A Multi-Band W7SX Array Including 6 Meters

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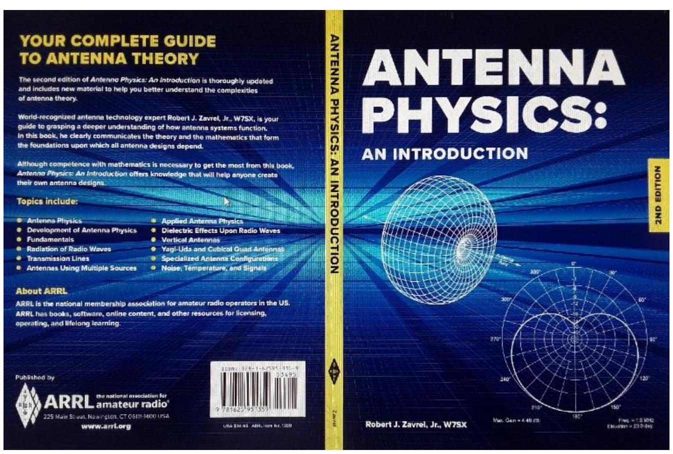
For Spokane VHF Club presentation

Feb 11, 2021

Two expanded versions of this presentation will be published in both QST (April 2021) and a more in-depth technical version in QEX (March/April 2021 issue). The editor of QEX named this technique as the “W7SX” array.

Most amateurs are familiar with the ubiquitous Yagi-Uda array. Yagis are almost always built using a ½ λ dipole element for the driven element, a slightly longer than ½ λ element for the reflector and (if used) slightly shorter than ½ λ elements for the director(s). There are multiple methods of building multi-band Yagis by using traps, interlacing, element loading, etc. Some of these designs “cut” the elements’ lengths for resonance at the higher frequencies, thereby wasting the potential gain of longer elements. This design uses the entire lengths of all elements on all bands. A little-known term used for defining an antenna is its equivalent *aperture.* I provide a detailed description of aperture in *Antenna Physics, and Introduction,* now it its 2nd edition published by the ARRL.



One of the implications of using more “aperture” in an antenna design is that the aperture is directly proportional to the gain. Longer elements have more aperture and thus if you can employ longer element lengths you can achieve more gain. The W7SX array simply uses element lengths between a bit less than ½ up to 1¼ λ long (the length of an extended double Zepp).

So, how do we create a parasitic element from a non-resonant (or near-resonant element)? The answer is deceptively simple: we add a proper reactance at the element's center (a proper value capacitor or inductor).

