

Radio and Antenna Systems

Ryan Herbst, N6AMQ

Robert (Bob) Lombaerde, WB6WGM

17 September 2026



Presentation Outline (needs update)

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- Wavelength, resonance, and SWR
- HTs and attached antennas
- Mobile operation
- Home base stations
- Q & A



How long is an RF cycle ?



- Speed of light 299,792,458 meters/sec
- Frequency is 146.445 MHz (Mcycles/sec)
- Length 1 cycle = $\text{m/s} / \text{c/s} = \text{meters/cycle}$



Let's simplify the math

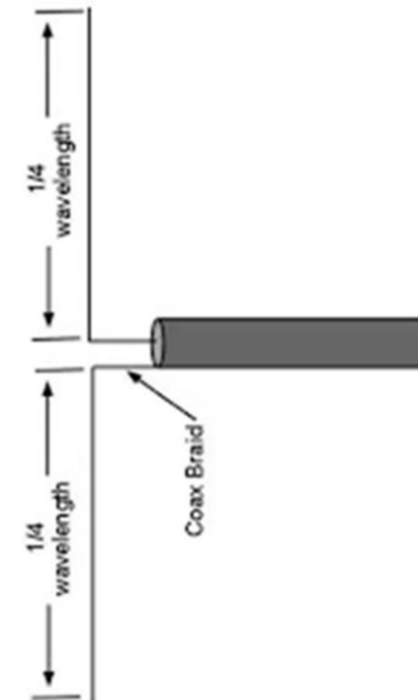
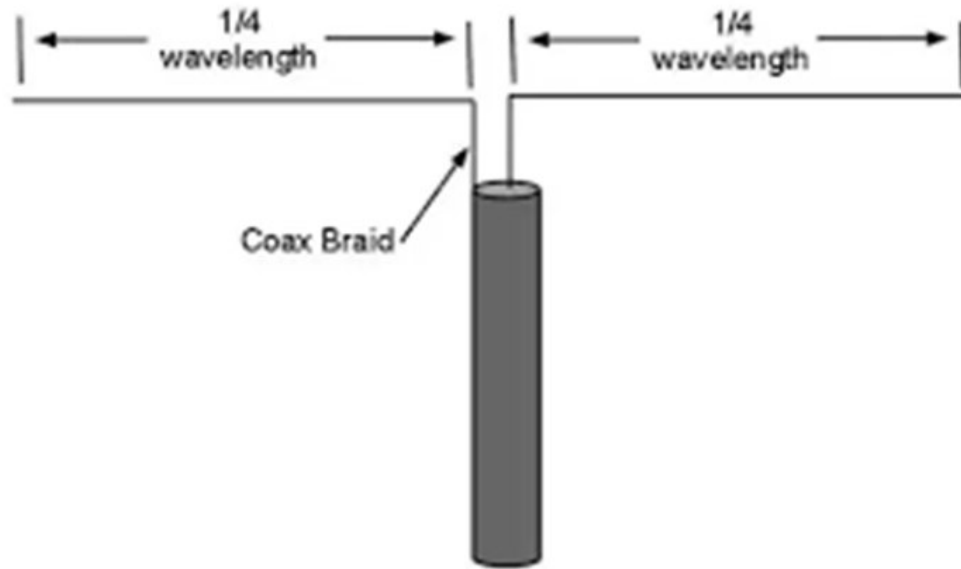


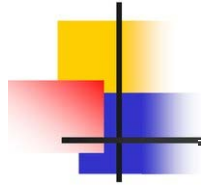
- Speed of light = 300,000,000 meters/sec
- Frequency is 150 MHz (Mcycles/sec)
- Length 1 cycle = $\text{m/s} / \text{c/s} = \text{meters/cycle}$
- $300,000,000 / 150,000,000 = 2 \text{ meters}$
- $2\text{m} @ 146.445\text{Mhz} = 80.5958 \text{ inches} = \text{length of 1 cycle}$



