

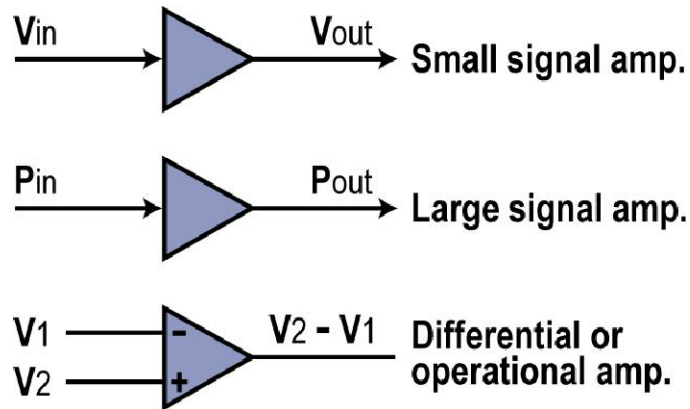
# Electronic Processes

# Electronic Processes

Most electronic circuits process electrical signals to perform some useful operation. There are only a few basic processes that are used over and over again.

These processes include amplification, attenuation, filtering, phase shifting, modulation, demodulation, frequency translation, decision-making, rectification, inversion, impedance matching, arithmetic, compression, and decompression. They are described over the next slides.

# Electronic Processes: Amplification

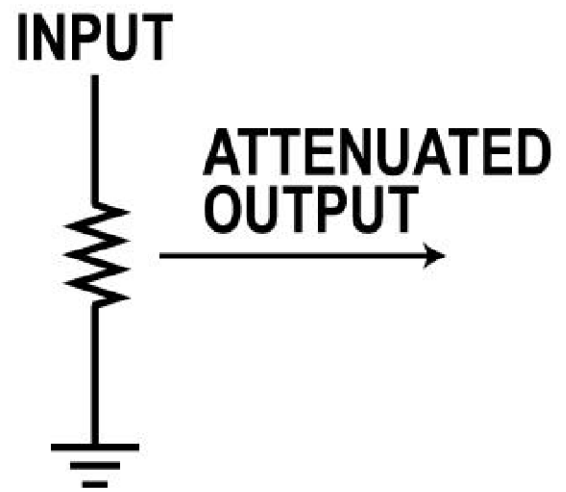


Amplification is probably the most common process. It is used to increase the voltage or power level of a signal. Most electronic signals start out very weak so they must be increased in level so that further processing can take place.

Amplifiers are usually represented by the symbol shown above. The two most common types are small signal amplifiers that increase the voltage level of a signal and large signal amplifiers that increase the power level of a signal.

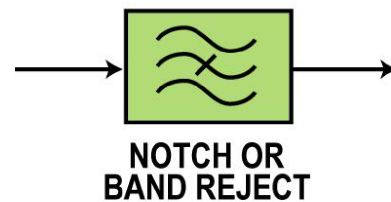
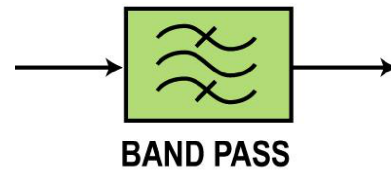
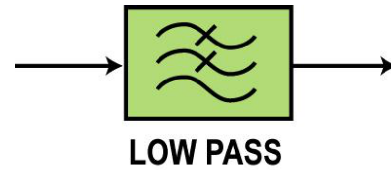
# Processes: Attenuation

Attenuation is the opposite of amplification. It is the process of reducing the voltage or power level of a signal. In some applications, the signal is too big and must be reduced before other processing. Attenuation comes from a voltage divider or other resistive network. One example is volume control. In some cases, attenuation is simply the by product of another process.



