clipping indicator

for compact disc

A little while ago a reader wrote to say that he had found overdrive on some of his compact discs. This sort of news comes of course like a thunderbolt since it is assumed by most people that compact discs are examples of the quality of today's digital technology. The first reaction to such an allegation is one of outright disbelief or at least scepticism. Moreover, it has been alleged by other readers that several producers have admitted (sic!) to overdriving, that is clipping, of CDs at the request of the relevant artists. Be that as it may, it was reason enough to design an indicator to bring overdrive to light and help the consumer in his/her quest not to buy flawed CDs*.

*It should be noted that overdrive on a CD is not a legal reason for asking your money back.

Designed by T. Giesberts

Most people will not believe that there are CDs that are overdriven by the producer: they generally assume that manufacturers know what they are doing and supply discs that are technically correct within the confines of modern digital technology. If the experiences of some of our readers are accepted, this may not always be true.

One reader wrote to say that he had noticed that some CDs in his collection sounded 'less than perfect' and others even 'downright poor'. Since he thought that his ears were playing him tricks, he decided to check the level with a VU (visual unit). To his surprise he found that the level varied around 0 dB. A surprise, indeed, for the level on a CD should reach 0 dB only during very brief peaks in the signal. The average signal strength should be not less than 6 dB and preferably 10–12 dB below 0 dB.

In view of these findings, our reader decided to take his investigation a little further and connected an oscilloscope to the output of his CD player. This showed that on certain CDs the signal was clipped; on one or two, the clipping led to 'audible distortion'. **Fig-**

1

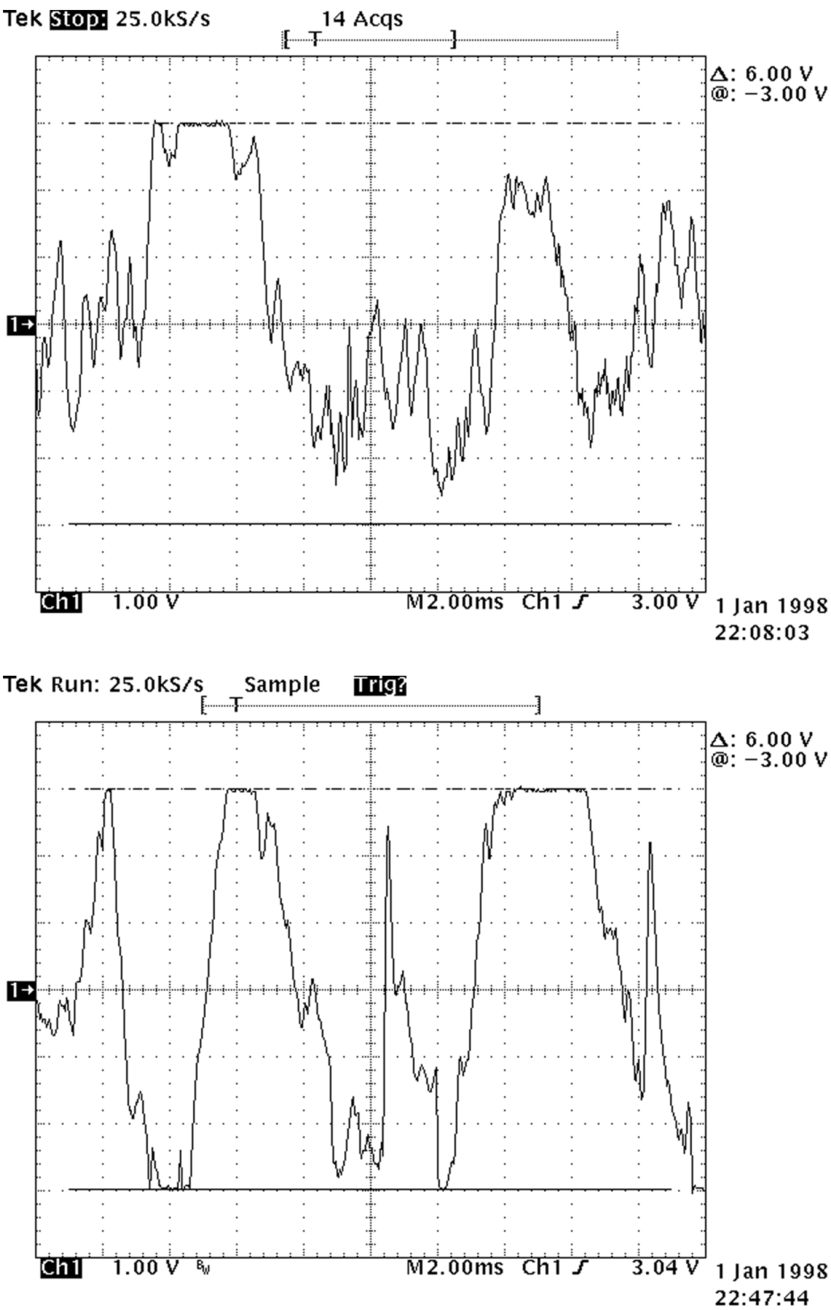
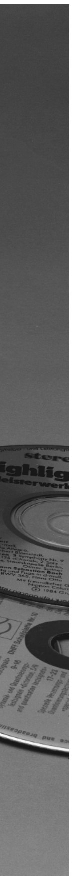


