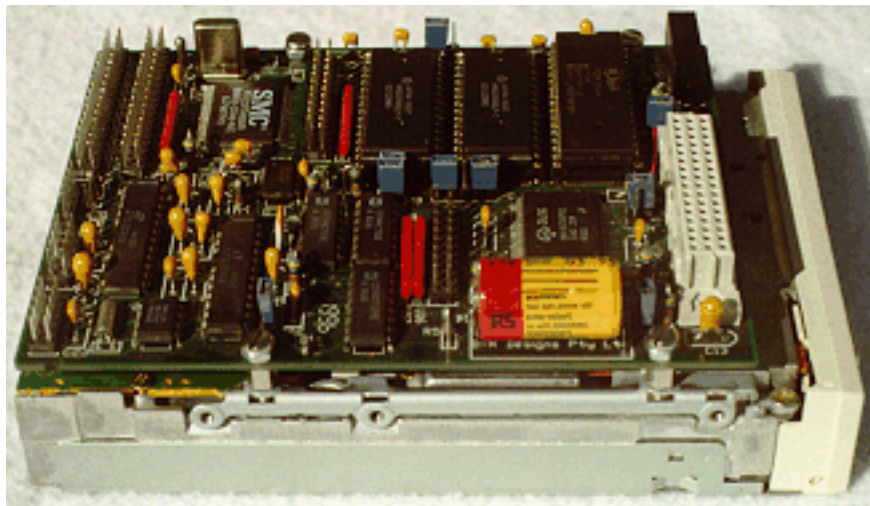


P112 Single Board Computer Assembly and Operation Manual Revision 1.7

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Wednesday October 8, 2014



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1 Introduction

1.1 What is this thing?

This document provides detailed illustrated instructions on building and using the P112 single board computer. This board has the footprint of a typical 3.5" floppy drive and may be mounted on the underside of one. Its CPU is a Zilog Z180 (an enhanced version of the venerable Z80). A multifunction I/O chip provides serial ports, a parallel port, and support for up to four floppy drives. A terminal, or at least a null-modem cable connected to another computer running a terminal-emulator is required to communicate with the P112.

The P112 was designed by David Brooks in 1996. He sold boards with the five surface-mount components preinstalled for about a year, then stopped due to lack of demand. Since then, the P112 has gained a reputation as a well-designed machine for running CP/M and similar operating systems. In late 2004, in response to growing interest in the P112 board, another run of boards was produced by David Griffith. After a lot of work, unexpected problems, and gnashing of teeth, kits started to ship in late 2005.

Much of the content of this manual is taken directly and usually verbatim from two PDF files produced by David Brooks in 1996 as documentation for the first run of P112 boards. Other content comes from documentation from related utilities written specifically for the P112.

This introduction, assembly instructions, software documentation, and photographs were created by David Griffith.

1.2 What do I need to know?

You should know the basics of soldering. Because of the small size of this board and certain delicate parts, I do not recommend this for a first soldering project. Get a little project kit from Jameco and practice with that first.

1.3 What's in this kit?

In this kit you will find the following:

One four-layer printed circuit board

A four-layer circuit board is not something one can easily make in the garage. This board has two surface-mount chips (the CPU and the IO controller) and some discrete devices already mounted. Since there was no way around using those surface-mount parts, that part has been done for you.

One set of electronic components

All the hard work of finding these components at good prices has already been done for you.

One copy of the Walnut Creek CP/M CDROM

This CD dated November 1994 contains assorted utilities, games, system software, source code, and other things for computers running CP/M or similar operating systems. It has long been out of print and Walnut Creek has said that no permission is needed to reproduce it.

One documentation CDROM

This CD contains the new P112 documentation (which you are now reading) and lots of other goodies like utilities, operating systems, languages, and so on. Shortly before he died, Rlee Peters created an

archive of CP/M-related material similar to the Walnut Creek CP/M CD. That archive is also included on this disc.

1.4 What's not in this kit?

This kit doesn't include things that can be found at a typical consumer electronics parts shop. Other things you might want to complete this project can be easily found on auction websites like Ebay. You might also have much of these things already.

Soldering equipment All of these soldering items can be found at Radio Shack (<http://www.radioshack.com/>).

A soldering iron drawing 15 to 30 watts is plenty powerful for this job. Don't go any higher or else you'll risk damage to the board and/or components. Make sure you have a narrow tip. One of those cylindrical tips that you sharpen to a point with a file will work, but will be very frustrating to use when mounting the expansion connector.

Plain old 60/40 solder of .032" or .064" (.6mm to 1.2mm) is good. If you prefer 63/37, that's good too. Make sure you get rosin-core solder. Acid core solder will ruin electronics. A solder of 96% tin and 4% silver is a good choice of lead-free solder, but is more expensive. Two ounces (about 50 grams) of solder will be plenty.

It *may* be necessary to flux the board. I needed it. Others have reported that it's not necessary. You'll know if you need it if molten solder will not wet the connection you're trying to solder. The type of flux is not particularly important. Just make sure it's okay for electronics use and you have the correct flux remover. Radio Shack stocks suitable paste flux and flux remover.

Picks, tweezers, and brushes will be handy.

Desoldering braid is essential for cleaning up mistakes. Don't fool yourself into thinking you won't make any mistakes.

Grounding strap This is also available at Radio Shack. This device is essential to prevent static electricity damage to chips.

Chip puller and inserter This is also available at Radio Shack. They are frequently included in "computer tool kits".

Chip pin straightener You may or may not need one, but it's a good idea to have one just in case. They sometimes can be found at Radio Shack. The Jameco part number is #99362. Mouser doesn't appear to carry it.

Serial terminal You'll need some way to talk to your new computer. A second-hand dumb terminal found on Ebay (<http://www.ebay.com>) will serve you well. Make sure you also get the correct cables. A null modem adapter may be necessary.

Null modem cable or null modem adapter If you can't get a terminal, you can use a null modem cable and a terminal emulator program.

Floppy drives You'll need at least one floppy drive. Two is nicer. You can have as many as four, but two drives is best. This board can use any internal 34-pin-interface floppy drive that an x86 PC can. Purists might want to use 5.25" drives. 5.25" disks can be a bit hard to find, but it shouldn't be a big problem. Since this kit includes only 3.5" disks, use 3.5" drives unless you know what you're doing. If you *really* know what you're doing and know where to look, you can use those big 8" floppies.

Chassis You'll probably want a case to put your computer in when you're finished. Radio Shack carries a small variety of cases that might suit you. A better choice may be to get an old external hard drive case.

Power supply This computer draws about 150 milliamps not including the floppy drives. Even the tiniest computer power supply should work fine. If you mount your computer in an old hard drive case, chances are that you'll have a good power supply too.

Mounting hardware and tools I can't anticipate what situations that may arise when mounting your computer. A computer shop or Radio Shack will be helpful. You'll have to look at how you want to mount the board and what you'll need to do it. If you want to mount it to the underside of a floppy drive, you'll need some standoffs and screws.

2 Cables and Components

2.1 Cables

All the basic I/O connections are at the left edge of the PCB. You will need the following cables to run the board:

2.1.1 Power Cable

Connects to P6. Reading from top to bottom the pins are

GND

VCC

Reset

VCC

GND

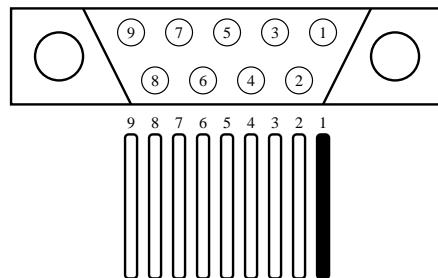
The Reset pin may be left unconnected (it has a pull-up). To force a reset, pull this line low.

Nominal power consumption (PCB only) is 150mA at 5V.

This part is best made with three lengths of wire, each terminated on one end with Jameco part number JS-1105-T-R, tinned on the other. Make sure you use the correct colors: black for GND, red for VCC, green for Reset. Insert these three wires into Jameco part number TMT-25402H-1X5. If you don't already have one, get the appropriate crimper (Jameco part number HT-213-R).

2.1.2 Terminal Cable

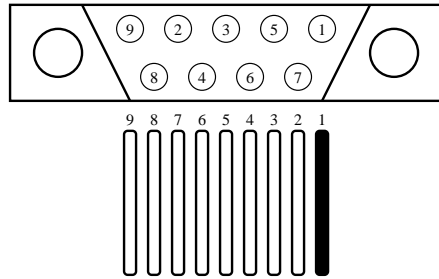
RS-232 terminals may be connected to P4 and P8 with the primary terminal being at P4. A 10-conductor ribbon cable connects via a standard IDC socket to the board. The tenth conductor is clipped off and the rest are crimped or soldered to a standard IDC DB-9 plug as follows:



Serial connector wired straight through (solder side view).

