

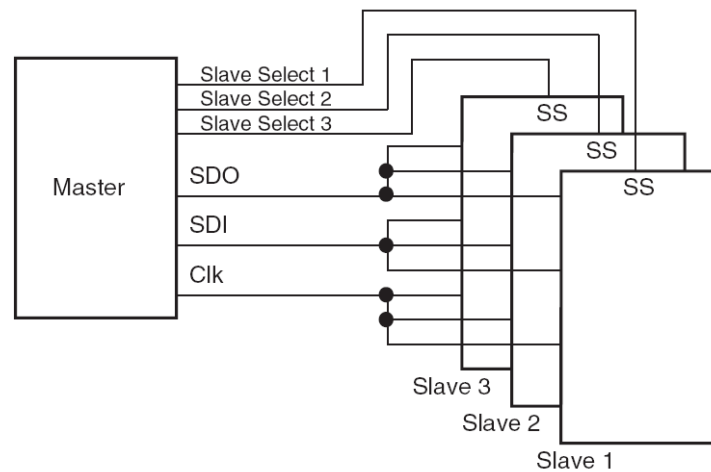
Embedded Systems (0907333)

Homework 3

Solutions

*Problems 1, 2, 3, 4, 5, 7, and 8 three points each. Problem 9 six points.
Problem 10 four points*

Problem 1: Draw a diagram that shows the connections of a synchronous master with three slaves.

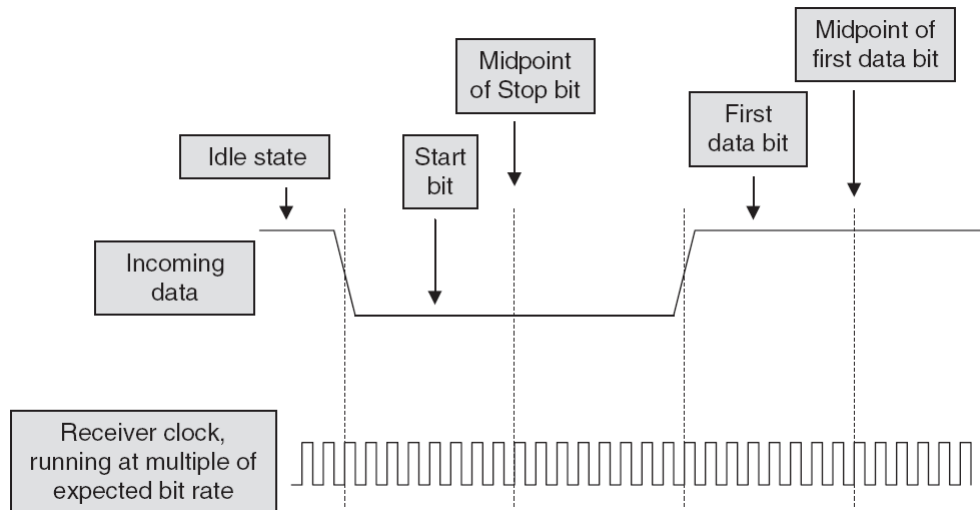


Problem 2: State three disadvantages of synchronous communication compared with asynchronous communication.

1. An extra line is needed to go to every data node for the clock
2. The bandwidth needed for the clock is always twice the bandwidth needed for the data
3. Over long distances, clock and data themselves could lose synchronization

Problem 3: Explain how asynchronous receiver usually synchronizes with an incoming asynchronous data signal.

Refer to the figure below. The receiver runs an internal clock whose frequency is an exact multiple of the anticipated bit rate. Usually, a multiple of 16 is chosen, but this is not essential. The receiver monitors the state of the incoming data on the serial receive line. When a Start bit is detected, a counter begins to count clock cycles until the midpoint of the anticipated Start bit is reached, i.e. eight clock cycles when a $\times 16$ clock is being used. It tests the state of the incoming data line again, to confirm a Start bit is present. If not, the receive is aborted. If the Start bit is confirmed as present, the clock counter counts a further 16 cycles, to the middle of the first data bit. At this point, it clocks that bit into the main receive shift register. In this manner it continues to clock in bits, waiting each time for a bit width before clocking in the next.