# Processes: Filtering

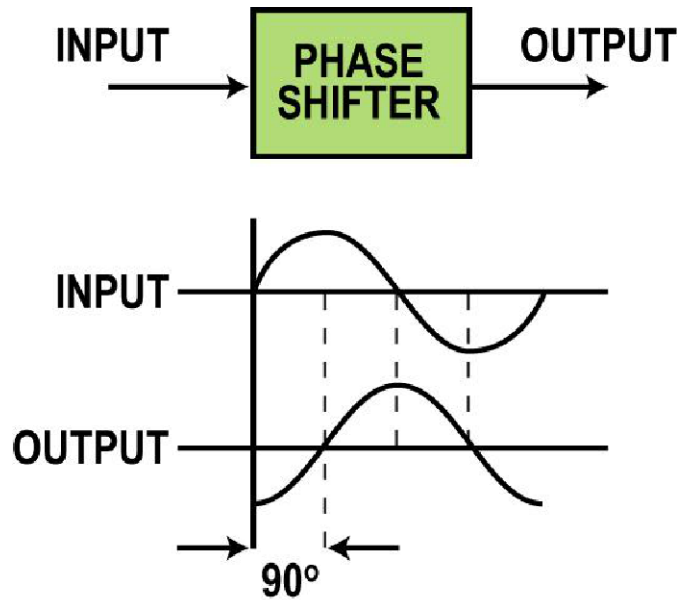
Filtering is the process of frequency selection or elimination. Most applications employ band pass, band reject, low pass, or high pass filters. These may be RC or LC passive networks, crystal, ceramic, or SAW passive filters, or active filters using RC networks and op amps, or digital signal processing (DSP) filters. The figure shows the commonly used symbols for representing filters. Note the three sine waves inside the block. A line through one or more of these sine waves indicates the type of filter as shown.



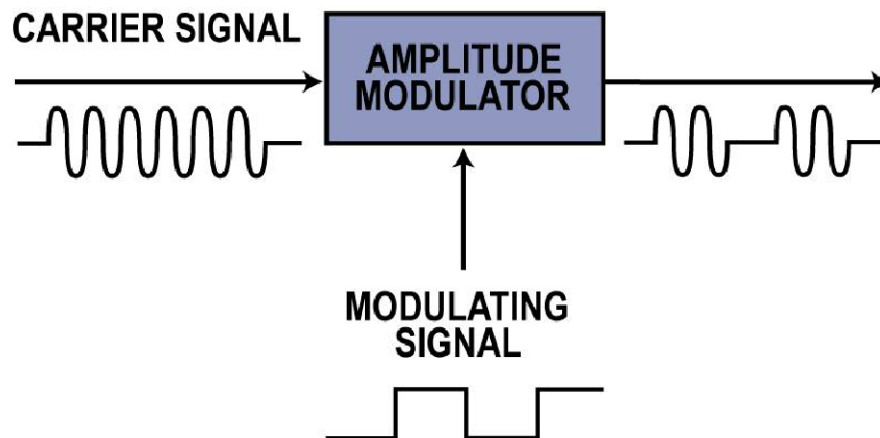
# Processes: Phase Shifting

It is often necessary to phase shift a sine wave. This is done with a phase shifter which can be an RC network, LC network, or transformer. Amplifiers and filters also introduce phase shift although this is a by product rather than a desired trait.

The most common phase shifts are  $45^\circ$ ,  $90^\circ$ , and  $180^\circ$ .

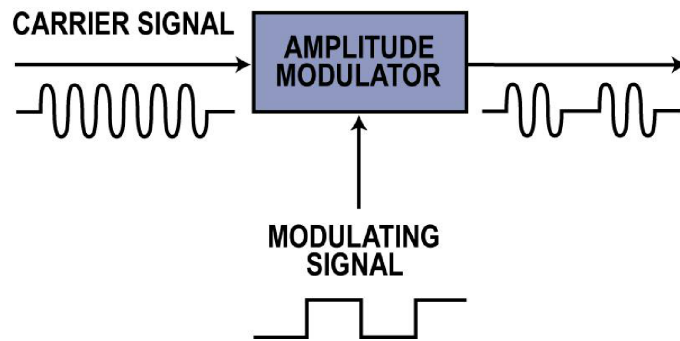


# Processes: Modulation



Modulation is the process of modifying a high frequency signal called a carrier with a lower frequency information signal for the purpose of transmitting it via radio or on a cable. Modulation makes a signal compatible with the transmission medium such as free space (radio) or a coax cable.

