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elektor

up-to-date electronics for lab and leisure

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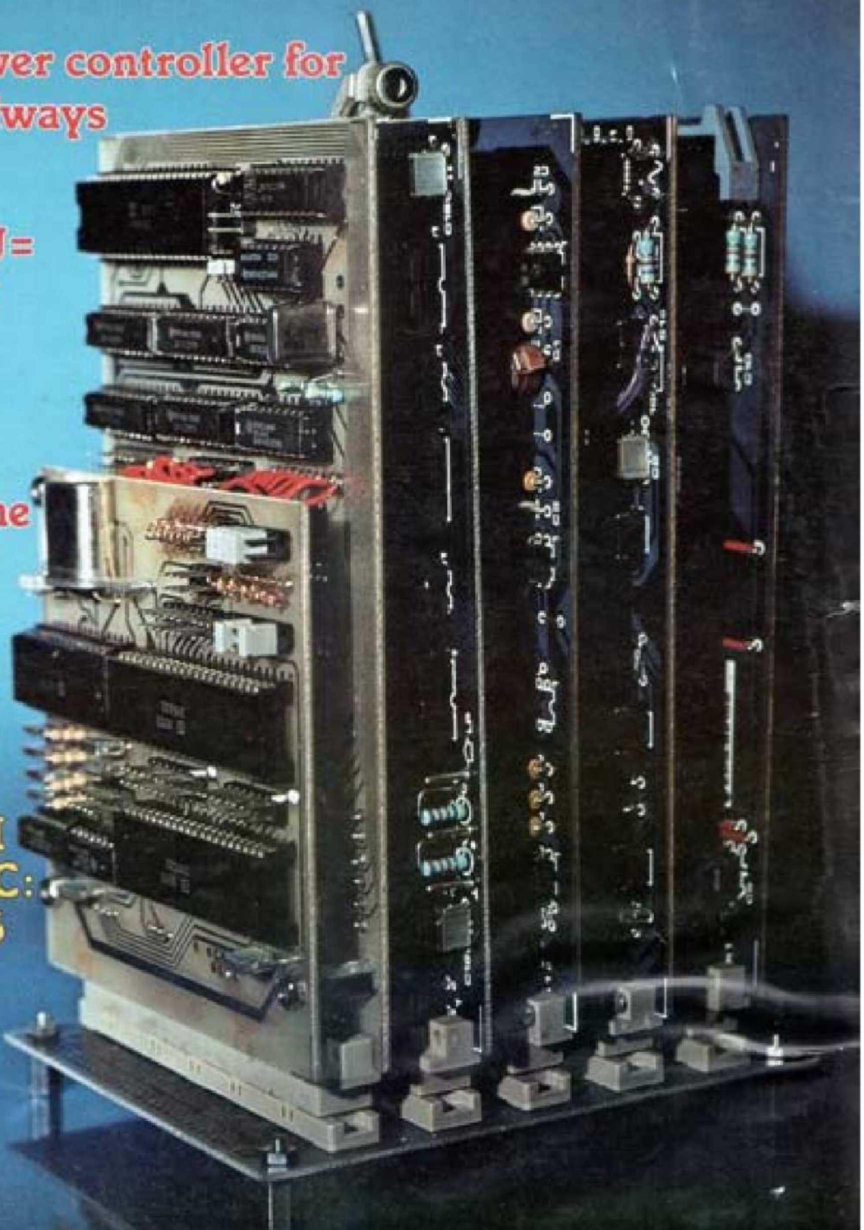
AIR-MAIL COPY

PWM power controller for model railways

CPU+VDU= intelligent video terminal

Metronome with optional quavers

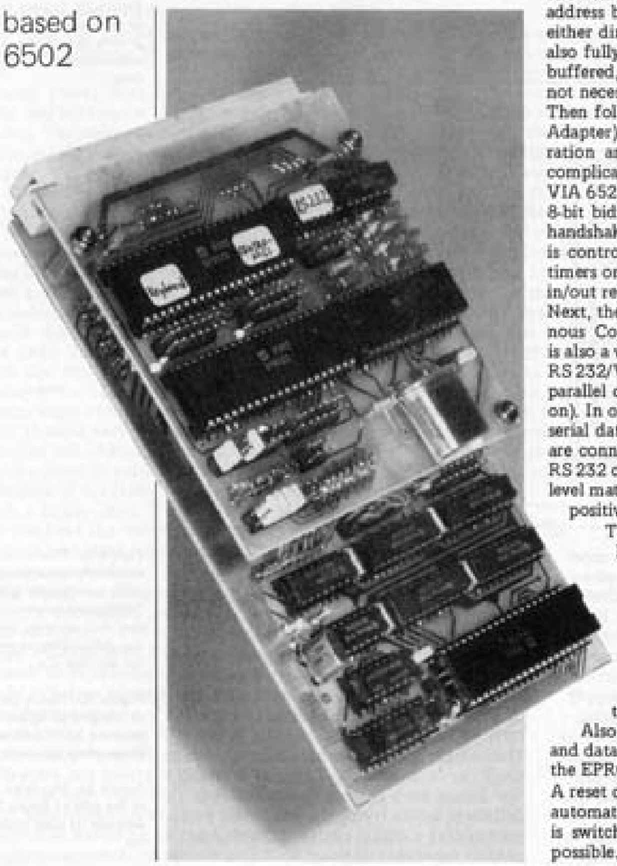
A new AM receiver IC: the ZN415



The most appropriate description of this new CPU card might well be: an independent, single-board computer in eurocard format. Much effort has gone into ensuring that the card is truly universal. The choice of a 6502 microprocessor is a natural: well-known from the Junior Computer, it has the advantage that a range of well-tried hardware and software is readily available.