This generates the same pinout as a 9-pin serial port found on a typical x86 PC. Depending on how your terminal's serial port is wired, you may need a null modem cable or adapter. Pigtails like this, already made up, can be found on eBay and other places. Sometimes the pigtails are wired one-to-one, so open up the hood to take a look and rewire if necessary.

If you want to eliminate the need for an external null modem adapter, rewire the pigtail as follows:



Serial connector with null modem crossovers (solder side view).

This will allow you to connect the P112 to an x86-style serial port with a cable wired straight through. Again, depending on your terminal, you may be able to use a standard 9-to-25-pin modem cable to connect the P112 to a standard serial terminal. Depending on how your terminal works, you may need to link pins 4 and 6 together as well as 7 and 8 together.

2.1.3 Disk Drive Cable

This is wired as for a PC-AT, ie a direct 34-way connection from P9 or P10 to the first drive, then cores 10-16 reversed in the path to the 2nd drive. In P9, the first drive will be Drive 0, and the second Drive 1. From P10, they are Drives 3 and 2 similarly (note the reversed assignment).

In other words, a standard two-drive floppy ribbon cable is what you need.

2.1.4 Parallel Port Cable

A standard 26-way IDC receptacle fits the board. Clip off core 26 of the cable, and run the others to a DB-25 socket (Pin-1 to Pin-1). This generates a standard PC-type printer interface.

These cable assemblies are easy to find on eBay and other online places.

2.2 Complete List of Parts

Capacitors	Qty.	Manufacturer	Part Number	Location
22 ρ F ceramic	4	Vishay	K220J15C0GH53L2	C1 C2 C25 C26
120 ρ F ceramic	1	AVX	SR151A121KAR	C12
.1 μ F bypass	14	Vishay	A104K15X7RF5UAA	C3 C15 C16 C17 C18 C19 C20 C21 C22 C23 C24 C28 C29 C30
1 μ F, 16V tantalum ^a	9	AVX	TAP105K020SCS	C4 C5 C6 C7 C8 C9 C10 C11 C27
22 μ F, 10V tantalum	2	AVX	TAP226K010SRW	C13 C14

^aThis with a 16V voltage rating seems hard to find now. A 20V part is okay.

Resistor Packs	Qty.	Manufacturer	Part Number	Location
7x220 Ω SIP bussed	1	TT Electronics	L081S221LF	U13
7x2.2k Ω SIP bussed	1	TT Electronics	L081S222LF	U14
7x47k Ω SIP bussed	2	TT Electronics	L081S473LF	U16 U17

Resistors	Qty.	Manufacturer	Part Number	Location
4.7k Ω 0.25W	3	Xicon	291-4.7K-RC	R3 R4 R11
10k Ω 0.25W	3	Xicon	291-10K-RC	R5 R7 R10
27k Ω 0.25W	1	Xicon	291-27K-RC	R9
47k Ω 0.25W	6	Xicon	291-47K-RC	R1 R2 R6 R8 R12 R13

Semiconductors	Qty.	Manufacturer	Part Number	Location
74hct00	1	Texas Instruments	CD74HCT00EE4	U5
74act02	1	Texas Instruments	CD74ACT02E	U8
74act139	1	Texas Instruments	CD74ACT139E	U11
DS1302 (RTC chip) ^a	1	Maxim Integrated	DS1302+	U6
TL7705ACP (reset gen) ^b	1	Texas Instruments	TL7705ACPE4	U15
LT1133 (RS232 tx/rx) ^c	2	Linear Technologies	LT1133ACN#PBF	U7 U10
62256 (512KB SRAM)	2	Alliance Memory	913-AS6C4008-55PCN	U2 U3
29c256 (32KB FLASH) ^d	1	Atmel	AT29C256-25PC	U4
NMF0512S (5/12V converter) ^e	1	Murata	MEV1D0512DC	U12

^aDS1202 also works. A later edition might work.

^bCheck specs carefully before substituting.

^cNot readily substitutable.

^dSee section 7.2.2 for a list of substitutes.

^eYou can safely omit this one because 12V flash ROMs are now quite rare and this part is quite expensive.

Crystals	Qty.	Manufacturer	Part Number	Location
16MHz (CPU Clock)	1	CTS	ATS16B-E	Y1
32.768kHz (RTC crystal)	1	Citizen	CFS206-32.768KDZB-UB	Y2
24MHz (IO chip clock)	1	CTS	ATS240B	Y3

Pre-installed Parts	Qty.	Manufacturer	Part Number	Location
BAR43C (diode)	1	ST Microelectronics	BAR43FILM	D1
BAR43 (diode)	1	ST Microelectronics	BAR43CFILM	D2
BCW71 (transistor)	1	NXP	BCW71,215	Q1
Z8018216FSC (CPU)	1	Zilog	Z8018216FSC	U1
FDC37C665IR (Super-IO) ^a	1	SMSC	FDC37C665GTQFP	U9

^aAll subvariants of FDC37C651 and FDC37C665 are acceptable.

Headers	Qty.	Location
2 pins	2	P5 P11
3 pins	2	P12 P13
5 pins	2	P2 P6
2x2 pins (4 pins)	1	P3
2x5 pins (10 pins)	2	P4 P8
2x10 pins (20 pins)	1	P14
2x13 pins (26 pins)	1	P7
2x17 pins (34 pins)	2	P9 P10
1x3 and 1x1 together ^a	1	P1

^aThis is a T-shaped header made from a 1x3 strip and a single pin by itself. To make things easier, it can be held together with a jumper block while soldering.

Sockets	Qty.	Manufacturer	Part Number	Location
DIN48 expansion ^a	1	FCI	86093488314755V1LF	J1
8-pin DIP	2	Varies ^b	Varies	U6 U15
14-pin DIP	2	Varies	Varies	U5 U8
16-pin DIP	1	Varies	Varies	U11
24-pin DIP	2	Varies	Varies	U7 U10
32-pin DIP	3	Varies	Varies	U2 U3 U4
20mm button cell holder ^c	1	Renata	VBH2032-1	B1

^aMake sure all the positions are populated.

^bAny DIP socket will work. Some people prefer machined sockets.

^cI have seen similar ones by other makers. Check footprints.

Misc Parts	Qty.	Location
Jumper block	10	
#2032 lithium coin cell	1	B1
Chassis mount serial cable	2	P4 P8

2.2.1 Notes on Parts

Most parts are readily substitutable. Those that aren't or have special caveats are noted in section 2.2. Headers are easily made up by taking long pieces and breaking them into appropriate lengths. Choice of DIP sockets is frequently a source of much debate. While your board will certainly do fine with regular dual-wipe sockets, some people prefer machined sockets. Please stay away from single-wipe sockets.

3 Construction

3.1 Before Anything Else

Before you do anything else, please take the time to completely go through this manual. Done? Okay, let's begin.

3.2 Getting Started

It's a good idea to have a few paper plates or bowls handy for spreading parts out while keeping them neatly coralled and organized. Beware that you'll be playing with small shiny things. Cats like small shiny things, so make sure cats can't get to your workspace. It's also extremely important that you do all this on an anti-static surface. Keep in mind that cats are fantastic generators of high-voltage static electricity.

Put on your grounding strap.

Your parts may be individually wrapped (or at least wrapped in groups) because you ordered your parts using a shared project from me at Mouser's website. All of the Mouser parts should have a location identifier as the part name. Check these against the list of parts in section [2.2](#).

The colored bands on resistors are read with the gold band to the right. That band indicates that these are 10% tolerance parts.

Now it's time to turn on your soldering iron. Make sure the tip is clean and tinned (consult the iron's manual).

I'll assume you know how to solder. Remember that this is **not** a raw beginner's project.

3.3 Soldering the First Parts

RTC Crystal

Solder the low-lying parts first. Since we'll mount the resistors on edge, the chip sockets look like the logical choice. Don't do that yet. We'll start with the RTC clock crystal (Y2). Notice the rectangle extending from its mounting holes. The crystal will lie parallel to the board in this area. Solder the crystal into its holes leaving enough of the leads above board to let you bend it down into the rectangle. Put a dab of epoxy or silicone RTV adhesive in that rectangle and gently press the crystal into it.

Chip Sockets

Tape them down with some masking tape before flipping the board over to solder them. If you're brave you can hold the socket in with a finger and tack-solder the corners on the other side.

3.4 Soldering Everything Else

Capacitors

Our next-tallest components are the capacitors. Remember that the tantalums are polarized. A magnifying glass or loupe is strongly recommended to check for the tiny "+" mark. Look at the rectangle silkscreened

around each capacitor. The positive lead of a polarized capacitor goes in the tapered end of the rectangle.

Resistor Packs

These are also polarized. Hold the part with the lettering facing up. There's a dot on the leftmost pin. That's pin one and it goes in the pin surrounded by a square.

