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SKIP II: A Very Inexpensive Microcomputer

"SKIP II, my low-cost introduction to microcomputers."—Author.

The SKIP II kit as it arrived in the mail. The black object in the center is the 40-pin socket for the SC/MP-II microprocessor chip, shown wrapped in foil just below the socket.

When I first began to look at home computer systems with the idea of actually buying one, it wasn't long before I had to decide exactly what I wanted. Did I want a system that you take home, unpack, plug it in and begin programming? Or would it be more fun—and would I learn more—if I bought a basic, single-board system that could be expanded at a later date? A trip to my local computer store made the decision for me—the ready-to-run systems were simply out of my price range. Therefore, it would have to be a single-board computer.

Once I made that decision, I was faced with another: which single-board system should I buy? There were, and still are, many of these on the market, and it's no easy task to decide which one best suits your purpose. After reading literature on the more popular and well-known systems (such as the

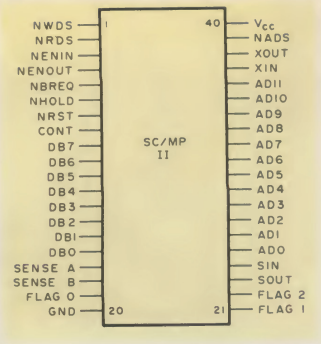


Fig. 1. Pin-out information.

KIM, the COSMAC Elf and the E&L MMD-1), I found what I was looking for in a kit manufactured and sold by NBL in Richardson, Texas.

Basically, I was looking for three things. First, I wanted to learn as much as I could about the hardware end of microcomputers, both the design phase and construction techniques. Second, I wanted a kit that could be expanded to a maximum configuration system at a *reasonable* cost and on a "money available" basis. Finally, I didn't want to have to mortgage my house and car to buy the basic computer.

The SKIP II kit from NBL filled the bill perfectly, and I would like to tell you about both the kit and my experiences in constructing it. Please bear in mind that I had never worked with printed circuits before this and knew very little about hardware or digital design. My knowledge was confined to software design and systems programming on large, multi-user systems.

The SC/MP-II Chip and SKIP II

The heart of the SKIP II microcomputer is the SC/MP-II microprocessor chip manufactured by National Semiconductor. This little known but quite powerful processor chip is gaining in popularity among hobbyists. Constructed as a standard n-channel, 8-bit microprocessor in a 40-pin DIP, the SC/MP-II was originally intended for use in general-purpose applications such as test systems, process controllers, word-processing systems and the like. However, because of its low cost, strong instruction set, versatility and ease of interfacing with almost all of the peripherals available today, the SC/MP-II is ideally suited for the hobbyist.

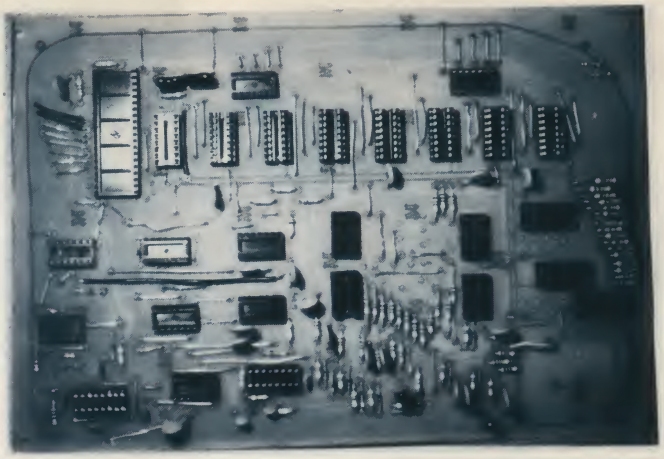
The Simple Cost-effective Micro Processor, version II is capable of addressing up to 65K of memory, contains both serial and parallel data transfer instructions as well as its own timing circuitry and is designed for low power consumption. It requires a single +5 volt power supply (unlike the original SC/MP, which required both a +5 and a −7 volt supply). The pin-out information is shown in Fig. 1, while a typical application utilizing the SC/MP-II is shown in Fig. 2. Note that the SC/MP and the SC/MP-II are software compatible but *not* pin-out compatible—several signals changed from active low on the SC/MP to active high on the SC/MP-II or vice versa.

