Interfacing Concepts

A. Introduction
B. Input/Output Subsystems and Registers
C. Memory or Input/Output Mapping
D. Interfacing Using Polling or Interrupts
E. The Parallel I/O Subsystem
F. Serial Systems
G. Analog/Digital I/O Subsystems
H. The I/O Subsystem Registers
I. Interface Standards

Introduction

- An interface is a device and/or set of rules to match the output of one device to send inf to the input of another device
  - physical connection
  - the hardware
  - rules and procedures
  - the software
- Interfacing is the process of connecting devices together so that they can exchange info
- The process of reading input signals and sending output signals is called I/O
- I/O conventions
  - I/O direction is relative to the MCU
  - Input is data read by the MCU
  - Output is data sent out by the MCU

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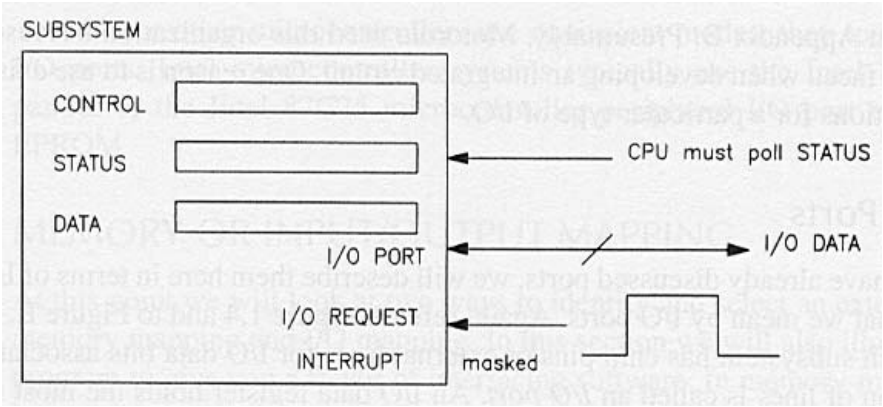
Input/Output Subsystems and Registers

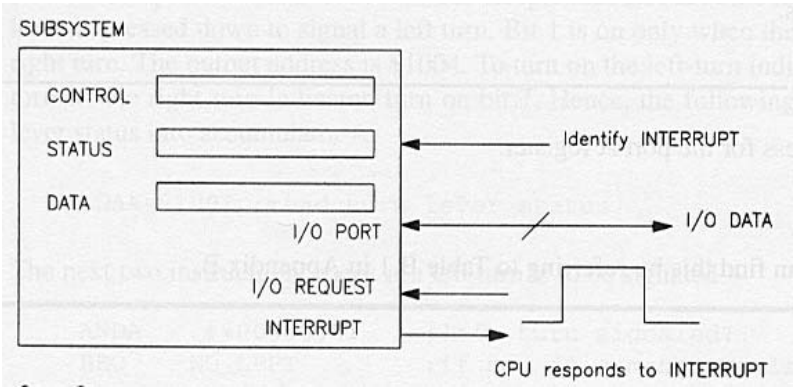
- Microcontrollers and programmable I/O chips handle I/O processing using registers
- Each interface is regarded as a subsystem
- Each subsystem has registers as:
  - control
  - status
  - data
- 68HC11 registers
  - the subsystems use different names for registers
  - some registers contain bits used by different subsystems
- I/O ports
  - Each subsystem has chip pins or external lines for I/O data bits
  - each section of lines is called an I/O port

Input/Output Subsystems and Registers



Polled I/O, no interrupt CPU must check a status bit to determine whether an I/O request occurred

Input/Output Subsystems and Registers



Interrupt – driven I/O I/O request causes interrupt and CPU responds to interrupt

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Memory or Input/Output Mapping

- **Memory-mapped I/O**
  - each I/O register has an address just like a memory location
  - Ex. 68HC11, Intel 8051, ARM

```
LDAA $1003  ;read turn lever status
            ;from port C
ANDA #%00000001 ;left turn?
BEQ NO_LEFT ;if no, go to no_left

LDAA $1004   ;get old output data
            ;from port B
ANDA #%01111111 ;turn off right
            ;signal indicator
ORAA #%01000000  ; turn on left
            ;signal indicator
STAA  $1004  ;this sends out the
            ;new data to port B
```

Memory or Input/Output Mapping

- **Input/Output mapping technique**
- Have separate memory and I/O instructions
- Ex. Intel, Zilog models
- Ex. Turn indicator application using 8086

```
IN AL,03H  ;read turn lever status
AND AL,00000001B ;left turn?
JE  NO_LEFT  ;if no go to no_left
IN  AL,04H  ;get old output status
AND AL,01111111B ;turn off right
          ;signal indicator
OR  AL,01000000B ;turn on left
          ;signal indicator
OUT  04H,AL  ;this sends out
          ;the new data
```


