Telephone exchange

surface-mount devices

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This month's cover of a typical surface-mount assembly shows clearly that this has a rather different appearance than conventional printed-circuit boards. Although they differ externally from their current counterparts, surface-mount devices are internally basically the same, except that they are generally of better quality. Although surface-mount technology is undoubtedly the assembly technique of the future, largely replacing printed-circuit boards within the next decade, it is still in its infancy and dynamic development is likely to continue for some years.
Communicating electronics

Electronic is the world's No. 1 industry. In India, too, it has emerged as the most important one and is on the verge of dwarfing such giants as steel, chemical, automobile, et al.

Such is the impact that electronic has made on the society; it has brought about progressive sophistication and automation; progressive reduction in cost without compromise in quality; and progressive increase in speed and accuracy of operation. Indeed, electronics is progressively leading us to become a high level information society.

At the beginning of this century which could have foreseen such a remarkable metamorphosis in scientific technology. And the developments that have taken place in the last decade are a pointer to things to come in the 21st century.

If the progressive and pragmatic policies adopted by our country are any indication, the year 2000 will usher in a century of changes thereby leading us to enjoy convenience and comfort to the full in every aspect of life.

On this cheerful note, elektor, the magazine that communicates electronics, enters the New Year. The elektor group comprises a team of 150 professionally skilled and dedicated people working in Holland as well as in many countries of the world with a common goal—of throwing light on the existing world of electronics on a continuing basis. The group has made a dynamic success story over last 25 years producing a diverse range of electronic designs for textiles, telecommunication, cars, computers, stereos, ships, and many more.

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Sales Tax Slashed

Television sets used to cost more in Bombay and other parts of Maharashtra compared to the rest of the country. A stiff sales tax imposed by the state government had upset the manufacturers, dealers and buyers as well. The government of Maharashtra, after a persistent demand from all sections, has decided to reduce the sales tax on electronic goods. All manufacturers of electronic goods, components and peripherals and computer companies have welcomed this move.

The sales tax reduction, establishment of three electronic industrial estates, single window clearance and setting up of a high-level Maharashtra Electronics Development Agency will go a long way in adding to the growth of Rs. 3,000 crore in electronics exports by 1990, according to the Bombay Chamber of Commerce and Industry.

The All India Radio and Electronics Association heralds the sales tax cut as a badly needed boost to the industry urging the government to levy a uniform four per cent tax on electronic goods, irrespective of the place of production.

The Maharashtra TV manufacturers' association has expressed the hope that the production of TV sets in the state would increase manifold and assure the government that the concession would be fully passed on to the consumer.

The All India Association of Industries said the sales tax cut would encourage entrepreneurs to set up new units in the state. The government has taken a step in the right direction by this announcement.

TV manufacturers, true to their word, seem to have already implemented their decision to pass on the concession to consumers as advertisements have been appearing announcing a reduction in prices.

Export Zones

The chairman of the Electronics Commission, Dr. M.S. Sanjeev Rao, has urged the foreign firms to consider relocation of electronic units in India from export processing zones in other countries.

The wage rates in countries like Hong Kong, Korea and Singapore, where foreign subsidiaries have been set up to cater to the export market, have increased considerably compared to the wages prevailing in India. It would be profitable for those foreign firms to locate their units in Indian export processing zones.

Dr. Rao said while inaugurating a seminar on 'Export processing zones as an instrument of export promotion' organised by the Trade Development Authority, recently known as the SEEPZ, Bombay.

Value and output

Electronics will become a forgotten industry unless a demand is created among consumers, according to Mr. S.R. Vijaykar, Secretary to the Department of Electronics.

Research and Development facilities in electronic units should improve not merely to indigenous the imported equipment but also to understand the sustainability and adaptability of foreign goods to Indian conditions. Mr. Vijaykar said while delivering the keynote address at a workshop on "Banking requirements of the Electronics Industry".

The seventh plan target of Rs. 10,000 crores of output set for the electronics industry should be viewed not in terms of value but in terms of output, he opined. To meet the objective of modernisation, accepted by the planners, the electronics industry would have to become internationally compatible both in quality and in price.

Mr. Vijaykar termed the plan allocation of Rs. 4,000 crores to the communication sector as meagre and said at least double the amount was needed to achieve the programme of producing 100,000 microcomputers by 1990.

Dr. C. Rangarajan, Deputy Governor of the Reserve Bank of India, who inaugurated the workshop said the banks should take maximum care in financing electronic products as these faced a high degree of obsolescence. He desired the development of a new financial norm to ensure that both the promoters and financiers shared the risk equally.

Mr. D.N. Ghosh, Chairman of the State Bank of India said the aim of the workshop was to understand the emerging financial needs of the electronics industry particularly in view of the envisaged massive expansion of investment under the new economic policy.

High-Tech MECCA

The Media Laboratory, a new experiment which began early in 1985 at the Massachusetts Institute of Technology, is backed by more than 40 giant corporations with an investment of 40 million dollars for the building and computers alone with another four million dollars for operating expenses every year.

Media Lab's mission is to explore what computers could do and what people would do with them. It has diverse and mind-boggling projects that range from talking computers to electronic newspapers, from computer programmes for kids to computers that make music.

The founders of the lab, Nicholas Negroponte, an MIT professor of media technology and Jerome Wiesner, president emeritus of MIT and science adviser to President Kennedy, have convinced a lab different from others. Here researchers buy off-the-shelf equipment and programme them for new uses in creative fields like broadcasting, publishing, motion pictures, music and theatre.

None of the lab's work is proprietary. The lab's sponsors can use the lab for five years and then anything they want of the various projects.

Marvin Minsky of MIT who is called the dean of artificial intelligence, using computers to try to emulate human thought, Seymour Papert, the math and education professor of MIT, who developed the computer language, Logo, used by school children all over the world, Negroponte himself, an architect and pioneer in computer-aided design technology, are among the staffs of the Media Lab.

The Media Lab believes executives will find computers more friendly in offices of the future. Instead of wrestling with keyboard and enigmatic codes the businessmen will be able to work with the computers by talking to it, pointing to it or even by glancing at it.

One of the research scientists, Richard A. Bolt, wearing special glasses, sits facing many es 40 television pictures, all running simultaneously on a giant screen. Sensors on the glasses track where his eyes are looking and that information goes by cable to a central computer. If his gaze rests on a single picture, the other 39 recede and that one fills the screen. The exciting project is named Gaze Orchestrated Dynamic Windows project.

The Conversational Desktop is Media Lab's talking computer. It can perform secretarial tasks as making phone calls and reminding the boss of important meetings.

Scientist Bolt has a wristband with a magnetic sensor that can move an image from one location on a computer screen to another. As Bolt's hand moves through a magnetic field, sensors on the wristband send signals by cable to the computer, relaying where on the
Another section of the Media Lab is busy programming a computer to play a synthesiser, following the tempo set by the conductor. When the conductor slows his baton, a sonar sensor following his hands tells the computer to have the synthesiser play more slowly. The synthesiser can react as quickly as a live musician and plays in nearly perfect synchronisation with a violinist and a flutist.

Marvin Minsky wants to study what goes on in the mind when someone writes music or listens to it as he believes that understanding how people think about music will ultimately lead to smarter machines.

Patrick Purcell, an associate professor of computer graphics, is developing a suit that emits infrared signals to be read by four light sensors connected to a computer which then generates a stick figure on its screen, copying every movement. The stick figure could be dressed in any way one likes. NHK, the Japanese counterpart of the BBC, has already picked up this technology and created a computer-animated host for a new show on the 21st century.

New Entrants

Munograppa Electronics Ltd., a new company has entered the capital market and its project is located at Hebbal industrial area in Mysore district. MEL is setting up a project to manufacture 2.350 million metres of 3.81 mm width high quality audio-magnetic tapes. It has also registered for manufacturing 23 million audio tapes, using its own production. The cost of the project is Rs. 53 million. The company is expected to go into commercial production by April 1986 and in the first full year of operation it hopes to market about five million cassettes, increasing to about 12 million at the end of the third year of operation.

Computer Point (India) Ltd., which opened the first retail shop for all computer related items under one roof, has completed one year and is now entering the capital market. The company has retail outlets in Bombay, Bangalore and Madras. It has commenced a computer education service called "Chip Club".

Snoookered — by a robot

The world's first snooker-playing robot is expected to be in action in about a year's time. The robot is the brainchild of scientists from Bristol University and London's Imperial College. They say that the robot will initially have fairly limited skills at the game, but there are plans to develop it further so that it will be capable of taking on top human players such as Steve Davis. The metal maestro of the green baize table will be programmed to learn the rules of the game and to study the position of the balls so that it can work out the best shots. It will then propel itself around the snooker table on wheels to play. The robot will have TV camera eyes and the sight will be fed into a computer which will operate as the robot's brain.

Snooker is particularly well suited to robotic research because the game requires a high level of co-ordination between hand and eye. Scientists have been long been trying to build such skills into robots for industrial applications.
This digital clock makes use of the giant displays published in the August/September 1985 issue of Elektor India. It has a face of 720 mm wide by 280 mm high, which makes it readable at distances of up to 100 m. The display alternately shows the time and the ambient temperature.

JUMBO CLOCK

by A. Sevrians

The circuit diagram in Fig. 1 shows that the clock is designed around well-tried ICs. The clocking frequency is derived from the mains: T1 is provided with part of the secondary voltage of T2 and converts this into a suitable rectangular signal. Low-pass filter R1 C1 and monostable IC1 ensure a noise-free 50 Hz signal. This signal is divided by 6 in IC2, then by 5 and 10 in IC3, and finally by 10 in IC4. The signal at pin 12 of IC4 is, therefore, 1/60 Hz, which is 1 pulse per minute.

Circuit IC5 functions as a frequency converter: signals of 8 1/2 Hz, 1 1/2 Hz, and 1/60 Hz are applied to its D4, D3, and D2 inputs respectively. When S4 is in the centre — NORM — position, control inputs A, B, and C of the IC are logic low, and D0 is then connected to output W. The clock is then supplied with normal minute pulses and operates normally. The clock may be set by switching S4 to FAST or SLOW as the case may be.

Clockwork

The clockwork is formed by the chain consisting of four bit synchronous counters IC11 to IC15. The Q-outputs of these circuits give the counter position in 11-bit digital code, where Q3 of IC11 has the lowest value bit. Connections between the output and gate N4 are so arranged that when the counter position reads 1001111111 (decimal 1439), the three ICs are reset to 0. The counter position corresponds to 23 hours 69 minutes. The clock can also manually be set to 00 hours 00 minutes with the aid of reset button S5.

Thermometer

Circuit IC16 is the temperature sensor. Its temperature-dependent current causes a voltage drop across R11 which, after amplification in A1, is supplied to digitizer IC7. Provided P1 and P2 are adjusted correctly, the Q-outputs of IC16 have logic levels corresponding to the temperature. The digitizer is clocked via gate N4.

Decoding

The 11-bit digital information as to time and the 8-bit data on temperature are applied to the A and B outputs of multiplexers IC17...IC19 respectively. The signals at the A/B input of these three ICs determine whether the time or temperature information is provided to their outputs. The signals at the A/B inputs are derived from the clock oscillator, and arrange for a regular change-over at three-second intervals.

The output signals of the multiplexers are simply used as addresses for EPROMs IC18 and IC19. Two EPROMs provide 16-bit data, and, since four digits are used for the clock, these are divided into four groups of four bits. At each address in the EPROMs now exists the relevant BCD code for controlling each of the four clock digits.

Display

How the output of the EPROMs control the individual display boards is shown in Fig. 2. Each of the display boards has a BCD to seven-segment decoder — see Fig. 4. This decoder converts the BCD code into control voltages for each individual LED element of the display in accordance with Fig. 3. The RBI input of the left-hand display board is connected to the D0 output of IC16. If this is logic low, the display cannot light (so that zeros are not shown in this position). The colon required for time indication is switched off by T5 when temperature is displayed.

The degree symbol is obtained by making the B-input of IC15 logic high. This results in segments b, f, and g of the right-hand display board being activated via the BCD code, and segment a via T5 and the Z terminal. Connections to the collecters of T5 and T7 must still be made, because they were not provided for in the Jumbo displays article in the August/September issue. These displays have a number of advantages:

- they are entirely solid-state, which prevents segment failure since the life of LEDs is much longer than, for instance, that of incandescent lamps;
- they do not need intricate reflector constructions;
- if any one LED fails, they remain fully legible by virtue of the unusual segment construction;
- they are easily arranged in a variety of colours — red, green, blue, yellow, orange;
- they work from 24 V with relatively high efficiency, which keeps heat dissipation low.
Fig 1. Circuit diagram of the jumbo clockwork.
It may be said that the large number of LEDs is a disadvantage, but, in our opinion, this is largely negated by the advantages.

The seven-segment display, shown in Figure 4, is based on a type 74LS48 decoder, which has the same features as the well-known type 74LS47/247, but has in addition internal pull-up resistors and inverted output signals, so that external transistors can be used to cope with the large currents drawn by the segments. The inputs and outputs to the decoder, the read-outs, and the additional functions are correlated in Figure 3. All input and output controls have been arranged external to the decoder, so that they can be used in the same way as with normal displays. Wire link M serves to interconnect the earths of the +5 V and +24 V supplies.

At the output of the decoder there is a switching stage for each segment that switches the relevant segment on or off. Each segment consists of four parallel groups of eight or nine LEDs in series with

---

**Fig. 2. Connections between the display and control boards.**

**Fig. 3. The BCD-to-seven-segment decoders on the display boards function according to this table.**

<table>
<thead>
<tr>
<th>number or function</th>
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X = a relevant
a current limiting resistor.
The displays can be powered from a non-stabilized 20–24 V supply. The current
drawn per segment varies from 60 mA to 100 mA.
Figures 1b and 1c give the diagrams for
displays with a ‘1’ and a ‘2’ respectively.
Both can be used for a 12-hour clock. The
‘1’ display has provision for a lamp test (LT);
open inputs are considered active, i.e., the
display lights. This is in contrast to the
seven-segment display which treats inputs
that are not connected as logic high, that is,
inactive.
As mentioned earlier, read-out boards
consisting of several figures may be composed
by mounting a number of displays side by
side on a flat base. The whole may be pro-
tected by translucent red perspex: this also
acts as a light filter, which improves the
legibility considerably.
As you need a large number of LEDs, shop
around for these because many dealers are
prepared to allow a quantity discount.
Uniformity of brightness of these diodes is
not so important for this application,
because at the distances for which these
displays are intended, differences in
brightness do not shown up.

Power supplies
Fig. 1 shows that the temperature process-
ing circuits have their separate power supply, +5 A, provided by an additional
voltage regulator Type 7805. This arrange-
ment is necessary to prevent the analogue
circuits being affected by the digital pulses
in the remainder of the unit.
The displays have their own power supply —
see Fig. 5, which is not regulated. The sec-
ondary voltage of T2 was chosen at 2×18 V
for red LEDs and good brightness. If green
or yellow LEDs are used, or the displays
need not be so bright, a secondary output of
2×15 V at 1.5 A will suffice.

Construction and setting up
The only problem in the construction is like-
ly to be a wandering of concentration, since
there are no fewer than some 2500 soldering
points to be made. It is, therefore, all too easy
to make a dry joint.
The clock itself needs no adjustments, but
the temperature circuits need to be set up
as indicated below.
The temperature sensor is not yet fitted at
this stage: in its place, connect a variable
power supply (+ to the cathode terminal).
The output voltage of the supply should be
monitored with a digital volt meter. As the
LM388 provides a voltage of 10 mV/K, the
voltage should be set to 2.53 V to simulate a
temperature of -20 °C.
Next, connect the digital voltmeter across pins 6 and 7 of $IC_{14}$. Set the voltmeter to its most sensitive range and adjust $P_2$ so that the meter reads exactly 0.000 V. Then, set the power supply to 3.230 V, and measure and note the voltage now pertaining across pins 6 and 7 of $IC_{14}$. Finally, connect the voltmeter between pin 9 of $IC_{14}$ and earth and adjust $P$, so that the meter reads exactly half the voltage noted before.

Greater accuracy may be obtained by connecting $P_3$ as shown in dashed lines in Fig. 1, and adjust this preset with the aid of dishes of water at exactly 0 °C and +50 °C. Now, fit $IC_{19}$ into place.

