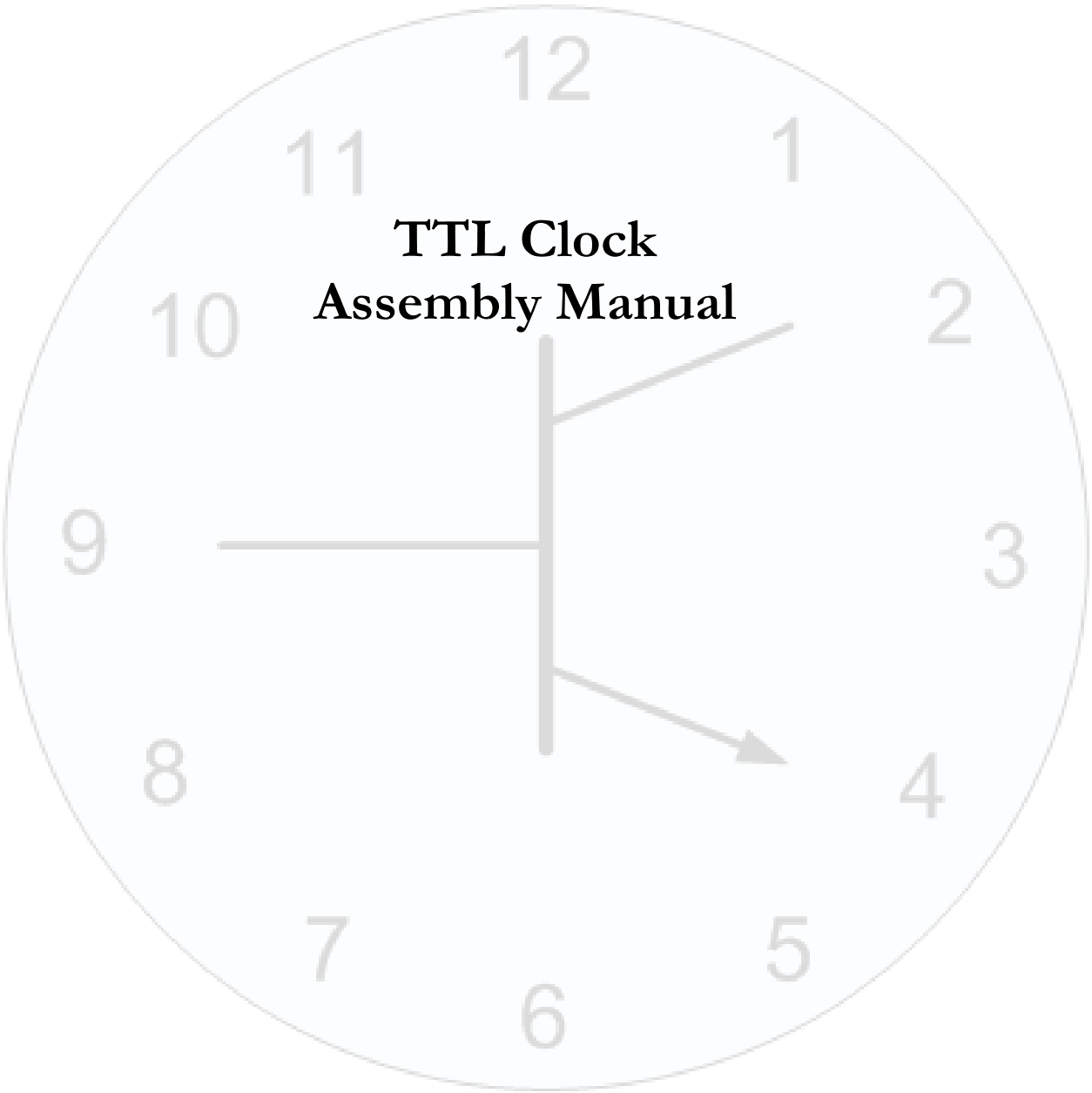
TTL Clock
Assembly Manual



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Document version 3 for use with PC board version 4

Introduction

Thanks for buying this kit. After a few hours of assembly, and with a clock to show for your efforts, I hope you will thank me for offering this kit.

To all the experienced electronic hobbyists, let me apologize right now for the simple tone and overload of information in this manual, I am attempting to give enough information to allow a motivated beginner a chance to get this working. All you experienced folks can turn right now to the assembly section and go for it (watch out for the 7-segment LED placement, otherwise, this kit really is as simple as it seems).

If you are not skilled in soldering parts onto a PC board, you should read the soldering section and also search the web to learn about soldering, there are many good sites that teach soldering.

You need to make 593 good solder joints to have the clock work.

If you are not familiar with components, you should read the parts identification section, but frankly, this kit was designed for a somewhat knowledgeable electronic hobbyist. Be certain of a part before you solder it.

Unpacking/Parts List

Gently unpack the contents of the box. Check off the items below as you unpack. This will also serve as a chance to become familiar with the parts.

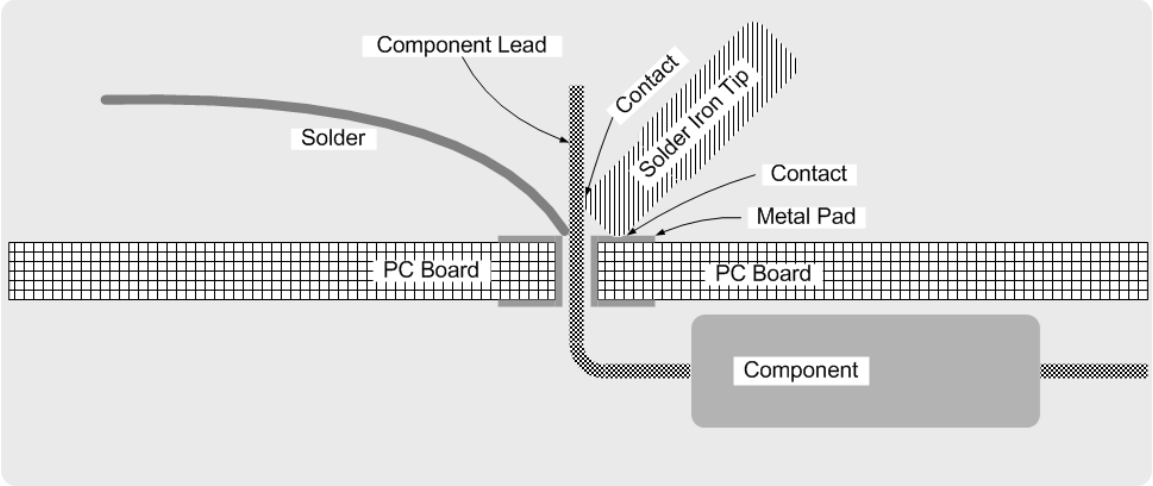
Item	Desc	Qty	Unpacked
1	0.01 poly cap	1	
2	0.1 poly cap	25	
3	10000uF electrolytic cap	1	
4	KBL04 bridge rectifier	1	
5	1N4148 diode	1	
6	LED, single	4	
7	LDS8164 7 segment display	6	
8	3 Ohm 5 Watt resistor	1	
9	330 resistor	4	
10	4.7K resistor	5	
11	82K resistor	1	
12	100K resistor	2	
13	180 resistor pack	5	
14	47K resistor pack	1	
15	LM339/3302	1	
16	LM7805	1	
17	74LS00	1	
18	74LS47	6	
19	74LS51	1	
20	74LS74	1	
21	74LS83	1	
22	74LS85	1	
23	74LS90	3	
24	74LS92	4	
25	header, wire capture	1	
26	push switch	2	
27	Heat sink	1	
28	Bolt	1	
29	Nut	1	
30	Nylon Tie Strap	1	
31	PC Board	1	
32	Wall Transformer	1	
33	Solder	1	
34	Desolder Braid	1	

Soldering

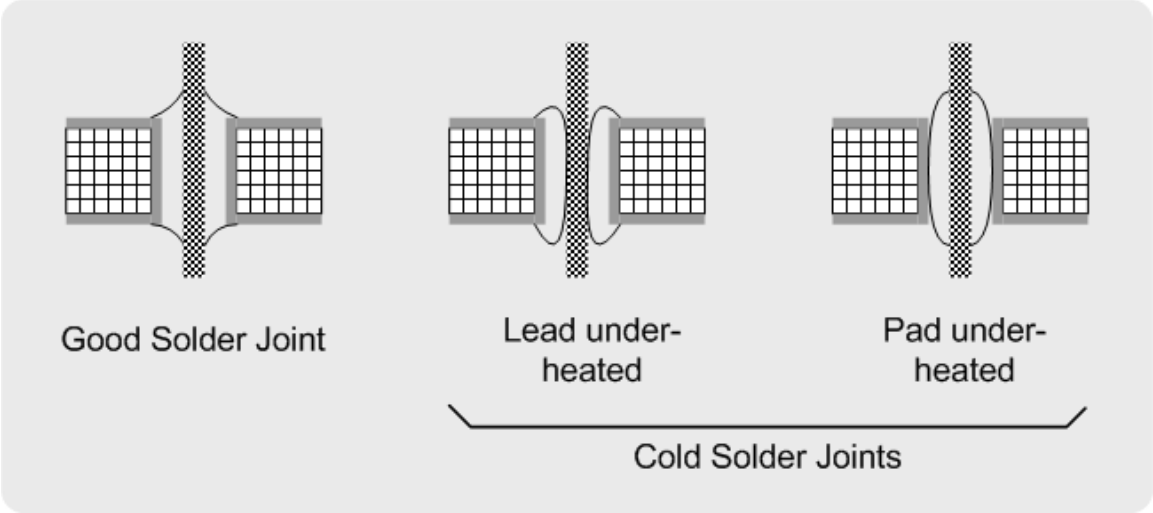
This manual can't teach the art of soldering, but here are the basics. Remember, you need to make over 590 **GOOD** solder joints; each bad joint will be an adventure in troubleshooting.

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

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



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



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

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

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

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

Unsoldering

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

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

Optional Clean-up

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

Assembly Instructions

At the highest level, the assembly instructions are;

Place each component in its identified location with its leads through the proper holes, solder the leads into place leaving the component snugly against the PC board, and clip the component leads flush with the top of the solder joint. Repeat for all 81 components.

OK, that's a bit too short. After the following general information, there are detailed instructions.

Find a location to build this clock where you have room to place the board and still have room to place the components within easy reach. Place a garbage can within reach of the work, you will find you need to deal with the clipped off leads of components.

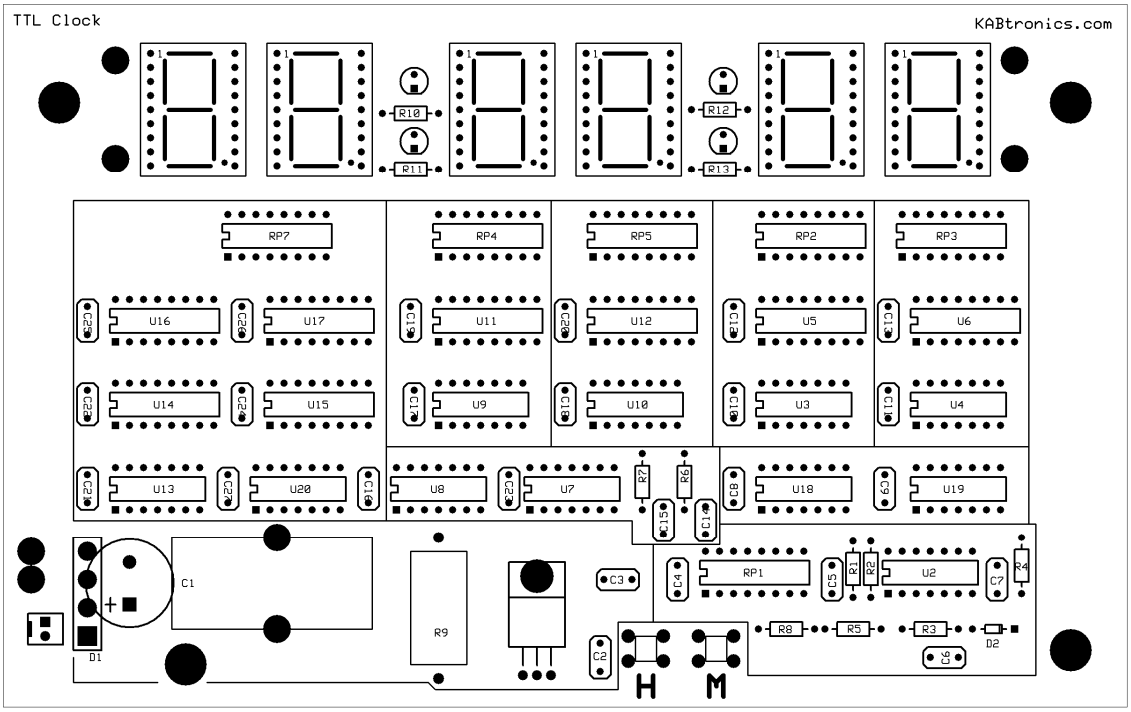
You will need the following tools to build your clock.

- Soldering Iron meant for electrical work
- Small Diagonal Cutter
- Very small flat-blade screwdriver to tighten the wire terminals
- A VOM meter to check for shorts and power supply operation
- Maybe an oscilloscope, while not necessary, may come in useful if you find yourself unable to diagnose a problem. If you can't fix your problem by inspection and location of bad soldering or misplaced components, you will need an oscilloscope.

