Antenna Briefs #8 -- Antenna Design (plus EMC)

Slides downloaded from: https://ecefiles.org/rf-design/

Companion videos at: https://www.youtube.com/watch?v=_Gj_hiMrdok (Part 1)

and https://www.youtube.com/watch?v=MfF_jCdBgS8 (Part 2)

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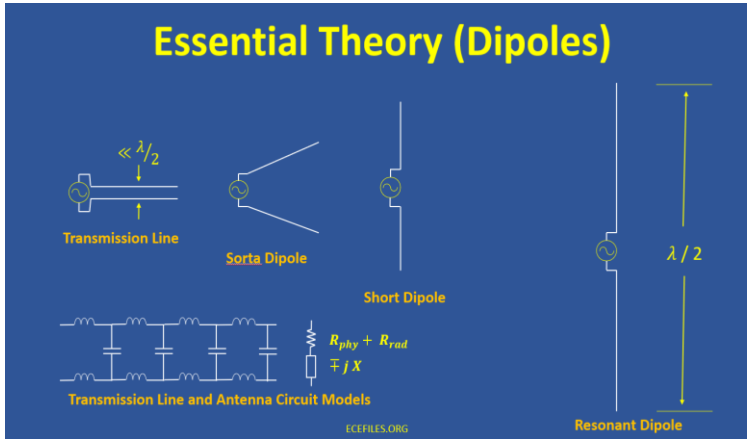
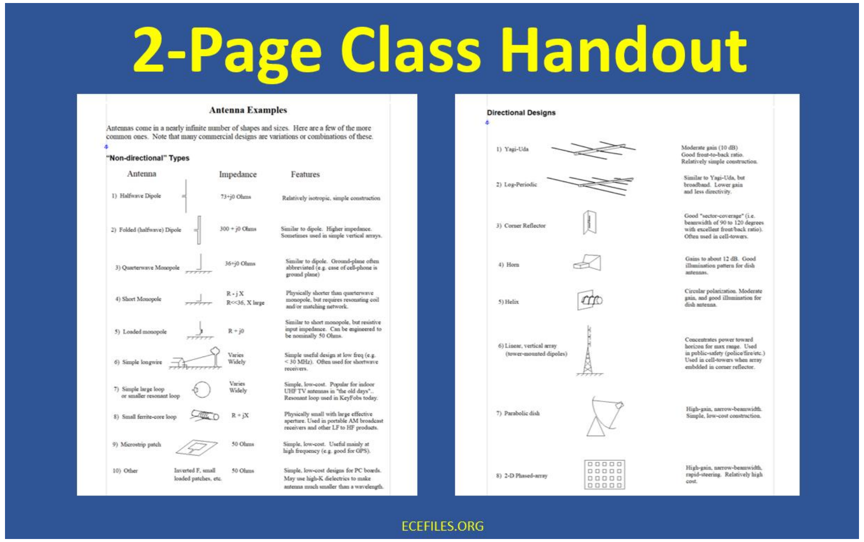
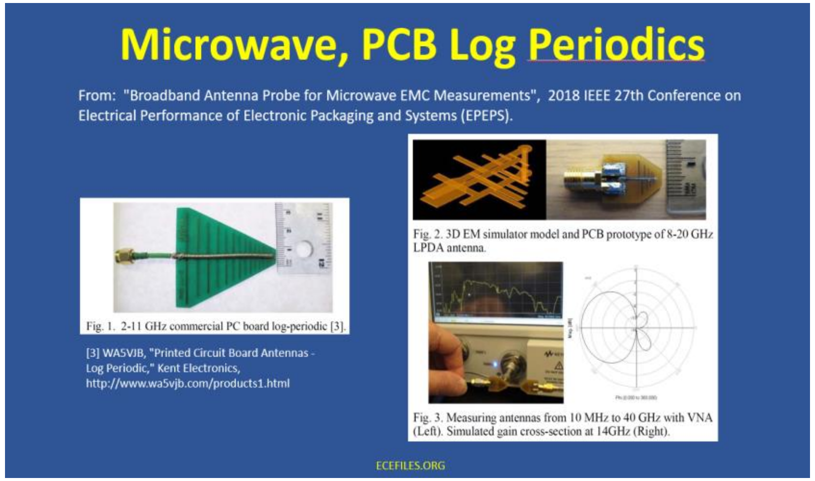
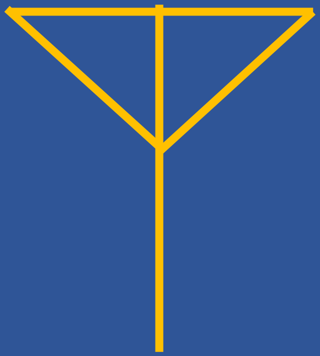
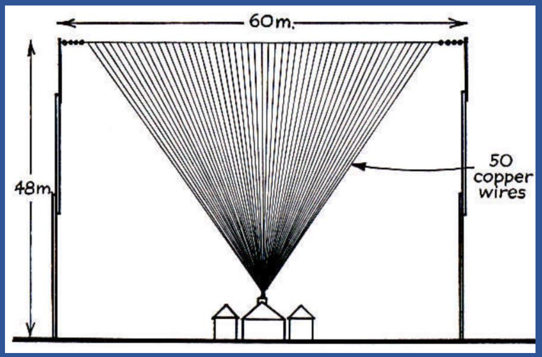
This final episode in the series focuses on antenna design, with underlying theory covered in the Part 1 video. Practical issues are also covered. In addition, the related subjects of radio frequency interference (RFI) from electronic products is touched on, and some electromagnetic compatibility (EMC) mitigation strategies are offered. Part 2 goes into additional detail on the vast set of antenna configurations possible and offers suggestions for designing your own antennas by showing and talking through a large set of examples. Given the size of the subject(s) details on design equations are not covered, but references are offered at the end for further study.





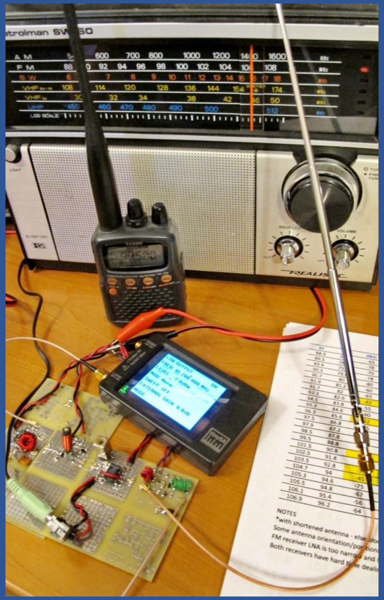






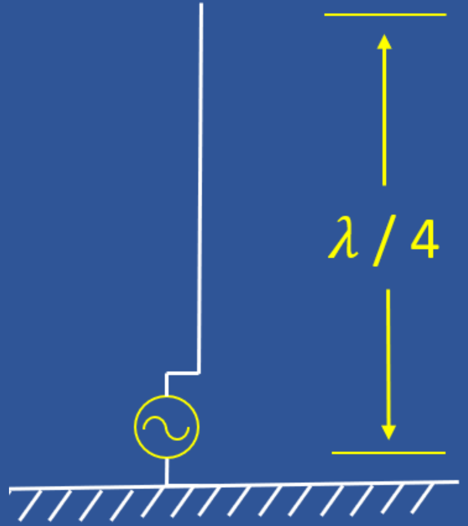
http://www.newscotland1398.net/nfld1901/marconi-nfld.html

Antenna Briefs #8



Designing Antennas

Part 1 – Essentials



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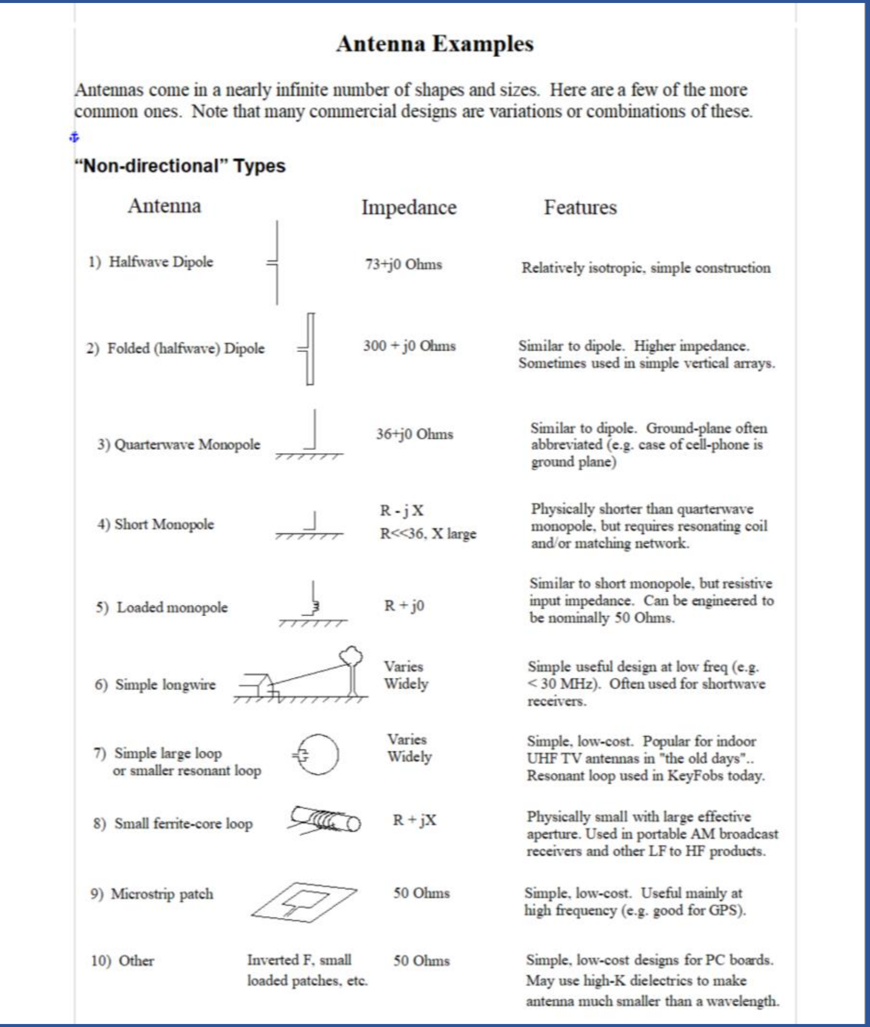
2-Page Class Handout



Antenna Examples

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"Non-directional" Types

Antenna		Impedance	Features
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5) Loaded monopole		R + j0	Similar to short monopole, but resistive input impedance. Can be engineered to be nominally 50 Ohms.
6) Simple longwire		Varies Widely	Simple useful design at low freq (e.g. < 30 MHz). Often used for shortwave receivers.
7) Simple large loop or smaller resonant loop		Varies Widely	Simple, low-cost. Popular for indoor UHF TV antennas in "the old days".. Resonant loop used in KeyFobs today.
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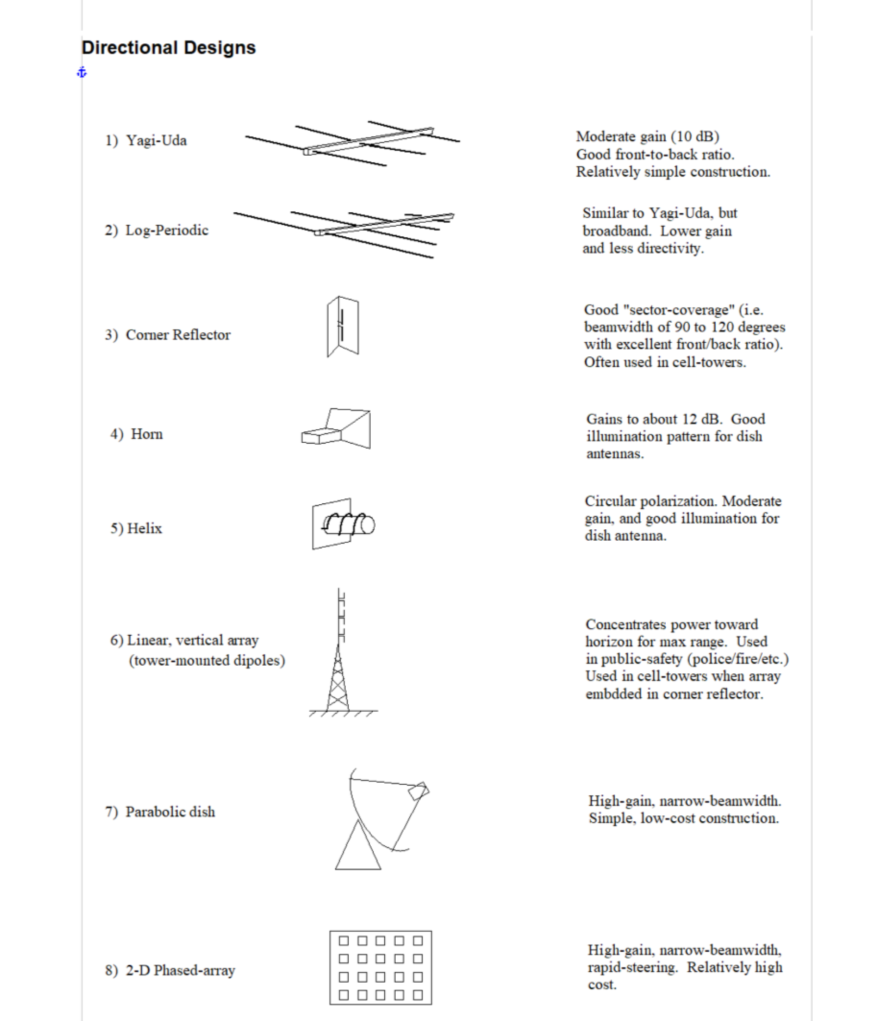

Directional Designs

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7) Parabolic dish	High-gain, narrow-beamwidth. Simple, low-cost construction.
8) 2-D Phased-array	High-gain, narrow-beamwidth, rapid-steering. Relatively high cost.