Problem 4: For a PIC 16P877A microcontroller running on an external clock of rate = 4 MHz, write the assembly instructions needed to initialize its USART for the following communication setup:

- 8-bit asynchronous continuous communication with parity bit.
- Baud rate = 25 kbps

Using the high baud rate option (BRGH=1):

$$\text{Baud rate} = \text{fosc} / 16(\text{SPBRG}+1)$$

$$25 \text{ kbps} = 4 \text{ MHz} / 16(\text{SPBRG}+1)$$

$$\text{SPBRG} = 4000 / (16 * 25) - 1 = 9$$

;Initialise USART

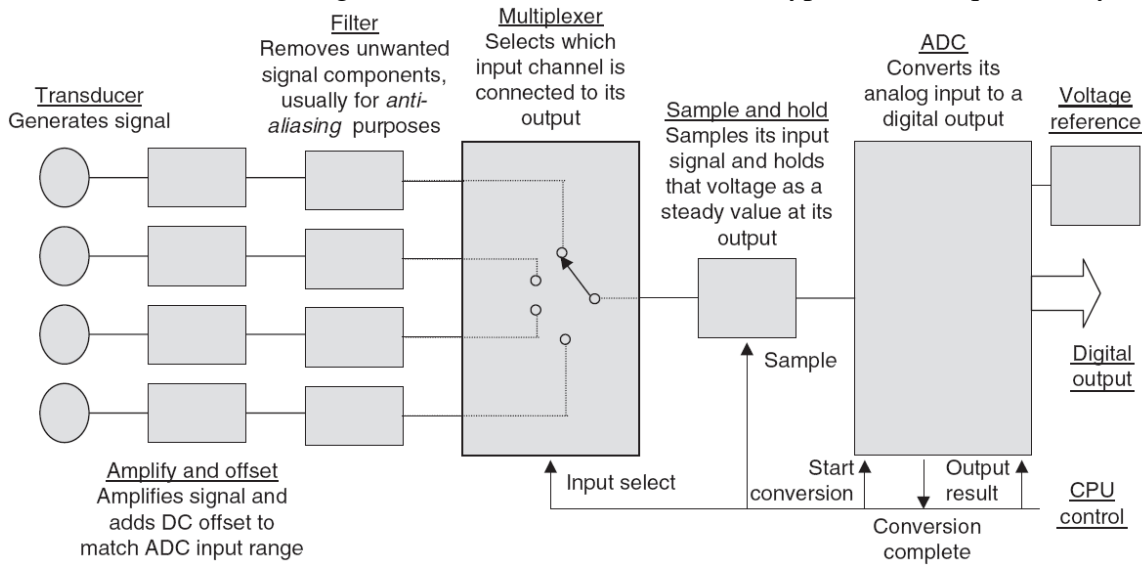
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bcf    status, rp0
movlw  B'11010000' ;port is on, 9-bit,
movwf  rcsta      ;continuous receiving
bsf    status, rp0
movlw  B'01100100' ;TX enabled, 9-bit,
movwf  txsta      ;high speed baud rate
movlw  09         ;baud rate = 50k @4MHz
movwf  spbrg
bcf    status, rp0

```

...

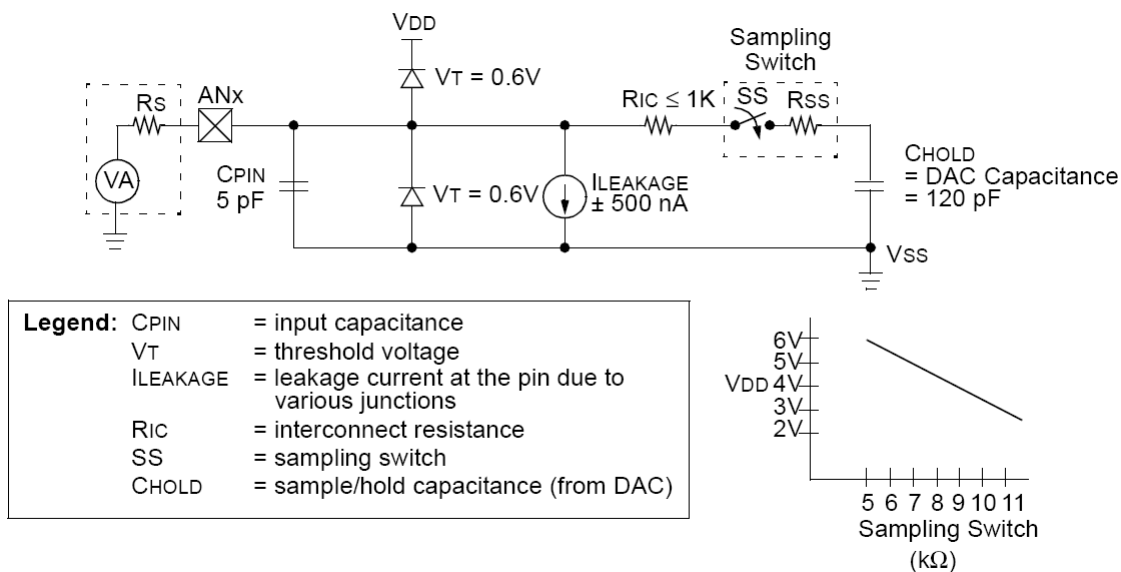
Problem 5: Draw a block diagram that shows the elements of a typical data acquisition system.



Problem 6: Initialize the following two registers so that Timer 0 introduces a 100-second delay. Assume using an external 160-Hz crystal oscillator (show your calculations).

This problem is cancelled.

Problem 7: Refer to the analog input model of the PIC 16P877A's ADC shown below. What is the total acquisition and conversion time given $V_{DD} = 5V$, $R_{IC} = 1k\Omega$, $R_S = 0$, $Temp = 15^\circ C$, $T_{AD} = 1.6 \mu s$?



$$\begin{aligned}
 t_{ac} &= \text{Amplifier settling time} + \text{Hold capacitor charging time} + \text{Temperature coefficient} \\
 &= 2 \mu s + 7.6RC + (Temperature - 25^\circ C)(0.05 \mu s/^\circ C) \\
 &= 2 \mu s + 7.6(7k\Omega + 1k\Omega + 0)(120pF) + (15 - 25)(0.05 \mu s/^\circ C)
 \end{aligned}$$

$$= 2 + 7.3 - 0.5 = 8.8 \mu\text{s}$$

$$\text{Total time} = t_{ac} + 12T_{AD} = 8.8 + 12 * 1.6 \mu\text{s} = 28 \mu\text{s}$$

Problem 8: For a PIC 16P877A microcontroller running on an external clock of rate = 4 MHz, write the assembly instructions needed to initialize its ADC for the following setup:

- Right-justified result format
- All Port A's pins are analog inputs

T_{AD} should be $\geq 1.6 \mu\text{s}$

Hence conversion rate should be $\leq 1/1.6 = 625000$

Conversion rate = F_{osc} / X

$625,000 \geq 4,000,000 / X$

$X \geq 4,000,000 / 625,000 = 6.4$

Select $X = 8$

Hence: Conversion rate = 500,000 Hz, $T_{AD} = 2 \mu\text{s}$

