BitPipe IoT Interface™
Cellular devices

Datasheet

Rev 1.4

13/06/2018

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1. Document revision history

Revision	Date	Comments
1.0	2016-08-22	Initial releases
1.1	2016-11-04	Added BP43G1-US-UFL 4G LTE Device specifications. Update of general technical information and addition of Conformity statements
1.2	2017-06-09	Updated information regarding for the new firmware FW1.1 API1. Added USB interface information.
1.3	2018-03-13	Added BP4T1-USV-UFL Added alternative user connector Part Number
1.4	2018-06-13	Added BP43T4-US-UFL Removal of 4mm Connector option

2. Overview

The Bitpipe IoT Interface™ is a family of fully integrated compact wireless interface devices that allow you to rapidly and easily deploy IoT solutions, reduce R&D costs and accelerate time to market. Out of the box our BitPipe devices incorporate everything you need to provide IoT connectivity including a certified cellular radio, DC-DC converter, digital and analog inputs & outputs, serial communications and a software API. Our devices support multiple radio technologies and are form and fit interchangeable with other BitPipe family devices.

Product	Radio Technologies	USB	RF connector	SIM
BP32G-W-UFL	2G, 3G	Yes	1x U.FL	SIM-Card (3FF)
BP43G1-US-UFL	3G, LTE-Cat1	Yes	2x U.FL	SIM-Card (3FF)
BP4T1-USV-UFL	LTE-Cat1 for Verizon	Yes	2x U.FL	SIM-Card (3FF)
BP43T4-US-UFL	3G, LTE-Cat4	Yes	2x U.FL	SIM-Card (3FF)

Table 2.1: Products covered by this Datasheet

3. RF compatibility

3.1. BP32G-W-UFL

Technology	Frequency bands	Maximum Data rate Downlink	Maximum Data rate Uplink
GSM/GPRS/EDGE (2G)	850, 900, 1800, 1900MHz	236.8kbps	236.8kbps
UMTS/HSPA+ (3G)	800, 850, 900, 1900, 2100MHz	7.2Mbps	5.7Mbps

Table 3.1: BP32G-W-UFL RF compatibilities

3.2. BP43G1-US-UFL

Technology	Frequency bands	Maximum Data rate Downlink	Maximum Data rate Uplink
UMTS/HSPA+ (3G)	850, 1700/2100(AWS), 1900MHz	7.2Mbps	5.7Mbps
LTE-Cat1 (4G)	700, 850, 1700/2100(AWS), 1900MHz	10.2Mbps	5.2Mbps

Table 3.2: BP43G1-US-UFL RF compatibilities

3.3. BP4T1-USV-UFL

Technology	Frequency bands	Maximum Data rate Downlink	Maximum Data rate Uplink
LTE-Cat1 (4G)	700, 1700/2100(AWS), 1900MHz	10.2Mbps	5.2Mbps

Table 3.3: BP4T1-USV-UFL RF compatibilities

3.4. BP43T4-US-UFL

Technology	Frequency bands	Maximum Data rate Downlink	Maximum Data rate Uplink
UMTS/HSPA+ (3G)	850, 1900MHz	42.2Mbps	5.76Mbps
LTE-Cat4 (4G)	700, 850, 1700/2100(AWS), 1900MHz	150Mbps	50Mbps

Table 3.4: BP43T4-US-UFL RF compatibilities

4. Operating modes

BitPipe devices provide two different modes of operation; Autonomous and Modem. The mode is selected according to the state of the "Autonomous/Modem" mode pin after powering on the device and boot up of the onboard microcontroller.

4.1. Autonomous mode

In Autonomous mode, the device operates without the need of an external processor. Once powered on, it will automatically connect to the cellular network and establish a connection to the pre-configured server. Using MQTT messages, the device will act as a remote controller. The 4 GPIOs are available for monitoring or controlling, and the I2C interface can be used to communicate with sensors. In this mode, the USB interface is not activated and the Serial Communication interface (UART) is only used to Read / Write the connection information to the non-volatile memory of the microcontroller (Cellular carrier APN & PIN, Server address, Username & Password). Please see Section 9.1 for more details.

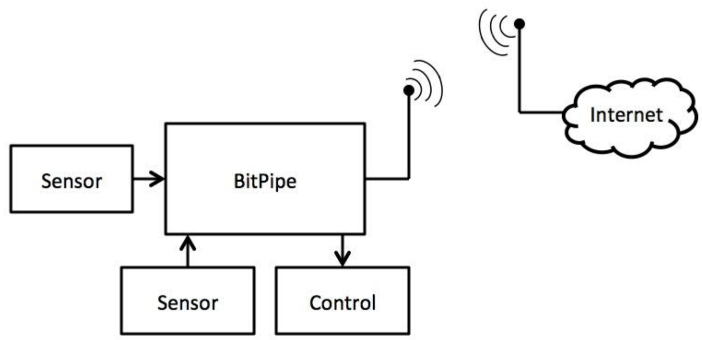


Figure 4.1: BitPipe Autonomous Mode simplified block diagram

4.2. Modem mode

In Modem mode, an external processor communicates with the BitPipe device through either the UART interface or the USB interface. It is recommended for external host microcontrollers to activate the UART interface, leveraging the communications capabilities of the BitPipe Serial API. The API provides the means to exchange data with any server over the Internet using TCP, HTTP and MQTT protocols. In addition, the API provides an efficient way to send and receive SMS messages. For external host microprocessors, mainly running on Linux OS, it is recommended to activate the USB interface and use the standard network interface to communicate over the internet. I2C pin strapping and GPIO-0 control allows UART-less operation when the USB interface is used. Please see Section 9.2 for more details.

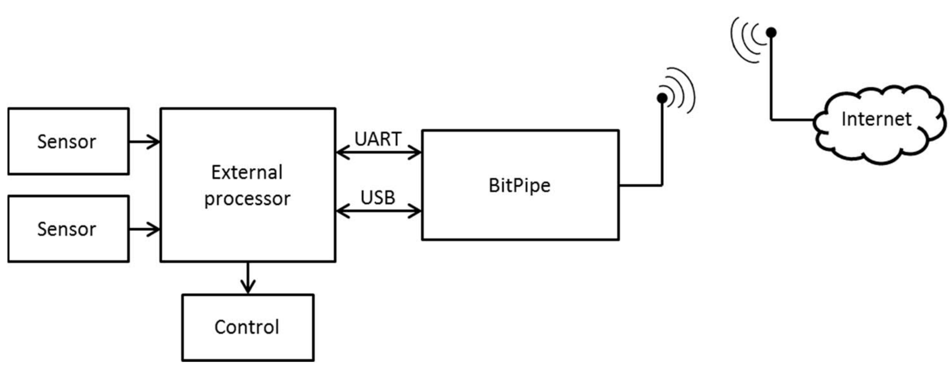


Figure 4.2: BitPipe Modem Mode simplified block diagram

4.3. Low Power mode

When used in "Modem with UART" mode, it is possible to put the device into a Low Power state through an API command. In this state, the Radio is powered down and the onboard microcontroller stops all activities, waiting to be woken up by any transitions on the UART serial communication interface. Please see Section 9.3 for more details.

5. BitPipe IoT Interface™

5.1. BitPipe standardized user interface

The BitPipe User Connector provides a standardized interface that is common throughout all BitPipe family of devices. The following is a detailed description of the interface.

