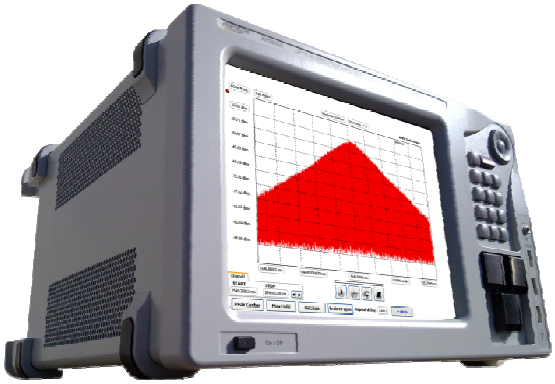
High Resolution Optical Spectrum Analyzer (OSA) /Optical Complex Spectrum Analyzer (OCSA)

19/02/2013

Ultra High Resolution OSA/OCSA for Characterizing and Evaluating Optical Frequency Comb Sources



Thanks to its Ultra High Resolution, the advanced Optical Spectrum Analyzer/Optical Complex Spectrum Analyzer (UHR-OSA/OCSA) provided by *APEX Technologies* plays an essential role in the Optical Frequency Comb Source (OFCS) implementation as a powerful characterization and evaluation tool.

Optical Comb Source Overview

Fast development of bandwidth consuming services has stimulated the explosive growth of the internet making stringent the need to deploy long haul, metro and access networks with increased capacity.

For long haul networks, the move to higher data rates requires higher capacities per wavelength as well as improved spectral efficiency in WDM (Wavelength Division Multiplexing) systems. In light of these requirements, the advanced optical modulation formats have attracted a lot of attention due to its improved spectral efficiency. Especially, the use of multi-carrier spectrally efficient transmission technique with sub-channel spacing equal to the symbol rate of each sub-channel represents a promising solution to further increase robustness and spectral efficiency. This technique can be deployed by electrically and/or optically generated OFDM (Orthogonal Frequency Division Multiplexing) or Coherent WDM (CoWDM). Optical Frequency Comb Source (OFCS) remain a vital component in the transponders of OFDM or CoWDM systems thanks to its ability to generate coherent optical carriers (1–5).

In addition, the Free Spectral Range (FSR) tunability provided by OFCS is a useful feature for super-channel systems. Indeed, it allows OFCS to be easily adapted to the required FSR, to suit the chosen symbol rate and modulation format (6).

On the other hand, WDM Passive Optical Network (WDM-PON) technologies combined with advanced modulation formats may be the future solution of the Next Generation Access Networks (NGANs) except that their deployment is hampered by the high cost and energy consumption of current Optical Line Terminal (OLT) transmitters and Optical Network Unit (ONU) receivers. As a cost efficient solution, the generation of a number of frequency tones from single device provided by the use of OFCS in WDM-PON networks can intrinsically reduce the lasers transmitters' number in the OLT as well as the wavelength stabilization cost (7).

In this context, OFCS with good spectral flatness, high stability, low linewidth, low cost, simplicity and wavelength flexibility are highly desirable for such purposes.

Why using the APEX UHR-OSA/OCSA?

Many academic and industrial researchers are focusing on developing new robust and cost-effective OFCS architectures in order to increase the competiveness of coherent optical OFDM, CoWDM, super channel and WDM-PON systems. The APEX OSA and OCSA (Optical Complex Spectrum Analyzer) have recently stirred a lot of interest in OFCS research area due to their **high resolution (up to 5 MHz, 0.04 pm), wavelength accuracy (+/- 3 pm) and phase measurement ability** respectively as key factors for OFCS architecture evaluation, characterization and validation.

APEX UHR-OSA/OCSA: characterization tool of commercial OFCS

The APEX UHR OSA and OCSA are perfect tools to verify and evaluate some important specifications mentioned in OFCS datasheets. Indeed, we report in figures 1 and 2 two commercial OFCS produced respectively by ***OptoComb, Inc*** and ***Pritel, Inc*** whose spectrums are measured by the APEX-UHR-OSA.

