



**GTCU-002**  
**Theory of Operation**

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## Legal Notice

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## 1 Overview

This document provides the theory of operation for the Globe Tracker Communications Unit (**GTCU**). The GTCU is battery operated and features GSM/GPRS Cellular, Wi-Fi, 433 MHz, and GPS radio frequency (RF) technologies. The GTCU system consists of the Globe Tracker Communications Module (**GTCM**) and the Globe Tracker Antenna Module (**GTAM**).

The GTCM contains the main PCB, battery, and an internal 433 MHz trace antenna located in the GTCM end cap. The GTAM contains an antenna array with cellular (GSM) and 433 MHz PCB trace antennas, as well as Wi-Fi and GPS patch antennas. The GTAM also contains a low noise amplifier (LNA) for the GPS.

The GTCM and GTAM connect via four (4) SMB RF cable assemblies that protrude through sealed openings in their housings. The GTCM uses a connection plate in the housing for mounting the SMB connectors, a DB-9 connector for external interfacing, and LED indication.

The GTCU is able to be powered from an internal battery pack or an external input. Units powered from the internal battery pack are typically in a stand-by power down state to conserve battery energy.

In the simplest configuration for battery powered units, the GTCU will wake-up at pre-defined and customizable intervals. Upon wake-up the GTCU will power on the various sub-circuits, attempt to obtain a GPS fix, log any relevant data from its sensors or communication interfaces (typically UART or 433MHz), and transmit data via an appropriate wired or wireless interface if applicable (e.g. UART, 433MHz, Cellular, or Wi-Fi). Units powered externally operate similarly to battery powered units but may not enter into stand-by mode, and may have increased data acquisition and reporting frequency.

The GTCM main circuit board has the following sub-circuits.

- Main Processor (STM32F2)
  - SPI Flash Memory
  - JTAG
- Wireless Interfaces
  - GSM/GPRS Cellular (Telit GE865-Quad)
  - Wi-Fi (802.11 b/g/n) (GainSpan GS1011MIE13)
  - 433 MHz Transceiver (Texas Instruments CC1110)
  - GPS Receiver (U-Blox IT530M)

- Wired Interfaces
  - External UART
  - Debug UART
- Internal Sensors
  - Accelerometer (LIS3DH)
  - Temperature Sensor (TMP112AIDRLT)
- Power Regulation and Control
  - 2 linear LDO (Low Drop Out) regulators
  - 3 switching regulators
  - Battery Input
  - External Input
  - FET switching networks

## 2 Main Processor

The main processor is an ST Microelectronics STM32F2 series which features an ARM Cortex M3 core. The processor is driven from an internal R/C oscillator with a base frequency of 16MHz, an internal phase locked loop (PLL) multiplies the base to provide a core frequency of 120MHz.

No formal operating systems is used, rather a simple scheduler is implemented. The STM32F2 supports a standard JTAG interface for programming and debug. An external SPI flash is used for data logging.

## 3 Wireless Interfaces

The GTCU features three (3) RF transceivers and a GPS receiver. Device firmware prevents the transceivers from being active at the same time. Generally, a GPS fix is acquired first and the specific transceiver then used to transmit data depends on the devices location. For example, cellular communications are suspended if it is determined that the device is in the middle of the ocean where there is no cellular service.

### 3.1 GSM/GPRS Cellular

A Telit GE865-Quad pre-compliant module is used for GSM/GPRS cellular communications.

<b>Model:</b>	Telit GE-865 Quad
<b>Band:</b>	Quad-Band EGSM 850/900/1800/1900 MHz
<b>Sensitivity:</b>	-107 dBm @ 850 / 900 MHz -106 dBm @ 1800 / 1900 MHz
<b>GPRS Data:</b>	GPRS class 10 Mobile station class B
<b>Antenna Gain:</b>	3 dBi @ 1900 MHz 1.4 dBi @ 850 MHz
<b>Antenna Type:</b>	PCB trace
<b>FCC ID</b>	RI7GE865
<b>CE Notified Body</b>	CE 0889

### 3.2 Wi-Fi (802.11 b/g/n)

A Gainspan GS1011MIE13 pre-compliant module is used for Wi-Fi 802.11 b/g/n communications. Globe Tracker Inc. has been granted a change in identification for this module as specified under 47CFR2.933 of the FCC rules. Device firmware limits operation to 802.11b mode only.

