where do we go from here?
The Proto-Board®

Now circuit designing is as easy as pushing a lead into a hole.

No soldering.
No de-soldering.
No heat-spoilt components.
No wasted time.

With a Proto-Board you can hook your circuit together as quickly as you can think.

And you can have second thoughts, and third thoughts, equally quick and easy, till you've got the whole thing right.

Then you can solder up if you want to, but most engineers don't because the Proto-Board push-fit connectors are highly reliable.

And everything is visible; come back next week and you 'read' the circuit immediately.

Contact terminals are arranged in sets of five, each connected across the back, and in the Model 203A illustrated you get 1770 contacts, in six rows of 59 x 5, plus four double power rails, each with 100 contacts connected lengthwise and two horizontal power units with 40 contacts each. Many other models; see chart.

Proto-Board breadboards will accept transistors, ICs, LSI packages, resistors, capacitors, LEDs, trimmers, relays etc.; most plug straight in.

Try one. You'll wonder how you ever managed without it.

<table>
<thead>
<tr>
<th>Model Number</th>
<th>No. of solderless tie points</th>
<th>IC Capacity (34 pin DIPs)</th>
<th>Unit Price</th>
<th>VAT</th>
<th>Total Price</th>
<th>Other features</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB-6</td>
<td>630</td>
<td>6</td>
<td>£9.20</td>
<td>£0.82</td>
<td>£11.01</td>
<td>Kit - 10 minute assembly</td>
</tr>
<tr>
<td>PB-100</td>
<td>750</td>
<td>10</td>
<td>11.80</td>
<td>1.02</td>
<td>13.82</td>
<td>Kit - with larger capacity</td>
</tr>
<tr>
<td>PB-101</td>
<td>940</td>
<td>10</td>
<td>17.20</td>
<td>1.48</td>
<td>18.68</td>
<td>Distribution buses, higher capacity</td>
</tr>
<tr>
<td>PB-102</td>
<td>1240</td>
<td>12</td>
<td>22.95</td>
<td>1.94</td>
<td>24.89</td>
<td>Large capacity, moderate price</td>
</tr>
<tr>
<td>PB-103</td>
<td>2250</td>
<td>24</td>
<td>34.45</td>
<td>2.88</td>
<td>37.33</td>
<td>Even larger capacity; only 1.73 pence per tie-point</td>
</tr>
<tr>
<td>PB-104</td>
<td>3060</td>
<td>32</td>
<td>45.95</td>
<td>3.80</td>
<td>49.75</td>
<td>Largest capacity; lowest price per tie-point</td>
</tr>
<tr>
<td>PB-203</td>
<td>2250</td>
<td>24</td>
<td>55.15</td>
<td>4.53</td>
<td>60.68</td>
<td>Built-in 1%; regulated 5V, 1A low ripple power supply</td>
</tr>
<tr>
<td>PB-2206</td>
<td>2250</td>
<td>24</td>
<td>74.10</td>
<td>6.10</td>
<td>80.20</td>
<td>As above plus separate ½ Amp + 15V and - 15V internally adjustable regulated supplies</td>
</tr>
</tbody>
</table>

How to order. Telephone 01-890 0782 and give us your Access, Barclaycard or American Express number, and your order will be in the post that night. Or, write your order, enclosing cheque, postal order, or stating credit card number and expiry date. (Don't post the card!). Alternatively, ask for our latest catalogue, showing all CSC products for the engineer and the home hobbyist. (Prices are for UK only. For Europe add 10%, outside Europe add 12½% to total prices.)

CONTACTENIAL SPECIALTIES CORPORATION (UK) LTD
SPUR ROAD NORTH FELTHAM TRADING ESTATE FELTHAM
MIDDLESEX TW14 1PD
TELEPHONE: 01-890 0782 TELEX: 8813069.

Registered in London 317790 VAT No: 224470 7477
TRADE MARK APPLID FOR "CSC" UK LTD 1977
DEALER ENQUIRIES WELCOME

How to order. For delivery by return please send cheque or order. Personal customers can use Access, Barclaycard or American Express Card; order by post or phone, or send for complete CSC catalogue.
Happy birthday transistor

Within the lifetime of many Elektor readers a revolution has occurred whose consequences are so far reaching that they cannot accurately be predicted. In the space of 30 years the semiconductor industry has grown from nothing to the multi-million pound giant that it is today.

The following - of necessity somewhat generalised - article traces the major developments in the evolution of semiconductors, showing how they have affected the life of the average person. The discussion is rounded off with a look at what the future holds - in what areas semiconductors will continue to exercise a shaping force in modern life.

Although the junction transistor was invented during the last days of 1947, and indeed the field-effect transistor had been postulated some years earlier, it was 1948 that marked the birth of the semiconductor industry, for in that year the first practical transistor was produced by Bell Telephone Laboratories. This was a point-contact device developed by Bardeen and Brattain, who discovered it almost by accident whilst investigating the properties of point contact diodes in an attempt to develop a fuller understanding of the physics involved. While probing a germanium base material with wire contacts, one emitting current into the base material and the other collecting current from it, they discovered that current amplification was occurring.

