AN14098

KW45B41Z-LOC RF Test Report

Rev. 1 — 15 November 2023 Application note

Document information

Information	Content
Keywords	AN14098, KW45B41Z, KW45B41Z-LOC, RF
Abstract	The KW45B41Z localization (KW45B41Z-LOC) board is a highly configurable, low-power, and cost-effective evaluation and development platform for NXP KW45B41Z MCU.

1 Introduction

The KW45B41Z localization (KW45B41Z-LOC) board is a highly configurable, low-power, and cost-effective evaluation and development platform for NXP KW45B41Z MCU. It offers an easy-to-use user interface with a virtual serial port and standard programming and run-control capabilities. The localization board is mainly determined for the distance estimation applications, because it contains the SP4T RF switch with four inputs/outputs, including two on-board chip antennas. Two external antennas can be added attached to the board using the u.FL connectors. However, this platform can be used also for general application development.

This document provides basic RF test results of the KW45B41Z localization board. The document describes the following sections:

- Antenna gain, efficiency, and radiation patterns
- Antenna reflection coefficient and antenna-matching network
- KW45B41Z RF ANT output matching for RX and TX operation
- Verification of the maximum RF output power
- RF sensitivity measurement

This is a complementary document of the KW45B41Z-LOC board, which helps to better understand the RF performance. The basic description of the localization board is in the KW45B41Z-LOC board user manual. You can download also the manufacturing package, which contains all the information for board production including schematic, layout, bill of material, and Gerber files.

Further information about the KW45B41Z MCU is available online:

- KW45: 32-Bit Bluetooth® 5.3 Long-Range MCUs,Arm® Cortex®-M33 Core

A general KW45B41Z evaluation board kit for application development is available online:

- KW45B41Z Evaluation Kit with Bluetooth® Low Energy

The NXP Community web, focused on the wireless connectivity, is available online:

- NXP Community - Wireless Connectivity

1.1 Related documentation

Table 1 lists the additional documents and resources that you can refer to for more information about the KW45B41Z-LOC board. Some of the documents listed below may be available only under a Non-Disclosure Agreement (NDA). To request access to these documents, contact your local Field Applications Engineer (FAE) or sales representative.

Table 1. Related documentation

Document	Description	Link / how to access
KW45B41Z-LOC Board User Manual	A detailed description of the KW45B41Z-LOC board interfaces, RF interface, power supplies, clocks, push buttons, jumpers, and LEDs.	Available online
KW45B41Z-LOC manufacturing package	All the important files for the KW45B41Z-LOC board PCB manufacturing. It contains schematic, PCB layout, and Gerber files.	Available online
Kinetis K32W148/KW45B41Z Generic FSK Link Layer Software Quick Start Guide	This document describes the Generic FSK (GENFSK) Software for the K32W148/KW45B41Z MCUs. It covers installation of the software packages,	Part of the SDK documentation package.

Table 1. Related documentation...*continued*

Document	Description	Link / how to access
	hardware setup, build, and usage connectivity test application.	
KW45B41Z Reference Manual	Intended for system software and hardware developers and application programmers who want to develop products with KW45B41Z MCUs.	Available online
KW45 Product Family Data Sheet	Provides information about electrical characteristics, hardware design considerations, and ordering information.	Available online
Antenna Diversity Board User Guide	Provides information about enabling the antenna-diversity feature in the antenna-diversity shield board for the widely available NXP KWxx development kits.	Contact NXP FAE / sales representative

2 Acronyms

Table 2 lists the acronyms used in this document.

Table 2. Acronyms

Acronym	Description
LOC	Localization
SP4T	Single-Pole Four-Throw
VNA	Vector Network Analyzer
BLE	Bluetoth Low Energy
HCI	Host Control Interface
PER	Packet Error Rate
LR	Long Range
USB	Universal Serial Bus

3 Antenna-matching network estimation

The KW45B41Z-LOC board uses the 2450AT42A100 Johanson chip antennas. It is important to perform a reflection coefficient measurement and estimate the matching circuit for a given PCB size and those antennas.

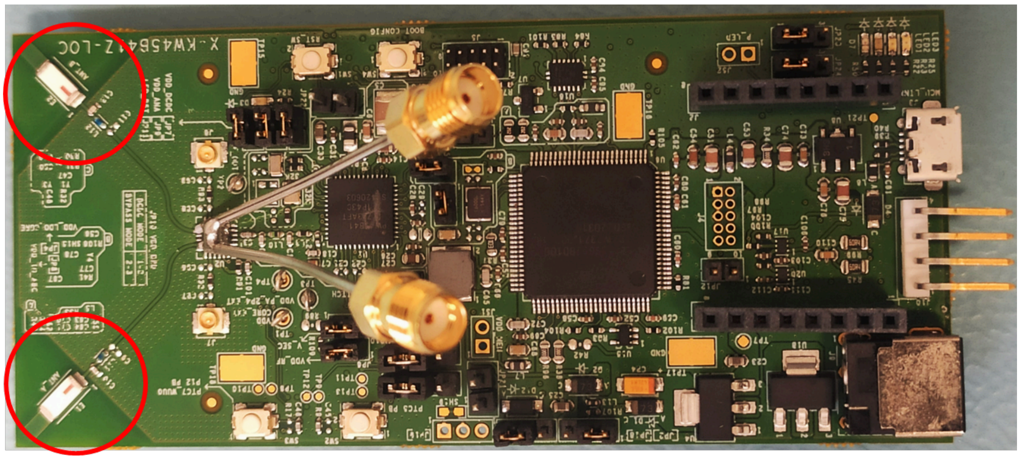


Figure 1. KW45B41Z-LOC board with semirigid cables soldered for antenna reflection coefficient measurement

The VNA port calibration plane is moved to the antenna PI filter using the port-extension function on the VNA. This was calibrated on short and open circuits. This is needed for precise measurement. The calibration plane is shown in Figure 2.

The following measurement instruments were used:

- VNA - Keysight P5001A
- Calibration method (open/short/load) with the ECal Module N7551A calibration kit

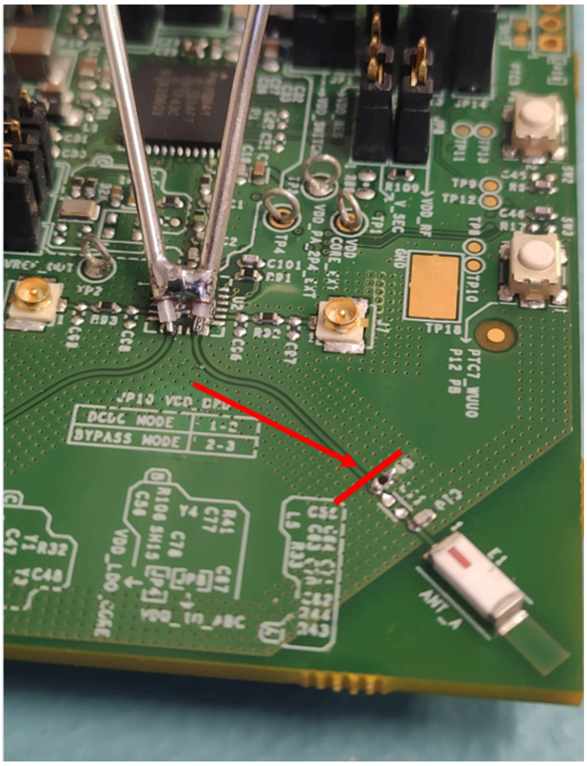


Figure 2. VNA calibration plane moved to the antenna PI filter

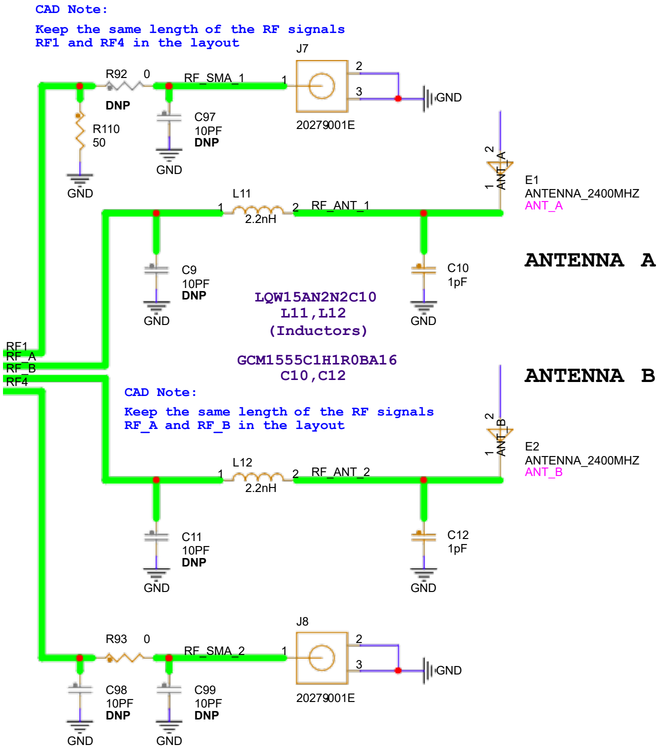


Figure 3. Schematic of the antenna-matching network

The matching network is estimated and verified for both antennas (ANT_A and ANT_B) with the given values:

- 2.2-nH serial inductor (L11, L12 - LQW15AN2N2C10)
- 1-pF shunt capacitor (C10, C12 - GCM1555C1H1R0BA16)

The reflection coefficient charts, including the Smith diagram for both antennas, are shown below. Table 3 summarizes the measured results. In general, the s11 values below -10 dB are accepted as good performance.

Table 3. Reflection coefficient values measured for both antennas

	s11 [dB]		
	2400 MHz	2440 MHz	2480 MHz
ANT_A	-16.09	-16.95	-10.88
ANT_B	-15.15	-20.31	-9.9

The measurement shows reasonable results in the whole frequency range (2.4 GHz – 2.48 GHz) for both antennas.

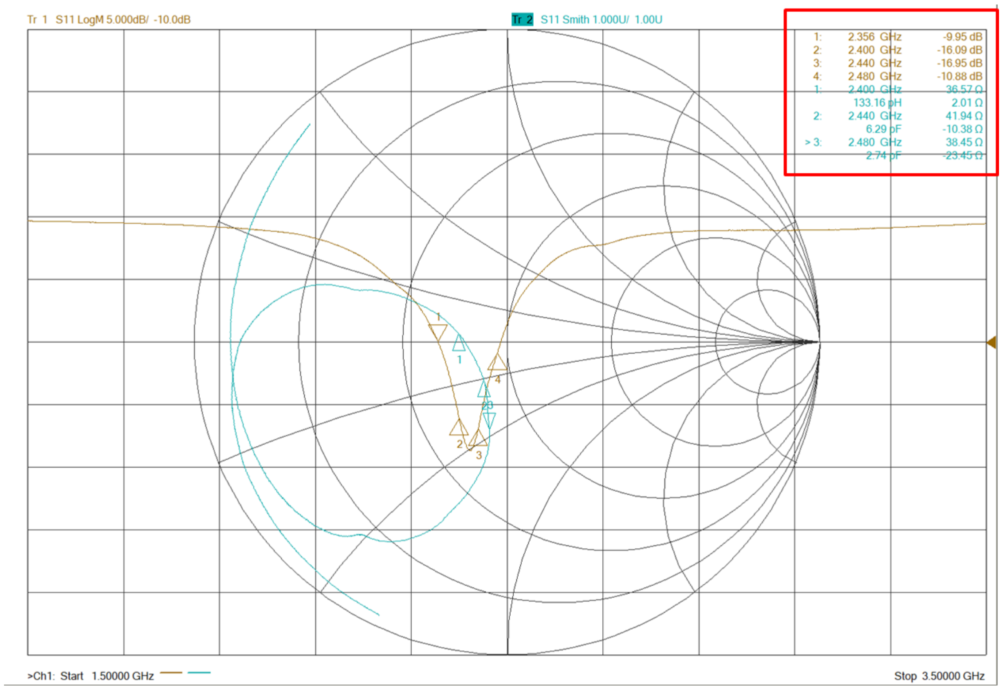


Figure 4. Reflection coefficient s11 – ANT_A

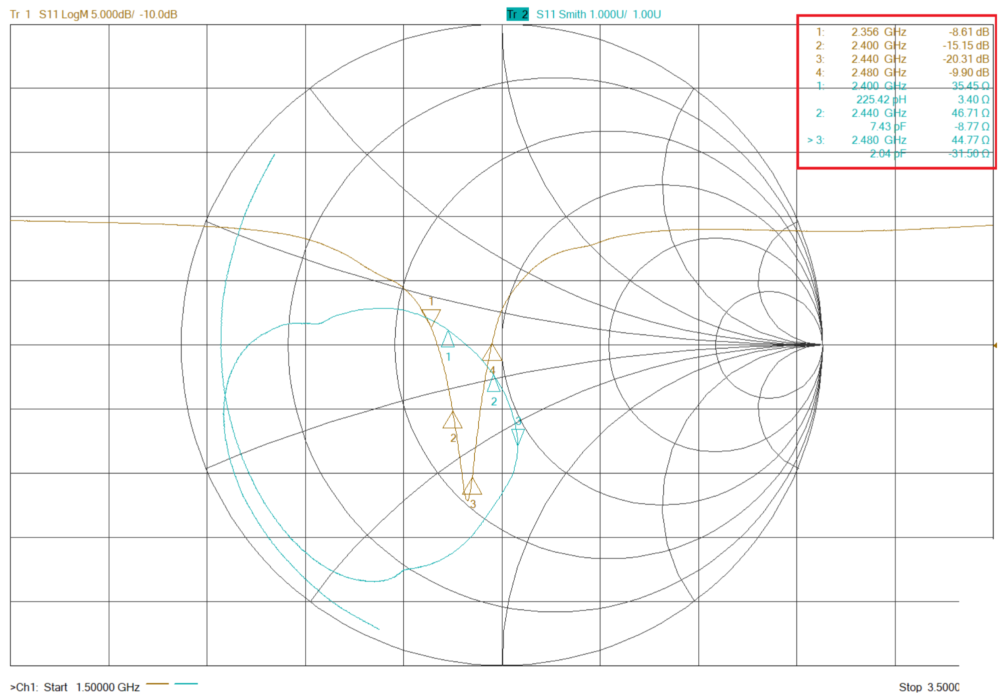


Figure 5. Reflection coefficient s11 – ANT_B

4 Antenna gain measurements

The antenna gain and efficiency listed below were measured after impedance matching. The board orientation and all the planes are in Figure 6.

