ORBCOMM™

CONNECTING THE WORLD'S ASSETS

ORBCOMM Generation 2 (OG2) Modem Consolidated Operational Description

Document Number:

Revision: Initial

Date: October 27, 2015

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Document History

Version	Issued By	Issue Date	Comments
1	ORBCOMM	October 2015	Initial

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1. Introduction

ORBCOMM is in the initial stages of defining the modem functionality required to operate with the ORBCOMM Generation 2 (OG2) satellite system providing OG2 Messaging Services. The first OG2 satellites will launch in 2013 with OG1 legacy support and in 2014 have OG2 functionality uploaded.

There will be significant differences between OG1 and OG2 such that current OG1 subscriber communicators herein referred to as "modem" will not be able to use the portion of the OG2 satellites dedicated to OG2 functionality. It is envisioned that the next versions of modems will be able to seamlessly switch between the two service sets. Initially, however, current users will only be to use the OG1 functions on the satellite.

It is expected that many of the environmental specifications for OG2 modems will be the same as OG1 modems. In the interest of providing more information earlier, these requirements have been omitted from this document.

The purpose of this document is to provide preliminary information on the physical interface of OG2 modem. This document should not be construed as a specification. It is the basis for developing the ORBCOMM Generation 2 Subscriber Communicator Standards and Specifications. In the interim, this document can be used for determining the magnitude of development on the hardware side.

1.1 References

Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Non-voice, Non-Geostationary Mobile Satellite Service (FCC docket no. 92-76, FCC 93, 47B, released November 16, 1993)

ORBCOMM Application Amendment and Supplement: File No. 22-DSS-MP90(20) (submitted December 21, 1993)

U.S. Code of Federal Regulations (vol. 47, Part 25, § 202)

SAE J1455 "Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy Tracks)"

EN 301 832 "Electromagnetic compatibility and Radio spectrum Matters (ERM); Electro-Magnetic Compatibility (EMC) for Mobile Earth Stations (MES) providing Low Bit Rate Data Communications (LBRDC) using satellites in Low Earth Orbits (LEO) operating in frequency bands below 1 GHz"

EN 301 721: "Satellite Earth Stations and Systems (SES); Harmonized EN for Mobile Earth Stations (MES) providing Low Bit Rate Data Communications (LBRDC) using Low Earth Orbiting (LEO) satellites operating below 1 GHz covering essential requirements under article 3.2 of the R&TTE directive"

2. Physical Design

2.1 Module Dimensions

Overall dimensions and weight of the OG2 modem are indicated below. RF connections will require space for routing miniature coax cables to antenna port locations.

Mechanical Dimensions	
Length	70 mm
Width	40 mm
Height	9.5 mm
Weight	20g

2.2 Interface

Product developers should plan for connection to the host system as indicated in the following table.

2.2.1 User Connector Pin Description Table

Pin #	Title	In-Out /Voltage	Description
1	USB	Diff, 1.8v [1]	Data, negative
2	Main Power	4 - 15v [2]	Input Power
3	USB P	Diff, 1.8v [1]	Data, positive
4	GND	Input	Ground
5	Master RX	Input, pin 6 user volt. [3]	RX, UART 0
6	User Data Power	1.8 to 3.6 V [3]	Master & Debug Serial Logic Level
7	Master TX	Output, pin 6 user volt. [3]	TX, UART 0
8	SPI1 PCS0	Output, 1.8v [1]	PCS0, SPI #1 chip select
9	GND	Input	Ground
10	SPI1 CLK	Output, 1.8v [1]	CLK, SPI #1 clock
11	Debug UART RX	Input, pin 6 user volt. [3]	RX, UART 5
12	SPI1 SOUT	Output, 1.8v [1]	SOUT, SPI #1 data out
13	Debug UART TX	Output, pin 6 user volt. [3]	TX, UART 5
14	SATELLITE-IN-VIEW	Output, 1.8v [4]	GPIO or SIN, SPI #1 data in
15	MASTER RESET	Hi-Z, active LO [5]	Internal 10k ohm PU, PD with FET or transistor.
16	GPIO0/FTM/CAN RX	Input/Output 1.8v[1]	RX CAN-0, Capacitive Touch, GPIO
17	TAMPER 1	Input, 1.8v [1]	Internal PU
18	GND	Input	Ground
19	EXT INT2	Input, 1.8v [1]	External Interrupt
20	GPIO1/FTM/CAN TX	Input/Output 1.8v[1]	TX CAN-0, Capacitive Touch, GPIO
21	GND	Input	Ground
22	UART 4 RX	Input, 1.8v [1]	RX, User serial port