It is amusing to note how the terms associated with transistors, and indeed the circuit symbol for a transistor, sprang from those early experiments.

It soon became apparent that the point contact transistor was difficult to produce in large quantities, and also had severe performance limitations, particularly in regard to power handling. The junction transistor, which had been developed by Bardeen and Brattain's co-worker Shockley, was a much more practical device, and 1950 saw the introduction of the first commercial junction transistor. These early devices were of the alloy junction type, typically fabricated by alloying pellets of indium to either side of a thin silver of germanium, as shown in figure 1.

The late 1940s and early 1950s saw the rapid growth of electronics for military and aerospace applications, where small size, low power consumption and reliability were of paramount importance. The 1940s also witnessed the birth of the electronic digital computer. Although calculating machines using relay logic had been developed prior to and during World War II, primarily for cryptanalysis, these were slow and frequently unreliable. The first completely electronic computer, using valves, was developed by mathematicians from Cambridge University in order to decipher the German 'enigma' codes. This was followed in 1945 by ENIAC, a massive computer employing some 18,000 valves and occupying 3000 cubic feet, which was developed at the University of Pennsylvania. The use of valves instead of electromechanical elements greatly increased the speed at which data manipulation and mathematical operations could be performed. However, ENIAC more or less represented the limit of valve computers because of reliability problems, to say nothing of size and power consumption. The relatively high failure rate of valves meant that a computer with several thousand valves would spend a significant part of its life having valves replaced, whilst a computer with tens of thousands of valves would be almost impossible to maintain in working order.

With transistors, on the other hand, once early 'infant mortality' failures have been eliminated the life of a device is almost indefinite, and of course even early transistors offered a considerable size advantage over valves, as shown in figure 2.
Military and aerospace requirements gave a large initial impetus to the semiconductor industry and as the potential of computers were realised, so the developing computer industry became a large user of semiconductors.

The initial impact of semiconductors on the average person was less dramatic, since domestic electronic equipment of the 1950s was generally limited to simple, linear circuits such as radios, TV sets and record players, employing relatively small numbers of valves, which at that time were cheaper than transistors. It was not until the late 1950s and early 1960s, when transistors became cheaper due to their extensive use for military and computer applications, that the craze for compact transistor radios marked the first inroads of semiconductors into the consumer market.

The early transistors were almost exclusively germanium devices. However, as the semiconductor industry grew the properties of other semiconductor materials were investigated, and silicon ultimately displaced germanium as the most widely used material. Silicon offers a number of advantages; to begin with, it is an extremely common element, the world's beaches contain vast amounts of silicon in the form of sand (silica). Silicon transistors exhibit lower leakage currents than germanium types and can operate at higher temperatures.

Planar devices
Alloy junction transistors, although offering considerable advantages over valves, were far from ideal. In particular the cutoff frequency (the maximum frequency at which a transistor will operate) was limited to a few hundred kilohertz in early transistors, or exceptionally a few Megahertz. The cutoff frequency of a transistor is limited by the time taken for charge carriers to cross the base region, and hence by the thickness of the base region. With the alloy junction process it was extremely difficult to achieve base widths much thinner than 25 microns. The alloy junction process was also not suitable for extremely high volume production because of the fact that each transistor had to be processed from an individual sliver of base material.

The problems of more closely controlled manufacture and high-volume production were solved with the introduction of the planar process, which was developed by Jean Hoerni of the Fairchild company in 1958. This allowed many transistors to be fabricated simultaneously on a large wafer of semiconductor material. An outline of the planar processing technique is shown in figure 3.

The starting material for a batch of NPN transistors would be a thin wafer of uniformly doped N-type silicon, which ultimately forms the collectors of the finished transistors. The first step in the manufacturing process is to grow, over the entire surface of this wafer, a thin layer of silicon dioxide. On top of this is laid down a photographic resist essentially similar to that used in the production of printed circuit boards. Over the wafer is placed a photographic mask which has transparent areas defining the base regions of the transistors, and through this mask the photoresist is exposed to (ultraviolet) light. The photoresist is then developed, when the exposed portions are dissolved away.

The wafer is then placed in hydrofluoric acid, which etches away the silicon dioxide where it is not protected by the photoresist, a process known as photolithography. The resist is then removed using hydrogen peroxide solution.

The next step is to place the wafer in a furnace containing a P-type
Figure 3. Fabrication of a planar transistor.
dopant gas. Where the silicon dioxide has been etched away the gas diffuses into the wafer and changes the doping to P-type, thus defining the base regions of the transistors. Elsewhere the dopant does not penetrate the impervious silicon dioxide layer.

The silicon dioxide is then removed using hydrofluoric acid, a new layer is grown and the whole process is repeated using a mask to define the emitter regions, and an N-type dopant gas.

