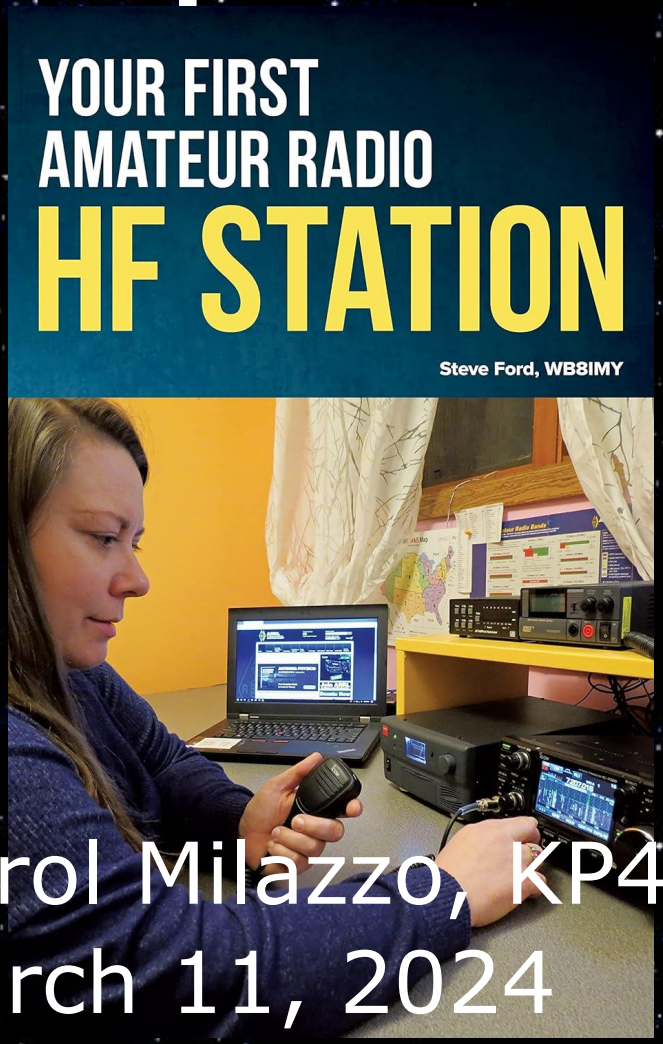
Are You Ready for HF?
Set Up Your First HF Station



Carol Milazzo, KP4MD
March 11, 2024

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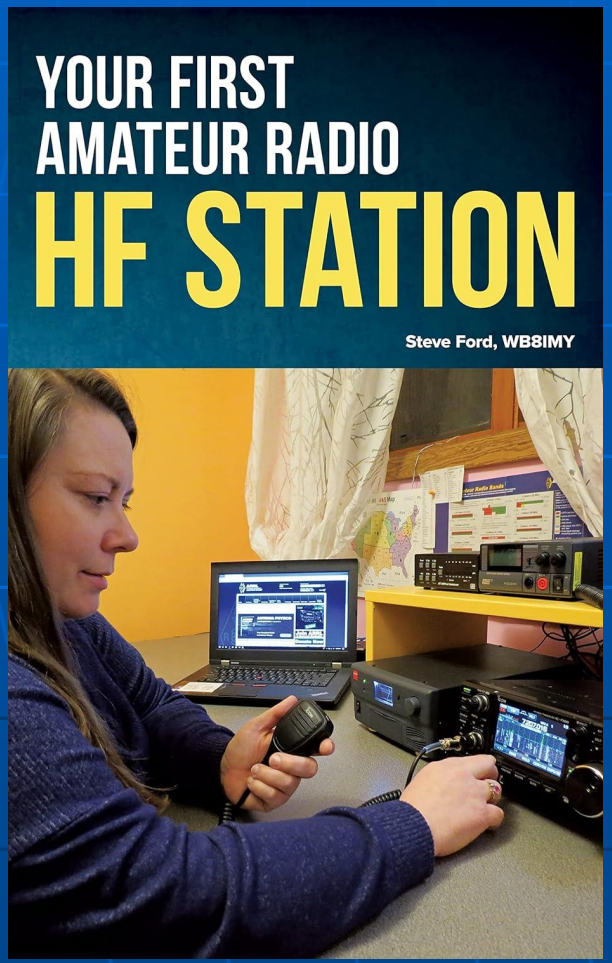
SACRAMENTO, CA

Technology Advances



- Published in 2014
- Content is dated
- Icom IC-7300 SDR radio became mainstream after 2016
- FT8 released in 2017.

Outline of Topics

1. Home, Portable, Mobile, Stealth
2. RFI, RF Exposure, RFI
3. Choose Your Radio
4. Power source options
5. Grounding and Bonding
6. Transmission Lines
7. Voice, CW and Digital Modes
8. Maintenance and Station Accessories

Home Station Factors

- Budget
- Available space
- RF environment
- Geography
- Esthetic impact
- CCNRs & HOAs

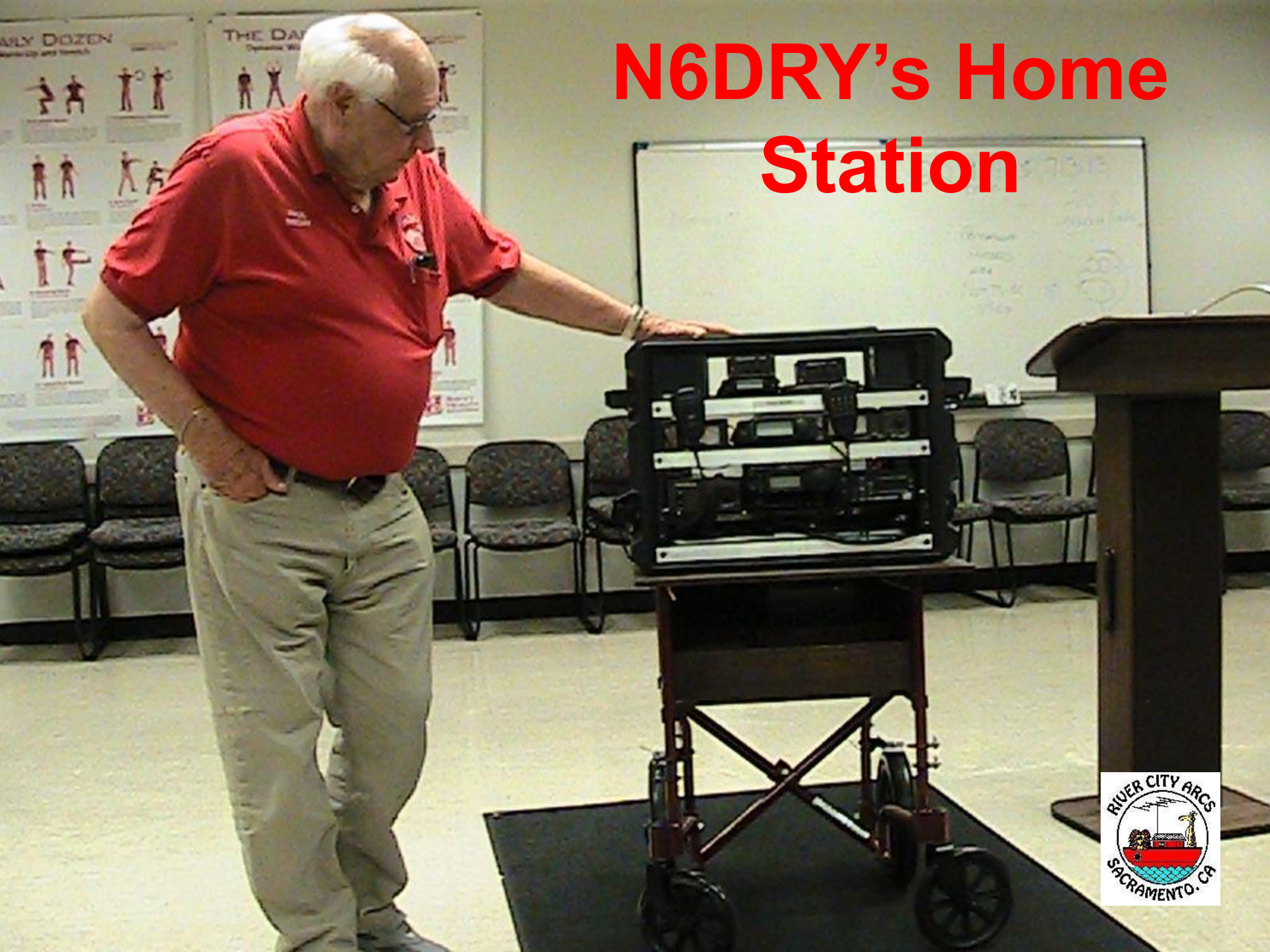
K9XN's Home Station

Typical Home Station

Sit/Stand Desk with Yaesu 991a and FTM 400

Limited Space Home Station

Vertical Spaces


N6DRY's Home Station
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Portable Station Factors

