Discussion and findings between Gerald K5GW and Doug VK3UM with respect to 432 MHz dual dipole feed system.

Background

Gerald (K5GW) has done considerable investigation into the feed system used by myself Doug (VK3UM) as available on this web site. Given that Gerald has the necessary precision test equipment available he has now been able to analyse, to a high degree, the performance and installation ambiguities that will be experienced with installing such a feed.

Gerald as spent a great deal of time and considerable patience in bringing to fruition the best performance and his efforts are most note worthy. I feel his findings will be of considerable benefit to those following similar paths, not only using this feed type, but other feeds in varying dish sizes. Gerald's' work supplements the excellent paper written by Peter Blair (G3LTF) several years back.

I have also provided a link to Peter Blair (G3LTF) article as mentioned by Gerald which sheds light on similar problems and sets out to explain how and why some effects occur.

In the following discussion, noting that Gerald has only the 432 MHz dipoles installed and it is a single band feed (no 1296 MHz feed installed), many interesting points have arisen which I believe will be of interest to those installing similar feeds in dishes.

With Gerald permission I have provided our discussion emails (minor editing where appropriate) hopefully for your interest and "enlightenment".

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30th September 2011

Hi Doug, the new dish and feed are all done and ready for the contest next month.

I encountered some interesting and challenging issues that I thought you might also find interesting. You may well already know about these things but it was all new to me.

First, the feed was built along the lines in your dual band feed article. It showed excellent return loss of about 30 dB at 432 MHz. The dipoles were mounted on a 30" X 30" square reflector plate. When installed in the dish, the return loss degraded to about 18 dB. No amount of dipole length adjustment would make it better than 19 dB.

I then discovered G3LTF's article from the early 90's that revealed a similar scenario and how he fixed it by adding a tuning device to the dipole feeds. The cause of the problem is the dish reflection creating a VSWR that combines with the original feed VSWR to create a new composite VSWR. The new VSWR is greatly determined by the phase relationship between the feed VSWR and the dish reflection VSWR. The composite VSWR when vswr1 and vswr2 are in phase is vswr1/vswr2 and when out of phase vswr1 X vswr2. The phase is determined by the focal length which in turn is a function of f/d.

My f/d of .465 has a focal length that causes the phase difference to be nearly out of phase, a worst case. At frequencies near 418 and 449 MHz, the system VSWR was very low, like 1.05 or so. These are the frequencies that the reflections are in phase and vswr1/vswr2 is near 1.

After nearly a month of screwing around with tweaks and measurements, I tried moving the feed back a couple of inches. Almost instantly the VSWR improved dramatically to about 1.15. When the two coax relays were added, they introduced a fourth VSWR that cancelled some of vswr3 and now the total is less than 1.1. The sun noise measures the same in both feed positions so the change had a negligible effect on gain.

The circular polarity on transmit was implemented by a two way power divider, a 225 degree cable on V polarity and a 315 degree cable on H polarity. Return echoes peak 12 to 13 dB above the noise floor in a 2400 Hz bandwidth and are the same for V and H polarity on receive. The two polarities don't peak at the same time but have the same amplitude when they do peak.

The feed reflector was trimmed to a round shape and a 50mm choke was added per our discussions. This change improved the cold sky readings about 1 dB on both polarities. The cs to sun noise improved about 1.5 dB so apparently the cleaner pattern helped about a dB and the gain improved about .5 dB. You know the difficulty in making repeatable measurements so I consider the numbers to show a positive change of maybe 1 to 1.5 dB.

I am a happy camper now but have learned more than I really wanted to know about dish feeds If someone reports VSWR issues with your feed design, this likely will be the cause. It appears to me that each f/d will probably need a unique focal position and dipole length for minimum VSWR. The dipole balun/feed transformer could be adjusted to compensate as well, But who has the time and patience for that? Not me!

Thanks for your help with the project and witting the construction article. There was a tremendous amount of help buried in the write up!

