HELPING HAND

In our October 1975 issue we announced a competition which we were holding in conjunction with the Royal National Institute for the Deaf. We presented readers with three problems for which we felt that there may be an electronic solution.

The winning entry, submitted jointly by John Howden and Clive Musgrove of Bristol was for Problem 1:

"A sick person is looked after by a deaf person. The deaf person has no useful hearing and requires to know whether the sick person is all right and above all needs to know if the sick person is in a state of distress anywhere in the sick room".

The competition winners built up a working prototype which has been somewhat modified subsequently though it uses exactly the principles and ideas described by John and Clive.

More details are given in News Digest.

THE SOLUTION to the problem posed by the competition was to provide the sick person with a small hand-held unit, capable of (in the original prototype) emitting a piercing two-tone note. When the sick person requires attention, by activating the noise generator, they trigger a control unit which is elsewhere in the sick room.

The control unit, after picking up the noise via a microphone, superimposes a high frequency signal upon the mains. This high frequency signal is coupled, via the house wiring, to a modified mains adaptor. This detects the signal and switches on the load (usually a lamp) connected to it. This attracts the deaf person's attention.

Because the mains adaptor is small and inexpensive, it is possible to install such devices throughout the house so that the deaf person is always in touch with the sick person.

Different Approach

This then was the first prototype. Its ideas were incorporated in the final design — the major difference being that the final circuit uses an ultrasonic instead of audio link between the control box and hand-held trigger.

The original unit featured a two-tone audio transmitter in order that the control unit did not respond to ambient sounds but only to the specific two-tone note. This however involved some complex filtering and decoding.

Ultrasonics had originally been rejected because the sick person would have no confirmation that a signal had been sent. This problem was solved by fitting an audio mimic to the control unit to confirm that a signal has been received.

The final system thus comprises an ultrasonic transmitter, receiver and adaptor.

The receiver has two modes of operation. With the latch control out, the unit will be activated only for the duration of the transmitted signal. With the latch in, the unit, once triggered, will continue to send its signal down the mains. The unit also has a local call button that can send out the call signal.

Construction

The transmitter was mounted in a hand held torch case. The ultrasonic transducer replacing the lamp assembly, and the PCB and battery occupying the original battery compartment.

Most of the receiver is mounted on the large PCB. Take care that all the polarity conscious components are mounted correctly.

We used fairly expensive switches in our unit, but considerable savings could be made in this area by using cheaper panel lamps and separate switches.

The adaptor components are so few that it was not thought necessary to design a PCB, the components are "birds nested".

When complete the frequency of the oscillator should be adjusted in order that it oscillates at the resonant frequency of the transducer.

This can be done by monitoring the waveform across the transducer on a scope and adjusting RV1 for maximum output. This adjustment can also be performed by adjusting RV1 to provide for maximum voltage at the D1 / C7 junction.

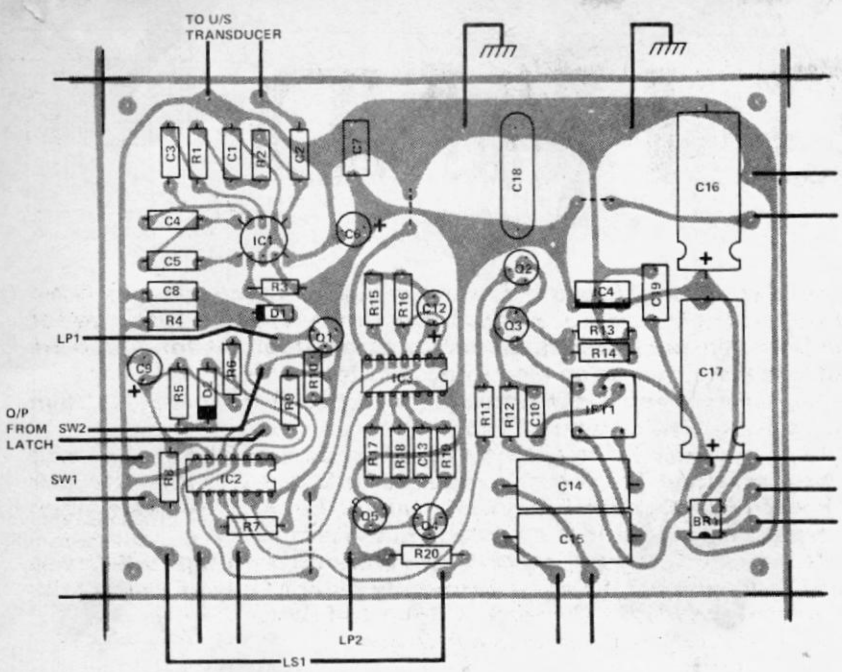
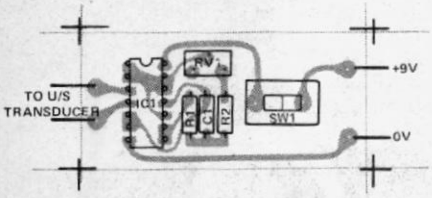


Fig. 1. Overlay of the ultrasonic receiver board.



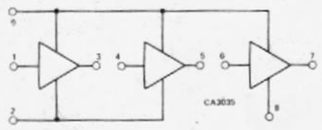


Fig. 2. The ultrasonic transmitter board.

