

Morrow County ARES

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How to get the best signal out, for the least work and least \$

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- 60 years combined experience on HF
- built (not "bought") hundreds of dipoles
- we made all the mistakes - you don't have to
- this applies to Field Day OR your back yard...

Highlights:

- Why is a dipole best?
- Dipole myths
- The ideal dipole
- Efficiency
- Feeding it
- SWR
- Antenna "tuners"
- Antenna tuner capability
- Feeding your antenna properly
- Baluns
- The G5RV
- The "real G5RV"
- POOR alternatives to the simple dipole
- GOOD alternatives to the simple dipole

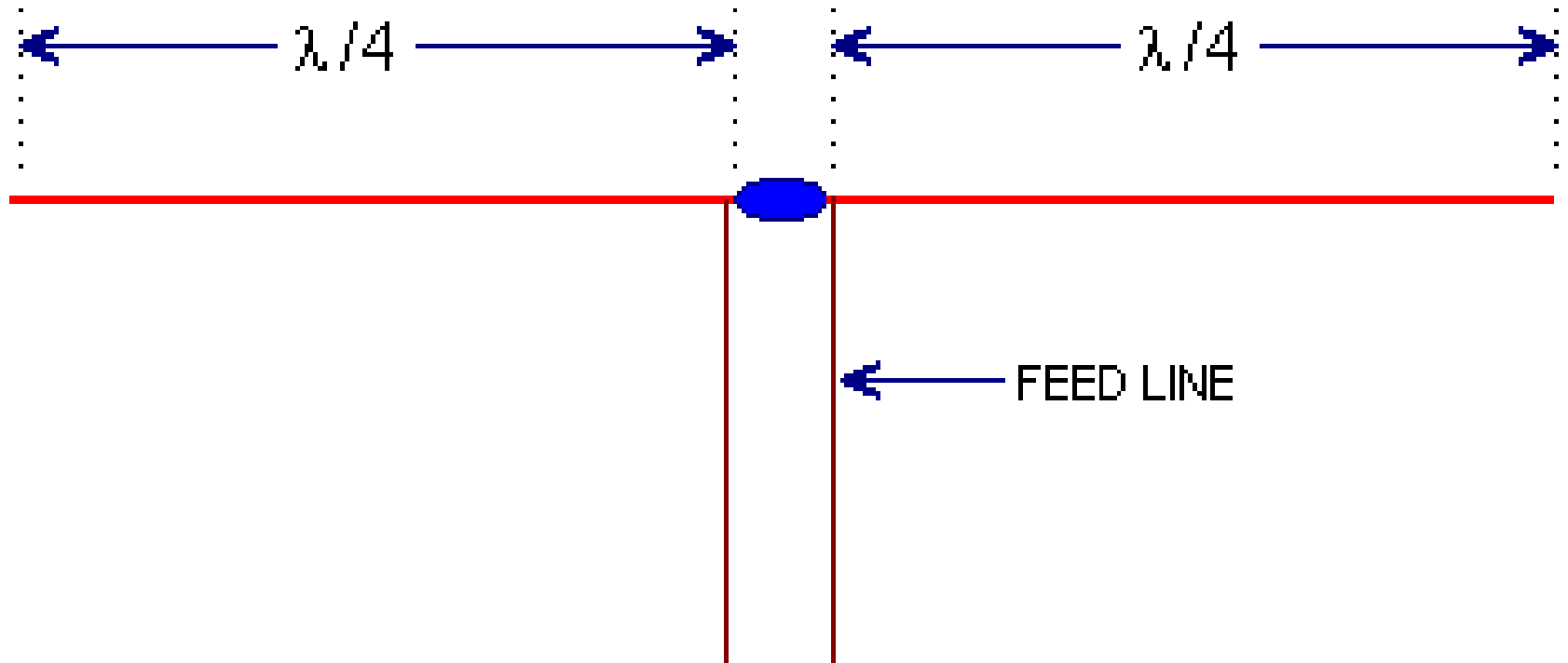
Terminology

- "**wavelength**" ($1W$ - $1/2w$ - $1/4w$ - etc.) - wavelength is in meters, just like ham bands
- "**balanced feedline**" = open wire or ladderline from antenna to within 3' of the transmitter
- "**impedance**" = the combination of inductance and capacitance that a transmitter or other device will "see" at a certain frequency - expressed in ohms

Dipole Length

- practical conversion formula (for feet) is **468/F**
- a 1/2W dipole for 40m would be 20m long (a meter is approximately 3 feet)
- OR $468/7.1\text{MHz} = 66 \text{ feet}$ (20 meters)
- you can just remember 40m = 66' - and then double or halve as necessary for other bands

The Humble Dipole



Why is a dipole best?

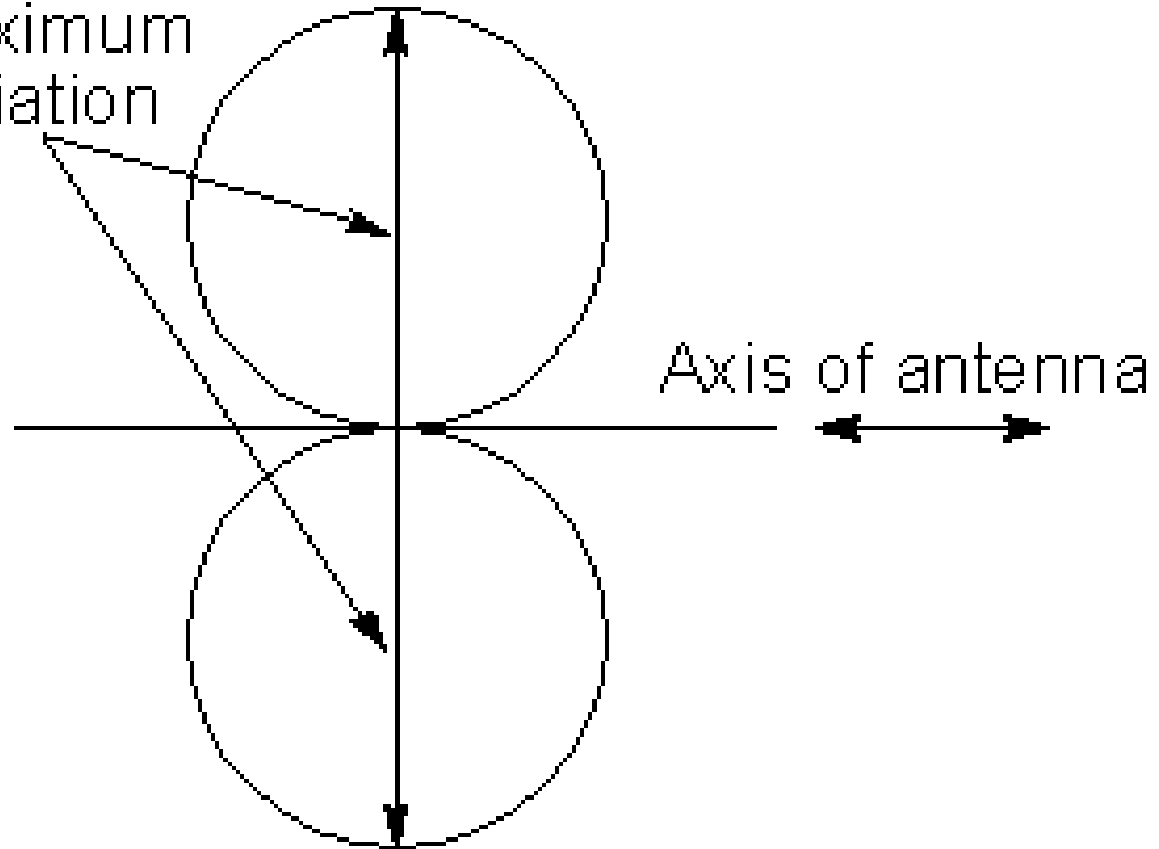
- (it may not be, especially on lower bands)
- close to the same shape as a radio wave in space
- you can often use existing supports, and/or one easily-erected center support
- adaptable - you can tilt it, drop the ends, etc. and it still works
- wire is cheap, and readily available
- it works well (matching) with your radio with relatively little adjustment

Dipole myths

- if my SWR is OK, I will get out OK
- If my SWR is bad, I won't get out OK
- inverted vees are as good, or better
- a G5RV works well on all bands

Directionality

Directions of maximum radiation



The Ideal Dipole

- $1/2\lambda$ long
- up in the air $1/2\lambda$
- fed with a $1/2\lambda$ long piece of coax, or any length balanced feedline (the Doublet)
- the feedline is perpendicular to the antenna
- 50 ohms impedance presented to the transmitter, and 100% efficiency

Efficiency

- efficiency is related to “radiation resistance”:

“that part of an antenna's feedpoint resistance that is caused by the radiation of electromagnetic waves from the antenna”

- unfortunately, it can't be measured – but CAN be predicted
- a properly constructed (and erected) dipole is 90% efficient
- (don't forget that even if the efficiency is great, you can still use it up heating dirt, if the antenna isn't high enough...)
- we don't want anything, anywhere, to get **HOT**

Feeding it

- ideal feedline = open wire, 4" to 6" spacing (commercial broadcast)
- a more practical alternative = ladderline, 1" spacing
- capacitance is your enemy = related to loss
- [coax loss is not a significant problem with typical Field Day lengths of 100' or less]
- 1" ladderline = 2" hardline

SWR myths

Myth Number 1 : High SWR is bad –

- antennas that show high SWR are inefficient and do not radiate well
- **false!** – an antenna's efficiency is determined by the ratio of its radiation resistance to its total input resistance. Power reflected by the antenna travels back to the transmitter and is re-reflected back to the antenna

Myth Number 2 : Low SWR is good

- antennas that show low SWR radiate better
- **false!** – a dummy load has an SWR of 1.0 and it doesn't radiate at all
- a short vertical antenna with a radiation resistance of 0.1 ohm and a loss resistance of 49.9 ohms radiates only 0.2% of its input power but has an SWR of 1.0

What does SWR really mean?

