Preferred-Value Attenuators

Choosing Suitable Resistors from a Limited Range

By

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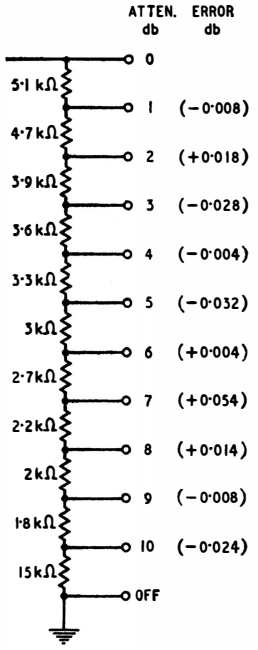


Fig. 1. Potentiometer giving attenuation of 1 db per stud, with maximum errors of − 0.032 db and + 0.054 db. Total grid-earth resistance is 47.3 kΩ.

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 kΩ, 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 kΩ, which is sufficiently near the nominal total of 50 kΩ 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-kΩ nominal potentiometer, but the values must not be transposed to give other totals.

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-kΩ 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 kΩ at the upper end to give the potentiometer shown in Fig. 3, which has a total resistance of 320 kΩ. Note that the resistances at the lower end are not changed. Owing to Miller capacity

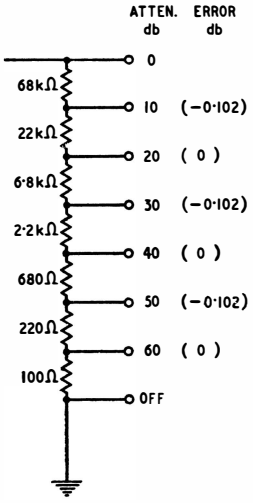


Fig. 2. Potentiometer giving attenuation of 10 db per stud, with a maximum error of − 0.102 db. The total resistance is 100 kΩ.

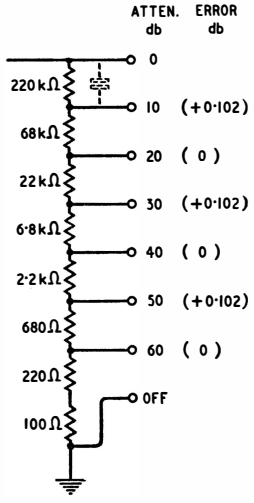
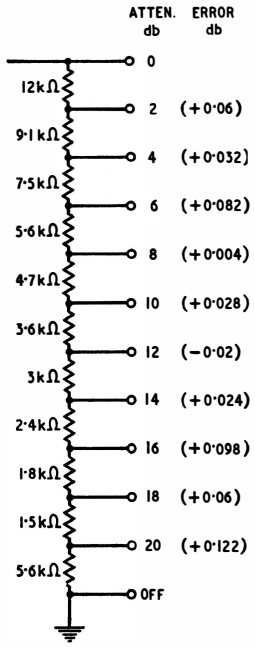


Fig. 3. Potentiometer giving attenuation of 10 db per stud, with a maximum error of + 0.102 db. The total resistance is 320 kΩ.

Fig. 4 (below). Potentiometer giving attenuation of 2 db per stud, with maximum errors of − 0.02 db and + 0.122 db. Total resistance here is 56.8 kΩ.



