

Electronics Signal Conditioning

Terry Sturtevant

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

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- ③ *either*; either kind of signal in; same type out

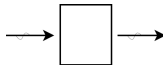
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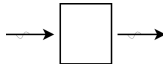
- ① *analog*; analog signal in, analog signal out
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- ③ *either*; either kind of signal in; same type out
- ④ *interface*; involves both analog and digital signals in some way

Analog Signal Conditioning

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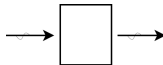
- *amplification or attenuation*

Analog Signal Conditioning



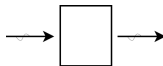
- *amplification* or *attenuation*
- *level shifting*

Analog Signal Conditioning



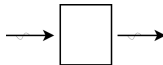
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Analog Signal Conditioning



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- *filtering*
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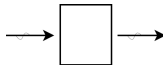
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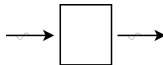
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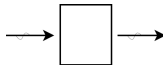


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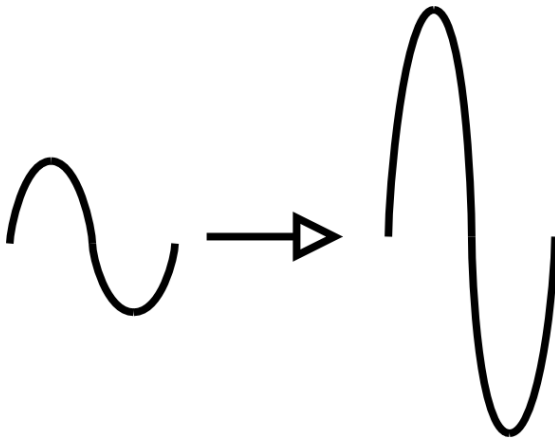
Analog Signal Conditioning



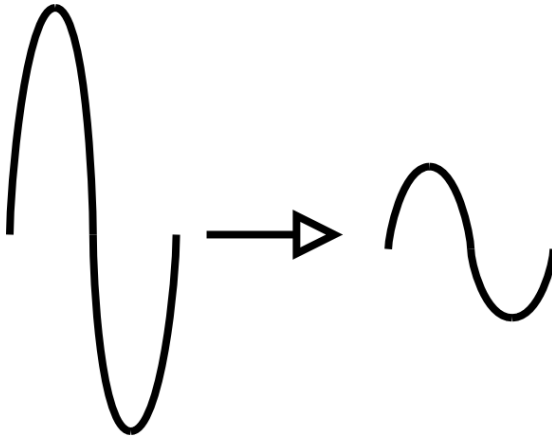
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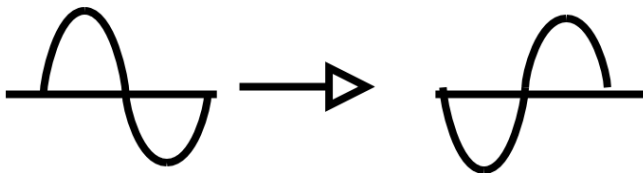
- *clipping*
- *clamping*



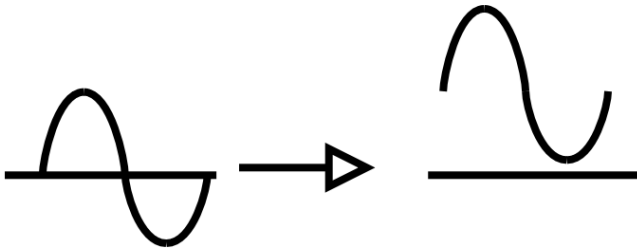
Amplification



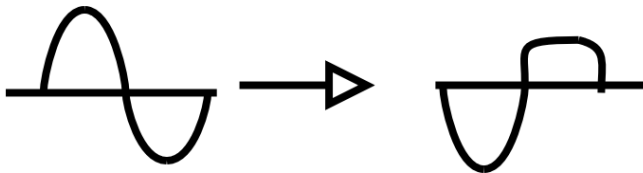
Attenuation



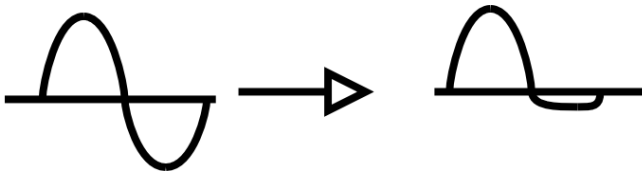
Inversion



Level shifting



Clipping



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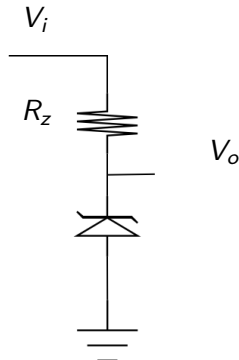
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This can be done using a Zener diode.



