

Preferred-Value Attenuators

Choosing Suitable Resistors from a Limited Range

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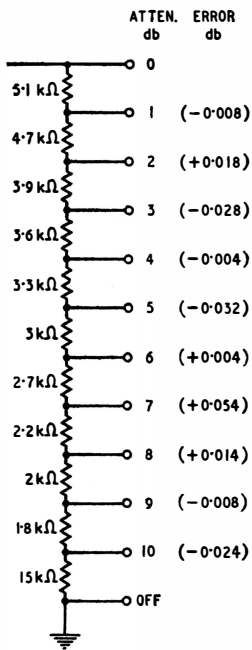


Fig. 1. Potentiometer giving attenuation of 1 db per stud, with maximum errors of -0.032 db and $+0.054$ db. Total grid-earth resistance is 47.3 k Ω .

IN audio engineering the demand often arises for a stepped attenuator in the form of a grid potentiometer, the steps giving equal increments of attenuation of one or more decibels. For many applications the accuracy, and hence the cost, of a commercially obtainable precision attenuator is not justified.

It is perhaps not generally realized that a very useful range of potentiometers can be constructed, using preferred-value carbon resistors and ordinary wafer type switches. The maximum possible error introduced by the preferred values can, for the purposes of computation, be broken down into two components: (a) a maximum standing error of about $+0.1$ db, representing the difference between the ideal calculated resistance and the nominal value of the nearest preferred resistor; and (b) an error representing the greatest deviation from the *mean error* of all the resistors used. To make (b) a little clearer, we will take an example. Supposing that we decide to use resistors of ± 5 per cent tolerance, we may find in practice that all the samples chosen fall between $+2$ per cent and $+4$ per cent of their nominal value. The *mean error* of the resistors is then $+3$ per cent, and the greatest deviation from this is ± 1 per cent, representing 0.09 db. So for this particular example we see that the maximum possible error in the attenuator, (a) plus (b), will be 0.1 db $+ 0.09$ db = 0.19 db, say 0.2 db. This assumes the worst case, of course, when both the components (a) and (b) are additive on the same resistor, and in general the actual errors encountered will probably be considerably less than this value.

With the figures quoted in the above example, the overall resistance of the potentiometer will be about 3 per cent above the designed value, due to the mean error in the resistors, but this fact is usually of no consequence. The first example is a potentiometer having a nominal resistance of 50 k Ω , suitable for working into a triode grid. Attenuation is provided in ten steps of 1 db, together with an "off" position.

The appropriate resistance values are as shown in Fig. 1, and it will be noticed that all the figures quoted appear in the list of preferred values. The total resistance works out at 47.3 k Ω , which is sufficiently near the nominal total of 50 k Ω for most practical applications. The resistors are assembled on a single-pole 12-way make-before-break wafer switch, which provides the click action usually desirable with step type attenuators. Obviously this selection of values is equally applicable in any decade, say, for a 500 - Ω or 500 -k Ω nominal potentiometer, but the values must not be transposed to give other totals.

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Higher Values of Attenuation

Another example sometimes useful is a potentiometer giving attenuation of 10 db per step. Here each two steps give 20 db loss, a resistance ratio of 10:1, so that we require only two values, repeated as often as required in successive decades. Suitable figures are 68 and 22, with 10 between the lowest stud and earth, and a 100-k Ω potentiometer based on these numbers is shown in Fig. 2. The range of attenuation has been limited to 60 db because it is not practicable to exceed this value for normal applications, on account of the peak-signal/noise ratio of the following valve.

In this example it would be permissible to add an extra resistance of 220 k Ω at the upper end to give the potentiometer shown in Fig. 3, which has a total resistance of 320 k Ω . Note that the resistances at the lower end are not changed. Owing to Miller capacity

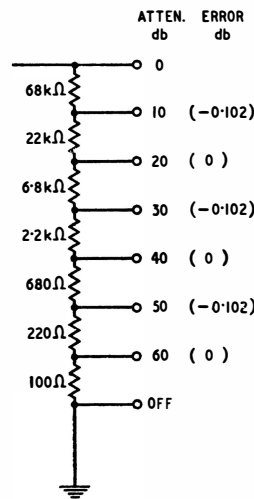


Fig. 2. Potentiometer giving attenuation of 10 db per stud, with a maximum error of -0.102 db. The total resistance is 100 k Ω .

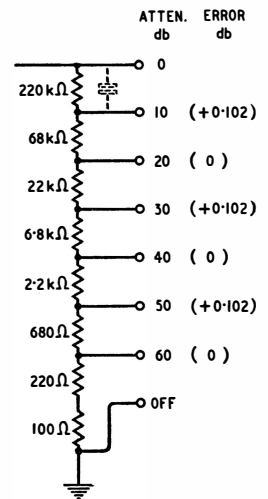


Fig. 3. Potentiometer giving attenuation of 10 db per stud, with a maximum error of $+0.102$ db. The total resistance is 320 k Ω .

