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We show you how to conduct experiments on a wide variety of different circuits and turn the information gained into a working knowledge of testing, servicing and maintaining all types of electronic equipment, radio, t.v etc.

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**FEATURES:** Complete pre-amplifier in single pack—Multi-function equalization—Low noise—Low distortion—High overload—Two simply combined for stereo.

**APPLICATIONS:** Hi-Fi—Mix—Disco—Guitar and Organ—Public Address

**SPECIFICATIONS:**
- INPUTS: Magnetic Pickup 3mV; Ceramic Pickup 30mV; Tuner 100mV; Microphone 10mV; Auxilary 3-10mV; input impedence 7.0 76 at 1kHz.
- OUTPUTS: Tone 500mV; Main output 500mV R.M.S.
- ACTIVE TONE CONTROLS: Treble ±50dB at 1kHz; Bass ±40dB at 1kHz.
- DISTORTION: 0.1% at 1kHz; Signal/Noise Ratio 80dB.
- OVERLOAD: 3dB on Mainsite Pickup—SUPPLY VOLTAGE ±15-160V.
- Price £50 + 5% VAT P&P free.

**HY30**
15 Watts into 8Ω

The HY30 is an exciting new kit from I.L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. The HY30 is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.

**FEATURES:** Complete Kit—Low Distortion—Short and Open Thermal Protection—Easy to Build.

**APPLICATIONS:** Updating audio equipment—Guitar practice amplifier—Test amplifier—Mobile amplifier.

**SPECIFICATIONS:**
- OUTPUT POWER 1W R.M.S. into 8Ω; DISTORTION 0.1% at 1W.
- INPUT SENSITIVITY 100mV; FREQUENCY RESPONSE 10kHz—18kHz—3dB.
- SUPPLY VOLTAGE ±15-160V.
- Price £32 + 5% VAT P&P free.

**HY50**
25 Watts into 8Ω

The HY50 leads I.L.P.’s total integration approach to power amplifier design. The amplifier features an internal heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust Hi-Fidelity modules in the World.

**FEATURES:** Low Distortion—Internal Heatsink—Only five connections—AMP output transistors—No external components.

**APPLICATIONS:** Medium Power Hi-Fi systems—Low power disco—Guitar amplifier

**SPECIFICATIONS:**
- OUTPUT POWER 25W R.M.S. into 8Ω; LOAD IMPEDANCE 4-6Ω; DISTORTION 0.05% at 25W at 1kHz.
- SIGNAL/NOISE RATIO 65dB FREQUENCY RESPONSE 1kHz—45kHz—3dB.
- SUPPLY VOLTAGE ±15-160V SIZE 105 105 85mm
- Price £82 + 5% VAT P&P free.

**HY120**
60 Watts into 8Ω

The HY120 is the baby of I.L.P.’s new high power range. Designed to meet the most exacting requirements including line load and thermal protection this amplifier sets a new standard in modular design.

**FEATURES:** Very low distortion—Internal heatsink—Load line protection—Thermal protection—No external components.

**APPLICATIONS:** Hi-Fi—High quality disco—Public address—Monitor amplifier—Guitar and organ.

**SPECIFICATIONS:**
- INPUT SENSITIVITY 350mV
- OUTPUT POWER 60W R.M.S. into 8Ω; LOAD IMPEDANCE 4-6Ω; DISTORTION 0.05% at 60W at 1kHz.
- SIGNAL/NOISE RATIO 85dB FREQUENCY RESPONSE 1kHz—45kHz—3dB SUPPLY VOLTAGE ±15-160V SIZE 114 105 85mm
- Price £135 + 5% VAT P&P free.

**HY200**
120 Watts into 8Ω

The HY200 now improved to give an output of 120 Watts has been designed to stand the most rugged conditions such as disco or group while still retaining true Hi-Fi performance.

**FEATURES:** Thermal shutdown—Very low distortion—Load line protection—Internal heatsink—No external components.

**APPLICATIONS:** Hi-Fi—Disco—Monitor—Power slave—Industrial—Public Address

**SPECIFICATIONS:**
- INPUT SENSITIVITY 350mV
- OUTPUT POWER 120W R.M.S. into 8Ω; LOAD IMPEDANCE 4-6Ω; DISTORTION 0.05% at 120W at 1kHz.
- SIGNAL/NOISE RATIO 95dB FREQUENCY RESPONSE 1kHz—45kHz—3dB SUPPLY VOLTAGE ±15-160V SIZE 114 105 85mm
- Price £235 + 5% VAT P&P free.

**HY400**
240 Watts into 4Ω

The HY400 I.L.P.’s “Big Daddy” of the range producing 240W into 4Ω. It has been designed for stage/Disco address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power in-line power module.

**FEATURES:** Thermal shutdown—Very low distortion—Load line protection—No external components.

**APPLICATIONS:** Public address—Disco—Power slave—Industrial

**SPECIFICATIONS:**
- OUTPUT POWER 240W R.M.S. into 4Ω; LOAD IMPEDANCE 4-6Ω; DISTORTION 0.1% at 240W at 1kHz.
- SIGNAL/NOISE RATIO 98dB FREQUENCY RESPONSE 1kHz—45kHz—3dB SUPPLY VOLTAGE ±15-160V
- INPUT SENSITIVITY 500mV SIZE 114 100 85mm
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Radio No. 1023830

Practical Wireless, July 1978
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<tr>
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<td>0.83</td>
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</table>

The following are the more
popular types of 2N
TRANSISTORS by well
known manufacturers such as Motorola, SGS, RCA,
Fairchild. They are brand
new and should not be
confused with surplus offers
often being advertised!
Also we stock, or can obtain,
other 2N transistor types not
listed below. So please write
and let us know what you are
looking for.
Please add 8% VAT to your
2N transistor orders, plus 25p
per order for postage and
packing.

Manufacturers and trade enquiries
invited for larger quantities.

Mainline
380 Bath Road, Slough, Berks.
Tel: 06286 (Burnham) 63616

Practical Wireless, July 1978
FROM time to time, Practical Wireless receives letters decrying the fact that we continue to publish circuit diagrams in which symbols other than those laid down in BS:3939 are used. We are by no means the only “offender”, and in fact a letter published in the latest issue of Electronic Technology, the journal of the Society of Radio and Electronic Technicians, slates the whole of the UK technical press, with the exception of the text-book publishers.

The writer of that letter, a lecturer in Radio and TV studies at a south coast technical college, complains that his students have to learn not only the BS:3939 symbols for their examinations, but also a variety of other symbols in order to understand circuits published in technical journals. He sees this as a waste of time, and exhorts those responsible to get into line.

While I am, in general, in favour of standardisation, it is as well to realise that we live in a real world. Even if all UK technical journals and magazines used BS:3939 symbols exclusively from now on, there is a wealth of material, both existing and still coming in from abroad, which uses other symbols. If we are not to dismiss that material completely, we must accept that there is this variety and learn to interpret the various forms encountered.

It is, in any case, arguable whether some of the BS:3939 symbols are the best. Taking the humble resistor as an example, while the rectangular box may be simple for a computer or other mechanical draughting machine to draw, the zigzag is much easier to draw freehand with a little practice. Since many draughtsmen now use rub-down transfers to produce finished drawings, it makes little difference to them anyway, so why not make life a little easier for the student and development engineer trying to produce a neat sketch, by sticking with the zigzag? Again, with logic symbols, it has always struck me that the familiar shapes of MIL-STD-806B make a diagram much easier to understand than do the featureless outlines of their BS:3939 counterparts.

It has been said that the prime reason for the adoption of some of the BS:3939 symbols was that they were easier for machines to draw. Since the vast majority of circuit diagrams must surely still be produced by human means, the justification for those symbols is therefore highly questionable. It makes one wonder whether, at some time in the future, the standard which will replace BS:3939 will consist merely of rectangular boxes containing numbers from 1 to n, each indicating a different type of circuit element!

Geoffrey C. Arnold

PLEASE NOTE—CORRESPONDENCE

We do not operate a Technical Query Service except on matters concerning constructional articles published in PW. We do not supply service sheets or information on commercial radios, TV’s or electronic equipment.