Discrete Resistors

To save space, the P112 board was designed to have its discrete resistors mounted vertically. Hold a resistor with the gold band facing down. Bend the top lead over so it's parallel to the lower one. Mount the resistor with its body in the circle silkscreened in its footprint. This leaves the part carrying the active signal easily accessible at the top. Actually, it doesn't matter which end gets bent over which. I just like to put the gold end down so it's easier to read the bands when the resistor is mounted.

R5 somehow didn't get a circle in its footprint. This resistor is connected to the battery and it doesn't matter which hole the body is mounted over.

Headers

Tape these down before soldering them. If you're brave, you can hold them in with a finger and tack down the ends. One header (P1) is made up of a single row of three pins and a single pin. While soldering, put a jumper block on this to hold it together.

Tall Crystals

There's nothing special about these. Just make sure you put each crystal where it needs to go.

Battery Holder

A holder for a #2032 lithium coin cell was substituted for the 1/2AA cell originally specified. If you want to use a 1/2AA cell as Dave Brooks did for the 1996 run of boards, you can do that. The holes for that are still present. If you to use a 1/2AA cell, make sure you get a 3.6/3.7 volt lithium Thionyl Chloride cell with lead pins welded on. *DO NOT* use a 3.0 volt lithium manganese cell! They have the same footprint, but opposite polarity!

In retrospect, the height of this battery holder may interfere with a mounted expansion board. There wasn't much of a choice when looking for coin cell holders. A 1/2AA holder was considered until it was realised that it was far too wide for the available space.

One alternative to this problem is to mount the holder laid flat, hanging off the edge of the board. Bend the two positive leads out at 90 degree angles and solder into place. Bend the negative lead to point at its hole and solder a short length of bare wire between it and the hole. Still another solution could be to use a battery holder mounted elsewhere and wired to the board.

4 Setting Up

If you haven't yet washed the board with flux solvent, do so now. That flux goo isn't just ugly, but it can corrode circuits if left there. This is especially true if you used paste flux.

Take a break. It's best if you continue tomorrow. Don't let yourself get too anxious to get this board running. Rest your mind and body and you'll be less likely to do something stupid later on.

With the board assembled, basic tests may begin with the "obvious" checks for Vcc-Ground shorts and so on using a multimeter.

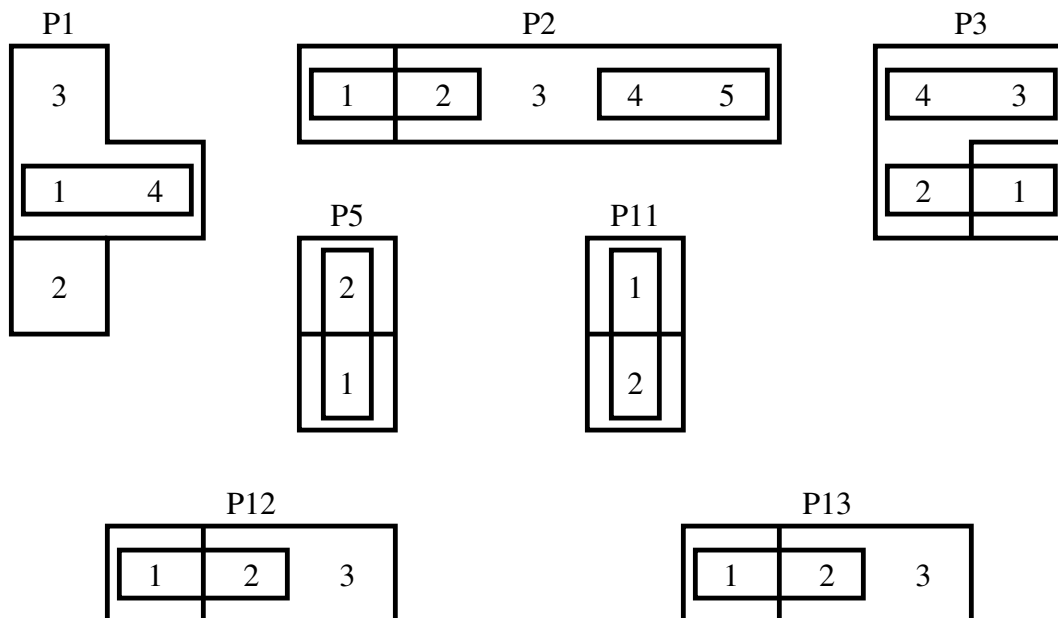
If you don't have any shorts, connect power to the board using the power pigtail you made in section 2.1.1. Red is positive. Black is ground. Green is reset. Ground that wire and the board will do a warm restart. Turn the power on and see if anything heats up, smokes, or stinks. If so, go back and check polarities, especially the tantalum capacitors.

Install the two SRAM chips in U2 and U3, and the flash ROM in U4. For 28-pin parts, make sure you install these chips with their *bottom ends flush with the bottom ends of the sockets*. If mounted with their tops flush, you probably won't let out the Magic Smoke, but it definitely will not work correctly, if at all.

Install the rest of the chips and insert the lithium battery into its holder. Pay close attention to the alignment notches. Chips mounted backwards will usually get very hot and fail.

4.1 Jumper Settings

The jumper settings shown in the drawing below are for the default configuration with 64kB RAM installed. Initially, it is recommended that jumper P11 be left off so that the battery is isolated. This jumper is required when the real-time clock chip and NVRAM is in use (which is most of the time). The jumper may be removed in order to blank the NVRAM contents. If the P112 board will be unused for a long period of time, the battery itself should be removed to avoid the possibility of leakage. See section 9 for alternative jumper settings and their purposes.



Caution: Lithium batteries have a low internal impedance. Do not place the populated board on a metallic surface, in case you short the solder pads on the bottom side. It's recommend that you put an insulating sheet under the battery area, to guard against accidents.

4.2 Terminal Settings

The default terminal set-up is 9600bps, 8 bits, no parity, 1 stop. The primary terminal (“console” to CP/M) connects to P4. Use a null-modem cable, the nulled pigtail described in section 2.1.2, or short pins 1,6 and 7 of P4 together. This is necessary to force the modem control lines active, without which the serial port will not operate.

4.3 Disk Drives

The board can run a variety of PC-AT type 3.5” drives, “out of the box”. Specifically, the drives should be jumpered with DS1 active (as is normal in a PC-AT). There appears to be little standardisation regarding the location of the connectors on disk drives. For example; the location of P9 will give a direct connection with Teac drives, but is awkward with Panasonic ones.

4.4 Powering Up

The board should draw about 150mA from 5V. With a terminal connected, a message such as:

```
SMC IO chip identified (FDC37C665GT): configuring
ROM-code built: 21 Nov 2005 CPU clock: 16.000MHz
RAM available: 64kB. From 40000 to 4FFFF
```

```
Z80 Series ROM-Resident Debugger V1.06: D-X Designs Pty Ltd 1997
Special P112 version: interrupts supported
Type "?" for help
```

=

should appear. You can type “?” for a list of commands and experiment with the ROM-resident debugger (see below). At this time, only the upper 32kB of RAM is accessible. The lower 32kB is overlaid by the ROM.

With a 3.5” drive connected as Drive 0, and the supplied disk loaded, you can type “Z” <return> at any Debug prompt to boot the system. The first time you boot the ZSDOS system boot disk, you should see the following:

```
..OS Loaded...Booting..
```

```
D-X Designs P112 Bios (V3)
```

```
ZCPR3 LDR, Version 1.6
Loading Z33.ENV
```

```
ZEX, Version 3.1
```



```
A0> ZEX: ldr z33.z3t,z33.ndr,z33.rcp,z33.fcp
```

```
ZCPR3 LDR, Version 1.6
```

```
Loading Z33.NDR
```

```
Loading Z33.RCP
```

```
Loading Z33.FCP
```

```
Loading Z3TCAP.Z3T
```

```
File Z3TCAP.Z3T Not Found
```

```
Path Loaded
```

```
A0:BASE> ZEX: if ~EX z3tcap.z3t
```

```
A0:BASE> ZEX: type note.txt
```

```
;NOTE: The STARTUP Loader did not load a Z3T TCAP file. You must  
; run the TCSELECT program to create a file called Z3TCAP.Z3T.  
; You can do so by running the following command line now:  
;  
; TCSELECT Z3TCAP.Z3T  
;  
; This command will open a library of TCAP definitions, and  
; allow you to select the one that fits your terminal. When  
; the program finishes, enter the following command line:  
;  
; LDR Z3TCAP.Z3T  
;  
; This will load the TCAP definition file for your terminal.  
; Future Cold Boots will then load the file automatically.  
;  
; Afterwards, you can edit the file STARTUP.ZEX and remove  
; the if--fi lines at the bottom of the file. You can also  
; delete this file - NOTE.TXT.
```

```
A0:BASE> ZEX: fi
```

```
A0:BASE> ZEX: Done>
```

```
A0:BASE>
```

At this point, you should follow the directions given above so the system knows what terminal you are using. Z3CAP is a library analogous to the Termcap library on Unix systems. These libraries provide an abstraction layer to allow programs to support a wide variety of terminals on the fly. Because standard CP/M doesn't do this, a programmer writing for standard CP/M must code for a specific terminal or provide some way to patch a program to use different terminals. Either way, that can get very tedious.

