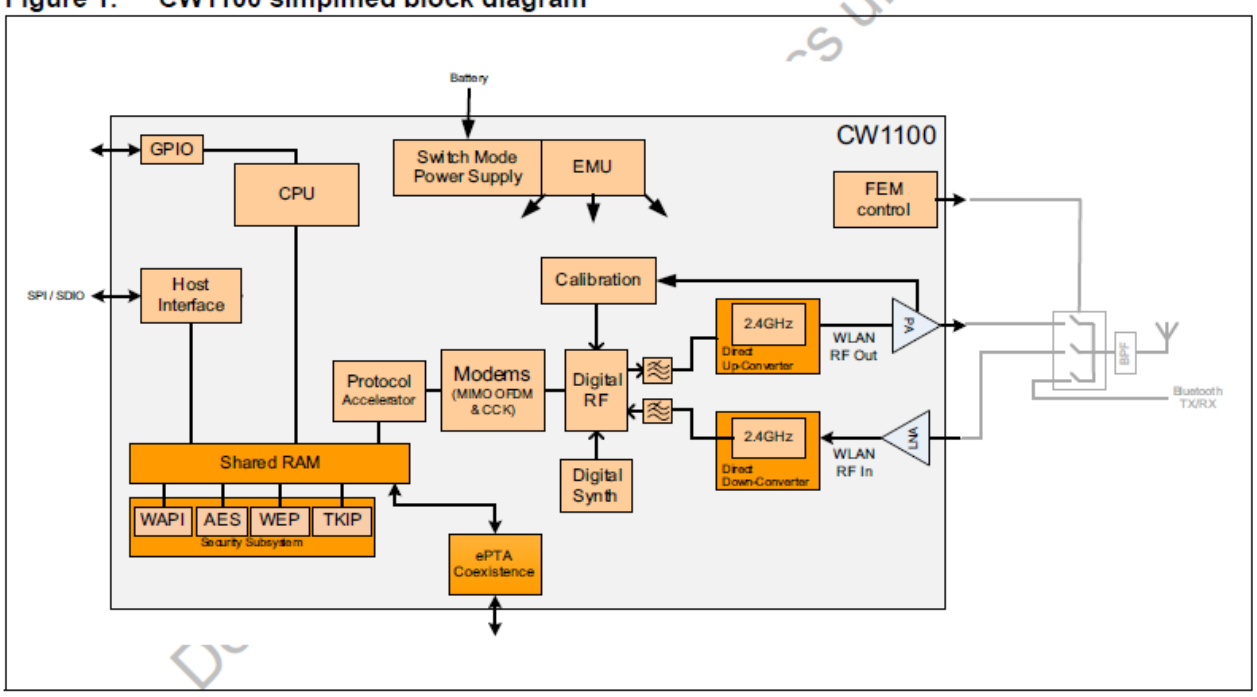
SPWF04SA/C module: some technical note about the Radio device embedded in the module, displayed in the Module Block Diagram as “CW1100”.

CW1100 Brief Description

The CW1100 is an IEEE 802.11b/g/j/n WLAN single-chip device solution fully optimized for mobile applications such as mobile phones, smart phones, PDAs and portable media players. The extremely low power consumption and intelligent host off loading of beacon as well as the packet processing ensure industry leading battery life. High levels of integration allow for very compact and cost effective reference designs delivering fast time-to-market for new WLAN enabled products. Built on the CW1100 successful predecessors, the STLC4370 and the STLC4560, the CW1100 integrates a power amplifier and switch mode power supply. All RF ports are single ended. CW1100 is an ideal partner for ST-Ericsson CG2900 GPS/BT/FM system on chip. The CW1100 offers proprietary enhanced BT/WLAN coexistence power consumption and shared power supply and clock reducing WGBF BOM costs. A comprehensive suite of software is provided, which includes proven drivers for Symbian/S60, Linux/Android, Windows CE and Windows Mobile along with production test and engineering software utilities.
The CW1100 is a system-on-chip WLAN device packed in Wafer Level Chip Scale Package (WLCSP) of 3.90 mm x 3.84 mm x 0.6 mm with 0.4 mm pitch.

