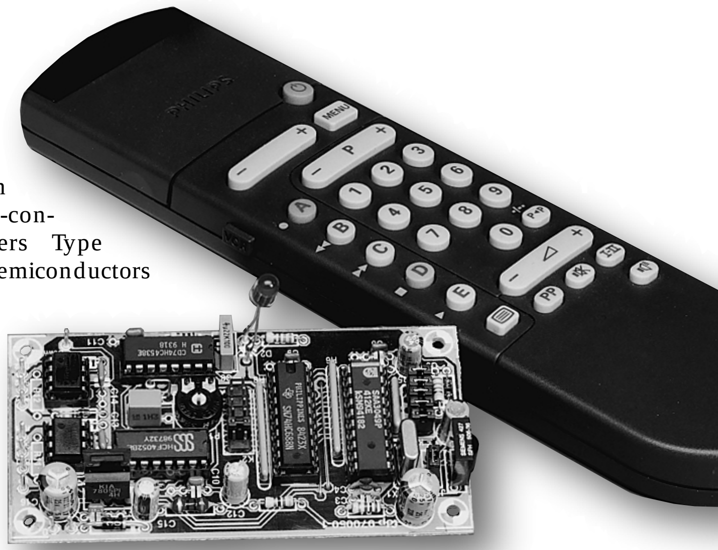
Contents

infra-red-controlled noiseless volume control

with Type DS1669 electronic potentiometer

The circuit described in this article is eminently suitable for those who appreciate comfort as well as sound quality. In the circuit two integrated electronic potentiometers are operated by an RC5 infra-red remote controller to provide a volume control that is not only free of crackles and other annoying noises, but is also free of wear and tear. It is intended to be built on a small printed-circuit board that can be conveniently built into almost any existing amplifier.

Design by T. Giesberts



ELECTRONIC POTENTIOMETER

The design is based on two electronically-controlled potentiometers Type DS1669 from Dallas Semiconductors that were described in the January 1997 issue (page 38) of this magazine.

Briefly, these potentiometers consist of a resistance track tapped at 64 positions separated in equal steps, a 64:1 multiplexer, control circuits, and an EEPROM. The devices are available in a DIP case (Type DS1669), or an SMD (SO8) case (Type DS1669S). Both types are available in one of three values: 10 kΩ, 50 kΩ, or 100 kΩ. The value is identified by adding the number 10, 50, or 100, as the case may be, to the type coding.

The 64 outputs of the resistance track are fed to the multiplexer, which determines which of the outputs is required; the relevant data is then stored in the EEPROM. This ensures that even when the supply to the device is switched off, the set value of resistance is retained.

The control circuits are driven by (1) an up/down switch connected between UC and earth (input DC is connected to the supply line), or (2)

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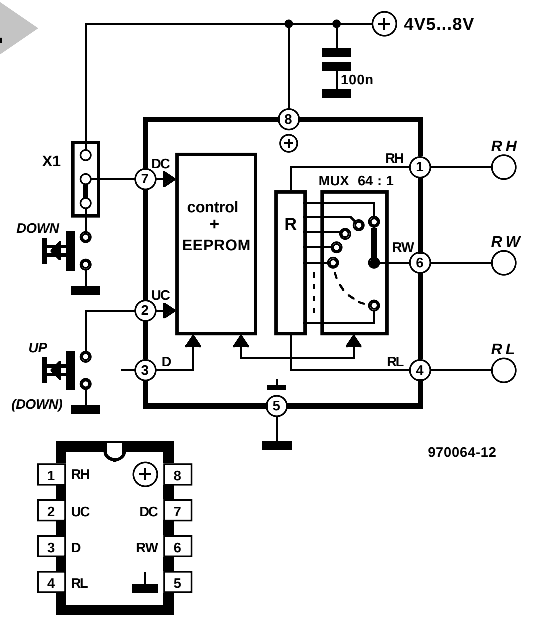

Figure 1. Block schematic of the Type DS1669 electronic potentiometer. The device is controlled by pulses provided by a microcontroller or generated manually.

