Production Tests for QM35-Based Products

APS512

Application Note

1 Introduction

This Application Note describes production tests to be performed for end products using the Qorvo QM35 family of UWB ICs. This document is intended to be used as a guide for the production testing of QM35-based products. The tests suggested in this document refer only to tests associated with QM35; additional tests may be needed to cover other aspects of the product's functionality. The tests can be reduced or edited depending on the particular QM35 use case.

These tests assume the main active component in the product is the QM35 IC. This IC is delivered pre-tested however a number of product tests are required to ensure that the product is assembled correctly. For some tests the product also needs to be calibrated for correct operation and to ensure that FCC, ETSI or other spectral mask regulations are met.

Calibration data can be programmed into a non-volatile area of memory (RRAM) on the QM35 IC as part of your production test or into off-chip non-volatile memory (NVM) so that firmware in the DUT can subsequently access it and use it to configure the QM35 during product operation.

Table of Contents

2 Production Test Setup

2.1 Test Setup Overview

Figure 1 below shows the test set up for testing QM35-based products. The diagram assumes that the product contains one or more integral antennas, i.e. there is no RF connector and therefore the product must be tested in an over-the-air (OTA) test set up. Typically, this setup consists of an RF absorber-lined screened box in which the Device-Under-Test (DUT) and the test antenna are installed at a known distance apart.

This setup allows three different test and calibration modes:

- DUT tests, where the RF section on the DUT is not used.
    - Board function test, RTC test, OTP test, PLL test, Etc.
- DUT transmitter tests, where the Test antenna is connected via the RF switch to the spectrum analyzer so that the transmit output of the DUT can be observed, measured and adjusted.
    - TX power control function test, Spur test, etc.
    - Crystal trim calibration, PA gain offset calibration, Tx power calibration
- DUT receiver tests, where the Test antenna is connected via the RF switch to the Reference Test Board (RTB) so that a known signal can be provided to the DUT and the signal observed by the DUT can be analyzed.
    - Rx tests, PER test, etc.
    - Antenna Delay calibration

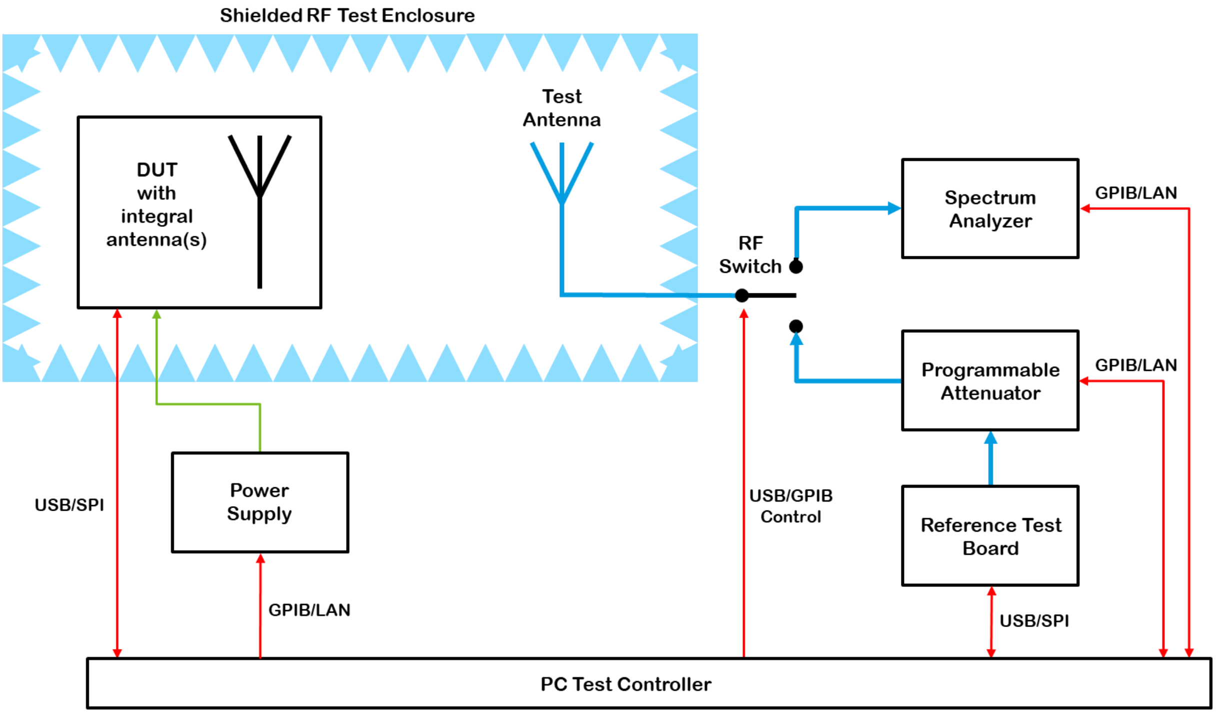

Figure 1: Production test setup diagram

The following is a list of suggested test equipment. Where particular manufacturers' equipment is suggested, equipment with similar specifications should be perfectly acceptable.

Table 1: Suggested Test Equipment

Item	Test Equipment	Comments
1	Programmable Power Supply	Any supply capable of providing the required voltage and current and which supports remote control over GPIB / LAN etc.
2	GPIB Controller	Any GPIB controller with the requisite number of ports and which is compatible with the other equipment being used is acceptable.
3	RF Switch	e.g. Mini Circuits USB-1SPDT-A18 or similar.
4	Spectrum Analyzer	Any analyzer with the appropriate frequency range and an RMS detector is acceptable.
5	Programmable Attenuator	e.g. Agilent 11713A controller / Agilent 8495H 70 dB attenuator / Agilent 8494 11dB attenuator.
6	Shielded Test Cell	e.g. Tieok TK-B1332M

An integrated UWB test set such as Litepoint IQgig-UWB or Rohde&Schwarz CMP200 can be used to replace the Spectrum Analyzer, Programmable Attenuator and Reference Test Board in Figure 1.

2.1.1 General Test Conditions

During production testing, the device should be supplied with the nominal voltage that is intended for the device in its normal operation. The actual voltage used during test should be recorded.

The temperature of the QM35 IC should be recorded during testing. Some calibration parameters can vary with temperature as detailed in the datasheet.

2.2 Calibrating the Test Setup

2.2.1 Overview

In general, test setup calibration should be regularly carried out until such time as the test setup is proven to be stable. Thereafter the calibration interval can be extended.

Tests requiring the test setup to be calibrated fall into two categories.

1. Tests that deal with absolute power levels transmitted or received by the DUT (e.g. transmit power calibration, receiver sensitivity).
2. Tests that deal with calibrating the antenna delay or PDoA offset of the DUT (e.g. if your product is intended to be used in or as a location system or range measurement device and you have decided that antenna delay calibration is necessary to achieve the accuracy you require in your application.)

2.2.2 QM35 Reference Test Board

Any tests in which the DUT needs to receive a calibrated UWB signal requires the use of a Reference Test Board (RTB). This RTB needs to be connected to the test setup via coax cable.

Qorvo uses its own QM35 development board, correctly calibrated, as an RTB for in-house testing.

2.2.3 Calibrating Transmit Path Losses

This section describes the method used to calibrate the losses in the transmit path from the DUT to the spectrum analyzer such that the observed measurement at the spectrum analyzer can be corrected for the path loss to give the actual transmit signal from the DUT. Figure 2 shows the components of the path loss.