Pin #	Title	In-Out /Voltage	Description
23	EXT INT1	Input, 1.8v [1]	External Interrupt
24	Main Power	4 - 15v	Input Power
25	VREGIN	2.7 - 5.5v [1]	USB regulator input
26	GND	Input	Ground
27	GND	Input	Ground
28	UART 4 TX	Output, 1.8v [1]	TX, User serial port
29	GND	Input	Ground
30	ADC #0 –P	Input, 1.8v [1]	16 bit, 1.7v TOS
31	CAN1-TX/UART4-TX,Tamper	Input/Output 1.8v[1]	TX CAN-1, UART4, Tamper
32	ADC #0 -N	Input, 1.8v [1]	16 bit, 1.7v TOS
33	CAN1-RX/UART4-RX,Tamper	Input, 1.8v [1]	RX CAN-1, UART4, Tamper
34	GND	Input	Ground
35	GND	Input	Ground
36	ADC #1 –P	Input, 1.8v [1]	16 bit, 1.7v TOS
37	SDHC0_CLK, ADC6, SPI1_CLK	Input/Output 1.8v	SD Card clock, 10 bit ADC, SPI-1 CLK
38	ADC #1 -N	Input, 1.8v [1]	16 bit, 1.7v TOS
39	SDHC0_CMD, ADC7, SPI1_SIN	Input/Output 1.8v[1]	SD Card cmd, ADC, SPI-1 data in
40	GND	Input	Ground
41	SDHC0_DO, ADC5, SPI1_SOUT	Input/Output 1.8v[1]	SD Card data #0, ADC, SPI-1 data out
42	SPI0, PCS0	Input, 1.8v [1]	PCS0, SPI #0 chip select
43	SDHC0_D1, ADC4, SPI1_PCS1	Input/Output 1.8v[1]	SD Card data #1, ADC, SPI-1
44	SPI0, modemK	Output, 1.8v [1]	modemK, SPI #0 clock
45	SDHC0_D2, SPI1_PCS0	Input/Output 1.8v[1]	SD Card data #2, SPI-1 chip sel, GPIO
46	SPI0, SOUT	Output, 1.8v [1]	SOUT, SPI #0 data out
47	SDHC0_D3, SPI1_SDA	Input/Output 1.8v[1]	SD Card data #3, SPI-1 data in, GPIO
48	SPI0, SIN	Input, 1.8v [1]	SIN, SPI #0 data in
49	SD CARD DETECT	Input, 1.8v [1]	SD Card detection, GPIO
50	GND	Input	Ground

Pin #	Title	In-Out /Voltage	Description
51	SD Card WP	Input, 1.8v [1]	SD Card detection, GPIO,
52	Main Power	4.0-15v [2]	Input Power

Table 2-1 Pin Definition

1) These signals are connected to the processor and are intended for future use, however they are shut-off and not supported by the firmware at this time. These signals can be left floating/not connected.
2) RF power will be gradually reduced from 6W to 2W as input voltage drops below 4.0 volts. User Data Power is the user defined the input voltage so serial ports are translated to the desired DC level.
3) Master and Debug serial interface voltages are determined by the voltage supplies to USER_DATA_POWER. This voltage must be within the indicated voltage range.
4) SATELLITE_IN_VIEW indicates that the receiver has currently locked on to a satellite downlink. This is the first stage of creating a message session.
5) Master reset is pulled high (to 1.8v) within the modem. The signal can be pulled down to an active state via a FET or transistor. The current is <200uA.

2.2.2 User Connector Mechanical Information

All non-RF connections are provided by a MINI PCI Express format connector. This card edge connector uses .8mm pitch fingers to provide 52 connections, 26 per side. This connector is available in several heights to allow the user to retain PCB area for most components. Mechanical drawings are provided below. This drawing specifies the mechanical position of the User connector with respect to the mounting holes.

