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Optimizing Phase Noise Performance of Linear Photonics TimeLink Fiber Optic Links

APPLICATION NOTE 118-1
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Phase vs Amplitude Noise

Phase noise is an undesired deviation in the phase or frequency of a carrier. The noise is *part of* the carrier; it increases or decreases in proportion to the carrier power. For this reason we often plot phase noise *with respect to the carrier*, or dBc/Hz.

Amplitude noise is random signal fluctuation independent of the carrier; it is additive. It is caused by thermal (molecular) variations and added instabilities of an amplifier or other system component. The *Noise Figure* of a system defines the degradation in signal-to-noise ratio, and refers to amplitude noise. This type of noise has a definite power spectral density, whether or not a carrier is present. For this reason, we usually plot it in absolute terms such as dBm/Hz.

Direct-detection fiber optic links are analogous to amplitude modulation. In the case of LO distribution, a carrier of, say, 10 MHz, is modulated onto the intensity of a laser. At the receive end of the link the envelope is extracted from the optical source.

This modulation scheme results in amplitude noise, which can often be quite high. Alternatively, the scheme adds little or no phase noise to the 10 MHz carrier.

A phase noise test (PNT) system doesn't distinguish between amplitude and phase noise. It will measure and report the spectral energy density with respect to the carrier level. In dBc/Hz terms, the amplitude noise will increase as the carrier level decreases.

Optimization of Noise with Respect to the Carrier

As an example, Linear Photonics TimeLink HF LO distribution links exhibit end-to-end gain of about 0 dB (unity), and noise figure of about 44 dB. The output amplitude noise from a TimeLink HF is then equal to -174 + 44 = -134 dBm/Hz. If we drive this link at 0 dBm then the output amplitude noise *with respect to the carrier* is -134 dBc/Hz. Figure 1 shows the resulting PNT measurement overlaying the amplitude noise with the output phase noise.

If we drive the link at a higher power, say +15 dBm, then the amplitude noise at the output with respect to the carrier will be 15 dB lower, or -149 dBc/Hz. Figure 2 shows the result of a PNT measurement in this case.

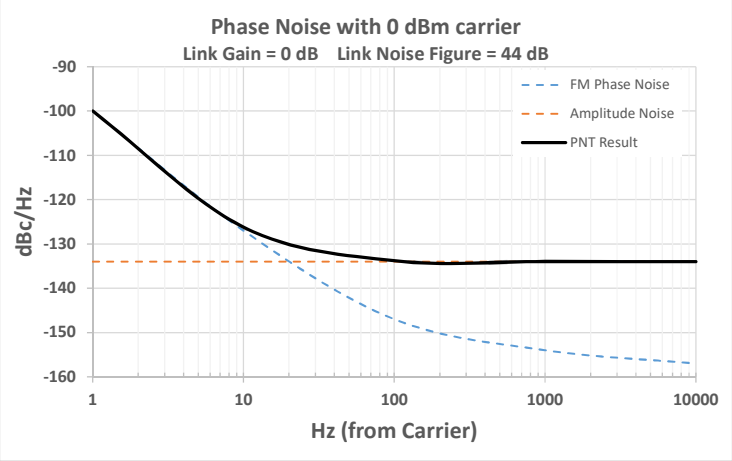

Figure 1. Phase Noise Measurement result with 0 dBm carrier

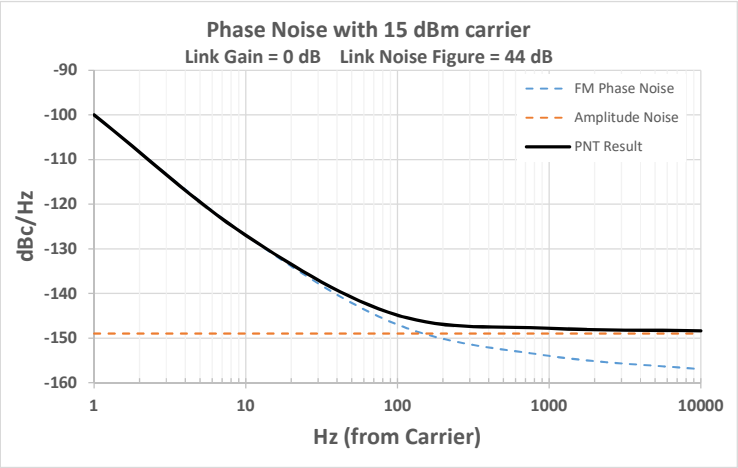

Figure 2. Phase Noise Measurement result with +15 dBm carrier

This shows that to optimize phase noise performance, we should minimize the amplitude noise by increasing the carrier level as far as possible. TimeLink HF links have an input 1 dB compression level (P1dB) of approximately +15 dBm. Once the carrier is saturated, the signal at the output will no longer increase, so there is little benefit gained by driving the link much above P1dB. For this reason, we recommend +15 dBm input power for our TimeLink LO distribution links.