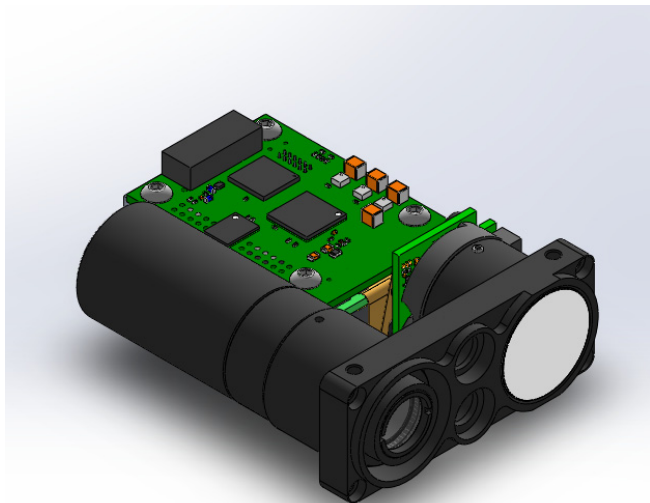


# EYESAFE LASER RANGEFINDER (LRF) OEM MODULE

# TURNKEY 1534-NM LASER RANGING MODULE



Voxtel's *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 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 LRF OEM Module is the industry's most compact and power-efficient pulsed laser ranging solution, with a range of available laser pulse energies and receiver optical apertures that allow for long-distance ranging. The 21-mm-aperture option enables standoff ranges beyond: 5 km with the 29-kW DPSS laser; 10 km with the 48-kW DPSS laser; and 12 km with the 115-kW DPSS laser. With multi-pulse processing, range is about twice as far. And, the 50-mm-aperture option enables standoff ranges about twice as far as the 21-mm option.

The 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 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. or 50-mm-diam. optical apertures. Custom receiver options are also available.

*Equipment described herein is subject to US export regulations and may require a license prior to export. Diversion contrary to US law is prohibited. Specifications are subject to change without notice. Accession number 1811183-00.*

*Voxtel Literature DTS-LRF-0001\_REV00 08Apr2019 ©. Voxtel makes no warranty or representation regarding its products' specific application suitability and may make changes to the products described without notice.*

## 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:** 29 kW, 48 kW, or 115 kW
- **Receiver Aperture:** 21-mm or 50-mm-diam.; custom sizing available
- **Transmitter Collimators:** 17x standard; other magnification available upon request
- **Auxiliary Board:** Integrated AHRS with 9-axis IMU, Bluetooth low-energy communications module, and 8-bit ADC

## CONTACT INFO

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The 17x magnification collimated lasers have excellent beam quality— $M^2 < 1.15 \times DL$ , where  $DL$  is the diffraction limit—which allows for the maximum pulse energy to be placed on the target—even at long distances and in difficult atmospheric conditions.

The highly sensitive APD photoreceiver enables long-distance ranging using less laser pulse energy. The LRF OEM Module integrates pulsed DPSS micro-lasers with 17x-magnification collimating optics, providing low beam divergence.

Easy to integrate and operate, each turnkey 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.

## ORDERING INFORMATION

	LRF OEM Module Base Unit without Housing	LRF OEM Module with Integrated Aluminum Housing	LRF OEM Module With Aux Board Without Housing
<b>29 kW Laser</b>			
21-mm dia. receiver aperture	DUKL-KCBC	DUKT-KCBC	DUKS-KCBC
<b>48 kW Laser</b>			
21-mm dia. receiver aperture	DUML-KCBC	DUMT-KCBC	DUMS-KCBC
50-mm dia. receiver aperture	DUQL-KHBC	DUQT-KHBC	DUQS-KHBC
<b>115 kW Laser</b>			
21-mm dia. receiver aperture	DUNL-KCBC	DUNT-KCBC	DUNS-KCBC
50-mm dia. receiver aperture	DUNL-KHBC	DUNT-KHBC	DUNS-KHBC

