

WATERPIK BLUETOOTH LOW ENERGY MODULE USER MANUAL

The 20028186 module has been evaluated in stand-alone conditions. For different operational conditions from a stand-alone modular transmitter in a host (multiple, simultaneously transmitting modules, or other transmitters in a host), may require additional testing.

If this module is intended for use in a portable device, you are responsible for separate approval to satisfy the SAR requirements of FCC Part 2.1093.

The modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuitry), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed. The end product with an embedded module may also need to pass the FCC Part 15 unintentional emission testing requirement and be properly authorized per FCC Part 15.

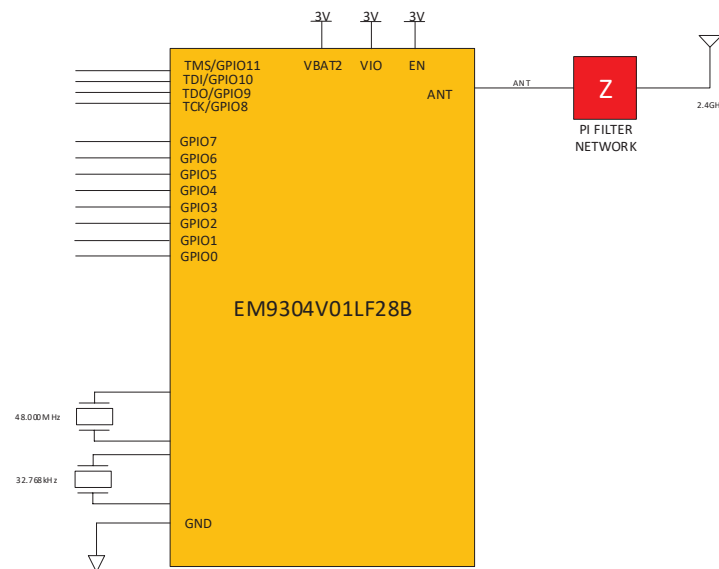


Figure 1 - 20028186 Block Diagram

This module is not intended to transmit simultaneously with any other antenna or transmitter.

The host end product must include a user manual that clearly defines operating requirements and conditions that must be observed to ensure compliance with current FCC RF exposure guidelines.

The final host/module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device. The User's Manual or Instruction Manual for an intentional or unintentional radiator shall caution the user that changes for modifications not expressly approved by the party responsible for compliance could

void the user's authority to operate the equipment. In cases where the manual is provided only in a form other than paper, such as on a computer disk or over the Internet, the information required by this section may be included in the manual in that alternative form, provided the user can reasonably be expected to have the capability to access information in that form.

To ensure compliance with all non-transmitter functions the host manufacturer is responsible for ensuring compliance with the modules(s) installed and operational. For example, if a host was previously authorized as an unintentional radiator under the declaration of Conformity procedure without a transmitter certified module and a module is added, the host manufacturer is responsible for ensuring that after the module is installed and operational the host continues to be compliant with the Part 15B unintentional radiator requirements.

1. VERSION HISTORY

Version	Comment
0.0	Initial Draft
0.1	Updated regulatory certifications
1.0	Removed Schematics and Bill of Material and updated Figure reference. Initial Release
1.1	Added ISED sections
1.2	Adjustments to exposure limits
1.3	Added CMIIT information; updated rf shield labeling.

2. DESCRIPTION

Features:

- System-on-a-Chip Core:
 - ARC EM4 32-bit MCU running at 24MHz
 - Floating-point unit for supporting sensor processing
 - 136KB ROM (including link layer and stack)
 - 128KB OTP (for parameters, profiles, and applications)
 - 48KB instructions RAM
 - 28KB Data RAM
 - I²C and SPI master interfaces
 - Up to 12 GPIOs
- Optimized Bluetooth 5.0 Low Energy 2.4GHz RF Transceiver
 - BT 5.0 Controller Subsystem
 - Bluetooth stack in ROM
 - SPI and UART HCI/ACI Transport Layers
 - Up to 8 simultaneous connections supported
 - Extended PDU length and enhanced security
- Firmware Over-the-Air (FOTA) updating
- Secure
 - True Random Number Generator
 - AES-128 Hardware Encryption Engine
 - Key Generation (ECC-P256)
- On board step down DC to DC converter
- High performance RF:
 - -34dBm to +6.1dBm output transmit power range
 - ISM Band 2.405GHz – 2.48GHz Operation
- Small size: 0.450" x 0.645" x 0.077", surface Mountable
- Integrated crystals (48MHz and 32.768KHz), Internal Voltage Regulator, Matching Circuitry and PCB Antenna
- Radio Regulation Certifications for United States (FCC), Canada (IC), and Europe (ETSI)
- Up to 400 ft. Range

Operational:

- Operating Voltage: 1.9V – 3.6V (Module Configured for Buck Operation)
- Temperature Range: -40°C - 85°C
- Low-Current Consumption:
 - RX Mode: 3.0mA (typical)
 - TX Mode: 5.2mA (typical) peak transmitter current at 0.4dBm
 - Sleep: 1.0µA connected
- Bluetooth low energy Receiver Sensitivity: -94dBm (1Mbps operation and 37 byte payload)

The pin diagram for the 20028186 module is as follows:



MODULE PIN	PIN NAME	DESCRIPTION	PRIMARY FUNCTION	ALTERNATIVE FUNCTION
1	GND	Ground pin for the module	GROUND	See Figure 3
2	VBAT2	Power input (V _{CC}), 1.9V to 3.6V	VCC	
3	VIO	Voltage reference pin for IO. Connect to V _{BAT2}	VCC2	
4	EN	Chip enable. Active high.	ENABLE	
5	GPIO5	General Purpose Input/Output pin	GPIO	
6	GPIO6	General Purpose Input/Output pin	GPIO	
7	GPIO0	General Purpose Input/Output pin	GPIO	
8	GPIO1	General Purpose Input/Output pin	GPIO	
9	GPIO2	General Purpose Input/Output pin	GPIO	
10	GPIO3	General Purpose Input/Output pin	GPIO	
11	GPIO7	General Purpose Input/Output pin	GPIO	
12	GPIO4	General Purpose Input/Output pin	GPIO	
13	GPIO8	General Purpose Input/Output pin	GPIO	TCK (JTAG)
14	GPIO9	General Purpose Input/Output pin	GPIO	TDO (JTAG)
15	GPIO10	General Purpose Input/Output pin	GPIO	TDI (JTAG)
16	GPIO11	General Purpose Input/Output pin	GPIO	TMS (JTAG)

The GPIO pins can be further mapped for the following functions:

Figure 3 - GPIO Configurations

GPIO Pins can be configured as digital input, push-pull output, or selectable pull-down/pull-up resistors. There are 3.3V standard protections against VSS and VIO.

Peripherals for the module include I²C master, SPI master and slave, UART, GPIO, and timers. Flow control is included for SPI slave mode maximum transfer efficiency. Both the I²C master and SPI master have 16 byte buffers. Both UART slave and SPI slave have FIFOs implemented for 64 byte FIFOs for RX and TX and 1 to 4 byte register reads from RX FIFO or writes to TX FIFO. FIFO status registers and interrupts are available for many different conditions.

4. ELECTRICAL CHARACTERISTICS

The information provided (below) is based on information provided from the EM Microelectronic EM9304 Datasheet and has not been independently verified for accuracy.

