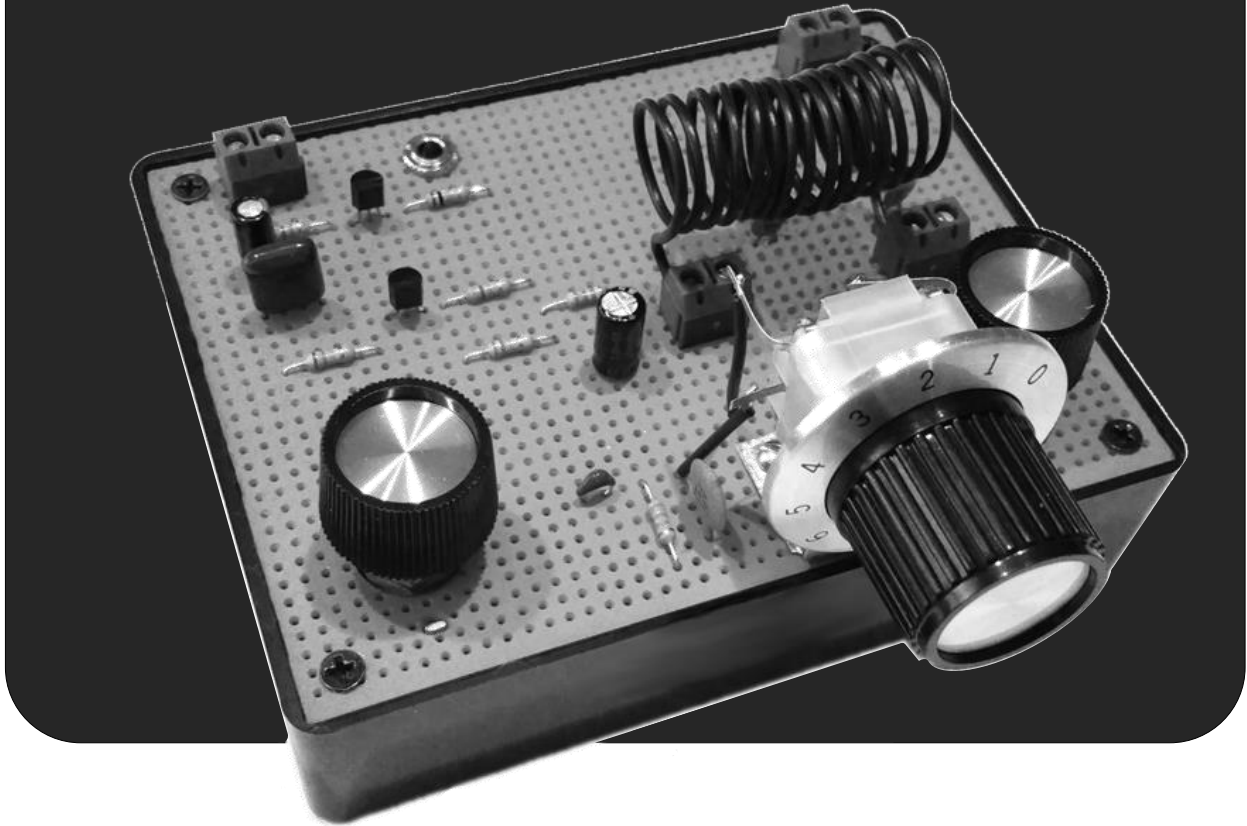


Science FairTM

INSTRUCTION MANUAL PRICE: 50¢

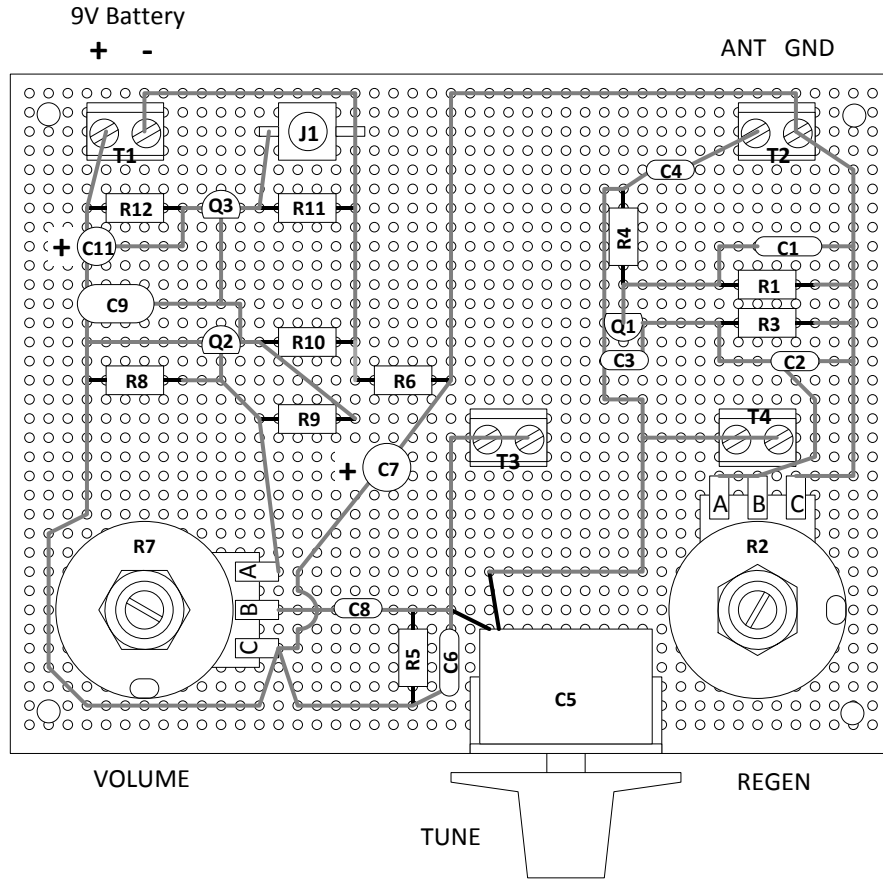


ELECTRONIC PROJECT KIT #28-110 THREE TRANSISTOR SHORT WAVE RADIO

The air is literally full of radio signals from practically every country in the world. These “short wave” signals are propagated through space and refracted back to earth by the ionosphere to points many miles from the transmitter source. As a result, communications services, international broadcasters, radio amateurs, and others depend on this “refraction” and return to earth of short wave signals for long distance communications around the globe. Still, it is difficult to believe that you will be receiving signals from far off places with only a three transistor radio. A regenerative high gain detector with two stages of equally high gain audio amplification provides enough audio drive for either a crystal earphone or any audio power amplifier. Have fun “DX-ing” – distancing around the world!

FIG. 1 – PICTORIAL DIAGRAM

TOP VIEW



PARTS LIST

Quantity	Identification	Desc	Quantity	Identification	Desc