Half wave dipole, the standard resonant antenna

- Half wave at 2 meters is ~40 inches
- Quarter wave at 2 meters is ~20 inches





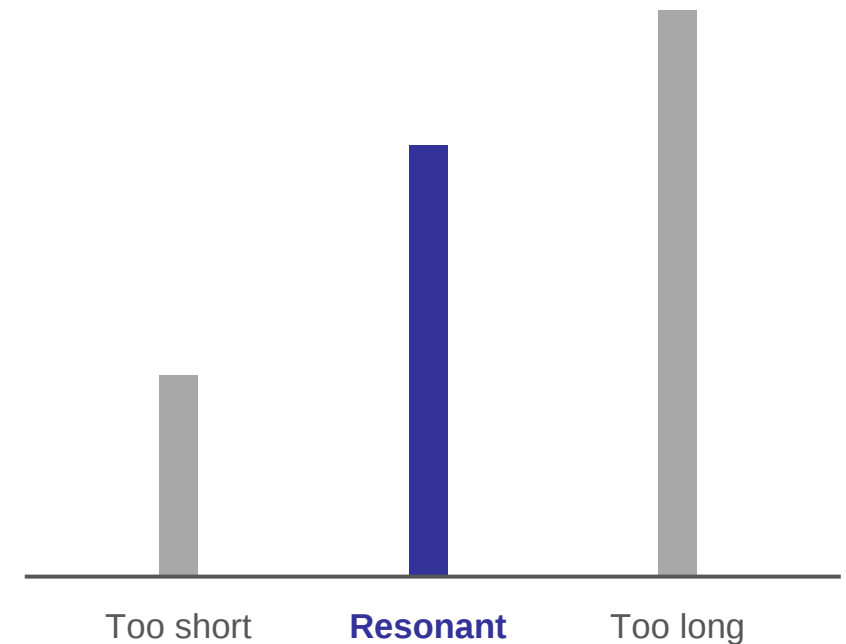
What antenna resonance really means

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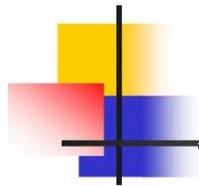


- Every antenna has one length that matches one frequency, the way a tuning fork rings at one note
- Push a swing in rhythm and it climbs with no extra effort. A resonant antenna accepts power the same easy way
- Right length and the power goes out. Wrong length and the radio and the antenna fight each other
- The stubby antenna on an HT is a deliberate compromise. Coils inside make it act longer, and you pay in efficiency

One band, three lengths



Longer is not automatically better. Only the resonant length is an easy load for the radio.

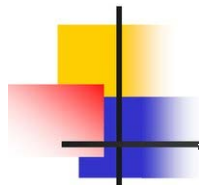


SWR: is your power actually getting out?