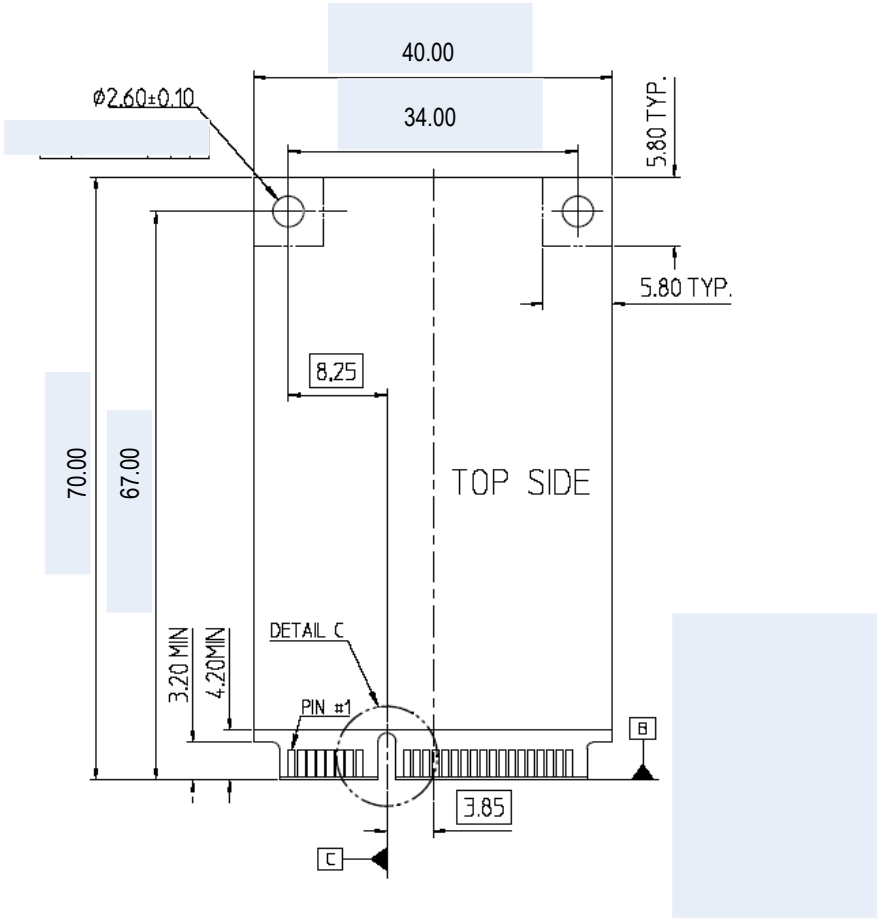


Figure 2-1 Board Dimensions

The OG2 Modem module inserts into the connector at an angle, and is held in place with screws and standoffs that match the connector height. Ideally, the standoffs and screws would interface to a ground connection on the host board. Mounting screws should be properly tightened to 0.7909 Newton-Meters (7 pound-inches) of torque.

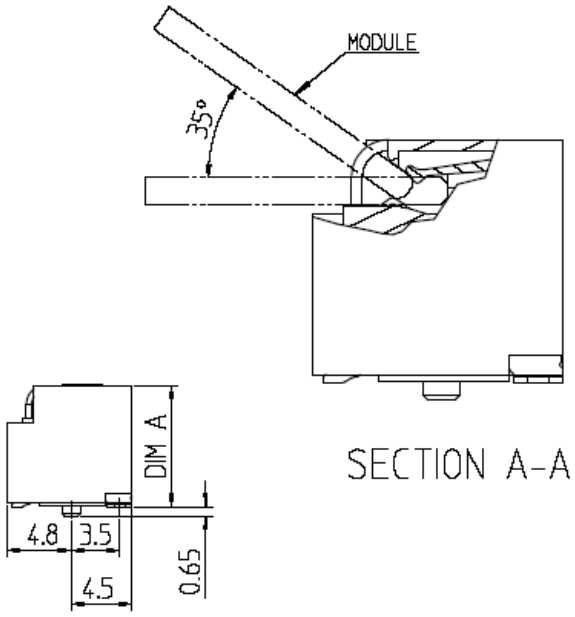


Figure 2-2 Board Insertion Angle

2.2.3 Board Connection

ORBCOMM recommends the following connector/standoff set when mounting the modem.

Molex 48338-0057 - PCI Express/PCI Connectors, 0.8mm pitch

PEM SMTSO-256-4ET - Mounting standoffs

2/56 thread, 3/16” length, 18-8 stainless steel, pan-head, Phillips screws

2.2.4 RF Connections

The GPS and ORBCOMM VHF RF connectors are Hirose U.FL series parts. There are several mating plugs available, allowing different coaxial cable diameters. Cable assemblies and plug adapters are available to transition to several standard miniature RF connector types. Ideally, final antenna connections should have a chassis-bonded ground connection.