- Budget
- Weight
- Deployment ease
- Power sources
- RF environment
- Geography

Compact Home/Portable Station

Station in a Rollerbag

Go Box Portable

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K4SWL's Backpack Portable

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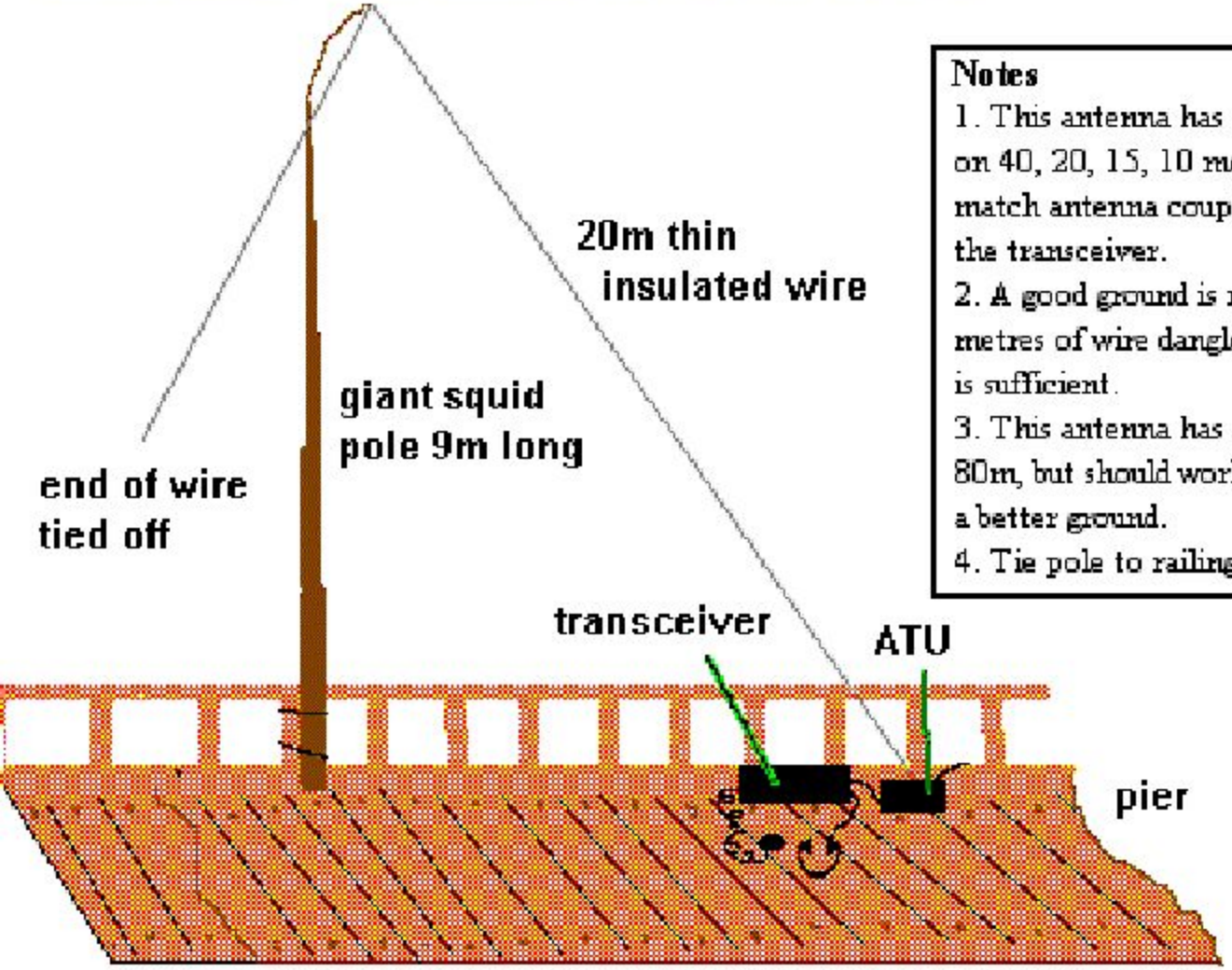
Antenna Deployment

End-Fed Inverted Vee



Notes

1. This antenna has a high impedance on 40, 20, 15, 10 metres. Use an L-match antenna coupler between it and the transceiver.
2. A good ground is not essential - a few metres of wire dangled in to the water is sufficient.
3. This antenna has not been tried on 80m, but should work, particularly with a better ground.
4. Tie pole to railing with rope or wire.

Giant squid poles are available from fishing shops. Expect to pay between $30 and $100, depending on length and brand. The poles are light and collapse to 1.1 metres so are easy to store and carry.

Performance This antenna was used near the end of a pier several hundred metres from the shore. KH6 on 40m and ZL, JA & CP6 on 20m were worked in under an hour with 5 watts SSB.

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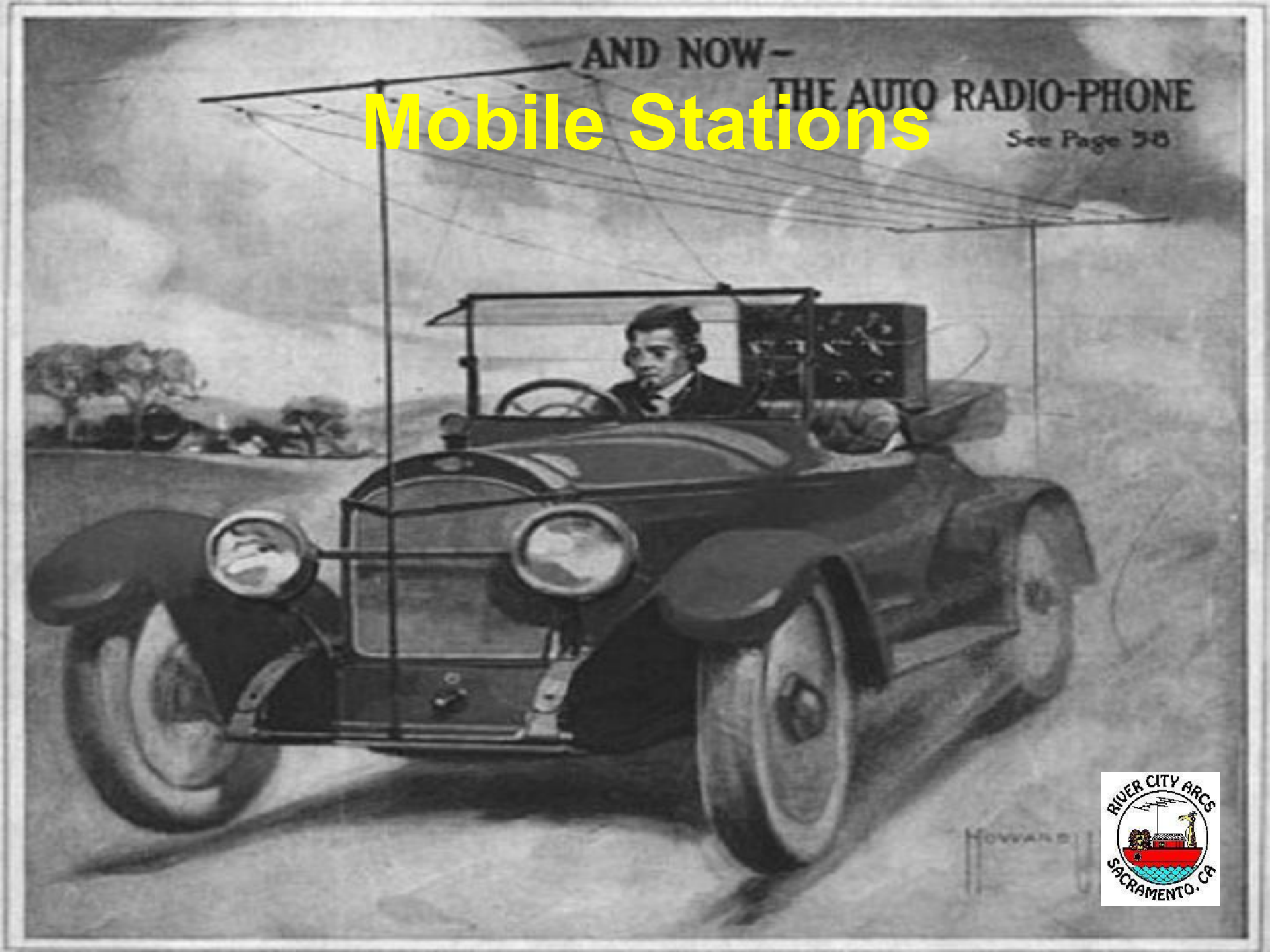
Mobile Stations