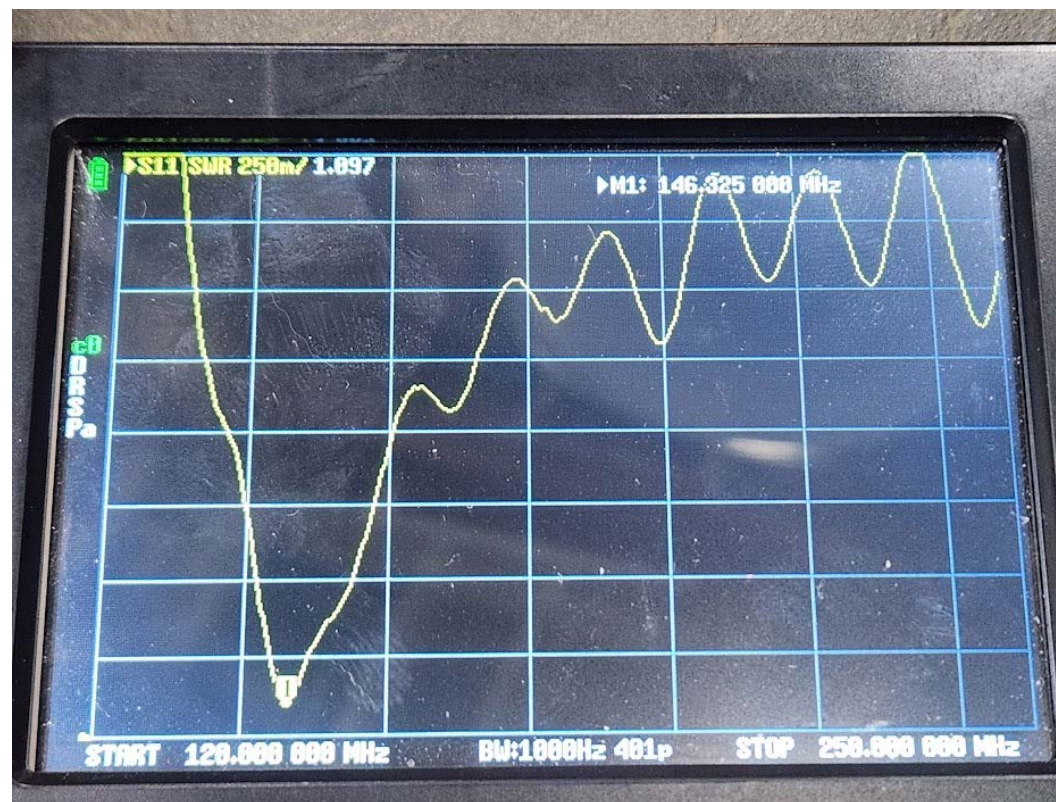
- SWR tells you how much of your transmit power the antenna accepts. What it will not accept comes back down the coax
- A modern radio protects itself by turning its power down, so bad SWR shows up as people simply not hearing you
- Common causes: an antenna cut for the wrong band, a loose or corroded connector, water in the coax, a mag mount on a roof that is not metal (see later slides)
- Check it with an SWR meter or antenna analyzer before the event, not during it

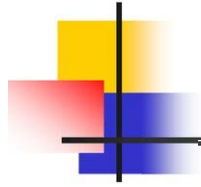
SWR	Power that comes back	What to do about it
1.0 : 1	none	Perfect, and almost never seen in the real world
1.5 : 1	about 4%	Very good. Nothing to fix
2.0 : 1	about 11%	Fine for voice on 2 meters and 70 cm
3.0 : 1	about 25%	Check the antenna, the coax and the connectors
5.0 : 1	about 44%	Stop transmitting and find the fault



SWR For 2M Resonant Antenna

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SWR For 2M Non-Resonant Antenna

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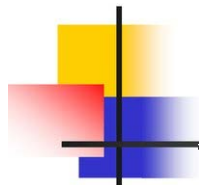




