Morse Micro
reaching farther™

HaLow RF Test Guide

APPNOTE-43

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1. Scope

This application note offers detailed technical guidance and foundational background for conducting and interpreting cabled RF measurements of MM6108 and MM8108 Wi-Fi HaLow devices.

This application note introduces foundational theoretical concepts, including essential RF measurement parameters, HaLow test modes, and the use of Vector Signal Transceivers (VSTs) for conducting Transmit (TX) and Receive (RX) evaluations. It also provides a comprehensive overview of the test environment setup, detailing each critical component—such as LitePoint testers, HaLow devices under test (DUT), and associated RF instrumentation. In addition, it includes guidance on using the RF Tester software package provided by Morse Micro to configure and control the HaLow device under test.

By the end of this document, readers should be able to:

- Understand the key measurement parameters essential for evaluating the quality of HaLow TX and RX performance
- Configure a complete RF test setup for HaLow TX and RX measurement
- Execute consistent and repeatable RF measurements using standard equipment
- Identify and resolve typical device behavior issues

This document is intended for RF test engineers, validation teams, and embedded developers working with Morse Micro's HaLow chipsets, particularly in environments where accurate wireless performance evaluation is critical.

2. Background Information

2.1. HaLow Test Modes

2.1.1. Random Packet Generator (RPG)

To evaluate the quality of a Wi-Fi HaLow transmit signal, the Device Under Test (DUT) must actively transmit. Rather than establishing a HaLow connection with another device, the MM6108 and MM8108 offer several test modes designed specifically for this purpose. One such mode is Random Packet Generator (RPG) mode, which enables the DUT to continuously transmit packets with randomized payloads. These packets can then be captured by RF test equipment, and analyzed to evaluate key signal metrics and overall transmit performance.

Note: RPG mode is not included in standard production firmware. Specialized test firmware is required. Please contact your Morse Micro representative to obtain access.

2.1.2. Fast Symbol Generator (FSG)

The Fast Symbol Generator (FSG) is a test mode to allow testing of higher duty cycles than is possible with RPG mode. RPG mode is limited to ~90% duty cycle due to interframe spacing requirements, and internal overhead within the HaLow chip.

FSG mode is used for regulatory testing where the minimum duty cycle is more than RPG is capable of. Note that FSG packets may not be able to be decoded by VSTs, and this mode should ONLY be used for regulatory testing, not for any transmitter or receiver verification.

Note: FSG mode is not included in standard production firmware. Specialized test firmware is required. If needed, contact your Morse Micro representative to obtain access.

2.2. Vector Signal Transceiver

For Wi-Fi HaLow testing, a Vector Signal Transceiver (VST) is employed as a near-ideal transceiver to both generate the RF transmission signal and receive the response signal, enabling accurate characterization of the device under test (DUT) with minimal distortion or noise introduced by the test equipment.

This application note specifically details the use of LitePoint testers as the Vector Signal Transceiver (VST) for RF measurements. Although other test equipment may be compatible, they have not been officially validated by Morse Micro.

2.2.1. Recommended LitePoint Model

The recommended LitePoint model is the IQxel-MW 7G. As the latest generation hardware, it offers full support for all Wi-Fi HaLow features and benefits from ongoing firmware updates and active technical support from LitePoint.

Figure 1. LitePoint IQXel-MW 7G model with 8 ports.

2.2.2. Discontinued LitePoint Models

LitePoint no longer supports legacy test instruments such as the IQxel-MW and IQxel-M. Continued use of these models is not recommended. For full support, ongoing firmware updates, and optimal RF performance, migration to the IQxel-MW 7G is advised.

Due to firmware limitations on older models, RF metric reporting differs from that of the IQxel-MW 7G. Comparative testing conducted by Morse Micro shows that transmit power and EVM measurements remain aligned across units. However, SEM results from legacy testers are less accurate due to the inability to upgrade their firmware.

At power levels where SEM limits become marginal, inaccuracies from older units may lead to false module failures. In such cases, the module may be operating within acceptable parameters, but the outdated LitePoint model incorrectly reports a failure.

To ensure accurate test outcomes, it is recommended IQxel-MW 7G model is used in production workflows. This avoids inconsistencies caused by unsupported hardware and ensures reliable RF performance assessment.

2.2.3. LitePoint Firmware Version

Maintaining up-to-date LitePoint firmware is critical to ensure accurate and reliable RF measurements. As firmware versions may vary by model, it is recommended to contact LitePoint support to verify that the correct and latest version is installed.

3. Key Measurement Metrics

This section outlines key RF metrics captured by VSTs and the HaLow devices to evaluate the quality of TX and RX performance. While not an exhaustive list of all parameters measured by the VST, the metrics presented here represent the core set used by Morse Micro to validate device performance and ensure compliance with the IEEE 802.11ah specification.

3.1. Transmit (TX) Metrics

3.1.1. Power

Description:

Power is the strength of the transmitted RF signal; used to verify signal levels and regulatory compliance. There are typically two power measurements of interest, average power and peak power. Average power is calculated over the full packet duration, and is used as the primary indicator of TX output performance. Peak power reflects the highest instantaneous power observed, and is critical for meeting regulatory requirements. Both measurements are specified in dBm.

Typical Measurement:

On a LitePoint, this is typically observed either through TX Quality Orthogonal Frequency-Division Multiplexing (OFDM) plot, and the spectrum plot. Instructions for accessing these plots are provided in the Performing HaLow Measurements section. Note that the LitePoint reports the channel power, rather than the total power. In the example shown below, this means it is the power across the 8 MHz signal, and does not include any of the sidelobes or harmonics.

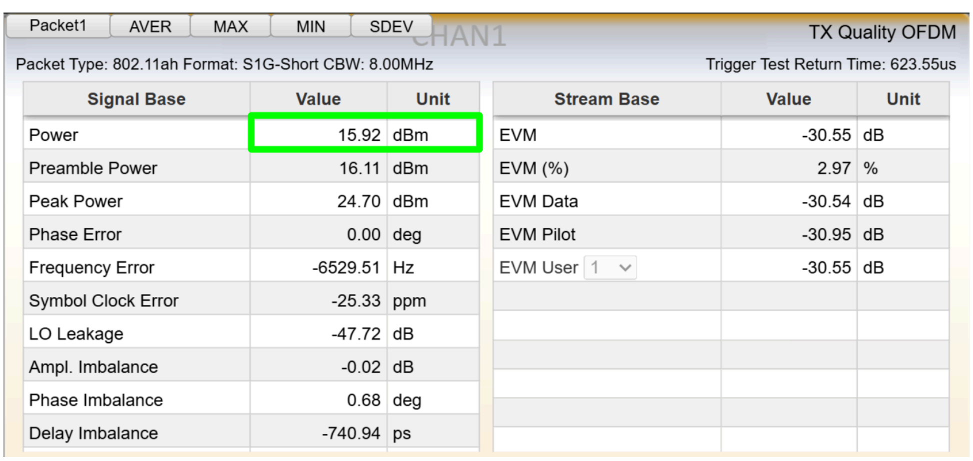


Figure 2. Example power measurement in the LitePoint GUI.

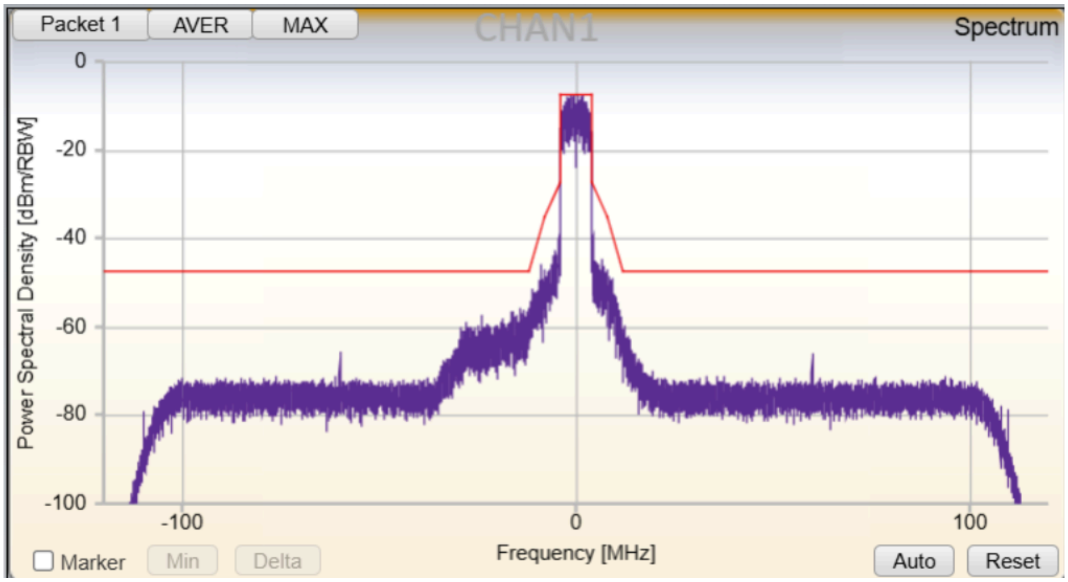


Figure 3. Spectrum plot within the LitePoint GUI.

Expected Result:

The expected result will vary upon the device being used, bandwidth, channel, and Modulation and Coding Scheme (MCS) rate. Please consult the relevant chip or module datasheet for expected power numbers.

The measured power reflects the signal level received at the LitePoint connector. It does not account for any cable losses or external attenuation present in the signal path by default. Instructions for compensating for path loss are found in the Inputting External Attenuation section.

Common Failure Modes:

- Incorrect or misconfigured Board Configuration File (BCF).
- Components on the transmit path with high insertion loss are unaccounted for.
- Inaccurate Path loss has been applied.

3.1.2. Error Vector Magnitude (EVM)

Description:

Error Vector Magnitude quantifies the modulation accuracy of a transmitted OFDM signal. It measures the difference between the ideal (reference) constellation points and the actual received points for the In-phase and Quadrature (I/Q) plane. Mathematically, EVM is expressed as a percentage or in decibels (dB), and is defined as:

$$\mathrm{EVM}_{\%} = \frac{\text{RMS of error vectors}}{\text{RMS of reference vectors}} \times 100\%$$

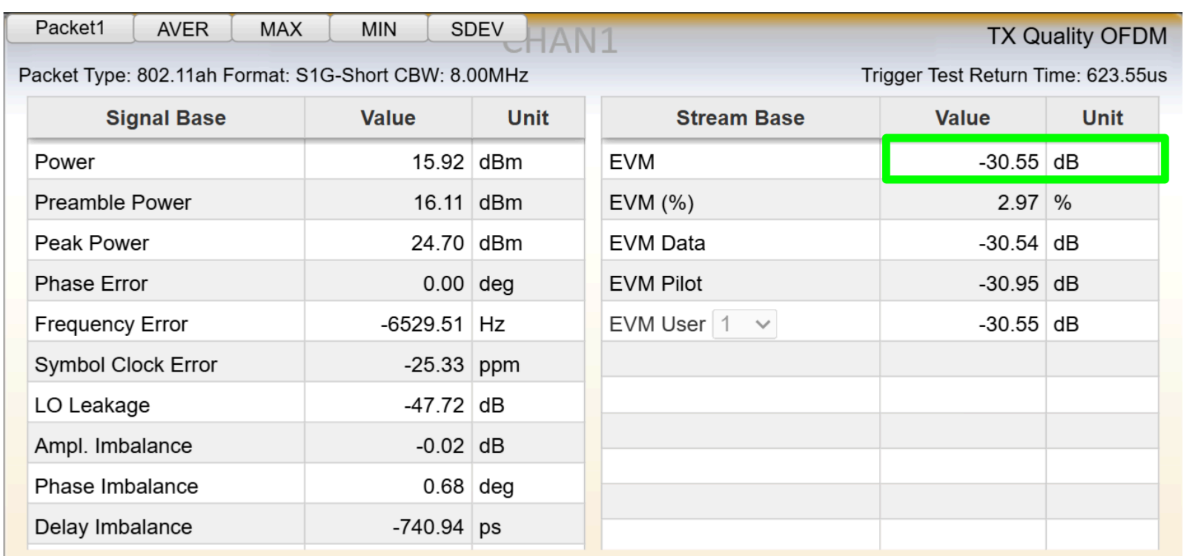
$$\mathrm{EVM}_{\mathrm{dB}} = 20\log_{10}\left(\frac{\mathrm{EVM}_{\%}}{100}\right)$$

Figure 4. EVM Equation

Lower EVM values indicate better modulation accuracy and overall signal quality. In Wi-Fi HaLow, maintaining EVM within specified limits is critical for ensuring reliable communication and compliance with the standard's Physical (PHY) layer requirements.

