Application Note

Conducted Spurious Emission into VSWR Measurement Method

MS2830A
Signal Analyzer

1. Introduction

With the recent shift of Land Mobile Radio (LMR) to narrower bandwidths and digital technologies, there is a need for more channels in the limited frequency allocation and spurious measurement standards are becoming more severe in an attempt to reduce the impact on other radio equipment.

As an example, digital and analog transmitters in North America using the latest standards require measurement of spurious emissions at the antenna under varying loads.
For the main digital radio communication technology in N. America, these measurement standards are specified in P25 (Phase 1 and Phase 2) of TIA-102 as 'Conducted Spurious Emission into VSWR.' For analog communication technology, they are specified in TIA-603-D as Transmitter Stability into VSWR.

Conventionally, spurious is measured using only a spectrum analyzer but because these new standards for spurious measurement take load variation into consideration, a combination of multiple pieces of measurement equipment, such as spectrum analyzer, signal generator, etc., is required.

This application note explains the basic procedure for measuring Conducted Spurious Emission into VSWR.

2. Test Objective

The Conducted Spurious Emission into VSWR test evaluates the UE spurious level assuming a real usage environment.
Usually, radio spurious is measured by connecting a spectrum analyzer using an RF cable, etc., to the antenna connector. However, sometimes, the antenna VSWR may be different from the design value.
If the connected antenna has different VSWR characteristics than the design values, the load (reflected wave) imposed on the front end of the radio equipment will be different from the design value, sometimes resulting in different spurious measurement values.
Measurement of Conducted Spurious Emission into VSWR uses a variable attenuator to ensure that the antenna VSWR meets the specifications as well as a line stretcher (variable phase device) to change the phase like that in an actual usage environment. In addition, the line stretcher is replaced by a variable impedance to evaluate radio devices with a carrier frequency of less than 175 MHz.

3. Measurement Method

This section explains the basic method for measuring Conducted Spurious into VSWR.
The measurement procedure is divided into three steps.

- Settings: The VSWR is adjusted to meet the specifications by using a variable attenuator at the output of the radio equipment.
- Spurious Generation Location Check: The line stretcher phase is changed through 360° to check the location where the maximum spurious is generated.
- Spurious Level Measurement: The connected radio equipment is changed to a signal generator and the output level at the spurious generation frequency is measured. The spurious level is calculated from the difference in the output level of the radio equipment. The accuracy of the signal generator output level and the linearity are very important in this measurement.

The actual procedure is explained on the following pages.

1. Adjusting Variable Attenuator

The variable attenuator is adjusted so the VSWR meets the standards. The variable attenuator is used to reproduce the VSWR when the antenna is connected. The value of the attenuator is changed until the value of the VSWR is within the following range measured using the network analyzer (Fig.1).

Mobile: VSWR = 3:1
Portable: VSWR = 6:1
Base Station: VSWR = 2:1

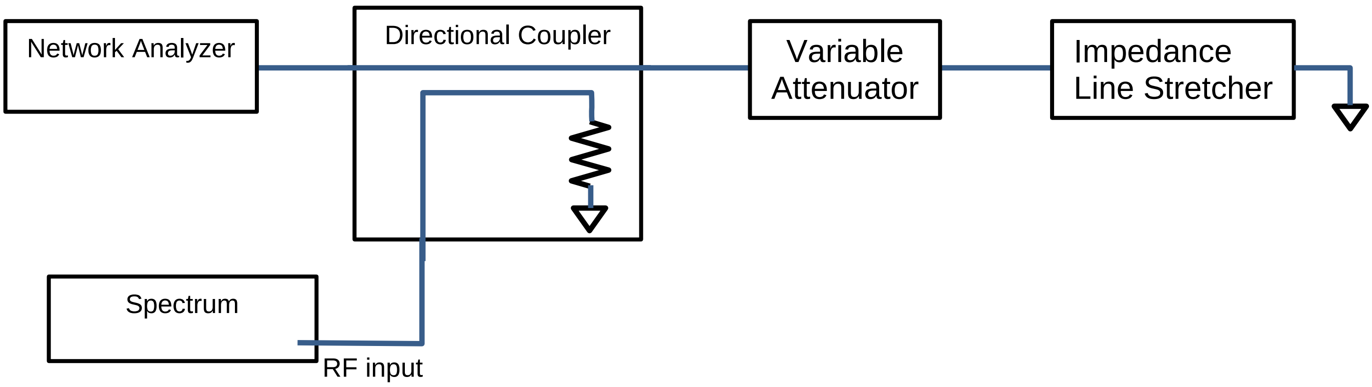

Fig.1. Variable Attenuator Adjustment Setup

The Impedance Line Stretcher is used in the following procedure to change the phase so that the spurious level becomes maximum. It is used when the frequency 175 MHz or more; if the frequency is less than 175 MHz, a Lumped Constant Line Stretcher (LCLS) is used (Fig.2). It is a short (to ground) after the Impedance Line Stretcher. The LCLS used instead of the line stretcher changes the impedance by varying the oscillation frequency using a variable capacitor.

