SC200C Scope Clock Board Kit Assembly and User Manual

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Foreword

The Manual

This user manual is divided into sections. The sections are arranged in the order that you will build the clock and make it work. The Theory of Operation section at the end 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 text refers to the photo page on occasion. A page of color photographs is included in the Appendix to show clearly those things that are hard to explain in words.

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

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Introduction

The Clock

The SC200 scope clock is an electronic clock that displays the time 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 SC200 display is optimized for aesthetic appeal.

Features

Clean display – the text looks like a schoolteacher wrote it

Works with most electrostatic CRTs from 1.2” to 7” diameter

12 or 24 hour display modes, selectable DST, etc.

Pleasant menu-based user interface uses rotary encoder with push switch

Serial port allows connection to PC or GPS receiver (Garmin GPS 18 LVC recommended)

Packaging

The clock PC board and CRT should be installed in a suitable cabinet of the user's choosing. Wiring harnesses are provided to simplify this task. A plastic cabinet will be available from Cathode Corner in the near future.

Source Code

The source code of the software that runs the SC200 is available at www.cathodecorner.com and is licensed under the GPL. Feel free to add features to your clock, but please consider sharing your work with others in the spirit of free software. Thank you.

CRT Selection

The scope clock needs an electrostatic deflection CRT to operate. Magnetic deflection tubes simply won't work. The other big requirement is that the filament use 6.3V at 0.6 amps or less.

The clock works best with a tube made for 1500 to 2000V second anode voltage such as the 3RP1. By modifying the power supply, it is possible to make the board put out less voltage, so that it will work with a 600 to 1000V tube such as the DG7-32.

The clock has been run with tubes as small as the 7/8" 1DP1 and as large as the 7" 7VP31. Small diameter tubes can be hard to read at a distance, and large tubes tend to be long and therefore difficult to package. The ideal display for general use is a 3" diameter tube. Cathode Corner maintains a stock of 3BP1 and 3RP1-A tubes for sale.

Below is a list of CRTs that will work with the scope clock. The OK? column says whether each tube will work with the scope clock. LV means that the low voltage modification must be made when building the PC board. The details of this modification are in the assembly instructions.

The Base column has the name of the socket that the tube uses. The names are weird, but they are meaningful to a CRT dealer. Cathode Corner maintains a supply of newish and used CRT sockets for sale if you need one.

The HV multiplier is a small PC board that generates +1500V for the third anode of tubes that provide it. Powering the third anode with high voltage makes a much brighter display on these tubes.

If you need pinout information, feel free to request it from Cathode Corner. We have many data sheets and other info available for free.

Tube	Pinout	OK?	Base	Comments
1CP1	8	LV	Loctal	Low quality display
1DP1	9	LV	9 pin	low voltage (needs power supply mods)
1EP1	11V	Yes	unidekar	
2AP1	11B	LV	magnal	low voltage (needs power supply mods)
2BP1	12E	Yes	duodecal	
3BP1	14A	Yes	diheptal	
3EP1	11A	Yes	magnal	
3FP7	14B	Yes	diheptal	needs HV multiplier for A3
3GP1	11N	Yes	magnal	
3JPx	14J	Yes	diheptal	needs HV multiplier for A3
3KP1	11M odd	Yes	magnal	Sell it to a Pilot TV owner for big $$$
3LO1i	12	LV	Russian	low voltage (needs power supply mods)
3MP1	12F odd	Yes	duodecal	Non-standard duodecal pinout
3RP1	12E	Yes	duodecal	
3SP1	12E	Yes	duodecal	
3WP1	12E	Yes	duodecal	Left & Right swapped
3ACP11	14J	Yes	diheptal	needs HV multiplier for A3
3ASP1	8	Yes	small octal	plus button for A2
3E50	8	Yes	small octal	plus button for A2
5ADP1	14J	Yes	diheptal	needs HV multiplier for A3

5BP1	11A	Yes	magnal	
5CP1A	14J	Yes	diheptal	needs HV multiplier for A3
5DEP1	12E	Yes	duodecal	
5JP1	11E	Yes	magnal	needs HV multiplier for A3
5LP1	11A	Yes	magnal	needs HV multiplier for A3
6LO1i	12	Yes	Russian	
7JP1	14A	Yes	diheptal	
7VP1	14A	Yes	diheptal	
DG7-32	12E	LV	duodecal	low voltage (needs power supply mods)

PC Board Assembly

The SC200 scope clock is not difficult to assemble, but it is recommended that the builder have some experience soldering circuit boards together before beginning this project. This instruction manual has not been created with the man-years of effort that Heathkit put into theirs. That said, the circuit board is carefully laid out to allow the parts to be installed easily, and the assembly order was arranged to have the lowest profile parts installed first so that placing the board upside-down will hold the parts in place in most cases.

Tools needed

Soldering Iron, 1/16” wide tip, 650-700 degrees F, adjustable temperature preferred
Solder, 63/37 (60/40 is OK), .031" diameter or smaller, rosin or no-clean flux
Small diagonal cutters
Small long-nose pliers
#1 Phillips screwdriver

Getting Started

Dump the parts from the bag into a large tray to make them easy to sort. Then sort out the parts by type for easy identification as they are needed. If any parts are missing, contact Cathode Corner (see page 3) for assistance.

The steps below each have a header:

Step	Qty	Description	Marking	RefDes

Step is in numerical order.

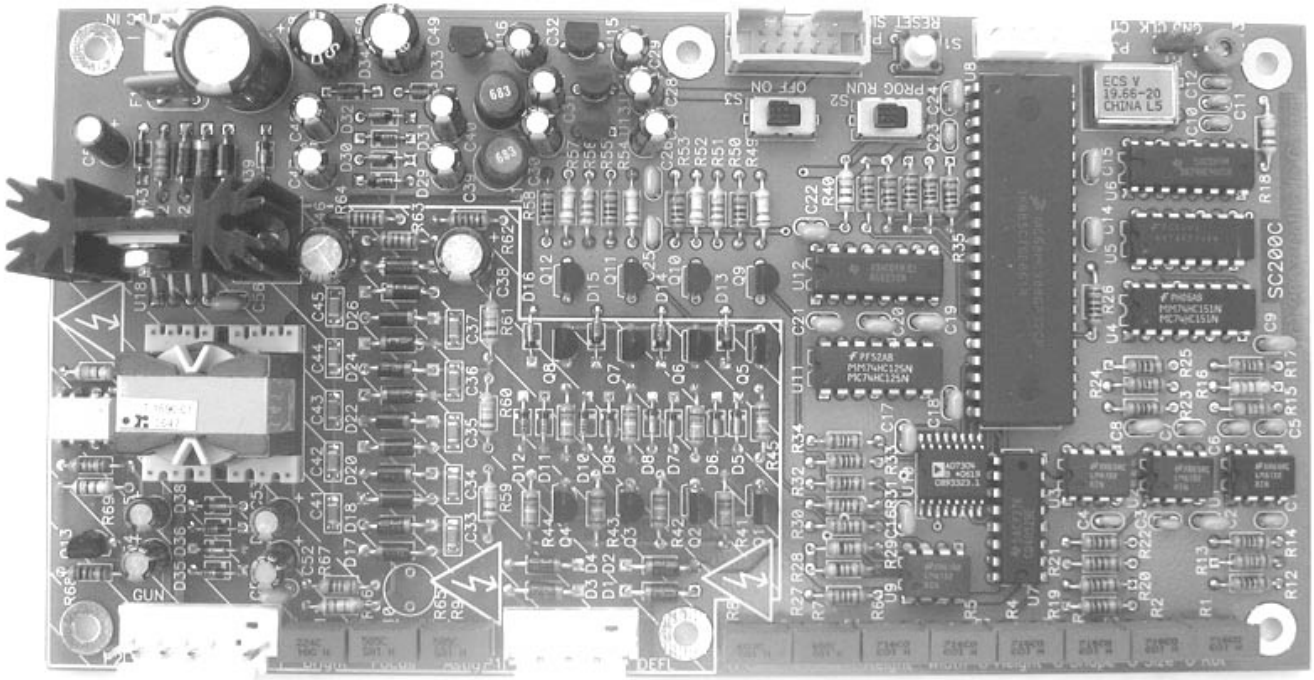
Qty is how many parts of this exact type to install.

Description tells what the part is, and its value or part number. Res is resistor, Cap is capacitor, Ind is inductor, etc.

Marking is what is printed on the part, or its color if unmarked. Resistor color codes are abbreviated.

RefDes is the reference designator, the code printed on the board silkscreen that identifies which part goes where.

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



Step by step guide

The PC board has already had some parts soldered to it – these are the parts that are only available in surface mount form. All the parts you need to install are old-fashioned through-hole parts.

The first parts to install are the small glass diodes. To install a diode, first pull it loose from the tape strip, then bend the legs at right angles to the body using your thumb and finger. The leg will want to bend about 1/16" from the end of the body, resulting in the proper 0.30" leg spacing to fit on the board.

The diodes have a stripe on one end, which is shown on the PC board legend. When installing a diode, be sure to orient it so that the diode's stripe is at the same end as the board's stripe.

Insert the diode into the board all the way, so that the body is touching the board at both ends. Then hold the diode in place with a finger while bending the legs apart from each other about 30 degrees. This will hold the diode in place until it's soldered down.

It is reasonable to install a row of diodes at a time before soldering them. This saves a lot of assembly time. Just be sure to solder all of the legs! Then trim the excess wire from the solder joints.

Install the diodes shown below. After they are all placed in the board, solder all their legs and remove the excess leg lengths with cutters.

Step	Qty	Description	Marking	RefDes
1a	8	Diode,switching	1N4148	D5-12

Install the diodes shown below. After they are all placed in the board, solder all their legs and remove the excess leg lengths with cutters.

Step	Qty	Description	Marking	RefDes
1b	10	Diode,switching	1N4148	D13-16,D35-39,D43

Install the diodes shown below. After they are all placed in the board, solder all their legs and remove the excess leg lengths with cutters.