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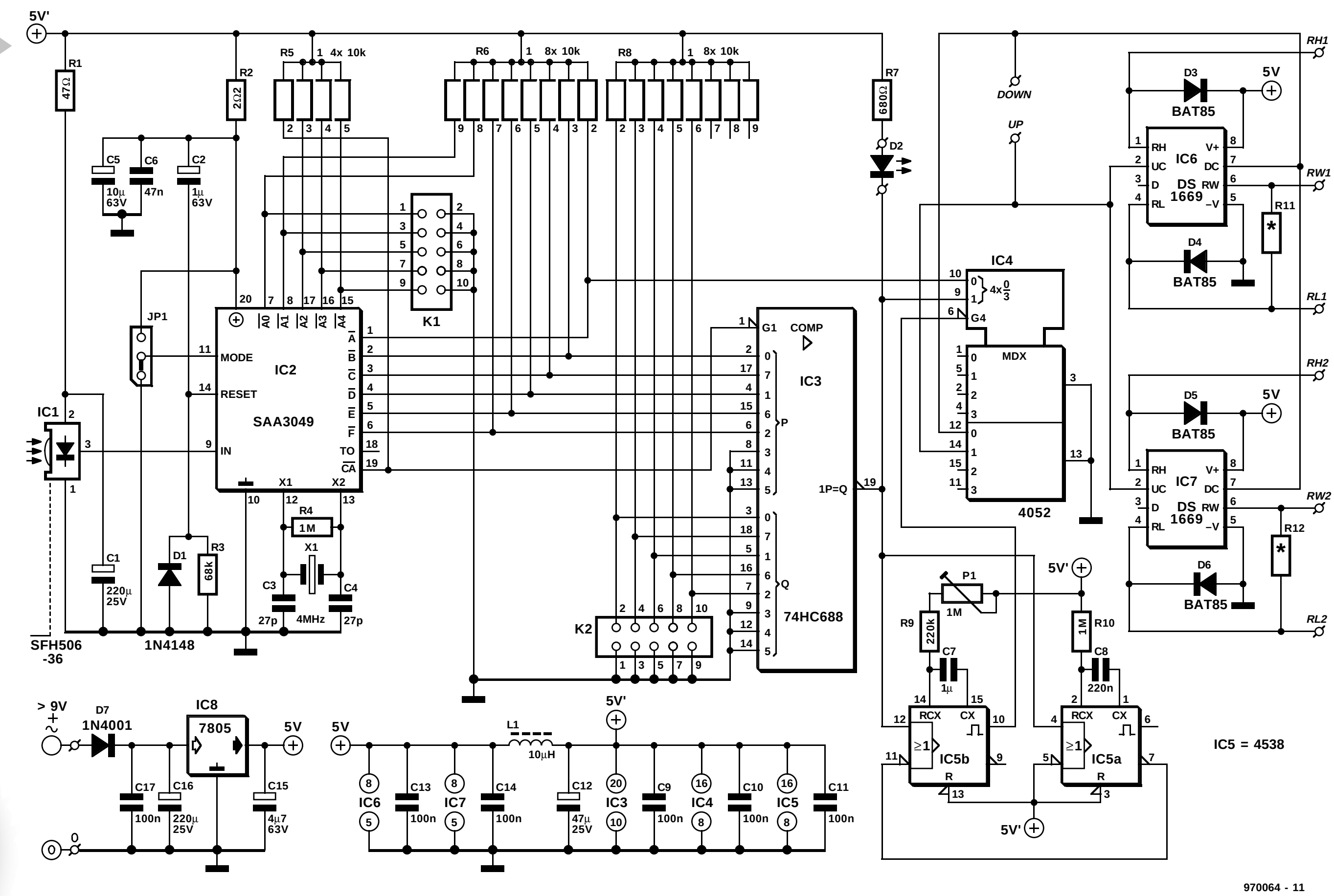

Figure 2. The circuit diagram of the volume control in which IC_6 and IC_7 are the actual potentiometers controlled by IC_4 and IC_5. The infra-red control signals are processed by IC_1–IC_3.

two down/up switches connected between DC and earth and UC and earth respectively, or (3) a microcontroller. The resistance track, *R*, is terminated into pins 4 (RL = *R* low) and 1 (RH = *R* high) (see **Figure 1**). In single-switch operation, when the switch is pressed, the imaginary wiper moves towards one end of the resistance track; when that is reached, it reverses direction and moves towards the other end. The same happens when the circuits are controlled by pulses from a microcontroller. In two-switch operation, when the 'down' switch is pressed, the imaginary wiper moves towards RL and when the 'up' switch is pressed, towards RH.

