Application Note :

Measuring Polarization Dependant Frequency in DPSK Demodulator

1. General Description

The polarization dependant frequency (PDf) of an interferometer is the maximum shift in frequency at a given phase at every polarization.

2. Measurements

The Stokes measurement[1] are performed using the 4 polarizations: linear horizontal, vertical, diagonal and circular right hand. Post-processing these transmission data provide PDL and PDf.

3. Post-Processing Data

The transmission of the demodulator is expressed as follow:

$$Q_j(\nu) = \left[\frac{T_j(\nu)}{2} \times \left\{ 1 + \sin\left(2\pi \frac{\nu}{FSR} + \varphi_j(\nu) \right) \right\} + \varepsilon_j(\nu) \right]$$

Where:

- j (= 1 to 4) represents the polarization state as defined in Stokes measurements;
- Q is the transmission of the device under test;
- ν is the frequency ;
- T is the amplitude of the sine function (interferometer modulation);
- FSR is the free spectral range of the interferometer. It is independent on polarization and wavelength, at least an order of magnitude below requirements for PDf measurement;
- φ is a reference phase that can change with polarization. It will be referred to as “null frequency phase”;
- ε is the remaining transmission when the interferometer is on a destructive interference frequency (it roughly is the interferometer isolation).

A sinus fitting algorithm is applied to the 4 transmissions to retrieve the experimental values of the above equation. One can show that taking exactly the same procedure as in [1], it is possible to express the maximum and minimum of the null-frequency phase over every polarization. Therefore, the PDf can be expressed from this analysis and takes the following form:

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$$PDf \approx \frac{\sqrt{\left(\frac{\varphi_1 - \varphi_2}{2}\right)^2 + \left(\varphi_3 - \frac{\varphi_1 + \varphi_2}{2}\right)^2 + \left(\varphi_4 - \frac{\varphi_1 + \varphi_2}{2}\right)^2}}{\pi} FSR$$

The detailed mathematics about the technique will be presented [2].

One can see that it is more relevant to express PDf as a shift normalized in frequency since it scales with FSR. Therefore, we recommend referring to PDf as a fraction of the FSR instead of absolute value in Hz.

4. References

1. Hentschel C., Schmidt S., *Polarization Measurements using the Agilent 8169A Polarization Controller*. Product note available on Agilent's website. http://www.home.agilent.com/agilent/redirector.jspx?action=ref&cname=AGILENT_EDITORIAL&cc=US&lc=eng&ckey=115278&nid=-35518.536883082&pid=72344
2. Max J.-J., O'Reilly S. *From Stokes measurements to PDF post-processing*. White paper available on ITF Labs website