Jonathan W. Valvano April 13, 2007, 1:00pm-1:50pm.

(15) Question 1. A 32k by 8 bit PROM is interfaced to a 6811 running at 2 MHz

RDA = Read Data Available (from the ROM timing diagram in the question)

= (↓/CE + t_a, ↑/CE + t_b)

= (↑E + [10ns, 15ns] + t_a, ↓E + [10ns, 15ns] + t_b)

= (↑E +[10ns, 15ns]+ [100ns, 150ns], ↓E +[10ns, 15ns] + [15ns, 20ns])

= (250 +[10ns, 15ns]+ [100ns, 150ns], 500 +[10ns, 15ns] + [15ns, 20ns])

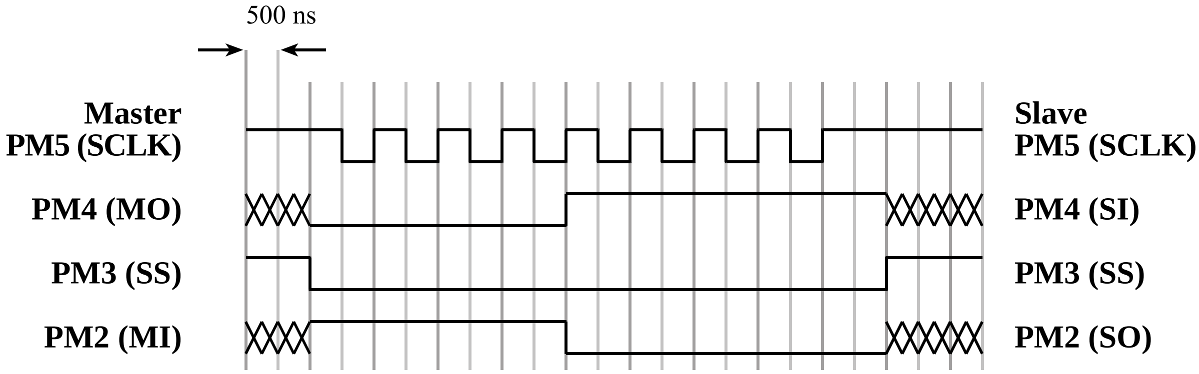
= (250 + 15ns+ 150ns, 500 +10ns+ 15ns)

= (415ns, 525ns)

RDR= Read Data Required (from the 6811 timing diagram in the book)

= (t_1 - t_4 - t_{17}, t_1 + t_{18}) = (500 - 20 - 30 , 500 +10) = (450 , 510)

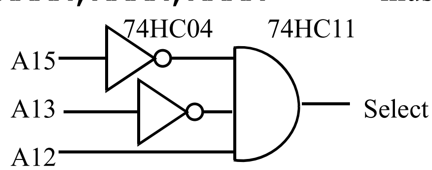
(15) Question 2. CPOL=1, CPHA=0 means clock normally high, master data and slave data are both shifted out on rising edge of SCLK. There should be exactly 8 clock pulses of duration 1 µs.



(15) Question 3.

RAM	\$4000-\$47FF	**0100,0XXX,XXXX,XXXX**	must choose A12
YourDevice	\$5000-\$57FF	**0101,0XXX,XXXX,XXXX**	
ROM	\$6000-\$7FFF	**011X,XXXX,XXXX,XXXX**	must choose A13
ROM	\$C000-\$FFFF	**11XX,XXXX,XXXX,XXXX**	must choose A15

A12 \ A15,A13	00	01	11	10
0	0	0	0	0
1	1	0	0	0

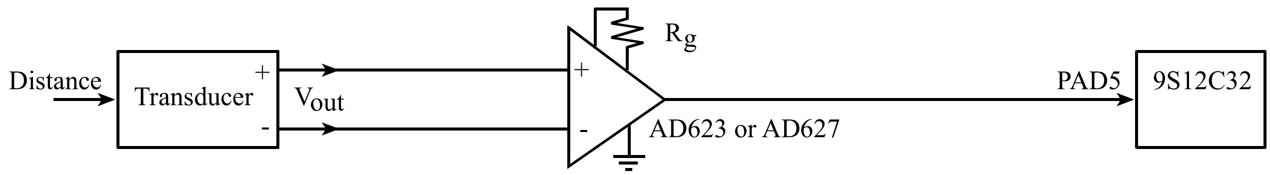


Select = not(A15)*not(A13)*A12

(55) Question 4. You will design a data acquisition system to measure distance.