PARTS LIST

ULTRA SONIC RECEIVER

RESISTORS (all ¼w 5%)	
R1	150k
R2, 19	33k
R3	22k
R4	2M2
R5, 11, 12	10k
R6	47k
R7, 9, 15	100k
R8	100R
R10	15k
R13, 14, 20	220R
R16	56k
R17	1M
R18	470k
CAPACITORS	
C1	22n Polyester
C2	4n7 Polystyrene
C3	47n Polyester
C4	3n3 Polystyrene
C5	2n2 Polystyrene
C6	10u 16V Electrolytic
C7	100n Polyester
C8, 13	1n0 Polystyrene
C9	4u7 10V Tantalum
C10	220p Polystyrene
C11	Supplied with IFT 14
C12	2u2 10V Tantalum
C14, 15	1n0 600V Mixed Dielectric
C16	1 000u 16V Electrolytic
C17	1 000u 35V Electrolytic
C18	470n Polyester
SEMICONDUCTORS	
IC1	CA3035
IC2, 3	CD4011
IC4	7812
Q1, 2, 4	BC108
Q3	BFY85
QJ	BFY50
SWITCHES	
SW1	Push to make (momentary)
SW2	Change over (latching)

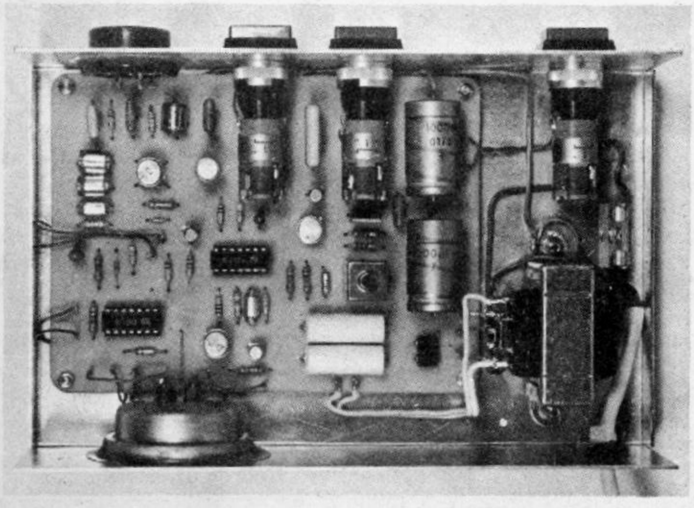
MISCELLANEOUS

Ultra sonic transducer, Denco IFT14 coil, PCB as pattern, 12-0-12 volt transformer, GPO insert.

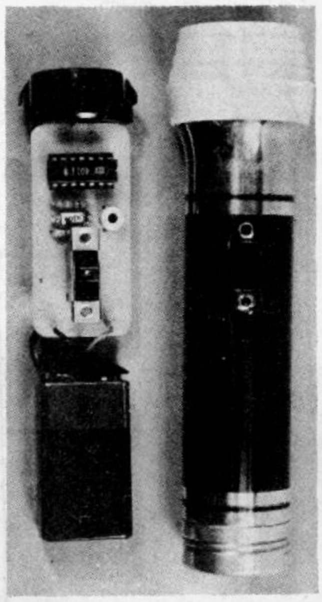
BUYLINES

Arrow Electronics at Leader House, Coptford Road, Brentwood, Essex, will be selling a complete kit of parts for the helping hand. Price is £20.97 excluding case and switches. The switches cost £14.56, but as mentioned in the text cheaper alternatives could be found.

The ultra sonic transducers are now stocked by most of the larger mail order firms.



To the left we see the ultra sonic receiver from above. We glued the ultrasonic transducer in place but it would be preferable to insulate this from the rest of the case with foam rubber. The picture on the right shows the transmitter out of its shell.



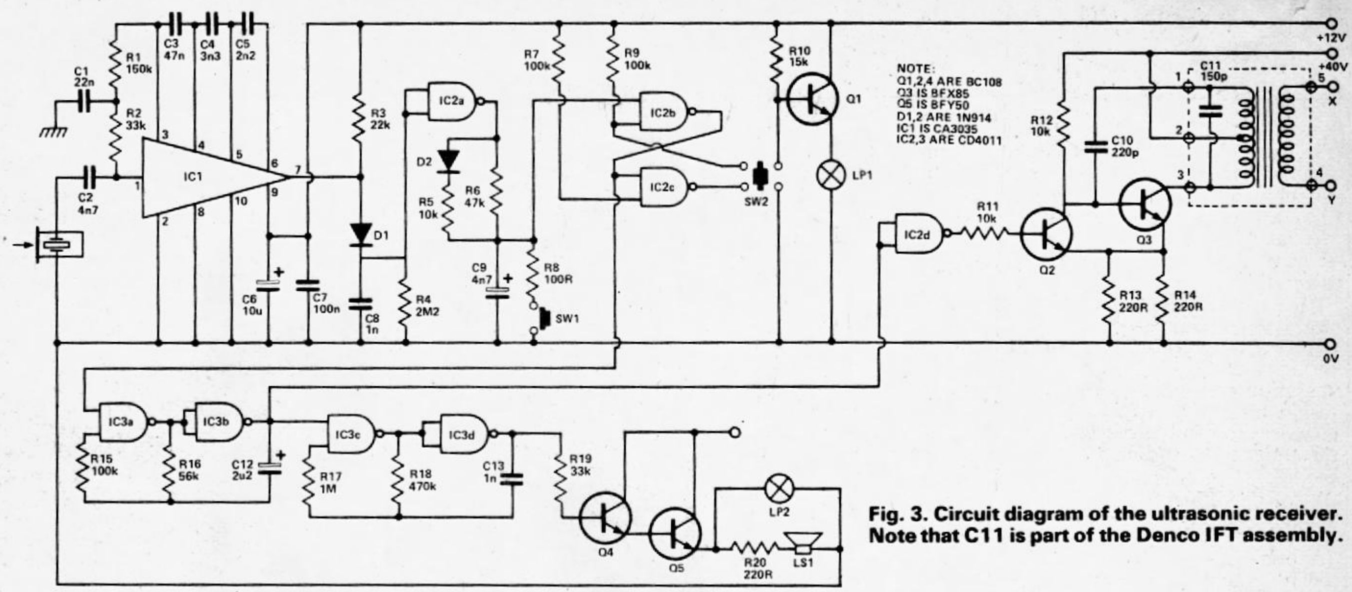


Fig. 3. Circuit diagram of the ultrasonic receiver. Note that C11 is part of the Denco IFT assembly.