Step	Qty	Description	Marking	RefDes
2	4	Diode,Schottky	BAT48 - blue	D29-32
3	2	Diode,Zener,3.0V	1N5224B	D33-34

The resistors are the blue cylinders with colored bands, supplied on two strips of tape. The color code is shown with each resistor step, so you can just find the strip of resistors with that color code and install them.

You may be familiar with resistors with ony four bands. These resistors have five bands – they are 1% tolerance precision resistors with three dignificant figures of resistance value. There is a wider gap between the fourth and fifth bands to help you hold the resistor the right way.

You may want to use an ohmmeter to verify the resistor values since the brown, orange and red stripes can be confusingly similar.

Install the resistors shown below. After they are all placed in the board, solder all their legs and remove the excess leg lengths with cutters.

* Note: If you are building the board to run a low-voltage CRT such as a DG7-32, do not install resistors R59-60.

Step	Qty	Description	Marking	RefDes
4	2	Res,1.00KΩ,1%,1/4W	Brn-Blk-Blk-Brn-Brn	R40,R69
5	5	Res,1.00MΩ,1%,1/4W	Brn-Blk-Blk-Yel-Brn	R18,R59-61*,R66
6	1	Res,1.21KΩ,1%,1/4W	Brn-Red-Brn-Brn-Brn	R64

Install the resistors shown below. The kit comes with an extra 10.0KΩ resistor. After they are all placed in the board, solder all their legs and remove the excess leg lengths with cutters.

Step	Qty	Description	Marking	RefDes
7	15	Res,10.0KΩ,1%,1/4W	Brn-Blk-Blk-Red-Brn	R19-22,R25-26,R35,R37-39, R50,R53,R55,R58,R68

Install the resistors shown below. One of the 20.0KΩ resistors is not on the tape with the others. After they are all placed in the board, solder all their legs and remove the excess leg lengths with cutters.

Step	Qty	Description	Marking	RefDes
8	2	Res,121KΩ,1%,1/4W	Brn-Red-Brn-Org-Brn	R62-63
9	2	Res,2.21KΩ,1%,1/4W	Red-Red-Brn-Brn-Brn	R51,R56
10	13	Res,20.0KΩ,1%,1/4W	Red-Blk-Blk-Red-Brn	R12-14,R17,R23-24,R27,R30-34,R36

Install the resistors shown below. After they are all placed in the board, solder all their legs and remove the excess leg lengths with cutters.

Step	Qty	Description	Marking	RefDes
11	2	Res,221KΩ,1%,1/4W	Red-Red-Brn-Org-Brn	R49,R54
12	1	Res,221Ω,1%,1/4W	Red-Red-Brn-Blk-Brn	R16

13	8	Res,249KΩ,1%,1/4W	Red-Yel-Wht-Org-Brn	R41-48

Install the resistors shown below. After they are all placed in the board, solder all their legs and remove the excess leg lengths with cutters.

Step	Qty	Description	Marking	RefDes
14	1	Res,3.32KΩ,1%,1/4W	Org-Org-Red-Brn-Brn	R72
15	2	Res,332KΩ,1%,1/4W	Org-Org-Red-Org-Brn	R52,R57
16	1	Res,332Ω,1%,1/4W	Org-Org-Red-Blk-Brn	R71
17	1	Res,4.75KΩ,1%,1/4W	Yel-Vio-Grn-Brn-Brn	R70
18	3	Res,40.2KΩ,1%,1/4W	Yel-Blk-Red-Red-Brn	R28-29,R67
19	1	Res,80.6KΩ,1%,1/4W	Gry-Blk-Blu-Red-Brn	R15

* Note: If you are building the board to run a low-voltage CRT such as a DG7-32, you need to install some jumpers on the board. Use resistor leads for these jumpers. Jumpers go in the following places:

1. Instead of R59, R60 (bend the resistor lead into a U shape first)

2. Across C41, C43, C44 (hold a resistor lead across the top of the capacitor with pliers and solder both ends, then trim to length)

The next parts to install are the small ceramic capacitors supplied on tape. They need to be cut off the tape before installing. These have both legs coming out one end, so no bending is required to get them in the board.

Step	Qty	Description	Marking	RefDes
20	2	Cap,Cer,100pF,50V	101	C3-4
21	5	Cap,Cer,1000pF,50V	102	C1,C5-7,C23
22	2	Cap,Cer,22pF,50V	22J	C10,C12
23	1	Cap,Cer,27pF,50V	27J	C11

The next parts to install are the loose small ceramic capacitors. An extra capacitor is supplied in case you lose one. After installing each capacitor, spread the legs apart about 30 degrees to keep it in place until soldering. Solder all the capacitors when finished with the installation.

Step	Qty	Description	Marking	RefDes
24	17	Cap,Cer,0.1uF,50V	104K	C2,C8-9,C14-22,C24-26,C51,C56

The large plastic diodes are next. These parts have a stripe on one end, which is shown on the PC board legend. When installing a diode, be sure to orient it so that the diode's stripe is at the same end as the board's stripe. These diodes' lead spacing is 0.40" like the resistors. The diode body is shorter than the resistor body, but the legs are stiffer so they bend with a larger radius.

Install the diodes shown below. After they are all placed in the board, solder all their legs and remove the excess leg lengths with cutters.

* Note: If you are building the board to run a low-voltage CRT such as a DG7-32, do not install diodes D18-19 or D21-D24.

Step	Qty	Description	Marking	RefDes

25	18	Diode,fast,400V	UF1004	D1-4,D17-28,D40,D42
26	1	Diode,TVS,18V	P6KE18A	D41

Next are the small integrated circuits or ‘chips’.

The chips are supplied with their two rows of pins angled outward to facilitate automatic insertion, Since you are not automatic, this is just a hindrance. You need to squeeze the two rows of pins together, but there is no easy way to do this. You can press a row of pins against the tabltop and press down on the chip to make them go together, or you nay be able to use a smooth-jawed vice to compress the part slightly.

After squeezing the legs together, install the chips listed below. Sometimes a row of pins doesn’t want to go into the row of holes – in that case, use the wide side of a knife to push the pins into position.

Be sure to align the notched end of the chip with the notch mark on the PC board.

Bend over two corner pins on each chip to keep the part in the board while installing the other chips.

Double check that each chip’s notch is at the same end of the chip as the board legend’s notch.

After all the chips are installed, solder two corner pins on each chip to finalize their position. Check that all chips are fully inserted. If a chip is not fully seated on the board, adjust if necessary by heating the pin and pressing the corner down with a thumb.

Then solder the rest of the pins on all the chips.

Step	**Qty**	**Description**	**Marking**	**RefDes**
27	1	IC,optocoupler	6N137	U17
28	1	IC,buffer	74HC125	U11
29	1	IC,multiplexer	74HC151	U4
30	1	IC,counter,14bit	74HC4060	U6
31	1	IC,flipflop,D	74HC74A	U5
32	1	IC,multiplexer	CD4052	U7
33	4	IC,opamp,dual	LM6132B	U1-3,U9
34	1	IC,interface,RS-232	MAX232	U12

The next part is the crystal. Bend its legs to the rear so that it will lie flat on the PC board. Then place its legs through the holes, hold it in place, and bend the legs apart 30 degrees to hold it in place. Turn the board over and solder the legs. Cut off the excess leg length.

Step	**Qty**	**Description**	**Marking**	**RefDes**
35	1	Xtal,19.6608MHz	19.66	Y1

Install the variable capacitor next. Align the flat end of the capacitor with the flat end on the silkscreen. Its legs are kinked to hold it in place while soldering. Solder it.

Step	**Qty**	**Description**	**Marking**	**RefDes**
36	1	Cap,Var,3-10pF	blue	C13

Install the microprocessor next. Press together the two rows of legs as described previously. Be sure to align the notched end of the part with the notch mark on the PC board. Solder two corner pins, check that it is fully inserted, adjust if necessary by heating the pins. Then solder the rest of the pins.

Step	**Qty**	**Description**	**Marking**	**RefDes**
37	1	IC,microprocessor	MC908GP32	U8

Install the short TO-92 parts next. These need to be cut from the tape before installing. The legs are formed to fit into the PC board with no extra bending. Note that one side of the package is flat. Match that with the flat side on the legend. Again, after each part is installed, spread the two outer legs about 30 degrees to hold it in place.

Turn the board over and solder the center leg of each part, then turn the board over and straighten all the parts so they stand perfectly straight up (important if you will be displaying the PC board). Turn the board over and solder the two outer legs of each part. Cut off all excess wire.

Step	**Qty**	**Description**	**Marking**	**RefDes**
38	5	Transistor,NPN,80V	MPSA06	Q9-13
39	3	IC,regulator,+5V	KY5050	U14-16

Install the straight-leg TO-92 regulator next. Bend the two outer legs to resemble the parts you just installed. Note that one side of the regulator is flat. Match that with the flat side on the legend. Again, after the regulator is installed, spread the two outer legs about 30 degrees to hold it in place.

Solder the center leg of the regulator, then turn the board over and straighten it to stand perfectly straight up (important if you will be displaying the PC board). Turn the board over and solder the two outer legs. Cut off all excess wire.

Step	**Qty**	**Description**	**Marking**	**RefDes**
40	1	IC,regulator,-5V	79L05	U13

Install the two slide switches next. These parts will fall out, so install one at a time.

Put a switch in the board, solder one pin, then reheat that pin while pressing on the switch with your thumb to make sure it’s fully seated. Check that it is fully seated and even, then solder the other pins. Repeat for the other switch.

Step	**Qty**	**Description**	**Marking**	**RefDes**
41	2	Switch,slide,DPDT		S2-3

Install the pushbutton switch next. This part has formed legs to hold it in place while soldering. However, the formed legs make it a bit hard to install. Press down on the switch body with two thumbnails to get it in the holes. Solder it.

Step	**Qty**	**Description**	**Marking**	**RefDes**
42	1	Switch,tactile		S1

Install the small black two-pin header next. This part can be tricky to install, since the metal pins will burn your fingers after poking holes in them. Check that your health insurance is paid up.

The best method is to press the board against the bench while soldering one pin to get it in place, then reheat that pin while wiggling the board to get it to sit straight if needed. Then solder the other pin.