Figure 1. Two clear cases of overdrive allegedly measured on modern compact discs (Sony Music 099748 393227/1996 and 099748 698421/1997).



ure 1 shows a few examples (not necessarily the worst!).

Apart from leading to distortion, clipping also results in another phenomenon. Since the average signal strength is too high, the dynamic range of the music is reduced, so that the reproduced sound is much too flat, which can easily lead to 'listening fatigue'.

COINCIDENCE?

Could these findings be coincidence? It is hard to say, but evidence from other readers and our own measurements seem to indicate that there are CDs on which the signal has been purposely overdriven. [The allegation by another reader that two producers admitted to him that they sometimes used overdrive on CDs at the request of the relevant artists seems far-fetched – because it would be contrary to their commercial acumen – but not impossible. Also, the reason given by these producers that they 'dared not go against the wishes of these artists' seems highly suspect. No artist is bigger than a bona fide recording studio. Editor].

DETECTION

What can the consumer do to avoid buying a flawed disc? After all, a CD cannot be repaired or enhanced. Overdrive used in the recording studio cannot even be eradicated during manufacture of the disc.

The only thing a consumer can do is not to buy the suspect CD. But how is he/she to detect that a certain CD suffers from overdrive? Listening to it at the retailer's premises normally does not indicate anything awry, but once it is played on a good-quality installation at home a deficiency may come to light.

The solution appears to be a small portable indicator that can be taken to the retailer, assuming that it is possible to connect it to the retailer's playback equipment.

What should the indicator react to? It is clear that on a good-quality CD the 0 dB level will be reached only during short high-signal peaks. If the 0 dB level is sustained for more than a fraction of a second, there may be reason to be suspicious. Consequently, the indicator is designed so that an LED lights when two or more samples

