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Signal Analyzer MS2830A Application Note

Millimeter-wave Measurement

26.5 GHz Signal Analyzer MS2830A-044

43 GHz Signal Analyzer MS2830A-045

External Mixer MA2740C/MA2750C series

Version 5.01

Introduction

Mixing using an external mixer expands the signal analyzer measurement frequency up to 325 GHz.

This presentation explains millimeter-wave measurement method and its principle with the MS2830A-044/045 (26.5/43 GHz) Signal Analyzer using an external mixer.

It also explains the advantages when down-converting the MS2830A-044/045 (26.5/43 GHz) Signal Analyzer for millimeter-wave wideband modulation signal measurements, such as the 1 GHz modulation bandwidth.

Measurement using External Mixer

Millimeter-wave measurements using an external mixer mix the millimeter-wave signal to be measured with a harmonic of the signal analyzer local oscillator (LO) and down-convert to the signal analyzer IF signal frequency. In comparison with direct measurement using a signal analyzer, the measurement setup is complex and the measurement results require interpretation. To help increase understanding, this presentation first gives a simple explanation of harmonic mixing.

Measurement using External Mixer(1/14)

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1. Harmonic mixing

General microwave signal analyzers (spectrum analyzers), including the MS2830A-044/045, use fundamental wave mixing and harmonic mixing at the internal 1st frequency converter stage, depending on the frequency range. Fundamental wave mixing supports high dynamic range characteristics with a simple internal configuration. However, a high-performance local oscillator (LO) covering a higher frequency than the frequency range is required; this is not ideal as the 1st frequency converter method for the microwave region in terms of cost. Therefore, many signal analyzers (spectrum analyzers) are used from the lower limit frequency to 4 GHz for fundamental wave mixing. The MS2830A-044/045 fundamental wave mixing is 9 kHz to 4 GHz.

A general-purpose signal analyzer (spectrum analyzer) covering the microwave band uses harmonic mixing at the microwave band region of the 1st frequency converter. However, millimeter-wave measurement also uses harmonic mixing with an external mixer. Harmonic mixing mixes the LO harmonic generated by the internal mixer with non-linear characteristics with the high-level LO signal. The following equation shows the relationship. The input signal is mixed with the LO signal harmonic and the response of the conversion components equal to the IF frequency is displayed on the analyzer screen.

$$F_{RF} = n \times F_{LO} \pm F_{IF} \quad \text{--------------} \quad (1)$$

n: LO harmonic order

F_{IF}: Analyzer IF (1.875 GHz for MS2830A-044/045)

At harmonic mixing using the signal analyzer (spectrum analyzer) with an internal or external mixer, measurement is displayed as the frequency relationship using the + or – polarity of Eq. (1).

Measurement using External Mixer(2/14)

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2. Harmonic Mixing Features (strengths, weaknesses) (1/2)

Since harmonic mixing uses the LO harmonic generated in the mixer, a strong point is that even for millimeter-wave measurement it is possible to use the LO and IF circuit used at the fundamental mixing measurement band. However, a weakness is the harmonic mixing performance.

(1) Lower sensitivity

The power of the harmonic in the mixer drops as the harmonic order increases. As a result, since this is equivalent to a drop in the LO drive level required by mixing, the mixer frequency conversion efficiency (conversion loss) is degraded. Consequently, the signal analyzer DANL is degraded because a high frequency is required by a higher harmonic order. The 1st LO signals output from the MS2830A-044/045 to the external mixer use a high frequency from 5 to 10 GHz to maintain the harmonic order. This reduces the deterioration in converter loss and minimizes DANL degradation.

(2) Generation of Unnecessary Mixer Response (Non-existent response)

Since the input signal is mixed with the LO harmonic for the entire LO frequency linked to the signal analyzer display span, the response established in equation (1) is displayed entirely. At harmonic mixing using the signal analyzer (spectrum analyzer) internal 1st frequency converter, there is a tunable BPF (preselector) before the mixer to suppress generation of unnecessary responses. However, since this preselector is not present at measurements using an external mixer, unnecessary response components are displayed. To identify the true signal within the unnecessary response, the Signal ID function explained in section 5 is required.

Measurement using External Mixer(3/14)

2. Harmonic Mixing Features (strengths, weaknesses) (2/2)

(3) Complex Measurement Setup

Measurements using an external mixer require a more complex setup than normal measurements using an internal mixer. At harmonic mixing, the mixer diode bias point for optimizing the conversion efficiency differs according to the mixing harmonic order. As a result, sometimes it is necessary to supply an appropriate bias current to the external mixer. In addition, input of correction values for the external mixer conversion loss and loss of the cable connecting the external mixer and signal analyzer as well as amplitude calibration work are required too. Moreover, since the high-frequency signal path is outside the signal analyzer, detailed attention must be paid to connectors, cables, and settings. If inadequate attention is paid to these details, the measurement reproducibility will be poor.

