

# elektor microprocessors

No less than three microprocessor systems have been published to date by Elektor. To the beginner this may seem rather confusing. It is hoped that the following description will serve as a guide to anyone wishing to construct an Elektor system.

The systems were published in the following chronological order: the SC/MP, the games computer and the Junior Computer (JC). Although the purpose of this article is to provide a general survey rather than a detailed discussion of the manifold possibilities of microprocessors, practical examples will be given by way of illustration. (This does not imply, however, that no other uses may be found for the systems.)

First of all, let us deal with the SC/MP (pronounced 'scamp') system. Its principal feature is its modular construction. The microprocessor of the same name is manufactured by National (type number INS8060). This involves a number of printed circuit boards of the Euro-card format (approximately 10x 16 cm) which are interconnected by means of a bus system. The bus is nothing more than a set of conductors connecting all the 1 points, the 2 points, etc. Its modular construction allows it to be a highly flexible unit. Its smallest version is made up of only two cards. The system may be extended by adding more cards to the bus printed circuit board. These will not only provide

more memory capacity (additional RAM and/or ROM), but a printer, for instance, may also be installed.

The Junior Computer is constructed on a single printed circuit board (excluding the supply). An attempt has been made to build the cheapest and smallest unit possible, without eliminating any of its 'real' microprocessor characteristics. By means of a connector on the board, the Junior Computer can be coupled to the SC/MP system. The result is a SC/MP system using an additional processor.

The odd man out of the threesome is the games computer. It was designed to generate colour TV pictures directly on the screen. The pictures are programmed to move and change in form and colour. Thus, it is in fact a luxury TV game device. Additional games may be introduced (such as space war, football and Master Mind). The hardware (the computer itself) has been specially adapted: It consists of two individual keyboards of 12 keys and of a 4 key section to be used by both players. In addition, there is an input for two joysticks ('steering levers') and a loudspeaker has been

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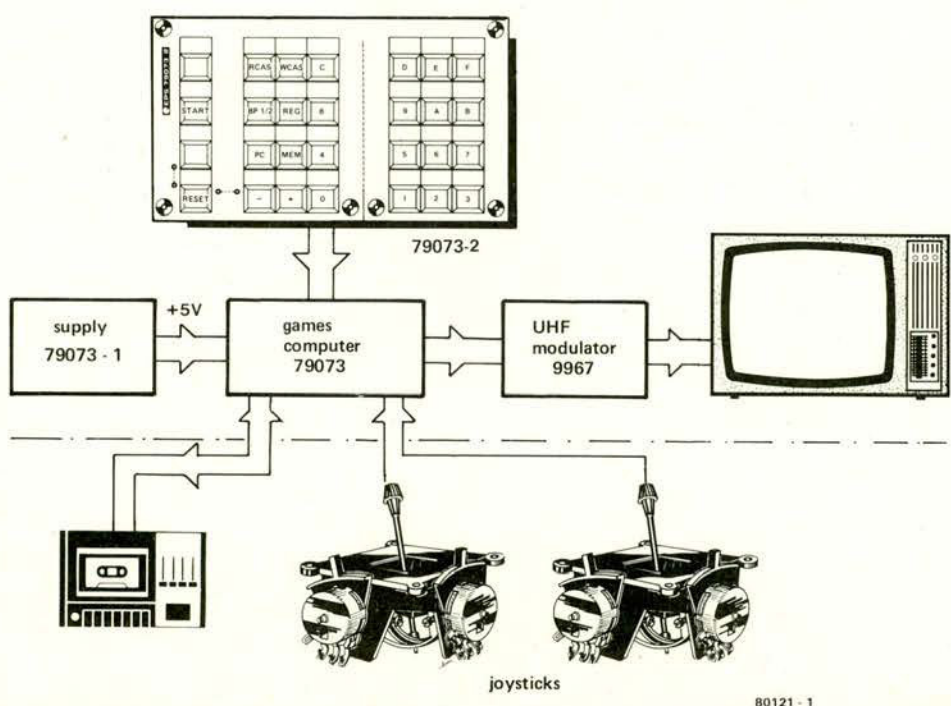


Figure 1. The system structure of the games computer.



built in for special sound effects. Programmes may be easily changed with the aid of a cassette recorder which tapes them, so that they may be played whenever required.

The games computer was not designed for expansion since its prime purpose was for programming. Any possible future additions will only affect its memory capacity.

Both the Junior Computer and the SC/MP were designed for more general use. Not only do they carry out specific tasks, but games may also be played (without a TV). Both machines are capable of developing programmes (already included in the standard monitor programme) and of operating in high-level computer languages. The SC/MP, for instance, can use tiny BASIC.