## SPECIFICATIONS

	DUKL-KCBC	DUML-KCBC	DUQL-KHBC	DUNL-KCBC	DUNL-KHBC
Laser peak power (typical) <sup>1,2</sup>	29 kW	48 kW		115 kW	
Aperture diameter	21 mm	21 mm	50 mm	21 mm	50 mm
Multi-pulse range <sup>3,4,5</sup>	7km	11 km	18 km	12 km	21 km
Singe-pulse range <sup>4,6</sup>	4 km	6 km	10 km	9 km	12 km
Multi-pulse extinction ratio (500 m/85%) <sup>3,7</sup>	32 dB	37 dB	42 dB	39 dB	46 dB
Single-pulse extinction ratio (500 m/85%) <sup>7</sup>	28 dB	33 dB	41 dB	35 dB	42 dB
<b>Performance Specifications</b>					
Maximum number of returns per pulse <sup>8</sup>	20				
Minimum target separation <sup>7</sup>	5 m				
Range accuracy, single-/multi-pulse <sup>9</sup>	500 mm / 100 mm				
Minimum range <sup>10</sup>	20 m				
<b>Transmitter Specifications</b>					
Voxtel DPSS laser	LAK0-E00C	LAM0-FX0C	LAMM-FB0C	LAN0-F00C	
Transmitter wavelength	1534 nm	1534 nm		1534 nm	
Transmitter pulse width <sup>1</sup>	4 ns	7 ns		5 ns	
Transmitter rep. frequency, max (multi-pulse) <sup>11</sup>	10 Hz	10 Hz		10 Hz <sup>5</sup>	
Transmitter beam diameter	4.25 mm	5.10 mm		6.78 mm	
Transmitter beam divergence, full angle (1/e <sup>2</sup> )	0.7 mrad	0.5 mrad		0.4 mrad	
Transmitter beam quality (M <sup>2</sup> )	1.15 x DL	1.15 x DL		1.15 x DL	
<b>Receiver Specifications</b>					
NEI <sup>1</sup> (quanta/energy)	45 photons/ 5.805*10 <sup>-18</sup> J				
Dynamic range, total	70 dB				
Dynamic range, linear	25 dB				
APD Gain (M)	1 – 20				
APD Responsivity (M = 1) <sup>6</sup>	1.1 A/W				
<b>Electrical Specifications</b>					
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 <sup>1</sup>	700 mW	900 mW		1400 mW	
Communication interface	Serial commands over UART 3.3V CMOS logic				
<b>Mechanical Specifications</b>					
Weight, all components	106 g	112 g	135 g	129 g	153 g
Weight, including optional housing and mounting hardware	216 g	221 g	244 g	239 g	261 g
<b>Environmental</b>					
Operating temperature <sup>12</sup>	-45 °C to +65 °C				
Storage temperature	-55 °C to +85 °C				
Lifetime (MTTF)	50 million shots				

<sup>1</sup> 25 °C

<sup>2</sup> 1534 nm

<sup>3</sup> 30% reflective extended target (larger than beam area), multi-pulse processing time 1.1 – 1.5 seconds.

<sup>4</sup> 90% probability of detection, < 2% false alarm probability (single pulse), < 60 mW/cm<sup>2</sup> ambient solar background

<sup>5</sup> Preliminary data

<sup>6</sup> 30% reflective 3.3 x 3.3 m<sup>2</sup> target

<sup>7</sup> Target return level ≤ 10x NEI

<sup>8</sup> Max including one T0 pulse

<sup>9</sup> When calibrated with time-over-threshold (1 σ)

<sup>10</sup> 10 m possible with lower-energy laser models

<sup>11</sup> Heat sinking required for 115-kW LRF

<sup>12</sup> 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.

AHRS Specifications	
Heading repeatability (total error)	±0.5 deg
Heading noise (std. dev.)	0.17 deg
Pitch repeatability (total error)	±0.01 deg
Pitch noise (std. dev.)	0.15 deg
Gyroscope Noise	
Sensitivity (125 deg/s full scale)	256 LSB/deg/s
Total RMS noise (57-Hz bandwidth)	0.1 deg/s
Output noise density	0.014 deg/s/√Hz
Max output data rate	2,000 Hz

Accelerometer Sensitivity	
Sensitivity (2g full scale)	1024 LSB/g
Zero-g offset temperature drift	±1 mg/K
Output noise density	150 µg/√Hz
Total RMS noise, at 100 Hz	1.5 mg-rms
Max output data rate	1,000 Hz
Magnetometer Sensitivity	
Full scale range (x-, y- axes)	±1300 µT
Full scale range (z-axis)	±2500 µT
Sensitivity scale factor (x-, y- axes)	0.32 µT/LSB
Sensitivity scale factor (z-axis)	0.15 µT/LSB
Total RMS noise, at 20 Hz	0.3 µT
Maximum output data rate	300 Hz

### *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 Voxel document *LRF Software ICD: Modules, Kits, and Components*, which is shipped with the product and is available at voxel-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.

