Understanding Polarization

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Many times as we Field Service Representatives are walking around a camp or base, it is not unusual for us to look at all the different types of satellite dishes. Some are C-band, some are Ku-Band, and a few are Ka-Band. Other than the type of dish they are using, they all have one thing in common: Polarization.

This paper will introduce you to the different types of polarization being used now. Chances are the powers that be and the great minds of our scientist will eventually invent a new type of polarization, but for now we need to be familiar with the current types.

There are two major types of polarization: Cross-pol and Co-pol. We are going to concentrate on cross polarization as that is primarily what we will be working with the most.

There are two types of cross polarization that we are familiar with but probably only deal with one. The two type are circular and linear. Within the circular realm there is the Left Hand Circular, or LHCP, or Right Hand Circular, or RHCP. This type of polarization is used in C-Band and in X-Band. One will be hard pressed to find circular polarization on Ku- or Ka-Band frequencies.

Linear polarization on the other hand will be seen all the time on Ku- and Ka-Band antennas. With linear, there are two types: Horizontal and Vertical. What exactly is happening in the linear world that we need to know about? Before understanding how linear is used, one must understand the device being used on the satellite dish to let one signal pass while blocking the other signal. This is called the Orthogonal Mode Transducer, or OMT for short.

Satellites have a series of transmit frequencies that start at 14,000 MHz and end at 14,500 MHz. These are used for sending a signal from the earth station to the satellite. Once there, they are translated to a lower frequency and then returned to earth. This translation is different depending on which part of the world one is located in. For the U.S., the translated frequencies are 11,700 MHz to 12,200 MHz. In Europe and the Middle East, the frequencies are translated to 10,900 MHz to 11,700 MHz. In Australia and New Zealand, the frequencies are translated to 12,200 MHz to 12,700 MHz.

With that in mind, we also have to understand that all these frequencies are reused. In other words, the frequency is used twice, but they are on separate polarization. One frequency is send down in the horizontal plane and the other, the vertical plane. Without getting into too much detail about how this is done, suffice it to say that it is being done. There are many documents that explain this in much more detail that I ever could. Do a search on Wikipedia.

Figure 1 is a crude image of an OMT.

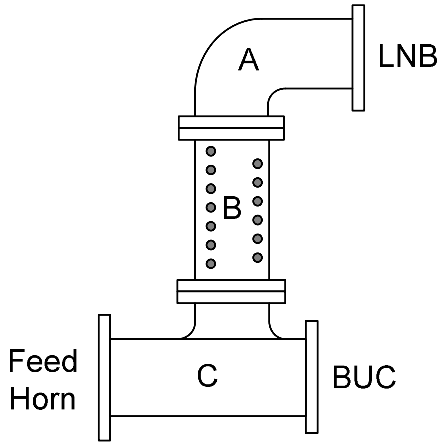

Figure 1: Orthogonal Mode Transducer

In Figure 1, section A is the a waveguide that is bent on the "H" plane, or the Hard plane . Section B is a transmit reject filter and is used to prevent transmitted energy from getting into the LNB. Section C is a straight piece of waveguide that connects the Block Up Converter to the feed horn. The OMT is an integral part of the entire feed assembly and is responsible for the linear polarization process at the earth station dish. Figure 2 shows the OMT from the BUC end.

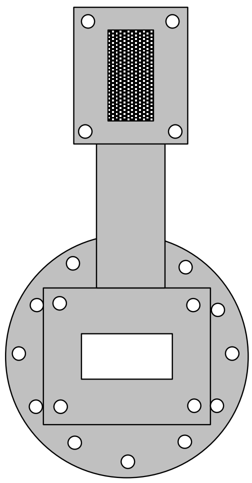

Figure 2: OMT viewed from BUC end

Looking at Figure 2 one will notice two rectangular openings. One is situated in the vertical plane while the other is in the horizontal plane. These are the ports where the BUC and LNB are connected. They are just hollow waveguides that the energy travels to or from the dish. They are specifically tuned to the frequencies they are designed to support. C-Band cannot work with a Ku-Band OMT, as a Ku-Band OMT cannot work with a Ka-Band OMT.

Figure 3 shows how we derive at the horizontal and vertical elements of the polarization. As one see, it is the actual antenna element that indentifies if the signal is horizontal or vertical.

