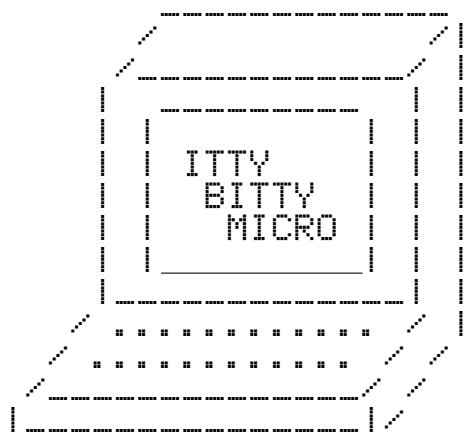
**I**tty **B**itty **M**icro Company
8080 Future Drive
Rochester, NY 14650




January 22, 1980

Dear Wiz,

I know, I know... the West Coast Computer Faire is coming up FAST! You SAID you're on vacation; but I KNOW you, man! You're probably still at home, hacking on that PDP-8 you got at the hamfest.

Well, forget that old crap. THIS IS IMPORTANT! The boards for "Project Z" arrived. PLEASE get them assembled and working NOW! If we don't have something INCREDIBLE for the show, we're dead! I already talked to Jim Warren, and got a great booth at the show, right across from Heathkit.

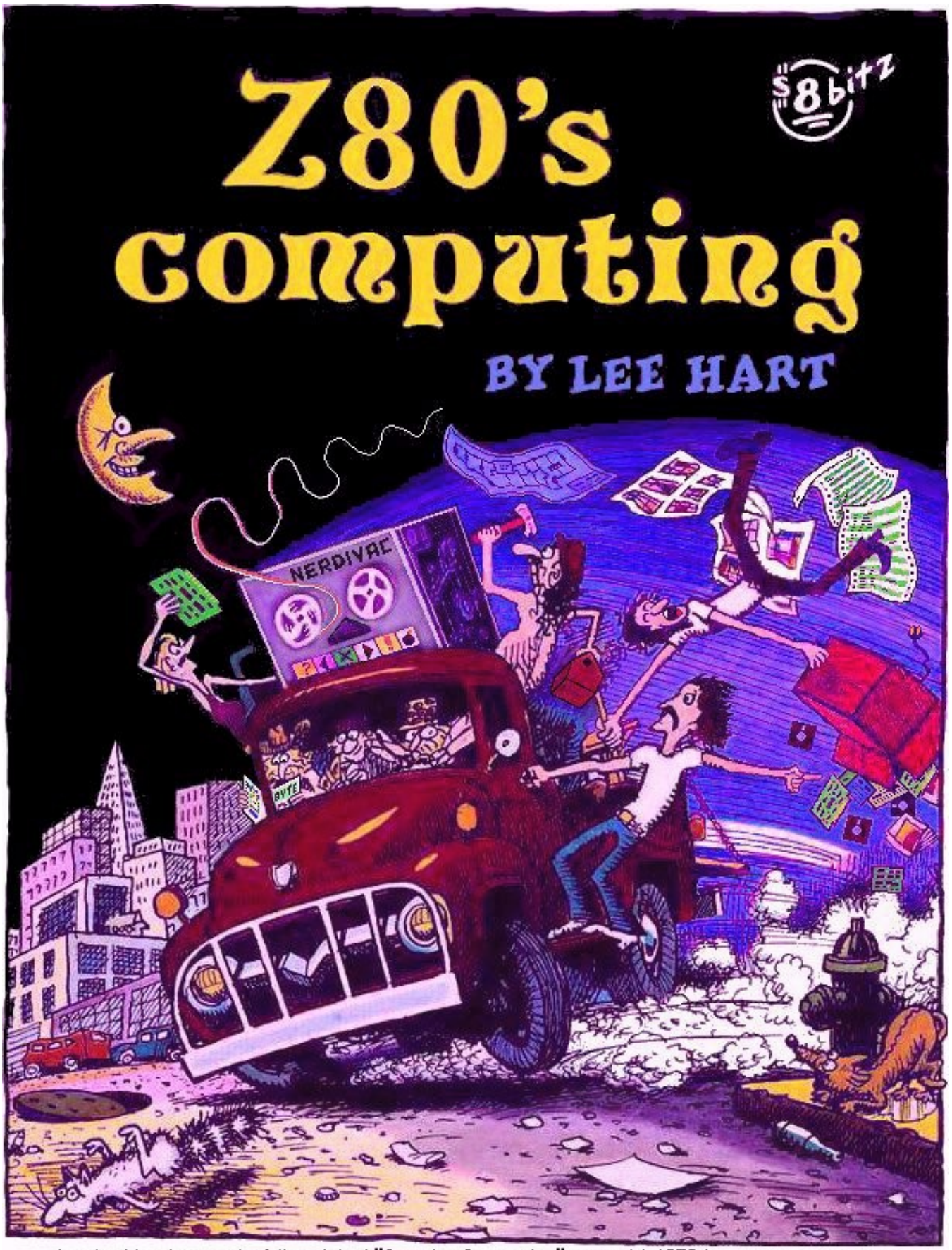
I put everything in the box we could find. You've got the boards (aren't they GORGEOUS?), all the parts (I hope!), and every scrap of paper Chip thought you might need. Crash also burned his latest monitor program into the EPROM, and included a copy on disk.

Remember, this is going to be the world's first POCKET COMPUTER! There's no time to get a custom case; so for now just stick it in an Altoids tin. It's a hacker classic, and "everyone knows" you can't make a computer that small (but WE can)! In a world full of big beige boxes, we've got something people will REMEMBER! Aha... we'll call it the "**Altaid 8800**" -- an Altair in a Altoids tin!

Yours truly,

Gil Bates
Emperor of Marketing
**I**tty **B**itty **M**icro Company

cc: Chip Hacker, hardware herder
Crash Kernigan, codemeister
Trace Weaver, PCB artiste




Inspired by the wonderfully original "Creative Computing" cover (c) 1979 by GILBERT SHELTON

# Introduction

January 1975. My gawd; was it really 40 years ago that the microcomputer revolution began?!? It was the tipping point of momentous events. You could ***see*** the world changing right before your very eyes. America had just put men on the moon, and the Arab Oil Embargo had shown us that oil was not forever. And there on the cover of the January issue of Popular Electronics magazine was the MITS Altair 8800; a computer you could build yourself for only $400.

I was just out of college with a fresh BSEE degree; idealistic, enthusiastic, and out to change the world. I went to work for Eastman Kodak in Rochester NY. They told me how wonderful the company was, that film was forever, and that they were the most advanced imaging company in the world.

But when I saw their old tube and relay circuits from the 50's, it reminded me of a story. Two shoe salesmen arrive in a remote village where everyone goes barefoot. The first salesman writes back, "Situation hopeless. They don't wear shoes". The second salesman writes, "Prospects unlimited. No one has shoes yet." I figured Kodak needed shoes; so I set out to make 'em.

By day, I worked inside the system, seeking to reform the dinosaur from within. That didn't work out so well. The other young EEs and I built digital cameras with a CCD imaging chip. We stored photo albums on audio cassette tapes, and displayed them on a TV set. We modified photocopiers to print text received from a serial port. We built systems to replace the messy chemical processing and costly silver with clean modern efficient electronics. At every turn, they said the electronics weren't good enough and that film will always be better.

So by night, I built my own computers. And I conspired with other eager experimenters working at Kodak, 3M, Xerox, Rochester Institute of Technology, and the other high-tech outfits in the area. We ***knew*** the world was changing fast! Microcomputers were exactly the right tool to do it. And we were a part of it. We were inventing the future!

This is the true (*) story of the computer we made. Or could have made back then, if we'd been just a little smarter, or luckier, or worked a little harder, or had a little more nerve... or had found ***you*** to help!

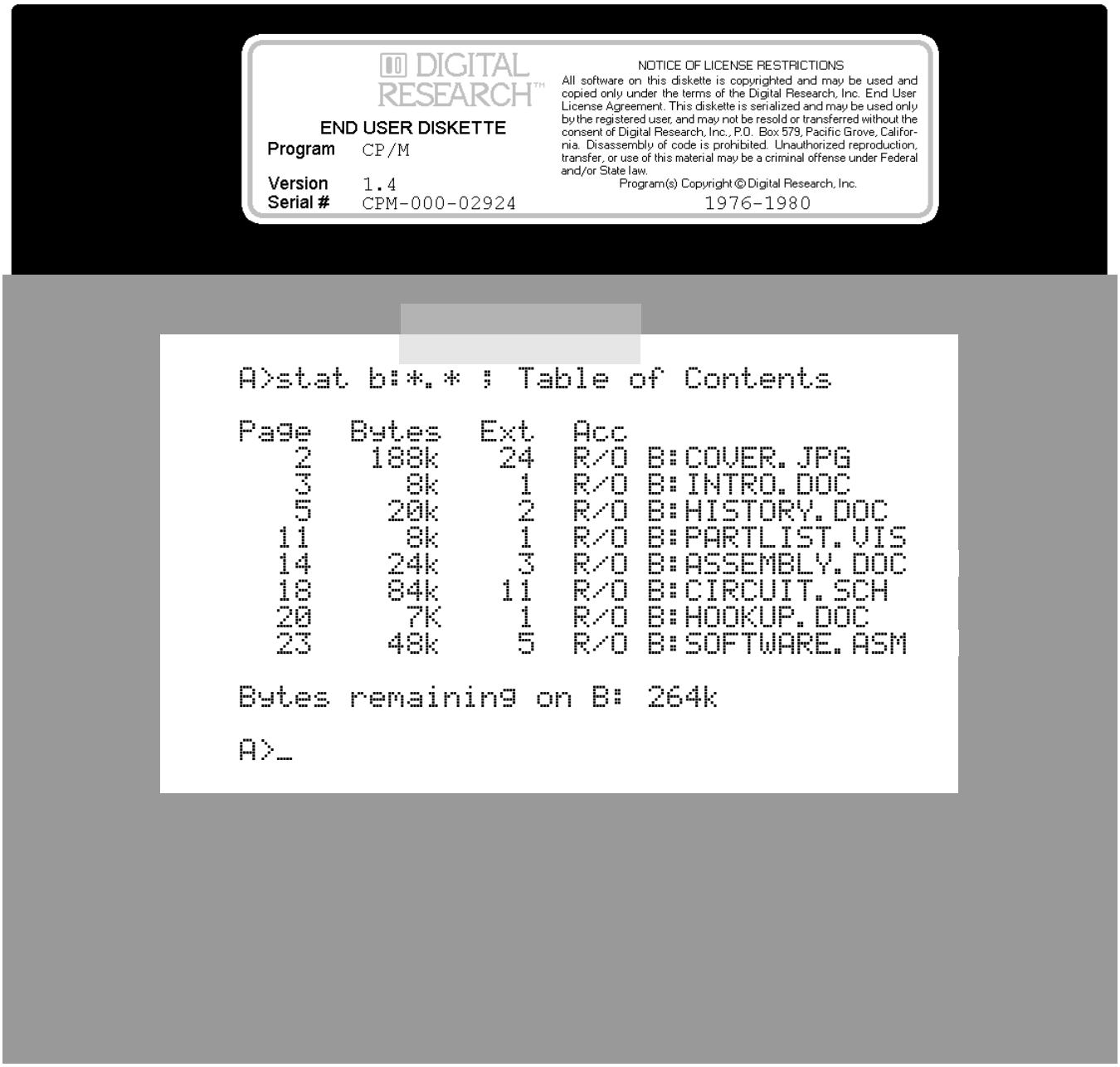
But now ***you*** are part of the team. You've picked up the Altaid 8800 Project where we left off. Build it, test it, then invent your own incredible new gadgets. Show us what ***could*** have been done way back then, if we'd only known then what we know now. C'mon – we're depending on you!

TMSI c/o Lee A. Hart
814 8th Ave N, Sartell MN 56377
(320) 656-9574
leeahart@earthlink.net
http://www.sunrise-ev.com/z80.htm
Rev.A -- November 28, 2015

--

* OK; so it's only partly true. Hey, I'm an old man now! My forgettery is better than my memory. I may have changed a few names, dates, details, facts, or even made some things up entirely. Sometimes the facts alone don't tell the whole truth, so a little artistic license is needed to communicate the ***real*** story.

Warning: May contain nuts.




Wiz,

Here's an 8” floppy disk with all the “Project Z” files. It holds up to 1.2 megabytes depending on formatting (single- or double-sided; single-, double-, or extended-density). That's a LOT for 8-bit software. Hey; this is the high-tech way to do software development in the 1970's!

Yeah, a hard disk would be nice; but then I couldn't send it to you. Besides, they are insanely expensive. Hobbyists or even small outfits like us can't afford them. Good thing we're not REALLY poor, or we'd be saving programs on cassette tapes!