Component Side

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

The following diagram is a copy of the white markings on the board, which is known as the silkscreen. Following that is the Bill of Materials, knows as the BOM.



So, to build this clock you need to;

- pick a location on the board,
- read the reference designator there, either from the board or the silkscreen drawing,
- use the BOM to cross index that reference to the part,
- find that part,
- place it in the holes oriented correctly,
- solder it in place, and
- clip off the leads
-

Repeat for all components.

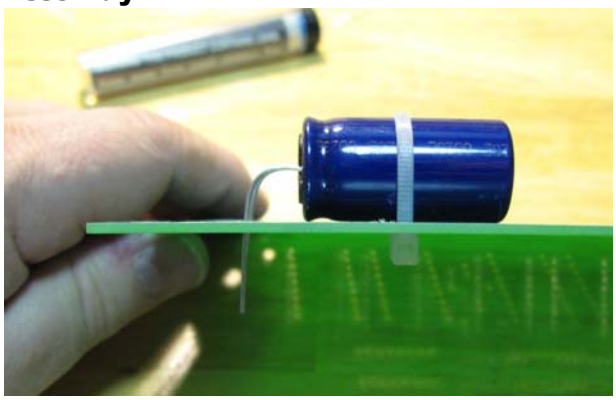
Following the BOM, there is a suggested order of assembly. If you want to build in your own order, you may want to read through the following pages to pick up some hints on mounting odd components.

Bill Of Materials

Ref	Component
C1	10000uF
C2	0.1
C3	0.1
C4	0.1
C5	0.1
C6	0.01
C7	0.1
C8	0.1
C9	0.1
C10	0.1
C11	0.1
C12	0.1
C13	0.1
C14	0.1
C15	0.1
C16	0.1
C17	0.1
C18	0.1
C19	0.1
C20	0.1
C21	0.1
C22	0.1
C23	0.1
C24	0.1
C25	0.1
C26	0.1
C27	0.1
D1	KBL04 Bridge
D2	1N4148
D3	LED
D4	LED
D5	LED
D6	LED
DIS1	LDS8164
DIS2	LDS8164
DIS3	LDS8164
DIS4	LDS8164
DIS5	LDS8164
DIS6	LDS8164
J1	Terminal

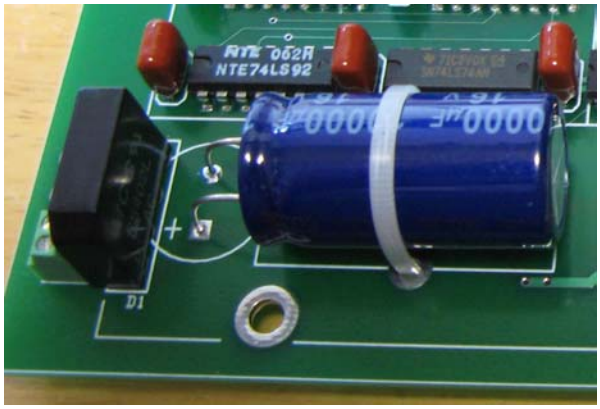
Ref	Component
R1	100K
R2	4.7K
R3	4.7K
R4	82K
R5	4.7K
R6	4.7K
R7	4.7K
R8	100K
R9	3 ohm 5 W
R10	330
R11	330
R12	330
R13	330
RP1	47K
RP2	180
RP3	180
RP4	180
RP5	180
RP7	180
SW1	PB switch
SW2	PB switch
U1	LM7805
U2	LM339
U3	74LS92
U4	74LS90
U5	74LS47
U6	74LS47
U7	74LS00
U8	74LS51
U9	74LS92
U10	74LS90
U11	74LS47
U12	74LS47
U13	74LS92
U14	74LS85
U15	74LS83
U16	74LS47
U17	74LS47
U18	74LS92
U19	74LS90
U20	74LS74

Assembly



( ) C1

Mount this large electrolytic capacitor on its side. Be sure to place the + lead in the + hole and the – lead in the other hole. Often the minus lead is shorter or marked by a line of arrows on the side. Use a nylon strap to hold it snug against the board before soldering the two leads.

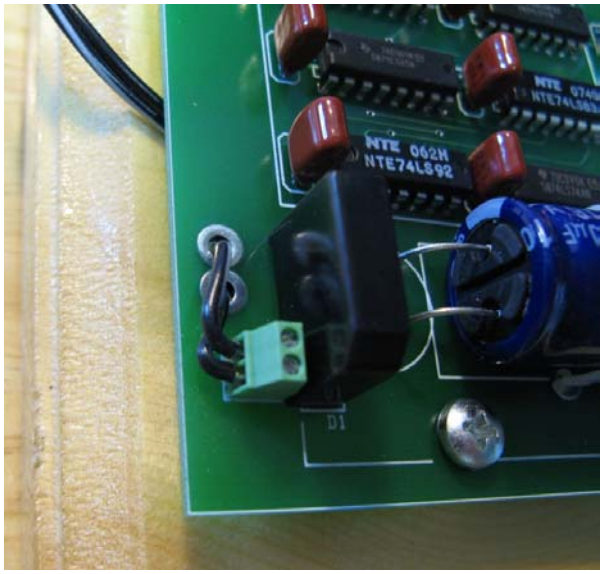


( ) D1

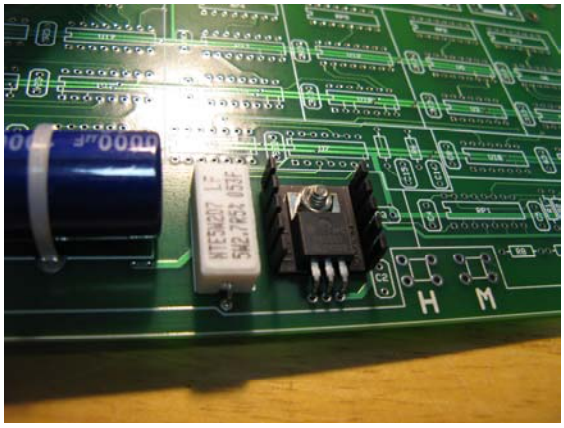
Mount the bridge rectifier with the plus lead in the hole near the + sign. The plus side may also be beveled for identification.

( ) J1

Clip off the two small plastic nubs on the bottom so it will sit flat when the leads are in the holes.

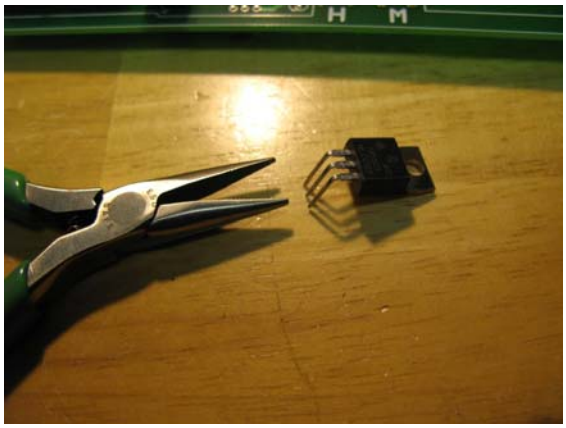


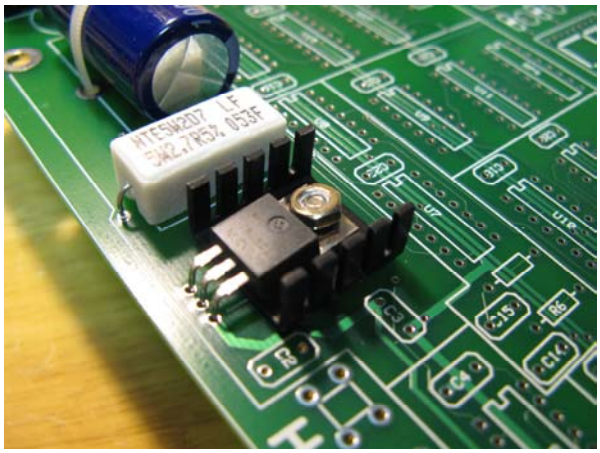
…, then mount the connector with the openings for the wires towards the board edge. (You will connect the wires later)



( ) R9

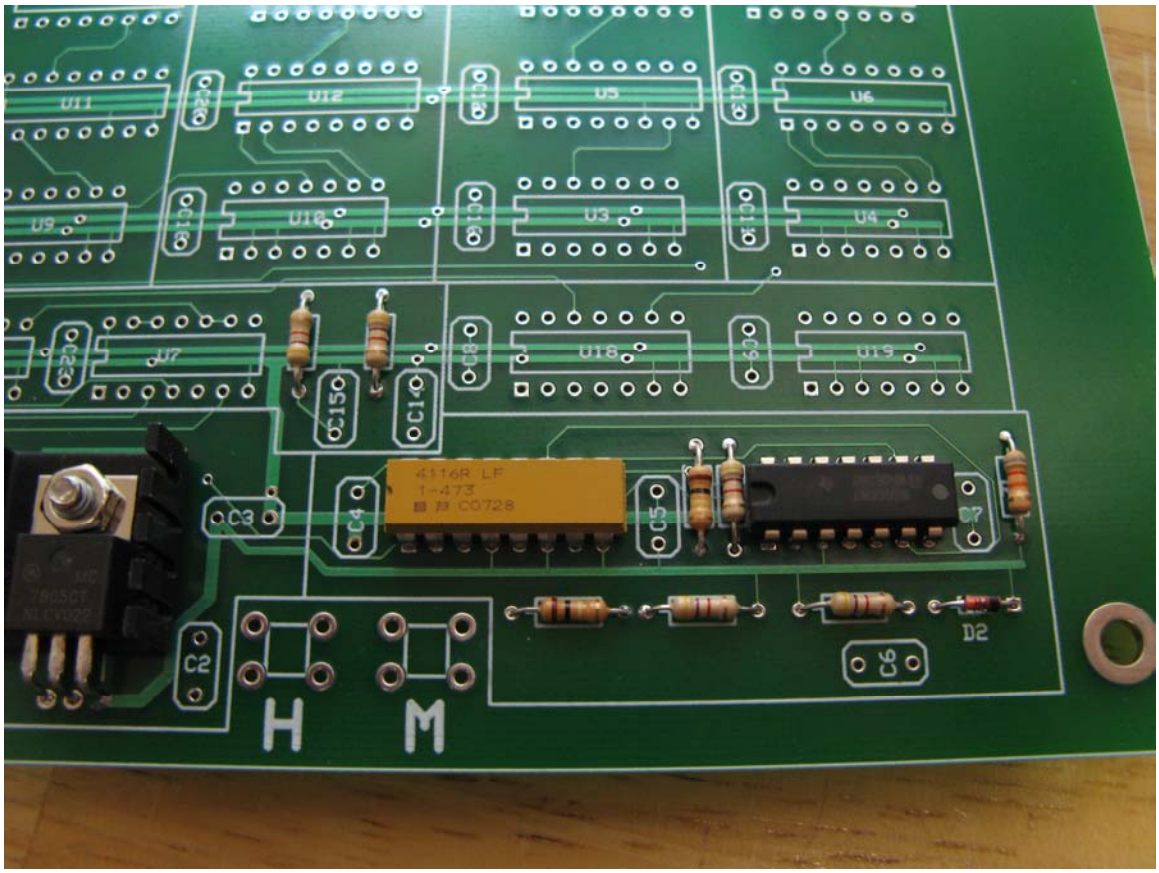
Mount the 5 watt resistor snugly to the board.





( ) U1

Mount it with a nut and a bolt and sandwich a heat sink between the IC and the board. Don't solder the three leads until the assembly is tightly fastened.