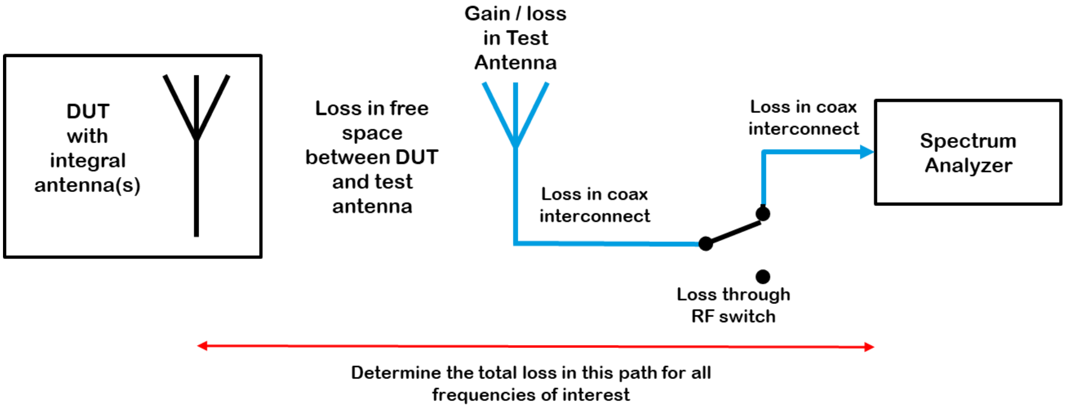

Figure 2: Components of test setup transmit path losses

The power observed at the spectrum analyzer, P_{SA}, is given by:

$$P_{SA} = P_{DUT} - (L_{FREESPACE} + L_{TA} + L_{I1} + L_{RFSW} + L_{I2})$$

or

$$P_{DUT} = P_{SA} + (L_{FREESPACE} + L_{TA} + L_{I1} + L_{RFSW} + L_{I2})$$

Where:

P_{DUT}	=	Actual signal power transmitted by the DUT
$L_{FREESPACE}$	=	Free space path loss between the DUT antenna and test antenna
L_{TA}	=	Loss in the test antenna. If the test antenna has gain, this needs to be subtracted.
$L_{I1,2}$	=	Losses in the coax interconnect
L_{RFSW}	=	Loss in the RF switch

Calibrating the test setup involves inserting a DUT that has been previously calibrated in an anechoic chamber and whose radiated output power is known. By observing the power measured at the spectrum analyzer and knowing the power transmitted by the calibrated source, the path loss can be determined by subtraction.

It is important to perform this calibration for all UWB channel frequencies intended to be used in your final product since the path loss will vary depending on frequency.

These path loss figures should be recorded for subsequent use in production testing.

The flowchart in Figure 3 below describes the measurement procedure.

A DUT should be calibrated in an anechoic chamber in a calibrated measurement setup. Once calibrated there, it can be used as a “golden unit” to calibrate the test setup.

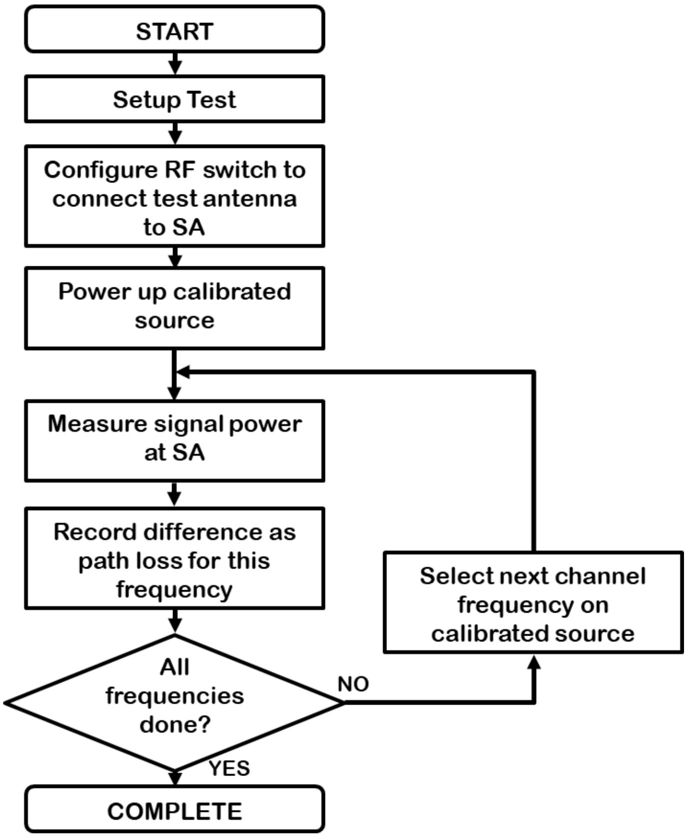

Figure 3: DUT test setup for transmit path loss measurement procedure

It is recommended that the transmit path loss of the test setup be calibrated at regular intervals and it **must** be carried out if any part of the transmit path in the test setup is replaced or modified.

2.2.4 Calibrating Receive Path Losses

This section describes the method used to calibrate the loss in the receive path from the RTB to the DUT such that the received signal level at the DUT can be determined for a given transmit signal level from the RTB. Figure 4 shows the components of the receive path loss.

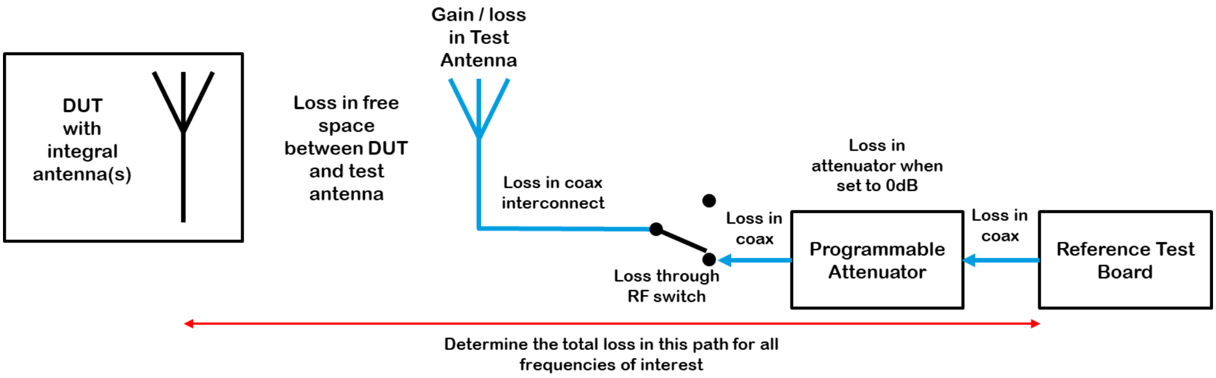

Figure 4: Components of test setup receive path losses

The received signal power observed at the DUT, P_{RDUT}, is given by:

$$P_{RDUT} = P_{RTB} - (L_{I1} + L_{ATT} + L_{I2} + L_{RFSW} + L_{I3} + L_{TA} + L_{FREESPACE})$$

Where:

P_{RDUT} = Signal power received at the DUT
P_{RTB} = Signal power transmitted by the reference test board

$L_{I1,2,3}$ = Losses in the coax interconnect
L_{ATT} = Loss in the attenuator
L_{RFSW} = Loss in the RF switch
L_{TA} = Loss in the test antenna. If the test antenna has gain, this needs to be subtracted.
$L_{FREESPACE}$ = Free space path loss between the test antenna and the DUT antenna

Calibration involves the physical substitution of the DUT with a calibrated measurement setup. A spectrum analyzer is connected to an antenna of the same type as that used in the DUT (or to an antenna whose performance has been correlated with the DUT antenna) via coax interconnect whose loss is known at the frequencies of interest.

The RTB is configured to transmit a known signal power and the power received at the spectrum analyzer is measured and adjusted for gain / loss in the calibrated antenna and coax interconnect to give the actual received power.

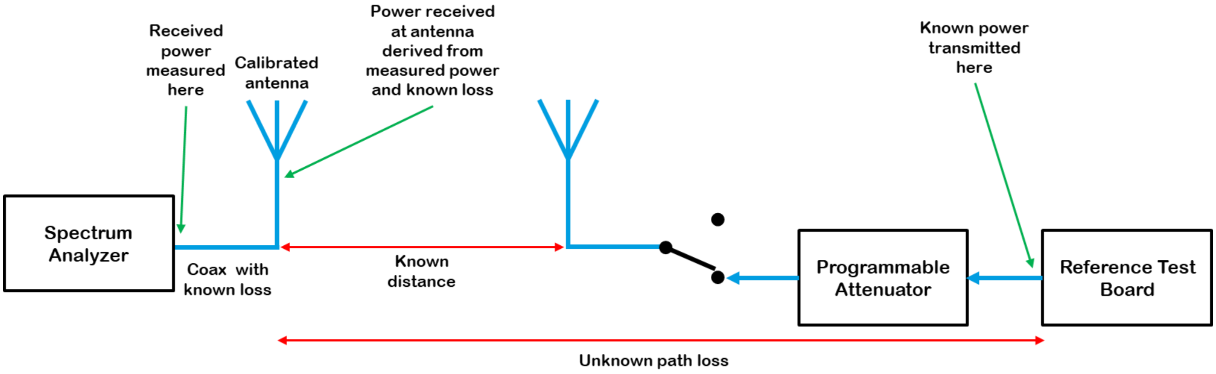

Figure 5: Components of test setup receive

The difference between the signal power received at the calibrated antenna and the power transmitted by the reference test board is the path loss.