Figure 1. CW1100 simplified block diagram

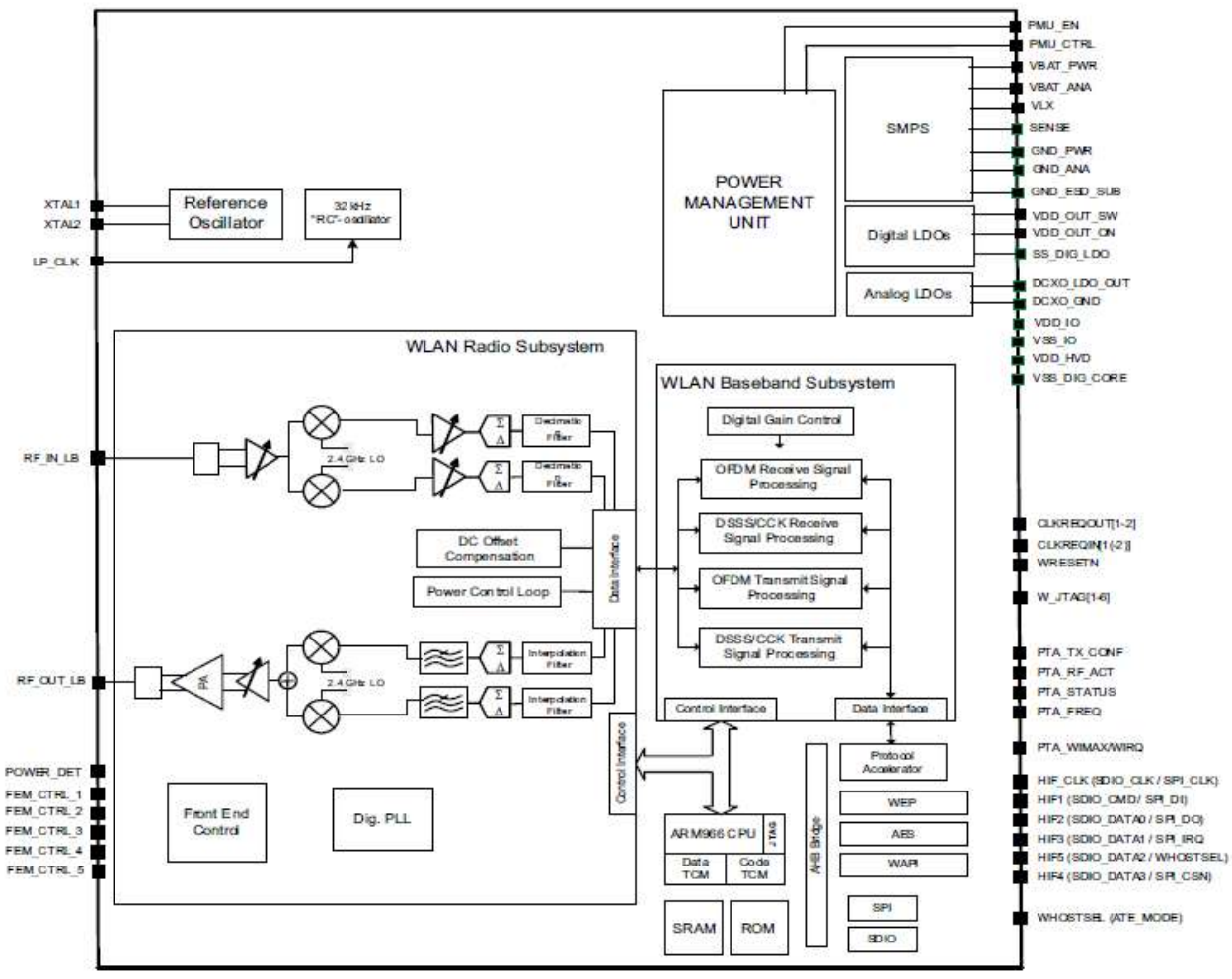


The CW1100 SoC is built on the proven success of integrating previous generation WLAN devices into cellular handsets providing the lowest power consumption, best-in-class BT/WLAN co-existence mechanism in addition to high throughput performance and better range. The CW1100 supports a comprehensive range of 802.11 standards and amendments:
• Enhanced throughput and range through 802.11n support - single stream with support for WiFi 802.11n certification including STBC Rx and STBC control frame optional

features
• 2.4 GHz operation compliant to 802.11g and 802.11b
• QoS support compliant to 802.11e/WMM/WMM-PS standards
• Robust security based on 802.11i/WPA/WPA2 standards
• Regulatory domain operation support based on 802.11d operation
• Radio resource measurements support based on 802.11k standard
• Fast BSS transition support based on 802.11r standard
• Protected management frame support based on 802.11w standard
The CW1100 supports also the CCX version 5.
The WLAN subsystem includes a ZIF transceiver, RF synthesizer/VCO, high-speed data converters, an OFDM/CCK digital baseband processor, a power amplifier, switch mode power supply and an ARM9-based MAC.
A comprehensive single band reference design is provided that includes a switch that combines the TX and RX ports from the WLAN with the RF port from a Bluetooth device onto one 2.4 GHz antenna. A band-pass filter is added between the switch and the antenna depending on the presence of other wireless devices in the same application.

