ZeMo Satellite Transmitter

User's Manual

1.1

Prepared By

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REVISION HISTORY

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1. Description

The ZeMo device is a radio transmitter module that creates the radio frequency (RF) signals to relay small packets of data to the Globalstar Simplex Data Service satellite network. The ZeMo serves as a communication gateway in an embedded application to send transmit-only (simplex) data. Data packets are in small, 9-byte segments. The ZeMo supports 9, 18, 27 or 36 byte data payloads. The Globalstar Simplex Data Service comprises a set of low-earth-orbit (LEO) satellites operating as bent-pipe data relay devices to ground earth data collection points. This user's manual provides an overview of the operational and physical requirements for the ZeMo transmitter device that is compatible with this satellite network system.

The ZeMo device is the radio transmitter only. This user's manual does not stipulate application requirements nor the radiating (antenna) requirements of an application. The ZeMo must be fully integrated into a larger application device to provide application utility.

1.1. Definitions

The following definitions used herein shall have the meanings as defined below:

Globalstar

a) Globalstar. The term "Globalstar" means Globalstar, Inc., a Delaware USA Corporation having offices at 461 South Milpitas Blvd, Milpitas, California 95035

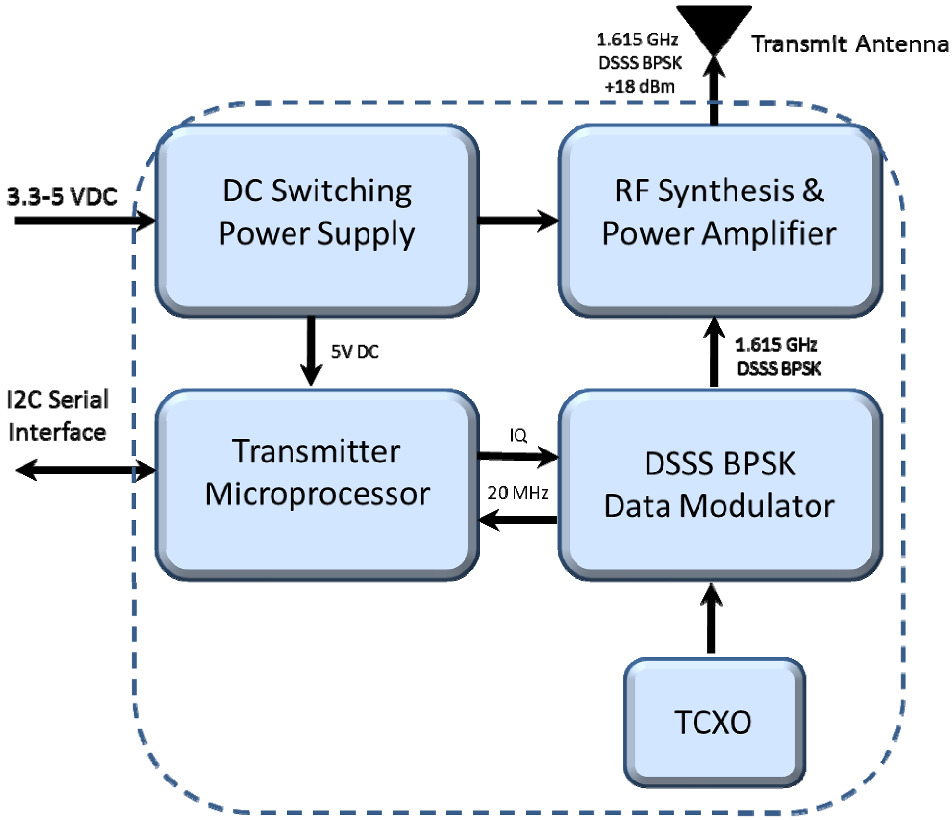
b) Globalstar Simplex Data Service. The term "Globalstar Simplex Data Service" refers to communications from simplex transmitters relayed over Globalstar's network of low earth orbit satellites to Globalstar gateways for distribution to end customers.

c) LEO. The term LEO is an acronym meaning low earth orbit.

d) GPS. The term GPS is an acronym meaning global positioning system.

