PROTOTYPING BOARD FOR IBM PCs

The insertion card described here enables you to build, quickly and easily, extension circuits intended to stay inside an IBM PC or compatible.

by A. Rigby

A prototyping card is an essential item if you want to equip your PC with a new feature, say, a sound generator, a voice synthesizer, or a relay driver card, which is as yet in the development phase. Although prototyping cards for the PC are available ready-made from PC hardware suppliers, they are pretty expensive. As regards the choice of the interface to which the prototyping board is connected, the extension bus of the PC is the only viable alternative. Adequate as they are for their specific applications, the other interfaces, the parallel printer ports and the serial ports, are not really suitable for prototyping purposes, if at all they are 'free'. The prototyping card described here is, therefore, designed as an insertion card for the internal bus of the PC.

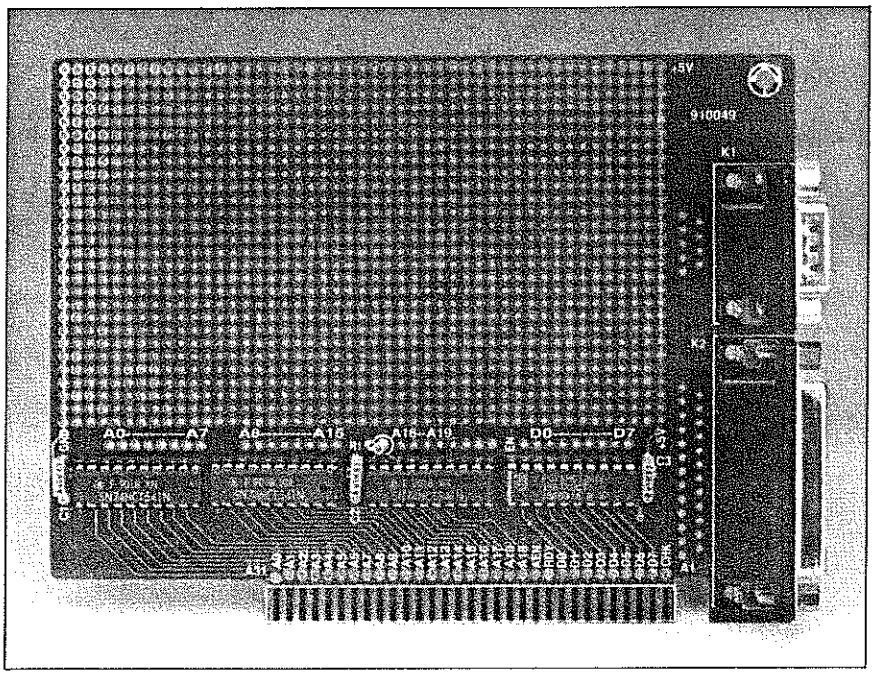
The circuit

The circuit diagram of the prototyping board, Fig. 1, is really not more than a couple of buffer devices that serve to protect both the PC hardware and the circuit under development. Address decoding is not implemented here—this function has be provided by the circuit you wish to develop. In most cases, the address area reserved for prototyping boards will be used. According to the address assignment drawn up by IBM (see Table 2), prototyping cards must be located between 300_H and $31F_H$ in PC XTs and ATs.

Returning to the circuit diagram, the contact fingers on the board that connect to the PC bus extension slot are shown at the left as rows A and B. The card is equally suitable for 8-bit and 16-bit slots.

At the top of the diagram we find the databus buffer, IC4, whose direction (DIR) input is controlled by the buffered $\overline{IORD}$ signal supplied via buffer IC3. The logic level of the $\overline{IORD}$ line indicates whether the PC performs a read or a write operation. The enable ($\overline{G}$) input of the databus buffer is pulled to +5 V by resistor R1, and may be driven by the prototype circuit.

The address bus of the PC is buffered by IC1 and IC2, and four buffers contained in IC3. These three ICs are Type 74HCT541 octal non-inverting buffers with three-state outputs. Their outputs may be used to drive an address decoder in the prototype circuit. All three ICs have their enable inputs, $\overline{G1}$ and $\overline{G2}$, tied to ground, so that they are permanently enabled.



