GARMIN.

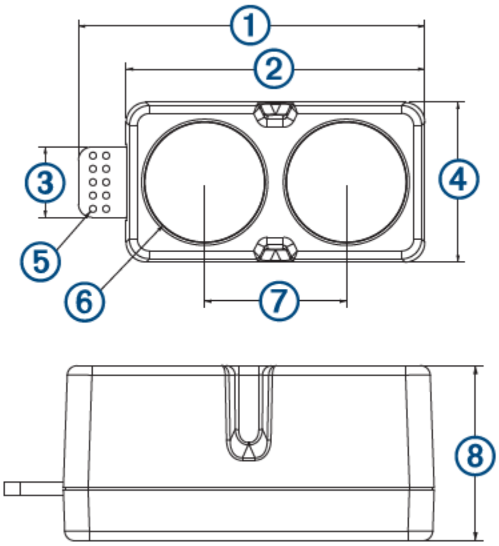
LIDAR-LITE LED V4

OPERATION MANUAL AND TECHNICAL SPECIFICATIONS

Specifications

Specification	Measurement
Unit dimensions (L × W × H) **NOTE:** Measurements do not include an attached connector.	52.2 x 24 x 21.2 mm (2.1 x 0.9 x 0.8 in.)
Weight	14.6 g (0.5 oz.)
Operating temperature	-20 to 60°C (-4 to 140°F)
Storage temperature	-40 to 85°C (-40 to 185°F)
Power (operating voltage)	4.75 to 5.25 Vdc
Current consumption	2 mA idle 85 mA during an acquisition
Range	5 cm (1.97 in.) to 10 m (32.8 ft.)
Resolution	1 cm (0.4 in.)
Beam divergence	4.77º
LED wavelength	940 nm
Optical aperture:	14.9 mm
Update rate	I2C: >200 Hz typical ANT: Up to 200 Hz to a 90% reflective target indoors at 2 m in normal operating mode
Interface	I2C or ANT® User configurable for SPI
Measurement repeatability **NOTE:** As measured indoors to a 90% reflective target; 1 cm is equivalent to 1 standard deviation. Measurements were obtained using high accuracy mode.	± 1 cm to 2 m ± 2 cm to 4 m ± 5 cm to 10 m

Device Dimensions



①	52.17 mm (2.05 in.)
②	44.98 mm (1.77 in.)
③	10.6 mm (0.42 in.)
④	24.03 mm (0.95 in.)
⑤	1 mm (0.04 in.)
⑥	18 mm (0.71 in.)
⑦	21.35 mm (0.84 in.)
⑧	21.2 mm (0.83 in.)

Mounting Options

There are various ways you can mount the LIDAR-Lite LED v4 device. You should choose an option that works best for your application.

Cable tie: You can secure the device to your application with a 3/16" cable tie. You should route the cable tie through the channel in the center of the device.

Double-sided tape: You can secure the bottom of the device to your application using double-sided tape. For best results, you should select a tape that has a high strength bond.

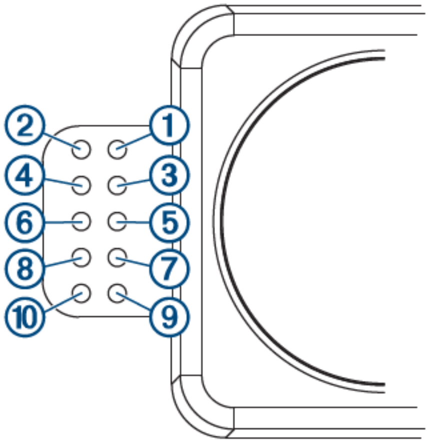
Connections

LIDAR-Lite LED v4 Connection Diagram

The through-holes on the LIDAR-Lite LED v4 device consist of 2 rows of 5 holes with a 2 mm pitch between each connection.

NOTICE

The LIDAR-Lite LED v4 device is not tolerant to 5 V signaling. Use 3.3 V signaling only.