The silicon dioxide layer is again removed, a layer of aluminium is deposited over the whole surface of the wafer. This is then selectively etched away using the photolithographic process, leaving aluminium connection 'pads' to which the collector, base and emitter wires will eventually be bonded. Each transistor is then tested automatically, rejects being marked with an ink spot, after which the wafer is diced up into individual transistor 'chips' which are then packaged.

Unpackaged semiconductors and other components are added later, after which the whole assembly is mounted in a protective package with connection pins. However, for mass production a technique was required whereby entire circuits could be fabricated in one piece, in other words monolithic integrated circuits.

Using the planar process it was possible to produce large numbers of transistors and/or diodes on a single silicon wafer. Reverse-biased p-n junctions could also be used to form modest value capacitors (up to 1000pF) whilst the bulk resistance of the silicon could be used to make a limited range of resistor values. In fact the only components impossible to fabricate on a semiconductor wafer were (and still are) inductors. All the components required for an integrated circuit could be produced, and the only problems which needed to be solved were a) electrical isolation of the components, since normally they would be joined by the silicon substrate, b) interconnection of the components into the desired circuit pattern.

The first problem was solved by making use of the isolating properties of a reverse-biased p-n junction. For example, if a number of NPN transistors are fabricated in a wafer of P-type material then the junction formed by the P-type substrate and the N-type collector regions of the transistors can be reverse-biased, thus isolating the transistors from one another.

The solution to the second problem was inherent in the highly insulating silicon dioxide layer which was a vital part of the planar process. An insulating layer of this oxide could be grown over the entire surface of the finished chip, except for 'windows' at points where connections were to be made to components. On top of the oxide layer an aluminium interconnection pattern could be deposited, which would not make contact with the silicon except through the windows. The steps in the fabrication of a typical bipolar integrated circuit are illustrated in figure 4.

**Integrated circuits**

Even with the planar technique the individual transistors still had to be physically separated, packaged in a protective casing and subsequently assembled into electronic circuits. The miniaturisation requirements of the military/aerospace industries and the use of thousands of identical circuits in digital computers led to a demand for the integration of complete circuits into small packages. *Hybrid* circuits were an early attempt at integration, and indeed are still used in many applications. In a hybrid circuit resistors and 'wiring' are printed onto a ceramic substrate, whilst

---

Figure 4. A cross-section of an IC showing the aluminium interconnection pattern on top of an insulating layer of silicon dioxide.
The first successful monolithic integrated circuits were developed around 1959 and the 1960s saw a rapid growth in the quantity, variety and complexity of ICs, with an equally dramatic fall in cost. If the 1950s was the decade of the transistor, then the 1960s was certainly the decade of the IC. The rate of increase in the complexity of ICs since their inception has been absolutely staggering. Taking 1959 as the starting point, up to which time only single transistors could be made, the maximum number of components in an IC (i.e. the most advanced IC for a particular year) has doubled every year. This exponential growth, which is illustrated in figure 5, shows no signs of decreasing and probably will not until the physical limitations of IC manufacturing technology are reached.

MOS ICs
Early integrated circuits utilised exclusively bipolar transistor technology, and indeed many still do. Whilst the power consumption of bipolar ICs was many orders of magnitude less than that of valves it was still appreciable, especially in complex ICs. The development of ICs based on Metal Oxide Semiconductor Field Effect Transistors (MOSFETs) allowed the production of complex (Large Scale Integration or LSI) circuits in milliwatts. Until the early 1970s the effect of ICs on the consumer market had largely been to replace functions previously performed by discrete components, for example the integration of audio amplifiers, TV i.f. amplifiers and colour decoders, and so on.

The introduction of MOS LSI technology allowed the creation of new types of consumer products, and the mid 1970s saw a proliferation of pocket calculators, digital watches and TV games which marked the beginning of the swing from linear to digital circuits in consumer electronics.

Memories
Computers require large amounts of memory in which to store data. Until the advent of semiconductor memories the usual form of memory was magnetic core store, backed up by magnetic tape or disc for long term storage. With the advent of semiconductor memories, the size and cost of data storage systems fell dramatically. Since their cost can be measured in terms of 'price per bit', semiconductor memories provide a useful indicator to the downward trend of IC costs, as shown in figure 6. The complexity of memories has also increased greatly. Whereas a few years ago, a memory capable of storing 1k (1024 bits) of data was considered as 'state-of-the-art' 4k and 16k memories are now commonplace, whilst 64k, 256k and 1M (one million bit!) memories are confidently predicted. The rapidly falling cost of electronic data storage will undoubtedly have a profound influence on life in the 1980s and beyond.

Figure 5. This graph shows how the complexity of ICs has doubled every year since 1959.