Measurement using External Mixer(4/14)

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3. Connection with External Mixer

The 1st LO output connector on the front panel of the MS2830A-044/045 supplies the 1st LO signals and mixer bias to the external mixer, and inputs down-converted IF signals from the external mixer.

The MS2830A-044/045 Signal Analyzer supports a two-port type external mixer supporting the LO/IF end-to-end signal in one port. A three-port type external mixer with separate LO and IF connectors is not supported.

Measurement using External Mixer(5/14)

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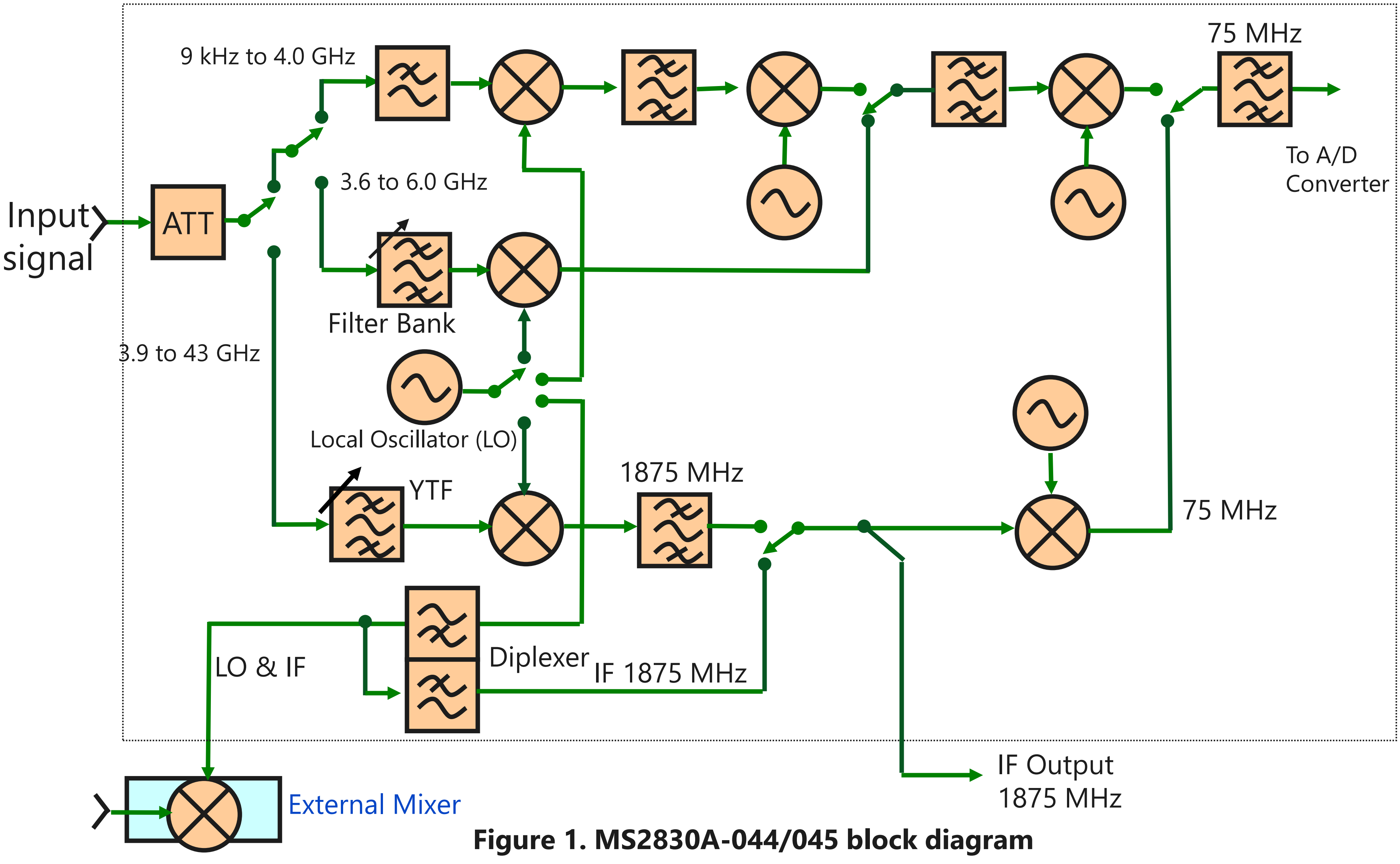

Figure 1. MS2830A-044/045 block diagram

4. Measurement Example (1/6)

This explains a measurement example using the MS2830-044/045 with an external mixer (DUT signals: SW signal with signal generator frequency 47 GHz, level –10 dBm)

4.1 External Mixer Connection

The MS2830-044/045 1st LO Output and external mixer are connected by SMA cable.