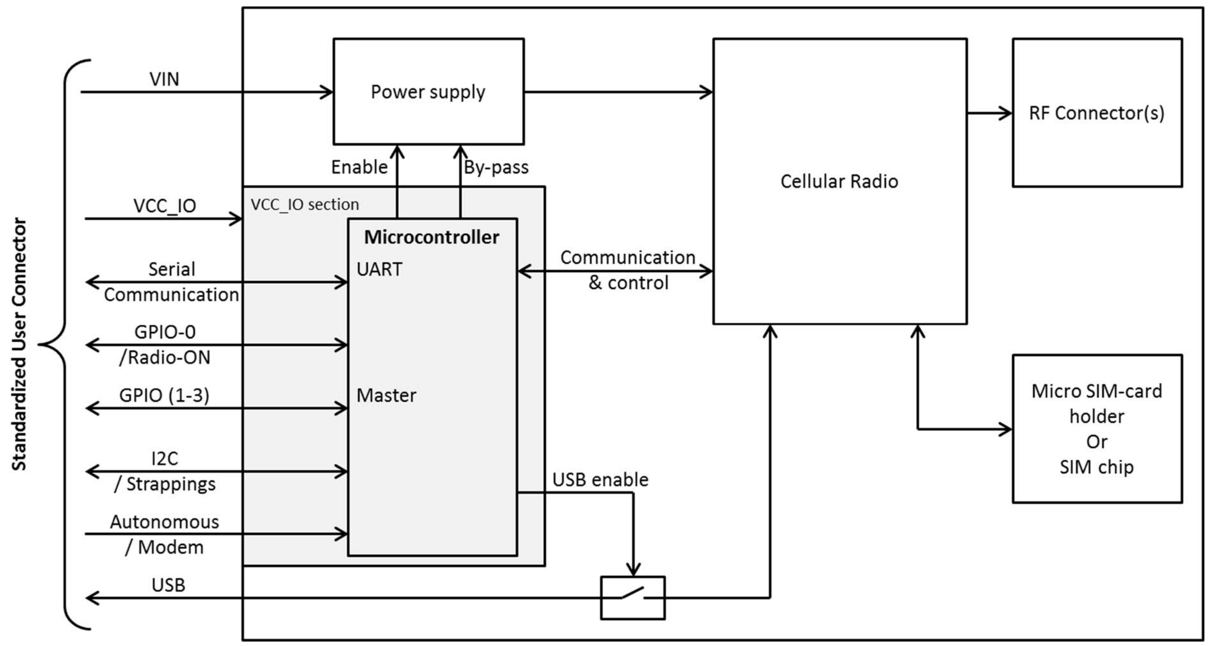


Figure 5.1: Simplified BitPipe wireless device block diagram

5.1.1. VIN & DC-DC converter

Main supply input VIN. Powers the cellular radio and will accept a wide voltage range of 3.4Vdc to 18Vdc. An onboard DC-DC buck converter when in Autonomous mode can be enabled for VIN voltages of 4.75Vdc to 18Vdc, or bypassed when VIN is between 3.4Vdc and 4.5Vdc. Bypass mode should mainly be used when powered directly from a lithium battery.

In Autonomous mode, the onboard microcontroller will measure the VIN voltage before powering-on the radio and select the appropriate DC-DC or bypass mode automatically.

In Modem mode, the external processor controls selection of the DC-DC converter or bypass mode when sending the "Power-On Radio" command (See BitPipe API documentation for more details). The onboard microcontroller will measure VIN to ensure the actual voltage is within the required range prior to execution of the command.

5.1.2. VCC_IO

Communication interfaces and GPIOs power input VCC_IO. To simplify device integration, the communication interfaces and GPIOs are powered through a separate VCC_IO supply pin, independent from the VIN main supply. VCC_IO supports a voltage range of 2.4Vdc to 3.6Vdc, allowing direct connectivity to an external processor when applicable.

5.1.3. Serial communication (UART)

Device communication interface. Mainly used when in Modem mode, this is the communication interface between the BitPipe device and an external processor. In Autonomous mode, this interface is used to Read/Write connection information to the onboard microcontroller non-volatile memory. Serial communication settings are the following:

- Baud rate: 115200 bps
- Data: 8 bits
- Parity: None
- Flow control: None
- Stop bit: 1

The UART pins are powered by the VCC_IO supply. Leave these pins unconnected when not used.

5.1.4. GPIO

In Autonomous mode, the device provides four (4) general-purpose input/output (GPIO) pins that can be configured as digital input, digital output, analog input and pseudo-analog output. At power-up, all GPIO pins are high impedance input (Hi-Z) until a connection to the pre-configured server has been established. After a successful connection to the server, the GPIOs will be configured according to the settings found on the server and thereafter kept in sync based on MQTT messages. Digital inputs and outputs are TTL and CMOS compatible. Refer to Section 7.2 for Recommended Operating Conditions.

Analog inputs use a precision ADC (Analog to Digital Converter) and can read voltages from 0V to VCC_IO. The Pseudo Analog Outputs are based on high frequency PWM (Pulse width modulation) and require external filtering for precise applications. Refer to application note AN0030 for more details on settings and limits.

In Modem mode, the GPIO_1, GPIO_2 and GPIO_3 are disabled and put into high impedance (HI-Z) state. In “Modem with USB” mode, the GPIO_0 may be used to control the radio power ON/OFF state providing a UART-less operation. The rising edge emulates the API “Power-On Radio” command and the falling edge emulates the API “Power-Off Radio” command with graceful deregistration from network.

The GPIOs pins are powered by the VCC_IO supply. Leave GPIO pins unconnected when not used.

5.1.5. I2C / Strappings

In Autonomous mode, the BitPipe device provides a dedicated I2C master interface running in Standard Mode at 100kbps. This interface can be used to communicate with additional devices such as temperature sensors, accelerometers or GPS. The required pull-up resistors to VCC_IO on both I2C_CLK and I2C_DAT signals are not provided on the device and must be installed on the users baseboard PCB. Refer to Table 7.2 for recommended pull-up resistor values. In Autonomous mode, I2C pins should both be concurrently pulled-up, left unconnected or pulled-down to GND when not used.

In Modem mode, the I2C pins are used to select the UART or USB as the communication interface. Please see Table 5.1 for the I2C pin strapping combinations.

I2C_CLK	I2C_DAT	Mode
0	0	Modem with UART
0	1	Reserved
1	0	Reserved
1	1	Modem with USB

Table 5.1: I2C Strappings

At BitPipe boot-up, the pins are sampled at the exact same time as the "Autonomous / Modem" pin. Thereafter, they are continuously monitored for changes. The transition from 0,0 state to 1,1 state or the transition from 1,1 state to 0,0 state will force a graceful deregistration from the network, followed by a reboot of the BitPipe in the new selected mode. When changing from one mode to the other, both pins must have completed their transition in less than 100ms to avoid falling in the "Reserved" states.

5.1.6. Autonomous / Modem

The Autonomous/Modem pin is read when the onboard microcontroller boots-up (upon detection of the rising edge of VCC_IO) and selects if the device will be used in Autonomous or Modem mode. This signal is ignored until the next boot-up of the microcontroller.

When shorted to VCC_IO, the device will boot-up in Autonomous mode. When shorted to GND or left unconnected, the device will boot-up in Modem mode. This pin is pulled down by an internal 100k ohm resistor. Please read Section 9 for more details about those two operating modes.

5.1.7. USB

The USB interface is only available in Modem mode and is directly linked to the BitPipe cellular radio module. The BitPipe Serial API, and the associated radio abstraction layer is not used when communicating through the USB interface. Note that BitPipe Cellular Modems may have a slightly different procedure to integrate it in your operating system depending on model used. Please refer to Application note AN0031 for more information on operating system integration.

When using the USB communication interface, The GPIO-0 controls the power state of the radio.

5.1.8. User connector pin-out

All BitPipe family of devices are defined with the same user connector pin-out. Refer to Table 5.2 for connector signal allocations.