Typical Measurement:

On a LitePoint tester, this is typically observed using the TX Quality OFDM table as a value or the Constellation OFDM plot.



Packet1 | AVER | MAX | MIN | SDEV — CHAN1 — TX Quality OFDM

Packet Type: 802.11ah Format: S1G-Short CBW: 8.00MHz — Trigger Test Return Time: 623.55us

Signal Base	Value	Unit	Stream Base	Value	Unit
Power	15.92	dBm	EVM	-30.55	dB
Preamble Power	16.11	dBm	EVM (%)	2.97	%
Peak Power	24.70	dBm	EVM Data	-30.54	dB
Phase Error	0.00	deg	EVM Pilot	-30.95	dB
Frequency Error	-6529.51	Hz	EVM User 1	-30.55	dB
Symbol Clock Error	-25.33	ppm			
LO Leakage	-47.72	dB			
Ampl. Imbalance	-0.02	dB			
Phase Imbalance	0.68	deg			
Delay Imbalance	-740.94	ps			

Figure 5. Example EVM measurement in the LitePoint GUI.

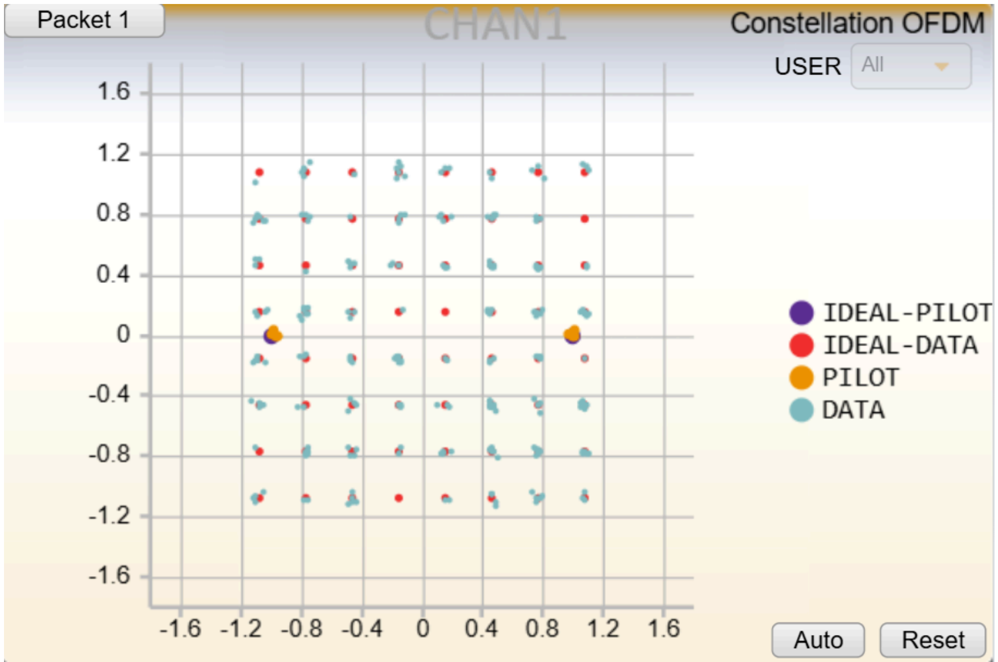


Figure 6. Example constellation of a 64-QAM signal.

Expected Result:

EVM limits are MCS rate dependent. Table 23-30 from the IEEE 802.11ah specification document shows the specification limits. An individual device must meet or exceed the IEEE limit in all circumstances. For example: MCS8 must have an EVM ≤ 30dB.

⚠️Important: For volume production, the manufacturer must apply an additional limit margin to accommodate process variation and sample size variability. See Test Margin Considerations for detailed guidance.

Table 1. EVM Limits per IEEE 802.11ah specifications

MCS	Limit (dB)
10	-4
0	-5
1	-10
2	-13

3	-16
4	-19
5	-22
6	-25
7	-27
8	-30
9	-32

Common Failure Modes:

- Incorrect or misconfigured BCF.
- Impedance mismatches on the DUT's transmission line.
- Driving the Power Amplifier (PA) near its saturation regions.
- Poor cable quality.

3.1.3. Spectrum Emissions Mask (SEM)

Description:

The spectrum emissions mask specifies the maximum permissible signal power levels at various frequency offsets from the centre frequency of a transmitted signal. The image below is taken from the IEEE 802.11ah specification document, and shows the mask of an 8 MHz signal.

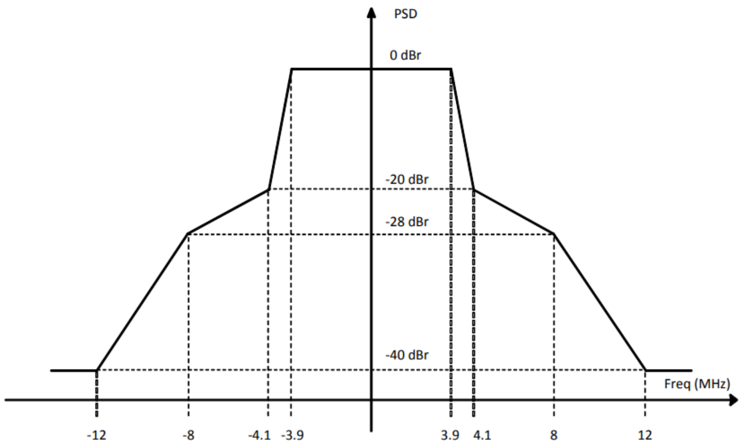


Figure 23-25—Transmit spectral mask for 8 MHz channel

Figure 7. Example spectrum mask from the IEEE 802.11ah specification.

This measurement is critical to ensure compliance for both specification and regulatory requirements.

Note: It is important to clarify that the LitePoint SEM measurement does not report absolute power (in dBm). Instead, it calculates the **margin** (in dB) between the spectral mask (internal limit) and the measured power levels at various frequency offsets.

Typical Measurement:

The SEM value is displayed in the Spectrum Mask Margins plot on the LitePoint system. It provides individual margin values for each spectral mask segment.

For SEM margin measurements, LitePoint divides the analysis bandwidth into segments based on the IEEE 802.11ah spectral mask. These segments are organized into lower and upper regions relative to the channel center frequency. Each region includes segments 1 through 4, progressing outward from the center frequency. Segment 1 corresponds to the edge of the occupied bandwidth, approximately 0.5 times the channel bandwidth from the center. Segment 2 spans from the edge of segment 1 to 1× the channel bandwidth. Segment 3 extends from 1× to 1.5× the channel bandwidth, and segment 4 covers the region beyond 1.5× the channel bandwidth.

If a single SEM value is required, it is typically reported as the minimum margin observed across all spectral mask segments.

Packet 1 | AVER | MAX — CHAN1 — Spectrum Mask Margins

Packet Type: 802.11ah

Signal	Frequency	Margin	Unit
	1		
Lower 4	-15.0	5.85	MHz dB
Lower 3	-11.13	7.07	MHz dB
Lower 2	-4.2	11.43	MHz dB
Lower 1	-4.09	14.42	MHz dB
Upper 1	4.09	16.25	MHz dB
Upper 2	4.17	12.8	MHz dB
Upper 3	9.36	10.25	MHz dB
Upper 4	13.12	16.05	MHz dB
Occupied BW		7.51	MHz

Figure 8. Example SEM measurement in the LitePoint GUI.

In the example above, the lowest (minimum) margin across all measured frequency offsets is 5.85 dB, which is reported as the final SEM result for this segment.

Expected Result:

All SEM margin points must be ≥ 0 dB to be IEEE compliant.

⚠️Important: For volume production, the manufacturer must apply an additional limit margin to accommodate process variation and sample size variability. See [Test Margin Considerations](#) for detailed guidance.

Common Failure Modes:

- Incorrect or misconfigured BCF.
- Impedance mismatches on the DUT's transmission line.
- Driving the Power Amplifier (PA) near its saturation regions.
- Poor cable quality.
- Shielding issues.

3.1.4. Spectral Flatness (SF)

Description:

Spectral flatness ensures that the transmitted signal maintains uniform power distribution across its occupied bandwidth. The specification defines allowable power deviations across individual subcarriers, and accordingly, the LitePoint reports spectral flatness measurements in dB per subcarrier.

Typical Measurement:

This can be seen on the LitePoints Spectral Flatness OFDM measurement.

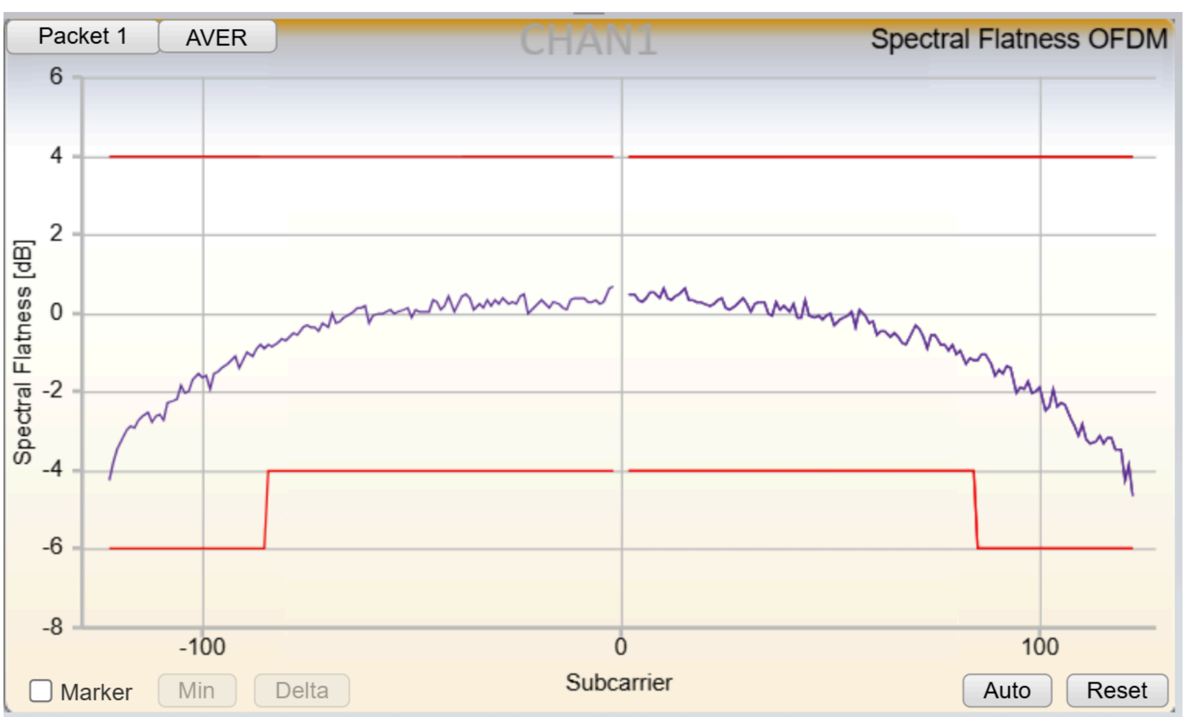


Figure 9. Example SF measurement in the LitePoint GUI.

The lowest (minimum) value across all subcarriers is recorded and compared against the defined spectral flatness limits.

Expected Result:

All Spectral Flatness measurements must remain within the defined limit lines under all conditions. Similar to SEM, the minimum margin across the subcarriers is typically used as the reported Spectral Flatness value. If this minimum exceeds the limit (0 dB), the Spectral Flatness test passes for that subcarrier.

For example, in Figure 9 the subcarrier measurement line (purple) is above the lower limit and below the upper red limit line. Therefore, all values pass the SEM requirement.

⚠️Important: For volume production, the manufacturer must apply an additional limit margin to accommodate process variation and sample size variability. See Test Margin Considerations for detailed guidance.