Episode 8 Topics

Topics

- → Design Requirements
- How to Make a (decent) Antenna
- How to NOT make an Antenna
- Surveying Common Antenna Designs
- Custom Design Examples

Design Requirements

- Frequency, bandwidth, and size
- Main use – Transmit, receive, or transceive
- Impedance
- Directivity and Gain (pattern)
- Polarization
- Installation (feedline, siting, structure, environment)

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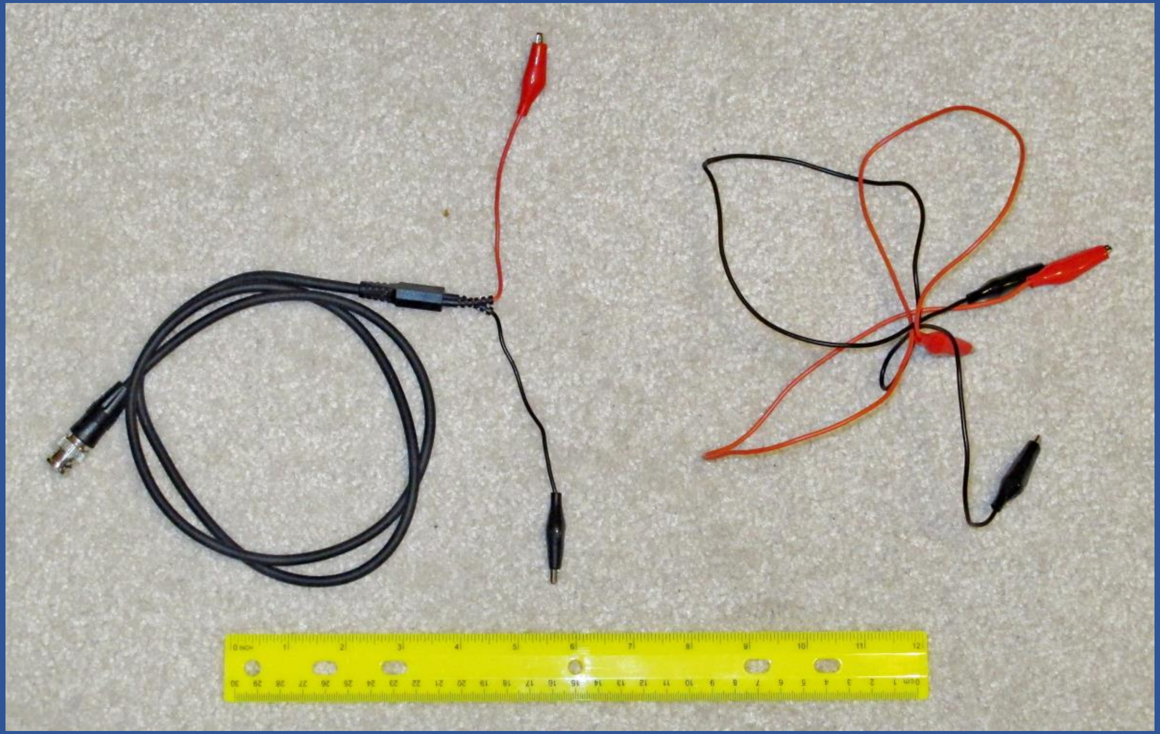
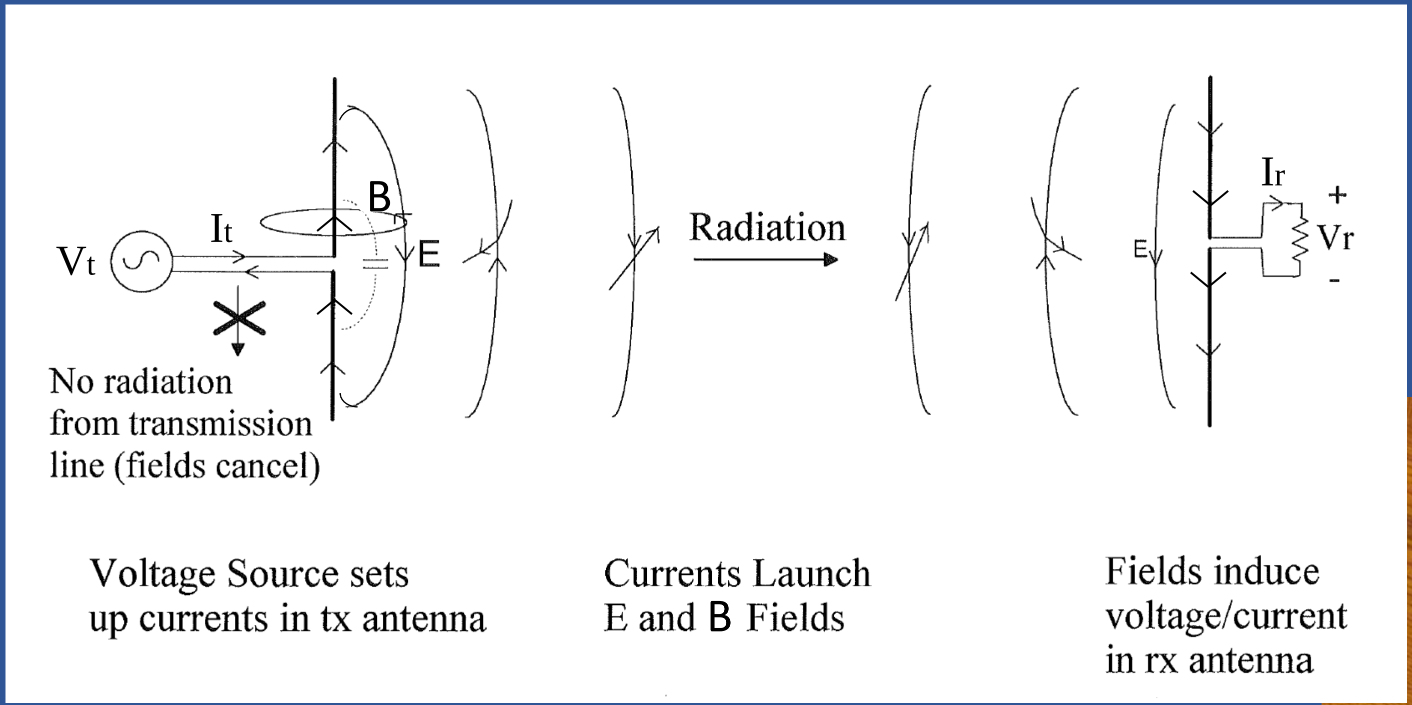
How to Make a (decent) Antenna

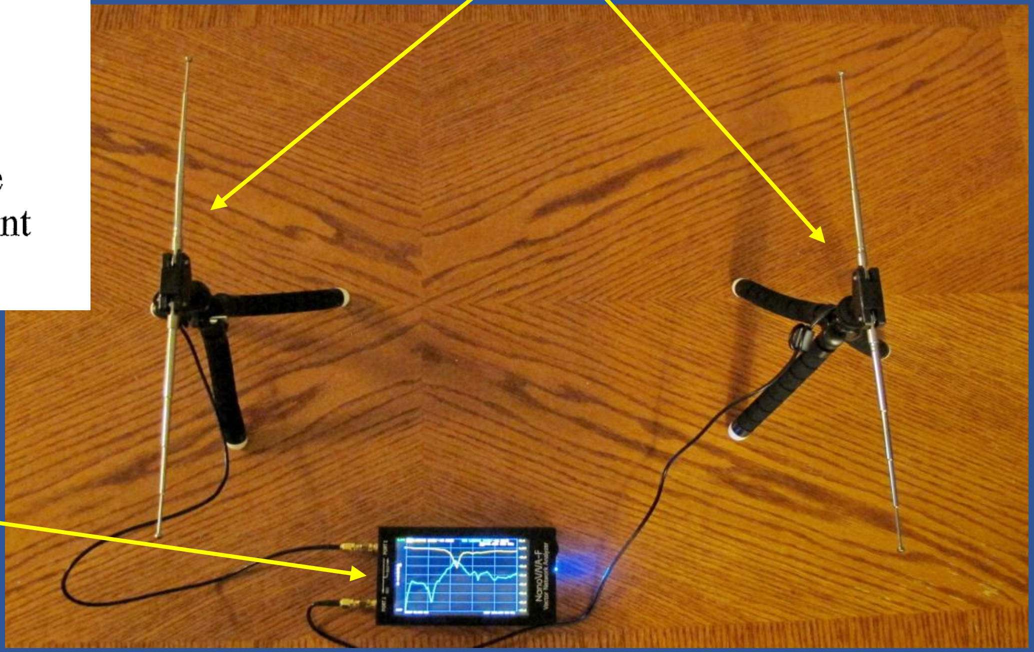


- Frequency, bandwidth, and size — 440 MHz, 5%, 30 cm (1 ft)
- Main use – Tx, Rx, or transceive — Yes ☺
- Impedance — About 50 Ohms
- Directivity and Gain (pattern) — Not very much (2 dBi)
- Polarization — Linear (horizontal or vertical?)
- Installation
  - feedline, — RG58 coax
  - siting, — On my (upstairs) floor
  - structure, — Not much ☹
  - environment) — Carpet/wood underneath

Essential Theory (From Episode 5)