Now load the ¼ watt resistors and a diode

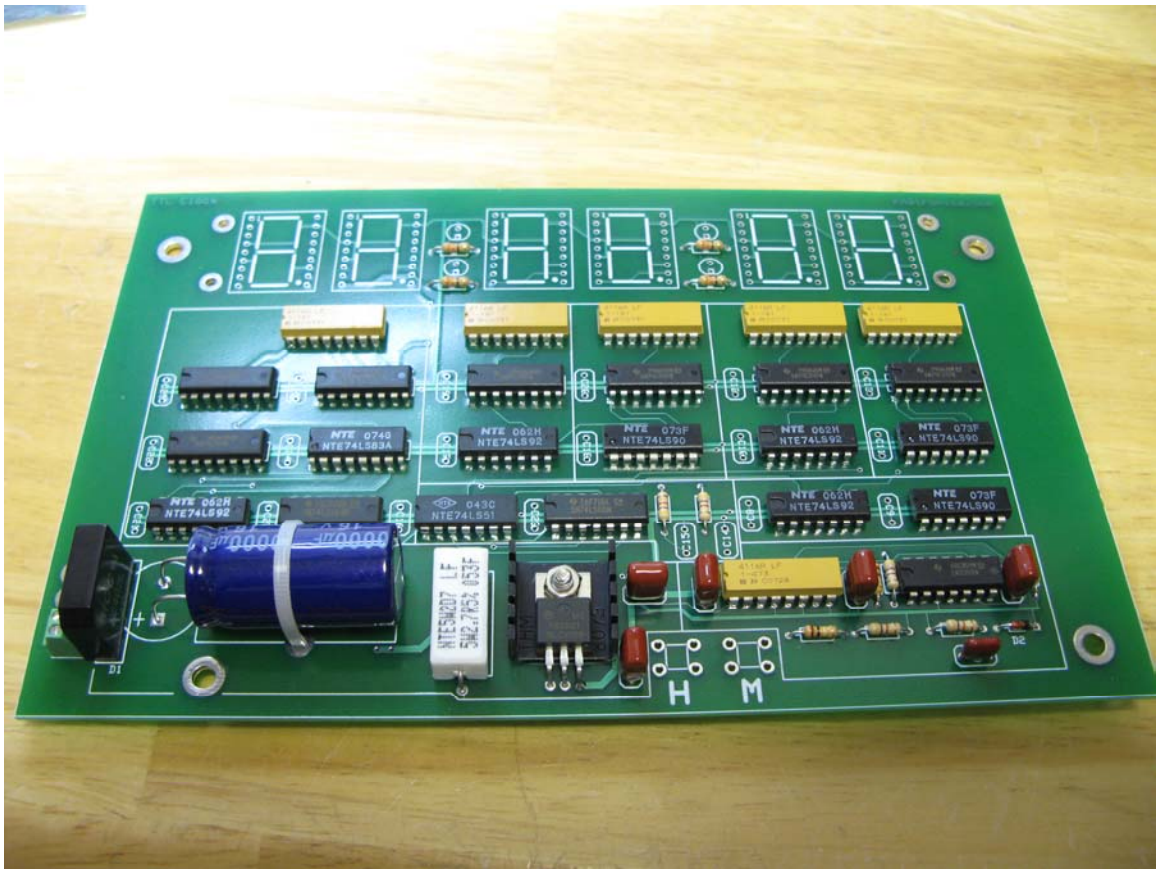
( ) R1 100K (Brown-Black-Yellow)
( ) R2 4.7K (Yellow-Purple-Red)
( ) R3 4.7K (Yellow-Purple-Red)
( ) R4 82K (Gray-Red-Orange)
( ) R5 4.7K (Yellow-Purple-Red)
( ) R6 4.7K (Yellow-Purple-Red)
( ) R7 4.7K (Yellow-Purple-Red) (this is missing the R7 marking on PC board Version 3, it is near R6, to above and left of C15)
)
( ) R8 100K (Brown-Black-Yellow)
( ) D2 Small Diode, 1N4148, mount with the line on the diode matching the line on the board.

( ) RP1 47K

There is only one 47K resistor pack. The leads may be spread a bit wide, be gentle when bending the leads, they will break off if flexed too much.

( ) U2 LM339 or 3302 IC

Mount this IC like the resistor pack, note the orientation on the package and match the silkscreen orientation.



Mount the rest of the ICs

( ) U3 74LS92

( ) U4 74LS90

( ) U5 74LS47

( ) U6 74LS47

( ) U7 74LS00

( ) U8 74LS51

( ) U9 74LS92

( ) U10 74LS90

( ) U11 74LS47

( ) U12 74LS47

( ) U13 74LS92

( ) U14 74LS85

( ) U15 74LS83

( ) U16 74LS47

( ) U17 74LS47

( ) U18 74LS92

( ) U19 74LS90

( ) U20 74LS74

Mount the resistor packs

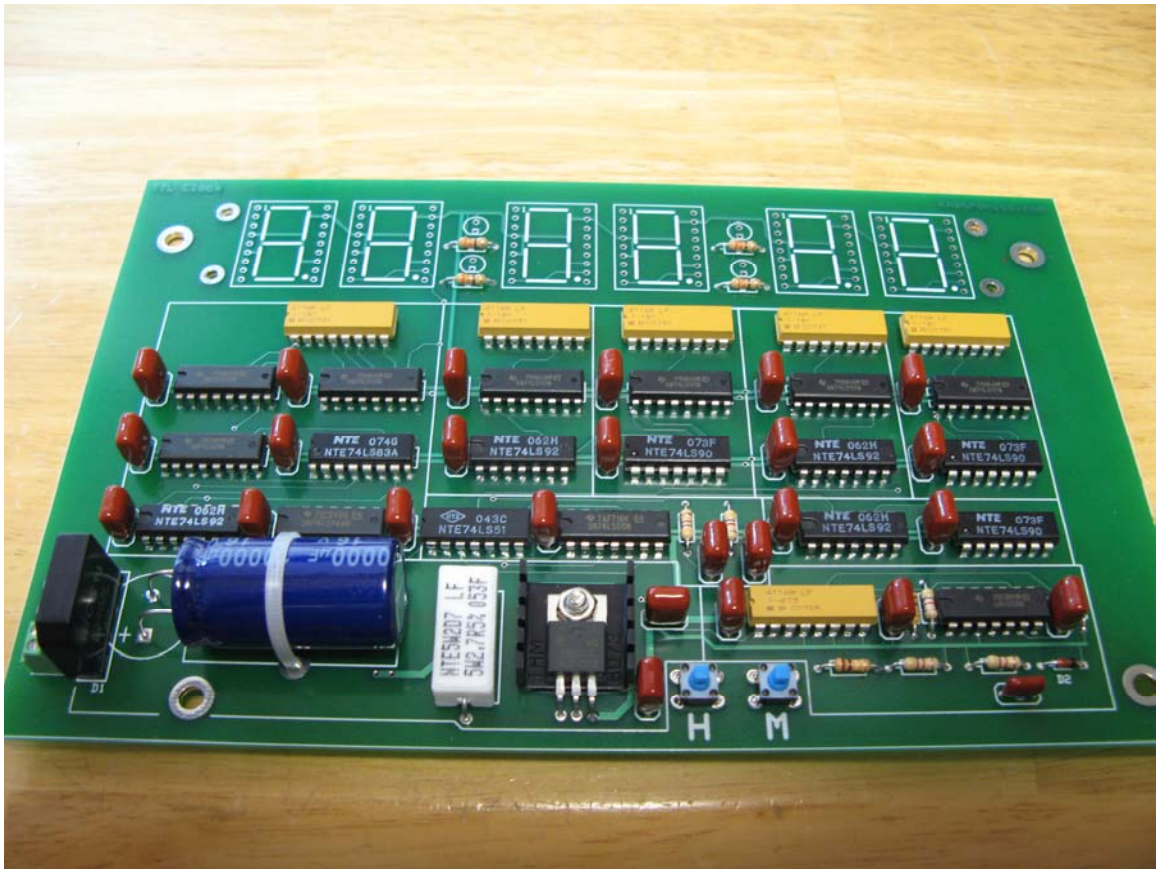
( ) RP2 330

( ) RP3 330

( ) RP4 330

( ) RP5 330

( ) RP7 330



Moount the single 0.01 poly cap.

( ) 0.01 Poly Cap at C6. The cap is marked 103

Mount all the other poly caps, they are all 0.1 value, marked 104

( ) C2 0.1

( ) C3 0.1

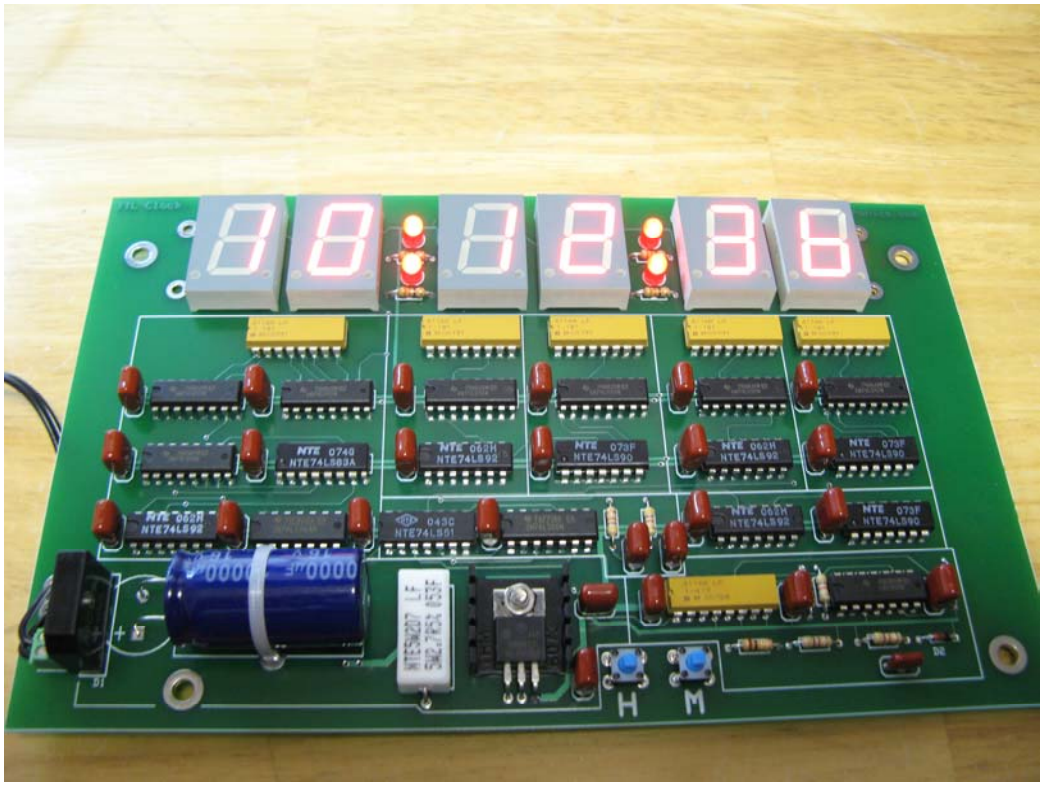
( ) C4	0.1	( ) C17	0.1
( ) C5	0.1	( ) C18	0.1
( ) C7	0.1	( ) C19	0.1
( ) C8	0.1	( ) C20	0.1
( ) C9	0.1	( ) C21	0.1
( ) C10	0.1	( ) C22	0.1
( ) C11	0.1	( ) C23	0.1
( ) C12	0.1	( ) C24	0.1
( ) C13	0.1	( ) C25	0.1
( ) C14	0.1	( ) C26	0.1
( ) C15	0.1	( ) C27	0.1
( ) C16	0.1		

