TECHNIQUES FOR USING CABLE TELEVISION (CATV) HARDLINE FOR AMATEUR RADIO HF USE

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DATE: 11 AUGUST 2020

DISCUSSION TOPICS

- Introduction
- CATV Hardline
- Methods for “Hams” to use CATV Hardline
- Adapting to CATV Hardline via Connectors
- Conclusion – Which method is best for my use?

Many concepts in this presentation have been researched, but not yet proven by AC4G. Further experimentation to be studied and implementation is planned!

INTRODUCTION

- **Most modern amateur radio transceivers are solid state designs designed with tuned input of 50-Ohm impedance at the SO239 connector & designed to connect to 50-Ohm antennas**
- **Ladderline (300-Ohm & 450-Ohm) feedline is also used quite often with 6:1/ 9:1 Baluns to match 50-Ohm antennas**
- **The most common 50-Ohm coaxial cables feedlines in use today are RG-8, RG-213, RG-58, LMR-400, 50-Ohm Hardline, etc. 50-Ohm Hardline has one of the lowest losses of the feedlines listed above**
- **AC4G Dilemma: Having bulk CATV hardline as my disposal, <u>is it worth trying to use CATV hardline for my HF ham station?</u> And if so, <u>how do I get it to work with my 50-Ohm transceiver & antenna(s)??</u>**

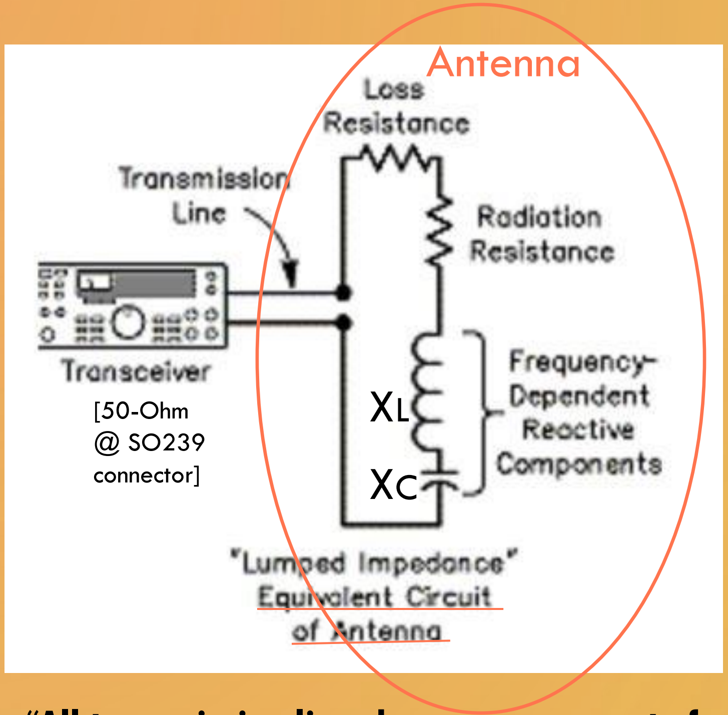
3/4" CATV Hardline

CATV Hardline with Aluminum jacket

CATV Hardline with Aluminum and outer PVC jacket

FEEDLINES FOR THE HF/VHF/UHF TRANSCEIVER (TUNED CIRCUIT) & ANTENNA

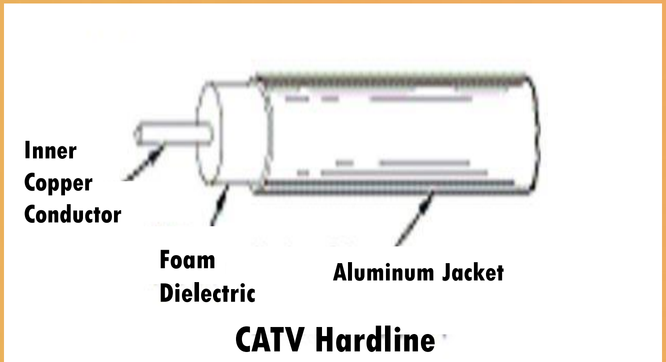
- **Require maximum power transfer from transceiver to antenna via feedline (transmission line)**
- **If the flow of power from the transceiver encounters an unmatched impedance at the antenna, some power is reflected in the feedline making standing waves**
    - **The ratio of forward to reverse power measured result in an impedance mismatch, a line loss, and attenuated signals resulting in higher the SWR**



"All transmission lines have some amount of loss. It's just a question of how much at what frequencies." AA6ZM

RF power in a transmission line acts in a similar fashion to a flashlight being shined toward a window at night in a darkroom. Light travels across the room unnoticed, then encounters the window, which reflects some light back toward the light source

DIFFICULTIES WITH CATV HARDLINE



Short Piece of 3/4" 75-Ohm CATV Hardline easy to kink

- **Many years ago, CATV companies began giving away short runs of CATV hardline and many individuals either gave theirs away or sold the hardline for a cheap price because on no utility [AC4G obtained CATV hardline from N4KG estate]**
- **Why do hams see little use of CATV hardline in the amateur radio community?**
  - **<u>One</u>: CATV hardline impedance is 75-Ohms - The CATV industry uses a 75-Ohm system; Ham operators utilize 50-Ohm systems**
  - **<u>Two</u>: The Standard PL259 connector does not fit CATV hardline; the ham operator has no easy method to connect their HF/VHF/UHF transceiver to their antenna**
- **So, what can a ham do to remedy these drawbacks and utilize CATV hardline which has very low feedline losses???**

WHAT DO WE GAIN BY USING CATV HARDLINE?

Radiated Power in Feedlines

Transmission	3.5 MHz		28 MHz		146 MHz	
Line Type	1:1 SWR	6:1 SWR	1:1 SWR	6:1 SWR	1:1 SWR	6:1 SWR
RG-58A	85	65	56	33	22	11
RG-8U	91	79	76	52	48	27
¾" 50-Ohm Hardline	98	93	93	81	83	63
450 Ohm Ladder line	99	98	98	91	91	79

Power in watts

Note: Assumes a 100W transceiver is connected to one of the transmission lines above with an appropriate load

[Reference ARRL QST June Year Unknown, Page 2, "Let's Talk Transmission Lines", Edward J. Farmer, AA6ZM]

Comparative Losses for ½" CATV Hardline (dB/100 feet)

