Data Sheet

PulsON® 400 MRM

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1 Overview

This data sheet describes Time Domain's PulsON 400 (P400) Monostatic Radar Module (MRM). The MRM consists of four key components:

- P400 hardware platform
- Application Programming Interface (API)
- Graphical User Interface (GUI)
- MRM Service

Hardware: The P400 MRM, shown in **Figure 1**, is a small, low-power and affordable mono-static radar platform that provides more than one gigahertz (GHz) of radio frequency (RF) bandwidth at a center frequency of approximately 4 GHz. The device is intended for use as an OEM module. Except for the addition of a second antenna, the MRM hardware is identical to that used by Time Domain's Ranging and Communications Module (RCM).

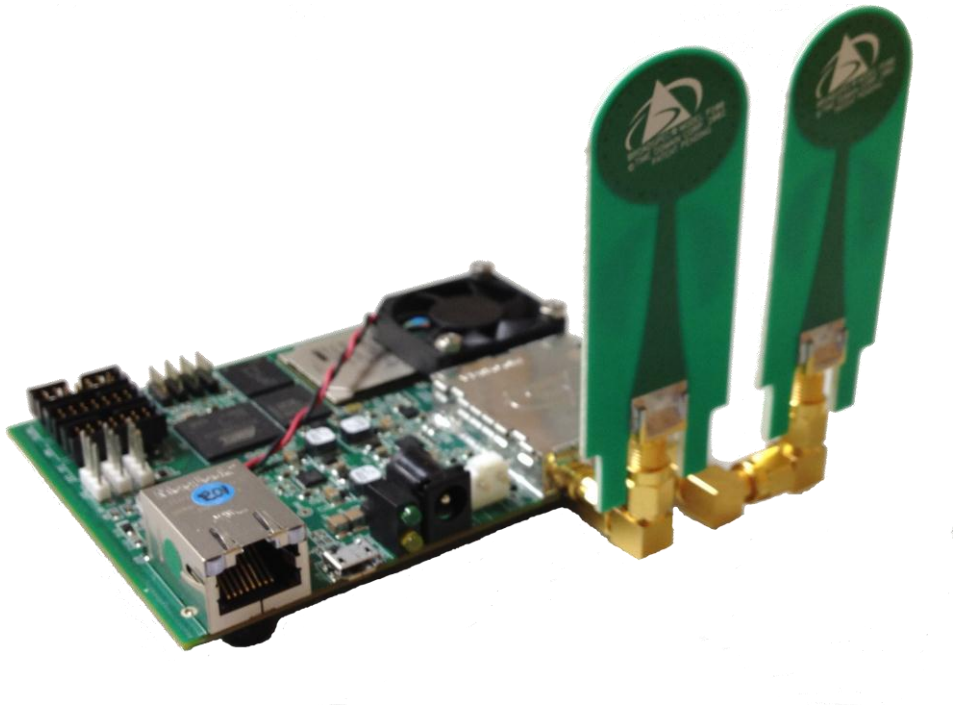

Fig. 1: P400 MRM with pair of attached Broadspec antennas

API: The user controls and monitors the P400 MRM through a simple API over either an Ethernet or Serial connection. The API provides the commands and capabilities required by a user to develop applications for a single MRM or a networked system of multiple MRMs. The API runs on both Windows Vista® and Windows 7®. Time Domain is focused on providing a robust, high-performance radar front-end, with a full-featured, flexible interface that provides coherently integrated radar scan information.

GUI: In order to demonstrate performance, the MRM is provided with a simple, PC-based GUI called the Monostatic Radar Module Reconfiguration and Evaluation Tool (MRM-RET). MRM-RET also provides sample motion filters and a detection reporting engine. However, these are provided as examples to illustrate performance. They are not optimized for any specific application and it is anticipated that the user will need to make adjustments (perhaps significant ones) to meet the needs of the target application.

This demonstration software uses all of the API commands and provides the following capabilities:

- It provides programmers with a visual example instantiation of a host application which interfaces to the MRM through the API.
- It allows users to evaluate the radar performance by using a sample Motion Filter, sample Detection Processor, and a graphic display of raw and processed radar scans
- It allows system analysts to collect raw radar waveforms and develop filter and detection strategies tailored to a given application.