CPU card . . .

. . . based on the 6502



This new CPU card may well be considered the most versatile in the Elektor microprocessor programme. And not without reason. However, before we have a closer look at its characteristics, let's see what applications it offers: that should give you some idea of its versatility.

- Single-board control computer for:
  - machine control;
  - processing guard;
  - morse decoder;
  - telephone selector;
  - simulator or emulator;
  - PROM/EPROM programmer.
- In combination with other µP cards:
  - with VDU card: a universal terminal (see elsewhere in this issue);
  - with VDU card, dynamic RAM card, and a floppy disk interface: an intelligent terminal (see the article 'VDU card' in our September 1983 issue where this set-up was already suggested).

The block schematic

The microprocessor is shown at the left-hand side of figure 1: it can be either type 6502 or its CMOS low-power version, the 65C02 (see 'applikator' in our October issue). The clock generates frequencies of 1, 2, and 4 MHz: the required clock frequency can be selected by means of a wire bridge. The address bus is fully buffered and available either direct or inverted. The data bus is also fully buffered. The control bus is not buffered, but that is,of course, normally not necessary.

Then follow two VIAs (Versatile Interface Adapter), type 6522 or 65C22. The operation and construction of these fairly complicated ICs are fully described in our VIA 6522 book. Briefly, this IC offers two 8-bit bidirectional input/output ports, four handshake lines (by which data interchange is controlled), two programmable 16-bit timers or counters, and an 8-bit serial shift in/out register.

Next, the 6551 or 65C51 ACIA (Asynchronous Communication Interface Adapter) is also a versatile IC. Here it is used for the RS 232/V 24 interface (baud rate, serial/parallel conversion, error detection, and so on). In other words, the ACIA arranges the serial data transfer. Some additional gates are connected between the 6551 and the RS 232 connector to provide any necessary level matching (the RS 232 operates from a positive and a negative supply).

There is space on the card for one RAM-IC and one EPROM-IC. For the RAM there is a choice between a 2 kbyte and an 8 kbyte CMOS memory. There are also various possibilities for the EPROM: 2, 4, 8, or 16 kbyte.

The VIAs and the ACIA have a common address decoder, while the memory-ICs each have their own. Also, all ICs are connected to the address and data buses, and, with the exception of the EPROM, to the control bus.

A reset circuit ensures that the computer is automatically reset when the power supply is switched on. Manual resetting is also possible.

1

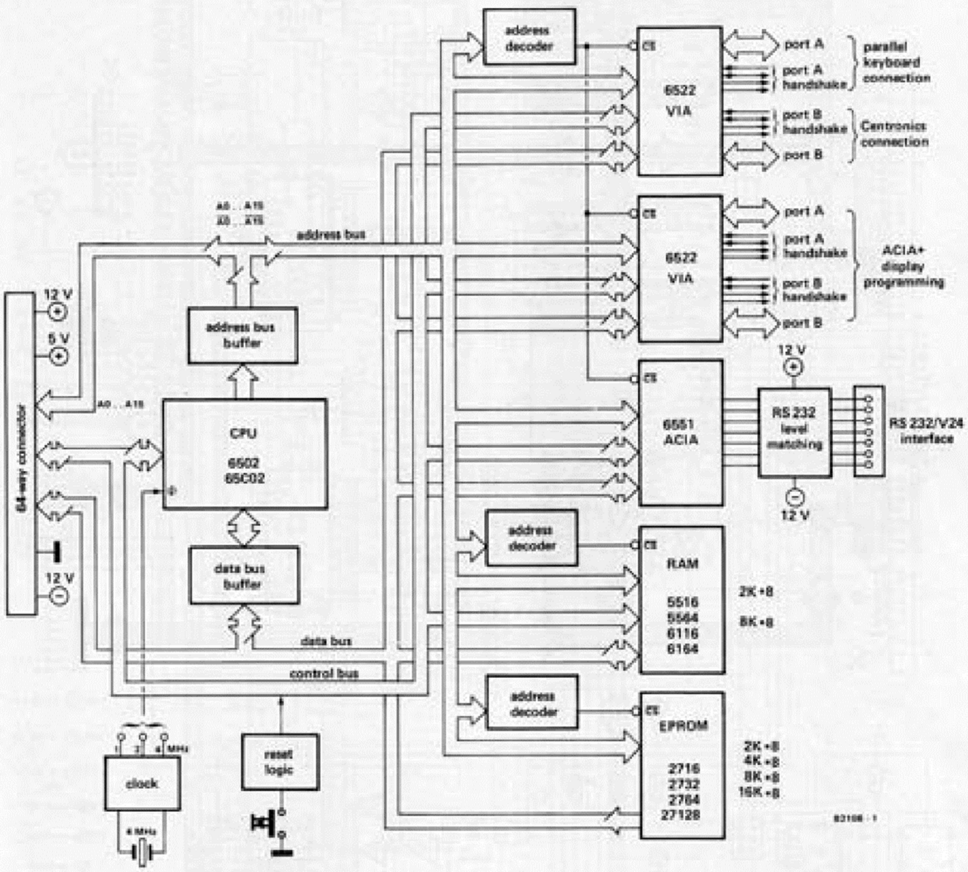


Figure 1. The block schematic of the CPU card. Note the large number of connections!