Bus signals

The pin functions of the 8-bit extension slot connector in IBM PCs and compatibles are given in Table 1. A number of the signals available on this connector are of special interest, and described below.

OSC (pin B30) carries the clock signal of the I/O bus. The standard frequencies are 4.77 MHz in XTs, and 14.318 MHz in ATs. The mark/space ratio of this clock signal is 1:1.

CLK (pin B20) carries the system clock signal, which in the standard IBM PC is one third of the oscillator frequency, i.e., 1.59 MHz (4.77 MHz/3). The mark/space ratio of this signal is 1:2. It should be noted that the OSC and CLK frequencies used in today's PCs are much higher than those in the original IBM PC XT.

RESET (pin B02) serves to initialize the system when the power is switched on, or after a 'hang up' or hardware reset.

$\overline{IOWR}$ (pin B13) is supplied by the bus controller, usually a Type 8288, and serves to indicate memory write operations.

$\overline{IORD}$ (pin B14) is also supplied by the bus controller, and serves to indicate memory read operations.

$\overline{MEMRD}$ (pin B12) indicates read operations by the processor or the DMA controller.

$\overline{MEMWR}$ (pin B11) indicates that the data on the databus can be written to the location addressed by address lines A0 to A19.

The first thing to design into any circuit to be built on the prototyping card is a decoder that ensures proper addressing in the range reserved for the application. Figure 2 shows

a simple address decoder based on a word comparator IC, the 74HCT688. All that is required to actually use this circuit is to set the switches in the DIL switch block to the required address, and connect the $\overline{\text{SELECT}}$ output to the EN input of the databus buffer in the PC interface, IC4. The address comparator uses 'full' I/O access decoding by making use of a logic combination (in an AND and an OR gate) of the AEN (address enable), $\overline{\text{IORD}}$ and $\overline{\text{IOWR}}$ signals, the latter two being supplied via buffers in IC3. The $\overline{\text{SELECT}}$ input goes low when the address preset on the switch block matches that supplied by the PC.

Finally, note that the memory area reserved for prototype card is relatively

Signal name	Pin designation track side		Pin designation component side	Signal name
GND	B01		A01	$\overline{\text{I/O CHCK}}$
RESET	B02		A02	D7
+5V	B03		A03	D6
IRQ2	B04		A04	D5
−5V	B05		A05	D4
DREQ2	B06		A06	D3
+12V	B07		A07	D2
reserved	B08		A08	D1
+12V	B09		A09	D0
GND	B10		A10	I/O CHRDY
$\overline{\text{MEMW}}$	B11		A11	AEN
$\overline{\text{MEMR}}$	B12		A12	A19
$\overline{\text{IOWC}}$	B13		A13	A18
$\overline{\text{IORC}}$	B14		A14	A17
$\overline{\text{DACK3}}$	B15		A15	A16
DREQ3	B16		A16	A15
$\overline{\text{DACK1}}$	B17		A17	A14
DREQ1	B18		A18	A13
$\overline{\text{DACK0}}$	B19		A19	A12
CLK	B20		A20	A11
IRQ7	B21		A21	A10
IRQ6	B22		A22	A9
IRQ5	B23		A23	A8
IRQ4	B24		A24	A7
IRQ3	B25		A25	A6
$\overline{\text{DACK2}}$	B26		A26	A5
TC	B27		A27	A6
ALE	B28		A28	A3
+5V	B29		A29	A2
OSC	B30		A30	A1
GND	B31		A31	A0

Table 1. Pinning of 8-bit bus extension slot.

