Electronics
Signal Conditioning

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- This kind of “bridging” function is doing what I call “signal conditioning”.

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2. *digital*; digital signal in, digital signal out
3. *either*; either kind of signal in; same type out
4. *interface*; involves both analog and digital signals in some way

Analog Signal Conditioning

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- *amplification* or *attenuation*

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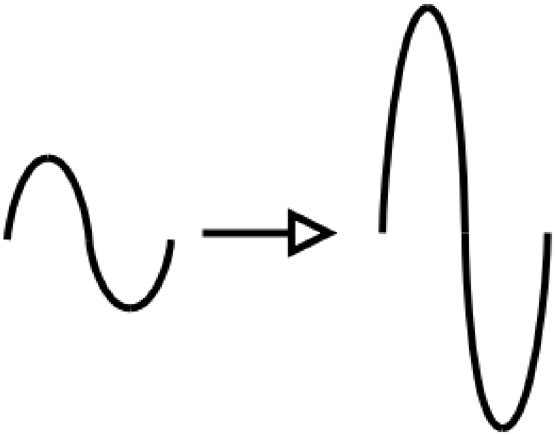
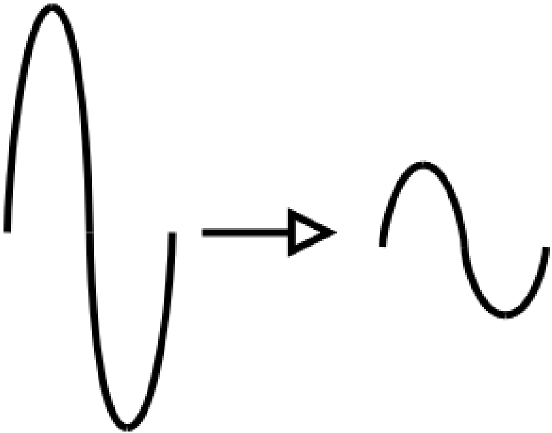
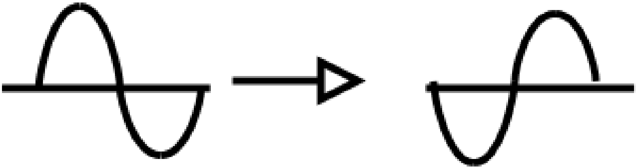
- *clipping*
- *clamping*



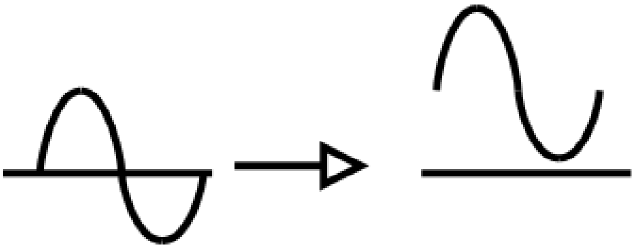
Amplification



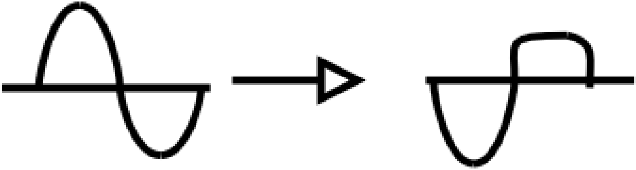
Attenuation



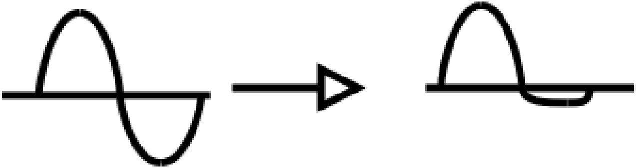
Inversion



Level shifting



Clipping



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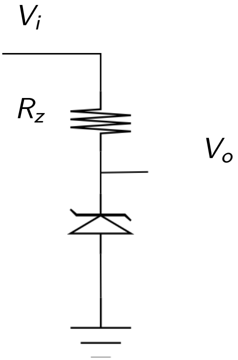
V_i
R_z
V_o

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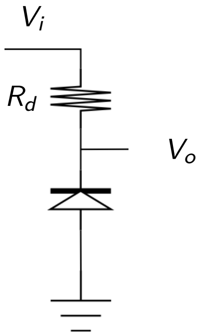
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These two cases will now be discussed.

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- A **Schmitt trigger** is a gate which uses *hysteresis* to remove noise from a signal.
- This is in contrast to an ordinary gate, where the output changes state as the input passes some unknown voltage between the manufacturer's specified $V_{il_{max}}$ and $V_{ih_{min}}$.

