

WLAN

Connection Establishment

Application Note

Products:

- | R&S®CMW500
- | R&S®CMW290
- | R&S®CMW270

For establishing a WLAN connection between R&S CMW and device under test (DUT), the WLAN properties at the R&S CMW have to be adapted to the test conditions. These can vary in several aspects, particularly due to the different WLAN standards and characteristics of the DUT. This document describes the critical parameters and provides step-by-step procedures for the configuration.

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1 Introduction

Connection establishment at the R&S CMW is controlled by the WLAN Signaling application.

WLAN Standards

The figure shows the WLAN standards for 20 MHz channels which are relevant for this document and the mapping onto the “Standard” parameter of the WLAN Signaling application. Note that some “Standard” values cover more than one WLAN standard.

IEEE Standard	802.11b	802.11a	802.11g	802.11n
Frequency Band	2.4 GHz	5 GHz	2.4 GHz	2.4 GHz, 5 GHz
Channels	1 – 14	36 – 200	1 – 14	1 – 14, 36 – 200
Transmission Scheme	DSSS, CCK	OFDM	DSSS, CCK OFDM	OFDM
Data Rates Modulation	1 Mbit/s		1 Mbit/s	
	2 Mbit/s		2 Mbit/s	
	5.5 Mbit/s	6 Mbit/s	5.5 Mbit/s	6 Mbit/s
		9 Mbit/s		9 Mbit/s
	11 Mbit/s	12 Mbit/s	11 Mbit/s	12 Mbit/s
	
		54 Mbit/s	54 Mbit/s	
				65 Mbit/s
				6.5 Mbit/s
				13 Mbit/s

„Standard“ in WLAN Signaling	802.11b	802.11a	802.11g	802.11n (GF)
			802.11g (OFDM)	
			802.11g(OFDM)/n	
			802.11g/n	
		802.11a/n		802.11a/n

Figure 1: WLAN standards, data rates (20 MHz channels) and mapping on the R&S CMW “Standard”

The 802.11n standard also allows 40 MHz channels not considered here.

OFDM: Orthogonal Frequency Division Multiplex

DSSS: Direct Sequence Spread Spectrum

CCK: Complementary Code Keying

Message Sequence for Connection Establishment

Connection establishment between the R&S CMW and the DUT is done automatically and in the background after the WLAN Signaling application has been started (by pressing the ON OFF key) – assumed that the parameter settings are correct.

With the R&S CMW in access point mode, the WLAN Signaling application sends beacon frames which the DUT (acting as station) detects via passive or active scanning (active scanning includes a Probe Request message from the DUT and a Probe Response message from the R&S CMW). Then the usual authentication and association process takes place. Finally, the R&S CMW assigns an IP address to the DUT using the DHCP (Dynamic Host Configuration Protocol) mechanism.

