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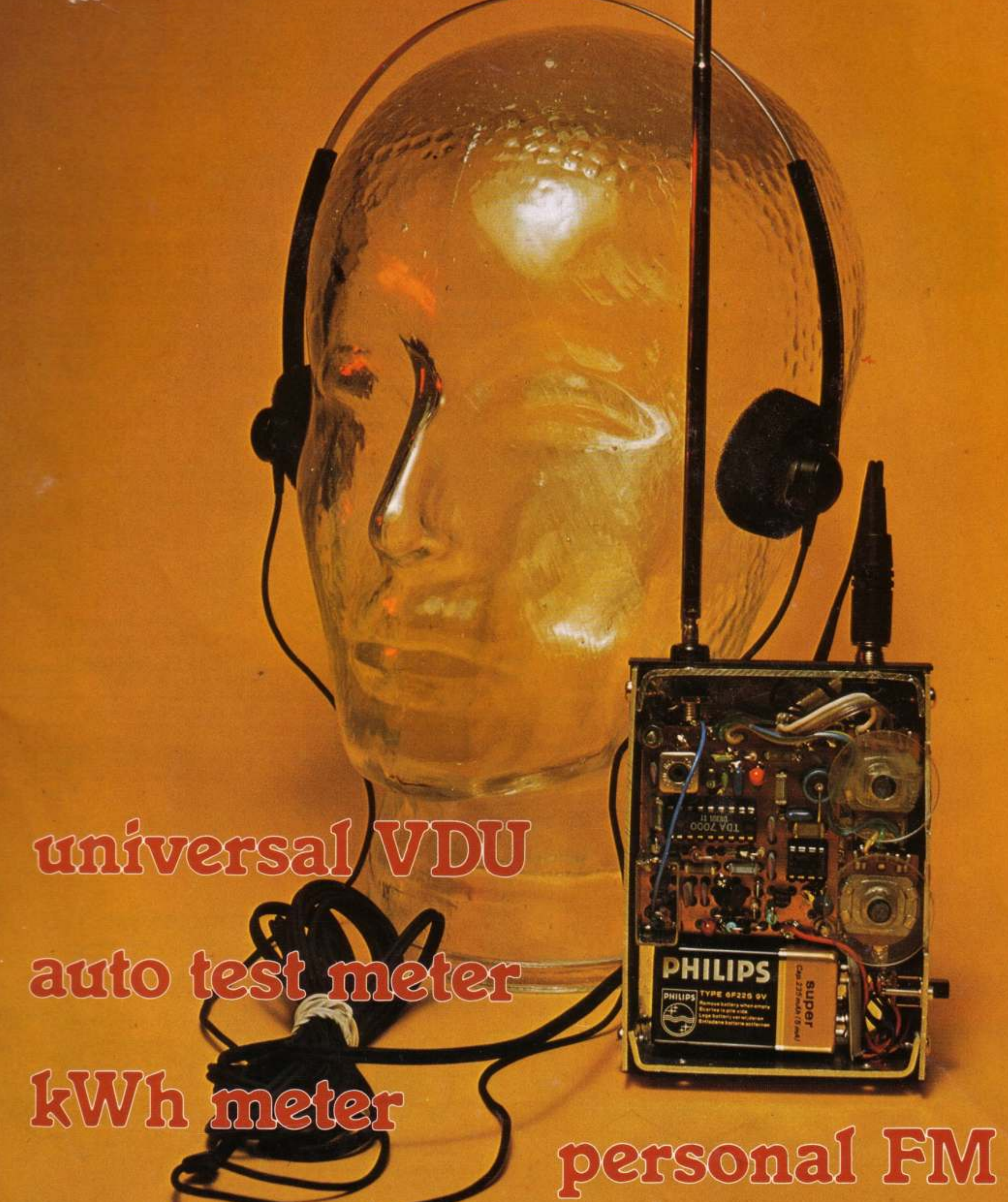
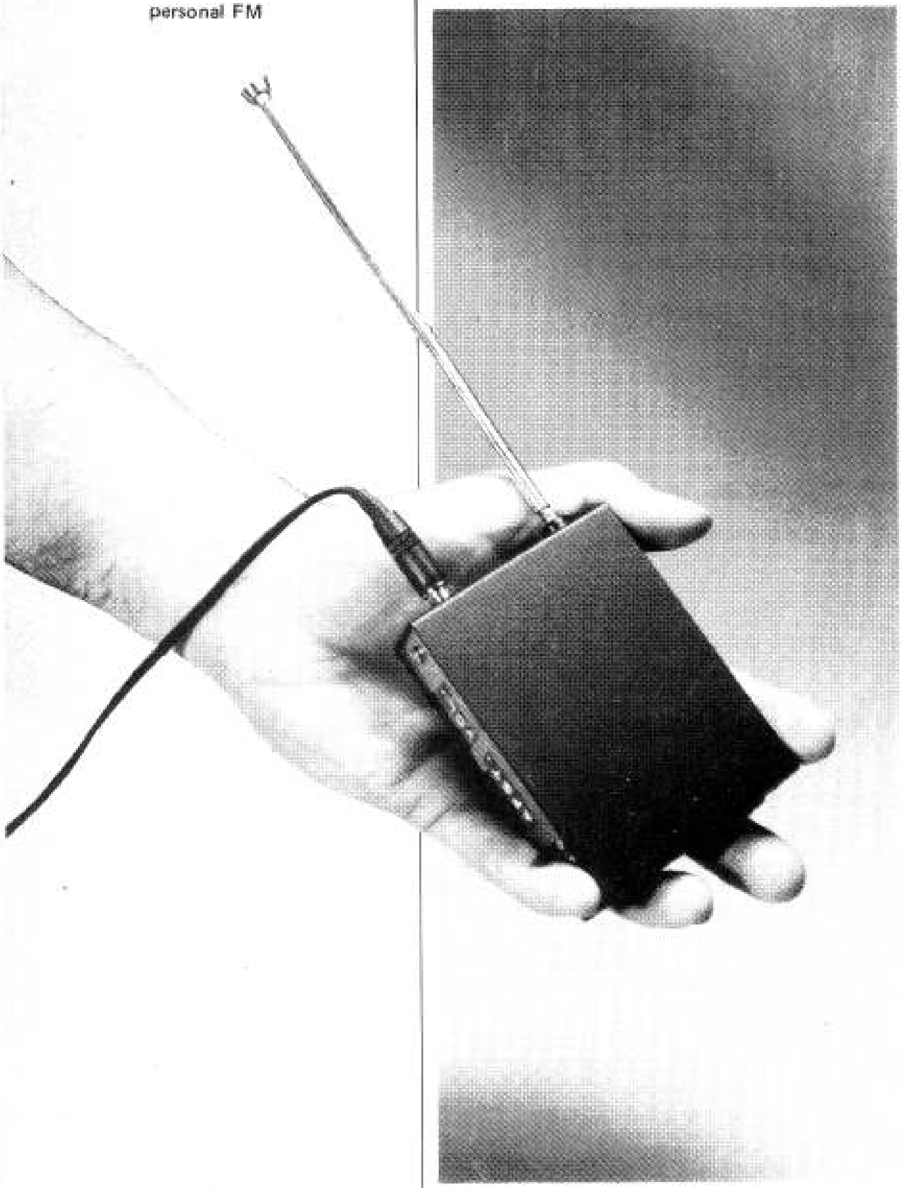


