The Importance of Dynamic Range in Fiber Optic Links

Traditionally satellite transponders were 36 MHz wide and the Spurious Free Dynamic Range (SFDR) of an RF over fiber link was less important. Ultra-wide dynamic range fiber optic links were a "nice-to-have" because the same product could be used for both the up and down links. However, with High Throughput Satellites (HTS), that have transponder bandwidths of 500 or 800 MHz, the signals have increased hugely; consequently so have the demands on dynamic range. This means that ultra-wide dynamic range fiber optic links are now a "must-have" for anyone transporting HTS signals. Within this document we compare the SFDR and real dynamic range obtained with HTS satellite signals.

Calculating Spurious Free Dynamic Range

SFDR is a measure of the dynamic range of a fiber optic link and is relative to 1 Hz of bandwidth - which is not particularly relevant as most signals are much greater than 1 Hz.

To calculate SFDR you must use the thermal noise floor (kTB), the noise figure (nf) and the third order intercept point (IP3).

The thermal noise floor is -174 dBm/Hz.

The noise figure is the Signal to Noise Ratio (SNR) degradation caused by the fiber optic link and is a product of the design of the link – it is usually stated in the supplier's data along with the P1dB which will allow you to calculate SFDR.

The 1 dB compression point (P1dB) is the power level at which the gain drops by 1 dB from its small signal value.

The third order Intercept Point or IP3 is a theoretical point at which the third-order distortion signal amplitude equals the input signal. In a fiber optic link this is typically 12 dB above the P1dB. The calculation for SFDR is:

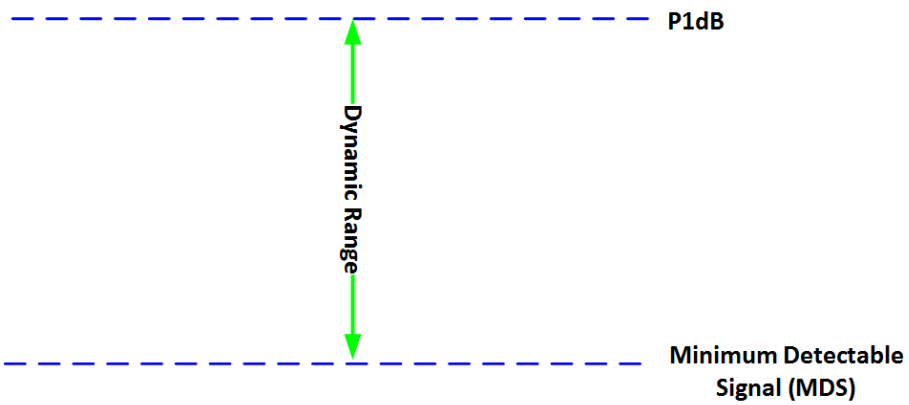
SFDR = 2/3((P1dB+12) - (Thermal Noise Floor + Noise Figure of the link))

***ViaLite* SFDR = 2/3((-1+12) - (-174+20)) = 110 dB/Hz 2/3**

Therefore the SFDR is affected by the P1dB and the nf of a fiber optic link. It is a useful measure to compare the performance of fiber optic links when looking at dynamic range.

Dynamic Range

The Dynamic Range (DR) is the difference between the minimum and maximum signal that you can put through a link for a given traffic bandwidth. The minimum detectable signal (MDS) is usually assumed to be just above the system noise floor and the maximum signal level is the largest peak power without distortion. Unlike gain or noise figure, dynamic range cannot be improved using amplification, but the window can be moved to suit higher or lower signals.



Calculating Minimum Detectable Signal (MDS)

The calculation for MDS is:

MDS = Thermal Noise Floor+10log (traffic bandwidth in Hertz) + Noise Figure of the link

Typically High Throughput Satellites (HTS) have a traffic bandwidth (BW) of 500 or 800 MHz. ***ViaLite*** MDS for a 500 MHz bandwidth is:

***ViaLite* MDS for 500 MHz BW = -174+(10log(500x10^6)+20 = -67 dBm**

P1dB, Minimum Detectable Signal and Dynamic Range

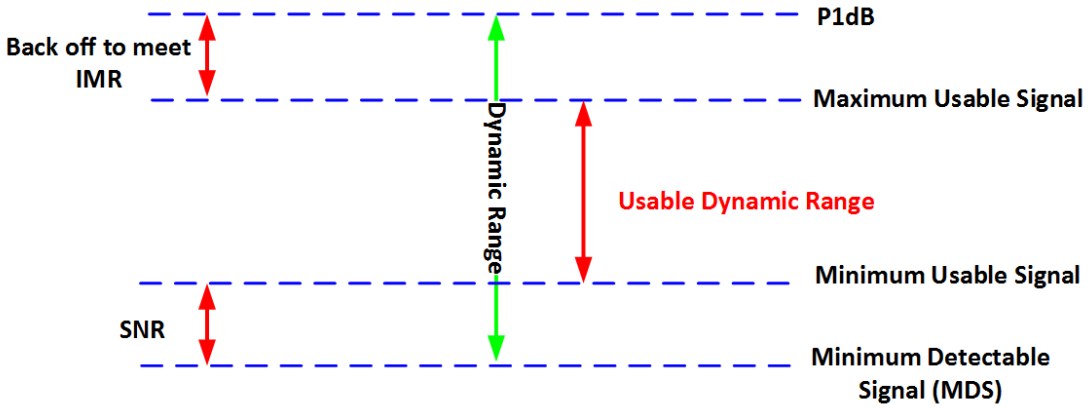
As described above, the dynamic range is the difference between the MDS and the P1dB. So, for a ***ViaLite*** fiber optic link with a traffic bandwidth of 500 MHz the dynamic range is:

DR = P1dB-MDS

***ViaLite* DR = -1 dBm-(-67 dBm) = 66 dB**

The dynamic range as described above does not take into consideration any Signal to Noise Ratio (SNR) or any back off (signal power reduction) to meet Intermodulation Ratio (IMR) requirements for higher order modulation schemes. These are normally customer or application specific but need to be taken into consideration – especially if the fiber optic link has a narrow dynamic range.

