ECE/CS 5780/6780: Embedded System Design

Chris J. Myers

Lecture 5: Interfacing Methods

Introduction

- Embedded systems often have many special I/O devices, so I/O interfacing is a critical task.
- I/O interfacing includes both physical connections and software routines that affect information exchange.
- Chapter 3 introduces basic interfacing methods.
- Chapter 4 introduces interfacing using interrupts.

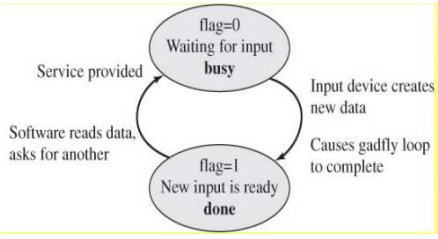
Performance Measures

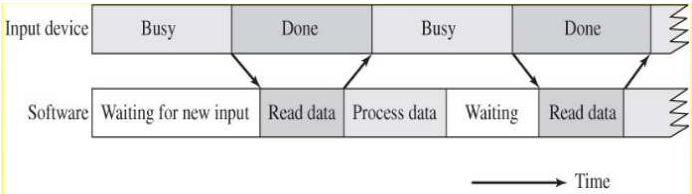
- *Latency* is the delay from when an I/O device needs service until the service is initiated.
- It includes both hardware and software delays.
- *Real-time* systems guarantee a worst-case latency.
- *Throughput* or *bandwidth* is maximum rate data can be processed.
- Can be limited by I/O device or the software.
- *Priority* determines order of service when two or more requests are made at the same time.
- *Soft real time* system is one that supports priority.

Synchronizing the Software with the State of the I/O

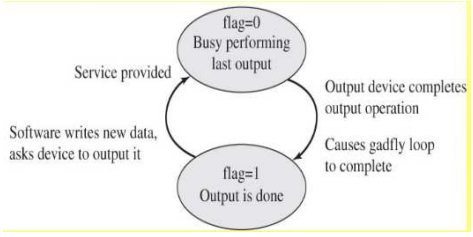
- Hardware is in 1 of 3 states: *idle*, *busy*, or *done*.
- When working, device alternates between busy and done.
- I/O devices usually much slower than software, so synchronization is required for proper transmission.
- When an I/O device is slower than software, it is *I/O bound*, otherwise it is *CPU bound*.
- Interface can be *buffered* or *unbuffered*.

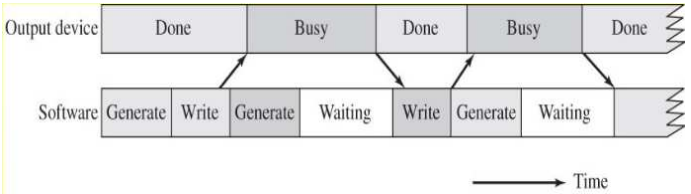
Synchronizing Software with an Input Device





Synchronizing Software with an Output Device

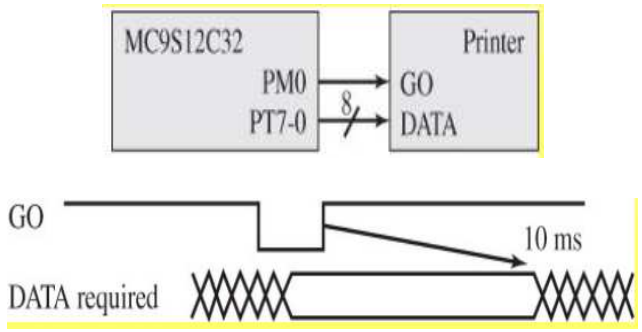




Synchronization Mechanisms

- *Blind cycle* - software waits a fixed amount of time for the I/O to complete.
- *Gadfly* or *busy waiting* - software loops checking the I/O status waiting for the done state.
- *Interrupt* - I/O device causes special software to execute when required.
- *Periodic polling* - clock interrupts periodically to check I/O status.
- *Direct memory access* - I/O device directly transfers data to/from memory.

