Optimising Telemetry Links in Mil-Aero Environments

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Military and commercial aerospace businesses involved with the testing of multiple and simultaneously present powered flying objects such as manned aircraft, drones or missiles, need to be able to receive and send telemetry data during the entire course of the test flights. By its remote nature, this can be accomplished wirelessly using radio communications systems to provide high quality communication links with no signal dropouts or data corruptions.

In the case of Military Aerospace applications, the Air Force, Navy and Army facility radio systems often work simultaneously across frequencies in all of the P, L, S and C bands, so in effect, to have multiple wideband frequency coverage up to at least 6 GHz. The telemetry antennas utilized can be of various types including parabolic dishes and directional horn feed antennas. This type of telemetry set-up is also known as boresight communications and testing. When the physical nature of the deployment prohibits the use of coaxial cables to transport the RF signals due to high cable losses and RF immunity concerns, the signals received need to be sent to the mission control room through an RF over Fiber (RFoF) backhaul network, to be analyzed and recorded. The mission control room can also be required to transmit RF signals back out as well, making this system bi-directional and a more challenging design, since receive signals are very low power and transmit signals need to be much higher power. The ability to add additional low noise amplification for the transmit signal is not always available.

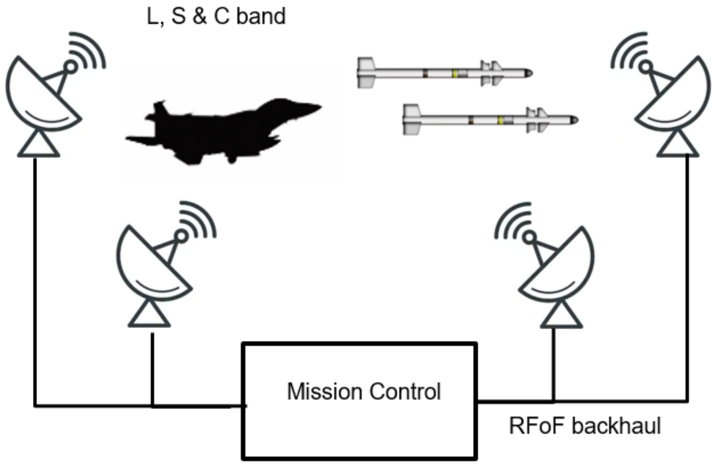

Figure.1 Typical Mil-Aero telemetry system using RFoF across backhaul

Why is RF over fiber used in the backhaul? Fundamentally, it's due to distances and the frequencies used. Linking the telemetry antennas to the mission control can involve distances up to a number of kilometres. Using frequencies up to 6 GHz across long distance makes traditional RF coaxial cable far too lossy and not appropriate to the task. RF over fiber has the advantage of super low loss at 0.2 dB/km, and can easily cope with the wide frequency bandwidth of multiple and simultaneous telemetry signals. RFoF also benefits from a very small conversion delay with very low signal dispersion. This very important for this application where fast moving objects can affect the radio signal though frequency Doppler shift, multipath propagation and shadowing, critically ensuring that the backhaul connection does not add to the these negative effects. The fibre optic cable is also a very inexpensive and lightweight medium, is extremely stable across different environmental conditions and offers RF immunity as well as an added benefit.

The technique of using RFoF in this Mil-Aero telemetry backhaul application is not new. The key questions are what makes a good performing link and under what conditions? How do you design and optimize the RFoF system for an uplink, downlink or different types of aerospace vehicle telemetry and tracking?

ViaLite* Communications** introduced an updated product line specifically aimed to the Mil-Aero telemetry market. The ***ViaLite 6GHz Mil-Aero link pair actually covers the full frequency range from 10MHz through to 6GHz without sacrificing Noise Figure (NF) or reduction in Spurious Free Dynamic Range (SFDR). Traditional coaxial cable systems have a challenge under similar conditions.

