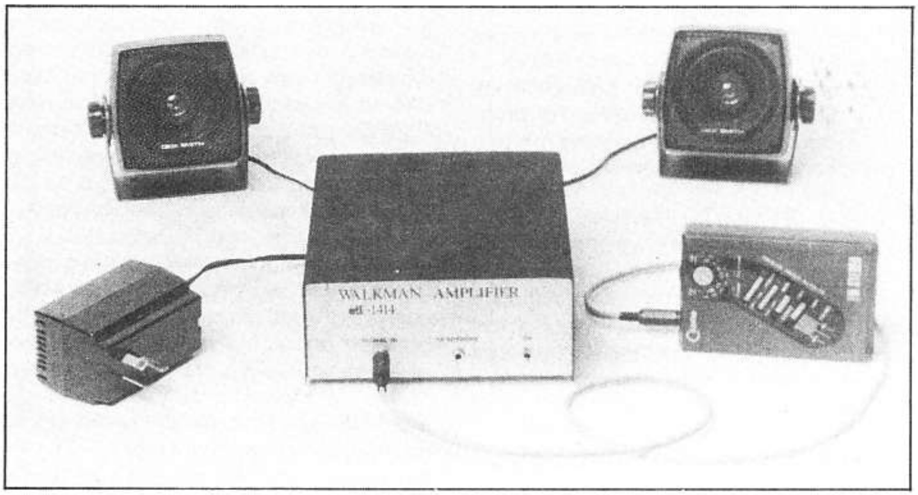
WALKMAN AMPLIFIER

S K Hui



Speaker connectors and the plug pack input sockets are mounted on the rear panel.

THE WALKMAN TYPE radio and tape player is one of the most popular electronic gadgets of modern times. Surprisingly, their fairly high price tag has survived simply because of one unique feature — portability.

Their biggest disadvantage is that the output is available to only one person. The aim of this project is to change that. One solution would be to put the line-out of the walkman directly into a big amplifier. If you experiment with this you will find that the walkman doesn't sound nearly as good as it used to. This is because it uses the headphone cord as part of its antenna system. In fact, the antenna is coupled into the audio output section of the walkman via a pair of capacitors. A second problem is that the essential portability of the walkman system is lost because the amplifier will require mains power.

So the requirements of a walkman amplifier are that it should be able to match the antenna correctly in its output, be small, drive a set of small speakers to a reasonable loudness level and be powered by batteries.

The ETI-1414 walkman amplifier has been designed deliberately to tackle this requirement. Every walkman owner should build one or your unit is just like coffee without coffeemate.

The circuit is housed in a tough mild steel box. It can be powered from either an internal battery pack, a 12 V dc plug pack for use as a bookshelf amplifier or directly from the cigarette lighter socket in your car. The spec' for this little beauty is shown in the table.

Construction

The emphasis of this project is on portability and simplicity. Construction of this project should take no more than a couple of enjoyable hours on a Sunday afternoon. By the evening you should have a fully working amp on your bookshelf. No time consuming tuning is required. The only tool used in testing is a multi-meter.

The pc board itself sits on four plastic standoffs. One edge of the pc board has a switch (SW1), and two 3.5 mm phono sockets (SK1, SK2). This side of the board has to be flush against the metal front panel of the box to allow the switch and the sockets to be accessed from the front. This scheme reduces a lot of time consuming wiring and mistakes. The only difficult task is the accurate positioning of the holes that have to be drilled on the box. So before you assemble the pc board, make sure you have the mounting holes on the bottom floor of the box for the standoffs.

In order to get the positions of the holes drilled correctly, place the pc board on the floor of the box against the front metal panel. By using the pc board itself as a template mark the four holes to be drilled. Next, drill the holes on the front and rear panels of the box. Use the published panel artwork in the article as a drilling template if you like, but don't touch your plastic Scotchcal panels at this stage. Save them for last, as they are easily damaged. To ensure the holes drilled have the right sizes, use the actual components to try them out. A round needle file or a small reamer may be needed. Always start with a small drill bit and gradually enlarge it to the size required with a file or a reamer. It takes longer but you get a perfect hole.