MRM Service: The MRM Service is a Windows Service provided with MRM-RET. It is installed on the host computer during the initial software installation and runs when the PC is booted. If the service is selected, then the raw scans produced by the P400 MRM are post processed and provided to MRM-RET. Based on operator instruction, the MRM Service will band-pass filter, motion filter, and perform Constant False Alarm Rate (CFAR) target detection processing on the raw scan data. The processed data is provided to MRM-RET for display and logging. The user has the option of applying several different types of filters. For more a detailed description, consult the *MRM-RET User Guide*.

A system block diagram is provided in **Figure 2.**

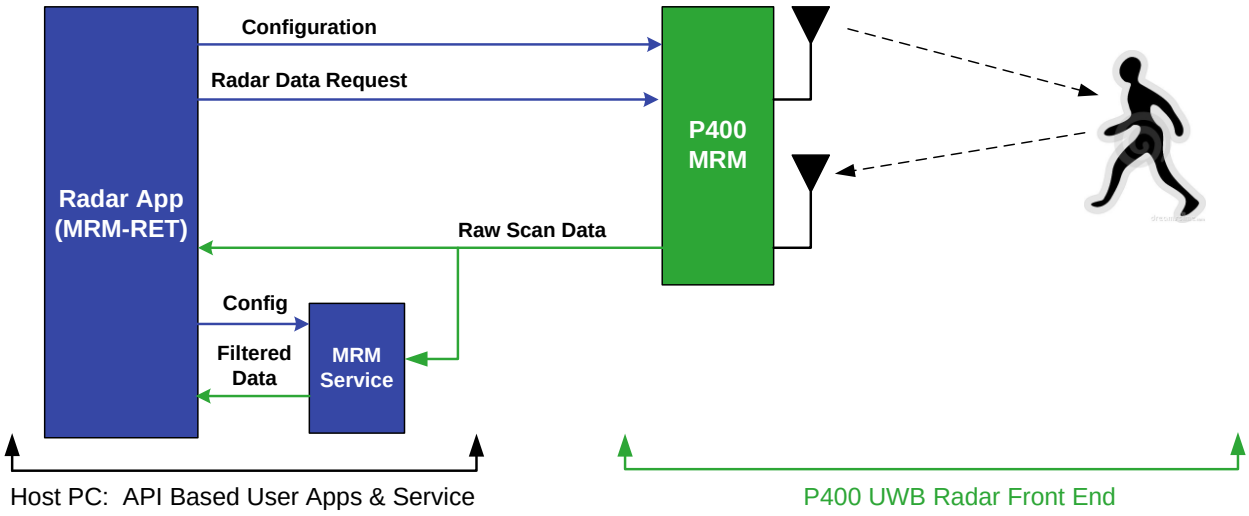

Fig. 2: Illustration of the interface to an MRM.

MRM-RET will receive the raw data either directly from the MRM (if the MRM Service is not connected) or from the MRM Service (if the MRM Service is connected).

Key Features of the P400 MRM

- Excellent performance in high multipath and high clutter environments
- Coherent signal processing extends operating range at very low signal power levels
- P400 MRM provides raw scans for post processing
- 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
- Seven separate channels provided, more are possible
- RF transmissions from 3.1GHz to 5.3 GHz, with center at 4.3 GHz
- Two user-configurable antenna ports for dual antenna operation
- RF emissions compliant with FCC limits
- Single 3"x 4" (7.6 x 10.2 cm) board
- Ethernet or Serial interface

In the very near future it is anticipated that the MRM will also support the following enhancements:

- Different integration rates for different distances (segment control)
- Operation with a single antenna

Typical Applications of the P400 MRM

- Robotics
- Tagless tracking
- Proximity detection
- Collision avoidance
- Security applications
- Presence/intrusion detection
- Unattended ground sensors
- Surveillance
- Through-wall sensing

It should also be noted that since the P400 MRM and P400 RCM share the same hardware, it is also possible to construct hybrid systems that combine the capabilities to address applications that would benefit from monostatic radar, UWB communications and UWB ranging.