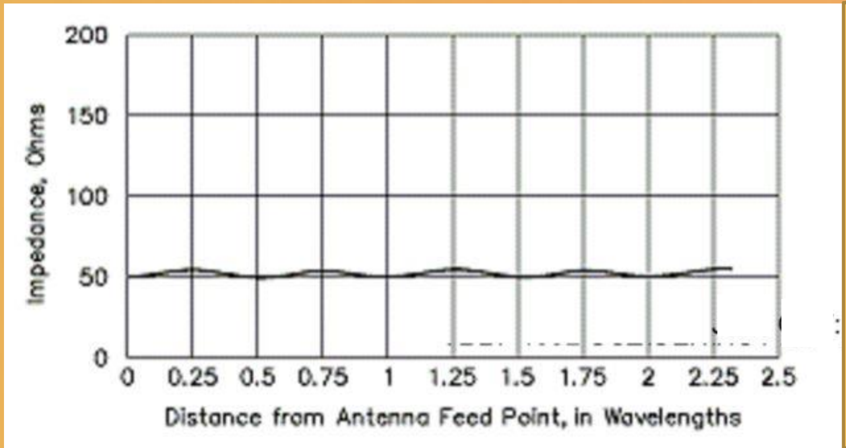
Frequency (MHz)	RG-8	LMR 600	½" Hardline	½" CATV (75-Ohm)
50	0.9	0.6	0.5	0.5
144	1.5	1.0	0.8	0.8
222	1.8	1.2	1.0	1.1
432	2.6	1.7	1.5	1.6

½" CATV losses not bad!

Reference QST January 2000, Emil Pocock (W3EP)The World Above 50MHz, "Using ½-Inch 75-Ohm CATV Hardline"

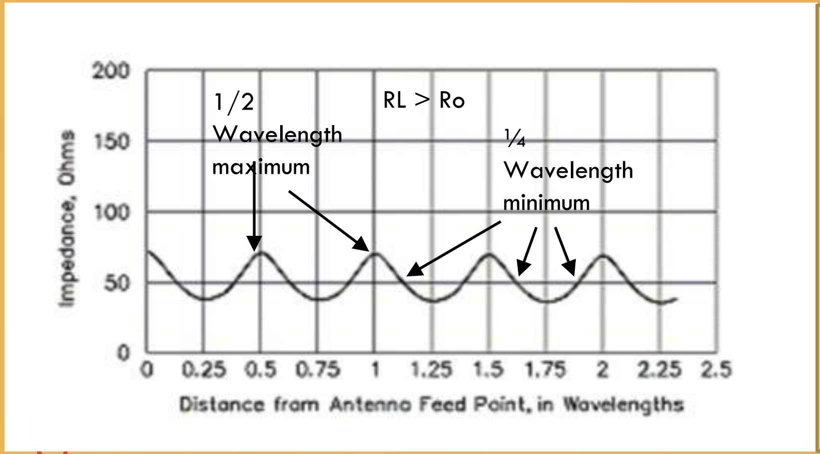
FEEDLINE ATTACHED TO ANTENNA

MATCHED 50 OHM FEEDLINE TO 50-OHM ANTENNA



Impedance varies along a near matched 50 Ohm feedline as one gets further from the antenna with minimal variation

50-OHM FEEDLINE ATTACHED TO 75-OHM ANTENNA



<u>Substantial</u> impedance variations occur along the length of the feedline

A difficult match can be helped by changing feedline length

When RL >Ro:
A maximum impedance point occurs every half-wavelength from the antenna.
A minimal impedance point occurs at every ¼-wavelength point between.
RL is load impedance and Ro is characteristic impedance

When RL <Ro:
The maximum and minimum impedance point swap places

Reference ARRL QST June Year Unknown, Page 2, "Let's Talk Transmission Lines", Edward J. Farmer, AA6ZM

FEEDLINES

- Feedline loss increases with frequency - the higher the frequency, the higher the loss
- Length of feedline is another factor to consider - the longer the line, the greater the loss
- Standing Wave Ratio (SWR) which is the amount of energy returning to your transceiver due to radio waves either combining, adding or subtracting from each other affects feedline loss. The higher the SWR, the greater the standing wave along the feedline resulting in lost RF energy. [Hams measure SWR using an SWR meter in line with their transceiver and antenna.]
- Using the loss table in the ARRL Antenna Handbook, one can calculate the loss in one's feedline
  - To calculate the additional losses due to the SWR that will be imposed on the line, one must calculate the SWR for the feedline.
  - Second, one must find the 'additional losses' from the graph in the ARRL Handbook
  - Finally, one must add up all the losses

My antenna analyzer (Rig Expert AA-170) can measure and provide two complex impedances for my feedline

ANTENNAS & FEEDLINE RESONANT FACTS

- **Impedance Z=R +/- jX Ohms where jX is either +XL or –XC [Rectangular form]**
- **An antenna at resonance has capacitance reactance (XC) cancelled by the inductive reactance (XL) and the net affect is R (resistance)**
- **If the operating frequency is “below” resonance, the capacitive component dominates**
- **If the operating frequency is “above” resonance, the inductive component dominates**
- **Example: A wire antenna “shorter” than required for resonance is “capacitive”, while a wire antenna “longer” than resonance is inductive**

Reference ARRL Handbook, Section “Radio Fundamentals”

PROPOSE 7 WAYS TO UTILIZE CATV HARDLINE FOR AMATEUR APPLICATIONS

Seven methods for using CATV Hardline for the Radio Amateur:

1. Do Nothing
2. Tune Antenna to 75-Ohms & use CATV Hardline with characteristic impedance of 75-Ohms
3. Cut CATV Hardline to a multiple of half wavelength at the operating frequency
4. Add 50-Ohm resistors to each end of hardline
5. Build a Quarter-Wave transformer
6. Build a Twelfth-Wave transformer
7. Building Broadband 50-to-75 Ohm transformer

*Most of these steps require converting the CATV hardline impedance from 75 Ohms to 50 Ohms
**In all cases, must adapt connectors (PL259, SO239, etc) to fit this CATV hardline

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METHOD 1: DO NOTHING & USE CATV HARDLINE "AS IS"

- The easiest way to use CATV hardline is to not worry about the mismatch; however, we must contend with higher than perfect impedance results in:

1. Higher SWR with increased losses results in less power output at antenna
   - Significant impedance variations & loss with length (Reference previous graph)
   - HF transceiver or RF amplifier may not be able to match the impedance presented and will "faults out" or reduce output power because of the mis-match of the tuned input circuits in modern ham equipment and antenna/feedline
2. Distortion may be transmitted on output signal (not good, potential FCC violation)

The solution to the mismatch problem is to match the impedance of hardline with the transceiver/amplifier. How do we do this? We must transform the feedline to the correct impedance (Details follow)

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METHOD 2:
TUNE ANTENNA TO 75-OHMS

- **Must begin by making initial measurements to obtain baseline impedance of antenna**
- **Re-tune antenna to 75-Ohms – will transceiver respond with full power? Let the rough ends drag…! Be it what may!**
- **Multiband antennas will be affected – not all bands will accurately tune**
- **Mis-match may still be present due to 50-Ohm impedance of transceiver/amplifer**

- Definitely not a good solution -

May be able to use with single amateur band

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METHOD 3: CUT HARDLINE TO A MULTIPLE OF HALF-WAVELENGTH AT THE OPERATING FREQUENCY