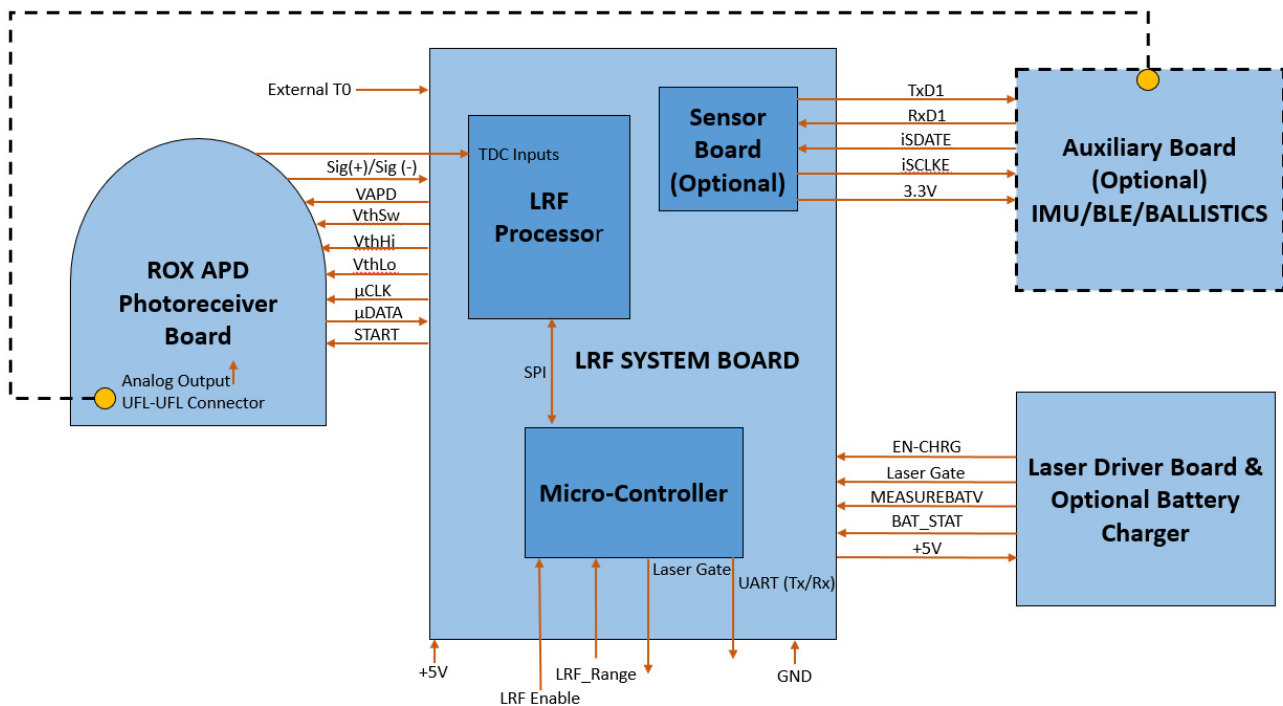
The available commands can be found in the Voxel document: *LRF Software ICD: Modules, Kits, and Components*

