AN14696

Loadpull Test Report for KW47

Rev. 2.0 — 10 December 2025 Application note

Document information

Information	Content
Keywords	KW47, AN14696, Loadpull, Tuner
Abstract	This document explains the purpose of measurements, such as monitoring the supply current, transmit power, and the harmonics level. These measurements are monitored while the complex output load seen by the DUT is tuned in amplitude and phase.

1 Introduction

This document explains the purpose of measuring the supply current, the transmit power, and the harmonics level. These measurements are monitored while the complex output load seen by the device under test (DUT) is tuned in amplitude and phase.

The automated impedance tuner MT982EU30VI from MAURY MICROWAVE is used to vary the DUT load.

1.1 Test limitations

The harmonics rate depends on the DUT load value at the fundamental frequency and the harmonic frequencies.

For the described measurements, you can control the load at the fundamental frequency. But, the return loss of the impedance tuner at the harmonic frequencies is not known.

1.2 Power and supply current results

The following results are the summary of power and supply currents:

- VSWR = 1:1
  - Power at µFL pin: +9.69 dBm for an EVK power consumption of 26.89 mA
- VSWR = 2:1
  - The power varies from +8.16 dBm to +9.97 dBm depending on the phase
  - Delta TX power is 1.81 dB and delta power consumption is 1.82 mA
  - Maximum power at µFL pin: +9.97 dBm for an EVK power consumption of 28.07 mA
  -
- VSWR = 3:1
  - The power varies from +6.92 dBm to +9.43 dBm depending on the phase
  - Delta TX power is 2.51 dB and delta power consumption is 3.44 mA
  - Maximum power at µFL pin: +9.43 dBm for an EVK power consumption of 28.55 mA

1.3 Conclusion

The test results of transmit power, supply current, and the harmonics are given below:

- TX power level: up to 2.51 dB variation with a poor quality antenna (VSWR = 3:1)
- Supply current: Significant extra consumption (~3.4 mA) with a poor quality antenna (VSWR = 3:1)
- Harmonics:
  - H2: More sensitive to poor quality antenna (out of ETSI limits sometimes)
  - H3: Sensitive, but maximum within an acceptable range

2 Hardware test setup

This section provides the DUT information and the software used for tuning. For details, see Section 2.1.

In addition, this section provides how to set up the software test bench for load pull and characterize the tuner.

2.1 Boards

Figure 1 shows the EVK board of KW47.

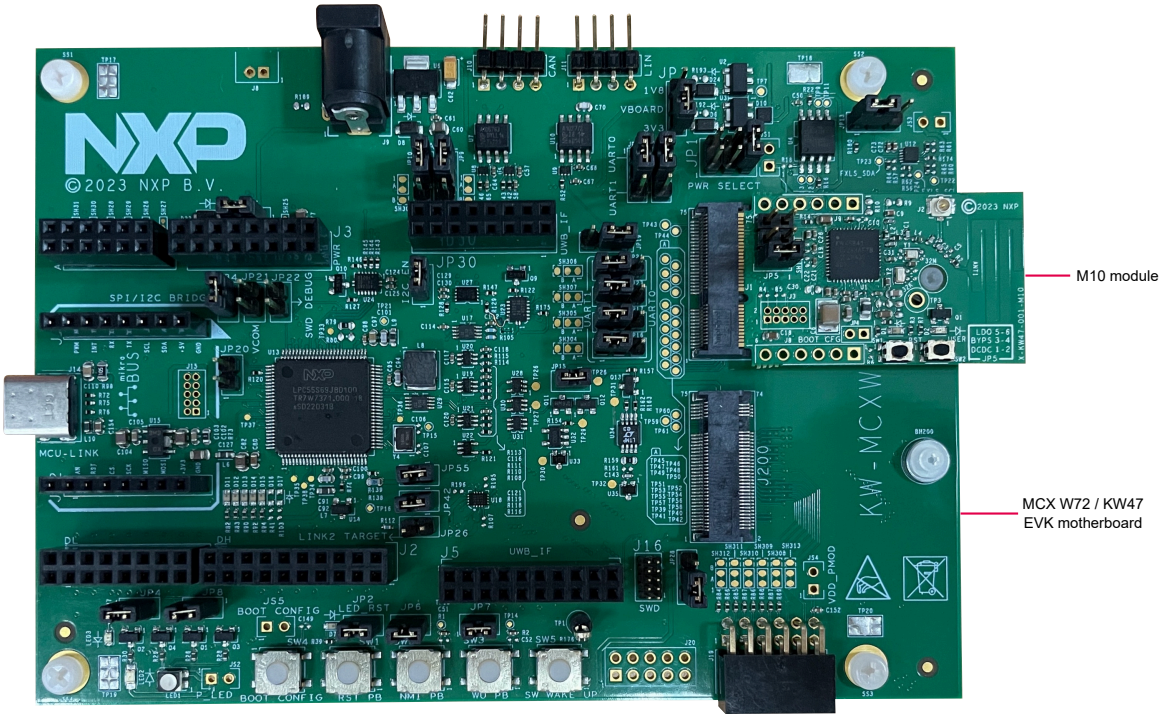

Figure 1. KW47-EVK board

2.2 Software

To control the measurement on the Maury tuner, use IVCAD from Dassault System.

2.3 Tuner description

The tuner information is provided in the following sections:

2.3.1 Tuner reference

The tuner used is from Maury and the model is MT982EU30VI.

2.3.2 Tuner characterization

After calibration, the impedance pattern is verified as shown in Figure 2.

Figure 2 represents 127 points distributed from VSWR = 1 (50 Ω) to VSWR = 3.

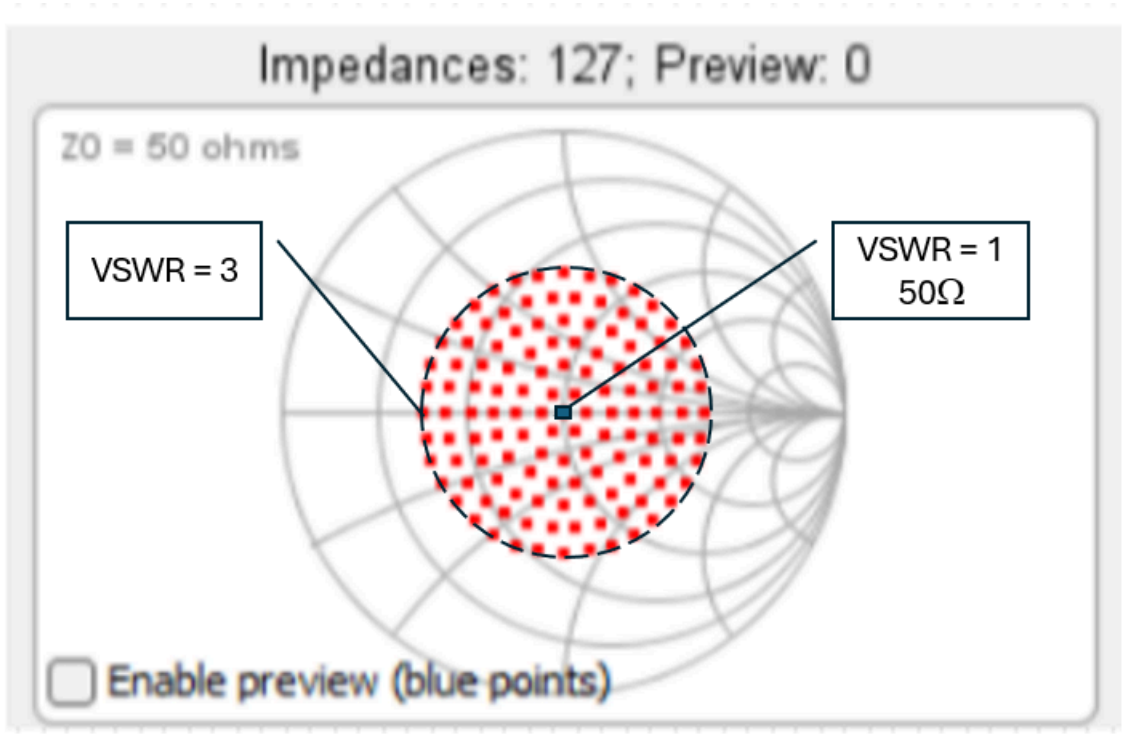

Figure 2. Impedance pattern

2.4 Load pull test bench description

This section provides the list of hardware and parameters for measurement.

2.4.1 Devices list

Figure 3 is the block diagram which shows the list of used hardware.

