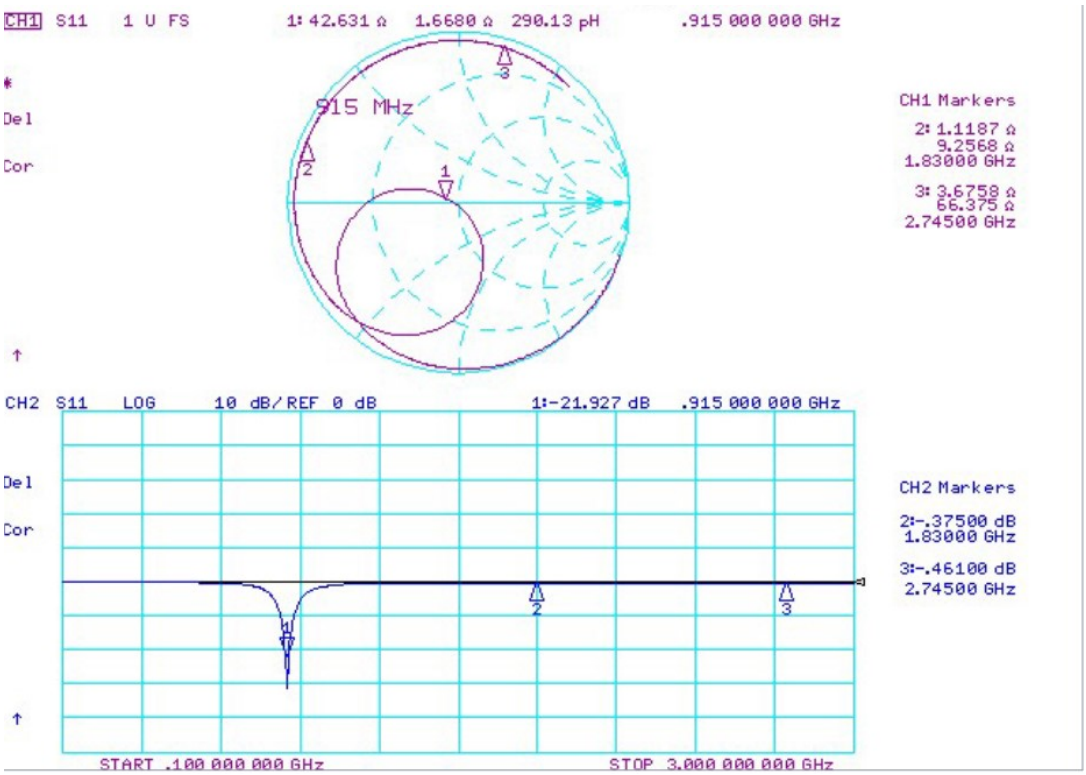
RF Technical Specification Sheet

Product Name：800s Z-Wave Light bulb　　Model：_

1. Power input rating：☒ AC 120 V, 60 Hz
2. Frequency Band：U.H.F
   Carrier Frequency:908.4/908.42/916MHz
3. Number of Channel：3
4. RF Output Power (ERP or EIRP) ：0 dBm = 1m W
5. Modulation Type：FSK ,GFSK
6. Mode of operation (duplex, simplex, half duplex) ：Half duplex
7. Bit Rate of Transmission：9.6/40/100Kbps
8. Antenna Type：PCB antenna
9. Antenna gain：- 3.6 dBi (max)
10. The antenna adopts the Monopole antenna, the center frequency is 915Mhz, and the matching line meets the 908~916Mhz band signal receiving transmitting signal. Antenna requirements S11 less than or equal to -10dB.



8. Small Sized Printed ILA Antenna (WES0118-01-APL915S-01)

The Small Sized Printed ILA antenna has the following characteristics:

- The distance between the antenna trace outer edge and the PCB cutting edge is 1.5 mm.
- The size of the separated PCB antenna area is 10x10 mm.
- An external matching network (shown in Figure 107) is required at the antenna input.

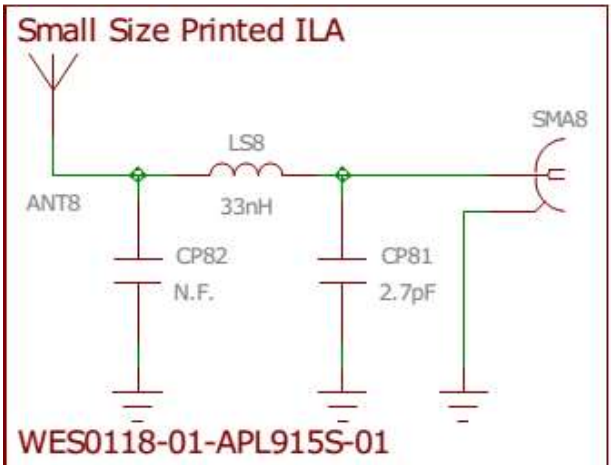


Figure 107. External Antenna Matching Network at 915 M for the Small ILA Antenna

The antenna is shown in Figure 108.

Figure 108. Small Sized Printed ILA Antenna

8.1. Antenna Impedance (WES0118-01-APL915S-01)

The impedance measurement setup is shown in Figure 109. The antenna board is connected to the 4460-PCE10D915 Pico Board through a male-to-male SMA transition with the WMB-930 Wireless Motherboard driving the Pico Board.

During the impedance tuning and range test, the user's hand holds the motherboard. A typical hand position is shown in Figure 110.

