BW2155
Zigbee Module Manual

FEATURES

- Small footprint: 32x21x3.4mm
- Dual antenna solution for diversity
- Antenna connector for optional Whip antenna
- Transmit power: +20 dBm typical
- Sensitivity: - 97 dBm; +117 dB RF link budget
- Outdoor range: Greater than 1.5 miles
- Operates on one of 15 selectable RF channels (2.45 GHz ISM band)
- Network speed: 250Kbps
- Integrated MCU functionality
- Up to 25 GPIO Pins
- Up to 60K Flash and 4K RAM
- Two independent serial communication interfaces (SCI)
- Inter-integrated circuit (IIC) interface
- 7-channel, 10-bit ADC

Applications

- Home Automation
- Mesh, point-to-point, and point-to-multipoint networks
- Sensor Networks
- HVAC
- Security

BW2155A Module

BW2155C Module

PRODUCT DESCRIPTION

The BW2155 is a 2.4 GHz IEEE 802.15.4 compliant module with internal voltage regulator, integrated crystal, Power Amplifier, LNA, matching circuitry, two chip antennas, and one Whip antenna connector.

The BW2155 Zigbee module is based on the Freescale MC13211/212/213 Zigbee transceiver. The MC1321x family is a Zigbee platform which incorporates a low power 2.4 GHz RF transceiver and an 8-bit MCU. The RF transceiver is an 802.15.4 Standard-compliant radio that operates in the 2.4 GHz ISM frequency band. The MCU can provide up to 60 KB of flash memory and 4KB of RAM.

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About This Manual

This manual describes the BeeWave Systems' BW2155 Zigbee module, which is an IEEE 802.15.4 compliant wireless device based on the Freescale MC1321x device and RFMD RF6555 front end module (FEM). The BW2155 provides a platform to evaluate the BeeWave modules and to develop software and applications to demonstrate module's RF capabilities.

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1. Introduction

The BW2155 is a 2.4 GHz IEEE 802.15.4 compliant module with internal voltage regulator, integrated crystal, Power Amplifier, LNA, matching circuitry, two chip antennas, and a connector for a Whip antenna.
The BW2155 Zigbee module is based on the Freescale MC13211/212/213 Zigbee transceiver. The MC1321x family is a Zigbee platform which incorporates a low power 2.4 GHz RF transceiver and an 8-bit MCU. The RF transceiver is an 802.15.4 Standard-compliant radio that operates in the 2.4 GHz ISM frequency band. The MCU can provide up to 60 KB of flash memory and 4KB of RAM.

The module includes a high performance RF Micro Devices (RFMD) Front End Module (FEM). The FEM includes an LNA, a PA with 20 dBm (100 mW) nominal RF output power, and an antenna switch. The use of the FEM increases the module output power to +20 dBm, making it one of the most powerful modules on the market. With its 117 dB link budget, the module provides range greater than 1.5 miles ensuring reliable transmission even in harsh environments and reducing the number of nodes needed in the network. The increased output power also provides better interior penetration from devices installed outside the home or within the home such as smart meters that need to connect to devices inside the home.

BeeWave Systems' BW2155 is compliant with Zigbee® Alliance specifications and IEEE 802.15.4, making it applicable for all Zigbee® applications and profiles. The transceiver MC13213 contains 60 KB of flash and 4 KB of RAM and is intended for use with the Freescale's fully compliant 802.15.4 MAC and the fully Zigbee® compliant Freescale Beestack. The other two transceivers in MC1321x family are MC13212, with 32 KB of flash and 2 KB of RAM; and MC13211, with 16 KB of flash and 1 KB of RAM. The RF functionality of all three transceivers is same. The only difference is in the memory size.

The BW2155 module has four versions. First version, BW2155A, has a µUSB connector, an antenna connector, two pushbuttons, two LEDs, and a temperature sensor. The µUSB connector is used to program the module and to connect it to a power supply, such as USB adapter. The second version, BW2155B, does not have the µUSB connector, pushbuttons, or temperature sensor. Module BW2155B can be integrated onto a PCB of another system by soldering. The third version BW2155C is same as BW2155A except that it does not have the antenna connector. Similarly, the fourth version BW2155D is same as BW2155B except that is does not have the antenna connector. The RF functionality of these four modules is the same.

