

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.
- **V_{ss}, 0 volts, ground, low, 0:** The terms used to refer to a signal in the binary state zero.
- **V_{cc}, 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 possibly 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 (V_{cc}).

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 V_{cc} .
- 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 V_{cc} (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.



$$E=I \cdot R$$

$$5=I \cdot 0$$

$$I=5/0 = \infty \text{ Amps} = \text{fzzzt!}$$

Special Outputs

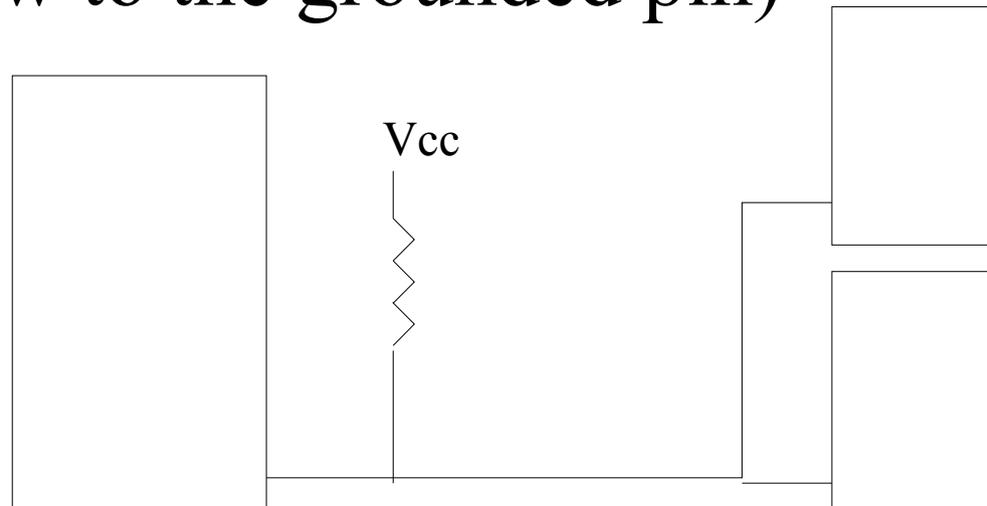
- Situations arise where it is desirable to share signals with multiple chips.
- To avoid bus fights two types of special outputs have been developed to allow sharing of a signal while avoiding bus fights.
 - Open Collector Outputs
 - Tri-State Outputs

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

- V_{cc} , 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)



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)