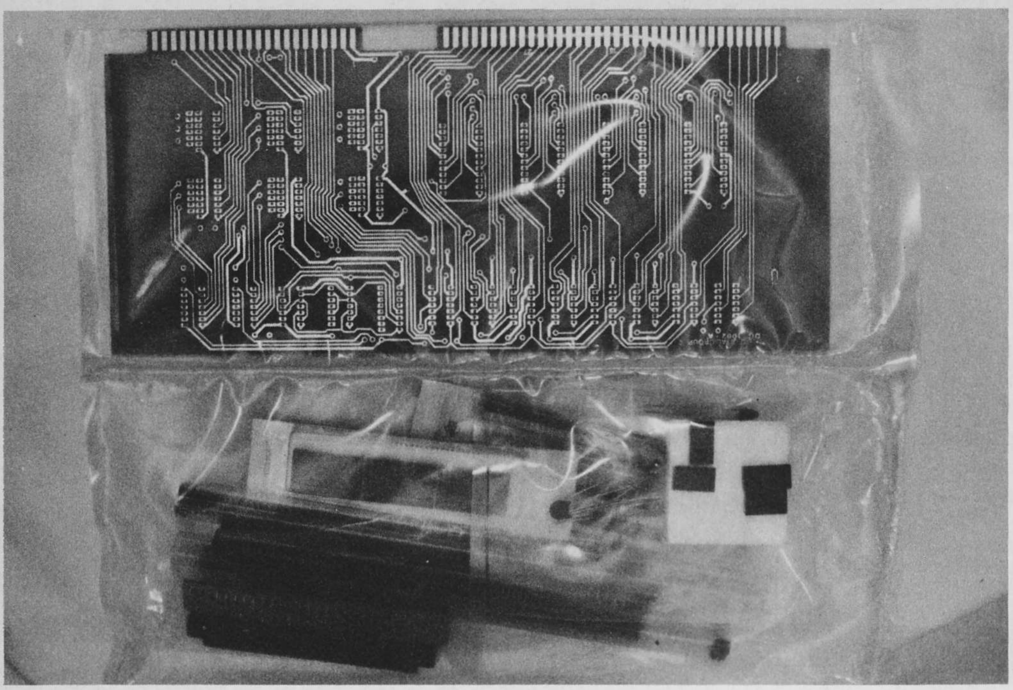

Photo 1: The typical board in a Digital Group kit comes in a sealed plastic bag with two compartments. One compartment contains the board and the second contains the necessary parts.

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Try This Computer on for Size

There are a number of fine microprocessor system kits available to the home computer enthusiast. One such system, which I just recently assembled, is the Digital Group 8080A. This microcomputer is marketed by the Digital Group in Denver CO. This concern, with Dr Robert Suding as its resident genius and designer, offers in my opinion the highest price performance of any home computer available. The Digital Group is somewhat unorthodox by not jumping on the bandwagon and being Altair bus compatible but their unit contains enough bells and whistles to placate even the most demanding computer owners.

This system, as is true of most others, has its good and bad points. I am an electrical engineer well versed in digital design and have been closely following the microcomputer scene since the advent of the MARK-8 in 1974. I have a Scelbi 8B and have helped friends build Altairs and IMSAIs from kits and feel that I can be completely objective. It is of course extremely difficult to restrain laudatory comments when one is so well satisfied, but bear with me.

The Digital Group sells a basic computer system which can contain one of four processor chips: the Zilog Z-80; AMD 8080A; MOSTEK 6800; or a MOS Technology 6502. I chose the 8080A because of a combination of price and software availability. The Digital Group System (DGS) is generally sold as a three board system with mother board. This three board microcomputer has the following functions and specifications.

Processor Board
- AMD 9080A
- 2 K bytes programmable memory and EROM bootstrap loader.
- Direct Memory Access (DMA) logic.
- 8 level hardware vectored interrupt.
- Buffered address and data bus lines.
- 16 bit (64 K) addressing capability.

Input Output Board
- Four 8 bit parallel input ports.
- Four 8 bit parallel latching output ports.
- Full 16 bit port addressing.

TV Readout and Cassette Interface Board
- Video Readout:
  - Software controlled cursor.
  - 512 characters organized as 16 lines by 32 characters.
  - 7 by 9 character matrix.
  - Full 128 ASCII character set.
  - Upper and lower case alphabet.
  - Math symbols.
  - Special symbols.
  - Greek alphabet.

Direct video output.

