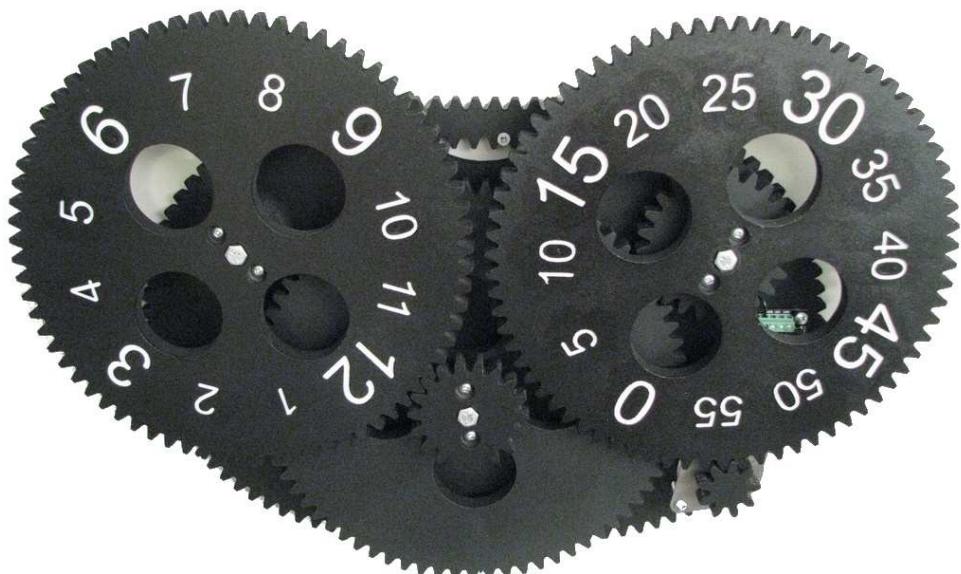


ALAN'S ELECTRONIC PROJECTS

Gear Clock

Assembly Instructions and User Guide



Rev 1.0

February 2010

www.alan-parekh.com

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Gear Clock Assembly Instructions and User Guide

Gear Clock Assembly Instructions and User Guide

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Revision History

Date	Revision	Author(s)	Description
Feb 2, 2010	1.0	Alan Parekh	<i>Document creation.</i>

1. Introduction

Thank you for purchasing the Gear Clock kit. This document will walk you through the assembly and usage of the kit. If you have any questions please don't hesitate to send us an email at support@alan-parekh.com.

Additional information can be found at <http://alan-parekh.com/kits/gear-clock-kit>.

1.1 Concept of Operation

The Gear Clock project is microcontroller based, what this means is there is a small self contained computer that controls the clock. This microcontroller uses an external 20MHz crystal oscillator to accurately keep track of time. The microcontroller is interfaced to two buttons and a motor. The buttons are used to set the clock and the motor is used to precisely control the gear rotation.

The six clock gears are arranged in such a way that the two large upper gears can be used to read time directly from them.

The gear arrangement is as follows:

- 9 tooth motor gear
- 72 tooth minute gear with a 24 tooth secondary
- 72 tooth intermediate gear with a 18 tooth secondary
- 72 tooth hour gear

1.2 Device Features

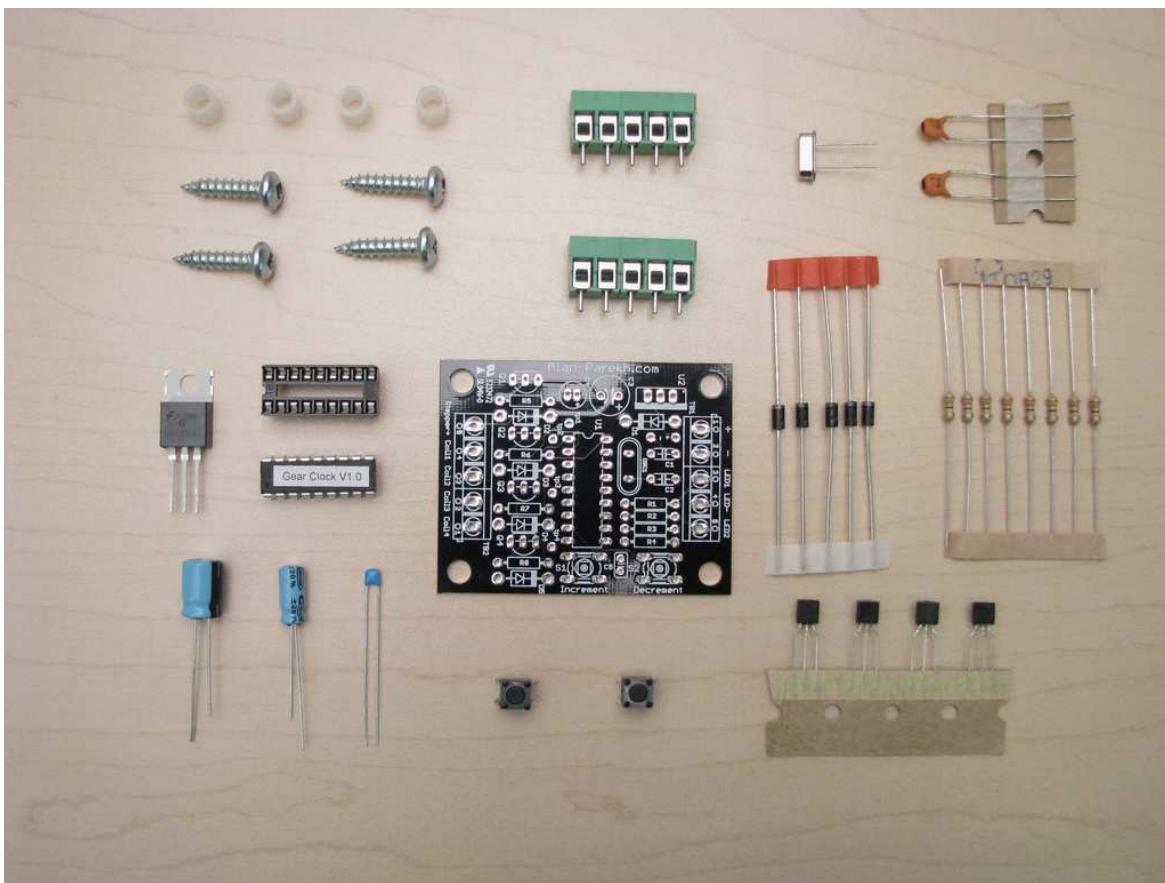
- Unique clock design.
- Simple to read.
- Accurate time keeping since a crystal oscillator is used.

2. Kit Assembly – Electronic Control Board

Many of the components in this kit are sensitive to static discharge. Before you begin it is important that you remove any static electricity from your body by grounding yourself. This is simply done by touching any grounded metal that is by the area you are going to be assembling the board in. A bare metal computer power supply is an example of something that might be close at hand and provides a good ground point. You must ground yourself again if you walk away and return to the location where you are assembling your control board. An antistatic wrist strap is a good investment if building many kits such as this one is in your future.

2.1 Unpack the Control Board Parts

Before we begin assembling the clock control board, make sure that your kit came with everything needed. Below are some pictures of the items that should be in the kit. Please note that some items might be in antistatic or crush protective casings.

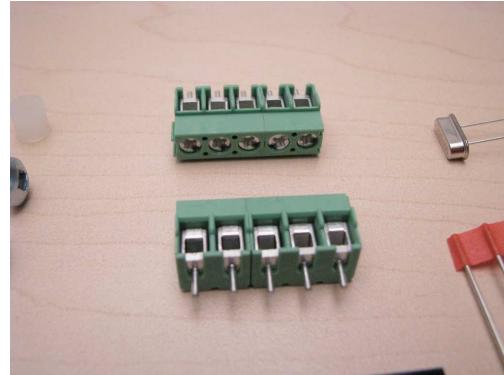


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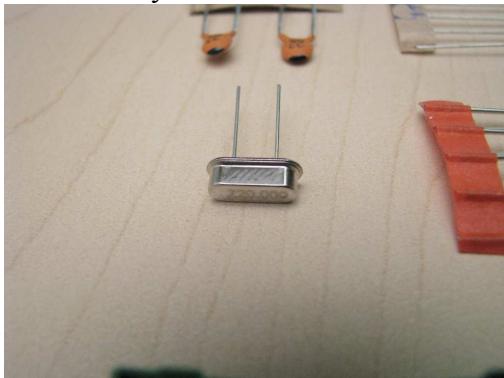
Mounting Hardware



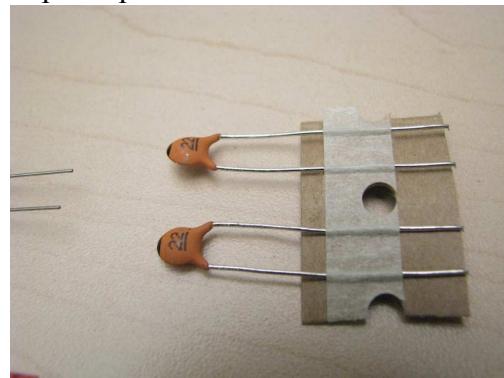
Terminal Blocks



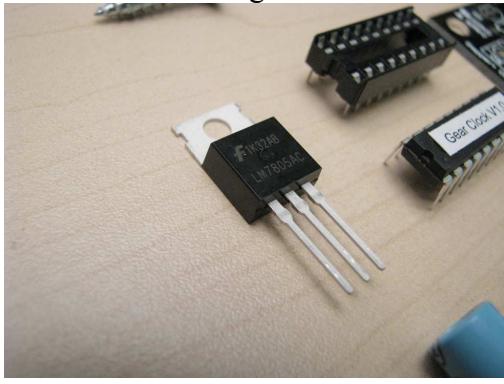
20 MHz Crystal Oscillator



22pF Capacitors



LM7805 5 Volt Regulator



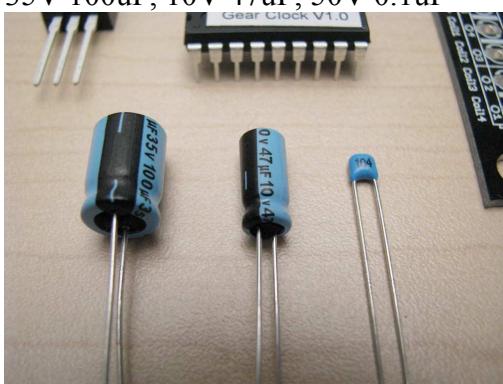
18 pin Socket and Microcontroller



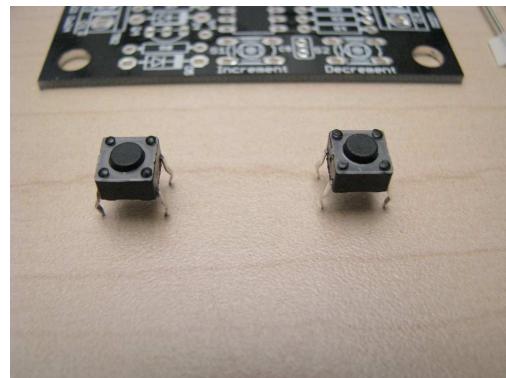
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Capacitors (left to right)

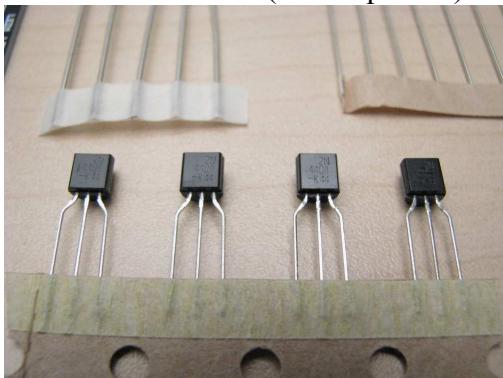
35V 100uF, 10V 47uF, 50V 0.1uF



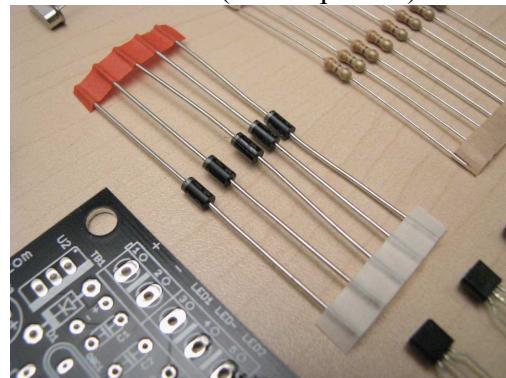
Tactile Buttons



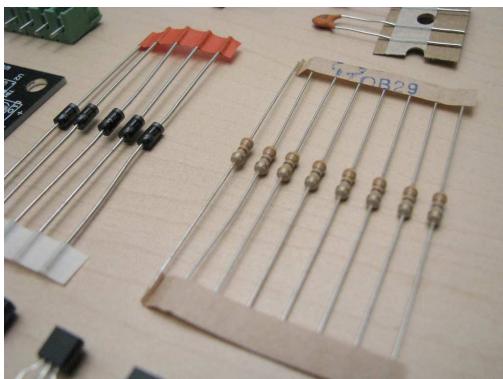
2N4401 Transistors (or compatible)



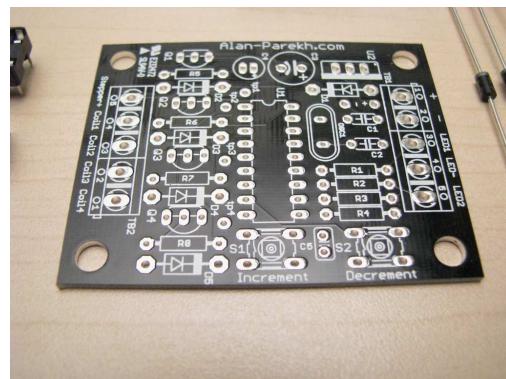
1N4001 Diodes (or compatible)



330 Ohm Resistors



Custom Printed Circuit Board



2.2 Control Board Assembly

To assemble the Gear Clock control board you will need a soldering iron, solder and wire cutters. Some masking tape would be helpful but is optional.

Many of the components look similar but if installed in an incorrect location can cause damage to the control board. It is very important to ensure that components are installed in the correct positions. We are going to start by installing the shortest components and progress to the larger ones. When the instructions say to “install” this means to place the leads through the required holes allowing the component to sit close to the board, soldering the component in place and trimming the leads. If you have never soldered before it is recommended that some online tutorials are reviewed prior to putting this kit together.

- 1. Install the resistors.** Resistors positions are marked with an “R” followed by a number. Resistors are non-polarized, this means that they can be installed in either direction.

There is only one value of resistor used in this kit to keep things simple. Please note that R4 selects the type of stepper motor that is being used, see the chart below to determine if you need to install it or leave it out. R3 is for future use, this resistor location should be left empty.

The value of the resistor is represented by colored bands on the resistor.
330 ohms is ORANGE, ORANGE, BROWN, GOLD.

