AN014 DYNAMIC RANGE, NOISE AND LINEARITY DEFINITIONS FOR *point2point* AC ANALOGUE LINKS

INTRODUCTION

PPM offer a range of AC coupled ***point2point*** Fibre-Optic-Links. The noise and linearity performance of these links is specified in the relevant data sheets. This application note explains the definition of these terms, and the calculations that may be used to determine additional performance parameters that may be of use in a particular application.

Dynamic Range

The dynamic range of a link is simply the difference between the maximum and minimum signals that the link can convey. The Simultaneous Dynamic Range (SDR) is the difference between the maximum and minimum signals that the link can transport at the same time. The use of attenuators or pre-amplifiers can shift the SDR up or down so that the effective DR is even wider.

Maximum Signal

The maximum signal that which may be accommodated by a link can be defined in a numbers of ways:

a) P1dB – the signal power at which the gain falls by 1dB relative to the gain at low signal levels.

b) Third Order Intercept Point – IP3. This is the point at which the third order product of two equal-level input signals is the same level as the input signals. The IP3 point is an imaginary (extrapolated) point that can never be reached in practice. However, it is extremely well defined and also permits the calculation of interference product levels at lower powers.

The ***point2point*** 40Hz to 250MHz AC Analogue Link has the following typical performance:

Input P1dB: 0dBm @ 100MHz

Input IP3: +10dBm @100MHz

Minimum Signal

The minimum signal is limited by the noise floor of the link, and also the bandwidth of the measurement system.

Output Noise

The sensitivity of any link is governed by the noise generated by the link. PPM ***point2point*** AC product specifications quote a Noise Figure. With this data and the gain of the link, it is possible to calculate the Output Noise Floor (ONF) and the Minimum Detectable Signal (MDS).

The Output Noise Floor (ONF) is normalised to a 1Hz bandwidth. The ONF is calculated using the following formula:

Output Noise Floor (ONF) = -174 + Noise Figure[dB] + Gain[dB]

As stated above, the ONF is normalised for a 1Hz bandwidth. In practice, 1Hz is not a practical Measurement Bandwidth (MBW). Therefore it is necessary to adjust the ONF for the MBW being used. This adjusted figure is the Output Noise.

Output Noise = ONF + 10 $\log_{10}$ (MBW)

Minimum Detectable Signal

The Noise Figure can also be used to determine the Minimum Detectable Signal (MDS). The MDS is the smallest signal that can be detected above the noise. As with the Output Noise, the MDS is dependent on measurement bandwidth (MBW). MDS is calculated using the following formula:

MDS = -174 + Noise Figure (NF) + 10 $\log_{10}$ (MBW)

Example calculations

The ***point2point*** 40Hz to 250MHz Fibre-Optic-Link has a typical Noise Figure of 22dB and 0dB gain. If we assume the link is used in conjunction with a Spectrum Analyser with a Resolution Bandwidth of 1kHz for these sample calculations, then:

ONF = -174 + Noise Figure + Gain = -174 + 22 + 0 = **-152dBm/Hz**

Output Noise = ONF + 10 $\log_{10}$ (MBW) = -154 + 10 $\log_{10}$ (1000) = **-122dBm in 1kHz BW**

MDS_{input} = -174 + Noise Figure **+** 10 $\log_{10}$ (MBW) = -174 + 22 + 10 $\log_{10}$ (1000) **= -122dBm in 1kHz BW**

NB It is usual to add a margin to the MDS (e.g. 3dB) to ensure that the wanted signal is far enough the noise floor to guarantee that it can be detected by the monitoring equipment (e.g. spectrum analyser or radio receiver).

Spurious Free Dynamic Range

The spurious free or true dynamic range of a link is defined as the range of signals over which the spurious outputs are below the level of the output signal.

Spurious Free Dynamic Range = $(^2/_3) \times$ (IP3 – Gain – MDS)

Using the data for the 40Hz to 250MHz link, standard configuration (0dB gain), and using a figure for MDS in a 1Hz bandwidth:

Spurious Free Dynamic Range = $^2/_3 \times (10 - 0 - 152) = ^2/_3 \times 162 = 108\text{dB/Hz}^{2/3}$

Pulse Power & Measurement (PPM) Ltd

- **Sentinel IIsc** Analogue FOL - a Folnet Compatible, high performance, analogue data link with unparalleled dynamic range, and frequency response of <2kHz to >1.1GHz. The Transmitter is shielded for operation in high level electric fields.
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