How to Transform Your ZS6BKW Into an All-HF-Band Antenna

by Cecil Moore, W5DXP, Rev. 3.0, 09/01/18

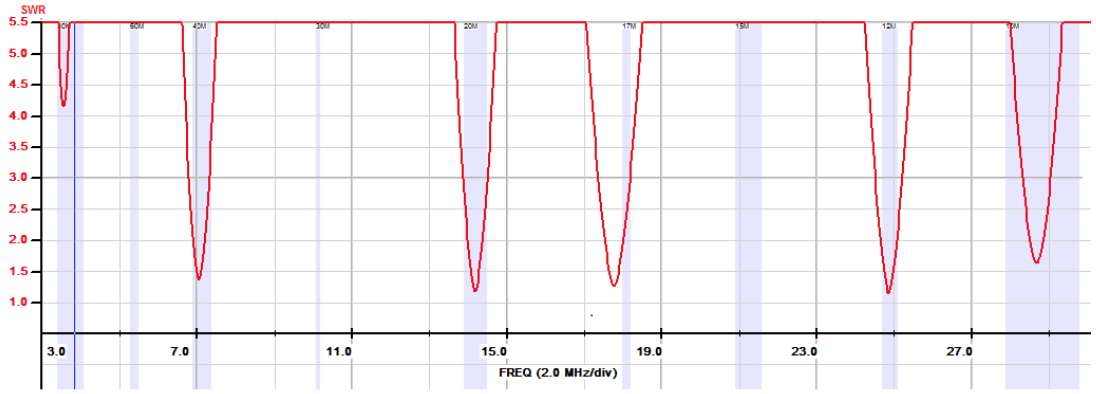
The ZS6BKW antenna evolved from an optimization of the G5RV antenna that, in general, sacrifices 75m operation to gain 17m and 10m operation. Where the G5RV is basically a four HF band antenna (80m, 40m, 20m, and 12m) the ZS6BKW is a five HF band antenna (40m, 20m, 17m, 12m, and 10m).

The G5RV is a 102 ft center-fed dipole fed with ~30 ft of 300 ohm twinlead plus coax the rest of the way to the shack.

The ZS6BKW is a 92 ft center-fed dipole fed with 40' of 450 ohm ladder line plus coax the rest of the way to the shack.

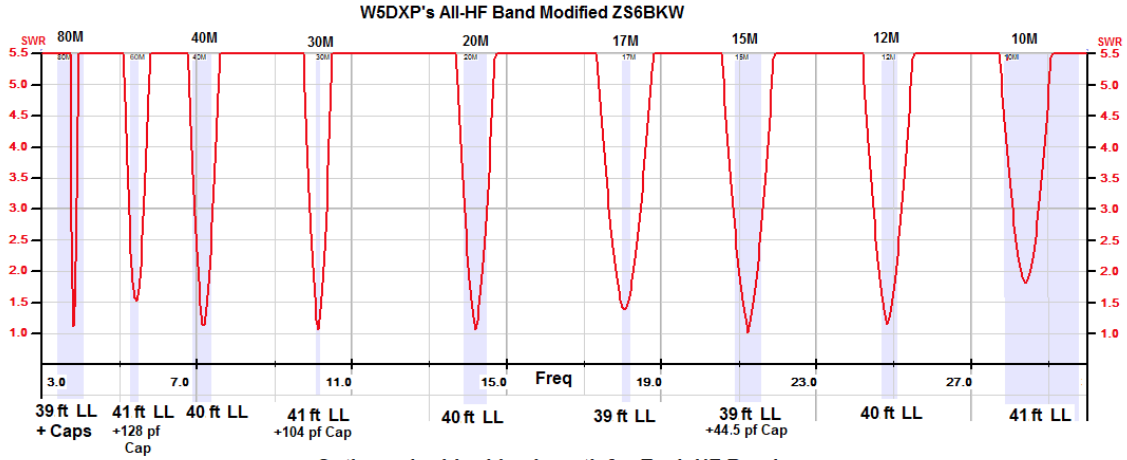
Both antennas need a 1:1 choke-balun at the BALanced twinlead to UNbalanced coax junction to minimize coax feedline radiation and RF-in-the-shack.

The ZS6BKW is not a perfect antenna. The SWR on 80m is too high and the 40 ft ladder line matching section is a little too long on 17m and a little too short on 10m putting resonance outside of the privileges of the technician license. The standard ZS6BKW is mismatched on 60m, 30m, and 15m and requires a relay-switched parallel capacitor (or open stub) across the ladder line to achieve resonance on those bands. Here's what the standard ZS6BKW SWR graph looks like before modifications.