2

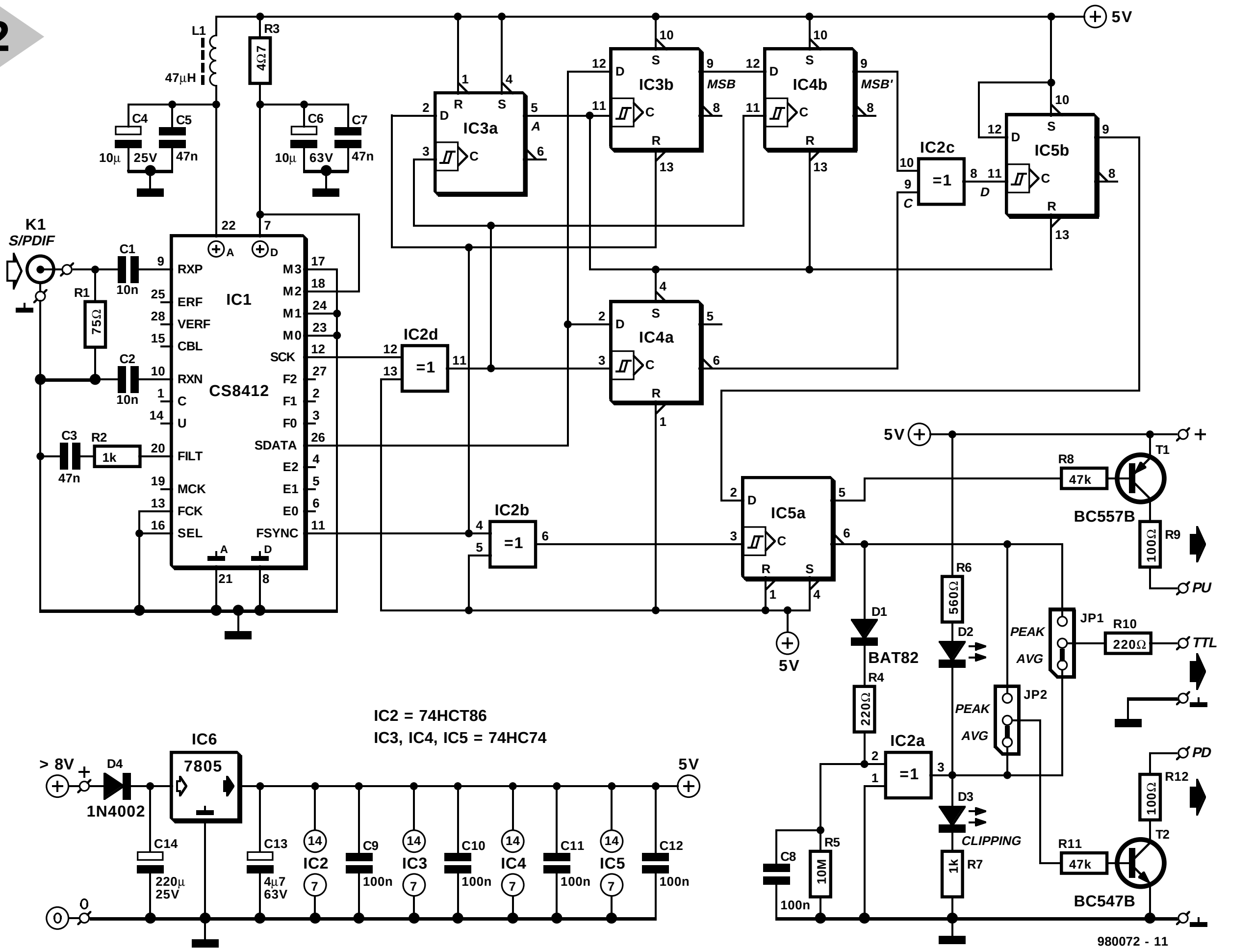


Figure 2. The circuit of the indicator consists of an integrated digital audio interface receiver and a number of gates and bistables forming the signalling section.

of the signal reach the peak value. The probability that some clipping then occurs is great. When the LED lights only once or twice per track, it must be assumed that this is caused by a couple of strong signals. If it lights more often, or it remains on for longer than a second, there is something not quite right.

To make a possible error indication as clear as possible, two LEDs are used: the green one lights as long as all is well, and the red one when there is something amiss. For those who have not the patience to keep an eye on the LEDs during the entire time the CD is played, there is an optional facility for connecting a counter module. This shows how many times during the playback clipping may have occurred.

In the design of the indicator it was assumed that the studio recording was transferred 1:1 to the manufactured compact disc.

CIRCUIT DESCRIPTION

The circuit diagram of the indicator is shown in **Figure 2**. Audio socket K_1 is for linking the indicator to the digital output of the CD player.

The relevant data are retrieved from the S/PDIF† signal with the aid of IC_1, an integrated interface receiver Type CS8412 (see Data Sheets elsewhere in this issue). This circuit can handle virtually all current sampling frequencies. The serial audio data (SDATA) are read with the aid of a bit-clock and a word-clock (SCK and FSYNC respectively). The output of the IC is set to a special format (normal mode FMT 4: $M_0=M_1=0$; $M_2=1$ $M_3=0$) in which a clock pulse follows each audio sample, irrespective of left or right.

The audio data are coded in 2s complement. To check whether a peak value has been reached, the MSB (most significant bit) must be inspected and compared with the remaining bits. In the case of digital minimum and maximum values, all remaining bits must be the opposite of the MSB. The minimum and maximum values are checked with an XOR function.

Gates & bistables

The comparing and indexing of the bits is carried out by a number of gates and D-bistables. The timing diagram of the most important signals is shown in **Figure 3**.