# Processes: Modulation and Demodulation

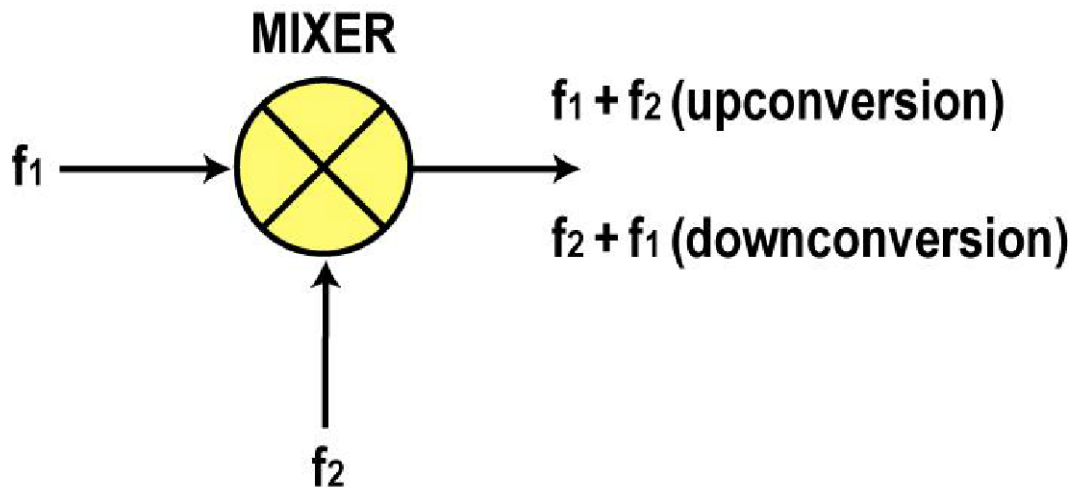


Modulation is used in every wireless application and many non-radio communications applications (e.g. cable TV). The three main types of modulation are amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM). There are many variations of each. The figure shows amplitude shift keying (ASK) used in transmitting binary data by radio.

Demodulation is the opposite of modulation. It is the process of recovering the original information signal from the transmitted carrier.



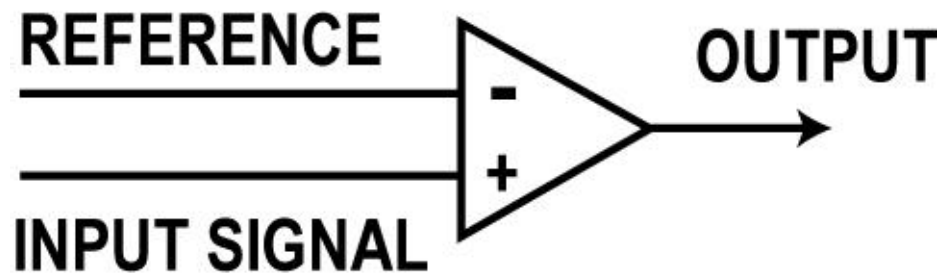
## Processes: Frequency Translation



Frequency translation, also called mixing, is used to convert a lower frequency to a higher frequency (upconversion) or a higher frequency to a lower frequency (downconversion). The circuit used is a mixer that has two inputs  $f_1$  and  $f_2$  and produces the sum and difference frequencies ( $f_1 + f_2$ ) and ( $f_1 - f_2$ ).

# Processes: Decision-Making

## Analog Comparator

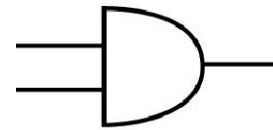


Decision-making uses input signals to make a decision such as yes-no, true-false, high-low, off-on, up-down, higher than-lower than, and so on. This is usually a digital rather than an analog process. An analog comparator, shown here, is an example.