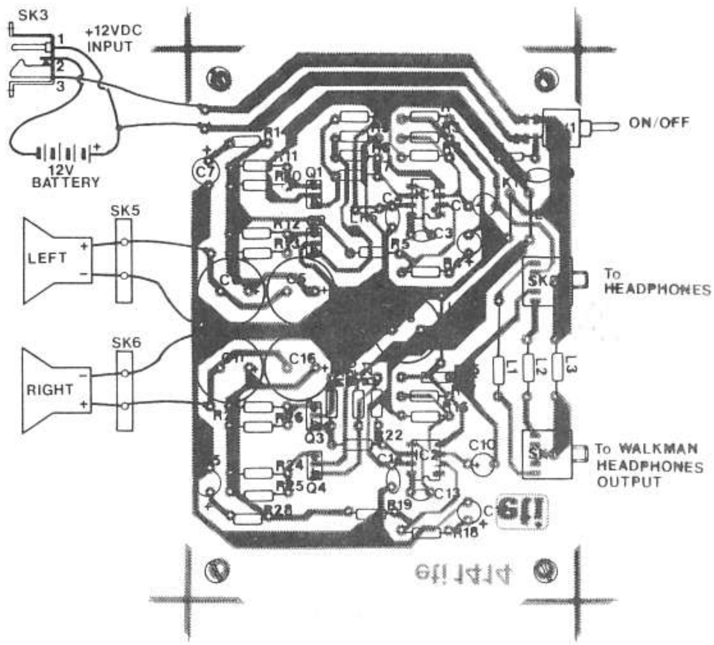
Apart from getting the right sizes, it is also important to get the right positions. Especially the three holes drilled on the front panel for SW1, SK1 and SK2 as they are rigidly soldered onto the pc board. Solder the three components on the pc board and see if you can mount the board on the standoffs. Usually, a bit of enlargement of the holes and re-adjustment of the board is needed.

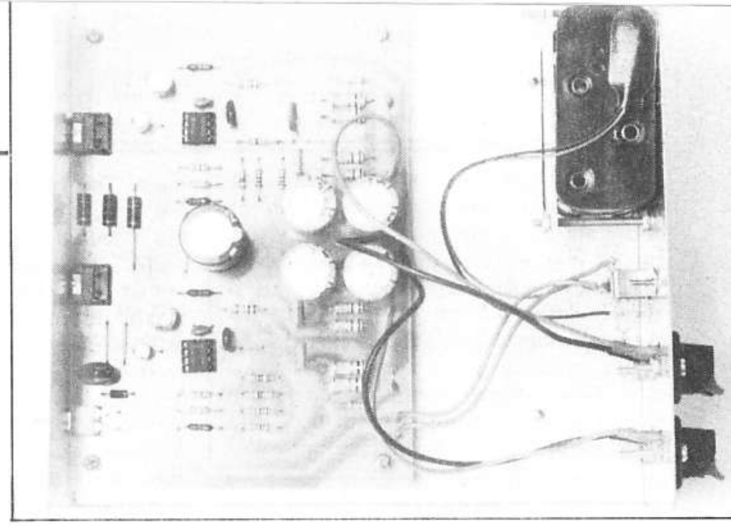
When you assemble the pc board, it doesn't matter which component you start with. If you have all the components available, the assembling should not take more than 45 minutes. To ensure success, watch out with the polarity of the transistors, diodes, electrolytic capacitors and the op-amps. Putting a heat sink on the transistor is not necessary with this type of power output. You can do so if you really wish but make sure the heat sinks do not short circuit each other.

Testing and Setting Up

Before you flick the power switch on, check again that the polarity of the battery or plug pack input is correct. Although the amplifier circuit is protected by diode D1 against any reverse power input, the testing procedure cannot proceed with the wrong input. Unplug the cord connecting the Walkman and the amplifier and the switching action of the socket SK1 will automatically ground the left(L) and right(R) channels. With the speakers disconnected, turn on the power switch (SW1) and put your fingers on the transistors for 30 sec to see if they get hot. Under normal circumstances, especially when there is nothing being played, it should stay cold. If any of them do get hot, you are likely to have the biasing voltage (hence, the biasing current) wrong for that transistor. The biasing current for the transistors Q1, Q2 is solely controlled by R6, R7, R8 and R9. Likewise, R20-R23 for transistor Q3 and Q4 in the right channel. Check that you have the right resistors in the right places.