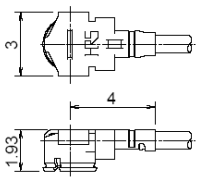
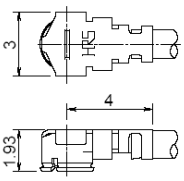
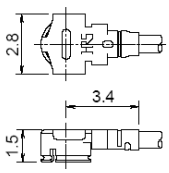
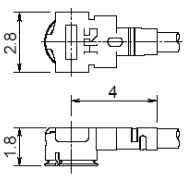
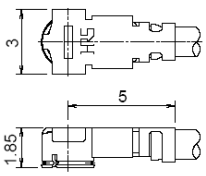
	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
Part No.					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 0.81mm Coaxial cable	Dia. 1mm Coaxial cable	Dia. 1.37mm Coaxial cable
Weight (mg)	53.7	59.1	34.8	45.5	71.7
RoHS	YES				

Table 2-2 U. FL Connectors

The image below indicates the proper location for each port. There are two modem models, with and without GPS and accelerometer. If the GPS antenna port and uBlox circuit are installed, then the unit has GPS functionality

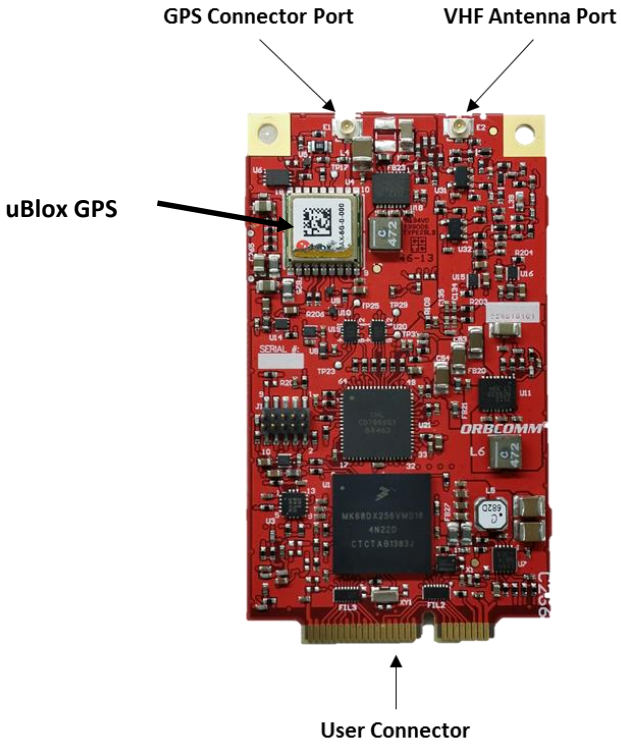


Figure 2-3 Connector Location

3. Radio Frequency Section

The OG2 modem includes:

- A VHF Receiver Section which performs RF filtering, frequency conversion and demodulation.
- A VHF Transmitter Section which performs modulation, frequency conversion and power amplification.
- A Processing Section that monitors and controls optional I/Os, handles the RF and serial interface.

