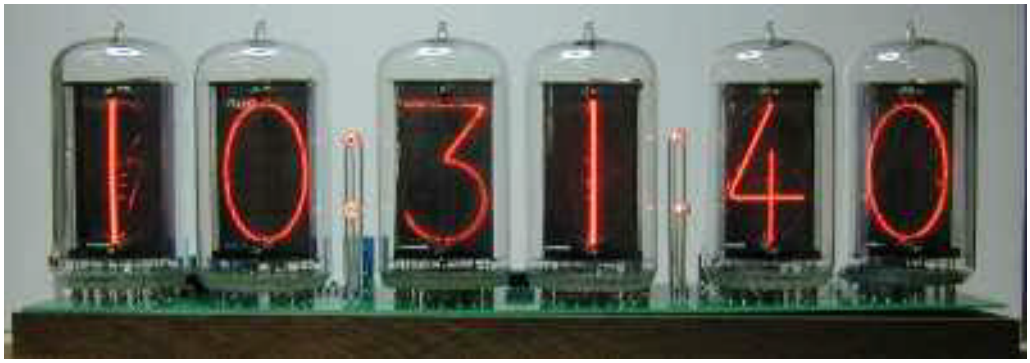
-NixiSat- The Satellite controlled Nixie Tube Clock



Introduction.
Thank you for purchasing NixiSat, the Satellite controlled Nixie Tube Clock. You are a member of a small community who own the worlds first commercially produced satellite disciplined nixie clock.
NixiSat began as an idea to develop the world's most accurate Nixie Tube clock by utilizing the NavStar satellite system as a precision timing reference. The project was established as a team effort by Jeff Thomas of Mesa, AZ, and John Miktuk of Panama NY, beginning in the fall of 2002. Hundreds of man-hours were dedicated to the hardware and software development of this product. We hope you enjoy the extensive list of integrated features in your ultra-precise timepiece.

This kit is intended for assembly by an experienced builder, who understands basic electronics theory, and owns a temperature controlled soldering station. Proper tools for PCB assembly work are required.
This kit is not intended for use as a teaching tool. If you are unsure of your abilities; do not attempt to assemble this kit alone without assistance by someone experienced in advanced electronics kit assembly.

If you have questions or problems during the assembly process, please call or email. I do respond quickly.

Never exceed 700 degrees soldering tip temperature. Damage to the PCB and components will occur if a higher tip temperature is used when soldering this clock kit.

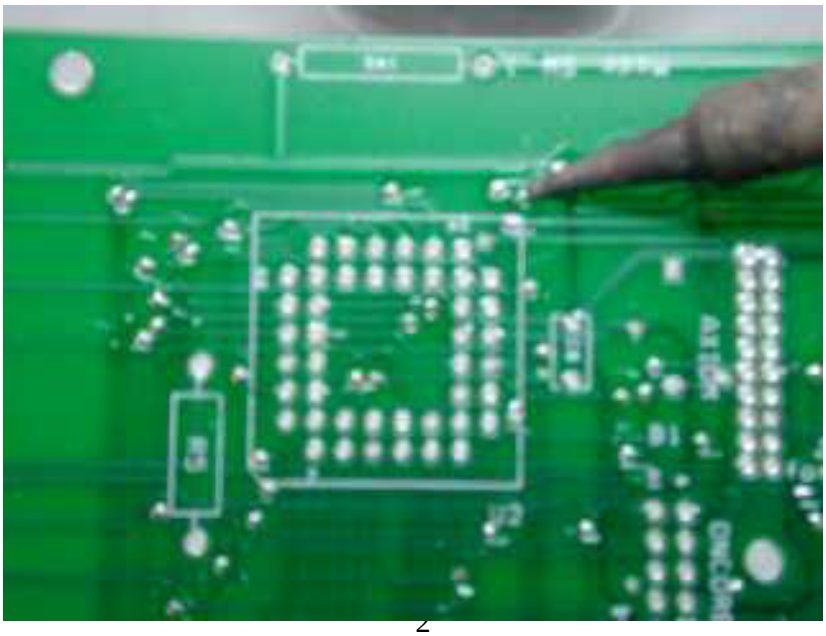
Lethal voltages are present on the PCB when power is applied. Do not handle the PCB when operating, or allow others to touch it when operating. Always keep the clock beyond the reach of children. Keep a protective cover over the electronics.

Never connect or disconnect the antenna from the GPS receiver while the clock is powered. The GPS receiver may be damaged.

Nixie Tube installation. Step one!
Examine the pins on the bottom of the Nixie tube, and verify all are straight. If they appear bent, carefully straighten them with needle nose pliers before proceeding.
Install a pin receptacle (BOM item 13) on each of the seventeen Nixie Tube pins, and ensure that all receptacles are completely seated to the base of the pin. Now, stand each of the Nixie Tubes up on a flat surface to ensure the tube stands straight. Compare them side by side to verify they are parallel to each other. Use a Sharpie pen to write an identifying number on top of each tube (1-6). The markings will ensure the tubes are returned to their original positions after soldering has been completed. Place the blank clock PCB onto a flat surface, with tube holes facing you and the component side up. Tape the edges of the circuit board to the table surface. Take the #1 Nixie Tube (with pins installed), and place it into the tens-hours (left most) tube position. The holes in the PCB were designed a little oversize to allow for +-2 degrees rotational alignment of the tubes to the front*.

Some tubes have a slight internal rotational alignment error, and could result in the tube not facing exactly front with respect to the mounting pins. The oversized mounting holes help to eliminate the rotation error by allowing you to turn the tube before soldering the pins into place.
Apply a small amount of Solder to each of the tube pins from the topside of the PCB, taking care not to contact the glass envelope with the soldering iron. Only use enough solder to fill the well. After one tube is completely soldered, carefully remove that tube and set it aside, then place another tube with pins into the adjacent position and repeat the procedure for all six tubes. After all of the tube pins have been soldered, place the tubes back in their wrappings, and secure them in a safe position away from where you're working. The tubes will not be needed again until the clock is ready to be powered.

PCB Preparation.
Begin the PCB preparation by filling all of the PCB via connection holes (small layer interconnect holes) with solder. All of the via holes must be filled before continuing to the assembly. Take care not to solder bridge any adjacent via connections, or fill mounting holes used by the components.



Component Installation.
Begin the component installation procedure by soldering the three 44 pin PLCC (Plastic Leaded Chip Carrier) sockets (BOM item 14) into the PCB.

Ensure the one angled corner of the socket is oriented to the PCB silkscreen angled corner. U1 and U2 are oriented the same, U5 orientation is reverse from U1, U2.

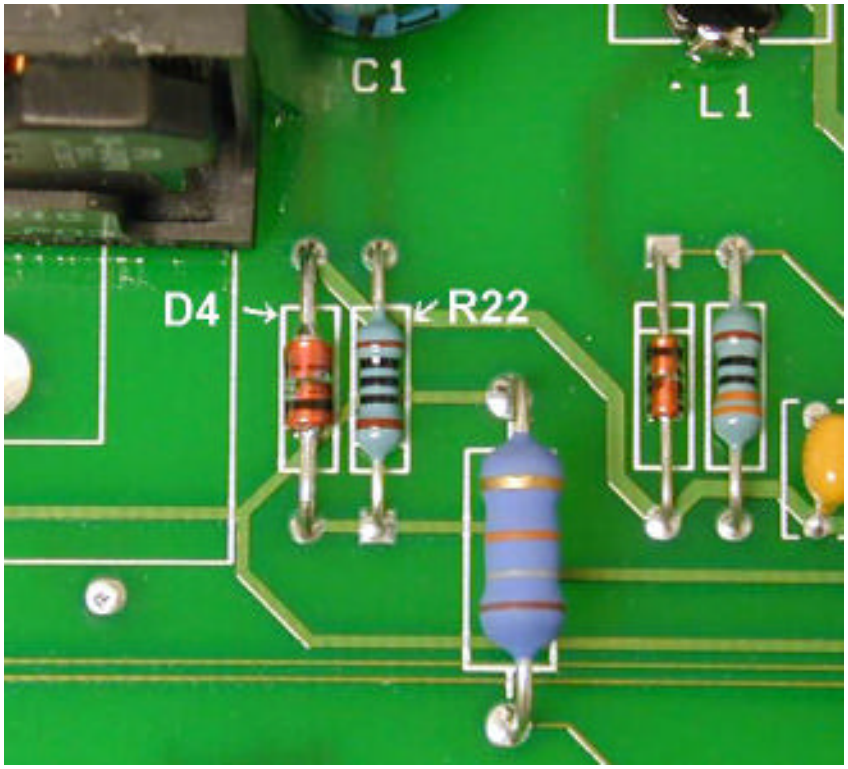
Next, solder the FET (BOM item 24) to the surface of the PCB. Align the FET to the mounting pad, and solder one of the two outside legs first. Then solder the tab of the FET to the PCB. Last, solder the remaining leg.

Align the inductor L1 (BOM item 22) to the silkscreened mounting position on the PCB, and apply a small amount of solder at the edge of one contact side. Realign while hot if necessary, then solder the other side of the inductor. The inductor is not polarity sensitive, and can be mounted in either direction. Inspect your work to ensure it is soldered properly. A poor connection here will result in failure of the HV to the Nixie Tubes.

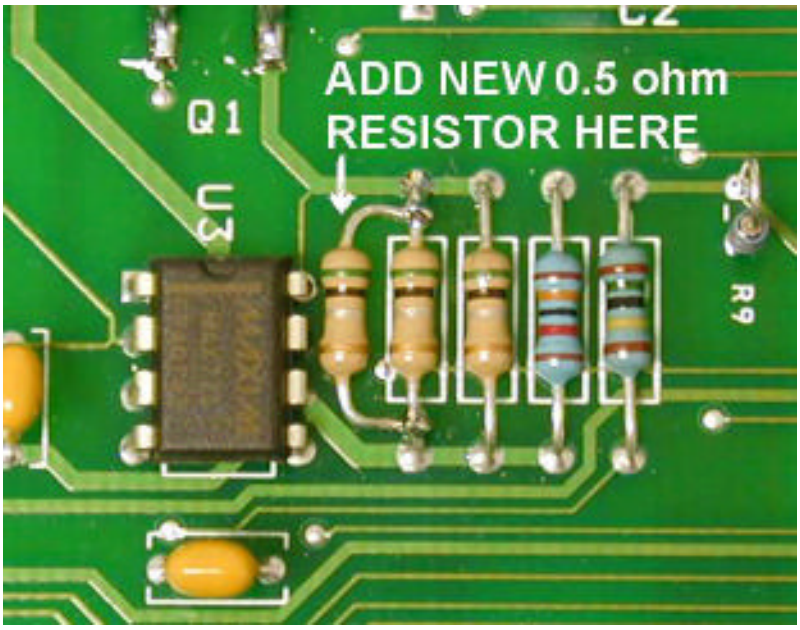
ASSEMBLY CHANGES TO PCB FAB REVISION B COMPONENT INSTALLATION:
Two changes to the PCB component installation have been noted below. Two images are provided for visual reference.

Component change #1
The component locations marked D4 and R22 on the PCB silkscreen are swapped, along with the polarity band of Zener D4.
Install D4 (BOM item 11) into the silkscreen location marked R22, with the cathode band facing towards the front of the NixiSat PCB.

Install R22 (BOM item 33) into the silkscreen location marked D4. Component R22 is not polarity sensitive, and can be installed in either direction.



Component change #2
An additional 0.5 ohm resistor has been paralleled across resistor R15. This resistor is noted on the schematic as Rnew. After installing and soldering R15 into the PCB, bend the leads of Rnew to fit onto the exposed leads of R15, and solder them onto the leads of R15.



End of assembly change procedure.

Reed Switches.
Note: ***the leaves inside the switch envelope should be aligned perpendicular to the PCB surface before bending the wires. This maximizes their sensitivity in the horizontal axis.***
Take great care in bending the leads of the reed switches (BOM item 34). Hold the wire at the envelope side with small needle nose pliers, then bend the lead to fit the hole spacing. Bending the wire without support will break the fragile envelope. Do not force the switch wires to fit the mounting holes. If needed, adjust the lead spacing with pliers.

Continue the component installation process by inserting the three Electrolytic capacitors into their mounting holes. Note the capacitor polarity marking. The Positive side of the capacitor is indicated on the PCB with a square mounting pad. C1 and C2 have the same size package, but are entirely different capacitors. Ensure they are installed into the correct location before soldering.

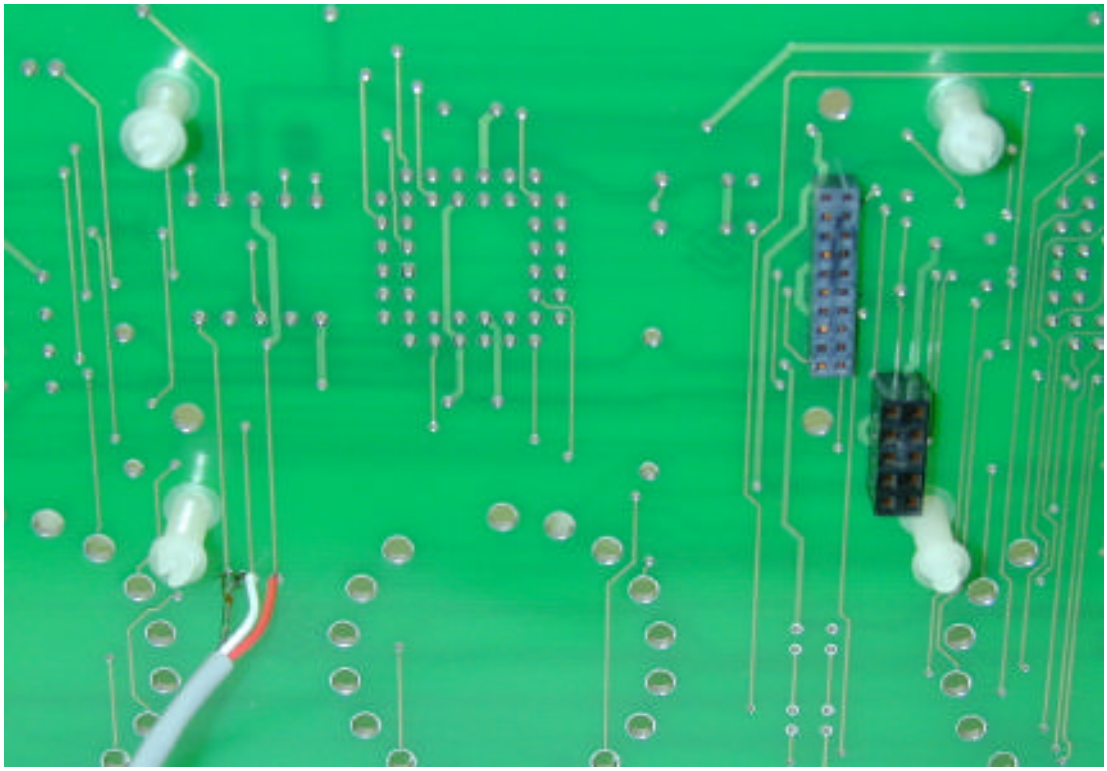
When installing the 1-watt power resistors (BOM item 25) into the PCB, insert a spacer beneath each resistor as you solder the leads to the PCB. The spacing provides heat dissipation. A distance of 1/8” is adequate.

When installing crystal Y1 (BOM item 41), space the crystal approximately 1/16” from the PCB to reduce the chance of damage in the event the crystal is accidentally struck. ***Allowing the leads to bend rather than fracture at their base***. A small coin will work as a spacer between the board and the edge of the crystal base when soldering.

Speaker PZ1 is not polarized. Though the PCB location is marked as polarized with a square pad, the Piezo speaker can be installed in either direction. Or, installed on the underside of the PCB if you are building your own clock enclosure and prefer the sound to exit at the bottom.

The following optional components are not provided in the kit, and not installed into the PCB: J2, J3, J6, C13-C16, and U6. NixiSat can support alternate configurations for Master/Slave communication, and a program development port. These components are not required for normal clock operation.

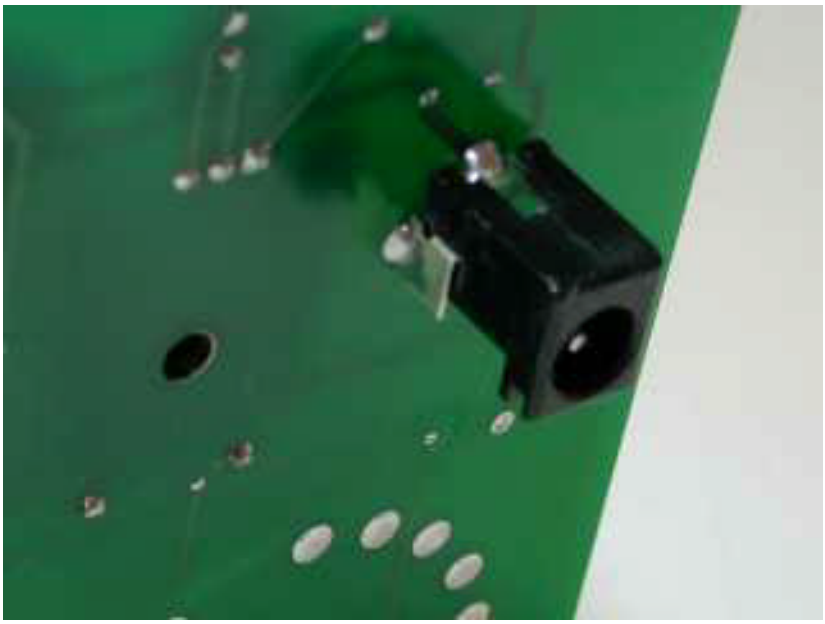
Solder side component installation.
Connectors J1, J4, J5, and U7 are installed on the solder side of the PCB. J1 provides power to the clock, and J4/J5 are the GPS receiver interface connectors. The kit may contain only J4 or J5. U7 is a digital temperature sensor, pre-assembled into a pigtail with three pre-tinned wires. The TO-92 package sensor is concealed inside shrink tubing for protection from damage, and is designed to extend a few inches from a hole on the underside of the wood base. U7 is soldered to the PCB after the tinned pigtail wires have been passed through the hole on the underside of the wood base. Pin 1 of U7 is the shield braid (GND), and is soldered to the square contact pad. The White wire (DATA) connects to the center pad position. The Red wire (+5v) connects to the third (right) pad position.
REMINDER: Be sure to insert the supplied brass eyelet into the sensor hole on the underside of the wood base before passing the temperature sensor pigtail through the hole.



Install the four nylon support posts into the holes on the PCB that will intersect the holes on the receiver. The Motorola Oncore receiver uses the outside hole pattern, and the Axiom uses the inside hole pattern. The Motorola Oncore receiver is the default configuration for this clock. If an Axiom receiver is installed, then bridge jumper JP1 on the component side of the PCB. Apply a small amount of solder to JP1 to set the configuration for Axiom receiver operation. Do not bridge JP1 for Oncore receiver operation.

Power connector modfication.
Connector J1 requires modification before installation into the PCB. Three conductor supports must be trimmed using side cutters to permit mounting close to the PCB underside. Without trimming, the connector standoff height interferes with the supplied power cable at the underside of the clock when using the enclosure offered with your NixiSat electronics kit.

An image of the modified connector is shown below after soldering to the underside of the PCB.



Battery holder.
Install the battery holder on the component side of the PCB, and solder the three mounting leads. Do not install the battery at this time.

PM indicator.
Cut two 1/4” pieces of Teflon tubing from the material supplied, and place one piece on each lead of one NE2 lamp (BOM item 21). Insert the lamp into the location marked LP9, and solder the leads.

1/8th watt resistor installation.
Use a small tool shaft to bend one wire of each 1/8th watt 220k resistor (BOM item 26) to form a loop. These five resistors are mounted vertically into the board at locations R3,R6, R9-R11. Solder all five resistors, and cut the wires flush to the underside of the PCB.

The 1/4 watt resistors supplied in the kit are 1% tolerance. If you are unfamiliar with resistor color coding, or unsure of the color, use a DMM to measure their values.

Install and solder all of the remaining components into the PCB. Carefully note polarity of the three axial diodes before installation. LED D3 must be installed with the short lead (or flat edge side) to the square pad on the PCB. It will not function if reversed. After all components have been installed, trim all component leads as close to the PCB as possible. The PCB should lay on the supplied wooden clock base with a gap no greater than 1/32” (with consideration for receiver and power connector recesses). If needed, you can use a flat file to reduce excessive solder height. Take care to avoid damage the PCB if you use a file for PCB cleanup.

After all remaining components have been soldered, open the conductive plastic container with U1, U2, and U5 inside. Insert the two HV5530PJ PLCC driver IC’s into locations U1 and U2. Be sure the angled corner of the IC is aligned to the angled corner of the socket. Then insert the 16F877 MCU PLCC into location U5. Again note the corner alignment; U5 is reversed from U1 and U2.

Colon posts.
A picture is worth a thousand words. Please download the two images I have posted here:

http://www.amug.org/~jthomas/colons1.jpg

http://www.amug.org/~jthomas/colons2.jpg

These are close up images of the colon post front and back. Follow the procedure for directions on how to build them.

The colon indicators in the image above are constructed from two NE2 lamps soldered to a 2 1/2" loop of .032" diameter steel piano wire. Lamps are spaced 1" apart, and centered in the digit elevation. The wire loop should be inserted into the bridged (connected) pair of holes for the NE2 lamps marked with a LP10/LP7, and LP11/LP8 between the tube pairs. Teflon tubing is used to cover the area of the steel wire that is exposed. The wire loop is at HV potential, and must be covered for safety reasons.

Begin the preparation for building the colon support posts by cleaning all oxidation from the two 5" piece of .032" steel wire with a foam backed 200 grit sanding block, or a sheet of 220 grit sandpaper. Next, bend each 5" segment at the center to form a loop. Use a small screwdriver shaft as the bending form. An 1/8th inch shaft is the perfect diameter. Continue the bend until the wires ends appear parallel to each other. Straighten as necessary to remove any visible twist. Use a file to remove the cutting burrs from each end of the wire, otherwise the wire will not pass through the colon post mounting holes in the PCB.

Take the Teflon tubing (BOM item 47), and cut two 1" segments, two 1 1/4" segments, two 1 3/8" segments, two 2 3/8" segments, and two 2 5/8" segments from the supplied material. This will leave 1/4" unused from the 18" supplied in the kit.

Take the 26ga wire (BOM item 48) and strip the insulation from it. Cut two 3" segments, and two 1" segments.

Solder one of the 26ga wire segments to one side of each of the four NE2 lamps (BOM item 21).

Hold each NE2 lamp, and wrap the remaining (not lengthened) wire around the .032" steel wire two complete turns, while providing an 1/8" inch standoff from the lamp and the .032 steel wire. Leave an approximately 1/8th inch distance between the wire and the lamp to allow for lamp aiming after the final assembly. Cut off the excess wire near the base of the loops and set the lamp aside.

Next, take one NE2 lamp, slide it onto the .032” steel wire, and position the lamp near the tangent of the loop in the wire (at the base of the 1/8” loop). Refer to the images above. Next, solder the wire loop to the .032” steel wire. Slide the 1” segment of Teflon tubing onto the .032” steel wire, beneath where the lamp was soldered on. Take another lamp, and slide it onto the .032” steel wire until it contacts the Teflon tubing. Solder that lamp into place. Then slide the 1 1/4” segment of Teflon tubing onto the .032” steel wire beneath the lamp you just soldered into place. A small section of .032” steel wire will be exposed, and that will be soldered into the PCB later.
Take one 2 5/8” segment of Teflon tubing, and slide it onto the other side of the .032” steel wire. Again, a small amount of wire will be exposed to solder into the PCB.

Repeat these last assembly steps to construct the other colon support post.

Slide one 2 3/8” segment of Teflon tubing onto the free wire of each upper colon lamp. Likewise, slide one 1 3/8” segment onto the free wire of each lower colon lamp.

Take one completed colon lamp assembly, and insert the loop of .032” steel wire into the rear-most pair of bridged mounting holes at LP10/LP7 or LP11/LP8. It may take a little wiggling to get the wires to pass through. Do not use force. If there are no burrs on the ends of the wires they should slip in with minimal pressure. Push them in until they are seated to the Teflon tubing. Carefully align the post so that it is vertical, then solder the .032” wire on the underside of the PCB. Use heavy duty wire cutters to cut any excess wire protruding from the underside of the PCB. Alternately, use a Dremel tool to remove the excess wire for an almost flush appearance. Then insert the long wire from the upper colon lamp into the front hole of LP10, or LP11 (left hole when facing the PCB). Likewise, insert the short wire from the lower colon lamp into the front hole of LP7, or LP8 (right hole when facing the PCB). Pull the wires tight until the Teflon tubing contacts the PCB using small needle nose pliers, and solder the wire in place. Cut the excess wire close to the PCB.

Repeat the assembly steps to complete and install the other colon support post.

Remove the GPS receiver from it’s protective bag, and install it to the underside of the PCB. Take care to ensure all contact pins mate with the connector, and the board is seated completely into the Nylon support post locking tabs.

Install the CR2032 Lithium battery. The battery + (positive) marking must face towards the microprocessor at U5. The + side is marked on the battery. A reversed battery can damage the GPS receiver.

Install each Nixie Tube into it’s respective position marked on the top of the tubes. Begin with #1 on the left, and finish with #6 on the right. The socket pins may be tight, but do not force the tube, check for interference if it seems too tight.

Attach the BNC connector from the antenna lead to the BNC receptacle on the adapter cable. Then insert the MCX connector on the adapter cable into the receptacle on the GPS receiver.

Installation and Operation.

Startup sequence:
Antenna has been connected, and the lithium battery is installed.
Insert the 5mm barrel connector into the power receptacle on the underside of the acrylic base.
Plug the AC adapter into a wall outlet.
“Charge” will sound on successful power up. After a moment, a nine will appear, and sweep across the display and decrement to zero. Colons will run an up-down test. A counter will start on the four right digits to gauge the acquisition time. The counter will continue incrementing until the receiver has acquired the satellite transmissions and their positions on the horizon.
The green LED will begin flashing at a rate of 1 pulse per second to indicate successful receiver initialization, and is seeking the satellites.

Place the GPS receiver antenna in a location with no obstruction from the sky. Wood frame single story homes may permit operation with the antenna located inside the structure. Multi-story, or hi-rise buildings require the antenna to be placed on a window ledge or support with a clear sky view.
Don't mount the antenna at the highest elevation**. It will not improve reception.** A high mounting will create a lightning hazard. Simply provide it a clear, unobstructed view skyward. Mounting the antenna a few feet from the ground will work adequately, and reduce the chance of damage or injury by lightning.

The initial startup after installation or after replacement of the Lithium battery is known as a "cold start". All ephemeris data is lost, along with satellite position information. The receiver begins by searching the sky to determine which satellites are currently in view, and their respective locations on the horizon. The cold start time to acquisition can be up to 30 minutes, depending on the signal strength received. If 30 minutes has elapsed, and no satellites were acquired, the antenna will need to be moved to a new location without obstruction.
After the receiver has acquired the satellite transmissions and their position, the clock will begin by displaying the time of day, referenced to UTC or Greenwich time (also known as Zulu time for you military folk).

After acquisition, if the main power to the clock is lost, the receiver will retain the critical satellite data, and will resume operation within 2 minutes of the power being restored; as long as a signal is being received. The CR2032 Lithium battery is responsible for maintaining the receiver's memory.

NOTE: Never connect or disconnect the antenna from the GPS receiver while the clock is powered. The GPS receiver may be damaged.

Setup menu.

NixiSat can be configured for operation in any time zone. All display and scrolling features are enabled from a menu. The menu items are accessed by actuating MODE SW1; a magnetic reed switch located near the centerline at the back of the clock. By waving the included rod magnet near SW1, the first of twenty one menu items will appear. The individual menu assignments are changed by waving the magnet near SW2 located at the right rear edge of the clock.

The menu items are displayed on the left digit of the display. Holding the magnet near SW1 will slowly increment the menu item number, finally returning to the time display after the last menu item. Each switch actuation will generate an audible tone. When the menu item you wish to change is displayed, wave the magnet near SW2 (the switch near the edge at the rear of the PCB) to change the setting shown on the right digits. After you have completed the change, wave the magnet near SW1 to advance to the end of the menu and exit. Alternately, the menu display will return to normal clock operation after ten seconds with no switch input.

(1) UTC OFFSET HOURS. Range of adjustment is: 0 to 14 hours. ***An example UTC offset for USA pacific time is 8 hours, where USA eastern time is 5 hours***

(2) UTC OFFSET MINUTES. Range of adjustment is: 0 OR 30. Yes, there are some countries off set by 30 minutes from UTC.

(3) OFFSET DIRECTION. Range of adjustment is: 0 = (negative) for USA, or 1 = (positive) for Europe. ***For USA clock owners, this setting should be set to 0***

(4) 12 OR 24 HOUR DISPLAY. Range of adjustment is: 12 = 12 hour display, and 24 = 24 hour display.

(5) SCROLL FREQUENCY. Range of adjustment is: 0, 1, 5, 15, 30, 60 minute interval. ***Assigns how often the display will scroll the enabled features.***

(6) SCROLL SPEED. Range of adjustment is: 0 = slowest, and 9 = fastest in a range of ten steps. ***Assigns how quickly the digits fly by during the scrolling cycle.***

(7) SCROLL DWELL . Range of adjustment is: 0 = shortest, and 9 = longest in a range of ten steps. ***Assigns the length of time the scrolled feature remains on the display.***

(8) COORDINATE SCROLLING. Range of adjustment is: 0 = Disabled, 1 = Enabled. Latitude and Longitude, represented in degrees, decimal minutes, and decimal seconds. As defined in the NMEA-0183 specifications.

(9) TEMPERATURE SCROLLING. Range of adjustment is: 0 = Disabled, 1 = Scroll in degrees Centigrade, 2 = Scroll in degrees Fahrenheit.

(10) TEMPERATURE SENSOR OFFSET. Range of adjustment is: + 3.75 degrees C to – 3.75 degrees C, in quarter degree C precision. ***Left lower colon represents a negative offset value.***

(11) DATE SCROLLING. Range of adjustment is: 0 = Disabled, 1 = Scroll Date European format, 2 = Scroll Date US format.

(12) CHIME FREQUENCY. Range of adjustment is: 0, 1, 5, 15, 30, 60 minute intervals. ***Assigns how often the chime will strike.***

(13) CHIME STYLE. Range of adjustment is: 1 = Single Chime, 2 = Double Chime, 3 = Chime high / low, 4 = Chime low / high, 5 = Tick – Tock, 6 = Morse Code hours announcement, 7= Mantle clock style hours chime, 8 = Naval Bells: Royal Navy with dog watches, 9 = Naval Bells: US Navy, no dog watches
Selections 1-4 are a simple chime, the specific hour is not indicated in the chime.

(14) MORSE CODE SPEED. Range of adjustment is: 5, 13, 20, 30, 40 WPM.

(15) DISPLAY WAKE BRIGHTNESS. Range of adjustment: 1 = Dim, 9 = Bright
This item assigns the display brightness level during normal viewing hours.

(16) DISPLAY SLEEP BRIGHTNESS. Range of adjustment: 0 = Off, 9 = Bright.
This item assigns the display brightness level during display sleep hours.
If set to zero, the HV supply will be completely disabled.

(17) DISPLAY SLEEP HOUR (TURN OFF). Range of adjustment is: 0 – 23
Using your time zone offset, this assigns the hour that the clock display will turn off.

(18) DISPLAY WAKE HOUR (TURN ON). Range of adjustment is: 0 – 23
Using your time zone offset, this assigns the hour that the clock display will turn on.

The display can be temporarily awakened from the sleep cycle by waving the magnet near SW1 or SW2. The display will return to sleep one minute since last activation. The display can also be awakened in input to RB4. See advanced info for details.

(19) 1PPS LED FLASH. Range of adjustment is: 0 = Disabled, 1 = Enabled.
The LED will always signal at startup, then can be disabled during normal operation.

(20) LEADING ZERO. Range of adjustment is: 0 = Disabled, 1 = Enabled.
Applies to12 hour mode only. If hours are less than 10, the leading zero can be disabled from the time display.

(21) AUTOMATIC DST CHANGEOVER (SUMMER TIME) Range of adjustment is: 0 = Disabled, 1 = USA, 2 = Europe, 3 = Australia, 4 = Manual N. Hemisphere, 5 = Manual S. Hemisphere.

NOTE: Menu items 22-25 are available only when manual modes 4 or 5 have been selected.

The GPS satellite transmissions do not contain offset information for DST changeover. Automatic DST changeover has been calculated and stored in a memory table contained within the programmed MCU. All automatic DST changeover dates are valid until the year 2099.

Countries not supported by the automatic DST changeover menu choices can manually program the month and day for start/finish. The manual changeover dates are valid only for the year programmed.

(22) SET START MONTH IF NORTHERN, END MONTH IF SOUTHERN.
(23) SET START DAY IF NORTHERN, END DAY IF SOUTHERN.
(24) SET END MONTH IF NORTHERN, START MONTH IF SOUTHERN.
(25) SET END DAY IF NORTHERN, START DAY IF SOUTHERN.
Confused? You are not alone. Look at a globe, you will understand why the manual offset menu separates the northern hemisphere from the southern hemisphere.

ALARM FEATURE.
Your clock supports a single alarm feature that can be accessed by holding the magnet near SW2 for two seconds.
The alarm menu is indicated when the left two Nixie tubes display 50. If you accessed the menu by accident, the clock will return to normal operation after 10 seconds with no input.

(50) ALARM ENABLE / DISABLE. Range of adjustment is: 0 = Disabled, 1 = Enabled.
When enabled, the clock will play a few bars of Menomonie, then reset to alarm again in 24 hours.

(50) ALARM HOUR. Range of adjustment is: 0-23 hours.

(51) ALARM MINUTES. Range of adjustment is: 0-59 minutes.

Menu settings are permanently saved in non-volatile Flash memory. In the event of a power loss, or if the Lithium battery is removed, all menu assignments are retained.

Program updates.

The NixiSat program software is a work in progress. As the customer base increases, requests for features and improvements are being accepted and added in future program releases. Please download and review the NixiSat_Operation.pdf user manual on the nixisat.com web page for updates and feature additions to the menu.

Secondary precision reference.

NixiSat incorporates a unique method of operation in the event of “spotty” reception resulting from poor or limited antenna placement possibilities.
If the signal is weak or obstructed after the clock has received the satellite transmission, the clock will continue operation without continuous satellite reception.
The GPS receiver contains an internal high-precision time base that is continuously compensated by the Cesium atomic reference transmitted from the satellites. Any cumulative error will be unnoticed, even with an extended signal loss.
NOTE:
The Latitude and Longitude coordinates will remain fixed until reception has been restored.

The right lower colon indicator may extinguish periodically to indicate the loss of GPS signal reception. The clock will continue operation using the satellite receiver’s internal time base.

The lower right colon indicator will remain illuminated while the satellite signal is being received. If you notice frequent periods of signal loss, you should move the antenna to a location without any obstruction from the sky.

Bill of Materials.

Menu settings are permanently saved in non-volatile Flash memory. In the event of a power loss, or the Lithium battery is removed, all menu assignments are retained.
Additional features will be added to the program as the clock matures. Please check the Nixisat.com web page in the future for updates and feature additions.

GPS Satellite controlled Nixie Tube Clock Revised: July 20, 2003 Revision: C

Bill Of MaterialsPage1

Item	QTY	Reference	Description	
1	1	B1	Battery CR2032	Mouser 614-CR2032
2	1	XB1	Coin cell holder, CR2032	Digikey BS-5-ND
3	1	C1	Capacitor 1000uf 25v	Mouser 140-XRL25V1000
4	1	C2	Capacitor 4.7uf 450v	Mouser 140-XRL450V4.7
5	7 (11)	C3-C5,C7-C10	Capacitor .1uf 50V	Mouser 80-C330C104K1R
		C13-C16 (optional, along with items 17 and 39)		
6	1	C6	Capacitor 470uf	Mouser 140-XRL25V470
7	2	C11,C12	Capacitor 18pf	Mouser 80-C315C180J2G
8	1	D1	Diode rectifier UF4007	Mouser 625-UF4007
9	1	D2	Diode Zener 8.2V 1N5237B	Mouser 625-1N5237B
10	1	D3	LED Green	DigiKey MV5452-ND
11	1	D4	Diode Zener 11V 1N4741A	Mouser 625-1N4741A
12	1	F1	Fuse 1.5A subminiature	Mouser 5761-51112
13	102	XLP1-XLP6	Receptacle, pin Mill-Max	Mouser 575-032700
14	3	XU1,XU2,XU5	Socket, IC PLCC 44 pin	Mouser 649PLCC44P-T
15	1	J1	Connector, POWER	Mouser 163-5013
16	0	J2 (engineering only)	Connector, ICD RJ14	Mouser 571-5551631
17	0 (1)	J3,J6 (option)	Header, .100” RS232	Mouser 517-6111TN
18	1	J4	Connector, ONCORE	Mouser 649-68683-305
19	0	J5	Connector, AXIOM	Mouser 538-791070009
20	6	LP1-LP6	Nixie Tubes, Z5680M	Jan Wuesten, Germany
21	5	LP7-LP11	Neon lamp, NE2	Mouser 36NE004
22	1	L1	Inductor,100uh PM3340-101M	DigiKey M9738CT-ND
		OR	Inductor,100uh DO3340P-104	JW Miller or Coilcraft
23	1	PZ1	Piezo, Speaker 4khz	Mouser 81-PKM13EPY-4002
24	1	Q1	FET, IRF740AS	Arrow IRF740AS
25	6	R1,R2,R4,R5,R7,R8	Resistor 18K 1W	Mouser ME261-18K
26	5	R3,R6,R9-R11	Resistor, 220k ohm 1/8W	Mouser ME270-220K
27	1	R12	Resistor 330 ohm 1/4W	Mouser ME271-330
28	1	R13	Resistor 1.5meg ohm 1/4W	Mouser ME271-1.5M
29	3	R14,R15,Rnew	Resistor .50 ohm 1/4W	Mouser ME291-0.5
30	1	R16	Resistor 13k ohm 1/4W	Mouser ME271-13K
31	1	R17	Resistor 470 ohm 1/4W	Mouser ME271-470
32	5	R18-R21,R23	Resistor 10k ohm 1/4W	Mouser ME271-10K
33	1	R22	Resistor 100 ohm 1/4W	Mouser ME271-100
34	2	SW1,2	Switch, Reed SPST	Digikey HE500-ND
35	2	U2,U1	IC HV5530PJ Supertex	Arrow Electronics Inc.
36	1	U3	IC MAX771CPA	Maxim
37	1	U4	IC 78ST205HC	DigiKey 78ST205HC-ND
38	1	U5	IC PIC16F877 (programmed)	Arrow PIC16F877-20/L
39	0 (1)	U6 (option)	IC MAX232A	DigiKey MAX232ACPE-ND
40	1	U7	IC DS18B20 (modified w/ pigtail)	Maxim
41	1	Y1	Crystal 20mhz	Mouser 520-HCA2000-20
42	4	GPS	Nylon standoff 1/2" #4	Mouser 561-L4.50
43	1	MAGNET	Magnet, Alnico, ROD 1.75 x .250	Bunting Magnetics
44	1	AC Adapter	Cincon Switcher PS 12VDC 15W	Mouser 418-TR1512
45	10in	COLONS	Wire, Piano, Steel 0.032”	Hobby Shop

46	18in	COLONS	Tubing, Teflon 18ga clear	JT&T J-3645
47	1	GPS	adapter, MCX to BNC female	Resonant
48	1	GPS	GPS receiver, Motorola Oncore	Resonant
59	1	GPS	Antenna, GPS receiver	Resonant
50	8in	COLONS	Wire, 26ga tinned copper	OK R26B1000

items listed below are referenced to the separate enclosure kit

43	6	ENCLOSURE	Screw #4 x 1/2, Round Brass	Copper State
52	1	ENCLOSURE	Custom enclosure (optional)	NIXISAT
53	4	ENCLOSURE	Screw #6 x 5/8, Round Brass	Copper State
54	4	ENCLOSURE	Feet, Rubber	Western Rubber
55	6	ENCLOSURE	Washer, small Flat #6	Copper State
56	1	ENCLOSURE	Eyelet, Brass .125 (temp sensor)	Copper State

Assembling and finishing the wood base.

The enclosure and base offered along with the NixiSat electronics kit contains all the materials necessary to assemble a functional clock. The BNC to MCX adapter has been inserted into the base for shipment. Grasp it, and pull lightly while turning to remove it. Do not use tools to grasp the receptacle. It must be removed prior to the sanding and finishing steps.

Four rubber feet, along with four #6 x 5/8 wood screws are included to secure the feet to the underside of the base. Measure 3/4 of an inch from each edge, and mark the position for drilling. Drill the four mounting holes using a 3/32 drill bit to a depth of 7/16 of an inch. Be careful not to exceed the depth and accidentally drill through the base.

Insert the brass eyelet into the pre-drilled temperature sensor hole on the underside of the base. If the temperature sensor wires have already been installed for testing, it must be removed before continuing with the PCB mounting.

Place the completed NixiSat clock electronics PCB onto the base, and mark the six mounting hole locations. Take care in centering the PCB on the stepped platform base. Then remove the PCB and drill the six mounting holes using a 3/32 drill bit to a depth of 1/2 inch.
The 3/32 bit is slightly oversize to the six #4 wood screws provided in the kit. The oversized holes will eliminate any chance of splitting the wood stepped base at the outside edges.
Six stainless washers are included as a spacer to separate the PCB from the wood base.

The upper stepped base and lower platform have not been sanded before their assembly.
Remove the six steel screws securing the two pieces together, and separate the pieces.
Both pieces must be individually sanded before finish is applied.

I begin by hand sanding each piece using 220 grit paper with the sandpaper placed on a flat surface, and always sanding with the grain. The edges are sanded using a machinists block to hold the piece perpendicular to the surface to achieve a square edge.
After coarse sanding with 220 grit, I repeat the process using 320 grit fine paper. Finally I check the squareness of the pieces. Re-sand them if necessary.

Finishing can be as easy as spraying on a clear polyurethane finish and allowing it to dry. Then reassembling the base. It depends on how “detail oriented” you are.
If you would like to achieve a very fine finish as a compliment to your work, it will take some time and effort. Some builders may already have their own finish process. Here’s how I do it:
Following a careful sanding regimen to ensure all edges are perfectly square and flat; I apply Deft clear gloss Lacquer using a brush. The lacquer application is repeated ten times on each side of the wood. Give approximately 1 hour between each application. The finish is thick, and literally built up like a candle. A full two weeks are allowed for the lacquer to cure before I begin with sanding. If you want to add more coats to the finish, be sure to apply it within a day of the last application, otherwise it will not bond properly. You will need to sand the surface and break the glossy finish seal or any added layers may chip during the final sanding process.
A long cure time is needed because of the heavy buildup, and the lacquer will “pull” into the grain after the lengthy sanding process is complete; ruining all your hard work.

Assuming you've achieved the depth of finish you want, and the finish has properly cured, begin sanding the top and bottom of each piece using 220 grit sandpaper placed on a flat surface. Sand with the grain, and avoid pushing the wood in a way that will thin the edge or corner finish. Alternately, you can wet sand the large surfaces using a 150 grit drywall screen installed into an electric orbital sander. Be sure to dip the sanding screen into a shallow pan of water (cookie sheet) frequently. The water keeps the lacquer from clogging the sanding pad, and marring the sanded face with debris. Apply plenty water to the working surface with a wet rag while working.

The edges of the platform and base can be sanded using a machinist block to align the board top/bottom side perpendicular to the sanding surface. Start with 220 grit until the edge is continuous (all the sealed glaze is removed), then change to 320 grit wet sanding to complete the process.
After all sides and edges are sanded and smooth, buff the lacquer finish with 0000 grit steel wool to remove any visible sanding marks. Again, work with the grain.
Last, reassemble the two base pieces and tighten the screws. Alternately, CA glue can be applied sparingly between the two mating surfaces before tightening the screws. Use a clean cloth to buff the unprotected surface to a moderate shine. Then, apply a fine (non abrasive) Carnuba wax to the surface, and buff to a fine finish using another clean cloth.

Troubleshooting.

After applying power, the display is dark, and the LED flashes at 1pps:
Check the components of the high voltage circuit. U3, Q1, L1, D1, D2, C2.
Verify the component polarity is correct, and there are no solder bridges.
Also check the resistors in the HV circuit.

After applying power, the display is dark, and the LED does not flash:
Check fuse F1, the components around the MCU at U5, Y1, C11, C12.
Check for presence of 5V using schematic for reference.
Verify the polarity of C1, C6.

Multiple digits are illuminated in each tube, or not all tubes are lighted.
Damaged or defective Nixie Tube, solder bridges involving U1, U2. OR U1, U2 are damaged.

The clock appears operational, but only shows the timer on the right four digits.
No signal. The clock was never able to initialize. A valid satellite signal is required upon startup. If none is available, then the clock cannot synchronize the nixie tube display.

When the clock was powered off, it required 30 minutes to begin displaying time again.
Check battery B1, it should read about 3v in circuit. Also check your antenna placement.

Warranty.

NixiSat is guaranteed to be free from defects in materials for a period of one (1) year from the date of purchase. Allowances for problems shortly after the warranty expiration may be considered on a case-by-case basis at the discretion of the manufacturer.
Failures caused by damage during assembly, incorrect assembly, misuse, or alteration from the original application; are not covered under the warranty.

I have been designing and building high precision, quality, Nixie Tube Clocks since 2000.
In the event of problems with assembly, or if you have questions, please call or email.

Again, I Thank you.

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