Voxtel’s Narrow-Profile Laser Rangefinder (LRF) Original Equipment Manufacturer (OEM) Module allows system integrators to efficiently integrate an eyesafe laser ranging capability into a thermal or electro-optical system, weapons scope, or consumer product. The Narrow-Profile LRF OEM Module includes Voxtel’s ROX™ InGaAs avalanche photodiode (APD) photoreceiver boresighted with a collimated near-diffraction-limited (DL) 1534-nm diode-pumped solid-state (DPSS) pulsed laser.

This Narrow-Profile LRF OEM Module is the industry’s most compact and power-efficient pulsed laser ranging solution. The 21-mm aperture enables standoff ranges out to 6 km with a 48-kW DPSS laser. With multipulse processing, range is approximately twice as far.

The Narrow-Profile LRF OEM Module includes Voxtel’s robust, low-noise, high-gain ROX APD photoreceiver that offers best-of-class sensitivity without the use of thermoelectric cooling, allowing for long-standoff range performance with less laser pulse energy and lower power. To allow optimal APD bias at all operating temperatures, the Narrow-Profile LRF OEM Module includes automatic APD bias temperature compensation that is calibrated at the factory.

The APD photoreceiver is integrated with standard 21-mm-diam. optical apertures. Custom receiver options are also available. The 17x magnification collimated lasers have excellent beam quality—$M^2 < 1.15 \times DL$, where DL is the diffraction limit, which allows for maximum pulse energy to be placed on the target—even at long distances and in difficult atmospheric conditions.

**FEATURES**

- **Turnkey:** Integrates erbium-glass pulsed laser, high-performance InGaAs APD, pulse-processing electronics, and programmable interface
- **Boresighted Optics:** Receiver and transmitter optics boresighted at the factory
- **Excellent Sensitivity:** Low-excess-noise InGaAs APD
- **Eyesafe:** Class 1, 1534-nm laser
- **High Accuracy:** 500-mm single-pulse; 100-mm multi-pulse
- **Near Diffraction-Limited Laser Beam Quality:** $M^2 < 1.15 \times DL$
- **Ultra-low Noise Equivalent Input (NEI):** as low as 45 photons
- **Long Lifetime:** > 50M shots

**OPTIONS**

- **Laser:** 48 kW
- **Receiver Aperture:** 21 mm
- **Transmitter Collimators:** 17x standard; other magnification available upon request
- **Pitch Plate** for fine pointing adjustment
- **Auxiliary Board:** Integrated AHRS with 9-axis IMU, Bluetooth low-energy communications module, and 8-bit ADC

**CONTACT INFO**

VOXTEL INC.
15985 NW SCHENDEL AVE #200
BEAVERTON, OR 97006
971-223-5642
WWW.VOXTEL-INC.COM
SALES@VOXTEL-INC.COM

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Voxtel Literature Narrow-Profile LRF OEM Module 9July2020 ©. Voxtel makes no warranty or representation regarding its products’ specific application suitability and may make changes to the products described without notice.
The highly sensitive APD photoreceiver enables long-distance ranging using less laser pulse energy. The Narrow-Profile LRF OEM Module integrates pulsed DPSS micro-lasers with 17x-magnification collimating optics, providing low beam divergence.

Easy to integrate and operate, each turnkey Narrow-Profile LRF OEM Module includes a simple UART interface controlled with a serial command software library that allows for flexible and dynamic operation. To enhance performance, various operating modes are provided, including time-variable-threshold (TVT) for reduced false-alarm rates (FARs), multi-pulse processing for extended range and improved range precision, automatic FAR determination and automatic threshold settings, background signal level compensation, time-over-threshold (TOT) range-walk compensation for more accurate range measurements over the entire standoff distance, and passive pulse-repetition-frequency sensing for remote laser detection and identification.

An optional auxiliary board is also available. It includes an Integrated attitude and heading reference system (AHRS) module, an 8-bit pulse digitizer, and a Bluetooth low-energy communications module. An optional pitch plate allows fine adjustment of the Narrow-Profile LRF OEM Module for aligning to a target for ranging.

