Building a Digital Group System

by Donald O. Southwick

I've had a long-standing interest in electronics that goes back to the venerable days of the #80 rectifier tubes, but had never worked in the field, much less thought of playing in it. A few years ago my interest was low key until my son got beyond the switches-and-light-bulb stage, then I found out that ICs were real and not expensive. Together we built a kit calculator, 555 timers, numerous decade counters, a digital clock and many other gadgets.

About this time microcomputers made the press in various magazines, and the devices aroused my interest. However, gathering information in those days was another matter. Hobby computerism was almost an underground movement. At last about two years ago the Digital Group was formed in Denver and I found other people of like interest. Most club members, however, knew much more than I, and it soon became clear to me that if I was to learn abut computers, I would have to build one. Besides, my son was playing with a terminal at school and I was yet to throw a switch on one.

Father and son with a little hardware background and absolutely no software background charged into the project.

Decision, frustrations and delays. . .

Now we have an operating system and I couldn't be more pleased. There's much more to learn; a whole new world lays ahead to conquer. I couldn't be more pleased. . .

The Digital Group had kept a low profile and took a long time to get their systems ready. For the hobbyist who is shy about small companies who operate out of post office boxes, I can say that I found them competent and honest. Of course the other side of the low-overhead, low-profit-margin picture is their inability to handle large numbers of inquiries with efficiency. Hence my system took three months longer than planned to be completed.

My system is a T.V./keyboard/cassette based with 8080A, 6800, 6502 and now a Z-80 CPU core. A minimum system consists of three or four 12" x 5½" plugable boards and a mother board, possessing either four or nine slots. Equipment included power supplies, a commercial T.V. monitor, cassette recorder, a computer-controlled tape deck and an impressive line of cabinets (See Photo 1).

I can highly recommend all the components. They have all proved reliable and easy to work with. The hobbyist especially appreciates the fact that this equipment is designed to be expandable and interchangeable. To change CPUs simply unplug the CPU board in the unit and plug in the CPU board you want, read in the appropriate operating software from cassette and you are operating again in a matter of minutes.

THE CPUs

On the bare board level the 6800 and 6502 share the same board. All CPUs contain the first 2K of RAM (2102 or equivalent) and a programmed EROM (1702A). The EROM enables you to operate your cassette software and to display your output on the T.V. monitor without an additional memory board.

Photo 1. System Complete.

T.V. CASSETTE BOARD

The T.V. board generates a picture 16 lines high by 32 characters wide for 512 spaces. The Motorola 6571L provides upper and lower cases and Greek-math symbols (see Photo 2). This board can be used as a stand-alone with the keyboard and T.V. The cassette interface on the right side of the board is designed for frequency shift keying and uses a relatively high ratio of discrete components. This section must be tuned with a calibrated A.F. generator and, although the procedure is well described and not tricky, the necessary equipment may not be available to the hobbyist. Digital Group will tune your board for a fixed fee.

IN/OUT BOARD

I recommend to start the project by building this board; it is the easiest one in the system. Each I/O provides four output ports, each an 8-bit parallel. On the first I/O, 1-1/8 ports (in and out) are used by the TVC keyboard and cassette. The rest is uncommitted.

MEMORY BOARD

Any expansion of a system is likely to include an 8K static RAM board. Digital Group's product has 64 2102s (or equivalent) and five other ICs. It is a very tightly packed board with over 1,100 solder connection. Don't let that scare you off, however. My 13-year-old son, with little soldering experience, did mine with no problem. Jumpers are used for different addresses — first 8K, second 8K onward. Pads are even provided for pull-up resistors.

Photo 2. **TV Display Showing TV Format and What the Character Generator Will Do.**

MOTHER BOARD

My *standard* (Photo 3) mother board measures 10-3/8" by 12" and has space for four I/Os or peripherals, for three 8K memories, for the TVCs and the CPUs.

The smaller four-slot mother board measuring 5-3/8" x 12" is the center section of the larger board and has space for only one I/O, one memory and TVC and CPU. Pads for jumpers are provided on both mother boards to jump to available memory or to I/O expansion. Besides the data and address busses and power connections, the mother board connect the TVC and CPU and the I/O. No point-to-point wiring is required within the system. Each socket on the mother is wire-wrap type and a special Molex socket is used to connect to the ends of the wire-wrap.

T.V.

Economics dictated my choice there. The hobbyist usually has to satisfy himself with dismantling the discarded old tube type. With so little experience I was reluctant to modify even that for direct video output. With some background education and a Sams schematic, I took courage. Once started I found the task surprizingly easy (Photo 2 and 4).