Block diagram

Figure 2. CW1100 complete block diagram



RF inputs and outputs

2.7.1 Electrical characteristics

Table 28. Electrical characteristics of the RF inputs and outputs

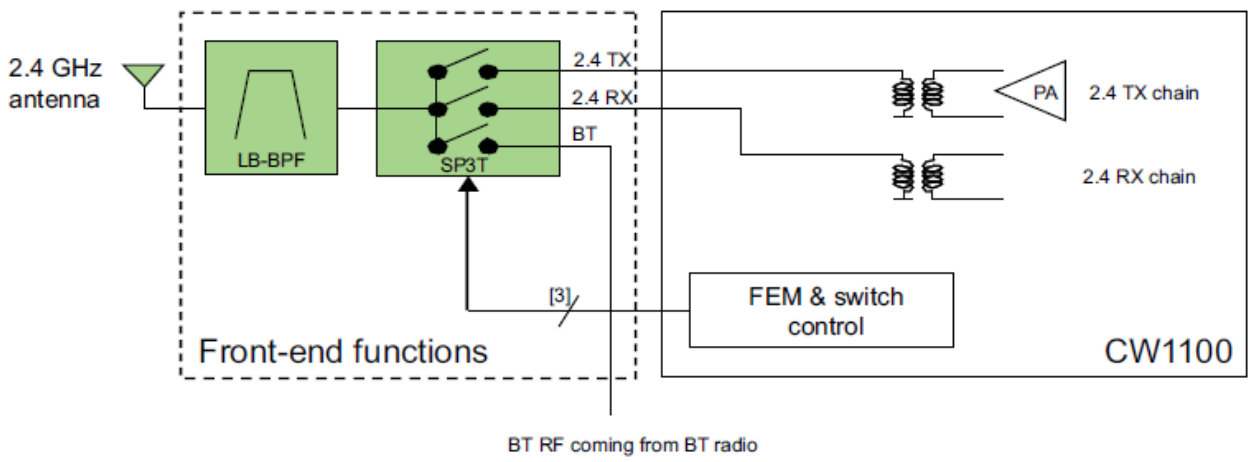
Ball name	Type	ZTyp, ohm(1)	Dedicated frequency range (GHz)
RF_IN_LB	Single-ended	50	2.4 - 2.4835
RF_OUT_LB	Single-ended	50	2.4 - 2.4835

1. This part of the circuit is biased. When unused portions of the circuit are powered down. Impedance may change.

2.7.2 Reference schematic

Figure 14 shows a simplified view of the components to be placed between the RF ports and the antenna. The assumption is made that a Bluetooth device shall share the 2.4 GHz antenna and BPF. For more details on the possible implementations, see the CW1100 Performance and architecture application note.

Figure 14. Schematic of the antenna interface



WLAN functional description

The WLAN subsystem implements the MAC and physical layer functionalities of the 802.11 specification and amendments. The radio is capable of operation in all of the available channels in the 2.4 frequency band.

The WLAN radio is based on a direct conversion architecture with two RF front-ends for operation in 2.4 band and a common analog and digital baseband.

The digital transceiver implements the OFDM (802.11n) and DSSS/CCK (802.11b/g) functions, supporting the following PHY features:

• OFDM:
– Bandwidth: 20 MHz
– Modulations: BPSK, QPSK, 16QAM and 64QAM
– Code rates: ½, 2/3, ¾, 5/6
– Preambles: legacy, greenfield and mixed mode preambles
– Single convolutional encoder
– Reception of 802.11n 2x1 STBC encoded signals for range enhancement
– Reception of 802.11n beam formed and channel sounding packets (support for maximum of two transmitter preambles)
– RIFS of 2 µs (802.11n only)
• DSSS/CCK:
– Modulations: DBPSK, DQPSK, CCK
– Preambles: long and short