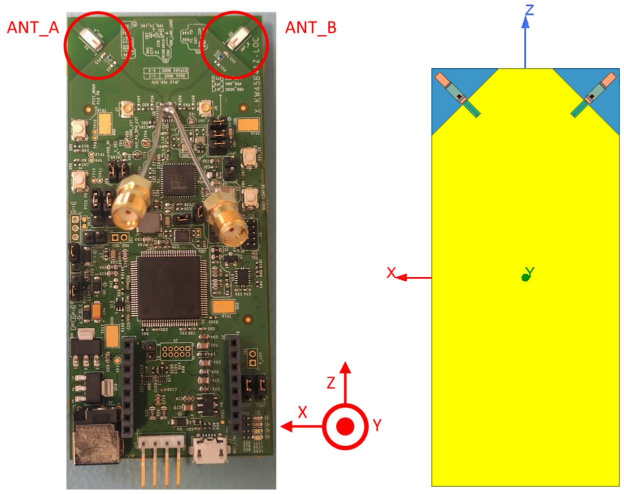


Figure 6. KW45B41Z-LOC board plane orientation during the radiation pattern measurement

All the values in Table 4 were measured with three different frequencies. The highest average gain is achieved in the YZ plane. The ANT_A has slightly better efficiency in comparison with ANT_B.

Table 4. Antennas gain table summary

Units in dBi	XY - plane		XZ - plane		YZ - plane		Efficiency [%]
	Peak	Avg.	Peak	Avg.	Peak	Avg.	
ANT_A 2400 MHz	-0.5	-4.1	1.0	-4.6	2.1	-1.3	57
ANT_A 2440 MHz	-0.2	-4.1	0.6	-4.7	2.0	-1.3	58
ANT_A 2480 MHz	-0.3	-3.9	0.5	-4.5	1.9	-1.5	58
ANT_B 2400 MHz	-1.3	-3.2	1.4	-4.3	1.2	-1.8	54
ANT_B 2440 MHz	-1.7	-3.9	1.2	-4.4	0.7	-2.0	54
ANT_B 2480 MHz	-2.8	-4.8	1.0	-4.7	0.9	-2.4	53

The overall performance shows comparable values for both antennas. The measurement was done in an anechoic chamber and it evaluates a single antenna at a time. Second antenna was always terminated by 50 Ω. This was done just to eliminate the influence of the unused antenna. After that, the measured and inactive antenna were swept.

5 Antenna radiation patterns

The 3D plane definition and orientation is considered according to Figure 6. However, the radiation plane is rotated. We can consider the radiation of both antennas as omni-directional, which corresponds to the simulated models.

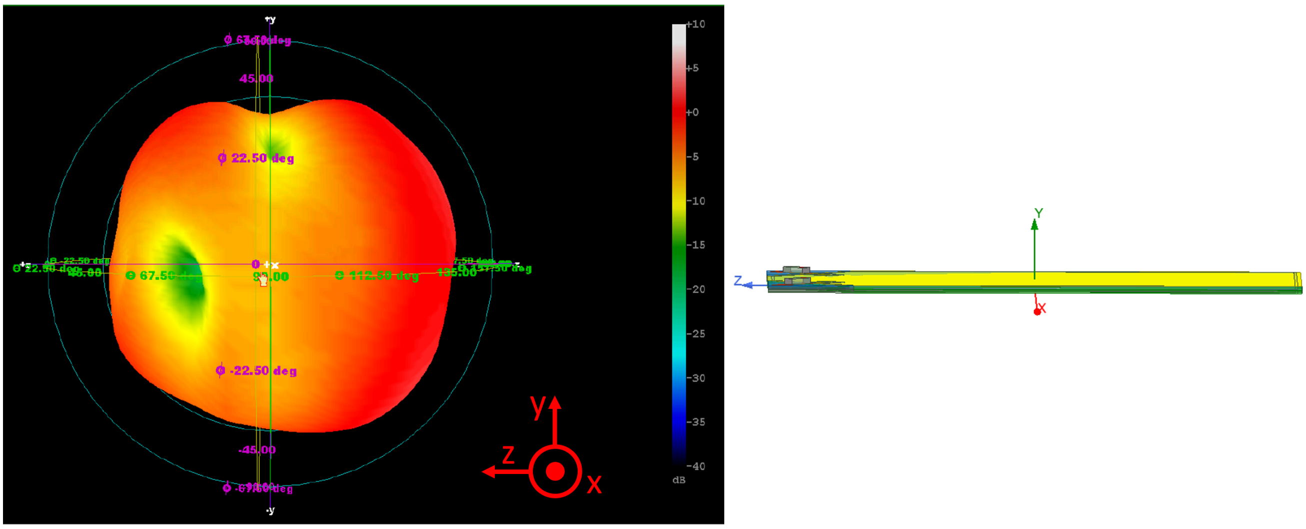


Figure 7. ANT_A 3D radiation pattern

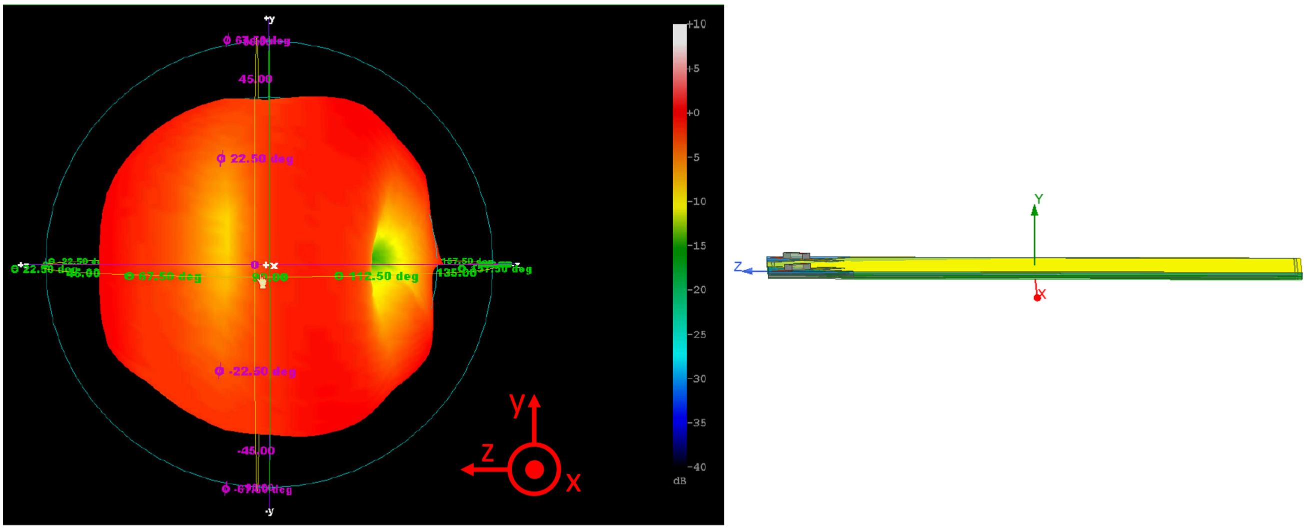


Figure 8. The ANT_B 3D radiation pattern

In addition, the 2D radiation patterns were measured for three planes at a frequency of 2440 MHz. This shows several cross-sections of the radiation. Both antennas have the lowest gain variation in the YZ plane. This also shows a relatively omni-directional radiation. The radiation cross-section corresponds to the theoretical expectation. The board orientation with dedicated planes are in accordance with Figure 6.