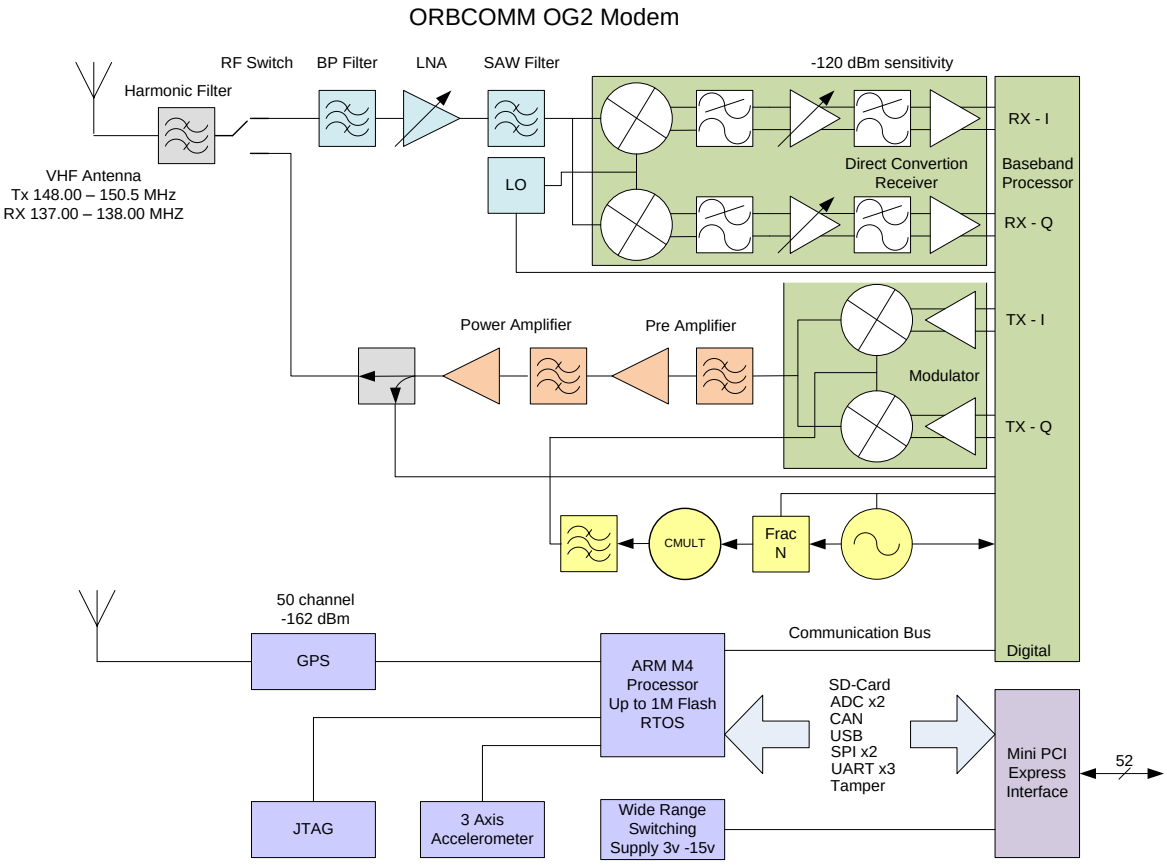


Figure 3-1 Modem Block Diagram

The different ports are:

- *Power Supply*. Capable of handling a wide range of DC input voltages.

- *I/Os*: Provides optional analog or digital input and outputs. These are typically used to connect sensors or to connect to the system elements which need to be controlled
- *Serial Data*: Serial interface through which another embedded application or external processor/sensor can transfer data.
- *RF In/Out*: The Modem has U.FL connectors for satellite and GPS antenna signals.

3.1 VHF Transmitter

3.1.1 Transmit Modulation

The transmitter uses Symmetric Differential Phase Shift Keying at 2400 bits per seconds.

3.1.2 Output Power

Output power is fixed at approximately 5.5 Watts ±0.5 Watts. Value is set at the time of manufacture and no further adjustments are made during operation.

3.1.3 Output Power Variance

During any transmission, the transmit power shall vary by no more than ±1.0 dB under any combination of temperature and frequency.

3.1.4 Transmitter Power

The maximum EIRP, measured in a 4 kHz bandwidth, transmitted from a modem shall not exceed 10 dBW in all directions. (EN 301 721)

The graph below shows the measured RF power output as the input is increased from 2.8 volts DC to 15 volts DC. Values provided below 6 VDC are provided for reference only. ORBCOMM's integration manual specifies an input voltage no lower than 6 VDC.