Cassette Interface:

- Uses standard cassette recorder.
- FSK recording technique.
- Wide shift Teletype frequencies.
- Operates at 1100 bps.
- Utilizes "software UART."

An additional 8 K programmable memory board is added to the three board set and is sold to make a four board set. The specs on the programmable memory are as follows:

8 K Static RAM Board

- Uses 2102-1 parts with 500 ns access time.
- No wait states.
- Buffered address lines.
- Address decoding covers full 64 K range.
- Power consumption 2 A at 5 V.

There are many variations of the basic system as described, and this listing is only representative of their total offering. Interested parties should contact the Digital Group at POB 6528, Denver CO 80206.

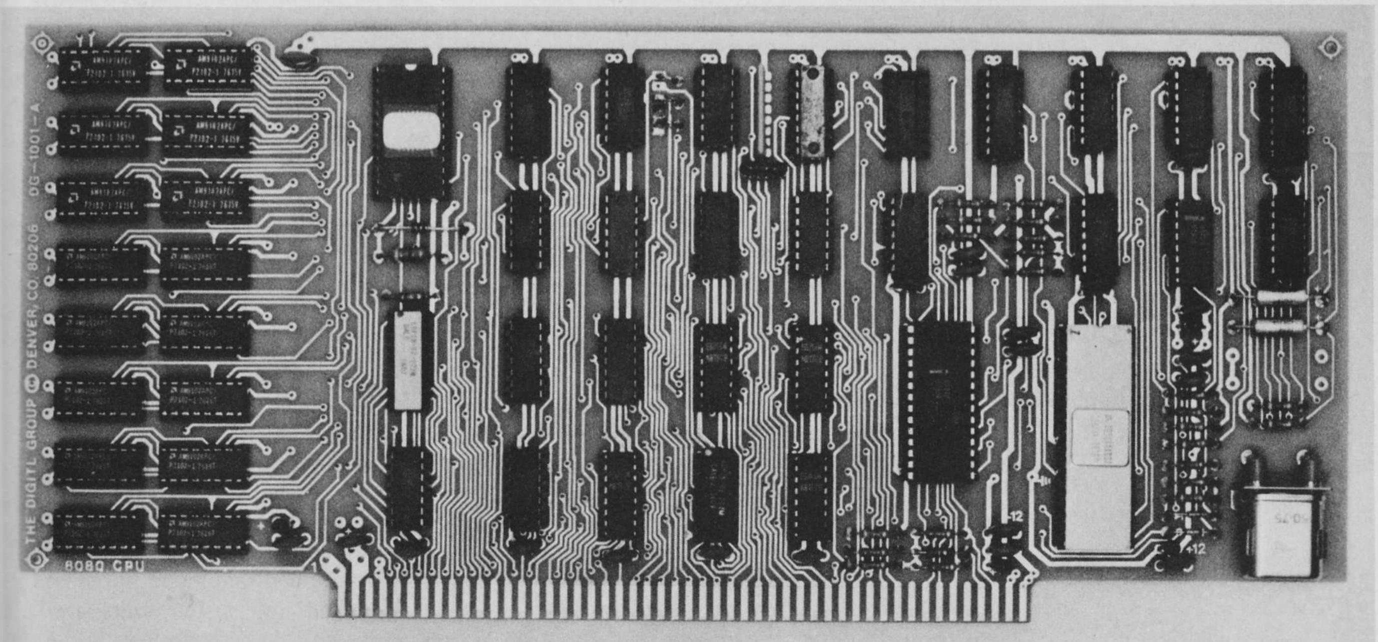
As I mentioned previously, I had been following the DG since they entered the microcomputer scene. Their first offering was a simple 300 bps "el cheapo" cassette interface which met absolutely nobody's standard. While everyone was arguing Kansas City and all the rest, I built this for $6 and had it operational in three hours. I have always been action oriented and all the talking in the world won't put your system on line. I have grown to expect and accept the unorthodox from the Digital Group.

Other manufacturers sell basic bare bones systems for prices starting around $600. For this price they contain a fancy case and front panel, gigantic overkill power supply, and a processor board with ancilliaries. There is no memory, IO, or mass storage capability: These are all extra cost options. Minimum capacity machine language and cassette storage system can approach $800 to $900. I affectionately refer to this nickel and diming as an "arm and a leg turnkey system."

The DGS is a profitmaking venture, I assure you; but it appears to have pricing and design philosophies which in my opinion better meet the needs and requirements of the knowledgeable experimenter.