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

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

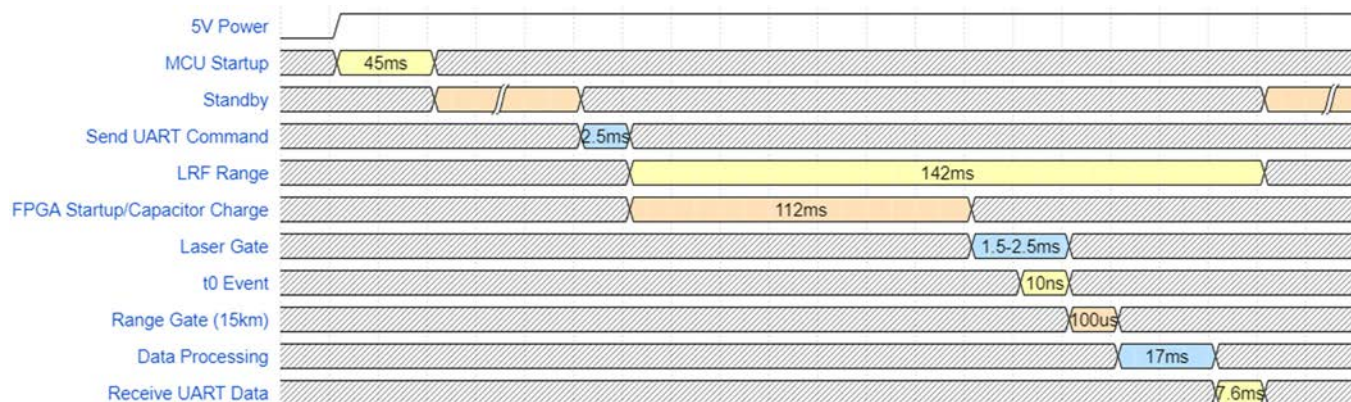
## ELECTRICAL

### Block Diagram



## Timing Diagrams

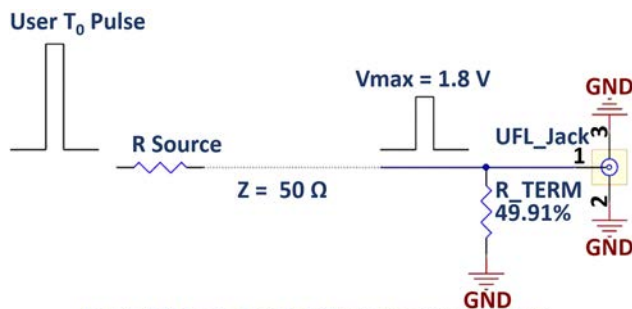
### LRF Single-Pulse-Range Cycle



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

### Configuration for Triggering the Time-to-Digital Converter Using an External Electrical T<sub>0</sub>

To configure the LRF to receive an electronic T<sub>0</sub> 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-Ω-terminated cable. The external T<sub>0</sub> control is enabled using software commands.



Use 1.8 V logic, level shifter, or source resistor.

## Connector Pin Assignments

### LRF System Board User Interface- J8 (Hirose DF3-8P-2Ds)

Pin	Name	In/Out	Description	Typ
1	LRF_RANGE	Input	Initiates a range measurement when a rising edge is detected on this pin.	3.3V
2	LASERGATE	Output	Laser gate signal to the laser diode driver board. This can be monitored or actively driven.	3.3V
3	LRF_ENABLE	Input	Active low enable. Pin pulled up to 5V with 100kΩ resistor. Pull low to enable LRF power.	
4	NC	NA	No Connect	NA
5	GND	Input	System Ground	Ground
6	TX	Output	UART Transmit	3.3V
7	RX	Input	UART Receiver	3.3V
8	5V	Input	System Power Input	5V

### ROX APD Photoreceiver Board

Connector	Out	Description	Typ
UFL	Analog Out	Analog Output; AC coupled (15.8 nominal gain)	- 3 VDC (into 50 ohms)

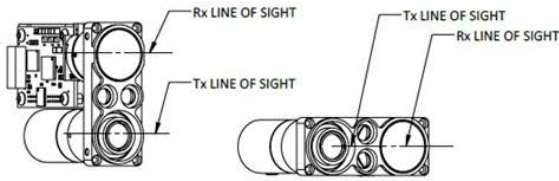
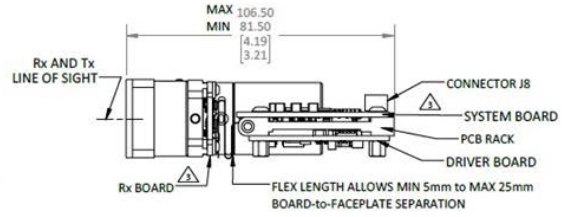
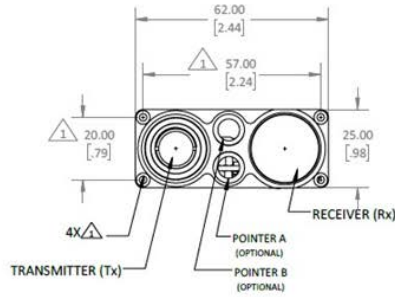
# MECHANICAL DRAWINGS

## OEM Module Base Unit (Without Housing)

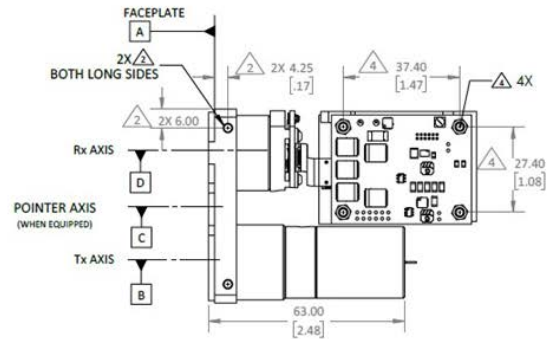
### 21-mm receiver aperture models

- 29-kW, 21-mm (model DUKL-KCBC)

