New LF and MF Amateur Bands

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Spectrum Subdivisions

- VLF = 3-30 kHz
- LF= 30-300 kHz
- MF= 300 kHz-3 MHz
- HF= 3-30 MHz

Some History

- The use of 500 kHz for distress was defined at the first International Radiotelegraph Convention (Berlin), effective 1 July 1908.
- US Radio Act of 1912 restricted amateurs to 200m and down, i.e. >1.5 MHz.
- Amateurs have been banished from the low bands for over 100 years!

More History

- Below 500 kHz was busy: marine and navy RT, WWV 60 kHz, beacons, navigation systems but by the 1990's many of these services had been discontinued or greatly reduced.
- 415-526 kHz was the maritime band until ≈1995 when Coast Guard ceased monitoring 500 kHz.
- This prompted some amateurs to start thinking of new LFMF bands for hams.

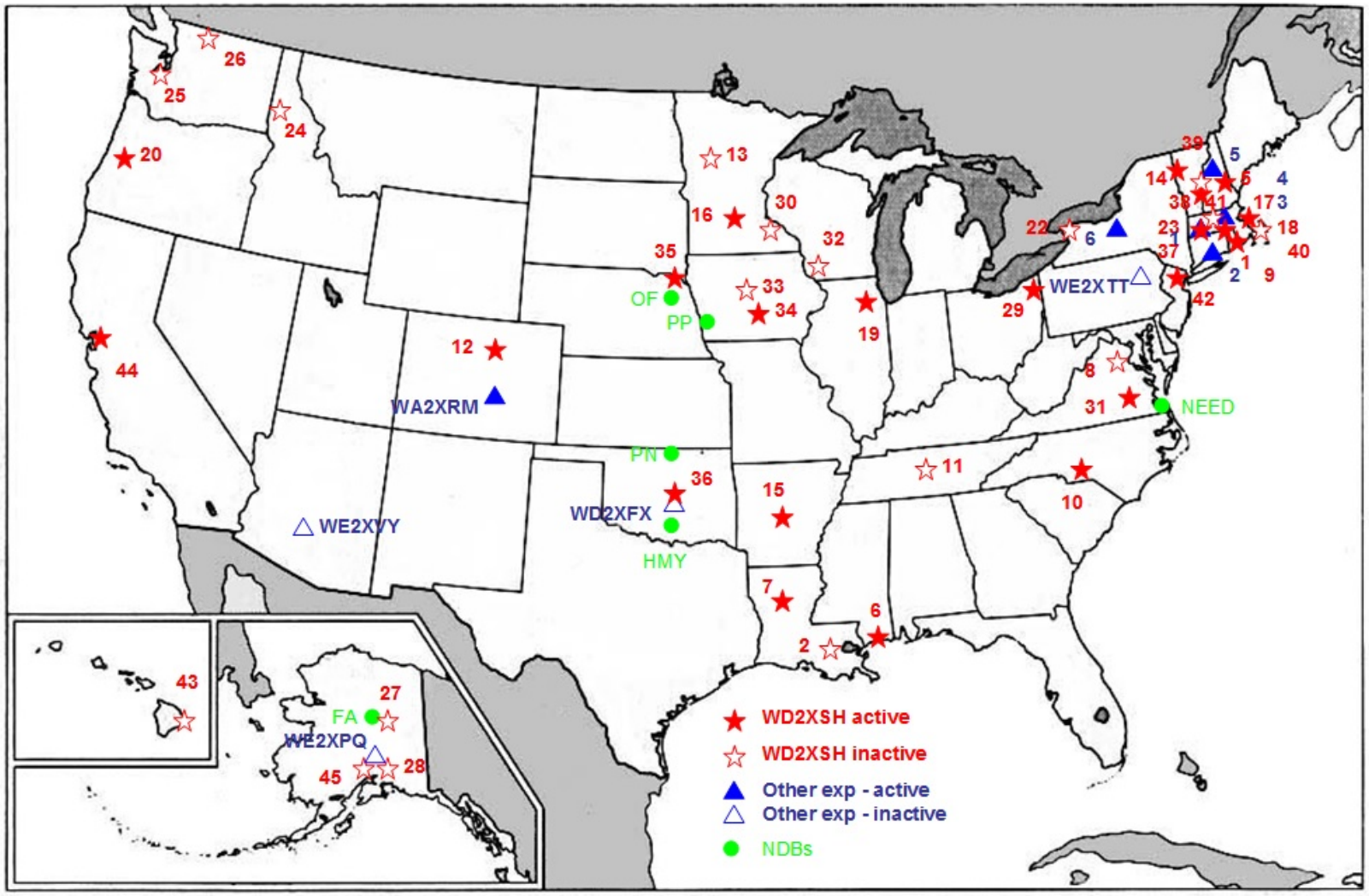
Experimental Licenses

- However, it took 20 years to make new bands real!
- The initial route was to apply for experimental licenses to operate around 500 kHz.
- One license was sponsored by the ARRL, WD2XSH. Operation began in September 2006 with Fritz Raab, W1FR, in charge. N6LF was part of this group (WD2XSH/20).