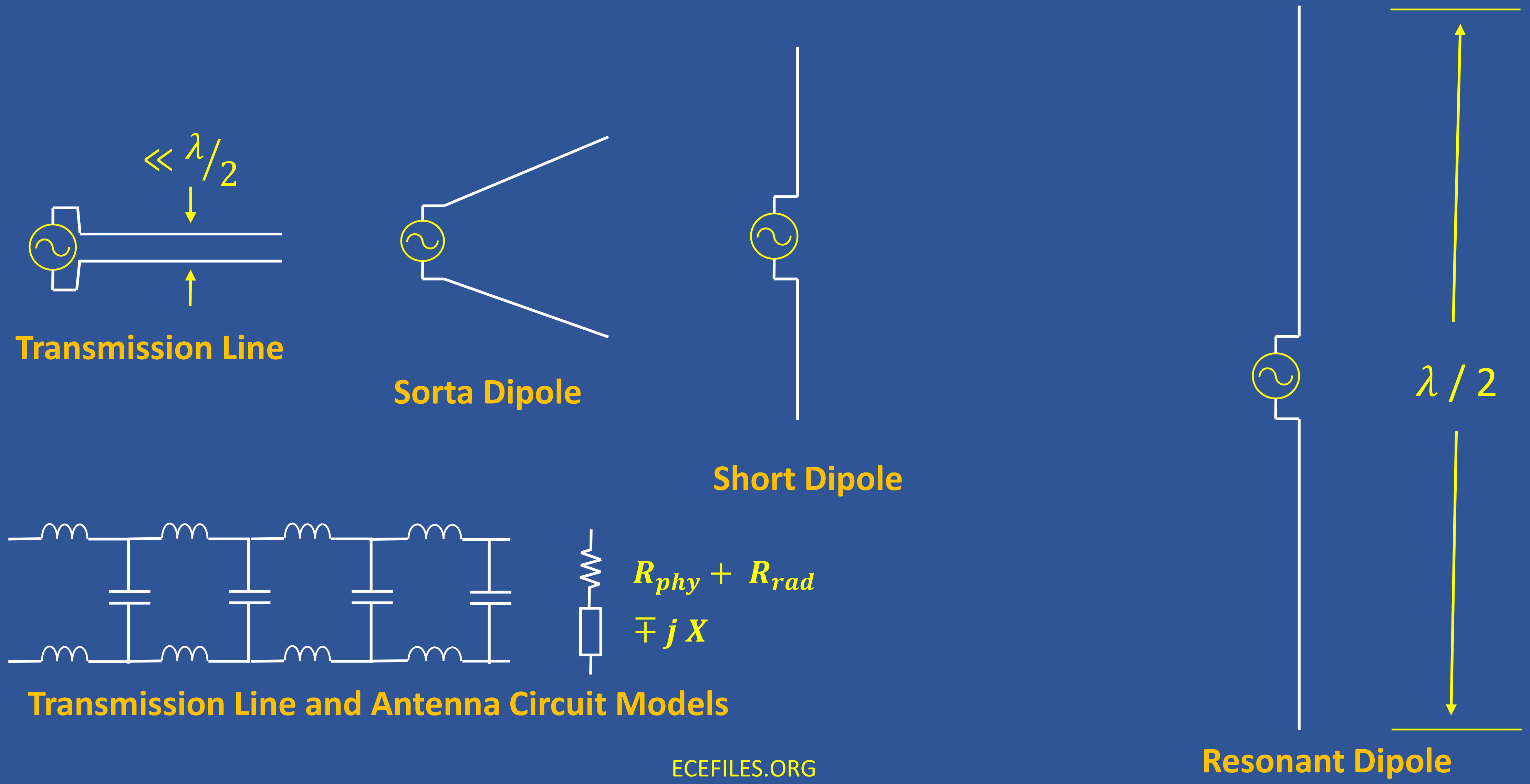
RTL-SDR Antennas



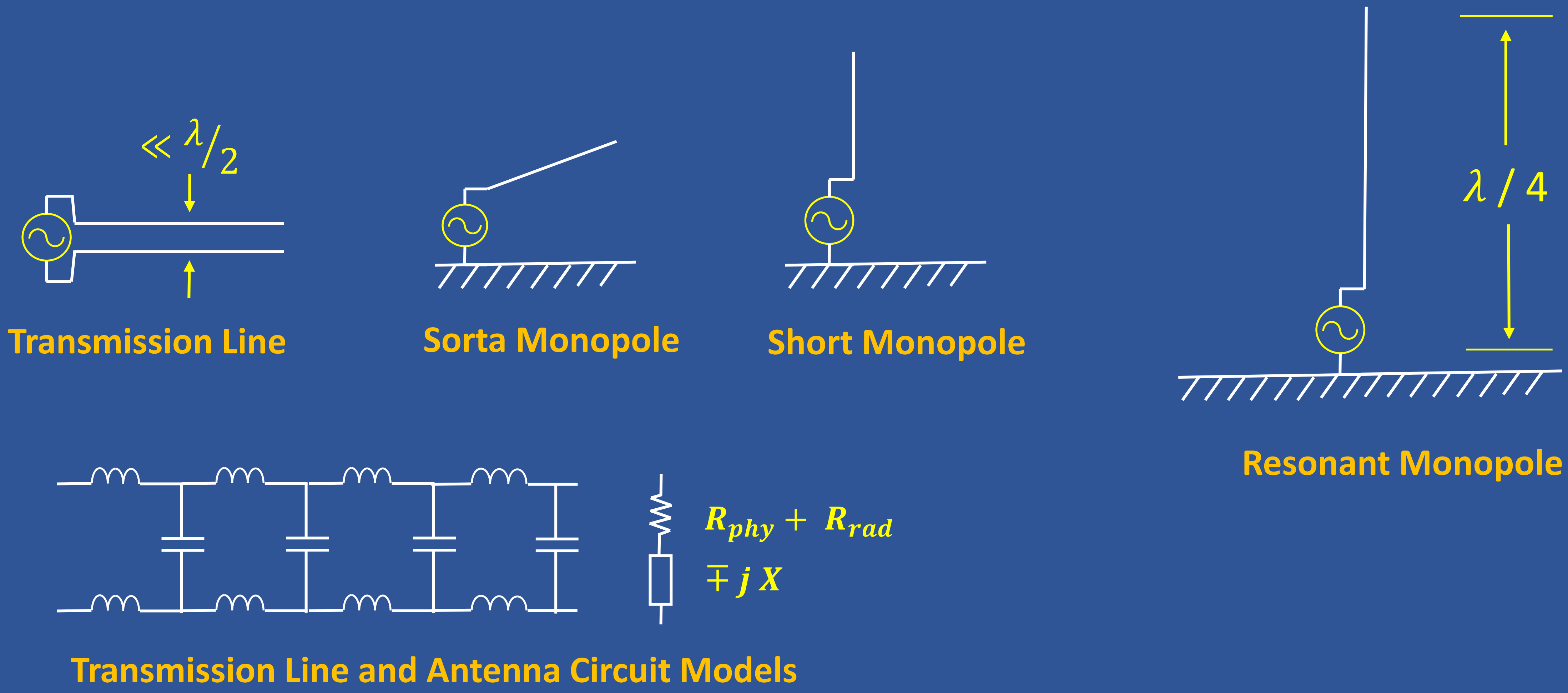
NanoVNA

(Transmitter, receiver, display)

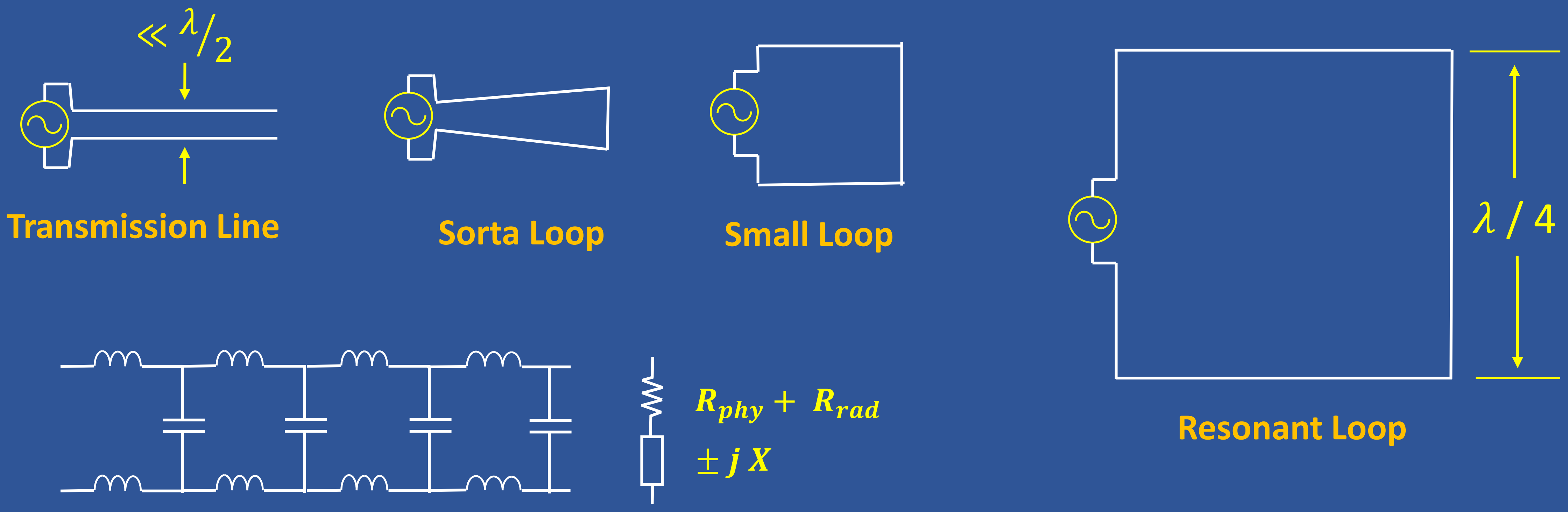
Essential Theory (Dipoles)



Essential Theory (Monopoles)



Essential Theory (Loops)



Transmission Line and Antenna Circuit Models

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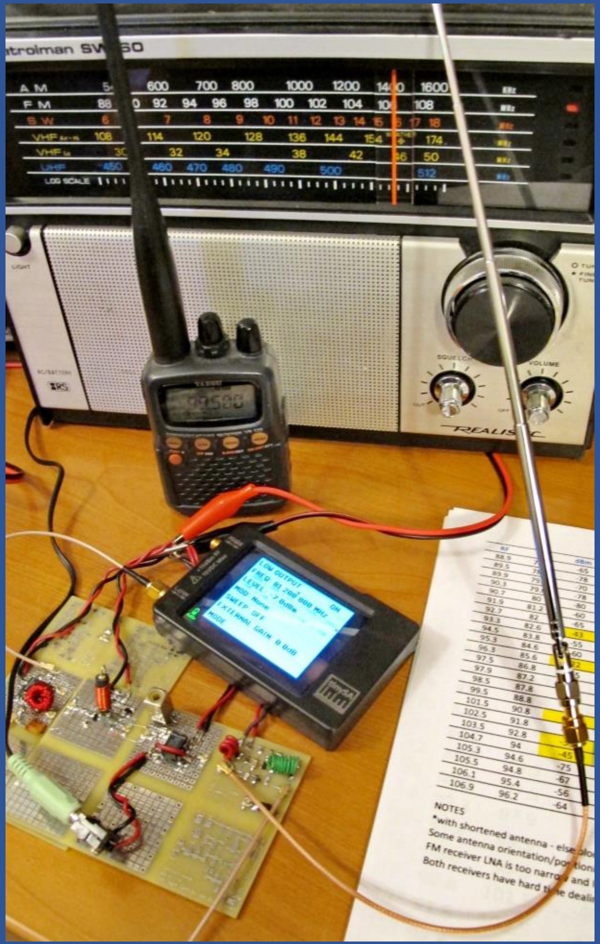
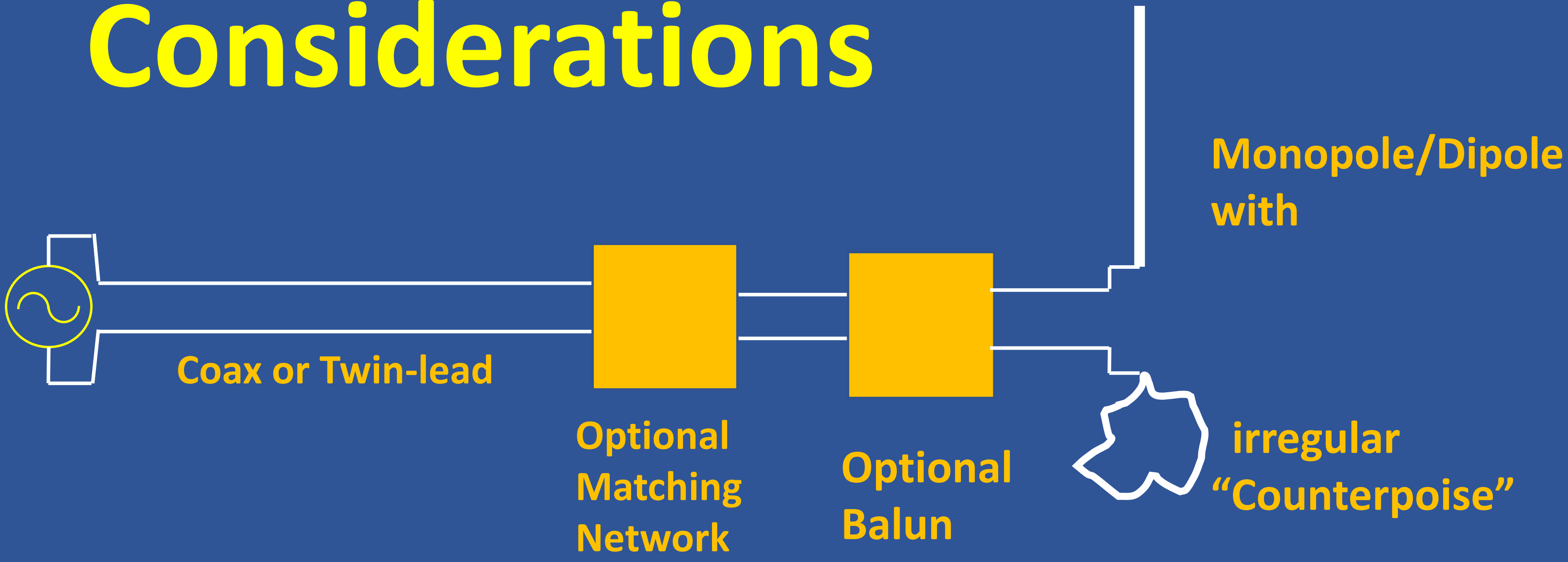
Real-World Examples and Considerations



From this channel:
Radio Design 101, Epilogue 1



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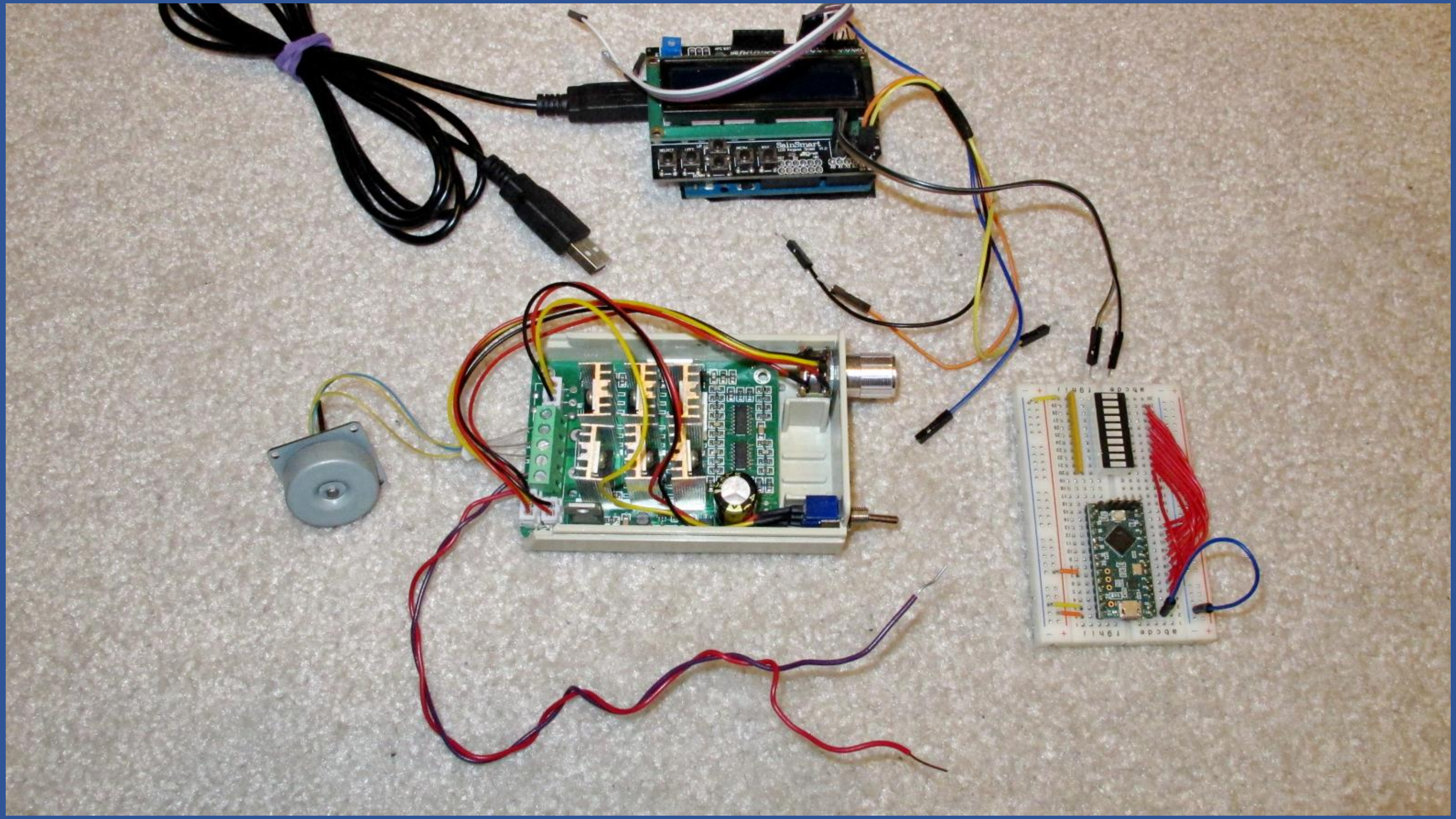
Unintentional Transmitters and Antennas



