Ultrasound Range Finder

PCB Version 1.0

Assembly Manual

Range Finder Assembly Instructions

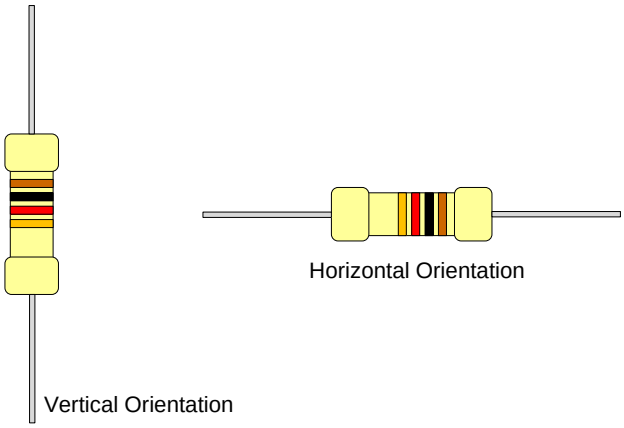
Read This Before You Begin

1. Avoid touching the PCB copper traces and pads with your fingers until you are ready to assemble. Chemicals on your hands will cause the copper to darken making it harder to solder the parts.

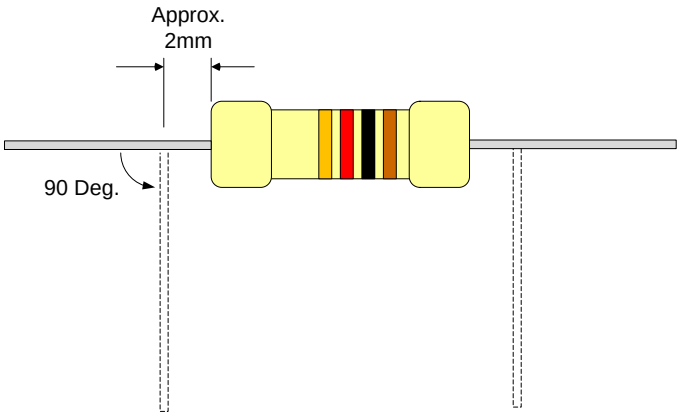
2. Before you begin soldering, lightly scrub the copper side of the board with hand soap to remove any mild tarnish. Rinse in cold water and pat dry with a towel. Try not to aggressively wipe the copper or component side. Allow the board to dry for a few minutes and you are ready to go.

3. **Soldering fixed resistors**

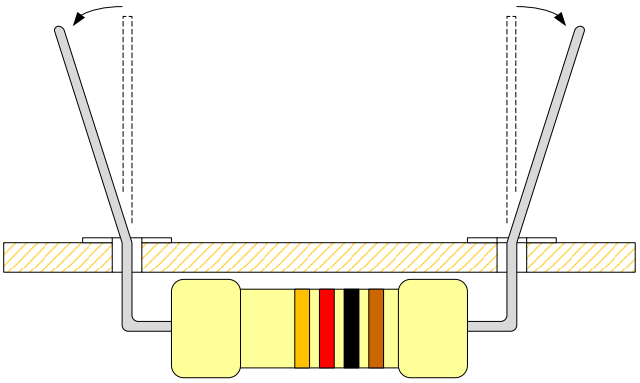
   A. Although it's not absolutely required, the project will look nicer and parts are easier to read if resistor color codes are oriented the same direction for horizontal and vertical orientations as indicated in the illustration below. It's your choice which direction to use as long as you are consistent.



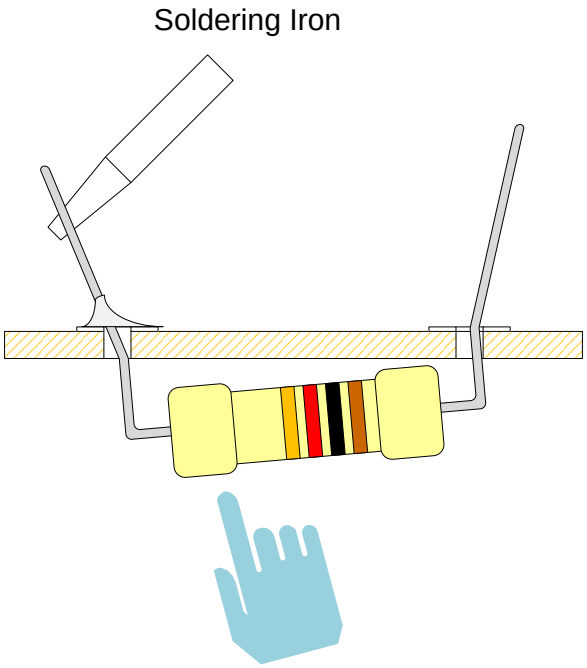
   B. Bend fixed resistor leads approximately 2mm from the resistor body at a 90 degree angle. You want the fixed resistor lead spacing to be just slightly longer than the PCB hole spacing so the resistor stays in place when fully seated against the board. This will make leads easier to solder.



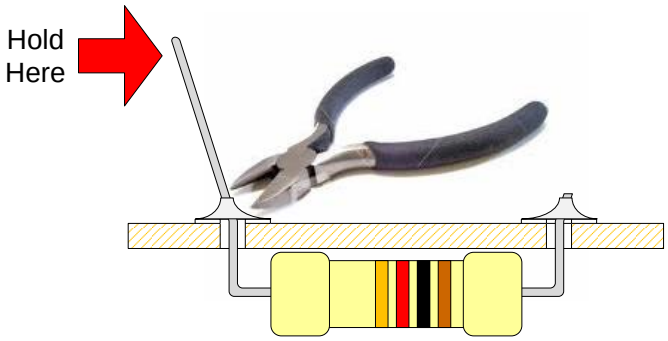
C. If the resistor is loose and tends to fall out when you turn the board over to solder, bend the leads out a 30 degree angle so that the resistor is trapped against the PCB.



D. Solder one resistor lead to the PCB first, then check that the resistor is fully seated against the board. If the resistor is fully seated, solder the other lead. If it isn't, push lightly against the resistor body while applying the soldering iron to the soldered resistor lead so that the solder melts and the resistors seats against the board. Then solder the remaining lead. <u>Be careful not to burn your finger as the resistor will get hot while soldering.</u>

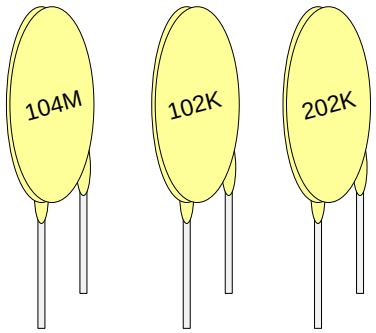


E. Clip the resistor leads flush with wire cutters using one hand while holding the lead being cut with the other hand. This will prevent sharp wire bits from flying around the room and becoming an eye hazard.

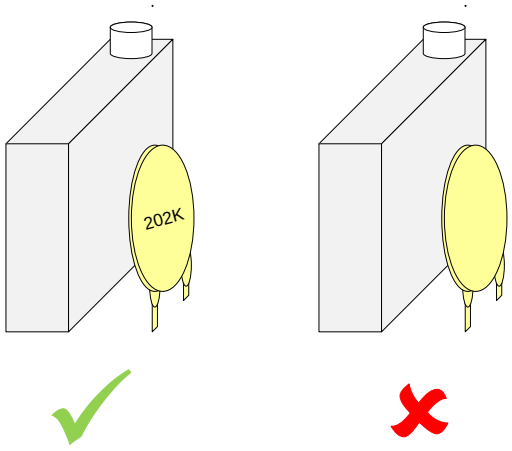


4. Soldering Disc Capacitors

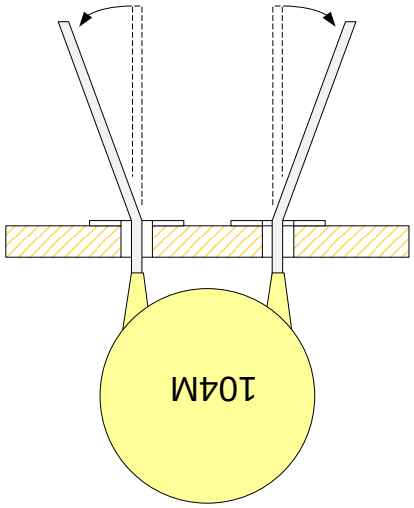
A. Although it's not absolutely required, the project will look nicer and parts are easier to read if disc capacitor values face the same direction for horizontal and vertical orientations as indicated in the illustration below. Disc capacitors do not have a polarity so it's your choice which direction you install them.



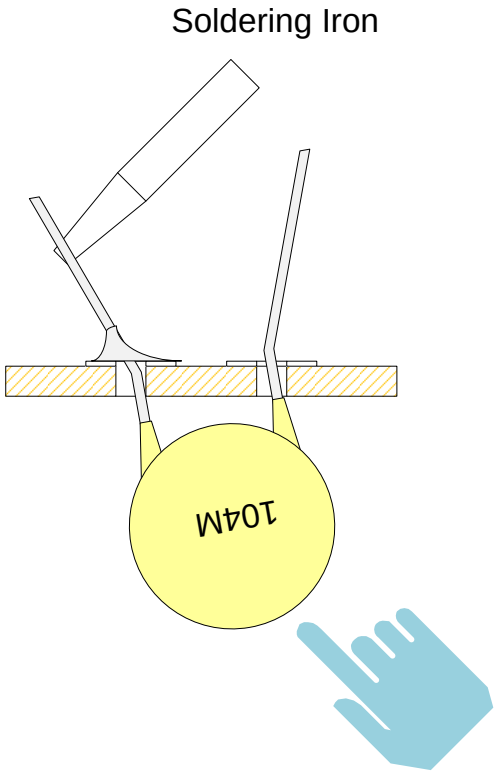
B. The exception to the suggestion above is when a disc capacitor is close to a variable resistor, transistor, or other component that obscures one side of the capacitor. Try to orient the capacitor value so that the capacitor value can be seen.



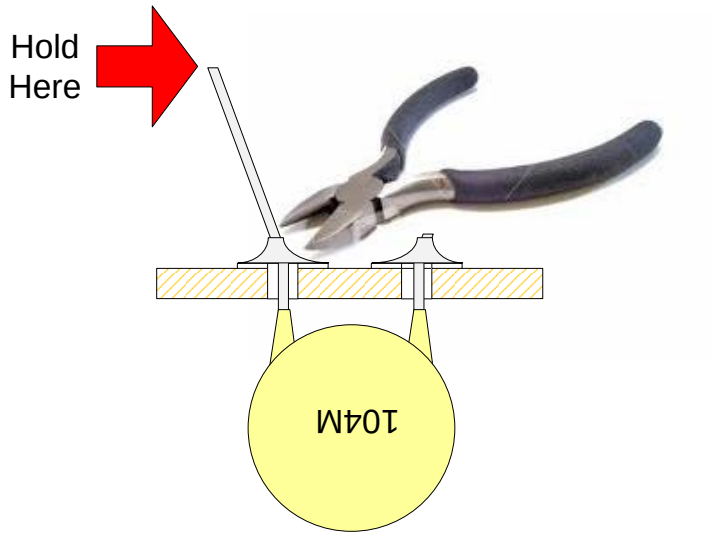
C. Insert the disc capacitor into the circuit board and bend the leads out a 30 degree angle so that the capacitor is trapped against the PCB. Leave the coated portion of the leads above the circuit board.



D. Solder one capacitor lead to the PCB first, then check that the capacitor is properly seated on the board. If the capacitor is properly seated, solder the other lead. If it isn't, push lightly against the capacitor body while applying the soldering iron to the soldered capacitor lead so that the solder melts and the capacitor seats properly on the board. Then solder the remaining lead. <u>Be careful not to burn your finger as the capacitor will get hot while soldering.</u>

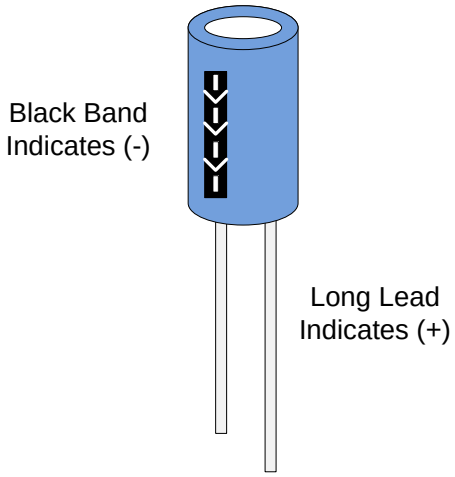


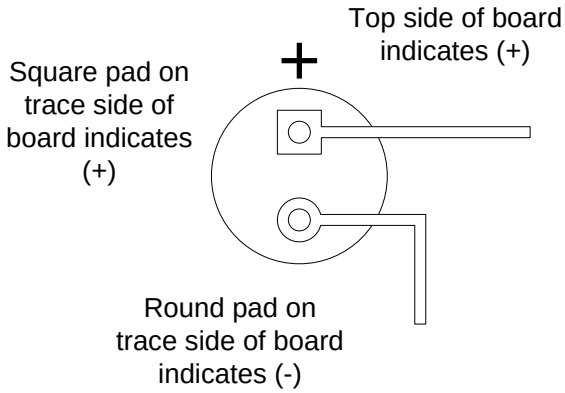
E. Clip the capacitor leads flush with wire cutters using one hand while holding the lead being cut with the other hand. This will prevent sharp wire bits from flying around the room and becoming an eye hazard.