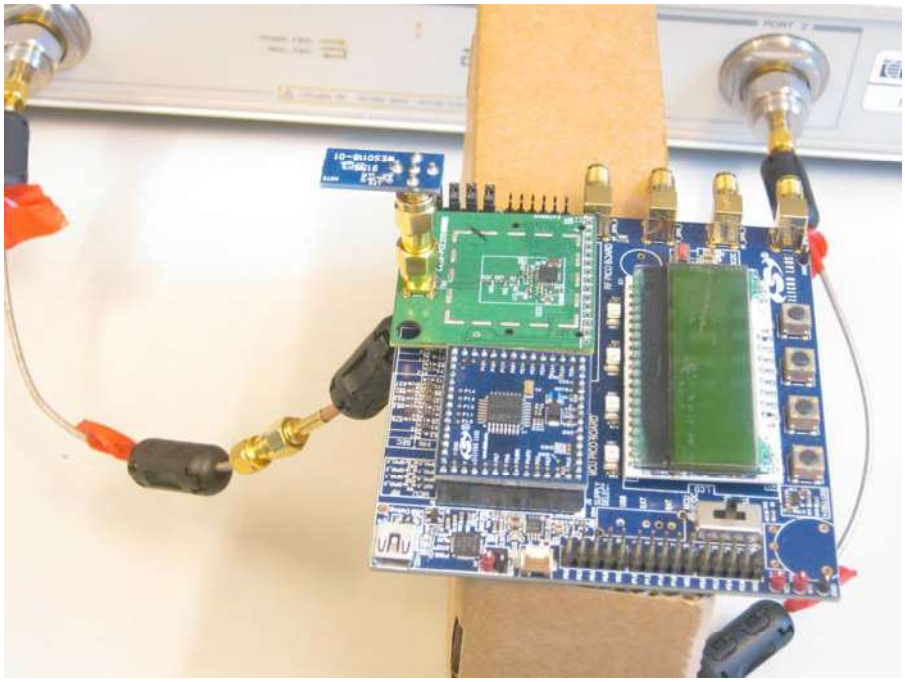


Figure 109. DUT (WES0118-01-APL915S-01) in the Impedance Measurement Setup

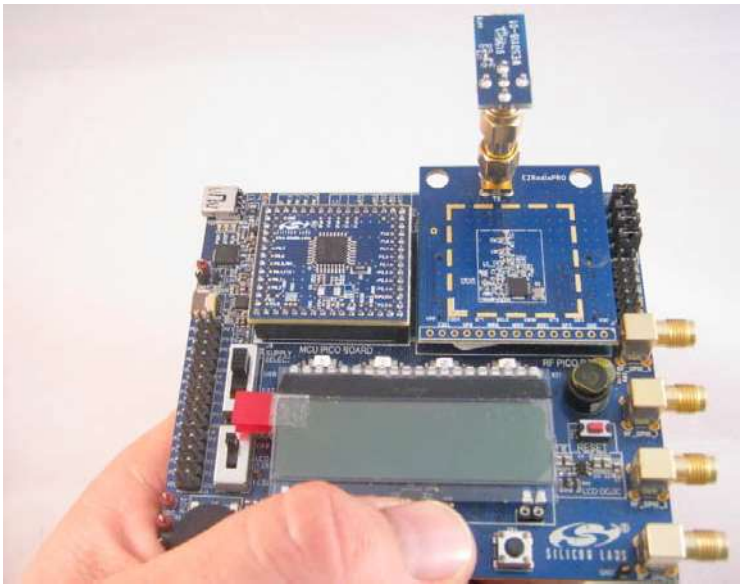


Figure 110. Typical Hand Effect on the Main Board During Impedance and Range Measurement (Small Sized Printed ILA Antenna Board)

The measured impedance of the antenna with its external matching network is shown in Figure 111 (up to 3 GHz) with motherboard hand effect.

