

**World Clock
Operating and
Assembly Manual**

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Document version 1.01 for use with PC board version 2

Introduction

This is a kit to build a clock displaying time for multiple locations.



This clock is made of slices, one controller slice, and multiple display slices.

This manual first guides the assembly of the slices, followed by operating the clock. There is a section describing the parts if you are unfamiliar with electronic parts, and a section describing the underlying design of the clock.

You need to make 670 good solder joints to complete a display slice and 719 for the controller slice.

Unpacking/Parts List

Gently unpack the contents of the box. You should find one display pack for each display,

DISPLAY SLICE PARTS LIST	
Qty	Description
1	IC,uProc PIC16F648A, DIP-18
8	IC, SAA1064, 7segDvr
14	LED, 16-segment, Red, LTP-587HR
4	LED, 7-segment, Red, LDS-A414RI
10	Cap, .22uF, Ceramic
4	Res, 22Kohm, 1/4 Watt, Cfilm
4	Res, 33Kohm, 1/4 Watt, Cfilm
16	Tran, NPN, 2N3904
1	Diode, Schottky
2	Cap, 10uF, 16V Tantalum
8	Cap, 0.0027uF Polyfilm
1	SKT, IC, DIP18, .3
1	Header, 20Pin, RtAngle
1	Connector, 20Pin, Rt Angle
2	LED, Red, 3MM
1	PCB, World, Version 2

and one controller pack if you are building a controller.

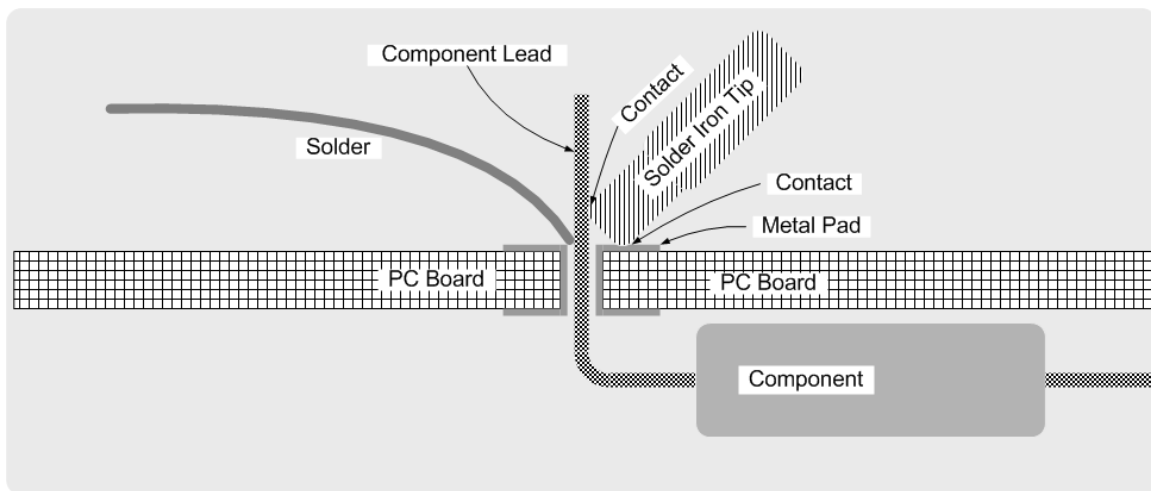
ADDITIONAL PARTS FOR MASTER SLICE	
Qty	Description
1	Res, 150 ohm, 1/4 Watt, Cfilm
1	Res, 1K ohm, 1/4 Watt, Cfilm
1	Res, 10K ohm, 1/4 Watt, Cfilm
3	Switch, Push, RtAng, PC board TH mount
3	CAP, BLACK
1	Cap, 1F, coin
2	Diode, Schottky
1	SKT, IC, DIP8, .3
1	IC, TCXO, 32KHz, DIP
1	JACK, 2.5mm, Right Angle
1	IC,Prom, Serial, 1Mbit, DIP8
1	Supply, 5Volt 4Amp

Soldering

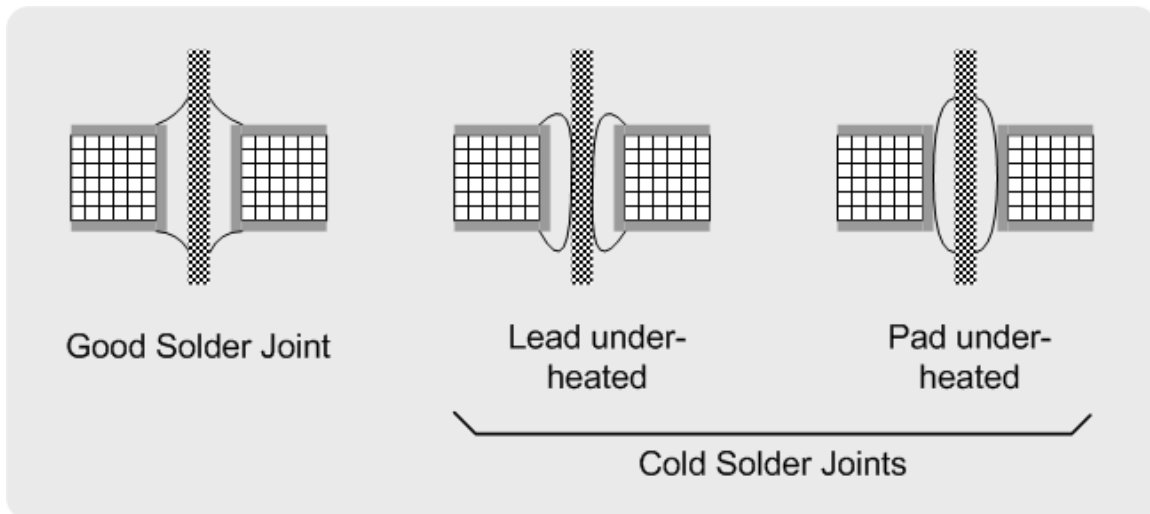
This manual can't teach the art of soldering, but here are the basics. Remember, you need to make over 670 **GOOD** solder joints for each slice; each bad joint will be an adventure in troubleshooting.

Wet the tip of the iron with a bit of solder and wipe off the excess solder on the wet sponge occasionally, or when you notice the joint is not heating properly. The small amount of solder left on the tip helps conduct heat to the lead and the pad.

Insert the component leads and press the component flat against the PC Board. Slightly spread the leads to hold it in place when you flip the board over to expose the back side with the component lead facing up.



- Make good contact between the iron, the lead, and the pad on the board so the lead and the pad both heat up enough to melt the solder.
- It should take from 0.5 to 1 second for the joint to become hot enough to melt the solder.
- Don't overheat the joint, as soon as the solder melts and wicks into the joint remove the iron and hold still for a few seconds until the joint freezes.



A good solder joint will form a shiny curved surface bonding the lead and the pad on the PC board. If the lead wasn't heated enough to melt the solder, the solder will wick in to the pad, but will not adhere to the lead. You may notice a dark line around the lead where the solder dives down through the hole.

A similar bad joint forms when the pad wasn't heated enough to melt the solder. A cold solder joint can often be fixed by reheating the joint; sometime a little more solder will be needed.

More detailed instructions can be found on the internet with a little searching on the topic of soldering.

After inspecting the solder joint, clip off the excess lead using the diagonal cutter. Cut at the top of the solder joint; don't dig into the solder joint.

Unsoldering

A supply of de-soldering braid is supplied with the kit. If you find the need to remove a component, use the de-solder braid by pulling out a few inches and pressing the braid against the lead and the pad using the iron. You will see the solder melt and spread into the wick leaving very little solder left in the pad.

Sometimes it helps to clip the lead off the component so you can deal with each lead separately.

Optional Clean-up

The clear sticky rosin left around the solder site can be cleaned up with alcohol and a toothbrush, but be sure to let the board dry before expecting the board to operate properly. You won't hurt the circuit by powering it up, but it won't count right until the board has completely dried. Water soluble rosin-cored solder is available at hobby stores. As for me, I don't bother to clean up the board unless the counters are not working right, then I clean off the rosin.

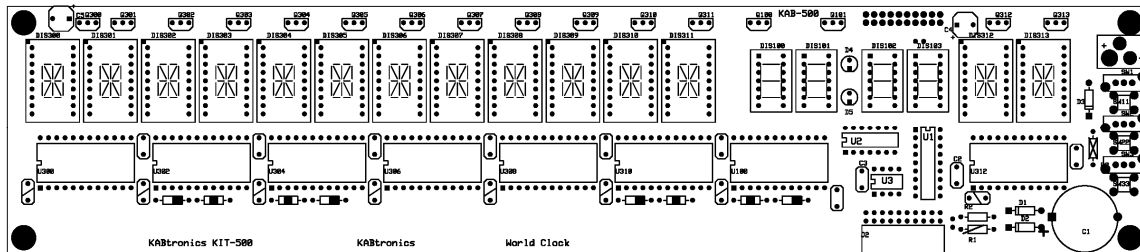
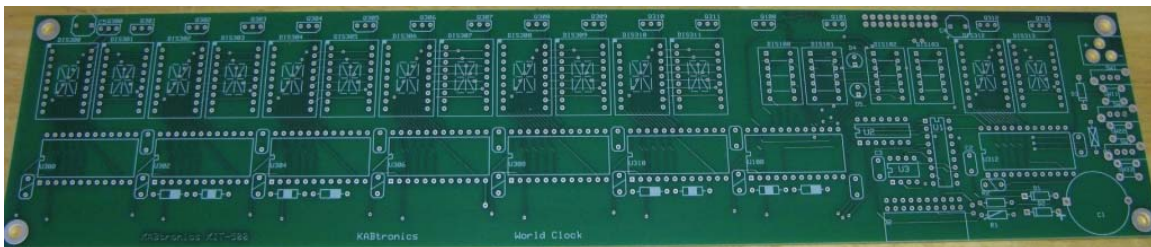
Assembly Instructions – Display Slice

You will need the following tools to build your clock.

- Soldering Iron meant for electrical work
- Small Diagonal Wire Cutter

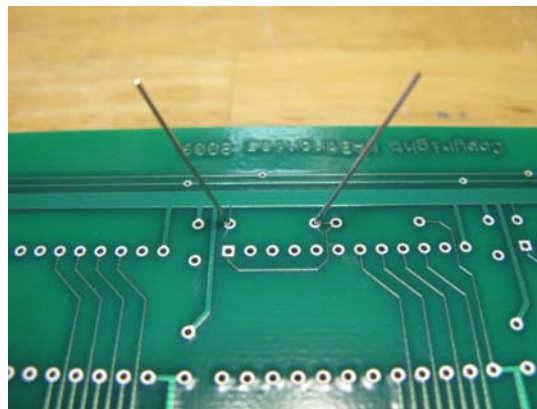
Instructions for building a display slice are first. The additional instructions for building the controller slice follow.

One side of the PC board has white paint markings, shapes, and reference designators. That marked side is the component side, upon which all the components will be placed.

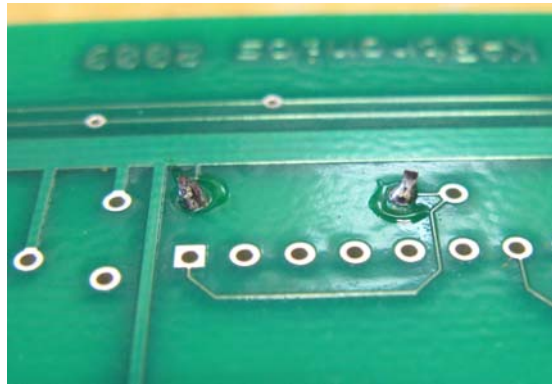


	22K
	33K
	1K (master slice)
	10K (master slice)
	150 (master slice)
Resistor Markings	

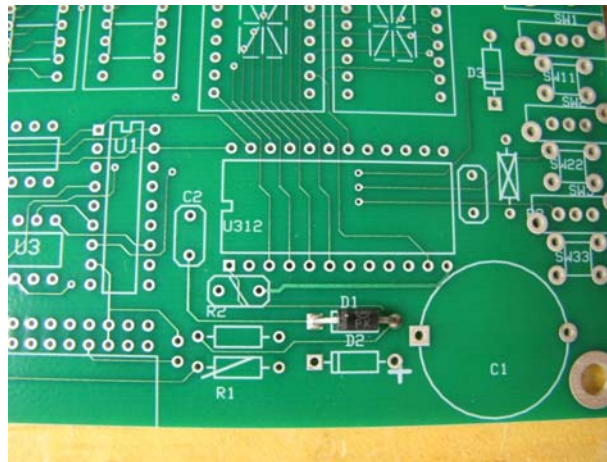
() Load the four 22K and four 33K resistors located on the lower edge of the board. Push the part flush onto the board, spread the leads slightly and solder.