MS2830A-044/045

1st Local Output

- Connector: SMA-J, 50Ω (nominal)
- Local Signal Output: 5 to 10 GHz
- IF Signal Frequency: 1875 MHz
- Operating LO level range: +10 to +18 dBm

SMA Cable

External mixer (MA2740C/MA2750C Series)

Model Name	Frequency Range	LO Order Harmonics
MA2741C	26.5 to 40 GHz	4
MA2742C	33 to 50 GHz	5
MA2743C	40 to 60 GHz	6
MA2744C	50 to 75 GHz	8
MA2745C	60 to 90 GHz	9
MA2746C	75 to 110 GHz	11
MA2747C	90 to 140 GHz	14
MA2748C	110 to 170 GHz	17
MA2749C	140 to 220 GHz	22
MA2750C	170 to 260 GHz	26
MA2751C	220 to 325 GHz	33

Figure 2. Connection with external mixer

Measurement using External Mixer(7/14)

4. Measurement Example (2/6)

4.2 MS2830A-044/045 Setting

(1) Output signals from signal generator.

(2) Select external mixer mode.

[Frequency] > [Page 2 of 2] > [F1: External Mixer] > On

(3) Select external mixer band.

The MS2830A-044/045 automatically sets the minimum mixing harmonic order and mixing mode when the external mixer band is selected (mixing harmonic order and mixing mode cannot changed). In this example, the U band (40 to 60 GHz) is selected.

[F2: External Mixer Band Select] > [Band U 40 – 60 GHz]

4. Measurement Example (3/6)

4.2 MS2830A-044/045 Setting

(4) Distinguishing signals

In this measurement example, a 47 GHz CW signal input is evaluated. However, as previously described the measurement results show an unnecessary mixing response due to the harmonic mixing. Consequently, when the measured signal is unknown, it is necessary to identify the actual real signal in the unrequired responses. Details of the Signal ID procedure and operation are explained in section 5.

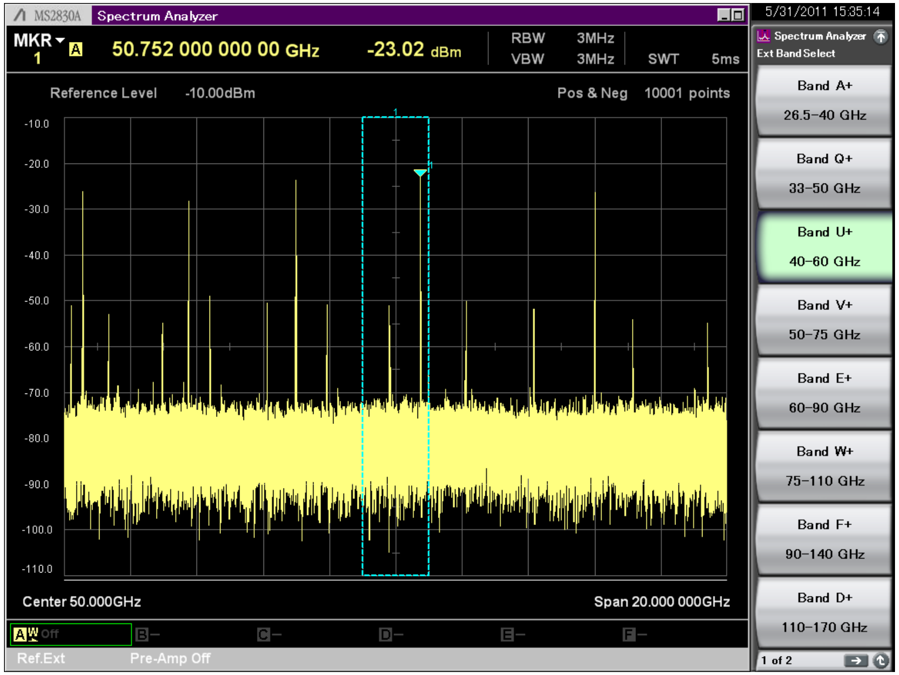

Figure 3. Measurement of 47 GHz signal using MA2473A

Many unnecessary responses are generated.

4. Measurement Example (4/6)

4.2 MS2830A-044/045 Setting

(5) Set center frequency and span.

After identifying the measured signals, set the center frequency, span and reference level to display the measurement parameter features (frequency error, occupied bandwidth, etc.).