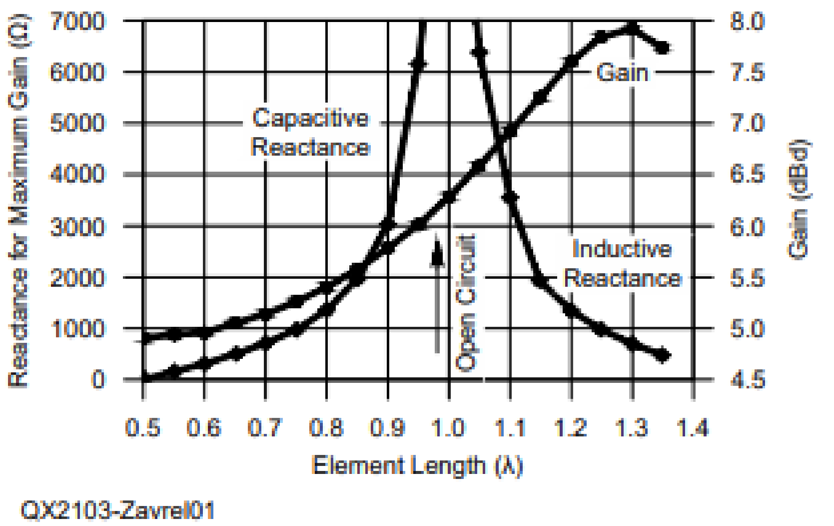
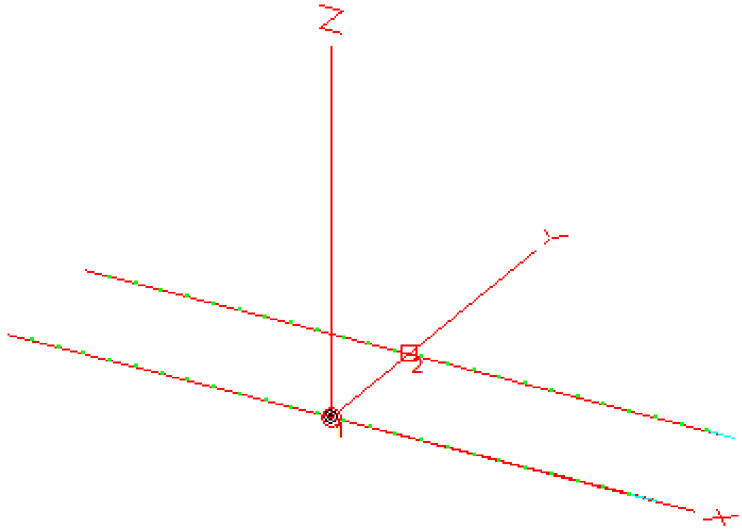


Figure 1 — Reactances needed to make a parasitic element from elements ½ to 1 ¼ wavelengths long , and the increase in gain for an increase in element lengths.

Figure 1 shows the necessary parasitic reactance and free space gain of a two element Yagi with a fixed 1/8 λ spacing. The element lengths shown are for both the driven and reflector elements.