2. ZeMo Device Theory of Operation

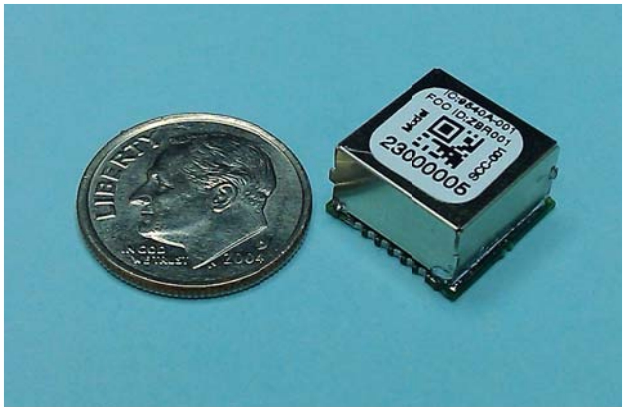
The ZeMo device is a radio transmitter module that contains the functionality to accept configuration and data from a host application and convey data to the Globalstar Simplex Data Service satellite system. The block diagram below depicts the integral components of the ZeMo device to fulfill this functionality.



The ZeMo module contains a microprocessor that controls the transmitter functions, provides power management and controls the RF transmitter functions. The ZeMo module conditions the input DC power to create the voltages necessary to perform the function

The ZeMo module is a two layer board assembly measuring ½" x ½" square and interfaces to the host application via a 6 pin connector. The connector provides power, I2C serial communications and the RF transmit signal.

The ZeMo module depicted below performs the transmit functions described when serially tasked by the host application processor via the I2C serial interface. When idle, the ZeMo module assumes a low-power state drawing mere microAmps.



3. Satellite Messaging Method

The ZeMo device manages all the required messaging to be compliant to the Globalstar Simplex Data Service. The application interface need only configure the device once and send data to the ZeMo using the I2C serial interface. The ZeMo will queue the data to be sent and manage the process of transmitting the data to the satellite system.

Because the messages are transmitted unsolicited and without the benefit of a two-way data link with the satellite system, each message is transmitted several times with a random delay component between transmits of roughly 7±2 minutes. Recommended configuration setting transmits each message three times with time delays between each transmission to allow for the satellite constellation to shift in position. The configuration parameters of the ZeMo allow for adjustment of number of transmissions and time delays between transmissions. This overview is provided to briefly demonstrate how the ZeMo functions in order for application developers to understand how the simplex system operates. Integrators should know that sending a message for transmit may therefore take up to 20 minutes to complete the transmit sequence. This does not mean that system latency is typically that long, but because the ZeMo has no way to discern if the message was successful on first or subsequent attempts, it will repeat the message transmit per configuration setting. The satellite system will deliver the first received message captured, typically the first message and thus the probabilistic system latency is seconds, not minutes. Nevertheless, on rare occasions the system may miss the first message and the data packet will have a new chance for packet delivery success on subsequent trials.

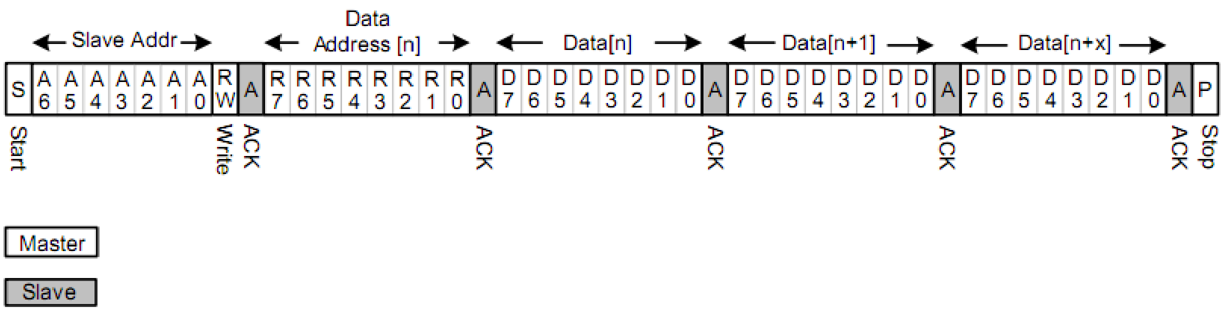
4. I2C Serial Host Interface

The ZeMo contains an I2C serial interface that operates in slave mode only in a application system. The external application host processor can configure and send data to the ZeMo using this two-wire serial interface. As a slave, the ZeMo operates similar to an EEROM device, with configuration and data read/write operations managed by the external host processor. ZeMo supports industry standard I2C slave operation up to 400 kbps with the following additional requirements:

- The ZeMo uses the I2C SCL input signal as both communication and “wake” signals. Any bus traffic on the I2C lines will cause the ZeMo to wake from sleep and set up the I2C interface for communications. For this reason, the host interface should use a dedicated I2C interface to the ZeMo as communicating with other devices on the bus will cause the ZeMo to wake and use application power.
- Time to wake for the ZeMo is ~250 usec. Application hosts should assert a low on the SCL signal and wait for this time to allow the ZeMo to transition from sleep to wake and ready.