Every command to be carried out by the SC/MP is then issued by a terminal. This is a separate unit which has a keyboard and VDU and/or printer. The keyboard consists of figures 0...9 as well as the alphabet and specific control characters. In order to operate this system effectively, therefore, a terminal is essential because it enables the computer to communicate in a high level language. Since 'normal' words are used, the alphanumeric keyboard is necessary.

The Elekterminal was described in Elektor's November and December 1978 issues. Instead of the Elekterminal a hexadecimal keyboard and display may be used. This is a separate module described in the earlier series on the SC/MP. The system is then fully oper-

ational at a machine language level, and the Elekterminal can always be added at a later date. Without extensions, the JC is also programmed on machine language.

## The microprocessor

The first aspect to consider is which microprocessor should be selected. The microprocessor is at the heart of any microcomputer system, and to a great extent it determines its capabilities and the speed at which tasks are carried out. At first sight the best choice would appear to be a microprocessor with great potential and high speed. On the other hand, it is very difficult to programme hundreds of instructions. Experience has shown, that, ideally speaking, the programmer should know them all by heart. As far as speed is concerned, it is of course an advantage for the processor to be fast, without needing a higher speed (and therefore higher priced) memory. In practice, however, programs tend to be held up only when high level languages are used or when complicated mathematical calculations are made.

Another aspect which merits attention is how many programmes are available. Generally speaking, a processor may take over other programmes, after minor modification, provided these were written for the same type of processor. In this respect, the 6502 is a good choice.

Each system hitherto discussed relies on a different microprocessor: the games computer on the 2650 from Signetics,

the SC/MP on the INS 8060 from National and the Junior Computer on the 6502 from Rockwell. Of these, the SC/MP (8060) operates in the simplest and slowest manner. The 6502, on the other hand is the most complex and fastest. Between the two extremes lies the 2650's performance. Since the SC/MP's relatively slow operation is sometimes considered a handicap, a processor card has been manufactured for it which is obtainable together with a faster Z-80 processor (not by Elektor). By way of conclusion, a brief description of the construction of each system will be given and especially with regard to their combination possibilities. For further technical details, reference should be made to articles on the subject published in Elektor.

## The TV Games Computer

Number one on our list is the games computer. It consists of a central printed circuit board, including a keyboard (see figure 1), a power supply and, usually, a UHF modulator so that a normal colour TV with an aerial input may be used. In addition, it is advisable to make use of a cassette recorder to store the programmes. To facilitate programming, the monitor is equipped with extensive debugging capabilities including two breakpoints. Two joy sticks may also be added to control the games.

## The Junior Computer

For simplicity, the Junior Computer

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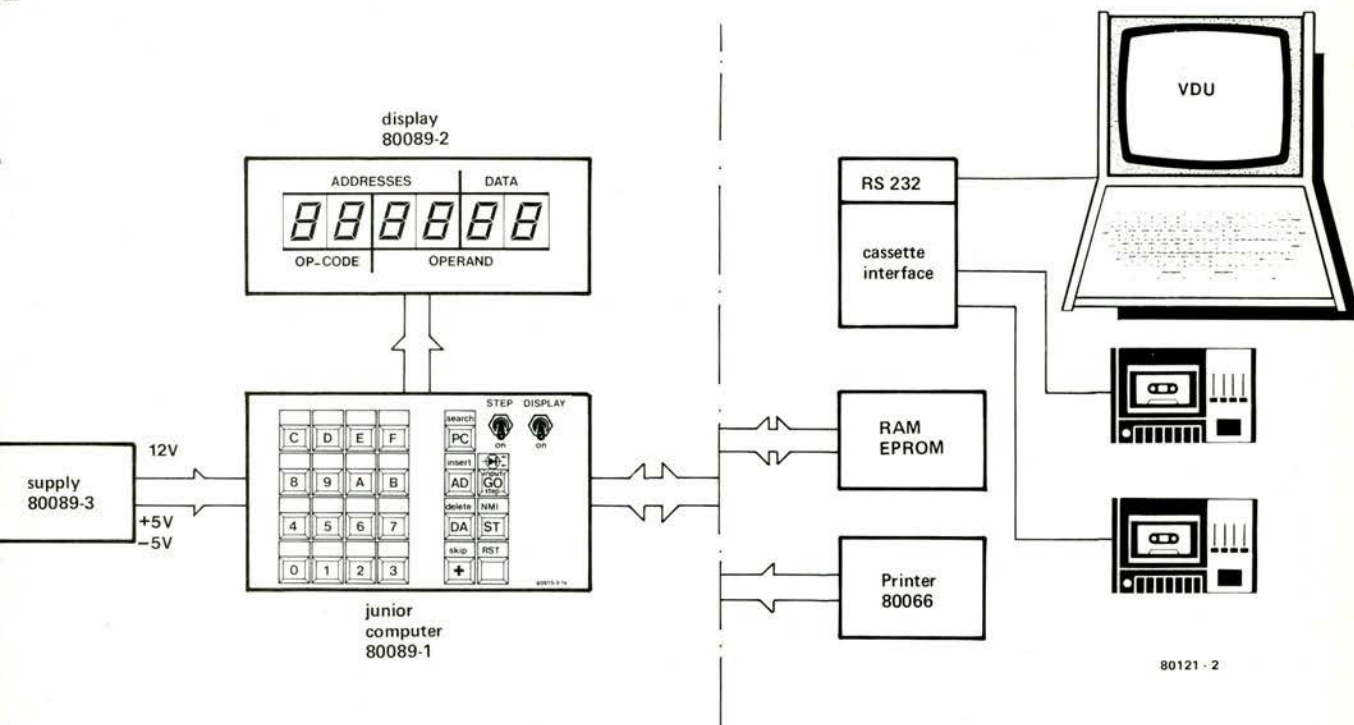


