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AN 8 mm FM and AM NOISE MEASURING EQUIPMENT

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ABSTRACT

A FM / AM noise measurement equipment, in which a resonator cavity has been used as a discriminator to measure the FM / AM noise of a single oscillator, has been introduced in this paper, the threshold for FM noise measurement is −120dBc / Hz (f = 50kHz) and for AM noise measurement is −158dBc / Hz (f = 50kHz).

INTRODUCTION

There are some difficulties for using the classic two−oscillator technique to measure FM noise at 8 mm waveband [1]. The first, it is usually difficult to build two sources at the same frequency and it would require a wide bandwidth phase lock loop which is rather expensive. The second, the noise of the reference source must be known, otherwise the result of the measurements will be the combination of the FM noise of two oscillators. the third , the two−oscillator technique is not adaptable for measuring AM noise, which is often as important as FM noise at millimeter frequency. Although a delay line can be used as a FM disriminator to measure FM noise, but it is usually impractical for measuring FM noise of fundamental millimeter−wave oscillator, due to the dispersion of the delay line, which is more adaptable at lower frequency band.

A new 8 mm waveband FM / AM noise measurement equipment has been developed. In this equipment, a single−oscillator technique has been used. A very high−Q reflection−type tunable cavity and a circulator are used as the FM discriminator[2]. This technique can make absolute measurement and the equipment has very high sensitivity

GENERAL PRINCIPLE

For FM noise measurements, the input signal is split into two parts through the directional coupler C1 and enter to the signal channel and reference channel respectively. The signal of reference channel through phase shifter to the local port of the balanced mixer, has been called Vr, the signal of signal channel through discriminator to signal port of the balanced mixer, has been called Vs, and assuming 1Vs1< <1Vr1. The phase shifer in reference channe is adjusted for ″phase quadrature″ of Vs and Vr. When the resonator cavity is adjusted carefully to critical coupling. Assuming that there is a small fluctuation in amplitude of signal, when the cavity is tuned precisely to ω_0, then $\omega_0 = \omega_c$. The discriminator slope is detemined by

$$\frac{\Delta V}{\Delta f} = \frac{AQ}{f_0} \quad (1)$$

Which shows that on the basis of performance of the discriminator and levels of output signal, we could determine phase noise of the oscillator under test. The calibration of the discriminator slope can be accomplish by appling a small audio frequency(10kHz) modulation signal to the oscillator under test. A rf spectrum analyzer is used to observe the frequency modulated signal.

For AM noise neasurement, the load of E-plane magic tee is terminated by waveguid switch. then the balanced mixer acts as a balanced detector. The balanced conditions of the detector is turned by the switch S_2. when it is in the balanced condition, the demodulated output voltage $V_1$is caused by system noise. In the unbalanced condition, the demodulatde output voltage is V_2, which consists of the AM noise from the source under test and system noise. The AM noise voltage of the source under test can be represent by $Vrms = \sqrt{V_2^2 - V_1^2}$. AM noise will be represented by [2]

$$AM = 20\log V_{ac} - 20\log V_{dc} - 10\log B - 20\log C - 6 \quad (2)$$

where

AM—— amplitude modulation signal-carrier-ratio in 1Hz

V_{ac}—— reading of the baseband analyzer

V_{dc}—— dc voltage of each detector

B—— noise bandwidth of baseband analyzer

C—— correction factor of diode detection characteristics

EQUIPMENT

(1) THE CAVITY At millimeter wave band, the cavity with 2 GHz tune range would be a rather long and small cylinder, it incareases difficulty in working. For the high-Q of cavity, both H013-mode and H019-mode have been selected. The cavity resonators with internal diameter 14 mm and 19 mm have designed. The cavity made by stainless stell, inner wall of the cavity was coated with gold, a new technology used in the coating process. the roughness can be $\triangle_{12}$after coating. The short-circuit piston at the bottom of cavity is noncontact type, which is driven by a microscrew. The steady parallel movement can be obtained. In order that the work mode of the discriminator can be pure and clear. We have made a small pole at the end of the cavity as a fine tuner. The tune sensitivity of the cavity is of the order of kHz.AT frequency range of the Q value of cavity D14 and D19 is 11000 —— 20000 and 17000—— 26000 respectively, which is measured by the swept reflective coefficient method.

(2) DESIGN OF THE EQUIPMENT All componets and devices are designed and made specially in China. The components and devices are fixed on a plane, so that equipment's rigidity is improved. A waveguide of " S" shape has been designed to connect magic tee and waveguide switch. The directional coupler $C_1$is a " +" type coupler with coupling 13 dB and directivity 26dB. The directional coupler $C_2$is a " +" type coupler with coupling 20dB. The isolators and phase shifter with small insertion loss are chosen. The incomplete performance of the circulator has been compensated by the slide screw tuner No.1. The slide screw tnner No.2 make the cavity appear to be critically coupled. The balanced mixer consists of a magic tee and two detectors. The insertion loss of the magic tee is smaller than 0.3dB, and it's symmetry is about 0.2dB.A pair of silicon plane contact Schottky-barrier diodes, which are carefully chosen, are used in the detector, so that a superior sensitivity has been obtained. The equipment is packed in a portable case, so that it can be carried easily.

(3) AUTOMATIC ACQUISITION The output voltage of balanced mixer can be read directly at the baseband analyzer. It also can be printed or plotted through A / D converter and IBM-PC computer by printer and plotter.

RESULT

The FM and AM noise for the Gunn oscillator and the phase-locked signal source at 8mm waveband with uncertainty about 3dB is given in table 1 and table 2.

Table 1. Data of Fm Noise and Threshold

fm (Hz)	400		1K		10K		50K	
FM (dBc/ Hz)	thre.	noise	thre.	noise	thre.	noise	thre.	noise
P L O.	-74	-67	-85	-78	-110	-86	-125	-93
G u n n	-70	-49	-81	-60	-108	-86	-124	-105

Table 2. Data of Am Noise and Threshold

fm (Hz)	5K		10K		20K		50K	
AM (dBc/ Hz)	thre.	noise	thre.	noise	thre.	noise	thre.	noise
4 1 #	-152	-146	-155	-150	-158	-153	-160	-155
5 1 #	-152	-146	-156	-149	-158	-153	-160	-155

In table thre. is the threshold of the equipment. noise is SSB phase noise of the oscillator under test.

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