2.49 GHz Low Phase-Noise Optoelectronic Oscillator using 1.55µm VCSEL for Embedded Systems Applications

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Introduction

We present a 1.55µm single-mode VCSEL based low phase-noise optoelectronic oscillator (OEO) operating at 2.49GHz for aerospace, avionics and embedded system applications. A phase-noise measurement of -107 dBc/Hz at an offset of 10kHz from the carrier is obtained. A 3-dB line-width of 16Hz for this oscillator signal has been measured. A parametric comparison with DFB Laser-based and multi-mode VCSEL-based oscillators is also presented.

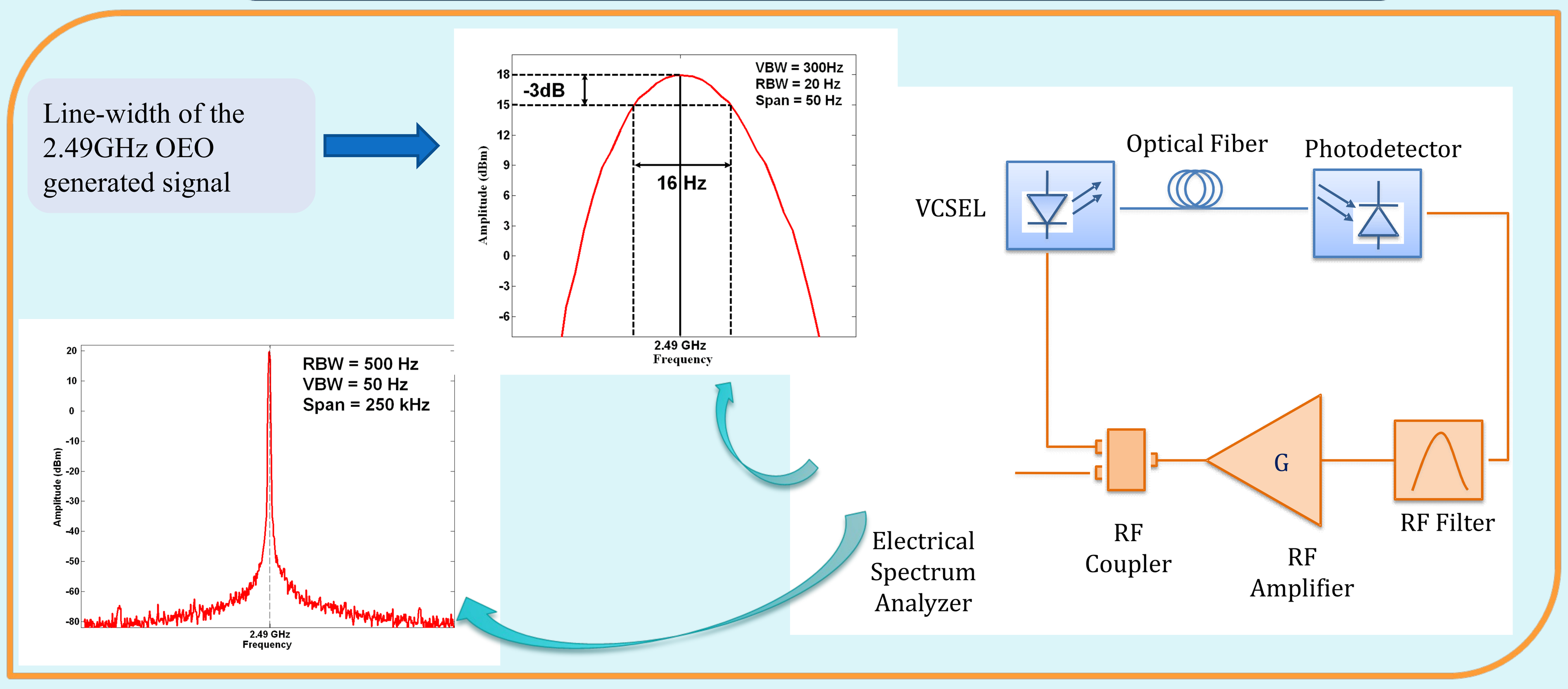
Optoelectronic Loop Oscillator

- High Frequency, Good quality signal.
- No need for a microwave reference.

