Embedded Systems (0907333)
Homework 1

Solutions

Problems 1-7: 4 points each; Problem 8: 7 points, Problems 9-11: 8 points each.

Problem 1: State seven features of the PIC microcontrollers.

1. **Low-cost**
2. **Self-contained**
3. **8-bit**
4. **Harvard structure**
5. **Pipelined**
6. **Risc**
7. **Single accumulator**
8. **Fixed reset and interrupt vectors**

Problem 2: What is the main difference between PIC 16C84 and PIC 16F84?

The 16F84's program memory is Flash instead of EPROM.

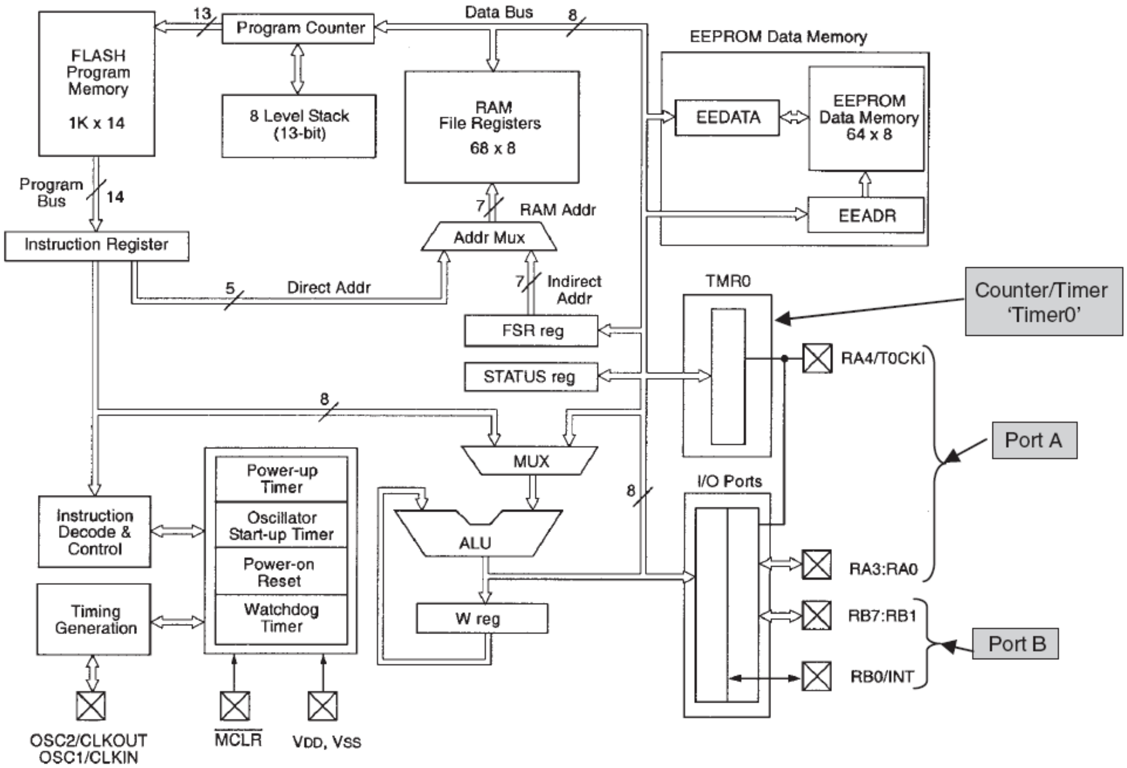
Problem 3: Describe how EPROMs are programmed and erased.

EPROM can be erased by exposing it to intense ultraviolet light. This gives the trapped electrons the energy to leave the floating gate. Then it can be reprogrammed.

Problem 4: What is the main difference between EEPROM and Flash memories?

In EEPROMs, one location is electrically erased at a time; but in Flash memories, a block of locations is erased at a time. Therefore, writing Flash memories is faster.

Problem 5: Draw the PIC 16F84A architecture.



Problem 6: Draw the PIC 16F84A status register.

IRP	RP1	RP0	$\overline{TO}$	$\overline{PD}$	Z	DC	C

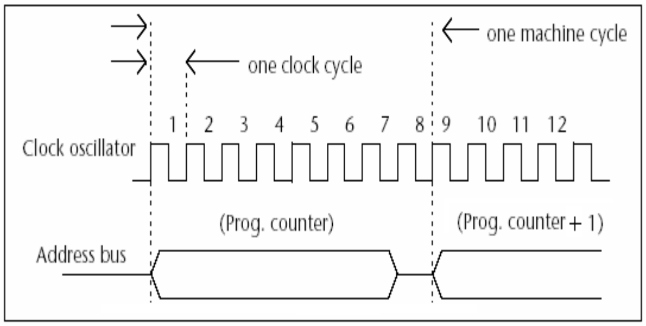
bit 7 … bit 0

Problem 7: Summarize the steps to write one byte in PIC 16F84A's EEPROM.

