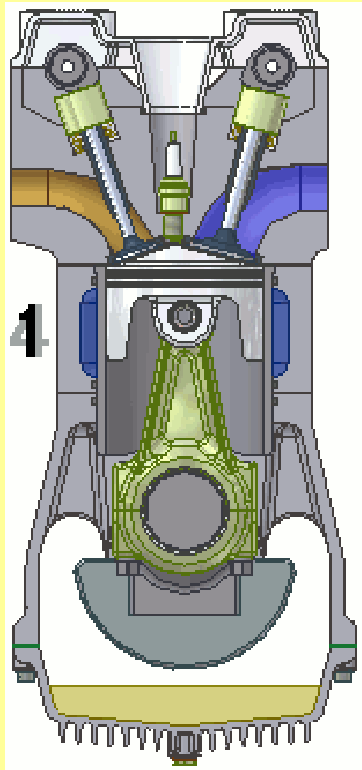
Automotive Electronics



[pl.wikipedia.org]

Sensors

A large number of sensors are installed in vehicles.

Acting as perception elements, the sensors have the task of converting a physical or chemical variable- e.g. pressure, temperature, distance, gas, speed - into an electrical variable (output signal).

Motor vehicle sensors must meet the following requirements:

-high degree of reliability,

-not too expensive,

-remain fully functional even under extreme operating,

-high degree of accuracy.

Sensors

Types of sensors:

-MAP Sensors,

-Tire Pressure Monitoring Sensors,

-Throttle Position Sensors,

-Camshaft and Crankshaft Position Sensors,

-Accelerator Pedal Sensors,

-Air Temperature Sensors,

-Coolant Temperature Sensors,

Sensors

-Knock Sensors,

-Vehicle Speed Sensors,

-Oxygen Sensors,

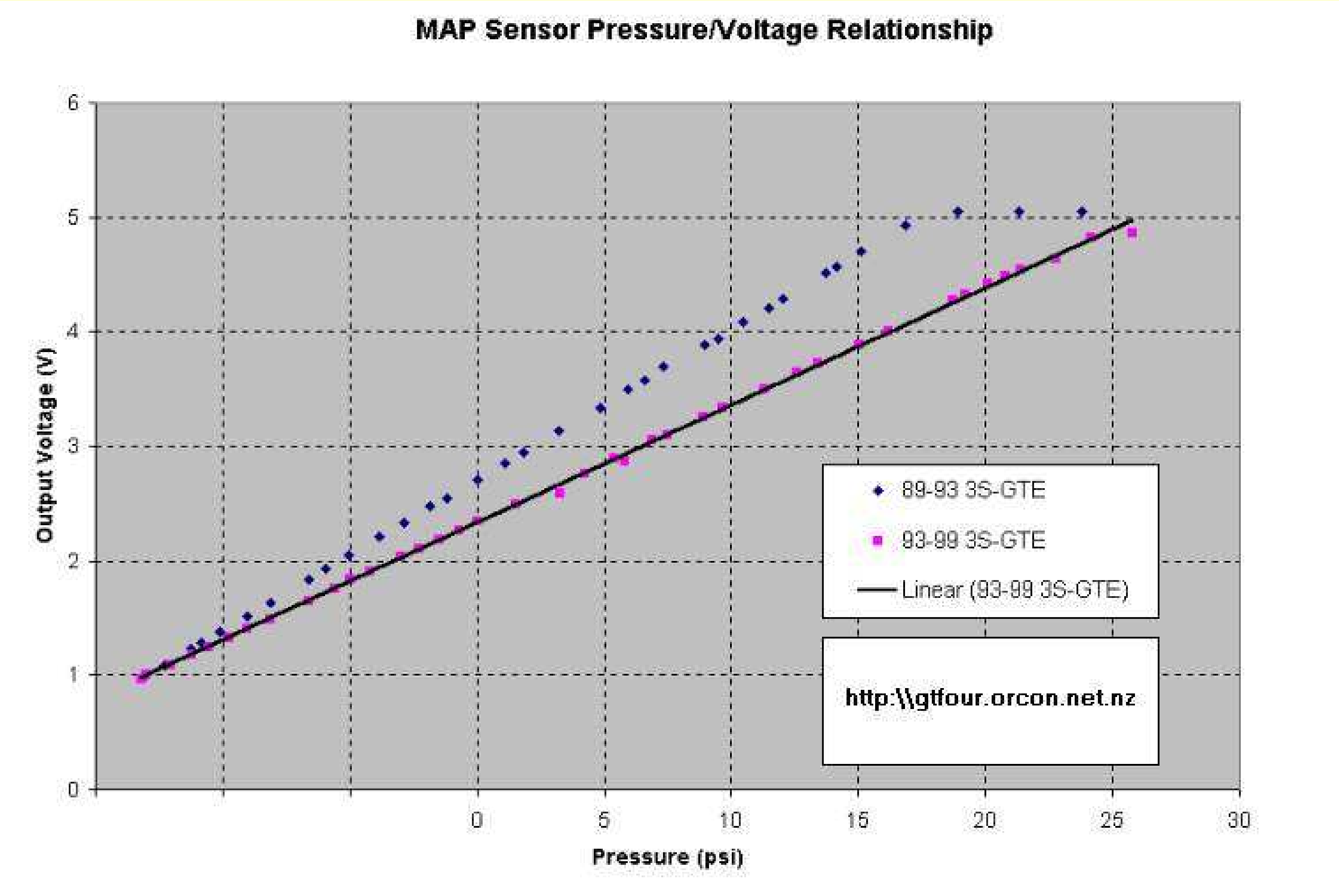
-ABS Sensors,

MAP- Manifold Absolute Pressure, Sensors

The MAP sensor converts engine vacuum/manifold pressure to an electrical signal so the computer knows how much load the engine is under.

[www.samochodowka.internetdsl.pl]

Sensors



psi- pounds per square inch

[http://gtfour.supras.org.nz/mapsensor.htm]

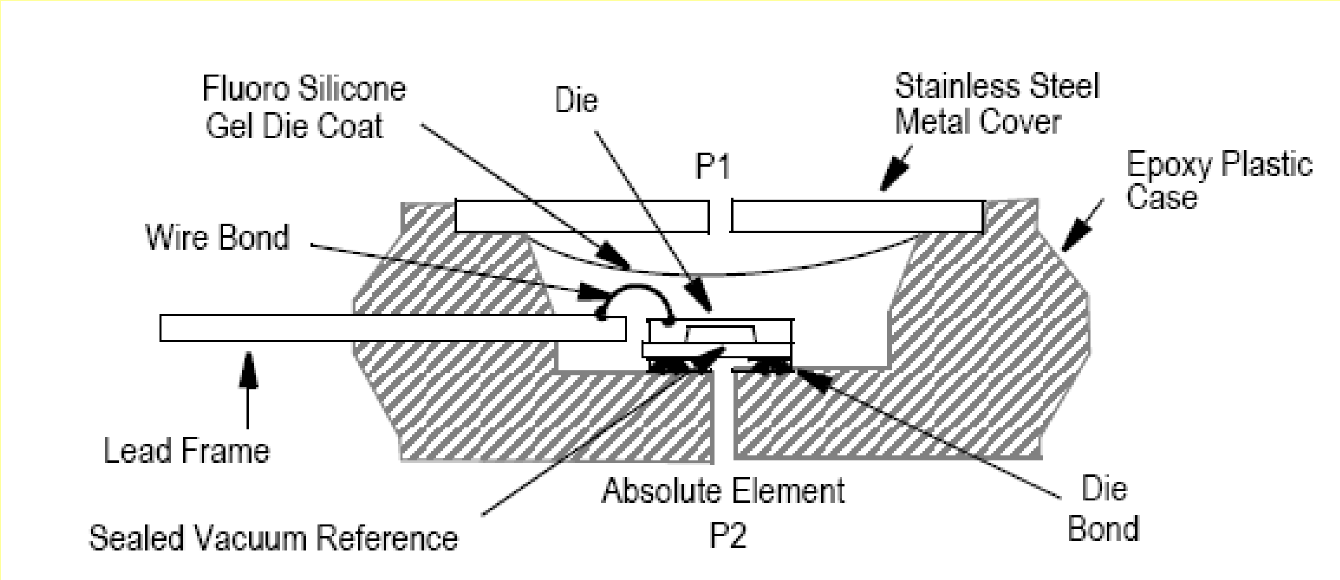
Barometric Pressure (BARO) Sensors

The Air Charge/Manifold Temperature sensor is used by the computer to measure air density for fuel mixture control.

[http://mybaycarparts.com/]

Sensors

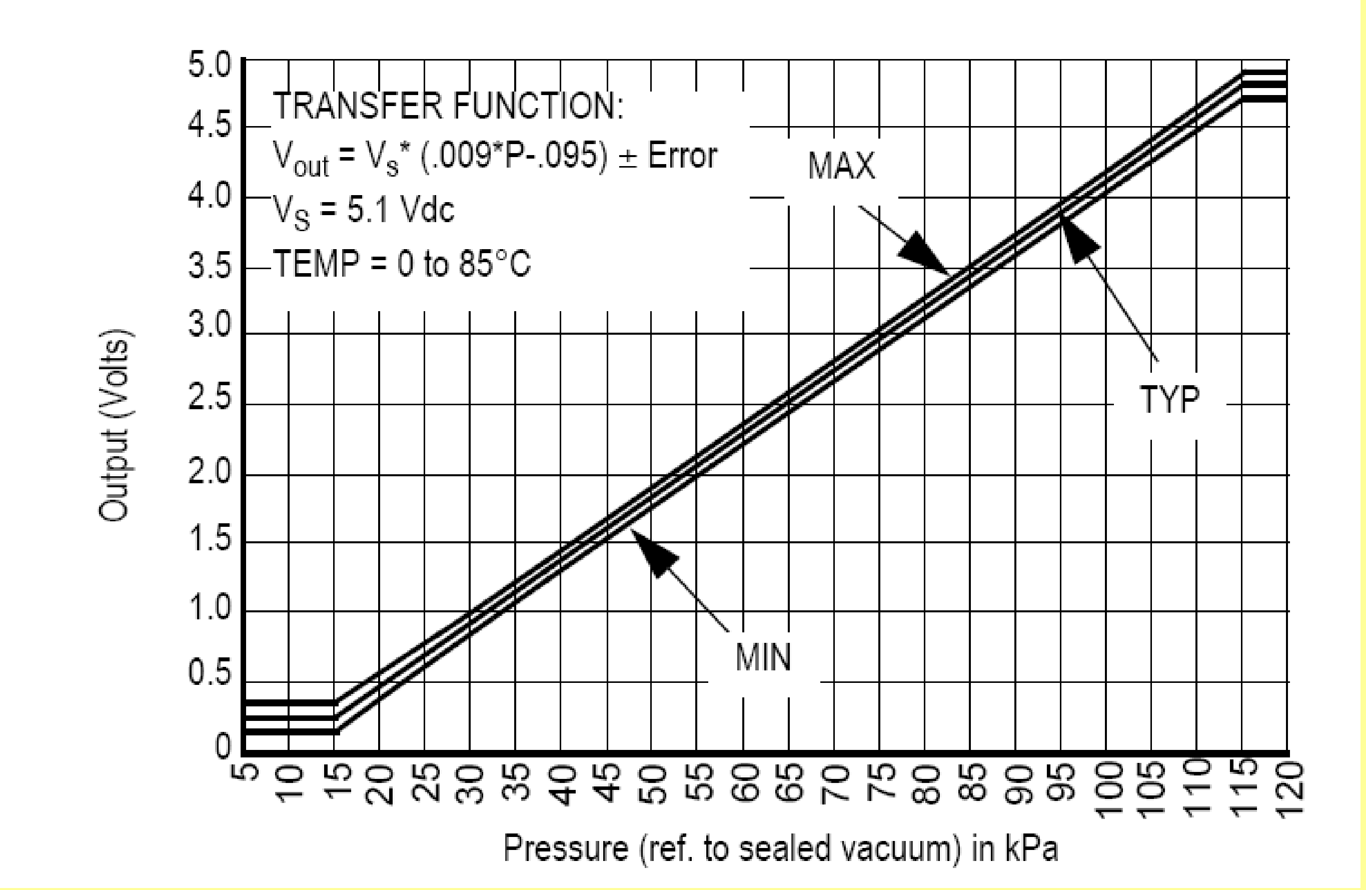
MPX4115 Freesclae



Cross-Sectional Diagram

[www.freescale.com/]

Sensors



Output versus Absolute Pressure

[www.freescale.com/]

Sensors

Tire Pressure Monitoring System Sensors

A Tire Pressure Monitoring System is a safety device that measures, identifies and warns the driver when one or more tires is significantly under-inflated.

[http://www.wjjeeps.com/]

Camshaft and Crankshaft Position Sensors

The Camshaft sensor determines which cylinder is firing to establish injector synchronization and coil firing sequence in DIS systems.

[www. http://www.pc-oscilloscopes.com/]

Sensors

Crankshaft sensors set ignition timing, supply the RPM signal and determine engine speed.

[http://www.mpatv.com/]

Sensors

Two types of Camshaft and Crankshaft Position Sensors

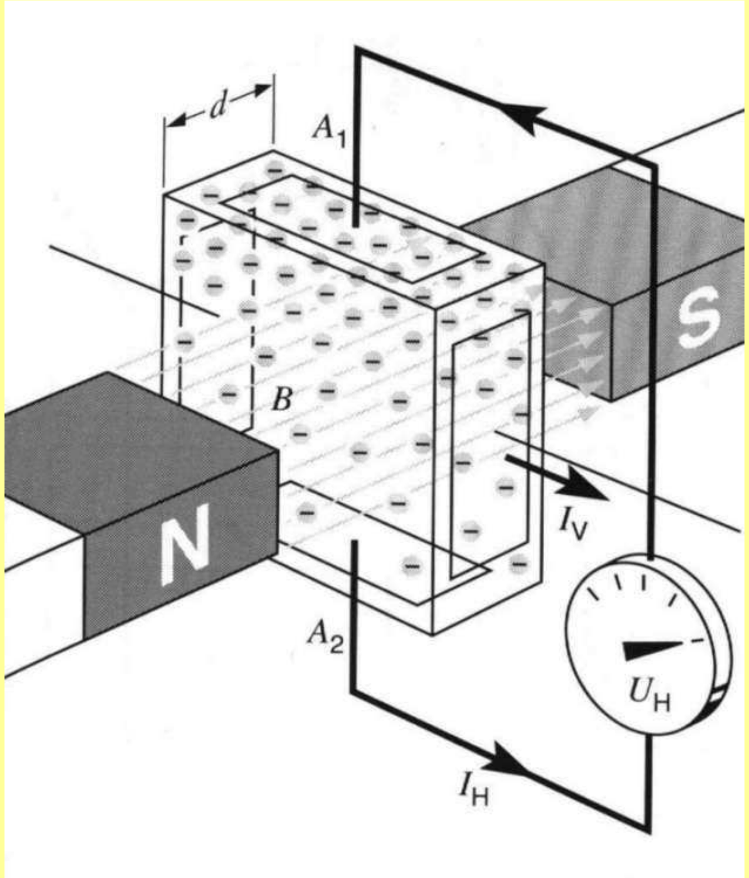
Hall Sensors

Hall sensors make use of the Hall effect. When a magnetic field acts on a current carrying semiconductor, an electrical voltage (Hall voltage) will be produced at its end faces. If the current strength through the semiconductor remains constant, the strength of the generated voltage will only depend on the strength of the magnetic field.

