ATTOLLO Engineering

CU1

MC1 & MU1

XM000002 User Manual
WASP-200 LRF Class 1

USER MANUAL - UART (CU1 AND MU1) AND CAN / RS-232 (MC1) VERSIONS

XM000002
Rev. 009

Contents

Laser Safety

WARNING

This device does not require regular maintenance. If the device becomes damaged or is inoperable, repair or service must be handled by factory authorized technicians only. Attempting to modify, repair or service the unit on your own will not only result in voiding the warranty, but is prohibited and could result in direct exposure to laser radiation and permanent eye damage.

For repair or service, contact Attollo Engineering for more information. Attollo Engineering is not responsible for injuries caused through the improper use or operation of this product.

CAUTION

Caution – use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Attollo Engineering
160 Camino Ruiz
Camarillo, CA 93012

This Laser Product is designated Class 1 during all procedures of operation. As designed, the laser is safe to look at with the unaided eye, however, it is advisable to avoid looking directly into the beam when operating the device and to turn off the unit when not in use.

Acronym List

APD	Avalanche Photodiode
CAN	Controller Area Network
CRC	Cyclic Redundancy Check
FAR	False Alarm Rate
FW	Firmware
GND	Ground
HW	Hardware
LRF	Laser Rangefinder
LSB	Least Significant Bit
MSB	Most Significant Bit
NVM	Non-volatile Memory
PWM	Pulse Width Modulation
RST	Reset
TLA	Three Letter Acronym
ToF	Time of Flight

Introduction

The WASP™-200 LRF is an ultra-compact laser rangefinder (LRF) device that is capable of quickly and accurately identifying the distance to a target ~175 m away assuming 18% or better target reflectance and under full sun illumination conditions; and even further away with higher reflectance targets and/or lower solar illumination levels. The WASP™-200 LRF supports range update rates of up to 56 ranges-per-second with improved accuracy at lower repetition rates with a variety of filtering and averaging features. Attollo has three configurations of the WASP™-200 LRF:

- CU1 – UART communication interface (basic features implemented with Ardupilot*)
- MU1 – Ruggedized, IP67, UART communication interface
- MC1 – Ruggedized, IP67, CAN and RS-232 communication interface using the Cloud Cap Technology Piccolo autopilot protocol

NOTE: This Laser Product is designated as Class 1 during all aspects of operation.

*https://ardupilot.org/copter/docs/common-wasp200-lidar.html

The WASP™-200 LRF has been designed with ease of use and flexibility in mind and therefore supports a +5V-compliant UART communication interface (CU1 and MU1 models) and requires just power and ground to operate out of the box. The UART interface can be used to set and save various user parameters and operating modes tailored to your specific application.

The MC1 is a ruggedized version of the WASP™-200 laser rangefinder that is IP67 compliant and is directly compatible with the Cloud Cap Technology Piccolo autopilot systems using their CAN and RS-232 interfaces. In addition to the Piccolo CAN interface, the user can access all of the commands and settings of the WASP™-200 over the RS-232 interface to set the various user parameters and operating modes for use while operating with the Piccolo flight controller.

Principle of Operation

The WASP™-200 LRF uses a highly sensitive avalanche photodetector (APD) and short-pulse laser diode. The laser is pulsed to produce an optical pulse of laser light with a peak power of about 40 Watts. This pulse is collimated with a lens and transmitted to the target up to 315 meters away (the maximum range capability of the WASP™-200 LRF). A small portion of the light will bounce off the targeted object and end up traveling back to the WASP™-200 LRF where it will be collected by the receiver lens and focused onto a small avalanche photodetector. This light will cause an avalanche of electrons to flow in the detector thus producing a current pulse which is subsequently amplified and converted into a voltage pulse.

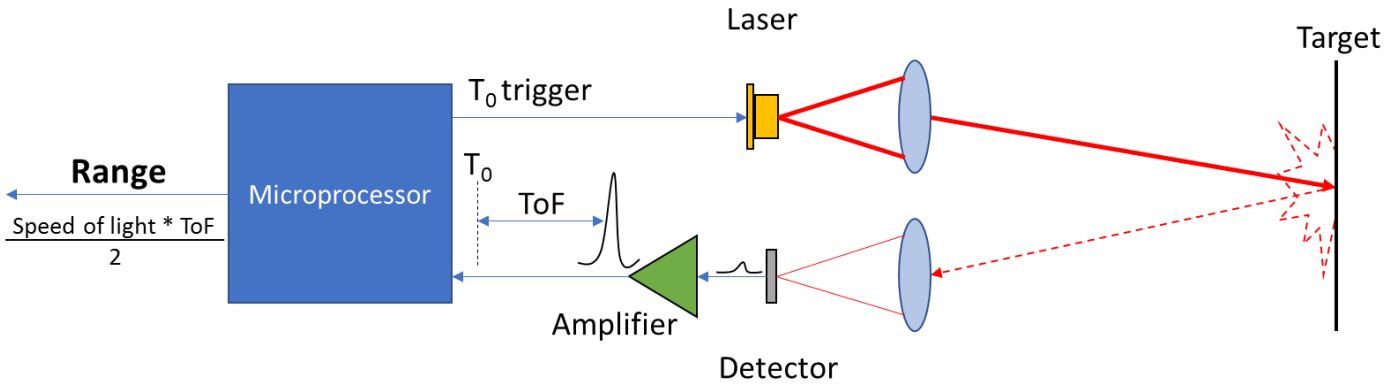


Figure 1 - Conceptual Schematic of the WASP™-200 LRF time-of-flight principle of operation

The WASP™-200 LRF makes a careful timing measurement between the firing of the laser and the receipt of the detector's signal pulse. This elapsed time, called the time-of-flight (ToF), is used to determine the distance to the object based on the speed of light and taking in to account the round-trip path of the light pulse.

The WASP™-200 LRF has an on-board microprocessor which performs many functions throughout the idle and operating states of the rangefinder. Examples include maintaining a high sensitivity state of the APD under changing environmental and illumination conditions, performing burst mode averaging of returns when requested, applying calibration parameters to the detected pulse to compensate for variability in target properties, compensating for changes in the ambient temperature, etc.

The default baud rate for the serial communications is 115,200 bits per second. 115,200 bps is sufficient for ranging up to approximately 1,500 ranges-per-second. Software allows for the baud rate needs to be increased to 921,600 bps. At either baud rate, the range reporting format can be changed to binary to enable data to be reported up to the maximum range rate of 10,000 ranges per second over the serial port for Class 3 operation only. Class 1 is limited to a 56 Hz maximum range rate.

Anytime the system cannot respond immediately to a range based on a requested range rate, the WASP™-200 LRF reports a code which will be denoted by a negative sign and a numeric code.

Performance

Using the built-in, real-time filtering functions (AVG, MVG, MDF) will reduce the maximum achievable repetition rate. In repetitive ranging mode, the system will take the time necessary to apply the active filters to the current measurement and then wait for the next internal trigger. If the time required to apply the filters exceeds a period time, the system will wait until the next period before beginning another range operation. The DIG_OUT function can be configured (via PWM) to generate a ~5 µsec pulse every time the system is carrying out a ranging operation and is time synchronized to the start of the laser pulse or set up to provide a pulse width proportional to the range measured.

Table 1 - Performance specifications of the WASP™-200 LRF

WASP™-200 LRF	
Specification / Feature	**CU1/MU1/MC1**
FDA Laser Classification	Class 1 Laser Product
Range Performance (Scattering Sunlit Target)	**0.15m to 175m - 18% reflectivity** **0.10m to 300m - 80% reflectivity**
Maximum Range	315 meters
Accuracy	< 10 cm
Resolution	1 cm
Update Rate	Single shot to 56 Hz (CU1/MU1) Single shot to 50 Hz (MC1)
Wavelength	905 nm
Beam Divergence	8 mrad x 1 mrad
Optical Aperture	18 mm
Input Voltage	3.5V to 16V (CU1/MU1) 3V to 16V (MC1)
Operating Current	< 75mA @ 5V Operating Voltage (CU1/MU1) < 75mA @ 10V Operating Voltage (MC1)
Inrush Current	< 100mA @ 5V Operating Voltage (CU1/MU1) < 100mA @ 10V Operating Voltage (MC1)
Connector	8 pin Hirose DF13 Connector (CU1) IP67 ODU (MU1 / MC1)
Communication Interface	UART (CU1/MU1) CAN/RS-232 (MC1)

Power

The WASP™-200 LRF is designed to operate with a wide range of input voltages. The steady state current is generally below 75 mA at a 5V operating voltage and may require temporary inrush currents of up to 100 mA upon power-on.

Laser Safety

The WASP™ uses a 905 nm, 75 W peak power laser with a beam divergence of 8 mrad x 1 mrad out of an 18 mm aperture.

NOTE: This Laser Product is designated as Class 1 during all aspects of operation. The U.S. FDA Laser Classification Label is shown below in Figure 2. The placement of the label is shown in Figures 3 through 5.

Figure 2 - U.S. FDA Class 1 Laser Label

Physical

There are two configurations of the WASP™-200 LRF: Commercial (CU) and Ruggedized (MU and MC). The commercial version features an injection molded plastic housing and a UART interface over a Hirose DF13 8-pin connector. The

ruggedized version utilizes a machined plastic housing base unit with IP67-designed sealing and an accessory module that provides a CAN & RS-232 or a UART interface to the host system.

