Z80-A CPU card

. . . for the Polyformant

As the Z80 is still one of the most popular microprocessors around, it is high time the device was mentioned in Elektor. However, that is not the only motive behind this article, for the Z80-A CPU is the heart of the control circuitry for the new Elektor synthesiser. The board is compatible with the Elektor microprocessor bus system, so that the Eurocard collection will now be accessible to Z80 users.

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RAM/EPROM card for the Z80
(Elektor 85 May 1982)
When the RAM/EPROM card is modified for Z80 systems, it is then not protected against programming errors. To overcome this 2C of IC7 is linked not to earth, but to the $\overline{RD}$ line. Incidentally, gate N3 is drawn in figure 3 as a NAND. It is, of course, an AND gate.

Considering the amount of brain power stored away inside the Z80-A, the CPU card circuit is surprisingly straightforward. As can be seen from figure 1 all that is needed to make the brain tick is a handful of ICs. Memory is organised according to the Elektor systems' page structure, in other words, it consists of 4K blocks. The first block (ØØØØ . . . ØFFF) is located on the CPU board and contains 2K of EPROM (ØØØØ . . . Ø7FF) and 2K of RAM (Ø8ØØ . . . ØFFF). This particular board was designed for use with the new polyphonic synthesiser or Polyformant and the combination is described in detail elsewhere in this issue. Since only 1K of RAM is required in this application IC18 and IC19 (see figure 1) may be omitted.

It is not absolutely necessary to position the memory ICs and their corresponding address decoders on the CPU board. Large amounts of software can best be stored on a separate (EP)ROM board, such as the Elektor RAM/EPROM card (ESS 80120). One or two minor modifications to the latter are required first, however, details of which are provided elsewhere in this issue.

Buffers

Any self-respecting CPU board will of course have to be properly buffered, as the CPU outputs are unable to drive a complete system directly. Since the buffers used here (IC9 . . . IC13) are tri-state and are enabled by the $\overline{BUSAK}$ signal, the DMA, or multiprocessing, facility of the Z80 is retained.

Speed

The processor is driven by a 4 MHz crystal oscillator. This is the highest possible clock frequency for a Z80-A or MK 3880-4 CPU. With the standard Z80 or MK 3880 the clock frequency should not exceed 2.5 MHz. It should be mentioned at this stage that the Polyformant requires a Z80-A (MK 3880 - 4) CPU.

Essentially, the operating speed of the processor mainly determines the time it takes to execute a program. In the Polyformant, the CPU must scan the keyboard and in the extended version it must also scan all the presets. Furthermore, it must pass on all the relevant data to the Polyformant modules (VCOs, VCFs and so on).

How much time these processes take depends on the response speed of the microcomputer. This is particularly important when the keyboard is being scanned. The faster the scan, the sooner a VCO will be able to react to a depressed key. Using the software package developed for the Polyformant, a VCO can respond within two or three milliseconds. This delay is far too short to be noticeable.

Wait cycles

The use of a high clock frequency automatically calls for corresponding processing speeds, or access times. The access time of a standard 2716 EPROM (IC15) will usually be too long for it to be addressed by the CPU. As for data entry, even less time is available for writing to the RAMs (IC16 . . . IC19)!

There are two ways in which this problem can be solved. The first method involves the use of high-speed memory devices, that is to say, EPROMs and RAMs with an access time of 350 ns and 250 ns, respectively. The latter are easily obtainable nowadays, but 350 ns EPROMs are a little harder to find. Strictly speaking, even 350 ns is 'cutting it a bit fine', although a short cut may be taken by implementing the $\overline{OE}$ (output enable) input instead of the $\overline{CE}$ (chip enable) input. This enables a 350 ns 2716 to be used without the need for any special measures.

The other alternative is to slow down the CPU and use normal 'low-speed' EPROMs. This is done by adding wait cycles to read operations. A wait cycle lasts exactly one clock period, that is 250 ns. The addition of a single wait cycle will therefore extend the EPROM access time to 500 ns, which gives plenty of leeway to even the most 'sluggish' types. The delay is effected by including flipflops FF1 and FF2 in the circuit.

The flipflops are only active while the EPROM (IC15) is being adressed (the D input of FF2 is low). They may be omitted if a 350 ns EPROM is available, in which case a wire link, J1 must be included instead of IC4. This deactivates the delay circuit. When testing the CPU however, readers are advised to carry out the first method initially and include a wait cycle, so as to be absolutely sure that a slow EPROM will not complicate matters.