R1: 330 ohms

R2: 330 ohms

R5: 330 ohms

R6: 330 ohms

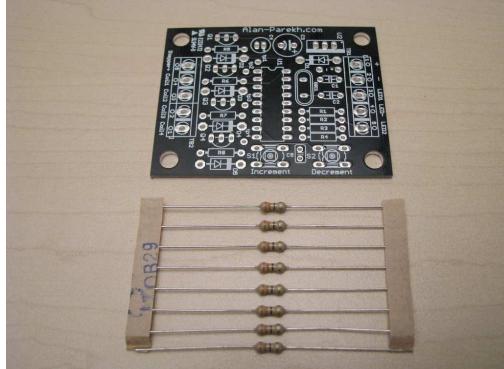
R7: 330 ohms

R8: 330 ohms

Motor Type	R4
48 Steps per rotation	R4 Should be left empty
200 Steps per rotation	R4 should have a 330 ohm resistor installed

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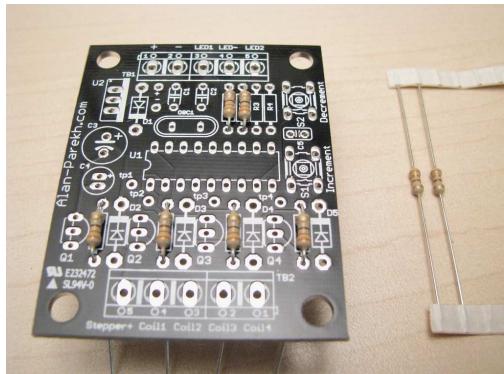
Resistors ready to install



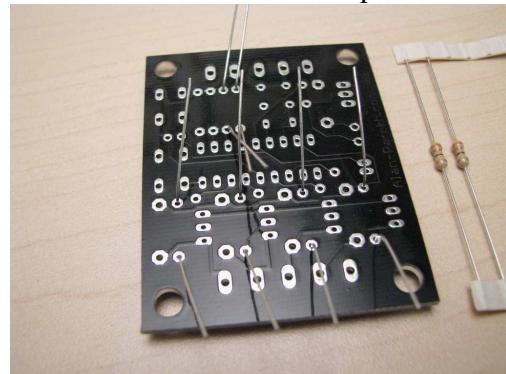
330 ohms resistors



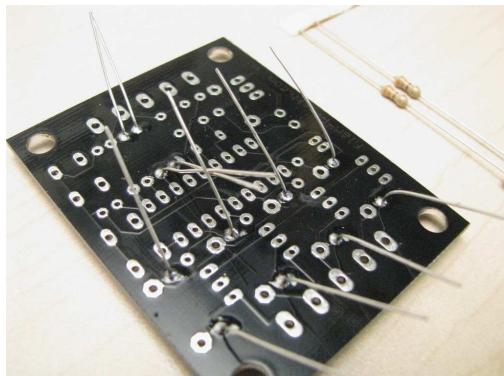
Insert resistors into PCB



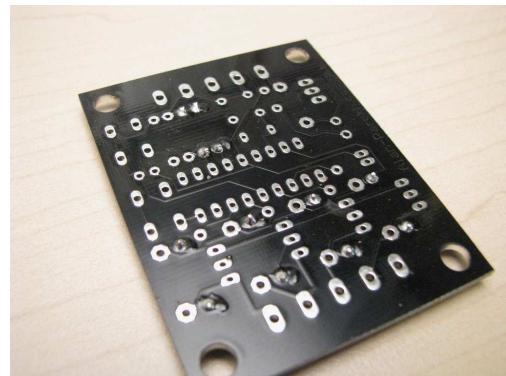
Flare leads to hold them in place



Solder all leads to PCB



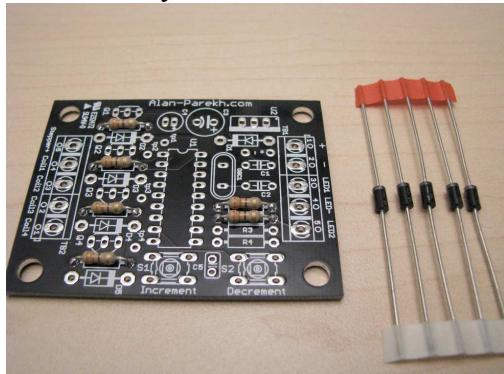
Trim leads



Gear Clock Assembly Instructions and User Guide

2. **Install the diodes.** There are five diodes to install and they are polarity sensitive. These components are listed as D1, D2, D3, D4 and D5 on the board. The white bar on one end of the diode represents negative, this marking is also on the board for easy reference.

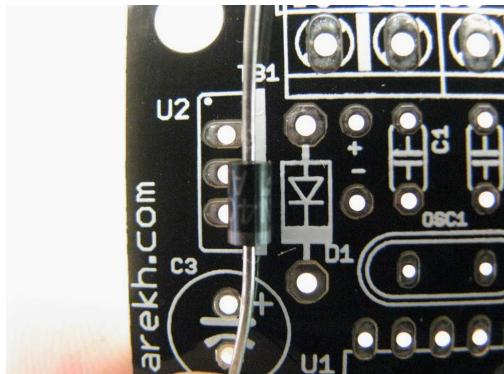
Diodes ready to install



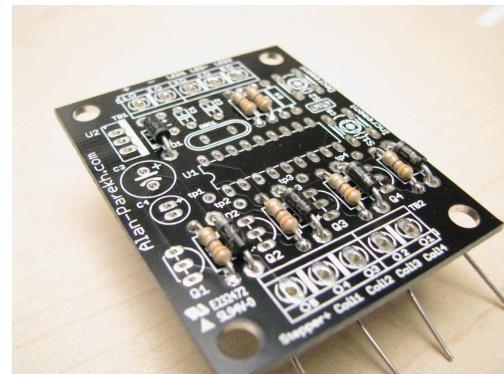
Note the white band on the top



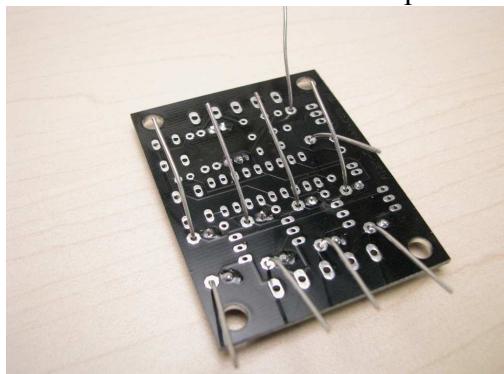
Note the white band on the PCB



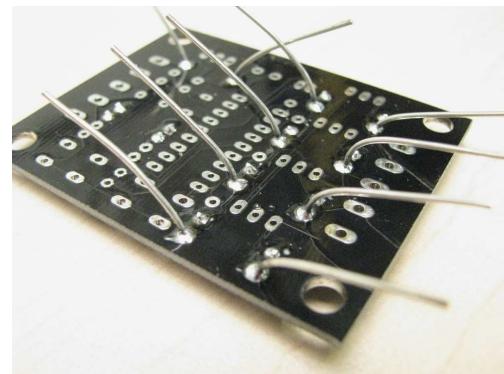
Insert diodes into PCB



Flare the leads to hold them in place

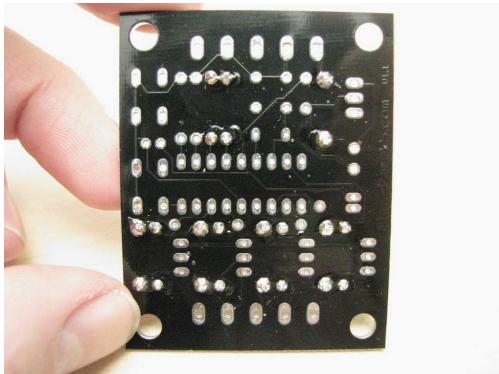


Solder all leads to PCB

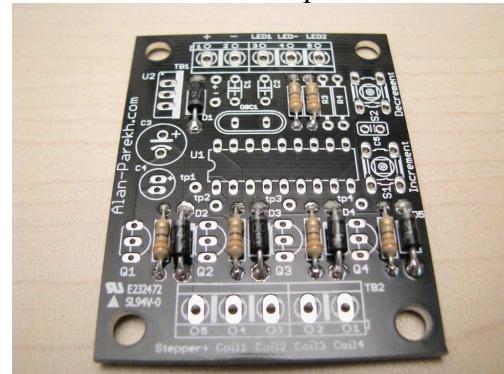


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Trim leads

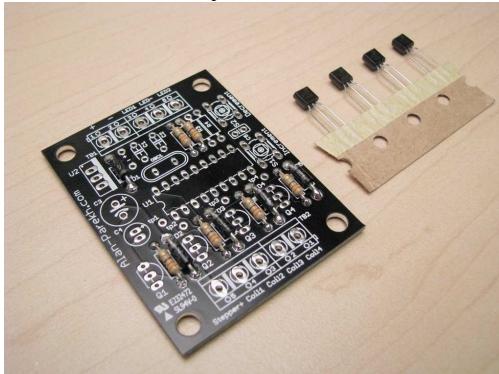


Diode installation complete

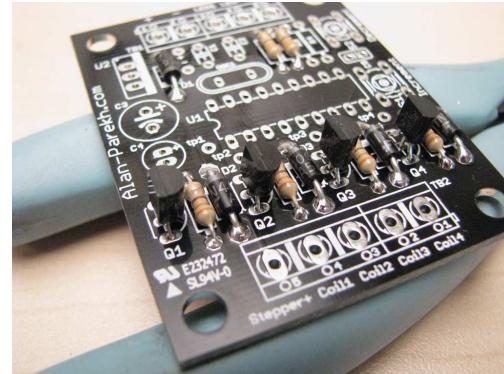


3. **Install the transistors.** There are four transistors to install and they are polarity sensitive. These components are listed as Q1, Q2, Q3 and Q4 on the board. The image on the board has a curved section which represents the correct part orientation.

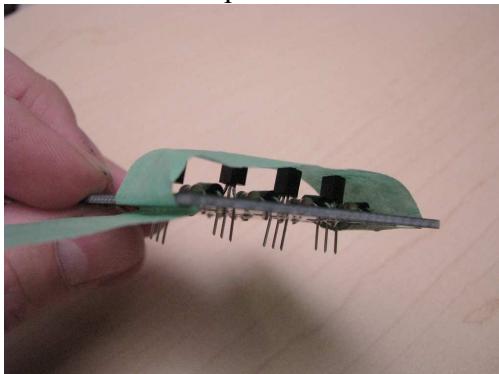
Transistors ready to install



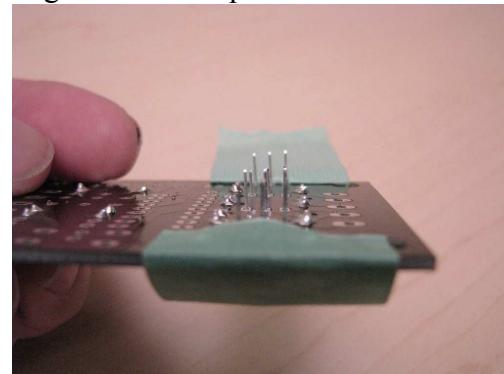
Insert transistors into PCB



Masking tape is helpful to hold the transistors in place

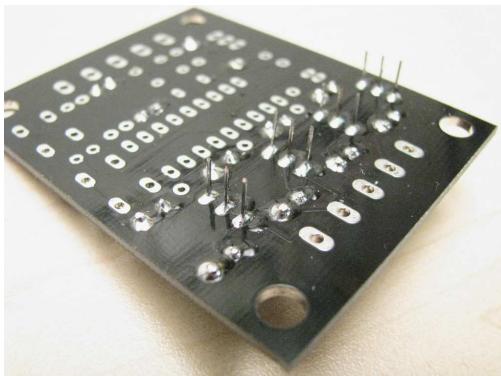


Flip the board and ensure good alignment of the parts

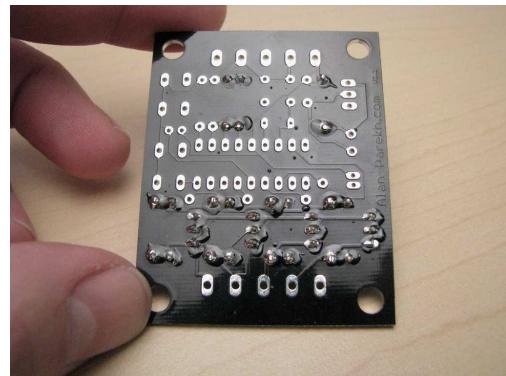


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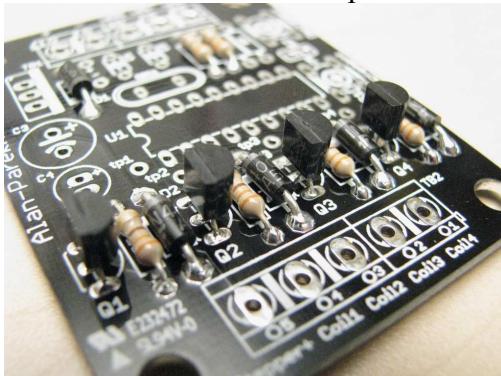
Solder all leads to PCB



Trim leads

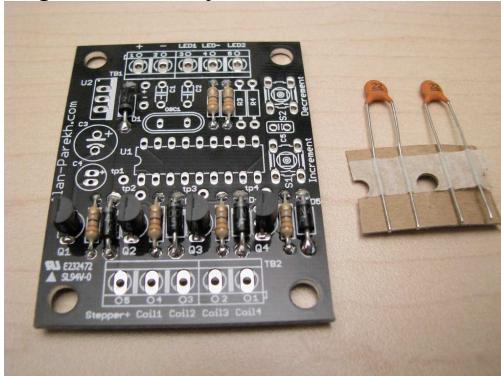


Transistor installation complete

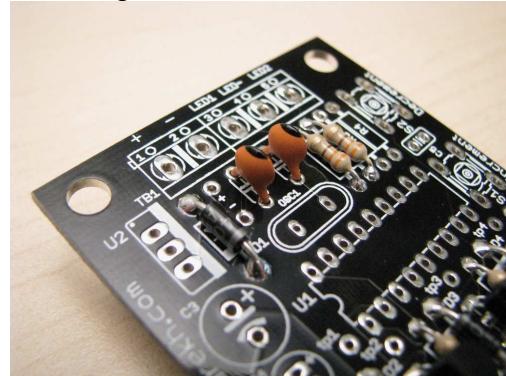


4. **Install the 22pF capacitors.** There are two 22pF capacitors to install, they are non-polarized, this means that they can be installed in either direction. These components are listed as C1 and C2 on the board.