Finally, connect an analogue voltmeter between $+5V$ and pin 3 of $IC_{21}$, and adjust $P_3$ so that the meter reads about 300 mV. The clock should then operate normally.
Fig. 6. The (double-sided) printed circuit board for the control circuits.

Parts list (control board)

Resistors:
- \( R_1, R_2 = 47 \, \text{k}\) 
- \( R_3, R_{14,15,16} = 10 \, \text{k}\) 
- \( R_4, R_5, R_17 = 100 \, \text{k}\) 
- \( R_6 = 82 \, \text{k}\) 
- \( R_7 = 6k8\) 
- \( R_8 = 1k5\) 
- \( R_9 = 3k9\) 
- \( R_{10} = 4k7\) 
- \( R_{11,12,20} = 2k2\) 
- \( R_{12,13} = 22 \, \text{k}\) 
- \( R_{13,18} = 88 \, \text{k}\) 
- \( R_{18} = 100 \, \Omega\) 
- \( R_{19} = 1 \, \text{M}\) 
- \( P_1, P_2 = 2 \, \text{k} \) multturn preset 
- \( P_3 = 50 \, \text{k} \) preset 
- \( P_4 = 10 \, \text{k} \) preset*

Capacitors
- \( C_1, C_6, C_{16}, C_{20} = 22 \, \mu\text{F}\) 
- \( C_5 = 1000 \, \mu\text{F}, 16 \text{V}\) 
- \( C_{6,10,11,15,19,21,22} = 100 \, \mu\text{F}\) 
- \( C_{26} = 47 \, \mu\text{F}\) 
- \( C_{12,13} = 180 \, \mu\text{F}\) 
- \( C_{14,15} = 1 \, \text{n}\) 
- \( C_{17} = 330 \, \text{p}\) 
- \( C_{24} = 1 \, \text{mc}\) 
- \( C_{31} = 4700 \, \mu\text{F}, 35 \text{V}\)

Semiconductors:
- \( D_1, D_4 = 1N4001\) 
- \( D_2, D_3 = 1N4148\) 
- \( T_1 = BC547B\) 
- \( T_2, T_4 = BS170 \) or \( VN10KE\) 
- or \( VN_\alpha < M\) 
- \( I C_1, I C_2 = 74HC04\) 
- \( I C_3 = 40106 \) or \( 74HC14\) 
- \( I C_4 = 4078\) 
- \( I C_5 = 74HC393\) 
- \( I C_6 = 4017 \) or \( 74HC4017\) 
- \( I C_7 = 74HC157\) 
- \( I C_{11,15} = 74HC163\) 
- \( I C_{14} = ADC0604\) 
- \( I C_{15,16} = 2716 \) or \( 27C16\) 
- \( I C_7 = 74HC30\) 
- \( I C_8 = LM255\) 
- \( I C_{11,12} = CA 3130\) 
- \( I C_1 = 855 \) or \( 7555\)

Miscellaneous:
- \( T_1 = \) mains transformer with \( 9 \, \text{V}, 500 \, \text{mA secondary}\) 
- \( T_2 = \) mains transformer with \( 2 \times 18 \, \text{V}, 2 \, \text{A} \) or \( 2 \times 15 \, \text{V}, 1.5 \, \text{A secondary}\) 
- \( E_1 = \) fuse, 1 A, delayed action 
- \( S_1 = \) double pole mains switch 
- \( S_2 = \) single-pole, parallel make button switch 
- \( S_3 = \) single pole change-over switch with open centre at rest position 
- heat sink for IC_2 
- PCB 85100 

*see text

Parts list (display board)

NOTE: every component is required four fold

Resistors:
- \( R_1, R_2 = 100 \, \text{k}\) 
- \( R_{10,12,14,15,16} = 200 \, \text{k}\) 
- \( R_{11} = 100 \, \text{k}\) 
- \( R_{19,20} = 200 \, \text{Q}\) 
- \( R_{21} = 270 \, \text{Q}\) 

Capacitors:
- \( C_1 = 100 \, \text{n}\)

Semiconductors:
- \( T_1, T_4 = BC547\) 
- \( I C_1 = \) ALSZ48B 
- PCB 85413-1

Parts list (colon display)

- \( R_1, R_2 = 270 \, \text{Q}\) 
- 18 LEDs, 5 mm, colour to choice 
- PCB 85413-3

*see text
There is probably no other interface that gives so many problems as the RS232. Quite a few connecting wires are needed to ensure the correct links for all possible applications. The reason for this lies in the number of possible handshakes pertaining to the RS232 protocol. With modern equipment, many of these handshakes are no longer strictly necessary, so that a much simpler connection will suffice. At the same time, many idiosyncrasies of various computer manufacturers can be circumvented. The zero-modem connector proposed is based on the idea of reducing the handshakes. Each equipment provides its own handshake, while the connector looks after the interconnections of the data lines. There is then, of course, no longer any control between the individual units, but there is a correct data link.

Normally, a cable is needed for connecting, for instance, a DTE (data terminal equipment) to a DCE (data circuit terminating equipment); the pins of the connectors terminating the cable are then linked direct, i.e., there are no cross-connections. When two computers are inter-connected (DTE to DTE), some cross-connections are required; a few examples of these are shown in Fig.1. Fig.1d is the cross-connection used in the present zero-modem connector. It is, therefore, possible to interconnect two computers with the cable shown in Fig.1a and the zero-modem connector.

Construction
Two D-25 shells are needed, of which the top is cut away with a metal saw. The...
The alarm described has been in continual use for over a year at a temperature of around —18 °C, which is, of course, quite normal for a deep-freeze alarm. Its function is to indicate an accidental rise in temperature. There are, of course, indicators provided on the deep-freeze unit, but as these are mains-operated they are of no much use in case of mains failure!

The principle of operation is quite simple: a green LED lights as long as the temperature stays within limits defined by the user, while a red LED shows when the temperature has risen above a critical level. Since operational amplifier IC, is arranged as a differentiator, two possible states ensue:

(a) the output voltage is positive as long as the potential at the non-inverting input is higher than that at the inverting input, and
(b) the output voltage is negative when the input levels are reversed with respect to those in (a). The voltage at the non-inverting input is derived from potential divider \(R_1/R_2P_1\) and is set by the user. The voltage at the inverting input varies with temperature. The sensor is formed by the base-emitter junction of n-p-n transistor \(T_1\), which can be almost any type. The value of resistors \(R_1\) and \(P_1\) depends on the transistor used. The values stated in the circuit diagram pertain to a 2N2221A, a threshold temperature of —18 °C, and a supply voltage of ±4.5 V.

If more than a visual indication is required, the circuit may be used to control an additional audible alarm. When \(D_2\) lights, transistor \(T_2\) is saturated, so that its collector is nearly at earth potential. This transistor can, therefore, operate a small buzzer or siren, or, indeed, anything else convenient to you. The additional alarm must be connected between \(S^+\) and \(S^−\).

If you are happy with the LED indication, transistor \(T_2\) may be omitted and resistor \(R_5\) replaced by a wire link.

If only periodic checks are to be carried out, the circuit may be supplied from two 4.5...9 V dry batteries via a spring-loaded push button switch. Where permanent monitoring is desired, however, it is advisable to use two 6...9 V rechargeable NiCd batteries (without a switch). The current drawn by the buzzer or siren should not exceed 500 mA.

Finally

This simple unit makes virtually every RS232 connection possible. Note, however, that it does not relate to connections via a secondary channel as indicated in the V23 protocol. Further, it is assumed that the data formats agree with one another.

deep-freeze alarm

C Sadot
Robots are now being used in a variety of industrial processes, but they are very unlike their namesakes appearing in science fiction fantasy. Robotics is by now a generally accepted science, and constitutes an interesting meeting point for applied electronics, mechanics, and computer programming. To control a simple robot, a computer will need input and output channels, so there's another reason to build this expansion for the universal I/O bus.

This circuit, together with the analogue computer input featured in the June 1985 issue of Elektor India, opens the world of control and measurement technology. It enables the measuring and logging of eight analogue and eight digital channels, as well as the control of eight digital outputs. All physical quantities, converted to electric signals by sensors, may be measured by the computer, which checks the results and takes corresponding action, or corrects an occasional system fault via the eight outputs. This procedure is called interactive control.

There is a constant exchange of data between the measured quantities, the computer, and the controlled systems. The software enabling such interactive procedures may be written in BASIC.

Applications

Have your computer perform a useful task instead of playing games. Have it guard and control all of your domestic appliances like heating, telephone, aquarium, slide projector, etc. You may also build a computer measuring device to check your loudspeakers or the entire hi-fi installation. These examples, of course, require a certain amount of software to handle the data. The nucleus of such a program is the correct supply of control data to the input and output channels. BASIC programs with PEEKs and POKEs will be quite adequate for the selection of these channels. The eight outputs are thoroughly buffered and may switch up to 50 V at 0.5 A by means of a ULN 2803.
The circuit
The ULN 2803 provides an ideal interface between TTL levels and relays, electromagnets, stepper motors, etc. with its high-current Darlington transistor arrays, which allow a peak current of 500 mA. All outputs are of the open collector type and diodes for momentary suppression of inductive surges are fitted internally. The maximum voltage is 50 V, so a variety of relays may be used to increase switching currents and voltages (e.g. 240 V).

As can be seen in the circuit — Fig. 1 — gates $N_1 \ldots N_6$ are driven by two bistable ICs which latch the output data. The bit combination at outputs $Q_6 \ldots Q_7$ is retained until:
1. the RESET button is pressed. Bus signal NRST goes low, is inverted by $N_6$, and clears any programmed data in IC$_2$ and IC$_3$ via their CLR inputs.
2. new output data is loaded by a POKE. This involves bus signals SS, R/W, and $\phi 2$. When the board has been selected by SS and R/W is on write, data from the databus is read into the bistables IC$_2$ and IC$_3$ during a $\phi 2$ cycle.
3. the mains supply fails, or the computer is switched off. IC$_6$ is selected by gates $N_1 \ldots N_6$. A low level at the $G_1$ and $G_2$ inputs enables data transfer to the bus. This low level exists for the duration of a $\phi 2$ cycle (high level), when the board has been selected by the SS (Slot Select) signal and when R/W is in the read mode (i.e. high). The inputs of driver IC$_6$ have pull-up resistors and accept TTL levels.

Construction
If the ready made PCB, available through our PCB service, is used, the construction of this I/O unit will present no difficulties. Moreover, no adjustments are required. More information on the I/O bus can be found in the June 1985 issue of Elector India.

The robot
There are many applications for interactive control, but undoubtedly the most appealing is robot control, for the very reason that one sees what happens. We already have

![Fig. 1. Another circuit for the universal I/O bus. It provides control of eight input and output channels.](image)
the controlling elements such as computer, I/O bus, analogue input, and the present circuit. Only the robot is missing. A prototype robot shown in the photograph was built from Pescher Technik parts. Its movements may be limited, but it is eminently suitable for demonstration purposes. These mechanical parts may also be used to build other devices like a lathe, elevator, antenna rotor, sorting machine, pantograph, or a solar cell tracking system.

The robot's arm (Fig. 3) may be moved up and down through an angle of thirty degrees. At the same time, it can revolve around its own axis, thus creating a cone-shaped working area: Fig. 4.

The robot is able to move small metal objects to and from different locations within its working area, by means of a small electro-magnet at the end of its arm. Two motors move the arm: one takes care of the movement in the vertical plane, while the other revolves the arm around its axis. A set of gears enables the spindle of potential

---

Fig. 2. The board is simply plugged into one of the I/O bus extension connectors.

Parts list

Resistors
\( R_1, R_2 = 47 \, k \)

Capacitor
\( C_1 = 100 \, \mu F \)

Semiconductors
\( IC_1 = 74LS04 \)
\( IC_2, IC_3 = 74LS173 \)
\( IC_4, IC_5 = 74LS00 \)
\( IC_6 = 74LS244 \)

Miscellaneous:
21 way DIN 41617 connector, right-angle model
K1, K2. 9-way D-connector, right-angle model
PCB 85079

Fig. 3. The most important parts: they enable the robot to move a coin from one place to another.
Potentiometer 1 is tuned in line with the first motor, while potentiometer 2 is driven directly by the axle of the arm.

Both potentiometers are connected between the +5 volts supply and ground, so that the voltages at their wipers vary between these potentials, according to the position of the arm. These two voltages may then be read by the computer via its analogue input, and thus provide information about the position of the arm. A level of 5 volts is translated to the binary value 1111 1111 = 255 by the A/D converter. Thus, 2.5 volts equals decimal 128, 1.75 volts equals decimal 64; etc. These values are subsequently read by the computer with a PEEK command for comparison with the position to which the arm is to be moved.

Motor control is effected by four output channels of the present I/O unit. Outputs 1 and 2 move the arm up and down, whereas outputs 3 and 4 move it in the horizontal plane. As far as their power consumption is concerned, the motors could be connected directly to the outputs, but this would preclude the possibility of reversing their direction of travel. For this purpose, a bridge circuit such as the one published in the August/September 1984 issue of Elektor India, page 8-98, will be needed.

The electro-magnet is switched by output bit 8. Table 1 shows the eight output bits and their corresponding functions. Switching the electro-magnet on and off is achieved by addition or subtraction of decimal 128 to or from the decimal value of the lower four bits. The wiring of the robot is evident from Fischer Technik's documentation. Fig. 5 shows the interconnections between robot, computer I/O, and analogue input. Any other connection results, of course, in different bit combinations. For other purposes, more I/O units or analogue inputs may be added onto the bus.

Finally, although the Fischer robot is an interesting demonstration model, clearly showing the workings of simple robotics, it is simply too small, too light, and lacking in precision for any useful applications. And yet, it offers a worthwhile comparison with an industrial robot, because technically it hardly makes any difference whether one moves tiny parts or heavy loads from one place to another.

Table 1. The stored bit-combination determines the movement and actuates the electro-magnet.

<table>
<thead>
<tr>
<th>Output Channel</th>
<th>Bit 1</th>
<th>Bit 2</th>
<th>Bit 3</th>
<th>Bit 4</th>
<th>Bit 5</th>
<th>Bit 6</th>
<th>Bit 7</th>
<th>Bit 8</th>
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<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
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<tr>
<td>POKE XXXX, 8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<tr>
<td>POKE XXXX, 128</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>POKE XXXX, 134</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
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Zero phase shift between the drive units in an active loudspeaker unit has been the goal of virtually all designers and constructors ever since the first multiple speaker unit was conceived. For a long time, it has been like trying to achieve a perpetuum mobile, but now it has become reality!

phase-corrected cross-over filter

It is well known that the loudspeaker is the weakest link in an hi-fi chain: it is the final factor that determines how the hi-fi installation sounds. The most serious problem is that presented by the processing of the wide range of frequencies. As long ago as the thirties, designers have tried to solve this problem by sub-dividing the audible frequency range and using a separate drive unit for each of the resulting bands. In the simplest case, this means that a bass speaker (woofers) is used for the low audio frequencies, and a so-called tweeter for the high audio frequencies.

Right up to the 1960s, the network that divides the frequency ranges consisted of a passive filter constructed from chokes and capacitors. When semiconductors became less expensive, designers began to use active filters and to provide each separate drive unit with its own power amplifier that is fitted inside the speaker enclosure. Such active systems are generally better than passive ones, but they are also more expensive. But whether active or passive, filters create problems of their own.

Problems with filters

The simplest two-way dividing filter consists of a choke in series with the bass speaker and a capacitor in series with the tweeter — see Fig. 1. At the cross-over between low and high frequencies, both drive units are fed with the same signal, the level of which is about 3 dB below that of the normal output at the input to the filter. Moreover, the signal at the bass speaker lags that of the input signal by 45°, while that at the tweeter leads that of the input signal by 45°. Because of the phase difference of 90° between the signals at the two speakers, the air pressures produced by them are added geometrically, so that the overall sound is as if caused by a signal that is identical to the original input signal to the filter. Provided, that is, that everything is ideal.

Tolerances in the components, differences in the drive units, and effects of the enclosure prevent such an ideal state being attained. Even tolerances of 10 per cent can alter the situation quite a lot. If, for instance, the capacitor is 10 per cent smaller, and the choke 10 per cent larger, the levels at the two drive units are almost 0.5 dB lower than in the ideal case: -3.444 dB. The phase difference is also larger: 95.5°. The result is that the overall signal is almost 0.9 dB lower than the original signal. This may not seem serious, until the considerations concern higher-order filters that give a Bessel, Butterworth, or Chebyshev response. Such filters have a much steeper cut-off profile. Even small component tolerances then cause a reduction of a few dB in the available gain.