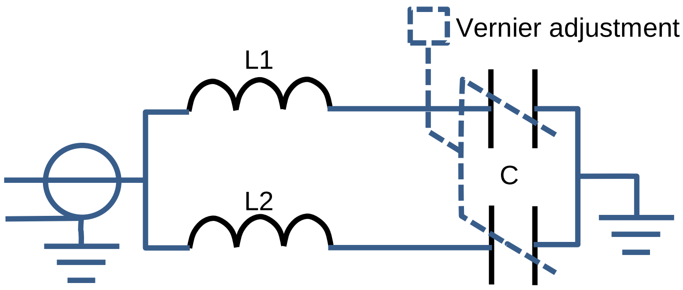

Fig.2. LCLS Schematic

Frequency (MHz)	L1 (nH)	L2 (nH)	C (pF)
25 to 33	113	554	10 to 365 pF Dual-Gang Variable Capacitor
33 to 42	69	410	
42 to 50	44	290	
130 to 150	33	123	5.9 to 50 pF Butterfly Capacitor
150 to 175	25	83	

Table 1 LCLS Settings

2. Checking Spurious Generation Location

Next, instead of the network analyzer, the radio is connected to the terminated Directional Coupler. The output of the radio is measured in this state using the spectrum analyzer and this measured value is made the reference level. The reason for setting the spectrum analyzer reference level is to control internal distortion of the spectrum analyzer mixer.

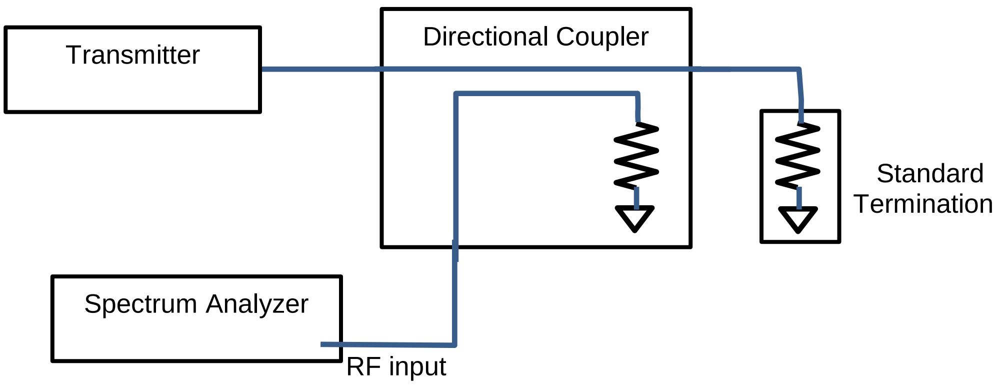

Fig.3. Reference Level Setting Connections

The spectrum analyzer settings differ according to the measurement frequency (Table 2).
P25 Phase 1 uses the peak detector setting, while TIA-603 uses the average.

	P25 Phase 2	P25 Phase 1	TIA-603
RBW <1 GHz	10 kHz	Same as P25 Phase 2	Same as P25 Phase 2
>1 GHz	1 MHz	Same as P25 Phase 2	Same as P25 Phase 2
VBW <1 GHz	30 kHz	Same as P25 Phase 2	Same as P25 Phase 2
>1 GHz	3 MHz	Same as P25 Phase 2	Same as P25 Phase 2
Sweep Time	Slow enough	Same as P25 Phase 2	<2000 Hz/s
Detector Mode	Average	Position Peak with Peak Hold	Mean or Average Power

Table 2 Spectrum Analyzer Settings

Next, instead of using a termination after the directional coupler, the variable attenuator adjusted in step 1 and the Impedance Line Stretcher are connected.
The phase of the Impedance Line Stretcher is rotated through 360° and the frequency and level when the spurious measured by the spectrum become maximum are recorded. Since measurement is performed with the reflection wave present, the recorded level is made the reference level for measuring the spurious level. Then accurate measurement is performed using the signal generator.