Modem receiver

The low and high band signals are demodulated by separate RF front-ends. The radio signal from the balanced 2.4 RF input is amplified by an LNA. The passive receive switching mixers are driven by quadrature LO signals supplied by the on-device RF PLL. The amplified mixer output is fed to a common analog baseband circuit. The analog baseband receiver performs part of the channel filtering and further signal amplification, such that the signal is presented at the correct range of the A/D converter. High speed sigma delta A/D converters are employed for signal sampling. High over-sampling ratio and noise shaping techniques provide high dynamic range, thereby reducing the analog complexity. The rest of the channel filtering and gain amplification is performed in the digital domain. DC compensation is performed partly in the analog and partly in the digital domain. AGC Control, DC tracking and control, quadrature imbalance tracking and control are implemented digitally. The RC time constants for the analog filters are calibrated automatically.
OFDM and DSSS/CCK signals are coherently demodulated and decoded by the digital modem. The digital modem also implements the CCA 802.11k functions to collect the link statistics like RSSI, RPI, IPI and RSNI.

Modem transmitter

The digital modem implements the OFDM and DSSS/CCK modulation for all frame-formats specified for a single layer/transmitter. The OFDM and DSSS/CCK modulated I/Q signals use a common circuit for digital up-sampling, filtering, quadrature imbalance compensation, LO leakage correction and digital power scaling. High speed sigma delta D/A converters are employed for digital to analog conversion reducing the analog complexity. The filtered analog I/Q signals are then up-converted using a modulator. The modulator is driven by the signal from the LO buffer/dividers supplied by the VCO. The up-converted RF signals are further amplified by a digitally controlled amplifier and a 21 dBm power amplifier, eliminating the need for any external amplification between the transceiver and the antenna.
Transmit I/Q calibration is implemented partly in both the analog and digital domains. The transmitter implements automatic level control by averaging the reading of the integrated power detector at the PA output. Both bands share the integrated ADC used to samples the power detector output. The power detector for the low-band is integrated inside CW1100 optimizing the coupling with the integrated PA.

RF PLL

A single RF LC oscillator PLL provides the quadrature LO signals to the up and down converters. A fractional synthesizer design is employed to accommodate different reference frequencies. The loop filter is fully integrated inside the CW1100

WLAN controller

The main components of the WLAN controller are the CPU subsystem, the MAC protocol accelerator subsystem, the encryption/decryption engines, the host interfaces and an enhanced PTA for WLAN/BT coexistence.

IEEE 802.11 standard compliance and support

General support

Support for operation in 802.11n, 802.11b and 802.11g networks, meaning support for basic mandatory MAC features and for the mandatory modes of:
• Clause 15, DSSS PHY (basic 802.11)
• Clause 18, HR/DSSS PHY (802.11b)
• Clause 19, ERP PHY (802.11g)
• Clause 21, HT PHY (802.11n), Compliant to WiFi Handset Profile
Support for operation as a wireless station (STA) in both infrastructure and ad-hoc networks; in particular, the module supports IBSS operation and also implements support for IBSS power save mode.

International regulatory support
Supports the IEEE 802.11d standard amendment for regulatory domain identification.

Radio resource management support
Supports the mandatory aspects introduced in the IEEE 802.11k amendment to the standard.

Security support
Support for basic WEP:
• Key lengths of 40, 104 bits for WEP encryption (IV generation and ICV verification) are supported
• Open and shared key authentication
• Cryptographically weak IVs are avoided
Supports the MAC mandatory aspects of RSNA security including TKIP and AESCCMP and the following optional security features:
• RSNA for IBSS is supported
Supports protected management frames introduced in IEEE 802.11w amendment to the standard:
• CCMP for unicast management frames
• BIP for broadcast/multicast management frames
Supports fast BSS transition in a RSNA introduced in the IEEE 802.11r amendment to the standard.

Quality of service
Supports the EDCA medium access method, four access categories, and TSPEC signalling.

Power saving
Support for basic PSM.
Support for Unscheduled Automatic Power Save Delivery (U-APSD) as defined by WMM-PS.

Fast roaming
Supports fast BSS transition introduced in the IEEE 802.11r amendment to the standard.

802.11n
Supports MAC enhancements for higher throughput as defined in the IEEE 802.11n amendment to the standard.
In addition to the above, the reference driver and associated software implement aspects of RSNA, CCX, 802.11w, 802.11k, Tspec setup and 802.11r not contained in the MAC but necessary to complete the system for reference or demonstration purposes, for example the supplicant necessary for RSNA security.

