Easy Guide to Building a Dipole Antenna for FM Transmission

This version of the Dipole Antenna build requires no soldering or splicing of coax cable or antenna wire. The design is improved by use of an Isolation Transformer (aka Balun) to convert the signal from 75ohm coax to 300ohm flat wire to the antenna. With this design the coax leading up to the antenna cannot resonate and become part of the transmission path. It also prevents the need for cutting and splicing to join the coax to the antenna wire.

The design has been further simplified by using a specific list of parts and measurements including a cut chart that removes the need for doing math to determine the length of wire and PVC pipe pieces to build the dipole antenna.

Materials

Qty	Part	Cost[1]	Description
1	6' x 14AWG Solid copper wire (2 x 3' lengths)	$8	 Romex or other stiff 14AWG wire will work. **TIP:** Buy 3' of 14/2 wire "off the roll" from Home Depot. With this inexpensive option you can use two of the three wires, just remove the jacket & insulation from the wire.
1	1" x 10' PVC* Pipe	$8	 Home Depot and most hardware stores sell the 1" ID (Inner Diameter) by 1 1/4" OD (Outer Diameter) Schedule 40 (white) PVC pipe.
1	PVC* 1" T-connector	$6	 Home Depot – 1 in. PVC Schedule 40 S x S x S Tee (S = Slip Tee, no threads inside)
1	PVC 1" 90-degree Elbow connector	$2	 Home Depot – 1 in. PVC Sch. 40 90-Degree Elbow or Corner connector
3	PVC 1" Socket Caps (aka End caps)	$5	 Home Depot – 1 in. PVC Schedule 40 Socket Cap
2	1/4" x 1 1/4" OD Fender Washers[2]	$1	Home Depot – 1/4" x 1-1/4" OD Fender Washer  **NOTE:** Outer Diameter is the same as the PVC pipe. The hole in the washer must be smaller than the locking end of a zip tie yet large enough for the flat part of the zip tie to fit through.
2	8-32 x 1/2" Machine Screws[2] (aka Stove Bolts)	$2	 Home Depot - #8-32 x 1/2 in. Combo Round Head Machine Screw
2	8-32 x 1/2" Nuts[2]	$2	 Home Depot - #8-32 Nylon Lock Nut
1	9mm Ferrite Choke	$12	 Amazon – 9mm Ferrite Cores Ring Clip-On RFI EMI Noise Suppression Filter
2	8" Zip ties	$3	 Amazon – 8 in. UV Cable Tie, Black (100-Pack) **TIP:** (The head of the zip tie just needs to be big enough it does not pull through the hole in the Fender washer)

1	Coax Cable Extension Coupler	$10	 Amazon – Coax Cable Extension Coupler, with Washer and Nut
Qty	**Part**	**Cost[1]**	**Description**
1	1.5 ft RG6 Coax Cable	$11	 Amazon – Quad Shielded RG6 Coaxial Cable 1.5 ft
1	Transformer Balun aka Isolation Transformer	$7	 Amazon – AEDIKO Matching Transformer 12pcs UHF/VHF/FM Balun Antenna Transformer 75 Ohm to 300 Ohm Adapter Converter with F Female Jack **IMPORTANT:** The Balun must have isolated wiring where the center wire of the coax shows resistance to only one of the flat wire leads. This design prevents the coax wire from becoming part of the transmission path of the antenna. If unsure use a multi-meter to test if you get resistance between coax center and both of the flat wire leads. If you do, the balun is not the isolated type. The AEDIKO part listed has isolated wiring.
2	M6 – 14AWG Blue Ring Crimp Terminals[2]	$4	Ace Hardware – 16-14AWG Insulated Terminals Ring Electrical Wire Crimp Connectors **NOTE:** The M6 size ring terminals have a larger ring / opening 
2	M4 – 14AWG Blue Ring Crimp Terminals[2]	$3	Ace Hardware – 16-14AWG Insulated Terminals Ring Electrical Wire Crimp Connectors **NOTE:** The M4 size ring terminals have a smaller ring / opening 
1	4” section of Pixel Strip (left-over from mega tree build)	$0	This is a 4” section of 1” spaced pixel strip which works great as an insulator. NOTE: Any 3”” long x 1” of less tall piece of non-conductive material (thin plastic or wood) will work as an insulator.  (Pictured assembled)
1	RG6 Coax Cable w/male ends	?	Long enough quality RG6 shielded coax cable to run from your FM transmitter to where you will be mounting your antenna.
1	Coax Adapter for your FM Transmitter	$6-$9	Varies based on the type of antenna hook-up on your FM Transmitter. **NOTE:** EDM FM Transmitter uses F-type Female to RCA Male SIGNSTEK FM Transmitter uses TNC Male Plug to F-type Female Jack
1	Optional: PVC Cement or Caulking	$11	Home Depot – If using indoors you can pressure fit the PVC antenna pieces together. If using outdoors, you can use PVC Cement or Caulk to water proof the joints.
2	Optional: Pipe clamps	$6-$10	Hose clamps can be used if mounting to a pole (i.e. mega-tree). Pipe Hangers can be used for mounting to wood.