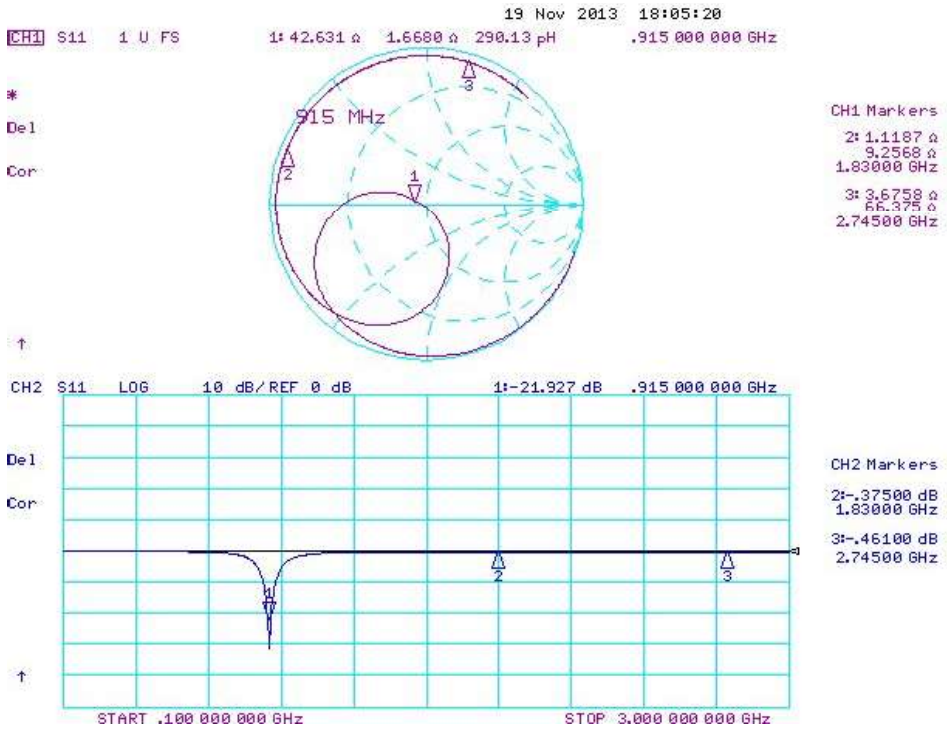


Figure 111. Measured Impedance (up to 3 GHz) with Hand Effect on the Main Board

8.2. Antenna Gain (WES0118-01-APL915S-01)

The antenna gain is calculated from the measured radiated power at the fundamental and from the delivered power to the antenna. In the radiation measurement, the 4463-PCE20C915 Pico Board is set to reduced (~+10.2 dBm) power state (0x1C) and the entire setup is fed by two AA batteries (V_{DD} is set to 2.6 V). The conducted SA measurement result of the 4463-PCE20C915 Pico Board in this reduced (~10 dBm) power state is shown in Figure 112. This method can be effectively applied because the S11 of the antenna is much better than –10 dB so the reflection is negligible.

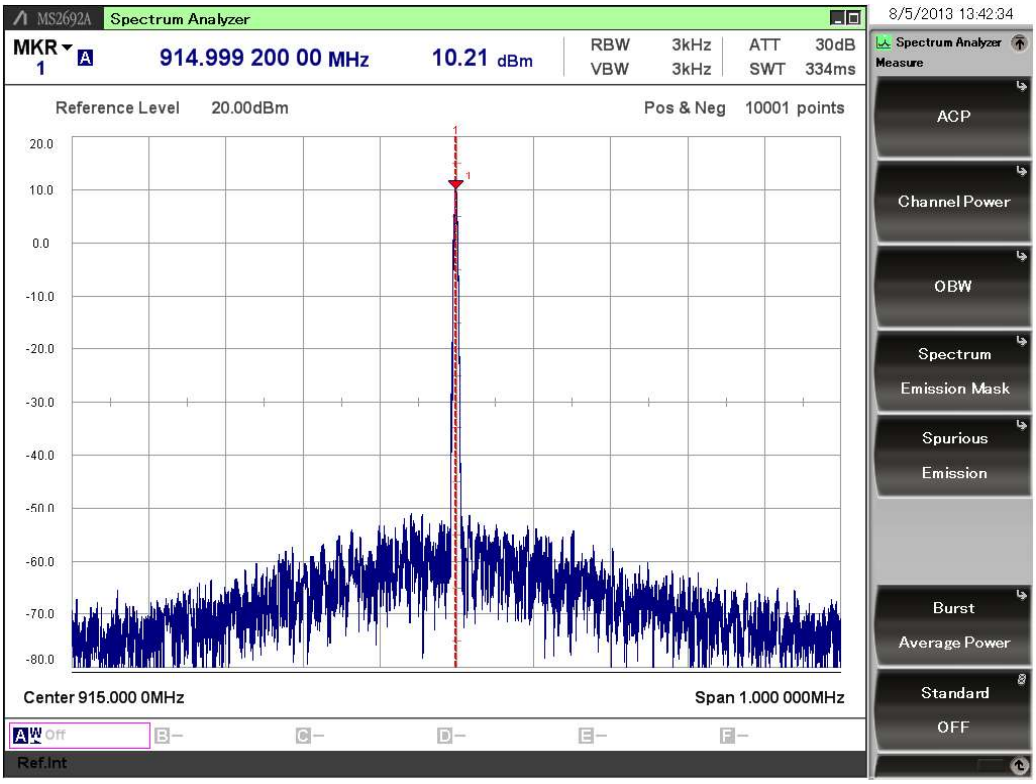


Figure 112. Conducted Measurement Result, 4463-PCE20C915 in a Reduced (~10 dBm) Power State

The measured radiated power maximum is at the XZ cut (Table 9). It is around +6.6 dBm EIRP, so the maximum gain number is ~–3.6 dBi, as shown in Figure 116.

This gain number is surprisingly high for such a small antenna. It should be emphasized that in typical, small remote applications, the grounding environment and the strength of the hand effect is different. Without the SMA connector, the SMA male-male transition, the Pico Board, and the wireless motherboard, the achievable antenna gain is much weaker.

8.3. Radiation Patterns (WES0118-01-APL915S-01)

The radiation patterns of the small sized printed ILA antenna were measured in an antenna chamber using the 4463-PCE20C915 Pico Board connected through a male-to-male SMA transition with the WMB-930 Wireless Motherboard driving the Pico Board. Figure 114—Figure 119 show the radiation patterns at the fundamental frequency in the XY, XZ, and YZ cut, with both horizontal and vertical receiver antenna polarization. The rotator was stepped in five degrees to record the radiation pattern in 360 degrees.

The DUT with coordinate system under the radiated measurements is shown in Figure 113. Rotation starts from the X-axe in the XY cut, and from the Z-axe in the XZ and YZ cuts.

