Embedded Applications

COMP595EA
Lecture 02
Hardware Fundamentals
Basic Terminology

- **Chip**: A semiconductor component designed to perform some function in a modular package.

- **Pins**: The metal conductors protruding from a chip to provide connections to power and other chips, components or other signals.

- **Datasheet**: Paper documentation describing a chip's function, usage, physical and environmental characteristics and tolerances (Basically, the manual) [ more EE information than CS ]
Terminology Continued

- **PCB:** *(Printed Circuit Board)* the flat board that is lined with copper conductors and is designed to support and connect the modular chips.

- **Vss,** 0 volts, ground, low, 0: The terms used to refer to a signal in the binary state zero.

- **Vcc,** 5volts, high, 1: The terms used to refer to a signal in the binary state one. *(CMOS technology operates on 3.3volts; TTL operates at 5volts typ.)*
about voltage interpretation

- Although ground is considered “0” and 5V is considered “1” these voltages are rarely present in these ideal values. Voltage is constantly fluctuating and the voltage present on a pin cannot possible change from 0V (ground) to 5V instantaneously.
  - 0-1V: considered “low” or “0”
  - 4-5V: considered “high” or “1” (CMOS 2.3-3.3V)
  - (or some other arbitrary value as documented by the manufacturer in the datasheet)
Assertions: a matter of convenience

- Most signals (pins) communicate binary data.
- Some signals are designed to inform a component of some external condition or event. Such as “Pressure exceeds critical value” or “Processor needs to service interrupt”.
- Signaling such a condition is known as “Assertion”.
- Some signals are considered “asserted” when they are held low (grounded) others are considered asserted when held high (Vcc).
Logic Gates

- Digital signals are combined and decisions and calculations are performed by logic gates.
- **AND**: output of the gate is high if both inputs are high.
- **OR**: output of the gate is high if any of the inputs are high.
- **NOT**: output is high when the input is low.
The Bubble

- Schematics use a symbol to denote inverting the logic level of a signal.
- This symbol appears as a small bubble.
- This would be a common method of denoting that the chip will be enabled when the CE line is asserted low. (Humans think of asserted as high)
Power

• Analog components are also used in digital circuits.

• Capacitors are commonly used.
  – Act like miniature rapid charge/discharge batteries.
  – Used to smooth out power signals
  – Used to effectively decouple chips and make them immune to the power fluctuations caused by other chips with high/ fluctuating power usage.
I/O

• Inputs: pins that are designed to receive data from an external source. Inputs do not drive a pin to either ground or Vcc.

• Outputs: pins that are designed to send data to an external part. To signal data the chip internally connects the pin to either ground (low) to signal a 0 or Vcc (high) (to signal a 1).

• Some pins are I/O pins and can operate in either mode. The mode is selected through software.
Bus Fights!

- If two outputs are electrically connected (as is the case in many interrupt lines or data buses) then the use of normal output pins can result in bus fights.

\[ E = I \times R \]
\[ 5 = I \times 0 \]
\[ I = \frac{5}{0} = \infty \text{Amps} = \text{fzzzt!} \]
Special Outputs

- Situations arise where it is desirable to share signals with multiple chips.
- To avoid bus fights two types of special outputs have been developed to allow sharing of a signal while avoiding bus fights.
  - Open Collector Outputs
  - Tri-State Outputs
Open Collector Outputs

- To tie devices together and share outputs a special output called an “Open Collector Output” is used.
  - Has two states: 0 (ground) or float (non-determined)
  - Basically: This output pin has no capability of supplying power to the pin and therefore cannot try to hold the line high while somebody else drives it low.
  - Cannot be used to signal a 1 without external glue logic such as a pull-up resistor.
Example: Open Collector Sharing

- Vcc, through a large value resistor keeps the signal held high.
- Any chip can override the resistor by connecting the signal to ground (the resistor limits the current that will flow to the grounded pin).

![Diagram of Open Collector Sharing]
Tri-State outputs

- Tri-State outputs are sort of binary but have a third state:
  - can be set to one of the states: Low, High or high-impedance
  - Caution must be exercised. Poor software programming can still lead to bus fights.
  - Careful programming makes such pins highly useful and flexible. Especially for data buses.
  - High-impedance = disconnected (basically)