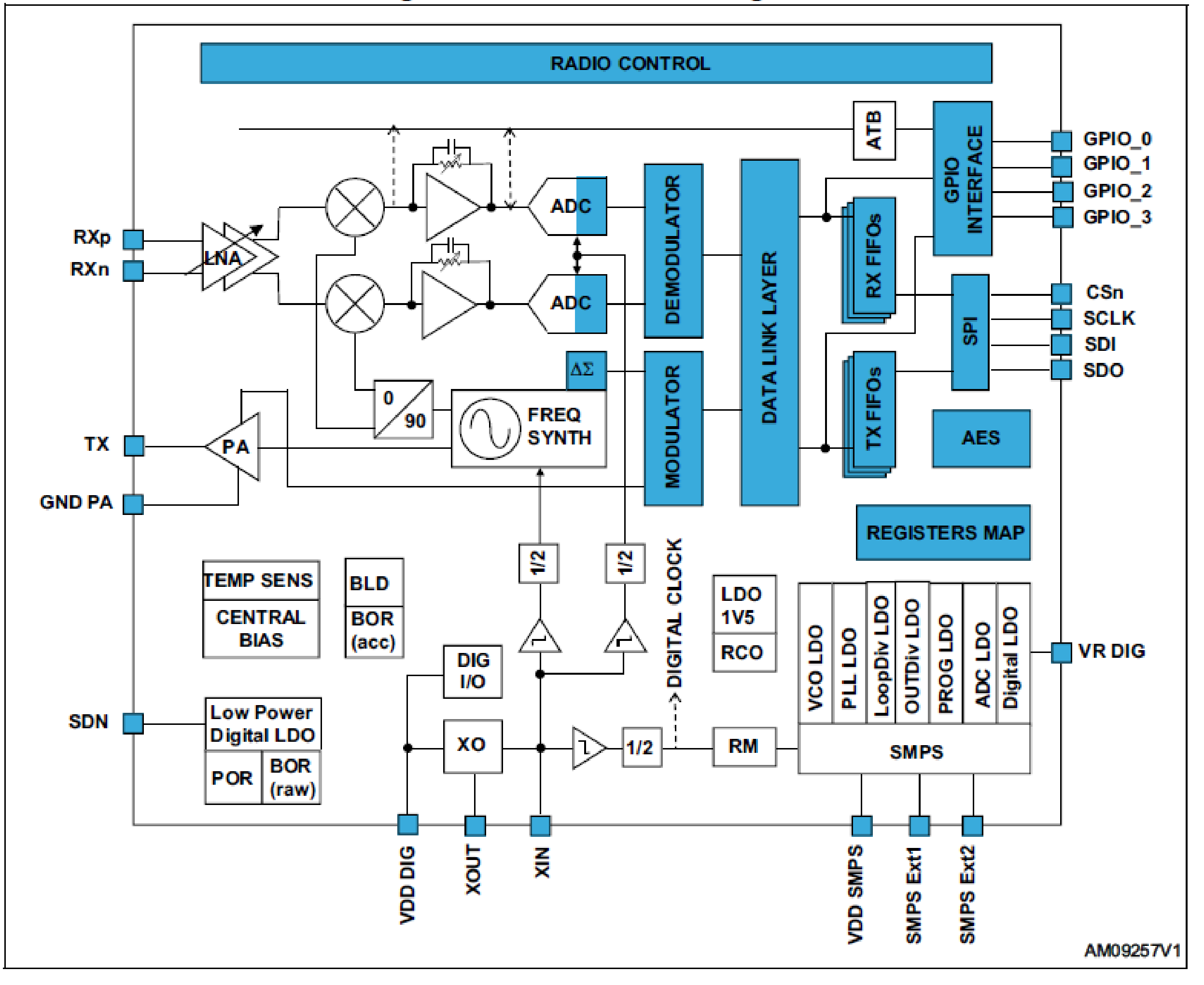
SPSGRFC-915 module: some technical note about the Radio device embedded in the module, displayed in the Module Block Diagram as “SPIRIT1”.

Description

The SPIRIT1 is a very low-power RF transceiver, intended for RF wireless applications in the sub-1 GHz band. It is designed to operate both in the license-free ISM and SRD frequency bands at 169, 315, 433, 868, and 915 MHz, but can also be programmed to operate at other additional frequencies in the 300-348 MHz, 387-470 MHz, and 779-956 MHz bands. The air data rate is programmable from 1 to 500 kbps, and the SPIRIT1 can be used in systems with channel spacing of 12.5/25 kHz, complying with the EN 300 220 standard. It uses a very small number of discrete external components and integrates a configurable baseband modem, which supports data management, modulation, and demodulation. The data management handles the data in the proprietary fully programmable packet format also allows the M-Bus standard compliance format (all performance classes).
However, the SPIRIT1 can perform cyclic redundancy checks on the data as well as FEC encoding/decoding on the packets. The SPIRIT1 provides an optional automatic acknowledgement, retransmission, and timeout protocol engine in order to reduce overall system costs by handling all the high-speed link layer operations.
Moreover, the SPIRIT1 supports an embedded CSMA/CA engine. An AES 128-bit encryption co-processor is available for secure data transfer. The SPIRIT1 fully supports antenna diversity with an integrated antenna switching control algorithm. The SPIRIT1 supports different modulation schemes: 2-FSK, GFSK, OOK, ASK, and MSK. Transmitted/received data bytes are buffered in two different three-level FIFOs (TX FIFO and RX FIFO), accessible via the SPI interface for host processing.

