F1950 Intermodulation Product at 3.5 GHz

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• AT0069

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Agenda

• Customer is interested in the Third Order Input Intermodulation (IIP3) product for the F1950 Digital Step Attenuator at 3.5 GHz.

• Customer would like the data to be collected with the following conditions:
  – Tone spacing 10 MHz
  – Center frequencies 3.515 GHz and 3.615 GHz
  – Input power levels of +10, 0, and -7 dBm.
  – Attenuation States 0, 8, 12, 15, 20, 25, and 31.5 dB

• Our datasheet only shows the data at 0.900 GHz and 1.900 GHz.

• The IIP3 is typically around +65 dBm.
Test Procedure

• Due to the high intermodulation products value (typically +65 dBm) extreme care must be taken in the setup.
• Here is a table to show the required power need to be measure for IM$_3$ term assuming a IIP3 value of +65 dBm.
• IL is the insertion loss for the DUT at a attenuator setting.

<table>
<thead>
<tr>
<th>Pin (dBm)</th>
<th>IM$_3$ (dB)</th>
<th>$P_{im}$ (dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+10</td>
<td>110</td>
<td>-100 - IL</td>
</tr>
<tr>
<td>0</td>
<td>130</td>
<td>-130 – IL</td>
</tr>
<tr>
<td>-7</td>
<td>144</td>
<td>-151 – IL</td>
</tr>
</tbody>
</table>
Test Procedure

• Equipment issues mean that ALL components must not interact.
• Any non-linearities must be eliminated or completely masked.
• Passive components, mostly filters, are used.
• Due to filters the following changes to the test plan are being done.
  – Tone spacing is 60 MHz. This allows the RF source tunable filters so there is 40 dB isolation one tone spacing away.
  – Center frequency will only be set for 3.5 GHz due to the limitation on setting the RF source tunable filters.
  – Added all major bits for testing.
Test Procedure

• Test setup configuration:
  – Low pass filter on RF Sources reduce the harmonics by another 30 dB.
  – Reduce source coupling by
    • Tunable filters on RF Sources create 40 dB isolation at one tone spacing.
    • Isolators add another 20 dB of isolation
  – Add 3 pads before and after to create a better match.
Test Procedure

• Test setup configuration:
  – Input power was set for the required power.
  – Power sensor is required to measure the fundamental power at the output to measure the insertion loss of the DUT.
  – Power sensor is highly nonlinear. Adding a 15 dB pad creates a better match. Sensor had a dynamic range from -70 to +20 dBm so the extra loss can be accommodated.
  – Only the lower IM product is measured to reduce the loss from the DUT to the spectrum analyzer.
Test Setup

\[ f_1 = 3.470 \text{ GHz} \]

\[ f_2 = 3.530 \text{ GHz} \]

\[ fc = 3.470 \text{ GHz} \]

\[ fc = 3.530 \text{ GHz} \]

\[ fc = 2 \times f_1 - f_2 = 3.410 \text{ GHz} \]
Test Setup Measurement

• With no RF power applied the Spectrum Analyzer has a noise floor of -149 dBm.

• With all the care taken in the setup, setting the input power to +10 dBm, and inserting a zero length transmission line, a IM$_3$ tone is still seen on the spectrum analyzer with a power level of -143.5 dBm.

• This yields a IIP3 of +83 dBm.
F1950 IIP3
+25 C, $f_c = 3.500$ GHz, Tone spacing = 60 MHz

Input IP3 (dBm)
Attenuation State (dB)

Pin=+10 dBm, IIP3
Pin= +5 dBm, IIP3
IM Power Measurements

F1950 IM3 Power Levels
+25 C, FC = 3.500 GHz, Tone spacing = 60 MHz

Device to Spectrum Analyzer loss is 6.5 dB which limits the actual noise floor.
Observations

• During the testing with an input power level of +5 dBm, the IM3 product was limited to the system IM3 for attenuation states greater than 15 dB.
• No testing can be done for input power of 0 and -7 dBm because the system noise is reached at the reference state (0 dB).
Conclusion

- At input power levels of +10 dBm and +5 dBm, the typical IIP3 is +66 dBm at 3.500 GHz.
- From the datasheet the input power compression for the F1950 Digital Step Attenuator is > +20 dBm. Since at both input power levels yield the same IIP3 value it is safe to assume the value is consistent for all input power levels below +5 dBm.

- **IIP3 measurements at 3.500 GHz are similar to the measured data at 0.900 and 1.900 GHz in the datasheet.**
- **This implies the IIP3 is around +65 dBm across the band.**