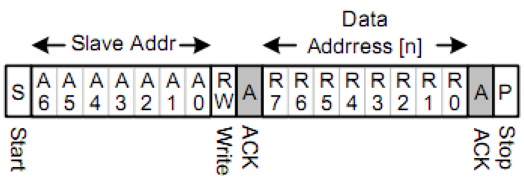
The diagram below depicts a typical configuration write of the ZeMo from the host application master I2C.

Write x Bytes to I2C Slave

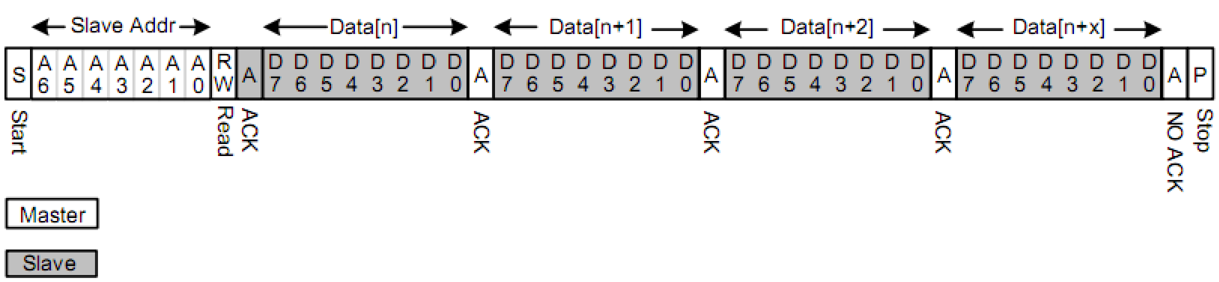


Similarly, the host application master can perform configuration and ESN reads from the ZeMo by first setting the slave data pointer (address to begin reading) and initiating a data read sequence as depicted below.

Set Slave Data Pointer



Read x Bytes from I2C Slave



When complete, the master releases the **SDA and SCL signaling lines which must be weakly pulled up on the host application.** The ZeMo will sense the signals high and timeout after 2 seconds to resume low-power state.

The I2C interface creates a virtual dual-port ram where the host application and the ZeMo can pass data and commands to each other. It is not a physical dual-port RAM however, and only one user can access the data store at a time. While the host application is reading or writing the I2C data store, the ZeMo is locked out. For this reason, users should refrain from continually polling the registers in tight software loops to create windows for the ZeMo to access the data store.
The ZeMo device is factory set to slave address 0x00.

5. On-Air Interface

The ZeMo transmits data in a radio format compatible with the Globalstar Simplex Data Service. This section provides a brief overview of the operation of the network service. Greater detail can be found in the requirements definitions set forth by Globalstar.

5.1. RF Modulation

The ZeMo transmits data using Direct Sequence Spread Spectrum (DSSS) carrier with a Binary Phase Shift Keyed (BPSK) data modulation. The ZeMo can be configured to send data on one of four radio center frequencies. Globalstar operational requirements for channel usage must be observed by application developers. Generally, channel A is used for North American operations except where the device is in proximity of Radio Astronomy Sites (RAS), where channel C is prescribed. Use in other global regions uses channel C. The channels are specified as:

RF Channel
Channel A = 1611.25 MHz center frequency
Channel B = 1613.75 MHz center frequency
Channel C = 1616.25 MHz center frequency
Channel D = 1618.75 MHz center frequency

The DSSS carrier is generated using a pseudo random maximal length feedback shift register utilizing a polynomial code prescribed by Globalstar.

The PSR chip rate is 1.25 Mchip/sec. The frequency accuracy is ± 10 ppm total frequency error over all operating conditions, with no more than 0.3 ppm error during a transmission of a single packet. Chipping rate and RF frequency are coherent.