When one buys a DGS three or four board system, you get Digital Group's version of the logically complete product: a system which in its basic price has no case, power supply or front panel. These are available from DG and can be purchased of course by the affluent or built from scratch by the frugal. Add a power supply, a video monitor salvaged from an old TV, a surplus

Photo 2: The author's Digital Group 8080 processor card. The actual processor is an AMD 9080A, one of the second sources of the original Intel 8080 design. The crystal which controls the processor clock is at the lower right, and the 2 K byte section of memory on the card is represented by the two rows of eight sockets at the left edge of the card. A UV erasable ROM chip (marked "80A" with a felt tip pen on the top edge at left of center) contains systems software which eliminates the need for a formal "blinkin' lights" front panel.



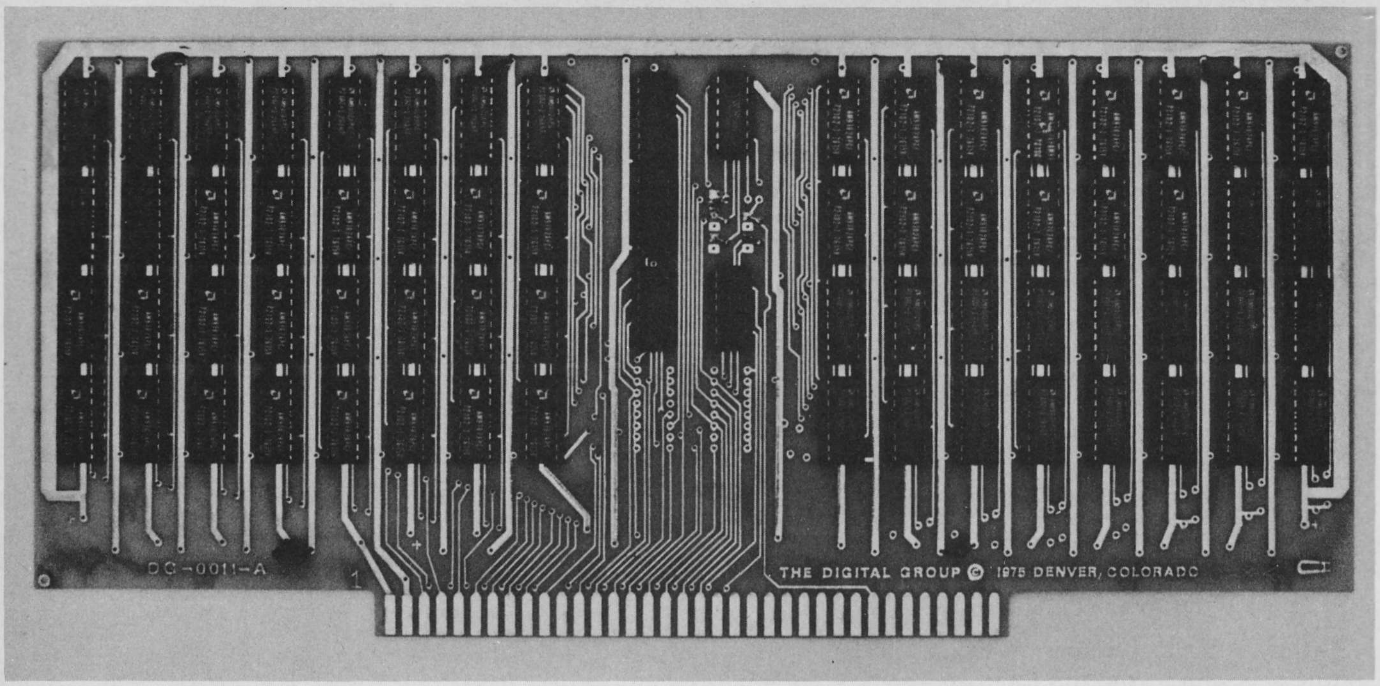


Photo 3: The author's Digital Group System 8 K byte memory card. The card contains 64 memory integrated circuits (in two arrayed segments) and in the center are various miscellaneous circuits used to interface the backplane bus of Digital Group system.

ASCII keyboard, and a decent cassette recorder; and you are in business with a complete functioning microcomputer.

I had been hearing this rhetoric and receiving DGS flyers for a while. Then I decided to take the plunge. I called DGS one morning in mid 1976 and ordered the four board 8080A system with standard mother board. Since this four board set contains 10 K bytes of programmable memory and is capable of supporting an Extended Tiny BASIC, I ordered the TBX software for $5. The total 10 K system as ordered was $645. Literature supplied by DGS quoted 30 day delivery but I had resigned myself to the possible two month wait that friends were experiencing with other companies. When the complete package arrived three weeks later I was ecstatic and set out immediately to the task of getting "on line."