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Clamping

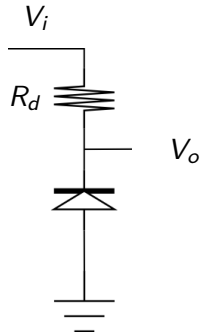
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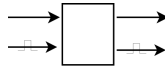
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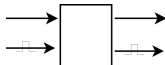
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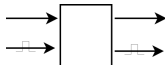


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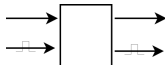
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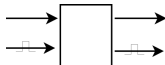
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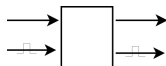
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These two cases will now be discussed.

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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 $V_{ih_{min}}$.

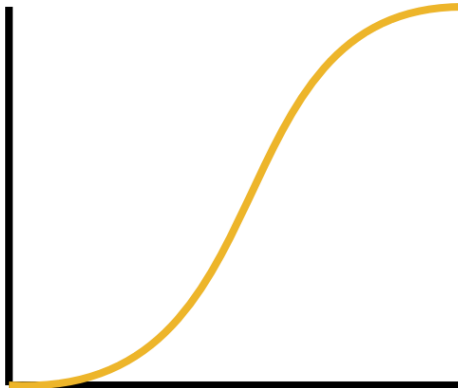
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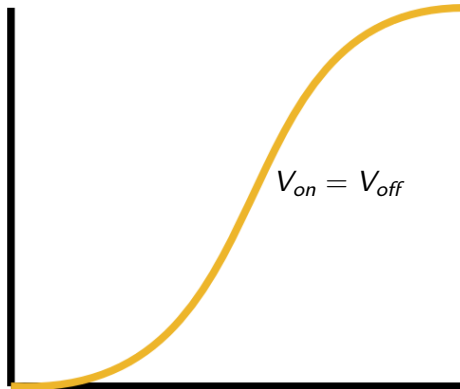
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- The farther apart V_{on} and V_{off} are, the more *noise immunity* is provided.

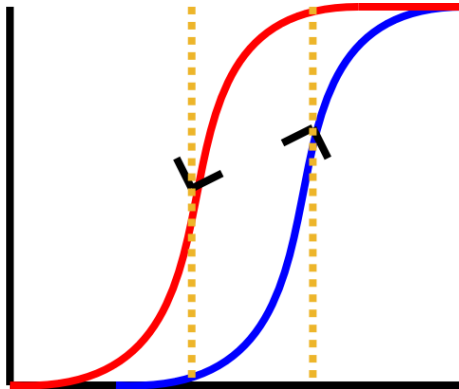
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(For a normal gate, is it as though V_{on} and V_{off} are the same.)



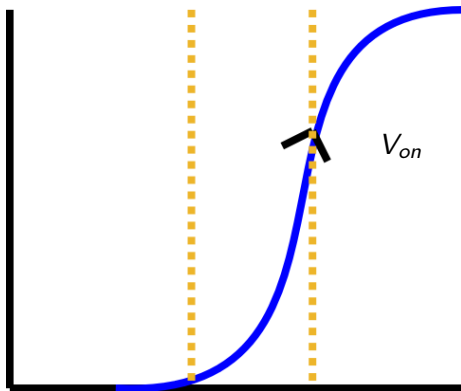
Normal TTL transfer characteristic



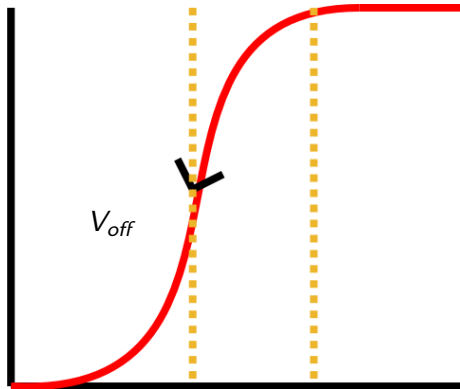
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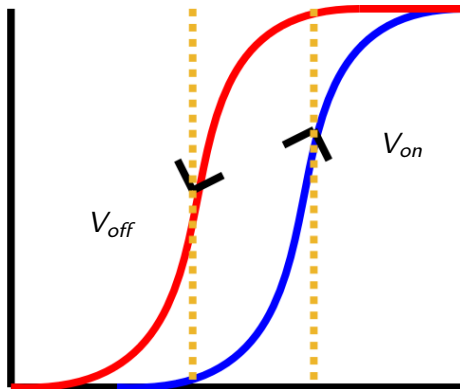
Schmitt trigger transfer characteristic; (i.e. with hysteresis)



