Control Systems

Control System Fundamentals

A control system is an electrical, electronic, or mechanical system, or some combination of the three, that is used to perform a control function. Control means making adjustment to the system output to fit necessary or desired conditions. Some examples are the speed control of the motor on a CD player, the physical position of a robot arm, the liquid level in a tank, or the temperature in a house.

Control systems usually monitor some variable such as position, speed, level, or temperature then make adjustments as necessary to bring the system into compliance with some predetermined condition.

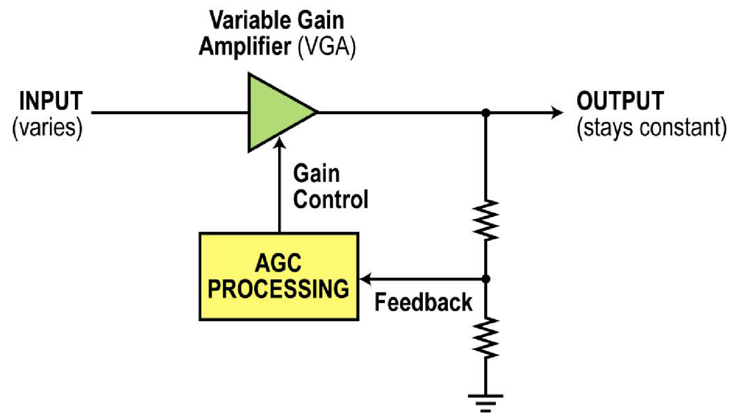
The key characteristic of most control systems is the presence of feedback. Feedback permits control systems to be fully automatic.

Types of Control Systems

The two main types of control systems are open loop and closed loop. The open loop system is designed such that with a specific input it gives the desired output to achieve the desired performance. Any example is an amplifier with a gain of 15. This gain was selected during the design because with a given input, the output level is that needed for the desired output.

A closed loop system is one in which feedback is used to produce automatic control of the output. Feedback is a signal derived from the output that is sent back to the input or processing circuits that will change the output in such a way as to maintain a desired output condition. An amplifier with automatic gain control (AGC) is an example.

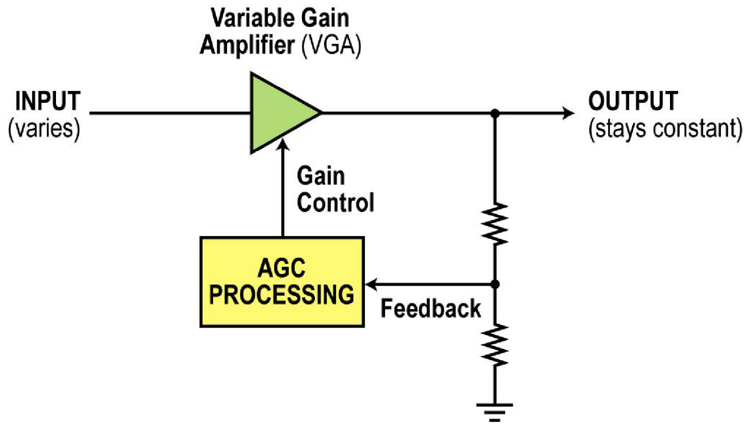
Automatic Gain Control (AGC)



AGC is used in amplifiers where a desired output voltage is needed but the input signal level varies over a wide range. If the amplifier has a fixed gain, then at some times the input is too low to give the desired output. At other times, the input signal is too high and will give more than the desired output or distortion will occur.

AGC is a closed loop system that monitors the output and produces a feedback signal that is then processed in such a way as to control the gain of the amplifier so that the output is always the same.

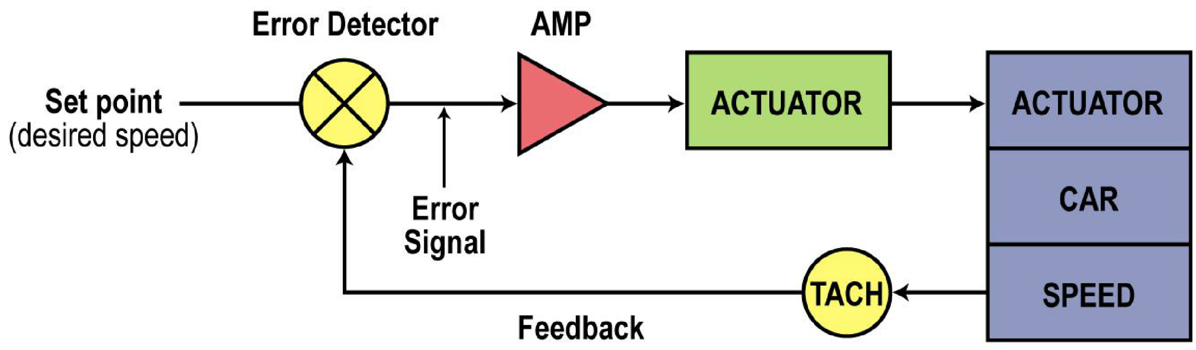
Automatic Adjustment



If the input signal increases, the output will increase. This output increase will be fed back to the AGC control circuits. The AGC control then reduces the gain to give the desired output. If the input signal level is too low, the feedback tells the AGC control to increase the amplifier gain to deliver the desired output.