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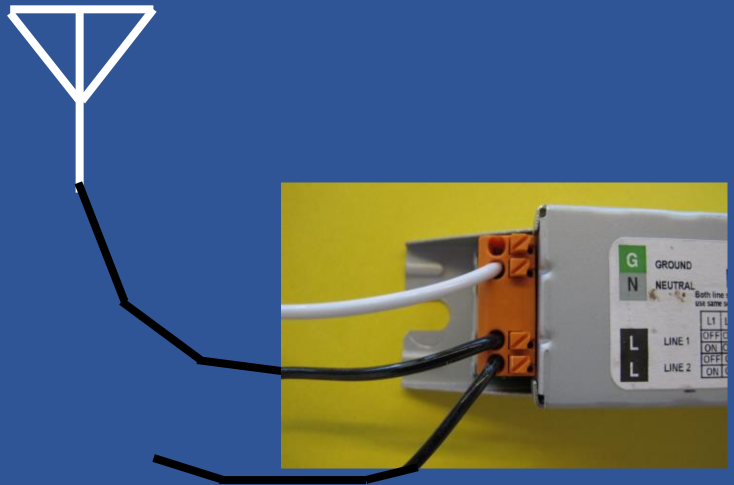
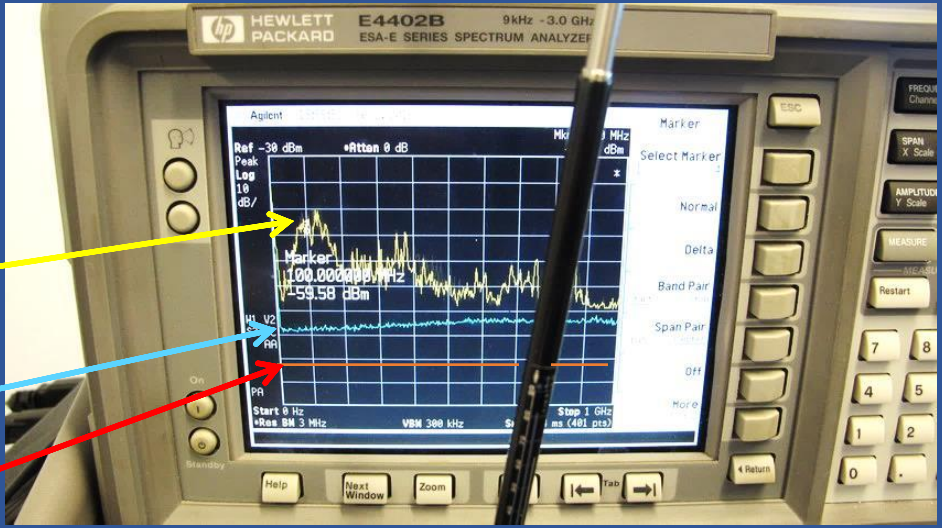
RFI From High Efficiency Lighting

See: "Wireless Communication Problems in Energy-Efficient Building Construction",

2016 IEEE International Symposium on Electromagnetic Compatibility (EMC)





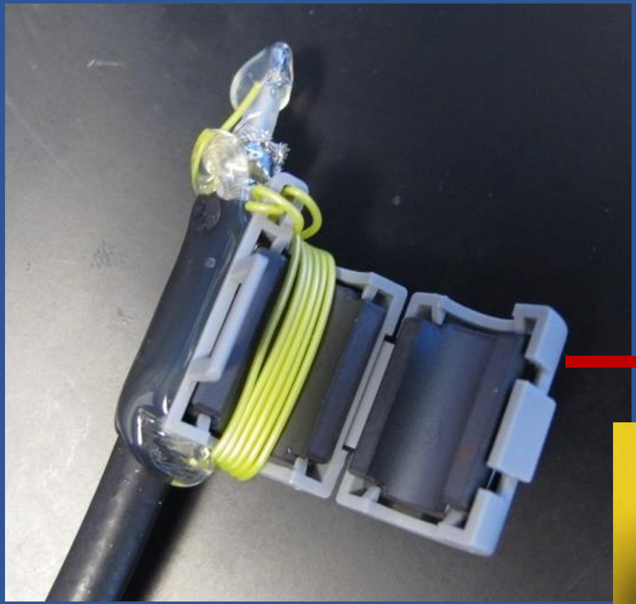
In-building RFI

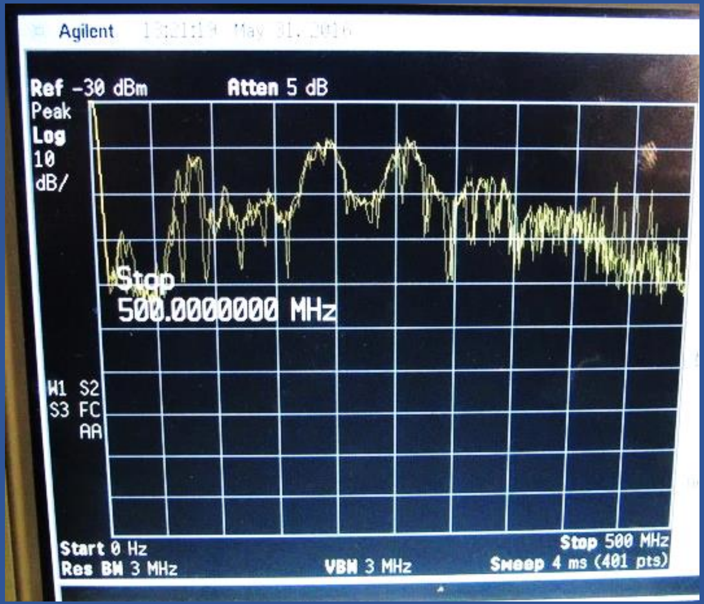
Analyzer noise floor

Thermal noise floor

Household LED Bulbs and SMPS

Some A19-base LED bulbs can be similar or worse, turning household wiring into a large distributed antenna transmitting broadband noise from 50 to 500 MHz and beyond…

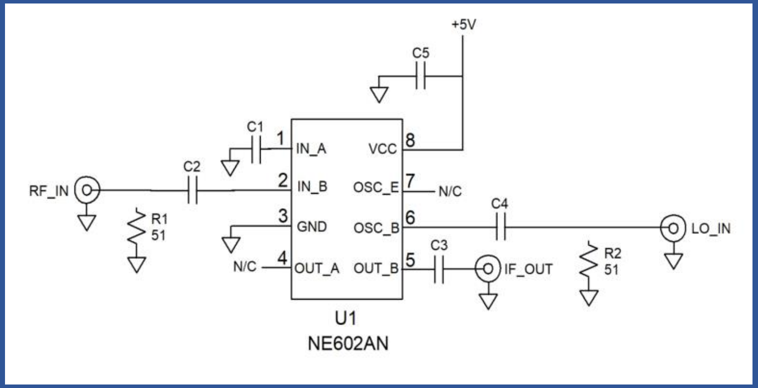




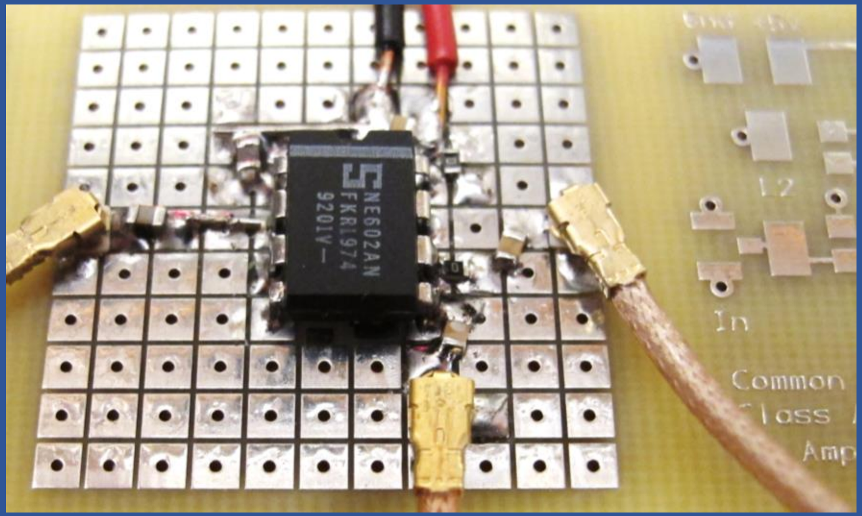
<u>Lots of other sources also exist – Anything with fast rise-time waveforms and inadequate bypass/filtering and/or shielding !</u>

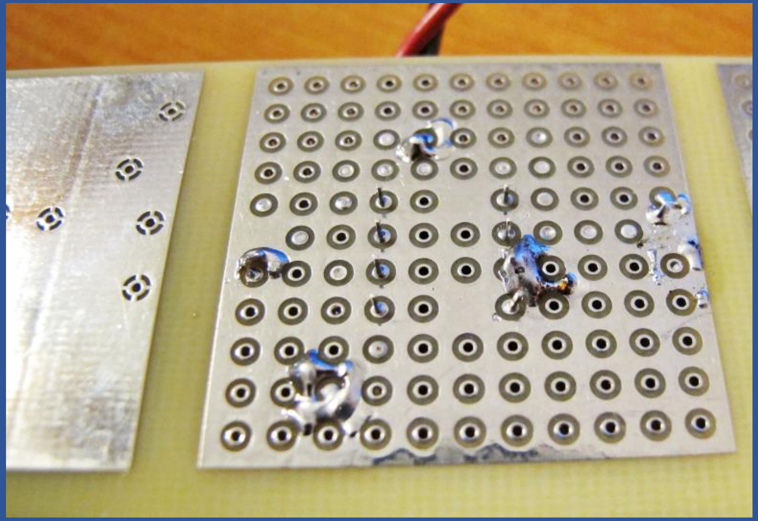
How to *NOT* make Transmitters / Antennas

- Provide good supply bypass/filtering
- Use PC boards with ground-planes and SMT components
- Use twisted-pair, ground-paired, or shielded wiring
- Test product/system for Electro-Magnetic Compatibility (EMC) compliance !
- Encase product in shielded enclosure if necessary



Simple circuit & RF PCB
example from Radio Design 101
video series





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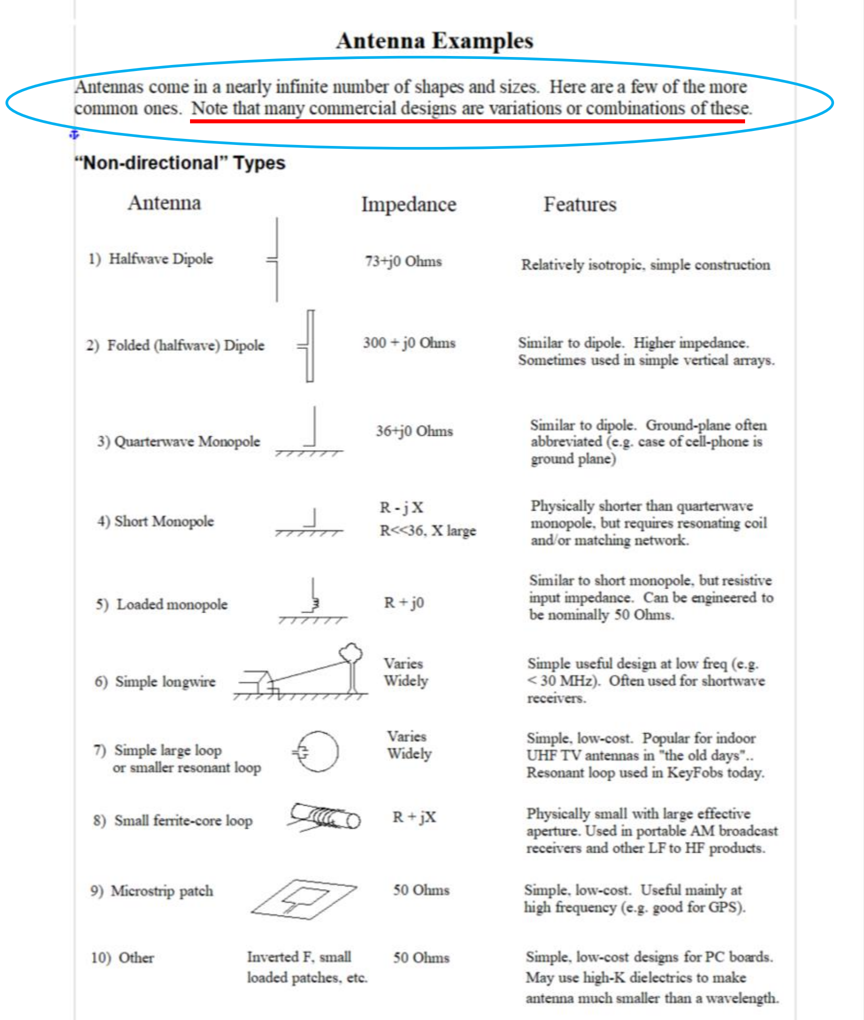
Common Antenna Designs