Next check the output voltages of the cir-

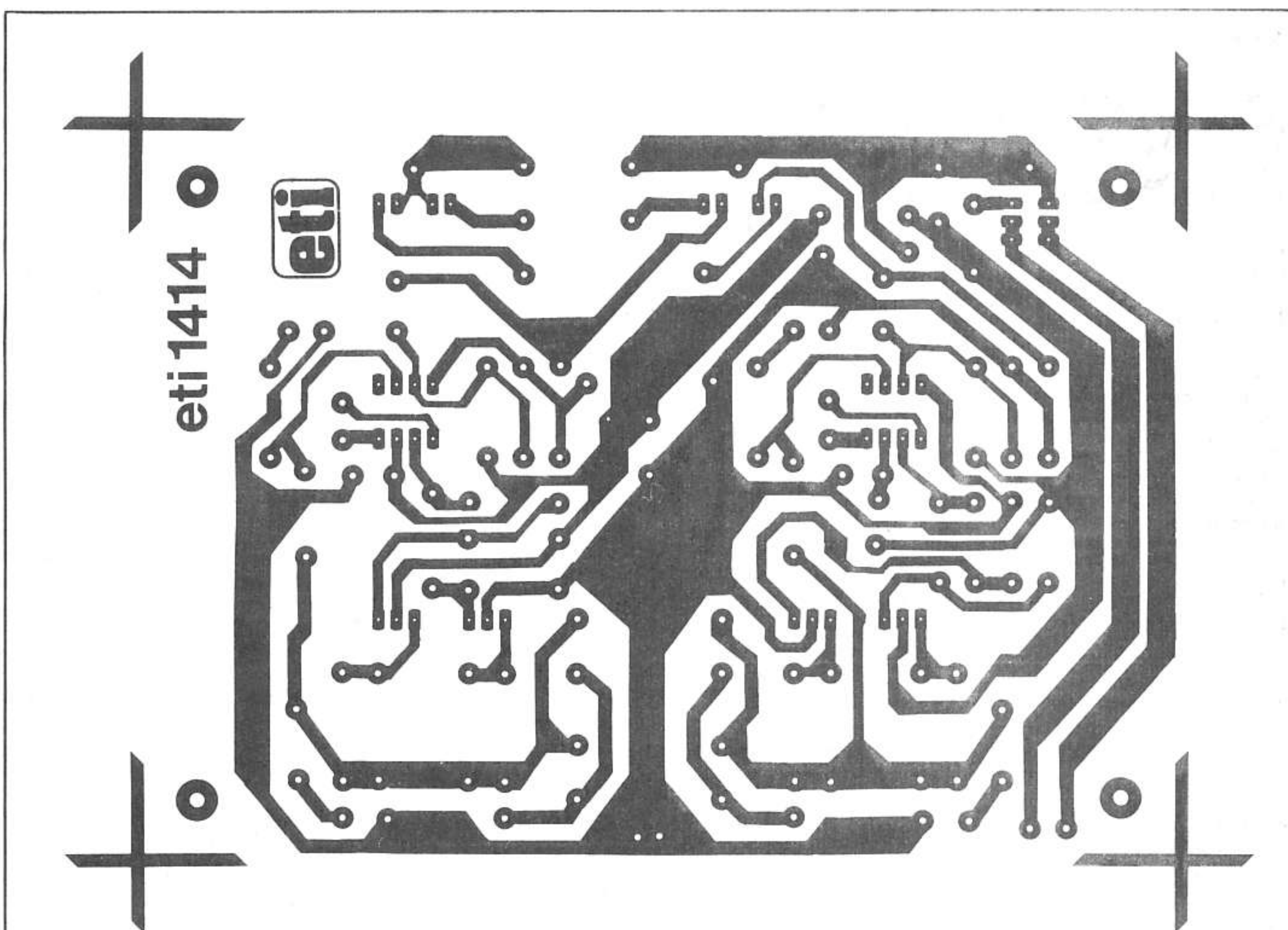




Top view of the pc board and the battery holder inside the box.