A 64-way connector, into which the control bus, the buffered address and data buses, ±12 V, and +5 V are terminated, is provided for connection to the Elektor bus.
Returning to the VIA connections: on the first VIA, port A is used for a parallel keyboard connection and port B for a Centronics connection. On the second, ports A and B are both used for the programming (by means of shorting-plugs) of the ACIA, of the image size (only in combination with the VDU card), and some others, all of which are enumerated in table 1.

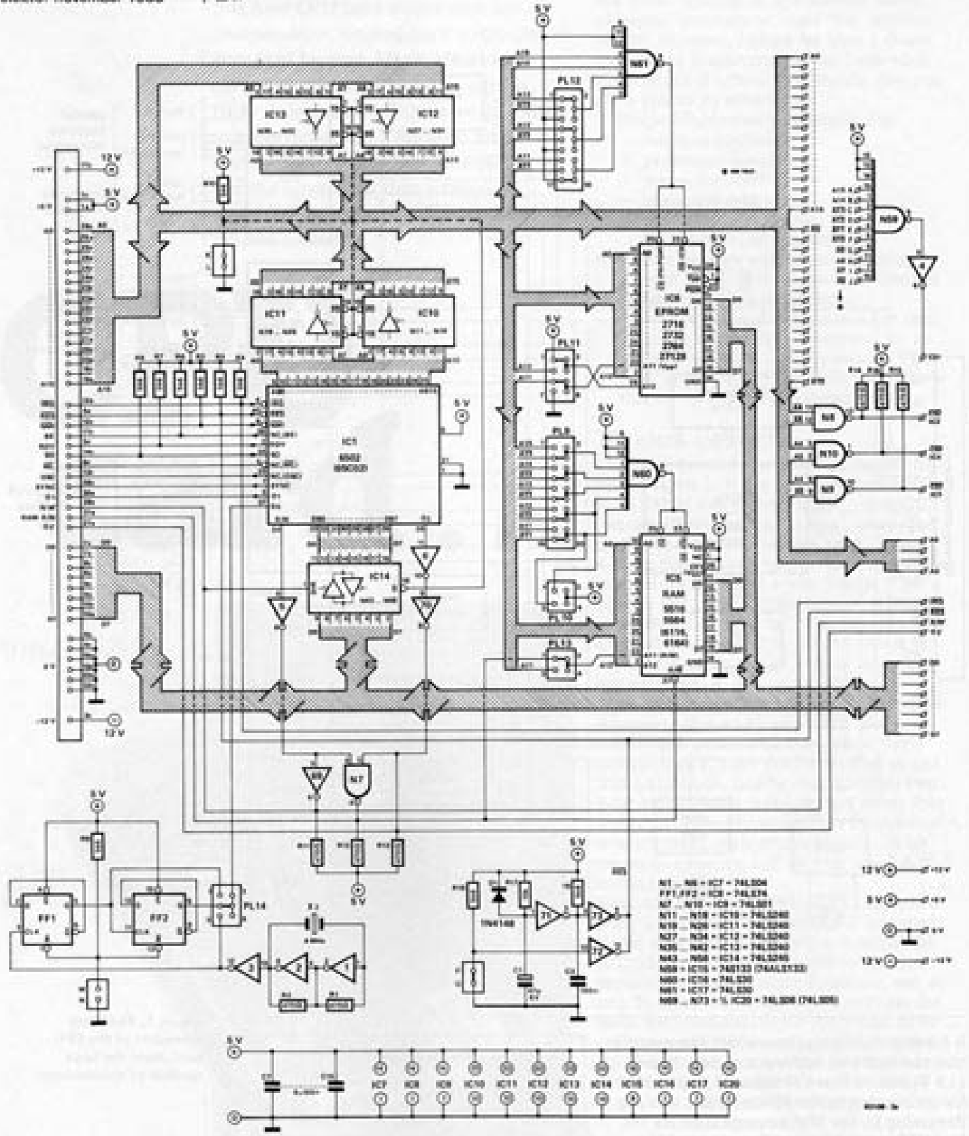
The electrical diagram

A look at figure 2 will soon show that there is not all that much to add to the description of the block diagram. At one side there is again the 6502 IC with beside it the three-state buffers N11 . . . N58 for the address and data buses. The clock consists of two

Features of the CPU card

- 6502/65C02 CPU
- 2 x 6522 VIA
- 1 x 6551 ACIA
- 2 or 8 k RAM
- 2, 4, 8, or 16 k EPROM
- complete address decoding
- fully buffered address and data buses
- 64-way Elektor bus
- DMA possibility
- clock frequencies of 1, 2, and 4 MHz
- four 8-bit ports
- four 16-bit timers
- two serial data ports
- eight handshake lines
- parallel keyboard connection
- Centronics connection
- RS 232 connection
- all I/O lines terminated into connectors