Capacitors ready to install

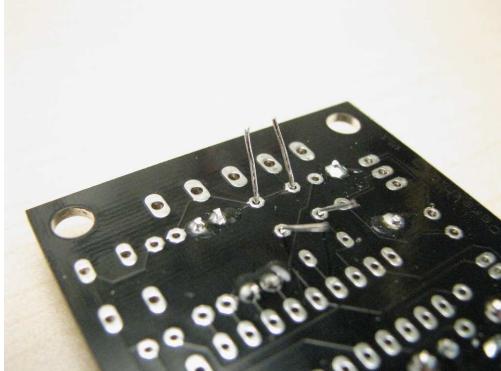


Insert capacitors into PCB

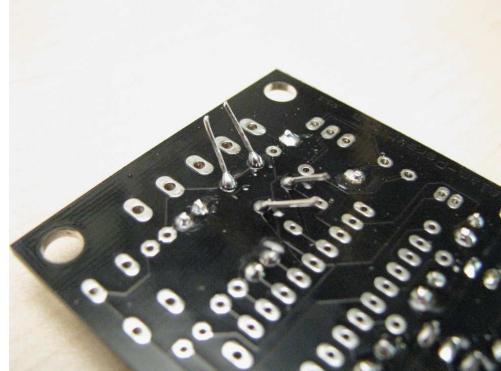


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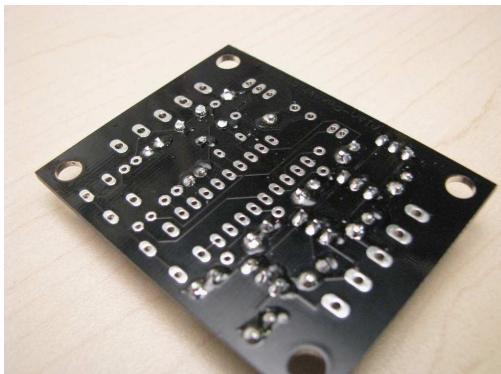
Flare the leads to hold them in place



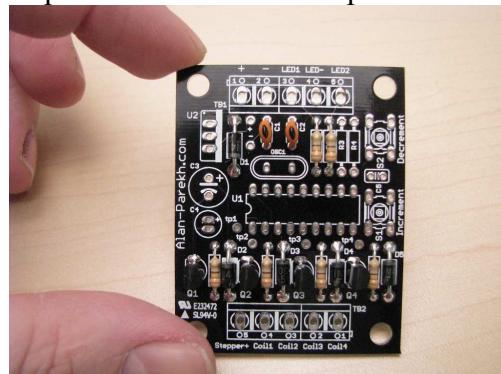
Solder all leads to PCB



Trim leads

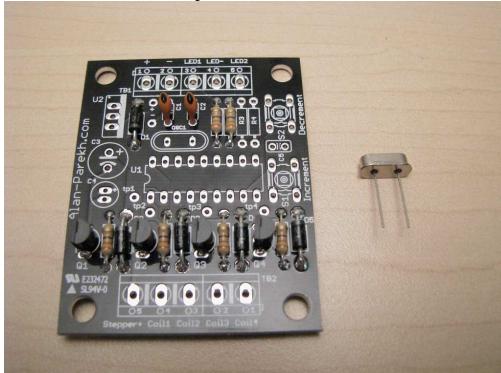


Capacitor installation complete

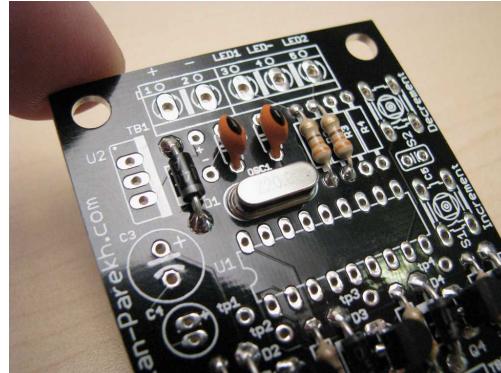


5. **Install the crystal oscillator.** The 20 MHz crystal oscillator gets installed in the position marked as OSC1 on the board. The oscillator is non-polarized, this means that it can be installed in either direction.

Oscillator ready to install

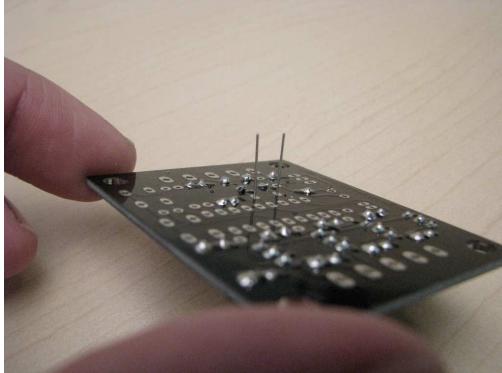


Insert oscillator into PCB

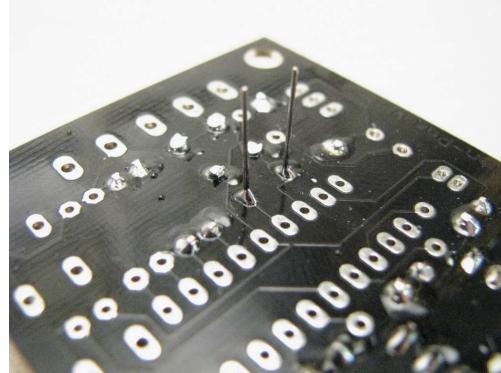


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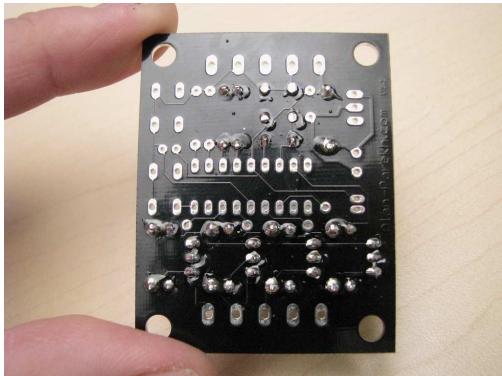
Flare the leads to hold them in place



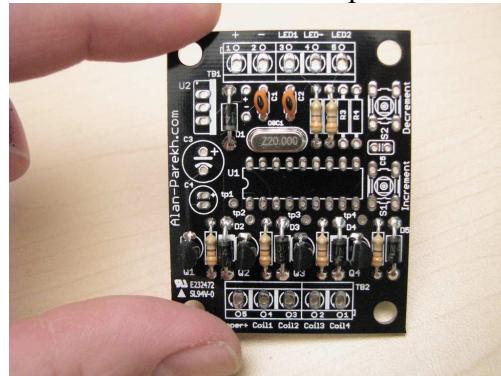
Solder all leads to PCB



Trim leads

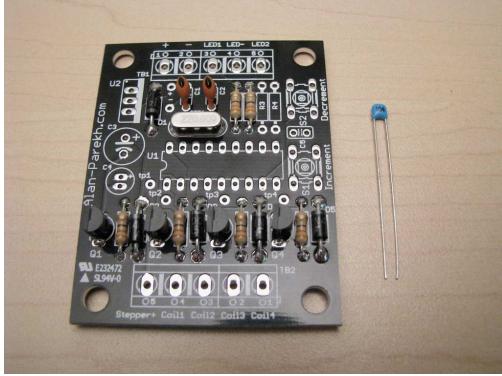


Oscillator installation complete

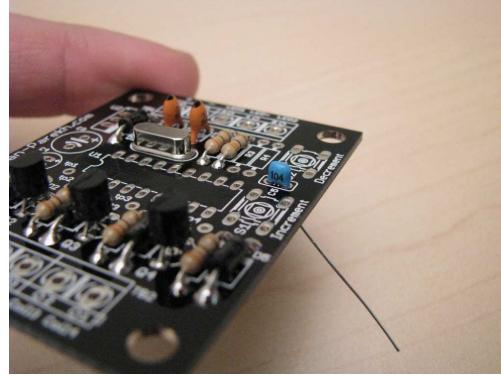


6. **Install the 0.1uF capacitor.** The 0.1uF capacitor gets installed in the position marked as C5 on the board. This capacitor is non-polarized, this means that it can be installed in either direction.

Capacitor ready to install

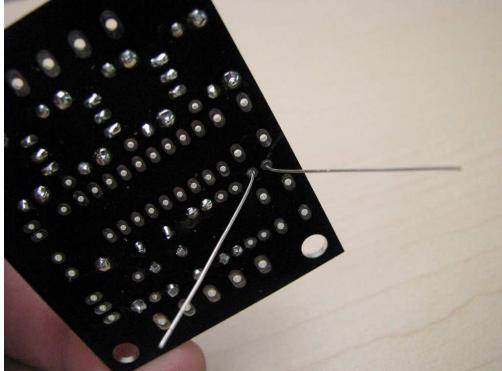


Insert capacitor into PCB

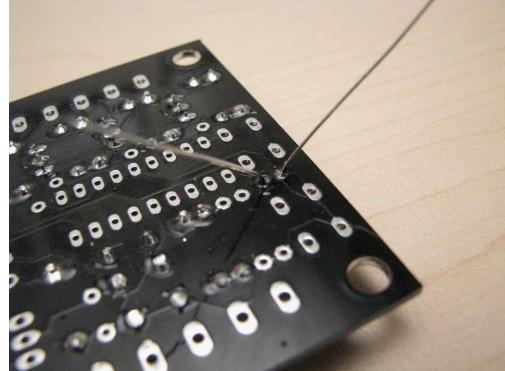


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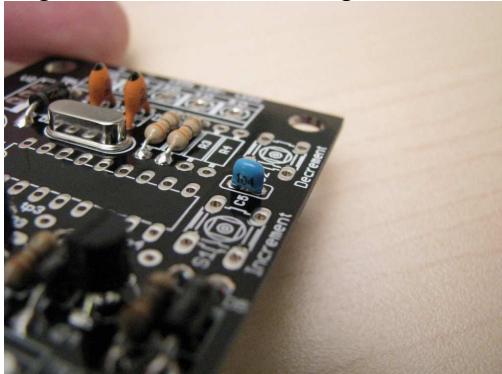
Flare the leads to hold them in place



Solder all leads to PCB and trim

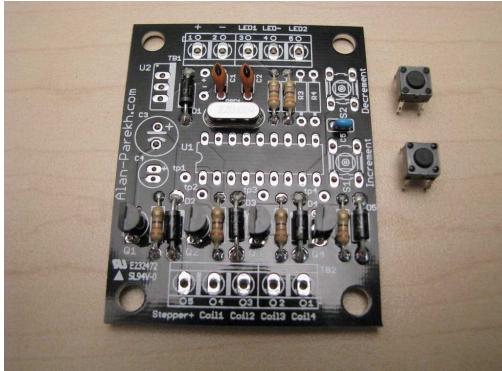


Capacitor installation complete



7. **Install the buttons.** The two buttons get installed in the positions marked as S1 and S2 on the board.

Buttons ready to install

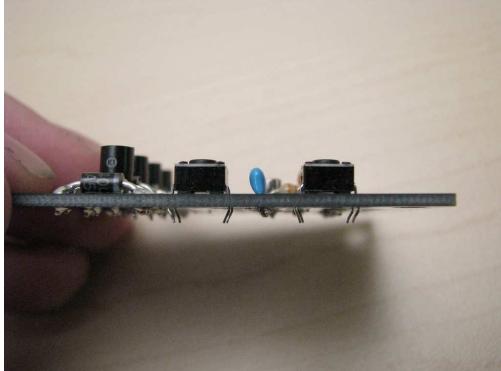


Insert buttons into PCB

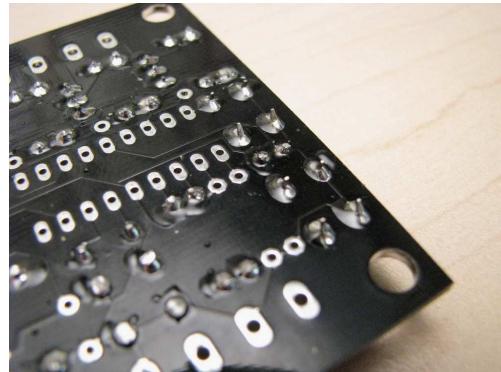


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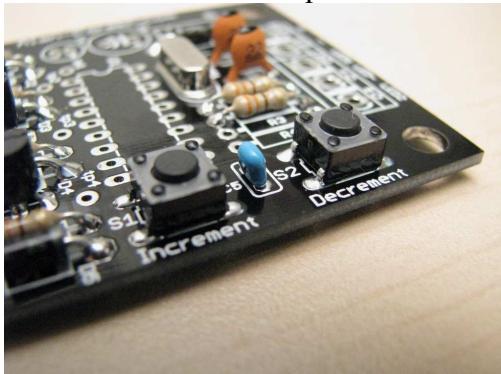
The leads will snap into position



Solder all leads to PCB

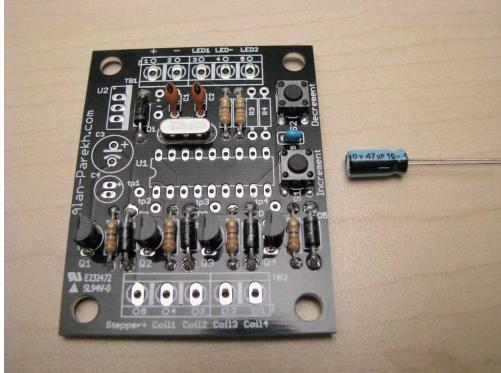


Button installation complete

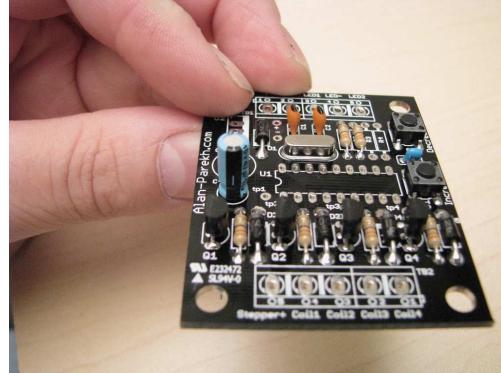


8. **Install the 47uF capacitor.** There is one 47uF capacitor that needs to be installed in location C4 on the board. This component is polarity sensitive, the positive lead is marked on the board and the negative lead is represented by a black stripe on the capacitor.

Capacitor ready to install

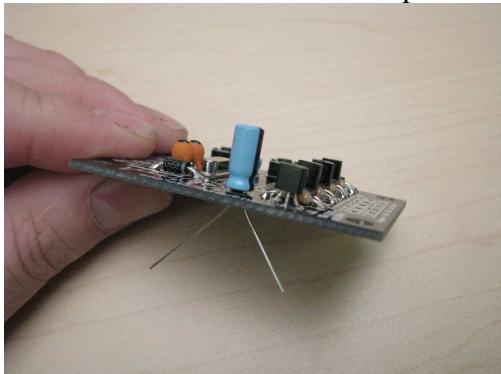


Insert capacitor into PCB

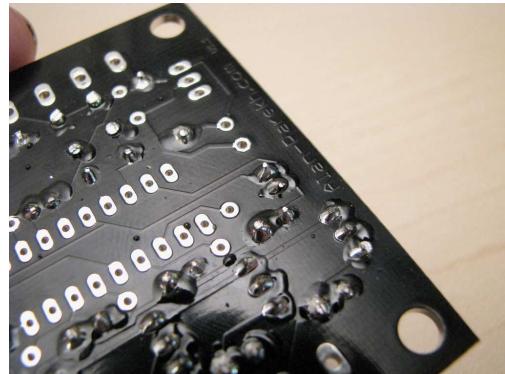


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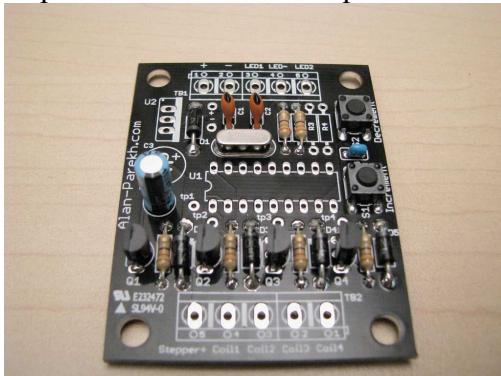
Flare the leads to hold them in place



Solder all leads to PCB and trim

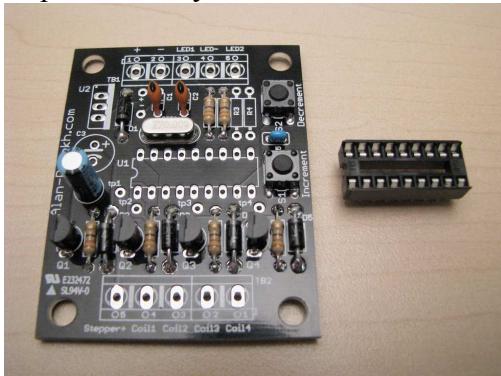


Capacitor installation complete

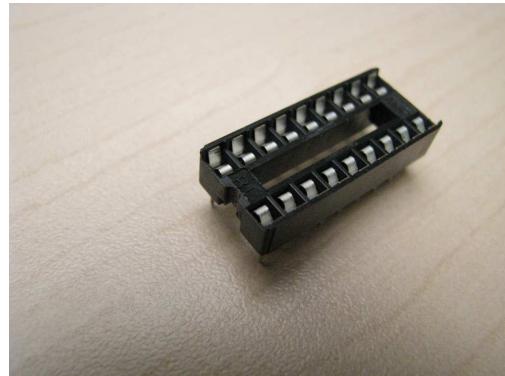


9. Install the chip socket. The chip socket gets installed in the location marked as U1. U1 is actually the listing for the microcontroller however since the microcontroller gets plugged into the socket the location is the same. This part is polarity sensitive, there is a notch on the socket and a notch shown on the board. Align these notches when installing.

