Harmonics, Distortion and Power Measurement of W-band X6 Multiplier

Lokesh Saggam, Shashi Saggam, *Engineering Department, Millimeter Wave Products Inc.*, Saint Petersburg, Florida,

lsaggam@miwv.com, ssaggam@miwv.com

Abstract----Harmonics are unwanted frequencies generated by system nonlinearities. They are multiples of the fundamental test frequency. RF power amplifiers are responsible for most of the unwanted harmonics. This paper discusses about harmonic distortion and power measurement of W-band X6 Multiplier with 15 dBm Output Power. Two methods of Harmonics measurement are compared, and their accuracy is discussed here.

I. INTRODUCTION

Harmonics are unwanted frequencies generated by system nonlinearities. They are multiples of the fundamental test frequency and generally, the higher the multiple, the less the amplitude of the harmonic. All "real" test systems have a finite amount of nonlinearities and thus, exhibit some degree of harmonic distortion. The test engineer must ultimately determine acceptable levels of harmonics. His determination is primarily based on test standard mandates. In RF testing applications, RF power amplifiers are responsible for most of the unwanted harmonics. 5th harmonic is higher due to high gain amplifier after the multiplier MMICS which is used inside the circuit to achieve the 15 dBm of output power. Figure 1. shows the Gain of MMIC Amplifier which is higher around 78.35 GHz and is contributing to the issue of lower rejection level for 5th Harmonic.

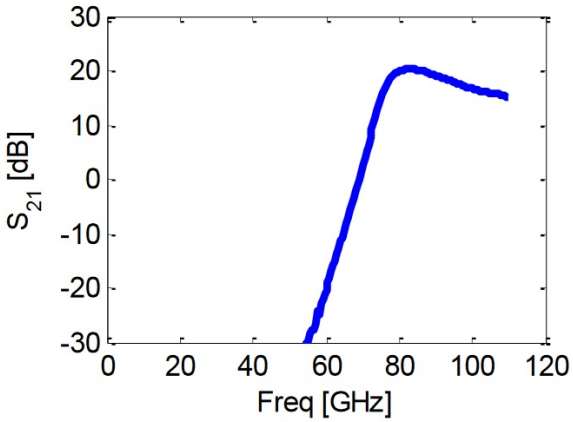

Figure 1.

II. DEVICE UNDER TEST

Device under test is W-band X6 Multiple.

A. Electrical Specifications

Input Frequency: 12.5-18.3 GHz

Input Power: +5 to +10 dBm

Output Frequency: 75-110 GHz

Output Power: +15 dBm typical over band

DC Bias: +12 Volts @ 500mA

DC Bias Max.: +15 Volts

RF Input Power Max: +15 dBm

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B. Physical Specifications

Input Port: SMA-Female Connector

Output Port: WR-10 Wabeguide with UG-387/U-M Flange

Bias Interface: Feed Thru Pins

Material: Aluminum

Finish: Gold Plating

C. Outline

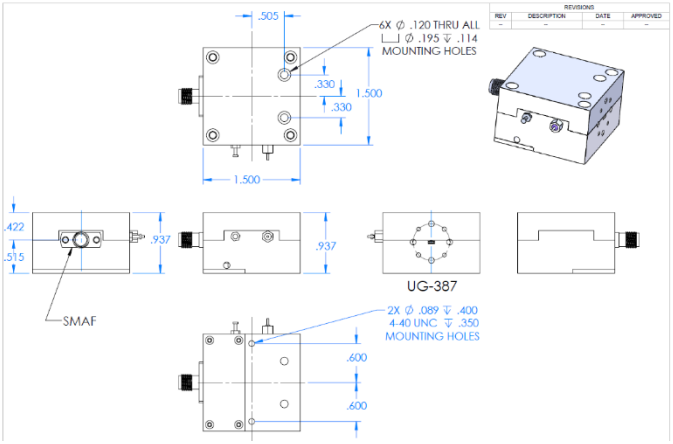

Figure 2.

III. HARMONICS MEASUREMENT TEST SETUP

Following RF harmonic testing procedure is used for RF harmonic and distortion measurement.

➡Do the setup as shown in the figure 3.

➡Feed the Multiplier with input Frequency 12.5-18.3 GHz at 7 dBm power level.

