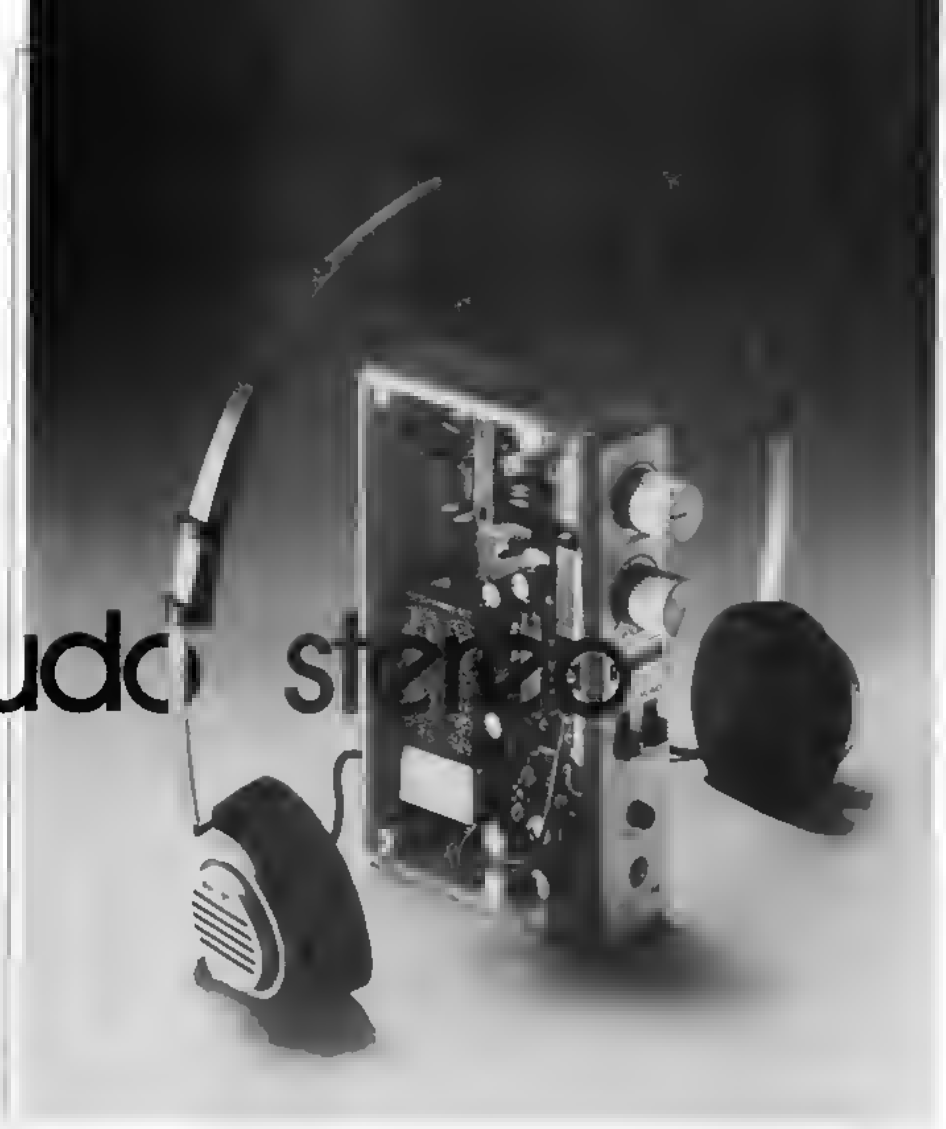
pseudo stereo

for the personal FM



The personel FM radio receiver publishad in the September 1983 issue was based on the TDA 7000 from Philips and has proved to be very popular. The good news is that this IC has been followed by another from the same source, the TDA 3810, and this can be used to put the personal FM receiver in en entirely different light.
We know thet the TDA 7000 is for mono reception only and therefore stereo reception is out of the question . . . almost! If not actual stereo, how about a 'pseudo stereo'? This is where this article and the TDA 3810 come in!