- Regardless of characteristic impedance of a feedline and where it is terminated, it repeats every half-wavelength along the line
- If an antenna of 50-Ohm is connected to one end of a feedline; that is, an exact half-wavelength, 50-Ohm will show up at the far end

Steps:

1. Adjust antenna to exactly 50-Ohms
2. Cut hardline to a multiple of a half-wavelength
3. Add temporary connector to each end
4. Add 50-Ohm dummy load to one end or use 50-Ohm antenna
5. Connect antenna analyzer to other end, select frequency, and make measurement at specific frequency to be used
6. Trim hardline if necessary and continue to make measurement with antenna analyzer until SWR approaches 1:1 to 1.3:1 SWR trimming hardline
7. Permanently install connectors
8. Use half-wavelength 50-Ohm coax at each end to attached to hardline

CATV hardline used for a single band @ VHF

Reference URL: https://www.qsl.net/lu5akf/N1BUG Web Using 75 Ohm Hardline at VHF.htm

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METHOD 4: ADD RESISTORS TO A PIECE OF ½-WAVE CATV HARDLINE

- Must begin by making initial section of CATV hardline about an electrical half wave longer at the frequency of operation
- For 160m, length could be 250’ longer to reach antenna making this method non-practical for lower bands
- Best suited for use on 10m, 6m, 2m, 70cm, and higher frequencies
- What about HF Bands?

Not a good solution for high power uses

[Reference URL: w9xt.com/page_/radio_gadgets_hardline.html, “Using 75-Ohm CATV Coaxial Cable”]

METHOD 4: METHOD TO ADD RESISTORS TO A PIECE OF 1/2 WAVE CATV HARDLINE

- **Lay out hardline making longer than needed making it about an electrical half wave longer at the frequency of operation**
- **Install connector at the shack end**
- **Strip off about ¾ inch of the outer conductor and insulation**
- **Attach a small 50 Ohm resistor between the center conductor and outer shield**
- **Use an antenna analyzer (Rig Expert) and measure the impedance (Probably will not read 50 Ohm resistive)**
- **Prune down the hardline until you get the 50 Ohm resistive reading**
- **Install a connector at antenna end and use regular 50 Ohm the rest of the way to the antenna**

Resistors must be small, but cannot handle high power operations – Suited for 2m, 6m, 70cm, etc

[Reference URL: w9xt.com/page_/radio_gadgets_hardline.html, “Using 75-Ohm CATV Coaxial Cable”]

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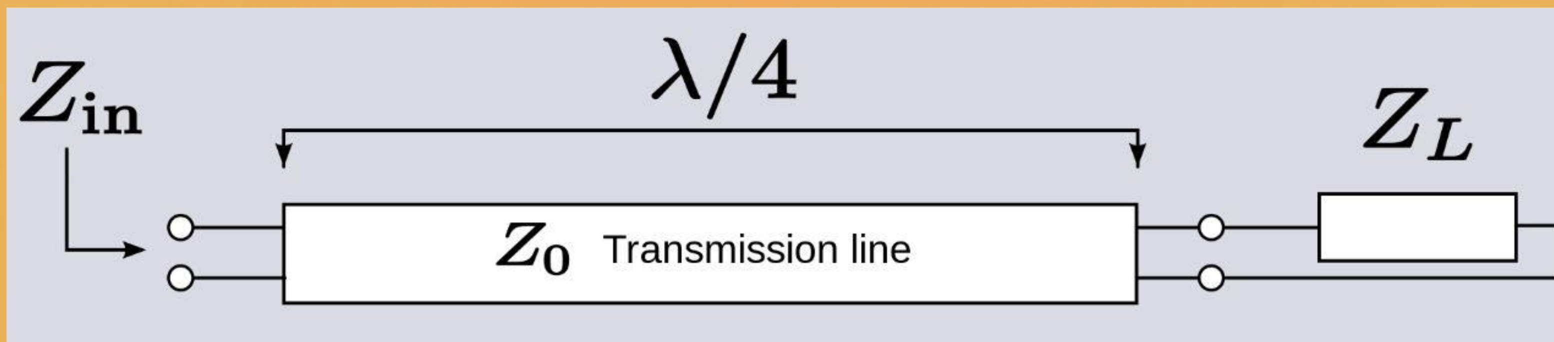
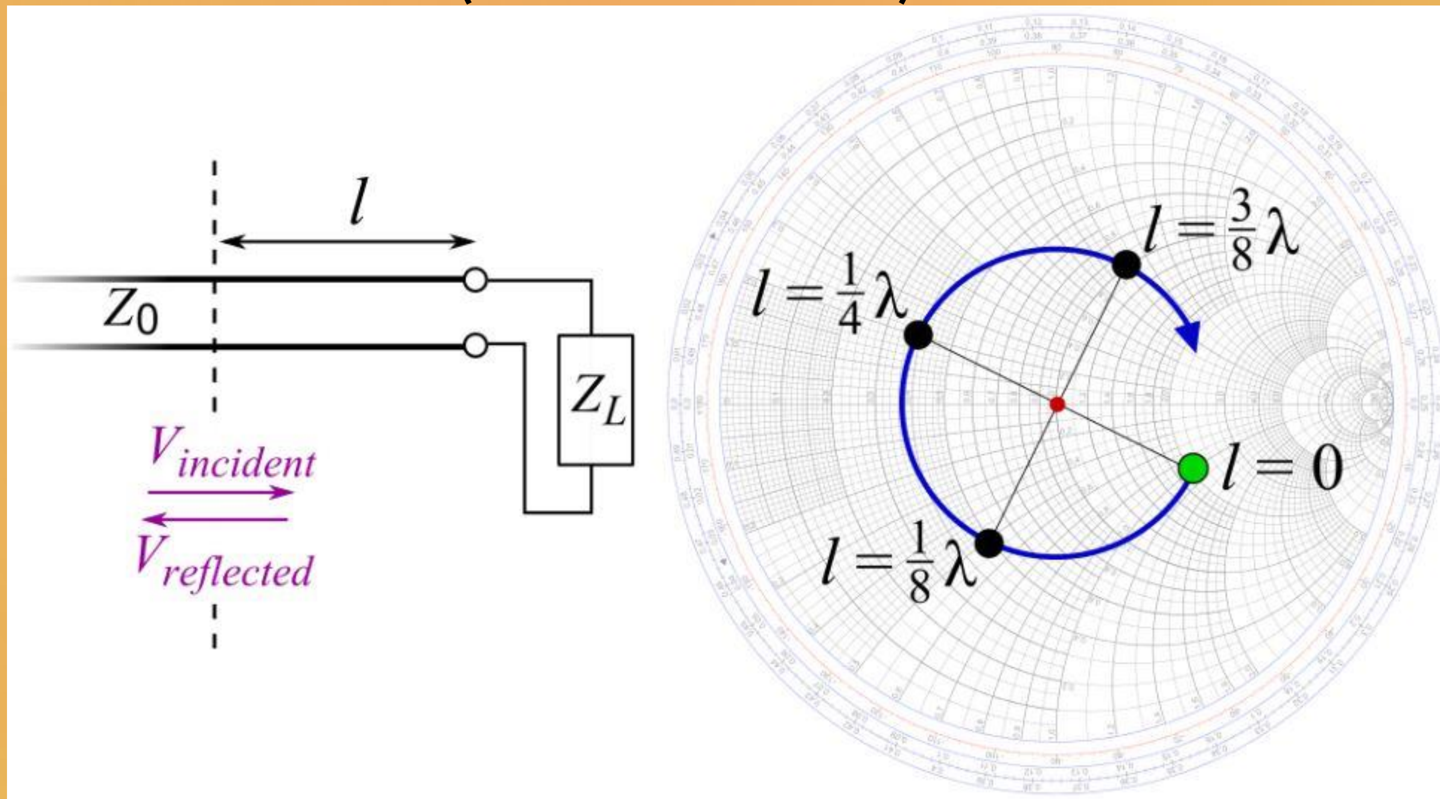
METHOD 5:
USE A QUARTER-WAVE (1/4) TRANSFORMER



