

GARMIN®

LIDAR-LITE V3HP

OPERATION MANUAL AND TECHNICAL SPECIFICATIONS

Laser Safety

⚠ WARNING

This device requires no regular maintenance. In the event that the device becomes damaged or is inoperable, repair or service must be handled by authorized, factory-trained technicians only. Attempting to repair or service the unit on your own can result in direct exposure to laser radiation and the risk of permanent eye damage. For repair or service, contact your dealer or Garmin® for more information.

This device has a protective housing which, when in place, prevents human access to laser radiation in excess of the accessible emission limit (AEL) for Class 1 laser products. This device should not be modified or operated without its housing or optics. Operating this device without a housing and optics, or operating this device with a modified housing or optics that expose the laser source, may result in direct exposure to laser radiation and the risk of permanent eye damage. Removal or modification of the diffuser in front of the laser optic may result in the risk of permanent eye damage.

⚠ CAUTION

This device emits laser radiation. Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

This laser product is designated Class 1 during all procedures of operation. When the ranging feature of the device is activated, a laser emitter of a ranging module may emit laser radiation and the device should not be aimed toward anyone. Avoid looking toward the laser emitter or into the laser radiation (beam) when operating the device. It is advisable to turn off the ranging module when it is not in use. This device must be used only according to the directions and procedures described in this documentation.

Do not leave this device within the reach of children.

NOTICE

CLASS 1 LASER PRODUCT

Classified EN/IEC 60825-1 2014

This product is in conformity with performance standards for laser products under 21 CFR 1040, except with respect to those characteristics authorized by a variance number.

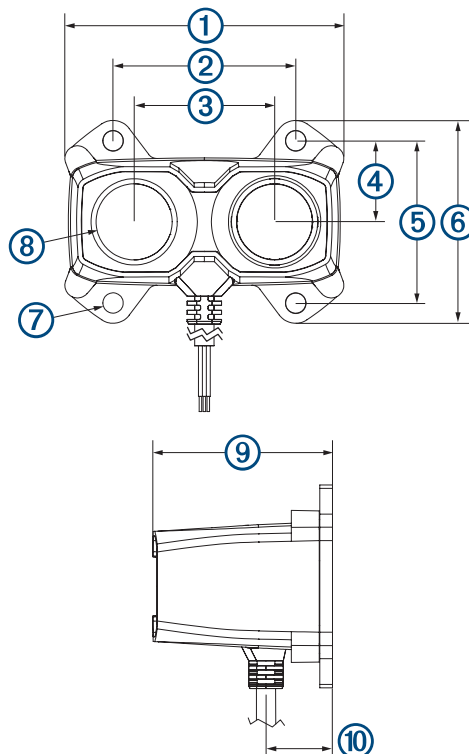
Specifications

Specification	Measurement
Size (L × W × H)	40.18 × 54.99 × 35 mm (1.58 × 2.16 × 1.38 in.)
Weight	38 g (1.34 oz.)
Operating temperature	-20 to 60°C (-4 to 140°F)
Power	5 Vdc nominal 4.5 Vdc min., 5.5 Vdc max.
Current consumption	65 mA idle 85 mA during an acquisition
Range (70% reflective target)	40 m (131 ft.)
Resolution	±1 cm (0.4 in.)
Accuracy < 2 m	±5 cm (2 in.) typical NOTE: Nonlinearity present below 1 m (39.4 in.)

Specification	Measurement
Accuracy ≥ 2 m	±2.5 cm (1 in.) typical Mean ±1% of distance max Ripple ±1% of distance max
Update rate (70% reflective target)	Greater than 1 kHz typical Reduced sensitivity at high update rates
User interface	I2C PWM External trigger
I2C interface	Fast-mode (400 kb/s) Default 7-bit address 0x62 Internal register access and control
PWM interface	External trigger input PWM output proportional to distance at 10 microsecond/cm
Water rating	IEC 60529 IPX7* Important: The bare wire portion of the wiring harness is not water resistant, and can act as a path for water to enter the device. All bare-wire connections must either be made in a water-tight location or properly sealed. Water may enter under the transmitting lens. This could affect performance, but will not affect the IEC 60529 IPX7 water rating.

NOTE: *The device withstands incidental exposure to water of up to 1 m for up to 30 min. For more information, go to www.garmin.com/waterrating.

Device Dimensions



①	54.99 mm (2.16 in.)
②	36 mm (1.42 in.)
③	27.69 mm (1.09 in.)

④	16 mm (0.63 in.)
⑤	32 mm (1.26 in.)
⑥	40.18 mm (1.58 in.)
⑦	4 mm (0.16 in.)
⑧	14.65 mm (0.58 in.)
⑨	35 mm (1.38 in.)
⑩	13.1 mm (0.52 in.)

Laser Specifications

Specification	Measurement
Wavelength	905 nm (nominal)
Total laser power (peak)	1.3 W
Pulse width	0.5 μ s (50% duty cycle)
Pulse train repetition frequency	10-20 kHz nominal
Energy per pulse	<280 nJ
Beam diameter at laser aperture	12 \times 2 mm (0.47 \times 0.08 in.)
Divergence	8 mRad

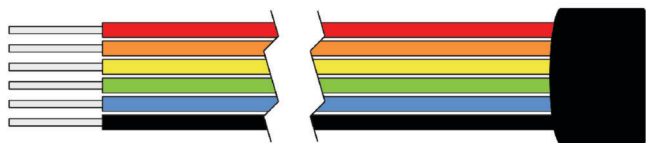
Connections

There are two basic configurations for this device.

