Sensitivity limits and design of THz absorption spectrometers

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***Abstract*—**Absorption spectrometers are used to analyze the vibrational and rotational transitions of chemical species. This article will discuss the limits of spectrometer sensitivity, and the design of spectrometers to enable the measurement of the minimum detectable amount of a species. The classic Townes sensitivity limit was derived by assuming a square law detection method. However, the minimum detectable signal can be shown to be independent of the method of detection used, leading to useful insights into the optimum spectrometer design. In particular, the spectrometer can utilize the well-established techniques of homodyne detection of amplitude modulated signals. Analysis and measurements of different spectrometer architectures will be considered. The effect of various noise sources on the sensitivity will be presented, including Johnson noise, diode noise, source amplitude noise, and flicker noise. The dependence of the sensitivity on the available transmitter power will be analyzed with respect to these noise sources. Measurements of spectrometer performance will be presented at WR-5.1 (140-220 GHz) and WR-5.1 (500-750 GHz).