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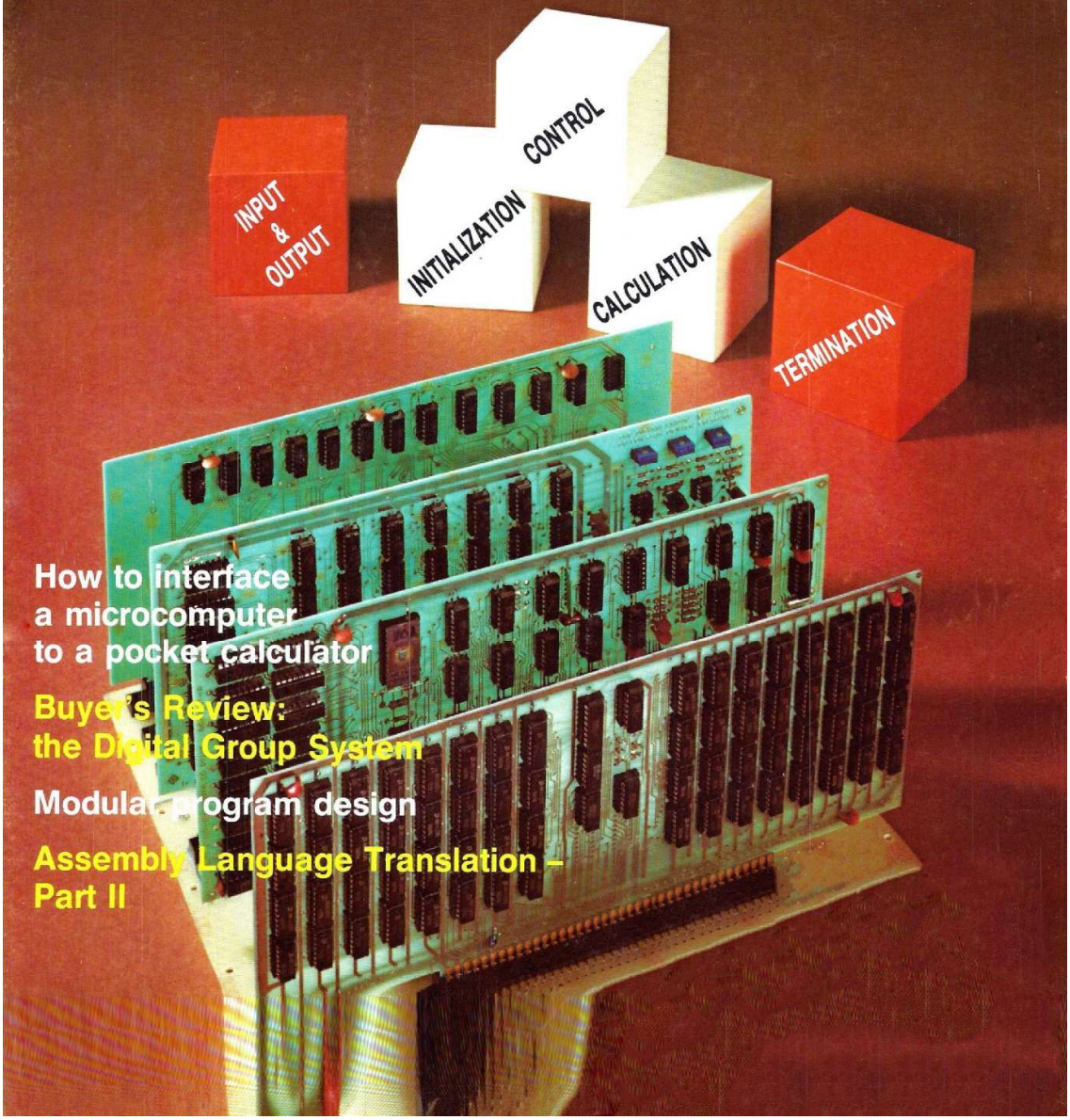

How to interface a microcomputer to a pocket calculator

Buyer's Review: the Digital Group System

Modular program design

Assembly Language Translation – Part II

buyer's report:

the Digital Group System

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"It plays the *Star Spangled Banner* on the radio while it draws a picture of the U.S. Flag on the TV," I argued. "We can't afford another expensive gizmo," countered my wife sharply. "And besides, it's a lot cheaper to watch the Bicentennial Minutes," she added. We were, of course, discussing the merits of my proposed purchase of a Digital Group (DG) System computer. Being a confirmed computerholic, I hocked my camera and bought the full-blown DG Z-80 system despite domestic objections.

