

Radials and Counterpoises

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Radio Society of Great Britain

Advancing amateur radio since 1913

Radials and Counterpoises

- What is a radial?
- What is a counterpoise?
- What's the difference?
- How can we use them?



Radials and Counterpoises

- A radial replaces the missing other half of a vertical antenna.
- That is, if it is a ground-dependent vertical, eg a Hustler 5BTV, DX Commander or a Butternut HF6V etc.
- Not so important on ground-independent antennas - eg EFHW, Cushcraft MA5V etc.



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- “The purpose of the ground system is to improve antenna efficiency so that less power is lost in the soil and more is radiated.”



Radials and Counterpoises

- With a vertical, how many radials do you need?
- How long should they be?
- See the work of Rudy Severns
N6LF



Radials and Counterpoises

- The ground isn't just a poor conductor. It's a lossy dielectric.
- So we need to find a way to reduce those losses.
- And that's where radials come into play.



Radials and Counterpoises

Table 2, σ_e and ϵ_{er} pairs for common types of soil

Soil type	σ_e [S/m]	ϵ_{er}	D @ 3.5 MHz
Fresh water	0.001	80	0.064
Salt water	5	81	317
Very good	.03	20	7.7
Average	0.005	13	1.98
Poor	.002	13	0.79
Very poor	0.001	5	1.03
Extremely poor	0.001	3	1.71

- Where σ_e is relative conductivity, ϵ_r is relative permittivity and D is the loss tangent

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So what is a loss tangent?

The dielectric loss tangent ($\tan \delta$) of a material denotes quantitatively dissipation of the electrical energy due to different physical processes such as electrical conduction, dielectric relaxation, dielectric resonance and loss from non-linear processes.



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What is the dielectric loss tangent of air?

The dielectric loss, or loss tangent, of a vacuum is zero, where air is close enough to zero that it is largely considered negligible.



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- So salt water reigns supreme
- Fresh water is roughly equal to very poor soil
- Quickest way to improve your soil is to bury salt in your garden. PS This will kill all your grass and plants, so you won't be popular!