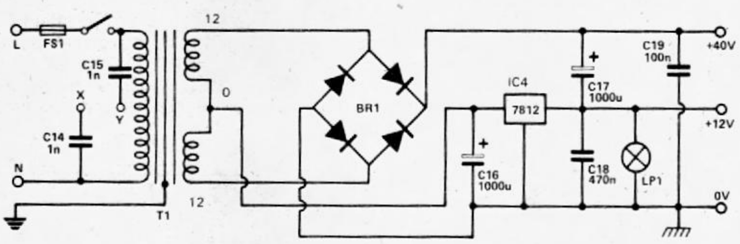


Fig. 4. The ultrasonic receiver's power supply.

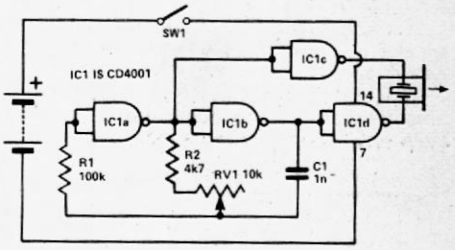


Fig. 5. The circuit of the ultra-sonic transmitter

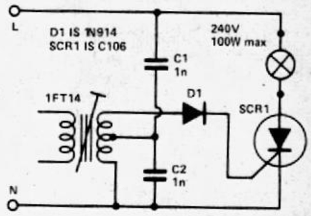
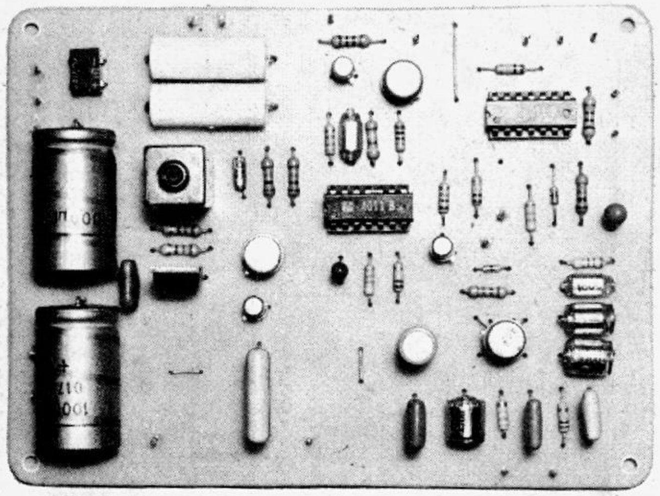


Fig. 6. Circuit of the mains adapter circuit.



The board of the ultrasonic receiver is shown above and to the left the modified mains adapter is displayed in all its glory.

PARTS LIST

MAINS ADAPTER

CAPACITORS
C1, 2, 1n 600V mixed dielectric

SEMI CONDUCTORS
SCRI C106

MISCELLANEOUS
Mains adapter, Denco IFT 14

ULTRASONIC TRANSMITTER

RESISTORS	
R1	100k
R2	4k7
POTENTIOMETERS	
RV1	10k
CAPACITORS	
C1	1n Polystrene
SEMICONDUCTORS	
IC1	CD4001

MISCELLANEOUS
Ultra sonic transducer, PC8 as pattern.

HOW IT WORKS

The transducer used in this circuit is forme from a piezo-electric crystal element that resonates at a frequency of about 40 kHz.

IC1a and IC1b form an oscillator whose frequency can be varied by means of RV1 to provide energy at the resonant frequency of the transducer used.

The oscillator produces two signals that are 180° out of phase.

These two waveforms are fed to the transducer via buffer ICs.

This method of driving the transducer results in an 18V (twice supply) drive. This increases the amount of energy radiated by the transmitter and provides a large useful range.

ULTRASONIC RECEIVER

The receiver transducer is matched to the one fitted to the transmitter and produces an EMF when energy at 40 kHz causes its crystal to resonate.

This EMF is fed via a DC isolation capacitor to the input of IC1, the CA 3035 high gain amplifier array.

It can be seen that this IC consists of three amplifiers and in this application the first stage is used as a simple high pass stage, this response being tailored by the feedback loop formed by R1, R2 and C1. The 40 kHz signal is coupled from this first stage via C4 and thence to the final stage by C5.

C6 and C7 decouple the IC's power supply pin.

The 40 kHz signal appearing at pin 7 of IC1 is rectified and smoothed by D1 and C8 before being fed to IC2a.

The output of this gate, is normally high and thus C9 is fully charged on receipt of a signal the output will go low and C9 will be discharged via R6 (D2 reverse biased) when the voltage at the junction of C9/R6 reaches the transition voltage of IC2b (one half of a flip flop) it will trigger this gate and initiate the sequence of events described below.

Note, however, that when IC2a returns high, C9 is charged up via R6 and R5 in parallel, D2 forward biased. This results in a faster charge than discharge time. This feature was incorporated to provide some protection against spurious triggering, as a brief signal will, although discharging C9 somewhat, have little effect as the capacitor is soon "topped up".

