SF02

The SF02 is a lightweight laser rangefinder module that provides fast and accurate distance measurements.

The module comprises all the necessary optical and electronic components along with embedded software for a pulsed laser, time-of-flight, distance measuring instrument.

Its configurable features and standard hardware interfaces make the SF02 an easy to understand module that can be used in unmanned aerial vehicles (UAV), radio-controlled aircraft and robots.

The indoor SF02 module has a range of 10 meters, and the outdoor SF02/F module has a range of 40 meters.

Features:

- *A laser-based rangefinder module suitable for many applications.*
- *Accurately measures the distance to natural surfaces and objects.*
- *Can detect surfaces and objects up to a distance of 40 meters.*
- *Measures distance at 12 readings per second.*
- *Includes digital and analog interfaces with programmable capabilities.*
- *Easy to configure using the built-in menus and LightWare's Terminal software.*
- *Fully calibrated and ready to run.*
- *Affordable for the student or hobbyist.*
- *Robust and reliable.*
- *Not affected by: wind; changes in barometric pressure; noise; ambient light; terrain or air temperature.*

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Disclaimer

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1. Overview

The lightweight, SF02 laser rangefinder module is an essential addition to any system that needs fast, accurate and reliable distance measurements.

Operating from a 9 V battery or a regulated 5 V DC supply, the SF02 includes analog, digital and serial interfaces that can be easily connected to an embedded controller or a standard processing platform such as Arduino® or Raspberry Pi®. Each interface on the SF02 can be configured using a simple software menu that is accessible through the built-in USB port.

The SF02 works by measuring the time it takes for a very short flash of laser light to travel to an object and back again. The accuracy of the measurement is not affected by the the color of the object's surface or the angle of incidence of the laser beam to the surface. The SF02 is virtually immune to background light, wind, noise and other environmental interference.

The maximum measuring range of the SF02 is 40 meters and readings are updated 12 times per second. There is an option to smooth the distance measurements if higher resolution is required or use the raw results if higher speed is needed.

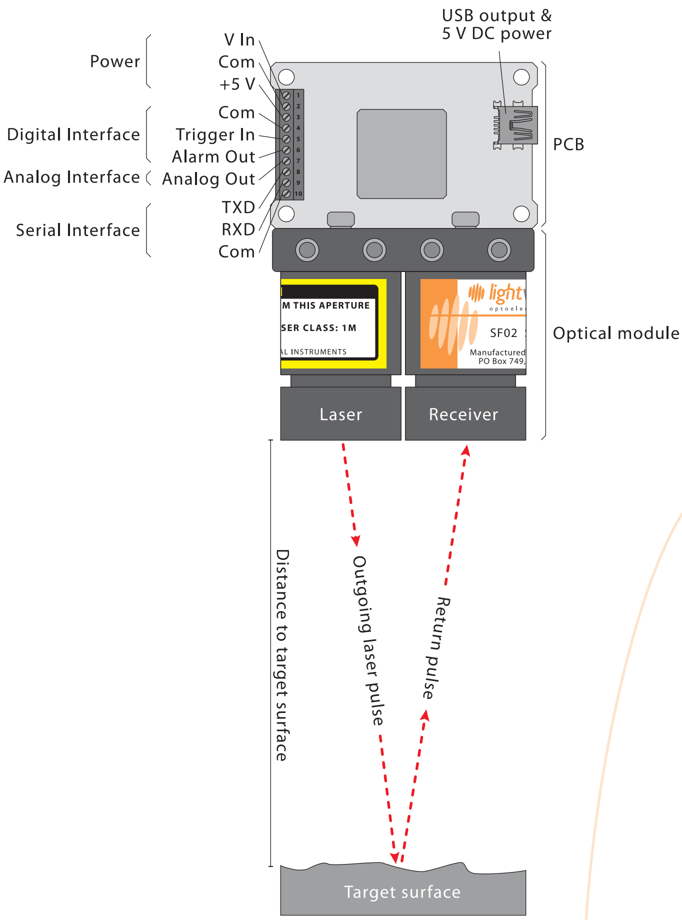
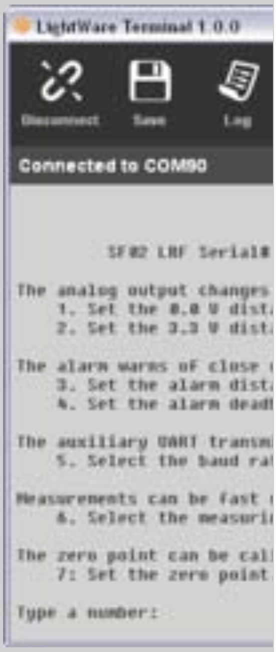


