

# Distorsion

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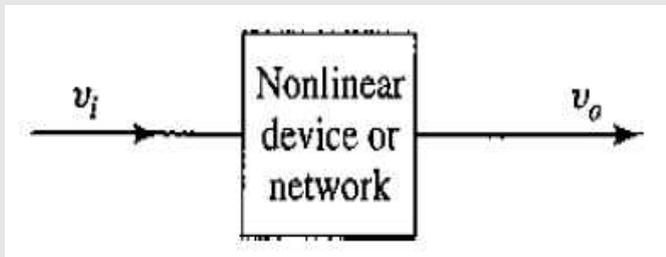
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# Impacto distorsión en RF

## No-linealidad =>

- Saturación => reducción ganancia de un amplificador
- Generación de Armónicos / Spectral Regrowth
- Distorsión por intermodulación (efecto de dos tonos de entrada)
- Conversión AM-PM: variación de amplitud altera la fase.



$$v_o = a_0 + a_1 v_i + a_2 v_i^2 + a_3 v_i^3 + \dots,$$

## Desarrollo de Taylor

$$a_0 = v_o(0)$$

$$a_1 = \left. \frac{dv_o}{dv_i} \right|_{v_i=0}$$

$$a_2 = \left. \frac{d^2 v_o}{dv_i^2} \right|_{v_i=0}$$

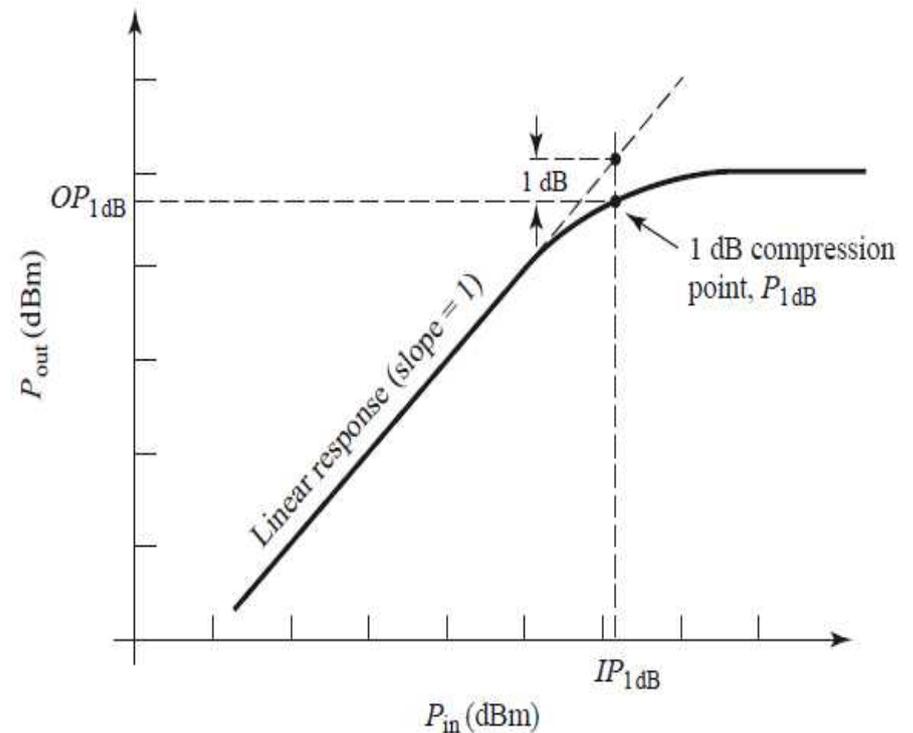
# Compresión de Ganancia

$$v_i = V_0 \cos \omega_0 t$$

$$\begin{aligned} v_o &= a_0 + a_1 V_0 \cos \omega_0 t + a_2 V_0^2 \cos^2 \omega_0 t + a_3 V_0^3 \cos^3 \omega_0 t + \dots \\ &= \left( a_0 + \frac{1}{2} a_2 V_0^2 \right) + \left( a_1 V_0 + \frac{3}{4} a_3 V_0^3 \right) \cos \omega_0 t + \frac{1}{2} a_2 V_0^2 \cos 2\omega_0 t \\ &\quad + \frac{1}{4} a_3 V_0^3 \cos 3\omega_0 t + \dots \end{aligned}$$

$$G_v = \frac{v_o^{(\omega_0)}}{v_i^{(\omega_0)}} = \frac{a_1 V_0 + \frac{3}{4} a_3 V_0^3}{V_0} = a_1 + \frac{3}{4} a_3 V_0^2$$