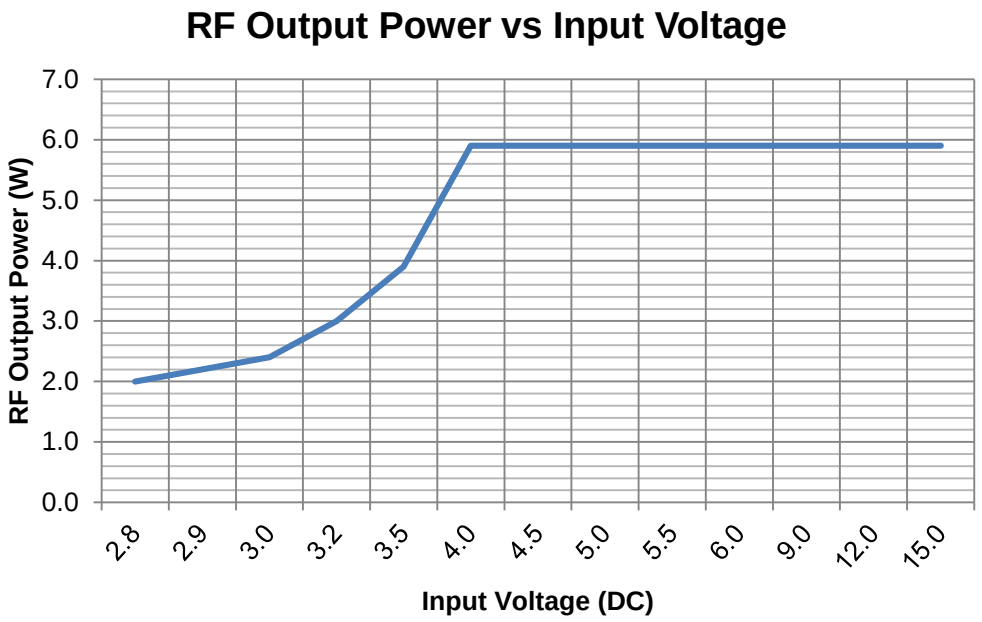


Figure 3-2 RF Output Power vs. input Voltage

3.1.5 Frequency Control

Frequency control is provided by the ORBCOMM System. The modem transmits an initial 7 bit (8 bits including the reference bit required by SDPSK modulation) burst to the satellite. Initial specifications published almost 20 years ago required this burst to arrive within ±1500 Hz. This frequency error budget includes oscillator uncertainty and Doppler effects. Current modem designs routinely transmit this acquire burst within ±500 Hz.

Frequency and timing corrections are provided to the modem based on the offset of the 7 bit burst. All subsequent transmissions for this message session are corrected to within ±50 Hz.

3.1.6 Transmit Frequency

The modem is capable of tuning to any 2.5 kHz channel between 148.0500 and 150.0000 MHz. Note that ORBCOMM's authorized spectrum is 148.0000 to 150.0500 MHz. Restriction of the channels at the edge of the authorized spectrum insure no spectral content above the specifications occur outside the authorized spectrum.

3.1.7 Occupied Bandwidth

Measured 20 dB occupied bandwidth is less than 4 kHz.

3.1.8 Transmitter Designator

The modem carries a 5K00G1D emission designator.

3.2 VHF Receiver

3.2.1 Receive Modulation

The transmitter uses Symmetric Differential Phase Shift Keying at 4800 bits per seconds.

3.2.2 Minimum Detectable Signal

The modem receives ORBCOMM downlink signals with at -120 dBm or better under all operational situations with a BER no worse than 1×10^{-5}.

3.2.3 Acquisition Frequency Range

The modem acquires ORBCOMM downlink signals over all operational situations in the frequency range: 137.1250 to 137.8750 MHz. This includes all effects of internal oscillator uncertainty in addition to Doppler effects which may be as much as ±3200 Hz during times when satellite is visible to the modem. Further, the Doppler rate of change may be as high as ±28 Hz/second.

4. Power Supply

The power supply is designed to operate in an efficient mode at all times. The processor has power available continuously. When the processor is in a low power mode, the quiescent current can be as low as 3 uA. Power sections required for frequency generation, receive modes, and transmit modes are turned off until they are required. The integrated accelerometer can be programmed to interrupt the processor during a pre-defined shock/vibration event, this allows a low power usage in typical "stop and go" mobile applications. Power to the GPS circuit can be switched ON and OFF if a 'cold fix' is acceptable. If a 'warm fix' is required, providing 22 uA will allow GPS fixes in only a few seconds.

4.1 Power Usage Profile

The ORBCOMM OG2 modem input voltage range allows for several battery chemistries and parallel configurations.

Input Voltage:	6.0VDC to 15 VDC	
Input Current:		
	Transmit Mode:	1.37 A @ 12VDC
		Duration: typically <300ms, 700 ms max.
	GPS On:	35 mA @ 12VDC

Receive Mode: 100 mA @ 12VDC

The graph below show the maximum current (transmit mode) requirements over a range of input voltages. Per integration requirements 6 VDC is the minimum operational voltage.