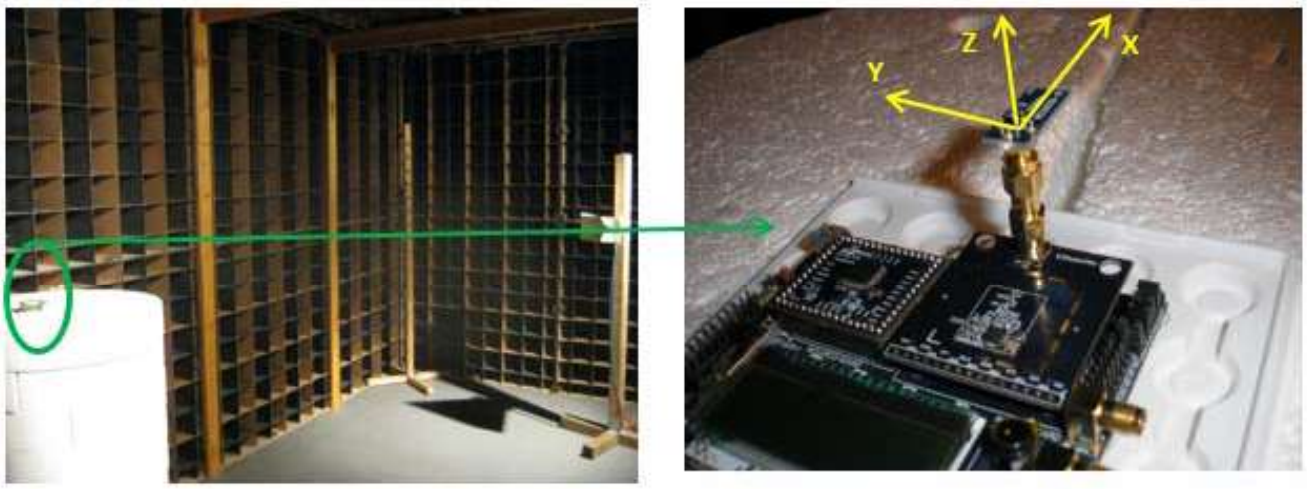


Figure 113. DUT in the Antenna Chamber

The measured radiation patterns (antenna gain in dBi) are shown in the following six figures (Figure 114–Figure 119).

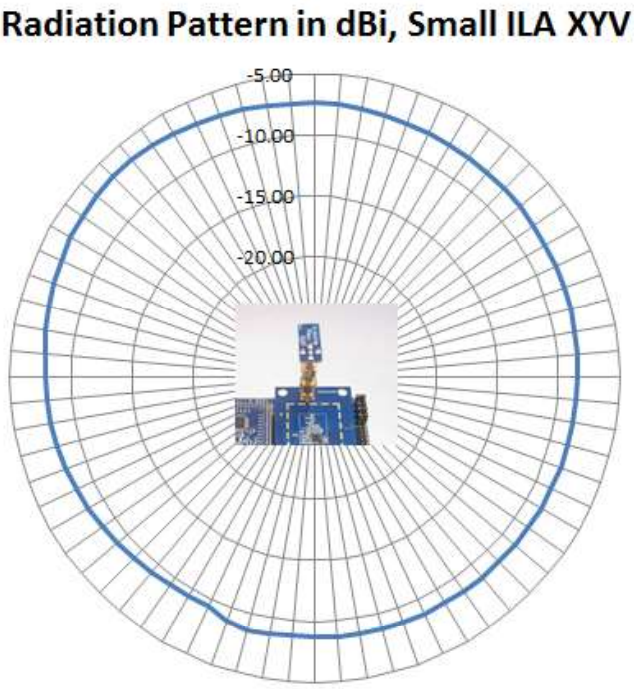


Figure 114. Radiation Pattern in the XY Cut with Vertical Receiver Antenna Polarization

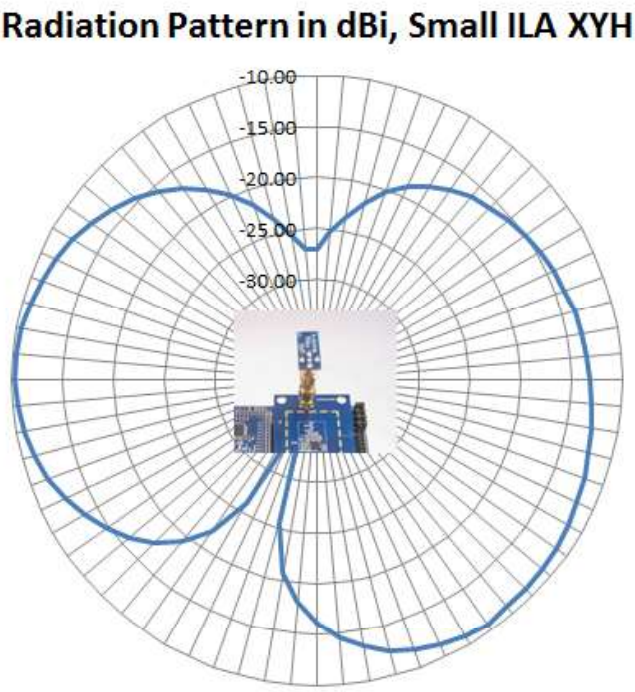


Figure 115. Radiation Pattern in the XY Cut with Horizontal Receiver Antenna Polarization