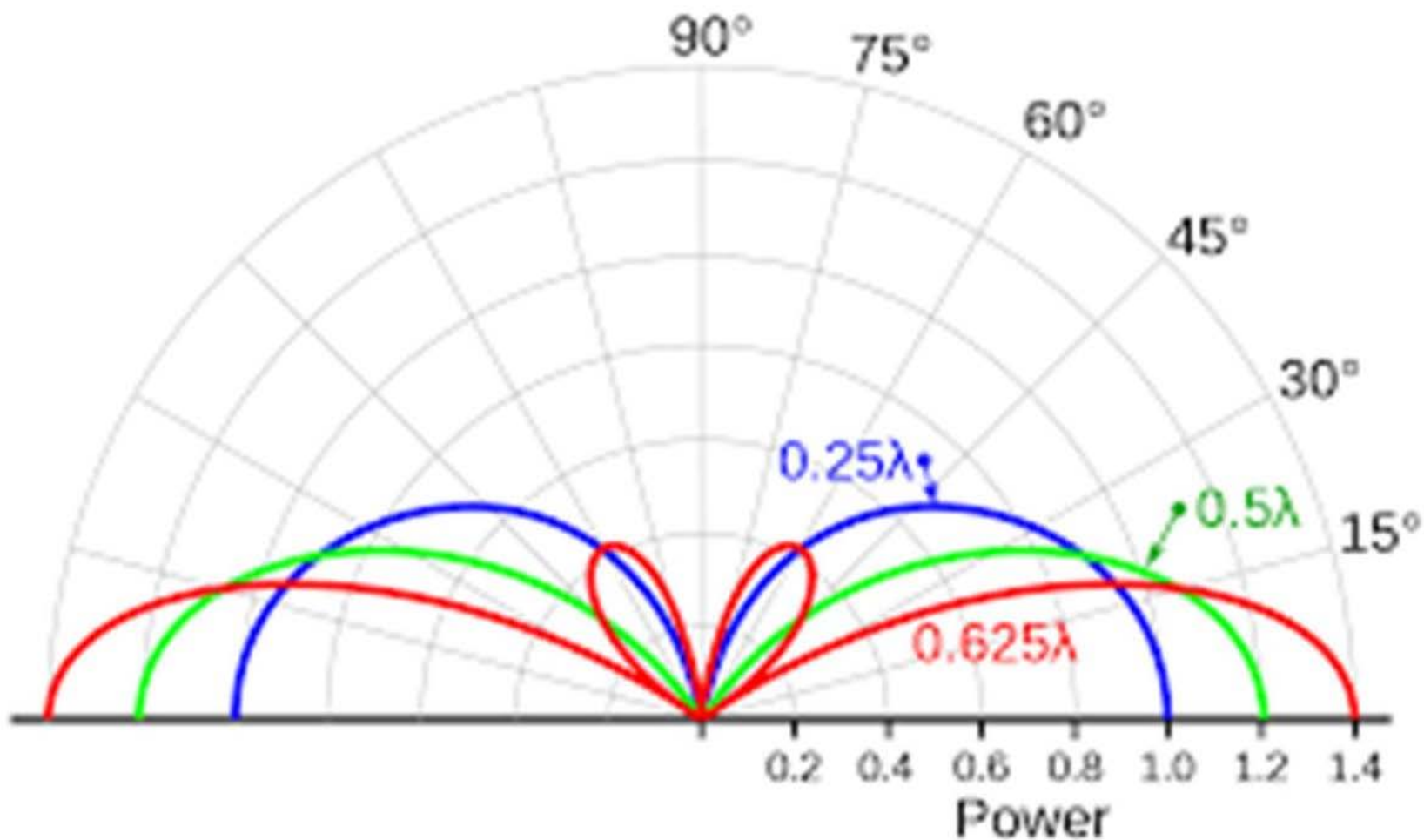
Taller is better?

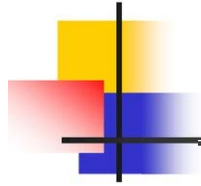


- Is 5 watts out, 5 watts out?
- Quarter wave antennas are the baseline
- 5/8 and half-wave gain antennas will focus more energy to the horizon than upward – achieving relative gain



$\frac{1}{4}$ vs $\frac{1}{2}$ vs $\frac{5}{8}$ antennas





Why $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{5}{8}$ are all resonant



Resonant means the radio sees an easy, near 50 ohm load. All three get there. They just take different routes.

$\frac{1}{4}$ wave

about 20 inches on 2 meters

- Only half an antenna. The metal roof mirrors it and supplies the other half
- No ground plane, no resonance
- Lands close enough to 50 ohms to feed directly

$\frac{1}{2}$ wave

about 40 inches on 2 meters

- A complete antenna. It borrows nothing from the vehicle
- Works on a fiberglass roof, a tripod, or in your hand
- Fed at the end, so a matching section in the base does the 50 ohm job

$\frac{5}{8}$ wave

about 48 inches on 2 meters

- Longer than resonant on purpose, so on its own it is not a match
- The coil in the base cancels that out and restores resonance
- Still needs a ground plane

The extra length does not make more watts. It aims more of them at the horizon instead of the sky: roughly 3 dB from a $\frac{5}{8}$ over a $\frac{1}{4}$ wave, on a good ground plane. A low SWR on its own does not prove an antenna is radiating, since a dummy load is a perfect match and radiates nothing.