Anything that pays for itself makes sense to me. That's why I chose the Z-80 version of the DG system (they can sell you just about any CPU board you might wish for). The additional cost of

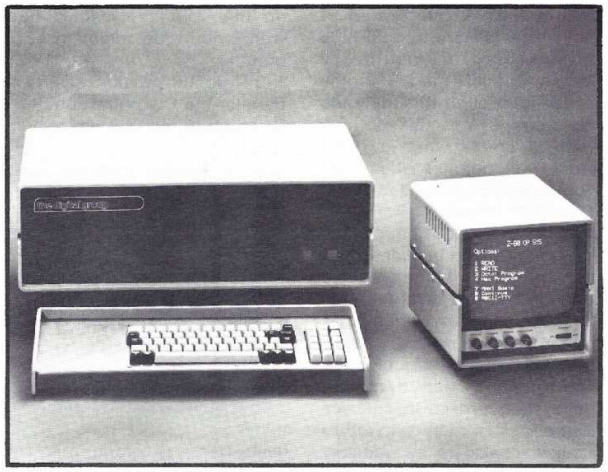

photo 1. The complete Digital Group System housed in distinctive tan and black cabinets. Promised shipping date to customers is early February.

powers of 2 which will add up to

approach to card-level design.

A 2N5129 video combiner pro-

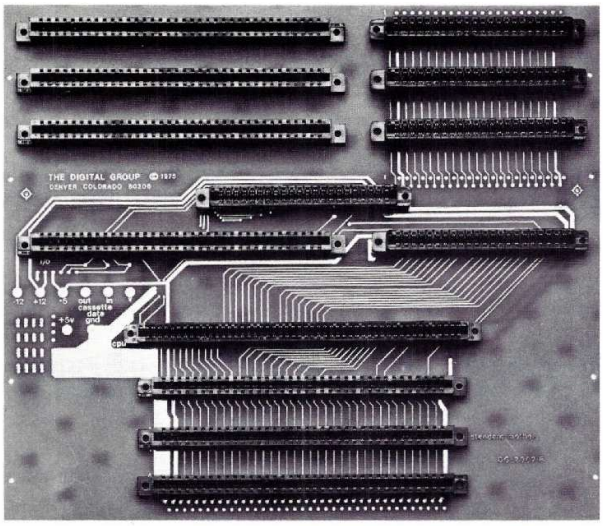

photo 2. This is the Standard Motherboard. It supports 26K of memory, 16 input ports and 16 output ports, in addition to the CPU, TV/Cassette cards.

the Z-80 CPU version is offset by the reduction in memory used by this super powerful chip. So there, 8080 fans — may the Bird of Paradise eat your 8228 system controller.

Since, as I mentioned, I hocked my camera to help hide the true cost of my new hobby from my spouse, the DG people were kind enough to supply the photographs for this article. **Photo. 1** shows what my CPU cabinet will look like when it arrives (promised ship date from DG is late January). For $895 (shipping included) I bought the Z-80 board (which includes 2K of memory), an I/O card, TV Readout/Cassette card, 8K RAM card, 12 Amp power supply, Standard Motherboard, Standard CPU cabinet, fan, binder, documentation, and hardware. The system arrived about one month after I ordered it (with a certified check to reduce delays). If you have a pressing need (or can't stand suspense), call the DG (303-777-7133) and get the current estimated shipping dates. I have found them to be exceptionally forthright and courteous. Call and get acquainted — and I suggest you do this with any manufacturer with whom you might invest a bundle.