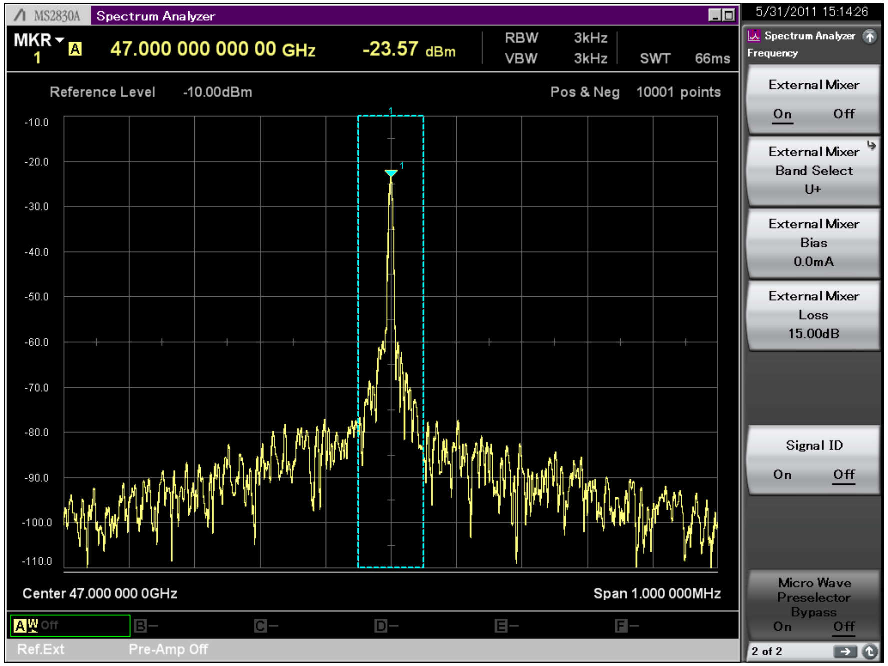

Figure 4. Example of center frequency and span settings

Measurement using External Mixer(10/14)

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4. Measurement Example (5/6)

4.2 MS2830A-044/045 Setting

(6) Set external mixer bias and external mixer loss input.

Adjust the external mixer bias to maximize the signal display level.

Input the total of the loss up to the MS2830A-044/045 input such as the external mixer and cable losses (27.5 dB for this case). The default external mixer loss is 15 dB.

[F3: External Mixer Bias] > Set to appropriate bias (max. 20 mA)
[F4: External Mixer Loss] > 27.5 dB