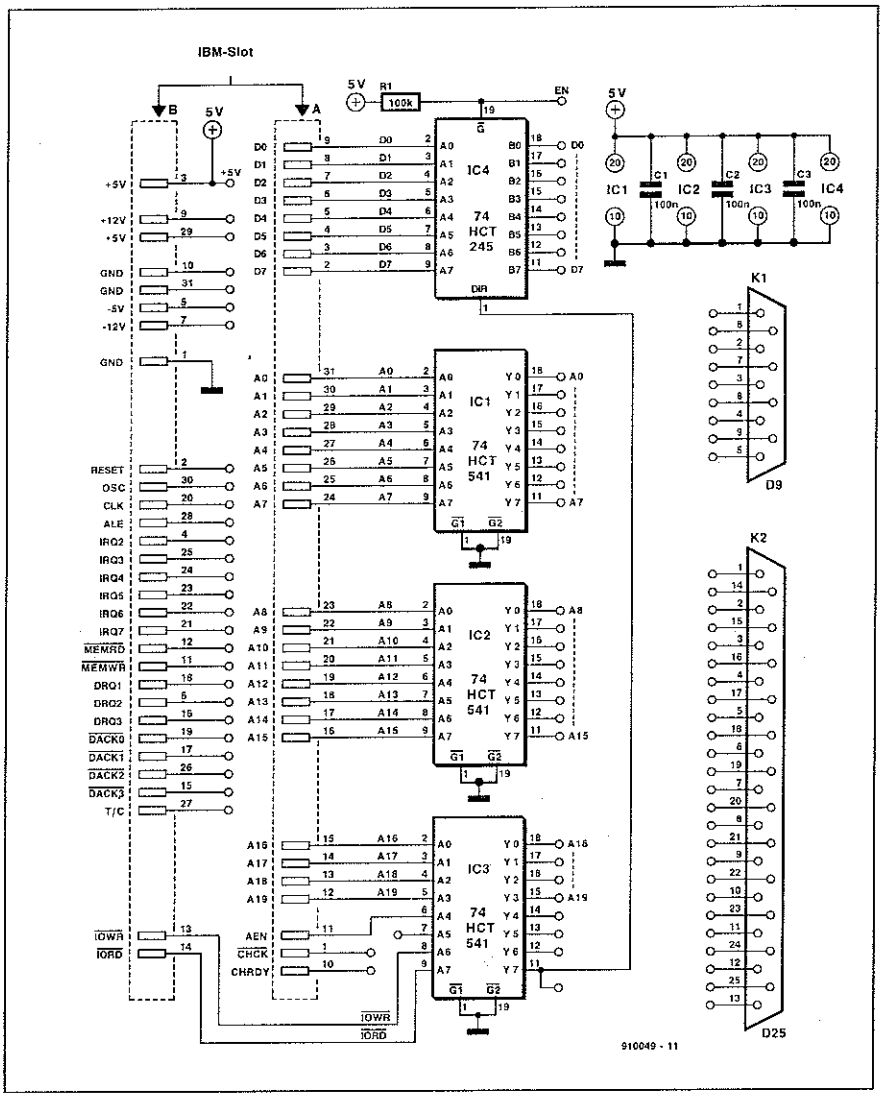


Fig. 1. Circuit diagram of the prototyping card. The ICs serve to prevent overloading of the PC's data lines, address lines, and a number of control lines.

