Wan7com, Inc.

TOIP3 or IIP3 Measurement

1. Introduction

As shown in **Figure 1**, the slope of the first order is the gain *G* of an amplifier or system, and the slope of the third intermodulation line is 3*G*. In other words, the third order output power level increases three times faster than the first order power level does. The two equations for describing the two lines are (all the units are in dB):

$$y_1 - a = G(P_{in} - P_1) \qquad (1)$$

$$y_2 - b = 3G(P_{in} - P_1) \qquad (2)$$

Then

for the output third order interception point (TOIP3)

$$a + G(P_{in} - P_1) = b + 3G(P_{in} - P_1)$$

$$\Rightarrow G(P_{in} - P_1) = \frac{a-b}{2} \qquad (3)$$

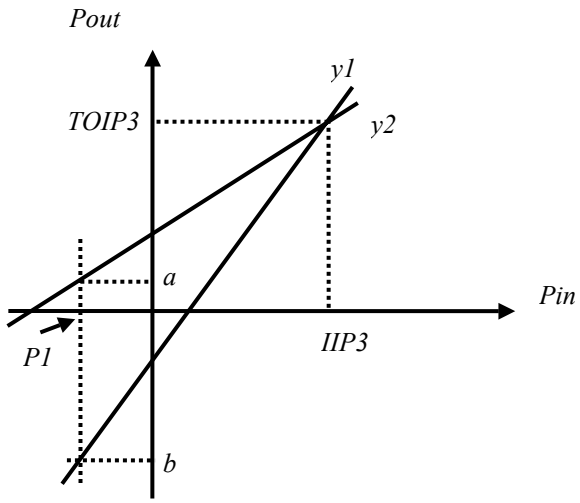

FIG. 1 TOIP3 and IIP3 concept

Substituting (3) into (1), the TOIP3 is given by

$$TOIP_3 = \frac{3a-b}{2} \qquad (4)$$

The input third order interception point (IIP3)

$$IIP_3 = TOIP_3 - G \qquad (5)$$

where *a* and *b* are the measured first order and third order output power levels, respectively.

Equations (4) and (5) can be reduced to, if the output power level of each tone is set at 0 dBm.

$$TOIP_3 = \frac{-b}{2} \qquad (6)$$

and

$$IIP_3 = \frac{-b}{2} - G \qquad (7)$$

2. Measurements of TOIP3 and IIP3

The set-up for measuring IM_3 is shown in **Figure 2**. Two signal generators are used to generate the two-tone signals. Each tone signal passes through the isolator and then is combined with the combiner. The combined two-tone signal then is fed in the DUT such as a low noise amplifier. A spectrum analyzer is used to measure the output power levels of the first product and intermodulation products such as the third order products.

The isolators are used to prevent the intermodulation products generated by the interaction between the two signal generators. The frequencies of the two-tone should fall in the pass band of the isolators. Adjust each tone source power level so that the output of each tone power level at the output of the DUT is the identical. The internal attenuation of the spectrum analyzer should be set at least 30 dB or higher than the power level of each tone to prevent the IMD products generated by the spectrum analyzer.

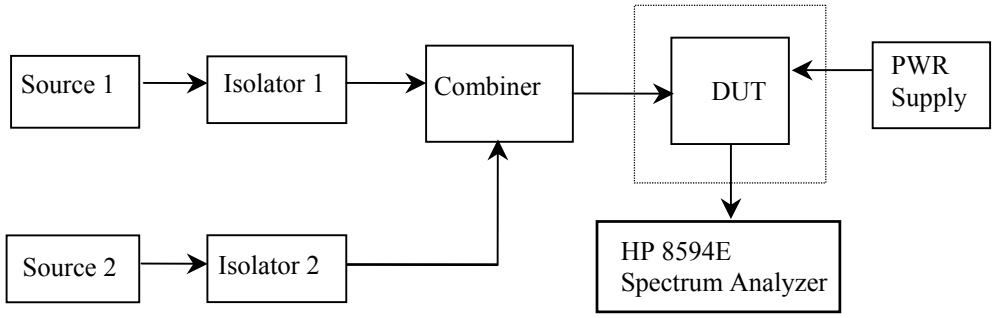

FIG. 2 The set-up for measuring IM3.

3. Example

a) Hardware List

DUT: WA08-3465 LNA, specifications:

Frequency Range	:	820 MHz ~930 MHz
Noise figure	:	1.0 dB
TOIP3	:	65 dBm
Gain	:	34 dB
Return Losses	:	>16 dB
P1dB	:	30 dBm
DC Biases	:	+8 V, 650 mA

Source 1 & 2 Signal Generators:		HP8648B
Spectrum Analyzer	:	HP8594E
Isolators + Combiner	:	WIC08-30A (WanTcom, Inc.)
Power Supply	:	HP3631A

b) Measurement Setup

- Set signal generator 1 at frequency at 894 MHz with the power level at –15 dBm;
- Set signal generator 2 at frequency at 895 MHz with the power level at –15 dBm;
- Set internal attenuation of the spectrum analyzer at 50 dB, reference level at 30 dB, center frequency at 896 MHz, and span at 5 MHz;
- Set the power supply voltage at + 8 V. Turn off the power supply;
- Connect the system as shown in Fig. 2;
- Turn RF output on at both signal generators;
- Turn on the power supply. The voltage and current displays show 08.00V and 0.650 A;
- Fine Adjust the power levels of both signal generators so that each tone power level is +20 dBm displayed at spectrum analyzer[1];
- Change Span of the analyzer to 1 kHz and press the Peak Search of the spectrum analyzer so that the marker catch the IM3 product spectrum;
- Record the third order intermodulation power level and it is –70 dBm;
- According to equations (4) and (5), TOIP3 is

$$TOIP3 = [3 \times 20 - (-70)] / 2 = 65 \text{ dBm} \quad (\text{or } IMD_3 \text{ is } 90 \text{ dBc})$$

$$IIP3 = 65 - 34 = 31 \text{ dBm}$$

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[1] Assume the cable loss between the output of DUT and the input of the spectrum analyzer has calibrated.