### ORDERING INFORMATION & SPECIFICATIONS

<table>
<thead>
<tr>
<th>Narrow-Profile Laser Rangefinder OEM Module</th>
<th>Narrow-Profile Laser Rangefinder OEM Module with Pitch Plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>48-kW laser, 21-mm dia. receiver aperture</td>
<td>DUMQ-NCBC</td>
</tr>
<tr>
<td>Laser peak power (typical)(^1,2)</td>
<td>48kW</td>
</tr>
<tr>
<td>Aperture diameter</td>
<td>21 mm</td>
</tr>
<tr>
<td>Multi-pulse range(^3,4,5)</td>
<td>11 km</td>
</tr>
<tr>
<td>Singe-pulse range(^6,7)</td>
<td>6 km</td>
</tr>
<tr>
<td>Multi-pulse extinction ratio (500 m/85%)(^3,7)</td>
<td>37 dB</td>
</tr>
<tr>
<td>Singe-pulse extinction ratio (500 m/85%)(^7)</td>
<td>33 dB</td>
</tr>
</tbody>
</table>

### Performance Specifications

- Maximum number of returns per pulse\(^8\): 20
- Minimum target separation\(^7\): 5 m
- Range accuracy, single-/multi-pulse\(^9\): 500 mm / 100 mm
- Minimum range\(^10\): 20 m

### Transmitter Specifications

- Voxel DPSS laser: LAM0-FX0C
- Transmitter wavelength: 1534 nm
- Transmitter pulse width\(^1\): 7 ns
- Transmitter rep. frequency, max (multi-pulse): 10 Hz
- Transmitter beam diameter\(^11\): 5.10 mm
- Transmitter beam divergence, full angle (1/e\(^2\))\(^11\): 0.5 mrad
- Transmitter beam quality (M\(^2\))\(^11\): 1.15 x DL

### Receiver Specifications

- NEI\(^1\) (quanta/energy): 45 photons / 5.805 \(\times\) 10\(^{-18}\) J
- Dynamic range, total: 70 dB
- Dynamic range, linear: 25 dB
- APD Gain (M): 1-20
- APD Responsivity (M = 1)\(^6\): 1.1 A/W

### Electrical Specifications

- Input voltage, typical/max: 5 VDC / 5.5 VDC
- Standby power: 200 mW
- Max current draw during range request: 1.8 A
- Power consumption, 1-Hz continuous ranging\(^1\): 700 mW

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\(^1\) 25 °C
\(^2\) 1534 nm
\(^3\) 30% reflective extended target (larger than beam area), multi-pulse processing time 1.1 – 1.5 seconds.
\(^4\) 90% probability of detection, < 2% false alarm probability (single pulse), < 60 mW/cm² ambient solar background
\(^5\) 30% reflective 3.3 x 3.3 m² target
\(^7\) Target return level ≤ 10 x NEI
\(^8\) Max including one T0 pulse
\(^9\) When calibrated with time-over-threshold (1 σ)
\(^10\) 10 m possible with lower-energy laser models
\(^11\) Measured through the beam expander

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Communication interface | Serial commands over UART 3.3V CMOS logic  
---|---
**Mechanical Specifications**  
Weight, all components | 175 g | 145 g  
**Environmental**  
Operating temperature | -45 °C to +65 °C  
Storage temperature | -55 °C to +85 °C  
Lifetime (MTTF) | 50 million shots

12 Custom to +75° C also available upon request

**AUXILIARY BOARD**

An optional auxiliary board includes an integrated AHRS module with 9-axis inertial measurement unit (IMU), and Bluetooth low-energy communications module. The AHRS module can be factory-calibrated.

**Attitude and Heading Determination**

To determine pointing direction and orientation (roll, pitch, and yaw), the auxiliary board incorporates an internal 9-axis IMU—including accelerometer, magnetometer, and gyroscope axis (three-axis MEMS gyroscope, three-axis accelerometer, and three-axis compass)—and integrated sensor fusion and motion processing. This constant-calibration technology polls individual sensors and integrates, fuses, and filters the sensor data with state-of-the-art Kalman filter algorithms, which allows users to determine the magnetic heading of the LRF (roll, pitch, and yaw) and the rate of the roll, pitch, and yaw of the LRF. The IMU provides attitude data in terms of Euler angles and quaternions.