Clip the leads off just above the solder joint; don't dig into the solder joint. Soldering and clipping won't be mentioned again, you need to do it for each part as you load it.



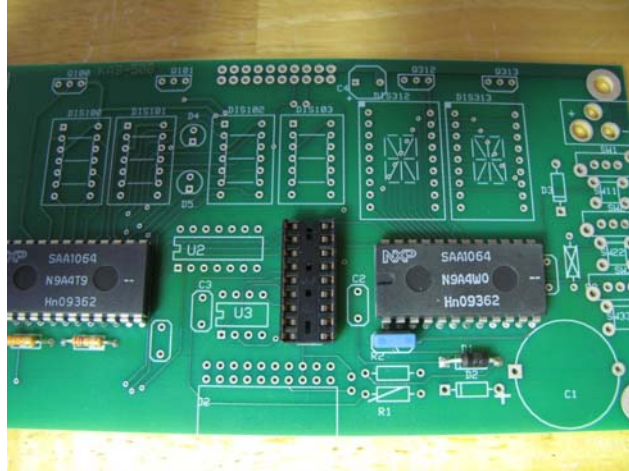
() load the diode into the space marked D1, be sure to line up the white line on the diode with the white line on the board.



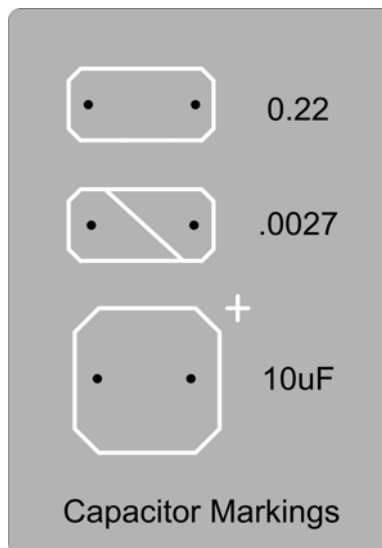
() load the eight 24 pin SAA1064 ICs. The notch on IC should match the notch on the board.



() load the 18 pin socket at location U1, match the mark on the board with the mark on the socket.



The capacitor locations are indicated by symbols shown in the table.



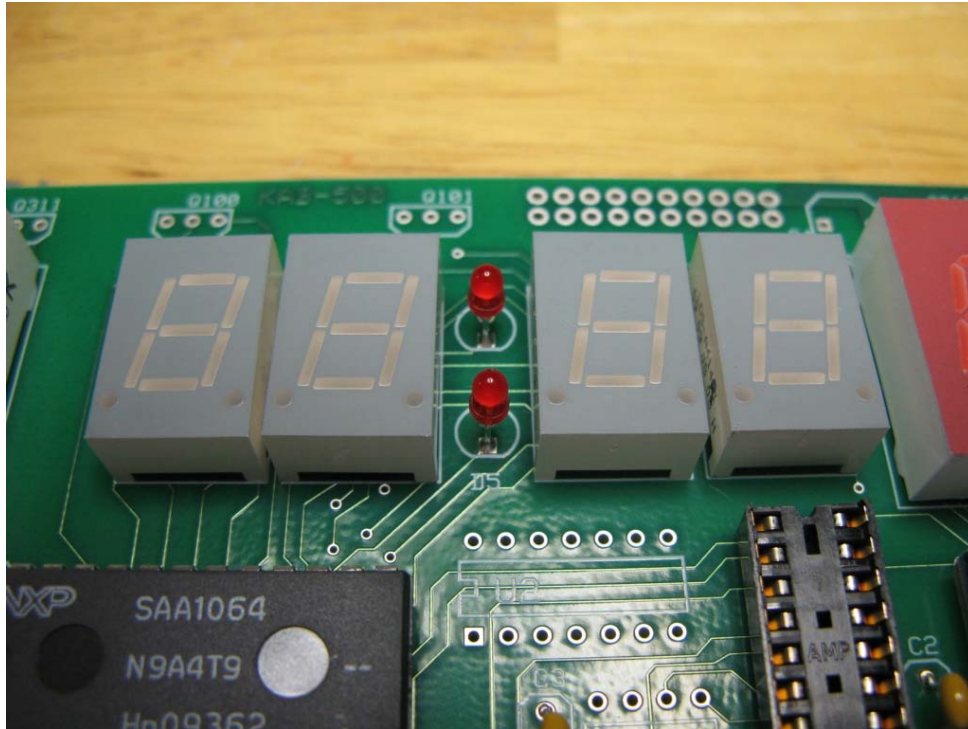
() load the eight 0.0027 capacitors

() load the ten 0.22 capacitors

Don't load the 10uF capacitors yet, they are loaded after the displays.

The four 7 digit displays have two decimal points, these decimal points can be used to orient the display; the decimal points go towards the bottom.

Hold the display flat against the board as you solder. These displays are very sensitive to overheating so be quick about soldering these pins.



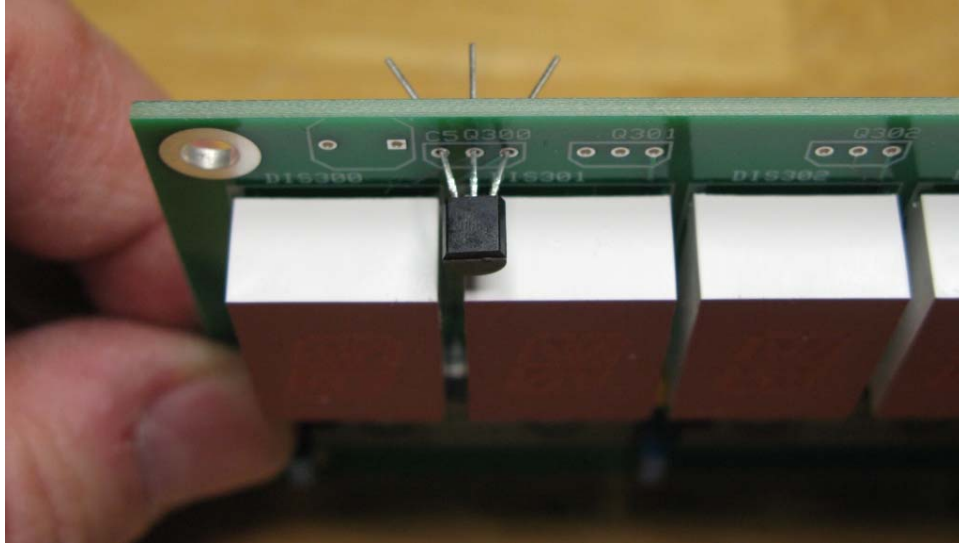
() load the two red LEDs between the displays as shown above.

The shorter lead goes in the hole near the flat part of the outline, closer to the bottom edge. Try to have the top of the LED even with the height of the display.

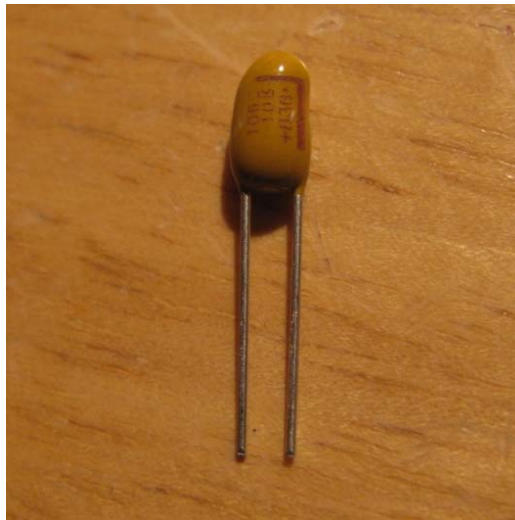
() load the 14 alphanumeric displays one at a time. These also have a decimal point that should go toward the lower edge. Push these against the board while you solder the leads, and be careful again about over heating the leads.



() load the 16 transistors as shown below.

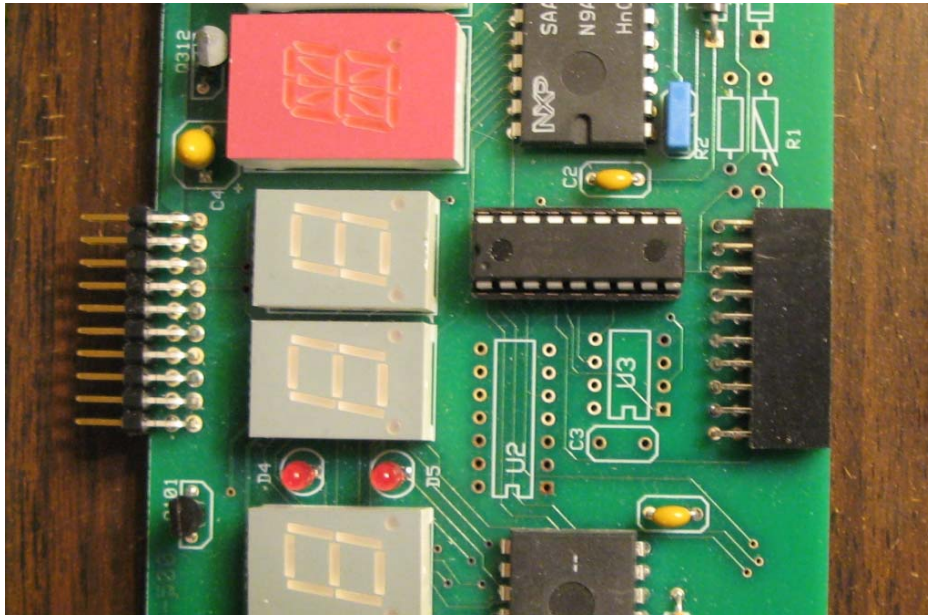


() load the two 10uF capacitors. They may have a small + sign near the + lead, or they may be marked with a line as below.



+ lead

Load the two connectors as shown below. Seat them flush against the board and level so they will connect with adjacent boards. It is easy to get them slanted when you flip the board over and solder, so be careful.



If you are building a display board, seat the 18 pin PIC16F648 IC carefully into the IC socket with pin 1 up.