The packing material, though sparse, was adequate; and, since there were no heavy components like transformers, its lack was inconsequential. Like any kit builder, I expected the first project would be to separate the pile of parts and boards and to sort components out among the respective boards. Anyone who has ever experienced sifting through a pile of resistors until their eyes cross can appreciate what I am saying. Fortunately this was unnecessary. Each board is packaged in a two compartment sealed plastic bag. One side contains the blank printed circuit board and the other contains all the integrated circuits, sockets, and other components as seen in photo 1. When unpacking, two things are immediately apparent. The boards are top quality with plated through holes and there are no jumpers.

I searched through the box looking for the usual last minute revision sheets and tackons but there were none. This apparently was a final design with absolutely no "kluge rigging" necessary to make it work. The Digital Group flyers indicate they do not sell interim designs nor advertise anything for sale until it is available "off the shelf." From my experience, this appears to be the truth.

The ease of construction of this system is a function of the particular board being assembled. I'll cover each board separately, but a word of caution first. The Digital Group System is not and should not be considered in the same realm as a Heathkit or similar undertaking. Hardware documentation is adequate and descriptive but is not as detailed pictorially as a Heathkit. This is not a kit but rather an unassembled microcomputer. Its construction should be attempted by the experienced kit builder only. If necessary, build several difficult Heathkits first to gain experience with electronics components and assembly. At the least, difficult assemblies should be purchased as fully assembled and tested units and the other cards carefully constructed.

Building the Processor Board

The processor board is of course the heart of the microcomputer. This card contains the microprocessor itself and supporting components. It is shown (after I assembled it) in photo 2. The Digital Group has sought to learn from the experiences of other manufacturers and builders and has obviously benefited. The most notable addition is the incorporation of integrated circuit sockets throughout. Even with the use of prime components, bad circuits are possible. The average hobbyist may have considerable experience doing the initial soldering, but unsoldering an integrated circuit is quite messy. Using sockets adds the capability of quickly changing a suspected bad component without either destroying the integrated circuit or the printed circuit board.

Significant effort and thought has been put into this microcomputer design as is evident in the system architecture of the processor card. The microprocessor is driven by a crystal controlled clock which exhibits none of the frequency instability of multivibrator controlled clocks. Crystals are currently used in most microprocessor systems for their "rock like" stability. In addition, there is 2 K of programmable memory on the board which can be selected to respond to any two consecutive 1 K positions in memory address spaces. For startup and checkout, this memory should be set for 0 to 2 K allowing the user to perform limited machine language programming without additional memory. I'll cover the procedure for checkout a bit later.

There are of course other goodies on this card. Direct Memory Access (DMA) and priority interrupt hardware is provided as a user option. The basic three and four board systems include test procedures for the interrupt request logic but DMA checkout is left for the brave of heart and is not addressed here. In addition to this circuitry, a 1702A EROM containing the tape cassette bootstrap loader is located in Page 0 of memory. When power is turned on, a power on reset signal initializes the system and reads in the operating system cassette. More on this later.

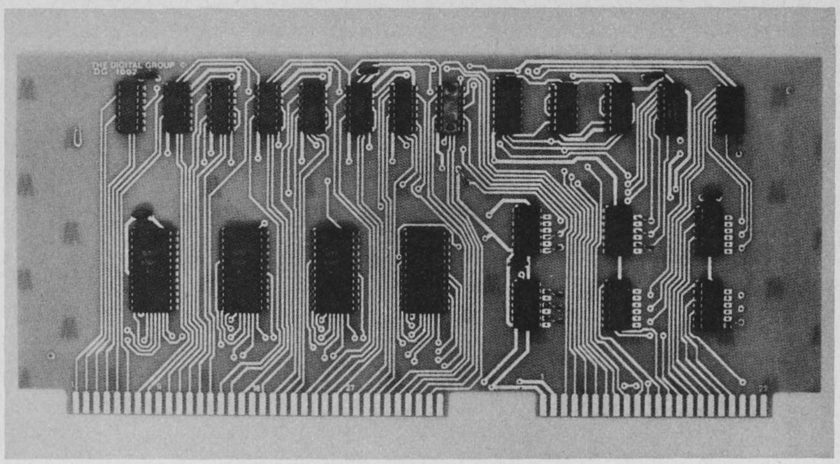


Photo 4: The author's Digital Group System IO card. This card interfaces to the system's bus, providing four parallel output ports and four input ports. These ports are routed to the backplane where they communicate to the video display, keyboard and cassette interfaces.