universal VDU

auto test meter

kWh meter

personal FM



personal FM

miniature high quality FM receiver

The relatively new TDA 7000 from Philips is an IC that forms the basis of a complete FM receiver just by adding a few passive components. This IC could be described as an 'aerial signal in – low frequency signal out' sort of chip. However, not being satisfied with that, we expanded a little on the basic theme by adding a bit here and there, designed a printed circuit board, and ended up with a high quality mono FM receiver that is quite literally pocket sized!

Manufacturers are always interested in miniaturising receiver circuits and they keep pushing the limits further and further. In a normal receiver set-up extreme integration is to be avoided especially as regards tuning coils, ceramic filters, band filters, and trimmers. Coils especially are a problem. Certainly they could be replaced by gyrator circuits, but because of their complexity these also have certain disadvantages at high frequencies, such as low Q factor, limited dynamic range and fairly high current consumption.

So Philips set out to develop a receiver that was less sensitive to the various problems posed by IC technology itself. And they succeeded with an 18 pin chip that needs only an oscillator and a few small capacitors to form an FM receiver. Everything else is internal, from the aerial input right through to the IF filters and demodulator! The break through came when they decided to abandon accepted practice and chose to use an FLL system (a type of feedback PLL). This system works with a low enough IF (intermediate frequency) so that the IF selectivity can be realised with RC filters which, unlike LC filters, can be miniaturised successfully. Moreover, the disadvantages inherent in this low IF were suppressed by using a clever muting system.

Figure 1 shows the block diagram of the IC, complete with the components needed for a bog-standard radio. A very simple affair! We will not go any further into this block diagram at the moment as we will concentrate on how this circuit is expanded into something more interesting.

Micro or mini

We are always interested in new ICs and how they can be used and this is the case with the TDA 7000. Now that we've decided we want to use it as the basis for a radio receiver we have to decide what sort of receiver it is going to be. Should it be a normal small FM radio? Or maybe something extremely small? Should the accent be not so much on small dimensions as quality . . .? The character of the IC is an invitation to make a micro radio . . . but that's easier said than done!

A real micro design does not seem so interesting. There are limits to how small it can be made if it is to be put on a printed circuit board and we would not seriously consider anything else. So what we want is a 'bigger than micro' design with somewhat higher quality and without the disadvantages of the 'as small as possible' design. It must have a suitable low frequency amplifier

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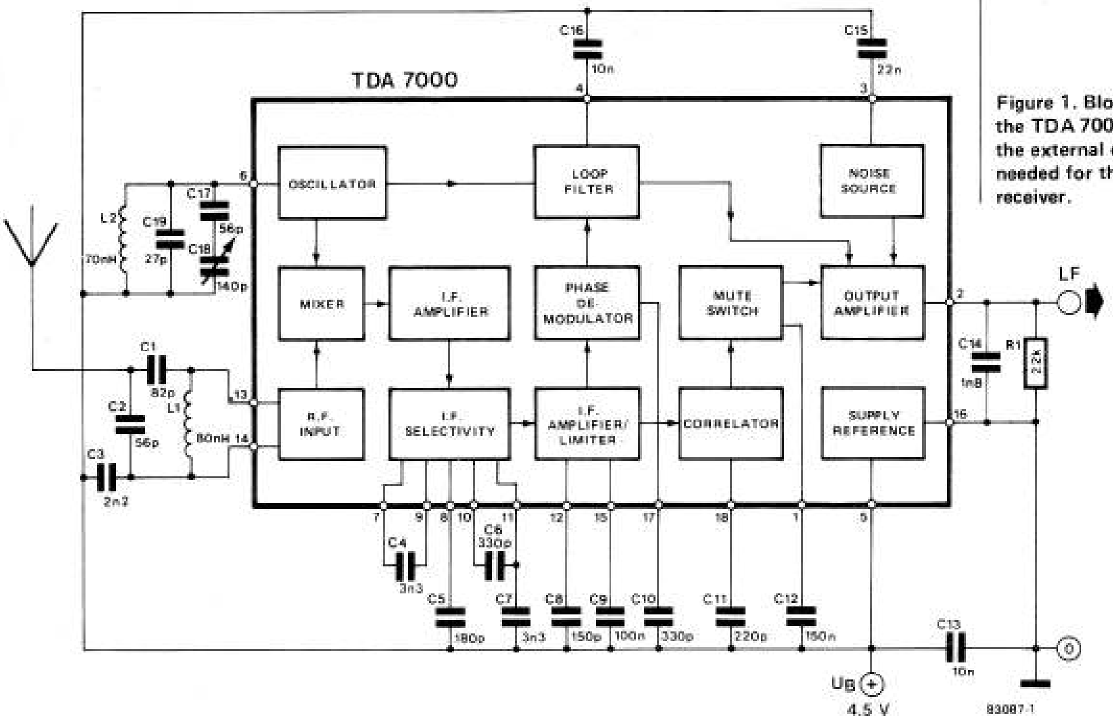