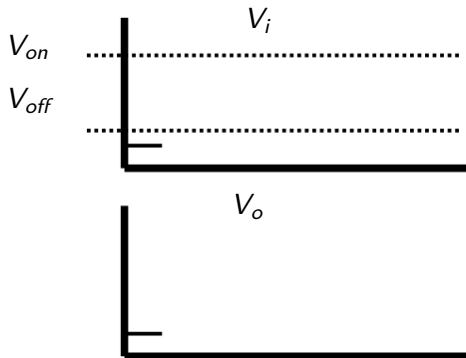
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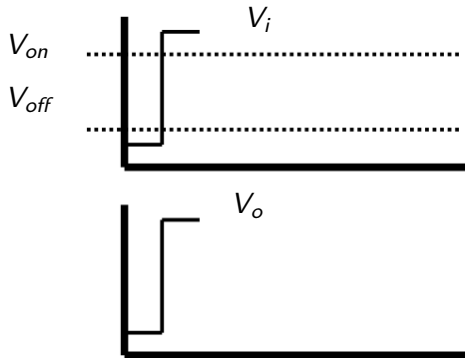
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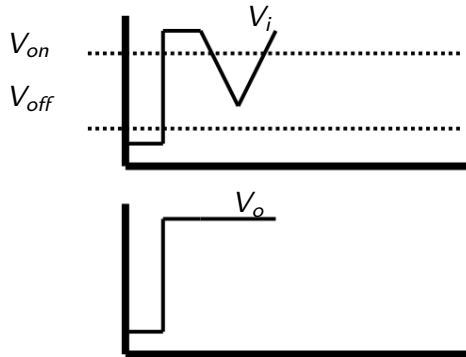
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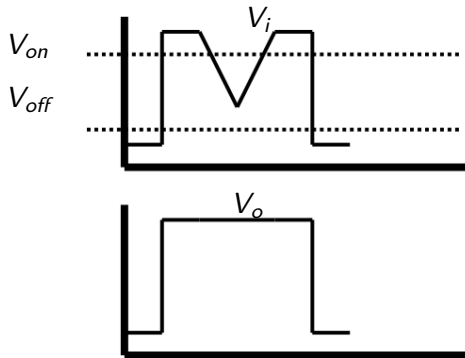
V_i and V_o both LOW



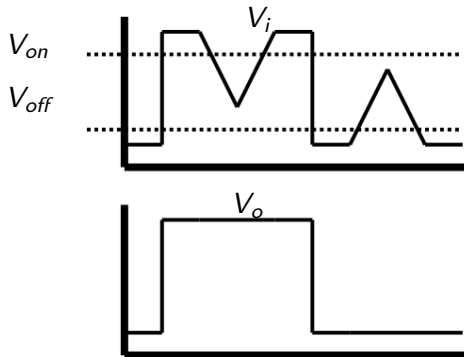
V_i goes above V_{on} , so V_o goes HIGH