Figure 6. Costs of semiconductor memories have fallen dramatically.
Figure 7. The 'chip' of a memory IC.
been known that electronic circuits could replace mechanical and electromechanical functions in many types of equipment. To take a mundane example, the cam-timer in an automatic washing machine could be replaced with an electronic timer and some logic circuits in an IC package. However, to design an IC specifically for this purpose would be uneconomic, and if any design change was required at a late stage in the development this would mean developing a different IC, which would be out of the question. A microprocessor, on the other hand, can be used in a wide variety of control applications simply by changing its programme, which can be stored in an inexpensive Read Only Memory (ROM). This gives great flexibility during the design phase and also offers the possibility of modifications at a later date without any of the retooling costs involved in changing a mechanical part. This illustrates the superiority of a software approach.

The future
What of the future? The advent of VLSI (Very large Scale Integration) with ever increasing numbers of electronic functions on a single chip means that electronics are entering into more and more fields which previously were cost-prohibitive. The introduction of electron beam and X-ray techniques in the fabrication of micro-electronic circuits is expected to lead to a further increase in the bit density of memories by a factor of 100, with only minor increases in cost. There will be few areas of our life, which ultimately will not be touched by this electronic revolution. The µP-controlled washing machine, sewing machine, and oven are already with us. They can be expected to take over the control of thermostats in central heating and solar energy systems, refrigerators, burglar and fire alarms etc. Microprocessors are already incorporated in automobiles, controlling exhaust emission and ignition timing, thus improving fuel economy, and in the near future they will be connected to safety devices such as anti-skid sensors. In industry, microprocessors are increasingly appearing on the shop floor in a wide variety of adaptive control processes, hopefully freeing many workers from boring and repetitive jobs. In education and leisure activities the microprocessor is a powerful learning tool. Children may well become as familiar with the CRT of their µP terminal as their parents were with the sight of their teachers. The home computer offering computing capability equal to that provided by the most powerful main-frame of only a few years ago is now available for no more than the cost of a colour TV set or a stereo system.

Microprocessors
Mention the word ‘microprocessor’ to many people and they will immediately think of ‘home computers’, but a microprocessor is much more than just this. Of course a microprocessor can be used as the central processor in a small computer system, and for a few hundred pounds one can purchase a system with the processing power of a large computer of the 1960s. However, the majority of applications for µPs are likely to be in dedicated systems. It has long
Perhaps the greatest impact of microprocessors and semiconductor memories however, will be the so-called 'paperless information revolution'. Teletext is already here — and Viewdata almost. The introduction of these two services could mark the beginning of a change in the lifestyles of a large percentage of the population, as the domestic TV set becomes more than just a box on which to watch the offerings of the TV companies. For example, why travel for half an hour or more on a crowded bus to do the shopping when one can simply select and order goods from a catalogue displayed on the TV screen? (Will this bring the demise of the high street shop?) Why commute 100 miles or more to the office when the same work could be done at home using the TV to call up the necessary data? Why watch boring repeat programmes when one could play chess with a friend (or a computer) hundreds of miles away? The list of speculations for a data network using the TV screen as a data terminal are virtually endless. However, bringing the world into one's living room in this way is certain to entail profound sociological changes. Will we become passive conditioned consumers of the products fed onto our screens by those who control the information media. Will there be increasingly less social contact between people? Will the TV end up watching us? Fanciful though it may seem, remember that nineteen eighty-four is not far away!

Semiconductor manufacturer directory.
The following is a list of some of the main semiconductor manufacturers whose products are distributed in the U.K. The manufacturers should be able to provide further details regarding local representatives/distributors in your area.

AEI Semiconductors
Carholme Road,
Lincoln.
LN1 1SG
Tel: 0522 29992

AEG Telefunken
Bath Road,
Slough.
SL1 4AW
Tel: 0753 87210

Analog Devices
Central Avenue,
East Molesey,
Surrey.
Tel: 01-941 0466

Advanced Micro Devices
Ebury Gate,
23 Lower Belgrave Street,
London, S.W.1
Tel: 01-730 0855

AMI Microsystems
108a Commercial Road,
Swindon,
Wiltshire.
Tel: Swindon 31345

Fairchild Semiconductor Ltd.
Kingmaker House,
Station Road,
New Barnet,
Herts.
ENS 1NX
Tel: 01-440 7311

Ferranti
Fields New Road,
Chadderton,
Oldham.
OL9 8NP
Tel: 061-624 0515

GEC Semiconductors Ltd.
East Lane,
Wembley,
Middlesex.
HA9 7PP
Tel: 01-904 9303

General Instrument
Microelectronics Ltd.
57/61 Mortimer Street,
London, W1N 7TD
Tel: 01-636 2022

Intel Corp. (U.K.) Ltd.
Broadfield House,
4 Between Towns Road,
Cowley,
Oxford.
Tel: 0865 771431

Intersil Inc.
8 Tessa Road,
Richfield Trading Estate,
Reading,
Berkshire.
Tel: 0734 595011