WiFi alliance interoperability testing
General support
The device when built into a system has sufficient features and performance to be passed by WiFi as an ASD device (Application Specific Device).

International regulatory support
Support for 802.11d.

Security support
Support for WEP, WPA (RSNA using TKIP & MIC), WPA2 (RSNA using CCMP).
The device supports the features that the new formed security marketing task group will define in the next TGw MRD.

Quality of service
Support for WMM (EDCA from 802.11e), WMM-PS (U-APSD from 802.11e, with interface for Tspec negotiation by upper layers).

High throughput

The device supports the mandatory features defined in the TGn MRD for the HH (HandHeld) market segment.

WiFi protected setup

For easy configuration.

CCX™

Note: CCX is a trade mark of Cisco Inc.

General support

The device when built into a system has sufficient features and performance to be passed by Cisco's nominated testing house as a CCX capable device in the category of ASD devices.
Support for CCX version 5, with interoperability with AP's down to CCX version 1.

Interoperability

Compatible with all the applicable features defined by Cisco CCX version 5 specification. CCX standards specify certain features (such as EAP methods) which require support on the host platform OS in which the CW1100 is integrated. CW1100 software provides necessary interfaces in such instances to realize full CCXv5 support for the ASD.

Security support

Support for encryption WEP, RSNA using TKIP & MIC, RSNA using AES-CCMP.
Support for authentication methods (Cisco LEAP, PEAP with EAP-GTC support, CCKM with EAP-FAST) depends on the host platform.

Quality of service

Support for WMM (EDCA from 802.11e), WMM-PS (U-APSD from 802.11e, with interface for Tspec negotiation by upper layers).
Interoperability with pre-standard EDCA, CCX certified equipment is maintained.

Network management

AP-assisted roaming.
Radio environment reporting.
AP-specified maximum transmit power (through support for TPC).

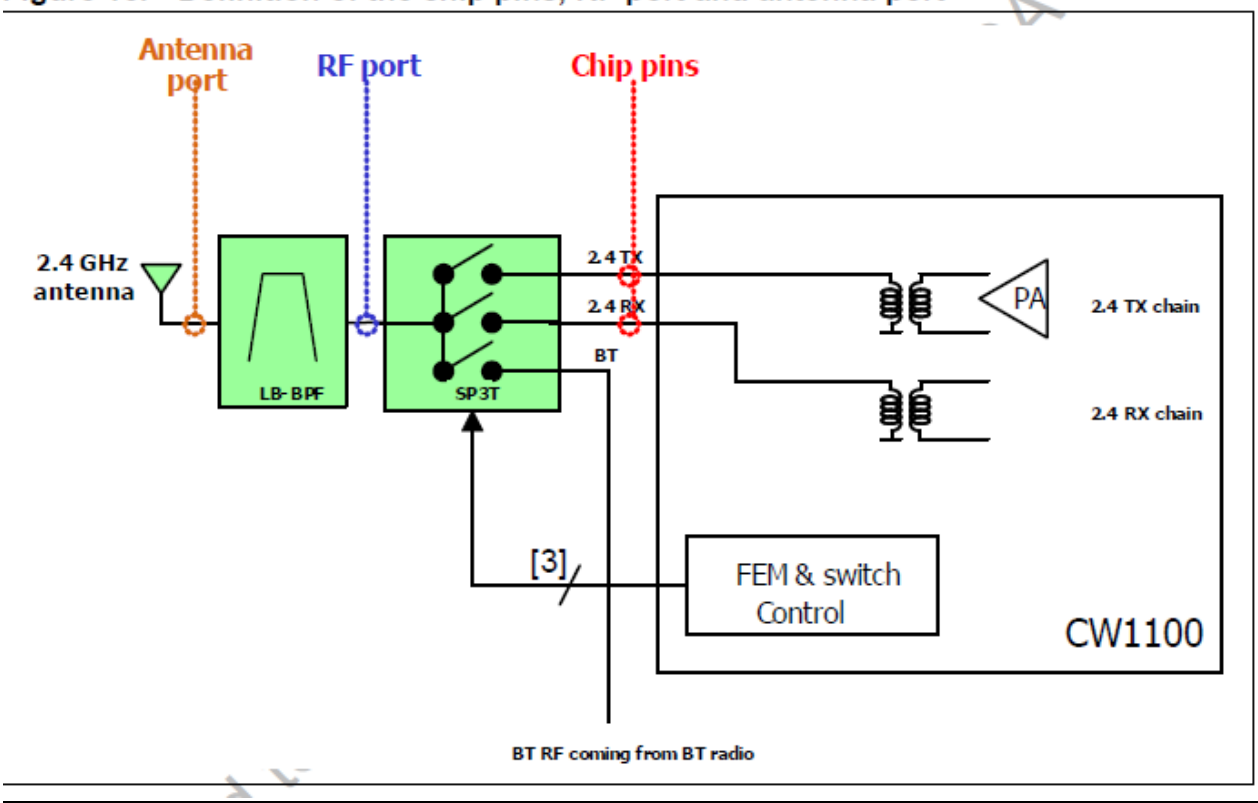
Other features of CCX are dependent on the host platform