The Digital Group System bus structure is similar but differs in detail from that of the Altair. Robert Suding's publicized philosophy dictates an interchangeable processor capability which hopefully decreases the obsolescence of the total system. As new and more powerful microprocessors such as the Z-80 come on the market, a new processor card should be interchanged with the bus of the older unit while not affecting the rest of the system. To accomplish this goal, the Digital Group system uses unidirectional address and data buses as in the

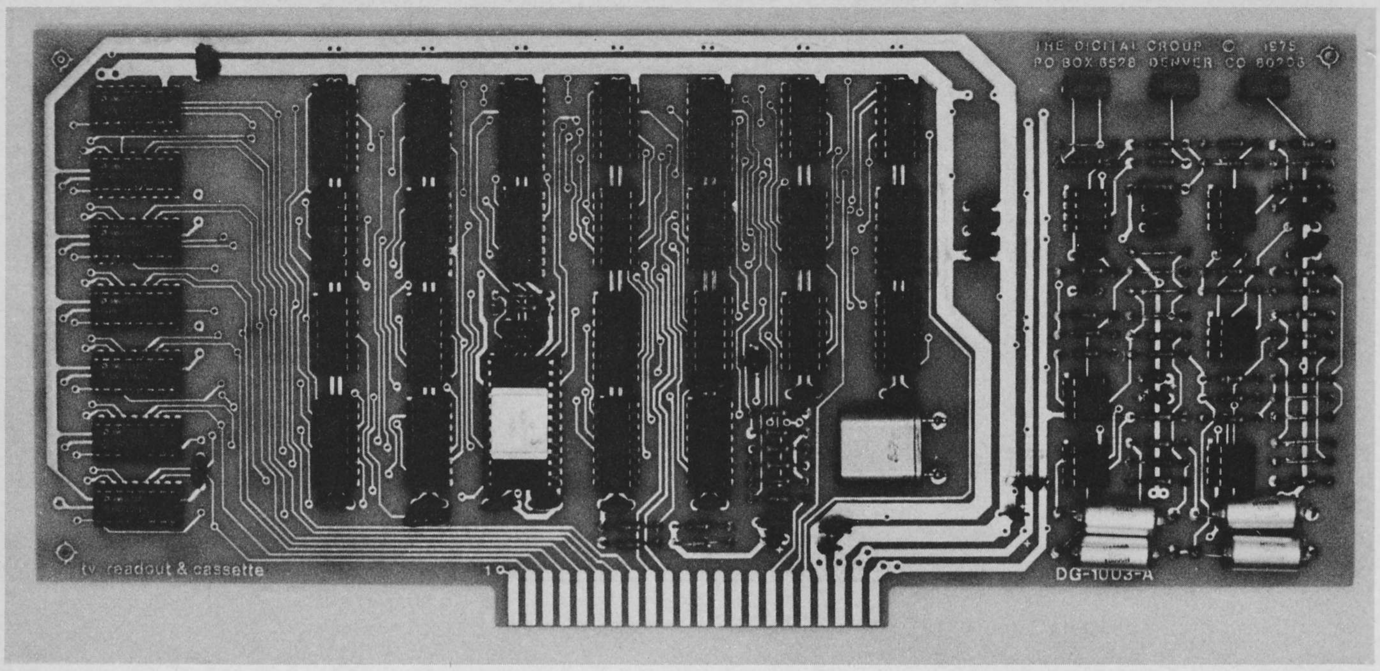


Photo 5: The cassette and CRT interface board. This board contains the video signal generation and audio processing circuits of the Digital Group System. [For more detailed descriptions, see the July and August 1976 issues of BYTE.]

Altair. Such a bus structure, as has often been seen in the marketplace, is easily adapted to any 8 bit processor. There is of course a basic disadvantage to owning a unique backplane pinout, that of having only a single source. Every microprocessor manufacturer knows that few designers will tie themselves to a single source part. That is the reason you see so many different companies producing 8080s. The Altair bus has been widely second sourced, which has led to some fierce competition resulting in modest benefits to the buyer. Obviously the small system owner does not have the same constraints as the high volume manufacturer but he should be aware of the lack of price competition and interchangeability when it comes to memory and IO card expansion. The Digital Group is apparently aware of their unique position and has sought to dispell concern by selling blank IO and 8 K memory boards at a very reasonable price. This allows the user to shop around for the best 2102-1 memory prices.