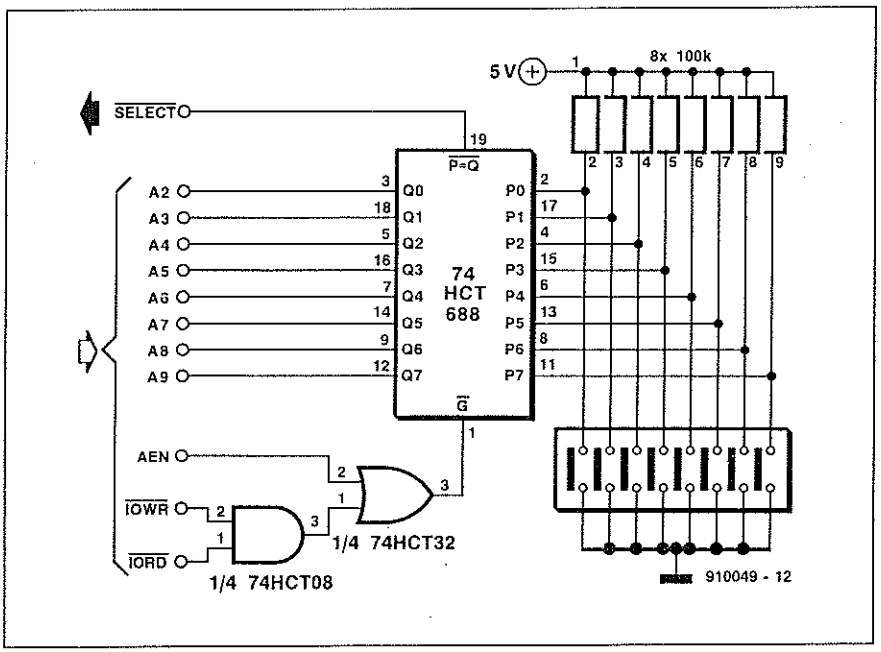


Fig. 2. A 'classic' address decoder based on an 8-bit magnitude comparator IC. The base address assigned to the prototyping card is set as an 8-bit word on the switch block.