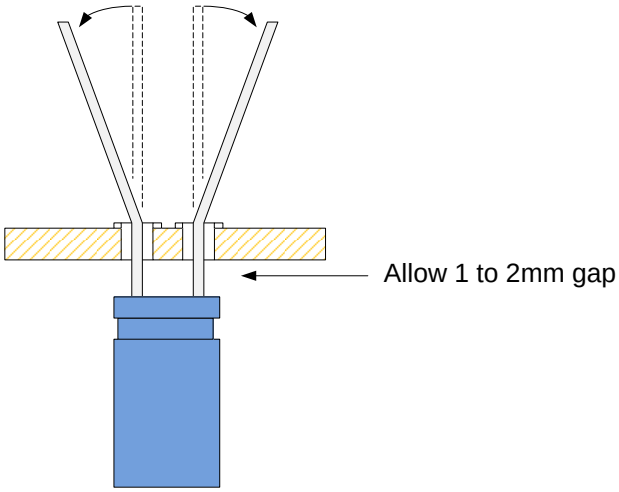
5. Soldering Electrolytic Capacitors

A. Electrolytic capacitors have a polarity that must be observed or the device can self-destruct when power is applied. New capacitors are shipped with one lead longer than the other. The long lead indicates the positive (+) terminal of the capacitor. The capacitor will also have black band on its body that indicates the negative (-) lead. The PCB will denote which lead goes into which hole. The component side of the board will denote the part reference number and a (+) polarity marking near the hole where the (+) lead on the capacitor will go. The trace side of the board uses a square pad to indicate the (+) lead of the capacitor and a round pad to indicate the (-) lead of the capacitor. Check and double-check capacitor polarity before soldering.

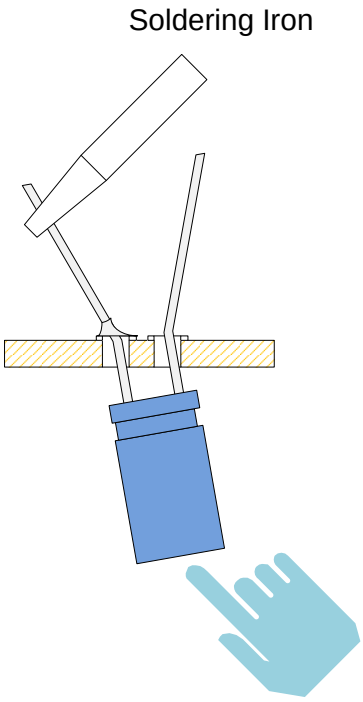




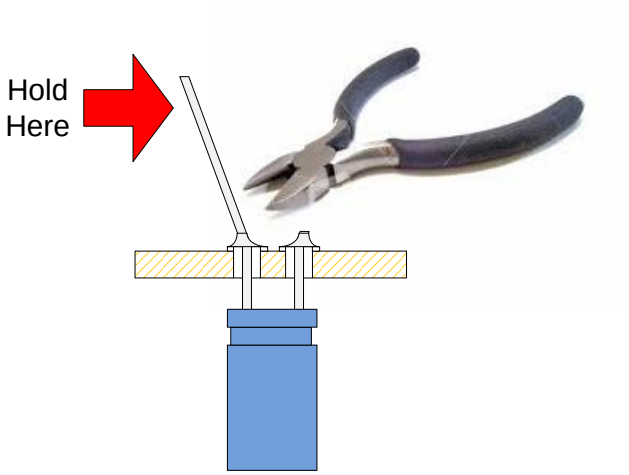
B. Insert the electrolytic capacitor into the circuit board and bend the leads out a 30 degree angle so that the capacitor is trapped against the PCB. Leave 1 to 2mm of lead length above the circuit board. This reduces the possibility of stress related seal failure at the component leads that could result in electrolyte leakage and capacitor failure later on.



C. Solder one capacitor lead to the PCB first, then check that the capacitor is properly seated on the board. If the capacitor is properly seated, solder the other lead. If it isn't, push lightly against the capacitor body while applying the soldering iron to the soldered capacitor lead so that the solder melts and the capacitor seats properly on board. Then solder the remaining lead.

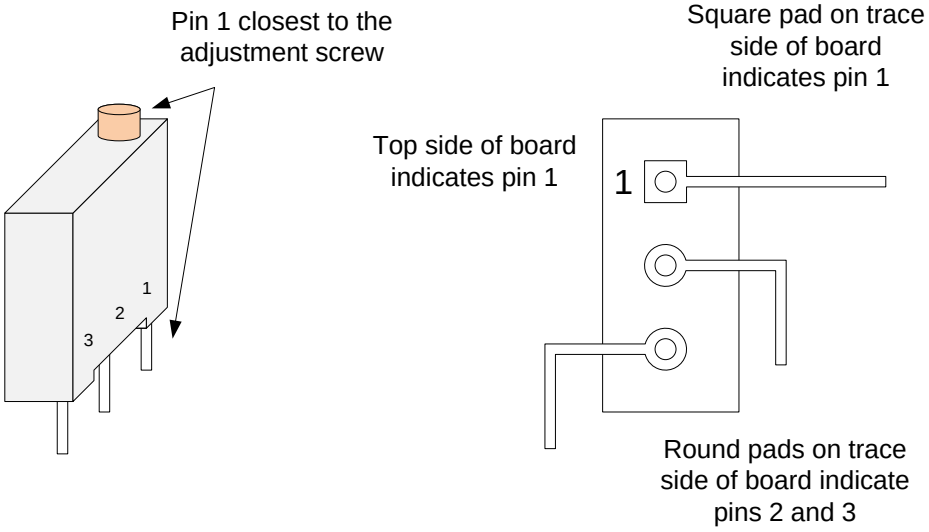


D. Clip the capacitor leads flush with wire cutters using one hand while holding the lead being cut with the other hand. This will prevent sharp wire bits from flying around the room and becoming an eye hazard.

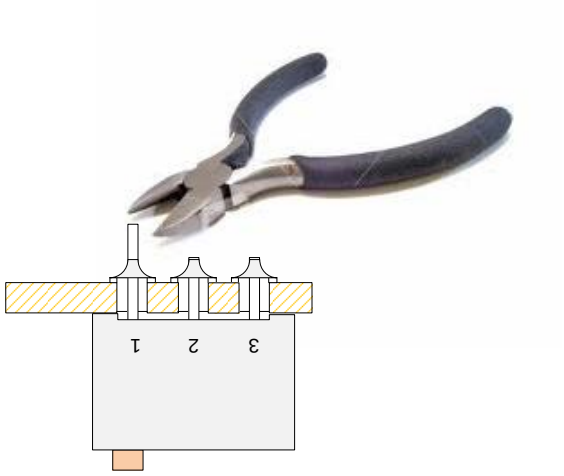


6. Soldering 20-Turn Trimmer Potentiometers

A. Potentiometers are 3-terminal devices composed of a resistive element and a wiper element. On most potentiometers, terminals 1 and 3 are used for the fixed resistor element and terminal 2 is used for the wiper element. In order for the circuit to work properly, potentiometers must be installed onto the PCB correctly. Pin 1 on the potentiometer can be found nearest the adjustment screw and is labeled on the body of the potentiometer. A square pad on the PCB denotes where potentiometer pin 1 is to be inserted.

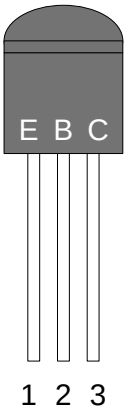


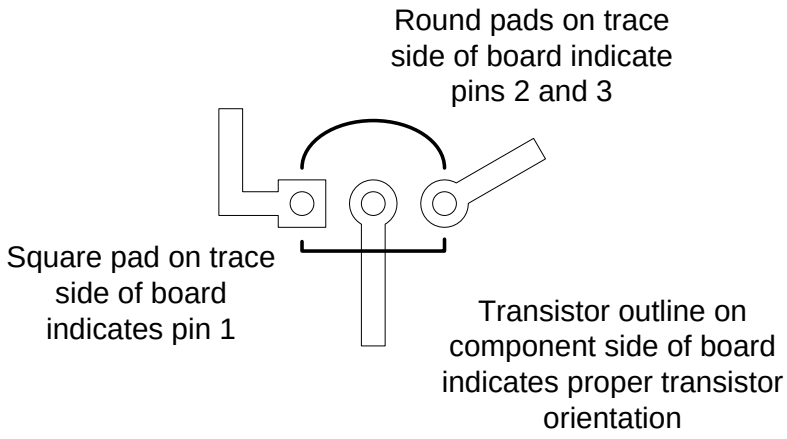
B. The 20-Turn potentiometers will fit flush with the PCB and are soldered in using the same process for a resistor or capacitor. Trim the leads flush with the solder joint.



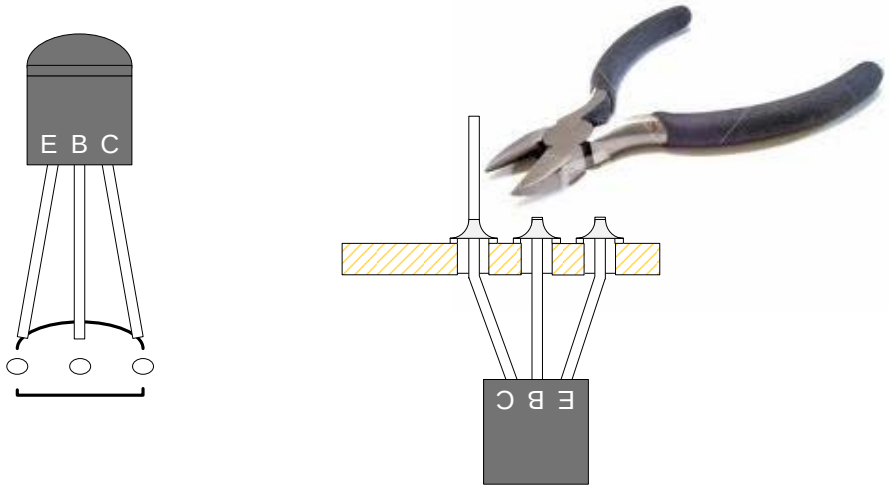
7. Soldering Transistors

A. Transistors are 3-Terminal devices that must be installed correctly on the PCB or they can self-destruct when power is applied. The 2N2222 transistors used in this project are plastic TO-92 case style with the following standard pin-out:



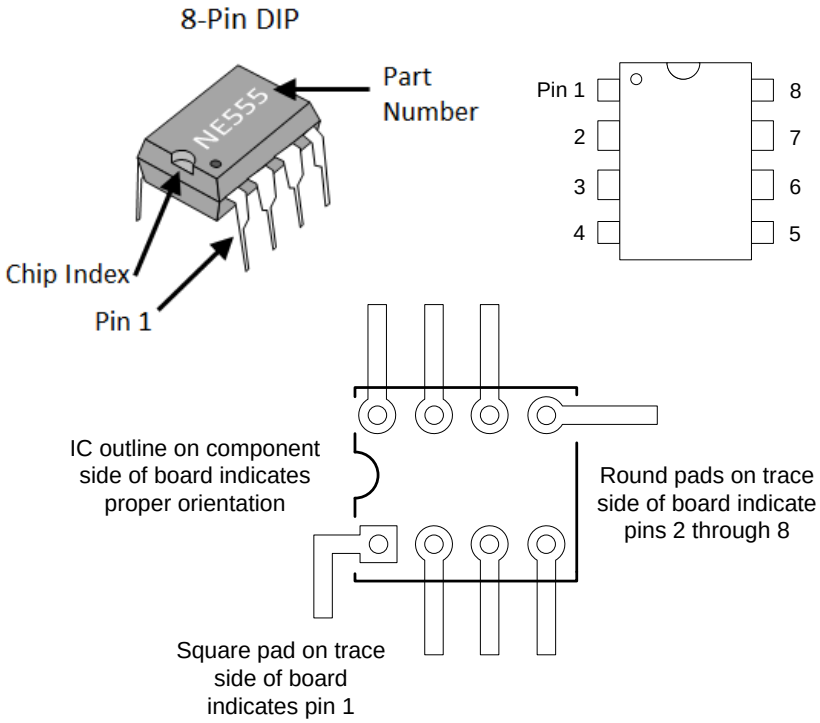


B. Orient the transistor according to the silkscreen diagram on the component side of the board. Allow about 6mm space between the PCB and the bottom of the transistor. The transistor PCB pads are spaced wider than they are at the transistor case to make soldering easier. Simply spreads leads 1 and 3 apart and insert into the holes in the PCB. Transistors are soldered in using the same process for a resistor or capacitor. Trim the leads flush with the solder joint.