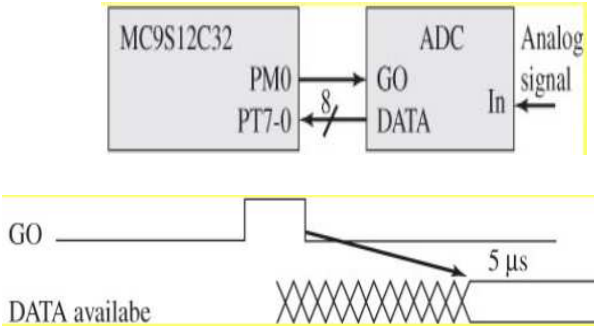
Blind Cycle Printer Interface



Initialize and Output to a Printer

```
void Init(void){
  DDRT = 0xFF;   // outputs
  DDRM|= 0x01;
  PTM |= 1;      // GO=1
  Timer_Init();} // Program 2.6
void Out(unsigned char value){
  PTT = value;
  PTM&=~0x01;  // GO=0
  PTM|=0x01;   // GO=1
  Timer_Wait(10000);}  // 10ms
```

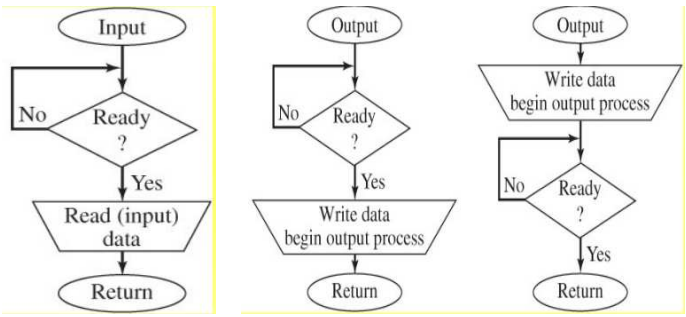

Blind Cycle ADC Interface



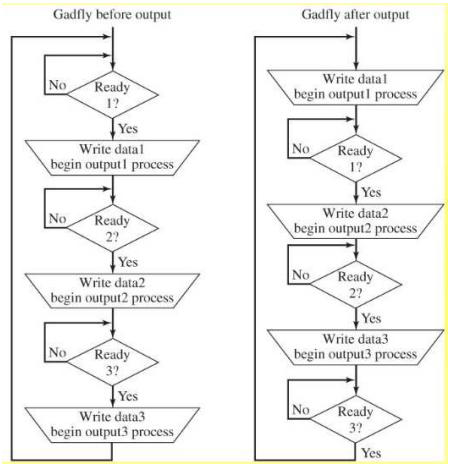
Initialize and Read from an ADC

```
void Init(void){
  DDRT = 0x00;   // input DATA
  DDRM|= 0x01;   // PM0 GO
  PTM &=~0x01;   // GO=0
  Timer_Init();} // Program 2.6
unsigned char In(void){
  PTM |= 0x01;    // GO=1
  PTM &=~0x01;    // GO=0
  Timer_Wait(10); // 10us
  return(PTT);}
```

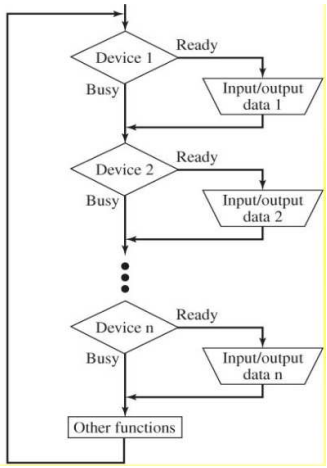

Gadfly or Busy Waiting Synchronization



Multiple Gadfly Outputs



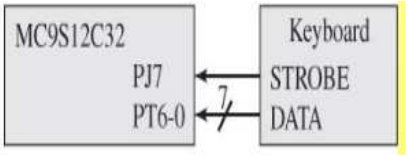
Multiple Gadfly Inputs and Outputs

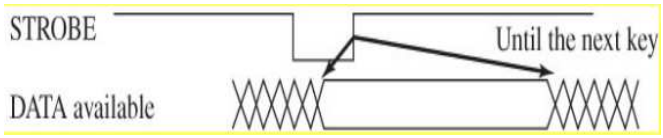


Key Wakeup Interrupts in the 6812

- Allows active edge on an input to set a flag or generate an interrupt.
- Available on two pins of Port J (PJ7 and PJ6) and all 8 pins of Port P.
- Only PP5 is available on your module.
- Direction register, DDRJ and DDRP, sets input or output.
- Active input edge sets a flag in PIFJ and PIFP.
- Either edge can be configured to be active using PPSJ and PPSP.
- Each has a separate interrupt arm bit in PIEJ and PIEP.
- Key wakeup interrupt generated if flag bit set, arm bit set, and interrupts enabled (I=0).
- Ports also have built in pull up or pull down resistors which are configured using PPSJ/PPSP and PERJ/PERP registers.
- RDRJ and RDRP determine drive strength, if bit is 1 then uses 1/3 drive current to save power.