Inductive Sensors

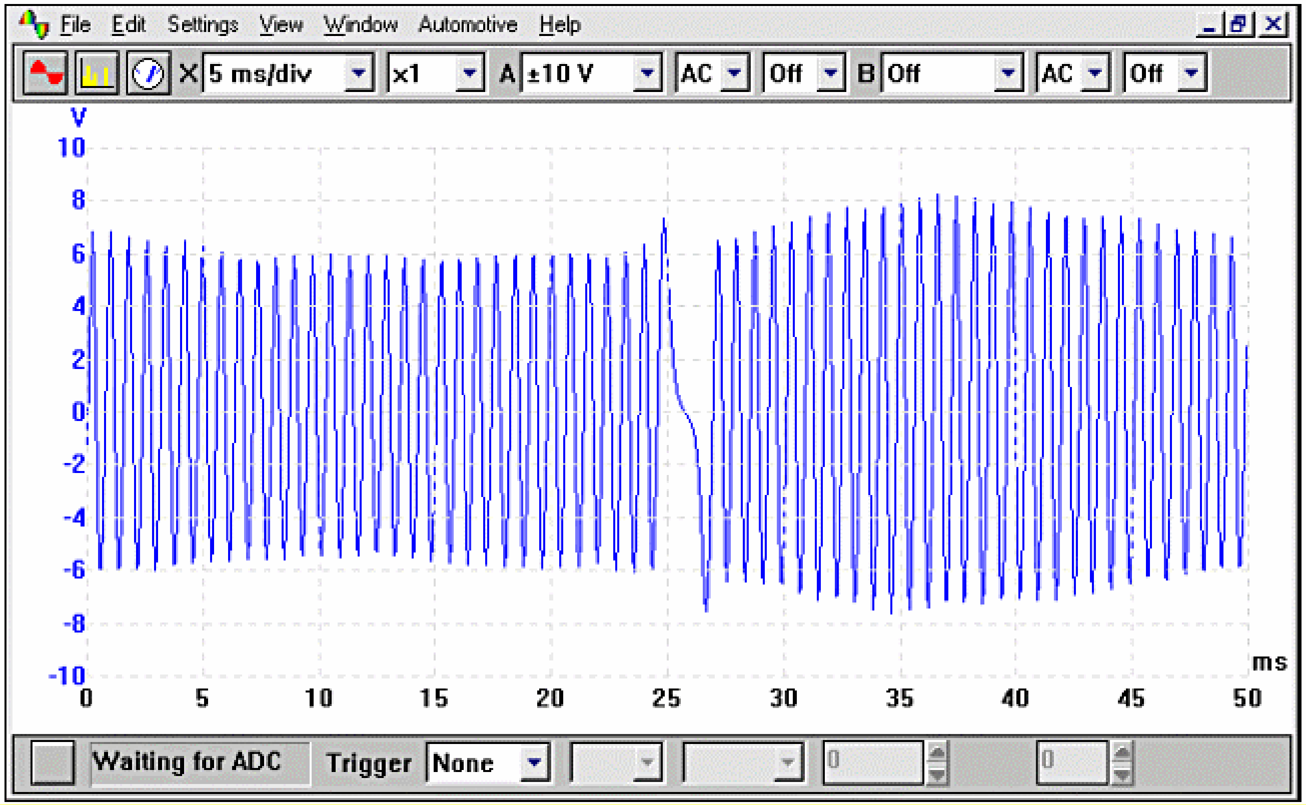
A coils.

Sensors



Hall Effect

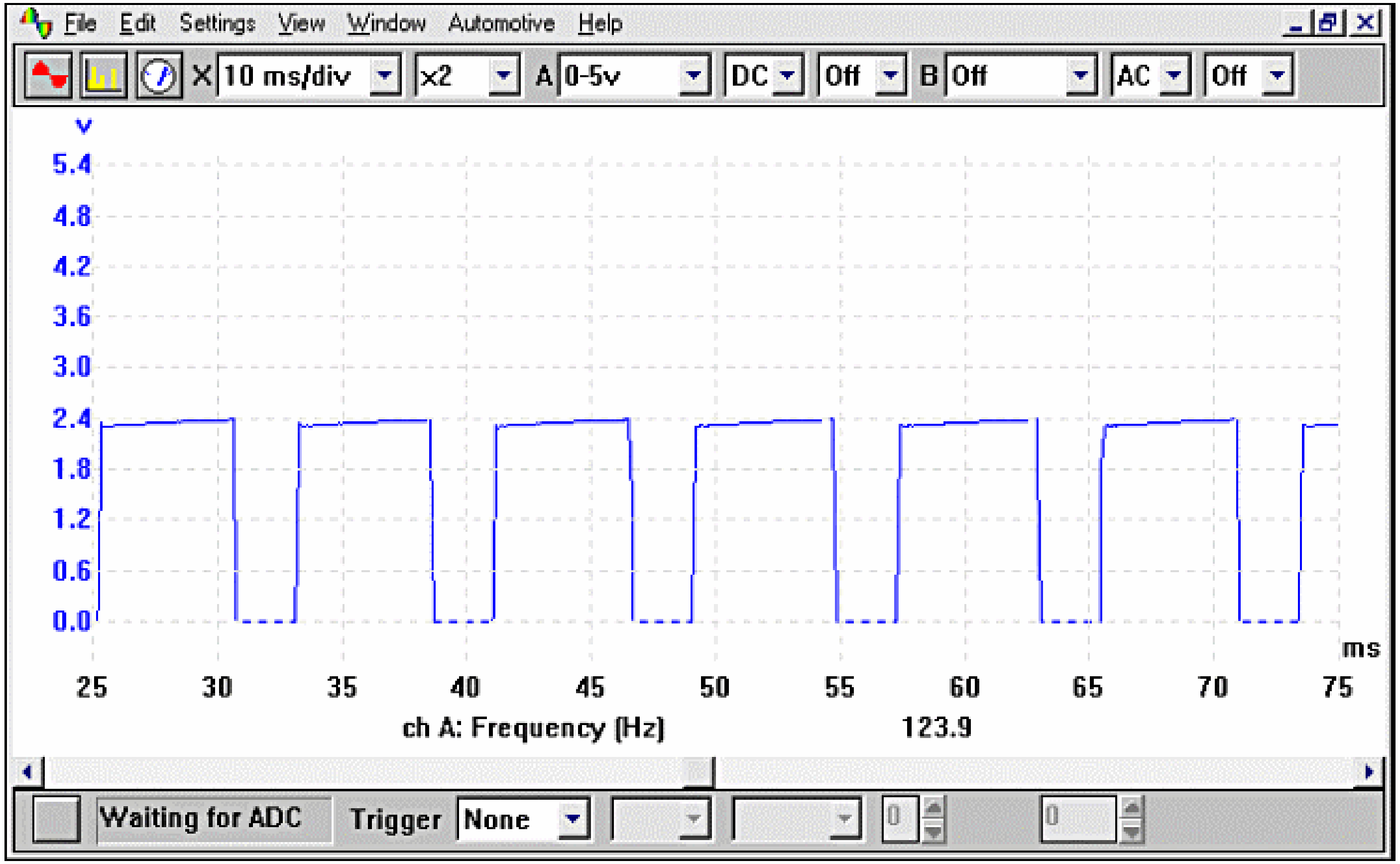
Sensors



Camshaft inductive sensor output signal

[http://www.picoauto.com/tutorials/trigger-signals.html]

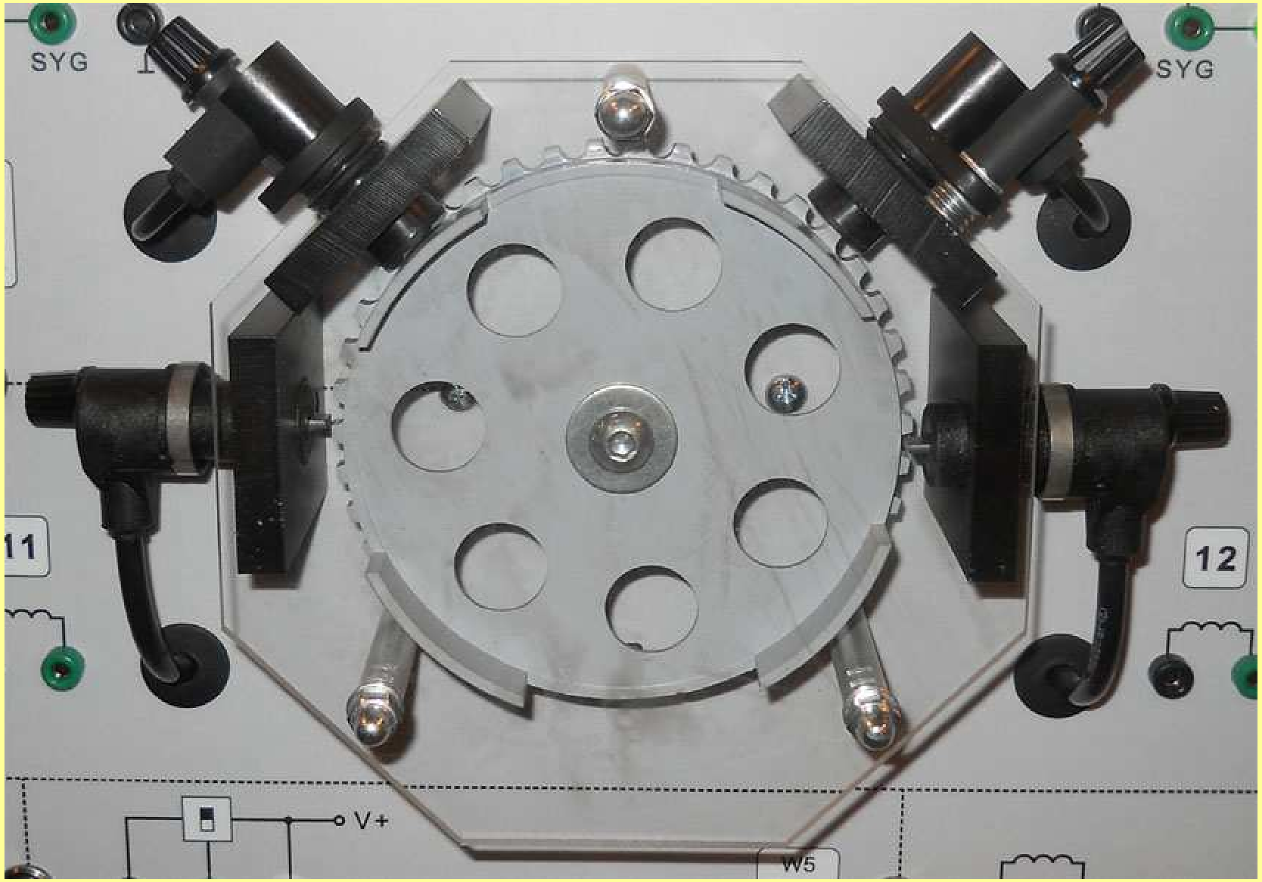
Sensors



Crankshaft hall-efect sensor outppout signal

[http://www.picoauto.com/tutorials/trigger-signals.html]

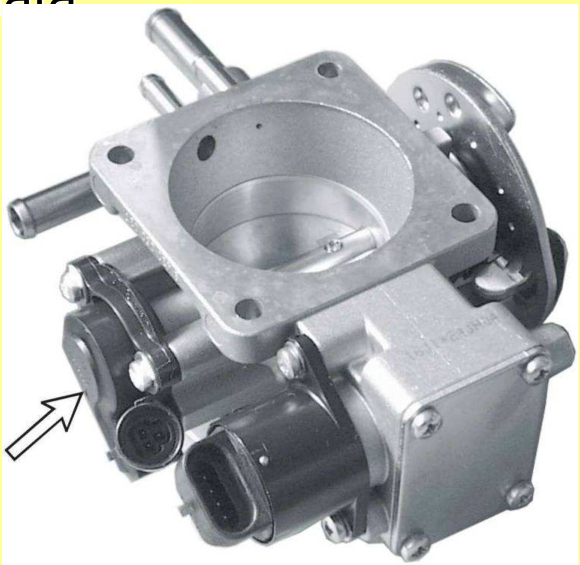
Sensors

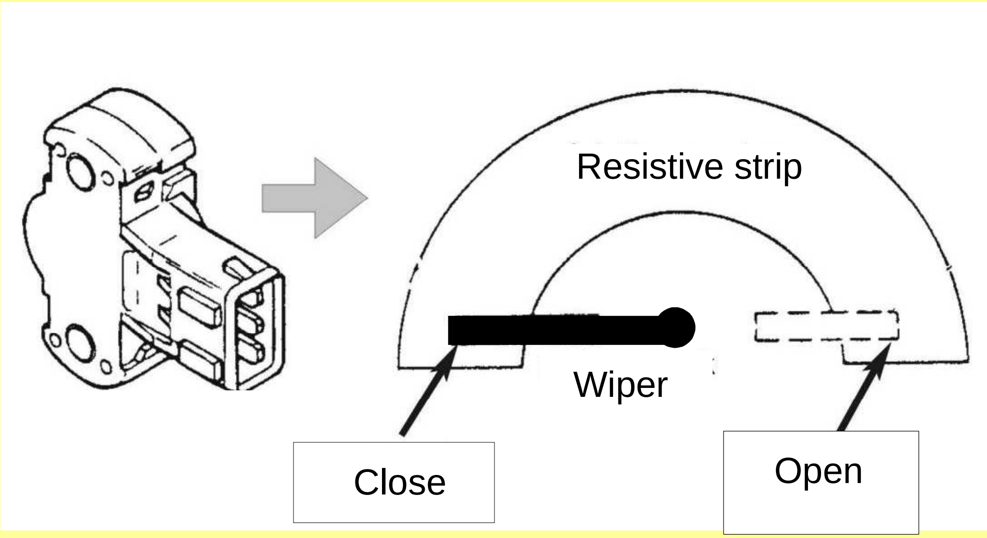


The Camshaft sensors

Throttle Position Sensors

The Throttle Position sensor moves with the throttle and sends a voltage signal to the computer indicating throttle angle and speed of movement data.





[www.samochodowka.internetdsl.pl]

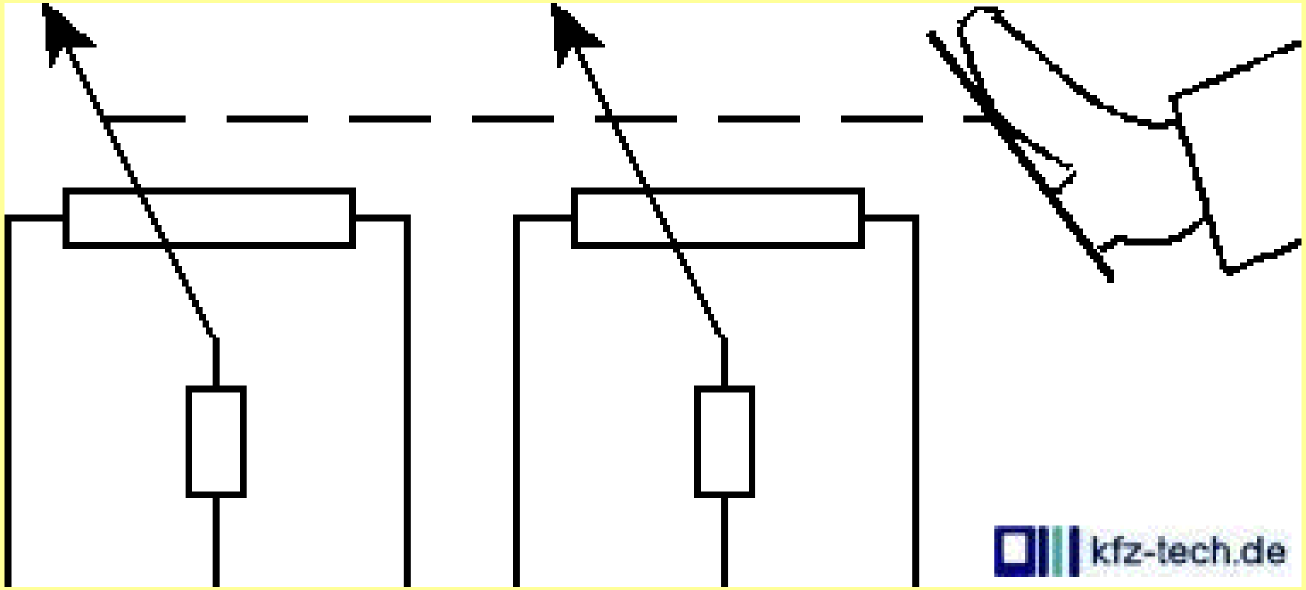
Sensors

Accelerator Pedal Sensors

The Accelerator Pedal sensor indicates the position of the accelerator on vehicle models with electronic throttle control.