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Radials and Counterpoises

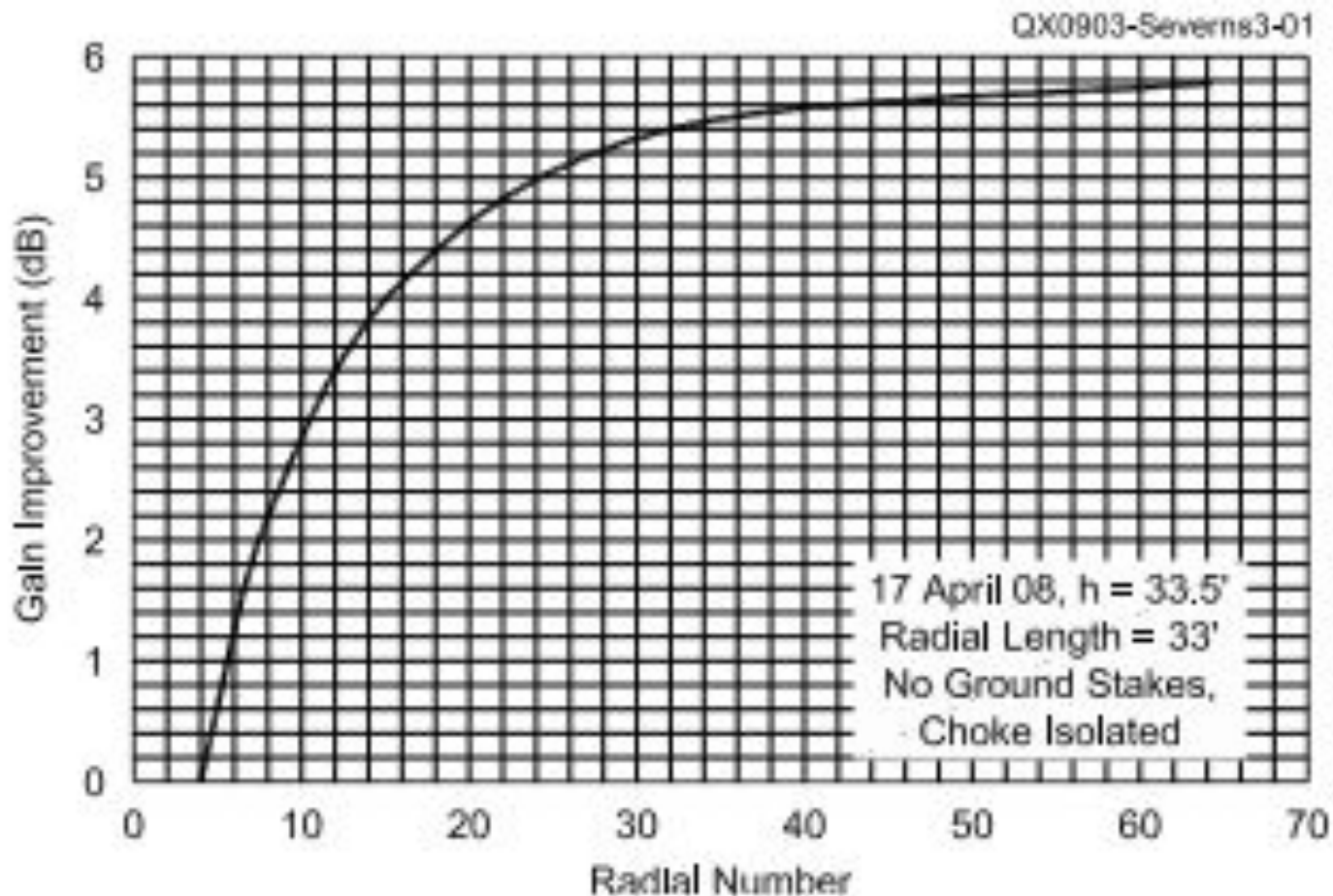
- So radials are the easiest way to go.
- They don't have to be a quarter of a wavelength long.
- Make them “as long as the antenna is high” is a good guide
- How many? As many as you can get down.
- “Use at least 16, or better yet, 32 radials”
- “Ground systems using only a few radials are a poor idea”



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Radials and Counterpoises



From work by Rudy Severns N6LF



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- “As a guide, for a given amount of wire, more short radials are better than fewer longer ones.”
- Note: This only applies to radials on/in the ground – not elevated radials.
- Note 2: An earth stake does very little for you effective ground.



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What about the SWR?

- A quarter wave vertical with just a ground post may give an SWR of 1:1. Magic? No!
- The impedance of a quarter wave vertical is about 36 Ohms (half of a dipole eg $72/2$ Ohms)
- Adding ground radials will increase the SWR, but make it more efficient.
- So add radials until the SWR doesn't change
- The SWR will end up at about $50/36 = 1.4:1$



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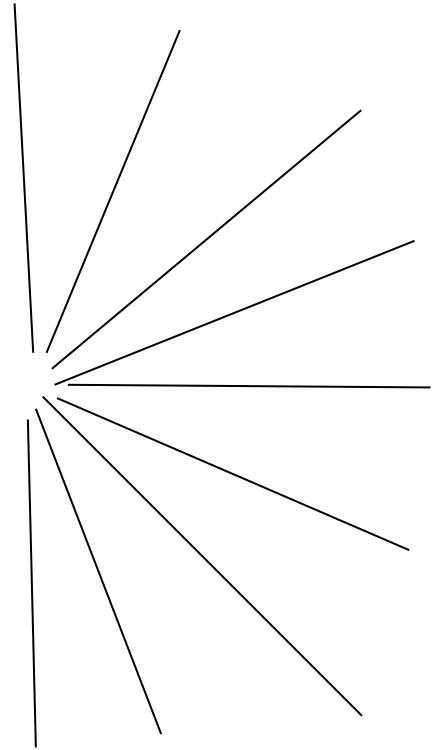
- Try to use at least sixteen $\frac{1}{4} \lambda$ radials.
- If you don't have the space for $\frac{1}{4} \lambda$ radials, lay down a larger number of shorter ones.
- More than 16 radials will help but give only a fraction of a dB over average or better soils.
- The shorter your antenna, the more you need a good ground system.
- The poorer your soil the more you need a good ground system.
- A surface-radial ground system will affect the resonant frequency and you may have to adjust the vertical height for that.
- Work hard at making the antenna itself more efficient. In other words, use high-Q loading coils, use top loading to minimize the size of loading coils, minimise conductor loss, and so on.