Pin	Pin Name	Function
①	VIN	5V Power
②	GND	Ground
③	I2C SDA	I2C Data
④	I2C SCL	I2C Clock
⑤	GPIOA	General Purpose I/O
⑥	GPIOB	General Purpose I/O
⑦	VRETURN	nRF52840 DBG
⑧	nRESET	nRF52840 DBG
⑨	SWDCLK	nRF52840 DBG
⑩	SWDIO	nRF52840 DBG

Operational Information

Technology

This device measures distance by calculating the time delay between the transmission of a near-infrared light and its reception after reflecting off of a target, using the known speed of light.

the LLv4 contains a nRF52840 SoC from Nordic Semiconductor. This is an Arm Cortex-M4 processor paired with extensive memory availability in both flash and RAM, 1 MB/256 KB respectively. It has a 2.4GHz multiprotocol radio and with the use of the S340 SoftDevice, the LLv4 supports Ultra Low Power wireless technologies ANT and Bluetooth 5 LE. The header on the LLv4 provides access to the nRF52840; this provides the ability to reprogram the device to create custom applications and removes the need for an external micro-controller to control the LLv4.

The LLv4 comes preloaded with an application that allows the developer to communicate with the device using several methods. An I2C interface allows the device to be connected to an external micro-controller or the LLv4 can be controlled and operated wirelessly. The LLv4 transmits and receives data wirelessly using the ANT wireless protocol; data is transmitted and received in accordance to the ANT Ranging Profile.

The LLv4 comes preloaded with a BLE secure DFU bootloader allowing for wireless SW updates using a BLE capable device.

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, the mode control pin, or using ANT.

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. Internal 3 kiloohm 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 *Configurable I2C Address*, page 2.

For a list of all available control resisters, see *Control Register List*, page 5.

For more information about the I2C protocol, see *I2C Protocol Information*, page 4.

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.

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 5) for additional settings.

Configurable 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. Additional I2C address information is available at https://github.com/garmin/.

Mode Control Pins

The mode control pins can be used to trigger distance measurements and check the status of the LLv4. These connections are not required; the purpose of these pins is to provide a simplified and faster method of controlling the LLv4. These pins are intended to be used in conjunction with the I2C interface. For more information see

Pin	Description	Functionality	Details
GPIO A	TRIGGER	Trigger Measurement	Toggle to start a distance measurement. The LLv4 will start a distance measurement on either the rising or falling edge. If a distance measurement is triggered while the device is busy, the requested measurement will be ignored.
GPIO B	MONITOR	LLv4 Status	Indicates when the LLv4 is busy. If low, the LLv4 is idle and is ready to start a distance measurement. If high, the LLv4 is busy taking a distance measurement. Wait for the signal to drop before toggling GPIO A to trigger a distance measurement.

Triggering and Reading Distance Measurements

1. Toggle the TRIGGER pin.
2. Wait for the MONITOR pin to go low.
3. Read two bytes from 0x0f (High byte 0x0f, then low 0x10) to obtain the 16-bit measured distance in centimeters.

   NOTE: If distance measurements need to be taken as fast as possible, steps 2 and 3 can be reversed so that the LLv4 is taking a distance measurement while the I2C register read is performed. In this case, the LLv4 will be in the process of measuring the distance while the registers are read. The distance returned will be the previously triggered measurement, not the measurement currently in progress.

ANT

ANT is a practical wireless sensor network protocol running in the 2.4 GHz ISM band. Designed for ultra-low power, ease of use, efficiency and scalability, ANT easily handles peer-to-peer, star, connected star, tree, and mesh topologies. LLv4 has been designed so that other ANT capable devices can easily connect to the LLv4 to control and configure it wirelessly. The LLv4 transmits the last measured distance and it can be received wirelessly. ANT messages are sent and received from the LLv4 in accordance to the ANT ranging profile.