The BW2155 module solutions deliver industry-leading range, high performance, and rich features. These modules can be used in many applications such as Smart Energy AMI, Home Entertainment, Asset Tracking, Commercial Building Automation and Monitoring, Security Systems and Industrial Device.

2. Module Description

2.1 Block Diagram

BW2155A system level block diagram is shown in Figure 1. The main components include a Freescale transceiver MC1321x, an RFMD front-end-module (FEM) RF6555, one 16 MHz crystal, and a voltage regulator. The MC1321x transceiver has its own voltage regulator to supply a stable 1.8V to its radio. The second on-board voltage regulator is rated for an input DC voltage range of 3.0 to 5.0 and provides a stable 3.0 V to the FEM and transceiver. The FEM includes an antenna switch to select one of the two RF power paths: (1) one path routes the RF power to the chip antenna A1. (2) The second path directs power to a series circuit consisting of an antenna connector A2 (which also has a built-in switch) and a second chip antenna A3. If an antenna is connected to A2, then the chip antenna A3 is disconnected from the RF circuit and the entire RF power is directed to the Whip antenna. On the other hand, if A2 is not used, the RF power will be directed to the chip antenna A3. Antennas A1 and A2 can be used in diversity antenna mode.

The module has been tested with the on-board chip antenna A1 and a whip antenna. Since the two on-board chip antennas A1 and A3 are the same type, with A3 smaller antenna gain compared to A1, the regulatory compliance results obtained for A1 are also valid for antenna A3.

The BW2155A module has a µUSB connector, two pushbuttons, two LEDs, and temperature sensor. The µUSB connector does not support USB functionality and is merely used to program the module and to connect it to a power supply, such as USB adapter. The pushbutton and LEDs are useful to develop applications, and to control and monitor a system based on the module.

A second version of the module, part number BW2155B, is also available. The RF functionality of BW2155B is same as that of BW2155A. The only difference is that BW2155B does not have the µUSB connector, pushbuttons, or temperature sensor. This module can be integrated into another system by soldering it on a host motherboard. The block diagram of BW2155B is shown in Figure 2.

Two other versions of the module, BW2155C & BW2155D, use a 0 ohm resistor instead of antenna connector A2. These boards are used in applications that do not require a Whip antenna.