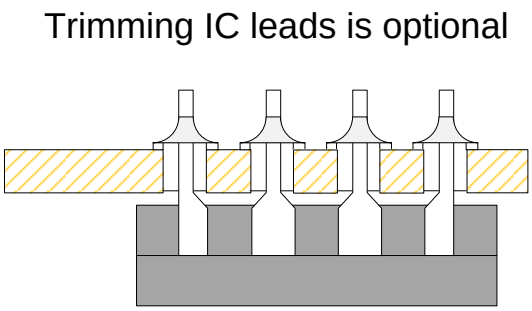


8. Soldering Integrated Circuits

A. Integrated circuits take many different forms, but the most common through-hole IC packages are the 8-pin DIP, 14-pin DIP, and the 16-pin DIP. Integrated circuits have an index mark that indicates where Pin-1 of the IC can be located. They must be installed correctly on the PCB or they can self-destruct when power is applied.

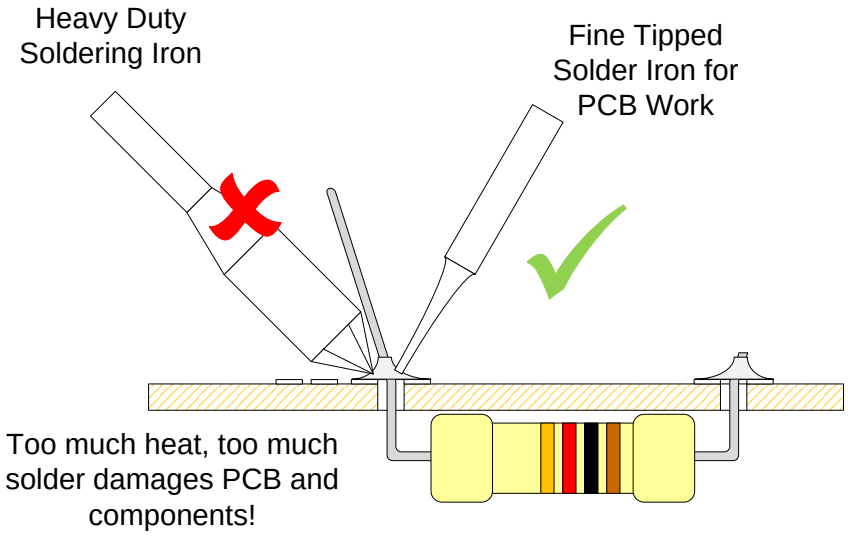


B. Orient the IC according to the silkscreen diagram on the component side of the board. Align the IC pins with their hole in the PCB and carefully press the IC all the way down. Check carefully while inserting the IC that a pin doesn't get folded up under the IC body. Verify that all pins are sticking up through the trace side of the PCB. Bend Pin 1 and Pin 5 outward slightly to make sure the IC remains in place while soldering, then solder all remaining pins in sequence. It is usually not necessary to trim the IC leads.



9. General Soldering Tips

A. A fine-tipped soldering iron and .8mm diameter rosin core solder are recommended.

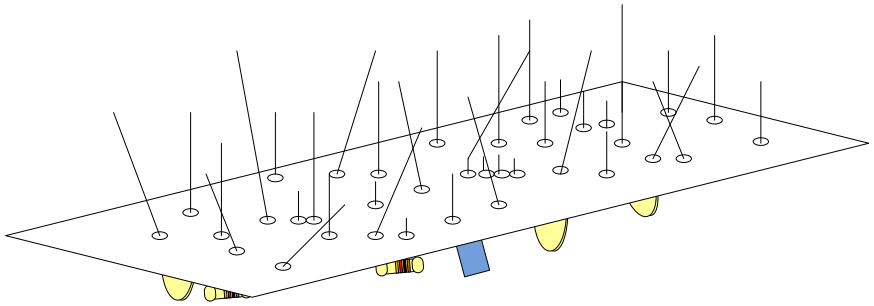


B. A brightly lit workspace with plenty of room for the PCB, soldering station, parts, and schematic (printed or on a laptop) is strongly recommended.

C. A 3X or 5X optical lens is recommended to closely inspect parts and connections after the PCB is completed.

D. Regularly clean the soldering iron tip with a wire sponge (recommended), wet synthetic sponge, or wet paper towel. Try to keep the soldering iron tip bright and clean with no solder blobs or flux dross adhering to it while soldering components on the PCB.

E. Insert no more than 3 or 4 parts on the board at one time. It is very difficult and frustrating to maneuver the soldering iron for the best position while keeping all the parts from falling out.

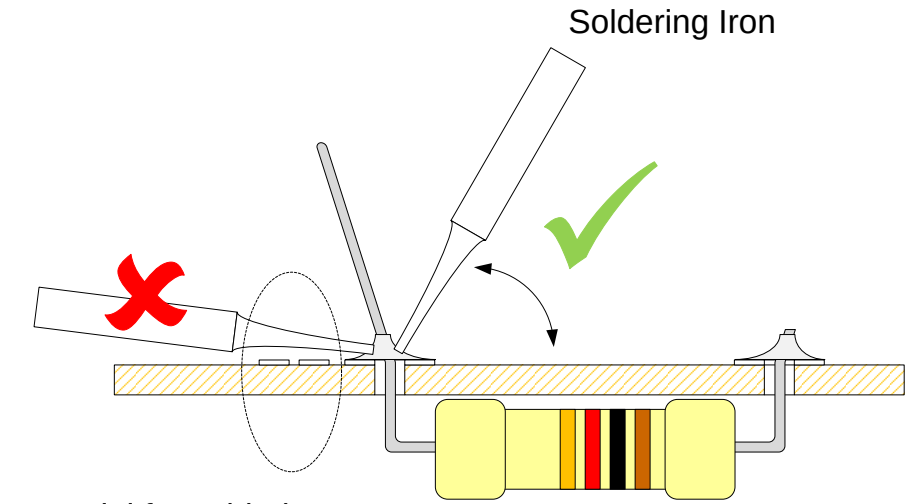


Does not look like a fun job.

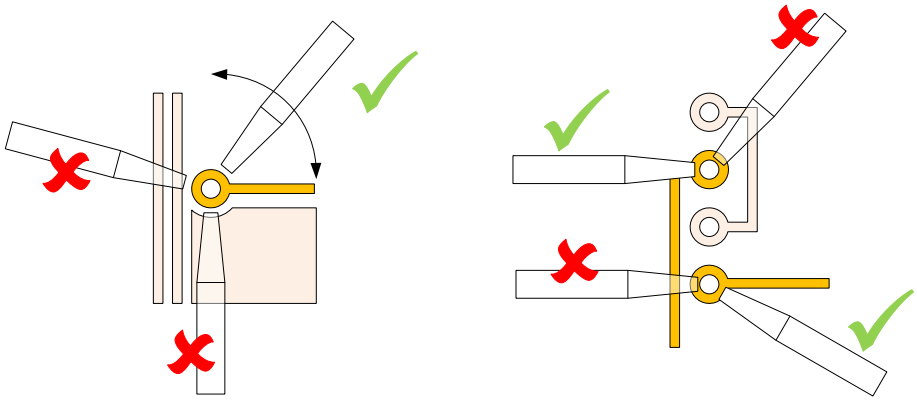
F. Solder the parts that lay closest to the board first (resistors) and then move up to IC's, then capacitors, then transistors and transducers, and finally potentiometers. This allows the board to rest mostly flat while soldering making the job much easier.

G. For each part type (resistors, capacitors, etc.) start with the lowest part numbers first and work your way up. This helps avoid missing a part and having to go back and solder it in later. It also helps avoid soldering a part in the wrong position.

H. Keep the soldering tip at a high angle to the PCB when soldering parts on the board. This helps avoid unwanted solder bridges to nearby pads or traces.



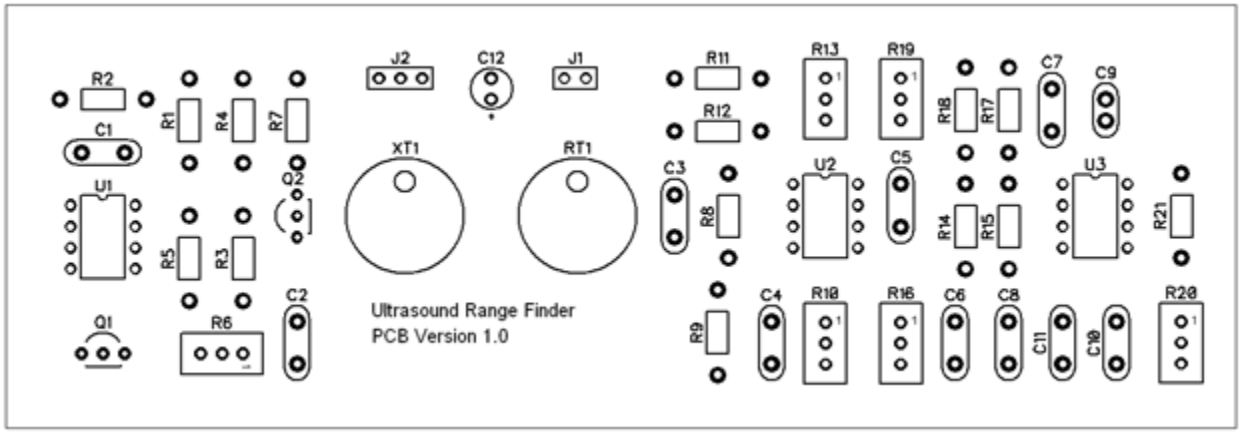
I. Before applying the soldering iron, look for a location to place the tip that is farthest way from other pads and traces if possible. This helps avoid unwanted solder bridge to nearby pads or traces.



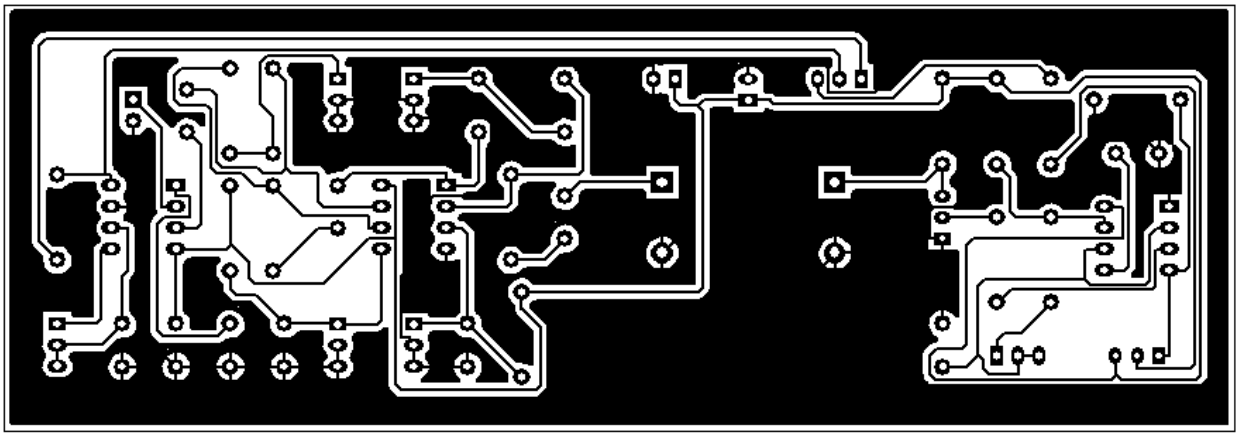
J. Take a break every 30 minutes. Soldering is hard work. Your hand will be steadier and your eyes more focused if you rest for 5 minutes between assembly steps.
K. Don't try doing PCB work on an empty stomach or without any sleep. Get something to eat and drink, then do the work. Get a good night's sleep and then do the work. Your hand will be steadier, your eyes more focused, and your mind more relaxed and less prone to frustration or panic.
L. Work slowly and carefully. Check and double-check before applying the iron.

Get Ready To Assemble

Become familiar with the PCB. It has a component side with a silkscreen layer that indicates part numbers and holes. The silkscreen is an assembly guide that helps get the right part installed in the right position with the correct orientation.

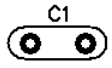


The PCB also has a solder side with pads and traces for connecting the components together.

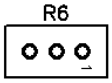


A few standards have been used to make identifying parts easier on the component side:

Fixed Resistors



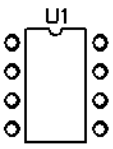
Disc Capacitors



Potentiometers

Electrolytic Capacitors (with polarity marking)

Transistors



Integrated Circuits (with index markings)

Group components by type and value so that it will be easy to identify them during each assembly step. Straighten all resistor, capacitor, transistor, and potentiometer leads. Kinks and twists in component leads may make it difficult to insert parts onto the PCB.

Tools Needed

1. 25W Soldering Iron with fine tip.

