Homework

- Reading
  - 7400 TTL Logic Data Sheets
- Machine Projects
  - MP3 due at start of class today
  - Start looking at MP4 now
- Labs
  - Continue labs with your assigned section

MP3 Discussion

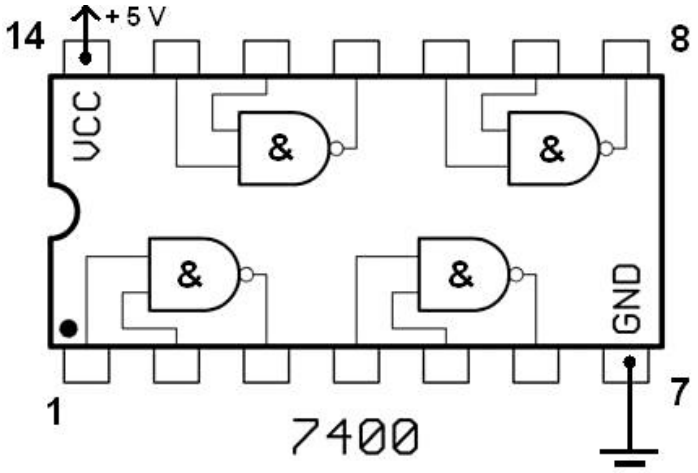
- What did you learn in MP3?

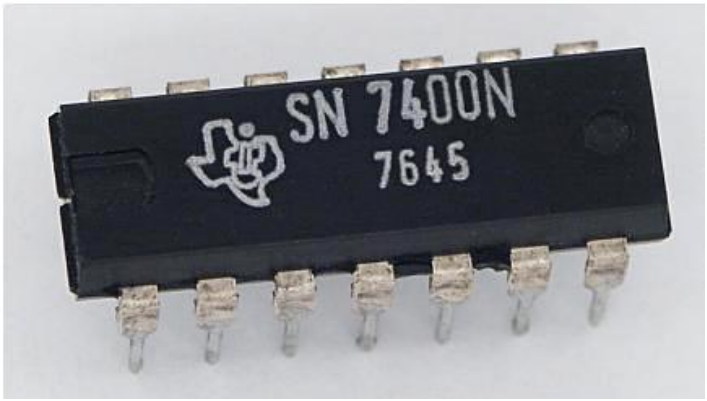
7400 Series Logic Implementation

- Transistor-Transistor-Logic (TTL) Chips
  - Small Scale Integration (SSI) < 12 gates/chip
  - Medium Scale Integration (MSI) 12 - 99 gates/chip
  - Large Scale Integration (LSI)
  - Very Large Scale Integration (VLSI)
- 7400 series – Low Power Schottky (LS)
  - A good compromise between speed and power
- Simple gate chips are 14- (or 16-pin) DIP package
  - V_{cc} (+5 volts) usually on pin 14 (or pin 16)
  - Ground (0 volts) usually on pin 7 (or 8)

7400 Series Logic Implementation

- Dual Inline Pins were a common packaging type for simple logic gates, e.g multiple NAND gates





Evolution of Logic Implementation

- However, as the number of pins grew on new more complex devices such as processors and motherboard chips, new form factors such as ball grid arrays were required

7400 Series Logic Implementation

- Logic Levels mapped to voltages in 2 ways:
- Normal Logic Signal (name w/o a bar or #)
  - Logic 0 is < 0.8 volt
  - Logic 1 is > 2.0 volt
- Inverted Logic Signal (name with a bar or #)
  - Logic 0 is > 2.0 volt
  - Logic 1 is < 0.8 volt

Evolution of Power Voltage

- Many newer logic chips are designed to work on 3.3 volt power supply instead of 5 volts
  - Zero represented by signal level <= 1.40 volts
  - One represented by signal level >= 1.55 volts
- Reduces power consumption and heat generation
- Allows more logic gates on a single chip than could be supported using 5 volts
- Better support for battery powered devices

Hardware Diagnostic Software

- Hardware can fail and software can be designed to detect hardware failures
- Types of hardware diagnostics
  - Factory / Manufacturing Test
  - Background Self Test
  - Power Up Self Test
  - On Demand Self Test

Factory / Manufacturing Test

- When a product development group creates a new product, they have to introduce it into manufacturing and manufacturing test groups
- Manufacturing needs parts lists, schematics, and assembly instructions to order production quantities of required parts and to develop their plans / program machines to manufacture it
- Manufacturing test needs a “golden unit”, i.e. a known good implementation of the product to develop their test plans and diagnostic software

Factory / Manufacturing Test

- They develop “test harnesses” and/or “test jigs” to automatically connect each manufactured copy of the product to diagnostic test equipment
- They stimulate the “golden unit” and capture its response to the stimuli in “test vectors”
- A test vector is a sequence of bits reflecting the state of the inputs and the corresponding outputs
- The manufacturing tests verify that the response from a “unit under test” matches the test vectors

Background Self Tests

- For embedded systems, it is important for the product software to perform self test(s)
- Background self tests provides an indication of a failure in a timely fashion:
  - User can revert to backup system
  - System can automatically switch to redundant HW
- Some limitation in coverage because the software must keep the product operating normally during the testing