2a

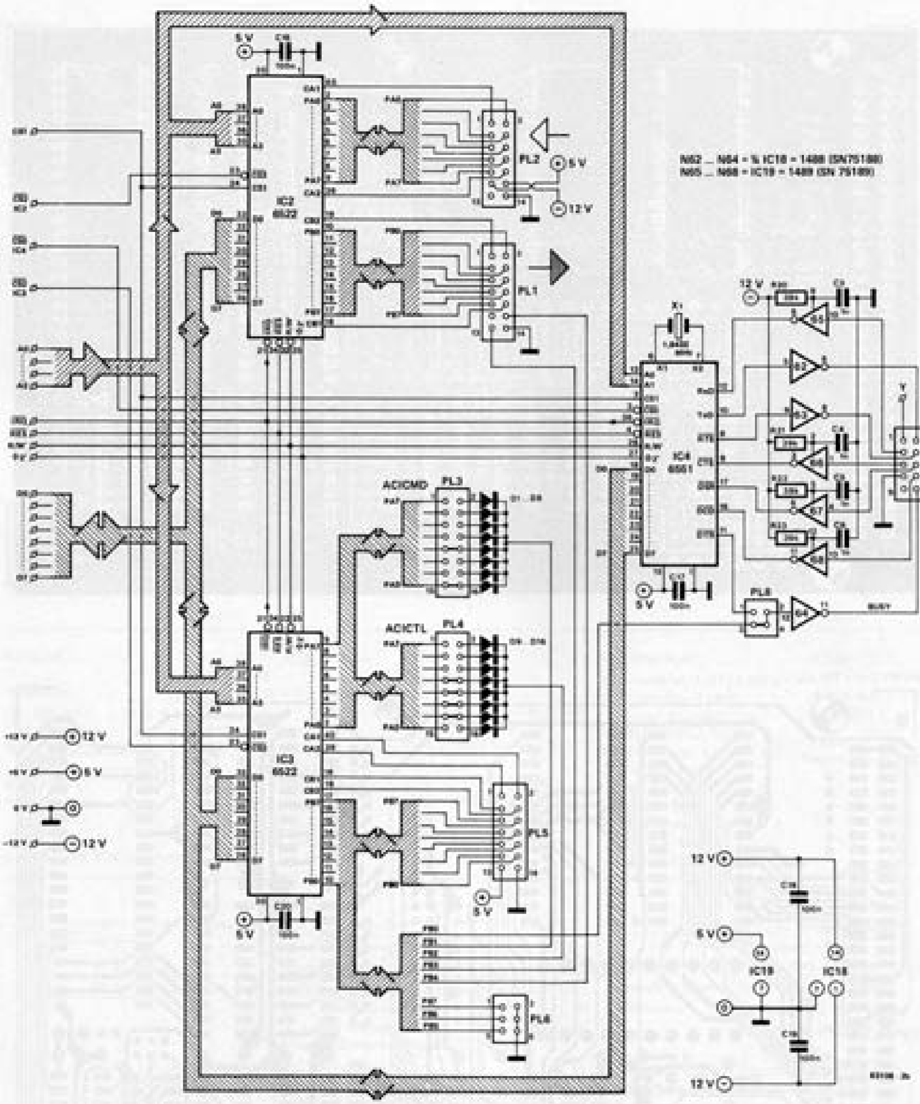


gates, N1 and N2, followed by two dividers, FF1 and FF2. Shorting plug PL14 enables selection of the required clock frequency. If, for instance, you want to use an external clock, dividers FF1 and FF2 can be made inoperative by connecting point M to N. Close to the clock you see the reset circuit consisting of gates N71 . . . N73. When the +5 V supply is switched on, the RC network R17/C1 ensures a half second delay before the reset input of the CPU is actuated. If required, a spring-loaded push-button switch may be connected between points P and Q to provide a manual reset facility.

The address decoder for the VIAs (IC2 and IC3) and the ACIA (IC4) consists of gate N59; that for the RAM (IC5) is N60, and for EPROM IC6 it is N61.

A crystal is connected to the ACIA for the generation of various baud rates. Gates N62 . . . N68 are level equalizers which translate the symmetrical signals of the RS 232 to asymmetrical 5 V ones for the CPU and vice versa.

2b



When bipolar ICs are used, power dissipation amounts to 100 mA at ±12 V and 1 . . . 1.5 A at +5 V. If, however, CMOS circuits are used, current consumption drops to about 100 mA overall, so that it is then possible to supply the CPU from primary cells or rechargeable batteries.

Construction

The printed-circuit boards for the CPU card are shown in figures 3 and 4. Two for a single-board computer? you will say. Well, unfortunately, because of our determination to make the card truly universal (which made necessary the use of shorting plugs to pre-program the card) we just could not get the whole CPU on one board of eurocard format, and in the end we had to compromise on one large (eurocard) and one small board.

Both boards are double-sided, so, before mounting any components, check with a multimeter that all through-plated holes are

Figure 2. If the 'blocks' in figure 1 are replaced by ICs the circuit diagram shown here results. It looks more complicated than it is because of the many connections.

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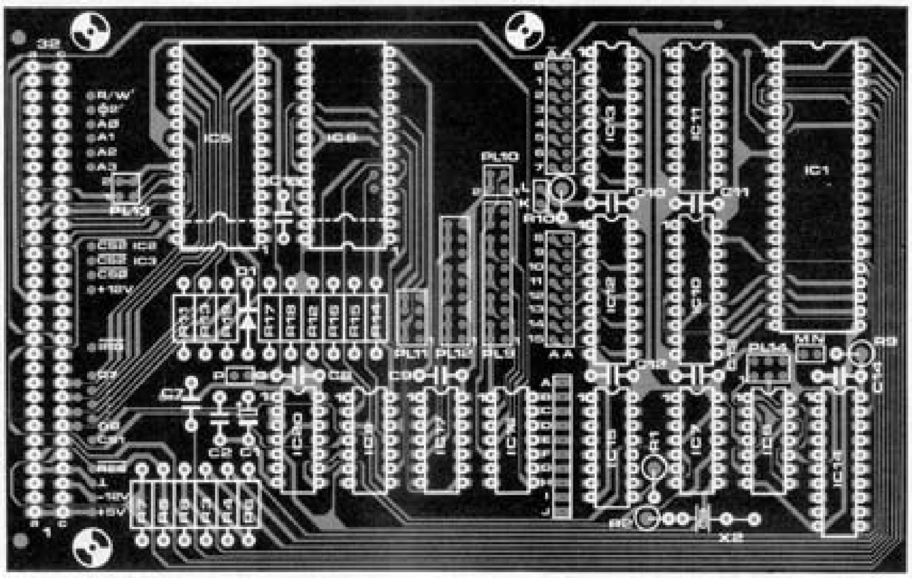