[1] Cost as of May 7, 2023

[2] Most small local hardware stores (Ace Hardware, True Value, etc.) sell nuts & bolts, & fender washers individually or in small packs. You may be able to get all the PVC parts and solid core wire also to save driving to multiple stores.

Tools Needed for Build

- PVC Pipe Cutter:
  - Home Depot Husky 1 ¼" Ratcheting Pipe Cutter or
  - Hacksaw with a fine-tooth blade
- Wire Cutter (for 14awg wire)
- Wire Crimper (for 14awg wire)
- Electric Drill
- 3/16" metal drill bit
- 3/8" metal drill bit
- #2 Philips Screw Driver
- 6" Adjustable Wrench
- Needle Nose Pliers (small)
- Sharpie / Permanent Marker
- Tape or Paint or Nail Polish

Step-by-step Directions

Cut the Antenna Wire and PVC Pipe

1. Determine the FM Frequency for your antenna. If you don't have an FM channel picked out you can use https://radio-locator.com/ to find potential available channels in your area. It is recommended you listen to the station on a radio at the time your show would play (i.e. after 5PM) to ensure there is no station broadcasting on that channel, during show hours. It's always best to find an "open" channel to transmit on.

2. Enter your FM Channel in the box below and press Enter to see Wire and PVC length boxes populated with measurements. Alternately, you can look-up the lengths from the chart in the Appendix.
   Example / FM Channel = **87.9FM** Wire length = **30 7/8"** PVC length = **32 5/8"**

   Enter Your **FM Channel** = **Wire** length = **PVC** length =

3. Straighten out the 14awg solid copper wire to make it as straight as you can. Using wire cutters, cut the 14awg solid core wire to the "Wire length" measurement shown in Step 2. You should have two identical wires the same length; for the top and bottom half of the dipole antenna.

4. Using the PVC Cutters, cut the 1" PVC pipe as follows:
   a. Cut one 6" length this is the Mounting Arm.
   b. Cut one 12" length this is the Mounting Leg.
   c. Cut two lengths using the "PVC length" number from Step 2. These are the Dipole Legs.
      NOTE: Any remaining PVC is scrap and should be set aside so it is not used during the build.

Build the Insulator Assembly

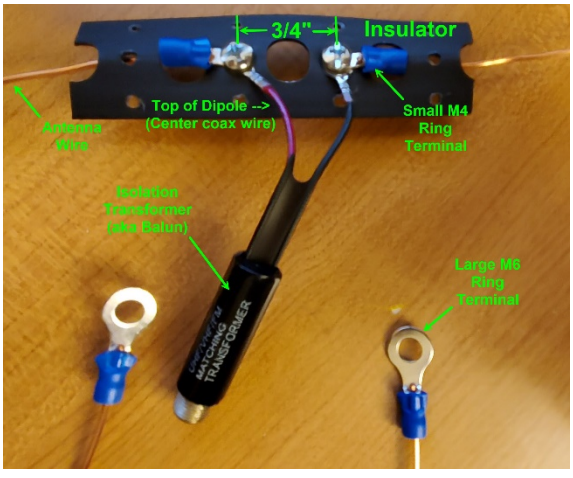

Figure 1 - Insulator Assembly

1. Using proper wire crimpers, attach a small (M4) and large (M6) Blue ring terminal to each end of the two 14awg wires. Squeeze the crimper hard and make sure the ring terminal is firmly attached to the wire, see *Figure 1*. We will be putting some tension on these ring terminals and don't want them to pop off the wire later in the build.

2. Drill two 3/16" holes 3/4" apart in the center of the Insulator material. The insulator needs to be able to pass easily through the inside of the PVC Tee. If using pixel strip as shown in *Figure 1* it helps to bend/crease the strip along the center after drilling out two of the existing holes to 3/16".