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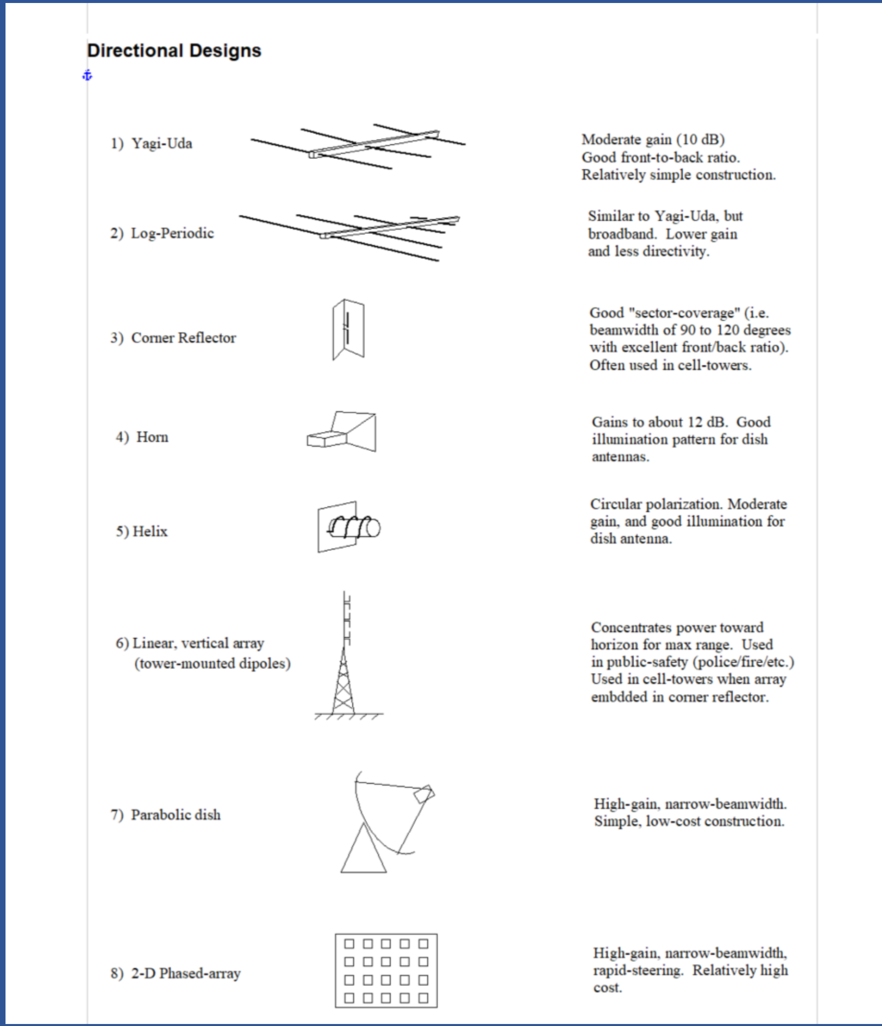

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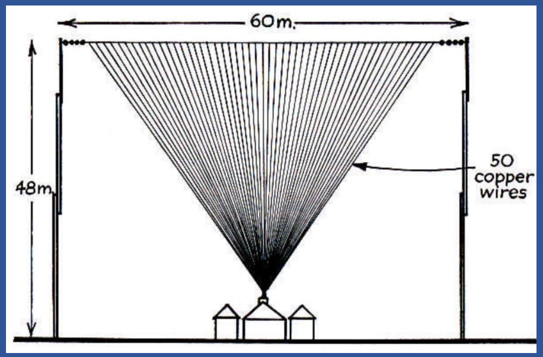
Thanks for Watching

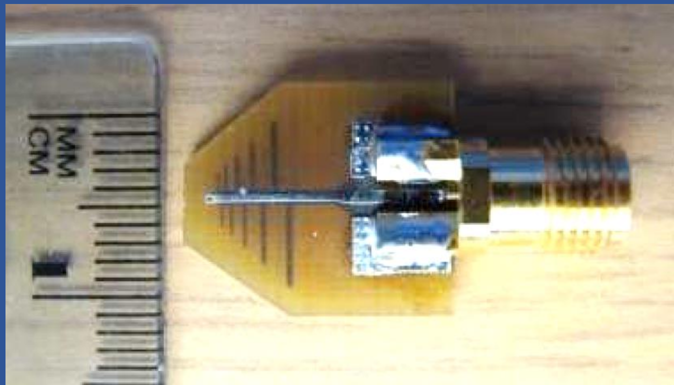


http://www.newscotland1398.net/nfld1901/marconi-nfld.html

Antenna Briefs #8

Designing Antennas

Part 2 - Examples



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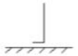
3) Quarterwave Monopole		36+j0 Ohms	Similar to dipole. Ground-plane often abbreviated (e.g. case of cell-phone is ground plane)
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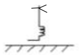
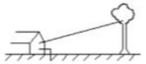
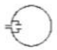
5) Loaded monopole		R + j0	Similar to short monopole, but resistive input impedance. Can be engineered to be nominally 50 Ohms.
6) Simple longwire		Varies Widely	Simple useful design at low freq (e.g. < 30 MHz). Often used for shortwave receivers.
7) Simple large loop or smaller resonant loop		Varies Widely	Simple, low-cost. Popular for indoor UHF TV antennas in "the old days".. Resonant loop used in KeyFobs today.
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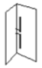
3) Corner Reflector		Good "sector-coverage" (i.e. beamwidth of 90 to 120 degrees with excellent front/back ratio). Often used in cell-towers.
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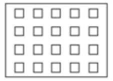
8) 2-D Phased-array		High-gain, narrow-beamwidth, rapid-steering. Relatively high cost.

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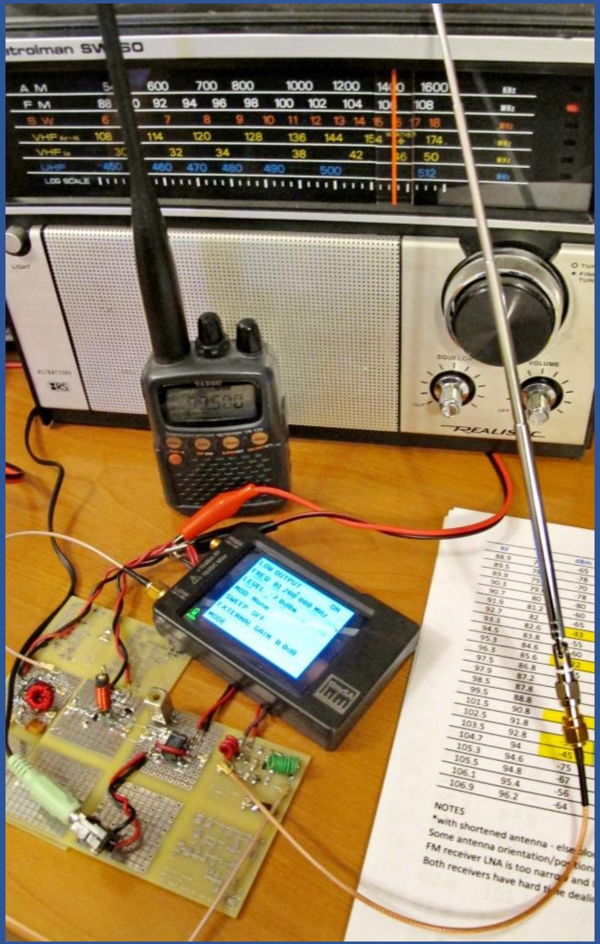
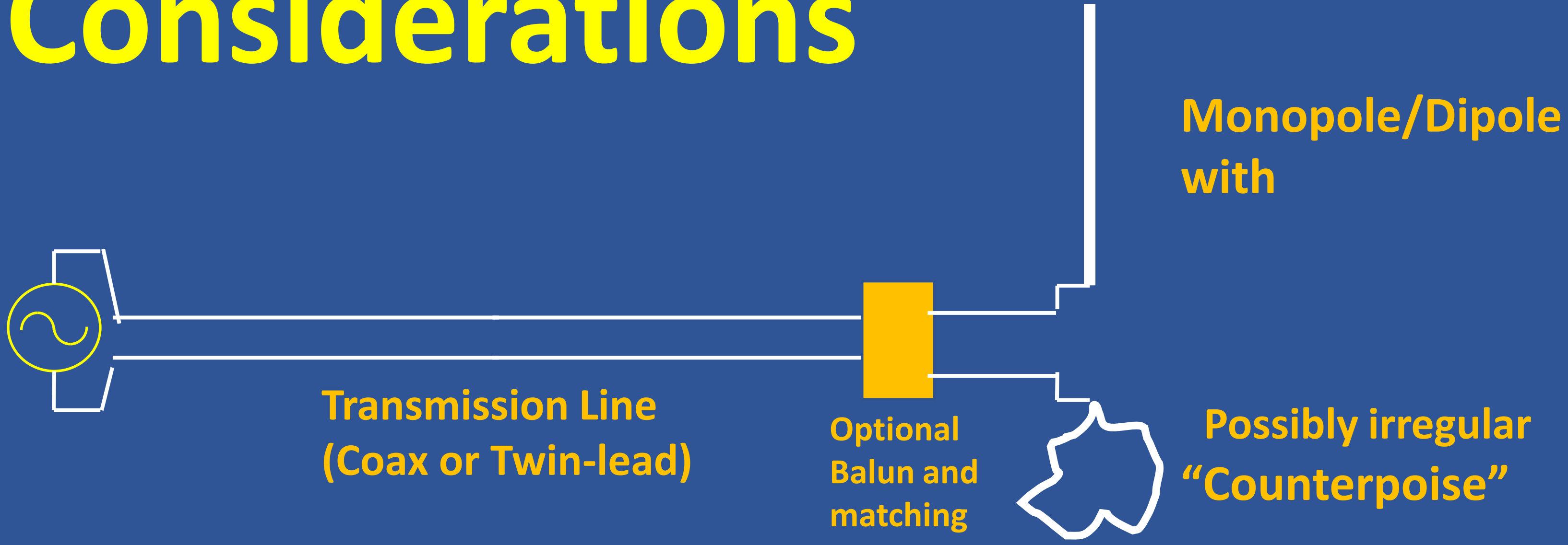


From this channel:
Radio Design 101, Epilogue 1



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A Couple Key Points

Antenna size is proportional to wavelength λ

$$\lambda = \frac{c}{f}$$

$f = 1\ MHz$ $\lambda = 300m$

$f = 100\ MHz$ $\lambda = 3\ m$

$f = 10\ GHz$ $\lambda = 30\ mm$

Designs can be scaled ! ☺

But watch out for near-field coupling, especially below 100 MHz …

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Hertz Loaded Dipole and Loop

Capacitively loaded 2.6-meter dipole

⇒ λ is about 6 m

⇒ f is about 50 MHz

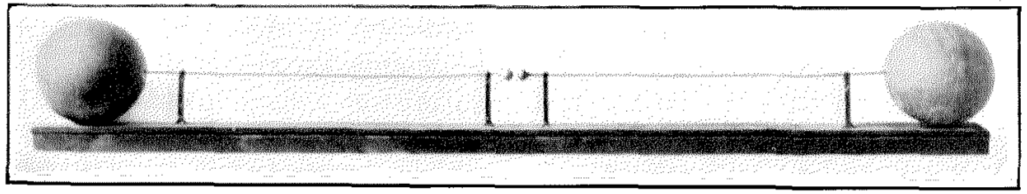


Figure 3—The First Oscillator of Hertz. Two copper wires, each 1 metre in length, supported on rods of sealing wax. The large spheres are of sheet zinc, and are 30 centimetres in diameter. Base 260 x 7.5 centimetres

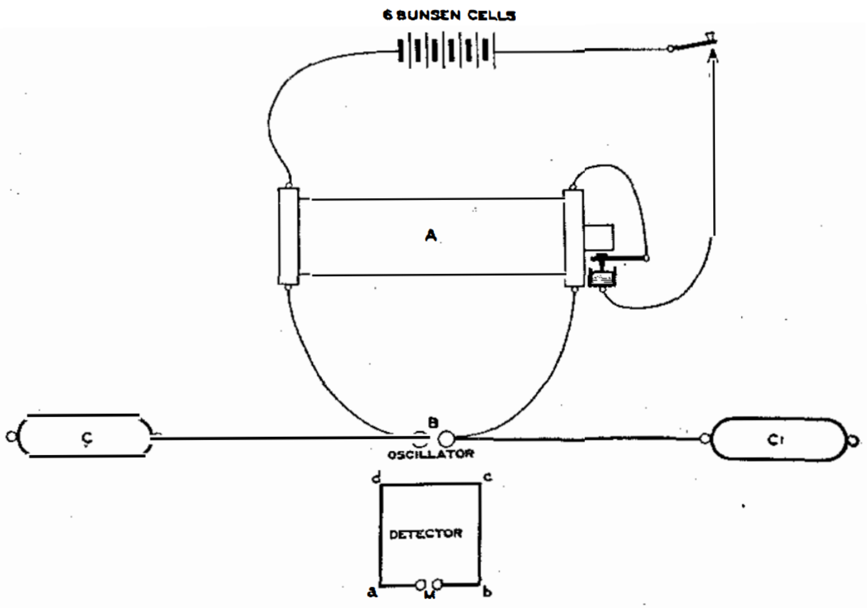
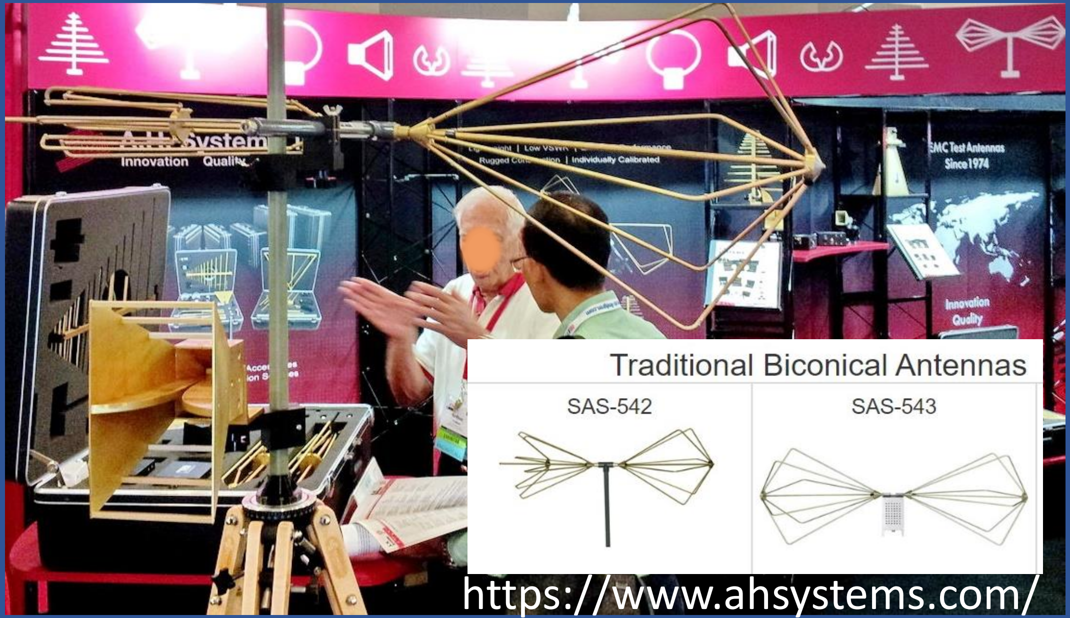