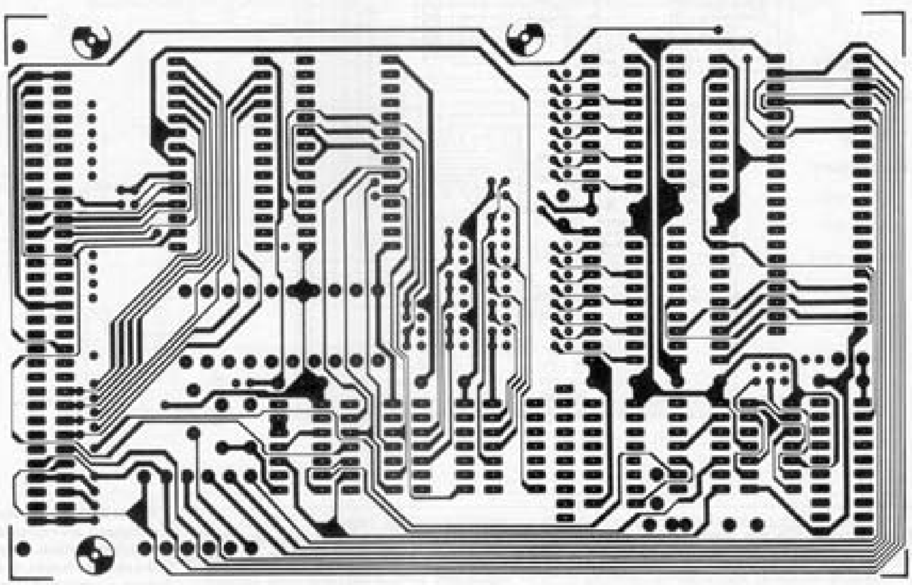
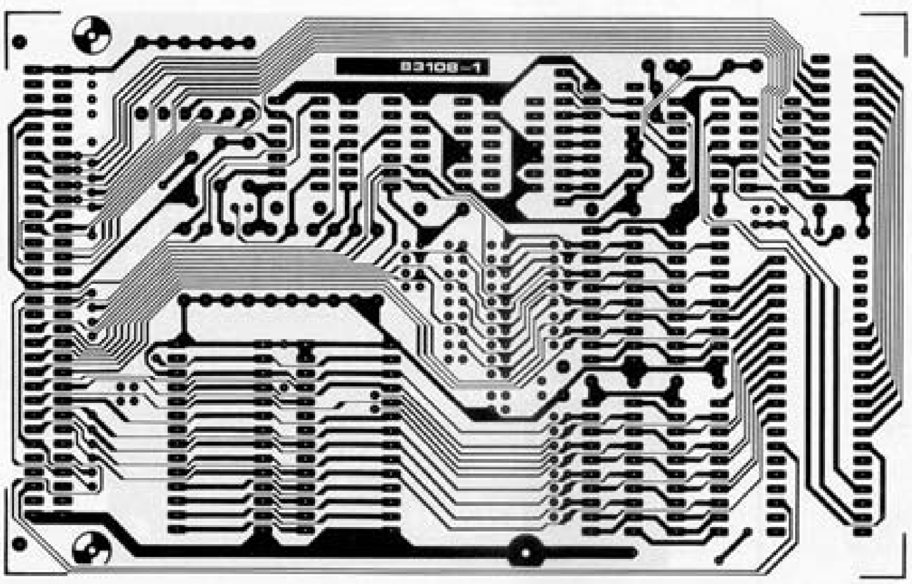


Figure 3. The double-plated main printed circuit board which houses the CPU, RAM, EPROM, clock, and reset logic.

sound. If so, solder all resistors, capacitors, crystals, IC sockets, and connectors in their respective positions. Apart from the 64-way connector, which should be a DIN 41612 male, it is recommended to use terminal strips for which shorting plugs are available: examples are shown in the parts list.
Once everything is soldered in place, insert the ICs into their respective sockets. If a 2716 or 2732 EPROM is used, the 24-pin



Parts list

Resistors:
R1, R2, R11 . . . R16 = 470 Ω
R3 . . . R10, R18, R19 = 5k6
R17 = 10 k
R20 . . . R23 = 39 k

Capacitors:
C1 = 47 μ/6 V electrolytic
C2, C7 . . . C25 = 100 n ceramic
C3 . . . C6 = 1 n ceramic

Semiconductors:
D1 . . . D16 = 1N4148
IC1 = 6502 (65C02)
IC2, IC3 = 6522 (65C22)
IC4 = 6551 (65C51)
IC5 = 5516, 5564
IC6 = 2716, 2732, 2764, 27128
IC7 = 74LS04
IC8 = 74LS74
IC9 = 74LS01
IC10 . . . IC13 = 74LS240
IC14 = 74LS245
IC15 = 74S133 (74 ALS133)
IC16, IC17 = 74LS30
IC18 = 1488 (SN75188)
IC19 = 1489 (SN75189)
IC20 = 74LS06