ARRL experimental group

- Originally 23 stations were licensed on 495-510 kHz, 20W ERP
- Ultimately it was expanded to 45 licensees with added frequencies: 461-478 kHz
- Initial transmissions began September 2006.
- Ultimately we logged over 300k hours of TX
- This operation and that of many others provided the ammunition for the WRC-12 (2013) allocation battle!

Experimental stations



The New LFMF Bands

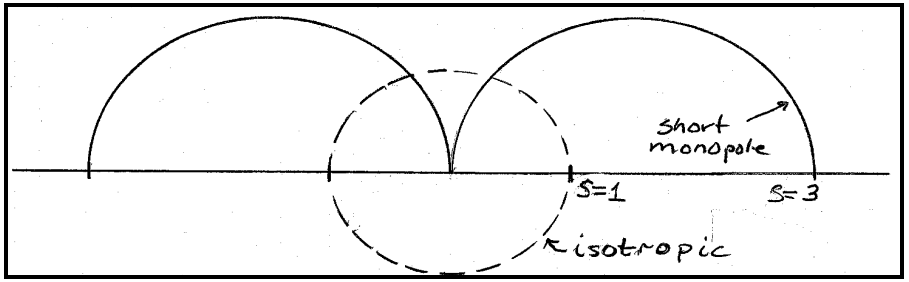
- It took another four years but in October 2017 US amateurs were granted two new bands and operation began:
- 630m – 472-479 kHz
- 2200m – 135.7-137.8 kHz
- The bands are available to general class and above.

Restrictions in FCC17-33

- Radiated power:
  - 630m 5W EIRP
  - 2200m 1W EIRP
- Maximum transmitter output power:
  - 630m – 500W
  - 2200m – 1.5kW
- Antenna height limited to 60m or less.
- Mobile operation is not permitted

What is EIRP?

- Equivalent Isotropic Radiated Power



- When a monopole is placed over ground, for the same total radiated power (Pr) the power density, at the same distance horizontally from the base, will be greater by a factor of 3 (+4.77 dB) from two effects: Pr is into a hemisphere rather than a sphere, =2X or +3dB and a further increase of 1.5X (+1.77 dB) due to the directivity of a short monopole

Authorized Emissions

- From FCC 1733 report and order:

"CW (international Morse code telegraphy), RTTY (narrow-band direct-printing telegraphy) Data, phone and image emissions"

- **Just about anything you want!**

Common Misperceptions

- The bands are too narrow to be of use!
- With the low power you can't be heard down the block!
- The manmade and natural noise levels are so high you can't hear anything anyway!
- It's impossible for amateurs on city lots to erect an effective antenna.
- Amateur equipment doesn't transmit below 160m.
- None of this is true!

Example

- Radiating only 1W EIRP N6LF had repeated two-way digital QSO's with VK4YB on 2200m, ≈7000 miles, using FST4-120 and -300.
- NO3M has earned WAS on 630m including 38 states with CW QSO's.
- Across the US there have been many CW QSO's but DXing on the lower bands is primarily digital.

Why 630 or 2200m?

- If you're a bit tired of the same old stuff LFMF is a fresh challenge:
  - Very different propagation
  - New very narrow digital modes
  - But also the oldest mode – CW
  - Building RX and TX equipment
  - Antennas
  - Boat anchor resurrection

