A Method for Primary Calibration of AM and PM Noise Measurements

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In the field of metrology, the term *primary*, or fundamental, means that the standard, the measure, or the instrument is *directly connected to the SI units*. The connection can be made with null measurements, with ratiometric measurements, or with the non-fundamental measurement of quantities whose uncertainty has a small and known effect on the accuracy budget. By contrast, the calibration methods generally used in phase-noise and in amplitude-noise measurements fall in the definition of "practical" or "empirical," as opposed to fundamental. In fact, however precise and satisfactory in practice, they lack the connection to the SI units. Some examples are:

1) a sideband of known sideband-to-carrier power ratio,
2) a white-noise source of known carrier-to-noise ratio,
3) a reference temperature used to generate a signal of known carrier-to-noise ratio, and
4) a calibrated low-index modulator.

The methods 1–3, inherently, produce both AM and PM of equal index. Unfortunately, the PM detectors used in practice have non-negligible sensitivity to AM. The method 4 shifts the problem to the calibration of the analyzer used to assess the gain and the AM-to-PM crosstalk, which is at most a secondary instrument.

This article proposes a method for the primary calibration of AM and PM measurements, based on the following ideas.

- The phase is defined as $\varphi = \arctan \frac{y}{x}$, where x and y are appropriate orthogonal phasors. Provided the orthogonality is guaranteed elsewhere, it holds that $\varphi = \arctan \frac{|y|}{|x|}$. This can be measured as the power ratio P_y/P_x. The normalized amplitude α is defined and measured in the same way, with the trivial difference that the phasors x and y must be parallel.
- The I-Q modulators and detectors, commonly used in telecommunications, provide an excellent way play with phasors, and to implement a Cartesian frame. The orthogonality defect and the gain asymmetry of the I-Q device can be corrected by taking the appropriate linear combination of the I and Q signals. The quadrature condition is detected as the null of a scalar product, as explained in [1].

This article is the abstract of a copyright-free report available[1] on http://arxiv.org and on the author home page http://rubiola.org. The conference slides are available on the author home page http://rubiola.org.

[1] E. Rubiola, V. Giordano, "Advanced interferometric phase and amplitude noise measurements," Rev. Sci. Instrum. **73** (6) 2445–2457, June 2002. Also available on http://rubiola.org and on http://arxiv.org, document arXiv:physics/0503015.

[1] Unfortunately, still not at the time of submission.

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