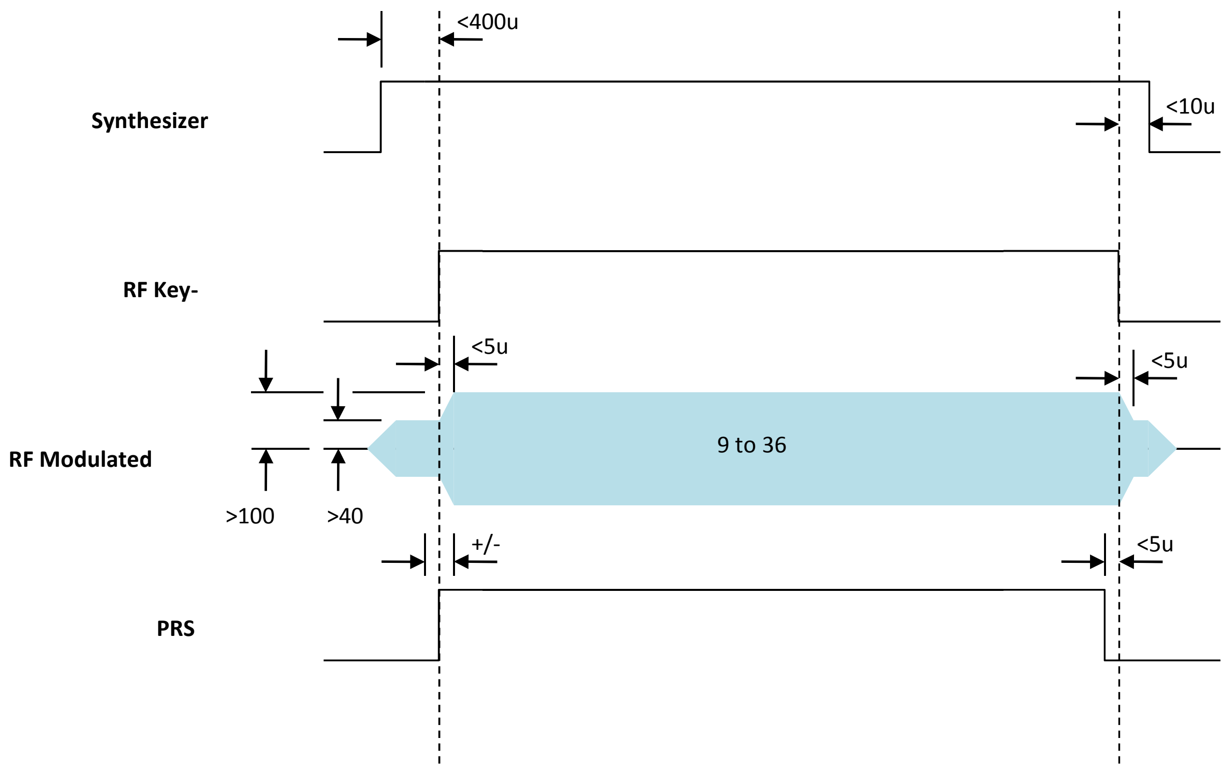
The symbol rate is 100.04 bps, derived from 49 PSR code repetitions, with symbol boundary occurring at epoch.

Transmit output power is 18 dBm ± 2 dB RMS over all operating conditions. The following timing considerations with regard to RF key-on will be observed:

The EVM (Error Vector Magnitude) is less than 15 % RMS for 1020 symbols. This corresponds to an RMS phase error of less than 18 degrees and a magnitude error of less than 10%.

- PRS code must be applied within ± 5 us of RF key-on
- RF output power is greater than 100 dB below nominal output power for RF key-off
- RF synthesizer is not to be turned on more than 400 us before the RF key-on. Transmit power will be attenuated a minimum of 40 dB from nominal output power during this period.
- RF key-off occurs no later than 10 us following data transmission
- RF power and data modulation is stable within 5 usec of RF key-on
- RF key-off function occurs within 5 usec
- PRS code is disabled no sooner than 5 usec before PA is turned off.
- The ZeMo will not transmit if the RF generation circuitry is not locked and modulation is stable.

The diagram below depicts the RF modulation operation timing.



The RF spectrum shall not contain harmonic levels that exceed -20 dBm when measured in a 5 MHz bandwidth. Non-harmonic related discrete spurs shall not exceed -30 dBm when measured in a 100 KHz bandwidth.

5.1.1. EMI/EMC Conformance

The ZeMo shall carry an FCC modular device certification, stipulating a maximum antenna gain of +5 dBi.

Regulatory Requirements :

ETSI TBR41

ETSI TBR41 Requirements is a summary of the ETSI requirements. As these values represents EIRP, they must be decreased by 4 dB to take in account the maximum antenna gain if a conducted measurement is performed.