It is important to perform this calibration for all UWB channel frequencies intended to be used in your product since the path loss will vary depending on frequency. These path loss figures should be recorded for subsequent use in production testing.

The flowchart in Figure 6 below describes the measurement procedure.

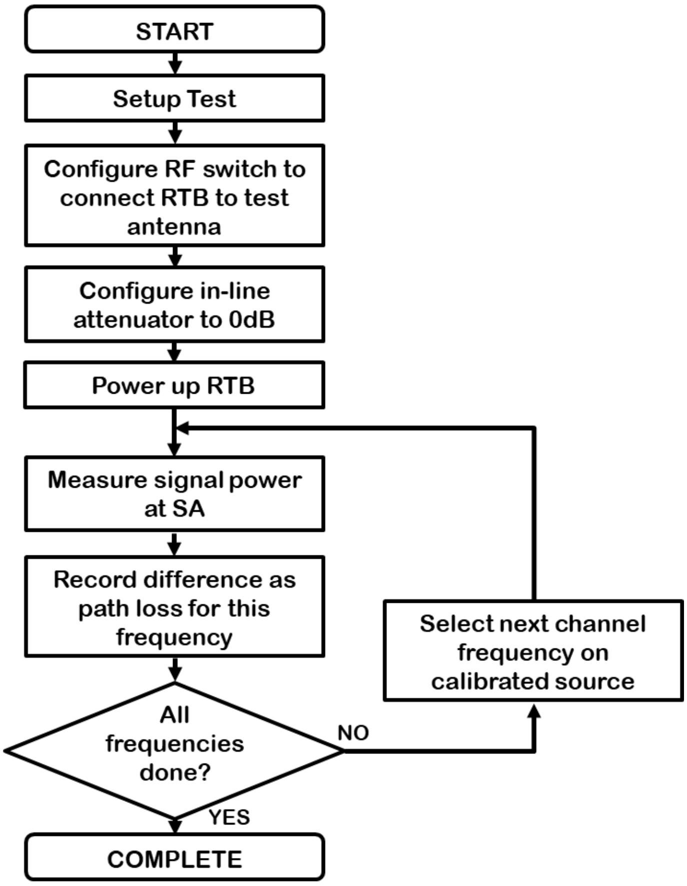

Figure 6: Receive path loss measurement procedure

It is recommended that the receive path loss of the test setup be calibrated at regular intervals and it **must** be carried out if any part of the receive path in the test setup is replaced or modified.

2.2.5 Calibrating for Antenna Delay

Two-way ranging (TWR) between two QM35-based units determines the time of flight between the two units by exchanging messages, noting transmit and receive times and using an algorithm to remove turn-around times at each node. TWR can be used to derive the delay in the test setup.

Calibrating the test setup involves two steps as follows.

- **Step 1:** Two-way ranging is performed between a DUT and the RTB (calibrated for Antenna Delay according to APS514) in free space, outside the test setup. The units are separated by a known distance (5-10m) and the antenna delay of the DUT is adjusted until the reported distance is correct. The units are now correctly calibrated to report ranging measurements.
- **Step 2:** The DUT and RTB are then inserted into the test setup and the process is repeated. The reported distance, which will be larger than the actual separation between the test antenna and the DUT, reflects the fact that the test setup introduces some additional delay. This difference in the reported distance should be noted as the “calibration distance” of the test setup.

The test setup can now be used for production testing. During production testing of DUTs the distance reported using two-way ranging with the DUT should be adjusted by this “calibration distance”. The antenna delay in the DUT can then be adjusted to give the correct distance measurement thereby correctly calibrating the antenna delay in the DUT.

For DUTs with multiple antennas, this procedure is done for each antenna. The “calibration distance” is recorded for each of the DUTs antennas.

It is recommended that the antenna delay of the test setup be calibrated at regular intervals and it **must** be carried out if any element of the path between the RTB and the DUT is replaced or modified.

2.2.5.1 Step 1: Free Space Measurement

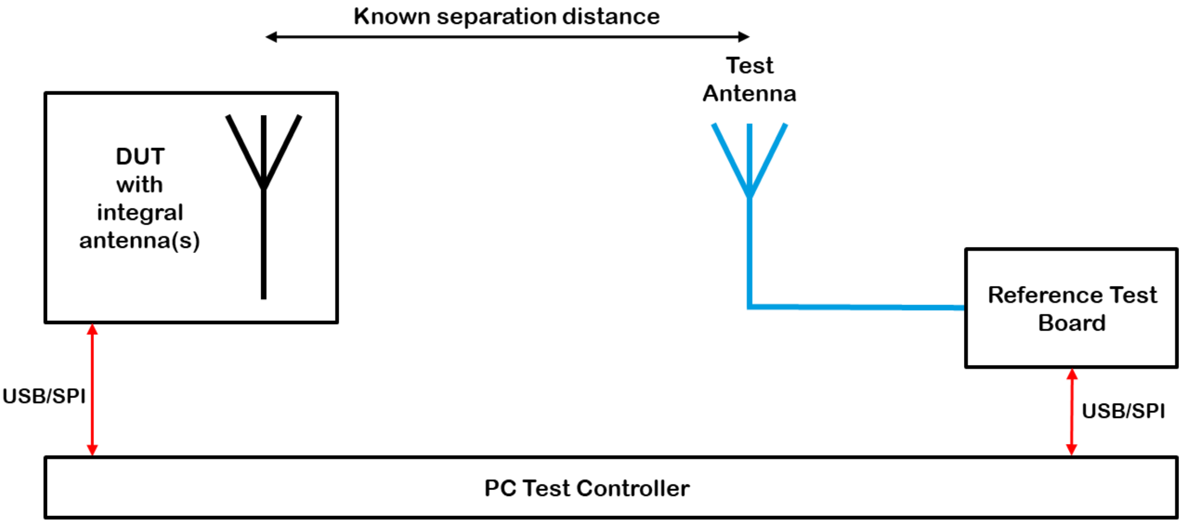

Figure 7: Two-way ranging calibration block diagram

Setting up a TWR exchange between DUT and RTB at a known distance allows the DUT to be calibrated by adjusting its antenna delay setting. Each increment of the antenna delay setting will change the reported distance by about 4.7mm; increasing the setting will reduce the reported distance. The separation distance should be about 6-9m and should be accurately measured with a laser range finder.

2.2.5.2 Step 2: Measurement in the Test Setup

Step 2 puts the DUT and RTB from step 1 into the test setup. Using the antenna delay that was found in step 1 for the DUT, TWR is performed between the DUT and RTB. The reported distance for each DUT antenna is recorded as the “calibration distance”. This will be used in the production test in section 3.1.

The programmable attenuator should be set to give approximately the same input power as was seen in step 1. The Friis transmission equation can be used to calculate the free space path loss, other losses in the setup should be accounted for.