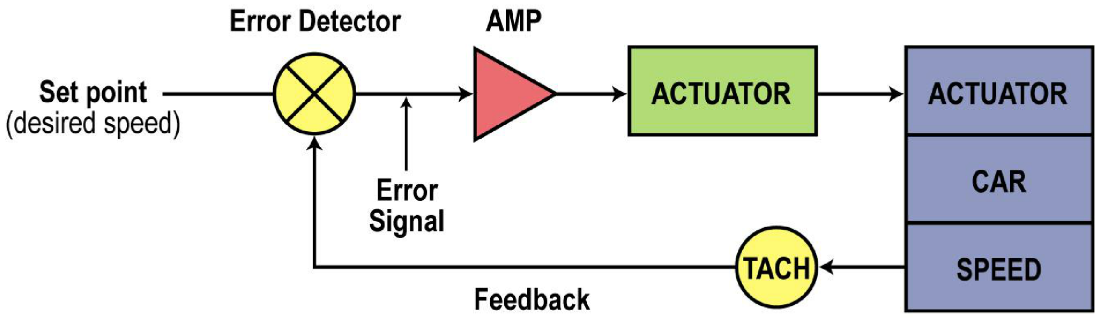
Closed loop systems like this provide automatic adjustment of conditions to maintain a desired output condition known as the set point.

Automatic Control System Example



A block diagram of an automatic (ACS) control system is given above. This is an automatic cruise control system in a car that maintains a constant speed. The input is a signal called the set point that determines what the output will be. It is derived from the present speed. This set point signal is fed to an error detector circuit along with the feedback signal. The error detector compares the set point to the feedback. If the two are the same, there is no error output so no corrective action is taken.

ACS Error Detection



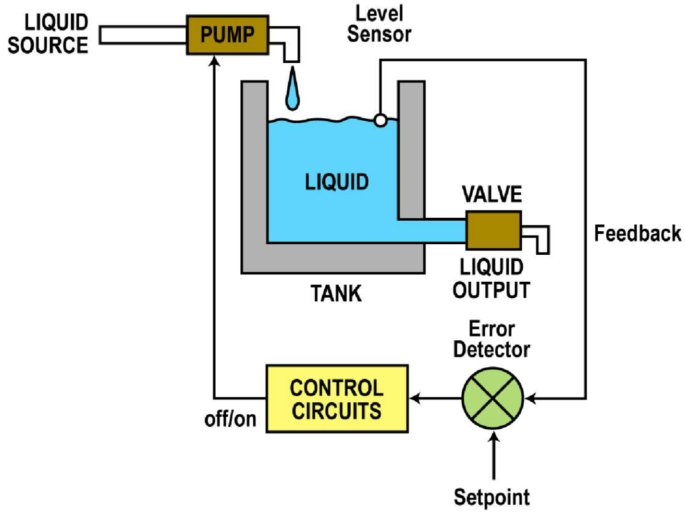
The output speed is determined by a tachometer circuit that develops a signal proportional to speed that is sent to the error detector.

However, if the output deviates from the set point value, the error detector will produce an output that is amplified and used to vary the output to bring it back to the set point value and reducing the error to zero. The output signal controls an actuator that varies the speed by controlling the fuel injection as if it were being controlled by the accelerator pedal.

ACS: Temperature Example

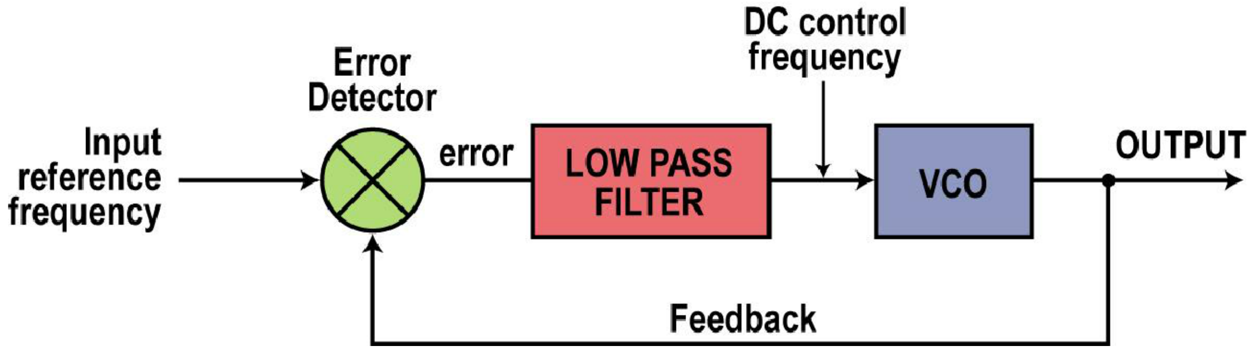
The temperature thermostat on a home heating/air conditioning system is a feedback control system. The temperature is set with a control. The temperature is measured. If it is too cold, the heating system turns on and raises the temperature to the set point at which time the heating system is turned off.