ETSI TBR41 Requirements

Absolute Frequency	Offset from Carrier	EIRP	Measurement Bandwidth / Method
0.1 to 30		-36 dBm	10 KHz Peak-Hold
30 to 1000		-36 dBm	100 KHz Peak-Hold
1000 to 1559		-30 dBm	1 MHz Average
1559 to 1580.42		-40 dBm	1 MHz Average
1580.42 to 1605		-40 dBm	1 MHz Average
1605 to 1610		-40 dBm to 20 dBm[1]	1 MHz Average
Frequency Offset (Does not apply below 1610 MHz)	-17.75 to –3.05 MHz	-26 dBm	30 KHz Average
	-3.05 to –2.165 MHz	-26 dBm to – 23 dBm[1]	30 KHz Average
	-2.615 to –1.9 MHz	-15 dBm	30 KHz Average
	-1.9 to –1.475 MHz	-15 dBm to –8.5 dBm[1]	30 KHz Average
	-1.475 to –1.41 MHz	-8.5 dBm to – 5 dBm[1]	30 KHz Average
	-1.41 to –1.25 MHz	-5 dBm	30 KHz Average
Frequency Offset (Does not apply above 1628.5 MHz)	1.25 to 1.41 MHz	-5 dBm	30 KHz Average
	1.41 to 1.475 MHz	-5 dBm to –8.5 dBm[1]	30 KHz Average
	1.475 to 1.9 MHz	-8.5 dBm to –15 dBm[1]	30 KHz Average
	1.9 to 2.615 MHz	-15 dBm	30 KHz Average
	2.165 to 3.05 MHz	-23 dBm to – 26 dBm[1]	30 KHz Average
	3.05 to 17.75 MHz	-26 dBm	30 KHz Average
1628.5 to 1631.5		-30 dBm	30 KHz Average
1631.5 to 1636.5		-30 dBm	100 KHz Average
1636.5 to 1646.5		-30 dBm	300 KHz Average
1646.5 to 1666.5		-30 dBm	1 MHz Average
1666.5 to 2200		-30 dBm	3 MHz Average
2200 to 12,750		-30 dBm	3 MHz Peak Hold

FCC Part 15.109

[1] Limit in dB varies linearly

FCC Part 15.109 Summary lists the spectrum limits when the ZeMo is actively processing data but not transmitting.

FCC Part 15.109 Summary

Absolute Frequency	Offset from Carrier	EIRP	Measurement Bandwidth / Method
30 to 88	-	90 µV/m	10 meters
88-216	-	150 µV/m	10 meters
216-960	-	210 µV/m	10 meters
Above 960	-	300 µV/m	10 meters

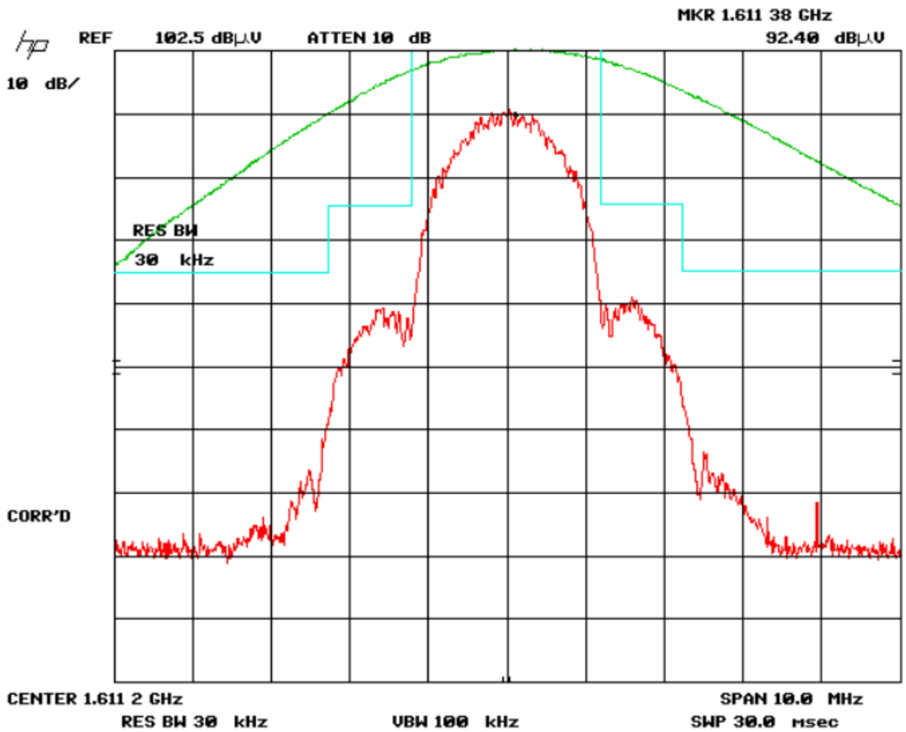
Part 25.202

Part 25.202 Summary lists the FCC spectrum limits when the ZeMo is transmitting.