I2C (Inter-Integrated Circuit): A serial computer bus used to communicate between this device and a microcontroller, such as an Arduino® board.

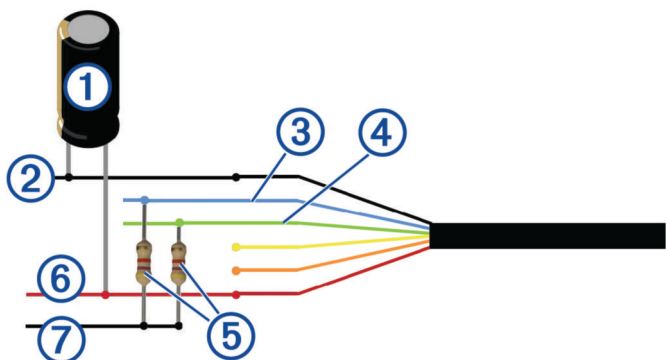
PWM (Pulse Width Modulation): A bi-directional signal transfer method that triggers acquisitions and returns distance measurements using the mode-control pin.

Wiring Harness



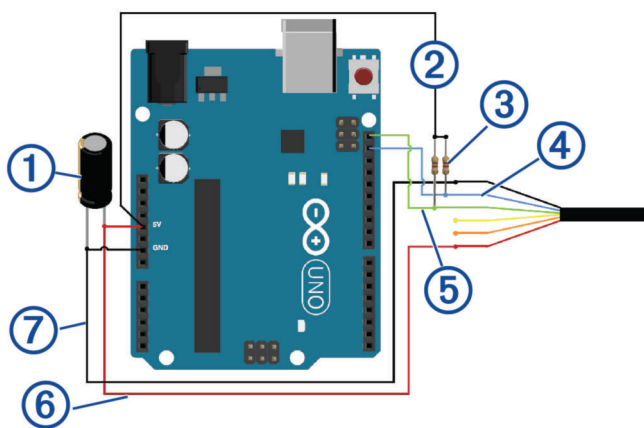
Wire Color	Function
Red	5 Vdc (+)
Orange	Power enable (internal pull-up)
Yellow	Mode control
Green	I2C SCL
Blue	I2C SDA
Black	Ground (-)

Standard I2C Wiring



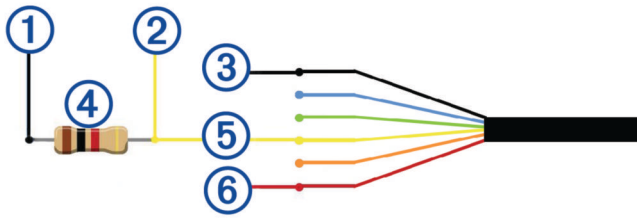
Item	Description	Notes
①	680microfarad electrolytic capacitor	You must observe the correct polarity when installing the capacitor.
②	Power ground (-) connection	Black wire
③	I2C SDA connection	Blue wire
④	I2C SCL connection	Green wire
⑤	4.7 kilohm pull-up resistor (not required in all applications)	In installations with long cable extensions or with multiple devices on the I2C bus, you must install a 1 kilohm to 10 kilohm pull-up resistor on each I2C wire to account for cable capacitance. It is recommended to start with 4.7 kilohm resistors and adjust if necessary.
⑥	5 Vdc power (+) connection	Red wire The sensor operates at 4.75 to 5.5 Vdc, with a maximum of 6 Vdc.
⑦	Logic rail connection	The pull-up resistors connected to both I2C wires must connect to the logic rail on your microcontroller board.

Standard Arduino I2C Wiring



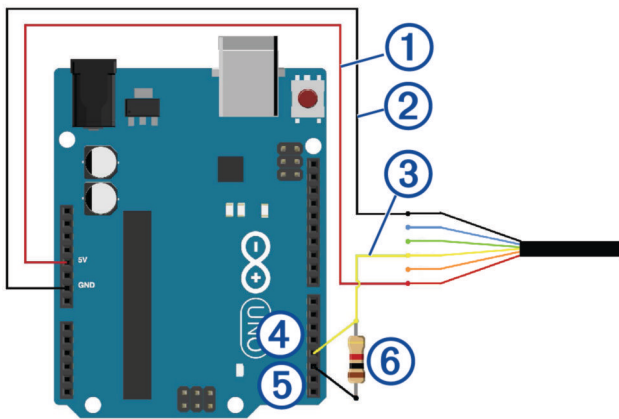
Item	Description	Notes
①	680 microfarad electrolytic capacitor	You must observe the correct polarity when installing the capacitor.
②	Pull-up resistor connection (not required in all applications)	In installations with long cable extensions or with multiple devices on the I2C bus, you must connect the pull-up resistors on the SDA and SCL wires to the logic rail on your microcontroller board. On an Arduino board, this is the 5 V pin.
③	4.7 kilohm pull-up resistor (not required in all applications)	In installations with long cable extensions or with multiple devices on the I2C bus, you must install a 1 kilohm to 10 kilohm pull-up resistor on each I2C wire to account for cable capacitance. Garmin recommends starting with 4.7 kilohm resistors and adjusting if necessary.
④	I2C SDA connection	Blue wire
⑤	I2C SCL connection	Green wire
⑥	5 Vdc power (+) connection	Red wire The sensor operates at 4.75 to 5.5 Vdc, with a maximum of 6 Vdc.
⑦	Power ground (-) connection	Black wire

PWM Wiring



Item	Description	Notes
①	Trigger pin on microcontroller	Connect the other side of the resistor to the trigger pin on your microcontroller.
②	Monitor pin on microcontroller	Connect one side of the resistor to the mode control connection on the device, and to a monitoring pin on your microcontroller.
③	Power ground (-) connection	Black wire
④	1 kΩ resistor	
⑤	Mode control connection	Yellow wire
⑥	5 Vdc power (+) connection	Red wire The sensor operates at 4.75 to 5.5 Vdc, with a max. of 6 Vdc.

