

# Data Sheet

PulsON<sup>®</sup> 400 RCM

## TIME DOMAIN<sup>®</sup>

Cummings Research Park  
4955 Corporate Drive Suite 101  
Huntsville, AL 35805 USA  
<http://www.timedomain.com>

Tel: +1 256.922.9229

+1 888.826.8378

Fax: +1.256.922.0387

320-0289B  
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## 1 Overview

This data sheet describes Time Domain's PulsON (P400) Ranging and Communications Module (RCM). The P400 RCM is an UltraWideband (UWB) Radio Transceiver that provides the following functions:

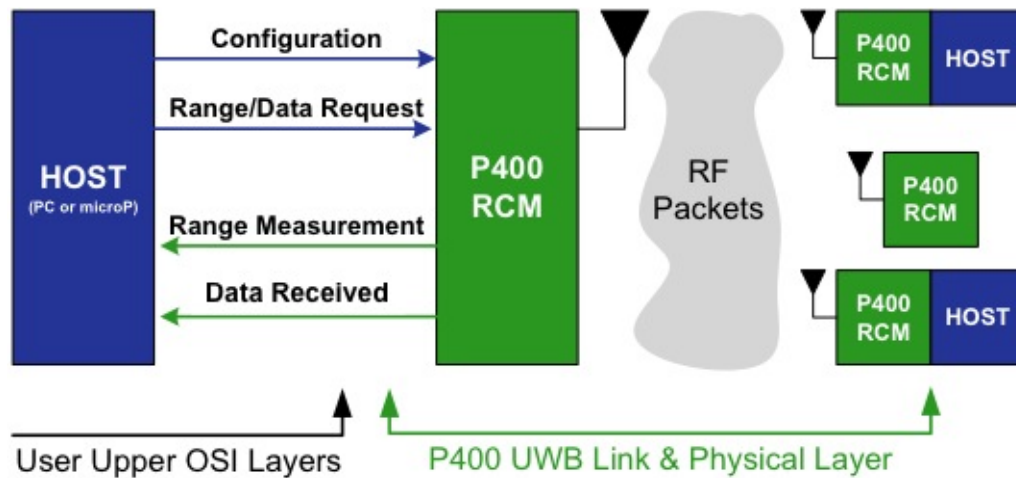
- It accurately and reliably measures the distance between two P400 RCMs and provides these measurements at a high update rate.
- It communicates data between two or more RCMs.

The P400 RCM, shown in **Figure 1**, is small, low power, affordable, provides accurate, high rate range measurements and has superior operational performance when compared to conventional RFID/RTLS devices. The device is intended for use as an OEM module.



**Fig. 1: P400 RCM with attached Broadspec antenna**

The user controls and monitors the P400 RCM through a simple Application Programming Interface (API) over either an Ethernet or Serial connection. The API provides all the commands and capabilities required by a user to design a network tailored for operating multiple RCMs as a system. Time Domain does not provide a standard network as part of the API. Instead, Time Domain is focused on providing a robust platform and a full featured, flexible interface. This focus includes all aspects of the physical and link layers as well as a few additional mechanisms to support implementation of a wide variety of network architectures. A system block diagram is provided in **Figure 2**.



**Fig. 2: Illustration of the interface with a system of RCMs**

### Key Features of the P400 RCM

- Excellent performance in high multipath and high clutter environments
- Coherent signal processing extends operating range
- Direct sequential pulse sampling allows measurement of received waveform (resultant waveform is available to the user for ranging optimization)
- High precision ranging with industry-leading update rate
- UWB chipset enables low cost, small size and low power operation
- UWB waveform and pseudo random encoding ensures noise-like transmissions with a very small RF footprint
- RF transmissions from 3.1GHz to 5.3 GHz, with center at 4.3 GHz
- Two user-configurable antenna ports for single or dual antenna operation
- RF emissions compliant with FCC limits
- Each unit is a full transceiver
- Single 3"x 4" (7.6 x 10.2 cm) board
- Ethernet or Serial interface