Memory or Input/Output Mapping

```
* Demonstrate automobile turn signal control using
* bit manipulation instructions
* Note:  Listing doesn't show all necessary pseudo-ops
* Some useful equates
BIT0     EQU     $01       ;bit 0
BIT6     EQU     $40       ;bit 6
REGBAS           EQU     $1000   ;start address of register block
PORTC EQU     $03       ;port C offset
PORTB EQU     $04       ;port B offset
         LDX     #REGBAS         ;point to register block
*                         ;if left turn signaled
         BRCLR PORTC,X BIT0 NO_LEFT
*                         ;then turn on left signal indicator
         BSET    PORTB,X BIT6
*        ; temporary label for assembly purposes
NO_LEFT
```

Memory or Input/Output Mapping

```
#include <hc11.h>

/* Declarations */
unsigned char In, Out;

void main(void)
{
        PORTB = Out;
        In = PORTE;
}
```

```
#include <hc11.h>

#define BIT0 0x01
#define BIT6 0x40
void main(void)
{
/* if PC0 == 0 then PB6 = 1 */
    if ((PORTC & BIT0)==0)
        PORTB = PORTB | BIT6;
}
```

- There are C compilers for most types of microprocessors
- Microprocessor-specific features such as their registers are not part of the C language standard
- A C compiler for a specific µprocessor or µcontroller typically include definitions to handle certain proc features

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Interfacing Using Polling or Interrupts

- Polled I/O
- Interrupt-driven I/O

Polled I/O

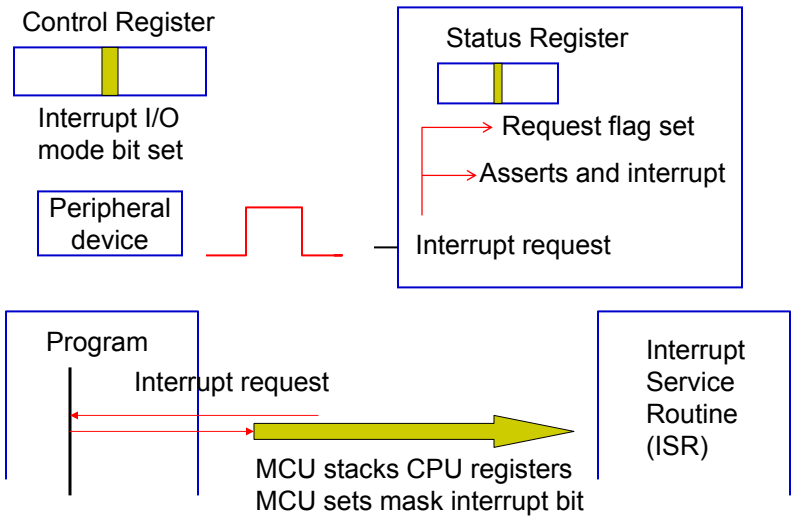
- **Configuration**
- refers to the initial settings for a subsystem
- each subsystem has its own control register
- a bit in the control register selects polled I/O mode

- **Description**
- the MCU checks periodically whether a peripheral requests servicing => polling
- when there is a request the MCU performs the data transfer operation
  - read or write

Polled I/O

- **Request**
- an external peripheral may request service by pulsing an I/O request line
- a L-H or H-L transition causes a flag bit in the status register to be set (or reset)
- **Polling**
- the MCU reads (polls) the status register periodically to check the status flags
- **Servicing**: through an I/O routine
- input: peripheral sends data to the I/O port => data register
- output: the MCU will write data to the data register => I/O port

Interrupt-Driven I/O



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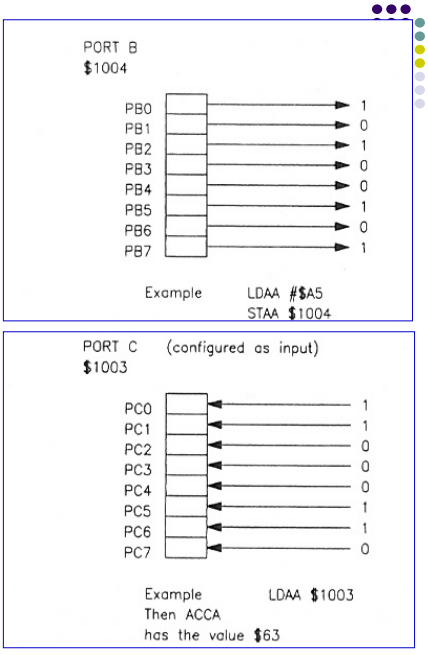
The Parallel I/O Subsystem