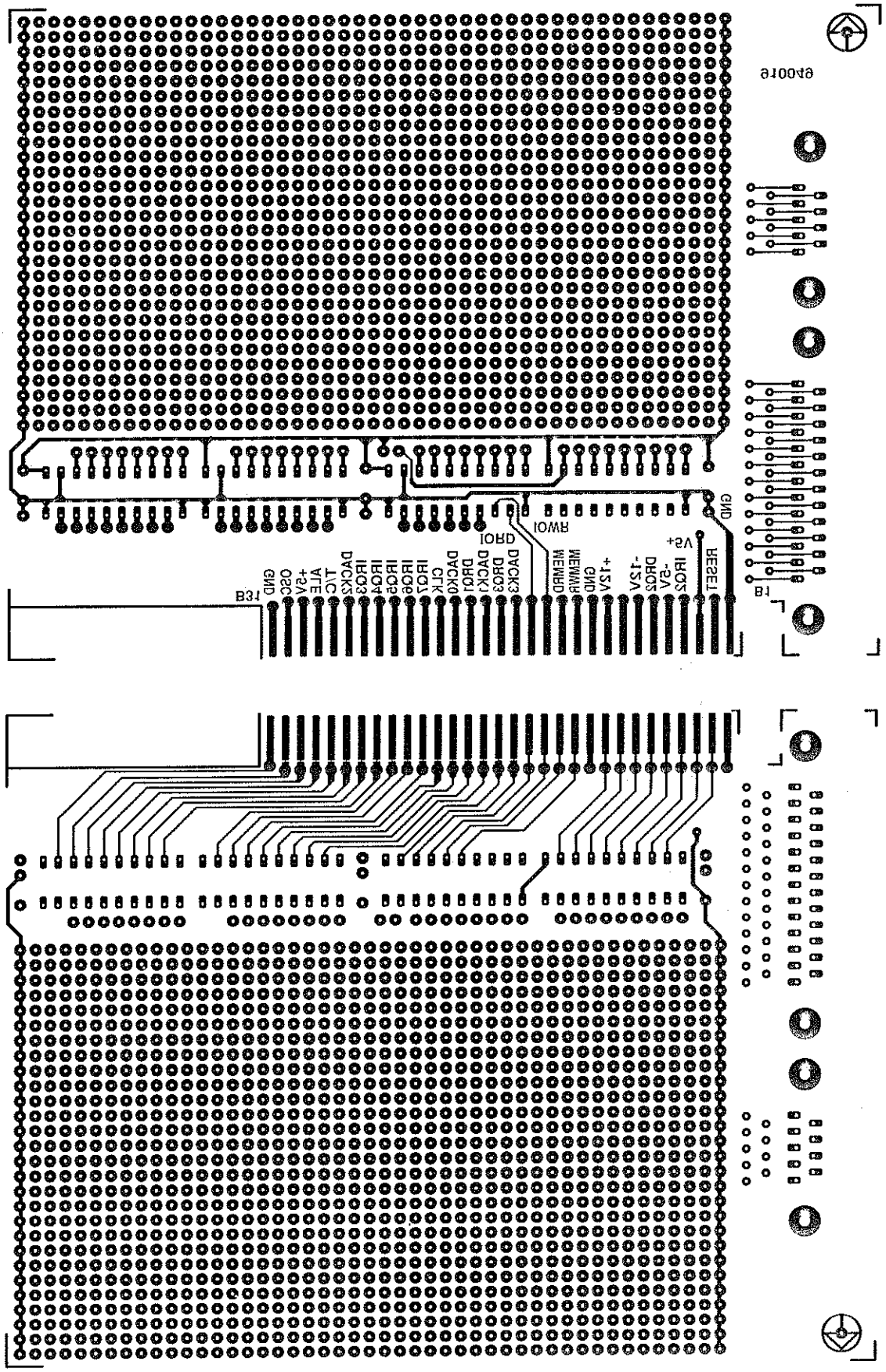
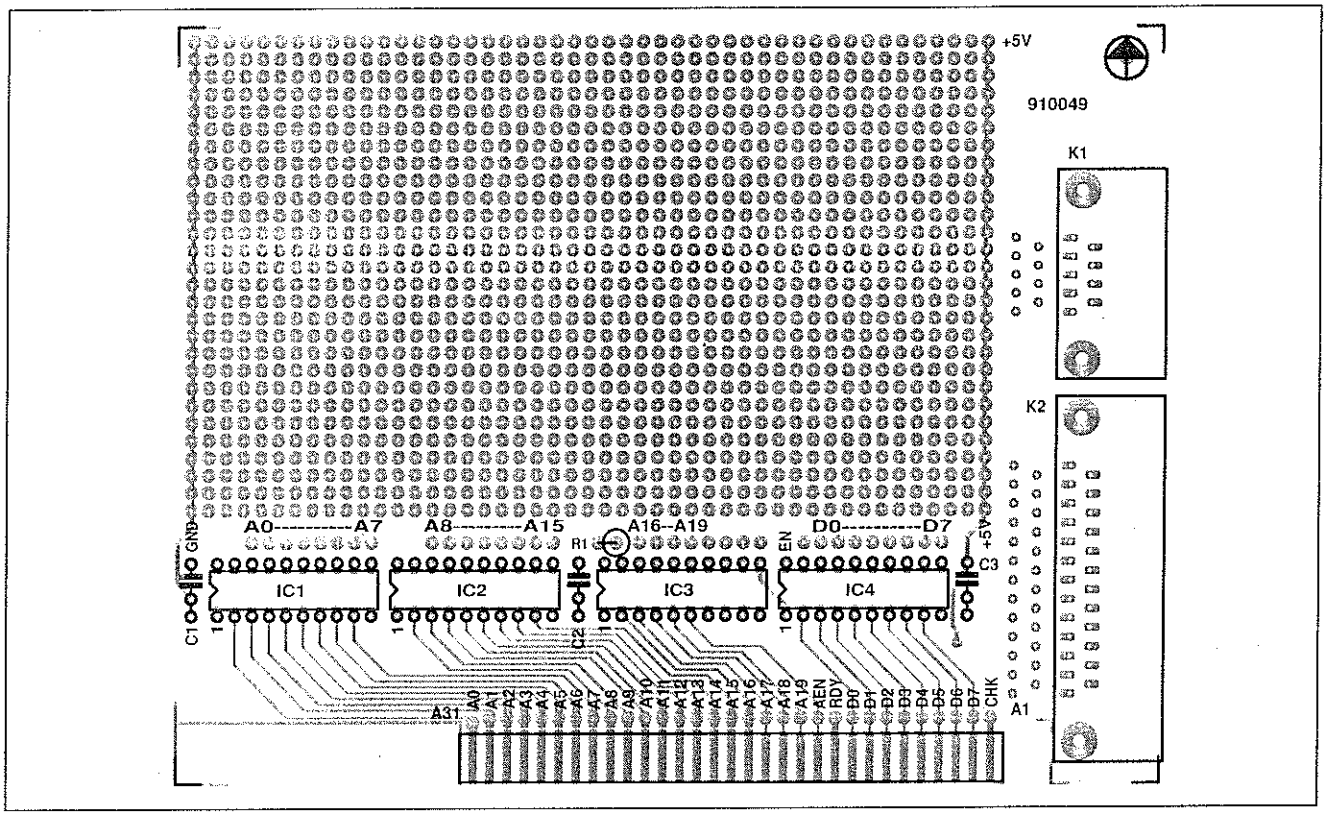