Figure 8—General Arrangement of Hertz Oscillator and Resonator

https://worldradiohistory.com/Archive-ITT/20s/ITT-Vol-06-1927-02.pdf

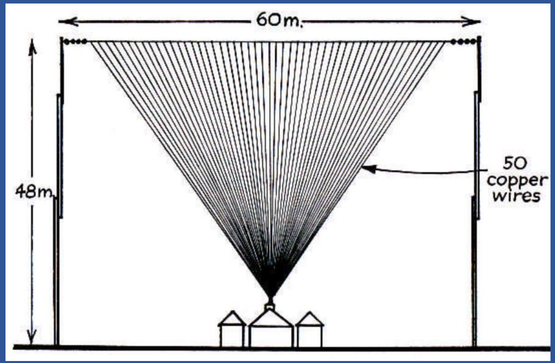
Modern Dipoles



MFJ-1796
40, 20, 15, 10 m (+6 and 2m) bands

Monopoles (and Discone)

https://en.wikipedia.org/wiki/Mast_radiator#/media/File:2008-07-28_Mast_radiator.jpg

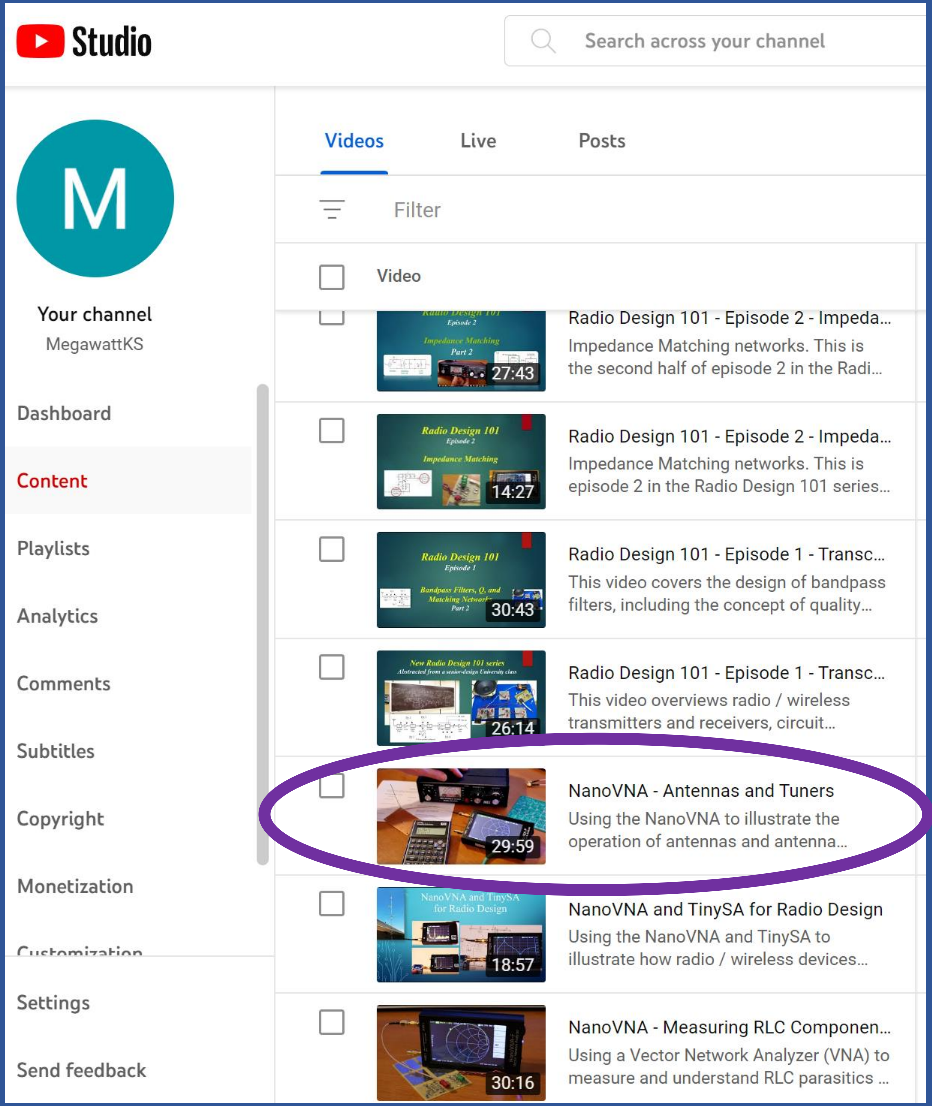


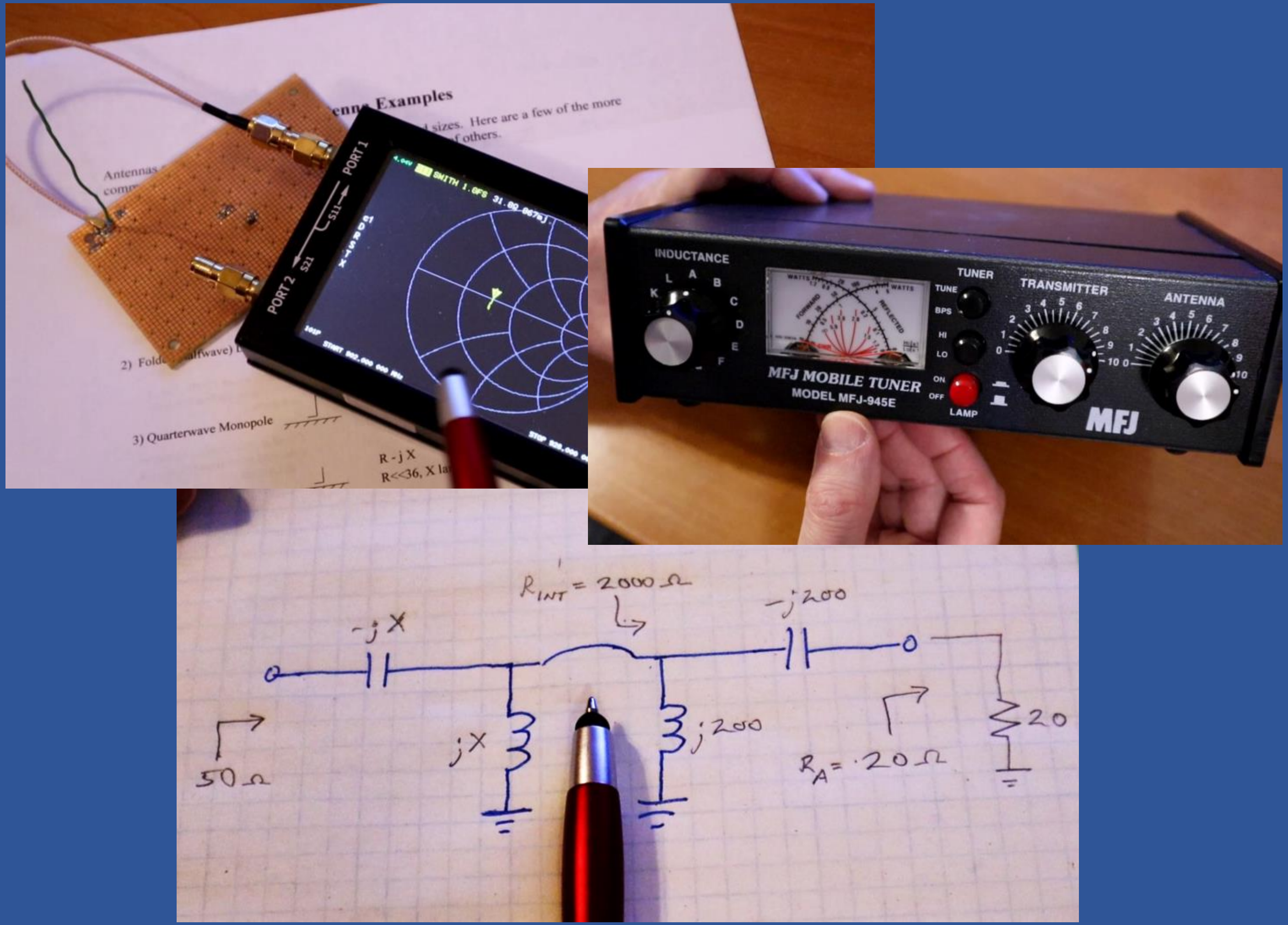
http://www.newscotland1398.net/nfld1901/marconi-nfld.html

DX Engineering 5-BTV with ground-radial plate

ECEFILES.ORG

Antenna Tuners





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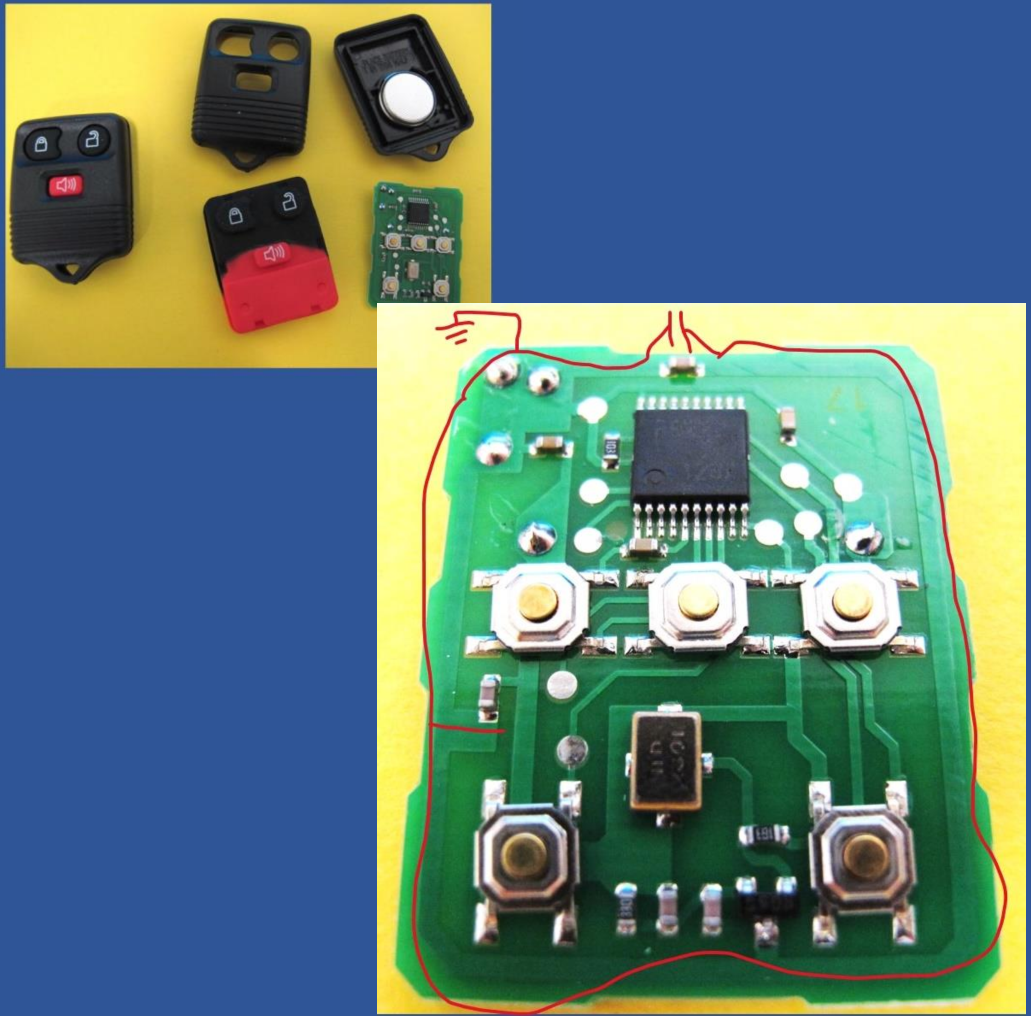
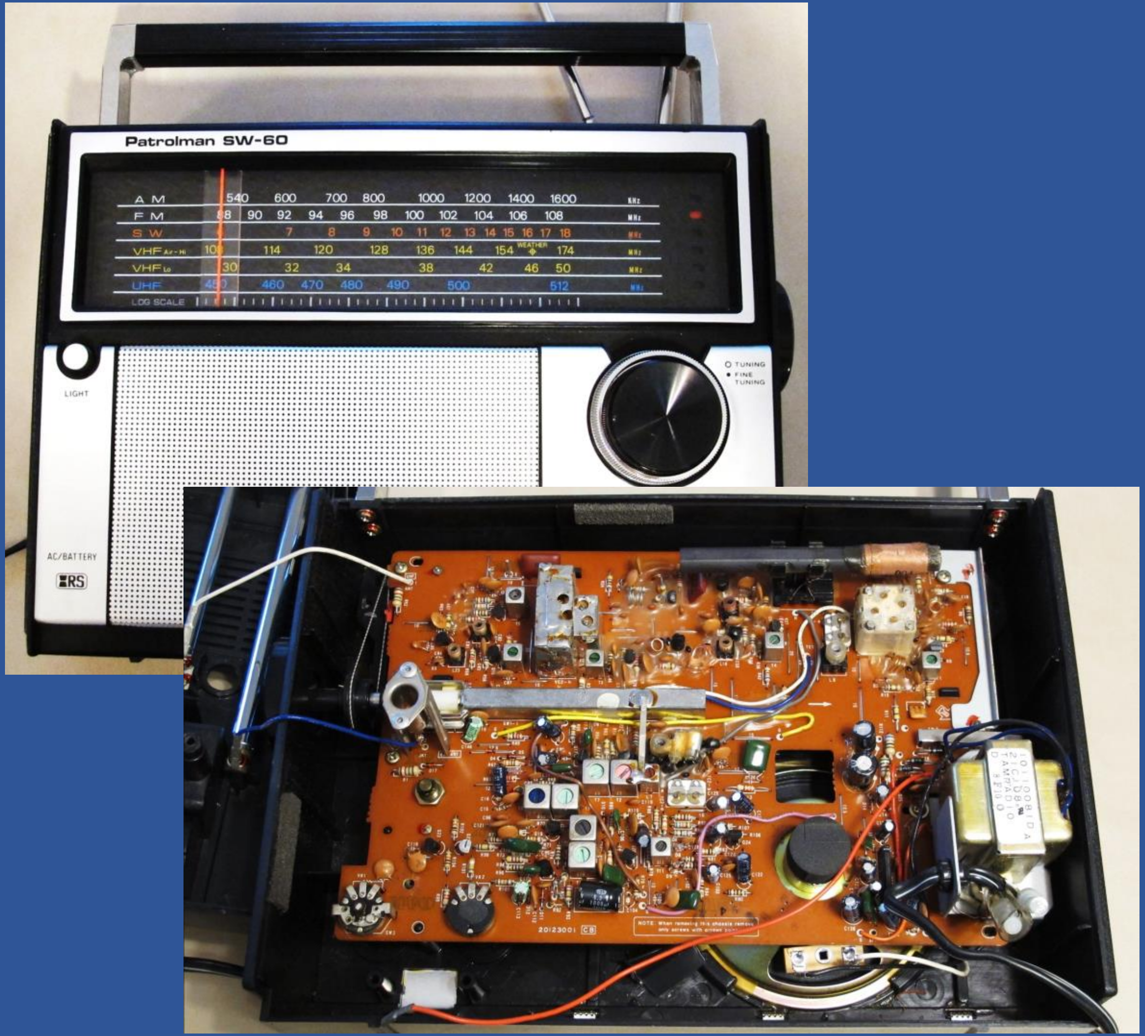
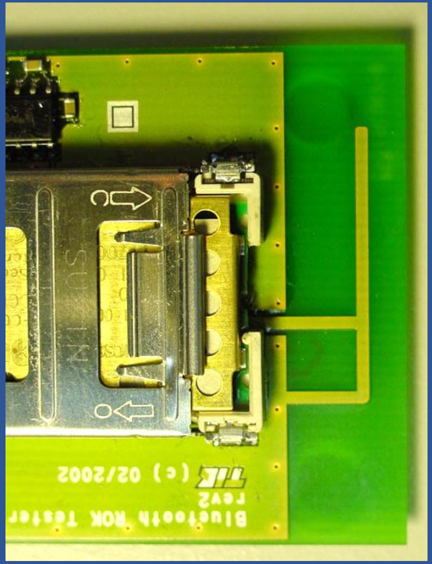
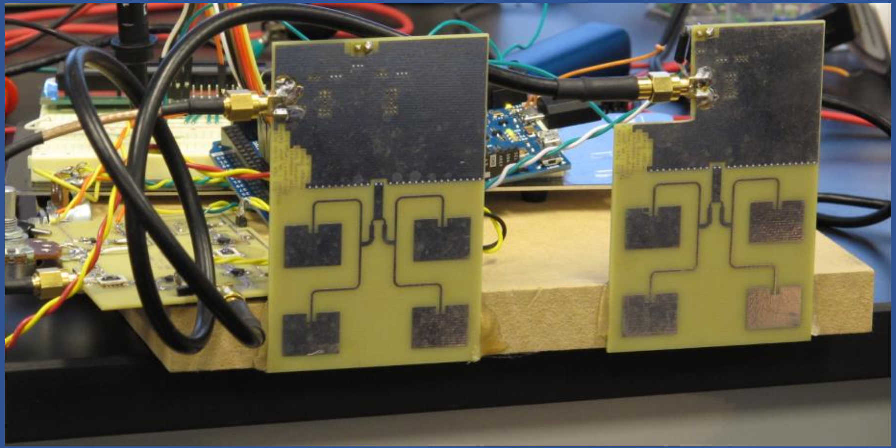
Loops