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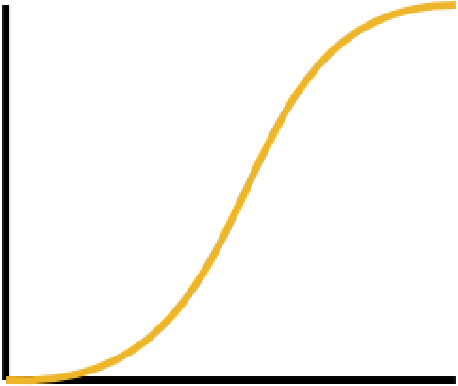
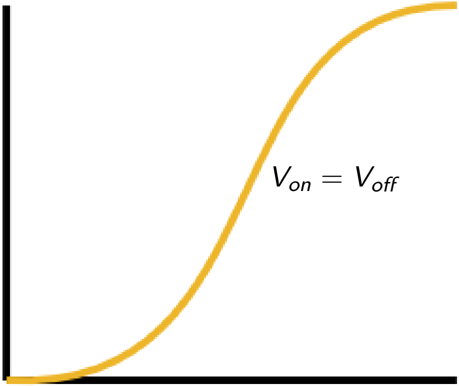
  (For a normal gate, is it as though V_{on} and V_{off} are the same.)



Normal TTL transfer characteristic



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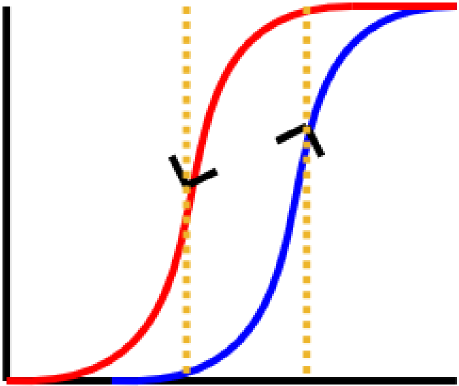

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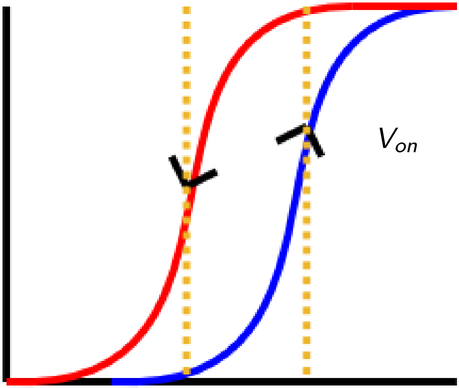

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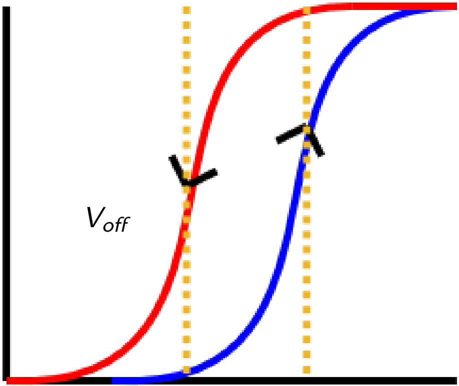

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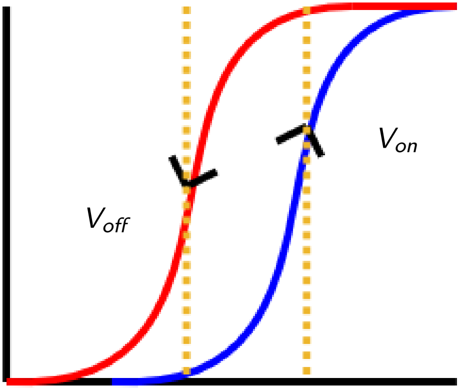

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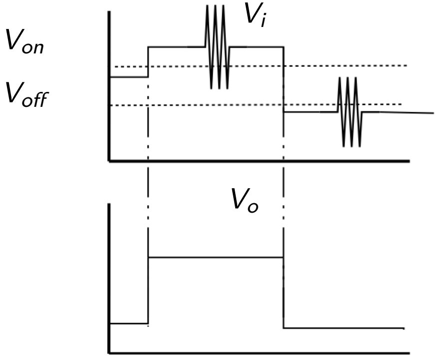
V_{on}
V_{off}
V_i
V_o