1	Transistor NPN (2N3904)	Q1	1	.047uF Multilayer Capacitor	C8
2	Transistor PNP (2N3906)	Q2, Q3	1	.1uF Mylar Capacitor	C9
2	33K Resistor 1/4W 5%	R1, R5	1	10uF Electrolytic Capacitor	C11
1	1K Resistor 1/4W 5%	R3	1	47uF Electrolytic Capacitor	C7
1	100K Resistor 1/4W 5%	R4	1	500 Ohm Potentiometer	R2
1	2.2K Resistor 1/4W 5%	R6	1	100K Ohm Potentiometer	R7
1	2.7K Resistor 1/4W 5%	R12	1	140pF Variable Capacitor	C5
1	22K Resistor 1/4W 5%	R9	4	2-Position Screw Terminal	
1	47K Resistor 1/4W 5%	R10	1	Crystal Earphone	
1	12K Resistor 1/4W 5%	R8	1	9V Battery Clip	
1	10K Resistor 1/4W 5%	R11	1	Mounting Hardware	
2	.01uF Disk Ceramic Capacitor	C1, C6	1	Knobs (3)	
2	47pF Disk Ceramic Capacitor	C2, C3	1	Bracket	
1	15pF Disk Ceramic Capacitor	C4	1	Wire	

RECOMMENDED SUPPLIER LIST

Joe Knows Electronics, www.joeknowselectronics.com

Amplified Parts, www.amplifiedparts.com

Mouser, www.mouser.com

Digikey, www.digikey.com

STEP-BY-STEP WIRING AND ASSEMBLY DIRECTIONS

Be sure to carefully follow all the directions. Do one step at a time and then check off the step in the box provided. Before beginning, read over the enclosed page labeled "Construction Hints".