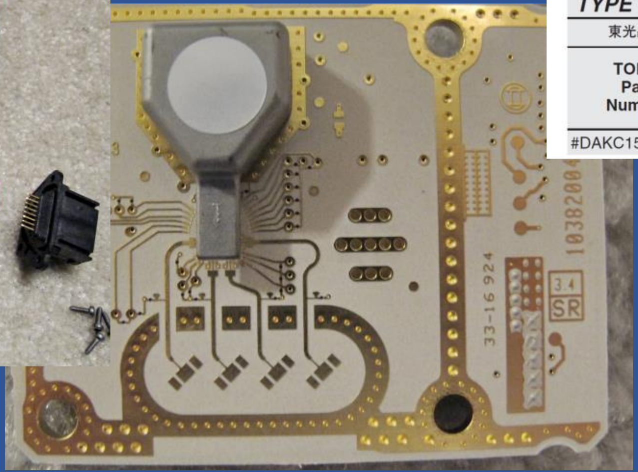




Planar/PCB Antennas








TOKO Dielectric Antenna
GPS用誘電体アンテナ素子

TYPE DAKC, DAG
DAKC

Unit : mm

Features

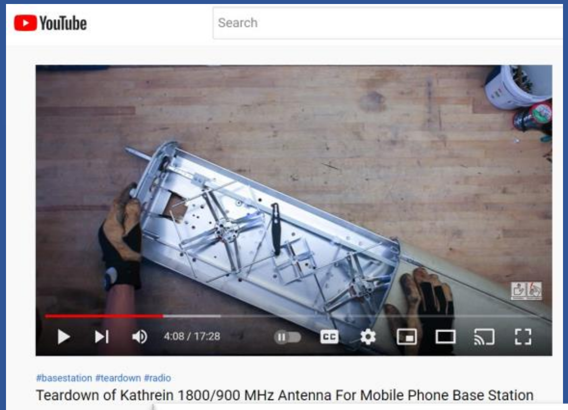
- Compact, Low-profile
- Rectangular microstrip structure, offset single feed through ground plane and substrate.
- Use of low temperature coefficient ceramics gives stability under changing temperature conditions.
- RoHS compliant

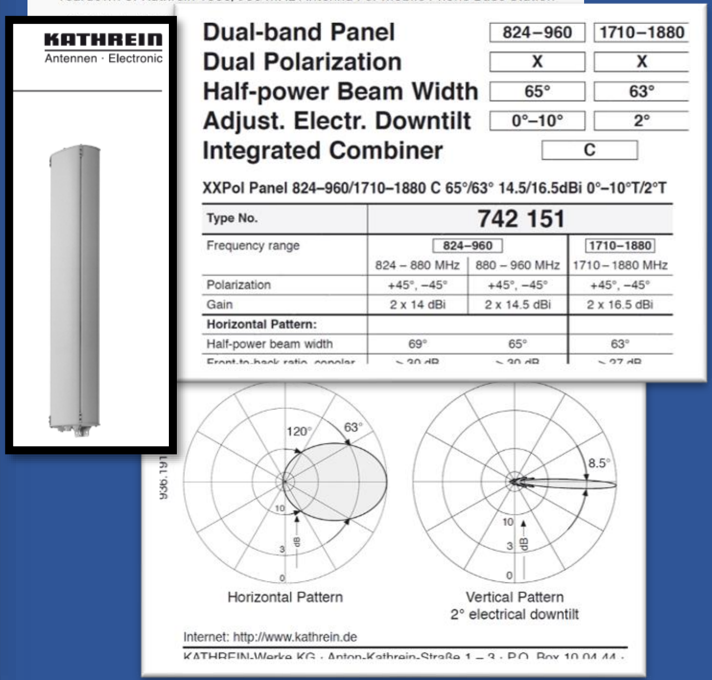
SELECTION GUIDE FOR STA

TYPE DAKC

東光品番 TOKO Part Number	受信周波数範囲 Range of Receiving Frequency (MHz)	中心周波数 Center Frequency (MHz)	帯域幅 Bandwidth (MHz) Min.
#DAKC1575MS74	1575.42±1.023	1580.5*	9.0

Directional Antennas





KATHREIN
Antennen · Electronic

	824–960	1710–1880
Dual-band Panel		
Dual Polarization	X	X
Half-power Beam Width	65°	63°
Adjust. Electr. Downtilt	0°–10°	2°
Integrated Combiner	C	

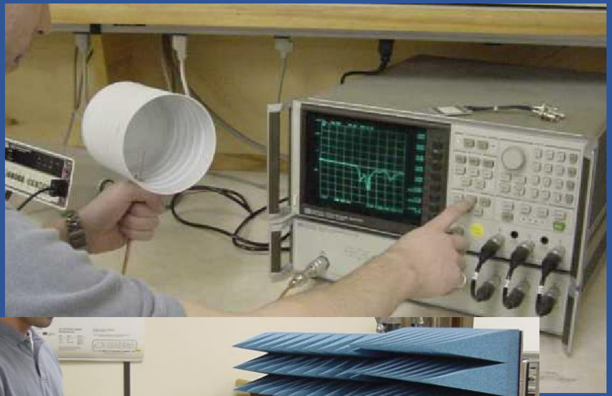
XXPol Panel 824–960/1710–1880 C 65°/63° 14.5/16.5dBi 0°–10°T/2°T

Type No.	742 151		
Frequency range	824–960		1710–1880
	824 – 880 MHz	880 – 960 MHz	1710 – 1880 MHz
Polarization	+45°, –45°	+45°, –45°	+45°, –45°
Gain	2 x 14 dBi	2 x 14.5 dBi	2 x 16.5 dBi
Horizontal Pattern:			
Half-power beam width	69°	65°	63°

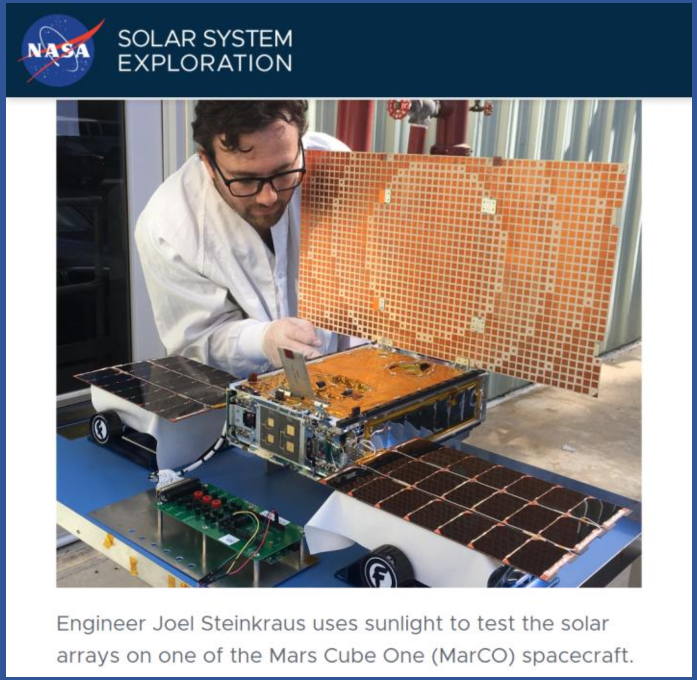
Horizontal Pattern

Vertical Pattern
2° electrical downtilt

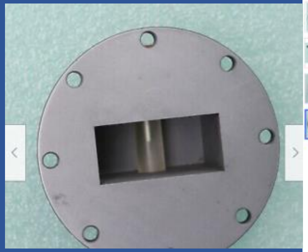
Internet: http://www.kathrein.de

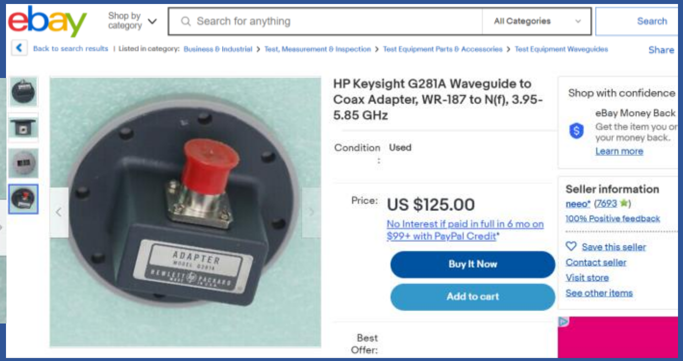


Directional Antennas



https://solarsystem.nasa.gov/missions/mars-cube-one/in-depth/





Episode 8 Topics

Topics

- Design Requirements
- How to Make a (decent) Antenna
- How to NOT make an Antenna
- → Surveying Common Antenna Designs
- Custom Design Examples

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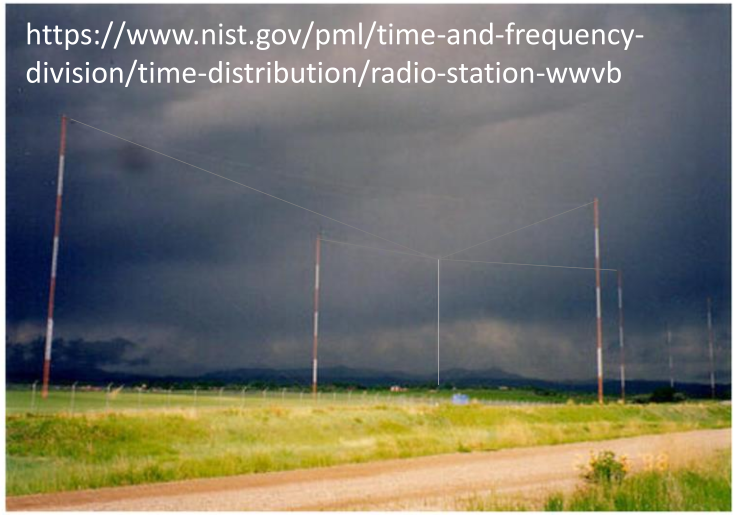
Body Area Network for Bio-Sensors in Space-suits

From: "Wireless Propagation Measurements for Astronaut Body Area Network", 2013 WiSEE conference.



