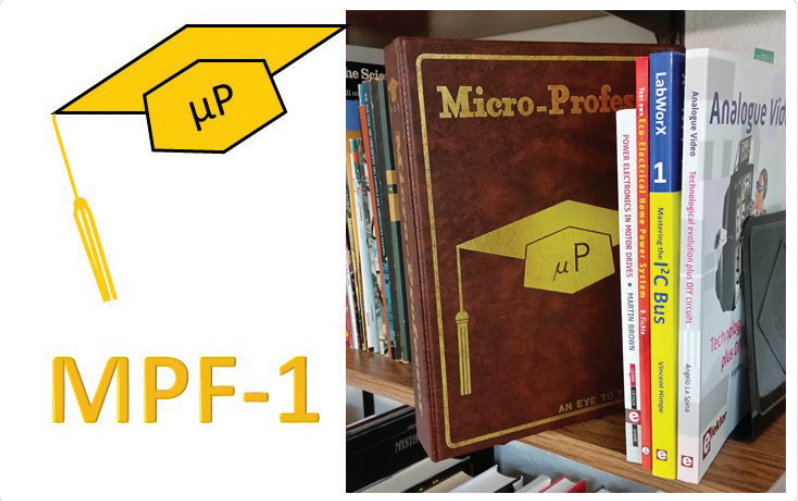
Micro-Professor

Learning Assembly Language on a Z80



By **Karl-Ludwig Butte** (Germany)

In 1981, there were lots of books about the Zilog Z80 microprocessor, which was introduced in 1976, but this particular book was different. With its spine width of 4 cm, you would anticipate around 500 pages of concentrated information, leading to many hours of tedious study of complicated and highly abstract material. But opening the book revealed a wonderful surprise: instead of the expected indigestible microprocessor documentation, what you saw was the microprocessor itself, mounted on a board and ready to use. Like to know more? Join me on a journey of discovery of how advanced training worked in 1981 with the Multitech Micro-Professor MPF-1.

In an industry sector that is progressing as rapidly as electronics, equally fast continuing education is the only way to avoid being quickly left behind. This was recognised by Stan Shih, his spouse Carolyn Yeh and five other business associates, who founded the company Multitech in Taipei (Taiwan) in 1976 — now better known under the name 'Acer'. Along with distributing spare parts for electronic devices and consulting on microprocessors, Multitech manufactured microprocessor learning systems in their own production plants. They therefore had prior experience with microprocessor learning systems when the Micro-Professor MPF-1 (**Figure 1**) was launched in 1981.

The Hardware

The MPF-1 was a single-board computer with a six-digit seven-segment display and a keyboard with 36 keys. It was built around a Zilog Z80 microprocessor clocked at 1.79 MHz. **Figure 2** shows the board layout. The Z80 microprocessor was accompanied by a Z80 PIO IC, a CTC IC, an 8255 IC, 2 KB of RAM and 4 KB of EPROM. The 8255, a programmable parallel I/O component, connected the keyboard and the seven-segment display to the processor. It also provided an interface to the built-in loudspeaker and the connector

Figure 1: The Micro-Professor MPF-1B in the opened book housing and the related documentation.

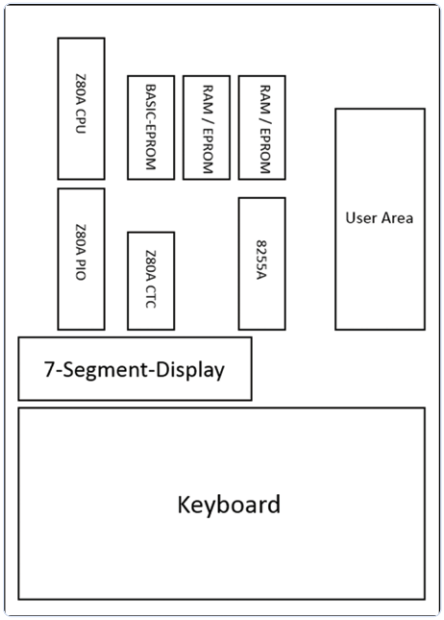


Figure 2: The board layout of the Micro-Professor.