To calculate the true usable dynamic range, the SNR in dB needs to be added to the MDS and, to ensure no distortion occurs at the maximum input signal, signal levels may need to be reduced to meet IMR specifications – this further reduces the usable range.



If you take a typical IMR of 40 dBc, the maximum signal will be reduced by 8 dB and, at a typical SNR of 20 dB, the minimum input signal is increased by 20 dB as shown below:

Usable DR = (P1dB-back off) - (MDS+SNR)

***ViaLite* DR = (-1 dBm-8 dB) - (-67 dBm+20 db) = 38 dB (Usable Range – Max -9 dBm to Min-47 dBm)**

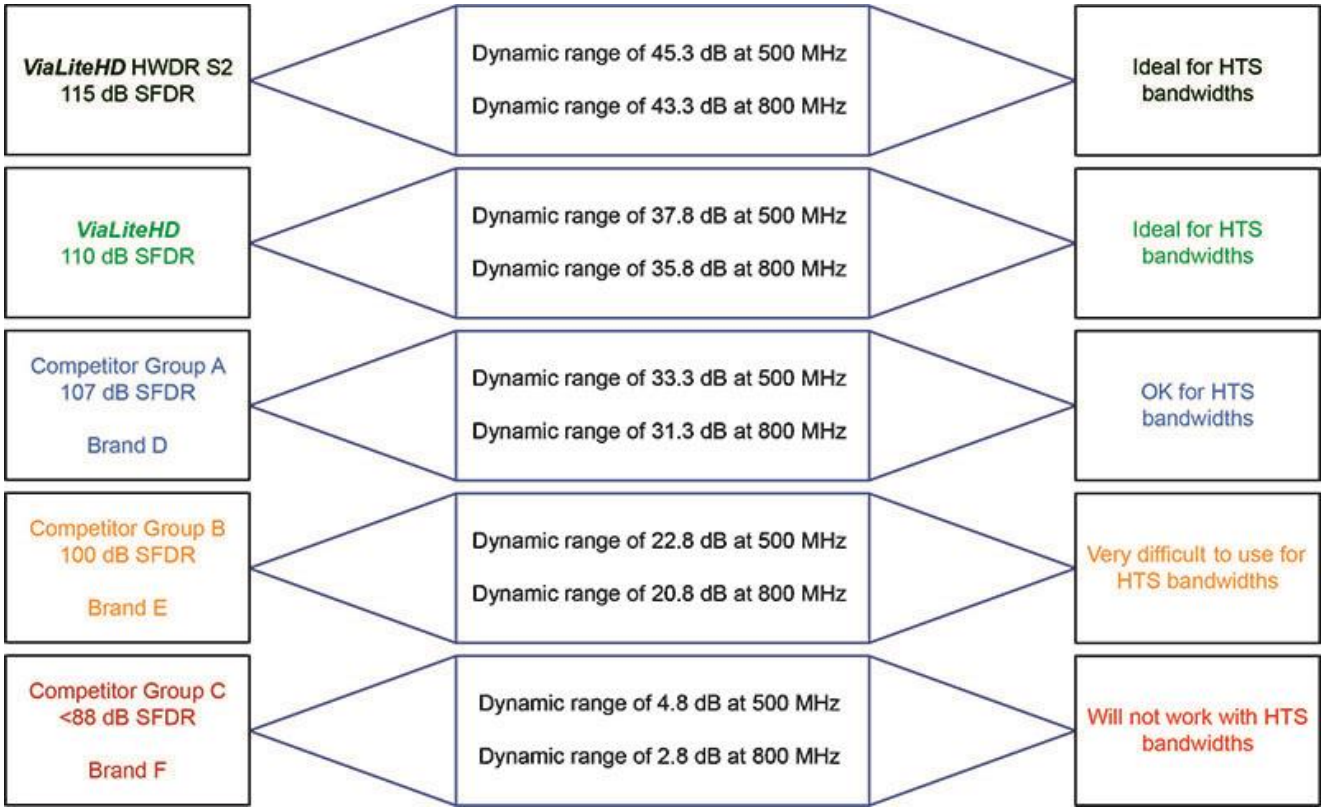
The following table shows a comparison of Dynamic Range/Usable Dynamic Range based upon the SFDR of different brands of fiber optic link products.

	ViaLite	Brand D	Brand E	Brand F
SFDR	110	107	100	88
DR at 500 MHz*	65.8 dB	61.8 dB	50.8 dB	32.8 dB
DR to meet 20 dB SNR and 40 dBc IMR**	37.8 dB (-46.8 to -9 dBm)	33.8 dB	22.8 dB (-40.8 to -18 dBm)	4.8 dB (-24 to -28.8 dBm)
% of ***ViaLite*** DR	100%	39.8%	3.16%	5.0%

* Using kTB of -173.8 dB/Hz
** At 800 MHz the dynamic range is 2 dB narrower and 5 dB narrower for full-band (1500 MHz)

What does this mean for RF over Fiber links in HTS ground stations?

HTS satellites use more bandwidth and this means that there is a need for higher dynamic range RF over fiber links. Fiber links that have an SFDR of 100 dB/Hz 2/3 or less are difficult or impossible to use in HTS applications.



For further information on specific dynamic range requirements or calculations – please contact ***ViaLite Communications*** at technicalsupport@vialite.com.