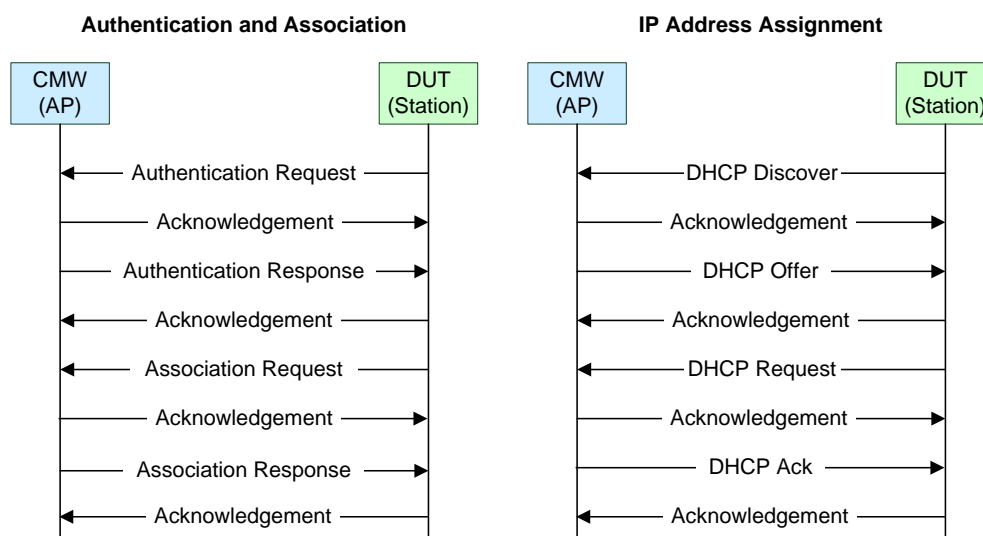


Figure 2: Message sequence charts

The connection establishment process for the R&S CMW in Station mode is the same with inverted roles of R&S CMW and DUT.

Beacon Frames

WLAN access points broadcast information required for association via beacon frames. The beacons are usually sent at the lowest mandatory data rate and in intervals of 102.4 ms. On the R&S CMW (acting in access point mode), the beacon interval can be changed in multiples of 1.024 ms. The period of 1.024 ms is called Time Unit (TU). The beacon frames include the SSID (Service Set Identifier, the name of the WLAN access point used by the WLAN station for access) and BSSID (Basic SSID) information. They also contain information about the supported rates, channel numbers, security requirements, time synchronization and more.

If the R&S CMW acts in station mode, the beacons from the DUT (acting as access point) might be seen in the measurements. Note that the DUT might use different data rates / modulations for transmitting data frames and beacons.

2 Test Setups

The device under test (DUT) is connected to one of the bidirectional RF COM connectors at the front panel of the R&S CMW. No additional cabling and no external trigger is needed. The input level ranges of all RF COM connectors are identical.

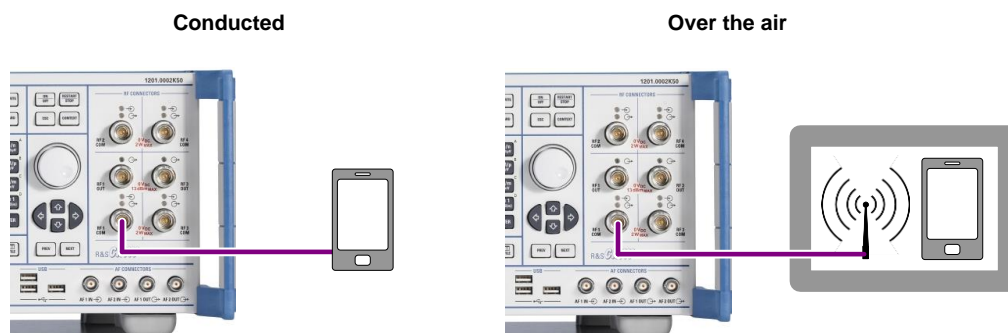


Figure 3: Test setups

The “Conducted” test setup is the easiest and preferred solution since it avoids power loss by over-the-air radio transmission.

In case of testing over-the-air via antennas, it is recommended to encapsulate the DUT and the RF antenna for the R&S CMW in an RF shielding box. Thereby interference from any WLAN access point and other devices using WLAN or Bluetooth is avoided. The over-the-air RF connection causes a power loss of 15 dB or more compared to the conducted RF connection. The path loss without RF shielding box would be much higher (typically about 30 to 39 dB compared to the conducted RF connection).



Figure 4: R&S CMW-Z10 RF shielding box

Notes on using the R&S CMW-Z10 RF shielding box:

- Position the DUT at the center of the box.
- A small displacement of the DUT in the RF shielding box can result in an additional external attenuation of about 10 dB.
- The optimum position of the DUT depends on its antenna arrangement. So try out several DUT positions around the center of the box.
- Close the RF shielding box cover in order to ensure that no interference by other WLAN devices operating in the same channel can occur.

The test setups are valid for all operating modes described in the table.