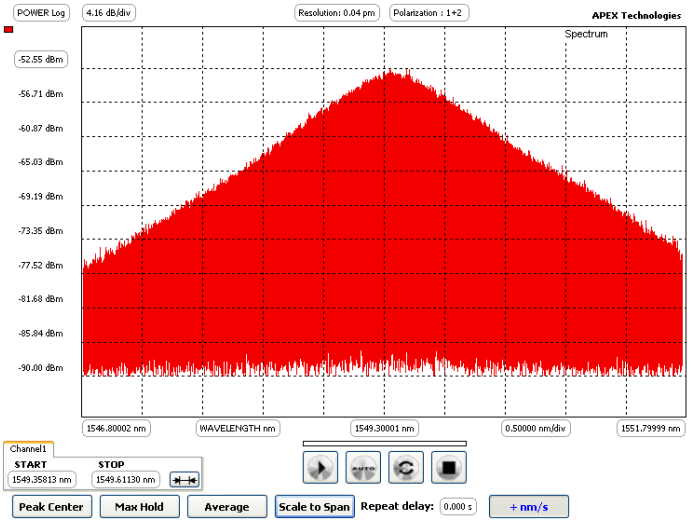


Figure 1: Pritel's OFCS spectrum measured by APEX-UHR-OSA with 5 MHz/0.04pm frequency resolution, the pulse repetition frequency is around 20 MHz.

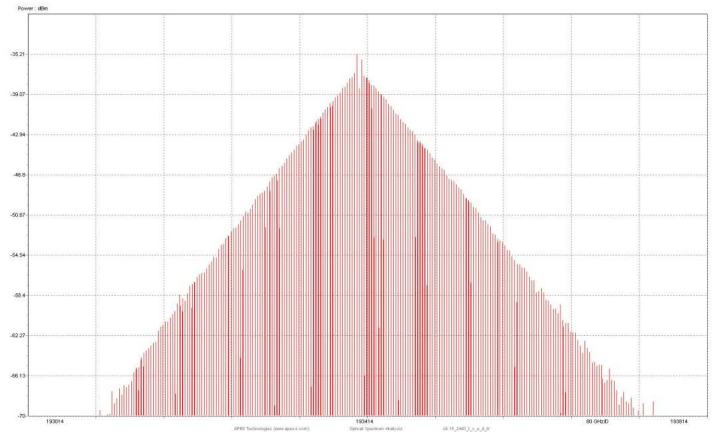


Figure 2: OptoComb's OFCS spectrum measured by APEX-UHR-OSA with 5 MHz/0.04pm frequency resolution, the pulse repetition frequency is around 2.856 GHz.

As depicted in these figures, the high resolution provided by APEX OSA allows showing all comb modes and not only the envelope as measured by the conventional grating-based OSAs. Even with a few tens of MHz comb modes spacing (example: 20 MHz for *Pritel*'s OFCS), the APEX OSA user can check and measure the OFCS pulse repetition frequency value provided by the manufacturer (see figure 3 and 4).

