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Study of Active Filters

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ABSTRACT

In recent years research on active filters has increased. Active Filters are basically a type of an analog electronic filter that uses active components such as an Amplifier. Amplifiers involved in a filter design can be used to improve the filter's performance and predictability, while avoiding the need for inductors (which are typically expensive compared to other components). An amplifier prevents the load impedance of the following stage from affecting the characteristics of the filter. This paper presents a review of Active Filters, comparison between Active and Passive Filters, types of Active Filters, present status of active filters. In near future term "Active Filters" will have much wider scope than it has now.

Index Term— ***Amplifier, Bandwidth, Filters, Frequency, Impedance, Noise.***

INTRODUCTION

In circuit theory, filter is an electric network that alters amplitude and/or phase characteristics of signal with respect to frequency. Ideally filter will not add any new frequency to the input nor it will change the frequency component of that signal but it will change amplitude and their phase relationships. An Active Filter uses amplifiers (usually operational amplifiers) along with resistors and capacitors to do the filtering. Inductors, which can be large and bulky, are not needed. Usually operational amplifiers (or op-amps) allow you to easily make many different kinds of filters. An Amplifier prevents the load impedance from affecting the characteristics of the filter. The shape of response, tuned frequency and Q (quality factor) can frequently be set with cheap variable resistors. In active filter circuits we can adjust one parameter without affecting the other. Since their basic compensation principles were proposed around 1970, much research has been done on active filters and their practical applications. Furthermore, the reliability is the key factor to evaluate the performance of the components, which is calculated by the failure rate of the components over the prescribed time period of use under various operating conditions. Moreover, the reliability of these components is varying by the selection of composition of the material as well as fabrication process. The reliability prediction (RP) is measured during the design and development phase, and the operation and maintenance phase at various system levels in order to evaluate, determine and improve the dependability of the component. To get the highly reliable active filters, various electronic industries are still struggling in the selection of reliable components. In this paper, we have analysed the different types of resistors and capacitors to evaluate the reliability and performance of the low pass active filters based on the empirical prediction method. In addition, power electronics technology has enabled engineers to put active filters into practical use. An Active Filter is also known as active power line conditioner, instantaneous reactive power compensator and active power filters. There are four main filter shapes: Low Pass, High Pass, Band Pass, and Band Reject (or Band Stop).

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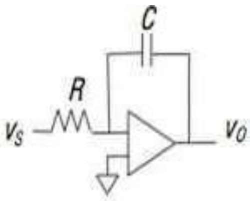
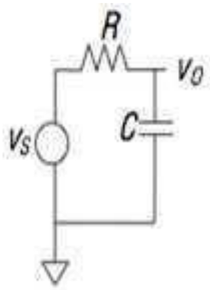
COMPARISON BETWEEN ACTIVE AND PASSIVE FILTERS

S No.	ACTIVE FILTERS	PASSIVE FILTERS
1	No inductors are required.	Large inductors are required for low frequencies.
2	It requires many components.	Least components are required.
3	Power Supply required.	No power supply required.
4	Op-amp provides gain and overcome circuit losses.	No power gain and voltage gain is possible.
5	High Zin and low Zout.	Low Zin and high Zout.
6	Noise arises from Op-amp.	Noise arises from resistance only.
7	No risk of overload and damage due to increase in current.	Risk of overload and damage due increase in current.



Active Filter



Passive Filter
Fig: 1

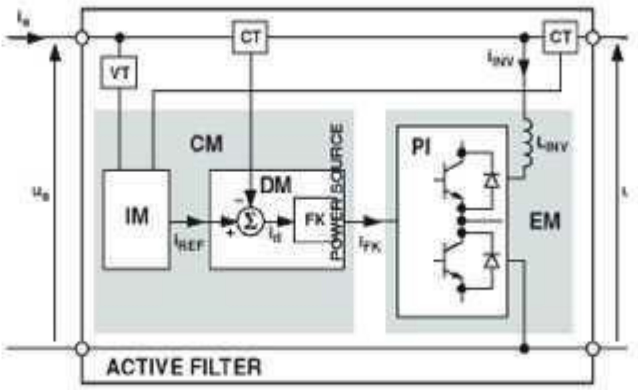


Fig 2: Block diagram of active filter

CLASSIFICATION OF ACTIVE FILTERS

The most widely used Active Filters are:

- Active Low-Pass filter
- Active High-Pass filter
- Active Band-Pass filter
- Active Band-Stop filter (also called as Band Reject and Band- Elimination/Notch)
- Active All-Pass Filter

Active Low-Pass filter

A low-pass filter is a filter that passes signals with a frequency lower than a particular cut off frequency and attenuates signals with frequencies higher than the cut off frequency. The amount of attenuation for each frequency component depends on the filter design. The filter is sometimes called a high- cut filter, or treble cut filter in audio applications. The circuit has been shown in fig 3 and frequency response in fig 4.