Miscellaneous:
X1 = crystal, 1.8432 MHz
X2 = crystal, 4 MHz
64-way connector to DIN 41612,male
2 off terminal strip 40 x 2 pins, e.g. Molex 8624-A-102 * (10-89-1801)
1 off terminal strip 16 x 2 pins, e.g. Molex 8624-A-102 * (10-89-1321)
25 off shorting plugs for above, e.g. Molex no. 7859 *

*Available from *Technomatic Ltd.*

Table 1

connector	interconnection	function
PL1	–	parallel-keyboard connection
PL2	–	Centronics-connection
PL3	see table 2	ACIA-programming 5, 6, 7 or 8 databits 1, 1.5 or 2 stopbits internal/external clock
PL4	see table 2	ACIA-programming enable/disable-interrupt enable/disable IRQ-line transmitter-control normal/echo-mode even/odd/no parity mark/space-parity
PL5	–	output of port and control lines
PL6	see 'universal terminal' elsewhere in this issue	image format: only in combination with VDU card
PL7	–	RS 232 connection
PL8	1-2 3-4	low speed modem high speed VT52-terminal
PL9 PL10 PL13	dependent upon application	RAM adress decoding (an example is given in 'universal terminal' elsewhere in this issue
PL11 PL12	dependent upon application	Eprom address decoding (see, for instance, the article 'universal terminal'.
PL14	 5-6 1-2 3-4	clock frequency: 4 MHz 2 MHz 1 MHz
–	M-N	interconnect if external clock is used
–	P-Q	with spring-loaded push-button for manual reset otherwise wire-bridge for automatic reset at power 'on'

Table 1. The various pre-programming possibilities of the CPU card: all required connections are included.

IC is inserted so that its pin 1 mates with pin 3 of the socket. Then, depending upon your individual requirements, and with the aid of Table 1, place the shorting plugs as appropriate.

Next, using three spacers, mount the small board onto the larger one. The necessary connections between the two – DØ . . . D7, AØ . . . A3, $\overline{CSØ}$, CS1, $\overline{CS2}$, Φ2', R/W', $\overline{RES}$, $\overline{IRQ}$, +12 V, –12 V, +5 V, and

4

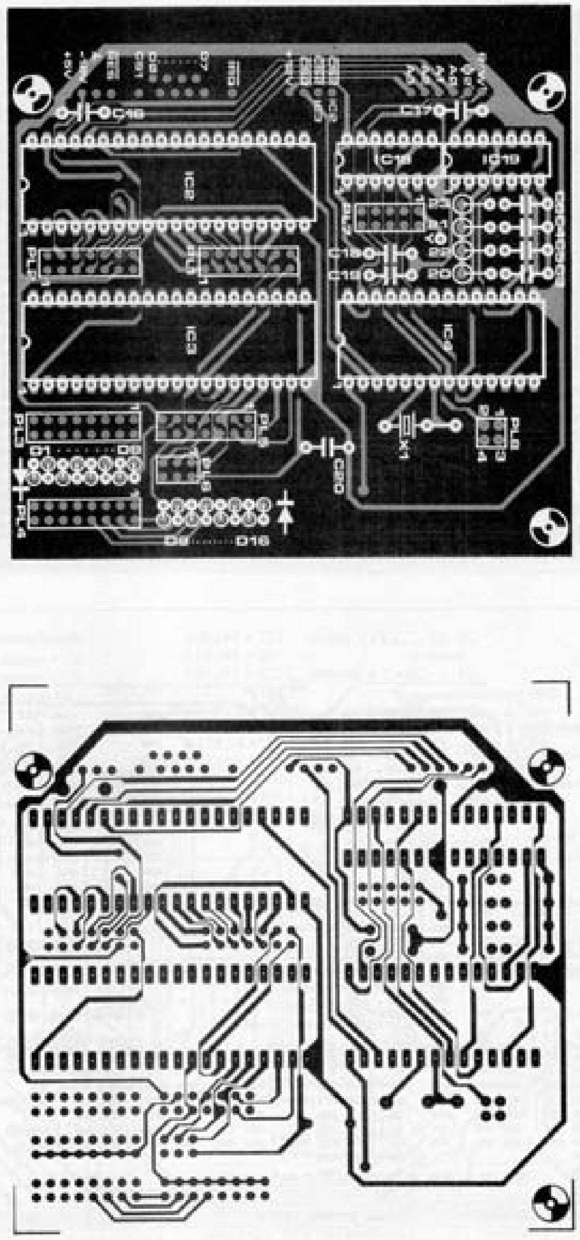


Figure 4. The auxiliary printed circuit board which contains the VIAs and the ACIA.

⊥ – should then be made with short lengths of wire.
Finally, mount the ICs onto the smaller board and place shorting plugs as appropriate. Suitable connectors, like that for the RS 232, may be added as required. Do not forget to connect the address decoder N59 by means of short wires.
This completes the CPU card. The choice of memory capacity of EPROM and RAM, as