The phase characteristic in these filters also has a steeper roll-off. Component tolerances may cause such a large phase shift that the gain is reduced by another few dB. Finally, the loudspeaker characteristics themselves should also be taken into account. The (larger) bass unit is inherently somewhat slower in action than the (smaller) tweeter. They have different rise times. The difference in frequency between these times manifests itself at the cross-over frequency as an additional phase shift. Odd-order filters have a phase difference of about 90°. In a two-way system with a cross-over frequency of 1 kHz and a difference in rise times of 100 μs (a typical, practical value), there is an additional phase shift of 36°, resulting in a total of 126°. Even if all other parameters of the network are one hundred per cent correct, such a phase shift results in a 2 dB loss.

In even-order filters, the situation is somewhat better: here an additional phase shift of 36° causes only 0.5 dB loss.

Solution

The requirement is, therefore, for a filter that produces no phase shift between the loudspeakers. This is not affected by component
tolerances, is easily reproducible, and, in spite of being a unit for home construction, is absolutely linear.

A critically damped second-order filter (i.e., one consisting of two cascaded simple RC high- or low-pass sections) has the same phase response as an all-pass filter. The filter in Fig. 2 consists of two high-pass sections, A₁ and A₂. The phase shift, Φ, is calculated from

$$\Phi = \arctan \frac{1}{\omega RC} [°]$$

where \(\omega = 2\pi f\) (and \(f\) is in Hertz); \(R\) is in ohms; and \(C\) is in farads.

The phase shift in all-pass filter A₁ in Fig 2 is determined by

$$\Phi = 2 \arctan \frac{1}{\omega RC} [°]$$

The phase shift vs frequency and gain, \(G = U_B/U_I\), vs frequency characteristics at B, C, and D in Fig 2 are given in Fig. 3. They show that the phase shift at B (output of the two high-pass sections) is identical to that at C (output of the all-pass section). The only difference between the signals at B and C is that the gain of the former is frequency dependent

$$U_{acb}/U_I = \frac{1}{\sqrt{1 + (1/\omega RC)^2}}$$

The amplification of the signal at C is unity, i.e.,

$$U_{acc}/U_I = 1$$

The output at B only contains high audio frequencies, whereas that at C includes all audio frequencies at the same level. If then the signal at B is deducted from that at C, the gain, \(G_D\), at D, i.e., Eq. (4) – Eq. (3) becomes

$$G_D = U_{acb}/U_I = 1 - \frac{1}{\sqrt{1 + (1/\omega RC)^2}}$$

Plotting Eq. (5) shows that the output voltage \(U_{acb}\) is very small at high frequencies and is equal to \(U_I\) at low frequencies. The signal at D is, therefore, the low-frequency output of

---

Fig. 3. Box B shows the phase vs frequency and gain vs frequency response at point B in Fig. 2. Boxes C and D show the same for points C and D respectively. Box B + D gives the phase and gain vs frequency response of the acoustically summed B and C outputs of Fig. 2.
the filter. Note, however, that its phase characteristic has the form of that of a high-pass section; that is, the phase of $U_{\text{out}}$ leads that of the input signal. This means that there is no phase difference between the high-pass and low-pass branches over the entire frequency range.

The dividing filter of Fig. 2 is a two-way version. It has a 12 dB/octave cut-off profile. Normally, such second-order filters have two RC networks in both the low- and high-pass branches. Problems may arise then if, owing to component tolerances, the time constants in the two branches are not the same. These problems are negligible in the set-up of Fig. 2, because, due to difference amplifier $A_0$, the sum of outputs $B$ and $D$ is always the same as input $A$, irrespective of component tolerances.

The cross-over frequency $f_c$ is defined as that frequency where both the low and the high-pass output are attenuated by 3 dB. This happens when $\omega_0RC=1$, whence

$$f_c=\frac{1}{2\pi RC} \quad \text{[Hz]}$$

where $R$ is in ohms and $C$ in farads

**Practical filter**

The foregoing considerations lead to a practical filter, the block schematic of which is given in Fig. 4 and the circuit diagram in Fig. 5. It concerns a three-way version with a 24 dB/octave cut-off profile: its response resembles that of a critically coupled network, i.e., there is no tendency of overshoot. The filter has two low-frequency outputs, which are inverted with respect to one another. This offers a simple push-pull amplifier for the bass drive unit, since this often requires more power than the middle- and high-frequency speakers.

The input signal — Fig. 4 — is applied via a buffer to a four-stage RC high-pass section, and is then available at the high-frequency output. Two of the RC stages are designated $a$; the other two, $b$. This is done to clarify that the phase shift in all-pass section $A_P$ is identical to that in the HP sections; the phase shift in $A_F$ is the same as that in sections HP — more about this later.

The difference amplifier forms its two input signals a low-frequency output, whose half power frequency $f_c$ — see Eq. (6), is the dividing frequency between the high- and middle-frequency branches. This signal is fed to another four-stage RC high-pass section, and is then available as the middle-frequency output. The low-frequency output is obtained in the same way as the middle-frequency output.

**Circuit description**

Opamp $A_1$ is the input amplifier, whose low-impedance output provides the audio signals for the remainder of the circuit. Opamps $A_2...A_5$ and $A_6...A_B$ are buffers that decouple successive high-pass sections from one another. Opamps $A_B$, $A_3$, $A_4$, and $A_5$ are connected as all-pass sections, with a leading phase shift characteristic. Opamps $A_2$ and $A_3$ are arranged as difference amplifiers, while $A_{15}$ functions as an inverter.

**Construction**

There is no ready-made printed-circuit board available for the filter, but it should fit on a vero board, or similar, the size of half an Eurocard, i.e., 80 x 100 mm. Before the construction is started, the two cross-over frequencies should be decided. The relevant component values in Fig 6 result in crossover frequencies of 570 Hz and 3600 Hz. That is a frequency ratio of 1.67 — about two and a half octaves, which is a convenient value. The frequency ratio should not be allowed to be less than 1.4. The cross-over frequencies $f_c$ are calculated from Eq. (8). The next aspect to be looked at is the impedance of the RC networks. To ensure low thermal noise and minimum delays, all resistors should have values between 10 k and 27 k. As the opamps also contribute to noise (see, for instance Intrusive IC Opamps by T M Frederiksen, published by National Semiconductor), the TL 074 should be preferred to the TL 084 Capacitor values are calculated from Eq. (6) once the resistor values have been determined.

Where absolute accuracy is desired, one per cent resistors should be used: these are much cheaper and more easily obtained than close-tolerance capacitors. However, in most cases five per cent resistors are perfectly all right, but it is preferable that resistors with the same letter indices, for instance, $R_{10}$ and $R_{20}$, or $R_{30}$ and $R_{40}$, have identical values. It is, therefore, more economical to buy, say, fifty 5 per cent 18 k resistors than thirty-two 1 per cent ones, and, with the aid of a digital multimeter, sort out equal-value ones: four groups of three- and eight sets of two identical resistors are required.

Capacitors can be sorted in a similar way — see Fig. 6. Connect one of the capacitors to
the output terminals of this test circuit and adjust the potentiometer for a reading of 1.8 V on its 2.0 V AC range. Without resetting the potentiometer, check all capacitors and group them in identical sets. The overall result of this grouping should be sets of resistors within 1 per cent, and sets of capacitors within 5 per cent. These tolerances will ensure a cross-over filter with an accuracy that exceeds even that found in expensive, professionally made loudspeaker units.

Fig. 5. Circuit diagram of the 24 dB/octave fourth-order filter.

Fig. 6. Test circuit to enable the sorting of capacitors in groups of near-identical values.
For more than ten years, lithium cells and batteries have been used in digital watches, pocket calculators, and pacemakers, but now they appear to be on the verge of coming into much wider use in other electronics equipment. Already, they are used for direct mounting onto printed circuit boards, and some ICs have already had them embedded inside their dual in-line packages.

Because of their small size and extremely high energy density, lithium batteries are eminently suitable for use in miniaturized electronic equipment. They operate over a wide range of temperatures (typically −20 °C to +50 °C), have an exceptionally low rate of self-discharge, and maintain their e.m.f. within tight tolerances with normal loads throughout their life.

Unfortunately, at present lithium batteries are not really suitable as direct replacement for conventional dry batteries: apart from their higher price, they do not stand up well to short circuits, and are also easily mechanically damaged. Under certain circumstances, they have a tendency to catch fire or even explode. None the less, as already stated, there are economically priced, perfectly safe versions for use in a variety of small electronic equipment.

Types of lithium battery

Lithium, a silver-white metal that tarnishes rapidly in air and reacts with water, halogens, nitrogen, and hydrogen, is, with a density of only 0.531, the lightest alkali metal. It is of particular interest as the anode material in a voltaic cell, where it provides a higher e.m.f. than other materials.

Because of its reaction with water — producing explosive hydrogen — lithium poses problems, since it is not easy to produce an electrolyte that is completely devoid of water. Sometimes acetonitrile, CH₃CN, is used. This is a poisonous liquid, prepared from ethyne and ammonia.

The choice of cathode material also has a decisive effect on the cell. This is the reason for the multiplicity of available lithium-based batteries and the differences in e.m.f. and energy density between the various versions. Basically, there are two main types of lithium battery, one uses a liquid or gaseous cathode, such as sulphur dioxide, SO₂, or thionyl chloride, SOCl₂; the second has a solid cathode, typically manganese dioxide, MnO₂, and polyacrylonitrile, (CF)n.

In general, solid cathodes are used in small to medium capacity batteries required to deliver relatively low load currents, while the other type of cathode finds application in larger capacity batteries that provide relatively high load currents.

It is worth noting that the data sheets of all manufacturers given even more stringent warnings against misuse and abuse of batteries with liquid or gaseous cathodes than those given with lithium cells generally. SAFT, for instance, warns specifically of the danger of explosion and the production of poisonous gases in the use of liquid or gaseous-cathode batteries.

Construction and properties

Externally, lithium batteries resemble NiCd batteries rather than conventional dry batteries. Both spiral-wound and pressed electrodes are found, again as in NiCd cells. Spiral-wound electrodes have a larger operating surface and are, therefore, able to provide a higher current than pressed electrodes. On the other hand, cells using pressed electrodes generally have a larger capacity-to-volume ratio. Fig. 1 shows the construction of a typical, sealed, cylindrical cell with solid (CF)n cathode.

Lithium batteries are available in cylindrical, button, or special shape; the latter, for instance, as a nylon-enclosed memory back-up cell for direct mounting onto a printed-circuit board.

It should be noted that there are appreciable differences in the characteristics of the same type of lithium battery produced by different manufacturers, and also between the various types. For instance, the data sheets of a number of manufacturers give low operating temperatures vary...
positive terminal paper insulation lid with seal insulating disc case PVC coating separation foil lithium anode LiCF in cathode negative terminal insulating foil

Lithium manganese dioxide, LiMnO$_2$
Solid cathode; e.m.f. 3 V; universal type for relatively small currents; can withstand short-circuits for brief periods; operating temperature range typically $-20 \degree C$ to $+50 \degree C$, maximum $-40 \degree C$ to $+85 \degree C$; capacity about 5 Ah; intended for use as back up battery for CMOS RAMs.

Lithium carbon monofluoride, LiCF$_n$
Solid cathode; e.m.f. 3 V; universal type for small to medium values of current up to 150 mA; higher current pulses up to 1 A permissible; cannot withstand short-circuits; operating temperature range $-40 \degree C$ to $+85 \degree C$; capacity up to 5 Ah; intended for use in cell camera flash equipment, distress signal transmitters, distress lights, and memory back up.

Lithium copper oxide, LiCuO
Solid cathode; e.m.f. 1.5 V; universal type for load currents up to 1 A; operating temperature range $-20 \degree C$ to $+55 \degree C$ (some manufacturers claim up to $+135 \degree C$); capacity up to 20 Ah; intended for use in distress signal transmitters and equipment operating at high temperatures.

Lithium copper oxynitride, LiCu$_x$O$_2$(PO$_4$)$_2$
Solid cathode; e.m.f. 2.4 V; derived from LiCuO cells; and properties therefore generally similar to those, but temperature range extended to $-40 \degree C$ to $+70 \degree C$ (for special appli-

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**Table 1.** Characteristics of some typical size C [IEC R14] lithium cells compared with conventional alkaline manganese, ZnMnO$_2$, type.

<table>
<thead>
<tr>
<th></th>
<th>ZnMnO$_2$</th>
<th>LiCuO</th>
<th>LiCu$_x$O$_2$(PO$_4$)$_2$</th>
<th>LiCF$_n$</th>
<th>USOC$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal e.m.f.</td>
<td>1.5 V</td>
<td>1.5 V</td>
<td>2.4 V</td>
<td>3.0 V</td>
<td>3.5 V</td>
</tr>
<tr>
<td>Recommended load</td>
<td>80 mA</td>
<td>40 mA</td>
<td>40 mA</td>
<td>150 mA</td>
<td>ca 100 mA</td>
</tr>
<tr>
<td>Maximum constant</td>
<td>$\geq 1$ A</td>
<td>$\geq 1$ A</td>
<td>$\geq 1$ A</td>
<td>$\geq 1$ A</td>
<td>$\geq 1$ A</td>
</tr>
<tr>
<td>Current pulses</td>
<td>$\geq 1$ A</td>
<td>$\geq 1$ A</td>
<td>$\geq 1$ A</td>
<td>$\geq 1$ A</td>
<td>$\geq 1$ A</td>
</tr>
<tr>
<td>Nominal capacity</td>
<td>5.5 Ah</td>
<td>10 Ah</td>
<td>5 Ah</td>
<td>5 Ah</td>
<td>5 Ah</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>20 $\degree$ C</td>
<td>$-40 \degree$ C</td>
<td>0 $\degree$ C</td>
<td>$-40 \degree$ C</td>
<td>40 $\degree$ C</td>
</tr>
<tr>
<td>Energy available</td>
<td>6 Wh</td>
<td>15 Wh</td>
<td>12 Wh</td>
<td>15 Wh</td>
<td>18 Wh</td>
</tr>
<tr>
<td>Weight</td>
<td>66 g</td>
<td>56 g</td>
<td>66 g</td>
<td>47 g</td>
<td>66 g</td>
</tr>
</tbody>
</table>

1. at 20 $\degree$ C for 75% nominal capacity  
2. at 155 $\degree$ C for 75% nominal capacity.  
3. Limiting value.  
4. at 20 $\degree$ C (15% of nominal capacity)
Application and use

It appears that not all types of lithium battery are suitable for general use yet. This has not so much to do with the price as with the care that needs to be taken by the user. Although short circuits do not necessarily cause an explosion, account must be taken of the tremendous rise in temperature (to well over 100 °C). Under these conditions, pressure inside the cell will rise, causing the safety valve to open and health damaging gases to escape. Batteries (consisting of more than one cell) are normally protected against short circuits by a fuse or series resistance. Lithium cells used as back-up for memory ICs should be provided with a protection diode to prevent any tendency to charge and also to avoid large discharge currents. Soldering direct to the battery terminals is not permissible. Many lithium batteries are, however, provided with soldering tags at their terminals, but even these should not be subjected to soldering heat for more than 10 seconds. The very low rate of self-discharge allows small charge and discharge currents — of the order of a few µA — so that these batteries may be charged from solar cells. At the time of writing, it is not known whether these batteries will become available in higher capacities and for higher load currents. Many lithium batteries can cope with the momentary short circuit during dip soldering, but normally require hours to recover their e.m.f. If a battery falls into the soldering bath, it may explode: it is, therefore, essential that it is securely fastened to the board or equipment being soldered.

State of the art

SAFT have produced a replacement for conventional 9-volt PP3 batteries that demonstrates the advantages of lithium batteries in an impressive manner. This new battery consists of two button cells of the LiSOCI 2 type, and thus provides an e.m.f. of 7 V. Since this voltage remains stable during the operational life, the battery is perfectly suitable as a substitute for a PP3. In contrast to most other lithium batteries, this new type stands up very well to short circuits: its temperature rise during such conditions rises only moderately. From a technical point of view, this battery would have to be recommended for any application requiring a 9-volt source. Unfortunately, at a retail price of well over £10, it is not going to replace too many PP3s just yet.