The D(igital) input intended for microcontrollers is internally debounced. For this purpose, the IC does not react immediately to a switch being pressed, but only after 1 ms. When a switch is pressed for less than 1 s, this is considered as one action. When the switch is held down longer than 1 s, the wiper is advanced one step every 100 ms; this is called the auto-repeat function. The wiper takes about 7 s to travel from one end of the track to the other.

The UC and DC inputs of the two potentiometers, IC_6 and IC_7 (see **Figure 2**) are switched by IC_4. In this, IC_{5a} and IC_{5b} perform a special function which will be reverted to later.

INFRA-RED CONTROL

The infra-red (IR) signal emitted by an RC5 controller contains two important data: the system address and the actual command. According to the RC5 code, the system address of a preamplifier is '16'. If this address is already occupied, or if the potentiometer is not fitted in a preamplifier but in another type of equipment, a different address may be used.

The address is set via inputs A_0–A_4. For address '16', inputs A_0–A_3 must be logic 0, which is arranged by short-circuiting pins 1 and 2, 3 and 4, 5 and 6, and 7 and 8, on K_1, and leaving 9 and 10 open. Address '0', reserved for television receivers, is set by short-circuiting all five sets of terminals. It is clear that the choice of key on the RC5 controller is determined by which of the pairs of terminals is short-circuited.

The signal from the RC5 controller is received by IC_1. This is a special device from Siemens which contains an IR photodiode and a complete receiver. The demodulated signal at its output, pin 3, is applied to decoder IC_2, which converts it into a digital signal. This signal is available as a logic level at outputs A–F. In the present circuit, only two commands are of interest:

address	F	E	D	C	B	A	command
16	0	1	0	0	0	0	louder
17	0	1	0	0	0	1	softer

Outputs B–F of IC_2 are linked to five of the P-inputs of digital comparator IC_3; the remaining three P-inputs are strapped to earth. The output, pin 19, of the comparator is low when the data word at the P-inputs is the same as that set at the Q-inputs via K_2. In that case, D_2 lights.

Output A of IC is purposely not linked to one of the comparator inputs, since the state of this bit (LSB) is different with commands 'louder' and 'softer' and might therefore upset the correct functioning of IC_3.

The receiver IC is decoupled by network R_1-C_1, and the decoder IC by network R_2-C_5-C_6.

Network R_3-C_2 provides a power-on reset for IC_2.

Jumper JP_1 enables decoder IC_2 to process RECS80 or RC5 codes. Normally, this will be the RC5 code, in which case the jumper must be between pin 11 and earth.

Crystal X_1, in conjunction with R_4, C_3 and C_4, ensures that the clock for IC_2 is correct.

Resistance arrays R_5, R_6, and R_8, function as pull-up resistors for the various inputs and outputs.

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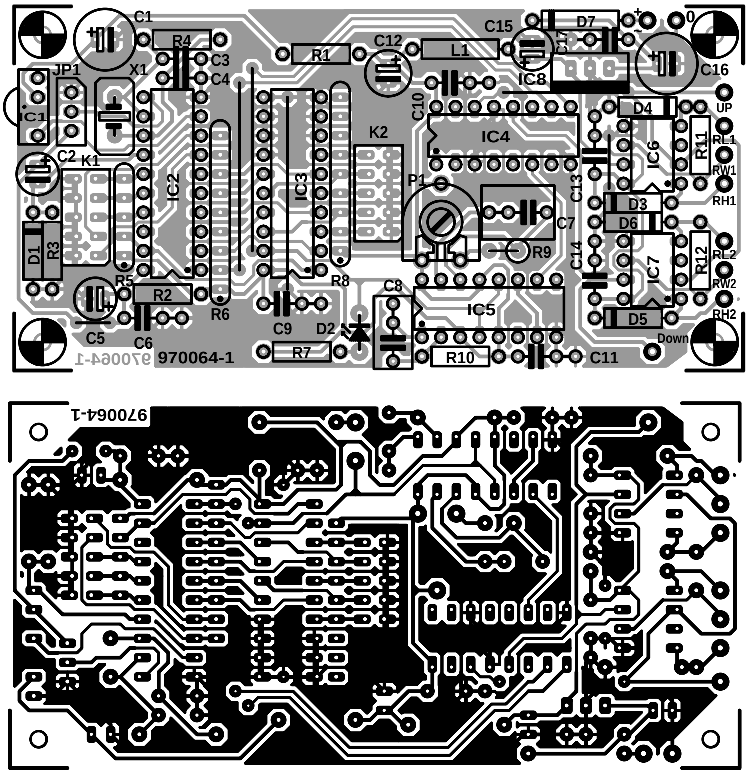