POINTING TOL. (mrad)		
B to A		±2.00
C to A		±2.00
D to A		±2.00
D to B		±4.00

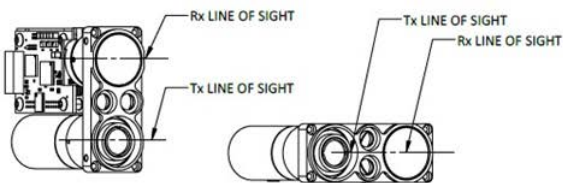
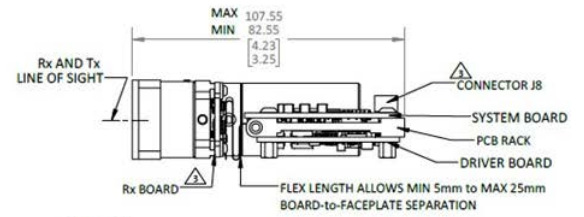
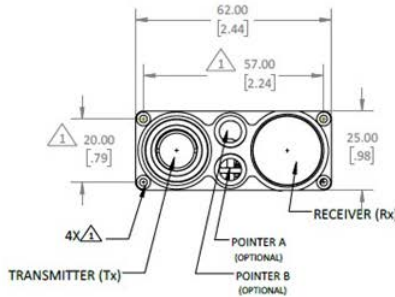


RECOMMENDED MOUNTING ORIENTATIONS

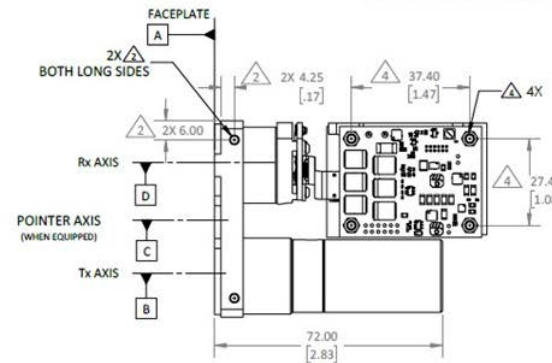


- 48-kW, 21-mm (model DUML-KCBC)

POINTING TOL. (mrad)		
B to A		±2.00
C to A		±2.00
D to A		±2.00
D to B		±4.00

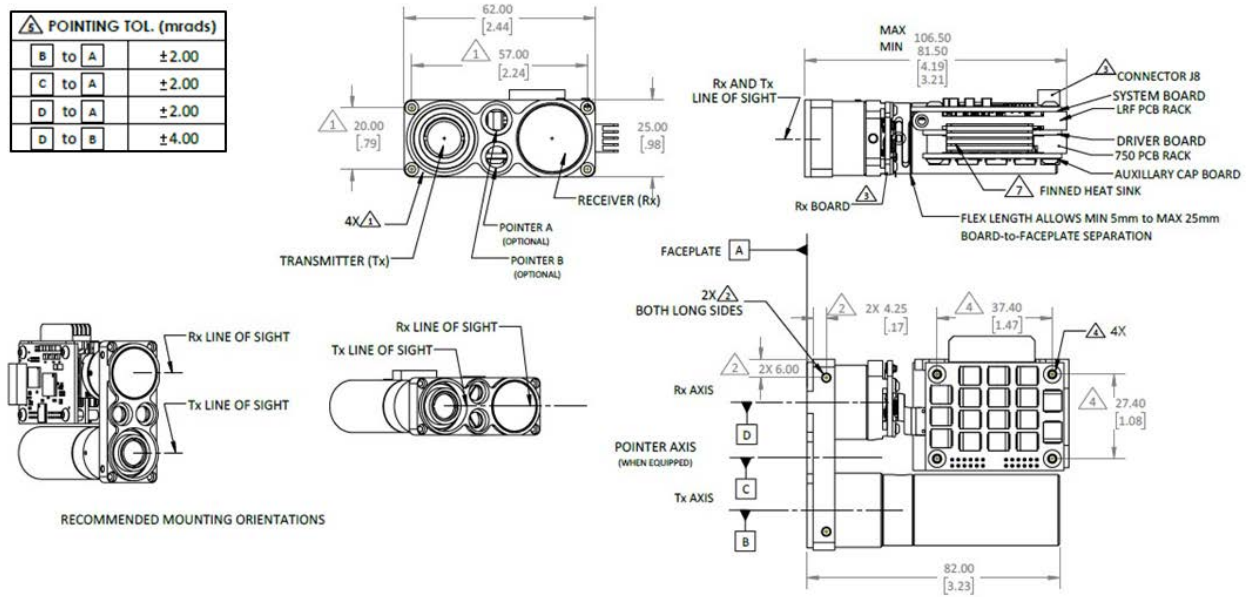


RECOMMENDED MOUNTING ORIENTATIONS



- 115-kW, 21-mm (model DUNL-KCBC)