To estimate the current attitude (roll, pitch, heading) of the device, the sensor fusion processor uses a Kalman filter to integrate the output from: 1) the three-axis MEMS rate gyroscope, which detects rotation about the x-, y- and z- axes; 2) the three-axis accelerometer, which detects acceleration due to gravity or movement in the direction of the x-, y-, and z- axes; and 3) the three-axis magnetometer, which detects the magnitude of the local magnetic field in the x-, y-, and z- axes.

The sensor fusion processor also provides built-in continuous calibration for each sensor, including hard- and soft-iron calibration for the magnetometer. The magnetometer calibration functionality minimizes the effect of ferrous metals (iron, iron alloys) and localized electromagnetic fields on the heading estimate.

<table>
<thead>
<tr>
<th>AHRS Specifications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Heading repeatability (total error)</td>
<td>±0.5 deg</td>
</tr>
<tr>
<td>Heading noise (std. dev.)</td>
<td>0.17 deg</td>
</tr>
<tr>
<td>Pitch repeatability (total error)</td>
<td>±0.01 deg</td>
</tr>
<tr>
<td>Pitch noise (std. dev.)</td>
<td>0.15 deg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gyroscope Noise</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity (125 deg/s full scale)</td>
<td>256 LSB/deg/s</td>
</tr>
<tr>
<td>Total RMS noise (57-Hz bandwidth)</td>
<td>0.1 deg/s</td>
</tr>
<tr>
<td>Output noise density</td>
<td>0.014 deg/s/√Hz</td>
</tr>
<tr>
<td>Max output data rate</td>
<td>2,000 Hz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accelerometer Sensitivity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity (2g full scale)</td>
<td>1024 LSB/g</td>
</tr>
<tr>
<td>Zero-g offset temperature drift</td>
<td>±1 mg/K</td>
</tr>
<tr>
<td>Output noise density</td>
<td>150 µg/√Hz</td>
</tr>
<tr>
<td>Total RMS noise, at 100 Hz</td>
<td>1.5 mg-rms</td>
</tr>
<tr>
<td>Max output data rate</td>
<td>1,000 Hz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Magnetometer Sensitivity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Full scale range (x-, y- axes)</td>
<td>±1300 µT</td>
</tr>
<tr>
<td>Full scale range (z-axis)</td>
<td>±2500 µT</td>
</tr>
<tr>
<td>Sensitivity scale factor (x-, y- axes)</td>
<td>0.32 µT/LSB</td>
</tr>
<tr>
<td>Sensitivity scale factor (z-axis)</td>
<td>0.15 µT/LSB</td>
</tr>
<tr>
<td>Total RMS noise, at 20 Hz</td>
<td>0.3 µT</td>
</tr>
<tr>
<td>Maximum output data rate</td>
<td>300 Hz</td>
</tr>
</tbody>
</table>

**Bluetooth Low-energy Communications Module**

To connect to a wireless personal area network, the auxiliary board includes a Bluetooth low-energy (LE) communications module (Bluetooth LE or Bluetooth SMART). The module includes support for mobile operating systems, including iOS, Android, and Windows, as well as macOS, Linux, Windows 8 and Windows 10, which natively support Bluetooth LE. The certified 2.4-GHz module includes a Bluetooth 4.4-compliant software stack. For easy system integration without the need for a separate antenna, the module includes an integrated high-performance chip antenna that allows transmission ranges to 50 m. The module supports up to eight simultaneous Bluetooth connections.
The Bluetooth interface can be used to command and receive data from the LRF using the serial commands available in the Voxtel document *LRF Software ICD: Modules, Kits, and Components*, which is shipped with the product and is available at voxtel-inc.com.