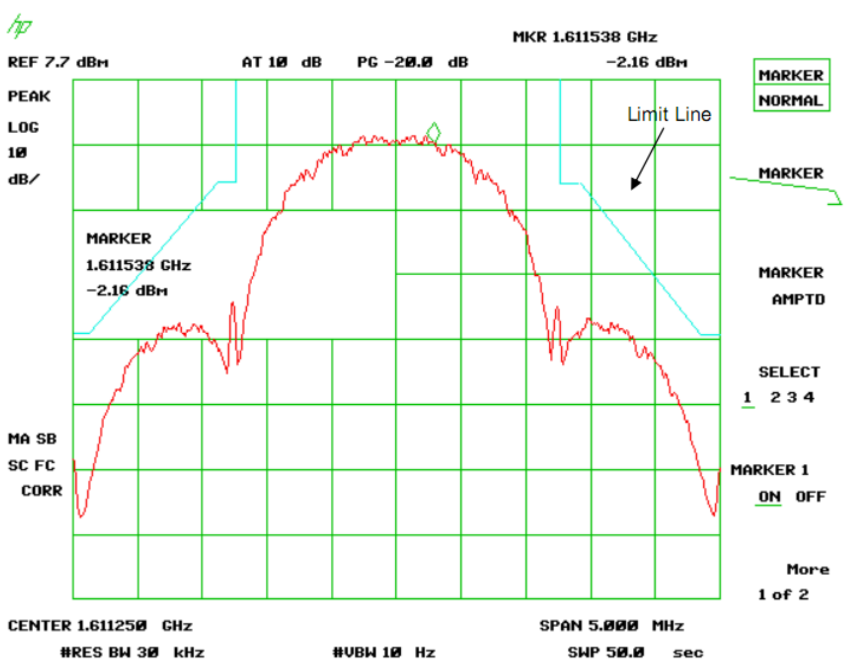
Part 25.202 Summary

Absolute Frequency	Offset from Carrier	EIRP	Measurement Bandwidth / Method
Frequency Offset (Authorized bandwidth 2.5 MHz)	Below –6.25 MHz	-35 dBc	4 KHz Average
	-6.25 to –1.25 MHz	-35 dBc	4 KHz Average
	-2.5 to –1.25 MHz	-25 dBc	4 KHz Average
Frequency Offset (Authorized Bandwidth 2.5 MHz)	1.25 to 2.5 MHz	-25 dBc	4 KHz Average
	2.5 to 6.25 MHz	-35 dBc	4 KHz Average
	Above 6.25 MHz	-35 dBc (Assuming 18dBm output power)	4 KHz Average

The graphs below depict the FCC part 25 and ETSI occupied channel bandwidth performance with limits shown compliant to the tables above.



FCC Part 25 Occupied Bandwidth and Emissions Limitations (FCC Sec. 2.1049, 25.202(f))



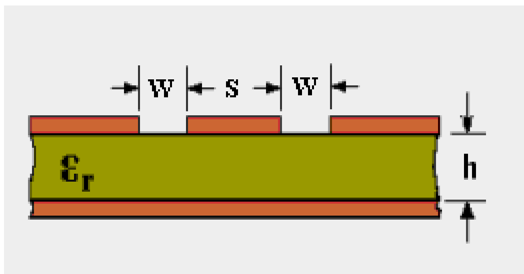
ETSI Unwanted Emissions Within the band (sub-clause 5.2.3)

6. Electrical and Mechanical Specifications

This section provides the mechanical and electrical requirements for the integration of the ZeMo into a host application.

6.1. RF Transmit Design Guidelines

The ZeMo sends the RF transmit signal through one of the pins on the connector. In order to avoid signal loss, the signal should be routed through a 50 Ohm coplanar RF signal path in the application design. For 0.062" FR4 circuit assemblies as depicted below, this is typically a 63 mil RF trace (s) with a 15 mil gap(w) to stitched ground skirt on top of ground on opposite side of the board (h).