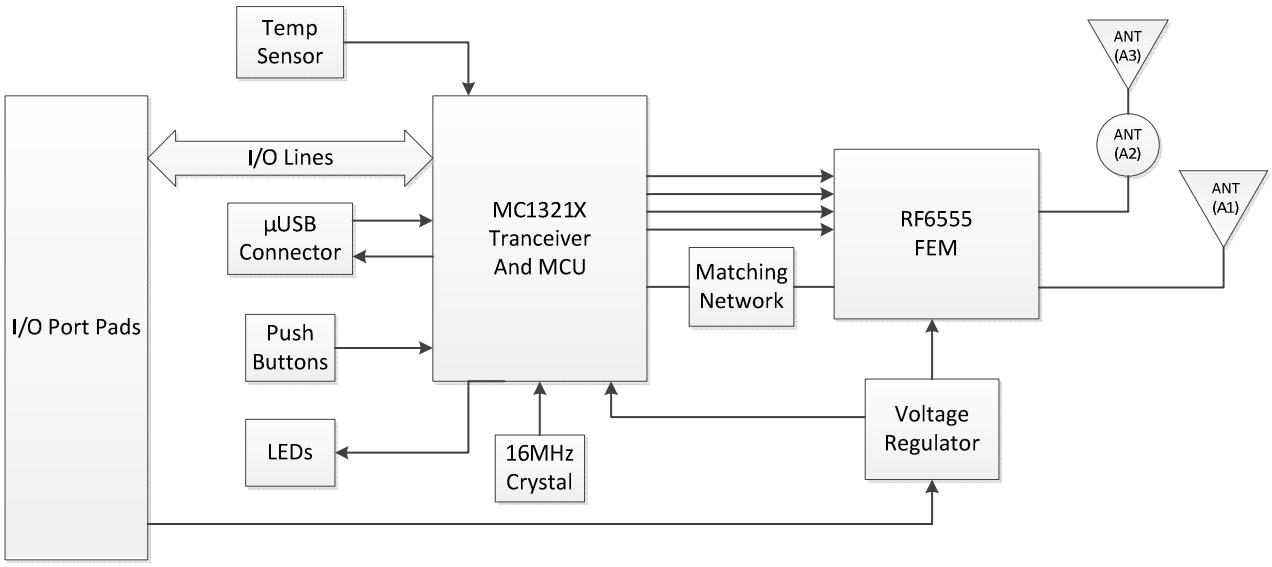

Figure 1: BW2155A block diagram

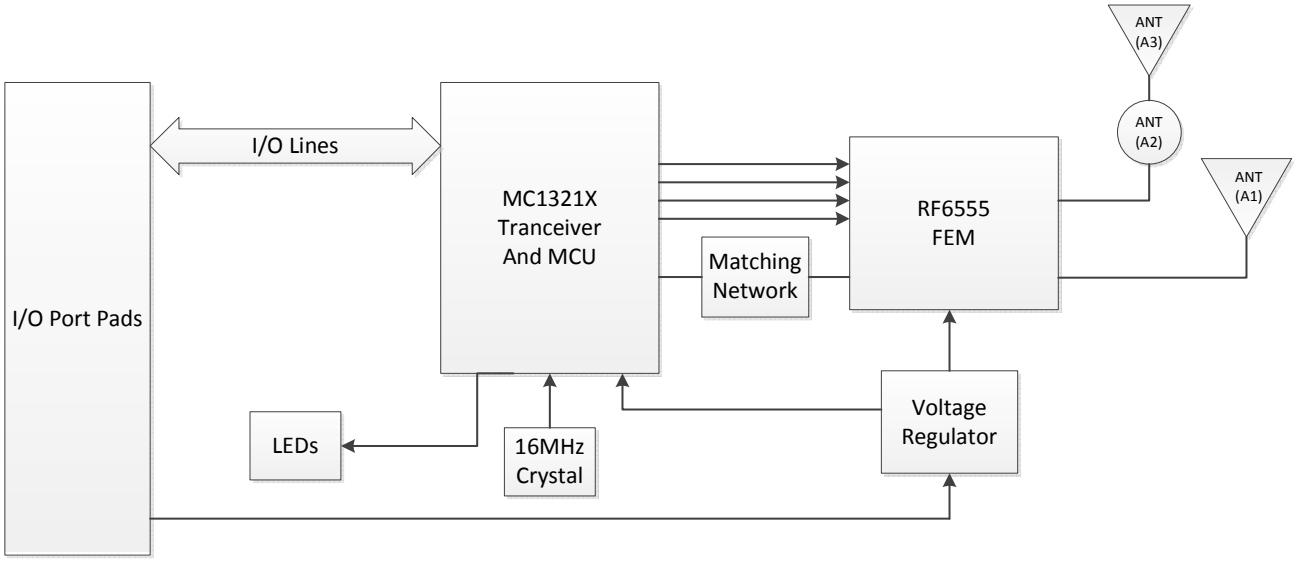

Figure 2: BW2155B block diagram

2.2 Module Top and Bottom View

The top view of BW2155A is shown in Figure 3. The part number BW2155B has similar top view except that the temperature sensor and pushbuttons are not mounted on the PCB. Similarly, the bottom view of module BW2155A is shown in Figure 4. Again, the bottom view of BW2155B is similar except that the µUSB connector is not mounted on the PCB.

As stated above, versions BW2155C and BW2155D are same as BW2155A and BW2155B, respectively, except that the antenna connector has been replace with a 0 ohm resistor.