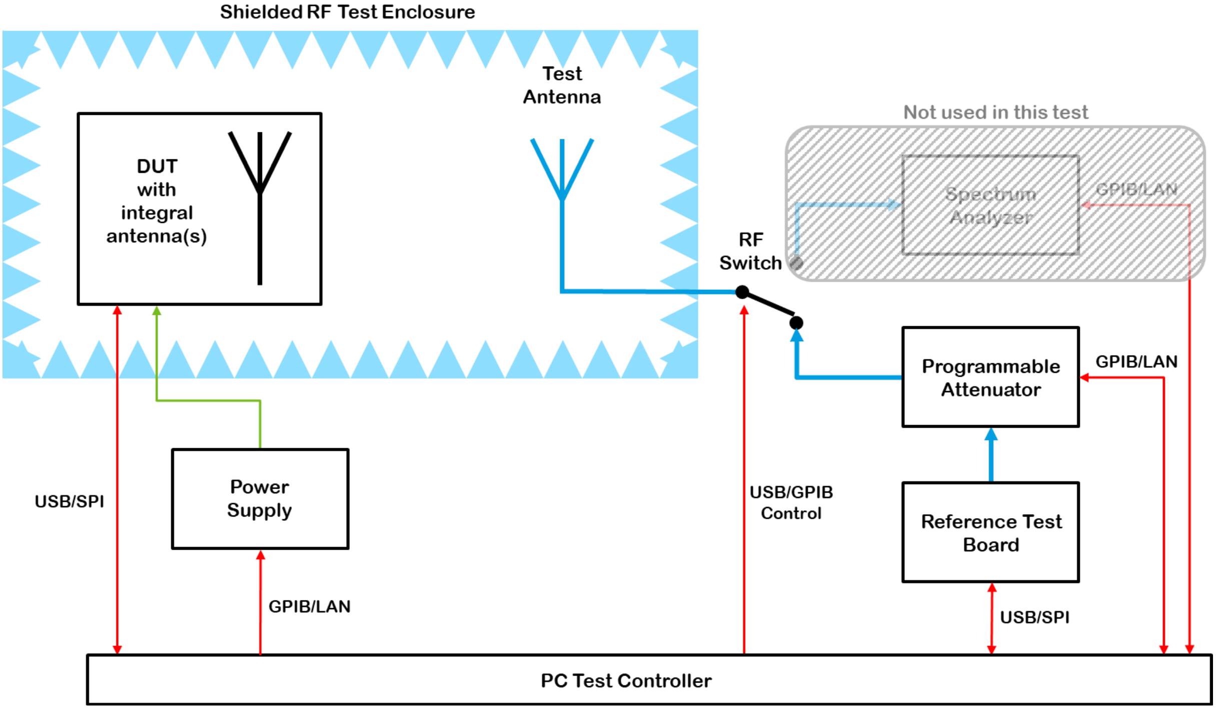

Figure 8: Test setup for antenna delay measurement using two-way ranging

2.3 Controlling the DUT and RTB

This document assumes that both DUT and RTB employ QM35xxx ICs and are flashed with a Qorvo SDK firmware that uses the FiRa UWB Command Interface (UCI). For instructions to flash the firmware please consult the SDK Quick Start Guide.

The SDK also supplies a set of python scripts called UWB Qorvo Tools (UQT) to operate Qorvo UWB devices through the UCI interface. Please refer to the UQT Guide for installation instructions for Windows or Linux PCs.

In the example commands given below, any file path or device port (COM, ftdi, /dev/uci0) may need to be adjusted depending on the operating system.

Prior to any production test or calibration, a configuration needs to be applied to each device. The configuration is managed using a Key/Value mechanism through the UCI interface. The settings for a device are stored in a JSON file, which is parsed and transmitted to the device. The configuration files typically include RF front end settings and default values for crystal trim, Tx power setting, antenna delay etc. For a comprehensive list of parameters, please refer to the L1 configuration document supplied with the SDK. To load a configuration file, run the load_cal script from the UQT directory.

```
load_cal -p ftdi://FT4222/433 -f
calib_files\QM35822S\jolie_omni_jolie_omni.json
```

During the course of the test setup calibration or production testing it may be necessary to alter single configuration keys. To set a single configuration key, use the set_cal command:

```
set_cal -p ftdi://FT4222/433 ant0.ch5.ant_delay 16384
```

Any configuration keys currently applied on a device can be retrieved by using the get_cal script.

```
get_cal -p ftdi://FT4222/433
```

To run TWR between two devices on channel 5 for 10 seconds, on the first device run:

```
run_fira_twr -p ftdi://FT4222/433 -c 5 –controlee -t 10
```

on the second device run:

```
run_fira_twr -p ftdi://FT4222/237 -c 5 -t 10
```

To send periodic UWB packets in continuous frame mode use:

```
run_fira_test_periodic_tx -p ftdi://FT4222/433 -c 5
```

Using `--help` as an argument to any command will print a list of options and additional arguments for that command. For a full list of commands and parameters for each command please refer to the UQT User Guide.

3 Production Tests

3.1 Operational Tests

The tests listed in Table 2 are intended to check the fundamental operation and soldering integrity of the QM35 IC.

Table 2: Summary of Operational Tests

Test Name	Test Description	Limits	Test Applicability	Comments
Idle mode current consumption	Apply supply voltage to product and measure current after 10 ms.	Min 10 mA Max 13 mA	Recommended on a per-DUT basis.	Limits depend on other circuitry in the product and the supply voltage used during test.
SPI test	Run SPI Test.	Pass / Fail	Recommended on a per-DUT basis.	
Current consumption	Configure DUT as transmit or receive.	Min 30 mA Max 90 mA	Recommended on a per-DUT basis.	Limits depend on other circuitry in the product and the supply voltage used during test.
GPIO strobe test	Use SPI commands to run GPIO strobe routing. Verify that all GPIO, IRQ and SYNC lines are asserted.	GPIO, IRQ and SYNC lines go high then low as requested.	Only necessary if you are using these signals in your product	
RSTn test	Check that the reset line goes high after power is applied.	Reset line goes high.	Recommended on a per-DUT basis.	Wait 5 ms after applying power.
WAKEUP test	Using SPI commands to set DUT device into SLEEP mode. Assert WAKEUP pin to bring device out of sleep.	Sleep mode current <1 µA, then as per Idle current above when WAKEUP asserted.	Only necessary if you are using WAKEUP functionality in your product.	Current after WAKEUP should be the same as Idle mode current above.
EXTON test	Check that the EXTON line goes high after power is applied.	EXTON line goes high.	Only necessary if you are using EXTON functionality in the product.	Wait 5 ms after applying power.
RTC test	Run RTC test.	Pass / Fail	Recommended on a per-DUT basis.	

3.2 UWB Transmit Tests

3.2.1 Crystal Trim Calibration

It is recommended that this test is carried out on a per-DUT basis to maximize range performance over the lifetime of each unit. This test is not applicable if the product uses a TCXO, OCXO or is intended to be driven by an external reference (e.g. an anchor node in an RTLS using wired clock distribution).

Table 3: Crystal Trim Test Summary

Test Name	Test Description	Limits	Comments
Crystal Trim	Configure the DUT to output a CW test mode signal on the chosen channel center frequency. Adjust the DUT crystal trim register until the output signal is as close to the channel center frequency as possible.	Channel center frequency in MHz ± 3 ppm.	This test is used to trim the loading capacitance on the DUT crystal oscillator to center the carrier frequency.

The crystal trim test setup is shown in Figure below. The test antenna is connected to the spectrum analyzer. The spectrum analyzer allows the frequency of the CW signal from the DUT to be observed.

Note: To perform this test, the product software should have a test mode that enables the QM35 to output a CW signal on your primary operating channel. Qorvo's software API includes a function to do this.