### Typical Applications of the P400 RCM

- Peer-to-peer ranging with moderate-rate wireless communications
- GPS augmentation for multipath resistance
- Inertial augmentation for drift removal
- Robotics navigation and tracking, precision formation
- Autonomous vehicle convoys
- First responder tracking and man-down locator
- Asset tracking, especially in applications that preclude the use of fixed infrastructure or involving moving frames of reference
- Distributed sensor automatic survey and dynamic mapping with fused data communications
- Wireless channel impulse response (CIR) measurements
- Wireless noise-like / covert data communications

This document focuses on describing the P400 hardware, and is broken into sections which are described below. Additional information including the API, software manuals, applications notes, white papers, examples, published papers, etc. can be found on the web at [www.timedomain.com](http://www.timedomain.com).

**Section 2** provides and describes the P400 block diagram

**Section 3** discusses the physical interfaces

**Section 4** provides mechanical details

**Section 5** describes performance

**Section 6** discusses regulations and export compliance

## 2 Hardware Block Diagram

This section provides and discusses at a high level the P400 RCM functional hardware block diagram, as shown in **Figure 3**. Additional detail on the various interfaces is provided in Section 3.

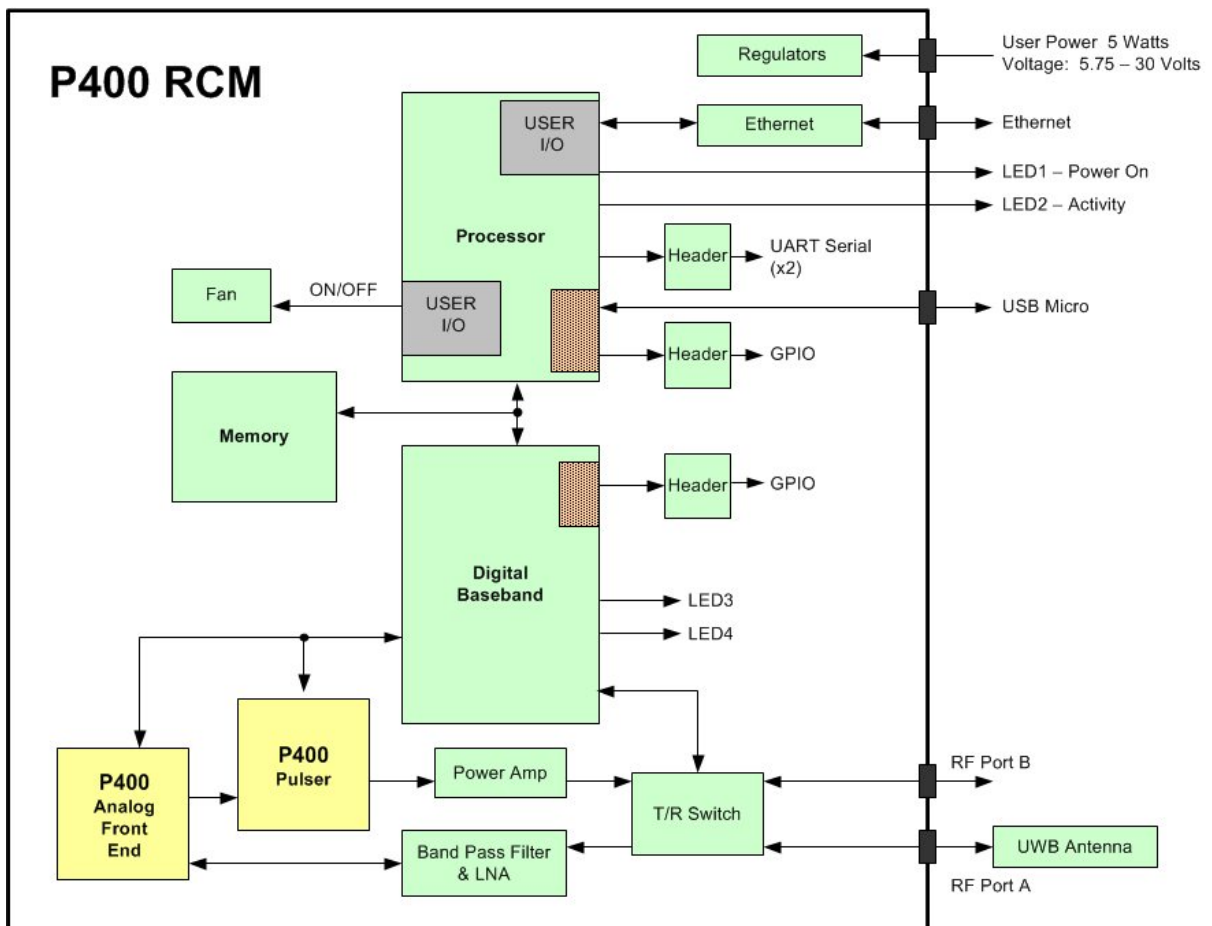


Fig. 3: P400 RCM hardware functional block diagram

To power the board, the user must supply 5 watts at any voltage between 5.75-30V. This can be accomplished either with the provided power supply or from a battery. Indicating lights provide operating status information.

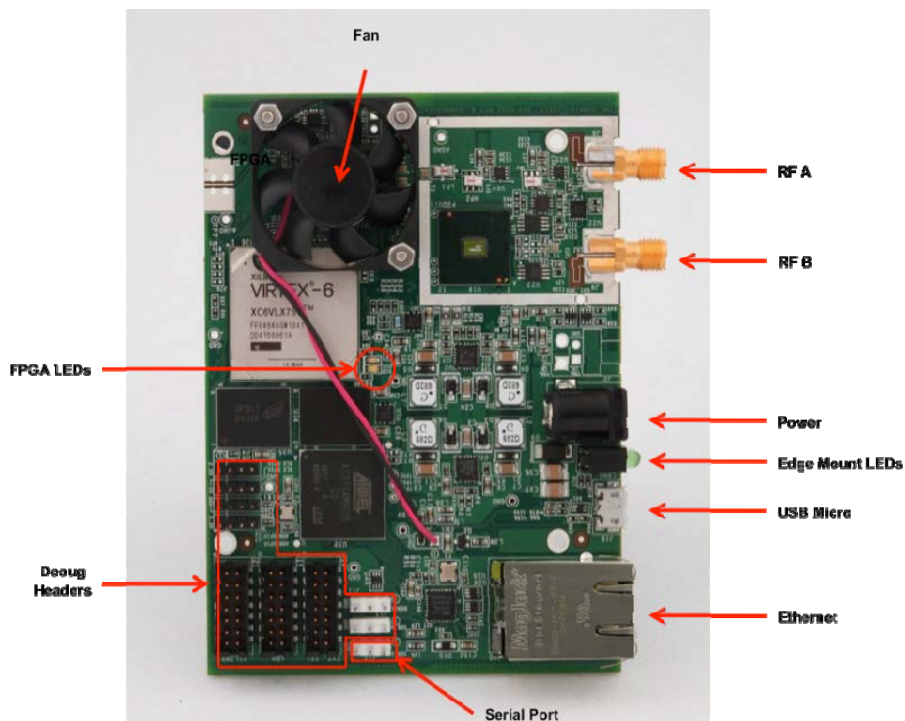
The user can interface to the RCM through either Ethernet (standard jack) or a Serial connection (header). In addition, the user can request the RCM to report the board temperature and can command the fan to turn on or off.

The processor controls the radio through a Digital Baseband FPGA interface. The Digital Baseband controls the UWB front end. More specifically, it configures the Time Domain P400 Pulser chip (UWB transmitter) and P400 Analog Front End (AFE) chip (UWB receiver), provides timing signals and out-going data, receives incoming data and controls the position of the transmit/receive (T/R) switch.