2. .8mm Rosin Core Solder

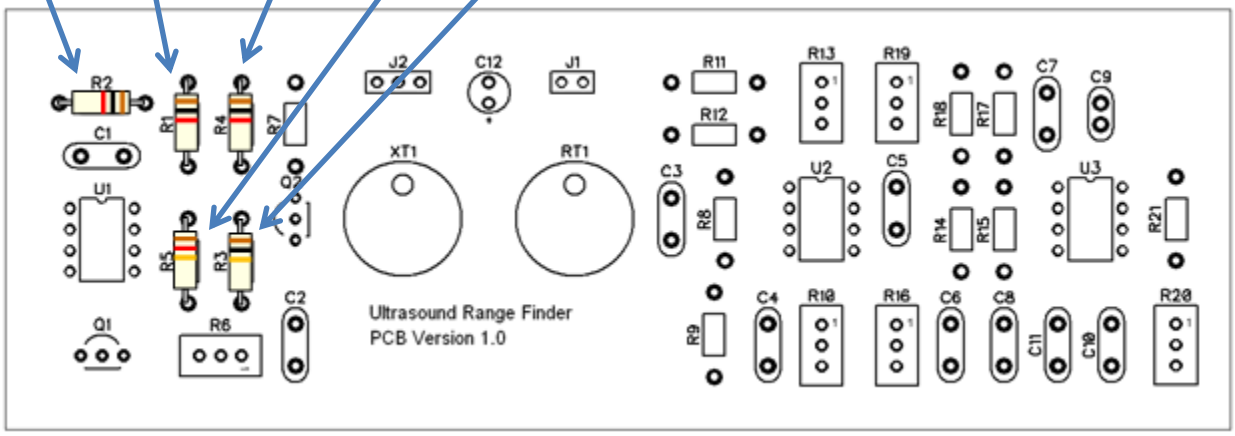
3. Small Long Nose Pliers

4. Small Wire Cutters

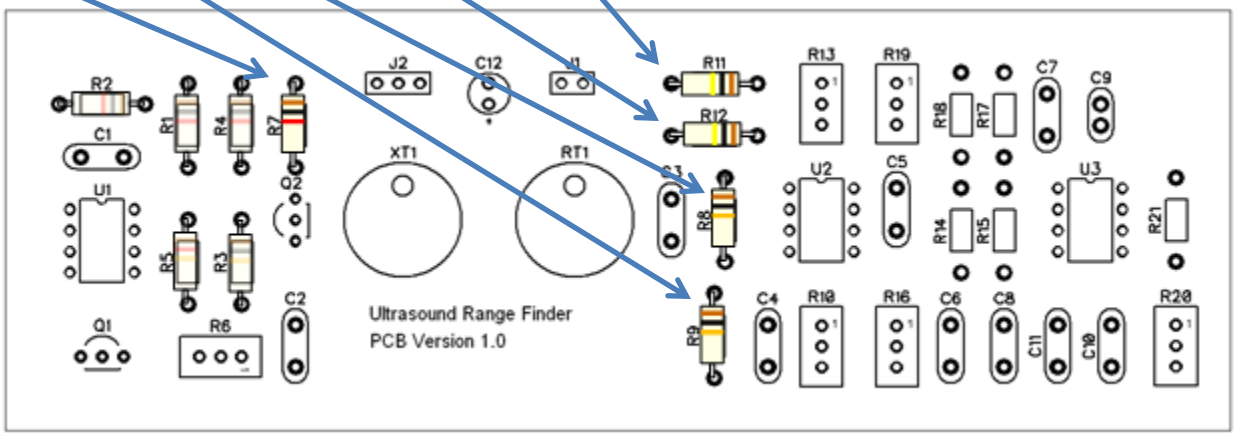
Assembly Step 1

Solder all resistors on the PCB starting with R1 and ending with R21 in the following order:

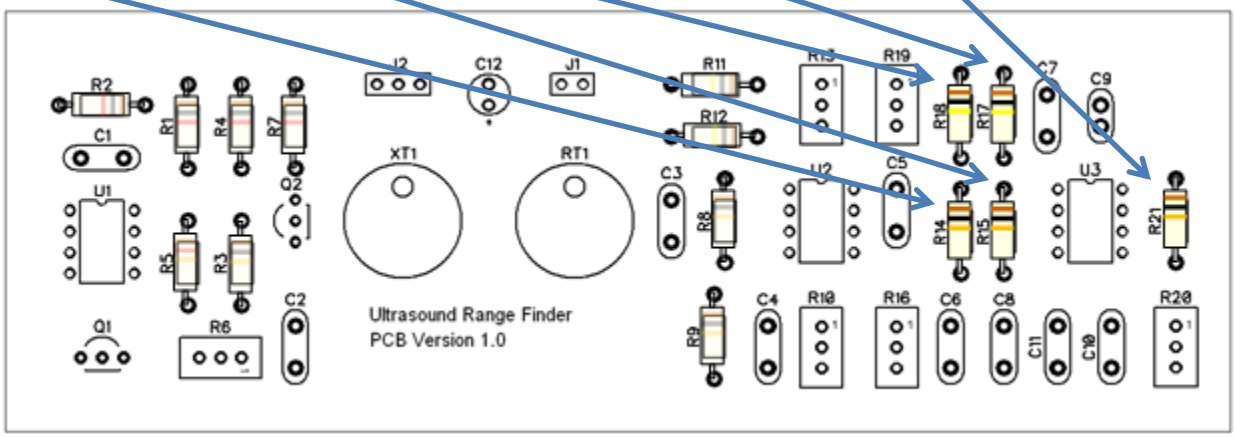
R2 (1K) R1 (1K) R4 (1K) R5 (12K) R3 (10K)



R7 (1K) R9 (10K) R8 (10K) R12 (100K) R11 (100K)



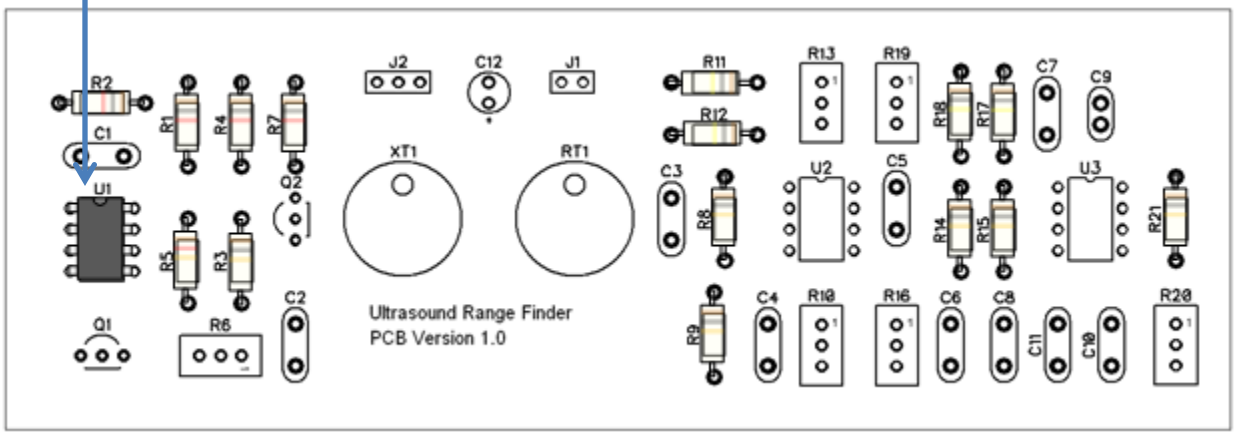
R14 (10K) R15 (10K) R18 (100K) R17 (100K) R21 (10K)



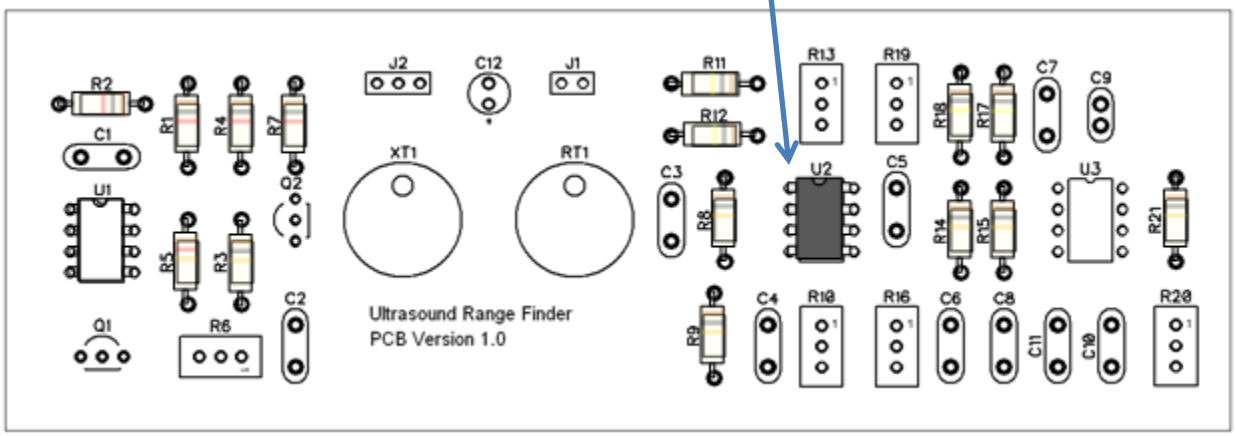
Assembly Step 2

Solder all integrated circuits on the PCB starting with U1 and ending with U3 in the following order:

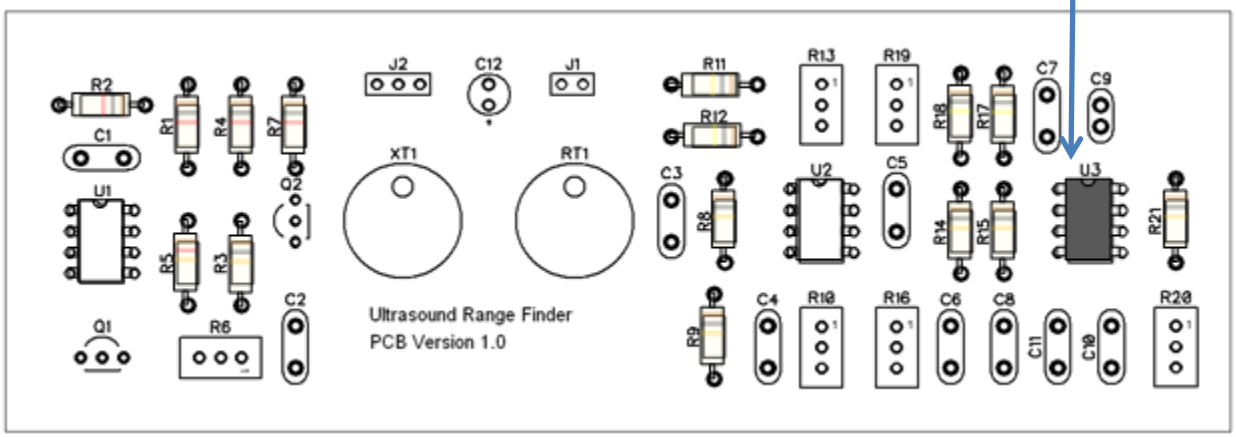
U1 (NE555)



U2 (LM6132)



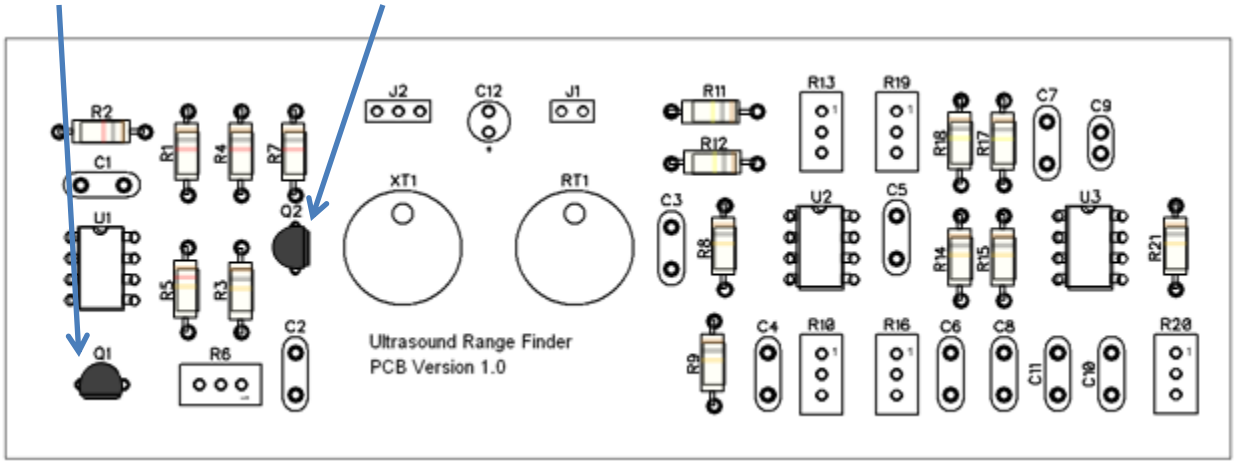
U3 (LM567)