Group	PIN#	Function	Description	Type
Power	8	VIN	Main dc input supply voltage for cellular radio	PWR
	9	VIN	Main dc input supply voltage for cellular radio	PWR
	12	VIN	Main dc input supply voltage for cellular radio	PWR
	4	VCC_IO	Input output signal dc supply voltage	PWR
	1	GND	Ground return for supply voltages	GND
	10	GND	Ground return for supply voltages	GND
	11	GND	Ground return for supply voltages	GND
	17	GND	Ground return for supply voltages	GND
	20	GND	Ground return for supply voltages	GND
Communication	18	UART_RX	Serial interface, UART receive data	I
	19	UART_TX	Serial interface, UART transmit data	O
GPIOs	13	GPIO_0	General purpose input or output	I/O
	14	GPIO_1	General purpose input or output	I/O
	15	GPIO_2	General purpose input or output	I/O
	16	GPIO_3	General purpose input or output	I/O
I2C	7	I2C_DAT	I2C data signal (Note 1)	I/O
	6	I2C_CLK	I2C clock signal (Note 1)	I/O
Control	5	Autonomous / Modem	Autonomous or Modem mode select (Note 2)	I
USB	2	USB_P	USB positive signal (Data+)	I/O
	3	USB_N	USB negative signal (Data-)	I/O

Table 5.2: User Connector Pin-out

Note 1 Requires external pull-up resistor (See Table 7.2)
Note 2 Internal 100k ohm pull-down resistor

PWR Power
GND Ground
I Input
O Output
I/O Input or Output

5.1.9. User connector and standoff height combinations

BitPipe devices can be mechanically fixed to a user provided baseboard PCB using an M2 screw (ex; B&F Fastener #MPMS 002 0005 PH). The user mating connector is available in 2 heights (3mm and 5mm). The standoff receiving the M2 screw must be selected with an equivalent height. The following table provides suggested part number combinations for both stack heights.

Stack height	User connector	Mechanical post (Wurth Electronics Inc)
3 mm	BW420C330 AXN420330 AXN420C330	9774030243R
5 mm	BW420C530 AXN420530 AXN420C530	9774050243R

Table 5.3: Connectors and mechanical posts

Top view of user provided baseboard showing mating connector orientation and pin positions.

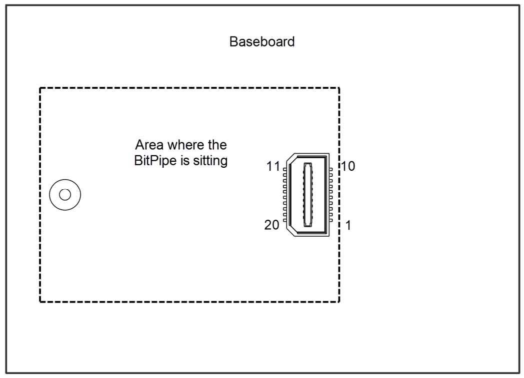


Figure 5.2: User connector pin position (top view)

5.2. BitPipe standardized cellular interface

BitPipe devices incorporating a cellular radio require a subscriber identity module (SIM) and suitable RF antenna in order to establish reliable connection to a cellular network. For convenience, these standard interfaces are provided as follows.

5.2.1. Micro SIM-card holder or SIM-chip

BitPipe devices are available with ether a micro SIM-card holder or a SIM-chip, depending on the selected family member. The micro SIM-card holder is a Push-Push type and accepts an industry standard 3FF SIM-Card (micro-SIM) form factor. If the SIM is removed during operation, the SIM interface is shut down immediately to prevent it from being damaged. An off-on power cycle is required to re-initialize the SIM interface.

The SIM-chip is a component soldered directly to the BitPipe circuit board and serves the same purpose as the SIM-Card. Not all mobile network operators (MNO) support the SIM-chip; please contact Briowireless for more information.

5.2.2. RF connector

BitPipe devices are available with SMA or U.FL Antenna RF connector(s) depending on the selected family member. In either case, the connection is electrically matched to a 50Ω transmission line.

5.2.3. RF antenna (user provided)

The user must provide a suitable antenna for their end application. The RF interface has an impedance of 50Ω. The BitPipe module is capable of sustaining a total mismatch at the antenna line without any damage, even when transmitting at maximum RF power.

The external antenna must be matched properly to achieve best performance regarding radiated power, modulation accuracy and harmonic suppression.

State of Module	Return loss of Module	Recommended return loss of application
Receive	≥ 8dB	≥ 12dB
Transmit	Not applicable	≥ 12dB

Table 5.4: Return loss in the active band

Refer to Section 10 for Regulatory and Conformity Statements regarding RF compliance.

6. Mechanical

6.1. BitPipe standardized mechanical features

One key feature of the BitPipe family of products is the inter-changeability between all devices. To make this possible, the most important mechanical parameters have been standardized to ensure physical compatibility between current and future BitPipe family products.

6.1.1. Dimensions and locations

The outside dimensions, user connector location, component thickness on both top and bottom and mechanical mounting hole location have been standardized as described in Figure 6.1. The component thickness on top (2.8mm) and bottom (3mm) are maximum values. Please refer to 3D files (.STEP) available for download on the Briowireless website for tighter design constraints.

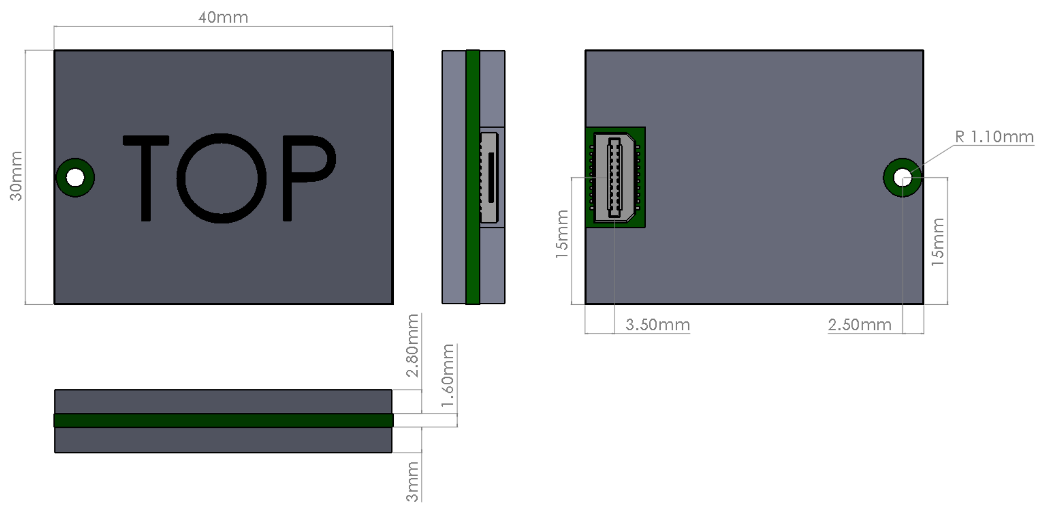


Figure 6.1: BitPipe IoT Interface™ standardized mechanical dimensions

6.1.2. U.FL RF connector location

The locations of the U.FL connectors are not precisely defined in the BitPipe family. However, they will always be placed on the topside and within the first 10mm at the front of the device, close to the mechanical mounting hole. This reserved zone is illustrated in Figure 6.2 with the "U.FL" marked area.