Figure 1. Block diagram of the TDA 7000 including the external components needed for the basic radio receiver.

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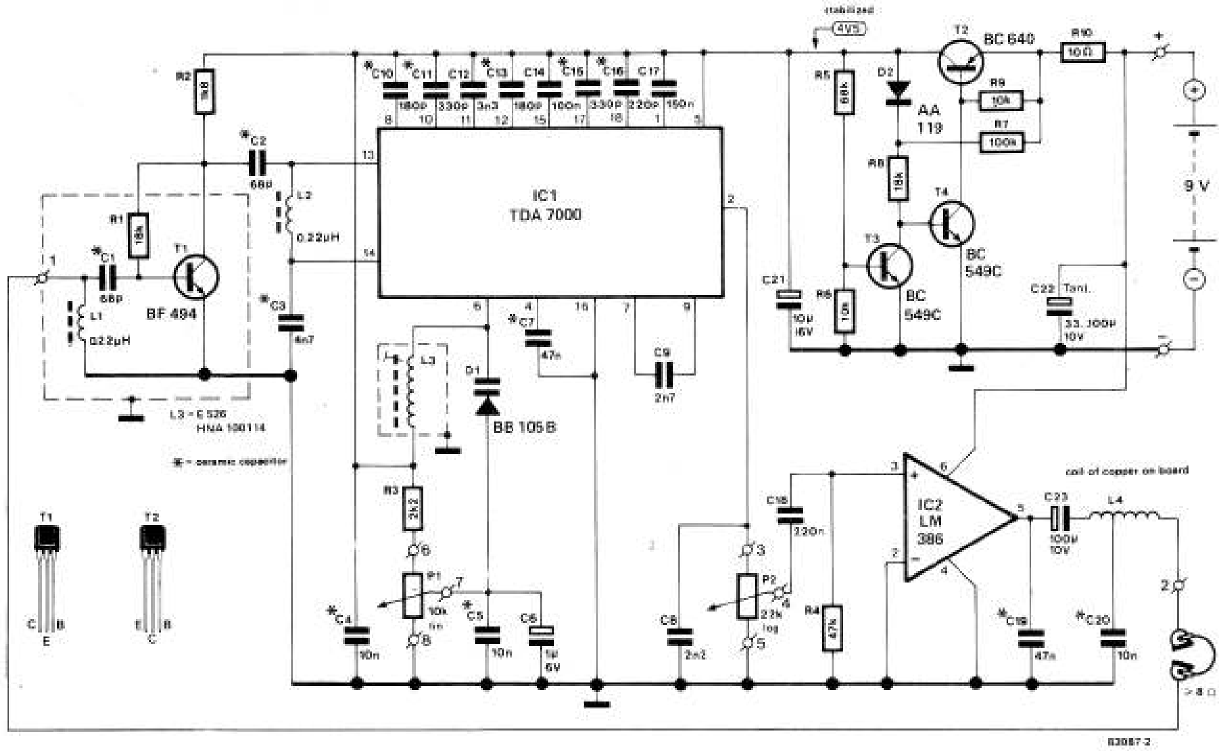


Figure 2. The circuit diagram of our personal FM receiver. The varicap tuning and the extra HF preamplifier improve the reception substantially.

included and the complete unit must all be contained on one printed circuit board so that only a battery, headphones and, possibly, an aerial have to be connected to it.