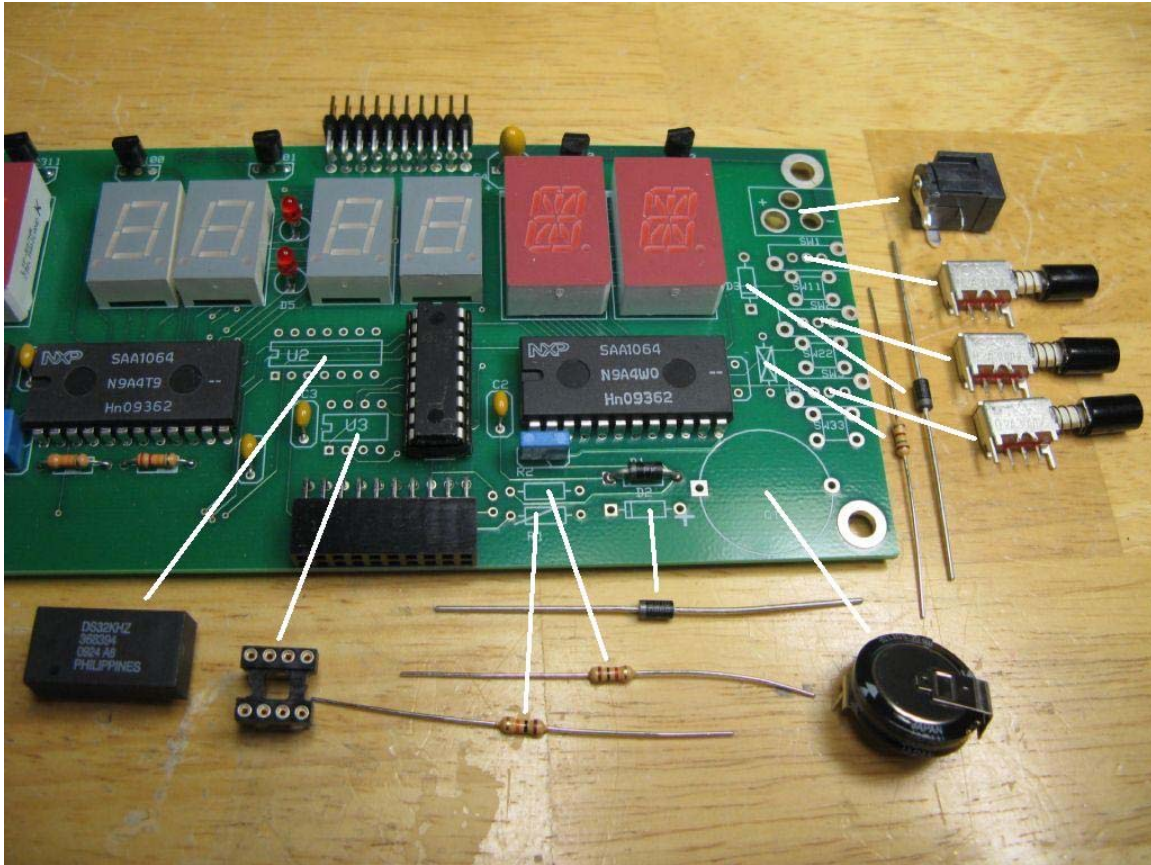
Your display board is done and ready to use.



Once you have all the display boards and the controller board built, read the configuration section to set up the clock.

Assembly Instructions – Controller Slice

A controller slice is made by adding a few parts to a display slice.



() load the DS32KHZ TCXO, the black block goes into the 14 pin IC labeled U2. It is missing pins 2 and 3, don't let that confuse you. Have the dot towards the notch on the left.

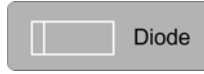
() load the 8 pin IC socket, and have the notch match the silk screen outline.

	22K
	33K
	1K (master slice)
	10K (master slice)
	150 (master slice)

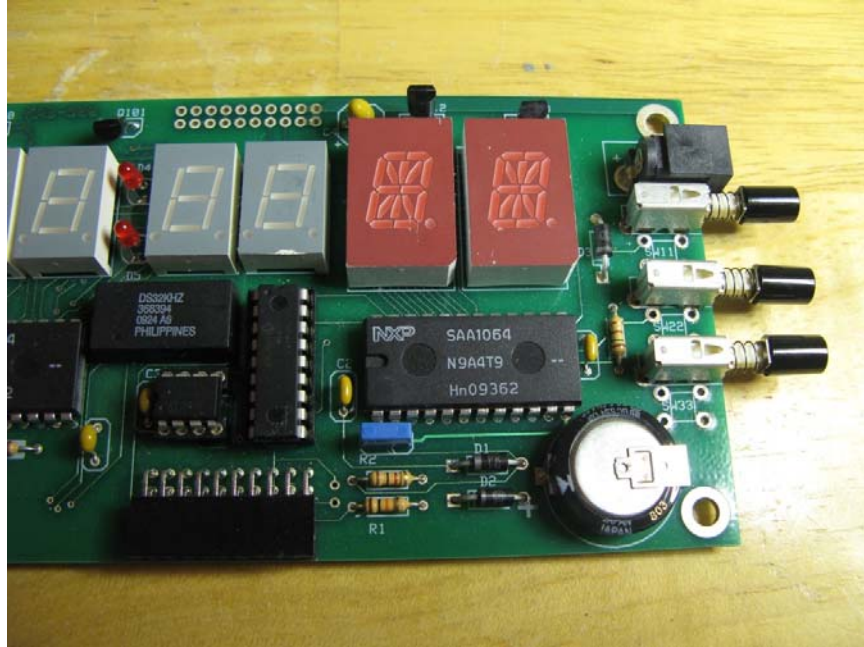
Resistor Markings

() load the 1K, 10K and 150 ohm resistors in the locations marked as shown on the left.

() load the two diodes into the locations marked



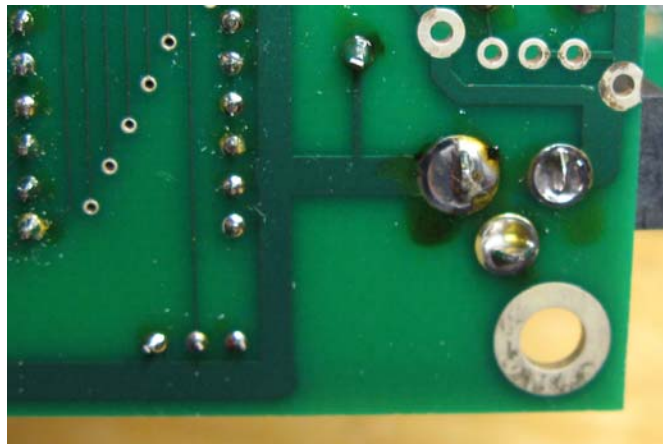
() load the 1 Farad capacitor as shown below, note the top strap goes to the right.



() load the switches one at a time, trying to keep them straight, you can see the middle switch above is a bit crooked, try to do better.

You have an option for the power jack, you can load it on any of the boards. The only reason to consider loading it on a display board other than the controller board is to avoid having the power cord adjacent to the upper switch. It really isn't a big deal; in normal operation you won't be pressing the buttons very often, perhaps only every few years. If you want to stay simple, just load it on the controller board.

() load the power jack. Fill the holes in the board with solder for strength as shown below.



() load the 8 pin EEPROM 25LC1024 into the 8 pin socket, matching the pin 1 markings.

() load the 18 pin controller PIC16F648A into the 18 pin socket, matching the pin 1 markings.

The controller slice is done and ready to test.



Tests

The controller slice can be tested after building and before configuration, power it up and use the menu buttons to advance to test. There are two tests, a segment test and an addressing test. After configuring the clock and adding the jumpers, you can rerun the tests on all the displays.

Cases and mounting

The boards can be mounted on a plaque in full view, or in shadow boxes or picture frames behind glass or colored acrylic. Acrylic can be found at plastic supply stores.

Board locations

A clock must have one and only one controller slice and up to five display slices. The controller slice can be in any position; on the top of the stack, on the bottom, or in the midst of the boards. The boards will auto number themselves at power-up starting with the board below the controller and continuing down where it wraps around to the top board, and stops at the controller board.

This auto-enumerate process can be watched by the address displayed at power-up. The inter-board signal needs to be configured using a pair of jumpers as described below.

Larger clocks

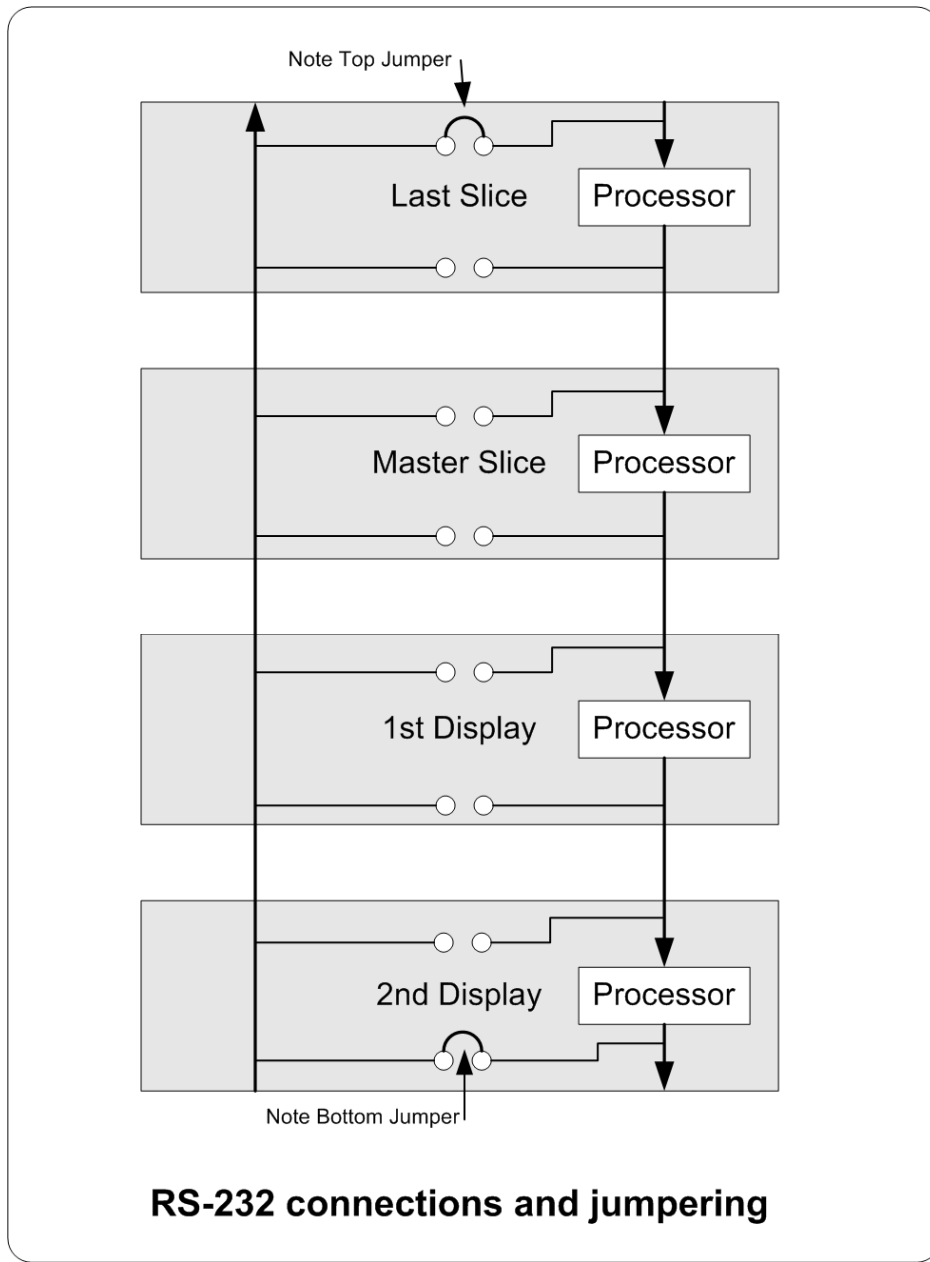
Clocks with more than 6 boards will require a larger power supply. Each board draws about 2/3 Amp which is 4 amps for 6 boards. The power is sent through the connectors using 4 pins for each rail: ground and +5. Each pin is rated at 3 amps per pin so that is a limit of 36 total boards. There may be a timing limit during the board enumeration, if you have problems feel free to email for code modification to support large clocks.

My 6 slice version will reset if I turn on the selftest because it draws a bit over 6 amps with all the test displays lit. The slices can be tested with smaller clock configurations. In normal operation many characters on the display slices are blank, lowering the current draw below 6 amps and allowing reliable operation.

