Harmonic Mixers

And their application with Spectrum Analysers

Application Note

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General

A harmonic mixer is another term for a sub-harmonic mixer (SHM) but is more commonly used for systems using higher multiples of the input local oscillator (LO) to produce the mixing LO. They lend themselves well at higher frequencies when it can be difficult to produce a suitable LO signal. For example, tuning range and output power become more difficult to achieve at higher frequencies, whilst the cost invariably increases.

Farran Technology's Harmonic Mixer series covers four bands from 40GHz to 110GHz and are 2-port balanced harmonic mixers.

Figure 1: WHMB-15 Harmonic Mixer

Applications

- Spectrum Analysis Frequency Extension

Features

Model	WHMB-19	WHMB-15	WHMB-12	WHMB-10
Frequency Range(GHz)	40-60	50-75	60-90	75-110
LO Frequency Range (GHz)	10-15.2	8-13	10-15.2	9.4-14
Conversion Loss Typ* (dB)	20	25	32	38
Max Input Power (mW)	10	10	10	10
Max LO Level (dBm)	18	18	18	18
Waveguide Size	WR 19	WR 15	WR 12	WR 10
Waveguide Flange	UG383/U-M	UG385/U	UG387/U	UG387/U-M
Output Connector	SMA-F	SMA-F	SMA-F	SMA-F

Description

Fully calibrated broadband balanced diode mixer.

***NOTE:** Conversion Loss specifications in the table are dependent on LO harmonic number used.

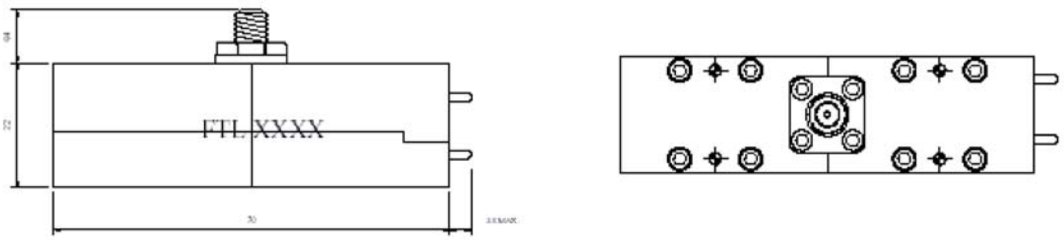

Figure 2: Mechanical Outline of Harmonic Mixer

The balanced harmonic mixer has advantages and disadvantages compared to an unbalanced harmonic mixer. Two significant advantages of the balanced mixer configuration are the suppression of odd LO harmonic mixing products and the elimination of the need for biasing. These result in a cleaner spectrum analyser display making signal identification easier, but an increase in LO power is also required.

Calibration Techniques

Any of the harmonic mixers can be used successfully with a Spectrum Analyser. In particular, the Agilent E4447A PSA series shall be discussed in the following paragraphs. To preserve quality in the millimetre wave spectrum analysis measurements, it is important to calibrate the combination of spectrum analyser and harmonic mixer at the desired frequency or frequencies of interest. Ideally the user must have a signal source of known amplitude for each frequency to be investigated and a method of power measurement to identify the amplitude of the signals.
In correctly choosing a harmonic mixer for the application, it is necessary to choose one that will cover that harmonic frequency of interest within the mixer's frequency band.

Once a measurable calibration signal has been achieved at the frequency of interest, the signal must be attenuated to a level of less than -20dBm to avoid compression of the harmonic mixer during calibration. It is recommended to use a precision rotary vane attenuator exhibiting full band and very flat response. Such attenuators can be most accurately calibrated with a millimetre wave capable vector network analyser (VNA). Farran Technology manufactures a range of Frequency Extension products to work with a VNA that can be used for this purpose.

