ECE 375 LAB 7

Remotely communicated Rock Paper Scissors

Lab session: 015

Time: 12PM Friday

Author name: Lucas Plaisted

Programming partner name: Astrid Delestine

Introduction

Lab 7 wraps up everything we have done thus far in the labs, and combines it together and throws communication in for fun. It requires use of timers/counters in conjunction with polling buttons and receiving data from another device.

Design

Most all of my design work is commented on in the code.

Program Overview

One of the main challenges of this lab is simply doing the initialization properly to set up USART, as well as the timer. Those will be described in their own sections, but the idea of this project is to play rock paper scissors over USART. While initially daunting, once everything is set up properly this becomes easy enough.

Initialization Routine

Sets the zero reg, stack pointer, preps ports B and D for their usage, initializes the LCD and sets up USART and the timer for 1.5s.

Main Routine

Begins the game setup. First waits for PD7 with appropriate text on display, then sends confirmation message and waits to receive. Checks the message, and if it is all good jumps to the game.

Game Start

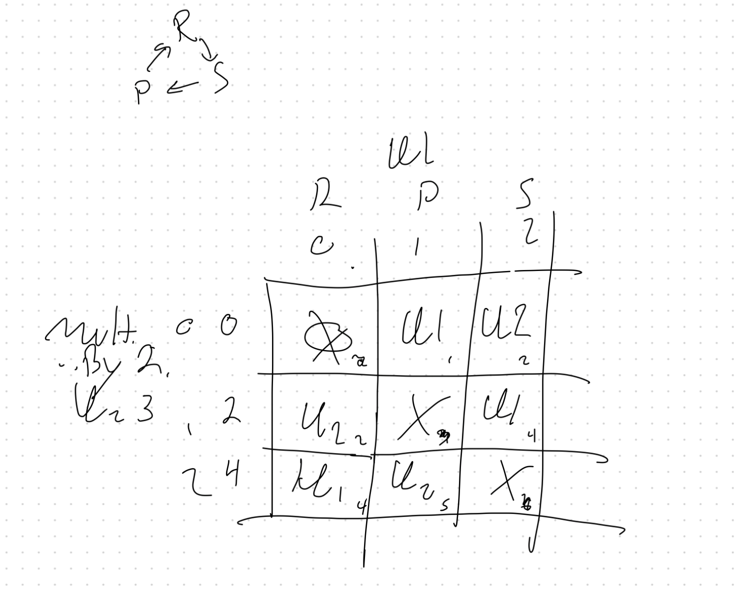
Starts the loop of being able to select the hand to throw and timer lights. Shifts the lights out every 1.5 seconds, and checks for falling edges on the button with debouncing. After the choice is made, GameStart2 is called.

Game Start 2

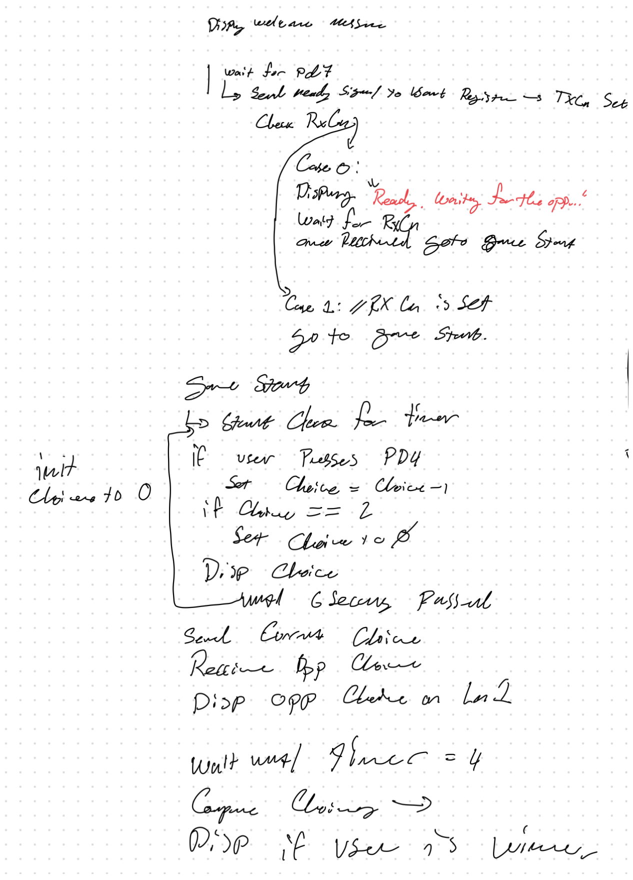
Transmits the final hand and receives the opponents. Displays this and waits 4 more counts before continuing to Game End