A slightly more detailed discussion of ZSDOS may be found in section [10.1](#)

5 Debugger

This section gives a quick guide to using the ROM debugger. Note that this code operates differently than, for example, ZSID.

5.1 Help Function

Entering “?” at a command prompt will display the help screen:

```
      C O M M A N D   H E L P

Separate all fields by one or more blanks

Commands Available:
: <Intel hex.>   Input line of Intel hex-format data
?               Display this help
B [addr [count]] Set/clear breakpoint
D addr [length] Display/change memory
G [addr]        Go run program (from addr)
I port         Input & display byte from port
N [count]      Run (next N) instructions
O port data    Output data byte at port
R [register name] Display/change user registers
Z             Boot First Available Device
  Z 1         Boot from Floppy Drive 0
  Z 2         Boot from SCSI, Unit 0
  Z 3         Boot from GIDE, Master
S             Setup DS-1302 RAM Parameters
T             Display Date/Time
  T S        Set Date/Time
L             Load OS (First Available) and return to DEBUG
  L 1         Load from Floppy Drive 0
  L 2         Load from SCSI, Unit 0
  L 3         Load from GIDE, Master
```

The input-line editor includes support for Tab (tabstops are fixed at every 8 columns) and Backspace, which is destructive, ie it echos backspace - space - backspace to the terminal.

Do not forget to enter at least one space after the command letter: else the first command argument will be skipped. The only exception to the spaces-between-fields rule is the Intel hex-format input: this follows the Intel conventions, and must have no spaces between fields.

5.2 Set Breakpoint

A single software breakpoint may be set at any editable location, by entering

```
B addr
```

The break is implemented by jamming a RST 38H instruction in that location, cancelling any pre-existent

breakpoint. Unlike (for example) MSDOS DEBUG, breakpoints are persistent: they are not automatically cleared when the test-program hits them. Rather, they are replaced in memory when the test program is re-run, so they remain in force. To clear the breakpoint, enter “B” with no arguments.

If a count value is entered after the address, the test program will not halt until the breakpoint has been reached [count] times.

Caution: Breakpoints should only be set on the first op-code byte of a machine instruction. Setting them elsewhere will have undefined consequences.

5.3 Display / Set Memory

The command format is

D addr [length]

If a length is given, the indicated number of bytes is rounded up to the next multiple of 16, and the memory contents are displayed, 16 bytes to a lines, thus:

```
=D 500 27
0500 69 6E 20 49 6E 74 65 6C 2D 68 65 78 20 66 69 6C >in Intel-hex fil<
0510 65 3A 20 6C 61 73 74 20 62 61 64 20 6C 69 6E 65 >e: last bad line<
0520 3A 20 00 20 20 20 00 CD 36 02 DD 21 FB 10 3E E0 >: .  ..6..!..>.<
=
```

If only an address is entered, the current contents of that byte are displayed, and a new value may be entered. If a blank line is entered, the value remains unchanged, and the next byte is similarly displayed. Enter “Q” to exit from this function.

```
=D 9500
9500 00 17
9501 00
9502 00 Q
=
```

If “D” is entered alone on a line, the missing address defaults to zero. Since altering address zero is not permitted, the message

```
Cannot edit memory in this area
```

is displayed.

5.4 Go (Run Program)

The command is

G [addr]

Any set breakpoint is activated, and control passes to the test program. Registers will be loaded with the values shown by a “Display / Set Register” command.

NB When the debugger starts up, all test-program registers, including PC and SP, default to zero. It is the user’s responsibility to load meaningful values in these registers, before executing code.

It is legal to start with SP=0: the stack will grow downward from FFFF.

5.5 Trace instructions

The “N” (“next”) command permits program instructions to be traced through automatically. Entering “N” alone will cause one instruction to be executed, before control returns to the debugger. If a count is entered, that number of instructions will be executed before the debugger regains control. After each instruction is executed, the resulting register-values are displayed (as for the “Display / Set Registers” command below).

Caution: Tracing under the “N” command runs the target program much slower than real-time execution. There are also significant lengths of interrupt-disabled code, and the execution environment constantly switches between the user program and the debugger (which allocates its own stack space). This command should not be used to test time-critical code segments.

The TRACE function temporarily stores an EI instruction at the location *before* the instruction being traced. This location must be writeable, or the command will be refused. For example, you cannot TRACE an instruction at location 8000H, since the preceding location, 7FFFH, is in ROM, and the EI cannot be stored.

5.6 Display / Set Registers

If this command is entered with no parameters, the current register values are displayed, as follows:

```
=R
A F B C D E H L A' F' B' C' D' E' H' L' IX IY PC SP <Instr.>
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0000 0000 0000 0000 00 00 00
```

The 3 bytes at & following the PC address are displayed, regardless of the actual length of the instruction at that address.

A single parameter is allowed, being a register name as in the above example. Similarly to the display/set memory command, that register is displayed, and may be altered. The next register (in the order above) will then be displayed in its turn. Again, the letter “Q” entered alone, will quit before all registers have been displayed.

```
=R C'
C' 00 05
D' 00
E' 00 07
H' 00
L' 00
IX 0000 446
IY 0000 Q
=
```

5.7 Loading Files

The debugger can read and store files in Intel-hex format. This facility is limited to storing in RAM: the debugger cannot program the flash ROM.

Typically, the debugger is connected to a PC running a suitable terminal-emulator program, and the “text upload” facility of that program is used to transfer the file. There is no facility for altering the stored addresses: data is stored as specified in the file.

Should errors be detected in the incoming file, they are noted, and displayed at the end of the file (since otherwise they would scroll off the screen). If the file is properly terminated with a “final record” (in the proper Intel format), errors will be displayed *after* this line. Otherwise, they will be displayed after the next non-Intel command is entered (which will be understood to mean the file has ended). Error reports include the line-number of the last faulty line read. This number (alone of all debugger output) is reported in *decimal* notation.

5.8 Input from Port

The command

I <port>

will read and display a single byte from the given port address. A 16-bit address is allowed, and the high-order bits will be set correctly. For an 8-bit address, they will be zero.

5.9 Output to Port

The command

O <port> <data>

will output the byte <data> at the given port. The address is set up as for the “I” command.

5.10 System Boot

Z <drive>

The <drive> parameter may take values of 1, 2, or 3, defaulting to 1. A parameter of 1 will start a boot from the first floppy drive (referred to as “drive 0”). A parameter of 2 will start a boot from device 0 on an attached SCSI interface. A parameter of 3 will start a boot from a GIDE-type IDE interface. Simply typing Z will attempt a boot from each of the three devices, Floppy, SCSI, and GIDE, in that order. If the floppy boot fails, it will attempt a SCSI boot. If that fails, a GIDE boot will be attempted. This sequence will repeat ten times before declaring an error.

5.11 Load OS and return to DEBUG

L <drive>

This is the same as Z above, except that control is returned back to DEBUG instead of running what was loaded.

5.12 DS-1302 RAM Parameters

This command should be run the first time you boot the P112 and whenever the DS-1302 timekeeping and NVRAM chip loses power, such as if the lithium battery goes dead.

When run, assorted system settings will be displayed. If this is the first time the NVRAM has been powered up since losing battery power, defaults will be displayed. When finished editing the settings, make sure you press **Escape** instead of **Return** to make sure the settings are saved. The options and possible settings are discussed below:

A. CPU Speed

One may choose to run the CPU at full or half speed.

Default is full speed.

B. Additional Memory Waits

70-nanosecond SRAM parts are necessary in order to use zero additional memory wait states. 70-nanosecond parts are provided in the kit, so it's okay to pick 0.

Default is 2 additional wait states.

C. Additional I/O Waits

The IO controller chip requires at least two additional wait states. Unpredictable IO errors will result if fewer than two are used.

Default is 3 additional wait states.

D. Console Data Rate

Speeds of 300, 600, 1200, 2400, 4800, 9600, 19200, and 38400 bits per second are available. BPS rates are determined by dividing the CPU clock pulses.

If you mess this up and forget what speed you set the P112 console to, simply turn off power to the board, remove the jumper at P11, wait a few seconds, replace the jumper, then turn the machine back on.

Default is 9600 bits per second. There are always 8 data bits, no parity bit, and one stop bit. In shorthand, 9600,8N1.

E. Floppy Drive 0

This allows you to describe Drive 0, otherwise known as "Drive A". You may choose 8-inch, 5.25-inch 40-tracks, 5.25-inch 80-tracks, or 3.5-inch. Other options include whether or not the drive is "high density", motor control needed, head load and drive step rate times in milliseconds.