```

;initialization
    bsf    status,rp0
    movlw B'00000000' ;set port A bits as inputs
    movwf trisa
    movlw B'10000000' ;all 8 bits are analog input,
    movwf adcon1      ;right justify result
    bcf    status,rp0
    movlw B'01000001' ;set up ADC: clock Fosc/8,
                    ;switch ADC on but not converting,
                    ;channel selection now is irrelevant
    movwf adcon0

```

Problem 9: Suppose you have the PIC 16F877A with $F_{osc} = 8 \text{ MHz}$. If $BRGH = 1$, answer the following questions:

- a) What value of SPBRG should you use if you want to communicate at asynchronous 19200 baud rate?

$$\text{Baud rate} = f_{osc} / 16(\text{SPBRG}+1)$$

$$19200 = 8 \text{ MHz} / 16(\text{SPBRG}+1)$$

$$\text{SPBRG} = 8000 / (16 * 19.2) - 1 = 25.042 \rightarrow 25$$

- b) If we want to transmit "C" character that has the ASCII code 43_{10} , draw the waveform of the transmitted packet.

1
0
1
0
0
0
0
0
1
1
0

stop
start

- c) What is the actual baud rate that you will achieve with this value of SPBRG?

$$\text{Baud rate} = f_{osc} / 16(\text{SPBRG}+1)$$

$$= 8 \text{ MHz} / 16(25+1) = 19231$$

- d) What is the resulting percent error in your baud rate?
Error = 100% * (19231-19200)/19200 = 0.16
- e) What is the lowest possible baud rate that can be achieved using the settings above?
Lowest baud rate when SPBRG = max. value
Lowest baud rate = fosc / 16(SPBRG+1)
= 8 MHz / 16(255+1) = 1953
- f) What is the highest possible baud rate that can be achieved using the setting above?
Lowest baud rate when SPBRG = min. value
Lowest baud rate = fosc / 16(SPBRG+1)
= 8 MHz / 16(0+1) = 500 kbps

Problem 10: Two sensors need to be connecting to the PIC 16F877A microcontroller. The first one is temperature sensor that measures temperature from (15 to 45°C), with voltage range from (-0.5 to 4.5V), the second is distance sensor that measures distance from (1 to 40 cm), with voltage range from (0.5 to 5.5V). Answer the following Questions:

- a) Find the value of the ADRESH and ADRESL registers if the measured distance is 40 cm.
As 40 cm gives the largest input, it will give the largest input and will map to the largest digital 10-bit value. Which is 111111111.

Result	ADRESH	ADRESL
Left justified	11111111	11000000
Right justified	00000011	11111111

- b) What is the digital value of the analogue input $V_{in} = 2\text{ V}$ for the temperature sensor?
2 V maps to = 111111111 * (2 - (-0.5)) / (4.5 - (-0.5))
= 111111111 * 2.5/5
= 011111111 or 100000000