Since the DGS has no front panel, the processor card cannot be checked out easily by itself. But then no real functional test of a processor system as a whole can be easily performed with a front panel, either. The rest of the system must be constructed to perform the necessary diagnostics.

Assembling the Memory and IO Boards

Both the 8 K memory and parallel IO boards are constructed in a very straightforward manner. Again all integrated circuits are socketed and literature supplied is both explicit and clear. The memory board (see photo 3) and components supplied to me contained premium grade AMD 2102-1 parts. With these parts no wait states are required and the processor runs at full rated speed.

The IO card which contains four parallel inputs and four latched parallel outputs must be set to the lowest order addresses when only one IO board is in the system. This is because the video display generator, keyboard and cassette interface are directly wired to IO ports on this card through the mother board. The ports are address selectable; but to utilize the DGS operating system software, the addresses must be set as described in the DGS write up. Additional memories or IO can have addresses to suit the user.

Assembling the Cassette and CRT Interface Board

This board is the external communications medium of the Digital Group microcomputer. Since the DGS has no front panel, it is solely dependent upon a video based operating system utilizing the video display generator interface and a television monitor, or modified television. The software for such an operating system is about 1.5 K and cannot be entered except through the cassette interface. I should clarify one thing though. The DGS which I purchased is quite amenable to front panel hookup. The three and four board units sold by the Digital Group do not incorporate front panels but they do provide a design for one. Obviously, if a user builds a DG system and both his processor and video display sections fail to function properly, he is dead in the water and would have to build the front panel. The design is neat and functional and plugs into any spare memory card slot. If, on the other hand, the user is thoroughly frustrated, suspect boards can be returned to DG for troubleshooting according to a price schedule supplied with the unit.

Now that you know how to get yourself out of the hole if it happens, I'll explain the proper method of digging.

The CRT and cassette interface sections are assembled using the same methodical approach as the other boards. The literature is very good in this respect. The problems come in calibration. The CRT is fairly straightforward, it either works or it doesn't. There are no adjustments. This section, when completed, is plugged into the mother board, attached to a monitor, jumpered as per the testing procedure, and powered up. If it works the screen will be immediately filled with 512 random characters. These characters include upper and lower case alpha symbols, and Greek lettering. When this works you are half done with the check out of the card.

Being half done in this case is not nearly enough. The assembly of the cassette interface is simply a matter of following directions but calibrating it is a bit of a task. There are operating system options which allow the computer to function as a frequency counter, but that is a little further downstream. To properly adjust the cassette interface, a scope, a frequency counter, an accurate DC voltmeter or DVM and a variable frequency oscillator are required. I fortunately have all this equipment, but not everyone's spouse is as understanding as mine. The frequency source is set to 1 V p to p at 2125 Hz and applied to the interface input, simulating the tape recorder output. Using a scope to determine the point of peak response, the active filters are adjusted correspondingly. This procedure is repeated for 2975 Hz. Next the comparator which detects whether the input frequency is at a mark or zero is adjusted to switch cleanly as the frequency source sweeps between the two valves. That takes care of the receiver sections.

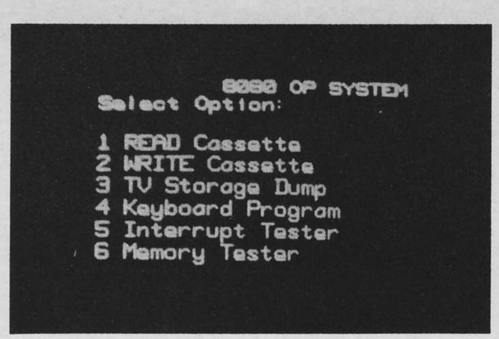


Photo 6: When you get this far, you know your Digital Group System has arrived in the land of the living.

The FSK (frequency shift keyed) modulator is a single VCO (voltage controlled oscillator) chip which switches between two frequency values corresponding to TTL one or zero inputs. In initial checkout, a voltage (3.5 V) simulating a TTL level one is applied to the control line of the oscillator and the output is adjusted to 2125 Hz. The control line is then grounded and the output adjusted to 2975 Hz. If this can be accomplished satisfactorily, you're in business.

System Checkout

When all of the cards are assembled, and the solder splashes cleaned off, take one last look at each card. Remember, this is the smoke test.