Capacitor ready to install

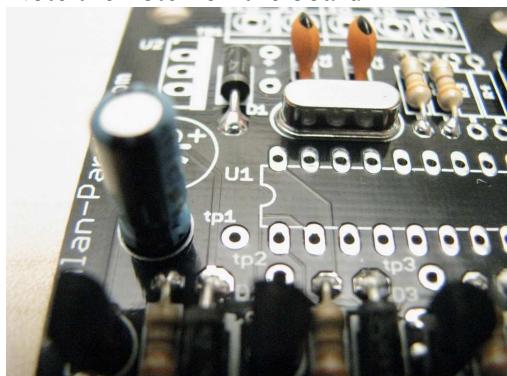


Note the notch on the left side of the socket

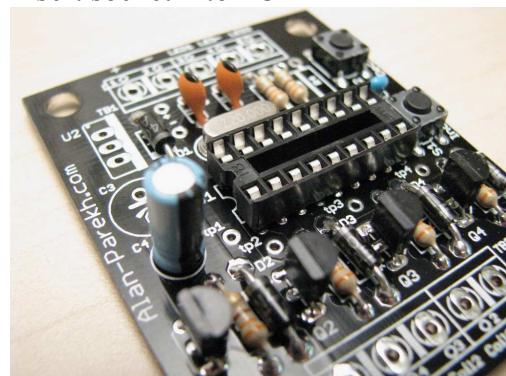


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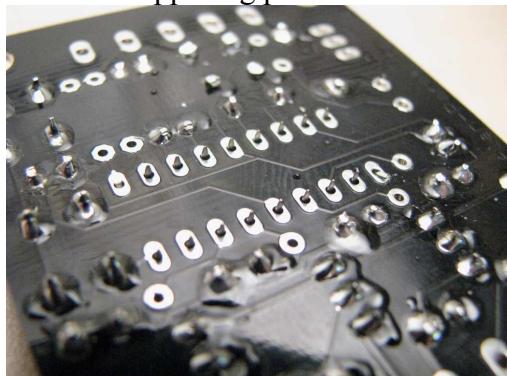
Note the notch on the board



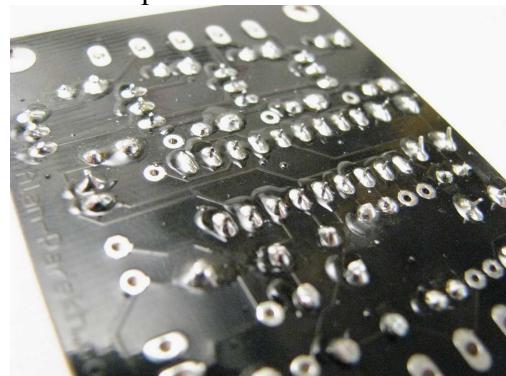
Insert socket into PCB



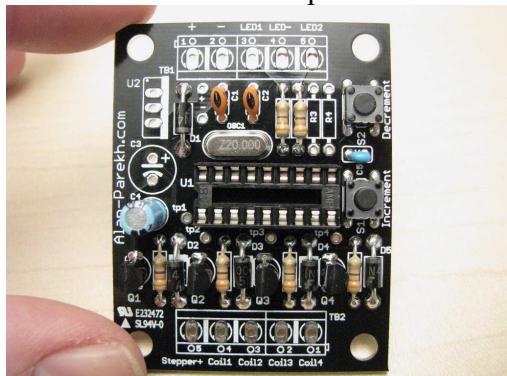
Bend two opposing pins to hold it in



Solder all pins



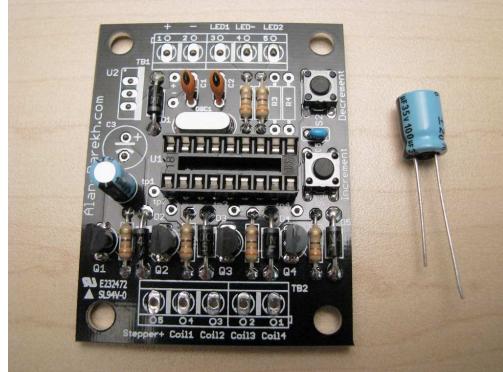
Socket installation complete



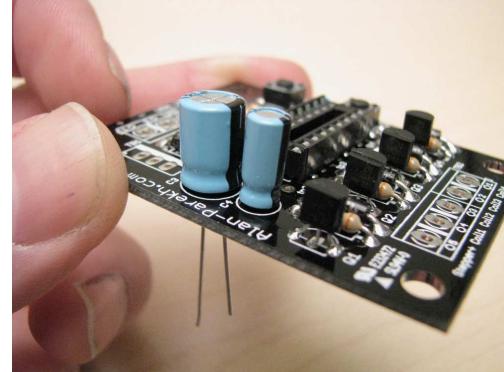
Gear Clock Assembly Instructions and User Guide

10. Install the 100uF capacitor. There is one 100uF capacitor that needs to be installed in location C3 on the board. This component is polarity sensitive, the positive lead is marked on the board and the negative lead is represented by a black stripe on the capacitor.

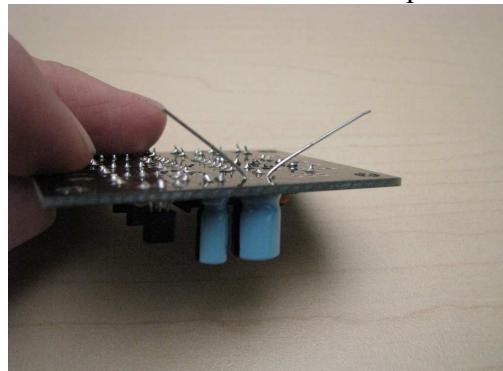
Capacitor ready to install



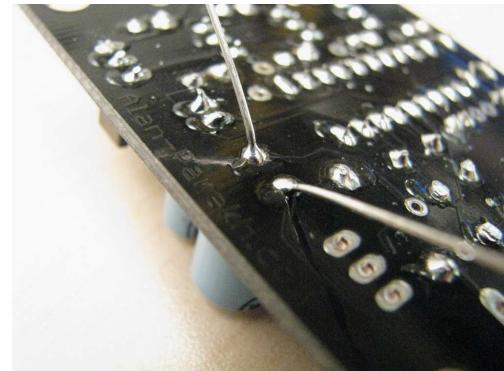
Insert capacitor into PCB



Flare the leads to hold them in place



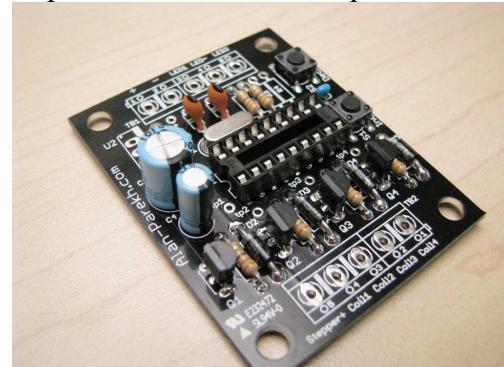
Solder all leads to PCB



Trim leads



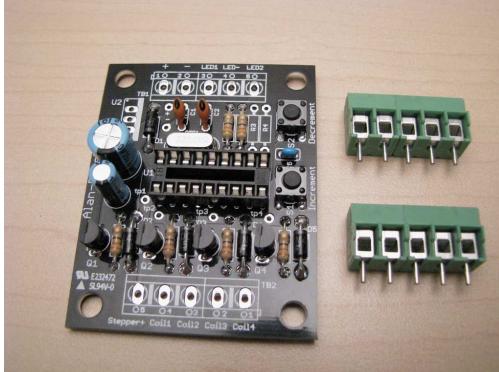
Capacitor installation complete



Gear Clock Assembly Instructions and User Guide

11. Install the terminal blocks. There are two terminal blocks that need to be installed. They are listed as TB1 and TB2 on the board. The terminal blocks need to be installed so that the wire openings are facing outward.

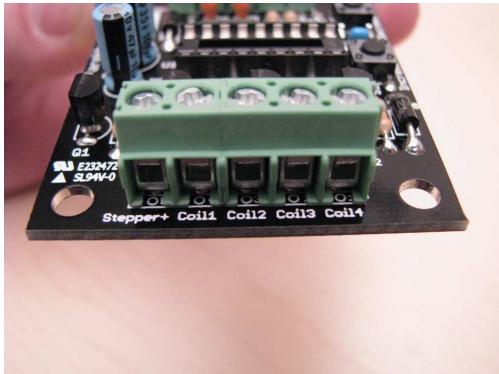
Terminal blocks ready to install



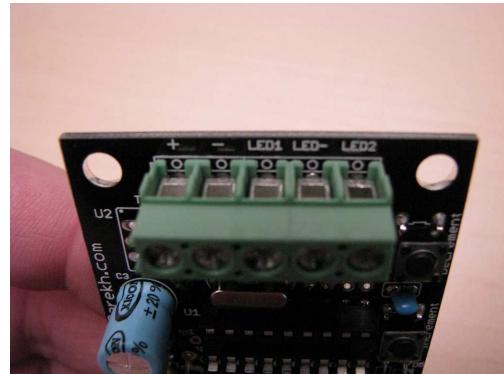
Insert terminal blocks into PCB



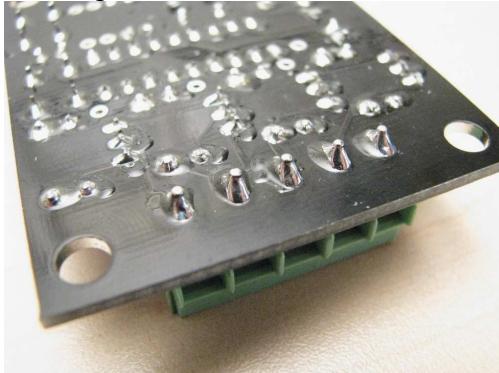
Ensure correct orientation of TB2



Ensure correct orientation of TB1



Solder pins



Terminal Block installation complete



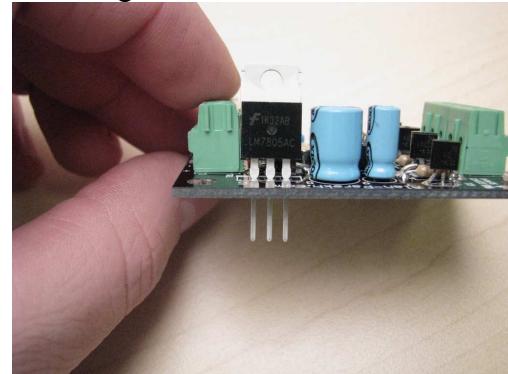
Gear Clock Assembly Instructions and User Guide

12. Install the voltage regulator. The voltage regulator needs to be installed in position U2 and is polarity sensitive. The heat sink side is indicated on the board with a white bar. The regulator lettering should be facing out when installed correctly.

Regulator ready to install



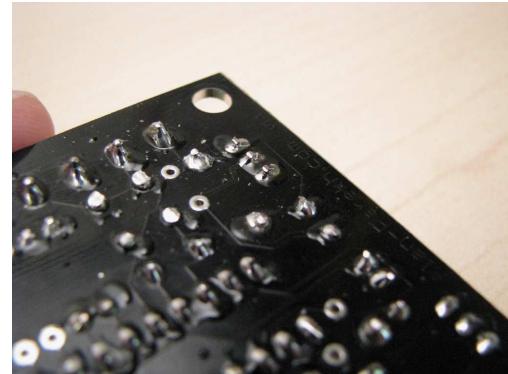
Insert regulator into PCB



Solder pins



Trim leads



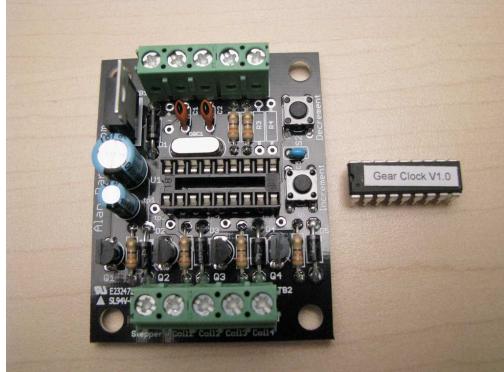
Regulator installation complete



Gear Clock Assembly Instructions and User Guide

13. Install the microcontroller chip. The microcontroller chip gets installed in the location marked as U1. There should be a socket soldered into this location already. The pins may need to be bent inward slightly to allow it to plug into the socket easily. If this is the case gently press all of the pins on one side against a table to slightly tweak the pins, perform this action equally on the opposite side pins. This part is polarity sensitive, there is a notch on the microcontroller that needs to be aligned with the notch shown on the board and socket. Align these notches when installing.

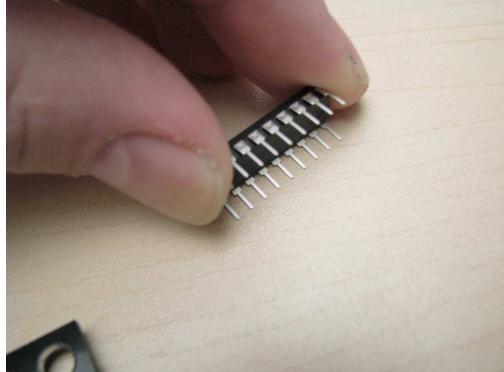
Microcontroller ready to install



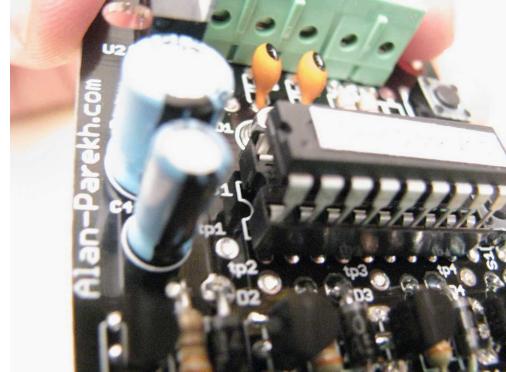
Note the notch on the left side of the chip



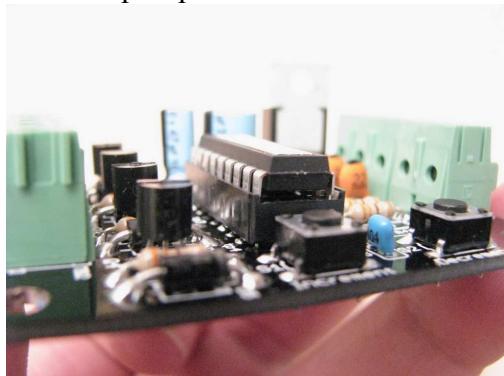
Gently bend pins inward if needed



Align notches on board, socket and chip



Press chip in place



Microcontroller installation complete



3. Kit Assembly – Clock Gears

The clock gears are made from MDF (medium density fiberboard) wood. If you ordered them painted you are ready to start the gear assembly, if not you will need to paint the MDF gears prior to assembly. See the gear finishing section for some tips on painting them.