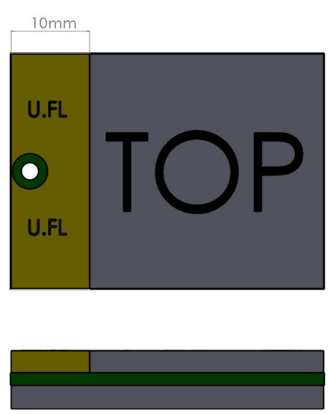


Figure 6.2: U.FL connector(s) location

6.1.3. SMA RF connector location

Available in some BitPipe family members, the SMA RF connector(s) location has been standardized for easy panel mount designs. Figures 6.3 and 6.4 show detailed SMA connector locations and dimensions for device single and dual SMA variations respectively.

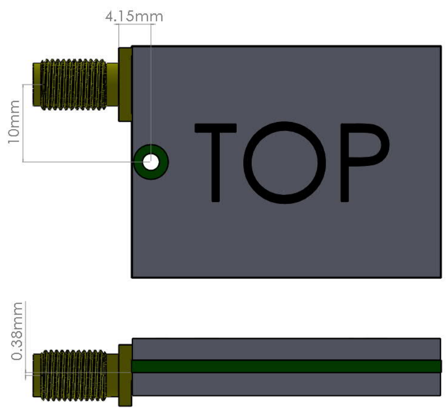


Figure 6.3: Single SMA version

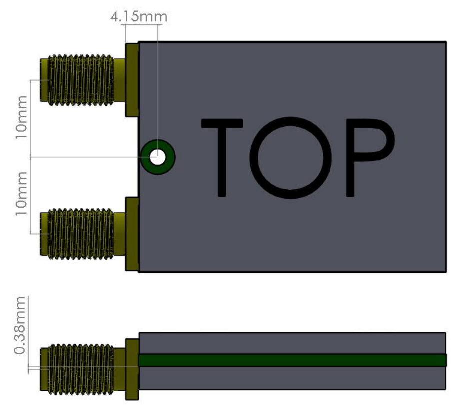


Figure 6.4: Dual SMA version

6.2. Cellular BitPipe device mechanical features

BitPipe cellular devices are available with an industry standard 3FF SIM-Card holder, allowing the user to easily install and remove a client SIM-Card.

6.2.1. SIM-Card holder

The SIM-Card holder is mainly associated with cellular based products. The holder is a Push-Push type and its location has been standardized on all BitPipe cellular devices. Refer to Figure 6.5 for details on the location of the SIM-Card holder with a SIM-Card inserted.

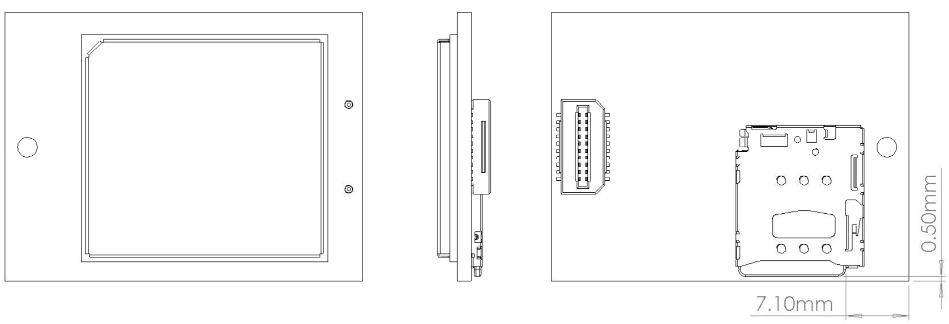


Figure 6.5: SIM-Card position while inserted

7. Electrical specifications

7.1. Absolute maximum voltage ratings

The absolute maximum ratings stated in Table 7.1 are stress ratings under any conditions. Stresses beyond any of these limits will cause permanent damage to the BitPipe device.

Signal name	Pin number	Min	Max
VIN	8, 9, 12	-0.3V	+20V
VCC_IO	4	-0.3V	+4.0V
A/M Control, I2C, GPIO, UART	5, 6, 7, 13, 14, 15, 16, 18, 19	-0.3V	+4.0V
USB	2,3	-0.3V	+5.25V

Table 7.1: Absolute maximum ratings

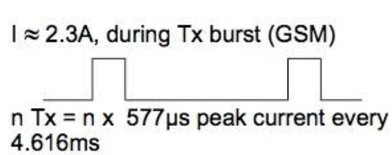
7.2. Recommended operating conditions

Parameter		Condition	Min	Typ	Max	Unit
Powers						
VIN		DC-DC Bypassed (Note 2)	3.4		4.5	V
		DC-DC enabled	4.75		18	V
VCC_IO			2.4		3.6	V
UART, Autonomous / Modem, GPIO (digital)						
V_{IL}	Low level input voltage		0		(0.3 x VCC_IO) + 0.07	V
V_{IH}	High level input voltage		(0.445 x VCC_IO) + 0.4		VCC_IO	V
V_{OL}	Low level output voltage	I_{OL} = -8 mA	0		0.4	V
V_{OH}	High level output voltage	I_{OH} = 8 mA	VCC_IO – 0.4		VCC_IO	V
I_{OL}	Low level output current				-8	mA
I_{OH}	High level output current				8	mA
GPIO (analog)						
V_{AI}	Voltage input range		0		VCC_IO	V
V_{AO}	Voltage output range	Pseudo-analog Output	0		VCC_IO	V
I_{AO}	Output current	Pseudo-analog Output	-8		8	mA
F	PWM Frequency	Pseudo-analog Output		480		KHz
I2C						
Pull-up resistors value				2.2		kΩ
Pull-up voltage		Pull-up = 2.2kΩ		VCC_IO		V
V_{IH}	High level input voltage	Pull-up = 2.2kΩ	(0.5 x VCC_IO) + 0.2		VCC_IO	V
V_{IL}	Low level input voltage	Pull-up = 2.2kΩ	0		(0.475 x VCC_IO) - 0.2	V
V_{OL}	Low level output voltage	Pull-up = 2.2kΩ			0.4	V
I_{OL}	Low level output current	Low level output current			-8	mA
USB						
	All		Respects the USB 2.0 Specification			
Temperature						
Operating temperature		(Note 1)	-40	+25	+85	C

Table 7.2: Recommended operating conditions

Note 1: The Cellular radio is protected by thermal shutdown. The temperature sensor precision is +/- 3 Deg C

Note 2: Maximum allowed voltage drop on VIN of 400mV during 2G GSM transmit burst. Battery or power supply output low ESR capacitor should be chosen in accordance to this limit.



7.3. Electro-Static Discharge (ESD) & Fast Transient Burst (FTB) protection

BitPipe devices are compliant to IEC61000-4-2 for ESD and IEC61000-4-4 for FTB. Excessive ESD discharge may lead to irreversible damage to the device. It is advisable to implement and adhere to industry standard ESD control guidelines related to handling and storage of electronic devices at manufacturing and assembly sites.

Important: The developer is responsible to include adequate ESD and FTB protection on their Baseboard design, according to their end application.