Figure 3: Top view of module BW2155A

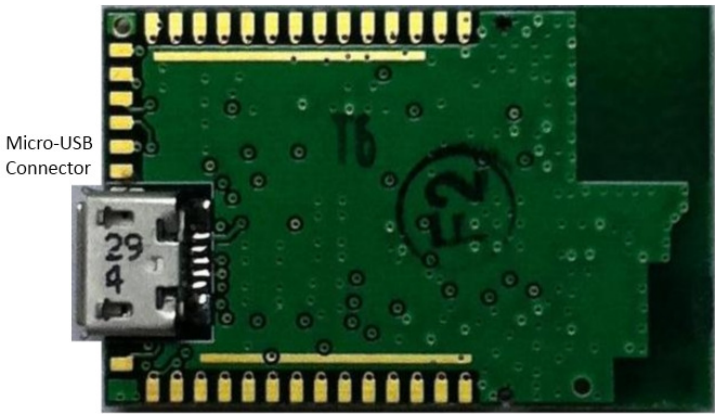

Figure 4: Bottom view of module BW2155A

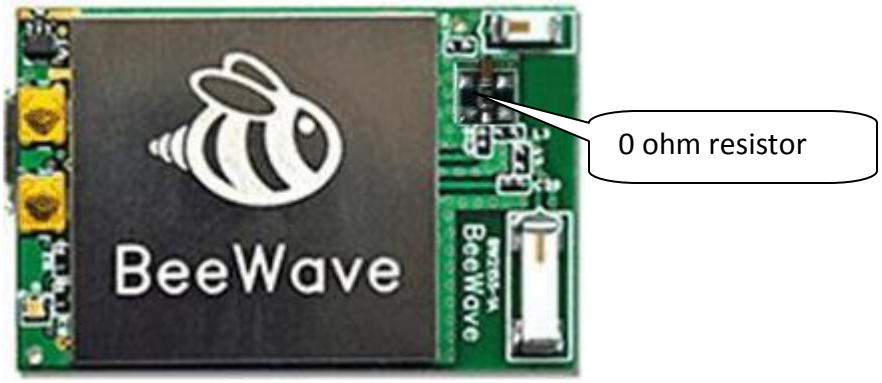

Figure 3(b): Top view of module BW2155C. The antenna connector has been replaced with a 0 ohm resistor

2.3 Module Pad Layout

Pad layout of module BW2155 is shown in Figure 5. The Pads on the bottom of module can be used to solder it onto the mother board of a host system. The functions of various pads are listed in Table 1. The module has 25 pads for digital I/O and analog inputs. Pads PTC4R and PTC5R are available for external LEDs. They are same as pads PTC4 and PTC5 except that they have series resistors to limit current in external LEDs. Pads 42 – 46 are used to solder the µUSB connector to modules BW2155A and BW2155C.