Table 2 - WASP-200 physical device configurations

WASP™-200 LRF		
Specification / Feature	**Commercial (CU1)**	**Ruggedized (MU1/MC1)**
Dimension (L x W x H)	44 x 20 x 42 mm³ (1.7 x 0.8 x 1.6 in³)	46 x 35 x 42 mm³ (1.8 x 1.4 x 1.6 in³)
Connector	Hirose DF13	ODU IP67
Water Protection	Splash Resistant	IP67 Rating
Weight	26 grams (0.92 oz.)	46 grams (1.62 oz.)
Operating Temperature	-40 to + 60 C (-40 to 140 °F)	-40 to + 60 C (-40 to 140 °F)

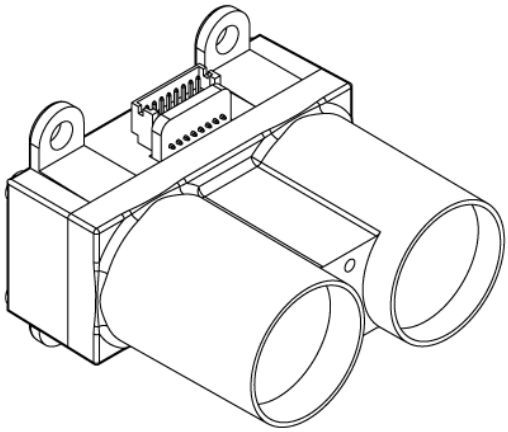
Two options for mounting the WASP™ in a system have been provided.

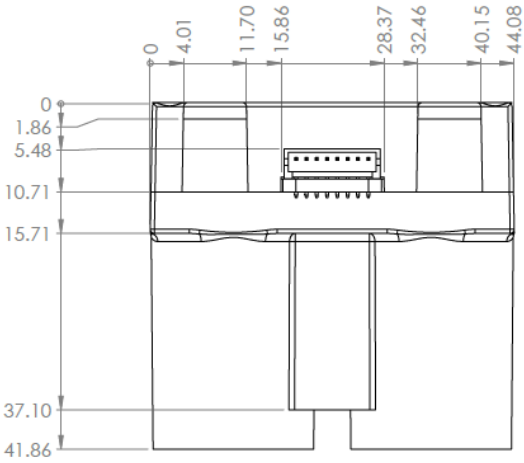
Option 1 – Rear mounting: There are four 0.150” diameter holes on the rear cover dog ears to flush mount the unit to a mounting surface. The holes are well-suited for a close clearance with a #6-32 socket head cap screw or they can be drilled out for slightly larger screws.

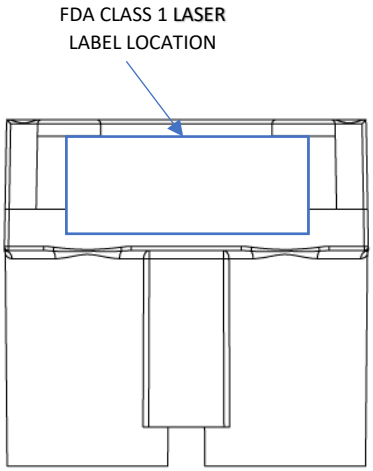
Option 2 – Front mounting: The WASP™-200 LRF can be mounted to a host-system by way of the 0.067” holes found on the front of the device and be flush-mounted to a 3/16” plate or panel. The mounting hole can be tapped for a #2-56 thread or self-tapping plastic screws can be used. The front lenses are waterproof and this type of bulkhead mounting can provide the customer with a waterproof seal.

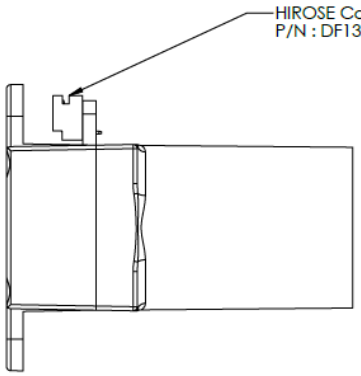
Dimensions

The exterior dimensions and mounting details of the WASP™-200 LRF are shown in Figure 3 and Figure 4 for the commercial systems and Figure 5 for the ruggedized systems. All dimensions are in millimeters. Contact Attollo Engineering for a 3D solid model.