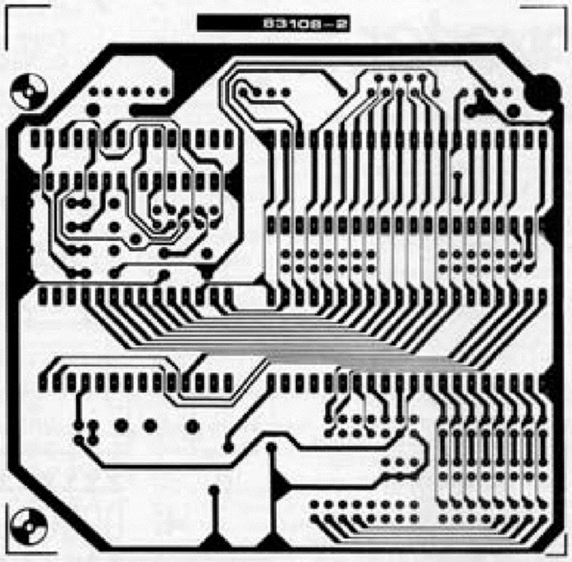


Table 2

connector	pin nos	function
PL3	1-2	number of stop bits
	0 (= open)	1 stopbit
	1 (= closed)	2 stopbits (1.5 for a word length of 5 bits)
	3-4 5-6	word length
	0 0	8 bits
	0 1	7 bits
	1 0	6 bits
	1 1	5 bits
	7-8	baud rate generator:
	0	extern
	1	intern
	9-10 11-12 13-14 15-16	baud rate:
	0 0 0 1	50 baud
	0 0 1 0	75 baud
	0 0 1 1	109.92 baud
	0 1 0 0	134.58 baud
	0 1 0 1	150 baud
	0 1 1 0	300 baud
	0 1 1 1	600 baud
	1 0 0 0	1200 baud
	1 0 0 1	1800 baud
	1 0 1 0	2400 baud
	1 0 1 1	3600 baud
	1 1 0 0	4800 baud
	1 1 0 1	7200 baud
	1 1 1 0	9600 baud
	1 1 1 1	19200 baud
	0 0 0 0	16 (external clock)

connector	pin nos	function
PL4	1-2 3-4 5-6	parity bit
	— — 0	none (— = don't care)
	0 0 1	odd
	0 1 1	even
	1 0 1	mark
	1 1 1	space
	7-8	mode:
	0	normal
	1	echo
	9-10 11-12	transmitter-controls:
	0 0	transmitter interrupt disabled $\overline{RTS}$-level high, transmit. off
	0 1	transmit. int. enabled $\overline{RTS}$-level low, transmit. on
	1 0	transmit. int. disabled $\overline{RTS}$-level low, transmit. on
	1 1	transmit. int. disabled $\overline{RTS}$-level low, transmit. break
	13-14	IRQ-interrupt:
	0	enabled
	1	disabled
	15-16	receiver + interrupts:
	0	disable
	1	enable

Table 2. Expansion of the ACIA programming by means of short-circuits in connectors PL3 and PL4.

well as of the program the EPROM shall contain, is, of course, dependent upon the application and size of the system in which the CPU card is to function.
Lastly, we would draw your special attention to Table 1. This table shows clearly which connections have to be made for specific applications and its importance to such a versatile circuit as this CPU card cannot be overstated! ◼

The combination of the CPU card featured elsewhere in this issue and the VDU card published in our September number, with the addition of a keyboard, a monitor, and the necessary software results in a universal terminal which is really inexpensive for its capabilities. The terminal has an RS 232 connection with VT 52 protocol and can therefore be coupled directly to any computer provided with such a connection. An example is the 16-bit Force II which, in conjunction with this terminal, gives an excellent cost/performance ratio.

universal terminal...

. . . linking the computer to the user

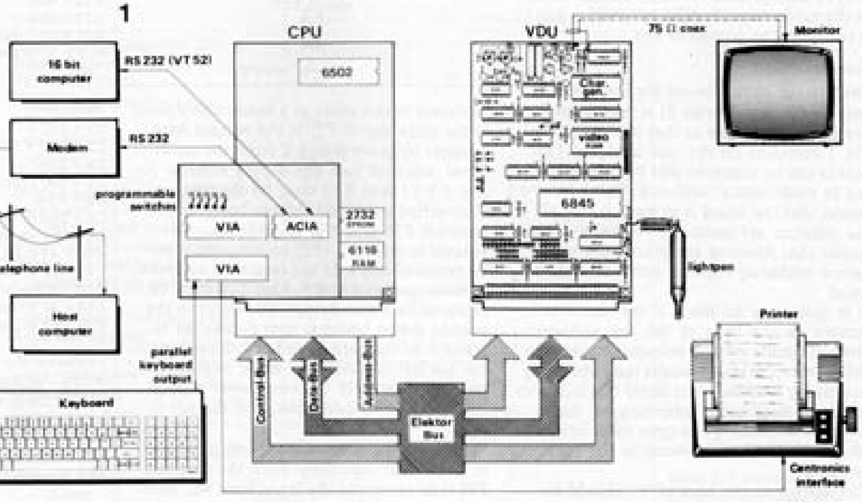
This universal terminal should not be thought of as just a replacement for the Elekterminal. Connecting the latter to a large computer gives immediate problems because it does not provide handshake lines. The present terminal, however, provided as it is with an RS 232 connection and VT 52 protocol, can be connected to a large computer without further ado. (The VT 52 protocol is a communication agreement extensively used in industrial terminal applications.) As the RS 232 is a serial connection, it is also possible, by means of a modem, to communicate with a so-called host computer anywhere in the world over a telephone line.
Moreover, this universal terminal, in contrast to the Elekterminal, provides an adjustable image format and graphics possibilities.