Simply accept the defaults unless you're using drives other than 3.5-inch drives. If you aren't, you probably know what you're doing.

Defaults are:

3.5" HD, DS, Mtr Ctl, 4 mS Hd Ld, 3 mS Steps

F. Floppy Drive 1

This is the same as the previous option, except it describes Drive 1, otherwise known as "Drive B".

G. Hard Drive Type

The P112 board can support homebrewed SCSI and IDE/ATA interfaces. Chips can be salvaged from SCSI interfaces for other machines and installed onto a board for the P112. The GIDE interface does not use a salvaged controller chip, but instead uses programmable logic chips. These interfaces, however, are beyond the current scope of this manual.

Default is 7 for the GIDE IDE/ATA interface.

H, I, and J. Logical Hard Drive Settings

These will probably be specific to individual hard drives. I have no access to a GIDE interface, so I cannot test these.

K. Hardware Flow Control

To avoid losing characters when the P112 is heavily loaded, hardware flow control can be used. This requires the RTS and CTS pins in the serial cable to be wired correctly and for the terminal to know that they should be used.

Default is "N" for no hardware flow control.

6 Troubleshooting

This section offers some tips and tricks learned in developing this board. The tips are in order; starting with a plain dead board, then to more bits of it working. On the production boards, every fault I have yet encountered came down to a missed solder joint! Do remember that I cannot electrically test a part-built board, so don't take my soldering of the SMD parts utterly for granted. I inspect those joints visually and mechanically, but something may get through. Experience has shown the area to check first is the two "short" sides of the Z182 CPU chip; almost all the bad joints I have had, have been there!

6.1 Stone Dead

You did of course, first use a current-limited power supply, just in case of shorts :-). At this point, there's no substitute for an oscilloscope. Start by verifying that the CPU clock oscillator is running (at the right frequency), and the reset pin is behaving. You can fake a Z80 (or its successor, the Z182) by plugging in an erased EPROM at U4: the CPU will execute FF opcodes continually. This will show a regular signature on the CRO. Be aware that the Z80182 drives the /M1 line differently to the Z-80: it is only active on interrupt acknowledge cycles.

A very small number of boards had a manufacturing defect in which the trace leading from pin 51 on the CPU to pin 15 of chip U11 was open. The board in your hands has already been checked to make sure it doesn't have this problem. Just to be thorough, check that trace to make sure that the trace wasn't just marginal. If the defect has shown itself, it can be fixed by running a length of 30-gage wire. Find pin 51 on the CPU, then track it to a via. Insert your wire from the solder side into that via and run the other end to pin 15 on U11. Very carefully solder the ends. The wire should stay put on its own.

6.2 Garbaged Sign-on Message

That message is the result of a lot of power-on self testing, so errors in it can tell you a lot. If it identifies the SMC chip, then the basic interface to that chip is OK (this has not tested interrupts or DMA). The clock-speed is measured by setting a spare serial port (on the SMC chip) to 1200bps, and counting CPU cycles while that port sends one byte. This again, proves out the clocks, and the SMC interface. The memory layout message verifies the memory mapping logic, and proves your PCB jumpers are correct!

6.3 Disk Drive Won't Work

First off, make sure you didn't hook up the drives incorrectly. The P112 was designed so that you could screw it to the underside of a floppy drive. This means that the socket on a floppy ribbon cable that used to be for "Drive A" is now for "Drive B" and vice versa. See Section 7.8.

Don't forget to wind out your power-supply current limit before trying the drive! This problem is most likely to manifest when you try to boot the system. The boot process does not give much in the way of error messages: you can learn much more by simulating the boot process manually. Use the debugger to enter the following bytes in memory:

```
8000: CF          ;RST 08, ie disk services
8001: FF          ;RST 38, ie break to debugger
```

Now set up registers as follows (registers not listed are don't care):

```
A 02            ;"Read" command
```



```

B 01          ;Read 1 sector
C 00          ;Track 0, side 0
D 00          ;Drive 0
E 01          ;Sector 1
HL 8200       ;Buffer address
IX 0480       ;Hardware parameters table in ROM (see note)
PC 8000       ;Point to the code previously entered
SP 0000       ;Stack down from FFFF

```

Note: The drive parameter table (IX value) may move with new ROM code revisions. The “future-proof” way to set IX is to use the pointer at 000B, ie `ld ix, (0BH)`. This will always work.

Insert the system disk, and execute “G”. The system will attempt to read the boot sector. When the debugger regains control, display the registers. If the read was successful, HL will contain 8400H (ie it will advance past the buffer), and the carry bit (Bit-0 of F) will be zero. After an error, carry will be set, and A will contain the error code, thus:

```

calerr        equ    1      ;Error in a recalibration function
ioerr         equ    2      ;Error posted by Result Phase: see (HL)
badsect       equ    3      ;Sector/Length will overrun track
lostdat       equ    4      ;DMA did not transfer full block
timeout       equ    5      ;Interrupt timed out
badcmd        equ    6      ;Invalid function code
sekerr        equ    7      ;Seek error

```

Further, the DE pair will point at the result vector returned by the controller hardware. The first two bytes are most useful, the bit assignments being:

Byte 1	
Bits 7, 6	00 - Normal termination 01 - Abnormal termination (This is a normal termination, in this system) 10 - Invalid command 11 - Abnormal due to polling
Bit 5	Seek or Recalibrate complete
Bit 4	Track-0 signal not found
Bit 3	Unused
Bit 2	Selected side
Bits 1, 0	Selected drive
Byte 2	
Bit 7	Did not see TC at end of sector (This is normal, in this system)
Bit 6	Unused
Bit 5	CRC error
Bit 4	DMA under/overrun
Bit 3	Unused
Bit 2	No data seen
Bit 1	Write Protect
Bit 0	Missing address mark

6.4 An Example

One board worked on everything except booting the system. Running the above disk test gave a “DMA underrun” error. A continuity checker showed a missed joint at the DMA request input to the CPU. Voilà!

7 Logic Description

The following descriptions should be read in conjunction with the accompanying schematics. Data sheets on the various chips are obtainable from the manufacturers' web sites.

7.1 CPU

Zilog recommends two parts for new designs: the Z84C15 and Z80182. For the present project, the Z80182 is appropriate, providing a Z180 core, with enhanced memory mapping features. This part is available in a range of clock speeds: the initial boards are clocked at 16MHz. This speed, while the highest the CPU chip can support, does limit the choice of serial-port speeds, as it does not factor well. This has minimal impact on the standard serial port, which uses the in-built baud-rate generator. This generator is very flexible in its range of possible divisors. If however, the expansion ports (see P16 below) are used, they have a much reduced set of divisors available, and will normally require a carefully-chosen clock frequency. The boot software can recognise and adjust to the following clocks:

- 12.288MHz
- 16.0MHz
- 18.432MHz
- 24.576MHz

The last two will require a faster CPU chip to be fitted.

The Z80182 includes several in-built peripheral functions. All these are fully supported by the Z80 vectored interrupt system. The following internal peripherals are used:

7.1.1 Serial Port

The Z80182 has a total of 4 serial ports. Of these, one is brought out as the default terminal port, at normal RS232 levels. The remaining 3 ports are available as un-buffered TTL signals, for use with off-board level converters. One of these additional ports features full SDLC functionality, and can be configured for DMA control.

The Z80182 serial ports do not support the DSR and RTS modem-control signals, so these are provided (in the main-terminal port) by two lines from the on-chip parallel port (see below). These lines are not used by the standard software.

7.1.2 Parallel Port

The Z80182 has one 8-bit parallel port available (the others have been overridden for other functions). This is used to support on-board facilities. The pin assignments are:

A0 RTC data I/O line (bidirectional)

A1 RTC Clock line

A2 RTC Reset line

A3..A4 Not used

A5 Set low to enable the 12V Vpp generator for flash ROMs

A6 DSR input from Serial Port 1

A7 RTS output to Serial Port

7.1.3 DMA

By default, DMA Channel 0 is used for the diskette controller, and Channel 1 is available to an expansion card (if fitted). Jumper P2 may be altered if required, to provide DMA support for Serial Port 1.

The Z180 DMA only provides the TENDx (end-of-block) signal during its write cycle. This makes it unusable with the floppy disk controller, when reading from the disk (the FDC requires TEND asserted during the DMA cycle addressed to it, not to the memory). Consequently, the FDC is programmed not to use TENDx, which implies that all transfers will post a “end of cylinder” error. This is allowed for by the software.

7.1.4 Memory Mapping

The Z80182 includes two levels of memory mapping logic. The first maps the 64kB logical address space into a maximum of 3 “zones” in the 1MB physical address space. The second decodes the /RAMCS and /ROMCS outputs from the translated physical address.