For more details about the ANT ranging profile and the capabilities and workings of the ANT wireless protocol, see *ANT Ranging Profile* and *ANT Message Protocol and Usage* at https://github.com/garmin/.

Connecting Wirelessly Using ANT

Before you can connect to the LIDAR-Lite LED v4 using ANT, you should confirm you have the following requirements:

- A PC running Windows 7 Service Pack 1 or higher
- .Net Framework 4.5
- Visual C++ 2008 SP1 Redistributable Package
- Garmin® ANT USB-m stick
- Garmin ANT demo PC application (https://github.com/garmin/)

1. Connect the USB ANT stick to your computer.
2. Download and install the Garmin ANT demo PC application on your computer.

Activating the Bluetooth Bootloader

NOTE: If you are installing a custom unsigned application to the LLv4, you should first test and debug the custom application using a J-Link before performing wireless updates.

The LLv4 comes preloaded with a BLE bootloader that allows the LLv4 SW to be updated wirelessly. The LLv4 uses the Nordic Secure DFU bootloader, so the BLE bootloader can be used to either install an official Garmin released SW update that is signed by Garmin, or a developer can install a custom unsigned application.

1. Remove power from the LLv4.
2. Ground the boot pin (GPIO B).
3. Power on the LLv4.

The BLE bootloader will start advertising as "LLV4 DFU Mode".

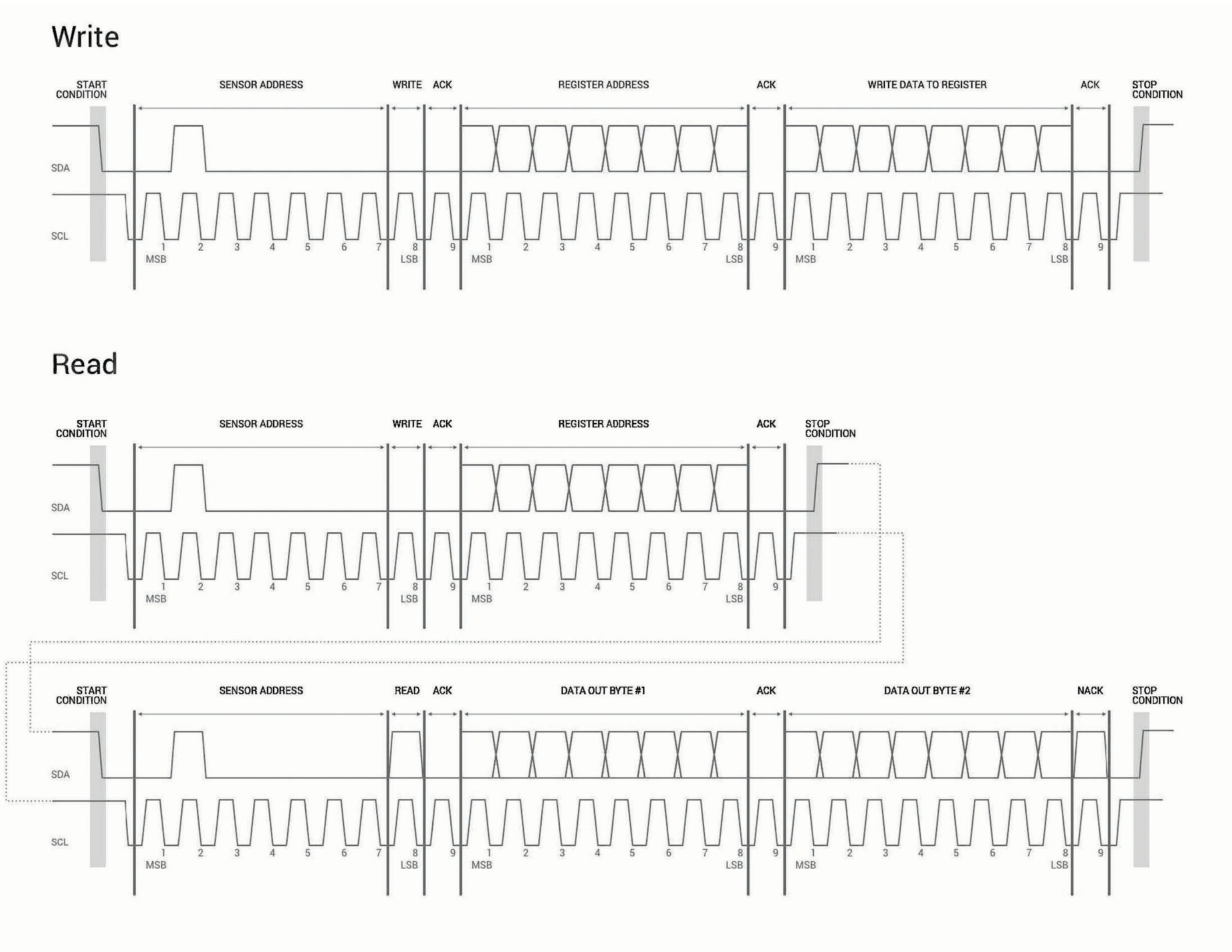
Updating the Firmware Using the Bluetooth Bootloader