PARAMETERS	CONDITION	MINIMUM	TYPICAL	MAXIMUM	UNITS
Supply Voltage for V _{BAT2} , V _{IO}	DC to DC step-down	1.9 ¹	3.3	3.6	V
Schmidt Trigger Hysteresis		0.05 X V _{IO}			V
Input High Voltage (V _{IH})	V _{IO} ≥ 1.9V	0.7 X V _{IO}	-	-	V
	V _{IO} < 1.9V	0.85 X V _{IO}	-	-	V
Input Low Voltage (V _{IL})	V _{IO} ≥ 1.9V		-	0.3 X V _{IO}	V
	V _{IO} < 1.9V			0.15 X V _{IO}	V
Output High Voltage High	I _{OUT} = -3mA, V _{IO} = 1.9V	1.5	-	-	V
	I _{OUT} = -8mA, V _{IO} = 1.9V	0.84	-	-	V
Output Low Voltage Low	I _{OUT} = 3mA, V _{IO} = 1.9V	-	-	0.4	V
	I _{OUT} = 0.8mA, V _{IO} = 1.9V	-	-	0.21	V
Pull Up resistor GPIO5		8	10	18	KΩ
Pull Up resistor GPIO		70	100	130	KΩ
Ambient Operating Temperature		-40	-	+85	°C

Table 2 - Recommended Operating Conditions

¹ – 2.3V is required for OTP programming.

PARAMETERS	MINIMUM	TYPICAL	MAXIMUM	UNITS
RX Mode	-	3.0	-	mA
TX Mode, TX Power Level 0	-	2.2	-	mA
TX Mode, TX Power Level 1	-	2.4	-	mA
TX Mode, TX Power Level 2	-	2.8	-	mA
TX Mode, TX Power Level 3	-	2.9	-	mA
TX Mode, TX Power Level 4	-	3.0	-	mA
TX Mode, TX Power Level 5	-	3.1	-	mA
TX Mode, TX Power Level 6	-	3.2	-	mA
TX Mode, TX Power Level 7	-	3.3	-	mA
TX Mode, TX Power Level 8	-	3.4	-	mA
TX Mode, TX Power Level 9	-	3.6	-	mA
TX Mode, TX Power Level 10	-	3.8	-	mA
TX Mode, TX Power Level 11	-	4.1	-	mA
TX Mode, TX Power Level 12	-	4.3	-	mA
TX Mode, TX Power Level 13	-	4.6	-	mA
TX Mode, TX Power Level 14	-	5.2	-	mA
TX Mode, TX Power Level 15	-	5.6	-	mA
TX Mode, TX Power Level 16	-	7.5	-	mA
TX Mode, TX Power Level 17	-	9.9	-	mA
Active RC ²	-	0/2	-	mA
Active XTAL ¹	-	0.4	-	mA
ECC ROM Execution in a loop	-	0.7	-	mA
Coremark test from IRAM1	-	1.2	-	mA
Coremark test from OTP	-	1.6	-	mA
Sleep Mode, LF RC	-	1.0	-	mA
Sleep Mode, LF XTAL	-	0.95	-	mA
Deep Sleep Mode	-	0.65	-	mA
Chip Disabled	-	5	-	mA
Battery Peak Currents ²	-	10.3	-	mA

Table 3 – DC Characteristics, DC to DC Step-Down Configuration, V_{BAT2} = 3.0V

¹ – CPU halted.

² – Typical value using pi-filter. Valid for 0dBm TX power level and below

PARAMETERS	CONDITION	MINIMUM	TYPICAL	MAXIMUM	UNITS
Step-Down, DCDC off	$V_{BAT} = 3.0V$, Ramp = $0.3V/\mu s$, LF RC	-	3.6	-	ms
Any	32KHz crystal or external signal used	-	1.2	-	s

Table 4 – Start-Up Characteristics

MODE 1	MODE 2	CONDITION	MINIMUM	TYPICAL	MAXIMUM	UNITS
Sleep	Active XTAL	HCI/ACI Command RDY (Depends on Crystal Q)	-	1.1	-	ms

Table 5 – Timing Characteristics – sleep to active

PARAMETERS	CONDITION	MINIMUM	TYPICAL	MAXIMUM	UNITS
Output Low Voltage	$I_{OUT} = 3mA$, $V_{IO} = 1.9V$	0.1	-	-	V
	$I_{OUT} = 2mA$, $V_{IO} = 1.9V$	0.21	-	-	V