ACS: Liquid Level Example



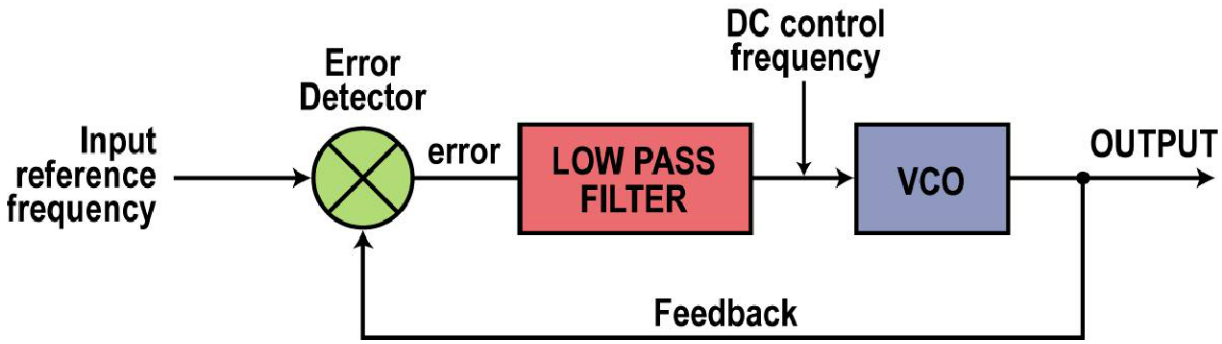
The liquid level in a tank is another example. A liquid level sensor detects the presence of the liquid level. This gives the desired set point. If during some process, the liquid is drained or pumped out, the level drops. The level sensor then provides feedback signaling the control circuits to turn on a pump that will begin refilling the tank. When the desired level is reached, the pump turns off. As you can see, the tank level automatically remains the same during usage.

Phase-Locked Loop



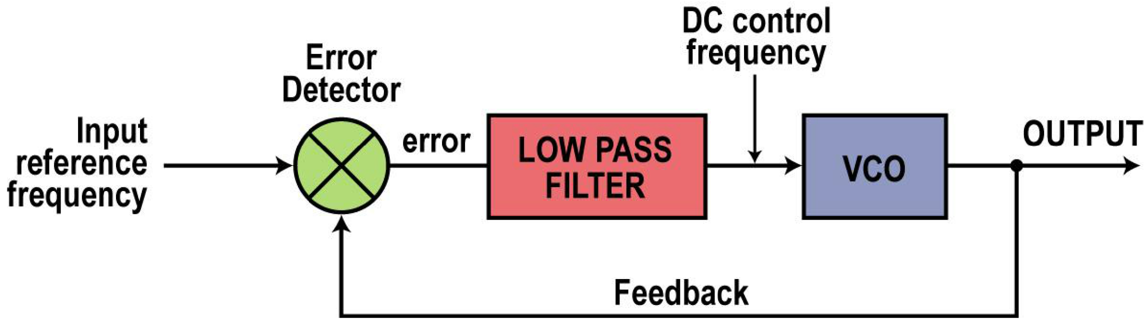
The phase-locked loop (PLL) is a widely used electronic circuit as a feedback control circuit. The set point input is a signal of a specific frequency. It is applied to the phase detector that is used as an error detector. The output is generated by a voltage controlled oscillator (VCO). The VCO output frequency is determined by a DC input control voltage.

VCO Output



The VCO output is fed back to the phase detector where it is compared to the input set point frequency. If the two frequencies are different, the phase detector will produce an output that is proportional to the phase/frequency difference between them. This error signal is filtered into a DC control voltage which is then used to vary the VCO output frequency. The adjustment is such that the VCO output frequency becomes equal to the input frequency. When the two signals are equal, the PLL is said to be "locked" and in a stable condition.

Automatic Adjustment



Any change in the output frequency or set point input frequency will result in automatic adjustment of the VCO frequency to make it equal to the input frequency. The output will track the input.

For greater detail, see the WRE module on PLLs.

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Control Systems

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