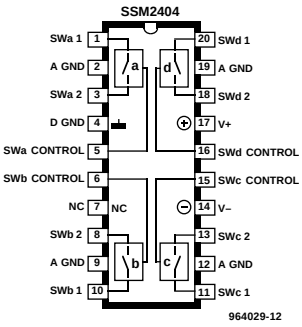
silent volume control

There is a growing tendency to fit audio equipment with electronic volume controls (virtually always remote controlled). This consists of a series of potential dividers actuated by electronic switches. Regrettably, this setup has a small drawback: faint click are sometimes heard when the volume is changed. These clicks are the result of the brief short-circuit of the multiplexers in 4000 series CMOS ICs to the negative supply line when they are switched over.

In the quad audio switch Type SSM2404 from Analog Devices this flaw is obviated by break-before-make logic drive circuits and by switching the output transistors gradually via



a sawtooth generator. This switch has further benefits in that R_{DSON} is low and that it can operate from a high supply voltage (up to 13.5 V).

Since break-before-make electronic switches are used, it is not possible to construct a volume control from a potential divider with several branches followed by a buffer stage. This is because the switches in series with the buffer would briefly not have a bias setting when switching takes place. Therefore, the present design uses an inverting amplifier with a virtual ground. The total amplification is –1, but that may be changed by altering the value of R_{17}.

The voltage divider is designed for steps of 1.25 dB, so that an attenuation of 0–8.75 dB is possible. Resistor values for a total range of 70 dB are given in the table. Connecting two of these circuits (one with a range of 8.75 dB, and the other with a range of 70 dB) in series gives a volume control with a range of 0 dB to –78.5 dB. The volume control may be driven by a 6-bit counter or a microprocessor.

In the diagram, the switches of one chain of attenuators are driven by a BCD-to-decimal decoder Type 4028. The attenuation may be set manually with DIP switch S_1. Resistor R_{18} and diodes D_1, D_2 serve as overdrive protection for IC_1 and IC_2. These components may be omitted between two successive attenuator sections.

As far as the d.c. setting of the circuit is concerned, it suffices to state that the level at all points in the output condition (all DIP switches open) is 0 V, except at pin 6 of IC_2, which is at +12 V.

The maximum undistorted input voltage is 7.6 V r.m.s. In the prototype, the THD+noise with an input voltage of 2 V r.m.s. was 0.0007% at 1 kHz and 0.0009% at 20 kHz. At the largest attenuation (–8.75 dB) this figures rose to 0.001% and 0.0016% respectively. The overall bandwidth of the amplifier is 200 kHz. The current drain of a complete attenuator section is about 6 mA.

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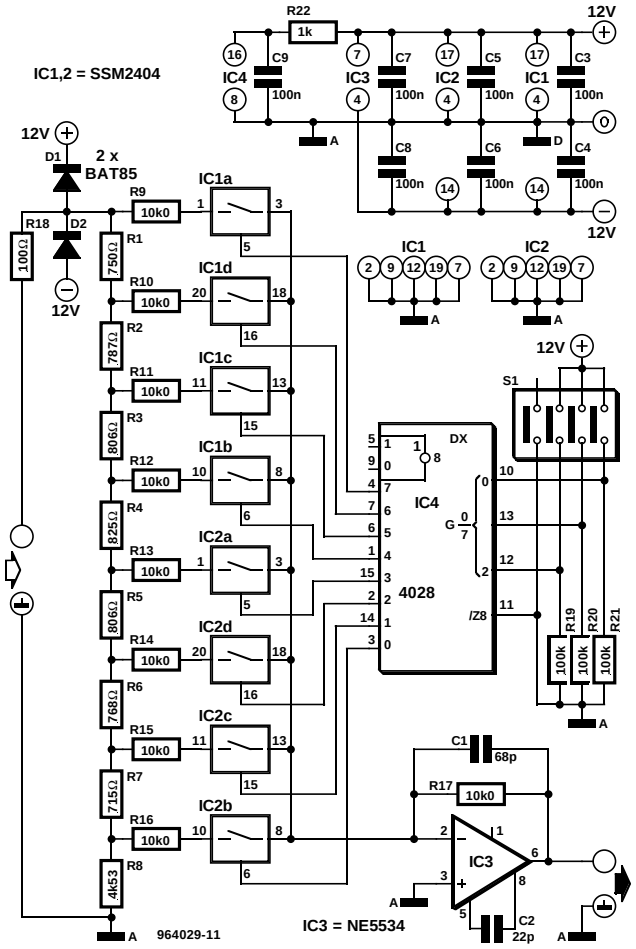

Table 1. Resistor values for a range of 0 dB to –70 dB.

R1	6.04 kΩ
R2	2.80 Ω
R3	768 Ω
R4	226 Ω
R5	69.8 Ω
R6	21.5 Ω
R7	6.81 Ω
R8	3.16 Ω