PWM Arduino Wiring



Item	Description	Notes
①	5 Vdc power (+) connection	Red wire The sensor operates at 4.75 to 5.5 Vdc, with a max. of 6 Vdc.
②	Power ground (-) connection	Black wire
③	Mode control connection	Yellow wire
④	Monitor pin on microcontroller	Connect one side of the resistor to the mode control connection on the device, and to a monitoring pin on your microcontroller board.
⑤	Trigger pin on microcontroller	Connect the other side of the resistor to the trigger pin on your microcontroller board.
⑥	1 kΩ resistor	

Operational Information

Technology

This device measures distance by calculating the time delay between the transmission of a near-infrared laser signal and its

reception after reflecting off of a target, using the known speed of light.

Theory of Operation

When the device takes a measurement, it first performs a receiver adjustment routine, correcting for changing ambient light levels and allowing maximum sensitivity.

The device sends a reference signal directly from the transmitter to the receiver. It stores the transmit signature, sets the time delay for “zero” distance, and recalculates this delay periodically after several measurements.

Next, the device initiates a measurement by performing a series of acquisitions. Each acquisition is a transmission of the main laser signal while recording the return signal at the receiver. If there is a signal match, the result is stored in memory as a correlation record. The next acquisition is summed with the previous result. When an object at a certain distance reflects the laser signal back to the device, these repeated acquisitions cause a peak to emerge, out of the noise, at the corresponding distance location in the correlation record.

The device integrates acquisitions until the signal peak in the correlation record reaches a maximum value. If the returned signal is not strong enough for this to occur, the device stops at a predetermined maximum acquisition count.

Signal strength is calculated from the magnitude of the signal record peak and a valid signal threshold is calculated from the noise floor. If the peak is above this threshold, the measurement is considered valid and the device will calculate the distance. If the peak is not above the threshold, it will report 1 cm. When beginning the next measurement, the device clears the signal record and starts the sequence again.

Interface

Initialization

On power-up or reset, the device performs a self-test sequence and initializes all registers with default values. After roughly 22 ms, distance measurements can be taken with the I2C interface or the mode control pin.

Power Enable Pin

The power enable pin uses an internal pull-up resistor and can be driven low to shut off power to the device.

I2C Interface

This device has a 2-wire, I2C-compatible serial interface (see *I2C-Bus Specification*, Version 2.1, January 2000, available from Philips Semiconductor). It can be connected to an I2C bus as a slave device, under the control of an I2C master device. It supports 400 kHz Fast Mode data transfer.

The I2C bus operates internally at 3.3 Vdc. An internal level shifter allows the bus to run at a maximum of 5 Vdc. Internal 3 kilohm pull-up resistors ensure this functionality and allow for a simple connection to the I2C host.

The device has a 7-bit slave address with a default value of 0x62. The effective 8-bit I2C address is 0xC4 write and 0xC5 read. The device will not respond to a general call. Support is not provided for 10-bit addressing. The device auto-increments the register address with successive reads or writes within an I2C block transfer. This is commonly used to read the two bytes of a 16-bit value within one transfer. See [Changing the I2C Address](#), page 4.

For a list of all available control registers, see [Control Register List](#), page 6.

For more information about the I2C protocol, see [I2C Protocol Information](#), page 5.

Obtaining Measurements from the I2C Interface

You can obtain measurement results from the I2C interface.

- 1 Write 0x04 to register 0x00.
- 2 Read register 0x01.

- 3 Repeat steps 1 and 2 until bit 0 (LSB) goes low.
- 4 Read two bytes from 0x0f (high byte 0x0f then low byte 0x10) to obtain the 16-bit measured distance in centimeters.

Mode Control Pin

The mode control pin provides a means to trigger acquisitions and return the measured distance via pulse width modulation (PWM) without having to use the I2C interface.

The idle state of the mode control pin is high impedance (High-Z). Pulling the mode control pin low will trigger a single measurement, and the device will respond by driving the line high with a pulse width proportional to the measured distance at 10 microseconds per centimeter. A 1 kilohm termination resistance is required to prevent bus contention.

The device drives the mode control pin high at 3.3 Vdc. Diode isolation allows the pin to tolerate a maximum of 5 Vdc.

As shown in the PWM Arduino wiring diagram ([PWM Arduino Wiring, page 3](#)), a simple triggering method uses a 1 kilohm resistor in series with a host output pin to pull the mode control pin low to initiate a measurement, and a host input pin connected directly to monitor the low-to-high output pulse width.

If the mode control pin is held low, the acquisition process will repeat indefinitely, producing a variable frequency output proportional to distance.

The mode control pin behavior can be modified with the ACQ_CONFIG_REG (0x04) I2C register as described in the 0x04 control register information ([0x04, page 7](#)).

Settings

You can configure the device with alternate parameters for the distance measurement algorithm. You can use this algorithm to customize performance by enabling configurations that allow speed, range, and sensitivity options. See the full control register list ([Control Register List, page 6](#)) for additional settings.

Acquisition Command

Address	Name	Description	Initial Value
0x00	ACQ_COMMAND	Device Command	--

NOTE: Writing any non-zero value initiates an acquisition.