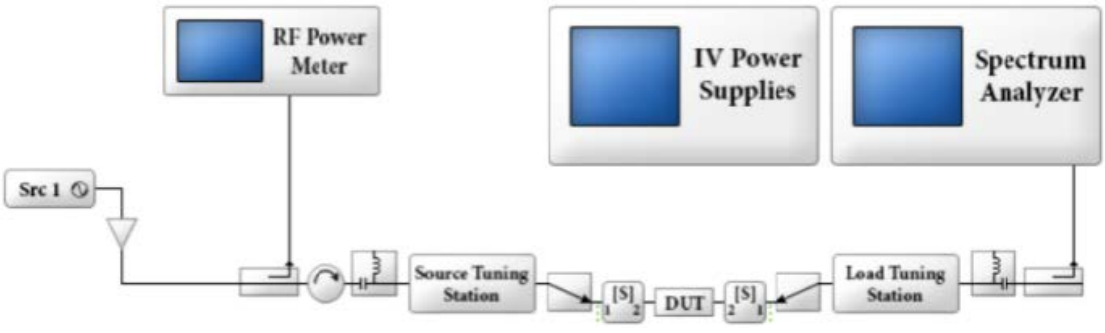

Figure 3. Hardware lab bench setup

Table 1. Hardware

Devices list	Reference
Power Meter	Keysight N1912A [05;40] GHz
Impedance Tuner	Maury MT982EU30VI

Table 1. Hardware...*continued*

Devices list	Reference
Spectrum Analyzer	Rohde ad Schwarz
Ammeter or Voltmeter	-
RF couplers	-

2.4.2 Measured parameters

The measured parameters are:

- The output load impedance,
- The RF output power, and
- The EVK power consumption.

The listed parameters are reported at the fundamental frequency, at the second, and the third harmonic frequency.

The tuner controls the only impedance at the fundamental frequency.

2.5 Software lab bench setup

Figure 4 shows the software used for tuning.

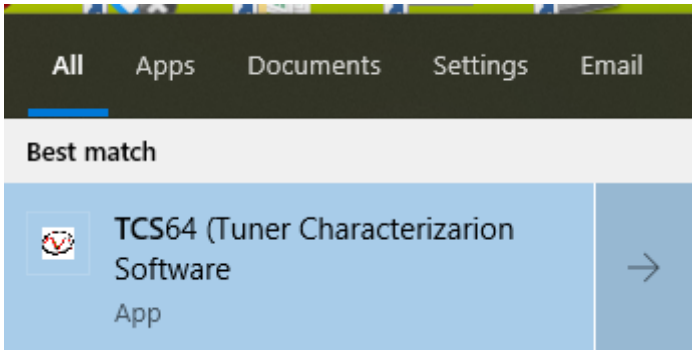

Figure 4. TCS software

The tuner and the spectrum are declared in the right way and ready to use.

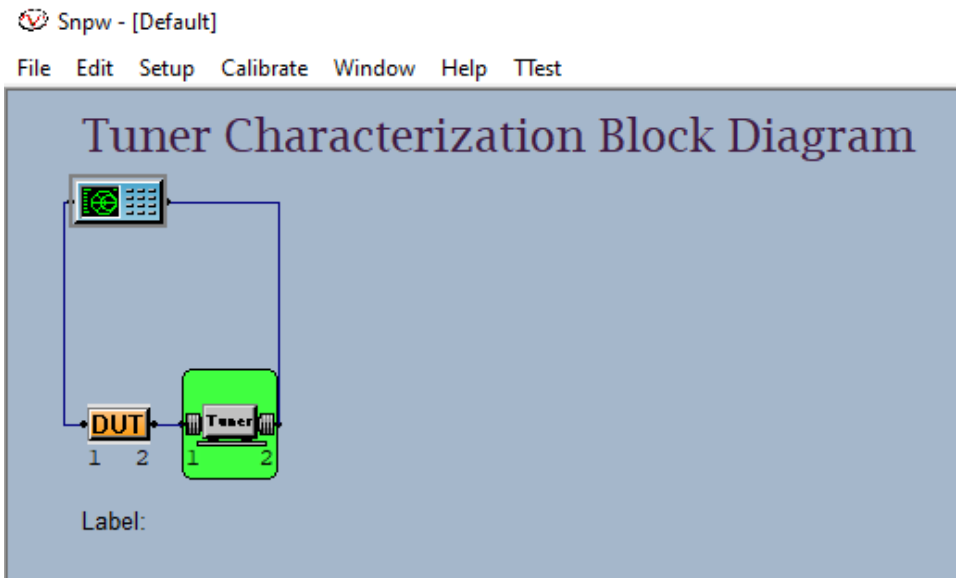

Figure 5. Tuner characterization block diagram

2.6 Characterizing the tuner

Perform the following steps, when the tuner is ready for characterization:

1. Verification: To move the tuner to one position, right-click the mouse and click ‘Move Tuner’
2. Check on Spectrum the S11
   For example:
   - Real Amplitude = 0.621 dB
   - Phase = 19.51°
   - Ga = -2.58 dB

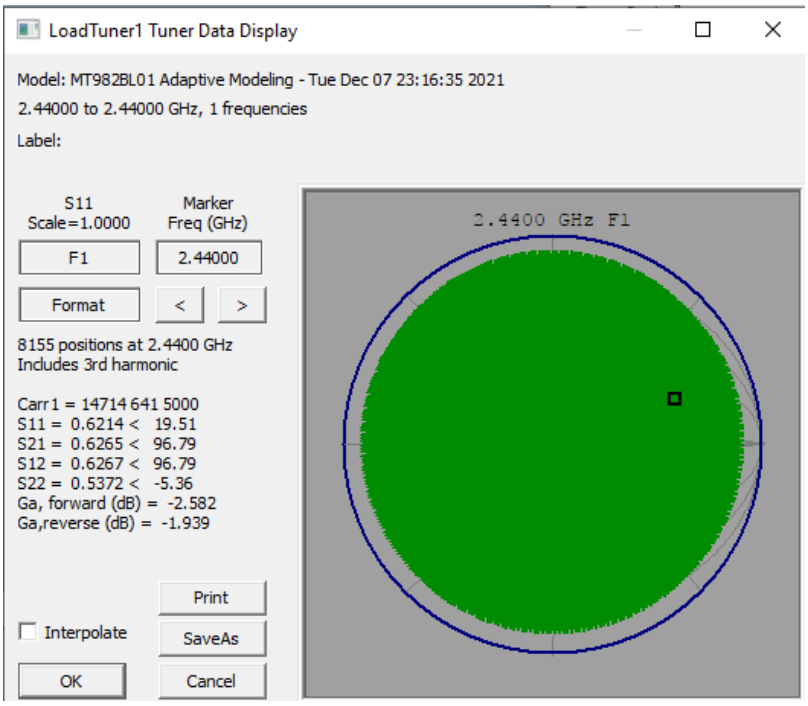

Figure 6. Characterizing the Tuner

2.7 DUT measurements

Figure 7 shows the block diagram of equipments connected for DUT measurements.

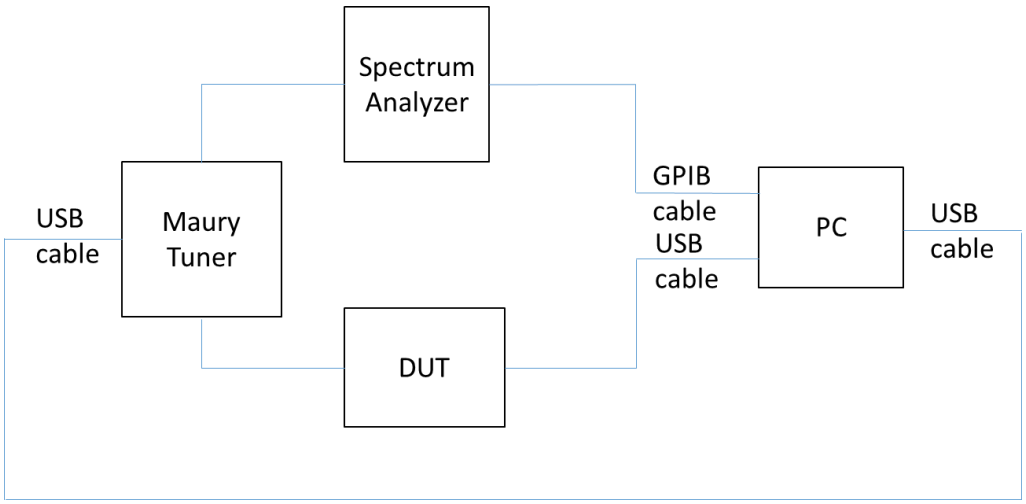

Figure 7. DUT measurement

For DUT measurements, perform the following steps:

1. Click the green tuner box as shown in Figure 8.
2. Verify that **Tuner 1** is selected and **Interpolate Impedance** is not selected (on the **Setup** tab).