Specifications

Test Conditions: 4 ohm load, +12V supply, 400mV ptp input at 1kHz
Frequency Response (–3dB point): 40 Hz to above 100kHz
Sensitivity: about 0.6V
Total Distortion: between 0.1 and 0.3%
Output Power (rms(: 0.8W per channel
Cross-talk: 400mV at 1kHz injected in one channel with signal amplitude measured at 80dB on another channel.



cuit with a multi-meter. The node where the four 1 ohm resistors are joined should be sitting at 6V dc above ground for a 12V supply. This allows a maximum swing in both directions above and below 6V. If it is slightly different from 6V, it is likely that the power supply voltage is not exactly 12V. In the circuit diagram, several vital points have their voltages given so a comparison can be made on yours. Check them with your multi-meter's dc voltage measurement. The values you obtain on yours do not have to be identical to mine, usually, a few hundred millivolts discrepancy is expected. The final check is on the speaker output connector SK5 and SK6. Make sure that no dc voltage (0V) exists at that point, or your speaker will be permanently damaged.

The last thing to make is a cable connecting the walkman headphone output into the 'signal-in' socket on your amplifier. Preferably, use a double-core (stereo) screened microphone cable. A standard 3.5 mm stereo phono jack is soldered on each end of the cable. Apart from serving as an audio link, the cable acts as an antenna for your walkman radio (see How it Works). Obviously, for better reception, the cable should be a generous length.

Connect the speakers the connectors SK5, SK6. Plug the cable link into the walkman and the amplifier and you are ready to go! Don't forget if you are using batteries as a power source, use new ones. ●

We would like to thank Dick Smith Electronics for supplying the walkman radio and speakers used in the development of this project.

Parts List

Resistors (all 0.25W, 1% metal film unless stated otherwise)

R1, R4, R15, R18 .... 1k5
R2, R3, R16, R17 .... 120k
R5, R19 .... 10k
R7, R8, R21, R22 .... 330R
R6, R9, R20, R23 .... 2k7
R10, R11, R12, R13, R24, R25, R26, R27 ...... 1R (0.5W, tolerance 5%)
R14, R28 .... 2R7

Capacitators

C1, C10 .... 10uF/25V (Elec)
C2, C12 .... 22uF/25V (Elec)
C3, C13 .... 220pF (Disc ceramic)
C4, C14 .... 33nF (Green)
C5, C6, C16, C11, C8 .... 470uF/25V (Elec)
C7, C15 .... 1uF/35V (Elec)
C9 .... 120nF (Green)

RF chokes

L1, L2, L3 .... 470uH
(From Dick Smith Electronics Cat L-1811)

Semiconductors

IC1, IC2 .... NE5534
Q1, Q4 .... BD139
Q2, Q3 .... BD140
D1 .... 1N4002 or iN4004

Miscellaneous

A standard rectangular battery holder for carrying eight 'AA' cells, Dick Smith cat. -6128. A single sided pc board. PC board mounting mini toggle switch (Sw1) for ON/OFF. I could only find this switch from Dick Smith Electronics. Two stereo 3.5mm phono sockets (SK1, SK2) with switching action can be obtained from Jaycar Electronics. A 2.5mm DC power socket with switching action (SK3), Dick Smith cat. p-1665. A metal box about 185 x 70 x 160mm, Dick Smith cat. H-2744. Two stereo clip-on type speaker connector Dick Smith cat. H-6770.

The following parts may or may not be supplied in the kit: The stereo audio cable link between the walkman and the 'Signal In' on to the amplifier. A piece of plastic or bare pc board with two 6BA screws and nuts for clamping the battery holder. For obvious reasons, a pair of book shelf speakers will definitely not be included.

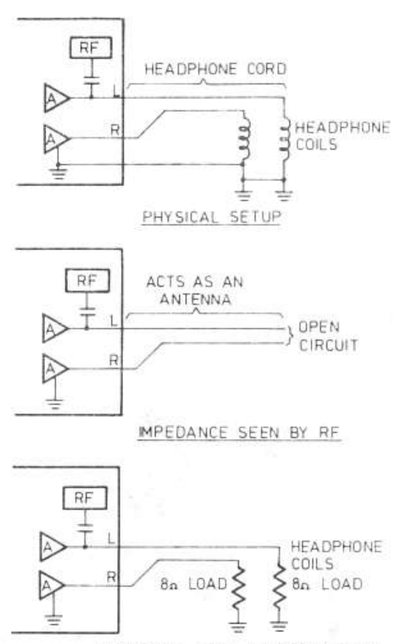


Figure 1: The walkman antenna system.