[http://image.made-in-china.com/]

Sensors



For safety reasons, the accelerator pedal sensor is equipped with 2 resistors (potentiometers) with varying operating ranges (1 - 4 V and 0,5 - 2 V and separate circuits.

[http://www.kfz-tech.de/]

Sensors

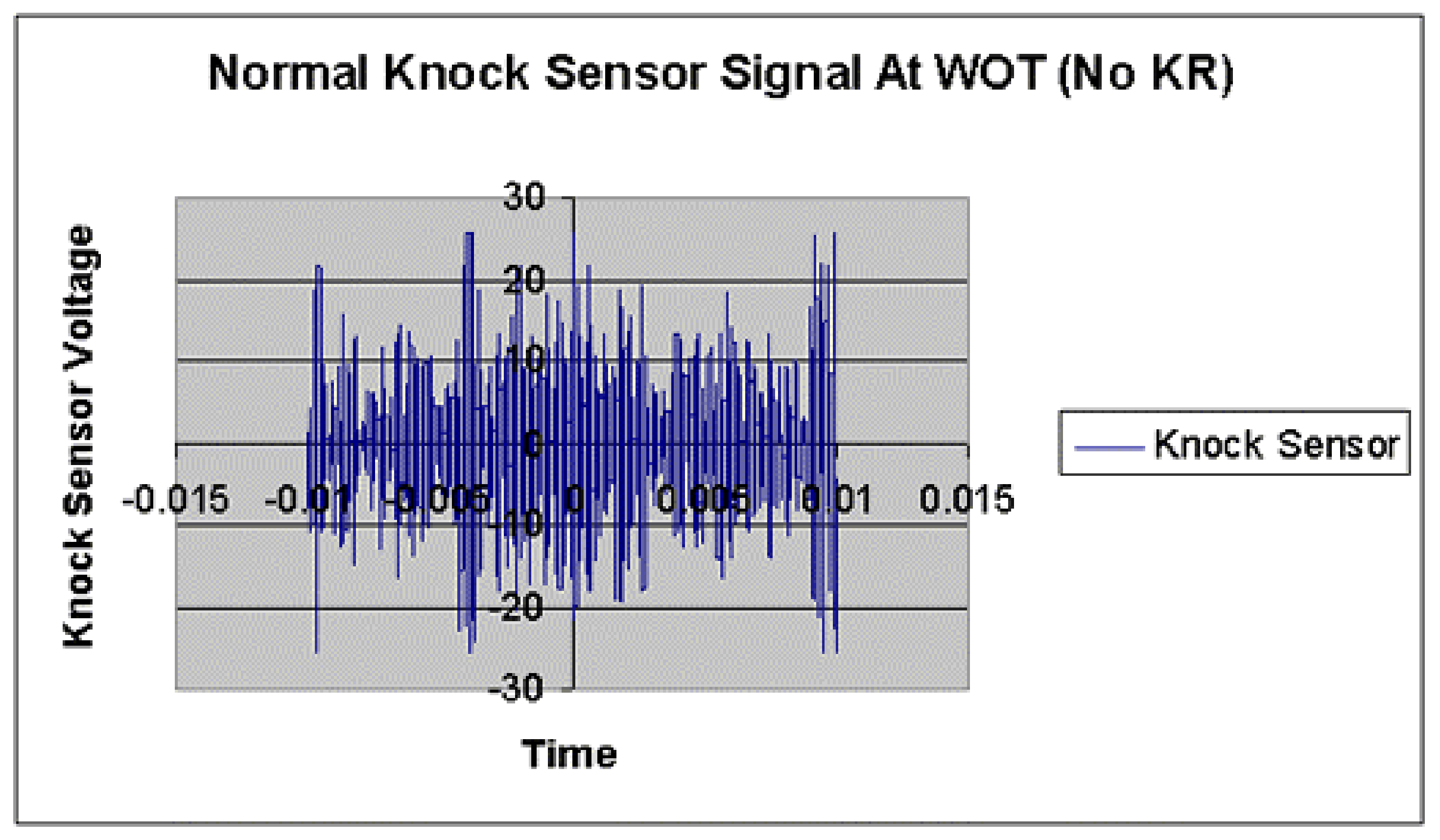
Knock Sensors

This sensor creates a voltage signal based on the vibrations caused by detonation.

The Knock sensor is located in the lower engine block, in the cylinder head.

[http://www.bosch.com.au/]

Sensors



[http://www.zzperformance.com/blog/kr-graph2-normal-knock-sensor-signal-at-wot/]

Sensors

Air Temperature Sensors, Coolant Temperature Sensors

The Temperature sensor changes resistance with the temperature.

[http://www.vdo.com/]

Sensors

There are two common types of coolant temperature sensors in use:

-**NTC**- Negative Temperature Coefficient

-**PTC**- Positive Temperature Coefficient

Most Automotive coolant temperature sensors are NTC sensors.

The **ECU** (Engine Control Unit) sends out a regulated reference voltage (typically 9 volts) to the Coolant Temperature Sensor. The voltage is decreased in relation to the internal resistance within the sensor which varies with temperature.

Oxygen Sensors

The Oxygen (or Lambda) sensor outputs a voltage between 0,1 volt and 1 volt based on the amount of oxygen in the exhaust.

The computer uses this information to trim the air/fuel ratio for the most efficient operation.

[http://oldfuelinjection.com/]

Sensors

1. Sensor housing 2. Ceramic support tube 3. Connection wire 4. Guard tube with slots
5. Active ceramic sensor layer 6. Contact 7. Protective cap 8. Heater element
9. Crimped connections for heater element 10. Spring washer

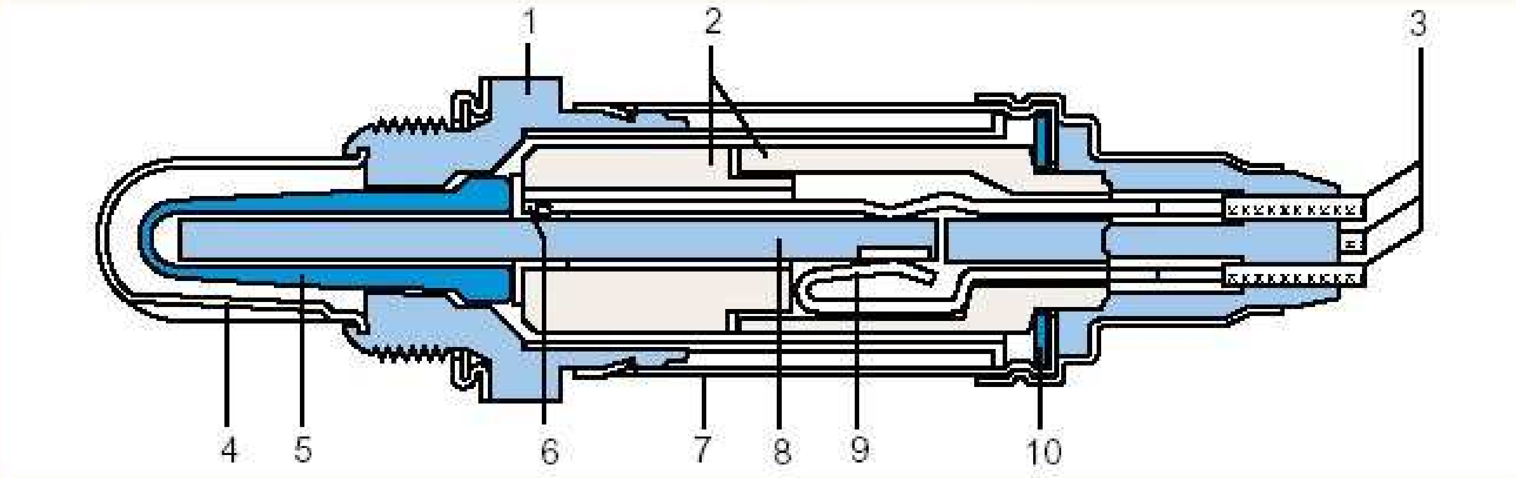
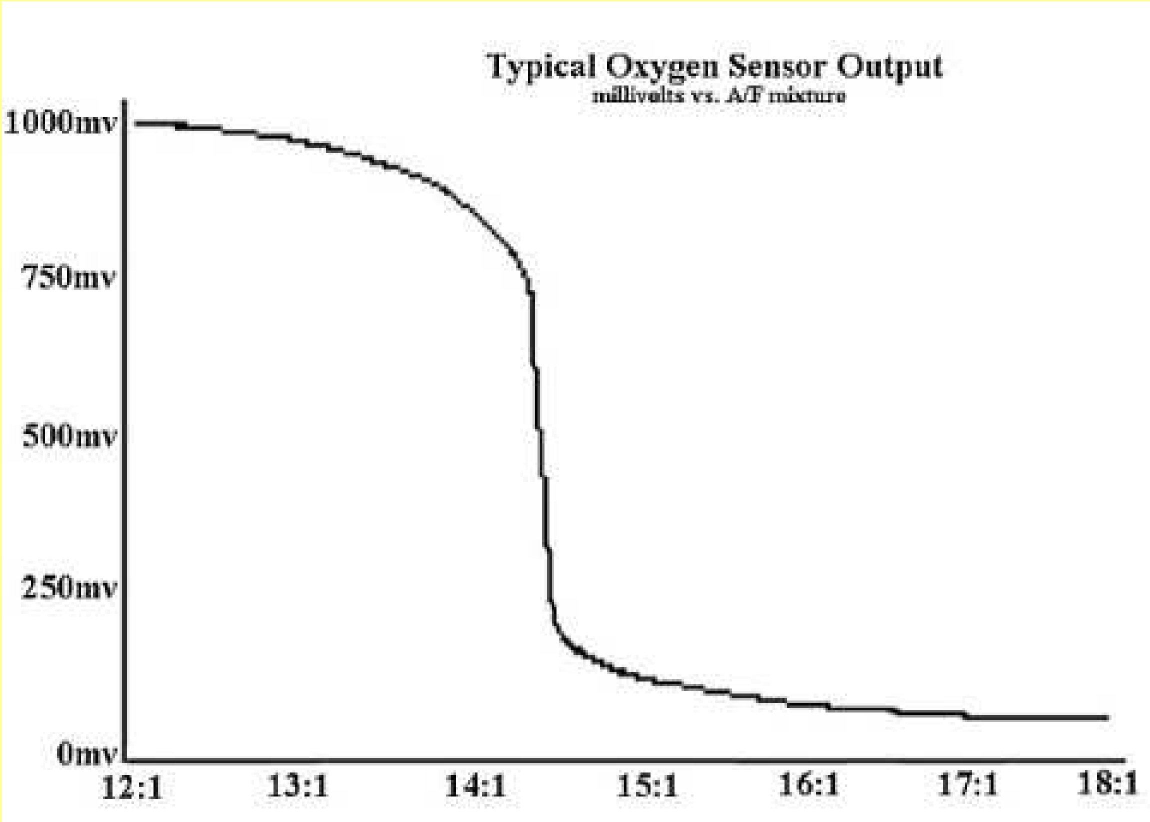


Figure 4. Heated oxygen sensor.

[http://mymiata.paladinmicro.com/Miata4-WireO2.htm]

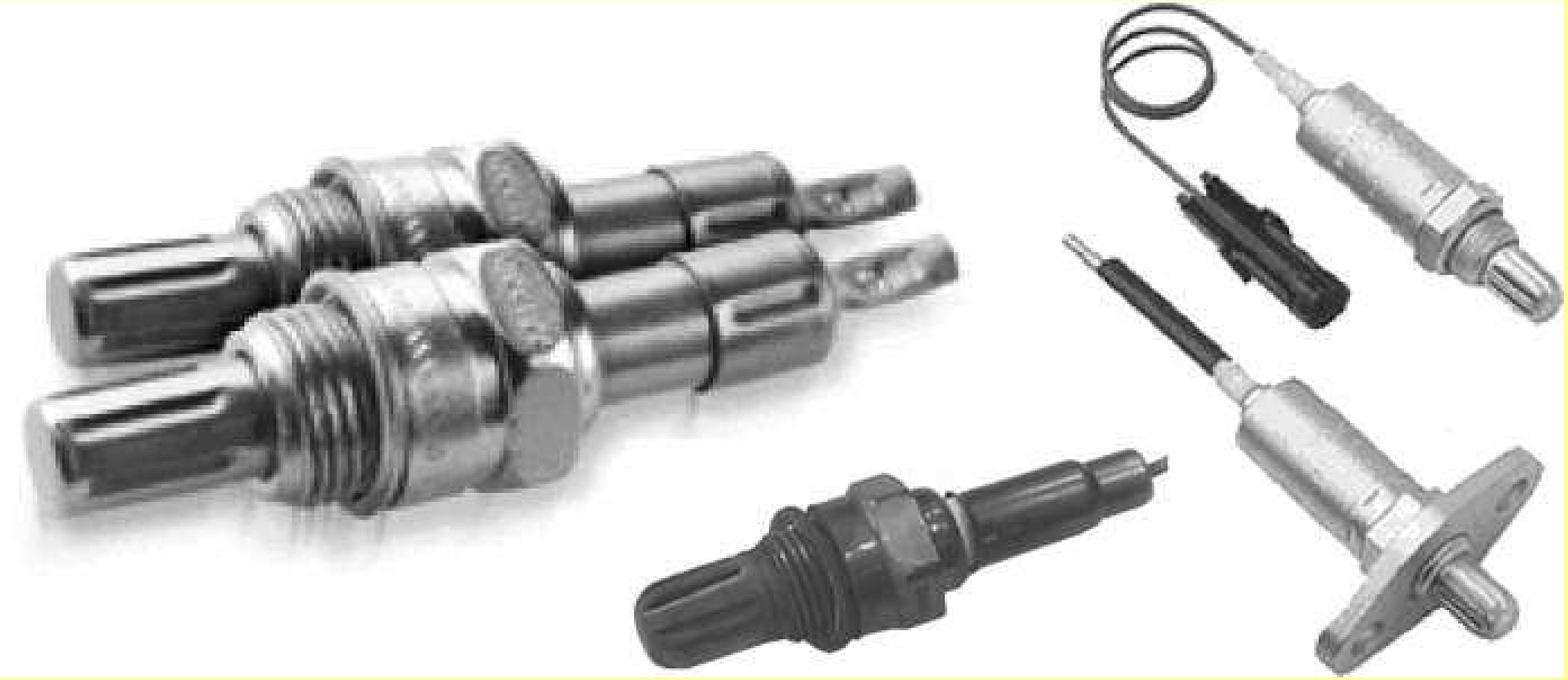
Sensors



Oxygen Sensor Output (milivolts vs (Air/Fuel mixture)

[www.vortexbuicks-etc.com]

Sensors



Oxygen Sensors

[www.samochodowka.internetdsl.pl]

Filters

Filters are so named according to the frequency range of signals that they allow to pass through them, while blocking or "attenuating" the rest.

Terminology:

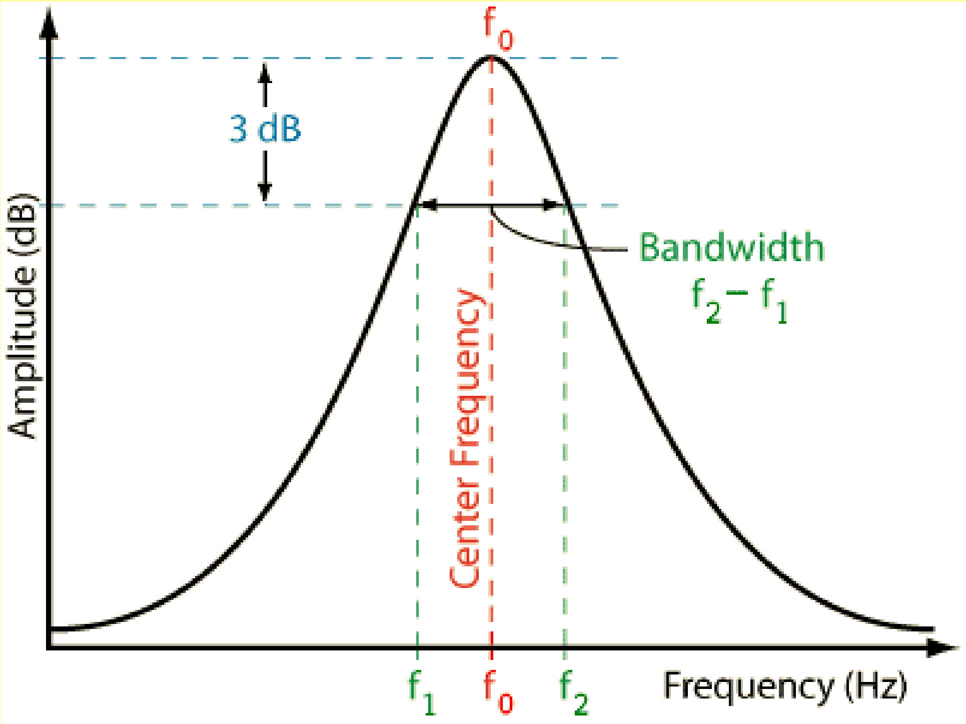
Cutoff frequency is the frequency beyond which the filter will not pass signals. It is usually measured at a specific attenuation such as 3dB.