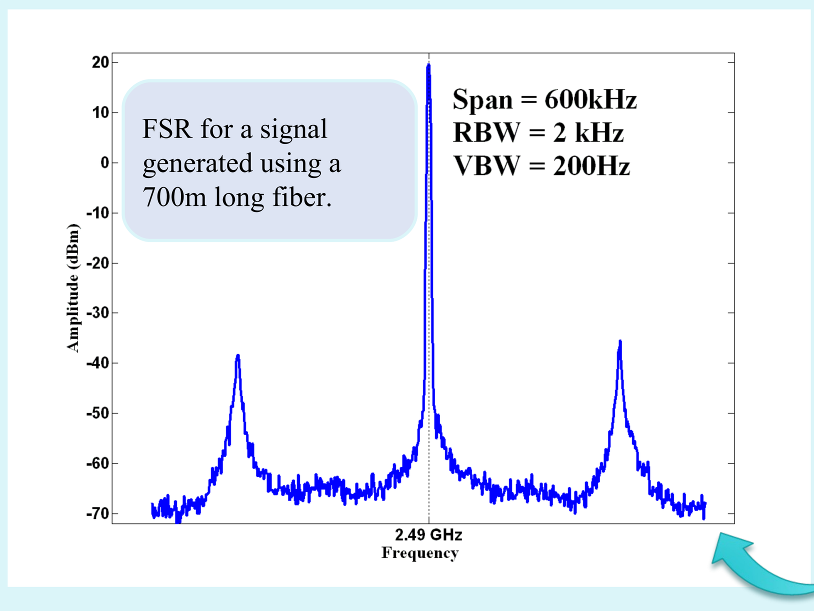
VCSEL Advantages

- Low Power Consumption.
- Light Weight and Compact.
- Low Temperature Dependence.

VCSEL Based Oscillator



Mode-Spacing Variation



Fiber Length (m)	FSR (kHz)
100	1300
200	790
300	580
700	210
1000	180

Mathematical Representation

The open-loop gain incorporating the VCSEL Transfer Function along with the Amplifier gain can be given as

$$\tilde{G}_{OL} = \tilde{\alpha}.\tilde{G}_{Ampli}.\tilde{\alpha}_o.\tilde{S}.R_{ph}.\tilde{F}\eta_d.\frac{h\nu}{q}.\frac{1}{R_d(I)|_{I=I_{pol}}}.H_{VCSEL}(\omega)|_{\omega=\omega_0}$$

The numerical expression for the interdependence between the FSR, the fiber length L and the fiber refractive index

$$S_\Psi(f) = \left(1+\frac{1}{f^2}\left(\frac{f_{osc}}{2.Q_c}\right)\right).\frac{S_\Phi(f).G^2{}_{Ampli}}{P_{osc}}\left(1+\frac{f_c}{f}\right)$$