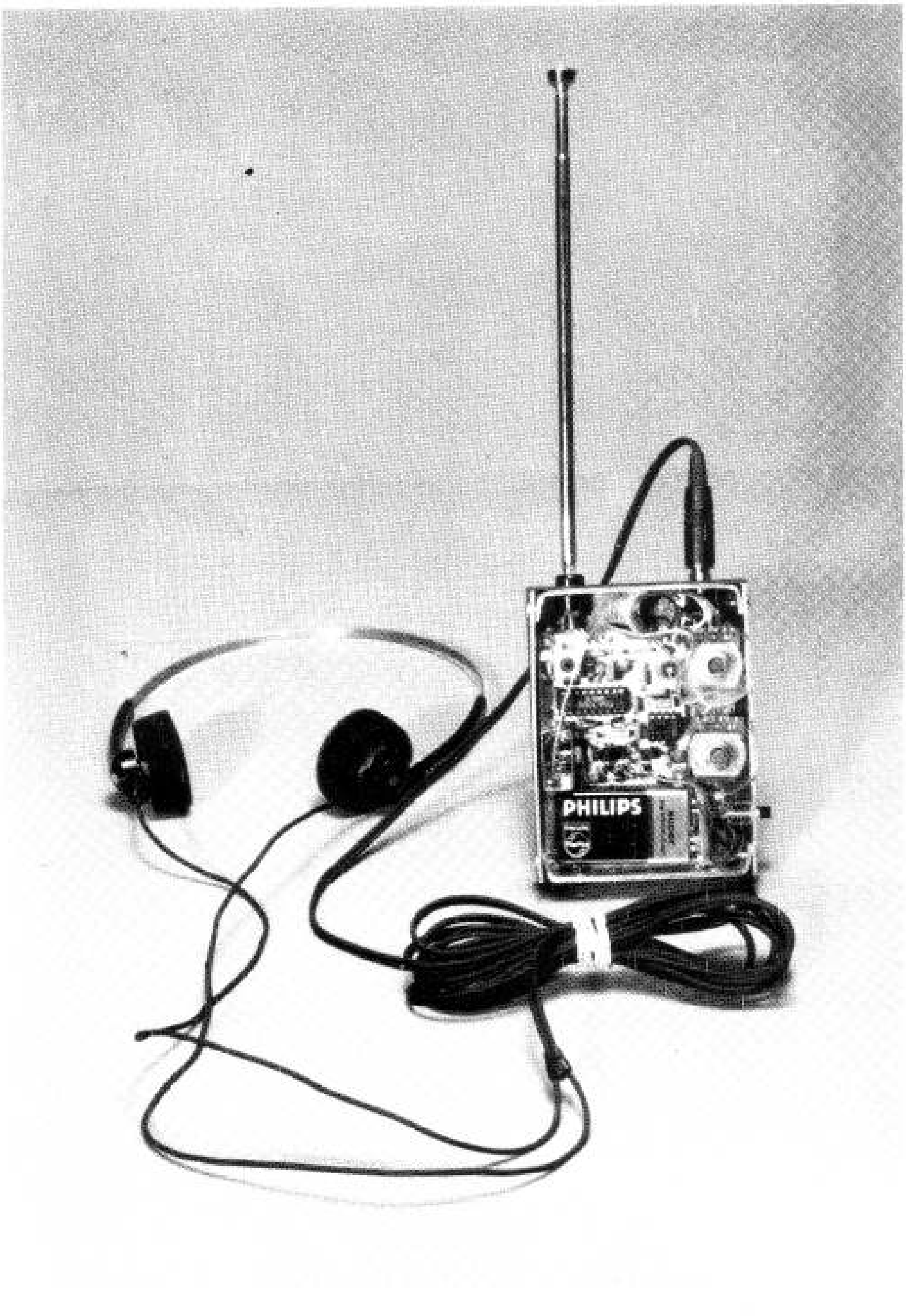
The circuit diagram

Let us start by saying that, no matter what type of receiver is designed around the TDA 7000, a large part of it will always be the same. Almost everything is included in the IC so there is very little designing to be done with external components, and the receiver design cannot really be changed. The similarities between the design of figure 2 and that in figure 1 are clear enough but there are also a few differences, principally in the input stage and the oscillator. Also the more advanced design (figure 2) includes power supply stabilization and the LF amplifier mentioned before.