Common Failure Modes:

- Incorrect or misconfigured BCF.
- IQ imbalance or DC offsets in the transmit chain.
- Nonlinearities in the power amplifier.
- High frequency error and phase noise.

3.1.5. Frequency Error

Description:

Frequency error is the difference between the measured frequency and the nominal (expected) frequency. For example, a signal intended to transmit at 924 MHz may actually be transmitting at 924.1 MHz due to frequency error. This measurement is essential for regulatory compliance—ensuring the signal stays within its allocated spectrum—and to reduce RX PER for the receiver.

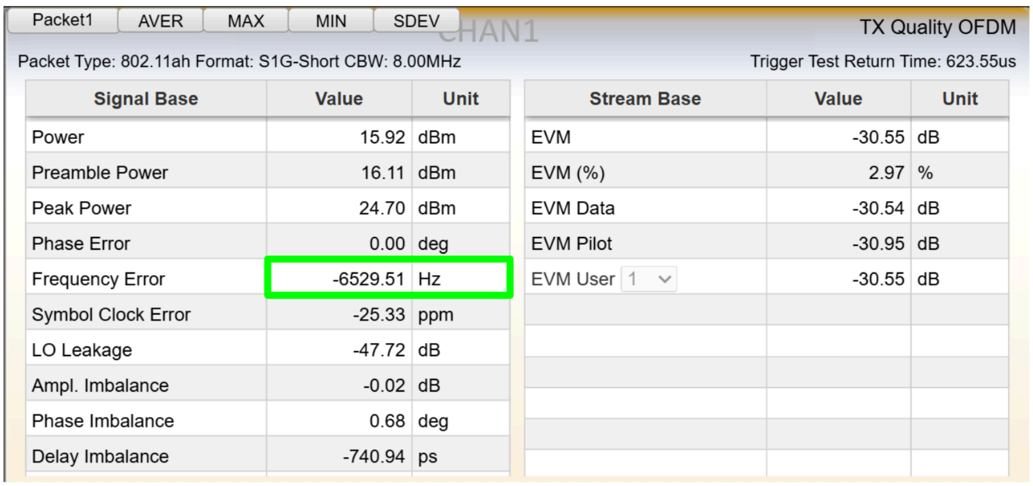
Frequency error can be defined in either Hz or PPM (Parts Per Million). The IEEE 802.11ah specification defines a frequency error limit of ±20 PPM. Frequency error can be converted from Hz to PPM as per:

$$\text{Frequency Error (PPM)} = \frac{\text{Frequency Error (Hz)}}{\text{Center Frequency (Hz)}} \times 10^6$$

Figure 10. Frequency error Hz to PPM equation.

Typical Measurement:

On a LitePoint tester, frequency error is typically seen on the TX Quality OFDM measurement. Here, the LitePoint presents the measurement in Hz.


Packet1 | AVER | MAX | MIN | SDEV — CHAN1 — TX Quality OFDM

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Phase Error	0.00	deg	EVM Pilot	-30.95	dB
Frequency Error	-6529.51	Hz	EVM User 1	-30.55	dB
Symbol Clock Error	-25.33	ppm			
LO Leakage	-47.72	dB			
Ampl. Imbalance	-0.02	dB			
Phase Imbalance	0.68	deg			
Delay Imbalance	-740.94	ps			

Figure 11. Example frequency error measurement in the LitePoint GUI.

Using the formula above and a center frequency of 924 MHz, the calculated frequency error is −7.07 PPM. This falls within the ±20 PPM limit and is therefore considered a pass.

Expected Result:

All frequency error values must be within ±20 PPM in all circumstances.

⚠️Important: For volume production, the manufacturer must apply an additional limit margin to accommodate process variation and sample size variability. See Test Margin Considerations for detailed guidance.

Common Failure Modes:

- Crystal oscillator inaccuracy.
- Incorrect or untuned load capacitors on the crystal oscillator.
- Temperature drift.
- Increased RX PER for the receiver.

3.1.6. Local Oscillator (LO) Leakage

Description:

Local oscillator leakage verifies that the transmitter does not leak significant energy at the carrier frequency when transmitting modulated signals. LO leakage is typically caused by IQ imbalance or Direct Current (DC) offsets in the transmit chain, can impact receiver performance, as well as cause issues for meeting CE regulatory requirements. This is given by the LitePoint in dB.

Typical Measurement:

This can also be viewed in the TX Quality OFDM measurement.

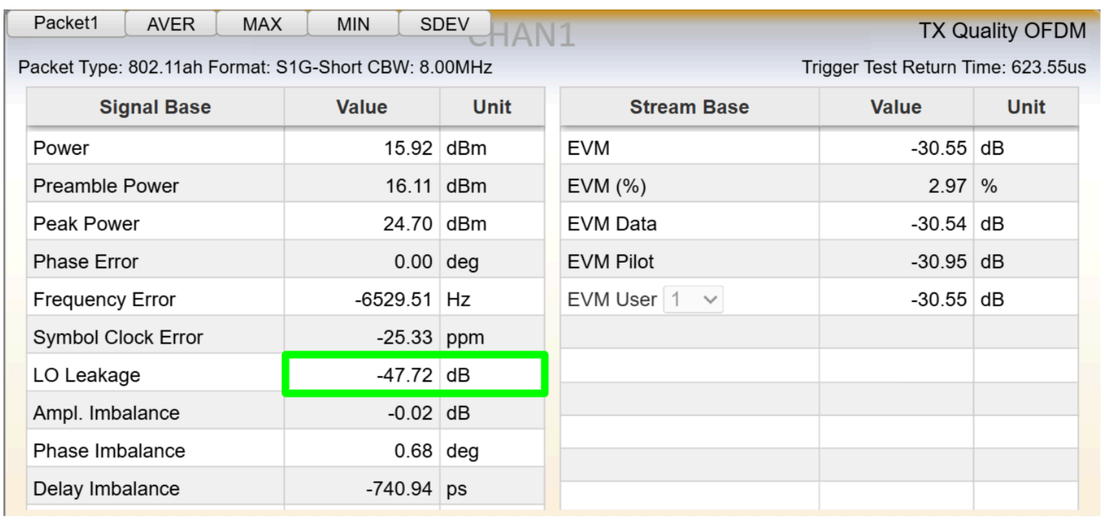


Figure 12. Example LO leakage measurement in the LitePoint GUI.

Expected Result:

LO leakage must meet or exceed the specified limits under all conditions, as outlined in the table below for each bandwidth.

Table 2. LO leakage limits.

Bandwidth (MHz)	Specification Limit (dB)
1	-14.2

2	-17.5
4	-20.6
8	-23.8

Common Failure Modes:

- Incorrect or misconfigured BCF.
- IQ imbalance or DC offsets in the transmit chain.
- Improper VSA reference level.
- Path loss not accounted for.

3.2. RX Items

3.2.1. Packet Error Rate (PER)

Description:

Packet error rate is the ratio of incorrectly received packets to the total number of transmitted packets. It reflects the overall reliability of the communication link and includes the effects of noise, interference, and signal quality. PER is especially useful for validating receiver sensitivity and end-to-end system performance.

Typical Measurement:

Packet Error Rate (PER) is performed by transmitting a known number of packets from the Vector Signal Generator (VSG)—in this case, the LitePoint tester. The HaLow device tracks statistics indicating how many packets were successfully received. By dividing the number of correctly received packets by the total number sent, the PER can be calculated as a percentage. Detailed steps for configuring both the LitePoint and the HaLow device to perform this measurement are provided in the Performing HaLow Measurements section.

Expected Result:

The PER will change depending on the bandwidth, MCS rate, and power level of the transmitter. More guidelines on expected RX sensitivity which reflects PER can be found in the RX Sensitivity section.

Common Failure Modes:

- Low signal power.
- Poor Signal to Noise Ratio (SNR).
- High EVM.
- External RF interference.
- Path loss unaccounted for.
- Impedance mismatches on the DUT's transmission line.
- Poor cable quality.

3.2.2. RX Sensitivity

Description:

RX sensitivity, as defined by the IEEE 802.11ah standard, is the minimum signal level at which the packet error rate (PER) remains below 10%. In practical terms, higher sensitivity allows a device to detect weaker signals, improving its performance at longer ranges or in high-interference environments.

Typical Measurement:

This measurement is typically performed by sweeping the input power across a range of fixed levels while monitoring the PER. The RX sensitivity is defined as the lowest input power at which the PER remains at or below 10%. Results are often presented as a graph, such as the example shown below, which depicts PER versus input power for a 1 MHz, MCS0 signal. The red line at 10% PER serves as the threshold; in this case, the RX sensitivity is determined to be approximately -107 dBm.

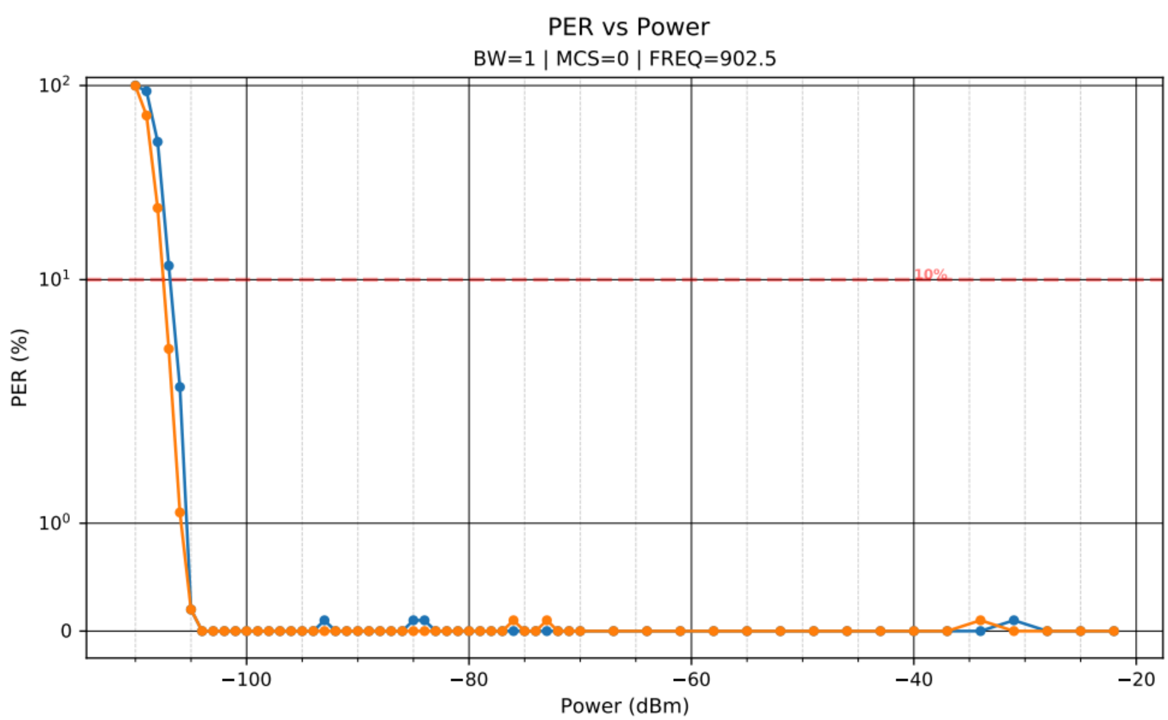


Figure 13. Example RX sensitivity graph for a 1 MHz MCS0 signal.

Expected Result:

RX sensitivity must meet or exceed the IEEE 802.11ah specification limits across all bandwidths (see Table 3). Morse Micro devices consistently and significantly surpass these requirements, offering enhanced performance and reliability. Therefore, it is recommended to align with Morse Micro targets rather than the minimum IEEE limits. For the latest approved RX sensitivity targets, please contact your Morse Micro representative.

Table 3. IEEE 802.11ah specification RX sensitivity limits.

MCS	IEEE 802.11ah Specification Limit - 1 MHz (dBm)	IEEE 802.11ah Specification Limit - 2 MHz (dBm)	IEEE 802.11ah Specification Limit - 4 MHz (dBm)	IEEE 802.11ah Specification Limit - 8 MHz (dBm)
10	-98	N/A	N/A	N/A
0	-95	-92	-89	-86
1	-92	-89	-86	-83
2	-90	-87	-84	-81
3	-87	-84	-81	-78
4	-83	-80	-77	-74
5	-79	-76	-73	-70
6	-78	-75	-72	-69
7	-77	-74	-71	-68
8	-72	-69	-66	-63
9	-70	-67	-64	-61

Common Failure Modes:

RX sensitivity shares all the same common failure modes of RX PER.