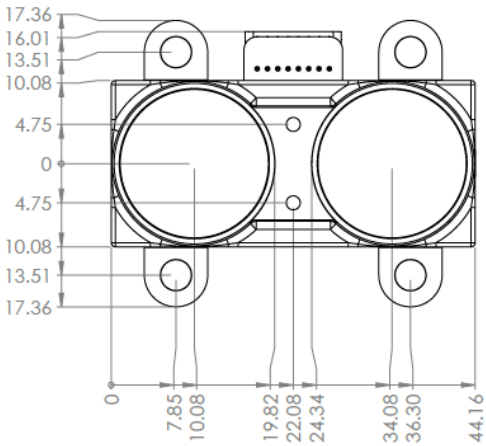


Figure 3 - Exterior and Mounting of the WASP™-200 LRF (CU1) up to HW Rev. 103

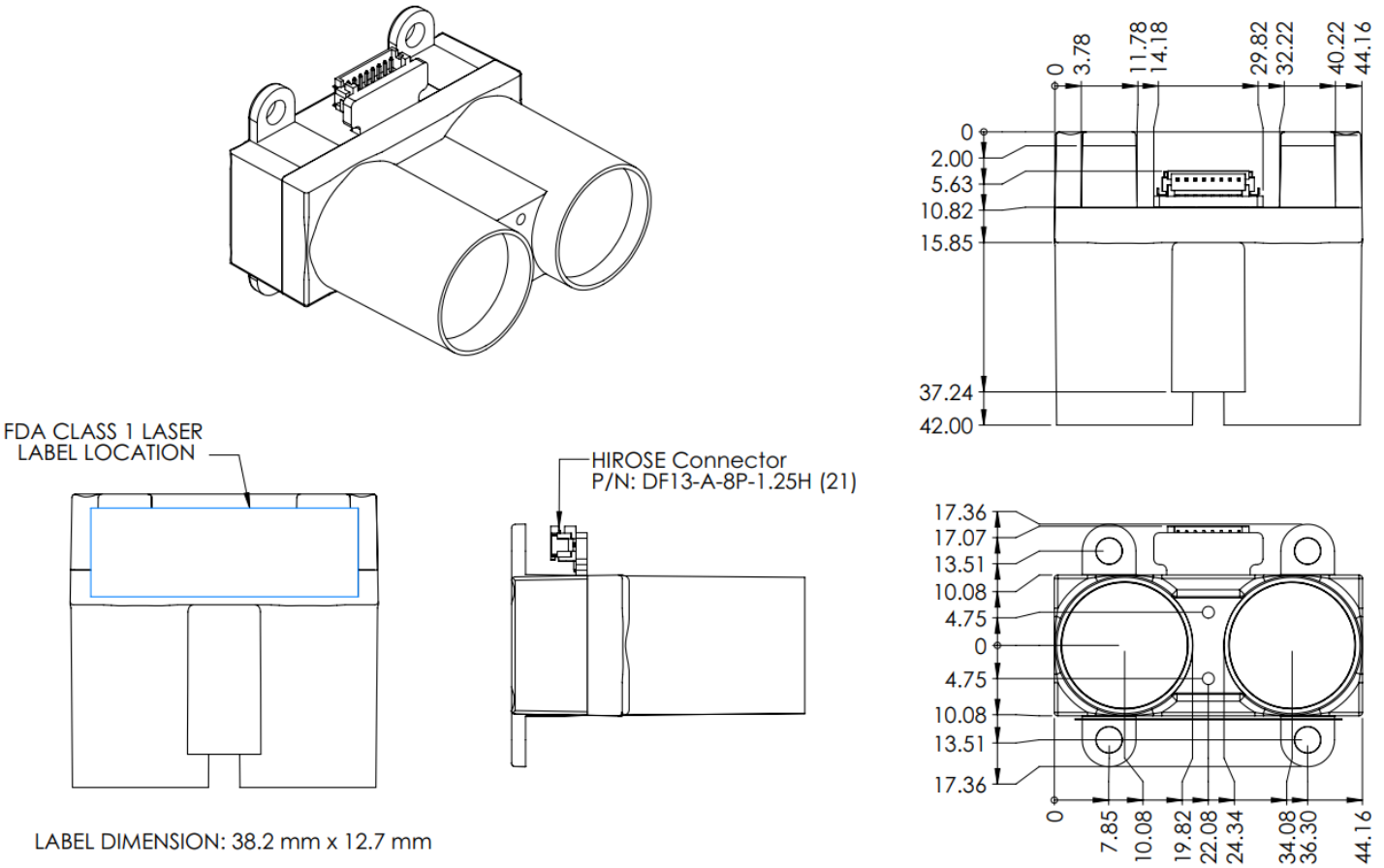


Figure 4 - Exterior and Mounting of the WASP™-200 LRF (CU1) - HW Rev. 104

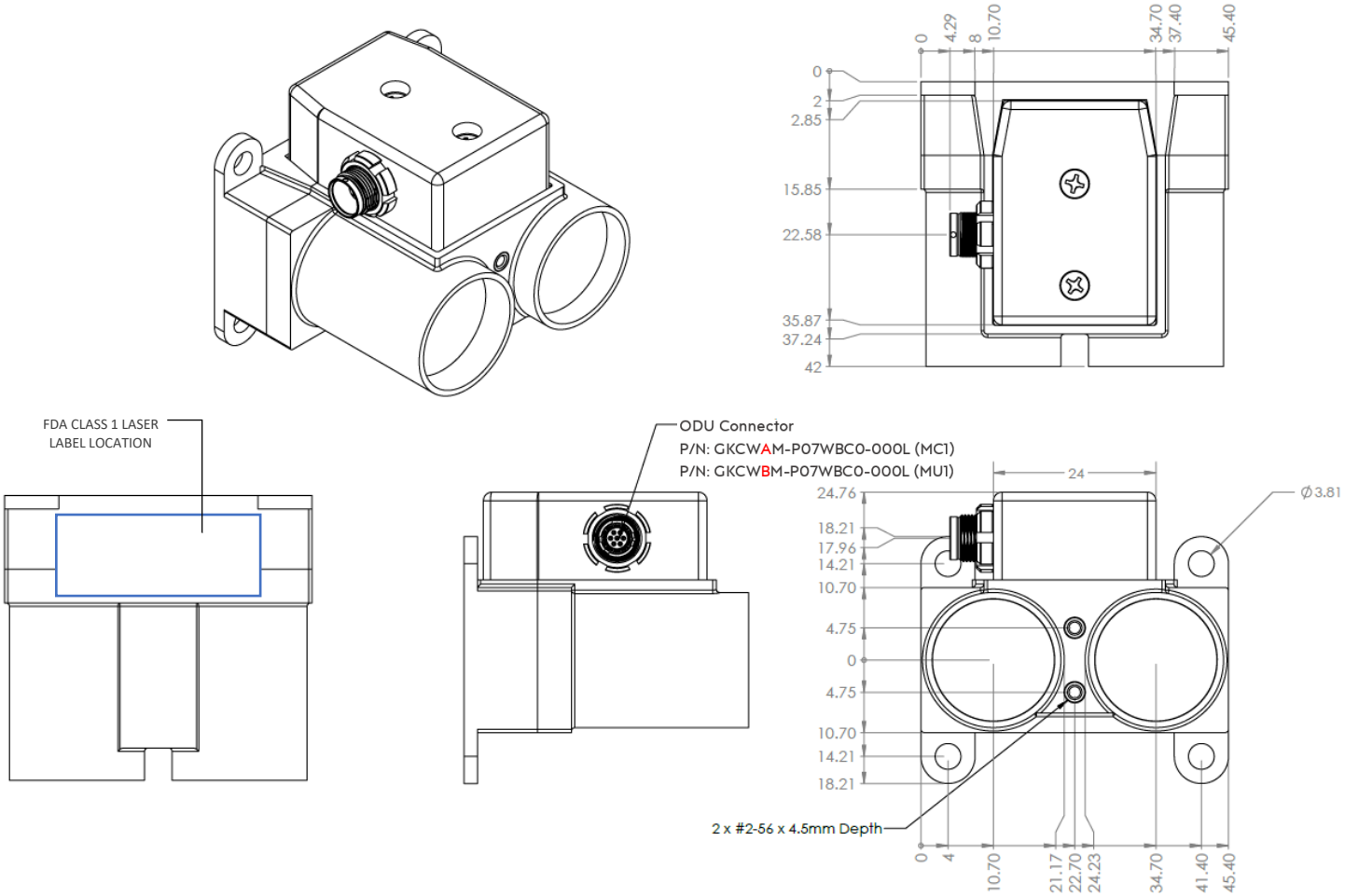


Figure 5 - Exterior and mounting dimensions of the Ruggedized WASP™-200 LRF (MU1 and MC1)

Filtered False Alarm Rejection

False alarms are an inherent artifact of high performance rangefinders. Spurious electrical noise spikes or ambient background noise spikes may exceed the extremely sensitive thresholds set for maximum range capability and cause an incorrect range to be reported. Attollo has designed the WASP™ to have below 1.0% false alarm rate (FAR) which is a generally accepted FAR for typical usage. The FAR can be improved (i.e. to 0.1%) by reducing the threshold value via an offset command (TOS), but this will come at the cost of slightly reduced range performance. Generally, the user should use a filtering mechanism to reduce the impact of false alarms on the control system.

To facilitate false alarm fitlering the WASP™-200 has a variety of onboard filtering options. These filtering options include burst mode averaging (AVG), moving averaging (MVG), and sorted filtering, aka Median or Long-Pass filtering (MDF). This section describes these filters.

The AVG command initiates a series of quick succsession ranges and the average value of these ranges is reported. The MVG command creates a buffer of ranges and reports the average value of the buffer once the number of ranges exceeds the requested average size. The WASP™ applies a false alarm filtering mechanism in both the averaging mode and moving average mode to detect and throw out high probability false alarms from the reported averaged value. The filter does this by comparing the indivual ranges to the median of the population to determine whether a given value is a false alarm or a valid measurement.

For the averaging mode, if the user selects an averaging of 8 pulses (`AVG8`), the WASP™ will take 8 ranges in quick succession, computes the average and he median, and then compare each range to the median. If a given range exceeds the median by the parameter stored by AVF (i.e. 2.00 meters by default), longer or shorter, then that range is thrown out and not included in the reported average. Avergaing mode can be used in conjunction with the moving average mode as well as the sorted filtering mode discussed later.

For the moving average mode, if the user selects a moving averaging of 8 pulses (`MVG8`), the WASP™ will take a range and adds it to the 8 range queue, computes the average of the queue, and then compares each range to the average of the queue. If a given range exceeds the average by the parameter stored by the percentage expressed by MVF (i.e. 20% is expressed as 0.20, the default value), longer or shorter, then that range is thrown out and not included in the moving average. For example a a range of 121 m compared to the average of 100 would be excluded from the computation but a range of 119 m would be included.

For both modes (`AVG` or `MVG`) the last parameter, RGF, describes the range above which the AVF and the MVF algorithms are applied. In other words, if a range is below the default value of 30.0 meters then these algorithms are not applied to incoming data in `AVG` or `MVG` mode. 30.0 m is the default because solar noise events are very rare in the 0 to 30 m range due to the internal design of the WASP™-200 LRF. If operating in rain a lower value of RGF would be logical.

The filtering is adjusted by three parameters, AVF, MVF, and RGF. By default these values are 2.00, 0.20, and 30.0, respectively. Generally the user will not need to change these parameters but there may be environmental factors (i.e. high frequency variation in actual range or the presence of rain) that may require these values to be modified.

The WASP™ also has a Median Filter Mode (MDF) that can be set to report any range in a sorted window of recent returns. The MDF command accepts two variables. The first is the number of most recent returns to include in the window. The second parameter is the index position in the sorted list, from longest range to shortest range to return. In this fashion the MDF filter can be used as a long-pass filter by setting the second parameter to a value much smaller than the window size or as a median filter by setting the second parameter to a value about half the size of the window. The second

parameter is optional or can be “0” and the WASP™ will interpret these the same and as if the Median value is desired and the echo will omit the “0”. In this way the MDF can be used as a simple median filter and is backward compatible with WASP™ firmware prior to FWV 23100005. When the window is not yet filled the WASP™ will report the laser range value until the window size has been filled at which point it will begin reporting the request index value in the window.

The median filter window and the moving average filter can be reset at any point with the RBF command. The RBF command should be used anytime stale data needs to be removed such as after stopping and restarting the ranging process. Usage of the median filter (MDF) and moving average filter (MVG) are mutally exclusive.

We have found these techniques, and the default values associated with them, support high accuracy ranging with low false alarm rates in typical environments. In fact, with these filters the effective false alarm rate in the average or moving average mode is signficantly improved over the 1%.

In addition to techniques for filtering false alarms, the WASP™-200 LRF has an onboard error register (ERR) that will report when the noise generated by the environment, particularly by the solar lighting background, has exceeded the calibation limit of the WASP™’s ability to compensate and leaves the system open to a higher than normal FAR. This value is the 3rd LSB in the Error Register Byte that reports at the end of the HTH query. If this ASCII decimal value is converted to binary and the third bit is a “1” then this means the background noise of the last measurement is at or beyond the noise calibration of the WASP™ and the probability of a fasle alarm range is higher. This can be mitigated by using the TOS command to reduced the threshold such as TOS-2 which reduces the threshold by two steps and can take a 2% False Alarm Rate (FAR) down as low as 0.4%.

Relative Signal Strength Reporting

The WASP™-200 LRF can report the relative signal strength of the most recent laser ranging event performed with the STH setting. This value is a ratio of the latest range reported strength to the maximum strength the unit can measure based on the factory calibration performed. This value is the space delimited from the range result as shown in the example below:

```
< 1.951 27
< 1.959 27
```

The command to enable the feature is:

```
>STH 1
< STH1
```

This feature is useful to provide mission planning related to impending range dropouts as the value is seen to approach the low single digit strengths. In addition, values of 100 may indicate that more range error is possible as the unit’s range calibration limit has been reached.

Note that the signal strength reported is always that of the most recent range regardless of any filtering that is being applied. Hence the strength reports may not be partnered with the range reported in cases such as when the Median filter is being employed.