Gadfly Keyboard Interface Using Latched Input

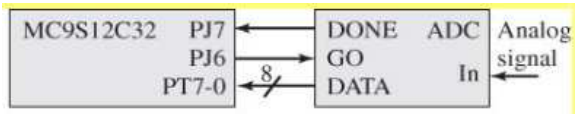


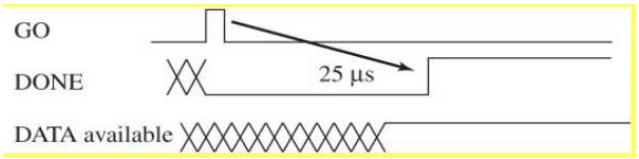


Initialize and Read from a Keyboard

```
void Init(void){ // PJ7=STROBE
  DDRJ = 0x00;   // PT6-0 DATA
  DDRT = 0x80;   // PT7 unused output
  PPSJ = 0x80;   // rise on PJ7
  PIFJ= 0x80;}   // clear flag7
unsigned char In(void){
  while((PIFJ&0x80)==0); // wait
  PIFJ = 0x80;  // clear flag7
  return(PTT);
}
```


Gadfly ADC Interface Using Simple Input

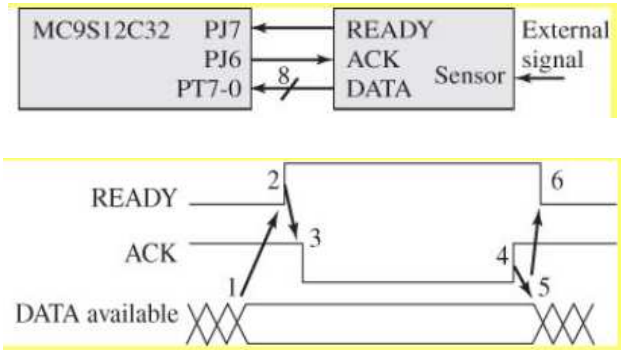




Initialize and Read from an ADC

```
void Init(void){ // PJ7=DONE in
  DDRJ = 0x40;   // PJ6=GO out
  PPSJ = 0x80;   // rise on PJ7
  DDRT = 0x00;   // PT7-0 DATA in
  PTJ &=~0x40;}  // GO=0
unsigned char In(void){
  PIFJ=0x80;     // clear flag7
  PTJ |= 0x40;   // GO=1
  PTJ &=~0x40;   // GO=0
  while((PIFJ&0x80)==0);
  return(PTT);}
```

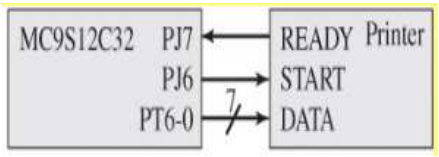

Gadfly External Sensor Interface Using Input Handshake

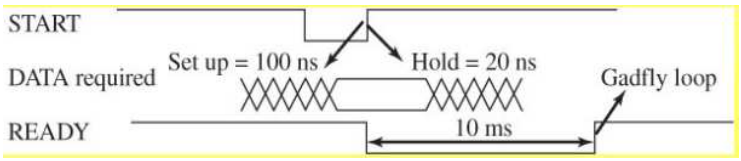


Initialize and Read from a Sensor

```
void Init(void){// PJ7=READY in
  DDRJ = 0x40;  // PJ6=ACK out
  PPSJ = 0x80;  // rise on PJ7
  DDRT = 0x00;  // PT7-0 DATA in
  PIFJ= 0x80;   // clear flag7
  PTJ |= 0x40;} // ACK=1
unsigned char In(void){
  unsigned char data;
  while((PIFJ&0x80)==0);
  PTJ &=~0x40; // ACK=0
  data = PTT;  // read data
  PIFJ=0x80;   // clear flag7
  PTJ |=0x40;  // ACK=1
  return(data);}
```