Power Up / On-demand Self-Test

- Most interface devices have loop back capability
- Diagnostic code activates a loopback and sends test data to verify correct HW operation
  - Power up: Run every time the product reboots
  - On-demand: Run based on user command(s)
- Can have better coverage than background tests because normal product operation does not need to be maintained during the testing

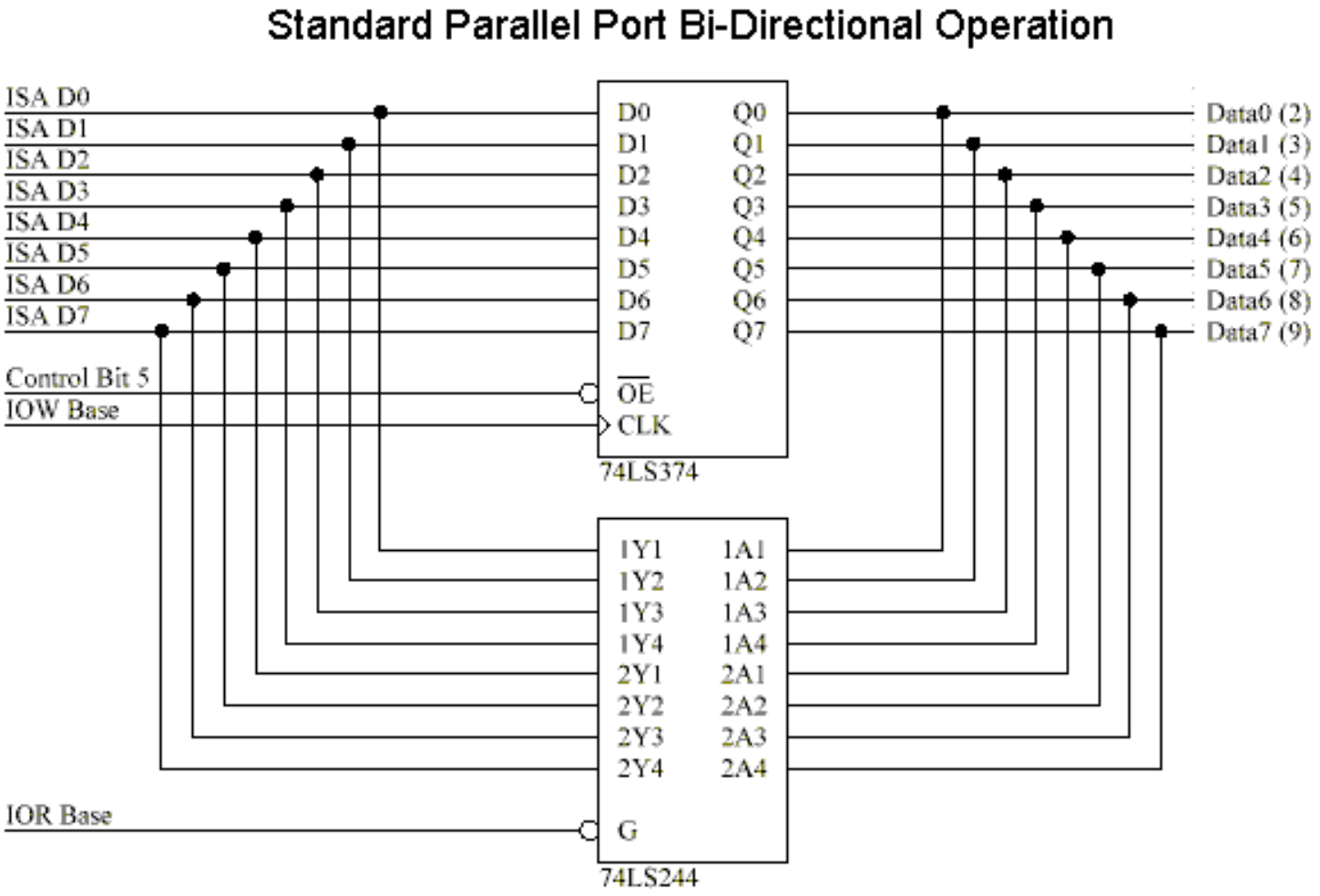
Introduction to MP4

- Your mp4 project will be to write and debug diagnostic tests for two interfaces
  - LPT1 Parallel Port
  - COM1 Serial Port
- Implemented in a PC-Tutor “test” command for “On-demand” self test
- Uses MP3 tickpack timer implementation

Parallel Port Implementation

- Two Registers
  - One write only register – holds output bit values
  - One read only register – senses input bit values
- Normally read register reflects write register
- Bi-directional Mode
  - LP_PDIR Bit turns off output register drivers
  - Writes to LP_DATA still get stored, but …
  - Reads from LP_DATA now sense external inputs