Emissions In General Use

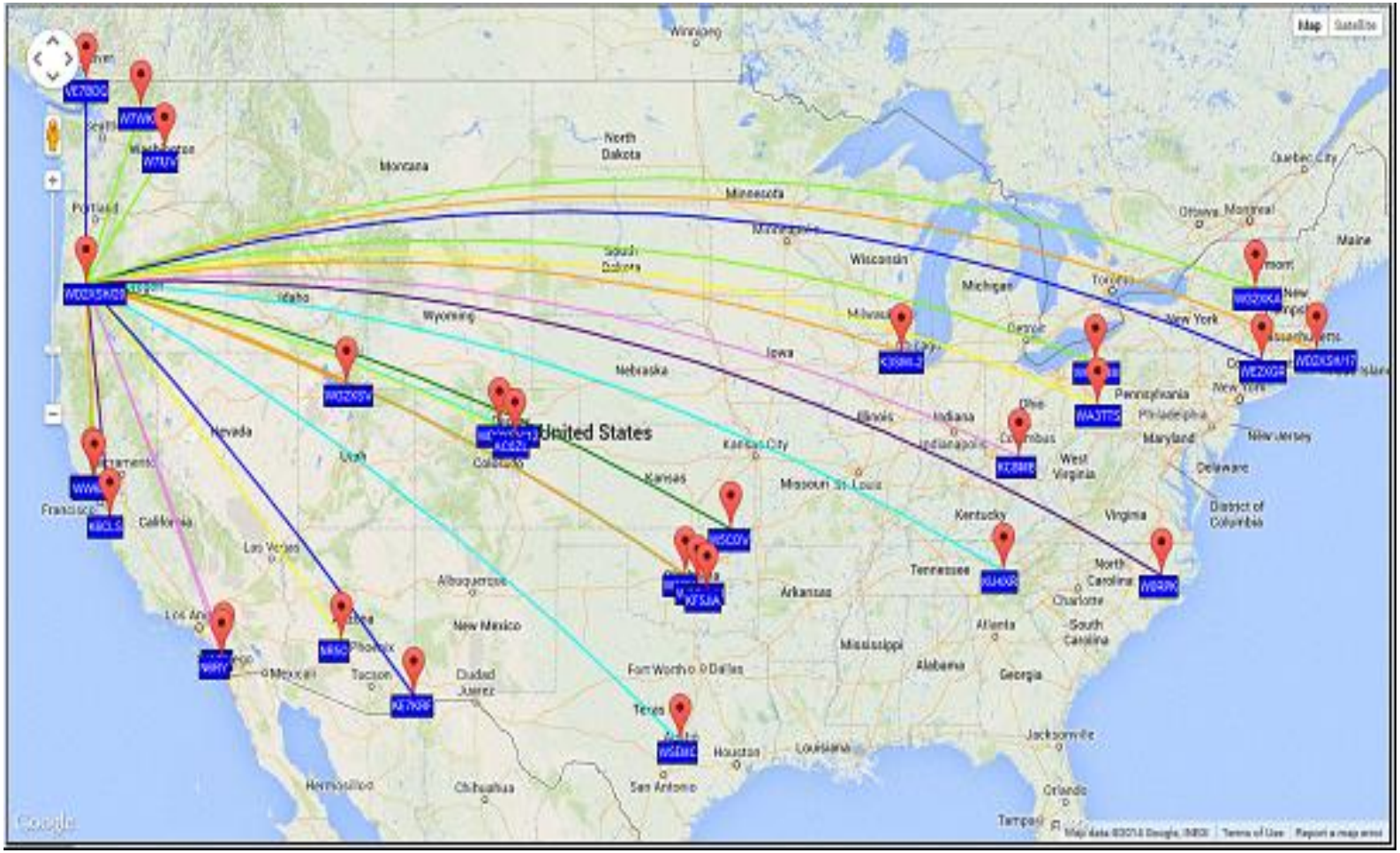
- WSPR-2, Weak Signal Propagation Reporting
- Digital:
  - FST4W -60, 120, ….. (WSPR)
  - FST4 -15, 30, 60, …..
- CW

WSPR

- WSPR-2 and FSTW are used for quantitatively testing propagation between two stations. The two minute messages are transmitted periodically with the receiving station recording the decodes and forwarding them on to the WSPRnet.org WSPR data base. :

Timestamp	Call	MHz	SNR	Drift	Grid	Pwr	Reporter	RGrid	km	AZ
2014-01-30 17:34	WG2XIQ	0.475666	-17	0	EM12mp	0.05	WG2XXM	EM15lj	306	359
2014-01-30 17:36	G3XIZ	0.475700	-29	0	IO92ub	0.5	DD7PC	JN49ax	627	108
2014-01-30 17:38	WG2XIQ	0.475666	-17	0	EM12mp	0.05	WG2XXM	EM15lj	306	359
2014-01-30 17:40	DL8YCA	0.475782	-11	-1	JO31or	0.01	PI4THT	JO32kf	60	338

WSPR Mapping



Activity Levels

- 630m
  - 10-15 stations transmitting WSPR or FT4W-120
  - 40-50 stations receiving and reporting
  - 5-10 stations QSO'ing with FT4-60
- 2200m
  - 2-5 stations transmitting WSPR or FT4W
  - 10 stations receiving and reporting
  - QSO's prearranged via internet

Propagation

- Daytime – ground wave
  - On 2200m 1W ERP = about 200-400 miles on a quiet day for a typically equipped receive station
- Nighttime – sky wave dominates plus some ground wave
  - Sky wave can extend thousands of miles
- 630m similar to bottom of the BC band
- Sometimes there are surprises