SW1 can trigger the circuit by taking IC2b low simulating an US input.

The flip flop formed by IC2b/IC2C can either provide a latching or non-latching operation.

Q1 and LP1 indicates the function selected, LP1 being lit if the latching option is selected.

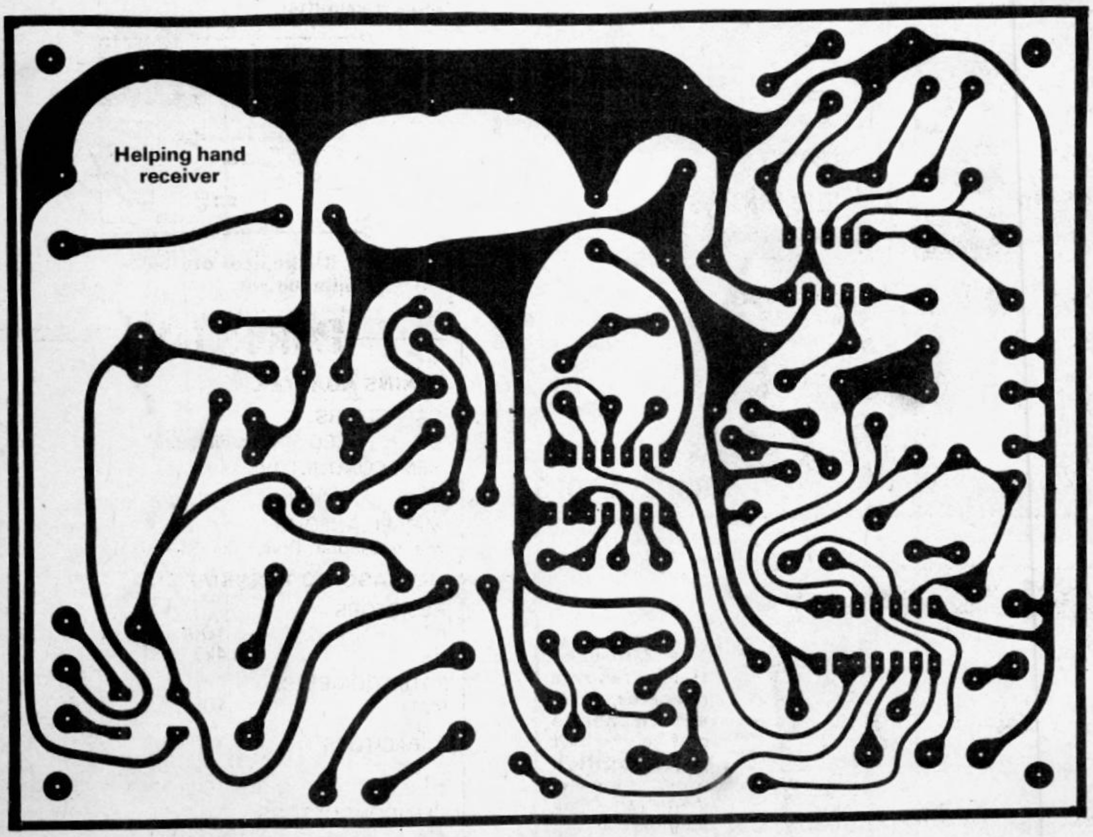
Whether latched on not as the output of IC2b goes high it enables the slow running oscillator formed by IC3a/IC3b. The output of this enables the tone generating section formed by IC3c and IC3d that provides an audio output from the speaker LS1 (driven from the Darlington pair Q4, Q5) and drives IC2d.

When the output of IC2d goes high it enables the Hartley oscillator Q3 via Q2.

This section provides a 470 kHz 40V peak to peak sine wave that is superimposed on the mains to trigger the remote receiver.

The power supply is a straightforward regulator circuit to provide the 12V rail with a smoothed 40V for the Hartley oscillator stage.

The remote receiver consists of a simple tuned circuit formed by C1, C2 and the IF transformer. This circuit resonates at 470 kHz, and any energy at this frequency is rectified by D1 and triggers thyristor SCR1 to light the load placed across the receiver's output.



Above is the foil pattern of the transmitter and to the right that of the receiver, both shown full size.

Ultrasonic Switch

Two-board design forms basis for a wide range of applications from door-bells to alarms, even data transmission!

THE USE OF an invisible beam to transmit information or to act as an alarm system has always been fascinating. We have described light operated systems of the infra-red (invisible), normal light and laser beam types. We have also published a radar alarm system. This unit uses a high frequency acoustical beam, well above the range of human hearing, which can be used simply as a door monitor, i.e. to give an alarm if the beam is broken, or can be modulated at up to several hundred Hz. This will allow information to be transmitted

CONSTRUCTION

The construction of the units is not critical – any method may be used although the PC boards are recommended. We didn't mount the relay on the PCB as it can vary in size and if the unit is later used with a modulated beam, the relay will not be needed.

The only adjustment on the unit is the sensitivity control and this should be set to give reliable operation. The transmitter needs a supply voltage of 8 V to 20 V at about 5 mA. This could come from the regulated supply on the receiver board.

If it is required to extend the effect of a quick break in the beam or a quick burst from the transmitter, the resistor R9 can be replaced by C4 and this will give a minimum operation time of about 1 second.