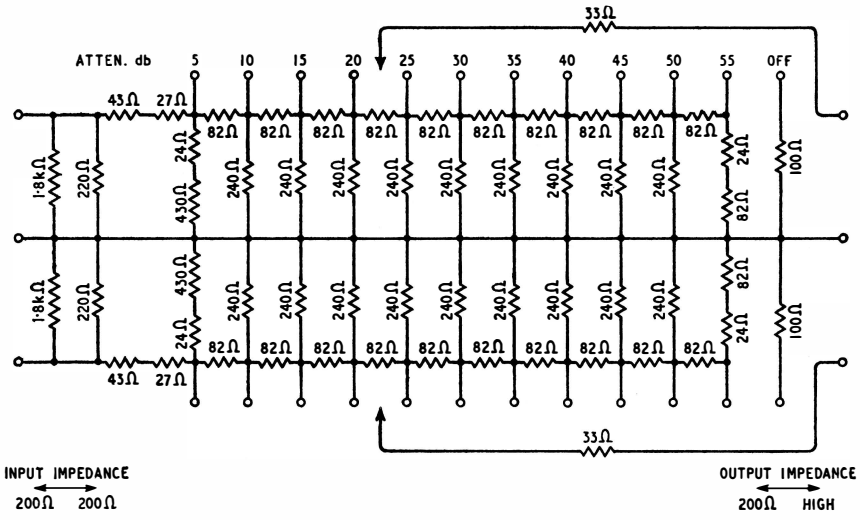


Fig. 5. (Above) Balanced-π attenuator. The resistors have been selected so that the positive and negative errors will alternate.

of the following valve, in combination with such a high value of grid potentiometer, some loss of high frequencies would probably be noticed on the stud giving 10 db attenuation, and a small condenser might be advisable between this stud and the top of the potentiometer, as shown dotted.

Another good example is the potentiometer giving 2 db per stud shown in Fig. 4, which has a total resistance of 56.8 kΩ. This has the useful property that, if extra studs are available, it may be extended either upwards or downwards as required, repeating the resistance values in the next decade, provided due attention is paid to the resistance between the lowest stud and earth.

The examples shown by no means exhaust the possibilities. They may, however, encourage the rather fascinating mental exercise of trying to produce others. As a final illustration, Fig. 5 shows a balanced-π attenuator having an insertion loss of 5 db and attenuation of 5 db per step, with terminations to match a 200-Ω source and present 200 Ω to the load. A 12-way double-bank switch is used, again with make-before-break contacts. With such a network, resistances of positive and negative error should alternate, in order to prevent the error becoming cumulative.

Choice of Radio Materials

THE high standard of reliability demanded of radio apparatus in its many and varied applications to-day and the consequent necessity for using exactly the right material for each particular job is the reason for the recent publication by the Radio Industry Council of Specification RIC/1000/A. This specification is described as a guide to manufacturers in the choice of materials for radio and electronic equipment and for components used in that equipment. It is intended to provide the industry with help in settling its own materials problems along lines comparable with those on which the Inter-Service Specification RCS/1000 helps the Services to deal with their distinct but similar problems. It is hoped that eventually the relevant sections of both these specifications may be linked together in one national standard to be published by B.S.I.

Specification RIC/1000/A deals with the following subjects: Ferrous metals; aluminium and aluminium alloys; copper and copper alloys; solders; zinc and zinc alloys; plastics (thermo-setting and thermo-plastic); elastomers; inorganic insulating materials; insulating, filling and sealing compounds; textile materials and paper; timber; lubricants; wire and sleeving; miscellaneous materials, including adhesives and fluxes.

The needs of manufacturers of equipment for export are borne in mind, and in many sections of the specification the suitability or otherwise of materials for tropical climates is touched upon.

The specification has been prepared jointly by the Technical Specification Committee of the R.I.C. and the Materials and Finishes Sub-Committee of the R.I.C. in consultation with the British Radio Equipment Manufacturers' Association, the Radio Communication and Electronic Engineering Association and the Radio and Electronic Component Manufacturers' Federation. It has been approved for publication by the Technical Directive Board of the R.I.C. on which all the constituent associations of the R.I.C. are represented.

Copies of the specification are obtainable from the Radio Industry Council, 59, Russell Square, London, W.C.1, for 3s 6d each, post free.

A further guide dealing with "Finishes" is being prepared by the R.I.C. but it is not expected to be completed until well into 1950.

The R.I.C., in conjunction with the Radio Communication and Electronic Engineering Association, have also recently published Specification No. RIC/271/A—Pin Connectors of Piezo-Electric Quartz Crystals mounted in B7G Valve-type Envelopes.