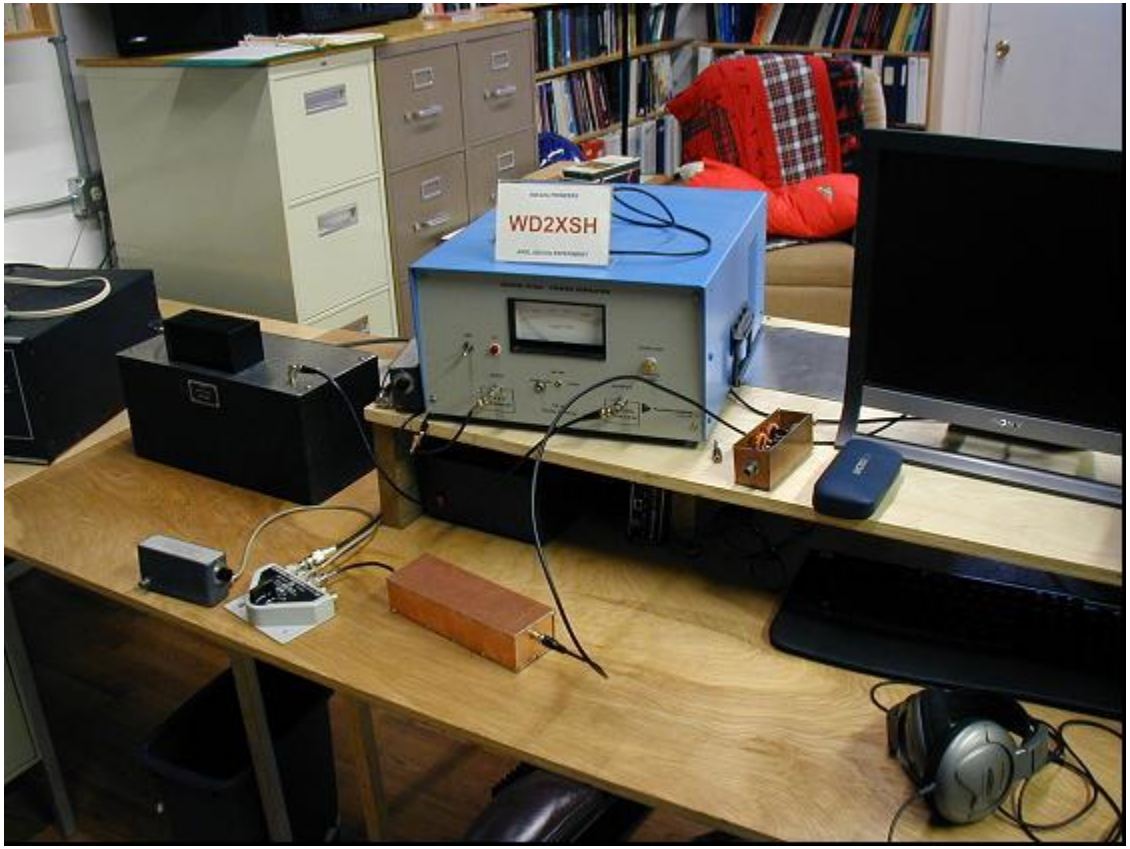
Amateur Receivers for LFMF

- Many HF transceivers will receive down to 2200m however, the performance may not be very good, especially at 2200m.
- The problem in older receivers is oscillator phase noise sidebands.
- I use a Kenwood TS590 which works well
- There are a number of down-converters available.

Amateur TX Equipment

- The Kenwood TS590 has a transverter output:
  - ≈2-3 mW
  - The full range of modulations and functions are available
  - A power amplifier is needed
- A variety of transverters and amplifiers are available but most require some assembly.
- Some stations use old military surplus transmitters. ART-13 for example.