Step	Qty	Description	Marking	RefDes
43	1	Header,2pin,black		H1

Install the two inductors next. Spread the legs 30 degrees to hold them in place while soldering. Cut off the excess wire after soldering.

Step	Qty	Description	Marking	RefDes
44	2	Ind,10uH,Radial	103	L1-2

Install the square trim pots next. There are four different 3-digit values, so be sure to get the right part in the right place. The kit may contain an extra trim pot marked 203. It is not used.

Spread the legs on each of these pots after installing.

Solder the center pin of each pot, then reheat the pin while pressing on the pot with your thumb to make sure it's fully seated. Turn the board over and square up each pot, double checking that they are flat against the PC board. Straighten them with respect to the board edge for a neat appearance.

Solder the outer two legs of each pot, then cut off the excess wire lengths.

Step	Qty	Description	Marking	RefDes
45	7	Pot,10K,.375"RA	103	R2-8
46	1	Pot,50K,.375"RA	503	R1
47	2	Pot,1M,.375"RA	105	R9-10
48	1	Pot,500K,.375"RA	504	R11

Install the grey ribbon cable header next. Align the notch in the housing with the mark on the PC board. Hold the board flat against the bench to keep the part flat while soldering one pin, then check it for flatness. Solder the remaining pins.

Step	Qty	Description	Marking	RefDes
49	1	Header,2x5pin	grey	P4

Install the tall TO-92 transistors next. These need to be cut from the tape before installing. The transistor legs are formed to fit into the PC board with no extra bending. Note that one side of the transistor is flat. Match that with the flat side on the legend. Again, after each transistor is installed, spread the two outer legs about 30 degrees to hold it in place.

Solder the center leg of each transistor, then turn the board over and straighten all the transistors so they stand perfectly straight up (important if you will be displaying the PC board). Turn the board over and solder the two outer legs of each transistor. Cut off all excess wire.

Step	Qty	Description	Marking	RefDes
50	8	Transistor,NPN,300V	MPSW42	Q1-8

Install the 8-pin header next. Align the plastic tab with the mark on the PC board. Hold the board flat against the bench to keep the part flat while soldering one pin, then check it for flatness. Solder the remaining pins.

Step	Qty	Description	Marking	RefDes
51	1	Header,8Pin,.100"	white	P3

Install the electrolytic capacitors next. Note that the Japanese manufacturers mark the negative lead of the electrolytic capacitors with a big white stripe, 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 30 degrees to hold them in place.

Double check that the + signs on the PC board are away from the white stripes on all the capacitors.

Solder the square pad of each capacitor, then turn the board over and straighten all the capacitors. Solder the remaining leg. Cut off all excess wire.

Step	Qty	Description	Marking	RefDes
52	12	Cap,Elect,10uF,25V	10uF	C27-32,C39-40,C47-48,C52,C54
53	3	Cap,Elect,0.47uF,50V	0.47uF	C53,C55,C57
54	2	Cap,Elect,1uF,450V	1uF	C38,C46
55	2	Cap,Gel,1F,2.5V	1F	C49-50

Install and solder the large white Molex headers. Pull out the pin with the missing hole on P2. This may be done with cutters used as a lever.

Make sure they are oriented as shown on the PC board legend. Solder one pin on each header, then check for flatness and reheat and reposition if needed. Again, don't hold your thumb on the pins while heating! Use the bench as the thumb and move the board slightly while heating the pin to get them to sit flat.

Check that the parts are all seated flat, then solder the remaining pins.

Step	Qty	Description	Marking	RefDes
56	1	Header,2Pin,.156"		P5
57	1	Header,5Pin,.156"		P1
58	1	Header,6Pin,.156"		P2

Install the fuse next. Spread the legs 30 degrees to hold it in place while soldering. Cut off the excess wire after soldering.

Step	Qty	Description	Marking	RefDes
59	1	Polyfuse,1.85A	R185	F1

Install the power transformer T1. Hold the board flat as you solder two corner pins to make it sit flat on the PC board. Check that it's fully seated and adjust if necessary. (It may not lie perfectly flat since the winding wires are wrapped on the pins, sometimes interfering with full seating.)

Solder the remaining pins. Cut off the excess pin length when done soldering.

Step	Qty	Description	Marking	RefDes
60	1	Transformer,power	T-1596-01	T1

Install and solder the large capacitor next. Again, the + sign is the long leg. Cut off the excess pin length when done soldering.

Step	Qty	Description	Marking	RefDes
61	1	Cap,Elect,1000uF,25V	1000uF	C58

Install the switching controller IC last. Hold the beige thermal pad onto the heatsink with its hole matching the top hole (the notch is at the bottom). Mount the IC on the heat sink with the 4-40 x 5/16" screw, lockwasher and nut in the top hole. Put the screw through the back of the heatsink, put the lockwasher and nut on the screw end which will be on the front of the IC, and tighten the screw snug but not tight. Make sure that the IC is straight on the heatsink.

Mount the heat sink/IC assembly to the board using the two #4x1/4" self-tapping machine screws.

Solder the pins, then clip the excess lead length.

Tighten the screw that holds the IC to the heatsink.

Step	Qty	Description	Marking	RefDes
62	1	Heatsink,TO220		
62	1	IC,switcher	LM2586	U18
62	1	Thermal pad,TO220		
62	1	Nut,hex,4-40		
62	1	lockwasher,#4		
62	1	Screw,4-40x5/16		
62	2	Screw,#4x1/4		

PC board assembly is complete.

You may choose to remove the solder flux from the PC board with commercially available flux remover, or you may leave it intact. Rosin-core flux will not hurt the board if left in place.

Inspect your work. Using a magnifying glass, look at every solder joint to make sure it is soldered well. Look at all polarized components to be sure that the stripe or notch or flat side on the part agrees with that on the silkscreen.

Wiring Harness Assembly

The wiring kit

The scope clock wiring kit comes with every wire and connector you will need to make the clock operational, except the CRT socket (unless ordered separately). See the CRT Selection section to determine which type of CRT socket you will be using.

Getting Started

Dump the parts from the bag into a large tray to make them easy to sort. Then sort out the parts by type for easy identification as they are needed. If any parts are missing, contact Cathode Corner (see page 3) for assistance.

Encoder wiring

The kit is supplied with a low-cost rotary encoder with internal pushbutton to use in testing the clock. This encoder may be replaced by a larger, higher quality unit if desired. The supplied encoder generates 12 quadrature pulses per revolution with 24 detents. The ratio of pulses to detents may be changed in software if you choose to use a different encoder.

Qty		Description	
1		Encoder w/nut,washer	Green
5	12"	Wires, thin	Small Molex pin
3.5"	3/32"	Heat shrink tubing	Black, small
1		Shell, Molex,.100"	8 Pin

Strip 1/4" of insulation off the end of each wire. Cut five 3/8" long pieces of small heat shrink tubing. Slide one tubing piece over each wire.

The encoder has three pins on one side and two pins on the other side. Tin each pin by applying some solder to it. Also tin the five stripped wire ends. This will make soldering the wires easier.

Solder the wires on the encoder pins according to the table below. The left-right pin assignment is based on the shaft pointing up. The photo page shows the connections on each side of the encoder.

Since the wires and terminals are tinned, you can solder them together by holding the wire on top of the pin and heating both with the iron. No extra solder is needed.

Encoder		Wire	Molex
Side	**Pin**	**Color**	**Pin**
3pin	Left	Red	2
3pin	Middle	Brown	1
3pin	Right	Orange	3
2pin	Left	Violet	7
2pin	Right	Grey	8

Twist the five wires loosely together. Plug the Molex pins into the 8-pin housing. The pin arrangement is shown on the photo page. If you make a mistake, press down on the metal tab of the pin through the slot in the housing and pull out the pin. Pry the small metal tab back up with a knife blade, then insert it into the correct spot.

The encoder has a 6mm diameter shaft and comes with a mounting nut and washer. It mounts in a 7mm (.280") hole in a panel up to 3mm (1/8") thick.

Power wiring

The scope clock uses 12VDC and is typically provided with a plug-in AC adapter with a coaxial DC power plug at the end of a long cable. The wiring kit contains a matching panel-mount coaxial DC power jack. You may use the supplied AC adapter or you may use your own source of 12VDC power.

If you choose to use the supplied AC adapter, the coaxial DC power jack must be wired to the 2-pin Molex plug using the supplied red and black 24 gauge wires with large pins on one end.

Qty		Description	
1		DC jack w/nut,washer	Black
2	12"	Wires, thin	Large Molex pin
1		Shell, Molex,.156"	2 Pin

Strip 1/4” of insulation from the other end of each wire. Cut two 1/2" long pieces of small heat shrink tubing. Slide one piece over each wire. Solder the two wires to the DC power jack as shown on the photo page.

Twist the two wires together. Plug the two pins into the 2-pin Molex shell as shown on the photo page.

If you will provide your own source of 12VDC, connect the red wire to the positive connection of your 12VDC source and the black wire to the negative connection. Plug the two pins into the 2-pin Molex shell as shown on the photo page.

Serial wiring

The serial cable connects the scope clock board to a PC or a GPS receiver. It is a flat cable with crimp-style connectors at each end. No special tools are required to crimp this sort of connector, just a vise or clamp in which the connector parts can be squeezed together. However, the process itself involves many small steps, so pay attention and do them in the proper sequence to ensure good results. It is difficult to reuse the connectors once they have been crimped.

Qty		Description	
1	16"	Cable,flat,10cond	
1		Conn,DE9,IDC	w/separate strain relief
1		Conn,2x5,IDC	w/separate strain relief

The ribbon cable needs some preparation before assembly. Trim both ends square with a pair of scissors – don't worry, the copper wire is softer than the steel blades. Notice the red stripe along one edge. This is pin 1. Since the DE9 connector has only nine pins, it is designed for 9-conductor cable. However, the 2x5 connector uses 10 conductor cable. To solve this problem, peel away about one inch of the conductor farthest away from the red stripe on one end of the cable and cut off the loose end. This is the end that accepts the DE9 connector. The other end accepts the 2x5 pin connector. The photo page shows the cable after shortening the tenth wire.

