Simple Fibre-Optic Link

Most fibre-optic audio link designs use a frequency modulated carrier wave, and the system described in Issue 20 of this magazine falls into this category. An f.m. system enables good range with a low signal to noise ratio to be obtained, but probably its main attraction is the low distortion level that can be attained. There is inevitably a degree of non-linearity through the transmitting LED and the receiving photocell (normally a photo-diode), but this lack of linearity does not affect the audio quality of an f.m. system. The photocells are merely handling pulse signals, and it is the frequency of the pulses rather than their precise waveform that is of importance. The linearity of the system is largely governed by the quality of the modulator and demodulators, and with modern circuits a distortion level of well under 1% can be achieved without having to resort to anything too exotic.

While there is probably no serious alternative to some form of pulse system where very high quality results are required, a somewhat more simple approach is perfectly valid where just a basic link is required. For example, if a voice link is all that is required there is little point in going to the expense of a system having the full audio bandwidth plus hi-fi noise and distortion figures. A simple amplitude modulation (a.m.) system will provide perfectly good results. The system described here shows just how simple a fibre optic link can be, and although I expected quite high levels of distortion from the design, provided it is not driven beyond the clipping level the distortion performance is surprisingly good. It certainly provides a speech link which has substantially better audio quality than an average intercom or telephone link. For someone who has yet to dabble in the field of fibre-optics it provides a very inexpensive introduction to this fascinating subject.

Transmitter

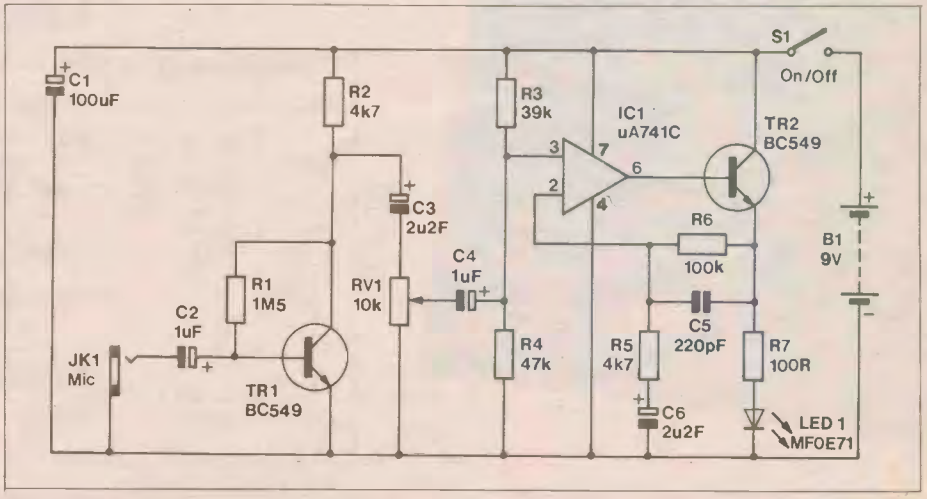
The system is designed to be fed from a microphone at the transmitter, and to drive an earpiece or headphones from the receiver. At the transmitter, TR1 is the microphone preamplifier, and this is a common emitter amplifier which provides over 40dB of voltage gain. The input characteristics of this stage are best suited to medium impedance dynamic (communications) microphones, but good results also seem to be obtained with low and high impedance dynamic microphones, or any types with similar output characteristics.

RV1 is the microphone gain control, and from here the signal is coupled to the output amplifier. This has IC1 as a non-inverting amplifier and TR2 as a discrete emitter follower output stage. Overall negative feedback is applied via R5 and R6, and these set the voltage gain at just over 20 times (26dB). The full audio bandwidth is not required in a simple system of this type, and so C5 is used to give a small amount of high frequency roll-off. This gives an improved signal to noise ratio. LED1 is the transmitting light emitting diode, and this is a type specifically designed for fibre optic applications. R7 sets the quiescent LED current at approximately 35 mA. When the unit is fully driven the output current varies between zero and about 70 mA, giving an average of 35 mA. This is comfortably within the 100 milliamp maximum current rating of the MFOE71 used in the LED1 position.