Maximum Acquisition Count

Address	Name	Description	Initial Value
0x02	SIG_COUNT_VAL	Maximum acquisition count	0xFF

The maximum acquisition count limits the number of times the device will integrate acquisitions to find a correlation record peak (from a returned signal), which occurs at long range or with low target reflectivity. This controls the minimum measurement rate and maximum range. The unit-less relationship is roughly as follows: rate = 1/n and range = $n^{1/4}$, where n is the number of acquisitions.

Measurement Quick Termination Detection

Address	Name	Description	Initial Value
0x04	ACQ_CONFIG_REG	Acquisition mode control	0x08

You can enable quick-termination detection by clearing bit 3 in this register (starting with the LSB in this register as bit 0). The device will terminate a distance measurement early if it anticipates that the signal peak in the correlation record will reach maximum value. This allows for faster and slightly less

accurate operation at strong signal strengths without sacrificing long-range performance.

Detection Sensitivity

Address	Name	Description	Initial Value
0x1c	THRESHOLD_BYPASS	Peak detection threshold bypass	0x00

The default valid measurement detection algorithm is based on the peak value, signal strength, and noise in the correlation record. This can be overridden to become a simple threshold criterion by setting a non-zero value. Recommended non-default values are 0x20 for higher sensitivity with more frequent erroneous measurements, and 0x60 for reduced sensitivity and fewer erroneous measurements.

Configurable I2C Address

Address	Name	Description	Initial Value
0x16	UNIT_ID_HIGH	Serial number high byte	Unique
0x17	UNIT_ID_LOW	Serial number low byte	Unique
0x18	I2C_ID_HIGH	Write serial number high byte for I2C address unlock	---
0x19	I2C_ID_LOW	Write serial number low byte for I2C address unlock	---
0x1a	I2C_SEC_ADDR	Write new I2C address after unlock	---
0x1e	I2C_CONFIG	Default address response control	0x00

Changing the I2C Address

The I2C address can be changed from its default value. Available addresses are 7-bit values with a 0 in the least significant bit, including hexadecimal numbers.

The I2C address will be restored to its default value after you cycle the power. You can use this process to run multiple devices on a single bus by enabling a device, changing its address, and then enabling the next device. Before you can change the I2C address, the I2C communications bus must read the UNIT_ID and write it back to the device.

- 1 Read the two-byte UNIT_ID from 0x96 (high byte 0x16 and low byte 0x17).
- 2 Write the UNIT_ID high byte to 0x18.
- 3 Write the UNIT_ID low byte to 0x19.
- 4 Write the desired, new 7-bit address to bits 7:1 at address 0x1a.
- 5 Set bit 4 at 0x1e high to enable the new I2C address.
- 6 If necessary, use the new I2C address to avoid errors and set bit 3 at 0x1e high to disable the default I2C address.

Power Control

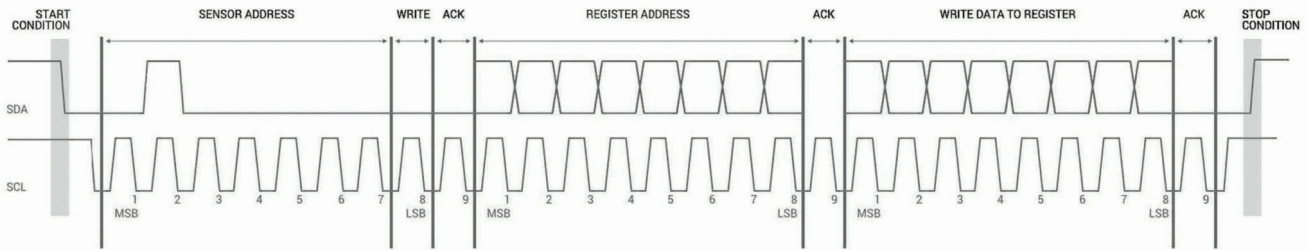
Address	Name	Description	Initial Value
0x65	POWER_CONTROL	Power state control	0

Setting bit 1 in this register disables the receiver circuit, which saves approximately 40 mA. When re-enabled, the receiver circuit stabilizes in time to perform a measurement.

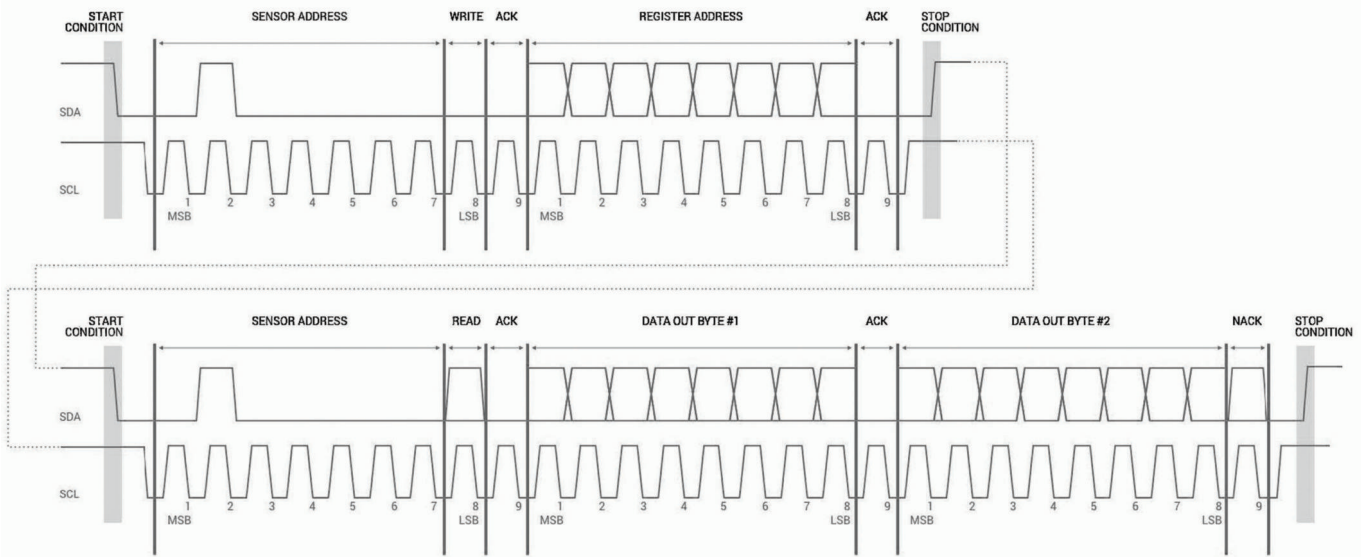
NOTE: To control power usage, you can use the power enable pin to deactivate the device when not in use.