Figure 2. The section to the left of the dotted line contains the basic Junior Computer. The modules to the right may be added if required.



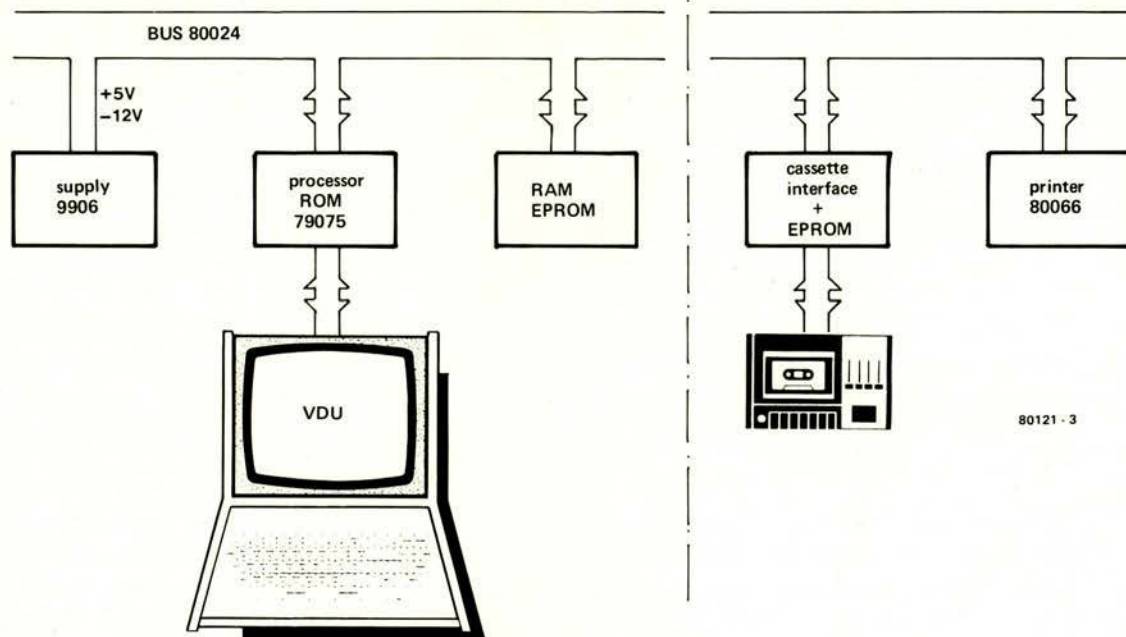


Figure 3. The SC/MP has been equipped with a terminal. By placing a pre-programmed ROM with Tiny BASIC on the processor circuit board, it may be operated in BASIC. Expansion possibilities are shown to the right of the dotted line.

is built on a single printed circuit board (see figure 2). Of course, it also needs a supply capable of producing +12, +5 and -5 V. The keyboard is constructed directly onto the board. The six seven-segment displays are mounted onto a small auxiliary board which is soldered in a slanting position onto the central board. Later on, a cassette interface and one or two cassette recorders may also be added. Furthermore, a connection may be made to the SC/MP bus by means of the connector which is on the board. This can come in handy, for instance, when more memory is required than is included in the circuit (1 K Eprom with the monitor programme and 1 K RAM).