4. Measurement Example (6/6)

4.2 MS2830A-044/045 Setting

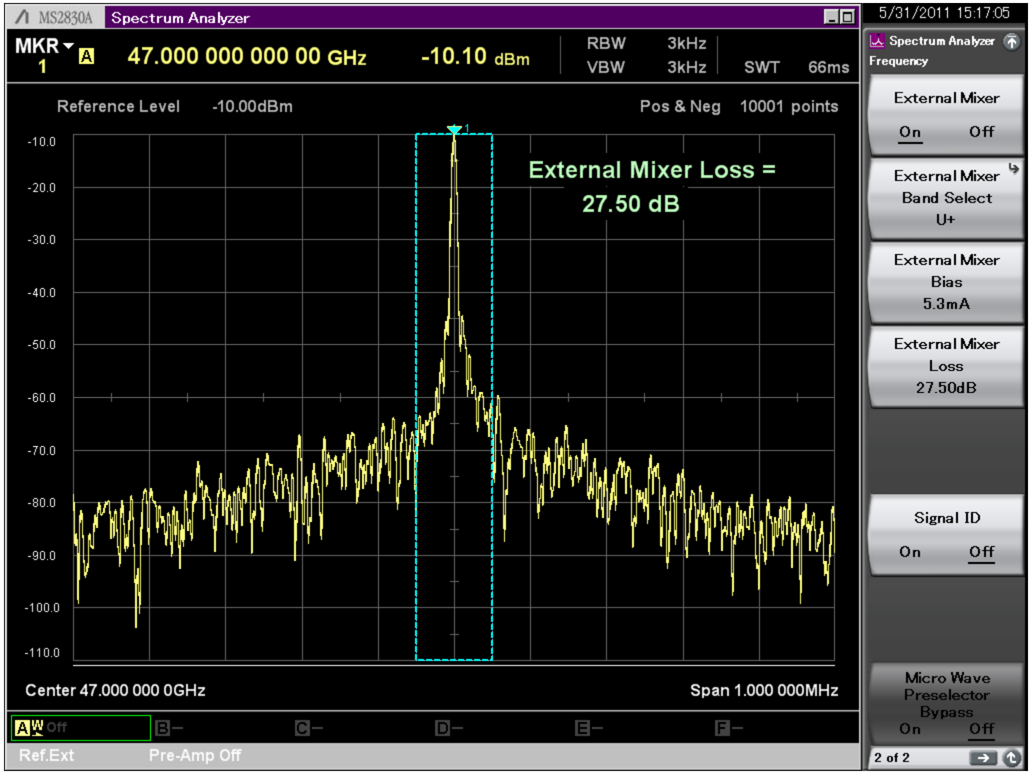

Figure 5. Example of external mixer bias and external mixer loss settings

5. Signal ID Function (1/3)

Equation (1) shows the relationship between the MS2830A-044/045 screen display frequency and internal LO signal at measurement using an external mixer. The + mode is used at normal sweeping.

$$F_{RF} = n \times F_{LO} \pm F_{IF} \text{ --------------- } (1)$$

n: LO harmonic order

F_{IF}: IF frequency of analyzer (1.875 GHz with MS2830A-044/045)

At measurement using an external mixer, because the LO harmonic for the entire LO frequency linked to the signal analyzer display span and the input signal are mixed, the response created by the relationship of equation (1) is fully displayed. Within this, the LO harmonic order is the same. The signal received with reversed ± polarity is called the image response (in the case of the MS2830A-044/045, the response is received as -). In addition, signals received with no regular LO harmonic order are called multiple responses.

When the Signal ID function is ON, the polarity corresponding to the local signal is reversed at each MS2830A-044/045 sweep. By this change of LO sweep mode, false signals such as image and multiple responses are frequency shifted on the MS2830A-044/045 screen at each sweep. However, since the frequency of actual true signals does not shift on the screen, it becomes possible to identify false image and multiple response signals from true signals. This process is shown in Figure 6.

However, when Signal ID is ON, sometimes, the level of the true signal will change at each sweep due to the effect of the frequency characteristics of the external mixer. When completing signal identification, always remember to set Signal ID to OFF when shifting to the stage of measuring signal characteristics such as level.

Measurement using External Mixer(13/14)

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5. Signal ID Function (2/3)

The MS2830A-044/045 gives priority to minimizing DANL by setting a minimum value for the LO harmonic order set at each external mixer band for the normal LO sweep mode. As a result, the LO harmonic order for the other LO sweep mode when Signal ID is ON (- polarity mode) becomes one order larger than the normal sweep mode due to the internal LO signal frequency setting range. Consequently, when using the ID function at the same harmonic order, sometimes the frequency shift of image and multiple responses is different but the Signal ID function effectiveness is unchanged.