Mode of the R&S CMW	Mode of the DUT
Access Point (AP) mode The R&S CMW operates as WLAN access point that allows to perform tests on an associated WLAN station	Station (STA) mode
Station (STA) mode The R&S CMW operates as WLAN station that allows to associate with and to perform tests on a WLAN access point.	Access Point (AP) mode
IBSS mode (= STA in IBSS mode) Allows WLAN stations to communicate directly with each other without the need of a dedicated wireless access point. This type of operation is often referred to as ad hoc network.	Station (STA) in IBSS mode
Hotspot 2.0 / Wi-Fi Direct mode The R&S CMW simulates a Wi-Fi Hotspot 2.0 access point or Wi-Fi direct group owner. Requires R&S CMW-KS660 "WLAN advanced signaling" option.	Station (STA) as Hotspot 2.0 or Wi-Fi Direct client

Table 1: Operating modes

3 Selected Configuration Topics

3.1 Power

The R&S CMW has the following nominal power limits:

- **Maximum nominal transmission power (max. “TX Burst Power”, CMW TX)**
 - -3 dBm at the RF OUT connector
 - -16 dBm at the RF COM connector
- **Minimum nominal reception power (min. “RX Burst Power”, CMW RX)**
 - -50 dBm for BPSK-modulated RF signals
(BPSK is applied for the lowest data rate(s), e.g. 6 and 9 Mbit/s in 802.11a/g)
 - -43 dBm for RF signals with higher modulation (QPSK, 16-QAM, ...)

See the first figure in chapter “Introduction” for relating the modulation to the standard and data rate.

For appropriate power settings, the attenuations on the RF transmission path have to be taken into account. An over-the-air connection via an RF shielding box might introduce an attenuation of about 15 dB or more, for example. Three cases of less power values than expected have to be paid attention to:

- The R&S CMW acting as WLAN access point provides much less power than a real WLAN access point (with around 20 dBm). So take care that the attenuations between R&S CMW and DUT are not too high (use a wire connection if possible) and that the DUT is configured to receive in the right power range.
- The DUT acting as station might send with too low power in case of high attenuations and modulation modes, leading to a signal strength at the R&S CMW receiver below its minimum value for accurate signal analysis.
- The expected peak envelope power, which has to be configured on the R&S CMW, might be set too low if the DUT’s nominal power is accidentally taken for the peak envelope power (see the following considerations).

Parameters

The default settings of the R&S CMW are sufficient for a successful WLAN association in many cases. Depending on your DUT and the test conditions, the following parameters of the WLAN Signaling application may need further attention.

- **Expected Peak Envelope Power / RX Expected PEP (CMW RX)**
Set this parameter to the maximum (not average!) DUT transmit power in dBm. Often, only the DUT’s nominal or average power is known. In this case, you have to add the crest factor of 13 dB for WLAN to get the DUT’s maximum transmit power.
Typical values:
 - 25 to 35 dBm (i.e. 12 to 23 dBm + 13 dB crest factor) for a conducted RF connection
 - 0 to 15 dBm for over-the-air (with RF shielding box) depending on the radio distance

The expected peak envelope power value is the maximum power level which the R&S CMW processes. An expected peak envelope power below the actual RF input power causes an over-flow in the input path. A value too much above the RF input power can reduce the measurement accuracy.

- **TX Burst Power (CMW TX)**
CMW in Station mode: Make sure that this power is sufficiently high for the DUT to detect the transmitted signal from the R&S CMW. Typical values:
 - -40 dBm for an RF conducted connection
 - -16 to -20 dBm for over-the-air transmission (with RF shielding box)
- **External Attenuation (for RF Output and RF Input)**
These parameters are used to compensate the cable loss and splitter/combiner loss (if available). The external attenuation is always positive. If you test over-the-air (with RF shielding box) and you want to compensate the over-the-air path loss via the external attenuation, then add 15 dB to the external attenuations and simultaneously set the Expected Peak Envelope Power to 20-30 dBm and the TX Burst Power to -40 dBm.