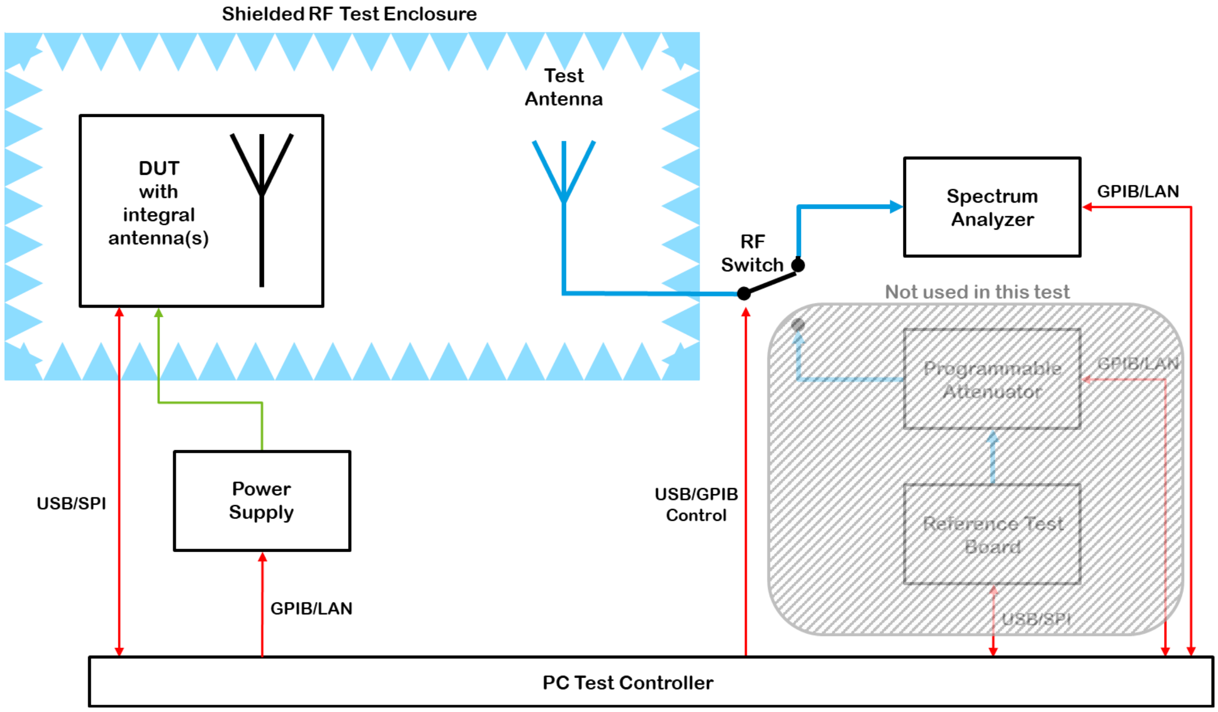

Figure 9: Test setup for crystal trim calibration

3.2.1.1 Alternative Method – Two Way Ranging

It is possible to use carrier frequency offset calculations from two-way ranging exchanges to calibrate the crystal. The DUT can range with a calibrated reference test board in the production setup and the QM35 can determine the frequency offset using the receiver's clock recovery circuit. By minimizing the reported frequency offset in the ranging exchanges, the crystal frequency of the DUT can be tuned to match that of the reference test board.

3.2.1.2 Alternative Method – GPIO Clock

An alternative test method is possible that does not require a spectrum analyzer. This method configures a GPIO pin on the QM35 to output a divided version of the internal system clock. This clock signal may then be observed using a frequency counter. Refer to UWB Qorvo Tools Guide for HW Test Mode details.

3.2.2 PA Gain Offset and Transmit Power Calibration

During design verification and characterization, you should measure the nominal loss in each RF path between the QM35 chip and antenna to determine the nominal transmit power value required from the QM35 to compensate for this loss. With the QM35 configured with this nominal transmit power value, the power radiated from the DUT antenna will vary between DUTs due to component tolerances etc.

It is recommended that this test be carried out in production on a per-DUT basis to ensure transmit power is as close to the allowed regulatory limit as possible to maximize range performance and compensate for any inter-unit variation. Not doing this test on a per-DUT basis will require the nominal Tx power index setting to be "backed-off" from the regulatory limit to ensure that all units are guaranteed to meet that regulatory limit. This will result in some loss in performance. This may be acceptable depending on your intended application and you need to weigh up the cost of performing this test at manufacturing time vs. the resulting loss in performance for your intended application.

Tx power index defines the Tx power level referenced to the maximum available Tx power on QM35. The step size is 0.25 dB and the Tx power level is inversely proportional to the Tx power index. For example, Tx power index 0 means the maximum power configuration, a Tx power index of 0x47 (decimal 71) would be 71·0.25dB = 17.75dB below the maximum power level.

QM35 ICs have a power amplifier (PA) which extends the output power range. QM35 SDK firmware automatically toggles the PA depending on the Tx power index value. At the transition of the PA state, there may be a step in the otherwise linear Tx power vs Tx power index plot, as shown in Figure 10. The PA gain offset calibration is used to minimize this step and get a linear Tx power range with 0.25 dB step size.

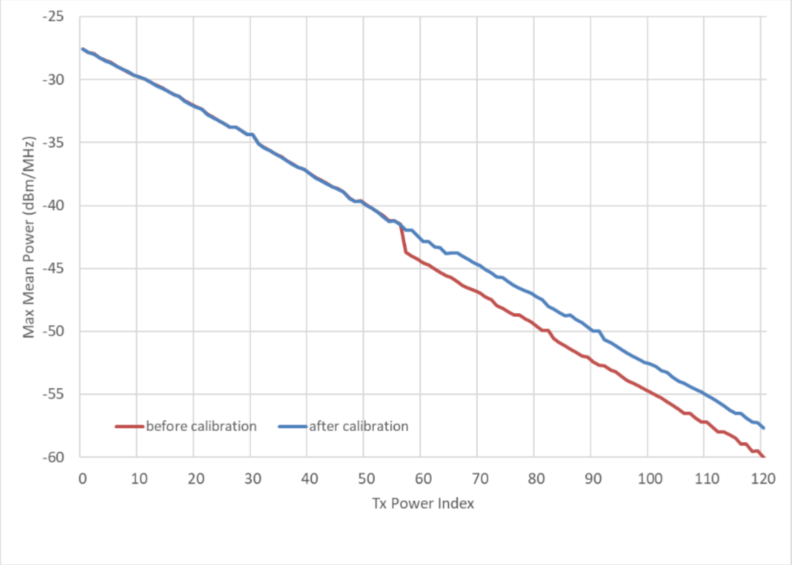

Figure 10: Step at PA Switching Point, before and after PA gain offset calibration

The PA gain depends on the output impedance of the application; antennas or coax cables can present different impedances to the PA. Therefore, calibrating the PA gain offset must be done in the radiated domain with antenna(s) attached.

The PA switching points are different for each channel. The Tx power index ranges for different channels are tabulated in Table 4 below. Hence, the switching point for Channel 5 is 50-51 and the switching point for

Channel 9 is 56-57. In order to calibrate the power settings below, it is required to disable the adaptive power control feature by setting the tx_power_control configuration key to 0.

Table 4: Tx Power Index Range

PA state	Channel 5	Channel 9
PA on	0-50	0-56
PA off	51-254	57-254

- Note: These values may vary with different SDK versions

Table 5: Tx Power Test Summary

Test Name	Test Description	Limits	Comments
PA Gain Offset Calibration	Configure DUT to transmit 1 frame per ms on the applicable channel(s) and antenna port(s). Measure Tx power *before* and *after* the PA switch point for each channel and antenna port.	PA gain offset = $\mathrm{round}\left(\frac{before - after}{0.25}\right) - 1$	Calibrate PA gain offset before Tx power
Tx Power Calibration	Configure DUT to transmit 1 frame per ms on the applicable channel(s) and antenna port(s). Set PA gain offset to the calibrated value. Adjust transmit power until transmit spectrum meets spectral regulations.	Spectrum should be within the appropriate mask for the desired jurisdiction. e.g. FCC and ETSI mask limits	Set spectrum analyzer to: Center frequency, Span = 1 GHz, Sweep time* = 1 s, VBW=RBW = 1 MHz, Detector = RMS

*It may be possible to reduce the sweep time and speed up this test. As the sweep time is reduced, the measured power changes. Provided there is good correlation between the power measured at the 1 s sweep time and the power measured at the faster sweep time and there is always a fixed offset between the two then the test can be carried out at the faster sweep time and can be adjusted by the fixed offset to give the actual transmit power.

The DUT transmit spectrum test setup is shown in Figure 11 below. The test antenna is connected to the spectrum analyzer. The spectrum analyzer allows the transmit spectrum to be observed. The path loss from the DUT to the spectrum analyzer should be calibrated as per section 2.2.3.