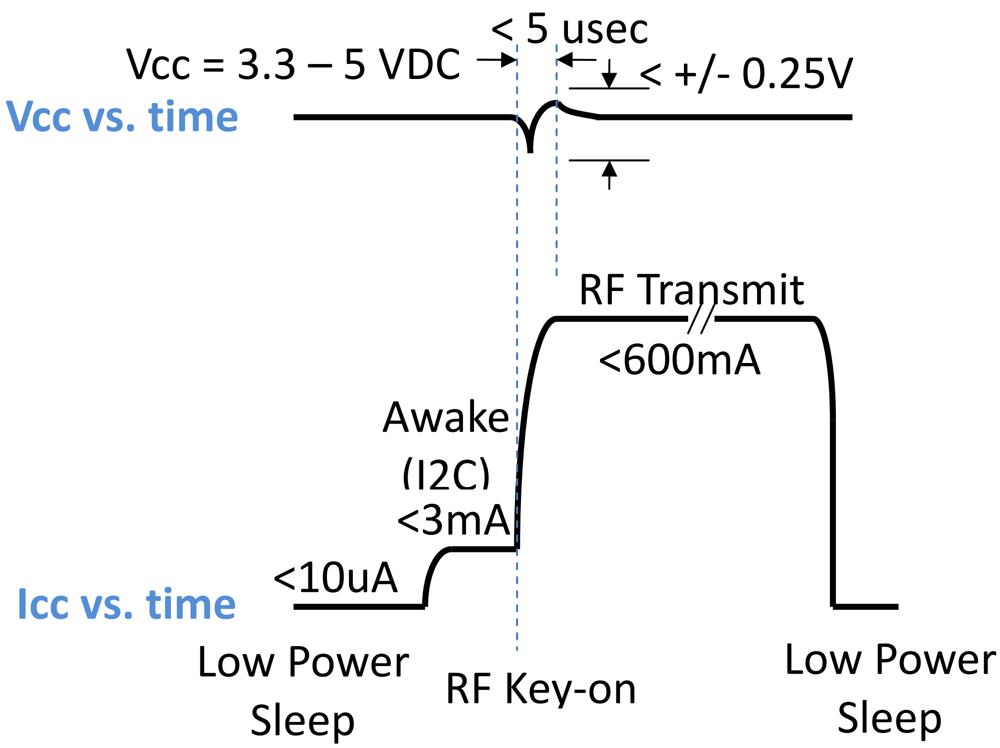


A printed circuit board impedance simulator (such as one found online at http://chemandy.com/calculators/coplanar-waveguide-with-ground-calculator.htm) can be used to design and evaluate an RF signal trace as described above. Designers must completely evaluate the impedance of the RF trace to avoid signal power loss and unintentional radiation. Appropriate design must also include adequate adjacent component placement to ensure application design conducts RF energy only to the designated antenna or RF connector.

It is the responsibility of the application developer to ensure that the antenna design and RF trace path loss deliver the RF energy to the antenna to ensure compliance with the radiation performance parameters of the modular and end-product RTU certifications (FCC ID ZBR001 and IC: 9540A-001 and the Globalstar certification processes then in place). Specifically, minimum and maximum EIRP values must be met and demonstrated by the application designer as part of the product certification process required by Globalstar. Additionally, the maximum antenna gain and unintended radiation limits set by the federal regulatory certifications must also be met.