Part a) The sampling rate should be at least twice the largest frequency component in the signal, according to the Nyquist Theorem. Any frequency greater than 2*499=998 Hz is ok. I choose 1000 Hz.

Part b) 5V/0.2=25, thus a gain of 25 is needed. A differential amplifier will be used because the input is differential. The output swings from 0 to +5V, so rail-to-rail electronics will be needed. We can solve this interface with an instrumentation amp, which has a good CMRR. For an Analog Devices AD623, the gain = 1+(100kΩ/R_g), so R_g is 4.17kΩ. For an AD627, the gain = 5+(200kΩ/R_g), so R_g is 10kΩ.



Part c) Range/precision is resolution. 10m/1024 is about 0.01 m.

Part d) I choose an unsigned decimal fixed-point number system with a resolution of 0.01 m. The conversion is linear, mapping 0 to 0, and 1023 to 1000. For example, if the distance is 5 m, the V_{out} voltage will be 0.1V, the PAD5 voltage will be 2.5V, the ADC conversion will be 512, and the output of the function will be 500. Overflow is handled by promoting to 32-bits. Any of these equations is ok

(1000*data)/1023
(1000*data)/1024
(1000*data+512)/1023
(1000*data+512)/1024
(125*data)/128
(125*data+64)/128

```
unsigned short Convert(unsigned short data){ unsigned long distance;
  distance = (1000*data + 500)/1024;
  return (unsigned short) distance;
}
```

Part e) Write the entire program implements this real time data acquisition system.

```
void main(void){
unsigned short data;     // ADC sample 0 to 1023
unsigned short distance; // fixed point, units 0.01m
  PLL_Init();            // initializes the PLL, changing the E clock to 24 MHz
  ADC_Init();            // initializes the ADC
  Fifo_Init();           // initializes a first in first out queue
  SCI_Init(115200);      // initializes the SCI at 115200 bits/sec
  TIOS |= 0x01;          // channel 0 is output compare
  TSCR1 = 0x80;          // activate timer
  TSCR2 = 0x00;          // TCNT at 24MHz
  TIE |= 0x01;           // arm channel 0
  TC0 = TCNT+50;         // interrupt right away
  asm cli                // enable
  for(;;){
    while(Fifo_Get(&data) == -1);   // removes a 16-bit data from fifo
    distance = Convert(data); // 0-1023 into 0-1000 (0.01m)
    SCI_OutChar(13);          // sends a CR to the PC
    SCI_OutFix(distance);     // sends a fixed-point data to the PC, 0.01
  }
}
interrupt 8 void TC0handler(void){ // executes at 1000 Hz
unsigned short data;    // ADC sample 0 to 1023
  TFLG1 = 0x01;         // acknowledge OC0
  TC0 = TC0+24000;      // 1 ms
  data = ADC_In(0x85);  // returns 10-bit sample from channel 5, 0 to 1023
  Fifo_Put(data);       // saves a 16-bit data into fifo, returns -1 if full
}
```

Fifo queue analysis. If **`SCI_OutFix`** sends 6 characters, each sample requires 7 SCI transmissions. There are 10 bits in a SCI frame (start, data, stop.) At 115,200 bits/sec, the SCI data rate is 11,520 characters/sec. The *consumer* rate is 11,520/7 characters/sec * sample/character = 1645 samples/sec. The *producer* rate is 1000 samples/sec. In fact, the time to produce 1 sample and the time to consume one sample are both fixed, therefore the Fifo will always have either zero or one element.