Game End

Does the math for who wins. It’s really fancy but Astrid was the one who did this part. Here is her work for how she did it:



		R	P	S
		0	1	2
0	0	X 0	U1 1	U2 2
1	2	U2 2	X 3	U1 4
2	4	U1 4	U2 5	X 6



```
Dispy welcome message

| wait for Pd7
L> Send ready Signal to Want Register -> TXCn Set
    Check RxCn
        Case 0:
        Displung "Ready. Waiting for the opp..."
        Wait for RxCn
        once Received goto game Start

        Case 1: //RX Cn is Set
        go to game Start.

Game Start
L> Start Clock for timer
init                  if user Presses PD4
Choice to 0               Set Choice = Choice -1
                      if Choice == 2
                          Set Choice to ∅
                      Disp Choice
                        until 6 Seconds Passed
Send Current Choice
Receive Opp Choice
Disp OPP Choice on Ln 2

wait until timer = 4
Compare Choices ->
Disp if User is winner
```

It branches to one of 3 possible outcomes, win, lose, draw. This is wrote to the LCD.

Game End End

Just counts down 4 more lights and then goes back to the beginning of Main.

Testing

Case	**Expected**	**Actual meet expected**
Input Rock, Receive Rock	draw	yes
Input Rock, Receive Paper	lose	yes
Input Rock, Receive Scissors	win	yes
Input Paper, Receive Rock	win	yes
Input Paper, Receive Paper	draw	yes
Input Paper, Receive Scissors	lose	yes
Input Scissors, Receive Rock	lost	yes
Input Scissors, Receive Paper	win	yes
Input Scissors, Receive Scissors	draw	yes
…	…	…

Conclusion

This lab was well suited to being the last lab and was very hard but very rewarding. It ensured that I had good knowledge of what we learned this term.