KEYBOARD

The keyboard I used was a ACSII encoded surplus unit with upper and lower case capability. The cabinet is home-made. I had trouble with the keyboard probably because of the length and type of cable I used. On first runs it was voltage sensitive; at optimum voltage there were too many "no entries" or multiple entries. After running the strobe pulse through both halves of a 7413 Schmitt trigger located near the input port, it is much improved.

CHASSIS

The power chassis is a 1" x ½", 18" aluminum channel frame with an aluminum plate on top and a clear plastic plate on the bottom. There is no voltage exposed, but I can still look for a smoke source (Photo 5). The main chassis at 13¼" x 17" is planned for expansion and is made from 2" x 1" aluminum channel with one end reversed

Photo 5. **Bottom View of Main Chassis Mother Board In Center, a Molex Socket on End of a Ribbon Cable Connecting Keyboard. On End, Back of Regulators.**

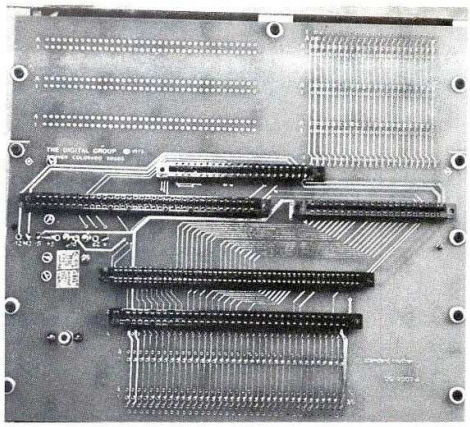
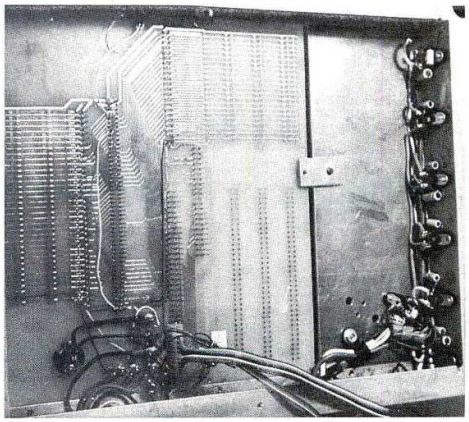


Photo 3. **Mother Board Top View. Top to Bottom—3 Spaces for Peripheral or L/O Boards, TVC, I/O, CPU, Memory, Spaces for 2 More Memory Boards. Smaller Mother Board is Like This but Cut Off Just Above and Below Existing Sockets.**

Photo 4. **Option List Displayed on TV From Supplied Operating Software.**



and drilled for six TO-3 regulators. An aluminum panel 5¼" wide over the regulator end adds rigidity, mounts the fuse panel and provides room to mount smaller than board-size devices. A gap is left at both ends of the mother board for wires or ribbon cable to be brought up.

POWER SUPPLY

Built on a separate chassis the power supply was designed around three available surplus units. The foot-operated power switch is on the supply chassis and no AC is on the main chassis. A switched and fused three-wire line goes to the T.V. This + 12V system will provide sufficient power for further expansion.

In-line bridge rectifiers are used and are mounted in pairs by sandwiching them between the plate and the chassis using silicone grease for maximum heat-sinking (Figure 1). The power plug might be of interest to hobbyists: it is a Hubbell (#5280) three-wire plug with a thumb screw on the ground pin locking it into any standard three-wire outlet to prevent accidental unplugging. Listing at over $4.00, it is somewhat expensive, but a good idea to prevent accidental loss of a program on which you have invested hours of work.

Editor's note: The power supply described here is Mr. Southwick's design and not supplied by Digital Group.

P C CARD

Voltage regulators (LM-309s, 320s and 340s) are mounted on end of the main chassis (Photo 6). I decided to use a separate + 5V regulator for each board and fuse the line from each regulator. I also installed 5W Zener diodes on each board at each voltage, (5.6 IN 5339 for ± 5V and IN 5352 for ± 12V) for overvoltage and reverse polarity protection. Excessive voltage drop occurred across the fuses which caused me to increase the fuse rating to about three times the nominal current. This however somewhat decreased the protective value of the original arrangement.