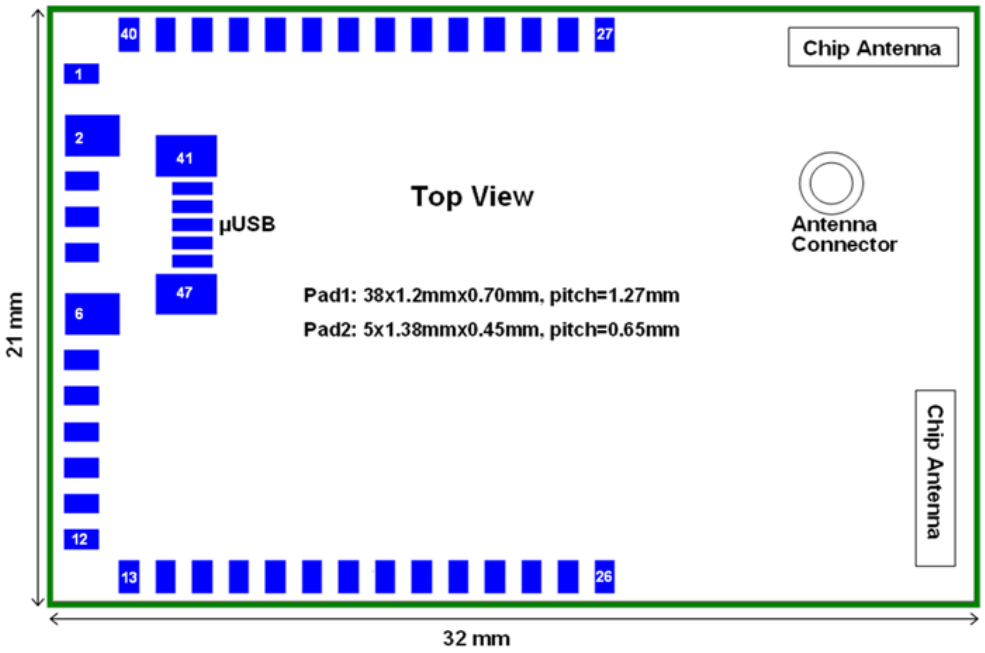

Figure 5: Pad layout of module BW2155

Table 1: BW2155 Module Pad Description

Pad	Function	Pad	Function	Pad	Function
1	PTA5/KBI1P5	17	PTC3/SCL1	33	PTB5/AD1P5
2	GND	18	PTC6	34	PTB6/AD1P6
3	+3V/Out	19	PTC7	35	VREFH
4	BKGD	20	PTE0/TXD1	36	PTA0/KBI1P0
5	RESETB	21	PTE1/RXD1	37	PTA1/KBI1P1
6	GND	22	PWR	38	PTA2/KBI1P2
7	NC	23	GND	39	PTA3/KBI1P3
8	PTA7/KBI1P6	24	+3V/Out	40	PTA4/KBI1P4
9	PTC4	25	+3V/Out	41	GND
10	PTC5	26	GND	42	GND
11	PTC4R	27	PTD7	43	+3V/Out
12	PTC5R	28	PTB0/AD1P0	44	BKGD
13	GND	29	PTB1/AD1P1	45	RESETB
14	PTC0/TXD2	30	PTB2/AD1P2	46	PWR
15	PTC1/RXD2	31	PTB3/AD1P3	47	GND
16	PTC2/SDA1	32	PTB4/AD1P4		

2.4 LEDs, Pushbutton and Temperature Sensor

Module BW2155A has two on-board LEDs, two pushbuttons and a temperature sensor. BW2155B only has LEDs on the board. The pins out of these components are listed in Table 2.

Table 2: Pushbuttons, Temperature Sensor and LED Pin Out

Modules	LED/Switch	MCU Port	I/O	Comments
All Four Versions	LED Red	PTC4	Output	LED on/off
All Four Versions	LED Green	PTC5	Output	LED on/off
BW2155A & BW2155C	Switch 1	PTA5	Input	Read Switch
BW2155A & BW2155C	Switch 2	PTA7	Input	Read Switch
BW2155A & BW2155C	Temp Sensor	PTA6	Output	Sensor on/off
BW2155A & BW2155C	Temp Sensor	AD1P7	Input	Sensor Output

2.5 µUSB Connector

The module BW2155A and & BW2155C support a µUSB connector that can be used to interface with a debugger (such as, BDM Multilink interface) to develop and debug applications. A customized cable is needed to connect the module to the Programmer/Debugger. The µUSB connector can be used to power the module with a USB power supply adapter or with a battery. For BW2155B and & BW2155D the µUSB option is not available on the module; however, connections to pads are available when the module is soldered onto a motherboard. Pin out of µUSB is shown in Table 3.

Table 3: µUSB Pin Out

Pin	Name	Cable color	Description	Comments
1	VCC	Red	Power Supply for Module	3 - 5 VDC
2	RESET	White	Used by Programmer/Debugger	MCU Pin
3	BKGD	Green	Used by Programmer/Debugger	MCU Pin
4	VDD	NA	Used by Programmer/Debugger	3.0 VDC from Module
5	GND	Black	Common Ground	

2.6 Module Integration in Host System

BW2155 is a surface mountable module and can be soldered onto a printed circuit board (PCB) or motherboard of a host system. The motherboard pad layout, recommended placement of the module onto the motherboard, and the board keep-out area are shown in Figures 6 and 7. The keep-out area around the antenna is clear of any metallic structures for best performance.

