Ham Radio Station Design

INTENTIONAL DESIGN, NOT ACCIDENTAL!

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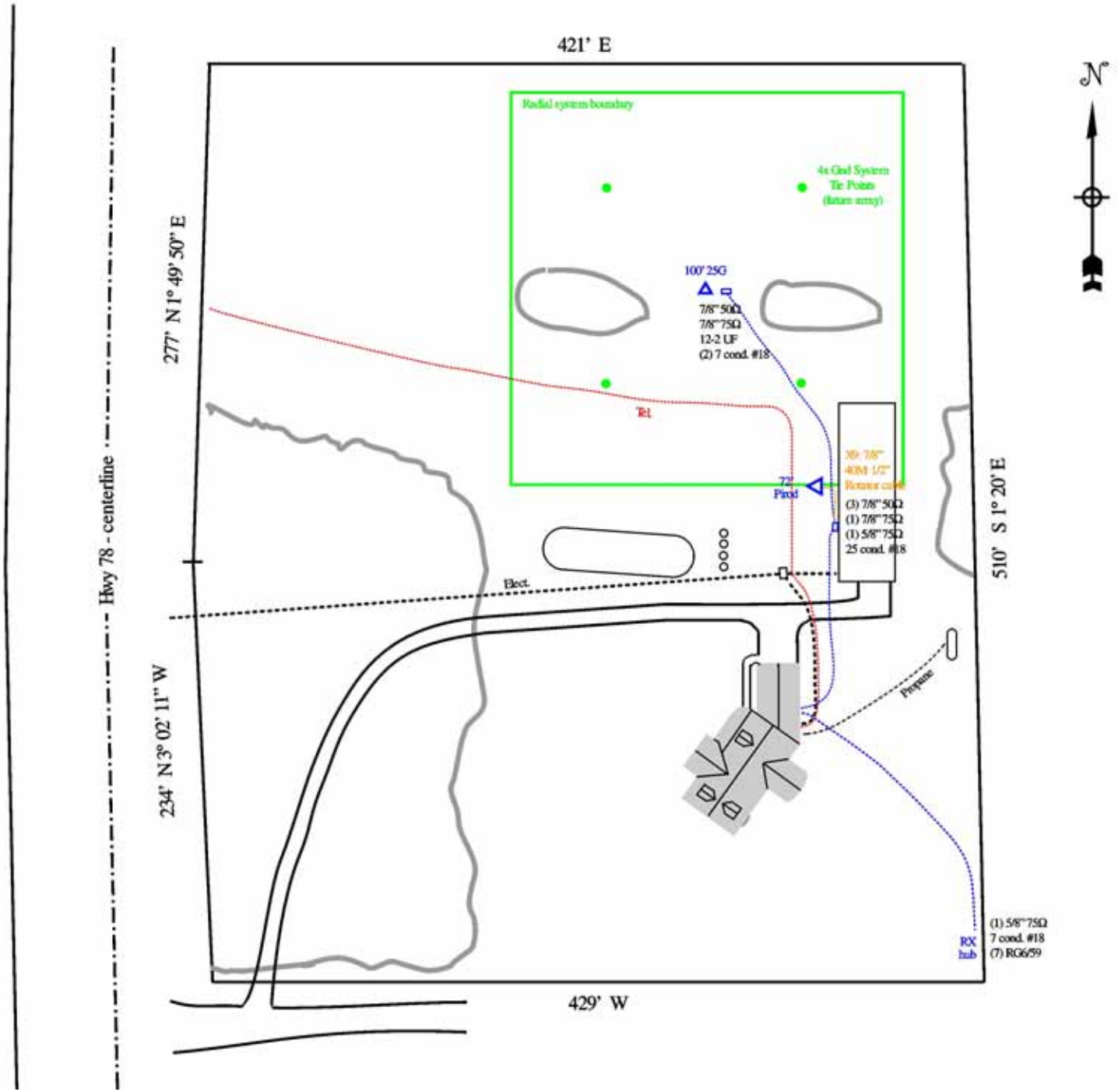
Big Picture: The Design Process

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


421' E
277' N 1° 49' 50" E
510' S 1° 20' E
234' N 3° 02' 11" W
429' W
Hwy 78 - centerline
N
Radial system boundary
4x Gnd System
Tie Points
(Return array)
100' 25G
7/8" 50Ω
7/8" 75Ω
12-2 UF
(2) 7 cond. #18
Tel
72'
Pivot
30' 7/8"
40M 1/2"
Rotator cable
(3) 7/8" 50Ω
(1) 7/8" 75Ω
(1) 5/8" 75Ω
25 cond. #18
Elect.
Propane
RX
hub
(1) 5/8" 75Ω
7 cond. #18
(7) RG6/59