It's a CP/M disk. CP/M is the most popular microcomputer disk operating system around. It's so popular that I hear IBM's PC-DOS is actually a copy of CP/M. If the disk is missing, or you can't read 8” disks, you can download the files from our BBS at www.sunrise-ev.com/z80.htm

Crash

HOW TO "READ" FM TUNER SPECIFICATIONS

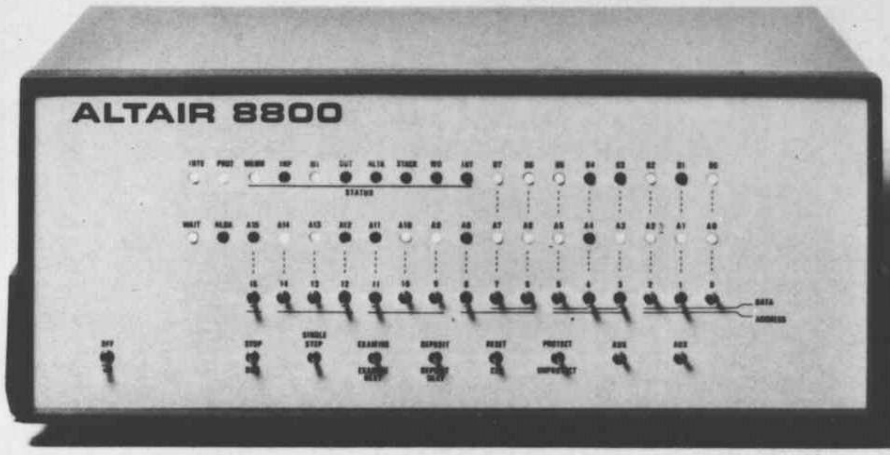
# Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE JANUARY 1975/75¢

## PROJECT BREAKTHROUGH!

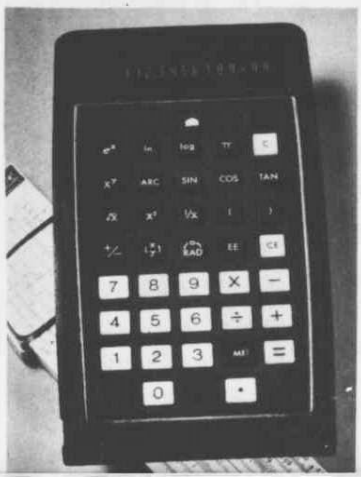
# World's First Minicomputer Kit to Rival Commercial Models...

## "ALTAIR 8800" SAVE OVER $1000




## ALSO IN THIS ISSUE:

- An Under-$90 (Chip!)



**Advanced Abacus Associates**

Subject: Altair 8800 !!!
To: Chip Hacker
From: Gil Bates

Did you see THIS? The kit is only $400! Forget that MARK-8 from Radio Electronics. The 8008 is only half a CPU. This has an 8080. It's a REAL computer, man! This is going to be BIG! I hate my dead-end job (and so do you). So let's

1975 C38080 JMP FUTURE ;NOW!

Jan 11, 1975

Hi Gil,

Yeah, I saw it. Interesting! But is it real? They never show the insides; just a shot of the front panel boards. Seems like an awful lot of parts. 58 ICs... in a $400 kit? Intel lists the 8080 for $360, and the 8111 256x4 RAMs are $26 apiece! Sounds too good to be true. But, I sent for literature more information. Let's see what we get.

Before we board this Titanic, may I remind you that it was YOU who talked me into buying the Mark-8 boards? I've got $400 in it, and it will take another $400 to get it to do anything more than blink LEDs. It's more like a bicycle with training wheels than a computer.

And before that, you got me to buy those calculator chips for $300. Weren't we going to make a killing selling scientific calculators?

Yours truly, Chip

February 1, 1975

Chip,

HP was selling their HP35 scientific calcluator for $395 at the time. We bought 10 of those MOS Technology chips for $30 each. And you did build a great desktop calculator with them! But it took a year to get it done. By that time, you could buy a Sinclair Scientific for $100. We were right; but too slow!

Still, we did sell enough to brake even. And you got a great calculator out of it. You learned a lot, and I'll bet you used it a million times, designing circuits and stuff. Money spent on brains and tools is well spent. Am I right?

Tell you what. I'll BUY the Mark-8 from you for $400. Use the money to by the Altair. The Mark-8 will be collectible someday; so I'll probalby make a profit!

Your Fiend, Gil

Feb 20, 1975

Dear "Fiend",

You're right, of course. (Even a broken clock is right twice a day.) Against my better judgement you talked me into it. As discussed by phone, I'll pack up the Mark-8 and send it to you. But before you put it in a glass case and sell it to some museum, PLEASE let me show you the neat things it can do!

I got the literature from MITS on the Altair. Their “System #1” is now to $542... and that's a minimum system, with only a front panel and 256 bytes of RAM (same as the Mark-8). It has an expansion bus that sounds great; but their accessory boards are expensive!

I thkink the way to go is buy their minimum system kit, and build my own memory an I/O boards. Their's are WAY over-priced! (Like you said, they sell the razors cheap, and make up for it on the blades).

so I placed my order today!

Anxiously awaiting it,
Chip Hacker

JUNE 2, 1975

DEAR GIL,

SORRY FOR NOT WRITING. I'VE BEEN BUSY! IT TOOK MONTHS, BUT THE ALTAIR ARRIVED. THIS AIN'T NO HEATHKIT. IT TOOK A WEEK TO BUILD. POOR MANUAL, LOTS OF HAND WIRING (60 WIRES TO THE FRONT PANEL, 100 TO THE EXPANDER BOARD). AFTER FIXING MISTAKES AND REPLACING SOME BAD PARTS, I FLIPPED THE SWITCHES TO LOAD A PROGRAM AND IT WORKS! IF WE DO BUILD A PRODUCT, IT'S -GOT- TO HAVE A GOOD MANUAL AND BE SIMPLE TO BUILD.

I ALSO GOT A TERMINAL... A MODEL 19 ASR BAUDOT TELETYPE! UPPER CASE ONLY, BUT IT HAS A PAPER TAPE READER/PUNCH (THAT NEEDS FIXING). MY FIRST PROJECT WAS TO INTERFACE IT TO THE ALTAIR.

OK SO YOU WERE RIGHT AGAIN. THE ALTAIR -HAS- BECOME POPULAR, AND IS WAY BETTER THAN THE MARK-8. BUT PIECE BY PIECE, I THINK I'M GOING TO REBUILD EVERY PART OF IT. ITS BETTER BECAUSE I KEEP IMPROVING IT.

EVEN WITH THE MEMORY BOARD FILLED TO 1K, THERES NOT ENOUGH TO DO MUCH. I GOT MY BAUDOT PRINTER DRIVER WORKING, BUT WITH IT LOADED THERES NOT ENOUGH ROOM FOR EVEN A MACHINE-LEVEL MONITOR. I HAVE TO TOGGLE IN A LOADER, THEN IT CAN LOAD A PAPER TAPE WITH A PROGRAM. BUT THAT TAPE HAS TO INCLUDE A PUNCH PROGRAM IF I EXPECT TO SAVE ANYTHING FROM IT TO LOAD LATER.

I GOT A PROTOBOARD AND WIRE-WRAPPED MY SERIAL INTERFACE. ITS JUST A PARALLEL PORT, TO BIT-BANG SERIAL DATA FOR THE TELETYPE. THERE WAS LOADS OF ROOM, SO I ADDED A 1702 EROM SOCKET. I PROGRAMMED IT AT WORK, SO NO MORE TOGGLING IN LOADERS AND HOPING THE PROGRAM WONT' CRASH, OR WORRYING THAT THE POWER FAILS AND I LOSE IT ALL.

I WAS GOING TO BUILD A MEMORY BOARD, BUT DIDN'T HAVE TO. I HEAR MITS BOARDS ARE TROUBLE, BUT THERE ARE ALREAADY LOTS OF OTHERS ON THE MARKET! MEMORY PRICES ARE DROPPING LIKE LEAVES IN FALL. FOR $195 I GOT A 4K RAM BOARD FROM PROCESSOR TECHNOLOGY.

OF COURSE WITH ALL THIS, I HAD TO UPGRADE THE POWER SUPPLY. I'M ALSO OUT OF CARD SLOTS, AND WILL HAVE TO ADD ANOTHER EXPANDER RBOARD TO GO MUCH FURTHER. WANNA BUY AN ALTAIR FOR YOUR COLLECTION? THE IMSAI 8080, WITH ITS BIG MOTHERBOARD AND POWER SUPPLY IS LOOKING PRETTY GOOD RIGHT NOW.

CHIP

June 8, 1975

Hi Chip!

Good to hear from you, man. I thought you died! But I see you're in turtle mode again... your head down and puttering slowly and methodically away, while the world madly races ahead. You do absolutely brilliant work; but it takes you forever.

Have you found anything we can make for the Altair market (that someone ELSE isn't already doing)? Not memory boards, not BASIC... that's already been done! You want to sell me the Altair? Then make it DO SOMETHING that someone ELSE (other than you) would love! How about this... a memory board but with BASIC already in ROM, so it's there the instant you turn it on. The BASIC can be “FREE” (not $150 like Altair BASIC) if it's on a $150 memory board!

Impatiently yours,
Gil Bates

JUNE 22, 1975

HI GIL,

BASIC IN ROM WOULD BE COOL! I CAN BUILD THE BOARD BUT I'M NO PROGRAMMER. KNOW ANY GOOD ONES? THEY'RE STARTING A COMPUTER CLUB (R.A.M.S. FOR ROCHESTER AREA MICROCOMPUTER SOCIETY). I'LL START ASKING AROUND.

MEANWHILE, I CAN SEE THAT A ROM BOARD WOULD BE GREAT. IT WOULD SAVE HOURS OF LOADING WITH PAPER TAPE (AND MY PUNCH IS STILL GIVING ME TROUBLE). SO, I STARTED ON A ROM BOARD. ALTAIR BASIC IS 4K, SO WE'LL NEED 16 1702'S. MAN, THAT'S GOING TO BE EXPENSIVE.

CHIP

Aug 75

Hi Chip!

Summer is nuts here. The old farts go on vacation, so I'm WAY busy. (They all get 6 weeks; I only get a lousy 2, and have to take it when none of them want it).

Don't worry about prices. They will come down FAST! Have you heard of Moore's Law? Gordon Moore at Intel says they can put TWICE the transistors on a chip every year. That means chip prices should fall by 2:1 a year. Or more! That 8080 that was $360 in Jan is now $75! You watch: Those $30 1702s will be $10 by Christmas.

So work like hell on that ROM board! Even if we can't sell it, you'll have a replacement for that flakey old teletype.



Gil Bates

OCT 7 1975

DEAR GIL,

GOT THE PARTS, AND WIRE-WRAPPED MY ROM BOARD. THE 1702 IS A MIGHTY ODD DUCK. READING IT IS BAD, BUT PROGRAMMING IT IS WORSE! AND THE BOARD HAS TO BE ABLE TO PROGRAM IT, OR THERE WON'T BE ANY WAY FOR A CUSTOMER TO GET HIS CODE INTO IT.

INTERFACING TO THE ALTAIR BUS IS A MESS. THEY JUST INVENTED IT AS THEY WENT, WITHOUT MUCH PLANNING. IT TOOK 12 ICS TO SUPPORT JUST 2 EPROMS. BUT IT WORKS! TODAY, I PROGRAMMED MY TELETYPE DRIVER INTO ONE AND AM USING IT NOW!

WENT TO THE RAMS MEETING. AMAZINGLY, THERE WAS ANOTHER ALTAIR! A PROF AT RIT DEMOED ONE HE BOUGHT FOR HIS LAB. HE GOT ALTAIR BASIC FOR IT, AND SAID HE'LL PUNCH A COPY OF THE TAPE FOR ME! BUT HIS TELETYPE IS ASCII AND MINE IS BAUDOT. NOT SURE HOW I'LL READ IT.

PS: YOU NEED A NAPOLEON HAT FOR YOUR TYPEWRITER ART SELF PORTRAIT.

CHIP

Oct 75

Hi Chip,

Great to hear it, man! I knew you could do it. The RIT connection sound great. Maybe he could be our first customer? See if he'd like a ROM board for his Altair. (Putting on my marketing hat).

Gil

NOV 11 1975

GIL,

THINGS ARE HAPENING! I WORK ALL DAY, THEN COME HOME AND COMPUTE TIL 1AM, THEN DO IT ALL AGAIN. "CRASH" APPLIES TO MORE THAN COMPUTERS.

THE PROF AT RIT HAS A GREAT SETUP. HE GOT EVERYTHING MITS HAD AVAILABLE (WHICH IS AOBUT HALF WHATS IN THEIR CATALOG). TOOK FOREVER TO ARRIVE (AND HE'S STILL WAITING FOR STUFF).

I TOOK MY ALTAIR OVER THERE, AND SHOWED HIM MY ROM BOARD. HE LOVED IT! I OFFERED TO MAKE ONE FOR HIM, AND HE'LL PUT BASIC IN THE ROMS AND GIVE A SET TO ME.

YEAH YEAH, I CAN HEAR YOU NOW. "YOU GAVE IT AWAY FOR FREE? IDIOT!" BUT THINK... THERE'S NO WAY 2 GUYS IN A GARAGE CAN GET A PURCHASE ORDER FROM THE U. BESIDES, THEY TAKE MONTHS TO PAY. BUT HE IS GIVING ME BASIC, AND THE ROMS! THATS OVER $200 WORTH OF IC'S ALONE!

CHIP(PING AWAY AT IT)

Dec 2, 1975

Chip,

That's fantastic! No, I think you're using your head. You're actually DELIVERING something, AND to an important client that can do lots of good things for us.
Pogo: "Brains is better'n money, 'cause brains'll GIT you money."
Albert: "Yeah? Who's buyin? I got brains I never use!"

On purchase orders: We ARE going to have to set up a company to look professional. I'll get working on it!


(look, it's an Altair!)

PS: SD Sales has 1702's for $6.95 in the Jan 1976 BYTE. See? Moore's Law rules!