Pinout and Electrical Interface

CU1

The signals used in operation of the commercial WASP™-200 LRF (CU1) are shown in the following table. The user is free to make their own cable set, but cables received from Attollo will be colored per the table below.

Table 3 – WASP™-200 LRF Signal Pinouts for the CU1 model

Pin # (CU1)	Signal	Voltage Range	Comment	Color
1	RST	0 – 3.3V	3.3V or float for normal operation 0V for greater than 10 us to reset system	Brown
2	GND	0V		Black
3	POWER IN	3.5 – 16V		Red
4	POWER ENABLE		3.3V or connect to POWER IN to enable system 0V or float to disable system	Green
5	UART RX	0 – 3.3V	5V tolerant	Blue
6	UART TX	0 – 3.3V		Orange
7	DIGITAL OUT	0 – 3.3V		Yellow
8	DIGITAL IN	0 – 3.3V	5V tolerant	Purple

WASP™-200 LRFs, up to HW Rev. 103, ship with a Hirose DF13-8P-1.25DS(20) 8-pin connector. Contact Attollo for a design variation that includes eight plated through holes, on a 1.25 mm pitch on the PCB tab of the WASP™-200 LRF for direct soldering of interface wires or a custom 8-pin, 1.25mm pitch connector. WASP™-200 LRFs, HW Rev. 104 and above, ship with the surface mount Hirose connector DF13A-8P-1.25H(21). Recommended connectors and mating components are listed in Table 4.

Table 4 - Recommended connectors and wires for the WASP™-LRF CU1 model

Part	Description	Mfg	Mfg P/N
CU1-001 Board Connector (*up to HW Ver. 103*)	8 Position Header Connector 0.049" (1.25mm) Through Hole, Right Angle Tin	Hirose	DF13-8P-1.25DS(20)
CU1-001 Board Connector (*HW Ver. 104 and above*)	8 Position Header Connector 0.049" (1.25mm) SMD, Right Angle Tin	Hirose	DF13A-8P-1.25H(21)
Wire Housing / Mating Connector	8 Position Rectangular Housing Connector Receptacle Beige 0.049" (1.25mm)	Hirose	DF13-8S-1.25C
Wire	26 – 30 AWG Wire	-	-

MU1

The MU1-001 uses a 7-pin circular IP67-rated connector from ODU for the power, communication, and I/O connection to the LRF.

Table 5 - MC1-0017-pin circular connector and mating part

MU1-001 Connector	ODU GKCWBM-P07WBC0-000L
Mating Connector	ODU A1CWBM-P07XBC0-0000

Note that the MU1-001 uses the "B" keyway of this connector family. The MU1-001 connector, from the perspective of looking at the connector from the outside of the LRF, is numbered according to Figure 6.

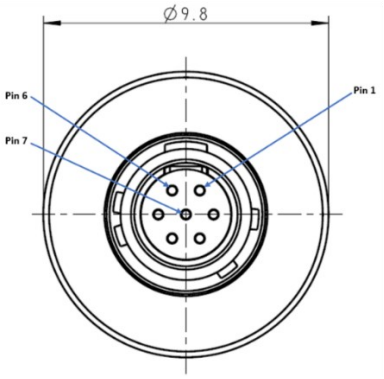


Figure 6 – MU1 – 7 Pin Circular Connector (ODU GKCWBM-P07WBC0-000L) pin numbering. Minor keyway information in drawing may not be accurate, but pin numbering with respect to the large key is accurate.

The pinout of the connector is defined in Table 86. Mating connectors and cable sets can be purchased from Attollo and are color coded as indicated in Table 86.

Table 6 - WASP™-200 LRF Signal Pinouts for the MU1 model

Pin # (MU1)	Signal	Voltage Range	Comment	Color
1	RST	0 - 3.3V	3.3V or float for normal operation 0V for greater than 10 us to reset system	Brown
Shell/Drain	GND	0V		Black
7	POWER IN	3.5 - 16V		Red
5	POWER ENABLE		3.3V or connect to POWER IN to enable system 0V or float to disable system	Green
2	UART RX	0 - 3.3V	5V tolerant	Blue
4	UART TX	0 - 3.3V		Orange
6	DIGITAL OUT	0 - 3.3V		Yellow
3	DIGITAL IN	0 - 3.3V	5V tolerant	Purple

*Note that there are two black wires on the pigtail end of the cable. However, one is heatshrink wrapped and is not fully insulated at the base where it meets the thick plastic insulation. This is the cable braid / drain of the cable. The black GND signal is stripped only at the tip like all of the other wires.

Minimum Recommended Configuration (CU1 and MU1)

To operate the WASP™-200 LRF with a minimal electrical configuration the cable can be configured like that shown in Figure 7.

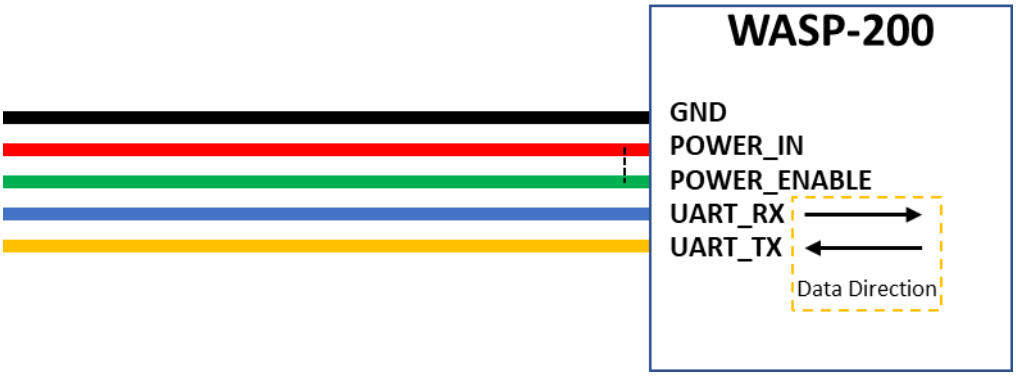


Figure 7 - The minimum required connections to operate the WASP™-LRF

POWER_ENABLE can be tied to POWER_IN to simplify the number of connections. POWER_ENABLE can tolerate the full voltage range (3.5V – 16 V) of POWER_IN.

MC1

The MC1-001 uses a 7-pin circular IP67-rated connector from ODU for the power, communication, and I/O connection to the LRF.

Table 7 - MC1-0017-pin circular connector and mating part.

MC1-001 Connector	ODU GKCWAM-P07WBC0-000L
Mating Connector	ODU A1CWAM-P07XBC0-0000

Note that the MC1-001 uses the "A" keyway of this connector family. The MC1-001 connector, from the perspective of looking at the connector from the outside of the LRF, is numbered according to Figure 8.

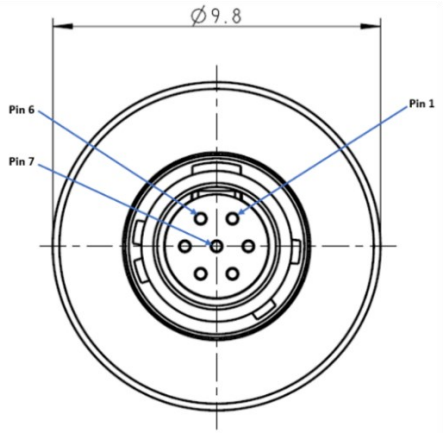


Figure 8 - MC1 - 7 Pin Circular Connector (ODU GKCWAM-P07WBC0-000L) pin numbering

The pinout of the connector is defined in Table 8. Mating connectors and cable sets can be purchased from Attollo and are color coded as indicated in Table 8.

Table 8 - WASP™-200 LRF Signal Pinouts for the MC1 model.

Pin #	Signal	Voltage Range	Comment	Color
1	RS-232 RX	0 - 3.3 V		Brown (or Gray)
6	RS-232 TX	0 - 3.3 V		Black
2	POWER IN	3.0 to 16 V		Red (or Pink)
3	CAN N	0 - 5 V		Green
7	GPIO	0 - 5 V		Blue
5	GND	0 V		Orange
4	CAN P	0 - 5 V		Yellow
NA	SHIELD	-	Should be tied to GND on customer end of cable	Purple
NA	SHIELD	-	Cable braid / drain – connected to shield	White – heatshrink wrapped

*Note that there are two black wires on the pigtail end of the cable. However, one is heatshrink wrapped and is not fully insulated at the base where it meets the thick plastic insulation. This is the cable braid / drain of the cable. The black RS-232 TX signal is stripped only at the tip like all the other wires.

The CAN Bus is terminated within the MC1-001 with a 120 Ω resistor. It is recommended that the user provide the appropriate termination within their system which is recommended to be a corresponding 120 Ω resistor on the host end of the system.

The MC1-001 can accept an input voltage from 3 to 16 V. Power consumption under steady state is approximately 800 mW. When enabling the LRF the system demands an inrush current for up to 5 ms. When connected directly to a power supply, the current compliance limits shown in Table 9 provided adequate supply current during this inrush period.

Table 9 - Maximum current required at the specified operating voltage to support the inrush current when enabling the LRF

Operating Voltage (V)	Maximum Current (mA)	Operating Current (mA)
3	400	290
5	250	150
12	100	70
16	75	50

Many electronic component distributors may sell pre-crimped wires of varying lengths and colors if you wish to build your own cable set. Attollo also sells pre-assembled cable assemblies with the DF13 and ODU connectors described above and color coded in accordance with the corresponding pinouts. Attollo sells a USB to UART adapter board for communicating with the WASP™-200 LRF over a computer's serial interface. Visit the website for configuration and ordering information.