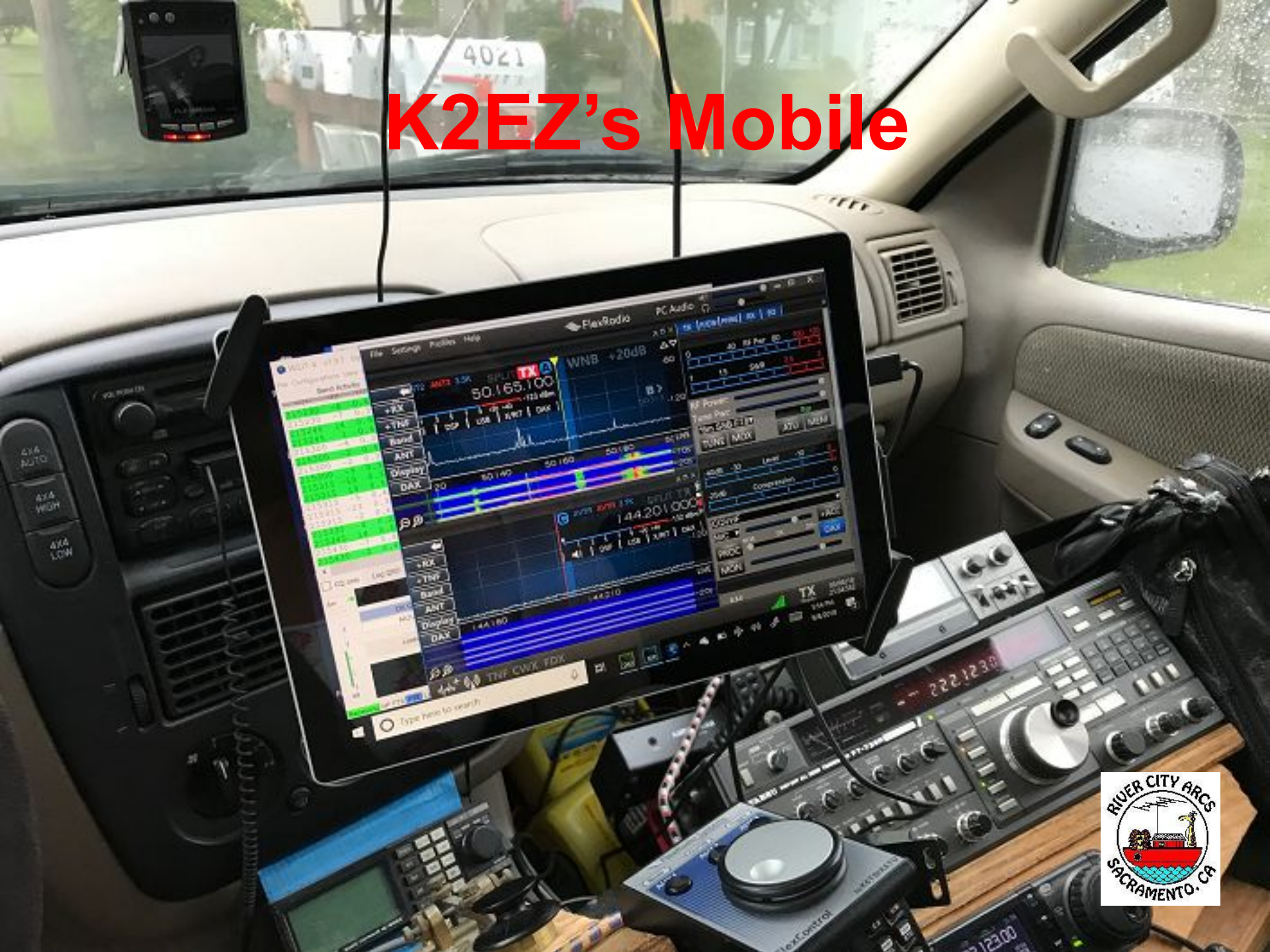


Mobile HF Stations

- Most portable and home station radios will work in a 12 volt vehicle (wire direct to the battery)
- Radios with separating faceplates are good for limited dashboard space
- 100 watt level is preferred due to inefficiency of shortened antennas
- Some vehicles generate RFI

K2EZ's Rover Mobile

K2EZ's Mobile



Bicycle Mobile

Bicycle Mobile

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HF Mobile Antennas

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Mobile Antennas

- HF mobile antennas are inductively (& sometimes capacitively) loaded electrically ¼-wave verticals.
- Radiation efficiency & SWR bandwidth decrease at lower frequencies.
- The vehicle chassis is a less effective counterpoise at lower frequencies.
- Vertical antennas are poor NVIS radiators.

HF Mobile Antenna Types

- **Hamstick® – Continuous loaded fiberglass rod with "stinger"**
- **Hustler® type – fixed lumped inductance**
- **Screwdriver – motor-driven variable loading inductor $$$**
- **All shortened antennas compromise dB gain compared to a full-sized half wave antenna.**

Hamstick® Antenna

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2E0WPZ's Hustler® Antenna

Screwdriver Antenna

Mobile Antennas

- Best efficiency when roof-mounted
- Feed line shield should be securely bonded to the chassis counterpoise
- You may use a shunt inductor across the feed point if the impedance is too low

Indoor & Stealth Stations

The HOA is getting suspicious

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Miklor.com

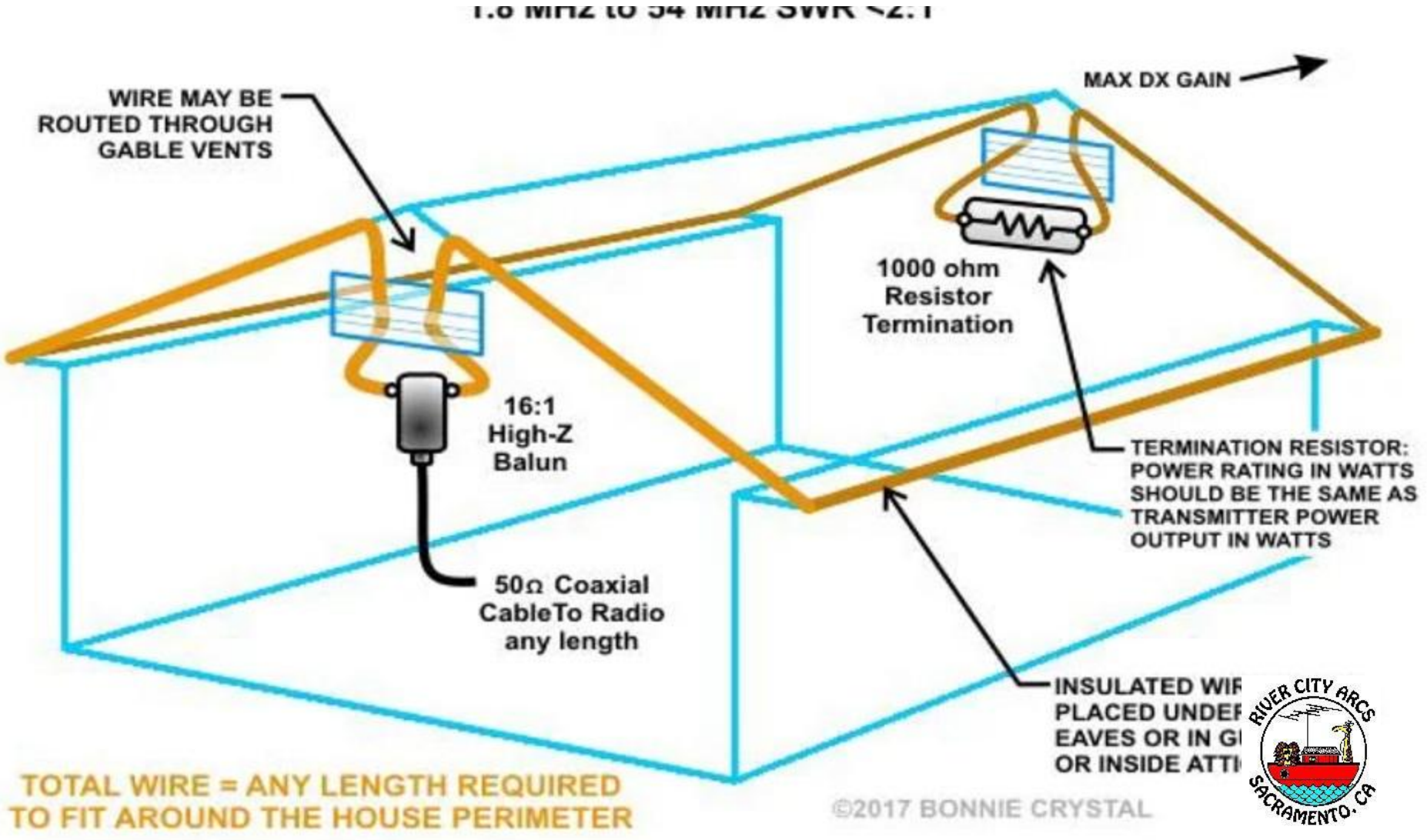
ZF2BR Station in Closet

Stealth Antennas

- Disguised antennas – Flagpole, bird feeder
- Gutters, downspouts
- Wire around eaves
- Invisible wires
- Indoor antennas