Assembly of the clock gears is quite simple, screws hold the gear sections together and the completed gears turn on large bolts. Everything is pre-drilled so there should be no alignment issues.

3.1 Unpack the Gears and Hardware

Before we begin assembling the clock hardware make sure that your kit came with everything needed. Below are some pictures of all the items that should be in the kit. Please note that some items such as the power supply and stepper motor might look slightly different than shown below. The clock control board needs to be assembled prior to this step, the assembled board is shown below.



Gear Clock Assembly Instructions and User Guide

72 tooth hour gear



72 tooth minute gear



72 tooth lower gear



Spacers and small gears, more details below



5 hole spacers, Qty 4



3 hole spacers, Qty 3



Gear Clock Assembly Instructions and User Guide

9 tooth motor gear



24 tooth gear



18 tooth gear



Motor spacer



Wire clamps and screws (8 X 3/8), Qty 2



Motor screws (8 X 1 3/4), Qty 2



Gear Clock Assembly Instructions and User Guide

Washers, Qty 3



Gear screws (8 X 3/4), Qty 18



Bolts (1/4 X 2 1/2), Qty 3



Control Board and mounting hardware



Stepper motor



Clock backplane



3.2 Mechanical Clock Construction

To assemble the Gear Clock mechanical portion you will need a Robertson #2 screw driver, terminal driver (small flat blade screw driver), 11mm wrench, wire cutters, wire strippers, painters tape. Some electrical tape may be also needed.

MDF wood is a strong material but use caution when tightening screws. It is possible to strip the material if a screw is over-tightened. You want the screw connections to be snug only.

- 1. Install the power cable.** The power cable enters the bottom center of the clock backplane. There is a wire path routed in the rear of the backplane to allow the wire to be concealed. Two nylon wire clamps are used to secure the wire in place and a hole behind the control board location allows the wire to pass to the front. Depending on the diameter of the wire being used, it may be necessary to increase the diameter of the wire using a few wraps of electrical tape to allow the wire clamps to hold it securely. If the length of the wire is not long enough the power supply wires can be extended using some similar wire, the joints should be soldered and protected using some heat shrink.

Power supply ready to install



Nylon clamps and 3/8 inch screws



Check to see how the clamp fits the wire, in this case it is too loose



Electrical tape is needed if the diameter of the wire is too small

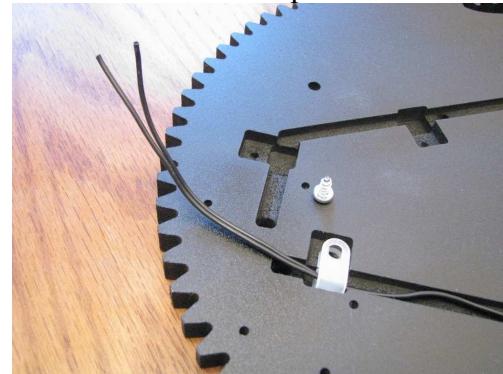


Gear Clock Assembly Instructions and User Guide

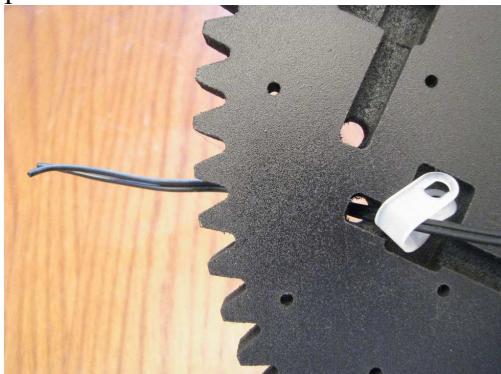
Run the power wire in the channel



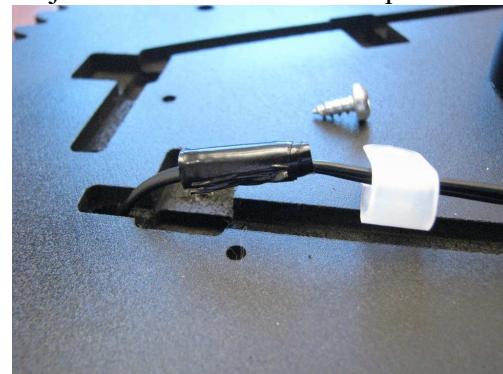
Leave about 4 inches past the second clamp



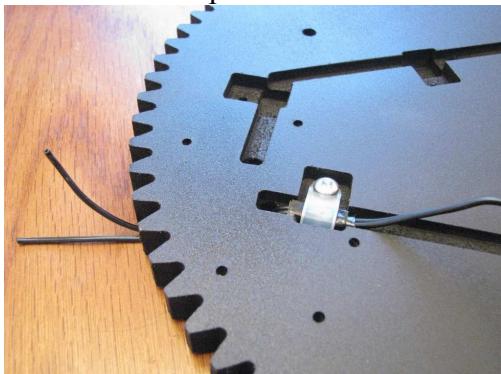
Pass the wire to the front through the provided hole



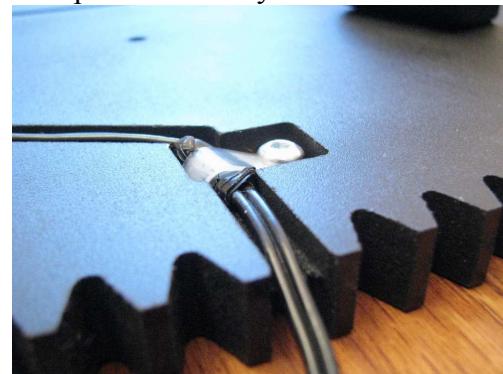
Adjust wire thickness with tape if needed



Secure the clamp



Keep the wire taught and connect the lower clamp the same way as the first

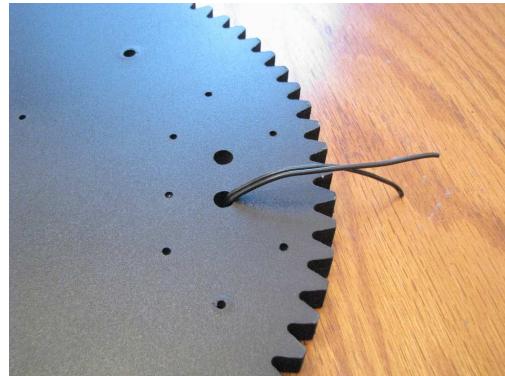


Gear Clock Assembly Instructions and User Guide

Wire routing completed



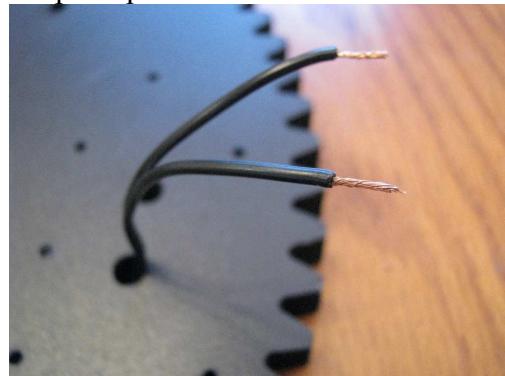
Front view of wire exit location



Front view of backplane



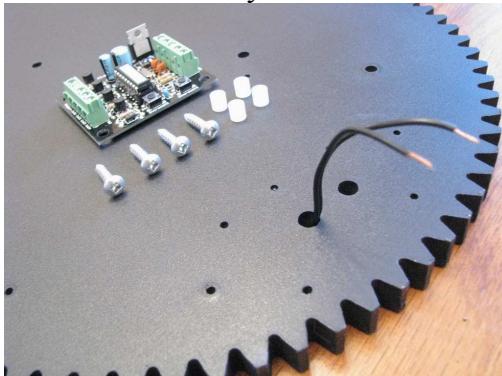
Strip the power wires



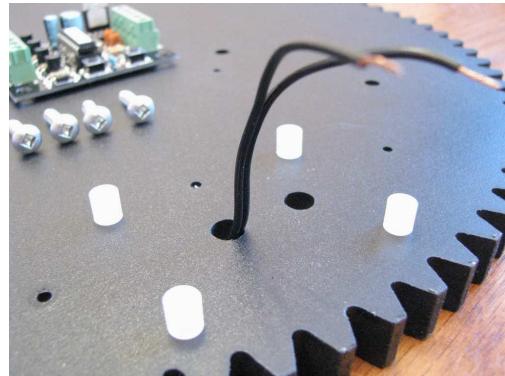
2. **Install the clock control board and connect power.** The clock control board needs to be installed onto the backplane. There are 4 pre-drilled holes surrounding the power cable. The control board gets mounted on top of 4 standoffs. The power wires also need to be connected to the control board.

The control board is expecting a 12 volt DC supply to be connected to the first 2 locations of TB1. If you are unsure of the power supply polarity use a meter to determine which lead is positive and which lead is negative.

Control board ready to install

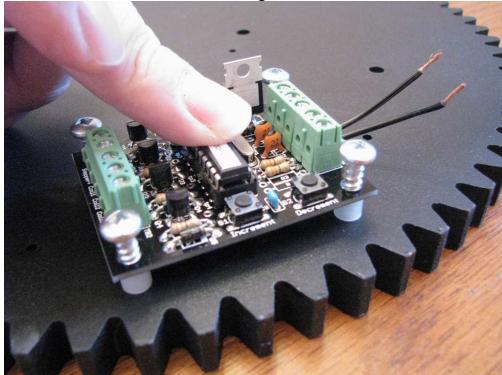


Place the 4 standoffs over the holes

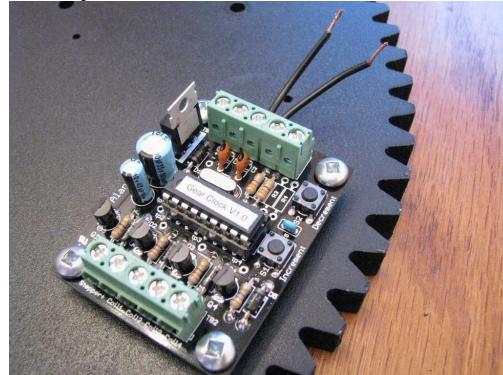


Gear Clock Assembly Instructions and User Guide

Place the control board and screws over the standoffs and adjust wire as shown



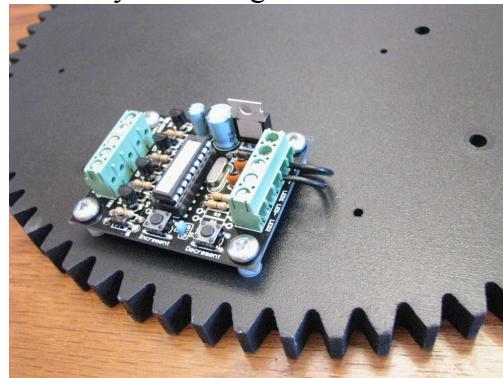
Gently screw in all 4 screws



Connect the power leads as shown positive on the left and negative on the right

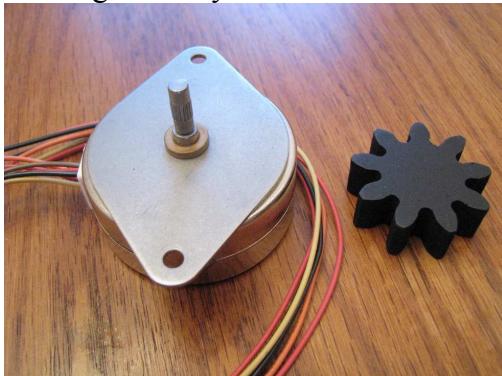


Tuck any remaining wire under the board

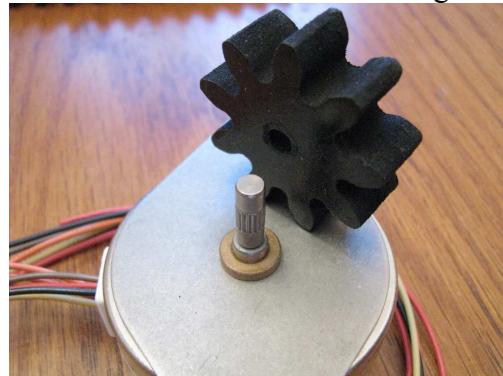


3. **Install the stepper motor.** The stepper motor needs to be mounted to the backplane and wired to the control board. There is a gear that needs to first be press fit onto the stepper motor shaft. Then the motor is attached to the backplane using 2 screws, a motor spacer is used to achieve the correct final height.