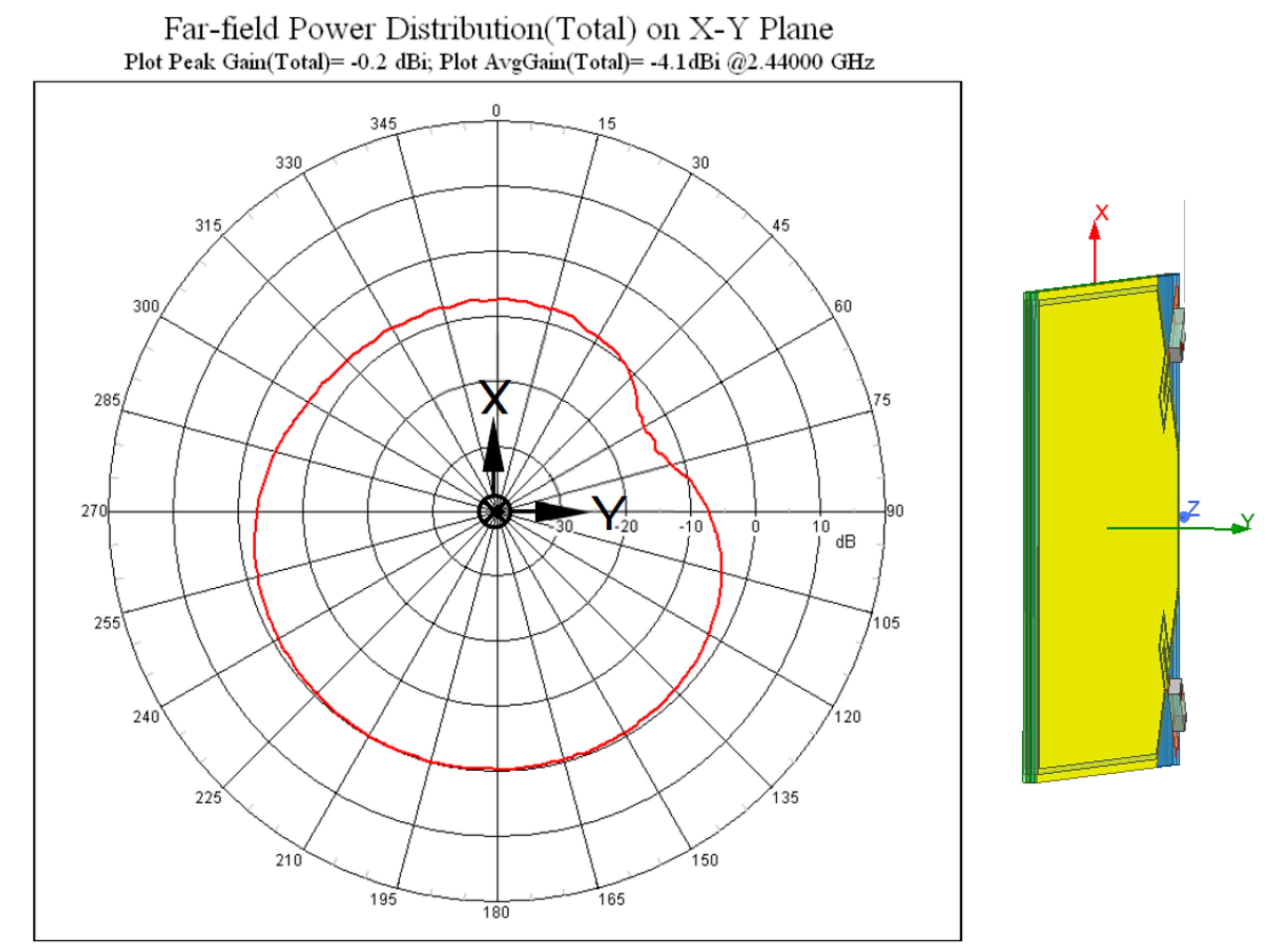


Figure 9. ANT_A - XY plane radiation pattern at 2440 MHz

Table 5. ANT_A - XY plane radiation pattern at 2440 MHz

	Peak gain [dBi]	Avg. gain [dBi]
XY - plane	-0.2	-4.1

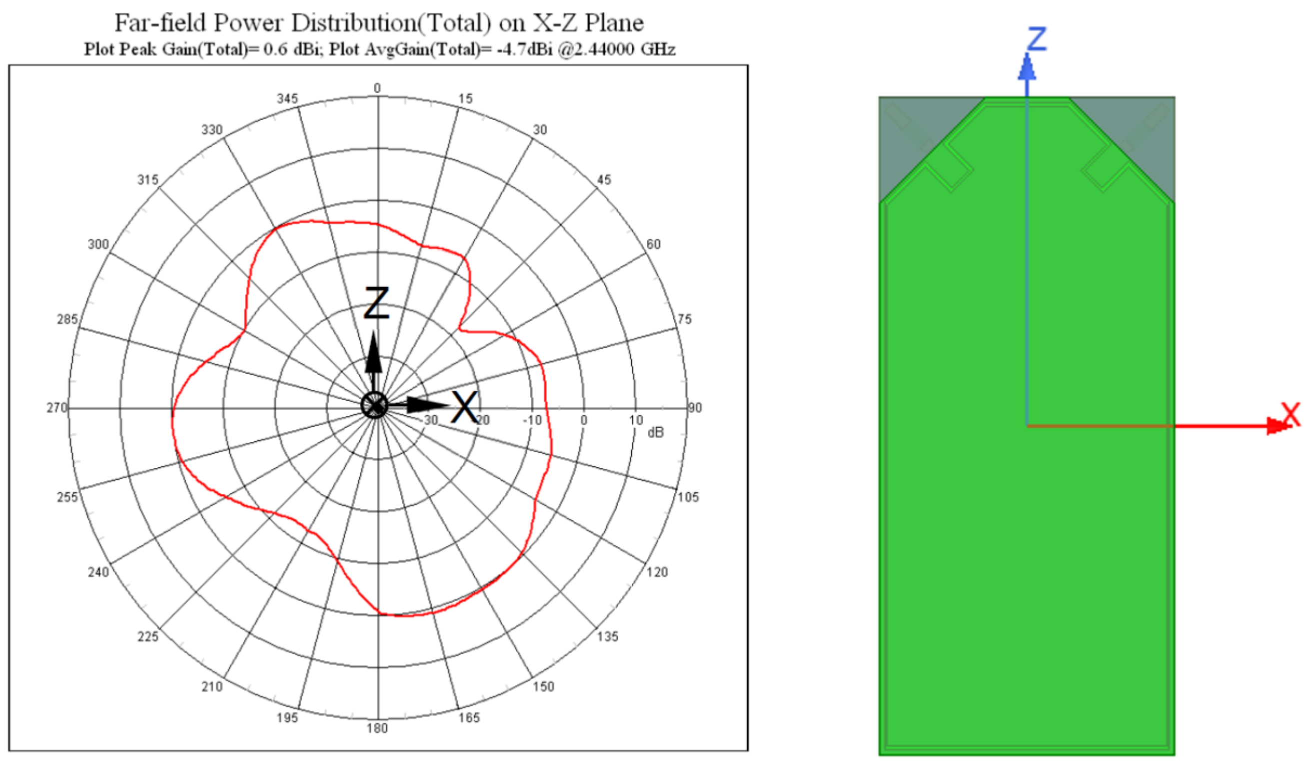


Figure 10. ANT_A - XZ plane radiation pattern at 2440 MHz

Table 6. ANT_A - XZ plane radiation pattern at 2440 MHz

	Peak gain [dBi]	Avg. gain [dBi]
XZ - plane	0.6	-4.7

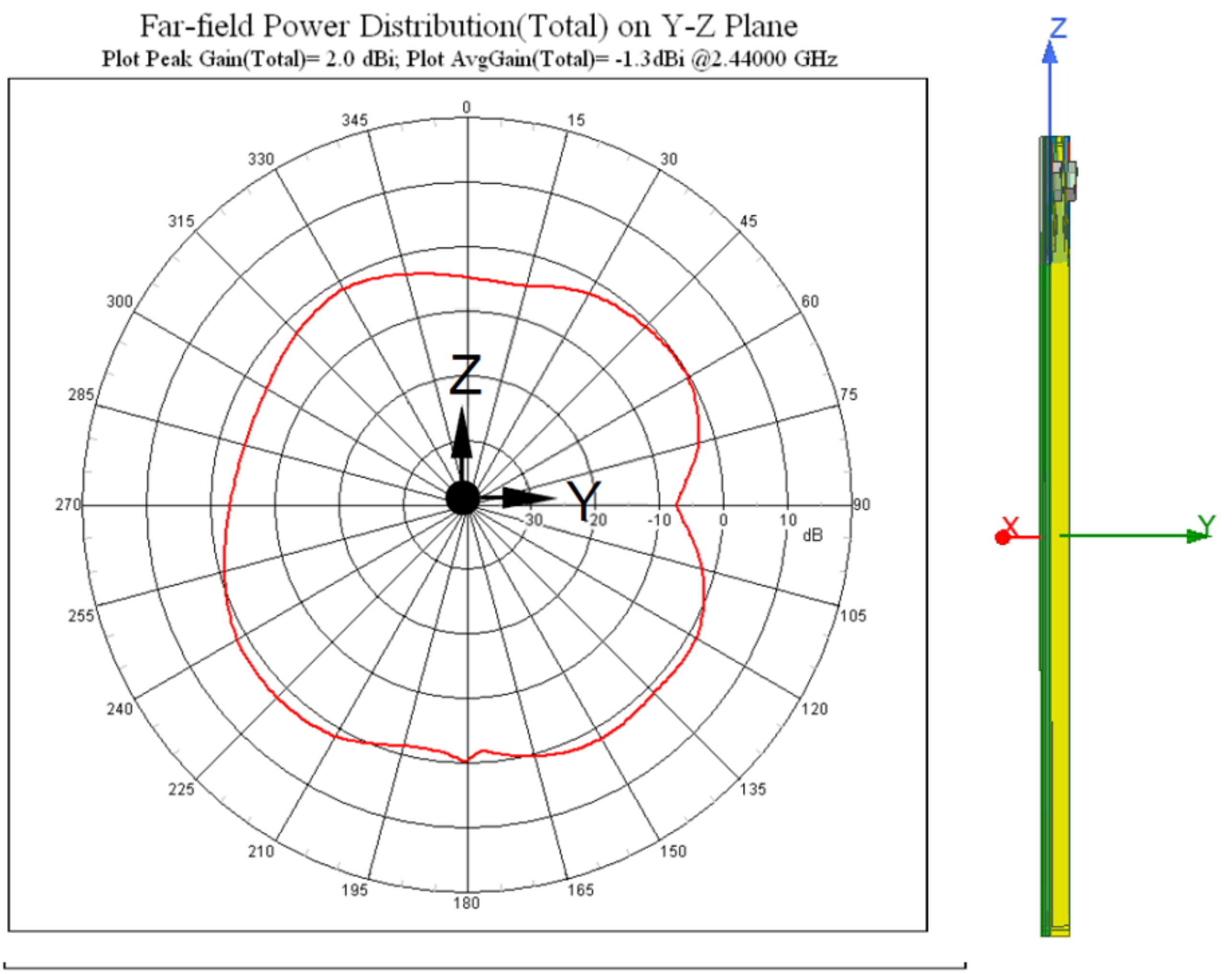


Figure 11. ANT_A - YZ plane radiation pattern at 2440 MHz

Table 7. ANT_A - YZ plane radiation pattern at 2440 MHz

	Peak gain [dBi]	Avg. gain [dBi]
YZ - plane	2.0	-1.3

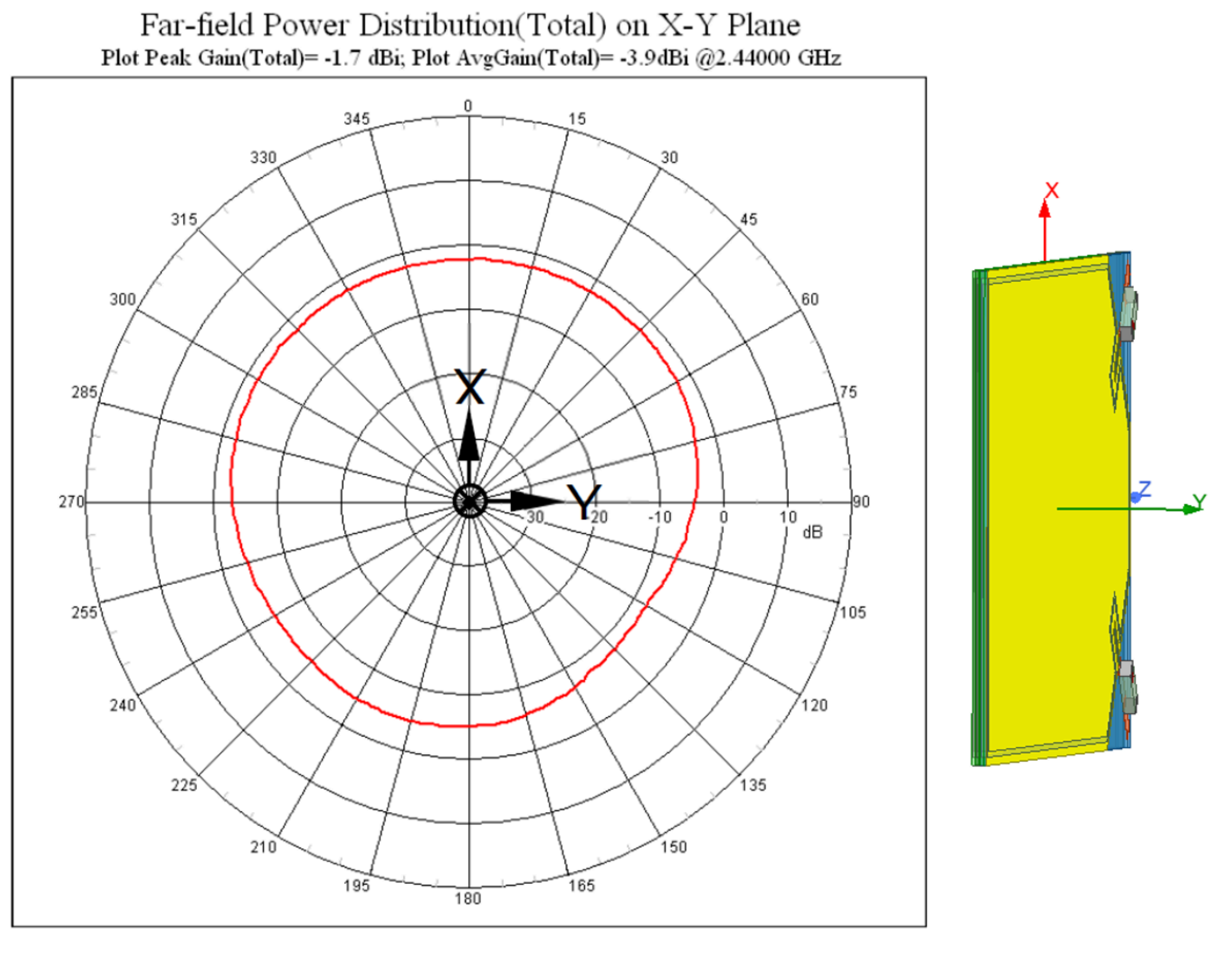


Figure 12. ANT_B - XY plane radiation pattern at 2440 MHz

Table 8. ANT_B - XY plane radiation pattern at 2440 MHz

	Peak gain [dBi]	Avg. gain [dBi]
XY - plane	-1.7	-3.9

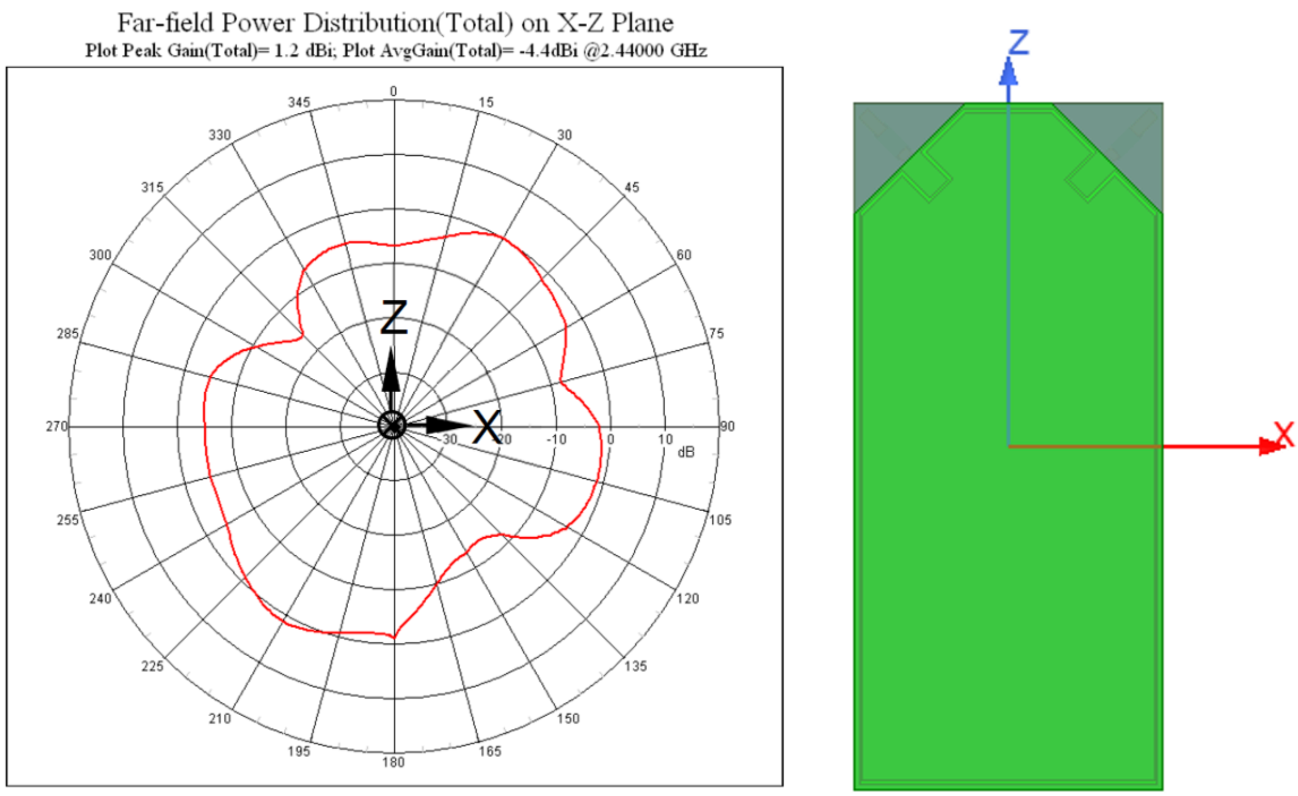


Figure 13. ANT_B - XZ plane radiation pattern at 2440 MHz

Table 9. ANT_B - XZ plane radiation pattern at 2440 MHz

	Peak gain [dBi]	Avg. gain [dBi]
XZ - plane	1.2	-4.4

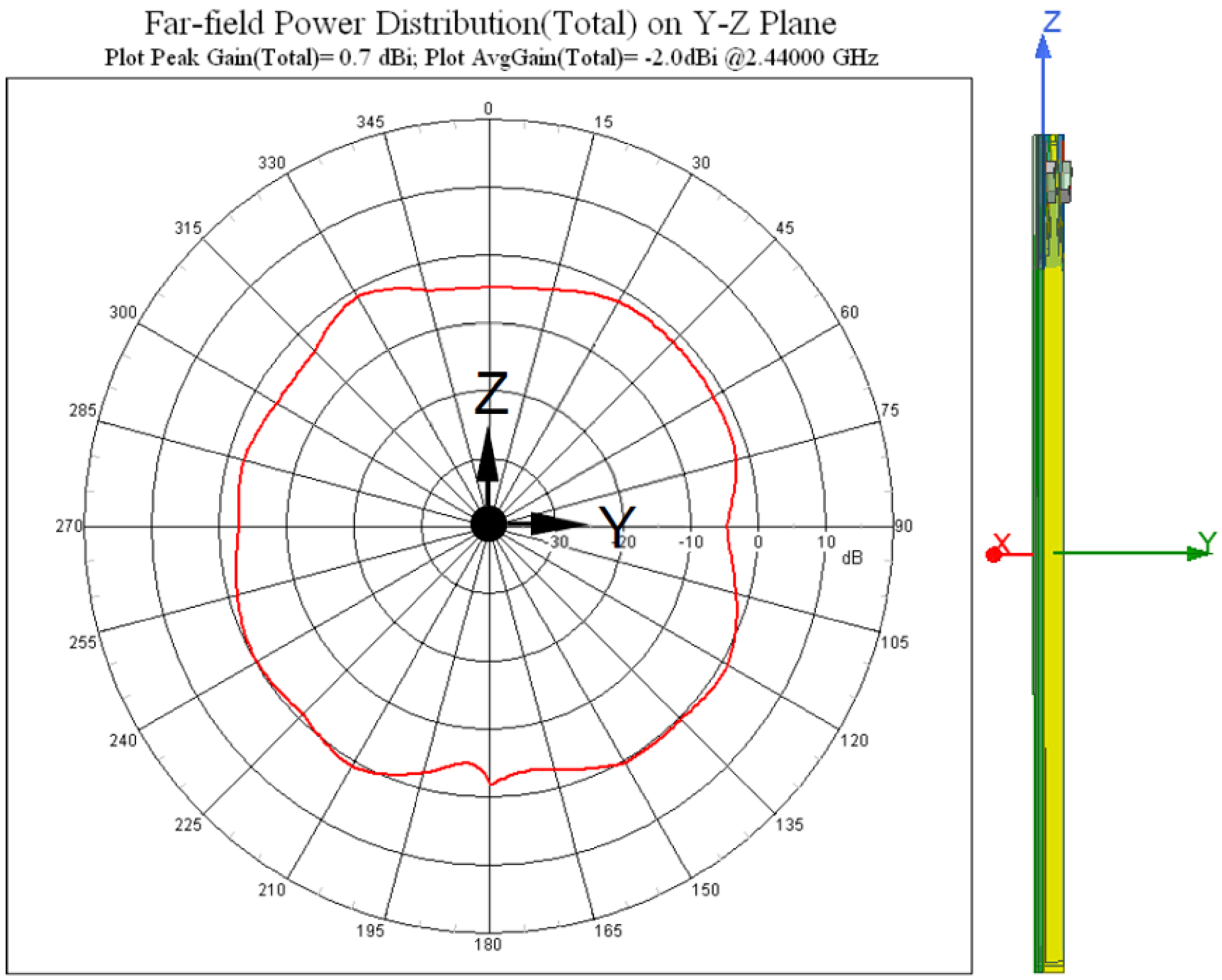


Figure 14. ANT_B - YZ plane radiation pattern at 2440 MHz

Table 10. ANT_B - YZ plane radiation pattern at 2440 MHz

	Peak gain [dBi]	Avg. gain [dBi]
YZ - plane	0.7	-2.0

6 KW45B41Z RF ANT output matching for RX and TX operation

The KW45B41Z antenna RF input/output impedance value is not directly equal to 50 Ω. Therefore, the external RF matching circuit must be used. Moreover, the external DC component must be provided to the PA through the L2 inductor, which makes the matching-circuit design even more complex. VDD_PA_2G4 allows to reach the RF output power of +10 dBm. The schematic of the matching circuit consists of C1, L10, and C2, as shown in Figure 15.

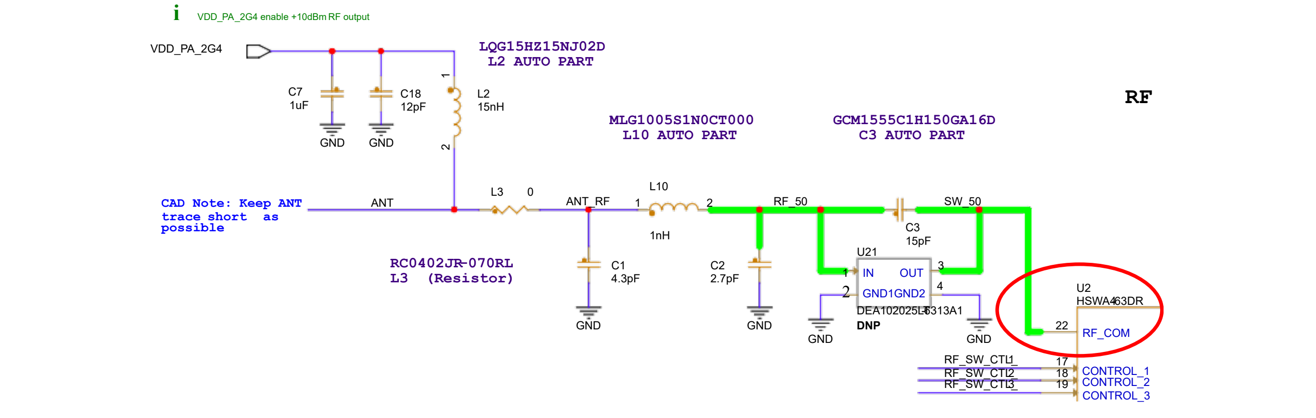


Figure 15. Schematic of MCU antenna RF input/output used on KW45B41Z-LOC board