There are three RF sections: 1) power amplification has been provided to boost the output of the Pulser from an FCC limit of -14.5dBm up to 2.3dBm; 2) the receive chain consists of gain stages and band pass filter; and 3) the T/R switch supports 4 configurations: Transmit/Receive on Port A, Transmit/Receive on Port B, Transmit on A, Receive on B, and Transmit on B, Receive on A. The T/R switch position is normally established on a packet basis.

### 3 Interfaces

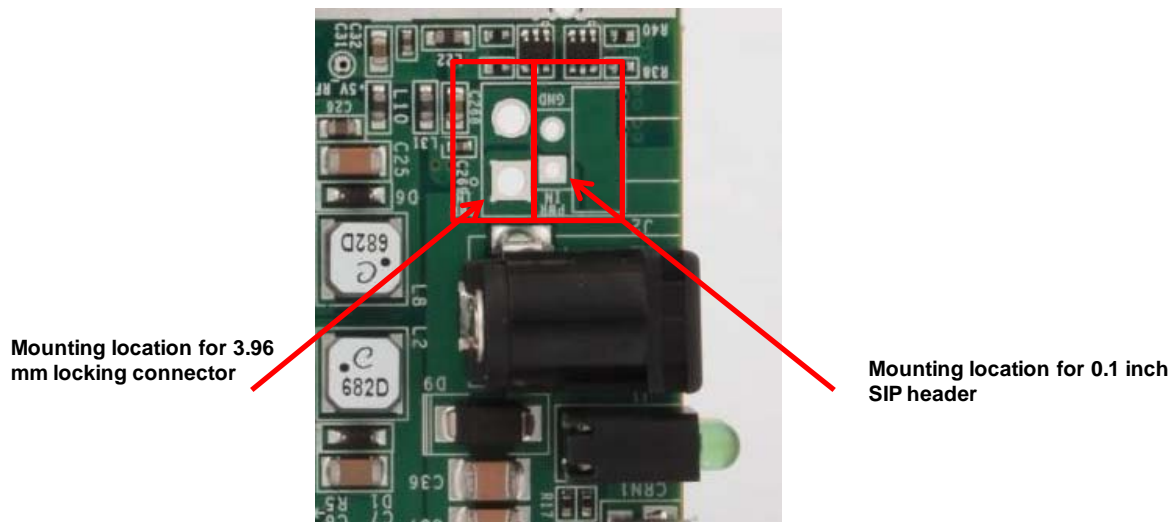
This section provides a detailed description of the various P400 RCM interfaces. The overall board image in **Figure 4** is referenced throughout this section.



**Fig. 4: Photo of the RCM highlighting key interfaces**

### 3.1 Power

The P400 RCM is normally powered by a modular power supply (sold by Time Domain) that plugs directly to the P400 barrel connector power jack. Alternatively, the user can install alternate SIP connectors using either of two pairs of mounting holes shown in **Figure 5**. The pair of holes on the right is intended for a two position, 0.1 inch pitch header (Digi-Key part number WM8072-ND). The pair of holes on the left is intended for a locking, two position, 3.96mm connector (Digi-Key part number 455-1648-ND). The round hole is connected to ground. The square hole is for the supply voltage. The input power is specified in **Table 1**.



**Fig. 5: Alternate Power Connections**

Parameter	Description	Min	Typical	Max	Unit
$V_{IN}$	Input voltage to P400	5.75		30.0	Volts
$I_{IN}$	Input current to P400	0.9		0.17	Amps

**Table 1: Input voltage and current requirements**

### 3.2 Indicator Lights

The P400 is provided with four indicator LEDs. Two are mounted on the edge of the board and two are mounted adjacent to the Digital Baseband FPGA. See **Figure 4** for exact locations.

Edge Mount LEDs - The amber LED indicates that power to the board is on. The green LED is off until P400 has booted and is running. Once running, the LED will turn on solid. After that, it will

toggle every time a packet is received or transmitted.

**FPGA LEDs** - The amber LED toggles at 1Hz to indicate that the FPGA has passed Built-In Test (BIT). If the FPGA fails BIT, then the amber LED will blink at approximately 10 Hz. The green LED is initially off indicating that the FPGA has not been loaded. It blinks rapidly to indicate that the FPGA has been loaded and is getting a clock. After that, a steady on or off indicates a failure.