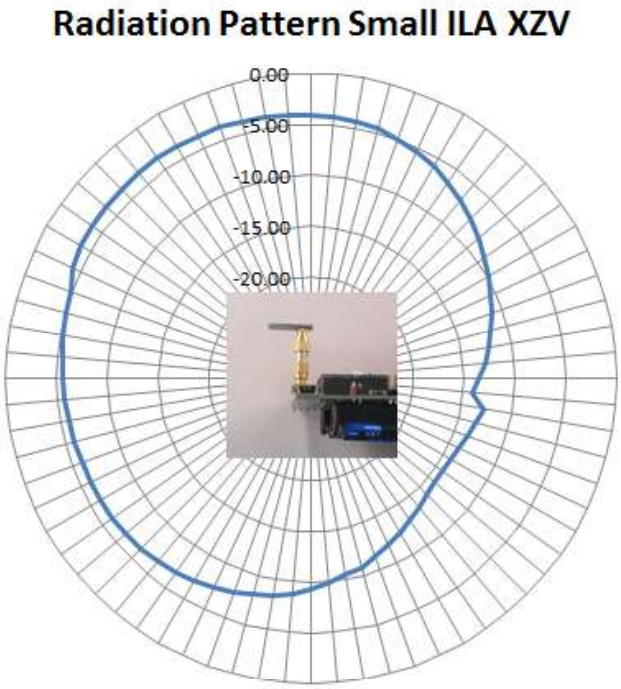


Figure 116. Radiation Pattern in the XZ Cut with Vertical Receiver Antenna Polarization

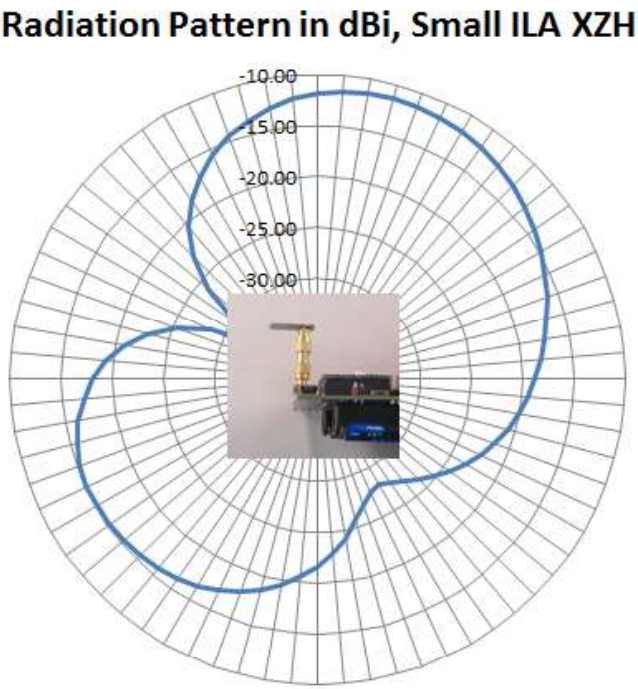


Figure 117. Radiation Pattern in the XZ Cut with Horizontal Receiver Antenna Polarization

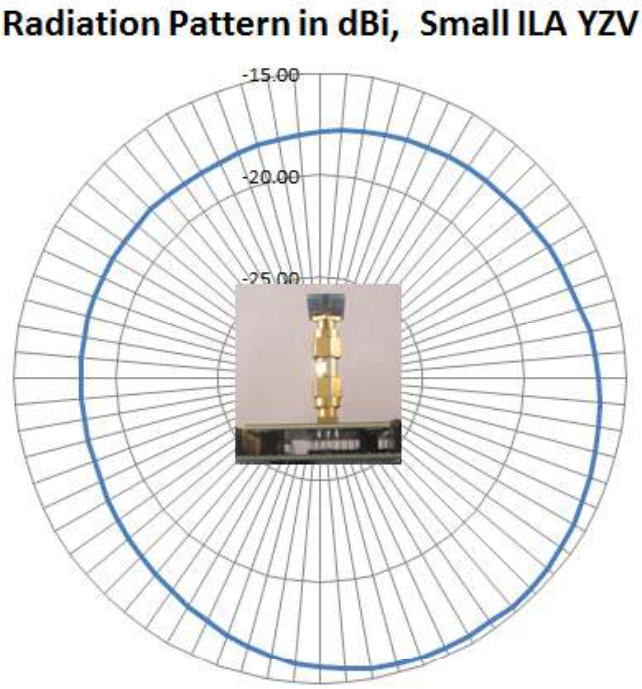


Figure 118. Radiation Pattern in the YZ Cut with Vertical Receiver Antenna Polarization

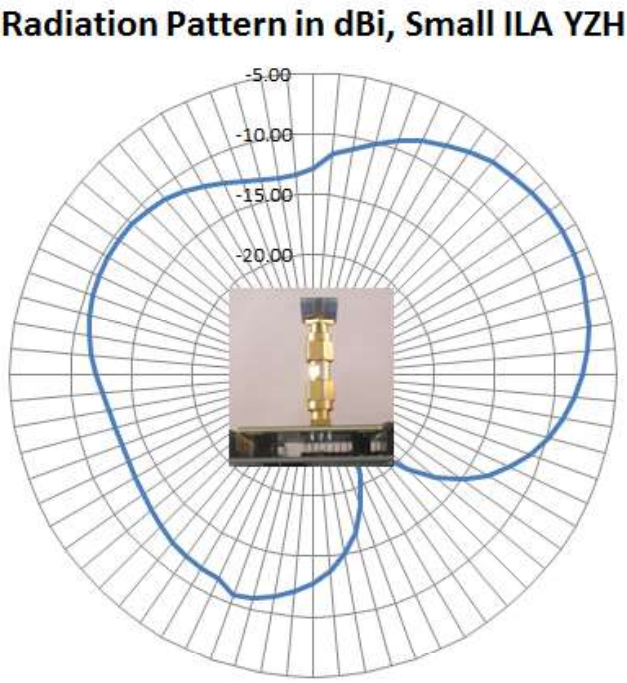


Figure 119. Radiation Pattern in the YZ Cut with Horizontal Receiver Antenna Polarization