An Example using a WHMB-15

The best way to demonstrate the technique is by way of an example. In this case a Farran Technology WHMB-15 Harmonic Mixer is to be used together with the Agilent E4447A Spectrum Analyser. First of all let's look at the Spectrum Analyser.

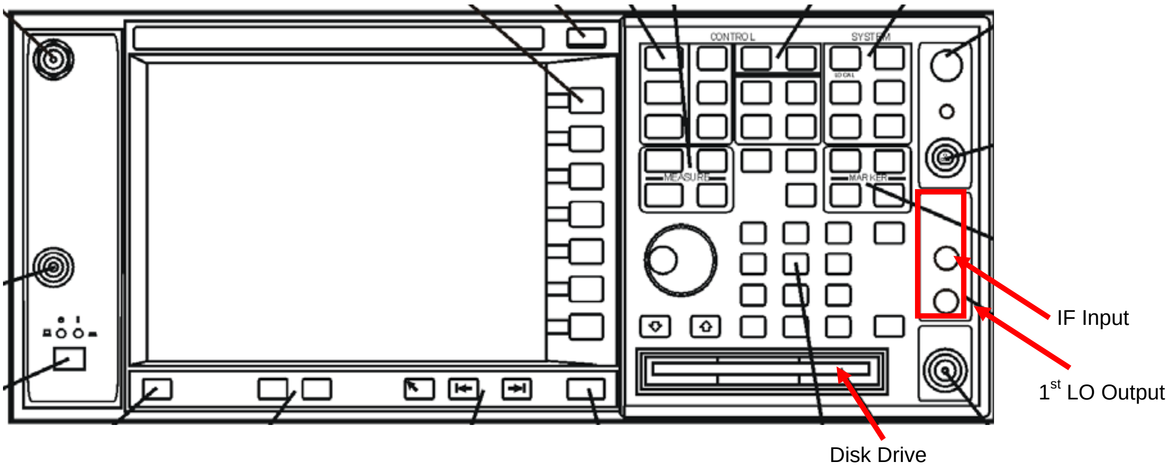

Figure 3: Diagram of Front Panel of E4447A

The highlighted box shows the IF input and 1st LO output ports of the E4447A. Note that these ports (hardware) and associated display functions (software) are only available with Agilent Option AYZ. These are the ports that allow connection for an external mixer. In order to connect a harmonic mixer, a diplexer is required. The purpose of the diplexer is to split the IF out so it can be connected to the IF port and combine the LO on to a single line connected to the mixers LO/IF line. A harmonic of the LO from the E4447A mixes with the incoming RF and an IF signal is generated. The IF is low pass filtered in the diplexer and sent to the IF port of the E4447A.

The harmonic mixer is typically shipped from the factory with calibration data for a specific harmonic. The calibration data as well as being physically printed on the harmonic mixer is available on a calibration diskette suitable for loading into the E4447A disk drive. The Amplitude Correction Factor (mixer conversion loss) can now be loaded and stored and the Amplitude Correction function should be enabled. The system is now ready for measurement.

If it is required that a calibration is required that is based on a different harmonic number then further techniques are described for user calibration of the harmonic mixer.

User Calibration of Harmonic Mixer

The following paragraphs show how a user can calibrate the harmonic mixer when it is required to use perhaps a different harmonic number. Note must be made of the fact that a suitable signal source and power measuring equipment must be available.

The test equipment set-up is defined for the calibration:

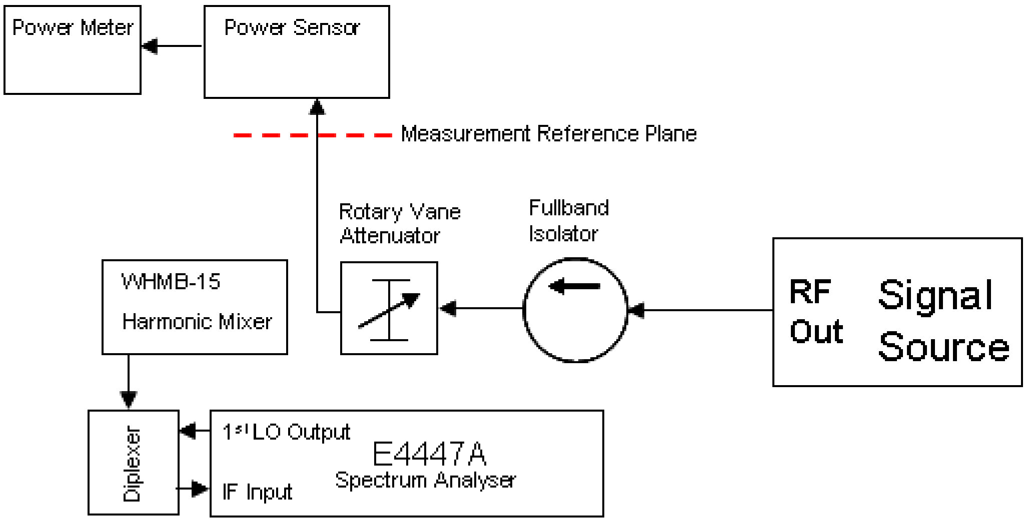

Figure 4: Test Set up for Calibration

After ensuring that the power meter is calibrated for the power sensor at the frequency of interest, adjust the calibrated attenuator to give a predetermined level of -20dBm. Select External Mixer mode on the E4447A and Mixer Type to be Unpreselected (the analyser default setting). Next select the external mixer band (in this case 50-75GHz). Load and store the Amplitude Correction Factor (mixer conversion loss – as provided with the mixer) and enable the amplitude correction function. Manually select the harmonic number as required.

Applying the -20dBm calibrated signal to the harmonic mixer, the level of the IF can now be measured on the E4447A.

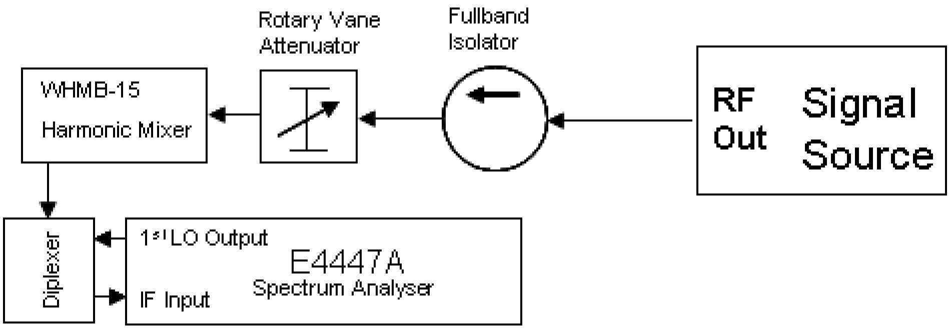

Figure 5: Test Set up for Measurement

Setting the appropriate start (50GHz) and stop (75GHz) frequencies on the analyser, the measurements can begin.
Initial analysis and signal identification is often done at this wide frequency span to find signals whose precise centre frequency is not known and to identify potential interfering signals or unwanted conversion products. After analysis, the span can be made smaller and centred on the frequency of interest.

Using the Signal Identification Features

The Image Shift function method does not remove undesired signals from the measurement but causes them to shift position on alternate sweeps. The desired signal is unaffected and in this way can be easily identified.

The Image Suppress function of the E4447A can actually remove undesired signals from the measurement display based on a multilayered function approach similar to that of the Image Shift function.

Conclusion

It can be seen that external mixing in the above described manner offers both a practical and economical solution for frequency extension using spectrum analysers. Attenuation must be paid by the user to correct calibration, set-up and knowledge of uncertainty in the test methodology in order to make meaningful, worthwhile and accurate measurements. This application note has demonstrated basic theoretical and practical examples for applications requiring external mixers.

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