Any external memory or peripheral devices are also able to generate wait cycles by way of the $\overline{WAITEX}$ input.

1

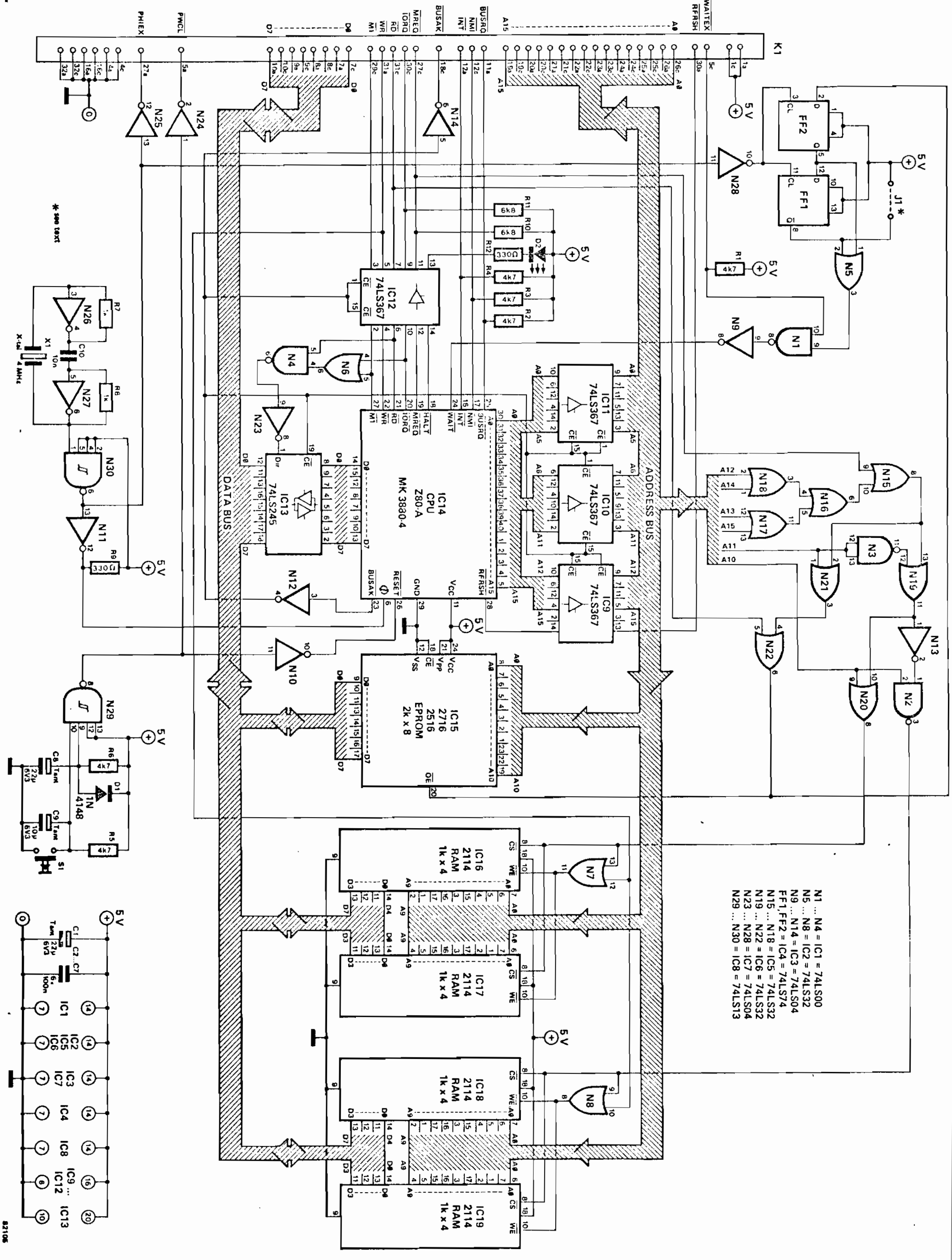

Figure 1. The circuit diagram of the Z80-A CPU card.