- Each line carries a bit of data word
- The ports can be configured as inputs or outputs
- Applications
  - programmable controllers
    - specialized industrial computers designed for a manufacturing plant environment
  - security systems
  - keyboards; printers



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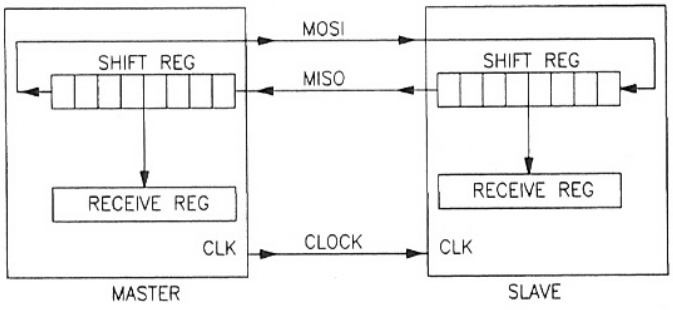
Serial Systems

- Synchronous serial I/O subsystems
- Asynchronous serial I/O subsystems

Synchronous Serial I/O Subsystem

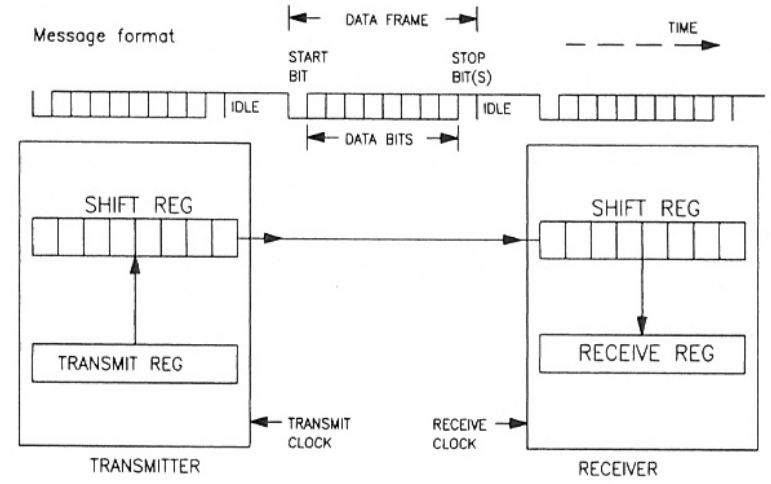


MASTER: initiate data transfer
MASTER: drives serial data clock to synchronize transfer
MASTER and SLAVE(s) typically are local
MISO = Master In, Slave Out
MOSI = Master Out, Slave In

Synchronous Serial I/O Subsystem

- Synchronous serial systems are typically used when all devices are local
- Full-duplex systems
  - data is received and transmitted at the same time
- Half-duplex
  - a data line can either transmit or receive at any one time
- Simplex
  - the data line is used only for transmitting or receiving
- Applications
  - display driving chips; data converter chips; real time clock chips; control bus

Asynchronous Serial I/O Subsystem



Asynchronous: each device uses its own clock

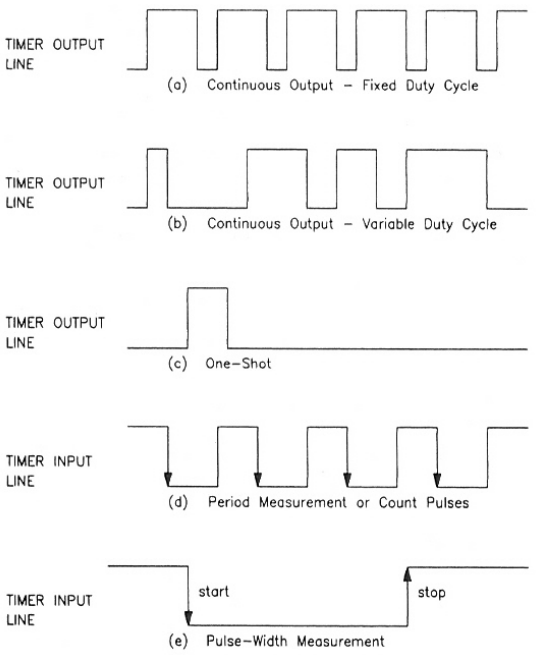
Asynchronous Serial I/O Subsystem

- The use of start and stop bits is referred as framing the data
- The rate of bit transfer => baud rate
- Applications
  - computer communications to peripherals such as modems, mice, instruments, printers, or to other computers
- One of the most common asynchronous standards is RS-232 interface
  - software development boards use RS-232

Programmable Timer I/O Subsystem

By using a timer the CPU does not have to execute software time-delay loops to keep track of time

Applications:
* automotive
* speed control of a dc motor
* reference timing signals etc.