Mount the four resistors in the display section

( ) R10	330	( ) R12	330
( ) R11	330	( ) R13	330

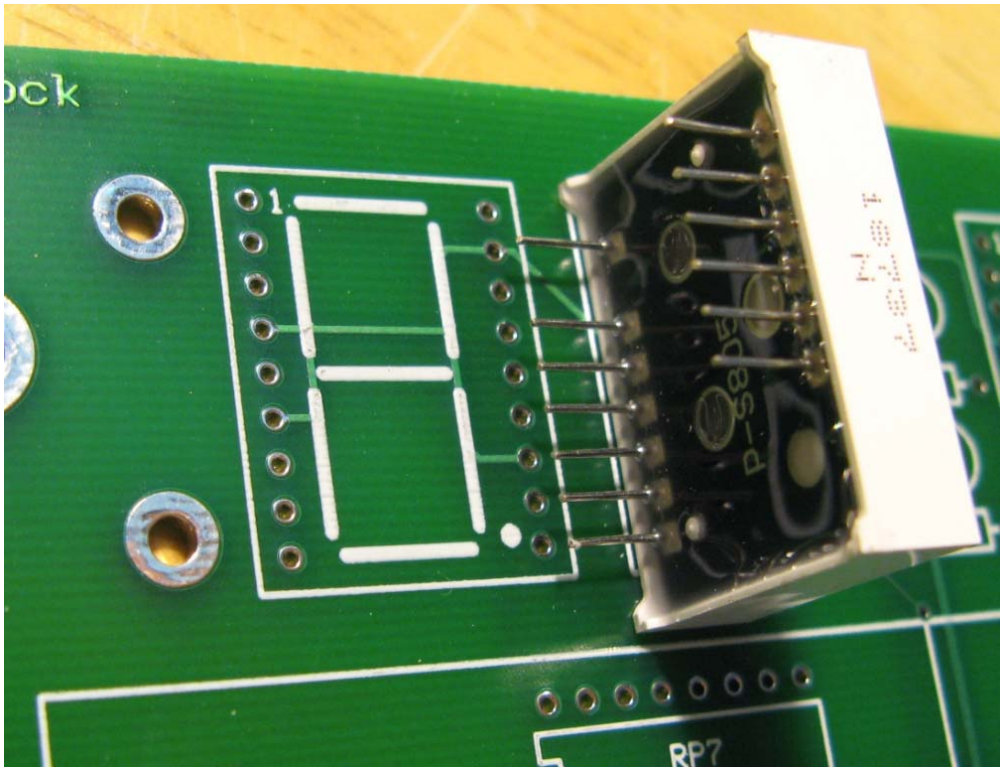
Mount the switches

( ) SW1 ( ) SW2



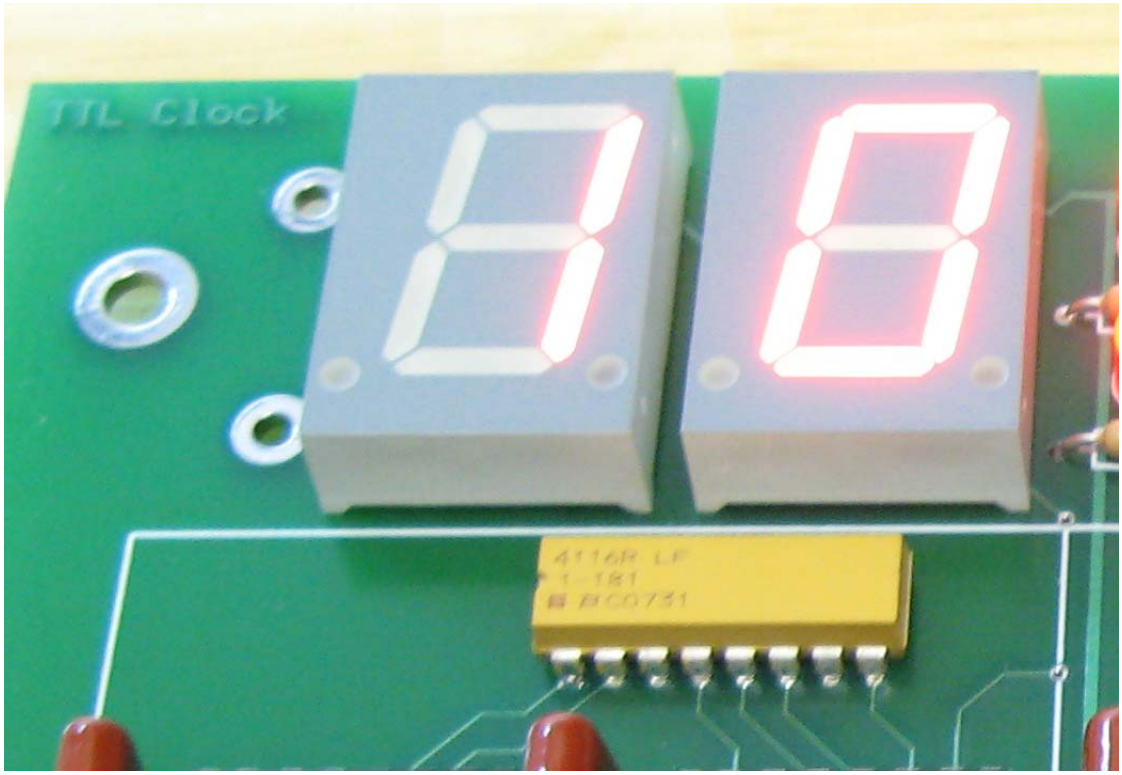
Mount the Displays.

There is a danger of incorrectly mounting these 7 segment displays.



Note how pin one is marked by the numeral 1 in the upper left. The white dot in the lower right of the silkscreen for the display is the DP - not a pin indicator.

The 7-segment LED displays are missing 5 pins; 1,8,9,16,18. This allows for the part to fit into the socket two ways, the wrong way and the right way. The right way is decimal points on the lower edge and the part towards the bottom edge, closer to the Resistor Packs. Pin one hole on the board will not have a lead in it when the part is mounted correctly.



( ) DIS1 7 segment display

( ) DIS2 7 segment display

( ) DIS3 7 segment display

( ) DIS4 7 segment display

( ) DIS5 7 segment display

( ) DIS6 7 segment display

Mount the LEDs. The short pin goes in the lower hole. The lower hole is marked with a square on the silkscreen

( ) D3 LED

( ) D4 LED

( ) D5 LED

( ) D6 LED

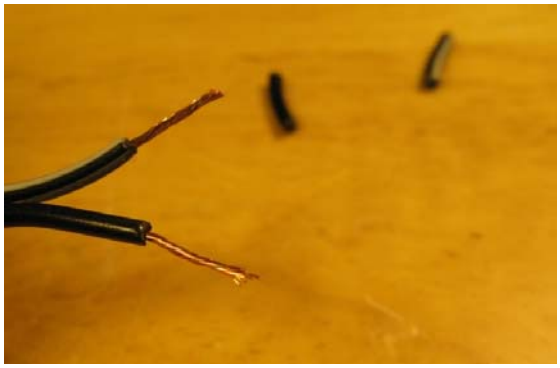
Your wall transformer may come with prepared wires, if not, prepare the wall transformer wires as shown below.

Find the wall transformer.

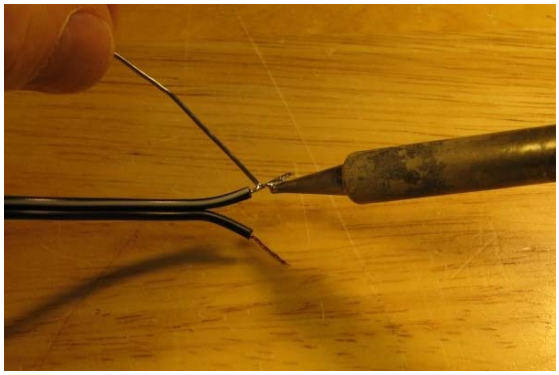
Cut off the connector at the end of the wire.

Separate the wires for an inch.

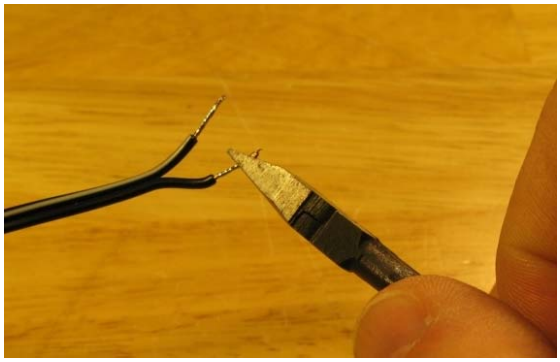
Strip off ½ inch of the insulation.



Twist the wire strands together

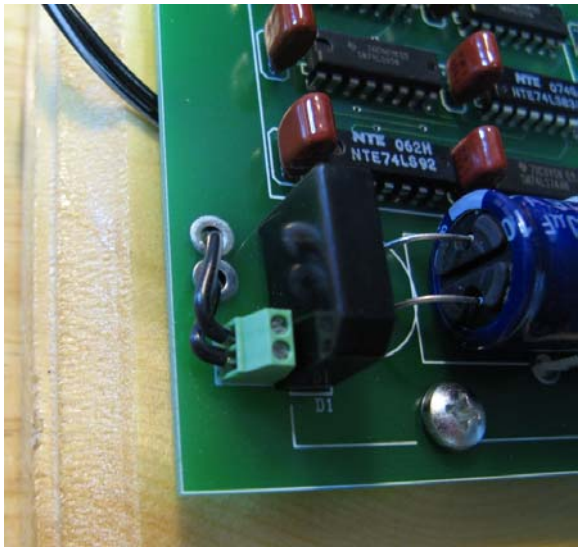


Use soldering iron to tin (coat with solder) the wire ends.



Clip off excess leaving ¼ inch

Finished wire ends.



Thread the wall transformer wires as shown and connect the wires to the terminal. You will need a very small screw driver to tighten the terminal screws. It does not matter which wire from the wall transformer goes into which hole of the connector.

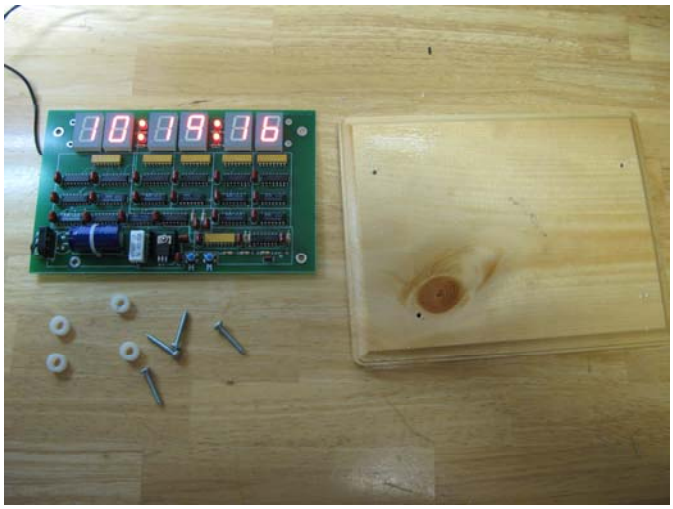
Final Tests

When the board is powered up, some of the counters can start in illegal states, such as 15 O'clock and 75 minutes, but the counters will count out of bad states and into legal times. Use the M and H switches to cycle the counters and stop at the correct time.

On your first power up testing, carefully watch each digit to be sure all counts are counted, 0-9 on seconds and minutes, 0-5 on tens of seconds and tens of minutes, and 1-12 on hours. Use the H and M switches, otherwise this test would take 12 hours to complete.

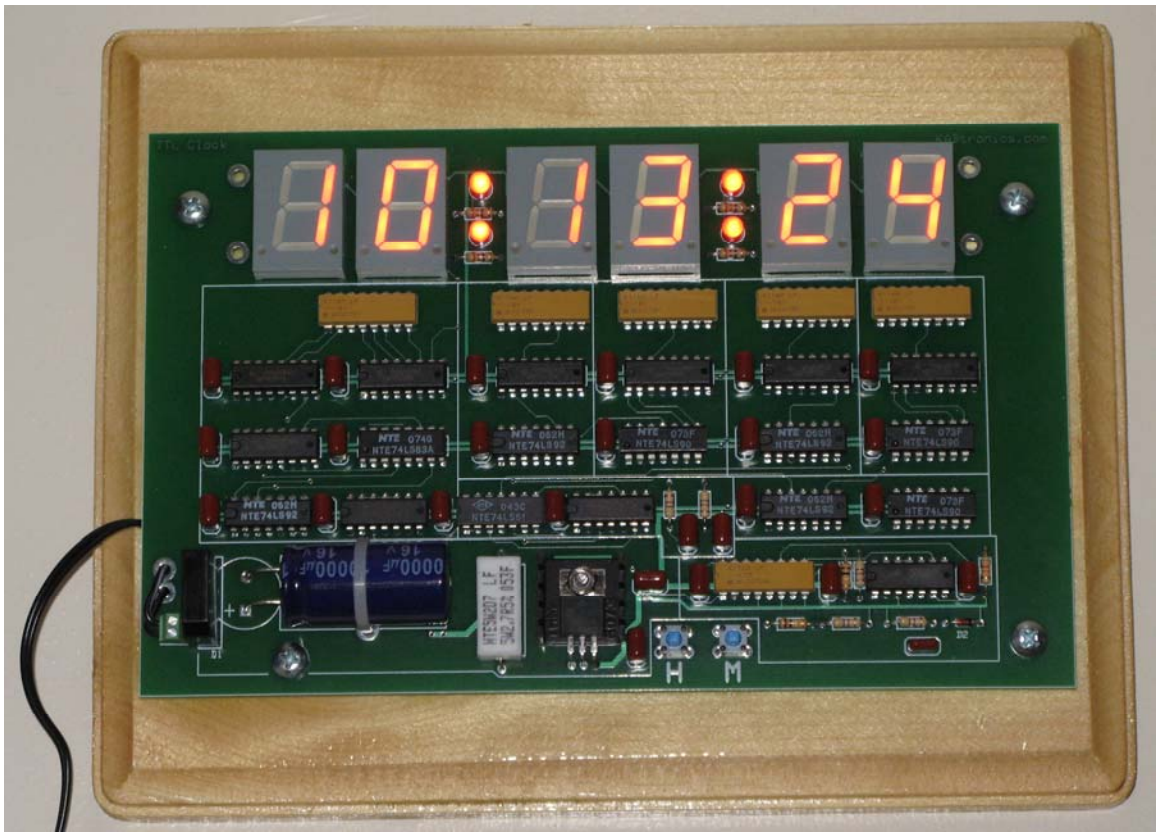
Optionally Mount the Clock on a Plaque

This clock fits well on a 7 by 9 inch plaque; I recommend 6 to 10 coats of spray shellac. Then mount the clock to the plaque using the nylon standoffs screws supplied.



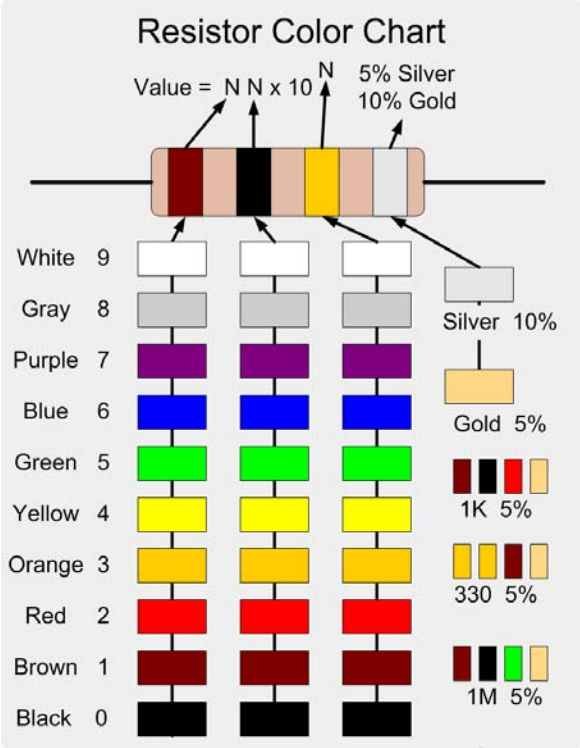
You are done!