Communication Interface (CU1 and MU1)

The WASP™-200 LRF provides a UART serial interface for communication. The UART communication settings are summarized in Table 10. The following section will provide detail on the command structure used for communicating with the WASP™-200 LRF.

Table 10 - WASP™-LRF UART communication settings

Specification	Measurement
Baud Rate	115200 & 921600
Data Bits	8
Stop Bits	1
Parity	None
Flow Control	None
Terminating Character	Linefeed (Hex: 0x0A)

All serial commands must append a linefeed character at the end in order to be properly received by the WASP™-200 LRF.

Serial Commands

Communicating with the CU1 and MU1 variants of the WASP™-200 LRF takes place through the serial command interface using ASCII-based commands. Each command to the LRF consists of an initialization character, a command mnemonic, and zero or more arguments. All commands are case sensitive and are UPPER CASE. The initialization character for all commands being transmitted to the rangefinder is the “>” character. For example:

```
>RNG
```

All serial commands must append a linefeed character at the end (ASCII (hex) 0x0A, ‘\n’) to be received by the LRF.

ASCII responses from the WASP™-200 LRF follow a similar format, except the initialization character is the “<” character. The initialization character can also be helpful as a dataflow direction indicator.

At power-on, after the WASP™-200 has initialized, it will report its model name (MNM), hardware revision (MHV), serial number (MSN), firmware version (MFW), and manufacturer (MFG). Receipt of these responses indicates the WASP™-200 is ready to receive commands and begin ranging.

The available commands for use with the WASP™-200 LRF are listed below. Commands are 3-characters with legacy support for commands from prior firmware revisions (ie. FWV 19390001). Users should use the new 3-character formats.

ANO	Analog Output
AUT	Auto-threshold enable / disable
AUV	Auto-voltage enable / disable
AVF	Maximum deviation for average
AVG	Number of multi-pulse averages
BAU (BAUD)	Baud rate of UART interface
CHK (CHKSUM)	Add 16-bit checksum to output
DCM (DCM?)	Detector dark current
ERR (ERR?)	Query Error Byte
FMT	Output format
FRQ	Continuous ranging frequency
HTH (HLTH?)	Health check
LBE	Binary output format endianness
LOM	Legacy Output Mode
MBL	Model Bootloader version
MDF (MEDF)	Median-filter window size
MFG	Manufacturer
MFW	Model firmware version
MHV	Model hardware version
MNM	Model name
MSN	Model serial number

MVF	Maximum moving avg ratio
MVG (MAVG)	Moving average
NSG (NSG?)	Detector noise
OFS	Range offset in meters
PWM	Digital Output Function
RBF	Reset range buffer
RGF	Filter range limit
RNG	Single range
RST (RSTB)	Software reset
RUN (GO)	Start continuous ranging
SAV (SAVE)	Saves current settings to flash
SET (SET?)	Current settings
SVC (SVC?)	Current Service Parameters
STH	Relative signal strength of return
STP	Stop continuous ranging
THR	Sensitivity threshold
TMP (TMP?)	System temperature
TOS (TOFS)	Sensitivity threshold offset
TRG (TRIG)	Triggered ranging
VLT	APD bias voltage

Command	ANO	Arguments	[0/XX.X (float)]
Description	Sets the maximum range that is represented by 3.3V output on the DIG_OUT pin. The analog output voltage is proportional to the measured range as a portion of the programmed maximum range. A value of 0 disables the analog output. This functionality is only enabled if the unit is configured for analog output before shipping.		
Example	>ANO 120 < ANO120		

Command	AUT	Arguments	[0/1]
Description	Enables (1) and disables (0) the auto-threshold adjustment. The auto-threshold feature ensures that the system is in its highest sensitivity state, while still ensuring a better than 1% false alarm rate, before every range measurement.		
Example	>AUT 1 < AUT1		

Command	AUV	Arguments	[0/1]
Description	Enables (1) and disables (0) auto-voltage adjustment. Auto-voltage adjustment maintains the sensitivity of the system over changes in the LRF's ambient environment.		
Example	>AUV 0 < AUV0		

Command	AVF	Arguments	[XX.XX (float)]
Description	This parameter works with the AVG filter and it is a floating point number that defines the maximum deviation from the median value for ranges that will be included in the filter computation. When this value is written to the WASP™, the value can be slightly modified as it is converted to an internal value. This modified value will report back. If a range exceeds the median by the parameter stored by AVF (i.e. 2.00 meters by default), longer or shorter, then that range is thrown out and not included in the reported average.		
Example	< AVF2.00 >AVF 2.0		

Command	AVG	Arguments	[1…32]
Description	Sets the number of pulses to be used in multi-pulse averaging mode. In this mode, a sequence of rapid-fire ranges are taken and then averaged to improve the accuracy of the measurement. Each range operation takes approximately 100 us to complete so the number of averages multiplied by 100 us should not exceed 1/FRQ. The LRF will prioritize maintaining the ranging frequency and will reduce the number of averages taken to remain within compliance with the Class 1 classification.		
Example	>AVG 8 < AVG8		

Command	BAU (BAUD)	Arguments	[HIGH/LOW]
Description	Sets the baud rate of the UART communication interface. A value of HIGH will set the baud rate to 921600 bps and a value of LOW will set the baud rate to 115200 bps. Baud rate changes will take effect upon issuance of the command.		
Example	>BAU LOW < BAUD 115200		

Command	CHK (CHKSUM)	Arguments	[0/1]
Description	Enables (1) and disables (0) the reporting of a checksum with every range report. The checksum is calculated as 16-bit CRC-CCIT with a polynomial of 1021 and an initial value of 0 and the data bytes reversed. Appendix A describes the CRC calculation in more detail. When enabled, the range response will look like the following: < 10.145d| < 10.459ô+ < 11.074ú* < 11.089N0 < 11.104ÑÂ where the two bytes after the 3 decimal point precision range response represent the binary-encoded checksum.		
Example	>CHK 1 < CHK1		

Command	DCM (DCM?)	Arguments	None
Description	Reports the current detector dark current value in arbitrary units.		
Example	>DCM < DCM?0		

Command	ERR (ERR?)	Arguments	None
Description	This error register reports in decimal number the converted error byte. A '1' in the byte position indicates an error is present. Bit 1 (LSB) = Temperature out of range: Temperature reading > 70C or <-20C Bit 2 = nonsense range: Range after calibration correction < 0 or the reported signal strength indicates erroneous range collection Bit 3 = Too Much Noise: Noise reading corresponds to an auto-threshold computed to be at or past the limit of the factory calibration. Reported ranges may include more than 1% False Alarms.		
Example	>ERR < ERR?0		

Command	FMT	Arguments	[BINARY/ASCII]
Description	Sets the output format for range reporting. ASCII will report range data as a 3 decimal precision floating point number. BINARY will report range data as a 32-bit floating point number. Regardless of the output format mode, the WASP™-200 LRF always expects inputs in ASCII format.		
Example	>FMT BINARY < FMT BINARY		

Command	FRQ	Arguments	[1…56]
Description	Sets the repetition frequency of the ranging operation in Hertz. The input argument is the desired frequency of operation. Upon entering the desired frequency, the system will calculate the nearest frequency that it can handle according to the U.S. FDA Laser Classification of the product and/or resolution of internal timers. This value will be reported back to the user. The frequency can be set / changed within this frequency range when the system is either active or idle. To remain Class 1 compliant, the WASP™ must never exceed 56 laser pulse outputs within a 1 second time period. Therefore, if the averaging function is being used, where the WASP™ sends out a burst of pulses and averages the results, the WASP™ will prioritize maintaining the ranging frequency and will reduce the number of averages taken to remain within compliance with the Class 1 classification.		
Example	>FRQ 50 < FRQ50		

Command	HTH (HLTH?)	Arguments	None
Description	Reports a summary of various health aspects of the rangefinder including dark current, temperature, noise level, whether ranging is presently active, and any current system errors (see error register)		
Example	>HTH < DCM?0 | TMP?032.88 | NSG?8320 | ACT?0 | ERR?0		

Command	LBE	Arguments	[BIG/LITTLE]
Description	Sets the endian-ness of the BINARY output during range reporting. LBE has no effect when the output format is ASCII. The default endian-ness is BIG.		
Example	>LBE LITTLE < LBE LITTLE		

Command	LOM	Arguments	[0/1]
Description	Sets the output formatting to that of the early version of the WASP™ with a line break before the range result for the RNG command and no carrots on each line of range results for the RUN command		
Example	>LOM 1 < LOM1		

Command	MBL	Arguments	None
Description	Reports the Bootloader version installed in the WASP™-200 LRF.		
Example	>MBL < MBL3		

Command	MDF (MEDF)	Arguments	[1…32]_space_[0…32]
Description	Sets the window size for the real-time sorted filter of most recent ranges. The second parameter is the index of the position within the sorted list from longest to shortest range. When a Median Filter is desired the second parameter can be 0 or omitted. When the first argument is greater than 1 the median filter is active.		
Example	>MDF 6 6 < MDF66 >MDF 6 1 < MDF61 >MDF 6 0 < MDF6 >MDF 6 < MDF6 >MDF1 < MDF1		