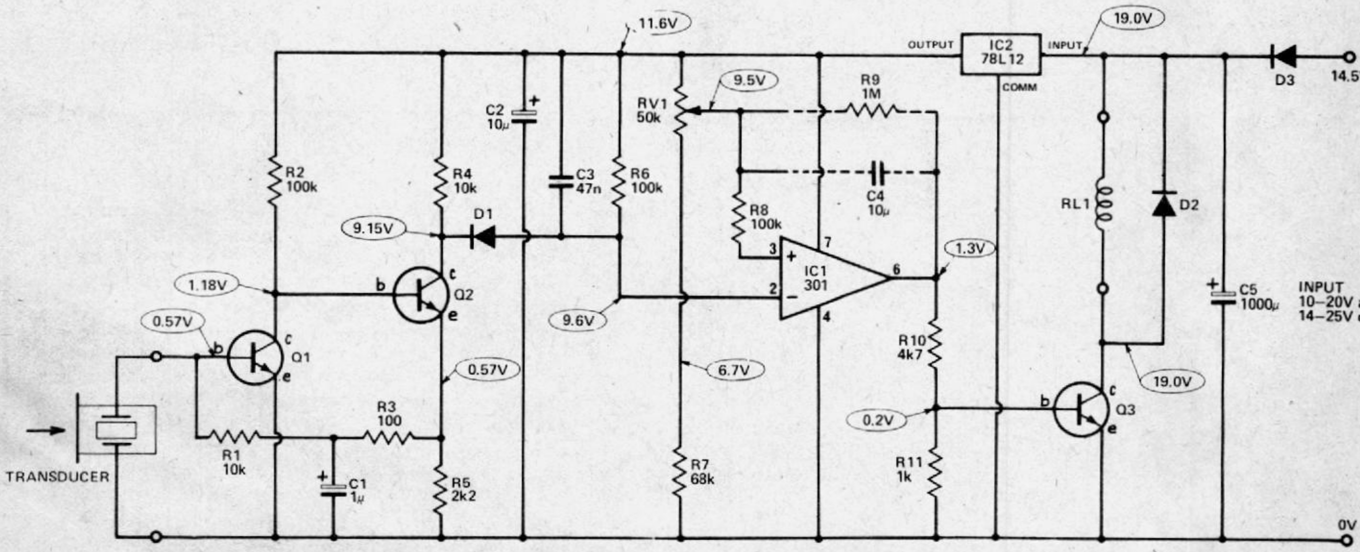


Fig. 1. Circuit diagram of the receiver.

NOTES:
VOLTAGES MEASURED WITH NO INPUT SIGNAL USING A VOLTMETER WITH 10 MEG OHM INPUT IMPEDANCE.
Q1–Q3 ARE 2N3904
D1 IS 1N914
D2,D3 ARE 1N4001
C4 IS USED INSTEAD OF R9 IF A MONOSTABLE ACTION IS REQUIRED.

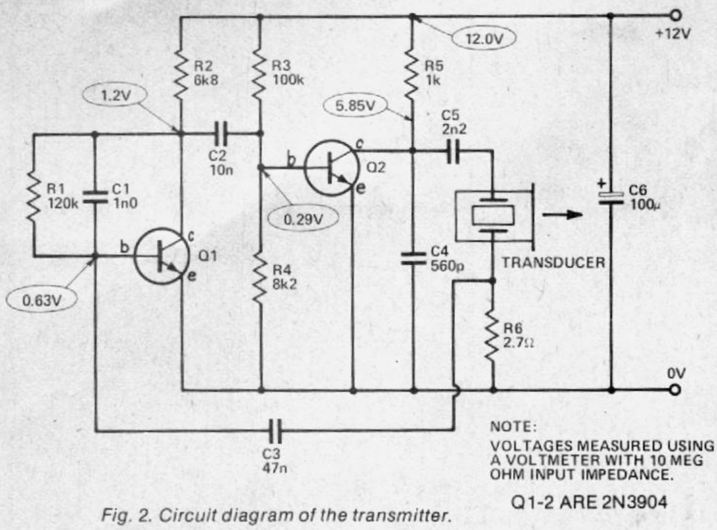


Fig. 2. Circuit diagram of the transmitter.

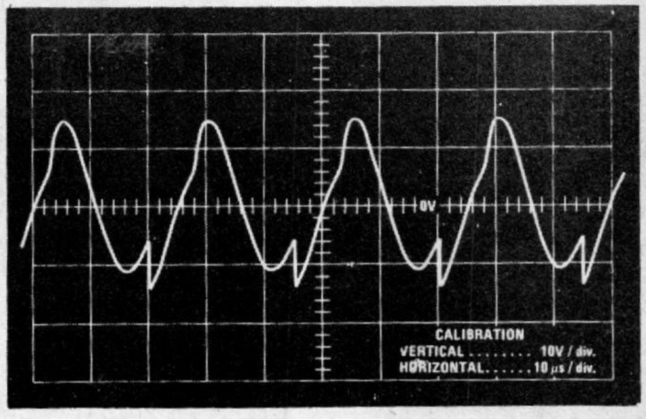


Fig. 3a. Waveform across the transducer on the transmitter.

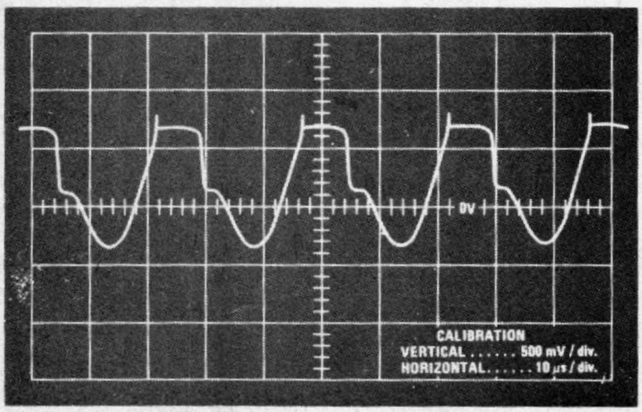


Fig. 3b. Voltage on the base of Q2 in the transmitter.