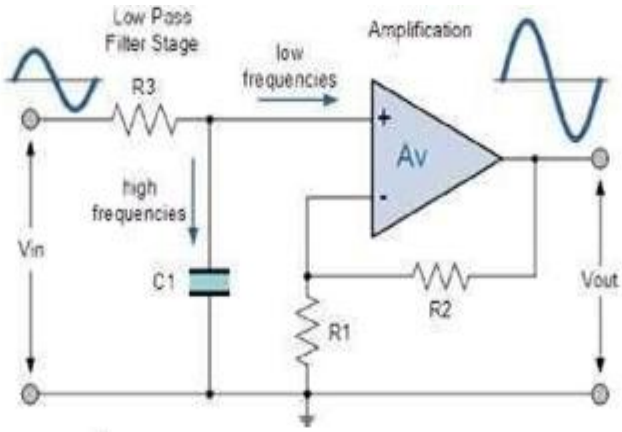


Fig 3: Active Low Pass Filter Circuit

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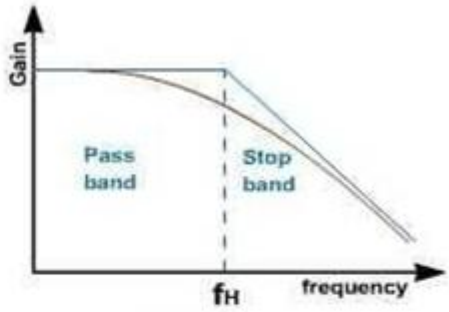


Fig 4: Frequency Response of Low Pass Filter

Active High-Pass filter

A high-pass filter (HPF) is an electronic filter that passes high frequency signals but attenuates signals with frequencies lower than the cut off frequency [1]. The actual amount of attenuation for each frequency component varies from filter to filter. A high pass filter is usually modelled as a linear time-invariant system. It is sometimes called a low-cut filter or bass cut filter. Fig 4 shows the circuit diagram and fig 5 shows the frequency response.

Fig 5: Active High Pass Filter circuit

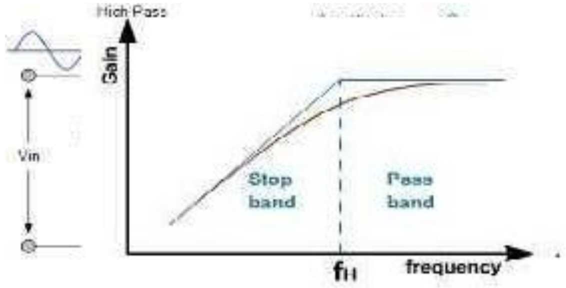
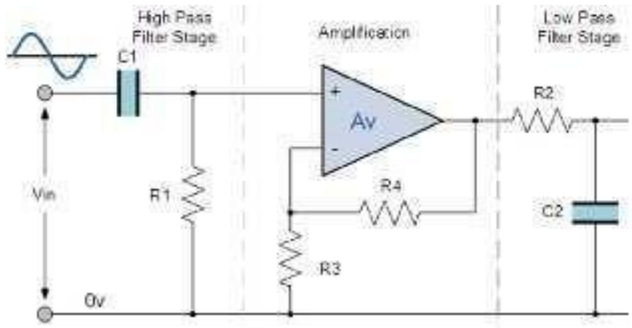


Fig 6: Frequency Response of High Pass Filter

Active Band-Pass Filter

As the name implies a band pass filter is one where only a particular band of frequencies are allowed through. All frequencies outside the required band are attenuated. There are two main areas of interest in the response of the filter. These are the pass-band where filter passes signals and the stop-band where signals are attenuated. As it is not possible to have an infinitely steep roll off, there is an area of transition outside the pass-band where the response is falling but has not reached the required out of band attenuation. Fig 6 shows the circuit diagram and fig 7 shows the frequency response.



