Recap

Local variables: scope and allocation
How these concepts apply to C
Binding, allocation, access, deallocation

Overview

I/O synchronization
LCD interface
Implementing local variables with a stack frame
Parameter passing

Blind Cycle Counting Synchronization

Blind cycle counting is appropriate when the I/O delay is fixed and known. This type of synchronization is blind because it provides no feedback from the I/O back to the computer.

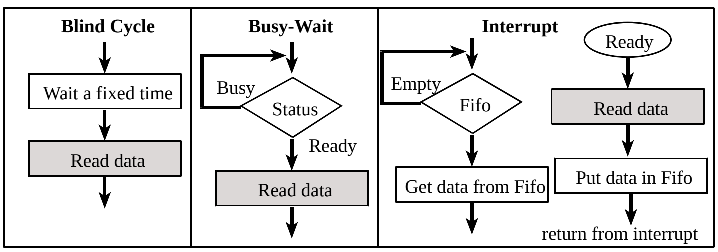
Busy Waiting Synchronization

Check busy/ready flag over and over until it is ready

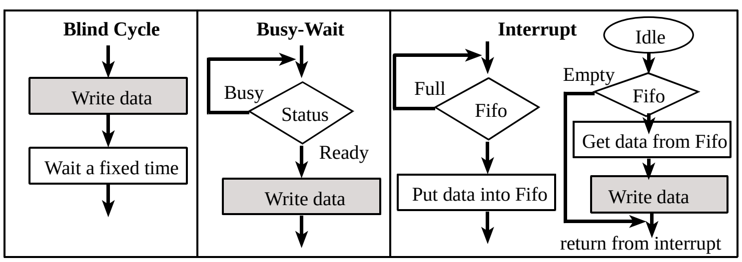
Interrupt Synchronization

Request interrupt when busy/ready flag is ready

Synchronizing with an input device



Synchronizing with an output device



8.5. Parallel Port LCD interface with the HD44780 controller

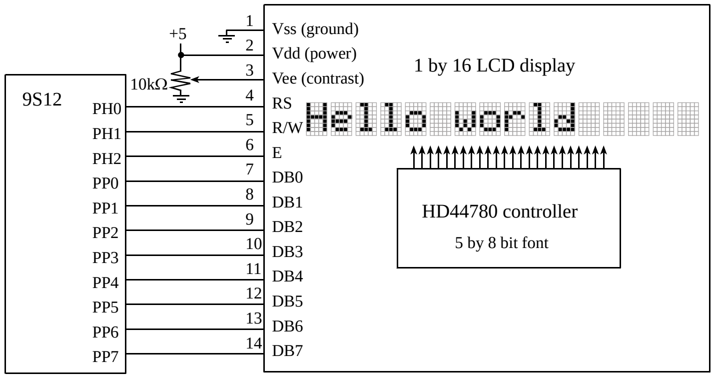
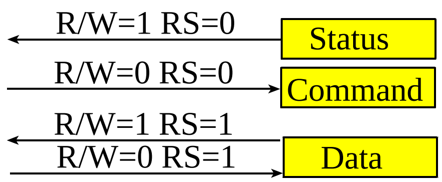


Figure 8.13. Interface of a HD44780 LCD controller.

Show **LCDOptrex.pdf** datasheet
Show interface in PCB Artist
There are four types of access cycles to the HD44780 depending on RS and R/W

RS	R/W	Cycle
0	0	Write to Instruction Register
0	1	Read Busy Flag (bit 7)
1	0	Write data from µP to the HD44780
1	1	Read data from HD44780 to the µP

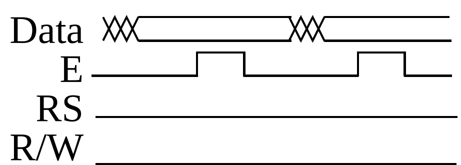
Table 8.12. Two control signals specify the type of access to the HD44780.