JAN 16, 1976

MERRY CHRISTMAS, AND HAPPY NEW YEAR!

MY PRESENT WAS THAT I GOT MY NEW ROM BOARD WORKING. MANY IMPROVEMENTS OVER THE 1ST ONE. I LUGGED MY SYSTEM OVER TO RIT LAST NIGHT, AND WE WORKED ON IT TIL 1AM. I WROTE A UTILITY TO TRANSFER BASIC BY LOADING THE ASCII TAPE WITH HIS TELETYPE, AND SAVING IT AS BAUDOT TO MY PUNCH. IT DIDN'T WORK...

BUT THE NEW ROM BOARD DID WORK! SO WE LOADED BASIC IN HIS ALTAIR, THEN TOGGLED IN MY BURNER CODE, AND PROGRAMMED A SET OF EPROMS FOR HIM. BUT IT WOULDN'T RUN FROM ROM FOR SOME REASON. HE HAD A HOT STUDENT THERE, WHO WAS STILL HACKING ON IT WHEN I HAD TO LEAVE.

SO TODAY HE CALLED. IT WORKS! HE JUST HAD TO PATCH THE I/O AND RAM STARTING ADDRESSES. AND, HE BURNED A SET OF ROMS FOR ME. I PICKED 'EM UP AFTER WORK, AND COULDN'T WAIT TO INSTALL THEM. IT TOOK ME A WHILE TO MODIFY MY BAUDOT DRIVER TO WORK WITH IT... BUT THEN BASIC CAME UP!

THE ONLY PROBLEM (AFTER A QUICK TEST) IS THAT BAUDOT IS MISSING MANY PUNCTUATION CHARACTERS THAT BASIC USES. NOT SURE HOW I'LL DEAL WITH THAT. BUT I JUST HAD TO WRITE AND TELL YOU THE NEWS!

CHIP

Jan 26, 1976

Hi Chip,

I had a GREAT time at your place last weekend! Thanks so much for putting up with me. It's INCREDIBLE that you built a computer more powerful than Apollo's AGC-1 that flew men to the moon! The contrast between it and your clattering old WW2 veeblefetzer of a printer is particularly striking.

I apologize again for monopolizing your computer all day... and all night... and most of the next day. I almost got my stock-picker program working, but ran out of memory. It's just so friggin' AMAZING to have a machine that you can actually program to do what you want RIGHT NOW, without having to wait in line or submit your deck to be run overnight. The possibilities are ENDLESS! Have you read Ted Nelson's "Computer Lib / Dream Machines" yet? We are living in the future RIGHT NOW!

Can we commercialize your ROM board? Please? NOW? People are DYING to get computers that work as well as yours (me included). This is an expensive hobby; to go anyplace, we need to find SOME way to pay for it.

I got a name for our company. How about Itty Bitty Micro Company? That pretty much describes us. And the initials are "IBM". o o

Gil ___/

19 MARCH 1976

HI GIL,

MY ROM BOARD IS JUST A DEVELOPMENT TOOL... A TOOL YOU HAVE TO MAKE FIRST, TO BUILD THE THINGS YOU REALLY NEED. LOTSA PROBLEMS SELLING IT:

1. 1702'S ARE TOO SMALL; TAKES TOO MANY. THERE'S A NEW 2708 CHIP THATS BETTER. 4 TIMES BIGGER, MUCH EASIER TO USE. AND IT HAS SPARE PINS, SO EVEN BETTER VERSIONS ARE COMING (THAT MOORE'S LAW THING).
2. IT COSTS LIKE $1000 TO GET A PCB LAID OUT AND BUILT. WE DON'T HAVE THAT KIND OF MONEY! CAN WE FIND SOMEONE WHOSE GOOD AT IT THAT MIGHT WORK IN TRADE FOR A COMPUTER?
3. WE CAN'T SELL ALTAIR'S BASIC (PIRACY, LAWYERS, JAIL!) WE HAVE TO FIND ONE OF OUR OWN. BUT GUYS ARE WORKING ON A PUBLIC-DOMAIN BASIC! SEE PEOPLE'S COMPUTER COMPANY, DR. DOBBS JOURNAL, ETC.
4. YOU'RE RIGHT... THINGS ARE MOVING FAST! BY THE TIME WE SOLVE THESE ISSUES, A DOZEN OTHER GUYS WILL ALREADY BE SELLING ROM BOARDS. WE HAVE TO THINK AHEAD, AND FIGURE OUT WHAT WILL HAPPEN NEXT, AND THEN BUILD THAT.

I THINK WE NEED TO WALK BEFORE WE RUN. KEEP LEARNING, AND BUILDING TOOLS. YES, WE NEED MORE MEMORY. BUT LET OTHER PEOPLE BUILD ROM AND RAM BOARDS FOR US. THAT'S WHAT EVERYONE ELSE IS ALREADY MAKING.

RICHIE KERNIGAN (THE RIT GUY THAT GOT MY BASIC WORKING) IS A SOFT-WARE GENIUS. HE MEMORIZED THE OPCODES AND ASSEMBLES CODE IN HIS HEAD! I'M BUILDING A COMPUTER FOR HIM, AND HE'S WRITING THE CODE FOR ME.

WE'RE WORKING ON SOMETHING YOU'LL LIKE. IT'S LIKE DON LANCASTER'S "TV TYPEWRITER", BUT IT WILL DISPLAY A SECTION OF THE COMPUTER'S MEMORY ON A TV SCREEN. WAY FASTER, CHEAPER, AND SIMPLER! WE THINK SOME KIND OF COMBINED COMPUTER AND TV TYPEWRITER MAY BE THE WAY TO GO!

CHIP

(More history to follow. But jumping ahead...)

Compuserve Email v1.2 <M>enu <N>ext <P>revious <Q>uit <H>elp

SUBJECT: Parts List
DATE: 23 January 1980
FROM: chip8080
TO: wizwireman

Wiz,

Gil says to send you a set of boards and parts. OK, I mailed it out today... hopefully to the right address! Knowing you, if it arrives by noon it will be built by midnite. I swear, you wire things faster than I can draw the schematics.

The Visicalc parts list is in the box. "Source" shows replacement parts; but I sent what I had on hand so there are differences. No worries, mate! We built 2 with these parts, and they WORK! Match the parts to the parts list to be sure you have everything. Note there are TWO boards; so TWO sets of parts (two C1, two R1, etc.)

CPU board: R3 is a yellow 10-pin SIP, marked 10X-2-202LF
R4 is a black 8-pin SIP, marked SMTA222G
R5 is a black 6-pin SIP, marked 6B202G
U8 is LM2940 (low dropout; better than the 7805)

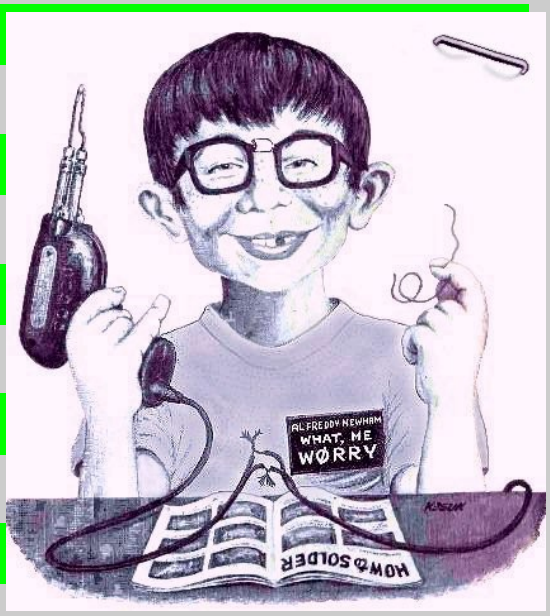
Front Panel: J1,J2,J3: Sent 3 10-pin sockets. Cut 1 to make a 4-pin, and two 2-pin.
C2 is blue, marked 475. Yes, it really *is* 4.7uF!
Q1, Q2, and Q3 are marked R3307
R4 is black, marked 6A222G
R5 is blue, marked CTSK003... \ Same part#! I cut two pins off the
R6 is blue, marked CTSK003... / 8-pin part to make the 6-pin part.
U5 is an unmarked black tube with 2 wires at each end. Dot is LED "-".
Y2 is a 1" diameter brass disk.

I included a Jameco ad, with pictures and notes to identify the parts. Also prices; but it's from an old issue of Byte magazine so they have changed a bit. Between the ad and parts list, you'll figure it out. Yell if you have any questions!
--
Chip Hacker | "There ain't no rules around here.
Chief (and only) engineer | We're trying to accomplish something!"
Itty Bitty Micro Company | Thomas A. Edison

SUBJECT: Re: Parts for Project Z
DATE: 27 January 1980
FROM: wizwireman
TO: chip8080

Got yer email, Chip. Will let you know when the package arrives.

Any assembly instructions? You want it done fast, or cheap, or right? Pick one. If "fast", I've got just the kid to do it!
--
Willard Wireman
Senior Technician
Eastern Coatrack Company
"A future you can hang your hat on"



**Z80 MEMBERSHIP CARD -- PARTS LIST**

| | A | B | C | D |
|---|---|---|---|---|
| 1 | QTY | ITEM | DESCRIPTION | SOURCE |
| 2 | --- | ---- | ---------- | ---------- |
| 3 | 1 | C1 | capacitor 3.3uF 15vdc tantalum | J 2024495 |
| 4 | 1 | C2 | capacitor 33uF 10vdc electrolytic | D 493-1730-ND |
| 5 | 3 | C3-5 | capacitor 0.1uF X7R ceramic 0.1”LS | J 1570161 |
| 6 | 1 | C6 | capacitor 0.1uF X7R ceramic 0.2”LS | J 544921 |
| 7 | 2 | P1,2 | header 30-pin 0.025”sq pins 0.1”LS | J 68339 |
| 8 | 2 | R1,2 | resistor 1 meg 5% 1/4w carbon film | J 691585 |
| 9 | 1 | R3 | resistor 2K x 5 10-pin SIP isolated | D 4610X-2LF-2K-ND |
| 10 | 1 | R4 | resistor 2.2K x 7 8-pin SIP bussed | D 4608X-1-222LF-ND |
| 11 | 1 | R5 | resistor 2K x 3 6-pin SIP isolated | D 4606X-2-202LF-ND |
| 12 | 1 | U1 | Z80A CPU NMOS (or Z84C00 CMOS) | J 35596 |
| 13 | 1 | U1s | socket 40-pin IC low height | D ED5640-ND |
| 14 | 1 | U2 | 32K x 8 RAM (62256 etc.) | J 42850 |
| 15 | 1 | U3 | 32K x 8 EPROM programmed (27C256 etc.) | J 39731 |
| 16 | 2 | U2s,3s | socket 28-pin IC low height | D ED5628-ND |
| 17 | 1 | U4 | 74HC368 hex tri-state inverter | D 296-33074-5-ND |
| 18 | 1 | U5 | 74HC138 3-to-8 decoder | J 45330 |
| 19 | 1 | U6 | 74HC273 octal D flip-flop | J 45743 |
| 20 | 1 | U7 | 74HC245 octal transceiver | J 45671 |
| 21 | 1 | U8 | 7805T 5v 1 amp regulator (or LM2940) | J 897381 |
| 22 | 1 | Y1 | resonator 4 MHz with capacitors | D 490-1208-ND |
| 23 | 1 | PCB | “Z80 Membership Card” PC board | TMSI (that's me!) |
| 24 | 1 | CASE | Altoids candy tin | candy store |

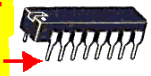
**Z80 MEMBERSHIP CARD FRONT PANEL -- PARTS LIST**

| | A | B | C | D |
|---|---|---|---|---|
| 1 | QTY | ITEM | DESCRIPTION | SOURCE |
| 2 | --- | ---- | ---------- | ---------- |
| 3 | 1 | C1 | capacitor 3.3uF 15vdc tantalum | J 2024495 |
| 4 | 1 | C2 | capacitor 4.7uF 25v X7R ceramic 0.1”LS | D 445-8309-ND |
| 5 | 1 | C3 | capacitor 0.1uF X7R ceramic 0.1”LS | J 1570161 |
| 6 | 1 | D1 | LED display 7seg 7digit Rohm LS-2074M2G | P 19391-OP |
| 7 | 1 | D2 | 1N4148 diode small signal | J 179215 |
| 8 | 3 | J2a,b,c | socket 10-pin Molex 22-18-2101 | D WM3241-ND |
| 9 | 2 | J1,3 | socket 2-pin (cut from end of J2c) | |
| 10 | 1 | P1 | header 5-pin (cut from end of P1 on Z80 Membership Card) | |
| 11 | 3 | Q1,2,3 | NPN transistor w.22K/47K FJN3307R | D FJN3303RTACT-ND |
| 12 | 2 | Q4,5 | PNP transistor w.22K/22K FJN4303R | D FJN4303RTACT-ND |
| 13 | 3 | R1,2,7 | resistor 1K 5% 1/4w carbon film | J 690865 |
| 14 | 1 | R3 | resistor 3.3K 5% 1/4w carbon film | J 690988 |
| 15 | 1 | R4 | resistor 2K x 4 5-pin SIP bussed | D 4605X-101-202LF |
| 16 | 1 | R5 | resistor 100 x 3 6-pin SIP isolated | D 4606X-102-101LF |
| 17 | 1 | R6 | resistor 100 x 4 8-pin SIP isolated | D 987-1253-ND |
| 18 | 16 | S0-F | pushbutton switch, tactile | D EG1832-ND |
| 19 | 1 | U1 | 74HC4040 12-bit binary counter | J 45920 |
| 20 | 1 | U2 | 74HC393 dual 4-bit binary counter | J 251504 |
| 21 | 1 | U3 | 74LS145 BCD-to-decimal decoder/driver | D 296-1641-5-ND |
| 22 | 1 | U4 | 74ALS01 quad 2-in NAND open collector | R 74LS01N |
| 23 | 1 | U5 | LED-resistor optocoupler Clairex CLI-6000 | E G15396B |
| 24 | 1 | Y2 | piezo speaker 2KHz PUI Audio AB2720BLW | D 668-1405-ND |
| 25 | 1 | PCB | “Z80 Membership Card Front Panel”PC board | TMSI (me again) |

