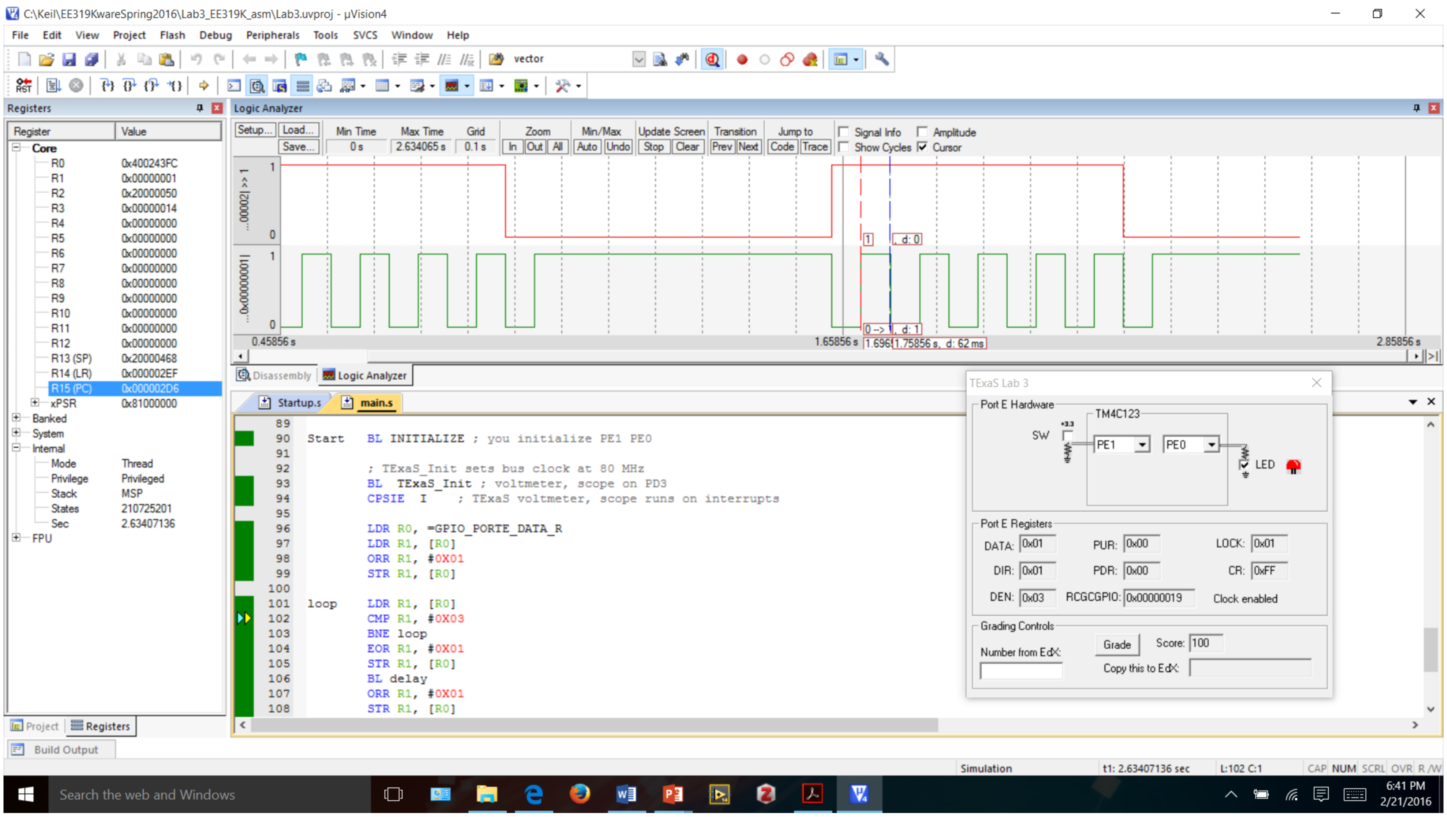
Part e - Debug Hardware + Software

Debug your combined hardware and software system.

Demonstration

(both partners must be present, and demonstration grades for partners may be different)

You will show the TA your program operation on the actual TM4C123 board. The TA may look at your data and expect you to understand how the data was collected and how the switch and LEDs work. Also be prepared to explain how your software works and to discuss other ways the problem could have been solved. Why the 7406 was used to interface the LED? I.e., why did we not connect the LED directly to the TM4C123. Why do you think you need the capacitor for 7406 chip? Why was the delay increased from 1 to 62 ms? How would you modify the software to change the rate at which LED flickers? What operating point (voltage, current) exists when the LED is on? Sketch the approximate current versus voltage curve of the LED. Explain how you use the resistor value to select the operating point. What is the difference between a positive logic and negative logic interface for the switch or the LED? We may test to see if you can measure voltage, current and/or resistance with your meter (so bring your meter to the demonstration).