DG documentation seems to parallel the DG philosophy — it is concise, correct, and complete. It's not a dissertation on microcomputer theory, but it tells you what you need to know to put the system together and get it running. Each board is documented in a separate section which is well written and very carefully organized. My only objection is that the few component value corrections which show up in the documentation might have been noted in the very first part of the documentation. Detailed board debugging is included.

Since the motherboard embodies the character of the entire system, we will evaluate this board first. Incidentally, the order in which we will examine the boards is the assembly order recommended by the DG.

the Standard Mother

Photo. 2 shows the 'Standard Motherboard' fully populated with the appropriate edge connector sockets. Since each board kit comes with the required socket to mate it to the motherboard, the Standard Motherboard is supplied bare. Molex connectors are recommended for slipping over the wire wrap sockets supplied with each I/O kit to connect the input and output ports to peripherals. These are *not* included with the kits since the number of connec-

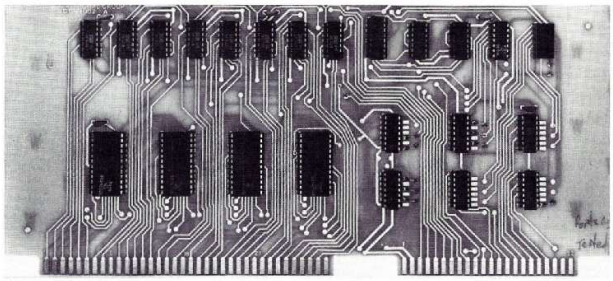

photo 3. Four latched 8-bit output ports and four gated (open collector to bus) 8-bit input ports reside on this board. Address jumpering permits addressing these ports at any four consecutive locations in the 65K range.

tors required depends on the number of I/O ports you wish to establish. For $35 you can buy a Molex connector kit, complete with flat cable, from the DG. Add $8.95 if you need the crimp tool. Refer to the DG Flyer No. 5 for details regarding the Molex connectors.

I/O Card features

The DG I/O card is not a fancy programmable type. Instead of inscrutable Peripheral Interface Adapters (the title is bigger than the chip), we find a simple, respected workhorse — the 74100 TTL latch — serving as the output port element, and the even simpler 7404 open-collector dual-input NAND functioning as the input port element. That's what I like about the DG design; it's so simple that you will understand it even when it doesn't work. If you've ever had to trouble-shoot some of the complex, kludgey systems designed by people who worship large-scale integration circuitry, you will be soothed by the shocking simplicity of the DG system.

Address lines terminate in 16 7404 gates which are in turn connected to 16 7404 gates. This series buffer configuration permits the user to pick off the inverted or non-inverted address line signal for the desired decoding. The four 8-bit input and output ports on the I/O card can be set up only as a block of four sequential (contiguous for you picky folks) locations; 0-3, 4-7, etc. Here's the procedure: determine the number of the highest port to be on the card. Then find the combination of the powers of 2 which will add up to this number. For example, if ports 24, 25, 26, 27 are the ones you want, figure that 27 is a binary 11011. Therefore, tie the address straps No. 0, 1, 3, 4 to logic one pins (next to the inverter chips), and strap No. 2, 5, .., 15 to logic zero pins. All four ports are now properly decoded. And if this isn't simple enough for you, the DG documentation has a map of the straps with an example to make sure you understand how easy it is to set up the addressing.

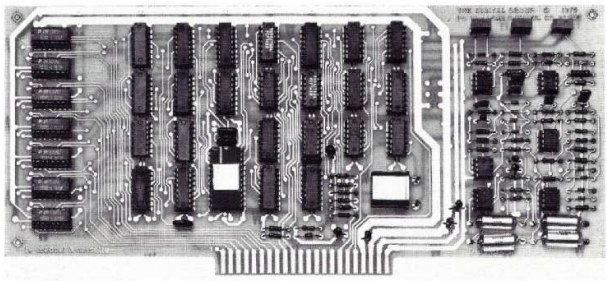

photo 4. Here we have the TV Readout/Cassette card. The readout employs a 7 X 13 dot matrix to produce each character for enhanced resolution. The display buffer consists of the RAM at the left, while the cassette interface active filter is on the right.