B=bgmicro.com D=digikey.com E=goldmine-elec.com J=jameco.com P=mpja.com R=jdr.com
Boards, parts, and complete kits available from TMSI c/o Lee Hart at <**www.sunrise-ev.com/z80.htm>.**

# 74LS

notch or dot end is Pin 1



| | | | | | |
|---|---|---|---|---|---|
| 74LS00 | .39 | 74LS73 | .65 | 74LS161 | 2.25 |
| 74LS01 | .39 | 74LS74 | .65 | 74LS163 | 2.25 |
| 74LS02 | .39 | 74LS75 | .79 | 74LS164 | 2.25 |
| 74LS03 | .39 | 74LS76 | .65 | 74LS181 | 3.69 |
| 74LS04 | .45 | 74LS86 | .65 | 74LS190 | 2.85 |
| 74LS05 | .45 | 74LS90 | 1.25 | 74LS191 | 2.85 |
| 74LS08 | .39 | 74LS92 | 1.25 | 74LS192 | 2.85 |
| 74LS10 | .39 | 74LS93 | 1.25 | 74LS193 | 2.85 |
| 74LS13 | .79 | 74LS107 | .65 | 74LS240 | 2.19 |
| 74LS14 | 2.19 | 74LS112 | .65 | 74LS245 | 2.25 |
| 74LS20 | .39 | 74LS132 | 1.55 | 74LS257 | 1.89 |
| 74LS26 | .49 | 74LS136 | .65 | 74LS273 | 1.89 |
| 74LS27 | .45 | 74LS138 | 1.89 | 74LS368 | .99 |
| 74LS30 | .39 | 74LS145 | 1.55 | 74LS373 | 2.85 |
| 74LS32 | .45 | 74LS151 | 1.89 | 74LS393 | 2.79 |
| 74LS40 | .49 | 74LS157 | 1.55 | 74LS670 | 3.95 |
| 74LS51 | .39 | | | | |
| 74LS55 | .39 | | | | |

MANY OTHERS AVAILABLE ON REQUEST
20% Discount for 100 Combined 7400's

# CMOS

| | | | | | |
|---|---|---|---|---|---|
| CD4000 | .25 | CD4035 | 1.85 | 74C04N | .75 |
| CD4001 | .25 | CD4040 | 2.45 | 74C10N | .65 |
| CD4002 | .25 | CD4042 | 1.90 | 74C20N | .65 |
| CD4006 | 2.50 | CD4044 | 1.50 | 74C30N | .65 |
| CD4007 | .25 | CD4046 | 2.51 | 74C42N | 2.15 |
| CD4009 | .59 | CD4047 | 2.75 | 74C73N | 1.50 |
| CD4010 | .59 | CD4049 | .79 | 74C74 | 1.15 |
| CD4011 | .25 | CD4050 | .79 | 74C90N | 3.00 |
| CD4012 | .25 | CD4051 | 2.95 | 74C95N | 2.00 |
| CD4013 | .47 | CD4053 | 2.95 | 74C107N | 1.25 |
| CD4016 | .56 | CD4060 | 3.25 | 74C151 | 2.90 |
| CD4017 | 1.35 | CD4066 | 1.75 | 74C154 | 4.00 |
| CD4019 | .55 | CD4069 | .45 | 74C157 | 2.15 |
| CD4020 | 1.49 | CD4071 | .45 | 74C160 | 3.25 |
| CD4022 | 1.25 | CD4081 | .45 | 74C161 | 3.25 |
| CD4023 | .25 | CD4511 | 2.50 | 74C163 | 3.00 |
| CD4024 | 1.50 | CD4518 | 2.50 | 74C164 | 3.25 |
| CD4025 | .25 | 74C00N | .39 | 74C173 | 2.60 |
| CD4027 | .69 | 74C02N | .55 | 74C193 | 2.75 |
| CD4028 | 1.65 | | | 74C195 | 2.75 |
| CD4029 | 2.90 | | | MC4044* | 4.50 |
| CD4030 | .65 | | | MC14016* | .56 |

# LINEAR

| | | | | | |
|---|---|---|---|---|---|
| LM309K | .99 | LM380N | 1.39 | LM709N | .29 |
| LM324N | 1.80 | NE555N | .45 | LM710N | .79 |
| LM339N | 1.25 | NE556N* | .75 | LM711N | .39 |
| LM340T-5 | 1.75 | NE561B* | 5.00 | LM723N | .55 |
| LM340T-5 | 1.75 | NE562B* | 5.00 | LM741CN | .35 |
| LM340T-6 | 1.75 | NE566CN* | 1.25 | LM1458C | .65 |
| LM340T-12 | 1.75 | NE567H* | 1.95 | LM3900N | .55 |
| LM340T-15 | 1.75 | | | LM7805T | 1.75 |
| LM340T-24 | 1.75 | | | LM78L05 | .99 |

# TRANSISTORS

Q1-5

| | | | | | |
|---|---|---|---|---|---|
| 2N2222A | 5/$1.00 | 2N4123 | 10/$1.00 | 2N5088 | 4/$1.00 |
| 2N2907A | 5/$1.00 | 2N4400 | 4/$1.00 | 2N5089 | 4/$1.00 |
| 2N3053 | 2/$1.00 | 2N4401 | 4/$1.00 | 2N5129 | 5/$1.00 |
| 2N3055 | $ .69 | 2N4402 | 4/$1.00 | 2N5138 | 5/$1.00 |
| MJE3055 | $1.00 | 2N4403 | 4/$1.00 | 2N5139 | 5/$1.00 |
| MJE2955 | $1.25 | 2N4409 | 5/$1.00 | 2N5209 | 5/$1.00 |
| 2N3904 | 4/$1.00 | 2N5086 | 4/$1.00 | 2N5951 | 5/$1.00 |
| 2N3905 | 4/$1.00 | | | C106B1SCR | 2/$1.00 |
| 2N3906 | 4/$1.00 | | | 2N5432 | $2.00 |

# DIODES

| TYPE | VOLTS | AMPS | PRICE |
|---|---|---|---|
| 1N4001 | 50 PIV | 1 AMP | 12/1.00 |
| 1N4002 | 100 PIV | 1 AMP | 12/1.00 |
| 1N4003 | 200 PIV | 1 AMP | 12/1.00 |
| 1N4004 | 400 PIV | 1 AMP | 12/1.00 |
| 1N4005* | 600 PIV | 1 AMP | 10/1.00 |
| 1N4006* | 800 PIV | 1 AMP | 10/1.00 |
| 1N4007* | 1000 PIV | 1 AMP | 10/1.00 |
| 1N4148 | 75 | 10mA | 15/1.00 |

# ZENERS

D2

| TYPE | VOLTS | W | PRICE |
|---|---|---|---|
| 1N4734 | 5.6 | 1w | .28 |
| 1N4736 | 6.8 | 1w | .28 |
| 1N4738 | 8.2 | 1w | .28 |
| 1N4742 | 12 | 1w | .28 |
| 1N4744 | 15 | 1w | .28 |
| 1N5232 | 5.6 | 500mw | .28 |
| 1N5235 | 6.8 | 500mw | .28 |
| 1N5236 | 7.5 | 500mw | .28 |

# CAPACITOR CORNER

C3-6

50 VOLT CERAMIC DISC CAPACITORS

| | 1-9 | 10-49 | 50-100 | | 1-9 | 10-49 | 50-100 |
|---|---|---|---|---|---|---|---|
| 10 pf | .05 | .04 | .03 | .001μF | .05 | .04 | .035 |
| 22 pf | .05 | .04 | .03 | .0047μF | .05 | .04 | .035 |
| 47 pf | .05 | .04 | .03 | .01μF | .05 | .04 | .035 |
| 100 pf | .05 | .04 | .03 | .022μF | .06 | .05 | .04 |
| 220 pf | .05 | .04 | .03 | .047μF | .06 | .05 | .04 |
| 470 pf | .05 | .04 | .035 | .1μF | .12 | .09 | .075 |

C1-3

+20% DIPPED (SOLID) TANTALUM CAPACITORS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.0/35V | .28 | .23 | .17 | 4.7/25V | .32 | .28 | .23 |
| 3.3/25V | .31 | .27 | .22 | 10/25V | .40 | .35 | .29 |

ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead

Radial Lead

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3.3/50V | .15 | .13 | .10 | 1.0/16V | .15 | .13 | .10 |
| 10/50V | .16 | .14 | .12 | 4.7/25V | .15 | .13 | .10 |
| 22/25V | .17 | .15 | .12 | 10/25V | .15 | .13 | .10 |
| 47/25V | .19 | .17 | .15 | 47/50V | .24 | .21 | .19 |
| 100/25V | .24 | .20 | .18 | 100/16V | .19 | .15 | .14 |
| 220/25V | .32 | .28 | .25 | 220/16V | .23 | .17 | .16 |
| 470/25V | .33 | .29 | .27 | 470/25V | .31 | .28 | .26 |
| 1000/16V | .55 | .50 | .45 | 220/16V | .23 | .17 | .16 |
| 2200/16V | .70 | .62 | .55 | 470/25V | .31 | .28 | .26 |

# CONSUMER ELECTRONICS

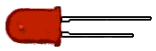
## PONG — $59.95 SINGLE GAME
## SUPER PONG — $89.95 4 GAMES IN ONE


GAMES INCLUDED IN SUPER PONG ARE:
- PONG
- CATCH
- SUPER PONG
- HANDBALL

FEATURES OF PONG AND SUPER PONG
- Incremental speed on volleys increases excitement.
- Playing field adjusts to any size screen.
- Game appears in color or in black & white, depending on television set.
- Unmistakable "PONG" sound accompanies each volley.
- Digital scoring flashes on the screen between each point.
- 2 player challenge or Solitaire
- Hooks up simply to any model television set; the screen actually becomes the playing field.
- English and other techniques can be used to make any member of the family a Pong champion.
- Battery operated by 4 size "D" flashlight batteries included with the Unit.

AC Adaptor (Eliminates Batteries) **$9.95**

# SUPER SAVINGS! DISCRETE LEDS DISPLAY LEDS



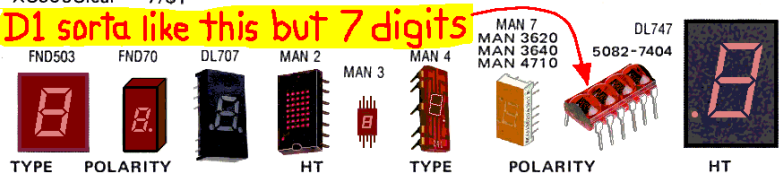
.200" dia.

| | |
|---|---|
| XC556Red | 10/$1 |
| XC556Green | 7/$1 |
| XC556Yellow | 7/$1 |
| XC556Orange | 7/$1 |
| XC556Clear | 7/$1 |

.125" dia.