Gadfly Printer Interface Using Output Handshake

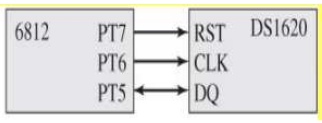


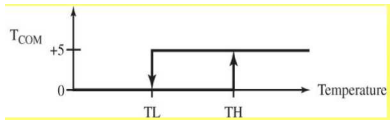


Initialize and Write to a Printer

```
void Init(void){// PJ7=READY in
  DDRJ = 0x40;  // PJ6=START out
  PPSJ = 0x80;  // rise on PJ7
  DDRT = 0xFF;  // PT7-0 DATA out
  PTJ |= 0x40;} // START=1
void Out(unsigned char data){
  PIFJ= 0x80;   // clear flag
  PTJ &=~0x40;  // START=0
  PTT  = data;  // write data
  PTJ |= 0x40;  // START=1
  while((PIFJ&0x80)==0);}
```

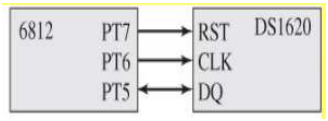

Gadfly Sync Serial I/F to Temperature Sensor





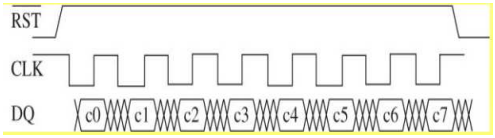
Temperature	Binary Value	Hex Value
+125.0°	011111010	$0FA
+64.0°	010000000	$080
0.5°	000000001	$001
0°	000000000	$000
-0.5°	111111111	$1FF
-16.0°	111100000	$1E0
-55.0°	110010010	$192

Initialization of the DS1620



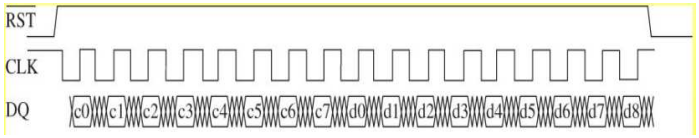

```
void DS_Init(void){ // PT7=RST=0
  DDRT = 0xE0;   // PT6=CLK=1
  PTT = 0x60;}   // PT5=DQ=1
```


Start/Stop the DS1620



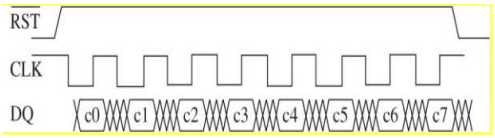

```
void DS_Start(void){
  PTT |= 0x80;   // PT7=RST=1
  out8(0xEE);
  PTT &= 0x7F;}  // PT7=RST=0
void DS_Stop(void){
  PTT |= 0x80;   // PT7=RST=1
  out8(0x22);
  PTT &= 0x7F;}  // PT7=RST=0
```


Send 9-bits Out to the DS1620



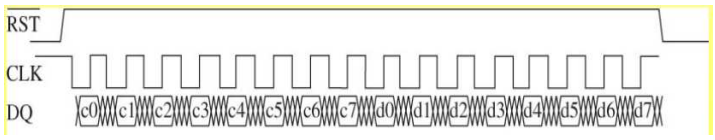

```
void out9(short code){ short n;
  for(n=0;n<9;n++){
     PTT &= 0xBF;   // PT6=CLK=0
     if(code&0x01)
       PTT |= 0x20; // PT5=DQ=1
     else
       PTT &= 0xDF; // PT5=DQ=0
     PTT |= 0x40;   // PT6=CLK=1
     code = code>>1;}}
```


Send 8-bits Out to the DS1620



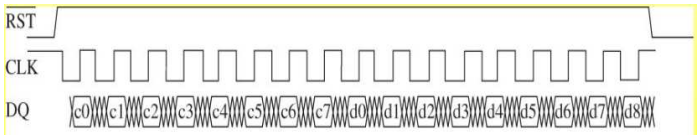

```
void out8(char code){ int n;
  for(n=0;n<8;n++){
    PTT &= 0xBF;   // PT6=CLK=0
    if(code&0x01)
      PTT |= 0x20; // PT5=DQ=1
    else
      PTT &= 0xDF; // PT5=DQ=0
    PTT |= 0x40;   // PT6=CLK=1
    code = code>>1;}}
```


Config the DS1620



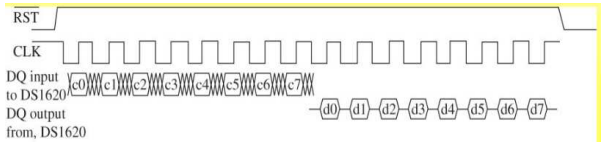

```
void DS_Config(char data){
   PTT |= 0x80;   // PT7=RST=1
   out8(0x0C);
   out8(data);
   PTT &= 0x7F;}  // PT7=RST=0
```