Photo. 3 reveals the clean, open layout which should make it a snap for you to construct. I spent only a few hours on this board and it worked right off. Just remember to mark the card so you won't put it into the wrong slot — each I/O card is *of course* given a unique block of addresses, and the external connections to I/O devices are wired to these *specific* I/O slots.

TV Readout/Cassette card

Since all address decoding for this card **(photo. 4)** is performed on the I/O card, the DG decided to combine both the TV readout and the cassette interfaces on this single card. We will examine the TV section first.

Getting to the point with minimum frills sums up the DGs' approach to card-level design. The simple but effective circuitry of the TV Readout is a good illustration of the reliable, low-cost character display which results from the implementation of this philosophy. Exotic functions such as reverse lettering (black letters on a white background) are not included, but a full range of upper and lower case ASCII characters, math symbols, Greek letters, and special symbols make this a very capable display for general programming and text editing (DG offers a Text Editor Cassette for $7.50).

An unusual feature in this TV typewriter is the hardware Write position counter. This controls the location of the next character to be written on the screen. Casting this function in hardware permits the use of this display with any ASCII encoded keyboard in a stand-alone mode, freeing the processor from the chore of character writing to the display buffer. If, on the other hand, software control of the cursor is desired, character positioning becomes cumbersome because the Write counter must be stepped until the desired location is arrived at. Incorperation of a circuit to preset the Write counter directly from the processor would overcome this objection nicely.

A 2N5129 video combiner provides a composite video signal (3V p-p) which may be coupled into a commercial monitor, a TV set modified to serve as a monitor or a simple modulator/oscillator circuit for use with an

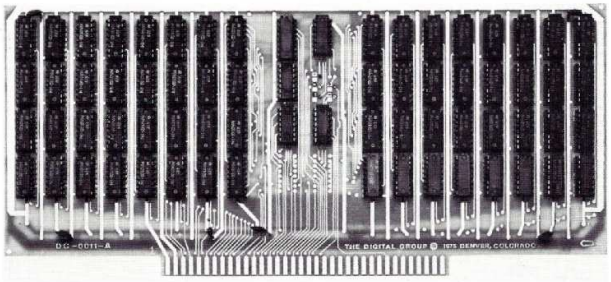

photo 5. The 8K RAM board shown here takes about four hours to assemble. A considerable number of uncommitted connector pins are provided, making it possible to support a 16 bit processor if desired.

unmodified TV set. The latter is possible because the display signal has a bandwidth of slightly more than 6 MHz.

Construction of the TV Readout portion of this card requires considerable care due to the high density of the data paths. It took me about 5 hours to assemble this part of the board. Unfortunately, in my haste to see something on the screen I overlooked the soldering of an IC pin. When the system was first turned on, writing to the display buffer produced no change on the screen. I was lucky — impatience cost me only an hour of Sherlock Ohmsing — you may not be so fortunate. One last piece of advice; epoxy the crystal to the card to ruggedize your system.

Cassette interface

1100 bits per second is a fairly high data transfer rate for an inexpensive mass storage system. This is the primary feature of this cassette interface. Data is recorded by converting a logic one (called a Mark) to a 2125 Hz. tone and a logic zero (Space) to a 2975 Hz. tone. This is accomplished with an extraordinarily simple 566 voltage controlled oscillator (VCO) circuit. The frequencies chosen for use with this frequency shift recording technique are widely spaced and are unrelated harmonically, providing good signal/noise ratio recording with any reasonably stable cassette recorder. Bit 0 of port No. 1 is used to input the data to be recorded. Memorex MRX2 or Maxell UD tape is recommended for optimum reliability. In addition, the DG recommends not using the first minute or so of any commercially prepared tape as their experience indicates a statistically high drop-out rate in this area of the tape due to handling.

data recovery

Audio tone-to-digital data conversion is performed by several op amp stages. The raw recorded output is clipped, passed by one of two active bandpass filters to a full wave detector, low-pass filtered to remove any remaining audio component, and adjusted to the proper TTL level for input to the processor.