Table 6 – I^2C Output Pin Characteristics

PARAMETERS	CONDITION	MINIMUM	TYPICAL	MAXIMUM	UNITS
Output Delay, Falling Edge ($V_{BAT} = 1.05V$ to $3.6V$)	Output Load = 25pF	-	-	500	ns
	Output Load = 150pF	-	-	520	ns
	Output Load = 400pF	-	-	540	ns

Table 7 – I^2C GPIO Timing Characteristics

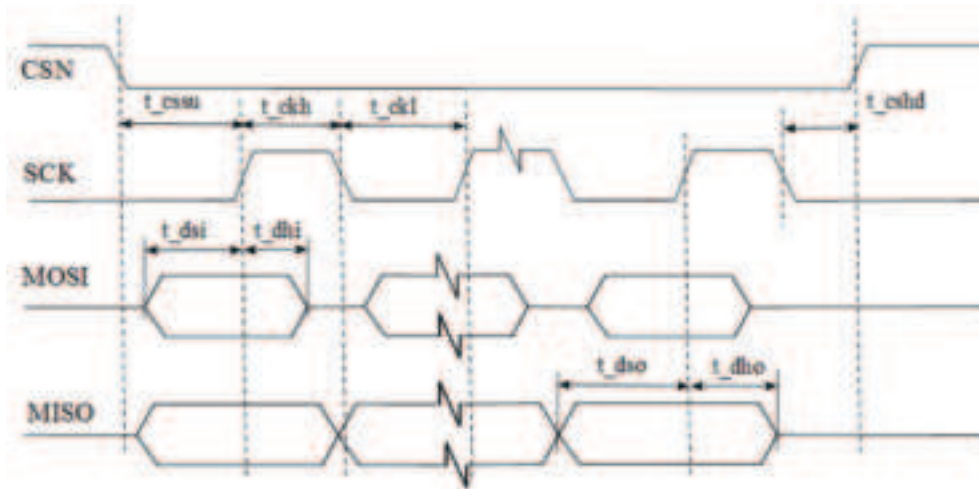


Figure 4 - SPI Timing Waveform

PARAMETERS	Symbol	MINIMUM	TYPICAL	MAXIMUM	UNITS
Clock Frequency Slave	t_{frq_s}			16	MHz
Clock Frequency Master	t_{frq_m}			6	MHz
Data Setup Time (input)	t_{dsi}	10			ns
Data Hold Time (input)	t_{dhi}	10			ns
Data Setup Time (output)	t_{dso}	$(1/t_{frq})-46ns$			ns
Data Hold Time	t_{dhd}	13			ns
CSN Setup Time	t_{cssu}	100			ns
CSN Hold Time	t_{cshd}	100			ns
Data Setup Time Master (input)	t_{dsim}	35			ns
Data Hold Time Master (input)	T_{dhim}	10			ns

Table 8 – SPI Timing Specifications for $V_{BAT} > 1.9V$

PARAMETERS	Symbol	MINIMUM	TYPICAL	MAXIMUM	UNITS
Clock Frequency Slave	t_{frq_s}			8	MHz
Clock Frequency Master	t_{frq_m}			3	MHz

Clock Pulse Width Low	t_clk_l	0.4/t_freq			μs
Clock Pulse Width High	t_clk_h	0.4/t_freq			μs
Data Setup Time (input)	t_dsi	10			μs
Data Hold Time (input)	t_dhi	10			μs
Data Setup Time (output)	t_dso	(1/t_freq)-46ns			μs
Data Hold Time	t_dhd	13			μs
CSN Setup Time	t_cssu	100			μs
CSN Hold Time	t_cshd	100			μs
Data Setup Time Master (input)	t_dsim	60			μs
Data Hold Time Master (input)	T_dhim	10			μs

Table 9 – SPI Timing Specifications for $V_{BAT} < 1.9V$

PARAMETERS	CONDITION	MINIMUM	TYPICAL	MAXIMUM	UNITS
RF Input Frequency	Compatible to IEEE 802.15.4, 2003	2.405	-	2.480	GHz
RF Sensitivity	1Mbps, 37 byte payload	-	-94	-	dBm
	1Mbps, 255 byte payload	-	-93	-	dBm
Maximum Input Power	1Mbps, 255 byte payload	-	0	-	dBm