I2C Protocol Information

Write



Read



The sensor module has a 7-bit slave address with a default value of 0x62 in hexadecimal notation. The effective 8 bit I2C address is 0xC4 write, 0xC5 read. The device will not respond to a general call.

- The ACK and NACK items are responses from the master device to the slave device.
- The last NACK in the read is optional, but the formal I2C protocol states that the master shall not acknowledge the last byte.

I2C Protocol Operation

This protocol description uses the term master to refer to the Arduino controller, and uses the term LIDAR device to refer to the LIDAR-Lite v3HP device acting as a slave on the I2C bus.

When working with the I2C serial bus protocol, the device operates as follows.

- 1 The master initiates data transfer by establishing a start condition, which consists of a high-to-low transition on the SDA line while SCL is high.
- 2 The master sends an address byte, which consists of the 7-bit slave address.
- 3 The master sends a read/write bit with a zero state indicating a write request. A write operation is used as the initial stage of both read and write transfers.
- 4 If the slave address corresponds to the LIDAR device address, the LIDAR device responds by pulling SDA low during the ninth clock pulse. This operation is considered the acknowledge bit. At this stage, all other devices on the bus remain idle while the selected LIDAR device waits for data to be written to or read from its shift register.

- 5 Data transmits over the serial bus in sequences of nine clock pulses (eight data bits followed by an acknowledge bit). These transmissions must occur on the SDA line during the low period of SCL and remain stable during the high period of SCL.
- 6 The master sends an 8-bit data byte following the slave address, which loads the I2C control register on the LIDAR device with the address of the first control register to be accessed.
NOTE: If the high bit (bit 7) is set, it enables automatic incrementing for successive reads/writes.
- 7 The master requests a read operation from the LIDAR device or sends a write operation to the LIDAR device.

Read Operation

After the master establishes communication with the LIDAR device, you can obtain a reading from the LIDAR device.

- 1 The first data frame sets the address of the desired read register.
- 2 The master sends a stop bit at the completion of the first data frame.

- 3 The master initiates a new start condition, which consists of the slave address with the read bit set (one state).
- 4 The master reads one or more data bytes in succession.
- 5 The LIDAR device sends an acknowledge bit to the master when it receives a valid address.
- 6 The master releases the SDA data line with continued clocking of the SCL line.
- 7 The master strobes the acknowledge bit and continues the read cycle.
- 8 After the read cycle is done, the master sends a stop condition to complete the operation.

Write Operation

After the master establishes communication with the LIDAR device, writing to the LIDAR device operates as follows.

Control Register List

NOTE: Unless otherwise noted, all registers contain one byte and are read and write.

Address	R/W	Name	Description	Initial Value	Details
0x00	W	ACQ_COMMAND	Device command	--	0x00, page 6
0x01	R	STATUS	System status	--	0x01, page 6
0x02	R/W	SIG_COUNT_VAL	Maximum acquisition count	0xFF	0x02, page 7
0x04	R/W	ACQ_CONFIG_REG	Acquisition mode control	0x08	0x04, page 7
0x06	W	LEGACY_RESET_EN	Enable unit reset	--	0x06, page 7
0x0e	R	SIGNAL_STRENGTH	Received signal strength	--	0x0e, page 7
0x0f	R	FULL_DELAY_HIGH	Distance measurement high byte	--	0x0f, page 7
0x10	R	FULL_DELAY_LOW	Distance measurement low byte	--	0x10, page 7
0x12	R/W	REF_COUNT_VAL	Reference acquisition count	0x03	0x12, page 7
0x16	R	UNIT_ID_HIGH	Serial number high byte	Unique	0x16, page 7
0x17	R	UNIT_ID_LOW	Serial number low byte	Unique	0x17, page 7
0x18	W	I2C_ID_HIGH	Write serial number high byte for I2C address unlock	--	0x18, page 7
0x19	W	I2C_ID_LOW	Write serial number low byte for I2C address unlock	--	0x19, page 7
0x1a	R/W	I2C_SEC_ADDR	Write new I2C address after unlock	--	0x1a, page 8
0x1c	R/W	THRESHOLD_BYPASS	Peak detection threshold bypass	0x00	0x1c, page 8
0x1e	R/W	I2C_CONFIG	Default address response control	0x00	0x1e, page 8
0x26	R/W	PEAK_STACK_HIGH_BYTE	Used for post processing of correlation peak data	--	0x26, page 8
0x27	R/W	PEAK_STACK_LOW_BYTE	Used for post processing of correlation peak data	--	0x27, page 8
0x40	R/W	COMMAND	State command	--	0x40, page 8
0x48	R	HEALTH_STATUS	Used to diagnose major hardware issues at initialization	--	0x48, page 8
0x52	R	CORR_DATA	Correlation record data low byte	--	0x52, page 8
0x53	R	CORR_DATA_SIGN	Correlation record data high byte	--	0x53, page 8
0x65	R/W	POWER_CONTROL	Power state control	0	0x65, page 8

0x00

R/W	Name	Description	Initial Value
W	ACQ_COMMAND	Device command	--

Bit	Function
7:1	Write any non-zero value to start a measurement
0	Performs a hard reset by reloading the FPGA and returning all registers to default values. This operation must be enabled by writing 1 to bit 0 on register 0x06. When reset the I2C lines go into a high-z state for up to 10 ms. This has the potential to cause legacy-microcontroller-interface code to crash.