$$OP_{1\text{dB}} = IP_{1\text{dB}} + G - 1 \text{ dB}$$



# Distorsión Armónica y por Intermodulación

$$v_i = V_0 \cos \omega_0 t \quad \longrightarrow \quad \text{Armónicos}$$

$$v_i = V_0(\cos \omega_1 t + \cos \omega_2 t) \quad \longrightarrow \quad \text{Intermodulación}$$

$$\begin{aligned}
 v_o &= a_0 + a_1 V_0(\cos \omega_1 t + \cos \omega_2 t) + a_2 V_0^2(\cos \omega_1 t + \cos \omega_2 t)^2 \\
 &\quad + a_3 V_0^3(\cos \omega_1 t + \cos \omega_2 t)^3 + \dots \\
 &= a_0 + a_1 V_0 \cos \omega_1 t + a_1 V_0 \cos \omega_2 t + \frac{1}{2} a_2 V_0^2(1 + \cos 2\omega_1 t) + \frac{1}{2} a_2 V_0^2(1 + \cos 2\omega_2 t) \\
 &\quad + a_2 V_0^2 \cos(\omega_1 - \omega_2)t + a_2 V_0^2 \cos(\omega_1 + \omega_2)t \\
 &\quad + a_3 V_0^3 \left( \frac{3}{4} \cos \omega_1 t + \frac{1}{4} \cos 3\omega_1 t \right) + a_3 V_0^3 \left( \frac{3}{4} \cos \omega_2 t + \frac{1}{4} \cos 3\omega_2 t \right) \\
 &\quad + a_3 V_0^3 \left[ \frac{3}{2} \cos \omega_2 t + \frac{3}{4} \cos(2\omega_1 - \omega_2)t + \frac{3}{4} \cos(2\omega_1 + \omega_2)t \right] \\
 &\quad + a_3 V_0^3 \left[ \frac{3}{2} \cos \omega_1 t + \frac{3}{4} \cos(2\omega_2 - \omega_1)t + \frac{3}{4} \cos(2\omega_2 + \omega_1)t \right] + \dots \quad (10.43)
 \end{aligned}$$

“Armónicos” de  
frec.  $m\omega_1 + n\omega_2$ ,  
con  $m, n = 0, +/-1, +/-2, \dots$

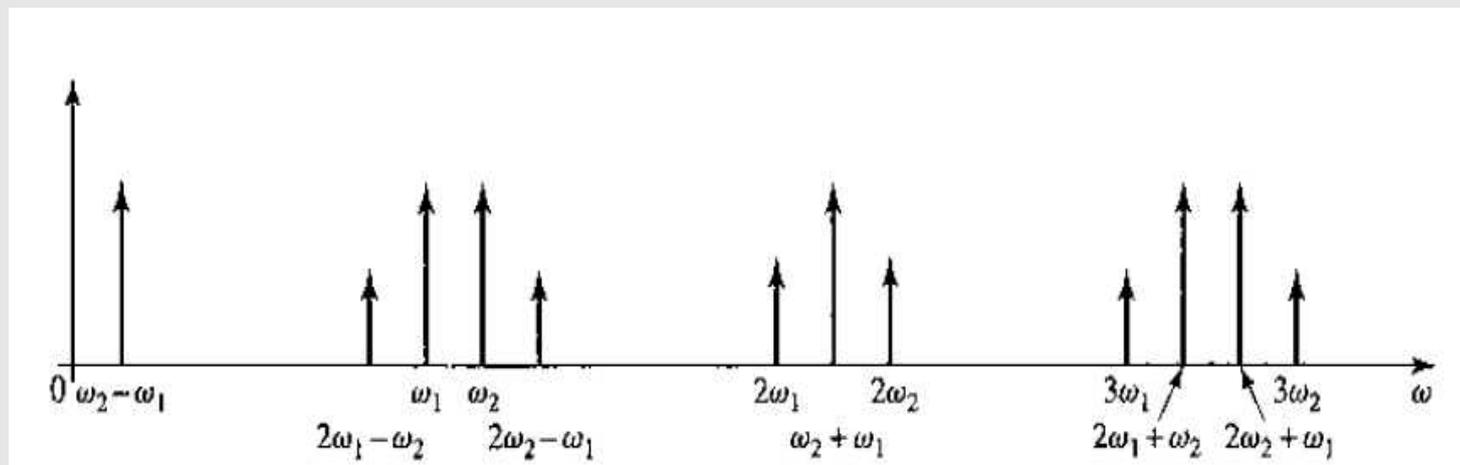
Existe en componentes pasivos (passive intermodulation) incluso uniones, más notoria a altas potencias