V_i doesn't go below V_{off} , so V_o stays HIGH



V_i goes below V_{off} , so V_o goes LOW

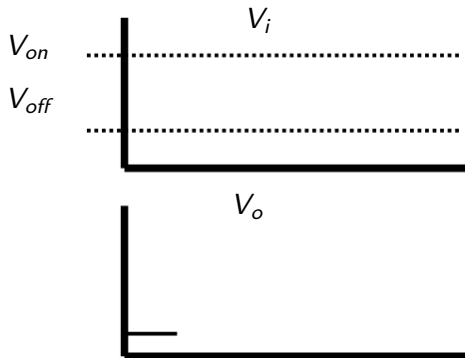


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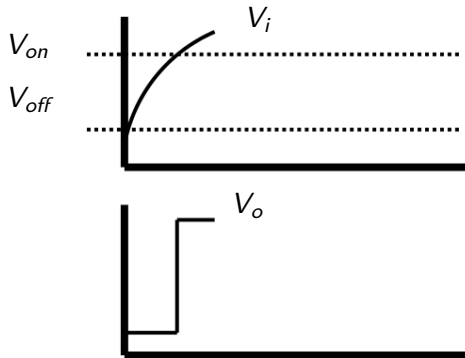
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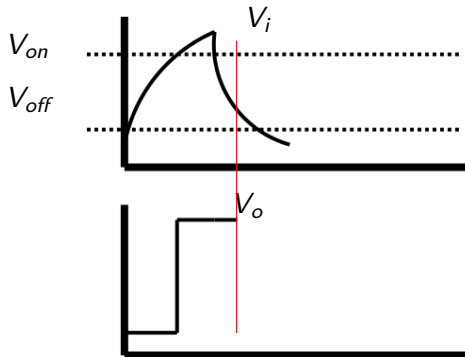
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- If this is a problem for subsequent circuitry, then a Schmitt trigger can restore sharp edges.



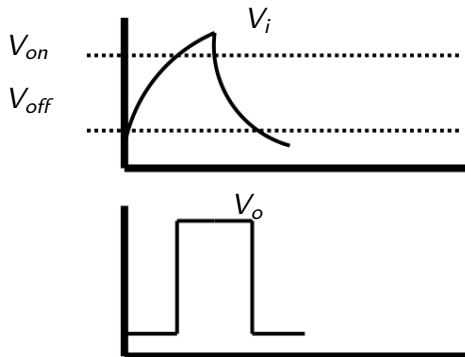
V_o LOW



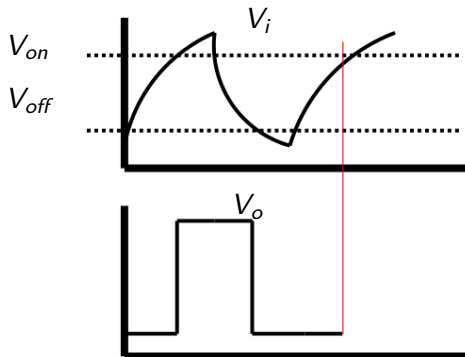
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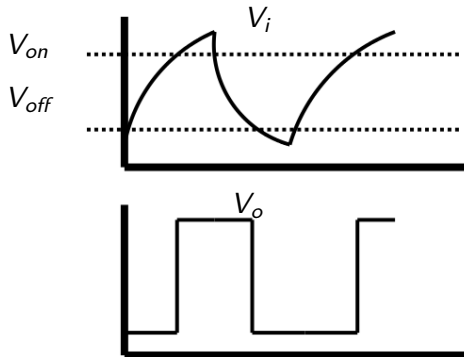
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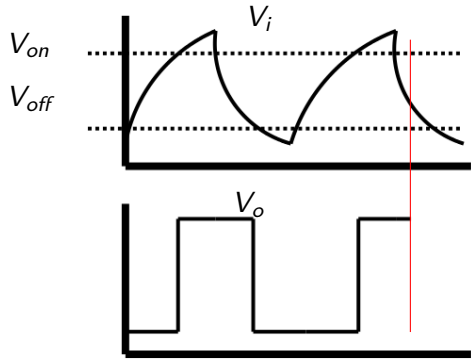
V_i goes below V_{off} , so V_o goes LOW



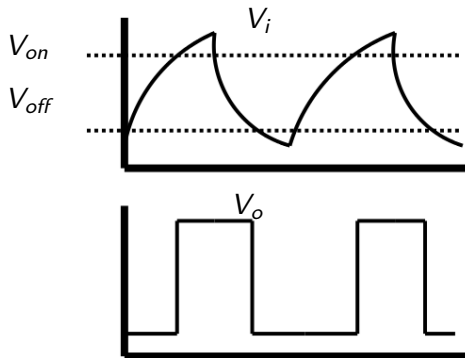
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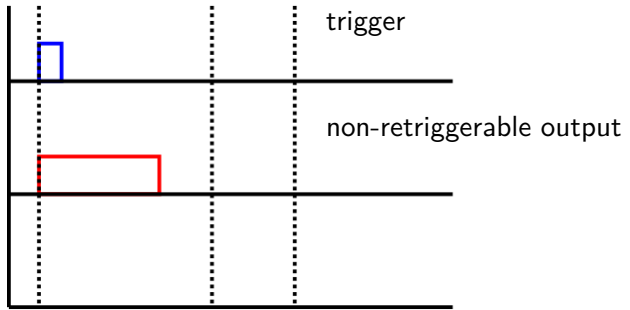
- *retriggerable*