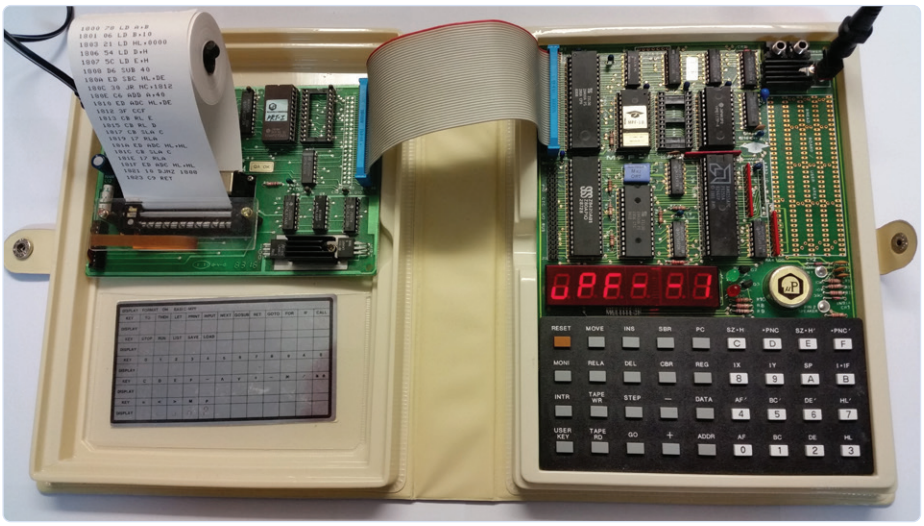


Figure 3: The MPF-1B with a connected thermal printer board.

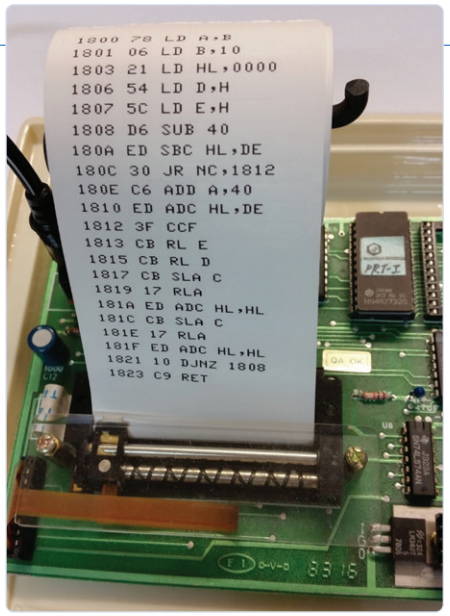


Figure 4: The assembly language listing of the square root program.

for the cassette recorder, which was used to store data and programs on audio tape – at the time the lowest-cost option for data storage. The Z80-CTC is a counter/timer IC containing four independent programmable counter/timers. Finally, the Z80-PIO is a parallel I/O component used to connect peripheral devices. Among other things, Multitech offered a thermal printer (see **Figure 3**) and an EPROM programmer as peripheral devices, as well as a voice output board. There were also other companies that manufactured or sold extensions for the Micro-Professor. For example, the distance learning institute Christiani in Constance (Germany) enhanced its Micro-Professor curriculum with its own I/O card specifically designed for the distance learning course.

Documentation

The documentation for the Micro-Professor (Figure 1) was just as minimal as the hardware configuration, and certainly not comparable to the lovingly composed user guide for the CP1 learning computer from Stuttgart-based Kosmos described in the July/August 2018 edition of Elektor [1]. It's no coincidence that a renowned distance learning such as Christiani took up the Micro-Professor and published their own educationally oriented course. Multitech provided a user manual of just 95 pages for the MPF-1. At least the manual that came with my Micro-Professor was in German. The *BASIC-MPF Operation Manual* was only 39 pages long, and like the *MPF-1 Experiment Manual* also included with the Micro-Professor, it was only available in the original English version.

The author(s) assumed that their readers had a good basic knowledge of microprocessor technology. For example, the MPF-1 user manual starts with the following sentences (after an enumeration of the technical data and a brief description of the various keys): "*The monitor program includes all service routines necessary to make things easy for the user: (1) Loading programs in RAM, followed by testing and/or modification.*" Although all essential information, such as the Z80 instruction set, the programming architecture of the Z80, the memory structure and the I/O pin assignments, was available further on in the manual, it was mostly in tabular form without any sort of explanation. It was therefore advisable to arm yourself with suitable reference material, such as *How to Program the Z80* by Rodnay Zaks. He had a lot more to say about the Z80 – his book contained over 600 pages.

Programming in Assembly Language

To learn first-hand what it's like to work with the Micro-Professor, I took the example program 'Square Root' from the manual. Fortunately it was printed not only in the abbreviated shorthand notation of Z80 assembly language but also in hex, since you can only enter hex code with the keyboard. First you have to press the ADDR key and enter the start address, then you can switch to data entry mode with the DATA key and enter the first data byte. After this you press the + key to advance to the next byte, where you can directly enter the next byte of the program. The program can be keyed in fairly quickly this way. To check the program, I printed it out using the Disassembler Listing Utility, which is provided by the connected thermal printer starting at hex address 6000 (**Figure 4**).