The open layout of the cassette interface portion of this card reduces the risk of solder shorts. The lack of silk screened component labels on the card, however, makes it slow going (component designations are specified in the assembly documentation).

Alignment and construction of the cassette section required about three hours to complete. Accurate alignment is required for optimum reliability, especially at a rate as high as 1100 bits/second.

The VCO circuit requires two simple adjustments; set the Mark potentiometer to 2125 Hz. with a logic one applied to the interface input; then apply a logic zero and adjust the Space potentiometer for 2975 Hz. at the output. A final tune-up is performed by programming the computer to supply the logic levels to the interface input and again trimming the Mark and Space potentiometers. The cassette interface is now ready to record data.

Alignment of the data recovery section of the cassette interface requires three simple adjustments. A scope and a source of clean audio signals (2125 Hz. and 2975 Hz.) will be needed. The two active filters are peaked at their desired bandpass frequencies by paralleling trimming resistors on the filters. The final adjustment involves setting the Read Offset potentiometer for a Mark Hold condition when no tone is applied to the interface input. The Cassette interface is now ready for use. If you wish, the DG will make the final alignment for $20.00. If a 'fix-it' is also required (sorry — basket cases will not be accepted), send $30 when returning the card.

8K Memory Card

If you've seen one 8K RAM card, you've seen them all. While I am quite impressed with the practical design approach which the DG has employed throughout their products, I was a little disappointed with their ultra-

plain 8K Memory card. There is no convenient DIP switch to select the address decoding (the board can be *strapped* to reside in one of 8 blocks of memory; 0-8K, 8K-16K, etc.). My main objection, however, is that there is no voltage regulator on this board. One voltage surge on the power line and it's 'Goodbye Mr. Chips.' I wish someone would pass a law to make it mandatory to put voltage regulators on memory boards and CPU cards. 2102-1's are standard with this card. That means that each 8K board will draw nearly 2 Amps.

Since there are 64 1K X 1 memory chips, they are wired up to produce an 8K X 8 matrix. The address lines are buffered with 7404's. There is a section of a 7420 four input NAND gate used to degate the RAM, permitting use of valuable lower address space by both RAM and ROM.

I would recommend that you construct this board in two sittings; do one side of the board, move onto another board, then return and finish the 8K RAM board. This will help you avoid fatigue caused by the never-ending task of soldering row-upon-row of DIP pins. Without this break it is very easy to overlook a pin to be soldered or worse still, a fatal bridge. If you do make an error on this board, the DG group has concocted a supper nifty memory test program to pinpoint the trouble, as we shall see.

Z-80 CPU card

EPROM bootstap loading on this board provides you with 'power-on smarts' to eliminate the need for toggling in this information from a front panel. DMA circuitry makes it possible for you to add a front panel in case of emergency debugging requirements. 2K of address strappable RAM is provided on this card to store the operating system which we will discuss shortly.

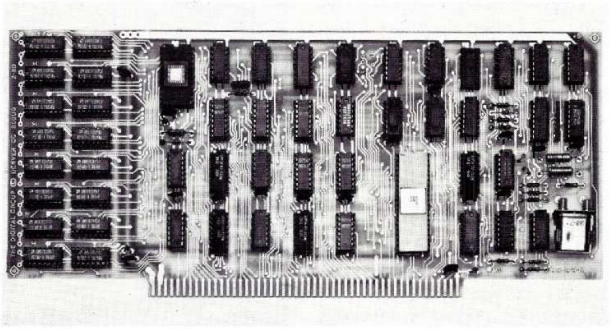

photo 6. The EPROM bootstrap loader and the 2K of RAM are on the left side of this Z-80 CPU board. Great care must be used in assembling this card due to the close proximity of the conductors. The external interrupt socket is the empty one near the top of the board on the right.