At the start of a new sample, a clock signal is generated exclusively for the MSB in D-bistable IC_{3a}-IC_{3b}. The FSYNC signal is clocked into IC_{3a} by the inverted bit-clock (IC_{2d}). The output of IC_{3a} (signal A) forms the clock for the MSB.

The clock input of IC_{3b} goes high in the middle of the MSB, after which the bit is held for the duration of the audio sample (pin 9 of IC_{3b}).

To ensure that the MSB is applied to comparator IC_{2c} simultaneously with the next bit, it is clocked again in D-bistable IC_{4b}.

The remaining bits are clocked by IC_{4a}. Since signal A is applied to the S-input of this bistable, the inverted output remains low until the first of the remaining bits is clocked (signal C).

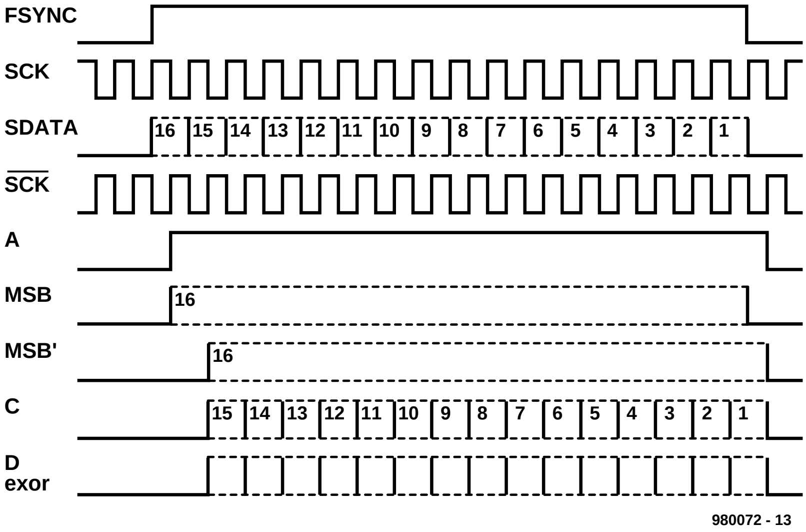
Use of the inverted output ensures that all bits there have the same level as the MSB if and when a minimum or maximum value is reached. If the level is not the same, IC_2 goes high at a certain moment, which causes IC_{5b} to be clocked. This means that the output of IC_{5b} is high when there is neither a minimum nor a maximum value.

So as to enable the actual state of each sample to be determined, most bistables, including IC_{5b}, are reset by signal A. Before this happens, the status of IC_{5b} for each sample is clocked to IC_{5a} by the FSYNC signal inverted by IC_{2b}. Since IC_{5a} is not reset by signal A, the data transferred to it are retained. Pin 6 of this bistable therefore remains low as long as there is no sample that contains a minimum or maximum value. If a peak value does occur, pin 6 briefly goes high.

Converting the change in level at the output of IC_{5a} into a usable optical indication is not too difficult. The design basis was to make a (red) LED (D_3) light for about one second if two or more consecutive samples reach peak value. Time constant R_4-C_8 averages a number of samples, while the discharge time of C_8, determined by R_5, results in an afterglow of about one second. The potential across C_8 is buffered by IC_{2a}. The indication becomes much clearer by the addition of a second (green) LED (D_2). The light-up behaviour of this diode is the opposite of that of D_3, so that when clipping occurs there is a distinctive change of colour.