Assembly Step 3

Solder all transistors on the PCB starting with Q1 and ending with Q2 in the following order:

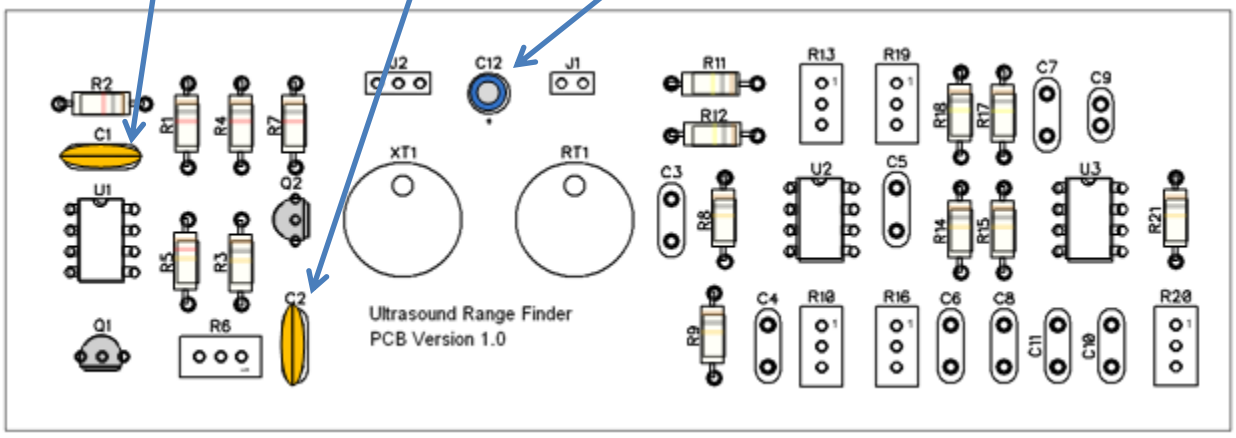
Q1 (2N2222) Q2 (2N2222)



Assembly Step 4

Solder all capacitors on the PCB starting with C1 and ending with C12 in the following order:

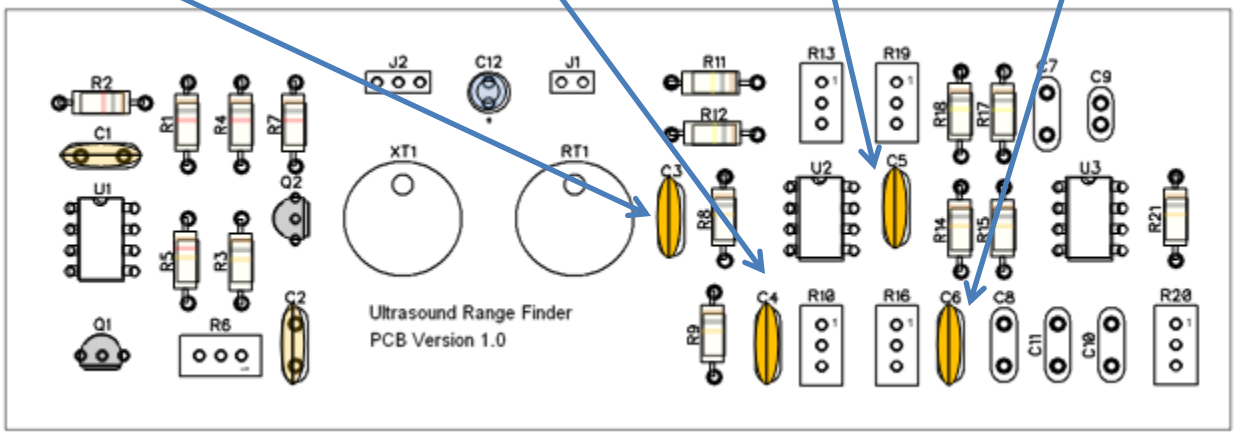
C1 (.1uF – 104K or 104M) C2 (.001uF – 102K) C12 (10uF)



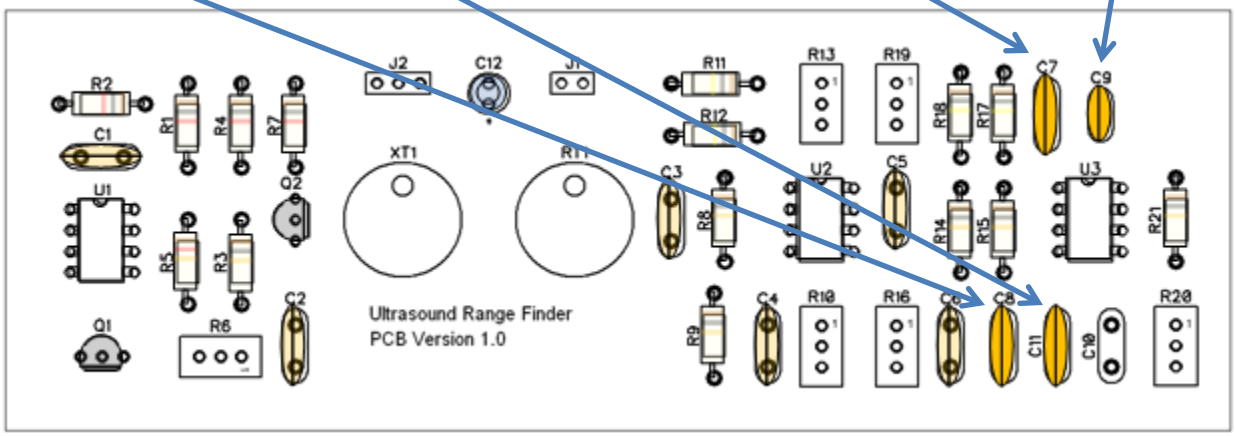
Assembly Step 4 (Continued)

Solder all capacitors on the PCB starting with C1 and ending with C12 in the following order:

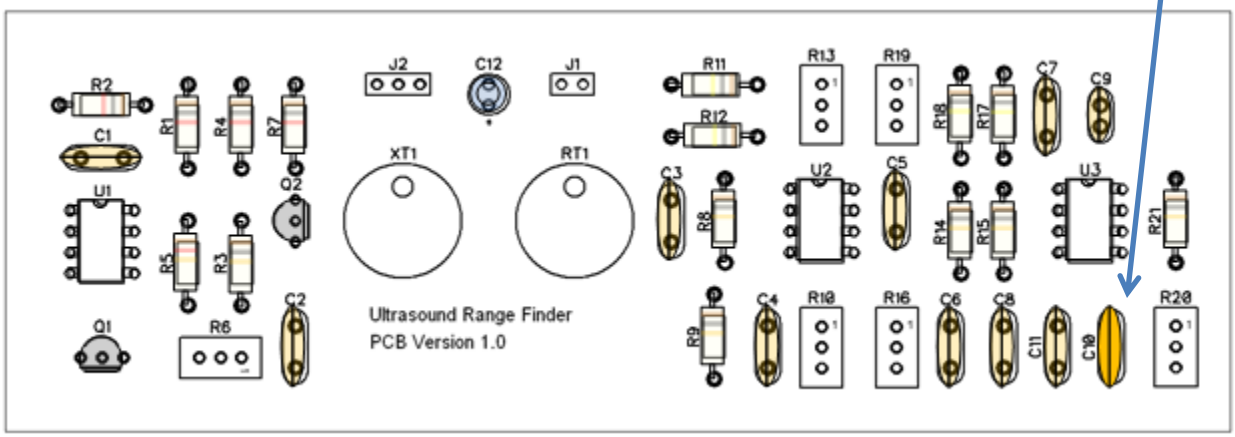
C3 (.1uF – 104K/104M) C4 (.1uF – 104K/104M) C5 (.1uF – 104K/104M) C6 (.1uF – 104K/104M)



C8 (.01uF – 103K) C11 (.1uF – 104K/104M) C7 (.1uF – 104K/104M) C9 (.001uF – 102K)



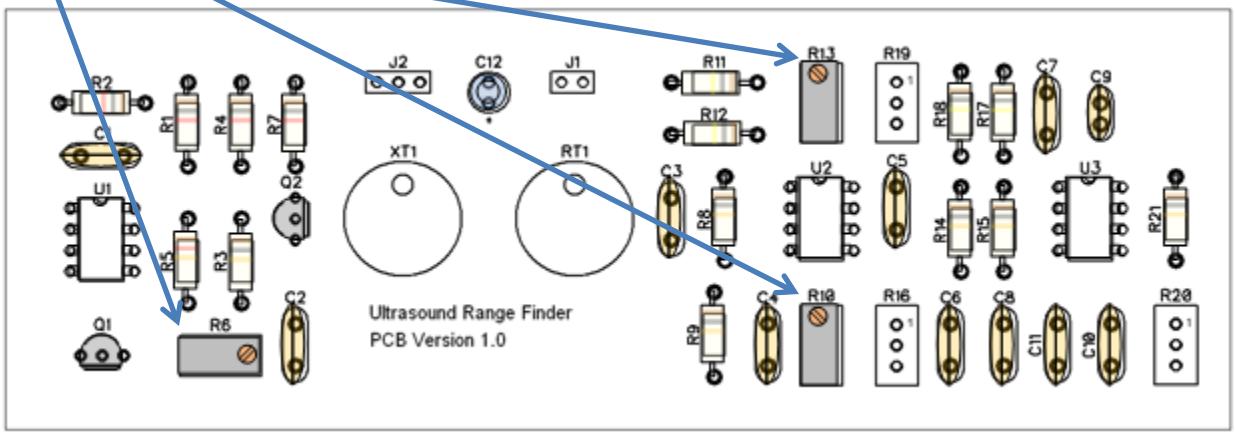
C10 (.02uF – 203K/203M)



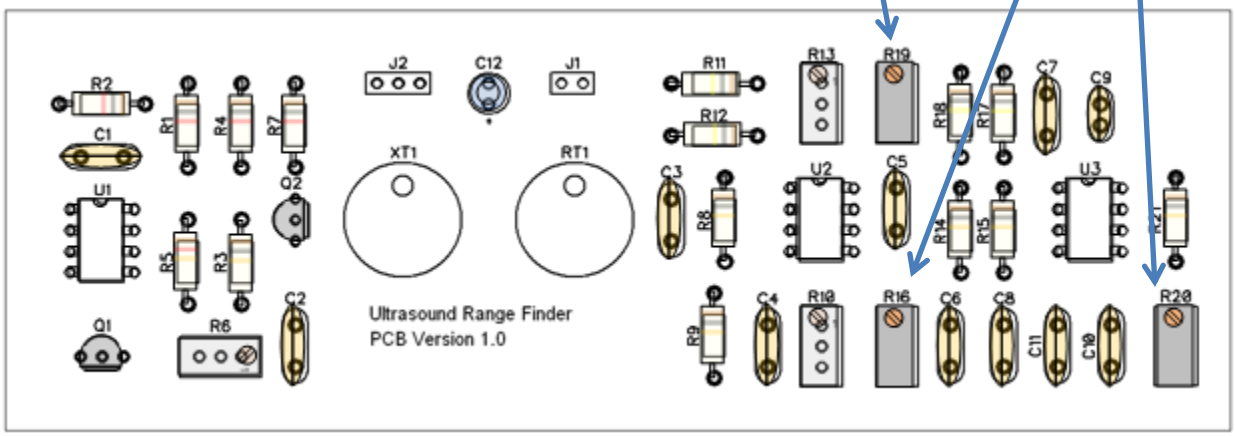
Assembly Step 5

Solder all potentiometers on the PCB starting with R6 and ending with R20 in the following order:

R6 (10K) R10 (20K) R13 (100K)

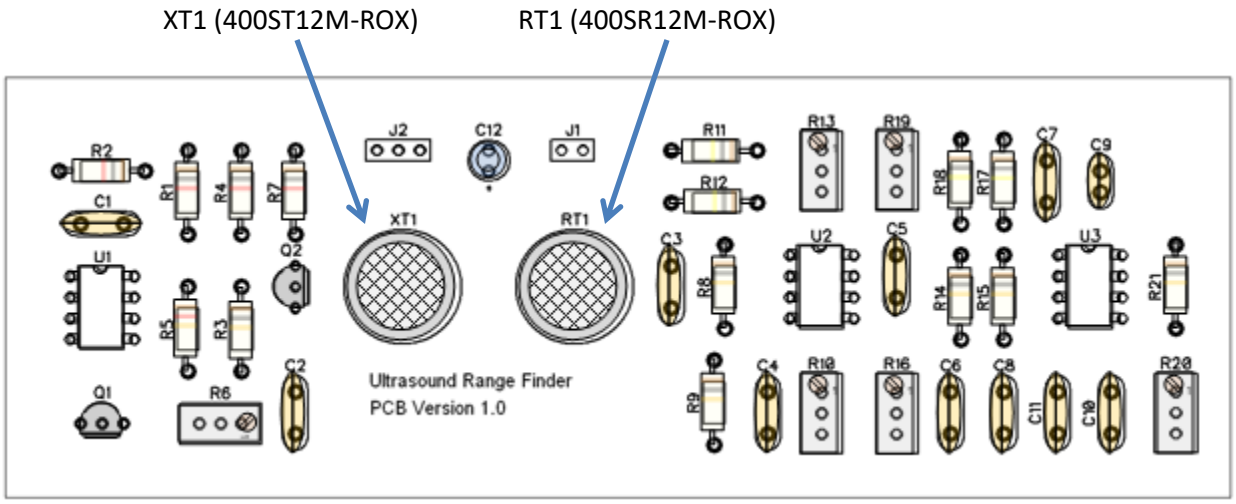


R19 (100K) R16 (20K) R20 (100K)