In time I have had to rework some of the regulator section. Present memory is now 10 K and growing. Increased current demands cause excessive heat build-up on that end of the chassis. This has been partly solved by moving some of the regulators to a heat sink mounted on the fuse mounting brackets above the chassis plate. The next step will have to be LM 323s (5V @ 3A) regulators or pass transistors, which may also let me consolidate some of the clutter.

DOCUMENTATION

A good-sized stack of unbound paper comes with the system. Some of what I received had omissions and mistakes, but by now they have been corrected. It is not comprehensive on computer architecture, nor software, nor does it teach you how to solder, but it does instruct you sufficiently to build if you have some hardware experience and access to test equipment.

Each board comes with its own leaflet which contains a circuit description, assembly instructions, trouble-shooting notes, parts lists, diagrams and schematics. A systems and operating manual provides overlap information on the mother board, overall construction cues, information on the bus structure, pin assignment, an 8080 instruction set and material on cabinets, cassettes, and T.V. monitors. The operating software and demonstration programs on the cassette provided with the system are also described.

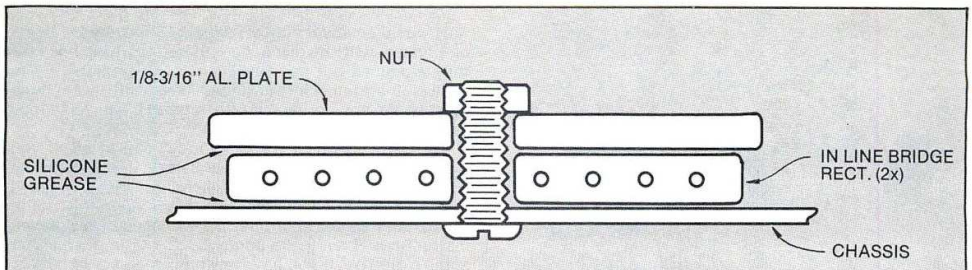


Figure 1. In-Line Bridge Rectifiers are Mounted in Pairs Sandwiched Between Plate and Chassis.

OPERATION/SOFTWARE

This is where it's hard to stay calm. The TV/keyboard approach, combined with the software you get on cassette takes the work out of having fun. Power up, push "reset", read in cassette, watch the pages load, and, in less than a minute, you may select from the four options displayed (Photo 4) by simply pressing the corresponding number on the keyboard.

1. Read Cassette
2. Write Cassette
3. T.V. Storage Dump
4. Keyboard Program
5. Your Title

1. Read Cassette: Allows you to read in additional programs while you watch the words load on the TV.

2. Write Cassette: Outputs to a recorder while the T.V. displays "Cassette being written". Besides the obvious value of being able to store and duplicate programs, before you run an untried program, put it on tape. If it self-destructs, you still have it, can read it back, look it over, and make necessary changes. After using this, or the other options, you can return to the display for another choice.

3. T.V. Storage Dump: This will first show the register, flag, stack, and status, then, by pressing the space bar, you may page through memory, 96 bytes at a time, in octal. By pressing "S" the T.V. will display "Page address" and by keying in 007, for example, it will start displaying memory at page 7 and you may proceed paging through from that point. Press "R" and you return to the option display, press "P" and go to the programing routine.

4. Keyboard Program: This lets you program in octal from the keyboard. Normally this starts on page 6, but it can be modified, or you may select an address. Of course, what you program is displayed as you do it, with address, and with several preceding addresses and their contents. "S" will put you back to the "Storage Dump" mode and "R" to the option display.

5. ————————: You can fill in your own title. It does whatever program you put in starting at page 6, 6/8ths of the way through the first 2K of memory. The operating software being described is in the first 1½K. There is room in this format for from five to ten option programs if you don't exceed the available memory.

Included in this software are several subroutines you can call and use in your own programs. These include T.V. display, T.V. erase, keyboard, a timing loop and others.

If this is insufficient, there are four more programs on the cassette. There is a Morse code sending and receiving program, requiring some external hardware, which will send code at a rate you select while you type the message.

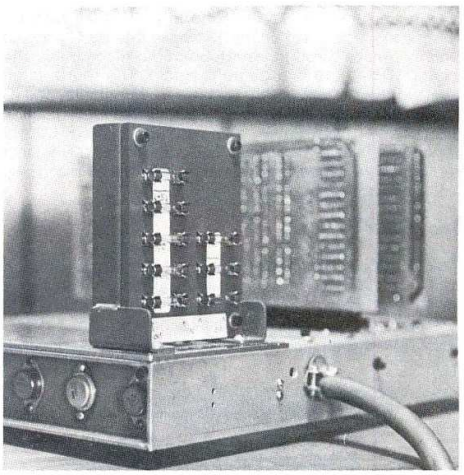


Photo 6. Main Chassis Showing Regulators and Fuse Block.