➡Anritsu MG394C is used as signal generator for this test.

➡Connect output port of Multiplier using waveguide to coax to Anritsu MS2760A Spectrum Analyzer.

➡Place the markers at point 78.35 GHz, 94.02 GHz and 109.69 GHz to measure 5th, 6th and 7th harmonic levels respectively.

➡Difference between power levels at 5th and 6th harmonic will provide 5th harmonic rejection measurement. Difference between power levels at 7th and 6th harmonic will provide 7th harmonic rejection measurement.

➡It is measured in dBc. Greater the difference between the points better is the system.

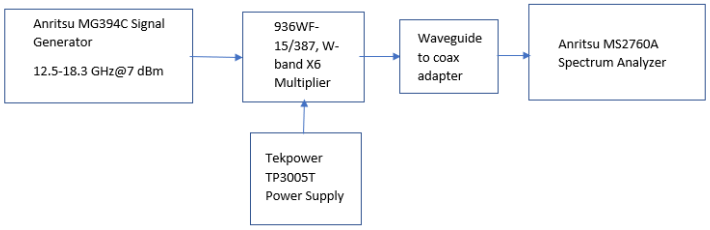

Figure 3.

A. Harmonics Data

Figure 4. is the data measured for 5th and 7th Harmonic.

5th Harmonic rejection: 18 dBc @78.35 GHz
6th Harmonic power level: 13 dBm @94.02 GHz
7th Harmonic rejection: 29 dBc@109.69

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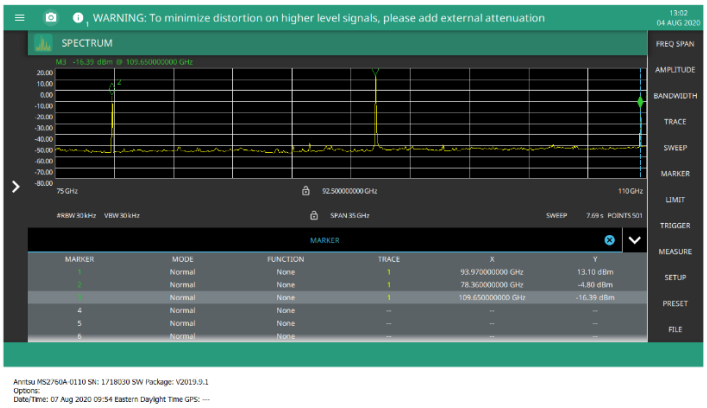

Figure 4.

B. Distortion Data in 50kHz Span

Test Conditions:

Input Freq: 15.67GHz
Output Frequency: 94.02 GHz
Input Power: +4dBm

The output signal is very clean with no distortion or spurs as shown in Figure 5.

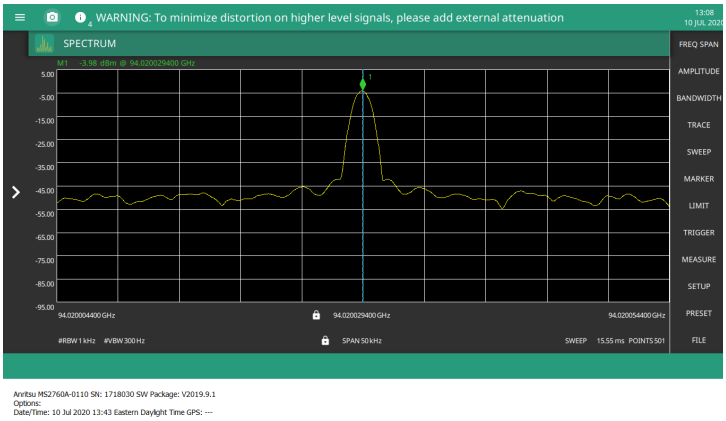

Figure 5.

IV. POWER MEASUREMENT TEST SETUP

Following RF power testing procedure is used for RF power measurement.

➡Do the setup as shown in the figure 6.

➡Feed the Multiplier with input Frequency between 12.5-18.3 GHz.

➡Anritsu MG394C is used as signal generator for this test.

➡Connect output port of Multiplier Power Sensor W8486A and Power is measured at E44188 Power Meter.

➡Measure the Power level at each frequency point.