Although in principle a small loudspeaker can be used for the output of the radio, it is intended, initially, that small personal cassette type headphones should be used. A secondary advantage of headphones is that the lead can act as an aerial. To avoid making the receiver any bigger and more complicated than absolutely necessary we used a readily available amplifier IC (the LM 386 from National) for the headphone amplifier. This chip supplies very good sound quality and, for a small loudspeaker or headphones, its power output of 0.5 watt is quite sufficient! Furthermore the LM 386 needs only three external components (R4, C19 and C20).

There are a few qualities of the basic design that we were not entirely happy about. In the first case it was found that the sensitivity of about 7 μV is a bit on the low side for a personal FM receiver. If you walk around with that sort of radio receiver the aerial is not always in the most ideal position and the chances are that the station that you are tuned in to will continually disappear under the squelch.

Therefore we decided to include a HF preamplifier (T1). This preamplifier stage is very easy to set up, not at all critical and ensures that the sensitivity is always under 1 μV. As the circuit diagram shows, its input is connected to one side of the headphones so that the lead can act as an aerial. The L4/C21 network has two functions. Apart from suppressing any spurious components



Parts list

Resistors:
R1,R8 = 18 k
R2 = 1k8
R3 = 2k2
R4 = 47 k
R5 = 68 k
R6,R9 = 10 k
R7 = 100 k
R10 = 10 Ω
P1 = 10 k ten turn pot
P2 = 22 k log pot

Capacitors:
C1,C2 = 68 p ceramic
C3 = 4n7 ceramic
C4,C5,C20 = 10 n ceramic
C6 = 1 μ/6 V
C7,C19 = 47 n ceramic
C8 = 2n2
C9,C12 = 3n3
C10,C13 = 180 p ceramic
C11,C15 = 330 p ceramic
C14 = 100 n
C16 = 220 p
C17 = 150 n
C18 = 220 n
C21 = 10 μ/6 V
C22 = 220 μ/10 V
C23 = 100 μ/6 V

Semiconductors:
D1 = BB 105
D2 = AA 119
T1 = BF 494
T2 = BC 640
T3,T4 = BC 549C
IC1 = TDA 7000
IC2 = LM 386

Inductors:
L1,L2 = 0.22 μH (coil on Toko former)
L3 = E 526 HNA 100114 (Toko)
L4 = inductance made with copper tracks on the printed circuit board

Miscellaneous:
Leightweigt headphones, at least 8 Ω impedance

3

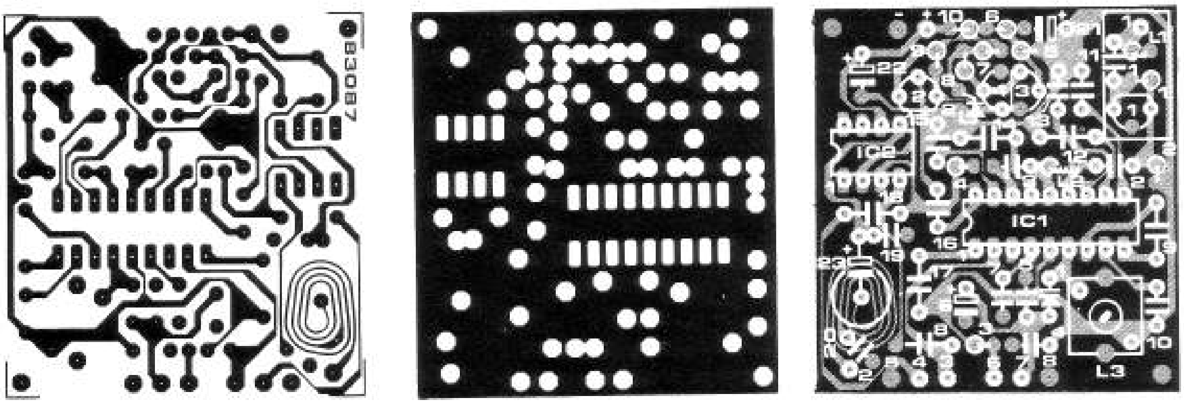


Figure 3. The component overlay for the double-sided board. The large area of copper on the upper side acts as an earth plain for the circuit.