Attach the power supply to the mother board and with no boards inserted and the power on, check that the proper voltages are present. Shut off the supply and insert the processor, IO and CRT cards. Cross your fingers and turn on the power. If all works correctly, the screen will display: "READ 8080 INITIALIZE CASSETTE". Successfully accomplishing this means that the processor is operating correctly, the CRT board works fine and at least part of the IO board is functioning.

The acid test is loading the operating system via the cassette interface. (To facilitate this endeavor and add more ease of operation, a Reset/Run button should be wired to the mother board as described in the DG literature.) With this message present on the screen, insert the 8080 operating system cassette and hit the play button. Adjust the output level to be about 1 V p to p and soon a leader tone should be heard. No change should appear on the screen. Immediately following the tone will be the asynchronous data at 1100 bps. Proper reception of this data will be evident on the video display. As each byte of data is processed and loaded into memory, it is read from memory to verify that it got there. If it loaded correctly, a number corresponding to the high order digit of the octal page address of this byte location is printed on the screen. With 256 bytes per page, there will be 256 number 1s, 256 number 2s, etc, until the tape is loaded. Should the memory check signify a bad byte, a period (".") will be displayed instead of the octal number. It's a good idea to watch the screen while the cassette is being read.

If the cassette was read in properly, the computer will display the operating system options on the screen as in photo 6. If not, try again. Be careful to watch that there are no numbers, signifying received data bytes, on the screen prior to the playback of the actual data on the tape. Should this occur due to a noise glitch, hit the reset, and it will clear this problem.

The DGS operating system requires that alphanumeric information be input on a parallel 8 bit input port in the form of ASCII. All this means is that you need a keyboard. The ASCII is 7 bits of the input port and the eighth bit corresponds to the key pressed or strobe signal. The operating system scans this bit looking for a transition from a zero to a one so therefore it must be a positive going strobe (TTL level) with a minimum duration of 50 μs. I have a surplus Sanders Associates 720 keyboard which a lot of people have. This keyboard has a 5 μs negative going strobe though and must be modified by adding a oneshot such as a 74121 to it. Since the whole keyboard runs on 5 V, this is an easy conversion and the keyboard is an exceptional buy. With keyboard and monitor, the system is totally operational. If you were able to get the operating system option list which appears in photo 6, you are ready to go. Hit 3 and the screen displays the contents of all the registers and flags. Hit space and you'll start to page through memory displaying all memory contents. Return to the operating system and hit option 4 and the keyboard can be used to enter octal machine language code anywhere the user desires. The complete explanation is included with operating system tape.

Where the Digital Group System really shines is the cheap software and system simplicity. Add the 8 K memory board, set the address for 0 to 8 K and reset the processor 2 K memory to occupy 8 K to 10 K and we are ready to run Extended Tiny BASIC.

With 10 K of memory installed, turn the system on and start the 10 K Tiny BASIC tape as you would the operating system tape. After a few minutes the tape will have been read and the system will display the Tiny BASIC options:

TINY BASIC

1. READ BASIC PROGRAM
2. WRITE BASIC PROGRAM
3. DISPLAY COMMANDS

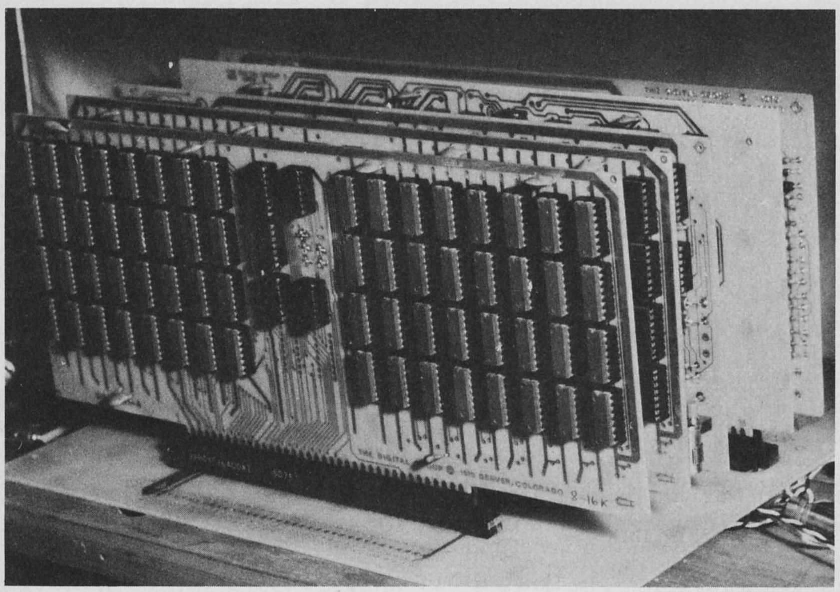


Photo 7: A view of Steve's assembled Digital Group System. [When a party from the BYTE office stopped by at Steve's basement laboratory in Connecticut on the way back from Atlantic City last fall, we found his system up and running as pictured here, with his older Scelbi 8B computer acting as a slave peripheral processor to control the vector graphics output device described on page 78 of the November 1976 BYTE. Steve cooked an excellent Quiche Lorraine for dinner that night while Dan Fylstra and I explored a game of KINGDOM running in Tiny BASIC . . . CH]