A proper matching-circuit estimation must be done with a board modification. The HSWA4-63DR RF switch is removed and a semirigid cable is soldered to the input pad number 22. The measurement uses the VNA, whose port is calibrated and connected to the semirigid cable. The VNA port calibration plane was moved to pin 22 using the port extension function. This was calibrated on short and open circuits, which helps to make a precise measurement. The calibration plane is marked in Figure 16.

The following measurement instruments were used:

- VNA - Keysight P5001A
- Calibration method open/short/load with the ECal Module N7551A calibration kit

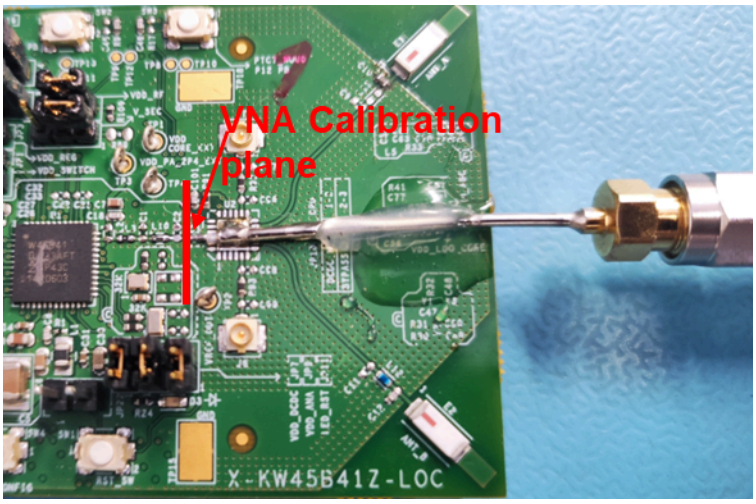


Figure 16. VNA calibration plane moved to the RF switch pad 22

The matching network was estimated and verified for RX and TX modes. Achieve an acceptable reflection coefficient values for RX and TX operations is a kind of compromise for both. The reason is that the tuning of the matching circuit values is highly sensitive and partially contradictory for RX and TX modes. The recommended values for the KW45B41Z-LOC board are as follows:

- Shunt capacitor C1 - 4.3 pF (QSCF201Q4R3A1GV001T auto qualified)
- Serial inductor L10 - 1 nH (MLG1005S1N0CT000 auto qualified)
- Shunt capacitor C2 - 2.7 pF (QSCF251Q2R7A1GV001T auto qualified)

6.1 MCU RF output matching for RX mode

The wireless connectivity test application is used to set the KW45 radio into the receiving mode, as shown by the command line application in Figure 17. The KW45B41Z-LOC SDK package download, including all the example applications, is described in the *KW45B41Z-LOC Board User Manual*.

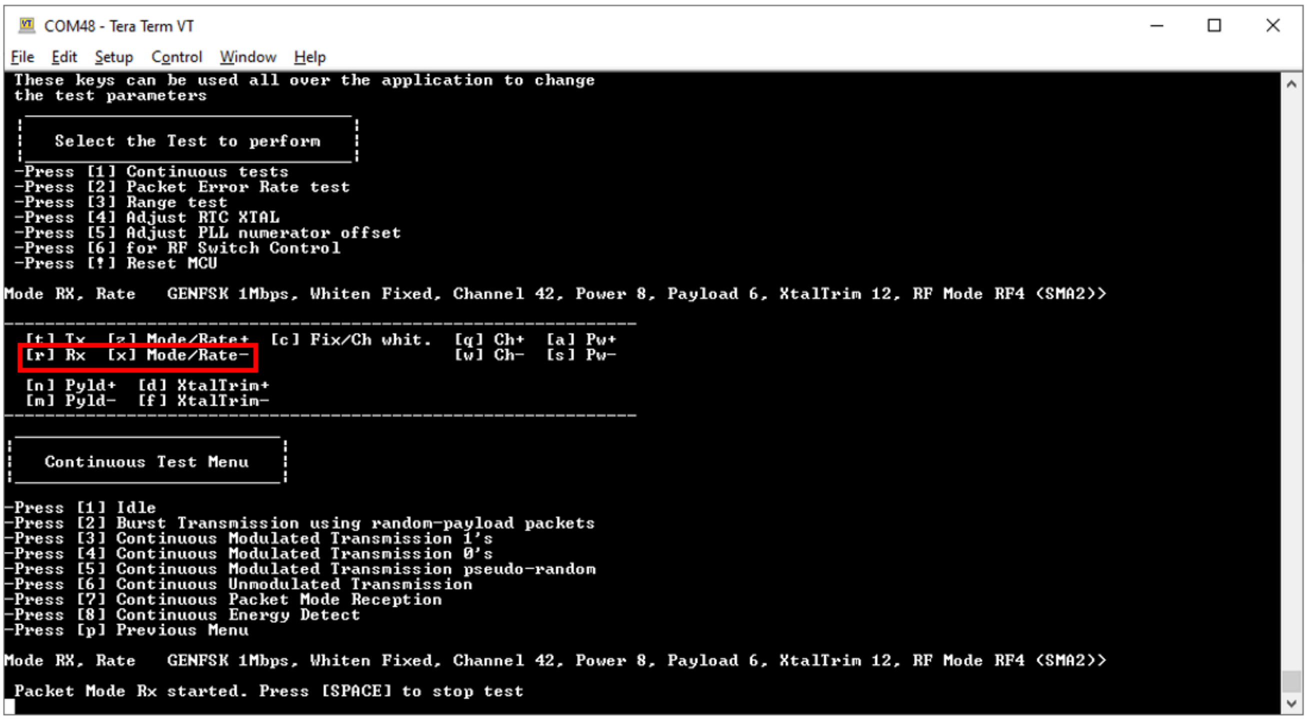


Figure 17. Connectivity test application set the KW45B41Z-LOC into the RX mode

The reflection coefficient s11 in the RX mode was measured with VNA, as shown in Figure 18. The receive mode is the default mode after the reset or application start. The mode can be changed anytime during the application. The chart shows a minimum around the frequency of 2.4 GHz, reaching values of -7.15 dB. The receiving-sensitivity measurement is a complementary evaluation of those values.