0x01

R/W	Name	Description	Initial Value
R	STATUS	System status	--

- 1 The master sends one or more 8-bit data blocks to the LIDAR device.
- 2 The LIDAR device sends an acknowledge bit to the master when it receives and writes a valid data byte.
- 3 The master releases the SDA data line with continued clocking of the SCL line.
- 4 The master strobes the acknowledge bit and continues the write cycle, if necessary.
- 5 After the write cycle is done, the master sends a stop condition to complete the operation.

Bit	Function
5	Health flag 0: Error detected 1: Reference and receiver bias are operational
4	Device command regulation flag 0: Device is not in DC regulation 1: Device is in DC regulation
3	Peak detection flag 0: No signal detected 1: Peak detected
2	Reference overflow flag 0: Reference data has not overflowed 1: Reference data in correlation record has reached the maximum value before overflow (occurs periodically)

Bit	Function
1	Signal overflow flag 0: Signal data has not overflowed 1: Signal data in correlation record has reached the maximum value before overflow (occurs with a strong received signal strength)
0	Busy flag 0: Device is ready for new command 1: Device is busy taking a measurement

Additional returns can be evaluated using data downloaded from the peak stack registers, 0x26 ([0x26, page 8](#)) and 0x27 ([0x27, page 8](#)).

0x02

R/W	Name	Description	Initial Value
R/W	SIG_COUNT_VAL	Maximum acquisition count	0xFF

Bit	Function
7:0	Maximum number of acquisitions during measurement

0x04

R/W	Name	Description	Initial Value
R/W	ACQ_CONFIG_REG	Acquisition mode control	0x08

Bit	Function
7	0: Record download resolution set at 9 bits (legacy) 1: Record download resolution set at 12 bits
6	0: Enable reference process during measurement 1: Disable reference process during measurement
5	0: DC compensation enabled 1: DC compensation disabled
4	0: Enable reference filter, averages multiple reference measurements for increased consistency 1: Disable reference filter
3	0: Enable measurement quick termination The device will terminate distance measurement early if it anticipates that the signal peak in the correlation record will reach maximum value. 1: Disable measurement quick termination
2	Bit unused
1:0	Mode select pin function control 00: Default PWM mode Pull pin low to trigger measurement, device will respond with an active high output with a duration of 10 us/cm. 01: Status output mode Device will drive pin active high while busy. Can be used to interrupt host device. 10: Fixed delay PWM mode Pulling pin low will not trigger a measurement. 11: Oscillator output mode Nominal 31.25 kHz output. The accuracy of the silicon oscillator in the device is generally within 1% of nominal. This affects distance measurements proportionally and can be measured to apply a compensation factor.

0x06

R/W	Name	Description	Initial Value
R	LEGACY_RESET_EN	Enables legacy unit reset	--

Bit	Function
0	Writing 1 to bit 0 enables the legacy reset operation using the 0x00 register (0x00, page 6).

0x0e

R/W	Name	Description	Initial Value
R	SIGNAL_STRENGTH	Received signal strength	--

Bit	Function
7:0	Received signal strength calculated from the value of the highest peak in the correlation record and how many acquisitions were performed.

0x0f

R/W	Name	Description	Initial Value
R	FULL_DELAY_HIGH	Distance measurement high byte	--

Bit	Function
7:0	Distance measurement result in centimeters, high byte.

0x10

R/W	Name	Description	Initial Value
R	FULL_DELAY_LOW	Distance measurement low byte	--

Bit	Function
7:0	Distance measurement result in centimeters, low byte.

0x12

R/W	Name	Description	Initial Value
R/W	REF_COUNT_VAL	Reference acquisition count	0x03

Bit	Function
7:0	Non-default number of reference acquisitions during measurement. ACQ_CONFIG_REG (0x04, page 7) bit 2 must be set.

0x16

R/W	Name	Description	Initial Value
R	UNIT_ID_HIGH	Serial number high byte	Unique

Bit	Function
7:0	Unique serial number of device, high byte.

0x17

R/W	Name	Description	Initial Value
R	UNIT_ID_LOW	Serial number low byte	Unique

Bit	Function
7:0	Unique serial number of device, low byte.

0x18

R/W	Name	Description	Initial Value
W	I2C_ID_HIGH	Write serial number high byte for I2C address unlock	--

Bit	Function
7:0	Write the value in UNIT_ID_HIGH (0x16, page 7) here as part of enabling a non-default I2C address. See I2C_ID_LOW (0x19, page 7) and I2C_SEC_ADDR (0x1a, page 8).

0x19

R/W	Name	Description	Initial Value
W	I2C_ID_LOW	Write serial number low byte for I2C address unlock	--

Bit	Function
7:0	Write the value in UNIT_ID_LOW (0x17, page 7) here as part of enabling a non-default I2C address. See I2C_ID_HIGH (0x18, page 7) and I2C_SEC_ADDR (0x1a, page 8).