$\frac{1}{4}$ VS $\frac{1}{2}$ VS $\frac{5}{8}$



- Ground plane needed for $\frac{1}{4}$ and $\frac{5}{8}$
- $\frac{1}{4}$ is optimized for one band. A 2 m quarter wave does work on 70 cm as a three quarter wave, with a higher angle pattern
- $\frac{1}{2}$ easy dual band 2m and 70 cm with reasonable length ~39 inches
- No practical dual band $\frac{5}{8}$ designs (single element with coil)
- 2m $\frac{5}{8}$ will tune on 6m, length ~48"

What a loading coil looks like

Comet GP-15 internals

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Baofeng antenna possibilities



- The Baofeng OEM antenna is about 6 inches
- A quarter wave at 2m is ~ 20 inches
- There is a compromise between convenience and efficiency
- Quarter wave length at 70 cm = 6.5 inches
- Internal components also let the same antenna work on 70 cm
- So the stock antenna is a real quarter wave on 70 cm and badly short on 2 meters. It is far more efficient on 70 cm.



Dual band antenna options on the Baofeng HT



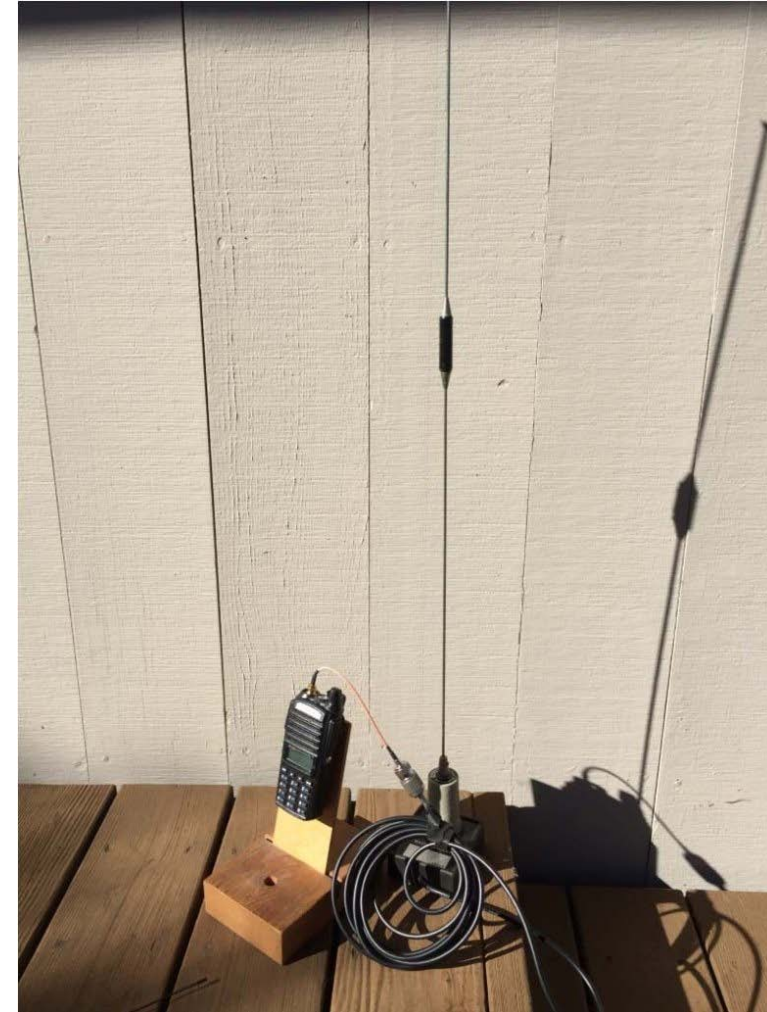
- The radio has an SMA male port, so the antenna must be SMA female. This is backwards from most ham HTs
- Do not buy anything marked RP-SMA. It threads on fine and gives you bad SWR
- An adapter is an option for conversion
 - Handheld Antenna Cable for Wouxun Baofeng Quasheng Linton - 2 for \$7 on Amazon
- Possible direct screw-in antennas:

Nagoya	NA-771	\$15 to \$20
Diamond	SRJ77CA	\$30 to \$35
Comet	SMA-24J	\$30





Interface HT to cable





Mobile Radio system



- Instead of HT install a mobile radio
- Dual band radio recommended: 2/70
- Use same vehicle antennas as with HT
- Make sure power handling of antenna is adequate
- 12 Volts supplied by vehicle (be sure to use a fuse)
- More power, better range, more reliable comms, install securely



Let's go mobile with the HT



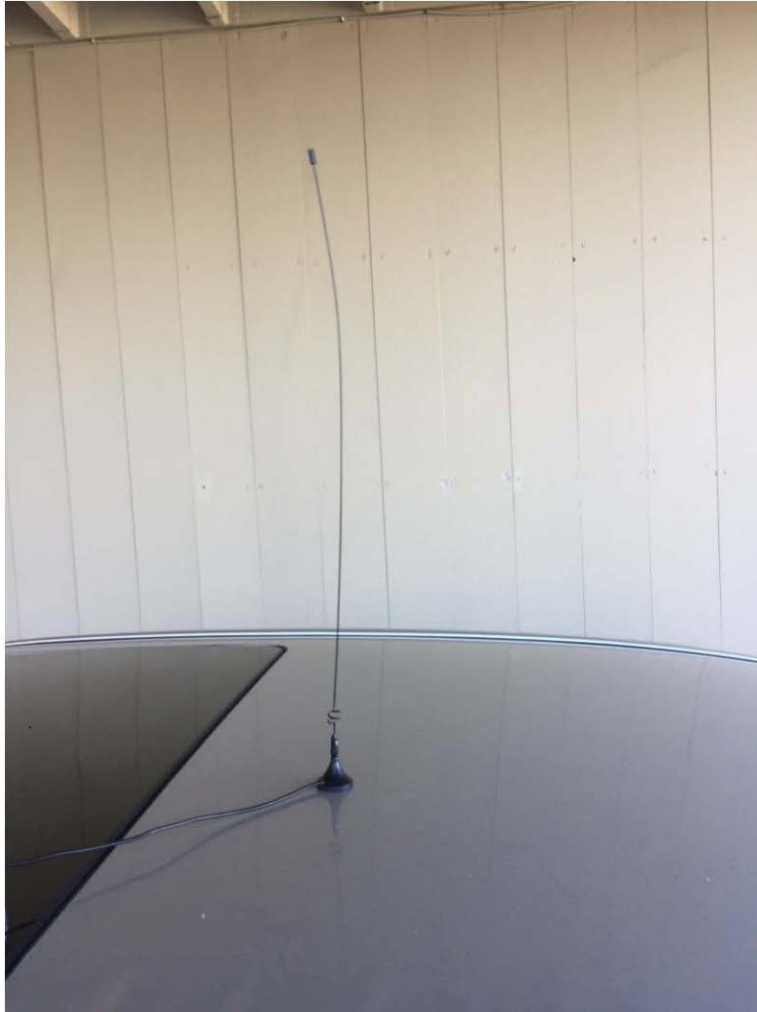
- NC in Redwood City PD can hear a 5 Watt HT on 2 meters using a mag-mount antenna
- Antenna installation: permanent or temporary? Drill a hole, attach mount, use mag-mount
- Vehicle acts as ground plane
- Mount antenna in middle of the roof
- Second option – on the trunk
- Interface to HT – may require adapter
- Use speaker mike for convenience in vehicle

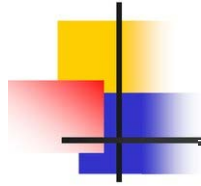


Mobile Antenna Possibilities: Hershey "Kiss", Larsen 2/70



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Mag mount grounding: what actually matters



A mag mount does not touch bare metal. Paint and the protective pad are in the way, so there is no DC connection to the roof at all. It still works, and here is why.