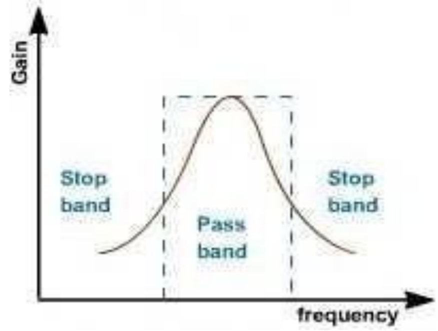


Fig 8: Frequency Response of Active Band pass Filter

Active Band-Stop filter

Also known as band-elimination, band-reject, or band notch filters, this kind of filter passes all frequencies above and below a particular range set by the component values. It can be made out of a low-pass and a high-pass filter, just like the band-pass design, except that this time we connect the two filter sections in parallel with each other instead of in series.

Fig 8 shows the circuit diagram and fig 9 shows the frequency response.

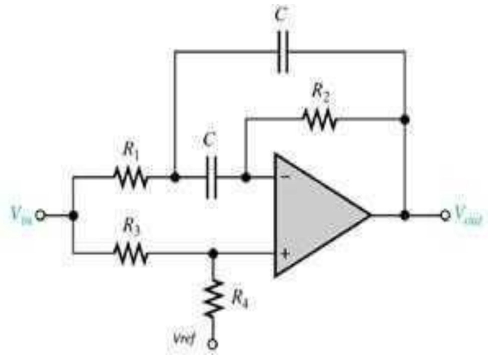


Fig 9: Active Band Stop Filter Circuit Filter

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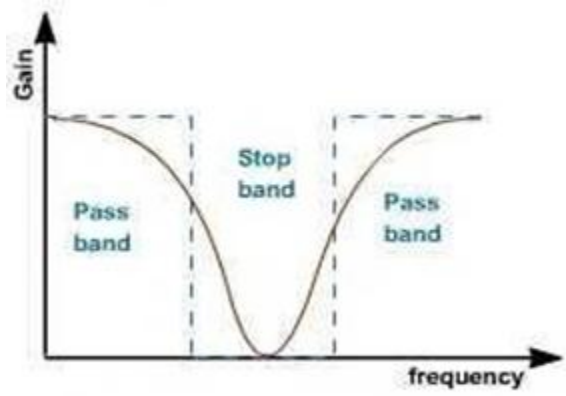

Fig: Frequency Response of Active

Active All-Pass Filter

An all-pass filter is a signal processing filter that passes all frequencies equally in gain, but alters the phase relationship between various frequencies. It does this by varying its phase shift as a function of frequency.

Generally, the filter is described by the frequency at which the phase shift crosses 90° (i.e., when the input and output signals go into quadrature – when there is a quarter wavelength of delay between them).

They are generally used to compensate for other undesired phase shifts that arise in the system, or for mixing with an unshifted version of the original to implement a notch comb filter. Fig 10 shows the circuit diagram and fig 11 shows the frequency response.