Mostek U.K. Ltd.
Masons House,
1 Walley Drive,
Kingsbury Road,
London, N.9
Tel: 01-204 9322

Motorola Ltd.
York House,
Empire Way,
Wembley,
Middlesex.
Tel: 01-902 8836

Mullard Ltd./Signetics
Mullard House,
Torrington Place,
London, WC1E 7HD
Tel: 01-580 6633

National Semiconductor
U.K. Ltd.
19 Goldington Road,
Bedford.
Tel: 0234 211262

Newmarket Transistors Ltd.
Exning Road,
Newmarket,
Suffolk.
Tel: Newmarket 3381

Plessey Semiconductors
Cheney Manor,
Swindon, Wiltshire.
SN2 2QW
Tel: 0793 6251

Precision Monolithic
UK representatives are:
Bourns Ltd.
Hodford House,
17/27 High Street,
Hounsslow,
Middlesex.
TW3 1TE
Tel: 01-572 6513

RCA
Windmill Road,
Lincoln Way,
Sunbury-on-Thames.
Tel: 09327 85511

Rockwell
UK distributor:
Pelco Electronics Ltd.
Enterprise House,
83-85 Western Road,
Hove,
Sussex.
BN3 1JF
Tel: Brighton 0273 722155

Siliconix Ltd.
30a High Street,
Thatcham,
Newbury,
Berks.
RG13 4JG
Tel: 0635 64846

SGS-ATES (U.K.) Ltd.
Planar House,
Walton Street,
Aylesbury,
Bucks.
Tel: 0296 5977

Siemens
Great West House,
Great West Road,
Brentford.
TW8 9DG
Tel: 568 9133

Teledyne Semiconductors
Heathrow House,
Bath Road,
Cranford,
Hounslow,
Middlesex.
Tel: 01-897 2501

Texas Instruments
Manton Lane,
Bedford.
Tel: 0234 211655

Thompson-CSF
Ringway House,
Bell Road,
Bнесенhill,
Basingstoke.
RG24 0GG
Tel: 0256 29155
QUALITY COMPONENTS BY RETURN

C&N STEVENSON (K1) 236 High St, Bromley Kent BR11PQ Tel: 01 464 2951/5770
TTL and CMOS data

5. Definition of terms

set: a 1 at a set input makes the corresponding output 1.
clear, reset: a 1 at a reset input makes the corresponding output 0.
preset, load: a 1 at a load input makes the output assume the same value as the data input.
enable: a 1 at an enable input causes the logic circuit to function.
latch enable: a 1 at a latch-enable input causes the input data to be 'frozen' (at the output of a latch).
strobe: a 1 at a strobe input causes the output to follow the input data (thus latch enable = strobe).
inhibit: a 1 at an inhibit input disables the logic circuit so that the output is fixed and is no longer a function of the input variables.

All the above terms of course have their inverted versions, thus, for example, when a set input is 0, the corresponding output becomes 1.

TTL ICs - electrical characteristics

recommended supply voltage range: 4.75 - 5.25V
input voltage range: maximum 5.5V, minimum 0.5V
logic levels:
output | 1 | 2.4V
0 | 0.4V
input | 1 | 2V
0 | 0.8V

Input and output currents

(fan-in, fanout)

For a standard TTL input such as the 7400 the input currents are as follows:
high (logic 1 = 2.4V) : 40μA
low (logic 0 = 0.4V) : -1.6mA

The direction of positive current flow is taken as being into the IC, therefore ‘+1.6mA’ indicates that current flows out of an input in the low state. An input having these characteristics is said to be one standard TTL load or to have a fan-in of 1. The drive capability of TTL outputs is defined in terms of the number of standard loads it can drive. A normal TTL output can supply a current of -400μA in the high output state and 16mA in the low state. It can thus drive 10 standard loads and is said to have a fanout of 10.

Most TTL ICs have a fan-in of 1 and a fanout of 10. Where the fan-in and/or fanout differ from these values then this is indicated on the pinout diagram. In some cases the fan-in or fanout may be different in the high and low output states, and in such cases the 'worst case' value is given, i.e. the higher value in the case of fan-in and the lower value in the case of fanout.

For example: fan-in (high) = 3, fan-in (low) = 5; fanout (high) = 5, fanout (low) = 25; fanout is given as 15.

Other TTL families

In addition to the standard 74-TTL family there are several other TTL families low-power (74L), low-power Schottky (74LS), Schottky (74S) and high-speed (74H) TTL. Many of the standard TTL functions are available in these other families. The input and output current of these families differ from those of standard TTL and when interconnection between different families is to be made then the manufacturers' data should be consulted to check drive capability. However, when used with devices of the same family the fan-in and fanout figures given in the pinout charts apply.

Unused inputs

Unused TTL inputs assume logic 1 level and may be left floating if a high level is required at the unused input. However, for better noise immunity it is best to tie unused inputs to positive supply via a 1k resistor, which will limit input current if any transients appear on the supply line. If an unused input is to be at logic 0 then it is simply connected direct to the 0V supply rail.