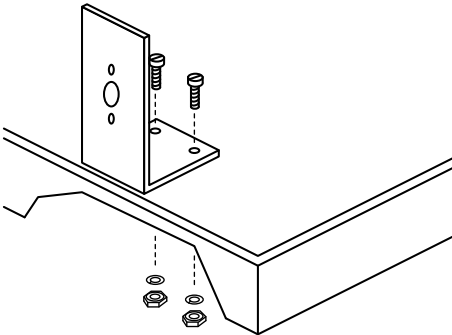
The step by step instructions indicate a soldering requirement; however, these connections can be made by firmly twisting joining wires together. If the connection is secure the circuit will work for temporary or testing purposes. If you wish a more permanent circuit, it is always best to secure these connections by soldering. Before soldering, read the instructions in "Construction Hints".

1. () Check the parts list to see that everything listed is included. Check each step as you progress (✓).

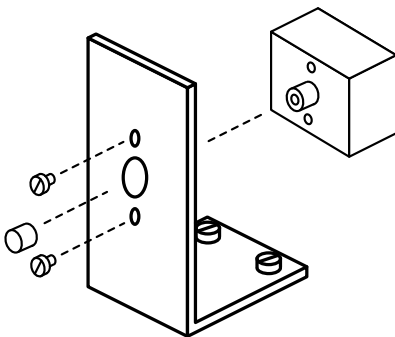
2. () Place the pictorial diagram near the perfboard chassis so that the pictorial can be used as a guide for exact placement of parts. The gray lines in the pictorial diagram indicate components and wires which are mounted under the circuit board. The solid lines indicate components and wires mounted on top of the circuit board.

3. () Slightly enlarge the perfboard holes so that terminal strips T1 through T4 fit snugly in the perfboard as shown in Fig. 1 so that they face toward the back of the radio.

4. () Slightly enlarge the holes for the tuning control bracket to accommodate the 4-40 X 3/8" screws. Mount the tuning control bracket as shown in the pictorial diagram Fig 1 using the two screws and two 4-40 nuts.



Mount the 140pF variable capacitor C5 as shown below using the short black screws. Thread the shaft extension on the variable capacitor and tighten.



5. () Mount potentiometer R2 orientating the lugs as shown in the pictorial diagram Fig 1. Fasten in place with the nut and washer provided.

6. () Mount potentiometer R7 orientating the lugs as shown in the pictorial diagram Fig 1. Fasten in place with the nut and washer provided.

7. () Mount the earphone jack J1 orientating the lugs as shown in the pictorial diagram Fig 1. Fasten in place with the nut provided.

8. () Remove all of the insulation from a 3" piece of wire. Connect one end to the Antenna Ground pin of the screw terminal T2. Do not solder yet. Solder the other end to the potentiometer R2 lug C and solder.

9. () Remove 2" of insulation from one end of a 4-1/2" piece of wire and 1/4" insulation from the other end. Solder the long stripped end to the 9V battery connector (+) pin of terminal T1. Connect the other end to the potentiometer R7 lug C. Do not solder yet.

10. () Insert the 2.2K resistor R6 into the perfboard and bend the leads out slightly to keep the resistor in place.

11. () Remove 1-1/2" of insulation from one end of a 3" piece of wire and 1/4" insulation from the other end. Solder the bare short end to the 9V battery (-) pin of terminal T1. Connect the long stripped end to the resistor R6 as shown in Fig 1. Do not solder yet.

12. () Bend down the earphone jack J1 terminal nearest the wire from the 9V battery (-) terminal and solder as shown in Fig 1.

13. () Remove 1/4" insulation from each end of a 4" piece of wire. Solder one end to the Antenna Ground terminal. Connect the other end to R6 as shown in Fig 1. Do not solder yet.

14. () Remove 1-1/2" insulation from one end of a 2-1/2" piece of wire and 1/4" insulation from the other end. Insert the long bare end of the wire into the perfboard near capacitor C6 as shown in Fig 1 and solder the short bare end to the middle lead of the variable capacitor C5. Solder the other end to both pins of the coil terminal block T3 as shown in Fig 1.

15. () Remove 2-3/4" insulation from one end of a 4" piece of wire and 1/4" insulation from the other end. Insert the long bare end of the wire into the perfboard above and to the right of capacitor C6 as shown in Fig 1 and solder the short bare end to the top lead of the variable capacitor C5. Solder the other end to both pins of the coil terminal block T4 as shown in Fig 1.

16. () Insert the 2.7K resistor R12 into the perfboard. Solder one end to the bare wire from the 9V battery (+) terminal as shown in Fig 1.

17. () Insert the 10uF electrolytic capacitor C11 into the perfboard so that the POSITIVE capacitor lead is closest to the bare wire from the 9V battery (+) terminal as shown in Fig 1 and solder. **IMPORTANT:** Most electrolytic capacitors only mark the NEGATIVE lead with a band or arrow. The positive lead usually does not have a marking. Make sure you solder the correct lead in this step.

