Talking about nonlinearity

- High power signals can sneak to other frequencies & swamp ours
- Need to be mindful in order to pick filters etc.

**Types**
- **Harmonic distortion** - one tone test \( i.e. V_{in}(t) = V_i \cos(\omega t) \)
  - Appears \( \leq 2\omega + 3\omega \) & 3rd order falls as \( \omega \rightarrow \text{gain compression} \)
  - Measure \( P_{1dB} \) to describe HD2 & HD3 in units of dBc
- **Intermodulation** - two tone test \( i.e. V_{in}(t) = V_1 \cos(\omega_1 t) + V_2 \cos(\omega_2 t) \)
  - Appears \( \leq 2\omega_1 + \omega_2 \) or \( 2\omega_2 + \omega_1 \)
  - Describe w/ IM2 or IM3 in dBc or III2 = III3

- Need to clean up intermodulation: defined when input voltages are equal
  - Cubic in product \( 3g_3 V_i^2 \cos(\omega t) \cos^2(\omega_3 t) = \frac{3g_3^3}{4} \left( 2 \cos(\omega t) \cos(\omega_3 \omega t) \right) \)
  - \( IM_3 = \text{amp in-band product w/ } V_1 = V_2 = \frac{3g_3^3}{4} \frac{V_i^3}{\omega_1 V_i} = \frac{3g_3^3}{4} \frac{V_i^2}{\omega_1} \text{ (at } +10\text{ dB}) \)
  - \( IM_2 \): similar \( = \frac{g_2}{\omega_1} V_i; \text{ (at } +6\text{ dB}) \)

**Summary table**

<table>
<thead>
<tr>
<th>Input Power</th>
<th>Gain Compression</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P_{1dB} )</td>
<td>( P_{1dB} + 1dB )</td>
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<tr>
<td>( V_i )</td>
<td>( V_i )</td>
</tr>
</tbody>
</table>

\[
IM_2 = \frac{g_2}{\omega_1} V_i; \quad \text{III } = \text{III } + 0\text{dB}
\]

\[
IM_3 = \frac{3g_3^3}{4} \frac{V_i^2}{\omega_1}; \quad V_i @ III2 = \frac{\omega_2}{\omega_1}
\]

\[
IVP = \frac{\omega_3}{\omega_1}; \quad V_i @ III3 = \sqrt{\frac{g_3^3}{\omega_1^2} \frac{1}{4}}
\]