0x1a

R/W	Name	Description	Initial Value
R/W	I2C_SEC_ADDR	Write new I2C address after unlock	--

Bit	Function
7:1	Non-default I2C address. Available addresses are 7-bit values with 0 in the least significant bit (even hexadecimal numbers). Program the 7-bit address to the 7 most significant bits (7:1) of this register. I2C_ID_HIGH (0x18, page 7) and I2C_ID_LOW (0x19, page 7) must have the correct value for the device to respond to the non-default I2C address.

0x1c

R/W	Name	Description	Initial Value
R/W	THRESHOLD_BYPASS	Peak detection threshold bypass	0x00

Bit	Function
7:0	0x00: Use default valid measurement detection algorithm based on the peak value, signal strength, and noise in the correlation record. 0x01-0xff: Set simple threshold for valid measurement detection. Values 0x20-0x60 generally perform well.

0x1e

R/W	Name	Description	Initial Value
R/W	I2C_CONFIG	Default address response control	0x00

Bit	Function
5	0: Disables the alternate status mode. 1: Enables an alternate indication status byte at STATUS register 0x01. NOTE: If bit 5 is enabled (1), the status word consists of all ones except for the bit position selected by bits [2:0] in this I2C CONFIG register (0x1e, page 8). This allows for the reading of the busy status of multiple units sharing the same active base address 0x62.
4	0: Disables the alternative I2C address. 1: Enables the alternative I2C address.
3	0: Device will respond to I2C address 0x62. Device will also respond to non-default address if configured successfully. See I2C_ID_HIGH (0x18, page 7), I2C_ID_LOW (0x19, page 7), and I2C_SEC_ADDR (0x1a, page 8). 1: Device will only respond to non-default I2C address. It is recommended to configure the non-default address first, then use the non-default address to write to this register, ensuring success.
2:0	Defines the bit position(s) to remain set as 0 when bit 5 is enabled.

0x26

R/W	Name	Description	Initial Value
R/W	PEAK STACK HIGH BYTE	Registers read successive values from the peak stack register. Data from the stack register is used for post processing.	--

Bit	Function
10:8	For every 11-bit stack value, this register (0x26) must be read first. Reading from this register latches the low order data into 0x27 (0x27, page 8) and increments the stack pointer. Writing 0x01 (0x01, page 6) to this register (0x26) resets the stack pointer to the first element.

0x27

R/W	Name	Description	Initial Value
R/W	PEAK STACK LOW BYTE	Registers read successive values from the peak stack register. Data from the stack register is used for post processing.	--

Bit	Function
7:0	Reading from 0x27 reads the low order data from this register.

0x40

R/W	Name	Description	Initial Value
R/W	TEST COMMAND	State command	--

Bit	Function
2:0	000: Test mode disable, resume normal operation 111: Test mode enable, allows download of correlation record Once test mode is enabled, read CORR_DATA (0x52, page 8) and CORR_DATA_SIGN (0x53, page 8) in one transaction (read from 0xd2). The memory index is incremented automatically, and successive reads produce sequential data.

0x48

R/W	Name	Description	Initial Value
R	HEALTH STATUS	Used to diagnose major hardware issues at system initialization.	--

Bit	Function
4:0	Reference value is within normal range.
3	Reference overflow occurred during the first acquisition.
2	An initial acquisition was completed at wake-up to set the initial reference value.
1	The receiver DC control command is within the normal range.
0	DC regulation was successful during wake-up.

0x52

R/W	Name	Description	Initial Value
R	CORR_DATA	Correlation record data low byte	--

Bit	Function
7:0	Correlation record data low byte. See CORR_DATA_SIGN (0x53, page 8) and COMMAND (0x40, page 8).

0x53

R/W	Name	Description	Initial Value
R	CORR_DATA_SIGN	Correlation record data high byte	--

Bit	Function
7:0	Correlation record data high byte. Correlation record data is a 2's complement 9-bit value, and must be sign extended to be formatted as a 16-bit 2's complement value. When repacking the two bytes obtained for the I2C transaction, set the high byte to 0xff if the LSB of the high byte is one.

0x65

R/W	Name	Description	Initial Value
R/W	POWER_CONTROL	Power state control	0x80

Bit	Function
0	1: Disable receiver circuit 0: Enable receiver circuit Receiver circuit stabilizes by the time a measurement can be performed.

Frequently Asked Questions

How do I use the device for fast-scanning applications?

Using the LIDAR-Lite v3HP device for fast-scanning applications may require you to change the program you used for continuous or burst mode functions with previous versions of the sensor.

This method uses slightly more I2C overhead, but it allows more efficient polling if you know your measurement time, which depends on maximum acquisition count settings. It also allows you to know exactly when the measurement begins. With no other functions running, the device has been able to reach >1.5 kHz with small acquisition count settings.

You can find sample Arduino code for this in the Garmin GitHub repository at https://github.com/garmin/LIDARLite_Arduino_Library.

- 1 Initiate a new measurement command.
- 2 Immediately read the distance registers, obtaining the previous measurement results while the new measurement is occurring.
NOTE: Measurement data stored in the sensor is valid until a new measurement concludes.
- 3 Perform other actions while polling the status bit until it indicates an idle state.
- 4 Repeat steps 1 through 3 as needed.

Does the device operate only on 5 Vdc?

The device requires 5 Vdc to function properly.

NOTICE

Connecting the device to a source greater or less than 5 Vdc is not supported and may result in poor performance or damage to the device.