Characteristics

Nominal capacity 1.1 Ah
Output voltage 7.0 V
Recommended load current (for 50% of nominal capacity at 20 °C) 50 mA
Weight 30 g
Operating temperature range +10°C — +70°C

Rechargeable lithium batteries

Although much research has been carried out, a number of patents have
been registered, and several prototypes have been publicized, there is, at present, only one rechargeable lithium battery in production. This is a Panasonic lithium carbon type, first introduced in early 1984. Production models are expected to become available in Europe during 1986. The most important characteristics are shown in the table below and in the accompanying charge and discharge curves. These curves show the truly amazing property of this battery, which enables the output voltage to be freely chosen between 1.5 and 3.0 V dependent upon the charging voltage. As regards the life-span, the makers claim that even after 2000 charge-discharge cycles the capacity shows no signs of deterioration.

**Characteristics**
- Nominal capacity: 1 mAh (at 2...3 V)
- Nominal voltage: 3 V
- Recommended load current: 1 μA to 5 mA
- Charging voltage: 1.5 to 3.0 V (constant with current limiting resistance)
- Life expectancy: At least 2000 charge-discharge cycles
- Diameter: 10 mm
- Thickness: 2 mm
- Weight: 1.9 g
Surface mount technology uses components that are much smaller than conventional ones. These SMDs (surface-mount devices) have no or very short connecting terminals since they are intended to be soldered directly to the copper tracks of a circuit board. It is expected that within five years half of all electronic circuits will use SMDs, while within another five years it will be hard to find current type components.

Most manufacturers engaged in the electronics industry are already firmly committed to surface-mount technology. This has come about not only because of further miniaturization, but also — and perhaps more importantly — because these manufacturers are under pressure to reduce their assembly costs.

Advantages of SMA (Surface-mount assembly)

Currently, the cost of an electronic circuit is determined primarily by the assembly and not by the components. This has come about because component manufacturers have continuously invested heavily in the development of better, smaller, and cheaper components, whereas equipment manufacturers have hardly changed their production methods since PCB assembly was automated. Relatively speaking, therefore, assembly costs have continued to rise, while component costs have become lower. The reduction in the number of layers of the printed-circuit board, the holes, and the cost of plating, together with the increase of the board density and complexity, is the key factor of surface-mount technology. This in spite of the fact that SMDs are currently still more expensive than conventional components.

SMDs have connecting terminals of 1 mm or less, whereas conventional components require at least 2.5 mm. This means not only a 70 per cent saving on board space (National Semiconductor figure), but also one third of the internal semiconductor leads. These two factors together result in substantially reduced parasitic parameters, which is of particular importance in high-frequency circuits. Reliability is of prime concern to any engineer. Most component manufacturers have run extensive reliability programmes, which show that the reliability of SMAs is better than that of conventional PCBs.

Some hidden difficulties

It must be pointed out that there are also unforeseen difficulties with surface-mount assembly, but only in existing system designs. These designs are often poorly partitioned for surface-mount realization, and this is hampering the introduction of surface-mount techniques by original equipment manufacturers (OEMs).

The difficulties originate in the current practice of including a mixture of control and associated higher dissipation interface circuits on PCBs. As these higher power components are not yet available in surface-mount, the designer is left with the choice of either using the unpopular mixed-plug board with a combination of through-hole and surface-mount devices, or repartitioning the design into surface-mount and through-hole boards. Such repartitioning represents a major design investment, which is difficult to justify for an existing system and, therefore, tends to restrict the use of surface-mount techniques to new systems.

Fig 1 Surface-mount tantalium capacitors from Siemens. Compared with the already small conventional tantalium capacitor, the SMD type is 80 per cent smaller.
Surface-mount devices
The photographs accompanying this article show that SMDs, compared with conventional components, have a rather different appearance: miniature blocks and cylinders, tiny ICs with very short pins, and other unfamiliar exteriors. As far as their interiors are concerned, however, there are no basic differences other than that SMDs are generally of better quality than their conventional counterparts. An important aspect is that SMDs are designed to withstand immersion into molten solder.

Rather than ask which components are already available in surface mount technology, ask which ones are not yet available, because about eighty percent of conventional components have a surface-mount counterpart, be they resistors; ceramic, electrolytic, or tantalum capacitors; diodes; transistors; ICs; even inductors and LEDs are already available in surface-mount.

Passive components
Surface-mount resistors are available in values from 1 ohm to 10 megohms, with tolerances of ±5%; ±10%; and ±20%. The construction of such a resistor is shown in Fig. 2a. It consists of a rectangular ceramic carrier onto which a layer of resistive material is deposited that is cut to its exact value by a laser. The whole is glazed for protection.

Ceramic capacitors are available in surface-mount in values from 0.47 pF to 1 μF. The value affects the dimensions, of course, and there are, therefore, quite a number of formats. All types have the same working voltage: 50 V (IEC standard). A typical construction is shown in Fig. 2b. Screened electrodes are pressed onto ceramic wafers, after which the wafers are pressed together, protected by foil, and then cut into small blocks. Finally, the two terminations are attached.

Electrolytic capacitors – see Fig. 2c – come in values from 0.1 μF to 22 μF and working voltages from 6.3 V to 50 V. They are constructed from etched aluminium foils, which are separated by paper impregnated with electrolyte. The tabular aluminium case is provided with a polystyrene sleeve. The bevelled edge identifies the anode (+). These capacitors come in two sizes.

Tantalum capacitors come either as chips or in moulded form; values of the former range from 0.1 μF to 100 μF, with working voltages of 4 V to 60 V, the latter in available values from 0.068 μF to 100 μF, and working voltages of 3 V to 50 V. A typical moulded tantalum capacitor is shown in Fig. 2d. Chip types have body coats of tough epoxy resin.

Active components
Virtually all current transistors and diodes can be produced in surface-mount technology without any difficulty: too many to describe in detail. There are general purpose, switching, high-frequency, low-noise, field-effect; and high-voltage transistors. Diodes are available from zener, Schottky, and switching to variable capacitance types. Various types of case are shown in Fig. 3: (a) SOT-23; (b) SOT-89; (c) SOT-143; and (d) SOD 80.

Integrated circuits
Many familiar ICs are already available in surface-mount technology: digital as well as analogues; TTL as well as CMOS. Inverters; multivibrators; buffers; decoders; multiplexers; shift registers; voltage comparators and regulators; timers; phase-locked loops; video amplifiers; digital-to-analogue converters; stereo decoders; IF amplifiers; and many more.

As far as cases are concerned, there are two basic styles, the length of which varies with the number of pins. Fig. 4 shows an SMD-IC in a 14-pin.
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Aylesbury

Bucks HP19 3RG • Telephone (0296) 33200

Sources.

Transistors & diodes for surface

mounting (ITT)

SMD Technik (Siemens)

Oppervlaktemontage (Philips)

Surface-mount Components

(sprague)

The future

It is clear that surface-mount technology is not a whim that is forgotten tomorrow; it is the assembly technique of the future. It is also still in its infancy, and dynamic development will no doubt continue for some years. At present, the technology is really only suitable for automatic mounting equipment in factories, but, no doubt, equipment for the smaller producer

SO-14 case.

The quality of SMD-ICs is, like that of transistors and diodes, at least as good as that of DIL types, since the same type of crystals are used. The smaller package results in a lower permissible dissipation, however.

Note that Hall-effect SMD-ICs are also available.

Mounting SMDs

For mass production purposes, SMDs are packed in blister tape — see Fig. 5. The tape protects the components and ensures that they are efficiently processed by the automatic mounting equipment. Mounting of SMDs in quantity production is, of course, fully automatic: that was the whole idea behind the new technique. It is beyond the scope of this article to give other than a brief description of this automatic process.

The most commonly encountered process uses droplets of thermal hardening epoxy glue which holds the SMDs temporarily in position. The glue may be applied to the substrate (the circuit board) or to the components. After the glue has been hardened, the components are attached to the board by two stages of wave soldering: one to ensure that all metal surfaces are provided with sufficient solder, and the second to remove any excess of solder. Home constructors, of course, have no access to automatic mounting equipment and wave soldering baths, and they will, therefore, have to mount SMDs with small pickers and a mini soldering iron. None the less, it is advisable to glue the components in place prior to soldering. Glue should be applied with the sharp end of a pin.

Soldering should be done very carefully, and the tip temperature should be electronically controlled. A special surface-mounting solder cream is produced by the Indium Corporation of America and is available in the UK from Dage (GB) Limited.

SMDs may also be attached to the board with special conductive epoxy, which is, however, quite expensive. Where this epoxy is used, it should be hardened at 150 °C for not more than 60 minutes. A termination material that will not oxidize, such as gold plating, should preferably be used if the epoxy forms the electrical connection between the component and the board.

Fig. 5. For mass production, SMDs are delivered in blister tape, i.e., a series of compartments separated by a thin polythene tape. The tape can be fed into automatic mounting equipment. SMDs are, however, also available in different packing.

Surface-mounting solder cream available from:

Dage (GB) Ltd • Intersem Division

• Rabans Lane • Aylesbury •

Bucks HP19 3RG • Telephone (0296) 33200

Texas Instruments

Fig. 6. A surface-mounted board has a different appearance than a conventional PCB. This sample board houses a simple flashing-light circuit.
audio, video and sound generation

- mini amplifier 8.83
- MOSFET power amplifier 8.86
- PL 301 loudspeaker 10.26
- portable guitar amplifier 2.28
- rumble detector 2.39
- 30 watt A loudspeaker 2.34
- sound-level indicator 8.40
- sync separator 8.93
- tone burst generator 7.16
- video amplifier for V/V television sets 8.98
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- video selector 8.70
- video transfer equalizer 8.49
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- programmable keyboard encoder 3.40
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- sync inverter for OL 8.71
- twin keyboard for Apple 11 9.02

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universal I/O bus 6.29
XY graphics plotter 9.24
shorthand BASIC 1.23

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- audio sweep generator 12.26
- audio tester 8.68
- automatic switch off 8.59
- crystal tester 8.38
- faultfinding probe for Ps 8.47
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- GHz prescaler 9.08
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- metering selector 8.39
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- noise generator 8.72
- opamp tester 8.37
- pH meter 2.41
- RLC meter 3.50
- RTTY calibrator indicator 8.45
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- the short search 7.80
- tone burst generator 7.18
- transistor unibest 4.48
- versatile counter circuit 4.44
- microprocessor controlled frequency meter (part 0) 1.56
- simple transistor tester 2.58
- sound pressure meter 4.54
- L.C.D. thermometer 6.48
- luxury transistor tester 11.44
- PET millivoltmeter 10.39
- minivolt 12.33
- function generator 1.26

music

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- fantasy on a MIDI theme 12.34
- portable guitar amplifier 2.28
- programmable rhythm box 3.40
- sound rotator 11.26
- swell pedal 8.76
- web-who box for guitars 8.87
- easy music 3.49

power supplies and batteries

- 10 A power supply 5.39
- 12 V NiCd battery charger 8.30
- active rectifier without diode 8.66
- battery charging indicator 8.39
battery fitness centre
DC/DC converter
direct-voltage doubler
economical power supply
heat sink monitor
lead-acid battery charger
mains interface
mains power supply with primary regulation
mains voltage monitor
negative supply converter
power supply sequencing for opamps
simple zero crossing detector
variable 3 A power supply
low voltage stabiliser
voltage frequency converter
inverter

1985

HF

electronic VHF/UHF aerial switch
light powered radio
NAVTEX receiver
RATTY calibration indicator
RTTY/CW filter
send-receive ident
simple field strength indicator
spot frequency receiver
VLF converter
VHF/UHF TV modulator

hobby and car

absorption-type metal detector
automatic car alarm
bicycle lights and alarm
digital joystick interface
garage stop light
KITT scanner
metal detector
model aircraft monitor
model railway monitor panel
remote model control with a microprocessor
revolution counter
service interval timer
7400 siren
simple sound effects

miscellaneous and design ideas

christmas star
clock oscillators (design ideas)
combining digital circuits
designing a low noise amplifier
DIY connector
electronic pentograph
fast opto-coupler
fast opto-isolator
gyro flush
jumbo displays
LED direction indicator
ludus
miniature running lights
on the air indicator
overload protection for electric drills
play ball with Elektrol
power supply sequencing for opamps
set pointer
solar battery
solid state relay
stage lighting (part 1)
stage lighting (part 2)
stepping motors
time-lapse unit
thrifty LED indicator
time stretcher
versatile counter circuit
XY graphic plotter
 economical crystal time base
temperature to voltage converter
check list for electronic fault finding
or 'where and how to look for what that doesn't'
Channel multiplier for flat TV panel

Scientists of the Philips Research Laboratories in Rechill, Surrey, have achieved a flat cathode-ray tube with a picture diagonal of 12 inches and normal TV resolution. The depth of this tube is less than 3 inches. The first flat, sealed-off monochrome tubes have been made. The problems of gain stability have been overcome and an acceptable operating life can now be obtained. The feasibility of achieving full colour has been demonstrated. For the near future applications are expected to be in professional use only.

System
The flat cathode-ray tube (see Fig.1) consists of an electron gun, deflection plates, an electron multiplier array, a phosphor screen, and a faceplate that is vacuum sealed in a metal can. Because of the electron multiplier, the electron beam can be of both low current (less than 1 μA) and low energy (400 eV). The electron beam travels down the back of the tube to a reversing lens where it is turned through 180° into the front section. A central partition carries a series of frame deflection plates which create a field to turn the beam forward on to the multiplier. The current from the gun is amplified several hundred times by the multiplier before the beam is accelerated to the screen. Because of the low primary beam energy and current, the scanning system can be orthodox. Vertical scan is achieved by progressively ramping the potentials on the frame plates. Electrostatic deflectors near the gun provide the line scan.

State of the art
Much progress has been made concerning the picture area and resolution. The spacing between the multiplier channel centres has been reduced to 0.55 mm, providing approx. 170,000 channels in the 305 mm diagonal display. The resolution of the screen image and the grey scale capability is appropriate for TV applications. The spot size is such that the resolution of the tube is limited by the pitch of the channels in the electron multiplier. The main factor which determines the life of the flat display tube is deterioration of multiplier gain. Multiplier tests show that after 7500 hours of continuous operating the gain falls to 63% of its original value. Colour is important for many professional applications and several methods have been studied. The presence of the electron multiplier poses problems which are very different from those of a shadowmask tube. Colour selection can be carried out either before or after the multiplier. If the selection process takes place before the multiplier then one channel must be dedicated to each primary of a colour triad. This limits the maximum colour display resolution to one third of its monochrome resolution. The Philips Research Laboratories are studying methods in which a system of electrodes on the output of the multiplier directs the emerging electrons onto phosphor of the desired colour. The ultimate tube design has one gun, and sequential colour selection is therefore needed. The low deflection voltages and the high picture brightness make the tube particularly suitable for this mode of operation. Two methods are being studied, the dots-and-rings method and the deflection method.

Dots-and-rings method
The electron source inside each multiplier channel is a ring which is imaged on to the screen. A system of dynode-like electrodes at the multiplier output can be made to act as a lens of variable focal length, enabling the size of the image to be altered. The phosphor triads on the screen consist of concentric patterns in the three primary colours, which are aligned with the multiplier channels. The emergent electrons from each channel can be focused into a spot exciting the red phosphor, a ring exciting blue, or a larger ring exciting green.

Deflection method
With the deflection method, the screen consists of a pattern of phosphor strips in the three colours. A positive voltage applied to a dynode-like extractor electrode is used to draw the electrons from the final multiplier stage. They are then deflected on to the desired colour by pairs of strip electrodes located between adjacent rows of channels. The strip electrodes and the extractor electrode form an asymmetric lens which causes the electrons to be focused on the screen as an elongated spot.

The results of both methods obtained so far are close to the requirements for various professional applications (such as data display) where flat screens are important; the possibilities for domestic applications are being studied. The practical work is carried out in demountable vacuum systems with small-area multipliers (2 by 2 inches). They now need to be developed into a large-area technology.

The results described here refer purely to laboratory research; they in no way imply the manufacturing or marketing of new products.

![Diagram of a flat cathode-ray tube](image-url)
The miniaturization and computerization of electronic navigational aids can only benefit today’s motor yachtsman as he voyages through increasingly crowded waters and marinas. His means of knowing his speed, direction, and the depth have been made simpler, largely thanks to the sophistication of microprocessor controlled alphanumeric displays, which are easy to recall and read and are small enough to fit into a handbag.