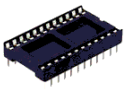
| | |
|---|---|
| XC209Red | 10/$1 |
| XC209Green | 4/$1 |
| XC209Yellow | 7/$1 |
| XC209Orange | 4/$1 |

D1 sorta like this but 7 digits




| TYPE | POLARITY | HT | | TYPE | POLARITY | HT | |
|---|---|---|---|---|---|---|---|
| MAN 2 | 5 x 7 Dot Matrix | .300 | 4.95 | MAN 3640 | Common Cathode-orange | .300 | .99 |
| MAN 3 | Common Cathode | .125 | 3/1. | MAN 4710 | Common Anode-Red | .400 | .99 |
| MAN 4 | Common Cathode | .187 | 1.95 | DL707 | Common Anode | .300 | 1.50 |
| MAN 7 | Common Anode-red | .300 | .99 | DL 747 | Common Anode | .600 | 2.25 |
| MAN 7G | Common Anode-green | .300 | 1.95 | 5082-7404 | Common Cathode | .110 | .99 |
| MAN 7Y | Common Anode-yellow | .300 | 1.95 | FND70 | Common Cathode | .250 | .50 |
| MAN 3620 | Common Anode-orange | .300 | .99 | FND503 | Common Cathode | .500 | 1.29 |

## IC SOCKETS -- ECONOMY LOW PROFILE SOLDERTAIL (TIN)



| | 1-24 | 25-49 | 50-100 | | 1-24 | 25-49 | 50-100 |
|---|---|---|---|---|---|---|---|
| 8 pin | $.17 | .16 | .15 | 20 pin | $.37 | .36 | .35 |
| 14 pin | .20 | .19 | .18 | 24 pin | .38 | .37 | .36 |
| 16 pin | .22 | .21 | .20 | 28 pin | .45 | .44 | .43 |
| 18 pin | .29 | .28 | .27 | 36 pin | .60 | .59 | .58 |
| 22 pin | .37 | .36 | .35 | 40 pin | .63 | .62 | .61 |

## MACHINE TOOLED LOW PROFILE SOLDERTAIL (GOLD)

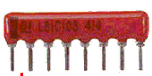
this kind

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8 pin | $.45 | .41 | .37 | 20 pin | $1.05 | .95 | .85 |
| 14 pin | .39 | .38 | .37 | 24 pin | 1.40 | 1.25 | 1.10 |
| 16 pin | .43 | .42 | .41 | 28 pin | 1.59 | 1.45 | 1.30 |
| 18 pin | .75 | .68 | .62 | 40 pin | 1.75 | 1.55 | 1.40 |

## 50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASST. 1 | 5 ea. | 10 | 12 | 15 | 18 | 22 | 27 | 33 | 39 | 47 | 56 | OHMS, 1/4 WATT 5% = 50 PCS. |
| ASST. 2 | 5 ea. | 68 | 82 | 100 | 120 | 150 | 180 | 220 | 270 | 330 | 390 | OHMS, 1/4 WATT 5% = 50 PCS. |
| ASST. 3 | 5 ea. | 470 | 560 | 680 | 820 | 1K | 1.2K | 1.5K | 1.8K | 2.2K | 2.7K | OHMS, 1/4 WATT 5% = 50 PCS. |
| ASST. 4 | 5 ea. | 3.3K | 3.9K | 4.7K | 5.6K | 6.8K | 8.2K | 10K | 12K | 15K | 18K | OHMS, 1/4 WATT 5% = 50 PCS. |
| ASST. 5 | 5 ea. | 22K | 27K | 33K | 39K | 47K | 56K | 68K | 82K | 100K | 120K | OHMS, 1/4 WATT 5% = 50 PCS. |
| ASST. 6 | 5 ea. | 150K | 180K | 220K | 270K | 330K | 390K | 470K | 560K | 680K | 820K | OHMS, 1/4 WATT 5% = 50 PCS. |
| ASST. 7 | 5 ea. | 1M | 1.2M | 1.5M | 1.8M | 2.2M | 2.7M | 3.3M | 3.9M | 4.7M | 5.6M | OHMS, 1/4 WATT 5% = 50 PCS. |

5 EACH MINIMUM PER VALUE ON ANY RESISTORS FROM 2.2 OHM TO 5.6M
5-25 PCS .05ea. 30-95 PCS .04ea. 100-495 PCS .03ea. 500-995 .0275ea.



SIP RESISTOR NETWORKS 125mW 5%
SPECIFY 6, 8, OR 10 PINS; ISOLATED OR BUSSED
100 220 470 1K 2.2K 4.7K 10K 100K OHMS

| 1-9 | 10-49 | 50-100 |
|---|---|---|
| .29 | .25 | .19 |


| | |
|---|---|
| 0 = BLACK | 5 = GREEN |
| 1 = BROWN | 6 = BLUE |
| 2 = RED | 7 = VIOLET |
| 3 = ORANGE | 8 = GRAY |
| 4 = YELLOW | 9 = WHITE |

Prices Good Thru Dec 1976. * Astrisk Denotes Specials This Month *
$5.00 Min. Order. U.S. Funds. California Residents — Add 6% Sales Tax
Send a 13c Stamp (postage) for a FREE 1976 Catalog — Data Sheets 25c each

R3-R6

R1, R2, R7

C2

# Jameco ELECTRONICS

1021 HOWARD AVE, SAN CARLOS, CA 94070
PHONE ORDERS — (415) 592-8097

Compuserve Email v1.2 <M>enu <N>ext <P>revious <Q>uit <H>elp

SUBJECT: Assembly Instructions
DATE: 27 Jan 1980
FROM: chip8080
TO: wizwireman

Hah. Be nice, or I'll tell Gil what you're REALLY doing on vacation!

No, I haven't written an assembly manual (yet). The boards we built here are kind of learn-as-we-go things, so I could check out the hardware, and Crash could debug the software. We still need to work out the best way to assemble them.

They're very good for rev.A boards -- Tracey did a fantastic job on the layout! But there are a few errors: Let's see...

CPU board:
- VCC was shorted to GND between U3 and U7! I fixed it with a Dremel tool.
- U8 has a TO92 outline as well as TO220; ignore the TO92 (it is backwards).

Front Panel:
- When it comes time to plug the two boards together, the silkscreen on the Front Panel is UPSIDE DOWN compared to the CPU board.
- Silkscreening errors: "J1" should be "P1"
  "P2" should be "J2"
  "J2" should be "J1"

Thinking "Inside the Box":

If you want it to fit in an Altoids box with the LID CLOSED, you need to go to some extra effort to get the boards very close together:

1. Keep the leads on the back sides of the boards VERY SHORT. Otherwise, they will short to the metal Altoids case or between boards.

2. Don't use normal IC sockets on the boards – they are too tall. I supplied special very-low-profile sockets for the Z80 and memory chips. Get more, or use socket pins if you want to socket the chips.

3. The plastic body of the 30-pin headers has to be REMOVED to let the boards sit closer together. I did it like this:
   - Pound the pins into the plastic bodies, so the plastic is all at one end.
   - Install them with the plastic body on the BOTTOM of the board.
   - Solder the pins from the TOP side.
   - Pry off the plastic body.
   - Stick the plastic body (or pieces of it) back on top of the pins, to act as a jig to hold them in place.
   - Cut off the extra pin length on the bottom of the board.
   - Re-solder the pins from the bottom (the plastic holds them in place).
   - Now you can permanently remove the plastic body.

If you DON'T CARE about putting it in an Altoids box, or are willing to remove the top cover of the box, assembly is much easier. Just solder the headers on the top of the CPU board as usual. The boards wind up being spaced another 0.1" apart. That gives you enough room to use ordinary IC sockets, too.

Male? Female? Keying?

I put the male pins on the CPU board, and the female sockets on the BOTTOM of the Front Panel board. This may (or may not) be the best way to do it. For one thing, it means there is no "keying", so the Front Panel can be plugged in backwards or off by a pin. Let me know if you have any ideas on this! -- Chip

**Z80 Membership Card – Assembly Details**

---

Here's a Polaroid of the board, with comments on how to assemble it. All parts go on top, and are soldered on the bottom. Cut off the excess lead length on the bottom as short as possible, so they won't cause shorts to the Altoids case! As you finish installing each part, CIRCLE the designator ("U7, C6" etc.) so you know it's done.

**Watch out** for the polarity of the ICs, C1, C2, and the SIP resistors. They **must** be installed right, or it won't work! The part numbers printed on the chips should be right side up in this view.

**U7 74HC245.** Be sure that pin 1 is on the left! End with notch or dot marks pin 1 -->

**R5 2K 6-pin SIP.** black, Marked 6B202G. pin 1->

**C5 0.1uF** yellow, marked 104

**C1 3.3uF** orange, + wire on top, - wire bottom

**Note:** C1 and C2 +/- point in opposite directions!

**C2 33uF** black, + - wire on top, + wire bottom

**C6 0.1uF** yellow, marked 104, is 0.2" wide

**U6 74HC273.** Pin 1 on left end.

**U4 74HC368.** Pin 1 on left end.

**Y1 4MHz resonator** yellow, 3 pins

**R1 1meg** brn-blk-grn-gold

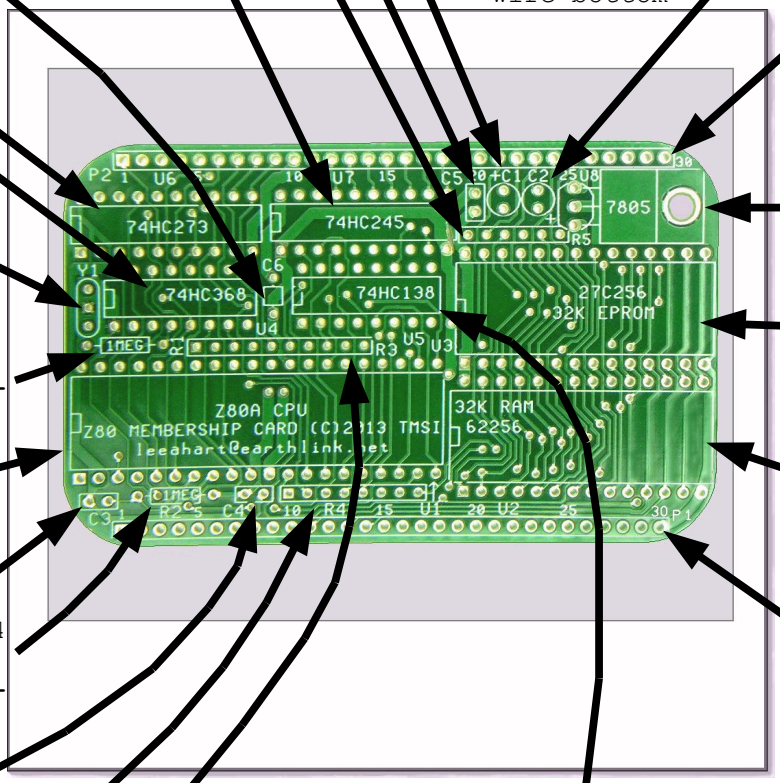
**U1 Z80.** Install socket 1st, then Z80. Pin 1 left!

**C3 0.1uF** yellow marked 104

**R2 1meg** brn-blk-grn-gold

**C4 0.1uF** yellow, marked 104

**R4 2.2k 8-pin SIP.** black, pin 1->, Marked SMTA222G, Pin 1 at left end




**R3 2k 10-pin SIP.** yellow, pin 1-->, Marked 10X-2-202LF, Pin 1 at left end

**U5 74HC138.** Pin 1 at left end

**P2 30-pin header.** Install it the same way as described for P1 (below).

**U8 LM2940.** Metal tab is against the board.

**U3 socket** first, then put the EPROM in it. Pin 1 on left!

**U2 socket** first, then put the RAM in it. Pin 1 on left!

**P1 30-pin header.**

1. Push pins into body. --> 
2. Put body on bottom of board.
3. Solder on top.
4. Cut off body and excess pin length from the bottom.

**Hint for P1 and P2:** If the solder joints look "ugly", put a piece of the body on the TOP of the pins to hold them in place. Then solder the pins again from the bottom to make them look "pretty".

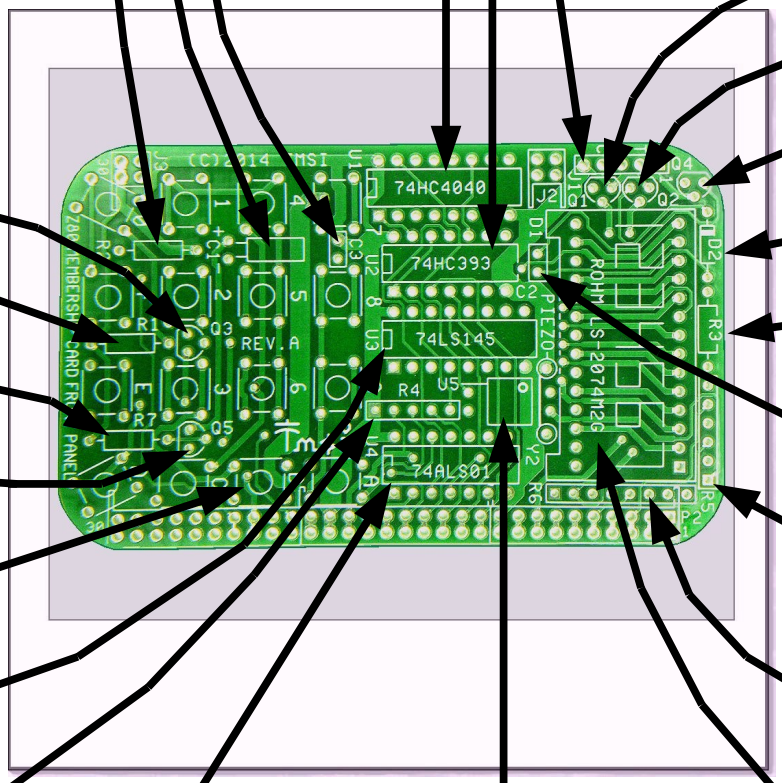
**Z80 Front Panel Card - Assembly Details**

---

Here's a Polaroid of the Front Panel board, with "hints and kinks" on how to assemble it. All parts go on the top of the board, EXCEPT for the female sockets at the locations that are silkscreened P2, J2, and J3. (Note that these silkscreened names are WRONG! It's something we have to fix in the next revision).

Follow the usual rules about +/- polarity and pin 1's. Sockets are not supplied, because they make the board too thick to fit in an Altoids tin.

Circle the designators for each part as you install it.




**Q3,Q5 transistors:** Install switches **FIRST.** Then install each transistor with its flat side **LEFT.** Bend its leads so it is as close to the board as possible (no higher than the switches).

Q1-Q5

Emitter | Base
Collector

**Q3 FJN3307R.**
marked R3307

**R1 1K** --|-- brn-blk-red-gold

**R7 1K** --|-- brn-blk-red-gold

**Q5 FJN4303R.**
marked R4303

**S0-SF Pushbutton.**
(16 switches)
Place on board and solder.

**U3 74LS145.**
pin 1 on left

**R4 2K 5-pin SIP.**
black,
marked 6A222G

**R2 1K** --|-- brn-blk-red-gold

**C1 3.3uF** orange
+ wire on top
- on bottom
lay it **FLAT.**

**C3 0.1uF**
marked 104

**U1 74HC4040.**
pin 1 left

**U2 74HC393.**
pin 1 left

**J1 5-pin header.**

**U4 74LS01 or 74ALS01.**
pin 1 left

**U5 Optocoupler.**
black, o--/ •/ \-o
4 pins o--____/-o
Put the lead with the dot into the top right hole.

**Q1,Q2,Q4 transistors:** Install J1 and D1 **FIRST.** Then install each transistor with its flat side **UP.** Bend its leads so it is as close to the board as possible (no higher than D1).