This is a good place to mention one of the characteristic features of the DG system; processor independent system design. If you are concerned about newer and better microprocessor chips appearing on the market and what effect this will have on your investment, the DG system is for you. DG has an ongoing program of offering the latest and most popular processor chips designed onto cards which can be used to directly replace your present DG CPU. In fact, they have offered an 8080-to-Z-80 upgrading kit so you could strip the expensive parts from your 8080 board, buy the upgrade kit containing the Z-80 and other parts, put it together and *presto* — your mild mannered 8080 board has turned into the powerful Z-80 board, able to leap tall instructions in a single bound! As you can see, the DG is wise when it comes to spending your money.

Take your time constructing this board. It took me 9 hours of careful assembly and checking with a voltmeter for proper DIP socket voltages before I went for the 'big switch' and the moment of truth. Data paths are dense as you can see from **photo. 6.** My experience with computer kits has instilled in me a great respect for the care which *must* be exercised during the assembly of CPU boards such as this where the high density data paths seem to attract solder splashes and wayward strands of wire. Pretend that you are assembling the main board for a NASA Mars probe — it might help.

A calibrated scope is required to confirm that the clock is oscillating at exactly 2.5 MHz. Even a slight error here will be amplified many times by software timing loops. Program a time-of-day clock to check this frequency if you do not have access to a quality scope.

DG software support

The DG has a professional software group to generate programming support. Their major object, I would say, is user convenience. This systems approach is embodied in the Operating System Cassette which transforms the collection of hardware into a real 'computer.'

Cassette Read, Cassette Write, Storage Dump, Keyboard Input, and the Operations Monitor are the five programs which comprise the operating system. DG cautions the user to stay above location 006 000 (octal) unless you wish to overwrite the operating system (if you do, merely reload the Operating System Cassette).

After thoroughly DC checking the system and inspecting for solder bridges, turn on the power. The monitor will display, "READ Z-80 INITIALIZE CASSETTE." Load the operating system from a cassette recorder and observe the screen. If a "." shows up instead of the octal page number of the data being read in, your system has determined that a bit of data has been read incorrectly. Reload and start again. I would recommend that you modify the remote speaker jack on your cassette recorder so that you can hear the data as it flows into the interface. This will permit you to locate the operating system beginning and end, as well as that of other programs on tape.

The user options will be displayed on the screen as shown in **photo. 7.** The jump in the option numbers is due to a program improvement made by the DG software people. READ and WRITE are the cassette operating programs and are used as you might expect. Options 3 and 4 are the DUMP program, 3 providing an octal dump, 4 a hex dump. For example, select option 3 (via the keyboard) and the registers and flags of the Z-80 will instantly appear on the screen. Press the Space key to page through memory, 96 bytes at a time (it's just like flipping the pages of a book). This memory scanning feature makes it easy to locate unused memory for new programs.

photo 7. Although I did not buy this fancy monitor offered by the DG, this photo does show the clarity of the readout and the software options posed by the operating system.

BASIC, games, etc.

MAXI-BASIC is the high-level programming language offered by the DG. It contains all the features of standard BASIC and then some. This version of BASIC occupies 8K and the DG recommends that you have at least 18K to run it. MAXI-BASIC is available on a cassette from the DG for $15.

And speaking of BASIC, Tiny BASIC Extended (TBX-Z80) is offered for $5, also on a cassette. Why, you ask, should you buy an abbreviated version of BASIC when you can get MAXI-BASIC to feed your Z-80? Well, the DG collection of games on cassettes must run under TBX-Z80, that's why. So, if you're a gamesman (gamesperson?), be sure to get the TBX-Z80. The DG offers not just one, but six Tiny BASIC Game Cassettes. See the DG Flyer No. 8 for the full games listings. By the way, the CLOCK program on Set 3 has a problem — the timing loops were not completely adjusted to the Z-80 speed (the games were adapted from their 8080 versions) — don't set your watch by the CLOCK. For Z-80 ignoramuses, there is the Z-80 Educator Cassette. This program will quickly teach you about the Z-80 instructions and addressing modes.