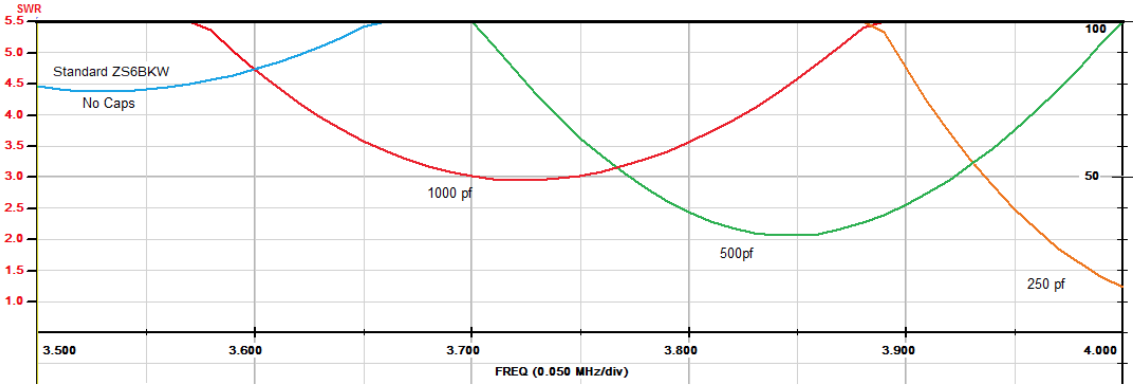
Standard ZS6BKW HF SWR

With a few modifications, the following measured SWR values were obtained from the modified ZS6BKW.



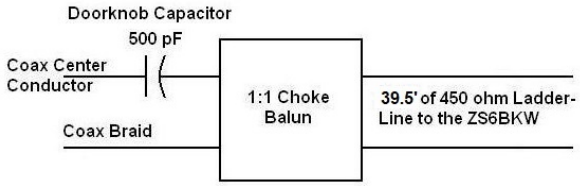
Optimum Ladder-Line Length for Each HF Band

The author's goal was a multi-band HF antenna that didn't require an external tuner. Implementing all of the improvements necessary to achieve the above SWR curve is probably more than the average ham wants to undertake. So these improvements will be taken one at a time from the easiest to the most time-consuming. First, let's look at lowering the SWR on 80m using a single series capacitor that can be left in the circuit permanently. The following graph shows the effect of a single series capacitor from no capacitor to a 250pf capacitor.



ZS6BKW with series Cap

Assuming a choice of 500pf which would result in an SWR of 2:1 on 3.85 MHz, here is how to install the capacitor on the coax side of the 1:1 choke-balun.

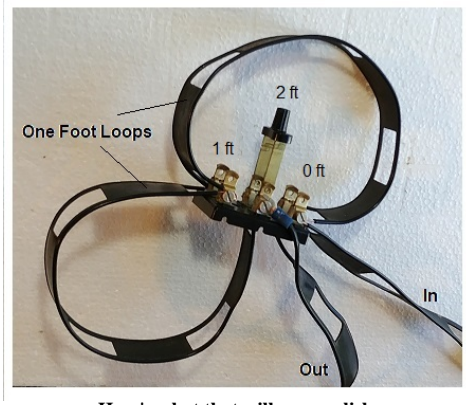


ZS6BKW Modification

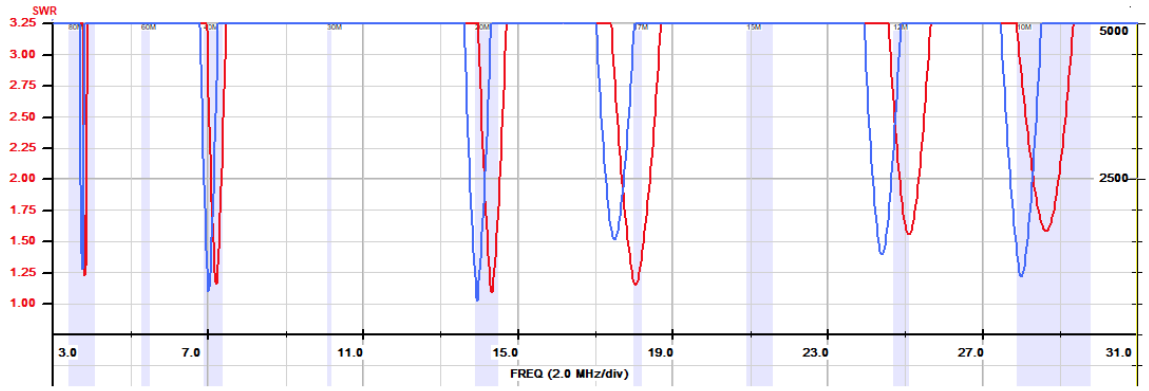
The author chose to install a 750 pf capacitor which gives an SWR of 2.5:1 at 3.77 MHz. Since the reactance of a capacitor decreases with frequency, this capacitor can be a permanent installation because it will have little effect on the higher frequency bands. Of course, if the choke-balun is outdoors, the capacitor will need to be weatherproof.