- The antenna does not have an SWR - the feedline does
- SWR has very little to do with how well the other station hears you
- it is only a reflection (!) of how happy the transmitter might be
- unhappy transmitters will not work hard

The right way to match

- a "perfect" match is only good in a portion of a band, and only for today – QSY or weather can eliminate it
- when using balanced line, whatever is at the feedpoint is transferred directly to the tuner, without loss - where it can be matched to the rig
- coax can't do that, capacitance makes it a much more active part of the system, so the loss can be much greater

How to fix it *at the antenna*

- one more popular (but difficult and/or expensive) alternative is to use coax + a remote-controlled tuner at the feedpoint

OR

- a SteppIR Dipole!

the antenna "tuner" - that magic box next to (or inside?) your rig

- actually an "impedance matcher" or "**transmatch**"
- they actually match the antenna + feedline TO the rig
- the further away from 50 ohms the antenna + feedline are, the more reactance you will need to match it
- BUT - the more reactance you need to dial in, the higher the loss (**heat**)
- a tuner with balanced output terminals is not always a balanced tuner – if there is a balun in there, you have additional loss (**heat**)
- **we don't want anything, anywhere, to get HOT**

antenna tuner capability

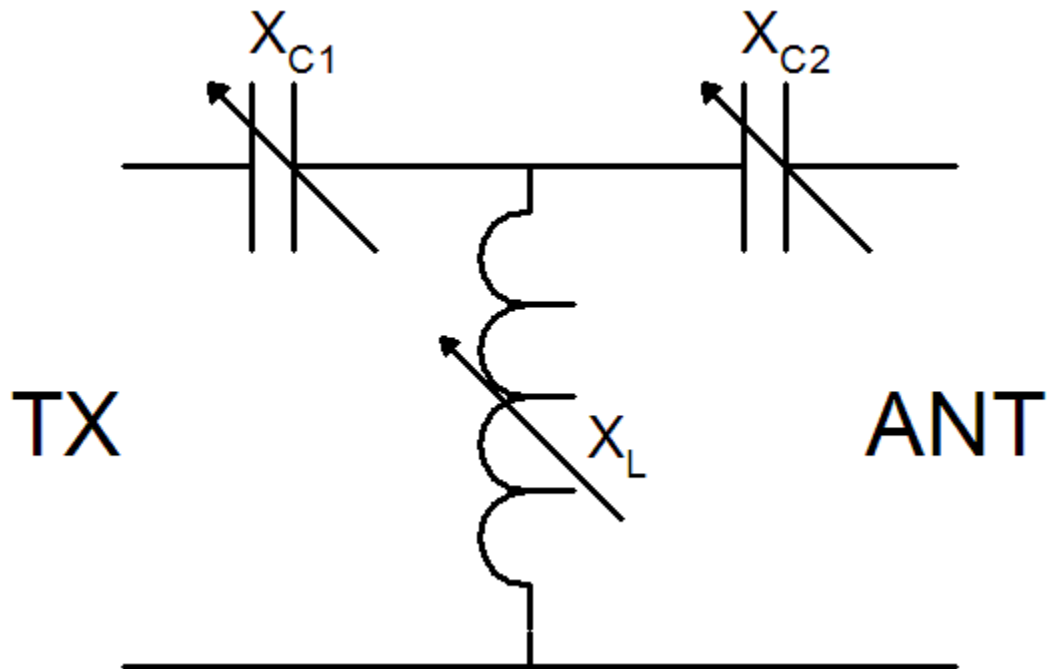
- greater mismatch = higher voltages and currents (and **heat**)
- **we don't want anything, anywhere, to get HOT**
- the limits of a tuner are the voltage and current ratings of it's components



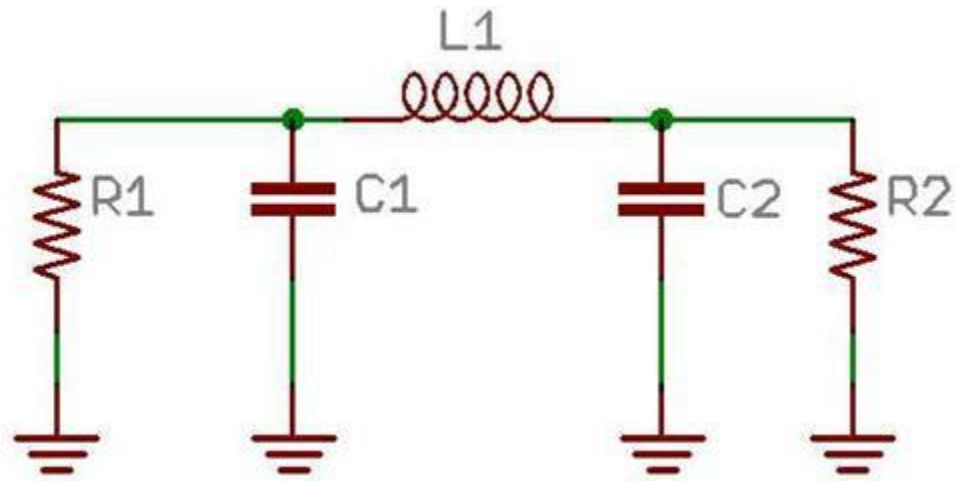
antenna tuner capability

- automatic tuners built on PC boards: circuit traces don't handle HV/current
- manufacturer ratings are hogwash - "watts" are not a valid measure
- example - a "300W tuner" matching 100W to a 15-ohm load will burn up
- building your own heavy-duty tuner is easy and educational!

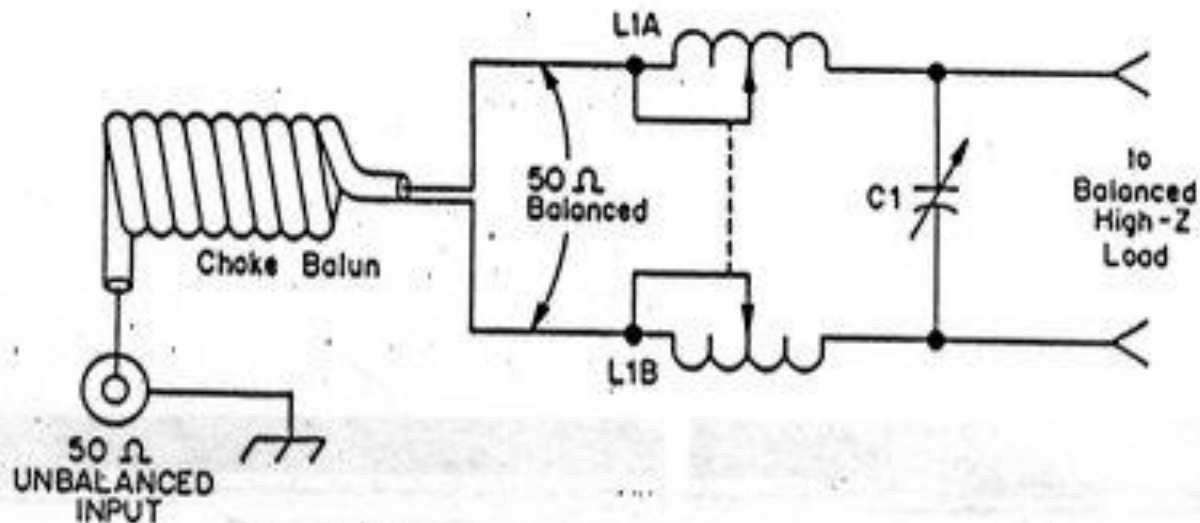
“T” Network



Pi Network



True Balanced Tuner



Balun: W2DU type choke balun, 12 inches of 50 ohm teflon coax cable and 50 ferrite beads.

