



Table 3.1. Switch measurements.

Parameter	Value	Units	Conditions
Resistance of the 10k Ω resistor, R1	9820	ohms	with power off and disconnected from circuit (measured with ohmmeter)
Supply Voltage, $V_{+3.3}$	3.27	volts	Powered (measured with voltmeter)
Input Voltage, V_{PE2}	0 0	volts	Powered, but with switch not pressed (measured with voltmeter)
Resistor current	0 0	mA	Powered, but switch not pressed $I = V_{PE2}/R1$ (calculated and measured with an ammeter)
Input Voltage, V_{PE2}	4.80	volts	Powered and with switch pressed (measured with voltmeter)
Resistor current	.048 0.33	mA	Powered and switch pressed $I = V_{PE2}/R1$ (calculated and measured with an ammeter)

Table 3.2. LED measurements (assuming the 220 Ω resistor is labeled R19).

Row	Parameter	Value	Units	Conditions
1	Resistance of the 220 Ω resistor, R19	221	ohms	with power off and disconnected from circuit (measured with ohmmeter)

2	+5 V power supply V_{+5}	7.41	volts	(measured with voltmeter relative to ground, <i>notice that the +5V power is not exactly +5 volts</i>)
3	TM4C123 Output, V_{PE3} input to ULN2003B	0.01	volts	with PE3 = 0 (measured with voltmeter relative to ground)
4	ULN2003B Output, pin 16, V_{k-} LED k-	5.28	volts	with PE3 = 0 (measured with voltmeter relative to ground)
5	LED a+, V_{a+} Bottom side of R19 (anode side of LED)	.19	volts	with PE3 = 0 (measured with voltmeter relative to ground)
6	LED voltage	5.09	volts	calculated as $V_{a+} - V_{k-}$
7	LED current	23.1 10	mA	calculated as $(V_{+5} - V_{a+})/R19$ and measured with an ammeter
8	TM4C123 Output, V_{PE3} input to ULN2003B	4	volts	with PE3 = 1 (measured with voltmeter relative to ground)
9	ULN2003B Output pin 16, V_{k-} LED k-	1.18	volts	with PE3 = 1 (measured with voltmeter relative to ground)
10	LED a+, V_{a+} Bottom side of R19 (anode side of LED)	2.71	volts	with PE3 = 1 (measured with voltmeter relative to ground)
11	LED voltage	1.53	volts	calculated as $V_{a+} - V_{k-}$
12	LED current	6.95	mA	calculated as $(V_{+5} - V_{a+})/R19$ and measured with an ammeter

```

; PortE device registers
GPIO_PORTE_DATA_R EQU 0x400243FC
GPIO_PORTE_DIR_R EQU 0x40024400
GPIO_PORTE_AFSEL_R EQU 0x40024420
GPIO_PORTE_DEN_R EQU 0x4002451C
; PortF device registers
GPIO_PORTF_DATA_R EQU 0x400253FC ;
GPIO_PORTF_DIR_R EQU 0x40025400 ;
GPIO_PORTF_AFSEL_R EQU 0x40025420 ;
GPIO_PORTF_PUR_R EQU 0x40025510 ;
GPIO_PORTF_DEN_R EQU 0x4002551C;
GPIO_PORTF_LOCK_R EQU 0x40025520 ;
GPIO_PORTF_CR_R EQU 0x40025524 ;
GPIO_LOCK_KEY EQU 0x4C4F434B ;;; Unlocks the GPIO_CR register
SYSCTL_RCGCGPIO_R EQU 0x400FE608 ;

```

```

IMPORT TExaS_Init

```

```

THUMB

```

```

AREA DATA, ALIGN=2

```

```

;global variables go here

```

```

NINEMIL EQU 9000000
SEVENMIL EQU 7000000
THREEMIL EQU 3000000
TWO MIL EQU 2000000
ONE MIL EQU 1000000
TWO HUNTHOU EQU 200000
HUNEIGHTYTHOU EQU 180000

```

TWENTYTHOU

EQU 20000

AREA |.text|, CODE, READONLY, ALIGN=2

THUMB

EXPORT Start

Start

; TExaS_Init sets bus clock at 80 MHz

BL TExaS_Init ; voltmeter, scope on PD3

; Initialization goes here

LDR R0, =SYSCTL_RCGCGPIO_R ;Turns on PORT E & F

LDR R1, [R0]