This figure shows an EZNEC diagram of the 2 element W7SX array for 6, 10 and 12 meters used an example here. The element lengths are 18.8 ft with a boom length of 4 feet.

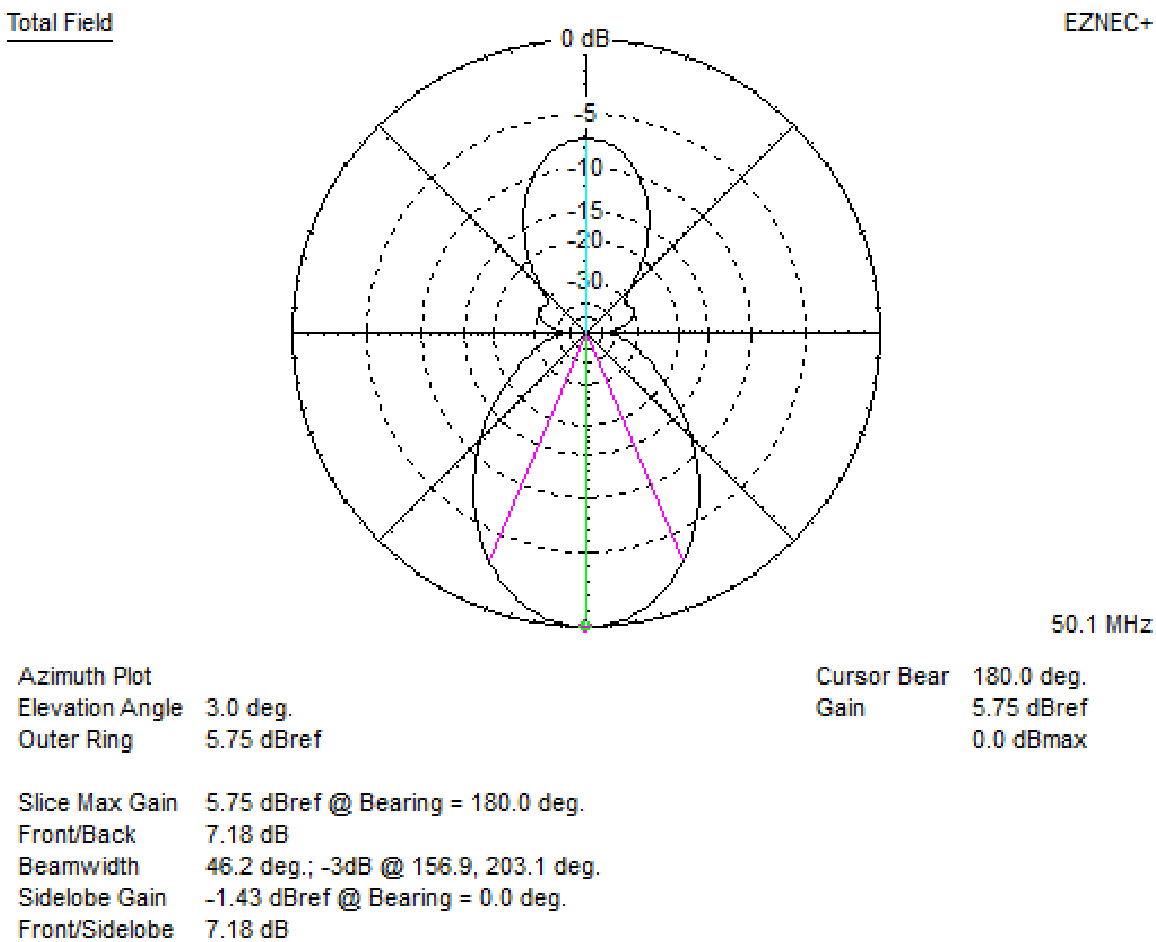
Starting on the left side of the chart (Figure 1) we see a typical gain of about 5 dBd (gain over a ½ λ dipole), which is the same a 7.15 dBi (gain over an isotropic). This is using ½ λ long elements for a "traditional" Yagi array. Notice also that the required reactance is 0Ω which is a short circuit, exactly what we use on a full size traditional Yagi.