Transition band, the (usually narrow) band of frequencies between a passband and stopband

[www.wikipedia.org]

Filters

Quality factor-Q: factor 3 dB Bandwidth- BW = f2 − f1= f0/Q



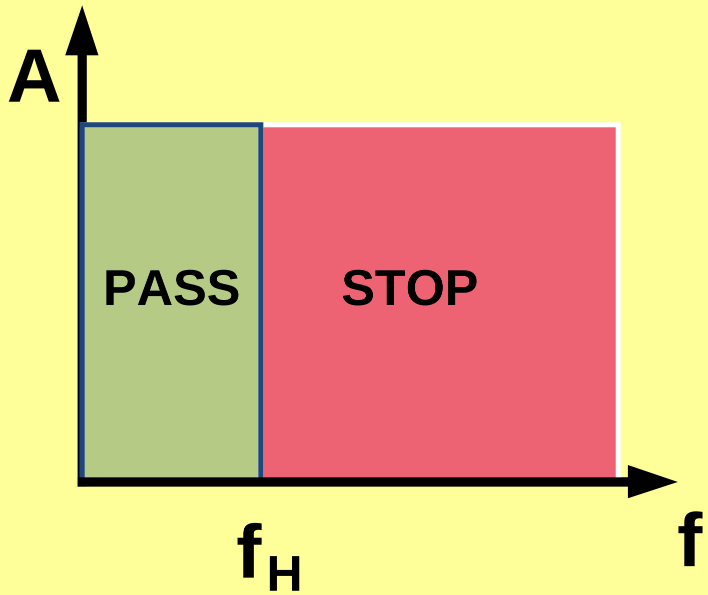
[http://www.sengpielaudio.com/]

Ripple is the variation of the filter's insertion loss in the passband.

The most commonly used filter designs are the:

Filters

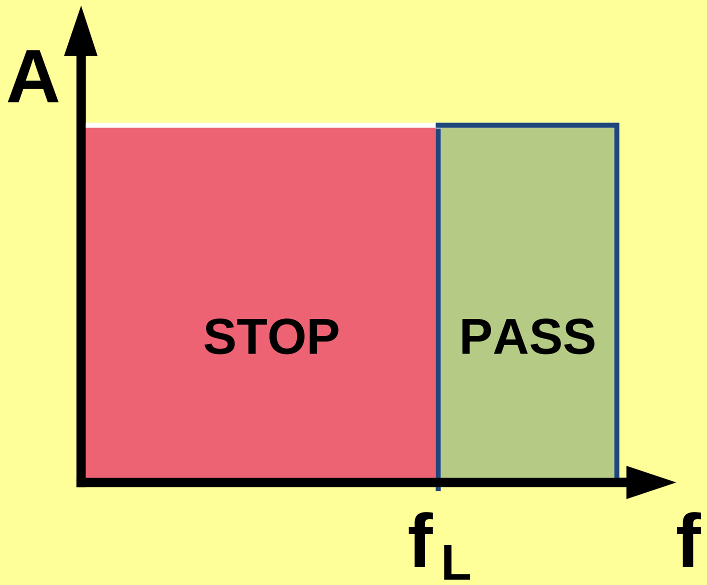
The Low Pass Filter



Ideal Filter Response Curves

Filters

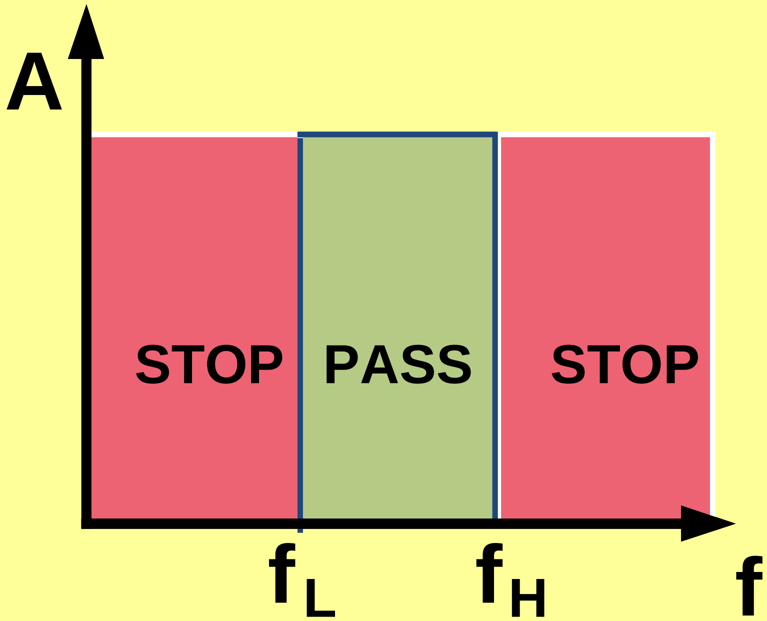
The High Pass Filter



Ideal Filter Response Curves

Filters

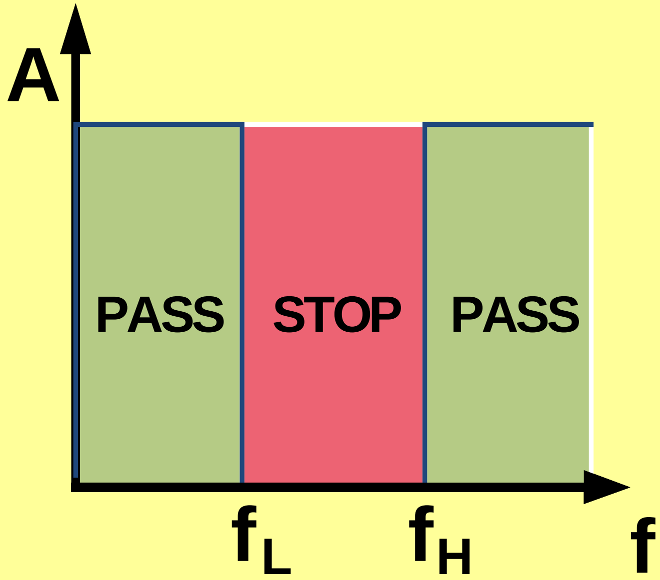
The Band Pass Filter



Ideal Filter Response Curves

Filters

The Band Stop Filter



Ideal Filter Response Curves

Filters

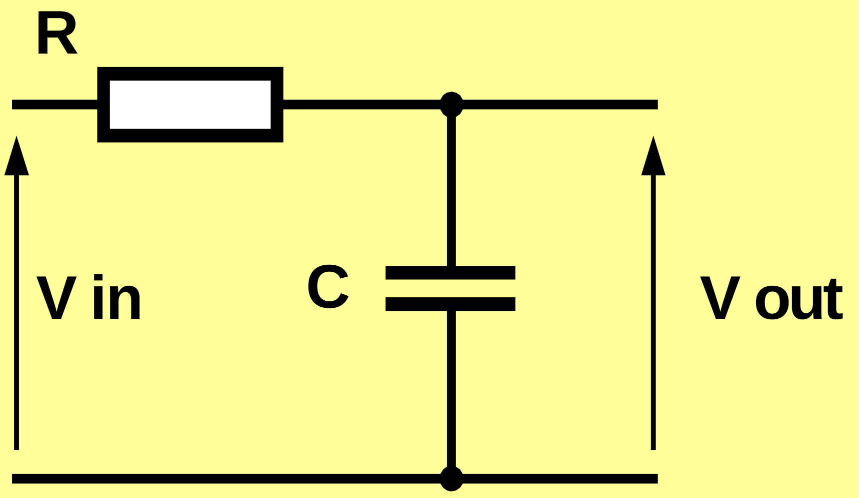
Filters can be divided into two types:

-passive filters,

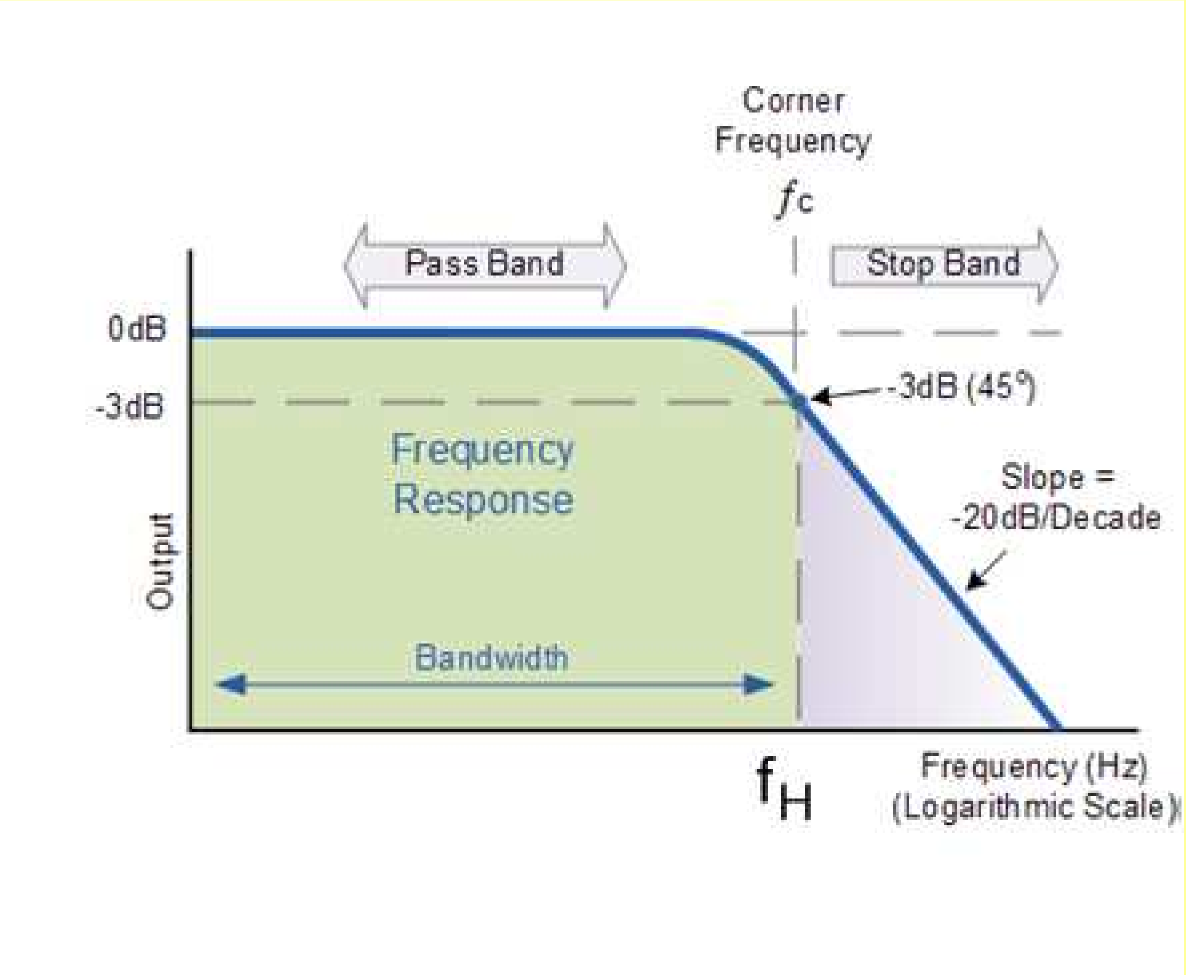
-active filters.

Active filters contain amplifying devices to increase signal strength.

Passive Filters



RC Low Pass Filter Circuit



Frequency Response of a 1st-order Low Pass Filter

[http://www.electronics-tutorials.ws]

Passive Filters

The capacitive reactance of a capacitor in an AC circuit is given as:

$$X_C = \frac{1}{2\pi f C}$$

For a series circuit consisting of a single resistor in series with a single capacitor, the circuit impedance is calculated as:

$$Z = \sqrt{R^2 + X_C^2}$$

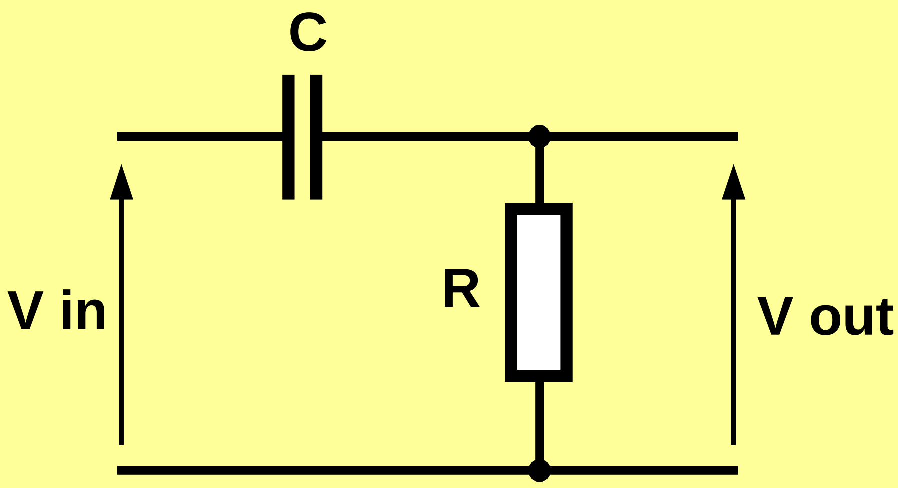
$$V_{OUT} = Vin \bullet \frac{X_C}{\sqrt{R^2 + X_C^2}}$$