3.3. Test Margin Considerations

3.3.1. Production Manufacturing

For module manufacturing, LitePoint testing is automated using test scripts. Morse Micro has developed a script suite called "Manufacturing Test" to evaluate module performance with the LitePoint system. This suite is maintained by the Morse Micro team and is updated and released as changes are implemented.

For more information on Manufacturing Test, please contact your Morse Micro representative.

3.3.2. Inherent Process Variation

All manufacturing processes exhibit inherent variation, typically modeled as a normal distribution characterized by a mean (μ) and standard deviation (σ). This variation results in a statistical spread of measured outcomes for any given parameter (e.g. Power, EVM, SEM), even under controlled conditions.

As a theoretical example, transmit power measurements for MCS0 BW1 across 100,000 modules may show a normal distribution with a mean of 25 dBm and standard deviation of 0.2 dB.

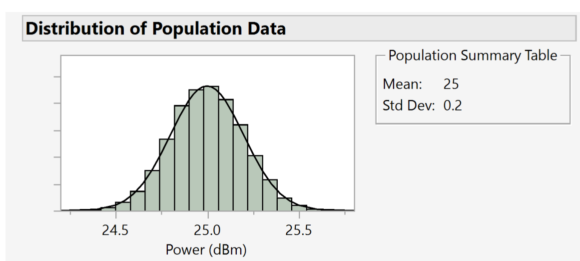


Figure 14. Transmit Power Normal distribution for MCS0 BW1 across 100,000 modules.

3.3.3. Tuning RF Parameters for Production Yield

For RF devices, transmit power is the primary factor influencing other RF metrics such as EVM and SEM. This is especially critical when tuning for maximum output power, where small variations can significantly impact these parameters. As a result, transmit power should be set at the highest practical level that maintains adequate margin across all key RF parameters, accommodates for process variation, and ensures high yield in volume production.

Consider MCS9 BW8, which has an IEEE EVM limit of −32 dB. EVM is typically directly influenced by transmit power; decreasing transmit power likely improves EVM and vice-versa. A non-robust approach is selecting transmit power using a limited sample size (e.g., 5 modules) and targeting an EVM that just meets the −32 dB limit.

This approach overlooks process variation and in high-volume production is likely to result in low yield. While the mean EVM may match the small-sample result of −32 dB, the standard deviation was not considered. With a standard deviation of 0.2 dB, the resulting distribution (as shown below) has a yield of approximately 50%.

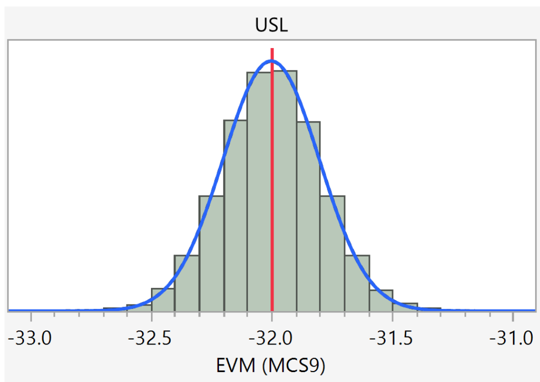


Figure 15. Normal distribution showing the consequences of inadequate margin from IEEE limits.

In contrast, the recommended approach is to characterize RF parameters process variation (e.g., EVM, SEM) using a larger sample size (e.g., 100 modules). This allows selection of transmit power levels with sufficient margin to account for both module-to-module and run-to-run variation. In the image below, the transmit power has been reduced so the mean EVM has been improved to -34dB. With the same standard deviation as the previous case, the expected yield in high-volume production is likely 100%.

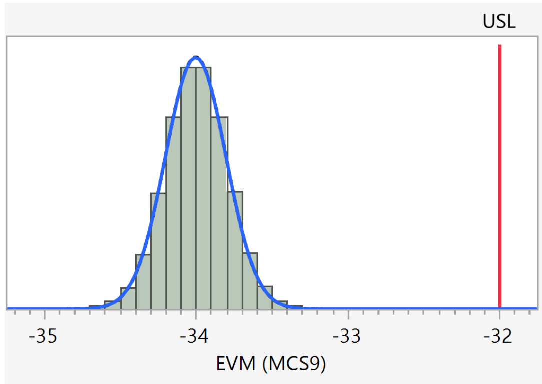


Figure 16. Normal distribution showing higher yield when designing in margin from IEEE limits.

Furthermore, RF parameters are commonly interdependent. For example, a module with poor EVM that exceeds the IEEE limit increases the likelihood of packet errors (PER) under field conditions, resulting in reduced average data throughput in practical environments.

3.3.4. Importance of Margin in Test Limits

To achieve target yield in high-volume production, test limits must be defined with sufficient margin beyond nominal IEEE specifications. This margin accounts for process variation, measurement uncertainty, and run-to-run variability, ensuring yield targets are met.

3.3.5. Risk of Inadequate Margin

Failure to account for process variation during limit definition may result in either low yield (due to over-constraining limits) or poor field performance (due to under-constraining limits). Therefore, test limit definition must be based on a statistical understanding of process capability and aligned with yield targets.

Note: All Morse Micro reference designs have undergone test limit selection and validation to achieve strong field performance and high manufacturing yield. Morse Micro limits and recommendations are available upon request.

3.3.6. Morse Micro Approach to Yield and Limit Optimization

The Morse Micro team analyzes module statistical distributions in conjunction with Process, Voltage, Temperature (PVT) data to account for process variation and external factors (e.g. temperature effects). Using measured data, we define performance targets and test limits to ensure high yield and robust field performance.

We follow a process of continuous improvement, routinely refining our manufacturing, design, and test methodologies to enhance module performance and yield. As a result, limit recommendations may be updated over time to reflect the latest characterization data. For this reason, this document does not specify Morse Micro limits.

For the most current target limits across all RF parameters, please contact your Morse Micro representative.

4. Test Environment Setup

This section will detail the environment setup to perform RF measurements on a HaLow device. This guide will focus exclusively on using an IQxel-MW 7G as the tester, and a Morse Micro HaLowLink 1 as the HaLow device under test. This guide will give limited details into configuring the HaLowLink 1, focusing more on the RF testing process as a whole.

4.1. Block Diagram

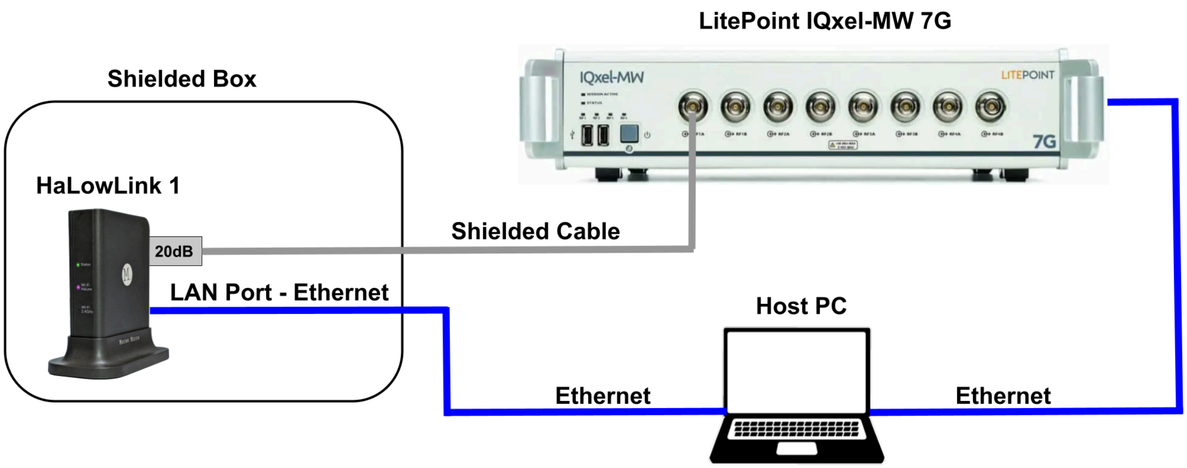


Figure 17. Block diagram of an example test setup.

An Ethernet connection is required to interface with both the LitePoint tester and the HaLowLink 1 device. A shielded RF cable must be used between the DUT and the LitePoint port to prevent external interference, which can significantly affect measurement accuracy—particularly RX sensitivity. A barrel attenuator should be placed in-line to ensure the received signal does not exceed the LitePoint's maximum input power. Note that LitePoint does not automatically account for any external attenuation; instructions for manually entering path loss compensation are provided in the LitePoint section of this document. Depending on the cabling, an RP-SMA to SMA adapter may also be required for connecting to the HaLowLink 1.

Some recommended parts are listed below:

- 20 dB barrel attenuator (500 mW): CATTEN-0200
- RP-SMA to SMA adaptor: ADP-RPSM-SMAF-G
- Shielded cable: CCSMA-MM-086-18

⚠️ **Important:** Ensure barrel attenuator is rated to handle the maximum output power of the device under test. For example, using a DUT that transmits at 30 dBm with an attenuator rated < 1 Watt (W) may result in damage or degraded performance, and should be avoided. Recommended 2W barrel attenuator: BW-S20W2+ (minicircuits)

4.2. Measuring Cable Loss

To obtain accurate TX power and RX sensitivity measurements, it is essential to compensate for cable loss between the DUT and the LitePoint tester. The recommended method is to use a Vector Network Analyzer (VNA) to perform an S21 (insertion loss) test.

Taking the block diagram from the previous section, the LitePoint and the HaLowLink 1 have been disconnected, and the exact same RF cables—including any intermediate connections or shielded enclosures—are instead connected to a calibrated VNA. This ensures that the measured path loss accurately reflects the real test configuration. Then, an S21 test will characterize the insertion loss across the frequency range of interest and can be used to inform and compensate future measurements.

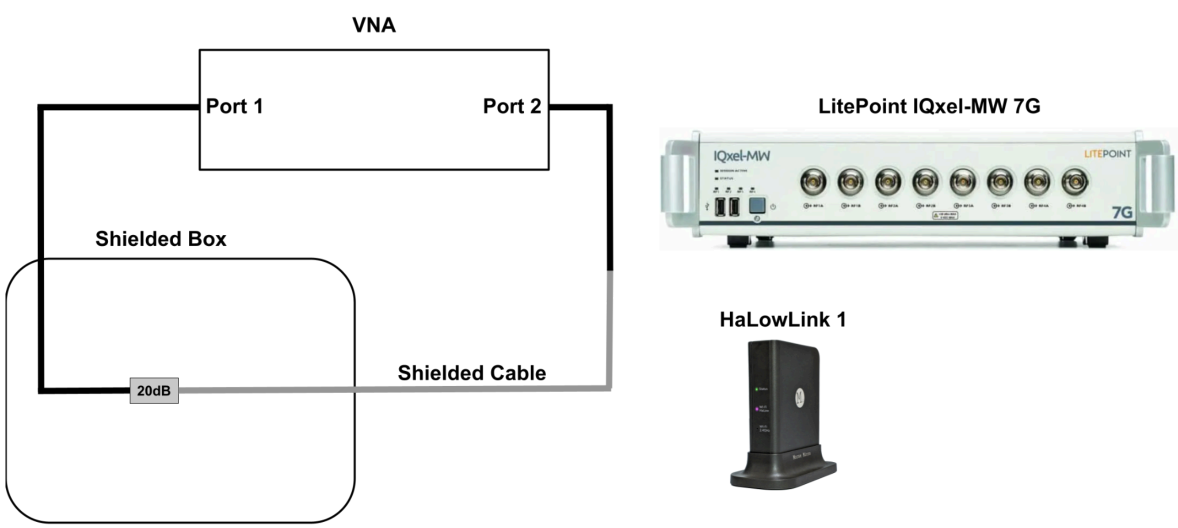


Figure 18. Block diagram of a path loss measurement with a VNA.