N6LF LFMF Amplifier

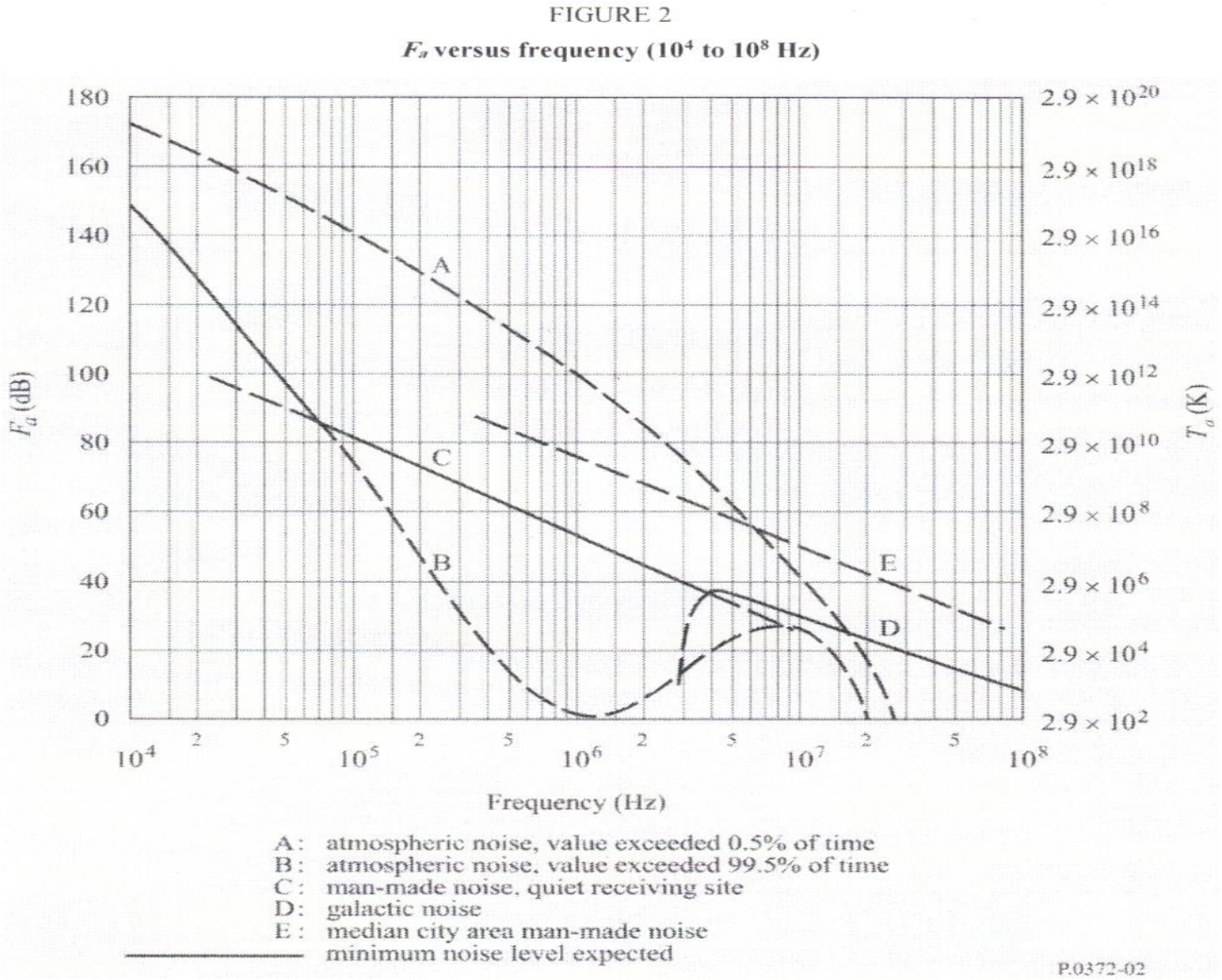


Start By Listening

Listen Where?

- Non-directional beacons (NDB)
  - 200-400 kHz
  - Low power, omnidirectional
  - and numerous, look up on-line
- Distant BC stations
- Download K1JT software:
  - https://wsjt.sourceforge.io
  - Then listen in the new bands starting with 630m.

Atmospheric Noise



Separate RX and TX Antennas

Transmitting and receiving antennas are different animals with different purposes.

Usually it is advantageous to use separate receiving and transmitting antennas.

This is done to manage noise, local or other, by introducing some directivity or polarization diversity.

RX Antennas

- Existing HF Antennas – dipole, random end fed wires, etc, whatever you have already!
- Loops
  - Vertical or horizontal loops
  - resistively terminated loops
- E-probe (very short vertical) with an amplifier
- Beverages and “Snakes” (BOG, LOG and DOG)
- Phased arrays of E-probes