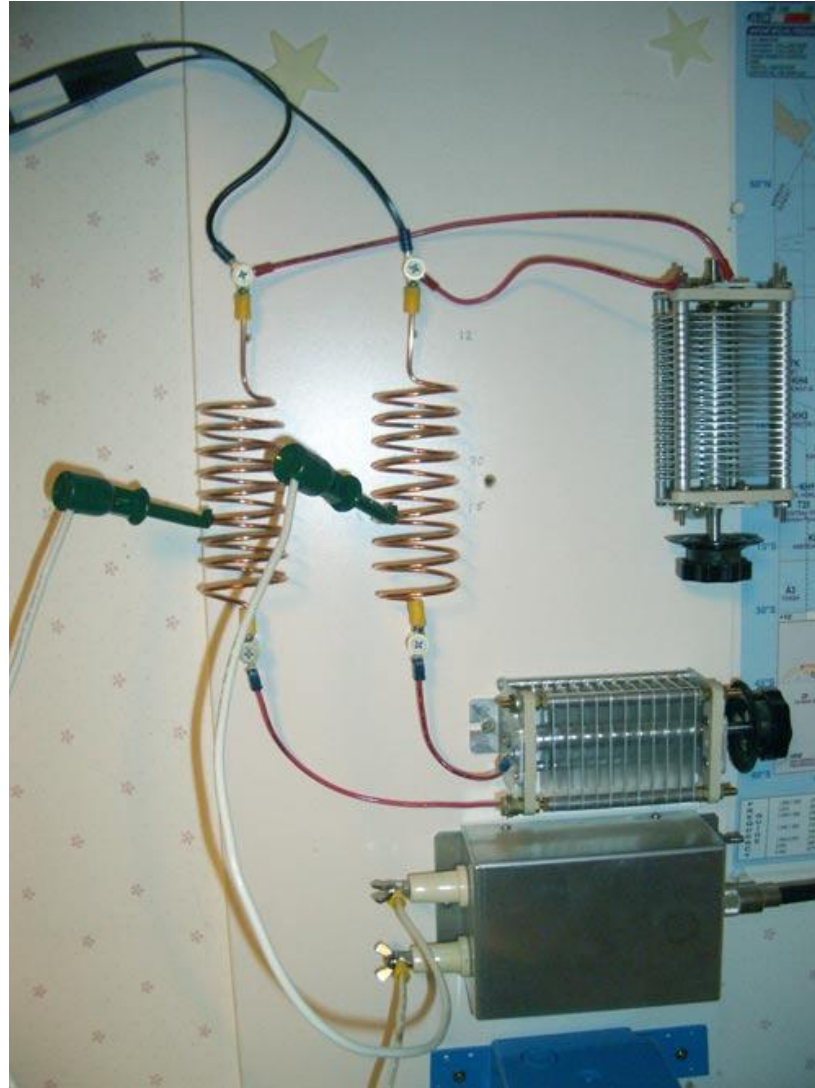
L1A & L1B: 20 or 28uH Roller Inductors, connected together with a miniature timing belt and two pulleys.

C1: 500pF 3.5 kV variable capacitor.

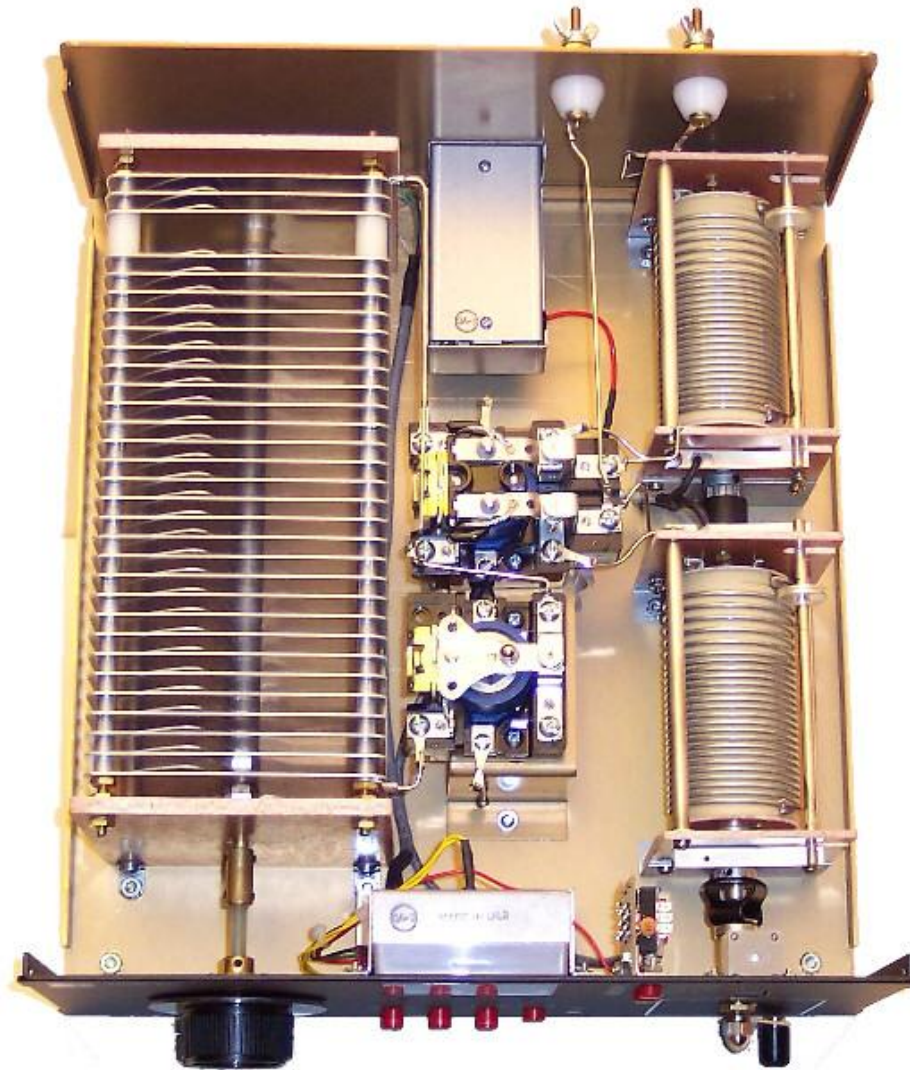
My First Tuner



My Second Tuner



My Third Tuner



My Last Tuner



My Present Tuner



“No thanks, I’m trying to quit..”

Feeding your dipole properly

The object of the game:

- create the best match to the rig by ***constructing the antenna and feedline properly in the first place*** - no tuner necessary

Bonus points:

- do this on multiple bands, with the least expense and effort

All the Balun You Need:



Baluns

- they are not necessary for a dipole in most cases
- they do NOT affect the radiation pattern significantly
- transformer-type baluns are built with heavy components, because they can get very hot = loss
- **we don't want anything, anywhere, to get HOT**
- best alternative - the "Ugly Balun" (10 to 20' of coax around an air core)

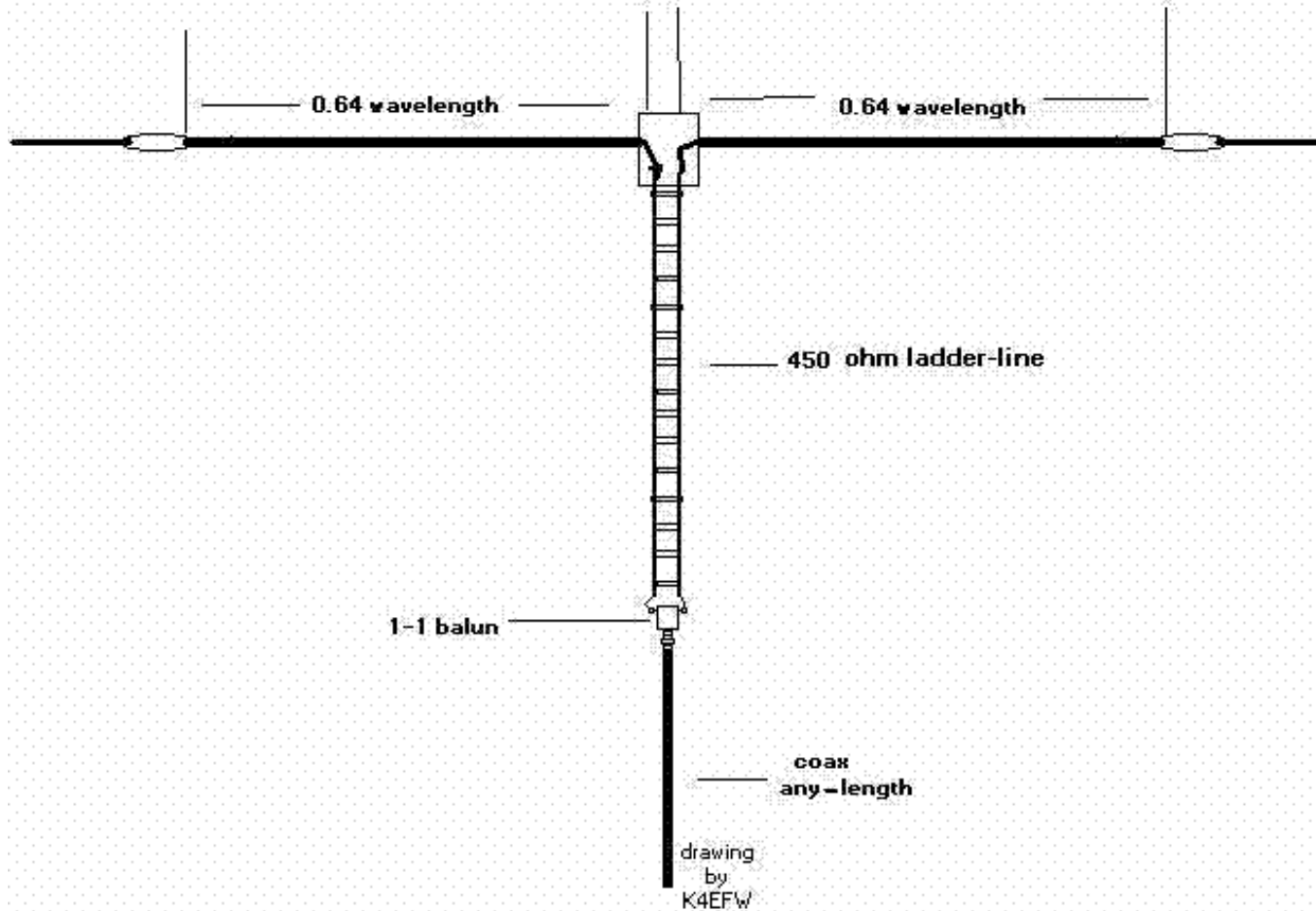
Traditional Transformer-Balun



The Ugly Balun



The G5RV



The G5RV - one size fits all?