Take, for example, the Triton F.15 as developed by Baron Instruments (1). Here is a 16 function yacht instrumentation system, fitted into a console measuring a mere 234 x 171 x 50 mm. It is designed with the express purpose of easing the congestion of a whole array of instruments.

The functions are boat speed; velocity made good; total log; resettale log; depth in fathoms; depth in metres; depth in fathoms; true wind speed; apparent wind speed; true wind angle; apparent wind angle; elapsed time; countdown timer (10 min); real time in hours, minutes and seconds; date (day/month).

Digital display

These functions may be recalled on a large digital display which makes use of a six digit, 25 mm, liquid crystal system. This is backlit for night illumination and also fitted with an anti-glare window. Another 14 light emitting diode indicators in traffic light red are positioned immediately beneath the display to denote the particular function selected. Below that again are the function switches themselves, placed over touch sensitive membrane devices.

Using the latest generation 8031 microprocessor, Triton F.15 works off a 12 or 24 V supply, consuming only 300 mA at 12 V. When the power is turned off, the clock calibration and alarm settings are retained by an internal nickel cadmium battery, rechargeable off the ship’s supply to give up to six months’ back-up.

Existing Baron water speed and depth transducers can be used with the Triton F.15 system.

As with the voice advice system used on the Austin Maestro and other cars, so has Seafarer (2) made it possible for the yachtsman to be “told” his depth, enabling him to focus his eyes on other tasks in hand. The Echovox talking repeat meter can be used in conjunction with the 110 m Seafarer 5 and the 183 m Seafarer 700 echo sounders.

Clear voice

Metric and imperial versions are available, offering presentation of soundings both through a numerical digital display and a variable volume, synthesized, clear English voice. Soundings are given in units and decimal parts of a unit in depths of less than 10 m. The voice repetition rate increases in shallowing water and a shallow water alarm signal can be preset to any depth up to 10 m.

Echovox operates from a ship’s supply of 12 V dc and measures a mere 158 x 188 x 75 mm.

If you do not like voice synthesis, there is the Navsounder, as developed by Stowe Marine Equipment (3). This is a microprocessor controlled digital depth sounder, with alarm settings that can be selected individually at either station — so that the yachtsman does not venture into water that is too deep or risk running aground.

The liquid crystal display gives a digital presentation to a range of 100 m. In this particular unit, the eight-bit microprocessor, with 2 K of fixed random access memory, gives special capacity to selectively process and interpret acoustic signals. Secondary acoustic signals caused by turbulence, debris and fish are rejected and do not appear on the display.

Deep and shallow alarms can be set to the nearest foot, fathom or metre, and allow for kedl offset. Audible deep and shallow alarms are distinguished from each other by tone, with dashes for deep, and dots for shallow. When selected, the “anchor watch” function continually monitors depth and warns of abnormal changes.

Universal sensor

Navsounder operates from a ship’s supply of 10 to 12 V and 80 mA, with 50 mA lighting when required. It measures 110 x 110 mm. Moving from depth to direction, development of the age old compass has certainly not stood still. This is evident in the Meteor Digitrac electronic compass system produced by Marinelex (4).

The detection of the earth’s magnetic field within a solid state, electronically damped universal sensor, enables up to five remote compass displays, both analog and digital, to be actuated without any extra circuitry.

Among these displays are an analogue pointer display, an analogue head-up display unit with rotating card or grip pointer options; a digital display unit, and a microprocessor controlled tape repeater with liquid crystal display. The Meteor system can also be used for satellite navigation, automatic direction finding, and autopilot interface.

The all-important universal sensor unit offers automatic compensation for changes in the horizontal field strength, and maintains absolute voltage control outputs. It is also constant over angles of dip of up to 80 degrees. This aids helmsmen of both power and sail boats to maintain an accurate course, even in very rough conditions.

By allowing analogue and digital displays to be inter-wired, both helmsman and navigator can see what is happening, on different types of compass.

Ship to shore

Apart from human-controlled direction, there is automatic control. With the Wheelpilot 4000, developed by Navico (5), the functions of rudder ratio, sea state, and trim are entered via keyboard control. Each and every command is confirmed on the liquid crystal display and by a beep.

There is also an off-course alarm, a port and starboard dodge facility, and a highly efficient gearbox. During the design stage, Navico researchers paid a great deal of attention to waterproofing, so that special seals and double gaskets were incorporated to function even in the wettest and roughest of sea conditions.

Last but not least, the ability to communicate ship to ship and ship to shore must be regarded as a vital aid to navi-
In the enthusiastic rush to gain the full benefits of computers, few companies seemed to have thought of the disadvantages and, in particular, the problems of computer security.

Computer crime is a new growth industry of the 1980s, with rich pickings being available. Many frauds are never made public and the increasing use of computers in routine commercial work offers increased scope for this type of crime. Even the most sophisticated computer lacks the human attribute of commonsense and so any transaction that conforms to the computer’s rules will be processed.

Computer frauds require a knowledge of the system’s characteristics and could involve tampering with data, programs or software. The perpetrators vary widely from trainees to senior management, and the sums involved range from tens to millions of pounds.

Heavy losses

A study of computer crime by an American Bar Association committee says that organizations often did not know who had committed a crime; many did not know when a computer crime had taken place and could not monitor their systems to detect it.

In a survey of 283 large corporations and government agencies about 48% reported some form of computer crime in the last year with losses conservatively estimated at between $145 million and $730 million.

A recent “Washington Post” series on computer crime suggested that annual losses may be between $100 million and $3000 million. No one knows with any certainty how many millions are going missing, and the problem is snowballing.

Open Computer Security says: “For every one computer crime that is reported it is estimated that probably a further 20 go completely undiscovered.” Such frightening figures indicate two things.

Coded messages

“First, without the proper safeguards almost every computer is prone to this type of attack and, second, there are more individuals than you would imagine who have the required degree of technical knowledge to carry out armchair robberies. Indeed, computer crime has become so rife and so lucrative that the head of the Scotland Yard specialist section in London recently predicted that, by the end of the decade, all cases of fraud would involve a computer.”

Open Computer Security goes to great lengths to ensure that its systems are secure. It says: “Due to the extremely high levels of encryption and verification which are built into our systems, not even we are able to overcome the security procedures inherent to our finished and installed product.”

Apart from putting a message into coded form there are special authentication codes built into our security units.

“This means that the host computer will accept instructions only from another computer that has previously been given clearance. Also, if the tamper-proof box is opened the memory is instantly wiped clear and the system goes into alarm. Every message that goes through the system automatically has an authentication code attached in it which tallies with the contents of the message.”

“This means that an instruction to transfer $1000 cannot be changed to $1000 000 — either by operator intervention or a fault on the line — without the change being highlighted.”

Automated security

Open Computer Security has designed and manufactured the authentication equipment for CHAPS, the Clearing Houses Automated Payment Scheme in London. CHAPS will replace the physical carrying of large cheques about the City of London by messengers. Approximately $370000 a day is handled between different clearing banks, the clearing banks, and the Bank of England.

CHAPS uses the data encryption standard (DES) as its basic scrambling device and the session key, which is changed daily, is held in a tamper-resistant module designed by Open Computer. The module fits into the authentication unit attached to the tandem gateways in each of the clearing banks.

The key itself is a series of random numbers produced by electronic noise and no one, neither the users nor Open Computer staff need know what it is. CHAPS has a way of identifying each bank’s module to prevent substitution. The authentication unit is designed to detect and reject any message that has been interfered with.

Many specialists believe that it is one of the most secure systems in the world and it is becoming a model for other financial institutions. One expert has commented: “CHAPS is more
secure than an armoured car — you are not going to get in there!".  

**Award winner**

Open Computer Security has won the British Computer Society/Computing Applications Award for its Padlock system which was designed to prevent software piracy. Padline 7, a more recent development, is operated at all seven levels of communication as defined by the International Standards Organisation in its OSI model. This allows the unit to be used in virtually all computer networks whether public — such as X25 — or private — such as SNA.

From the most basic physical layer — level 1 — Padline will perform through X25 layers right up to level 7. Here, encryption takes place under the control of the user’s actual applications software making this, the manufacturer believes, the most secure method yet devised. This “end to end” level gives total network transparency under all communications protocols. Data encryption is via the accepted DES algorithm.

Special circuitry in Padline allows the generation of truly random keys whilst the RSA public key provides a secure method of transporting the keys over non-secure networks, so that the user can confidently design a complete key management system. The codes used in Padline 7 are housed within one of the machine’s microprocessors.

To prevent the possibility of these codes being misused, the entire cabinet is designed as a totally sealed unit. Padline is without vulnerable air vents and, if it is tampered with, the memory is instantly wiped clear and alarms are triggered. Data can be loaded into the unit via its cassette input socket so the user can upgrade Padline on site — perhaps to operate on a different communications level — from a supplied tape.

**Double locked**

For security reasons, field upgrades can only be carried out in the presence of both keyholders. Additionally, the tape (which is prepared to order) is programmed to match only the particular Padline for which it was intended.

Racal Milgo [1] has designed the Datacryptor II which operates in a binary white pattern of information into an indistinguishable stream. This is achieved with the DES algorithm. By using this in a single bit cipher text feedback mode, Datacryptor II achieves a high degree of security with true protocol independency.

Both asynchronous and synchronous protocols can be managed by Datacryptor II operating in full or half duplex modes over point-to-point and multipoint networks. The unit will also operate over leased line or dial-up circuits. A point-to-point link merely involves two Datacryptor II units — one at both central and remote sites. Each unit has a small, hand held, removable memory device known as a key transport module (KTM). The KTM’s are normally double locked inside the Datacryptor II units and without them the system will not operate.

**Master key**

The Datacryptor II has randomly generated 64 bit keys. The user does not see these keys or have any influence over their generation. The initial or master key is generated at the central site Datacryptor and is loaded into two KTM’s. One KTM is then transported and loaded into the remote site Datacryptor and the other is left at the central site unit.

The central Datacryptor then generates a working key which is down-line loaded to the remote site. This operation is quickly and simply carried out at the central site Datacryptor II front panel. Working keys may then be changed as often as required — at both ends of the link — simply by pushing a button at the central site. The master key is also easily and quickly changed simply by generating a new key for loading into central and remote sites.

Down-line key loading provides an additional degree of security against the presence of the link indicator attempting to determine the working key. This dual level of keys therefore ensures a higher level of security for sensitive data networks and avoids costly and time consuming procedures of constant transportation of keys.

All key management and control functions are performed at the central site Datacryptor where key generation and down-line loading are also carried out.

All controls and the KTM are double locked behind a front panel which can only be accessed by the operation of two security key locks.

**Information rejected**

Once accessed, the controls consist of three pushbuttons, one to initiate the master key, one to copy this information into the second KTM, and one to generate down-line loaded working keys. The front panel LED indicators display transmission and security status.

Test indicators allow checking of keys and the data link. Datacryptor II is housed in a robust and secure package. Should any unauthorized access to the unit be attempted, the anti-tamper switches will automatically erase the keys, disabling the system, and maintaining the integrity of the data network.

In the event of a power failure, the working key and module security code are protected by a nickel-cadmium battery for a minimum of 1000 hours. As a standard feature, Datacryptor can be securely mounted on a desk top or in a rack. Removal requires the use of two keys. Datacryptor can be enhanced by the expansion module option which provides a module security code. This allows the user to provide each remote site with an individual address so that, unless the correct KTM is received, the key information is rejected.

2. Racal-Milgo Ltd, Richmond Court, 300 Fleet Road, Fleet, Hampshire, England, GU13 3BU.

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1.48 asakor india | january 1988

The Racal-Milgo Datacryptor II.
After the preliminary and theoretical considerations of the past three months, this fourth article in the series deals with the construction of the main printed-circuit board. The board is Euroformat (100 x 160 mm), double-sided, and has through-plated holes: clearly not a card for home production. It is not absolutely necessary to have read through the three previous articles, but it does help. It should be noted, however, that the circuit diagram was published in Part 3.

High-resolution Colour Graphics Card - 4

(December issue), and this, of course, is essential knowledge. The construction of the card is not all that difficult, particularly since there are no adjustments or calibration. None the less, a beginner in this type of work will almost certainly experience difficulties if it comes to fault-finding. A really good soldering iron is required, preferably with a temperature-controlled tip, which should not be heavier than indicated in the photograph. Because of the thinness of some of the tracks, the card may easily be damaged beyond repair if too much heat is applied to it.

The ICs may be mounted in good-quality sockets, but, at least as far as the dynamic RAMs are concerned, it is better not to. If any faults manifest themselves, do not immediately suspect the ICs: experience shows that in the initial stages most faults are not caused by faulty components, but rather by suspect workmanship. If in spite of all this, it is found that an IC is at fault, just cut off the pins, remove the body, and then unsolder the pins from the holes in the board. If you have a desoldering device available, so much the better.

Although the board is a very reliable component, it often pays to inspect it carefully (and possibly with a magnifying glass) for hairline breaks in the tracks. This can save a lot of tedious work later.

Fitting the Components

First, fit the five wire links. Since these carry a reasonable current, they should be made of relatively heavy insulated copper wire. The GDP (graphics display processor) is best fitted in a really first-class socket. DIL switches $S_1$ to $S_3$ are soldered direct to the board.

Make sure that the quartz crystal used is housed in a HC18U or HC25U case, and that its frequency is suitable for the GDP used (14 MHz for the 9365 or 9366, and 12 MHz for the 9367). Where available, $R_1$ to $R_6$, $R_{10}$ to $R_{15}$, and $R_{17}$ to $R_{34}$ should be bought as ready-made networks, which are easier to handle. Capacitors $C_{20}$ to $C_{34}$ are not yet fitted: more about this later. Connector $K_1$ may be also omitted for the moment, as it is not required until the colour extension is added. Movable wire links A/B, C/D, and I-J are best made with PCB pins and 2.54 mm matrix shorting sockets. Links K/G, K/H, E and F, on the other hand, consist of stout wire or of normal soldering pins — see also Table 8.

Once this done, a first test should be made to verify that the supply voltage is present at the IC sockets or relevant soldering terminal on the board. Note that in the case of $IC_3$ to $IC_{28}$ the +5 V line is connected to pin 8, and the return (earth) line to pins 1 and 16. Next, oscillator $IC_{28}$ and the address decoding ICs ($IC_1$ to $IC_3$) should be fitted. When the supply is connected, pin 8 of $IC_{26}$ should produce a clock signal of 12 MHz or 14 MHz, depending on the crystal.

When the decoding address for the graphics card is known, write to it the highest value byte with the aid of $S_1$ to $S_3$. The case of address range E1X0 to E1X9, the situation shown in Fig. 19 then pertains.

As soon as an address from this range appears on the address bus, output $P = Q$ (pin 19) of $IC_1$ goes low. Pin 9 of $IC_1$ must be low at address XX3A while pin 10 should be active at address XX90. As these addresses are present on the bus of the microprocessor for very short times only, it is impossible to detect them with an oscilloscope. It is, therefore, better to construct a small instruction loop with a port to produce the wanted addresses cyclically.

When the address decoding has been tested in this way, buffer $IC_4$ and registers $IC_9$, $IC_{11}$, $IC_{12}$, and $IC_{13}$ can be fitted. It is, of course, not permissible that these ICs affect the computer that controls the graphics card. Next, $IC_{28}$ to $IC_{30}$ (programmed PROM), and $IC_{15}$ should be fitted. After this it should be verified whether signals STR, RAS, CAS, CE, LD, and ATY are present at

by P Lavigne & D Meyer
Table 7
Order of actions and construction check list.

Table 8
Optional wire links.

Table 9
Memory ICs.