Back to the Operating System Cassette, we find six neat little routines on the tape after the operating system. There is the CW KEYBOARD routine — outputs keying signals for a code generator on the LSB of port 2. It has a software FIFO which permits the operator to get up to 256 characters ahead of the character being sent. The RTTY-TO-ASCII routine converts FSK at 60 wpm (Baudot) to ASCII. BRAIN TEASER is a game for stretching your gray matter. Use FREQUENCY COUNTER to align your cassette interface, if need be. STAR SPANGLED BANNER was the routine mentioned at the beginning of this article. Finally, we get to MEMORY TESTER. Use this program to check out your 8K RAM boards. It prints out (are you ready) the IC number of any memory chip which it finds to be faulty. Not only that, but this program automatically 'knows' how much memory you have in your system. Now that's convenience.

conclusion

The Digital Group offers a very complete, conservatively designed system. The quality of the hardware, I have found, is excellent. Perhaps the most outstanding features are the processor independent system design to cope with advances in the technology (or applications requirements) and the user convenience of their software. From their delivery, sales, and repair policies, I find that they are reliable and responsive, and that's important. If that's what you're looking for (and you should be), then perhaps it's time to give the DG a call and request their complete flyer package to see if you agree with my assessments. END

Cabinets clockwise from top: CPU, Dual-cassette drive, Keyboard, 9" Monitor.

Meet The Digital Group

If you are seriously considering the purchase of a microcomputer system for personal or business use... or just beginning to feel the first twinges of interest in a fascinating hobby... the Digital Group is a company you should get acquainted with.

For many months now, we've been feverishly (and rather quietly) at work on our unique, high-quality product—a microcomputer system designed from the inside out to be the most comprehensive, easy-to-use and adaptable system you'll find anywhere. And our reputation has been getting around *fast*. In fact, you may have already heard a little something about us from a friend. We've found our own best salesmen are our many satisfied customers.

There's a good reason. Simply, the Digital Group has a lot to offer: state-of-the-art designs, a totally complete systems philosophy, unexcelled quality, reasonable software, affordable prices and the promise that our products will not become rapidly obsolete, even in this fast-moving, high-technology field.

The Advantages

Here are a few specific advantages of our product line:

- We offer interchangeable CPUs from different manufacturers (including the new "super chip"—the Z-80 from Zilog) which are interchangeable at the CPU card level. That way, your system won't become instantly obsolete with each new design breakthrough. The major portion of your investment in memory and I/O is protected.
- Digital Group systems are complete and fully featured, so there's no need to purchase bits and pieces from different manufacturers. We have everything you need, but almost any other equipment can be easily supported, too, thanks to the universal nature of our systems.
- Our systems are specifically designed to be easy to use. With our combination of TV, keyboard, and cassette recorder, you have a system that is quick, quiet, and inexpensive. To get going merely power on, load cassette and go!
- Design shortcuts have been avoided—all CPUs run at full maximum rated speed.
- All system components are available with our beautiful new custom cabinets. And every new product will maintain the same unmistakable Digital Group image.

The Features

Digital Group Systems—CPUs currently being delivered: Z-80 by Zilog 8080A/9080A 6800 6500 by MOS Technology

All are completely interchangeable at the CPU card level. Standard features with all systems:

- Video-based operating system
- Video/Cassette Interface Card
  512 character upper & lower case video interface
  100 character/second audio cassette interface
- CPU Card
  2K RAM, Direct Memory Access (DMA)
  Vectored Interrupts (up to 128)
  256 byte 1702A bootstrap loader
  All buffering, CPU dependencies, and housekeeping circuitry
- Input/Output Card
  Four 8-bit parallel input ports
  Four 8-bit parallel output ports
- Motherboard

Prices for standard systems including the above features start at $475 for Z-80, $425 for 8080 or 6800, $375 for 6500.

More

Many options, peripherals, expansion capabilities and accessories are already available. They include rapid computer-controlled cassette drives for mass storage, memory, I/O, monitors, prom boards, multiple power supplies, prototyping cards and others. Software packages include BASICs, Assemblers, games, ham radio applications, software training cassettes, system packages and more (even biorhythm).

Sounds neat—now what?

Now that you know a little about who we are and what we're doing, we need to know more about you. In order for us to get more information to you, please take a few seconds and fill in our mailing list coupon. We think you'll be pleased with what you get back.

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the digital group

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Send me the whole package!

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