- the idea: one antenna to cover 80-10 meters, with no tuner
- originally meant to be used on 20m only
– produces a cloverleaf pattern
- based on choosing odd (non-resonant) lengths of antenna and feed, so as to cause the least-terrible mismatches

The G5RV - one size fits all?

- there is nothing wrong with non-resonant antennas, but -
- if this really worked, no one would use anything else! Very lossy.
- the reality - it is a set of mismatches, some worse than others
- even when it works, it will not cover both ends of a band
- it is never good on 10m - and still needs to be up at least 45'

The "real G5RV" = The "Flat Top" or "Doublet" (as old as ham radio)

- just a simple dipole, but with balanced feed the whole way...
AND a tuner
- usable on any band - some will be better than others
- if it doesn't tune the way you like, cut an inch off the feedline and try again

Doublet

- it will never work on a band it is not at least $1/2w$ for
- best when it is CLOSE to $1/2w$ for the bands you want to use it on
- getting balanced line into the shack is a challenge
- lots of adjusting - not the quickest for band changes



POOR alternatives to the simple dipole

G5RV (previously covered)

Folded dipoles

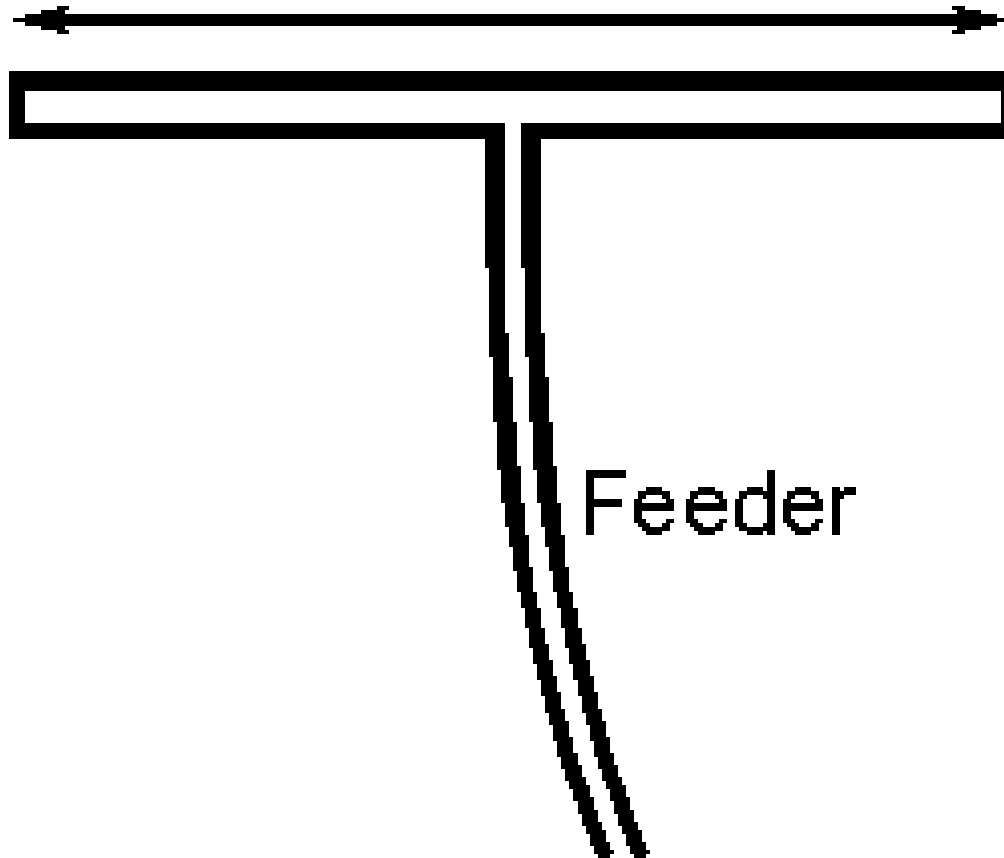
- supposedly lower noise on receive, more difficult to match, more expensive wire
- small ones used to come with FM radios -
- can be interesting if used with balanced feed/balanced tuner

T2FD - "tilted/terminated/folded/dipole"

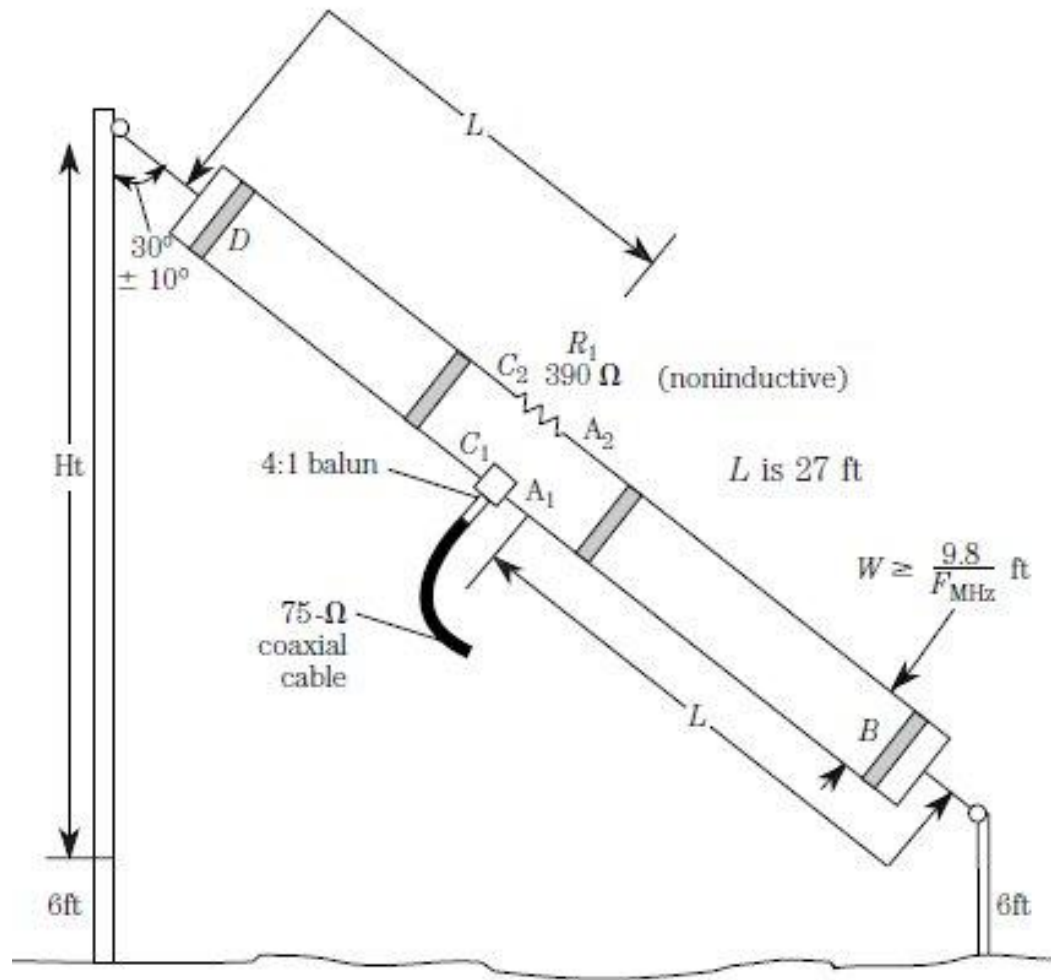
- commercial design, favored by military - halfway between a folded dipole and a loop, similar in concept to the G5RV - uses a heavy-duty terminating resistor...
- **(we don't want anything, anywhere, to get HOT)**
- covers 40 - 10m bands continuously - as with a G5RV, some bands better than others... but always good for receive.

Folded Dipole

Half wavelength



T2FD



POOR alternatives to the simple dipole

Carolina Windom

- yet another multi-band, non-resonant, compromise antenna - an off-center-fed version of the G5RV - vertical "matching" section radiates - works fine on some bands, if you are over high-conductivity soil, (not Ohio) OR lay a radial field under it, AND you can hoist it up high enough - beware of those heavy baluns...

Shortened dipoles

- coil loading = loss.
- (we don't want anything, anywhere, to get **HOT**)
- linear or capacitive loading is not too bad
- for 80/160, just use a vertical instead