Passive Filters

Cut-off Frequency

$$f_H = \frac{1}{2\pi RC}$$

Passive Filters



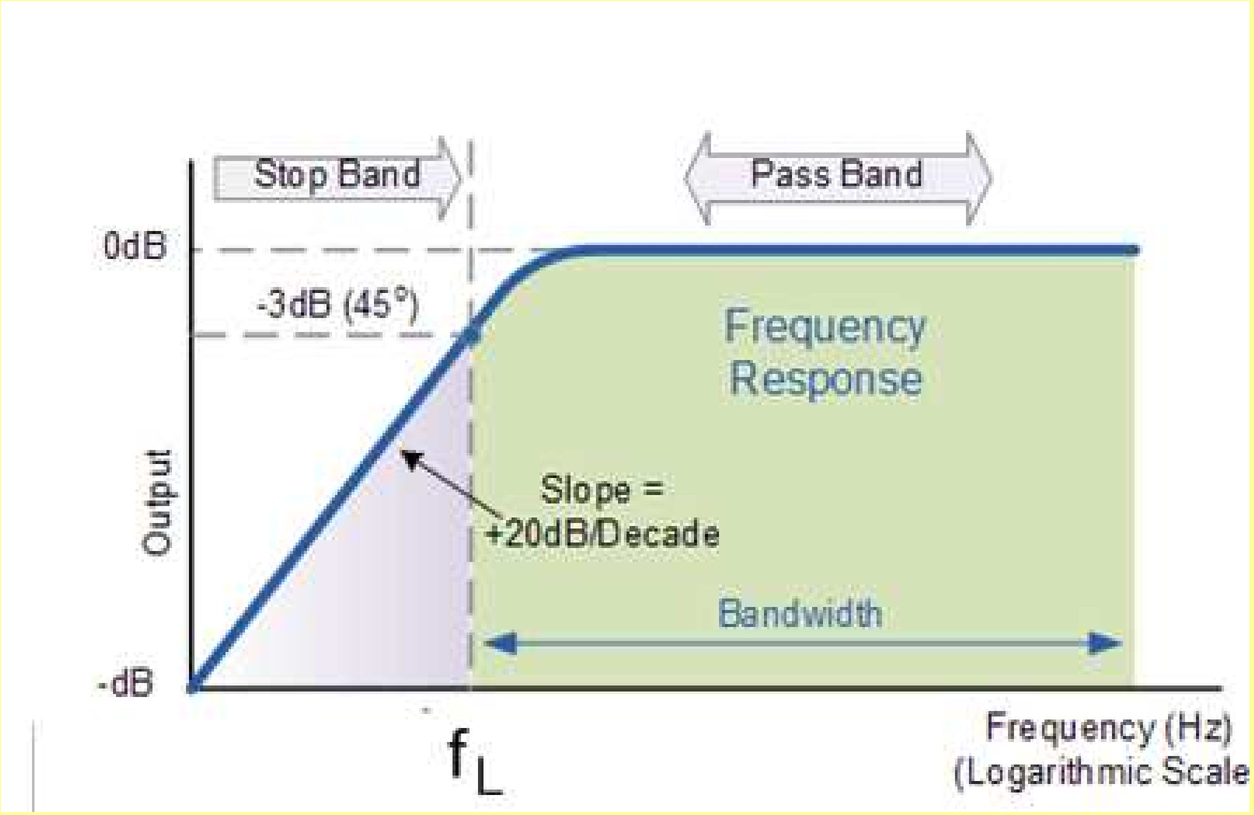
RC High Pass Filter Circuit

Passive Filters

Cut-off Frequency

$$f_L = \frac{1}{2\pi RC}$$

Passive Filters

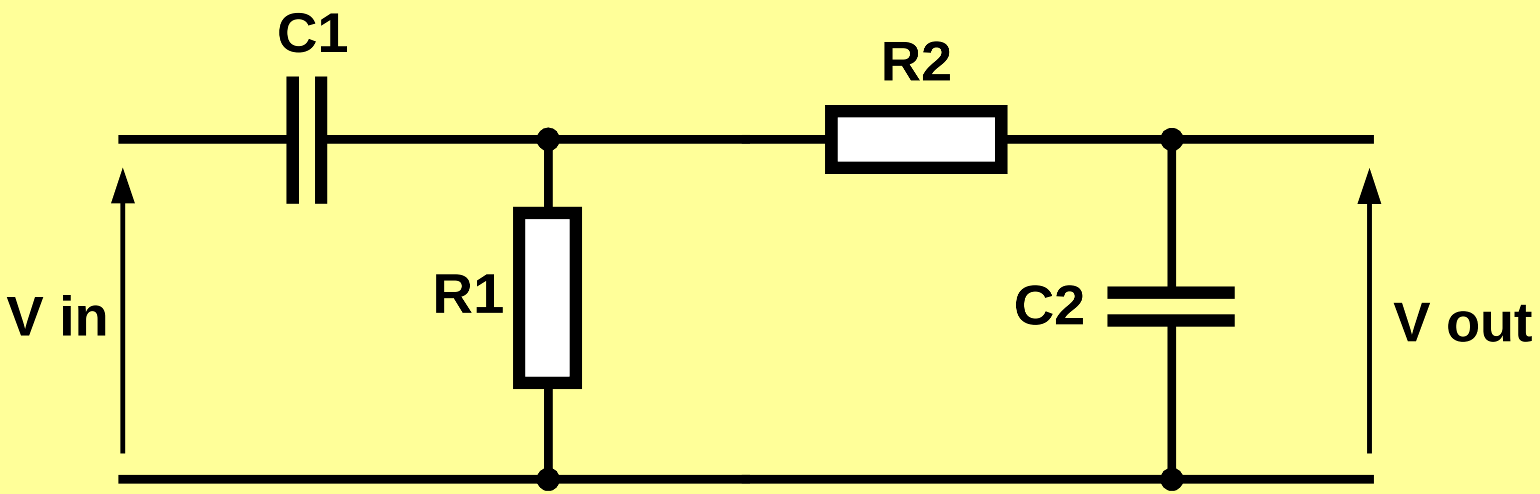


Frequency Response of a 1st Order High Pass Filter

[http://www.electronics-tutorials.ws]

Passive Filters

By connecting or "cascading" together a single Low Pass Filter circuit with a High Pass Filter circuit, we can produce another type of passive RC filter:



RC Band Pass Filter Circuit

Passive Filters

The upper and lower cut-off frequency points for a band pass filter can be found using the same formula:

$$f_X = \frac{1}{2\pi RC}$$

Centre Frequency Equation:

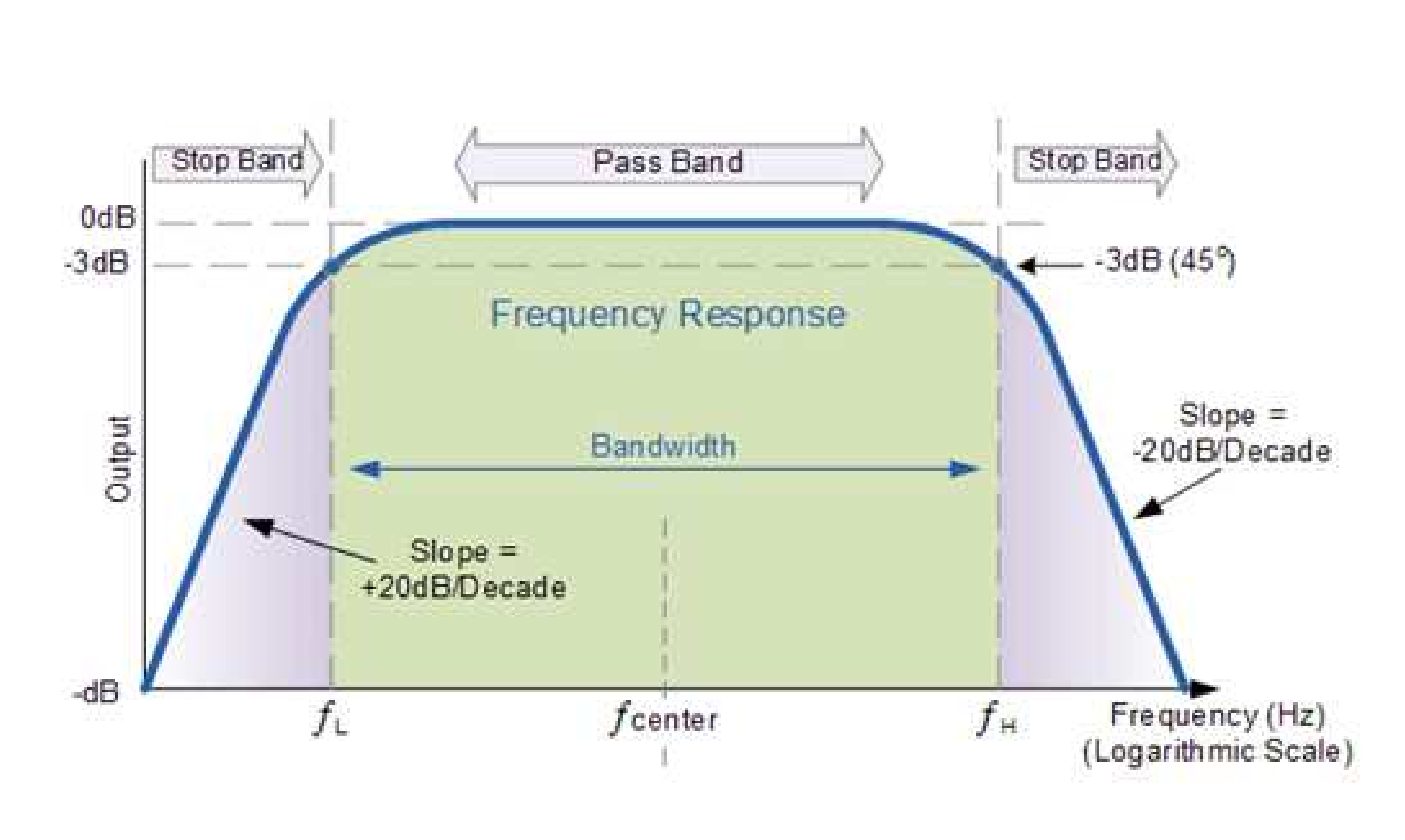
$$f = \sqrt{f_L \bullet f_H}$$

Where:

f_L is the lower -3dB cut-off frequency point

f_H is the upper -3db cut-off frequency point

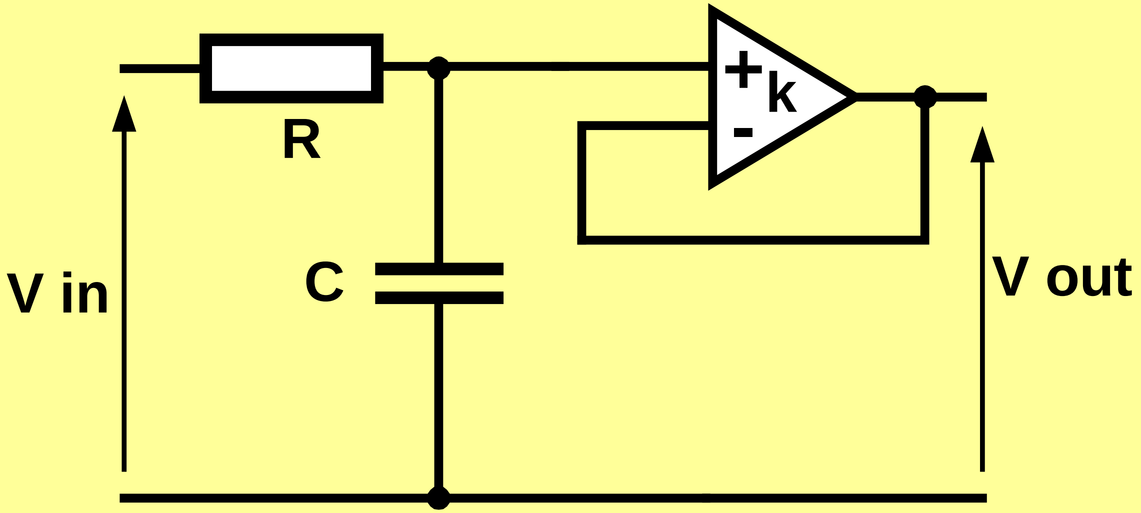
Passive Filters



Frequency Response of a 2nd Order Band Pass Filter

[http://www.electronics-tutorials.ws]

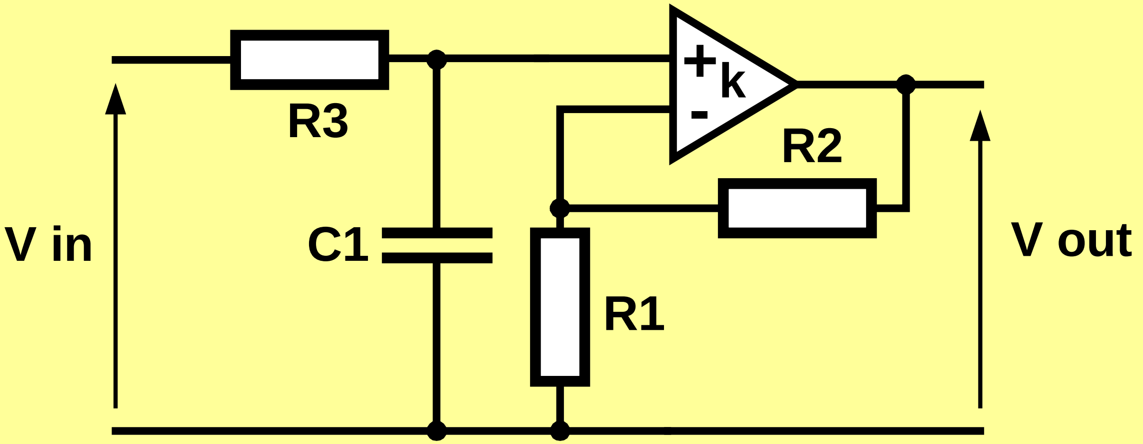
Active Filters



Active Low Pass Filter

$$f_H = \frac{1}{2\pi RC}$$

Active Filters



$$k = 1 + \frac{R2}{R1}$$

$$f_H = \frac{1}{2\pi R3C1}$$

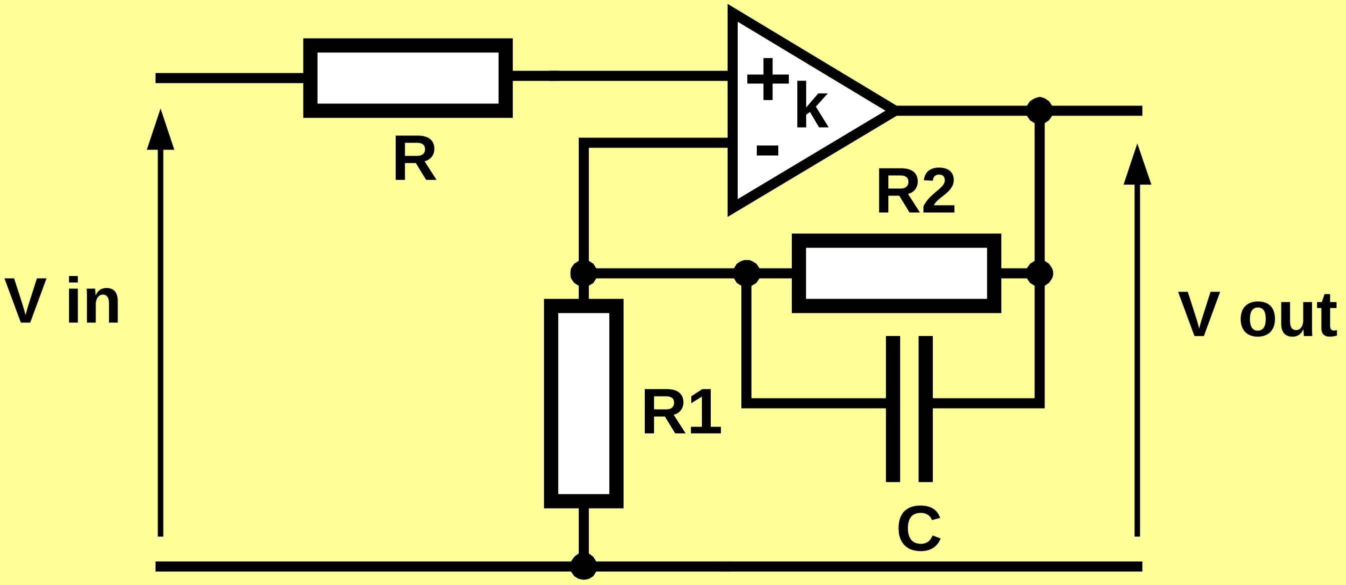
Active Low Pass Filter with Amplification

Active Filters

If the external impedance connected to the input of the circuit changes, this change will also affect the corner frequency of the filter One way of avoiding this is to place the capacitor in parallel with the feedback resistor R2. The value of the capacitor will change. The formula used to calculate the cut-off corner frequency is the same as that used for the RC passive low pass filter:

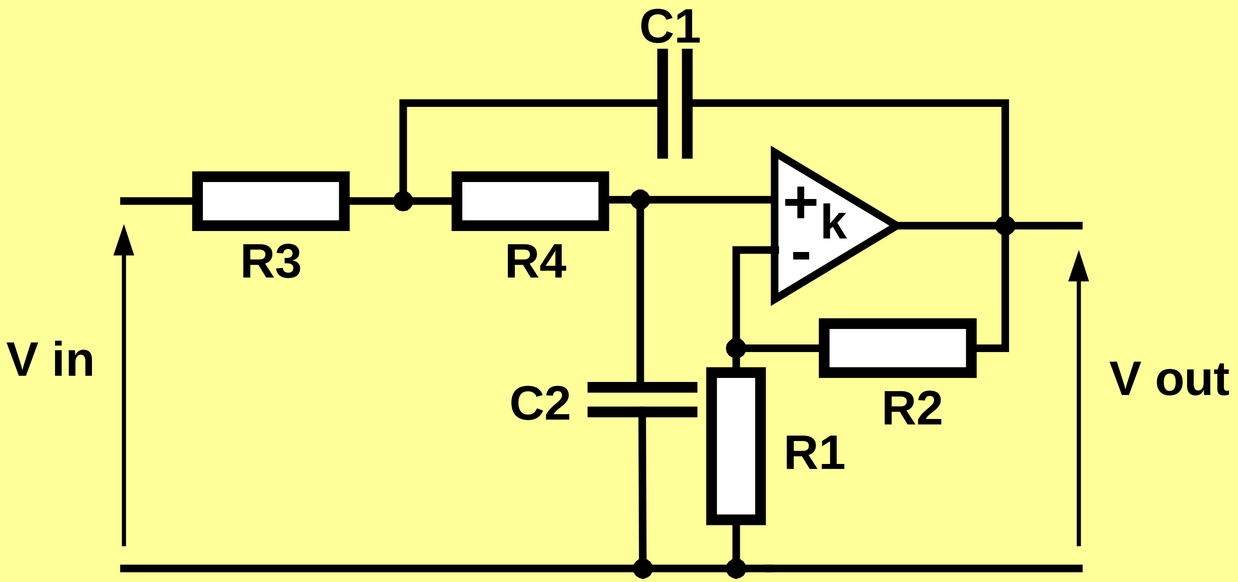
$$f_H = \frac{1}{2\pi R2C1}$$

Active Filters



Active Low Pass Filter With Modyfication

Active Filters

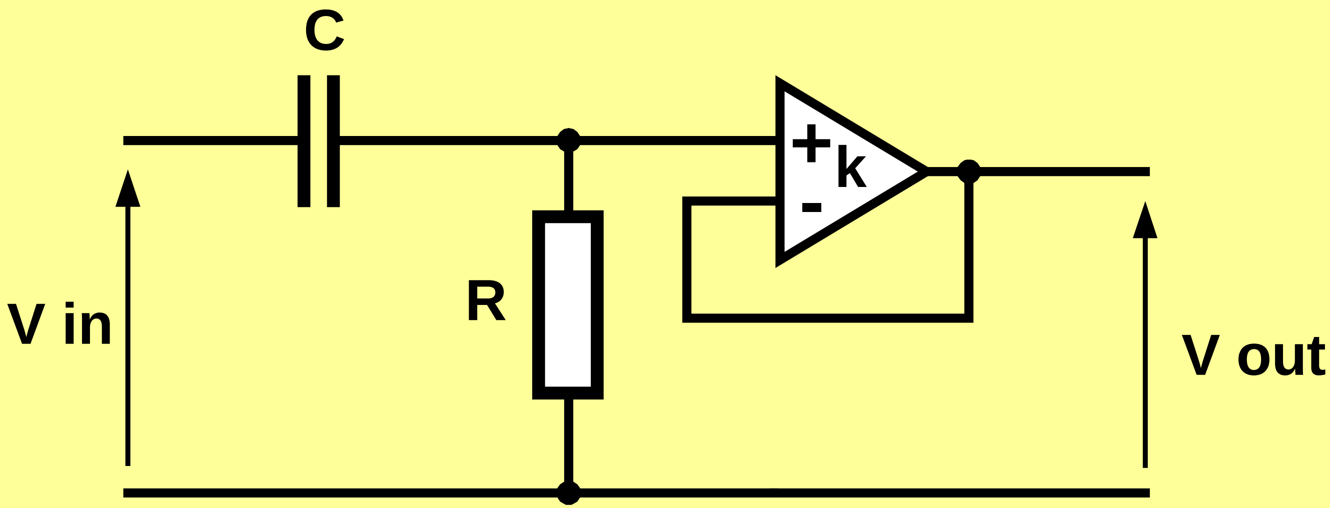


Second-order Active Low Pass Filter Circuit

$$k = 1 + \frac{R2}{R1}$$

$$f_H = \frac{1}{2\pi\sqrt{R3R4C1C2}}$$

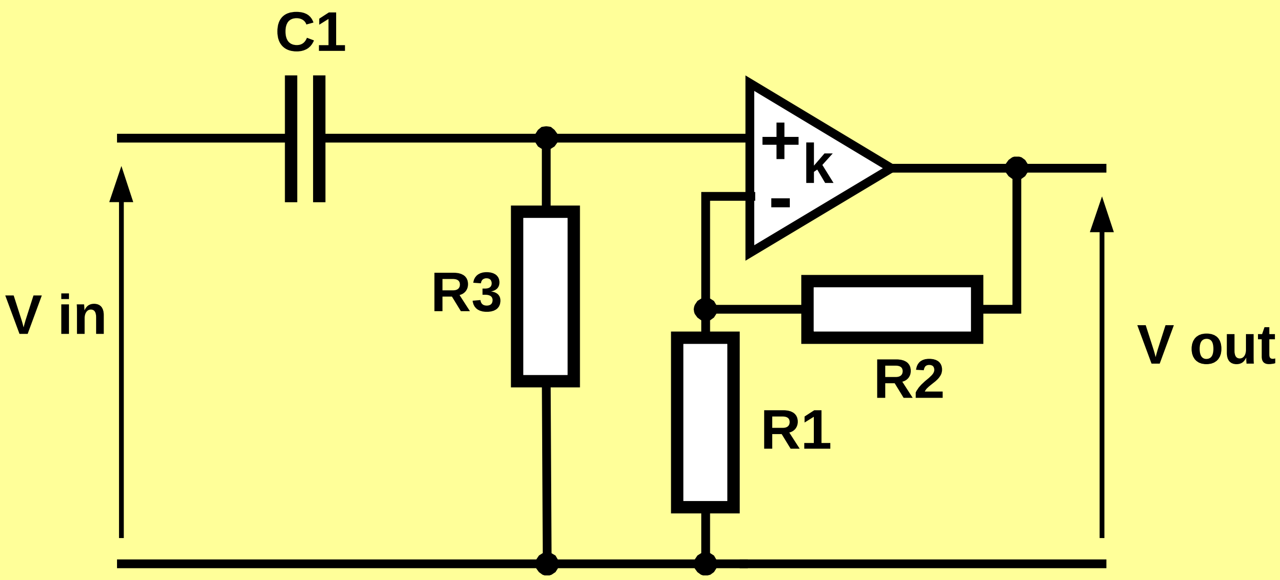
Active Filters



First Order Active High Pass Filter

$$f_L = \frac{1}{2\pi RC}$$

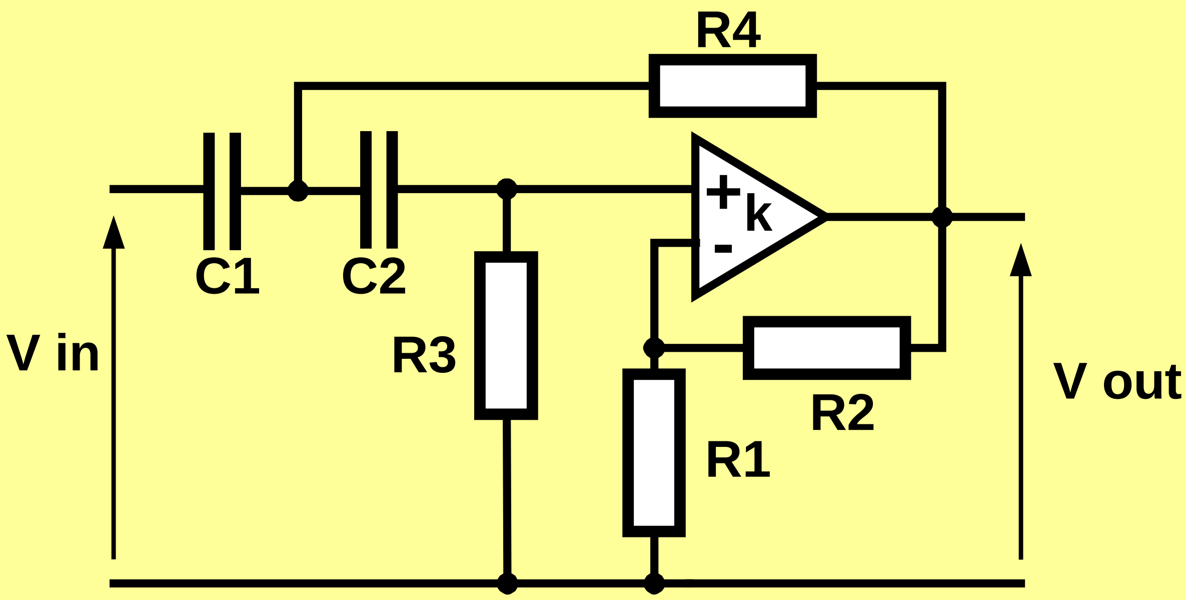
Active Filters



Active High Pass Filter with Amplification

$$f_L = \frac{1}{2\pi R3C1} \qquad k = 1 + \frac{R2}{R1}$$

Active Filters

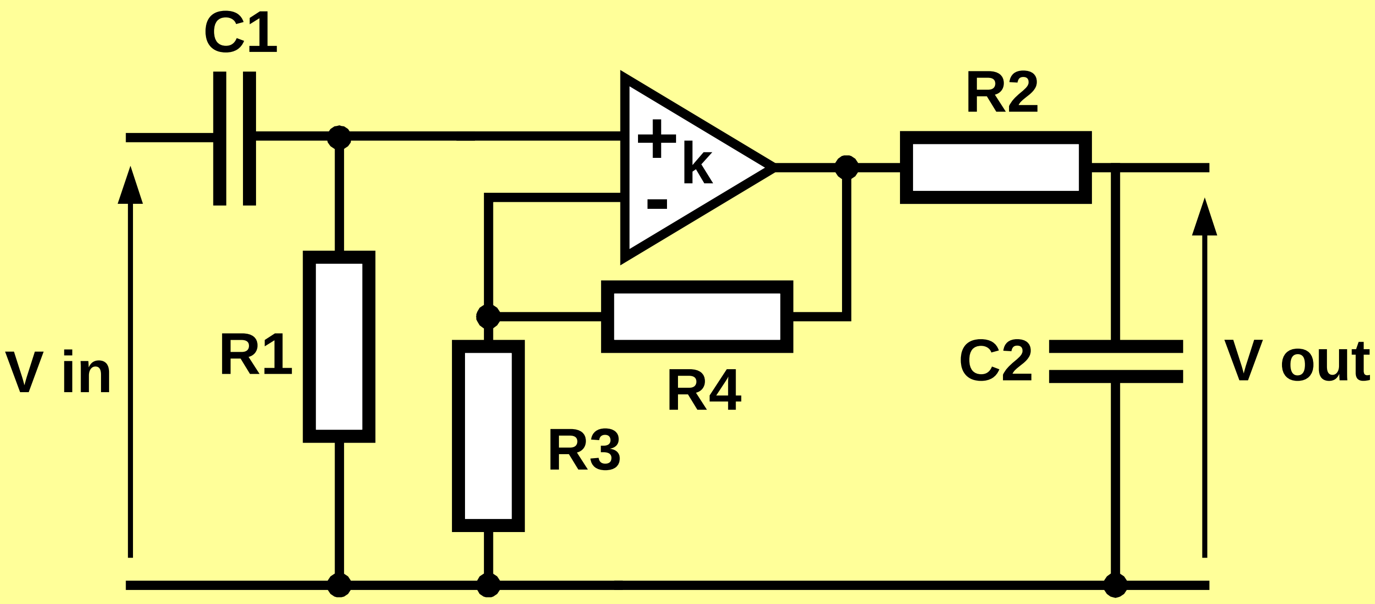


Second-order Active High Pass Filter Circuit

$$k = 1 + \frac{R2}{R1}$$

$$f_L = \frac{1}{2\pi\sqrt{R3R4C1C2}}$$

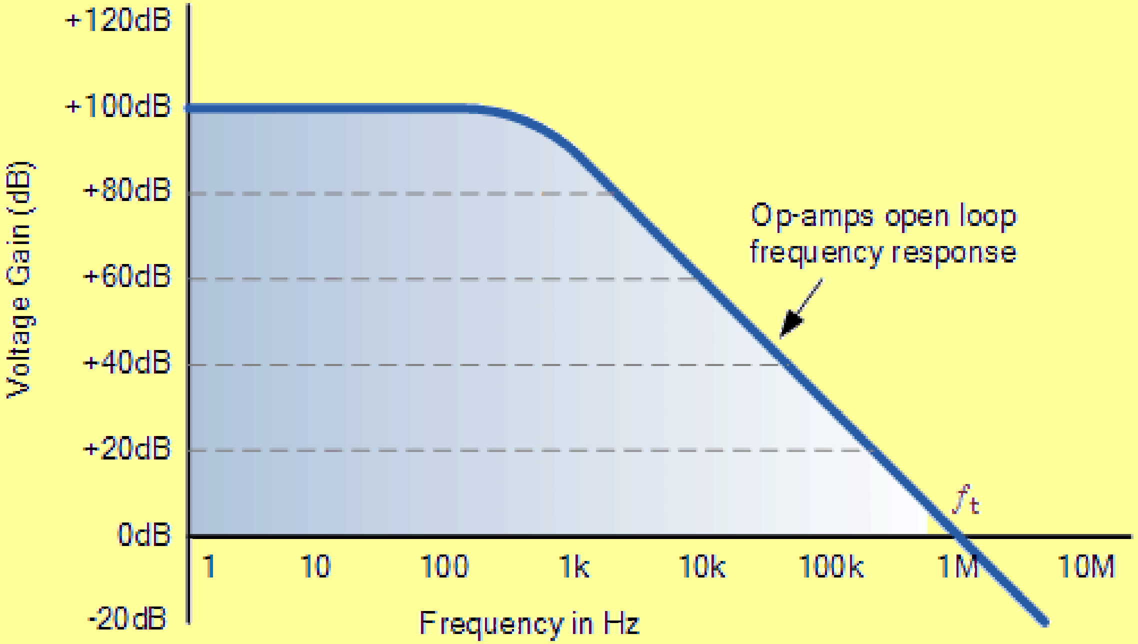
Active Filters



Active Band Pass Filter

Active Filters

In the Operational Amplifier tutorial we saw that the maximum frequency response of an op-amp is limited to the Gain/Bandwidth product or open loop voltage gain of the operational amplifier being used giving it a bandwidth limitation, where the closed loop response of the op amp intersects the open loop response.