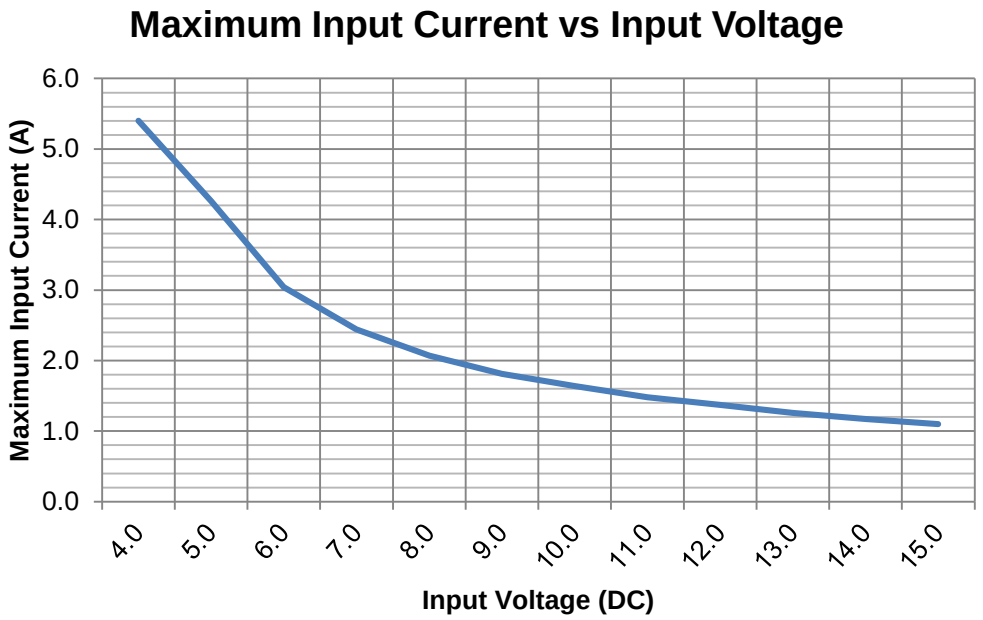


Figure 4-1 Maximum Input Current vs Input Voltage

4.2 Variations in Input Power

The power supply is a buck-boost configuration and can operate between 4.0 VDC and 15 VDC. A full RF output requires an input voltage above the minimum operating voltage. The system will control the switcher to run in a high efficiency burst mode and provide the required PWM mode to satisfy high demand events. The circuit is short-circuit protected, has a soft start feature, provides current limiting, and a thermal shutdown feature.

The diagram below shows voltage rise time for the processor (gray), receiver (pink), and power amplifier (blue) with a 4.0 VDC input voltage. The delay from power-on to processor operation is 1.3 ms. The other voltages are controlled internally by the processor and do not operate until the I/O ports are functional and a message has been queued by the user.

The pink line indicates the rise time of the receiver section.

The blue line indicates the rise time of the transmitter section, current draw is increased to maximum levels approximately 15 ms after this ramp up time.

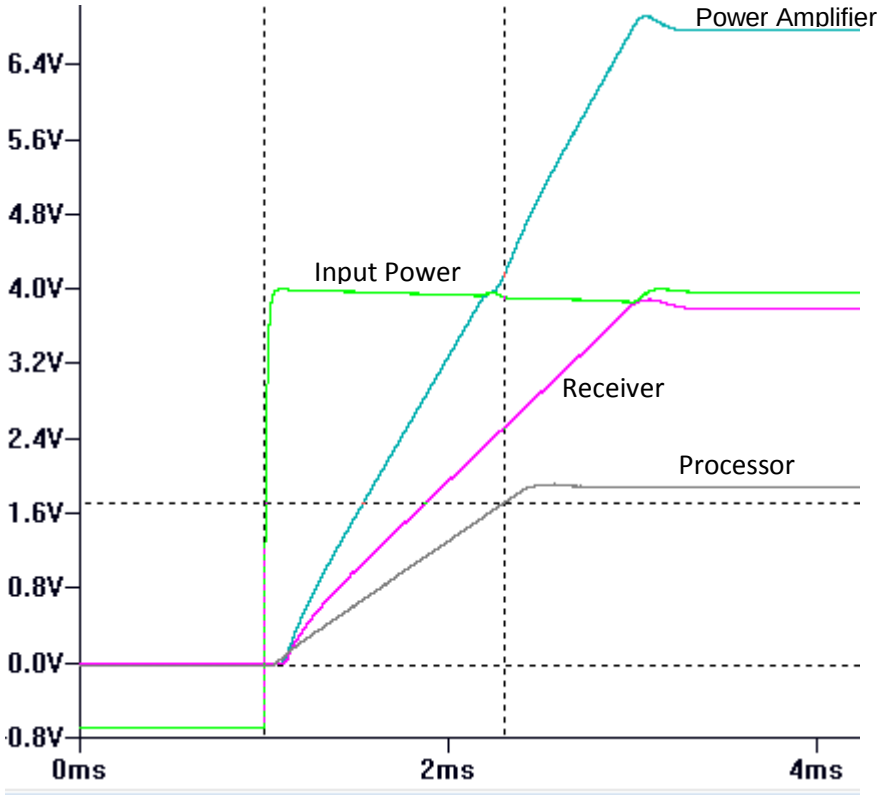


Figure 4-2 Input Voltage Rise Times

4.3 Dip, Interruptions, Surges, Fast transients

4.3.1 Dip & Interruptions

The power circuit has a soft start feature which allows a 750us rise or fall time for events which occur faster than this time frame. The time that would cause deregulation is dependent upon the input voltage and load at the time of the event.

Based on simulation, the processor (shown in gray) will operate for 1.3 ms after removal of an input voltage of 4.0v, and will operate for 220ms when operating with an input voltage of 10 volts.

