stepped volume control

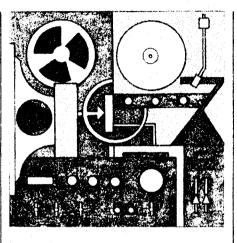
Conventional rotary or slider potentiometers suffer from several disadvantages when used as volume controls in an audio system. The ganged, logarithmic potentiometers which are frequently employed in stereo amplifiers frequently suffer from poor matching of the two channels, so that the relative signal 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.

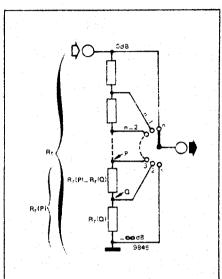
One solution to these problems is to use a stepped volume control consisting of a switched, resistive potential divider, as shown in figure 1. This circuit has several advantages over a conventional potentiometer.

- 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 = $20\log\left(R_T:R_t\right)dB$, where R_t is the total resistance of the potential divider chain and R_T 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_T .

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_T 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.





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dB	$R_r (R_t = 100.000 \Omega)$	dB	$R_r (R_t = 100.000 \Omega)^{-3}$	
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	

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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+39Ω) 25.082 -12.0 7.336 7.360 -15 17.783 (6k8+56Ω) 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+33ΩΩ) 8.922 -21.0 2.603 2.620 -24 6.310 (1k8+82ΩΩ) 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+10ΩΩ) 3.155 -30.0 923 920 -33 2.239 (820Ω+10ΩΩ) 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 (22ΩΩ+12Ω) 561 -45.0 164 164 -48 398 (82Ω+12Ω) 397 -48.0 116 120 -51 282 (12ΩΩ+12Ω) 561 -45.0 164 164 -48 398 (82Ω+82Ω) 397 -48.0 116 120 -51 282 82 -54 200 (82Ω) 196 -54.2 59 56 -57 141 (56Ω) 139 -57.1 41 39 -60 100 (39Ω) 100 -60.0	Table 2							
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$ \begin{array}{cccccccccccccccccccccccccccccccccccc$, , ,		29.206	29.200	00.072		
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		-3	70.794	20.200		70.772	-3.0	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$, i	70.754	20.676		70.772	0,0	
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$		-18	12.589	0		12.552	180	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$			12.000	3.676		, 2.552	-10.0	
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$			9,513	2.603		0.022	21.0	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		-24	6.310	2.000		6.302	24 0	
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$		-27	4.467			4.455	27.0	
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$		-36	1.585			1.593	-36.0	
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$		-42	794	3.0		793	-42.0	
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$		-45	562			561	-45.0	
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$		48	398	,		397	48.0	
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100 100		-60	100	- 7 7		100	-60 O	
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		_∞	0		(100Ω)	0	œ	

trol, 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

A reasonable choice of attenuation step

is 3 dB. This gives sufficiently fine con-

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_T. 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

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

and column 6 lists the actual values of

on.

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