3.2 Standard, Frequencies

Parameters

- **Standard**
Make sure that the DUT supports the selected WLAN standard.
CMW in Station mode: The configured standard must be compatible with the beacon format of the DUT (acting as AP).
- **Frequency**
Make sure that the configured WLAN frequency / channel is within the frequency band(s) supported by the DUT. The standard and frequency parameters are independent at the R&S CMW: There is no automatic restriction of the frequency band with respect to the selected standard. Some DUTs will not associate if the standard and frequency do not match.

Frequency Band	Carrier Frequencies	Channels	Standards
2.4 GHz	2412 MHz to 2484 MHz	1 to 14	11b, 11g, 11g/n
5 GHz	5000 MHz to 6000 MHz	36 to 200	11a, 11a/n

Table 2: Frequency bands and standards

CMW in Station mode: The configured WLAN frequency / channel must be the same as the one selected by the DUT (acting as AP). In the current implementation, the R&S CMW does not scan the supported frequency range.

3.3 Advanced

Parameters

- **Supported Rates**

"Supported Rates" defines the data rate(s) which the R&S CMW supports and consequently which the DUT is allowed to use.

Generally, you can use the default setting ("Supported Rates > User Defined" is deactivated) which sets the supported rates according to the selected WLAN standard.

Activate "Supported Rates > User Defined" only if you want to test the DUT with special supported rates. In case you have activated "... > User Defined", take the following considerations into account:

CMW as access point (AP): According to the 802.11 standard, the DUT shall avoid associating with an access point if it cannot receive and transmit at all mandatory data rates. This implies two reasonable configuration methods at the R&S CMW: The first one sets the basic (lowest) data rate and the desired DUT transmission rate to mandatory for the selected standard (not more rates in order to avoid that the DUT might change its transmission rate during a test). The second method sets the data rates from the lowest to the desired DUT transmission rate to mandatory.

