Simplifying the Path Alignment of Microwave Communication Systems

By Fernando Torrelio, Aurora Genesis Communications Inc.

Fernando Torrelio, BSEE , is President and Chief Engineer of Aurora Genesis Communications Inc. a microwave, cellular, PCS, & LMDS engineering, maintenance, installation, and testing company supporting the technical requirements of the wireless communications industry.

Wherever microwave links exist, the path between antennas has always required accurate antenna alignment. This process requires highly trained tower crews to physically align the antennas as well as ground technicians and sophisticated, expensive, and complex test equipment to monitor the results. The process of optimizing the transmission path of microwave communication systems is about to undergo a significant development in process, simplification and cost benefit without compromising performance or accuracy. The process can now be accomplished with the use of the ***Path Align-R™*** , Models 2200–2241, µwave Antenna Path Alignment Test Sets from Pendulum Instruments, formally XL Microwave. Tower installation crews can now perform the entire alignment process themselves, up the tower, at the antenna, without the need of additional ground technicians, equipment, or indeed, even the waveguides or radios installed.

The Traditional Process

The traditional process, more typically described as "microwave path alignment," requires the use of a transmitter and a receiver located at each end of the microwave link. The transmitter generates the signal that passes through the transmission line to the antenna, which radiates the signal over the free space link. The signal propagates towards the other end of the path and is received by the antenna, forwarding the signal through the transmission line to the receiver, connecting the two sites. The receiver processes the signal, producing information on its value relative to the amount that was originally generated at the transmitting end. If the antennas are optimally pointed to each other (aligned), the largest concentration of signal (main beam) is emitted and received, reducing the free space attenuation of the signal. Provided the transmission lines do not lose too much of the signal between the antennas and the radios, maximum signal transfer is achieved. If the antennas are not optimally aligned, then signal transfer is degraded and received dynamic range is lost.

There are several steps involved in the traditional preparation and process of aligning the antennas of a microwave communication system. These steps may include making sure the cable or waveguide transmission line was properly installed, with minimal RF reflection of the microwave signal; that each antenna polarization is properly setup; and that the transmitter output power is calibrated. A voice communication link between the personnel inside the radio room of each site and the tower technicians, located at each antenna, needs to be established using two way mobile radios or cellular phones. Some spread spectrum radios have an order wire over which to communicate, however, communication to each of the tower technicians will still need to be completed. The engineering profile is reviewed to determine the expected RSL (receive signal level) for the path under test and any adjustments for output power are applied. Once this setup is complete, the tower technicians are instructed to commence the adjustment of the azimuth alignment (bearing) of the antennas, one at a time. The antennas are panned over their azimuth profile and readings of the receiver signal output power are taken. Careful observation of the output power reading is necessary to distinguish the antenna side-lobe to main-lobe response. Once the maximum signal is achieved, the antennas are aligned for elevation optimization. It is evident that the communication between site to site and tower technician to receiver technician needs to be continuous and clear to ensure that the antennas optimum alignment setting is achieved.

Alternative Methods

Traditionally, the radios that will be placed at each site are used to complete the task of optimizing the path. However, there are several reasons for not utilizing the radios to complete the process. The radios may not be available at the time the test has been scheduled or their reliability may be questionable, thus alternate methods are needed. Another possible reason the radios might not be able to be used is that the FCC permits have not been granted, but the contractor needs to complete the path test on time to meet the customer's requirements, or ahead of expected turbulent weather. In addition, if the anticipated path is questionable, a quick, cost effective, reliable method is needed to test the link, prior to the significant investment of constructing towers, purchasing radios and other expensive equipment and hardware, etc.

