Microwave System Calculator: Tutorial #2
Finding IM3 products through IP3

This tutorial aims to explain how to use Microwave System Calculator to solve even simple but tricky tasks you may face in your design activity.

In particular it is very common the need to get the characteristics of an active device expressed both at the input and at the output and Microwave System Calculator can easily help you to calculate such quantities:

- IM3 [IM, IIM3, OIM3]
  Analysis of IM signals is an important part of designing RF systems where dynamic range should be optimized. Any couple of signal generates at least two spurious responses (referred to as **3**-order **I**nter**M**odulation products, IM3) when they are dealing with not linear devices. IM3 spurious signals are quite alarming because they are usually falling in the device operating frequency band. The most important factor that affects the IM value for most active devices is the capability to manage large signals: that is generally related to the output power handling capability of the device which take us to the next "point", IP3.

- IP3 [IIP3, OIP3]
  As widely known and easily demonstrable the 3rd order products are proportional to the cube of the input amplitude. So on a graph (Pin, Pout) representing both the fundamental signal and the third order products there will be, for sure, a point in which the two lines intersect each other, this point is called the Third Order Intercept Point (IP3 or TOI). The IP3 point is typically between 10 and 20 dB above the 1-dB compression point. It is worth to note that the IP3 point specification may be referred to either the input (IIP3) or the output (OIP3) but when the reference (input or output) is not specified, it is generally considered the OIP3.

So let's take a real device, for example, the Minicircuits surface mount monolithic amplifier Gali-5+; it is specified this way (f = 1GHz and I_{bias}=65mA):

Gain	19.4 dB
Pout@P1dB	18 dBm
NF	3.5 dB
OIP3	35 dBm

Let's see what can tell us Microwave System Calculator using this values as inputs (let's set input power, for example, at -20 dBm):

(Note that Microwave System Calculator use the Input IP3; getting the IIP3 from the OIP3 is quite simple:

IIP3 [dBm] = OIP3 [dBm] - Gain [dB] = (35 – 19,4) dBm = 15,6 dBm)

Microwave System Calculator input:
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Input chain:

Stage	Gain[dB]	NF[dB]	IIP3[dBm]	P1dB[dBm]	Psat[dBm]
GALI5	19.40	3.50	15.60	18.00	

Microwave System Calculator output:
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Result of calculation (by stage):

Stage	Pin[dBm]	Gain[dB]	NF[dB]	IIP3[dBm]	Pout[dBm]
GALI5	-20.00	19.40	3.50	15.60	-0.60

Result of calculation (system level):

Pin[dBm] = -20.00	**IM3[dBc]** = -71.20	**NF[dB]** = 3.50
Gain[dB] = 19.40	**IIM3[dBm]** = -91.20	
Pout[dBm] = -0.60	**OIM3[dBm]** = -71.80	
	IIP3[dBm] = 15.60	
	OIP3[dBm] = 35.00	

So, in the yellow cells the 3 values related to IM3 are reported and in the orange ones the IP3 values.

Of course in this case IP3 values were already known but when you are chaining more than just one component then this calculus could be useful.

We have shown how simple, fast and useful could be Microwave System Calculator to help you in identifying your system linearity performances.

Useful links:
http://www.minicircuits.com/products/amplifiers_monolithic.html (GALI5+)

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http://www.microwave-system-calculator.com