Phase modulation also has this property and, in fact, all the noise-immunity properties of FM except the noise triangle. Since noise phase-modulates the carrier (like the signal), there will naturally be no improvement as modulating and noise sideband frequencies are lowered, so that under identical conditions FM will always be 4.75 dB better than PM for noise. This relation explains the preference for frequency modulation in practical transmitters.

Bandwidth and maximum deviation cannot be increased indefinitely, even for FM. When a pulse is applied to a tuned circuit, its peak amplitude is proportional to the square root of the bandwidth of the circuit. If a noise *impulse* is similarly applied to the tuned circuit in the IF section of an FM receiver (whose bandwidth is unduly large through the use of a very high deviation), a large noise pulse will result. When noise pulses exceed about one-half the carrier size at the amplitude limiter, the limiter fails. When noise pulses exceed carrier amplitude, the limiter goes one better and limits the signal, having been "captured" by noise. The normal maximum deviation permitted, 75 kHz, is a compromise between the two effects described.

It may be shown that under ordinary circumstances ($2V_n < V_c$) impulse noise is reduced in Fm to the same extent as random noise. The amplitude limiter found in AM communications receivers does not limit random noise at all, and it limits impulse noise by only about 10 dB. Frequency modulation is better off in this regard also.

5-2.2 Pre-emphasis and De-emphasis

The noise triangle showed that noise has a greater effect on the higher modulating frequencies than on the lower ones. Thus, if the higher frequencies were artificially boosted at the transmitter and correspondingly cut at the receiver, an improvement in noise immunity could be expected, thereby increasing the signal-to-noise ratio. This boosting of the higher modulating frequencies, in accordance with a prearranged curve, is termed *pre-emphasis,* and the compensation at the receiver is called *de-emphasis*. An example of a circuit used for each function is shown in Figure 5-7.

Take two modulating signals having the same initial amplitude, with one of them pre-emphasized to twice this amplitude, whereas the other is unaffected (being at

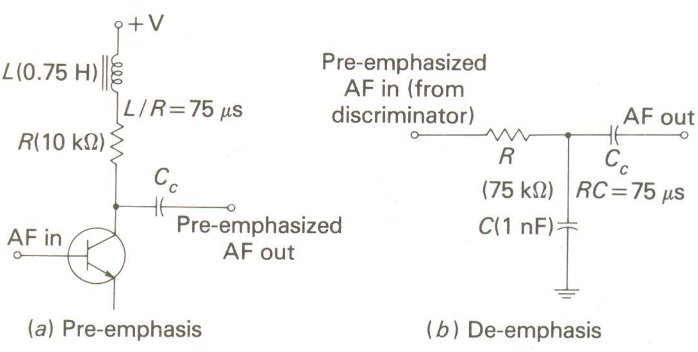

FIGURE 5-7 75-μs emphasis circuits.