Linear Loading

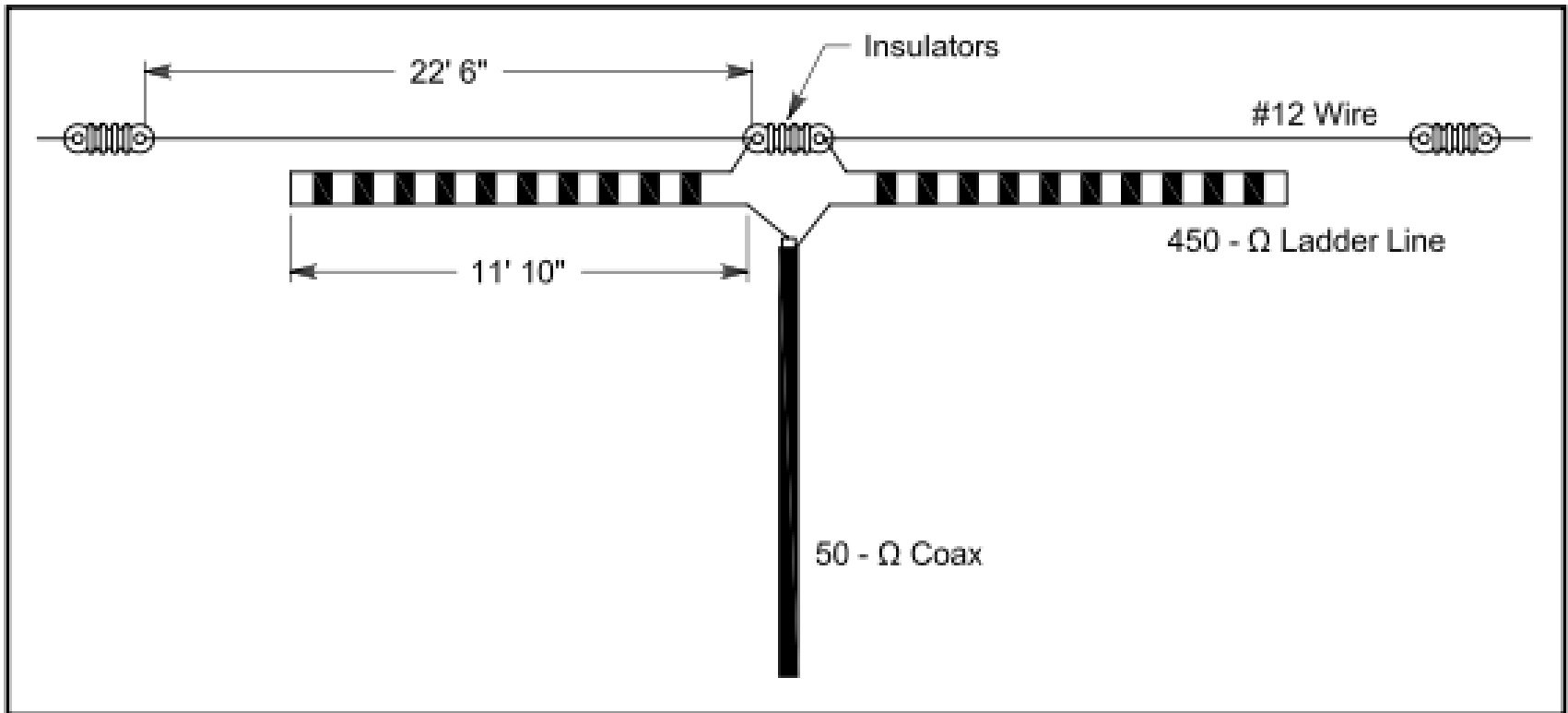
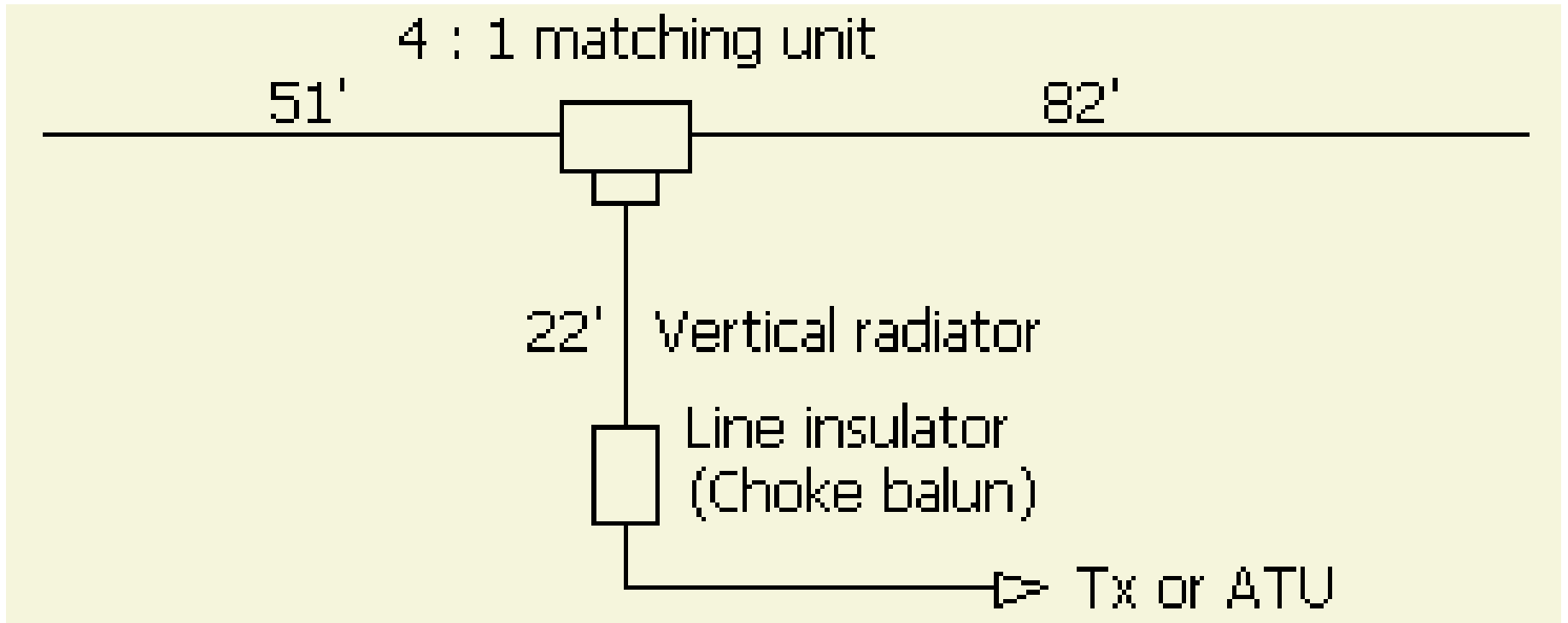


Figure 1—Layout of K4VX linear-loaded dipole. Although the #12 wire is threaded through the 450-Ω window line to support it, this is not shown in this drawing for clarity.

Carolina Windom



POOR alternatives to the simple dipole

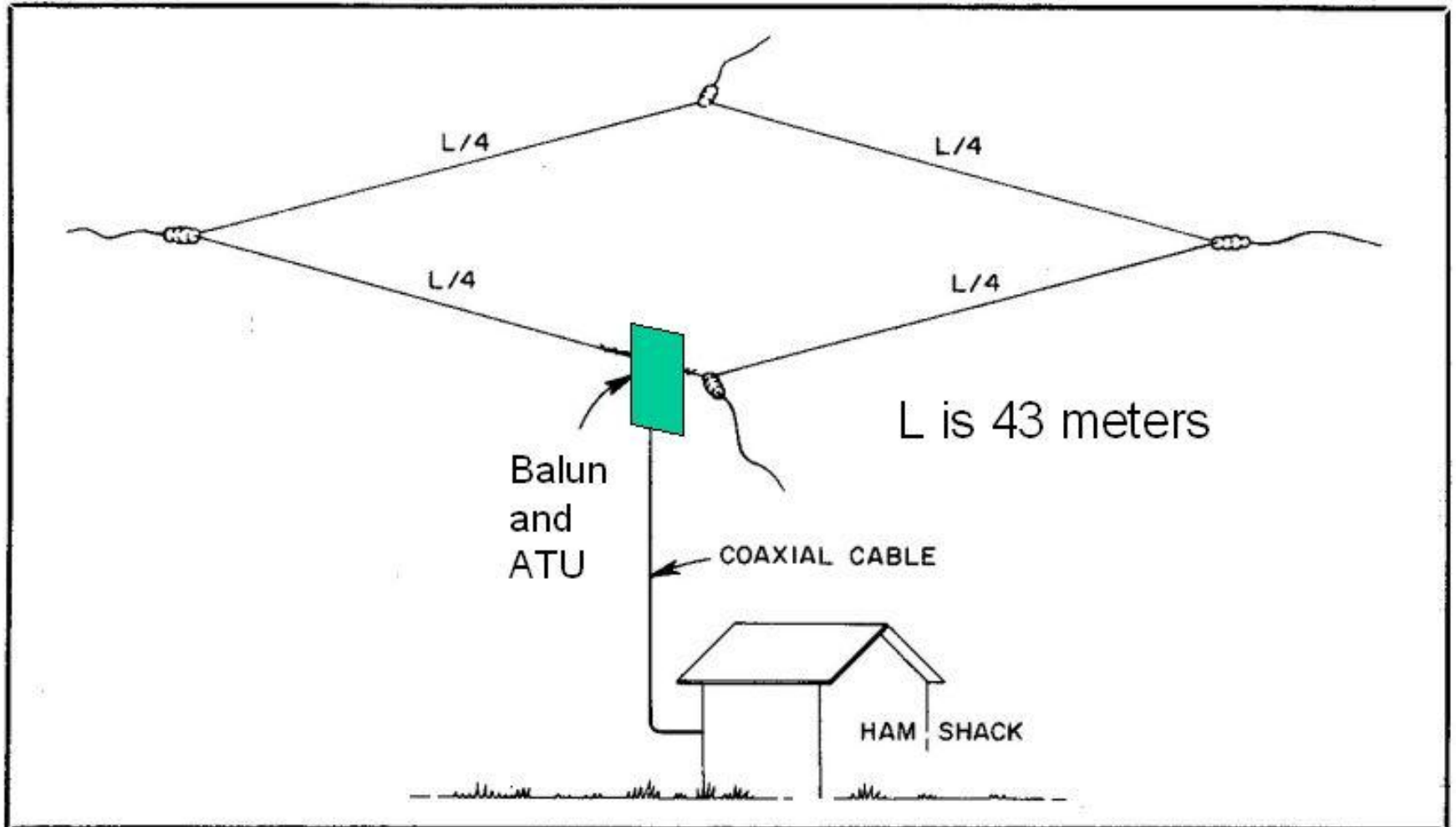
NVIS antennas - skywire loops, etc.