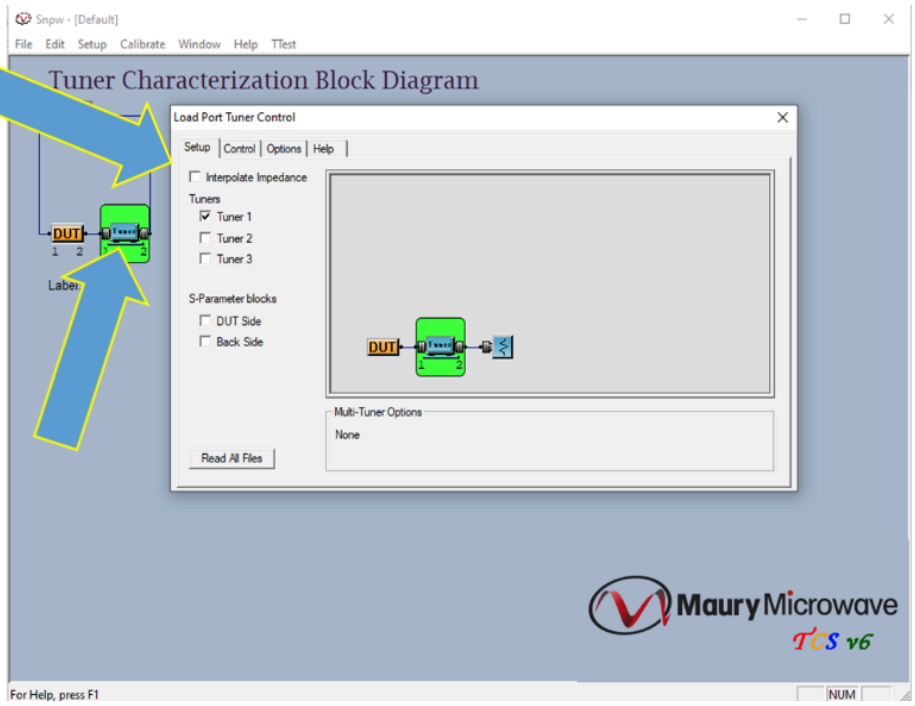

Figure 8. Selecting tuner 1

3. Select the **Control** tab.
4. Choose the **Target Mag** (VSWR) and **Phase** (°) values.
5. Click **Apply** and then **Move Reflection**.
6. Three markers (1:fund.; 2:H2; 3:H3) are represented in the Smith graph.

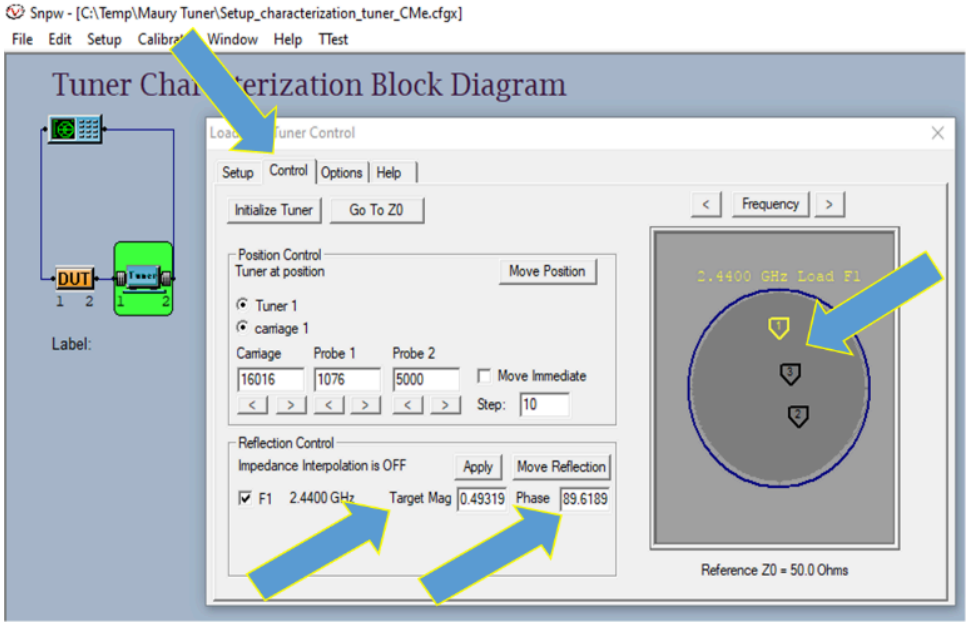

Figure 9. Selecting control

7. Click **Apply** and then **Move Reflection**.
8. Go to the graph.
9. Right-click the mouse and select **Show S-parameters**.

Example of setting values:

- Target magnitude:
  VSWR:1 ➔ 0 VSWR:2 ➔ 0.333 VSWR:3 ➔ 0.5
- Phase: 0°, 45°, …

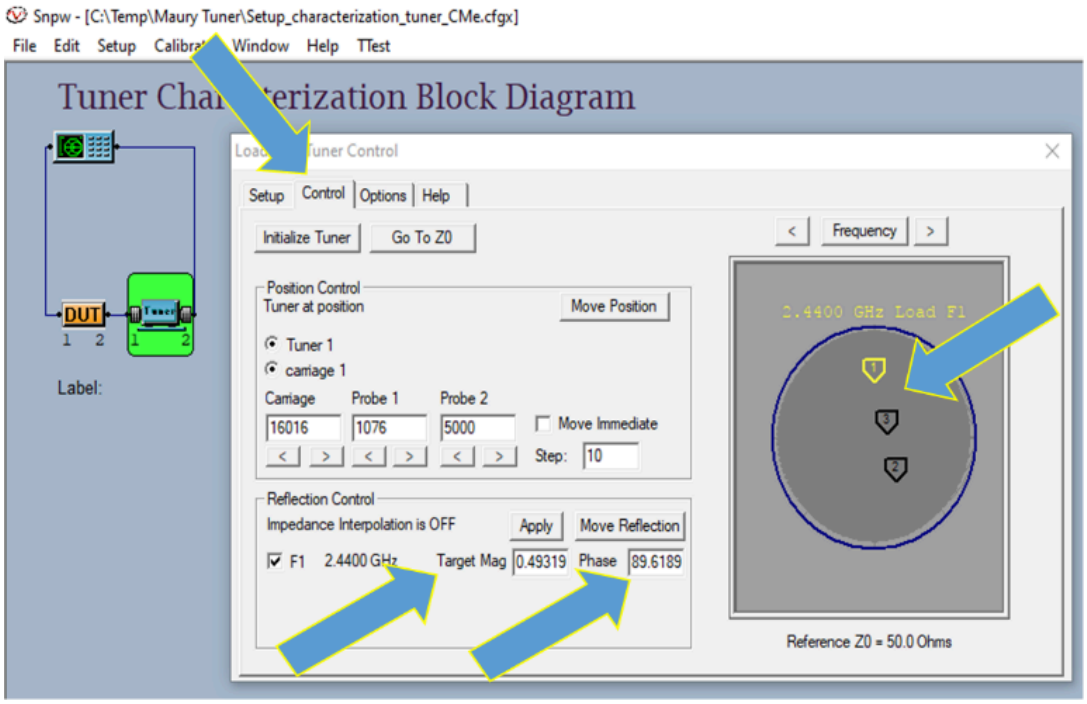

Figure 10. Clicking apply

- When the **Show S-parameters** is selected, the **Current Load Tuning Block** is opened.
  Available information:
  Fund., H2 and H3 frequencies: S11, S12, S21, S22 values