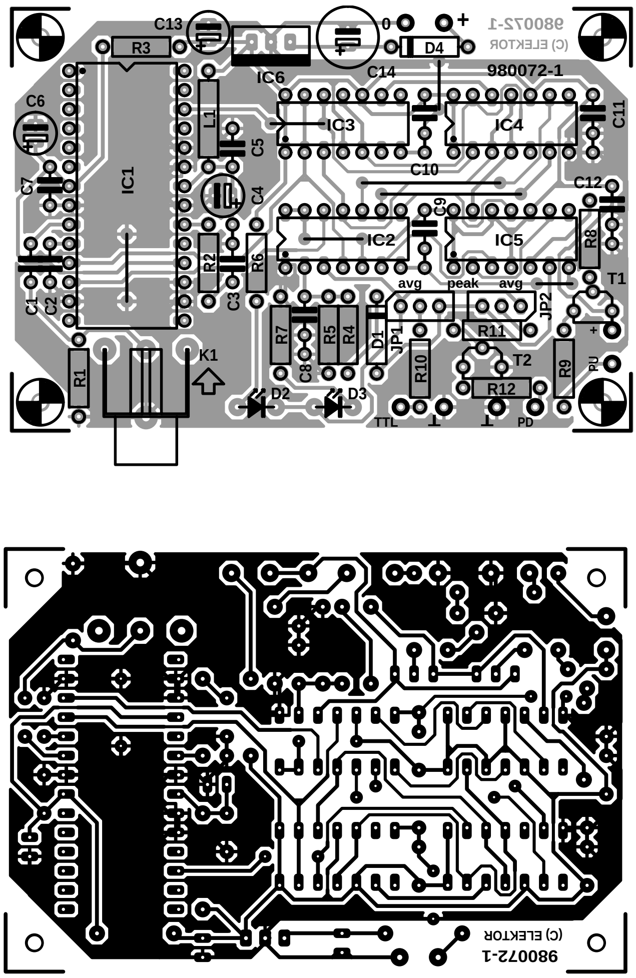
3

Figure 3. Timing diagram of the most important signals in the indicator.



4

Figure 4. The printed-circuit board for the indicator makes construction child's play.



Parts list

Resistors:
R_1 = 75 Ω
R2, R_7 = 1 kΩ
R_3 = 4.7 Ω
R_4, R_{10} = 220 Ω
R_5 = 10 MΩ
R_6 = 560 Ω
R_8, R_{11} = 47 kΩ
R_9, R_{12} = 100 Ω

Capacitors:
C_1, C_2 = 0.01 µF, ceramic
C_3 = 0.047 µF
C_4, C_6 = 10 µF, 63 V, radial
C_5, C_7 = 0.047 µF, ceramic
C_8–C_{12} = 0.1 µF
C_{13} = 4.7 µF, 63 V, radial
C_{14} = 220 µF, 25 V, radial

Semiconductors:
D_1 = BAT82
D_2 = LED, green, high efficiency
D_3 = LED, red, high efficiency
D_4 = 1N4002
T_1 = BC557B
T_2 = BC547B

Integrated circuits:
IC_1 = CS8412 (Crystal Semiconductor)
IC_2 = 74HCT86
IC_3, IC_4, IC_5 = 74HC74
IC_6 = 7805

Miscellaneous:
L_1 = choke 47 µH
JP_1, JP_2 = 3-way, 2.54 mm pin strip and pin jumper (Maplin)
K_1 = audio connector (male) for board mounting
Enclosure 120 × 65 × 41 mm (L× W× H), e.g., Bopla 430 (available from Phoenix 01296 398355)
PCB Order no. 980072 (see Readers Services towards the end of this issue)

