

High Resolution High Bandwidth Measurements of the RF Spectrum of Modulated Optical Signals using the BOSA

Abstract: BOSA provides high resolution high bandwidth capabilities to the Light Intensity Spectrum Analyzer (LISA) to derive the RF spectrum of modulated optical signals.

The RF spectrum analysis of modulated optical signals is limited in frequency in the electrical detection domain by the superimposed electronic limits. The alternative is the optical domain, not limited in bandwidth, through Light Intensity Spectrum Analyzer (LISA) concept¹ which uses a nonlinear interaction to convert the temporal intensity of the source under test into proportional optical field amplitude, so that the RF spectrum is obtained by measuring the optical spectrum of the converted field. In this application note we show how the LISA set-up becomes fairly improved by using a BOSA as signal spectrum analyzer, which provides an optical resolution of 0.08 pm (10 MHz), with up to 80 dB of dynamic range and very large bandwidth (> 3000 GHz).

The measurement set-up is depicted in Fig. 1.

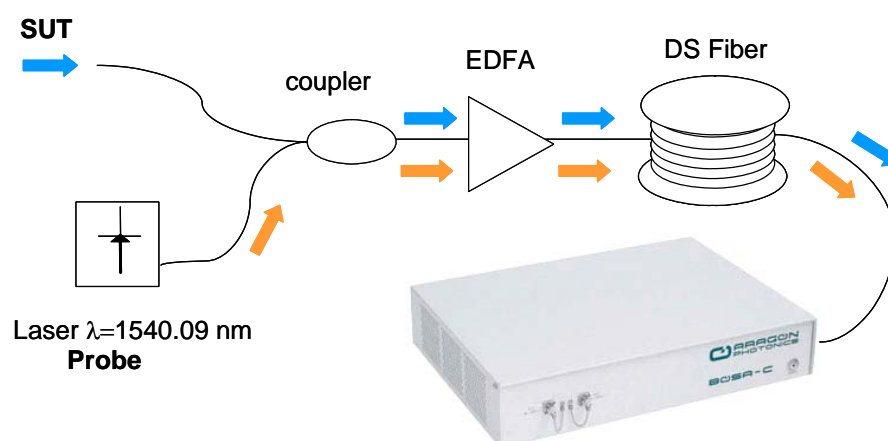


Fig 1. Measurement set-up

[1] C. Dorrer and D. N. Maywar, "RF Spectrum Analysis of Optical Signals Using Nonlinear Optics", J. Lightwave Technol. 22, 265-274 (2004).

Along the fiber, the probe wave is phase modulated by the nonlinear Cross-Phase-Modulation (XPM) that induces the Signal Under Test (SUT). Thereby, the probe optical spectrum $I(\omega)$ is broadened around its optical carrier frequency ω_0 proportional to the RF spectrum of the SUT, through equation¹:

$$I(\omega) = \delta(\omega - \omega_0) + |m|^2 \cdot S(\omega - \omega_0) \quad (1)$$

with $S(\omega - \omega_0)$ the SUT power spectrum and $m(\Omega) = 2\pi n_2(\Omega)L_{eff} / \lambda_0 A_{eff}$ representing the efficiency of the non linear effects, where L_{eff} is the effective fiber length, A_{eff} is the core effective area, n_2 is the fiber nonlinear refractive index and Ω is the modulation frequency.

Fig. 2 shows the SUT optical spectrum modulated with 10 Gb/s pseudorandom bit sequence (PRBS). It can be clearly seen the carrier double peak, which corresponds to adiabatic chirp, and an asymmetric shape as a consequence of transient chirp in the modulated laser, being not possible to isolate the intensity-modulation information from the phase-modulation one.

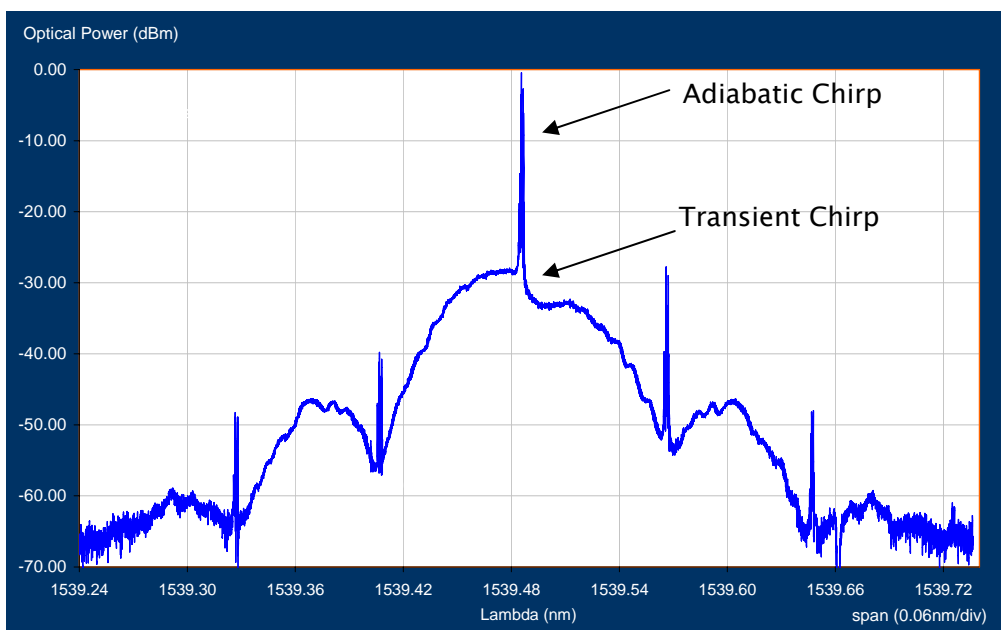


Fig. 2: The SUT optical spectrum measured by the BOSA

Fig. 3 shows the corresponding probe optical spectrum, which follows the intensity modulation pattern of the SUT (no chirp sign of the SUT is transferred to it, double peaks are not present and curves become symmetric). Orange curve represents the continuous probe optical spectra when SUT is turn off.