Now examine the 2x5 connector, which is black. Separate the three pieces: the body, the cover and the strain relief. The cover is a U-shaped piece with nine ridges on the inside to guide the ribbon cable conductors into place. The strain relief is smooth on the inside. The connector body has a triangle, an outward bump and a groove, all on one side. The triangle is the pin 1 indicator. The bump is a polarizing feature that mates with a corresponding notch in the PC board receptacle. Ignore the groove. The body also has two rows of teeth that press into the ribbon cable to cut its insulation and connect to the copper wires inside.

Fit the connector cover to the body by inserting the cover tabs into the slots in the body, so that the cover goes near the teeth, but don't press it in. It will slide in halfway easily, then meet some resistance.

Slide one end of the ribbon cable into the gap, making sure that the red stripe is close to the triangle. Gently squeeze the cover down over the cable with your thumb. Check that the cable end is flush with the edge of the body and that the cable is at right angles to the body. Clamp the connector in a vise or C-clamp, check again for cable alignment with the body, and turn the crank to compress the connector fully. You may hear one or two clicks as the cover latches snap shut.

Congratulations, you have crimped one end. Fold the cable over the cover, then press the strain relief into the connector and squeeze it into place by hand.

The blue DE9 connector works in the same way. The cover doesn't fall off, so just leave it in place. Pin 1 is indicated by a tiny "1" printed on the mating face of the connector. Repeat the crimping procedure described in detail above. Fold over the cable and install the strain relief.

CRT wiring

The kit is supplied with 10 different colored pieces of thick high voltage wire, each with a large Molex pin crimped to one end. These wires will be cut to length, then the free end of each wire will be soldered to a CRT socket pin and insulated with heat shrink tubing. Finally, the Molex pins will be inserted into their shells.

Qty		**Description**	
10	12"	Wires, heavy	Large Molex pin
8"	3/16"	Heat shrink tubing	Black, large
1		Shell, Molex,.156"	5 Pin
1		Shell, Molex,.156"	6 Pin

CRT pinouts vary, but the ones listed in the CRT Selection section as magnal (large 11-pin with octal-size key), duodecal (large 12-pin with large key) and diheptal (really large 14-pin) are almost all the same. These pinouts are listed below.

Note that the magnal base sometimes has the cathode on the heater pin 11. Since pin 2 is no-connect on these tubes and the orange and yellow wores are connectged together on the PC board, this works.

Signal Name	Wire Color	Magnal Pin	Duodecal Pin	Diheptal Pin
Grid	Brown	10	2	3
Heater	Red	1	12	14
Heater	Orange	11	1	1
Cathode	Yellow	2	3	2
Anode1	Green	4	4	5
Anode2	Blue	7	8	9
Down	Violet	9	7	7
Up	Grey	6	6	8
Left	White	8	10	10
Right	Black	3	9	11

The big Cinch 14-pin diheptal sockets are made of two parts. On these sockets, there is an insulating ring that fits over the solder terminals that must be removed before attaching the wires to the terminals. The wires pass through the same-numbered holes in the insulating ring. The insulating ring is then slid down the wires and reinstalled on the socket after all the wires have been soldered. There is no need to use heat-shrink tubing with this type of socket.

Other sockets have removable pins and a fiberglass cover plate held on with screws. These do not need heat shrink tubing either.

Strip 1/4" of insulation off the unterminated end of each wire.

Solder the wires to the CRT pins per the table above. Bend each wire's bare end into a J shape and hook it through the socket terminal first to ensure a tight mechanical connection.

If your socket requires heat shrink tubing, cut ten 1/2" long pieces of 3/16" diameter heat shrink tubing. Slide one piece of tubing over each wire on the CRT socket. Shrink the tubing over 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.

Twist together the violet and grey wires to form a pair.

Twist together the white and black wires to form a pair.

Twist together the red and orange wires to form a pair.

Plug the Molex pins into the white 5-pin and 6-pin connector shells per the table below. Pin 1 is closest to the corner of the PC board when plugged in. See the photo on the photo page to be sure you have the correct pin arrangement.

Shell	**Pin**	**Color**
6 pin	1	Brown
6 pin	2	Red
6 pin	3	Orange
6 pin	4	Yellow
6 pin	5	--none--
6 pin	6	Green
5 pin	1	Blue
5 pin	2	Violet
5 pin	3	Grey
5 pin	4	White
5 pin	5	Black

Initial Checkout

Before applying power to the clock for the first time, switch S1 to the Run position and switch S2 to the On position. These switches are only used to reprogram the processor and will never be changed in normal operation.

The potentiometer adjustments should be at or near the center of their travel as shipped from the manufacturer. The component values have been selected to produce a usable image with the controls centered, although the Bright control should be turned clockwise about 60 degrees to ensure a visible display, especially with an old CRT.

DO NOT TOUCH ANY METAL PARTS ON THE POWER SUPPLY HALF OF THE BOARD WHILE POWER IS APPLIED! There are hazardous voltages present in the area marked with white stripes and the lightning bolt symbol. Wait a second after unplugging power for the big capacitor to discharge before touching parts on the power supply board.

Plug the CRT socket onto the CRT gently but firmly. Rotate the socket first to line up with the key on the CRT center post. The pins may be stiff. It is sometimes necessary to place the CRT face-down on a table using a folded towel as a cushion, then press the socket down over the CRT pins.

Plug the 6-pin CRT plug into P2. Plug the 5-pin CRT plug onto P1. Plug the encoder cable onto P3. Plug the power cable onto P5. Connect the AC adapter to the power cable. Plug the AC adapter into a live outlet. Wait 10 seconds for an faint orange glow from inside the base end of the CRT, indicating that the heater is working. If this glow doesn't appear, skip ahead to the Troubleshooting section below.

After another 10 seconds, the CRT should display the splash screen shown on the CRT photo page. Don't worry if the display is too tall or off-center – you will fix that in the following steps. If the screen image doesn't appear, skip ahead to the Troubleshooting section below.

Push the encoder button by pressing the encoder shaft in. The splash screen should be replaced by a menu.

Display Adjustment

There is a menu selection called "Align CRT" which contains several alignment aids. Select it by turning the encoder until the "Align CRT" selection is bright, then pushing the button. You should see a circle or ellipse, several short lines around the screen, and a row of letters in the middle with the word Done below them. The purpose of each of these items is described below.

Adjust Bright so that the display is bright enough to see but not overly bright.

Adjust Focus to make the lines as sharp as possible in the center of the screen. A flat-face CRT may be out of focus near the edges of the display.

Adjust Astig to make the lines sharp in both directions 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.

Adjust X Cent and Y Cent so that the display is reasonably centered.

Adjust Width so that the marks at left and right sides are about 1/4" in from the edge of the screen. Readjust X Cent as needed to center the screen hortizontally.

Adjust Height so that the marks at top and bottom are about 1/4” in from the edge of the screen. Adjust Y Cent as needed to center the screen vertically.

Adjust O Size so that the big circle crosses the horizontal alignment marks to the left and right of the center letters (not the screen edge marks).

Adjust O Height so that the circle is as tall as it is wide. The vertical alignment marks help you judge this. You can redo this later, so don't put too much effort into it now.

Adjst O Shape so that the circle crosses the 45 degree angle marks evenly. It may not land on them, but split the difference. The circle should appear symmetrical instead of slanted to one side or the other.

Adjust O Rot so that the 2 and the S have the same size of gaps between their curved sections. This will change the circle size.

Adjust O Size again so that the circle crosses the center of the left and right alignment marks (not the screen edge marks).

Repeat the above adjustments as needed to get the best balance between circle size, shape and arc end positions. Perfection is neither necessary nor obtainable.

Regulating the time

You may skip the following procedure if you are using a GPS and/or 1PPS source to run the clock. In that case, the oscillator is not used for timekeeping, so its frequency is not critical.

Unlike most wall clocks, the scope clock gets its operating frequency from a crystal oscillator. This is because a switching power supply does not provide an isolated, low-voltage source of AC line frequency, which is how most other electric clocks obtain their timing.

Set the oscillator frequency by adjusting the trimmer capacitor C13 with a small slot screwdriver or tuning wand. The slot has an arrow in it - when it points to the flat side of the capacitor, the oscillator is running fast, and pointing the other way is slow. In-between positions to either clockwise or counter-clockwise rotation have the same effect, since the capacitor is made of two half-circles of metal on rotating and stationary ceramic discs.

The capacitor is shipped with the arrow pointing to the round end, which is the slow setting. Rotate the capacitor clockwise to set the clock faster, so it will be easy to remember that clockwise is faster and counterclockwise is slower.

A frequency counter may be used to measure the frequency, which will speed up the regulating procedure substantially. This assumes that you have access to a calibrated frequency counter. Connect the probe to the H1 pin labeled CLK, connect the ground lead to H1 pin GND, and adjust for 19.6608 MHz. The use of a metallic adjusting tool may throw off the frequency a small amount due to its capacitance, so be sure to remove the tool when checking the frequency.

Since crystal oscillators drift with age, the clock regulation may need to be reset periodically. Adjust the trimmer capacitor C13 as needed, annually if possible.

Final Adjustments

The Scope Clock is sensitive to the placement direction, since the CRT beam is deflected to some extent by the Earth's magnetic field. Consequently, the X Cent and Y Cent controls will need to be adjusted whenever the clock is reoriented or moved.

The Bright control also may need adjustment to match the ambient lighting.

Troubleshooting

If the power supply makes a buzzing noise for more than a few seconds or there is no orange glow or no image display, then there is likely a problem in the circuitry. It is reasonable to suspect a solder bridge or mis-installed part.

Unplug the AC adapter then unplug all connectors from the board. Inspect the board carefully for components installed backwards in the power supply areas, especially diodes. If this does not reveal the problem, look for solder bridges or component leads that are touching where they should not be.

You may connect an oscilloscope to the low voltage power supply winding at the cathode (striped) end of D29 to observe the behavior of the switching controller (use the large mounting hole near P5 for a ground connection). It should be oscillating at 100 KHz, with a squarish wave that has three parts: high low and medium voltage. The square part should be about 8 volts.