8. Power consumption

8.1. BP32G-W-UFL

8.1.1. VCC_IO

Operating mode	VCC_IO voltage	Average		Unit
		FW1.0	FW1.1	
Low Power Mode	2.5V	7.1	7.1	uA
	3.3V	8.5	8.5	
Normal Operating Mode	2.5V	17.8	1.4	mA
	3.3V	19.1	1.8	

Table 8.1: BP32G-W-UFL VCC_IO Current Consumption

8.1.2. VIN

Operating mode	VIN voltage	Average	Unit
Shutdown DC-DC converter = OFF Bypass = Disabled	3.4V	3.2	uA
	4.5V	4.4	
	5V	4.9	
	9V	10.0	
	12V	12.0	
	15V	16.0	
	18V	19.0	
2G Idle Connected to 2G network No data transfer	3.4V	14.0	mA
	4.5V	14.0	
	5V	16.4	
	9V	12.0	
	12V	10.5	
	15V	9.0	
	18V	7.5	
3G Idle Connected to 3G network No data transfer	3.4V	13.0	mA
	4.5V	13.0	
	5V	15.4	
	9V	11.3	
	12V	9.9	
	15V	8.4	
	18V	7.0	

Table 8.2: BP32G-W-UFL VIN Current Consumption at Idle & Shutdown

Operating mode	VIN voltage	GPRS 850/900 Average (Peak)	EDGE 1800/1900 Average (Peak)	Unit
2G TX (4tx/1rx)	3.4V	0.79 (1.60)	0.43 (1.60)	A
	4.5V	0.79 (1.60)	0.43 (1.60)	
	5V	0.67 (1.45)	0.36 (1.45)	
	9V	0.37 (0.78)	0.21 (0.78)	
	12V	0.29 (0.60)	0.16 (0.60)	
	15V	0.24 (0.49)	0.13 (0.49)	
	18V	0.20 (0.41)	0.11 (0.41)	
2G RX (1tx/4rx)	3.4V	0.24 (1.6)	0.15 (1.60)	A
	4.5V	0.24 (1.6)	0.15 (1.60)	
	5V	0.20 (1.45)	0.13 (1.45)	
	9V	0.12 (0.78)	0.08 (0.79)	
	12V	0.09 (0.60)	0.06 (0.60)	
	15V	0.08 (0.49)	0.05 (0.49)	
	18V	0.07 (0.41)	0.05 (0.41)	

Table 8.3: BP32G-W-UFL VIN Current Consumption 2G data transfer

Operating mode	VIN voltage	UMTS Band I Average	HSPA Band VIII Average	Unit
3G TX / RX	3.4V	0.50	0.58	A
	4.5V	0.50	0.58	
	5V	0.42	0.49	
	9V	0.24	0.28	
	12V	0.18	0.21	
	15V	0.15	0.18	
	18V	0.13	0.15	

Table 8.4: BP32G-W-UFL VIN Current Consumption 3G data transfer

8.2. BP43G1-US-UFL

8.2.1. VCC_IO

Operating mode	VCC_IO voltage	Average		Unit
		FW1.0	FW1.1	
Low Power Mode	2.5V	7.4	6.8	uA
	3.3V	8.7	8.2	
Normal Operating Mode	2.5V	12.7	1.2	mA
	3.3V	14.1	1.2	

Table 8.5: BP43G1-US-UFL VCC_IO Current Consumption

8.2.2. VIN

Operating mode	VIN voltage	Average	Unit
Shutdown DC-DC converter = OFF Bypass = Disabled	3.4V	1.2	uA
	4.5V	1.4	
	5V	1.4	
	9V	2.0	
	12V	2.4	
	15V	3.0	
	18V	3.8	
3G Idle Connected to 3G network No data transfer DRX = 6	3.4V	11.0	mA
	4.5V	11.0	
	5V	13.1	
	9V	9.7	
	12V	8.5	
	15V	7.2	
	18V	6.0	
4G LTE Idle Connected to 4G LTE network No data transfer DRX = 64 cycles	3.4V	13.0	mA
	4.5V	13.0	
	5V	15.4	
	9V	11.3	
	12V	9.9	
	15V	8.4	
	18V	7.0	

Table 8.6: BP43G1-US-UFL VIN Current Consumption at Idle & Shutdown

Operating mode	VIN voltage	HSPA 850 Band 5 Average	UMTS 1900 Band 2 Average	Unit
3G TX / RX	3.4V	0.31	0.49	A
	4.5V	0.31	0.49	
	5V	0.26	0.41	
	9V	0.15	0.24	
	12V	0.12	0.18	
	15V	0.10	0.15	
	18V	0.09	0.13	

Table 8.7: BP43G1-US-UFL VIN Current Consumption 3G data transfer

Operating mode	VIN voltage	LTE 850 Band 5 Average	LTE 1700/2100 Band 4 Average	Unit
4G LTE TX / RX	3.4V	0.36	0.57	A
	4.5V	0.36	0.57	
	5V	0.30	0.48	
	9V	0.17	0.27	
	12V	0.13	0.21	
	15V	0.11	0.17	
	18V	0.10	0.15	

Table 8.8: BP43G1-US-UFL VIN Current Consumption LTE data transfer

8.3. BP4T1-USV-UFL

8.3.1. VCC_IO

Operating mode	VCC_IO voltage	Average	Unit
Low Power Mode	2.5V	1.4	uA
	3.3V	1.7	
Normal Operating Mode	2.5V	1.0	mA
	3.3V	1.4	

Table 8.9: BP4T1-USV-UFL VCC_IO Current Consumption

8.3.2. VIN

Operating mode	VIN voltage	Average	Unit
Shutdown DC-DC converter = OFF Bypass = Disabled	3.4V	1.2	uA
	4.5V	1.4	
	5V	1.4	
	9V	2.0	
	12V	2.4	
	15V	3.0	
	18V	3.8	
4G LTE Idle Connected to 4G LTE network No data transfer	3.4V	13.0	mA
	4.5V	13.0	
	5V	15.4	
	9V	11.3	
	12V	9.9	
	15V	8.4	
	18V	7.0	

Table 8.10: BP4T1-USV-UFL VIN Current Consumption at Idle & Shutdown

Operating mode	VIN voltage	LTE 700, 1700/2100(AWS), 1900MHz Average	Unit
4G LTE TX / RX	3.4V	0.50	A
	4.5V	0.50	
	5V	0.42	
	9V	0.24	
	12V	0.19	
	15V	0.15	
	18V	0.13	

Table 8.11: BP4T1-USV-UFL VIN Current Consumption LTE data transfer

8.4. BP43T4-US-UFL

8.4.1. VCC_IO

Operating mode	VCC_IO voltage	Average	Unit
Low Power Mode	2.5V	1.4	uA
	3.3V	1.7	
Normal Operating Mode	2.5V	1.0	mA
	3.3V	1.4	

Table 8.12: BP43T4-US-UFL VCC_IO Current Consumption

8.4.2. VIN

Operating mode	VIN voltage	Average	Unit
Shutdown DC-DC converter = OFF Bypass = Disabled	3.4V	1.2	uA
	4.5V	1.4	
	5V	1.4	
	9V	2.0	
	12V	2.4	
	15V	3.0	
	18V	3.8	
3G Idle Connected to 3G network No data transfer	3.4V	15.0	mA
	4.5V	15.0	
	5V	17.6	
	9V	12.8	
	12V	11.2	
	15V	9.5	
	18V	8.0	
4G LTE Idle Connected to 4G LTE network No data transfer	3.4V	13.0	mA
	4.5V	13.0	
	5V	15.4	
	9V	11.3	
	12V	9.9	
	15V	8.4	
	18V	7.0	

Table 8.13: BP43T4-US-UFL VIN Current Consumption at Idle & Shutdown

Operating mode	VIN voltage	DC-HSPA+ 850 ,1900MHz Average	Unit
3G TX / RX	3.4V	0.44	A
	4.5V	0.44	
	5V	0.37	
	9V	0.21	
	12V	0.16	
	15V	0.14	
	18V	0.12	

Table 8.14: BP43T4-US-UFL VIN Current Consumption 3G data transfer

Operating mode	VIN voltage	LTE 700, 850, 1700/2100(AWS), 1900MHz Average	Unit
4G LTE TX / RX	3.4V	0.50	A
	4.5V	0.50	
	5V	0.42	
	9V	0.24	
	12V	0.19	
	15V	0.15	
	18V	0.13	

Table 8.15: BP43T4-US-UFL VIN Current Consumption LTE data transfer

9. Start-up and timings

This section describes device power-up behaviour and timings. There are no particular power-up sequences to respect for the VIN and VCC_IO supply inputs. VCC_IO is used to supply the onboard microcontroller and VIN is used to supply the Radio. As soon as VCC_IO is present, the microcontroller will boot keeping the UART and GPIOs signals in high impedance (HI-Z) to avoid any contentions. 3.5ms after stabilisation of VCC_IO, the I2C pins will momentarily be weakly pulled down (50 Kohm) followed by the sampling of "Autonomous / Modem" (A / M) and I2C pins. Floating pins will be sampled as logic-low state. The sampled values direct the device to boot in Autonomous or Modem mode and activate ether of the UART or the USB as the communication interface. The "Autonomous / Modem" signal will be ignored until next power-up.