N6CC's Gutter Antenna

KQ6XA's Eaves Antenna



Indoor Vertical

- Shortened vertical antenna in window with ¼ wave counterpoise wire

Indoor Magnetic Loop

AJ4VD's Apartment Antenna

Apartment Antenna

Attic Antennas

Indoor Antennas

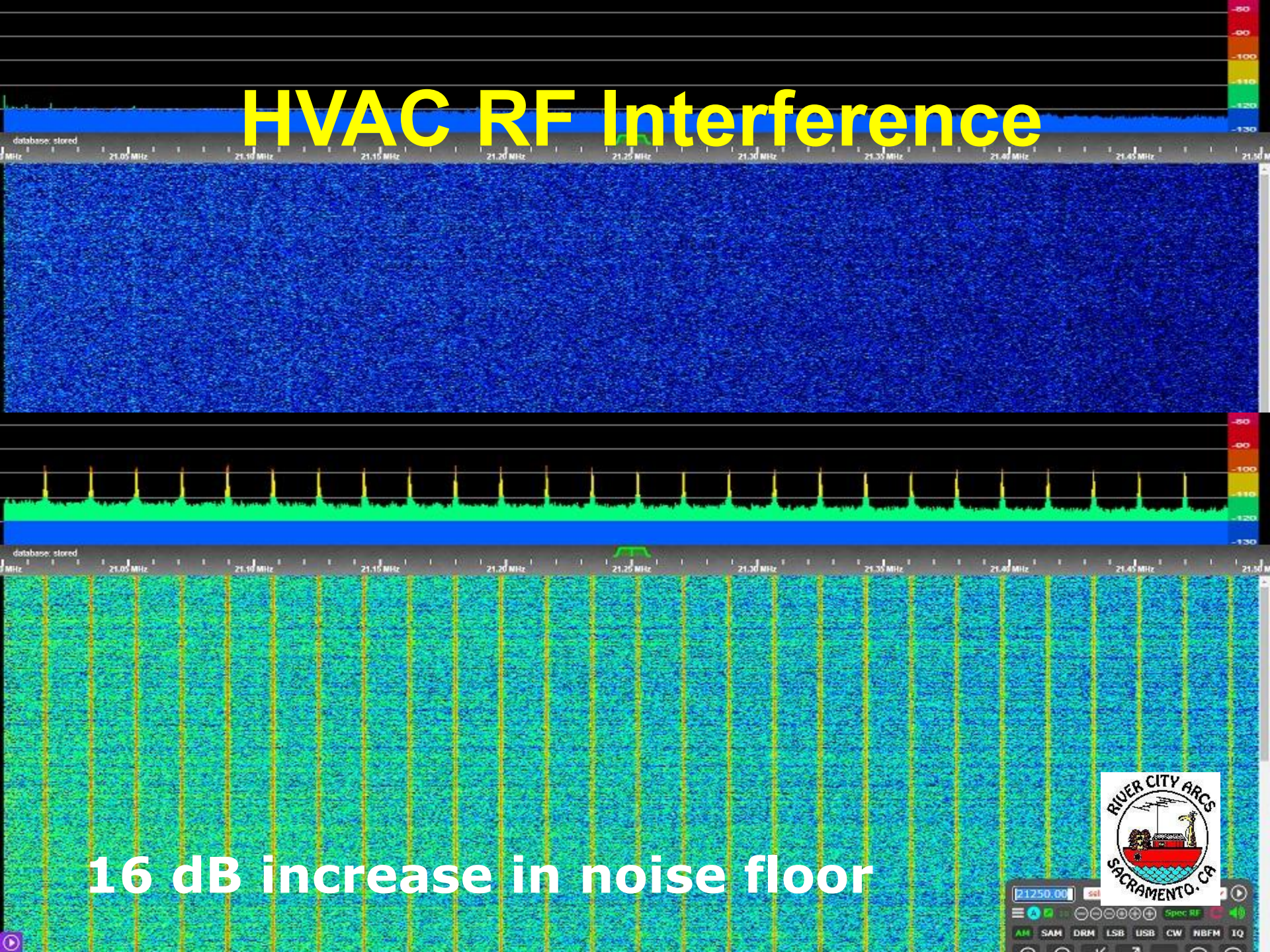
List of wall materials in order of increasing attenuation.

- **Dry wood**
- **Wet wood**
- **Composite shingle**
- **Brick, Concrete, Stucco**
- **Metal siding (Faraday cage)**

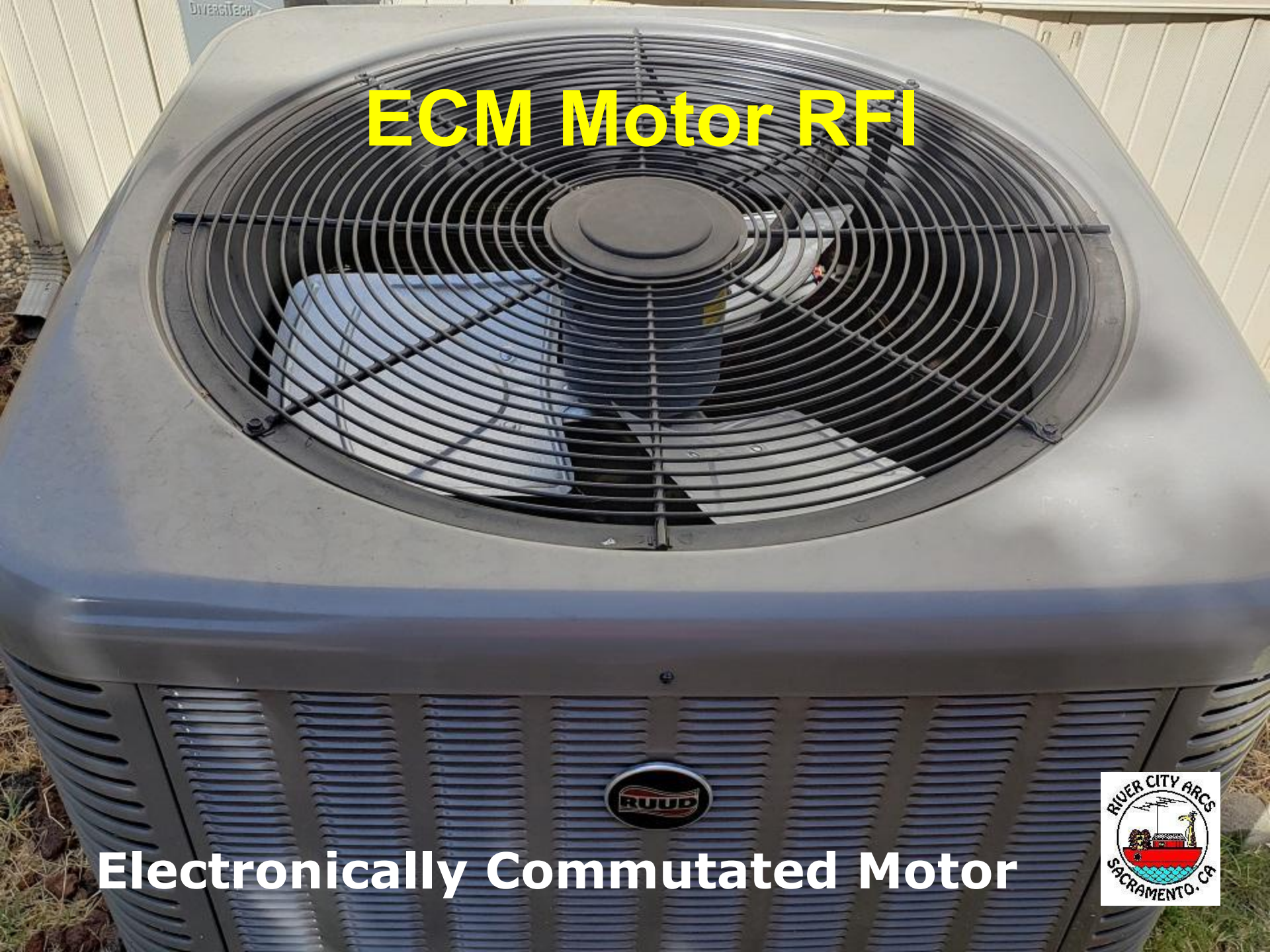
Home RF Noise Sources

- Switching power supplies and wall warts
- Computers & modems
- Ethernet switches & cables
- Touch lamps
- Light dimmers
- LED lighting
- Plasma televisions
- HVAC Motors

HVAC RF Interference



16 dB increase in noise floor


ECM Motor RFI
RUUD
Electronically Commutated Motor
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Ferrites on ECM Wires


Ferrites & EMI Filter
INSPECTOR
CUSTOMER
92-18390-05-04
CSC
40.0µF
43-101666-22
CW4L2-20A-S
EMI FILTER
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EMI Filter

S21 Gain (dB)