After verifying that the printout matched the listing in the manual, I gave it a try. The task for the Micro-Professor was to calculate the square root of 81. The program expected to find this value (in hexadecimal format, of course) in processor register BC. Using the REG and BC keys, I could view the current value of this register, and with the DATA key I was able to enter the first byte (BC is a 16-bit register). At this point I was faced with the question of which should come first: 51h (equivalent to 81 decimal) or 00h. Guided by the principle that practical experience takes precedence over book learning, I first tried 00h followed by 51h, which gave a completely meaningless result. This meant I had to start all over again and key in the sequence REG, BC, DATA, 5, 1, +, 0, 0 (**Figure 5a**). To start the trial run, I then had to set the address to 1800h and press the GO key (**Figure 5b**). Next came the exciting moment: I checked

INTERVIEW WITH MAX D. SOFFE, MANAGING DIRECTOR OF FLITE ELECTRONICS INTERNATIONAL LIMITED

Max D. Soffe is a member of the Industrial Advisory Board for the Department of Electronic Engineering at Royal Holloway, University of London, and the Institute of Engineering Technology (www.theiet.org). From 2000 to 2004 he was Chairman of the Educational Technology Engineering Manufacturers Association (ETEMA) in Great Britain. He also was the Director of the British Educational Suppliers Association (BESA).

Karl-Ludwig Butte: Flite Electronics International bought the intellectual property rights of the Micro-Professor MPF-1B from Acer. What was the motivation?

Max D. Soffe: Acer used to be called Multitech. I met them on my first trip to Japan in 1981. They were exhibiting the MPF-1B Z80 Microprocessor Trainer in Tokyo. I was fortunate enough to meet and make friends with the founders of Multitech. There were only 20 people in the company then, and they were based in Hsinchu Science Park, Taipei. I made a double-page advertisement in a magazine called *wireless world* in the UK and sold a hundred MPF-1B in three weeks. So Multitech gave me the UK distribution rights, although we started selling all over the world.

Later, Acer needed to up its turnover and wanted to concentrate on the booming PC market which was, as we know, very successful. The small Z80 trainers were effectively loss-making. Over 11 years, Flite Electronics had sold thousands of MPF1-Bs. As the product was still expensive for a private user, our customers were mainly tertiary education, universities and colleges. We were still selling a lot and so I negotiated with Acer to purchase the intellectual property rights. This was signed and sealed in February 1993.

It wasn't as successful as I'd wanted it to be because Acer just washed their hands of the product leaving it to us to stop the "pirating" of the product. We couldn't afford to take on three or four companies that were simply copying all of the MPF-1B, its manual, PCB and firmware. However, we did carry on and slightly redesigned the PCB, keeping all the firmware. The components started to become difficult to obtain and there have been problems with Z80 (declared) processor, EEPROM, and RAM speeds.

Karl-Ludwig Butte: There are websites on the Internet (e.g. https://en.wikipedia.org/wiki/Micro-Professor_MPF-I) that say that the Micro-Professor is still manufactured and distributed by Flite Electronics International today. Is that correct? And, if so, where can readers order their unit and at which price?

Max D. Soffe: Yes, of course we are still manufacturing the MPF-1B, albeit in very small batches. The last batch we did was 25 about six months ago for an order for a Middle Eastern university. As the lecturers, educated in the UK, have used the MPF-1B 20 years ago and still teach machine code/hexadecimal coding in their university syllabus.

Figure 5: A: Input value 81_{dec} in register BC. B: Start address. C: Result 9 in register DE.

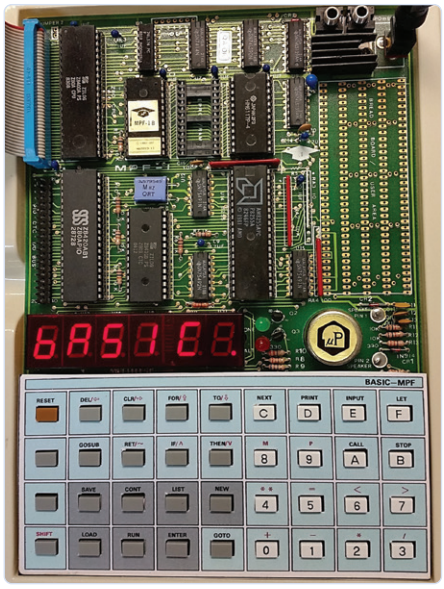


Figure 6: The Micro-Professor in BASIC mode with the keyboard overlay template.

the result in register DE, and lo and behold it lit up with the lovely number '9' (**Figure 5c**).