Table 8

2164 15 INTEL
2164 20 INTEL
M556 12 OKI
M556 15
MK4664 15 MOSTEK
MK4664 20
UPD4164 3 NEC
wUPD4164 21
wUPD4164 11
HM464 2 HITACHI
HM464 8
TM4164AP 2 TOSHIBA
TM4164AP 3
TM4164AP 12 TOSHIBA
TM4164AP 15
TM4164AP 20
MB3264 15 FUJITSU
MB3264 20
MSK4164AP 15 MITSUBISHI

Table 7

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</tr>
<tr>
<td>none</td>
<td></td>
<td>carefully check the board optically and electrically</td>
</tr>
<tr>
<td>none</td>
<td>IC1</td>
<td>fit permanent wire links, 64-way plug, and IC sockets</td>
</tr>
<tr>
<td>none</td>
<td>C12</td>
<td>fit optional wire links (see Table 8)</td>
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<tr>
<td></td>
<td>IC3</td>
<td>test the supply voltages</td>
</tr>
<tr>
<td></td>
<td>IC1, IC3</td>
<td>fit all resistors and capacitors, except C12, C15</td>
</tr>
<tr>
<td></td>
<td>IC11, IC13</td>
<td>fit crystal X1, check operation of clock oscillator</td>
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<tr>
<td></td>
<td>IC16, IC18, IC20</td>
<td>address decoding XX50, XX5F and XX64, XX67</td>
</tr>
<tr>
<td></td>
<td>IC23, IC24, IC26, IC28, IC30</td>
<td>check signals STR, RAS, CAS, CK, LD, and A7X</td>
</tr>
<tr>
<td></td>
<td>IC31, IC15</td>
<td>write 00...03, in that order, to address XX66, IC11</td>
</tr>
<tr>
<td></td>
<td>IC17</td>
<td>verify the signal at A7X changes in accordance with Fig 20</td>
</tr>
<tr>
<td></td>
<td>IC17</td>
<td>check signals ALL, BLK, ALLX, BLKX, DADA, DAD0, DAD6, SYN1</td>
</tr>
<tr>
<td></td>
<td>IC17</td>
<td>fit capacitors C10, C17</td>
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<tr>
<td></td>
<td>IC17</td>
<td>check signals MUX, SH1, RAST, RAST7</td>
</tr>
<tr>
<td></td>
<td>IC17</td>
<td>write XX50, 07, 05, or 00</td>
</tr>
<tr>
<td></td>
<td>XX51</td>
<td>XX51: 00</td>
</tr>
<tr>
<td></td>
<td>XX52</td>
<td>XX53: 03</td>
</tr>
<tr>
<td></td>
<td>XX64</td>
<td>write XX53, 00 (01, 02, or 03 for turning the page)</td>
</tr>
<tr>
<td></td>
<td>XX51</td>
<td>XX51: 81</td>
</tr>
<tr>
<td></td>
<td>XX52</td>
<td>XX53: 03</td>
</tr>
<tr>
<td></td>
<td>XX64</td>
<td>XX50: 0C (screen becomes white)</td>
</tr>
<tr>
<td></td>
<td>XX64</td>
<td>XX50: 0C (screen goes black)</td>
</tr>
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Table 8

A positive sync pulse (HS + VS - CSYNC) |
B negative sync pulse (HS + VS - CSYNC) |
C 4 pages, 256 lines, sequential scanning |
D 2 pages, 512 lines, interlaced scanning |
E 512 x 256 (EF3066), 512 x 512 (EF9366, EF9367) |
F 512 x 256 (EF9366) |

22

K

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<td>29</td>
<td>2A</td>
</tr>
<tr>
<td>2B</td>
<td>2C</td>
<td>2D</td>
<td>2E</td>
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<td>49</td>
<td>4A</td>
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<td>4D</td>
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<td>50</td>
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### Parts list

**Resistors:**
- $R_1$: $R_{16}$, $R_{21}$, $R_{37}$ - 1 kΩ
- $R_{17}$ - 22 Ω

**Capacitors:**
- $C_1$: 33 pF
- $C_2$, $C_3$: 10 μF, 16 V tantalum
- $C_4$, $C_5$, $C_6$ - 100 nF
- $C_9$ - 1 μF tantalum
- $C_{10}$ - $C_{17}$ - 100 nF

**Semiconductors:**
- $I_{C1}$: 74LS608
- $I_{C2}$, $I_{C3}$: 74LS138
- $I_{C4}$: 74LS245
- $I_{C5}$: EF9360, EF9366, EF9807
- $I_{C6}$, $I_{C7}$: 74LS274
- $I_{C8}$, $I_{C9}$: 74LS273
- $I_{C10}$, $I_{C11}$: 74LS117
- $I_{C12}$: 74LS244
- $I_{C13}$: 74LS113
- $I_{C14}$, $I_{C15}$: 74LS230
- $I_{C16}$: 74LS166
- $I_{C17}$, $I_{C24}$: 4164
- $I_{C30}$: R > 7 kΩ
- $I_{C35}$, $I_{C36}$: 74LS332
- $I_{C37}$: 74LS08
- $I_{C38}$: 74LS04
- $I_{C39}$: 74LS191

**Miscellaneous:**
- $X_1$ - crystal 14 MHz
- $I_{E1}$, $I_{E2}$, $I_{E3}$: 12 MHz
- $I_{E7}$, $I_{E8}$ in HC18U or HC25U case
- $K_1$ = test socket; double row, 17 way, matrix

2.54 mm for mating with flat ribbon plug

$K_2$ = 4 small soldering pins

$S_1$, $S_2$ = octal DIL switch in 16-way case

8 standard soldering pins

Three 3-pin test plugs with suitable short-circuit sockets

PCB: 85080 1

* see text
Fig. 19 Example of setting of DIL switches S1...S6, here set for address decoding at $4E1XX.

![Diagram]

<table>
<thead>
<tr>
<th>A12</th>
<th>A11</th>
<th>A10</th>
<th>A9</th>
<th>A8</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
</tbody>
</table>

1 1 1 0 0 0 1

Fig. 20. Timing diagram of a number of the more important signals. The chronological order of these is also important. Note that the four signals A7 do not appear simultaneously, since each belongs to a different page. These signals are produced by writing data 0, 1, 2, or 3 to XX66, in register IC11.

![Diagram]

The output of IC16 and the inputs of the relevant ICs — particularly pin 1 of IC16 (which has not yet been fitted). The timing diagram of these signals is given in Fig. 20 (see also Fig. 16 in the November issue).

The card is now in such a stage that the most important components can be fitted: graphics display processor IC1, and memories IC17...IC30, as well as all the other ICs, such as PROM IC16. Before any further progress can be made, a monitor is needed. If this has a separate SYNC (link A) or SYNC (link B) input, carry on. If, however, it needs a composite video signal, it is necessary to first build the mixer stage of Fig. 21.

When the supply is switched on (power on reset), nothing will initially be visible on the screen, because the image depends, among others, on the decoupling capacitors on the power lines to the dynamic RAMs. These capacitors, $C_{16},...C_{17}$, are not fitted on the component side of the board, but direct at the supply connections (pins 8 and 16) of the ICs as shown in Photograph 1. It is very important that the leads of these capacitors are properly insulated. Without these capacitors, the +5 V line would be badly affected by the current pulses which are so typically produced by the RAMs. There are, therefore, sound reasons for fitting the capacitors at the track side of the board.

When, after the capacitors have been soldered in place, no image at all appears on the screen, this is normal. It may also be that there are some vertical lines visible. All that is not so important; what is, however, is that the screen image does not change after the power has been switched on. It is also advisable to check the supply to the control computer before and after the graphics card has been switched on. The current should be of the order of 450 mA, but may vary widely from this figure, depending on the screen image. The only IC that may get slightly warm is the GDP: all the others should stay fairly cool.

When power is switched on, the registers of the GDP may be read; they should show XX56: 07, 06, or 0D

XX51: 00

XX53: 83

in hexadecimal, of course.

It is now possible to carry out a simple test:

- enable the write mode of the screen memory by writing 00 to addresses XX66 and XX64.

- Next, write 0C to XX50 in the command register of the GDP.

- If the contents of that register is 83 at XX53, the screen will go white.

The screen is cleared by writing 61 to XX64 and giving the GDP the command 0C at XX50. If everything is in order, the screen should now turn black. Note that the command 0C at XX50 cannot be read, since at this address of the graphics processor writing accesses the command register; and reading, the status register.

If nothing happens on the screen, either the graphics processor has not received any instructions, or the logic levels on the WRIS and DIS lines were not correct for a write operation. In either case, the WRIS line must be logic 0 to enable the memory to be accessed, while DIS must be logic low to light the pixels, and logic 1 to quench them. It may be that the output-register has not received signals HCK and SH/1 required for its proper operation. It is also necessary to verify signal STR at IC19, signal RAS for collective accessing at pin 14 of IC19, and signals RAS for individual accessing at pins 1...7 and 9 of IC19. The slightest short-circuit or bad contact at one of the signal lines can disrupt or even disable the whole system.

If something has gone wrong, a systematic search and verification of the various signals will soon show where the fault lies. For instance, if signal CK is not present at pin 1 of IC19, the device will not work. The same applies if signals RAS, CAS, or HCK are not present. If one of the signals RAS...RAS7 is missing, one eighth of the screen does not function; the remainder operates normally. If one of the DAD lines is short-circuited, the card will only function partly; the extent of the malfunction depends on the binary loading of the relevant address line.

The information given here, particularly that in Table 7, will enable anyone with some
experience in electronic construction to build the card satisfactorily. The colour extension will be dealt with in a forthcoming article. Remember that plug K will provide the connection between the black-and-white card and the colour extension. The wiring to this connector is shown in Fig. 22. Until the colour extension is there, the plug is useful in providing test signals.

Choosing the GDP and memory ICs

As the EF9365, EF9366, and EF9367 cost roughly the same, it is best to buy the EF9367. This is the latest model and also the most efficient; moreover, it can be used in interlaced as well as sequential scanning. In the present graphics card, it permits the following modes of operation:

- $512 \times 512$ (sequential scanning), and
- $512 \times 512$ (interlaced scanning)

It also offers the possibility of providing $1024 \times 512$ pixels, but this is not used in the card, mainly because this mode of operation demands a very high quality monitor, particularly as regards bandwidth and resolution.

The EF9366 is also an excellent device, but it cannot work in interlaced scanning mode and its resolution is, therefore, limited to $512 \times 512$ pixels in the present card. In most cases, this is, however, perfectly satisfactory. It should be noted in this context that a vertical resolution of $512$ pixels in interlaced mode requires a good-quality colour monitor.

Choosing the correct memory ICs is also important. In theory, they should be fast, say, 150 ns access time or better, so that the RMW mode functions properly. Practical experience with the GDP has shown, however, that in many instances access times of 200 ns or even 300 ns do not pose particular problems.

Moreover, these ICs do not get a refresh pulse on $A_7$ and $A_{15}$, and pin 1 (which is earthed) does not receive a refresh clock pulse. Table 9 shows all suitable types as far as they are known to us (column YES), those in column NO are definitely NOT suitable. The types in brackets in the YES column have an access time that, theoretically, is too long for the RMW mode. Photo 2 shows ICs of the Japanese firm Fujitsu as used in one of our prototypes.
Nowadays, there is a variety of inexpensive, yet sophisticated, telephone sets on the market. Not all of these are permitted to be connected to the British Telecom network, however. None the less, two or more of such sets may be used to form a simple, but effective, internal telephone system for the home, an office, or anywhere where a number of people want to communicate from different locations within the same building.

The proposed system may, of course, also be built around Brush Telecom approved sets. Note that the system is intended for up to eight sets each of which generates a pulse code when a number is dialled or keyed in.

Facilities
A telephone exchange does, of course, more than just connecting one set to another. In fact, this is about the only thing it need not do, because the set with which communication is required is already accessed by the pulses generated when the relevant number is dialled or keyed in. What the exchange is required to do is:

- to decode and process the pulses generated by the telephone sets;
- to generate a dialling tone;
- to generate and pass on a ringing tone;
- to interconnect sets as soon as the receiver is lifted;
- to prevent a third set listening in;
- to generate and pass on to a third set an engaged tone.

In addition, the system allows communication between two sets to be established in two ways:

- by dialling or keying in the required number and waiting till the other set responds;
- semi-automatic: when the receiver of one
set is off the hook, and the receiver of another set is lifted, the two sets are interconnected, even when no number has been dialled.

The exchange is provided with LEDs that show at all times which of the sets, if any, are engaged. A ninth LED indicates whether the exchange is engaged or not; this only goes out when the communication has been terminated, i.e., when the two relevant receivers have been replaced on their rests. All sets are powered from a common source via the standby and speech lines; the connection between each of the sets and the exchange is, therefore, in many cases possible, via two lines only. The bell voltage is placed on the speech line via a relay.

Calling one set from another is done by simply dialling or keying in the number of the wanted set, i.e., 1...8.

**Circuit description**

Since the telephone sets can only be connected to the exchange — see Fig. 1 — via the interface shown in Fig. 2, it is important to know how many sets the exchange will control before all the parts are bought. If, for example, only three sets are envisaged, the relevant part of the circuit in Fig. 2 needs to be built only three times. If, however, the full capacity of the exchange is used, eight interfaces are required.

As soon as the receiver of a set, say, number

---

**Fig. 1. Circuit diagram of the home telephone exchange**
Parts list

Resistors
R1, Rg = 3300
R6, R10, R13,
R2, R1, R3, R4, R5, R6, R7
R8, R10, R11
R9 10 k
R17, R4 470 Ω
R25, R31, R35, R41, R44
R61 100 k
R5, R35, R11 47 k
R6 - 100 k
R3 4 MΩ
R41 1 M
R2, R5, R35 1 k
R4 470 k
R5 10 M
R5, R6 88 k

Capacitors
C1, C1, C2 = 10 µF/16 V
C4, C4, C5 = 22 n
C1, C3 = 10 n
C6, C6, C7, C8, C9, C10
C2 100 n
C3 4.7 µF
C4, C5, C6, C7, C8, C9, C10
C11 2200 µF/40 V

Semiconductors
T1, T2 = BC5478
T4 = BC5578
T2, T3 = BC517
D1, D1, D1 = 1N4007
D2, D2, D2 = LED
D3, D3, D3
D4, D4, D4
IC1, IC2, IC3 = 4093
IC4, IC5 = 4017
IC6, IC7, IC8 = 4001
IC9 = 4038
IC10 = 4038
IC11 = 4013
IC12 = 3130
IC13 = 7615

Miscellaneous
S1, double pole main switch
Rg = 12 V relay for PCB mounting 1 g.
Siemens type
VZ3927 BU002 may be available from Electronworld
(07844 35933 or 0611 432 4945)
T1 = mains transformer,
2 x 18 V at 500 mA, 2 x 18 V at 500 mA, or
0.18 V at 500 mA + one of 0.36 V at 50 mA
R1 = 100 mA
PCB 85110

Fig. 3. Printed circuit board of the telephone exchange. Note that the mains transformer is not fitted on this board. The track side of the PCB is shown on page 49.
is taken off the rest, the relevant transistor, here \( T_1 \), is switched on, so that the output of \( N_1 \) goes high. After a time determined by the RC network at the input of \( N_2 \), this gate toggles and its output goes low.

If now from set 1 a number is dialled, the output of \( N_1 \) will toggle in rhythm with the pulses produced by the telephone set. Because of the RC network at its input, gate \( N_1 \) will not follow suit: its output remains logic low during the dialling of a number. The low logic level indicates to the exchange that the receiver is off its rest. As soon as the receiver of one of the other sets is also taken off its rest, the output of comparator \( IC_{16} \) goes low, which renders all other sets inoperative. How this is achieved will be reverted to later.

The pulses generated during the dialling of a number trigger monostable \( MMV_1 \) and \( MMV_2 \) via one of the lines \( D_1 \), \( D_2 \), and also serve as clock signal for \( IC_5 \), a counter with ten outputs. The contents of this counter, ie., the dialled number, is only accepted by bistables \( FF_1 \ldots FF_5 \) if two conditions are met: (a) only one receiver is off its rest, and (b) \( FF_1 \) is not generating a ringing tone. As long as pulses keep arriving at pin 11 of \( MMV_1 \), the Q output of this monostable will remain high. When this pulse train comes to an end, a short pulse is provided at the Q output (pin 6) of \( MMV_2 \). This pulse sets \( FF_1 \) (which generates the ringing tone) and clocks bistables \( FF_1 \ldots FF_5 \), depending on the output code of \( IC_6 \). The wanted set is then connected to the speech line via its associated relay. At the same time, \( N_{23} \) (an oscillator with a long '1' and a short '0') intermitently connects the bell voltage onto the speech line via contact \( R_e \) (see Fig. 2). The wanted telephone will then ring until its receiver is lifted.

To ensure that a third set cannot listen in, the logic levels at the Q outputs of \( FF_1 \ldots FF_5 \) are held: this is done by making both the set and reset inputs of these bistables low when the receivers of two telephone sets are off their rests. The set inputs are made low via \( IC_{16} \): the output of this opamp is low when two telephones are interconnected. The output of Schmitt trigger \( N_{13} \) is then high, and since this output is connected to \( FF_1 \ldots FF_5 \) via NOR gates \( N_{22} \ldots N_{28} \), the set inputs of the bistables are low. As long as two receivers are off the hook, the output of \( N_{23} \) is logic high. The output (pin 2) of \( N_{23} \) and consequently the reset input of bistables \( FF_1 \ldots FF_5 \) is then low.