All queries must be accompanied by a stamped self-addressed envelope otherwise a reply cannot be guaranteed.
Aid for R & D
The Dept. of Industry has set up an Electrical Technology Requirements Board (ETRB) to fund research and development in the electrical engineering industry. The Board will be composed of eminent British engineers and chaired by Mr. T. W. B. Sallitt, Director, Hawker Siddeley Group Ltd.
The Board will cover such products as motors and generators, transformers, switchgears, cables and accessories, domestic appliances, and miscellaneous electrical equipment including lamps and batteries.
Major objectives of The Board will be to identify those areas which will most benefit from additional research and development, so as to promote technological innovation and to increase the application of known technology.
The Board welcomes applications from private companies as well as research organisations, for financial support on research and development projects, usually on a co-operative basis, in any of the fields mentioned above.
Enquiries should be addressed to: Dr. L. Goldstone, Executive Officer/Secretary ETRB, Abell House, John Islip Street, London SW1. Tel: 01-211 3450.

Look in
Five new promotional films, to be shown by Independent Television programme companies, have been made by the IBA to promote ‘better viewing’.
The five films are:
(1) The importance of the receiving aerial (30 seconds).
(2) The importance of correct receiver alignment (60 seconds).
(3) The expanding coverage of the IBA transmitter networks (60 seconds).
(4) New technical developments in television broadcasting (60 seconds).
(5) Controlling the day-to-day quality of ITV broadcasts (30 seconds).
Film (2) on receiver adjustment is to be backed by a special leaflet which dealers and rental companies will be encouraged to distribute to viewers.
The films include shots of many IBA engineering installations and developments, including the unique Emley Moor concrete aerial tower, low-power solid-state transmitters for local relay stations, the special SABRE adaptive receiving aerial that brings ITV colour to the Channel Islands, DICE—the IBA’s pioneering digital standards converter used for intercontinental relays, optional subtitling for the deaf which may become possible by using ORACLE teletext techniques, etc.

New source
Amtest Radio and Electronic Equipment, is a new company set up to specialise in equipment and aerials for s.w. listeners.
They hope in the near future to provide a similar service for long, medium and v.h.f. listeners with the emphasis on DXing.
The company will answer any enquiry, provided it is accompanied by a SAE.
Amtest Radio and Electronic Equipment, 55 Vauxhall Hill, Worcester WR3 8PA. Tel: 0905 22704.

The Wireless?
A foreign spy, an astronaut in deep space, a man in the street… what have they in common? A radio receiver!
The cost and sophistication varies enormously over the range of available equipment, from a few pounds for the portable ‘transistor’ to thousands for radar and satellite communications. No matter what the application the advances since the days of the cat’s whisker crystal detector have been considerable and it is proposed to survey the subject at a conference on ‘Radio Receivers and Associated Systems’ organised by the I.E.R.E. to be held at the University of Southampton from 11-14 July, 1978.
Thirty-seven papers will be delivered formally and a further twenty will be presented in poster-booth sessions. An exhibition of relevant equipment is to be organised by the Electrical Research Association. Further details from:
Conference Secretariat, I.E.R.E., 99 Gower Street, London WC1E 6AZ. Tel: 01-388 3071.

Mobile Rally
The Nunsfield House Community Association Amateur Radio Group are holding a mobile radio rally on Sunday 11 June 1978 at Elvaston Castle Country Park, which is located 5 miles south-east of Derby on the B5010.
Talk-in stations will be available from 10.00am; G3EOO/P on 160m, G32ZI/P on 2m f.m. ch. S22, and on 70cm G8KGC/P on f.m. chs. SU8 and SU20. All the usual rally attractions will be present; over 40 trade stands housed in two marquees, bring and buy sale, RSGB bookstall, children’s rides and entertainments, sideshows and a full catering service at competitive prices. The I.B.A. will also be present demonstrating their ORACLE teletext service. The rally will be open from 11.00am and should provide an ideal day out for all the family. Further details are available from: Ian Cage G4CTZ, 25 Petersham Drive, Alvaston, Derby DE2 0JU.

Summer School
The Dept. of Electrical Engineering Science at the University of Essex will be holding its annual electronics summer school for teachers during the week 10-14th July, 1978. This year, as well as running two established courses in linear and digital circuit design, a third course in Electronics Systems is being introduced. The object of the course being to cover some of the more difficult material of the AEB Electronics Systems syllabus as well as discussing the teaching aspects of the ‘A’ level.
The linear design course is concerned with the use of transistors and operational amplifiers in analogue applications; particular emphasis being placed upon design related to basic circuits in a hi-fi amplifier. The digital design course concentrates on the use of the transistor as a switch and develops design using integrated logic circuits. A programme of laboratory work is included on each course. Teachers who require further information contact: R. J. Mack, Dept. of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester. Tel: 0206 44144 Ext. 2408/2999.
The purpose of this project is to provide an accurate calibration source for digital frequency meters. The 200kHz Long Wave BBC signal is the standard frequency employed, and by regeneration is formed into a 4 volt peak to peak square wave output. It is emphasised that the calibrator requires moderate signal strength for reliable operation, but should function in most areas of the British Isles.

**Circuit Description**

The aerial coil is tuned by a trimmer in addition to a fixed capacitor. The signal is fed direct to the gate of Tr1, an f.e.t., which is used purely as a high impedance buffer and works in the source follower mode. This feeds its output through C2 to the base of Tr2 which forms a direct coupled amplifier with Tr3. Tr4 is another buffer used to feed the digital frequency meter without influencing circuit performance.

Regeneration is effected principally by capacitive coupling between the can of Tr3 and the aerial circuit. The overall gain of Tr2-Tr3 is sufficient to clip what would otherwise be a sine wave into a sloping square wave at the collector of Tr3. Transistors 2-4 are not run at the full 9 volt supply but are fed via a decoupled resistor, R7, at about 4-5 volts. This, in conjunction with aerial damping resistor R1, serves to restrict the degree of feedback. This technique was adopted when trying to lock on to a French transmission at 180kHz, a rather weaker signal than the 200kHz transmission.

**Phase Locking**

The circuit as a whole constitutes a free-running multivibrator which happens to use a tuned aerial as part of its feedback loop. Now, as with any multivibrator, it can be triggered by a suitably strong impulse, and the closer the triggering frequency is to that of the multivibrator, the more readily will phase locking occur. By adjusting the aerial close to 200kHz we allow the received signal to trigger the circuit.

However, we have a problem with triggering in that the received signal strength will vary by vast amounts, depending mainly on the distance from the transmitter. One way to overcome this problem is to devise a multivibrator with minimal feedback level, thereby reducing the trigger level required: hence the technique described here.

**Construction**

The m.w. winding supplied with the ferrite rod is discarded. Only leads 3 and 5 on the l.w. winding are used; lead 4 may be cut short, the ends carefully cleaned, and the two wires resoldered. If “P” clips are not available for mounting the rod it can be glued with Araldite direct to the top of the board.

The board is drilled to take four 4 BA mounting bolts, two of which secure the “P” clips, and also, as appropriate, for the type of trimmer used. These bolts may also be used to mount the unit in a suitable case if desired.

The components are back-wired on 0.15in matrix plain Veroboard and the layout shown should be adhered to, as spurious feedback plays such an important role.

The leads of R8 are formed into loops close to the resistor body before they pass through the board; these loops form the earth and output terminals. A PP3 type connector is fitted enabling either a PP3 or PP6 to be used.

**Components**

<table>
<thead>
<tr>
<th>Resistor Values</th>
<th>Capacitor Values</th>
<th>Semiconductors</th>
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</thead>
<tbody>
<tr>
<td>All 1/2W 5% carbon</td>
<td>C1 220pF silvered mica</td>
<td>Trl 2N3819</td>
</tr>
<tr>
<td>R1 47kΩ</td>
<td>C2 1nF ceramic</td>
<td>Tr2, 3, and 4 BC109</td>
</tr>
<tr>
<td>R3 47kΩ</td>
<td>C3 22nF ceramic</td>
<td></td>
</tr>
<tr>
<td>R5 3.3kΩ</td>
<td>C4 10uF electrolytic 6V</td>
<td></td>
</tr>
<tr>
<td>R7 1.8kΩ</td>
<td>TC1 40pF compression trimmer</td>
<td></td>
</tr>
<tr>
<td>R8 1kΩ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Miscellaneous**

- L1 Denico 8RF, m.w./l.w. with ferrite rod, or similar, “P” clips, 4BA bolts—4 off, plain Veroboard 64mm x 95mm 0.15in, matrix, suitable case (optional), PP3 connector

*Practical Wireless, July 1978*
Alignment

The equipment required for setting up is no more than a Long Wave receiver and an insulated trimming tool (a plastic knitting needle filed to shape will serve). Proceed as follows.