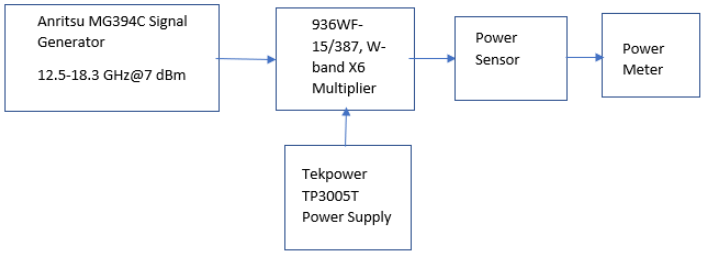

Figure 6.

A. Input Power vs. Output Power in 75-110 GHz Range

W-Band X6 Multiplier			
Input Frequency (GHz)	Output Frequency (GHz)	Input Power (dBm)	Output Power (dBm)
12.5	75	6.20	14.70
12.666667	76	6.00	14.66
12.833333	77	5.53	14.73
13	78	5.40	14.74
13.166667	79	5.10	14.85
13.333333	80	5.20	14.47
13.5	81	5.60	14.92
13.666667	82	5.60	14.81

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13.833333	83	5.80	14.23
14	84	5.80	14.24
14.166667	85	6.60	14.81
14.333333	86	6.90	14.62
14.416667	86.5	6.60	14.35
14.5	87	7.00	14.97
14.583333	87.5	7.00	14.20
14.666667	88	7.10	14.32
14.75	88.5	7.00	14.12
14.833333	89	7.00	14.62
14.916667	89.5	7.00	14.56
15	90	7.00	14.78
15.083333	90.5	7.00	14.86
15.166667	91	7.00	14.80
15.25	91.5	7.00	14.60
15.333333	92	7.10	14.39
15.416667	92.5	7.20	14.37
15.5	93	7.20	14.37
15.583333	93.5	7.00	14.02
15.666667	94	7.00	14.60
15.75	94.5	7.00	14.26
15.833333	95	7.20	14.46
15.916667	95.5	7.50	14.36
16	96	8.0	15.11
16.166667	97	8.20	14.52
16.333333	98	8.30	14.44
16.5	99	8.80	14.32
16.666667	100	8.90	14.35
16.833333	101	9.00	14.31
17	102	9.00	14.32
17.166667	103	9.30	14.26
17.333333	104	9.70	14.25
17.5	105	9.60	14.23
17.666667	106	9.80	14.16
17.833333	107	9.90	14.12
18	108	10	14.11
18.166667	109	10	14.10
18.333333	110	10	14.01

Table 1.

V. HARMONICS AND DISTORTION MEASUREMENT USING MIXER TO EXTEND SPECTRUM ANALYZER FREQUENCY RANGE

A. Measurement Setup

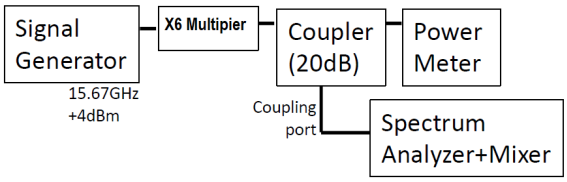

Figure 7.

B. 5th Harmonic data

5th Harmonic power level is measured as -10.04 dBm The 5th harmonic is shown higher than 6th harmonic using test method (using mixer) range as the power level of harmonics of mixer are adding to the multipliers harmonic which is causing the power level to be higher at 5th harmonic.

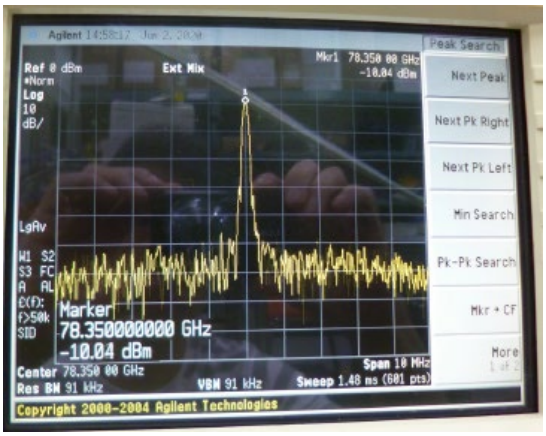

Figure 8.