Shortly after the introduction of the 'TDA 7000 single-chip FM receiver' IC, Philips follow it up with another new chip which, even though it is hardly likely to cause an uproar in 'The House', is still a very nice 'first' in many respects. It is, in fact, an interesting 18 pin IC, the TDA 3810, which converts a normal mono signal into a pseudo stereo signal, or a normal stereo signal into so-called spatial stereo.
This 'spatial' possibility (also called 'super stereo') is, of course, for enthusiasts, but pseudo stereo is, certainly when combined with the TDA 7000, a very interesting idea. This is all the more so as the 'stereo' effect is very good (we have already heard it!) and this also completely avoids the noise problem associated with true stereo personal receivers. Above all, this pseudo stereo IC is a lot cheaper than a full stereo decoder!

The design

The block diagram for the TDA 3810, along with the extemal components that are needed, is given in figure 1. It shows that the pseudo stereo circuit splits the incoming mono signal (connected to pins 2 and 17) into two channels. One channel goes straight to the output. In the second, however, all frequencies between 300 Hz and 2 kHz are delayed. The value of this delay is frequency dependent (for example, at 800 Hz it is 500 μs), and that gives the listener the illusion of stereo. Frequencies below 300 Hz and above 2 kHz from the second channel are passed unchanged to the output so that one speaker does not have a wider frequency range than the other. Because the effect is a matter of personal taste, the low-pass filter used has been kept off the chip to enable each user to set it to suit himself.

In stereo there is a difference of 60 dB between the channels. The spatial stereo effect is achieved by adding an anti-phase cross-talk between the channels. This 'anti-cross-talk' (about 50%) increases the *apparent* distance between the two loudspeakers.
Because using the TDA 3810 means that there is an extra element in the path of the audio signal, no effort was spared when the IC was designed to ensure that the figures for signal/noise ratio and distortion are as good as possible. The end result is a signal/noise ratio of 70 dB, which is quite good, and the harmonic distortion measured in the prototypes was less than −80 dB. Stereo noise is totally unknown to the TDA 3810, as is annoying 'switching noise' that occurs if a stereo receiver tuned into a weak stereo signal constantly switches between mono and stereo.
There are two switches connected from pins 11 and 12 to ground and these are used to switch between mono and pseudo stereo and between ordinary stereo and spatial stereo. Two LEDs can be directly driven from pins 7 and 8, by means of built in driver stages, to indicate whether the circuit is in pseudo or spatial stereo mode. The IC needs a voltage supply of between 4.5 and 16 V and has a current consumption of about 7 mA.
The three tables give the specifications for the TDA 3810. Table 1 is the maximum ratings, table 2 the normal specifications, and table 3 is a sort of truth table for how the various functions relate to the positions of the switches and the indications on the LEDs.

The stereo extension

The TDA 3810, with its pseudo stereo capability was developed with the intention of combining it with the TDA 7000 to provide a very small FM receiver with a 'better than mono' sound at a relatively low cost.
The printed circuit board for the stereo extension is fully compatible with the personal FM receiver, the full details of which was published in our September issue. The added circuit effectively replaces the volume control of the FM receiver so that the TDA 3810 decoder is connected between the receiver IC and the LF amplifier. Apart from that the only addition now required is an extra LF amplifier since we now have two channals.
Because the complete extension circuit, including the added LF amplifier, is contained on one printed circuit board, converting our personal FM from mono to pseudo stereo is straightforward. Now, of course, the case we built for the original receiver is no longer big enough but the whole assembly can still remain a very compact receiver.