Figure 1 :: The main features of the SF02

2. Quick start guide



1. CAUTION - The SF02 laser rangefinder contains a laser and should never be aimed at a person or an animal. Do not look at the beam directly with optical instruments.

2. Plug a USB cable into the SF02's mini USB connector and connect the other end into a PC. This provides both power and communication for the unit.

3. Download *LightWare Terminal* software from www.lightware.co.za > Library > Documents > Software onto your PC. Open the installer package and follow the install instructions and everything needed for communicating with SF02 will automatically be installed.

4. Start the *LightWare Terminal* software and click the "Connect" icon to open a communications port. The distance measurements should begin to scroll in the Terminal window. If the connection isn't made automatically then click the "Settings" icon and select the correct port from the list shown.

5. The configuration menu is accessed by pressing the <SPACE> bar on your keyboard. This stops the measurements and displays a list of settings along with a brief description of what each one does. Pressing the <SPACE> bar again restarts measuring.

6. A summary of the settings is given below:

Section	Setting	Range of values	Description
Analog voltage output	1. 0.0 V distance	0.00m to 40.00m	Sets the distance at which the voltage output will show 0.0V
	2. 3.3 V distance	0.00m to 40.00m	Sets the distance at which the voltage output will show 3.3V
Digital alarm output	3. Alarm distance	0.00m to 40.00m	Sets the distance at which the alarm will indicate a close object
	4. Alarm deadband	0.00m to 1.00m	Creates a deadband between the on and off points of the alarm
Auxiliary UART	5. Baud rate	4800 ... 115200	Selects the baud rate of the auxiliary serial port UART channel
Measuring	6. Speed	Fast or Slow	Selects the speed at which the measurements update
Zero calibration	7. Zero point	-1.00m to +1.00m	Adjusts the point from which measurements are taken

7. Once you have confirmed your settings, click the "Disconnect" icon and disconnect the USB cable from the SF02.

8. There are several power supply and interface options available on the green connector. These connections are used to integrate the SF02 into your system and details of all the options are explained later in this document.

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2. Making connections to the SF02

The SF02 has four power supply options and a number of digital and analog interfaces. Only one power supply needs to be connected for correct operation and any one of the interfaces may be connected to a host controller.

Power supply option 1: USB

The first option is to power the unit directly from the USB port of a PC or laptop. This is particularly useful for testing the SF02 before it is installed in your system and also for changing the settings in readiness for the final application.

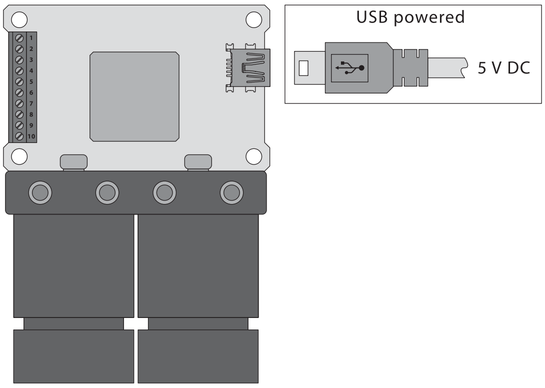

Figure 2 :: Power from the USB port

Power supply option 2: Battery

The second power supply option is to connect to an unregulated battery with a voltage of 6.5 - 9 V DC between screw terminals 1 and 2. In this configuration a regulated 4.7V DC power output becomes available on screw terminal 3 and this can be used by external circuitry as a source of regulated power.

