Construction Procedures for the Z80 Circuit Board Project:

Before beginning any installation, it would be valuable to study the "Architecture" of the board, and to compare it with the Silkscreen of the board.

Step #1: *Visual Inspection*

- Visually inspect the board for trace breaks, "whiskers" between traces, and pads or traces that might be too close together.
- Ohm's check the board for *no continuity* between Power and Ground.
- Observe which devices should go where, and ensure that the pictorial documentation matches the Silkscreen on the circuit board.
- Verify that the number of pins required for the appropriate devices match the board layout

Step #2: *Display Installation*

- Setup a test area on a breadboard to pre-test all LED's. (use the 330 ohm SIP's as part of your test)
- Install the 9leg 330 Ohm SIP's for the Address-Lines, being careful to see that the proper end is at pin #1.
- Install the LED's in groups of 4 at a time, with the Red LED's starting at the High-Bit, then 4 Yellow LED's, to comprise easy to read HEX Code results. Be careful not to allow them to get too hot!
- Install the 74LS540's (or sockets) for the appropriate Address & Data LED's, and install the 1K PU's for the 74LS540's. Place the 74LS540's into their sockets, if sockets were used.
- Temporarily connect +5V Power & Ground to the circuit board to allow testing of the LED Drivers & LED's.
- Test them by simply applying a Ground to the Control Leg of the 74LS540's. All the LED's should all light because of the floating inputs of the Drivers. Leave this ground attached for a while.
- Remove the Power to begin the next step
- Repeat the procedure for installing and testing the I/O Drivers & LED's (in the lower right-hand corner of the board)

Step #3: *Timer Circuit and Status Monitor*

- Install the 555 Timer Circuit and verify its operation.
- Install the 74LS14, and verify that the Clock Signal from the 555 Timer passes through correctly.
- Verify the Clock Signal to the "Test-Point" (a jumper will be required). Set the Clock for ~ 5Hz
- Install the 40-Pin Socket for the Z80 CPU, noting the orientation of the socket.
- Install the 1K PU's for the Z80 CPU, the surrounding area, and any remaining ones.
- Install the Reset Switch, observing the current orientation.
- Install the 74LS541 (or socket) for the 7-Segment Display, and the 330 Ohm Resistors (or R-Pack)
- Before installing and testing the Z80 CPU, apply Power to the board and note that *all* of the Address LED's and all of the Data LED's light.
- Test the 7-Segment Display by a carefully touching a ground wire at the appropriate pins of the Z80 CPU (noted as /M1, /MReq, /Rd, /IOReq, /WR, /RFsh, and /Wait).
- During the test of the 7-Segment Display, no other activity should be seen, except for the D.P.
- Remove the Power from the board.

Step #4: ***Address & Data LED Checkout, Decoder Circuit installation***

- Install the 74LS32 & the 74LS138 devices (or sockets, then devices).
- Apply Power to the board, and with a ground wire - carefully touch one at a time each one of the Address Lines at the CPU socket, starting with A15, looking for an appropriate response of that LED going off.
- Repeat this process for the Data Lines, starting at D7 to D0.

Step #5: ***Preparation for the Z80 CPU installation***

- Install the jumper for the Wait Line to the 1k PU (located above the 74LS221/74LS123).
- With Power applied to the board, verify that the PU's present +5V at the appropriate Input-Pins of the Z80 CPU socket, and that the +5V Power & Ground are applied to the correct pins, as described in the Z80 CPU Documentation.
- Remove the Power Source from the board

Step #6: ***Installation & Testing of the Z80CPU***

- Install the CPU into the socket, either using a 40-Pin Socket Insertion Tool, or if doing it by hand, use the "4-finger method" to carefully rock the chip into place. Be careful to note the proper orientation of the CPU – ***it will destroy the CPU*** if pins are not in place properly or oriented wrong.
- Temporarily attach a ground to the "WAIT" input of the Z80 CPU.
  (simply touch the ground wire to the jumper of the 1K PU)
- Apply Power to the board, and ***press and hold*** Reset.
  All of the Address LED's and the Data LED's should light.
  (note that with the slow clock, the Address & Data LED's take definite "timed" steps)
- Release the Reset
  All of the Address LED's should go out, (Address 0000)
  the Data LED's should light. (floating inputs)
  The 7-Segment Display should show: M1, MReq, Rd, Wait

  Note: If the Address Lines do not go to 0000, then speed up the clock, and repeat the process.
  Record the clock speed required for this result.

- Remove the ground wire from the Wait Input

  The Z80CPU should indicate changes at the 7-Segment "Status" Display, and the Address Lines should start changing.