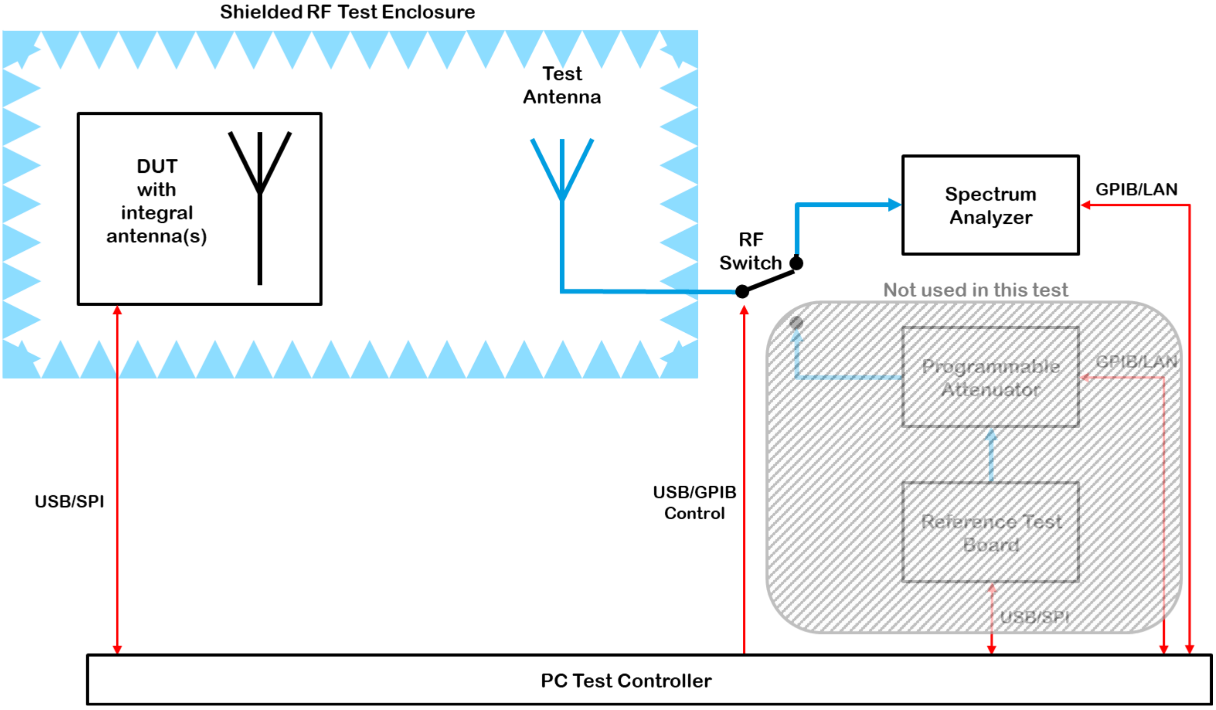

Figure 11: Test setup for Tx power calibration

To perform this test, the product software should have a test mode that enables the QM35 to transmit back-to-back repeated frames on each of the intended operating channels. Qorvo's software API includes a function to do this.

The flowchart in Figure 12 describes the procedure. The DUT is configured with the nominal PA gain offset and Tx power value previously determined during design verification and characterization. The resulting DUT output power is measured and the configured Tx power value adjusted until the desired limit is reached.

This calibration process needs to be carried out for each of the channels an each of the antennas on which the product transmits.

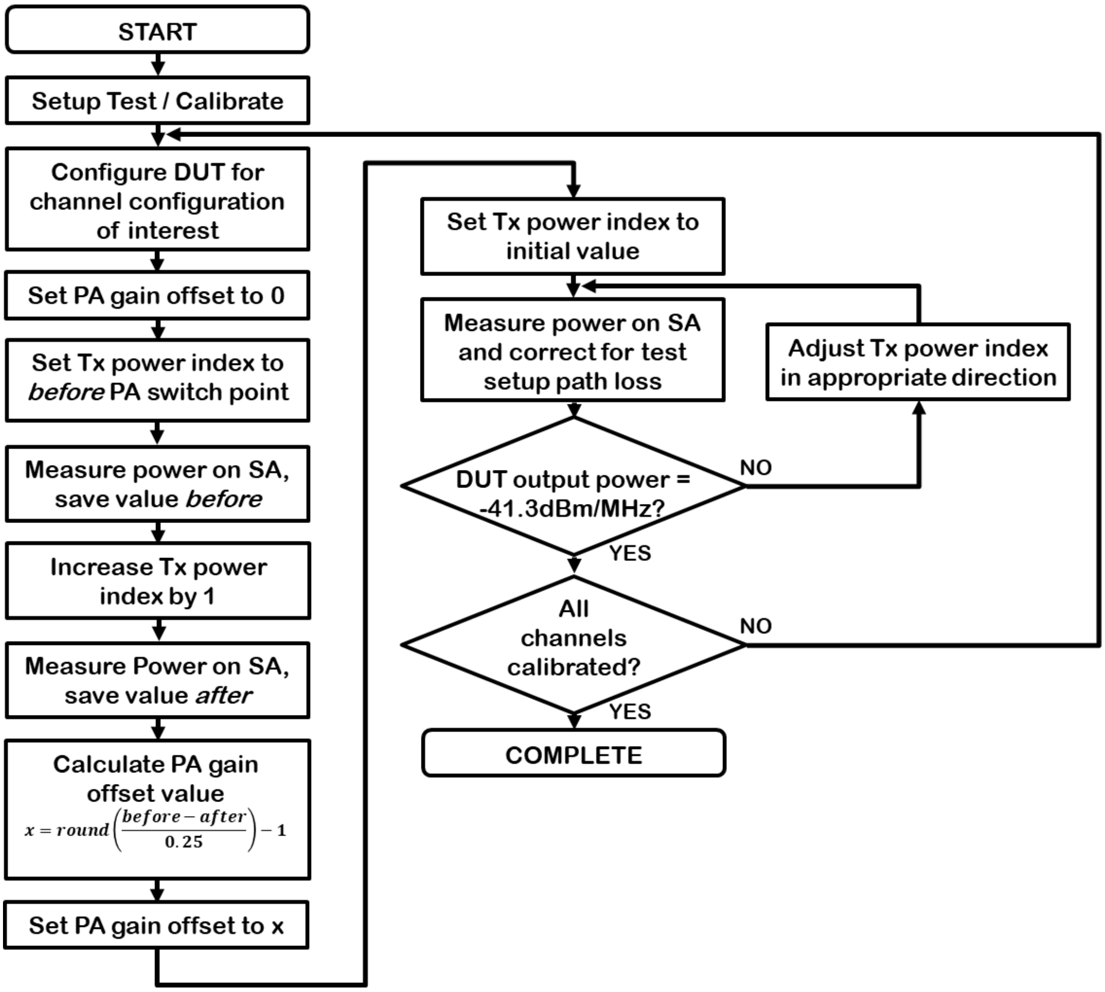

Figure 12: PA gain offset and Tx power calibration procedure

3.3 Receiver and System Tests

3.3.1 Receiver Sensitivity Tests

Receiver sensitivity testing must be carried out at design verification and characterization to verify that the performance of that design is acceptable. It should then be run on a per-DUT basis in production to ensure the DUT receiver is operating correctly.

If the DUT is a transmit-only device then this test is not applicable.

Table 6: Receiver Sensitivity Test Summary

Test Name	Test Description	Limits	Comments
Rx Sensitivity	Configure DUT to receive mode. Configure RTB to transmit mode. Transmit a fixed number of frames and check the receive packet error rate (PER) for different receive signal power levels. Repeat for all relevant channels and RF paths.	Design dependent	

The receiver sensitivity test sweeps the receiver power level at the DUT to determine the lowest power level at which the DUT correctly receives 99% of frames transmitted by the RTB.

The test setup is shown in Figure 13 below. The test setup is configured to connect the RTB to the DUT via the programmable attenuator. The RTB operates as the transmitter. The programmable attenuator controls the signal level presented to the DUT and is initially set to maximum attenuation. This attenuation is systematically reduced and the frame receive rate at each attenuation step is recorded.