5

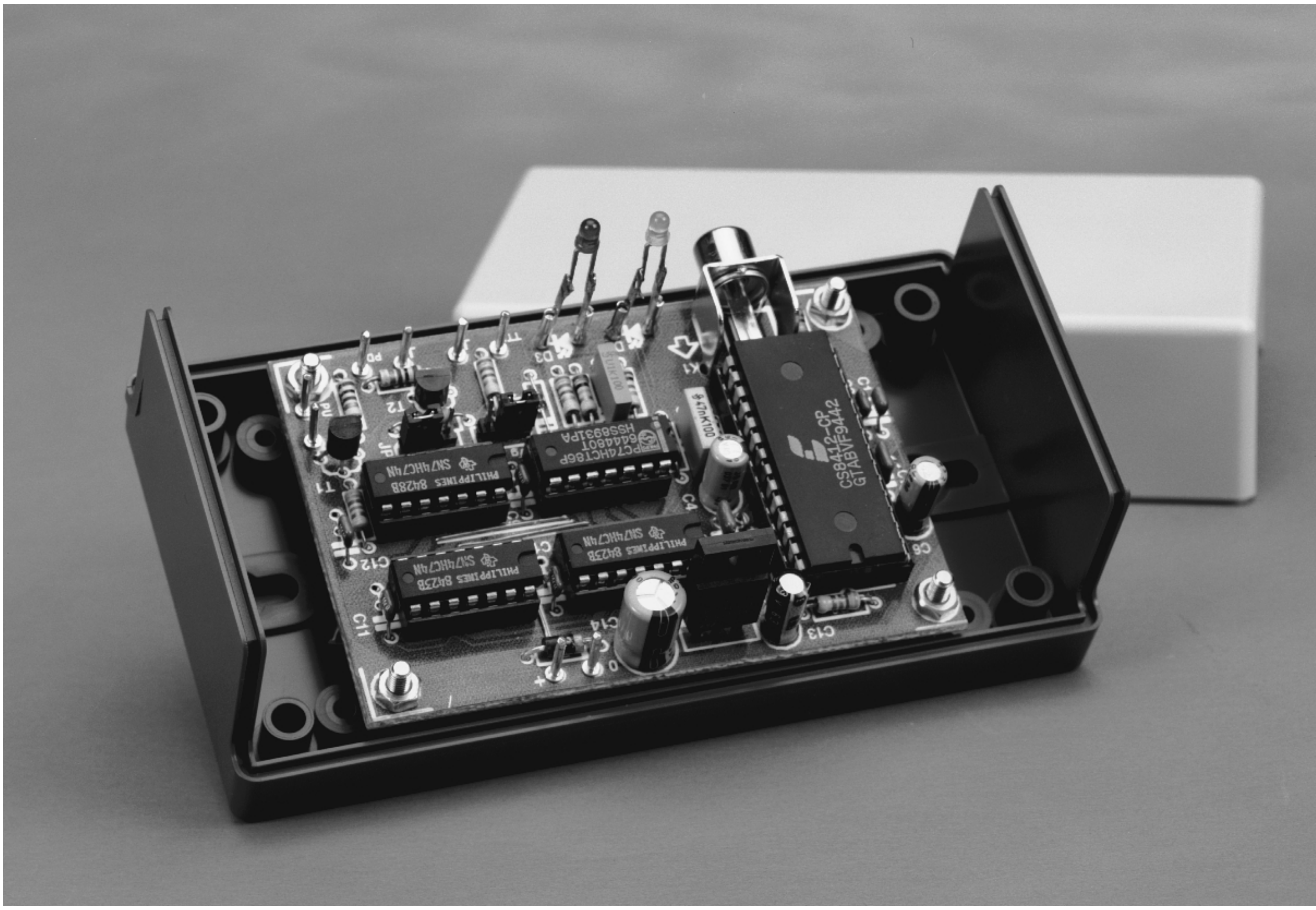


Figure 5. Photograph of the completed prototype indicator board.

COUNTER OPTION

As mentioned earlier, there is provision for linking a counter module to the indicator to show the number of times that clipping has occurred over a given period. There are three outputs: TTL, pull-down (PD), and pull-up (PU), so that almost any current type of module can be used.

Owing to the averaging by R_4-C_8, the output remains active even when brief interruptions occur. If, however, the output of IC_5 is used, count pulses are obtained for all discrete samples or strings of them. Both facilities may be used thanks to JP_1 and JP_2. This arrangement gives a choice at the TTL or PD output of either an averaged count of the number of times clipping has occurred or a count giving the peak value.

In practice, peak counting may be a little too severe, since normally nothing much happens when the peak signals just reach the 0 dB level. The averaged count is a more realistic measure of the number of clipping occurrences. A drawback of the averaged count is that the toggling of IC_{2a} may cause high-frequency pulses that may adversely affect fast counter modules. However, most modern modules are immune to these pulses and in any case the risk can be removed by connecting a 1 μF capacitor across the counter input.

CONSTRUCTION

The indicator is best built on the PCB shown in **Figure 4**. Populating the board with reference to the components list and the circuit diagram should not present any undue difficulties. Sockets should be used for the ICs. Mind the the polarity of the electrolytic capacitors and diodes. Note that D_1 must be of the type specified in view of the permissible leakage current.

Since the circuit provides for a 5 V regulator, IC_6, a mains adaptor with an output of not less than 8 V may be used as power source. The circuit draws a current of about 25 mA. This low current also facilitates the use of a 9 V battery if portable use is desired. A dry battery will give some 10 hours operation.

For portable use it is, of course, essential that the circuit is housed in a small, neat enclosure such as that specified.

[980072]