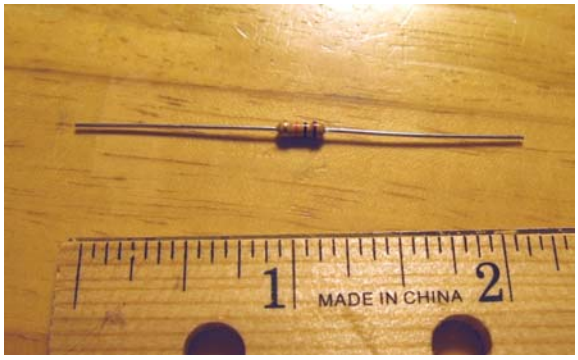
Enjoy your clock, show it off to your friends, and be proud of your work.



Parts Identification

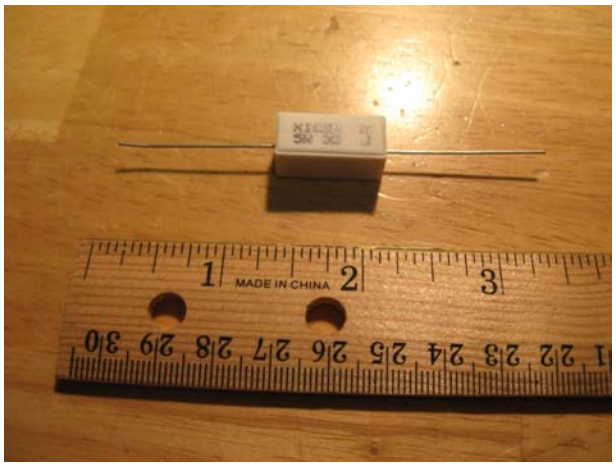
Resistors





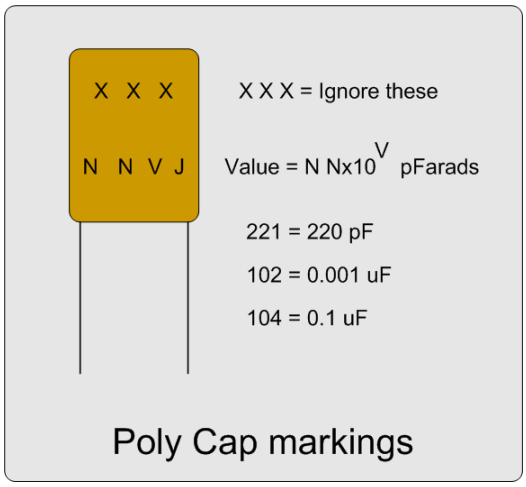
Resistors can be identified by the color bands as shown in the adjacent chart (if this manual is in color). These parts can be placed in either direction on the board, they are not polarized.

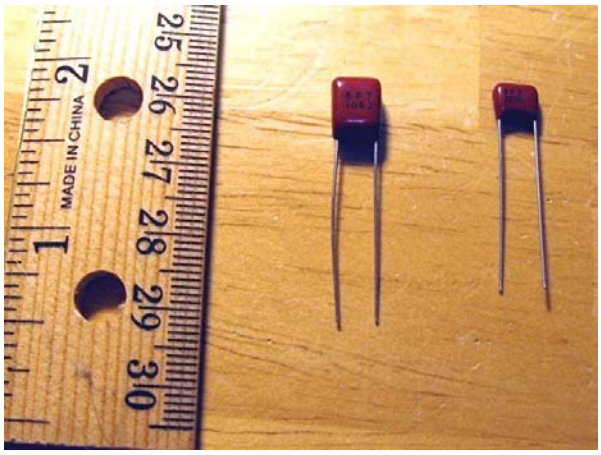
5 Watt Resistor



This large part is similar to the ¼ Watt resistors above but can dissipate much more power. This part is also non-polarized, the same as the ¼ watt resistors above.

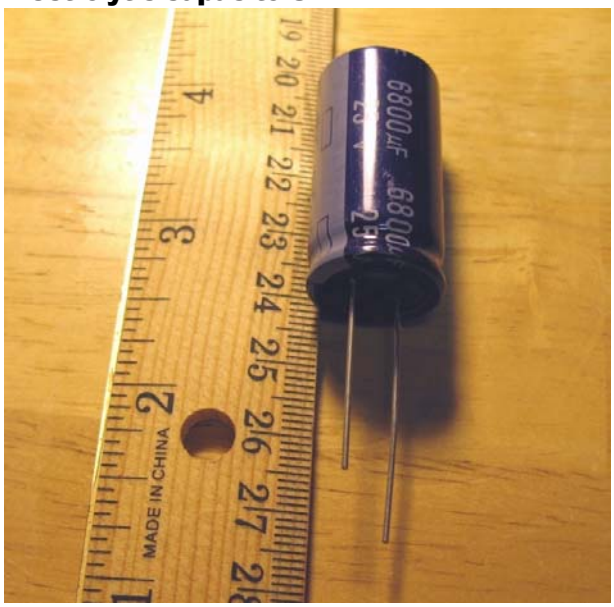
Poly Capacitors





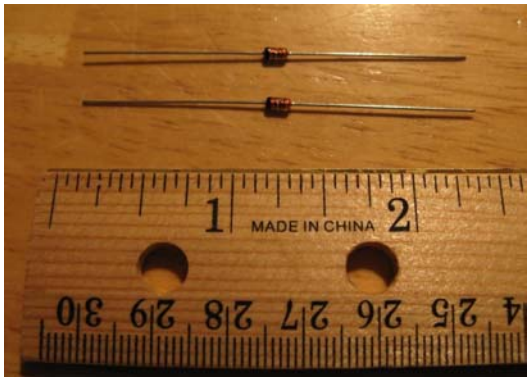
Poly capacitors are not polarized; place them either way on the board.

Electrolytic capacitors



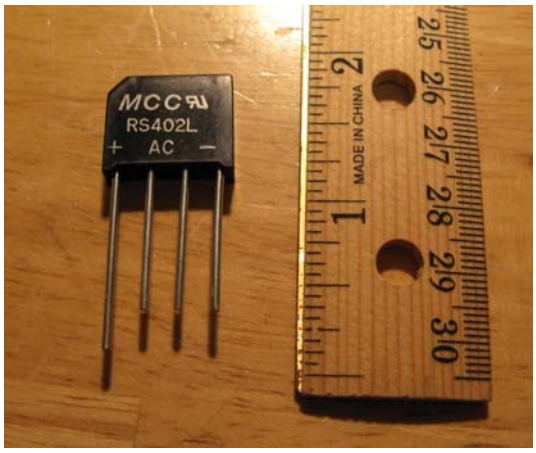
Electrolytic capacitors have the value printed on them. These are polarized parts; you must place them in the proper position on the board. There is only one of these on the board – in the power supply section. Follow the instructions carefully when mounting this part.

Diodes



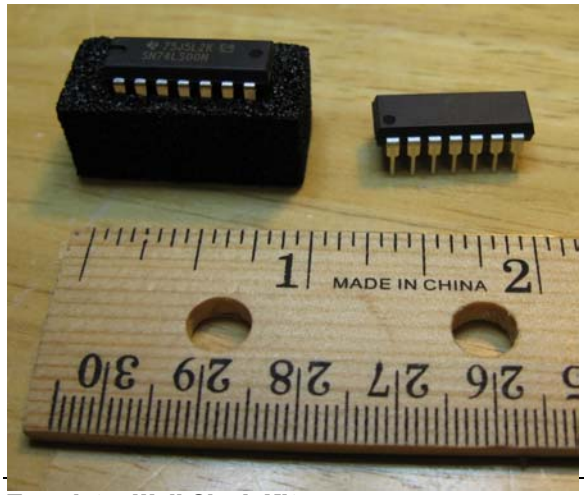
Diodes are polarized; the line on the component needs to match the line on the PC board symbol. Diodes can be damaged by overheating them during soldering, so be quick about it, but do heat the joint enough to make a good solder joint.

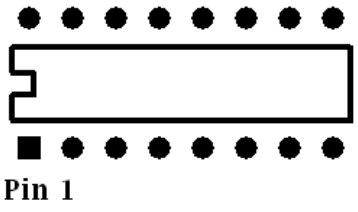
Bridge Rectifier



This four pin device must be placed properly; Pin 1 is marked with a square on the board and with a bevel on the package.

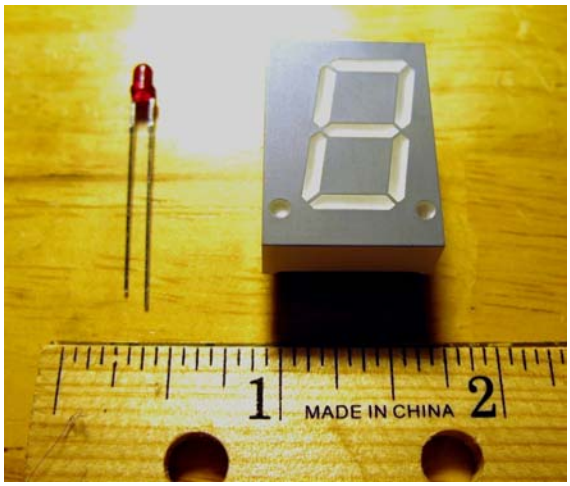
DIP ICs





These multi-pin parts must have the marking for pin one match the board markings.

LEDs



On the left is the single LED. It has a flat on the body and/or a short lead that should identify the cathode. The cathode lead should go into the square hole on the PC board.

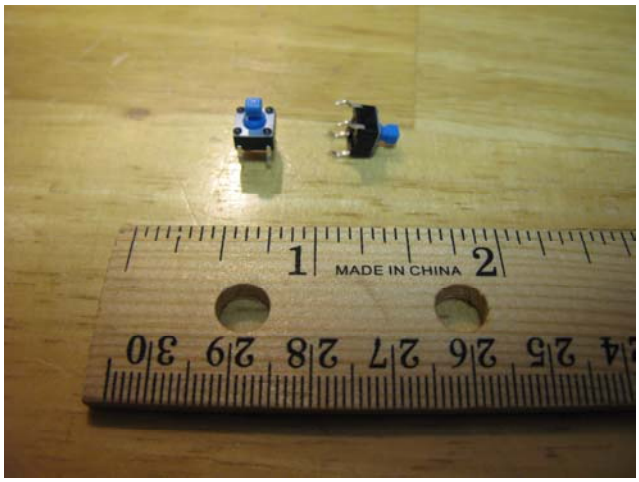
On the right is the 7 segment LED. It is in an 18 pin package outline, but many of the pins are missing – AND PIN 1 IS MISSING. The danger is that you **may mount this part in the wrong holes**. Note that pin 1 of the symbol on the PC board is marked, even though there is no pin 1 on the part.

The smaller dots on the Led display are decimal points, while they are not used in this kit, they do help orient the part. These dots should be at the lower part of the display when mounted. Just in case you hadn't figured this out yet, the LEDs are at the top edge of the finished clock.

When you mount this part, you will find that it fits in two positions, up-high with pins in the highest holes, and down-low with a pin on one side in a lowest hole.

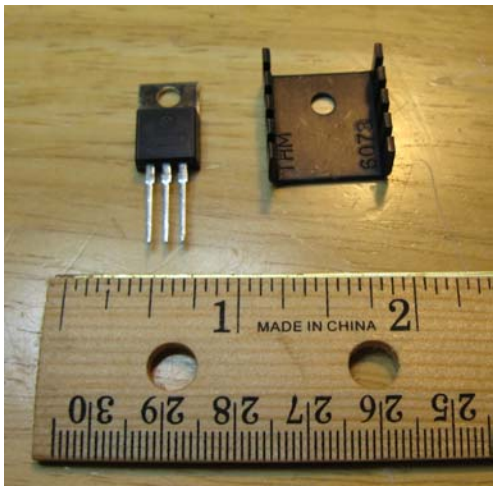
The hole for pin one should be empty when you have this part mounted properly.