NBL interfaced a keyboard and an array of LEDs to the various chip inputs, providing a way to input and output data. A complete 1K of RAM was added along with the required control circuitry. The entire computer consists of two parts: the printed circuit board containing 27 integrated circuits and a screen-printed front panel containing the keyboard, control buttons and LED readouts.

The keyboard is interfaced directly to the CPU without use of a ROM. Several control buttons are provided.

RESET aborts any program in progress and sets the program counter to zero so that the first instruction will be read from memory location 001. It also puts the computer under the control of the buttons on the front panel, where it remains until the EXECUTE button is depressed. While the computer is in this manual mode, data can be read into or out of sequential memory locations by contacting the READ/WRITE button. To debug programs, they may be executed one step at a time by use of the ADVANCE EXECUTE button. In fact, you can execute a program you are loading one step at a time by use of this ADVANCE EXECUTE button.

A bootstrap program is required to install breakpoint halts or to address a specific memory location anywhere within the memory. This very simple procedure is explained in detail in the programming guide accompanying the kit. More information on the SKIP II may be obtained by writing NBL, Box 1564, Richardson TX 75080.



Final stages of construction of the PC board. The SC/MP-II socket is in the upper left with the memory sockets to its right.

Constructing the SKIP II

Now that we know a little about the SKIP II and the SC/MP-II chip itself, let's turn our attention to building the kit. I'd like to discuss my experiences during kit construction, followed by a critical analysis of both the kit and my experiences, and end with some enhancement ideas I've been considering. Again, bear in mind that prior to the postman's delivering my SKIP II kit, my electronics experience was confined to building several simple Heath products.

Thanks to the excellent packing by NBL, even the postal service couldn't damage the kit components. It arrived in excellent condition (see "arrival" photo). Note that in my kit the only IC included was the SC/MP-II chip itself. I elected to save a few dollars by utilizing some chips already in my parts bin plus a few purchased through surplus sources. NBL offers all ICs as part of their package.

I was immediately impressed with the quality of the kit, especially the printed circuit board. Approximately 9 × 11 inches in size, all of the traces were cleanly etched with only a single copper "splatter," which

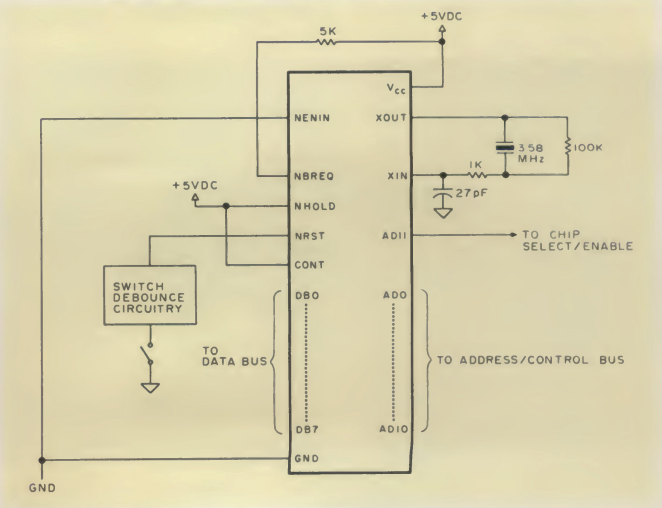


Fig. 2. A generalized SC/MP-II application.

I easily removed with an X-acto knife. There was also evidence of a quality-control type of inspection prior to shipment—one of the traces had been repaired by bridging a small gap with a piece of wire. I feel that this speaks highly of NBL and their concern for their finished product, since the first step in the construction process is to visually check the PC board for gaps, shorts, splatters and other defects. Even though NBL knows the customer is going to inspect the board himself, they still make that final check prior to shipment.

After carefully reading over all of the instructions several times, I began the actual construction by separating the various resistors, capacitors and diodes according to values. This, I reasoned, would make it easier to find the various parts during the soldering process. Besides, NBL furnishes a resistor value table that I wanted an excuse to use!

The next step was to cut the leads from most of the discrete components. It began to appear that this would take at *least* a week, until I realized that I could make a simple jig and not have to measure each lead individually. After measuring the various distances on a piece of paper taped to my bench, I finished the rest of the parts in less than 15 minutes.