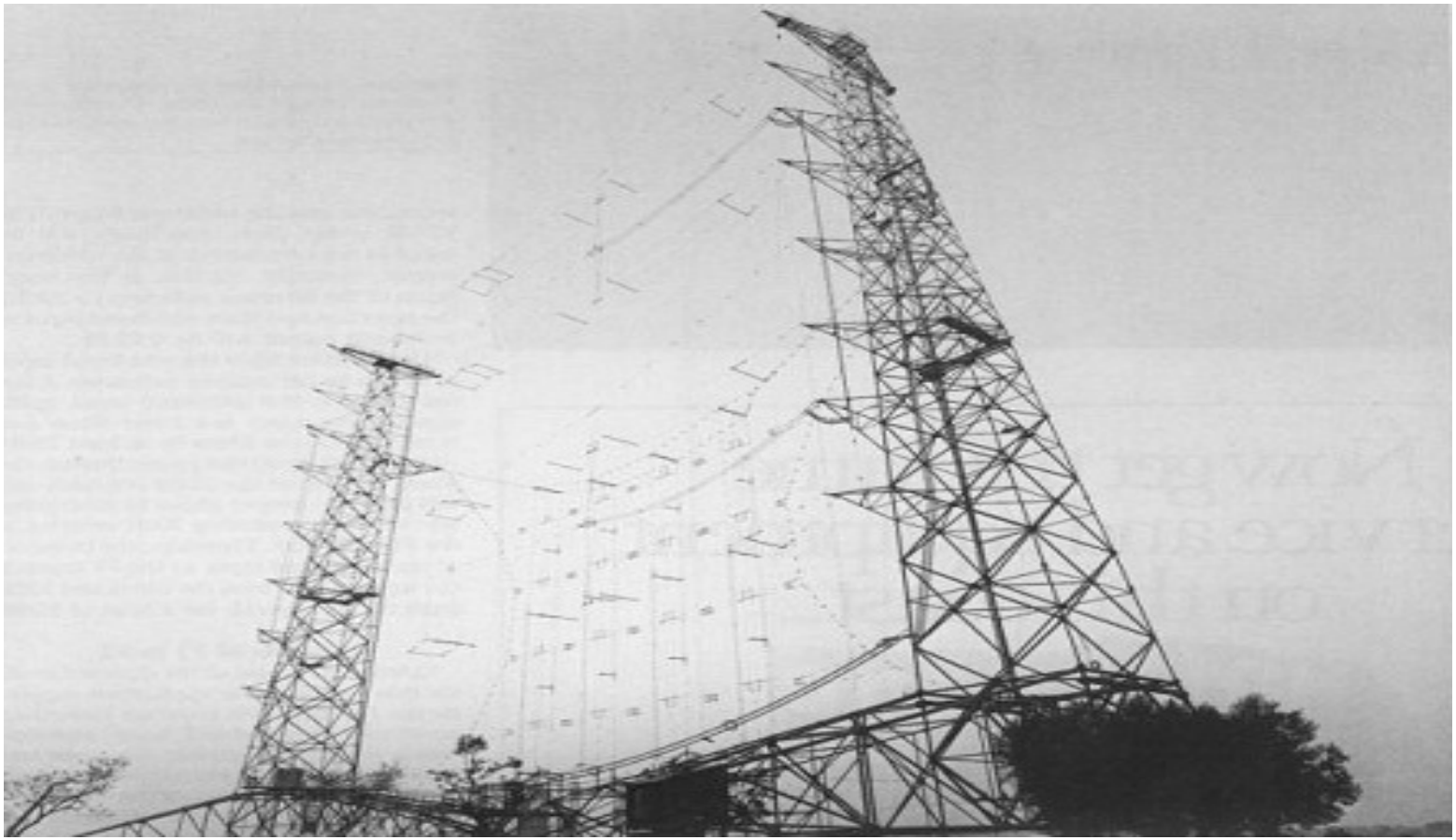
Loop RX antennas

Large loops

Some details W7IUV

TX Antennas

Nice but not required



Wavelengths

- 2200m = 7220’/1.37 miles
- 630m = 2067’/0.4 miles
- Long wavelengths limit TX antennas electrical size