Switches



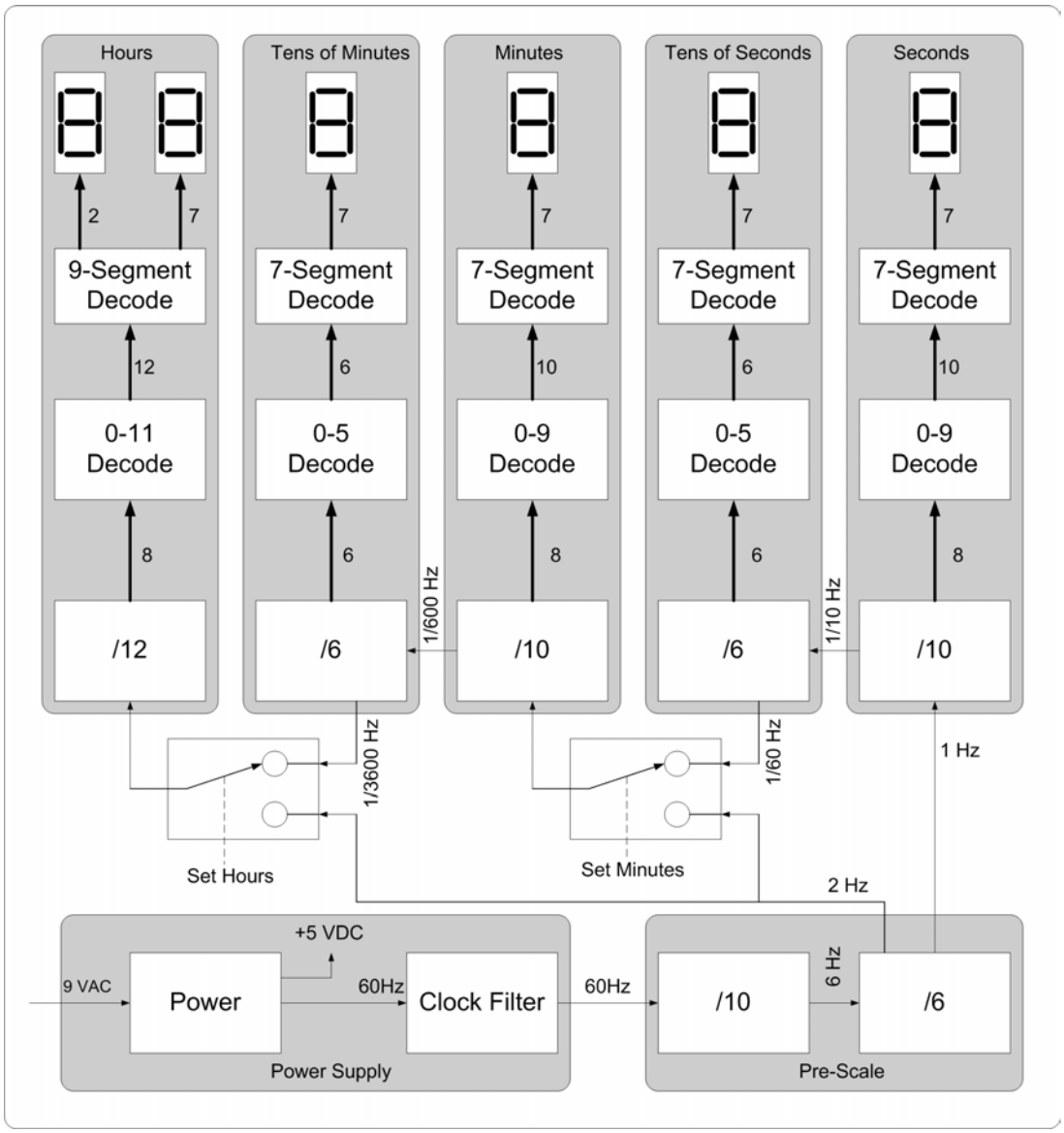
There's not much to say about these switches. They will fit two ways on the board, either way will work. Don't force it in 90 degrees off.

Voltage Regulator in TO-220 package with heat sink



Mount this part by following the instructions in the assembly narrative.

Theory of Operation



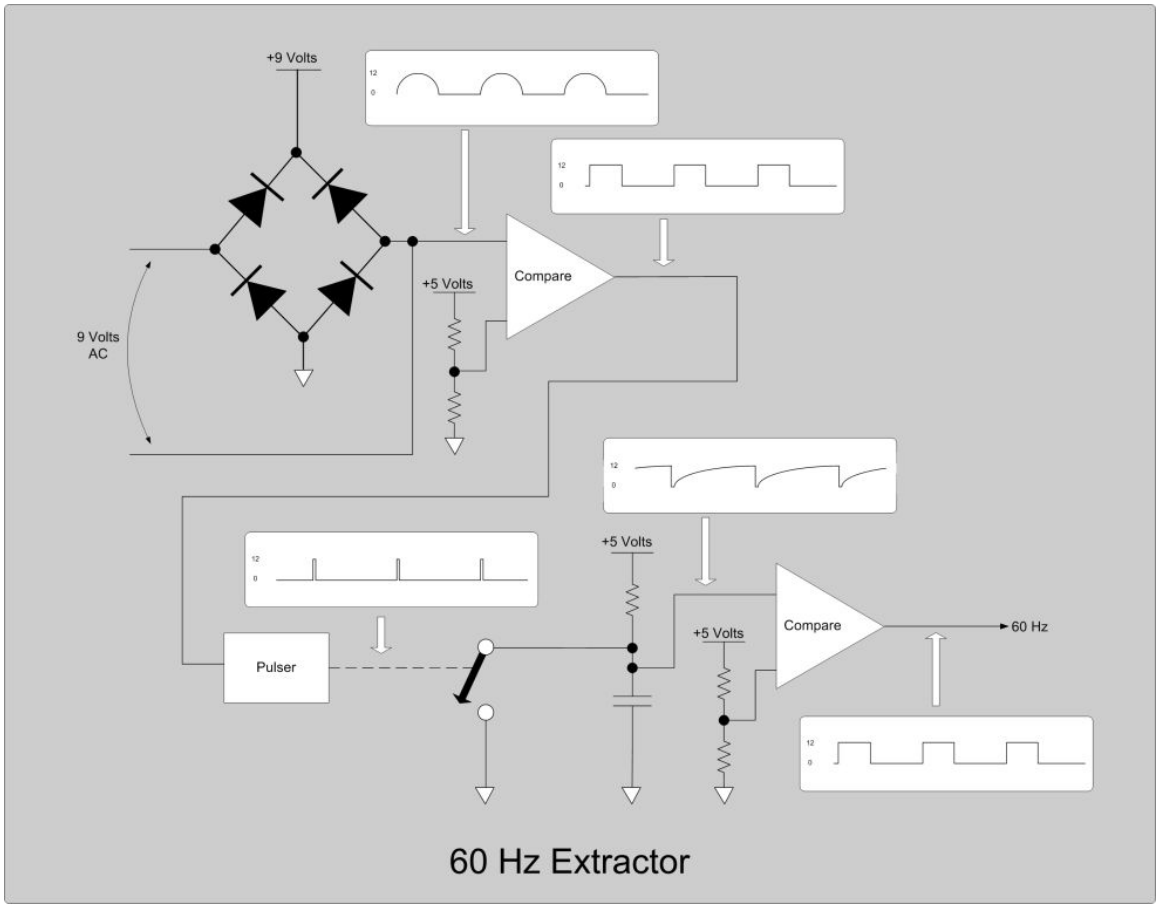
The clock extracts 60 Hz from the power supply, divides it by 60 to get seconds, and drives a chain of counters; seconds, minutes, and hours. The counters drive 7-segment decoder/drivers to light the displays.

Prescale, Seconds, and Minutes

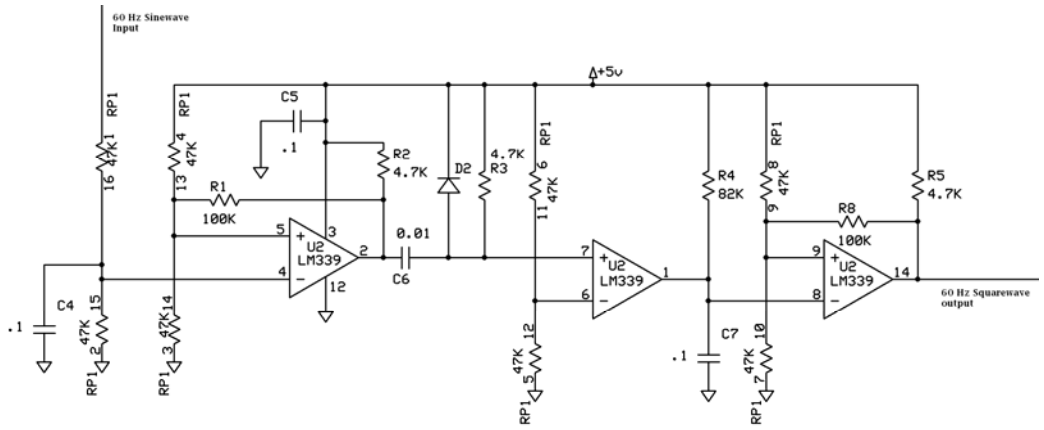
These sections use the 74LS90 divide by 10 IC and the 74LS92 divide by 12 (6&2) IC. The 74LS47 7 segment decoder driver takes 4 bits binary number and drive the display directly. The schematic shows simple circuitry of these sections.

The following sections will describe the more complex parts of the clock.

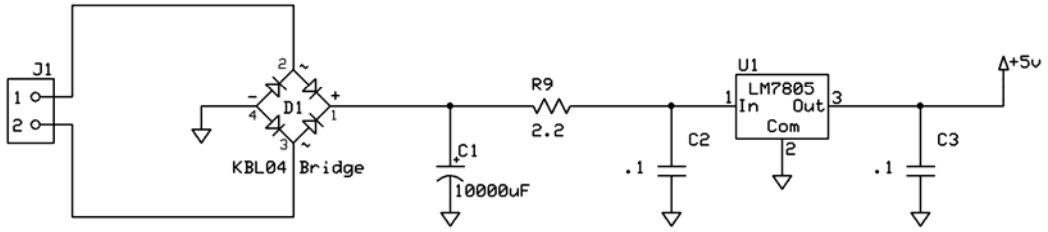
60Hz Extraction



The 60 Hz extraction circuit block diagram above, and the circuit below, show the sine wave from the input 9 Volts AC being converted to a square wave, a pulse train being generated, and a capacitor being discharged by the pulse train. The reason for this complicated circuit is so that if extra noise on the power line appears, the extra pulses will be ignored and not over clock the counter chain.

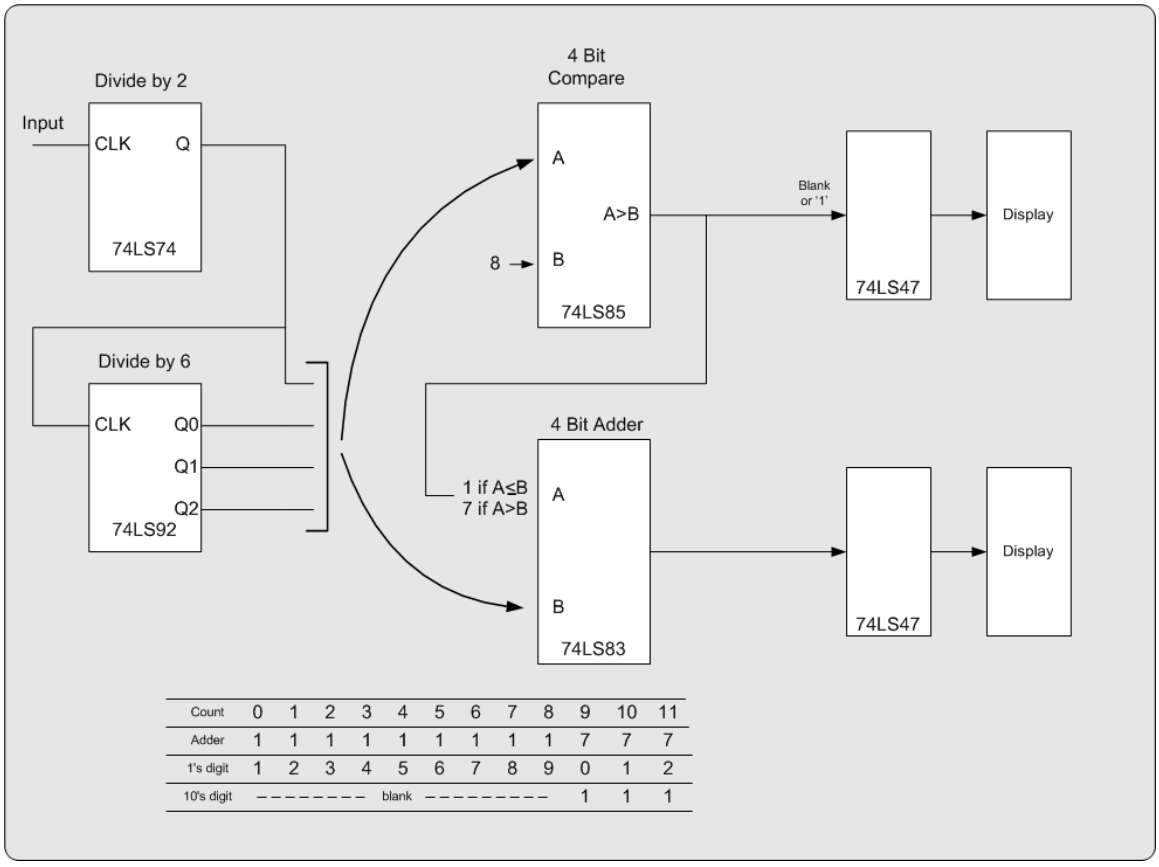


Power Section



The 9 volts AC is rectified to DC by the bridge, and filtered by the 10,000 uFarad capacitor. The 2.2 ohm (or maybe 3 Ohm) drops the voltage for the LM7805 regulator to share the power dissipation. The regulator produced 5 volts to power the clock.

Hours



Count	0	1	2	3	4	5	6	7	8	9	10	11
Adder	1	1	1	1	1	1	1	1	1	7	7	7
1's digit	1	2	3	4	5	6	7	8	9	0	1	2
10's digit	----------				blank			----------			1	1	1

The hours section converts a 0-11 count into a 1-12 display using a comparator and an adder. The table shows the values at the counter and adder for each count.

And that is the workings of the TTL clock.

In Case of Difficulty

General Troubleshooting

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

Start with the data showing the problem. If one of the displays is not counting properly, stop and think about it.

How is it counting?

- Is it changing at all? (this will tell you if the input clock is present)
- Is it changing at the right rate? (this will tell you if the clock to the counter is at the right frequency)
- Is it going through the proper number of states, even if the numbers displayed are wrong? (this will hint if the problem is in the decode/display area or the counter)
- Is it displaying only proper numbers, or are there odd characters and blanks showing? (this will hint at problems in the 7-segment decoders)

Make a most likely guess at the problem, then gather more data to either support or refute your guess. Repeat until you find the problem.