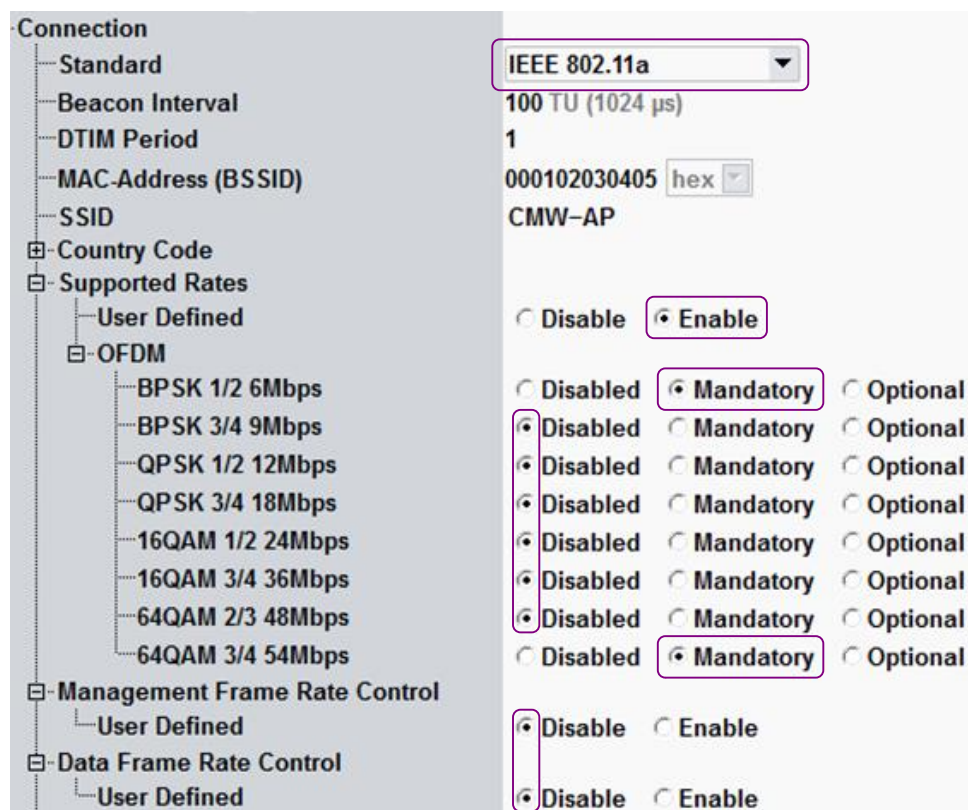


Figure 5: WLAN standard and two user defined supported rates

CMW in Station mode: If the R&S CMW does not include all mandatory rates which the DUT uses for its beacons, the DUT rejects the R&S CMW's association request. Typically, the mandatory rates for a DUT in AP mode are 1, 2, 5.5, 11 Mbit/s in the 2.4 GHz frequency band and 6, 12 and 24 Mbit/s in the 5 GHz frequency band. It is recommended to set these rates as mandatory at the R&S CMW.

If you change the supported rate, you have to disconnect (“Disconnect” hot-key) and associate the DUT again in order to prompt the DUT to get the new setting.

Only needed for the R&S CMW in station mode:

- **Connection Mode and SSID Connection**
Usually, you can keep the default values.



Figure 6: Connection Mode and SSID Connection

4 Procedures

4.1 Connection Setup with the R&S CMW as AP

The parameters to be configured are located in the WLAN Signaling application.

Starting steps:

1. Reset the R&S CMW to ensure a definite instrument state.
2. Open the configuration dialog of the WLAN Signaling application via the "Config ..." key in the bottom right corner.
3. Make sure the "Scenario" is set to "Standard Cell".
4. Set the "Operation Mode" to "AP".

RF Settings:

5. Select a bidirectional RF connector, for example:
 - At "RF Output > Routing": "Connector: RF1COM"
 - At "RF Input > Routing": "Connector: RF1COM"

You can keep the default "Converter" values.

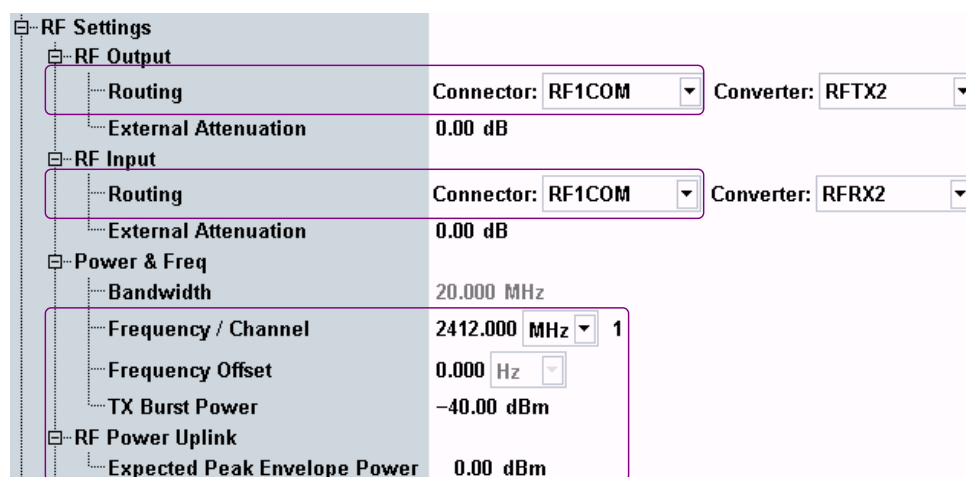


Figure 7: RF settings

6. If necessary, also adjust the "External Attenuation" (to compensate a cable loss).
7. Adjust the R&S CMW's RF output power and the used frequency/channel:
 - Set "Frequency / Channel" according to your needs (must be supported by the DUT).
 - Set the "TX Burst Power" according to your test setup: e.g. -40.00 dBm
 The "Bandwidth" is fixed to 20.000 MHz.
8. Set the "Expected Peak Envelope Power" according to the DUT's peak transmission power: e.g. 30.00 dBm. *Notes:*
 - The peak envelope power is about 13 dB (crest factor) above the expected average power. If the DUT's TX power is given as average value, then add this 13 dB to get the expected peak envelope power.
 - An over-the-air (with RF shielding box) RF connection between DUT and R&S CMW reduces the expected peak envelope power by about 15 dB compared to the RF conducted connection.