4. DISPLAY ERROR CODES
5. CONTINUE PROGRAMMING
6. TINY BASIC

With these options, an Extended Tiny BASIC, created by Dick Whipple and John Arnold and described in the January 1976 issue of *Dr Dobb's Journal of Computer Calisthenics and Orthodontia*, is ready to go. Buy a couple of simple programs such as Blackjack, Bantum and others from the Digital Group Software Systems, and you can utilize the computer immediately to entertain the whole family or bone up on Tiny BASIC and write your own programs.

Observations and Criticisms

As stated earlier, it is my opinion that the Digital Group System is one of the best offerings on the small systems market today. But as previously mentioned, anyone not having the proper equipment should not attempt to assemble the CRT and audio cassette interface. After receiving my system, I was up and running with the 2 K processor card memory with two evenings' work. Since I had the equipment and am very receptive to logical well written instructions, I had no troubles. My cassette interface didn't work at first, and I discovered that it was because of insufficient tape recorder bandpass. I had hoped to use the same el cheapo recorder that I used for my previous 300 bps interface, but no way. I rushed out and spent a whopping $39 for a new one from J C Penney which had been suggested by another Digital Group System owner. The first time I hit play, it worked perfectly. Since that time, I have discovered that the cassette interface is sensitive to both volume and tone settings during playback. This is probably only a function of the tape recorder I own and is not necessarily indicative of a general problem. Using a quality cassette recorder of the type suggested by the Digital Group should eliminate any playback problems.

Recording a program on tape is simply a matter of choosing the correct operating system option but getting accurate mark and zero frequencies may require minor tweeking. There appears to be some shift in the output frequencies from the time of the static calibration and actual dynamic operation. This is obviously due to the fact that 3.5 VDC and 0 V are not the actual TTL levels applied to the voltage controlled oscillator. A VCO is an analog device and not all TTL chips are exactly alike. After reading in the operating system tape I

Continued on page 129

Continued from page 121

recommend that a short program be written to cycle the cassette output between a one and zero every few seconds. Connect a frequency counter to the output and readjust the mark and space pots to the correct specifications. I also noticed that variations in power supply voltages from one time to the next can adversely shift this frequency. Having an adequate well designed power supply will limit variabilities even as more memory is added. My 10 K system draws approximately 4.4 A at 5 V and with 18 K on it; it now takes 5.7 A.

The last comment is no Digital Group problem, but rather mine. I assembled the 10 K memory board as instructed, plugged it into the system and ran the DGS memory test program for a couple of hours. It all checked out fine, but when I tried to read any program which occupied 10 K of memory (2 K worked fine) it bombed out. Since the memory test program said the memory was fine, I was led to suspect the 10 K BASIC tape. I shipped that tape off to a friend to try it on his DG system and contacted the Digital Group software people for a new tape. Within five days I had both a new tape from DG and confirmation from my friend that I had a problem because the tape was OK. But the memory test said the memory was OK! Well, don't believe it! In the process of removing and checking each 2102 on my 8008 system I found an IC with a pin bent under it. Straightening this pin and reinserting the 2102 was all that was needed, and the Tiny BASIC read and executed perfectly. Be careful of memory test programs.

In conclusion, my experiences with the Digital Group 8080A System have been gratifying. My system worked with no major problems, and any intelligent user either constructing the computer in whole or part should expect the same. The fact that I now have an operational microcomputer has caused a slight problem, though. I never get to use it! I seem to continually have people from my office over in the evenings programming one thing or another. In fact, I had to add another 8 K this week to allow more Tiny BASIC programming space for one guy who is writing a statistical program which he hopes will help him win at jai-alai. I suggest that if you get one of these small computers, just walk around with a pleasant pregnant smile, but for heaven's sake don't tell anyone that it really works!■

[Watch for Steve's humorous account of jai-alai in April's BYTE.]