9.1. Autonomous mode

When the "Autonomous / Modem" (A / M) pin is sampled in a logic-high state, the device will continue the booting process in Autonomous mode. The onboard microcontroller will wait for VIN to be present then automatically start the UART communication interface and radio simultaneously.

The UART serial communication interface is ready 425ms following the stabilisation of VIN. The GPIOs and I2C signals are kept in HI-Z, USB is disabled. At that point, the microcontroller is fully booted and can receive API commands for carrier network and MQTT server pre-configuration settings.

If VIN is between 3.4Vdc and 4.5Vdc, the device will assume it is being supplied by a Lithium battery and will activate the onboard high efficiency Bypass switch. Important to note; when the bypass switch is activated, the radio is directly connected to VIN. User designs must ensure the VIN voltage does not exceed 4.5V at any time when the Bypass switch is activated. Doing so could result in permanent damage to the radio. If VIN is between 4.75Vdc and 18Vdc, the device will automatically activate the DC-DC Buck converter. After the internal supply is stabilised, the radio will automatically boot.

Figure 9.1 illustrates the scenario whereby VIN is already present at the moment the microcontroller activates the radio and Figure 9.2, the scenario where VIN arrives later.

Cellular radio-boot time is radio dependant as indicated in Table 9.1. This time does not include the carrier network connection time that is carrier dependant.

Once the radio is booted, the process continues with the automatic connection to the carrier network using the pre-configured PIN (if required) and APN. The microcontroller will then use the pre-configured information to establish the connection with the MQTT broker (Server address, Username & Password). Finally, the GPIOs and I2C will be configured and kept in sync with the information found on the MQTT broker.

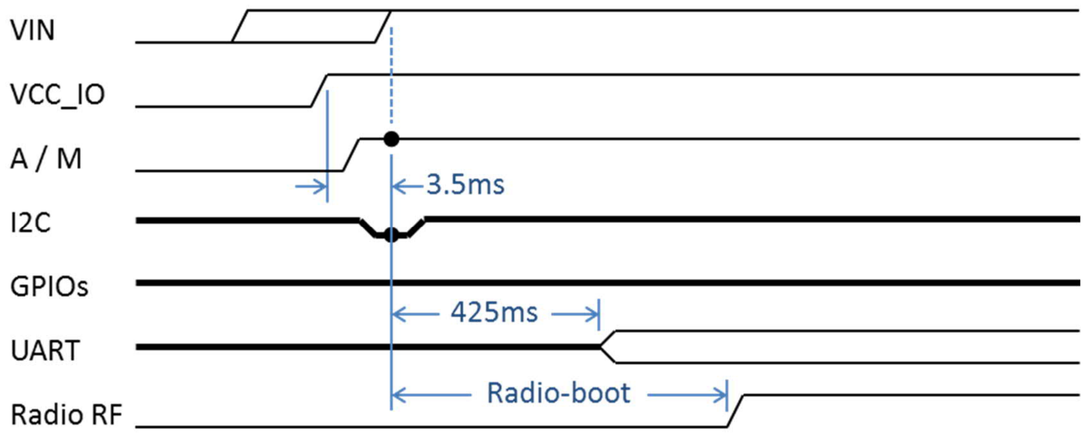


Figure 9.1: Autonomous mode timing when VIN present before A / M sampling

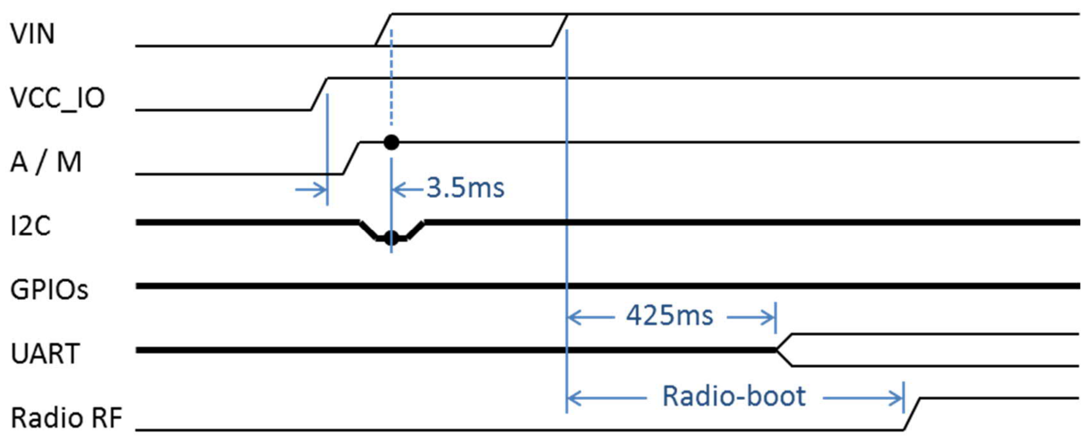


Figure 9.2: Autonomous mode timing when VIN present after A / M sampling

9.2. Modem mode

When the "Autonomous / Modem" pin (A / M) pin is sampled in a logic-low state, the onboard microcontroller will continue the booting process in Modem mode. If I2C pins were sampled at logic-low state, the UART communication interface is activated. If the I2C pins were sampled at logic-high state, the USB communication interface is activated. Figure 9.3 and Figure 9.4 illustrate UART and USB boot sequences respectively.

9.2.1. Modem mode with UART

When UART is selected as the communication interface, it is activated 7ms following the stabilisation of VCC_IO. GPIOs 1 to 3 are kept in HI-Z and the GPIO-0 and I2C pins are weakly pulled-down with 50Kohm resistors. At that point, the microcontroller is fully booted and can receive API commands for configuration and communication. If at any time, the I2C pins are detected in a state other than both in Logic-Low, the BitPipe will force a graceful deregistration from network followed by a reboot in the new selected mode. See Table 5.1 for more details, the state should be stable for 100ms before to trigger the reboot process.

In Modem mode the external processor controls when the onboard radio is powered-up by sending the "Power-On Radio" command with the specific request to use the DC-DC Buck converter or the High efficiency bypass switch. For safety purposes, the onboard microcontroller will measure the VIN voltage to ensure the actual voltage is within the required range prior to execution of the command (3.4Vdc to 4.5Vdc for bypass switch and 4.75Vdc to 18Vdc for DC-DC converter). User designs must ensure the VIN voltage does not exceed 4.5V at any time when the Bypass switch is activated. Doing so could result in permanent damage to the radio. After the internal supply is stabilised, the radio will boot. The Figure 9.3 illustrates the timing diagram in Modem mode with UART. Cellular Radio-boot time starts after receiving the "Power-On Radio" command and is radio dependant. This information is available in Table 9.1. This time does not include the carrier network connection time that may vary from one carrier to another. Please note, it is possible to control the radio with GPIO-0 in "Modem with UART" mode, however there is no advantage to doing so. This feature has been developed for the "Modem with USB" mode and will be described in the Section 9.2.2.