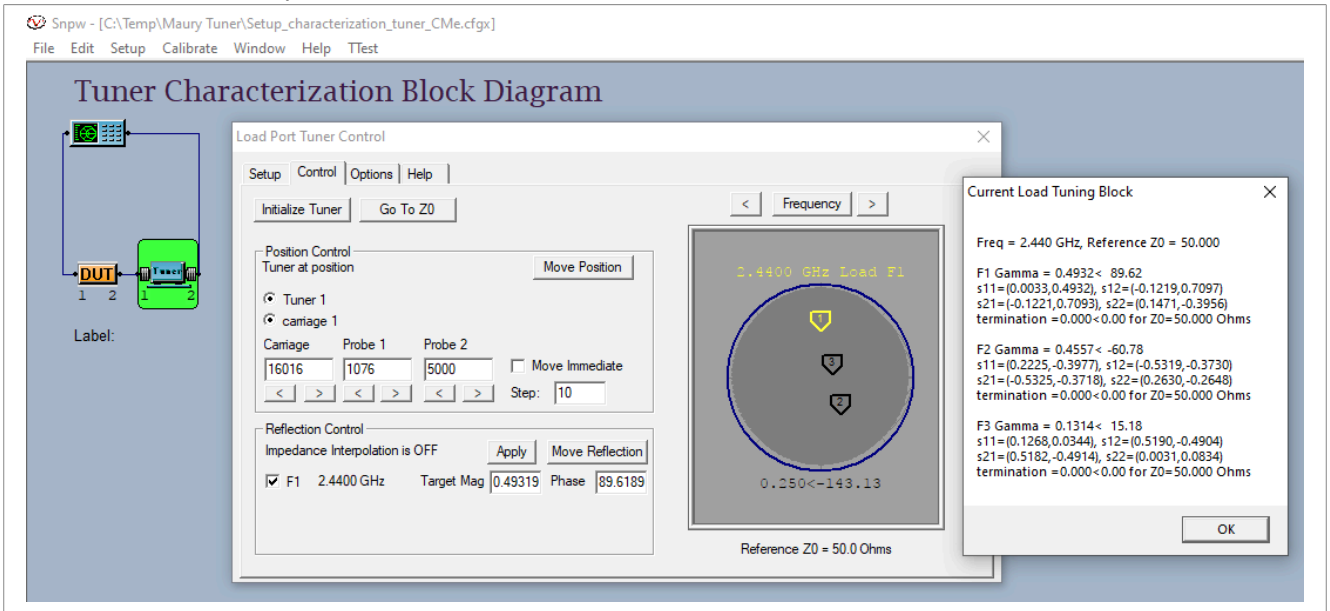

Figure 11. Opening Current load tuning block

3 Test

This section provides the conditions for testing and the corresponding test results. The results include f0, H2, and H3 harmonic frequencies and TX power results at fundamental frequency versus VSWR=1:1, VSWR=2:1, and VSWR=3:1.

3.1 Test conditions

Measurements are performed under the following conditions:

- Channel 19 (2440 MHz), continuous CW, Power level +10 dBm, Buck mode
- USB power supply (5.0 V), Temperature = room temperature
- The following three values of VSWR are tested:
  - 1:1 (return loss = 54 dB): good return loss
  - 2:1 (return loss = 9.5 dB): corresponds to a ceramic antenna without matching
  - 3:1 (return loss = 5.8 dB): poor return loss

  The phase is varied from:
  - 0° to 345° by 15° steps for VSWR = 2:1
  - 0° to 350° by 10° steps for VSWR = 3:1
- Spectrum analyzer settings for harmonic frequencies measurements
  - Reference amplitude: +12 dBm, RBW: 10 kHz, VBW: 30 kHz, Span 1 MHz, RF attenuation= 0 dB
- TX power fundamental frequency settings:
  - Center frequency: 2.44 GHz, RBW: 100 kHz, VBW: 300 kHz, Span: 10 MHz, Reference level: 20 dBm, Trace: average mode

Test condition: Figure 12 shows the test condition.

$$Reflection\ Coefficient = \Gamma = \frac{Z_L - Z_S}{Z_L + Z_S}$$

Where

$\Gamma = Reflection\ Coefficient$

$Z_L = Load\ Impedance$

$Z_S = Source\ Impedance$

Figure 12. Test condition

3.2 Test results

This section provides the tests results at fundamental, second and third harmonic frequencies and TX power results at fundamental frequency versus VSWR=1:1, VSWR=2:1, and VSWR=3:1.

3.2.1 Fundamental frequency

The following results are observed at the fundamental frequency f0:

Table 2. f0 power level for load at VSWR=1:1

VSWR=1:1	Values
Load impedance (W)@ f0	50.00000013
Phase (°)	0
Complex impedance (Re)@ f0	50.0
Complex impedance (Im)@ f0	-0.0036
TX power @ µFL (dBm)@ f0	9.69
Power consumption (mA)	26.89

Table 3. H1 power level for load at VSWR=2:1 @f0

VSWR=2:1	0° to 345° in steps of 15° for VSWR = 2:1																						
Load impedance (W)@ f0	100	96.92	88.91	78.68	68.15	58.46	50.01	42.75	36.69	31.8	28.12	25.81	25	25.79	28.1	31.78	36.68	42.77	50.01	58.47	68.14	78.63	88.92	96.94
Phase (°)	0	15	30	45	60	75	90	105	120	135	150	165	180	-165	-150	-135	-120	-105	-90	-75	-60	-45	-30	-15
Complex impedance (Re)@ f0	100.0	95.1	83.3	69.5	57.2	47.4	40.0	34.6	30.8	28.1	26.3	25.3	25.0	25.3	26.3	28.1	30.8	34.6	40.0	47.4	57.2	69.5	83.3	95.2
Complex impedance (Im)@ f0	- 0.0	18.5	31.2	36.9	37.1	34.3	30.0	25.1	20.0	14.9	9.9	4.9	0.0	- 4.9	- 9.9	- 14.9	- 20.0	- 25.1	- 30.0	- 34.3	- 37.1	- 36.9	- 31.2	- 18.5
TX power @ µFL conn (dBm)@ f0	9.9	9.8	9.7	9.5	9.3	9.0	8.8	8.6	8.4	8.3	8.2	8.2	8.2	8.3	8.4	8.6	8.9	9.1	9.4	9.6	9.8	9.9	10.0	10.0
Power consumption (mA)	28.07	28.02	27.89	27.7	27.45	27.16	26.86	26.57	26.3	26.07	25.88	25.75	25.69	25.69	25.76	25.89	26.09	26.38	26.71	27.07	27.42	27.7	27.92	28.04

Table 4. Delta minimum and maximum at VSWR=2:1

VSWR = 2:1	DeltaMinMax
TX power @ µFL conn (dBm)@ f0	1.8
Power consumption (mA)	2.4

Table 5. VSWR=3:1

VSWR = 3:1	0° to 350° in steps of 10° for VSWR = 3:1																	
Load impedance (W)@ f0	150	145	133	117	102	88	76	66	58	50	43	38	33	28	24	21	19	17
Phase (°)	0.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0	170.0
Complex impedance (Re)@ f0	150.0	141.4	120.8	97.7	77.6	61.7	50.0	41.3	34.8	30.0	26.3	23.6	21.4	19.8	18.6	17.7	17.1	16.8
Complex impedance (Im)@ f0	0.1	32.8	55.1	65.1	66.4	63.1	57.7	51.7	45.8	40.0	34.6	29.5	24.7	20.2	15.9	11.8	7.8	3.9
TX power @ µFL conn (dBm)@ f0	9.4	9.3	9.2	9.1	8.9	8.7	8.5	8.3	8.0	7.8	7.6	7.4	7.3	7.1	7.0	6.9	6.9	6.9
Power consumption (mA)	28.55	28.52	28.42	28.29	28.11	27.89	27.65	27.37	27.08	26.78	26.49	26.23	25.99	25.76	25.57	25.41	25.29	25.20
VSWR = 3:1	**0° to 350° in steps of 10° for VSWR = 3:1**																	
Load impedance (W)@ f0	17	17	19	21	24	28	33	38	43	50	58	66	76	88	102	117	133	145
Phase (°)	180.0	-170.0	-160.0	-150.0	-140.0	-130.0	-120.0	-110.0	-100.0	-90.0	-80.0	-70.0	-60.0	-50.0	-40.0	-30.0	-20.0	-10.0
Complex impedance (Re)@ f0	16.7	16.8	17.1	17.7	18.6	19.8	21.4	23.6	26.3	30.0	34.8	41.3	50.0	61.8	77.4	97.6	120.8	141.4
Complex impedance (Im)@ f0	0.0	-3.9	-7.8	-11.8	-15.9	-20.2	-24.8	-29.5	-34.6	-40.0	-45.8	-51.7	-57.7	-63.1	-66.4	-65.0	-55.1	-32.7
TX power @ µFL conn (dBm)@ f0	7.0	7.0	7.1	7.3	7.5	7.7	7.9	8.2	8.4	8.7	8.9	9.1	9.3	9.4	9.4	9.4	9.4	9.4
Power consumption (mA)	25.14	25.11	25.12	25.18	25.26	25.40	25.59	25.83	26.11	26.45	26.82	27.21	27.56	27.88	28.13	28.34	28.47	28.54