What is the spread of the laser beam?

At close distances (less than 1 m), the beam diameter is about the size of the aperture (lens). For distances greater than 1 m, you can estimate the beam diameter using the equation $\text{Distance}/100 = \text{beam diameter at that distance}$ (in whatever units you measured the distance). The actual spread is ~8 milliradians (~0.5 degrees).

How do distance, target size, aspect, and reflectivity affect returned signal strength?

The device transmits a focused infrared beam that reflects off a target. A portion of that reflected signal returns to the receiver. You can calculate the distance by taking the difference between the moment of signal transmission and the moment of signal reception. Several factors can affect the signal.

Target Distance: The relationship of distance (D) to returned signal strength is an inverse square. With an increase in distance, the returned signal strength decreases by $1/D^2$ or the square root of the distance.

Target Size: The relationship of a target's cross section (C) to returned signal strength is an inverse power of four. The device transmits a focused near-infrared laser beam that spreads at a rate of approximately 0.5° as distance increases (*What is the spread of the laser beam?*, page 9). When the beam overfills (is larger than) the target, the signal returned decreases by $1/C^4$ or the fourth root of the target's cross section.

Aspect: The aspect of the target, or its orientation to the sensor, affects the observable cross section. The amount of returned signal decreases as the angle of incidence to the target increases.

Reflectivity: Reflectivity characteristics of the target's surface also affect the amount of returned signal (*How does the device work with reflective surfaces?*, page 9).

A small target can be difficult to detect if it is distant, poorly reflective, and its aspect is away from the normal. In such cases, the returned signal strength may be improved by attaching infrared reflectors to the target, increasing the size of the target, modifying its aspect, or reducing distance from the sensor.

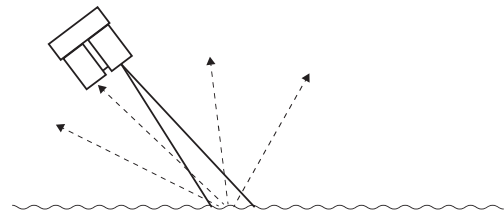
How does the device work with reflective surfaces?

Reflective characteristics of an object's surface can be divided into three categories.

- Diffuse reflective (*Diffuse Reflective Surfaces*, page 9)
- Specular (*Specular Surfaces*, page 9)
- Retroreflective

Diffuse Reflective Surfaces

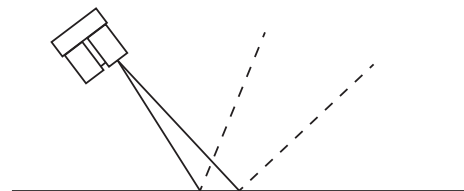
Purely diffuse surfaces are found on materials that have a textured quality that causes reflected energy to disperse uniformly. This results in a relatively predictable percentage of the dispersed laser energy returning to the device. As a result, these materials tend to read very well.



Some materials in this category are paper, matte walls, and granite. It is important to note that materials in this category due to observed reflection at visible light wavelengths may exhibit unexpected results in other wavelengths. The near infrared range used by the device may detect them as nearly identical. For example, a black sheet of paper may reflect a nearly identical percentage of the infrared signal back to the receiver as a white sheet of paper.

Specular Surfaces

Specular surfaces are found on materials that have a smooth quality that reflects energy instead of dispersing it. It is difficult or impossible for the device to recognize the distance of many specular surfaces. Reflections off of specular surfaces tend to have little dispersion, which causes a reflected beam of light to remain small and possibly miss a receiver altogether. The device may fail to detect a specular object in front of it unless viewed from the normal.



Mirrors and glass viewed at large angles of incidence are examples of specular surfaces.

How does liquid affect the signal?

There are a few considerations to take into account if your application requires measuring distances to, or within, liquid.

- Reflectivity and other characteristics of the liquid itself
- Reflectivity characteristics of particles suspended in the liquid
- Turbidity
- Refractive characteristics of the liquid

Reflectivity of the liquid is important when measuring distance to the surface of a liquid or if measuring through liquid to the

bottom of a container (*How does the device work with reflective surfaces?*, page 9).

Measuring distance with the device depends on reflected energy from the transmitted signal being detected by the receiver in the sensor. For that reason, the surface condition of the liquid may affect the overall reflectivity and detectability of the liquid. In the case of a flat, highly reflective liquid surface, the laser's reflected energy may not disperse adequately to allow detection unless viewed from the normal. By contrast, small surface ripples may create enough dispersion of the reflected energy to allow detection of the liquid without the need to position the sensor so that the transmitted beam strikes the liquid's surface from the normal.

Reflectivity of suspended particles is a characteristic that may help or hinder, depending on the application.

Turbidity, or the clarity of a liquid created by the presence or absence of suspended particles, can similarly help or hinder measurement efforts. If the application requires detecting the surface of the liquid, then suspended particles may help by reflecting more of the transmitted beam back to the receiver, increasing detectability and permitting measurements to be taken.

Attempting to measure through suspended particles in a liquid will only be successful if the transmitted beam is allowed to reflect off of the desired target without first being absorbed or reflected by the suspended particles.

When the near infrared energy transmitted by the device transitions from the atmosphere to a liquid, the energy may be bent, or refracted, and absorbed in addition to being dispersed. The degree to which the transmitted beam is refracted and absorbed is defined by its refraction index. The most important criteria impacting successful measurement through a liquid is the amount of dispersion of the transmitted beam and whether any of the dispersed beam makes its way back to the receiver on the device.

Electromagnetic energy travels slower through a liquid and may affect accuracy of the final measurement output.

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