0
-20
-40
-60
-80
-100
-110

100.0k 215.4k 464.2k 1.000M 2.154M 4.642M 10.00M 21.54M 46.42M 100.0M

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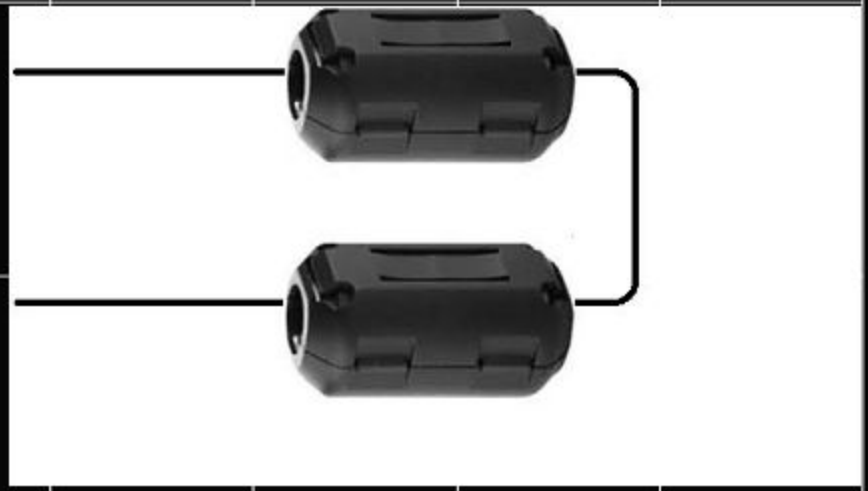
-8 dB @ 21 MHz



S21 Gain (dB)

0
-2
-4
-6
-8
-10

3.000M 6.000M 9.000M 12.00M 15.00M 18.00M 21.00M 24.00M 27.00M 30.00M

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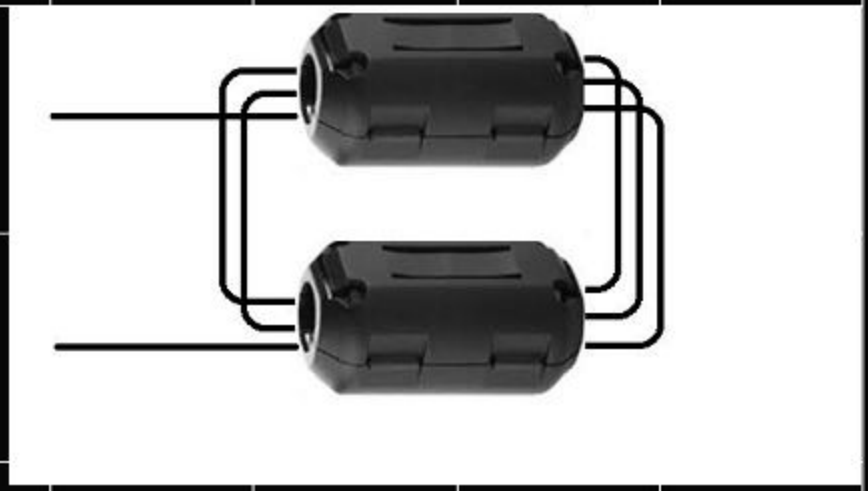
-24 dB @ 21 MHz



S21 Gain (dB)

0
-5
-10
-15
-20
-25
-30

3.000M 6.000M 9.000M 12.00M 15.00M 18.00M 21.00M 24.00M 27.00M 30.00M

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https://www.arrl.org/rf-exposure-calculator

RF Exposure

ARRL
The National Association for Amateur Radio®

Login
Register a Callsign
Login Help

Website Search
Keyword | Category | GO
Call Sign / Name Search
Search Licensees | GO

Home | On The Air | Licensing, Education & Training | Membership | Regulatory & Advocacy | Public Service | Technology | Get Involved | ARRL Store | About ARRL | News & Features

RF Exposure Calculator

- FCC RF-Exposure Regulations -- the Station Evaluation
- ARRL RF Safety Committee
- **RF Exposure Calculator**
- RF Exposure Calc Instructions
- Changes in the FCC RF Exposure Regulations

The FCC has changed its RF-exposure rules, eliminating service-specific exemptions from the need to do a routine RF-safety evaluation and replacing those exemptions with a formula that applies to all radio services. See the FAQ on the ARRL RF-Exposure page for more information. The rules did not change the exposure limits nor the two-tiered exposure environments for controlled and uncontrolled exposure. The controlled limits generally apply to amateurs and members of their household if those people have been given instructions by the amateur about RF safety. The uncontrolled limits apply in all other circumstances, such as exposure to the general public.

To use the RF Exposure Calculator, fill-in the form below with your operating power, antenna gain, and the operating frequency. Depending on how far above ground the RF source is located, you might want to consider ground reflections — and then click "Calculate".

You may need to run the calculator multiple times to get a complete picture of your situation, i.e. take into account the antenna's lobes and directionality.

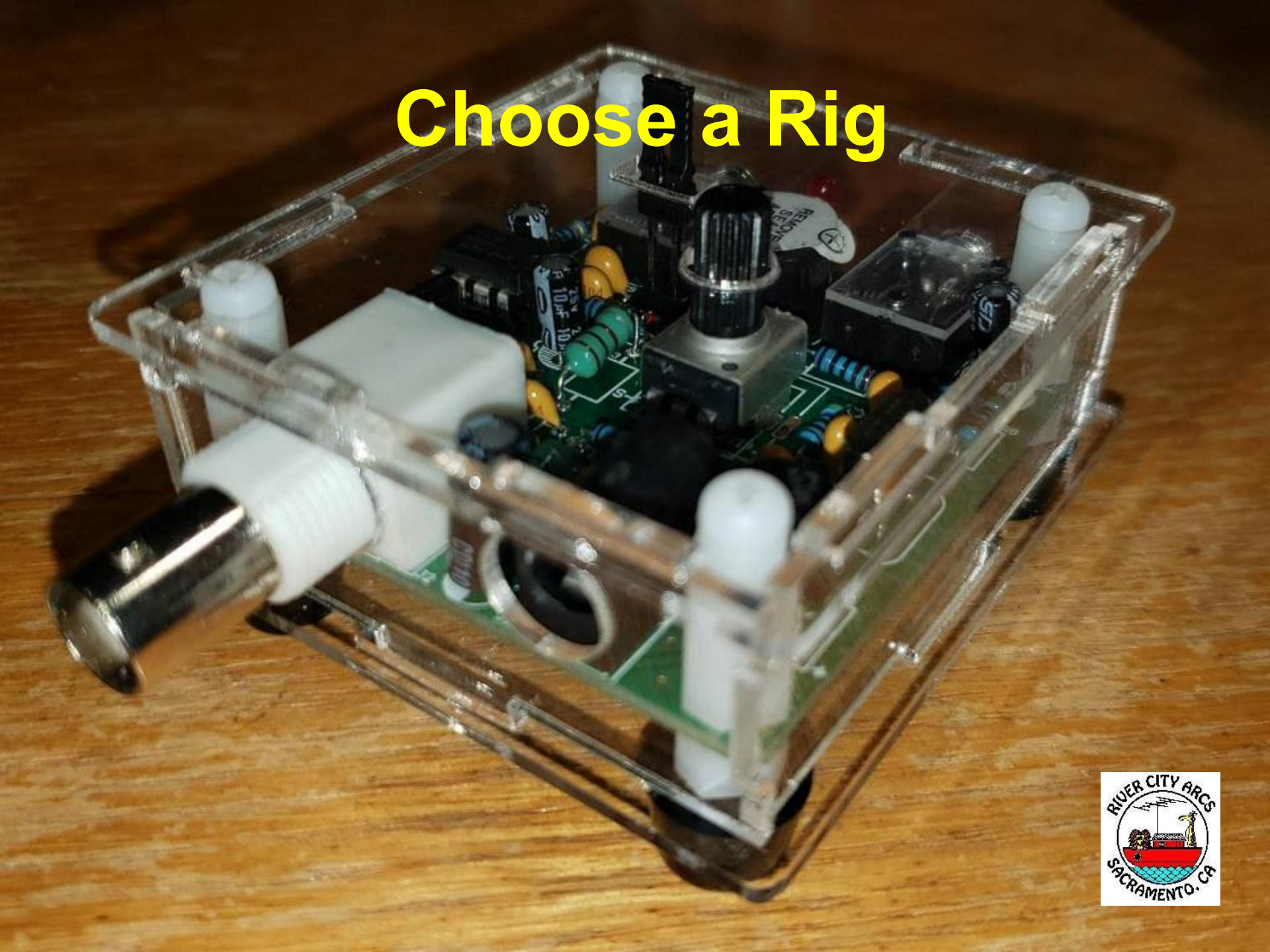
This calculator should not be used for antennas that are less than 20 cm (8 in) from a person.

View detailed instructions for each parameter. (opens in new tab/window)

Parameters

- Power at Antenna: (Need help with this?) _____ (watts)
- Mode duty cycle:

Choose a Rig



Build a Kit

- Lower cost
- You understand the insides of your radio
- Prepares you to repair it
- DIY-Radio kit building, mentoring available.

Kit Building is Fun!

Cheap vs. Quality

- Cheap radios offer poor performance, spurious emissions, little or no support.
- Quality radios offer better results, clean signals, ready support.

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QRP vs. QRO

QRP (<5 watts) requires an efficient antenna, patience, and skill for contacts. Best results with CW and digital modes. Not normally recommended for first rig.

Standard rig power (100 watts) yields more and easier contacts with all modes including phone.

QRO (>500 watts) is useful for net controls, serious DX and contest operation. May need 220VAC.

