Parallel IO Ports

- E.g. Port T, Port AD
- Used to interface with many devices
  - Switches
  - LEDs
  - LCD
  - Keypads
  - Relays
  - Stepper Motors

- Interface with parallel IO requires us to connect the devices correctly and write code to interface with the devices

HCS12 – Where can we connect external hardware?

- Unused ports (every port has DIO functionality)
- Expand through the serial interface
  - SPI serial peripheral interface
  - SCI serial communication interface RS232

Directly Controlling LEDs

- HCS12 can directly control LED from output ports
- Why would we NOT want to do this?

- Port B and A are not connected except PB4 and PA0
- Port S0,1 is RxD and TxD for SCI
- Port M2,3,4,5 are used for SPI
- Port M0,1 are used for CAN
- Port P is cross connected with Port T except PP3
- Port T0..7 can be sued for timer I/O and PWM
- Port A/D 0...7 is used for A/D input
Simple LED
- Output Port is High - LED is On
  - 7405 inverter output will be low
  - Current flows through 7405 to ground
- Output Port is Low - LED is Off
  - 7405 inverter output will be high impedance
  - No current flows through 7405
- Resistor used to control brightness: LED is about 2V, 10-20mA

LED - Open Collector
- NPN transistor is on if \( V_{BE} \) is High
- LED will be on if \( V_{BE} \) is High
- Can support up to 250mA

\[ I = \frac{2.4V - 0.5V}{250\Omega} = 0.1mA \]

LED - Open Emitter
- PNP transistor is on if \( V_{BE} \) is Low
- LED will be on if \( V_{BE} \) is Low
- Can support up to 250mA

Directly Controlling LEDs
- We can use external IC to drive the LEDs
  - Reduce current driven by microcontroller and protects it
  - 74LS244 IC Tri-state Buffer/Line Driver/Line Receiver
  - Used to provide power for LEDs
  - Has OE signals that can be used to disable the output
Directly Controlling LEDs
- Limitation: Can only drive as many LEDs as available pins
- Solutions:
  - Latching
  - Scanning
  - Multiplexing

LEDs - Latching
- Control LED by using a latch hardware
- Use additional hardware to control when to latch values
  - Similar to memory-mapped IO

What did we build?
Is there another way to implement the address decoding?
LEDs - Latching
- Use decoder for addressing LED banks

Decoder - Converts input binary number to single high output:
- 2-input decoder: four possible input binary numbers
  - Thus, four outputs, one for each possible binary number
- Enable signal
  - Outputs all 0 if e=0
  - Regular behavior if e=1

Enable signal

LEDs - Scanning
- Use software executing on the microcontroller to control LEDs row by row, col by col, or bank by bank (depending on organization)

Operation
- Continually scan LEDs fast enough that human eye cannot detect it
  - Similar to refresh rate of TVs and Monitors
- Enable one column of LEDs by writing 0 to output port controlling desired column
- Write LEDs value for select row
- Cannot access all LEDs simultaneously

LEDs - Multiplexed
- Use software executing on the microcontroller to control LEDs one at a time

Operation
- Continually scan LEDs fast enough that human eye cannot detect it
  - Similar to refresh rate of TVs and Monitors
- Enable LED column by outputting column address to column decoder
- Enable individual LEDs by outputting row address to row decoder
- Cannot access all LEDs simultaneously
How many LEDs can I control using only eight output pins using the following schemes?

Latched:
- 64 LEDs – Individual latch used for each LED
- 1 Enable Output, 6 Address Lines, and 1 Data Line
- Six address lines allow for access to 2^6 latches (or LEDs)

Scanned
- 16 LEDs – 4 columns by 4 rows

Multiplexed:
- 64 LEDs – 16 columns by 16 rows
- Enabled by using 4x16 decoder to select both row and columns

Mill Game

How many pins do we need to connect the 48 LEDs in the following diagram?
7-Segment LEDs

Common Cathode

Microcontroller

7-Segment LED - Design Example

- Control three 7-segment LED displays
- Scanning through the entire display must happen faster than the human eye can detect (> 40 Hz)
- The LED must look like it is continuously on at 10 mA
  - Average current = 10 mA

7447 – BCD to 7-Segment Display

Microcontroller

7-Segment LED – Design Example

- Use scanning to control 7-segment LEDs

10 mA DC

Time (ms)

Current (mA)

1/15 ms > 66 Hz