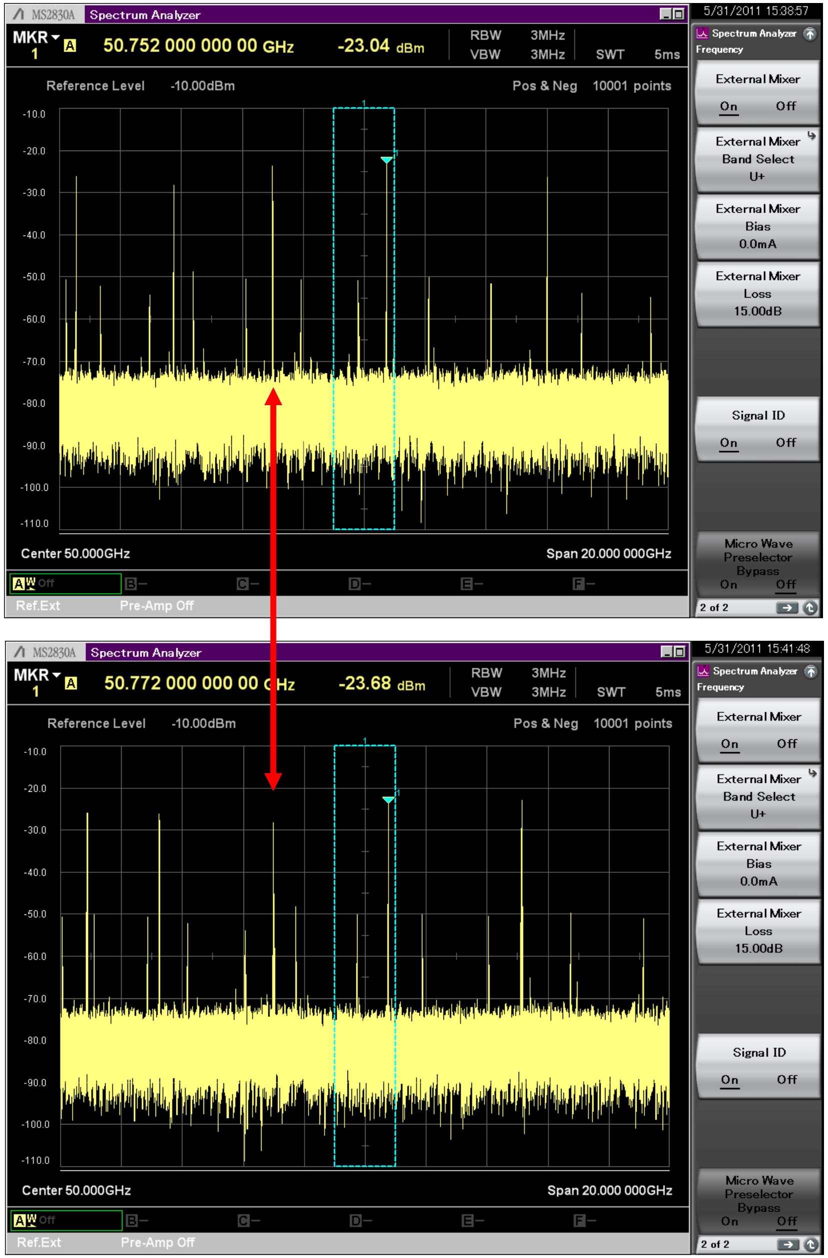

Figure 6. Signal ID function: Measurement when ON (alternate sweeping)

Top: Normal LO sweep mode

Bottom: Changed LO sweep mode

Red arrow shows actual signal position (47 GHz)

5. Signal ID Function (3/3)

The Signal ID function sweeps alternately in the two LO sweep modes (one is the normal sweep mode) shown in equation (1). As a result, the frequency of false responses changes at each sweep. By using this characteristic and setting the Storage Mode at Signal ID to ON to Min Hold, it becomes possible to remove false responses other than the true signal from the screen display.

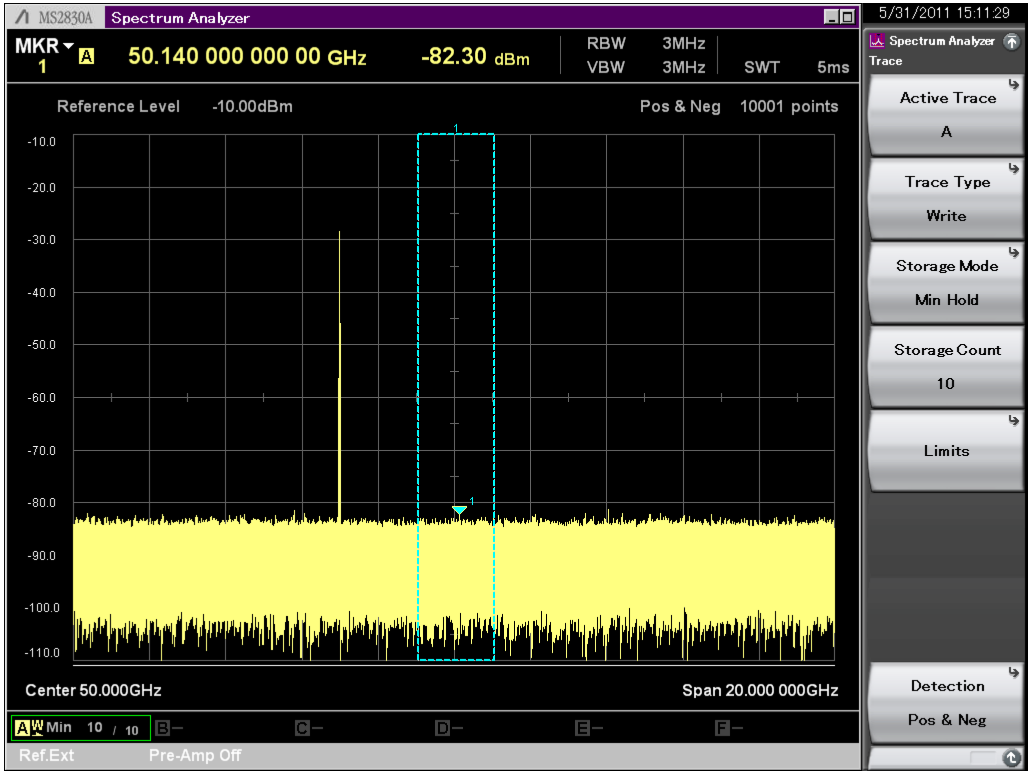

Figure 7. Signal ID: Measurement of 47 GHz signal with Min Hold setting ON

Wideband Millimeter-wave Signal Analysis(1/2)

Installing the Analysis Bandwidth (Opt-005/006/009/077*1/078*1) option up to 125 MHz supports millimeter-wave modulation analysis with the signal analyzer. In addition, harmonic mixing internal band and IF signals from the external mixer can be output from the back-panel IF Output connector. Because the IF frequency is 1.875 GHz, this can be used as a down-converter for millimeter-wave wideband modulation signal analysis, such as the 1 GHz*2 modulation bandwidth.