Motor gear ready to install



There is a small shaft hole in the gear



Gear Clock Assembly Instructions and User Guide

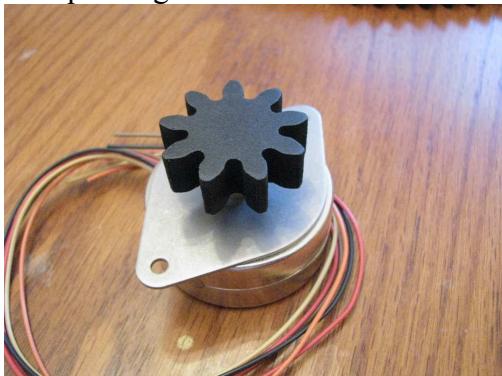
Position motor shaft into the hole



Gently press the gear straight onto the shaft



Completed gear attachment



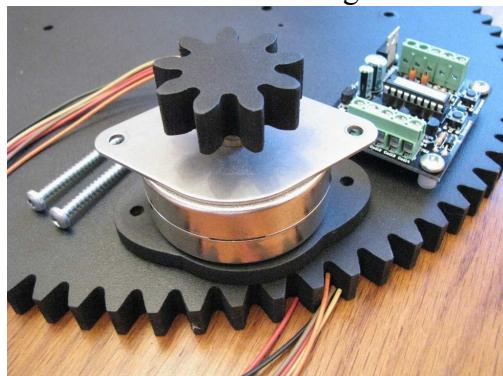
Motor assembly ready to install



Position the motor spacer over the Pre-drilled holes as shown

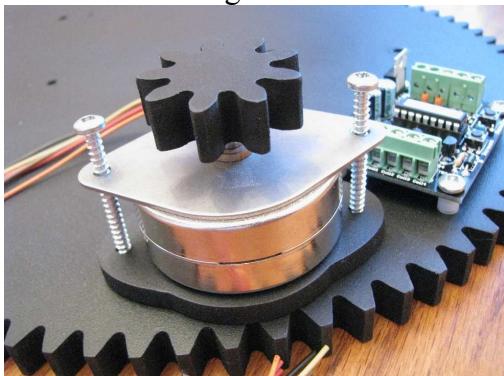


Place the motor onto the motor spacer ensure the wires are exiting to the rear

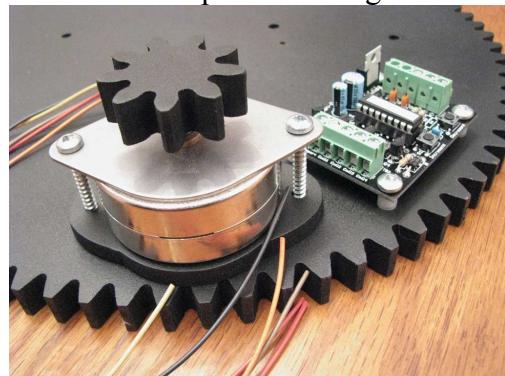


Gear Clock Assembly Instructions and User Guide

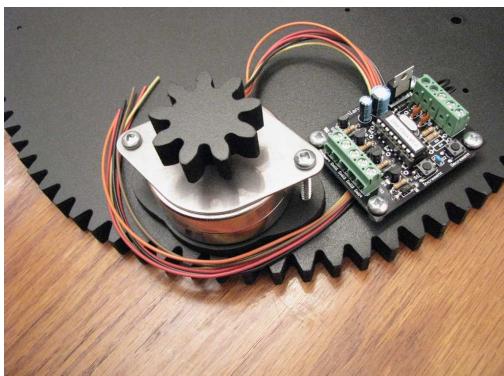
Position mounting screws as shown



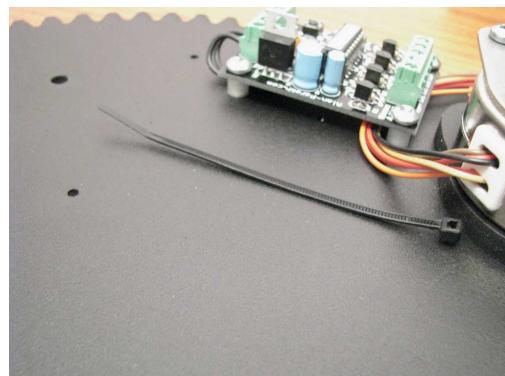
Screw them in place till snug



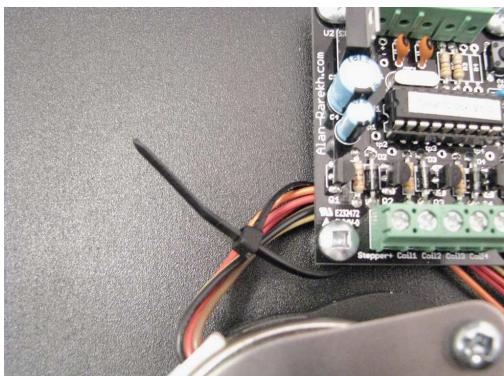
Loop the motor wire under the control board as shown



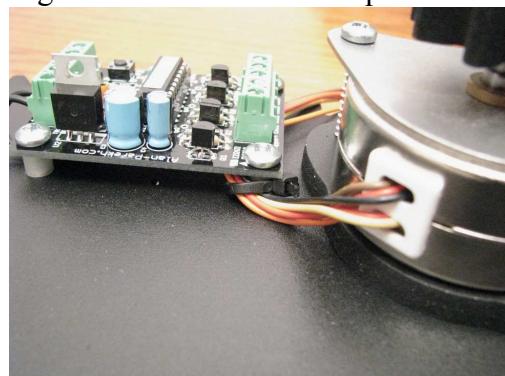
Tighten the wires against the standoff as shown



Loop a cable tie around the wires and around the standoff

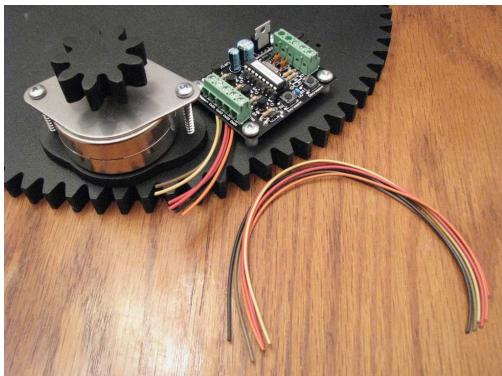


Tighten the cable tie and clip off excess

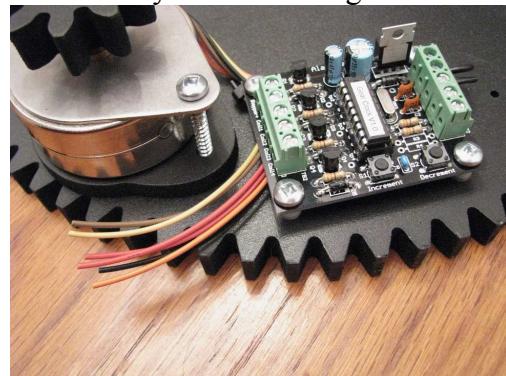


Gear Clock Assembly Instructions and User Guide

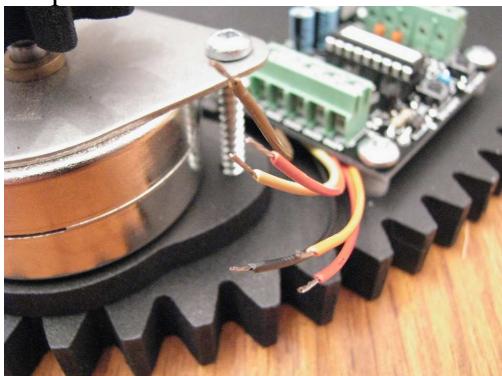
Cut off excess motor wire



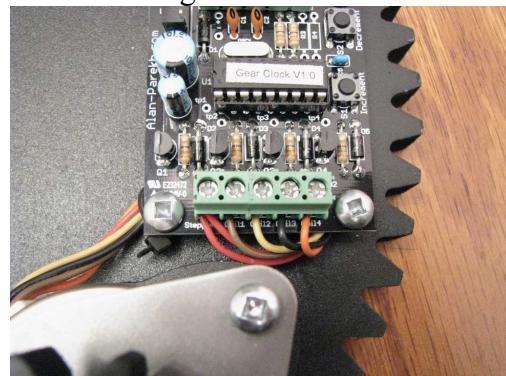
Make sure you leave enough to work with



Strip off the ends of all motor wires



Attach the motor wires to the controller
Stepper + = both red wires
Coil 1 = brown wire
Coil 2 = yellow wire
Coil 3 = black wire
Coil 4 = orange wire



Gear Clock Assembly Instructions and User Guide

4. Hour gear assembly. The hour gear consists of one 3 hole spacer, 2 five hole spacers, the large hour gear and 6 mounting screws. All of the pieces are attached together using screws starting with the 3 hole spacer which will eventually rest against a washer on the backplane. It is important to use the 2 1/2 inch bolt during this assembly process to ensure that the assembly remains properly centered.

Hour gear assembly ready to assemble



Set a 5 hole spacer above a 3 hole spacer



Insert the bolt in the center hole



Tighten the screws until snug



Set a 5 hole spacer above the assembly



Insert the bolt in the center hole



Gear Clock Assembly Instructions and User Guide

Tighten the screws until snug



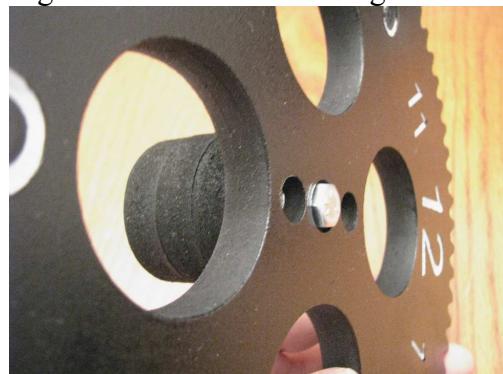
Set the hour gear above the assembly



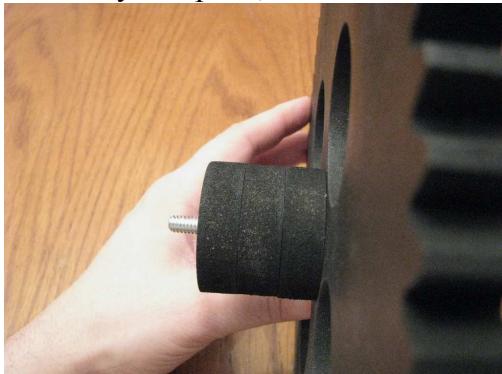
Insert the bolt in the center hole



Tighten the screws until snug



Assembly complete, side view



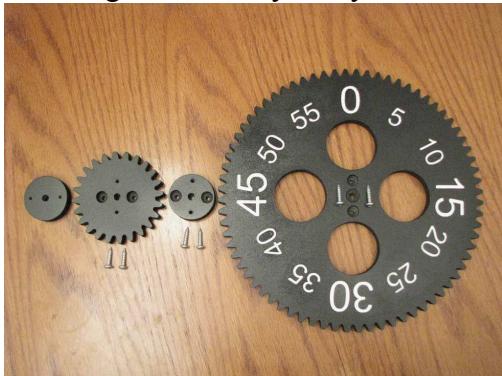
Assembly complete, top view



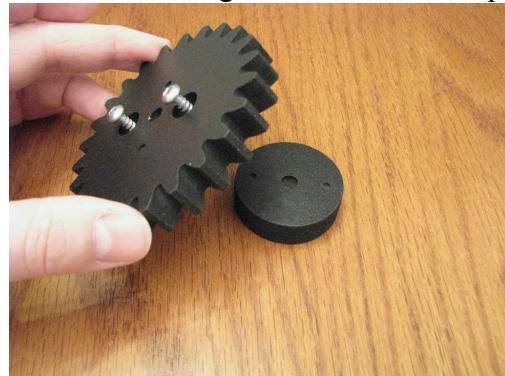
Gear Clock Assembly Instructions and User Guide

5. Minute gear assembly. The minute gear consists of one 3 hole spacer, a 24 tooth gear, 1 five hole spacers, the large minute gear and 6 mounting screws. All of the pieces are attached together using screws starting with the 3 hole spacer which will eventually rest against a washer on the backplane. It is important to use the 2 1/2 inch bolt during this assembly process to ensure that the assembly remains properly centered.

Minute gear assembly ready to assemble



Set the 24 tooth gear above a 3 hole spacer



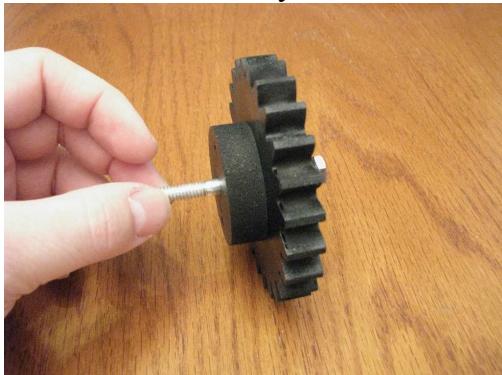
Insert the bolt in the center hole



Tighten the screws until snug



Side view of assembly so far



Set a 5 hole spacer above the assembly



Gear Clock Assembly Instructions and User Guide

Insert the bolt in the center hole



Tighten the screws until snug



Side view of assembly so far



Set the minute gear above the assembly



Insert the bolt in the center hole

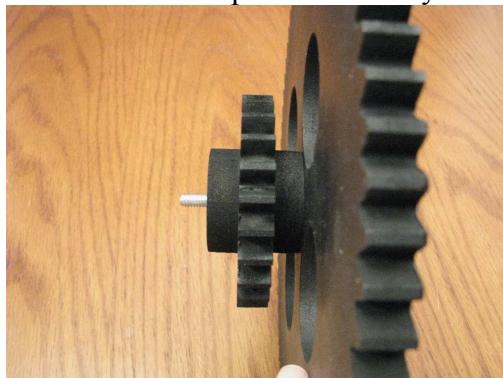


Tighten the screws until snug



Gear Clock Assembly Instructions and User Guide

Side view of completed assembly



- 6. Lower 72 tooth gear assembly.** The lower 72 tooth gear assembly consists of one 3 hole spacer, the large 72 tooth gear, 1 five hole spacers, an 18 tooth gear and 6 mounting screws. All of the pieces are attached together using screws starting with the 3 hole spacer which will eventually rest against a washer on the backplane. It is important to use the 2 1/2 inch bolt during this assembly process to ensure that the assembly remains properly centered.

72 tooth gear assembly ready to assemble



Set the 72 tooth gear above a 3 hole spacer



Insert the bolt in the center hole



Tighten the screws until snug



Gear Clock Assembly Instructions and User Guide

Set a 5 hole spacer above the assembly



Insert the bolt in the center hole



Tighten the screws until snug



Set the 18 tooth gear above the assembly



Insert the bolt in the center hole

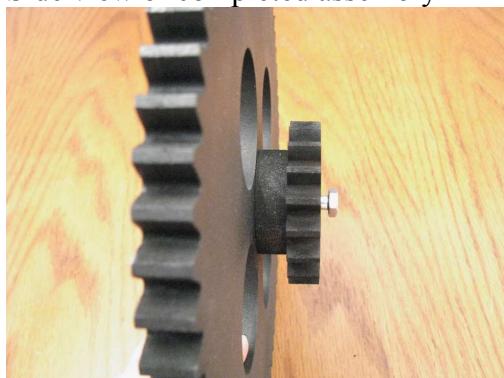


Tighten the screws until snug



Gear Clock Assembly Instructions and User Guide

Side view of completed assembly



Side view of completed assembly

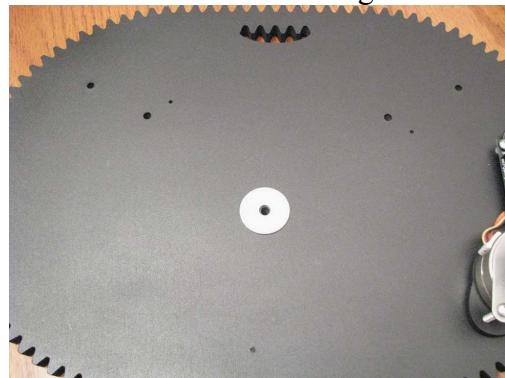


7. **Mount gear assemblies to backplane.** All three large gear assemblies need to be bolted to the clock backplane. A washer will be inserted between the gear assembly and backplane to reduce friction. The center bolts are used as rotating shafts and should not be tightened all the way down. There should be about 1/16 of an inch play in the gear when properly mounted to allow it to rotate with little friction. The bolts will self tap threads into the MDF when they are inserted, it is important that they are inserted very straight so that the gears run true.