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

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

So take a close look at the back of the board looking for bad solder joints and clipped leads in the area of the problem. Check for proper components and orientations. If you haven't found the problem, after thoroughly thinking through the problem and checking everything you can think of, feel free to email customerservice@transistorclock.com. I can't fix the problem for you, but I can work with you to find the problem and supply a spare part or two if needed to get you running.

Specifications

PC board Size: 5 inches wide by 8 inches high

(Allow ¼ inch behind board and ¾ inch above when loaded for parts clearance)

Weight: About 6.5 oz (not including wood plaque), (add 9 oz for wall transformer)

Power consumption: About 7.3 watts, (0.77 amps @ 9.5 volts AC)

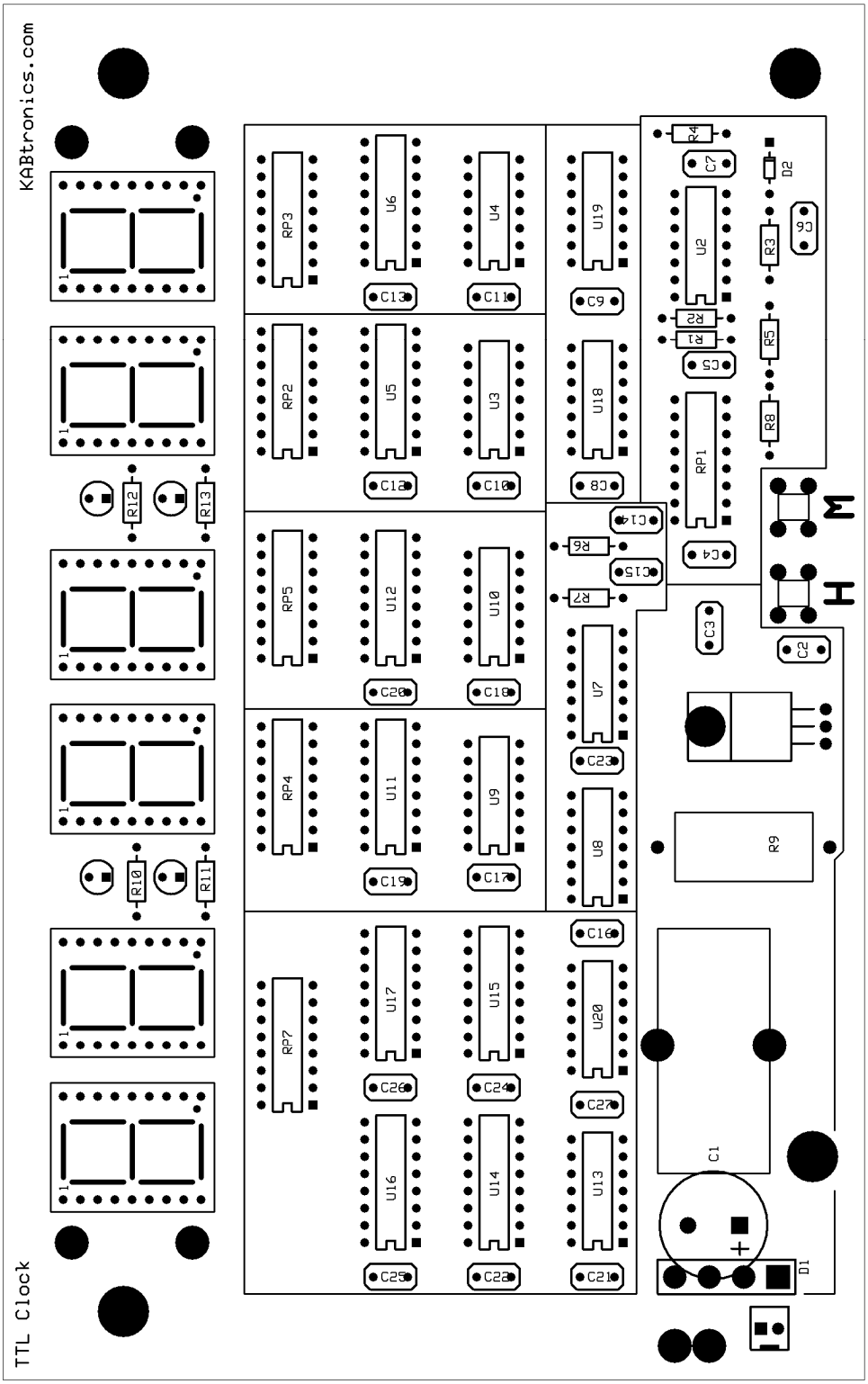
Temperature limits: Designed for room temperature operation, 60-80 °F

Longevity: The electrolytic capacitor will eventually dry out as the liquid gradually leaks out the pressure vent, you may need to replace it in 10 or 15 years. The LED displays will gradually grow dimmer, perhaps reaching 50% brightness in 10 or 20 years. The bridge rectifier may fail at some point, it is working hard. Any of these items can be easily replaced by you.