Proxy ARP.
Cisco compatible version control.
Interoperability with APs that support multiple SSIDs.

RF transmitter performance

This section specifies the performances of the RF transmitter referred to the input pins of the CW1100 (called chip pins) and gives indications of the performances at the antenna port or the RF port depending on which is the most relevant. This indication is obtained considering an attenuation of 3.5 dB between the antenna port and the chip pins and 0.7dB between the RF port and the chip pins. This corresponds to what is measured on the reference design described in the CW1100 hardware user manual including a switch, a band-pass filter and track losses. The chip pins, RF port, and antenna port are defined in *Figure 15*.

Figure 15. Definition of the chip pins, RF port and antenna port



Output power

The output power is specified as average conducted power at the antenna connector. The output power specifications are met over frequency, temperature and a battery voltage of 3.6 V upwards according to the full spec operating range.
In the full specification with output power backed-off (2.7 V < Vbat < 3.6 V) and the functional with reduced performance (2.3 V < Vbat < 2.7 V) operating ranges. The output power needs to be backed-off to sustain the transmit EVM, spectral mask, harmonic level and spurious emissions specifications.

Power control

The typical value of Pout can be adjusted in software within the limits defined by *Table 44* to *Table 47* and *Table 49*. See the ETF Software Delivery Note for details.

Table 44. Coding rate dependent output power vs. EVM at CW1100 pins for 802.11b/g

Modulation	Coding rate	Conditions	Specification at CW1100 pins				EVM		EVM	
			Min	Typ	Max	Unit	Max	Unit	Max	Unit
DSSS/CCK	--	All conditions typical: Vbat ≥ 3.6 V, 25 C, 50 Ω load; meeting spectral mask, EVM, harmonic levels, spurious emissions and regulatory requirements in general	20	21	-	dBm	-14.5	dB	18.84	%
BPSK	1/2		20	21	-	dBm	-14.5	dB	18.84	%
BPSK	3/4		20	21	-	dBm	-14.5	dB	18.84	%
QPSK	1/2		20	21	-	dBm	-14.5	dB	18.84	%
QPSK	3/4		20	21	-	dBm	-14.5	dB	18.84	%
16QAM	1/2		19.5	20.5	-	dBm	-17.5	dB	13.34	%
16QAM	3/4		18.5	19.5	-	dBm	-20.5	dB	9.44	%
64QAM	2/3		17.5	18.5	-	dBm	-23.5	dB	6.68	%
64QAM	3/4		16.5	17.5	-	dBm	-25.5	dB	5.31	%

Table 47. Coding rate dependent output power vs. EVM at RF port for 802.11n

MCS	Conditions or comments	Indication at RF port(1)				EVM		EVM	
		Min	Typ	Max	Unit	Max	Unit	Max	Unit
MCS-0	All conditions typical: Vbat ≥ 3.6 V, 25 °C, 50 Ω load; meeting spectral mask, EVM, harmonic levels, spurious emissions and regulatory requirements in general	19	20	-	dBm	-14	dB	19.95	%
MCS-1		19	20	-	dBm	-14	dB	19.95	%
MCS-2		19	20	-	dBm	-14	dB	19.95	%
MCS-3		18.5	19.5	-	dBm	-17	dB	14.13	%
MCS-4		17.5	18.5	-	dBm	-20	dB	10.00	%
MCS-5		16.5	17.5	-	dBm	-23	dB	7.08	%
MCS-6		15.5	16.5	-	dBm	-25	dB	5.62	%
MCS-7		14.5	15.5	-	dBm	-28	dB	3.98	%

Table 49. Output power control

Mode	Parameter	Note	Min	Typ	Max	UNit
2.4 GHz	Power control range	At antenna	15	-	-	dB
	Power resolution	At maximum power	-	0.25	-	dB
	Power accuracy	At maximum power (closed loop)	-1	0	+1	dB

The typical value of Pout can be adjusted in software within the limits defined by *Table 44* to *Table 47* and *Table 49*. See the ETF Software Delivery Note for details.