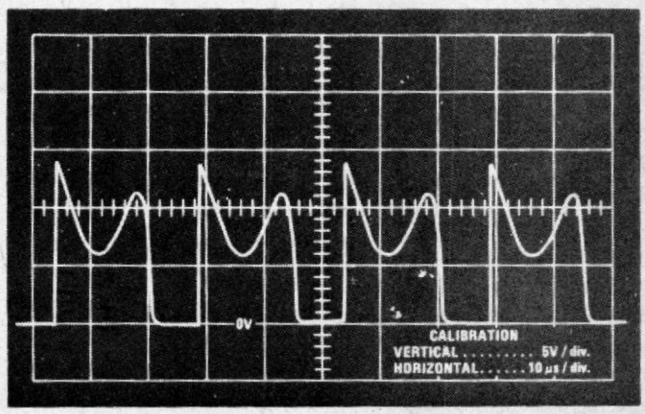


Fig. 3c. Voltage on the collector of Q2.

HOW IT WORKS

TRANSMITTER

This is an oscillator the frequency of which is determined by the transducer characteristics. The impedance curve of the transducer is similar to that of a crystal with a minimum (series resonance) at 39.8 kHz followed by a maximum (parallel resonance) just above it at 41.5 kHz.

In the circuit the two transistors are used to form a non-inverting amplifier and positive feedback is supplied via the transducer, R6 and C3. At the series resonant frequency this feedback is strong enough to cause oscillation.

Capacitors C1 and C4 are used to prevent the circuit oscillating at the third harmonic or similar overtones while C5 is used to shift the series resonant point up about 500 Hz to better match the receiver.

RECEIVER

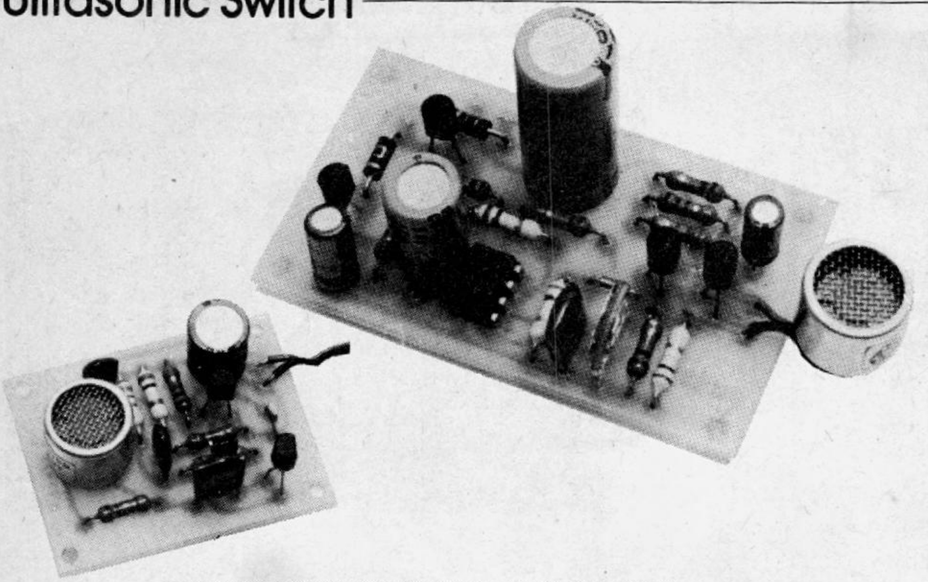
The output from the transducer is an a.c. voltage proportional to the signal being detected (40 kHz only). As it is only a very small level it is amplified by about 70 dB in Q1 and Q2. D C stabilization of this stage is set by R1 and R3 while C1 closes this feedback path to the 40 kHz a.c. signal.

The output of Q2 is rectified by D1 and the voltage on pin 2 of IC1 will go more negative as the input signal increases. If the input signal is strong the amplifier will simply clip the output, which on very strong signals will be a square wave swinging between the supply rails.

IC1 is used as a comparator and checks the voltage on pin 2, i.e. the sound level, to that on pin 3 which is the reference level. If pin 2 is at a lower voltage than pin 3, i.e. a signal is present, the output of IC1 will be high (about 10.5 volts) and this will turn on Q3 which will close the relay. The converse occurs if pin 2 is at a higher voltage than pin 3.

A small amount of positive feedback is provided by R9 to give some hysteresis to prevent relay chatter. If R9 is replaced by the capacitor C4 the IC becomes a monostable and if the signal is lost for only a short time the relay will drop out for about 1 second. If the signal is lost for more than 1 s the relay will be open for the duration of the loss of signal.

We used a voltage regulator to prevent supply voltage fluctuations triggering the unit. The relay was not included on the regulated supply, allowing a cheaper regulator to be used.



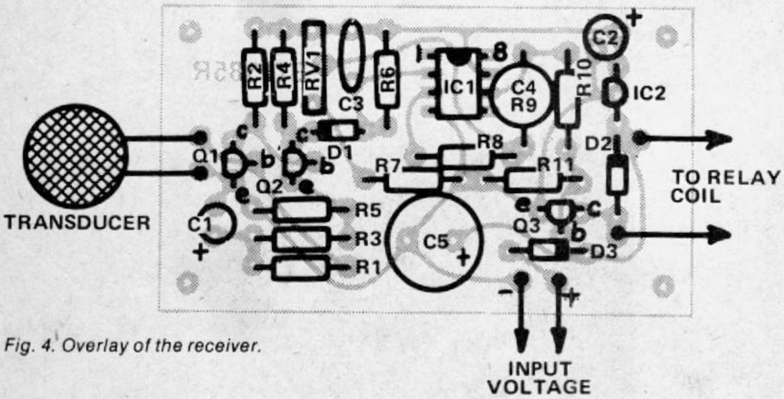


Fig. 4. Overlay of the receiver.