Finally, it is Time Domain's intention to offer the following additional capabilities in the future:

- Bi-static radar
- Multi-static radar
- Ranging/communications network

The balance of this document focuses on describing the P400 MRM 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.

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 a high level description of the P400 MRM functional hardware block diagram (shown in **Figure 3)**. Additional detail on the various interfaces is provided in Section 3.

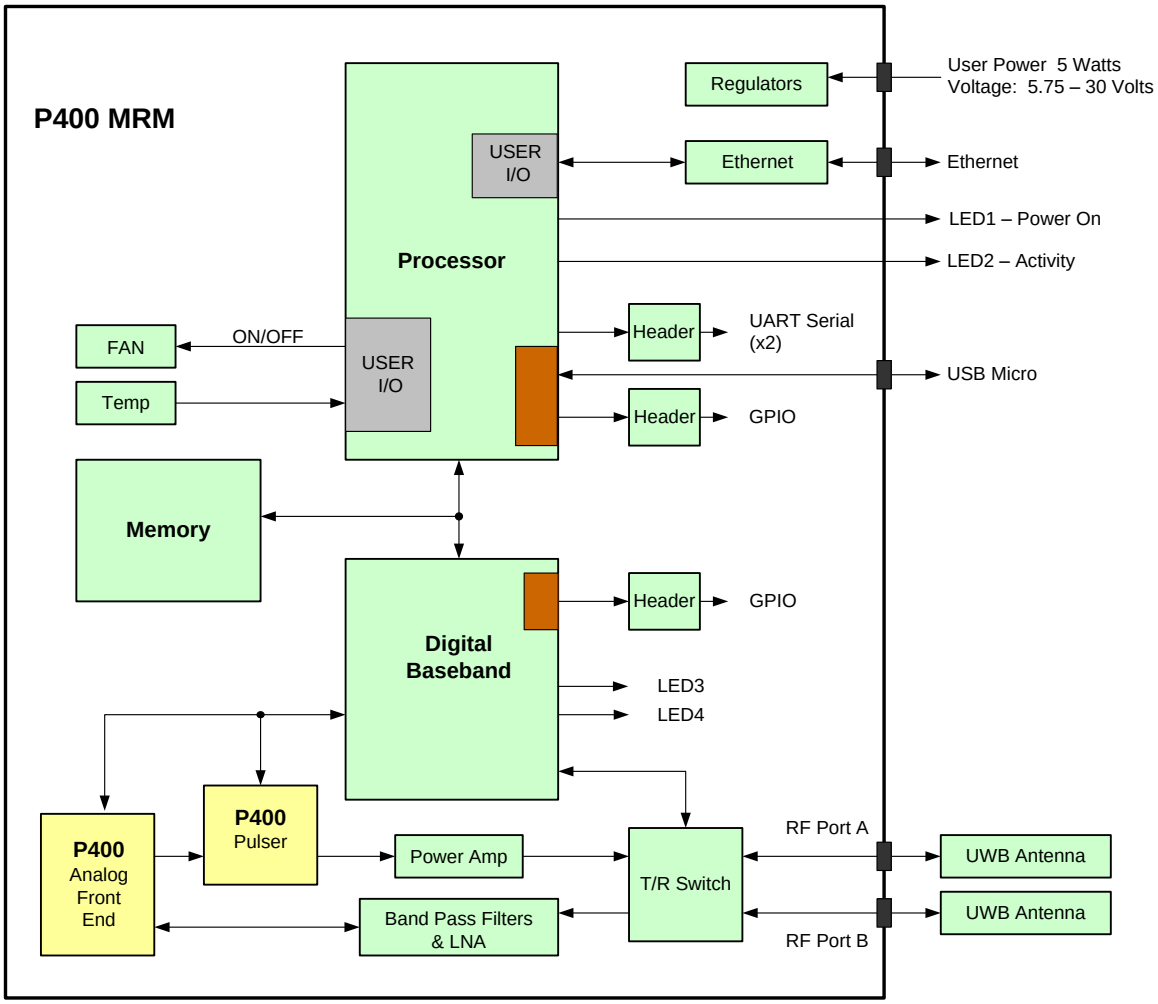

Fig. 3: P400 MRM hardware functional block diagram

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

The processor manages the interfaces and controls the radar front-end through a Digital Baseband FPGA. The radar front-end has been implemented using Time Domain's custom P400 UWB chipset.