18. () Insert the Mylar capacitor C9 into the perfboard. Solder one end to the bare wire from the 9V battery (+) terminal as shown in Fig 1. Mylar capacitors do not have a polarity so it does not matter which direction the capacitor is inserted into the perfboard.

19. () Insert the 12K resistor R8 into the perfboard. Solder one end to the bare wire from the 9V battery (+) terminal as shown in Fig 1.

20. () Insert the 10K resistor R11 into the perfboard. Solder one end to the bare wire from the 9V battery (-) terminal as shown in Fig 1. Solder the other end to the earphone jack J1 as shown in Fig 1.

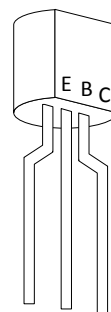
21. () Insert the 47K resistor R10 into the perfboard. Solder one end to the bare wire from the 9V battery (-) terminal as shown in Fig 1.

22. () Insert the 22K resistor R9 into the perfboard. Solder one end to the 47K resistor R10 as shown in Fig 1.

23. () Insert the 47uF electrolytic capacitor C7 into the perfboard so that the NEGATIVE end is closest to the

2.2K resistor R6. Connect the POSITIVE lead of C7 to resistor R6 as shown in Fig 1 and solder all leads and wires together.

24. () Bend the leads of PNP transistor Q3 as shown and insert into the perfboard.



Make sure the flat side of the transistor faces toward the front of the radio as shown in Fig 1. Solder the emitter lead to resistor R12 and capacitor C11. Solder the collector lead to resistor R11. Solder the base lead to capacitor C9.

25. () Bend the leads of PNP transistor Q2 as shown in step 24 and insert into the perfboard. Make sure the flat side of the transistor faces toward the front of the radio as shown in Fig 1. Solder the emitter lead to the bare wire from the 9V battery (+) terminal using a short piece of bare wire. Solder the collector lead to resistors R9 and R10, and capacitor C9 as indicated in Fig 1. Solder the base lead to R8 and R9 as indicated in Fig 1.

26. () Strip 1/4" of insulation from each end of a 1" piece of wire. Solder one end to resistor R9 and the other end to potentiometer R7 lug A.

27. () Bend down lug B of potentiometer R7 until it is flat against the perfboard.

28. () Insert the .047uF MLC capacitor C8 into the perfboard as close as possible to potentiometer R7 lug B and solder C8 to lug B as shown in Fig 1. MLC capacitors do not have a polarity so it does not matter which direction the capacitor is inserted into the perfboard.

29. () Strip 1/4" of insulation from each end of a 1" piece of wire. Solder one end to the positive lead of electrolytic capacitor C7. Connect the other end to potentiometer R7 lug C. Do not solder yet.

30. () Insert the 33K resistor R5 into the perfboard and bend the leads out slightly to keep the resistor in place.

31. () Insert the .01uF disk capacitor C6 into the perfboard and bend the leads out slightly to keep the capacitor in place. Disk capacitors do not have a polarity so it does not matter which direction the capacitor is inserted into the perfboard.

32. () Strip ¼" of insulation from each end of a 1" piece of wire. Connect one end to potentiometer R7 lug C and solder all wires to lug C. Solder the other end to resistor R5 and capacitor C6 as shown in Fig 1.

33. () Solder resistor R5 to capacitor C8 as shown in Fig 1.

34. () First solder capacitor C6 to the bare wire from variable capacitor C5 and coil terminal T3, and then solder C6 to resistor R5 as shown in Fig 1.

35. () The AF detector and amplifier circuit is now complete. Check that all components and wires in the AF/Detector stage have been properly soldered. Trim leftover leads flush with their solder joints.

36. () Insert .01uF disk capacitor C1 into the perfboard. Solder one end to the bare wire from the Antenna Ground pin of terminal strip T2 as shown in Fig 1.

37. () Insert 33K resistor R1 into the perfboard. Solder one end to the bare wire from the Antenna Ground pin of terminal strip T2 as shown in Fig 1

38. () Insert 1K resistor R3 into the perfboard. Solder one end to the bare wire from the Antenna Ground pin of terminal strip T2 as shown in Fig 1

39. () Insert 47pF capacitor C2 into the perfboard. Solder one end to the bare wire from the Antenna Ground pin of terminal strip T2 as shown in Fig 1

40. () Strip ¼" of insulation from each end of a 1" piece of wire. Solder one end to potentiometer R2 lug A and B. Solder the other end to capacitor C2 as shown in Fig 1.