In normal use, the first map may be changed frequently, as the operating system switches tasks. The second will normally be initialised at reset, in terms of the amount of memory actually fitted, and not changed thereafter. The boot-code includes a “smart” memory initialisation routine, which examines the chips actually fitted, and locates them in the physical space in an optimal manner. The sign-on message includes a report of the amount of RAM available, and its location in physical address space. If sufficient RAM is present, the ROM will be copied into low RAM, and afterwards disabled. This enables the CPU to be run faster.

The memory setup routine makes two requirements:

1. If two RAM chips are fitted, they must be of the same size.
2. The address-decode jumper P1 must be correctly set.

If these requirements are not met, the startup code will malfunction.

7.2 Memory

The board is designed to accept a wide variety of memory parts, in both 28 and 32-pin packages. The 0.6” DIP format was chosen as being compatible with the widest range of parts.

One ROM socket and two RAM sockets are provided. A pre-programmed ROM can be fitted in a RAM socket if desired. On-board RAM capacities from 32kB to 1MB are available.

The jumper P3 can interchange the select signals for the ROM and RAM-1 sites. This permits a pre-programmed ROM to be fitted in RAM-1 (U3), to program a blank flash device in U4. See section [10.2](#).

7.2.1 ROM

The ROM socket (U4) can accept a 32kB flash ROM part. The board includes facilities for in-system programming of 5V and 12V flash ROMs. For normal use, the header P12 should be jumpered across Pins 2-3 (/WE). For 12V parts (Intel or AMD 28F256), the 12V regulator U12 is required. At power-up, this converter will be disabled, causing a V_{pp} of 5V to be supplied via D2. This makes the circuit safe with 5V ROMs also. To program a ROM, set the CPU parallel port pin A5 low: this enables the 12V supply.

Since this board is supplied with a flash chip that requires only 5V for programming, the voltage regulator U12 has been omitted. Parts Q1 and D2 are still preinstalled. R3 and R4 are in the bag of parts. This omission was made because U12 is a fairly expensive part at US \$10 apiece. If you wish to use a 12-volt flash part, then you must obtain the regulator yourself.

7.2.2 ROM Substitutions

In the interest of maximizing flexibility in selecting parts, the P112 was designed with a variety of ROM parts in mind.

1. AMD AM28F256-150PC Flash Mem Parallel 5V 256K DIP-32 IC
These come in 5V and 12V versions. It's essentially a clone of the Atmel 29C256.
2. 27C256 UV erasable EPROM
The pinout is the same as the 29c256, but cannot be programmed by the P112 itself.
3. Atmel 29C512 Flash and Atmel 29C010 Flash
These are 512 kilobit and 1 megabit parts respectively in 32-pin DIP packages. If you're curious, examine the first sheet of the schematics and note that /MWR (write enable) is routed to both pins 3 and 31 of socket U4. This allows the /MWR to correctly trigger write-enable for both 28-pin 29C256 and 32-pin 29C512 and 29C010. However, this means that the A15 and A16 lines are unavailable for that socket and therefore you are limited to using only 32 kilobytes.
4. SST 27SF256, 27SF512, and 27F010
These are 12-volt programmable flash parts. I'm not sure if the P112 is capable of programming them.

7.2.3 On-Board RAM

Each RAM socket may accept a 32kB, 128kB or 512kB SRAM part. The address decoding must be set for the parts in use, as follows:

RAM size	RAM part (typical)	P1 setting	P13 setting
32kB/64kB	HM62256	1-4(A15)	1-2(Vcc)
128kB/256kB	HM628128	1-2(A17)	1-2(Vcc)
512kB/1MB	HM628512	1-3(A19)	2-3(A17)

It is not possible to mix RAM chips of different sizes.

For zero wait-state operation, 70-nanosecond parts are required.

7.2.4 Expansion RAM

Provision is made for an expansion board to carry up to 32kB of RAM, which may be mapped into the main memory space. By convention, such memory will be at the top of the 1MB physical space. The purpose of

this is to provide for dual-port memory for video drivers and similar devices. Of course, the 32kB may be extended by a bank-switching arrangement on the expansion board.

Expansion board memory should be selected when the signals `/ROMCS` and `/RAMCS` are both high (ie no on-board memory is selected). The read and write enables are `/MRD` and `/MWR`, which enable bus transactions.

If necessary, the `/WAIT` line may be driven low to delay the CPU.

7.3 IO Cycle Control

The multi-function IO chip requires two additional wait-states in every IO cycle, to satisfy its timing. This is provided by setting the IWI bits in the DCNTL register of the Z801821 CPU (IO address 32H).

7.4 Real-Time Clock

The Dallas DS1302 has a simple bit-serial interface. This is supported by 3 bits from the CPU's internal PIO device (see above). The DS1302 also provides a block of battery-backed RAM, which may be useful for storing BIOS setup parameters (memory size, serial communications setups, etc.).

7.5 Expansion Socket

The CPU bus is brought out to the expansion socket J1. Access to expansion memory has been described above. For external IO devices, `/IORQ` low and `/M1` high should be decoded to validate an IO access. Valid addresses for expansion boards are in the ranges 40..7F and C0..D7. The IO data strobes are `/RD` and `/WR`.

Support is provided for expansion boards using the Z80182 internal DMA. The `/EXTRQ` request line may be jumpered (at P2) to one of the internal DMA channels.

7.6 Multi-I/O Chip

The non-CPU IO functions are implemented in an SMC multi-function IO chip. These parts are available in several variants, and the board is designed to accept 4 different types: FD37C651, '652, '665 and '666. Further details on configuration options are given below.

7.6.1 Address Decoding

The multi-IO chip occupies the IO address space 80..BF. These addresses are mapped to appear to the IO chip as standard PC addresses. Programming of the multi-IO features follows standard PC practice. The address mapping is described below.

7.6.2 Cycle Timing

The IO chip latches address data at the beginning of `/IOR` or `/IOW`. This can cause problems with the Zilog timing, which regards the `/RD` and `/WR` signals as basically clock-enables. This is overcome by use of the CPU's "E" clock output, which goes high during the valid part of a bus cycle. This is used as a local enable

to /IOR and /IOW, via the decoder U11A. This decoder also provides the interlock from the safety-latch described below.

7.6.3 Safety Latch

As pointed out by Claude Palm (The Computer Journal, No. 76) the Z180-series devices can generate spurious IO selections during interrupt-acknowledge cycles. These are normally suppressed, since neither of the /RD or /WR data strobes appear. However systems which decode the /DACK (DMA acknowledge) from the address may malfunction, due to these spurious /IORQ signals. In the present design, this is prevented by the latch U8.

This is set at the beginning of a interrupt acknowledge cycle (/M1 and /IORQ both low), and blocks any address decodes. The latch is only cleared when /IORQ again goes high, at the end of the acknowledge cycle.

7.7 Serial Port 2

This is the “primary” serial port on the multi-IO device (the secondary port is not used). It is strictly PC compatible.

7.8 Diskette Port

The diskette interface emulates a standard PC-type diskette controller. The IO chip is configured to logically “swap” Drives 0 and 1. This assumes the drives have the DS1 jumper set, as is normal for PC-AT usage. Given this, Drive-0 connects directly to the PCB, with no ribbon-cable cores swapped. This is to enable the PCB to be mounted directly on the disk drive, with the PCB and drive connectors adjacent. Drive-1 will be the further away, and will have cores 10-16 swapped in the cable.

It should be noted that there is no universal standard regarding the placement of the data connector on diskette drives: it is not possible to have this card fit directly to *every* drive available. The direct fitting has been tested with Teac FD235 drives.

7.9 Printer Port

The printer port provides PC-like functions, in basic bidirectional mode. Enhanced ECP and EPP modes are not supported.

8 Major Components

The principal components are briefly introduced below, with particular reference to their use in the present application.

8.1 CPU Chip

The Z80182 provides a Z180 CPU core, multi-function serial IO port, and two DMA channels. Extensive use is made of the Z180's memory mapping ability, to fill in "holes" in the physical address space, and to switch the ROM in and out of circuit. This part is available in several speed grades: the initial build will be fitted for 16MHz clocking.

8.2 I/O Combination

Most of the IO functions are implemented in a SMC multi-IO part, designed for use in PC's. The board is multi-capable, and can accept any of the following parts:

- FDC37C651
- FDC37C652
- FDC37C665
- FDC37C666

The '651 and '665 are fully software configurable. However the '652 and '666 have some functions configured by external resistors. These are not otherwise fitted, and are the only surface-mount resistors on the board. Space limitations preclude putting reference designators on the board, however they are all 1206 size, 27k parts. Their reference designators are R101..R111. No harm will occur if they are fitted with a software-configurable IO chip.

These parts can be programmed to generate active-high or active-low interrupt signals. In this application, active-low is required, and is selected by the start-up code.