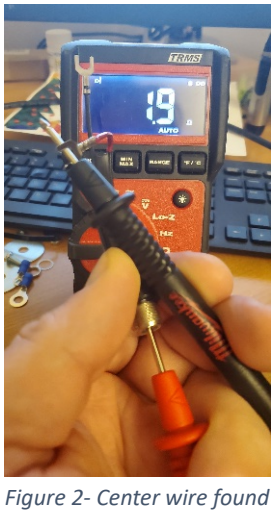

Figure 2- Center wire found

3. Next, determine which of the Transformer flat wires are connected to the center wire of the coax. This determines which wire is the top half of the dipole. Use a multi-meter set for a resistance/continuity test and probe the center of the coax connector while touching each of the twin flat wire leads separately, see *Figure 2*. Only one of the flat wires should show continuity (a non-zero number or tone) mark that wire with tape, paint, or even nail polish. WARNING: If both leads show resistance then you have the wrong type of Transformer (see parts list).

4. Attach the Transformer and Antenna Wires to the Insulator using two #8-32 Machine Screws & Nuts. For each of the two antenna wires:
    a. Insert the screw into the small M4 ring terminal and push it into the insulator.
    b. Slide one of the Transformers spade connectors under the ring terminal.
    c. Attach and tighten the nut to the screw on the back side of the insulator. Each screw will hold one small ring terminal and one transformer spade to each other and the insulator, see *Figure 1*.

Assemble Dipole Legs to T-Connector

Figure 3- Insulator Assembly in Tee

5. Slide half the antenna wire and the Transformer through the long part of the PVC T-Connector as shown.
6. Mark which end of the antenna is the top with an up arrow, see *Figure 3*. A permanent (Sharpie) marker works well for this. The arrow will be on the same side as the marking on the Transformers wire lead you made in step 4. In the picture, we marked the left wire with pink fingernail polish so the arrow gets drawn also on the left side of the PVC Tee.

7. Slide the antenna wire into one of the Dipole PVC Legs, see *Figure 4.*
8. Push the PVC Leg firmly into one end of the PVC Tee.
   TIP: Make sure your insulator material will slide into the PVC pipe. If not, you can cut it down or crease it to make it fit.

9. Repeat steps 7 & 8 for the other Dipole Leg.

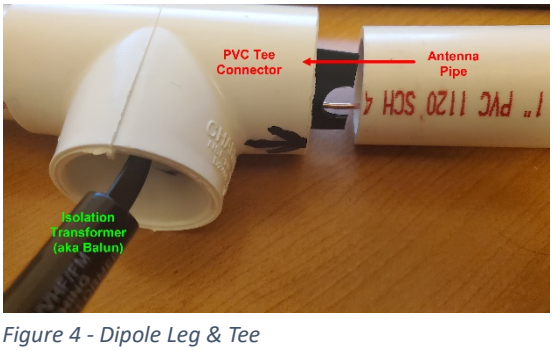

Figure 4 - Dipole Leg & Tee

End Cap Assembly

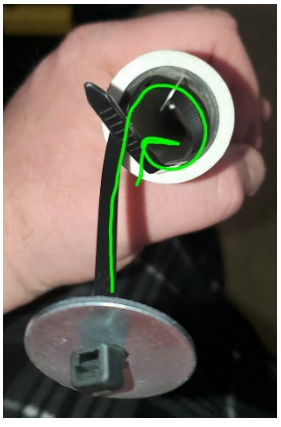

Figure 5 - Fish the zip tie through a Ring Terminal

10. Using your fingers, bend the end of a zip tie into a "J" hook shape.
11. Push the zip tie through the center of one of the Fender washers.
12. As shown in *Figure 5*, fish the zip tie through the hole in the large M6 ring terminal inside one end of the dipole antenna legs. Use needle nose pliers to reach in and pull the zip tie out of the pipe.
13. Push the zip tie back through the center hole of the Fender washer as shown in *Figure 6*.
14. Snug the head of the zip tie up against the washer. DO NOT fully tighten the zip tie yet. You may need to force the head down while pulling out of the tail to snug up the zip tie.
15. Repeat steps 10-14 for the other Dipole Leg.

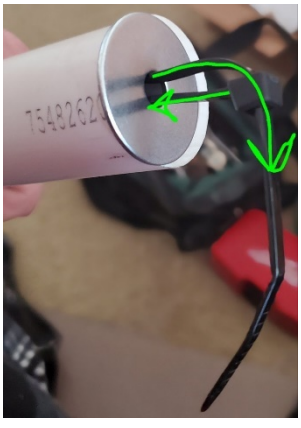

Figure 6 - Looping back through a Fender Washer

Figure 7 – Zip tie tight against a Fender Washer

16. Fully tighten the zip tie on one end, see *Figure 7.*
17. Once the zip tie is tight against the washer, cut the zip tie flush with the head.
    NOTE: At this point the antenna wire should be suspended inside the middle of the PVC pipe.
18. Push one of the PVC Caps onto the end of the Dipole Leg to cover the washer and zip tie, see *Figure 8*.
19. Repeat steps 14-17 for the other Dipole Leg.