Immediately following the boot-up of the radio, the onboard microcontroller will verify the SIM access profile and in the case where a PIN is required, will verify if the pre-configured PIN is valid. The onboard microcontroller will then send the unsolicited message "Radio Start Notify" on the UART with the current status. Following a successful boot and SIM access, the carrier network registration will begin with pre-configured information. Once registration is completed, the onboard microcontroller will send the unsolicited message "Mobile Connection Status Change Notify" on the UART with the connection status.

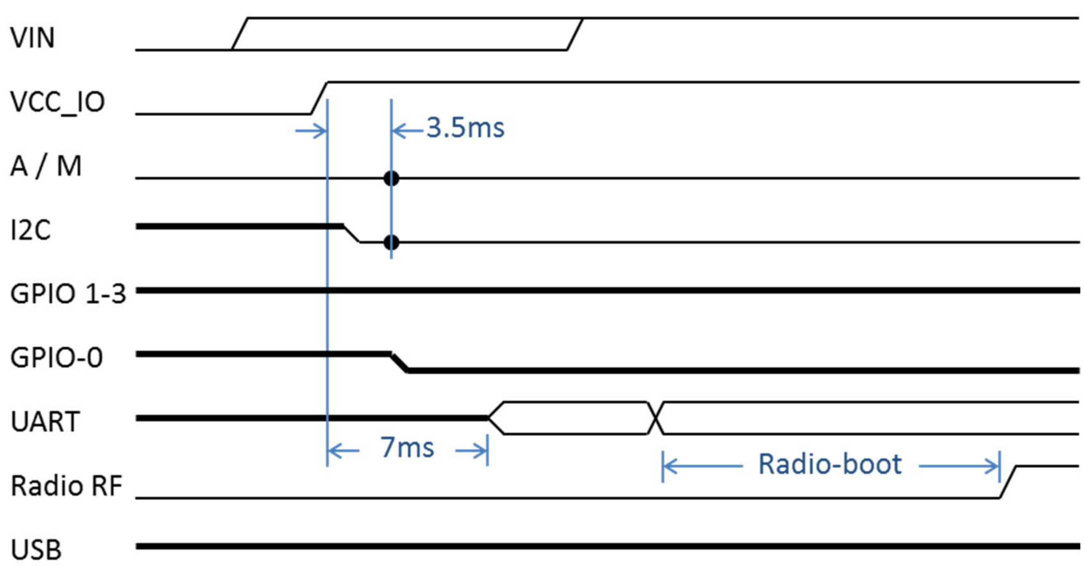


Figure 9.3: Modem with UART mode timing

9.2.2. Modem mode with USB

The USB interface is directly connected to the cellular radio that needs to be first started before communicating with it. In Modem mode with USB, the GPIO-0 controls the radio power ON/OFF. A rising edge emulates the API "Power-On Radio" command and the falling edge emulates the API "Power-Off Radio" command with graceful deregistration from network. GPIOs 1 to 3 are kept in a HI-Z state and the GPIO-0 is weakly pulled-down with 50Kohm resistor. The I2C pins are expected to stay at logic level high by user implementation and are internally weakly pulled-down with 50Kohm resistors. If at any time, the I2C pins are detected in a state other than both in logic-high, the BitPipe will force a graceful deregistration from network followed by a reboot in the new selected mode. See Table 5.1 for more details. The logic state of the I2C pins should be stable for at least 100ms before triggering the reboot process.

Figure 9.4 illustrates the timing diagram in Modem mode with USB. Following the mode detection, the onboard microcontroller will wait for the GPIO-0 to be sampled in logic-high to start the radio power-on sequence. The onboard microcontroller will then wait for VIN to be present and stable to determine if the DC-DC Buck converter or the high efficiency bypass switch will be activated.

If VIN is between 3.4Vdc and 4.5Vdc, the device will assume it is being supplied by a Lithium battery and will activate the onboard high efficiency Bypass switch. Important note; when the bypass switch is activated, the radio is directly connected to VIN. User designs must ensure the VIN voltage does not exceed 4.5V at any time when the Bypass switch is activated. Doing so could result in permanent damage to the radio. If VIN is between 4.75Vdc and 18Vdc, the device will automatically activate the DC-DC Buck converter. After the internal supply is stabilised, the radio will automatically boot and the USB interface will be activated. Cellular Radio-boot time is radio dependant and can be found in Table 9.1.

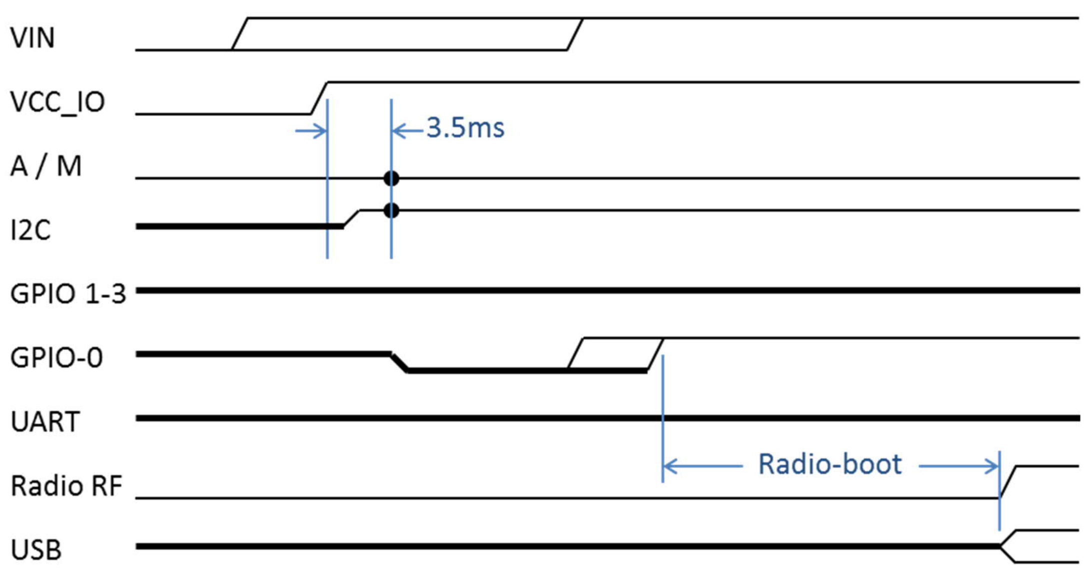


Figure 9.4: Modem with USB mode timing

9.3. Low Power mode

When used in Modem mode with UART, it is possible to put the device into Low Power mode by sending the "Set Low Power Mode" command. In this state, the Radio is powered down and the microcontroller stops all activities waiting to be woken up by a rising edge on the UART-RX pin.

If the device is connected to a carrier network, a clean disconnection from the network must be done first by sending the "Power-Off Radio" command with the "Graceful" parameter. The "Set Low Power Mode" command can then be sent to enable the low power state. The onboard microcontroller will set

GPIOs, I2C and UART-TX signals to HI-Z state to reduce power consumption and only monitor the UART-RX pin for activity. The process takes 1ms to execute as shown in Figure 9.4.

The wake-up process starts when the onboard microcontroller detects a rising-edge on UART-RX. It is recommended to weakly pull-down this signal on the user baseboard when the external processor is also planned to go in a low power mode.

As shown in Figure 9.4, the wake-up process takes 250us to execute whereby the UART is activated, GPIOs are kept in HI-Z and I2C pins are weakly pulled-down with 50Kohm resistors (same as Modem mode boot). If the wake-up activity was UART communication, some or all characters from this communication will be lost. It is recommended to send a dummy message (or character), wait 250us to let the device wake-up before sending valid communication.