- not bad, if your **ONLY** goal is 100-200 mi. away on 80 or 40m
- can be very useful on Field Day, in conjunction with a high dipole
- DX is possible if you put it up high enough
- most dipoles in use by hams are already NVIS, because they aren't up high enough - half your power is used to heat up dirt
- **(we don't want anything, anywhere, to get HOT)**

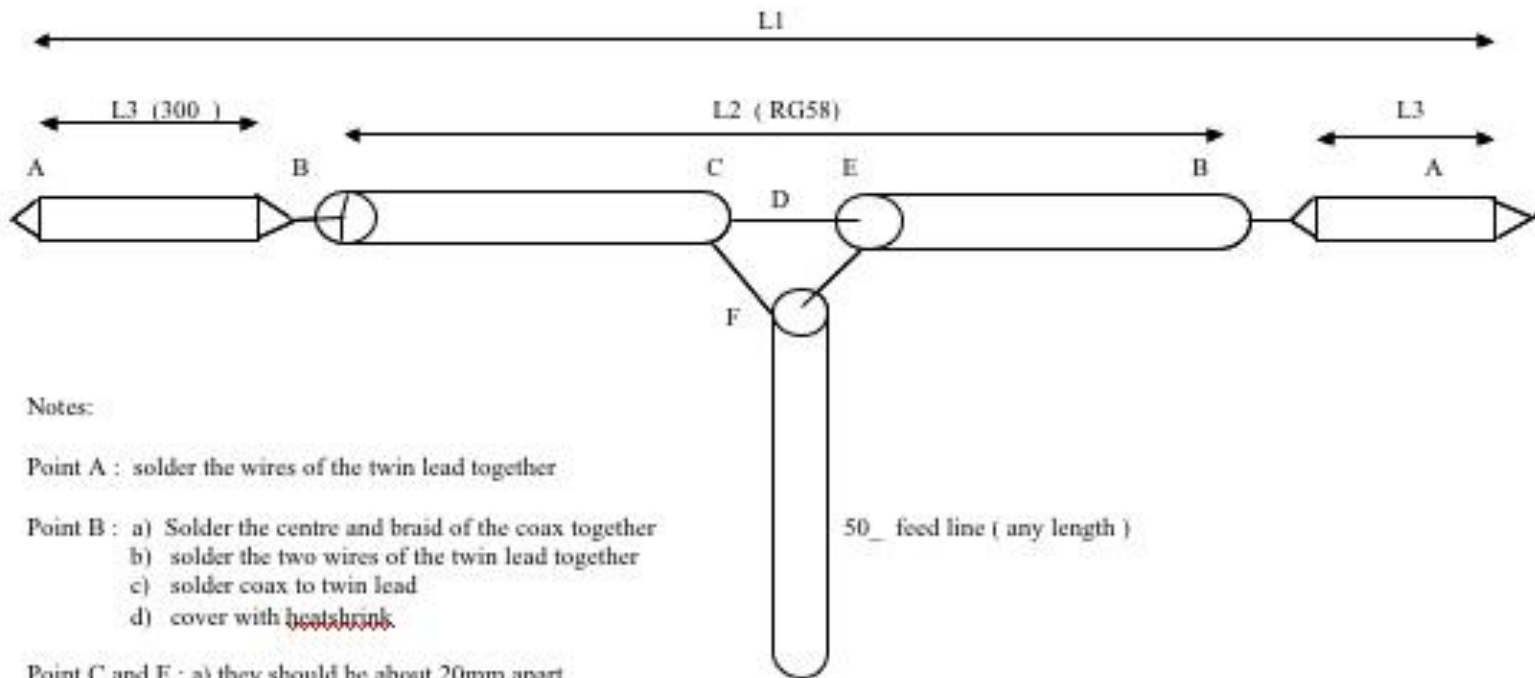
Double Bazooka

- promises greater bandwidth
- a lot of work and expensive wire, just to get an antenna that is heavier and less efficient than a simple dipole

The Loop Skywire



Double Bazooka



Notes:

Point A : solder the wires of the twin lead together

Point B : a) Solder the centre and braid of the coax together
 b) solder the two wires of the twin lead together
 c) solder coax to twin lead
 d) cover with ~~heatshrink~~

Point C and E : a) they should be about 20mm apart
 b) strip off outer cover
 c) cut braid and connect Braid at C to Braid at F, and braid at E to centre conductor at F

Point D : Centre conductor is continuous through this joint

Support points (by clamping etc) C, E and F to reduce strain

GOOD alternatives to the simple dipole


Doublet or Flat Top [previously covered]

Inverted Vees

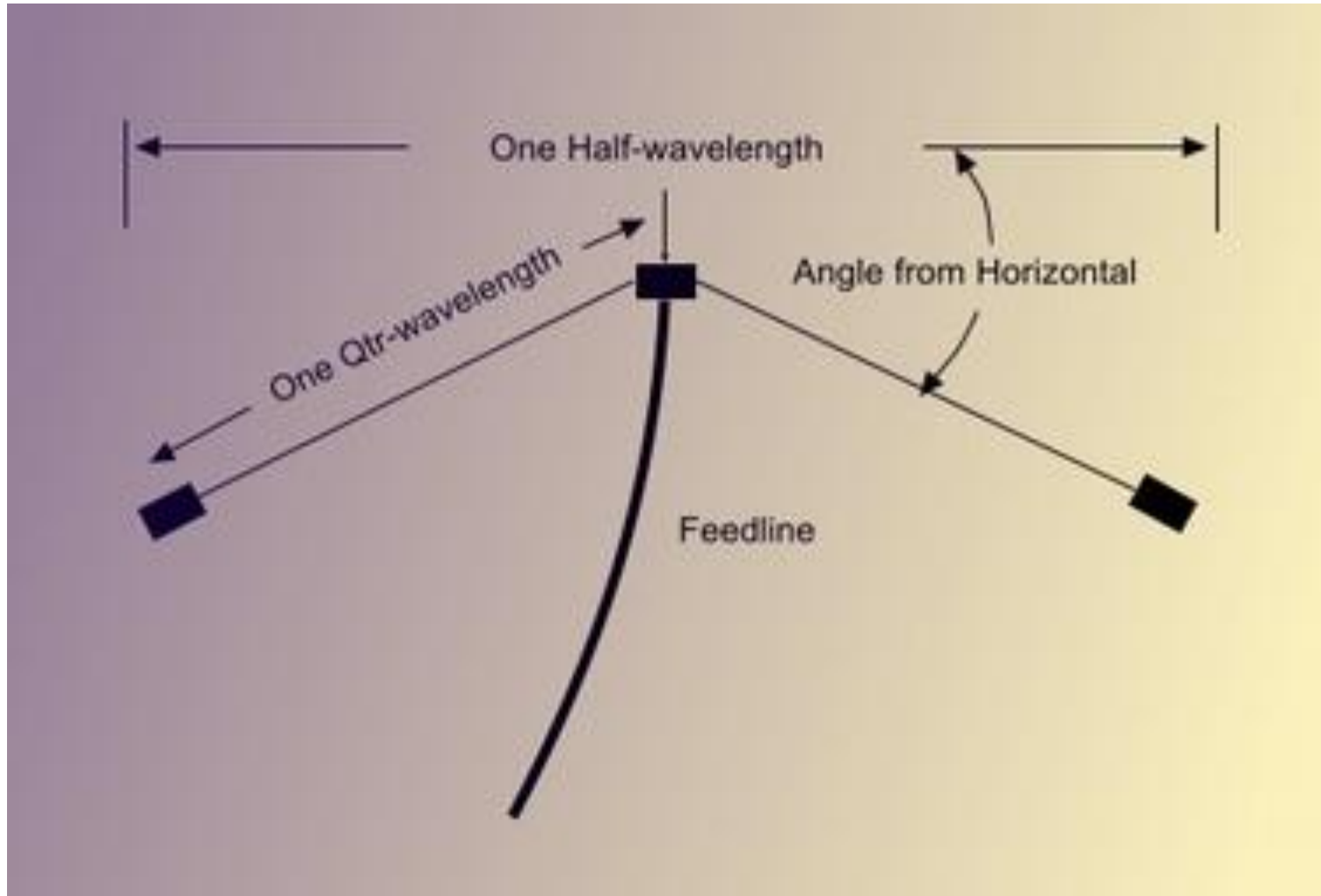
good if you only have one high support - but:

- the angle needs to be 90 degrees or greater
- the feedpoint still needs to be at least $1/2w$ high
- the ends still need to be at least $1/4w$ high

Lots of dipoles!

-  why not? 18ga. copperclad wire is cheap

Inverted Vee



GOOD alternatives to the simple dipole

Fan dipoles

- VERY nice - more work cutting/tuning due to interaction
- works to cover both ends of a band too
- the supports get tricky with more than 2 bands.