8.4. Radiated Harmonics (WES0118-01-APL915S-01)

The radiated harmonics of the small sized printed ILA antenna were also measured in an antenna chamber, using the 4463-PCE20C915 Pico Board connected through a male-to-male SMA transition with the WMB-930 Wireless Motherboard driving the Pico Board working in a reduced power (~+10.2 dBm) state (0x1C, V_{DD} is 2.6 V). The maximum radiated power levels up to the 10th harmonic were measured in the XY, XZ, and YZ cut, with both horizontal and vertical polarized receiver antenna. The results are shown in the following EIRP table (Table 9) with the corresponding standard limits.

The small sized ILA antenna driven by the Si4463 class E match in reduced (~10 dBm) power state complies with the FCC harmonic regulations with margin.

Table 9. Radiated Harmonics, Small ILA Antenna Board Connected to the Reduced Power (~10 dBm) 4463-PCE20C915, and Driven by the WMB-930 Wireless Motherboard

Cut.	Pol.	Freq.	f [MHz]	FCC (15.247) limit in EIRP [dBm]	Measured Radiated Power in EIRP [dBm]	Margin [dB]
XY	V	Fund.	915	30.00	3.58	26.4
XY	V	2nd	1830	–15.31	–53.92	40.5
XY	V	3rd	2745	–41.25	–51.26	10.0
XY	V	4th	3660	–41.25	–50.89	9.6
XY	V	5th	4575	–41.25	–60.54	19.3
XY	V	6th	5490	–15.31	–58.60	45.2
XY	V	7th	6405	–15.31	–56.51	43.1
XY	V	8th	7320	–41.25	–56.87	15.6
XY	V	9th	8235	–41.25	–52.18	10.9
XY	V	10th	9150	–41.25	–52.11	10.9
XY	H	Fund.	915	30.00	–0.09	30.1
XY	H	2nd	1830	–15.31	–56.52	43.1
XY	H	3rd	2745	–41.25	–49.66	8.4
XY	H	4th	3660	–41.25	–51.03	9.8
XY	H	5th	4575	–41.25	–61.59	20.3
XY	H	6th	5490	–15.31	–59.18	45.7
XY	H	7th	6405	–15.31	–57.84	44.4
XY	H	8th	7320	–41.25	–57.64	16.4
XY	H	9th	8235	–41.25	–55.02	13.8

Table 9. Radiated Harmonics, Small ILA Antenna Board Connected to the Reduced Power (~10 dBm) 4463-PCE20C915, and Driven by the WMB-930 Wireless Motherboard (Continued)

Cut.	Pol.	Freq.	f [MHz]	FCC (15.247) limit in EIRP [dBm]	Measured Radiated Power in EIRP [dBm]	Margin [dB]
XY	H	10th	9150	–41.25	–52.59	11.3
XZ	V	Fund.	915	30.00	6.57	23.4
XZ	V	2nd	1830	–15.31	–57.45	44.0
XZ	V	3rd	2745	–41.25	–50.56	9.3
XZ	V	4th	3660	–41.25	–53.31	12.1
XZ	V	5th	4575	–41.25	–60.77	19.5
XZ	V	6th	5490	–15.31	–59.32	45.9
XZ	V	7th	6405	–15.31	–58.91	45.5
XZ	V	8th	7320	–41.25	–57.37	16.1
XZ	V	9th	8235	–41.25	–54.62	13.4
XZ	V	10th	9150	–41.25	–52.34	11.1
XZ	H	Fund.	915	30.00	–1.24	31.2
XZ	H	2nd	1830	–15.31	–54.95	41.5
XZ	H	3rd	2745	–41.25	–53.18	11.9
XZ	H	4th	3660	–41.25	–47.76	6.5
XZ	H	5th	4575	–41.25	–61.11	19.9
XZ	H	6th	5490	–15.31	–59.39	46.0
XZ	H	7th	6405	–15.31	–57.31	43.9
XZ	H	8th	7320	–41.25	–56.79	15.5
XZ	H	9th	8235	–41.25	–53.28	12.0
XZ	H	10th	9150	–41.25	–51.96	10.7
YZ	V	Fund.	915	30.00	–5.06	35.1
YZ	V	2nd	1830	–15.31	–58.88	45.5
YZ	V	3rd	2745	–41.25	–49.38	8.1

Table 9. Radiated Harmonics, Small ILA Antenna Board Connected to the Reduced Power (~10 dBm) 4463-PCE20C915, and Driven by the WMB-930 Wireless Motherboard (Continued)