1. **<u>To write to an EEPROM location, the required data and address must be placed in EEDATA and EEADR respectively.</u>**
2. **<u>The write process is enabled by the WREN (Write Enable) bit being set high, followed by the bytes 55H followed by AAH being sent to the EECON2 register.</u>**
3. **<u>The WR bit is then set high and writing actually commences.</u>**
4. **<u>The write completion is signaled by the setting of bit EEIF in EECON1.</u>**

Problem 8: A microcontroller has the following features:

(a) 8 bit microcontroller
(b) 10-entry stack
(c) 200-ns minimum instruction execution cycle
(d) 30 instructions
(e) 15-bit wide instruction words
(f) 10-bit data memory address bus
(g) 10-bit program memory address bus
(h) All instructions execute in one cycle



According to the above specifications, answer the following questions:

1. Describe in one line *only* what we mean by the first two features.
   The width of internal microcontroller's ALU and registers is 8 bits

2. Find the maximum operating frequency for the above microcontroller.
   $1/(200*10^{-9}) = (5*10^{6}) \longrightarrow$ Max. Frequency = $8*(5*10^{6}) = 40*10^{6} \longrightarrow$ 40 MHz

3. The size of the data bus is **8** bits.

4. The maximum program memory size is **2^{10} =1024* 8 bit or 1 K byte** .

5. Is this microcontroller's core architecture is Von Neumann or Harvard? **Harvard** .

6. Is its instruction set is RISC or CISC? **RISC** .

7. The width of the Program Counter (PC) register is **10** bits.

Problem 9: Read the following code carefully, and then answer the following questions:

```
#include "p16F84.inc"   ; Assume external clock Frequency is 8 MHz
     cblock 0x22
            Count
     endc

     org 0x05
yy
     movlw   D'34'
     movwf FSR
     movlw 33
     clrf  Count
     subwf Count,W
     movlw 2
     addwf PCL,W
     goto  xx
     goto  yy
     goto  zz
---->xx
     btfsc Count,4
     goto  zz
     nop
     incf  Count,F
     goto  xx
---->zz
     movf  INDF,W
     nop
     end
```

a) The program flow between the two arrows is called ___***Iteration Pre-Check*** ____

b) The delay between the two arrows equal to ____***49.5***________ µs

16 * (2+1+1+2) + 1+ 2 = 6*16 +3 = 99 machine cycle

99 * 1/2µs = 49.5 µs

c) The basic element of assembly language `yy` is called ____***Label*** _____

d) The instruction that is executed after `addwf PCL,W` is ___***goto xx*** _____

e) The machine code of instruction `clrf  Count` is __***00000110100010 = (01A2)h*** __

f) The value of W and the three status flags after execute `subwf Count,W` is

C = 0 ; DC = 0 ; Z = 0 ; W = 0xCD

g) The value of W after executing the entire code above is _***(10)h = (16)d*** ___

h) The address of instruction `goto yy` in the program memory is __***0x0D*** ____

Problem 10: The Harvard memory structure gives some clear advantages over the von Neumann. Can you think of any disadvantages? (Consider and expand on: system complexity, flexibility of memory utilization, ease of accessing data tables in program memory, access to Stack).

Answer:
System complexity: given one memory area for data, and one for program, system now needs two data buses and two address buses, ie more complex flexibility of memory utilization: each memory area is defined by its address bus size, and is dedicated to either data or program memory function; it is not possible to reallocate memory from one memory space or function to the other.

Ease of accessing data tables in program memory: access to tables in program memory, eg by indexed addressing, is not so simple; different addressing modes may apply to each of the memory areas, and possible different data bus widths provide another restriction.

Access to Stack: in a von Neuman structure, the stack can be accessed equally for data and program storage, word sizes of all are equal; in a Harvard structure the stack may have to be dedicated to program memory, or two stacks used, as different bus widths inhibit common use of this area.

Problem 11: A microcontroller system is to generate a sine wave, taking values from a look-up table, and transferring them to a digital to analog converter (DAC). Negative values must be converted to two's complement. The table contains values from 0^o to 90^o, in increments of 2^o. Draw a flow diagram showing how the values from the table should be accessed and manipulated, in order to produce the required output.

Answer: