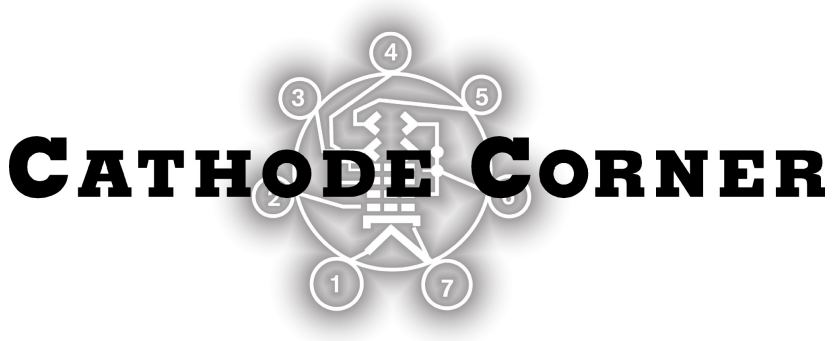


SCTV Scope Clock Kit
Assembly and User Manual

Table of Contents

Introduction

The Manual

This user manual is divided into sections. Not all sections are relevant to all users. The Theory of Operation section is provided for the curious and may be skipped, as it is not necessary to know exactly how the clock works in order to make it work.

The Clock

The SCTV scope clock is an electronic clock that displays the time and more on a small oscilloscope tube using artfully drawn numbers. While most digital clocks use a seven-segment display optimized for low cost and ease of manufacture, the SCTV is optimized for aesthetic appeal.

The clock is supplied with a laser-cut Plexiglass cabinet.

Contacting Cathode Corner

If you are having trouble assembling your clock, getting it to work, or you just want to talk with us about clocks, you may contact Cathode Corner in any of the following ways.

Visit Cathode Corner on the Web at www.cathodecorner.com

Phone: 520-989-1491

Email: david@cathodecorner.com

Mailing address:

Cathode Corner
2560 E Ross Pl
Tucson AZ 85716
USA

Theory of Operation

Power Supply

The power supply is of the switching type. 12V DC power is switched through a high-frequency transformer to produce the necessary operating voltages. The power supply uses a unique topology to drive the CRT and the logic circuits.

The most common types of switching power supplies are flyback and forward converters. A forward converter uses the power driven when the primary switch is conducting, and multiplies that voltage by the turns ratio. A flyback converter stores energy in the transformer while the switch is on, then transfers that energy to the secondaries when the switch turns off.

This supply is both of these types in one - its outputs are all fed through voltage doublers, so that both halves of the cycle are used. This is done to allow the voltage multiplier for the high voltage negative supply to be regulated as well as the lower-voltage supplies.

The reason is that a forward converter develops a secondary voltage proportional to the turns ratio, whereas a flyback converter develops a secondary voltage proportional to the duty cycle. These two functions are different with regard to load, so a regulator for one will not be well regulated the other way.

The switching IC is a National Semiconductor LM2586. It interrupts the current flowing through the primary winding of T1 at a rate of 100 Kilohertz, and controls the duty cycle of this interruption to provide regulated voltage outputs.

Moving on to the regulator, the deflection voltage is the one actually regulated. The other voltages follow this voltage in proportion to their turns ratios. The regulator samples the deflection voltage through a resistive divider.

The low-voltage supply provides -5V to the deflection amplifiers. The +5V supply is provided by a linear regulator, because the switching supply doesn't start up with a solid 5V to bring up the Teensy computer reliably. This was an engineering change after problems wee found in a few of the kits sent to early customers.

The filament supply is straight AC, since that heats up a wire as well as DC does. An AC-coupled connection to the filament supply feeds a doubler which powers the optoisolator used for the modulation signal. This optoisolator is a special logic-level photodiode unit with sub-microsecond switching time.

The Z modulation supply provides enough voltage to switch the grid on and off (~60VDC) and enough current to do so quickly. A simple transistor switch controls the grid.

CRT Beam circuits

The CRT requires the correct DC voltages at all of its electrodes in order to form a bright yet small spot on the screen. The cathode may be considered as the starting point of this system.

The grid requires a negative voltage relative to the cathode. This voltage is adjusted by the Intensity control.

Blanking is active whenever the beam is being moved from one location to another. The computer tells the blanking circuit when to blank the beam. Blanking is accomplished by switching the grid to a much more negative voltage by the Z modulation circuit to cut off the beam.

The focus anode requires about +500 volts with respect to the cathode. This voltage is adjustable over a wide range to accommodate different CRTs with different focus voltage requirements.

The second anode requires about +1500V with respect to the cathode. This voltage is adjusted by the Astigmatism control, which changes the second anode voltage with respect to the voltage on the deflection plates, since the deflection plates have the secondary effect of acting as focusing lenses, first in one axis then the other axis. The magnitude of this effect depends on the voltage on the second anode relative to the average DC voltage on the deflection plates.

Deflection Amps

The deflection amps are push-pull Class A amplifiers, which strive to keep the voltage at the transistor's emitter at 0.6V below its base by changing the current through the transistor. This in turn changes the voltage at the collector, according to Ohm's Law. It's not a real fast circuit, but it works for clock use.

Numeric display

The digits are formed from circles, lines and arcs. The basic method of drawing a circle on a CRT is called a Lissajous pattern. This is something that every student of electronics learns about early in school, then promptly forgets. The only other known use of this numeric display technique is in the HP 1600 logic analyzer.

A Lissajous pattern is displayed by applying sine waves of different phases to the X and Y deflection plates of a CRT. A sine wave on the Y plates and a cosine wave on the X plates give a circle. If the phase difference is zero, then the circle collapses to a slanted line. If Y=0, the line is horizontal, etc.

Each character is made up of segments. Each segment has a center, a size code, and a dwell time. The center places the segment within the digit's cell space. The size code indicates the X and Y radii of the circle/ellipse, as well as if it will be a line (x=cos, y=cos) or a circle (x-cos, y=sin). The dwell time is longer for larger circles to make the intensity appear consistent. An arc code tells the circuitry which octants of the circle to blank out to make an arc, such as in the number 2.

Computer program

The software running on the computer is written in C for the Teensy, using the Arduino environment. The program executes a main loop about 50 times per second, in sync with the mains frequency to prevent electromagnetic interference from being visible in the display. Each display screen is built of a draw list, with some extra parts that are drawn by special code such as the Tetris bucket and pieces, the Pong paddles and the clock hands. Other code monitors the USB port for GPS data messages, and the encoder knob for mode changes.

The code is open source. It resides at www.github.com/nixiebunny/SCTVcode

Optional GPS Input

An optional USB GPS connector allows the clock to take its timekeeping reference from the GPS satellite constellation. The firmware automatically connects to the GPS receiver as long as it emits an NMEA data stream at 4800 baud. The internal clock chip is reset to match GPS time every second, so that the time will still be correct if GPS reception is lost.

PC Board Assembly

Getting Started

Make sure that you have the following major parts:

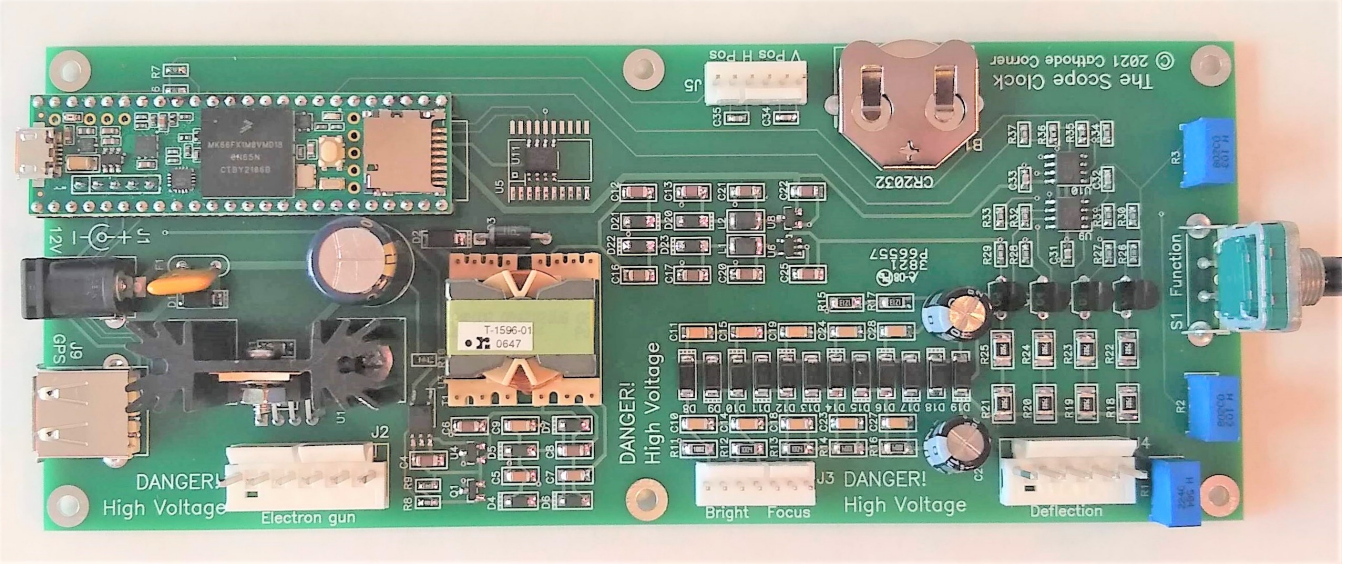
SCTV printed circuit board (PCB) with surface-mount parts already installed
Anti-static bag with thru-hole PC board components
Ziploc bag with CRT and pot wiring parts
Ziploc bag with hardware
Seven laser-cut plastic pieces (coated in paper)
3RP1-A CRT
12V wall power adapter

If anything is missing, please contact Cathode Corner for assistance.

The PCB is provided with all the surface-mount parts already soldered to it. These parts are rather difficult to solder without a lot of experience. The easy work is left for you to do.

Board photo

A photograph of the top side of the assembled board is shown below. Refer to this photo to see how the parts fit.



Tools needed

Soldering iron, fine tip, adjustable temperature preferred
Solder, high quality lead-free or leaded .031" diameter or smaller, rosin or no-clean flux
Small diagonal cutters
Small long-nose pliers
#1 Phillips screwdriver

Parts List

The parts supplied in the kit are listed below in order of installation. 'Step' refers to the assembly sequence. 'Marking' refers to any part number printed on the part itself. The assembly instructions begin after the parts list. Note that the only parts that may be confused are the three trim pots. There are two pots with the same value and a third with a different value, in case the numbers are too difficult to read.

PC Board parts

Step	Qty	Marking	Description	Designators
1	1	small	Battery contact	B1
2	1	big	Battery holder	B1
3	1	P6KE18A	Diode, TVS	D3
4	1		USB jack	J9
5	1	504	Trim pot 500K	R1
6	2	103	Trim pot 10K	R2, R3
7	2	black	Socket strip 24 pin	for U2
8	1	black	Socket strip 5 pin	for U2
9	1		DC power jack	J1
10	1		Header 6 pin .10"	J5
11	1		Header 7 pin .10"	J3
12	4	MPSW42	Transistor NPN	Q2-Q5
13	1		Header 5 pin .156"	J4
14	1		Header 6 pin .156"	J2
15	2	1uF	Capacitor 1uF 400V	C29, C30
16	1	1.85A	Fuse, PolySwitch	F1
17	1	1000uF	Capacitor 1000uF 25V	C3
18	1		Rotary encoder	S1
19	1	T-1596-01	Transformer	T1
20	1		Heat sink	for U1
21	2		Screws #4x1/4”	for U1
22	1		Screw, 4-40x5/16”	for U1
23	1		Thermal pad	for U1
24	1	LM2586T	Regulator	U1
25	1		Lockwasher, #4	for U1
26	1		Hex nut, 4-40	for U1
27	1	7805	Regulator IC with cap.	U7
28	1	black	Wire, 1.5” long	for U7
29	2	black	24 pin strip	for U2
30	1	black	5 pin strip	for U2
31	1	Teensy 3.6	Computer	U2
32	1	CR2032	Battery	B1

Step by step guide

Since the clock has a transparent case, the effort you put into making sure that all the parts are installed neatly will be reflected every time you or someone else looks at the clock. For this reason, it is recommended that you take your time to ensure that every part is straight before soldering the second pin. You can reheat a pin and move the part with your fingers to align it properly. This is the method used for the factory-assembled clocks.

0) Check that the surface-mount part U8 is not installed. If it is installed, then remove it by heating the side with two legs using a blob of solder, then prying it up a bit. Heat the leg on the other side and pry it up a bit. Repeat until the part is off the board. Remove the excess solder so that the pads are mot shorted together.

1 and 2) Install the small round battery contact in the center of the B1 footprint, then install the large battery holder on top of it, with the open side facing the edge of the PC board. Solder them both.

3) Install and solder the P6KE18A diode D3 next. Bend the legs to a 90-degree angle first. Install the diode with its striped end over the stripe shown on the board. Bend the legs apart at a 30-degree angle to hold it in place while you solder it. Trim the excess leads with diagonal cutters.

4) Install the USB jack J9. Snap it into place, then be sure that it is straight instead of tilted. Solder one of the big tabs first. Check that it's still straight. Reheat and straighten it if not. Then solder the other big tab and the four small pins.

5-6) Install the 500K trim pot R1 (marked 504) and the 10K trim pots R2 and R3 (marked 103). Spread the legs on each of these pots after installing. Solder the center pin of each pot, then reheat this pin while pressing the pot against the board, to ensure that it fits tightly against the board. Check also for square alignment to the board to keep a neat appearance. After they are aligned, solder the remaining pins. Trim the excess lead length.

7) Install and solder the long socket strips for U2 next. Place both strips in the board, turn it over and solder one pin in the center of each strip. Then turn the board over and make sure that the strips are straight. Then solder the remaining pins.

8) Install and solder the short socket strip in the middle of the U2 footprint. Again, solder one pin first, make sure it's straight, then solder the remaining pins.

9) Install the DC power jack J1. Solder the center pin, then reheat it and align the block so that it is square and flush. Solder the other two pins.

10-11) Install the two small headers J3 and J5. Be sure that the plastic tab is towards the center of the board. Solder one pin on each then check that they are fully seated. Reheat that pin while pressing down on the header if needed to make it flush with the board. Solder the remaining pins.

12) Install and solder the MPSW42 transistors Q2-Q5 next. Cut them from the tape strip with the leads as long as possible. Be sure to orient these parts with the flat side as shown on the board. Spread the outer legs 30 degrees to hold them in place while soldering. Check and adjust the parts' alignment after soldering the center pin of each before finishing the soldering work. Trim the excess lead length.

13-14) Install the two large headers J2 and J4. Be sure that the plastic tab is towards the center of the board. Solder one pin on each then check that they are fully seated. Solder the remaining pins.

15) Install and solder the 1uF electrolytic capacitors C29 and C30 next. Observe polarity! Note that the Japanese manufacturers mark the negative lead of the electrolytic capacitors, but the PC board marks the

positive hole with a + sign. The positive leads of the capacitors are longer. So put the long leads into the plus holes. Bend the legs apart to hold them while soldering. Trim the excess lead length.

16) Install self-resetting fuse F1, bending the legs apart to hold it in place. Solder it. Trim the excess lead length.

17) Install and solder the 1000uF capacitor C3 next. Put the long lead into the hole near the + sign. Trim the excess lead length.

18) Install the rotary encoder S1. It snaps into place in the two large holes. Use care when snapping it into place, so that all the small legs go into their holes. Ensure that it is aligned perpendicular to the board, then solder it.

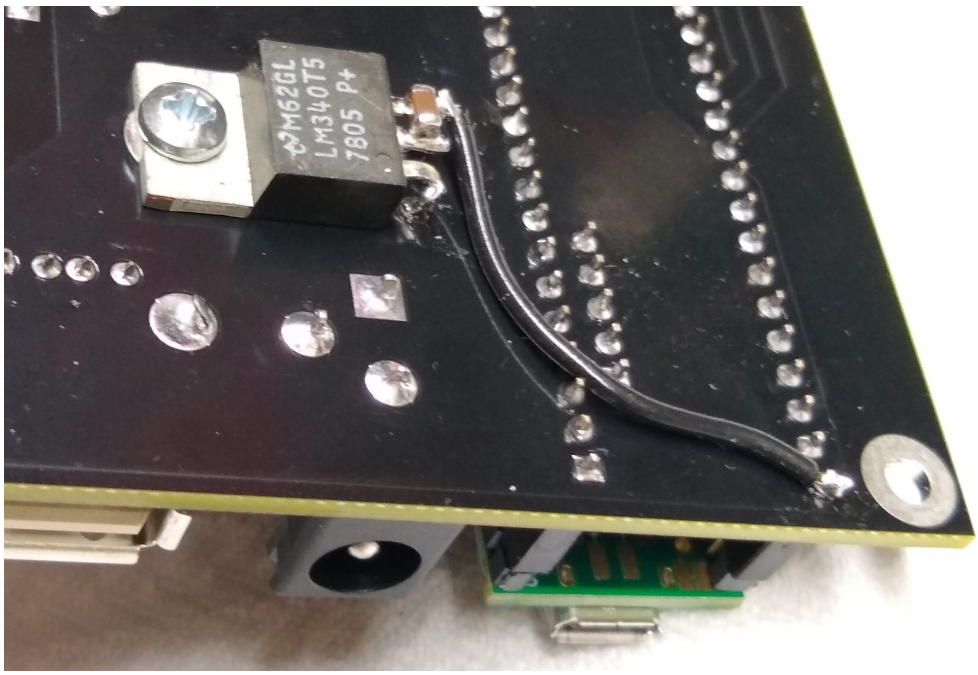
19) Install T1 next. You may have to straighten the leads to get them all to go into their holes. Make sure it sits straight on the board, which may require work since one corner tends to sit higher than the others due to the wires underneath it. Solder one pin on each side, then adjust it, then solder the remaining pins. Trim the excess lead length.

20-21) Mount the heat sink for U1 using the two #4x1/4" self-tapping screws. Orient it with the notch towards the board and the flat surface at the top. Blow all the metal filings off the board.

22-26) Put the 4-40 x 5/16” screw through the top hole of the heatsink from the capacitor side. Place the beige thermal pad onto the screw. Place U21 into the holes in the board and onto the screw, while holding the screw in place. Place the lockwasher and nut on the screw. Tighten the screw snug but not real tight.

Solder the pins on U21.

27) A late change to the design has added a 7805 regulator IC to the bottom of the board, to improve reliability of the power-on sequence. Remove the heat sink screw closest to the end of the board. Install the 7805 regulator IC under this screw, with the legs over the F1 pads. Bend the leg without the capacitor down so that it contacts the top of the F1 lead. Solder this pin to the F1 lead.



28) Strip 1/8” of insulation from each end of the black wire. Solder one end to pin 3 of the 7805, the end leg with the capacitor. Solder the other end to pin 48 of U2, the Teensy pin nearest the corner of the board.

29) Press the two 24-pin strips into the socket strips at U2.

30) Press the five-pin strip into the socket at J8.

31) Place the Teensy on the pin strips at U2. Orient the Micro-USB end of the Teensy with the edge of the board.

Solder the two 24-pin strips and the five-pin strip to the Teensy holes. Use care, as there isn’t much room to work on the Teensy and it has many small parts that don’t want your soldering iron to touch them. You may prefer to solder a few pins first, then remove the Teensy from the board and solder the rest of the pins. (Apologies for making you do this work, the Teensys with pins were all sold out.)

31) Remove the CR2032 battery from its package by trimming away the paper area with scissors, then insert it + side up into the B1 battery holder.

PC board assembly is complete.

Cabinet Assembly

Introduction

This section describes the wiring of the clock controls and CRT, and the assembly of the clock into the laser-cut Plexiglas cabinet. The wiring harnesses are made first, then the clock is assembled.

The wiring parts are packed in a separate bag. The wires are provided with pre-crimped terminals to simplify assembly and assure durable connections. Do NOT insert the terminals into the connector shells until instructed. If a terminal is inserted into the wrong shell hole, it may be removed by gently pushing down with a 1/8" slot screwdriver blade on the little tang visible through the slot in the shell while simultaneously pulling the wire gently out of the shell.

Each of the four control pots is soldered to a tiny cat-shaped PC board. Three wires from each pot are terminated in two Molex connectors. The CRT socket has ten wires soldered to it, which are terminated in two Molex connectors.

The cabinet assembly is the next step. The cabinet is made of seven pieces of laser-cut acrylic plastic. The clock base is two identical pieces that are sandwiched together for added rigidity. The base holds the PC board, the front and rear faces, and the cover. A bag of cabinet hardware is used to assemble the cabinet.

The PC board is first mounted to the base assembly, then the front and rear faces are added to this. The pots are installed and plugged in. The CRT socket is installed, the CRT clamp ring is installed, and the CRT is installed. At this point, the clock is plugged in and tested. Then the CRT is aligned with the case and its clamp tightened.

Next, the rear cup and cap pieces are installed (the tricky part). The cup is a small flexible piece that protects the neck of the CRT. The cap is a flat piece that fits into the end of the cup. The front and rear faces hold the controls and the CRT. Finally, the cover is installed over the clock.

Tools needed

1/16” hex driver or ball driver
Slip-joint pliers
5/16” wrench or nutdriver
#1 Phillips screwdriver
#2 Phillips screwdriver
Small file
Roll of duct tape or Gorilla tape (for peeling paper from laser-cut plastic)

Cabinet wiring parts

There is a bag of cabinet wiring parts provided, the bag with the wires. Check that all parts listed below are present.

Separate the wires carefully by length, as there are six different groups of wires that are soldered to different things. The pot wires have small gold Molex pins, while the CRT socket wires have large tin Molex pins.

2	103L	10K pots	Pos
1	504L	500K pot	Brightness
1	105L	1M pot	Focus
4	Kitty	Pot PC boards	
3	H pos	6" wires: brown, red, orange	
3	V pos	4" wires: yellow, green, blue	
3	Focus	8" wires: brown, red, orange	
3	Brightness	7" wires: green, blue, violet	
1	white	CRT socket	
5	CRT defl	11.5" wires: blue, violet, grey, black, white, with large pins	
5	CRT gun	7.5" wires: brown, red, orange, yellow, green, with large pins	
10	3/16” dia	½” long pieces of heat shrink tubing	
1		Shell, Molex, 6 pin .156”	P2
1		Shell, Molex, 5 pin .156”	P4
1		Shell, Molex, 6 pin .10”	P5
1		Shell, Molex, 7 pin .10”	P3

Control Wiring

Each of the four control pots is a blue square with a white shaft. The two pots with long shafts are the H position and V position pots. Their shafts need to be cut to length with diagonal cutters. The place to cut is ¼” from the end of the shaft, about where the flat spot begins. After cutting the shafts, clean the burrs off the end with a small file.

Each of the pots is soldered to a tiny, round PC board with cat ears. The pot is inserted into the board on the side with the white square. This work is done most easily by putting two pots in a vise, one near each end of the jaws with the pins pointing skyward. Place a cat PC board over the pot with the white square down, so that the square is facing the pot. Solder the three pins, then trim the leads flush. Repeat for the other two pots.

Each pot has a small number identifying its value. Be sure to use the two labeled 103L (with the cut shafts) for the H pos and V pos controls. 504L is the Brightness pot. 105L is the Focus pot.

V pos pot board

Find the three 4” long yellow, green and blue wires. Strip 1/4" of insulation off the free end of each wire. Tin the bare ends of the wires with solder, being careful to remove any blobs.

Mount a kitty board with a 103L pot in the vise with the pot facing up and/or away from you. A 45 degree angle works well if your vise is adjustable. Insert the yellow wire into the hole marked 1, with the insulation on the pot side of the board. Solder it from below/front.

Install the green wire in hole 2 and solder it. Install the blue wire in hole 3 and solder it. Trim the soldered wires with diagonal cutters. Set aside this wired board.

H pos pot board

Find the three 6” long brown, red and orange wires. Strip 1/4" of insulation off the free end of each wire. Tin the bare ends of the wires with solder, being careful to remove any blobs.

Mount the other kitty board with 103L pot in the vise. Insert the brown wire into the hole marked 1, with the insulation on the pot side of the board. Solder it from below/front.

Install the red wire in hole 2 and solder it. Install the orange wire in hole 3 and solder it. Trim the soldered wires with diagonal cutters. Set aside this wired board.

Brightness pot board

Find the three 7” long green, blue and violet wires. Strip 1/4" of insulation off the free end of each wire. Tin the bare ends of the wires with solder, being careful to remove any blobs.

Mount the kitty board with 504L pot in the vise. Insert the violet wire into the hole marked 1, with the insulation on the pot side of the board. Solder it from below/front.

Install the blue wire in hole 2 and solder it. Install the green wire in hole 3 and solder it. Trim the soldered wires with diagonal cutters. Set aside this wired board.

Focus pot board

Find the three 8” long brown, red and orange wires. Strip 1/4" of insulation off the free end of each wire. Tin the bare ends of the wires with solder, being careful to remove any blobs.

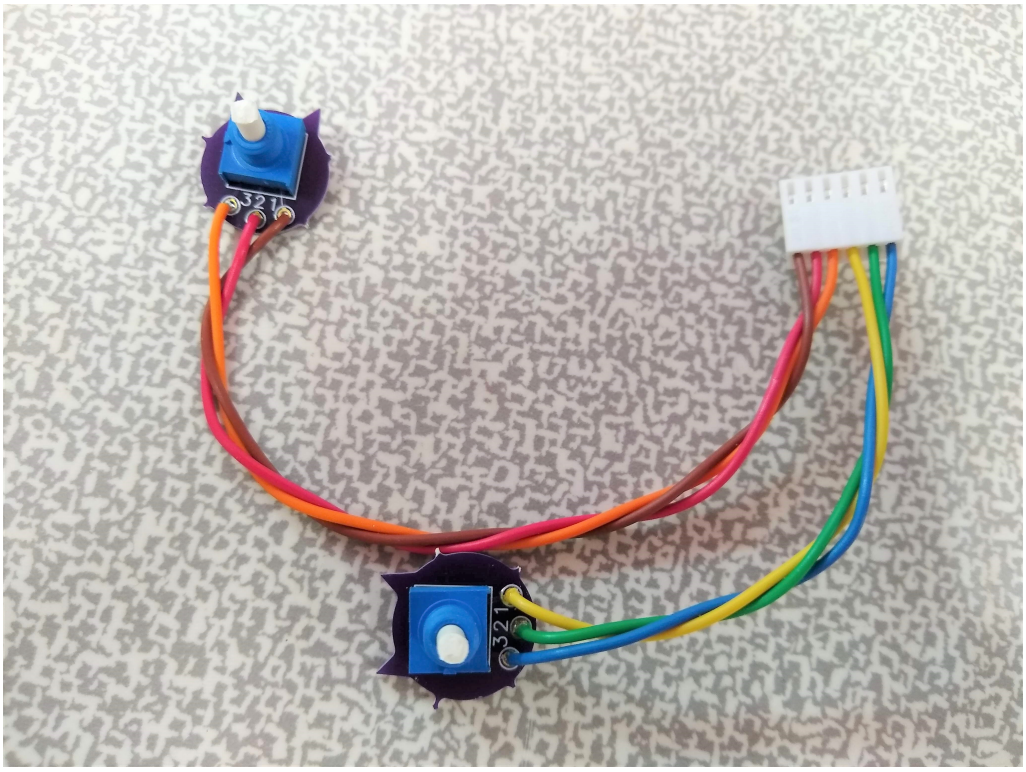
Mount the remaining kitty board with 105L pot in the vise. Insert the orange wire into the hole marked 1, with the insulation on the pot side of the board. Solder it from below/front.

Install the red wire in hole 2 and solder it. Install the brown wire in hole 3 and solder it. Trim the soldered wires with diagonal cutters. Set aside this wired board.

Position pot connector

On each of the four pot boards, twist the three wires around each other to form a twisted triad. See the picture below. Bend the wires down around the pot board so that they exit parallel to the board.

Find the small 6 pin header block. Orient it so that the large holes are facing you, and the small slots are at the top. This places pin 1 at the left end. You will insert the little terminals into this block with the tiny tab facing up. The pins need to be inserted with the pin aimed up slightly so that it will slide into an internal groove in the block. Don’t force it if it won’t slide in; pull it out and try again at a different angle. The pin will snap into place when properly guided in and seated.

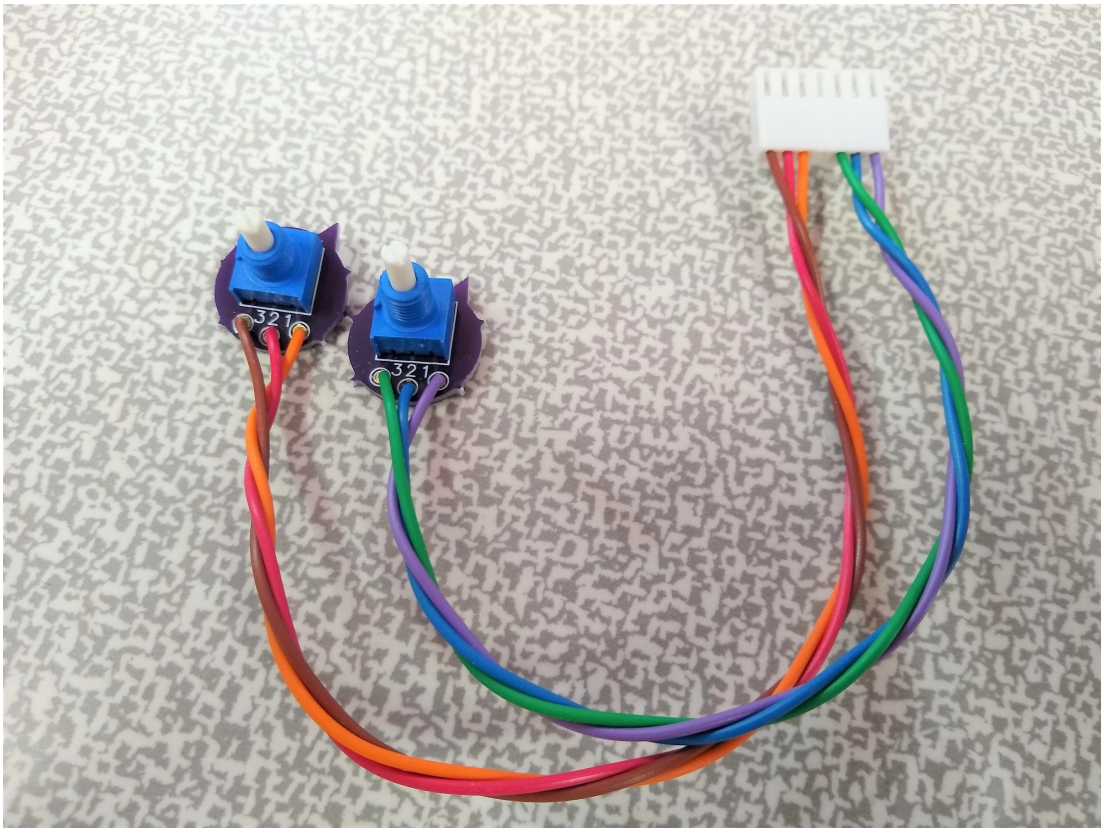


Insert the little terminals into this block as shown in the chart below.

Pin	Wire
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue

Bright/Focus pot connector

Find the small 7 pin header block. Orient it so that the large holes are facing you, and the small slots are at the top. This places pin 1 at the left end.



Insert the little terminals into this block as shown in the chart below.

Pin	Wire
1	Brown
2	Red
3	Orange
5	Green
6	Blue
7	Violet

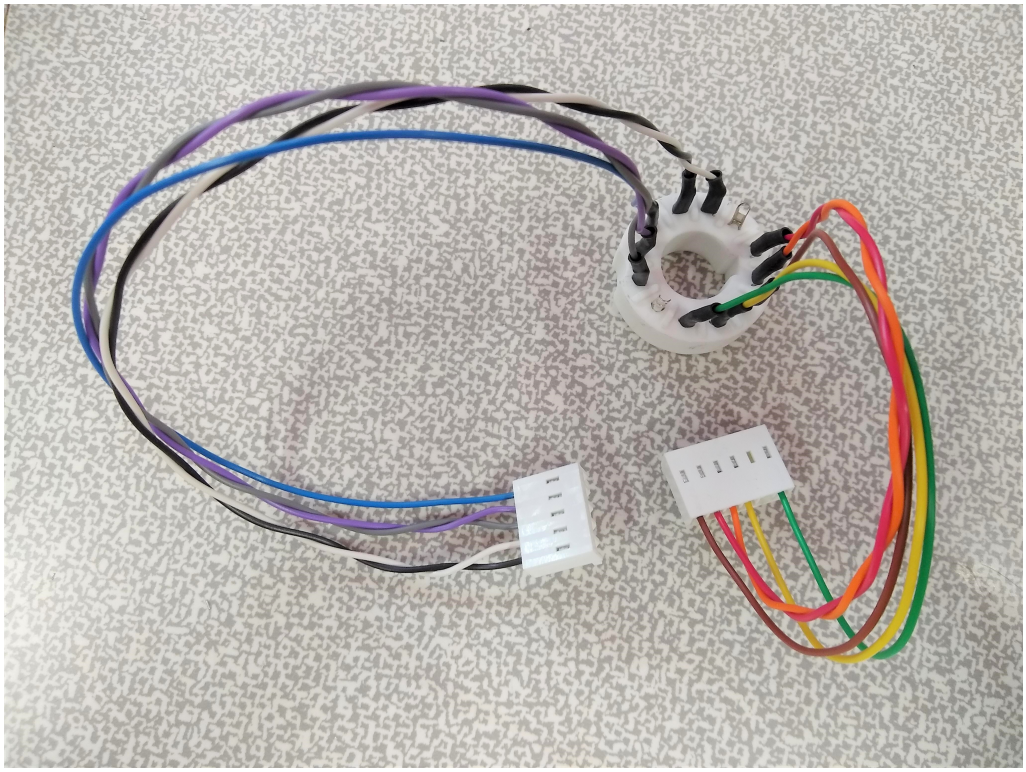
CRT socket wiring

The kit is supplied with 10 different colored pieces of wire, each with a large Molex pin crimped to one end. Strip 1/4" of insulation off the unterminated end of each wire.

Clamp the white CRT socket in the vise with the terminal pins facing you and pin 2 pointing down. There is a pin number molded into the ceramic next to each pin. Pin 1 is to the left of the notch in this orientation, and pin 12 is to the right of the notch.

Solder the wires to the CRT pins per the table below. Bend each wire's bare end into a V shape and hook it through the socket terminal, then squeeze it around the terminal, to ensure a tight mechanical connection. Start with pin 12 and orient the wires such that they curl downward from the CRT socket. Rotate the socket in the vise 180 degrees before soldering pins 6-10, so that the pin being soldered is always near the bottom.

Color	CRT Pin
Red	12
Orange	1
Brown	2
Yellow	3
Green	4
Grey	6
Violet	7
Blue	8
Black	9
White	10



Slide one piece of heat-shrink tubing over each wire on the CRT socket, making sure that each piece is seated against the socket. Shrink all the tubing pieces onto the CRT socket terminals using a match or lighter for heat, or a heat gun if you have one. It is best to hold the socket assembly by the wires when doing this, so that you don't burn your fingers. Don't worry, the heat shrink tubing is flameproof.

Clamp the socket in the vise again, then twist together the two wires in each of the following three pairs of CRT wires. Twist them by holding both wires out at a 20-degree angle from each other, then passing one over the other repeatedly until they're in a single cable with about 2 twists per inch.

Violet-Grey
White-Black
Red-Orange

Plug the Molex pins into the large 5-pin and 6-pin connector shells per the table below, using the photograph above for reference. Again, hold the shell with the large opening facing you and the slots at the top. In this orientation, pin 1 is on the left end.

Shell	Pin	Color
6 pin	1	Brown
6 pin	2	Red
6 pin	3	Orange
6 pin	4	Yellow
6 pin	5	-
6 pin	6	Green
5 pin	1	Blue
5 pin	2	Violet
5 pin	3	Grey
5 pin	4	White
5 pin	5	Black

Plexiglas Cabinet Parts

The cabinet is supplied as seven pieces of plastic, and a bag of hardware. Check that all the pieces are present. Sort out the hardware by size into a muffin tin or similar.

1		Front face with large CRT hole
1		Rear face with smaller hole
2		Base pieces
1	Cup	Small flexible sheet
1	Cap	Rounded square
1	Cover	Large flexible sheet
2	6-32x3/8	Screw, Phillips pan head
1	6-32x3/4	Screw, Phillips pan head
3	6-32	Hex nut
6	4-40x5/16	Standoff, aluminum
6	4-40x3/16	Screw, Phillips truss head
6	4-40x3/8	Screw, Phillips truss head
15	4-40x1/2	Screw, Phillips truss head (2 are spares)
15	4-40	Square nut (2 are spares)
1		Clamp, round, 1.5" diameter for CRT
1		Felt strip, 1/4"x10"
4	¼”	Pot nuts
4		Small knobs
1		Big knob
1	brass	Shaft adapter

Laser cut plastic pieces

The scope clock case is made of seven pieces of laser-cut acrylic plastic (commonly called Plexiglass or Perspex). These plastic pieces are shipped with a protective paper coating on each side. This coating needs to be removed from the pieces just before assembly.

It’s not too hard to remove the paper from the solid acrylic pieces. Start peeling at one corner and pull it up slowly. The paper may tear at the corners, so you’ll need to circle back to get the stray bits of paper.

Removing the tape from the flexible pieces is more complicated. It is described later when this work needs to be done.

PC Board Mounting

The base is made of two identical rectangles with notched for square nuts. These pieces are to be stacked together to make one thick piece.

These two pieces are to be stacked together with the same orientation, i.e. the top of one is stacked on the bottom of the other. Examine the edges to see which is the top – the bottom edge is rougher than the top edge due to the nature of the laser cutting.

It's best to do this work in a particular order to retain cleanliness between the two base pieces.

Peel the paper off the top of one piece, set it aside, then peel the paper off the bottom of the other piece.

Press the clear sides of the two pieces together.

Press a square nut into each of the eight slots, starting from the top side (the slots are slightly wider at the top than the bottom).

Finally, peel off the paper from the top and the bottom of the stacked pieces.

Install a 3/8” screw into one of the holes in the base stack.

Screw a 4-40 x 5/16” standoff onto the screw.

Repeat for the other five standoffs.

After all screws are installed, tighten them snug with a #1 Phillips screwdriver and a 3/16” nutdriver or end wrench.

Place the SCTV PC board on the standoffs.

Install a 4-40x3/16” screw in each of the six holes in the PC board. Tighten these screws snug.

Peel the paper from both sides of the front face, the one with the large hole.

Place it on the encoder shaft with the three small holes lined up in front of the three trim pots.

Install two 4-40x1/2” screws into the two screw holes at the base.

Peel the paper from both sides of the rear face. Place it on the base so that the two USB jack holes line up with the Teensy and the USB jack. Install two 4-40x1/2” screws into the two screw holes at the base.

Pot Installation

See the photo on the next page to see how the pots are installed into the front panel.

Plug the 6 pin Molex plug with the two position pots into J5. Plug the 7 pin Molex plug with the focus and brightness pots into J3.

Place the V position pot, with the short yellow, green and blue wires, into the lower right hole in the front face. Orient it with the kitty’s ears up. There is a small bump on the front of the pot that will engage into the small hole next to the pot hole. Thread a pot nut onto the bushing, being careful to keep the nut straight so that it doesn’t get cross-threaded. Tighten the nut finger tight.

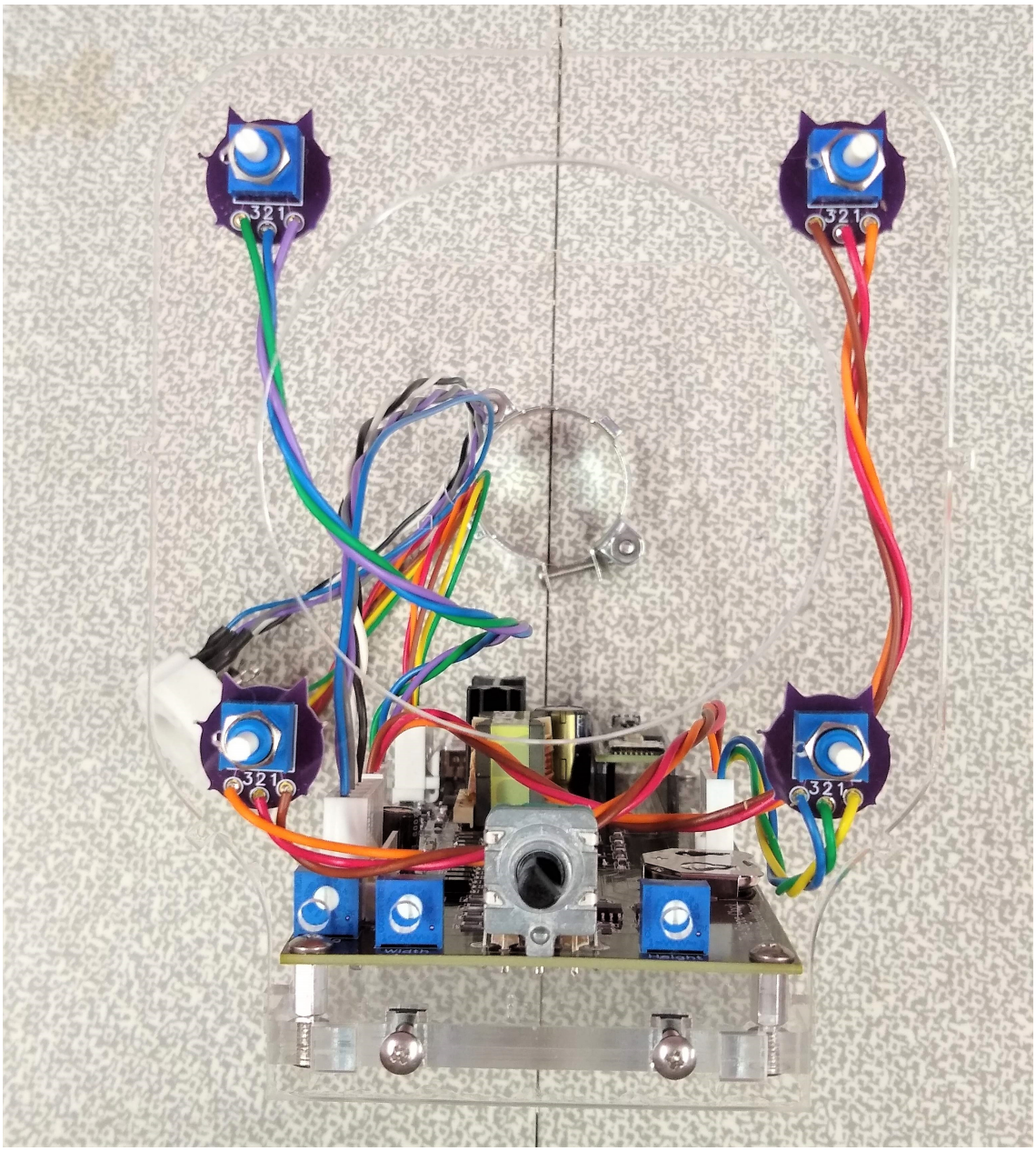
Place the H position pot, the other pot on J5, into the lower left pot hole in the front face. Thread a pot nut onto its bushing as above.

Place the focus pot from J3 with the brown, red and orange wires into the upper right hole in the font face. Thread a pot nut onto its bushing.

Place the brightness pot into the upper left hole in the front face. Thread the last pot nut onto its bushing.

Ensure that the wires from the pots to the board are not in front of the trim pots on the board edge.

Tighten the four pot nuts snugly with a 5/16” or 8mm nutdriver or wrench.



CRT wiring

The CRT fits through the front hole and is held in place at the rear by the round clamp. It must be rotated correctly to display the time right side up, with pin 1 down.

Pass the CRT socket wires through the hole in the rear face of the case.

Plug the 6-pin Molex plug into J2 on the PC board.

Plug the 5-pin Molex plug into J4 on the PC board.

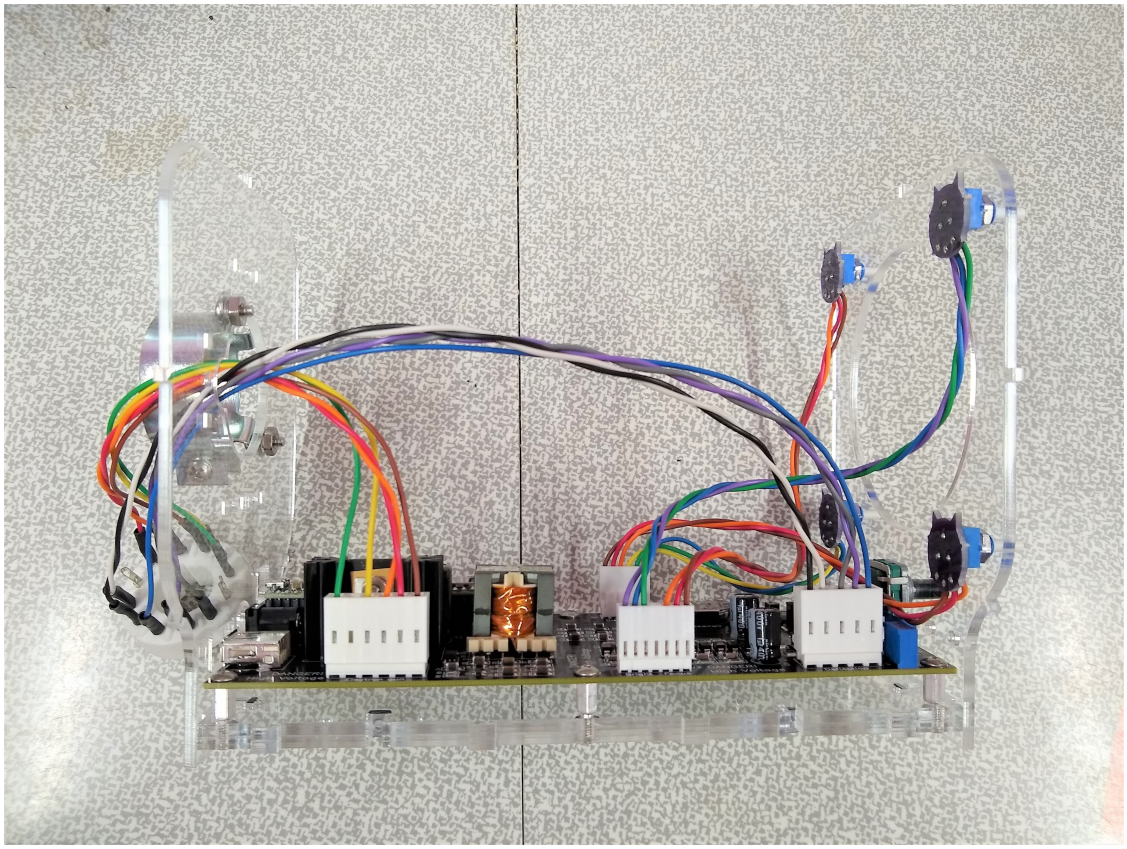
The wires will reside in the notch on the side of the hole after the clamp ring is installed in the next step.

The small end of the CRT is held in place with the clamp ring, which is bolted to the outside of the rear face. The 3/8" screws hold the clamp to the face, and the ¾” screw clamps the CRT neck in the metal ring. Assemble the CRT neck components in the following order:

The CRT neck clamp must be spread apart from its factory shape. Bend it evenly with your fingers to a larger diameter, so that there is 1/2" gap where the clamp screw goes. Now bend the two clamping tabs towards each other slightly with slip-joint pliers so that they are parallel to each other. Bend each of the two screw tabs and the other two tabs so they are perpendicular to the metal, so that they all lie flat on a table.

Install the 6-32x3/4" screw and nut into the clamping holes so that the nut is on the side closest to one of the screw tabs. Only thread the nut on a few turns, as the clamp needs to be loose.

While holding the CRT wires in the notch on the side of the rear face hole, hold the clamp ring to the rear face with the clamping screw towards the bottom. Install a 6-32x3/8" screw into the top clamp hole and through the rear face. Install a 6-32 hex nut on the screw inside the rear face. Repeat for the other clamp screw. See the photo below. Tighten these screws firmly while holding the clamp ring centered in the opening.



Felt Installation

The felt strip must be placed around the CRT, just behind the face, to make it fit snugly in the case.

Unpack the CRT from its box. HANDLE IT CAREFULLY! It is big and full of vacuum, so it is dangerous if dropped or broken. Set it back in its box when it is not being actively worked on.

Peel one inch of backing paper from one end of the felt strip. Take care to only peel the white paper, and not the clear adhesive, from the felt. This may require tweezers.

Stick the end of the felt to edge of the CRT just behind the face, in a direction that will allow you to easily rotate the CRT while pressing the felt onto it.

Peel the backing paper from the felt as you go, guiding the felt strip into place with two fingers as it makes contact with the CRT. If it starts going on crooked, peel it up and straighten it out as you go. When you have completed the circle, cut the felt strip to length so that the ends nearly meet but do not overlap.

CRT installation

Insert the CRT face-first into the front face from the rear. Insert the CRT base into the clamp ring, with pin 1 on the base towards the PC board. The felt may be a tight fit in the front face hole, so run your fingernail along the outside of the felt to compress it where it get stuck on the way into the hole.

Check that 1/16” of felt is protruding out from the plastic at the bottom of the CRT face. (The font panel may be tilted, so the bottom is a better reference than the top.)

Tighten the CRT clamp snugly with the CRT in this position. There will be a final adjustment later with the display on, so don’t put too much effort into the alignment now.

Fold a dish towel into a 3” x 6” or so rectangle, to use as a cushion for the CRT face. Place the clock face down on this cloth so that the face of the CRT can press firmly against the towel between the pot shafts.

Rotate the socket so that the key on the socket lines up with the key on the CRT, then press the socket down onto the pins. Some force may be required to do this. DO NOT press on the socket pins, as these are fragile and may break off. Press on the white ceramic only. You may not be able to seat it fully, but try to make the gap between CRT base and socket be less than 1/8” (3mm).

Check that the CRT wires are routed cleanly from the socket, through the rear face, to the PC board. The neatest appearance is with the gun wires below the deflection wires.

Knob Installation

Rotate each of the four pot shafts counterclockwise as far as possible.

Take one of the small knobs and adjust its setscrew out two turns with a 1/16” hex driver. Install the knob on one the pots, with the dot in the 7 o’clock position. This means that the hex driver will be in the one o’clock position, above and to the right of center. Tighten the set screw snug.

Repeat for the other three small knobs.

Place the brass spacer into the large knob. You will have to loosen the setscrew a couple of turns. Tighten the setscrew just enough to hold the spacer in place. Place the knob on the encoder shaft with the setscrew side facing the round side of the shaft. Check that it is pushed onto the shaft all the way. Tighten the setscrew snug.

Check that the big knob can be pushed in to hear a click, and that it springs back. If not, readjust its depth on the shaft to allow it to move in and out freely.

Initial Checkout

Before turning on the clock for the first time, inspect the bottom of the PC board for stray component leads that may be shorting together different pins. Also check for unsoldered pins. Clean off the flux if desired, using commercially available flux remover. (If you used no-clean flux solder, skip this step.)

Adjust all four pots to the center of their travel, with the dots at the 12 o'clock position.

Plug the wall adapter into the wall, then plug it into the DC power jack J1. The filament should glow orange after a few seconds, and a Cathode Corner splash screen should appear on the CRT screen after about 20 seconds. The display is likely to be very narrow.

Display Adjustment

Adjust the Brightness knob at upper left so that the display is bright enough to see but not overly bright.

Adjust the Focus knob at upper right to make the lines as sharp as possible.

Adjust the H Pos knob at lower left and the V Pos knob at lower right so that the display is approximately centered.

Using a screwdriver, Adjust H Size and V size screwdriver controls so that the image fills the center two thirds of the screen.

The display will probably be tilted with respect to the cabinet. Loosen the clamp screw and rotate the CRT so that the numbers form a horizontal line. This can be checked with a plastic ruler against the two tabs at either side of the center of the front face. Be sure that the felt is protruding 1/16" at the bottom, and tighten the neck clamp on the CRT snugly.

Adjust the Astig screwdriver control to make the lines sharp as follows: Turn Focus counterclockwise a bit to make the lines blurry. Turn Astig until the defocus is the same in both horizontal and vertical directions; i.e., the line width is the same in all directions. Now readjust Focus till the lines are sharp.

Turn the big encoder knob and see that the time is displayed in different formats, and you will see a few other screens. Go ahead and play some Pong against yourself using the position controls as paddles.

You will need to reset the Pos controls to center the display after playing a game, since they do double duty as the game paddles and the position controls.

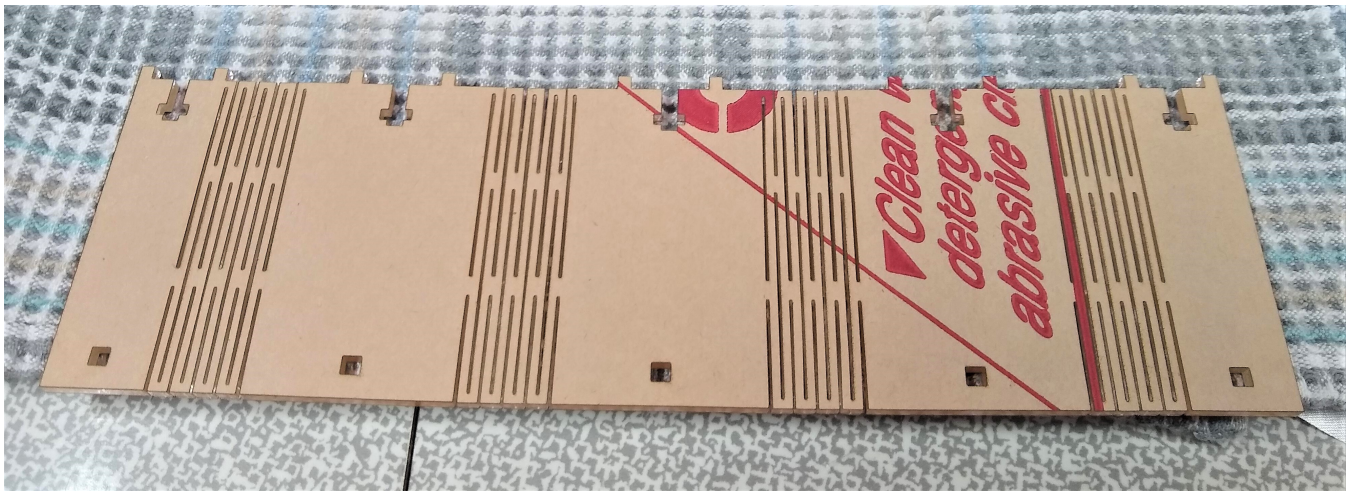
Final Assembly

Installing the rear cup and cap

The rear cup and cap are to be installed only after you are happy with the CRT alignment, since this adjustment is not possible with these pieces in place.

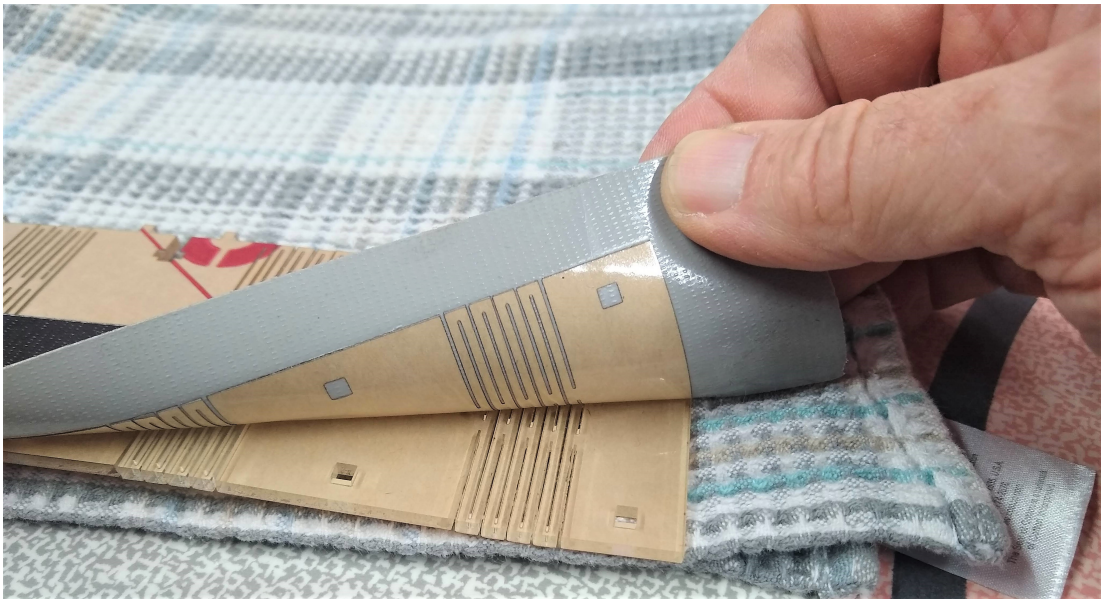
The cup is the small flexible piece. Its paper needs to be peeled off all the little slots as well as the large areas. This is best done with a piece of sticky tape. Gorilla Tape is recommended, although other brands of duct tape are likely to work.

To remove the paper coating from the flexible pieces, use the tape procedure. Set the plastic piece on the edge of a table with the edges of the slots facing you, with a cotton cloth under it.



Tear off a piece of duct tape a bit longer than the piece. Press the tape onto the edge of the piece so that it hangs over the edge by about half an inch. Rub firmly on the tape along the edge of the plastic piece to make it stick well. Be sure to stick it to every slot, so they will all be pulled up.

Start peeling up the tape at one corner of the paper. It should lift the paper off the plastic. If not, give it some help with your fingernail. Slowly lift the tape, being sure that it's taking the paper with it. Peel the rest of the paper off the piece, section by section.



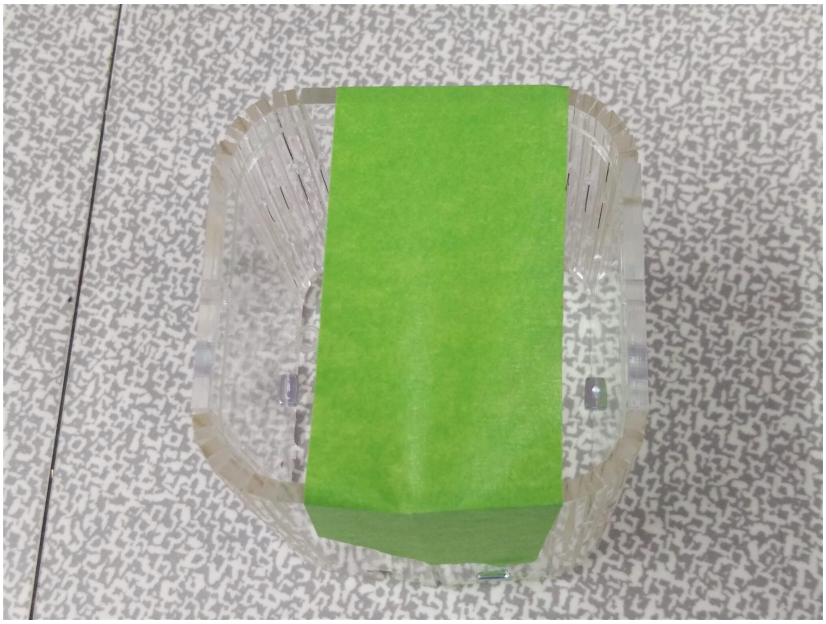
Flip the piece over and repeat with another piece of tape.

Use your fingernail to scrape of any small burnt pieces of paper. Goo Gone may be used with a soft cloth to remove any remaining sticky bits.

Peel the paper off the cap, which is the small square piece with writing on it. Again, use your fingernail to remove the small bits of paper from the text areas.

Find the top of the cup piece by feeling the edges for the smoother edge. Press a square nut into each of the five slots on the cup from the top side. Center each nut in the slot. If a nut falls out, save it for installation after the cup is installed.

Fold the cup around the cap, with the writing on the cap facing out. Hold the cup in this position, you will find that it takes several fingers to do this. Wrap a piece of painter's tape around the two ends of the cup so that the tape holds the cup around the cap.



The next part is the tricky part. Unplug the clock and set it on the bench pointing sideways.

Place the tabs on the center section of the cup into the slots at the top of the rear face of the clock. Insert a screw into the top hole in the rear face so that it engages the nut. Don't tighten it, just catch the threads.

The objective is to convince all the tabs to engage in all the slots. The plastic is fragile, so don't squeeze it. Instead, use a small slot screwdriver to guide each tab into its slot as you go around the cup.

The tabs on the bottom all must be engaged at the same time, since the cap holds the two halves of the bottom part at the same distance from the rear face. With some patience, it can be done. Just think of how much money you're saving by building the clock yourself.

After the cup is installed in all the tabs, carefully install screws from the inside of the rear face. Do the two sides first if possible. Then do the remaining screws. If a nut fell out earlier, now is the time to install it. It can be inserted carefully into the slot with long-nose pliers with the clock oriented so that you're working on the side of the cup. Don't push the nut in too far, or it will fall in and you'll have to start over. Think about childhood board games such as Operation.

Remove the painter's tape from the cup.

Installing the cover

The cover piece is the large flexible plastic piece. It also needs to have its paper coating removed using tape. The procedure is the same as for the cup.

The cover is installed by setting it on a cloth towel and placing the clock upside-down over the center of the cover so that the two tabs fit into the slots. Orient the cover so that one end is facing you.

Place the clock upside-down onto the cover, so that the two tabs on the top of the clock engage the two slots in the center of the cover. You may need to gently press the clock faces apart form or towards each other to get both tabs engaged.

Lift up on the end of the cover that is facing you and gently pull it up to fit over the tabs in the sides of the faces. The cover will need to be stretched a small amount, as it is made a bit short in order to fit tightly.

When doing the following steps, be careful to press only on the larger pieces of plastic in the cover instead of pushing on the narrow, slotted areas. This is to prevent any of the narrow pieces of the cover from breaking.

Once the side is engaged, gently guide the two ends of the narrow strip in the cover over the two tabs in the faces that are angled near the bottom of the clock. These will both engage, allowing the final fitting of the end of the cover over the four large tabs. This requires a gentle push inward and downward on the bottom edge of the cover piece, to tuck it under the tabs. Pay attention to the angled tabs to be sure they don't fall out. Take your time. The cover will fit, but it requires pushing the edge down to allow all four big tabs on the base to fit into the big square holes in the cover.

After the four large tabs have slipped into the cover, install two screws in the holes there and gently tighten them while applying pressure on the cover to hold it straight against the base.

Without lifting the clock, rotate the cloth on the bench so that the other side of the clock faces you. Repeat the procedure to install the other side of the cover. Install the screws after the cover snaps into place.

Congratulations, you have built a Scope Clock!

Using Your Clock

Adjusting the display

The top left knob is Brightness. It should be adjusted so that the green display is visible but not overly bright. The top right knob is Focus. It should be adjusted for sharp lines.

The lower left knob is Horizontal Position. It will center the display to the left or right. It also serves as the left player paddle for Pong, and the block position control for Tetris. It must be recentered after playing a game and switching back to clock mode.

The lower right knob is Vertical Position. It moves the display up and down on the screen. As with the Horizontal Position control, it serves double duty for Pong and Tetris. It is the right player paddle for Pong and the block rotation for Tetris.

The large knob at the bottom center is the Mode knob. It is used to select different clock or game displays, and to adjust the time or locale settings.

Setting the time

The USB jack allows a GPS receiver to set the time automatically, although you have to set the time zone and DST manually.

The setting mode is entered by pressing the big knob until it clicks. You may have to hold the clock case, as the knob requires some force to press. You will see a menu with three lines, the top line highlighted. Rotate the big knob to highlight Set Time and Date, then press the knob again. You will see the time and date displayed, with the top Exit line highlighted.

Turning the knob will change which item is highlighted. It will cycle through hours, minutes, seconds, century, year, month and day.

Pressing the knob will enable that item to be changed, which is indicated by blinking the item value. Rotating the knob will change the value. Pressing the knob again will highlight the next item, allowing it to be changed. Pressing the knob repeatedly will end up on the Exit line, which will exit the menu to the main setting menu when the knob is pressed. Pressing the knob once more will exit the menu and go back to time display mode.

Setting the locale

To set the clock's locale, push the large mode knob to enter the main menu. Rotate the big knob to highlight Set Locale, then press the knob again. You will see several options to set.

Zone sets the time zone used for GPS time. It has no effect unless the optional GPS receiver is used.

24 hour mode selects whether the hours are displayed as 0..23 or 1..12.

DST on/off selects whether the GPS time is adjusted ahead by an hour. This is not automatic, since the code required to handle all cases is beyond the abilities of the creator of the clock. Feel free to write your own code.

Mains tells whether the AC power in your location has a frequency of 50 or 60 Hz. This is used to synchronize the display to any magnetic fields that may be present. Having it set to the wrong value will cause the display to shimmy if the clock is near an AC-powered motor, transformer or electromagnet.

Optional GPS receiver

The optional GPS input is a USB connector mounted on the rear panel of the clock. It has been tested with a GlobalSat BU-353S4 GPS puck receiver.

The clock will set itself to GPS time when the GPS receiver is plugged in. This may take up to a minute. The locale setting becomes important at this point. The time zone and DST need to be set correctly for the GPS time to be correct.

The clock will stay set to the GPS time when the GPS receiver is unplugged. It may lose a second, since that's how often the GPS time messages are sent.

Care of the Cabinet

The cabinet is made of acrylic plastic. This plastic can be scratched by abrasive pads, so clean the cabinet only with a soft cloth. Novus plastic polish may be used to keep the plastic shiny.

Warranty

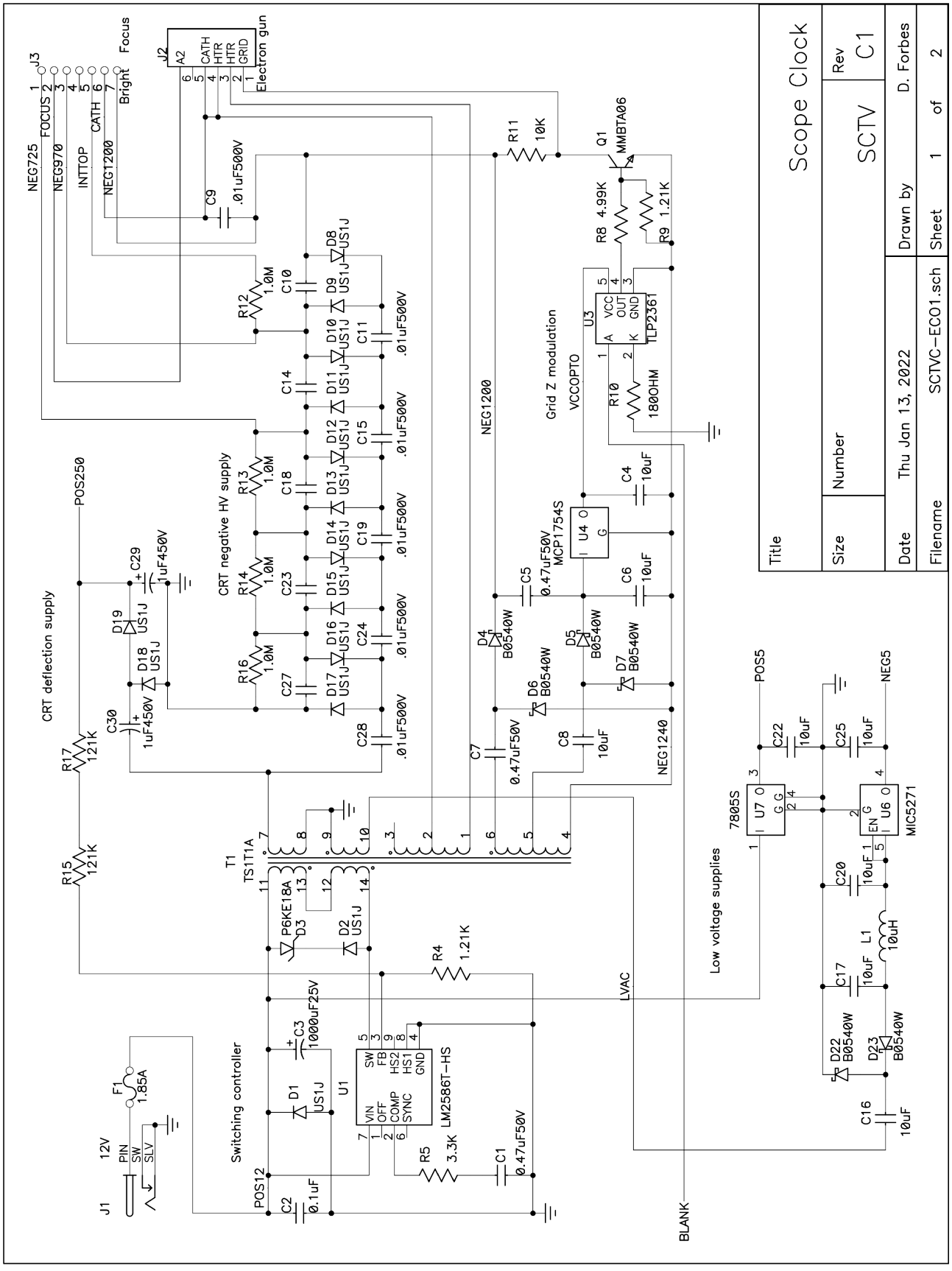
Cathode Corner warrants the SCTV Scope Clock to be free of manufacturing defects for a period of one year. If your clock fails to give satisfaction in that time period, contact Cathode Corner for shipping authorization and instructions. This warranty does not apply to assembly errors.

If you need replacement parts or assistance in getting your clock to work, please contact Cathode Corner as described on page 5.

Schematic Diagram

The schematic diagram of the clock is shown on the next two pages.

The only custom part is the power transformer. It's tricky to make. Six windings, triple insulated wire, the core is gapped just ever so.


Scope Clock
Title
Size
Number
Rev
C1
SCTV
Date
Thu Jan 13, 2022
Drawn by
D. Forbes
Filename
SCTVC-EC01.sch
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1
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CRT deflection supply
CRT negative HV supply
Grid Z modulation
Switching controller
Low voltage supplies
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NEG1240
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Focus
FOCUS
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12V
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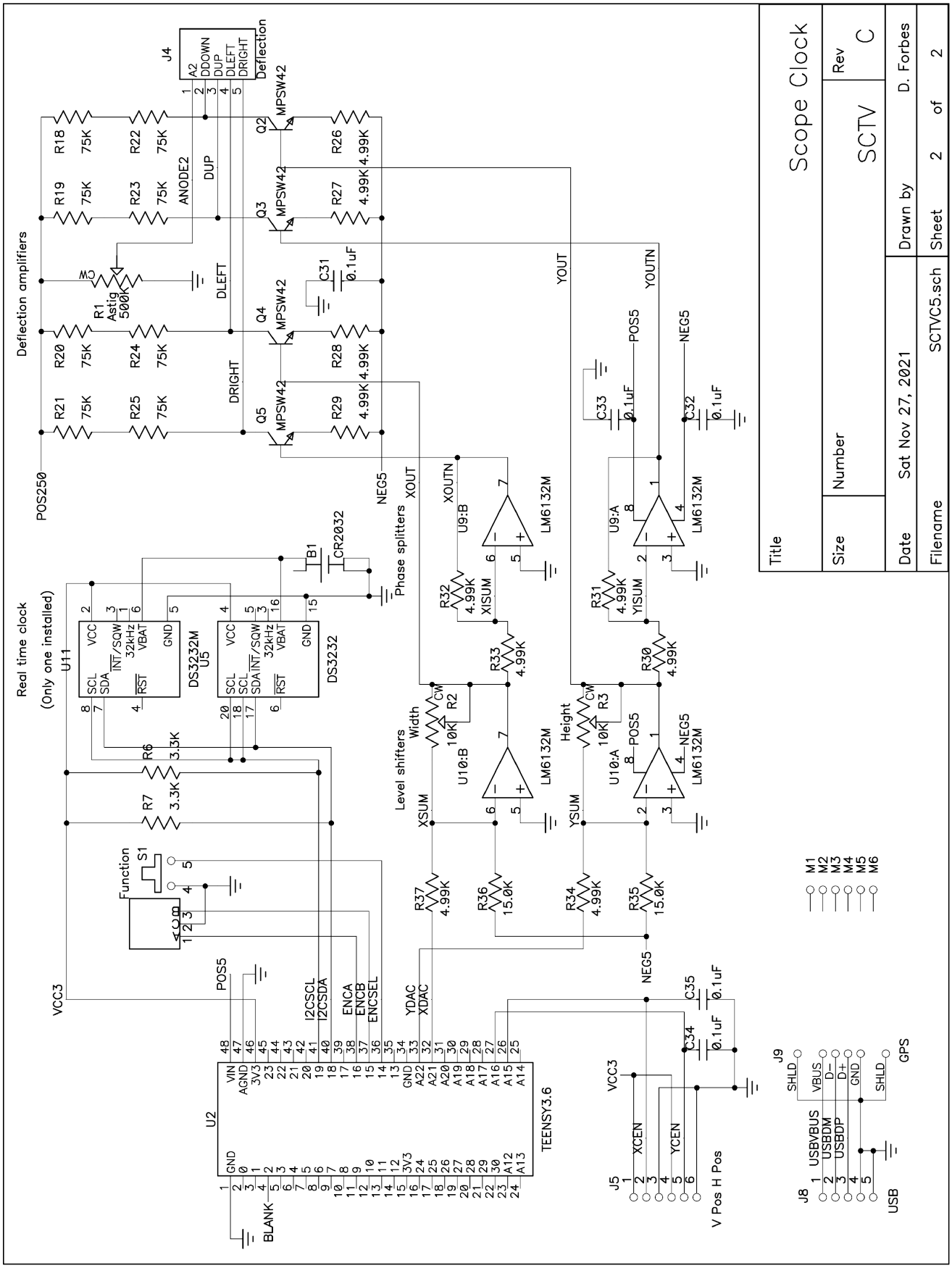
Scope Clock
SCTV
Rev C
D. Forbes
Sat Nov 27, 2021
SCTVC5.sch
Sheet 2 of 2
Deflection amplifiers
Deflection
Real time clock
(Only one installed)
Phase splitters
Level shifters
Width
Height
Function
TEENSY3.6
V Pos H Pos
GPS
USB