Receiver types

- Direct conversion receivers – simpler circuit, medium selectivity, e.g., QCX.
- Superheterodyne dual conversion receivers offer superior selectivity, e.g., IC-718, K3
- Direct Sampling receivers use an ADC and digital filtering and signal processing. Software defined radio offers spectrum & waterfall display. Susceptible to out of band interference, e.g., IC-7300, K4, FlexRadios
- Hybrid Superhet & SDR suppresses out of band interference, e.g., KX3, FT-710, FTDX-10

Sherwood Engineering Inc.

1268 South Ogden Street Denver, Colorado 80210 USA

email Phone: 303-722-2257

9 a.m. - 5 p.m. MST Monday - Friday

Look in on part of SEI's Laboratory

Receiver Test Data

(Terms Explained: DOC PDF)

Sorted by Third-Order Dynamic Range Narrow Spaced - or- ARRL RMDR (Reciprocal Mixing Dynamic Range) if Phase Noise Limited

The term RMDR has only existed since 2012. To convert column LO Noise to RMDR, subtract 27 dB. Example: an LO Noise of 127 dB would be an RMDR value of 100 dB

Note: The term blocking only applies to a superhet radio. For a direct sampling radio the value in the blocking column is the ADC overload point reference receiver noise floor.

Updated 19 January 2023. Added SunSDR2 DX

Device Under Test	Noise Floor (dBm)	AGC Thrshld (uV)	dB	100kHz Blocking (dB)	Sensitivity (uV)	LO Noise (dBc/Hz)	Spacing kHz	Front End Selectivity	Filter Ultimate (dB)	Dynamic Range Wide Spaced (dB)	kHz	Dynamic Range Narrow Spaced (dB)	kHz
LO Noise Corrected 05/10/19 Yaesu FTdx-101D/MP	-127 -136[b] -141[6]	4.5 1.6[b] 0.58[b1]	3	>147	0.60 0.20[b] 0.12[b1]	154 155	10 50	A Trk Presel	>115	110	20	110	2
Added 9/29/14 FlexRadio Systems 6700 Hardware Updated	-118 -135[b2]	3.0 1.0[b2]	Var	130 preamp Off	2.0 0.25[b2]	145 155	10 50	B Band Pass	115	99	20&2		&2
Added 12/30/20 Yaesu FTdx10	-126 -135[b] -140[6]	4.2 1.46[b] 0.54[b1]	3	141	0.63 0.21[b] 0.15[b1]	152 153	10 50	B Half Octave & Bandpass	105	107	20		

An Early Panadapter

- Heathkit HO-13 Ham-Scan Panadapter
- Vacuum tubes, CRT display of 100 kHz of IF
- Kit sold for $79 1964-1966

Power Sources

Linear Power Supply

- Heavy power transformer, rectifier, filter & voltage regulator
- Does not generate RF noise
- Bulky
- Expensive

Switching Power Supply

- Power oscillator, rectifier, filter & voltage regulator
- May generate RF noise
- Smaller & lightweight
- Cheaper

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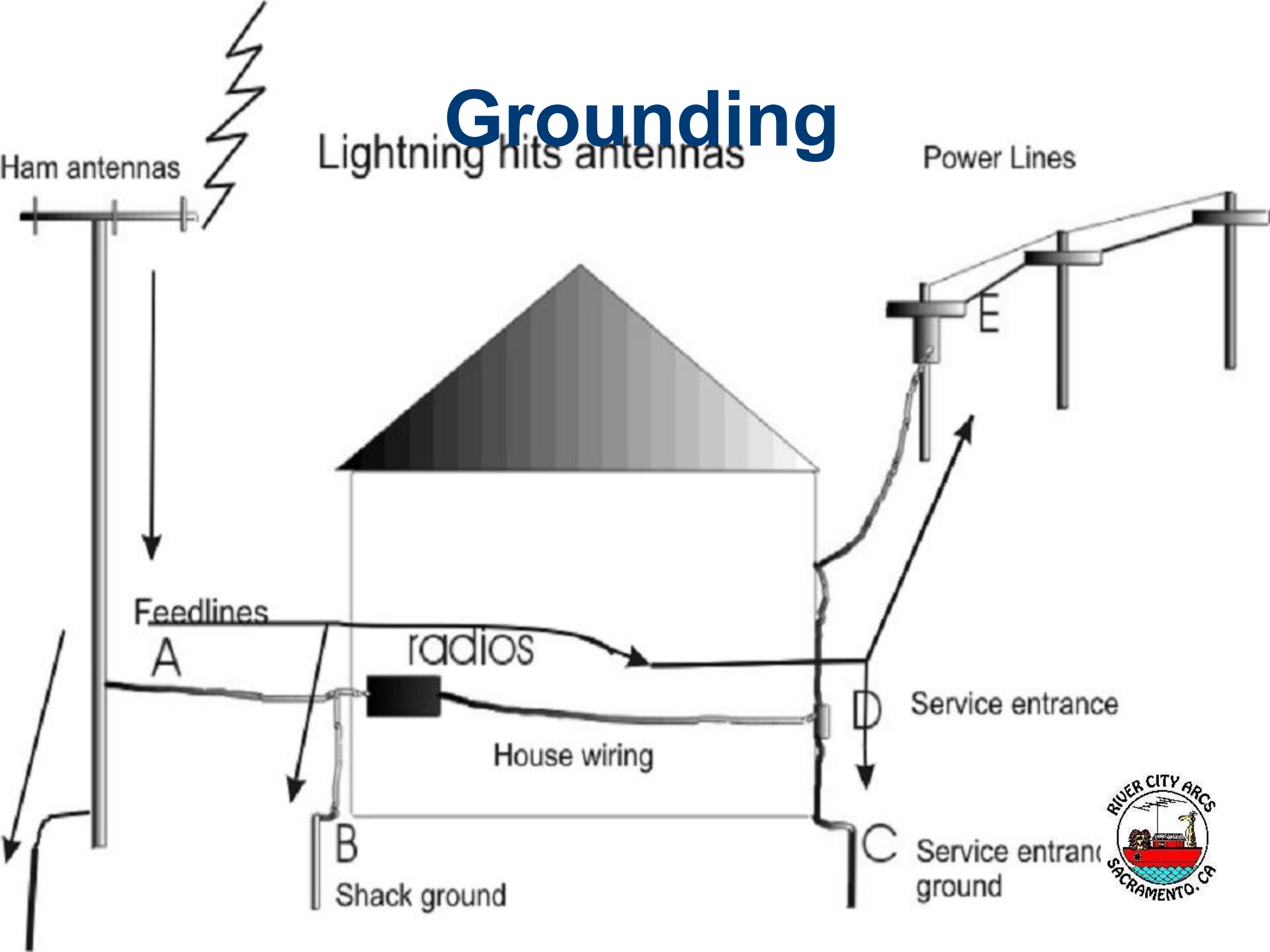
Battery Power

- Lithium – $$$, lightweight, high capacity
- Lead/AGM - $, heavy, medium capacity
- No RF noise
- Needs recharging, mains or solar

Battery Care

- Recommend do not draw more than half of the battery capacity in Ah (amp-hours) before recharging.
- Batteries self-discharge over time.
- Excess discharge will damage battery.
- Lithium batteries are prone to explode if punctured or overcharged.
- A Power Gate can automatically switch to battery power in case of mains power outage.

Grounding


Ham antennas
Lightning hits antennas
Power Lines
E
Feedlines
A
radios
D
Service entrance
House wiring
B
Shack ground
C
Service entranc
ground
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The Station Ground

Can help reduce common mode noise reaching the antenna and keep RF out of power lines, CATV lines and phone lines.

Can help keep antenna currents off station equipment and cables.

Might mask antenna installation or feed line problems.

Might improve lightning safety and reduce electric shock hazard.