Fig. 3. Track layouts (mirror images) of the double-sided PCB.



I/O Address	Function
000H–00FH	DMA-Controller (8237A-5)
020H–021H	Interrupt-Controller (8259-5)
040H–043H	Timer/Counter (8253-5)
060H–063H	System Register (8255A-5)
080H–083H	DMA-Side Register (74LS670)
0A0H–0BFH	NMI-Interrupt Register
0C0H–0FFH	Reserved
100H–1FFH	Front Panel Controller
200H–20FH	For Computer Games (Game Port)
210H–217H	Additional Unit
220H–24FH	Reserved
278H–27FH	Second Printer
2F8H–2FFH	Second Serial Interface
300H–31FH	Prototype Card
320H–32FH	Hard Disk-Controller
378H–37FH	Printer Interface (parallel)
380H–38FH	SDLC-Interface
3A0H–3AFH	Reserved
3B0H–3BFH	Monochrome Adaptor and printer
3C0H–3CFH	Reserved
3D0H–3DFH	Colour Graphics Card
3E0H–3E7H	Reserved
3F0H–3F7H	Floppy Controller
3F8H–3FFH	Serial Interface

Table 2. I/O address assignment in IBM PCs (source: IBM).

COMPONENTS LIST

Resistors:

1	100kΩ	R1

Capacitors:

3	100nF	C1;C2;C3

Semiconductors:

3	74HCT541	IC1;IC2;IC3
1	74HCT245	IC4

Miscellaneous:

1	PCB-mount 25-way male sub-D connector	K1
1	PCB-mount 9-way male sub-D connector	K2
1	Printed circuit board	910049

small, and located between 300_H and $31F_H$, which provides only 16 addresses.

The printed circuit board

This consists of three sections:

- a section containing the address and data bus buffers;
- a section for prototyping;
- a section containing the output connectors.

The buffers are located close to the contact fingers on the board that plug into the PC extension slot. Provision is made for a number of tracks that carry the address lines A0 to A16 to be 'broken'. This option is provided because it will seldom be necessary to use all address lines. Where some of these are not required, the buffers associated with them are thus made available for other uses.

The prototyping area contains no fewer than 1316 solder pads arranged in 28 'columns' of 47 pads each. The pads in the left-hand column are interconnected and form a ground line. They are connected to pin B01, the system ground, on the extension slot. The right-hand column similarly forms the +5 V rail for prototype circuits, and is connected to extension slot pin B03.

The prototyping card provides two output plugs: a 25-pin and a 9-pin sub-D type, K2 and K1 respectively. These PCB-style plugs allow the circuit built in the prototyping area to be connected to the outside world. Each plug has a staggered row of solder pads to facilitate the soldering of wires.

Construction

The prototyping board is simple to build, and the PCB (Fig. 3) is available ready-made through the Readers Services. As regards construction, all you have to do is consult the parts list and fit the components by reference number on to the card. Whether or not the sub-D plugs are mounted will depend on your application.

Now it is your turn to develop circuits that can be built in the prototyping area of the card. Suggestions abound: a speech synthesizer, a sound generator, a signal processor, etc.

Finally, when in doubt about the pinning of whatever connector, slot, cable or plug in your PC, consult the 'PC Connectors' wall chart supplied with the September 1991 issue of *Elektor Electronics*. ■