Figure 8 – Push End Cap onto a Dipole Leg

Coax to Balun Assembly

Figure 9 – RG6 Coax cable laying in Ferrite Choke

20. Open the Ferrite Choke clamshell using your fingernail or a small screwdriver to gently pry open the plastic tabs.
21. Position one end of the RG6 Coax cable into the choke's U-shaped magnet about an inch from the end of the cable, as shown in *Figure 9*.
22. Close the Choke's clamshell, ensuring the plastic tabs snap closed, as shown in *Figure 10*.
    NOTE: The choke should NOT slide around on the Coax cable. If it does check that you are using a 9mm choke. If so, then install zip ties in front and behind the choke on the Coax cable to prevent movement.
23. Screw the Coax cable end with the Choke onto the end of the Transformer sticking out of the PVC Tee, see *Figure 11*.

Figure 10 – Ferrite Choke installed on RG6 Coax cable

Figure 11 – Coax attached to Transformer with Choke installed

Mounting Arm Assembly

Figure 12 – Coax attached to Transformer

24. Slide the Coax cable through the Mounting Arm, as shown in *Figure 12*.
25. Slide the Coax cable through the PVC Elbow.
26. Push the Mounting Arm pipe firmly into the PVC Tee.
27. Push the Elbow firmly onto the Mounting Arm and position it facing down (opposite of the arrow you drew on the Tee).

Mounting Leg Assembly

Figure 13 – Coax attached to Transformer

28. Slide the Coax cable through the Mounting Leg, see *Figure 13*.
29. Push the Mounting Leg firmly into the PVC Elbow.

Bottom Cap Assembly

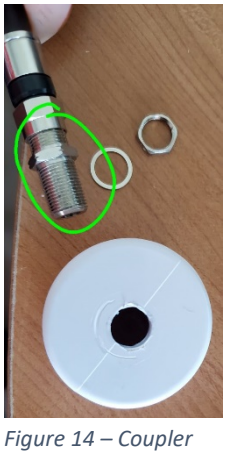

Figure 14 – Coupler attached to Coax

30. Gently pull the Coax cable out of the Mounting Leg until it stops.
31. Screw the Coax Coupler onto the Coax cable until tight, see *Figure 14*.
32. Using the 3/8” metal drill bit, drill a hole in the center of the last 1” PVC End Cap. WARNING: PVC does not drill smoothly, so use caution and a pair of vice grips or an actual vice to hold the cap while drilling. You may need to clear the edge of the hole with a file, knife, or flat blade screw driver to remove any remaining burrs.
33. Push the Coax Coupler through the hole in the End Cap, see *Figure 15*.

Figure 15 – Coupler through PVC Cap

Figure 16 – PVC Cap installed

34. Attach the washer and nut to the Coupler threads and tighten firmly.
    NOTE: You may want to use a wrench on the nut and needle nose pliers to hold the coupler inside the end cap so you can get the coupler tight against the end cap.
35. Gently push the Coax cable back into the Mounting Leg.
36. Push the End Cap firmly onto the Mounting Leg, see *Figure 16*.
37. Use a quality RG6 Coax cable and the appropriate Adapter (see parts list) to hook up your new Dipole Antenna to your FM Transmitter.

Congratulations on building the Dipole Antenna!

Appendix

Antenna Wire & PVC Pipe Length Chart by FM Frequency (Back to Step 1)