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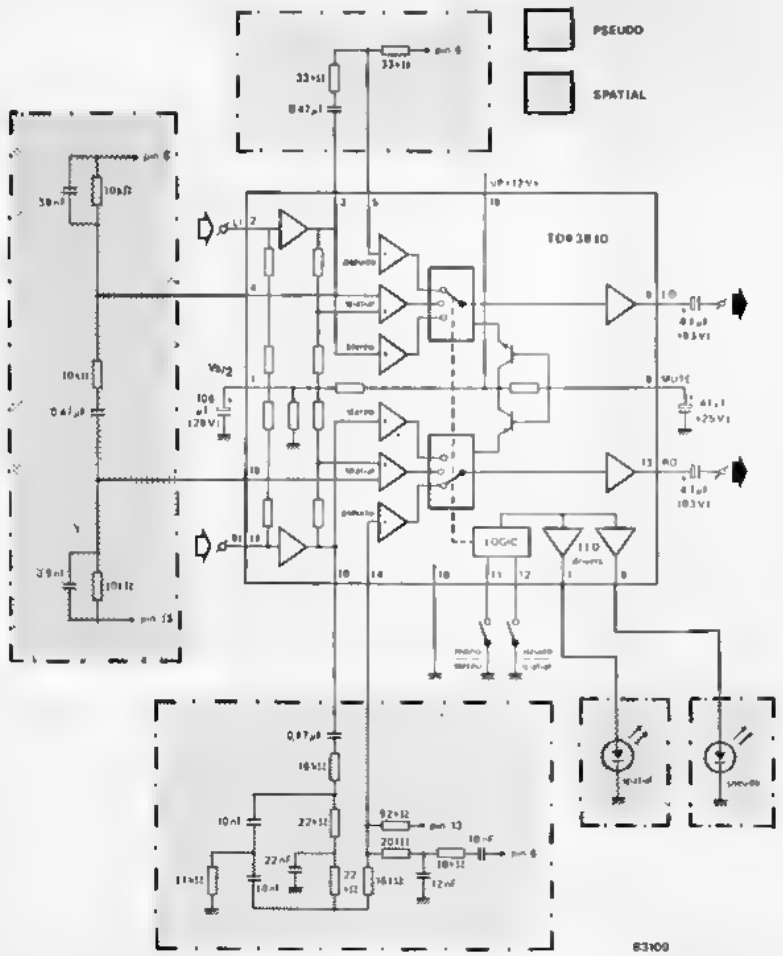

Figure 1. The block diagram of the TDA 3810, complete with the necessary external components. The pseudo stereo effect is achieved by a selective delay of a specific part of the audio spectrum, and spatial stereo by adding 'anti-cross-talk' to the audio signal.

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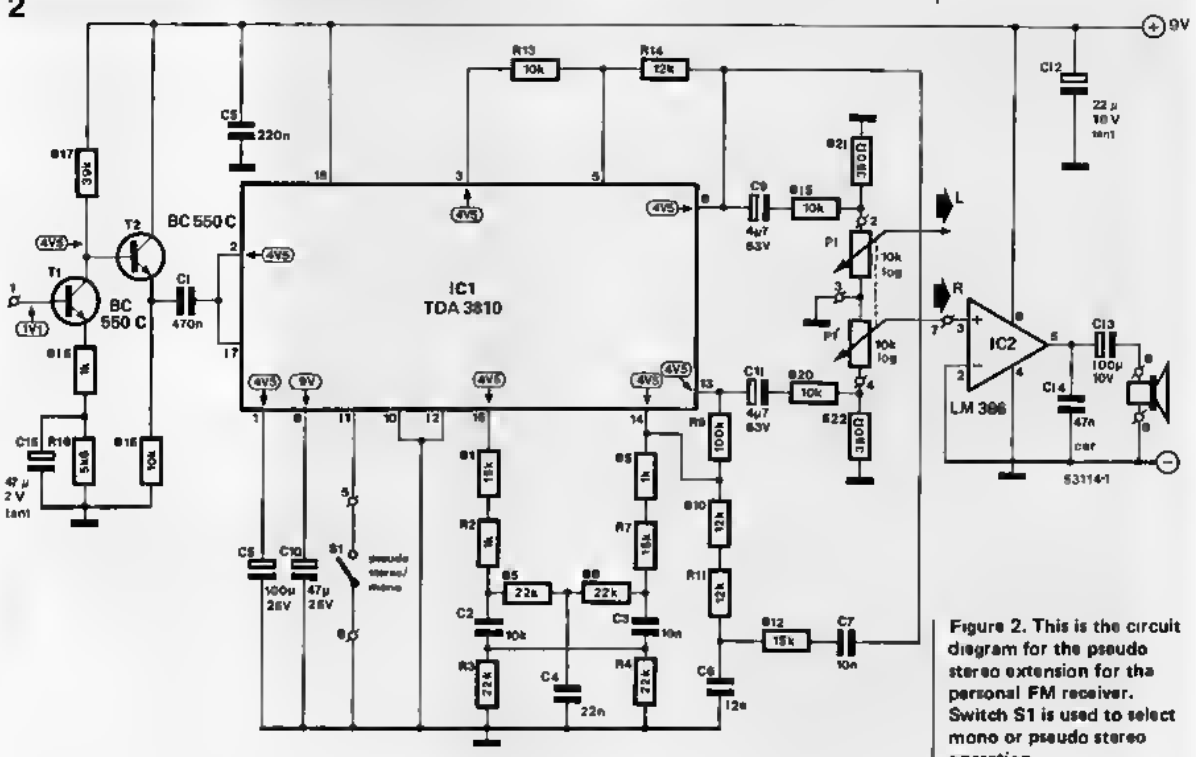

Figure 2. This is the circuit diagram for the pseudo stereo extension for the personal FM receiver. Switch S1 is used to select mono or pseudo stereo operation.