73,
Gerald K5GW

30th September 2011 de VK3UM

Hi Gerald
Thanks so much for your comments regarding all the work you have put into the feed.
Well it all fits just as you have described. I certainly did not take it to the extent you have done and the results I got now tie in with yours to a tee ... with a couple of minor differences.
The minor differences are easily explained by the fact I did not have the test equipment to make the measurements at the time and the dish / shack interaction.

I originally installed the 432 feed purely on its own and it was only when I added the 1296 horn did the phase problem show up dramatically (1296 .. 432 was assumed ok) when it was discovered that the feed was about 2" too close (for 1296) .. I am struggling to remember, but I seem to recall it made a 3dB or more to the Sun Noise. At that time it did improve the return loss on 432 as well .. but not greatly.

I tried the stubs (after a days work making them) and was not able to improve the return loss.
Now all this was done in the work shop / test range .. not when installed at the feed.

One thing I should point out (and you will see why if you look at my photos) when I tip the dish over and work on the feed at the platform the metal shack "illuminates" the dish dramatically along with the ground noise. I find it difficult and very time consuming to make fine measurements as I have to raise the dish 45 degrees and return down the ladder and into the shack to see the results. Boy the return loss changes dramatically as one would expect.

Honestly Gerald, I reached the point where near enough was good enough. The 432 feed has a return loss on the horizontal dipoles of about 25 and vertical 27dB. This can be annoying as it requires a slight nudge on the PA tuning going from one to another if I am running full steam. If I don't remember it will flash over .. dramatically ! 1296, I never have been able to get that just right and see about 23dB but that acts as added protection for the SSPA !!

Re the circular polarity. fascinating ... when you get time I would appreciate some photos ..
How I wish I had the test gear I had when I was working .. viz the network analyser !

We both followed the same path and arrived pretty well at the same conclusion given that our installation test limitations were different.

I will watch with great interest what you experience next month during the contest .. if we can find some stations to work!

Again many thanks for your most valued comments

73, Doug

30th September 2011 de K5GW

There is more to the story than mentioned. The smaller the dish and the lower the frequency, the worse the problem. Conversely, larger dishes, higher frequencies are influenced less. The actual equation for this is quite simple, originated by MIT in the early 40's. It is included in the paper done by G3LTF. and is available at PA3CSG's website if you haven't seen it.

I learned a lot about the effect by doing frequency sweeps over the 400 to 460 MHz range and observing return loss readings. The return loss maxima near 418 and 448 MHz were unexpected and puzzling.

I needed a network analyser to truly derive the best solution. Some R +j data would have been helpful. The return loss bridge is a wonderful tool to establish a circle on the Smith Chart but leaves the question: where on the circle is this reading?

In the end, I gave in and also said "good enough", and actually it is.

Another interesting effect came up with the c.p. that needs more research. When the phasing cables are at a favourable length and 90 degrees different, you can connect sources having enough j to cause a 1.25 VSWR to the power divider, and the two j components cancel, leaving a very low VSWR. In every test, the combined VSWR was better than the individual VSWR's.

In a c.p. feed, the dish reflection appears on the opposite port. This makes the problem less for those bands we use c.p.. I have not explored that at all.

There seems to be a lot more to all this than seen by a casual observation.

A new/different power divider is being used. It consists of a N Tee connector interfaced to a 30 degree long by 25.3 ohm zo line made of 3/4" copper pipe fittings. The center leg of the Tee connector is about 25 degrees long/50 ohms and becomes part of the transformer. The 30 degree line is terminated on one end with a N female chassis connector and the other end with a N Male chassis connector, both soldered to an end cap.. When modelling this on a computer, the short connection between the connector center pin and the large center conductor has to accounted for. In my case they were about 2 degrees long by 85 ohms. Short but makes the model match the device measurements. No real advantage over a normal 1/4 wavelength power divider other than slightly shorter but something different just to see if it works. The c.p. power divider has a 7/16 connector on the input in case I get around to installing these connectors on the transmit coax.

73,
Gerald K5GW