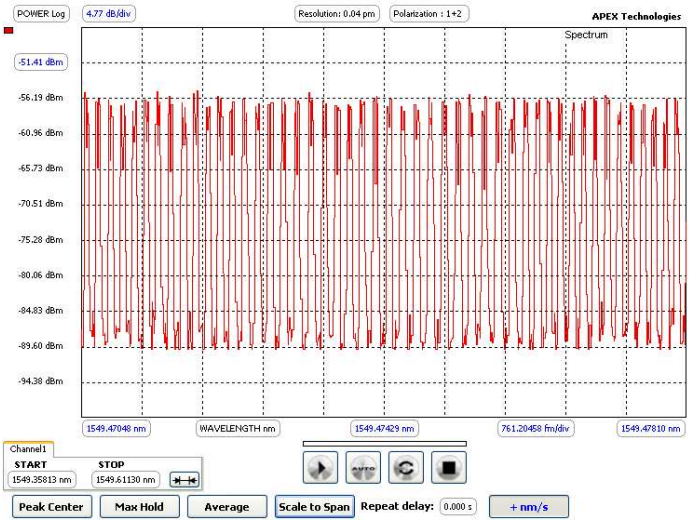


Figure 3: Zoom on Pritel's OFCS

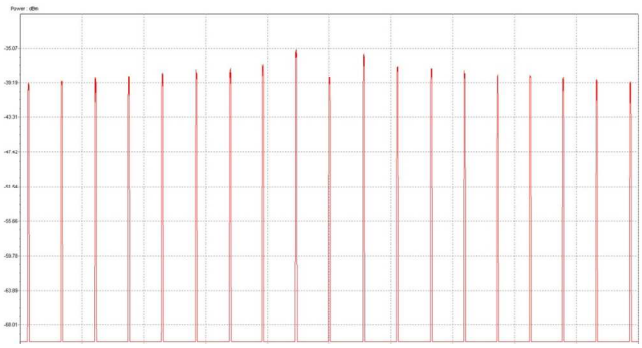


Figure 4: Zoom on OptoComb's OFCS spectrum

For some applications, temporal characterization of OFCS output pulses remains very important. By using the APEX OCSA, we can measure the pulse width, height and even chirp (figure 5). In certain cases, the use of the OCSA is essential to adjust the OFCS operating point (especially the RF input signal modulation frequency) value thanks to a direct observation of the optical phase time profile (see figure 6).

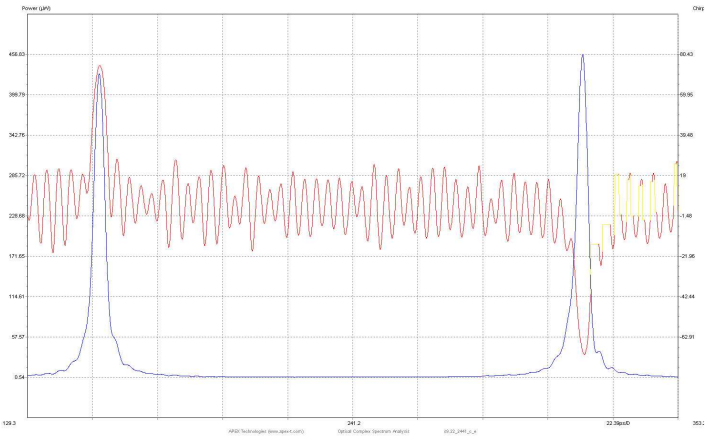


Figure 5: OptoComb's OFCS output power and chirp time profiles measured by APEX-OCSA

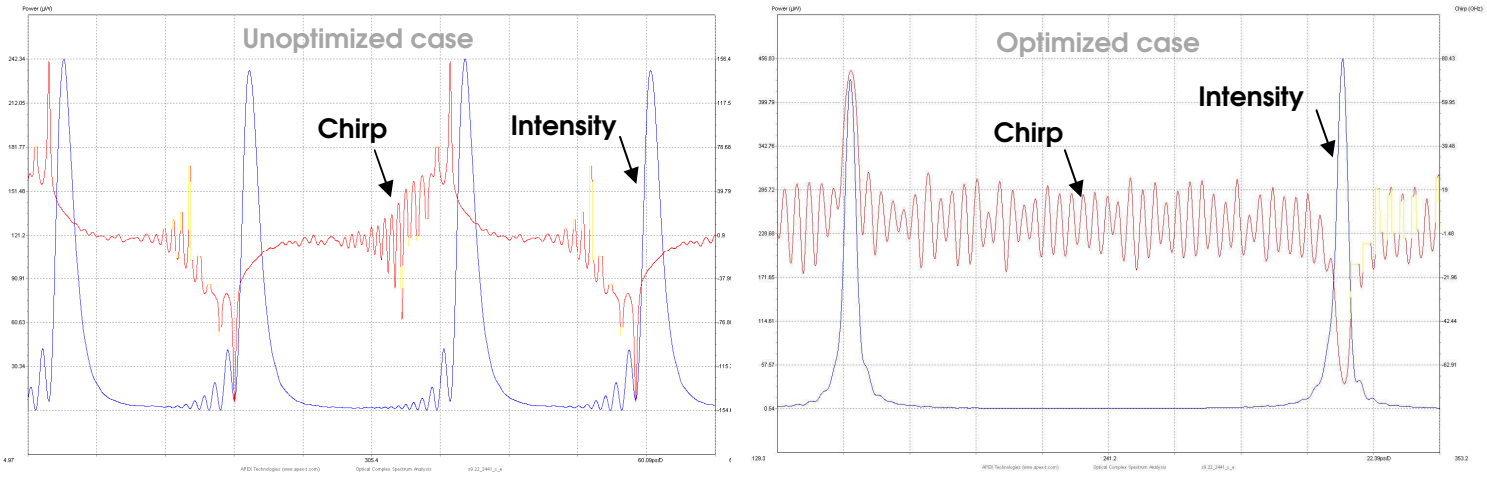


Figure 6: *OptoComb*'s OFCS operating point adjustment using OCSA

APEX UHR-OSA/OCSA: evaluation/validation tool of new OFCS architectures

Optical Frequency Comb generation remains the main topic of many research works in the world as well as the essential starting point of several companies. An illustrative example is that of ***Pilot Photonics Ltd***, a privately held company producing optical comb subsystems for next generation optical transmission applications.