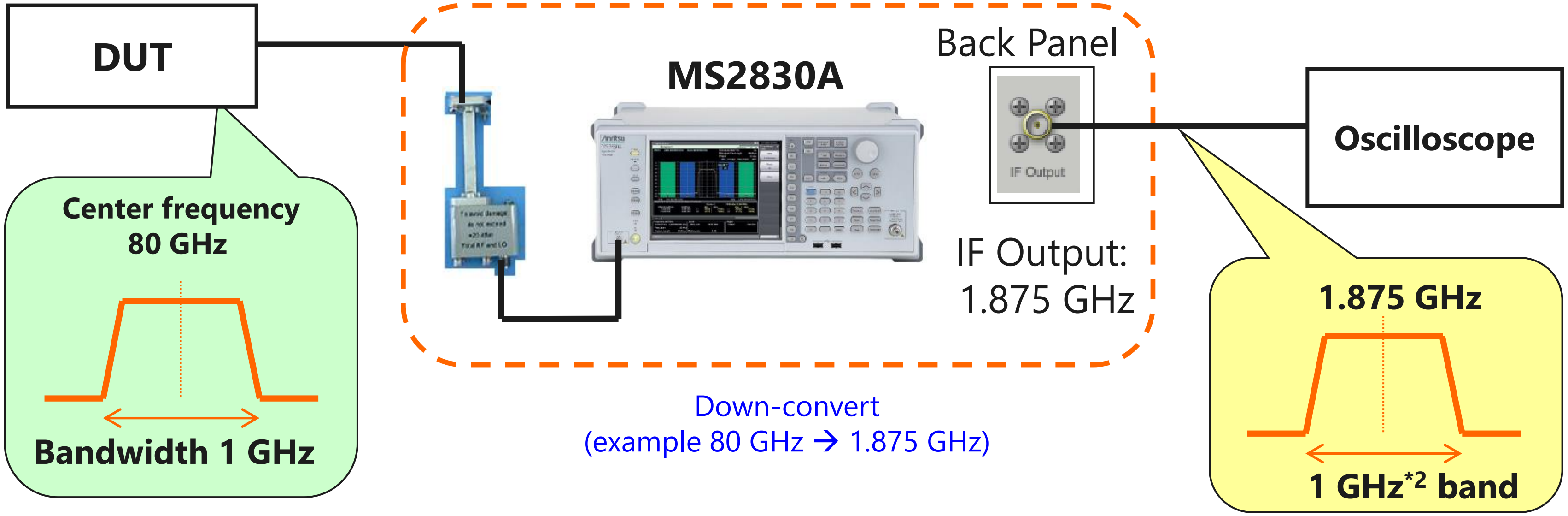

Figure 8. Measurement image: Down-convert signals with 80 GHz center frequency and 1 GHz* bandwidth to 1.875 GHz

*1: An image response is received when setting the bandwidth to more than 31.25 MHz. This can be used when not inputting a signal frequency outside the MS2830A analysis bandwidth (125 MHz max.).

*2: When using external mixer bands, or using internal micro frequency bands (Band; 3 to 9) with Microwave Preselector Bypass option: On

Wideband Millimeter-wave Signal Analysis(2/2)

The graph below shows the IF output (1.875 GHz) frequency reference characteristics. The characteristics are approx. +1/–2 dB within the 1 GHz band.

These frequency characteristics are for the internal MS2830A-044/045. Actual results include the frequency characteristics for accessories, such as the external mixer, and cables between the external mixer, MS2830A-044/045 and IF output terminal.