Measure the voltage across U1 pin 4 to pin 8. This should be 10.0V.

Installing in Your Own Cabinet

Selecting a Cabinet

The scope clock in its bare board form is neither cat- nor child-friendly. It requires a cabinet that will support the CRT safely, protect the user from coming in contact with the high voltages present on the PC board, and allow for adjustment of the controls. The controls R7-R11 on the edge of the board require adjustment after the clock is set into operating position, so they should be made accessible, either with holes in the cabinet or by having the cover removable. A third option is to wire up these controls to front panel potentiometers. Be aware that the Bright, Astig and Focus controls have HIGH VOLTAGE on them, and must be well insulated from both a metal cabinet and from the user.

One popular type of cabinet to use is an old oscilloscope. The oscilloscope cabinet will already have suitable controls on the front panel, and it provides a secure mounting for the CRT.

Mounting the PC Board

The PC board is mounted with the six mounting holes provided. It must be mounted on spacers to keep the bottom of the PC board at least 1/4 inch away from the baseplate or chassis.

Connecting Screen Controls

If the scope clock PC board is installed in an old oscilloscope cabinet, it may be desired to connect up some of the front panel controls to control the scope clock board. The obvious candidates are Inten, Focus, Astig, H Cent, V Cent, Height and Width.

This is a reasonable thing to do, with one caveat: there is HIGH VOLTAGE on the Bright, Focus and Astig controls. The Bright control has about -1300V on it, the Focus has about -900V, and Astig has +300V. Consequently, special high-voltage controls must be used. (Clarostat 392JB, available at Digikey and Newark, is a good choice.)

The controls in the oscilloscope may be up to the task if they are not too old, but it is best to get new controls of the proper resistance values (Astig and Focus values are not critical, but should be at least 500K ohms). Be sure to fully insulate the Focus and Bright controls from the user AND from the chassis, since they have over 1000V DC on them!

The Height and Width control wires may require shielding, since they are connected to the X-Y signals that move the beam. It may be best to leave these as internal adjustments. The centering controls should not cause a problem being remotely mounted, but it is a good idea to connect a 0.1uF capacitor from the center terminal to one end terminal of each control to reduce induced noise.

Using the Clock

Introduction

The scope clock is a versatile clock, and can do things that no ordinary clock can do. The operating modes and controls are described below.

Navigating the menus

The main operating mode of the clock is as a clock. Turning the knob when in clock mode will select different display formats. Choose one that you like, and leave it there. Or change it now and then – variety is nice.

Pressing the encoder button enters the main menu. A menu has one bright item, called the selection. The selection may be changed by turning the knob. The selection may be acted upon by pressing the button.

The setting menus have items that can not only be selected but their values can be changed. These are called fields. Examples are the hour, minute, day, DST on/off mode, etc.

To enter setting mode, press the button when a field is selected. The field will blink to indicate that it is in setting mode. Now the control functions are different. Turning the knob changes the value of the field, and pressing the button makes the next field blink.

After the button is pressed on the last field on a screen, the blinking mode is exited. This takes some getting used to, but is a fairly efficient way to control the clock with one knob.

The word Done at the bottom of each menu provides a way to return to the previous menu. In the case of the main menu, selecting Done returns to clock mode.

Setting the time

Pressing the button cycles the time-setting feature through the fields of the time and date, causing one field at a time to blink.

Turning the knob changes the number from 00-59 or whatever is appropriate for that field. The months cycle through from Jan to Dec and back to Jan.

When you are done setting the date, another press of the button will light up the Done field. Pressing the button to select this will exit the time setting menu and return to the main menu.

Programming the Processor

The processor is pre-programmed with the most up-to-date control software version available at time of shipment. However, since the source code is published, you may wish to reprogram the clock. If you know HC908 assembly language, you may be comfortable writing code yourself. If not, other customers may provide enhancements that you may wish to add to your clock. In either case, the code has to be put ointo the processor chip to be used.

The SC200 clock board has the ability to be reprogrammed over the COM port using a free-as-in-beer application called ICS08. You may download this from the vendor at www.pemicro.com or you may find a copy on the MegaSquirt support page at

http://www.bgsoflex.com/ics08asm.zip

You will also need:

A PC running Windows with a COM (serial) port
A DE9 M-F cable to connect to the clock board

In the course of researching the above, I discovered that the MegaSquirt fuel-injection controller uses the GP32 processor and has a wonderful serial bootloader program built in that makes programming much easier. I plan to incorporate this bootloader idea into the next version of the scope clock – perhaps you could help if you are familiar with it.

The source code files contain descriptions of what they do. Take some time to read these files and you will get a better understanding of how the clock code is structured and how it all works. If you have any specific questions, feel free to send an email to Cathode Corner.

The SC200C has a set of switches used to program the processor. These re normally set to Run and On. They are flipped during the programming process. The On-Off switch is used when the programming software requests a power cycle. The Prog-Run switch is flipped to Prog just before selecting the algorithm. The algorithm to use is gp32-highspeed.08p. To get the processor out of programming mode to execute the code, switch to Off, the Run, then On.

Theory of Operation

Power Supply

The power supply is of the switching type. The 12 volt DC input power is switched through a high-frequency transformer to produce the necessary operating voltages.

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. Its voltage ratio is controlled by the duty cycle of the switch relative to the load current.

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 line voltage, so a regulator designed for one will work poorly when used the other way.

The switching IC is a Simple Switcher made by National. 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 and compares it to an internal 1.2V reference.

The low-voltage supply is pretty straightforward. Since both phases of the switching cycle are used, one winding can generate both positive and negative DC outputs. These 8 volt outputs are further filtered and regulated to produce clean +/-5 volts for the analog circuitry, 5 volts for the digital circuitry, and an extra 5 volt supply for a GPS receiver.

The high-voltage supply uses a doubler to make +280V for the deflection plates. This supply makes lots of current to run the four high-speed deflection amplifiers. A lower-current multiplier chain produces the cathode voltage of -1200V using a total of 10 diodes and 10 capacitors. This circuit uses very small capacitors to produce less than one milliampere of current, so it's not nearly as dangerous as a big, old-fashioned power transformer.

The high-voltage power supply may be built differently to generate a lower voltage for such tubes as the 1CP1 and DG7-32 that only need 600-800V to operate. In this case, three of the multiplier stages are bypassed.

The filament supply is straight AC, since AC heats up a wire as well as DC does.

A separate winding on the secondary feeds a voltage doubler which powers the digital optoisolator used for the modulation signal. This optoisolator is a special photodiode unit with sub-microsecond switching time. Its 5 volt operating voltage is too low to switch the CRT grid on and off, so yet another winding powers the 50 volt grid modulation supply.

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, and for night-dimming purposes may be controlled by an optional CdS photocell.

Blanking is active for that part of the circle that is to be blanked when drawing an arc, and whenever the beam is being moved from one location to another. 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 for most 2" to 5" CRTs. This voltage is adjusted by the Astigmatism control. This control 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 Amplifiers

The deflection amplifiers are differential input and output totem-pole amplifiers. The input stage is a differential amplifier circuit referred to as a long-tail pair. The voltage from the X or Y signal presented to one transistor is developed across the emitter-coupling resistor to generate a current difference which causes a varying voltage to be generated across the high-voltage pullup resistor. The gain is controlled by the emitter coupling resistor's value.

The output stage has a pair of high-voltage amplifiers which serve to speed up the operation by actively pulling the output high or low as needed. The two diodes on the emitter of the upper transistor direct current into the base of one transistor or the other depending on whether the output needs to be driven higher or lower. This allows the output voltage to be driven high faster than the RC time constant of the CRT capacitance and the load resistor. The result is a slew rate of about 150 volts per microsecond.

Character display

The characters 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 one to five segments. Each segment has a center position, X and Y size, a shape code and an arc byte. The center position places the segment within the character's cell space. The size values set the X and Y radii of the circle/ellipse. The shape code tells whether will be a positive-slope line (x=cos, y=cos), a negative-slope line (x=cos, y=-cos), or a circle (x-cos, y=sin). The 8-bit arc code tells the circuitry which octants of the circle to blank out to make an arc, such as in the letter S.

The scope clock has special circuitry called a circle generator. This consists of five parts: The wave shaper, the shape selector, the DACs, the X-Y summer and the arc blanker.

The wave shaper starts with a 38.4 KHz square wave that is produced by dividing the 19.6608 MHz processor clock by 512. This square wave is sent through a series of low-pass and band-pass filters to turn it into a 38.4 KHz sine wave, then through more filters to shift its phase by 90 degrees. The sine wave is also inverted to produce a negative wave, needed to make a backslash.

The wave selector determines which version of the wave is sent to the Y axis. The X axis always receives the original sine wave. If that wave is sent to the Y axis also, then a forward slash, a line with positive slope, will be produced. If the inverted wave is sent to the Y axis, then a backslash will be produced. If a 90 degree quadrature wave is sent to the Y axis, then a circle will be produced.

The DACs are four digital-to-analog converters whose job is to scale the circle size and position the center of the circle on the screen. These are special DACs called multiplying DACs. A multiplying DAC will multiply, in the analog domain, the voltage applied to its reference input by a scale factor equal to the number loaded into the DAC divided by its input number range. For example, if a 1 volt peak-to-peak sine wave is fed into the DAC and its register is loaded with 64, which is 1/4 of its range of 256, then the output will be a 1/4 volt peak-to-peak sine wave.

Two of the DACs are used to scale the sine waves for the X and Y axes. The other two have 5 volts as their input, and simply produce X and Y offset voltages to move the circle on the screen.

There are two summers, one each for the X and Y axes. A summer adds the offset voltage and the sine wave and another offset voltage from the centering knob to produce a signal that is amplified and sent to the oscilloscope tube deflection plates.

The arc blanker switches the electron beam on and off as the sine waves sweep out the circle on the screen. It is made from an 8-way multiplexer that selects one bit of the arc code byte at a time as the circle is swept. The selection is done by using three higher-frequency bits from the frequency divider that produces the 38.4 KHz square wave.