An engaged tone, generated by gates \( N_{13} \) and \( N_{29} \) in combination with transistor \( T_{20} \), and applied to the wait line, indicates that the exchange is busy. This tone generator, as well as the dialling tone generator consisting of \( N_{27}, N_{33} \), and \( T_{29} \), is actuated by \( FF_9 \) as soon as the receiver of any one of the sets is lifted. The dialling tone generator is provided to indicate that the exchange is processing a number: it has no connection with the actual dialling pulses. In fact, as soon as a dialling pulse appears on one of the D lines, the dialling tone generator is switched on immediately by \( FF_9 \).

Semi-automatic operation is achieved as follows. As stated, bistables \( FF_1 \ldots FF_5 \) are rendered inoperative when two telephone sets are communicating. When only one receiver is off the hook, the output of \( N_{21} \) is low, and the bistables can still be accessed. When in that condition a second receiver is lifted, it takes a second before the bistables are really inoperative, and the two telephones are interconnected. Note that it is not necessary in this case to dial a number.

### Power Supply

The +15 V power supply is provided to the exchange via the speech and standby lines. The bell voltage — here chosen at 2 x 18 V — is also applied to the speech line, but in this case via relay \( R_e \). Transistors \( T_{21} \) and \( T_{22} \) ensure a high supply impedance to prevent attenuation of the speech signal.

### Construction

As no presetting or alignment is necessary, the exchange may be fitted in a suitable enclosure as soon as the wiring of the PCB shown in Fig 3 has been completed. The telephone sets are connected to terminals \( a_1 \ldots a_6 \) and \( b_1 \ldots b_9 \) on the board respectively. Note that British Telecom approved sets need a four-wire connection to the exchange, because their bell circuits need to be connected separately to the standby and speech lines respectively. The bell wires in these sets are coloured red and green, while the other two are blue and white respectively.

### Finally

Because of the RC network between gates \( N_1 \) and \( N_6 \) (or \( N_{55} \) and \( N_{46} \)) in the interface circuit of Fig. 2, the bell rings briefly when the wanted extension picks up the receiver. This could have been eradicated, but it was not thought that the cost of the additional electronics required was justified by this very minor flaw.
In a stabilized power supply the dissipation in the stabilizer may become very high when the difference between input and output voltages is large. This phenomenon occurs particularly in stabilized mains supplies, and can be remedied by lowering the secondary voltage before the stabilizer. The suggested circuit here does this in a neat manner by making it possible to select either the full or half the secondary voltage. And that with only a few components!

**dissipation limiter**

The stabilizer in a power supply may get very hot indeed when the output current is high and the output voltage is low, because it alone has to dissipate the difference between the input and output voltages. It should therefore not come as a surprise when the device gives up the ghost. Some supplies are fitted with a switch that enables the lowering of the secondary transformer voltage, \( u_i = u_i + u_2 \), in such situations, so that the stabilizer need not dissipate so much power.

The proposed circuit shown in figure 1 also makes it possible to lower the secondary transformer voltage but in a rather special way. With a centre-tapped transformer it is possible to halve the output voltage, \( u_o \), by switching the rectifiers from full-wave to half-wave rectification. The switching is effected without the use of a mechanical switch: all that needs to be done is to give the correct instruction and even that could be automated!

**From full-wave to half-wave and vice versa**

The two parts of the secondary winding of the transformer must be in series to give \( u_i = u_1 + u_2 \). All that is necessary to ensure this is to apply a voltage of \( 1 \ldots 10 \text{ V} \) to the base of T2. Both that transistor and T1 then conduct; silicon-controlled rectifiers (SCRs) Th1 and Th2 are consequently switched on via R1, R1', D4, and D5. The SCRs together with D1 and D2 now form the wanted full-wave rectifier in a simple Graetz circuit as shown in figure 3. Diode D3 ensures that in this configuration the secondary windings are not short-circuited via the centre tap and one of the SCRs.

When it is required to halve \( u_o \), the base voltage of T2 should be made zero. The SCRs are then off and rectification is carried out by D1 and D2 only: this is half-wave rectification. This situation is shown in figure 4 and illustrated in figure 2. You will see that the peak value of \( u_o \) rises appreciably when a base voltage is applied to T2, and drops to \( u_i = u_2 \) when the base voltage is removed.

No values have been given in this article because these will of necessity depend on the type of supply used. All component ratings, particularly those of D1 and D2, must, of course be chosen to comply with your particular requirements.
In the last chapter of Digi-Course II we have seen how two NAND gates can be connected to make a simple R-S Flipflop. The circuit and its truth table is again reproduced here for reference.

![Flipflop Circuit]

As we have already seen, the last line of the truth table is ambiguous. Its relation is not defined in isolation, but the previous history of the outputs is involved in deciding which of the outputs will be 1 and which will be 0. The gate which had a "0" input prior to going on "1" retains a "1" at the output. By placing a "0" on the \( S \) input (set input) the \( O \) output LED is turned on. By placing a "0" on the \( R \) input (Reset input) the \( O \) output LED is turned off. A practical application of this simple Flipflop circuit is the game of skill called "Old Shatterhand". This game tests how steadily you can move your hand?

Our R-S Flipflop works as an impartial judge of this game. The basic idea is very simple. A metallic ring is passed over a complexly bent wire such that the ring surrounds the wire but does not touch the wire at any place. If the ring touches the bent wire at any moment, that player has to drop out. Whether the ring touches the wire or not, it is faithfully recorded by the R-S Flipflop.

The bent wire is connected to the ground terminal on the Digilex board and the ring is connected to the input \( S \) (Pin K13). At the beginning of every round, the \( R \) input (Pin L10) is momentarily shorted to the ground terminal. This gives "0" input to \( R \) thus resetting the Flipflop, and turning off the \( O \) output LED. Now the player engages the ring around the bent wire at one end and starts moving it towards the other end, without touching the wire with the ring. Even if the ring touches the wire just for a fraction of a second, the Flipflop is immediately set and the \( O \) output LED glows, announcing the player to be an "Old Shatterhand".

The simple Flipflop circuit that we have just used can be said to have stored the information that the particular player has touched the wire with the ring. In short, the Flipflop is a memory device which stores the information last received. The information stored is always in form of zeroes and ones.

For complex memory applications like data storage, data processing, calculations which require large quantities of data to be handled, we require extremely large quantities of storage cells like Flipflops. Each Flipflop contains one bit which is either zero or one. Integrated circuits which serve this purpose are commercially available. One such IC is the popular 6116 memory IC, called a Static RAM. This Chip contains more than 16 thousand Flipflops. These Flipflops are internally arranged in such a way that they can be accessed externally using just a few pins (16 thousand pins are not required).

Now let us see another variation of our basic Flipflop. Connect two more NAND gates as shown in figure 3.

![Flipflop Circuit]

This arrangement is called a controlled or clocked R-S Flipflop. The Flipflop of this circuit can change its state only when a "1" appears on the control or clock input C.

![Flipflop Circuit]

The last condition which was present when \( C \) changed to "1" is retained, depending on which input had a "0" at that moment.

The \( C \) input thus behaves like a "Store" command input. The input conditions present when this input gets the "Store" command (logical "1" on \( C \)) are allowed to set or reset the Flipflop and this condition at the output is retained till a new "Store" command appears at pin \( C \).

One disadvantage that still remains in this circuit can be removed by modifying it as shown in figure 4. Now we have only one input D for Set/Reset and one input for the control command "Store".
The restriction of having to use a zero as an input on R and S is now removed. The pin D can accept either zero or one.

<table>
<thead>
<tr>
<th>D</th>
<th>C</th>
<th>Q</th>
<th>\overline{Q}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0/1</td>
<td>1/0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1/0</td>
</tr>
</tbody>
</table>

Depending on the last condition when a “1” appeared on C.

The functioning of this circuit can be summed up briefly as follows.

“1” appearing on D sets the Q output to “1”.

“0” appearing on D resets the Q output to “0” provided a “1” was present on C. When a “0” is present on C, input D becomes ineffective.

As we have already seen, truth tables in case of Flipflops have ambiguous entries due to the time dependent nature of Flipflop operation. A better way to understand Flipflop operation is the use of timing diagrams.

The NOR-Flipflop functions a bit differently from the NAND-Flipflop. Now that you have studied the NAND Flipflop in detail, it will not be difficult for you to prepare the truth table for the NOR-Flipflop as well, along with the timing diagrams.

A simplification of the circuit of figure 7 is also possible, and it is given below for reference.
... do you know different word for resistors?

"No"

"Semiconductors!"

"Why do you say that? Resistors are not semiconductors"

"Why not? If something has almost no resistance, we call it a conductor. If something has such a high resistance that it does not allow any flow of current, we call it a non-conductor. So if something has a resistance in between these two, we must call it a semi-conductor!"

"No, it is not so. The resistors are not semiconductors. The word semiconductor has a different meaning.

"Semiconductors are materials which sometimes conduct and sometimes don't. When they conduct and how much they conduct depends on various other factors."

"Then these semi-conductors must be some sort of switches!"

"No, these are not switches either. You are somewhere near the truth. We shall see a semiconductor with an example. You have seen a diode. This is a semiconductor. It has two leads, and its symbol is like an arrow head and a bar. A current can flow through the diode if it has a direction which coincides with that of the arrow. In the other direction, no current can flow.

For simplicity, let us say that when the plus pole of the applied voltage is behind the arrow, a current can flow. However, when the plus pole is in front of the arrow, the bar between the plus pole and the arrow head can be imagined as blocking the current flow. This is why we can call the diode as an electrical 'One Way street'."

"Exactly that is what a diode is!

It acts as a conductor for current trying to flow in the direction of the arrow and it acts as a non-conductor for current trying to flow in the opposite direction. This is the reason why it is called a semiconductor. We can also compare the diode with a unidirectional valve which opens only in one direction.

"But how do you compare this with a switch?"

"Let us again take the example of a diode."

This illustration shows a diode connected in series with a lamp and a battery. As we have already seen, the diode will allow the flow of current because the plus pole is behind the arrow head. The current will flow through the lamp and the lamp will glow. This diode is acting as a closed switch between the battery and the lamp.

Let us see now, what happens when the battery polarity is reversed.

This time the plus pole is in front of the arrow head and the bar comes between them. The current flow will be blocked by the bar and the lamp will not glow. The diode now behaves as an open switch."

"Then this circuit can be used as a polarity tester?"

"Right! The diode can certainly be used to check the polarity, because it behaves as a closed switch with the correct polarity and as an open switch with the wrong polarity."

"Is that all a diode can do?"

"Of course not! The diode is a very versatile device. Haven't you seen these diodes in a battery eliminator? There they work even longer at a time."

"What are these diodes doing in a battery eliminator?"

"Diodes are used to rectify the alternating voltage. We have already shown how alternating voltage behaves, haven't we?"

"Yes, I remember quite clearly. The alternating voltage changes its polarity hundred times every second. Therefore on every terminal of the plug socket there is always a plus pole and a minus pole alternately..."

"... and on the other terminal, it is the opposite, i.e., minus pole and plus pole."

"That is quite logical!"

"And for obtaining a direct voltage from an alternating voltage, we put a diode in the circuit. It allows the current to flow when the polarity is correct. It blocks the current flow when the polarity is wrong. As the diode allows only half the cycle of the alternating current to pass through, it is called a half wave rectifier."

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Transistors

"...What are transistors?"

"Transistors are also semiconductor devices like diodes. We have seen how diodes function like one way valves. Transistors also behave like valves, but with a difference. Transistors are valves for electrical currents which can be regulated. With transistors, we can make currents flow with greater or lesser intensity"

"They are the water taps of electronics"

"Right!"

"But then the current can also be regulated with a potentiometer"

"A potentiometer has to be turned mechanically. It has a rotating spindle and a knob. The transistor has no such mechanical parts, it functions fully electronically. Most of the transistors are quite small and they have three leads coming out at the bottom"

"Three terminals? Then certainly it has some kind of a potentiometer inside?"

"No, transistors and potentiometers have absolutely nothing in common. The transistors have two very intelligently designed diodes inside them as you can see in the illustration given here."

"How can you control current with two diodes?"

"No, it is not at all possible just with two diodes. But it can be done with a transistor. The illustration we just saw is nothing but a simplified view and not an actual combination of two ordinary diodes"

"I don’t understand!"

"This is how it happens. When a positive voltage is applied to the base, a current flows through the diode between the base and the emitter."

(Illustration)

"Now, if we apply a negative voltage to the collector current is also allowed to flow through the diode between the base and the collector."

(Illustration)

"That is right, and with a plus pole connected to the collector...

...the upper diode will block the current! What is the use of all this?"

"Just wait. It is certainly true that the upper diode will block. But as I have already said, these are just ordinary diodes. These diodes are designed in such a way, that the upper diode becomes conductive due to the current flowing through the lower diode. To simplify the matters we can say that the current flowing into the base terminal, takes along a current from the collector and comes out through the emitter terminal."

"Unbelievable! Do you mean to say that a current flowing into the base can make the upper diode conduct a current from collector to emitter even with a plus pole connected to the collector?"

"That is exactly what happens inside a transistor. However when there is no base current, the upper diode can block the current and no current can flow from collector to emitter."

"This means that the transistor is working like a remote control switch, which is switched on and off by the current flowing through the base."

"Yes, it can be used as a switch controlled by the base current. Incidentally, as the transistor is not just two diodes connected together, it has been given a different symbol."

"Does the transistor work only like a switch? Then what does it do in an amplifier?"

"The collector current is not only switched on and off by the base current. It can also be regulated by the base current. As in case of our water tap, the quantity that can flow through is adjustable. The collector current can be as strong as 500 times the base current. A base current of just two microamperes can cause a collector current of about one milliampere, which is quite a substantial amount in electronic circuits."

"This means that a transistor can also be called an amplifier?"

"Yes, and the ratio of the collector current and the base current can be said to be the amplification factor of that transistor."

"Do the Hi-Fi Stereos also function in the same manner?"

"You are right! However, a large number of transistors and many other components are necessary to obtain the Hi-Fi quality stereo amplification."

"Has nobody ever thought of building an amplifier from water taps? We could call it an Under-water Hi-Fi?"
**Resistance Bridges**

In electronics, circuits similar to that shown in figure 1 are called bridges. When all the elements of such a circuit are rectifier diodes, we call it a rectifier bridge - which is commonly used in battery eliminators. When all the elements of such a circuit are resistors, we call it a resistance bridge. The circuit of figure 1 is also known as a 'Wheatstone Bridge'.

Now, let us see the functioning of this bridge circuit. Figure 2 shows a practical bridge circuit, drawn in a simplified manner for better understanding. The two branches made up of R, R, and R, R, are nothing but voltage dividers. The meter connected between these two branches at the junctions between R, R, and R, R, measures the difference between the two junction points.

In the circuit of figure 2, the left branch R, R, divides the voltage into 2V on R1 and 3V on R2. The right branch divides the 5V supply voltage into 2.5V and 2.5V across R, & R.

The difference voltage thus becomes $3V - 2.5V = 0.5V$ which is measured by the meter and indicated.

If we now reduce R1 to 260Ω instead of 400Ω, the voltage across R2 will increase by about 0.5V. This will increase the reading on the meter across the junction points by 0.5V. The meter connected directly across R2 will also show an increase in reading by 0.5V.

A very important fact can be observed here that for a rise of about 17% in the voltage across R2 there has been a rise of 100% in the difference voltage across the junction points of the bridge, which can also be called as the bridge voltage. The above observation shows how sensitive the bridge voltage is, in relation to any change in the individual branch voltages. Even the slightest change in branch voltages will be reflected as a large deviation in the bridge voltage.

When the ratios of the voltage divider branches on left and right are both exactly identical, the bridge voltage is zero.

This condition of the bridge when the voltage divider ratios of both the branches are identical is known as the balanced condition - the bridge is said to be a balanced bridge.

A simple application of this bridge circuit is shown in figure 3, which works as a light intensity meter. One of the resistors in the left branch of this bridge is an LDR. The Resistance of an LDR in darkness is very high, whereas its resistance in light falls as the intensity of light increases. Thus the voltage across R1 becomes dependent upon the intensity of light falling on the LDR. The potentiometer P1 can be adjusted to compensate for voltage across R1 so that
the meter reading becomes zero. If the potentiometer knob is provided with a dial, it can be calibrated to read the light intensity.