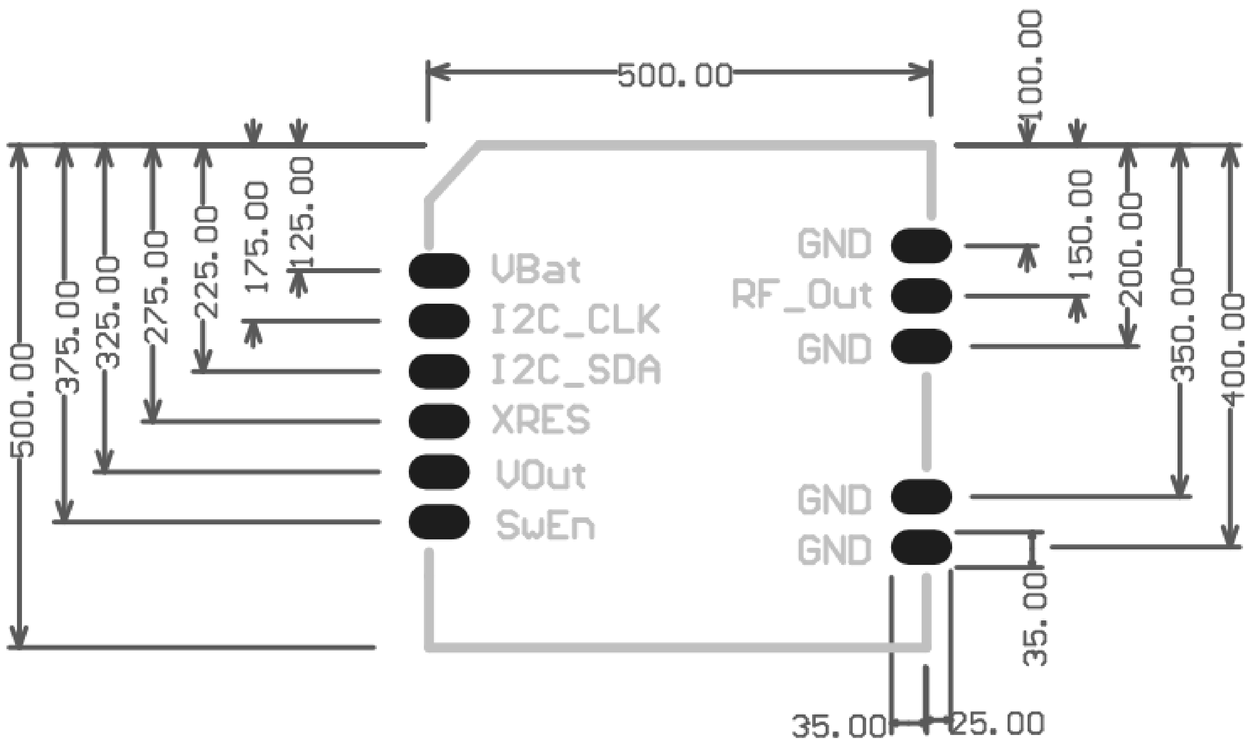
6.2. Electrical Supply Guidelines

The ZeMo has dynamic power management features, idling at microamps but requiring pulse current on radio transmit. The power supply feeding the ZeMo must be able to source 500 mA of supply current within 5 usec of transmit start without drooping supply voltage below 0.5V.



6.3. Mechanical Interface

The ZeMo is a board-level module that integrates into the host application via the surface mount pads shown below. The Zemo top-side host solder footprint is shown below.



ZeMo Host Footprint (top side view)

The ZeMo is an RF module assembly. Care should therefore be taken in application design to ensure the power and data signals are electrically clean. Running RF or digital signals under the ZeMo module is not advised. It is preferred to provide a solid ground plane on the top layer of the application board layout.

7. Integration Guidelines

Integrating the ZeMo into an application requires compliance with the network operation guidelines as set forth by Globalstar. This section highlights the primary guidelines and restrictions, however users must consult with Globalstar for any updates or changes to operation that govern use of the Simplex Satellite service.

The ZeMo is approved for use in mobile devices only. Installation in human-worn devices is not permissible. Applications must be installed in such a way as to prevent approach within 20 cm of the transmitting antenna. This warning and notice must be provided by product integrator that utilizes the ZeMo device.

7.1. Regulatory Certifications and ZeMo Labeling

The application that incorporates the ZeMo device must be properly certified for the region of operation. ZeMo will carry modular certifications for FCC, IC and EU, but the integrator must confirm operation of the final integrated unit in compliance with the modular use and regional regulatory restrictions including the required marking of the end device. The ZeMo device (Model SCC-001) is marked with the FCC ID and IC certification number as shown below.

Each ZeMo transmitter label will also contain a Micro-QR barcode and human readable Electronic Serial Number (ESN). The left-most digit in the labeled ESN is the manufacture ID, so as shown above, the ESN is 2-3000045. The ESN notation is decimal, with the Manufacture ID weighted as 2^23. The formula below provides the conversion for the ESN labeling to hexadecimal notation used in ESN reads from the ZeMo (see section 3.1.3).

$$ESN_{hex} = (MFG\_ID * 2^{23}) + ESN_{dec}$$

For the example label above:

$$ESN_{hex} = 0x012DC6ED = (2 * 2^{23}) + 3000045$$

When the ZeMo is incorporated into a product, it must be appropriately labeled. The application designer must ensure the product labeling is accurate and complete. At a minimum, it must contain a statement or marking to designate the device contains the radio transmitter.

“Contains Transmitter Module FCC ID: ZBR001” or

“Contains FCCID: ZBR001”

Consult the regulatory requirements for product marking for the latest requirements for each region or application for the application product to ensure compliance.

Note Well: This equipment has been tested and found to comply with the limits for a Class B device, pursuant to part 25 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 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.

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

7.2. Globalstar Certifications

The application that incorporates the ZeMo device must be properly certified by Globalstar before use over their network. This will include proper channelization for regional use and other radio telemetry requirements. Contact Globalstar for RTU certification procedures. Special attention must be given to channelization of use as specified in Globalstar document GS-07-1248.

7.3. Antenna Guidelines

The ZeMo may be integrated with an antenna with a maximum directivity gain of +5dBi, such as the Spectrum Advanced Specialties Products antenna part number **PA25-1615-025SA** or **PA451615-1575SA (dual band sat+gps)**. Application designers are warned that strict adherence to antenna RF trace impedance and radiated performance is required.

7.4. Production Compliance Guidelines

Application developers must comply with all regulatory requirements of the modular certifications of the ZeMo in order to use the FCC and/or IC identifiers. The Application developers must ensure that adequate processes are in place at point of manufacture to ensure that the products produced continue to comply with regulatory and network operator requirements. The integrator is forewarned that manufacturing processes that do not adequately screen for the introduction of non-compliant device operation may void use and may result in regulatory and/or network certification dismissal. In all cases, the application developer is forewarned that they must comply with all applicable use and marking requirements as set forth in Part 25 and Part 15 regulations which shall govern.