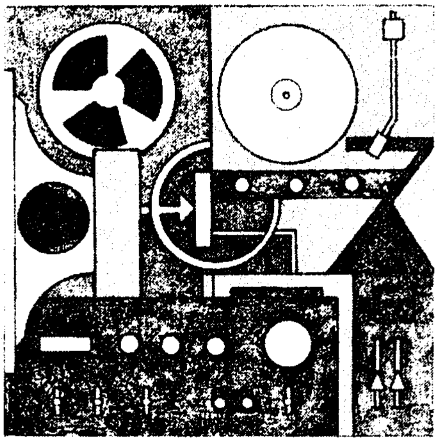
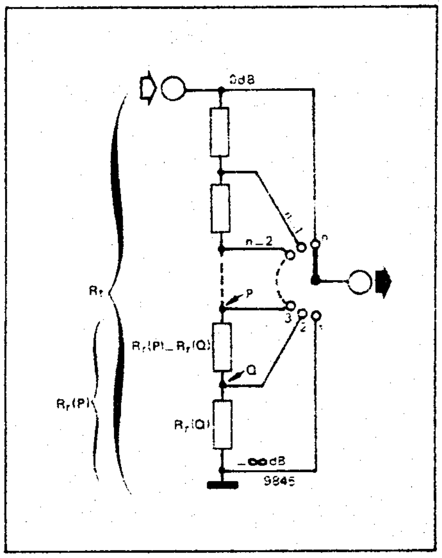
stepped volume control





Conventional rotary or slider potentiometers suffer from several disadvantages when used as volume controls in an audio system. The ganged, logarithmic potentiometers which are frequently employed in stereo amplifiers frequently suffer from poor matching of the two channels, so that the relative signal levels or balance of the left- and right channels vary as the control is operated. Carbon potentiometers also have a relatively limited life and soon become noisy in operation.

One solution to these problems is to use a stepped volume control consisting of a switched, resistive potential divider, as shown in figure 1. This circuit has several advantages over a conventional potentiometer.

- matching between channels is determined solely by resistor tolerances (5% tolerance should be adequate for most applications)
- the control can be made to have any desired 'law' by suitable choice of resistor values
- within reason, any number of channels can be catered for by using a switch with more wafers
- a long life is obtained, provided a reasonable quality switch is used.

The degree of attenuation produced for a particular setting of the control is given by attenuation = $20 \log (R_r : R_t)$dB, where R_t is the total resistance of the potential divider chain and R_r is the remaining resistance between a particular switch position and ground. The value of individual resistors connected between two adjacent positions of the switch is obviously obtained by subtracting two adjacent values of R_r.

For a volume control a logarithmic law is desirable, which means that the difference in attenuation between any two adjacent settings of the control must be a constant number of dB. Table 1 shows the values of R_r required for 1 dB steps of attenuation from 0 to –60 dB for an R_t value of 100 k (plus an extra step for infinite attenuation). Obviously a practical volume control cannot have this number of steps, as this would require a 62-way switch. On the other hand, the number of switch positions must not be too small, as this will not give sufficiently fine control.

Table 1

dB	R_r (R_t = 100.000 Ω)	dB	R_r (R_t = 100.000 Ω)
0	100.000	–31	2.818
–1	89.125	–32	2.512
–2	79.794	–33	2.239
–3	70.794	–34	1.995
–4	63.095	–35	1.778
–5	56.234	–36	1.585
–6	50.118	–37	1.413
–7	44.668	–38	1.259
–8	39.810	–39	1.122
–9	35.481	–40	1.000
–10	31.622	–41	891
–11	28.184	–42	794
–12	25.119	–43	708
–13	22.387	–44	631
–14	19.952	–45	562
–15	17.783	–46	502
–16	15.849	–47	447
–17	14.125	–48	398
–18	12.589	–49	355
–19	11.220	–50	316
–20	10.000	–51	282
21	8.913	–52	251
–22	7.943	–53	224
–23	7.079	–54	200
–24	6.310	–55	178
–25	5.623	–56	158
–26	5.012	–57	141
–27	4.467	–58	126
–28	3.981	–59	112
–29	3.548	–60	100
–30	3.162	–∞	0

Table 2

1	2	3	4	5	6
0	100.000			99.972	0
		29.206	29.200		
−3	70.794		(27k+2k2)	70.772	−3.0
		20.676	20.600		
−6	50.118		(15k+5k6)	50.172	−6.0
		14.637	14.700		
−9	35.481		(10k+4k7)	35.472	−9.0
		10.362	10.390		
−12	25.119		(10k+390Ω)	25.082	−12.0
		7.336	7.360		
−15	17.783		(6k8+560Ω)	17.722	−15.0
		5.194	5.170		
−18	12.589		(4k7+470Ω)	12.552	−18.0
		3.676	3.630		
−21	8.913		(3k3+330Ω)	8.922	−21.0
		2.603	2.620		
−24	6.310		(1k8+820Ω)	6.302	−24.0
		1.843	1.847		
−27	4.467		(1k8+47Ω)	4.455	−27.0
		1.305	1.300		
−30	3.162		(1k2+100Ω)	3.155	−30.0
		923	920		
−33	2.239		(820Ω+100Ω)	2.235	−33.0
		654	642		
−36	1.585		(560Ω+82Ω)	1.593	−36.0
		463	470		
−39	1.122		(470Ω)	1.123	−39.0
		328	330		
−42	794		(330Ω)	793	−42.0
		232	232		
−45	562		(220Ω+12Ω)	561	−45.0
		164	164		
−48	398		(82Ω+82Ω)	397	−48.0
		116	120		
−51	282		(120Ω)	277	−51.1
		82	82		
−54	200		(82Ω)	195	−54.2
		59	56		
−57	141		(56Ω)	139	−57.1
		41	39		
−60	100		(39Ω)	100	−60.0
		100	100		
−∞	0		(100Ω)	0	−∞

A reasonable choice of attenuation step is 3 dB. This gives sufficiently fine control, yet allows 60 dB of attenuation to be achieved in 21 steps. Allowing an extra step for the zero (infinite attenuation) position means that 22 ways are required in all.

The resistance values for a 22 position control are given in table 2. Column 1 lists the required attenuation in dB for each switch position. Column 2 lists the corresponding values of R_r. Column 3 lists the resistor values required between the switch positions. Column 4 lists the actual values used (made up from standard E24 series resistors). Column 5 lists the actual values of R_r obtained and column 6 lists the actual values of attenuation obtained using these resistor values.

Resistor values for values of R_t other than 100 k can be obtained simply by scaling the resistor values given. For example, for a 50 k control the values should all be halved, for a 10 k control they should be divided by 10 and so on.

One final point to note is that the switch contacts should be of the make-before-break type to avoid switching clicks as the control is operated.