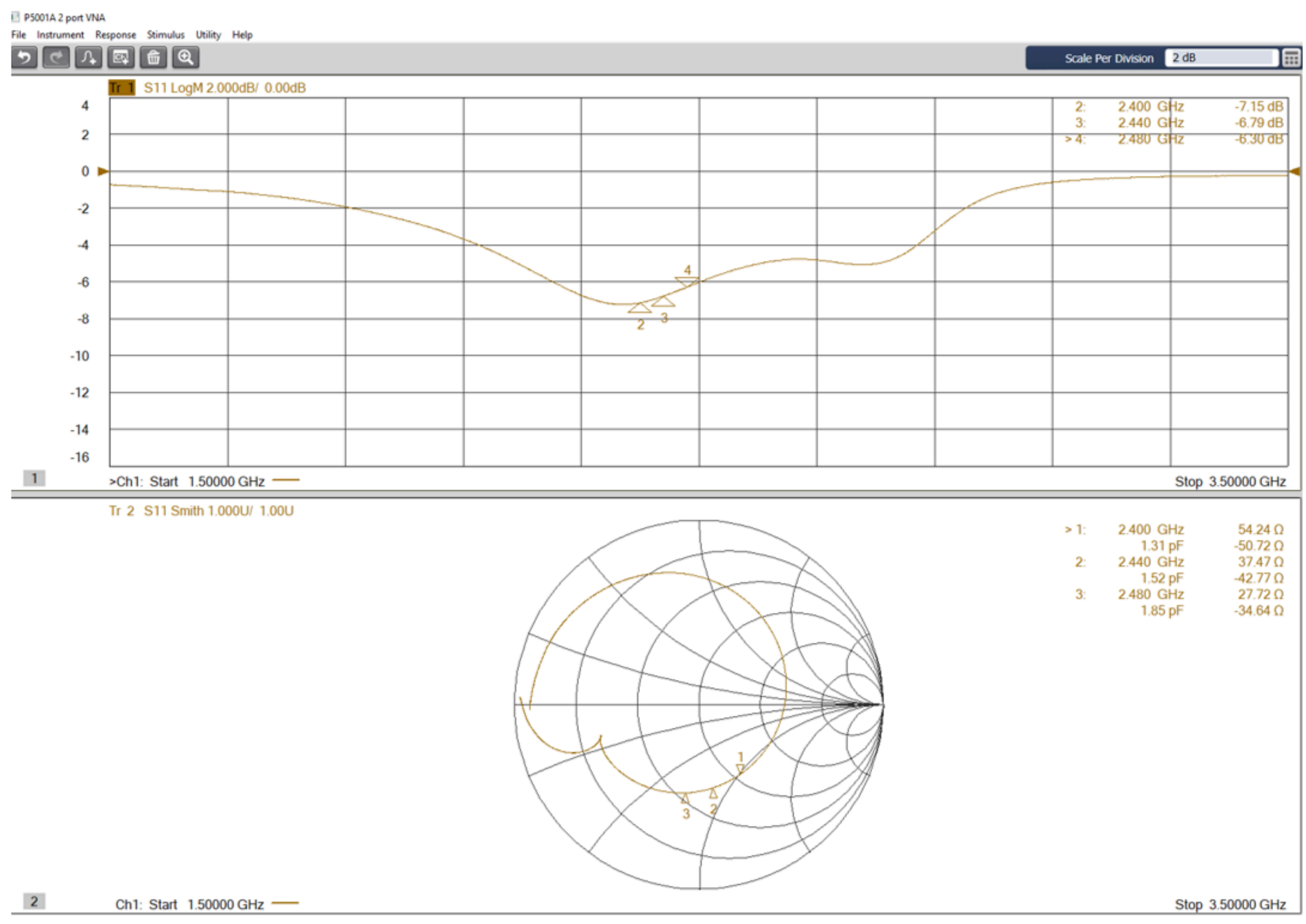


Figure 18. Reflection coefficient s11 of the RX mode

6.2 MCU RF output matching for TX mode

The matching network is verified for the set of maximal RF output power +10 dBm. The KW45 radio is to set to transmit the energy on a specific carrier frequency using the connectivity test application, as shown in Figure 19. The transmitting mode can be changed using the command line interface window including the frequency and output power.

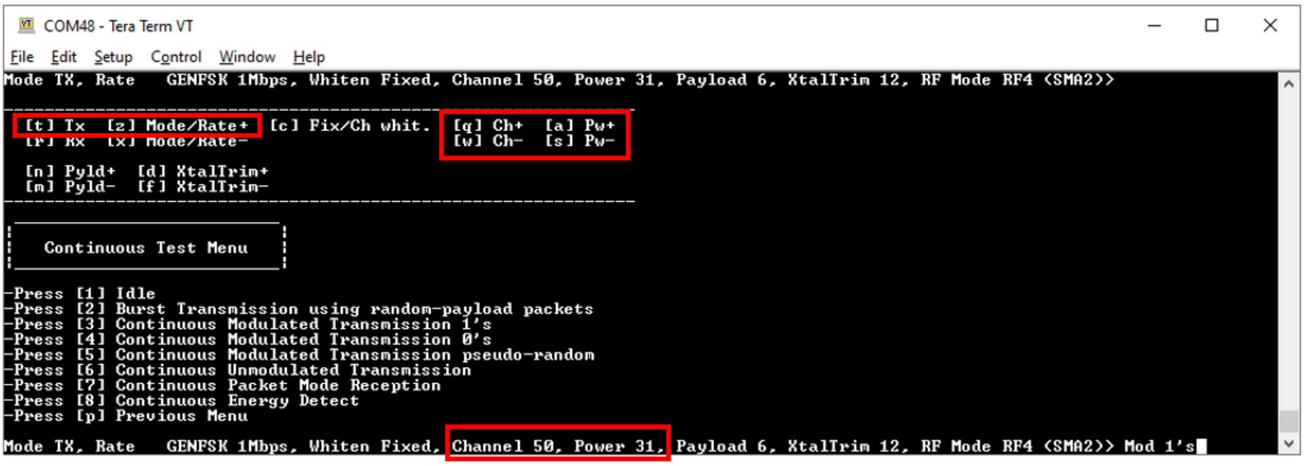


Figure 19. Connectivity test application sets the KW45B41Z-LOC board into the TX mode

The transmitted carrier frequency was set to 2410 MHz and the reflection coefficient s11 is shown in Figure 20.

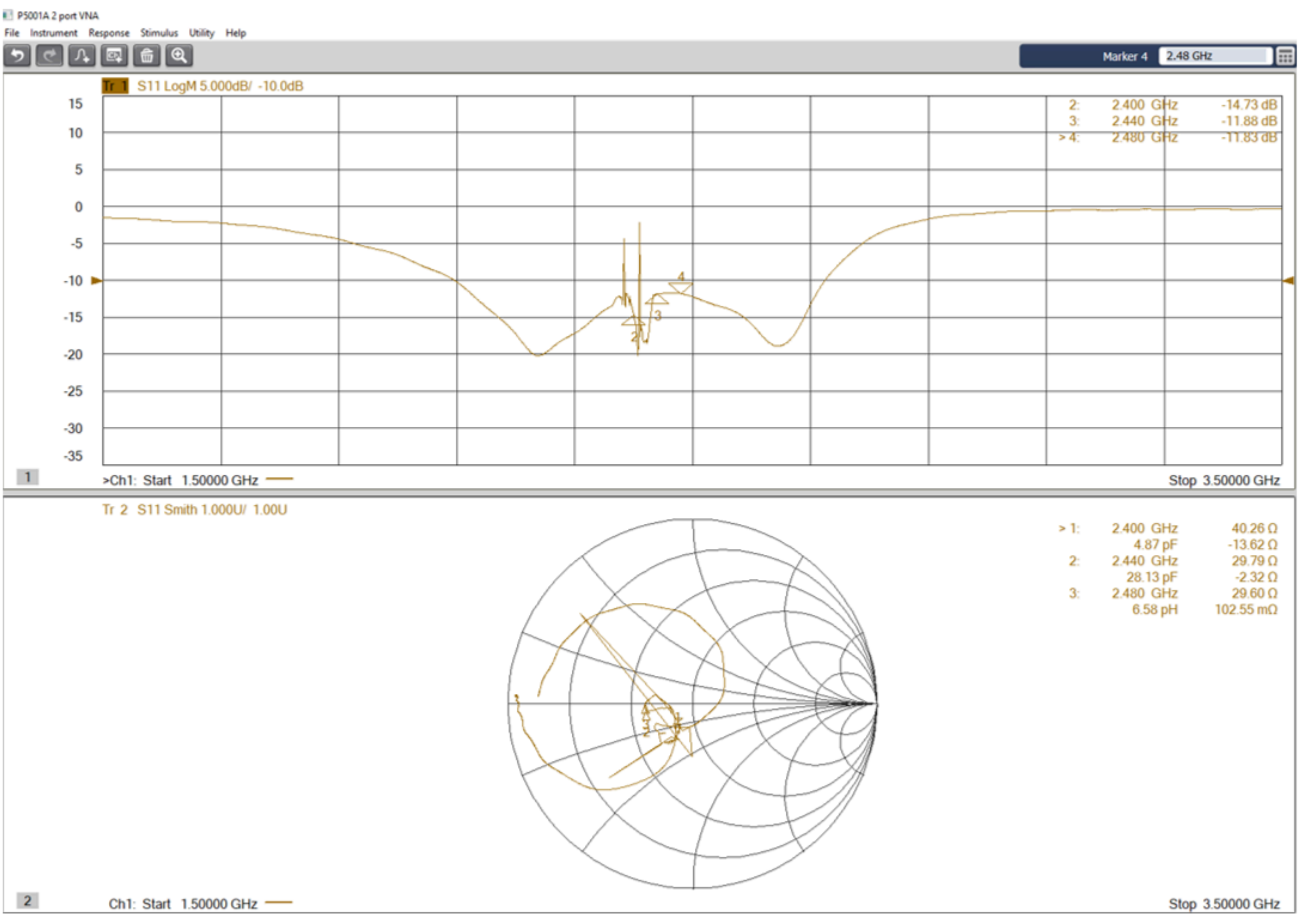


Figure 20. Reflection coefficient s11 of the TX mode

The measured values of the s11 for TX mode reached -11.88 dB at a frequency of 2.44 GHz. This is considered as an acceptable performance of the current design. The maximum output power level measurement will be directly related with the measured values of the s11. The reflection coefficient summary for both RX and TX operations is shown in Table 11.

Table 11. Reflection coefficient summary

s11 measurement	s11 [dB] at 2.4 GHz	s11 [dB] at 2.44 GHz	s11 [dB] at 2.48 GHz
RX mode	-7.15	-6.79	-6.3
TX mode +10 dBm	-14.73	-11.88	-11.83

7 KW45B41Z-LOC board RF output matching for RX and TX operation

The KW45B41Z-LOC board RF input/output impedance was verified for receiving and transmitting operations, including the RF switch influence. The measurement was done with the RF signal routed to the u.FL connector J8. The RF switch must be set to the low isolation state on the RF4 input/output. The whole RF path from the MCU ANT pin to J8 is shown in Figure 21.

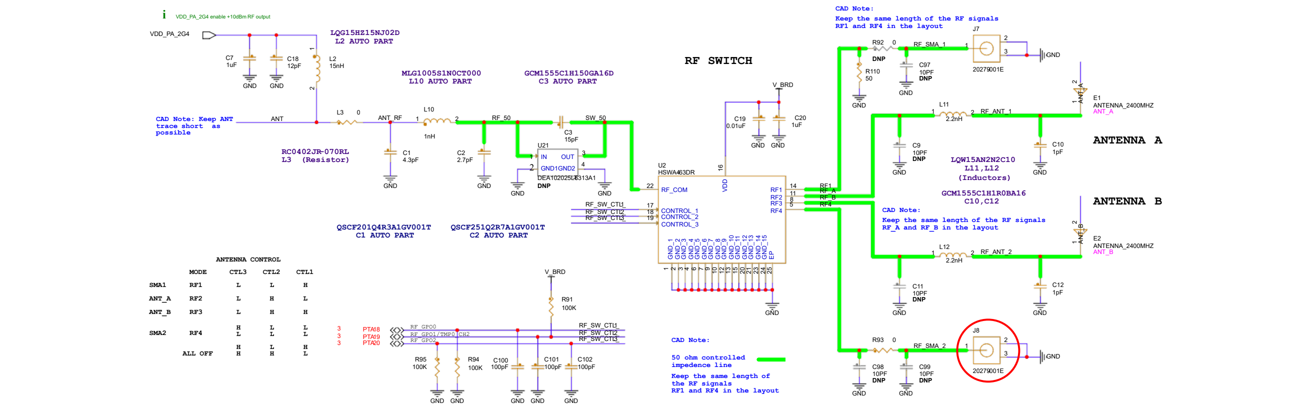


Figure 21. Schematic of the KW45B41Z-LOC board RF paths

The measurement was done with the VNA port calibrated and then connected to the u.FL – SMA straight adapter. The VNA port calibration plane was moved to the u.FL J8 connector using the port extension function. This was calibrated on the open circuit. The calibration plane is shown in Figure 22.

The following measurement instruments were used:

- VNA - Keysight P5001A
- Calibration method open/short/load with the ECal Module N7551A calibration kit

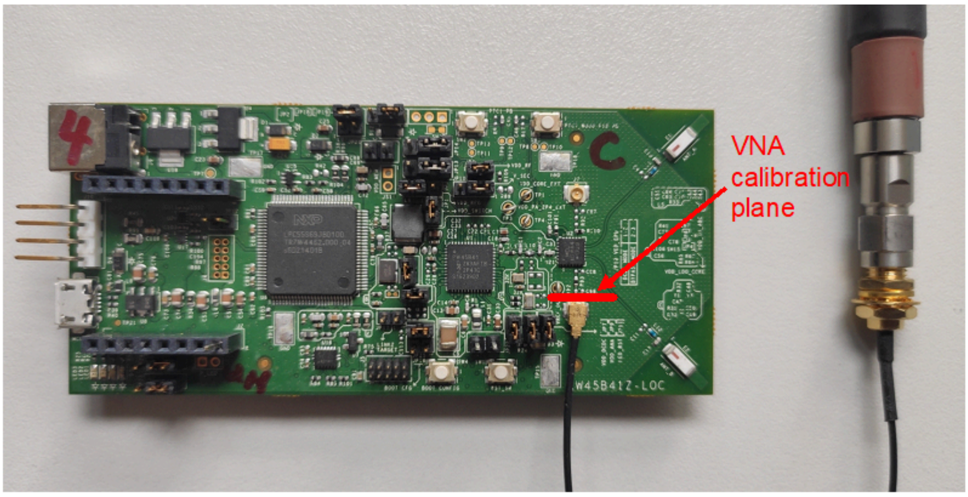


Figure 22. VNA calibration plane moved to the J8 connector

7.1 KW45B41Z-LOC board RF output matching for RX mode

The wireless connectivity test application is used to set the KW45 radio into the receiving mode and activate the RF switch into the RF4 low isolation state (see Figure 18). The reflection coefficient was measured using VNA, as shown in Figure 23.