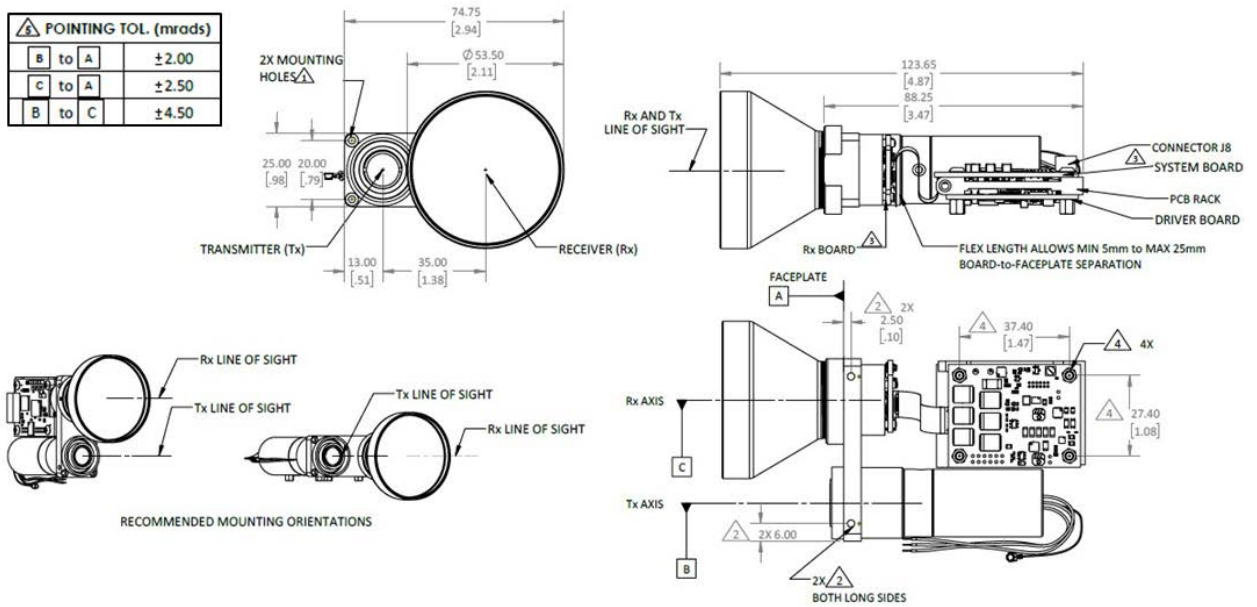
POINTING TOL. (mrad)		
B	to A	±2.00
C	to A	±2.00
D	to A	±2.00
D	to B	±4.00