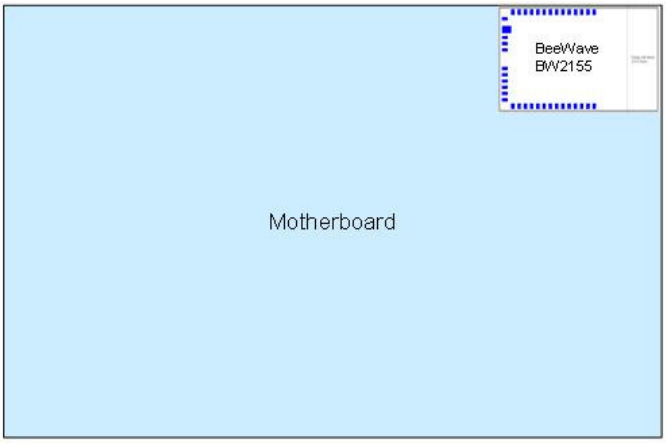

Figure 6: Recommended placement of the module on motherboard

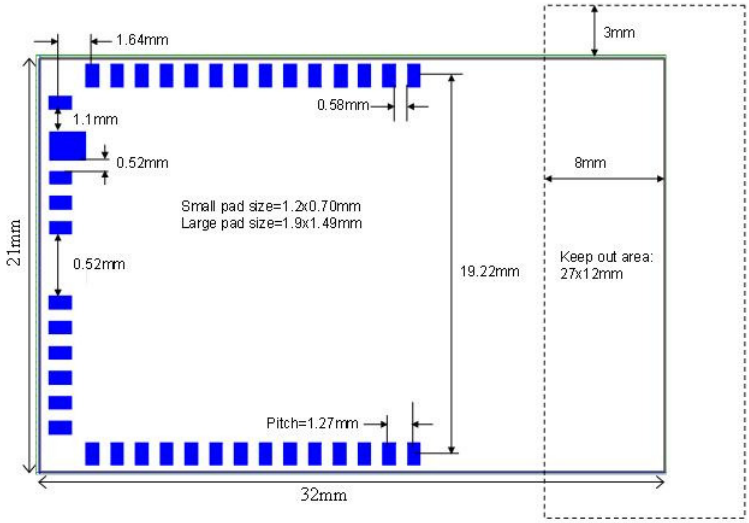

Figure 7: Recommended pad layout and keep out area for the host mother board

3. Module Specifications

Table 4: Module BW2155 Specifications

Parameter Name	BW2155	Unit
Supply voltage	3.0 to 5.0V	Volt
Frequency band	2.405-2.475	GHz
Number of channels	15	Note 1
Nominal output power	20	dBm
Sensitivity (PER 1%)	-97	dBm
Current consumption, RX	57	mA
Current consumption, TX	133	mA
Current consumption, Doze mode	40	µA
Data rate	250	kbps
Flash Memory	60/32/16	KB
RAM Memory	4/2/1	KB
Operating Temperature	-40 to +85	C

Note 1: Channel 26 at 2.480 GHz is not available for this high output power module

4. Application Development

Freescale's Simple MAC (SMAC) provides a simple and cost effective solution for wireless networking. Based on the 802.15.4 PHY, it provides command to create simple point-to-point and star networks. Freescale's CodeWarrior studio and SMAC is used to develop a program called BeeWave Test Tool Software" (BTTS). BTTS uses SMAC functions to select between transmit and receive mode, change the channels, and set the transmitter output power. BTTS and the USB HCS08/HCS12 Multilink from PE Micro can be used for programming and debugging an application program.

5. Module Operation

The transceiver MC1321x has various modes of operation including transmit mode and receive mode. The microcontroller unit (MCU) in MC1321x controls the operation of the transceiver and the RF6555 front end module (FEM). MCU's digital lines are connected to four FEM pins to control transmit and receive mode and to select one of the two antenna ports. The MCU control line and the FEM pin out connections are shown in Table 5.

Table 5: MCU Control Lines and FEM Pin Out

MCU Pins	FEM Pins	FEM Function
PTD2	CE	Chip Enable
PTD4	RX/TX	Selects Receive or Transmit Mode
PTD5	LNA	LNA/LNA Bypassed
PTD6	ANTSEL	Select ANT Port 1 or Port 2

5.1 Power Amplifier (PA) and LNA Control

Operation of PA and LNA is controlled by the MCU. In transmit mode, first PA is turned on and an antenna port is selected before activating the transmitter in MC1321x. Similarly, in receive mode LNA is turned on before activating the receiver.

5.2 Duty Cycle Considerations

The IEEE 802.15.4 Zigbee standard is a low duty cycle protocol with a low bit rate of 250 kbps. The Zigbee Alliance specifies no more than 10% duty cycle. For Zigbee transmitters with a data rate of 250 kbps, it takes 32 µs to transmit a byte. Since a Zigbee packet contains a maximum of 133 bytes, the transmitter on-time is only 4.26 ms to transmit one packet. This information can be used to calculate duty cycle for a specific application. As an example, with one full packet (133 bytes) transmitted with no acknowledgement received followed by 3 more packets transmitted, the total on-time is 17 ms. This yields a duty cycle of 17% in a 100-ms time duration as defined by FCC.
To comply with output power restrictions for this module, the user calculates the duty cycle for their specific application, and if it is greater than 10%, applies the maximum output power limit for a selected channel listed in Table 6.