Why it works anyway

- The magnet, the paint and the steel roof form a capacitor. At 2 meters and 70 cm that is a good enough RF path back to the body
- A bigger magnet base couples better. Small bargain mounts are the usual culprit
- This is not a safety ground and not a DC ground. A meter will read open across it, and that is normal

How to get it right

- Center of the roof. A quarter wave on 2 meters wants roughly 20 inches of metal in every direction
- Clean the roof and the pad. Grit lifts the magnet, costs you coupling and scratches the paint
- Leave the vinyl cover on. Bare metal would couple better but it grinds the paint and starts rust
- Size the base to the antenna. A tall 5/8 whip on a small magnet will let go at highway speed

Prove it, do not assume it. Read SWR with the antenna where it will actually live. Good in the middle of the roof and poor on the trunk lid points at the ground plane, not the antenna.

Check the vehicle first. A composite roof or a large glass sunroof means no ground plane at all. An aluminum body gives you a fine ground plane but nothing for a magnet to hold, so you need a lip mount or a through-hole mount.

Mobile Remote Dead Installation

FT-8900 Left - FTM-300R Right

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Car Antenna Mounting



6/2/70 Antenna on mount, Note thin cable into trunk



Dual band with mount designed for F250 hood



Home Base Station



- A mobile rig is usually used as a base station for its higher power and heat dissipation, longer talk power
- 12V power supply or battery required
- Connect the rig to an external antenna on the roof
- A mag-mount on a metal cabinet works too, check how well it works inside



Yaesu FT-8100 dual band and 12V Power Supply





Base dual band antennas



- Diamond X50A 2/70 5.6 ft
- Comet GP-3 2/70 5.9 ft
- Mount antenna high, with no obstructions
- Use low loss quality coax cable
- Buy cable with connectors installed



Coax loss at 100 ft



	LMR-1200	LMR-900	LMR-600	1/2" Superflex	LMR-400	Belden 9913F7	9914	RG214 RG213	LMR-240	Belden RG8X	LMR-200	LMR-195	RG-58/U
Frequency/Size	1.200"	0.870"	0.590"	0.520"	0.405"	0.405"	0.400"	0.405"	0.240"	0.242"	0.195"	0.195"	0.195"
30 MHz	0.209	0.288	0.421	0.561	0.7	0.8	0.8	1.2	1.3	2.0	1.8	1.8	2.5
50 MHz	0.272	0.374	0.547	0.730	0.9	1.1	1.1	1.6	1.7	2.5	2.3	2.3	3.1
150 MHz	0.481	0.658	0.964	1.29	1.5	1.7	1.7	2.8	3.0	4.7	3.9	4.0	6.2
220 MHz	0.589	0.803	1.18	1.58	1.8	2.1	2.1	3.5	3.7	6.0	4.8	4.8	7.4
450 MHz	0.864	1.17	1.72	2.32	2.7	3.1	3.1	5.2	5.3	8.6	6.9	7.0	10.6
900 MHz	1.27	1.70	2.50	3.41	3.9	4.4	4.5	8.0	7.6	12.8	9.9	9.9	16.5
1,500 MHz	1.69	2.24	3.31	4.57	5.1	6.0			9.9		12.7	12.9	



External Antennas

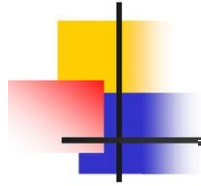


- Waterproof connections with tape, wrap bottom up, so layered tape acts like roof shingles shedding water
- Provide service loops and drip loops
- Provide lightning protection, DC grounding