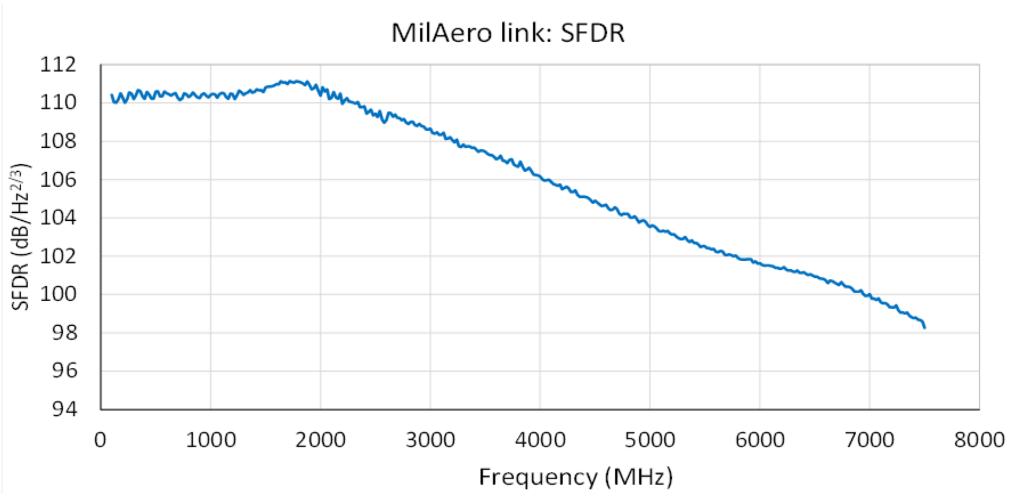

Figure.2 Typical SFDR measurement from ***ViaLite*** 6GHz Mil-Aero link pair

The ***ViaLite* Communications** 6GHz Mil-Aero RF over Fiber link pair link pair comes in various form factors*; OEM module, rack card for use in a chassis, and a uniquely integrated module with an IP rating for outdoor use without needing an additional outdoor enclosure. The modules also have an up-to-date USB-C connector to enable out in field engineering access to check status, performance or adjust gain by software command. Most importantly for the Mil-Aero telemetry application, the ***ViaLite* Communications** product range also includes a number of link gain options optimised for specific uses in the telemetry backhaul.

Use Case #1 – Telemetry Downlink Traffic

For the typical telemetry downlink path it's important that the RF-to-Optical (E/O) transmitter is able to handle objects that pass "close-in", like an aeroplane taxiing near a boresight antenna, which may present signals up to 0dBm after the first LNA stage. The ***ViaLite* Communications** link pair for this circumstance has the default transmitter gain set to -10dB, and the Optical-to-RF (O/E) receiver set to +15dB, so with a lossless optical connection would provide a link gain of +5dB, but with real-life connection losses would practically be closer to a 0dB unity link gain.

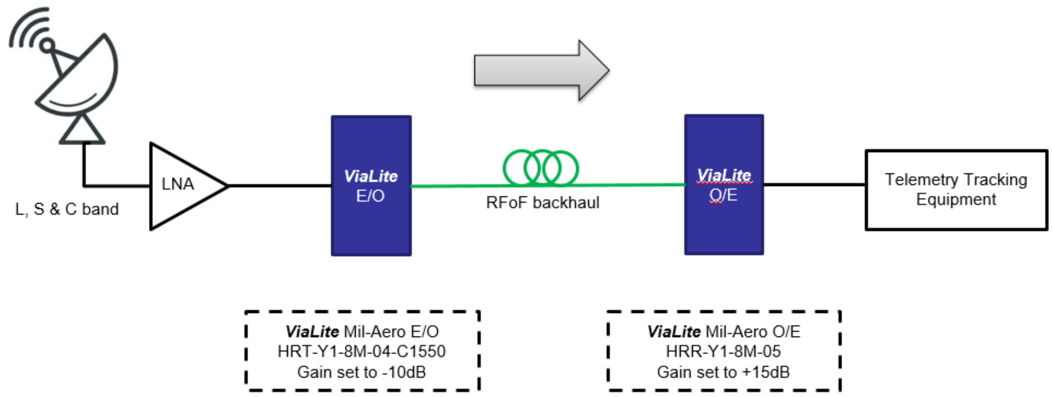

Figure.3 ***ViaLite*** 6GHz Mil-Aero standard gain link pair

Use Case #2 – Telemetry Uplink Traffic

For the telemetry uplink path, typically present are higher power RF signals output from the Telemetry Tracking Equipment which in turn need to be connected to the input of an uplink Power Amplifier (PA) positioned near the antenna. Dealing with higher power levels and with uplink gain, design care is critical to keep output harmonics to a minimum, e.g. less than -35dBc at highest power level. In the example shown in Figure.4, depicted is the ***ViaLite* Communications** transmitter (E/O) set to -12dB gain (attenuation) with the ***ViaLite* Communications** receiver (O/E) set to +24dB. These precisely optimized gain settings (from factory default gain settings) can be adjusted live in a real-life field setting using a readily available USB-C cable, or SNMP software if a rack card option in a ***ViaLite*** 1U or 3U chassis is used. To find the typical gain adjustment range for the ***ViaLite*** 6GHz Mil-Aero pair, use the ***ViaLite*** website hyperlinks listed at the end of this white paper. This particular combination of gain settings is one actual proven solution found to give best in class performance for an Air Force Base customer using this equipment in the uplink path.