C:\Keil\EE319KwareSpring2016\Lab3_EE319K_asm\Lab3.uvproj - µVision4
File Edit View Project Flash Debug Peripherals Tools SVCS Window Help
Registers
Register Value
Core
R0 0x400243FC
R1 0x00000001
R2 0x20000050
R3 0x00000014
R4 0x00000000
R5 0x00000000
R6 0x00000000
R7 0x00000000
R8 0x00000000
R9 0x00000000
R10 0x00000000
R11 0x00000000
R12 0x00000000
R13 (SP) 0x20000468
R14 (LR) 0x000002EF
R15 (PC) 0x000002D6
xPSR 0x81000000
Banked
System
Internal
Mode Thread
Privilege Privileged
Stack MSP
States 210725201
Sec 2.63407136
FPU
Logic Analyzer
Setup... Load... Save... Min Time 0 s Max Time 2.634065 s Grid 0.1 s Zoom In Out All Min/Max Auto Undo Update Screen Stop Clear Transition Prev Next Jump to Code Trace Signal Info Show Cycles Amplitude Cursor
0.45856 s 1.65856 s 1.696 1.75856 s, d: 62 ms 2.85856 s
Disassembly Logic Analyzer
Startup.s main.s
89
90 Start BL INITIALIZE ; you initialize PE1 PE0
91
92 ; TExaS_Init sets bus clock at 80 MHz
93 BL TExaS_Init ; voltmeter, scope on PD3
94 CPSIE I ; TExaS voltmeter, scope runs on interrupts
95
96 LDR R0, =GPIO_PORTE_DATA_R
97 LDR R1, [R0]
98 ORR R1, #0X01
99 STR R1, [R0]
100
101 loop LDR R1, [R0]
102 CMP R1, #0X03
103 BNE loop
104 EOR R1, #0X01
105 STR R1, [R0]
106 BL delay
107 ORR R1, #0X01
108 STR R1, [R0]
TExaS Lab 3
Port E Hardware
TM4C123
SW PE1 PE0 LED
Port E Registers
DATA: 0x01 PUR: 0x00 LOCK: 0x01
DIR: 0x01 PDR: 0x00 CR: 0xFF
DEN: 0x03 RCGCGPIO: 0x00000019 Clock enabled
Grading Controls
Number from EdX: Grade Score: 100
Copy this to EdX:
Project Registers
Build Output
Simulation t1: 2.63407136 sec L:102 C:1 CAP NUM SCRL OVR R/W
Search the web and Windows
6:41 PM
2/21/2016

```
;****************** main.s ***************
; Program written by: HYDER SHAD, MIRA SENGAL
; Date Created: 1/22/2016
; Last Modified: 2/8/2016
; Section THURSDAY 2-3 PM
; Instructor: V. JANAPA
; Lab number: 3
; Brief description of the program
;   If the switch is presses, the LED toggles at 8 Hz
; Hardware connections
;  PE1 is switch input  (1 means pressed, 0 means not pressed)
;  PE0 is LED output (1 activates external LED on protoboard)
;Overall functionality of this system is the similar to Lab 2, with
six changes:
;1-  the pin to which we connect the switch is moved to PE1,
;2-  you will have to remove the PUR initialization because pull up is
no longer needed.
;3-  the pin to which we connect the LED is moved to PE0,
;4-  the switch is changed from negative to positive logic, and
;5-  you should increase the delay so it flashes about 8 Hz.
;6-  the LED should be on when the switch is not pressed
; Operation
;   1) Make PE0 an output and make PE1 an input.
;   2) The system starts with the LED on (make PE0 =1).
;   3) Wait about 62 ms
;   4) If the switch is pressed (PE1 is 1), then toggle the LED once,
else turn the LED on.
;   5) Steps 3 and 4 are repeated over and over

GPIO_PORTE_DATA_R       EQU   0x400243FC
GPIO_PORTE_DIR_R        EQU   0x40024400
GPIO_PORTE_AFSEL_R      EQU   0x40024420
GPIO_PORTE_DEN_R        EQU   0x4002451C
GPIO_PORTE_AMSEL_R      EQU   0x40024528
GPIO_PORTE_PCTL_R       EQU   0x4002452C
SYSCTL_RCGCGPIO_R       EQU   0x400FE608
countdown EQU 992000 ; how many times delay routine must be executed
to achieve 62 ms delay running on 80 MHz clock
       IMPORT  TExaS_Init
       AREA    |.text|, CODE, READONLY, ALIGN=2
       THUMB
       EXPORT  Start

;----------------------------------------------------------------------
-----------------------------------------

INITIALIZE

; 1) activate clock for Port E
    LDR R0, =SYSCTL_RCGCGPIO_R
```

```
    LDR R1, [R0]
    ORR R1, #0X10                                              ;SET
BIT 4 HIGH TO ENABLE PORT E CLOCK
