ACTIVE AND PASSIVE FILTERS

Comparison:

The simplest approach to building a filter is with passive components (resistors, capacitors, and inductors). In the R-F range it works quite well but with the lower frequencies, inductors create problems. AF inductors are physically larger and heavier, and therefore expensive. For lower frequencies the inductance is to be increased which needs more turns of wire. It adds to the series resistance which degrades the inductor's performance.

Input and output impedances of passive filters are both a problem, especially below RF. The input impedance is low, that loads the source, and it varies with the frequency. The output impedance is usually relatively high, which restricts the load impedance that the passive filter can drive. There is no isolation between the load impedance and the passive filter. Thus the load will have to be considered as a component of the filter and will have to be taken into consideration while determining filter response or design. Any change in load impedance may significantly alter one or more of the filter response characteristics.

An active filter uses an amplifier with R-C networks to overcome these problems of passive filters. Originally built with vacuum tubes and then transistors, active filters now normally are centered around op-amps. By enclosing a capacitor in a feedback loop, the inductor (with all its low frequency problems) can be eliminated. By proper configuration input impedance can be increased. The load is driven from the output of the op-amp, giving a very low output impedance. Not only does this improve load drive capability, but the load is now isolated from the frequency determining network. Thus variation in load will have no effect on the characteristics of the active filter.

The amplifier allows us to specify and easily adjust passband gain, passband ripple, cutoff frequency, and initial roll-off. Because of high input impedance of the op-amp, large value resistors can be used and therefore size and cost of the capacitors used are reduced. By selecting a quad op-amp IC, steep roll-off can be built in very little space and at very little cost.

Active filters also have their limitations. High frequency response is limited by the gain bandwidth (GBW) and slew-rate of the op-amps. High frequency op-amps are expensive, making passive filters a more economical choice for RF applications. Active filter needs a power supply. For op-amps this may be two supplies. Variations in the power supplies output voltage may affect, to some extent, the signal output from the active filter. In multi-stage applications, the common power supply provides a bus for high frequency signals. Feedback along the power supply lines may cause oscillations unless decoupling techniques are rigorously applied. Active devices, and therefore active filters, are much more susceptible to RF interference and ionization than are passive R-L-C filters. Practical considerations limit the Q of the bandpass and notch filters to less than 50. For circuits requiring very selective (narrow) filtering, a crystal filter, because of its high Q value, will prove to be the best.

Although active filters are most widely employed in the field of communications and signal processing, they are used in one form or another in almost all sophisticated electronic systems. Radio, TV, telephone, RADAR, space-satellites, and biomedical equipment are but a few systems that make use of active filters.

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