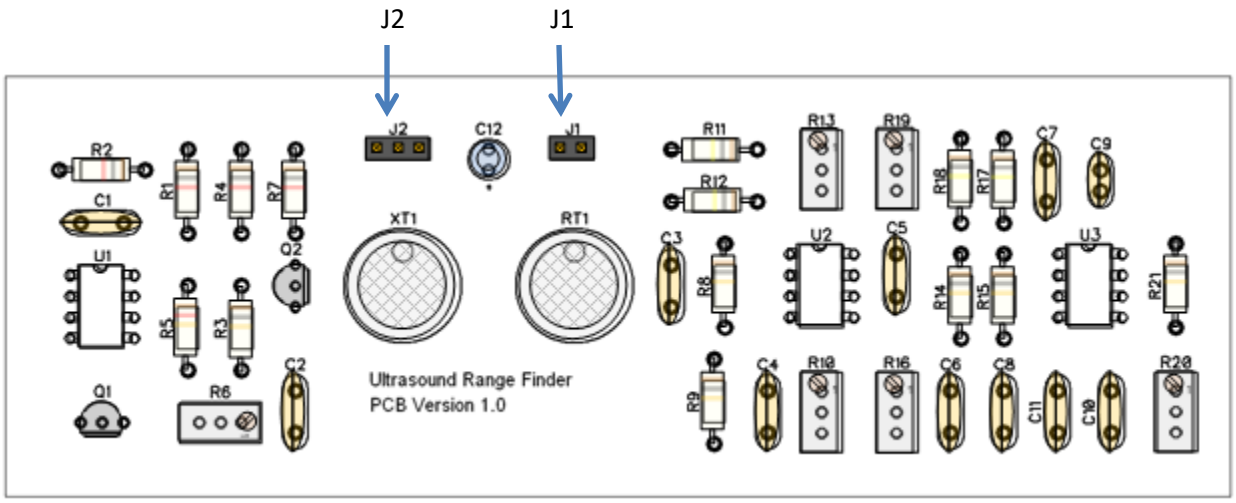
Assembly Step 6

Solder the ultrasound transmitter and receiver on the PCB:

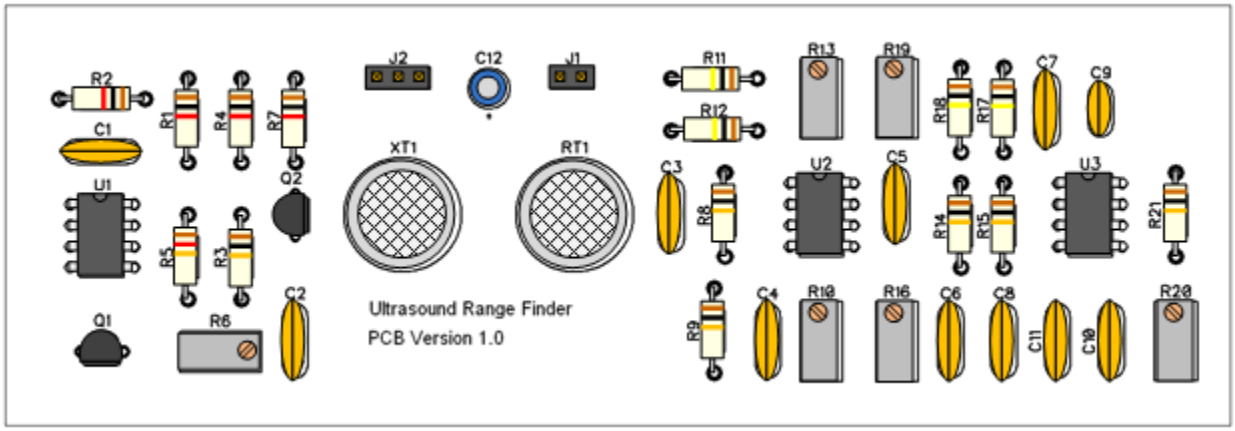


Assembly Step 7

Solder the connectors to the PCB:



Completed Range Finder Circuit Board



Congratulations on successfully completing the assembly of the Ultrasound Range Finder board! The receiver circuit was designed to allow the builder to adjust the gain and output offsets for different receiver configurations. Before the Range Finder can be used, the transmitter and receiver circuits need to be tested and tuned for the correct frequency, gain, and offset parameters. Follow the procedure steps below to get the Ultrasound Range Finder ready for operation.

Pre-Test Procedure

Step 1 Review the assembly steps once more and observe each resistor color code, capacitor code, and IC part number to verify that all parts are in their correct positions on the board. If any parts were accidentally soldered in the wrong place, carefully unsolder the parts from the PCB and re-solder them in their correct position.

Step 2 Observe the transistor and IC's on the board to verify that each is soldered in the proper orientation as indicated on the PCB silkscreen and the assembly documentation.

Step 3 Verify that electrolytic capacitor C12 is soldered in the correct orientation (negative lead is closest to the board edge). If the orientation is not correct, carefully unsolder C12 and re-solder it to the PCB in the correct orientation.

Step 3 Inspect the trace side of the PCB to confirm that all leads have been properly soldered to their circuit pad. Look carefully at each solder joint to verify that they are smooth and shiny, and that they completely cover the lead and the PCB pad.

Step 4 Look around the PCB and in the area of each pad and make sure there are no solder bridges between traces and pads.

Test and Alignment Procedure

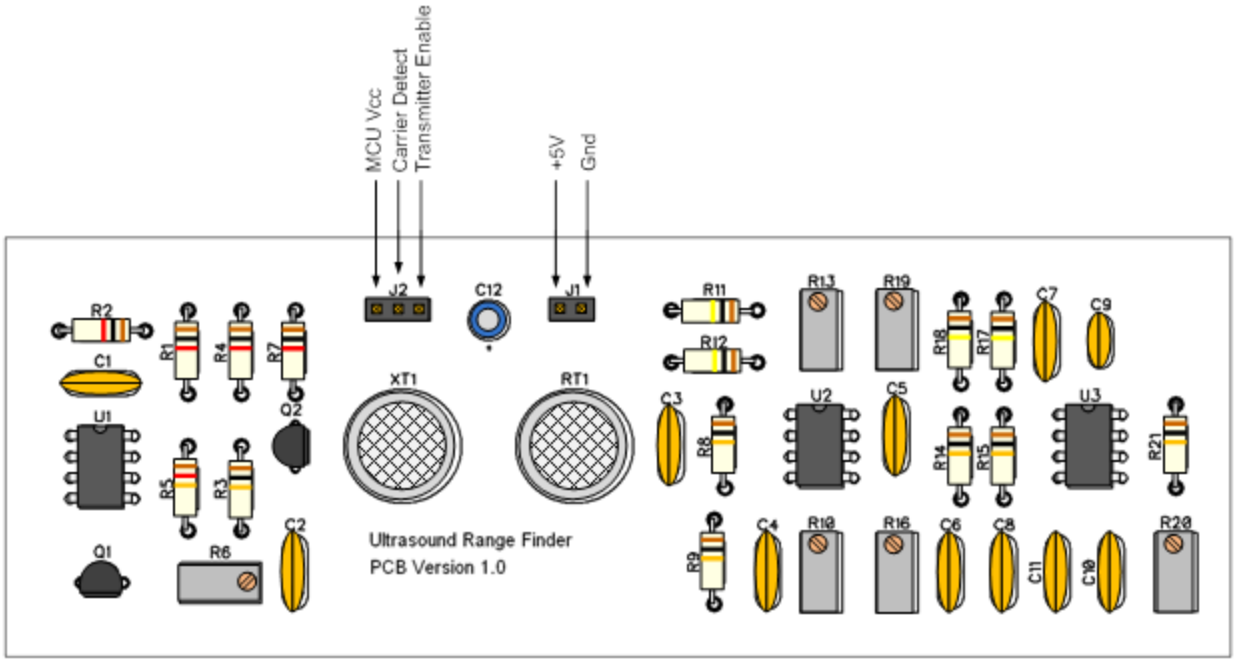
After the circuit board assembly steps are completed, the Ultrasound Transmitter and Receiver circuits need to be adjusted so that each circuit operates correctly. In order to complete this step, the following equipment is required:

Oscilloscope or Frequency Counter

Digital VOM

DC Variable Power supply

The DC variable power supply can be substituted with the 5V power output pin of the microprocessor system (Arduino, Raspberry Pi, etc.) to be used with the Ultrasonic Range Finder. An old 5V power adaptor can also be used as long as the positive and negative leads are identified before connecting it to the Range Finder board.



Step 1 Using a digital VOM set to Ohms, measure the resistance between the **+5V** and **GND** pins at connector J1. The VOM should display between 3K Ohms and 20K Ohms. If so, proceed to Step 2. If the VOM reads near 0 Ohms, there is a short circuit somewhere on the PCB. If the VOM reads "OL", there is an open circuit somewhere on the PCB. Refer to the Troubleshooting Section on how to locate and fix the problem before proceeding to Step 2.

Step 2 Using a digital VOM set to Ohms, measure the resistance between the **MCU Vcc** and **Carrier Detect (CD)** pins at connector J2. The VOM should display between 9.5K Ohms and 10.5K Ohms. If so, proceed to Step 3. Otherwise refer to the Troubleshooting Section on how to locate and fix the problem before proceeding to Step 3.

Step 3 Using a digital VOM set to Ohms, measure the resistance between the **GND** pin of connector J1 and each pin of J2 in sequence. The VOM should display "OL" or very high resistance (>1M Ohms) between the **GND** pin of J1 and each pin of J2. If so, proceed to Step 4. Otherwise refer to the Troubleshooting Section on how to locate and fix the problem before proceeding to Step 4.

Step 4 Using a digital VOM set to Ohms, measure the resistance between the **+5V** pin of connector J1 and each pin of J2 one at a time. The VOM should display "OL" or very high resistance (>1M Ohms) between the **+5V** pin of J1 and each pin of J2. If so, proceed to Step 5. Otherwise refer to the Troubleshooting Section on how to locate and fix the problem before proceeding to Step 5.

Step 5 Rotate the adjustment screws on variable resistors R6, R10, R13, R16, R19, and R20 counter clockwise 20 turns or until you hear a clicking sound indicating the variable resistor has reached its end of travel.

Step 6 Rotate the adjustment screws on variable resistors R6, R10, R16, and R20 clockwise 10 turns.

Step 6 Rotate the adjustment screws on variable resistors R13 and R19 clockwise 5 turns.

Step 7 Attach a 5V power supply to the **+5V** and **GND** pins of connector J1 and switch on the power supply.

Step 8 Using a digital VOM set to DC, measure the voltage between the **GND** pin of connector J1 and pin 1 of IC U2. Adjust R10 until the voltage at U2 pin 1 is approximately 2.5V. If the voltage on U2 pin 1 cannot be adjusted to 2.5V, refer to the Troubleshooting Section on how to locate and fix the problem before proceeding to Step 9.

Step 9 Using an Oscilloscope or Frequency Counter, measure the U3 oscillator frequency between the **GND** pin of connector J1 and pin 5 of U3. Adjust R20 until the oscillator frequency is approximately 40.000KHz. If the frequency at pin 5 of U3 is zero or cannot be adjusted to 40Khz, refer to the Troubleshooting Section on how to locate and fix the problem before proceeding to Step 10.

Step 10 Using an Oscilloscope (recommended) or digital VOM set to AC, measure the voltage between the **GND** pin of connector J1 and pin 7 of IC U2. Adjust R16 clockwise or counter clockwise until an AC noise voltage is observed. Slowly adjust R16 until the voltage at U2 pin 7 is approximately 0V. Do not over adjust R16. If necessary, rock the adjustment of R16 back and forth until pin 7 of U2 just reaches 0V. If pin 7 of U2 cannot be adjusted as indicated in this step, refer to the Troubleshooting Section on how to locate and fix the problem before proceeding to Step 11.

Step 11 Attach the **Transmitter Enable (TE)** pin of connector J2 to the positive terminal of the power supply to enable the transmitter circuit.

Step 12 Using an Oscilloscope or Frequency Counter, measure the U1 oscillator frequency between the **GND** pin of connector J1 and pin 3 of U1. Adjust R6 until the oscillator frequency is approximately 40.000KHz. If the frequency at pin 3 of U1 is zero or cannot be adjusted to 40Khz, refer to the Troubleshooting Section on how to locate and fix the problem before proceeding to Step 13.