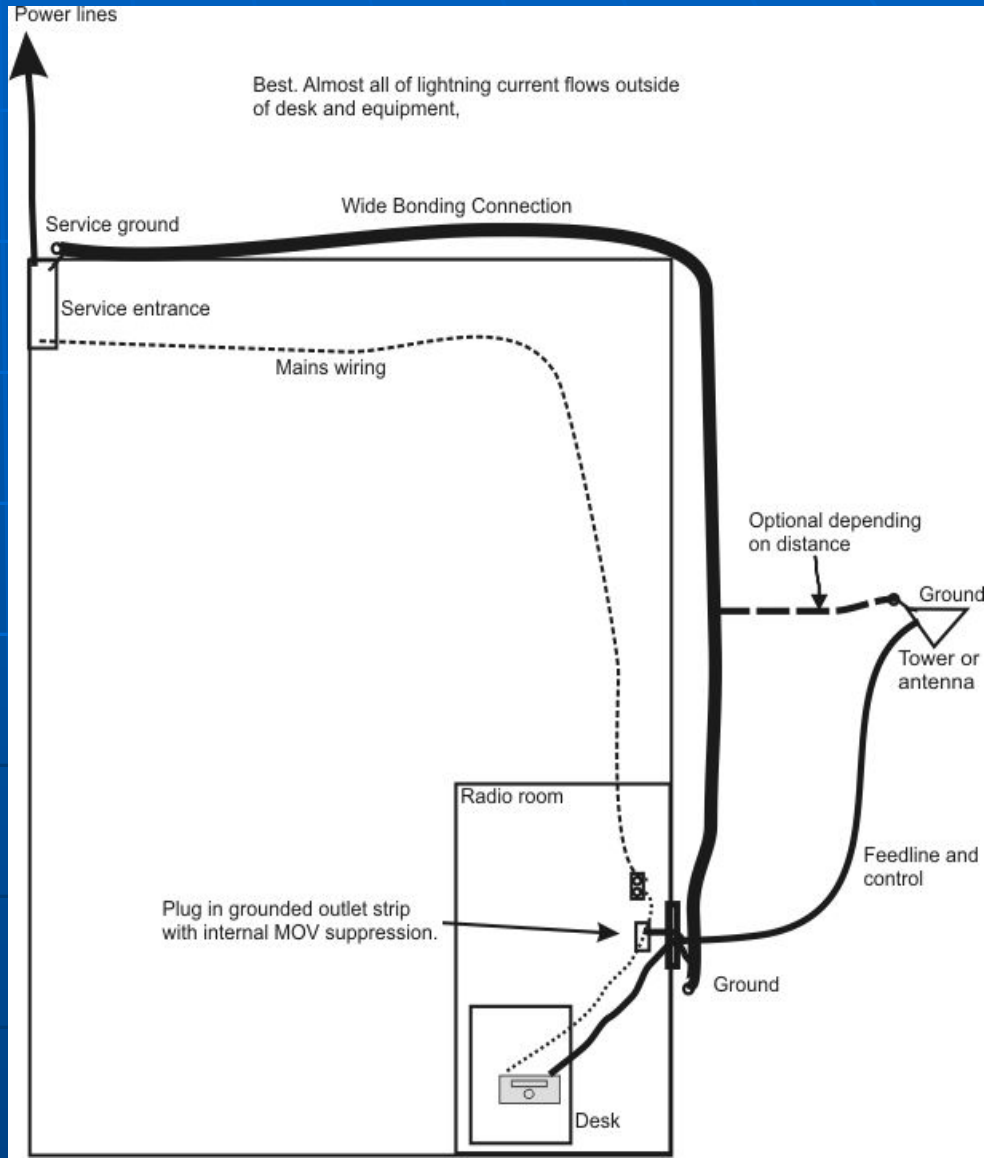
Will not reduce the chance or number of lightning strikes. Use a lightning arrestor/disconnect.

Best Grounding for Code

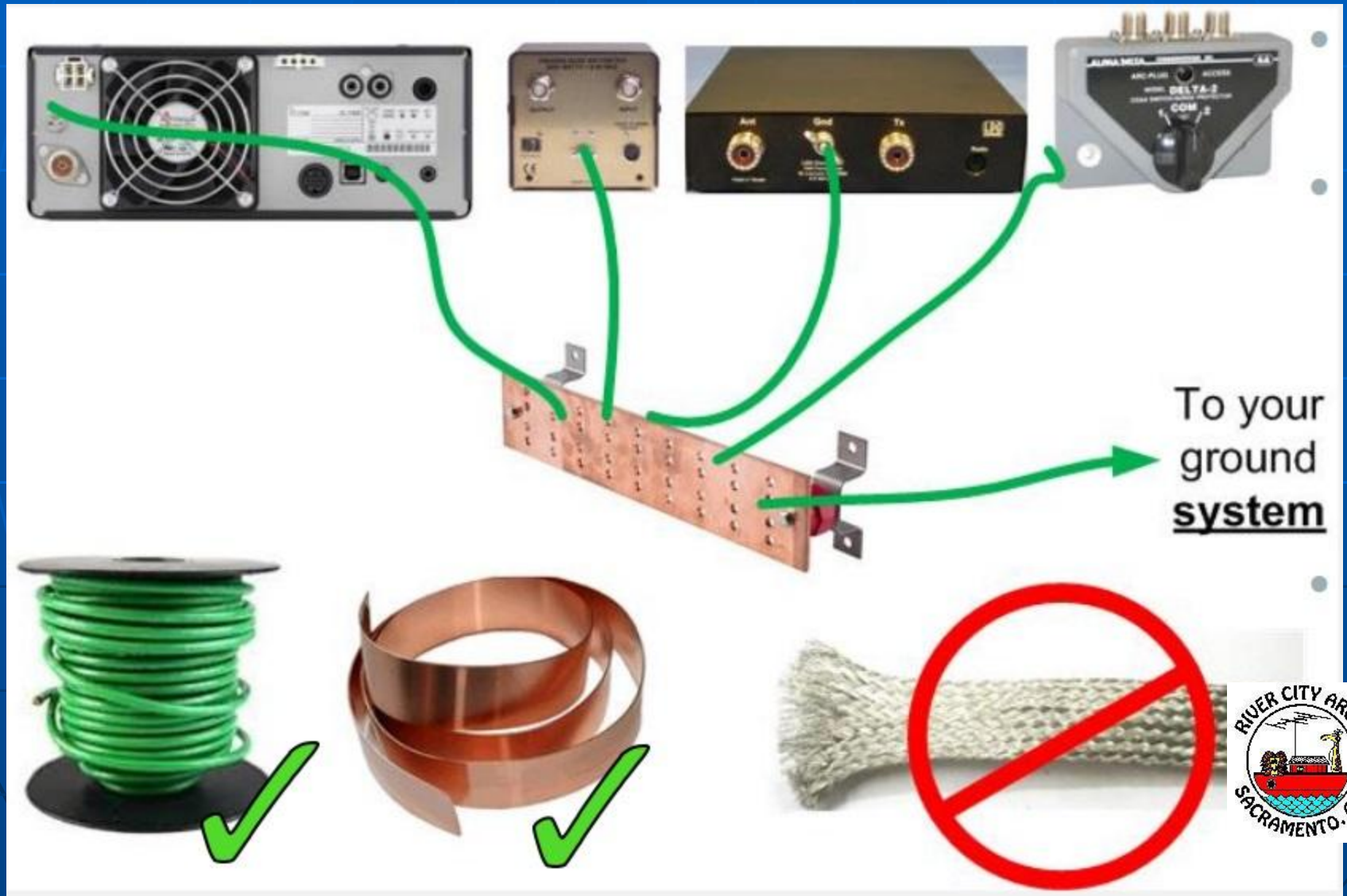
This system meets all codes.

EVERYTHING on the desk in the radio room has to run from the room common point entrance.

Courtesy of W8JI



Station Bonding



Station Bonding

- Mount the ground bus as close to the equipment as possible.
- Ground leads to each device should be as short as possible and of low impedance.
- The goal is to keep all equipment at same RF ground potential to avoid ground loops, equipment damage and RF burns.

Station Bonding Bus

Copper plated Steel Pipe Bracket

Transmission Lines

50 ohm Coaxial Cables

- RG-58/U, RG-58A/U, LMR-240 & RG8-X
  Power max ~800W @ 28 MHz
  2.4 dB Loss per 100 ft
- RG-8/U, RG-213/U & LMR-400
  Power max ~3500W @ 28 MHz
  1 dB Loss per 100 ft

Coax is very lossy at high SWR.

Coaxial Connectors

- UHF type – PL-259, SO-239, >1 kW
- Coax Seal, Silicone Tape, Vaseline
- UG-175 UHF reducer for RG-58/U
- BNC Bayonet Neill-Concelman constant impedance connectors, either 50 or 75 ohms, 80-100W
- N type are weatherproof & constant impedance connectors used for VHF-UHF to 11 GHz

Coaxial Switches

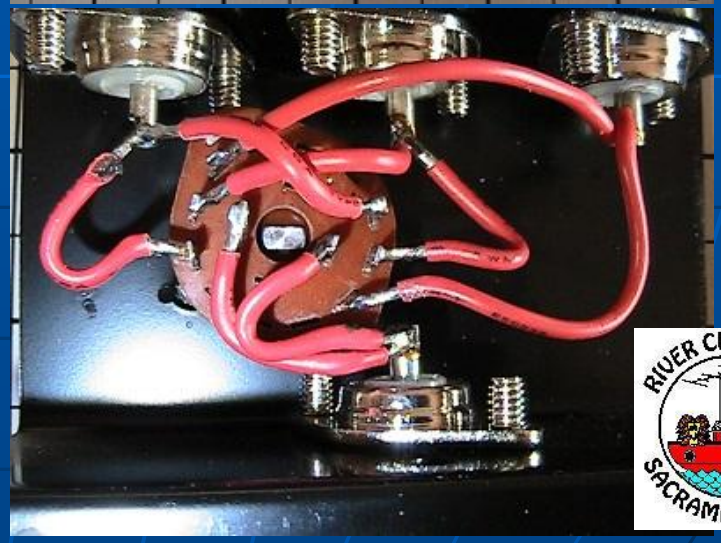
Can be used to select one radio to different antennas, or one antenna to different radios.

The insufficient isolation of the unused ports in cheap coaxial switches can damage attached equipment.

Cheap Coaxial Switch

This CX-3 switch cannot handle 1000 watts. Its impedance mismatch and poor isolation between ports can damage radio equipment.