Table 6. Delta minimum and maximum at VSWR=3:1

VSWR=3:1	DeltaMinMax
TX power @ µFL conn (dBm)@ f0	2.5
Power consumption (mA)	3.4

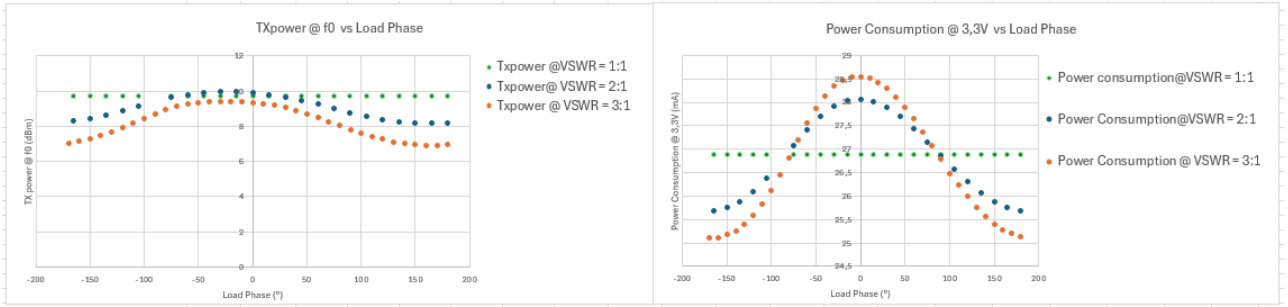

Figure 13. Graphs versus load phase

3.2.2 Second harmonic frequency

The following are the results of load at the second harmonic H2 power level:

Table 7. H2 power level for load at VSWR=1:1 @f0

VSWR = 1:1	Values
Load impedance (W) @ f0	50
Phase (°)	0
Complex impedance (Re)@ f0	50.0
Complex impedance (Im)@ f0	-0.0036
H2 power @ µFL conn (dBm) @ 2f0	-41.07

Table 8. H2 power level for load at VSWR=2:1 @f0

VSWR = 2:1	0° to 345° in steps of 15° for VSWR = 2:1																							
Load impedance (W)@ f0	100	96.92	88.91	78.68	68.15	58.46	50.01	42.75	36.69	31.8	28.12	25.81	25	25.79	28.1	31.78	36.68	42.77	50.01	58.47	68.14	78.63	88.92	96.94
Phase (°)	0	15	30	45	60	75	90	105	120	135	150	165	180	-165	-150	-135	-120	-105	-90	-75	-60	-45	-30	-15
Complex impedance (Re)@ f0	100.0	95.1	83.3	69.5	57.2	47.4	40.0	34.6	30.8	28.1	26.3	25.3	25.0	25.3	26.3	28.1	30.8	34.6	40.0	47.4	57.2	69.5	83.3	95.2
Complex impedance (Im)@ f0	- 0.0	18.5	31.2	36.9	37.1	34.3	30.0	25.1	20.0	14.9	9.9	4.9	0.0	- 4.9	- 9.9	- 14.9	- 20.0	- 25.1	- 30.0	- 34.3	- 37.1	- 36.9	- 31.2	- 18.5
H2 power @ µFL conn (dBm) @ 2f0	-41.4	-42.1	-42.7	-43.5	-44.5	-44.8	-45.1	-44.9	-44.6	-43.6	-43.1	-42.4	-42.1	-41.3	-41.0	-40.4	-40.3	-40.0	-39.7	-39.7	-39.7	-39.8	-40.1	-40.8

Table 9. H2 power level for load at VSWR=1:1 @f0

VSWR = 1:1	Values
Load impedance (W) @ f0	50
Phase (°)	0
Complex impedance (Re)@ f0	50.0

Table 9. H2 power level for load at VSWR=1:1 @f0*...continued*

VSWR = 1:1	Values
Complex impedance (Im)@ f0	-0.0036
H2 power @ µFL conn (dBm) @ 2f0	-41.07

Table 10. Delta minimum and maximum at VSWR=2:1

VSWR = 2:1	DeltaMinMax
H2 power @ µFL conn (dBm) @ 2f0	5.4

Table 11. H2 power level for load at VSWR=3:1 @f0

VSWR = 3:1	0° to 350° in steps of 10° for VSWR = 3:1																	
Load impedance (W)@ f0	150	145	133	117	102	88	76	66	58	50	43	38	33	28	24	21	19	17
Phase (°)	0.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0	170.0
Complex impedance (Re)@ f0	150.0	141.4	120.8	97.7	77.6	61.7	50.0	41.3	34.8	30.0	26.3	23.6	21.4	19.8	18.6	17.7	17.1	16.8
Complex impedance (Im)@ f0	0.1	32.8	55.1	65.1	66.4	63.1	57.7	51.7	45.8	40.0	34.6	29.5	24.7	20.2	15.9	11.8	7.8	3.9
H2 power @ µFL conn (dBm) @ 2f0	-41.6	-42.4	-43.1	-44.2	-45.2	-46.2	-47.2	-48.0	-48.3	-48.2	-47.8	-47.1	-46.2	-45.6	-44.4	-44.0	-43.5	-42.9

Table 12. H2 power level for load at VSWR=3:1 @f0

VSWR = 3:1	0° to 350° in steps of 10° for VSWR = 3:1																	
Load impedance (W)@ f0	150	145	133	117	102	88	76	66	58	50	43	38	33	28	24	21	19	17
Phase (°)	0.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0	170.0
Complex impedance (Re)@ f0	150.0	141.4	120.8	97.7	77.6	61.7	50.0	41.3	34.8	30.0	26.3	23.6	21.4	19.8	18.6	17.7	17.1	16.8

Table 12. H2 power level for load at VSWR=3:1 @f0*...continued*

VSWR = 3:1	0° to 350° in steps of 10° for VSWR = 3:1																	
Complex impedance (Im)@ f0	0.1	32.8	55.1	65.1	66.4	63.1	57.7	51.7	45.8	40.0	34.6	29.5	24.7	20.2	15.9	11.8	7.8	3.9
H2 power @ µFL conn (dBm) @ 2f0	-41.6	-42.4	-43.1	-44.2	-45.2	-46.2	-47.2	-48.0	-48.3	-48.2	-47.8	-47.1	-46.2	-45.6	-44.4	-44.0	-43.5	-42.9

Table 13. H2 power level for load at VSWR=3:1 @f0

VSWR = 3:1	0° to 350° in steps of 10° for VSWR = 3:1																	
Load impedance (W)@ f0	17	17	19	21	24	28	33	38	43	50	58	66	76	88	102	117	133	145
Phase (°)	180.0	-170.0	-160.0	-150.0	-140.0	-130.0	-120.0	-110.0	-100.0	-90.0	-80.0	-70.0	-60.0	-50.0	-40.0	-30.0	-20.0	-10.0
Complex impedance (Re)@ f0	16.7	16.8	17.1	17.7	18.6	19.8	21.4	23.6	26.3	30.0	34.8	41.3	50.0	61.8	77.4	97.6	120.8	141.4
Complex impedance (Im)@ f0	0.0	-3.9	-7.8	-11.8	-15.9	-20.2	-24.8	-29.5	-34.6	-40.0	-45.8	-51.7	-57.7	-63.1	-66.4	-65.0	-55.1	-32.7
H2 power @ µFL conn (dBm) @ 2f0	-42.3	-41.8	-41.5	-41.3	-40.8	-40.6	-40.0	-39.7	-39.5	-39.6	-39.3	-39.3	-39.5	-39.5	-39.9	-40.4	-40.7	-41.3