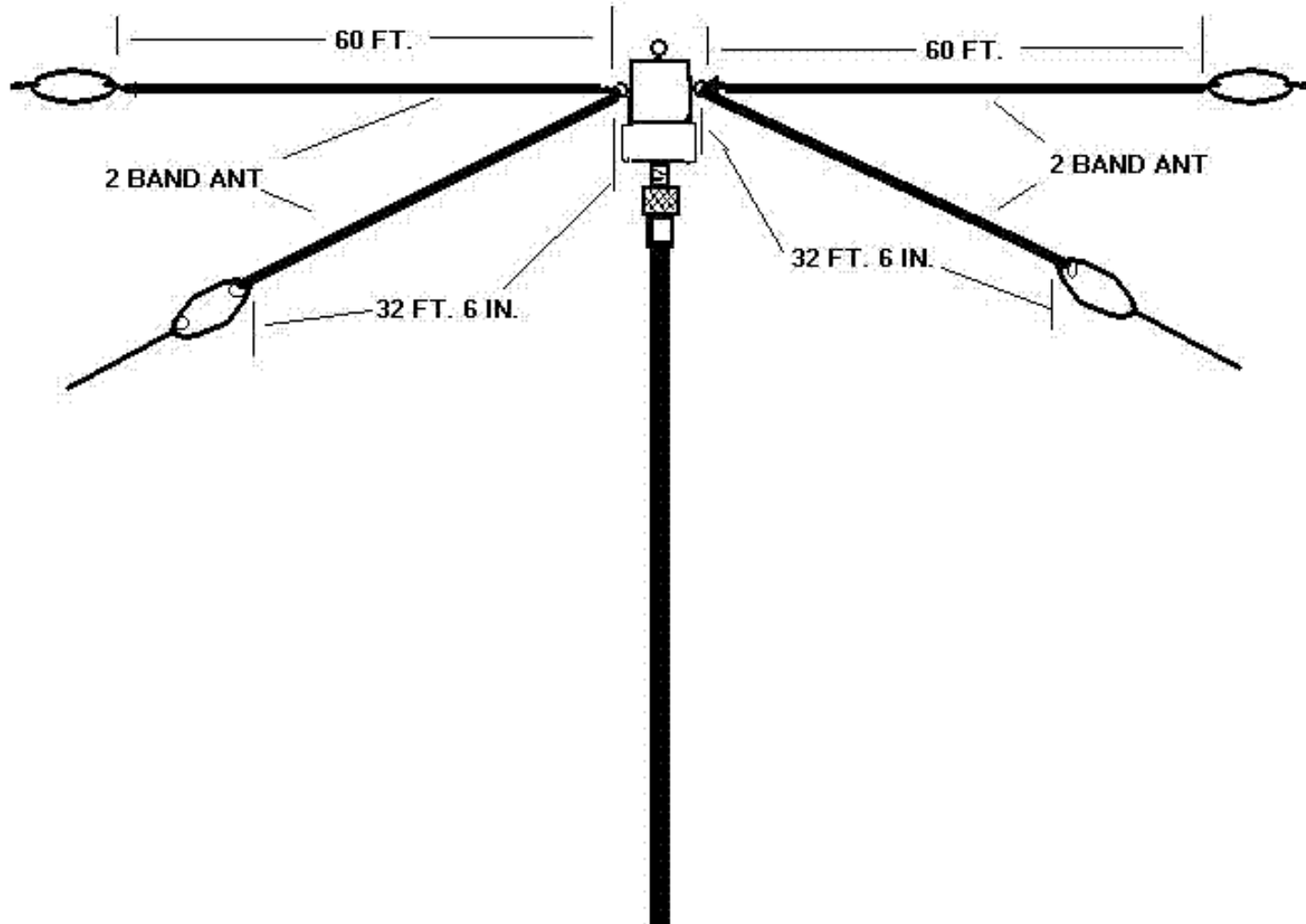
Cage dipoles

- lots of wire, and work, to get more bandwidth, but they work great

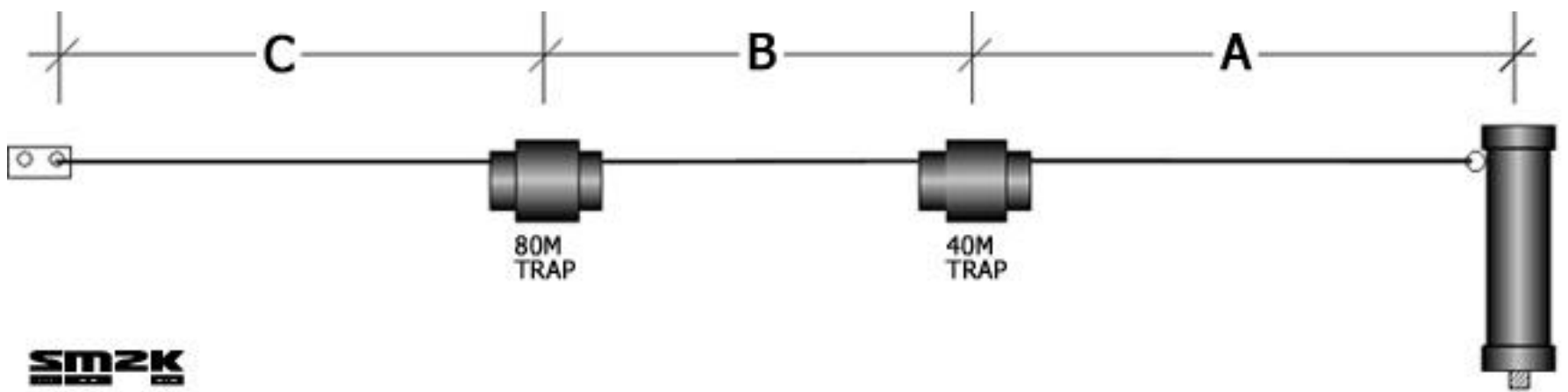
Trap dipoles

- traps = loss... more traps = more loss
- not bad for only 2 bands
- might be just what you need for Field Day

Fan Dipole



Trap Dipole



SM2K

GOOD alternatives to the simple dipole

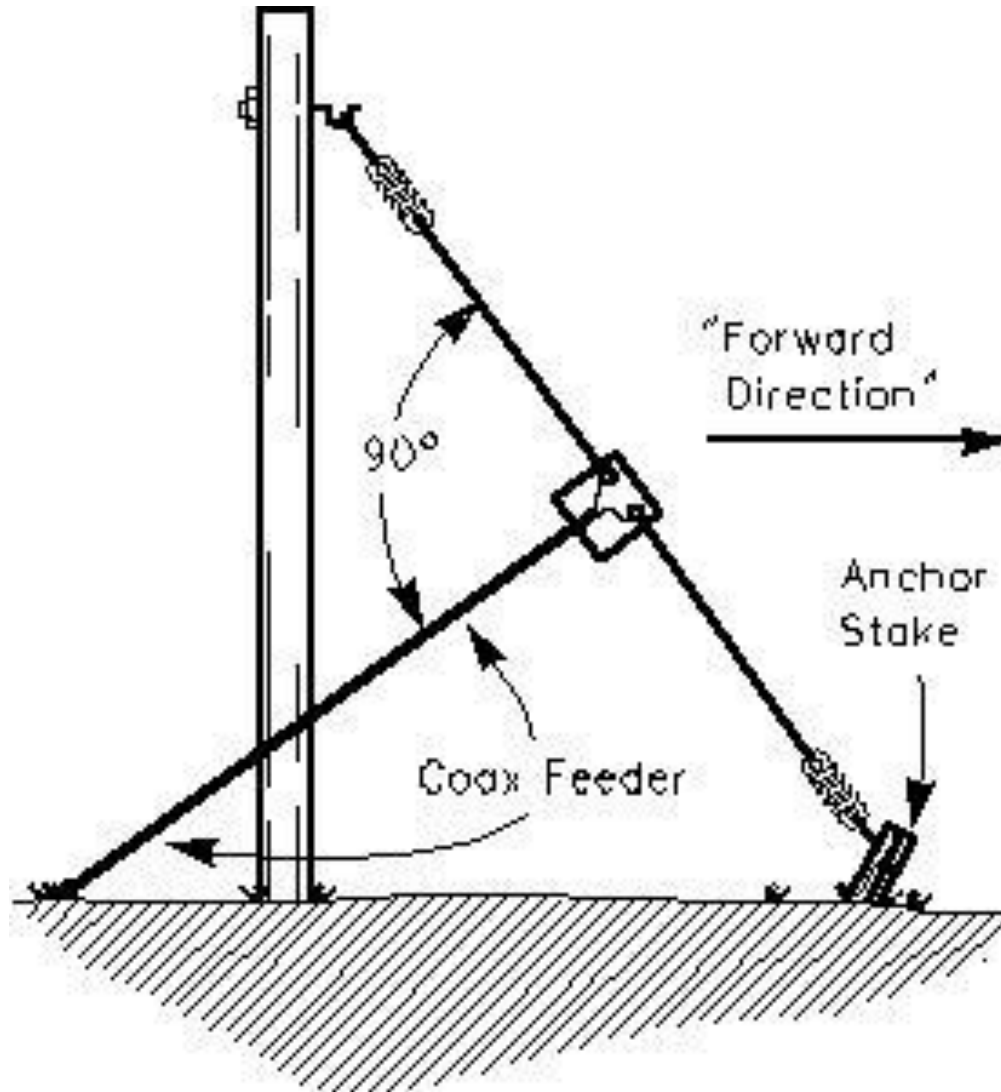
Sloping dipoles

- excellent, convenient antenna - slightly directional, good for DX - make sure the feed is perpendicular
- not to be confused with "slopers" (such as "1/2 slopers," etc.) - those are closer to being inverted vees, and are fed at the top

Vertical dipoles (see sloping dipoles)

- one of the best DX antennas you can put up, requires tall supports, but can be self-supporting (tricky...)
- OK at low heights - a favorite for DXpeditions

Sloping Dipole



GOOD alternatives to the simple dipole

Ground Planes (vertical dipoles, with multiple legs tilted upward AKA "radials")

- famous as CB base antennas (see the Solarcon A99) - can be scaled up to any band - 4 elevated radials are equal to 120 buried radials
- things really get interesting when we try making them $1/2$ or $5/8W$.