Now as we begin to increase the element lengths (or increase the frequency) we see the gain begins to rise, but we also need to place a capacitor at the reflector's center (very low capacitive reactance implies a large capacitor value). As we continue to increase the antenna lengths, the required reactance increases so the capacitor decreases until we reach element lengths about 1λ, which by definition is a 2 element colinear arrangement. At this length the array is now a 4 element colinear array with the reflector center being *open*, or *infinite* reactance. Another way to look at it is two 2 element Yagis side-bay-side.

Making the elements even longer (approaching an extended double Zepp) we optimize the reflector by adding a very large inductive reactance and then reduce the reactance and inductive value until we reach the maximum possible gain at about an element length of 1.3 λ.

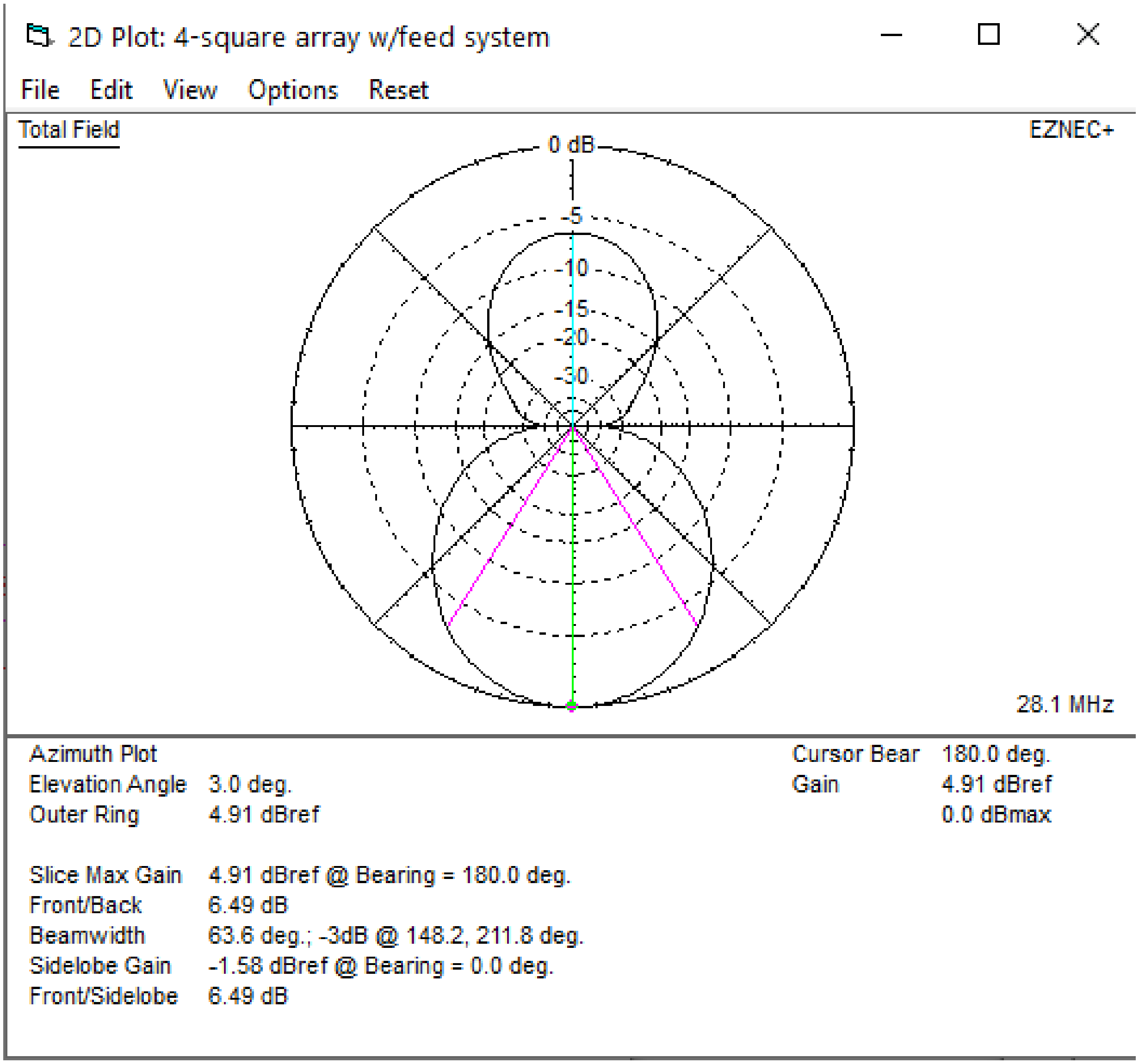
So, with 1.3 λ length elements, we achieve about the same gain as an optimized 4 element traditional Yagi.

But let us assume that the ½ λ version is tuned for 6 meters (element lengths about 1λ, or 18.8 ft.). With a 4 foot spacing we can derive about 5.75 dBd gain, or the equivalent of a standard 3 element Yagi.