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C. 6th Harmonic Data

6th Harmonic power level is measured as -15.61 dBm

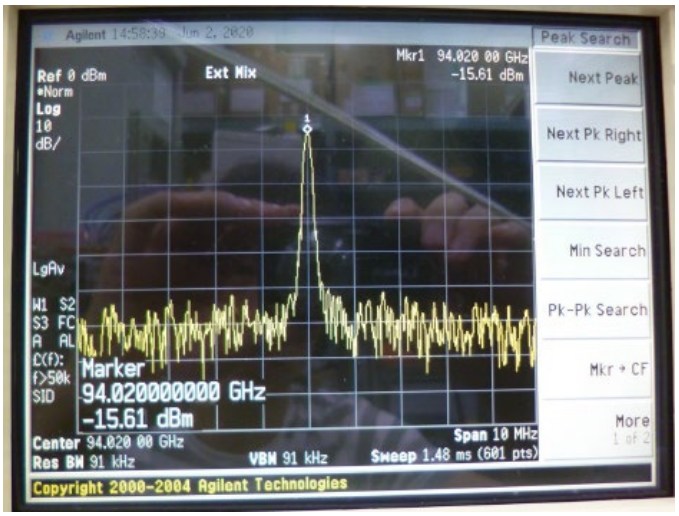

Figure 9.

D. 7Th Harmonic Data

7th Harmonic power level is measured as -47 dBm

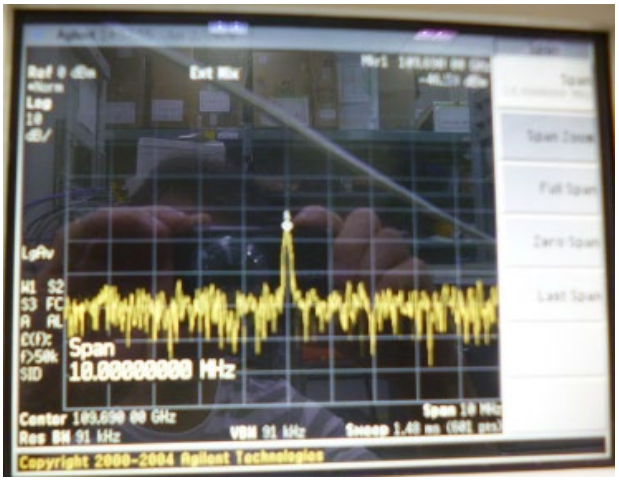

Figure 10.

E. Distortion Data in 1 MHz Span

Test Conditions:
Input Freq: 15.67GHz
Output Frequency: 94.02 GHz
Input Power: +4dBm

The distortion data in 1 MHz span with test setup (using mixer) is not clean. It contains lot of spurs due to the fact that mixer harmonic and spurs are visible on the spectrum analyzer.

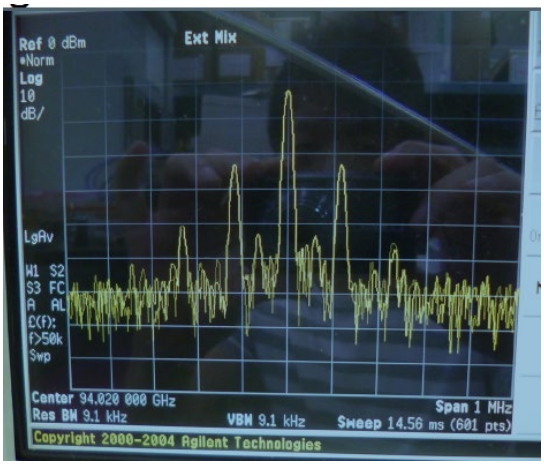

Figure 11.

VI. CONCLUSION

For accurate measurement of harmonics, the spectrum analyzer should not use external mixer. Spectrum Analyzer cannot differentiate between mixer or multiplier's harmonics and unwanted harmonics, distortion and spurs are shown on the spectrum analyzer with inaccurate power levels and hence test setup with mixer cannot tell true rejection levels of harmonics and distortion data of the multiplier. This experiment also highlights the importance of power meter for true power level measurements as we have seen that output power level is lower when it is measured on Spectrum Analyzer.