A simplified block diagram of the SPIRIT1 is shown in *Figure 1*.

Figure 1. SPIRIT1 block diagram



The receiver architecture is low-IF conversion. The received RF signal is amplified by a twostage low-noise amplifier (LNA) and down-converted in quadrature (I and Q) to the intermediate frequency (IF). LNA and IF amplifiers make up the RX front-end (RXFE) and have programmable gain. At IF, I/Q signals are digitized by ADCs. The demodulated data is then provided to an external MCU either through the 96-byte RX FIFO, readable via SPI, or directly using a programmable GPIO pin. A 128-bit AES co-processor is available to perform (offline) data encryption/decryption to secure data transfer.

The transmitter part of the SPIRIT1 is based on direct synthesis of the RF frequency. The power amplifier (PA) input is the LO generated by the RF synthesizer, while the output level can be configured between -30 dBm and +11 dBm in 0.5 dB steps. The data to be transmitted can be provided by an external MCU either through the 96-byte TX FIFO writable via SPI, or directly using a programmable GPIO pin. The SPIRIT1 supports frequency hopping, TX/RX and antenna diversity switch control, extending the link range and improving performance.

The SPIRIT1 has a very efficient power management (PM) system.

An integrated switched mode power supply (SMPS) regulator allows operation from a battery voltage ranging from +1.8 V to +3.6 V, and with power conversion efficiency of at least 80%.

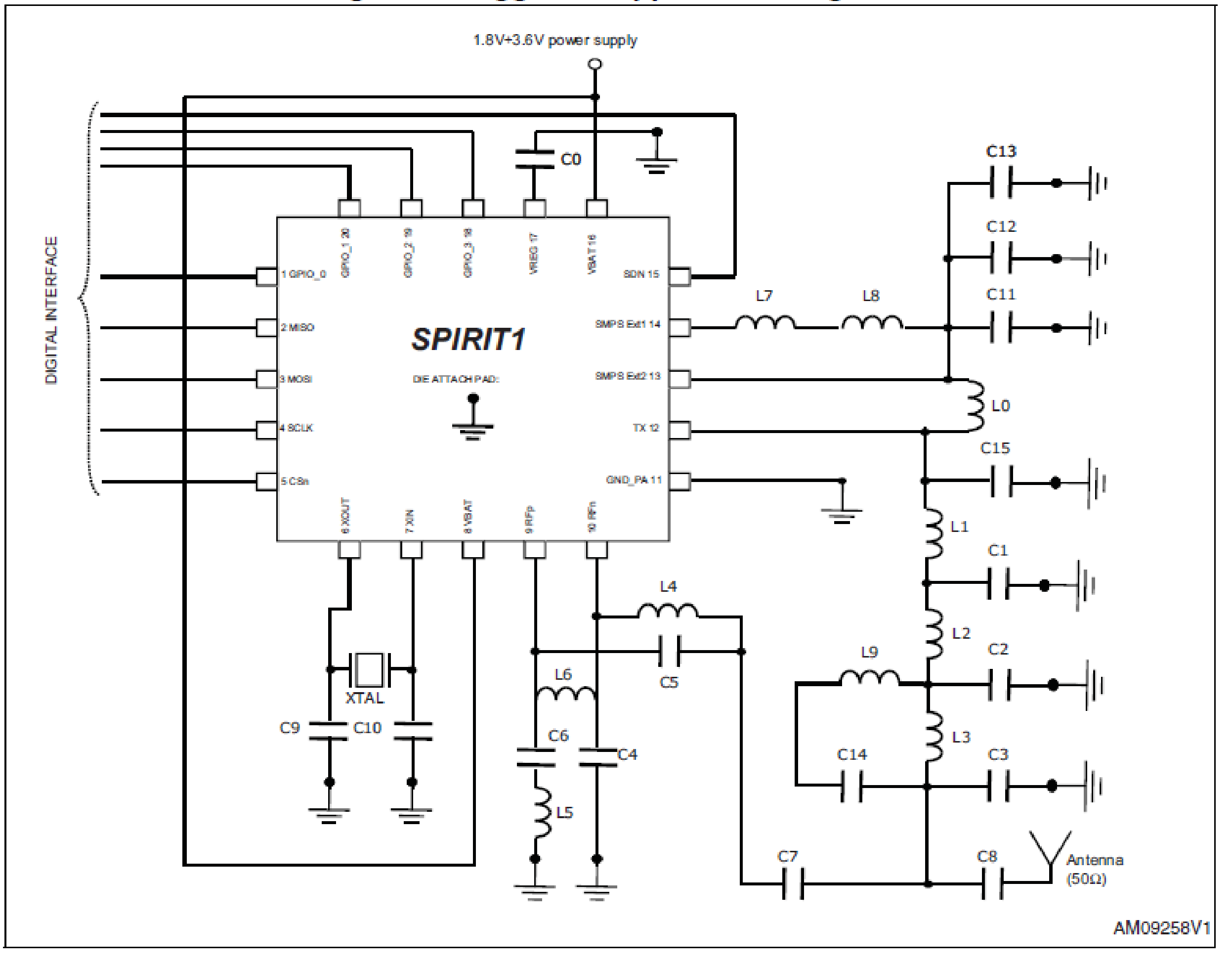
A crystal must be connected between XIN and XOUT. It is digitally configurable to operate with different crystals. As an alternative, an external clock signal can be used to feed XIN for proper operation. The SPIRIT1 also has an integrated low-power RC oscillator, generating the 34.7 kHz signal used as a clock for the slowest timeouts (i.e. sleeping and backoff).