Verticals (vertical dipoles, with the lower half made out of dirt)

- if it's good enough for the AM broadcast industry, it's good enough for me - lots of work, requires 60+ radials... best antenna there is for 80/160m

Ground Plane



GOOD alternatives to the simple dipole

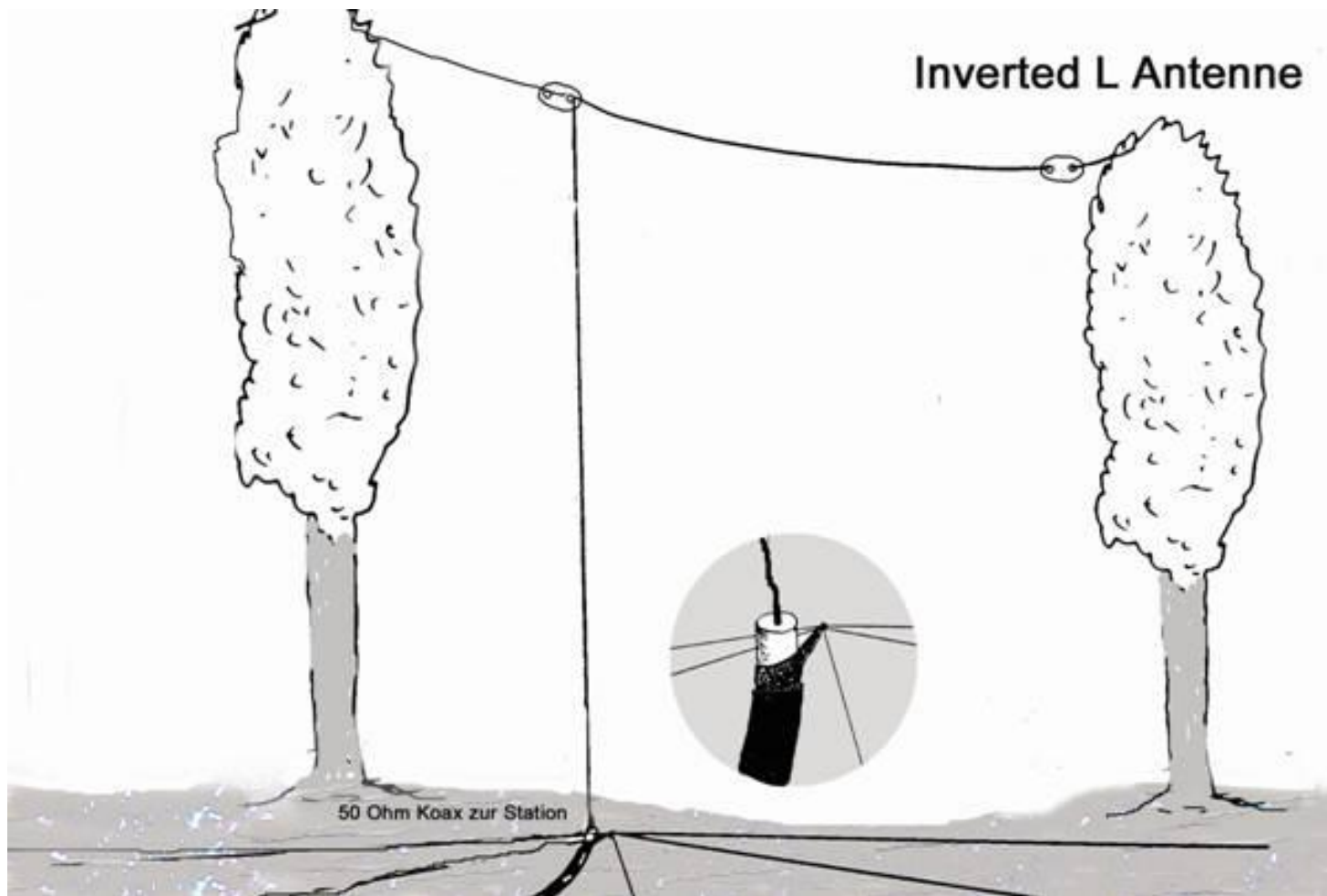
inverted-L's

- (vertical dipoles, with the lower half made out of dirt, and the top bent over - a favorite on 160m)

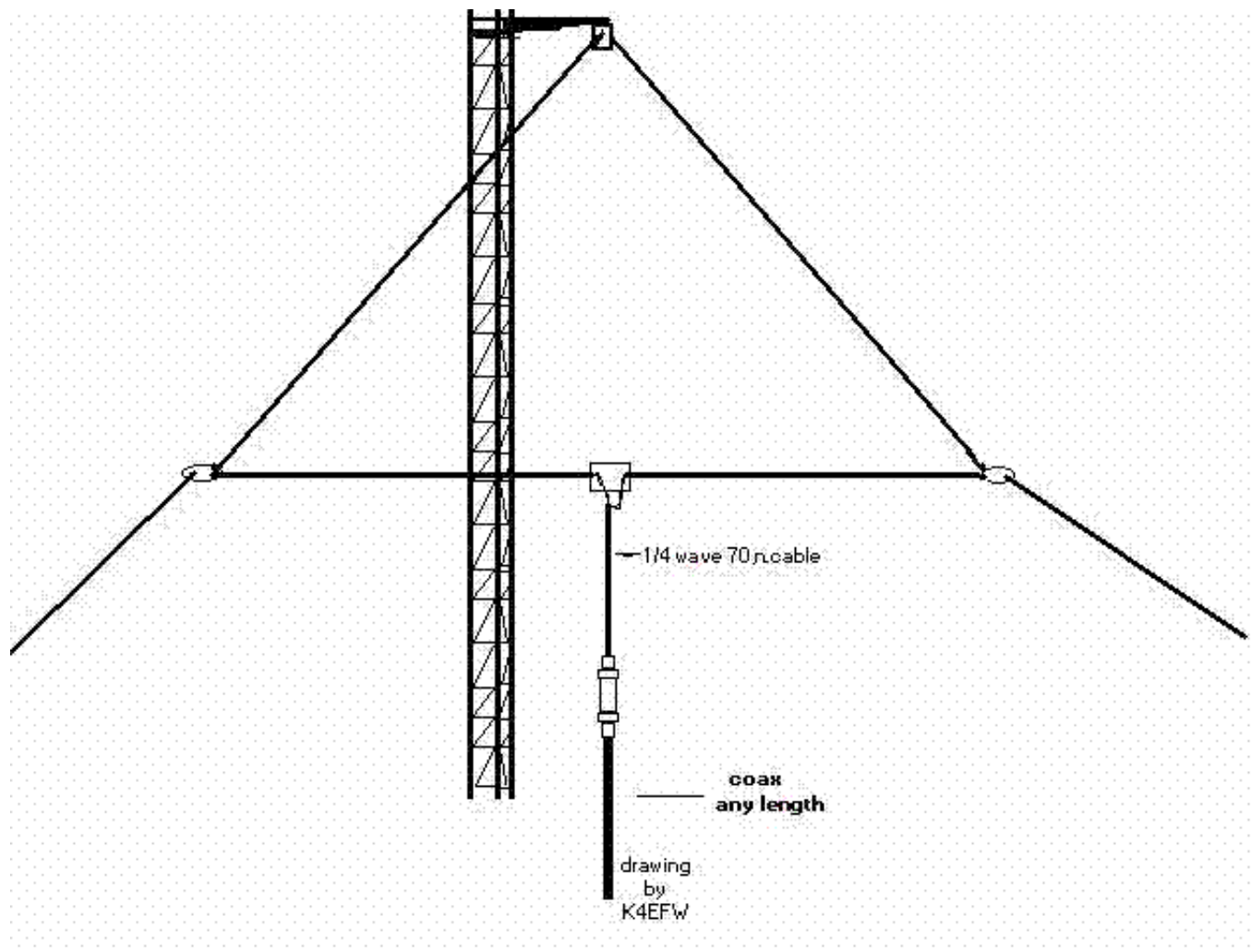
full-wave loops (delta, quad, circular, etc.)

- a "1-element quad" - more directional than a dipole – tricky construction, unless ground-mounted (40/80)
- tricky match, but very efficient - OK at low heights (doesn't heat up the dirt)
- still best if you get them up high

Inverted - L



Full-Wave Loop



Final Thoughts

- **To summarize:**
- Dipoles are easy, inexpensive, and work great. It is rather difficult, and/or expensive - to make one work well on multiple bands. You may just want to put up 4 or 5 of them, and invest in a good antenna switch.
- If you like to experiment, a "real" tuner could be the best piece of antenna hardware you ever buy, and at worst, will give you a great hands-on education about what works, and what doesn't.

References and further reading:

- **The Wirebook**, by Press Jones N8UG. (*"The Wireman."*) The best book for the budget-minded antenna hobbyist. All you need to know about wire antennas, nothing extra.
- **centre-fed multiband HF dipoles - G5RV derivatives**
<http://vk5ajl.com/info/g5rv.php>
- **resonant antennas and SWR**
<http://www.eham.net/articles/16690>
- **Further explanation of radiation resistance and efficiency**
http://www.w8ji.com/radiation_resistance.htm
- **"Folded Terminated Dipoles"**
http://www.tennadyne.com/td_line.htm
- **"Top Five get-on-the-air-quickly antennas"**
<http://www.donkeith.com/n4kc/article.php?p=22>

Thank you and 73!