Table 14. Delta minimum and maximum at VSWR=3:1

VSWR=3:1	DeltaMinMax
H2 power @ µFL conn (dBm)@ 2f0	9.0

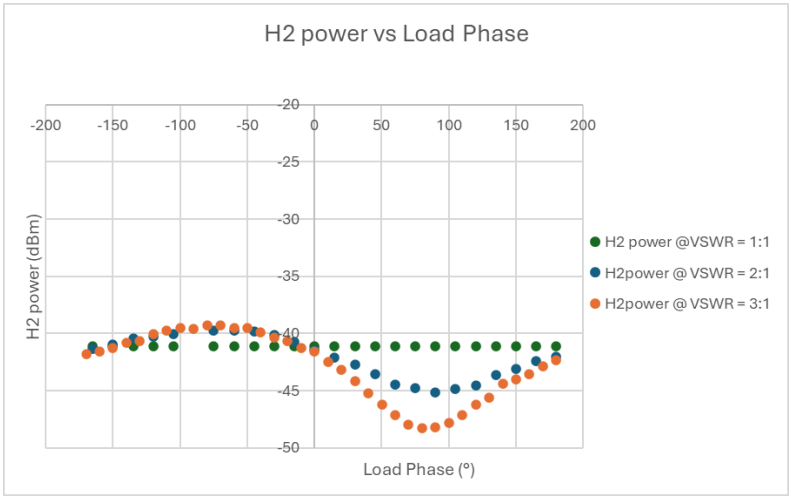

Figure 14. H2 power level vs load phase

3.2.3 Third harmonic frequency

The following results are observed at the third harmonic frequency H3:

Table 15. H3 power level for load at VSWR=1:1

VSWR = 1:1	Values
Load impedance (W) @ f0	50
Phase (°)	0
Complex impedance (Re)@ f0	50.0
Complex impedance (Im)@ f0	-0.0036
H3 power @ µFL conn (dBm) @ 3f0	-40.63

Table 16. H2 power level for load at VSWR=2:1 @f0

VSWR = 2:1	0° to 345° in steps of 15° for VSWR = 2:1																						
Load impedance (W)@ f0	100	96.92	88.91	78.68	68.15	58.46	50.01	42.75	36.69	31.8	28.12	25.81	25	25.79	28.1	31.78	36.68	42.77	50.01	58.47	68.14	78.63	88.92	96.94
Phase (°)	0	15	30	45	60	75	90	105	120	135	150	165	180	-165	-150	-135	-120	-105	-90	-75	-60	-45	-30	-15
Complex impedance (Re)@ f0	100.0	95.1	83.3	69.5	57.2	47.4	40.0	34.6	30.8	28.1	26.3	25.3	25.0	25.3	26.3	28.1	30.8	34.6	40.0	47.4	57.2	69.5	83.3	95.2
Complex impedance (Im)@ f0	- 0.0	18.5	31.2	36.9	37.1	34.3	30.0	25.1	20.0	14.9	9.9	4.9	0.0	- 4.9	- 9.9	- 14.9	- 20.0	- 25.1	- 30.0	- 34.3	- 37.1	- 36.9	- 31.2	- 18.5
H3 power @ µFL conn (dBm) @ 3f0	-39.5	-39.4	-39.5	-40.5	-42.2	-44.3	-45.6	-42.7	-42.4	-41.8	-41.3	-41.2	-40.4	-40.9	-40.2	-41.6	-43.2	-42.7	-41.3	-40.5	-39.9	-40.9	-41.1	-40.9

Table 17. Delta minimum and maximum at H3 power level

VSWR = 2:1	DeltaMinMax
H3 power @ µFL conn (dBm) @ 3f0	6.2

Table 18. H3 power level for load at VSWR=3:1 @f0

VSWR = 3:1	0° to 350° in steps of 10° for VSWR = 3:1																
Load impedance (W)@ f0	150	145	133	117	102	88	76	66	58	50	43	38	33	28	24	21	19	17

Table 18. H3 power level for load at VSWR=3:1 @f0*...continued*

VSWR = 3:1	0° to 350° in steps of 10° for VSWR = 3:1																	
Phase (°)	0.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0	170.0
Complex impedance (Re)@ f0	150.0	141.4	120.8	97.7	77.6	61.7	50.0	41.3	34.8	30.0	26.3	23.6	21.4	19.8	18.6	17.7	17.1	16.8
Complex impedance (Im)@ f0	0.1	32.8	55.1	65.1	66.4	63.1	57.7	51.7	45.8	40.0	34.6	29.5	24.7	20.2	15.9	11.8	7.8	3.9
H3 power @ µFL conn (dBm) @ 3f0	-40.7	-40.1	-39.7	-39.7	-38.8	-39.9	-40.9	-42.1	-44.6	-46.5	-48.0	-44.6	-42.9	-43.1	-41.7	-42.1	-40.3	-40.9

Table 19. H3 power level for load at VSWR=3:1 @f0

VSWR = 3:1	0° to 350° in steps of 10° for VSWR = 3:1																	
Load impedance (W)@ f0	17	17	19	21	24	28	33	38	43	50	58	66	76	88	102	117	133	145
Phase (°)	180.0	-170.0	-160.0	-150.0	-140.0	-130.0	-120.0	-110.0	-100.0	-90.0	-80.0	-70.0	-60.0	-50.0	-40.0	-30.0	-20.0	-10.0
Complex impedance (Re)@ f0	16.7	16.8	17.1	17.7	18.6	19.8	21.4	23.6	26.3	30.0	34.8	41.3	50.0	61.8	77.4	97.6	120.8	141.4
Complex impedance (Im)@ f0	0.0	-3.9	-7.8	-11.8	-15.9	-20.2	-24.8	-29.5	-34.6	-40.0	-45.8	-51.7	-57.7	-63.1	-66.4	-65.0	-55.1	-32.7
H3 power @ µFL conn (dBm) @ 3f0	-40.4	-41.1	-41.3	-42.9	-43.4	-45.4	-45.7	-42.6	-41.7	-41.8	-40.5	-40.0	-40.3	-40.7	-42.2	-43.3	-42.2	-40.9

Table 20. Delta minimum and maximum at H3 power level

VSWR = 3:1	DeltaMinMax
H3 power @ µFL conn (dBm) @ 3f0	9.2

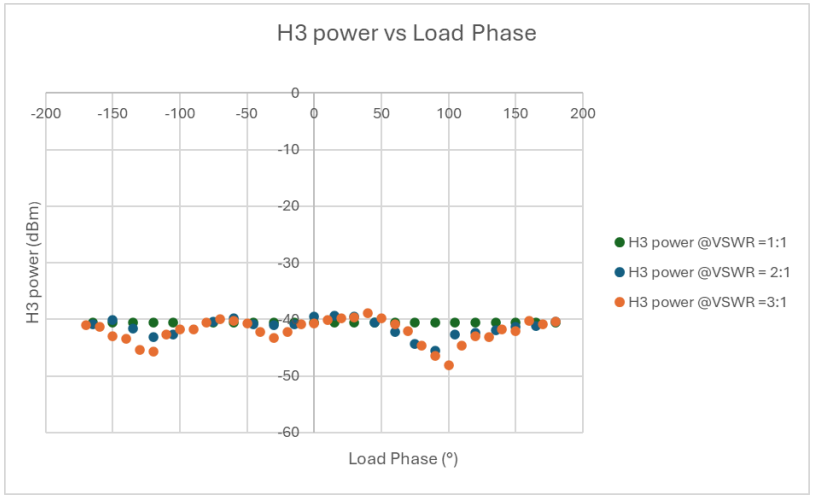

Figure 15. H3 power level versus load phase

3.2.4 TX power results at fundamental frequency versus VSWR=1:1

The TX power at µFL connector pin: +9.69 dBm (VSWR:1:1) for a power consumption of 26.89 mA.

In comparison, the maximum TX power is uncentered on the Smith chart. For more information, see Figure 16.

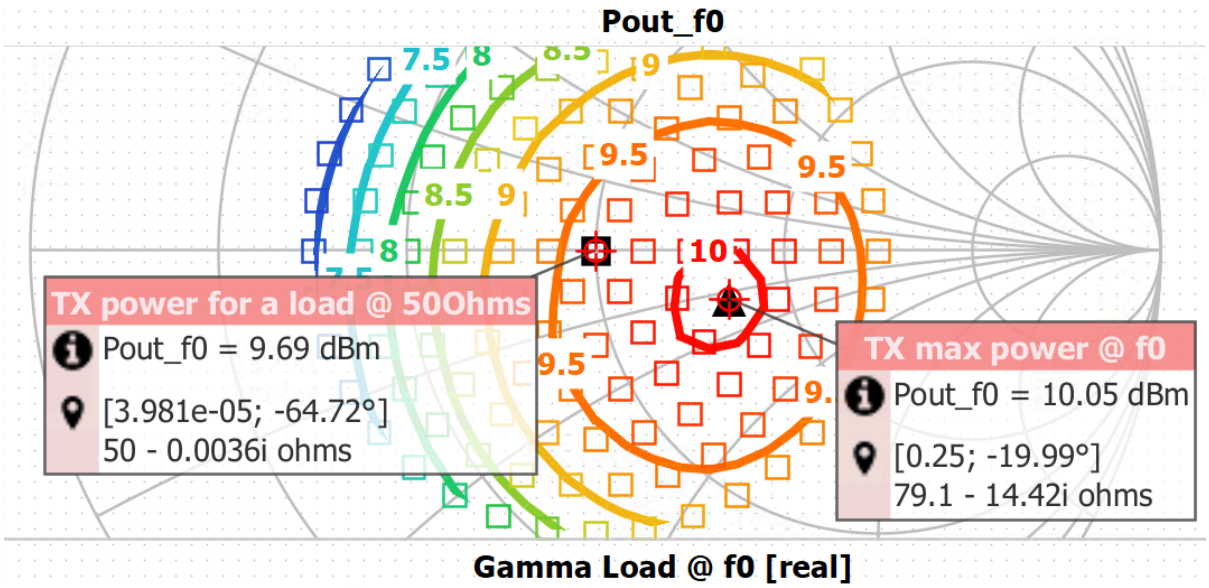

Figure 16. Result

The TX power at f0 is not maximum when the load is on 50 Ω but it is on (79.1 - 14.42i) Ω as shown in Figure 16.

