Photo courtesy of L3 Narda-MITEQ

Using Uplink Power Controllers to reduce rain fade effects on transmitted signals

No matter how far we advance, rain fade remains a very real problem faced by many in the satellite industry today. Signal attenuation caused by scattering or adsorption of electromagnetic waves by raindrops or snow is only amplified when the operating frequency increases. Here, Mitch Haft, Director of Sales at L3 Narda-MITEQ, outlines methods of mitigating atmospheric conditions.

Earth station designers are extremely sensitive to the effects of rain fade on the transmitted signal performance. Adverse weather conditions such as rain or snow can cause signal attenuation due to scattering or adsorption of electromagnetic wave by the raindrops. This effect becomes worse as the operating frequency is turned higher. With the latest talk about Q and V-band stations, the attenuation effect would be more significant at these frequencies.

Modern Earth station architecture includes management of the uplink signal level with control and monitoring capability. The uplink signal integrity is usually determined by monitoring the downlink signal level from a beacon receiver. The uplink and downlink are subjected to the same atmospheric conditions, and the beacon signal level can provide an indication of the atmospherics conditions present. In best cases, under clear sky conditions, there will be minimum atmospheric attenuation of the uplink and downlink signals. By monitoring the beacon signal level relative to its clear sky level, the losses due to atmospheric conditions can be determined. A level correction can then be computed and applied to the transmitted signal.

The Uplink Power Control (UPC) includes variable attenuator channels that are integrated into the RF terminal uplink chain to control the transmit level. Configured correctly, the attenuators adjust the transmitted signal level to maintain a constant level at the satellite regardless of atmospheric conditions. Under clear sky conditions, the UPC is configured to the reference level. When atmospheric attenuation increases due to rain fade, the UPC will adjust the transmit level to compensate for the loss in signal. Consequently, the transmitted signal level reaching the satellite will be constant regardless of the atmospheric conditions.

Typical UPCs will have more than one attenuation channel and can be remotely controllable via RS485, RS422, and/or Ethernet. The unit should also include a fail-safe path in case of system errors or unit malfunctions.

The brains of the UPC will do all the calculations to determine the required attenuation levels based on the clear sky condition. The UPC should include a calibration step during the initial setup to correlate the beacon input voltage to the downlink signal strength. The voltage input at clear sky will represent the downlink signal strength with minimum atmospheric attenuation. When this state prevails, the signal strength will be reported as 0dB. When there is an atmospheric event (rain, snow, etc.), the downlink signal strength will change and be reported differently. The UPC should include several different methods of calculating these conditions including open-loop, closed-loop, comparison, and dual-track algorithms.

Correction algorithms

The open-loop algorithm is a technique of correction for the measured downlink signal not subject to the uplink power corrections. A beacon signal is monitored, and the power correction is based on changes in the downlink signal strength and the relationship between the uplink and downlink frequency bands.

The closed-loop algorithm is a closed-loop method of correction. A carrier is transmitted at an uplink and looped back from the satellite to a downlink receiver at the same Earth station. The signal measured at the downlink is degraded twice, once on the uplink and again on the downlink. The uplink correction is therefore based on the downlink signal strength and the uplink and downlink frequencies.

The comparison algorithm is superior to the other algorithms and can be used when both a beacon signal and a looped-back carrier is monitored. Because the beacon is subjected only to the downlink effects while the looped-back carrier is subjected to both the uplink and the downlink, the difference in downlink signal strengths can be attributed to the uplink. Uplink power corrections are based on this difference.

With the dual-track algorithm, both beacon inputs must be active. The downlink signal strength reported by both receivers must be within 0.5dB range. If this is achieved, correction is applied using the open-loop algorithm based on the average downlink signal strength of both receivers. Otherwise, the UPC will suspend any automatic correction adjustment.

Finally, the diversity beacon algorithm can be used when there are two receivers available at a single site. With this algorithm, the UPC will select the receiver with the highest reported signal strength as the primary receiver. The signal strength reported by the other receiver must exceed the signal strength reported by the primary receiver by at least 0.5dB in order to switch that system to primary mode.

Site diversity

Another means of migrating the effects of atmospheric conditions on the uplink signals is with site diversity switching. Two redundant uplink systems, in separate geographic locations, are configured such that uplink signals will only be transmitted from the site experiencing the best weather conditions. All relevant content to be uplinked must be distributed and present at both sites simultaneously. An Ethernet link connecting the UPCs at the two sites can communicate key parameters to determine which of the two systems should transmit. This configuration can also provide backup in the event of a hardware failure.

In addition to site diversity, the UPC should include a redundant power supply to ensure continuous operation in the event that a power supply is faulty. The unit should also include the capability to provide two beacon inputs for redundancy purposes. The beacon diversity should include an algorithm when there are two beacon signals at one site.

The L3 Narda-MITEQ Uplink Power Control (UPC2) Model is the second-generation unit to provide automated signal monitoring and control utilizing the beacon signal strength and up to 10 internal attenuation channels for both IF and L-Band signals. The UPC2 can be used in standalone mode or in a site diversity configuration. Ethernet and RS-485/RS-422 interfaces are provided to monitor and control the unit. With built-in redundant power supplies, the unit always remain functional.L3 Narda-MITEQ UPC2 Model

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