Alternative test instrumentation must be utilized, in lieu of the radios, whenever the previously mentioned circumstances arise. Scheduling of the path alignment test and installation of the associated hardware (cables, waveguide, antenna, etc.) can be facilitated to reduce excess mobilization costs. Some of the most widely used equipment for this application are signal generators (used as the transmitter) and spectrum analyzers (used as the receiver). The signal generator should be a broadband, synthesized device (phase locked to a reference clock) with accurate output power, equal to or greater than 0 dBm. The spectrum analyzer should be tunable, and have at least –100 dBm of sensitivity at the frequency band of interest. Signal acquisition speed of the receiver is essential to quickly spot subtle changes in antenna response or to support investigation of problem paths. Most importantly, ease of use is vital in order to reduce the training costs of test technicians. Much of the test equipment used in this alternate method of path alignment tends to be expensive and complicated.

Application Specific Solution

Recent test instrumentation has brought on feature rich, expensive systems that shoot for the stars in offering the latest and greatest in technology. However, these systems are mostly not fit, nor are they practical, for specific applications such as antenna path alignment. The most successful new instrumentation in the industry has been equipment that is application specific, portable, battery powered, and easy to use, without compromising performance. The ***Path Align-R™***, is a new addition to this practical, application specific category. It is specifically designed for use as a microwave path alignment test set. Among its many features and functions, eight specific traits fit those identified as important to microwave antenna path alignment.

1. *Portable* - Each of the two units in the ***Path Align-R™*** Test Set weighs only 7 pounds, fully loaded, and is 3.5" x 8.375" x 13.1" (HxWxD) in size. This significantly reduces the shipping costs and logistics of transporting test equipment to and from the site.
2. *Battery powered* – A rechargeable lead acid battery is fitted to provide four to five hours of operation. Not only is this ideal for field use but each unit can easily be taken up the tower, in its weather-resistant instrument back-pack, and attached directly behind the antenna using a carabiner and a nylon runner, strap, or lanyard.
3. *Ease of Use* – A pair of units (sold as a 'set'), one at each site, reads out the path loss, identically, at both ends of the link. Simply turn them on, connect the output to the antenna using the supplied cable, tune the frequency, connect the headset, and you are ready to test. Rarely has an instrument been so easy to use without compromising on performance.
4. *Performance* – A ***Path Align-R™*** test set provides 100 dB of effective dynamic range. This is the result of the 100 dBm sensitivity of the receiver and 0 dBm output power of the transmitter. Four bands (1.8–2.5 GHz, 5.8–6.6 GHz, 11–12 GHz and 18.1–19.4 GHz) are provided in the standard Test Set. The specific operating frequency can be tuned by the operator within these band limits, using the thumbwheel switches, to a resolution of 1 MHz. An antenna system whose link frequency is designed

outside the frequency band edge of the ***Path Align-R™*** (e.g. 6.8 GHz) can still have its path alignment correctly adjusted, as long as the antenna system (antenna, waveguide, etc.) can operate at both the link frequency (6.8 GHz) and a nearby frequency covered by the ***Path Align-R™*** (e.g. 6.6 GHz).

5. *Speed* - An LCD readout of direct path loss, with a 0.1 dB resolution, automatically updates its reading every 300 milliseconds, and can quickly find subtle changes to the antenna response, thus allowing for small adjustments to antenna azimuth or elevation for optimum signal transfer.
6. *Voice Channel* – Communication between sites, and from radio room to tower top, is significantly improved, with a full duplex voice channel. Each tower technician can speak to the other through the included headset, without having to key a radio. Voice communication is enabled immediately after setup and activation. The antennas do not even have to be fully aligned for the voice channel to work.
7. *Accurate* – The ***Path Align-R™***'s output is a synthesized source that provides a very accurate and stable signal. When compared to a synthesized source (HP 8360) and a fully featured spectrum analyzer (HP 8594E), the ***Path Align-R™*** test set measures path loss within 1.0 dB of each other.
8. *Cost Effective* – The ***Path Align-R™*** test set is priced far below that of a synthesized source and spectrum analyzer combination. However, price is not the only savings achieved with the use of the test set. The cost of communicating between sites can become quite expensive when using cellular technology (about $300 per event when considering long distance, roaming, and calling time charges that are typically the case in a remote microwave test). The use of two technicians operating the radios, and two tower climbers working behind the antennas, can potentially be reduced to three; with the supervisor level on the ground floor and two tower climbers. The transportation costs of shipping the test sets to job sites from the central office can significantly reduce company expenses.