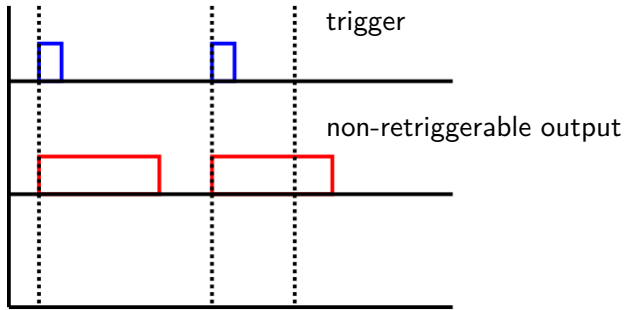
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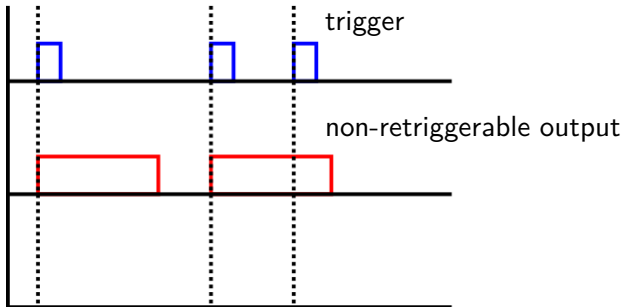
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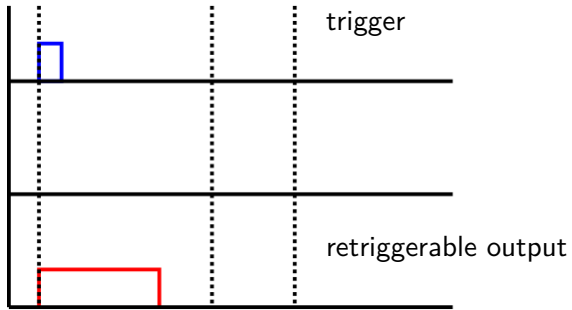
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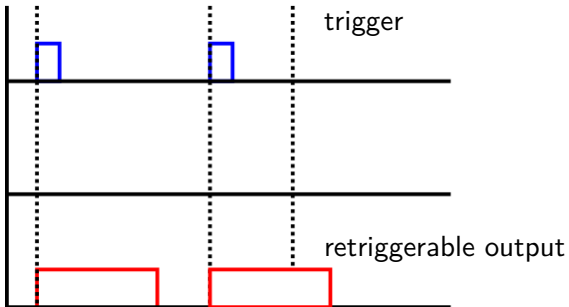
- *retriggerable*
- *non-retriggerable*