**Processing and Ballistics**

The auxiliary board features an ARM Cortex M4 processor with FPU up to 38.4 MHz, with 32 kB RAM and 256 kB flash memory, which we can use to implement custom customer specific application code, install a software ballistics computer, or implement additional features into the module.

**Ancillary Sensor Support**

The auxiliary board provides an I2C interface that allows additional sensors and hardware to be connected to the LRF module.

**SOFTWARE CONTROL**

The LRF OEM Module can be easily programmed using the simple serial communications command set over a simple serial UART interface.

User-programmable features include:
- **time-variable threshold (TVT)**, used to reduce false alarms due to nearfield scattering,
- **time-over-threshold (TOT) range-walk compensation**, used to reduce amplitude-dependent timing errors,
- **autocalibration**, used to set the threshold to achieve a user-defined FAR given ambient background optical radiation conditions
- **multi-pulse processing**, used to enhance range and resolution
- **passive operation**, used to measure the pulse-repetition frequency of external lasers.

The available commands can be found in the Voxtel document: *LRF Software ICD: Modules, Kits, and Components*

To configure and operate the LRF OEM Module using a terminal emulator of a graphical user interface, see the Quick Start section of the Voxtel document: *LRF User Manual: Modules, Kits, and Components*

These are shipped with the product and are available at voxtel-inc.com. The tools on the website can be used to update device drivers and firmware.

**ELECTRICAL**

**Block Diagram**
**Timing Diagrams**

**LRF Single-Pulse-Range Cycle**

![Timing Diagram](image)

Parameters: Capacitor charge time: 100ms, Returns: 7, Max range: 15km, Return string: 40 characters

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**Configuration for Triggering the Time-to-Digital Converter Using an External Electrical \( T_0 \)**

To configure the LRF to receive an electronic \( T_0 \) pulse, users can supply a maximum 1.8V DC pulse to the UFL connector located on the LRF System Board (see Mechanical Drawings, LRF System Board) using a 50-\( \Omega \)-terminated cable. The external \( T_0 \) control is enabled using software commands.

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**Connector Pin Assignments**

**LRF System Board User Interface- P1 Connector**

(Hirose DF3-8P-2Ds)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>In/Out</th>
<th>Description</th>
<th>Typ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LRF_RANGE</td>
<td>Input</td>
<td>Initiates a range measurement when a rising edge is detected on this pin.</td>
<td>3.3V</td>
</tr>
<tr>
<td>2</td>
<td>LASERGATE</td>
<td>Output</td>
<td>Laser gate signal to the laser diode driver board. This can be monitored or actively driven.</td>
<td>3.3V</td>
</tr>
<tr>
<td>3</td>
<td>LRF_ENABLE</td>
<td>Input</td>
<td>Active low enable. Pin pulled down to ground. Pulled high to disable LRF power.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>NC</td>
<td>NA</td>
<td>No Connect</td>
<td>NA</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Input</td>
<td>System Ground</td>
<td>Ground</td>
</tr>
<tr>
<td>6</td>
<td>TX</td>
<td>Output</td>
<td>UART Transmit</td>
<td>3.3V</td>
</tr>
<tr>
<td>7</td>
<td>RX</td>
<td>Input</td>
<td>UART Receiver</td>
<td>3.3V</td>
</tr>
<tr>
<td>8</td>
<td>5V</td>
<td>Input</td>
<td>System Power Input</td>
<td>5V</td>
</tr>
</tbody>
</table>

**ROX APD Photoreceiver Board**

<table>
<thead>
<tr>
<th>Connector</th>
<th>Out</th>
<th>Description</th>
<th>Typ</th>
</tr>
</thead>
<tbody>
<tr>
<td>UFL</td>
<td>Analog Out</td>
<td>Analog Output; AC coupled (15.8 nominal gain)</td>
<td>-3 VDC (into 50 ohms)</td>
</tr>
</tbody>
</table>
MECHANICAL DRAWINGS

Narrow-Profile Laser Rangefinder OEM Module

48-kW, 21-mm-aperture module (model DUMQ-NCBC)

48-kW, 21-mm aperture module with pitch plate (model DUMU-NCBC)