You can use the Bluetooth bootloader to update the LLv4 firmware using a BLE-equipped smartphone or a PC equipped with an nRF52 DK or nRF52840 dongle.

1. Copy the DFU.zip file provided by Garmin or a custom DFU.zip file to a smartphone or a PC.
2. Using nRFConnect or nRFToolbox app, start the firmware upgrade using the DFU.zip file you copied.
3. After the DFU process reaches 100%, verify the new application runs correctly.

For more information about how to update the nRF52840 using the Nordic secure DFU bootloader, you can reference a step-by-step guide on the Nordic Semiconductor website https://devzone.nordicsemi.com/nordic/nordic-blog/b/blog/posts/getting-started-with-nordics-secure-dfu-bootloader.

I2C Protocol Information



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 host controller, and uses the term LIDAR device to refer to the LIDAR-Lite LED v4 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.

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.

Control Register List

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

Address	R/W	Name	Value	Description
0x00	W	LL_REGISTER_ACQ_COMMANDS	0x00	Reset FPGA
	W		0x03	Take distance measurement without receiver bias correction
	W		0x04	Take distance measurement with receiver bias correction
0x01	R	LL_REGISTER_STATUS		Internal status of FPGA
0x10	R	LL_REGISTER_FULL_DELAY_LOW	--	Distance measurement low byte
0x11	R	LL_REGISTER_FULL_DELAY_HIGH	--	Distance measurement high byte
0x16	W	LL_REGISTER_UNIT_ID_0	Non zero	This command writes a new secondary I2C slave address. The 5-byte sequence is composed of a 4-byte UNIT_ID plus a 1-byte slave address. The UNIT_ID must be entered with the least significant byte first. Example: UNIT_ID = 0x01020304, (LSB = 04, MSB = 01) Example write: 0x0403020155, would match on UNIT_ID and set slave address to 0x55
	R	L_REGISTER_UNIT_ID_0	--	Returns the UNIT_ID, four bytes
0x17	R	LL_REGISTER_UNIT_ID_1	--	UNIT_ID[byte one]
0x18	R	LL_REGISTER_UNIT_ID_2	--	UNIT_ID[byte two]
0x19	R	LL_REGISTER_UNIT_ID_3	--	UNIT_ID[byte three]
0x1A	R	LL_I2C_SEC_ADDR	--	retrieve the secondary slave address, set with a register write to 0x16

0x1B	W	LL_REGISTER_I2C_CONFIG	Mode	Mode = 0x00: Use the default I2C address only 0x62
				Mode = 0x01: Use the secondary I2C address only (requires the address to be configured using write command 0x16)
				Mode = 0x02: Use both addresses.