A standard 4-pin SPI bus is used to communicate with the external MCU. Four configurable general purpose I/Os are available.

Typical application diagram

This section describes different application diagram of SPIRIT1 that can be used according to customer needs. In particular *Figure 2* shows the default configuration, *Figure 3* shows the TX boost mode configuration and *Figure 4* shows the SMPS off configuration. The default configuration is giving the best power consumption figures. The TX boost mode configuration is used to increase TX output power and the SMPS off configuration is used to enhance sensitivity at the expense of power consumption. When using SMPS off configuration, SMPS should disabled by setting to1 bit DISABLE_SMPS in PM_CONFIG register. It is important the SDN pin to be driven by an external microcontroller. It should be set low when the supply voltage of the device is steady to VDD. A short circuit connection of the SDN pin to ground should be avoided.

Figure 2. Suggested application diagram



RF receiver

Characteristics measured over recommended operating conditions unless otherwise specified. All typical values are referred to T_A = 25 °C, V_{BAT} = 3.0 V, no frequency offset in the RX signal. All performance is referred to a 50 Ohm antenna connector, via the reference design.

Table 12. RF receiver characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
RL	Return loss	169.4-169.475 MHz, 433-435 MHz, 868-868.6 MHz, 310-320 MHz, 902-928 MHz(1)			-10	dB
CH_{BW}	Receiver channel bandwidth		1		800	kHz
P_{SAT}	Saturation 1% PER (packet length = 20 bytes) FEC DISABLED	868 MHz 2-GFSK (BT=1) 38.4 kbps (20 kHz dev. CH Filter=100 kHz)		10		dBm
IIP_3	Input third order intercept	Input power -50 dBm 915 MHz	-37	-31	-26	dBm

Table 12. RF receiver characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$C/I_{1\text{-}CH}$[2]	Adjacent channel rejection, 1% PER (packet length = 20 bytes) FEC DISABLED 868 MHz	Desired channel 3 dB above sensitivity level. 12.5 kHz Δf, 2-FSK 1.2 kbps, (1 kHz dev. CH Filter=6 kHz)		49		dB
		Desired channel 3 dB above sensitivity level. 100 kHz Δf, 2-FSK 1.2 kbps, (4.8 kHz dev. CH Filter=58 kHz)		40		dB
		Desired channel 3 dB above sensitivity level. 200 kHz Δf, 2-GFSK (BT=1) 38.4 kbps, (20 kHz dev. CH Filter=100 kHz)		40		dB
		Desired channel 3 dB above sensitivity level. 750 kHz Δf, 2-GFSK (BT=1) 250 kbps, (127 kHz dev. CH Filter=540 kHz)		38		dB
$C/I_{2\text{-}CH}$[3]	Alternate channel rejection, 1% PER (packet length = 20 bytes) FEC DISABLED 868 MHz	Desired channel 3 dB above sensitivity level. 25 kHz Δf, 2-FSK 1.2 kbps, (1 kHz dev. CH Filter=6 kHz)		52		dB
		Desired channel 3 dB above sensitivity level. 200 kHz Δf, 2-FSK 1.2 kbps, (4.8 kHz dev. CH Filter=58 kHz)		43		dB
		Desired channel 3 dB above sensitivity level. 400 kHz Δf, 2-GFSK (BT=1) 38.4 kbps, (20 kHz dev. CH Filter=100 kHz)		44		dB
		Desired channel 3 dB above sensitivity level. 1.5 MHz Δf, 2-GFSK (BT=1) 250 kbps, (127 kHz dev. CH Filter=540 kHz)		46		dB
IM_{REJ}[3]	Image rejection, 1% PER (packet length = 20 bytes) 1% PER (packet length = 20 bytes) FEC DISABLED	868 MHz 2-GFSK (BT=1) 38.4 kbps (20kHz dev. CH Filter=100 kHz), desired channel 3 dB above the sensitivity limit, with IQC correction.		47		dB
RX_{BLK}[3]	Blocking at offset above the upper band edge and below the lower band edge 1% BER	@ 2 MHz offset, 868 MHz 2-GFSK (BT=1) 38.4kbps, desired channel 3 dB above the sensitivity limit		-42		dBm
		@ 10 MHz offset, 868 MHz 2-GFSK (BT=1) 38.4kbps, desired channel 3 dB above the sensitivity limit		-40		dBm