<b>Model:</b>	Gainspan GS1011MIE13
<b>Modes Supported</b>	802.11 b
<b>Antenna Gain:</b>	3.5 dBi @ Zenith
<b>Antenna Type:</b>	Patch
<b>FCC ID</b>	2AAZL-GTCU-GS-001

### 3.3 433 MHz

A Texas Instruments CC1110F32RSPR transceiver IC is used for 433 MHz communications. There are two (2) ports on the GTCM selected with a Peregrine Semiconductor PE4529 RF switch. One port is for an internal antenna placed in the end-cap of the GTCM, the other port connects to the external GTAM antenna array. A Johanson Technology 0433BM15A0001E balun-filter is used to match the RF circuit. The filter has a bandpass of 430-435 MHz.

<b>Model:</b>	Texas Instruments CC1110F32RSPR
<b>External Antenna Gain:</b>	0 dBi
<b>External Antenna Type:</b>	PCB Trace
<b>Internal Antenna Gain :</b>	-9.2 dBi
<b>Internal Antenna Type:</b>	PCB Trace
<b>Modulation:</b>	GFSK
<b>Data Rate:</b>	79.9255kBaud
<b>Channels:</b>	Channel 1: 433.263565 MHz Channel 2: 433.922745 MHz Channel 3: 434.370987 MHz
<b>Transmission On Time</b>	< 12.11 mSec
<b>Transmission Idle Time</b>	≥ 10 Sec

### 3.4 GPS

A U-Blox IT530Mis used for GPS reception. Cold, warm, and hot start modes are supported. A patch antenna in the GTAM antenna array is supported with an LNA (Low Noise Amplifier).

## 4 Wired Interfaces

The GTCM supports RS-232 compliant serial port communications from the external DB-9. A 3.3V UART is also available from the GTCM main board for debug purposes. In the field the 3.3V debug UART is contained within the GTCM enclosure and is not available for use.

## 5 Internal Sensors

The GTCM features internal sensors for detection of motion, temperature, and battery voltage.

### 5.1 Motion Sensor

An ST Microelectronics LIS3DH is used for motion and free fall detection.

<b>Model:</b>	ST Microelectronics LIS3DH
<b>Type:</b>	3 Axis
<b>Communication</b>	SPI, Interrupt

### 5.2 Temperature Sensor

A Texas Instruments TMP112AIDRLT is used for temperature sensing.

<b>Model:</b>	Texas Instruments TMP112AIDRLT
<b>Communication</b>	I <sup>2</sup> C

### 5.3 Voltage Sensing

The GTCM monitors analog voltage fed into the main processor A/D converters from external inputs and battery voltage.

## 6 Power Regulation and Control

The GTCM may be powered from its internal battery pack or externally through the DB-9 connector located on the mid-plate. The battery and external power inputs are connected in a “diode-or” configuration. When a minimum external voltage is applied, power consumption from the batteries is disabled. Detection circuitry informs the main processor if external power is available thereby permitting a less conservative energy management profile.

The battery pack is comprised of two separate configurations; one at a nominal 3.0V used for stand-by, and the other at a nominal 7.5V used for primary operation. The main processor uses a minimal amount of power from the 3.0V rail during a wake up event. After wakeup, the 7.5V rail is switched in and the 3.0V rail power consumption returns to the minimal stand-by level. The 7.5V rail is switched off before returning to stand-by mode.

The following power regulators are used in the GTCM circuit:

- TPS40200 Buck Regulator,  $F_{SW} = 297$  kHz,  $V_{REG} = 15V$
- TPS62140 Buck Regulator,  $F_{SW} = 2.5$  MHz,  $V_{REG} = 2.8V$
- TPS62140 Buck Regulator,  $F_{SW} = 2.5$  MHz,  $V_{REG} = 3.8V$
- MAX16910 Linear LDO,  $V_{REG} = 3.6V$
- MCP1703T Linear LDO,  $V_{REG} = 2.8V$

## 7 GTCM Connection Mid-Plate

The GTCM connection mid-plate contains the 5 RF SMB connectors, a DB-9 connector, and a light pipe for multi-color LED status indication.



### 7.1 SMB Connectors

Four (4) of the SMB connectors are used for external RF connections to the GTAM. One (1) of the 433 MHz connectors is used for connection to an internal end cap antenna.

### 7.2 DB-9 Connector and Power-On Jumpers

The DB-9 connector supports external power inputs and RS-232 communications. There are two pairs of redundant power on jumpers that connect the battery and enable the device. The jumper connections are not required when powering the device from the external power connections.

### 7.3 LED Indicators

The mid-plate holds a light pipe that channels light from three (3) separate LEDs on the GTCM. Red, Amber, and Green are supported.

## **FCC WARNING**

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.

NOTE 1: 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 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.

NOTE 2: Any changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.