of the output signal from IC2, it also acts as a decoupling circuit between the LF output and the HF input.
There are also a few details about the oscillator which should be changed. First of all the coil. To alleviate supply difficulties we used a standard off-the-shelf Toko coil. There are two problems with using a tuning capacitor for this circuit: availability is often a problem and some sort of mechanical gearing must be used in order to make tuning easier. We decided to kill two birds with one stone and used a varicap diode (D1) in combination with a 10-turn potentiometer (P1) for the control voltage.
Because the tuning voltage must remain very stable, some form of voltage stabilization must be used. In order to spare the (small) battery as much as possible, the losses (voltage drop and current consumption) of the stabilizer should be small. This explains the use of a discrete circuit here (T2, T3 and T4) in preference to an IC. Even if the battery voltage drops to 5.5 V this stabilizer still supplies a constant 4.5 V.
And that is the whole circuit. Note that pin 3 of the TDA 7000 is left unconnected because it was considered that using squelch suppression with artificial noise is going a bit too far. For anybody who wants to use this built in noise generator, a 22 nF capacitor can be connected between pin 3 and the positive supply.

The printed circuit board

Although it was not intended as a micro circuit, the 50 x 50 mm dimensions of the double sided printed circuit board shown in figure 3 still make it very diminutive for a complete FM receiver. Even when the 9 V battery is included the end result can justly be called a personal receiver.
In the case of the HF stage there are absolutely no problems with construction. The worst thing is trying to remember the type number of the oscillator coil, L3. It is an E 526 HNA - 100114 from Toko, and that's quite a mouthful for 'the morning after the night before'. However, L4 is not so difficult as it is already etched onto the printed circuit board.
The input and oscillator stages should ideally not be able to 'see' each other. Therefore the area around T1 should be screened, preferably with mu-metal or copper. Space has been left on the board for these screens and their locations are indicated. The four pieces of screen are soldered into a box and then soldered to the upper side of the printed circuit board. Most of this upper side (or component side) of the board is an 'earth plane'. Therefore, all points which should be connected to earth are soldered to the top of the board and the rest simply connect to the under side. These latter (non-earth) points are of course the copper 'islands'. When construction of the printed circuit board is completed, only the tuning and volume potentiometers (P1 and P2 respectively) have to be connected, not forgetting the battery and headphones of course. The connection points are clearly marked.

Adjustment

Normally quite a large section of an article describing the construction of an FM receiver would be devoted to setting up, but that is hardly necessary with the TDA 7000. The simple adjustment of L3 to ensure the correct receiver range (87.5 . . . 104 MHz) is all that is required. That can be done with a frequency counter of course but the simple method is to compare it with another receiver!
One final point. Even though it is extremely handy to use the headphone lead as an aerial, it is much better to use a 60 cm (or even 30 cm!) aerial. And that does not apply only for this receiver, but also for any other personal radio. If an aerial is used it should be connected to the junction of L1/C1 (aerial input) and the headphones between the LF input and ground.
We have spent hours listening to our FM receiver (mainly before the morning coffee break? Ed.) and it must be said that it gives a very good account of itself. The sensitivity is reasonable and the quality of the sound is actually very good. The only 'but' is that the TDA 7000 is only a mono receiver. But you can't have everything and who knows, maybe it is only a matter of time before we get a pin compatible version suitable for stereo. In the meantime we have a trick up our sleeve that may be just as good but that will have to wait until – maybe the next issue! ◾