Table 13. RF receiver characteristics - sensitivity

Symbol	Parameter	Test condition	SMPS ON	SMPS OFF	Unit
RX_{SENS}	Sensitivity, 1% BER (according to W-MBUS N mode specification)	169 MHz 2-FSK 1.2kbps (4 kHz dev. CH Filter=10 kHz)	-117	-123	dBm
		169 MHz 2-GFSK (BT=0.5) 2.4kbps (2.4 kHz dev. CH Filter=7 kHz)	-114	-121	dBm
		169 MHz 2-FSK 38.4kbps (20 kHz dev. CH Filter=100 kHz)	-104	-109	dBm
		169 MHz 2-GFSK (BT=0.5) 50 kbps (25 kHz dev. CH Filter=100 kHz)	-104	-108	dBm
	Sensitivity, 1% PER (packet length = 20 bytes) FEC DISABLED	315 MHz 2-FSK 1.2 kbps (4.8 kHz dev. CH Filter=58 kHz)	-109	-110	dBm
		315 MHz MSK 500 kbps (CH Filter=800 kHz)	-88	-88	dBm

Table 13. RF receiver characteristics - sensitivity (continued)

Symbol	Parameter	Test condition	SMPS ON	SMPS OFF	Unit
RX_{SENS}	Sensitivity, 1% PER (packet length = 20 bytes) FEC DISABLED	433 MHz 2-FSK 1.2 kbps (1 kHz dev. CH Filter=6 kHz)	-116	-120	dBm
		433 MHz 2-GFSK (BT=1) 1.2 kbps (4.8 kHz dev. CH Filter=58 kHz)	-106	-110	dBm
		433 MHz 2-GFSK (BT=1) 38.4 kbps (20 kHz dev. CH Filter=100 kHz)	-103	-107	dBm
		433 MHz 2-GFSK (BT=1) 250 kbps (127 kHz dev. CH Filter=540 kHz)	-96	-100	dBm
	Sensitivity, 1% PER (packet length = 20 bytes) FEC DISABLED	868 MHz 2-FSK 1.2 kbps (1 kHz dev. CH Filter=6 kHz)	-118	-118	dBm
		868 MHz 2-GFSK (BT=1) 1.2 kbps (4.8 kHz dev. CH Filter=58 kHz)	-108	-109	dBm
		868 MHz 2-GFSK (BT=1) 38.4 kbps (20 kHz dev. CH Filter=100 kHz)	-105	-106	dBm
		868 MHz GFSK (BT=1) 250 kbps (127 kHz dev. CH Filter=540 kHz)	-98	-99	dBm
		868 MHz MSK 250 kbps (CH Filter=540 kHz)	-93	-94	dBm
	Sensitivity, 1% PER (packet length = 20 bytes) FEC DISABLED	915 MHz 2-FSK 1.2 kbps (4.8 kHz dev. CH Filter=58 kHz)	-108	-109	dBm
		915 MHz 2-FSK 38.4 kbps (20 kHz dev. CH Filter =100 kHz)	-106	-106	dBm
		915 MHz 2-FSK 250 kbps (127 kHz dev. CH Filter=540 kHz)	-98	-99	dBm
		915 MHz MSK 500 kbps (CH Filter=800 kHz)	-94	-95	dBm
	Sensitivity, 1% PER (packet length = 20 bytes) FEC DISABLED	922 MHz 2-FSK 1.2 kbps (4.8 kHz dev. CH Filter=58 kHz)	-108	-109	dBm
		922 MHz 2-FSK 38.4 kbps (20 kHz dev. CH Filter =100 kHz)	-106	-106	dBm
		922 MHz 2-FSK 250 kbps (127 kHz dev. CH Filter=540 kHz)	-98	-99	dBm
		922 MHz MSK 500 kbps (CH Filter=800 kHz)	-94	-95	dBm

RF transmitter

Characteristics measured over recommended operating conditions unless otherwise specified. All typical values are referred to T_A = 25 °C, V_{BAT} = 3.0 V. All performance is referred to a 50 Ohm antenna connector, via the reference design.

Table 14. RF transmitter characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$P_{MAX\_TX\_BOOST}$	Maximum output power(1)(2)	Delivered to a 50 Ohm single-ended load via reference design using TX boost mode configuration	-	16		dBm
P_{MAX}	Maximum output power(2)	Delivered to a 50 Ohm single-ended load via reference design	-	11		dBm
P_{MIN}	Minimum output power	Delivered to a 50 Ohm single-ended load via reference design	-	-30		dBm
P_{STEP}	Output power step		-	0.5		dB

Table 14. RF transmitter characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$P_{SPUR,ETSI}$	Unwanted emissions according to ETSI EN300 220-1 (harmonic included, using reference design)	RF = 170 MHz, frequencies below 1 GHz	-		-36	dBm
		RF = 170 MHz, Frequencies above 1 GHz	-		< -60	dBm
		RF = 170 MHz, frequencies within 47-74, 87.5-108,174-230,470-862 MHz	-		-55	dBm
		RF = 434 MHz, frequencies below 1 GHz	-		-42	dBm
		RF = 434 MHz, Frequencies above 1 GHz	-		-46	dBm
		RF = 434 MHz, frequencies within 47-74, 87.5-108,174-230,470-862 MHz	-		-61	dBm
		RF = 868 MHz, frequencies below 1 GHz	-		-51	dBm
		RF = 868 MHz, Frequencies above 1 GHz	-		-40	dBm
		RF = 868 MHz, frequencies within 47-74, 87.5-108,174-230,470-862 MHz	-		-54	dBm