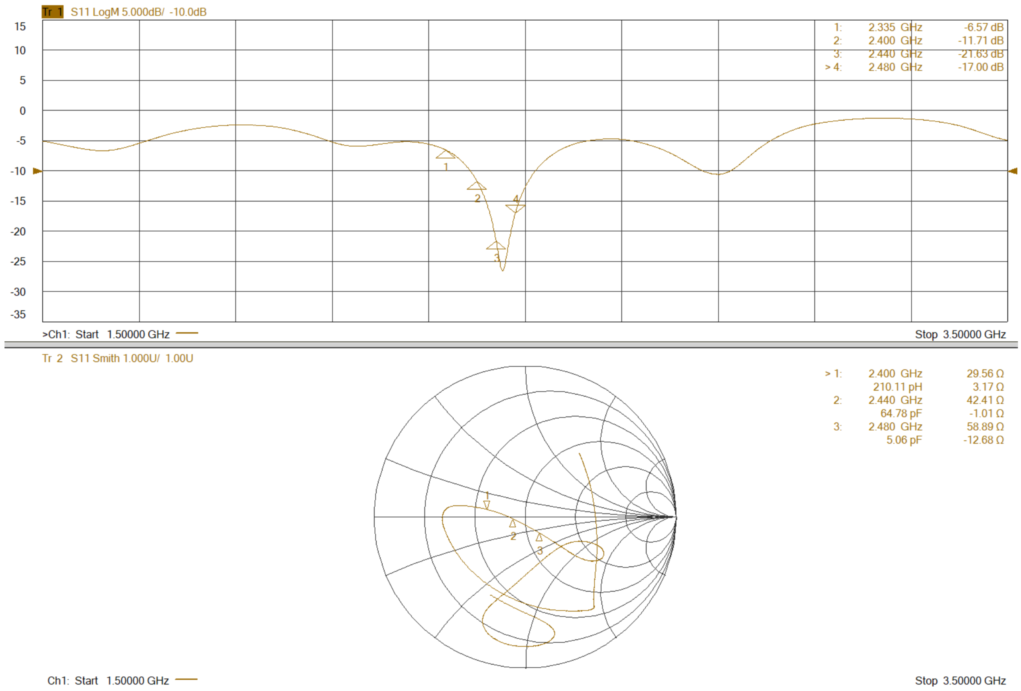


Figure 23. Reflection coefficient s11 of the RX mode

The measured performance shows a minimum notch around the frequency of 2.45 GHz, reaching values of -25 dB. This is considered as a very good achievement of the RX mode operation for the entire frequency range around 2.44 GHz.

7.2 KW45B41Z-LOC board RF output matching for TX mode +10 dBm

The transmission operations are verified for the maximum RF output power of +10 dBm. The KW45 radio is to set to transmit the energy on a specific carrier frequency using the connectivity test application (see Figure 21). The RF switch activates the RF4 input/output as a low-isolation state. The transmitted carrier frequency was set to 2400, 2440, and 2480 MHz. The s11 reflection coefficient is shown in Figure 24.

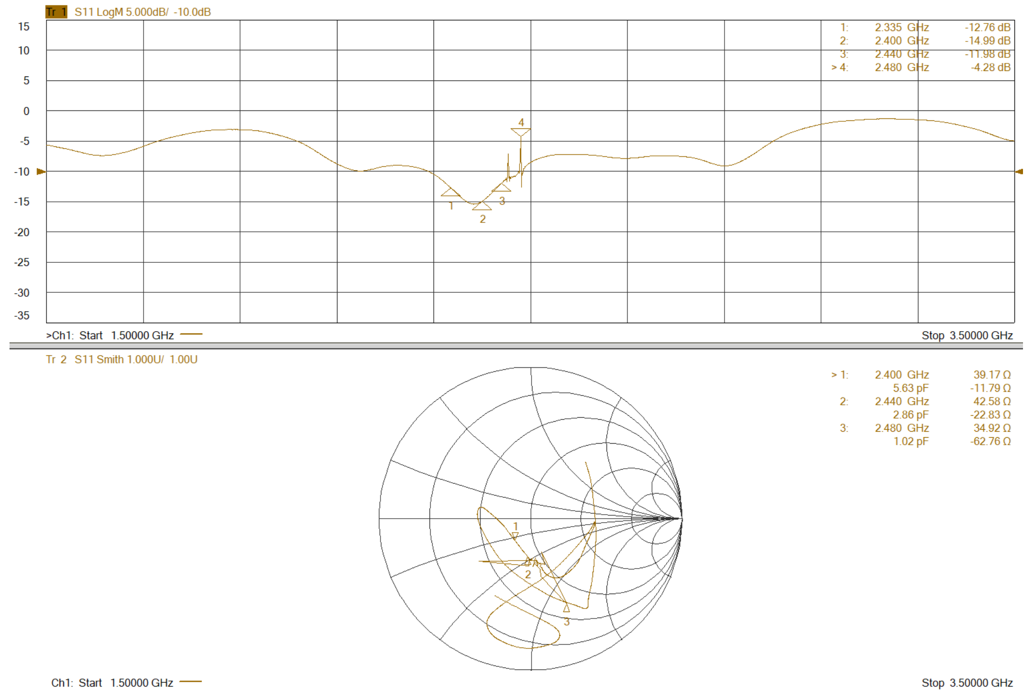


Figure 24. Reflection coefficient s11 of the TX mode

The measured values of the s11 in the TX operations shows a minimum notch of -15 dB around the frequency of 2.4 GHz. The current transmitted carrier frequency was set to 2480 MHz, which is the main reason of the spike captured by the marker at 2.48 GHz. This is considered as a good achievement of the TX mode operation for the entire frequency range around 2.44 GHz.

Table 12 shows good matching values in the certain frequency range of 2.4 – 2.48 GHz. This is needed to achieve appropriate sensitivity and maximum power output levels.

Table 12. Reflection coefficient s11 summary

s11 measurement	s11 [dB] at 2.4 GHz	s11 [dB] at 2.44 GHz	s11 [dB] at 2.48 GHz
RX mode	-11.71	-21.63	-17.00
TX mode 2.40 GHz	N/A	-9.43	-8.23
TX mode 2.44 GHz	-12.73	N/A	-8.48
TX mode 2.48 GHz	-14.99	-11.98	N/A

8 KW45B41Z-LOC maximum RF output power

The maximum TX output level was verified by the R&S Wireless Connectivity Tester CMW270 and KW45B41Z-LOC running the connectivity test application. This example application can switch the KW45 radio into the Generic FSK transmission mode and control the RF switch on the board. See Section 10.1 for a detailed description of the connectivity test application settings. The maximum output level of +10 dBm was set and all frequency channels were swept. Figure 25 shows the frequency spectrum measured via the conductive way on the u.FL J8 connector of the KW45B41Z-LOC board.

The following equipment was used for the measurement:

- Wireless Connectivity Tester – R&S CMW270

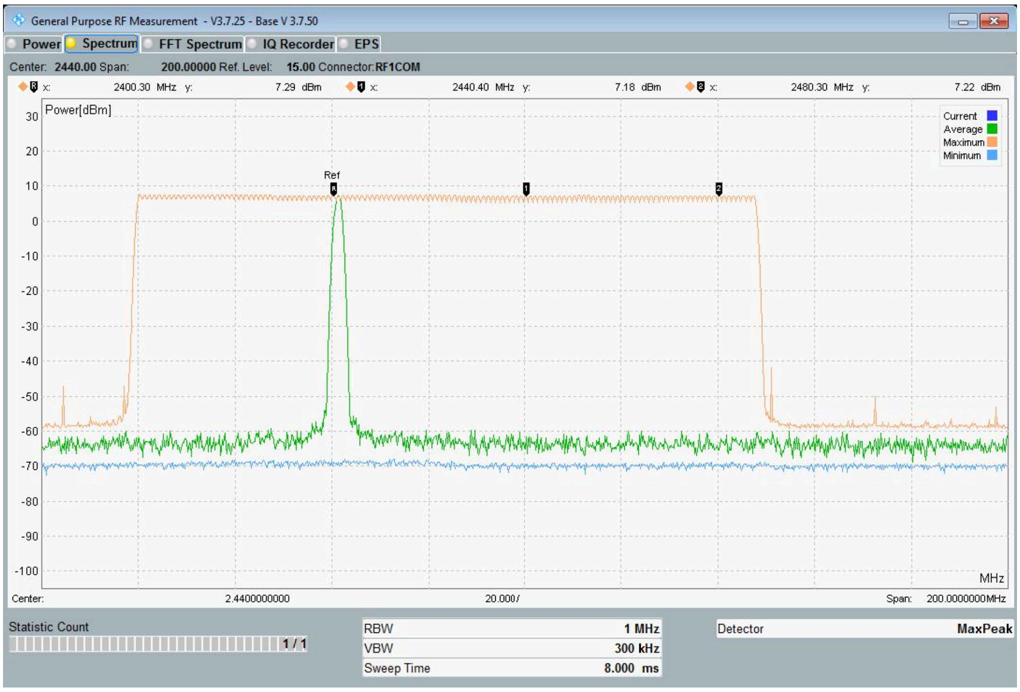


Figure 25. Frequency spectrum captured during maximum TX output level measurement

Table 13 summarizes the measured values of the TX output level for the three frequencies. Additional attenuation must be added to reach correct output-level values.

Table 13. Measured TX output levels of KW45B41Z-LOC board

		Measured TX output level [dBm]				Real TX output level [dBm]			
	Max TX Output level from data sheet [dBm]	Frequency 2400 MHz	Frequency 2440 MHz	Frequency 2480 MHz	Additional insertion loss [dB]	Frequency 2400 MHz	Frequency 2440 MHz	Frequency 2480 MHz	Average power [dBm]
KW45B41 Z-LOC Rev C	10	7.29	7.18	7.22	2.05	***9.34***	***9.23***	***9.27***	***9.28***

Additional loss incorporated during the measurement is shown in Table 14. It contains several values which must be added to calculate the real TX output level.

Table 14. Additional attenuation during maximum TX output level measurement

Losses during maximum TX output measurement	Attenuation [dB]
RF switch insertion loss	1.4
SMA jack to U.FL plug adapter	0.6
N connector adapter	0.05
Total attenuation	**2.05**

The average power-output level reaches 9.28 dBm. The maximum TX output level of the RF ANT pin reaches 10 dBm according to the data sheet, which shows the difference of approximately 0.7 dB. This is considered as a good performance of the KW45B41Z-LOC board.

9 KW45B41Z-LOC RF sensitivity measurement

The RF sensitivity of the KW45B41Z-LOC board was verified using Wireless Connectivity Tester and HCI BlackBox application running on the KW45B41Z-LOC board. The measured device must be placed into a shielded box to eliminate the RF noise background. The measurement below shows sensitivity level values measured on the u.FL J8 connector (conductive way) of the KW45B41Z-LOC board.

The following equipment was used during the measurement:

- Wireless Connectivity Tester – R&S CMW270
- RF shield box – R&S CMW-Z10

The CMW-270 generator is used in the ARB mode to generate a pattern of 2000 packets. The Wireless Connectivity Tester directly controls the application on the KW45B41Z-LOC board using the HCI commands. The measurements were done following the steps below:

- Four BLE data rates checked - 2 Mbit/s, 1 Mbit/s, LR 500 kbit/s (S=2), and LR 125 kbit/s (S=8)
- Checked channels 0, 20, and 39
- Connection is automatically established and PER (Packet Error Rate) is measured
- Decrease the level of the signal generator at the RF input of the module until PER is approximately 30 %
- Desired lowest-input signal level is measured

Figure 27 shows the measurement screenshot for the BLE data rate of 1 Mbit/s on channel 20.