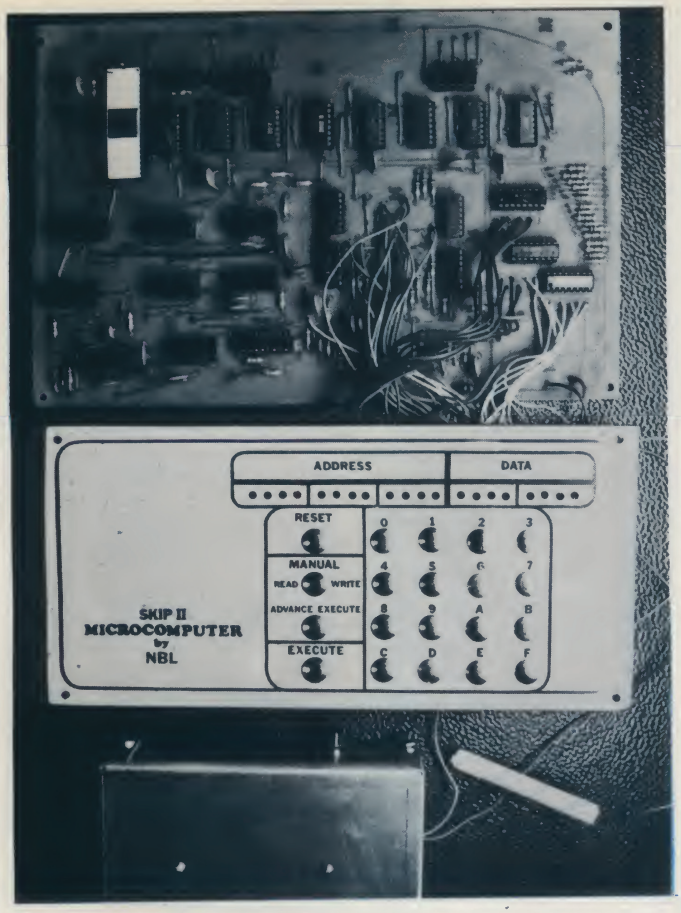
Next, following instructions, I used the cut leads (where possible) or insulated hookup wire to insert the jumper wires into the PC board. There were quite a few, but the illustrated instructions made it easy. I checked and double-checked the placement of the wires, then soldered them into place and checked the solder joints. Everything appeared to be OK, so I continued on to the next step: installing the resistors, diodes, capacitors and transistors.

Again, the clearly illustrated instructions made it easier than I thought it would be. The only problems I encountered resulted from my own errors—I installed one of the diodes backwards and had to replace it. Fortunately, I hadn't gone too far before discovering the error, so the board was relatively uncluttered. Things were really going smoothly, and the computer began taking shape before my eyes.

Next came the SC/MP-II socket. This was the only area in which I had problems with my soldering—those solder pads are *so* small! Diverging from the instructions just a bit, I also installed sockets for the rest of the ICs. These aren't called for by NBL—indeed, you could probably do without them and save a few dollars—but I wasn't too experienced in soldering and didn't want to take a chance on ruining the components. After soldering all the sockets into place—there are a *lot* of leads on that board—I inserted all the ICs *except* the SC/MP-II chip. I only bent one lead over—not too bad, considering all of the opportunities I had! The PC board was now complete. On to the front panel!

The unique keyboard arrangement is one that I personally like. It consists of 20 thumbtacks for keys and a probe with which the operator contacts the desired key when entering data or instructions. Granted, it is such a novel approach that it looks a little strange when you first see it, especially when you compare it to the *fancy front* panels on the higher-priced machines. However, it works well and is extremely easy to use. The cost savings realized by using the thumbtack-probe assembly instead of an expensive hex keyboard were used to improve the overall performance of the computer, making the SKIP II the only computer with a full 1K of RAM selling for less than $100.

The reverse side of the front panel contains solder pads for connection with the data, control and address lines, the LEDs (all 20 of them) used for display of the data and address bus contents, and the keyboard probe assembly. Following instructions, I soldered the LEDs and their associated current-limiting resistors into place, then connected the various bus wires from the PC board to the



The completed SKIP II kit with all ICs installed and the address, data and control buses in place. The box at the bottom of the photo is the 5 volt power supply.

front panel. The only problems I encountered here were caused by a basic lack of coordination on my part—I could have used at least three hands! Fortunately, my wife was willing to assist me, and we finally got everything soldered into place.

Once the front panel was complete, it was time to apply power to the circuit. Connecting a regulated 5 volt power supply to the board (I used a Radio Shack project board, but NBL furnished complete instructions for scratch-building a suitable power source), I made one last visual check of both the board and the front panel. Not finding any obvious errors, I applied power and, lo and behold, it worked! Not only did the lights come on, but there was neither smoke, nor flames nor strange noises!