### 50-mm receiver aperture models

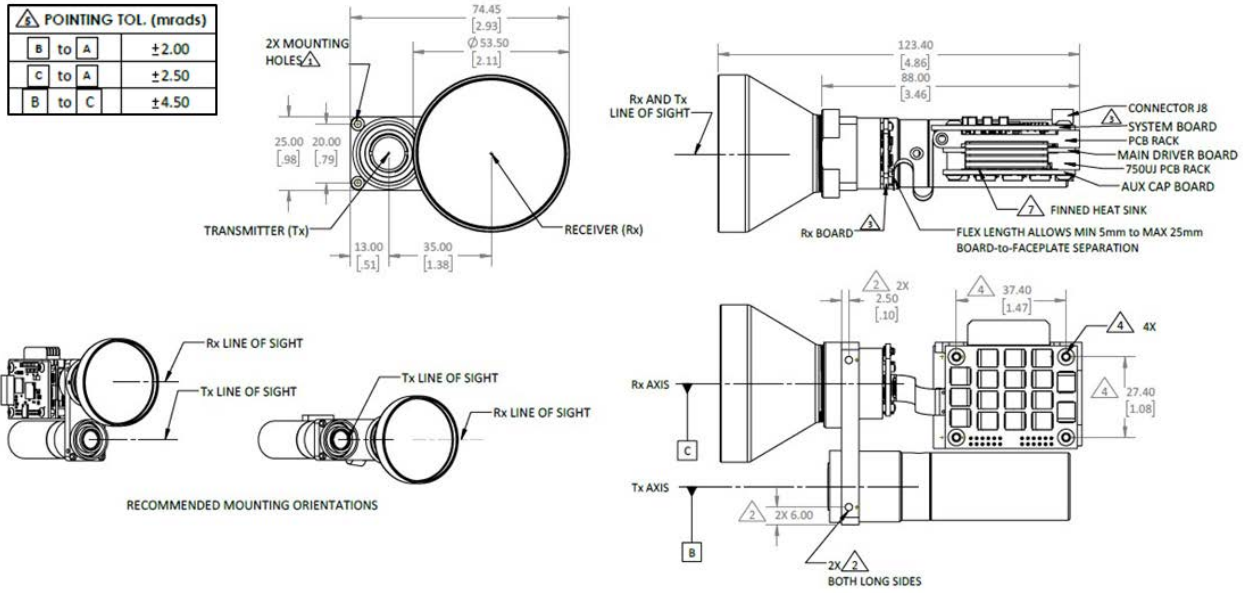
- 48-kW, 50-mm (model DUQL-KHBC)

POINTING TOL. (mrad)		
B	to A	±2.00
C	to A	±2.50
B	to C	±4.50





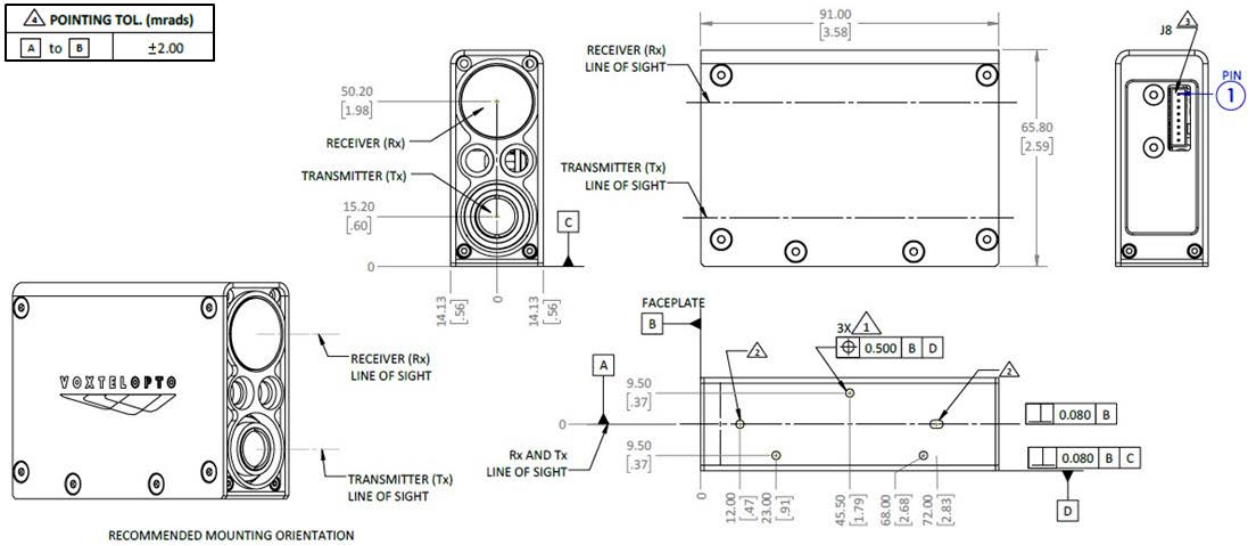
- 115-kW, 50-mm (model DUNL-KHBC)