If the processor experiences an interruption, the processor low voltage detection will operate. The circuit warning mode will create a system interrupt service routine and protect memory contents. In the reset level detect mode a lower voltage threshold causes a power-on reset. The processor will be held in reset until the rise-voltage threshold is achieved, then clock circuits will begin to operate, when the voltage rises above the low-voltage threshold the system begins to operate. If the processor is writing a new message in to memory during a power interruption, a protocol will not provide an acknowledgement so the user processor will retry. The malformed message will be

removed from memory when the processor checks the queue after bootup. During a transmit event, the system will hold up for 200us with an input voltage of 10 volts.

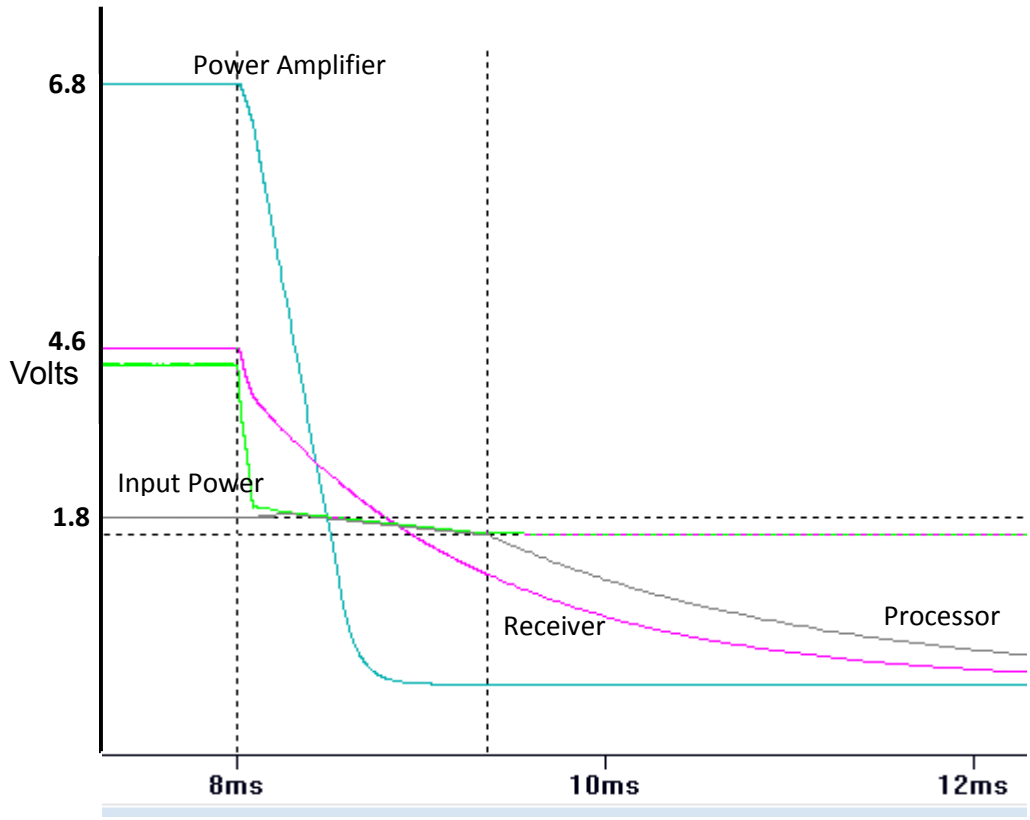


Figure 4-3 Voltage Fall Times vs. Input Power Switched Off

4.3.2 Fast Transients

All data lines are protected with low pass RF filters and ESD protection. The filters are designed to meet IEC61000-4-2 level 4, and provide up to 40 dB of EMI protection from 800 MHz to 3GHz.

The Secure Digital High Capacity (SDHC) memory card interface is designed to meet JESD 84A43 specifications.

5. Environmental Specifications and Compliance

Temperature:	SAE J1455 Operating/Storage Temperature(Sec. 4.1.3.1)
Operating:	-40°C to +85°C
Storage:	-50°C to +125°C
Vibration:	SAE J1455, Cab Mounted & Transverse Axis
Radiated Emissions	EN 300 832 Sec. 7 EN 300 721 V1.21 Annex C
Unintentional Emissions	EN 300 721 V1.21 Annex E
Conducted Emissions	EN 300 721 V1.21 Annex D
RD Immunity	EN 300 832 Sec. 7
Transients & Surges	EN 300 832 Sec. 9

Table 5-1 Environmental Specifications and Compliance

5.1 Operational Temperature

Efforts should be made to keep the modem from operating at temperatures exceeding 80°C. This may require additional venting and/or forced air.