### 3.3 Ethernet and Serial Interfaces

The P400 RCM offers several different interfaces that allow users to control the module according to their specific application needs. The two standard interfaces currently supported by the API are: Ethernet 10/100 through an industry standard RJ-45 jack and a serial interface through a 0.1" SIP header.

The protocol used to communicate with the RCM is fully defined in the *API Specification*. That document also has additional information oriented to customers using the Ethernet interface to control the RCM.

The RCM board has a 3.3V serial universal asynchronous receiver transmitter (UART) port which customers can also use to communicate with the RCM. The Serial interface is documented in Time Domain application note *Using the RCM Serial Interface*.

Although the RCM currently supports Ethernet and TTL Serial data interfaces to the host, Ethernet is recommended for PC/Laptop hosts while Serial is intended primarily for embedded hosts. In addition, the board has the hardware capability to potentially implement the RCM command/response protocol through additional interfaces including: USB (Micro), USB Host, two separate SPI ports, an additional serial port, four processor 3.3 volt FPGA GPIO pins, and four 2.5V FPGA GPIO pins. Logic and drivers for these interface resources will be developed based on individual service agreements.

### 3.4 Antennas

The P400 RCM has two antenna ports, designated Port A and Port B. The connector used on each port is a standard polarity SMA connector (Digi-Key part number J801-ND). The two ports enable single and dual antenna modes of operation.

An RF transfer switch on the P400 RCM controls how the RF electronics are connected to the SMA connector. The switch supports 4 configurations: Transmit/Receive on Port A, Transmit/Receive on Port B, Transmit on A, Receive on B, and Transmit on B, Receive on A. The user specifies the desired antenna configuration through the API.

While Time Domain provides our standard BroadSpec UWB antenna with the development kit, the SMA ports are standard and any third party UWB antenna can be used depending on gain and directionality requirements. Please be aware that using alternate UWB antennas will likely change the RF time-of-flight electrical distance between the antenna port and the phase center of the antenna. Failure to account for such changes will result in an offset or bias error in range measurements. See the *API Specification* for details on how the electrical distance is defined and calibrated.