4.3. LitePoint

4.3.1. LitePoint Firmware Version

The LitePoint firmware version can be checked by navigating to the LitePoint web Graphical User Interface (GUI), and clicking the **Admin** → **Information** tab.

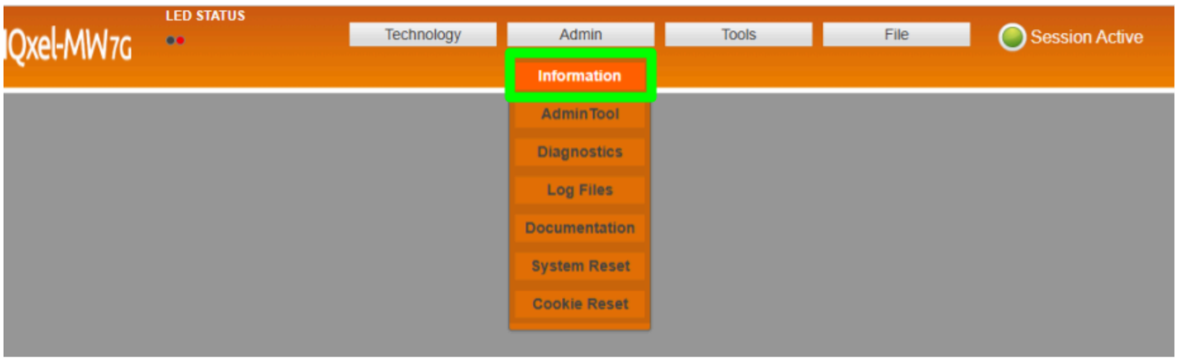
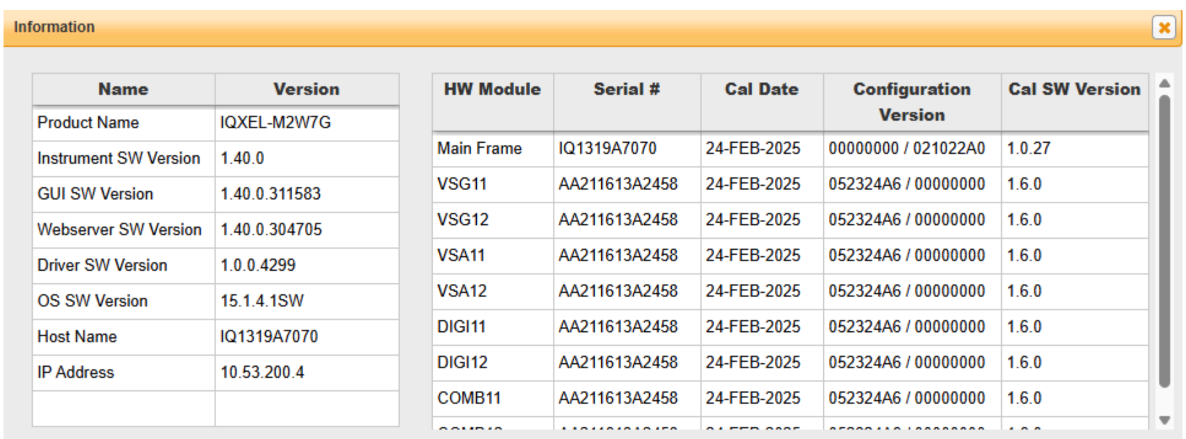


Figure 19. How to view firmware versions in the LitePoint GUI.

The "Instrument SW Version" field indicates the firmware version. As stated earlier, it is recommended to check with LitePoint support that this version remains up to date.



Information

Name	Version
Product Name	IQXEL-M2W7G
Instrument SW Version	1.40.0
GUI SW Version	1.40.0.311583
Webserver SW Version	1.40.0.304705
Driver SW Version	1.0.0.4299
OS SW Version	15.1.4.1SW
Host Name	IQ1319A7070
IP Address	10.53.200.4

HW Module	Serial #	Cal Date	Configuration Version	Cal SW Version
Main Frame	IQ1319A7070	24-FEB-2025	00000000 / 021022A0	1.0.27
VSG11	AA211613A2458	24-FEB-2025	052324A6 / 00000000	1.6.0
VSG12	AA211613A2458	24-FEB-2025	052324A6 / 00000000	1.6.0
VSA11	AA211613A2458	24-FEB-2025	052324A6 / 00000000	1.6.0
VSA12	AA211613A2458	24-FEB-2025	052324A6 / 00000000	1.6.0
DIGI11	AA211613A2458	24-FEB-2025	052324A6 / 00000000	1.6.0
DIGI12	AA211613A2458	24-FEB-2025	052324A6 / 00000000	1.6.0
COMB11	AA211613A2458	24-FEB-2025	052324A6 / 00000000	1.6.0

Figure 20. Information tab within the LitePoint GUI.

4.3.2. Inputting External Attenuation (Optional)

The LitePoint tester allows users to manually input path loss values to compensate for external attenuation in the RF setup. This adjustment affects only power-related measurements, such as TX output power and RX sensitivity. First, click on the **Tools** → **Port Routing** tab.

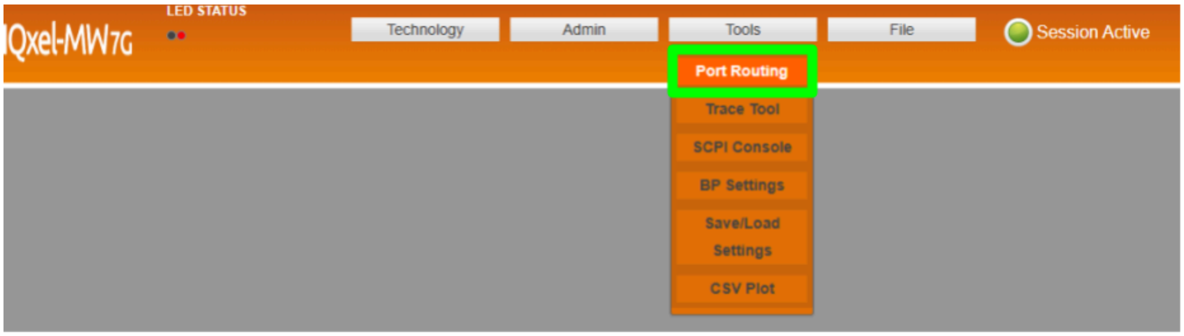


Figure 21. Port routing tab within LitePoint GUI.

Then, click on the **PathLoss Info** tab from the window that pops up.

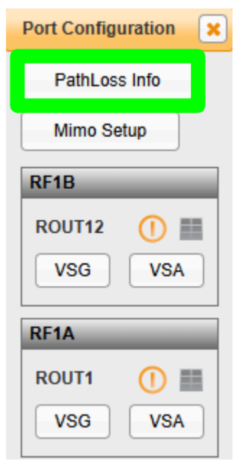


Figure 22. Where to configure path loss in the LitePoint GUI.

Users are presented with the following interface.

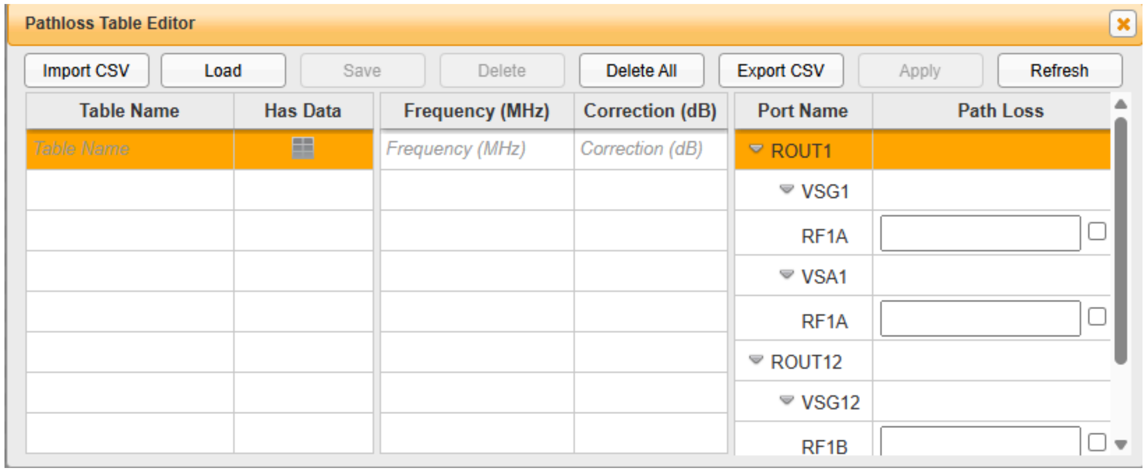


Figure 23. Blank path loss information within the LitePoint GUI.

Begin by setting a "Table Name" for the path loss profile. Then, enter the relevant frequencies (in MHz) and their corresponding correction values (in dB) into the table. For example, if the measured path loss is 11.2 dB at 920 MHz and 11.3 dB at 924 MHz, enter these as separate rows. Once the data is populated, assign the correction table to specific LitePoint ports by selecting the appropriate checkboxes for the desired VSG and/or VSA paths, then clicking **Apply**.

Note: This step must be repeated for each port requiring path loss compensation.

In the example below, corrections of the name "Example" are applied to port RF1A for both the VSA and VSG.

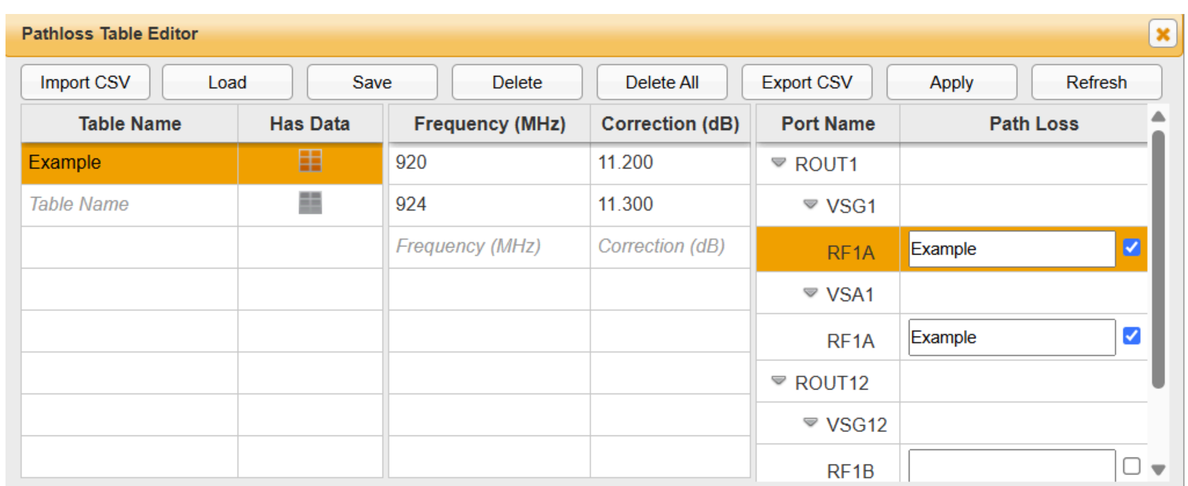


Figure 24. Example path loss inputs for 920 and 924 MHz.

Optionally, these settings can also be saved and applied later from the **Load** and **Save** buttons.

4.4. RF Tester Software

The RF Tester software is a GUI application developed by Morse Micro to support engineers conducting RF measurements. It provides a point and click interface to do the following:

- Connect to a DUT.
- Set radio parameters such as Bandwidth, Channel, MCS rate etc.
- Start/Stop transmitting or receiving packets.
- Retrieve the RPG statistics.
- Clear the RPG statistics for isolated testing.