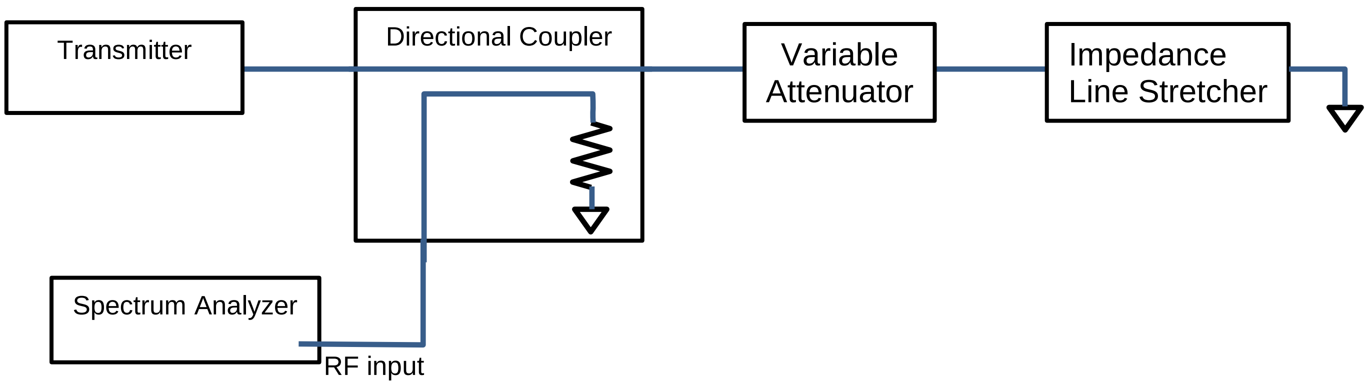

Fig.4. Spurious Generation Frequency Check Setup

3. Setting Spurious Level

Next, the signal generator is connected instead of the radio. The directional coupler is terminated so there is no reflection wave. The signal generator is set to the same frequency as the frequency at which the spurious was monitored in step 2 and a CW signal is output. The output level of the signal generator is also adjusted so that the level is the same as that of the spurious monitored at step 2. The signal generator setting level becomes the level of the spurious output from the radio.

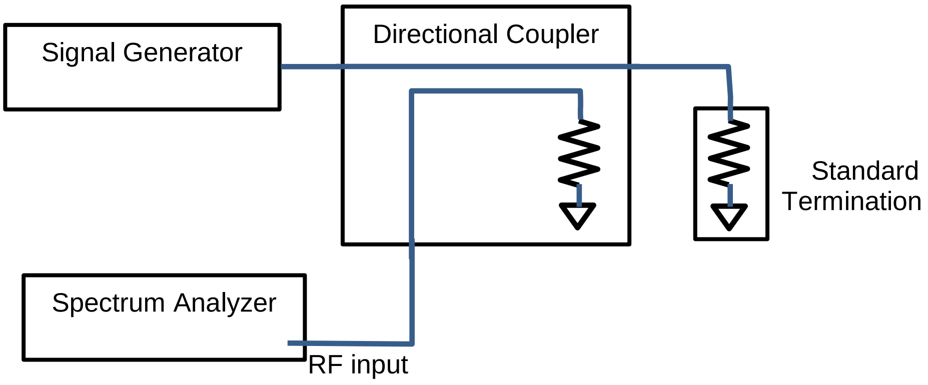

Fig.5. Spurious Level Measurement Setup

Since the MS2830A has a signal generator option, measurement can be performed using the following setup.

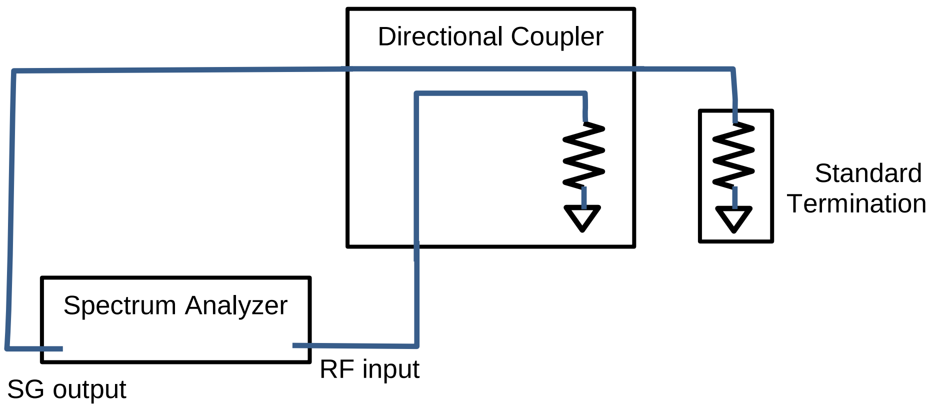

Fig.6. Spurious Level Measurement Setup

The spurious level is calculated from the radio Tx power and the output level of the signal generator measured in step 3.

$$10 \times log_{10}\left(\frac{Tx\ power\ (W)}{0.001}\right) - level\ at\ step\ 3$$

As an example, when the Tx power is 10 W and spurious frequency SG setting level is –50 dBm, the calculation is:

10 x log (10/0.001) – (–50) = 90 dB

The standard value is:

50 + 10log (P) dB, or 70 dB, where P is the average carrier power in watts.

In this example, the standard value is 70 dB because the calculation is 60 dB.

Summary

Unlike conventional spurious measurement, when a load is impressed on the output, spurious may be generated from front-end active devices. In addition, the effect of the standing wave at second- and third-order harmonics can sometimes cause larger variations in the spurious value than previously.
Consequently, this method, which adds the effect of the standing wave, is the ideal method for spurious measurements.

Specifications are subject to change without notice.

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