Table 14. RF transmitter characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$P_{SPUR,FCC}$	Unwanted emissions according to FCC part 15(harmonic included, using reference design)	RF = 310-320 MHz, harmonics (measured with max output power)	-		-37	dBm
		RF = 310-320 MHz, 1.705 MHz <f< 30 MHz	-		<-60	dBm
		RF = 310-320 MHz, 30 MHz <f< 88 MHz	-		<-60	dBm
		RF = 310-320 MHz, 88 MHz <f< 216 MHz	-		<-60	dBm
		RF = 310-320 MHz, 216 MHz <f< 960 MHz	-		<-60	dBm
		RF = 310-320 MHz, 960 MHz <f	-		<-60	dBm
		RF = 902-928 MHz, 1.705 MHz <f< 30 MHz (@ max output power)	-		<-70	dBm
		RF = 902-928 MHz, 30 MHz <f< 88 MHz (@ max output power)	-		<-70	dBm
		RF = 902-928 MHz, 88 MHz <f< 216 MHz (@ max output power)	-		<-70	dBm
		RF = 902-928 MHz, 216 MHz <f< 960 MHz (@ max output power)	-		-52	dBm
		RF = 902-928 MHz, 960 MHz <f (@ max output power)	-		-41	dBm
		2^{nd} and 7^{th} harmonics	-		-25	dBc

Table 14. RF transmitter characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$P_{SPUR,ARIB}$	Unwanted emissions according to ARIB	RF = 312-315 MHz, frequency below 1 GHz (@ max output power, according to ARIB STD-T93)	-		-41	dBm
		RF = 312-315 MHz, frequency above 1 GHz (@ max output power, according to ARIB STD-T93)	-		-48	dBm
		RF = 426-470 MHz (@ max output power, according to ARIB STD-T67)	-		<-40	dBm
		RF = 915-917 MHz and RF = 920-930 MHz, f< 710 MHz (@ max output power, according to ARIB STD-T108)	-		<-55	dBm
		RF = 915-917 MHz and RF = 920-930 MHz, 710 MHz <f< 915 MHz (@ max output power, according to ARIB STD-T108)	-		-55	dBm
		RF = 915-917 MHz and RF = 924-930 MHz, 915 MHz <f< 930 MHz (@ max output power, according to ARIB STD-T108)	-		-36	dBm
		RF = 920-924 MHz, 915 MHz <f< 920.3 MHz (@ max output power, according to ARIB STD-T108)	-		<-36	dBm
		RF = 920-924 MHz, 920.3 MHz <f< 924.3 MHz (@ max output power, according to ARIB STD-T108)	-		-55	dBm
		RF = 920-924 MHz, 924.3 MHz <f< 930 MHz (@ max output power, according to ARIB STD-T108)	-		-36	dBm
		RF = 915-917 MHz and RF = 920-930 MHz, 930 MHz <f< 1000 MHz (@ max output power, according to ARIB STD-T108)	-		-55	dBm
		RF = 915-917 MHz and RF = 920-930 MHz, 1000 MHz <f< 1215 MHz (@ max output power, according to ARIB STD-T108)	-		<-60	dBm
		RF = 915-917 MHz and RF = 920-930 MHz, 1215 MHz <f (@ max output power, according to ARIB STD-T108)	-		-38	dBm

Table 14. RF transmitter characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
P_{HARM}	Harmonics level	RF = 170 MHz, 2nd harmonic (max power level)	-		-36	dBm
		RF = 170 MHz, 3rd harmonic (max power level)	-		-55	
		RF = 315 MHz, 2nd harmonic (max power level)	-		-52	dBc
		RF = 315 MHz, 3rd harmonic (max power level)	-		-52	
		RF = 433 MHz, 2nd harmonic (max power level)	-		-43	dBm
		RF = 433 MHz, 3rd harmonic (max power level)	-		-46	
		RF = 868 MHz, 2nd harmonic (max power level)	-		-40	
		RF = 868 MHz, 3rd harmonic (max power level)	-		-42	
		RF = 915 MHz, 2nd harmonic (max power level)	-		-28	dBc
		RF = 915 MHz, 3rd harmonic (max power level)	-		-42	dBm
		RF = 922 MHz, 2nd harmonic (max power level)	-		-39	
		RF = 922 MHz, 3rd harmonic (max power level)	-		-60	
PA_{LOAD}	Optimum load impedance (simulated values)	170 MHz, using reference design	-	46 + j36		Ohm
		315 MHz, using reference design	-	25 + j27		Ohm
		433 MHz, using reference design	-	29 + j19		Ohm
		868 MHz, using reference design	-	34 - j7		Ohm
		915 MHz, using reference design	-	15 + j28		Ohm
		922 MHz, using reference design	-	42 - j15		Ohm

1. In ASK/OOK modulation, indicated value represents peak power.
2. V_{BAT}=3.6 V. Please refer to the AN4198 for more information.

(For more information, please refer to the STM SPIRIT1 Datasheet).

SPSGRFC module: some technical note about the Antenna device used during the “FCC” and “IC” certifications as “EXTERNAL RF antenna”.