2

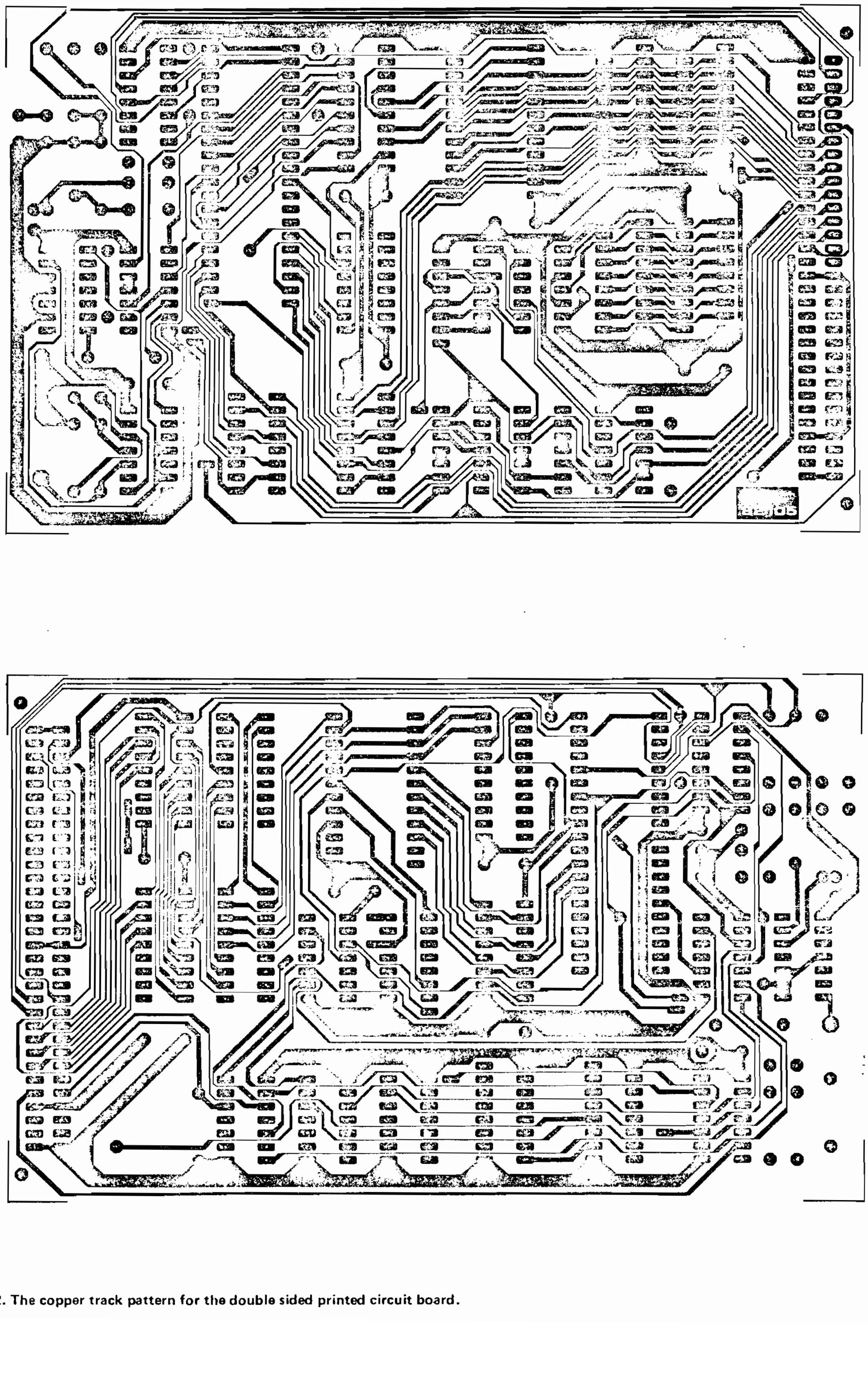

Figure 2. The copper track pattern for the double sided printed circuit board.