The selected control bit is passed to the blanking circuit, which shifts it in voltage and applies it to the grid of the CRT.

If you look closely exactly when the hour changes, you will see the entire display move slightly. This is the screensaver feature - by moving the display hourly, it will take much longer for a particular spot on the CRT's phosphor to be burned in.

The screensaver is implemented in software by adding a small X,Y displacement to the entire image. The path taken by the screen image is a zig-zag. This displacement is changed slightly once an hour, and goes through a prime number of steps (31) before retracing its path in the other direction so as to cycle through the hours in an evenly distributed sequence so that no hour digit is favored in any position on the screen.

Computer program

The software running on the computer is a complex real-time embedded control program. It has to keep track of the time, send new display segments to the display circuits on a regular basis, keep track of the rotary encoder movement, and keep in sync with the power line frequency for a stable display.

1PPS input

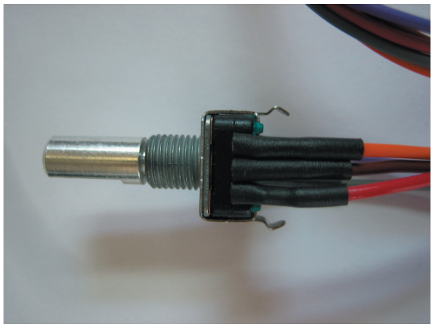
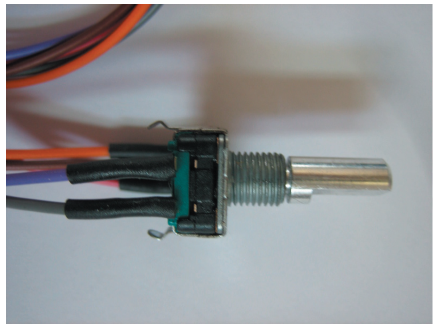
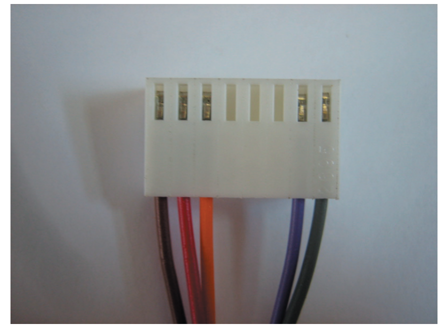
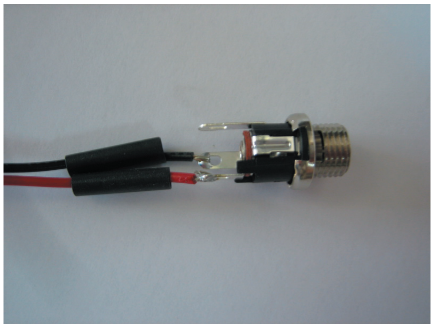
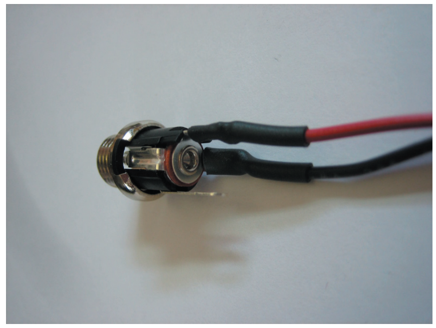
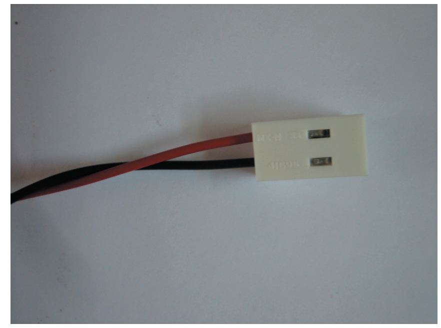
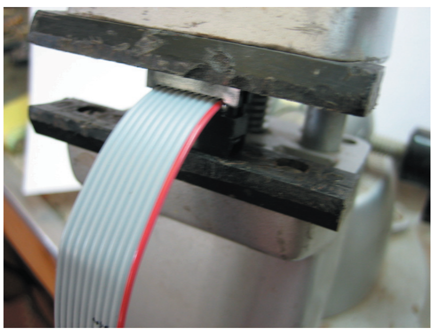
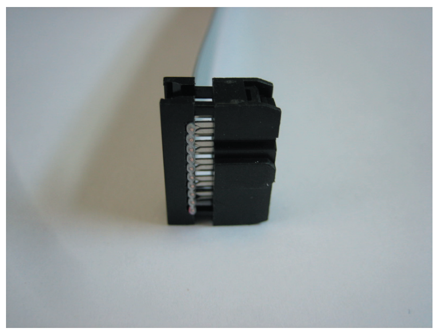
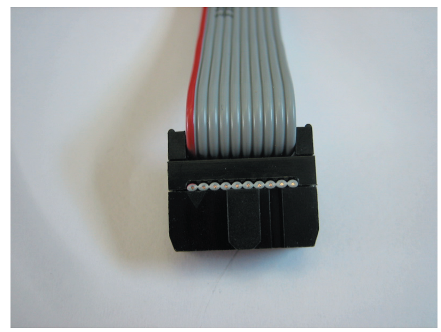
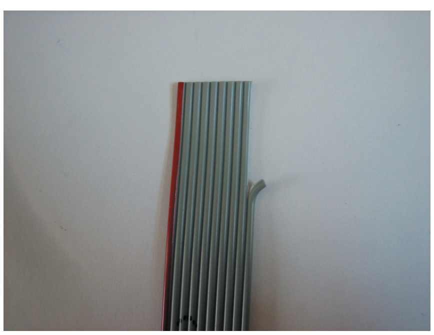
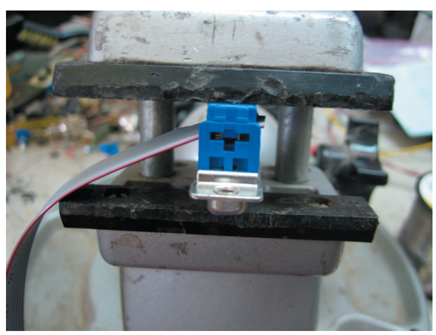
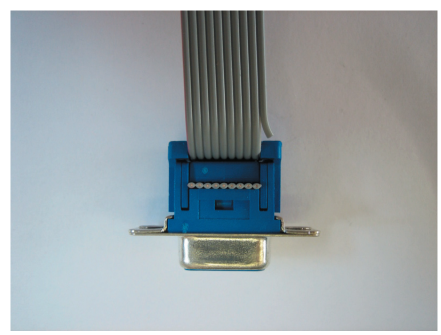
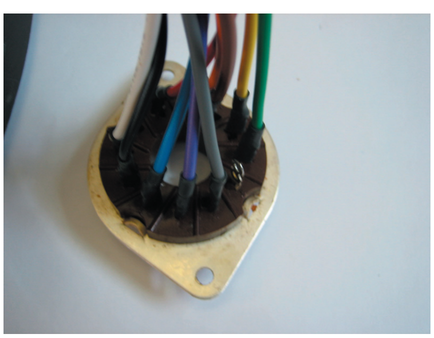
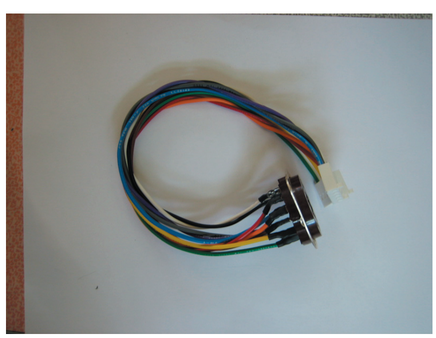
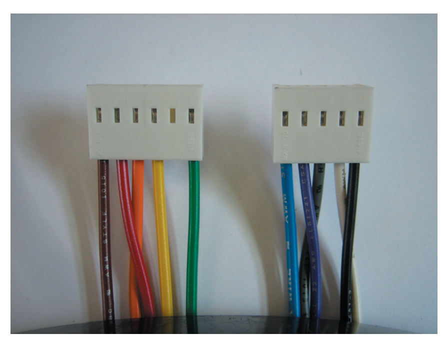
An optional one-pulse-per-second (1PPS) input allows the clock to take its timekeeping reference from an external atomic clock, GPS receiver or other accurate reference source. The required input signal is TTL or RS-232 level. The clock advances the time on the rising edge of the pulse. The signal is inverted by the MAX232 line receiver and fed to the CPU's interrupt request (IRQ) input. Since the interrupt is edge-triggered, pulse width is not critical.

The software detects an interrupt on this pin to enter the 1PPS timekeeping mode. Until and unless such an interrupt occurs, the clock will use the crystal oscillator divided by the CPU's timer as the time source. When the IRQ interrupt happens, the software changes to a mode in which it advances the seconds counter on each receipt of an interrupt. The clock will not keep time if the 1PPS signal is connected then removed. This could be changed in the software. Feel free to.

Optional GPS input on Com port

The clock may listen to the NMEA 0183 text strings sent from a GPS receiver connected to the serial port. The clock was designed to connect directly to the Garmin GPS 18 LVC receiver, but will work with any GPS receiver that puts out an RS-232 or TTL-level active-low serial data stream. The default baud rate is 4800-8-N-1.

The string that is monitored is the GPRMC sentence, which contains the time, date, position and course information. (Course is not too interesting unless the clock is mounted in a moving vehicle.)