1. Screw down TC1, then unscrew $\frac{1}{2}$ to $\frac{3}{4}$ of a turn.
2. Connect the frequency meter earth to the 0V side of R8 and the probe to the output loop. Ensure that the unshielded section of the probe runs directly away from the aerial.
3. Connect a battery to the calibrator and then tune in 200kHz on the receiver which is placed nearby with both aligned for best reception.
4. Adjust the coil former on the ferrite rod until a heterodyne whistle is heard from the receiver; continue until the note is fairly low.
5. Using the trimming tool adjust TC1 until the beat disappears altogether. At this point the calibrator is phase locked to 200kHz.

Final Notes

Remember that any digital frequency meter will have a last digit error of plus or minus one, so don't expect the readout to be rock steady. Static or man-made interference, including radiations from the meter itself, if too close, can cause a momentary spurious reading. The circuit, which consumes about 4mA, is quite tolerant of falling battery voltage.

The prototype was used some 90 miles from the transmitter at which range locking occurs without difficulty, but at appreciably greater ranges it could be more of a problem.

Practical Wireless, July 1978
Receiver with Screened-grid H.F. Amplification covering 20-46 metres. The circuit consisted of a screened grid h.f. stage followed by a leaky grid detector with reaction and two i.f. stages; the price, £25, exclusive of royalty, valves and batteries.

Receiver Designs

Somewhat different to the Short-Wave 2 described by H. B. Dent, Wireless World (4.11.52) covering from 15 to 80 metres with 5 plug-in coils. The blueprint was obtainable from WW for 1s.6d, post free, the receiver was available for inspection at their Editorial Offices in Fleet Street and the approximate cost of the parts, excluding valves, was £4.12s.0d.

For some years, up until the end of 1924, Wireless World was the official organ of the Radio Society of Great Britain, and in July 1925 the first issue of the T and R Bulletin, forerunner of today's Radio Communication, was published at the instigation of Henry Bevan Swift, G2TI, and Gerald Marcuse.

In later years the Marcuse family moved to the picturesque seaside village of Bosham, Sussex, where today, outside the church stands a teak seat on which is a bronze plaque inscribed:"—In Memory of Gerald Marcuse, G2NM, Pioneer of Empire Broadcasting, President RSGB 1929-30", accompanied by the badges of both the RSGB and RAOTA. This memorial seat was handed over to the Chairman of Bosham Parish Council (Mr Frank Parham) by representatives of the Radio Amateur Old Timers' Association at a short ceremony outside the church on July 21st, 1962. In the same year RAOTA also arranged for a commemoration plaque to be installed at Gerry's former home in Caterham which reads:—"From this house Gerald Marcuse, G2NM, inaugurated Empire Broadcasting in September 1927".

The QSL card of special event station G2NM, operating from Bosham, West Sussex, on 24/25th June, 1978

To commemorate the 50 years of Empire Broadcasting, the Chichester and District Amateur Radio Club are operating a station from Bosham on June 24th and 25th, and have a special QSL card to mark the occasion. Although they will be active on 2m, G8NMF, they intend to concentrate their efforts on the DX bands, as Gerry did. Owing to the limited space available, people wishing to visit the station must first contact Terry Allen, G4ETU, QTHR, to make arrangements.

Practical Wireless, July 1978
During the past few years something of a revolution has taken place in the field of amateur electronics. The valves and transistors of the past have been overtaken by a wide range of integrated circuits (i.c.s) or "chips" as they are often called. These new devices make possible amateur electronic projects which, only a few years ago, would have been just science fiction dreams. The integrated circuits available range from simple two- or three-stage audio amplifiers up to microprocessors with some 20,000 or more transistors packed on to a tiny chip of silicon.

Some integrated circuits, such as those for audio, radio or television applications, are linear types and they work in much the same way as their discrete component counterparts. It will be noticed however, that the great majority of i.c.s advertised have type numbers in the 74 and 4000 series. These are logic devices originally developed for use in digital computers and industrial control systems.

What can Logic do for us?

So all of these digital logic chips are available but how can they be used in amateur projects? Let us consider radio communication. Amateur radio operators and keen short wave listeners often need to measure frequencies accurately. The old methods of using heterodyne wavemeters, calibration charts or even crystal markers work quite well but they are rather inconvenient. Modern communications receivers often indicate the frequency, to perhaps the nearest 100 hertz, as a number on a digital display. This facility is achieved by using logic circuits.

Basically all we need do to measure frequency is to count the number of cycles of the signal that occur in an accurate time period. If the time period is a millisecond then the answer will be the frequency in kilohertz. Logic devices are very good at counting things and measuring time periods.

To measure time we simply count down from an accurate crystal-controlled oscillator. The count can be arranged to provide the answer in hours, minutes and seconds. In fact this is precisely how a digital watch or clock works.

Many amateur radio stations use the radioteletype (RTTY) mode of communication where signals from a typewriter-style keyboard are converted into coded patterns of pulses and then transmitted. At the receiving end, the pulse patterns are decoded and the message is printed out as text on a sheet of paper. Because printers are rather expensive some stations display the messages as text on a modified television receiver. Extensive use is made of digital logic for coding, decoding and displaying the RTTY messages.

Morse code, still used by many radio amateurs, can be dealt with in the same way. Messages, typed on a keyboard, are converted by logic to perfect Morse code and at the receiver the signals are decoded and displayed as text on a TV screen.

Logic is very good at sequential control tasks such as running a model railway, controlling a machine, or even switching the lights on a Christmas tree. There are many ways we can use this capability for amateur projects.

Recently logic has crept into television in the form of TV games and Ceefax/oracle decoders. There are some TV sets which can display the time or channel number on the screen by using logic. In other cases, digital techniques may be used for tuning and for remote control. Even those touch switches on the front of some sets use digital logic.

Some large scale integrated (l.s.i.) digital circuits have been specially developed for use in electronic organs, digital multimeters, digital clocks and calculators. By far the most complex of the logic devices are microprocessors which, unlike the more specialised circuits, can easily be programmed to perform an almost infinite variety of tasks perhaps only limited by the imagination of the user.

People sometimes regard digital circuits as rather mysterious. It is true that when we enter the digital world we shall meet some new concepts, new devices, new circuit symbols and a whole new vocabulary of technical terms. In fact, however, digital systems are not too difficult to understand, and in this series we shall explore the way in which they work and some of the ways in which they can be used.

Digital Signals

First, let us take a look at the signals involved in a digital logic system. Readers will already have met analogue signals, such as those in an audio amplifier, where the level of the voltage or current in the circuit varies in proportion to the signal level. Thus the amplitude can vary continuously over the whole range of signal levels to give a virtually infinite number of discrete voltage or current levels.

In contrast to the analogue case the signals in a digital logic system can have only two possible levels. One of these is called the "zero" or 0 level, and this corresponds to the signal being turned off. The second level is called the "one" or 1 level and is equivalent to the signal being turned on.

Sometimes in the literature and in data sheets for logic circuits, other names may be used to describe these two signal levels. As an example the 0 level may be referred to as the "low" or "false" level, but it will still have the same value as the 0 level. Alternative names for the 1 level are "high" and "true" respectively. In this series we shall use the 0 and 1 terminology since it seems to be the most popular.

Practical Wireless, July 1978
When both A AND B inputs are set to 1 both of the diodes will cut off and no current will flow in R. Now the output level will rise to +5V to give a 1 output state. Thus the diode circuit produces the same logical results as the electrical lamp and switch circuit.

If we needed to have more input signals these could be provided by merely adding more diodes. With more inputs the 1 at the output should only occur when all of the input lines are at the 1 level.

**Truth Table**

A convenient way of setting down the various logic conditions in a gate circuit is by means of a Truth Table. In this table all of the possible combinations of input states are listed, together with their corresponding output states.

For a two-input AND gate such as that shown in Fig. 2 the truth table would be as shown in Table 1. In the case of an AND gate which has three inputs the truth table will have eight possible states as shown in Table 2.

![Truth Table](https://via.placeholder.com/150)

<table>
<thead>
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<th>Input</th>
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<tbody>
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**TABLE 1**

<table>
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<th>Output</th>
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<tbody>
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<td>A</td>
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<td>1</td>
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<td>1</td>
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</tbody>
</table>

**TABLE 2**

Try working out the truth table for a four-input AND gate and you should end up with 16 combinations but the output will be at 1 only when all of the inputs are at 1.

**Integrated Gate Circuits**

In an actual TTL 2-input AND gate the circuit is roughly as shown in Fig. 3 and is much more complex than our simple diode gate.