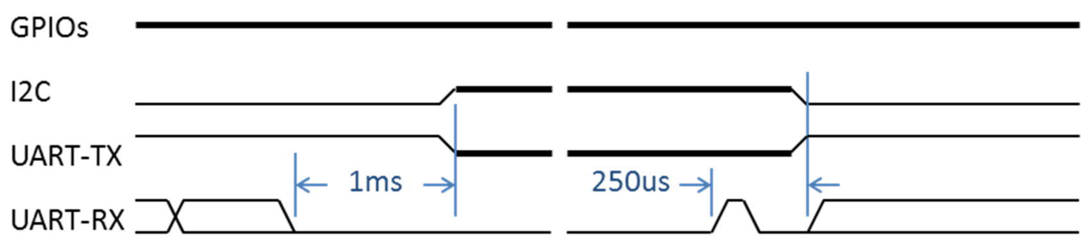


Figure 9.5: Going to Low Power mode and coming back from Low Power mode timings

9.4. Radio boot time

BitPipe cellular family devices may use different cellular radios depending on the technology and network compatibility they have been designed for. Radio-boot time from power-up to a ready-to-connect state is dependent on the radio manufacturer implementation as indicated for each BitPipe device in the Table 9.1.

BitPipe	Maximum Radio boot time	Unit
BP32G-W-UFL	11	Sec
BP43G1-US-UFL	11	Sec
BP4T1-USV-UFL	8	Sec
BP43T4-US-UFL	6	Sec

Table 9.1: Maximum Radio boot time

10. Certifications and conformity

10.1. BP32G-W-UFL

Conformity	Description
PTCRB	This device is PTCRB certified as an end device. It can be found in the PTCRB database with Model #: BP32G-W-UFL
FCC	This product contains FCCID: QIPEHS6
Industry Canada	This product contains IC: 7830A-EHS6
CE	CE conformity declaration in progress
RoHS EU Directive	All hardware components fully compliant with EU RoHS Directive

Table 10.1: BP32G-W-UFL conformities

10.2. BP43G1-US-UFL

Conformity	Description
PTCRB	This device is PTCRB certified as an end device. It can be found in the PTCRB database with Model #: BP43G1-US-UFL
FCC	This product contains FCCID: QIPELS61-US
Industry Canada	This product contains IC: 7830A-ELS61US
CE	Not applicable for North American device
RoHS EU Directive	Not applicable for North American device

Table 10.2: BP43G1-US-UFL conformities

10.3. BP4T1-USV-UFL

Conformity	Description
VERIZON OD	This device is Verizon Wireless certified as an end device. It can be found in the Verizon Open Development website with Model #: BP4T1-USV-UFL
FCC	This product contains FCCID: RI7LE910SVV2
Industry Canada	Not applicable for Verizon device
CE	Not applicable for North American device
RoHS EU Directive	Not applicable for North American device

Table 10.3: BP4T1-USV-UFL conformities

10.4. BP43T4-US-UFL

Conformity	Description
PTCRB	This device is PTCRB certified as an end device. It can be found in the PTCRB database with Model #: BP43T4-US-UFL
FCC	This product contains FCCID: RI7LE910NAV2
Industry Canada	This product contains IC: 5131A-LE910NAV2
CE	Not applicable for North American device
RoHS EU Directive	Not applicable for North American device

Table 10.4: BP43T4-US-UFL conformities

10.5. SAR requirements specific to portable mobile equipment

Fixed or mobile transmitters and receivers incorporating a cellular radio module must be in accordance with the guidelines for human exposure to radio frequency energy. This requires the Specific Absorption Rate (SAR) of portable cellular based applications to be evaluated and approved for compliance with national and/or international regulations.

Since the SAR value varies significantly with the individual product design manufacturers are advised to submit their product for approval if designed for portable use. For North American markets the relevant directives are mentioned below. It is the responsibility of the manufacturer of the final product to verify whether or not further standards, recommendations or directives are in force outside these areas.

Products intended for sale on US markets

ES 59005/ANSI C95.1 Considerations for evaluation of human exposure to Electromagnetic Fields (EMFs) from Mobile Telecommunication Equipment (MTE) in the frequency range 30MHz - 6GHz. Please note that SAR requirements are specific only for portable devices and not for mobile devices as defined below:

- Portable device: A portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user.

- Mobile device: A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. In this context, the term "fixed location" means that the device is physically secured at one location and is not able to be easily moved to another location.

10.6. Compliance with FCC and Industry Canada Regulations

Manufacturers of mobile or fixed devices incorporating BitPipe cellular modules are authorized to use the FCC Grants and Industry Canada Certificates of the cellular modules for their own final products according to the conditions referenced in these documents. In this case, an FCC/ IC label of the module shall be visible from the outside, or the host device shall bear a second label stating "Contains FCC ID: see Tables 10.1, 10.2, 10.3 & 10.4 for FCC ID according to BitPipe device used", and accordingly "Contains IC: see Tables 10.1, 10.2, 10.3 & 10.4 for IC ID according to BitPipe device used ". The integration is limited to fixed or mobile categorized host devices, where a separation distance between the antenna and any person of min. 20cm can be assured during normal operating conditions.

IMPORTANT: Manufacturers of portable applications incorporating BitPipe cellular modules are required to have their final product certified and apply for their own FCC Grant and Industry Canada Certificate related to the specific portable mobile. This is mandatory to meet the SAR requirements for portable mobiles (see Section 10.5 for detail).

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

Note: 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 and with Industry Canada license-exempt RSS standard(s). 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 or more 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.
- Consult the dealer or an experienced radio/TV technician for help.

This Class B digital apparatus complies with Canadian ICES-003.

If Canadian approval is required for devices incorporating BitPipe cellular modules the below notes will have to be provided in the English and French language in the final user documentation. Manufacturers/OEM Integrators must ensure that the final user documentation does not contain any information on how to install or remove the module from the final product.

(EN) This Class B digital apparatus complies with Canadian ICES-003 and RSS-210. Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

(FR) Cet appareil numérique de classe B est conforme aux normes canadiennes ICES-003 et RSS-210. Son fonctionnement est soumis aux deux conditions suivantes: (1) cet appareil ne doit pas causer d'interférence et (2) cet appareil doit accepter toute interférence, notamment les interférences qui peuvent affecter son fonctionnement.

(EN) Radio frequency (RF) Exposure Information. The radiated output power of the Wireless Device is below the Industry Canada (IC) radio frequency exposure limits. The Wireless Device should be used in such a manner such that the potential for human contact during normal operation is minimized. This device has also been evaluated and shown compliant with the IC RF Exposure limits under mobile exposure conditions (antenna at least 20cm from a person‘s body).

(FR) Informations concernant l'exposition aux fréquences radio (RF). La puissance de sortie émise par l'appareil de sans-fil est inférieure à la limite d'exposition aux fréquences radio d‘Industrie Canada (IC). Utilisez l'appareil de sans fil de façon à minimiser les contacts humains lors du fonctionnement normal.

Ce périphérique a également été évalué et démontré conforme aux limites d'exposition aux RF d'IC dans des conditions d'exposition à des appareils mobiles (les antennes se situent à moins de 20cm du corps d'une personne).

10.7. RoHS Compliance

BitPipe products meant for European markets are in compliance with Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003, on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) and its amendments.

11. Support

support@briowireless.com

For online support and downloads please go to:
http://briowireless.com/product/bitpipe-iot-interface/

You will find the following downloads:

Datasheet
Module API documentation
Altium Schematic Symbol
Altium Layout Footprint
3D Step files
3D Solidworks files

Dev-Kit User guide
Dev-Kit PC Software
Dev-Kit Altium Schematics and Layout files
Dev-Kit Gerbers files
Module Serial Interface Stack Source code
Application Note: AN00030