    STR R1, [R0]
    NOP
    NOP                                 ;ALLOW TIME TO FINISH
ACTIVATING (2+ CYCLES)
    NOP

; 2) set direction register

        LDR R0, =GPIO_PORTE_DIR_R              ;SET BIT 3 HIGH FOR
TO BE OUTPUT
        LDR R1, [R0]
        ORR R1, #0X01                                          ;using
pin PE0 as output, PE1 as input
        STR R1, [R0]

; 3) disable analog functionality

        LDR R0, =GPIO_PORTE_AMSEL_R            ;DISABLE ANALOG
CAPABILITIES, SOLEY DIGITAL I/O
    MOV R1, #0X0
    STR R1, [R0]

; 4) configure as GPIO

        LDR R0, =GPIO_PORTE_PCTL_R
    MOV R1, #0X0                               ;CLEAR PORT CONTROL
FIELD TO SET UP PINS FOR GPIO
    STR R1, [R0]

; 5) regular port function

        LDR R0, =GPIO_PORTE_AFSEL_R            ;DISABLE ALT FUNCTIONS
FOR BIN BY SETTING BITS TO ZERO
    MOV R1, #0
    STR R1, [R0]

; 6) enable digital port

        LDR R0, =GPIO_PORTE_DEN_R              ;R1 =
&GPIO_PORTD_DEN_R
    ORR R1, #0X03                              ;ENABLE DIGITAL I/O ON
PINS 0 and 1
    STR R1, [R0]

; 7) exit initialization process

        BX LR
```

```
;-----------------------------------------------------------------------
-------------------------------------------

Start   BL INITIALIZE ; you initialize PE1 PE0

                ; TExaS_Init sets bus clock at 80 MHz
                BL  TExaS_Init ; voltmeter, scope on PD3
                CPSIE  I    ; TExaS voltmeter, scope runs on
interrupts

                LDR R0, =GPIO_PORTE_DATA_R              ;load R0 with
address of Port E data (memory mapped I/O)
                LDR R1, [R0]                                    ;load
Port E data into R1
                ORR R1, #0X01                                   ;set
bit 0 (PE0) HIGH to turn on LED (positive logic)
                STR R1, [R0]                                    ;write
modified data back to memory mapped I/O

loop    LDR R1, [R0]                                    ;load data
into R0
                CMP R1, #0X03                                   ;check
to see if the switch has been pressed, bit 1 HIGH means pressed,
toggle led
                BNE loop
        ;if switch pressed
                EOR R1, #0X01                                   ;EOR
to turn off LED since always on
                STR R1, [R0]                                    ;write
modified data back to memory mapped I/O to turn LED off
                BL delay
        ;execute delay subroutine, return using link register
                ORR R1, #0X01                                   ;ORR
to set bit 0 (PE0) HIGH, turn LED on
                STR R1, [R0]                                    ;write
modified data back to memory mapped I/O
                BL delay
        ;execute delay subroutine, return using link register
                B loop
        ;loop to check for switch press

delay   LDR R8, =countdown                              ;time delay,
count down from calculated value for 80 MHz Clock, with delay taking 5
cycles each time
count   ADD R8,
#-1                                             ;subtract 1 from
countdown
                CMP R8, #0
        ;compare to see if countdown has reached 0
```

```
                BNE count
        ;countdown = 0, then exit delay subroutine, otherwise loop to
count
exit    BX LR                                                   ;exit
delay subroutine, use link register to return to main program code

;----------------------------------------------------------------------
-------------------------------------------------------

        ALIGN      ; make sure the end of this section is aligned
    END        ; end of file
```