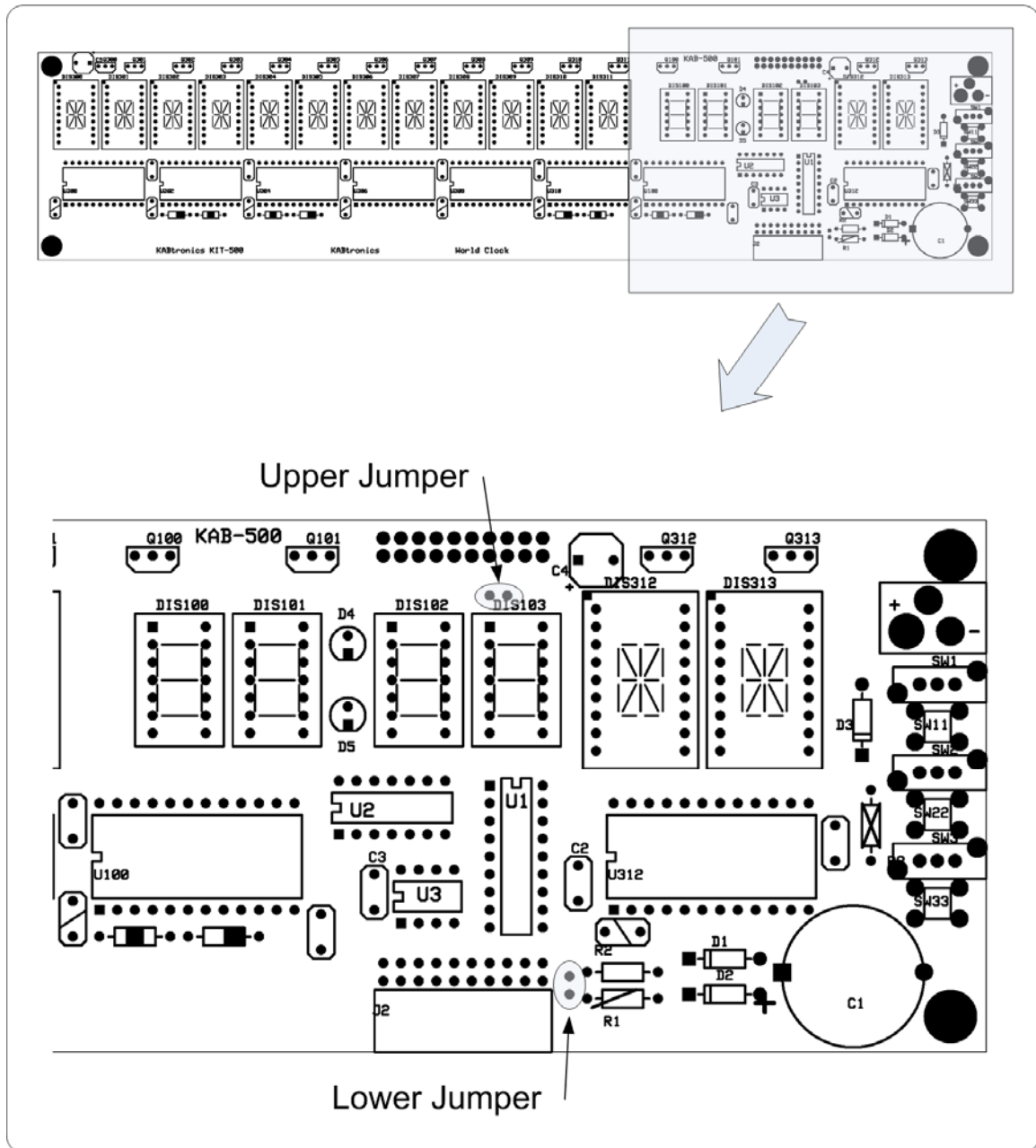
Data jumpers

The slices communicate using serial signal that needs to loop back to the controller slice. Each slice sends data down to the next board. Both the lowest board and the highest board need a jumper to send the signal around the chain and back to the controller.

The example below has the controller in the second position, but it can be in any position. The top board and the bottom boards whether controller or display slice, need the jumper described below.

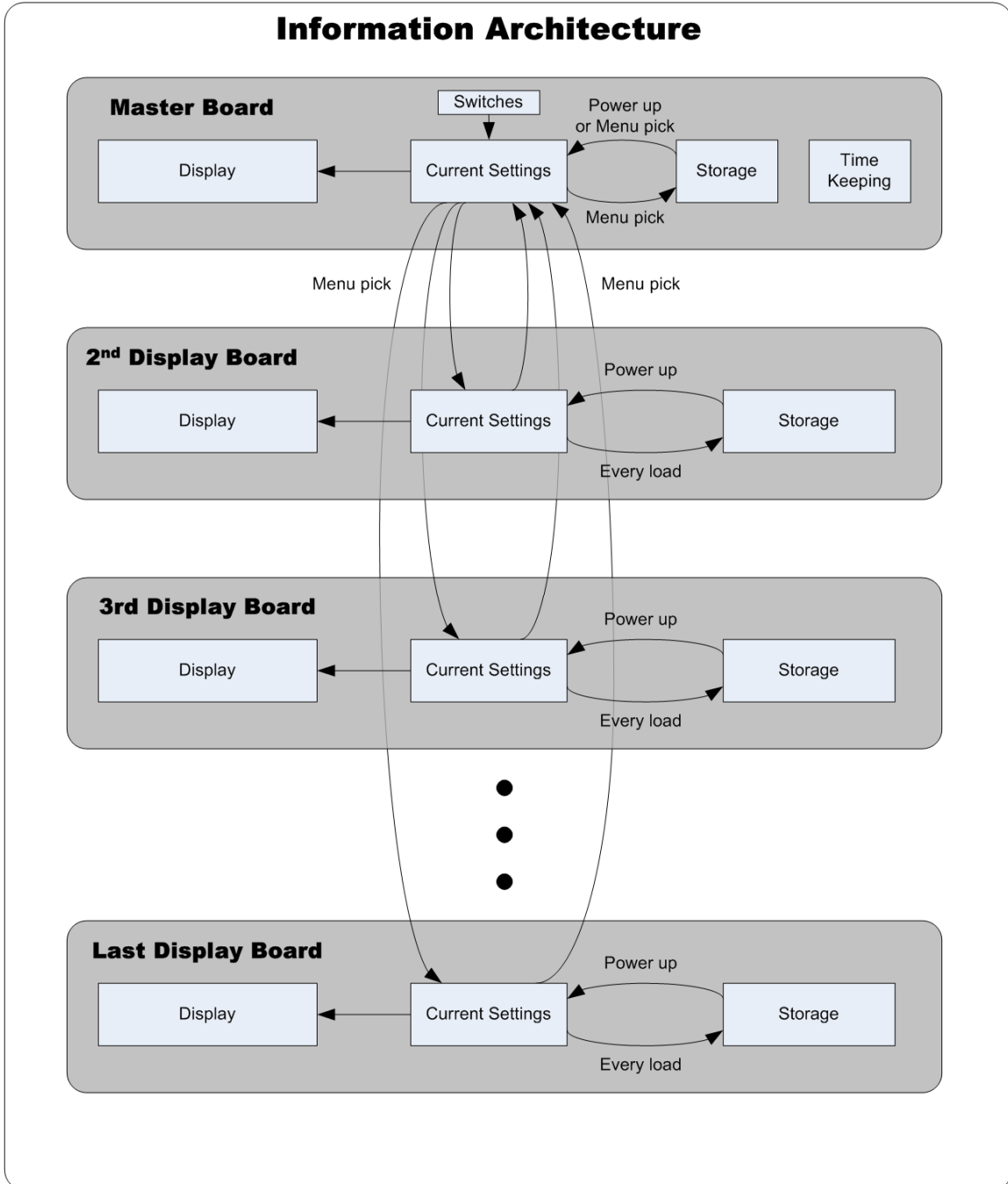


Solder a small wire into the upper jumper location of the top slice, and a wire jumper into the lower jumper location of the bottom slice.



Operating the World Clock

In order to set up and operate this clock, one needs to understand the concepts and information structure of this clock.



The data in the storage block persists through power outages; it is permanent until written over by a menu action.

Setting the clock.

This clock consists of one controller board and additional optional display slices.

The controller clock keeps the current time as Universal Time Coordinated (UTC, Greenwich time) and all display boards (and the controller display) translate that UTC to local times. Each display slice and the display part of the controller slice hold their own Location-Data translating UTC to local time.

The controller clock has three push buttons allowing one to set all aspects of the clock, from locations, current time, UTC offsets, daylight savings periods, and display formats. Each display has 10 settings, call as a group Location-Data:

- Location name
 - Format: 12 or 24 hour
 - Offset Hours from UTC
 - Offset Minutes from UTC
 - Daylight Savings Start Month
 - Daylight Savings Start Day
 - Daylight Savings End Month
 - Daylight Savings End Day
 - Daylight Savings UTC offset Hours
 - Daylight Savings UTC offset Minutes
- } Location-Data

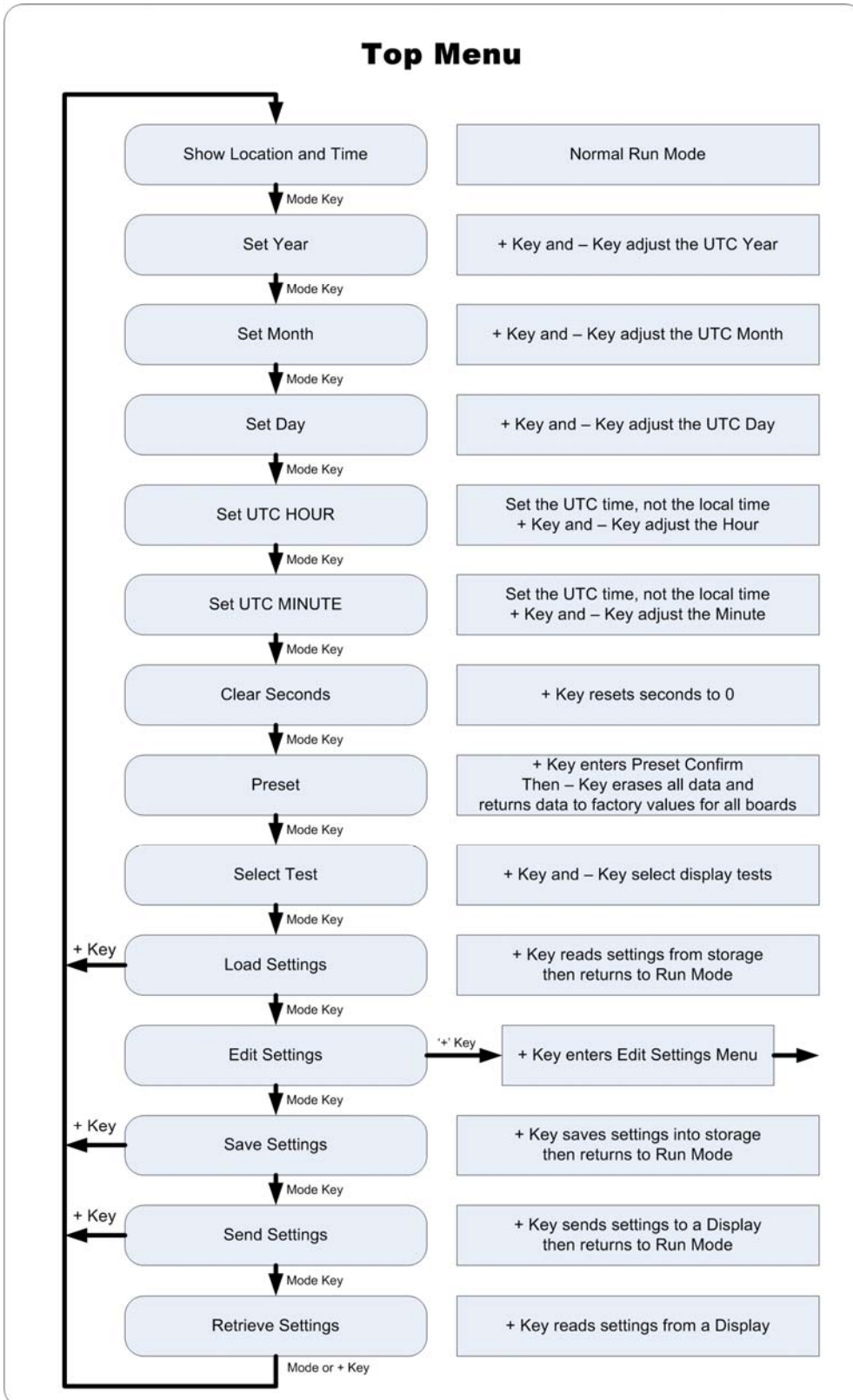
In addition to the above, the controller slice allows setting of;

- Current Year
 - Current Month
 - Current Day
 - Current Hour (UTC, Greenwich time)
 - Current Minute (UTC, Greenwich time)
- } Time Keeping Data

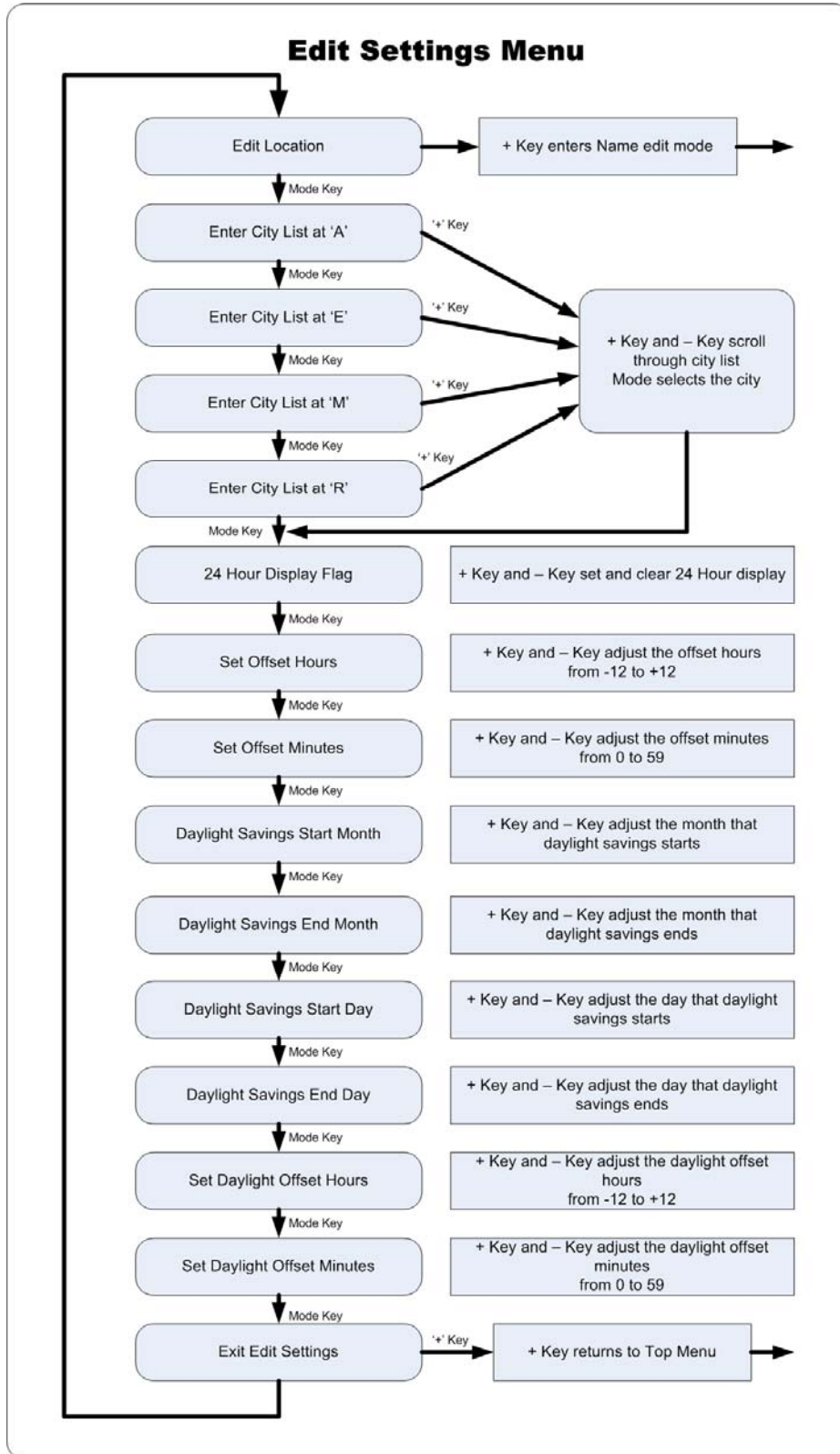
The controller slice also has these functions available;

- Test displays
- Preset all data to factory values
- Load Location-Data from storage
- Save Location-Data to storage
- Transfer Location-Data from controller to a Display
- Transfer Location-Data from a Display to controller

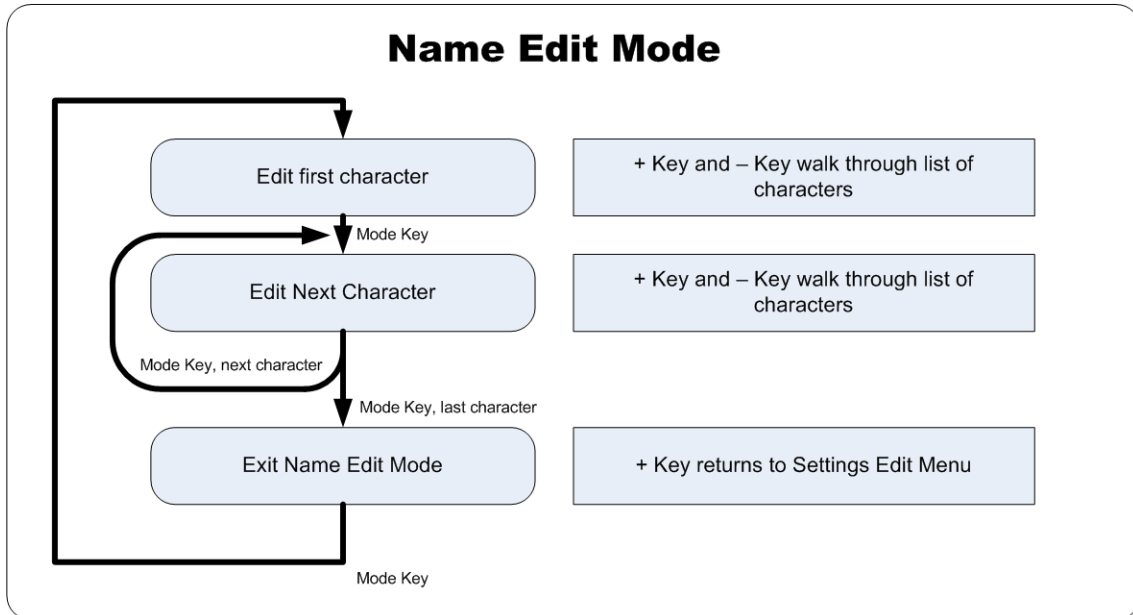
The controller top level menu is shown below. The '+' key, minus '-' key and Mode key are used to navigate and operate the menu.



This Edit menu modifies the Location-Data currently showing on the controller slice. The edited settings can be stored into any display or into the storage on the controller slice.



The Name Edit mode allows setting of the location name string by walking through the character positions and stepping through available characters at each of the 12 character locations. This is a painfully button intensive process, but the data is stored in nonvolatile memory, and with the transfer functions of the controller allowing editing of the Location-Data, the name should never need to be entered more than once.



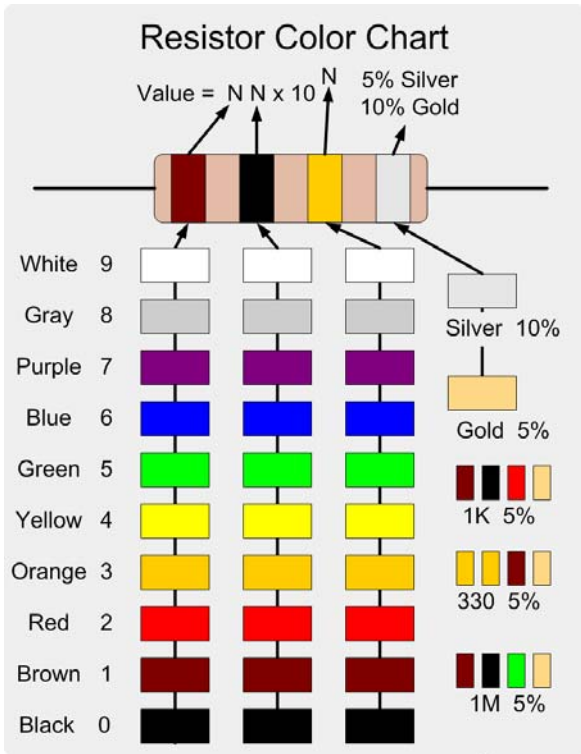
Step-by-step setting up a display slice;

- Use the top menu to enter Edit Location-Data Mode
- Enter the Edit Name mode from the Edit Location-Data Mode
- Set each character of the name and exit back to Edit Location-Data Mode
- Step through each value of Location-Data and adjust – note that a 0 in the DS Start Month will cause the rest of the Daylight settings to be skipped.
- Exit back to the Top Menu – the clock will enter the Run mode.
- Use the Mode key to cycle to Xfer to display mode and select the target display using the mode button
- Press the ‘+’ key to transfer the data, and it will also be stored in the storage on that display board.
- To return the controller board to original values, Use the Mode key to cycle to the Get Loc Data and press ‘+’ to reload.

The only difference when editing LOC-DATA from a display board is to first retrieve that data using the “FROM REMOTE” mode. Then use the above steps.

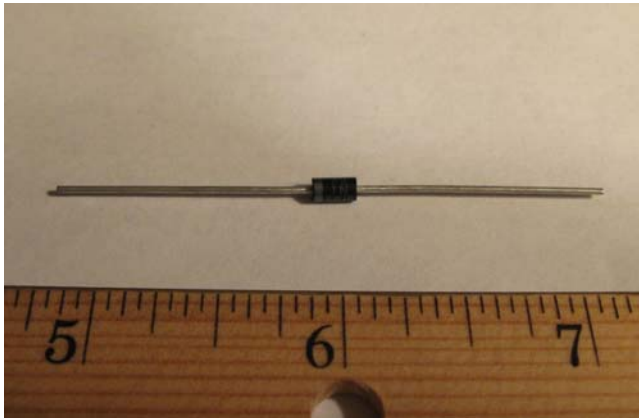
Parts Identification

Resistors

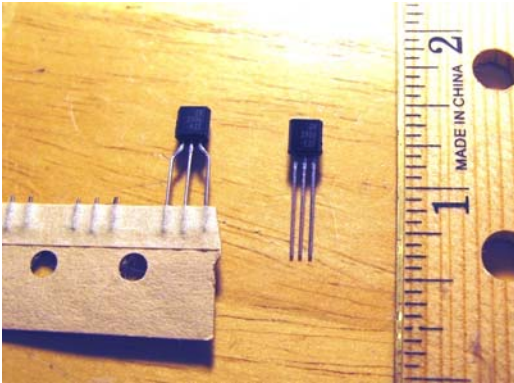


Resistors can be identified by the color bands as shown in the adjacent chart. These parts can be placed in either direction on the board, they are not polarized.