	Dipole Antenna / Leg Length	
FM Channel	Wire*	PVC
87.9	30 7/8 in	32 5/8 in
88.1	30 13/16 in	32 9/16 in
88.3	30 3/4 in	32 1/2 in
88.5	30 11/16 in	32 7/16 in
88.7	30 5/8 in	32 3/8 in
88.9	30 1/2 in	32 1/4 in
89.1	30 7/16 in	32 3/16 in
89.3	30 3/8 in	32 1/8 in
89.5	30 5/16 in	32 1/16 in
89.7	30 1/4 in	32 in
89.9	30 3/16 in	31 15/16 in
90.1	30 1/8 in	31 7/8 in
90.3	30 1/16 in	31 13/16 in
90.5	30 in	31 3/4 in
90.7	29 7/8 in	31 5/8 in
90.9	29 13/16 in	31 9/16 in
91.1	29 3/4 in	31 1/2 in
91.3	29 11/16 in	31 7/16 in
91.5	29 5/8 in	31 3/8 in
91.7	29 9/16 in	31 5/16 in
91.9	29 1/2 in	31 1/4 in
92.1	29 7/16 in	31 3/16 in
92.3	29 3/8 in	31 1/8 in
92.5	29 5/16 in	31 1/16 in
92.7	29 1/4 in	31 in
92.9	29 3/16 in	30 15/16 in
93.1	29 1/8 in	30 7/8 in
93.3	29 1/16 in	30 13/16 in
93.5	29 in	30 3/4 in
93.7	28 15/16 in	30 11/16 in
93.9	28 7/8 in	30 5/8 in
94.1	28 13/16 in	30 9/16 in
94.3	28 3/4 in	30 1/2 in
94.5	28 11/16 in	30 7/16 in
94.7	28 5/8 in	30 3/8 in
94.9	28 9/16 in	30 5/16 in
95.1	28 1/2 in	30 1/4 in
95.3	28 7/16 in	30 3/16 in
95.5	28 3/8 in	30 1/8 in
95.7	28 5/16 in	30 1/16 in
95.9	28 1/4 in	30 in
96.1	28 3/16 in	29 15/16 in
96.3	28 1/8 in	29 7/8 in
96.5	28 1/16 in	29 13/16 in
96.7	28 in	29 3/4 in
96.9	27 15/16 in	29 11/16 in
97.1	27 7/8 in	29 5/8 in
97.3	27 13/16 in	29 9/16 in
97.5	27 3/4 in	29 1/2 in
97.7	27 11/16 in	29 7/16 in
97.9	27 5/8 in	29 3/8 in
98.1	27 9/16 in	29 5/16 in
98.3	27 1/2 in	29 1/4 in
98.5	27 7/16 in	29 3/16 in
98.7	27 3/8 in	29 1/8 in
98.9	27 5/16 in	29 1/16 in
99.1	27 5/16 in	29 1/16 in
99.3	27 1/4 in	29 in
99.5	27 3/16 in	28 15/16 in
99.7	27 1/8 in	28 7/8 in
99.9	27 1/16 in	28 13/16 in
100.1	27 in	28 3/4 in
100.3	26 15/16 in	28 11/16 in
100.5	26 7/8 in	28 5/8 in

FM Channel	Dipole Antenna / Leg Length Wire*	PVC
100.7	26 13/16 in	28 9/16 in
100.9	26 3/4 in	28 1/2 in
101.1	26 3/4 in	28 1/2 in
101.3	26 11/16 in	28 7/16 in
101.5	26 5/8 in	28 3/8 in
101.7	26 9/16 in	28 5/16 in
101.9	26 1/2 in	28 1/4 in
102.1	26 7/16 in	28 3/16 in
102.3	26 3/8 in	28 1/8 in
102.5	26 3/8 in	28 1/8 in
102.7	26 5/16 in	28 1/16 in
102.9	26 1/4 in	28 in
103.1	26 3/16 in	27 15/16 in
103.3	26 1/8 in	27 7/8 in
103.5	26 1/16 in	27 13/16 in
103.7	26 in	27 3/4 in
103.9	26 in	27 3/4 in
104.1	25 15/16 in	27 11/16 in
104.3	25 7/8 in	27 5/8 in

FM Channel	Dipole Antenna / Leg Length Wire*	PVC
104.5	25 13/16 in	27 9/16 in
104.7	25 3/4 in	27 1/2 in
104.9	25 3/4 in	27 1/2 in
105.1	25 11/16 in	27 7/16 in
105.3	25 5/8 in	27 3/8 in
105.5	25 9/16 in	27 5/16 in
105.7	25 1/2 in	27 1/4 in
105.9	25 7/16 in	27 3/16 in
106.1	25 7/16 in	27 3/16 in
106.3	25 3/8 in	27 1/8 in
106.5	25 5/16 in	27 1/16 in
106.7	25 1/4 in	27 in
106.9	25 1/4 in	27 in
107.1	25 3/16 in	26 15/16 in
107.3	25 1/8 in	26 7/8 in
107.5	25 1/16 in	26 13/16 in
107.7	25 in	26 3/4 in
107.9	25 in	26 3/4 in

** 1" subtracted for length of ring terminals*

Version Control

Date	Author	Change
5-11-2023	John Creed	Version 1.0 – Initial release of this guide.
5-23-2023	John Creed	Version 1.1 – Added 3/8” drill bit for drilling the hole for the coax coupler.