3

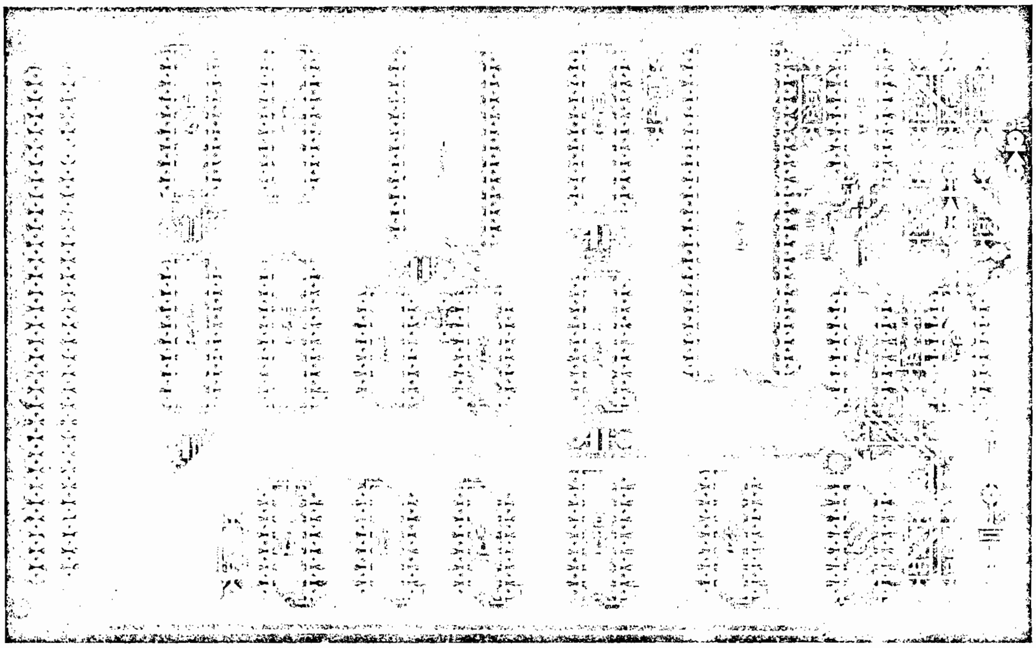

Figure 3. The component overlay for the Z80-A CPU card

Parts List

Resistors:
R1 . . . R6 = 4k7
R7,R8 = 1 k
R9 = 330 Ω
R10,R11 = 6k8
R12 = 470 Ω

Capacitors:
C1,C8 = 22 μ/6.3 V tantalum
C2 . . . C7 = 100 n ceramic or MKH
C9 = 10 μ/6.3 V tantalum
C10 = 10 n MKH

Semiconductors:
D1 = 1N4148
D2 = LED
IC1 = 74LS00
IC2,IC5,IC6 = 75LS32
IC3,IC7 = 74LS04
IC4 = 74LS74
IC8 = 74LS13
IC9 . . . IC12 = 74LS367
IC13 = 74LS245
IC14 = Z80-A (or MK 3880 - 4)
IC15 = 2716/2516
IC16 . . . IC19 = 2114-Z or 2114A-5
(access time 250 ns)

Miscellaneous:
S1 = push button switch
X1 = 4 MHz crystal
K1 = 64-pin connector

Reset

Reset circuitry is needed to initialise the CPU. When the power supply is switched on, R6, C8 and D1 hold the reset input of the CPU low for a while via N29 and N10. This is the $\overline{PWCL}$ signal and serves to reset any other boards connected to the system bus. An external reset facility has been provided for emergencies. It is advisable to place S1 'out of reach' to prevent it from being inadvertently depressed thus causing valuable information to be irrevocably lost.

The printed circuit board

Apart from S1, all the components in figure 1 are mounted on a Eurocard sized, double-sided, plated-through printed circuit board. This is shown in figure 2. As the pin assignment of the 64-pin connector corresponds to that of the Elektor bus system, the board may be used in combination with a number of existing cards.

The components should be mounted on the CPU card with due care, because in some places on the board the copper tracks are so close to each other that soldering may easily cause a 'short'. Although the board is provided with a solder mask to reduce this sort of problem, a great deal of care is still required.

Further information on the Z80

Enough has been written about the Z80 to fill an entire library. Plenty of software is available too, but users must be well-informed of the requirements of their particular system. Often the software has to be adapted for specific purposes and this does call for a fair amount of expertise. The CPU board published here was designed for the Polyformant and a special article is devoted to its use with the synthesiser. A brief description of the software is also given.

The Polyformant is, of course, just one application possibility out of thousands. The advantage of using the board in a different system is that the hardware can be adapted to existing software packages. Such modifications are usually left up to the user, but nine times out of ten it is much easier to rearrange computer circuitry than to re-write programs.

Elsewhere in this issue an article describes how to modify the 8K RAM + 8K EPROM card for use with the Z80 and therefore how readers can create their 'own' computer system.