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

Circuit Board Views

Silkscreen

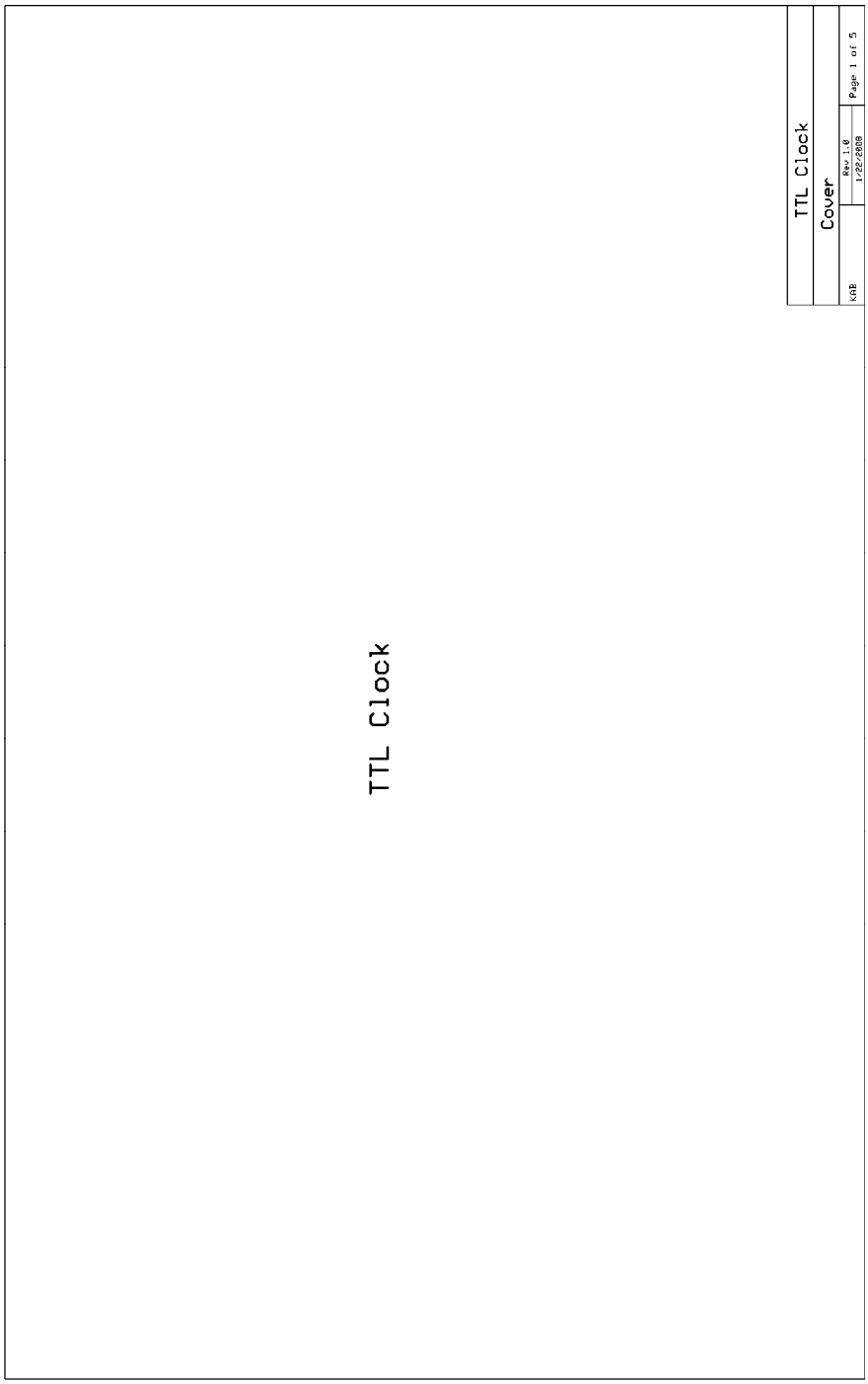


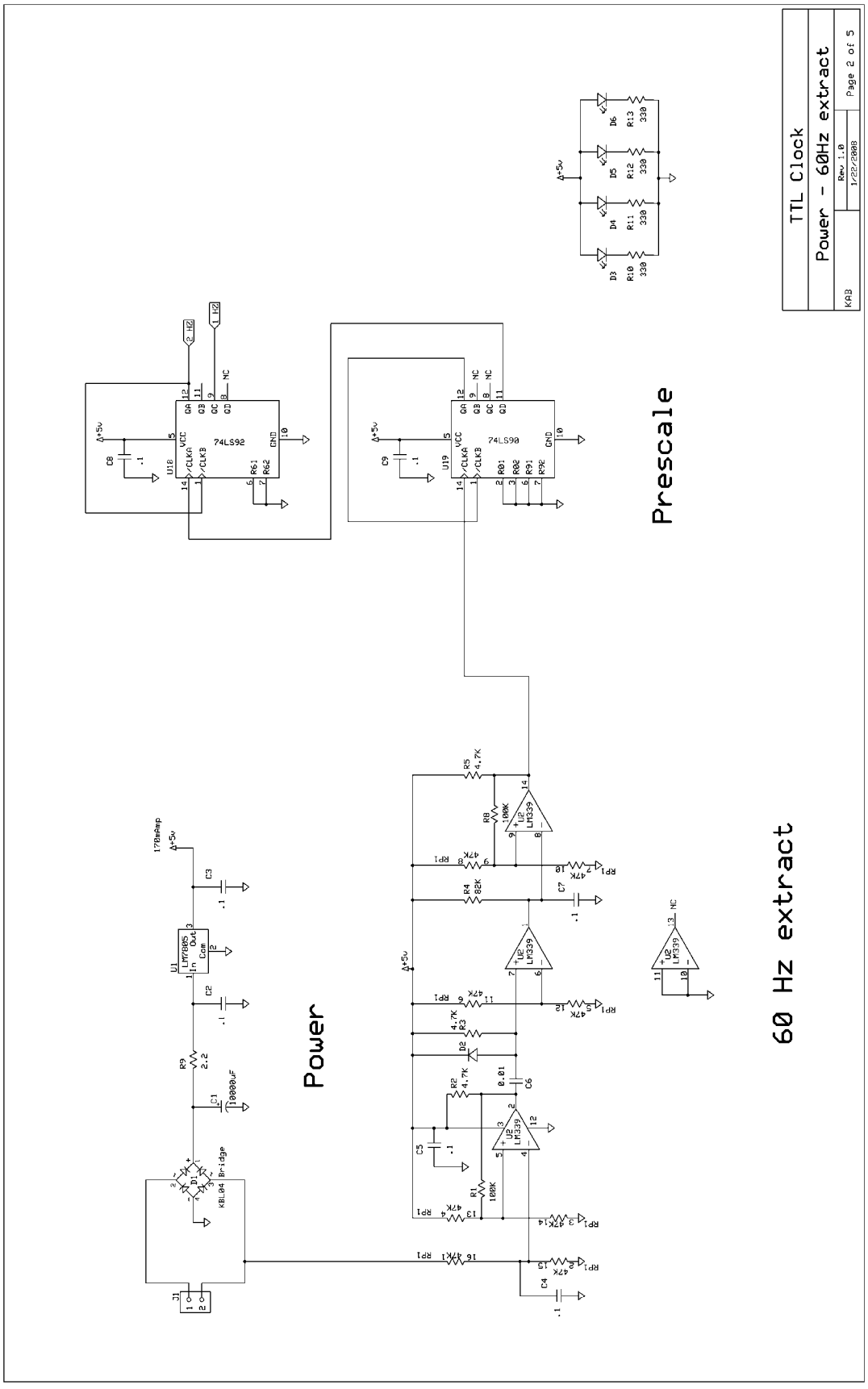
Reference Designators

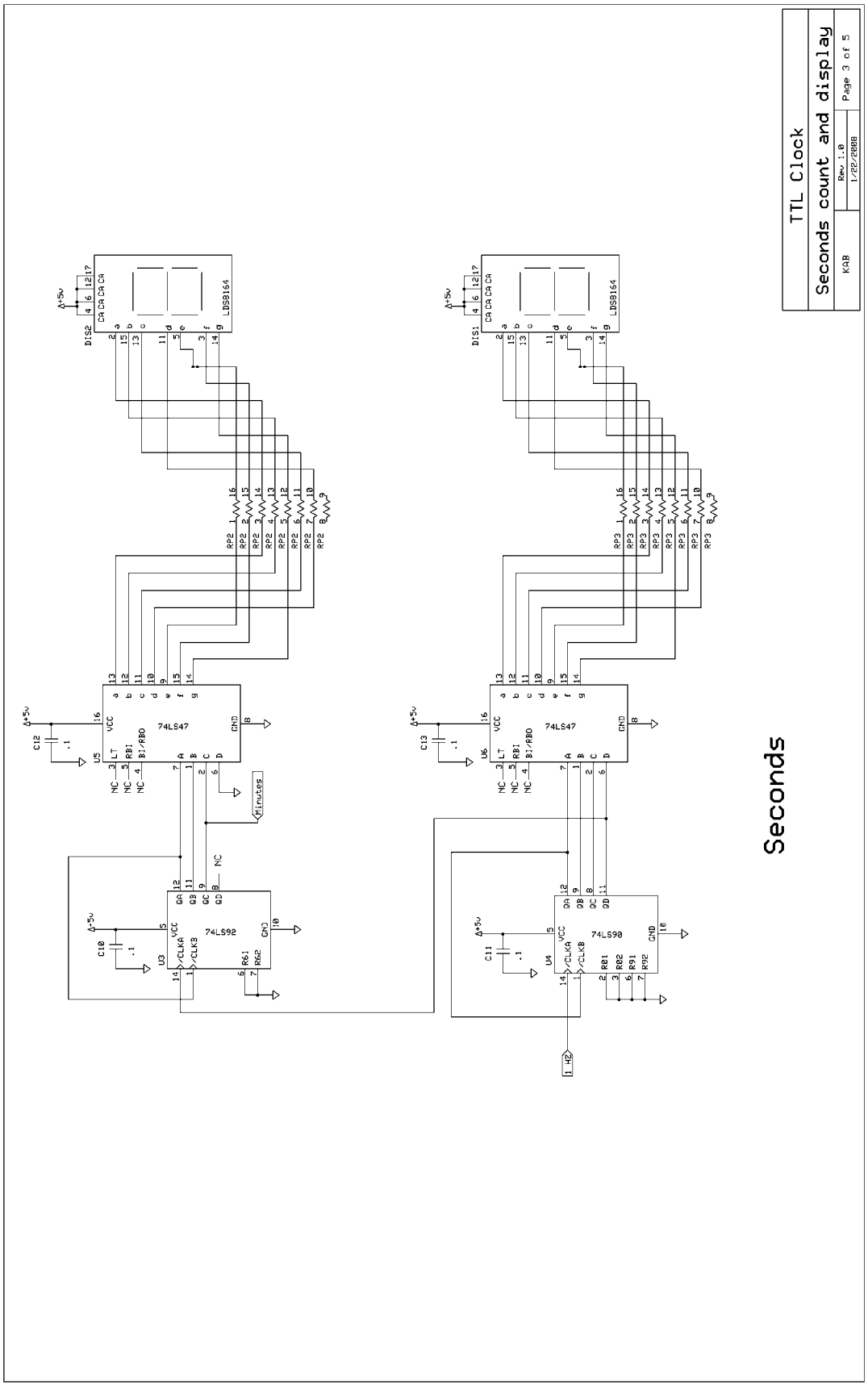
Ref	Component
C1	10000uF
C2	0.1
C3	0.1
C4	0.1
C5	0.1
C6	0.01
C7	0.1
C8	0.1
C9	0.1
C10	0.1
C11	0.1
C12	0.1
C13	0.1
C14	0.1
C15	0.1
C16	0.1
C17	0.1
C18	0.1
C19	0.1
C20	0.1
C21	0.1
C22	0.1
C23	0.1
C24	0.1
C25	0.1
C26	0.1
C27	0.1
D1	KBL04 Bridge
D2	1N4148
D3	LED
D4	LED
D5	LED
D6	LED
DIS1	LDS8164
DIS2	LDS8164
DIS3	LDS8164
DIS4	LDS8164
DIS5	LDS8164
DIS6	LDS8164
J1	Terminal

Ref	Component
R1	100K
R2	4.7K
R3	4.7K
R4	82K
R5	4.7K
R6	4.7K
R7	4.7K
R8	100K
R9	3 Ohm 5 W
R10	330
R11	330
R12	330
R13	330
RP1	47K
RP2	180
RP3	180
RP4	180
RP5	180
RP7	180
SW1	PB switch
SW2	PB switch
U1	LM7805
U2	LM339/3302
U3	74LS92
U4	74LS90
U5	74LS47
U6	74LS47
U7	74LS00
U8	74LS51
U9	74LS92
U10	74LS90
U11	74LS47
U12	74LS47
U13	74LS92
U14	74LS85
U15	74LS83
U16	74LS47
U17	74LS47
U18	74LS92
U19	74LS90
U20	74LS74

Schematic




TTL Clock
Power - 60Hz extract
Rev 1.0
1/20/2008
KAB
Page 2 of 5
Prescale
Power
60 Hz extract
74LS92
74LS90
LM339
LM7805
KBL04 Bridge


TTL Clock
Seconds count and display
KAB
Rev 1.0
17-02-2008
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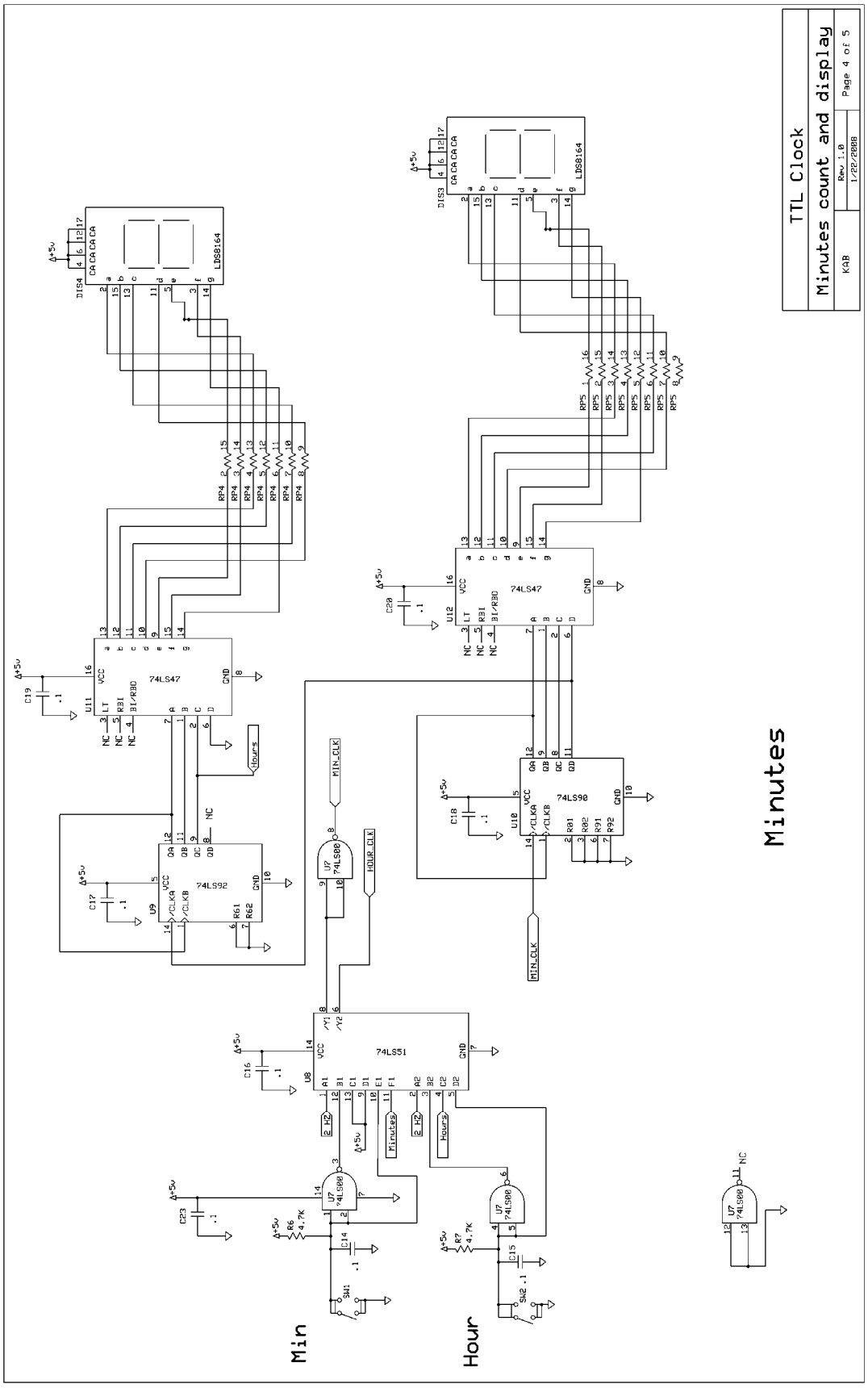
Seconds
DIS1
DIS2
LDS8164
74LS47
74LS90
74LS92
U3
U4
U5
U6
C10
C11
C12
C13
RP2
RP3
Minutes
1 HZ
+5v
GND
VCC


TTL Clock
Minutes count and display
KAB
Rev 1.0
1-22-2008
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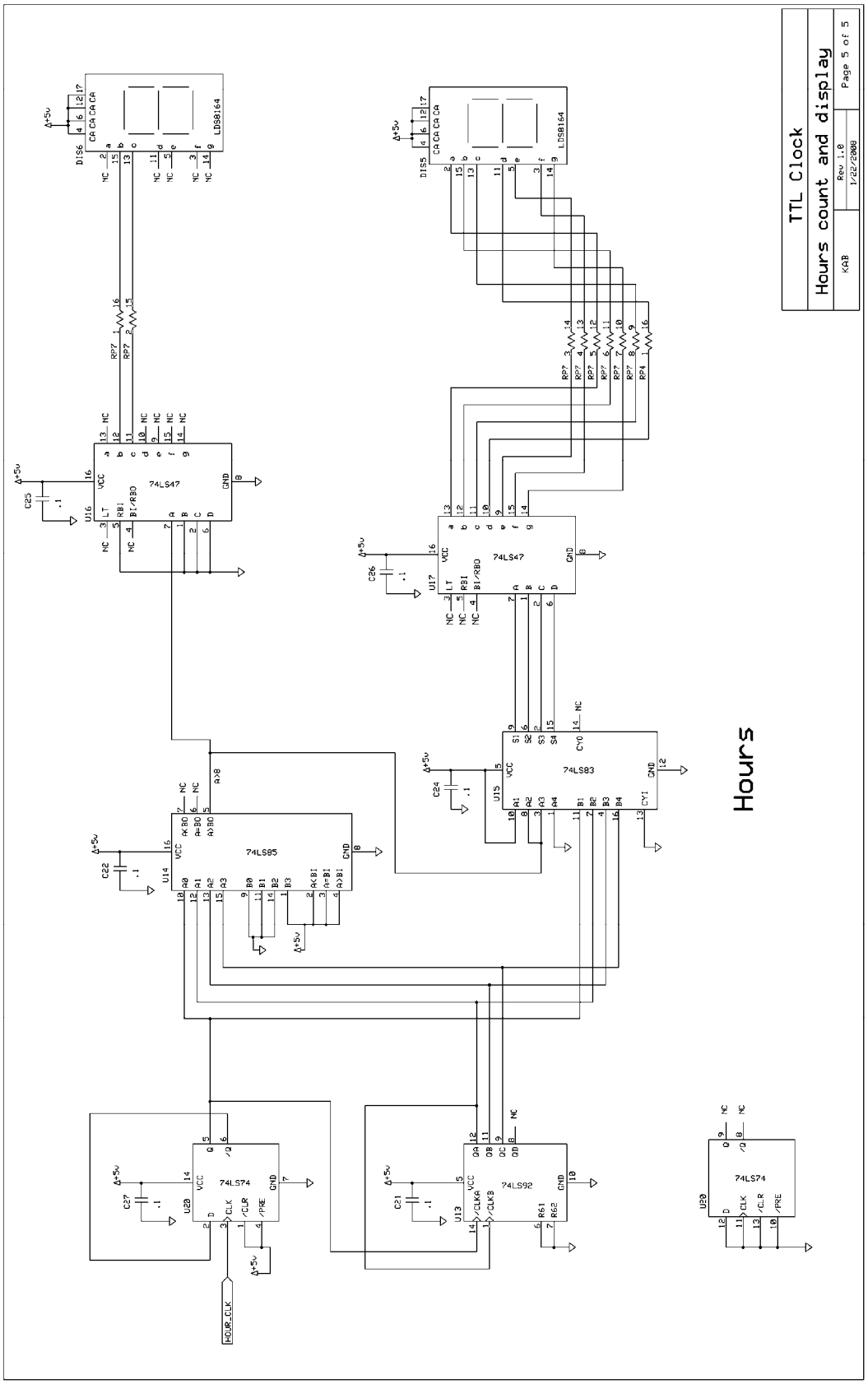
Minutes
Min
Hour
74LS47
74LS92
74LS90
74LS51
74LS00
LDS8164
Hours
MIN_CLK
HOUR_CLK


TTL Clock
Hours count and display
KAB
Rev 1.0
1/22/2008
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Hours
74LS47
74LS85
74LS83
74LS74
74LS92
LDS8164
HOUR_CLK