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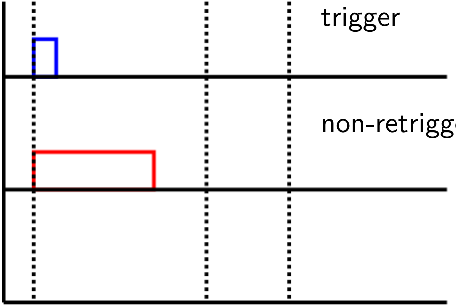
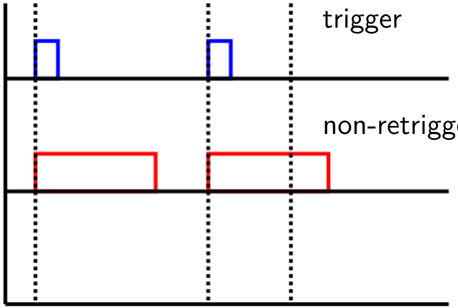

trigger
non-retriggerable output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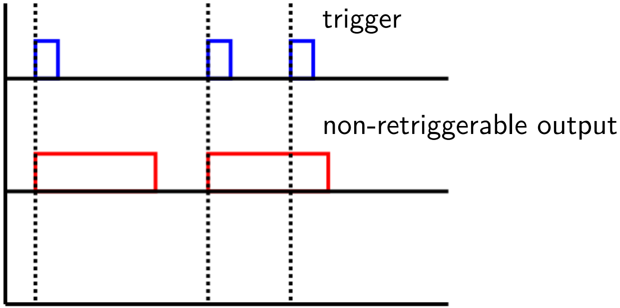
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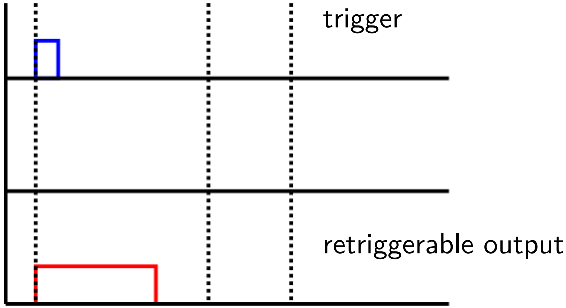
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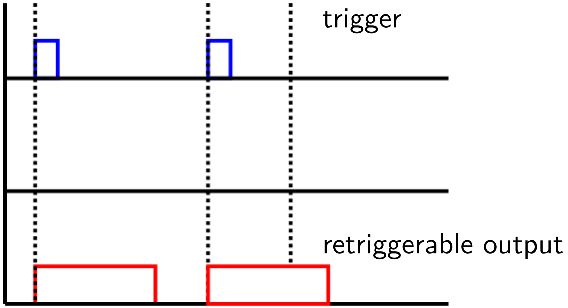
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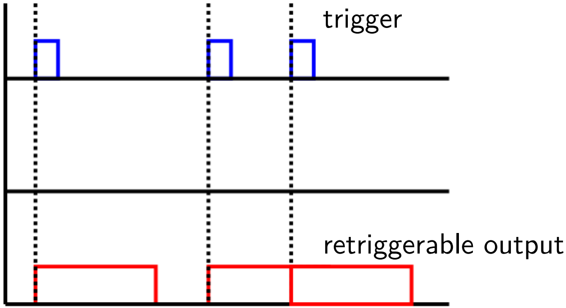
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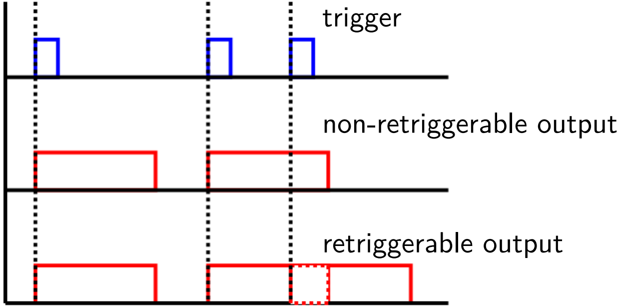
trigger
non-retriggerable output
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- In other words, the output pulse is always the same length.

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  (For instance, inside a car engine, the ignition system produces sparks of thousands of volts, while the electronics runs on normal logic levels.

  The spark plug voltages could not be directly sensed by the microprocessor. At least more than once.....)

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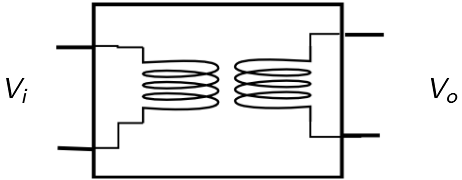
- the above two conditions mean that care must be taken as voltage spikes at the *input* end can be transmitted to the *input* end and vice versa

Keep in mind that different numbers of windings in the two coils allow the input signal to be increased or decreased while any DC offset is removed.


V_i
V_o

Optical isolation using an LED and a phototransistor or photodiode

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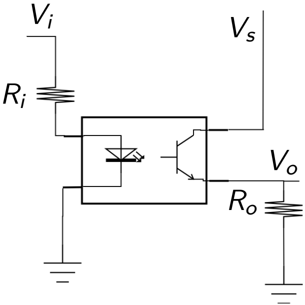
- The amount of DC isolation provided by an optoisolator is usually in the range of kV.
- At some point the insulation will break down and arcs can occur.


