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A STANDARD FOR PM AND AM NOISE AT 10.6, 21.2 AND 42.4 GHZ

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Abstract

A portable amplitude-modulation (AM) and phase-modulation (PM) noise standard has been developed for carrier frequencies of 10.6, 21.2 and 42.4 GHz. The noise level from the carrier 1/2 $S_\phi(f)$ (phase noise) or 1/2 $S_a(f)$ (amplitude noise) is -122.6 dBc/Hz at 10.6 GHz, -119.6 dBc/Hz at 21.2 GHz and -116.3 dBc/Hz at 42.4 GHz. For Fourier frequencies of 1 kHz to 10 MHz the added noise is flat with an uncertainty of ± 0.25 dB. The uncertainty of the noise level for Fourier frequencies of 1 kHz to 100 MHz is ± 0.5 dB. The residual PM noise floor between the signal and reference outputs at 100 kHz is less than -182 dBc/Hz.

Introduction

A portable amplitude-modulation (AM) and phase-modulation (PM) noise standard has been developed at frequencies of 10.6, 21.2 and 42.4 GHz. The standard is based on a 5, 10 and 100 MHz PM and AM noise standard that has been described in detail [1] and will be used to establish a calibration assurance program at these frequencies.

Design of the PM / AM Noise Standard

The theory of operation of the PM/AM noise standard is described in detail in reference[1]. The 10.6, 21.2, and 42.4 GHz noise standard follows the same basic design. A dielectric resonator oscillator (DRO) was used as the frequency source at 10.6 GHz. The DRO was selected to have low PM and AM noise and a stable output power. The carrier on/off function was implemented by either switching the source into a 50 ohm termination, or splitting it into reference and modulated signal paths using a reactive power splitter (Fig. 1). The noise source was selected to be broadband, very flat over the Fourier frequency range of interest (9.6 to 11.6 GHz), and stable with temperature. The noise source can be turned on, off, or attenuated using microwave relay switches and a calibrated attenuator.

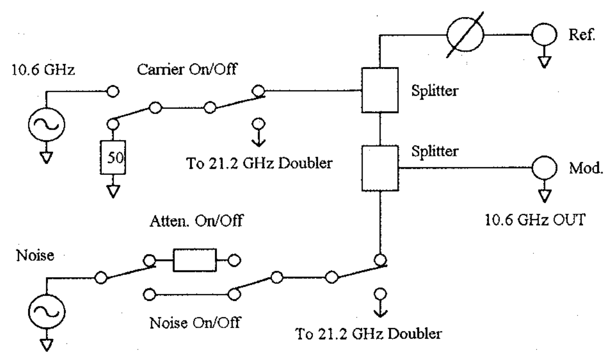

Fig. 1 Diagram of the 10.6 GHz noise standard.

The noise is linearly summed with the carrier in the modulated signal path using a broad-band power combiner. Since the carrier and noise are neither amplitude nor phase coherent and the total noise power is very small compared to the carrier signal, the resulting modulated output has virtually equal AM and PM noise components. The reference signal has an adjustable phase shifter that is used to provide 0-360 degrees of phase shift relative to the modulated output.

The 10.6 GHz signal and noise sources can be switched to the input of doublers producing the 21.2 GHz signal and noise sources for the 21.2 GHz noise standard. The 21.2 GHz noise standard is similar in layout to the 10.6 GHz noise standard (Fig. 2). A directional coupler is used in this standard, as well as the 42.4 GHz standard, in lieu of a power combiner to maximize the carrier power level (Fig. 3). The attenuator in the noise path is used to select the carrier-to-noise ratio.

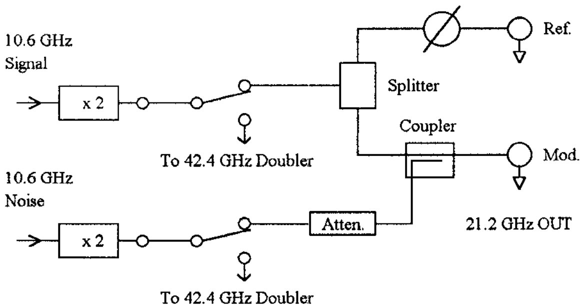

Fig. 2 Diagram of the 21.2 GHz noise standard.

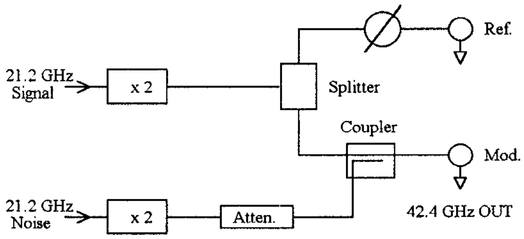

Fig. 3 Diagram of the 42.4 GHz noise standard.

Design considerations

The noise power relative to the carrier power is such that the compression of the measured $S_\phi(f)$ is smaller than 0.04 dB.

$$\int_0^\infty S_\phi(f) << 0.01 \qquad (1)$$

However, the added noise must be high enough to be far above the noise floor of the measurement system. The residual differential PM noise between the reference and modulated signals must be small to provide source noise immunity when conducting measurements. The coherence of the source noise in the reference and modulated outputs must be residual PM noise. This is done by keeping the reference and modulated path lengths the same. The flatness of the standard is determined by the flatness of the noise source, flatness in the components and the voltage standing wave ratio (VSWR). Keeping VSWR to a minimum is critical for the flatness and accuracy of the standard. The use of isolators is essential. They ensure a proper termination for all components, reflections are minimized, and the carrier and noise sources are isolated from changing loads at the output ports. The carrier and noise powers track with temperature, to better than 0.2 dB through the warm-up cycle of 15 degrees Celsius. The evaluation of the phase noise standard yielded the performance detailed in table 1.

Conclusion

A portable amplitude modulation (AM) and phase modulation (PM) noise standard has been developed at frequencies of 10.6, 21.2 and 42.4 GHz. It is now available as part of the NIST calibration assurance program. It may be used to evaluate the accuracy and noise floor of PM and AM measurement equipment to ± 0.5 dB for a Fourier frequency range of 1 kHz to 100 MHz. The uncertainty and flatness is improved to ± 0.25 dB for Fourier frequencies from 1 kHz to 10 MHz.

Acknowledgments

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References

1. F. L. Walls, "Secondary standard for PM and AM noise at 5, 10, and 100 MHz," IEEE Transactions on Instrumentation and Measurement, Vol. 42, No. 2, pp. 136-143, 1993.

	10.6 GHz	21.2 GHz	42.4 GHz
Mod. Power	14.8 dBm	10.5 dBm	9.3 dBm
Ref. Power	17.2 dBm	9.7 dBm	9.1 dBm
L(0-10MHz) Atten. off	-122.6 ± 0.25 dBc/Hz	-119.6 ± 0.25 dBc/Hz	-116.3 ± 0.25 dBc/Hz
L(0-100MHz) Atten. off	-122.6 ± 0.5 dBc/Hz	-119.6 ± 0.5 dBc/Hz	-116.3 ± 0.5 dBc/Hz
L(0-10MHz) Atten. on	-132.6 ± 0.5 dBc/Hz	-125.2 ± 0.5 dBc/Hz	-119.6 ± 0.5 dBc/Hz
L(0-100MHz) Atten. on	-132.6 ± 0.7 dBc/Hz	-125.2 ± 0.7 dBc/Hz	-119.6 ± 0.7 dBc/Hz

Table 1.