Table 1

Maximum ratings

Supply voltage (pin 18)	V_P	max. 16 V
Supply current (pin 18)	I_P	max. 12 mA
Storage temperature range	T_{stg}	−25 to +150°C
Operating ambient temperature range	T_{amb}	0 to +70°C
Thermal resistance from crystal to ambient	$R_{th\ cr\text{-}a}$	80 K/W

Table 1. The most important maximum ratings of the IC (to IEC 134) standard. These must be adhered to strictly!

Table 2

Characteristics

V_P = 12 V; T_{amb} = 25°C; test circuit (figure 1) in stereo mode (pin 11 to ground) unless otherwise specified.

parameter	symbol	min.	typ.	max.	unit
Supply voltage range (pin 18)	V_P	4.5	–	15	V
Supply current	I_P	–	7	12	mA
Reference voltage	V_S	5 3	6	6.7	V
Input voltage (pin 2 or 17) THD = 0.5%	$V_{i(rms)}$	2	–	–	V
Input resistance (pin 2 or 17)	R_i	50	75	–	kΩ
Voltage gain (V_o/V_i)	G_v	–	0	–	dB
Channel separation (R/L)		–	–	0.5	dB
Total harmonic distortion f = 40 to 16,000 Hz; $V_{o(rms)}$ = 1 V	THD	–	0.1	–	%
Power supply ripple rejection	RR	–	50	–	dB
Noise output voltage (unweighted) left and right output	$V_{n(rms)}$	–	–	10	μV
Spatial mode* (pins 11 and 12 not grounded)					
Antiphase crosstalk		–	50	–	%
Voltage gain	G_v	1.4	2.4	3.4	dB
Logic inputs (pins 11 and 12)					
Input resistance	R_i	70	120	–	kΩ
Switching current	$-I_i$	–	95	160	μA
LED drivers (pins 7 and 8)					
Output current LED indication	I_o	10	12	15	mA
Forward voltage	V_F	–	–	6	V

*The effect of pseudo stereo is determined by the external fihers.

Table 2. Technical specifications of the TDA 3810. These were measured from the test circuit in figure 1.

The current consumption increases by about 5 . . . 9 mA, so the total consumption for the pseudo stereo personal FM radio is about 24 . . . 30 mA, depending on the volume.

The circuit

The circuit for the extension is shown in figure 2. The heart of the circuit is the TDA 3810 and the external components needed by this IC to convert mono into pseudo stereo. The mono signal comes into this IC at pins 2 and 17 and is thus split into two channels. One channel goes straight to the output, but in the second one all frequencies between 300 Hz and 2 kHz are subject to a frequency dependent delay. Other frequencies pass unchanged to the output. The phase shifting needed for the pseudo stereo effect is achieved with the circuitry between pins 6, 14 and 16.
The output of the TDA 7000 has to be brought to a suitable level so that the pseudo stereo decoder gives the best possible signal/noise ratio, and for this a voltage amplification of about forty times is needed. This is exactly what the input stage of T1/T2 provides, and it also ensures that the de-emphasis network at the output of the TDA 7000 is not loaded.
After the signal is amplified by the T1/T2 stage it enters IC1 and when this IC has done its thing the processed signal appears at pins 6 and 13. The signals then go via a voltage divider and stereo pot P1 to the two LF amplifiers, one on the extension board (IC2 and the associated components) and the identical one already on the board of the personal FM.
One final point about the circuit. There is, as we have already pointed out, a facility in the TDA 3810 for driving a LED to indicate when this IC is operating in pseudo stereo mode. However, as LEDs consume a fair amount of current, we decided to do without it and avoid wasting any of the 9 V battery's power. We have included a switch (S1) to change from mono to pseudo stereo, as the mode depends only on whether pin 11 is connected to ground or not.