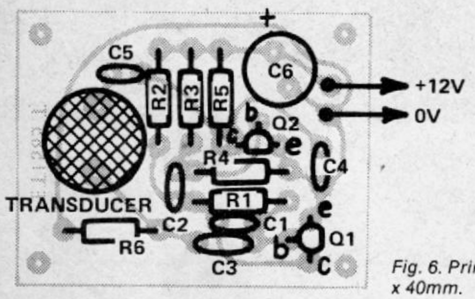


Fig. 5. Overlay of the transmitter.

Fig. 6. Printed circuit board of receiver. Full size 70 x 40mm.

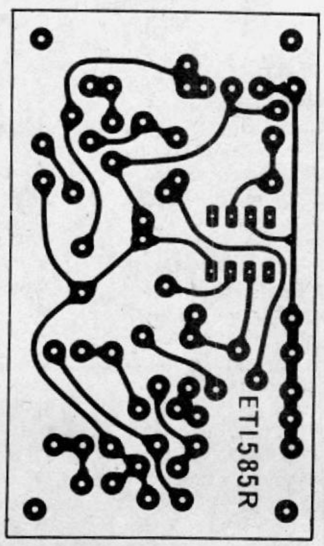


Fig. 7. Printed circuit board of transmitter. Full size 46 x 36mm.

RECEIVER

RESISTORS all ½ W 5%

R1,4	10k
R2,6,8	100k
R3	100R
R5	2k2
R7	68k
R9	1M
R10	4k7
R11	1k

POTENTIOMETER

RV1	50k preset

CAPACITORS

C1	1u 25 V electrolytic
C2	10u 25 V electrolytic
C3	47n polyester
C4	10u tantalum
C5	1000u 16 V electrolytic

SEMICONDUCTORS

Q1—Q3	2N3904
IC1	LM301A
IC2	78L12
D1	1N914
D2,3	1N4001

MISCELLANEOUS

PCB as pattern, 40 kHz receiver, 12 V relay, case to suit

TRANSMITTER

RESISTORS all ½ W 5%

R1	120k
R2	6k8
R3	100k
R4	8k2
R5	1k
R6	2R7

CAPACITORS

C1	1n polyester
C2	10n polyester
C3	47n polyester
C4	560p
C5	2n2 polyester
C6	100u 25 V electrolytic

TRANSISTORS

Q1,2	2N3904

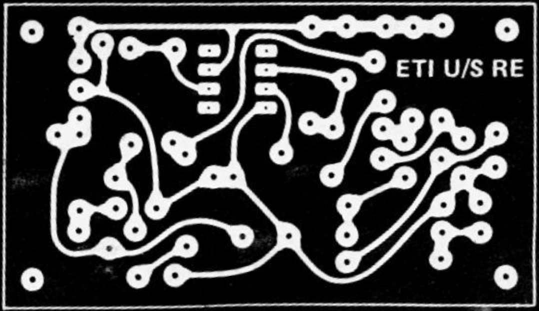
MISCELLANEOUS

PCB as pattern, 40 kHz transmitter, case to suit.

Kits and parts (including transducers) for this project are available from Dominion, see their ad in this issue.

SPECIFICATIONS

FREQUENCY	40 kHz
RANGE	5 metres
MAXIMUM MODULATION FREQUENCY (NOT WITH RELAY OUTPUT)	250 Hz
OUTPUT	relay, closed when beam is made
POWER SUPPLY	
TRANSMITTER	14—25 V DC 10—20 V DC
RECEIVER	8—20 V DC, 4 mA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ETI U/S TR

Ultrasonic processor readies data for gray-tone display

by W. H. M. van Dreumel and Henk van der Hoek
Delft University of Technology, Delft, the Netherlands

If combined with a suitable ultrasonic receiver,[1] this circuit will convert ultrasound energy into 10 distinct gray tones for display on a cathode-ray tube. Thus defects and other imperfections in materials may be detected by this low-cost measuring system that provides a visual indication of the faults by means of trace-intensity modulation, where the intensity will be proportional to the amplitude of the input signal, or equivalently, the magnitude of the fault (the so-called C-scan method). The circuit can process signals having a pulse-repetition rate of up to 10 kilohertz and an individual pulse width of 70 microseconds or less.