ORR R1, R1, #0x30

STR R1, [R0]

NOP

NOP

LDR R0, =GPIO_PORTE_DIR_R ;Initializes PTR

LDR R1, [R0]

ORR R1, #0x08 ;Makes PE3 Output

STR R1, [R0] ;Stores results into R0

LDR R0, =GPIO_PORTE_DEN_R ;Enable Port E digital port

LDR R1, [R0]

ORR R1, #0x0C ;Enable digital I/O R1<-0000 1100

STR R1, [R0] ;Stores result into R0

LDR R1, =GPIO_PORTE_AFSEL_R ; 6) regular port function

MOV R0, #0 ; 0 means disable alternate function

STR R0, [R1]

;PortF Initialization

LDR R1, =GPIO_PORTF_LOCK_R ; 2) unlock the lock register

```

    LDR R0, =GPIO_LOCK_KEY
    STR R0, [R1]
LDR R1, =GPIO_PORTF_CR_R    ; enable commit for Port F
    LDR R0, [R1]
    ORR R0, #0x010          ; 1 means allow access
    STR R0, [R1]
LDR R1, =GPIO_PORTF_DIR_R   ; 5) set direction register
    LDR R0, [R1]
    AND R0, #0xFFFFFEF      ; PF4 input
    STR R0, [R1]
LDR R1, =GPIO_PORTF_AFSEL_R ; 6) regular port function
    AND R0, #0x00           ; 0 means disable alternate function
    STR R0, [R1]
LDR R1, =GPIO_PORTF_PUR_R   ; pull-up resistors for PF4
    ORR R0, #0x10           ; enable weak pull-up on PF4
    STR R0, [R1]
LDR R1, =GPIO_PORTF_DEN_R   ; 7) enable Port F digital port
    ORR R1, #0x10           ; 1 means enable digital I/O
    STR R0, [R1]

```

CPSIE I ; TExaS voltmeter, scope runs on interrupts

BEFORE

```

    LDR R2,=THREEMIL
    LDR R3,=SEVENMIL
    LDR R4,=TWOMIL
    LDR R5,=NINEMIL

```

```

        LDR R6,=ONEMIL

;30%
loop1
; sets output high
        BL    check                ;Loads Inputs to check
        BEQ   loop1
        BL    check2              ;Loads PF4 input
        BNE BREATHE
        ORR R1, R1, #0x8          ;Turns LED ON
        STR   R1, [R0]

;high delay
        BL delay150

;bit clear
        AND R1, R1, #0xF7        ;Turns LED OFF
        STR   R1, [R0]
        BL check
        BEQ   loop2              ;+20% if input detected

;low delay
        BL delay350
        BL check
        BEQ   loop2              ;+20% if input detected
        BL    check2              ;Loads PF4 input
        BNE BREATHE

B    loop1

```

;50%

loop2

; sets output high

BL check

BEQ loop2

BL check2

;Loads PF4 input

BNE BREATHE

ORR R1, R1, #0x8

STR R1, [R0]

;high delay

BL delay250

;bit clear

AND R1, R1, #0xF7

STR R1, [R0]

BL check

BEQ loop3

;low delay

BL delay250

BL check

BEQ loop3

BL check2

;Loads PF4 input

BNE BREATHE

B loop2

;70%

loop3

; sets output high

BL check

BEQ loop3

BL check2 ;Loads PF4 input

BNE BREATHE

ORR R1, R1, #0x8

STR R1, [R0]

;high delay

BL delay350

;bit clear

AND R1, R1, #0xF7

STR R1, [R0]

BL check

BEQ loop4

;low delay

BL delay150

BL check

BEQ loop4

BL check2 ;Loads PF4 input

BNE BREATHE

B loop3

;90%

loop4

; sets output high

BL check

BEQ loop4

BL check2 ;Loads PF4 input

BNE BREATHE

ORR R1, R1, #0x8

STR R1, [R0]

;high delay

BL delay450

;bit clear

AND R1, R1, #0xF7

STR R1, [R0]

BL check

BEQ loop5

;low delay

BL delay50

BL check

BEQ loop5

BL check2 ;Loads PF4 input

BNE BREATHE

B loop4

;10%

loop5

; sets output high

BL check

BEQ loop5

BL check2

;Loads PF4 input

BNE BREATHE

ORR R1, R1, #0x8

STR R1, [R0]