- Quarter-wave (1/4-wave) impedance transformer is a transmission line of length one-quarter wavelength terminated with some known impedance presented at its input the dual of the impedance with which it is terminated
- 1/4-wave transformer is a predetermined length and the termination is designed to produce the required impedance
- If the impedance and characteristic impedance of a feedline to be matched are known, the characteristic impedance needed for a ¼-wave matching section is expressed as:
- $Zin=Z_LZ_o$ where Z is the characteristic impedance needed for matching and Z_L is antenna impedance and Z_o is characteristic impedance of the line which is to be matched [Reference 2018 ARRL Handbook, Page 20.14]

METHOD 5:
¼-WAVE TRANSFORMER ILLUSTRATED
(SEE SMITH CHART)

Z_0 - *characteristic impedance*
Z_{in} *input impedance*
Z_L – *load impedance*
l – *Length of transmission line*



- **Looking toward a load through *l* of lossless transmission line, normalized impedance changes as *l* increases (Blue circle)**
- **At *l*=1/4 wavelength, normalized impedance is reflected about the center of the chart**

METHOD 5: QUARTER-WAVE (1/4) TRANSFORMER CALCULATIONS

- **Quarter-wave transformer is a section of transmission line whose impedance is equal to the square root of the product of the two impedances being matched**
- **Transformer is cut to a 1/4 of the free space wavelength at desired frequency**
- **Z = Square Root (50-Ohm X 75-Ohm) = 61.2 Ohm**
- **Add 61.2 Ohm impedance matching section to each end of 75-Ohm CATV hardline**

50- Ohm Rig	61.2 Ohm Match Section	75-Ohm CATV Hardline	61.2 Ohm Match Section	50- Ohm Antenna
	17.57 feet long		17.57 feet long	

- **¼ Wave (feet) for 20m band = 246/f (MHz)= 246/14.000 = 17.57 feet**
- **For 432Mhz, length is about 6 inches**

Tuned for a single band

Reference 2018 ARRL Handbook, Pages 20.14-20.15

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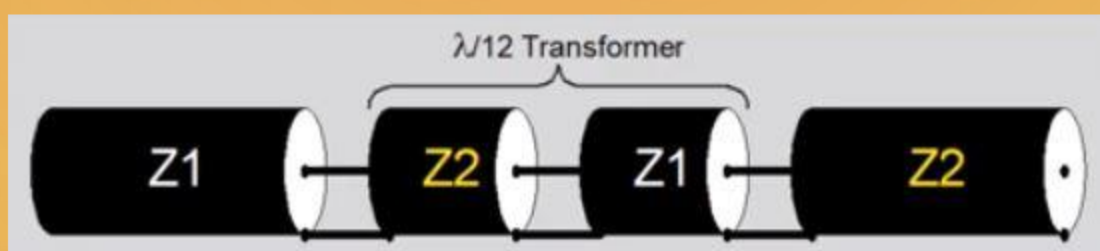
METHOD 6: USE A TWELFTH WAVE TRANSFORMER

Introduced in the 1950’s by Paul Bramham at the CERN European Org for Nuclear Research, “A Convenient Transformer for Matching Coaxial Lines


ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

- **Place a 1/12 wave transformer at the antenna and transceiver ends of CATV**
- **This allows a long run of low loss CATV hardline to be used with low SWR for antennas and transceivers designed for 50 Ohm impedance systems**
- **Ratio of impedances matched is 1.5:1**
- **Electrical length of 2 coax lines to be matched is .0815 wavelength (29.3 degrees) quite close to 1/12 (.0833) resulting in name of “Twelfth” wave**
- **Works on one band at a time**



Reference 2: ARRL QST Nov 2019, Pages 42-43, “About…Impedance Matching with Transmission Lines and 2018 ARRL Handbook, Page20.15

TWELFTH-WAVE IMPEDANCE THEORY

- If the feedline is a multiple of a half wavelength, it can be used to our advantage when the antenna & feedline are differing impedances
- The impedance at the far end will be reflected on the near end; thus, our 50 Ohm antenna at the other end of the 75 Ohm will appear as 50 Ohms to the transmitter
- This will happen on <u>one</u> frequency, but is close enough to cover most frequencies of a <u>single</u> ham band (Narrowband match)