Now we will turn our attention to the next easy-to-fix problem and that is the resonant frequency on 10m which is about 28.7 MHz, 2-3 kHz higher than the tech frequencies of 28.3-28.5 MHz. What can we do to bring the resonant frequency down to 28.4 MHz? If we mount a 10 inch parallel open stub of 300 ohm twinlead about 5 feet up from the choke-balun, we will shift the resonant frequency to 28.4 MHz with an SWR of about 1.8:1 at that point. Here's a picture of the author's 10 inch stub. Because the parallel reactance is so large on the lower frequency bands, the stub can be made permanent without appreciably affecting conditions on any other band.

The following modification looks like it would have little effect on the ZS6BKW. In fact, if one wants to avoid an antenna tuner, it has a large effect especially on the higher frequency bands. It can be implemented locally with a DPDT knife switch or remotely with a DPDT relay. Note that because of capacitive effects, it can only be mounted at the output of the 1:1 choke-balun at the ladder line to coax junction on the ZS6BKW antenna system.[1] The following device will add zero or one or two feet to the ZS6BKW matching section at the 1:1 choke-balun.

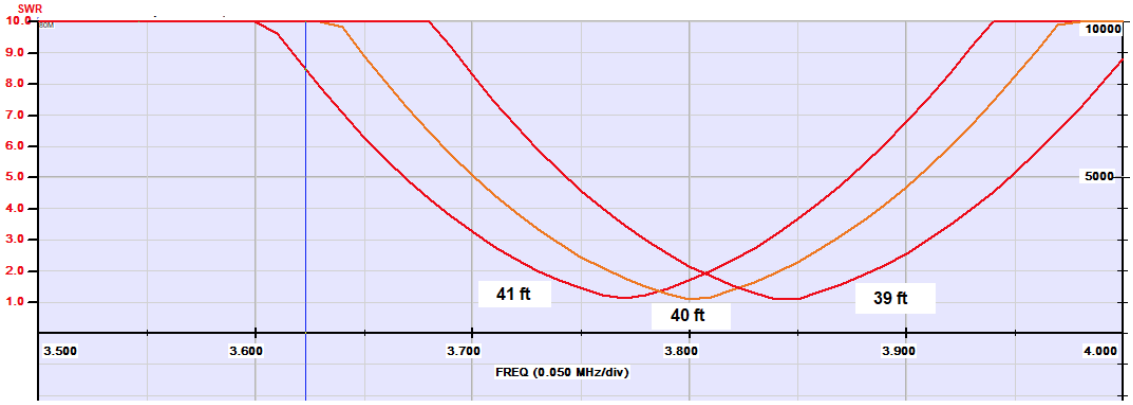


Here's what that will accomplish:



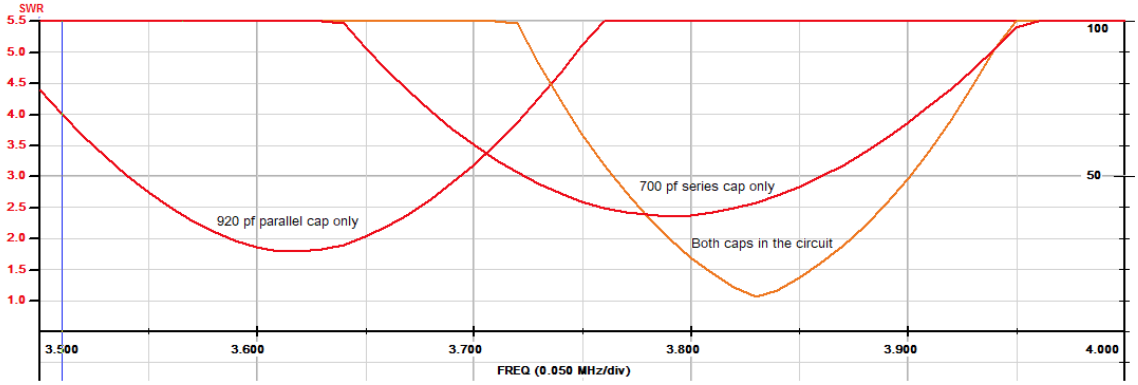
W5DXP's ZS6BKW Blue Trace - Matching Section = 41 feet Red Trace - Matching Section = 39 feet