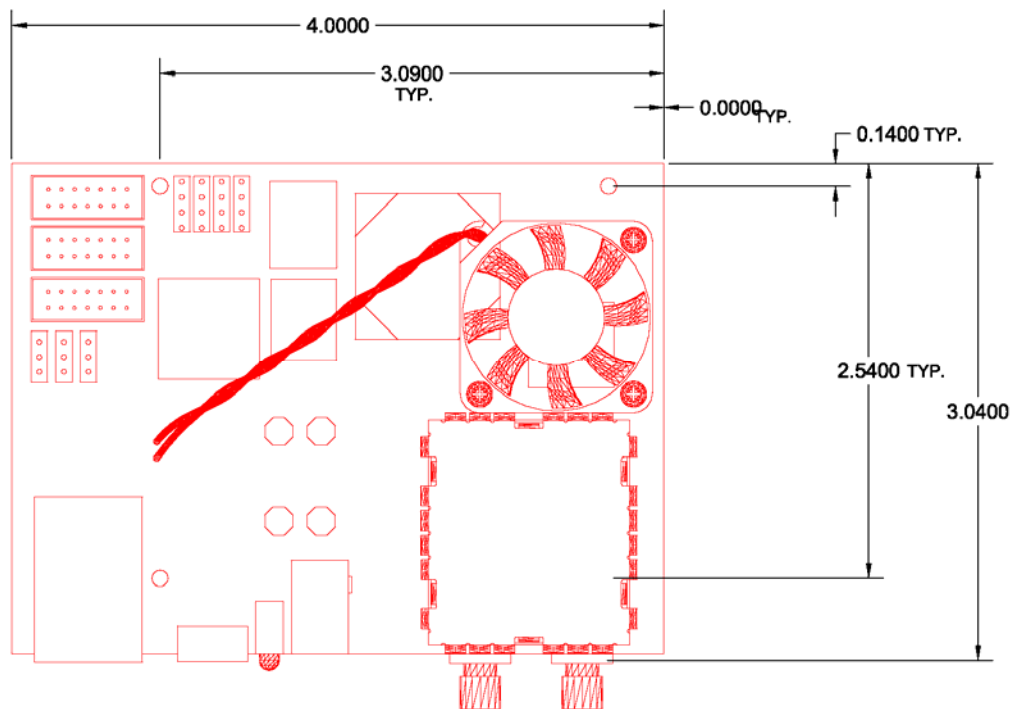
### 3.5 Fan

A small fan (2.5CFM) has been provided on the RCM. This fan is located between and above the FPGA and P400 AFE chip. Although these chips are manufactured to operate at high temperatures the fan is used to provide modest amount of heat removal required for optimal operation across all specified temperature and performance ranges. The fan can be turned off (through the API) or removed, but some degradation in maximum distance or accuracy may be encountered at high temperatures.

## 4 Mechanical

Board outlines and mounting hole locations are indicated in **Figure 6**. There are 4 mounting holes. Three are indicated in the drawing, the fourth is located underneath the RF shield and is not shown on the drawing. The fourth hole is symmetric with the other three. Board profile is shown in **Figure 7**. The board comes with 4 rubber feet, which are removable. All units are English.

Contact Time Domain for 3D CAD files in support of integration or enclosure design.



**Fig. 6: P400 top view**

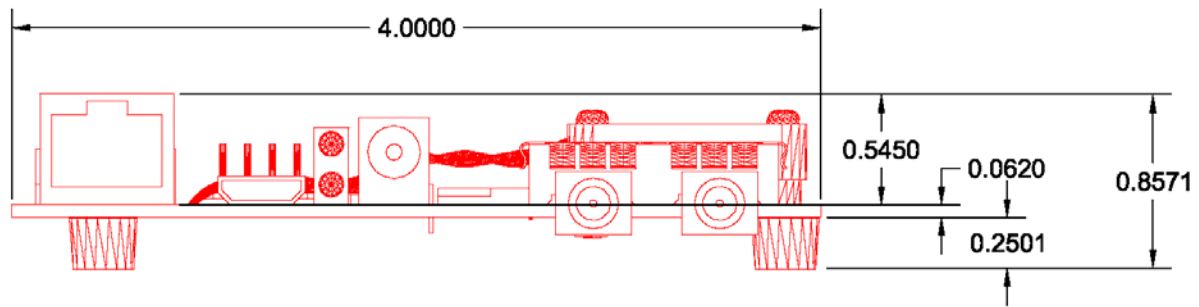


Fig. 7: P400 front view

## 5 Performance

**Table 2** summarizes the P400 specifications and key performance parameters. All performance metrics represent field measurements of acquisition time, data rate, range of operation and accuracy. Performance of a fielded system will be based on an optimal selection of pulse integration, which affects both maximum distance and update rate.

P400 Specs	Value
<b>Physical Parameters</b>	
Dimensions (with mounting feet):	4" x 3" x 0.85" = 10.2 in <sup>3</sup>
Dimensions (without feet or Ethernet jack)	4" x 3" x 0.60" = 7.2 in <sup>3</sup>
Temperature:	Operating: -10C to 65°C Storage: -40C to 85°C
Humidity:	Up to 95%, non-condensing
Power Requirements:	5.75V to 30V DC
Power Consumption:	5 Watts
<b>User Interfaces/Devices</b>	
Standard PC/Laptop Interface:	Ethernet/UDP
Standard embedded host interface:	3.3V TTL Serial UART 115.2kbps, 8, n, 1
Hardware Interfaces available but not currently supported:	<ul style="list-style-type: none"> <li>• USB Micro</li> <li>• USB Host</li> <li>• Additional Serial UART</li> <li>• SPI #1 and SPI #2</li> <li>• Four 3.3V GPIO</li> <li>• Aux 5.0V, 3.3V and 2.5V supply</li> <li>• Four FPGA controlled 2.5V GPIO</li> </ul>
On Board Temperature Sensor	-20°C to 55°C +/- 1.0 °C