DETAILS OF MAKING A 1/12TH WAVE TRANSFORMER FOR CATV HARDLINE

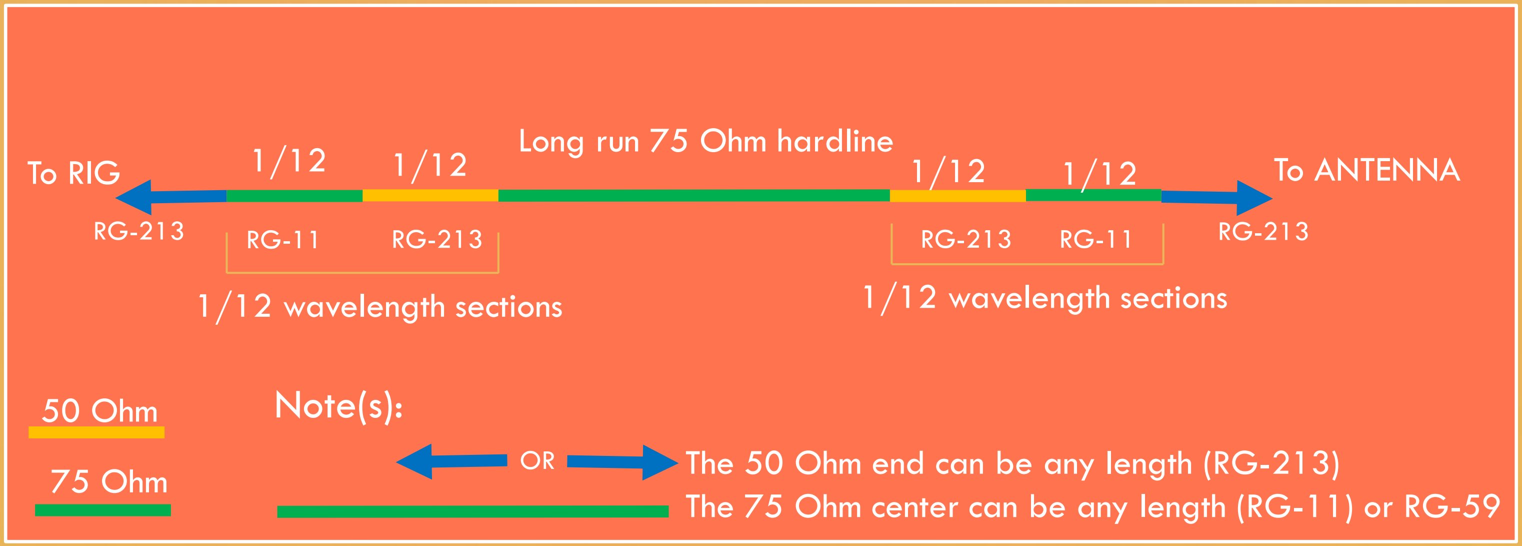


Figure: 50:75 Impedance transformation

Impedance transformation can be achieved by using two sections of 1/12 wavelength feed line using impedance transforming effects of transmission lines

Reference URL: http://w9xt.com/page_radio_gadgets_hardline.html

FORMULA FOR CALCULATING LENGTH OF COAX FOR 1/12TH WAVE

- Wavelength = 300/f (Mhz)
- Velocity factor (Vf is a correction value) needed for calculation physical wavelength of cable
- Calculate the length in free space for the wavelength & frequency of operation, then multiply that length by the velocity factor to find physical length of coax needed
- Typical Vf [velocity factors] are .66 and .90 (RG-213 & LMR400, respectively) of the free space length
- Physical Length of needed coax: L = [(S * W *Vf)/f]/12

L equals length in meters or feet
S equals speed of light in free space (use 300 for meters or 984 for feet)
W equals number of wavelength desired (1, .5, etc.)

FORMULA FOR CALCULATING ESSENTIAL LENGTH OF COAX FOR 20M

- Example at 14.000Mhz
- Typical Vf [velocity factors] are .66 (RG-213) and .90 (LMR-400) of the free space length
- Physical Length of needed coax: L = [(S * W *Vf)/f]/12

  [984 * 1 * .66)/14.000]/12 = 3' 8" (RG-213)

- Length of matching impedance coax needs to be 3 feet 8 inches long at antenna end and transceiver end

L equals length in meters or feet
S equals speed of light in free space (use 300 for meters or 984 for feet)
W equals number of wavelength desired typically .0815
Vf is the velocity factor
F is frequency in MHz

North Alabama DX Club

1/12 WAVE LENGTH TRANSFORMER LENGTHS

Band	Vf of .66	Vf of .79 (foam)
160m	68' 5 ½"	35" 8 ¼"
80m	14' 8"	17' 7"
40m	7' 5"	8" 10"
20m	3' 8"	4' 6"
15m	30"	36"
10m	22"	27"
6m	1' 1"	1' 3 ½"
2m	4 ½"	5 ¼"
70cm	1 1/2 "	1 ¾"

Lengths based of this formula as previously discussed: L = [(S * W *Vf)/f]/12

L equals length in meters or feet
S equals speed of light in free space (use 300 for meters or 984 for feet)
W equals number of wavelength desired typically .0815
Vf is the velocity factor
F is frequency in MHz

SPREADSHEET CAN HELP WITH TRANSFORMER DESIGN

Twelfth-Wave Matching Transformer

Matching Coaxial Lines of Different Impedances

Based on an article by Darrel Emerson, AA7FY, http://ourworld.compuserve.com/members/demerson/twelfth.htm

where Z_1=Line 1 impedance in Ohms

Z_2=Line 2 impedance in Ohms

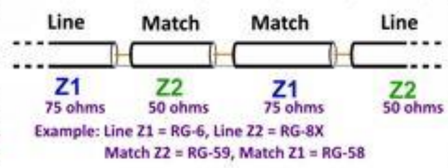
L_{Z1}=Length of Matching section for Z_1

L_{Z2}=Length of Matching section for Z_2

Vf1=Velocity Factor of Z1 Matching Section

Vf2=Velocity Factor of Z2 Matching Section

NOTE: Lengths and VF of the lines to antenna are unimportant



Equations:

$B = Z_1 / Z_2$

$L = [\arctan(\mathrm{sqrt}(B/(B2+B+1)))]/(2\cdot\pi)$

NOTES:

(1) *Make sure you use the Velocity Factors for the exact type of cables used for the " matching section pieces*
The Vf depends on the dielectric: poly, foam, PTFE etc. For example RG58 may be 0.78 (foam) or 0.66 (The Wireman RG58B/U)
See http://www.repeater-builder.com/antenna/wa2ise-coaxial-cable.html , https://thewireman.com/products.html, https://www.dxengineering.com
For the small lengths needed for matching sections, it may be worth it to buy new cable to be sure.
Cable Vf and Z also may be measured. See W2AEW's YouTube video #162.

(2) *The author recommends using the equation for ratios of 10:1 or less due to SWR bandwidth, cable losses, and maximum power capability*

Matching Sections:

Enter Characteristic Impedances of line sections Z1 and Z2

Enter Velocity Factors of matching sections Z1 and Z2

Solve for $L_{(Z1)}$ and $L_{(Z2)}$

Section1 Line Z	75	Ω	Matching Section Impedance
Section2 Line Z	50	Ω	Matching Section Impedance
Section1 Match	0.66		"Matching Section cable Vf
Section2 Match	0.66		"Matching Section cable Vf
Freq.	14.175	MHz	
LZ1 Match	44.7	Inches	Matching Section Length
LZ2 Match	44.7	Inches	Matching Section Length

Math Area

B calculation			Wavelength calculation		
Z1	75	Freq	#####	MHz	
Z2	50	λ	21.16	meters	
B	1.5				