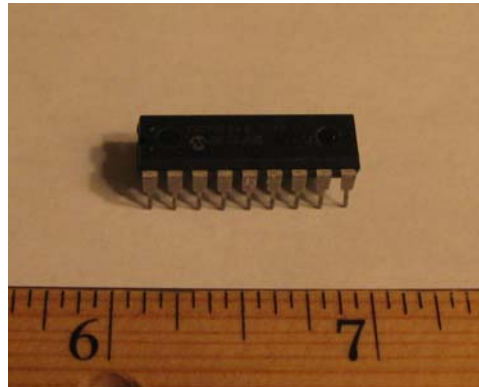
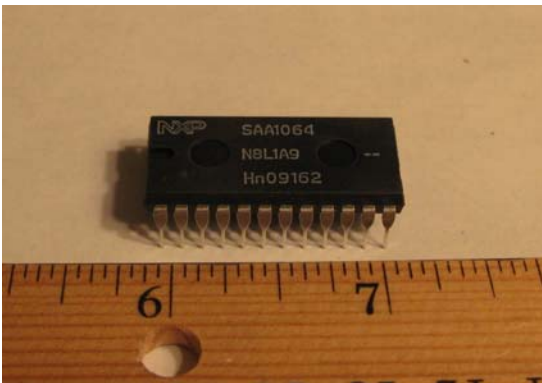
Diodes



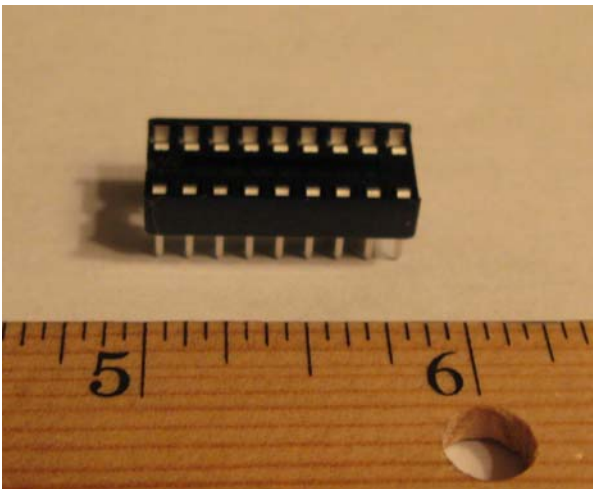
This is a polarized part; the stripe needs to match the stripe on the PC board.

Transistor

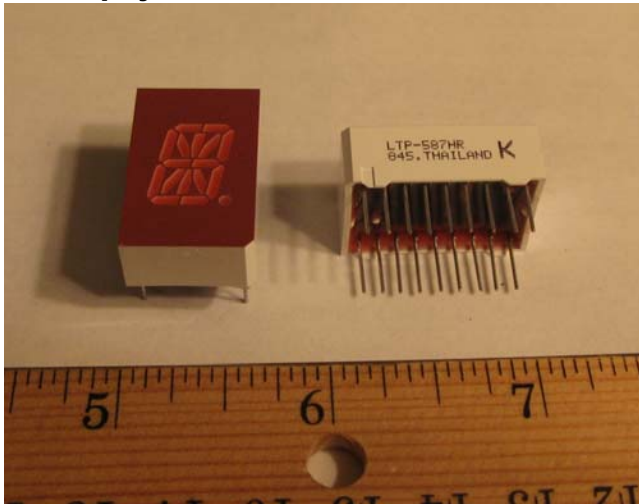
Try not to overheat this part when soldering.

ICs (Integrated Circuits)

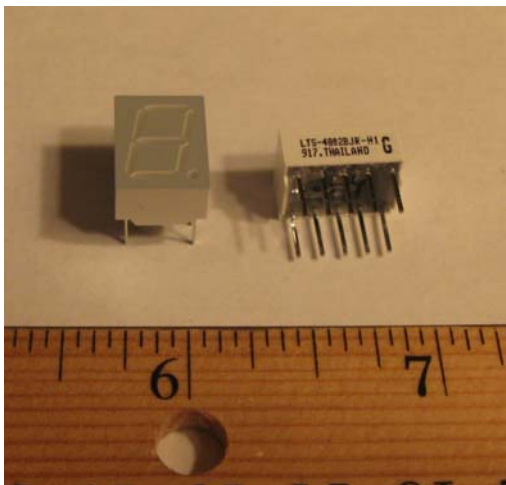
These come in 18 pin, 24 pin, and 8 pin versions. The 24 pin IC is soldered directly to the board, the 8 and 18 pin ICs are placed in sockets, mainly because they are reprogrammable parts, and you may want to update the software.

IC sockets

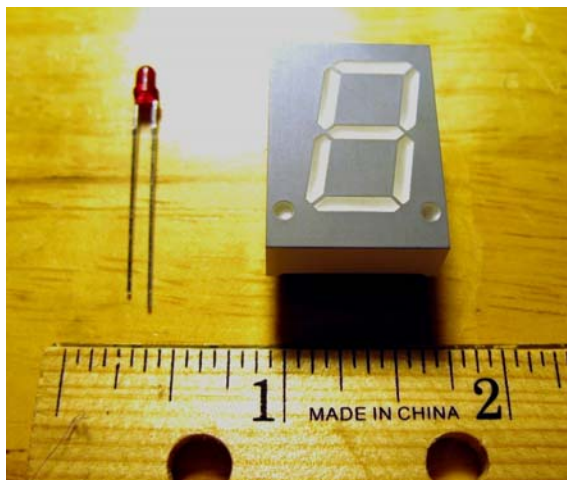
These come in 8 pin and 18 pin versions. Be sure to mount this part with the marking for pin one matching the PC board.

LED Displays

16 segment LED display

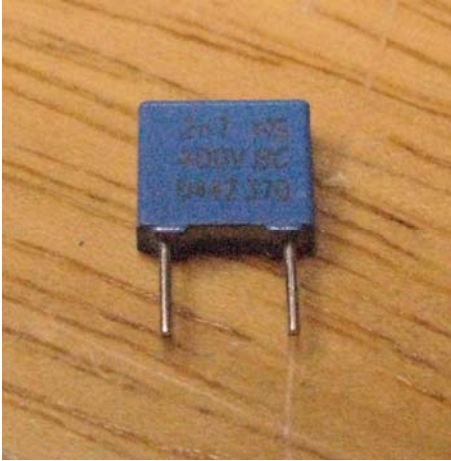


7 segment LED display



7 segment display on the right and a single LED on the left. The short lead goes into the square hole on the board.

Try to be quick when soldering these displays, they are sensitive to overheating.

0.027 caps**.22 caps**

Both this and the 0.0027 cap are non-polarized; mount it either way

1 Farad cap

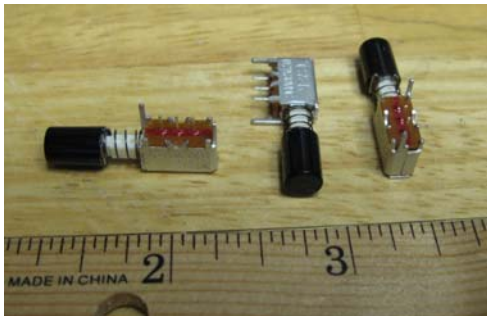
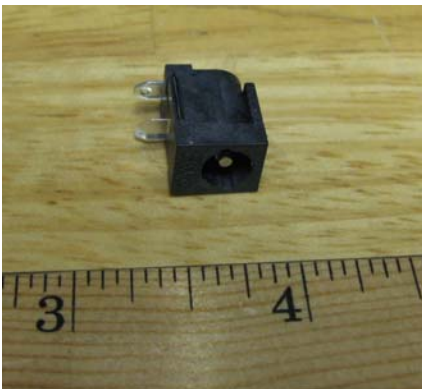
This part needs to be installed carefully, it is polarized. Look carefully at the picture in the mounting instructions. The metal strap is negative side of the capacitor.

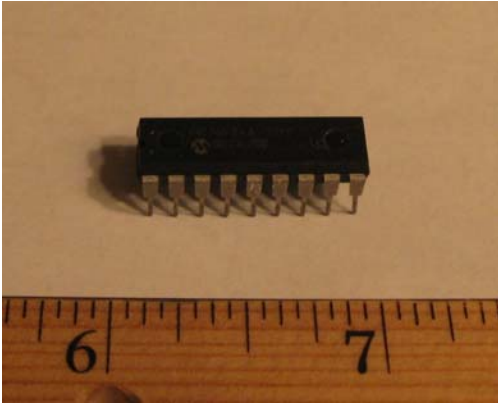
10 microfarad cap

Negative side

Positive side

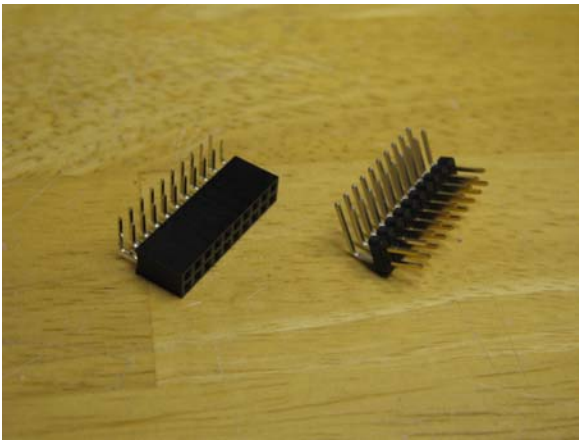
The long line identifies the positive side which need to go into the hole near the + sign.

Switches**Power Socket****ICs (Integrated Circuits)**



This kit has 8 pin, 18 pin, and 24 pin ICs

Header and Connector

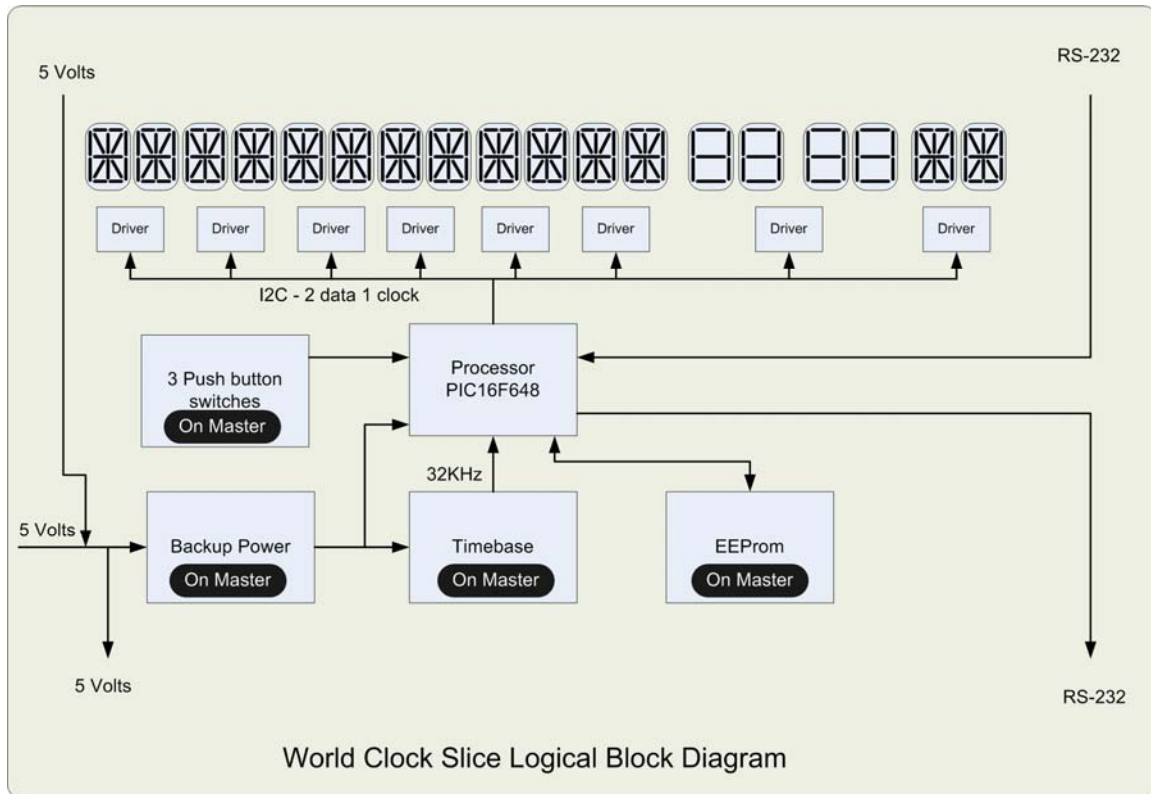


Connector

Header

These are a pair of mating 20-pin right-angle connectors. The header goes in the top location and the connector goes into the lower location.