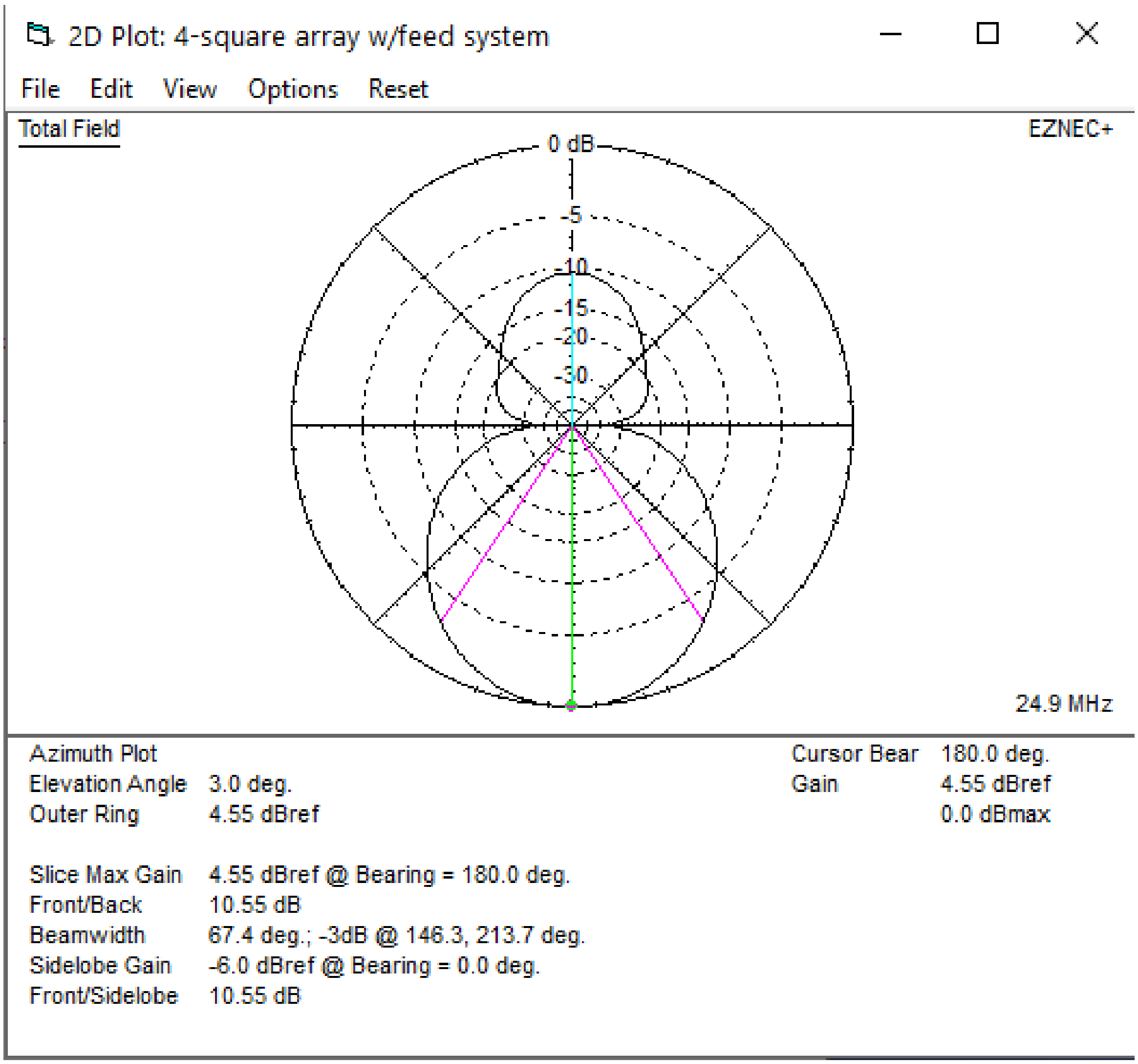
However, at 10 meters, 18.8 ft. is about .537λ. On this band we can achieve a near=optimized 2 element Yagi.

Capacitance value at reflector center: OPEN



Capacitor value at reflector center: 70 pF

Finally, on 12 meters, The element lengths are just a bit shorter than 1/2 λ so we add an inductor at the reflector center and also achieve about the same as a 2 element Yagi.



Inductor value at reflector center: 0.2 uH

The antenna is ideally fed with open wire line. With the introduction of automatic antenna tuners, such a tuner can be placed in a box at the tower base to provide a perfect match over all three bands. The different reactive values at the reflector can be switched with relays, or performed automatically with LC circuits. The later technique is explained in detail in the upcoming QEX article. If we extend the antenna length to the full 10/8 λ on 6 meters we can create a 4 band array that includes 15 meters.