From work by Rudy Severns N6LF



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If you can't have a completely symmetrical radial field expect up to 1.9 - 3dB of losses in the "missing" direction.



From work by Rudy Severns N6LF



Radials and Counterpoises

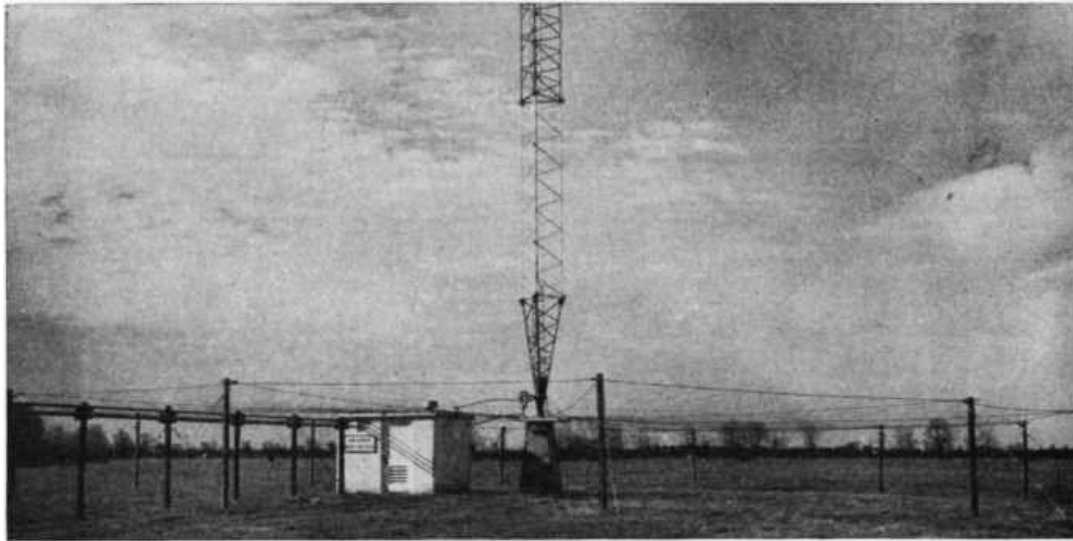
So what's a counterpoise?

- “A network of wires or cables that acts as a substitute for an earth connection.”
- “A counterpoise is a network of suspended horizontal wires or cables (or a metal screen), used as a substitute for an earth (ground) connection in a radio antenna system.”