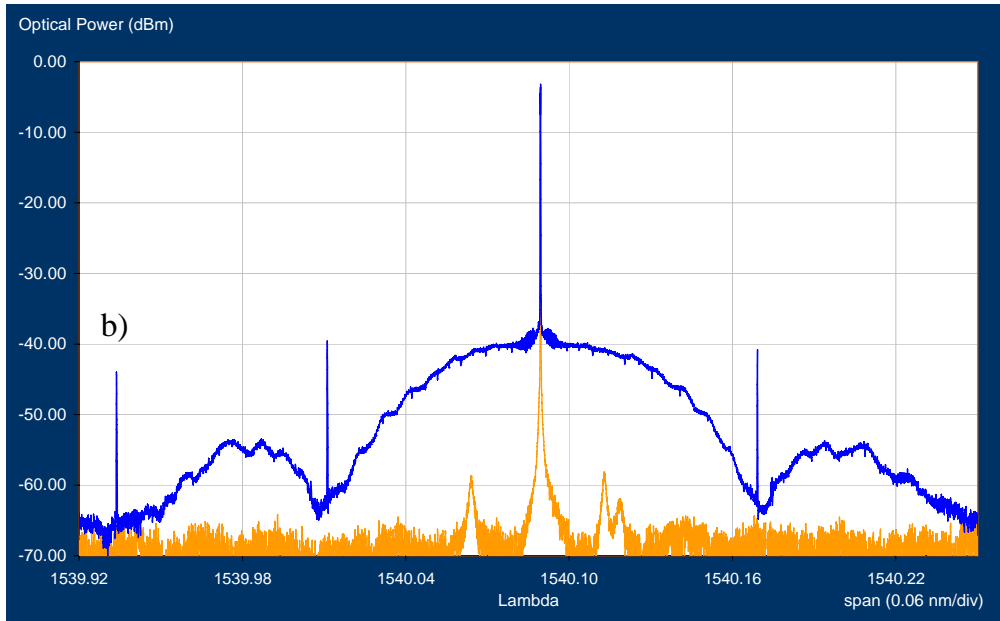


Fig. 3: The probe optical spectrum. Continuous probe wave (orange) and XPM-broadened probe wave (blue).

The SUT RF spectrum is directly derived from the measured XPM-broadened optical spectrum (blue curve in Fig. 3) by using Eq. (1). The result is shown in Fig. 4 (blue curve) and is compared in the same figure with the RF spectrum measured in the electrical domain (green curve).

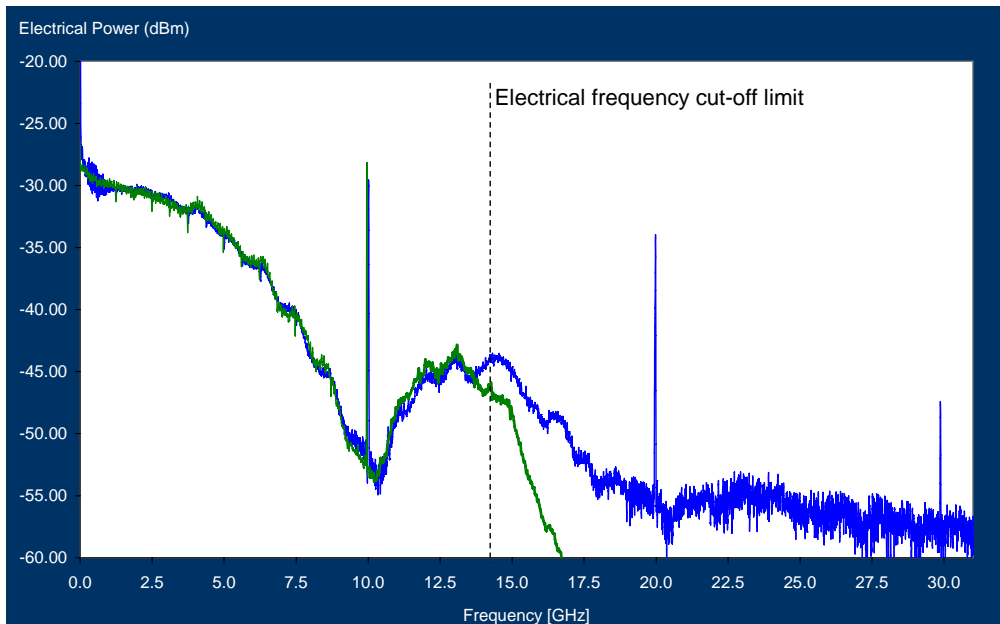


Fig. 4: RF spectra for the PRBS modulated optical signal at 10 Gb/s.

The RF spectra measured with the BOSA in the LISA setup extends over higher frequencies (approximately 3000 GHz for the C-band) since no frequency cut-off limit exists. Additionally, and simultaneously the BOSA

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provides the ultra high resolution of 10 MHz to the LISA technique and then to the RF spectra analysis of optical sources.

Benefits of using the BOSA in the LISA technique to get RF spectra of modulated optical sources:

- RF spectra of optical sources obtained by LISA technique are extensive improved by using the BOSA in the spectral analysis of the signals
- BOSA provides spectral analysis with simultaneously high resolution (10 MHz), high dynamic range (up to 80 dB) and high bandwidth (> 3000 GHz)
- Significant information contained at frequencies higher than 50GHz in high bit-rate signals can be now revealed and analyzed.

All the best

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