Cut.	Pol.	Freq.	f [MHz]	FCC (15.247) limit in EIRP [dBm]	Measured Radiated Power in EIRP [dBm]	Margin [dB]
YZ	V	4th	3660	–41.25	–53.07	11.8
YZ	V	5th	4575	–41.25	–59.65	18.4
YZ	V	6th	5490	–15.31	–59.26	45.8
YZ	V	7th	6405	–15.31	–58.29	44.9
YZ	V	8th	7320	–41.25	–56.94	15.7
YZ	V	9th	8235	–41.25	–53.07	11.8
YZ	V	10th	9150	–41.25	–51.85	10.6
YZ	H	Fund.	915	30.00	4.02	26.0
YZ	H	2nd	1830	–15.31	–54.48	41.1
YZ	H	3rd	2745	–41.25	–49.36	8.1
YZ	H	4th	3660	–41.25	–49.66	8.4
YZ	H	5th	4575	–41.25	–59.97	18.7
YZ	H	6th	5490	–15.31	–58.82	45.4
YZ	H	7th	6405	–15.31	–56.43	43.0
YZ	H	8th	7320	–41.25	–56.45	15.2
YZ	H	9th	8235	–41.25	–51.21	10.0
YZ	H	10th	9150	–41.25	–52.90	11.6

8.5. Range Test (WES0118-01-APL915S-01)

The available range was measured using the Range Test Demo. This application is supplied with the standard development kits for EZRadioPRO®. The target of this measurement is to find the distance between the transceivers where the bidirectional PER (Packet Error Rate, number of lost packets) is not more than 1% at each side with ten byte packet length. The GPS coordinates have been recorded for each spot. The distance between the spots was measured using Google Maps, and results are shown in meters. The range was tested between two identical units with the WMB-930 Wireless Motherboard, 4463-PCE20C915 Pico Board, and the DUT (as shown in Figure 110) held by the users hand. The 4463-PCE20C915 Pico Board worked in a properly reduced power state (either +13 dBm or 0 dBm).

The range was tested in a flat land area without obstacles.

During the range test, the following settings have been used:

- Set 1: Txpow=13 dBm, 50 kbps, 25 kHz dev., RXBW=103.06 kHz (sens ~–106.3 dBm)
- Set 2: Txpow=13 dBm, 100 kbps, 50 kHz dev., RXBW=206.12 kHz (sens ~–103.4 dBm)
- Set 3: Txpow=0 dBm, 1.2 kbps, 1.2 kHz dev., RXBW=7.15 kHz (sens ~–118 dBm)

Using the above settings (Set 1, Set 2, and Set 3) the following range tests are done here:

1. Range measurement with the SMALL SIZE ILA Antenna Boards—The antenna boards are HORIZONTALLY polarized and the X-axes are facing each other (i.e., normal usage position). The applied setting is "Set 1".
2. Range measurement with the SMALL SIZE ILA Antenna Boards—The antenna boards are VERTICALLY polarized and the X-axes are facing each other (i.e., normal usage position). The applied setting is "Set 1".
3. Range measurement with the SMALL SIZE ILA Antenna Boards—The antenna boards are VERTICALLY polarized and the X-axes are facing each other (i.e., normal usage position). The applied setting is "Set 2".
4. Range measurement with the SMALL SIZE ILA Antenna Boards—The antenna boards are VERTICALLY polarized and the X-axes are facing each other (i.e., normal usage position). The applied setting is "Set 3".
5. Range measurement with the SMALL SIZE ILA Antenna Boards—The antenna boards are VERTICALLY polarized and the boards are facing each other in their direction of maximum radiation. The applied setting is "Set 1".
6. Reference range measurement with two 868/915 MHz REFERENCE MONOPOLE (W1063 from Pulse) in VERTICAL polarization using the setting denoted by "Set 1".
7. Reference range measurement with two 868/915 MHz REFERENCE MONOPOLE (W1063 from Pulse) in VERTICAL polarization using the setting denoted by "Set 3".
8. Reference range measurement with a 868/915 MHz REFERENCE MONOPOLE (W1063 from Pulse) in HORIZONTAL polarization using the setting denoted by "Set 1".

The measurement results are summarized in Figure 120.

Note: These range test results are valid with the above configuration and with moderate hand effect. In normal battery-operated, remote applications, where there is no large GND (motherboard) close to the antenna and where the antenna is usually very close to the user's hand, the achievable range is most likely much shorter.

The indoor range test was not performed, due to the lack of a large enough building. But from the TX power and sensitivity data, an indoor range estimation can be given if one assumes a propagation factor of 4.5, which is a typical value in normal office environments. Use the Silicon Labs' range calculator, which can be found here:

http://www.silabs.com/support/pages/document-library.aspx?p=Wireless&f=EZRadioPRO&pn=Si4460

Assuming –7.4 dBi antenna gain (front direction, X-axes facing) and the setting "Set 1" (50 kbps, 1% PER, 13 dBm), the estimated indoor range is 60 m, as shown in Figure 121. If the boards are facing with the direction of maximum radiation, the indoor range increases to 90 m.