Receiver

The photocell at the receiver is a photo-diode that is designed to complement the LED at the transmitter. Both have peak response in the visible red to near infra-red part of the spectrum, and both work well with the Maplin fibre optic cable. Normally photo diodes are operated in the reverse biased mode, and generate an output signal due to the increased leakage caused by received light. In this application a stronger output seemed to be obtained using LED2 in the voltaic mode. In other words, it acts rather like a solar-cell, with the received light being converted directly into electrical signals. In this mode the polarity of LED2 is unimportant.

Only a very low output level of typically under 1 millivolt peak to peak is



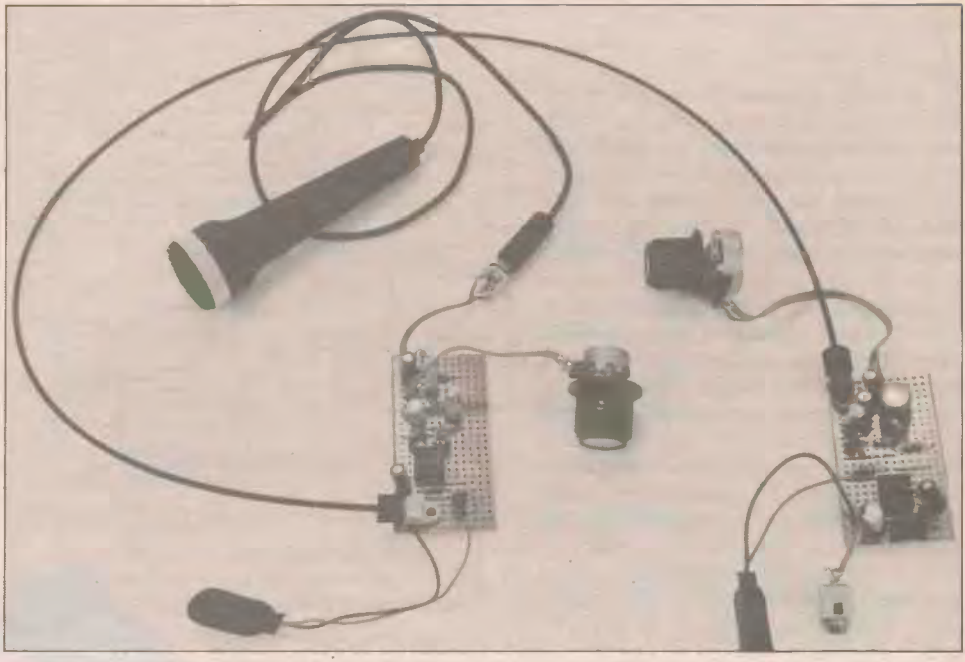
Fibre-optic Transmitter Circuit

produced by LED2, and consequently a great deal of amplification is needed in order to produce a strong enough output to give good volume from headphones. A two stage amplifier is used, and this has obvious similarities to the transmitter circuit. It differs mainly in that the emitter follower output stage has been omitted, and the feedback values for IC1 have been altered slightly in order to give increased voltage gain. IC1 provides about 40dB of gain, giving an overall gain in excess of 80dB (10000 times).

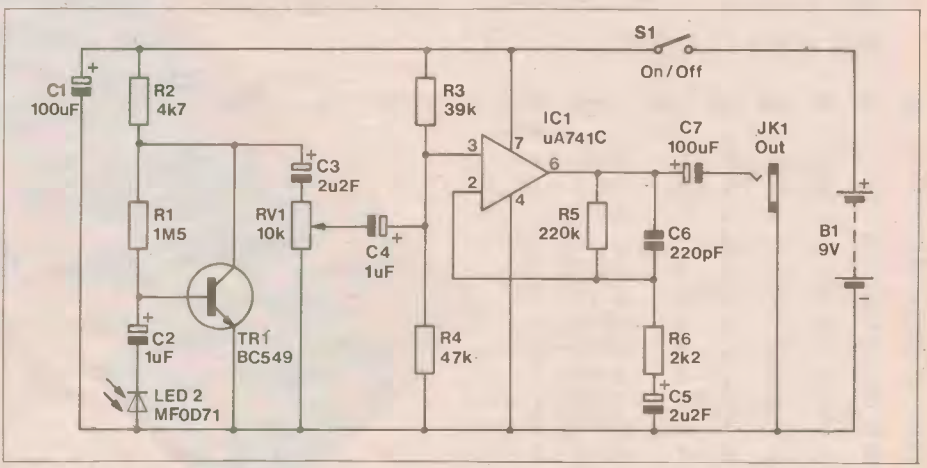
The output will drive a crystal earphone, or most types of headphone. With high impedance types it is preferable to use parallel connection of the earphones if possible, but with low and medium impedance types series connection will almost certainly give better results. Note that it is only possible to drive reasonably sensitive headphones from the unit, and types which are intended for direct connection to loudspeaker outputs are unsuitable. The current consumption of the unit is only about 3 mA, but this might increase somewhat when the unit is used at high volume levels with some types of headphone.