The length of the matching section naturally has more effect as the frequency is increased. The longer length results in a lower frequency of resonance and the shorter length results in resonance at a higher frequency. Note that the shorter length eliminates the need for a tuner on 17m. The above graph is an actual scan of the author's ZS6BKW using an AIM-4170D antenna analyzer. The resonant frequency on 10m has been shifted to 28.5 MHz and high SWR on 80m has been improved. Here is an expanded graphic of what the plus or minus one foot of matching section can accomplish on 80m

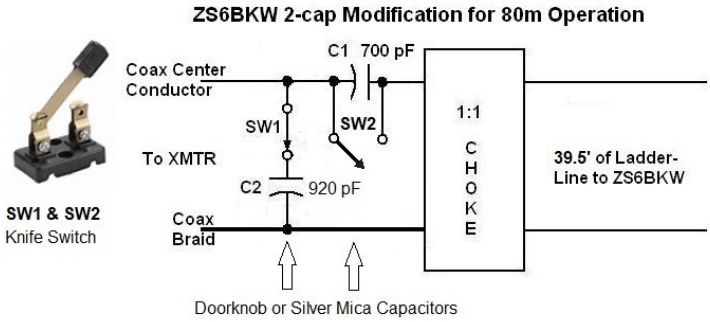


Extra Bandwidth Obtained by the Ability to Vary the Ladder Line Length by Plus or Minus One Foot from 40 ft

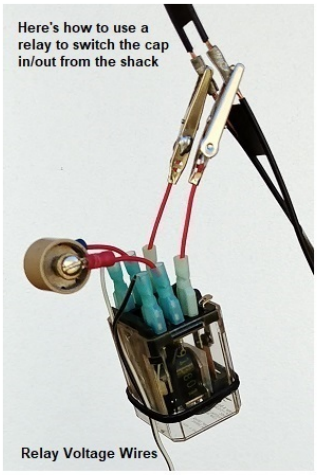
Now we come to the modifications that most hams will probably think are not worth the effort. However, in the spirit of completeness for an all-HF-band antenna, the author has designed and tested each of these modifications on his ZS6BKW and they work as advertised. The 80m SWR can be further improved to perfect (at one frequency) by the addition of a parallel capacitor on the coax at the 1:1 choke-balun terminals. Unfortunately, that capacitor must be removed for operation on the higher frequency bands and thus requires remote control of a relay (or manually lowering the antenna each time 80m operation is desired.) The following graph shows what happens with the various combinations of a series capacitor and a parallel capacitor at the balun input.



And here is how to do the switching with knife switches when one has access to the balun position as does the author. Most hams would have to use a relay (or two) for this function.



We have three bands left on which the ZS6BKW is known to be a very poor performer, 60m, 30m, and 15m. How can we get the ZS6BKW to perform well on those bands? The answer is simple - the implementation is a little difficult. We need to switch in a parallel capacitor at a point on the 450 ohm matching section that will result in a low SWR at the balun. One SPST relay is all that is needed for each band. The author had surplus DPDT relays in his junkbox and that is what he used below:



If voltage is supplied to the relay, the capacitor is switched in. If no voltage, the capacitor is switched out. Thus if we have three relays for 60m, 30m, and 15m, only one of them will be activated at a time. Here's where to hang the relays and the capacitor values that are required.