Dr Prince Anandarajah, a *Pilot Photonics* founder and a researcher at Dublin City University presents us his testimony about the APEX OCSA essential role in evaluating and validating his OFCS architecture:

"Some of the most important characteristics that optical frequency comb sources should demonstrate are good spectral flatness, high frequency stability, low linewidth and a tunable free spectral range (FSR). We found the APEX OCSA was an invaluable tool in characterizing the above-mentioned comb criteria. Features such as the 5MHz resolution, excellent wavelength accuracy and high dynamic range enabled the accurate characterization and optimization of the comb. To date, we have not found a suitable alternative!!"

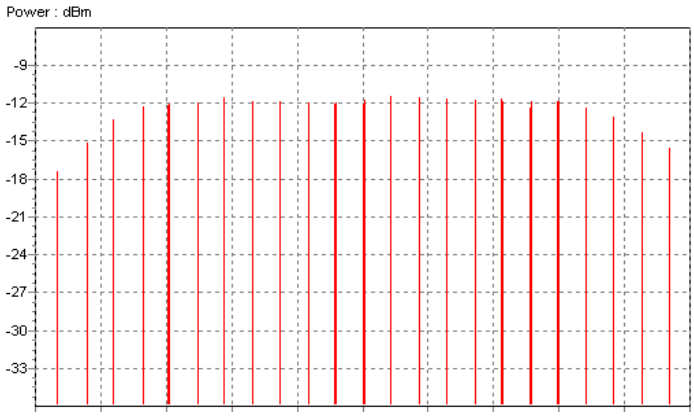


Figure 7: Optical spectrum of Pilot Photonics' OFCS measured by APEX UHR-OSA

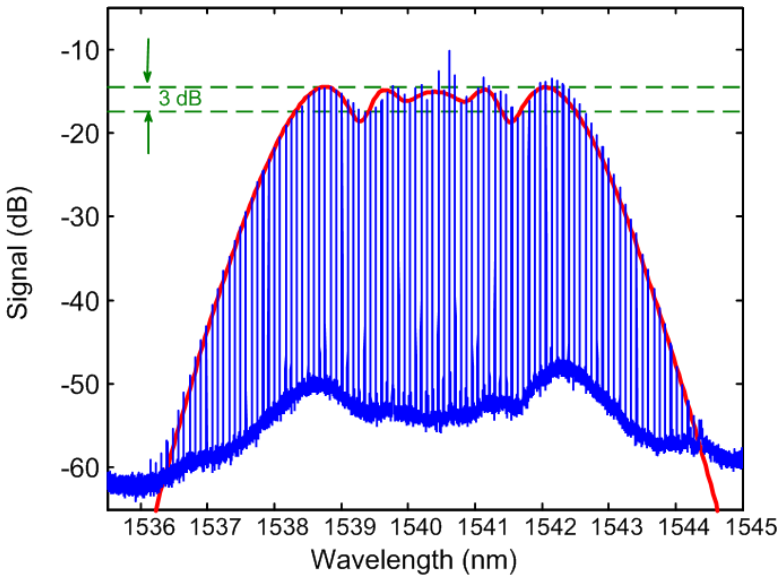


Figure 8: Optical spectrum of expanded Pilot Photonics' OFCS measured by APEX UHR-OSA, by fiber nonlinearities based expansion techniques

An example of Pilot Photonics OFCS based on a gain switched Laser Diode is shown in Figure 7. One can notice 20 coherent frequency tones within a 3 dB spectral bandwidth, with an FSR (Free Spectral Range) of 10.7 GHz, and extinction ratio of at least 45 dB. This plot was obtained using the APEX UHR-OSA.

The OFCS viability could be further improved by enhancing the number of generated comb lines. Figure 8 depicts optical spectrum of an expanded *Pilot Photonics'* OFCS using spectral expansion techniques based on optical fiber nonlinearities. The number of frequency tones within a 3 dB spectral ripple is around 50 respectively.

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Acknowledgments

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