0x1C	R	LL_REGISTER_DETECTION_SENSITIVITY	--	Read the detection sensitivity value
	W		Non zero	Write the detection sensitivity value 0x00: Use default valid measurement detection algorithm based on the peak value, signal strength, and noise in the correlation record. 0x01 - 0xFF: Set simple sensitivity for valid detection. Values 0x20 - 0x60 generally perform well.
0x1D	R/W	LL_REGISTER_ACQUISITION_COUNT	Non zero	Set the acquisition count for the ranging unit
0x30	R	LL_REGISTER_LIB_VERSION	--	Read l brary version string for LLv4
0x52	R	LL_REGISTER_CORR_DATA	--	Read a two-byte value from correlation memory
	W		0x00	Reset correlation internal pointer to zero
0x72	R	LL_REGISTER_GVER_HI	--	Read Garmin software version high byte
0x73	R	LL_REGISTER_GVER_LO	--	Read Garmin software version low byte.
0xE0	R	LL_TEMP_MEASUREMENT	--	Retrieve the board temperature **NOTE:** This is a two pass retrieval.
0xE1	R	LL_HARDWARE_VERSION	--	Retrieve the hardware version for the board. **NOTE:** Rev 1 boards = 16
0xE2	W	LL_POWER_LEVEL	0x00 0x01 0xFF	ASYNCHRONOUS MODE => FPGA is always OFF unless a distance measurement is requested or a register access is required SYNCHRONOUS MODE => Distance measurement is tied to the ANT channel period. FPGA is turned on and off as required ALWAYS ON => FPGA is not turned off, this mode consumes the most current, ~ 70mA

Address	R/W	Name	Value	Description
0xE3	W	LL_MEASUREMENT_INTERVAL	0x00 - 0xFF	Used in conjunction with the LL_POWER_LEVEL = SYNCHRONOUS_MODE.
0xE4	W	LL_FACTORY_RESET	Non zero Not 0xFF	This virtual register will reset the NVM / flash storage information back to their defaults and then execute a soft device reset.
0xE5	W	LL_QUICK_TERMINATION	Non zero	Quick termination. When taking distance measurements, the FPGA will stop the measurement early if it detects a strong signal. Accuracy may be affected slightly.
0xE6	W	LL_RESTART_BOOTLOADER	Non zero	This virtual register will force the BootLoader to restart
0xEB	R/W	LL_HIGH_ACCURACY_MODE	0x00 - 0xFF	0x00 - Disable high accuracy mode Non zero - enable high accuracy mode and value is used as the number of distance measurements to accumulate/average and return to the user.
0xEC	R	LL_SOC_TEMPERATURE	--	Retrieve the SoC temperature