The Junior Computer system operates in a hexadecimal code: in other words, using 0...9 and then A, B, C, D, E, F. The monitor program features a hex assembler. When jump instructions are encountered, the hex assembler provides the correct byte for the corresponding location. The monitor then passes on the addresses to the computer.

Before more complicated tasks (using high level languages, assemblers, etc.) can be fulfilled, a terminal must be connected. This can be done with the aid of the cassette interface board. For the necessary memory power, however, more EPROM will have to be introduced. This involves using the 8 K EPROM + 8 K RAM card belonging to the SC/MP.

For taping programmes, the cassette interface board will have to be added. Additional EPROM and/or RAM will have to be included, whenever one wishes to operate the available editor

assembler, disassembler or when programming in high level languages (such as BASIC).

### The SC/MP system

Finally, it is time to consider the SC/MP system. Because of its modular construction, several configurations are possible. The minimum (BASIC version) system is based on two cards (see figure 3). The first is the processor card which includes an address and data bus buffer and the possibility to connect a terminal (RS 232 interface). For the second the 8 K EPROM + 8 K RAM may be chosen. If so, the monitor programme must be part of the EPROM and as much RAM as required (from 1 K to 8 K) may be added. When a keyboard is used with the 2 card system it is able to run BASIC programs. The processor card has an IC (ROM) socket specifically for this.

For programme storage purposes the cassette interface may be added. With the aid of the matrix printer card a printed listing of machine language programmes may be obtained. The supply voltages required depend on which EPROMs are used. The 8 K EPROM + 8 K RAM card employs 2716 EPROMs and requires 5 V. On the cassette interface card there is room for EPROMs of the 5204 type and these require +5 and -12 V. Instead of the 2716, the 2708 may also be used. As a result, two more supply voltages (+12 and -5 V) will have to be added to the 8 K circuit and the memory capacity will be halved (to 4 K). The existing supply already produces the +5 V and

-12 V. On the SC/MP bus lines, all voltages mentioned are available.

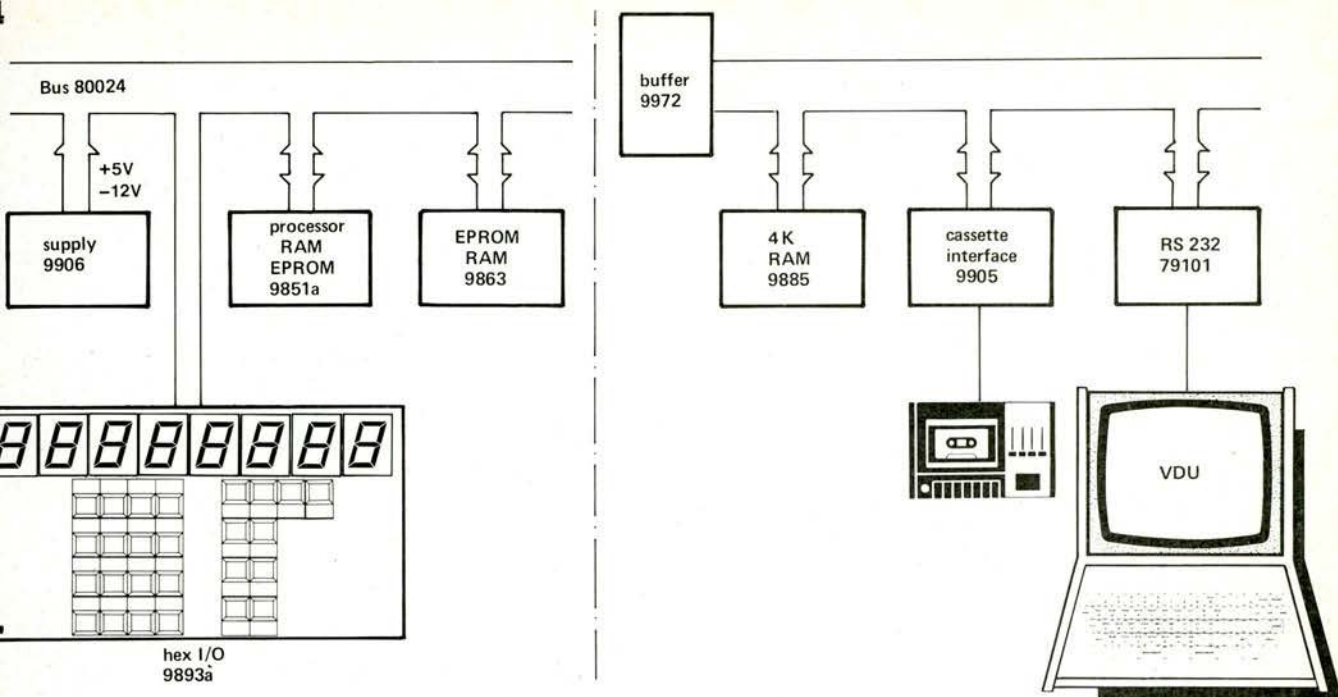
Apart from the modules mentioned above, there are still a few cards available which are based on a somewhat smaller system which communicates with the outside world by means of a keyboard, and eight seven-segment displays. This model resembles the Junior Computer in its elementary form. With the aid of these cards, a unit may be assembled as follows. (figure 4).