The gate action proper occurs in transistor Tr1 which has two emitters. This stage acts in much the same way as the diode gate so that the transistor stops conducting if both emitter inputs are at 1. Transistors Tr5 and Tr6 form a "totem pole" output stage which gives a low output impedance and fast switching. For a 1 output Tr5 is "on" and Tr6 is "off" and vice versa for the 0 state. Thus the output is clamped to either 0V or +5V through one or other of the output transistors. The other transistors in the circuit provide the required drive signals for the output stage.

In the 4000-series CMOS circuit a 2-input AND gate would be made up roughly as shown in Fig. 4. In this circuit the series n-channel transistors provide the AND gate action operating in much the same way as the series switches in our electrical circuit. The p-channel f.e.t.s Tr1 and Tr2 are used to pull the point X up to the supply rail if either of the inputs is at 0. When both inputs are at 1 Tr3 and Tr4 will both conduct to bring point X down to 0V. The output stage in this case is a push-pull complementary pair. If X is at 0, Tr6 will be "off" and Tr5 will be "on" so the output terminal will be clamped to the positive supply rail to give a 1 output. If X is at 1 the output level will be clamped to 0 via Tr6. In some cases there may be several other stages to provide full drive for the output stage but the operation is much the same.

For more inputs a TTL gate would have more emitters on Tr1, whilst a CMOS gate will have more transistors in series.

**Symbol for an AND Gate**

Obviously we cannot draw out the complete circuit for every gate so a special symbol is used to indicate an AND gate. This is shown in Fig. 5(a) for a 3-input gate. Where there are a lot of inputs the gate symbol may be modified as in Fig. 5(b) for drawing convenience.

![Symbol for an AND Gate](https://via.placeholder.com/150)

*Practical Wireless, July 1978*
This month's instalment deals with the construction of Board 3, the Y amplifier. This board uses a ground plane, in view of the high gain and wide bandwidth. With a ground plane, a low impedance earth return is available everywhere, ensuring that decoupling capacitors are fully effective.

As double sided boards were ruled out on the grounds of excessive cost, the component interconnections use conventional wiring. It may well be possible to produce a successful single sided printed wiring layout, but the author lost a considerable amount of time trying to do just this and therefore returned to the ground plane construction used in a previous oscilloscope design. Figs. 3 and 5 show the component layout and wiring, which should be followed closely to avoid instability. Note that i.c. sockets must not be used.

Up to this point, the components mentioned have all been fairly conventional, apart from the special mains transformer and the tube itself, of course. On this board we encounter some more out of the way components, but their use is more than justified by the performance which is obtained.

Take the dual junction gate f.e.t. type E421 (Siliconix) used in the input stage for example. The low temperature coefficient of input offset results in no drift of the trace level from switch on, even on the most sensitive setting of about 2.5 mV per division.

This dual f.e.t. acts as a source follower, providing the necessary high input impedance for use with the frequency compensated input attenuator S3 and a low output impedance to drive the 733 video amplifier IC301. Network R301, R302 and C301 protects Tr301a from excessive input voltages without causing deterioration of high frequency response. R305, R304 and R306, R307 provide d.c. level shifting of Tr301's outputs to bring them within the input range of IC301. They result in a small degree of attenuation of the input signal at d.c. and are therefore not bypassed, to keep the a.c. and d.c. gains equal.

The purpose and adjustment of VR301 is covered in the last article, and at this stage it should simply be set to mid-travel.

The 733 video amplifier IC301 forms the main gain block, and its gain is switched by S301 to provide an overall sensitivity for the complete instrument of 5, 10 and 20 mV/division. A fourth position of S301 brings VR302 into circuit, providing a continuously variable gain facility and incidentally providing a maximum sensitivity of approximately 2.5 mV per division.

The bandwidth of the 733 varies with gain, but even at maximum gain it is 40 MHz, so that in practice the bandwidth of the complete instrument is determined entirely by the Y deflection amplifier Tr303 to 308.

Note that owing to its common mode rejection (typically 60 dB even at 5 MHz) the output of IC301 is balanced, even though an unbalanced input is applied at pin 1.

Practical Wireless, July 1978
Tr302 is the trigger pick off amplifier. This is by no means a trivial function, as the action of an oscilloscope's trigger slicer circuit can easily reflect back a small disturbance into the Y amplifier. This results in slight notches in each cycle of the displayed waveform, which move up and down as the Trigger Level control is varied. Here, R311, R312 attenuate the signal by a factor of 2 and emitter follower Tr302 acts as a buffer.

An emitter follower provides only limited reverse isolation at high frequencies, but disturbances emanating from the trigger circuit, before they can reach the Y deflection amplifier input, are also attenuated by the ratio of R311 to the output impedance of IC301. This ratio is very much greater than 2:1, as IC301’s output stages are emitter followers.

Further buffering is provided by another emitter follower and 2:1 attenuator on Board 4, described next month. R314, like the 47Ω resistors in the Y deflection amplifier, is an anti-parasitic stopper resistance.

The bandwidth of an oscilloscope is usually limited by the Y deflection amplifier. Certain steps can be taken to maximise the bandwidth and a fairly obvious one is to use symmetrical deflection, i.e. to drive the deflection plates in antiphase. For if only one of the two plates were driven, twice the voltage swing would be required, so needing twice as high a collector supply voltage.

For a given deflection transistor dissipation, we would then have to halve the standing current through the output transistor. Twice the voltage at half the current means four times the collector load resistance and this would result in a quarter of the bandwidth!

The Y output transistors Tr303 and Tr304 are used in the grounded base mode. The low input impedance at their emitters results in virtually no signal voltage

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**Practical Wireless, July 1978**
swing at the collectors of Tr305 and Tr306. There is therefore no Miller multiplication of their internal collector/base capacitance, minimising capacitive loading on IC301's outputs.

The collector/base capacitance of a BF336 is approximately 3·5 pF and this, together with the Y plate capacitance of the 3BP1 c.r.t. and wiring strays, results in a total capacitive loading at the output of Tr303 (and Tr304) of around 10 pF. A peak to peak voltage swing of around 90V is required to provide a reasonable degree of overscan and choosing a conservative value of dissipation for Tr305 and 304 leads us to a standing current for each of just over 15 mA, of 3·3kΩ collector loads. Allowing a minimum Vce of 10V to maintain a good high frequency response leaves us with an h.t. requirement of 120V—the excess 30V is dropped by R316.

* components

<table>
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<tr>
<th>Resistors</th>
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<tr>
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<tr>
<td>Printed circuit board test pins and matching sockets (3)</td>
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</table>

Now 3·3kΩ and 10pF gives a time constant of 3·3×10⁻⁸ sec corresponding to a -3dB point of 5MHz and this is in fact the measured -3dB frequency of the oscilloscope for full screen Y deflection. With suitable inductive peaking in the collector circuits, this could be extended by about 20 per cent to 6MHz or a shade more if overshoot were accepted on fast edges. This bandwidth would be independent of the amplitude of the Y deflection. However, in this design a different approach has been adopted. The voltage gain of the Y deflection amplifier from the bases of Tr305, 306 to the collectors of Tr303, 304 is the ratio of the collector to collector load resistance (3·3kΩ+3·3kΩ) to the emitter to emitter resistance (R326, 220Ω).

A gain of 30 for a cascade stage is quite modest, considerably more gain could be obtained by using a lower value for R326. Advantage has been taken of this extra available gain by partially bypassing R326 at high frequencies with capacitors C309, 310, 311 and 314. This provides increased output current swing at Tr303, Tr304 collectors at high frequencies to charge the capacitance of the Y plates, so maintaining the frequency response level.

This substantially reduces the rise time when displaying pulses or square waves, but there is a limit.

After all, the available current through Tr303 and Tr304 together is set by the tail resistor R333. All the input signal can do is alter its distribution between them.

If due to the large size and fast risetime of an input square-wave, the current needed to charge the deflection plate capacitance quickly enough exceeds the tailcurrent, then we cannot faithfully display the waveform.

The “in” phrase for this is to say that the output voltage of the Y deflection amplifier is “slow-rate-limited”. If either the amplitude of the input were

![Fig. 2: An ideal square wave is shown in (a) with typical degradations which occur in practice shown in (b). At (c) are the output waveforms from a slew-rate-limited amplifier for three increasing values of input](image-url)
Fig. 4: The copper ground plain pattern of the Y amplifier board

smaller, the higher their frequency.