Source Code

```
;***********************************************************
;*
;*    This is the TRANSMIT skeleton file for Lab 7 of ECE 375
;*
;*      Rock Paper Scissors
;*     Requirement:
;*     1. USART1 communication
;*     2. Timer/counter1 Normal mode to create a 1.5-sec delay
;***********************************************************
;*
```

```
;*     Author: Astrid Delestine & Lucas Plaisted
;*     Date: 3/13/2023
;*
;***********************************************************

.include "m32U4def.inc"      ; Include definition file

;***********************************************************
;*  Internal Register Definitions and Constants
;***********************************************************
;DO NOT USE 20-22
.def   mpr = r16             ; Multi-Purpose Register
.def    ilcnt = r18
.def    olcnt = r19
.def    zero = r2
.def    userChoice = r17
.def    tmrcnt = r15
.def    button = r13
.def    oldbut = r14
; Use this signal code between two boards for their game ready
.equ   SendReady = 0b11111111
.equ    lcd1L = 0x00                 ; Make LCD Data Memory locations constants
.equ    lcd1H = 0x01
.equ    lcd2L = 0x10                 ; lcdL1 means the low part of line 1's location
.equ    lcd2H = 0x01                 ; lcdH2 means the high part of line 2's location
;***********************************************************
;*  Start of Code Segment
;***********************************************************
.cseg                        ; Beginning of code segment

;***********************************************************
;*  Interrupt Vectors
;***********************************************************
.org   $0000                 ; Beginning of IVs
       rjmp   INIT                   ; Reset interrupt


.org   $0056                 ; End of Interrupt Vectors

;***********************************************************
;*  Program Initialization
;***********************************************************
INIT:
    ; Most important thing possible!!!!!
        clr    zero
        clr    userChoice
        clr tmrcnt
               ;)
       ; Initialize the Stack Pointer (VERY IMPORTANT!!!!)
        ldi    mpr, low(RAMEND)
        out    SPL, mpr       ; Load SPL with low byte of RAMEND
        ldi    mpr, high(RAMEND)
        out    SPH, mpr       ; Load SPH with high byte of RAMEND

       ; Initialize Port B for output
        ldi    mpr, $F0       ; Set Port B Data Direction Register
        out    DDRB, mpr      ; for output
        ldi    mpr, $00       ; Initialize Port B Data Register
        out    PORTB, mpr     ; so all Port B outputs are low

    ; Initialize Port D for input
        ldi    mpr, $00       ; Set Port D Data Direction Register
        out     DDRD, mpr       ; for input
        ldi     mpr, $FF        ; Initialize Port D Data Register
        out     PORTD, mpr      ; so all Port D inputs are Tri-State

    ;init the LCD
        rcall LCDInit
        rcall LCDBacklightOn
        rcall LCDClr


/*    I/O Ports
    ;USART1
        Need to set USCR1B and C
        B: x00xxx00 -> 0b0_00_1_1_0_00
               2:     USCZ12
               3:     TXEN1: Transmitter enable
               4:     RXEN1: Receiver enable
               7:     RXCIE1: Receive complete interrupt enable flag,
                                     enable if using interrupts
        C: xxxxxxxx    -> 0b00_00_1_11_0
               0:     UPOL1: Clock Polarity
               2-1: USCZ11 and USCZ10
               3:     USBS1 stop bit select
               5-4: UPM1 parity mode
               7-6: UMSEL1 USART mode select
        x's are bits that need to be set
        0's are status bits, no setting, only reading
    USCZ1:    011 for 8 bit
    UMSEL1:    00 for asynchronous
    UMP1:    00 for disbled
    USBS1:    1 for 2-bit
    USPOL1:    0 for rising edge
*/
        ; Set baudrate at 2400bps, double data rate
        ; Asynchronous Double Speed mode eq:

/*    UBRR1 = fOSC/(8*BAUD)
        fOSC is just the system clock, so 8MHz
        BAUD is 2400
    UBRR1 = (8*10^6)/(8*2400) = 10^6/2400 = 416.66
    about 417 or 0b1_10100001
*/
               ldi mpr, 0b00000001
               sts UBRR1H, mpr
               ldi mpr, 0b10100001
               sts UBRR1L, mpr

               ldi mpr, 0b0_00_1_1_0_00
               sts UCSR1B, mpr
               ldi mpr, 0b00_00_1_11_0
               sts UCSR1C, mpr

    ;TIMER/COUNTER1
        ;Set Normal mode, WGM13:0 = 0b000
/*
TIMER MATH
    Need 1.5sec delay
    Max count of 2^16-1 = 65,535
    65,535/1.5 = 43690 counts/sec ideal, lower is okay
    CPU @ 8MHz = 8*10^6 counts/sec
    8*10^6/prescale <= 43690
    prescale >= 8*10^6/43690
    prescale >= 183
    prescale should be 256 :)
    WGM1 = 0b100
    at 256 prescale how much we counting?
    x/(8MHz/256) = 1.5s
    x = 1.5s(8Mhz/256) = 46,875
    so we need to load 65535-46875 = 18660
    into the counter in order to have it count for the
    correct amount of time

    In two 8-bit numbers, that value is