Interfacing TTL to CMOS

TTL ICs will drive CMOS ICs' direct, provided that the CMOS supply voltage is the same as that for the TTL circuits (+5V). To ensure that the logic 1 output voltage of the TTL circuit is sufficiently high, connect a 2k2 pullup resistor between the output and +5V.
TTL Logic ICs – numerical index of popular types

7400 decade counter
7402 divide-by-12 counter
7403 4-bit binary counter
7405 4-bit parallel-in-parallel-out shift register
74121 monostable multivibrator
74122 retriggerable monostable multivibrator with clear
74123 dual retriggerable monostable multivibrator with clear
74125 quadruple buffer (3-state)
74132 quadruple 2-input NAND Schmitt trigger
74141 BCD-to-decimal decoder/driver with high voltage outputs (max 60V, 7mA)
74148 priority encoder
74164 8-bit serial-in, parallel-out shift register
74174 hex D flip-flop with clear
74190 synchronous BCD up/down counter
74191 synchronous 4-bit binary up/down counter
74192 synchronous decade up/down counter
*74LS241 octal buffer and line driver (3-state)
*74LS242 quadruple bus transceiver (3-state)
*74LS243 quadruple bus transceiver (3-state)
*81LS95 octal buffer (3-state)
*81LS97 octal buffer (3-state)
*Low-power Schottky types only, not available in standard TTL.

TTL Logic ICs – functional index gates, buffers, inverters

7400 quadruple 2-input NAND gate
7401 quadruple 2-input NAND gate with open-collector outputs
7402 quadruple 2-input NOR gate
7403 as 7400 but open-collector outputs
7404 hex inverter
7406 as 7404 but open-collector, high-voltage outputs (max 30V, fanout = 25)
7408 quadruple 2-input AND gate
7409 as 7408 but open-collector outputs
7410 triple 3-input NAND gate
7411 triple 3-input AND gate
7412 as 7410 but with open-collector outputs
7430 8-input NAND gate
7437 as 7400 but power driver (fanout = 30)
7440 as 7420 but power driver (fanout = 30)
7445 BCD-to-decimal decoder/driver
7447 BCD-to-7-segment decoder/driver
7470 AND-gated positive-edge triggered JK flip-flop with preset and clear
7472 AND-gated JK flip-flop with preset and clear
7473 dual JK flip-flop with clear
7474 dual D positive-edge triggered flip-flop with preset and clear
7475 4-bit bistable latch
7476 dual JK master-slave flip-flop with preset and clear
7478 4-bit comparator
7486 quadruple 2-input exclusive-OR gate
7489 64-bit read/write memory

7490 decade counter
7492 divide-by-12 counter
7493 4-bit binary counter
7495 4-bit parallel-in-parallel-out shift register
74121 monostable multivibrator
74122 retriggerable monostable multivibrator with clear
74123 dual retriggerable monostable multivibrator with clear
74125 quadruple buffer (3-state)
74132 quadruple 2-input NAND Schmitt trigger
74141 BCD-to-decimal decoder/driver with high voltage outputs (max 60V, 7mA)
74148 priority encoder
74164 8-bit serial-in, parallel-out shift register
74174 hex D flip-flop with clear
74190 synchronous BCD up/down counter
74191 synchronous 4-bit binary up/down counter
74192 synchronous decade up/down counter
*74LS241 octal buffer and line driver (3-state)
*74LS242 quadruple bus transceiver (3-state)
*74LS243 quadruple bus transceiver (3-state)
*81LS95 octal buffer (3-state)
*81LS97 octal buffer (3-state)
*Low-power Schottky types only, not available in standard TTL.

3-state buffers
74125 quadruple buffer
*74LS241 octal buffer and line driver
*74LS242 quadruple bus transceiver
*74LS243 quadruple bus transceiver
*81LS95 octal buffer
*81LS97 octal buffer
*Low-power Schottky types only, not available in standard TTL.