More specifically, the FPGA configures the Time Doman P400 Pulser chip (UWB transmitter) and P400 Analog Front End (AFE) chip (UWB receiver), provides timing signals and out-going data, receives incoming data, controls the position of the transmit/receive (T/R) switch, and performs coherent pulse integration.

3 Interfaces

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

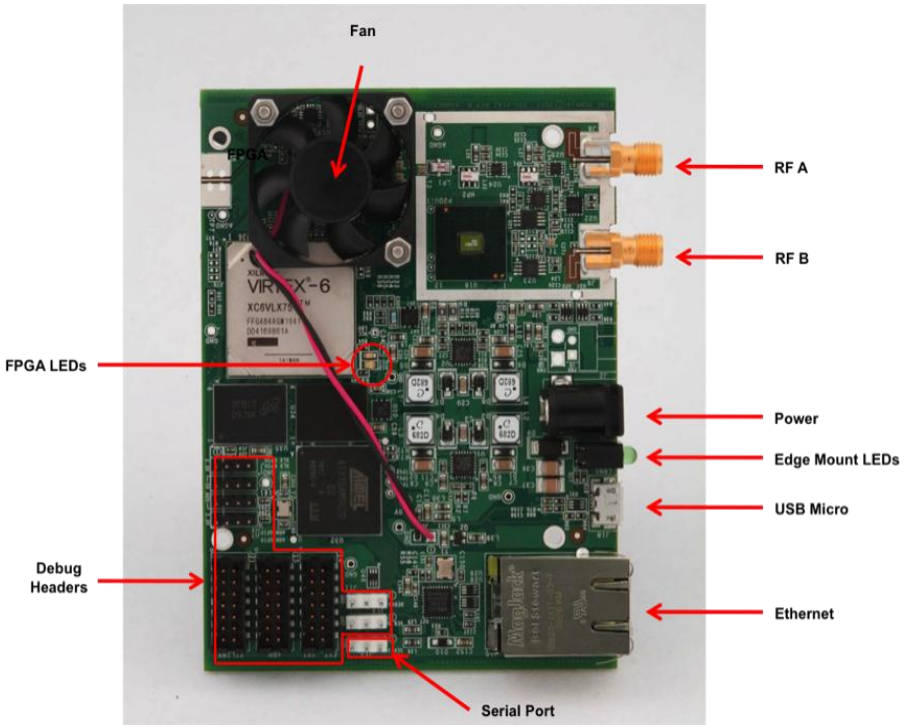

Fig. 4: Photo of the MRM highlighting key interfaces

3.1 Power

The P400 MRM 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**.