Command	MFG	Arguments	None
Description	Reports the manufacturer of the WASP™-200 LRF.		
Example	>MFW < MFW ATTOLLO ENGINEERING		

Command	MFW	Arguments	None
Description	Reports the WASP™-200 LRF firmware version (ie. MFW 23100005).		
Example	>MFW < MFW 23100005		

Command	MHV	Arguments	None
Description	Reports the hardware revision of the WASP™-200 LRF.		
Example	>MHV < MHV 104		

Command	MNM	Arguments	None
Description	Reports the model name of the WASP™-200 LRF.		
Example	>MNM < MNM CU1-001		

Command	MSN	Arguments	None
Description	Reports the serial number of the WASP™-200 LRF.		
Example	>MSN < MSN 22300030		

Command	MVF	Arguments	[0.XX (float)]
Description	For the moving average mode, if a given range exceeds the average by the parameter stored by the percentage expressed by MVF (i.e. 20% is expressed as 0.20, the default value), longer or shorter, then that range is thrown out and not included in the moving average.		
Example	>MVF0.20 < MVF0.20		

Command	MVG (MAVG)	Arguments	[1…64]
Description	Sets the number of historic range results to use for calculating the current range result. When MVG is greater than 1, the current range result will be the current measured value averaged with the N-1 previous results.		
Example	>MVG 10 < MVG10		

Command	NSG (NSG?)	Arguments	None
Description	Reports the current system noise in arbitrary units.		
Example	>NSG < NSG?8560		

Command	OFS	Arguments	[-10.0…10.0]
Description	Applies an offset to the reported range. Valid arguments can be negative or positive floating point numbers.		
Example	>OFS 0.23 < OFS0.230		

Command	PWM	Arguments	[0/1/2]
Description	Defines the function of the DIG_OUT line. A setting of “0” provides a 5 µsec wide pulse synchronized with the firing of the laser. Mode “1” and “2” cause the DIG_OUT line to go high for a time that is proportional the range according to the user defined resolution. Once the DIG_OUT line has been high proportional to the amount of time that represents the range, it will remain low until the next range occurs. A parameter value of 0 will disable PWM output, 1 enables PWM output with a high time of 1 ms per meter, and 2 enables PWM output with a high time of 0.1 ms per meter.		
Example	>PWM 1 < PWM1		

Command	RBF	Arguments	None
Description	Resets the range buffer. The range buffer is a 64-element queue of the last 64 ranges that is used for carrying out the moving average (MVG) and median filter (MDF) functions. Resetting the range buffer may be useful if the user suspects that stale range data may be in the queue (i.e. there was a break in the ranging while the vehicle was still moving) and the user wishes to use the moving average or median filter.		
Example	>RBF < RBF		

Command	RGF	**Arguments**	[XX.XX (float)]
Description	For both modes (AVG or MVG), RGF, describes the range above which the AVF and the MVF algorithms are applied. If a range is below the default value of 30.0 meters then these algorithms are not applied to incoming data in AVG or MVG mode. 30.0 m is the default because solar noise events are very rare in the 0 to 30 m range due to the internal design of the WASP™-200 LRF. If operating in rain a lower value of RGF would be logical.		
Example	>RGF 30.0 < RGF30.0		

Command	RNG	**Arguments**	None
Description	Executes a single shot range operation and returns a single range result. The range result is reported according to the formatting options selected using the FMT and LBE commands. Assuming ASCII formatted output (FMT ASCII) the range result will be a floating point number with 3 decimal points of precision. All ranges are referenced from the rear of the unit. The OFS command can be used to apply an offset to this reference datum. The RNG command can be called sequentially and will be limited to 56 Hz. Exceeding this rate will result in a "RANGE_NOT_READY" error code (-6).		
Example	>RNG < 5.832		

Command	RST (RSTB)	**Arguments**	None
Description	Conducts a software reset of the WASP™-200 LRF. The last line reported will always be as indicated below.		
Example	>RST < MNM CU1-001 < MHV 104 < MSN 22300030 < MFW 23100005 < MFG ATTOLLO ENGINEERING		

Command	RUN (GO)	**Arguments**	None
Description	Starts continuous ranging at the frequency specified by FRQ. The range results will be reported in the format specified by the FMT and LBE parameters. By default, the range result is reported as plain text ASCII floating point number with 3 decimal places of resolution.		
Example	>RUN < RUN		

Command	SAV (SAVE)	**Arguments**	None
Description	Saves all currently active user parameters to the non-volatile flash memory. The WASP™-200 LRF will re-load these parameters after the next software or power-on reset. The currently active user parameters can be viewed using the SET command.		
Example	>SAV < SAV		

Command	SET (SET?)	Arguments	None
Description	Reports the current system parameters.		
Example	>SET < THR250 TOS0 OFS0.000 FRQ56 VLT605 AVG1 AVF2.00 MVG1 RGF30.0 MVF0.20 AUT1 AUV1 MDF1 LBE|BIG FMT|ASCII CHK0 TRG0 PWM0 ANO000.0 SAV1 STH0		

Command	SVC (SVC?)	Arguments	None
Description	Reports the current Service parameters.		
Example	>SVC < TPT190|250 TPTD60 ABSB|908 PWLMT1679 MAXT251 MINT226 APDT34.33 TLUTC|2.705E+02 -3.730E-01 8.080E-04 0.000E00 PLUTC|5.996E+02 -5.495E-01 -2.599E-04 3.220E-06 -5.891E-09 4.957E-12 -2.022E-15 3.230E-19 ECOEF|-6.610E-01 3.120E+01 DCMADJ|18000 LOM0 PWA0 DCOEF|4.893E-01 DEBUG_LEVEL0		

Command	STH	Arguments	[0/1]
Description	Turns on (‘1’) relative signal strength reporting of the last range returned. This is the fraction of the signal strength measured for the last range measurement compared to the maximum signal strength measurable by the unit. Use this to determine the quality of the range return and predict when the maximum range is close at hand. If performing AVG, MVG, or MDF, the strength is the last range made before reporting the result regardless of whether this range was used in the computation.		
Example	>STH 0 < STH0		

Command	STP	Arguments	None
Description	Stops continuous ranging.		
Example	>STP < STP		

Command	THR	Arguments	[1…255]
Description	Sets the system sensitivity. Larger values of THR represent higher sensitivity. When in auto-threshold mode the system will control the value of THR to prevent excessive false alarm rates based on settings made at the factory. The maximum system value is 255.		
Example	>THR 240 < THR240		

Command	TMP (TMP?)	Arguments	None
Description	Reports the current system temperature in degrees Celsius.		
Example	>TMP < TMP?34.05		

Command	TOS (TOFS)	Arguments	[-10…10]
Description	Applies an offset, positive or negative, to the sensitivity threshold (THR) of the rangefinder. Negative values reduce the WASP™ sensitivity and positive values increase the sensitivity. The offset only applies in auto-thresholding mode (AUT1) and is ignored when in manual thresholding mode (AUT0). Care should be taken such that the sum of TOS and the present THR (without offset applied) value does not exceed 255 or does not subceed 0, otherwise undesirable behavior may occur. Typically, useful offset values are small (i.e. value of 1 to 3) and may be used to improve sensitivity at the expense of a higher false alarm rate (positive values) or to counteract a strong sunlight on particularly reflective or specular target (negative values).		
Example	>TOS 2 < TOS2		

Command	TRG (TRIG)	Arguments	[0/1/2]
Description	Enables (1 or 2) and disables (0) the external range triggering via the DIG_IN pin. A value of 1 enables rising edge triggered ranging and a value of 2 enables falling edge triggered ranging. The minimum pulse width in either case must be greater than 1 µs. The active edge rate must not exceed the maximum range rate of the rangefinder otherwise a RANGE_NOT_READY error will be reported and the request will be ignored.		
Example	>TRG 1 < TRG1		

Command	VLT	Arguments	[0…1023]
Description	Sets the APD bias, in arbitrary units. Upon power-up, the system will automatically set the APD bias and continue to adjust it depending on varying ambient conditions and it should not need to be further adjusted. However, VLT gives the user the ability to change the bias. Increasing the bias too far past the start-up value risks over-biasing the APD and causing permanent damage to the APD. You must disable auto-voltage adjustment (AUV 0) before setting the voltage using the VLT command.		
Example	>VLT 510 < VLT510		

Range Error Codes

Range error codes are reported by the WASP™-200 LRF by a "-" sign followed by a code instead of the expected range value.

Table11 – WASP™-200 LRF UART ERROR Codes

Error	Error Code	Description
RANGE_NULL	-1	No range received from target.
RANGE_MAVG_BUFFER_NOT_FULL	-2	Moving average buffer has not been filled yet.
RANGE_AVG_NULLS	-4	50% or greater of the averaged pulses were NULLs
RANGE_MAVG_BUFFER_NULLS	-5	50% or greater of the ranges in the moving average buffer are NULLs
RANGE_NOT_READY	-6	LRF not ready for range request. Range requested in excess of maximum allowable range rate (i.e. 56 Hz for Class 1 operation)
RANGE_NONSENSE	-7	The LRF computed a range that was nonsense, such as negative

Error codes are reported similar to a range result but with the space between the > and the value replaced with a "-" sign.