Execute the initialization routine using blind-cycle

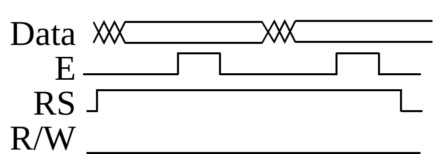
4-bit protocol write command (`outCsr`)

1) E=0, RS=0
2) 4-bit DB7,DB6,DB5,DB4 = most sign nibble of command
3) E=1
4) E=0 (latch 4-bits into LCD)
5) 4-bit DB7,DB6,DB5,DB4 = least sign nibble of command
6) E=1
7) E=0 (latch 4-bits into LCD)
8) blind cycle 90 us wait



4-bit protocol write ASCII data (`LCD_OutChar`)

1) E=0, RS=1
2) 4-bit DB7,DB6,DB5,DB4 = most significant nibble of data
3) E=1
4) E=0 (latch 4-bits into LCD)
5) 4-bit DB7,DB6,DB5,DB4 = least significant nibble of data
6) E=1
7) E=0 (latch 4-bits into LCD)
8) blind cycle 90 us wait



7.3. Local Variables

Introduction

scope => from where can this information be accessed
- **private** means restricted to current program segment
- **public** means any software can access it

allocation => when is it created, when is it destroyed
- **dynamic** allocation using registers or stack
- **permanent** allocation assigned a block of memory

Example of local variables on stack

```
     org $4000
; calculate sum of numbers
; Input: RegD num
; Output: RegD Sum of 1,2,3,...,num
; Errors: may overflow
; 1) binding
num  set  2   ;loop counter 1,2,3
sum  set  0   ;16-bit accumulator
calc
; 2) allocation
     pshd            ;allocate num
     movw #0,2,-sp   ;sum=0
; 3) access
;Draw a stack picture
;    SP   -> sum
;    SP+2 -> num
;    SP+4 -> return address
loop ldd  sum,sp
     addd num,sp
     std  sum,sp  ;sum = sum+num
     ldd  num,sp
     subd #1
     std  num,sp  ;num = num-1
     bne  loop
     ldd  sum,sp  ;result
; 4) deallocate
     leas 4,sp
     rts
```

Example of local variables on stack, using a stack frame

Advantage: you can use the stack for other temporary

Disadvantage: slower ties up the use of a register

```
     org $4000
; calculate sum of numbers
; Input: RegD num
; Output: RegD Sum of 1,2,3,...,num
; Errors: may overflow
; 1) binding
sum  set  -4   ;16-bit accumulator
num  set  -2   ;loop counter 1,2,3
calc
; 2) allocation
     pshx            ;save old frame
     tsx             ;create frame
     pshd            ;allocate num
     movw #0,2,-sp   ;sum=0
; 3) access
```

```
;Draw a stack picture relative to frame
;    X-4 -> sum
;    X-2 -> num
;    X   -> oldX
;    X+2 -> return address
loop ldd  sum,x
     addd num,x
     std  sum,x  ;sum = sum+num
     ldd  num,x
     subd #1
     std  num,x  ;num = num-1
     bne  loop
     ldd  sum,x  ;result
; 4) deallocate
     txs
     pulx        ;restore old frame
     rts
```

7.5. Parameter passing

input parameters

data passed from calling routine into subroutine

output parameters

data returned from subroutine back to calling routine

input/output parameters

data passed from calling routine into subroutine
data returned from subroutine back to calling routine

call by reference

how

a pointer to the object is passed

why

fast for passing lots of data
simple to implement input/output parameters
both subroutine and calling routine assess same data

```
void OutString(char *pt){
  while(*pt){
    OutChar(*pt);
    pt++;
  }
}
void OutString(char buf[]){ unsigned int i;
  i = 0;
  while(buf[i]){
    OutChar(buf[i]);
    i++;
  }
}
```

call by value

how

a copy of the data is passed

why

simple for small numbers of parameters
protection of the orginal data from the subroutine

```
void OutChar(char letter){
  PTT = letter;  // output to port
}
```

Parameters and locals on stack, using a stack frame
Advantage: you can pass lots of data
Disadvantage: slower
Strategy:

- **number of parameters?**
  - ***few*: use registers**
  - ***a lot*: use the stack**
- **size of the parameter**
  - ***1 or 2 bytes*: call by value**
  - ***buffers*: call by reference**
- **use call by reference for read/modify/write parameters**

The bottom line

- **Blind, Busy-wait, Interrupt synchronization**
- **Follow the directions when performing output to LCD**
- **Stack frame implementation**
  - **allows you to use stack for other purposes**
  - **needs dedication use RegX or Reg Y**
  - **good on machines with a lot of registers**
- **Call by value makes a copy of the data**
- **Call by reference passes a pointer to the original**