41. () Solder capacitor C1 to resistor R1 as shown in Fig 1.

42. () Solder capacitor C2 to resistor R3 as shown in Fig 1.

43. () Insert 15pF disk capacitor C4 into the perfboard. Solder one end to the Antenna pin of terminal strip T2.

44. () Insert 100K resistor R4 into the perfboard. Solder capacitor C4 to one end of resistor R4 as shown in Fig 1.

45. () Bend the leads of NPN transistor Q1 as shown in step 24 and insert into the perfboard. Make sure the flat side of the transistor faces toward the back of the radio as shown in Fig 1. Solder the emitter lead to resistor R3 as shown in Fig 1. Solder the base lead to resistor R4 and R1 as shown in Fig 1. Solder the collector lead to resistors R4 as shown in Fig 1.

46. () Insert 47pF disk capacitor C3 into the perfboard. Solder one end to the emitter of transistor Q1. Solder the other end to the collector lead of transistor Q1.

47. () Strip all insulation from a 1" piece of wire. Solder one end to capacitor C3 as shown in Fig 1. Solder the other end to the bare wire from coil terminal strip T4.

48. () The RF regenerative stage is now completed. Check that all components and wires in the RF stage have been properly soldered. Trim leftover leads flush with their solder joints.

49. () Install the small knobs on potentiometers R2 and R7 and tighten the set screws until the knobs hold firmly to the potentiometer shaft. Install the large knob on the tuning capacitor C5 and tighten the set screw until the knob holds firmly to the tuning capacitor shaft. Do not overtighten the set screws.

50. () Remove ¼" of insulation from both ends of a 16-1/2" piece of wire. Holding the wire as shown in the drawing below, wrap it around a "AA" battery for 8 full turns. Leave at least ¼" left over for lead length.



The completed coil should look like the coil in the drawing. Wrap the coil with clear tape to prevent it from springing apart. Mount the coil (L1) by inserting one end into terminal strip T3 and the other end into terminal strip T4. Tighten the terminal strip screws until the coil leads are firmly held in place.

You have completed all connections, both wiring and soldering. Carefully double check the work against the pictorial diagram.

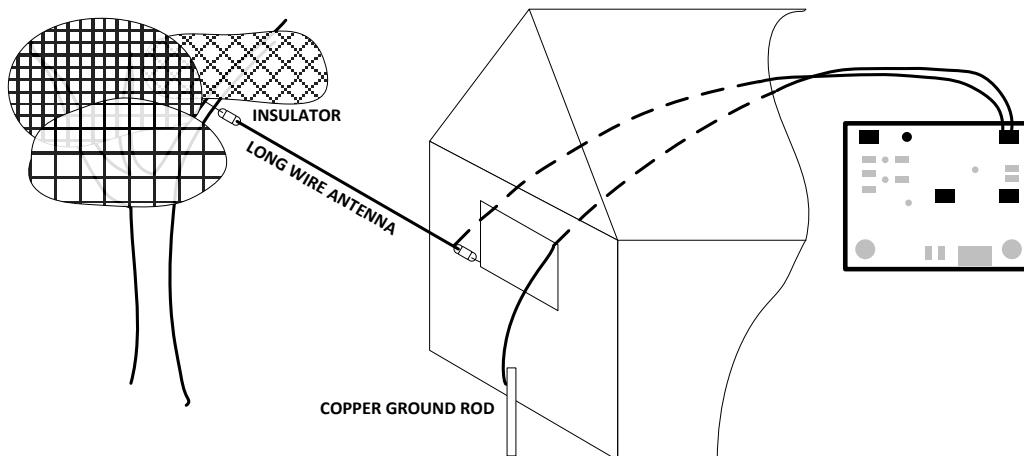
OPERATIONS

This radio will work with a 10' or 20' piece of wire strung across the floor used as an antenna. However, for top efficiency you will need a good antenna and ground connection. Your radio reception will never be any better than your antenna system. You may use a cold water pipe for ground; however, a metal rod driven 2' or 4' into the ground works best. Excellent for this use is the Radio Shack ground rod (Radio Shack Cat. #15-530). Connect the wire from the ground rod to the Antenna Ground terminal of terminal strip T2. The Antenna terminal of terminal strip T2 should be connected to an outdoor antenna of the type illustrated in figure 3 (Radio Shack Cat. #278-1373), and can be as long as facilities permit. The longer the antenna you are able to construct, the better quantity of reception you will receive, especially at low frequency. If this is not practical, such makeshift antennas

can be used as your television antenna, citizens band antenna, or even the metal dial stop of your telephone.