Normal Range:

```
>RNG
< 5.877
```

Error Code:

```
>RNG
<-1.000
```

Communication Interface (MC1)

The WASP™-200 MC1 LRF has both a CAN interface and an RS-232 serial interface. The CAN interface is formatted according to the CAN 2.0B standard and is configured to be compliant with the Latitude AGL-M/N communication protocol and therefore compatible with the Cloud Cap Technologies Piccolo autopilot. The baud rate of the CAN channel is 1,000,000 bps.

Similarly, the RS-232 interface is designed to be compliant with the Latitude AGL-M/N communication protocol and therefore compatible with the Cloud Cap Technologies Piccolo autopilot. The baud rate of the RS-232 channel is 9,600 bps. Note that unlike the UART versions of the WASP™-200 LRF (CU1 and MU1), no terminating character is used for the Piccolo-compatible RS-232 interface.

The RS-232 interface also provides a passthrough mode, accessible through the use of the "LRF" command, which can be used to issue the serial commands described in the previous section to the underlying WASP™-200 LRF. This is useful for configuring the LRF for utilize more advanced filtering modes when being utilized via the Piccolo command protocol. For instance, the LRF can be configured for moving average or multi-pulse filtering when in use with the Piccolo autopilot.

CAN

The CAN frame is formatted as shown in Table 11.

Table 11 - CAN Frame Structure

Field	Name	Description
0	29-bit identifier	See Table 12 for field description
1	Control	Contains the data length
2	Data	Up to 8 data bytes
3	CRC	CRC sequence
4	ACK	Ack field

The 29-bit identifier bits are broken down into the fields shown in Table 12.

Table 12 - CAN 2.0B Frame Identifier

Bits	0:4	5:12	13:28
Field	Group ID	Message ID	Serial Number. Use "0" for "all broadcast"

CAN Bus Commands

The CAN commands are nearly a complete subset of the Latitude Engineering AGL CAN command set (Title: AGL-Comms-Interface, Dated: 12/15/15). This allows the WASP™-200 MC1-001 to be a drop-in replacement, communication-wise, with the Cloud Cap Technology Piccolo family of autopilots. The supported commands are listed in Table 13 and a description for the CAN group IDs are shown in Table 14.

Table 13 -WASP™ MC1-001 Data Packet Types

Name	CAN Group ID	Message ID	Description	Direction
READING	0x04	0x00	Contains the data from a single reading	Down
LASER_MODE	0x04	0x01	Sends sensor setting information to the LRF	Up
SINGLE	0x04	0x02	Requests a single range reading	Up
LASER_MODE_2	0x04	0x03	Sends sensor setting information when requiring range rates in excess of 20 Hz	Up
CONFIG	0x15	0x0C	System configuration and user settings	Up
POWER	0x04	0X0E	Controls the ON/OFF state, allows testing, and sets the startup behavior	Up
EXT_POWER	0x15	0x0E	Controls ON/OFF state via Piccolo uplink	Up
UPDATE_OFFSET	0x04	0x1F	Updates the laser offset calibration	Up
DATE_VERSION	0x04	0xFF	Sends the firmware version and build date	Up/Down
CAN_BAUD	0x15	0xCB	Updates the CANBUS Baud rate. Must be decimal 125, 250, 500, or 1000 (kbps)	Up
SAVE	0x15	0xAE	Saves NVM settings (CAN_BAUD rate)	Up

Table 14 - CAN Group IDs

Group ID	Name	Description
0x04	AGL Output	Used for message I/O via the Piccolo External Sensors protocol
0x14	Piccolo Downlink	Used for messages from the AGL Sensor via the Piccolo downlink
0x15	Piccolo Uplink	Used for messages to the AGL Sensor via the Piccolo uplink

CONFIG

This packet allows the user to specify general system settings. Since this packet has the potential to conflict with other devices on the CAN Bus by using the general Piccolo uplink group ID (0x015), a unique identifier has been embedded into the message to help distinguish it from others. The unique identifier is 0x1A5.

Table 15 - CONFIG packet byte structure

Byte	Name	Description
0	Flags	8-bit flags Bit 0 (MSB): Enable raw laser reading output over CAN Bus - **Not used; Always '0'** Bit 1: Reserved Bit 2: Reserved Bit 3: Reserved Bit 4: Reserved Bit 5: Reserved Bit 6: Reserved Bit 7: Reserved
1	Flags	8-bit flags Bit 0-7: Reserved
2	AGL ID0	0x1A (unique identifier)
3	AGL ID1	0x5E (unique identifier)

READING

Table15 - READING packet byte structure

Byte	Name	Description
0	Flags	8-bit flags Bit 0 (MSB): Reading is bad Bit 1: Accuracy exceeds limit – **Not used; Always '0'** Bit 2: Reading is high resolution, else low – **Not used; Always '0'** Bit 3: Nearest Target mode - **Not used; Always '0'** Bit 4: Furthest Target mode - **Not used; Always '0'** Bit 5: Max range multiplier (0 = 5 meters; 1 = 100 meters) Bit 6: Time multiplier (0 = 50 ms; 1 = 10 ms) Bit 7: Reserved
1	Altitude	24-bit unsigned laser range in millimeters
2		
3		
4	Period	Indicates the period of the measurement, units indicated by the time multiplier bit.
		Special Cases:
		0x00 | Period is out of range or unknown
5	Latency	Unsigned integer; indicates the latency of the measurement. Set to '0x00' as the time from measurement to CAN Bus message transmission is less than 1 ms.
6	Accuracy	Unsigned integer; Un-used. Set to '0x00'
7	Max Range	Unsigned integer; the maximum useable range of the sensor in 5's or 100's of meters, depending on the state of the Max Range bit in the Flag byte.

LASER_MODE & LASER_MODE_2

This packet will set the laser's mode. This state is remembered through a power cycle.

Table 16 – LASER_MODE packet byte structure

Byte	Name	Description
0	Flags	8-bit flags Bit 0 (MSB): Set continuous readings on ('1') or off ('0') Bit 1: Nearest target mode - **Not used; Always '0'** Bit 2: Farthest target mode - **Not used; Always '0'** Bit 3-7: Reserved
1	Period	Indicates desired period of the measurement, in **50 ms** units. A value of 5, for example, will result in a measurement period of **250 ms** or **4 Hz**. This allows measurement periods from **50 ms (20 Hz)** to **12.75s**. If longer measurement periods are required, use the SINGLE packet to take individual readings.
		Special Cases:
		0xFF | No change to current period setting

In order to request range rates in excess of 20 Hz the LASER_MODE_2 packet should be used.

Table 17 – LASER_MODE_2 packet byte structure

Byte	Name	Description
0	Flags	8-bit flags Bit 0 (MSB): Set continuous readings on ('1') or off ('0') Bit 1: Nearest target mode - **Not used; Always '0'** Bit 2: Farthest target mode - **Not used; Always '0'** Bit 3-7: Reserved
1	Period	Indicates desired period of the measurement, in **10 ms** units. A value of 5, for example, will result in a measurement period of **50 ms** or **20 Hz**. This allows measurement periods from **10 ms (100 Hz)** to **2.55s**. If longer measurement periods are required, use the SINGLE packet to take individual readings.
		Special Cases:
		0xFF | No change to current period setting

POWER & EXT_POWER

This data packet is used to turn the laser power on and off and, optionally, set the initial power-on behavior. Since this packet has the potential to conflict with other devices on the CAN Bus by using the general Piccolo uplink group (0x15), a unique identifier has been embedded into the message to help distinguish it from others. The unique identifier is 0x1A5.

The Piccolo will periodically send this message at the appropriate phases of flight to control the on/off state of the laser.

Table 18 – POWER & EXT_POWER packets byte structure

Byte	Name	Description
0	Power Flags	8-bit flags Bit 0 (MSB): 1: Turn Power On; 0: Turn Power Off Bit 1-7: Reserved, set to 0
1	Behavior Flags	8-bit flags Bit 0 (MSB): 1: Set this message's behavior as default power-on behavior (only applies to Byte 0, bit 1); 0: No change Bit 1-7: Reserved, set to 0
2	AGL ID0	0x1A (unique identifier)
3	AGL ID1	0x5E (unique identifier)

NOTE: Specific power-on behavior may be required to satisfy laser safety requirements. External interfaces used during day-to-day operations should not alter this setting.

SINGLE

This data packet is used to request that the laser take a single measurement, using the mode settings already in memory. If sent while the laser is in continuous mode, the unit will return an extra measurement between the normal period, if time allows, and then resume the continuous readings.

Table 19 – SINGLE packet byte structure

Byte	Name	Description
0	Request	'0x05' – Requests the AGL sensor to take a reading and return a single READING packet

UPDATE_OFFSET

This data packet is used to update the unit's unique, manufacturer specified laser offset value. As this value is supplied by the manufacturer and calibrated at the factory, this packet is not intended to be used by the end user.

Table 20 – UPDATE_OFFSET packet byte structure

Byte	Name	Description
0	OFFSET_0	1st byte of the unsigned 16-bit integer representing the factory calibrated offset in millimeters which is added to the laser measurements. This offset is a product of the calibration process and is unique to the laser within each unit.
1	OFFSET_1	2nd byte of the aforementioned unsigned 16-bit integer.

DATE_VERSION

This packet sends the firmware version, build date, and the hardcoded offset.