This circuit can work even without the resistance R2 (1KΩ) shown in dotted lines, but to protect the LDR from excess current when the potentiometer is in the extreme lower position, R2 should be included in the circuit.

The potentiometer position required, to obtain zero reading on the meter when the LDR is in total darkness, can be marked as zero intensity. The light can then be increased in known steps of intensity level and every time the position of potentiometer can be marked with the known value.

This circuit can be easily assembled on a small SELEX board and calibrated using a standard light intensity meter as a reference.

For a resistance bridge, the individual values of the resistances are not important. The operation depends only on the resistance ratios of the individual branches. When the resistance ratios of the left and right branch become equal, the bridge voltage becomes zero, irrespective of the individual values of resistors and supply voltage.

Figure 1:
Standard configuration of a bridge circuit. The individual elements can be any type of impedances, or even rectifier diodes.

Figure 2:
The meter connected across the junction points measures the voltage difference between those two points. The sensitivity of this measurement is much more than that of a meter directly connected across one of the voltage divider resistors.

Figure 3:
A simple light intensity meter. The potentiometer is used to balance the bridge in such a manner that the voltage across the shunt arm of the bridge is zero.

Figure 4:
The circuit of figure 3 can be assembled on a small SELEX PCB.

Resistance Decade Box

Even though the resistance decade is not a very sophisticated circuit, it has very great practical utility. The resistance decade box can be used for experiments, testing, bridge balancing, voltage dividers, and many other practical applications. The values available being adjustable from 10Ω to more than 1MΩ.

The circuit is shown in figure 2. This is a selectable series connection of total 50 resistors. Individual resistors are added in to the series combination by selecting the switch positions. Each switch selects the number of resistors from a group of 10 resistors from a group of 10 resistors of equal value. The total resistance of equal value. The total resistance comprises of effectively 6 different resistance values selected by the 5 switches, as shown in figure 3. The individual values of resistors used in each group are selected in such a way that each switch represent a decimal place in the final effective combination of the five groups.

The series combination of five groups R1...R5, added up to make the total resistance Rg = R1 + R2 + R3 + R4 + R5, lies between the external sockets A and F of the decade box. It is not essential that sockets A & F must be used as the two ends of the effective resistance from the decade box. Any pair of.
Sockets can be used for this purpose, depending on the required resistance value, as shown below:

\[ R(A-C) = R1 + R2 \]
\[ R(B-D) = R2 + R3 \]
\[ R(C-F) = R3 + R4 + R5 \]

As the 5 groups of resistors covered by the 5 switches have 10 resistors of equal values each - the switch position multiplied by the individual resistor value gives the effective values of \( R1 \) to \( R5 \).

For example, switch 1 controls a group of 10 resistors of 100K\(\Omega\) each. Thus the switch 1 set to position 3 will give a value of 300K\(\Omega\) for \( R1 \). Switch 1 set to positions 0 to 10 will give values of 0 to 1M\(\Omega\) in steps of 100 K\(\Omega\) each.

The individual values within each group are selected as multiples of 10. Group 1 has 10 resistors of 100K\(\Omega\) each, group 2 has 10 resistors of 10K\(\Omega\) each and so on, group 5 has 10 resistors of 10\(\Omega\) each. 

Advantage of this selection of values is that each switch represents one decimal place.

Every switch is connected with an external socket, so that any of the 5 groups can be used to make up the required value of resistance. Using all five decimal places may turn out to be ineffective due to the individual tolerance values of resistors. For instance, let us examine a setting of switches in the sequence 51381 \( (513810\Omega) \). As we have used resistors with 1% tolerance, the error on the 1st switch itself can build up to 5\(\Omega \) (1% of 500K\(\Omega\)) thus making the setting of 4th and 5th switches superfluous. In spite of this drawback, the decade box is provided with five switches, so that the full range of values is available to the user.

**Construction Details**:

The construction of resistance decade box mainly consists of soldering work and mechanical fitting work. The 50 individual resistors must be soldered onto the lugs of the 5 different switches as shown in figure 5. The final fitting into a standard enclosure is simple, as shown in figure 4.

1% Metal Film Resistors must be used if a good accuracy is to be achieved. Even 5% Carbon Film Resistors will work equally well if the accuracy aspect is neglected.

**Applications**:

This resistance decade box can be used as an adjustable resistor, or as a voltage divider.

When using this as a adjustable resistance, only 3 digits (switches) can be used at a time due to the accuracy consideration we have already seen. The remaining two switches can either be set to zero or

![Diagram](image-url)
we can use only the sockets relating to the switches of interest.

When using the circuit as a voltage divider, any one of the sockets B, C, D, E can be used as the output socket for the divided voltage and the switches can be set to suitable positions to achieve the desired voltage division.

A more useful application of this circuit is as a decimal voltage divider. For this the switch settings must be in the sequence 9, 9, 9, 9, 10 on the five switches from left to right. The effective distribution of resistors is as shown in figure 5. By connecting a voltage $V$ across sockets A and F we are able to get the following voltage outputs on the sockets:

A = $V$
B = $V/10$
C = $V/100$
D = $V/1000$
E = $V/10000$
F = 0

This has been achieved by the fact that the resistance between the pairs of sockets are distributed as follows:

$R_{(A-F)} = 1M\Omega = R_g$
$R_{(B-F)} = 100\; K\Omega = R_g/10$
$R_{(C-F)} = 10\; K\Omega = R_g/100$
$R_{(D-F)} = 1\; K\Omega = R_g/1000$
$R_{(E-F)} = 100\; \Omega = R_g/10000$

Using this circuit it is possible to obtain very small voltages. For instance, a 4.5V battery connected across sockets A and F will give a voltage of 450 micro volts at socket E.

Figure 1:
A good sturdy sheet metal enclosure gives a professional appearance to the decade box. The front panel graphics has been designed for ease of understanding the operation.

Figure 2:
The resistance decade contains 50 resistors. They are divided into 5 groups. Each group has one selector switch for selecting the individual digit value of that decimal place.

Figure 3:
The effective combination of the resistances. R1, R2, ...... R5 are selected by the switch positions. A, B, C, ...... F are the sockets on the front panel.

Figure 4:
Inside view of the assembled decade box. The switches are mounted on front panel.

Figure 5:
Use of the resistance decade box as a decimal voltage divider. Voltage divisions available are from $1/10$ to $1/1000$

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The Digilex-PCB is made from best quality Glass-Epoxy laminate and the tracks are bright tin plated, the track side is also soldermask after plating. Block schematic layout of components and terminals is printed on the component side.

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SOUND WAVE GAUGE
Anushya have developed the Cut (compensated ultrasonic technique) instrument for measuring the travel time and velocities in solids. Based on NGRI’s Patent No. 406 DEL/83, the solid-state digital instrument uses a direct pulse for opening an electronic gate from a compensating set of no delay acoustic transducers, and another delayed pulse from a second set of acoustic transducers to close the gate of an electronic timer/counter, displaying the gated interval digitally. The instrument finds applications in studying the sound wave velocities under varying environmental conditions in geology, geophysics, civil and mining engineering, and material sciences.

DIGITAL TACHOMETER
Spectrum Services offer the digital tachometer Model AT-100 to measure rotational surface speeds over a range of 0 to 10,000 RPM, to an accuracy of 1 RPM. A memory circuit facilitates measurement of speed at inaccessible places. The memory is actuated by a touch switch. Storage is indicated by LED. The built-in auto shut-off circuit switches off power after 35 seconds if left unattended. The instrument works on 6V DC off four pen cells.

SOLID-STATE RELAY
ERI’s J Series solid-state relays offers the features of logic compatibility (TTL/CMOS), zero turn-on/random turn-on, 2,500 VAC optoisolation, or microsecond switching. It is totally potted to minimise the effects of humidity and vibration. The relay can handle up to 40 A and 480 VRMS. It finds applications in programmable logic controllers, machine tool controls, process control instrumentation, traffic controls, etc.

CONTACTLESS MAGNETIC PROXIMITY SWITCHES
IEC have brought range of magnetic proximity switches, basically Reed switches actuated by a magnet in their proximity. The actuating magnet is either provided separately (NO type) or in the same housing as the switch (NC type). The switches are available in both AC and DC versions, and can switch loads of up to 750 mA. They feature applications make use high speed counting, where the performance of microswitches would fail short. Typical applications can be found in lifts, plain paper copiers, counters, etc.

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ELECTRONIC PROJECT KIT
EHC offer the 40-in-1 electronic project kit, an electronic educational aid with fun and games. The kit covers sound, music, disco test circuits, timer, communication circuits, etc., from basic to advance. A feature of the kit is that it involves no soldering part and can be used repeatedly — and even a non-electronic person can handle the kit easily. A 50-page instruction manual in colour is provided with the kit, which comes in a plastic cabinet of 30 x 20 x 5 cm with accessories.

* Alekai India January 1969.1.69
new products

DIGITAL PANEL METER
The DIC DI 80 3½ digit panel meter, suitable for OEM production of digital instruments, is housed in 88 x 28 mm panel cut-out metallic box. It is available in two basic ranges of 200 mV and 1.999 V DC operating at 5 or 15 V for a range of parameters. Also available are DMPs for measuring high DC and AC voltages, ohms and DC AC current. The DPMs are provided with auto polarity, over-range indication and programmable decimal indication. Other options are also available with facilities such as mains operation, multiplexer of parallel 8CD output. Hold condition, use of external reference, etc.

DISPOSABLE DISC WITH HOLDER
Imexu (India) have developed a disposable disc with holder based on technical know-how from the Fabrlt Organisation of UK. The disc is suitable for applications such as cleaning, surface preparation and conditioning, micro-deburring, polishing decorative finishing, deburring, and drilling in a variety of industries—electronics, woodworking, aerospace, automotive, ceramic, metal, and non-metal. The 75-mm dia disc is made from low density, three dimensional impregnated abrasive with controlled cutting action fits the holder without the use of any tool, by positive mechanical locking in a fraction of a second. The holder has a 6-mm dia spindle and, as such, can be mounted on any portable stationary tool. The holder need not be removed from the tool/machine for changing the disc. The disc is available in four types of construction—plan, sprial wound back, and pura—end in aluminium oxide and silicon carbide of 80–600 grit. The product comes in kits of 15 discs each with two holders.

SOLDERING IRON
SOLDRON have recently introduced a 50 Watt/230V soldering iron. This new model has features similar to the 25 Watt quick heating light weight soldering iron. Due to its high efficiency, the 50 Watt soldering iron can replace the conventional 65 Watt soldering iron and the resulting saving is electrical consumption is claimed to be about 20%. The iron comes with a 'Cool Grip' polypropylene handle, 5mm spade and 5mm chisel type slip on bits are available.

QUARTZ DIGITAL STOPWATCH
ION Electicals have developed a quartz digital stop-watch, which features the Lap function (useful in sports events), an accuracy of 0.001% at 25°C, and a resolution of 0.01 second (for readings up to 30 minutes). The full range covers 12 hours. The stop-watch has two modes of operation—Start/Lap/Stop and Start/Stop. The ergonomically designed case fits perfectly in the palm and operation is controlled by two thumbswitches. On the switch being pressed, a beep sound indicates that the switch has made proper contact. The switches are positioned such that left or right handed operation is equally easy. The stop-watch works on a single penlite cell with a service life of about two years. It measures 6.5 x 11 x 3 cm and weighs less than 150 g. A silk strap is provided for safe handling.

LIGHTED PUSH BUTTONS
Efficient Engineers have developed a new series of lighted push buttons and indicators with rectangular bezel of 48 x 24 mm. Two independent lamp circuits and one or two pole self cleaning and snap acting microswitches in momentary or maintained action are offered. Any legend can be engraved on the front fascia. These push buttons are suitable for process control instrumentation, supervisory remote control systems, data acquisition, control systems, sequencing logic controls, hierarchy controls and tum key instrumentation.

16 PIN IC CLIP
Contech have introduced their T-161C clip for 16 pin DIL packages. It provides easy access to ICs through non-shorting electrical contacts with positive mechanical clamping. Selectively gold plated spring bress contacts are designed for wiping action. The contact-comb with its insulating barriers provides easy positioning and prevents accidental shorting of adjacent leads.

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Great little printer

Now available from STC Electronic Services is the Centronics GLP (Great Little Printer) Series dot matrix printer. Completely portable at 3 kg, a measures just 330x261x70 mm, features a print speed of 50 c.p.m. (dot printing), near letter quality printing (12 c.p.m.): character pitch of 5, 8, 5, 10, and 17 c.p.m.; horizontal tabulation, 48 international characters, high resolution pin addressable and IBM PC block graphics. The GLP offers a choice of enlarged, condensed, emphasized, and double-strike print modes, as well as subconc, superscript, and underlining facilities. In addition, two coats besides the original may be obtained.

To interface the printer with a wide range of commercially used PCs, simply requires a connecting cable to a Centronics parallel interface or a single unit incorporating the parallel interface plus the RS232. The GLP's low cost, ease of operation, size and compactness make it an ideal choice for the personal computer user. STC Electronic Services, Edinburgh Way, Haltow, Essex CM20 2DE, Telephone: 0279 26881 (3280 11)

New rotary step switch

A new range of versatile rotary miniature step switches, manufactured by Henripot of Switzerland, is now available from Stanley Components. The HS 24 12 range allows users to choose up to 12 switching positions and segments all have a make or break switching option.

Various output pin arrangements are available. Maximum switching voltage is 250 V AC or 150 V DC, and the maximum switching current is 0.5 A AC or DC. Stanley Components Limited, Business Centre, Hay Lane, Buntingstoke, Essex CM7 6ST, Telephone: (0378) 40902 (3280 7F)

µP programmable mapping decoder

A new low power 16D-CMOS programmable mapping decoder, the type MV74HC715, designed for use in high speed memory and peripheral address decoding systems, has been announced by Philips. The device can also be used as a 9 bit pin programmable decoder.

The MV74HC715 encodes two binary inputs, A<0> to A<7>, to select one of four mutually exclusive, active low outputs (00 to 03). It is able by a pin-programmable 9 input AND gate. Each output is active high while E<9> is active high; while E<9> may be programmed active high or active low in any combination by hard wiring inputs P<1>, P<2> and P<3>.


Hybrid and stepper motors

Creutz's new range of hybrid and permanent stepper motors which includes twenty-one types plus controllers for the hybrid servo step per motor range and five types plus controllers for the permanent magnet stepper motor range, offers significant advantages over many existing products.

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Crouzet Limited, 108 Hawley Lane, Farmborough, Hants GI4 4YH, Telephone: (0263) 55211, Telex: 856901 (3280 4F)

Capacitive proximity sensors

Following the recent introduction of inductive proximity sensors and photoelectric devices, Sigma has now added a new range of capacitive proximity sensors to its already extensive switch and sensor range. The new capacitive range contains both DC and AC models which will sense most materials including liquids.

DC models are tubular with either plain all plastic bodies or threaded metal-cased bodies. The shielded models have a sensing range of 15 mm, unshielded ones 20 mm. Output is a p n p or n p n, normally open, with a maximum output current of 200 mA.

A similar range of sensors is available for AC input. The shielded and unshielded models have sensing ranges of 15 mm and 20 mm respectively, while a flat disc model offers an extended sensing range of 70 mm. AC sensors have NC or NO output at 5...200 mA.

Sigma Limited, Springfield Road, Letchworth, Herts SG6 4AJ, Telephone: (0462) 3841, Telex: 856386 (3280 11F)

Single-chip TV control and tuning IC

The new SAA1280 from ITT Semiconductors provides push-button synthesized tuning of up to 16 stations, and analogue volume, brightness, contrast, and saturation controls. The chip features three bandswitch and one VCR switch outputs, four analogue outputs, four half-standard switching output for a 1½ digit station display, muting during change of station or band, and tuning voltage generation with rate multiplexer. The device connects to a 28-pin package which automatically debounces. The keypad and display use common lines for economy, the display being interrupted for key pad scanning. In addition to direct station selection, the SAA1280 also provides sequential station selection, automatically scanning through the stations at 150 millisecond intervals.
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 corrections

QL RAM extension

[Aug/Sept 1986, p. 54] In the text (penultimate paragraph) it is erroneously stated that in the 64-k extension pin 11 instead of pin 13 of IC must be used as CS. In fact pin 11 must be used in both extensions
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