    High: 0b01001000
    Low:  0b11100100
*/
    ; Configure 16-bit Timer/Counter 1A and 1B
                ; TCCRIA Bits:
                        ; 7:6 - Timer/CounterA compare mode, 00 = disabled
                        ; 5:4 - Timer/CounterB compare mode, 00 = disabled
                        ; 3:2 - Timer/CounterC compare mode, 00 = disabled
                        ; 1:0 - Wave gen mode low half, 00 for normal mode
                ldi mpr, 0b00_00_00_00
                sts TCCR1A, mpr
                ; TCCRIB Bits:
                        ; 7:5 - not relevant, 0's
                        ; 4:3 - Wave gen mode high half, 00 for normal
                        ; 2:0 - Clock selection, 100 = 256 prescale
                ldi mpr, 0b000_00_100
                sts TCCR1B, mpr

    ; Load text data from program mem to data mem for easy access
    ldi ZH, high(STRING1)
    ldi ZL, low(STRING1)
    lsl ZH      ; shift for program mem access
    lsl ZL
    adc ZH, zero ; shift carry from lower byte to upper byte
    ldi YH, high(welcome)
    ldi YL, low(welcome)
        ; Z has the loading address, Y the offloading address
        ; Need to load 16*number of phrases letters
        ;    16*11 = 176
    ldi ilcnt, 176
LOADLOOP:
        lpm mpr, Z+    ; load letter into mpr
        st Y+, mpr    ; store letter into data meme
        dec ilcnt    ; count 1 more done
        cp ilcnt, zero    ; are we done yet
        brne LOADLOOP



;***********************************************************
;*  Main Program
;***********************************************************
MAIN:
    ldi ilcnt, 0
    ldi olcnt, 1
    rcall WRITESCREEN
MAIN2:
    sbic PIND, 7 ;wait for 7 button
    rjmp MAIN2
    clr mpr
    clr olcnt

    ldi mpr, $FF
    rcall USART_TX ; send confirmation
    ldi ilcnt, 2
    ldi olcnt, 3
    rcall WRITESCREEN
    rcall USART_RX ; Wait until receive, placed in mpr
    cpi mpr, $FF
    brne MAIN
    rcall GAMESTART


    rjmp    MAIN

;***********************************************************
;*    Functions and Subroutines
;***********************************************************


USART_TX: ; transmits mpr
    push mpr
    lds mpr, UCSR1A
    sbrs mpr,UDRE1
    rjmp USART_TX
    pop mpr
    sts UDR1, mpr
    ret

USART_RX:
    lds mpr, UCSR1A
    sbrs mpr, RXC1 ; received = skip
    rjmp USART_RX
    ;get data from usart into mpr
    lds    mpr, UDR1
    ret




GAMESTART:
    ldi olcnt, $FF    ; start screen
    ldi ilcnt, 4
    rcall WRITESCREEN
    ;start clock for timer
    rcall STARTTIMER ; start 1.5sec timer
    clr userChoice
    inc userChoice
    inc userChoice
    ldi mpr, 0b11110000
    mov tmrcnt, mpr
    out PORTB, mpr
    clr oldbut    ; button has never had value checked!
GAMELOOP:
    ;check if timer is over
    sbis TIFR1, TOV1    ; if timer overflowed
    rjmp NOTIMER
        lsl tmrcnt
        mov mpr, tmrcnt
        out PORTB, mpr
        cpi mpr, 0
        breq GAMESTART2    ; if all 4 done next
        rcall STARTTIMER ; start a new timer
    NOTIMER:
    mov mpr, oldbut
    cpi mpr, 0 ; if we weren't pressing the button already
    brne ALREADYPRESSED
        sbic PIND, 4 ; if button pressed
        rjmp ALREADYPRESSED
               ldi mpr, 1
               mov oldbut, mpr ; mark down for next loop that its pressed
               inc userChoice ; cycle to next choice
               cpi userChoice, 3
               brne BUTSKIP ; if we rolled over
                      clr userChoice ; reset to rock
               BUTSKIP:
               ; Now we need to write the screen
               ldi ilcnt, 4
               ldi olcnt, 5
               add olcnt, userChoice
               rcall WRITESCREEN
    ALREADYPRESSED: ; button not pressed or was already pressed landing spot
    rcall SMALLWAIT
    sbic PIND, 4 ; if button 4 not pressed
        clr oldbut
    rjmp GAMELOOP

GAMESTART2:
    mov mpr, userChoice
    rcall USART_TX
    rcall USART_RX
    push mpr
    ldi olcnt, 5
    add olcnt, userChoice
    ldi ilcnt, 5
    add ilcnt, mpr
    rcall WRITESCREEN

    rcall STARTTIMER ; start 1.5sec timer
    ldi mpr, 0b11110000
    mov tmrcnt, mpr
    out PORTB, mpr
GAMELOOP2:
    ;check if timer is over
    sbis TIFR1, TOV1    ; if timer overflowed
    rjmp NOTIMER2
        lsl tmrcnt
        mov mpr, tmrcnt
        out PORTB, mpr
        cpi mpr, 0
        breq GAMEEND    ; if all 4 done next
        rcall STARTTIMER ; start a new timer
    NOTIMER2:
    rjmp GAMELOOP2
GAMEEND:
       pop mpr ;load mpr with p2 val
    cp userChoice, mpr
    breq uDraw

    lsl mpr ; effective mul 2
    add userChoice, mpr
    cpi userChoice, 1
    breq uWin
    cpi userChoice, 2
    breq theyWin
    cpi userChoice, 4
    breq uWin
    cpi userChoice, 5
    breq theyWin

    rjmp GAMEEND; THIS HSOULD NO THPPEN



uWin:
    ldi ilcnt, 8
    rcall WRITESCREEN
    rjmp ENDEND

theyWin:
    ldi ilcnt, 9
    rcall WRITESCREEN
    rjmp ENDEND

uDraw:
    ldi ilcnt, 10
    rcall WRITESCREEN
    rjmp ENDEND