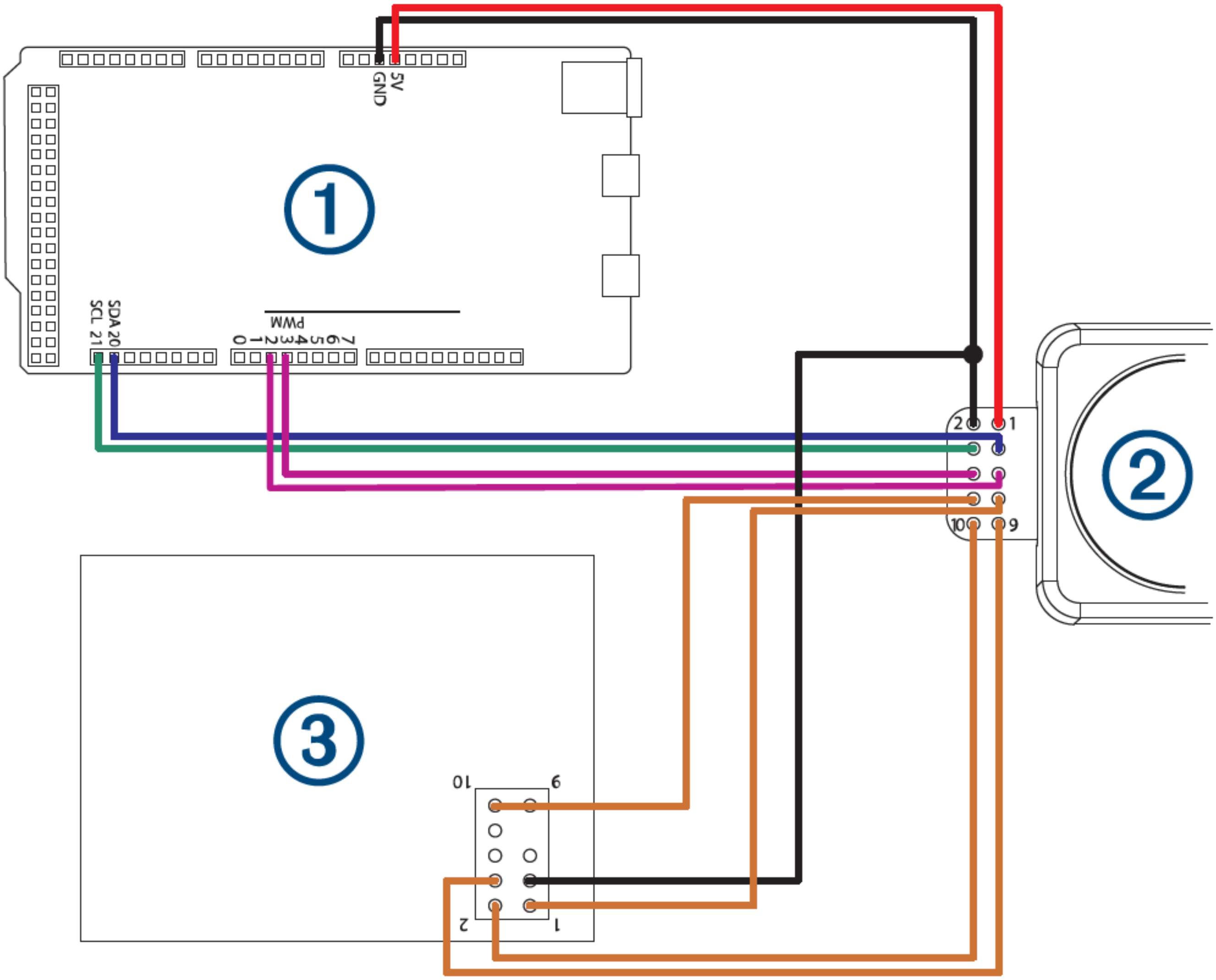
Appendix

nRF52840 SoC

The header on the LLv4 provides access to the nRF52840 system on chip. You can reprogram the device to install custom applications to control the LLv4 for a custom use case. If you reprogram the nRF52840 SoC, you can run your application directly on the device and remove the need to use an external microcontroller to control the LLv4.

You can use the four configurable GPIOs (pins 3 through 6 on the LLv4) to customize the device for your use case. For more information about the capabilities of the nRF52840, go to www.nordicsemi.com/nrf52840.

Standard Arduino® DUE I2C Wiring



Board	Arduino DUE ①	LIDAR-Lite LED v4 ②	J-Link Lite CortexM-9 ③
Connections	5V	1 (5V)	
	GND	2 (GND)	3 (GND)
	SDA 20	3 (SDA)	
	SCL 21	4 (SCL)	
	PWM 2	5 (GPIOA)	
	PWM 3	6 (GPIOB)	
		7 (VRETURN)	1 (VCC)
		8 (nRESET)	10 (nRESET)
		9 (SWCLK)	4 (SWCLK)
		10 (SWDIO)	2 (SWDIO)

You should connect the Arduino DUE, LIDAR-Lite LED v4, and the microcontroller as shown in the diagram and table.

NOTE: The ground wires must be spliced so all components share a common ground. These components include the power supply, the programmer, the microcontroller operating I2C, and any GPIOs.