The instructions say to let the system "burn in" for a few minutes. I left it powered up for about 15 minutes, then powered it down to insert the SC/MP-II chip. One more visual check, and I powered it up again with identical results—no surprises at all.

The construction manual also contains a preliminary system checkout guide that allows you to exercise each portion of the circuit and test the function of each key. While performing this preliminary check, I discovered that the READ/WRITE key didn't function properly. Trying to utilize this opportunity for learning to the fullest, I got into the final portion of the manual—troubleshooting.

I traced the circuit through from panel to board, comparing the readings from my VTVM to the chart of pin voltages supplied in the troubleshooting section of the manual. Everything seemed OK. I was just about to throw up my hands in despair when I realized that the signal

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at that last pin was high when it should have been low and that it had remained low for an extra cycle. Stepping back to the previous component, I discovered that I had inadvertently inserted the two transistors backwards!

After unsoldering the connections, I re-oriented the components and re-soldered them to the board. I then ran through the preliminary check again and discovered that everything worked exactly as advertised. My computer was finished!

Now came programming—my favorite activity, I might add—and here again NBL was prepared with a complete, easy-to-understand programming guide. I had previously joined a users' group sponsored by National Semiconductor for those owning systems based on the SC/MP (both I and II), IMP and PACE products, and had read everything available on programming the SC/MP. I had also purchased National's programming guide, which, with my experience in programming, would really have been sufficient for me to start programming my SKIP II. However, the NBL programming text had a basic advantage over the National text because it was written specifically for the system I had. National's book assumes that you have, as a minimum, a TTY with their Kitbug monitor routine stored in ROM.

The NBL programming guide takes each of the SC/MP-II's 46 instructions and three addressing modes and explains each one in detail. A simple program centered around each instruction is introduced with a full explanation of what the system is doing at each step. The programs progress in complexity from an easy "2 + 2 = 4" to the point where, as NBL states, "the only limitation is the imagination of the programmer." After covering the programming guide, I struck out on my own and to date have written several programs that, although they solve no earth-shattering problems, allow me to develop a feel for the way my new computer system operates.

Evaluation

Overall, I have to say that the SKIP II kit is great. The printed circuit board is quite well done, the components are of the highest quality and the documentation is superb. Although I *did* have a few problems during construction, the majority of them were as a result of my own errors or lack of knowledge. I received one of the first kits off of the assembly line and, as a result, found a few errors in the diagrams, instructions and commentary in the construction manual. However, a quick letter to NBL resulted in a clarification and corrected page in all cases. If asked whether I would purchase another kit from these folks, I would have to answer resoundingly, "yes!"

Speaking of other kits leads me into the last topic of this article. What enhancements to the basic system are planned? Obviously, with only 1K of RAM, a 20-key hex keyboard and a string of LED readouts, the system is limited to somewhat simpler tasks. In order to increase the usefulness of my system, I have planned, and am currently working on, the following:

1. A full ASCII keyboard—possibly a kit (such as the one from Radio Shack) or perhaps a scratch-built unit.
2. Conversion of the 20 separate LEDs to the popular 7-segment readouts.
3. Installation of PROM (at least 8K) to contain the monitor and service routines I currently have and those I will develop.
4. At least 8K of RAM. Of course, this will entail building a larger power supply, designing a suitable cabinet, etc.
5. An experiment to attempt to interface a scientific calculator chip to the system. I'm not entirely sure this is practical, but I can't find anything that says it's impossible!

In addition, the folks at NBL tell me that they are working on what I call "variations on a theme," i.e., they are designing a series of kits and games to utilize the various sense inputs and outputs currently unused in the SKIP II. They are also working on TV and cassette interfaces and considering the possibility of offering compatible memory boards, games and related products.

Conclusion

Well, there you have it. I hope you found my experiences with the SKIP II kit interesting and informative. I believe that I accomplished what I originally set out to do: I have a system that I built (and thus understand the operation of), that is expandable to as large a system as I wish and that taught me a tremendous amount about digital design and construction techniques utilizing printed circuit boards.

I hope that those of you who are in the position I was in before I built the SKIP II will seriously consider this fine kit as a low-cost introduction to the fascinating world of microcomputers. I really enjoyed building the system, and am having even more fun "playing" with it. It was, in short, a valuable learning experience for me—I think it will be for you, too. ■

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