<b>RF Characteristics</b>	
Operating Band:	3.1GHz to 5.3 GHz
Center Freq:	4.3 GHz
Transmit power:	Mode 1: FCC 15b compliant (-14.5 dBm) Mode 2: experimental non FCC up to +2.3 dBm
Antenna Ports A&B:	Standard 50 Ohm SMA coaxial connector
Antennas Supported	Compatible with Time Domain BroadSpec™ Toroidal Dipole Antenna (0 dB) as well as a wide variety of 3 <sup>rd</sup> party antennas.
Antenna Control:	User cross-bar configured as either Tx/Rx on either, or Transmit on one, Receive on the other.
Noise Figure:	4.8 dB
Dynamic Range:	
Integration: 1 (instantaneous)	30 dB
Integration: 64 (PII=6)	48 dB
Integration: 1024 (PII=10)	60 dB
Transmit Pulse Repetition Rate	10.1MHz (default - others available)
<b>RF Communications</b>	
Channelization:	7 user selectable pseudo-random pulse interval channels
Raw (Symbol) rates:	158k, 79k, 39.5k, 19.7k, 9.86kbps (standard)
Max Distance (FCC Part 15 0dB Antennas, Freespace):	88m, 125m, 177m, 250m, 354m (standard)
Comms type:	Packet transmission
Max user bytes/packet:	1024
<b>Ranging</b>	
Ranging technique:	Pulsed Two Way Time of Flight, highest multipath immunity
Range resolution:	1mm
Typical range accuracy LOS:	3.5cm
Typical range accuracy NLOS (unobstructed):	6.6cm
Range Update Rate:	40Hz to 3.5Hz
Max Distance (FCC Part 15 0dB Antennas, Freespace):	88m, 125m, 177m, 250m, 354m (standard)

Table 2: RCM performance characteristics

## 6 Regulations and Export

The RCM has been designed to be in compliance with the Federal Communications Commission (FCC) regulations governing both UWB hand-held systems (Part 15.519) also known as “battery powered devices” and UWB Surveillance Systems (Part 15.511). This means that the device can be incorporated in a wide variety of products including mobile tracking systems, mobile locators, radar-based locators, guidance and position systems, radar fences and communication devices.

Please note that while the RCM is designed for compliance, it has not been certified by the FCC. Certification must be done once the RCM is integrated into the final mechanical design or housing, as well as with the intended antenna for product rollout or fielding. Both the housing and the antenna can impact unintentional and intentional emissions respectively. If you intend to certify a product including the RCM under the FCC rules, you will have the best performance by removing the power amplification, which is provided on the standard RCM as discussed below. The removal of the power amplifiers will save significant power consumption as well as aiding in meeting the FCC spectrum masks. Time Domain is available to assist you with the certification process.

Based on requirements from a number of government customers, the RCM is capable of transmitting at power levels in excess of the FCC limits for enhanced performance. In order to use these higher powers, please consult and seek authorization from the appropriate regulatory agencies. Time Domain has expertise in working with regulatory agencies and can help as needed.

Additionally, the FCC regulations do not apply to government or military applications. Proper governmental use is described in “Government Regulations for Non-Licensed UWB Systems - Annex K”. Developers interested in building a device for a particular government agency should discuss their application and Annex K with that agency’s Spectrum Manager.

Related to export, the Department of Commerce’s Bureau of Industry and Security has assigned the Export Commodity Control Number (ECCN) of 5A001b.4 to the P400 RCM. Products falling under ECCN 5A001b.4 are controlled for export purposes pursuant to the Commerce Control List for National Security and Antiterrorism. For the latest information from the Commerce Department on Export, please go to: <http://www.bis.doc.gov/licensing/exportingbasics.htm>.