NIST radio station WWVB is located near Fort Collins, Colorado.
Credit: NIST

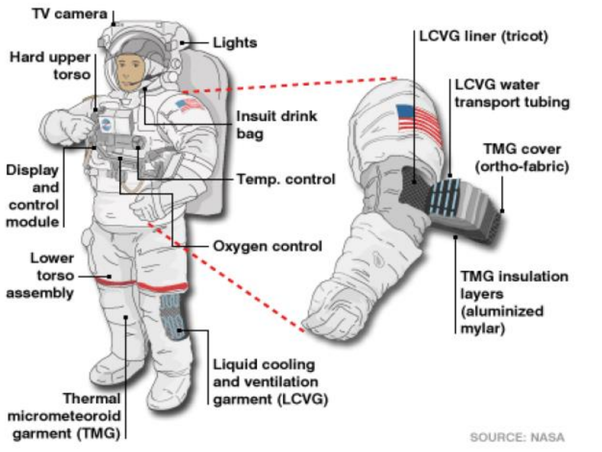


Fig. 1. General Structure of EMU spacesuit [5]

Fig. 3 Side view of top hat monopole antenna

has electrical properties similar to that of a real space suit (Fig. 9). The tube is 0.70 m long and has radius of 0.095 m. The air gap between the skin and the inner surface of tube is around 0.045 m, which is comparable to the space-suit.

Fig. 8 Transmitter and receiver are mounted directly on arm with initial distance of 30 cm before the arm is inserted inside the tube.

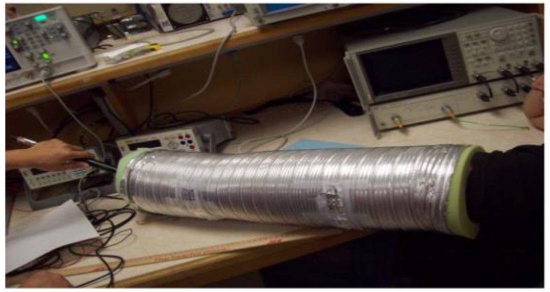


Fig. 9 Measuring the total loss in small scale (arm).

Microwave, PCB Log Periodics

From: "Broadband Antenna Probe for Microwave EMC Measurements", 2018 IEEE 27th Conference on Electrical Performance of Electronic Packaging and Systems (EPEPS).

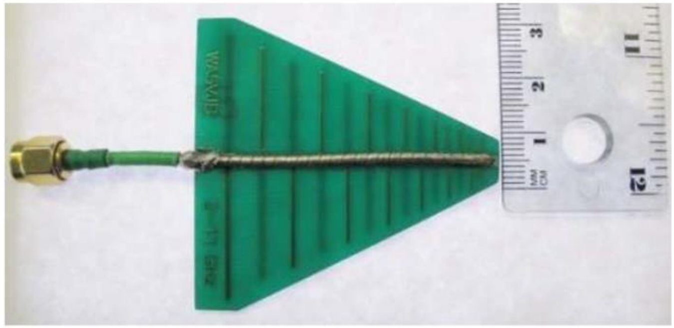


Fig. 1. 2-11 GHz commercial PC board log-periodic [3].

[3] WA5VJB, "Printed Circuit Board Antennas - Log Periodic," Kent Electronics, http://www.wa5vjb.com/products1.html

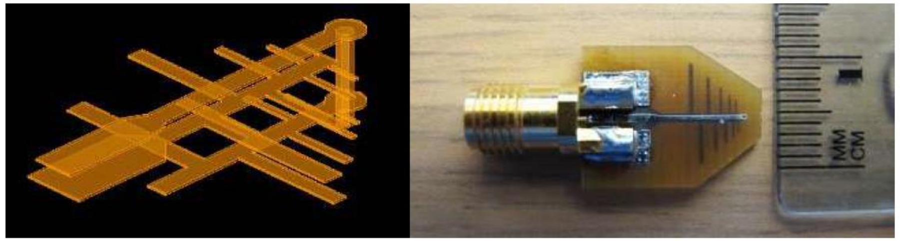


Fig. 2. 3D EM simulator model and PCB prototype of 8-20 GHz LPDA antenna.

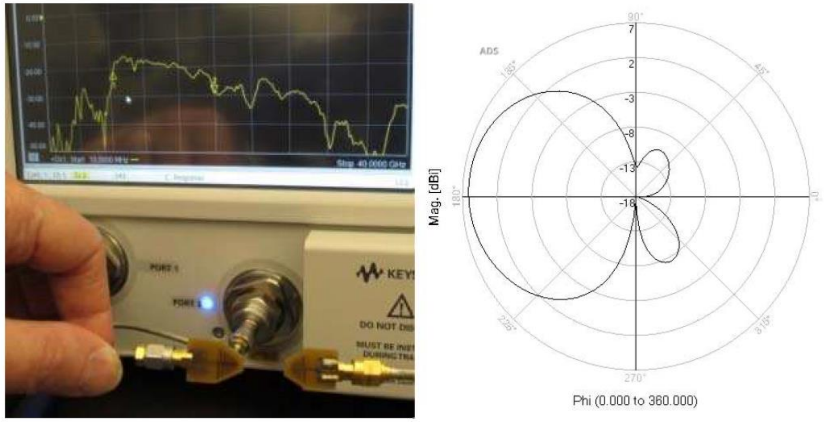


Fig. 3. Measuring antennas from 10 MHz to 40 GHz with VNA (Left). Simulated gain cross-section at 14GHz (Right).

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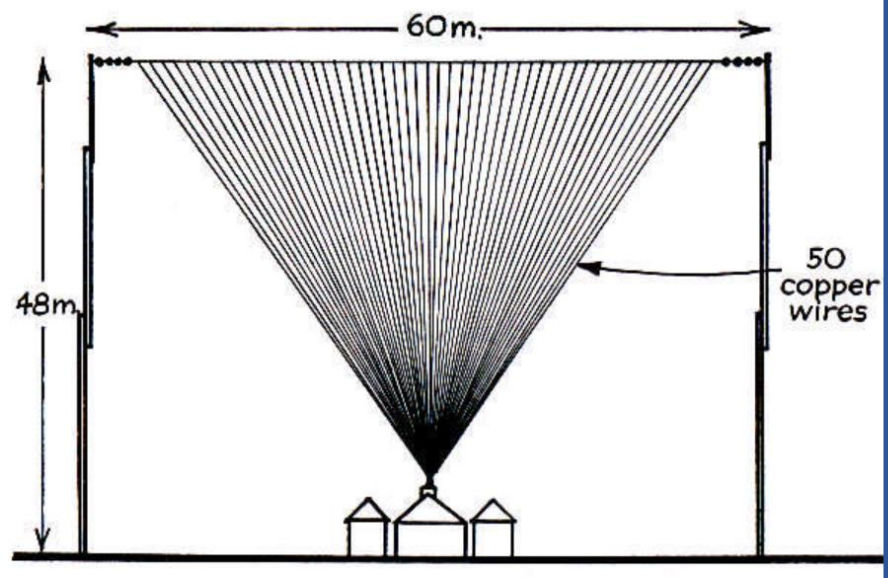
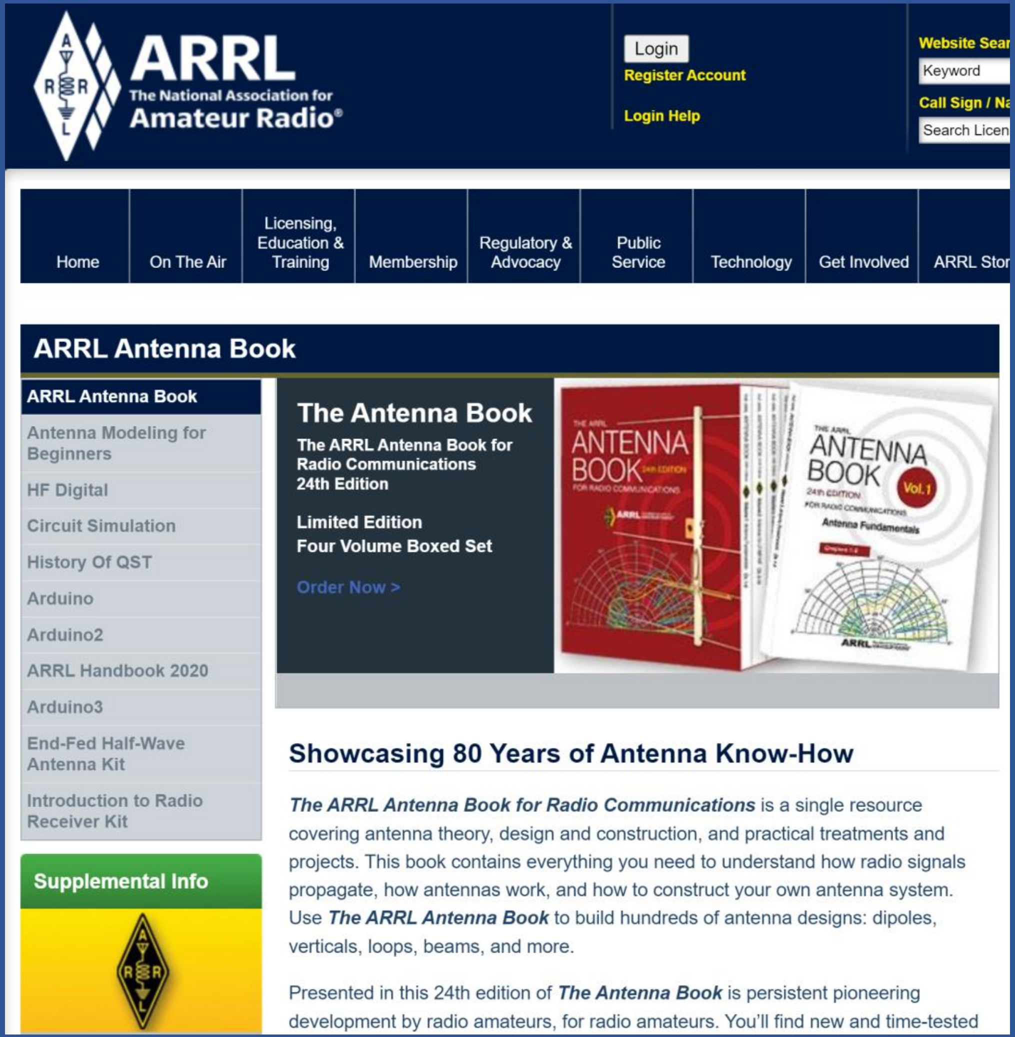
Thanks for Watching

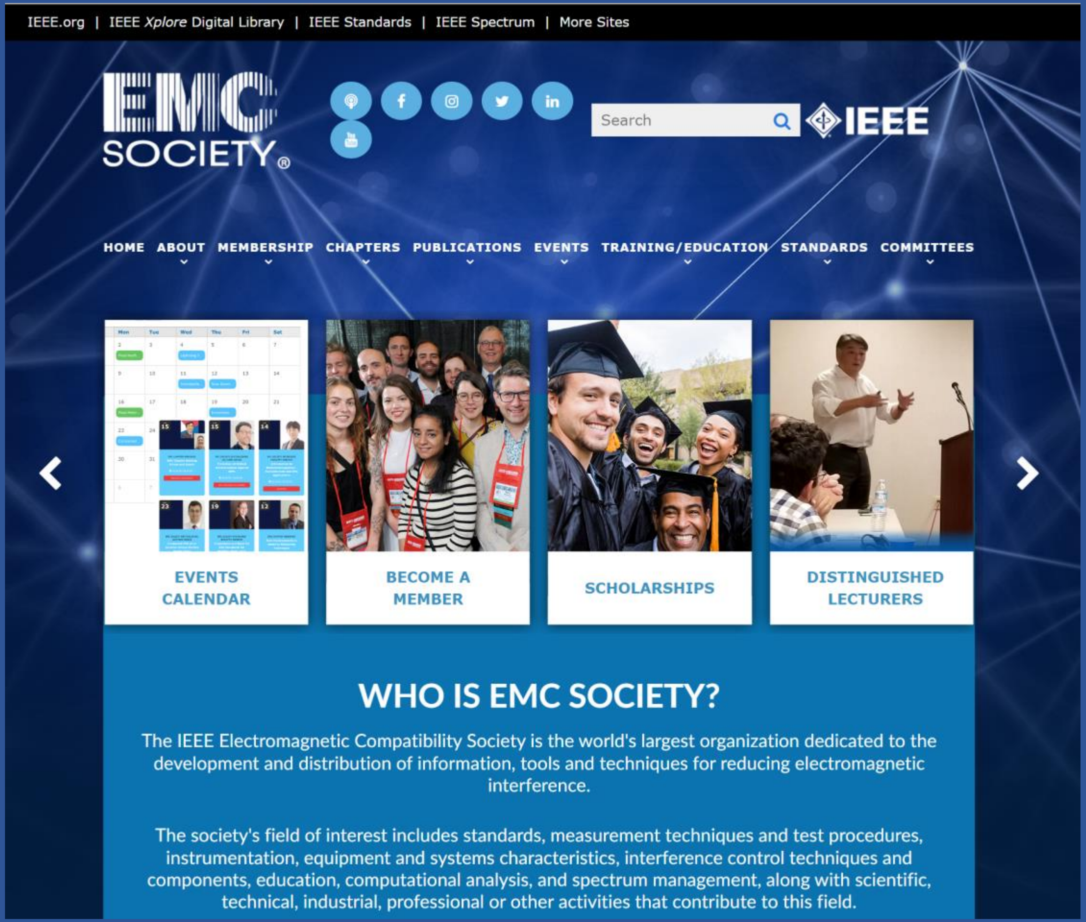
Some Good References



http://www.newscotland1398.net/nfld1901/marconi-nfld.html



Some Good EMC References



https://www.emcs.org/

https://emcfastpass.com/rightfirsttime/

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