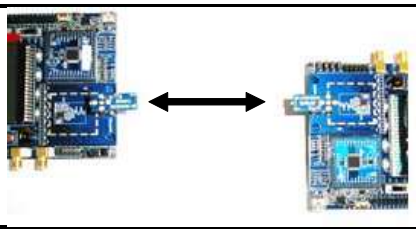
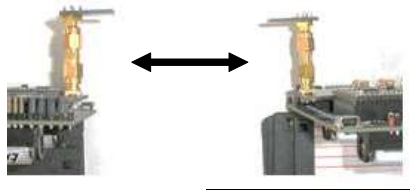
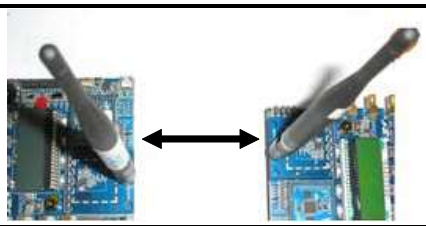
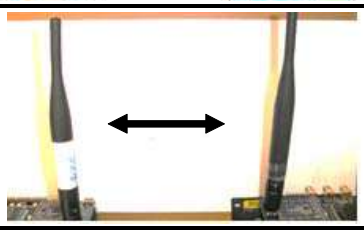
		Set1	13dBm	50kbps	+/-25kHz				
		Set2	13dBm	100kbps	+/-50kHz				
		Set3	0dBm	1.2kbps	+/-1.2kHz		GPS		Distance [m]
							N	E	
	Small Printed ILA				Base		47.152880°	19.180930°	0.0
Small Printed ILA (WES0118)				H pol; Norm. direction					
							GPS		
							N	E	
		1	Set1	13dBm	50kbps	+/-25kHz	47.161860°	19.173600°	1142.0
				V pol; Norm. direction					
							GPS		
							N	E	
		2	Set1	13dBm	50kbps	+/-25kHz	47.161270°	19.173610°	1084.8
		3	Set2	13dBm	100kbps	+/-50kHz	47.159130°	19.174030°	869.0
		4	Set3	0dBm	1.2kbps	+/-1.2kHz	47.160740°	19.173780°	1027.7
				Max. direction w/o hand: XZV 325° //Meas w hand: 240°					
							GPS		
							N	E	
		5	Set1	13dBm	50kbps	+/-25kHz	47.164830°	19.173110°	1454.4
W1063				V pol; Norm. direction					
							GPS		
							N	E	
		6	Set1	13dBm	50kbps	+/-25kHz	47.174060°	19.171540°	2459.8
		7	Set3	0dBm	1.2kbps	+/-1.2kHz	47.171470°	19.17201	2174.3
				H pol; Norm. direction					
							GPS		
							N	E	
		8	Set1	13dBm	50kbps	+/-25kHz	47.176200°	19.171200°	2695.4

Figure 120. Outdoor Range Test Result with Two Identical Small Sized Printed ILA Antennas with the 4463-PCE20C915 Pico Board Working in a Reduced Power (~10.2 dBm) State Driven by the WMB-930 Wireless Motherboard

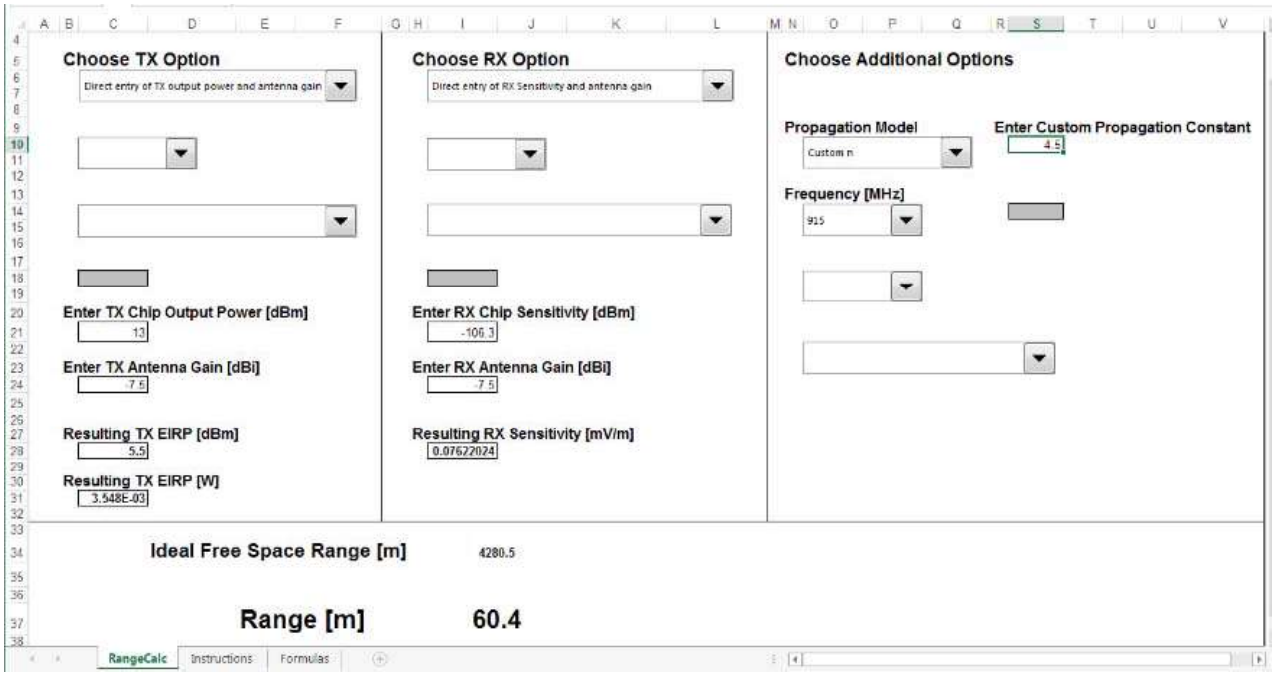


Figure 121. Indoor Range Estimation with Two Identical Small Sized Printed ILA Antennas and with the 4461-PCE14D915 Pico Board Working in a Reduced (~+13 dBm) Power State Driven by the WMB-930 Wireless Motherboard