# Intermodulación

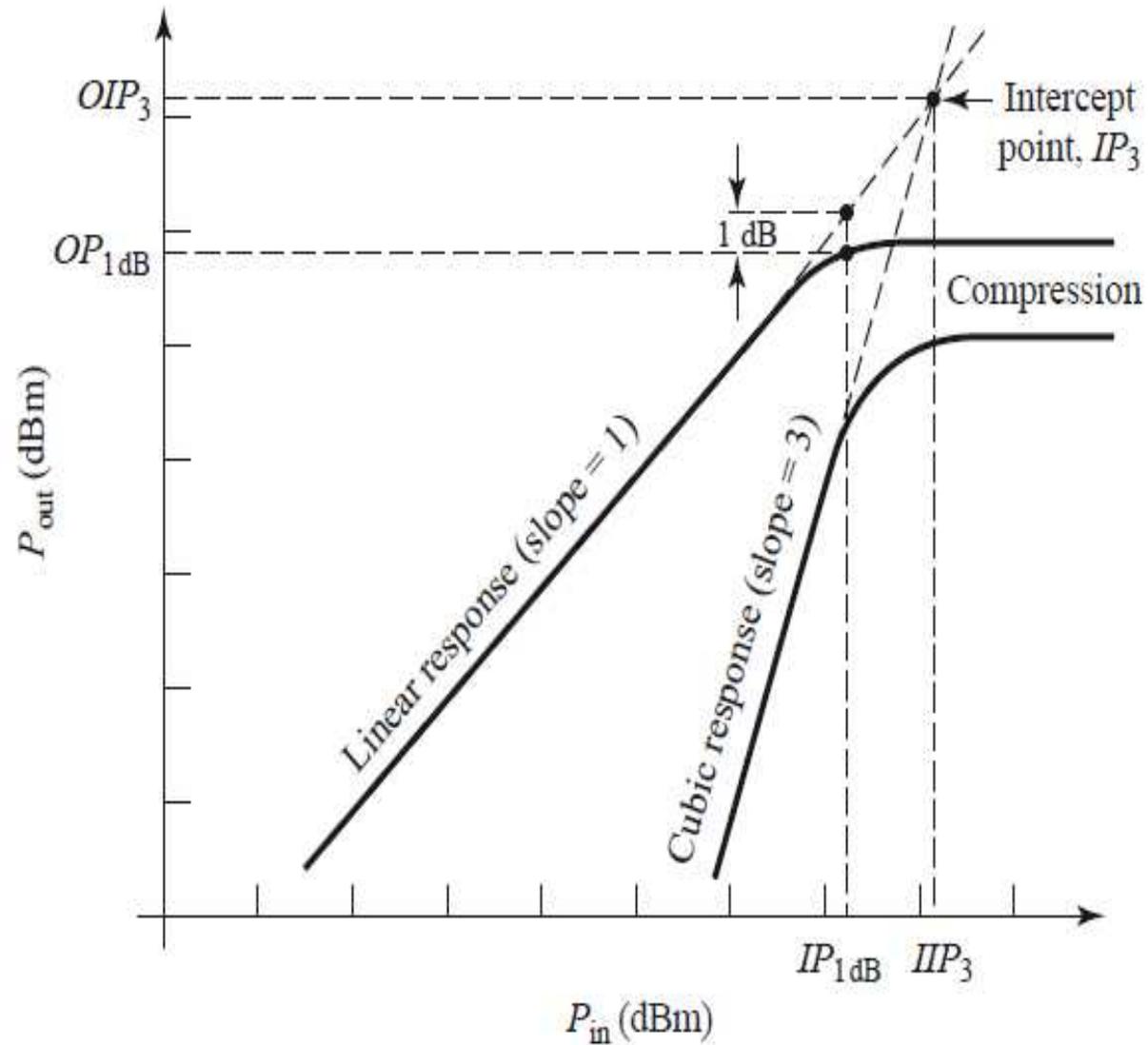
2do orden => lejos de  $\omega_1, \omega_2$

$2\omega_1$	(second harmonic of $\omega_1$ )	$m = 2$	$n = 0$	order = 2,
$2\omega_2$	(second harmonic of $\omega_2$ )	$m = 0$	$n = 2$	order = 2,
$\omega_1 - \omega_2$	(difference frequency)	$m = 1$	$n = -1$	order = 2,
$\omega_1 + \omega_2$	(sum frequency)	$m = 1$	$n = 1$	order = 2.