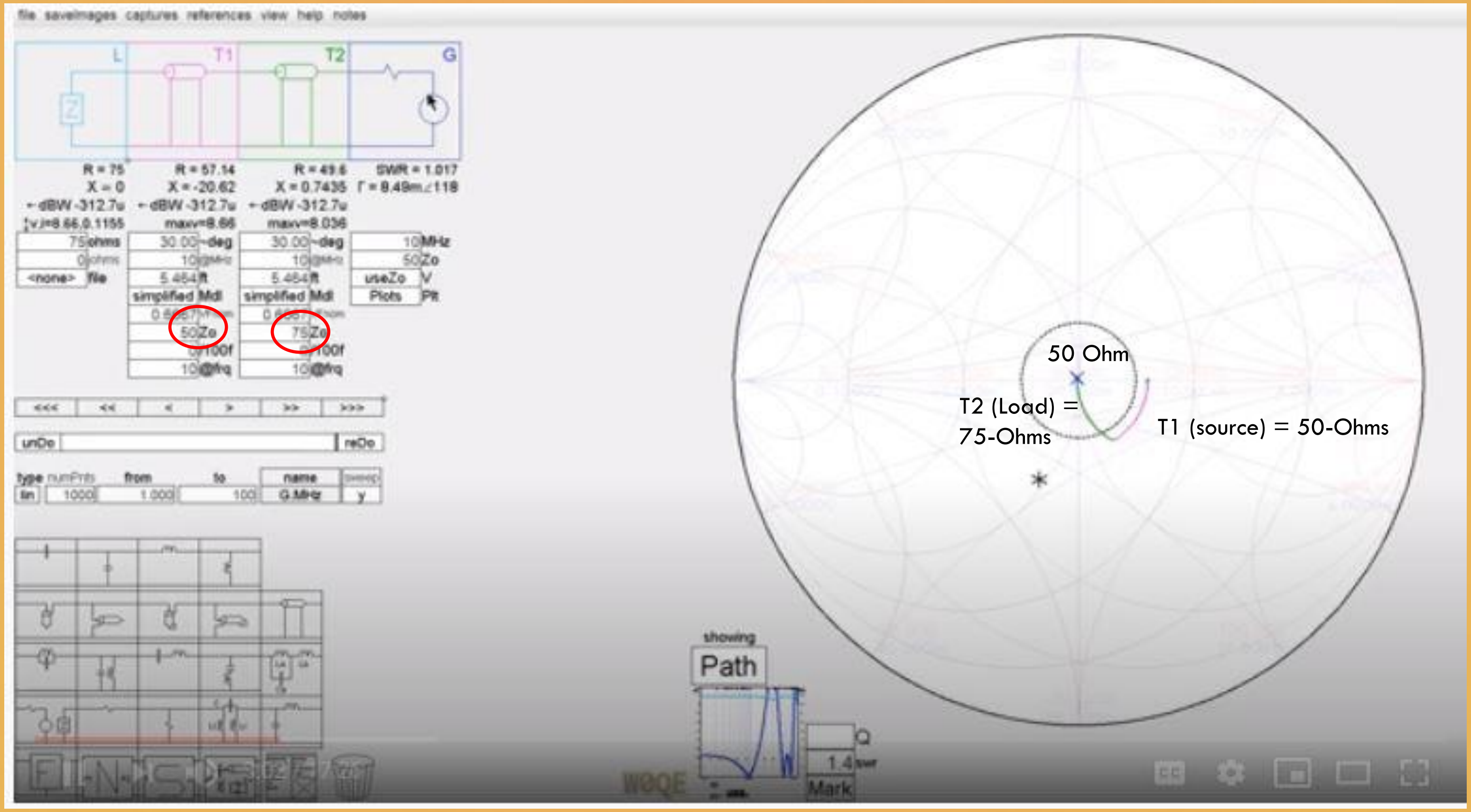
L unadjusted calculation in wavelengths

Step1	4.75	Step3	0.512
Step2	0.3158	Step4	0.0815
Step3	0.562	L	0.0815

L_{Vf1}	0.0538	wavelengths
L_{Vf2}	0.0538	wavelengths
L_{Vf1}	44.738	inches
L_{Vf2}	44.738	inches

Reference URL: Article by Darrel Emerson, AA7FY, QST, June 1997, “The Twelfth-Wave Matching Transformer”, pages 43-44 and https://www.qsl.net/kx4om/Techsolutions/12th-wave/

SIMSMITH PLOT 75-50 OHM 1/12TH WAVE TRANSFORMER



- 75-Ohm feedline and 50-Ohm feedline make-up 1/12-wave transformer
- Center of circle 50-Ohm point, T1 (source), T2 (Load)
- Correct length of 50-Ohm coax & length of 75-Ohm coax in series with long run CATV hardline feedline results in 50-Ohms feedline transformation
- SimSmith allows for tweaking & optimizing length of 50-Ohm & 75-Ohm coax sections

HOW MANY 12TH WAVE SECTIONS ARE REQUIRED?

- **Dipole: Approximate feed point impedance is 70-Ohm to 75-Ohm; only one 75-to-50 Ohm 12th-Wave transformer is needed at the shack entry end of the feedline**
- **Yagi/Beam antenna using gamma match of 50-Ohm, two 12th-wave transformers are required; one for 50-to-75 Ohm at the antenna and one for 75-to-50 Ohm at shack end of feedline**

Twelfth-Wave Transformer is only good for one HF Band

MAKING A 1/12TH WAVE TRANSFORMER FOR 20M (14.000 MHZ)