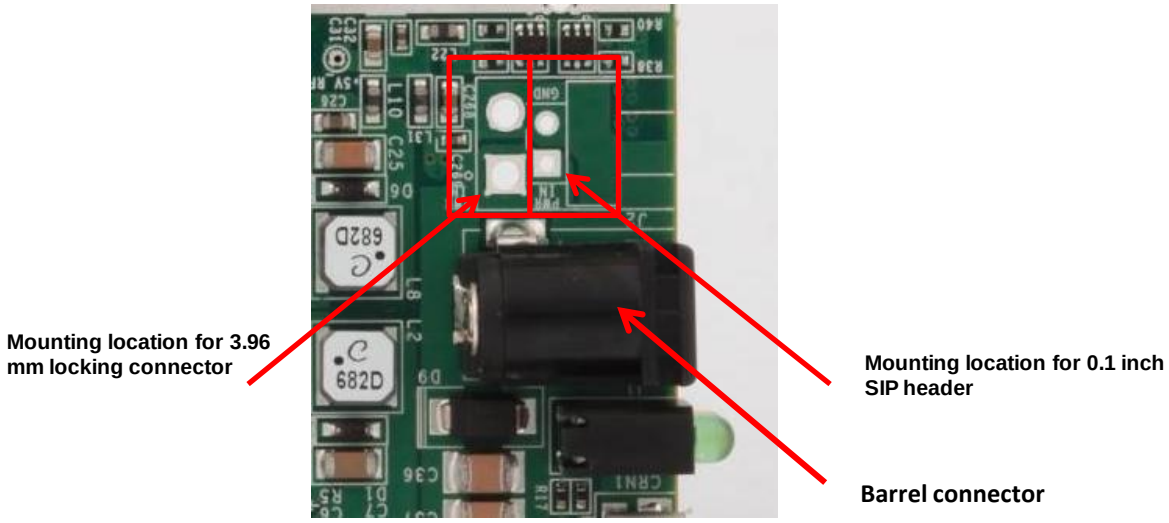

Fig. 5: Alternate Power Connections

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 the P400 has booted and is running. Once running, the LED will turn on solid. After that, it will toggle every time a scan is produced.

FPGA LEDs - The amber LED is initially off. After a few seconds, it will toggle at 1Hz to indicate that the FPGA has passed Built-In Test (BIT). If the FPGA fails BIT, then the amber LED will blink much faster 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 MRM 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 MRM is fully defined in the *API Specification*. That document also has additional information oriented to customers using the Ethernet interface to control the MRM.

The MRM board has a 3.3V serial universal asynchronous receiver transmitter (UART) port which customers can also use to communicate with the MRM. The serial interface for the MRM is identical to that of the RCM. Information on the serial interface for both is provided in the Time Domain application note *Using the RCM Serial Interface*.

Although the MRM 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 MRM 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 MRM 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 MRM 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 and 90^{o} elbow SMA connectors with the development kit, the SMA ports are standard. Any third party UWB antenna and extension cables can be used with these 50 ohm ports. Please be aware that using alternate UWB antennas will likely change the RF electrical distance between the antenna port and the phase center of the antenna. Failure to account for such changes may result in an offset or bias error in range computation.

3.5 Fan

A small fan (2.5CFM) has been provided on the MRM. 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 a 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 physically 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.