How It Works

Input section

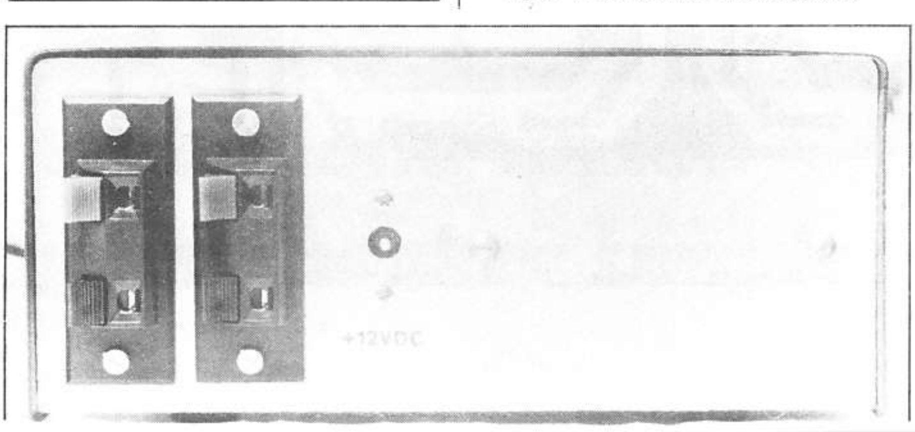
The input section begins with three RF chokes in series with the signal. Their function is to stop the amplifier input impedance from loading the Walkman antenna. To get good radio reception, a Walkman radio uses a headphone cord that serves as an antenna. The headphone coils inside the headphone have such a high impedance at RF frequencies that it is nearly an open circuit as far as RF frequencies are concerned. For audio frequencies, the Walkman sees a dc load of about 8 ohm (for an 8 ohm impedance headphone). Without the coils, the cable (antenna) will be loaded by the input impedance of the amplifier of about 1.5 k. Figure 1 shows the effective impedance as seen by the audio and the RF frequencies.

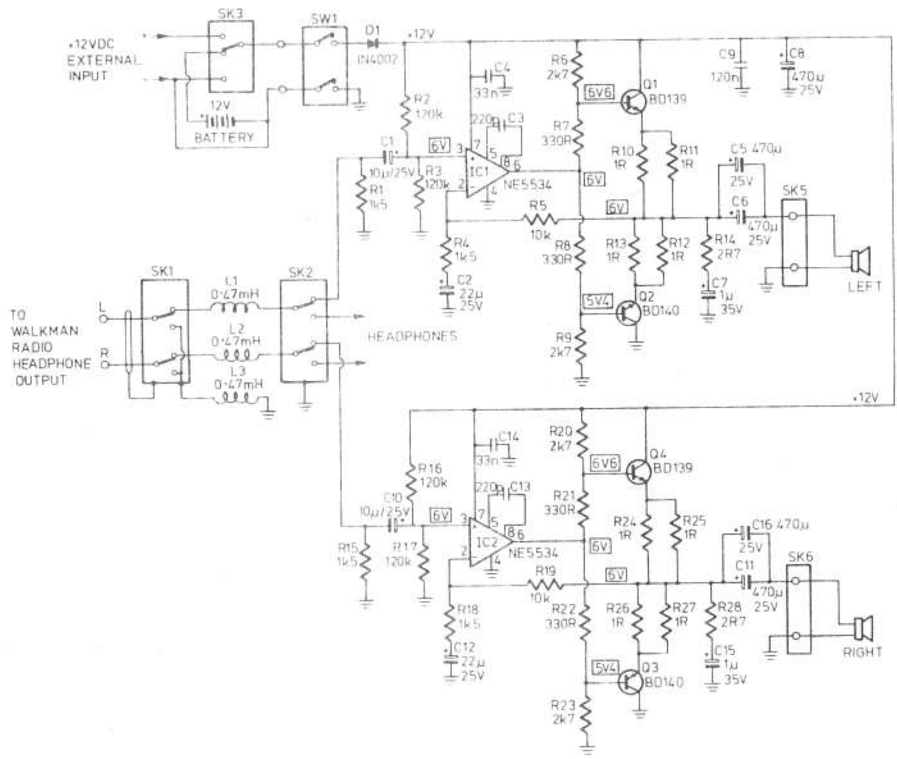
The audio input impedance of the amplifier is simply equal to the parallel resistance of R1, R2 and R3 (R16, R15 and R17 for the right channel). It works out to be around 1.5 k, which is a compromised value after some iterative testing. Lower impedance is possible but will start to load the Walkman output, resulting in a poorer transient and bass response. Any higher impedance and the coils (L1, L3) will start to pick up strong signals nearby like a generator or a alternator, etc. The cutoff, frequency at the input is determined by an emperical equation,