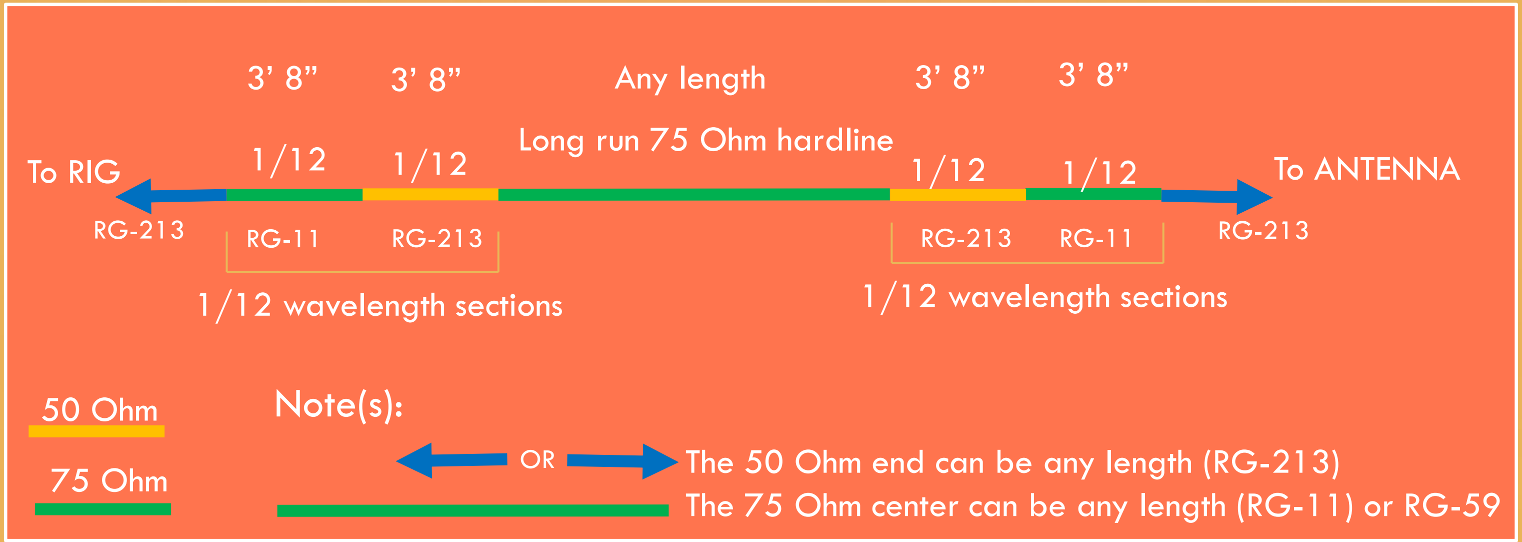


Figure: 50:75 Impedance transformation

Impedance transformation can be achieved by using two sections of 1/12 wavelength feed line using impedance transforming effects of transmission lines

Covers a single band

PROPOSE 7 WAYS TO UTILIZE CATV HARDLINE FOR AMATEUR APPLICATIONS

Seven methods for using CATV Hardline for the Radio Amateur:

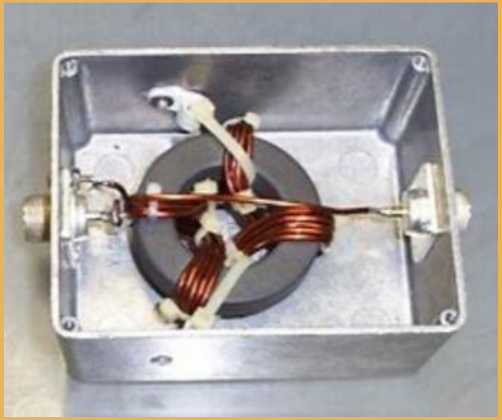
1. Do Nothing
2. Tune Antenna to 75-Ohms & use CATV Hardline with characteristic impedance of 75-Ohms
3. Cut CATV Hardline to a multiple of half wavelength at the operating frequency
4. Add 50-Ohm resistors to each end of hardline
5. Build a Quarter-Wave transformer
6. Build a Twelfth-Wave transformer
7. Building Broadband 50-to-75 Ohm transformer

*Most of these steps require converting the CATV hardline impedance from 75 Ohms to 50 Ohms
**In all cases, must adapt connectors (PL259, SO239, etc) to fit this CATV hardline

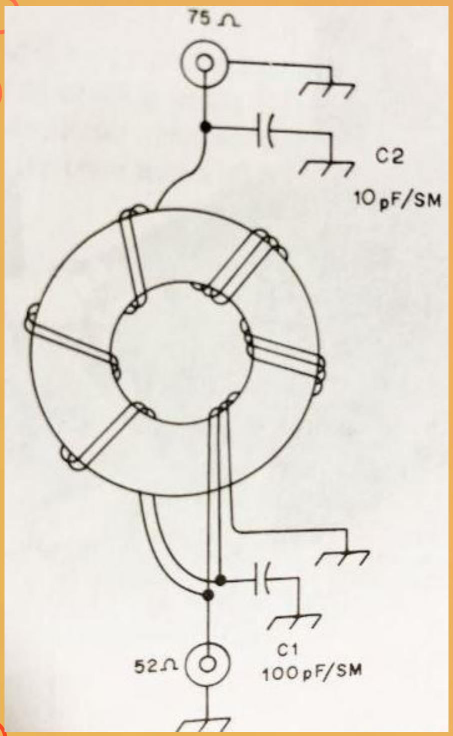
METHOD 7: BUILD A 50-TO-75 OHM BROADBAND TRANSFORMER

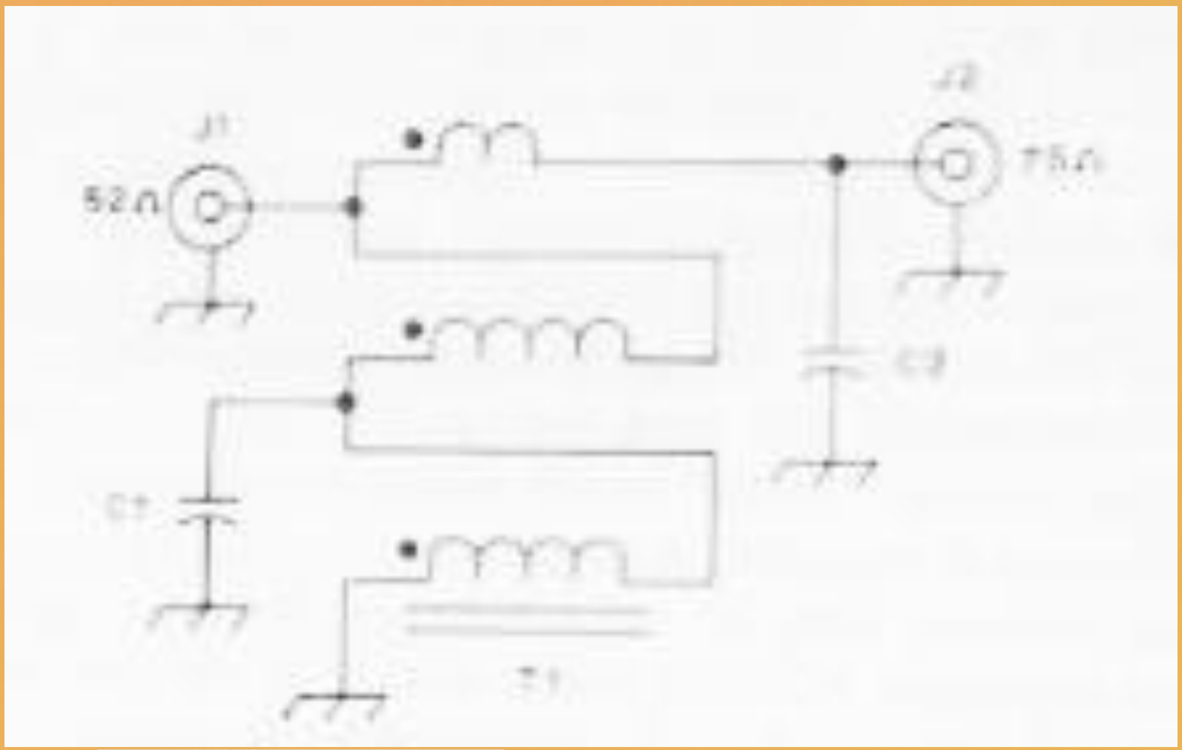
- **Allows operation on multiple bands (1.8 - 60 MHz)**
- **Installs at each end of the CATV hardline**
- **Handles full power 1500W**
- **Insertion loss: Negligible**
- **SWR: Better than 1.1:1 entire BW**