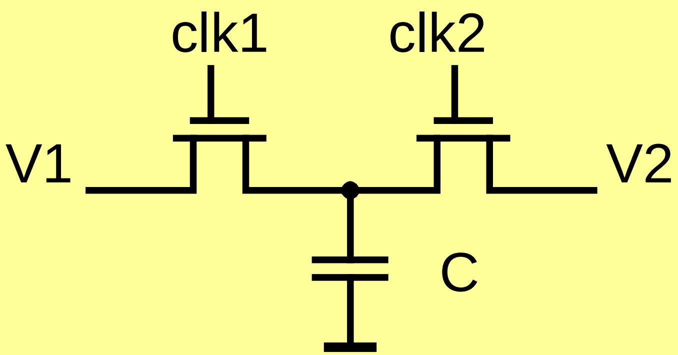


Frequency response curve of a typical Operational Amplifier

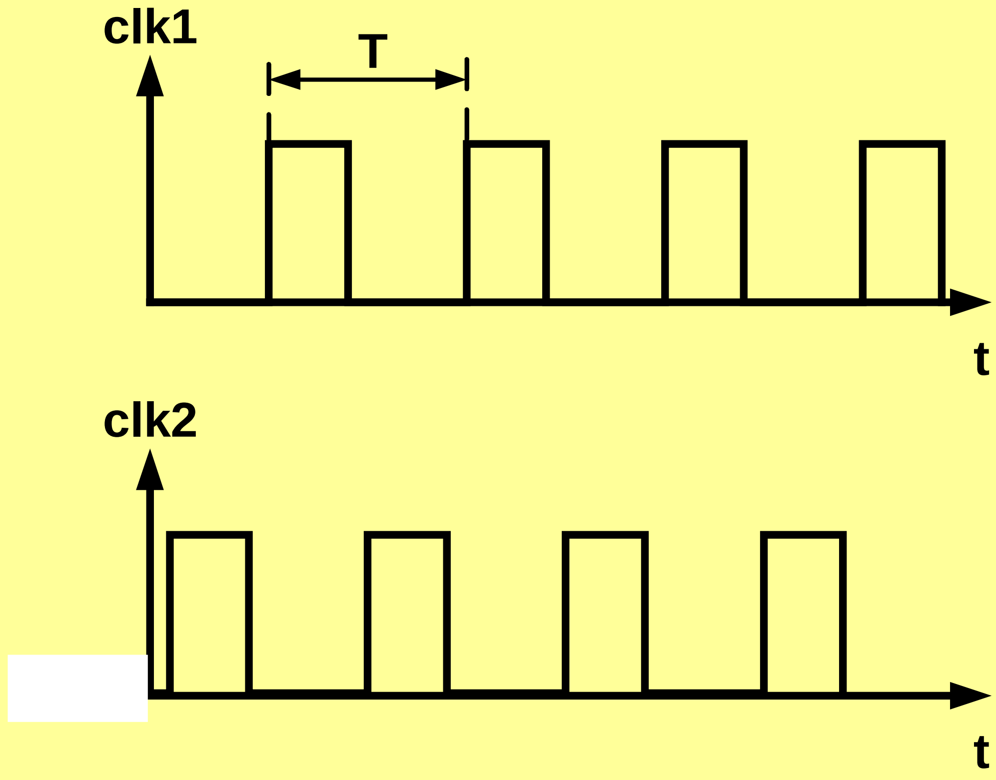
[http://www.electronics-tutorials.ws]

Switched-Capacitor Filters

Switched-Capacitor Resistor Equivalent:



Switched-Capacitor Filters



Non-Overlapping Clocks

Switched-Capacitor Filters

C1 charged to V1 and then V2 during ich period T

$$\Delta Q = C \cdot (V1 - V2)$$

Equivalent average current:

$$Iavg = \frac{C \cdot (V1 - V2)}{T}$$

For equivalent resistor:

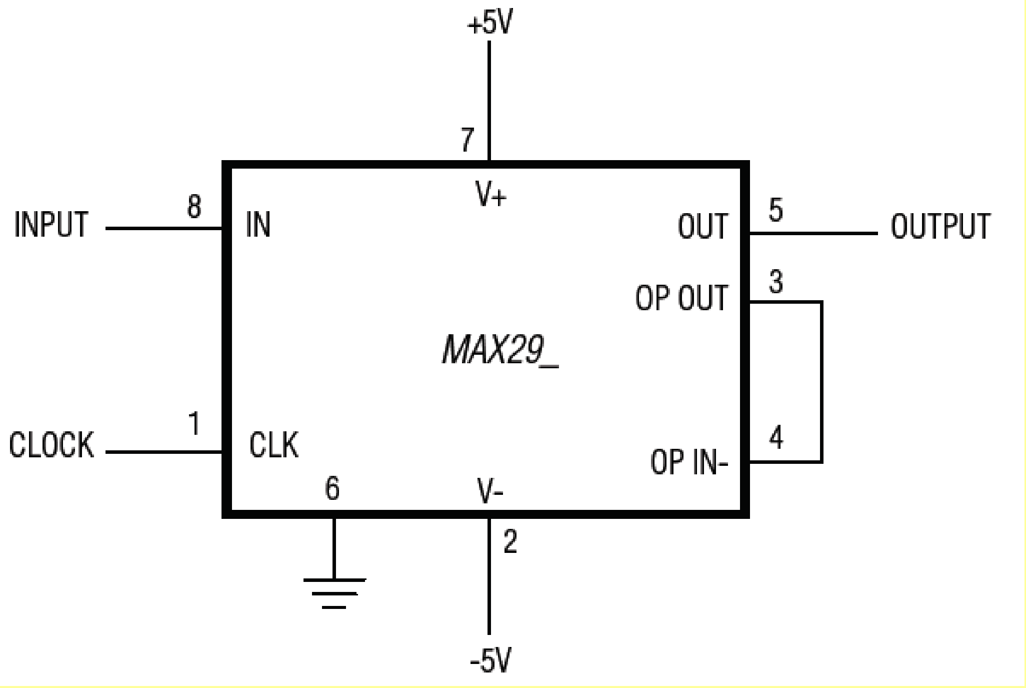
$$Iavg = \frac{V1 - V2}{\mathrm{Re}\,q}$$

We have:

$$\mathrm{Re}\,q = \frac{T}{C} = \frac{1}{fC}$$

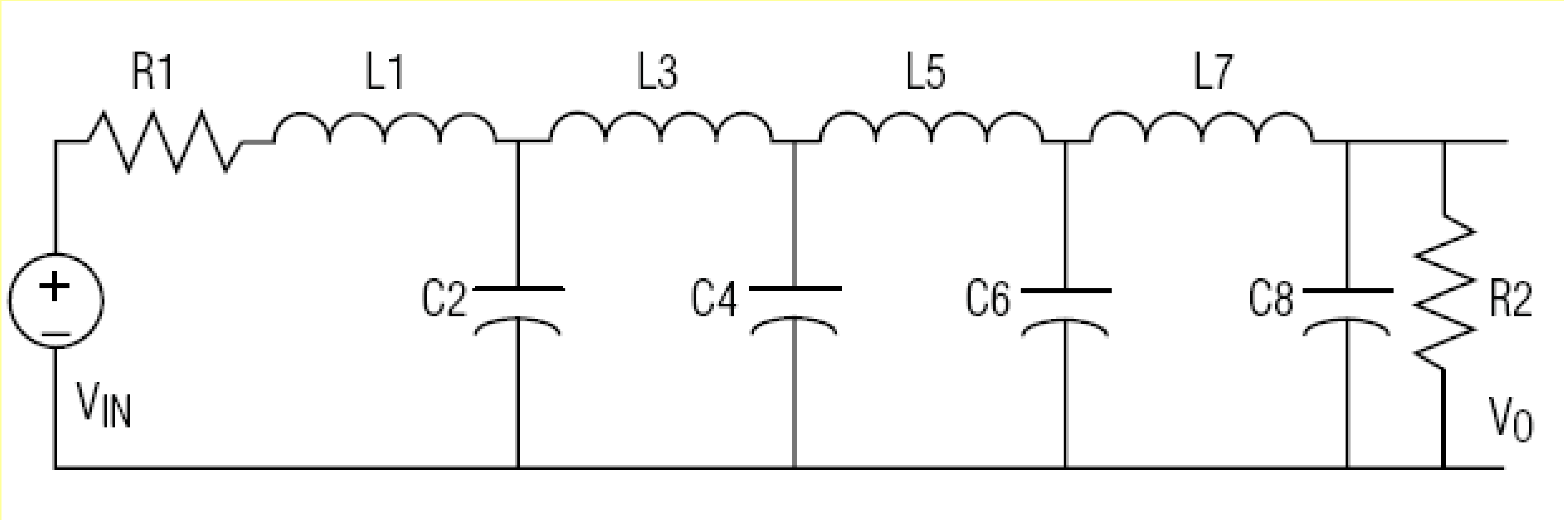
Switched-Capacitor Filters

The MAX291/MAX292/MAX295/MAX296 are easy-to-use, 8th-order, lowpass, switched-capacitor filters that can be set up with corner frequencies from 0.1Hz to 25kHz (MAX291/MAX292) or 0.1Hz to 50kHz (MAX295/MAX296).



Typical Operating Circuit [www.maximintegrated.com]

Switched-Capacitor Filters



8th-Order Ladder Filter Network

Clock to Corner Frequency Ratio:

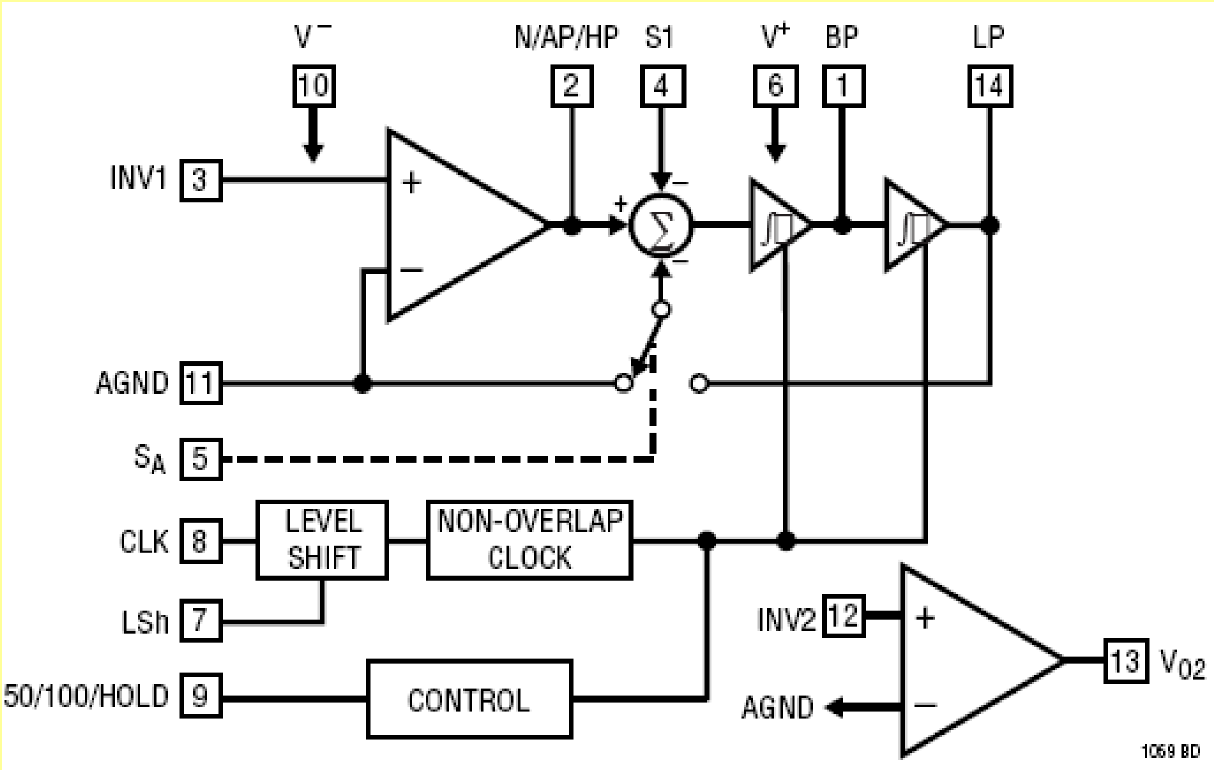
100:1 (MAX291/MAX292)

50:1 (MAX295/MAX296)

[www.maximintegrated.com]

Switched-Capacitor Filters

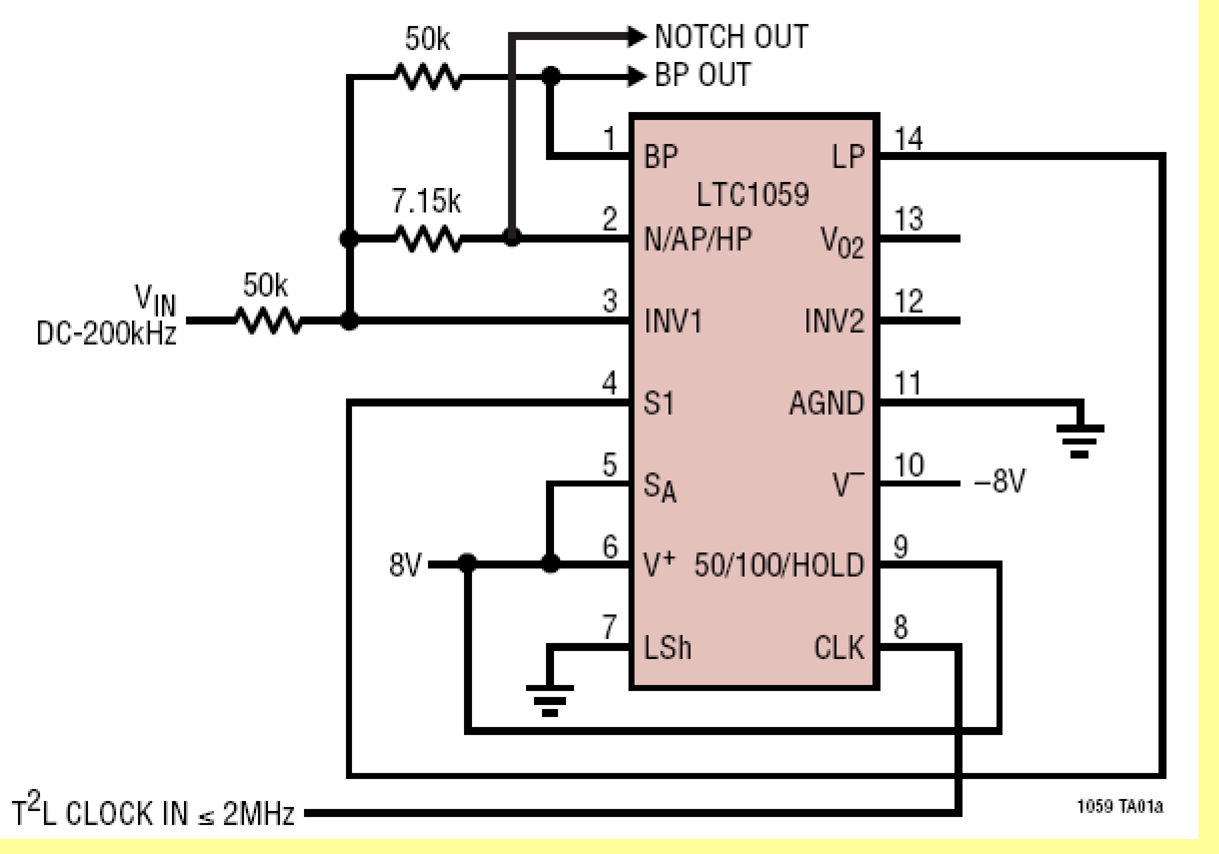
LTC1059- High Performance Switched Capacitor Universal Filter



Block Diagram

[http://cds.linear.com]

Switched-Capacitor Filters



Wide Range 2nd Order Bandpass/Notch Filter

[http://cds.linear.com]

Switched-Capacitor Filters

Center Frequency Range: 0.1Hz to 40kHz

Clock-to-Center Frequency Ratio:

50:1, f_{clk} = 250kHz, Q = 10

100:1, f_{clk} = 500kHz, Q = 10

[http://cds.linear.com]