Theory of Operation



This clock is based on a temperature-compensated crystal oscillator (TCXO) with an output of 32.768KHz. After dividing by 256, a periodic interrupt at 128 Hz keeps time and date.

Once a minute, a message with the current UTC time is sent around the RS-232 signal loop described in the configuration section.

Each display slice holds the local time offset, accounting for daylight savings, and computes the local time.

The controller slice detects power loss and reconfigures the board for low power consumption, keeping only the time base and processor active. On power restoration, all boards are reconfigured and the time messages restart on the minute interval.

In Case of Difficulty

General Troubleshooting

The most useful tool you have when troubleshooting is your brain.

Start with the data showing the problem.

- Is one display misbehaving or all displays?
 - The displays are driven in groups (2 for alpha-numeric, and 4 numbers) by the SAA1064 28 pin IC below the group. If the problem is within one driven group, suspect the driver.
- Is the address test out of order?
 - The addressing is controlled by the 22K and 33K resistors below the drivers; miss-loaded resistors will cause addressing errors, or blank groups.
- Are the boards enumerating at power up? The controller board will display the number of boards found.
 - Is the number found equal to zero? That means the link is not complete. Check the jumpering.
 - Remove any display board without a jumper to simplify the problem to the minimum number of boards.

This list is my guess at the cause of any problem in decreasing order of probability;

- Wrong component loaded
- Component loaded backwards
- Bad solder joint causing open or short to adjacent pad
- A clipped-off lead has stuck to the back of the board and is shorting out the circuit
- The board is resting on something conductive shorting out the circuit
- A component is bad because;
 - it was over heated when soldered (medium chance)
 - came that way with the kit (low chance)
 - was damaged by static electricity when handled (unlikely)
- The PC board is damaged or was fabricated incorrectly (very unlikely)

So take a close look at the back of the board looking for bad solder joints and clipped leads in the area of the problem. Check for proper components and orientations. If you haven't found the problem after thoroughly checking out the above list, email me at:

customerservice@transistorclock.com

Specifications

PC board Size: 13.8 inches wide by 3.0 inches high

(Allow $\frac{1}{4}$ inch behind board and $\frac{3}{4}$ inch above when loaded for parts clearance)

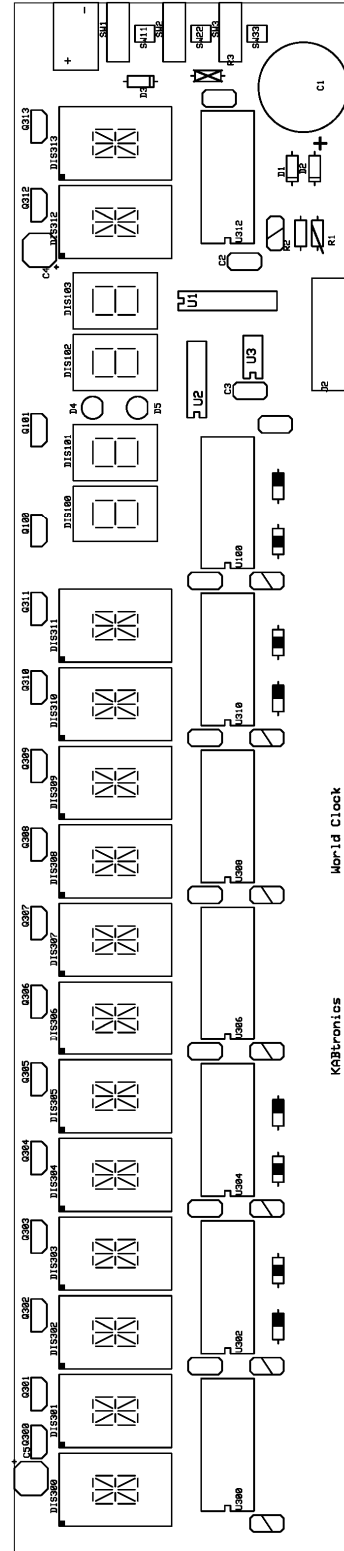
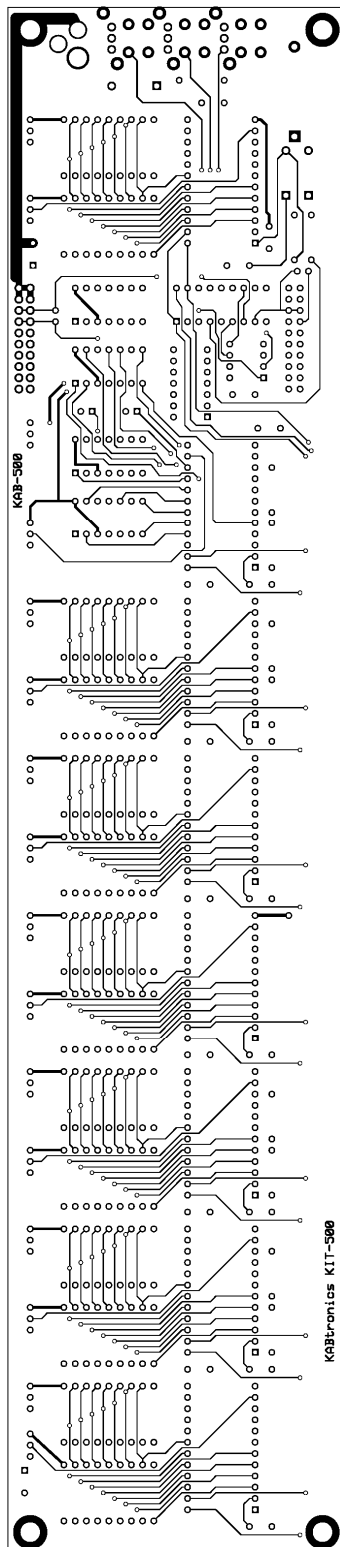
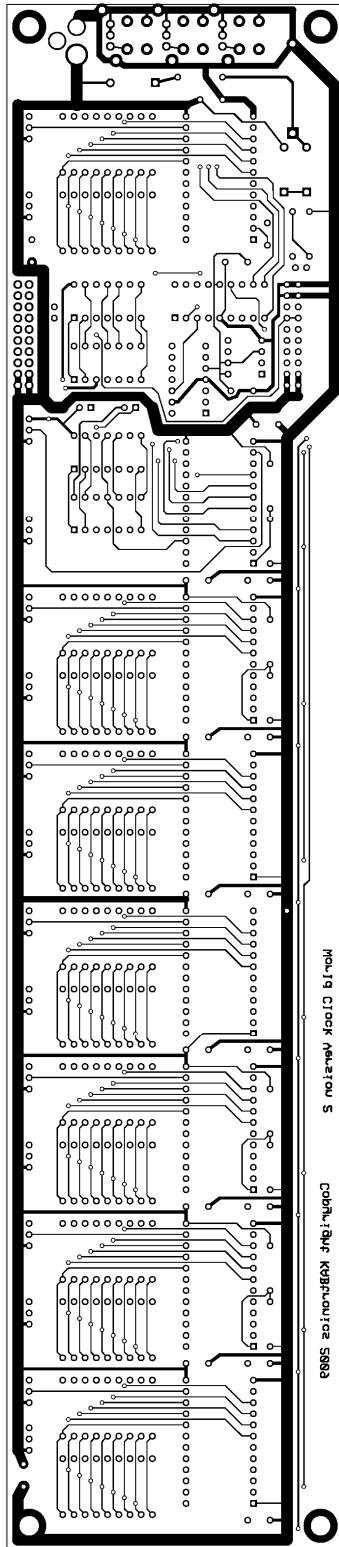
Weight: About 7 oz

Power consumption: About 3.7 watts, (0.75 amps @ 5 volts DC) per board

Temperature limits: Designed for room temperature operation, 60-80 °F

Warranty: There is no warranty of any kind. KABtronics wants you to succeed and be happy with your clock, so don't hesitate to email customerservice@transistorclock.com with questions if you are having difficulty.

Circuit Board Views



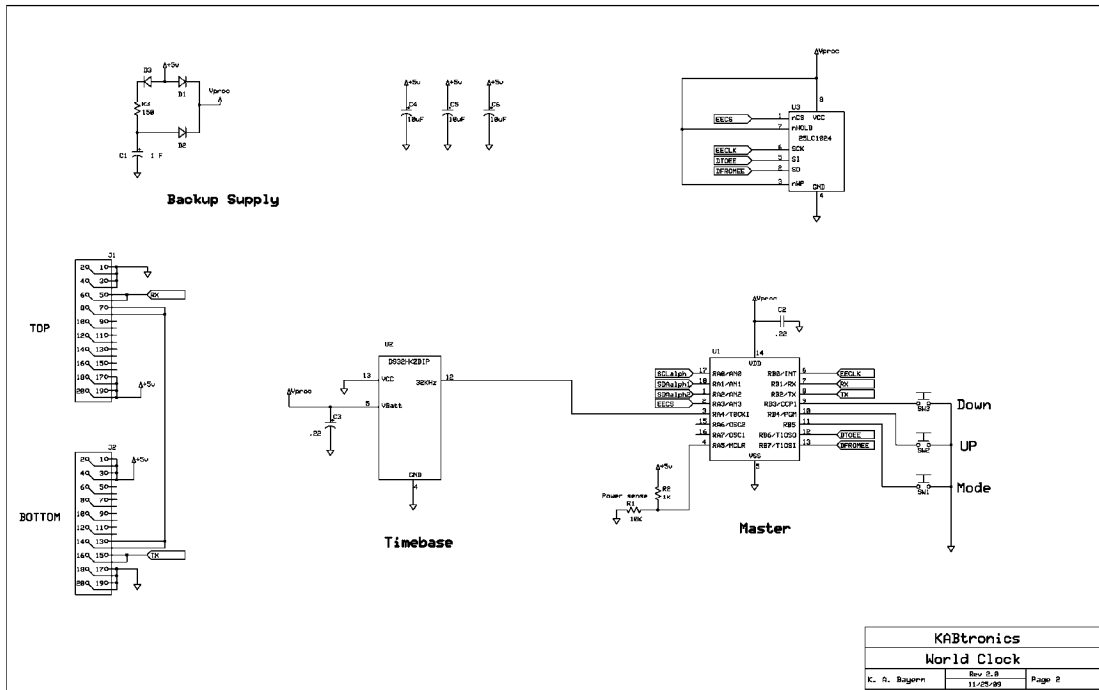
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Top Side Copper