**Q1 FJN3307R.**
marked R3307

**Q2 FJN3307R.**
marked R3307

**Q4 FJN4303R.**
marked R4303

**D2 1N4148** diode.
Band end on top

**R3 3.3K**--|-- org-org-red-gold

**C2 4.7uF**
marked **475**
(not 104M!)

**R5 100 6-pin SIP**
blue,
marked CTSK003...

**R6 100 8-pin SIP**
blue,
marked CTSK003...

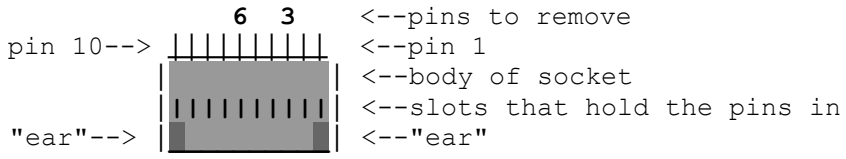
**D1 LED display.**
If it doesn't sit level on the board, trim the two left "feet" a little bit shorter.

**Y2 Piezoelectric Speaker** -- This is a brass disk about 1" in diameter. It sits on TOP of U2 and U3, so install it AFTER the rest of the parts are on the board. We'll be ordering them with wire leads. But the ones I have DON'T have leads, so you'll have to attach them yourself. The ceramic is very fragile, so solder them QUICK with as little solder and heat as possible.

1. Cut and strip both ends of a 1/2" long piece of very small wire. A piece of wire wrap wire will work; or a piece from some cheap broken toy.
2. Solder one end to the outer edge of the silvered top surface.
3. Cut and strip another 1/2" long piece of small wire. This can be stiffer; a scrap piece left over from a cut resistor lead, for example.
4. Solder one end to the outer edge of the brass back side of the disk.
5. Lay the piezo disk, silver side up, on top of U2 and U3. It JUST fits between the LED display, pushbuttons, and optocoupler U5.
6. Bend the free ends of the two wires to go into the circled holes labeled "PIEZO" and "Y2" on the board. Solder them to hold the piezo in position.

**P2, J2, and J3 Sockets** -- We actually need one 24-pin socket (P2), and two 2-pin sockets (J2 and J3). All I could get were 10-pin parts. So you'll have to cut up one of the 10-pin connectors to make a 4-pin, and two 2-pin connectors. Use the 4-pin piece with two of the 10-pin parts to make the 24-pin socket. To cut it:

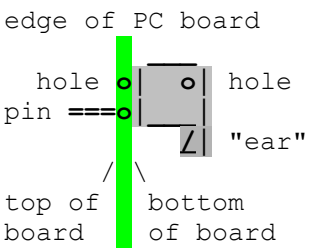
1. Position the socket with the pins pointing away from you, and the two "ears" at the ends pointing up. There is a tiny "1" at the right end, and a tiny "10" at the left end. These are the pin numbers.




2. Use a small screwdriver to push down the tab inside the slots of pins 3 and 6. Now pull pins 3 and 6 out of the body.
3. Using a sharp knife, CUT the socket in the middle of pin positions 3 and 6. This leaves you with a 4-pin, and two 2-pin sockets with ragged cut ends.
4. Trim and smooth the cut ends to satisfy your artistic sense. (They won't get in the way; they just look ugly.) You can use a knife, sandpaper, file, etc.

Install these female sockets on the **BOTTOM** of the board. There are pairs of holes for each one. Solder the pins of the socket into the **INNER** holes that are **AWAY** from the edge of the board.

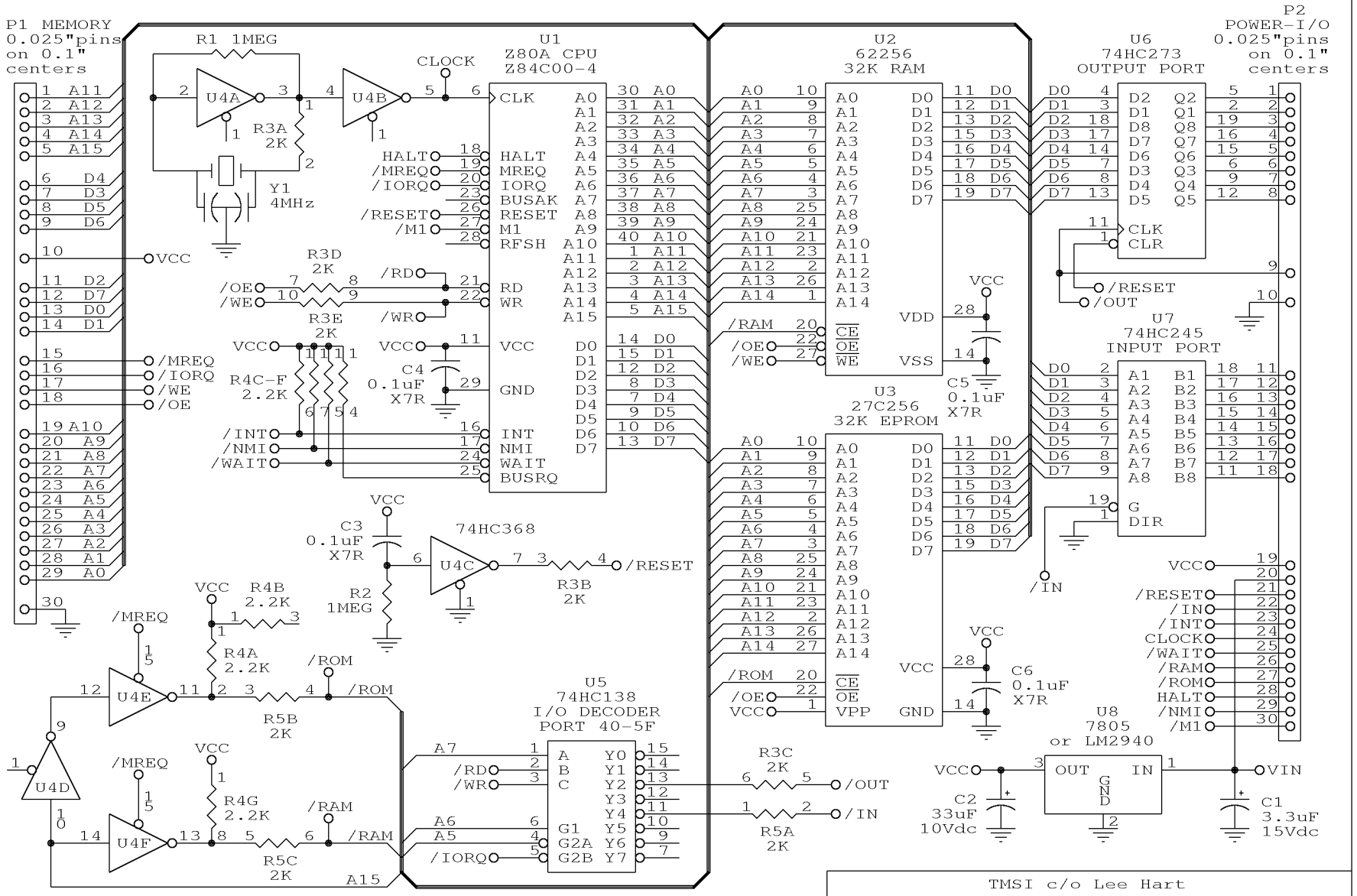
**Like this...**




**J2 2-pin socket.** Install it on the BOTTOM, solder it on top.
**J3 2-pin socket.** Install the same as J2.
J2 and J3 aren't being used as connectors. They are just spacers to hold the two boards apart.

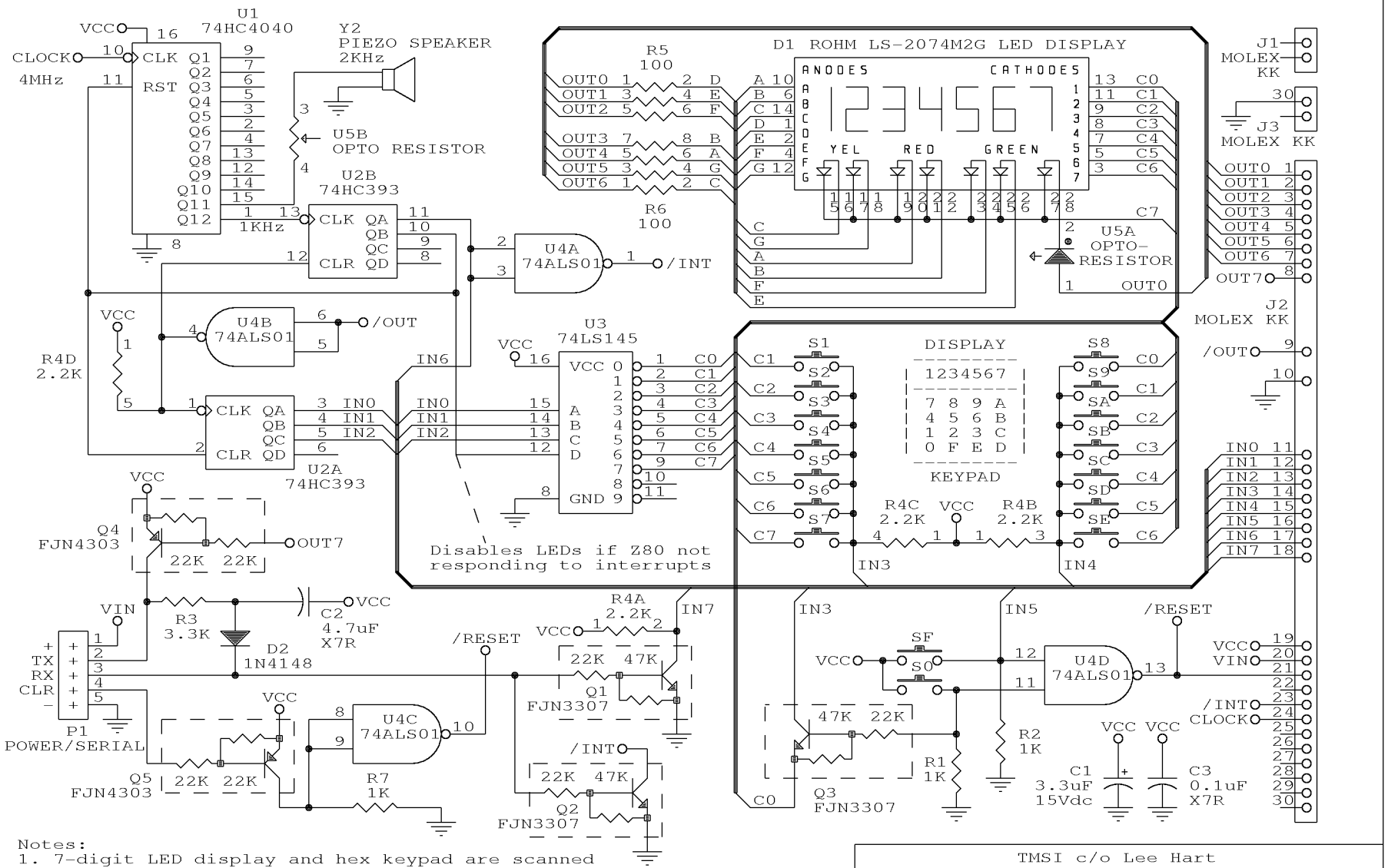
**P2 24-pin socket.** Install one 10-pin socket at pins 1-10. Install a second 10-pin socket at pins 11-20. Install the 4-pin socket piece at pins 21-24. There will be NO SOCKET at pins 25-30. These pins aren't used by the Front Panel. Besides, they get in the way of regulator U8 on the Z80 board.

**That's it! You're done!**




Notes:
1. All ICs powered by VCC. Uses C1-6, P1-2, R1-5, U1-8, Y1.
2. ROM at 0-32k, RAM at 32-64k. /RAM, /ROM, /IN, and /OUT can be externally forced high or low to change memory and I/O maps.
3. With NMOS and 74LS chips, mount U8 on bottom of board, with tab down and attached to a metal heatsink.

| | | |
|---|---|---|
| TMSI c/o Lee Hart | | |
| Title: Z80 Membership Card | | |
| Size: A | Document Number: C:\ORCAD\SHEET\Z80\Z80-MC.SCH | REV: A |
| Date: October 8, 2015 | Sheet 1 of 1 | |




Notes:
1. 7-digit LED display and hex keypad are scanned by ROM program on Z80 Membership Card.
2. All ICs powered by VCC. Uses C1-3, P1, J1-3, Q1-5, R1-7, U1-5.
3. 4MHz clock provides 1mSec real time clock interrupt.
4. RESET if P1 pin 4 (CLR) low, or F and 0 keys pressed at same time.
5. IN0-2 has key=0-E. IN3=0 if key=0-7. IN4=0 if key=8-E.
   IN5=1 if F key down; can use as Shift key with 0-E keys.
6. IN6=1 if 1 mSec RTC set /INT low. IN7=0 if TX high set /INT low.
7. RX, TX, DTR is BASIC Stamp2 type bit-banger RS-232 serial port.
8. 11/2/14: Old J1 renamed P1, old P2 renamed J1.