Miscellaneous
7485 4-bit comparator
7489 64-bit read-write memory
74148 priority encoder
CMOS Logic ICs — numerical index of popular types
4000 dual 3-input NOR gate plus inverter
4001 quadruple 2-input NOR gate
4002 dual 4-input NOR gate
4011 quadruple 2-input NAND gate
4012 dual 4-input NAND gate
4013 dual D flip-flop
4015 dual 4-bit static shift register
4017 divide-by-10 synchronous counter
4018 synchronous presettable divide-by-'n' counter
4020 14-bit binary ripple counter
4023 triple 3-input NAND gate
4024 7-stage binary ripple counter
4025 triple 3-input NOR gate
4027 dual JK flip-flop
4028 BCD-to-decimal decoder
4029 synchronous presettable binary/decimal up/down counter
4030 quadruplicate 2-input exclusive-OR gate
4035 4-bit parallel-in-parallel-out shift register
4040 12-bit binary ripple counter
4042 quad clocked 'D' latch
4046 micropower phase-locked loop
4047 monostable/astable multivibrator
4049 hex inverting buffer
4050 hex buffer
4051 8-channel analogue multiplexer/demultiplexer
4054 liquid-crystal display driver
4056 BCD-to-7-segment decoder/driver
4060 14-bit binary ripple counter and oscillator
4066 quadruplicate bilateral switch
4068 8-input AND/NAND gate
4070 as 4030 but will drive 2 low-power TTL loads
4071 quadruple 2-input OR gate
4073 triple 3-input AND gate
4078 8-input OR/NOR gate
4081 quadruple 2-input AND gate
4093 quadruple 2-input NAND Schmitt trigger
4098 dual monostable multivibrator
40106 hex inverting Schmitt trigger
4511 BCD-to-7-segment latch/driver
4518 dual 4-bit synchronous BCD up-counter
4520 dual 4-bit synchronous binary up-counter
4528 see 4098

CMOS Logic ICs — functional index gates, inverters, buffers
4000 dual 3-input NOR gate plus inverter
4001 quadruple 2-input NOR gate
4002 dual 4-input NOR gate
4011 quadruple 2-input NAND gate
4012 dual 4 input NAND gate
4023 triple 3-input NAND gate
4025 triple 3-input NOR gate
4030 quadruplicate 2-input exclusive-OR gate
4049 hex inverting buffer
4050 hex buffer
4066 8-input AND/NAND gate
4070 as 4030 but will drive 2 low-power TTL loads
4071 quadruple 2-input OR gate
4073 triple 3-input AND gate
4078 8-input OR/NOR gate
4081 quadruple 2-input AND gate
4093 quadruple 2-input NAND Schmitt trigger
4098 dual monostable multivibrator
4015 dual 4-bit static shift register
4035 4-bit parallel-in-parallel-out shift register
4042 quad clocked 'D' latch
4048 dual 4-bit synchronous BCD up-counter
4051 8-channel analogue multiplexer/demultiplexer
4054 liquid-crystal display driver
4056 BCD-to-7-segment decoder/driver
4511 BCD-to-7-segment latch/driver
4047 monostable/astable multivibrator
4098 dual monostable multivibrator
4528 see 4098

miscellaneous
4046 micropower PLL
4051 8-channel analogue multiplexer/demultiplexer
4066 quadruplicate bilateral switch.

Interfacing with TTL
A CMOS gate will drive one low-power (Schottky) TTL input, except for buffers such as the 4049 and 4050 which will drive two standard TTL inputs. The supply voltage of the CMOS circuit must obviously be the same as that of the TTL circuit (+5V).
EXPERIMENTING WITH SC/MP
BUILD YOUR OWN MICROPROCESSOR DEVELOPMENT SYSTEM
The Elektor Elector series leads to the construction of a hexadeclical seven segment microcomputer with a cassette interface. Further development is planned to produce a graphite compatible computer with visual display unit, cassette based programs and an extended memory capacity.

To enable you to reduce your costs we are preparing a kit order list for each part of the series to enable your to order just those parts you need and not to duplicate components you already have.

Please send your order list to the latest issue of Kettering 526010 for further details about the series

74 SERIES TTL

<table>
<thead>
<tr>
<th>PARTS</th>
<th>PRICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>7412</td>
<td>2.01/100</td>
</tr>
<tr>
<td>7414</td>
<td>2.10/100</td>
</tr>
<tr>
<td>7474</td>
<td>1.50/100</td>
</tr>
</tbody>
</table>

74 SERIES TTL (continued)

HARDWARE & EQUIPMENT

Edge connector 23 pin Ceramic........ 7.00 Edge connector 36 pin Ceramic........ 14.00

SWITCHES

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>PRICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIP Switch 12 mm........ 1.96</td>
<td>3.92</td>
</tr>
<tr>
<td>3 Way........ 1.36</td>
<td>2.72</td>
</tr>
<tr>
<td>1 Way........ 1.36</td>
<td>2.72</td>
</tr>
</tbody>
</table>

VERDICTS BOARD 1.5 mm

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>PRICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Way........ 1.36</td>
<td>2.72</td>
</tr>
<tr>
<td>1 Way........ 1.36</td>
<td>2.72</td>
</tr>
</tbody>
</table>

ST3 Soldering Iron Stand, complete with sponge 14.00

For X25 160

ORDERING DETAILS

DISCOUNT Mail order customers discount 10% in addition to the VAT and free delivery on orders over £50.00.

ORDER FORMS Printed order forms available at cost. All orders must be accompanied by full payment. PAYMENT Cash, cheque or postal order. Orders accepted. VISA, ACCESS, Diners, Mastercard and American Express accepted. Credit cards must be charged in advance. All credit cards must be cancelled within 30 days of order. Goods delivered by Royal Mail or by express courier. All goods delivered within 30 days of order. All goods must be unpacked and checked immediately on receipt. If returned, goods must be in good condition and undamaged, otherwise store will not accept returned goods.