A 100 watt signal on port 1 couples nearly 1/2 watt of RF power to port 2 at 28 MHz.



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Alpha Delta Coaxial Switch

- The Alpha Delta switch shows adequate shielding, 60 dB isolation, and grounding of unused ports.
- This switch can safely switch multiple radios to one antenna.

Ladder Line/Open Wire

- 300 ohm, 450 ohm Window Line
- 600 ohm Open Wire w/spreaders

Lowest loss transmission lines.

Best for multi-band antennas that vary impedance over frequency.

Route a few inches away from metal.

Feed with a tuner and 1:1 current balun or a balanced tuner.

Voice Operation

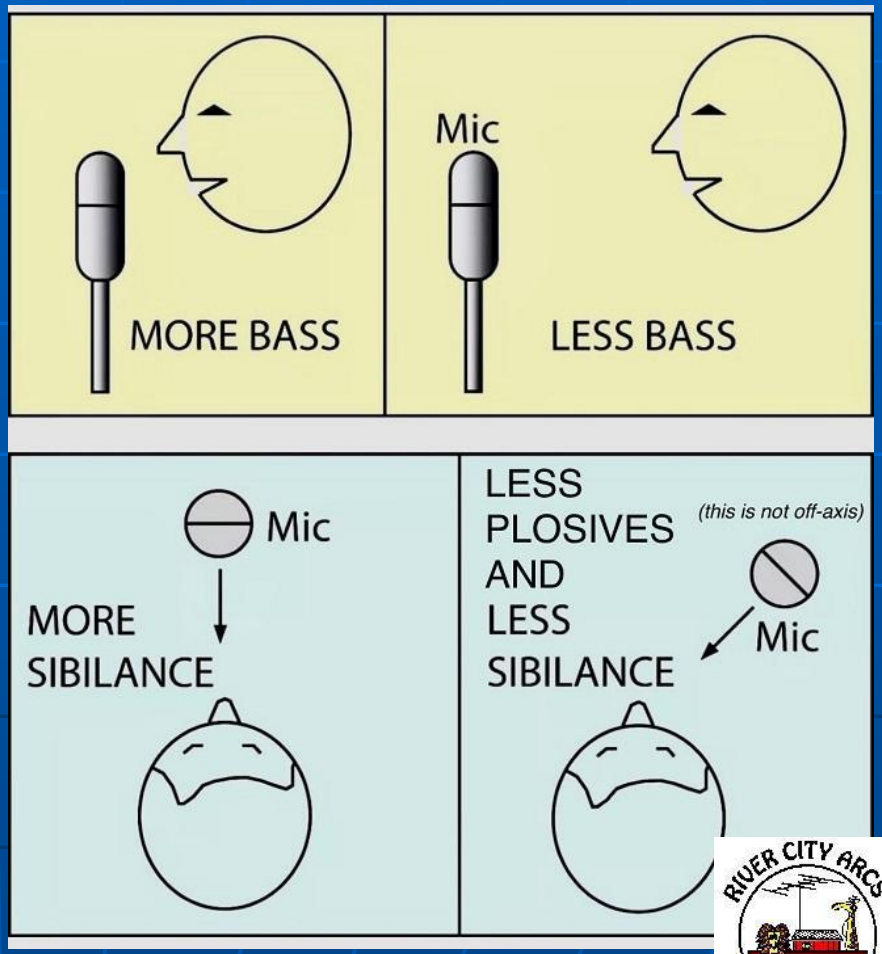
Microphone Placement

Too close causes too much bass.

Too far away causes low volume.

Straight into the mike causes popping & breathing sounds.

Mike to the side is the ideal position.



Handheld Microphones

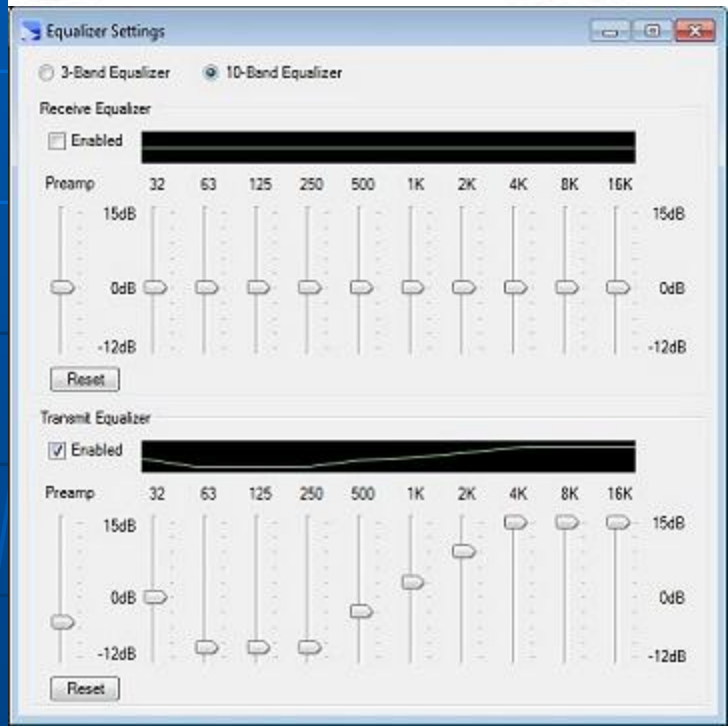
1. Hold the microphone below or to the side of your mouth to avoid noise from breathing.
2. Point the front of the microphone towards your mouth.
3. Keep the microphone about one to three inches away from your mouth.
4. Hold the microphone consistently when you use it.

Headset Microphones

1. Position the microphone by the corner of your mouth and angle it to the center of your mouth. This avoids the pops and bursts of air from your nose and mouth.
2. Keep the microphone element about one inch away from your mouth.

Good Transmitted Audio

- Monitor transmitted audio & adjust transmit equalizer for good natural sound.
- Adjust the microphone gain per instruction manual.
- Use a microphone with correct impedance & DC bias.
- Compression distorts audio but may help when your signal is weak.
- Stray RF & ground loops may cause transmitted hum & distortion.



Good Receiver Practice

Use the receiver preamp only on 14 MHz & above.

Set the AGC to fast for AM, slow for SSB.

Set the AF gain (volume) for a comfortable level.

Decrease RF gain slowly until the signals volume just drops, then back off a little. This yields the best SNR.

Raise the RF gain as needed to hear weaker signals.

Good Receiver Practice

Use the attenuator to reduce distortion on very strong signals and overload interference from other strong in-band signals.

Turn the RIT off unless working split.

Use the auto notch filter to reduce heterodynes.

Adjust the bandwidth filter for the mode and the IF shift to reduce adjacent frequency QRM.

Use the Noise Blanker to reduce pulsatile noise.

Noise Reduction reduces the white noise but can introduce distortion (gargling sound).

Receiver Noise

- Assure all antenna and ground connections and cable connectors are tight and secure.
- Separate the antenna away from power lines and other RF noise sources.
- Orient wire antennas perpendicular, not parallel to power lines.
- Horizontal receive antennas receive less noise than vertical antennas on 7 MHz and below. E.g., the "Loop on Ground" is a very quiet receive antenna.

Receiver Noise

Place a 1:1 current balun (common mode choke) on the feed line at the feed point & at the radio.

Place ferrites & filters on RF noise sources.

If all else fails, receive through a webSDR.

A noise canceller with a sensing antenna may reduce external RF noise.

Morse Code (CW)


Digital Modes
SAE 5W-30
MOTOR OIL
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Data Modes dB Comparison

Relative Sensitivity of Communication Modes		
Mode	Signal to Noise Ratio Threshold	Power Equivalence
WSPR	-27 dB	5 W
JT65	-24 dB	10 W
Olivia	-17 dB	50 W
PSK31	-7 dB	500 W
CW	-1 dB	2,000 W
RTTY	+5 dB	8,000 W
SSB	+10 dB	25,000 W

Figure 1. Relative Sensitivity of Communication Modes in a 2500 Hz Bandwidth*

*Source: "Interpreting WSPR Data for Other Communication Modes", Milazzo C. 2013.

Data Mode Station

- Computer
- Software,
  - e.g., WSJT-X, Fldigi, WinLink MMSSTV
- HF Transceiver
- Sound Interface
  - e.g., SignaLink*
- CAT Cable*

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Slow Scan Television

- *28.620 MHz USB – Scottie 2*

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Periodic Maintenance

- Check Equipment Operation, Power & Antenna SWR. Dust heat sinks & fans.
- Test and Recharge or Replace Batteries.
- Physically Examine Antennas, Feed Lines & Grounds for corrosion and damage, especially after storms.
- Tighten Loose Antenna Hardware & Connectors.
- Inspect guy wires and supports for wear and tension.
- Trim Tree Branches that touch Antennas.

Station Accessories

- SWR/Power Meter
- Antenna analyzer or NanoVNA
- Antenna "Tuner"
- Dummy Load
- Digital Multimeter
- Household hand tools
- Soldering iron & solder
- Diagonal cutter
- Needle nose pliers
- Contact cleaner

Questions?

Thanks for Coming!

See you at our next meeting.