TMSI c/o Lee Hart
814 8th Ave N
Sartell MN 56377

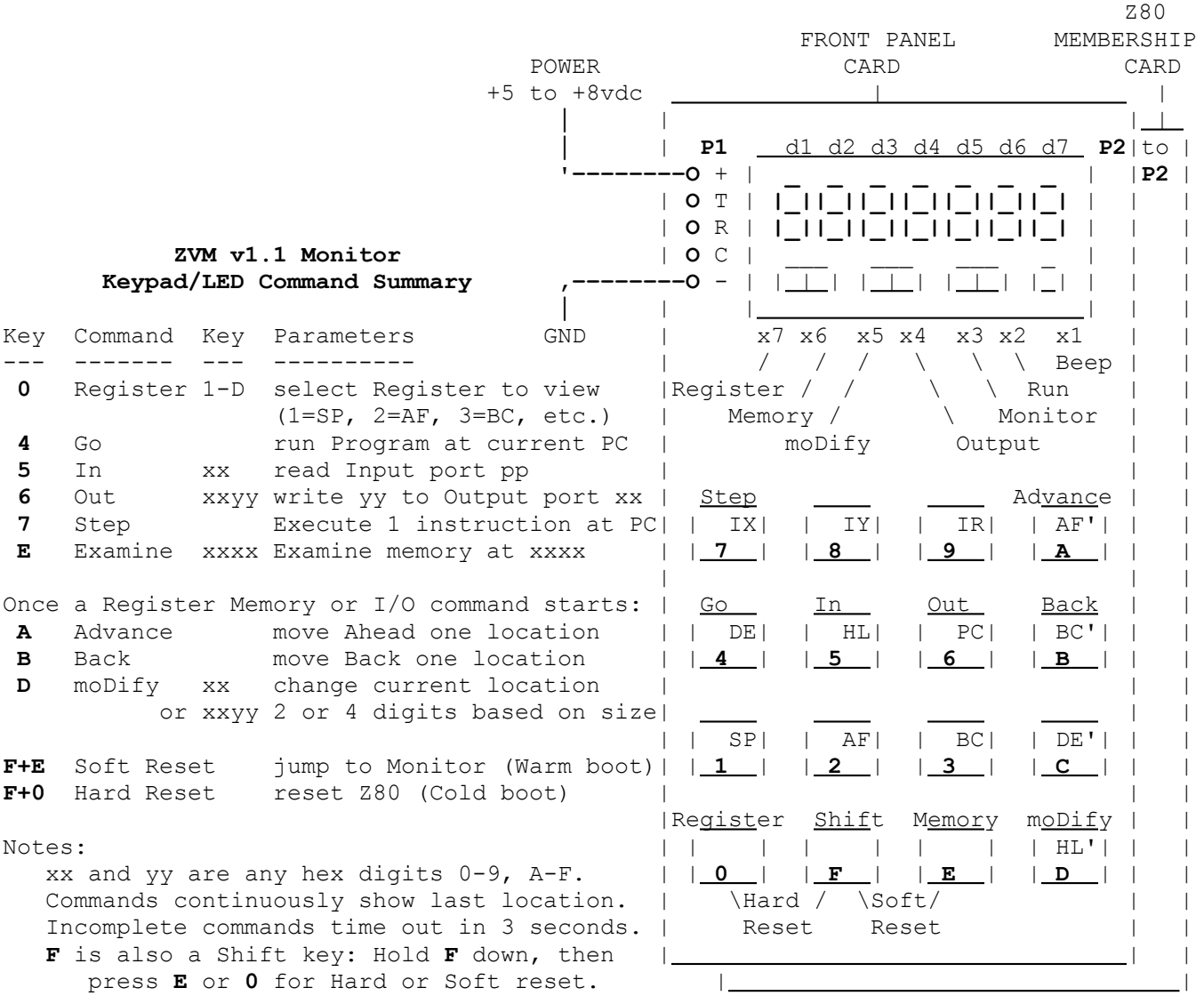

| Title | | |
|---|---|---|
| Z80 Membership Card Front Panel | | |
| Size: A | Document Number: C:\ORCAD\SHEET\1802\Z80-SP.SCH | REV: A |
| Date: June 11, 2015 | Sheet 1 of 1 | |

**A C R A S H  C O U R S E  I N  C O M P U T I N G**
**on the Z80 Membership Card**
**by Crash Kernigan ***

So you got it built; now you want to see it **WORK**! This "Quick Start" section will get you going fast. Don't worry about breaking anything. If it crashes, just turn it off and back on again, and everything will be fine.

First, plug the two boards together. P2 on the Z80 Membership Card plugs into P2 on the Front Panel Card. **BE SURE TO GET THIS RIGHT**! Plugging them together backwards or off by a pin will be an expensive mistake! When it's right, 5v regulator "U8" will be underneath keypad switch "D".

Next, it needs power. Any well-filtered source of +5v to +8v DC that can supply about half an amp will do. Connect power as shown below; Positive POWER to "+", and negative GND to "—" on the 5-pin header on the Front Panel.




**ZVM v1.1 Monitor**
**Keypad/LED Command Summary**

| Key | Command | Key | Parameters | |
|---|---|---|---|---|
| **0** | Register | 1-D | select Register to view | |
| | | | (1=SP, 2=AF, 3=BC, etc.) | |
| **4** | Go | | run Program at current PC | |
| **5** | In | xx | read Input port pp | |
| **6** | Out | xxyy | write yy to Output port xx | |
| **7** | Step | | Execute 1 instruction at PC | |
| **E** | Examine | xxxx | Examine memory at xxxx | |

Once a Register Memory or I/O command starts:

| | | | |
|---|---|---|---|
| **A** | Advance | | move Ahead one location |
| **B** | Back | | move Back one location |
| **D** | moDify | xx | change current location |
| | | or xxyy | 2 or 4 digits based on size |
| **F+E** | Soft Reset | | jump to Monitor (Warm boot) |
| **F+0** | Hard Reset | | reset Z80 (Cold boot) |

Notes:
- xx and yy are any hex digits 0-9, A-F.
- Commands continuously show last location.
- Incomplete commands time out in 3 seconds.
- **F** is also a Shift key: Hold **F** down, then press **E** or **0** for Hard or Soft reset.

Figure 1. Keypad/LED Monitor Summary

--
* OK, true confession time. The ZMC monitor and this section were actually written by Josh Bensadon, and edited by Lee Hart. But this is how Crash would have written it, if he existed outside of our heads. :-)

## K E Y P A D / L E D  M O N I T O R

On power-up, the display shows COLd 00. This means the system was COLD booted, and 00 because it's the first time since power-up. Annunciator LED x3 is on because it is in *Monitor* mode.

There are two modes: *Monitor* and *Run*. *Monitor* mode lets you examine and modify RAM, CPU registers, and I/O ports. *Run* mode will execute programs in memory.

There are nine keypad commands (plus two "oh shit!" Resets). Pressing a key starts that command. Most commands expect parameters(s) after the command. Once a command is started, enter its parameters with less than 3 seconds between keys, or it will time out and ignore the command.

**Examine Memory**

| | | |
|---|---|---|
| Press **E FFF1** | Display shows the address and its contents. | FFF1 23 |
| | Address FFF1 is the high byte of the "tick" counter, so you will see it counting up in real time. | |

**Examine Next or Previous Memory**

| | | |
|---|---|---|
| Press **A** | Advance to next address and show contents. | FFF2 34 |
| Press **B** | Backup to previous addr and show contents. | FFF1 56 |
| | Use **A** and **B** as many times as you like to move around. | |

**moDify RAM**

| | | |
|---|---|---|
| First, **E**xamine the location you want to change. | | |
| Press **D** | LEDs x5 and x6 light to show you will mo**D**ify Memory. | |
| Press 2 hex digits | Each digit pair forms a byte that is written into RAM. The address then advances to the next location. | |
| Press 2 more digits | To modify successive locations. Wait 3 seconds to end the command. | |

RAM is located at 8000-FFFF. Obviously, you can't change ROM (Read Only Memory), which is at 0000-7FFF. Let's enter a simple program: JP SELF (Jump on Self.. ouch!) The opcode for JP is C3. We'll enter it at address 8000, so the next two bytes are 00 and 80. The Z80 is a "little endian" CPU, which means it stores the lower byte in the lower memory address. (Don't change FE00-FFFF; they're used by the monitor.)

| | | |
|---|---|---|
| Press **E 8000** | to **E**xamine address 8000 (initially random). | 8000 nn |
| Press **D** | mo**D**ify mode. LEDs x5 and x6 light. | |
| Press **C3** | Change 8000 to C3. Display advances to next. | |
| Press **00** | Change 8001 to 00. Display advances to next. | |
| Press **80** | Change 8002 to 80. Wait 3 seconds to end the command. | |

You can prove it worked by checking the contents of 8000-8002. The easiest way is to press **B** a few times to Backup to 8000, then **A** to Advance and check what's in 8001 and 8002 as well.

8000 C3
8001 00
8002 80

**Examine and Modify Register**

To run a program, we have to point the PC register (Program Counter) to it.

| | | |
|---|---|---|
| Press **0 6** | to view Register PC. | PC nnnn |
| Press **D 8000** | mo**D**ify it to 8000 (if not already there) | PC 8000 |

**Run Mode**

| | | |
|---|---|---|
| Press **4** | LED x2 turns on (*Run* mode) and x3 turns off. | |

It's now running your program! The PC is displayed; but not changing. What did you expect for a 1-instruction program? Let's enter a bigger program so we can see it do something. Here's our program (in the format used by an "assembler" program).

```
addr  data        assembler mnemonics     comments
8000  3C          HERE: INC   A           ; increment register A
8001  C2 00 80          JP    NZ,HERE     ; jump here (i.e. to 8000) if A is not 0
8004  03                INC   BC          ; increment register BC
8005  C3 00 80          JP    8000        ; jump to "here" (so it repeats forever)
```

To enter it:

**Monitor Mode**

Press and hold **F**, then press **E** — X2 off, x3 on, and display shows SoFt 01

This switches back to *Monitor* mode. The display shows you got here with a "soft reset" (using the keypad). The number shows how many soft resets have been done since power-up.

**Enter the program**

| | |
|---|---|
| Press **E 80 00** | **E**xamine memory address 8000. |
| Press **D 3C C2 00 80 03 C3 00 80** | mo**D**ify it to enter the program. (Hint: Use **A** and **B** to check for mistakes.) |
| Press **0 6** | Check that Register PC is still at 8000. If not, set it to 8000 as described above. |

Is it working? Let's see...

**Single Step**

Press **7 7 7 7 ...** — Go to *Run* mode, execute one instruction, then return to *Monitor* mode.

One step of the program is executed each time you press Single-Step. Since it is displaying the PC, you see it step from 8000, 8001, 8004, 8005, and back to 8000. Single-Step can trace programs in ROM as well as RAM. That's quite a useful trick!

Whatever you are viewing when you Step will continue to be viewed after the step. This means you can watch any Memory location, Register, or Input port change as you step through or *Run* a program.

| | |
|---|---|
| Press **0 2** | To view Register AF (A and its Flags). |
| Press **7 7 7 7 ...** | Every 4th step, see A get incremented (as it executes the INC A instruction). |
| Press **4** | Switch to *Run* mode. Now the AF display counts up too fast to read. |
| Press **0 3** | View Register BC. It is counting up 256 times slower than A; but still very fast! |

**Input Port**

Press **5 12** — Read Input port 12. In12 00

There **IS** no Input port 12; so this displays "air" on the data bus (unless you add an accessory board). To see it work, connect a 10K resistor from any Data bus bit to VCC or GND; you will see the corresponding bit change in the Input display.

**Output Port**

Press **6 12 34** — Write 34 to Output Port 12. Ou12 34

Likewise, there is no Output port 12. This command isn't useful until you add your own accessory boards. (Don't read or write to Ports 40-5F; they're the Front Panel, which is being used by the ZMC Monitor.)

**Hard Reset**

Press and hold **F**, then press **0** — Reset Z80, and show # of resets. COLd 01

This resets everything, just as if you had removed power and powered it up again. It works even if the Z80 is not responding to interrupts or your program crashed.