Connection:

9. Select the "Standard".
The selected standard must be supported by the DUT and must be consistent with the "Frequency / Channel" selected under "RF Settings" (no automatic control).
10. The default values for "Beacon Interval", "MAC-Address", "SSID" and the other parameters in the "Connection" section can be kept.

Final steps:

11. Connect your DUT to the R&S CMW. Use the RF connectors as set in the "RF Settings".
12. Switch on the WLAN Signaling application.
The R&S CMW transmits beacons.
13. On the DUT, turn on WLAN.
The DUT searches for an access point and initiates the connection to it.
14. Observe the "Connection Status" panel in the main view and wait until the DUT has entered the "Associated" state.

**Figure 8: Connection state: Associated**

Depending on the DUT it may take a few seconds until the authentication and association procedures have finished.

After the DUT has completed its association, the "UE Capabilities" are displayed on the left side of the main view.

UE Capabilities	
MAC Address	78F5FD6E69A2
MAC Version	0
RX Burst Power	-16 dBm
UE IP Address V4	172.22.1.100
UE IPV6 Prefix[0]	fc01:abab:cdcd:efe0::

Figure 9: UE capabilities**Checks in Case of Failed Association**

- The "TX Burst Power" must be sufficiently high so that the DUT can receive the transmitted signal.
- The "Expected Peak Envelope Power" must be in accordance with the received maximum (not average) signal power.
- Make sure that the configured WLAN channel is within the frequency band(s) supported by the DUT.
- Make sure that the DUT supports the selected WLAN standard.

4.2 Determining the Expected Peak Envelope Power

Starting situation:

The R&S CMW has been configured as WLAN access point and the DUT is associated with the R&S CMW.

Proceed as follows:

1. In the WLAN Signaling view look for the “RX Burst Power” value in the “DUT / UE Capabilities” section on the left side.

DUT / UE Capabilities	
MAC Address	B05CE54CF470
MAC Version	0
RX Burst Power	14dBm
UE IP Address V4	172.22.1.100
UE IPV6 Prefix[0]	fc01:abab:cdcd:efe0::

Figure 10: DUT / UE capabilities

2. In the “Common Settings” section on the right side, adjust the “RX Expected PEP” such that the “Approximate RX Burst Power” gets the same value as the “RX Burst Power” value in the “DUT / UE Capabilities” section.

Common Settings	
Frequency / Channel	2412.000 MHz
TX Burst Power	-40.0 dBm
RX Expected PEP	27.0 dBm
Approximate RX Burst Power	14.0 dBm

Figure 11: DUT / UE capabilities

4.3 Connection Setup with the R&S CMW as Station

This procedure is similar to the one where the R&S CMW acts as access point. So, only the deviating configurations are described here.

- Set the “Operation Mode” to “Station”.
- Make sure that the “Frequency / Channel” at the R&S CMW is the same as the one selected at the DUT (acting as access point).
- Make sure that the “TX Burst Power” is sufficiently high for the DUT to detect the signal.
- In the “Connection” section, enable “Auto Connect” at “Connection Mode”. Enable “Any” at “SSID Connection”.

Connection	
Connection Mode	<input checked="" type="radio"/> Auto Connect <input type="radio"/> Manual
SSID Connection	<input checked="" type="radio"/> Any <input type="radio"/> SSID

Figure 12: Additional connection parameters for the R&S CMW in station mode

5 Required Options

- R&S CMW-KS650, "WLAN IEEE 802.11a/b/g basic signaling"
providing basic signaling functionality according to the IEEE standards 802.11a, 802.11b, 802.11g and 802.11g(OFDM)
- R&S CMW-KS651, "WLAN IEEE 802.11n basic signaling"
providing basic signaling functionality according to the IEEE standards 802.11a/n, 802.11g/n, 802.11g(OFDM)/n and 802.11n, 20 MHz SISO