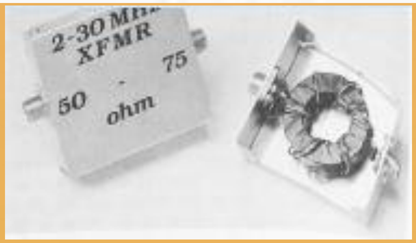
AS-75-1 Array Solutions or AS-75-50-1 (custom-built)
UN-UN transformer 5KW Capable
$299 (need 2each; one at each end of CATV hardline)



SCHEMATIC OF A 50-TO-75 OHM BROADBAND TRANSFORMER







Reference ARRL Antenna Book, 16th Edition

Can be used on multiple HF Bands

ADAPTING TO CATV CONNECTOR

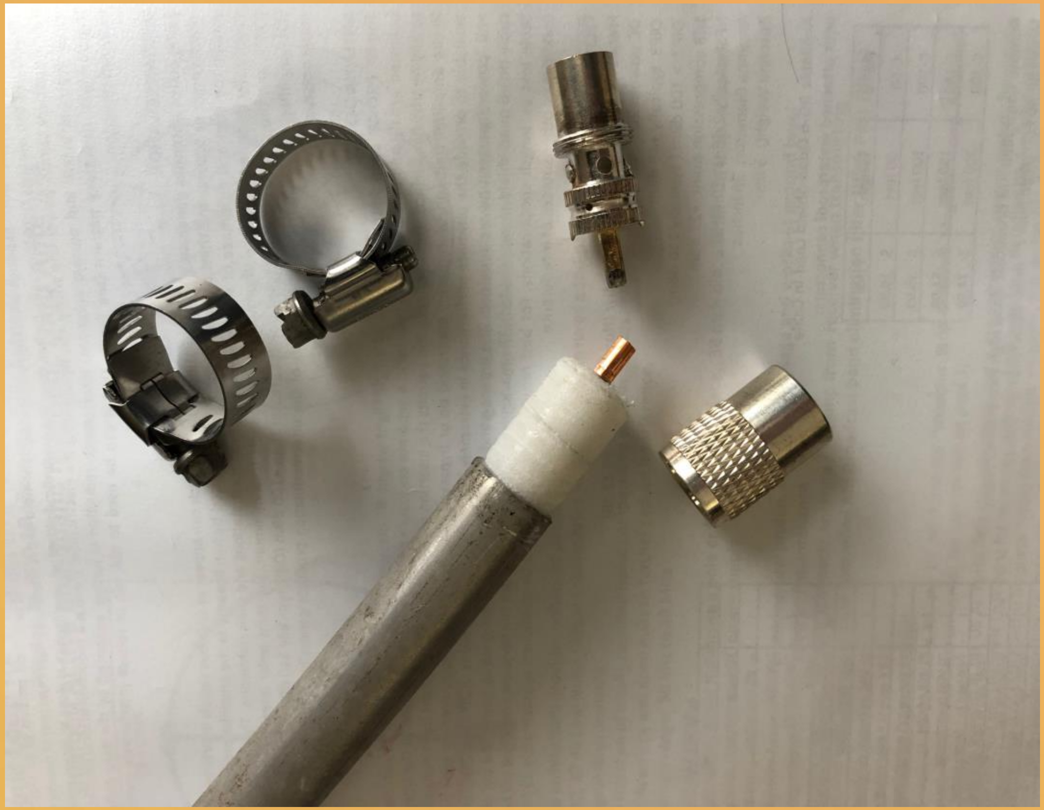
Requires a method to install a connector on the hardline

- Use of a barrel connector and hose clamp with RTV sealant (Fits inside ¾" CATV Hardline
- There are designs on the internet for fabricating CATV hardline connector(s)

<u>NOT</u> the best method to connect to 75-Ohm CATV Hardline

FABRICATION OF A ½” CATV HARDLINE CONNECTOR

½” CATV hardline is easy to make a connector using PL-259



½” CATV hardline center conductor can be inserted and soldered to PL-259 center conductor

Slotted Aluminum sleeve to be slid over hardline and barrel of PL-259 and tightened with stainless steel hose clamps

But AC4G has ¾” CATV Hardline…does anything change? How do I mate to it?

The “Q” of ¾” CATV hardline is higher than ½” CATV hardline, so no worries!

FABRICATION OF A 3/4" CATV HARDLINE CONNECTOR

Below is how to assemble the connector –

Connector plug center pin is being soldered to the cable center pin via a 1/2" length of 1/4" copper tubing (used in ice maker installation)

Insert dielectric material to hold ¼" tubing in place

Thread on the Aluminum shield coupler and secure with self-tapping stainless screws ground flat

Parst to assemble ¾" CAYV hardline connector

Completed connector

Reference www.eHam.net/articles/23136

CONCLUSION

- **Ham operators can use 75-Ohm CATV hardline for running long coaxial runs with low losses rather than accepting long-run losses using garden variety coaxial cables**
- **The ham operator must be willing to"**
  - **Transform mismatched feedlines and to amateur equipment using impedance match techniques discussed**
  - **Fabricate connectors in order to use CATV hardline**
- **All methods discussed (except broadband transformer) work on a single band or on bands that are harmonically related such as 144 and 432 or 14 and 28 MHz**
- **50-to-75 Ohm Broadband transformers are most versatile for DX'ers allowing 75-Ohm CATV hardline to be used covering multiple HF BANDS**
  - **Broadband transformer method is not economically feasible to purchase, but is the best method if one makes their own broadband transformer with in-house spare parts/components**

Requires additional research but broadband transformers seem to be best for AC4G HF needs

REFERENCES

- ARRL QST Nov 2019, Pages 42-43, H.W. Silver, "About…Impedance Matching with Transmission Lines
- Chapter on Transmission Line System Techniques, ARRL Antenna Book & ARRL Handbook
- ARRL QST, 1973, Walter Maxwell, W2DU, "Another Look at Reflections"
- ARRL QST, 1978, "Matching Transformers"
- ARRL QST, January 1980, Pages 43-43, Doug DeMaw, "Hints and Kinks from Abroad"
- ARRL Antenna Handbook
- RADCOM (RSGB Journal) October 1971, Technical Topics", Pat Hawker G3VA
- ARRL QST, Vol 81, No.6, June1997, Pages 43-44, Darrel Emerson, "The Twelfth-Wave Matching Transformer
- CERN 59-37 Nuclear Conference, November 1959, Paul Bramham, "A Convenient Transformer For Matching Co-Axial Lines"