La Trobe University
Department of Electronic Engineering
ELE2EMI
Electronic Measurements and Instrumentation
Lecture 5: Special-purpose Laboratory Amplifiers

0. Outline

- Problems
- Signal filters
- Chopper amplifiers
- Carrier amplifiers

1. Problems in measurement systems

- In a measurement system, the presence of noise is inevitable. An undesired voltage or current appearing in an electronic circuit is referred to as noise. Noise can arise in many different ways, to which some can be eliminated, but others are unavoidable and can merely be minimised. Electronic components, such as resistors, transistors or op-amps, produce noise. Noise is also generated by the electro-magnetic interference in the measurement environment. A special type of noise encountered in an op-amp is the drift of the output DC level caused by some minor variation in the input circuit. It is most often the result of slow temperature changes.

- Noise is usually specified in terms of nanovolts per square root hertz. A typical low-cost op-amp has a noise specification of 100 nV / $\sqrt{Hz}$.

- A drift is specified by the voltage change per degree, e.g. 50 μV/°C. This indicates that the output voltage will increase 50 μV as the temperature increases one degree.

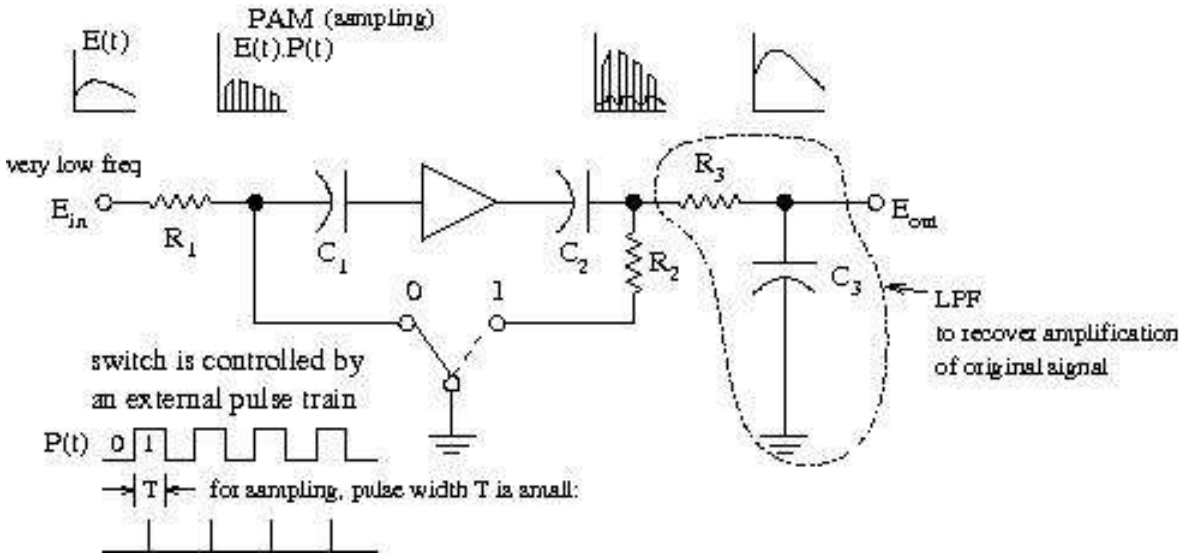
- The basic technique to filter out noise is based on the assumption that the bandwidth of the signal being measured is narrower than that of noise. To solve the drift problem, an AC amplifier can be used.

2. Signal filters

A low pass filter can be used to filter out the high frequency component of noise. If the measured signal contains only frequencies in a bandwidth from DC to a limit f_1, then a low pass filter with cut off frequency greater than f_1 will effectively remove noise whose frequencies are greater than f_1. For a bandpass signal (such as an AM signal), a bandpass filter can be used. An interesting case occurs if the signal is wideband but is also steady during the time of measurement. A typical example is a video camera capturing a still scene. Noise due to the imaging system can be effectively removed by averaging many frames of the captured image of the same scene. This is because the video signal remains unchanged as long as the scene is not changed. Therefore, the averaging has no effect on the video signal. On the other hand, because noise is assumed to have zero mean, the averaging process will significantly reduce noise.

3. Chopper amplifiers

A chopper amplifier is an instrument that includes a pulse amplitude modulator, followed by an amplifier and a demodulator. As shown below, a very low frequency signal is modulated to high frequency by the pulse amplitude modulator, then the modulated signal is amplified (by an AC amplifier) to the required value, and the amplified original is recovered by a demodulator. The use of an AC amplifier solves the problem of voltage drift, while the modulation and demodulation process can be configured to reject wideband noise (by adding an appropriate narrow bandpass filter).



4. Carrier amplifiers

A carrier amplifier is any type of signal-processing amplifier in which the signal carrying the desired information is modulated onto another signal, i.e. the "carrier". The chopper amplifier can be regarded as a carrier amplifier. The carrier amplifier can be DC-excited or AC-excited. Shown below is a DC-excited carrier amplifier. The principle of a carrier amplifier is basically the same as that of the chopper amplifier.