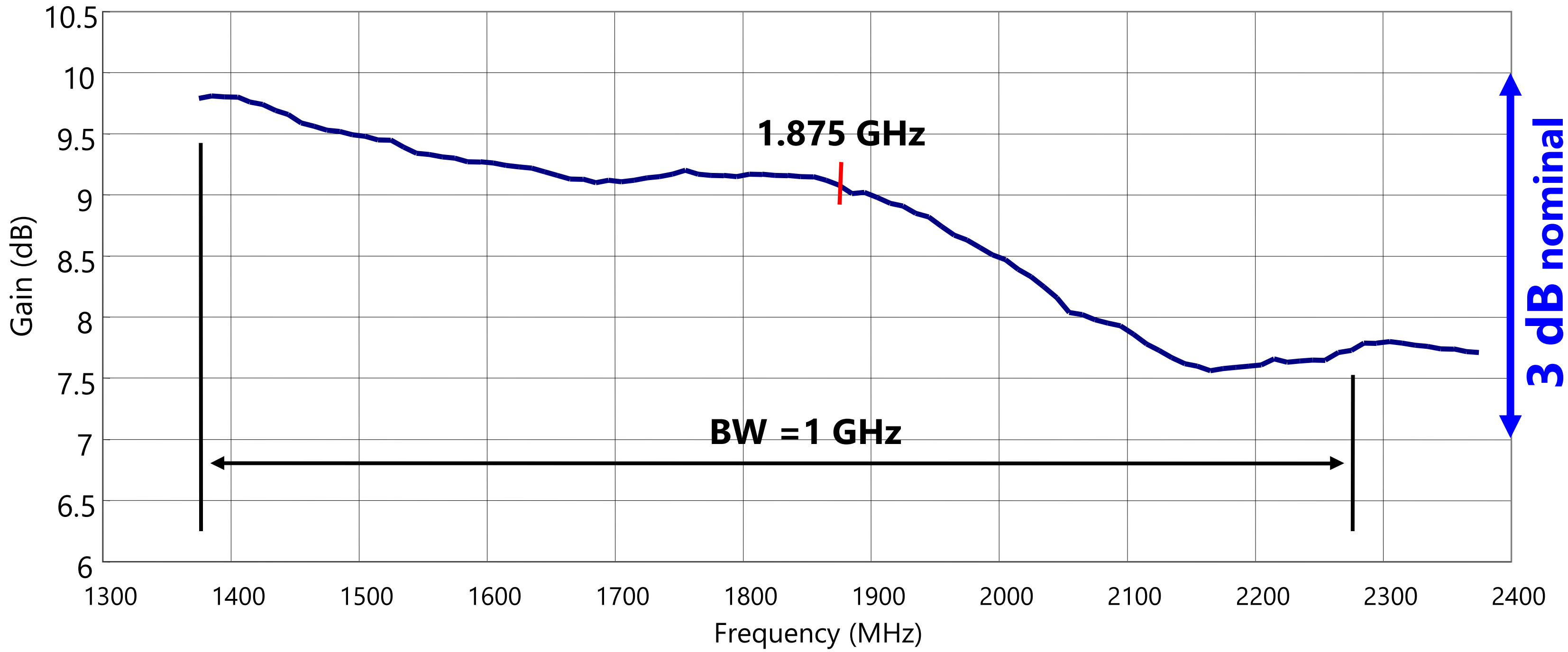

Figure 9. IF Output frequency characteristics reference values (internal MS2830-044/045 only)

External Mixer Product Lineup

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Anritsu supports external mixers for the MA2740C/MA2750C series.

Using these external mixers enables monitoring up to 325 GHz.

Table 1. External mixer band list

Model	Frequency Band	Frequency Range	LO Harmonic Order	Mixing Mode	Conversion Loss* (dB)	Waveguide flange		Waveguide size
							UG-xxx/U Equivalent	
MA2741C	A Band	26.5 to 40 GHz	4	+	23	MIL-DTL-3922/54-003	UG-599U	WR28
MA2742C	Q Band	33 to 50 GHz	5	+	26	MIL-DTL-3922/67D-006	UG-383U	WR22
MA2743C	U Band	40 to 60 GHz	6	+	28	MIL-DTL-3922/67D-007	UG-383U-M	WR19
MA2744C	V Band	50 to 75 GHz	8	+	32	MIL-DTL-3922/67D-008	UG-385/U	WR15
MA2745C	E Band	60 to 90 GHz	9	+	36	MIL-DTL-3922/67D-009	UG-387/U	WR12
MA2746C	W Band	75 to 110 GHz	11	+	39	MIL-DTL-3922/67D-010	UG-387/U-M	WR10
MA2747C	F Band	90 to 140 GHz	14	+	40	MIL-DTL-3922/67D-M08	UG-387/U-M	WR08
MA2748C	D Band	110 to 170 GHz	17	+	45	MIL-DTL-3922/67D-M06	UG-387/U-M	WR06
MA2749C	G Band	140 to 220 GHz	22	+	50	MIL-DTL-3922/67D-M05	UG-387/U-M	WR05
MA2750C	Y Band	170 to 260 GHz	26	+	65	MIL-DTL-3922/67D-M04	UG-387/U-M	WR04
MA2751C	J Band	220 to 325 GHz	33	+	70	MIL-DTL-3922/67D-M03	UG-387/U-M	WR03

*: Conversion Loss value is a typical value near the center frequency of each band and it doesn’t guarantee.

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