Table 10 – Receiver AC Characteristics ($V_{DD} = 3.3V$ and $T_A = 25^\circ C$, LO Frequency = 2.445GHz)

PARAMETER	COMMENT	SYMBOL	MINIMUM	TYPICAL	MAXIMUM	UNITS
Output Power	TX Power Level 0	P _{TX0}	-	-33.5	-	dBm
	TX Power Level 1	P _{TX1}	-	-29.0	-	dBm
	TX Power Level 2	P _{TX2}	-	-17.9	-	dBm
	TX Power Level 3	P _{TX3}	-	-16.4	-	dBm
	TX Power Level 4	P _{TX4}	-	-14.6	-	dBm
	TX Power Level 5	P _{TX5}	-	-13.1	-	dBm
	TX Power Level 6	P _{TX6}	-	-11.4	-	dBm
	TX Power Level 7	P _{TX7}	-	-9.9	-	dBm
	TX Power Level 8	P _{TX8}	-	-8.4	-	dBm
	TX Power Level 9	P _{TX9}	-	-6.9	-	dBm
	TX Power Level 10	P _{TX10}	-	-5.5	-	dBm
	TX Power Level 11	P _{TX11}	-	-4.0	-	dBm
	TX Power Level 12	P _{TX12}	-	-2.6	-	dBm
	TX Power Level 13	P _{TX13}	-	-1.4	-	dBm
	TX Power Level 14	P _{TX14}	-	0.4	-	dBm
	TX Power Level 15	P _{TX15}	-	2.5	-	dBm
	TX Power Level 16	P _{TX16}	-	4.6	-	dBm
	TX Power Level 17	P _{TX17}	-	6.2	-	dBm
Power in 2 nd harmonic	Output power step = 17 50Ω for typical value. PT for maximum value.	P _{TX2}	-	-50	-	dBm
Power in 3 rd harmonic		P _{TX3}	-	-60	-	dBm
Power in 4 th harmonic		P _{TX4}	-	-60	-	dBm
Deviation from the channel center frequency		Δf _c	-150	-	150	KHz
Frequency drift for any packet length		Δf _{cpkt}	-	-	50	KHz
Drift rate		Δf _c /ΔT	-	-	400	Hz/μs
Modulated Frequency Deviation		Δf _{mod}	-	±250	-	KHz
In-band spurious emissions, power transmitted outside the selected channel, at a frequency offset f _{offs}	f _{offs} = 2MHz	P _{OUT} (f _c +f _{offs})	-	-	-20	dBm
	f _{offs} ≥ 3MHz		-	-	-30	dBm

Table 11 – DC Characteristics, DC to DC Step-Down Configuration, VBAT2 = 3.0V

5. REGULATORY CERTIFICATIONS

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1). This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

The 20028186 Module is modular certified and complies with the following regulatory requirements:

US – FCC:

EMC

- FCC CFR 47, Part 15, Subpart B (10-1-17 Edition), Secs. 15.109

RF

- FCC Part 15.247, 10-1-17 Edition: Operation within the bands 902 – 928MHz, 2400 – 2483.5MHz, and 5725 – 5850MHz.
- FCC Part 15.209, 10-1-17 Edition: Radiated emission limits; general requirements.

CANADA – IC

EMC

- ICES-003 Issue 6 – Update April (2017).

RF

- RSS-247 Issue 3 (August 2023).
- RSS-Gen Issue 5 (April 2018).

CE

The module conforms with RED Radio Equipment Directive 2014/53/EU, following the provisions of ERP Directive 2009/125/EC, EU RoHS Directive 2011/65/EU, including the amendment 2015/863/EU.

EMC

- ETSI EN 301 489-1 V2.2.0
- ETSI EN 301 489-17 V3.2.0

RF

- ETSI EN 300 328 v2.2.2 (2019-07)

CHINA – CMIIT

RF

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EMC

- GB 9254:2008

6. ISED REGULATORY NOTICES

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This device complies with ISED license-exempt RSS(S).

Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

7. ISED LABELLING REQUIREMENTS FOR HOST DEVICE

The host device shall be properly labelled to identify the modules within the host device. The certification label of the module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labelled to display the IC of the module, preceded by the words "Contain transmitter module", or the word "Contains", or similar wording expressing the same meaning as follows:

Contains IC: 23221-20028186

8. RF EXPOSURE SAFETY ISED

This device complies with the ISED RF exposure limits and has been evaluated in compliance with **portable** exposure condition.

To comply with the measured SAR value/SAR testing exclusion, the equipment must be installed and operated with a minimum distance of 5 mm of the human body.

9. Avis de Conformité Réglementaire - ISED

Les changements ou modifications non expressément approuvés par la partie responsable de la conformité peuvent annuler le droit de l'utilisateur à utiliser l'équipement.

L'équipement est conforme aux CNR d'ISED applicables aux appareils radio exempts de licence.

L'exploitation est autorisée aux deux conditions suivantes:

1. L'appareil ne doit pas produire de brouillage;
2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement

10. Exigences d'étiquetage pour le équipement hôte

L'équipement hôte doit être correctement étiqueté pour identifier les modules au sein du équipement hôte.

L'étiquette de certification du module doit être clairement visible à tout moment lorsqu'il est installé dans l'hôte, sinon l'hôte doit être étiqueté pour afficher l'IC du module, précédé par les mots "Contient un module émetteur", ou le mot "Contient", ou un libellé similaire exprimant la même signification, comme suit:

Contains IC: 23221-20028186

11. Sécurité d'exposition aux RF

Cet appareil est conforme aux limites d'exposition RF d'ISDE et a été évalué conformément aux conditions d'exposition portable.

Pour respecter la valeur SAR mesurée / l'exclusion des tests SAR, l'équipement doit être installé et utilisé à une distance minimale de 5 mm du corps humain.

12. PERMITTED ANTENNA

Radio transmitter model (FCC ID: 2ANTU-20028186, ISED IC: 23221-20028186, CMIIT ID: 2023DJ15923) has been approved by the FCC to operate with the antenna listed below with the maximum permissible gain indicated (below). Antenna types not listed below, or having a gain greater than the maximum gain indicated below, are strictly prohibited for use with this device.

Approved Antenna	Antenna Type	Maximum Gain
Abracon AMCA31-2R450G-S1F-T	Surface mount Chip	0.5dBi

13. LABELING REQUIREMENTS

The module itself will have the following information displayed on its RF shield:



The label has the following contents:

- Waterpik company name
- Model: 20028186
- FCC ID: 2ANTU-20028186
- IC ID: 23221-20028186
- CMIIT ID: 2023DJ15923
- CE, and RoHS markings

The shield dimension is 9.50mm wide x 10.28mm high.

In addition to the module labelling, the Host device shall properly label the end device to identify the modules within the host device. The certification label of the module shall be visible at all times when installed in the host device, or the host device must be labelled to display the IC of the module. The IC of the module must be preceded by the words “Contains transmitter module”, “Contains”, or similar wording to express similar meaning as:

Contains FCC ID: 2ANTU-20028186

Contains IC: 23221-20028186

Contains CMIIT ID: 2023DJ15923

14. ENVIRONMENTAL SAFETY

The 20028186 is compliant with:

- RoHS, according to EU Directive 2011/65/EU and its amendments including 2015/863/EU
- Halogen Free according to IEC 61249-2-21:2003
- REACH compliant according to EU Regulation 1907/2006

15. RF EXPOSURE SAFETY

This device complies with the FCC RF exposure limits and has been evaluated in compliance with **portable** exposure condition.

To comply with the measured SAR value/SAR testing exclusion, the equipment must be installed and operated with a minimum distance of 5 mm of the human body.

16. REFERENCE DOCUMENTS

EM9304 Device Specifications (Datasheet)

Abracon LLC AMCA31-2R450G-S1F-T Datasheet