Step 13 Attach the **MCU Vcc** pin of connector J2 to the positive terminal of the power supply to enable the receiver output circuit.

Step 14 Using a VOM set to DC, measure the voltage between the **GND** pin of connector J1 and the **Carrier Detect (CD)** pin of connector J2. The voltage at the **Carrier Detect (CD)** pin should be less than 0.7V. Otherwise, refer to the Troubleshooting Section on how to locate and fix the problem.

Step 15 Disconnect the **Transmitter Enable (TE)** pin of connector J2 from the positive terminal of the power supply to disable the transmitter circuit.

Step 14 Using a VOM set to DC, measure the voltage between the **GND** pin of connector J1 and the **Carrier Detect (CD)** pin of connector J2. The voltage at the **Carrier Detect (CD)** pin should be approximately equal to the **MCU Vcc** voltage. Otherwise, refer to the Troubleshooting Section on how to locate and fix the problem.

Step 15 Turn off the 5V power supply and disconnect all leads from the Ultrasound Range Finder.

The Ultrasound Range Finder is now aligned and ready for operation.

Troubleshooting

If there are problems with the Ultrasound Range Finder after assembly, don't worry. The Range Finder circuits were designed to be easily understood, tested, and repaired. The troubleshooting steps below will help locate most anything that can go wrong.

Keep in mind that the majority of circuit problems are caused by a component in the wrong place, a weak solder joint, or too much solder in the wrong place. Take a moment to examine both sides of the PCB very carefully to be sure that all components are in their assigned location and oriented the right way. Look for a resistor in the wrong position, a transistor soldered in backwards, a tiny bit of solder touching a nearby trace, or a component lead that solder didn't quite stick to. When assembling a PCB with a lot of components, it's easy to forget to solder a component lead to its pad so look closely at each pad. It is highly unusual for a resistor, capacitor, transistor or IC to fail during assembly as long as proper soldering technique is used (i.e. not too much heat).

If a close visual inspection doesn't identify the problem, the troubleshooting steps below will.

Ultrasound Transmitter Troubleshooting

Step 1 Using a VOM set to Ohms, measure the values of each resistor to confirm they are within +/- 5%.

R1 = Between 950 Ohms and 1050 Ohms
R2 = Between 950 Ohms and 1050 Ohms
R3 = Between 9.5K Ohms and 10.5K Ohms
R4 = Between 950 Ohms and 1050 Ohms
R5 = Between 11.4K Ohms and 12.6K Ohms
R7 = Between 950 Ohms and 1050 Ohms

If any resistor measurement does not fall within the range specified above, replace that resistor and try the Test and Alignment Procedure again.

Step 2 Using a VOM set to the Diode Check function, verify Q1 and Q2.

Q1 Base (VOM Red Lead) to Emitter (VOM Black Lead) = .650 to .670
Q1 Base (VOM Red Lead) to Collector (VOM Black Lead) = .650 to .670
Q1 Collector (VOM Red Lead) to Emitter (VOM Black Lead) = Low Ohms or Open Circuit
Q2 Base (VOM Red Lead) to Emitter (VOM Black Lead) = .650 to .670
Q2 Base (VOM Red Lead) to Collector (VOM Black Lead) = .650 to .670
Q2 Collector (VOM Red Lead) to Emitter (VOM Black Lead) = Low Ohms or Open Circuit

If any transistor junction does not fall within the range specified above or measures as a short circuit, replace that transistor and try the Test and Alignment Procedure again.

Step 3 Attach a 5V power supply to the **V+** and **GND** pins of J1.

Step 4 Using a VOM set to DC, confirm the following voltages:

U1 Pin 8 = 5V
U1 Pin 1 = 0V
Q1 Collector = 5V
Q1 Emitter = 0V
Q2 Collector = 5V
Q2 Emitter = 0V

If any measurement does not fall within the indicated values, verify all solder joints to pins on connector J1, IC U1, R2, R7, and transistors Q1 and Q2. Re-solder each pin and repeat Step 4.

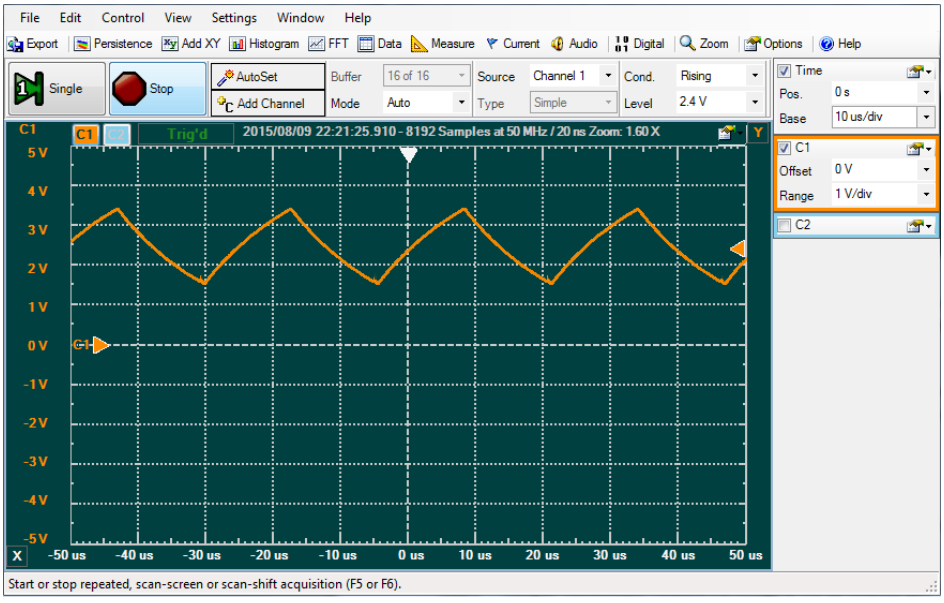
Step 5 Attach a test lead to the **Transmitter Enable (TE)** pin of connector J2.

Step 6 Using a VOM set to DC, measure the voltage across R2 while connecting and then removing the **Transmitter Enable (TE)** test lead to V+ of the 5V power supply.

Voltage on R2 with test lead disconnected = <0.4V
Voltage on R2 with test lead connected to 5V = >4V

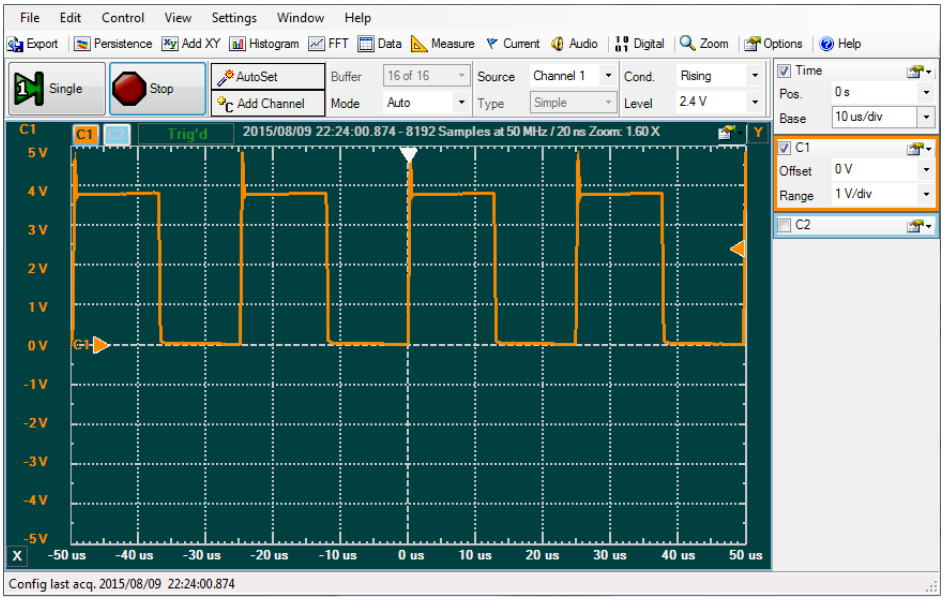
If any measurement does not fall within the indicated values, verify all solder joints to Q1, R1, and R2. Re-solder each pin and repeat Step 6. If re-soldering fails to fix the problem, replace Q1 and repeat Step 6.

Step 7 Using an Oscilloscope, measure the voltage at U1 Pin 6 with the **Transmitter Enable (TE)** test lead connected to V+ of the 5V power supply. The scope probe ground lead should be connected to the **GND** pin of J1 or the 5V power supply GND connection. The scope waveform should look something like the image below:



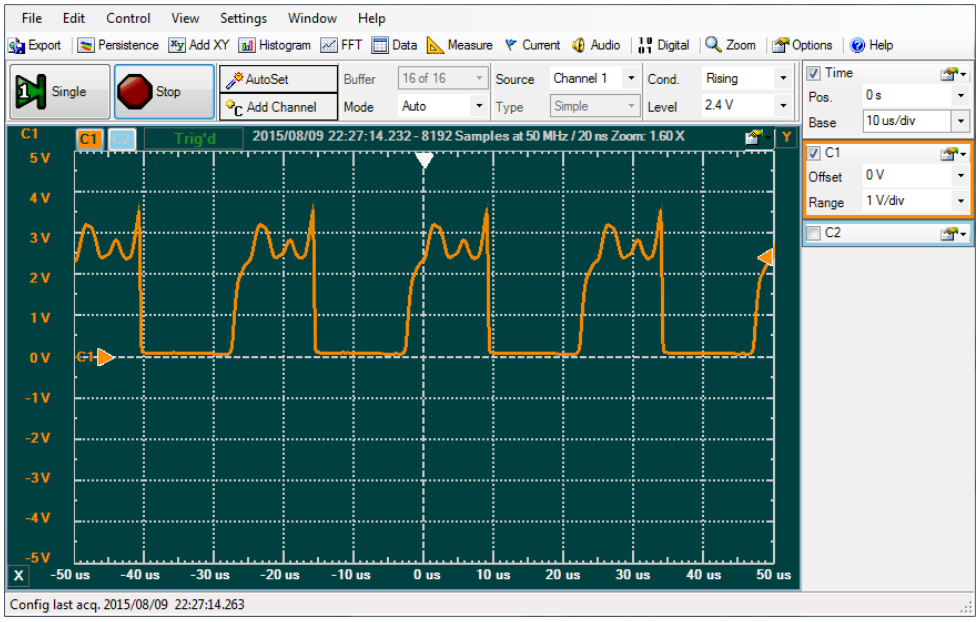
If the Oscilloscope does not display the indicated image, confirm all solder joints to R4, R5, R6, C2, and U1. Re-solder each pin and repeat Step 7. If re-soldering fails to fix the problem, replace U1 and repeat Step 3 through 7.

Step 8 Using an Oscilloscope, measure the voltage at U1 Pin 3. The scope probe ground lead should be connected to the **GND** pin of J1 or the 5V power supply GND connection. The scope waveform should look something like the image below:



If the Oscilloscope does not display the indicated image, replace U1 and repeat Step 3 through 8.

Step 9 Using an Oscilloscope, measure the voltage at the Q2 Collector pin. The scope probe ground lead should be connected to the **GND** pin of J1 or the 5V power supply GND connection. The scope waveform should look something like the image below:



If the Oscilloscope does not display the indicated image, confirm all solder joints to R3, R7, Q2, and U1 Pin 3. Re-solder each pin and repeat Step 8. If re-soldering fails to fix the problem, replace Q2 and repeat Step 8.

Ultrasound Receiver Troubleshooting

Step 1 Using a VOM set to Ohms, measure the values of each resistor to confirm they are within +/- 5%.

R8 = Between 9.5K Ohms and 10.5K Ohms
R9 = Between 9.5K Ohms and 10.5K Ohms
R11 = Between 95K Ohms and 105K Ohms
R12 = Between 95K Ohms and 105K Ohms
R14 = Between 9.5K Ohms and 10.5K Ohms
R15 = Between 9.5K Ohms and 10.5K Ohms
R17 = Between 95K Ohms and 105K Ohms
R18 = Between 95K Ohms and 105K Ohms
R21 = Between 9.5K Ohms and 10.5K Ohms

If any resistor measurement does not fall within the range specified above, replace that resistor and try the Test and Alignment Procedure again.

Step 2 Turn the adjustment screws on variable resistors R10, R13, R16, and R19 counter clockwise 20 turns.

Step 3 Using a VOM set to Ohms, measure the resistance between pin 1 and pin 2 (PCB trace side) of each variable resistor. The value measured should be approximately 0 ohms for each variable resistor.

Step 4 Turn the adjustment screws on variable resistors R10, R13, R16, and R19 clockwise 20 turns.

Step 5 Using a VOM set to Ohms, measure the value of each variable resistor (PCB trace side) to confirm they are within +/- 10%.