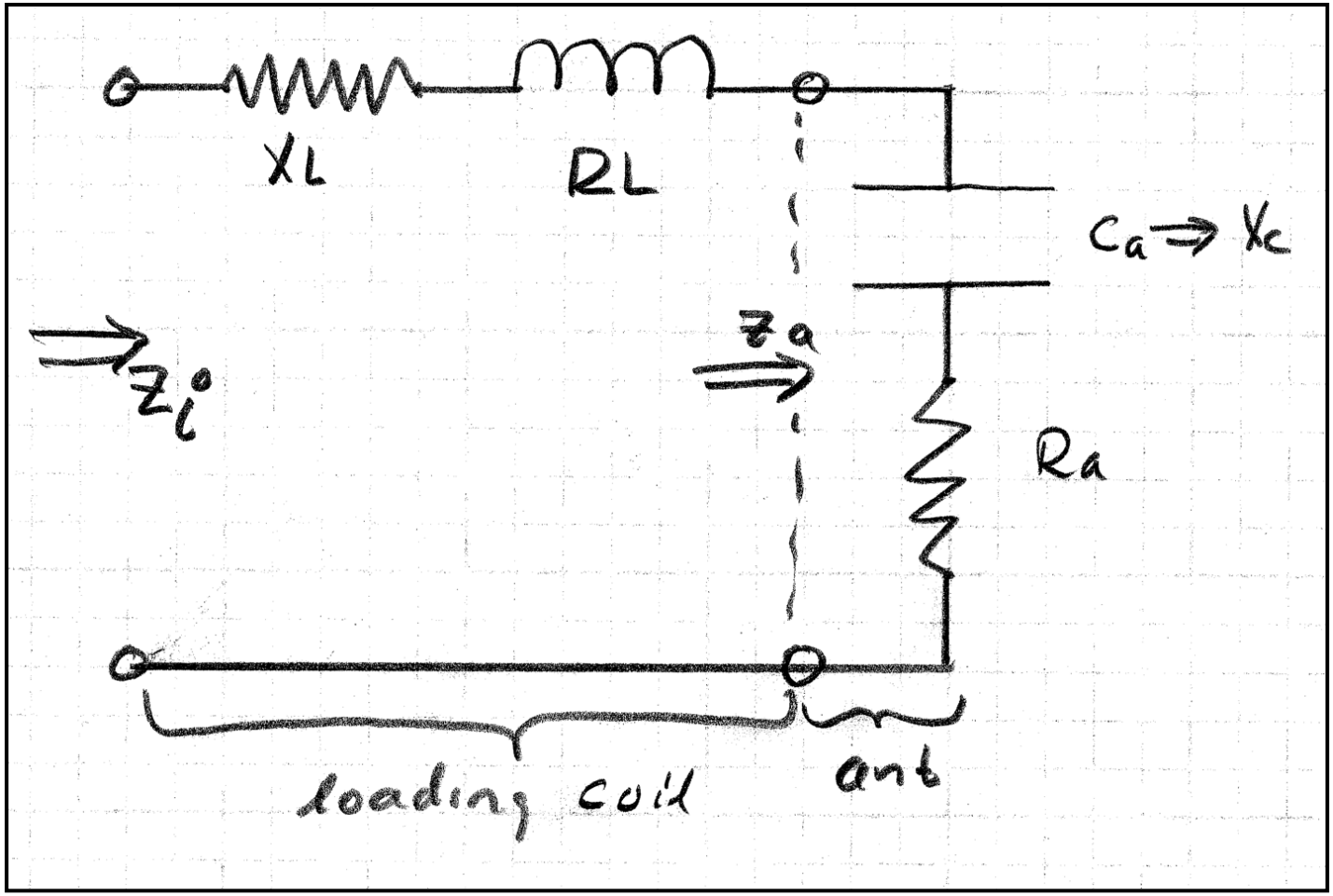
Sage advice

- Woodrow Smith, 1947
  - *"The main object in the design of low frequency transmitting antenna systems can be summarized briefly by saying that the general idea is to get as much wire as possible as high in the air as possible and to use excellent insulation and an extensive ground system."*
  - This simple advice should be taken literally!

Priorities

- 1) Make the vertical as tall as you can.
- 2) Use as much capacitive top-loading as practical.
- 3) Use high Q loading coils. See k6sti.neocities.org
- 4) Put substantial effort into the ground system, with the radial density high near the base of the vertical and under the top-loading hat.
- 5) Minimize conductor losses by using multiple wires and/or large diameter conductors.
- 6) Use high quality insulators, at the base and at wire ends.

Short vertical equivalent Circuit

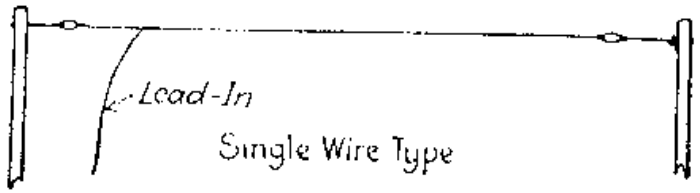


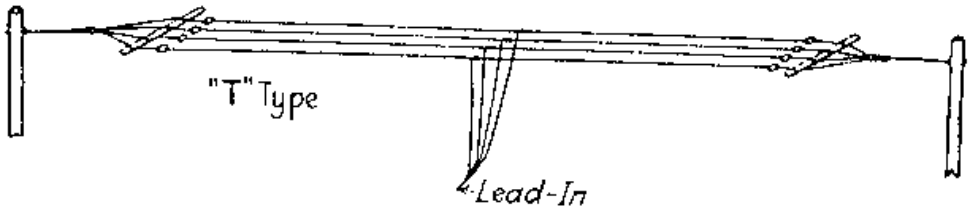
Efficiency

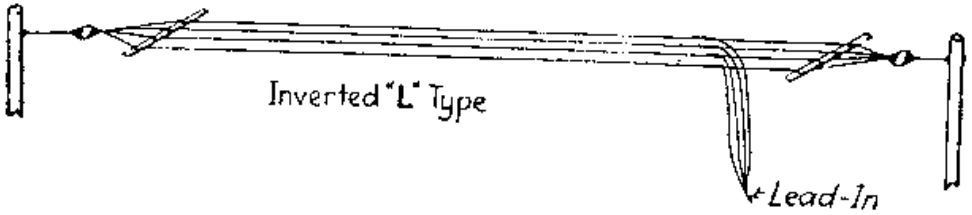
$$\eta \equiv \frac{P_r}{P_t} = \frac{R_r}{R_r + R_g + R_{loss}}$$

- Basic problem: the radiation resistance (Rr) is very small, often only mΩ, Rg and Rloss are much larger.