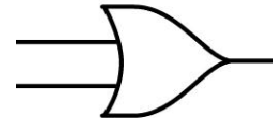
# Logic Circuits

Digital logic circuits like the AND, OR, and XOR gates shown here also make decisions.

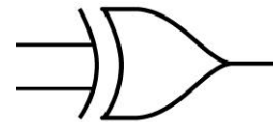
## Logic Circuits



AND gate



OR gate



XOR gate

# Processes: Rectification, Inversion, and Impedance Matching

Rectification is the conversion of AC into pulsating DC while inversion is the conversion of DC into AC.

A common need is to match the output impedance of a circuit (output impedance) to a load impedance for the purpose of achieving maximum power transfer. Impedance matching can be accomplished with a transformer, passive LC circuits, etc.

# Processes: Arithmetic

Arithmetic processes are common in digital circuits like a computer but are also found in analog circuits. Addition and subtraction are the most common math operations, but multiplication and division are also widely used. Other mathematical operations include square root, logarithms, and trigonometric functions.

Most arithmetic operations are performed in the arithmetic logic unit (ALU) of a computer or embedded controller. Analog arithmetic operations are usually performed with op amp circuits.

# Processes: Compression and Decompression

Signals are often compressed to contain their dynamic range. The dynamic range is that range from the highest to the lowest levels that exist. Compression of analog signals helps in noise reduction. Digitized signals are also compressed to reduce the number of bits needed to represent the information. Voice is compressed in cell phones and in voice over Internet Protocol (VoIP) telephones. Video is also compressed in most kinds of video transmissions (HDTV, etc.). Compressing digital data allows more of it to be stored in a memory of a given size and permits the information to be transmitted faster. MP3 players are another example of data compression.

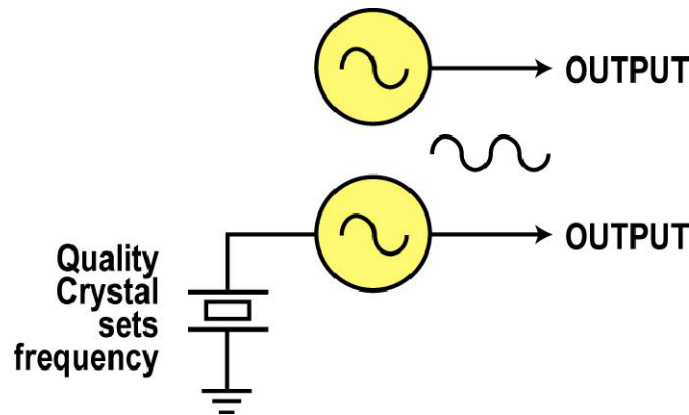
Decompression is just the reverse process of compression used to recover the original signal.

# Signal Sources

Signal sources are the circuits or other devices that actually generate the signals to be processed. These fall into two basic categories: sensors and transducers and signal generators.

Sensors or transducers are devices that sense physical characteristics and generate an output voltage in response. Solar cells, thermocouple temperature sensors, and quartz pressure sensors are examples.

# Types of Signal Generators



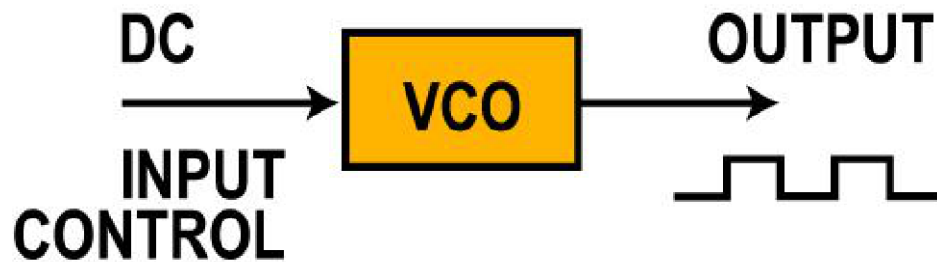
A signal generator is a circuit that generates a single frequency sine wave. An LC resonant circuit or a quartz crystal sets the frequency.