Figure 3. The printed-circuit board for the volume has been kept as small as possible to facilitate its being built into an existing equipment. Make sure that IC_1 is exposed to the outside world.

Parts list

Resistors:
R_1 = 47 Ω
R_2 = 2.2 Ω
R_3 = 68 kΩ
R_4, R_{10} = 1 MΩ
R_5 = array 4×10 kΩ
R_6 = array 8×10 kΩ
R_7 = 680 Ω
R_9 = 220 kΩ
R_{11}, R_{12} = optional, see text
P_1 = 1 MΩ preset potentiometer

Capacitors:
C_1, C_{16} = 220 µF, 25 V, radial
C_2 = 1 µF, 63 V, radial
C_3, C_4 = 27 pF
C_5 = 10 µF, 63 V, radial
C_6 = 0.047 µF, ceramic
C_7 = 1 µF, MKT (metallized polyester), pitch 5 mm or 7.5 mm
C_8 = 0.22 µF
C_9–C_{11}, C_{13}, C_{14}, C_{17} = 0.1 µF, ceramic
C_{12} = 47 µF, 25 V, radial
C_{15} = 4.7 µF, 63 V, radial

Inductors:
L_1 = 10 µH

Semiconductors:
D_1 = 1N4148
D_2 = LED, high efficiency
D_3–D_6 = BAT85
D_7 = 1N4001

Integrated circuits:
IC_1 = SFH506-36 (Siemens)
IC_2 = SAA3049P (Philips)
IC_3 = 74HC688
IC_4 = 4052
IC_5 = 4538
IC_6, IC_7 = DS1669 (Dallas Semiconductors)
IC_8 = 7805

Miscellaneous:
JP_1 = 3-way terminal strip with jumper
K_1, K_2 = dual 10-way terminal strip with 5 jumpers
X_1 = crystal, 4 MHz
PCB Order No. 970064 (see Readers Services toward the end of this issue)

SYNCHRONOUS CONTROL

It was stated earlier that the potentiometers are controlled by linking the UC and DC inputs to earth. This is effected by an analogue multiplexer, two of which are contained in IC_4. The use of a multiplexer makes it possible for two switches to be added if desired. For this purpose, pins ‘up’ and ‘down’ are provided on the printed-circuit board. The Type 4052 used for IC_4 has the added advantage of not needing additional logic circuits for the correct decoding of the rotary direction.

The address of the multiplexer is a combination of the decoded LSB (output A of IC_2) and the output of IC_3.

As mentioned earlier, when the UC or DC input of IC_6 or IC_7 is actuated longer than 1 s, their wiper is shifted automatically one step every 100 ms. In the present circuit, in which the ICs are controlled in parallel, the wipers may not always move in synchrony, and this is why the auto-repeat function is disabled. Instead, the ICs are driven by discrete pulse trains available at the CA output of IC_2. When the signal from the RC5 controller is sustained, a 15 ms wide pulse appears at the CA output every 120 ms. Both the width and the repetition frequency of these pulses are eminently suitable for repeated actuation of the potentiometers. More importantly, synchrony of operation is guaranteed.

DEAD TIME

The output of comparator IC_3 remains low as long as the CA output of IC_2 is active, which makes it difficult to ensure that the wipers of IC_6 and IC_7 do not move more than one defined step. Therefore, a dead time is provided by IC_5, which may be set between 0.22 s and 1.22 s with P_1. The arrangement is that the first wiper movement takes place immediately IC_3 outputs a pulse. Then follows the dead time, and then the pulse train.