In other words, the amplitude/frequency characteristic of the amplifier matches the requirements for displaying square waves and pulses. For a vertical deflection of 1 division, the rise time of the oscilloscope is 20 ns, so the display of a 5 MHz square wave looks commendably square, whilst even a 10 MHz square wave looks as if it is obviously meant to be square! L301, 302 provide a modest degree of peaking, as so L1 and L2, but are not in any way critical. L301, 302 are 35 turns of 38 s.w.g. wire on 100 kΩ carbon composition resistors. L1, 2 (see Part 3) are similarly constructed with 15 turns of 38 s.w.g. wire. R306 and R325 shape the peaking provided by C311, 314 to give a flat frequency response and minimise overshoot and ringing on fast edges.

The emitter current of Tr305, 306 is provided by a long-tailed pair TR307, 308. These provide a convenient means of injecting the Y shift voltage via R315. If the Y shift were injected ahead of IC301, the position of the trace would change when the Y gain selected by S301 was changed.

The author has not seen six transistors used in this configuration before: readers might like to think up a name for it—a long-tailed cas-cas-cas-cas-cas-cas? perhaps.

WARNING

Extra care must be taken when working on any part of this instrument while power is switched on. 1100 volts can kill. When delving into the insides of the scope for any reason with power on keep one hand in your pocket
When Board 3 has been assembled, check each power supply pin to 0V with an ohmmeter to make sure none is short circuit and centre all pre-set pots and C309. Then plug it into the main frame, disconnect the Y plates from the temporary 47kΩ and 100kΩ resistor chain across the +150V STAB supply (see last month) and connect them via R21, L1 and R20, L2 sockets to pins Y1 and Y2 of the board.

Don't forget the ground link at the rear of the board either. You can also put up a crude timebase of sorts by disconnecting one of the X plates from the 47kΩ and 100kΩ resistors and reconnecting it via a 47kΩ resistor. A 0.1μF capacitor from the Y plate to pin 2 of Board 1 will give a small 50Hz sinusoidal X deflection. So, plug in briefly and check that all stabilised supply voltages are normal, indicating no short circuits anywhere.

It should be possible to centre the trace vertically with the Y shift control. If not, adjust VR301 as necessary. With a suitable range selected at S3, feed in a sine wave from an audio oscillator. When its frequency is carefully adjusted to exactly 50Hz, 100Hz, 150Hz, etc, a stationary pattern known as a Lissajous figure should be obtained. At 50Hz, this will vary from a line to an ellipse and more complicated figures will be obtained at higher frequencies.

This simple test will enable you to check that the Y amplifier is basically operational and to test that the Y shift works, also that the gain can be varied in steps by S301 and in position 1, by VR302.

Next month we will look at the construction of Board 4, which carries the timebase circuits.
therefore not multiplied by the audio frequency gain of the circuit and the quiescent output voltage is very close to the ground potential; the steady quiescent current passing through the loudspeaker can therefore be kept very small.

The bandwidth (or rather the high frequency response) of the circuit is controlled by the value of C3, the compensation capacitor. The bandwidth is approximately equal to $2.7 \times 10^{-3} \frac{R2}{R5C5}$; thus with the values shown, the response extends to about 160kHz, but can be reduced by increasing C3.

The capacitors C6 and C7 are required for good high frequency decoupling to ensure stability; they should be soldered close to the ESM 532. Although these capacitors are connected in parallel with very much larger capacitors in the power supply, the latter capacitors are electrolytics with a fairly large effective series inductance and may be some distance from the device. C6 and C7 have a far smaller series inductance than electrolytics.

**Power Supply**

A simple power supply for feeding the circuit of Fig. 2 is shown in Fig. 3. D1 to D4 may be four separate diodes (e.g. IN4002) or a single bridge rectifier containing four diodes (e.g. type REC 63 from Doram). Full wave rectification occurs in this circuit, the output voltage being nearly $1\frac{1}{2}$ times the transformer secondary voltage.

The use of the light emitting diode and its series resistor R1 to indicate when the power supply is switched on is, of course, optional.

**Single Supply**

The circuit of Fig. 4 has a similar performance to that of Fig. 2, but a single power supply is used. A positive bias must be applied to the non-inverting input in this circuit otherwise the output would be at a low voltage and would not be able to swing lower in voltage to amplify negative going peaks. The positive bias brings the output potential to a positive quiescent value and therefore a large electrolytic capacitor C4 must be included in series with the loudspeaker to prevent a constant quiescent current from flowing through the loudspeaker.

The gain of the circuit is approximately equal to $\frac{R7}{R5} + 1$ or about 28 (29db) with the circuit values shown. The bandwidth is about 12Hz to 140kHz with the value of C5 shown. At high values of gain a capacitor in series with a resistor should be connected from the junction of R7 and R5 to ground, the product of the values of this capacitor and resistor being appreciably less than the product of the value of C4 and the loudspeaker impedance.

**Comparison**

In general readers will find the circuit of Fig. 2 more convenient than that of Fig. 4, since no large output capacitor is needed in series with the loudspeaker. Thus the high switch-on transient currents are eliminated together with the switch-on 'plop' noise and one obtains optimum response at low frequencies. On the other hand, the power supply used with the Fig. 2 circuit does require a tapped secondary winding on the mains transformer.

Heat sinks suitable for use with the ESM 532 are available from Staver Thermal Products Ltd., Heron Trading Estate, Bruce Grove, Wickford, Essex SS11 8BS under the type numbers V3-3-2020 and V3-3-2020, the latter having the lower thermal resistance of 4.5°C/W. When the ESM 532 has been connected on its circuit board, silicone grease should be placed on it and the heat sink bolted to the board so that it is held in good contact with the ESM 532. Readers can make their own heat sinks using a sheet of metal of area not less than about 70 sq. cm. and bending it as required, leaving the part in contact with the device quite flat.

**Other devices**

One may well ask how the ESM 532 compares with other 20W devices? It has the same maximum current rating as the SGS-ATES TDA2020, but has a somewhat lower voltage rating than the latter. At present the ESM 532 appears to be somewhat cheaper than the TDA2020 and has the advantage that its typical quiescent current is only 25mA at 28V. The TDA2020 has the lower thermal resistance of 3°C/W (junction to case). The other characteristics of the two devices are quite similar, but the connections are different.

A lower voltage version of the ESM 532 is produced with a maximum rating of 30V under the type number ESM 432. The ESM 532N is similar to the ESM 532, but has a bracket for the connection of a heat sink.

**Availability**

The ESM 532 is available from Phoenix Electronics Ltd., 46 Osborne Road, Southsea, Hants at £2.95 including VAT and packing and postage.

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Fig. 3. A power supply circuit suitable for driving the Fig. 2 circuit

Fig. 4. A 20W amplifier using a single power supply

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Using a soft, lead pencil, draw out the islands on the board, and then draw around these and the interconnections of the earth plane edge. The small islands and fine connections are then filled in by means of an etch-resist pen or fine paint brush, using quick drying paint, such as car touch-up paint, thinned down if necessary. The larger areas are then put in carefully and when the board is dry, each island and connection examined to make sure no copper bridges exist between them. One should also ensure adequate clearances.

Place the board in a suitable plastic or earthenware container and pour on just sufficient ferric chloride solution as is necessary to cover it. The solution can be purchased ready-mixed from most radio component stores, or can be made up by a chemist. It is however a corrosive, albeit a mild one, so handle carefully and wash off any of the solution that comes into contact with the skin immediately.

Initially, leave the board submerged for about twenty minutes, agitating occasionally. You will see the chemical action taking place quite clearly and when all the unwanted copper has been eroded, take out the p.c.b., wash in clean water and then dry. Using a wet abrasive pad—such as a Brillo pad—the paint is now removed and a final wash and dry will leave the copper gleaming. After a final check of the work, drill the mounting holes for fixing to the metal chassis.

Each board in the transmitter is etched in this way and provided the simple instructions are followed you should easily be able to provide good examples.
Mounting Components (Fig. 3)

There is no hard-and-fast rule about fixing the components to the board, but the Author favours soldering the resistors first, followed by the capacitors, the coils and finally the transistors. Keep lead lengths short—typically 6-12mm for transistors—and solder neatly, holding the iron in place just long enough for the solder to flow to the joint. An iron of 15W rating with a bit size of 3mm or so is to be preferred for work of this nature.
Fig. 5: Copper side layout of Board 2. Available from Reader's PCB Service (see page 27)

Fig. 6: Component layout of Board 2. Note components soldered direct to copper side of p.c.b.
Nothing is more frustrating than getting all the bits to build a PW project, spending time putting it all together and then switching on only to find it doesn’t work! Unfortunately, however much care one takes in the constructional stage, this is always a possibility and when it happens, many readers are at a loss to know how to proceed.