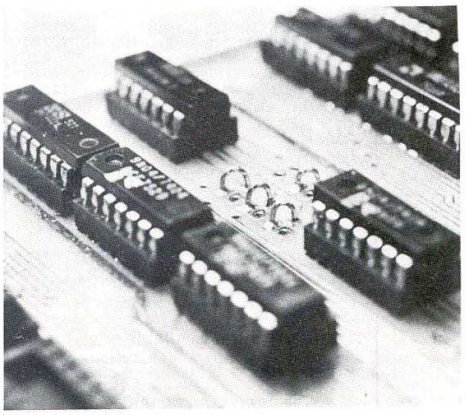


Photo 7. Jumpers on I/O Board, Zener in Background Is Homebrew.

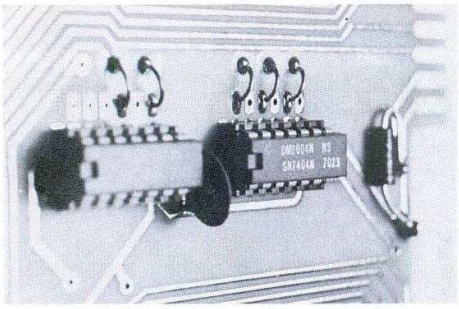


Photo 8. Jumpers on Memory Board.

You may type up to 256 words ahead and the message displays on the T.V. The receiving program also displays the received message, for example, from a shortwave receiver on the T.V. The second is a "FLAG" program which constructs a flag on the T.V. while the "Star Spangled Banner" plays through a portable radio placed near the system! The third is a game program. The fourth is an interrupt test — a memory test which will display the IC number of any defective memory, and a frequency counter circuit which will display the frequency of a TTL level conditioned signal. Besides interrupt capability the system can be single-stepped and some more involved diagnostic routines are described.

CONCLUSION

Do I like the system? Yes, I do and I have barely begun to use its potential. In fairness, I would probably be happy with the other available systems too, but I feel this one has the most favorable pleasure-to-money ratio.

As for the Digital Group I think they are great. However, they would be absolutely overwhelmed if everyone wrote or phoned with involved questions, not just because they are small but because they would probably try to answer them all. I'm convinced they will do anything reasonable, and perhaps more, to try to make you happy and to get your system going.

Are these systems for everybody? Not at all. If you want to write one check, however large, get a kit complete with every necessary nut and washer to make a finished looking piece in a slick cabinet, this is definitely not it. If you can't solder and must have consecutive detailed instructions, then make some clock kits until you gain some expertise. If you have any hardware, construction, and soldering experience and especially with a knowledgeable friend who can help then you should be able to do it. Try some of the easier boards and buy the difficult ones pre-assembled. If you've done kits before, have a suitable power supply, chassis, are determined to build your own, *and*, if money is important, then this sounds like the system for you.

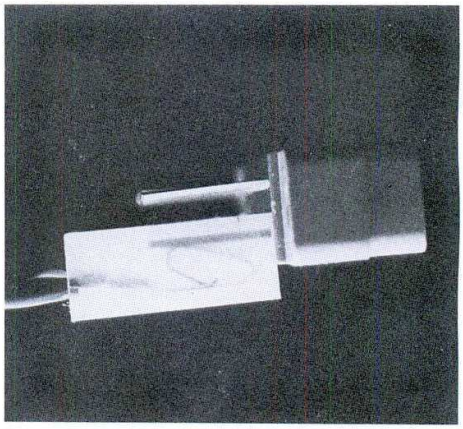


Photo 9. Special Molex Socket Shown Plugged On To Pins of a Wire Wrap P.C. Board Socket.

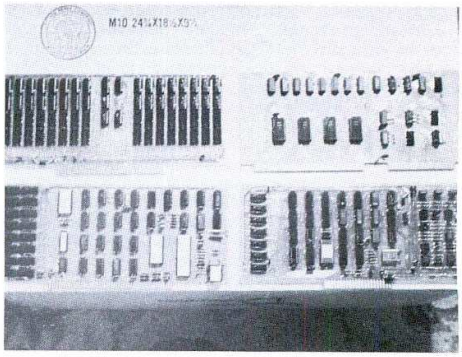


Photo 10. Boards of the Digital Group System. Top L to R—Memory, I/O. Bottom—CPU, TVC.