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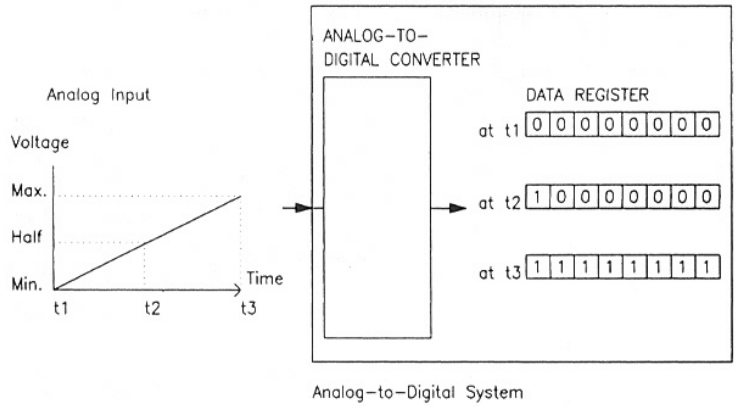
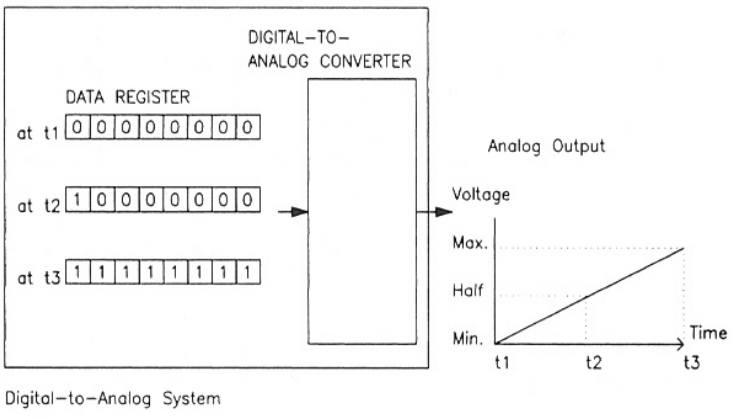
Analog/Digital I/O Subsystem



The smallest binary number represents the minimum analog value
The largest binary number represents the maximum analog value

Analog/Digital I/O Subsystem



68HC11 has 8 built-in A/D channels, but no built-in D/A

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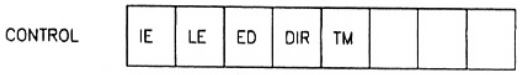
The I/O Subsystem Registers

- Control register and system configuration
- Status registers
- Data registers

Control Registers and System Configuration



IE = Interrupt Enable
enabled or disabled
LE = I/O Request Level
active high or low
ED = I/O Request edge sensitive
edge or level sensitive
DIR = I/O Data Direction
output or input
TM = Transfer Mode
depends on subsystem

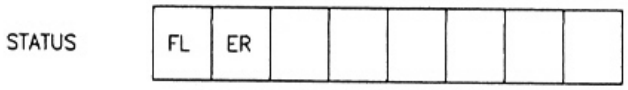
Control Registers and System Configuration

- Configuration
- Default values are what the registers contain after reset
- The control register must be configured if the default values are not the desired ones

Example
IE =1; LE = 1; ED = 0;
DIR = 1; TM = x;

```
LDAA  #$D0
STAA  CONTROL_REG
```

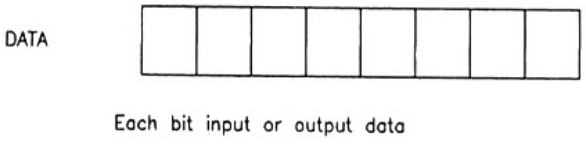
Status Registers



FL = I/O Request Flag
yes/no request occurred
ER = Error Flag
yes/no error occurred

- Many status registers are called flag bits
- Software performs two basic operations with status bits
  - reads the status bits
  - clears the status bits

Data Registers



- Data register hold the input data that has been received or the output data that was most recently sent out
- Subsystems may have several data registers
  - result; capture; compare; port registers

Example:
Output to register B:
B_{7-0} = 00011000

```
LDAA   #$18
STAA  DATA_REG
```

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Interface Standards

- Technical associations have become standards organizations
  - The Institute of Electrical and Electronics Engineering (IEEE)
  - The American National Standards Institute (ANSI)
  - The International Standards Organization (ISO)