The BASIC Interpreter

Shortly after the launch of the MPF-1, the MPF-1B came on the market, and after that the MPF-1 was called MPF-1A to distinguish it from the B version. What could the MPF-1B do that its predecessor couldn't? The answer is that Multitech had added a new EPROM containing a small BASIC interpreter. I naturally wanted to try this out, since BASIC with a seven-segment display and a hex keyboard was something totally new for me. The MPF-1B came with a keyboard overlay for his purpose, which in the case of my device had long since gone missing. Nowadays the Internet is the answer to this sort of problem. I quickly found the template and printed it

If Elektor readers email sales@flite.co.uk, and be patient, we will answer their email and give them a quotation. We have about eight in stock. Please note when those units are sold, it could be two to three months before we build another batch. I have noticed there are a few second-hand units being sold on eBay.

As I've explained, the components are now quite expensive for what they are, and you can tell by the production date code on the IC (e.g. 9243) that the components were manufactured in the 43rd week of 1992. So, we do spend a lot of time testing components and the finished product for speed and race conditions with component incompatibility failures. For this reason, we have all the ICs on sockets. So we can quickly jockey ICs around. Obviously, when we supply a finished new unit, it is fully working and guaranteed for a year.

Due to all of this we realise we will never make a successful business model out of such a product. It was a stepping stone for Acer to become a massive international brand, but like Acer the Micro-Professor will never make us any notable profits. Unfortunately, we cannot afford to sell the product for less than £250 plus VAT and postage.

Karl-Ludwig Butte: What kind of documentation do you deliver with the Micro-Professor?

Max D. Soffe: The documentation is very important. We deliver each Micro-Professor with a Student Workbook. This manual should take the student from unpacking and powering up the micro system through to understanding microprocessor systems, architecture, hardware, software and interfacing. It was initially intended to be a self-teach manual to train students in hexadecimal programming. As we know, computers work on binary and the next step up from that is hexadecimal. The beauty of hexadecimal coding was in the time when memory was expensive and very limited. The Micro-Professor taught the student to write very tight code, and not sloppy code as many coders do nowadays. Indeed, it is not really coding by just moving cartoon balloons around.

Karl-Ludwig Butte: What is Flite Electronics International's main business today?

Max D. Soffe: Due to the pirating of the Micro-Professor during the 1990s, Flite Electronics teamed up with a company in Taiwan called K&H which manufactures educational technology equipment. This was because our customer base was mainly educational establishments, not private individuals. We are K&H's UK educational technology product distributors. We recently installed a £240,000 electrical machines laboratory in Coventry University. We didn't design the system, we integrated it from existing K&H modules. Last week, we added a £50,000 extension to this laboratory.

Also, we do still supply general microprocessor trainers for the Motorola 68000, the Intel 8086, and the 8032 microcontroller; here again we sell 10 of each a year, mainly supporting existing customers and agents, but we will be happy to quote on these products. Another add-on product that we designed back in the 1990s to add on to all our microprocessor training systems is an all-in-one laboratory called the APB (applications board). This too comes with a training manual.

Karl-Ludwig Butte: Thank you very much for this interview.

out on fairly heavy paper. Cutting out the holes with a scalpel took a little while. The admirable result can be seen in **Figure 6**.

As an example program, I chose a routine from the *BASIC-MPF Operation Manual* that can generate multiple signal tones. The BASIC interpreter is located in memory with a starting address of 0800h and can be launched with the GO command. It announces its presence with 'bASIC' on the display, as can be seen in Figure 6. Now the program can be entered. First the line number, then the BASIC statement, followed by any variables, numbers or parameters. Each BASIC statement can be entered with its own keypress. Finally, you press ENTER, just like the old days with an Apple II, PET 2001 or TRS-80. Everything worked fine up to a point, but I had trouble entering the statement `FOR A=1 TO C`. Instead of the equal sign, I kept seeing a 5 on the display, despite pressing the SHIFT key first. That turned out to be due to an old habit: as the keyboard of the Micro-Professor so closely resembles the keypad of a pocket calculator, I was pressing and releasing the SHIFT key instead of holding it pressed, as with a PC. It took a while before I realised that the Micro-Professor considers itself to be a sort of PC, so I had to hold the SHIFT key down while pressing the = key.

After surmounting this small obstacle, entering the rest of the program was easy. **Figure 7** shows a couple of examples of how BASIC instructions are represented on the seven-segment display. **Figure 7a** is `10 Input C` in normal notation, while **Figure 7b** represents the line `50 Next B`. The manual contains a table of the BASIC

Figure 7: A: 10 Input C. B: 50 Next B. C: Input prompt.