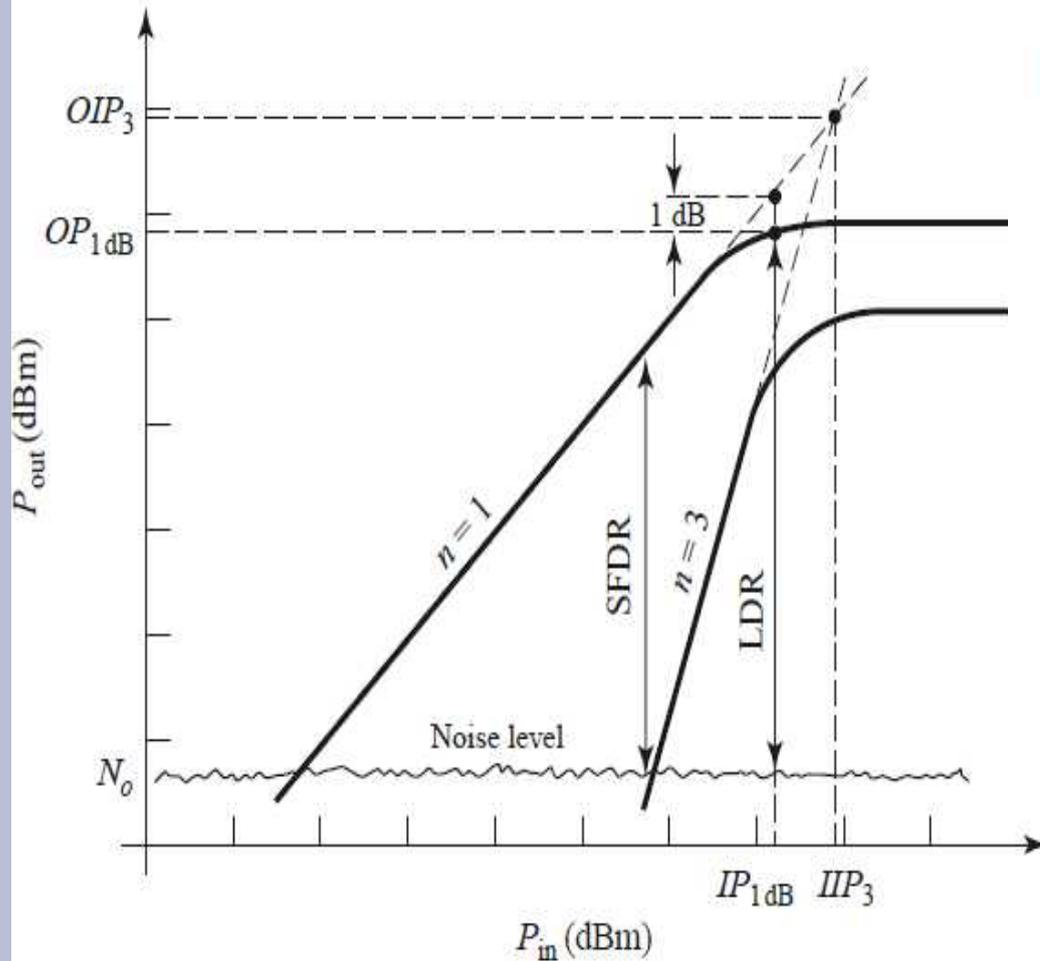
3er orden =>  $3\omega_1, 3\omega_2, 2\omega_1 + \omega_2, 2\omega_2 + \omega_1, 2\omega_1 - \omega_2, 2\omega_2 - \omega_1$



# Third-Order Intercept Point



# Rango Dinámico



$$LDR \text{ (dB)} = OIP_{1dB} - N_o$$

$$SFDR = \frac{P_{\omega_1}}{P_{2\omega_1 - \omega_2}} \Big|_{P_{2\omega_1 - \omega_2} = N_o} = \left( \frac{OIP_3}{N_o} \right)^{2/3}$$

$$SFDR \text{ (dB)} = \frac{2}{3} (OIP_3 - N_o)$$

$OIP_3$  y  $N_o$  en dBm

Si se requiere S/N (SNR) mínimo

$$\Rightarrow SFDR \text{ (dB)} = \frac{2}{3} (OIP_3 - N_o) - SNR$$

Illustrating linear dynamic range (LDR) and spurious free dynamic range (SFDR).