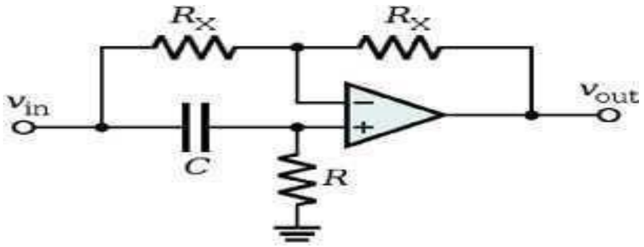

Fig 11: Active All Pass Filter circuit

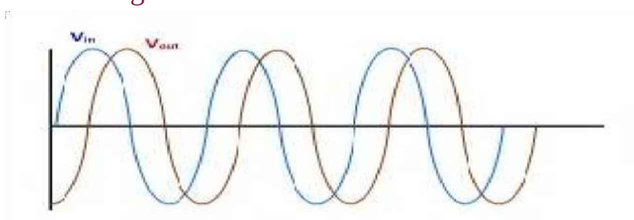

Fig 12: Frequency Response of Active All Pass Filter

ACTIVE FILTERS DESIGN TECHNIQUES

There are four most common techniques and the one discussed in this paper are: A. Butterworth B. Chebyshev C. Bessel D. Elliptical There are many more but 90% of all applications can be solved with one of the above implementations. A. Butterworth The Butterworth implementation ensures flat response ('maximally flat') in the pass band and an adequate roll-off. This type of filter is a good 'all-rounder', simple to understand and is good for applications such as audio processing. B. Chebyshev The Chebyshev implementation gives a much steeper roll-off, but has ripple in the pass band, so it is of no use in audio systems. It is however; far superior in applications where there is only one frequency present in the pass band but several other frequencies that are needed to remove (e.g. deduce a sine wave from a square wave by filtering out the harmonics). C. Bessel The Bessel filter shows a constant propagation delay across the input frequency spectrum. Therefore, applying a square wave (consisting of a fundamental and many harmonics) to the input of a Bessel filter will give a 'square' wave on the output with no overshoot (i.e. all the frequencies will be delayed by the same amount). Any other filter will delay different frequencies by different amounts and this will manifest itself as overshoot on the output waveform. D. Elliptical There is the one more popular implementation, the Elliptical Filter that is a much more complicated. Similar to the Chebyshev response, it has ripple in the pass band and severe roll-off at the expense of ripple in the stop band. Fig 12 shows the frequency response curve of all the four techniques.

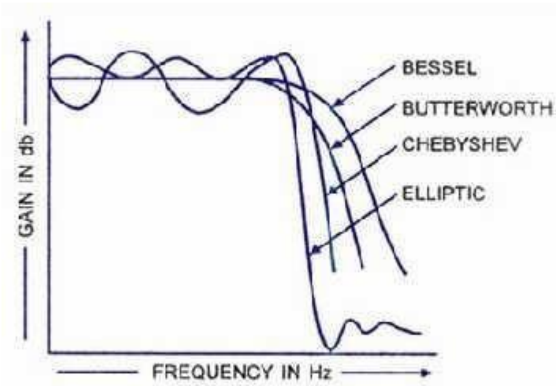

Fig 13: Frequency Response Curve

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NEW TRENDS IN ACTIVE FILTERS

At Present, attention has been paid to active filters for power conditioning which provides multifunction like reactive power compensation, harmonic compensation, flicker compensation and voltage regulation. Active Filters of range 50kVA-60MVA have been practically installed in JAPAN. In Future "Active Filter" will have much wider meaning then it did in the past [5]. For instance, active filters intended for harmonic solutions are expanding their functions from harmonic compensation of nonlinear loads into harmonic isolation between utilities and consumers, and harmonic damping throughout power distribution systems.

ADVANTAGES

Active filters have many advantages over passive filters:

- Active filters are more economical than passive filters.
- The components used in active filters are smaller in size then passive filters.
- In active filters as an OP-AMP can provide a gain, the input signal is not attenuated and active filters are easy to tune so easy frequency adjustment is possible.
- It does not exhibit any insertion loss. v. It also allows for interstate isolation control of input and output impedance.

APPLICATIONS

- In communication Systems, active filters are used to suppress noise, to isolate a single communication from many channels, to avoid spill over of adjacent bands and to recover the original message signal from modulated signal.
- In instrumentation systems, engineers use filters to select a desired frequency component and remove undesired ones. We can use these filters to limit the bandwidth of analog signals before converting them to digital signals. You also need these signals to convert digital signals back to analog signals.
- In audio systems, engineers use these filters in crossover networks to send different frequencies to different speakers. In music industry record and playback applications require control of frequency components.
- In biomedical systems, these filters are used to interface psychological sensors with data logging and diagnostic equipment's.

FUTURE SCOPE

At present, active filters are well developed and many manufacturers are fabricating it with large capacities. Utilities in the long run will influence consumers with nonlinear load to use the active filters for maintaining the power quality at efficient levels [10]. A large number of active filter's configuration will be available to compensate harmonic current, reactive power, neutral current and unbalanced current. The consumer can select the active filter with required features in the near future.

CONCLUSION

This paper gives brief review about active filters. A comparison between active and passive filters, types of active filters, active filter techniques have been given in this paper. New trends in active filters are also described. It is interesting that advancement in active filters has made a great contribution in power conditioning for power quality improvement. The advanced active filters characterized by low-cost, high efficiency, high-performance, and value-added functions for the customers will come onto the market in the near future, thus being viable and cost-effective in power conditioning. In this paper we have been also discussed about advantages, applications and future scope of active filters.

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