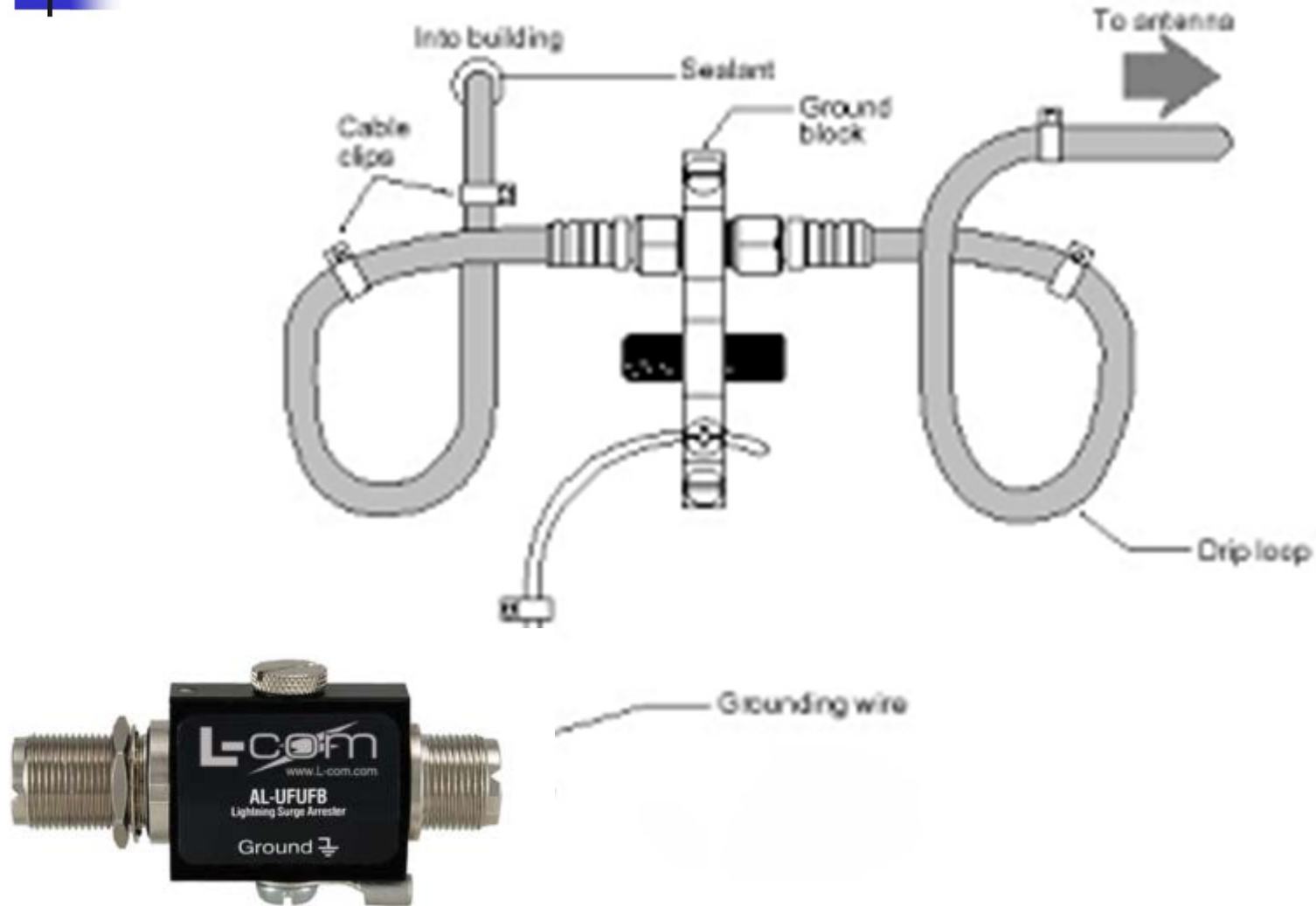


Service Loop, Drip Loop





Grounding, lightning protection





Q & A



- Over – to you