Digital Electronics By Experiment

IAN SINCLAIR'S NEW SERIES IS DESIGNED TO IMPART THEORETICAL KNOWLEDGE THROUGH SIMPLE PRACTICAL EXPERIMENTS

MANY EXPERIENCED Constructors with several acres of transistor circuits behind them still fight a little shy of using digital integrated circuits. The reasons for this are not difficult to see. Most of the transistor circuits with which an experimenter learns his trade are fairly simple and show rather well how a transistor works, giving a feeling of confidence to the user.

The many excellent projects using digital integrated circuits which have been published do not give any such help to the constructor, however. They may be comparatively easy to build on a prepared PCB, they may even be reasonably easy to understand, but they do not give the constructor the experience which enables him to design confidently with ICs.

This series is intended to remedy that deficiency, so that the reader will gain a firm grasp of the principles of digital IC behaviour, how they work, and also a considerable amount of "hands-on" experience on a board designed to make experimenting with digital ICs particularly easy. We shall confine ourselves to the smaller scale ICs so that nothing as involved as a microprocessor will be used — the components however are chosen so that they give a good range of experience with some useful devices.

One and none

We can assume that any reader of ETI will already have some knowledge of what digital circuits are about, but perhaps a very brief reminder may be of some use. Digital ICs are made up from transistor circuits of very high gain, designed to run with inputs and outputs which take up one of two states which we call 1 and 0. In most applications, 0 will mean a voltage very near to earth potential, and 1 near to the full supply rail.

The ICs we shall use in this course will be from the well-known TTL series, developed by Texas, and also available from several other manufacturers. There are several reasons for this: the devices are readily available at very low prices, advertised in ETI and they are much less easily damaged electrically than the alternative CMOS.

O/C Inputs

When an input of a TTL gate is left open-circuit it automatically reverts to a "1". The reason for this is that the input to TTL gates is to one emitter of a multiple-emitter transistor whose base is connected through a limiting resistor to the +5 V line. Leaving an input o/c means that the emitter terminal will take up the same voltage as the base terminal. This cannot be done when CMOS devices are used.

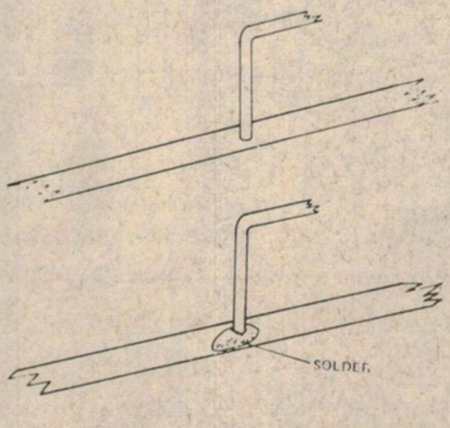

Fig.1. The method of attaching components to the Blob Boards. The 'leg' can be simply bent to one side and then soldered 'blobed' over the lead to hold it. Since the boards are tinned, and the leg ought to be, a sound joint is usually obtained.

For our course on digital electronics we shall need seven digital ICs and one "jumbo" display, a full inventory of semiconductors being shown in Table 1, and in addition we shall also need a few other assorted components. Where a 5 V supply is not available, a stabiliser can be included on the board, so that the experiments can be carried out using a car battery or any DC supply in the 6 V to 12 V range. Note that the current taken will be up to 350 mA.

Breadboard

The heart of the whole project is the circuit board on which the ICs and all other components can be mounted. This is one of the series of "Blob Boards" advertised in ETI — in this case the ZB-8-IC. Blob Boards consist of wide strips of tinned copper on the usual insulating board, and their main feature is that components are mounted on the same side of the board as the strips.

This, of course, is not a new principle in digital IC construction, since this method has been used for some time where digital ICs are mounted on double-sided boards.

The ZB-8-IC as its name suggests, has mounting pads for eight ICs, including the display which we have specified. The suggested layout for the ICs is shown in Fig. 3, where we can see that the top left hand corner houses the 7414 Schmitt inverter, and the 7400 Nand gate; the top right hand corner has the two 7476 J-K flip-flops. At the bottom left hand corner, we have a 7494 shift register and the 7490 decade counter. The bottom right hand corner contains the 7447 BCD-7 segment decoder-driver and the display. All of the ICs have conventional DIL fourteen or sixteen pin bases, but the display has a base which is an eighteen pin type

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with several pins omitted, so that this will just fit the pads on the board. The spacing between the lines of pins (0.6") is a little on the large side compared to the other ICs, but with care it can be accommodated. In the circuits which we are using we shall not normally need the decimal point on the display, but its connection may as well be made just in case.