### LRF Module (With Integrated Aluminum Housing)

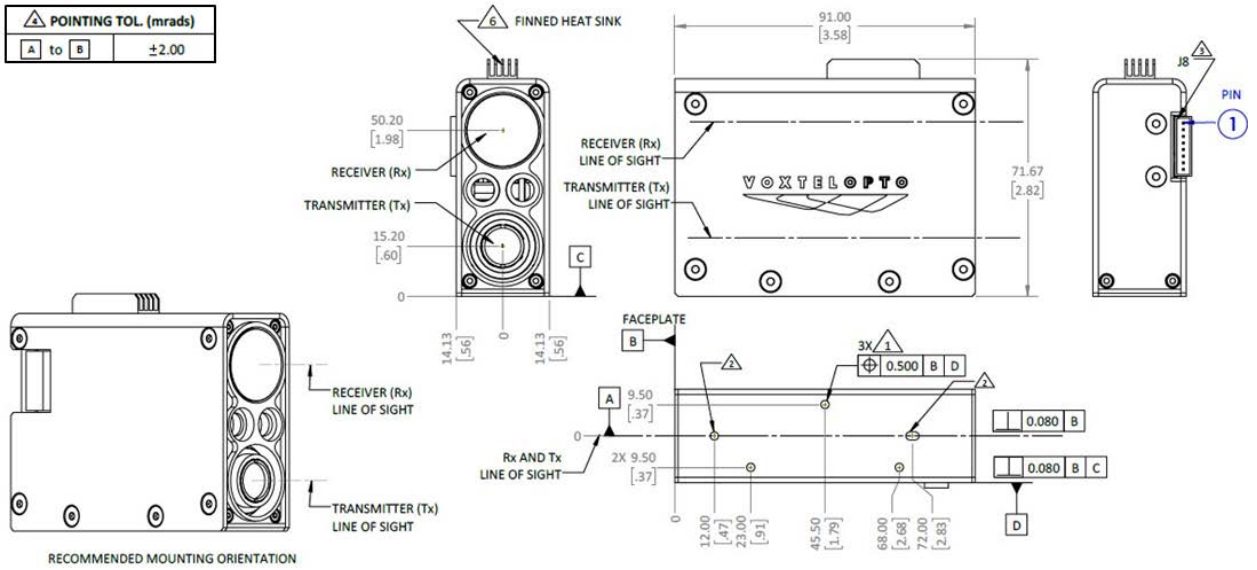
#### 21-mm receiver aperture models

- 29-kW, 21-mm (model DUKT-KCBC); and
- 48-kW, 21-mm (model DUMT-KCBC)



- 115-kW, 21-mm (model DUNT-KCBC)

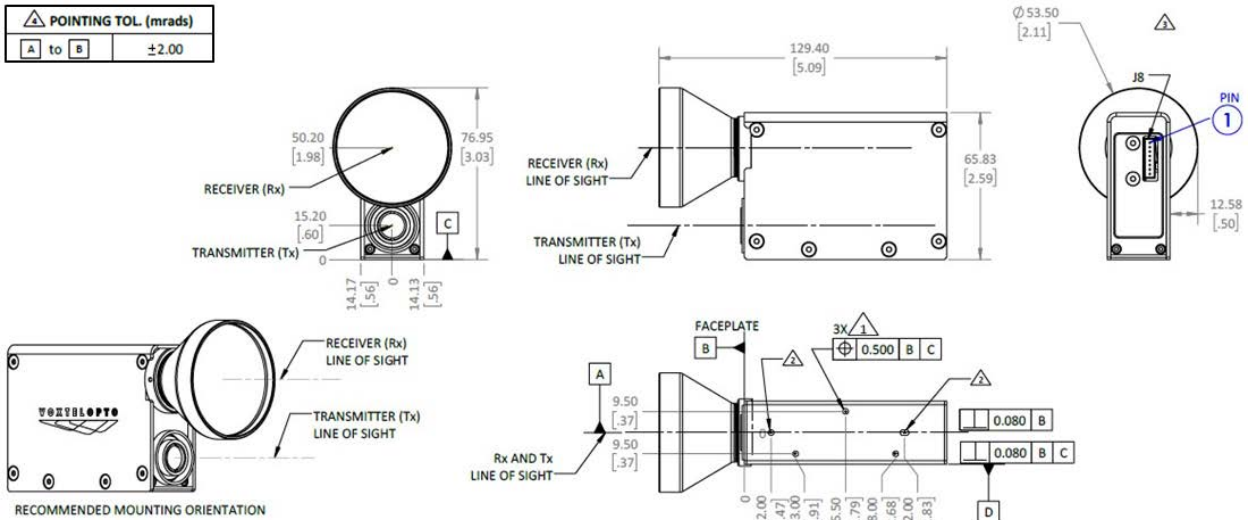
△ POINTING TOL. (mrad)	
A to B	±2.00



### 50-mm receiver aperture models

- 48-kW, 50-mm (model DUQT-KHBC)

△ POINTING TOL. (mrad)	
A to B	±2.00



- 115-kW, 50-mm (model DUNT-KHBC)

△ POINTING TOL. (mrad)	
A to B	±2.00