The SC/MP processor card plus the extension card constitute the actual computer. The data lines are not buffered, thereby restricting the size of the system. In order to build up a more complex system, a data bus buffer must be added (printed circuit board number 9972). The operator has 1½ K of EPROM available (the monitor programme) and 1 K of RAM. The RAM may be expanded with the aid of the 4 K RAM card. Data is written and read by means of 26 keys and eight seven-segment displays, installed in the hex-I/O printed circuit board. An auxiliary board will be needed for the connection of a cassette recorder (number 9905). A terminal, however, may be fitted with another circuit board (79101, interface for micro-processor). The layout is shown in figure 5.

### Which one is for you?

These then are the Elektor computers to date. Three complete systems designed for different purposes. The SC/MP for constructors with a desire for a





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Figure 4. The smaller SC/MP system (using different cards)

large system which can be expanded and/or modified as and when required. The TV Games Computer for those who want to see the results of their programming instantly in a visual form. The Junior Computer for the beginner, easy to construct and economical with great potential.

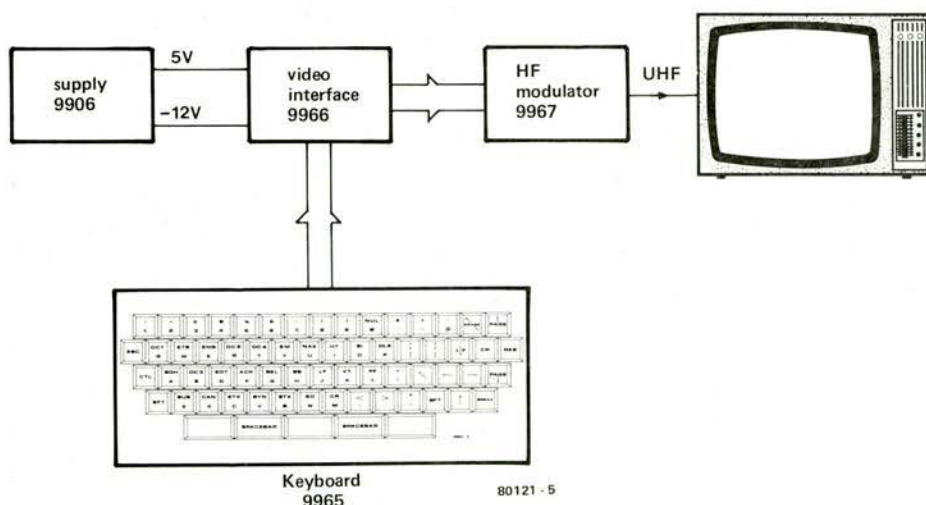
For the beginner... the obvious choice will be the Junior Computer with its excellent teaching facilities. For the expert... the SC/MP will probably be the most desirable with its many system variation possibilities. Why not add

- the Junior Computer to it (have a two computer family)?
- For the programmer... The TV Games is 100% FUN. Designed specifically for programming, it succeeds in its purpose very well.
  - For the constructor... If building is your wont the SC/MP will be fine. You can fill two kitchen tables with it.
  - For the experimenter... We are all one of these at heart really. And if you fit all of the above categories there can only be one answer...
- It is worth noting here that two new

computer books will be available from Elektor, one for the SC/MP and one for the Junior Computer.

### What does the future hold?

There are two things you can be sure of with Elektor, we always have something up our electronic sleeve. How about a PASCAL compiler for the Junior Computer or a complete computer cassette system? There are even rumours of a new VDU system using an unconverted TV set. Maybe even a new computer... who can tell? Just watch this space!



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Figure 5. A terminal may also be built with the aid of Elektor printed circuit boards. 16 rows of 64 characters may be displayed onto an ordinary TV screen.