Before any experiments are started then, it is advisable to solder all the ICs and the display on to the board, so that this does not have to be done when it becomes cluttered by other components. Since each circuit mounts on to pads which are isolated unless other connections are made, no harm is done by leaving an IC soldered on to the board.

It is for this reason, incidentally, that it is not desirable to use CMOS circuits in such a project, since the protection diodes built into CMOS ICs will operate only when the power supplies are connected.

In the prototype, the lines running round the edge of the Blob-board were used for supplies, the outer line taken as the positive 5 V line, and the inner as earth. It is quite convenient also if the shorter lines running across the board between each pair of IC pads are also used as 1 and 0 lines as well. The vertical lines at the centre of the board may also be used. If a regulated 5 V supply is available for operating the board then little else needs to be done other than connecting the power pack to the lines at the edge of the board.

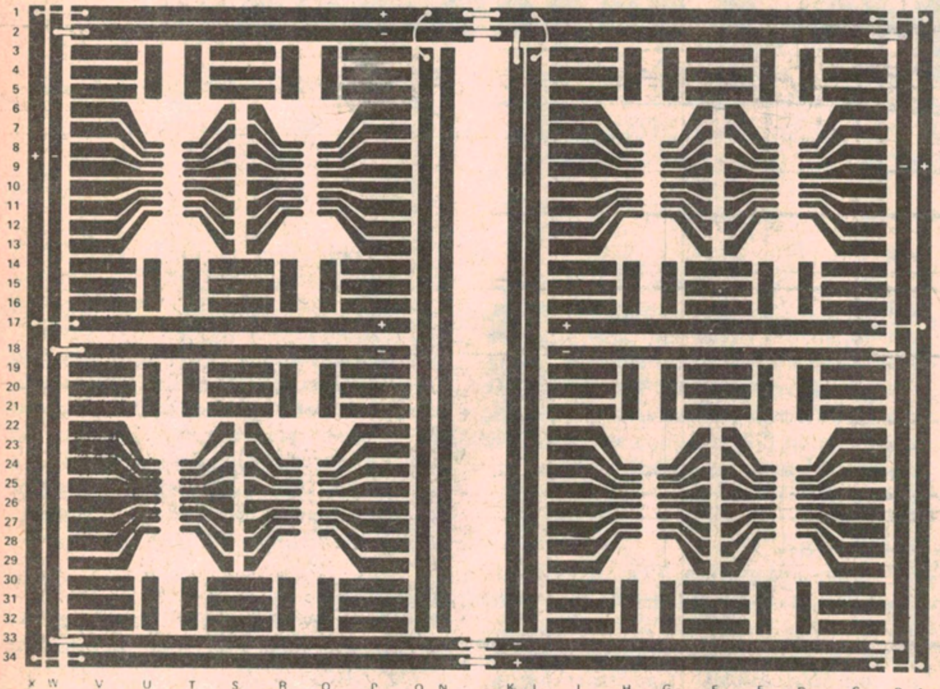


Fig. 2. Above: This is the track pattern for the ZB-8-IC used in this series. Note the wire links which need to be made in order more easily facilitate application.

Fig. 3. Below: Components in place on the board. Note that unlike our usual overlays, the tracks are on the SAME side as the components.

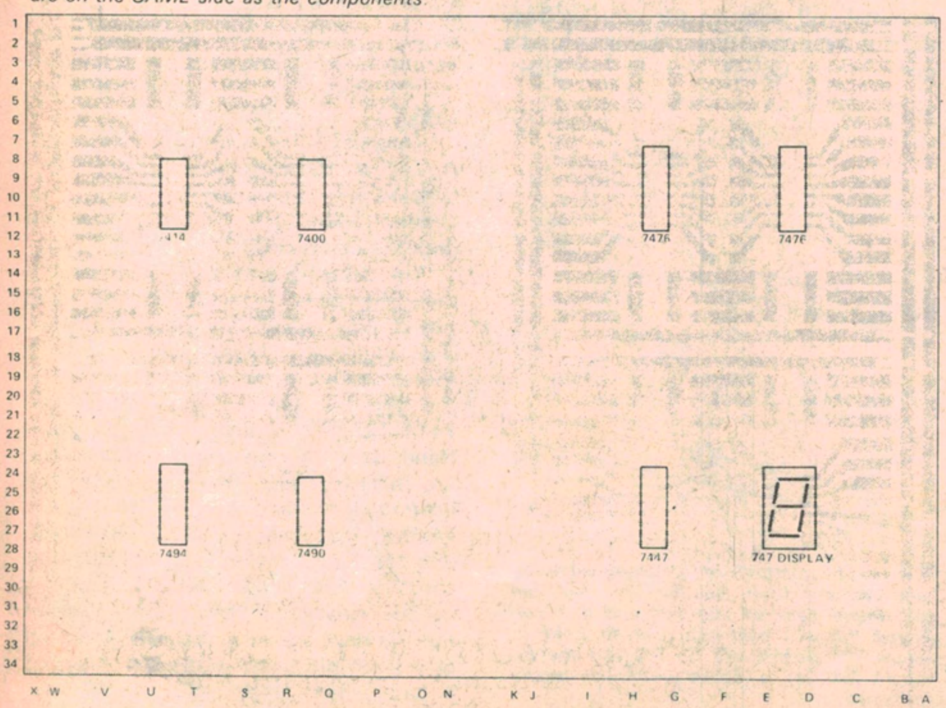
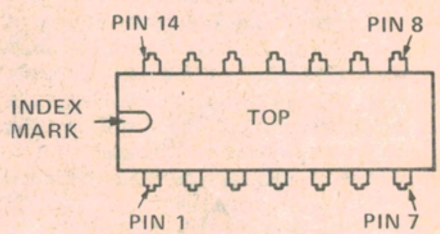
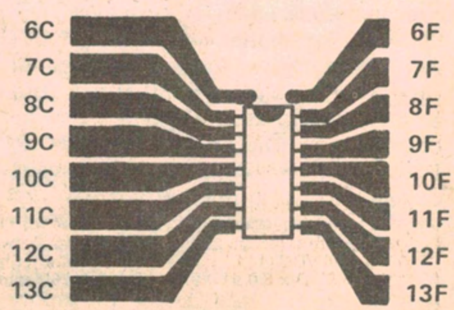