;high delay

BL delay50

;bit clear

AND R1, R1, #0xF7

STR R1, [R0]

BL check

BEQ loop1

;low delay

BL delay450

BL check

BEQ loop1

BL check2

;Loads PF4 input

BNE BREATHE

B loop5

BREATHE

MOV R12,#0

LDR R11,=TWOHUNTHOU

LDR R10,=TWENTYTHOU

LDR R9,=HUNEIGHTYTHOU

MOV R8,R11 ;WILL ORR WORK???

MOV R7,R12

MOV R3,#0

MOV R4,#0

BREATHSTART

BL LEDLOW

MOV R2,R8

SUBS R6,R2,#0

BEQ DE10

BL DELAY

DE10

LDR R0,=GPIO_PORTF_DATA_R

LDR R1,[R0]

AND R1,#0x10

SUBS R1,#0x10

BEQ RETURNFROM

```
BL    LEDHIGH
MOV  R2,R7
SUBS R6,R2,#0
BEQ  DE10TWO
BL    DELAY
```

DE10TWO

```
LDR R0,=GPIO_PORTF_DATA_R
LDR R1,[R0]
AND  R1,#0x10
SUBS R1,#0x10
BEQ  RETURNFROM
```

```
SUBS R4,#1
BEQ  DECREMENT
B     INCREMENT
```

INCREMENT

```
SUB  R8,R10
ADD  R7,R10
ADD  R3,#1
SUBS R4,R3,#10
BEQ  CHANGESTAT
MOV  R4,#0
B     BREATHESTART
```

CHANGESTAT

```

MOV R4,#1
MOV R3,#0
B    BREATHESTART

```

DECREMENT

```

ADD R8,R10
SUB R7,R10
ADD R3,#1
SUBS R4,R3,#10
BEQ CHANGE2
MOV R4,#1
B    BREATHESTART

```

CHANGE2

```

MOV R4,#0
MOV R3,#0
B    BREATHESTART

```

RETURNFROM

```

B    BEFORE

```

check

```

LDR R0, =GPIO_PORTE_DATA_R    ;Checkpoint incase switch is still pressed
LDR R1, [R0]
SUBS R5, R1, #0x4
BX   LR

```

check2 pressed

;Checkpoint incase PortF switch is

```
LDR    R2,=GPIO_PORTF_DATA_R
LDR    R5,[R2]
AND    R5,#0x10
SUBS   R5,#0x10
BX     LR
```

delay50

```
MOV    R4,#1000                ;Counter 1 million
```

aa

```
MOV    R3,#1000
```

bb

```
SUBS   R3,R3,#1
```

```
BNE    bb
```

```
SUBS   R4,R4,#1
```

```
BNE    aa
```

```
BX     LR
```

delay150

```
MOV    R4,#1000
```

cc

```
MOV    R3,#3000
```

dd

```
SUBS   R3,R3,#1
```

```
BNE    dd
```

```
SUBS   R4,R4,#1
```

BNE cc

BX LR

delay250

MOV R4, #1000

ee

MOV R3, #5000

ff

SUBS R3, R3, #1

BNE ff

SUBS R4, R4, #1

BNE ee

BX LR

delay350

MOV R4, #1000

gg

MOV R3, #7000

hh

SUBS R3, R3, #1

BNE hh

SUBS R4, R4, #1

BNE gg

BX LR

delay450


```

        MOV R4, #1000
ii
        MOV R3, #9000
jj
        SUBS R3, R3, #1
        BNE jj
        SUBS R4, R4, #1
        BNE ii
        BX LR

```

```

,***** LED subroutines *****

```

LEDHIGH

```

        LDR R0,=GPIO_PORTE_DATA_R
        LDR R1,[R0]
        ORR R1,#0x08
        STR R1,[R0]
        BX R14

```

LEDLOW

```

        LDR R0,=GPIO_PORTE_DATA_R
        LDR R1,[R0]
        AND R1,#0xF7
        STR R1,[R0]
        BX R14

```

DELAY

SUBS R2,#1

BNE DELAY

BX R14

ALIGN ; make sure the end of this section is aligned

END ; end of file