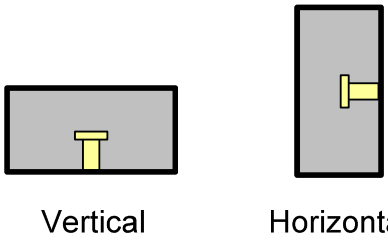

Figure 3: Vertical and Horizontal elements

Now that we have an understanding of what is used for polarization control, let's see how to apply our new found knowledge. Adjusting the polarization for linear polarized signals is as simple as looking at the face of the feed horn. Regardless if the dish is prime focus (feed horn in the center of the parabolic dish) or off-set feed (standard or inverted), or if you are using dual optics (Gregorian or Cassegrain), polarization is done from the face of the feed horn.

Figures 4 through 9 depict how the whole entire feed assembly is moved to achieve the correct pol angle whether vertical or horizontal. Let's start with the LNB in the 12 o'clock position. This is with the long edge of the LNB in the vertical position, so the element in the LNB is oriented horizontal (see Figure 3). This, therefore, would be considered Horizontal Down, or the down link signal are in the horizontal plane.

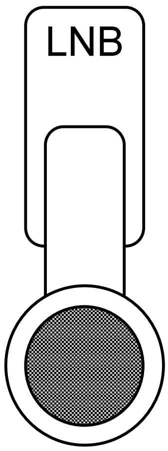

Figure 4: LNB in 12-o'clock position - Horizontal Polarization

This seems to be the starting position for most installations, but may not be the finished position. It depends on where the satellite is with respect to your meridian, or your longitude. While facing directly south, everything to your right is considered POSITIVE while everything to your left is considered NEGATIVE. So if the transmission plan indicated that you are to receive horizontal down with a polarization of 23 degrees, you would know the satellite is to your west. This is true wherever you are in the northern hemisphere. If you are in the southern hemisphere you will have to reverse the information.

Right then, your transmission plan said horizontal down, +23 degrees polarization. So which way will you rotate the feed assembly? Remember that when looking south (from the northern hemisphere) everything to your west is positive, you would rotate the feed assembly clockwise to 23 degrees. Figure 5 depicts what your polarization will look like.

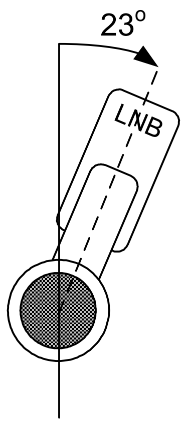

Figure 5: Horizontal Polarization, +23 degrees

Another way to look at this is viewing the feed assembly while looking at the sky, or looking towards the satellite. However, the easiest way to remember is the face of the feed horn is facing you.

Let's assume now that the transmission plan said horizontal down, -23 degrees polarization. Now which way do we rotate the feed assembly? Well, back to our discussion of facing south. If everything to our west was positive, then everything to our east, or our left, is negative. It would then be correct to say the rotation would be anti-clockwise, or counter-clockwise. Figure 6 shows the polarization in the negative.

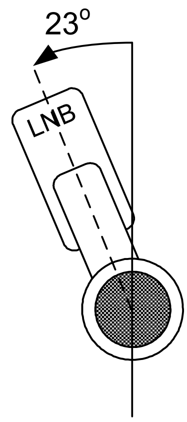

Figure 6: Horizontal down, -23 degrees

So, could the polarization be 0^o? It sure can. If the satellite's meridian and your meridian were equal, then the polarization is 0^o. An example would be a satellite located at 90^o and your earth station is located at a longitude of 90^o, then your polarization is 0^o.

So just to give you visual, Figure 7 shows the direction to rotate your LNB if you are in the northern hemisphere.

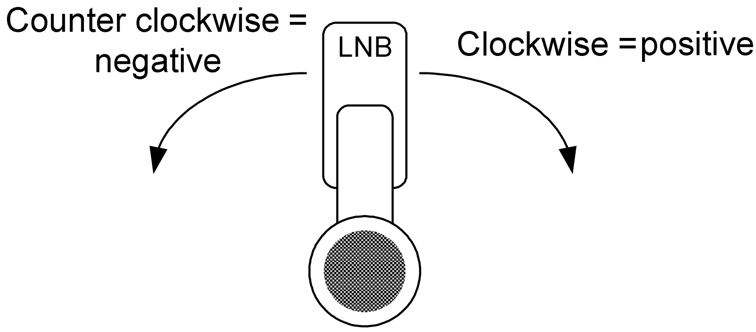

Figure 7: Horizontal Polarization - Positive and Negative

Let's now tackle Vertical polarization. Remember in Figure 3 we showed you the difference between horizontal and vertical? Well, in order to achieve vertical horizontal polarization, we need to rotate the whole feed assembly 90^o. But which way? Ah… now you are going to have to decide which way will be the easiest to adjust for positive and negative. So which one of the two feeds in Figure 8 is correct?