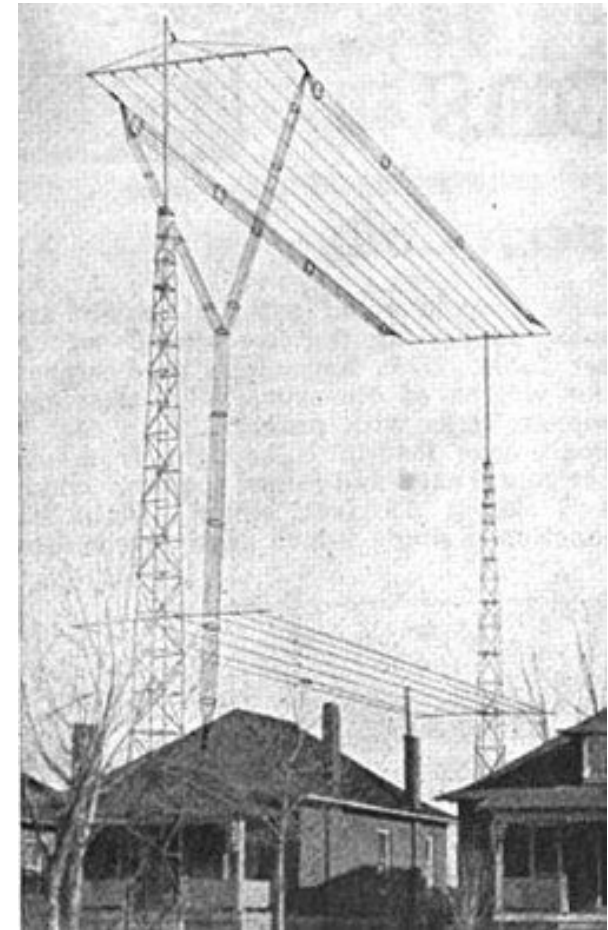


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So what's a counterpoise?

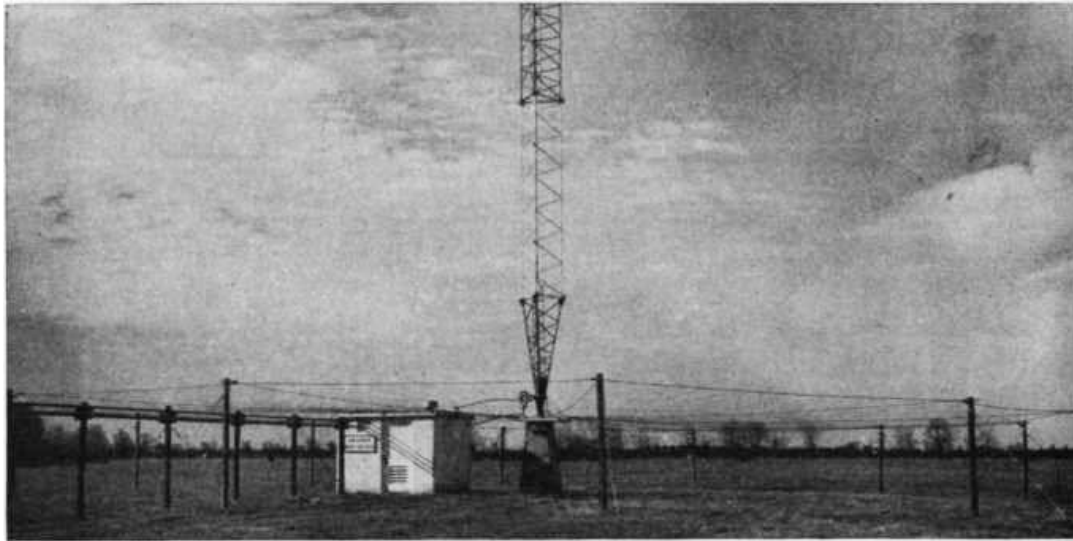


Above: A counterpoise system at a commercial broadcast station (KTBS).
Right: A radio amateur in 1920 (probably single!).