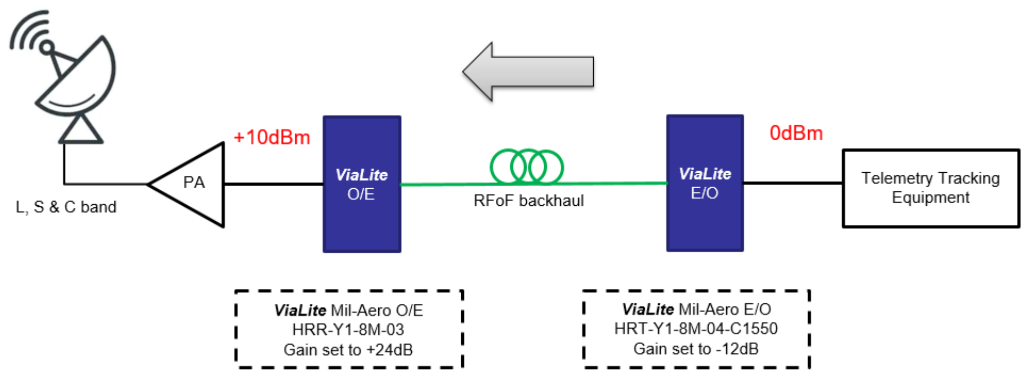

Figure.4 ***ViaLite*** 6GHz Mil-Aero high output link pair

Use Case #3 – Telemetry, Multiple targets operating in C-band

In this use case example, the application scenario requires tracking multiple simultaneous flying objects and at a long distance away from the antenna, operating in C-band. This situational solution requires a high sensitivity, high gain front end, with low Noise Figure in order that the Telemetry Tracking Equipment can pick up the smallest of small level signals, all present at the same time and possibly very near to each other, even with guard bands. C-band frequency communication presents superior performance in terms of signal dispersion, but can suffer more with signal shadowing, so minimising signal black out is essential. In the example shown in Figure 5, it can be seen that the ***ViaLite* Communications** transmitter (E/O) is set to +5dB (which helps to provide a lower NF and added sensitivity) and the ***ViaLite* Communications** receiver (O/E) is set to +15dB, giving a link gain of +20dB (minus any fibre connectivity losses).

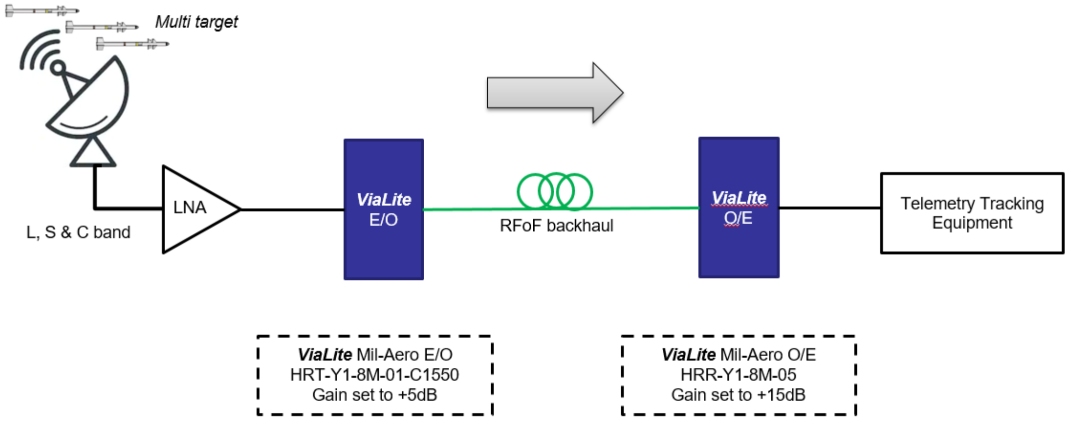

Figure.5 ***ViaLite*** 6GHz Mil-Aero high gain link pair

ViaLite* Communications 6GHz Mil-Aero Link Pair form factors:

Figure.6 ***ViaLite*** 6GHz Mil-Aero 3U Rack Card, Blue OEM, Black OEM

**Useful links:

https://www.vialite.com/product/mil-aero-6-ghz-link-pair/

https://www.vialite.com/resources/guides/mil-aero-link-output-performance-gain-selection/