(Data reported from the TAOGLAS Antenna Datasheet)

taoglas
antenna solutions

SPECIFICATION

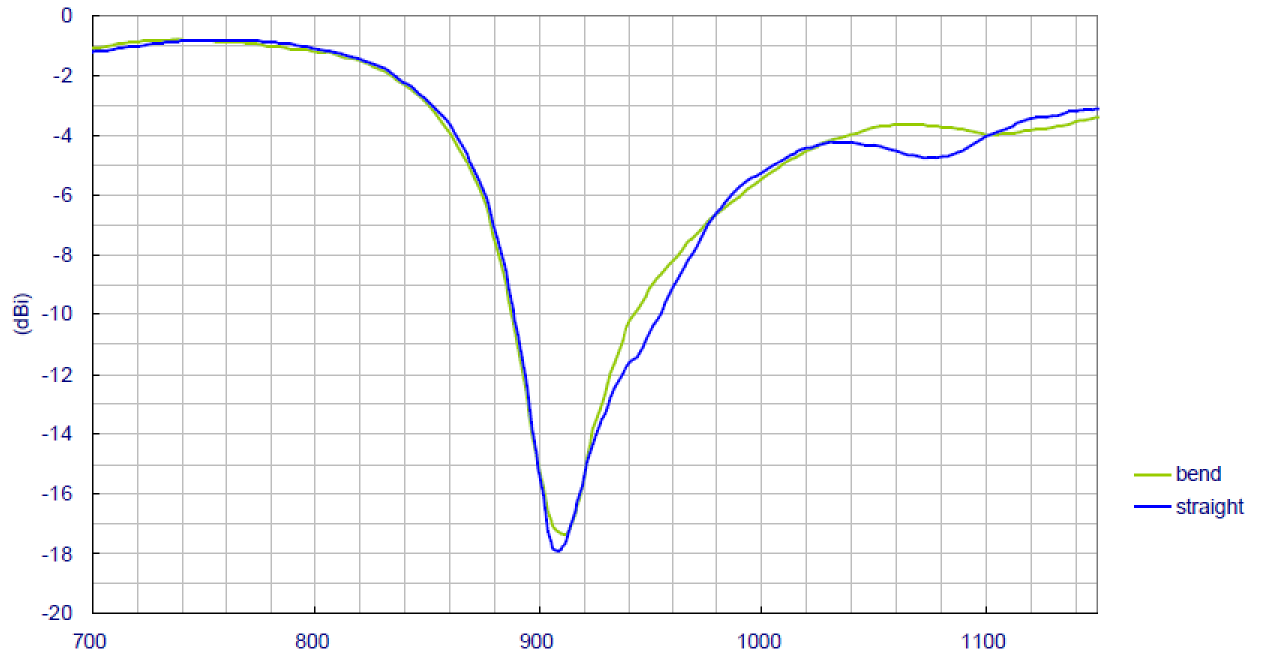
Part No.	:	**TI.19.2113**
Product Name	:	2dBi 915MHz ISM Band Dipole Terminal Antenna, SMA(M) Hinge
Feature	:	High efficiency dipole terminal antenna ROHS compliant

TI.19 is a high performance 915MHz ISM band dipole omni-directional antenna. The hinged design enables the antenna to be positioned at its most suitable angle. This antenna features a SMA(M) Plug Connector.
For a lot of antenna applications, such as Wi-Fi Hotspot or cellular Pico-cell, the antenna of the operator's device and the antenna of the user's remote device are not on the same horizontal level. The TI.19 has been designed with a butterfly shape radiation pattern, to help counteract this effect.

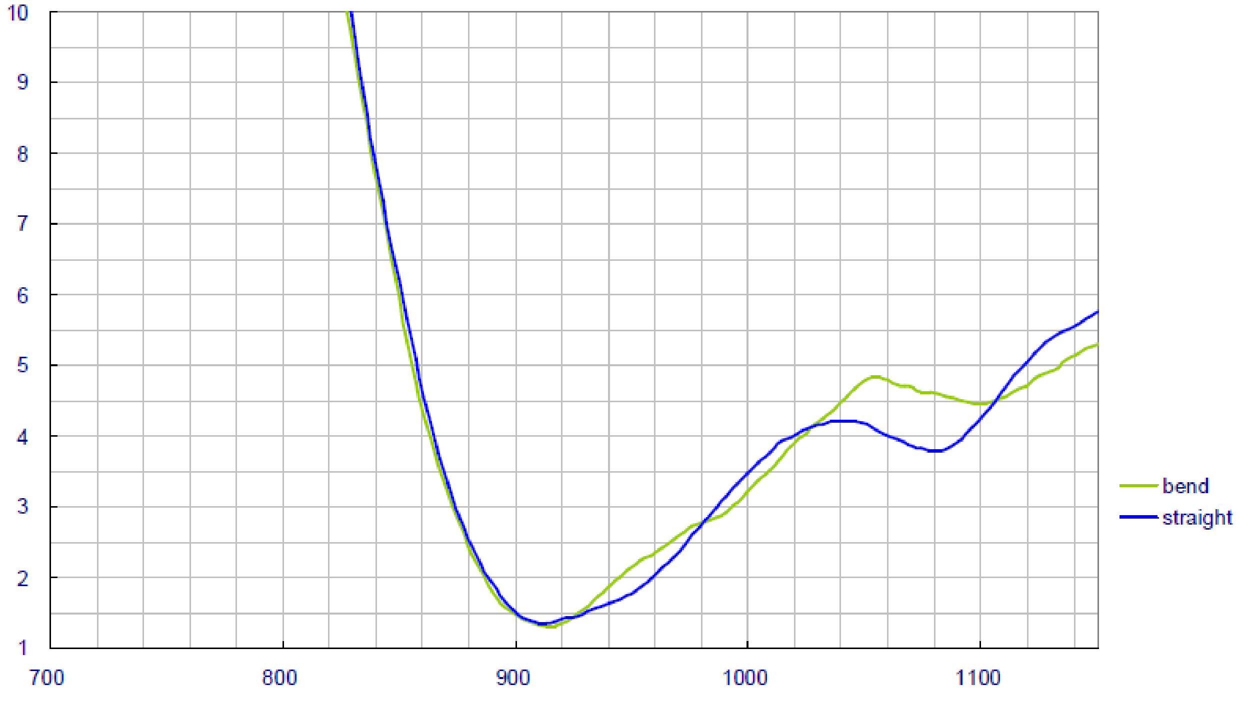
Antenna General Data Specifications:

ELECTRICAL	
Frequency	902 ~ 928MHz
Peak Gain (bend)	2.5dBi
Peak Gain (straight)	2.4dBi
Average Gain (bend)	-1.0dBi
Average Gain (straight)	-0.9dBi
Efficiency (bend)	81%
Efficiency (straight)	82%
Impedance	50Ω
VSWR	< 1.9 : 1
Polarization	Linear
Radiation Pattern	Omni
Input Power	10 W
MECHANICAL	
Antenna Length	389 ± 5 mm
Antenna Diameter	13 ± 0.5 mm
Casing	TPU
Connector	SMA Male
ENVIRONMENTAL	
Temperature Range	-40°C to 85°C
Humidity	Non-condensing 65°C 95% RH

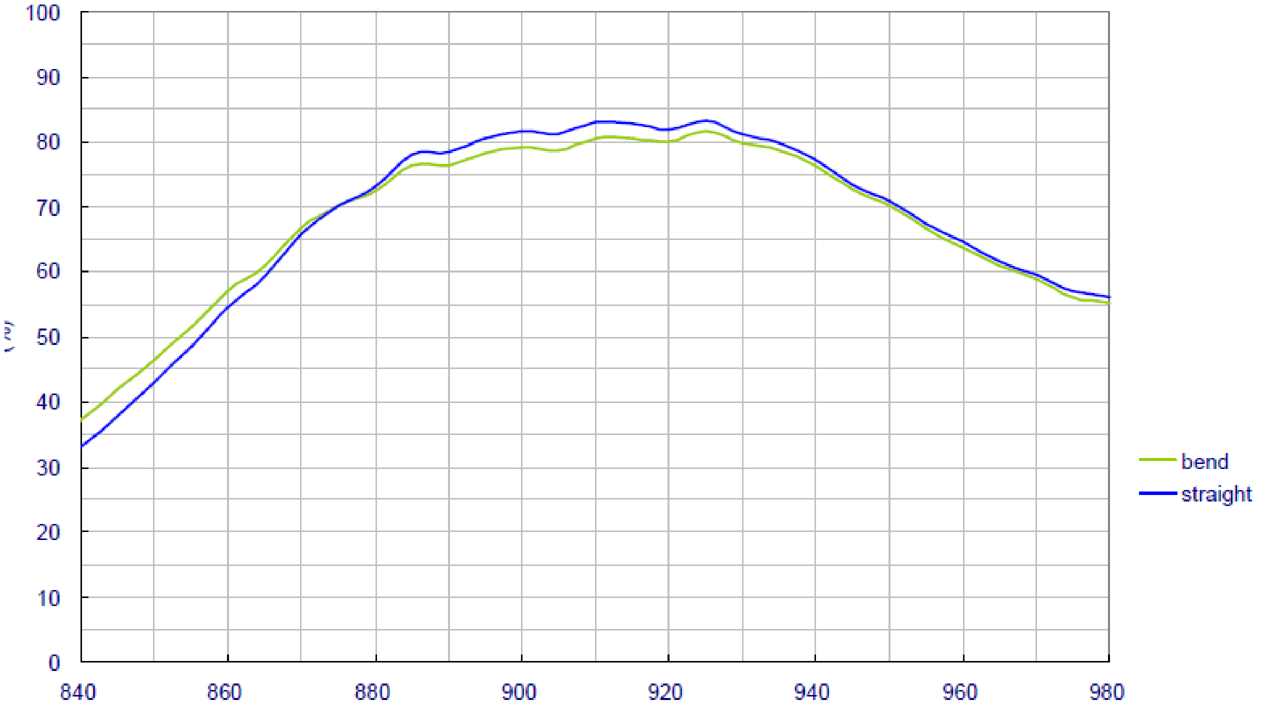
Antenna return loss



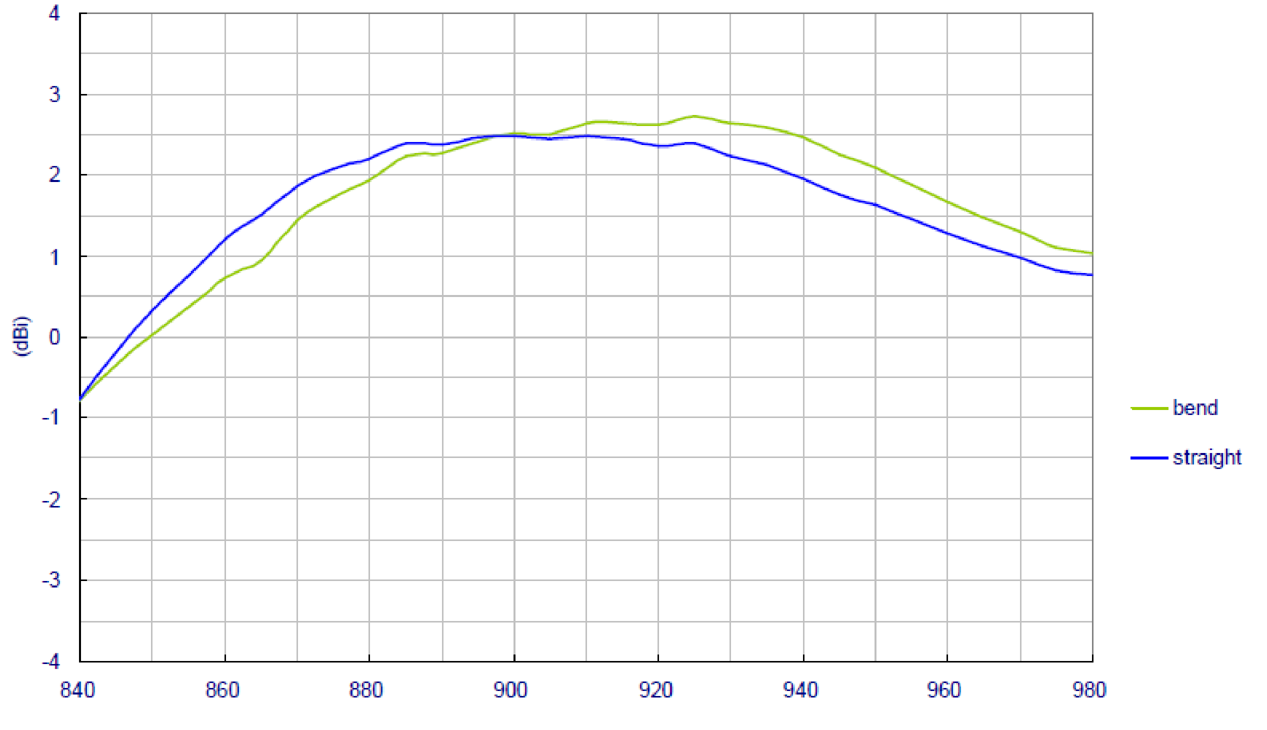
Antenna VSWR



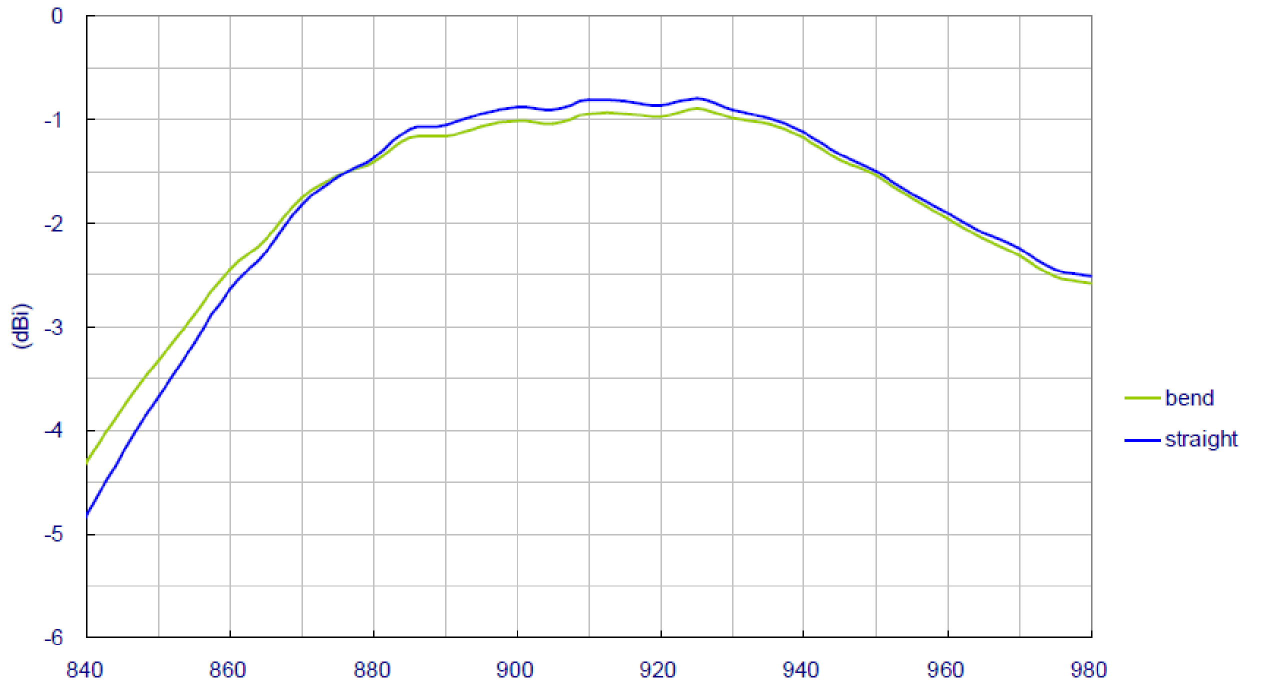
Radiation Efficiency



Peak Gain



Average Gain



Radiation Pattern (Typical)