The reason is because the 2nd harmonic at this impedance is exceeding the FCC limit (-41.2 dBm) as shown in Figure 17.

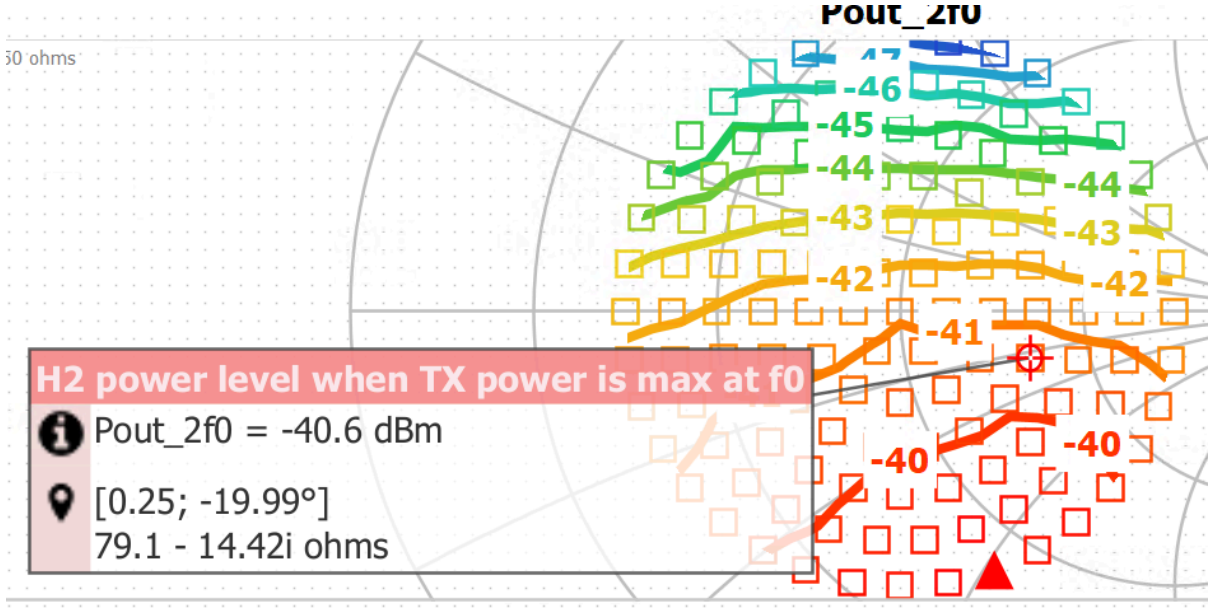

Figure 17. Result

3.2.5 TX power results at fundamental frequency versus VSWR=2:1

The maximum TX Power at the µFL connector: +9.97 dBm (VSWR:2:1, phase -15°) for a power consumption of 28.04 mA.

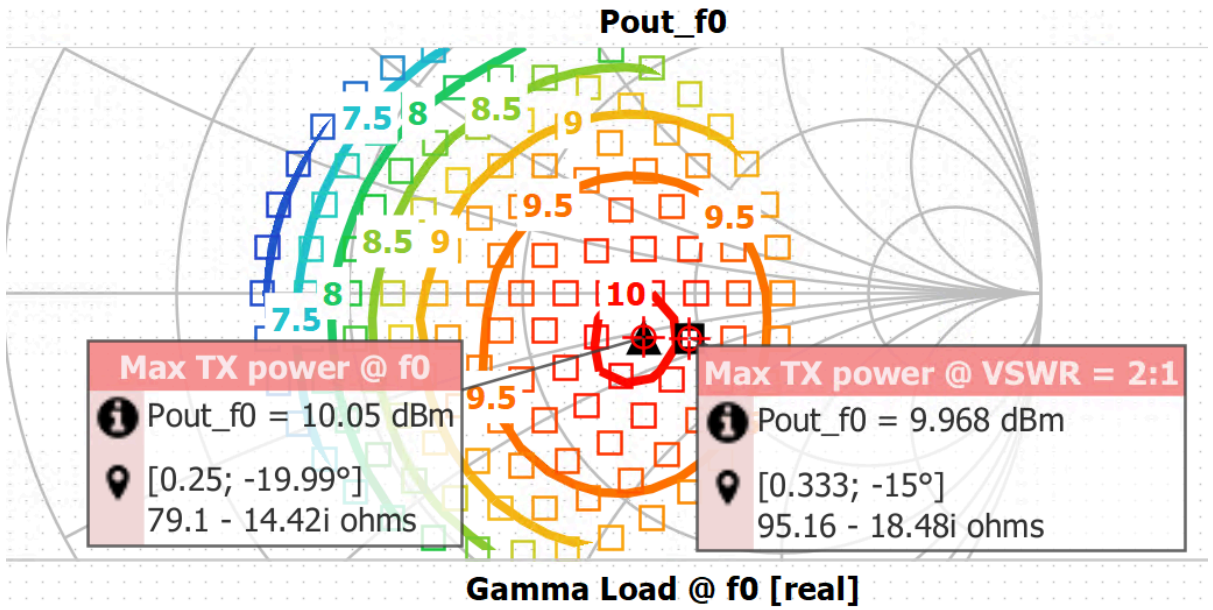

Figure 18. Result

The result shows that for an antenna not at 50 Ω, the maximum TX power can reach 9.97 dBm for a few load phases. But in these cases, the 2nd and 3rd harmonics are exceeding the FCC limit.