ENQUIRIES Please send enquiries to ELEKTRONIQUE

LEAD SOLDER 0.35 mm........ 1.20

CAPACITORS

<table>
<thead>
<tr>
<th>CAPACITORS</th>
<th>PRICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 µF 10 PLY Tantalum........ 2.20</td>
<td></td>
</tr>
<tr>
<td>0.01 µF 10P Elna .............. 1.00</td>
<td></td>
</tr>
<tr>
<td>0.047 µF 10 PLS.............. 1.00</td>
<td></td>
</tr>
<tr>
<td>0.001 µF 10 PLS.............. 1.00</td>
<td></td>
</tr>
</tbody>
</table>

ORDERING DETAILS

DISCOUNT Mail order customers discount 10% in addition to the VAT and free delivery on orders over £50.00.

ORDER FORMS Printed order forms available at cost. All orders must be accompanied by full payment. PAYMENT Cash, cheque or postal order. Orders accepted. VISA, ACCESS, Diners, Mastercard and American Express accepted. Credit cards must be charged in advance. All credit cards must be cancelled within 30 days of order. Goods delivered by Royal Mail or by express courier. All goods delivered within 30 days of order. All goods must be unpacked and checked immediately on receipt. If returned, goods must be in good condition and undamaged, otherwise store will not accept returned goods.

ENQUIRIES Please send enquiries to ELEKTRONIQUE

LEAD SOLDER 0.35 mm........ 1.20

OPTOELECTRONICS

<table>
<thead>
<tr>
<th>OPTOELECTRONICS</th>
<th>PRICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 pF............ 1.50</td>
<td></td>
</tr>
</tbody>
</table>

ORDERING DETAILS

DISCOUNT Mail order customers discount 10% in addition to the VAT and free delivery on orders over £50.00.

ORDER FORMS Printed order forms available at cost. All orders must be accompanied by full payment. PAYMENT Cash, cheque or postal order. Orders accepted. VISA, ACCESS, Diners, Mastercard and American Express accepted. Credit cards must be charged in advance. All credit cards must be cancelled within 30 days of order. Goods delivered by Royal Mail or by express courier. All goods delivered within 30 days of order. All goods must be unpacked and checked immediately on receipt. If returned, goods must be in good condition and undamaged, otherwise store will not accept returned goods.

ENQUIRIES Please send enquiries to ELEKTRONIQUE

LEAD SOLDER 0.35 mm........ 1.20

LOW COST CMOS

<table>
<thead>
<tr>
<th>LOW COST CMOS</th>
<th>PRICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>6000A........ 1.00</td>
<td></td>
</tr>
<tr>
<td>6000A........ 1.00</td>
<td></td>
</tr>
</tbody>
</table>

ORDERING DETAILS

DISCOUNT Mail order customers discount 10% in addition to the VAT and free delivery on orders over £50.00.

ORDER FORMS Printed order forms available at cost. All orders must be accompanied by full payment. PAYMENT Cash, cheque or postal order. Orders accepted. VISA, ACCESS, Diners, Mastercard and American Express accepted. Credit cards must be charged in advance. All credit cards must be cancelled within 30 days of order. Goods delivered by Royal Mail or by express courier. All goods delivered within 30 days of order. All goods must be unpacked and checked immediately on receipt. If returned, goods must be in good condition and undamaged, otherwise store will not accept returned goods.

ENQUIRIES Please send enquiries to ELEKTRONIQUE

LEAD SOLDER 0.35 mm........ 1.20

CVRS, FILTERS & INDUCTORS

<table>
<thead>
<tr>
<th>CVRS, FILTERS &amp; INDUCTORS</th>
<th>PRICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 pF............ 1.50</td>
<td></td>
</tr>
</tbody>
</table>

ORDERING DETAILS

DISCOUNT Mail order customers discount 10% in addition to the VAT and free delivery on orders over £50.00.

ORDER FORMS Printed order forms available at cost. All orders must be accompanied by full payment. PAYMENT Cash, cheque or postal order. Orders accepted. VISA, ACCESS, Diners, Mastercard and American Express accepted. Credit cards must be charged in advance. All credit cards must be cancelled within 30 days of order. Goods delivered by Royal Mail or by express courier. All goods delivered within 30 days of order. All goods must be unpacked and checked immediately on receipt. If returned, goods must be in good condition and undamaged, otherwise store will not accept returned goods.

ENQUIRIES Please send enquiries to ELEKTRONIQUE

LEAD SOLDER 0.35 mm........ 1.20

TRANSISTORS & DIODES

<table>
<thead>
<tr>
<th>TRANSISTORS &amp; DIODES</th>
<th>PRICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 pF............ 1.50</td>
<td></td>
</tr>
</tbody>
</table>