5.3 Output Power Setting

Users can calculate the duty cycle for their application and the select appropriate channel and power level to meet the maximum output power limit listed in Table 6. For duty cycle up to 10% the maximum output power allowed is 20.8 dBm (Register12 setting: 0x7C) for channels 11 to 25. Channel 26 is not available for these high output power devices. To maintain FCC compliancy for a duty cycles greater than 10%, the maximum output power for a channel must be limited to values shown in Table 6. The output power is controlled by setting SPI Register 12 of transceiver MC1321x as shown in Table 6. Users can implement the output power requirements by using the power setting function, available in SMAC and MAC software from Freescale, to set the output power before a channel is selected. BeeWave Test Tool Software (BTTS) disables channel 26 and limits the transmitter output power. The software controls the transmitter power dynamically as the channel or antenna is changed during transmit operation.

Table 6: Maximum Output Power as a function for Antenna, Channel, and Duty Cycle

Antenna Type	RF Channel	Max Duty Cycle (%)	Max Output Power (dBm)	Register12 Setting
On-board Chip	11-15	17	20.8	0x7C
	16-18	100	20.8	0x7C
	19-20	67	20.8	0x7C
	21-23	30	20.8	0x7C
	24-25	17	17.4	0x78
Whip	11-15	17	10.8	0x73
	16-18	67	20.8	0x7C
	19-23	30	20.8	0x7C
	24-25	17	17.4	0x78

6. FCC Certification

6.1 FCC Notice

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.
To fulfill FCC Certification requirements, an Original Equipment Manufacturer (OEM) must comply with the following regulations:
The modular transmitter must be labeled with its own FCC ID number, and, if the FCC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module.

The OEM product containing BeeWave module may use the following of label to meet the FCC requirement.

Contains Transmitter Module FCC ID: OIPBW2155 or Contains FCC ID: OIPBW2155
The enclosed 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.

6.2 Warning

To comply with FCC's RF radiation exposure limits for general population, this module must be installed such that a minimum separation distance of 20cm is maintained between its antennas and all persons at all times. In addition this module must not be collocated with any other antenna or transmitter.

6.3 Caution

Changes or modifications not expressly approved by BeeWave Systems, LLC could void the user's authority to operate the equipment. While a product that incorporates BW2155 module does not require obtaining a new FCC authorization for the module, this does not preclude the possibility that some other form of testing or certification may be required for that product.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures: Reorient or relocate the receiving antenna, increase the separation between the equipment and receiver, connect the equipment into an outlet on a circuit different from that to which the receiver is connected, or consult the dealer or an experienced radio/TV technician for help.

6.4 Host System Labeling

To fulfill the FCC labeling requirements, a clearly visible label is required to be placed on the outside of the host enclosure specifying BeeWave FCC identifier for this module as well as the FCC Notice above. The FCC identifier is FCC ID: OIPBW2155. This FCC ID is valid for both versions of module BW2155. The BW2155 module is labeled with its own FCC ID Number. If the FCC ID is not visible when the module is installed inside a host device, then a label is required to be placed on the outside of the device into which the module is installed. The label on the outside of the host enclosure may use wording such as: "Contains Module FCC ID: OIPBW2155".

6.5 Approved Antenna List

The device BW2155 has been tested to comply with FCC CFR Part 15 using two on-board chip antennas and one Whip antenna. The module is tested using chip antenna 1 and the Whip antenna 3, listed in Table 7. Since antenna 1 and 2 are the same type and antenna 2 has smaller gain, it is deemed to comply with FCC CFR Part by similarity.

The modules (BW2155A and BW2155B) with antenna connector can only be used by OEM to install a Whip antenna on the board and place the board and the Whip antenna in an enclosure. When integrating this module into the OEM's products, a Whip antenna other than item 3 in Table 7 must be tested to comply with FCC emissions.

Table 7: Approved Antenna List

Antenna	Type	Part Number	Manufacturer	Freq Band	Gain (dBi)	Comment
1	Chip	2450AT43A100E	Johanson Tech.	2.45 GHz	2.0	On-board
2	Chip	2450AT18B100E	Johanson Tech.	2.45 GHz	0.5	On-board
3	Whip	0600-00014	Laird Tech.	2.40 GHz	2.0	External

Note: The Whip antenna has RP-SMA termination

7. Contact Information

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