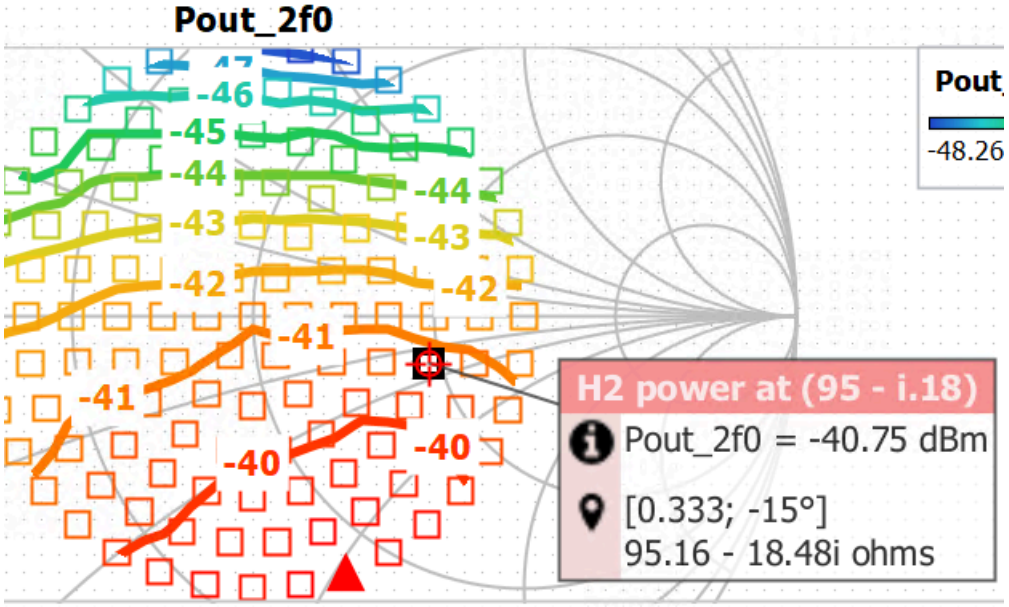

Figure 19. Result

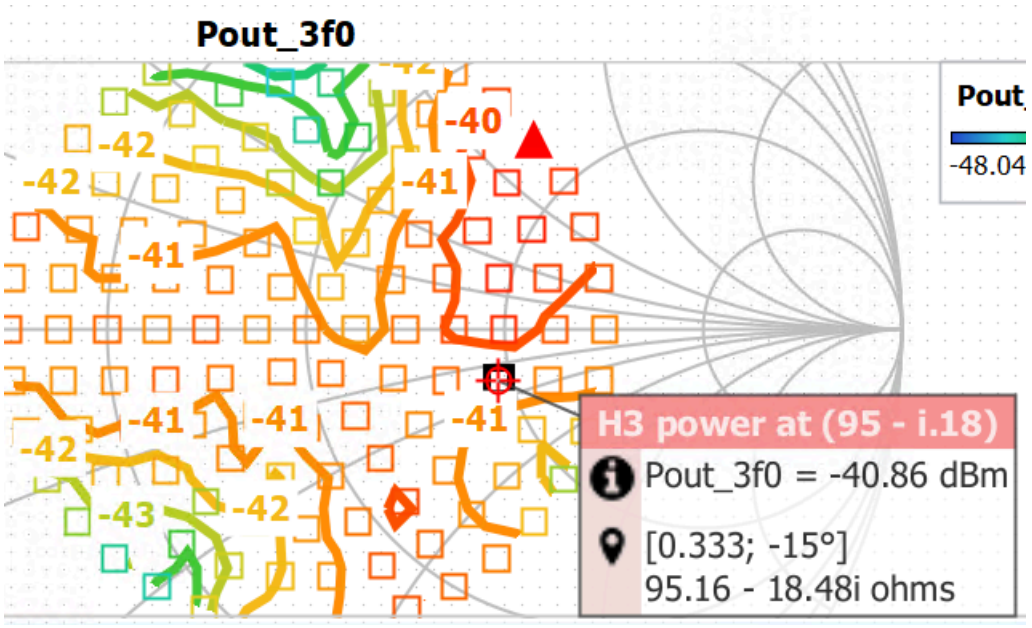

Figure 20. Result

3.2.6 TX power results at fundamental frequency versus VSWR=3:1

Power at the SMA pin: +9.43 dBm (VSWR:3:1, phase -20°) for a power consumption of 28.47 mA.

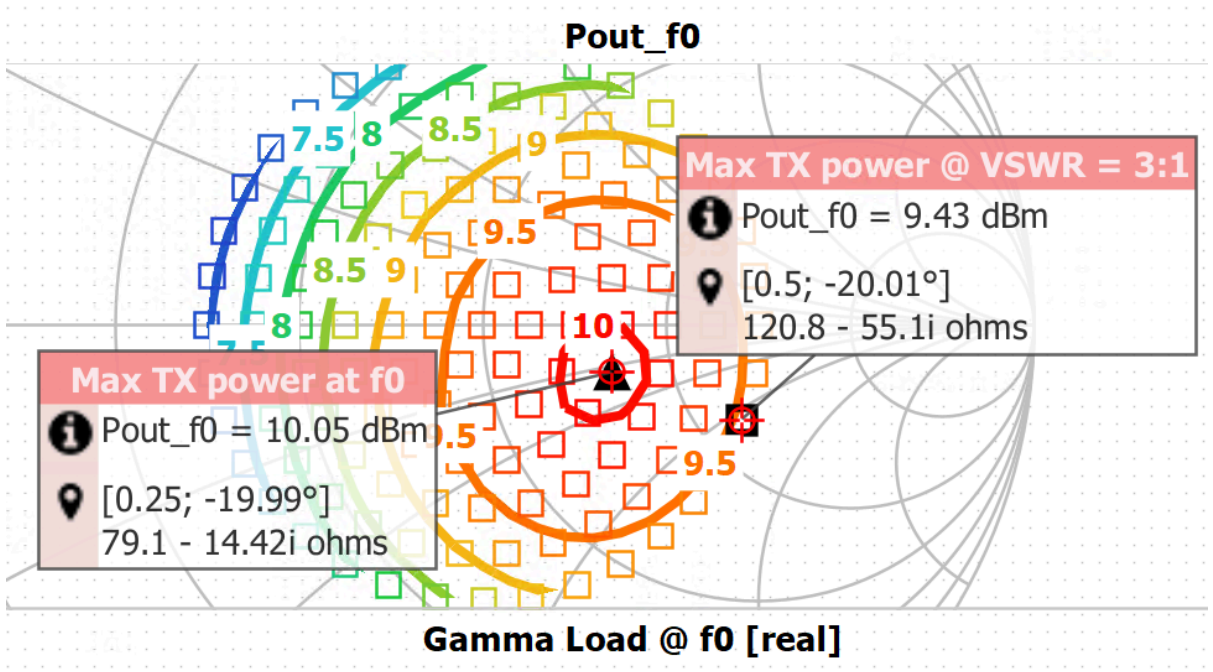

Figure 21. Result

Result:

For a poor antenna, the module can still reach a TX power level between 6.9 dBm and 9.4 dBm.

For this latter, at impedance (120.8 – 55.1i) Ω, the level of 2nd harmonics are also exceeding the FCC limits as shown in Figure 22:

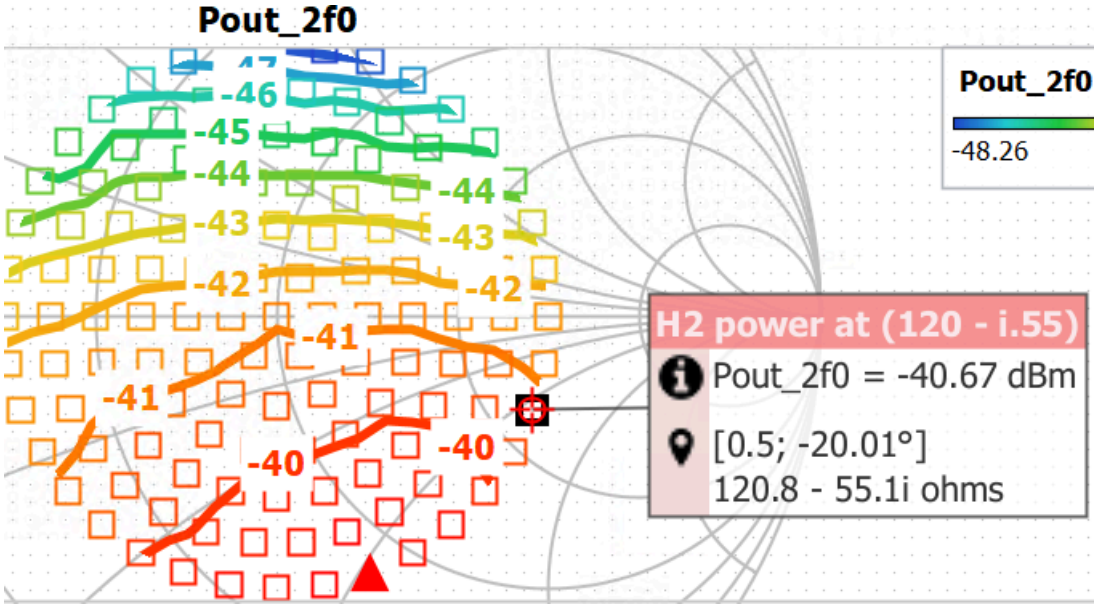

Figure 22. Result

4 Conclusion

The following load pull measurements are observed:

- If you try to reach the highest TX power level impedance, then it generates many harmonics.
- In a poor antenna case, the TX power reaches acceptable levels for a few impedances. But attention is required to the harmonics levels, because the FCC limits can be exceeded.
- For the other load impedances, as the VSWR is 2 or 3, the transmitter power level is always above 6.9 dBm.
- The power consumption variation is less than 12 % overall.

5 Acronyms

Table 21lists the acronyms used in this document.

Table 21. Acronyms

Acronym	Description
CAN	Controller Area Network
CTS	Clear-to-Send
DC	Direct Current
DNP	Do Not Populate / Do Not Place
DUT	Device Under Test

6 Revision history

Table 22 summarizes the revisions done to this document.

Table 22. Revision history

Document ID	Release date	Description
AN14696 v.2.0	10 December 2025	Initial public release
AN14696 v.1.0	07 July 2025	Initial NDA release

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