Parallel Port Implementation



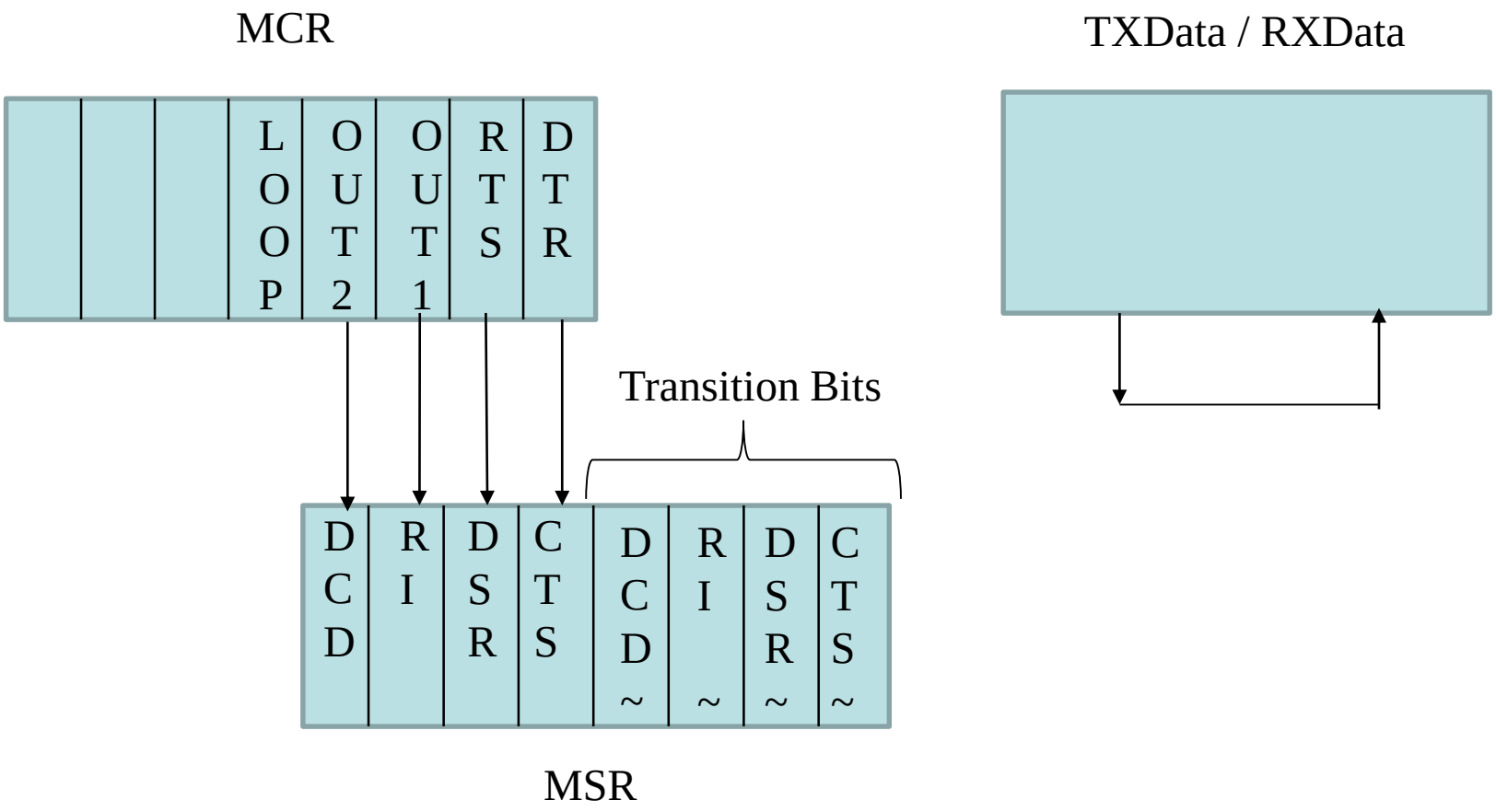
Sample Display for LPT1 Diagnostic

```
PC-tutor> test LPT1
Normal Read/Write mode
DATA: ff OK
DATA: 00 OK

Set in Bi-directional mode now
DATA: ff OK

PC-tutor>
```

Serial Port Implementation

- There is a loopback bit in the UART Modem Control Register (MCR)
  - Set to zero for normal operation
  - Set to one for loopback testing
- In Loopback mode, UART
  - Loops transmit data back to receive data
  - Loops four MCR outputs to MSR inputs
  - Transition bits reflect changes in MCR outputs

UART in Loopback



Sample Display for COM1 Diagnostic

```
PC-tutor> test COM1
Not in loopback.
Write 0x0f to MCR
MSR: 00 OK

In loopback now.
MCR: 1f OK
MSR: fb OK
MSR: f0 OK
MCR: 10 OK
MSR: 0f OK
MSR: 00 OK

Loop Test Data Passes.
Not in loopback now.
PC-tutor>
```

Sample Display for COM1 Diagnostic

```
PC-tutor> test COM1
Not in loopback.
Write 0x0f to MCR
MSR: 00 OK

In loopback now.
MCR: 1f OK
MSR: fb OK
MSR: f0 OK
MCR: 10 OK
MSR: 0f OK
MSR: 00 OK

Loop Data Timeout.          ← Test timer by running without loopback set up
Not in loopback now.
PC-tutor>
```