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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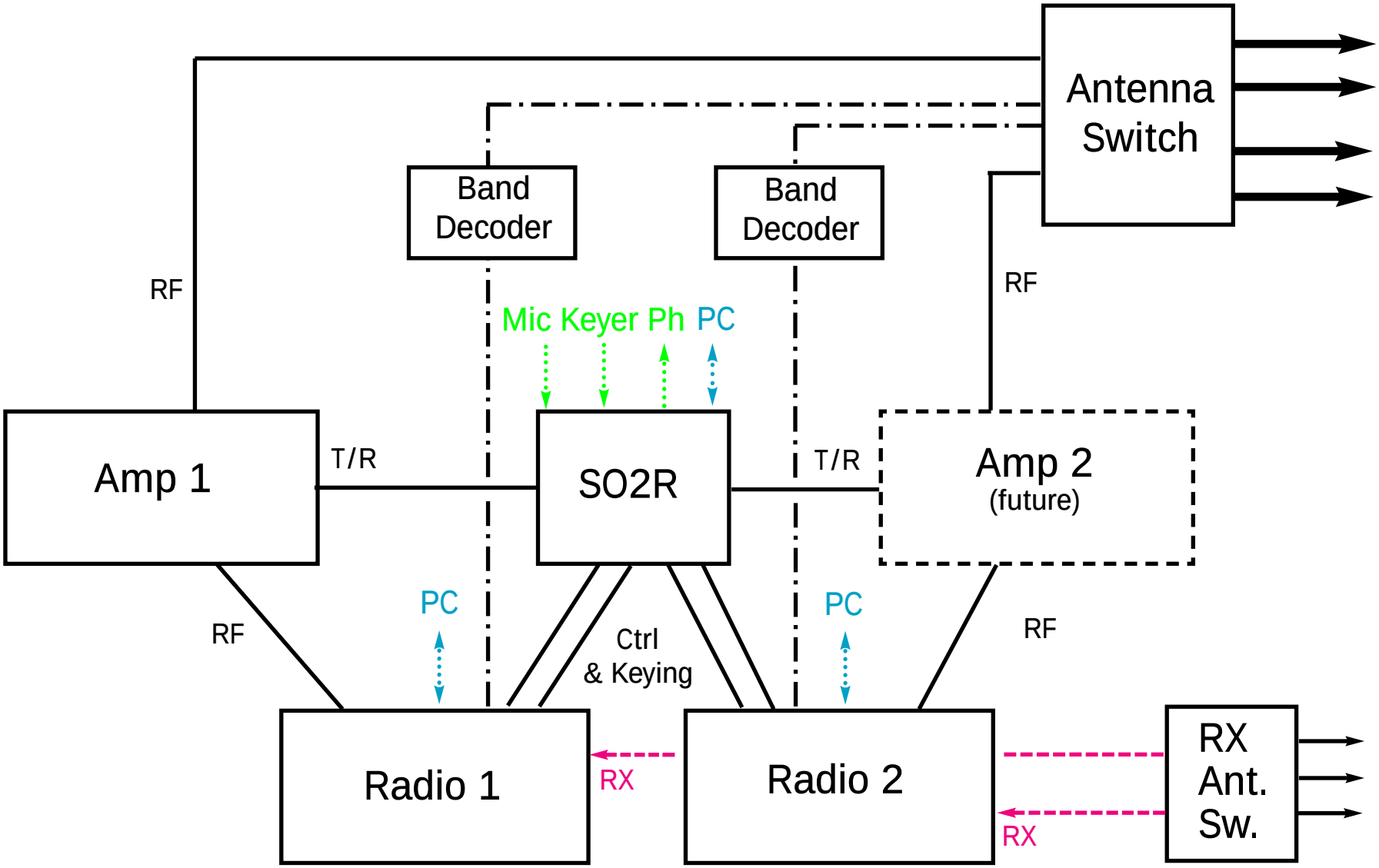
The design process:

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

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

3. Block diagram design (rough outline)


Antenna Switch
Band Decoder
Band Decoder
RF
RF
Mic Keyer Ph PC
Amp 1
T/R
SO2R
T/R
Amp 2
(future)
PC
PC
RF
RF
Ctrl & Keying
Radio 1
RX
Radio 2
RX
RX Ant. Sw.

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4. Details for each block (equipment selection, interconnections)

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

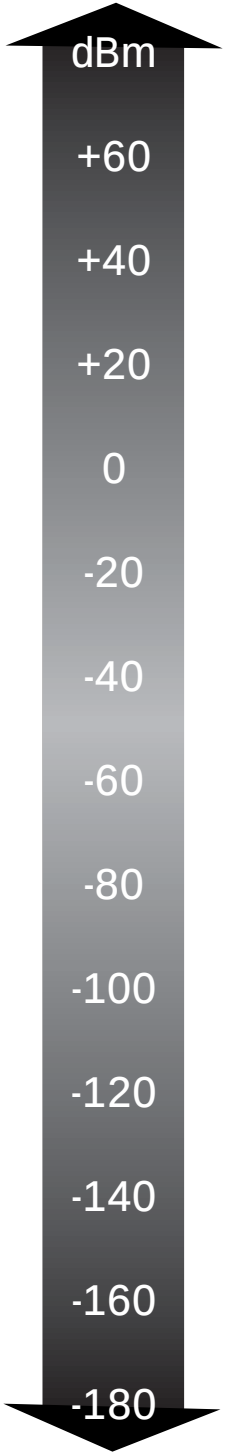
$\times 10 = 10^1 = 10$ dB

$\times 100 = 10^2 = 20$ 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

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)

Chart: 242 dB = 10^{-21} to 1.5×10^{3} Watts =
×1,500,000,000,000,000,000,000,000

Dead Band to 1500W ≈ 200 dB

Dead Band to Strongest Signals ≈ 130 dB

Human Hearing Audio Range ≈ 100 dB

Human Eyesight Perception Range ≈ 100 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:	100 ft. Top-Loaded:	
Feedpoint: 22 ohms	Feedpoint: 46 ohms	
Ground resistance (est): 3 ohms	Ground resistance (est): 3 ohms	
Power loss: 1.27 dB	Power loss: 0.59 dB	+0.68
Feedline: 300 ft. 9913 & RG8	Feedline: 275 ft. 7/8” Heliax	
Loss: 0.62 dB	Loss: 0.14 dB	+0.48
	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!