Table 21 – DATE_VERSION packet byte structure

Byte	Name	Description
0	Major Version	The 1 in 1.2.3
1	Minor Version	The 2 in 1.2.3
2	Sub Version	The 3 in 1.2.3
3	Date month	
4	Date day	
5	Date year	For 2018, the value will be 18
6	OFFSET_0	1st byte of the unsigned 16-bit integer representing the factory calibrated offset in millimeters which is added to the laser measurements. This offset is a product of the calibration process and is unique to the laser within each unit.
7	OFFSET_1	2nd byte of the aforementioned unsigned 16-bit integer.

The DATE_VERSION packet can be requested by sending a packet with the DATE_VERSION packet type, a size byte of 0, and no data bytes.

CAN_BAUD

This packet updates the CAN Baud rate. Bytes 0 (lower 8 bits) and 1 (upper 8 bits) must combine to be 125, 250, 500, or 1000 in kbps.

Table 22 – CAN_BAUD packet byte structure

Byte	Name	Description
0	Lower Bits	Ex. Baud Rate 500 = 0x01F4. This byte would contain 0xF4
1	Upper Bits	Ex. Baud Rate 500 = 0x01F4. This byte would contain 0x01

SAVE

This packet saves all NVM parameters, including the CAN Baud rate, so that on future power cycles, the current settings will be used. No data is required to be sent for this command.

RS-232

All RS-232 communications take place using packets whose general format is described in Table 23. Note that all multi-byte values are always sent with the most significant byte first, i.e. in Big-Endian order. This document identifies the bit order of a word as starting at 0 which is the left-most or most-significant bit (MSB).

Table 23 - RS-232 datalink layer packet definition

Byte	Name	Description
0	SYNC1	First synchronization character used to signal the receiving state machine that a packet may be forthcoming. Must be 0xFF.
1	SYNC2	Second synchronization character used to signal the receiving state machine that a packet may be forthcoming. Must be 0x5A.
2	PktType	The packet type. i.e. Message ID.
3	Size	Number of data bytes in the packet.
4…Size+3	Data	Data of the packet
Size+4	Check_0	Most and least significant bytes of the Fletchers checksum. The checksum is formed from byte 0 up to and including the last data byte.
Size+5	Check_1	

RS-232 Pass-Through Commands

The RS-232 interface can be used to access the rangefinder settings and parameters associated with the WASP™-200 MC1 with the use of the “LRF” command. This allows the user to configure with customized settings like multi-pulse averaging, fixed threshold, etc. which are features that are not accessible via the Piccolo interface.

LRF

This command sends an LRF command, according to those listed the Serial Commands section of this manual. The user may use the LRF command to set the number of averages, set the median filter window size, etc. which will be utilized when requesting range information via the CAN Bus interface.

The following commands should not be used in conjunction with the LRF command as they may cause the MC1-001 to stop communicating properly:

FMT
BAUD
CHK
TRG

An example of usage of the LRF command is:

```
>LRF SET
< THR220 TOS0 OFS0 FRQ4 VLT698 AVG1 MVG1 AUT1 AUV1 MDF1 LBE|BIG FMT|ASCII CHK0 TRG0 SAV1
```

Use with Cloud Cap Piccolo Autopilot

Simply install the MC1-001 LRF. The default settings enable the CAN message output in continuous mode, which will be recognized and utilized by the Piccolo with no additional settings necessary.

Appendix A – CRC Calculation

The WASP™ LRF reports an optional cyclic redundancy checksum (CRC) that can be used to detect errors in the transmitted range returns. The CRC used in the WASP™ is a 16-bit CRC-CCIT which has a number of parameters defined as:

Polynomial: This is the key that actually does the encoding of the data
Initial Remainder: This is the initial condition for the polynomial to work on
Final XOR value: Depending on the CRC spec, the result may need to be XORed with all 0's or all 1's
Reflect Data (Reversing Data Bytes): If true, reverse the bits in each data byte.

- For example: 0b1100 1010, 0b0100 0001 (0xCA, 0x41) would become: 0b0101 0011, 0b1000 0010 (0x53, 0x82). Note, this does not affect ordering of bytes, on the bits within each byte.

Reflect Result: If true, the reverse the bits of the final result.

- For example: 0x31 (0011 0001) would become 0x8C (1000 1100).

The WASP™ LRF uses the following parameters:

Polynomial: 1021
Initial Value: 0
Final XOR: 0
Reflect Data: Yes
Reflect Result: No

Example code for calculating the CRC is shown below:

```
typedef unsigned short  crc;

#define CRC_NAME                "CRC-LRF"
#define POLYNOMIAL                      0x1021
#define INITIAL_REMAINDER               0x0000
#define FINAL_XOR_VALUE                 0x0000
#define REFLECT_DATA                    TRUE
#define REFLECT_REMAINDER               FALSE

crc   crcSlow(unsigned char const message[], int nBytes);

/*
 * Derive parameters from the standard-specific parameters in crc.h.
 */
#define WIDTH    (8 * sizeof(crc))
#define TOPBIT   (1 << (WIDTH - 1))

#if (REFLECT_DATA == TRUE)
#undef  REFLECT_DATA
#define REFLECT_DATA(X)                 ((unsigned char) reflect((X), 8))
#else
#undef  REFLECT_DATA
#define REFLECT_DATA(X)                 (X)
#endif

#if (REFLECT_REMAINDER == TRUE)
#undef  REFLECT_REMAINDER
#define REFLECT_REMAINDER(X)     ((crc) reflect((X), WIDTH))
#else
#undef  REFLECT_REMAINDER
#define REFLECT_REMAINDER(X)     (X)
#endif
```

```
/*****************************************************************
 *
 * Function:    reflect()
 *
 * Description: Reorder the bits of a binary sequence, by reflecting
 *                                them about the middle position.
 *
 * Notes:               No checking is done that nBits <= 32.
 *
 * Returns:             The reflection of the original data.
 *
 *****************************************************************/
static unsigned long
reflect(unsigned long data, unsigned char nBits)
{
        unsigned long  reflection = 0x00000000;
        unsigned char  bit;

        /*
         * Reflect the data about the center bit.
         */
        for (bit = 0; bit < nBits; ++bit)
        {
                /*
                 * If the LSB bit is set, set the reflection of it.
                 */
                if (data & 0x01)
                {
                        reflection |= (1 << ((nBits - 1) - bit));
                }

                data = (data >> 1);
        }

        return (reflection);

}       /* reflect() */

/*****************************************************************
 *
 * Function:    crcSlow()
 *
 * Description: Compute the CRC of a given message.
 *
 * Notes:
 *
 * Returns:             The CRC of the message.
 *
 *****************************************************************/
crc
crcSlow(unsigned char const message[], int nBytes)
{
    crc            remainder = INITIAL_REMAINDER;
        int            byte;
        unsigned char  bit;


    /*
     * Perform modulo-2 division, a byte at a time.
     */
    for (byte = 0; byte < nBytes; ++byte)
    {
        /*
         * Bring the next byte into the remainder.
         */
        remainder ^= (REFLECT_DATA(message[byte]) << (WIDTH - 8));

        /*
```

```
         * Perform modulo-2 division, a bit at a time.
         */
        for (bit = 8; bit > 0; --bit)
        {
            /*
             * Try to divide the current data bit.
             */
            if (remainder & TOPBIT)
            {
                remainder = (remainder << 1) ^ POLYNOMIAL;
            }
            else
            {
                remainder = (remainder << 1);
            }
        }
    }

    /*
     * The final remainder is the CRC result.
     */
    return (REFLECT_REMAINDER(remainder) ^ FINAL_XOR_VALUE);

}   /* crcSlow() */
```

Appendix B – Change Log

Version	Date	Comments
001	2018-05-16	Initial version
002	2018-10-15	FDA Laser Compliance approval updates
003	2018-11-21	Update to version command formatting, RANGE_NOT_READY error code added. Added CHKSUM and TRIG commands. Note in introduction regarding 10 kHz only applying to Class 3 operation. Not available in Class 1 product.
004	2018-12-20	Combining Commercial Version with CAN Bus Version into One User Manual Added commands associated with FWV 18500001 Firmware Update.
005	2018-12-21	Made TLA command deprecation consistent throughout documentation Corrected examples Added LOM command
006	2019-04-18	Added documentation supporting Cloud Cap Piccolo RS-232 interface Updated LRF passthrough example to explicitly show linefeed Updated Table 6 & 8 - correct wire colors from Grey to Green.
007	2020-04-28	Updated Company Address Updated Fig. 2 – FDA Label Updated Table 8 – correct Shield wire colors from Black to White Added Custom Commands – ANO, PWM Filtered False Alarm Detection Section
008	2021-09-30	Added Appendix A for CRC calculation Added Dimensional drawing for CU1-001 HW Rev. 104 Updated CU1-001 Connector description with SMD Part Number Updated MC1-001 Input Power Specifications, Table 9. For CANBUS FW Version 21340002 and greater: Added CAN commands for changing CAN Baud Rate and Save
009	2023-03-13	Current Firmware for all WASP: 23100005 Current Bootloader for WASP: 3 Added Ardupilot link Updated Datasheet Updated Table 1 – Range Specifications. Removed dimensions, weight and temp. Updated Table 2 – updated weight and corrected dimensions Added waterproof mounting description Added median/long-pass filtering function and description Added error register query and description of new solar noise reporting Added relative signal strength reporting within SET command Added Detector Coefficient reporting within SVC command Added new commands no longer requiring “?” Added Bootloader Version reporting