$$\text{Low Frequency Cutoff} = \frac{1}{2\pi\, C1 \times 1.5\,K} \quad 11\ HZ$$

The amplifier

The amplifier is basically configurated as a high current output op-amp by buffering the output of the op-amp to drive a low impedance speaker. Since the supply is only fixed at +12 V, it is desirable to have the ouput sitting at a dc level of +6 V for maximum swing in both directions. To achieve that input level, pin 3 of the op-amp is fixed at +6 V with a potential divider consisting of R2 and R3. Using the op-amp as a linear amplifying device (as opposed to a comparator), the inverting input of the op-amp (pin 2) must carry the same dc voltage (neglecting input offset voltages). Hence the dc voltage on the output of the op-amp is also fixed at +6 V. If the bases of the npn and pnp transistors connect directly to it, a standard class B amplifier is obtained. The usual cross-over distortion is fairly bad for class B operation, so the transistors have to be biased slightly on during no signal conditions. For the output (where R10-13 joins) sitting at +6 V, the base of Q1, Q2 must be sitting at roughly 0.6 V higher/lower than +6 V respectively. This requires that resistors R6 and R7,R8 and R9 be a fixed ratio. To calculate that, assume we have a +12 V supply and the op-amp output is sitting at exactly 6V. We want the





base of the pnp transistor (Q2) sitting at 6 − 0.6 V = 5.4 V, so we have

$$\frac{6\text{ V}}{(R8 + R9)} \times R9 = 5.4\text{ V, hence } R9 = 9(R8)$$

The above equation only gives an indication of their ratio but the actual value depends solely on the gain of the output transistors. After some trial-and-error, I came up with 330R and 2k7 for R8 and R9. The output emitter resistors R10-R13 form a current feedback to stablize the quiescent current due to fluctuation supply voltage. The higher the emitter resistance, the more the stablizing effect. But at the same time, the output voltage swing is more limited due to the drop in the resistors and results in smaller output power. Hence a good compromise is about 0.22 R, but I have checked around with a few major kit supplier only to find 1R in a 0.5 W package. In my design, I have used two commonly available 1 ohm resistors connected in parallel to achieve a 0.5 ohm resistance.

Feedback

The network is controlled by R5, R4 and C2. In the design, the dc voltage feedback from R5 is one. Since dc voltage can't go past capacitor C2, the +6 V dc on the output of the transistor is fully fed back directly onto pin 2 of the op-amp. This overall dc feedback is essential to keep the quiescent state of the circuit unchange. Any drift to voltage on the output of the circuit will cause an opposing change on the op-amp output to suppress the drift.

On the other hand, ac signals are fed back with a ratio determined by R4/ (R4 + R5). A five second mathematical manipulation shows that the gain for the ac signals is equal to;

$$\text{AC Voltage Gain} = 1 + \frac{R5}{R4} = 7.6$$

Bear in mind that this gain figure is frequency dependent. As frequencies drop to below 100 Hz, the gain will be largely determined by C2 and R4. The high frequency gain roll off at a point controlled by the compensating capacitor C3.

Wiring

Sockets SK1 and SK3 are 3.5 mm stereo phono sockets with in built switching action. As indicated in the circuit diagram, with the cable link unplugged from the amplifier, the coils L1 and L3 are grounded to avoid picking up any spurious signals. SK2 will divert the input signals from the Walkman to the headphone if it is plugged into the socket and hence, the speakers will be quiet. Socket SK3 is a dc plug pack type socket with a single pole switching action. If nothing is plugged in, the internal battery pack is connected to the circuit board. If an external power source is plugged in, the battery pack is switched out and power is drawn directly from the external source.