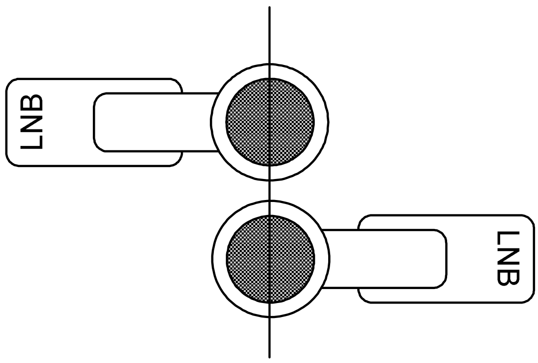

Figure 8: Vertical Polarization. Which one is correct?

The feed in Figure 8 upper is oriented to the 9 o'clock position while the feed on the bottom is oriented to the 3 o'clock position. So which one is correct? Well, they both are. The position is oriented to ease the adjustment in the positive or negative plane. If we think about this for a few minutes, you will see that rotating the upper in the positive (clockwise) rotation will be easier than the bottom. Conversely, rotating the bottom feed would be easier in the negative (anti-clockwise, counter-clockwise) direction. Why? Remember that there is a support plate holding the feed assembly and one might not have enough room to obtain the correct polarization value.

Let's look at Figure 9 now and see that the correct orientation is directly proportional to the direction of the adjustment. If we are going to a positive value, we need the feed on the 9 o'clock position so it move up. If we are using negative values, then we start at the 3 o'clock position so the feed move… that is correct… up! Regardless, we want the feed to move up and away from the support plate. It is just easier to adjust in this position. If you are just adjusting in a 1^{o} or so movement, either direction is fine.

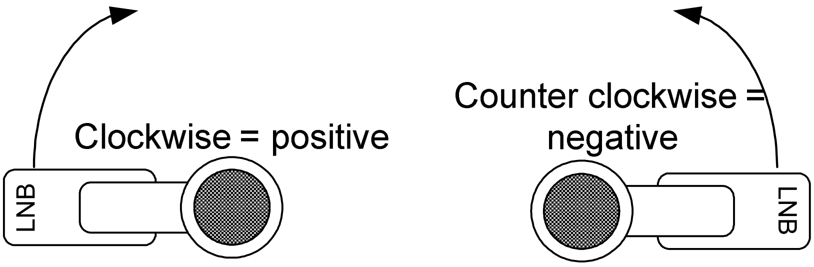

Figure 9: Vertical Polarization

What if the polarization was, say, 45^{o}? IS it vertical or horizontal? Well, how low of an angle is the dish? That will tell you right away. Simply because the farther to the east or west the satellite is, the lower the angle of radiation, and, the steeper the polarization angle will be. So it really is quite simple. Also, the maximum polarization angle one can have is 55^{o}. Any steeper and the dish will be looking below the horizon.

Let's talk about dish polarization vs. feed assembly polarization. You may see some dishes that look like they are tilting. Well , they probably are. Two types that I can think of right now are the HughsNet dish and a rectangular dish. These dishes do not use the conventional method of polarization. The feed is set for either horizontal (12 o'clock position) or vertical (3 o'clock or 9 o'clock position). The entire dish will then b e rotated into the correct polarization.

For the purpose of identification, the following rectangles signify the various waveguides you will see. First will be C-band, then Ku-Band, and finally Ka-Band. You can see that they are not compatible.

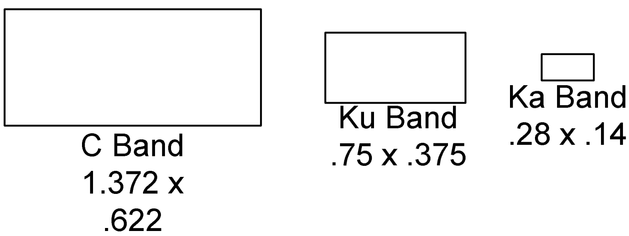

Figure 10: Waveguides size vs. band

There was a lot of information presented, but no math. So that should have made this paper a lot easier to read and understand. Next time you are waking about, look at the dishes in your area and see if you can tell if they are east or west of your position and if they are positive down or horizontal down.

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