Switched-Capacitor Filters

LMF40 High Performance 4th-Order

Switched-Capacitor Butterworth Low-Pass Filter

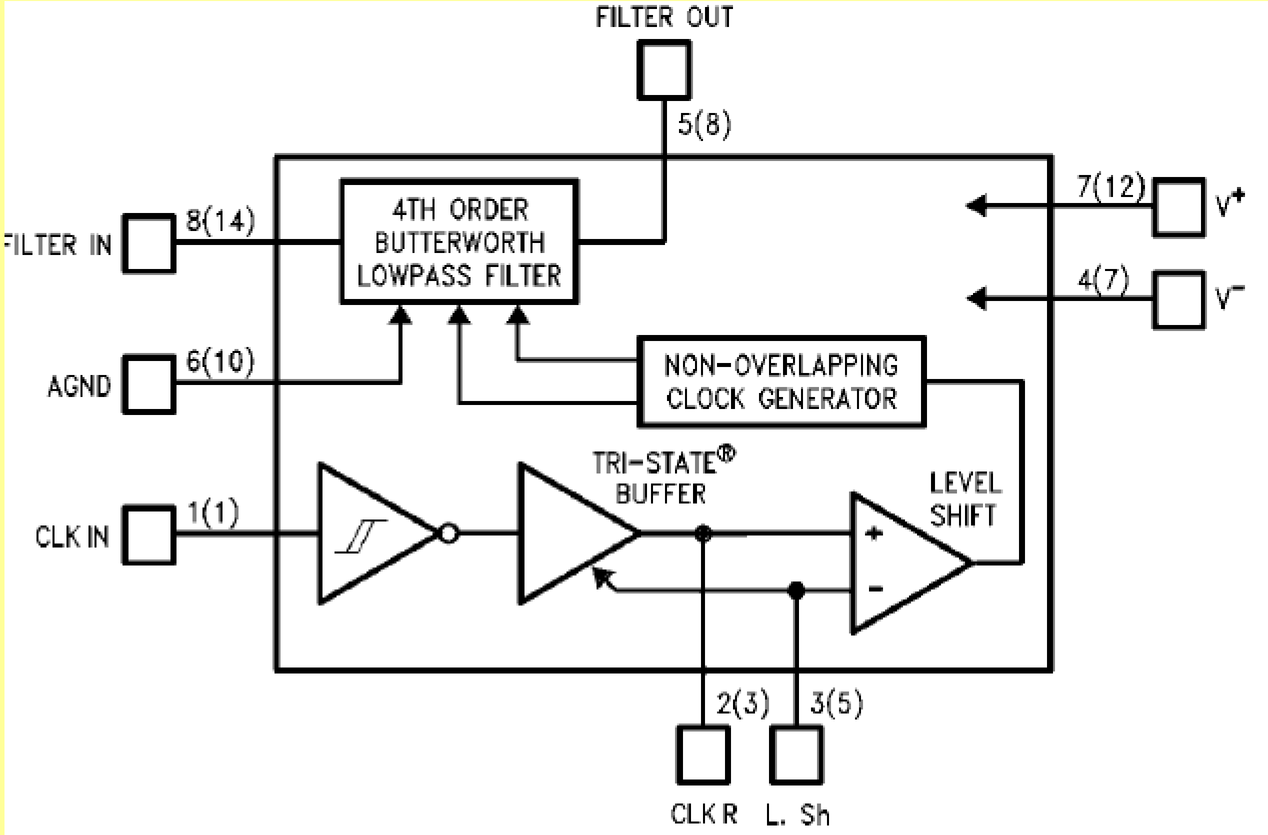
Frequency range of 0.1 Hz to 40 kHz

Clock to Cutoff Frequency Ratio:

50

100

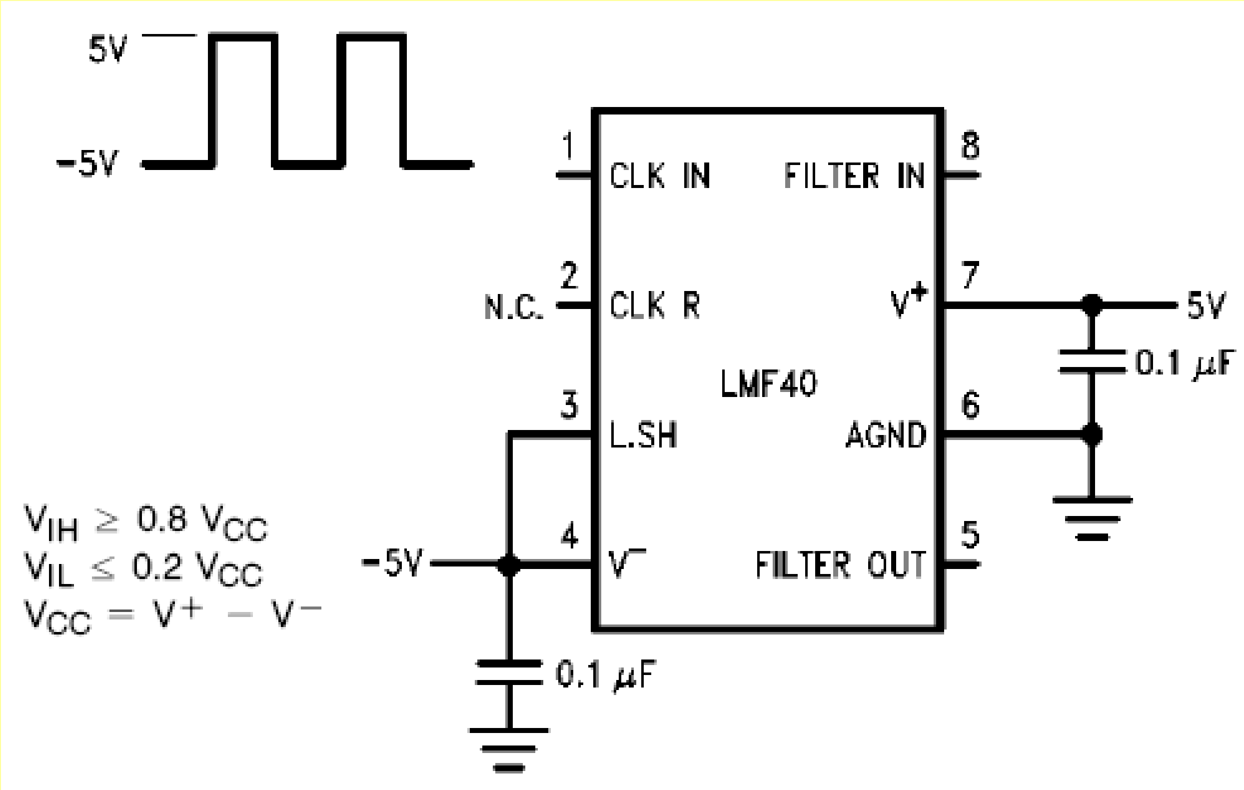
Switched-Capacitor Filters



Block and Connection Diagrams

[www.elenota.pl]

Switched-Capacitor Filters



Typical application

[www.elenota.pl]

Voltage-to-Frequency Converters

LM231A/LM231/LM331A/LM331 Precision Voltage-to-Frequency Converters

The LM231/LM331 family of voltage-to-frequency converters are ideally suited for use in simple low-cost circuits for analog-to-digital conversion, precision frequency-to-voltage conversion.

Parameters:

-Operates on Single 5V Supply

-Pulse Output Compatible with All Logic Forms pulse

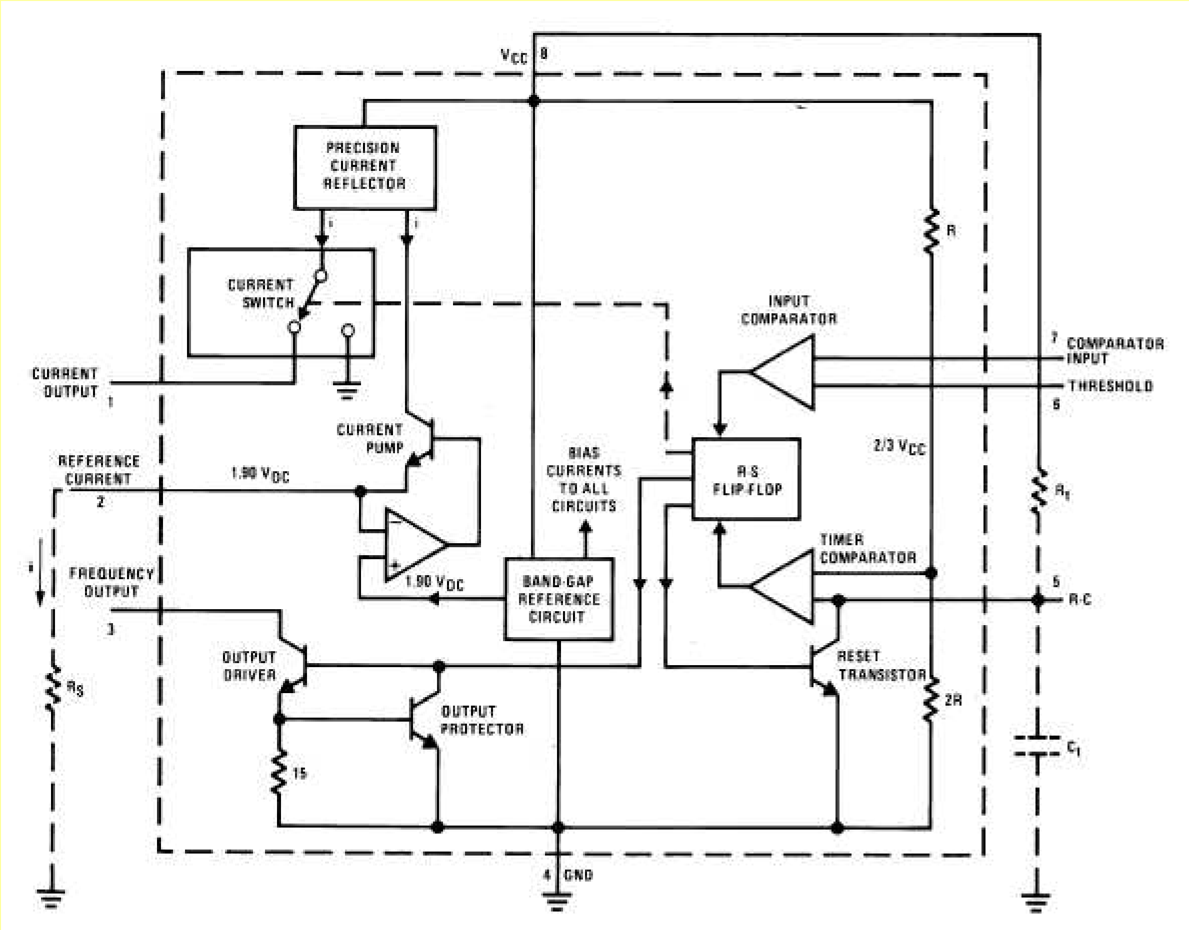
-Low Power Consumption: 15 mW Typical at 5V

-Wide Range of Full Scale Frequency: 1 Hz to 100 kHz

-Low Cost

[www.ti.com]

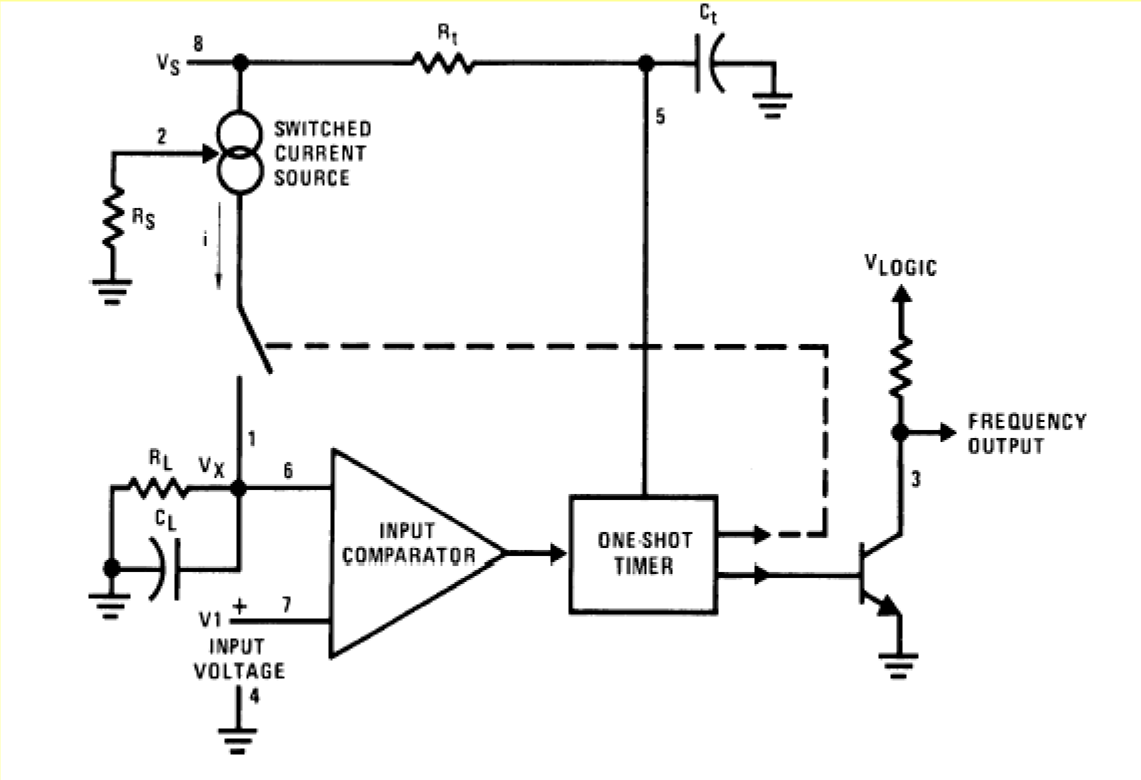
Voltage-to-Frequency Converters



Functional Block Diagram

[www.ti.com]

Voltage-to-Frequency Converters



Simplified Block Diagram of Stand-Alone Voltage-to-Frequency Converter and External Components

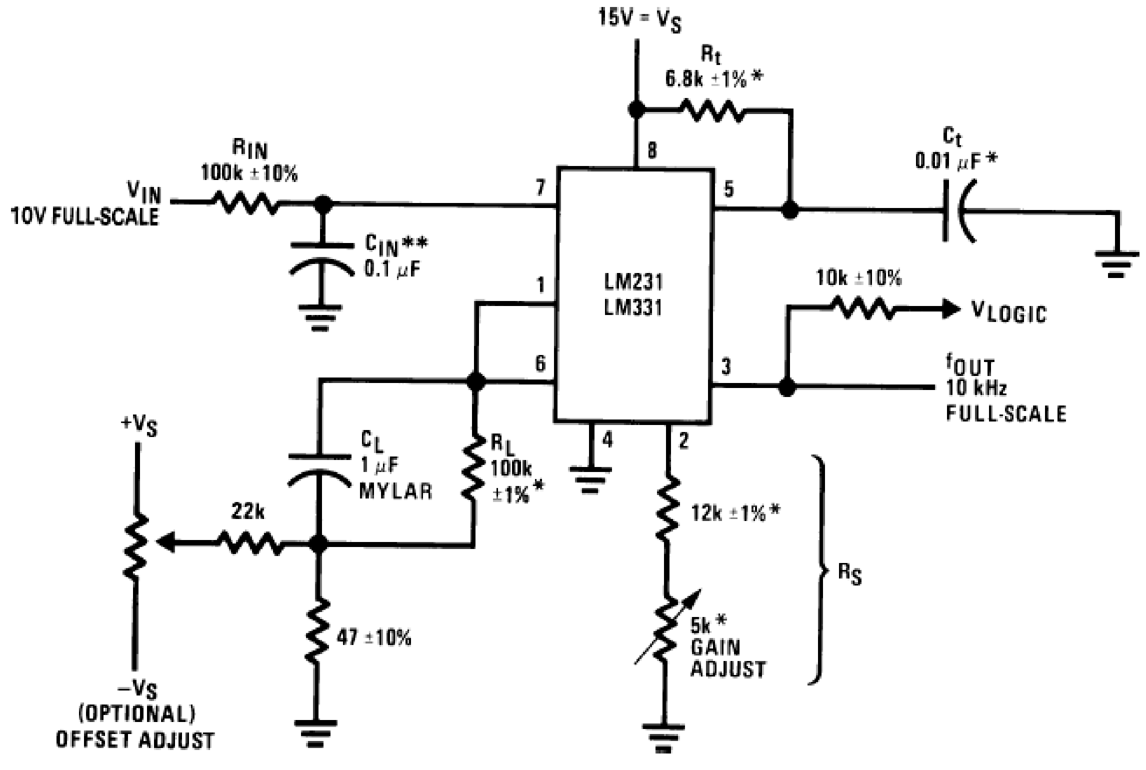
[www.ti.com]

Voltage-to-Frequency Converters

The voltage comparator compares a positive input voltage, V1, at pin 7 to the voltage, Vx, at pin 6. If V1 is greater, the comparator will trigger the 1-shot timer. The output of the timer will turn ON both the frequency output transistor and the switched current source for a period t=1.1 RtCt. During this period, the current i will flow out of the switched current source and provide a fixed amount of charge, $Q = i \times t$, into the capacitor, CL. This will normally charge Vx up to a higher level than V1. At the end of the timing period, the current will turn OFF, and the timer will reset itself.

[www.ti.com]

Voltage-to-Frequency Converters



$$f_{OUT} = \frac{V_{IN}}{2.09\ V} \bullet \frac{R_S}{R_L} \bullet \frac{1}{R_t C_t}$$

Simple Stand-Alone V-to-F Converter with ±0.03% Typical Linearity (f = 10 Hz to 11 kHz) [www.ti.com]

Bibliography:

http://www.electronics-tutorials.ws/

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