Construction

The general layout of the terminal is shown in figure 1. As can be seen, all constituent parts have already been described: in 'CPU card' elsewhere in this issue, and in 'VDU card' in the September issue. Basically, the construction consists of combining a CPU card and a VDU card by, for instance, the Elektor bus board, and connecting a monitor (or normal TV receiver) to the VDU card, and a keyboard to the CPU card. The required software for the system can be contained in a 2732 EPROM for which there is a convenient slot on the CPU card.
It is also possible to connect a printer with Centronics interface to the terminal. Furthermore, some preliminary work has been done towards a light-pen connection, but this option will have to wait until a future issue.
The CPU card is programmed by means of shorting plugs, for instance, as regards image format and memory index. The shorting-plug positions for these specific applications are given in table 1. The memory index will then look as shown in figure 2. The image format must, of course, be chosen in relation to whether a proper monitor or a TV set is used. If the latter, it is recommended that fewer characters per line are selected than with a monitor.
The address decoding of the 2 k RAM and 4 k EPROM used in the present project is also arranged by means of shorting plugs as

Figure 1. The layout of the universal terminal with all possible connections. Connecting a 16-bit computer (for instance, a Force II which is based on a 68000 CPU) yields, to the best of our knowledge, the cheapest 16-bit computer system available.

1



indicated in table 1.
Furthermore, a number of connections have to be made on the CPU card between the outputs of the address buffers and points A . . . J to obtain the chip-select signal for the various ICs. These connections should be made by short lengths of wire soldered to the appropriate connector-pins, according to the circuit diagram of the CPU card.
The programming of the ACIA (PL3 and PL4 on the CPU card) should be carried out with the aid of the manual of the computer used, and table 2 in the CPU card article.

Software for the terminal

Appropriate software is, of course, indispensable for the correct operation of the terminal. An associated program (ESS 525) is available from Technomatic Ltd. This program consists of the following parts:

- Console Command Processor, which ensures that the various commands are executed
- Video routines and sub-routines (cursor control, and so on) which are necessary for the proper operation of the VDU card
- Table of commands, which ensures that keyed-in commands are 'understood'
- Centronics output routine, which is necessary for printer control
- Image format table with which the preset image format is realized.

The Console Command Processor reads the keyboard and distinguishes between normal text and commands, a list of which is given in table 2.
A source-listing of the relevant program together with additional information (VDU Paperware) will become available through our book service in a few months' time. The additional information refers to the combination of the VDU card with the CPU board and to the CRT controller, the ACIA, and the character generator. ■

2

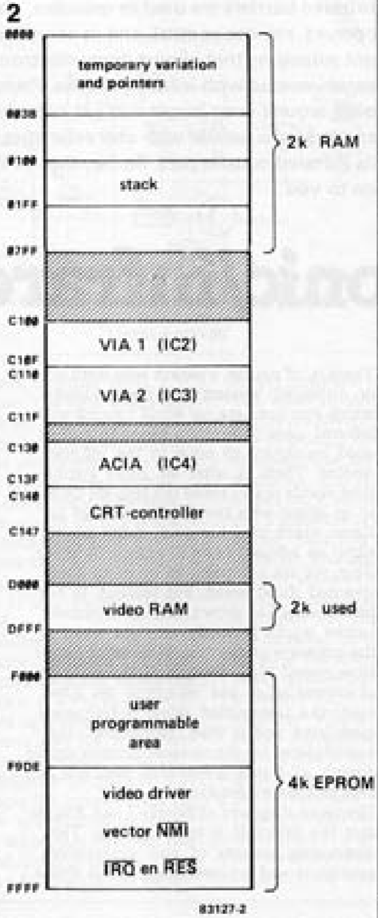


Figure 2. Summary of the memory index.

Table 1

connector	interconnection	function
PL6		image format setting:
	none	80 x 24
	5-6	80 x 25
	3-4	64 x 16
	3-4, 5-6	64 x 24
	1-2	90 x 22
	1-2, 5-6	48 x 12
	1-2, 3-4	24 x 24
	1-2, 3-4, 5-6	user programmable
PL9	3-4, 7-8, 11-12 15-16, 19-20	RAM address decoding
PL10	none	for addressing
PL13	1-2	0000-07FF
		EPROM address decoding
PL11	1-2, 5-6	for addressing
PL12	1-2, 7-8, 17-18	F000-FFFF

Table 1. This shows how the CPU card is programmed for this application by means of shorting plugs. Programming of the ACIA is carried out with the aid of the manual of the computer used and table 2 of the CPU card article in this issue.

Table 2

	code	keyed	command
VT 52	000D	(CR)	carriage return
	000A	(LF)	line feed
	0008	(BS), (CTRL-H)	back space
	1B48	(ESC) (H)	cursor home
	1B41	(ESC) (A)	cursor up
	1B42	(ESC) (B)	cursor down
	1B43	(ESC) (C)	cursor right
	1B44	(ESC) (D)	cursor left
	1B4B	(ESC) (K)	erase to end of line
	1B4A	(ESC) (J)	erase to end of screen
CP/M	000B	(CTRL-K)	cursor up
	000C	(CTRL-L)	cursor right
	0011	(CTRL-Q)	erase to end of screen
	0018	(CTRL-X)	erase to end of line
	001A	(CTRL-Z)	clear screen & home
	001E	(CTRL-^)	cursor home
	000A	(CTRL-J)	cursor down
	0010	(CTRL-P)	select/deselect centronics
	1B52	(ESC) (R)	delete line
	1B2A	(ESC) (x)	clear screen & home
	1B3A	(ESC) (:)	clear screen & home
	1B54	(ESC) (T)	erase to end of line
	1B74	(ESC) (t)	erase to end of line
	1B59	(ESC) (Y)	erase to end of screen
	1B79	(ESC) (y)	erase to end of screen
	0006	(CTRL-F)	select/deselect auto LF
	0002	(CTRL-B)	select/deselect half duplex

Table 2. Commands for the cursor control and the erasing of (parts of) the screen.
(CTRL . . . means that a key is pressed *while* the control key is pressed and ESC . . . indicates the *successive* pressing of the escape key and another as shown.)