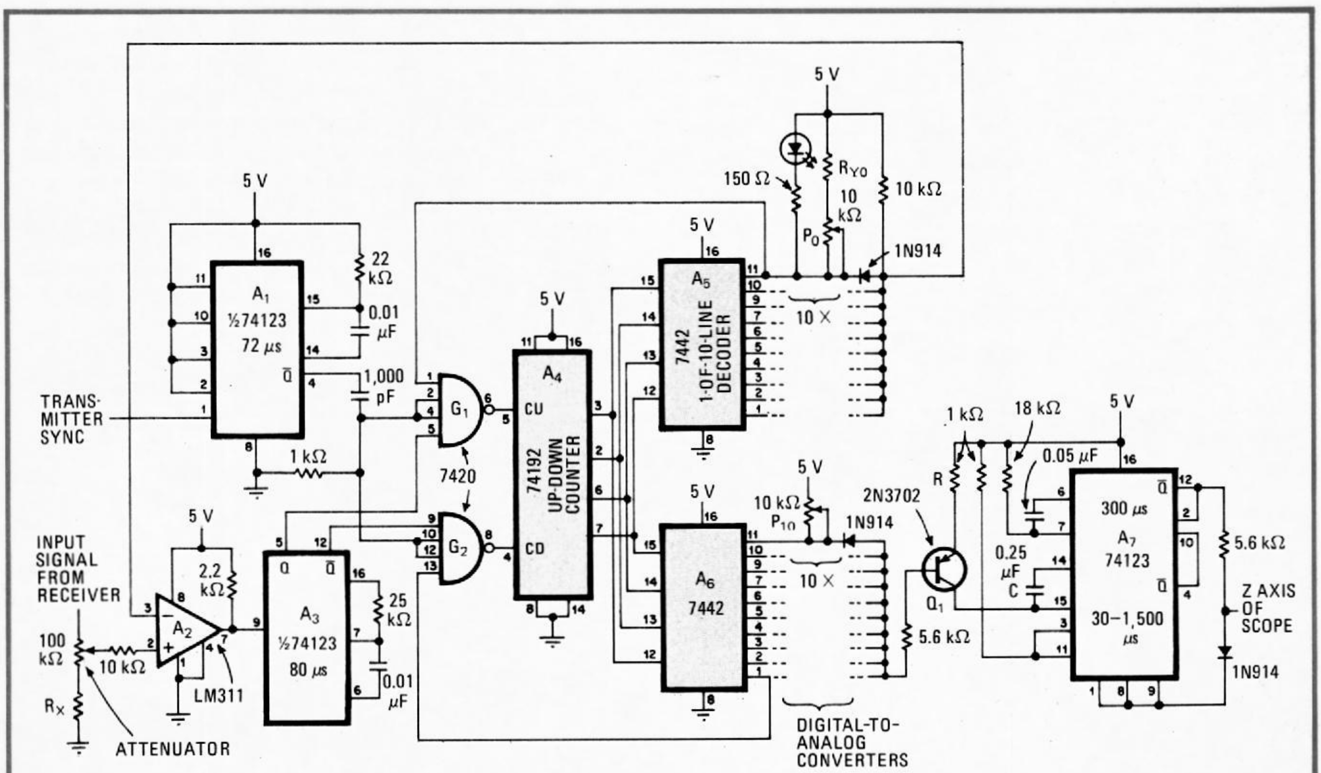
The system is synchronous, requiring a source- or transmitter-derived trigger to initialize the circuit, as shown in the figure. After the transmitter-sync signal fires monostable multivibrator A_1, the input signal at comparator A_2 is compared with the output of a digital-to-analog converter that is monitoring the contents of an up-down counter through a 1-of-10 line decoder.

If the amplitude of the receiver signal exceeds that of the d-a converter's output, the one-shot, A_3, is triggered. After 70 μs, A_1 times out, and the contents of A_3 are transferred through G_1 or G_2, incrementing the 74192 4-bit counter if A_3 has fired and decrementing it if A_3 has not fired. The output of the counter in turn drives two 7442 1-of-10 line decoders, sending one line on each device into the logic 0 state.

The d-a converter is essentially nothing more than a voltage-divider network, P_0–R_{y0} through P_9–R_{y9}, each connected to the 10 lines of A_5 and set to generate any 10 dc voltages corresponding to the range of input voltage expected. The magnitude of the voltage fed back to A_2 will depend on which line of the 7442 is active low, and therefore a dc signal is developed whose envelope closely follows the amplitude of the received pulses.

In a typical C-scan application, the dc output signal from A_6, which is wired in much the same way as A_5, is used to control the duty cycle of astable multivibrator A_7, through transistor Q_1. A_7's output is presented to the Z axis of the scope. A_7 is low for a period of 300 μs per scan (10 kHz); during that time, no trace appears on the CRT.

The trace will be observed during A_1's on time, t_{on}, however, and its intensity will be proportional to t_{on}, which can be varied from 30 to 1,500 μs by P_{10} through



C-scan. The amplitude of ultrasonic pulses having a duty cycle of less than 0.01% is converted to 1 of 10 dc voltages. Voltages are converted to gray tones by scope, enabling detection of material flaws. Seriousness of flaw is proportional to intensity of trace.

P_{19}. Q_1 is in the resistance-capacitance timing loop of A_7. Because the set voltages to the transistor base determine its conducting state, or equivalently, its emitter-to-collector resistance, Q_1 is thus used to modify the charge rate of the RC components by adding, in essence, additional resistance to the loop.

P_{10} through P_{19} should be adjusted such that the trace will generate a continuous-tone, or progressively deepening, gray scale in 10 equally spaced steps as the counter advances from 0 to 9. Although it would appear that only one 7442 is needed in the circuit, using both A, and A_6 protects the counter from reaching the underflow or overflow condition and also allows independent setting of the gray-scale voltages and the feedback voltages presented to A_2.

The light-emitting-diode array that monitors the contents of A_5 is useful for setting dc levels to conform to the range of input signals expected. It is also useful in determining signal-voltage trends; the relative brightness of each LED is discernible, even at a sampling rate as high as 10 kHz.

Resistors R_x and R_{y0} through R_{y9} are used for trimming purposes. Once the attenuator setting has been determined, all resistors must be set to minimize the voltage across the inputs to A_3 under no-signal conditions. This, of course, means that the 7442 counter, A_5, must be stepped sequentially. □

Reference

1. Gammell, Paul M., "Fast attack detector optimizes ultrasonic receiver response," *Electronics*, Aug. 4, 1977, p. 96.