Set Threshold Registers on the DS1620



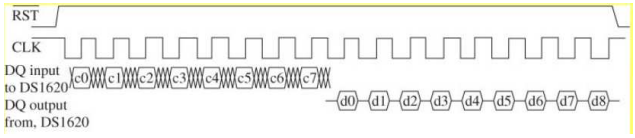

```
void DS_WriteTH(short data){
   PTT |= 0x80;   // PT7=RST=1
   out8(0x01);
   out9(data);
   PTT &= 0x7F;}  // PT7=RST=0
void DS_WriteTL(short data){
   PTT |= 0x80;   // PT7=RST=1
   out8(0x02);
   out9(data);
   PTT &= 0x7F;}  // PT7=RST=0
```

Read 8-bits from the DS1620



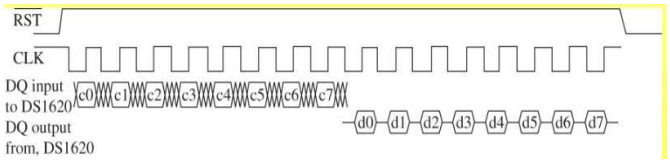

```
unsigned char in8(void){ short n;
  unsigned char result;
  DDRT &= 0xDF; // PT5=DQ input
  for(n=0;n<8;n++){
    PTT &= 0xBF;   // PT6=CLK=0
    result = result>>1;
    if(PTT&0x20)
      result |= 0x80; // PT5=DQ=1
    PTT |= 0x40;}  // PT6=CLK=1
  DDRT |= 0x20; // PT5=DQ output
  return result;}
```


Read 9-bits from the DS1620



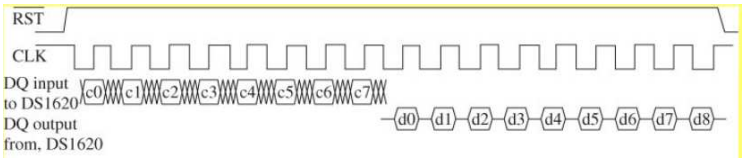

```
unsigned short in9(void){ short n;
unsigned short result=0;
  DDRT &= 0xDF;  // PT5=DQ input
  for(n=0;n<9;n++){
    PTT &= 0xBF;   // PT6=CLK=0
    result = result>>1;
    if(PTT&0x20)
      result |= 0x0100; // PT5=DQ=1
    PTT |= 0x40;}  // PT6=CLK=1
  DDRT |= 0x20;    // PT5=DQ output
  return result;}
```


Read the Configuration Register on the DS1620



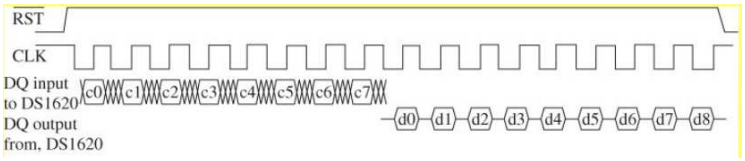

```
unsigned char DS_ReadConfig(void){
  unsigned char value;
  PTT |= 0x80;   // PT7=RST=1
  out8(0xAC);
  value = in8();
  PTT &= 0x7F;   // PT7=RST=0
  return value;}
```


Read the Temperatures from the DS1620



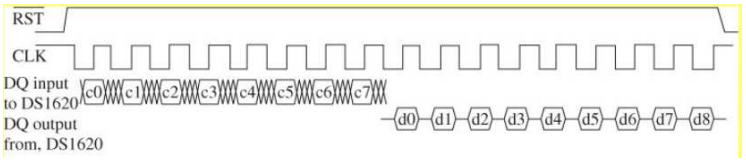

```
unsigned short DS_ReadTH(void){
unsigned short value;
  PTT |= 0x80;   // PT7=RST=1
  out8(0xA1);
  value = in9();
  PTT &= 0x7F;   // PT7=RST=0
  return value;}
```


Read the Temperatures from the DS1620 (cont)




```
unsigned short DS_ReadTL(void){
unsigned short value;
  PTT |= 0x80;   // PT7=RST=1
  out8(0xA2);
  value = in9();
  PTT &= 0x7F;   // PT7=RST=0
  return value;}
```


Read the Temperatures from the DS1620 (cont)




```
unsigned short DS_ReadT(void){
unsigned short value;
  PTT |= 0x80;   // PT7=RST=1
  out8(0xAA);
  value = in9();
  PTT &= 0x7F;   // PT7=RST=0
  return value;}
```