Connect the read lead of the battery clip to the positive (+) terminal of the terminal strip T1 and the black lead to the negative (-) terminal of the terminal strip T1. Insert the earphone plug into the earphone jack J1. Insert a 9V transistor battery (Radio Shack Cat. #23-464 or 23-152) and you are ready to operate your radio.

There are three controls on your short wave radio. The potentiometer R7 is the volume control for the audio output, the other potentiometer R2 is the regeneration control. The variable capacitor C5 is your tuning capacitor. To operate the radio, advance R7 fully clockwise, turn R2 half way clockwise. Now slowly tune the variable tuning capacitor until a station is heard. Adjust the potentiometer R2 until a maximum signal is heard. If the regeneration control R2 is advanced too far, a loud pop or squeal will be heard in the earphone. This indicated that you have gone into full regeneration and the potentiometer should be backed off slightly. It is possible to receive code (CW) in this condition. In order to hear a voice signal you need to adjust the regeneration control just prior to this oscillation condition. This point is referred to as the threshold point. If necessary reduce the volume to a comfortable listening level using the volume control R7, not the regeneration control.



ADDITIONAL COIL WINDING INFORMATION

Your shortwave radio can be operated at frequencies ranging from 4.5 to about 50MHz depending on the number of turns in the coil. A chart is given below which indicates the number of turns required for a given frequency of operation. Construct the coil as shown in the step by step instructions but with the number of turns required for the

frequency desired. For the larger coils cellophane tape can be used to hold the coil together. Different frequencies or operations have better reception depending on the time of day. Included below is additional information which shows the best time to listen to the frequency that you are interested in.

Frequency	Coil Turns	Best Reception Time
4.5-7 MHz	46	Late night
6-10 MHz	25	Night often sunset
9-14 MHz	15	Late afternoon-night
13-20 MHz	8	Morning-afternoon
19-28 MHz	5	Morning-early afternoon
26-50 MHz	2	Morning

POWER SUPPLY

For more permanent use you can completely eliminate the need for batteries with the AC-DC power supply kit #28-104. It supplies either 6 or 9 volts DC for most of the Science Fair Kits as well as most transistor radios, tape recorders, and phonographs. Complete connections are shown below.

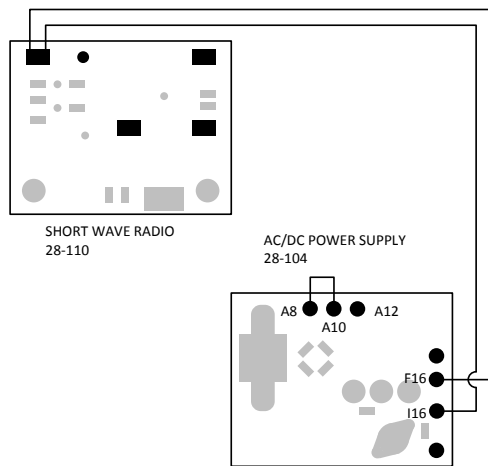
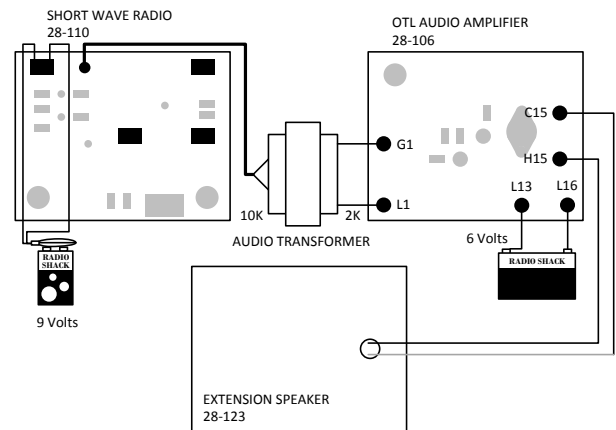


FIG. 2 – SCHEMATIC

AMPLIFIER CONNECTIONS

If you wish to use a speaker with your radio it is necessary to use additional amplification. Ideal for the purpose is the Science Fair OTL Amplifier #28-106 and the Science Fair Extension Speaker #28-123. It is necessary to couple the radio to the amplifier with a dropping transformer #273-2378. The unit will probably work better in this condition if resistor R-11 is removed. Complete connections are shown below.



SHORT WAVE RADIO