ENDEND:
    rcall STARTTIMER ; start 1.5sec timer
    ldi mpr, 0b11110000
    mov tmrcnt, mpr
    out PORTB, mpr
ENDLOOP:
    ;check if timer is over
    sbis TIFR1, TOV1    ; if timer overflowed
    rjmp NOTIMER3
        lsl tmrcnt
        mov mpr, tmrcnt
        out PORTB, mpr
        cpi mpr, 0
        breq ENDENDEND    ; if all 4 done next
        rcall STARTTIMER ; start a new timer
    NOTIMER3:
    rjmp ENDLOOP
ENDENDEND:
    ret




;***********************************************************
;*      Write Screen
;*    Writes two words to the screen, assuming that they are
;*    stored in ilcnt and olcnt, il being the top line and
;*    ol being the bottom line
;*
;*    If the register has $FF written to it, write a blank line
;*
;*    The number stored in ilcnt will be from 0 to 10, referring
;*    to the words in the order shown at the bottom of the program
;*
;***********************************************************
WRITESCREEN:
    push XH
    push XL
    push YH
    push YL
    push ZH
    push ZL
    push mpr
    push r0
    push r1

    push ilcnt
    push olcnt

    ldi XH, $03
    ldi XL, $00

    rcall LCDClr

    pop  mpr           ; mpr has lower byte (olcnt)
    cpi mpr, $FF    ; if mpr != FF
    breq SKIPWRITE1
        ldi YH, lcd2H    ; load Y with line 2 location
        ldi YL, lcd2L
        ldi ilcnt, 16
        mul mpr, ilcnt
        mov ZH, r1
        mov ZL, r0    ; Z loaded with offset from $0300 of data
        add ZH, XH    ; offset ZH by 3
WRITELOOP1:    ; moves one letter from data mem to screen data mem
        ld mpr, Z+    ; does this until 16 are moved
        st Y+, mpr
        dec ilcnt
        cp ilcnt, zero
        brne WRITELOOP1
        rcall LCDWrLn2
SKIPWRITE1:

    pop mpr     ; mpr has lower byte of top line phrase (ilcnt)
    cpi mpr, $FF    ; if mpr != FF
    breq SKIPWRITE2
        ldi YH, lcd1H    ; load Y with line 1 location
        ldi YL, lcd1L
        ldi ilcnt, 16
        mul mpr, ilcnt
        mov ZH, r1
        mov ZL, r0    ; Z loaded with offset from $0300 of data
        add ZH, XH    ; offset ZH by 3
WRITELOOP2:    ; moves one letter from data mem to screen data mem
        ld mpr, Z+    ; does this until 16 are moved
        st Y+, mpr
        dec ilcnt
        cp ilcnt, zero
        brne WRITELOOP2
        rcall LCDWrLn1
SKIPWRITE2:

    pop r1
    pop r0
    pop mpr
    pop ZL
    pop ZH
    pop YL
    pop YH
    pop XL
    pop XH
    ret

;***********************************************************
;*      Start Timer
;*    Starts the timer for 1.5 seconds and clears the
;*    overflow flag
;***********************************************************
STARTTIMER:
    push mpr
    ;TIFR1 bit 0 has overflow flag
    /* Timer Value:
    High: 0b01001000
    Low:  0b11100100*/
    ldi mpr, 0b01001000    ; Must write H first
    sts TCNT1H, mpr
    ldi mpr, 0b11100100 ; If reading, L first
    sts TCNT1L, mpr    ; timer reset
    ldi mpr, $01
    out TIFR1, mpr    ; clear overflow flag
    ; Timer is running for 1.5 sec now,
    ; just wait for bit 0 of TIFR1 to be set for the
    ; timer to be done
    pop mpr
    ret
;***********************************************************
;*      Small Wait
;*    Waits for some amount of time. How much? Only god knows.
;*
;*    Useful for debouncing
;*
;***********************************************************
SMALLWAIT:
    push ilcnt
    ldi ilcnt, $FF
SMALLWAITLOOP:
    dec ilcnt
    nop        ; if the switch is bouncing add more nops
    nop
    nop
    cpi ilcnt, 0
    brne SMALLWAITLOOP
    pop ilcnt
    ret
;***********************************************************
;*    Stored Program Data
;***********************************************************

;-----------------------------------------------------------
; An example of storing a string. Note the labels before and
; after the .DB directive; these can help to access the data
;-----------------------------------------------------------
STRING1:
.DB     "Welcome!    "
STRING2:
.DB     "Please press PD7"
STRING3:
.DB     "Ready. Waiting  "
STRING4:
.DB     "for the opponent"
STRING5:
```

```
.DB     "Game start   "
STRING6:
.DB     "Rock         "
STRING7:
.DB     "Paper        "
STRING8:
.DB     "Scissor      "
STRING9:
.DB     "You won!     "
STRING10:
.DB     "You lost     "
STRING11:
.DB     "Draw         "

;************************************************************
;*    Data Memory Allocation
;************************************************************
.dseg
.org    $0300
welcome:    .byte 16
press:          .byte 16
ready:          .byte 16
for:    .byte 16
start:          .byte 16
rock:           .byte 16
paper:          .byte 16
scissor:    .byte 16
win:    .byte 16
lose:           .byte 16
draw:           .byte 16

;************************************************************
;*    Additional Program Includes
;************************************************************
.include "LCDDriver.asm"      ; Include the LCD Driver
```