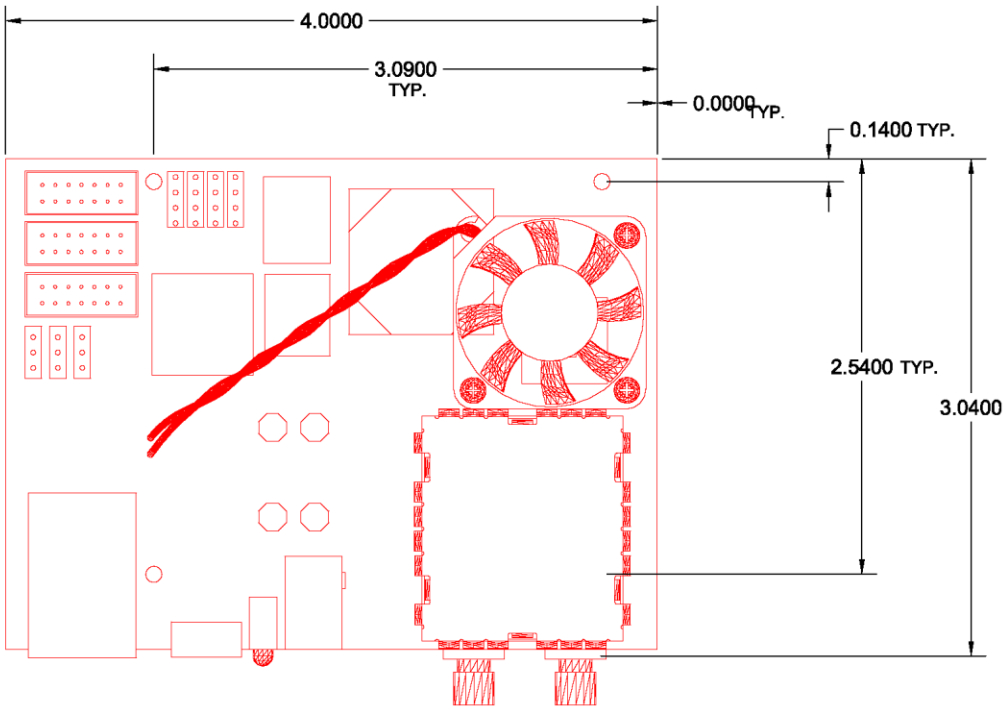

Fig. 6: P400 top view

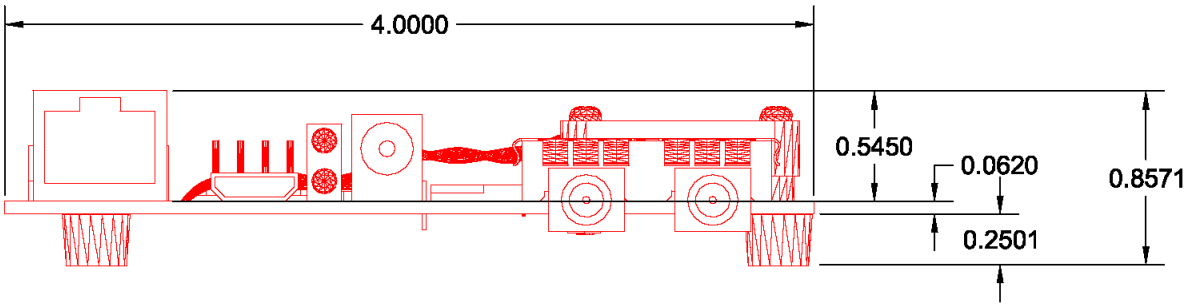

Fig. 7: P400 front view

5 Performance

Table 2 summarizes the P400 MRM specifications and key performance parameters. 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
Physical Parameters	
Dimensions (with mounting feet): Dimensions (without feet or Ethernet jack)	4"x 3"x 0.85" = 10.2 in^3 4"x 3"x 0.60"= 7.2 in^3
Temperature:	Operating: -10C to 65^oC Storage: -40C to 85^oC
Humidity:	Up to 95%, non-condensing
Power Requirements:	5.75V to 30V DC
Power Consumption:	5 Watts
User Interfaces/Devices	
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:	• USB Device (Micro connector) • USB Host (header) • Additional Serial UART • SPI #1 and SPI #2 • Four 3.3V Processor controlled GPIO pins • Aux 5.0V, 3.3V and 2.5V supply • Four FPGA controlled 2.5V GPIO pins
On Board Temperature Sensor	-20^oC to 55^oC +/- 1.0 ^oC
RF Characteristics	
Operating Band:	3.1GHz to 5.3 GHz
Center Frequency:	4.3 GHz
Received Equivalent Rectangular Bandwidth:	1.35 GHz
Average transmit power (10.1MHz):	Mode 1: FCC 15b compliant (-14.5 dBm) Mode 2: experimental non FCC up to +2.3 dBm
Peak transmit power:	Mode 2: 23.7dBm
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 variety of 3rd party UWB antennas.
Antenna Control:	User cross-bar configured as either Tx on A and

	RX on B or Rx on A and Tx on B.
Noise Figure:	4.8 dB
Integration Limit:	Min: 64:1 Max: 32768:1
Dynamic Range:	
Integration: 1 (instantaneous)	30 dB
Integration: 64 (PII=6)	48 dB
Integration: 32768 (PII=15)	75 dB
Transmit Pulse Repetition Rate	10.1MHz (default - others available)
Channelization:	7 user selectable pseudo-random pulse interval channels. Others available for special applications.

Table 2: MRM performance characteristics

6 Regulations and Export

The MRM 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 MRM is designed for unlicensed operation, it has not been certified by the FCC. Certification must be done once the MRM has been integrated into the final mechanical design or housing, as well as with the antenna intended for product rollout or fielding. Both the housing and the antenna can impact unintentional and intentional emissions respectively. Time Domain is available to assist you with the certification process.

Based on requirements from a number of government and site-license customers, the MRM 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 many 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 MRM. 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.