R10 = Between 18K Ohms and 22K Ohms
R13 = Between 90K Ohms and 110K Ohms
R16 = Between 18K Ohms and 22K Ohms
R19 = Between 90K Ohms and 110K Ohms

If any variable resistor measurement does not fall within the range specified in Step 3 and Step 5, verify all solder joints at R9, R10, C4, R15, R16, C6, U2 Pin 3, and U2 Pin 5 making sure there are no open or shorted pads. Re-solder each pin and repeat Step 5. If any variable resistor still does not fall within the indicated range, replace that variable resistor and try the Test and Alignment Procedure again.

Step 6 Turn the adjustment screws on variable resistors R10 and R16 counter clockwise 10 turns. Turn the adjustment screws on variable resistors R13 and R19 counter clockwise 15 turns.

Step 7 Attach a 5V power supply to the **V+** and **GND** pins of J1.

Step 8 Using a VOM set to DC, confirm the following voltages:

U2 Pin 8 = 5V
U2 Pin 4 = 0V
U3 Pin 4 = 5V
U2 Pin 7 = 0V

If any measurement does not fall within the indicated values, verify all solder joints to pins on connector J1, IC U2, and IC U3. Re-solder each pin and repeat Step 8.

Step 9 Using a VOM set to DC, measure the voltage between J1 GND and U2 Pin 3 while turning the adjustment screw of R10 clockwise a few turns and counter clockwise a few turns. The measured voltage at U2 Pin 3 should increase as the adjustment screw is turned clockwise and decrease as the adjustment screw is turned counter clockwise. If the voltage does not change, examine the solder joints at R9, R10, C4, and U2 Pin 3. Re-solder each pin and repeat Step 9.

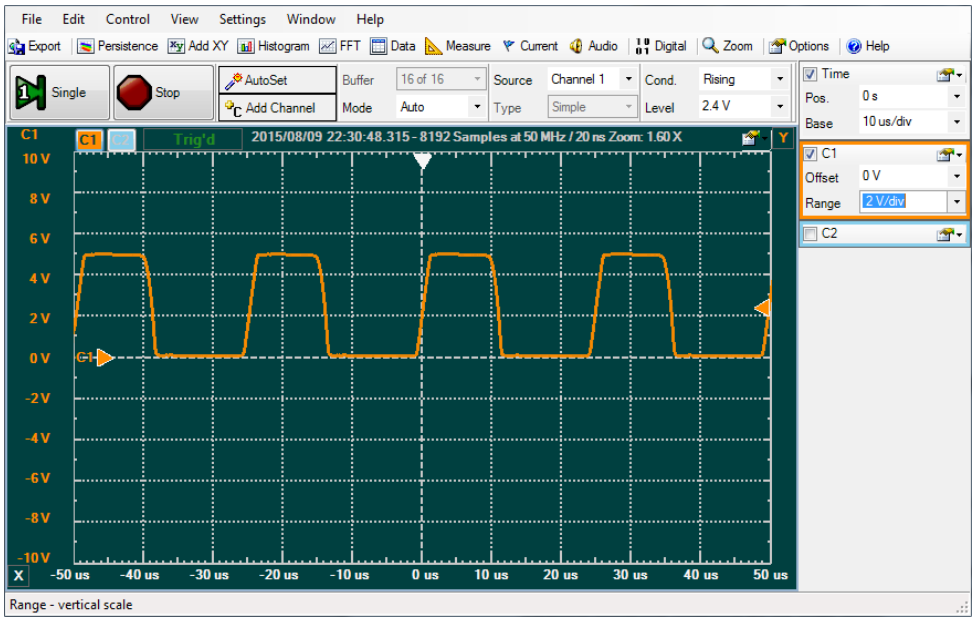
Step 10 Using a VOM set to DC, adjust R10 until the measured voltage between J1 GND and U2 Pin 1 is 2.5V. If the voltage in U2 Pin 1 stays near 0V or 5V regardless of the setting of R10, verify all solder joints at U2 Pin 1, U2 Pin2, U2 Pin 3, R11, R12, and R13. Re-solder each pin and repeat Step 10. If U2 Pin 1 still won't change, replace U2.

Step 11 Using a VOM set to DC, measure the voltage between J1 GND and U2 Pin 5 while turning the adjustment screw of R16 clockwise a few turns and counter clockwise a few turns. The measured voltage at U2 Pin 5 should increase as the adjustment screw is turned clockwise and decrease as the adjustment screw is turned counter clockwise. If the voltage does not change, examine the solder joints at R15, R16, C6, and U2 Pin 5. Re-solder each pin and repeat Step 11.

Step 12 Using a VOM set to DC, adjust R16 until the measured voltage between J1 GND and U2 Pin 7 is 2.5V. If the voltage in U2 Pin 7 stays near 0V or 5V regardless of the setting of R16, verify all solder joints at U2 Pin 5, U2 Pin6, U2 Pin 7, R17, R18, and R19. Re-solder each pin and repeat Step 12. If U2 Pin 7 still won't change, replace U2.

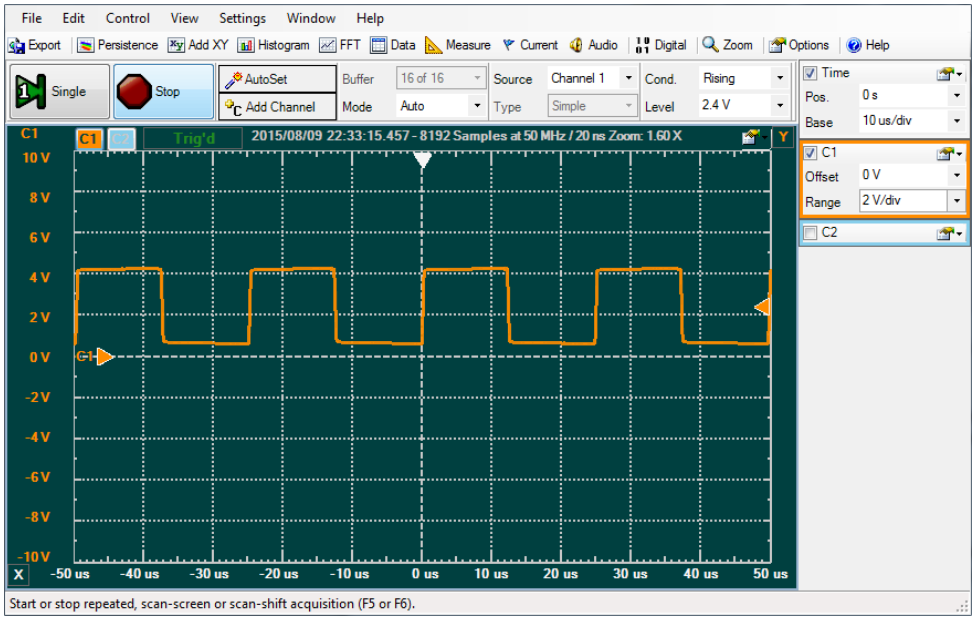
Step 13 Attach a test lead to the **Transmitter Enable (TE)** pin of connector J2.

Step 14 Using an Oscilloscope, measure the voltage at U2 Pin 7 while connecting the **Transmitter Enable (TE)** test lead to V+ of the 5V power supply. The scope probe ground lead should be connected to the **GND** pin of J1 or the 5V power supply GND connection. The scope waveform should look something like the image below:



If the Oscilloscope does not display the indicated image, replace XT1 and RT1 and repeat Step 14.

Step 15 Using an Oscilloscope, measure the voltage at U3 Pin 5. The scope probe ground lead should be connected to the **GND** pin of J1 or the 5V power supply GND connection. The scope waveform should look something like the image below:

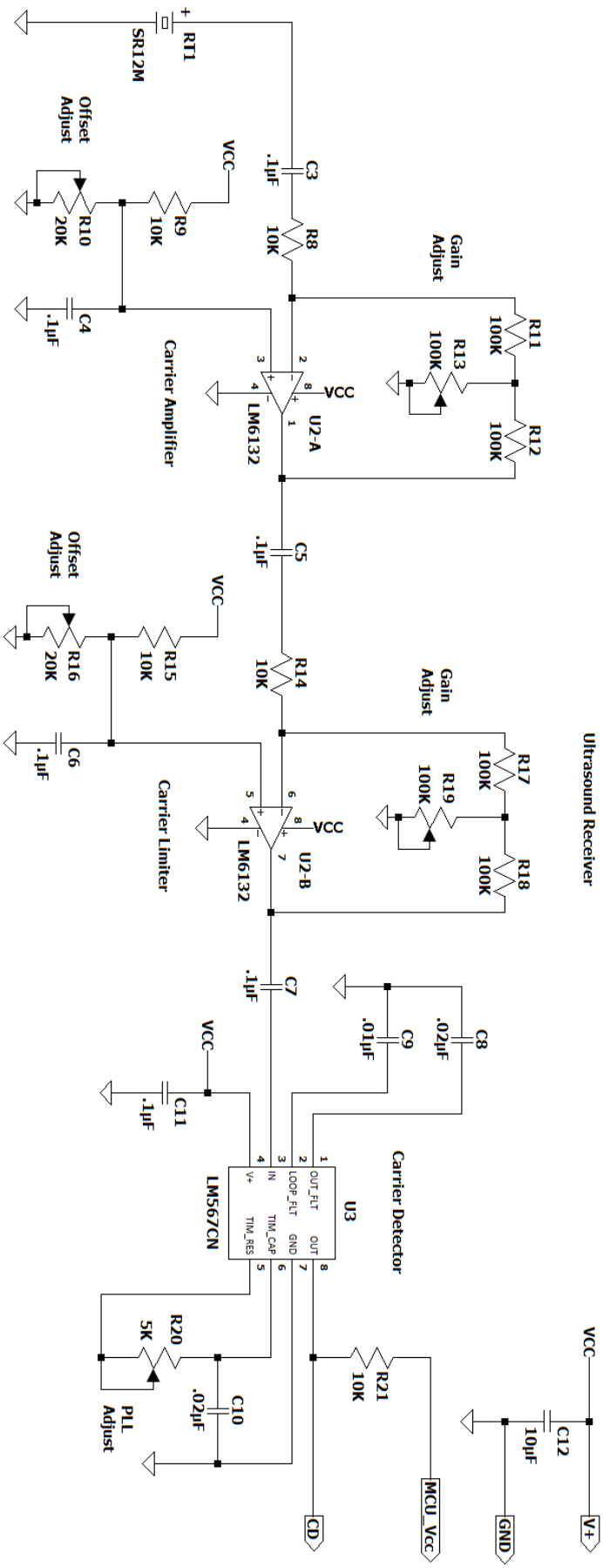


If the Oscilloscope does not display the indicated image, verify all solder joints at U3 Pin 5, U3 Pin 6, U3 Pin 7, C10, and R20. Re-solder each pin and repeat Step 13. If U3 Pin 5 still does not have the signal expected, replace U3.

Ultrasound Range Finder Parts List

Reference Number	Supplier	Supplier Part Number	Component Type	Component Value
C1, C3, C4, C5, C6, C7, C11	Mouser	140-50P5-104K-RC	Ceramic Disk Capacitor	.1uF, 50V
C9	Mouser	140-50P5-103K-RC	Ceramic Disk Capacitor	.01uF, 50V
C2	Mouser	140-50P2-102K-RC	Ceramic Disk Capacitor	.001uF, 50V
C8, C10	Mouser	140-50Z5-203M-RC	Ceramic Disk Capacitor	.02uF, 50V
C12	Mouser	871-B41002A4106M000	Aluminum Electrolytic Capacitor	10uF, 16V
J1	Mouser	649-68015-402HLF	3-Pin Header Connector	J2
J2	Mouser	649-68015-402HLF	2-Pin Header Connector	J1
Q1, Q2	Mouser	863-P2N2222AG	NPN Silicon Switching Transistor	2N2222
R1, R2, R4, R7	Mouser	291-1K-RC	Carbon Film Resistor	1K, 1/4W, 5%
R3, R8, R9, R14, R15, R21	Mouser	291-10K-RC	Carbon Film Resistor	10K, 1/4W, 5%
R5	Mouser	291-12K-RC	Carbon Film Resistor	12K, 1/4W, 5%
R11, R12, R17, R18	Mouser	291-100K-RC	Carbon Film Resistor	100K, 1/4W, 5%
R20	Mouser	858-67WR5KLF	20 Turn Linear Taper Potentiometer	5K
R6	Mouser	858-67WR10KLF	20 Turn Linear Taper Potentiometer	10K
R10, R16	Mouser	858-67WR20KLF	20 Turn Linear Taper Potentiometer	20K
R13, R19	Mouser	858-67WR100KLF	20 Turn Linear Taper Potentiometer	100K
RT1	Mouser	255-400SR12M-ROX	Ultrasound Piezo Receiver	--
XT1	Mouser	255-400ST12M-ROX	Ultrasound Piezo Transmitter	--
U1	Mouser	NE555N	Timer Integrated Circuit	--
U2	Mouser	LM6132BIN/NOPB	Dual High Speed Single Ended Op Amp	--
U3	Mouser	LM567CN/NOPB	Analog Tone Decoder	--

Schematic Diagrams



Schematic Diagrams