- Remember that there are 3 principle clocking "Cycles" associated with this process:

  The Clock Cycle (the Basic Input Clock)
  The Machine Cycle (composed of Clock Cycles)
  The Instruction Cycle (composed of Machine Cycles)

- There will be some unusual activity in the Address & Data Lines, which is normal.
- Remove the Power from the board.

Step #7: ***Initial Checks, using NOP's***

Install the 2816 EEPROM that has been pre-programmed with NOP's (all 00's), and install the SRAM

- Apply Power to the board, and ***press and hold*** Reset.

  (note that with the slow clock, the Address & Data LED's take definite "timed" steps)

  All of the Address LED's and the Data LED's should light.

- Release the Reset

  All of the Address LED's should go out, ***(Address 0000)***
  the Data LED's should go out. ***("NOP" inputs from the EPROM)***
  The 7-Segment Display should show: ***M1, MReq, Rd, Wait***

Note: ***if the Data LED's do not go out, verify that the EEPROM is being properly selected.***
(apply the ground wire to the Wait input, if necessary)

- Remove the ground wire from the Wait Input

  The Z80CPU should indicate changes at the 7-Segment "Status" Display, and the Address Lines should start changing.

- The Address Lines should now sequence from 0000h in Binary fashion.

  Special Note: Some Z80 CPU's do not operate at very low frequencies, and it may be necessary to speed up the clock to as high as 250Hz.

  Make special note of the Address Sequence from 0000h to 007Fh, and then what happens afterward! What's happening? (hint: look up documentation on the Z80 Refresh Signal)

- Since the EEPROM is addressed from 0 to 2047 (decimal), and the SRAM is addressed for the next 2048 locations, what Hexadecimal Addresses are represented?

  0000h to _____h and _____h to _____h

Step #8: ***Checking Memory Data & I/O Data – Reading & Writing***

- Re-program the EEPROM with the LDA, STA, IN, OUT instructions, and repeat **Step #7**

  - *The Data LED's should show the proper program data each time the M1 Cycle initiates the Machine-Cycle-Sequence. Especially note the "Status Indication".*
  - *The Address Lines will indicate the Address that the Program Data is being read, and then where Data is being fetched from, for the LDA Instruction. Again, note the appropriate "Status Indications".*

    Note: The Address associated with the LDA should enable the SRAM, and Data should be Read from the SRAM

  - *The Address Lines will again indicate the Address that the Program Data is being read, and then where Data is being Stored to, for the STA Instruction. Again, note the appropriate "Status Indications".*

    Note: The Address associated with the STA should enable the SRAM, and Data should be Written to the SRAM

  - *When the Instruction for an "Input from an I/O Device" is reached, first the Instruction itself must be read from memory, and then an "IOReq" Signal, with "RD" is issued.*

    Note: At this time, the Data from the 8-Bit Data Switch should pass through the 74LS373 to the Data Bus and on to the Z80 CPU

  - *When the Instruction for an "Output from an I/O Device" is reached, first the Instruction itself must be read from memory, and then an "IOReq" Signal, with "WR" is issued.*

    Note: At this time, the Data from the Z80 CPU should be fed to the 74LS374 and Latched. The data should then be displayed at the Data I/O LED's.

  - *The JMP Instruction should cause the CPU to go to location 0000h, and re-start to process.*

- **Special consideration can be given to when the Address Display is enabled, such as:**
  - ***All the time***
  - ***Only during MReq, or IOReq***
  - ***Only during RD, or WR***
  - ***Only during Rfsh***

Step #9: ***Other Program Code Nuances***

- Re-program the EEPROM for other various Commands to be able to observe the appropriate actions.

Board Options:

True Hexadecimal Displays:

- Installation
- Enabling/Disabling
- Latching

Single-Step Control:

- Installation
- Control of the WAIT Input to the Z80 CPU
- The timing necessary to allow for various clock speeds.

XTAL Oscillator/Divider:

- Installation (usually a 1Mhz Oscillator Can)
- Selection of desired "Taps", by 12-Stage Divider Circuits
- Re-adjustment of the Single-Step as (or if) required.

Intel 8255 PPI I/O Devices:

- Installation as desired (They are "Memory-Mapped" Devices)
- Cabling to the "Outside World" for Input/Output. Programmed as required.
- Three 8-Bit-Ports are available for each Device.

  (Suggest using Mode 0)

Motorola 6821 PIA Devices:

- Installation as desired (They are "Memory-Mapped" Devices)
- Cabling to the "Outside World" for Input/Output. Programmed as required.
- Two 8-Bit-Ports are available for each Device.

Additional Output Display Modules:

- 8-Bit Inputs are provided for each Module.