From time to time articles have appeared purporting to give the answer to this problem, but people still get stuck, as my postbag shows. Yet really, with a methodical approach one can steadily and reliably progress through a circuit and finish up with it all working. So how? Instead of abstract generalisations, readers may get a much better insight into how to go about it if I give a specific example—a “case study” if you like. And since it has proved such a popular constructional project, I’ve chosen my “Handy-Mini Power Supply” published in the August 1977 issue, page 260, as the example.

Systematic Approach

With so many readers building this design, one or two were bound to hit some snag or other, e.g. “... have completed the Mini Power Supply... cannot adjust it at all with VR3... please can you help?” from J. D. of Huddersfield. This is where a systematic approach comes into its own, resulting in “... After following your instructions... Another Tr4 and everything is working correctly... Thanking you once again for your help” from—you’ve guessed it—our old friend J. D. again.

So how do we go about it? Well, let’s assume you’ve made up a Handy-Mini Power Supply, tried it and found that it doesn’t work. First of all, you may have noticed a slip-up in the editing (mea culpa!). Fig. 3 incorrectly labels the capacitor between base and emitter of Tr3 as C5, actually it’s C4, 5μF, as shown in the circuit of Fig. 1 reproduced here, and the component list. (A correction has, in fact, since been published, but never mind, either value in either place would actually work.)

Multimeter

The technique is to get the circuit working bit by bit. First of all, check that all the circuitry is completely insulated from the metal box, heatsink, etc. Use the highest ohm range on your multimeter for this purpose. If you haven’t got a multimeter yet, you really should. It’s not necessary to pay an enormous

Fig. 1: Circuit diagram of the Handy-Mini Power Supply, published in the August, 1977 issue of PW.
price, but it is worth getting one with a sensitivity of at least 10,000 ohms per volt. Very good value for money is the U4324, advertised in this magazine at £14-50 upwards, but adequate multimeters can be found at a few pounds less than this. They usually use 3V internal batteries for the ohms range and are not likely to damage any common diodes or transistors on any of the ohms ranges.

Stage by Stage

Next, set all preset pots to mid travel, put a short circuit across R4 and disconnect: Tr1 collector, Tr2 base and collector, Tr3 collector, Tr4 base and emitter and the point P. Switch S2 to OFF. These moves have isolated the current limit circuit (Tr1, etc.) and divided the rest of the circuit up into sections so we can bring it into operation in stages. With experience you will get into the habit of building a circuit in stages and testing it again and again as each stage is added. Now switch on and check that there is approximately 15V across C1 and 30V across C2. (All voltages measured with the negative lead of the voltmeter on the negative lead of C5).

If only one of the voltages is correct, most likely the wiring or B1 is faulty. Before replacing the latter, remember it may have been damaged by a short-circuited C1 or C2, so check these as well. If neither voltage is there, the trouble may be the wiring, the fuse or T1. From now on, I won’t keep saying “the wiring” every time when pointing out possible faults, but remember that if you are using good quality components from a reliable supplier, the wiring is always the most likely cause of trouble. If you are using salvaged components or gems from the junk box—well, good luck! Apart from costing you a lot of time, dud components can cost you money by burning out other good components.

Safety

So now you’ve checked your “raw supplies” are present and correct, reconnect point P and check that there is approximately 26V across C5 and 16V across D1. ALWAYS PULL OUT THE MAINS PLUG AND DISCHARGE C1 AND C2 THROUGH A 470Ω RESISTOR BEFORE WORKING ON THE UNIT. Faults should be fairly obvious, e.g. 30V or so across D1—it’s open circuit; just under 1V—it’s in back to front! Having checked that the voltages are now right, measure the voltage across the track of VR3 and set it to 12-7V by adjusting VR2. Check that the voltage at the slider of VR3 can be adjusted from 0 to 12-7V. Reconnect the base of Tr2 and temporarily link its collector to point “c”—i.e. top end of R5. We have thus connected Tr2 as a straightforward emitter follower and adjusting VR3 should swing the voltage at Tr2 emitter from 0 to 12V. If it doesn’t, it can only be wiring or components and our bit-by-bit approach has only added R9, Tr2 and R7 since the last stage.

Progressing

So assuming you’ve surmounted that hurdle, remove the temporary connection from Tr2 collector and connect the collector to R6 as in Fig. 1. Also reconnect Tr3 collector to R10. You should now be able to vary Tr2 emitter voltage from 0 to 12V with VR3 as before. Tr2 and Tr3 are now acting as a “complementary compound emitter follower”. Sounds technical doesn’t it? All it means is that Tr3 does most of the work, with the slider of VR3 just enough to provide sufficient base current to Tr3 to cause it to turn on and pull Tr2 emitter up to about 0-6V below the voltage at the slider of VR3. So Tr3 is supplying most of the current drawn by the load, which in this case consists just of R7 and your voltmeter.

If for any reason you aren’t getting this negative feedback from Tr3 via R10—C4 short circuit or Tr3 open circuit for example—Tr2 emitter voltage might not quite make 12V because now all the load current will have to pass through R6. To make quite sure, temporarily put 2-7kΩ in parallel with R7—you should still be able to make 12V at Tr2 emitter.

Assuming all is well, reconnect Tr4 base and emitter. Now we have two d.c.-coupled complementary stages of amplification (Tr2 and Tr3) driving an emitter follower which provides 100 per cent negative feedback to the emitter of Tr2, and again we should be able to adjust the output from 0 to 12V with VR3. At this stage, we have only added a single component, Tr4, so if something is wrong now the answer is pretty obvious.

Load Testing

Set the voltage at Tr2 emitter to 12V and connect a 100Ω resistor (at least 1/2W rating) in parallel with the voltmeter. The output voltage as measured by the voltmeter should not change by more than the thickness of the pointer. With S1 open, remove the short from across R4 and reconnect Tr1 collector. Check that VR3 can set Tr2 emitter volts to 12V as before. Now on connecting 100Ω in parallel with the meter the output voltage should fall (set VR1 so that it falls to around 5V) but should return to 12V on closing S1. If this is not the case, one of the components in the current limit circuit, R3, S1, R4, VR1 or Tr1, is faulty. For example, output stuck at 0V—Tr1 collector-emitter short circuit. Now close S2 and check that 0 to 12V is available at the output terminals. We have now checked that everything is functional and it only remains to calibrate the unit as in the original article.

The principles of systematically getting a circuit going stage by stage are well illustrated by the above. If you are new to electronics or sometimes have problems getting a circuit to work, it would be well worth while studying the circuit of the original article in conjunction with the systematic approach described above, even if you have no intention of making up a Handy-Mini Power Supply. You will then grasp the principles and be able to apply them to repairing a transistor radio or getting a hi-fi amplifier to work, etc. Although the example given is a simple one, the principles are quite general and the more complex the circuit, the more important it is to divide it up and get it going stage by stage.

Purbeck Oscilloscope

This approach is followed in the PW Purbeck now being published, and should allow any PW reader with an elementary knowledge of how transistors work and a little constructional experience to build a high-performance oscilloscope for a fraction of the cost of a comparable commercial instrument.
Although we try to take every reasonable precaution to ensure accuracy of presentation and technical efficiency in our constructional projects, it sometimes happens that circuit references turn out to be incorrect or the occasional instance of a reversed diode or capacitor causes universal consternation. When this happens, the editorial department attempts to publish a correction as soon as possible.

In the case of the Morse Tutor, of our August 1977 issue, the details have only just emerged of a divergence between the theoretical and practical instructions. The details are as follows:

The circuit diagram on p. 264 is correct except for the omission of the input B connection to IC2. This should be shown as pin 1. In the 'Pin Connections' table on p. 266, "R" and "S" are reversed, i.e. "S" is the 0V terminal.

The facts concerning the layout on Veroboard are not so simple. It appears that the component overlay was somehow confused with a Veroboard layout, resulting in the essential interconnections being lost. This refers to board A only, and the two remaining boards are correct. How the error arose is not clear, but was probably due to the major changes occurring at the time in the editorial team, with a retiring member handing over the half-formed details to his replacement, the fault probably appearing at the original artwork stage.

Whatever the facts, we have now prepared an accurate p.c.b. layout, complete with component overlay, to assist those who attempted this project. The new p.c.b. and the original code cards are available from Reader's PCB Service.

NEW BOOKS

THE SECRET WAR
by Brian Johnson
Published by the British Broadcasting Corporation,
35 Marylebone High Street, London W1M 4AA
352 pages, 243 x 170mm. Price £6.50
Those who have been fascinated by the recent BBC Television Series The Secret War will be enthralled by this book, which is based upon it, with some additional material. The earliest developments in radar and other radionavigational systems by both the combatants are described in some detail, with a wealth of photographs and drawings. In all, there are over 350 illustrations in the book, many of them previously unpublished.
Some original circuit ideas provided by our readers. These designs have not been proved by us, and we cannot therefore guarantee their effectiveness. They should at least provide a basis for experimentation.