Construction does not present any great difficulties, and although both units contain high gain amplifiers, these do not seem to be especially fussy about the component layout. However, the leads which carry the microphone signal and the signal from LED2 at the receiver must be screened types unless they are no more than about 20 millimetres or so in length. The photocells both have a sort of screw terminal arrangement that is used to hold the cable in position, but the ends of the cable must be suitably prepared first. This is a matter of first cutting the ends of the cable cleanly at right angles with a sharp modelling knife, and then removing about 3 to 5 millimetres of the outer sleeving at both ends of the cable. Make sure that the cable is fully pushed into each photocell, and only tighten the 'terminals' just enough to firmly lock the cable in place.

When initially testing the system it is probably best to use a piece of cable about 30 millimetres or so in length. Talking into the microphone should be so strong that the volume control (RV1 at the receiver) has to be almost fully backed off. For optimum results the microphone gain control should be advanced as far as possible without the signal becoming clipped and seriously distorted. The volume control is then adjusted to give the required volume level. Although the gain of the unit might seem to be excessive when tested with a short cable (and is in fact about 40dB too high), bear in mind that losses through a fibre optic cable are generally far higher than those through an ordinary audio cable. The maximum range of the unit is therefore unlikely to be more than about 10 to 20 metres. If necessary, R6 can be made a little lower in value so as to boost the gain of the receiver.



Fibre-optic Transmitter and Receiver



Fibre-optic Receiver Circuit

FIBRE OPTIC TRANSMITTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	1M5	1	(M1M5)
R2,5	4k7	2	(M4K7)
R3	39k	1	(M39K)
R4	47k	1	(M47K)
R6	100k	1	(M100K)
R7	100Ω	1	(M100R)
RV1	10k log pot	1	(FW22Y)
CAPACITORS			
C1	100μF 10V PC Electrolytic	1	(FF10L)
C2,4	1μF 100V PC Electrolytic	2	(FF01B)
C3,6	2μ2F 100V PC Electrolytic	2	(FF02C)
C5	220pF Ceramic	1	(WX60Q)
SEMICONDUCTORS			
TR1,2	BC549	2	(QQ15R)
IC1	μA741C	1	(QL22Y)
LED1	MFOE71	1	(FD14Q)
MISCELLANEOUS			
B1	9 Volt Battery (PP9)	1	(FM05F)
S1	SPST Ultra-min Toggle	1	(FH97F)
JK1	3.5mm Jack	1	(HF82D)
	8 pin DIL Socket	1	(BL17T)
	Battery Clips	1	(HF27E)
	Microphone	1	(YB31J)
	Fibre-optic Cable	As req	(XR56L)

FIBRE OPTIC RECEIVER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	1M5	1	(M1M5)
R2	4k7	1	(M4K7)
R3	39k	1	(M39K)
R4	47k	1	(M47K)
R5	220k	1	(M220K)
R6	2k2	1	(M2K2)
RV1	10k log pot	1	(FW22Y)
CAPACITORS			
C1,7	100μF 10V PC Electrolytic	2	(FF10L)
C2,4	1μF 100V PC Electrolytic	2	(FF01B)
C3,5	2μ2F 100V PC Electrolytic	2	(FF02C)
C6	220pF Ceramic	1	(WX60Q)
SEMICONDUCTORS			
TR1	BC549	1	(QQ15R)
IC1	μA741C	1	(QL22Y)
LED2	MFOD71	1	(FD12N)
MISCELLANEOUS			
B1	9 Volt Battery (PP3)	1	(FK58N)
S1	SPST Ultra-min Toggle	1	(FH97F)
JK1	3.5mm Jack	1	(HF82D)
	8 pin DIL Socket	1	(BL17T)
	Battery Clip	1	(HF28F)
	Earphone	1	(LB25C)