The Scope Clock
from
Cathode Corner
Version 1.00


Set Time & Date
Set Locale
Set up GPS
Align Display
Done

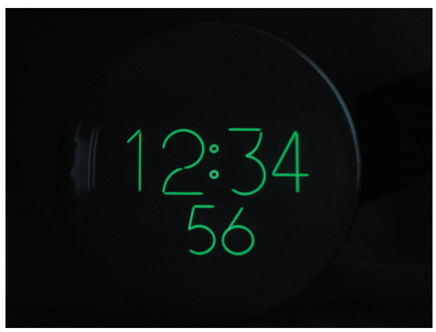

00:00:28
2008-Jan-1
Done


Zone: GMT+0:00
24 hour mode
DST Off
Done


Set up GPS
Init GPS receiver
Done


EXS28U
Done


12:34


12:34
56

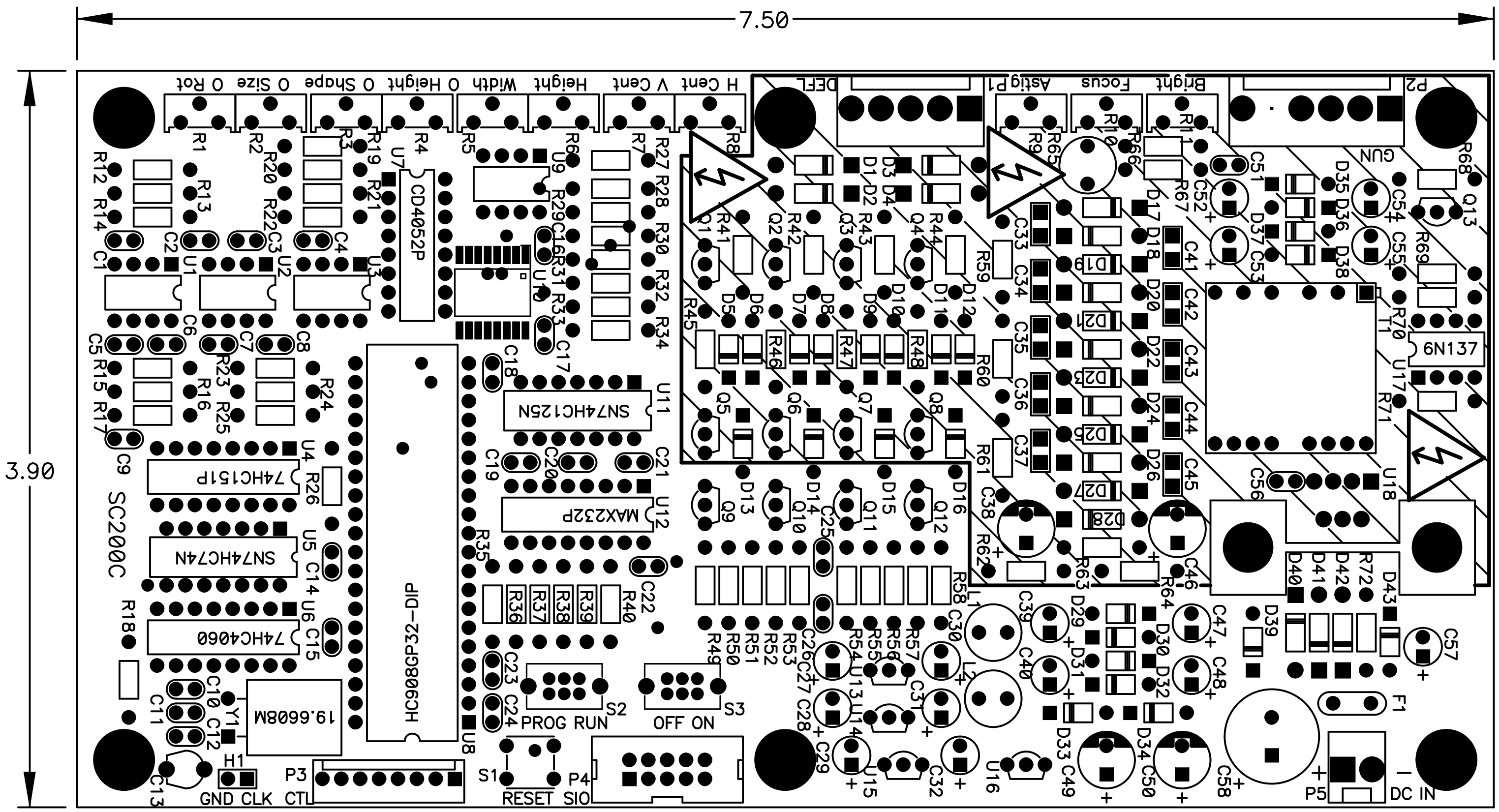

XII
IX
III
VI


Friday
12:34
July 4


July 4
12:34
56


Friday
12:34:56
July 4
2008

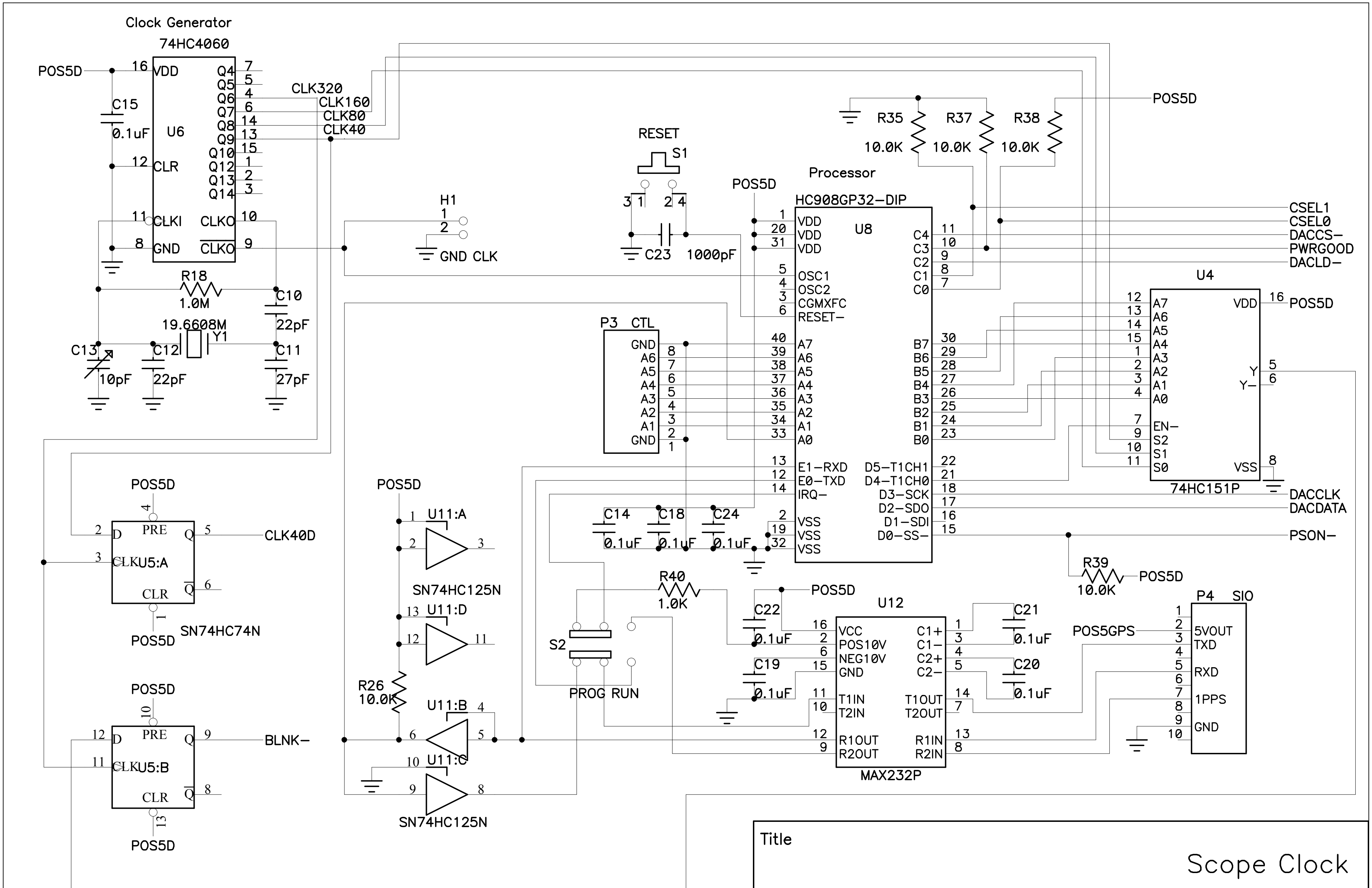

acme



TOP SILK SCREEN

TOP MASK

Cathode Corner	
Thu Apr 10, 2008 11:23:02	2602 E Helen Tucson AZ 520-795-7228
SC200C Scope Clock PCB	