V_i
V_s
R_i
V_o
R_o

Whenever sensors are in a place where it is *possible* for high voltages to be induced, optical isolation should be used to protect electronic devices which follow.

Analog Comparators

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- This device is basically an operational amplifier with a digital output, so that the output indicates which of the inputs is higher.

Analog Switches and Multiplexers

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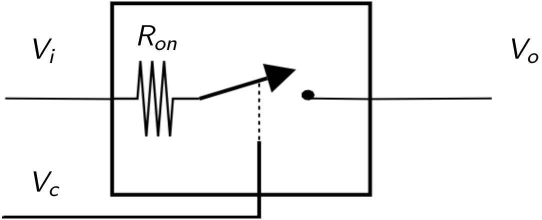
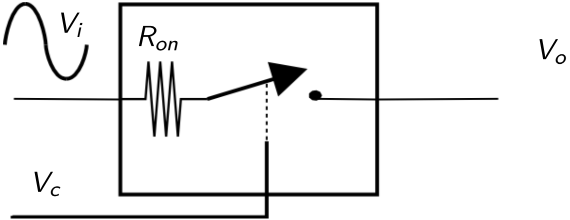
An **analog switch** works just like a mechanical switch in allowing an analog signal to flow between two points in a circuit when it is closed, and preventing the flow when it is open. The difference with an analog switch is that the control of the opening and closing of the switch is provided by a digital signal. Like mechanical switches, there are a variety of switch types, such as SPST, SPDT, DPDT, and so on. The resistor R_{on} is to indicate a finite resistance between the input and output when the switch is closed. The value of R_{on} should be in the device specifications.


V_i
R_{on}
V_o
V_c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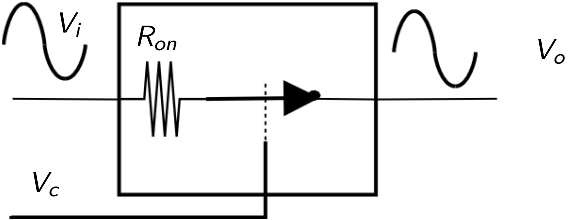
V_i
R_{on}
V_o
V_c

An **analog multiplexer** is similar to a digital multiplexer in that a set of digital signals controls which *analog* signal is passed through to the output. Since the internal construction is similar to that of an analog switch, there is an on resistance as before.

Current Amplification

Current Amplification

Operational amplifiers make good *voltage* amplifiers, but usually their current output is very limited. *Current amplification* is a job more suited to transistors.

Basic BJT Operation

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The BJT operates as a current amplifier. In the common emitter configuration, controlling the current to the base results in change to the collector current. Since

$$\beta = \frac{I_c}{I_b} \approx 100 \rightarrow 500$$

then a substantial increase in current is possible. A few choices of how to do this in a circuit follow. (NPN transistors will be assumed. It's easy to change to PNP after you understand the principles.)

Darlington Transistors

Darlington Transistors

If a very great current gain is desired, ie. up to $\approx 1000\times$, a **Darlington** configuration may be used. This has the emitter of one transistor fed directly into the base of another, with the collectors in common. In this way the two β values get multiplied, so a much greater gain is possible. *Darlington transistors* are devices which are connected this way internally, so they look like an ordinary transistor from the outside.

Grounded Load

Grounded Load

In this configuration, the load , shown as a resistance R_l, is placed between the emitter of the transistor and ground. It is often useful to have one end of the load grounded. For a transistor to be "on", the base–emitter junction must be forward biased so

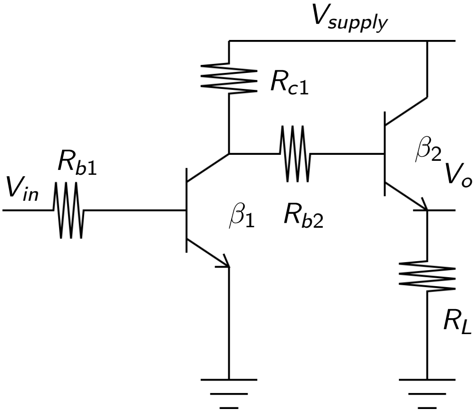
$$V_{be} \geq 0.7V$$

This means that the base of the transistor must be able to go *above* the highest load voltage desired.

Floating Load

Floating Load

If the base voltage cannot easily be raised above the desired load voltage, it is possible to place the load between the *collector* of the transistor and the supply voltage, and then ground the emitter of the transistor.


V_{supply}
R_{c1}
R_{b1}
V_{in}
β_1
R_{b2}
β_2
V_o
R_L