Gear assemblies ready to install



Place a washer over center gear location



Place lower 72 tooth gear on washer

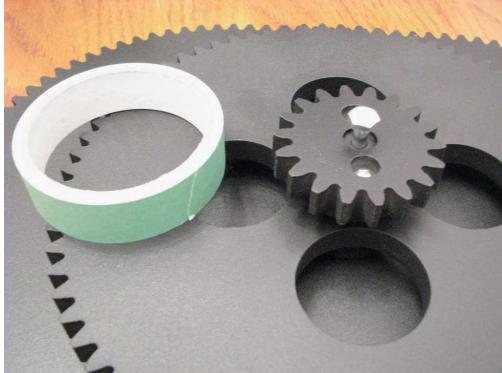


Gear in place, ready to secure

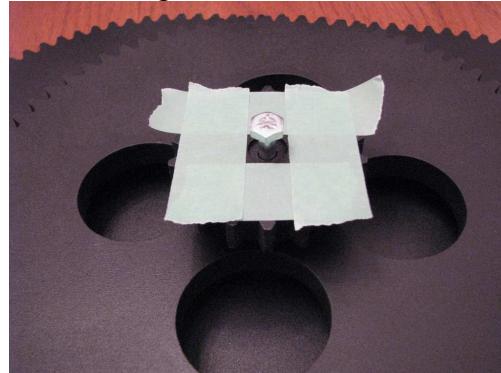


Gear Clock Assembly Instructions and User Guide

Painters tape can be used to protect paint



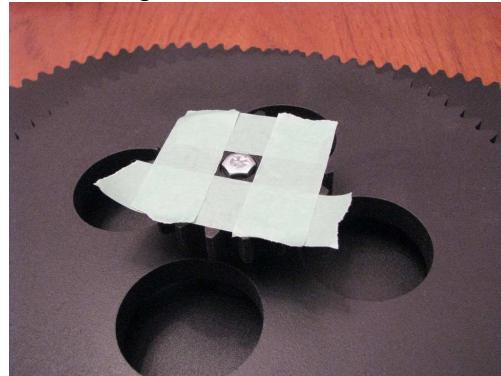
Place the tape where the wrench will contact the gear



Gently tighten till there is about 1/16 inch of play



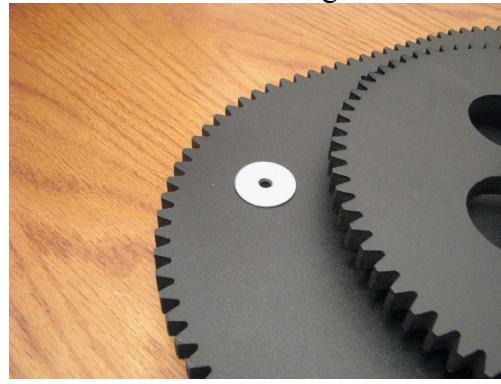
Bolt head will be partially countersunk when complete



Lower 72 tooth gear install complete
Ensure the screw pattern remains vertical



Place a washer over left gear location



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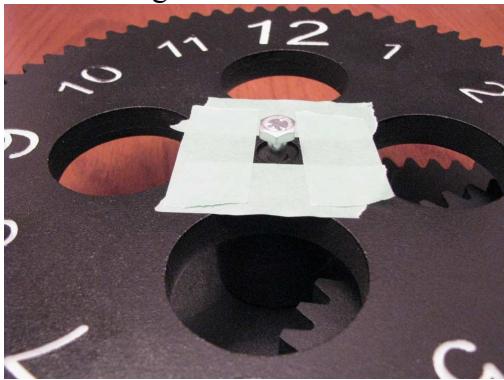
Place hour gear on washer



Gear in place, ready to secure
Ensure the screw pattern remains vertical



Place tape where the wrench will contact the gear



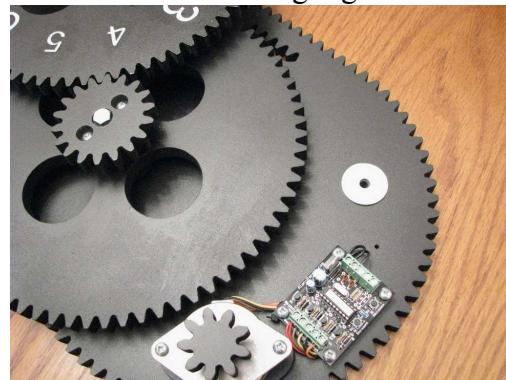
Insert this bolt the same as the last one



Hour gear install complete

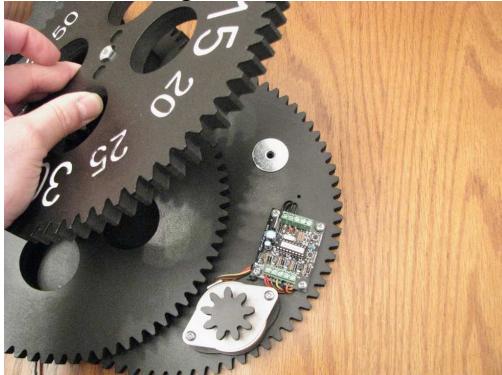


Place a washer over right gear location



Gear Clock Assembly Instructions and User Guide

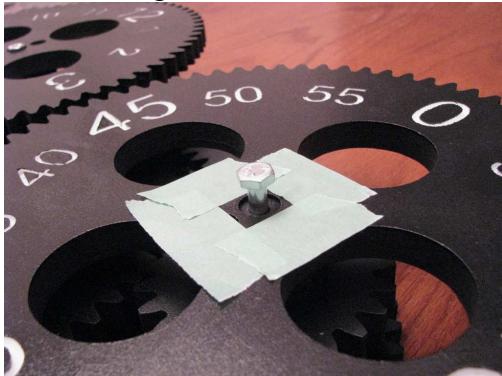
Place minute gear on washer



Gear in place, ready to secure
Ensure the screw pattern remains vertical



Place tape where the wrench will contact the gear



Insert this bolt the same as the last one



Clock assembly complete



Side view of completed clock



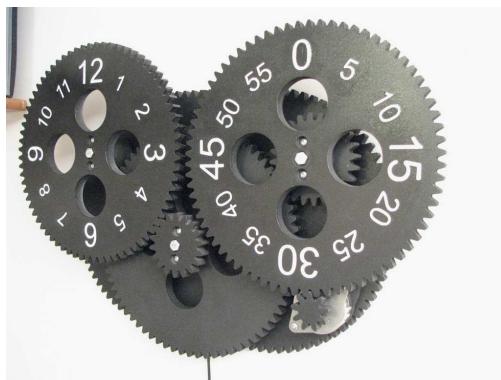
4. Clock Operation

The clock was designed to be simple to read and operate. There are only two buttons used to set the clock and the clock numbers are large enough to easily be seen from across the room.

4.1 How to read the time

Time is read by seeing what number is on the top of each number wheel. The left number is the hour indication and the right number is the minute indication. Below are some examples.

Time shown is 12:00



Time shown is 7:25



Time shown is 9:52

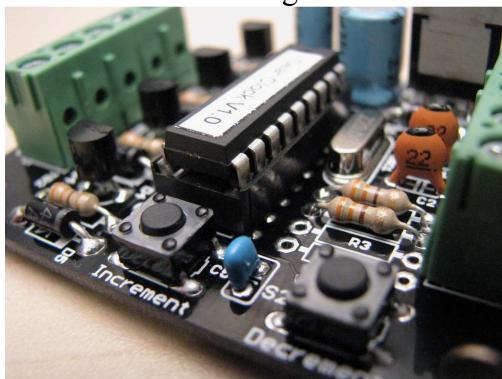


4.2 How to Adjust the Time

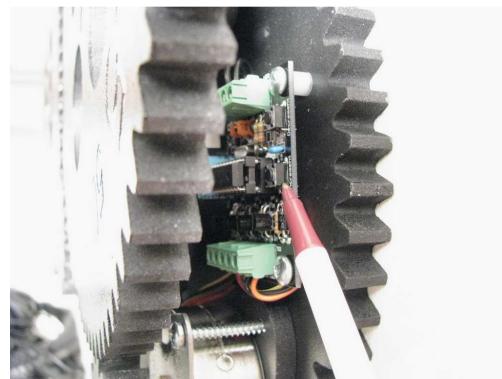
There are two buttons on the control board which are used to adjust the time displayed.

- To **increment time** press the Increment button which is the lower button when the control board is mounted on the backplane.
- To **decrement time** press the Decrement button which is the upper button when the control board is mounted on the backplane.
- To **release the stepper motor** allowing the minute gear to be turned by hand press both buttons at the same time.

Increment is on the left,
decrement is on the right



When mounted the lower button
is increment



When mounted the upper button
is decrement



5. MDF Clock Gear Finishing

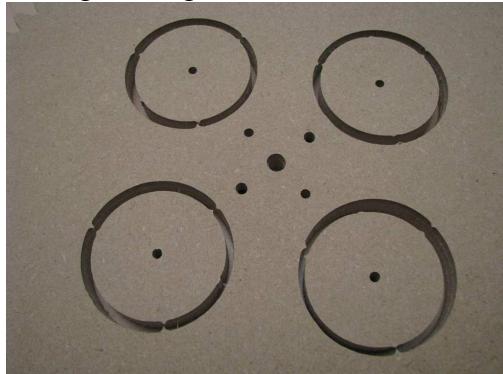
If you ordered your clock un-painted you will need to follow some simple steps to achieve a nice looking finish.

5.1 Tab removal

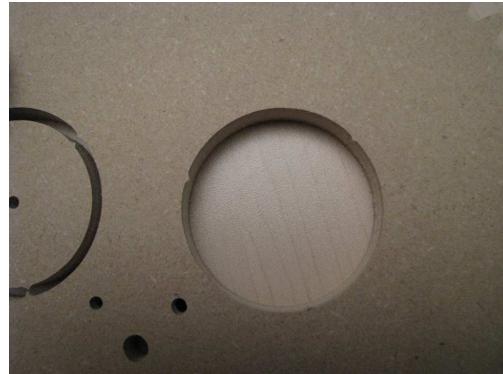
Some of the MDF parts will have small tabs left over from the milling process. Since they are so small they will often break apart by themselves. If the tabs still connect two pieces together simply twist the part to remove it.

Once the parts have all been separated there will be some small bumps on some of the surfaces. Three or four light sweeps of 120 grit sand paper will remove the bumps completely.

Example of a part that has small tabs



Three inner tabs can been seen here



120 grit sand paper can be used to remove the remaining bumps



3 or 4 light rubs is all it take to remove them



5.2 MDF cleaning

All of the parts are thoroughly vacuumed after they are cut out however there may still be some dust deposits in tight spots such as in the wire channels and in the gear teeth. It is recommended that a small stiff brush be used to remove any remaining light dust, then vacuum all the wood pieces a final time. A few blasts of compressed air is also effective at cleaning out the brush loosened dust.

5.3 MDF painting

It is a good idea to prime the MDF parts prior to painting them. Pay special attention to the center gear holes since if you build up too many layers in there the gears may not spin freely on the bolt shaft. You can stuff the center holes with cotton balls if you want to prevent this from happening.

One tip for painting the recessed numbers of the two time gears is to paint the number color first then when that is dry use a foam roller with just a bit of paint to lightly roll paint on the surface. This has to be done in a number of very light coats to prevent any paint from getting into the recessed number area.

The edges of the gears will be rubbing against each other for a long time. To ensure the paint in this area lasts a long time it is important that the gears spin freely and are not being pinched anywhere. A tough clear coat can be painted onto the edges of the gears to enhance the wear protection if desired.

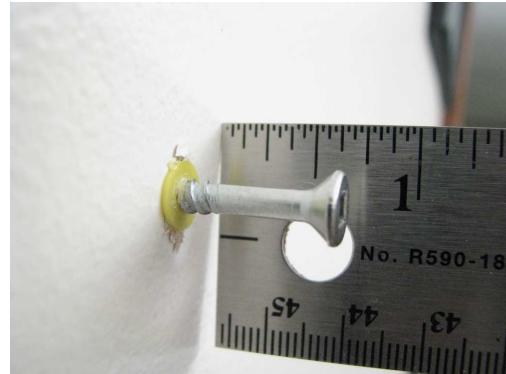
6. Clock Hanging

The final weight of the clock will be around 3KG (6.6 LBS). Because of this weight a standard picture hanger will not be strong enough. To support the weight it is recommended that a screw with a length of around 2 inches is used. It is preferable for this screw to be driven into a wall stud however a drywall anchor can also be used as shown below.

Drywall anchor and screw mount



Leave out a little more than 1/2 inch



Due to the weight imbalance caused by the heavy stepper motor the notch right of center should be ideal



A few felt pads could be installed on the rear of the clock to prevent direct wall contact