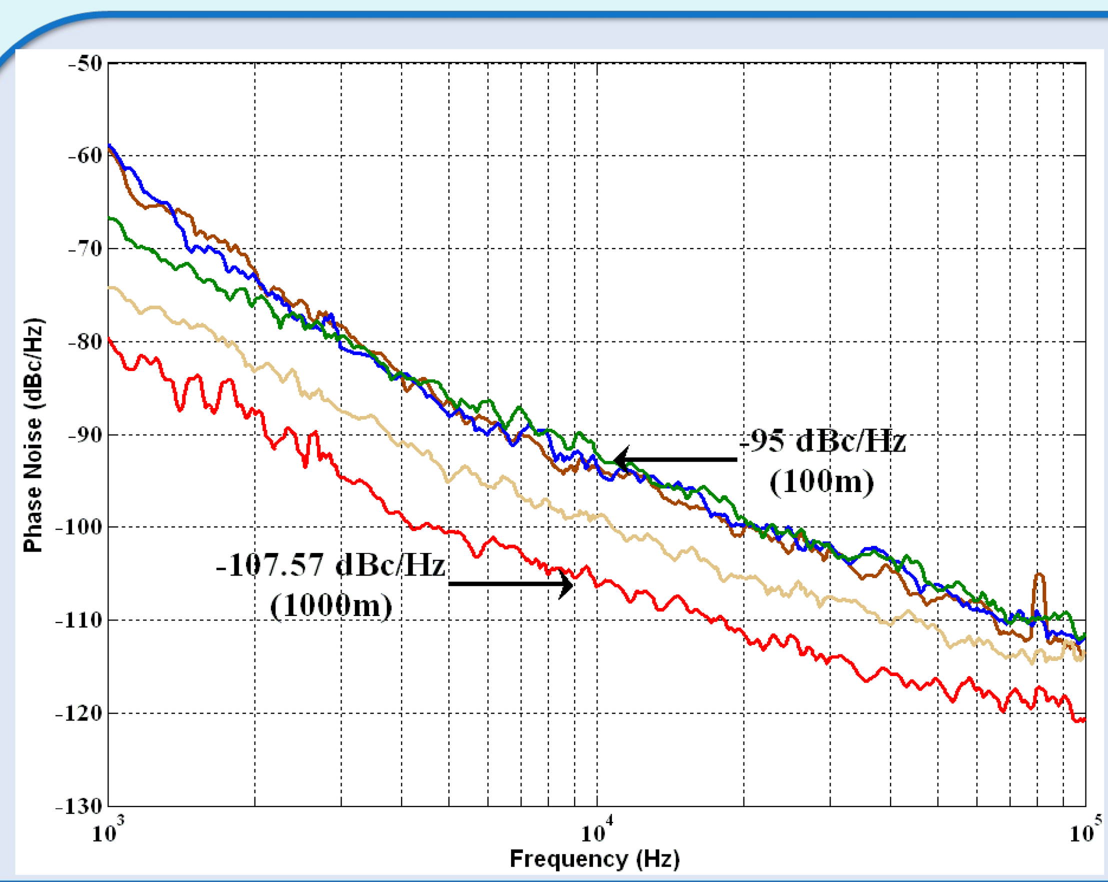
The phase-noise power spectral density In terms of total system noise power spectral density

$$FSR = \frac{1}{\tau_E + \frac{\eta_F.L}{c}}$$

Comparison of OEOs

Oscillator	Fiber Length (m)	I_{bias} (mA)	Laser RIN (dB/Hz)	FSR (MHz)	P_{osc} (dBm)	Phase-Noise @ 10kHz (dBc/Hz)
VBO 850 nm MM 2,49 GHz	120	12.5	-130	1,1	16	-100
VBO 1560 nm SM 2,49 GHz	1000	6	-135	0,180	15,6	-107.57
DBO 1560 nm SM 900 MHz	100	50	-138	1,3	10	-108

Phase-Noise Evolution



The phase-noise curves corresponding to different fiber lengths are presented in this figure. A phase-noise measurement of -107 dBc/Hz at an offset of 10 kHz from the carrier is obtained.

Conclusion

The advantages of using 1.55µm single-mode VCSELs to generate high spectral purity signals are their relative insensitivity to temperature variations, their compactness and their very low operation currents. The usage of a single-mode VCSEL guarantees a priori a more spectrally pure system as compared to multi-mode VBOs. The employment of single-mode 1.55µm VCSELs combines the advantages of single-mode 1.55µm DFB-lasers and VCSELs while at the same time eliminating the inconveniences of high power consumption and temperature related output fluctuations.

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