Three common types of signal generators are the clock generator, the voltage controlled oscillator, and the frequency synthesizer.

The clock generator is an oscillator that produces a rectangular wave output to operate embedded controllers, microcomputers, or other digital circuits. The frequency is set by a quartz crystal.



# VCO and Frequency Synthesizer

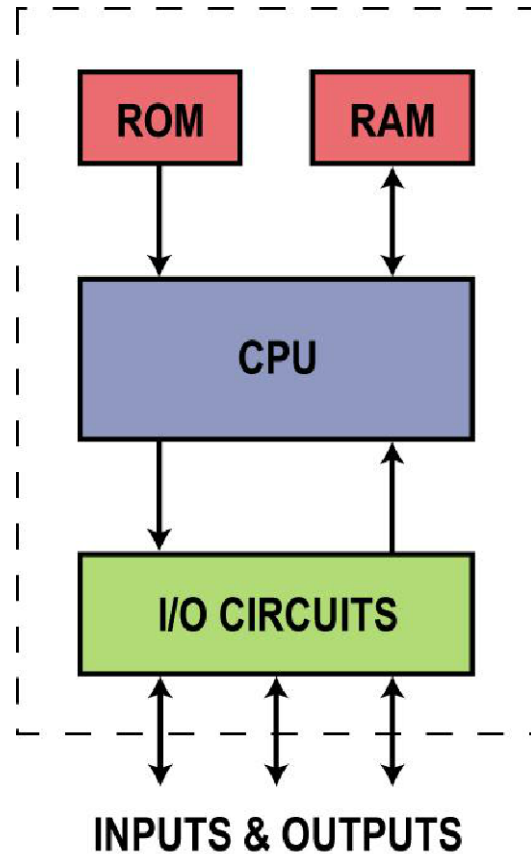


A voltage controlled oscillator (VCO) is an oscillator whose frequency can be changed by a DC input control voltage as shown in the figure.

A frequency synthesizer is a special type of oscillator or clock whose output frequency is adjustable in steps or increments and can be set by some external digital input.

# Embedded Controller

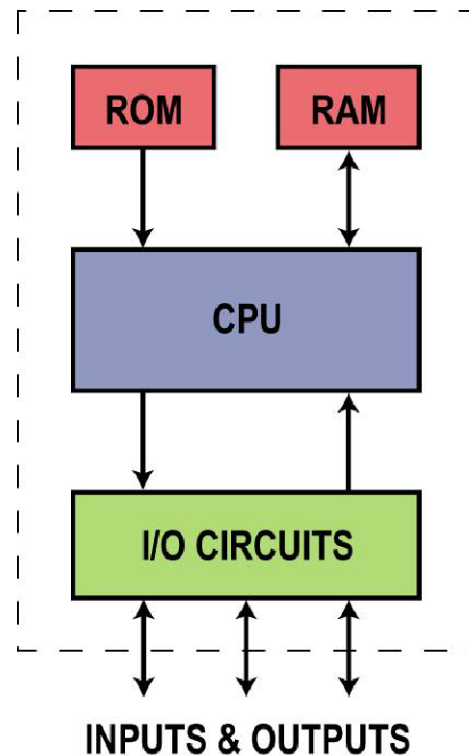
An embedded controller, also called a microcomputer, is a single chip computer. It is an IC containing a central processing unit (CPU), memory, and input/output (I/O) circuits.



# Embedded Controller Operation

A control program is stored in the read-only memory (ROM). When executed by the controller, this program performs any one or more of an almost unlimited number of input monitoring or output control functions. The data to be processed is stored in a random access (read/write) memory (RAM). The embedded controller communicates with the external devices and circuits through its I/O lines.

Virtually all electronic equipment today contains one or more embedded controllers.



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