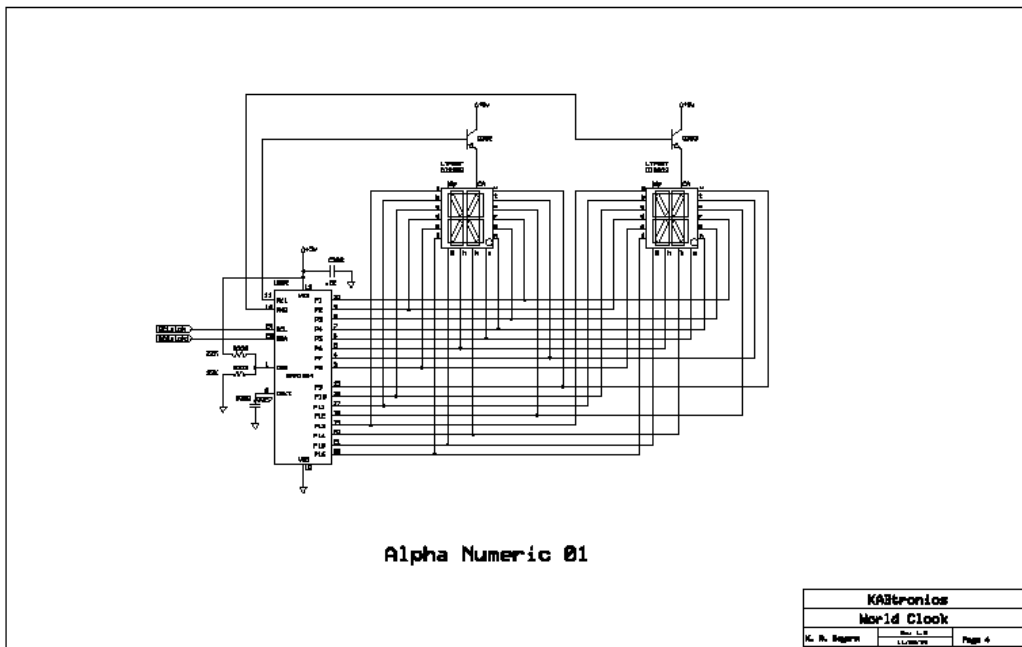
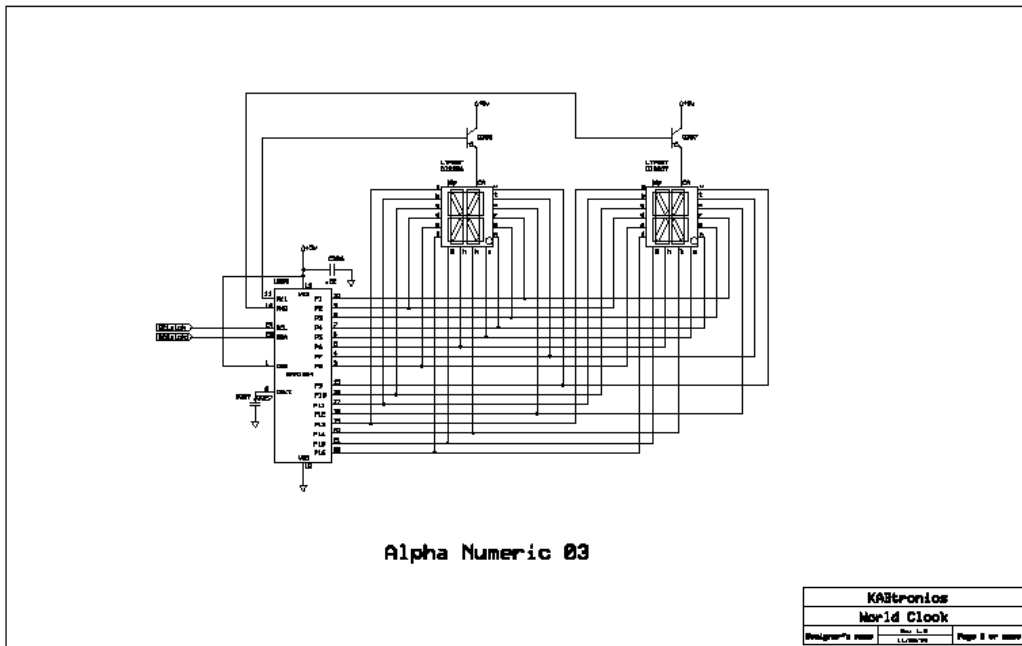
Bottom Side Copper

Silk Screen

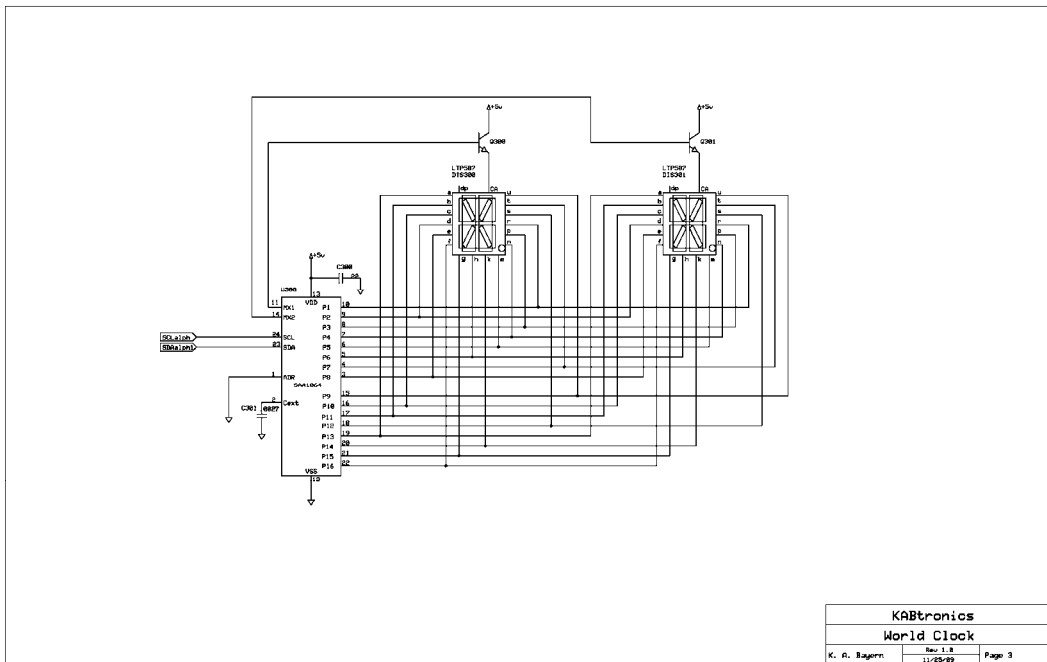
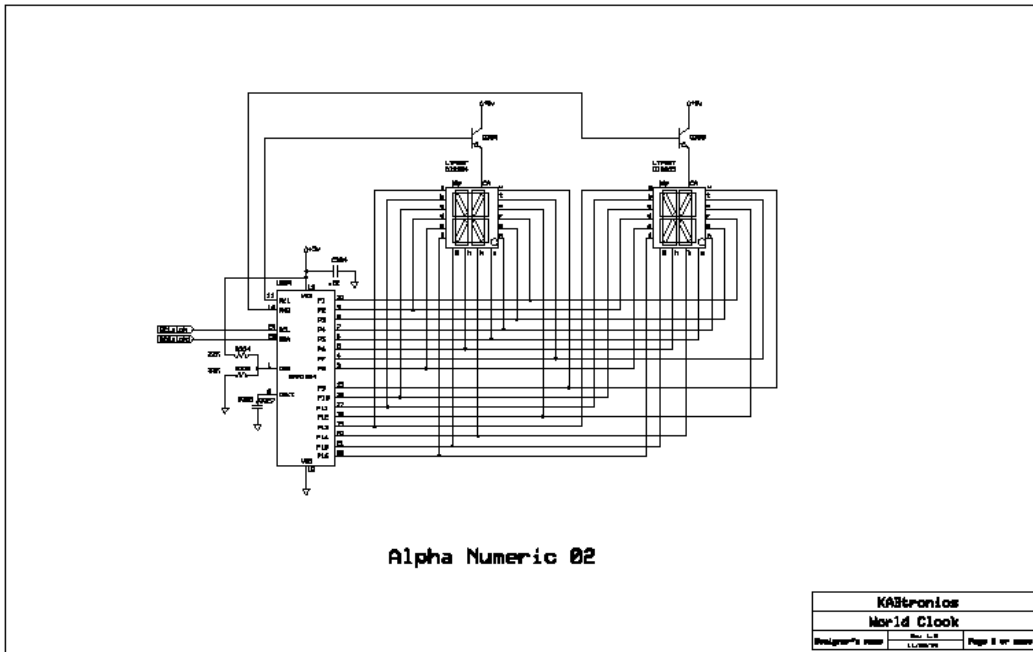
Schematic



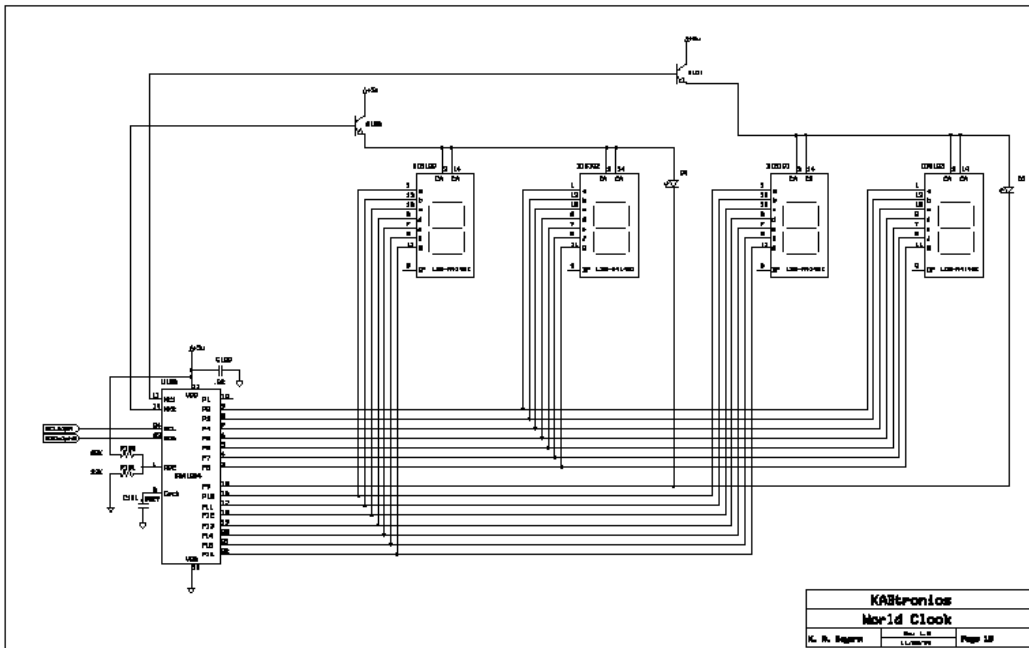
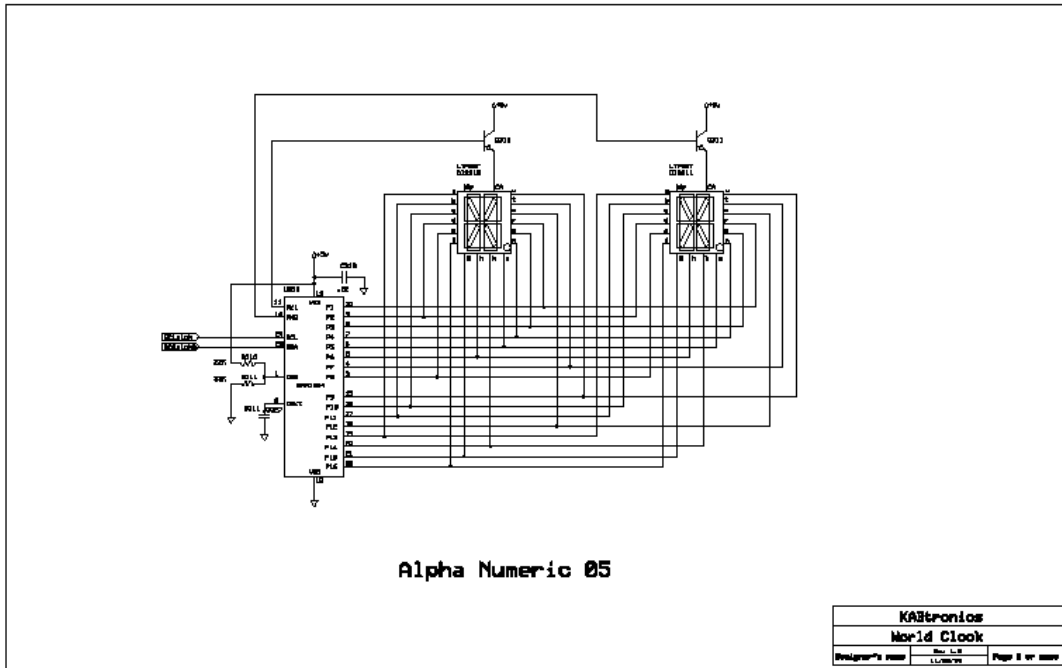
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