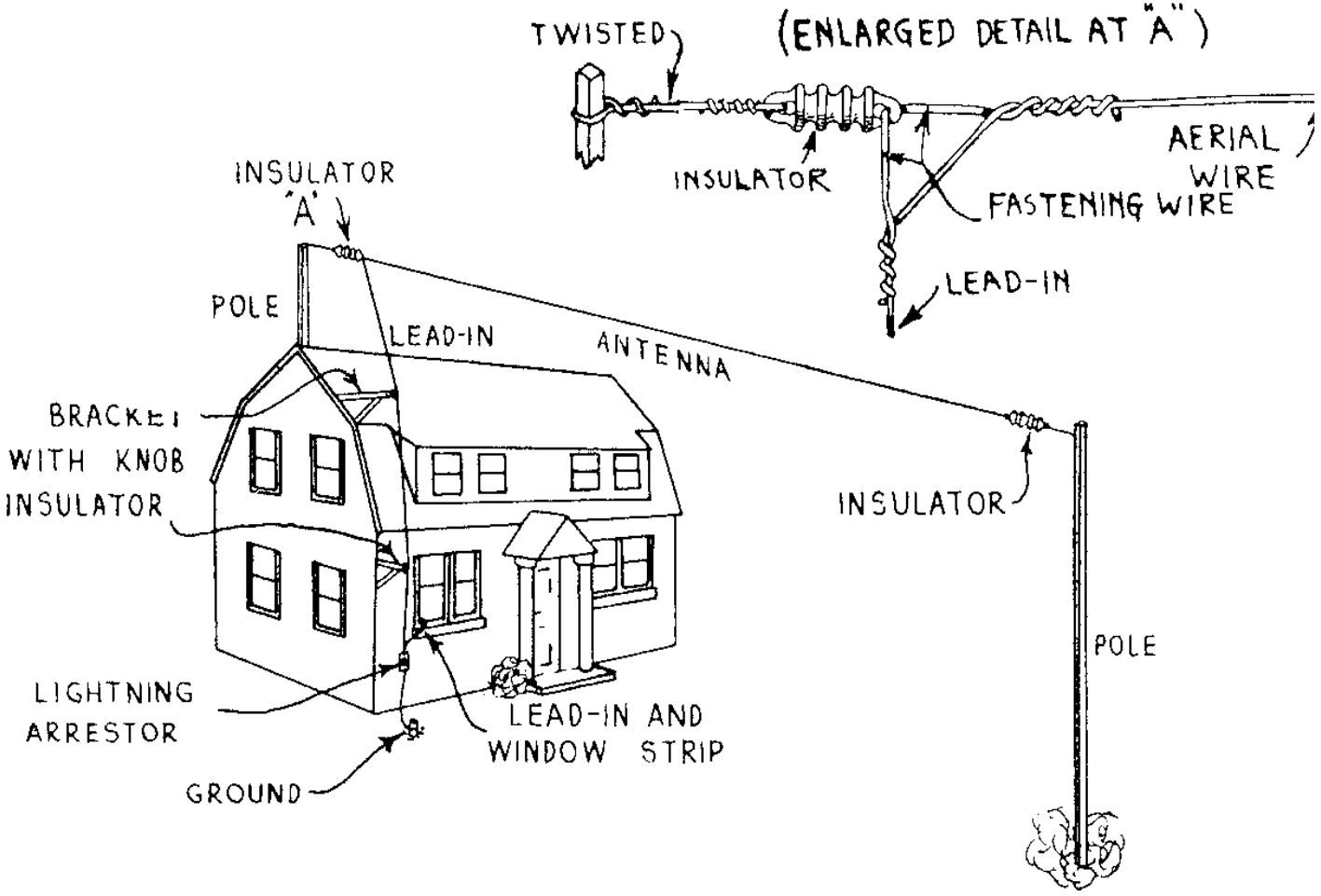
T and L antennas







Use the available supports



Present N6LF TX Antenna

Base of N6LF TX Antenna

Free LFMF Book

- Go to www.antennasbyn6lf.com
- You will find six chapters (about 200 pages) describing LFMF antennas and tuning inductor design in great detail.

The future?

- The present power levels are very low but future increases may be possible.
- The 160m band is a good example:
  - Right after WWII, no band
  - But after a few years low power and limited frequency access was obtained
  - In a very gradual process over years we are now at today's power levels and frequency allocation
- There is a reasonable chance of future power increases for the LFMF bands.

The Quest Continues!

Hams versus limits