Third Order Intercept Measurements
How are the third order products produced?

2 signals @ -10 dBm

\[ S = F_2 - F_1 \]

- \( \text{dBc} = -60 \text{ dBc} \)

\[ OIP_3 = \frac{P_{out} + \text{dBc}}{2} \]

\[ +20\text{dBm} = -10 \text{ dBm} + 30\text{dB} \]

\[ IIP_3 = OIP_3 - \text{Gain} \]

Frequency in GHz

F2-F1 = signal spacing S

.001 GHz = 1 MHz
For every dB increase in input power, the third order products will increase by 3 dB. Plotting third products versus input power predicts a 3:1 response which intersects the 1:1 response at the third order intercept point. Third order intercept point will be approximately 10 to 20 dB higher than P1dB the 1 dB gain compression point.
Intercept Point Measurements

Minimize intermod products being generated in RF sources and spectrum analyzer.

Additional attenuation between RF sources and power combiner improves isolation and minimizes interaction/mixing of sources.

Lowpass filters minimize generation of harmonics in RF sources and spectrum analyzer.

Isolation of power combiner minimizes interaction of RF sources.

Spectrum analyzer should have very high dynamic range.

Attenuators and/or isolators improve match to DUT.

Weak third order products near noise floor are actually \((S+N)/N\). Must convert to \(S/N\).

Lowpass filters minimize generation of harmonics in RF sources and spectrum analyzer.

Measure IP3 of test system by bypassing DUT.
Intercept Point Measurements

Converting \((S+N)/N\) to \(S/N\)

\[
\frac{S + N}{N} = \frac{S}{N} + 1
\]

Therefore

\[
\frac{S}{N} = \frac{S + N}{N} - 1
\]

Convert dBs to ratios, then substitute in equations

<table>
<thead>
<tr>
<th>(S+N)/N</th>
<th>S/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 dB</td>
<td>19.96 dB</td>
</tr>
<tr>
<td>10 dB</td>
<td>9.54 dB</td>
</tr>
<tr>
<td>7 dB</td>
<td>6.03 dB</td>
</tr>
<tr>
<td>5 dB</td>
<td>3.35 dB</td>
</tr>
<tr>
<td>3 dB</td>
<td>-0.02 dB</td>
</tr>
<tr>
<td>2 dB</td>
<td>-2.33 dB</td>
</tr>
<tr>
<td>1 dB</td>
<td>-5.87 dB</td>
</tr>
</tbody>
</table>

Best to set up power levels such that third order products are at least 10 dB over the noise. However, if high end dynamic range limits power that spectrum analyzer can read without saturation, then be sure to convert \((S+N)/N\) to \(S/N\) before calculating -dB/C
LNA Components and The Effect on IP3

Any mismatch due to noise matching C1/L1 improves input IP3.

Increasing L2/L3 reduces gain and improves input IP3 - watch for microwave oscillations with excessive inductance.

C9 can be used to improve IP3 - provides gain roll-off at 2X F1 or 2X F2?

R3 provides Q1 stability while reducing IP3 - R3 less than 27 Ω for about a dB reduction in IP3.

C3 and C6 normally provide a VHF/HF termination for Q1. Depending on spacing of signals used for IP3 test, values may not be large enough - may necessitate additional low frequency bypassing in the form of C7 and C8. Typical values 0.01 to 0.1 uF.

The combination of C3/C7 and C6/C8 must provide a low impedance relative to Q1 input and output impedance at F2 - F1. May have to add resistance between caps to De-Q.

C7 and C8 also used to minimize power supply noise from modulating the DC on gate and drain.

Other methods to reduce 2X F1 and 2X F2?

Printed circuit board losses.

Input (Zo)
Cascade IP3 Calculation

ATF-38143

Band Pass Filter

MGA-72543

Stage#1

Stage#2

Stage#3

OIP3 +21dBm(125.9) ∞ dBm(∞) +25 dBm(316.2)

Gain 15 dB (31.62) -3 dB (.5) 15 dB (31.62)

\[
\frac{1}{OIP3} = \frac{1}{OIP3_1 \cdot G_2 \cdot G_3} + \frac{1}{OIP3_2 \cdot G_3} + \frac{1}{OIP3_3}
\]

\[
\frac{1}{OIP3} = \frac{1}{125.9 \cdot (.5) \cdot 31.62} + \frac{1}{\infty \cdot 31.62} + \frac{1}{316.2}
\]

OIP3 = 273.075 = 24.4 dBm, IIP3 = 24.4 - 33 = -8.6 dBm