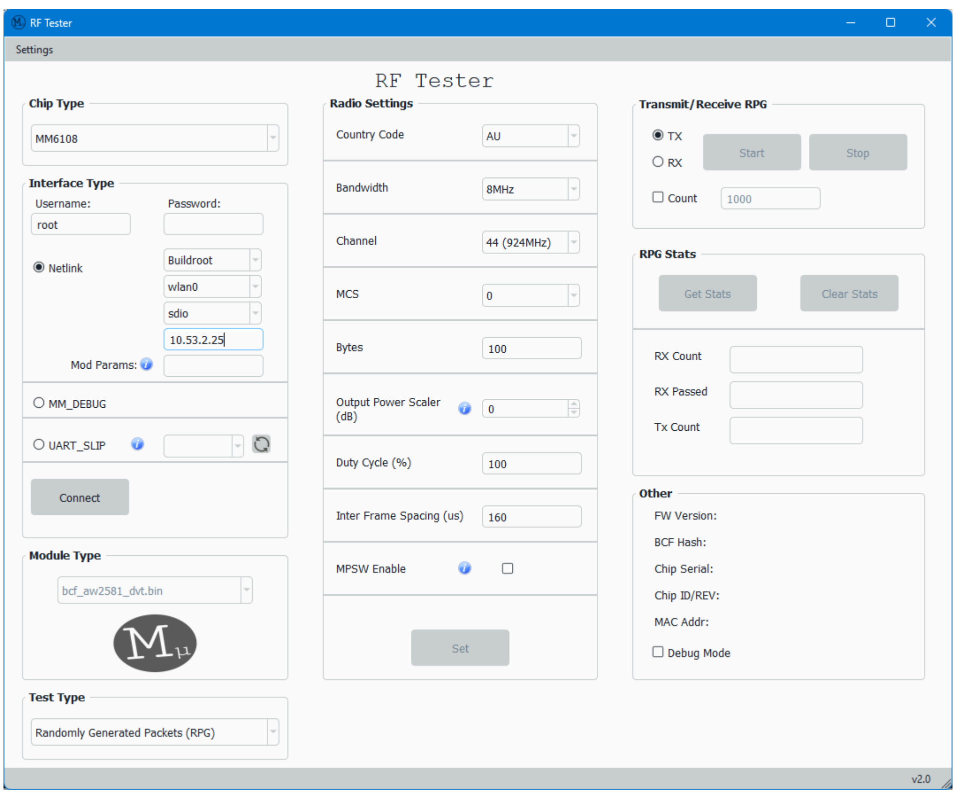


Figure 25. RF Tester software initial screen.

Access to this software is restricted. To obtain access, please contact your Morse Micro representative.

5. Performing HaLow Measurements

5.1. Transmit Tests

To perform TX tests, configure the LitePoint port as a Vector Signal Analyzer (VSA). First, click **Technology** → **WiFi SISO**.

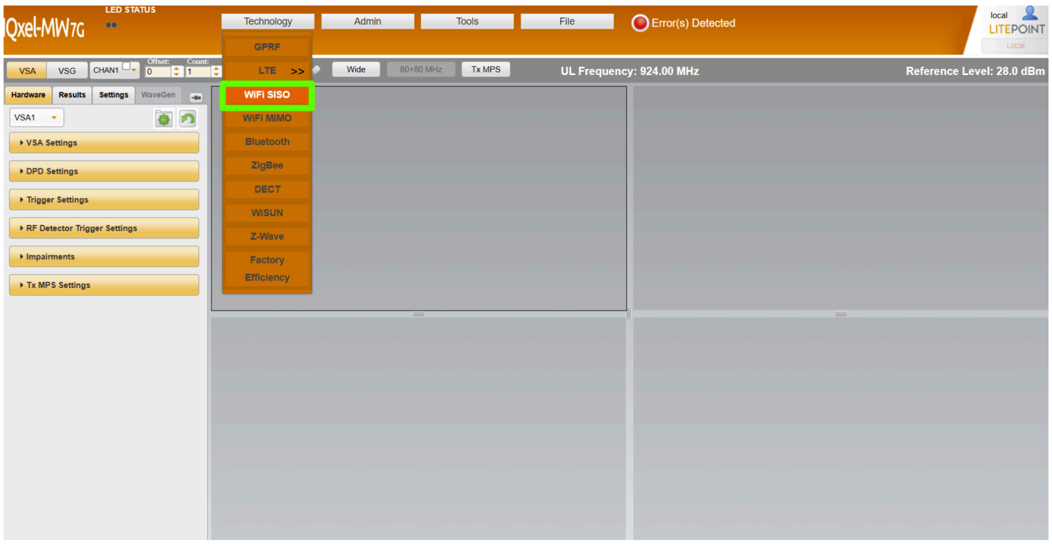


Figure 26. WiFi SISO menu within the LitePoint GUI.

Next, click the dots below "LED STATUS". Then set the port being used to VSA. In this case, RF1A.

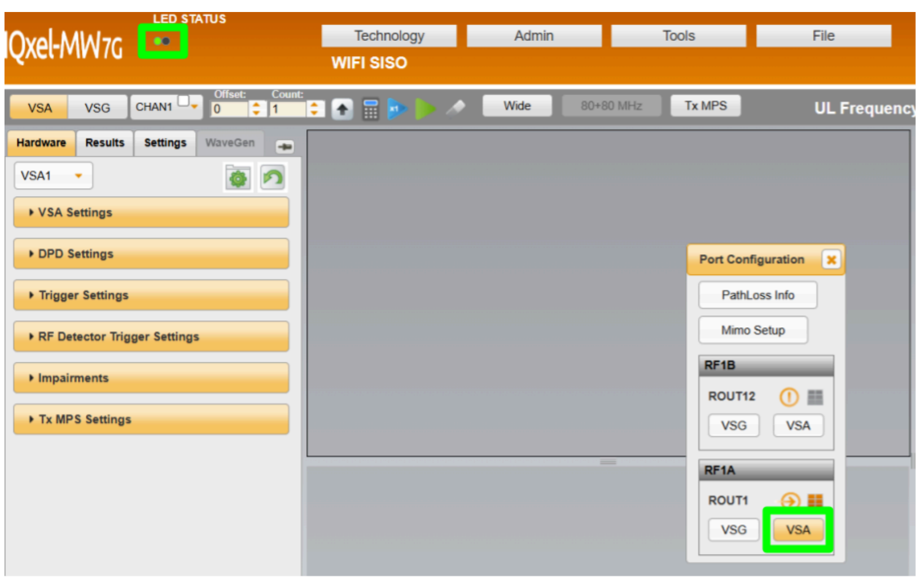


Figure 27. How to configure the LitePoint port as a VSA.

Next the results can be set up to measure the parameters of interest. Click the **Results** tab, and then drag the options of interest to the empty windows to the right. In this example, the Spectrum, TX Quality OFDM, Spectrum Mask Margins, and Spectral Flatness OFDM tabs are chosen. These give all of the main parameters mentioned in the Key Measurement Metrics section.

Figure 28. Results tab showing different measurement options available.

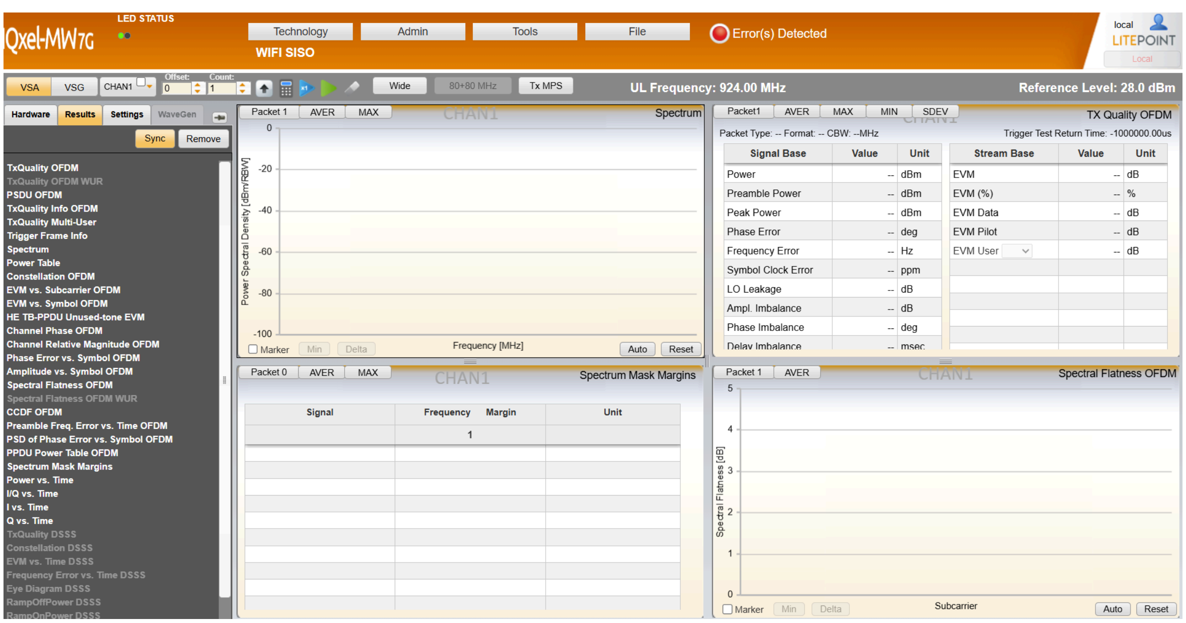


Figure 29. Example layout with 4 different result tabs open.

Next, the user should navigate to the **Hardware** tab and expand the **VSA Settings** dropdown. This is where the center frequency is configured to match the transmission frequency of the DUT. The reference level can also be set in this section to optimize signal capture.

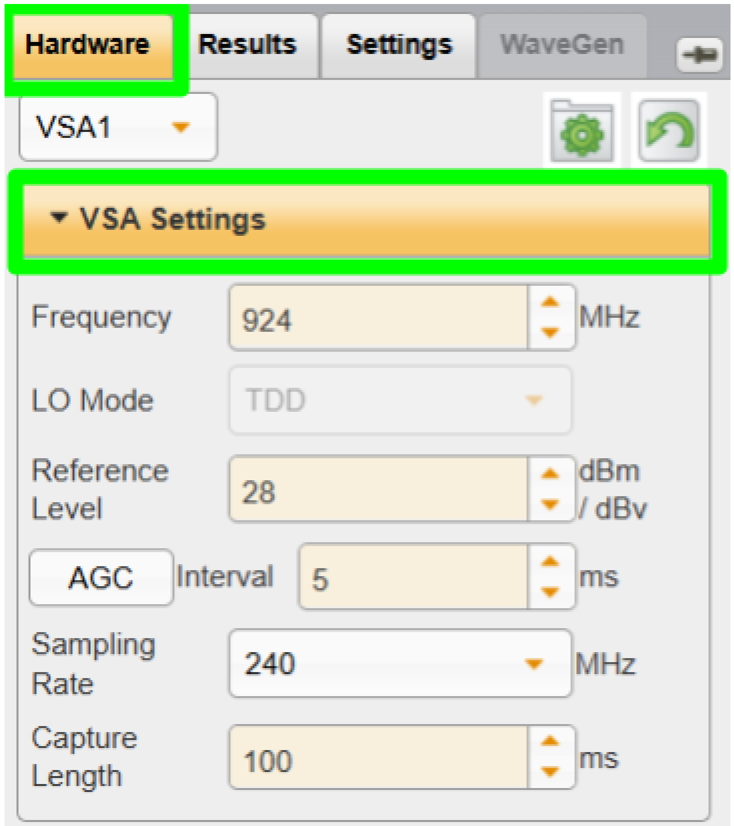


Figure 30. VSA settings menu within the LitePoint GUI.

It is also recommended to set the “Symbol Clock Correction Type” to “TIME” in order to achieve best EVM results. This can be found and set in the **Settings** tab, under the **OFDM** menu.