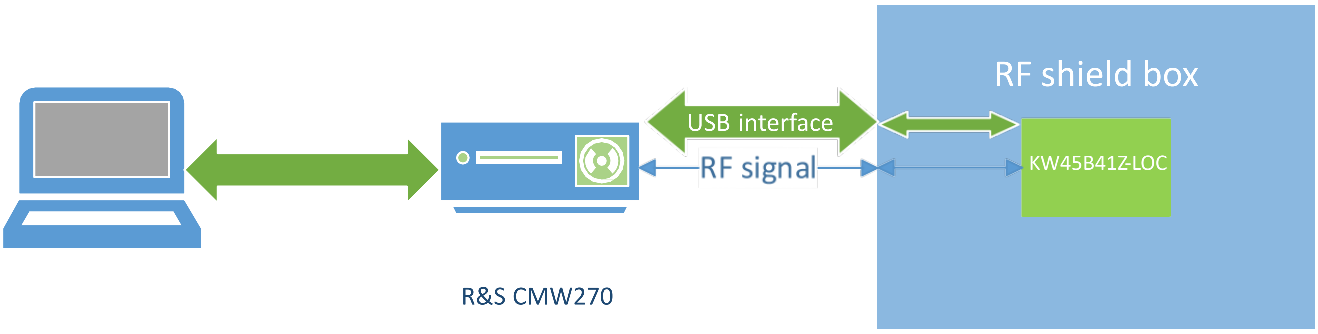


Figure 26. RF sensitivity measurement – block diagram

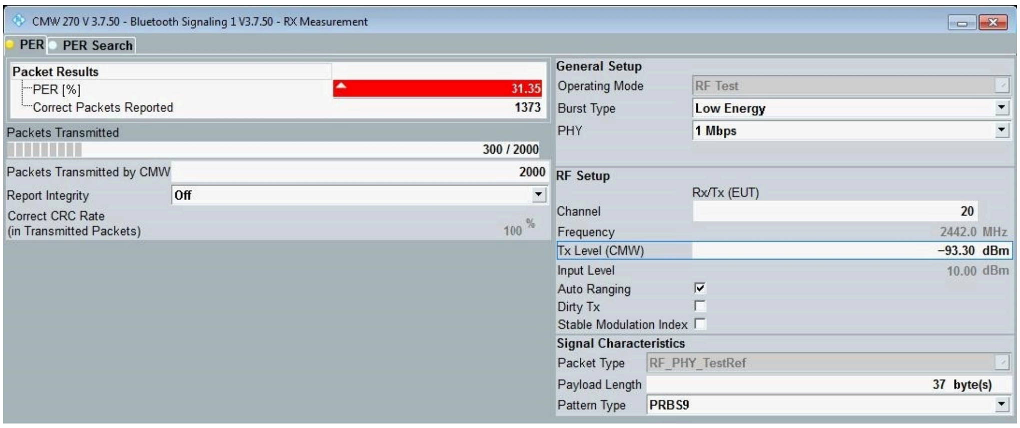


Figure 27. Sensitivity measurement of KW45B41Z-LOC board for BLE data rate of 1 Mbit/s on channel 20

Table 15 shows the sensitivity values for all measured data rates and three frequency channels.

Table 15. Measured sensitivity values of KW45B41Z-LOC board

		Measured sensitivity [dBm]				Real sensitivity values [dBm]		
Sensitivity measurement with RF switch	Sensitivity data sheet values [dBm]	Channel 0	Channel 20	Channel 39	Additional insertion loss [dB]	Channel 0	Channel 20	Channel 39
BLE data rate 2 Mbit/s	-95	-89.7	-89.4	-89.4	3.2	***-92.9***	***-92.6***	***-92.6***
BLE data rate 1 Mbit/s	-97.5	-93.6	-93.3	-93.3	3.2	***-96.8***	***-96.5***	***-96.5***
BLE data rate LR 500 kbit/s S2	-102	-95.8	-95.7	-95.5	3.2	***-99***	***-98.9***	***-98.7***
BLE data rate LR 125 kbit/s S8	-106	-101.9	-101.8	-101.6	3.2	***-105.1***	***-105***	***-104.8***

The additional loss incorporated during the measurement is shown in Table 16. It contains attenuation values that must be added to calculate the sensitivity RX input level of the KW45B41Z MCU device.

Table 16. Additional attenuation during RX sensitivity measurement

Losses during maximum TX output measurement	Attenuation [dB]
RF switch insertion loss	1.4
SMA jack to U.FL plug adapter	0.6
N connector adapter in shield box	0.2
Huber & Huber + Suhner N cable	1
Total attenuation	**3.2**

The table summary shows the lowest RX sensitivity difference between the data sheet value and the current measurement for the BLE data rate of 1 Mbit/s and 125 kbit/s.

10 Software support for KW45B41Z-LOC RF measurements

A few software application examples allowing to perform measurements using the KW45B41Z-LOC board above are part of the SDK. The SDK package contains modifications that allow the RF switch control and specific signal output selection. The most of the measurements were performed using the connectivity test application. The sensitivity measurement was realized using the HCI black box application. The SDK package supporting the localization board is currently provided under controlled access on the MCUXpresso website https://mcuxpresso.nxp.com/en/welcome. The description how to download the SDK package supporting the KW45B41Z-LOC platform is mentioned in the *KW45B41Z-LOC Board User Manual*.

10.1 Example of the wireless connectivity test application control

- Download the KW45B41Z-LOC SDK ZIP package.
- Compile the wireless connectivity test application for the localization board. Flash the application into the localization board.
- Before testing, the Teraterm application (or other serial terminal emulator - PuTTY) must be installed on the PC. If it is not installed, install a serial terminal emulator application.
- Plug a USB cable between the KW45B41Z-LOC board (J3) and the PC (USB Port). The LED3 (Green) turns on.

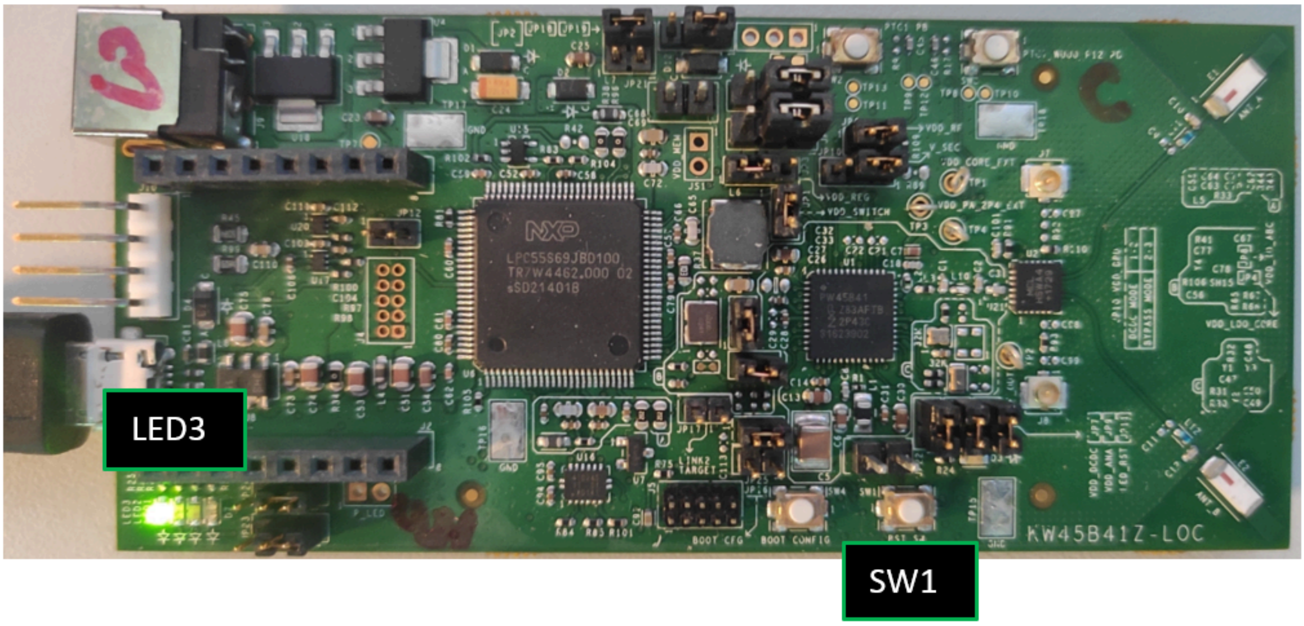


Figure 28. Powered KW45B41Z-LOC board

- Go to "Device Manager" and check the COM port number under "Ports (COM & LPT)". It must look similar to Figure 29.

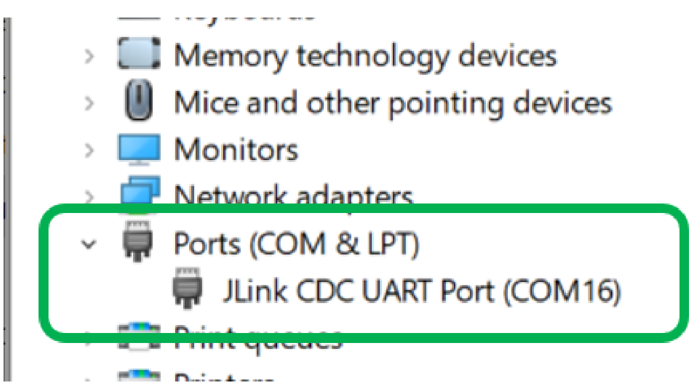


Figure 29. Windows device manager screenshot

- Open the Teraterm software. Select the “serial” option and click “OK”.
- The port COM can change on each PC or connected KW45B41Z-LOC board (shown in the last step).
- Go to the “Setup” tab and click the “Serial Port…” option.

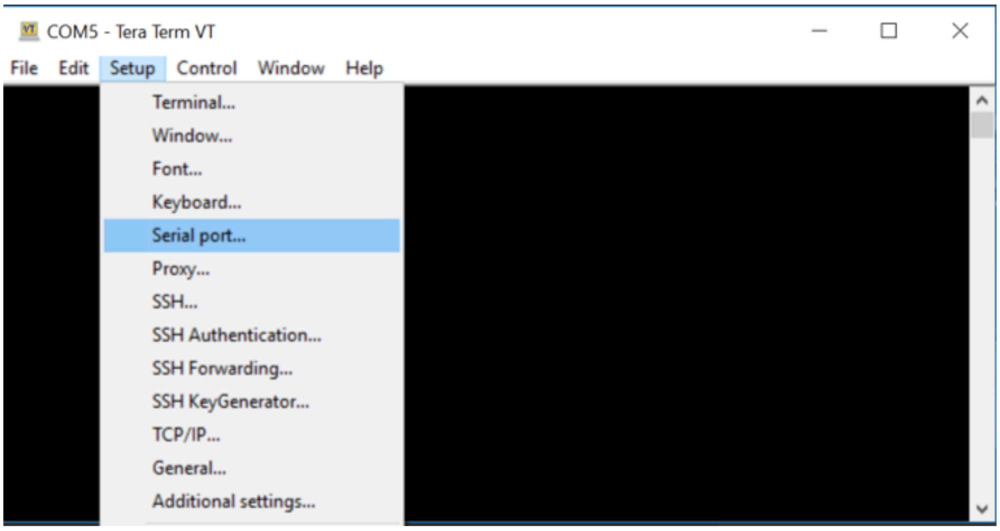


Figure 30. Teraterm Serial port setup selection

Select the COM port number that the KW45B41Z-LOC board is connected to.

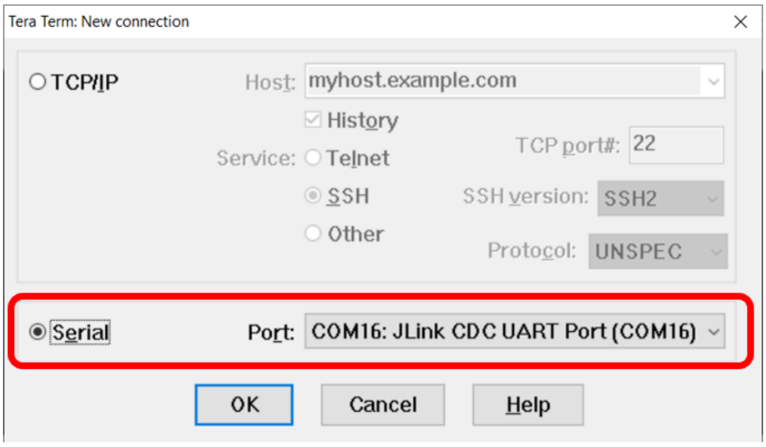


Figure 31. Teraterm Serial port setup selection

In the “Serial port setup” window, select “115200” in the "speed" option and click the “OK” button.

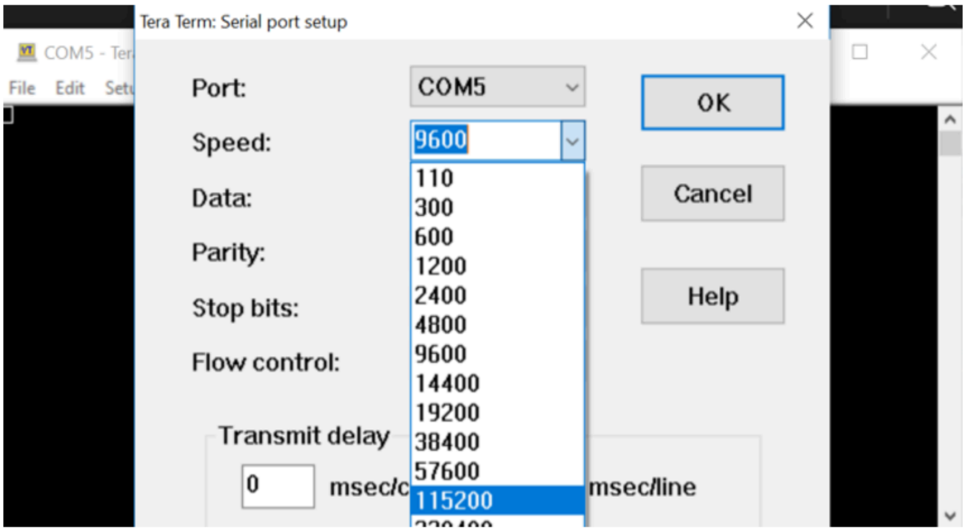


Figure 32. Teraterm Serial COM port settings

Note: *In the "Terminal Setup", both "New-line Receive" and "New-line Transmit" should be set to "CR".*

- Push the SW1 (RST_SW) button to reset the board. The window shown in Figure 33 appears.