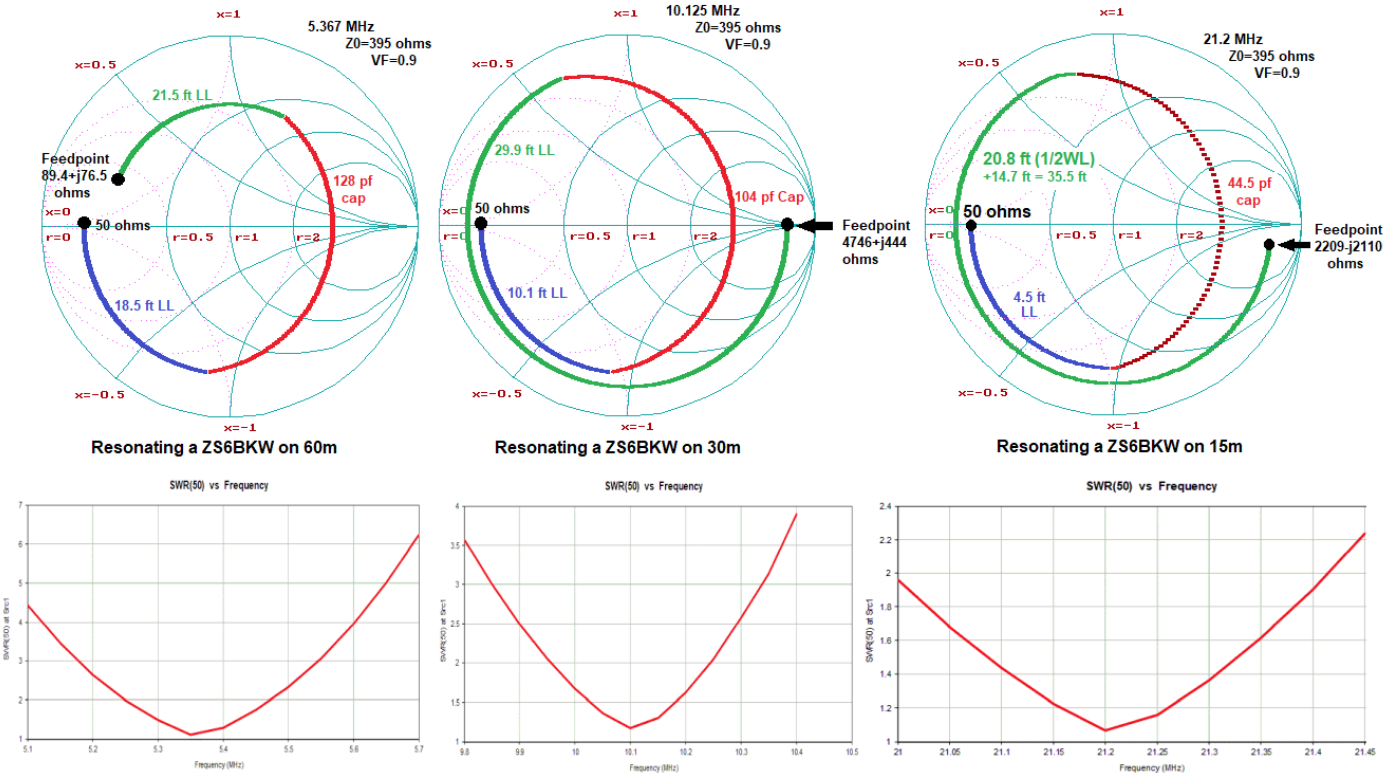
40 ft of 450 ohm ladder line

XCVR-----50 ohm coax-----balun==========capacitor==========92 ft Dipole

	L1	parallel	L2
60m	18.5 ft	128 pf	21.5 ft
30m	10.1 ft	104 pf	29.9 ft
15m	4.5 ft	44.5 pf	35.5 ft

Switched Parallel Capacitor for 60m, 30m, or 15m Operation on a ZS6BKW

For those of you who can read a Smith chart, here they are for the 60m, 30m, and 15m bands along with the SWR graphs for those bands.



If all of the modifications described above are implemented, the modified ZS6BKW literally becomes an All-HF-Band Antenna.

[1] Someone apparently misunderstood the purpose of this device and asked Owen Duffy about it. https://owenduffy.net/blog/?p=13621

The misunderstanding was apparently communicated to Owen because he complains that this is not a general purpose way to change the length of ladder line. What Owen seems to have missed is that this device was never intended to be a general purpose device. The description appears only in this article about the ZS6BKW antenna system, applies only to the ZS6BKW antenna system, and can only be mounted on the output of the 1:1 choke at the ladder line to coax junction. As can be seen from the graph, it only works for 40m, 20m, 17m, 12m, and 10m (with a stub) where the ZS6BKW antenna system is already close to resonant and on 80m only with the series capacitor. W5DXP apologizes for any misunderstanding about the application of this device. It may or may not work for other applications.