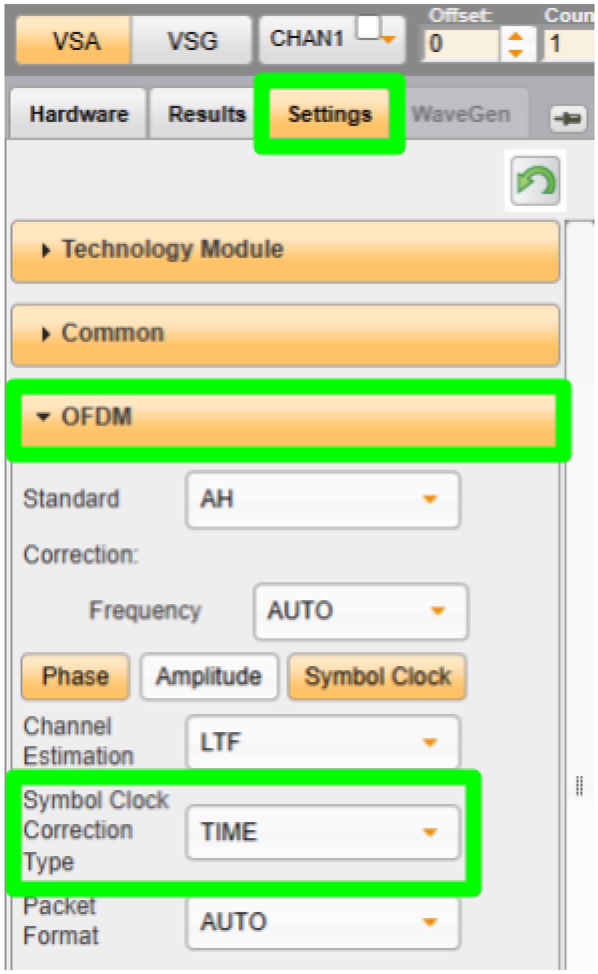


Figure 31. Setting the Symbol Clock Correction Type parameter.

Once the settings are confirmed, the **Continuous Analysis** button can then be clicked to begin continuous measurement acquisition.

Figure 32. Continuous analysis button to take measurements.

Next, the DUT can be configured through the RF Tester. The first step is to establish a connection to the DUT, then configure the desired radio parameters such as bandwidth and MCS rate. Transmission can then be initiated by clicking the "Start" button. In this example, the DUT is transmitting an 8 MHz, MCS 0 signal at 924 MHz.

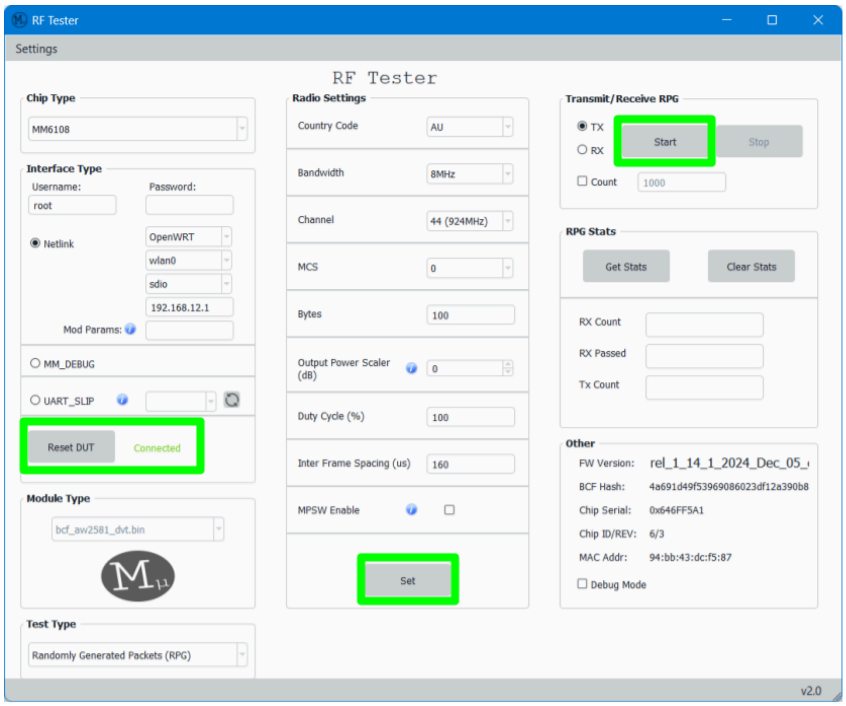


Figure 33. RF Tester configuring the DUT to transmit.

This signal and associated measurements can then be seen on the LitePoint. The Automatic Gain Control (AGC) button may need to be pressed to set a sensible reference level.

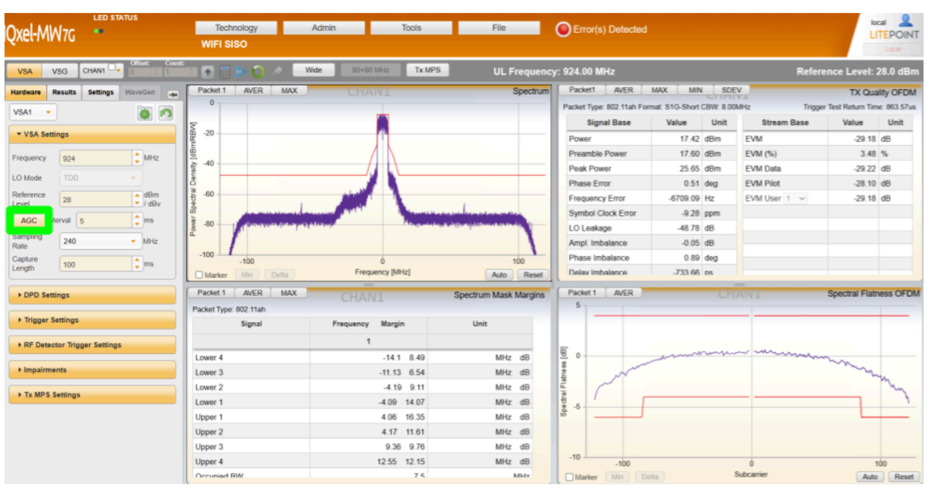


Figure 34. AGC button in the LitePoint GUI.

5.2. Receive Tests

To perform receive tests, the LitePoint needs to be configured as a Vector Signal Generator (VSG). To do this, click the two dots below “LED Status” again, and set the port being used to VSG instead of VSA. The VSG menu can then be clicked on the left hand side to open the VSG settings.

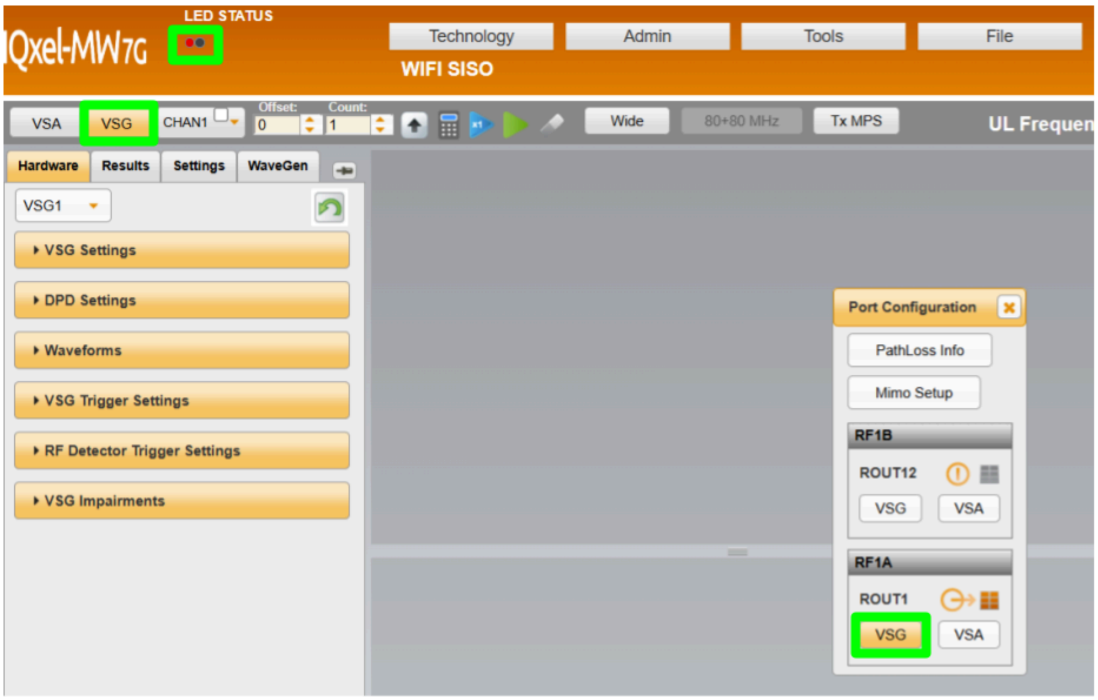


Figure 35. How to configure the LitePoint port as a VSG.

In this example, the LitePoint is set to transmit on 924 MHz at -20 dBm.

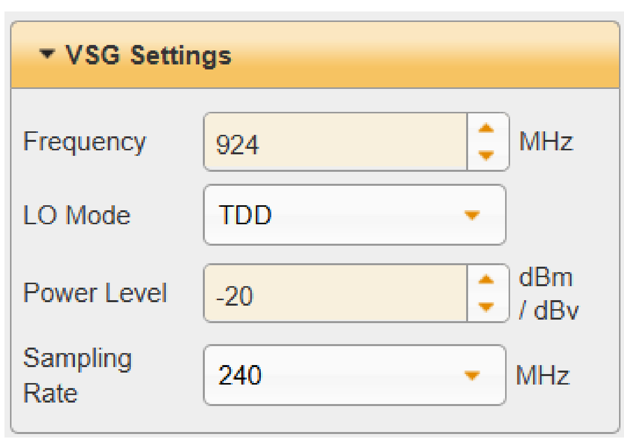


Figure 36. VSG setting menu.

Next, the waveform to transmit needs to be selected. This can be done through the **Waveforms** tab. Here, the **Load** button is used to select an 8 MHz, MCS0 waveform from the LitePoint memory. Please contact your Morse Micro representative for access to Wi-Fi HaLow example waveforms. Then, a count of 1000 packets is set. Ensure **Wave** and **RF(on)** are selected.

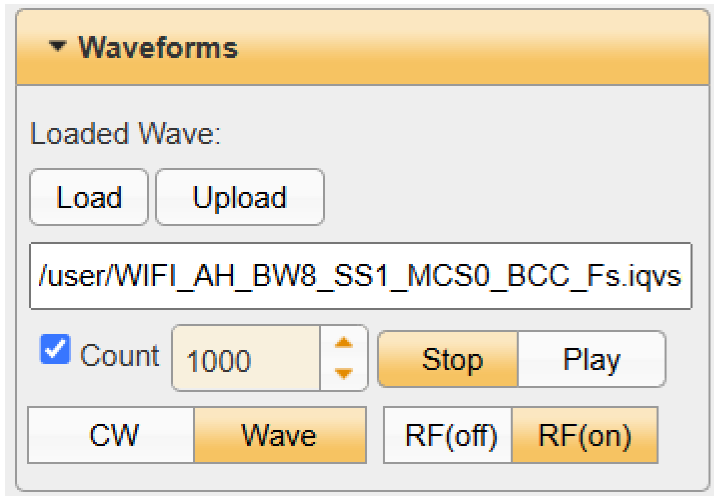


Figure 37. Waveforms menu used to set the parameters of the signal to be transmitted.

The channel bandwidth must next be set on the LitePoint. This can be done through the **Settings** → **Technology Module** tab. This must match the bandwidth to be transmitted.

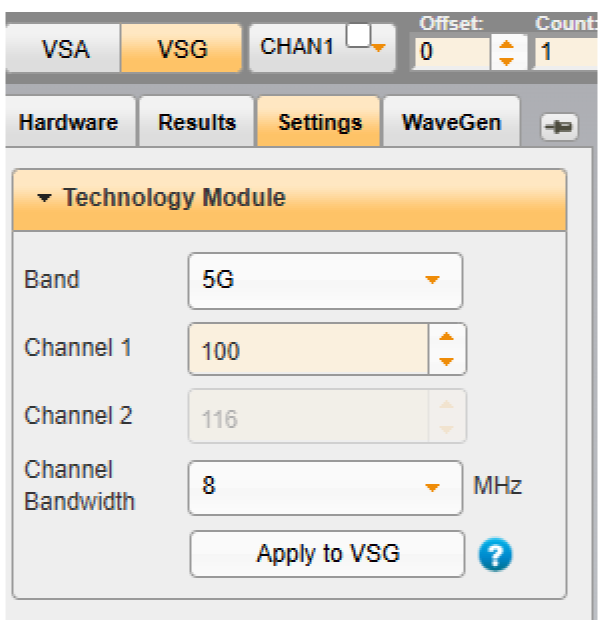


Figure 38. Applying channel bandwidth settings.