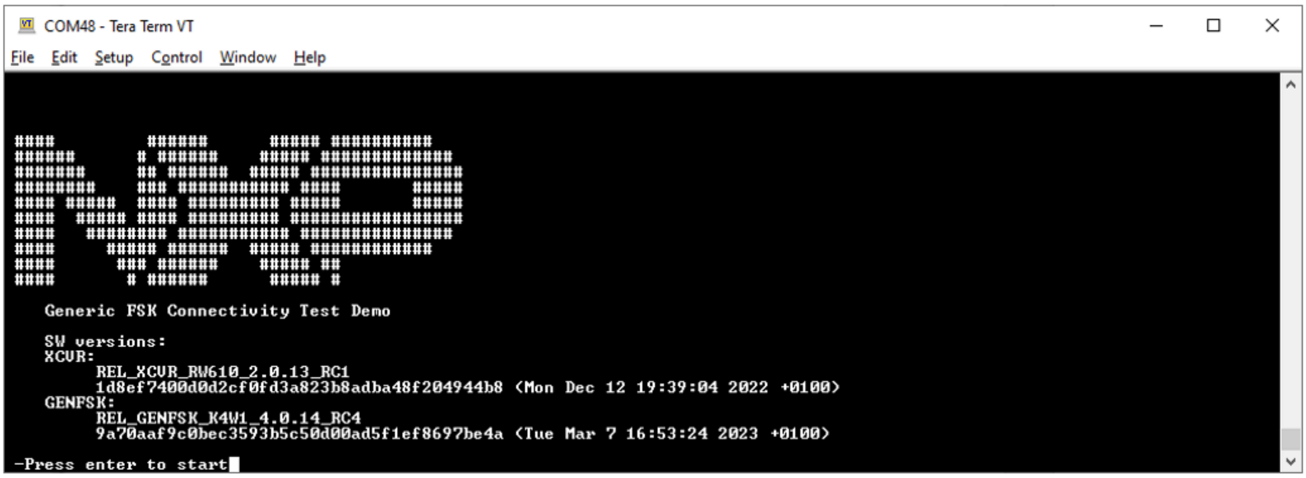
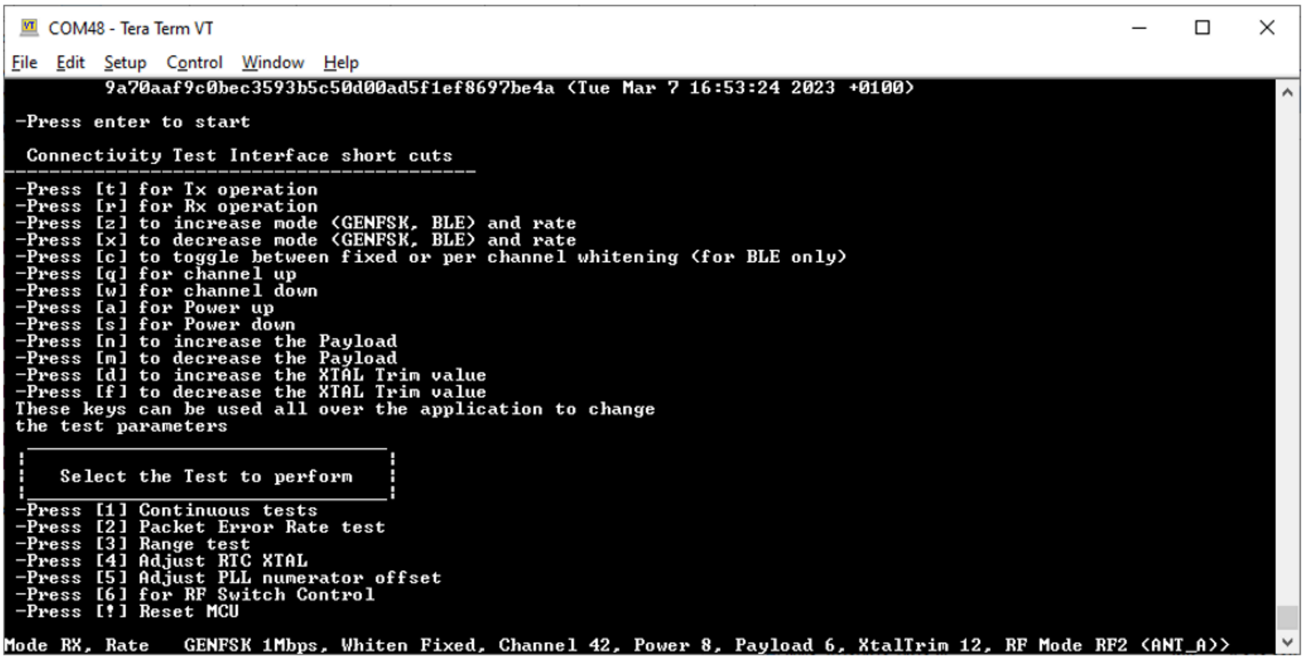


Figure 33. Initial connectivity test application window after reset

- Press “Enter” on the keyboard until you see the menu shown in Figure 34.



```
COM48 - Tera Term VT
File  Edit  Setup  Control  Window  Help
         9a70aaf9c0bec3593b5c50d00ad5f1ef8697be4a (Tue Mar 7 16:53:24 2023 +0100)

 -Press enter to start

  Connectivity Test Interface short cuts
------------------------------------------
 -Press [t] for Tx operation
 -Press [r] for Rx operation
 -Press [z] to increase mode (GENFSK, BLE) and rate
 -Press [x] to decrease mode (GENFSK, BLE) and rate
 -Press [c] to toggle between fixed or per channel whitening (for BLE only)
 -Press [q] for channel up
 -Press [w] for channel down
 -Press [a] for Power up
 -Press [s] for Power down
 -Press [n] to increase the Payload
 -Press [m] to decrease the Payload
 -Press [d] to increase the XTAL Trim value
 -Press [f] to decrease the XTAL Trim value
 These keys can be used all over the application to change
 the test parameters

    Select the Test to perform

 -Press [1] Continuous tests
 -Press [2] Packet Error Rate test
 -Press [3] Range test
 -Press [4] Adjust RTC XTAL
 -Press [5] Adjust PLL numerator offset
 -Press [6] for RF Switch Control
 -Press [!] Reset MCU

Mode RX, Rate   GENFSK 1Mbps, Whiten Fixed, Channel 42, Power 8, Payload 6, XtalTrim 12, RF Mode RF2 (ANT_A)>
```

Figure 34. Main menu of the connectivity test application

- Type “6” to select the RF switch activated output and a sub-menu appears. Type “1-5” to select one of the RF outputs. For example, number 4 activates the RF4 output (SMA2) for conductive measurements. Pres “p” to go into the previous menu.

```
   RF Switch Control Menu

-Press [1] for RF1 (SMA1) mode
-Press [2] for RF2 (ANT_A) mode
-Press [3] for RF3 (ANT_B) mode
-Press [4] for RF4 (SMA2) mode
-Press [5] for ALL OFF mode
-Press [p] Previous Menu

Current Mode: RF2 (ANT_A)
RF4 (SMA2) Mode Selected
```

Figure 35. RF switch selection menu

- Type “1” to enter the continuous test menu.

```
---------------------------------------------------------------
  [t] Tx  [z] Mode/Rate+  [c] Fix/Ch whit.  [q] Ch+  [a] Pw+
  [r] Rx  [x] Mode/Rate-                    [w] Ch-  [s] Pw-

  [n] Pyld+  [d] XtalTrim+
  [m] Pyld-  [f] XtalTrim-
---------------------------------------------------------------

    Continuous Test Menu

-Press [1] Idle
-Press [2] Burst Transmission using random-payload packets
-Press [3] Continuous Modulated Transmission 1's
-Press [4] Continuous Modulated Transmission 0's
-Press [5] Continuous Modulated Transmission pseudo-random
-Press [6] Continuous Unmodulated Transmission
-Press [7] Continuous Packet Mode Reception
-Press [8] Continuous Energy Detect
-Press [p] Previous Menu

Mode RX, Rate   GENFSK 1Mbps, Whiten Fixed, Channel 42, Power 8, Payload 6, XtalTrim 12, RF Mode RF2 (ANT_A)>
```

Figure 36. Continuous test menu of the connectivity test application

- Type “7” to start the continuous receive packet mode.

Figure 37. Continuous packet receive mode

- Press “space” to stop the receive mode test and press “enter” to continue to the previous window menu.
- Type “6” to start the continuous unmodulated transmission (the "Unmod" text appears at the end of line in the console). Verify that the board is in the TX mode ("Mode TX" at the start of the line). The instructions are in Section 10.2.

Figure 38. Continuous unmodulated transmission

- Section 10.2 shows additional settings in the connectivity test application that may be useful during the RF performance measurements.

10.2 Configuration of the other settings in the connectivity test application

- After the KW45B41Z-LOC board reset, the main menu shows the connectivity test interface shortcuts. The menu shows how to switch between TX and RX operations, to increase or decrease the mode, channel, power, and so on. When typing the letter, the parameter change is shown in the last line of the window console. Those parameters can be changed before or after a test is selected.

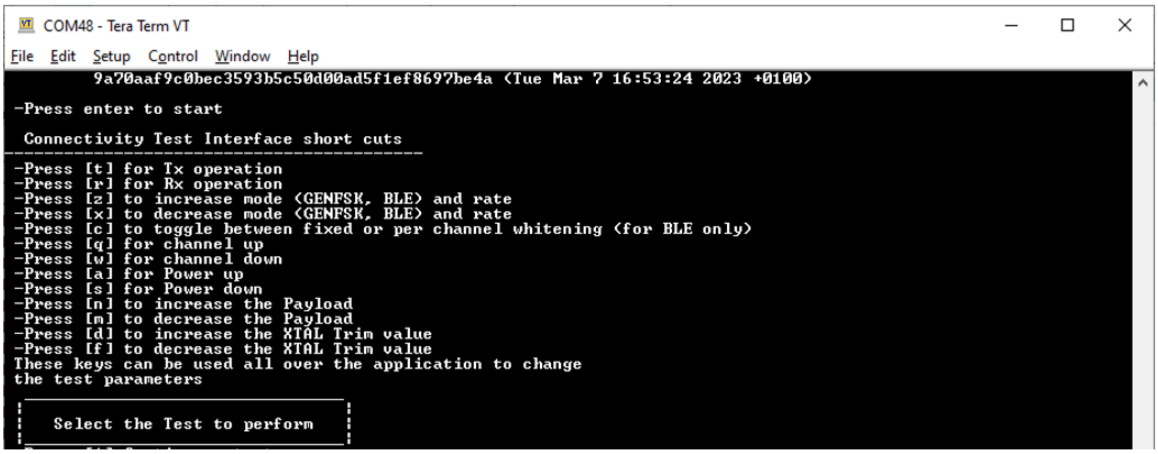


Figure 39. Connectivity test interface shortcuts menu

- The application can change the operation or increase or decrease any parameter at any time when the continuous unmodulated test is running. This is done by typing the letter of the parameter. An example is shown in Figure 40.

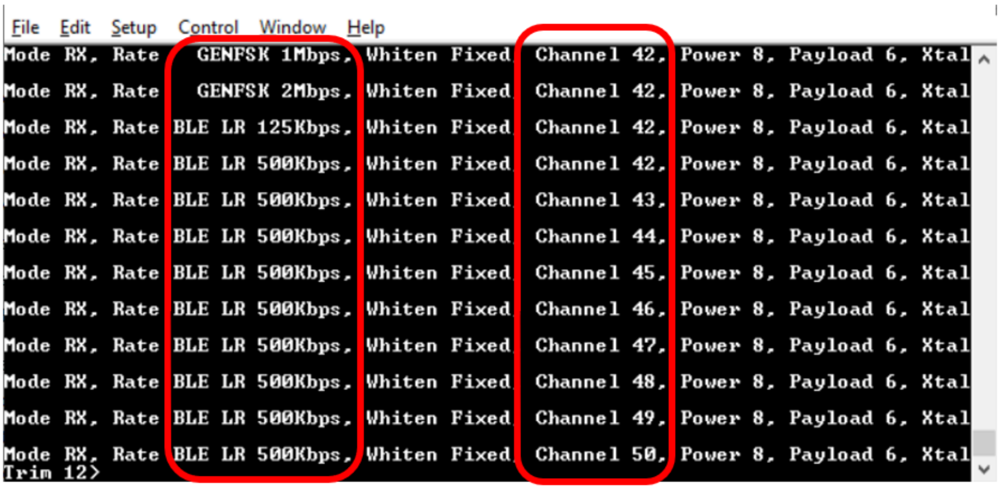


Figure 40. Example of the parameters change during the running continuous test application

- Detailed description of the connectivity test application is a part of the *Kinetis K32W148/KW45B41Z Generic FSK Link Layer Software Quick Start Guide*. This document is availiable in the SDK documenatation package.

11 Conclusion

This application note describes the RF performance tests with the KW45B41Z-LOC board. It covers the antenna matching network and antenna gain measurements including the radiation patterns. The MCU RF output matching results are described with and without the RF switch on-board. This can help during the custom board development with the KW45B41Z MCU device. The document also shows the measurement of the board RF sensitivity and maximal power output level. The connectivity test application, including the RF switch control, is briefly described at the end of the file.

12 Revision history

Table 17 summarizes the changes done to this document.

Table 17. Revision history

Revision number	Release date	Description
1	15 November 2023	Initial external release

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