(For more details, please refer to the CW1100 Datasheet - CD00256436 Rev. 15).

SPWF04SA module: some technical note about the Antenna device embedded in the module, displayed in the Module Block Diagram as “internal RF antenna”.

ANTENNA DESCRIPTION

Rufa is intended for use with all 2.4 GHz applications. The antenna uses a ground plane in order to radiate efficiently, but this ground plane must not extend underneath the antenna itself.
The antenna is available in two versions with the feed locations on the right or left hand side of the antenna.

Rufa Left: 3030A5839-01

Rufa Right: 3030A5887-01

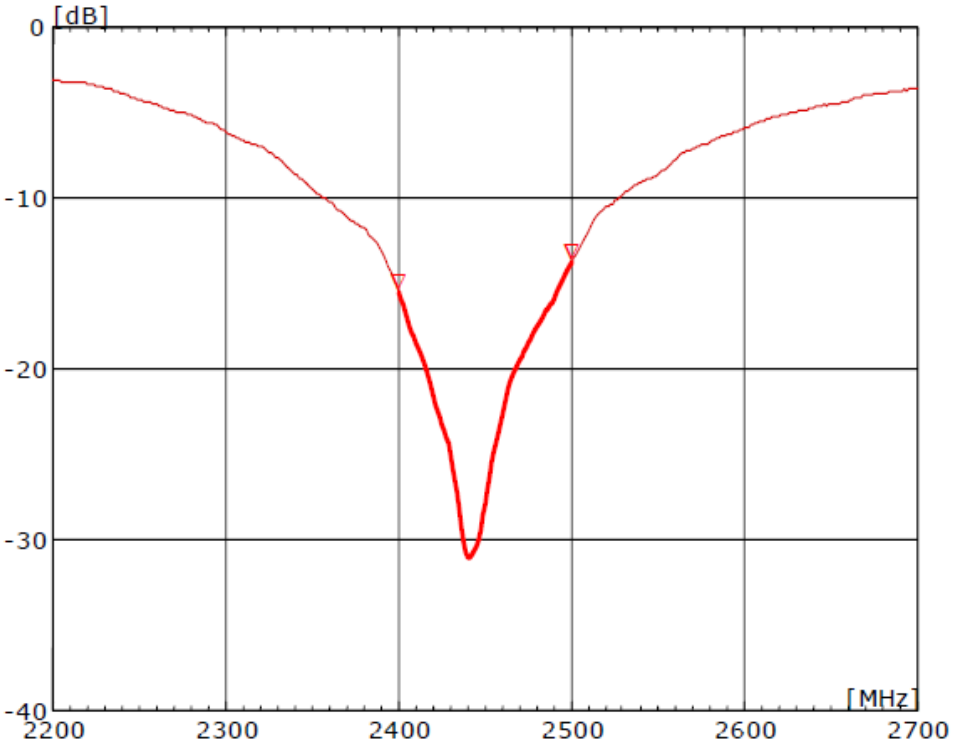
Antenna general data

Product name	Rufa 2.4 GHz
Part Number	3030A5839-01 (Left)
	3030A5887-01 (Right)
Frequency	2.4 – 2.5 GHz
Polarization	Linear
Operating temperature	-40 °C to +85 °C
Impedance with matching	50 Ω
Weight	0.1 g
Antenna type	SMD
Dimensions	12.8 x 3.9 x 1.1 [mm]

Antenna electrical characteristic

	Typical performance	Conditions
Peak gain	2.1 dBi	All data measured on Antenova's reference boards, part numbers AN-1-0543-1 and AN-1-0556-1 Data given for the 2.4 – 2.5 GHz frequency range
Average gain	-1.2 dBi	
Average efficiency	75%	
Maximum Return Loss	-11 dB	
Maximum VSWR	1.8:1	

Antenna return loss



Antenna VSWR