The dead time is actuated by triggering monostable IC_{5b} at the leading edge of the first pulse output by IC_3. The Q-output of IC_{5b} is then high and prevents any further wiper movement by disabling the inhibit input of IC_4.

Since the Type 4538 used for the monostable is retriggerable, IC_{5a} has been added to prevent unwanted lengthening of the dead time. Both monostables are triggered simultaneously, so that IC_{5a} at once disables the trigger input of IC_{5b} by making pin 11 low. Since the mono time of IC_{5a} is longer than the repetition time of IC_3, any pulses repeated at the output of the comparator have no effect.

The length of the dead time is best determined empirically; normally, it will be sufficient to set P_1 to the centre of its travel.

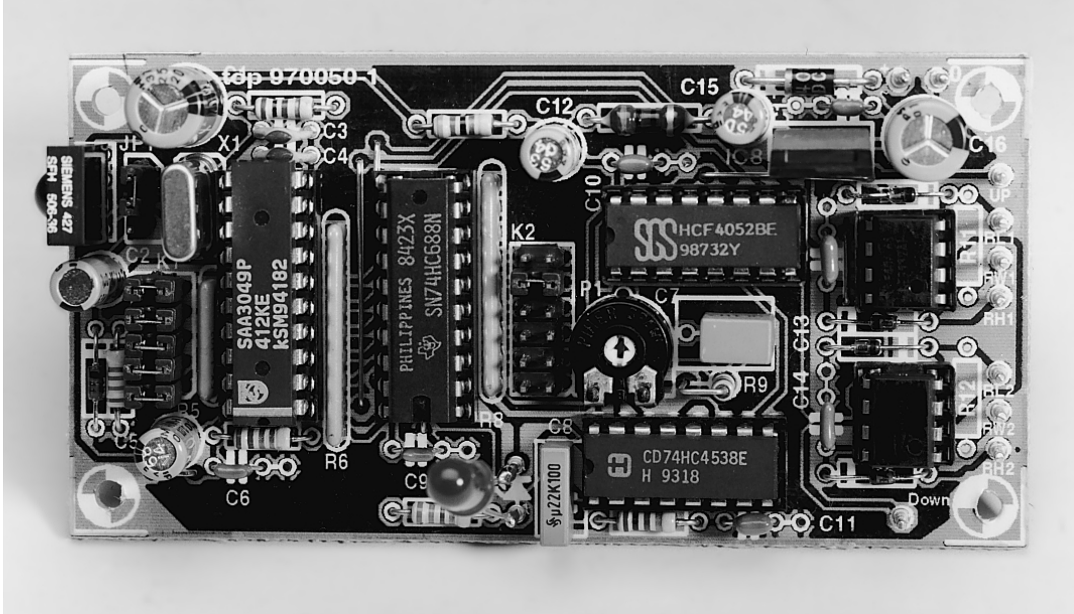
PRINTED-CIRCUIT BOARD

The circuit is best constructed on the printed-circuit board shown in **Figure 3**, which has been kept as small as possible since it is expected that most constructors will want to built it into an existing equipment to replace the volume control(s) in this. The connections to this control must be cut and linked to terminals RH, RW, and RL on the board.

FINALLY…

Although IC_6 and IC_7 are protected against high input voltages by diodes D_3–D_6, the applied input signal should not exceed 1.5 V r.m.s.

The linear characteristic of the potentiometers may be given a rather more logarithmic aspect by connecting



resistors R_{11} and R_{12} between the RW and RL terminals as shown in Figure 2. The value of these resistors should be $\frac{1}{4}$–$\frac{1}{16}$ of the value of the potentiometer. Be careful, however, not to damage the ICs, because the current flowing through the wiper must not exceed 1 mA. This means that the resistors should only be used with 100 kΩ potentiometers.

When the circuit is built into an existing equipment, it must, of course, be done in such a way that the IR receiver is exposed to the outside world. It may be necessary in some cases to extend the terminals of the IC with three short lengths of insulated circuit wire.

Since the circuit has its own rectifier (D_7) and regulator (IC_8), the input power supply may be any a.c. or d.c. source providing 9 V or more. This may be a mains adaptor, but it may also be possible to draw it from the equipment into which the volume control is to be fitted.

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