8.2.1 Port Addressing

The IO chip may be configured for several different internal address decoding schemes, corresponding to different IO assignments in a PC environment. In the present application, the following addresses are used:

Function	Address (CPU)	Address (IO Chip)
Parallel Port	8C...8F	3BC...3BF
Diskette (program access)	90...97	3F0...3F7
Serial Port	98...9F	3F8...3FF
Diskette (DMA Access)	A0...BF	N/A

8.3 Flash ROM

The board is designed to program a variety of flash ROM parts. If 5V-only parts (eg Atmel) are used, the voltage converter U12 and its associated components may be omitted.

8.4 Realtime Clock

A Dallas DS1302 realtime clock/RAM is used. This has a serial interface, which is implemented using 3 spare parallel-port pins from the CPU chip.

Be aware that this chip, when first powered-up, defaults to write-protected and oscillator disabled. Before it will run normally, you must first turn off write-protect, then activate the oscillator. Each is a single-byte write operation.

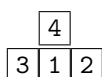
9 Connector Pins

The pin assignments of the various connectors are tabulated below. All are 0.1" pitch headers.

9.1 P1 — RAM Size Selector

Pin	Assignment
1	Address decoder input
2	A17 (128kB chips)
3	A19 (512kB chips)
4	A15 (32kB chips)

This jumper selects the address at which the address logic switches between the RAM chips. In effect, it defines the capacity of each RAM chip. The pin assignment is as follows:



9.2 P2 — DMA Requests

Pin	Assignment
1	Diskette controller request
2	DMA request 0 (to CPU)
3	Expansion socket request
4	DMA request 1 (to CPU)
5	SIO request

This header selects the sources for DMA requests. The Z180 core includes 2 DMA channels, which may be connected among 3 possible sources: diskette, expansion socket, and serial IO channel. The standard boot code requires Pins 1 and 2 jumpered.

9.3 P3 — Flash Bootload Selector

Pin	Assignment
1	RAM select from CPU
2	RAM socket 1 select
3	ROM socket select
4	ROM select from CPU

For normal use, jumper pins 1-2, 3-4. For ROM duplicating, jumper pins 1-3, 2-4. Pin 1 is at the bottom-right when holding the board with the battery to the bottom-right.

This jumper allows the ROM (U4) and RAM-1 (U3) sockets to be logically interchanged. The effect is that the CPU will boot from RAM-1. This enables the board to serve as a flash-ROM duplicator, using the following procedure.

Set P3 in the "normal" position, and fit the standard boot ROM in U4, with a 32kB RAM in U2 and U3. Boot the system: it will report RAM available at 40000..4FFFF (physical locations). The logical space is mapped as 0000..7FFF to U4 (ROM), and 8000..FFFF to U3 (RAM). U2 is currently inaccessible (being overlaid by the ROM).

NB The following procedure will be superseded by future software.

Now copy the existing boot code into U3 as follows. Manually enter the following code into high memory:

```
FFF0  di          F3
FFF1  ld  hl,0    21 00 00
FFF4  ld  de,8000 11 00 80
FFF7  ld  bc,FFF0 01 F0 FF ;Copy up to this code
FFFA  ldir       ED B0
FFFC  halt      76
```

Set SP=FFFF, and Go FFF0. The ROM code will be copied into U3 RAM (*overwriting the Debugger workspace*), and the CPU will then halt.

Without removing power, hold the Reset input pin low. Then interchange the J3 jumpers, and fit the new ROM in U4 (*do this carefully: you are “hot-plugging” the ROM*). Finally remove the Reset. The board will reboot, and will report RAM at 40000...47FFF (physical). The code now sees logical addresses 0000...7FFF in U3, and 8000...FFFF in U2. The ROM is currently inaccessible.

The system is now live, with 64kB of logical RAM available. You can boot the operating system normally, and use the ROM-burning program (*not yet available*) to program the ROM. *Remember to use an OS version with a RAM-resident BIOS!*

To boot from your new ROM, don't forget to reset the P3 jumpers before resetting. If you do not, it will boot from the RAM image: this may be a useful technique for checking-out a new boot program before burning it in ROM.

The above procedure is not, of course, limited to building boot ROMs. In this mode, the board serves as a general-purpose flash-ROM programmer, for 32kB parts.

9.4 P4 — Serial Port 1

Pin	Assignment
1	DCD (in)
2	DSR (spare in)
3	RXD (in)
4	RTS (spare out)
5	TXD (out)
6	CTS (in)
7	DTR (out)
8	SYNC/RI (in)
9	Ground
10	Not used

Pin 1 is at the top-left when holding the board with the battery to the bottom-right.

The pin assignments are such that a 10-way ribbon cable (with the 10th core removed) can connect a 10-way header to a DB-9 plug, and generate the standard PC/AT pin arrangement. This port is implemented as a Z180 port, which does not support the DSR and RTS lines. These are therefore implemented using parallel port pins. This port can support synchronous modes, in which the CPU's SYNC pin (normally used as the RI input) becomes an output. To prevent contention with the RS232 receiver, the jumper at P5 should be removed in synchronous working.

The Z180 uses the CTS and DCD pins as hardware enables. For the port to operate, these must either be strapped to the DTR output, or connected via (for example) a “null modem” cable to another PC-AT

compatible port. *If left open, the port will be disabled.*

9.5 P5 — SYNC Jumper

Pin	Assignment
1	From SYNC receiver
2	To SYNC pin on CPU

See P4 above. This link may be removed to prevent contention between the SYNC output of the CPU chip, and the RS232 receiver output. The link should be fitted in asynchronous operation, and removed for synchronous operation.

9.6 P6 — Power Supply / Reset

Pin	Assignment
1	Ground
2	+5V
3	Reset
4	+5V
5	Ground

Pin 1 is at the top when holding the board with the battery to the bottom-right. This isn't terribly important though since the pinout remains the same if reversed.

The reset input is intended for a switch to ground. It may be left open. The board will automatically reset when powered up.

9.7 P7 — Parallel Printer

Pin	Assignment
1	/Strobe
2	/AutoFeed
3	D0
4	/Error
5	D1
6	/Init
7	D2
8	/Select-In
9	D3
10	Ground
11	D4
12	Ground
13	D5
14	Ground
15	D6
16	Ground
17	D7
18	Ground
19	/Ack
20	Ground
21	Busy
22	Ground
23	PaperEnd
24	Ground
25	Select
26	Ground

Pin 1 is at the top-left when holding the board with the battery to the bottom-right. The pin assignment is such that a 26-way ribbon cable (with line 26 removed) may run direct to a DB-25 connector, presenting a standard IBM parallel printer interface.

The interface offers basic bidirectional capability; expanded (ECP/EPP) features are not available.

9.8 P8 — Serial Port 2

Pin	Assignment
1	DCD (in)
2	RXD (in)
3	TXD (out)
4	DTR (out)
5	Ground
6	DSR (in)
7	RTS (out)
8	CTS (in)
9	RI (in)
10	Not used

Pin 1 is at the top-left when holding the board with the battery to the bottom-right.

See P4 for details. This port is implemented on the combination IO chip, and is strictly PC compatible.

9.9 P9 — Disk Drives 0 and 1

Pin	Assignment
2	/DENSEL
4	Not used
6	DRATE0
8	/INDEX
10	/MTR0
12	/DR1
14	/DR0
16	/MTR1
18	/DIR
20	/STEP
22	/WDATA
24	/WGATE
26	/TK0
28	/WPROT
30	/RDATA
32	/HDSEL
34	/DSKCHG

Pin 1 is at the bottom-right when holding the board with the battery to the bottom-right.

All odd-numbered pins are Ground. Drive wiring is the usual PC/AT type, with lines 10..16 switched around between the drives. The Drive 0 and 1 signals are logically interchanged within the IO chip, so that the drive connected without a twist in the cable is Drive 0. This will typically be the drive on which the board is mounted.

9.10 P10 — Disk Drives 2 and 3

Same as P9, but decodes Drives 2 and 3.

9.11 P11 – Battery Isolator

Pin	Assignment
1	Ground
2	Battery -ve

9.12 P12 — ROM Pin-3 Function

Pin	Assignment
1	+5V
2	U4 pin 3
3	/Memory Write

Pin 1 is at the left when holding the board with the battery to the bottom-right.

This jumper connects Pin 3 of the ROM socket either to /MWR, or to Vcc. For normal use, connect to /MWR.

9.13 P13 — RAM Pin-30 Function

Pin	Assignment
1	+5V
2	U2 and U3 pin 30
3	A17

For 512kB RAM chips, this pin should connect to A17. For smaller parts, connect to Vcc.

9.14 P14 — Extra Serial Ports

Pin	Signal
1	TXA1
2	RXA0
3	RTS0
4	CTS0
5	RTSB = TEND1
6	DTRB
7	CTS1
8	TXA0
9	RXA1
10	DCD0
11	CTSB
12	DCDB
13	Vcc
14	TXDB
15	TRXCB
16	RXDB
17	RTXCB
18	SYNCB
19	GND
20	GND

Pin 1 is at the top-left when holding the board with the battery to the bottom-right.