***Fig.4.** The layout for the digital TTL series. This is looking down at the device from above. Usually, but NOT always power is applied to pin 14 and pin 7 is earthed.*

***Fig.5.** Bottom: Positioning the ICs onto Blob-Board pads. Make shure the legs line up.*





Regulation

If a regulated supply is not available, however a regulator can be constructed, either on a separate board, or onto the Blob-board itself. A 7805 monolithic regulator IC, with 10 μF tantalum capacitors from input to ground and output to ground, can easily be mounted on the centre tracks J, K, and N (with N as input).

It is extremely important that TTL circuits should not be operated at voltages above 5.25 V AT ANY TIME, since the inputs to TTL circuits are to the emitters of transistors, with the bases connected to the positive supply. If the inputs to the emitters are earthed, too much current will flow in the base-emitter junctions, though if all the inputs are earthed, over-voltage is much less likely to cause damage.

Led about the board

Above and below each mounting pad there are several short pads, usually three horizontal and two vertical, and these are very useful for mounting components such as LEDs, which are used to indicate the state (0 or 1) of any output. Note that on most LEDs there is a flat portion of the plastic case near the leadout wires which indicates which leadout wire is the cathode. Since we are using the LEDs to light on a "1" state, the cathode of each LED is connected to earth, and the anode through a limiting resistor to the IC output. This resistor value is higher than we would normally use, but suits this application, as we do not want the LEDS to draw too much current from the IC outputs. When we come to use the display, we shall also use large value limiting resistors.

With all the ICs mounted in place, we are ready to start our work on Digital Electronics By Experiment, with the first set of experiments in next month's issue.

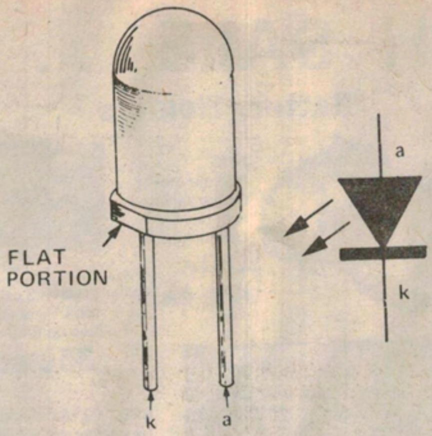


Fig.6. Identifing LED connections has caused many a paralysed moment of doubt — look for the flat bit, if there's one present then your problems are over.

Note: Only the essential basic components are listed here. For various additional suggested experiments, additional resistors and capacitors will be needed; these values will be critical.

SEMICONDUCTORS

1 x SN7414N
1 x SN7400N
2 x SN7476N
1 x SN7494N
1 x SN7490N
1 x SN7447N
1 x 747 Display

OTHER COMPONENTS

1 x 0.1uF
1 x 1.0uF
1 x 10uF
1 x 100uF
1 x 680uF
1 x 1000uF
All the above 10V working, or more.
10 x 470R resistors, 0.125W or more
6 Miniature push-button switches.
5 metres of single-core wire.

BOARD

1 ZB-8-IC Blob-Board

For a few applications in later parts of this series, a silicon NPN transistor may be used as an alternative to some long stretches of wiring (to connect a reset terminal on a counter). For this application, any working small signal type is suitable.