Construction

The printed circuit board for the pseudo stereo extension (figure 3) is near enough exactly the same size as that of the personal FM. Depending on the case used, the two boards can be mounted side-by-side or they can be made into a 'sandwich'. Part of the reason that the board is so small is that all the resistors are mounted vertically. This means that locating everything correctly before soldering requires more care than usual.
It is quite easy to check if the circuit is correct on the basis of the test voltages given. If some of the voltages measured differ from the stated values then obviously something is amiss. Most likely this is due to some resistors being interchanged, but it could be something else (you never can tell, what with Murphy hovering in the background).
The voltage at the base of T1 should be about 1.1 V. However, as this is the output of the TDA 7000, there may be some deviation in this value so a better checkpoint is the collector of T1. If the voltage here deviates by more than 1 V from the anticipated value of half the supply voltage (i.e. 4.5 V) then R16 must be changed.
Connecting the pseudo stereo board to the personal FM board is no problem. The volume control pot (P2) on the radio must be removed and a 22 kΩ resistor is soldered between points 3 and 5. Also C18 must be replaced by a wire bridge. The input to the pseudo stereo board is now connected to point 3 on the radio board and the output for the left channel (the wiper of P1) to point 4. Now only the two power supply lines have to be connected and the job is done.
A final note: if the pseudo stereo extension is to be used separately from tha personal FM then obviously the input level will have to be adapted. This can be done using the small interface circuit shown in figure 4.

Table 3

	switch pin 11	mode	switch pin 12	SPATIAL LED pin 7	PSEUDO LED pin 8
MONO	H (off)	PSEUDO	L (on)	off	on
	H (off)	SPATIAL	H (off)	on	off
STEREO	L (on)	–	X	off	off

L = LOW = 0 to 0.5 V H = HIGH = 2 V to Vp X = state is immaterial

Table 3. This is a sort of truth table of the relationships between the different functions, the positions of the switches and the indication of the LEDs.

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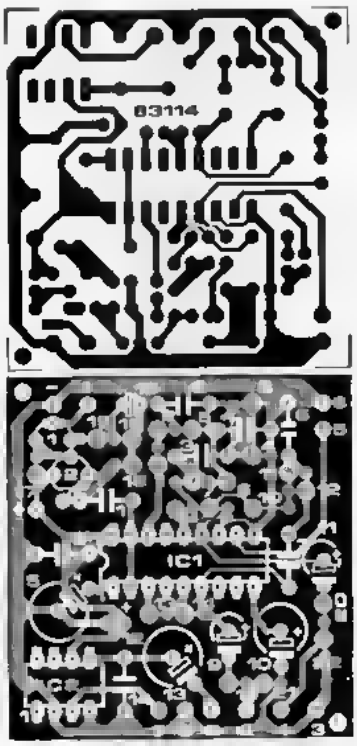

Figure 3. The printed circuit board layout shown here has the same dimensions as the personal FM board. All resistors must be mounted vertically.

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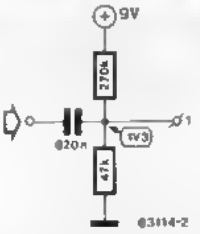

Figure 4. This is a small interface circuit needed at the input of the pseudo stereo extension to adapt it to equipment other than the personal FM receiver.

Parts list

Resistors:
(1/8 W)
R1,R7 = 15 k
R2,R8,R15 = 1 k
R3 . . R6 = 22 k
R9 = 100 k
R10,R11,R14 = 12 k
R12 = 18 k
R13,R18 R20 = 10 k
R16 = 5k6
R17 = 39 k
R21,R22 = 390 Ω
P1,P1' = 10 k log stereo pot

Capacitors.
C1 = 470 n
C2,C3,C7 = 10 n
C4 = 22 n
C5 = 100 µ/25 V
C6 = 12 n
C8 = 220 n
C9,C11 = 4µ7/63 V
C10 = 47 µ/25 V
C12 = 22 µ/10 V tantalum
C13 = 100 µ/10 V
C14 = 47 n ceramic
C15 = 47 µ/2 V tantalum

Semiconductors.
T1,T2 = BC 550C
IC1 = TDA 3810
IC2 = LM 386

Miscellaneous.
S1 = single pole toggle switch
Two loudspeakers, 8 Ω, ½ W