It is apparent that the ***Path Align-R™*** test set is well featured to offer impressive results in accomplishing the goal of an optimum solution for the microwave path alignment test process.

Simplifying the Process

We have laid the groundwork for establishing the ***Path Align-R™*** test set as a viable and effective solution for the path alignment process. We will now describe how this process of aligning the microwave link is greatly simplified.

1. Review the Engineering Profile to determine the expected RSL (received signal level, or path loss) for the link under test (this should include the free space path loss and the gain of the antennas). Note that the loss exhibited by the installed cable or waveguide transmission lines are not included in this value because the ***Path Align-R™*** test sets are connected *directly* to the antennas with a short coax cable with minimal insertion loss to impact the test.
2. Both tower climbers (technicians) should go over their check lists, prior to climbing the tower, to assure that, included with the ***Path Align-R™***, they have:
    - A charged battery installed (possibly a spare if you are planning to be up for over 4–5 hours);
    - The proper waveguide-to-coax adapter for the antenna;
    - A coax cable (SMA to coax connector on the coax-to-waveguide adapter);
    - The supplied headset; and,
    - A carabiner and a nylon runner, strap, or lanyard of appropriate length to attach the back-pack's 'D' ring to the tower.
3. Set one ***Path Align-R™*** unit to ‘Master’ and the other ***Path Align-R™*** unit to ‘Slave’ (it doesn’t matter which is which, as long as they’re different).
4. Using the front panel thumbwheel switches, select the proper link frequency (Note: both units must be set to the same frequency, e.g. 6.2 GHz).
5. After reaching the antenna, check that the antenna polarization is properly setup.

6. Locate each Align-R™ unit near the back of the antenna, with its weather-resistant instrument back-pack's 'D' ring attached to the tower structure using a carabiner and a nylon runner, strap, or lanyard.
7. Attach the coax-to-waveguide adapter at the back of the antenna's waveguide flange.
8. Connect the coax cable from the appropriate output connector on the ***Path Align-R™*** to the adapter.
9. Connect the headset to the ***Path Align-R™***.
10. Turn the Power Switch ON. An LED will indicate which output connector is active (make sure the cable is connected to that connector) and begin talking. Typically, the antennas can be off alignment by as much as several beamwidths and the voice channel will still operate.
11. While one technician simply observes the reading of the path loss meter at his/her site, the other site commences Azimuth (horizontal) adjustment. As the voice channel is full duplex (FM), each technician can communicate with the other during the alignment process. Check for both side lobes as well as the main lobe response to ensure that the antenna is being aligned to the main lobe and not one of the side lobes. The ***Path Align-R™*** test sets have enough sensitivity (-100 dB) and update speed (300 ms) to quickly check for side lobe and main lobe response
12. Once Azimuth has been optimized, the Elevation adjustment is performed.
13. When steps 11 & 12 have been completed at the first site, the technicians switch roles and steps 11 & 12 are repeated by the other technician at the second site.
14. Once step 13 is completed, for both Azimuth and Elevation, the link is aligned. As a record, note the final path loss value displayed on the meter.

Summary

The difficulties of scheduling an antenna alignment test *with the radios* can cause significant delays, as described earlier. Furthermore, *traditional test methods* can produce significant costs in mobilization, deployment and testing of the antenna system. If the *transmission lines* (waveguides, etc.) connecting the antenna to the radio were to have a problem, the test is in jeopardy until they are corrected. If the path under test is questionable (due to site choice, obstructions, etc.), the ***Path Align-R™*** can step right in with minimal effort to verify if there are any problems. Using the ***Path Align-R™*** test set, the overhead associated with offering path alignment services (cost of equipment, level of expertise required, and training time) has been greatly reduced. Offering path alignment services with the ***Path Align-R™*** translates to providing more revenue opportunities for your company.

Information on the ***Path Align-R™*** as well as other products manufactured by Pendulum Instruments, Inc. (Incorporating XL Microwave) can be found at www.pendulum-instruments.com.