This connector carries unbuffered signals for the spare CPU serial ports. Uncommitted inputs have 47kΩ pull-up resistors. The signal names follow those used in the Z80182 data-book, which should be consulted for the capabilities of these ports.

The 3 ports are designated by the final characters in the names, thus:

0 & 1 Basic asynchronous ports

B Full-function a/synchronous port

Note that RTSB and TEND1 share a pin. Either role is possible, by suitably programming the CPU chip. The standard software does not use this pin at all.

9.15 J1 — Bus Expansion

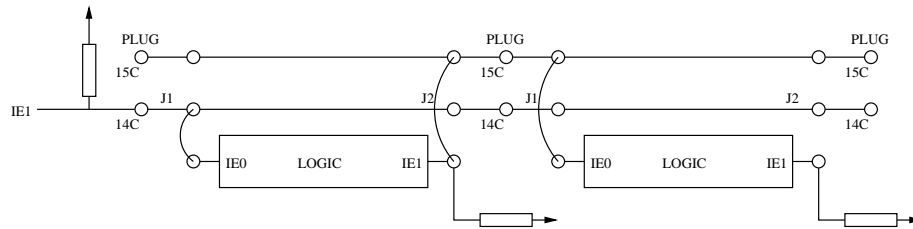
Pin	Assignment
1A	Ground
1B	Ground
1C	+5V
2A	D0
2B	A8
2C	D1
3A	D2
3B	A9
3C	D3
4A	D4
4B	A10
4C	D5
5A	D6
5B	A11
5C	D7
6A	A0
6B	A12
6C	A1
7A	A2
7B	A13
7C	A3
8A	A4
8B	A14
8C	A5
9A	A6
9B	/RAMCS
9C	A7
10A	/Mem-Read
10B	/Mem-Write
10C	Ground
11A	/M1
11B	/WAIT (input to CPU)
11C	/RD
12A	/IORQ
12B	/ROMCS
12C	/WR
13A	/RST (reset)
13B	E
13C	/INT0 (dedicated interrupt)
14A	/TEND0 (DMA Ch-0 End signal)
14B	/TEND1 (DMA Ch-1 End signal)
14C	IEI (daisy-chain interrupt enable in)
15A	/EXTRQ (Z-80 vectored interrupt)
15B	PHI (main CPU clock)
15C	IEO (daisy-chain out)
16A	+5V
16B	Ground
16C	Ground

In essence, a subset of the CPU bus is brought out on these pins. The lines are unbuffered, and are not intended to drive long backplane lines.

The pin assignments are such that for basic IO functions, only the two outer rows of the connector are used. This enables the cheaper 2-row connectors to be used. The centre row is needed only when a memory page is mapped on to an external board.

The intended mating connector is the same half-DIN41612 format, with wire-wrap tails. These are soldered through the expansion board, and are plugged into J1. This technique enables several expansion boards to be stacked on each other, if required.

The IEO pin is not connected on the CPU card. It is assigned for use by expansion cards, to enable the daisy-chain to be propagated through a maximum of two expansion cards. The method is shown below:



Each expansion board has 2 jumpers, J1 and J2. It may be seen that by setting these jumpers as shown, a daisy-chain of up to two vectored-interrupt expansion boards is possible.

The “E” clock output may be used to gate the /RD and /WR signals, as described for the IO combination chip. It also provides a convenient clock to control a logic analyser. For this purpose the *falling* edge is appropriate, and will give exactly one clock (with valid data available) per bus cycle. If a logic analyser is used, bear in mind that CPU accesses to internal chips usually do not generate external bus cycles.

10 Software

10.1 Z System and ZSDOS

For this new release of the P112, Terry Gulczynski has painstakingly prepared a set of system disks based on the Z-system. Z-system (or ZSDOS) is a CP/M “look-alike” with lots of very useful enhancements. In your kit is a boot disk. This contains most of the usual ZSDOS utilities as well as a sophisticated “HELP” application. Just type “HELP” at the command prompt to use it. Full documentation is found on the documentation CD in the PDF file zsdos.pdf.

ZSDOS is copyright ©1986, 1987, 1988 by Harold F. Bower and Cameron W. Cotrill and is released under the GNU General Public License. See the full copyright notice on the disk. As required by the GNU General Public License, full source code is provided. For lack of room on the boot disk, a separate source code disk is provided as an image file on the documentation CD. This necessarily requires a two-drive system, but since a one-drive system is mostly useless for real work, this isn’t much of a burden.

ZSDOS commands are roughly similar to MSDOS. If you’re familiar with straight CP/M, you should be able to jump right in. All the usual commands are present and work the same way.

The user areas and their contents on the boot disk look something like this:

```
0:BASE>      Startup files and READMEs.
1>           (empty)
2>           (empty)
3>           (empty)
4:PUBLIC>    Assorted build tools.
5>           (empty)
6>           (empty)
7>           (empty)
8>           (empty)
9>           (empty)
10:HELP>     Help files are stored here.
11:DISKUTIL> DISKCOPY.COM, SYSTRACK.COM, MAKESYS.COM and others are here.
12>         (empty)
13>         (empty)
14>         (empty)
15:ROOT>     External commands go here.
```

User areas 16 through 31 are all empty.

The user areas and their contents on the source disk look something like this:

```
0:P112ROM>
1:P112BIOS>
2:P112BDOS>
3:P112ZCCP>
4:Z33-RCP>
5:Z33-FCP>
6:ENVIRON>
7:Z-EDIT>
8:DISKSRC>
9>         DISKCOM.COM source
10>        DISKZAP.COM source
```

User areas 11 through 31 are all empty.

“User areas” are roughly equivalent to directories under MSDOS and Unix. MS Windows and MacOS prior to version 10.0 calls them “folders”. One cannot nest user areas the way you can nest directories. Type “DIR” right now and you’ll see some files.

To go into another user area, type “1:” at the prompt and press <return> (or <enter>). You should then see something like this:

```
A0:BASE> 1:  
A1>
```

Type “DIR” again. Hm, no files here! You may notice that this sort of command is the same used to switch drives in MSDOS. In fact, that’s exactly how one changes drives in ZSDOS and CP/M. Just type “B:” to switch to drive B.

10.2 Flash Programmer

The application used for programming flash chips for the 1996 run of P112 boards was written for DOSPLUS and does not yet work under ZSDOS. Please don’t fool around with it unless you really know what you’re doing and you have a chip programmer besides the P112 handy. It was felt that this functionality is of lesser importance compared to the rest of the operating system. If an updated ROM becomes necessary, then this program will indeed be completed and released.

11 Warranty, Etc.

If you have purchased this board fully assembled, David Griffith of Griffith Consulting warrants it in respect of faulty components or workmanship, for a period of ninety days from delivery, providing it has not been subject to damage or abuse. Defective boards must be returned, freight prepaid, to our United States address. We will (at our option) repair or replace such boards, and return them to you. If you have purchased a kit of parts, we cannot guarantee performance, since the conditions of handling and assembly of parts are beyond our control.

To the extent permitted by applicable laws, this warranty excludes all others express or implied, and defines our complete liability. This warranty, and the associated contract of purchase, shall be governed by the laws of the State of California.

This board, and its accompanying software, are not designed or intended for use in safety-critical or life-support applications. No liability of any kind is accepted for such use. See also the file LICENSE.TXT on the accompanying diskette, with respect to software.

This board is not a complete electronic system, but a component thereof. As such, it does not include shielding measures to limit spurious electromagnetic emissions. It is the responsibility of the person constructing a complete apparatus, to take such precautions as may be necessary to comply with relevant regulations regarding such emissions.

APPENDIX

A Resistor Color Code Chart

Color	1st band	2nd band	3rd band	Multiplier	Tolerance
Black	0	0	0	1 Ω	
Brown	1	1	1	10 Ω	
Red	2	2	2	100 Ω	
Orange	3	3	3	1K Ω	
Yellow	4	4	4	10K Ω	
Green	5	5	5	100K Ω	
Blue	6	6	6	1M Ω	
Violet	7	7	7	10M Ω	
Grey	8	8	8	100M Ω	
White	9	9	9		
Gold				0.1	$\pm 5\%$
Silver				0.01	$\pm 10\%$

COLOPHON

This manual was typeset using L^AT_EX. Xfig was used to create drawings. A Kodak DX3500 digital camera was used for photographs. NetPBM was used for further processing and conversion.

The cover photograph is of a P112 constructed by Dave Brooks which was screwed onto a 3.5-inch floppy disk drive.

The designer of the P112, Dave Brooks, has a website on the P112 at

<http://members.iinet.net.au/~daveb/p112/p112.html>.

A new website, specifically for this release of the P112 is at

<http://661.org/p112>

Lots of software specifically for the P112 can be found at

<http://p112.sourceforge.net/>

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