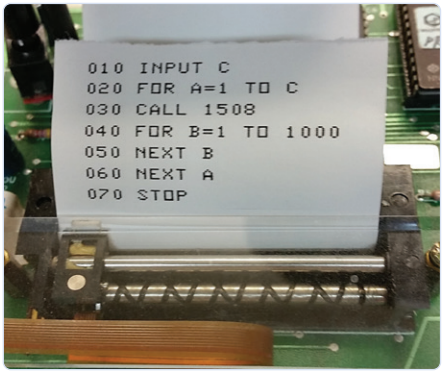


Figure 8: Example BASIC program printout on the thermal printer.

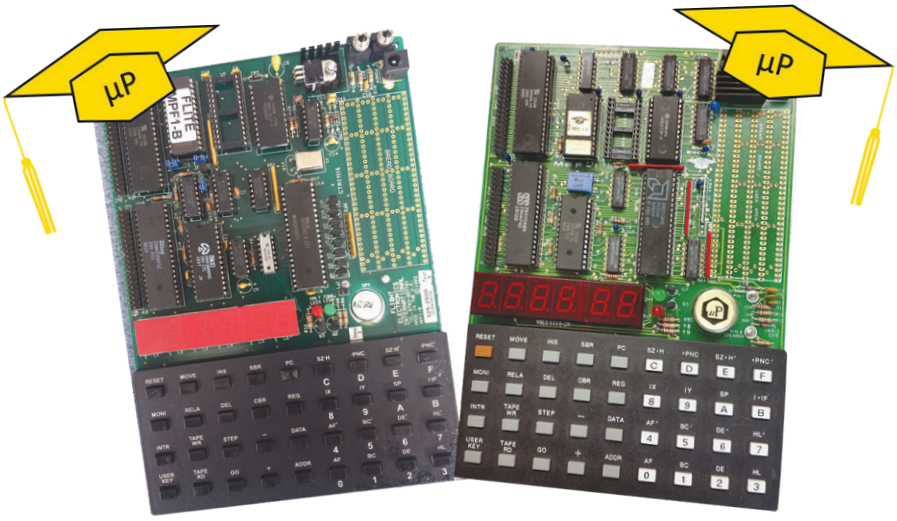


Figure 9: The Micro-Professor from Flite Electronics International (left) and its counterpart from Multitech (right).

instructions and their respective representations on the display. This is certainly necessary, since in some cases you need a lot of imagination. Editing is also possible, but it makes the vi editor from the Unix world look very user friendly.

Now it's time to try the BASIC program we just entered. After you start the program with the RUN key, you are first asked for the number of signal tones to be generated (**Figure 7c**). I entered 3 and pressed ENTER, and then I heard three relatively high-pitched tones, exactly as expected.

With a relatively long program, there is a fairly good chance of typos somewhere. In my view, trying to find typos with only a cryptic seven-segment display appears very tedious. Fortunately, BASIC programs can be printed out as normal text if you have a printer connected to the system. **Figure 8** shows the listing of the signal tone program.

A Worthy Endeavor

One thing is certain: once you have worked extensively with the Micro-Professor, you will be on a first-name basis with every bit of the Z80 microprocessor and its peripherals. The path is not always easy, and you will need persistence, but in my view, it's worth the effort. It's also amazing how similar the concepts are to the "Assembler Crash Course" series by Miroslav Cina published in *Elektor* starting with the July/August 2015 edition [2].

In the course of researching this article, I found indications on the Internet that the Micro-Professor MPF-1B is still being manufactured and sold. I checked out these indications and contacted the company Flite Electronics International Ltd in Waltham Chase, Hampshire, Great Britain [3]. They confirmed that they have acquired the rights to the Micro-Professor and are still manufacturing the device. **Figure 9** shows the Micro-Professor from Flite Electronics side by side with its Taiwanese counterpart from Multitech. Flite Electronics generously provided me with a sample product, and I can confirm that it is of excellent quality. Of course, I wanted to know all the details, and Max D. Soffe, Managing Director of Flite Electronics, kindly agreed to an interview (see inset).

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Questions or Comments?
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WEB LINKS

[1] **Butte, Karl-Ludwig: "Introduction to Microprocessor Technology with the Kosmos CP1 (1983)", Elektor 7-8/2018**: www.elektormagazine.com/magazine/elektor-201807/41747

[2] **Cina, Miroslav: "PIC® Assembler Crash Course", Elektor 7-8/2015**: www.elektormagazine.com/magazine/elektor-201507/27958

[3] **Flite Electronics International Limited**: www.flite.co.uk