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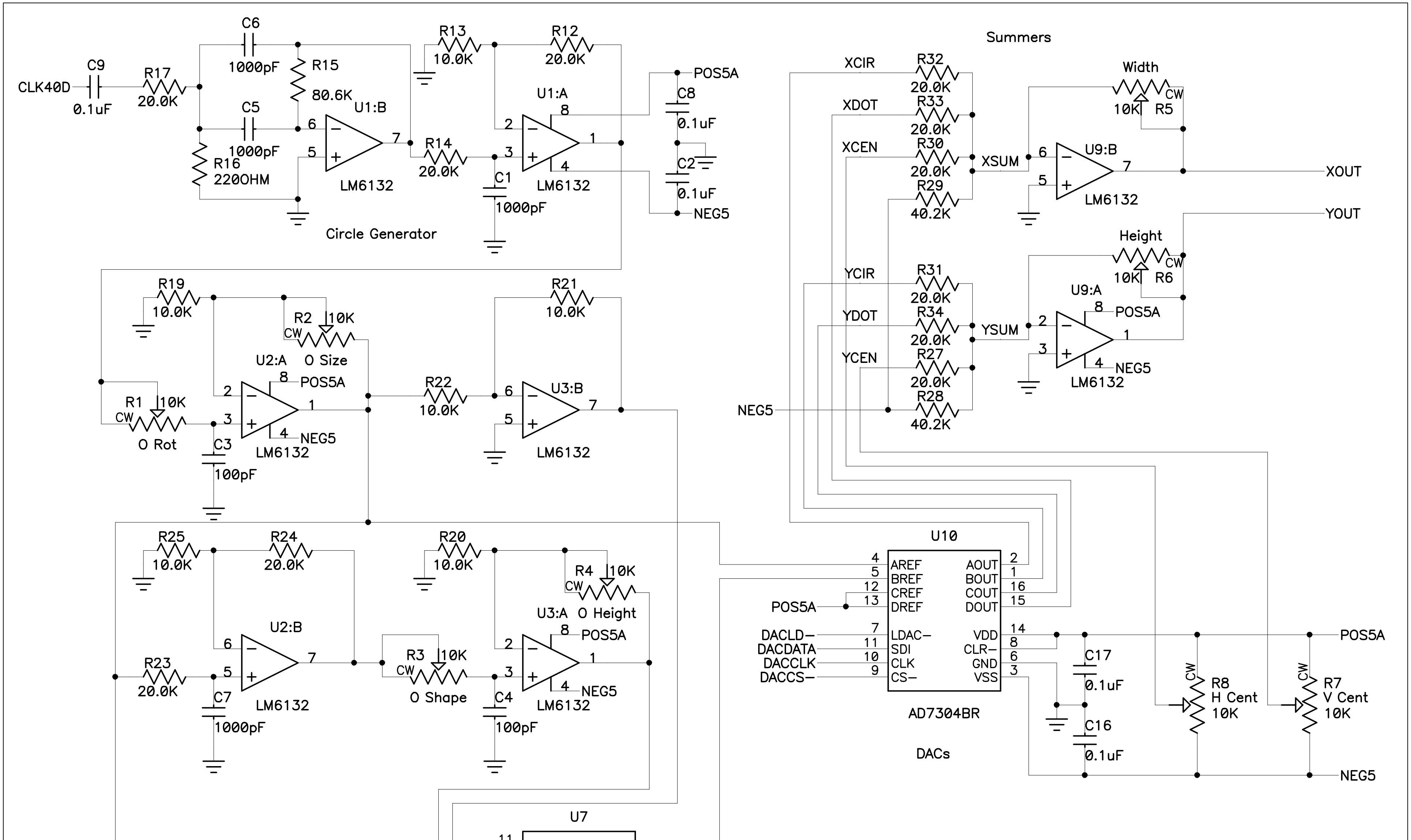
Date: Wed Mar 19, 2008	Drawn by: D. Forbes	
Filename: SC200C5.sch	Sheet 1 of 4	



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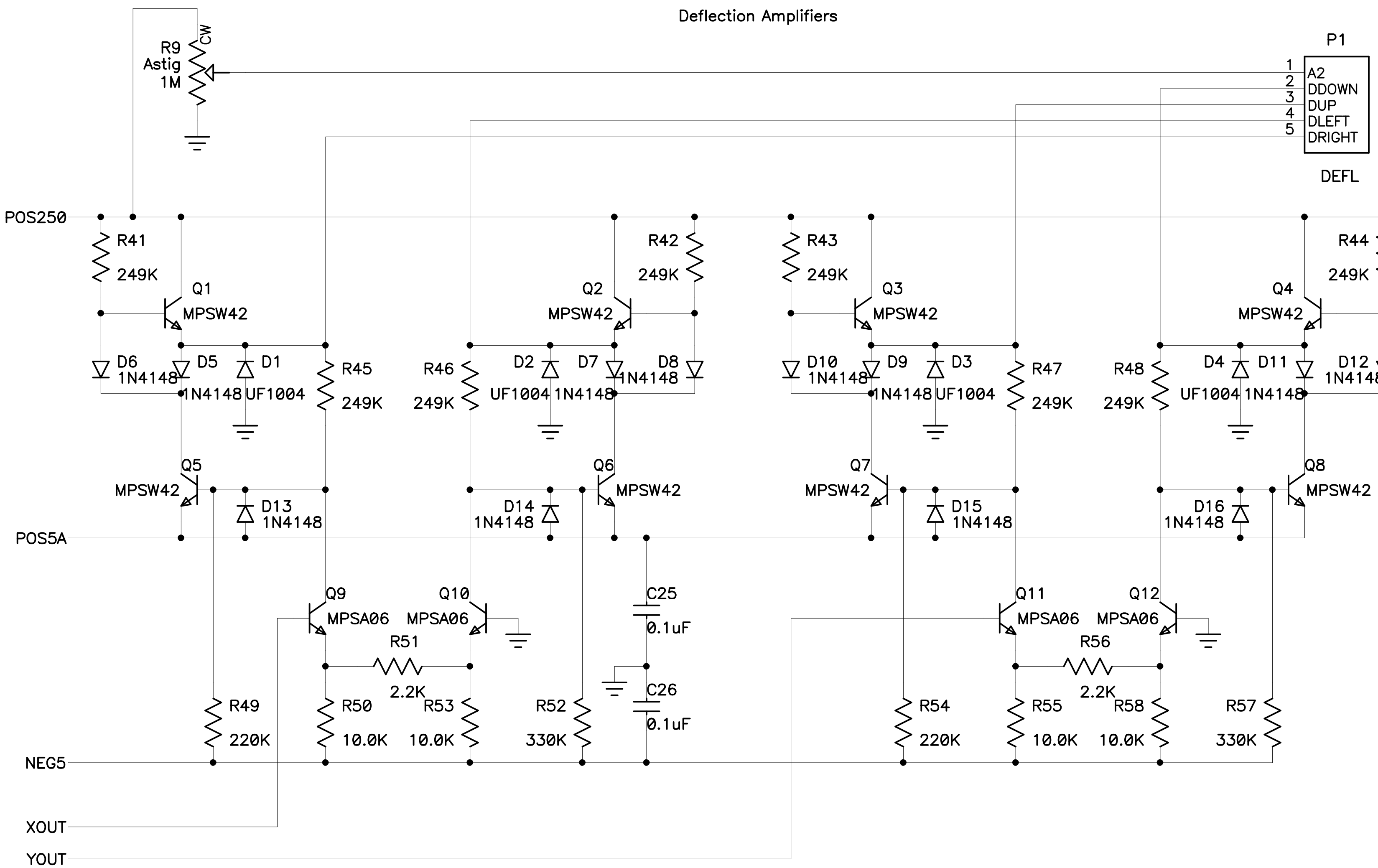
Rev	C
Date	Wed Mar 19, 2008
Drawn by	D. Forbes
Filename	SC200C5.sch
Sheet	2 of 4

Deflection Amplifiers



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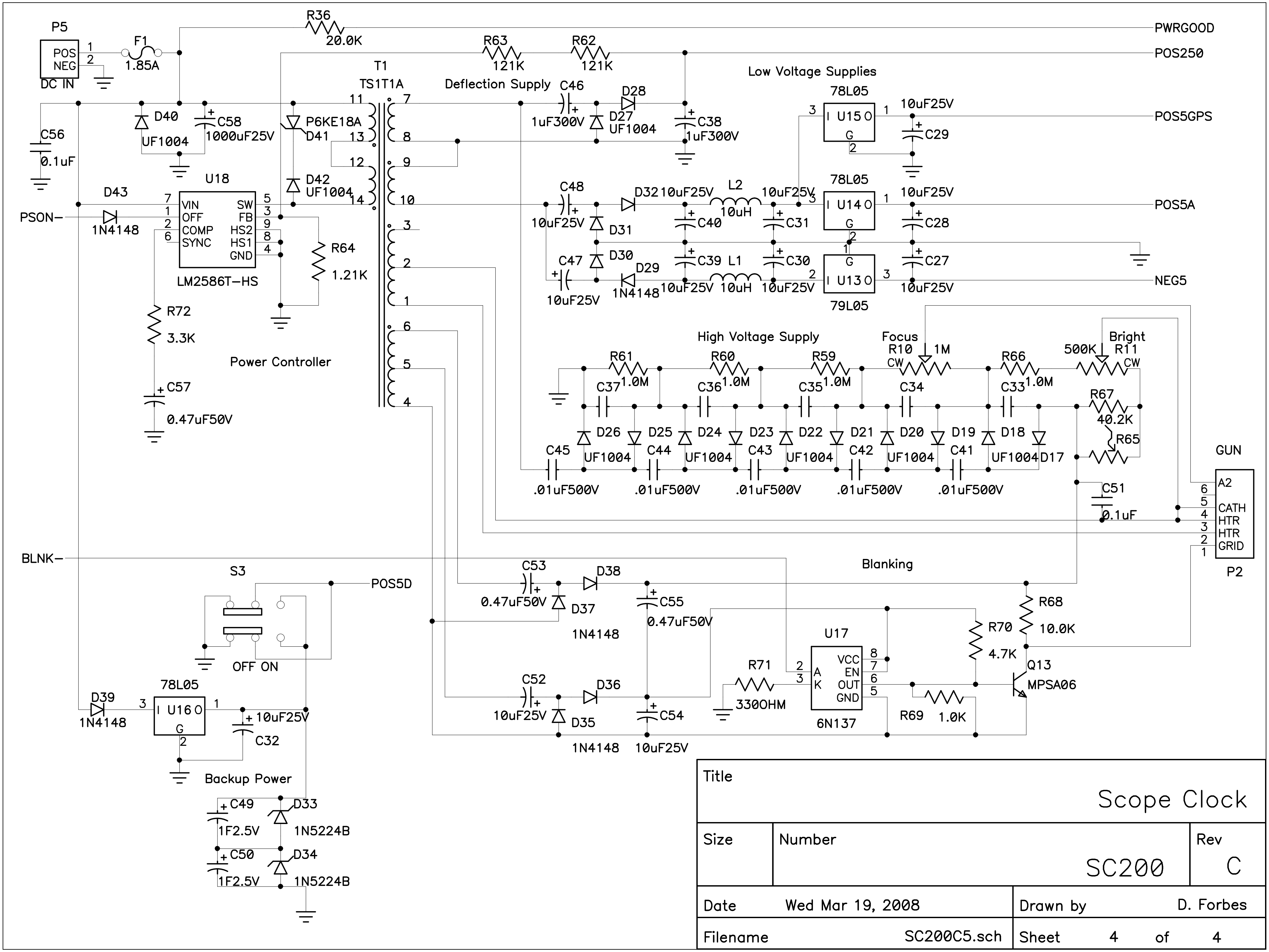

Title	Scope Clock		
Size	Number SC200		Rev C
Date	Wed Mar 19, 2008	Drawn by	D. Forbes
Filename	SC200C5.sch	Sheet	4 of 4