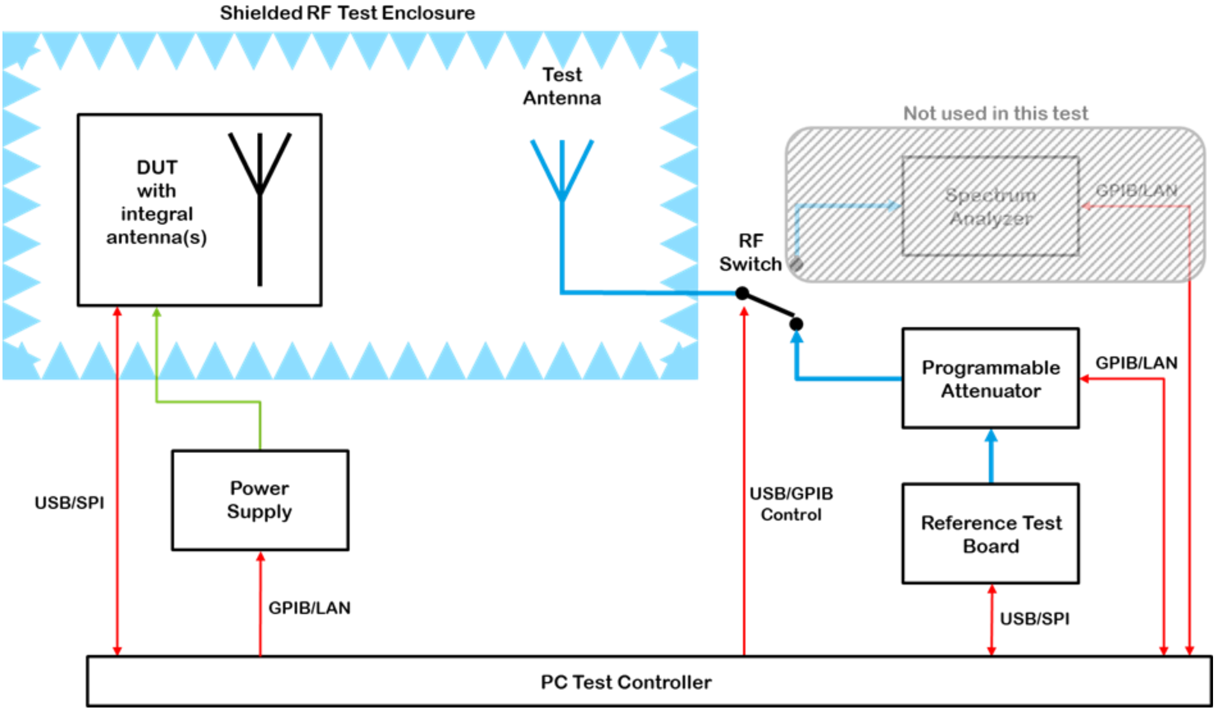

Figure 13: Receiver sensitivity test setup

The RTB, programmable attenuator, interconnect cables and test antenna must be calibrated as per section 2.2.4 so the signal power level presented to the DUT is known.

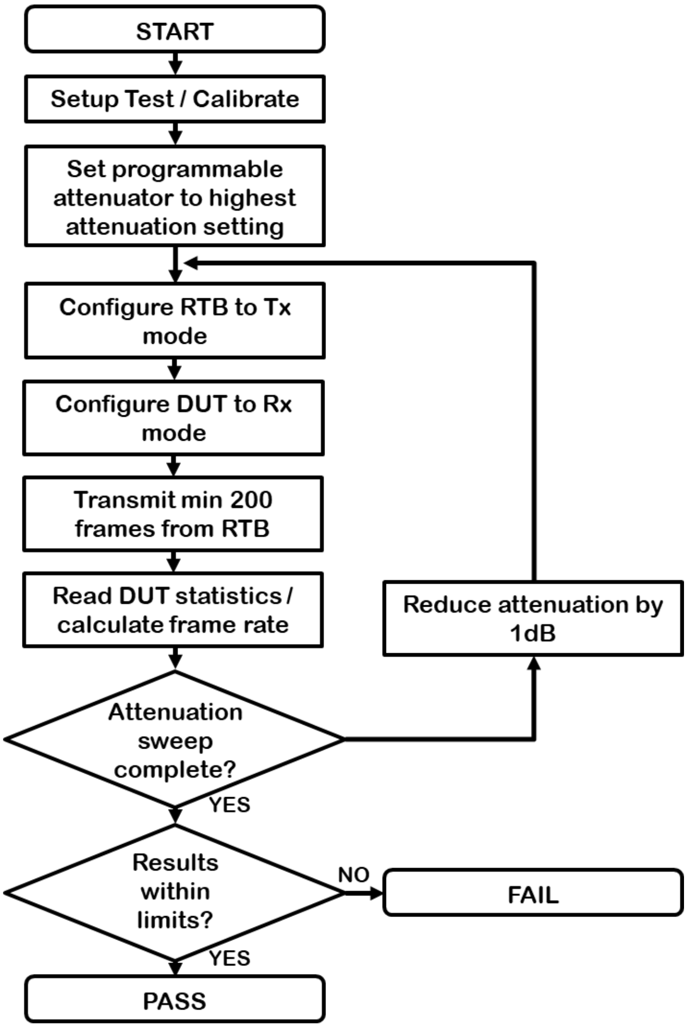

Figure 14: Receiver sensitivity test procedure

3.3.1.1 Calculating Packet Error Rate

The statistics reported by the QM35 IC are used to calculate the packet error rate (PER). The PER is the following ratio:

$$\frac{Number\ of\ received\ frames}{Nuber\ of\ transmitted\ frames} = PER$$

3.3.2 Antenna Delay Calibration

At design verification and characterization the nominal value of antenna delay for your design should be determined by testing over a sufficient sample of units.

During production testing, antenna delay may be calibrated for each DUT to remove any inter-DUT variation and maximize the achieved ranging accuracy. This test is carried out in the test setup as described in section 2.2.5.

Table 7: Antenna Delay Test Summary

Test Name	Test Description	Limits	Comments
PA Gain Offset Calibration	Configure DUT and RTB for TWR exchanges on applicable channel(s). Perform TWR exchanges and log reported range average and standard deviation.	Measured range = target ±4cm Std dev < 4cm	Depending on required accuracy for the application these limit may be relaxed

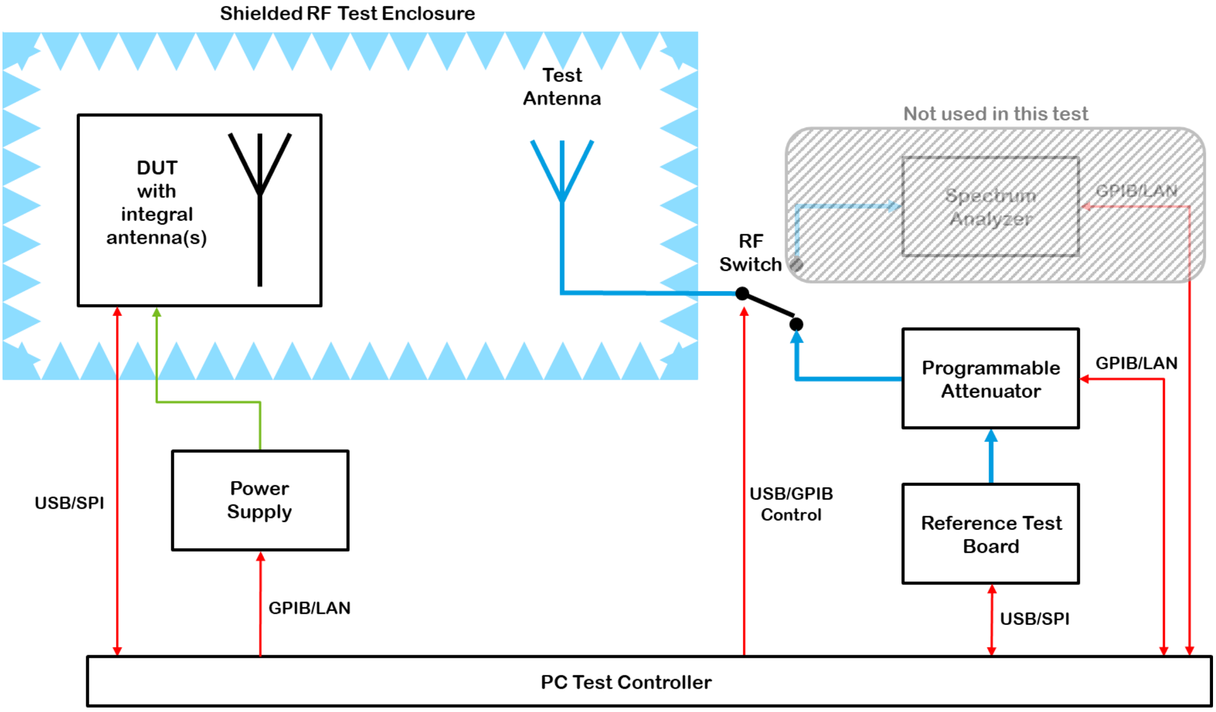

Figure 15: Test setup for antenna delay measurement using two-way ranging

3.3.2.1 Calibration procedure

Starting with an initial or nominal antenna delay value setting for the DUT, a number of (at least 200) TWR exchanges are performed between the DUT and the RTB and the average reported distance is calculated. The antenna delay of the device is adjusted until the reported distance matches the "calibration distance" determined in section 2.2.5. Each increment of the antenna delay setting will change the reported distance by about 4.7mm; increasing the setting will reduce the reported distance. The adjustment can be calculated as:

$$adjustment = \mathrm{round}(\,(reported\ distance\ [mm] - \text{'}calibration\ distance\text{'}\ [mm])\ /\ 4.7[mm]\,)$$

This adjustment is added to the initial delay value and the TWR measurement is repeated until the adjustment is 0.

The calibrated antenna delays are recorded and can be stored in a calibration file in each device. Antenna delay must be calibrated for all relevant channels and RF paths/antennas.

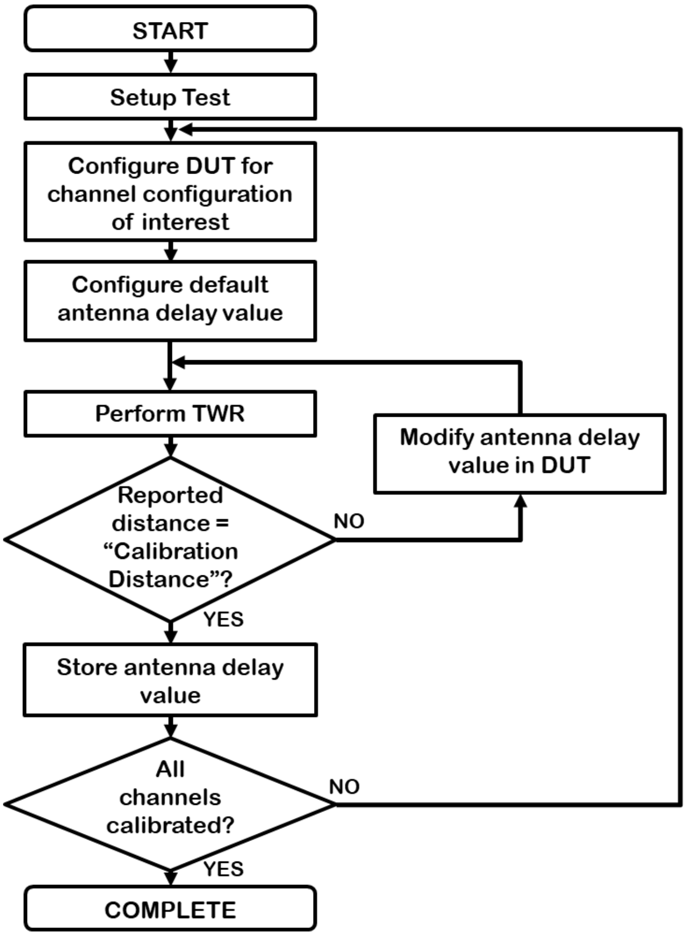

Figure 16: Antenna delay calibration procedure

3.3.3 PDoA Offset Calibration

Phase Difference of Arrival (PDoA) is a solution where a node with antennas connected to each of the QM35 RF ports can be used to determine the position of a tag based on measurements of distance and angle.

There are differences in the propagation time of signals on the two RF paths, caused by process variation in the PCB, any front-end components such as RF switch ICs, the QM35 IC, etc. These need to be calibrated out in order to ensure accurate results across devices.

PDoA offset must be calibrated for each channel. If PDoA is measured on multiple pairs of antennas in a device, the calibration has to be done for each antenna pair.

To calibrate the PDoA offset on each DUT in the factory, the device should be placed directly in front of a transmitting antenna. The resulting phase difference measurement for this 0° position can then be stored for each channel and used as a fixed offset to correct each PDoA measurement.

An illustration of a typical setup is shown in Figure 17. A large shielded test cell is recommended, with EM absorbing foam to limit reflections.

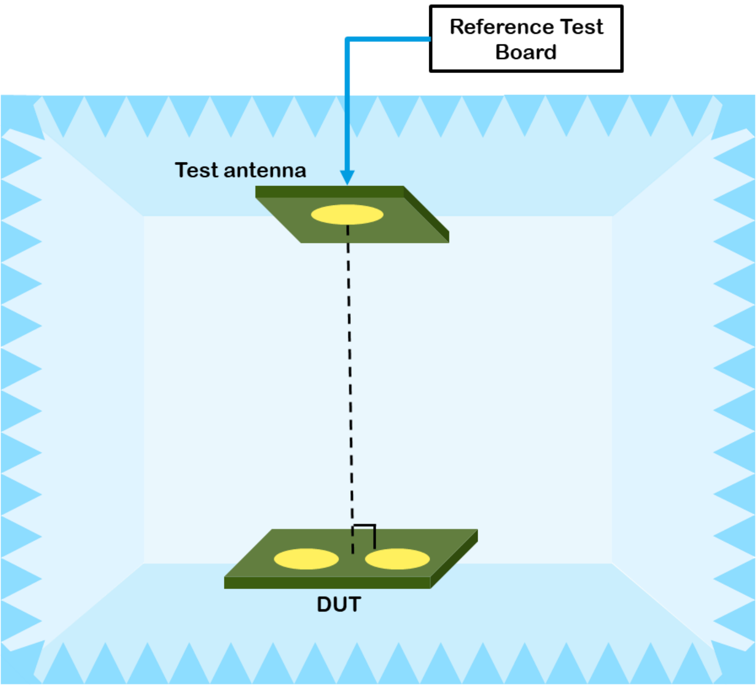

Figure 17: PDoA offset factory test setup

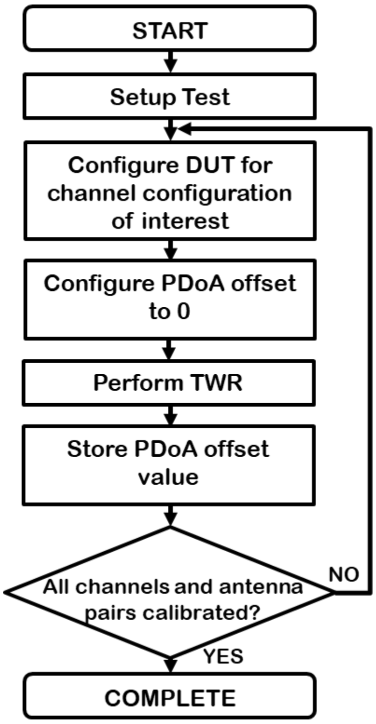

Figure 18: PDoA offset calibration procedure

References

[1] QM35xxx Datasheet

[2] QM35xxx HW User Guide

[3] QM35 SDK Quick Start Guide

[4] UWB Qorvo Tools Guide

[5] UWB-Stack L1 Configuration

[6] APS514 Antenna Delay Calibration

Abbreviations

CW	Continuous Wave
DUT	Device Under Test
GPIB	General Purpose Interface Bus
IC	Integrated Circuit
OTA	Over-the-Air
PA	Power Amplifier
PCB	Printed Circuit Board
PDoA	Phase Difference of Arrival
PER	Packet Error Rate
RTB	Reference Test Board
SDK	Software Development Kit
SPI	Serial Peripheral Interface
TWR	Two Way Ranging
UCI	UWB Command Interface
UQT	UWB Qorvo Tools
USB	Universal Serial Bus
UWB	Ultra-Wide Band

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