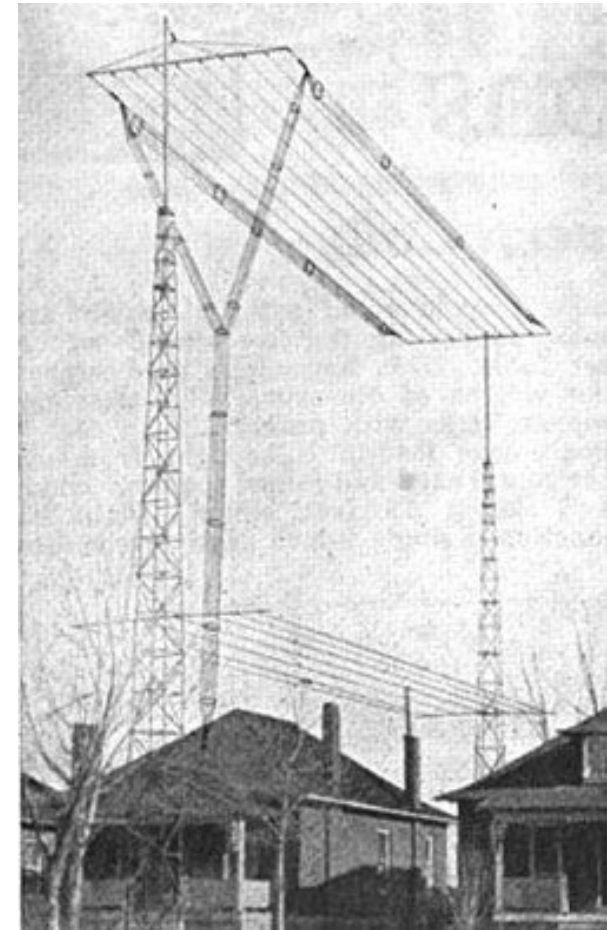


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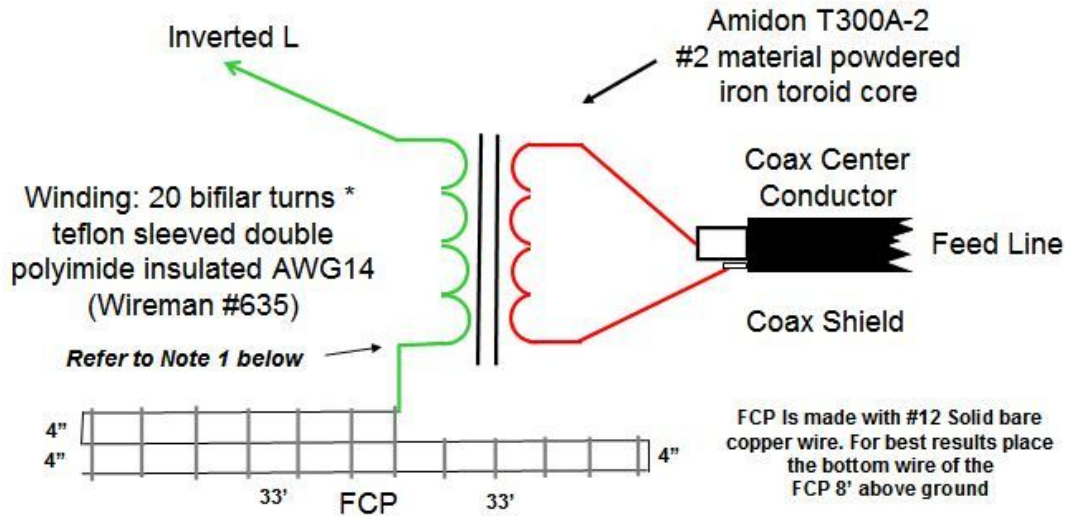


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Radials and Counterpoises

K2AV 33 x 33 160m Folded Counterpoise (FCP) and Isolation Transformer



* Bifilar turns: Instead of the two windings kept separate, one wire on one side of the toroid and one wire on the other side, the two wires are kept in a pair like a length of zip cord. The PAIR of wires is wound around the toroid twenty times. For this application 15 feet of wire and teflon sleeve, cut in half, provides the required PAIR length of 7.5 feet.

“When we installed this as a counterpoise at W0UCE – at 2.5 meter(8 feet) above ground – Jack started being heard well on 160m from his small lot using his smallish inverted L.”



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Sources:

Rudy Severn's articles on radials for QEX:

<https://rudys.typepad.com/ant/page/2/>

Folded Counterpoises for 160m:

<https://hfdxarc.com/technical-pages/aerials/folded-counterpoise-fcp/>



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Any questions?