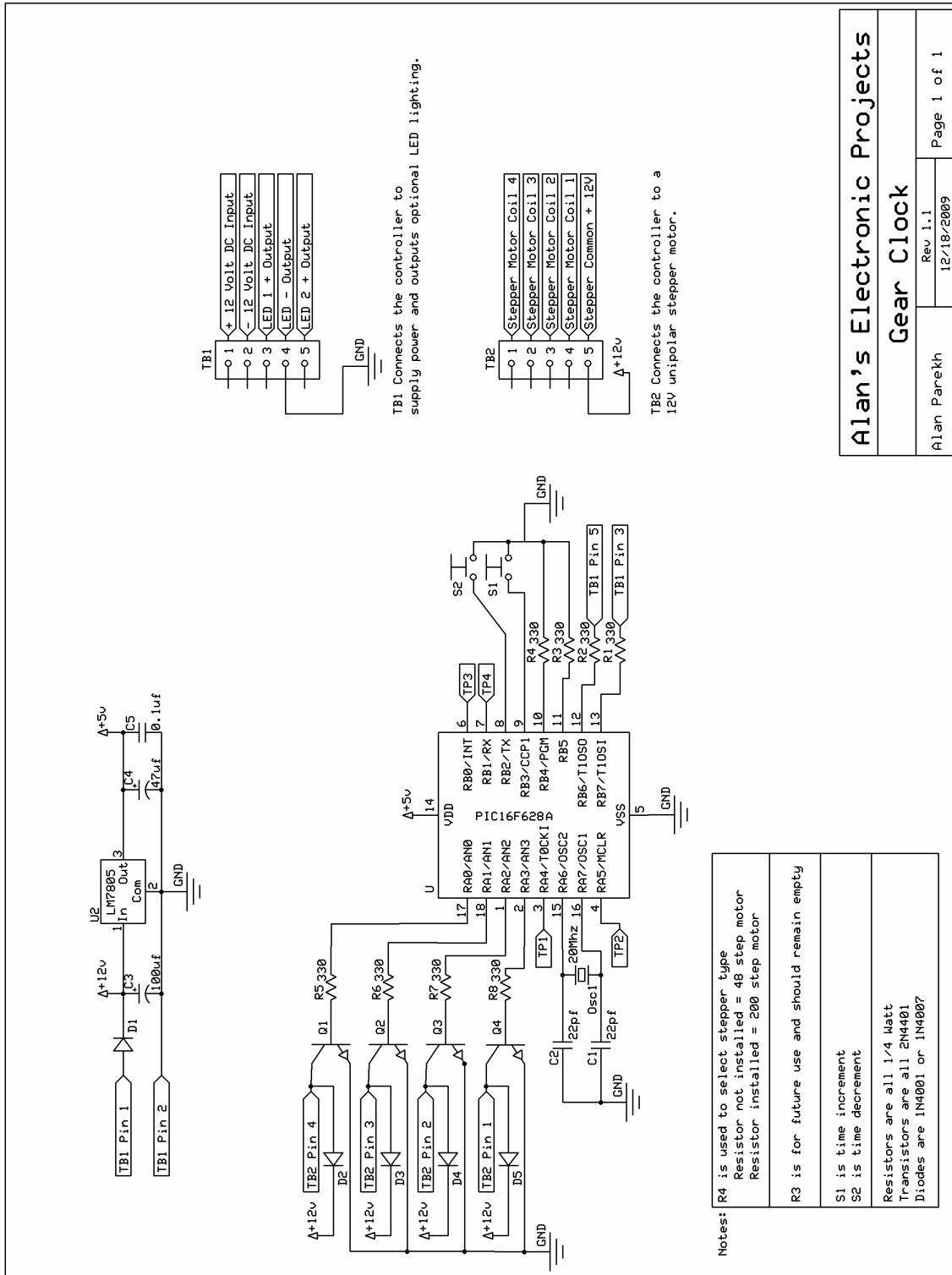


7. Maintenance

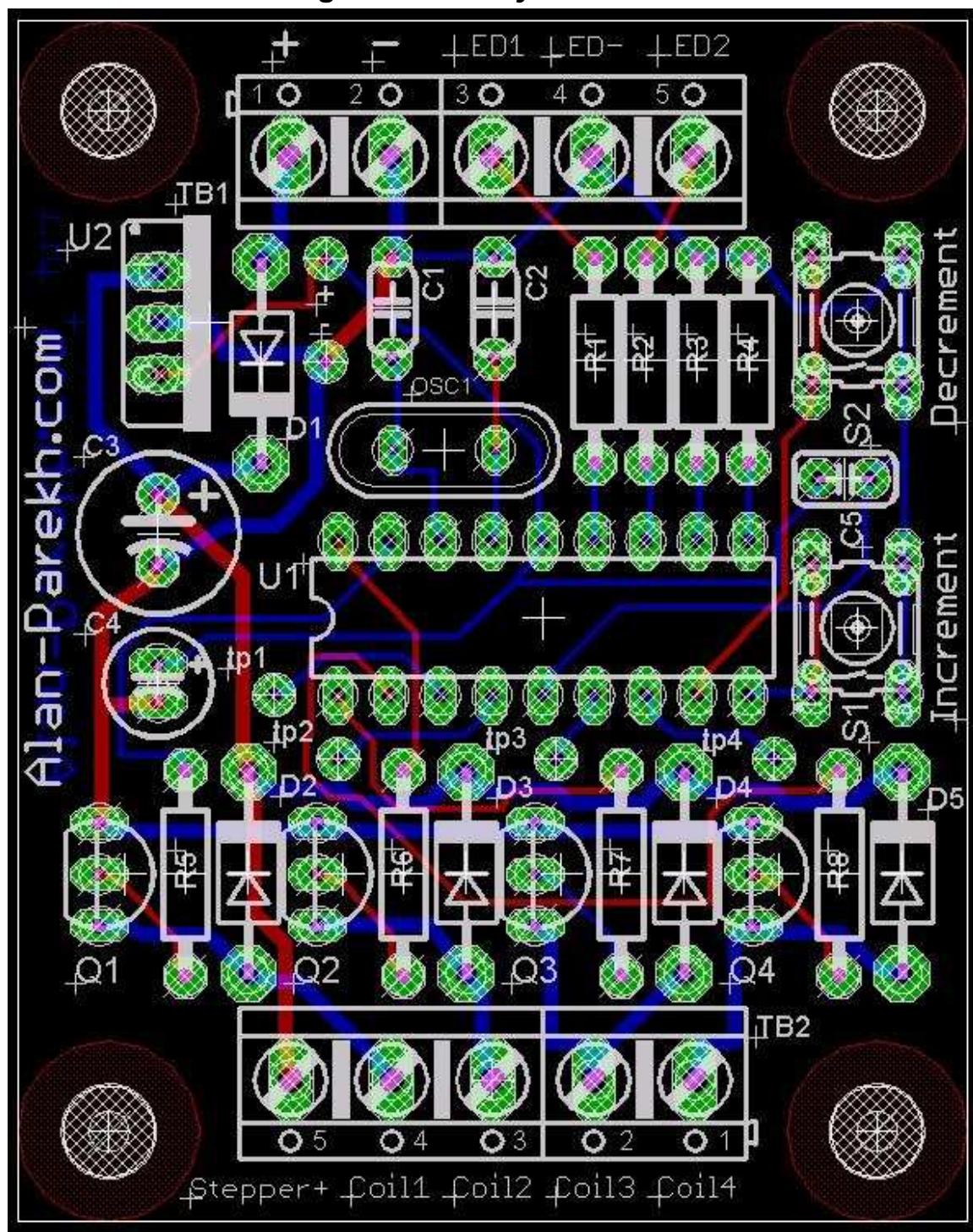
Any dust accumulation on the Gear Clock Control circuit board should be blown off. Canned compressed air works well for this purpose and is available at any computer store. We recommend powering down the controller during cleaning.

8. Appendix

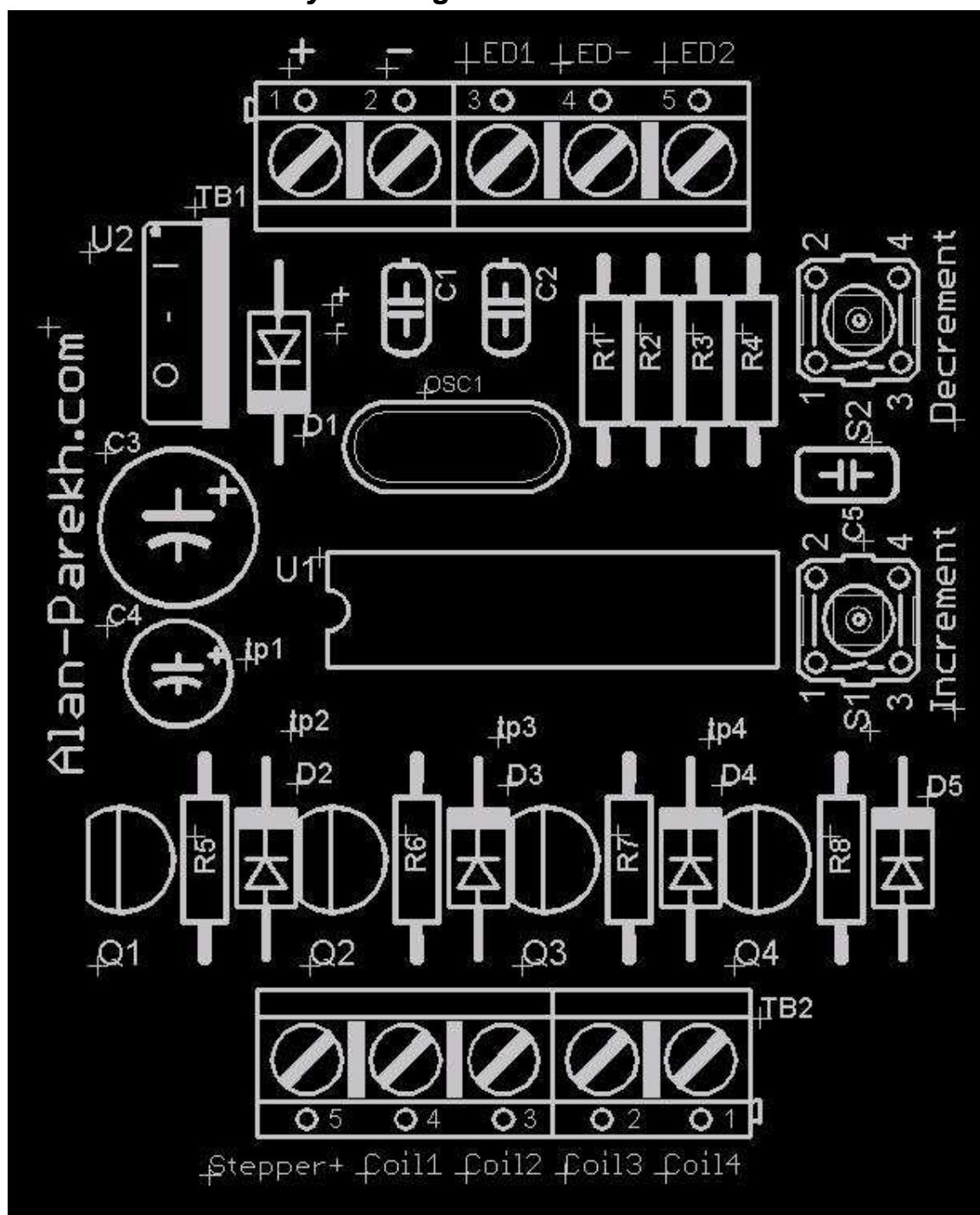
8.1 Gear Clock Control Board Schematic



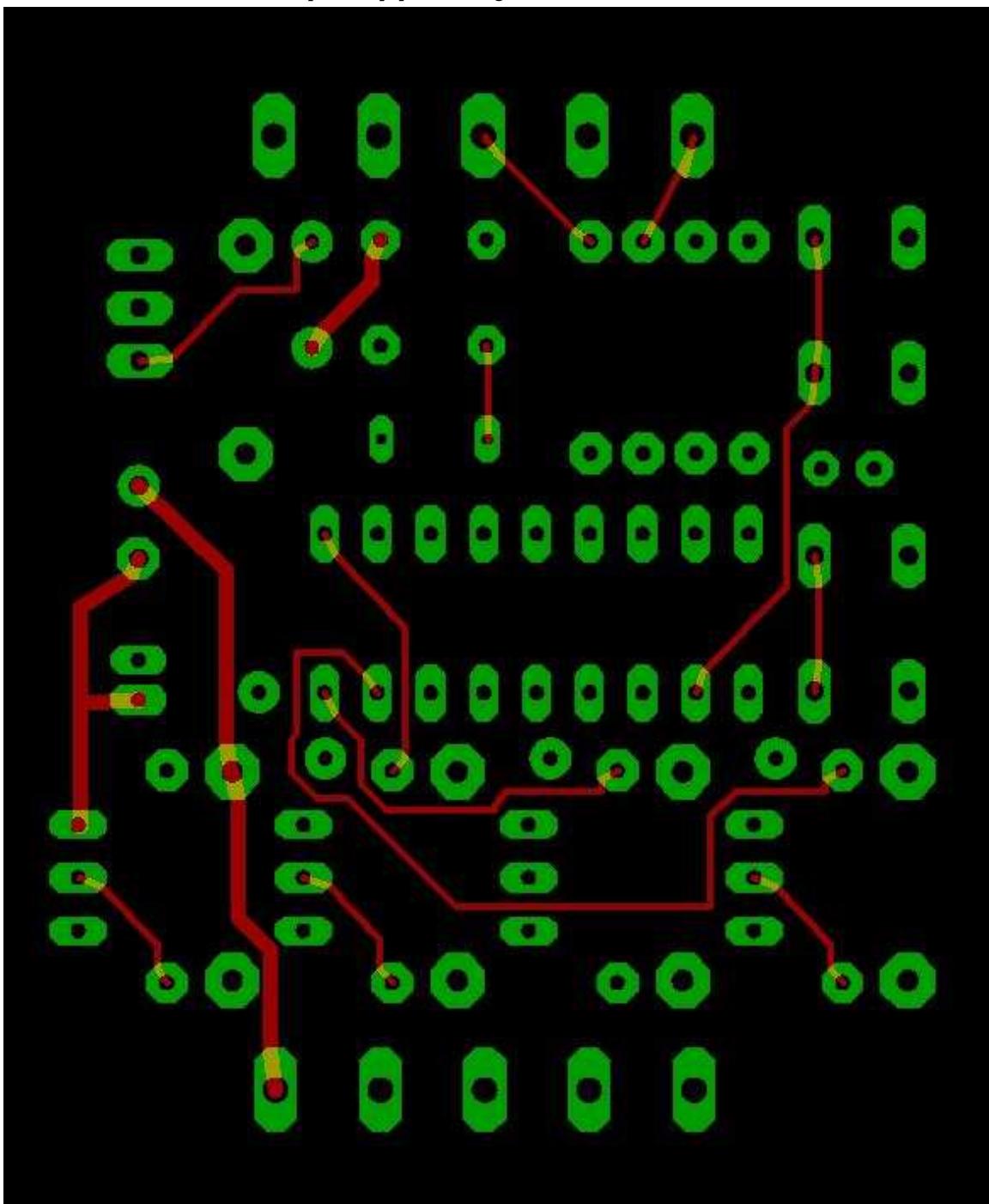
8.2 Circuit Board Diagram – All Layers



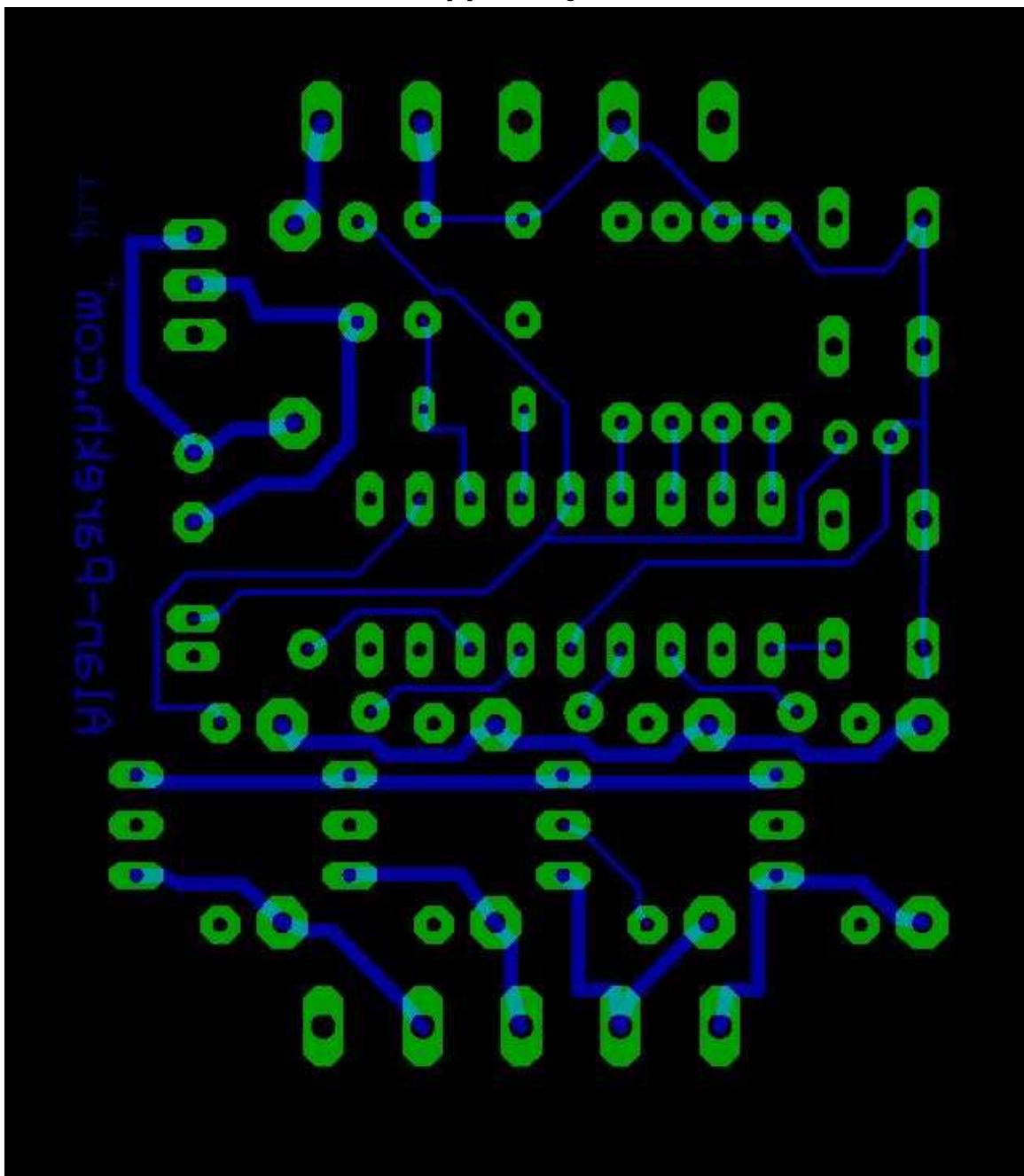
8.3 Circuit Board Layout Diagram



8.4 Circuit Board Top Copper Layer



8.5 Circuit Board Bottom Copper Layer



8.6 Circuit Board Assembled Photo