Why not send us your idea? If it is published, you will receive payment according to its merits. Articles submitted should follow the usual style of PW in circuit diagrams and the use of abbreviations. Diagrams should be clearly drawn on separate sheets, not included in the text.

Each idea should be accompanied by a declaration that it is the original work of the person submitting it, and that it has not been accepted for publication elsewhere.

This circuit was developed to improve the stereo effect experienced when listening with stereo headphones. When listening with loudspeakers the stereo effect is produced by the interaction between the two speakers. With headphones, however, there is no such interaction and to obtain a realistic stereo image some form of blend circuit is needed.

The network of capacitors and inductors alters the amount of blend with frequency, the amount increasing at those frequencies which provide the main directional information.

The phones used for the prototype were of an inexpensive type which could be taken apart easily and the components were mounted inside the headphone bodies. The 10mH chokes used were Repanco type CH4 and the capacitors were of the tantalum variety. An extra wire was threaded through the headband to connect the right- and left-hand parts of the circuit. The original signal wires to the headsets need to be disconnected and the blend circuit inserted. R1, C1, C2 and L1 are mounted inside the left headphone and R2, C3 and L2 inside the right-hand one. The circuit can be used with all stereo headphones of 4 to 8Ω nominal impedance.

R. N. Soar, Mexborough, S. Yorks.

When testing JK flip-flops it is unsatisfactory to use an ordinary switch connected to the clock input. This electronic switch uses a 7400 i.c. in an 'anti-bounce' circuit, with an l.e.d. to indicate a high or low output.

Connect a +5V supply to pin 14 and 0V (Ground) to pin 7. A 6V battery could be used. The unit is a bistable which does not change state when the switch is momentarily open circuit. The circuit can be constructed simply using Veroboard.

A. P. Cooper, Wimborne St. Giles, Dorset.
Introduction

This is a design for an electronic lock which can replace the standard mechanical lock in many applications. It is impossible to “pick” as with a mechanical lock, and can have over 250,000 million different combinations, which will take all but the luckiest thief many hours to work through!

The lock can be used to disable a burglar alarm, taking the place of a mechanical key switch. Operation of the lock consists of depressing five keys on a keyboard in the correct sequence, the first key resetting the lock, and the other four keys providing the code.

The circuit can easily be extended with the addition of another i.c. and a few diodes to accept a nine digit code, which provides for extra security, although for most applications it is very tedious keying nine digits once the novelty has worn off, let alone trying to remember them! The operating code is programmed into the lock by the wiring between the keyboard and the p.c.b. and can easily be changed in the future.

The lock uses CMOS logic integrated circuits which have the advantage of negligible power consumption, thus continuous battery operation is quite feasible.

On the prototype, the quiescent current was about 1µA, giving a battery life of well over 6 months. The output can be used to switch almost any solenoid, via a separate relay, if necessary, or can be used to disable a burglar alarm direct.

Operation

The operation of the lock is dependent on a decoded decimal counter type CD4017. From the truth table for this device given in Fig. 1, it can be seen that for each clock pulse, the counter switches to another output in sequence. The circuit for the lock is shown in Fig. 2.

Each time a key is depressed, one of the diodes D1-D5 conducts and Cl charges through R2. When the voltage on Cl reaches the threshold voltage of IC1d, the output will go low, charging C2 through R5 thus producing a pulse of about 50ms duration at the output of IC1c. Cl and R2 delay the production of the pulse to eliminate any effects due to contact bounce in the keyboard switches.

The first key to be depressed can be any one of the keys connected to the “reset keys” input. Irrespective of the position of the counter, none of the keys will be gated to R4, therefore it will be at logic 0. The pulse produced by depressing the key is therefore gated through IC1b to the reset input of IC5, which resets the counter. After a short delay due to R5 and C3, this pulse clocks the counter to output 1, enabling IC2c, which is an analogue switch. This sounds rather complex, but can be considered as an electronic relay.

When the control terminal is low, there is a very high resistance between the input and output (about 10^6Ω), and is effectively an open switch. However, when the control terminal is high, the resistance between the input and output is about 500Ω, which is virtually a closed switch. Thus any voltage on pin 8 of IC2 will appear across R4 when the counter is at position 1. This effectively connects the first key of the code to R4, and if this key is depressed, pin 6 of IC1 will be at logic 1, and the pulse will be inhibited from the reset input of the counter by the action of the NOR gate IC1b. The clock pulse will still reach the counter and advance it to output 2. This enables the second key, and the process is repeated.

If the wrong key is depressed at any time, R4 will be at logic 0 and the counter will reset to its initial condition as described above. As the correct keys are

![Fig. 1: Truth table for the CD4017 counter](image-url)
depicted, the counter will increment to output 5, which will switch on the complementary output pair, Tr1 and Tr2. This energises the load, D6 providing protection against back e.m.f. from inductive loads. C4 also charges through R6, and after about 2½ seconds, the counter is reset to its initial condition via gate IC1a. C5 provides suppression of spikes that can appear on the supply line and interfere with the logic activity.

**Component Selection**

Probably the most difficult item to obtain will be the calculator keyboard. This consists of 19 switches mounted on a p.c.b., which should be waterproof types, for use outdoors. These are dome type switches, operated by a thin piece of domed metal collapsing and making contact when pressure is applied.

This type of keyboard really needs a mounting frame and buttons, which are not readily available, however, the following method makes a presentable unit from this keyboard.

A small piece of white Fablon may be stuck over the entire front face of the unit, and Letraset numbers (or letters if you are hopeless at remembering numbers—the code can easily consist of an easily memorised word) put over the top of each dome.

The entire keyboard is then covered with a sheet of transparent self-adhesive plastic to protect the Letraset from rubbing off while in use. The keys can still be operated through the layers of plastic, and this makes the keyboard reasonably immune to cups of coffee being spilt over it!

Many types of calculator keyboard have the keys wired in a matrix arrangement, as opposed to one common rail and a lead to each switch. If this is the case, it will be necessary to remove the interconnecting tracks from the board, and rewire the unit.

If a keyboard is available, with more than 12 keys, the remainder can be wired to the “reset keys” input on the p.c.b., thus effectively increasing the number of combinations available. Indeed as few as five keys could be used, with only one key connected to the “reset keys” input, the number of different combinations going down to a mere 3,125.

Solenoid selection can also be a problem. The lock will operate on any supply voltage between 4 and 15 volts, and the solenoid should be chosen to suit this.

The other components are non-critical: almost any silicon diodes can be used, and most silicon transistors will suffice for the output stage, although the current rating of Tr2 should be well in excess of the load current of the solenoid.

**Construction**

Most of the components are mounted on a p.c.b., the track and component layout being shown in Figs. 3 and 4 respectively. There are four links needed on the board, and these should be inserted first, followed

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*Practical Wireless, July 1978*
by the other components, leaving the integrated circuits until last, as they are easily damaged by static. The use of sockets is advised unless you have a properly earthed soldering iron. Tr2 is mounted with its metal face in contact with the board, with a short 6BA nut and bolt securing the transistor to the board. It is a good idea to connect fairly long wires from the keyboard to the p.c.b. as the code, and consequently the wiring, may need to be changed in the future. The load should not be connected yet, but if a spare l.e.d. is available, this can be connected across the load pins on the board with a 1kΩ series resistor for testing purposes.

★ components

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<td>C3 10nF Ceramic</td>
<td>C4 2.5μF Electrolytic (16V)</td>
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<td>Tr1 2N3704</td>
<td>Tr2 BD132</td>
<td>IC1 CD4001AE or MC14001CP</td>
<td>IC2 CD4016AE or MC14016CP</td>
<td>IC3 CD4017AE or MC14017CP</td>
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<tr>
<td>Other Components</td>
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<td>1 off 16 pin DIL socket</td>
<td>Keyboard (see text)</td>
<td>Solenoid (see text)</td>
<td>PP9 Battery and Connector</td>
<td>Printed Circuit Board</td>
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Testing

If the lock does not work, connect a voltmeter between pin 10 and IC1 and earth. Each time a key is pressed, the voltmeter should give a short positive “kick” and then return to zero. This should be checked for all the keys, and they must work every time if the lock is to be reliable.