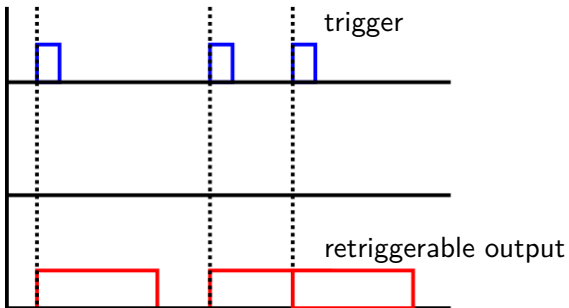


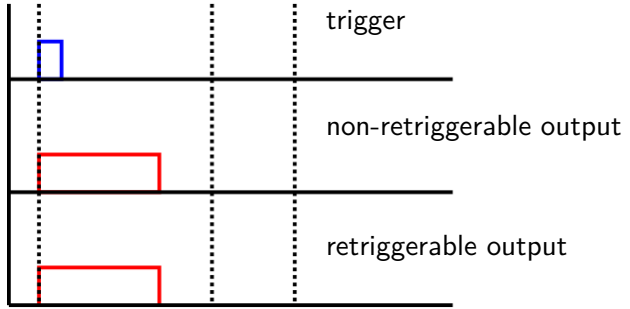


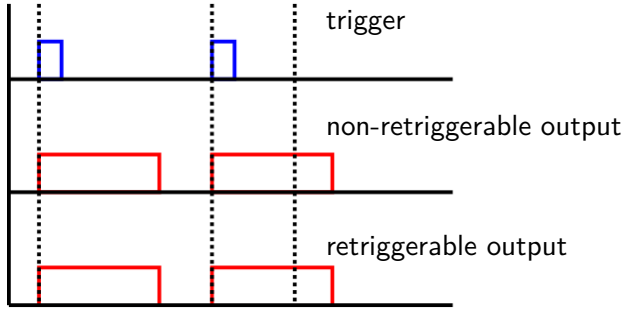


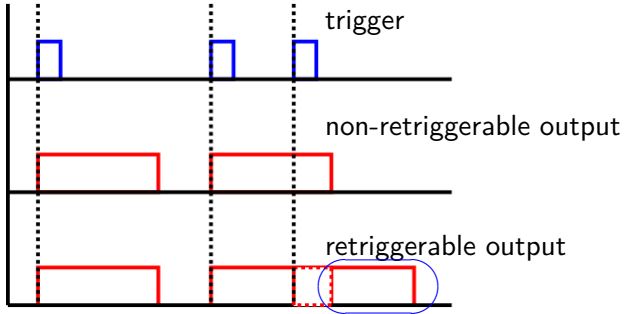












The situation which differentiates retriggerable and non-retriggerable

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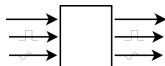
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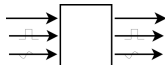
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- With a non-retriggerable one shot, any trigger pulses occurring while the output is active, (i.e. during a pulse created by a previous trigger pulse), will be ignored.
- In other words, the output pulse is always the same length.

Either

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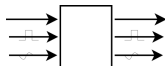


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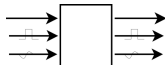
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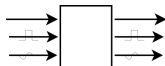
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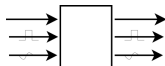
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The spark plug voltages could not be directly sensed by the microprocessor. At least more than once.....)

Inductive isolation using a transformer

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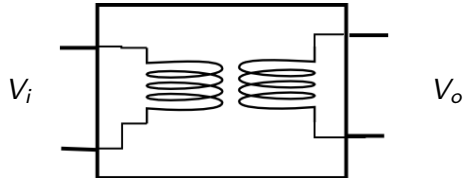
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- the above two conditions mean that care must be taken as voltage spikes at the *input* end can be transmitted to the *input* end and vice versa

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.



Optical isolation using an LED and a phototransistor or photodiode

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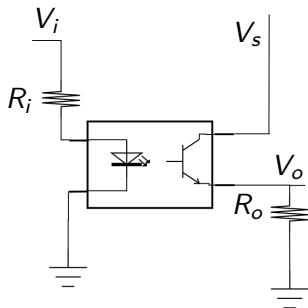
- can transmit DC (i.e. steady-state values)
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- cannot transmit power
- the above two conditions mean that there is no danger of voltage spikes as there is with inductive isolation

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- The values chosen for the resistors should be consistent with the current specifications for the device.
- 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.



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

Analog Comparators



Analog Comparators



- Two analog voltages can be compared with an analog **comparator**.

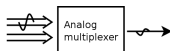
Analog Comparators



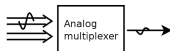
- Two analog voltages can be compared with an analog **comparator**.
- This device is basically an operational amplifier with a digital output, so that the output indicates which of the inputs is higher.

Analog Switches and Multiplexers

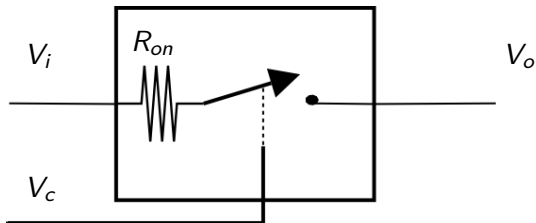
Analog Switches and Multiplexers

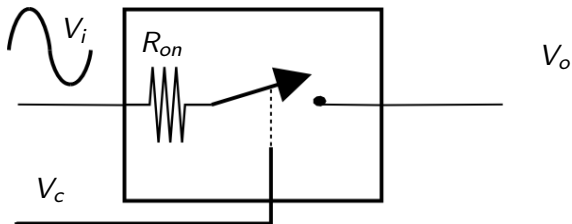


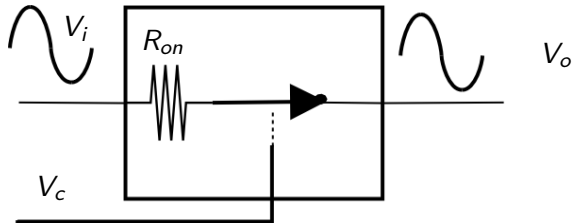
Analog Switches and Multiplexers



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.







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

Basic BJT Operation

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, i.e. 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.

