Ham Radio Station Design

INTENTIONAL DESIGN, NOT ACCIDENTAL!

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Big Picture: The Design Process

Zoom in: Finding a Few More dB

Wrap up: Notes on Operator Efficiency
design

- to create, fashion, execute, or construct according to plan
- to conceive and plan out in the mind
- to make a drawing, pattern, or sketch of
The Usual Process

• You buy the best radio equipment you can afford

• You put up the tallest towers you can manage

• You install the biggest possible antennas

• You acquire a bunch of useful station accessories

...does it all work together?

...does it do what you want?
Design First, then Buy & Build
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The design process:

1. Set overall objective (All bands/favorite bands? Competitive level?)

2. Develop the specifications (features, performance, cost, labor)

3. Block diagram design (rough outline)
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5. Determine plan of action (timetable, which pieces first)

6. Constant feedback — things come up, so modify the plan as needed
Be Organized, But Avoid Pitfalls

• Listen to others, but analyze your own wishes and capabilities
• Don’t hesitate to adapt the design, but update all of it
• Prioritize — Decide where to start, then get things done
• Don’t spend all your time designing — build it!
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Finding a Few More dB

- Being a few dB louder
- Hearing a few dB better
- Even when you have a good station: finding the “next dB”
The Marvelous dB

The decibel (dB) uses a logarithmic scale ($\log_{10}$ —powers of 10) to compress very large numbers into smaller, more easily managed form.

- $\times 1 = 10^0 = 0$ dB
- $\times 10 = 10^1 = 10$ dB
- $\times 100 = 10^2 = 20$ dB
- $\times 1000 = 10^3 = 30$ dB
- $\times 1,000,000 = 10^6 = 60$ dB
(+51.8 dBm) 150W Low Power
(+37 dBm) 5W QRP Power
Ham down the street
Shortwave broadcast stations
20M at start of Sweepstakes

160M on a very quiet night
Typical 20M noise
Dead band noise at 15M — VHF

Chart: \( 242 \text{ dB} = 10^{-21} \text{ to } 1.5 \times 10^3 \text{ Watts} = \times1,500,000,000,000,000,000,000,000,000,000 \)

1500W Legal Limit Power (+61.8 dBm)
Start of overload (blocking) on a good receiver
S9 +40 dB
~Maximum signal level with no IMD, good RX
S9 meter reading (-73 dBm)

Receiver noise floor — no preamp
Receiver noise floor — preamp on

1 Hz Noise Floor, Room Temp. (-174 dBm)
Dead Band to 1500W \( \approx 200 \, \text{dB} \)

Dead Band to Strongest Signals \( \approx 130 \, \text{dB} \)

Human Hearing Audio Range \( \approx 100 \, \text{dB} \)

Human Eyesight Perception Range \( \approx 100 \, \text{dB} \)

Note: Human hearing and eyesight have a logarithmic (dB) response
Despite the wide dB range of signals and our senses...

We can detect audio level differences of less than 1 dB

Fractions of a dB really matter!

(...but only after you get all the easy dB)
Where do we find another dB?

- Bigger antennas (3 el. to 4 el. is ~1 dB) (16 to 64 radials ~1 dB)
- Higher antennas (or optimized height)
- Increased power (1200W to 1500W)
- Lower loss coax (RG8x → 9913 → hardline)
- SSB speech processing
Where do we find another dB?

• Radio is TWO-WAY communications!

• Better receiver (lower IMD, better NF)

• Receive antennas (mainly low bands)

• Reduce ambient noise (fix it or move)

• Determine best DSP settings
Case History:
160M Vertical vs. Inverted-L

• 2005/6 - 2007/8: Inverted-L, 55 ft. vertical portion
  Radial system 26 × 110 ft.

• 2008/9: 100 ft. tower with top-loading capacity hat
  Same type radial system as previous Inv-L

• Subjectively, the new tower works much better than the Inv-L,
  with greater difference than simple EZNEC models predict

• Since A/B comparison is not available, can I identify differences
  that explain the improvement?
Inverted-L:  
Feedpoint: 22 ohms  
Ground resistance (est): 3 ohms  
Power loss: 1.27 dB

100 ft. Top-Loaded:  
Feedpoint: 46 ohms  
Ground resistance (est): 3 ohms  
Power loss: 0.59 dB

Feedline: 300 ft. 9913 & RG8  
Loss: 0.62 dB  

Feedline: 275 ft. 7/8” Heliax  
Loss: 0.14 dB

Net improvement: +1.16

Notes:

1. Inv-L has about 0.2 dB “front-to-back” in line with top wire. Otherwise, modeled radiation patterns have little difference except at high angles.

2. Location difference of 75 ft., new tower ~6 ft. uphill. Small additional slope on radials raises radiation resistance, and slightly improves low angle radiation.

3. Future 1-ohm equiv. resistance radial system = another 0.4 dB improvement
Final Topic: Operator Efficiency

You are Unique!

• Comfort and efficiency requirements can be quite different

• Spend some time analyzing your personal habits for the best...

  Equipment layout
  Especially rotator controls, switches, other “reach for” items
  Right-handed or left-handed
  Computer-centric vs. Radio-centric
  SO1R, SO2R or some type of mix (SO1.5R)

• Before you copy someone else’s idea – try it out!