If that does not identify the problem, connect a voltmeter across R4. The meter should read almost supply volts while the correct keys are pressed. When the lock is working, connect the supply direct to the board, and the load across the output. After further checking, the digital lock can be installed.

Possible Modifications

If a nine digit code is required, an extra CD4016 can be wired to switch 4 more keys to R4, controlled from outputs 5-6 of IC3. The output stage is taken from output 9 of IC3. Remember to include a diode from each extra key to R1, so that these keys produce a clocking pulse to operate the circuit.

If the lock is to be used with a burglar alarm, a relay can be used to disable the alarm, and the output stage can be made to stay on until another key is pressed by removing R6 and replacing C4 with a link.

However, the current drawn when the relay is on for long periods will probably be too high for economical battery operation, therefore the lock could draw its supply from a mains operated power supply, or from the burglar alarm itself.

If the load is to be switched on for other periods the values of R6 and C4 can be altered, the time the load is on being approximately given by \( T = R6 \times C4 \). R6 can be increased up to about 10MΩ, but if an electrolytic capacitor is used for C4, R6 should not be increased above 4.7MΩ, due to leakage current in the capacitor causing large timing errors. Care should be taken to prevent voltage spikes greater than 15V reaching the CMOS, since they can cause irreparable damage.

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Complete Page 25226 1978
Notes on the Jubilee Organ project

Although the Jubilee Organ has undoubtedly emerged as very popular, in the time which has elapsed since its final part was published in our January 1978 issue, certain points have arisen which could cause some confusion. In order to dispose of these details, the following notes are provided as a complete list of published corrections, along with suggested modifications.

General Constructional Corrections:

(1) September 1977, p 353. Transistor BYF71 should read BCY71.

(2) November 1977, p 509. The circuit diagram of the accompaniment section shows the base of TR5 connected to the 12V positive rail. This connection should be broken, leaving the base of TR5 connected to the free end of R44 (1MΩ) only. The p.c.b. provided via Reader’s PCB Services is correct.

The end of R45, shown connected to the 12V positive rail, should be connected to the junction of R40 and C17. Again, the recommended p.c.b. is correct.

(3) The collated components list, September 1977 p 353, contains the information “3-off 33μF”. This should read “3-off 3.3μF Polystyrene”.

Operational and Setting-Up Instructions:

November 1977, p 506—in describing the interim keying tests, a mistake was made in the text. When the flying lead is connected to the +12V point (positive end of C8) the note is inhibited. It is when the lead is removed from this point that the note will sound, and it is under this condition that VR5 should be adjusted. Re-applying the 12V will terminate the tone according to the sustain setting of VR6. When S2 is open the tone burst will occur when the flying lead is removed from the 12V point. The same reversed logic would apply to testing the repeat percussion effect.

Our “Postscript” in the final part of the article (January 1978) gave details of a modification to enable major chords to be memorised, thereby introducing a continuous “vamp” facility. The fact that no drawings accompanied the text seems to have caused considerable confusion, so in order to illuminate the situation, the relevant diagram, showing the necessary switching, is now provided for reference.

Suggested Modifications

Manfred Pfeifer of Bristol suggests in a letter to the author the following swell pedal modification: “The volume is controlled by a foot operated pedal, linked via a l.d.r. To maintain a suitable range, the l.d.r. (ORP12) is connected in series with a 16μF capacitor, and then wired in parallel with R92. A small bell transformer supplies 5V a.c. to provide a light source for the l.d.r.”

Another constructor, Lorin Knight, of Letchworth, suggests some further improvements. He has included three extra stops (one for future use), with one used for continuous rhythm as already described, and one used as an additional percussion stop for the melody. C12 is shunted with a 47kΩ preset and an extra 4.7μF preset. The preset is adjusted so that the amplitude only drops 6-10dB after the percussive attack, giving rise to a gradually “flattening” envelope shape, similar to that of a piano.
INTRODUCTION TO LOGIC—continued from page 31

He also suggests modification of the DIN output socket, to introduce stereo effect. This gives drums to the left, melody centre, and accompaniment to the right.

Circuit diagram for Stereo Effect modification

Several readers have requested detailed cutting and drilling instructions for alternative keyboard versions. It was felt that in cases where the calculator keyboard was not opted for, general details for other types would necessitate a proliferation of differing instructions. Aside from this confusion, the conventional keyboard, for which we had approximate constructional details, appeared to be in limited supply (very limited supply as it eventually proved), and so we decided to confine our constructional notes to the details for the calculator version in general, and the initial measurements for the front and back panels. This was considered enough to cover the bare essentials, and the majority of constructors seem to have come to terms with this problem.

Fig. 5: AND gate symbols

Practical Gate Devices

Let’s now take a look at some of the actual AND gates available in integrated circuits.

In 74-series TTL the most commonly met AND gate is likely to be the 7408, which contains four separate 2-input AND gates in one package. Other types are the 7411 which has three 3-input AND gates, and the 7421 which is a dual 4-input AND gate. The function and pin connections for these types are shown in Fig. 6.

Fig. 6: Some actual TTL AND gates

The 7408 and 7421 have very similar connections and functions, as shown in the diagram. The 7411 has a third input, labeled ‘C’, and is useful in applications requiring a 3-input gate.

Fig. 7: Some actual CMOS AND gates

The 4081 in the CMOS series provides the same logic functions as a 7408 but the pin layout is different. Other gates in the CMOS series are the 4073 triple 3-input AND gates and the 4082 which contains two 4-input AND gates. Fig. 7 shows the pin connections and functions of these CMOS devices.

If we wanted a 6-input AND gate this could be made up by using two 3-input gates feeding into a 2-input gate to form a cascaded tree of gates as shown in Fig. 8. This principle could be extended to give any number of inputs if desired.

Next month we shall look at some of the other types of gate circuit used in logic systems.

Fig. 8: Cascading AND gates to provide more inputs

The coil winding details for this project were inadvertently omitted from the components list. L1 60 turns 40 s.w.g. enam. copper wire on 6mm dia. former with dust core. L2 5 turns 22 s.w.g. tinned copper wire 6mm dia. x 8mm long air-spaced, tapped 4, turn from top.

Tr1 should be a BC108.

C24 should be connected to the tap on L2, not as shown in the circuit diagram (the printed circuit board is correct).

A small section of track is missing from the p.c.b. copper track pattern shown in the article. To overcome this a thin wire link should be used to connect together the pads for the +ve ends of C12 and C13. Solder this link onto the copper track side.

D3 to D12 are type IN4148.

R52 is selected according to type of indicator used. (Shown in Fig. 7.)

KINDLY NOTE!

Bovington Tank Battle Game, June, page 38

The coil winding details for this project were inadvertently omitted from the components list. L1 60 turns 40 s.w.g. enam. copper wire on 6mm dia. former with dust core. L2 5 turns 22 s.w.g. tinned copper wire 6mm dia. x 8mm long air-spaced, tapped 4, turn from top.

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Practical Wireless, July 1978
In recent years "fuzz boxes" have been rife on the pop scene particularly with regard to guitars. The idea seems to be that one uses a fuzz box to make a guitar not sound like a guitar!

This month's μDeCnology circuit shows a very simple circuit for obtaining a fuzz effect. It is very sensitive and can be used to fuzz sound direct from a microphone or even a record player.

The commonest approach to fuzzing involves taking a luckless sine wave, chopping the tops or peaks off (known by the purists as "squaring"), and then amplifying the resultant noise with an ordinary audio amplifier.

We are cheating a little with our circuit by simply using the very high gain of the 741 op. amp. with no negative feedback. To increase the sensitivity still further, an extra stage of preamplification has been added by using a BC107 transistor. This preamp stage is also very simple, being reduced to a bare minimum of components.

When you have "plugged" the components into your μDeC by their own leads (see Fig. 1) you should connect 6V to holes Q1(+) Q23(-). The input is connected to holes F22 and E23. On test it was found that almost any microphone would work well and give a horrendously fuzzed voice output. Those tried included a cheap crystal insert, a commercial crystal microphone, a magnetic type (some 300ft impedance), and a small loudspeaker. Even small earpieces were tried and found to work.

Six volts proved ample for good sensitivity. Increasing this to 12V made the circuit super sensitive and if this is done there is a good chance of positive feedback which will make the circuit oscillate. In a permanent form, one could transfer the components from μDeC to Blob Board and then put the Blob Board in a metal case thus screening the circuitry from both the output loudspeaker and the microphone. This should prevent instability and make a useful fuzz box which could be used in many applications. For example, as a party game or at a disco, records could be announced with fuzz in followed by the record. Alternatively, the participants might be
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