Next, the DUT can be prepared through the RF Tester. Connect to the DUT, and set the radio parameters that match the waveform to be transmitted by the VSG. After that, the “RX” radio button should be selected, followed by clicking “Start” to set the device into receive mode on the specified channel. It is recommended to click “Clear Stats” before beginning transmission to ensure accurate measurement results.

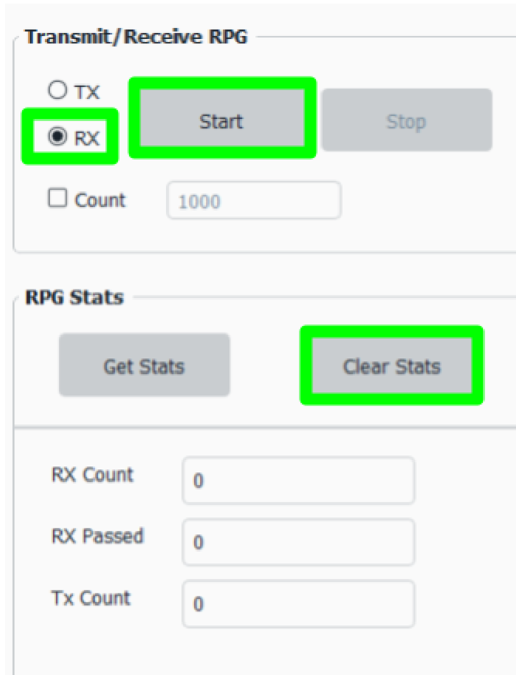


Figure 39. Preparing the RF Tester to receive packets.

Next, the **Play** button on the LitePoint can be pressed to begin waveform transmission. The packet count will decrement in real time as packets are transmitted.

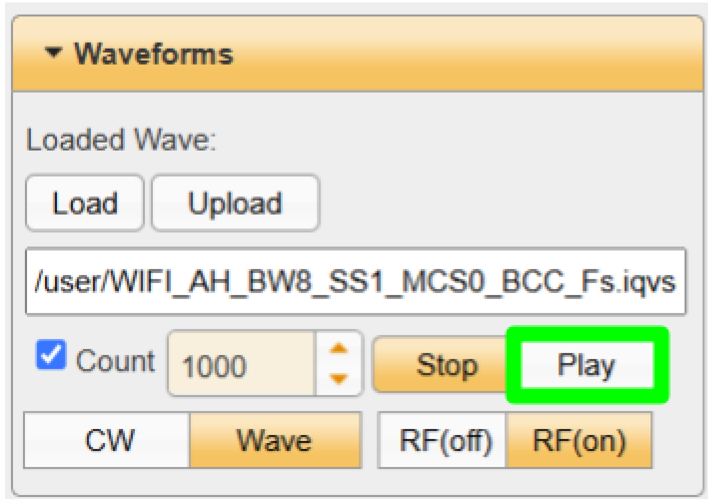


Figure 40. Instructing the LitePoint to transmit the loaded waveform.

Once all packets have been transmitted, the user can use the RF Tester to retrieve the statistics. In this example, the RX Passed statistic shows 1000 packets, resulting in a PER of 0%.

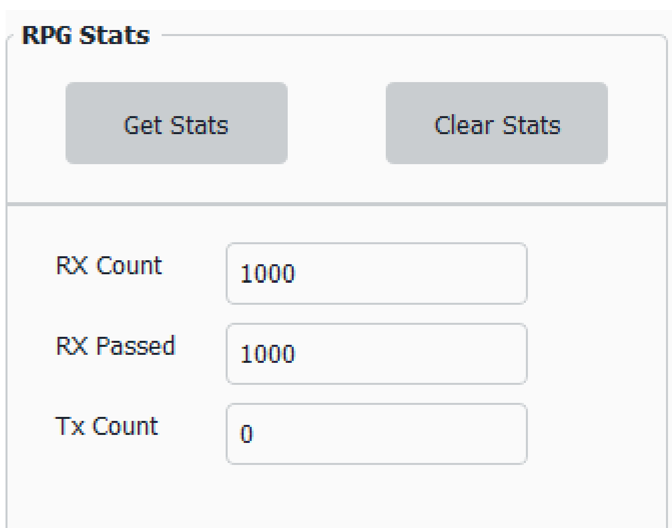


Figure 41. Example RX measurement showing 0% PER in the RF Tester.

It is important to note that RX Count represents the number of packets for which the header was successfully decoded, whereas RX Passed indicates packets where both the header and payload were correctly decoded. For PER calculations, only RX Passed should be used.

6. Glossary

Abbreviation	Full Term	Description / Context
RF	Radio Frequency	Refers to electromagnetic wave frequencies used in wireless communication.
VST	Vector Signal Transceiver	Test equipment capable of both signal generation and analysis with magnitude and phase information.
TX	Transmit / Transmission	The process of sending RF signals from a device.
RX	Receive / Reception	The process of receiving RF signals by a device.
DUT	Device Under Test	The hardware unit being tested in RF measurements.
RPG	Random Packet Generator	A test mode where the DUT transmits random packets without establishing a full connection.
FAE	Field Application Engineer	Technical specialist providing customer support and guidance on engineering products.
EVM	Error Vector Magnitude	A key RF metric measuring the modulation accuracy of a signal.
SEM	Spectrum Emissions Mask	Defines maximum allowed signal power at various frequency offsets from the carrier.
SF	Spectral Flatness	Measures how evenly power is distributed across all subcarriers in an OFDM signal.
LO	Local Oscillator	Refers to the signal generator inside the RF system; leakage is an unwanted emission at the carrier frequency.
PER	Packet Error Rate	The ratio of incorrectly received packets to total packets sent, used to evaluate communication reliability.

PPM	Parts Per Million	Unit for expressing small frequency variations or tolerances.
Hz	Hertz	Unit of frequency, indicating cycles per second.
dB / dBm	Decibel / Decibel-milliwatts	Logarithmic units for expressing signal strength or power level.
OFDM	Orthogonal Frequency-Division Multiplexing	A modulation scheme used in Wi-Fi and other communication standards.
MCS	Modulation and Coding Scheme	Defines data rates and robustness in Wi-Fi standards.
PHY	Physical Layer	The lowest layer in the OSI model, responsible for raw bit transmission over a physical medium.
BCF	Board Configuration File	A configuration file defining DUT-specific settings for RF testing.
PA	Power Amplifier	A component that amplifies the RF signal before transmission.
IQ	In-phase and Quadrature	The two components of a modulated RF signal used to carry information.
DC	Direct Current	In this context, refers to DC offsets that may distort RF signals.
AGC	Automatic Gain Control	A feature that adjusts the receiver gain to maintain optimal signal levels.
VSA	Vector Signal Analyzer	Equipment for analyzing both the amplitude and phase of incoming RF signals.
VSG	Vector Signal Generator	Equipment that generates modulated RF signals with defined amplitude and phase.
GUI	Graphical User Interface	A user interface that allows interaction with electronic devices through graphical icons.

SNR	Signal-to-Noise Ratio	A metric expressing how much stronger a signal is compared to background noise.
S21	Scattering Parameter 21	A measurement of forward transmission gain or loss in a network (used in VNAs).
VNA	Vector Network Analyzer	Test equipment used to measure S-parameters, especially insertion and return loss.
USL	Upper Specification Limit	The maximum allowable value of a measured parameter as defined by design or regulatory specifications.
PVT	Process Voltage Temperature	A reliability and performance verification method that evaluates a device across variations in semiconductor manufacturing process, supply voltage, and operating temperature.

7. Revision History

Release Number	Release Date	Release Notes
01	27/06/2025	Initial release.

Morse Micro Pty. Ltd. - HQ
Level 8, 10-14 Waterloo Street,
Surry Hills, NSW 2010, AUSTRALIA

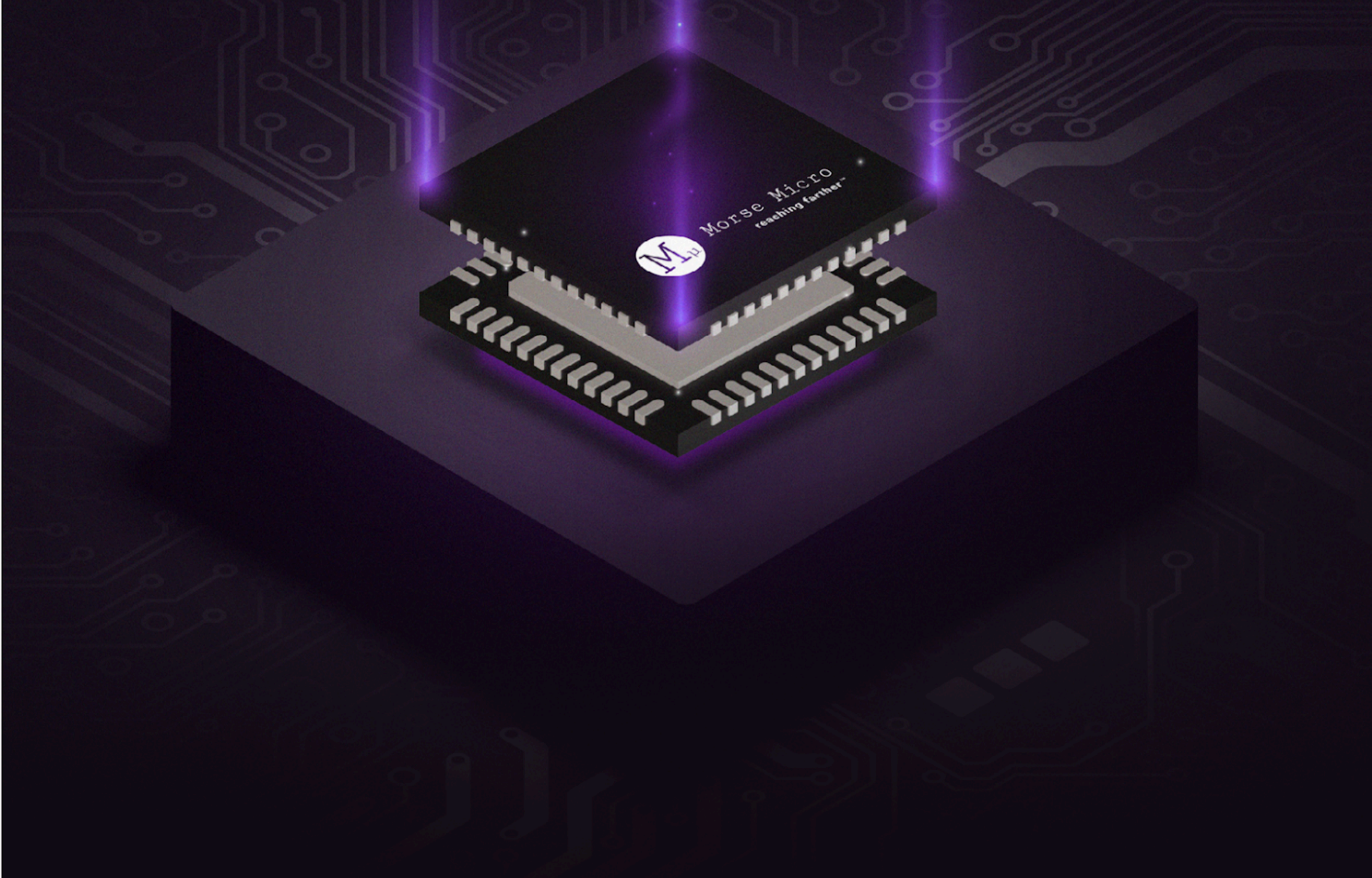
Morse Micro Inc. – USA
40 Waterworks Way
Irvine, CA 92618, UNITED STATES

Office Locations:
Bangalore, India
Cambridge, UK
Hangzhou, China
Irvine, CA - USA
Picton, NSW - Australia
Portola Valley, CA - USA
Shenzhen, China
Taipei, Taiwan

sales@morsemicro.com

www.morsemicro.com

About Morse Micro
Morse Micro is a leading Wi-Fi HaLow fabless semiconductor company based in Sydney, with global offices. As the world's premier Wi-Fi HaLow company, we pioneer next-gen IoT wireless connectivity solutions. Morse Micro is now sampling its Wi-Fi CERTIFIED HaLow MM6108 production silicon: the fastest, smallest, lowest power and longest-range Wi-Fi HaLow chip available in the market.



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