## T E R M I N A L  M O N I T O R

The ZMC ROM has a second monitor. It works with an RS-232 serial terminal to give you a full-size keyboard and display. You can use a real data terminal; or a PC with a serial port (or USB-to-serial RS-232 adapter) running a terminal emulation program like HyperTerm; or just about anything else that can send and receive ASCII data at 9600 baud. Connect it as shown in fig.2 (below):

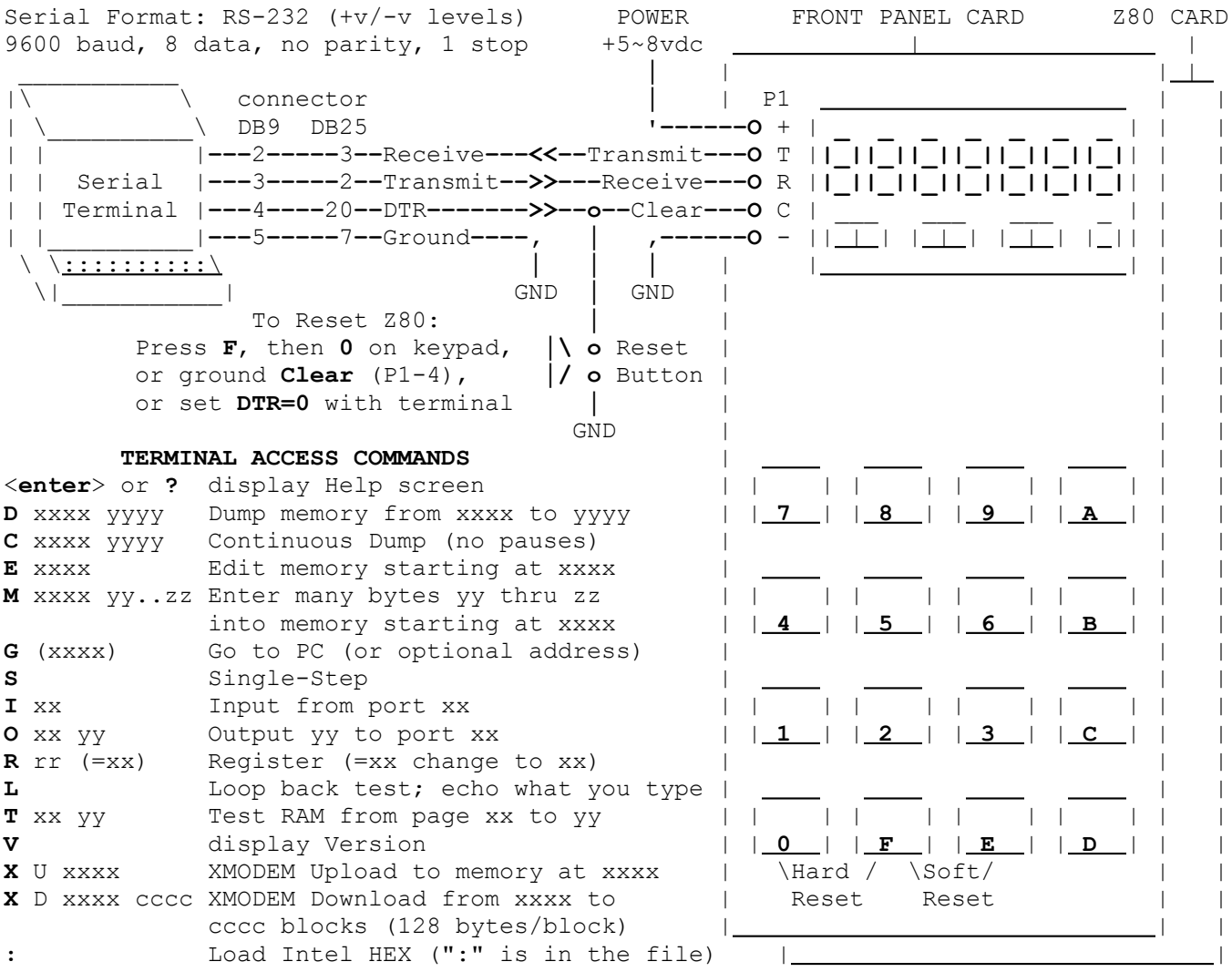



Figure 2. Terminal Access Summary

Commands can be entered in upper or lower case. All numbers are typed and displayed in hexadecimal. Leading zeros are assumed (so typing address 55 is treated at 0055). Only the last 4 digits are used; so you can correct a mistake by simply typing the correct value (typing 11550155 is treated as 0155).

They say a picture is worth a thousand words (2k bytes); so here are screen dumps of the commands. The parts you type are **BOLD**. My comments are in *italics*.

```
Cold Start                          The opening screen

Z80 MEMBERSHIP CARD. v1.0           Version number (and output of the Version command)

Main Menu >                         ZMC prompt, when it's ready for your input
```

**Dump memory** **D <StartAddr> <EndAddr>**

```
Main Menu >d 2200230  23f          note corrected address, and skipped leading zero
M0230  0D 0A 43 6F 6C 64 20 53 74 61 72 74 0D 0A 00 0D ; ..Cold Start....
Main Menu >
```

Dumps memory in ASCII format. Each line starts with M, the address, up to 16 bytes, a semicolon, then the same bytes expressed in ASCII (or a dot if not printable). Spaces are included for readability. D pauses and waits for a key after each page (so the data won't scroll off the screen too fast to read).

**Continuous dump memory** **C <StartAddr> <EndAddr>**

C is the same as D, but does *not* pause. Use C to print out, or capture a Dump on tape or disk. The format is the same as the Memory load command, so you can "play it back" to automatically load it into memory without having to type the M command.

**Edit bytes in memory** **E <StartAddr>**

```
Main Menu >e 8000                  start at 8000
8000 : FF c3 C3                    was FF, changed to C3, confirmed that it did it.
8001 : FF 00 00                    automatically incremented to next address
8002 : FF 80 80                    C3 00 80 is the same JP 8000 as earlier example
8003 : FF <esc>                    press the ESC key when done
Main Menu >
```

**enter Many bytes in memory** **M <StartAddr> <1stByte> <nextByte>...**

Like E, but doesn't show memory contents before or after your entry. The M command automatically loads ASCII dumps created by the C or D command. The "Main Menu >" prompt is suppressed but the monitor is ready for the next command after each line. If your terminal sends too fast, enable "pacing" (try 100 msec/line, 2 msec/char).

**Go execute program** **G <Addr>**

```
Main Menu >g 8000 PC=8000          go to Run mode; your program is now running!
<Ctrl>-C 02                        control-C (Soft Reset) returns to Monitor mode
AF=0045  BC=0000  DE=D800  HL=2000  AF'=BFBD  BC'=BDFF  DE'=FFFF  HL'=FDBF
IX=AFFF  IY=FFFF  IR=0076  PC=8000  SP=FF5A
Main Menu >                        shows registers to see what it was doing
```

**Single-step** **S**

```
Main Menu >s                       execute ONE instruction at PC,
Step 01                            show number of steps so far,
AF=0045  BC=0000  DE=D800  HL=2000  AF'=BFBD  BC'=BDFF  DE'=FFFF  HL'=FDBF
IX=AFFF  IY=FFFF  IR=0076  PC=8000  SP=FF5A
Main Menu >                        and show registers so you can see what it did
```

**Register examine or modify** **R <Register>=<Value>**

```
Main Menu >r                       R alone shows all registers
AF=FFFF  BC=BFBD  DE=FFFF  HL=FFFF  AF'=BFBD  BC'=BDFF  DE'=FFFF  HL'=FDBF
IX=AFFF  IY=FFFF  IR=001B  PC=8000  SP=FF5E
Main Menu >r b?                    register name is CASE SENSITIVE, so b won't work
Main Menu >r BC                    R with a register name shows its contents
BC=BFBD
Main Menu >r BC=1234=1234          follow register name with "=value" to change it
Main Menu >
```

**Input port read** **I <port>**
**Output port write** **O <port> <byte>**

```
Main Menu >I FF 00                  Input port FF is 00 ("air"; there is no port FF)
Main Menu >O FF 11                  Output 11 to port FF (also does nothing, since
Main Menu >                         there is no port FF)
```

**Loop back test** **L**

Anything you type is simply echoed back to the screen and to the Front Panel LEDs. <Enter> starts a new line, and <Esc> ends the command. Use L to test your serial connection, or to see what ASCII looks like on the LED display.

**Test RAM** **T <StartPage> <EndPage>**

```
Main Menu >T 80 FE                  tests RAM from 8000-FEFF
TESTING RAM                         don't test RAM page FF; it's used by the monitor
RAM PAGE MARCH PASSED
RAM BYTE MARCH 1 PASSED
RAM BYTE MARCH 2 PASSED
RAM BIT MARCH PASSED
RAM SEQUENCE TEST PASSED
```

**Version** **V**

```
Main Menu >v
Z80 MEMBERSHIP CARD. v1.0

Main Menu >
```

**Upload Intel HEX file** **:**

Here's the easiest way to upload a program: Have your terminal send it as an Intel HEX file. These are produced by most assemblers. It includes the load addresses, the bytes to load, and checksums for error checking. It's just a simple ASCII text file, so it's easy to send. In HyperTerminal, click ...Transfer...Send Text File.

Intel Hex format starts each line with a colon. This colon is the Monitor's command to receive a hex file. You don't have to type this colon; just upload and watch. :-)

```
Main Menu >:188C840056D3F808F556D38EF63BD5F801F456F880AED38EFE3BD5F82D
:188C9C0001F556F80130D5F8FCA796B7E7F805BDF8ADF4F4ADF8F5A620
:188CB400E672AE93BC4DACDC4DACDC8E2656D4F800BC300BF801BCF82F
:188CCC00F5A6E672AE9BBFF0AFEF8EF3BE8EF23A1F15159C3A249E5FCE
:188CE400D49BBAD4455AE58AF4AA159A7C00BAD445A60A56302A45A686
:188CFC00065A302A2AD4F814AFF8005A1A2F8F3A45D40309010300015F
:188D140009020708090100030102030001020203030400FCFCFCFCFC1F
:188D2C00FCFC722222224742427208152532598EE0A0E004070217063D
:068D44003F0817040800BF
:00000001FF                         Normally the last line, which ends the command.
                                    If it's missing, wait 10 seconds or press <esc>.
HEX TRANSFER COMPLETE ERRORS=00     no errors (good!)
Main Menu >
```

**XMODEM file transfers**

Here's the fastest way to save and restore your work. XMODEM is a classic binary file transfer protocol that includes error checking. This version works with either Checksum or CRC error checking, and will auto-detect and auto-negotiate this.

**XMODEM download** **X D <StartAddr> <#blocks> send data TO Terminal**

```
Main Menu >x d 8000 fc          XMODEM Download, start at 8000, send FC blocks.
TRANSFER COMPLETE               this sends a copy of all RAM from 8000 to 7DFF.
```

This example sends all of RAM except for the top two pages (FExx and FFxx), which are used by the Monitor. It is pointless to save them, and it will crash the stack if you restore them! (Cold Boot time...) XMODEM sends 128-byte blocks. 8000-FDFF is 126 256-byte pages, which is 252 128-byte blocks, which is FC hex blocks.

To receive this download, your terminal needs a program that supports the XMODEM format. Luckily, just about every modem program made in the last 30 years has it. Here's an example using HyperTerm:

1. Type the command **x d 0 8000 fc** as shown above. The Z80MC is ready to send data.

2. Within 2 minutes (before the command times out):

   - Click **Transfer... Receive File...**
   - Select **Xmodem** (not 1K Xmodem) from the drop-down list,
   - Select the filename to receive,
   - Then click **Receive.**

3. The transfer will complete automatically. To cancel it, type <Ctrl>-X.

**XMODEM upload** **X U <StartAddr> receive data FROM Terminal**

```
Main Menu >x u 8000             XMODEM Upload, starting at 8000
TRANSFER COMPLETE               this receives the above RAM image 8000-7DFF.
```

This example receives the same blocks of data sent in the previous example, and loads them into RAM starting at 8000. You don't need to specify the number of blocks here, as it's set by the sending program (your terminal).

Here's an example for uploading this file using HyperTerm:

1. Type the command **x u 8000** as shown above. The Z80MC is ready to receive data.

2. Within 2 minutes (before the command times out):

   - Click **Transfer... Send File...**
   - Select **Xmodem** (not 1K Xmodem) from the drop-down list,
   - Select the filename to send,
   - Then click **Send.**

3. The transfer will complete automatically. To cancel it, type <Ctrl>-X.

---

There... this should get you going! Read the software manuals and source listings for more details on operation, and how to use the routines in the ZMC monitor for your own programs.

Background: (not part of the manual)

Chip Hacker
---
The hardware designer. He starts with a Mark-8, then switches to an Altair 8800, and keeps upgrading it until there's nothing original left of it. Gets tired of all the problems, and buys a Heathkit H8.

When the Z80 comes out, he recognizes it as superior to the 8080, and builds a CPU board with it. Adds memory, then parallel and serial I/O. Then a keypad and LEDs to make a front panel like the H8. It winds up a single-board computer that evolves into the Z80 Membership Card.

Gil Bates
---
The “idea” man and marketing manager. Always looking ahead for “the next new thing”. He realizes that:

1. Computers are a BIG DEAL that will change the world.
2. The change is happening fast. You can't succeed by copying what other people are doing, or looking just one step ahead.
3. Computers come in big beige boxes. People prefer SMALL packages (calculator-sized) that they can take anywhere.
4. Sees that microcomputers need lots of “hacking” to make them work. But sees how successful Apple is selling “computers for the rest of us”.
5. Sees that people are insanely focused on CHEAP, but traditional computers are expensive.
6. So he's out to make something Small, Easy to use, and Cheap, but that's ahead of what everyone else is doing.

Tracy (Trace) Weaver
---
She enters the picture when they need to get PCBs laid out. She works at a firm where she can “borrow” CAD time to do it. Can layout boards that pack the parts much tighter than is normally done at the time (smaller, lower cost).

Willard (Wiz) Wireman
---
He enters as a tech. Can build things faster than Chip, so things get done quickly. But he has poor attention to detail (thus the inclusion of assembly instructions).

Richie C (Crash) Kernigan
---
Archetype software genius. Writes the software. The name is a play of C creators Dennis Ritchie and Brian Kernighan. I mis-spelled Kernigan on purpose. If it's still too close for comfort, I figure I can use “Crash Runagain”.