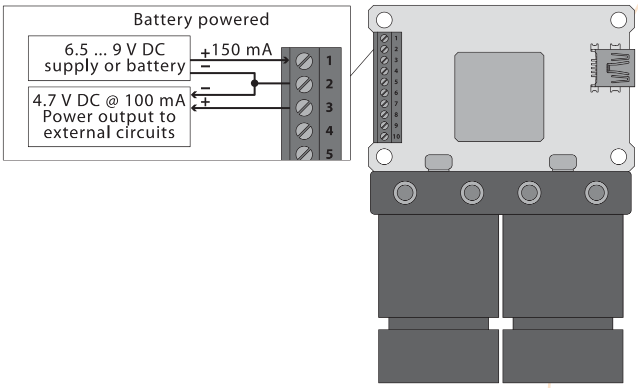

Figure 3 :: Battery power

Power supply option 3: Regulated

The third power supply option is to use a regulated 5 V supply connected between screw terminals 2 and 3. In this configuration terminal 1 is not used. The 5 V DC supply would typically be taken from an existing power rail that is used to supply other electronic equipment.

CAUTION: The +5 V power input on screw terminal 3 is not protected from reverse polarity. Damage to the SF02 will result if this connection is reversed.

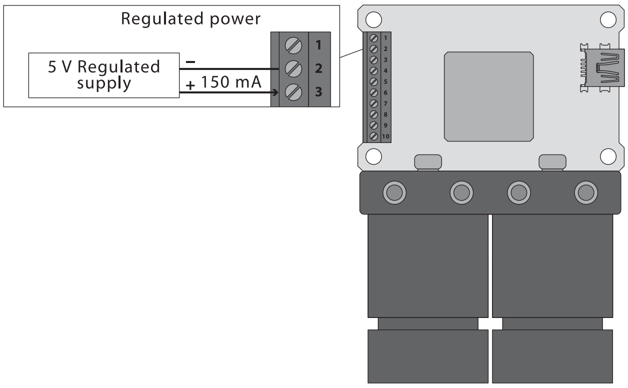

Figure 4 :: Regulated 5V DC supply

Power supply option 4: Dual redundancy

For high reliability applications, dual redundancy of the power supply can be achieved by connecting both a battery and a regulated 5 V supply. In this configuration, the +5 V must be supplied through a reverse protection diode with a low forward voltage drop. We recommend using a 1N5819 Schottky diode. Under normal conditions power is drawn from the +5 V supply but if this supply fails then power will be drawn from the battery.

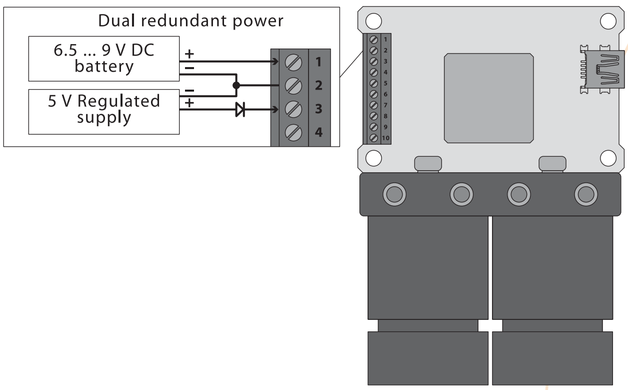

Figure 5 :: Dual redundant power supplies

USB interface

The SF02 has a mini USB interface that can be used to communicate with *LightWare Terminal* software on a PC. This connection also provides power to the unit thereby presenting a quick way to test and configure the SF02. The associated serial port transmits at 115200 baud with 1 stop bit and no parity or handshaking. More details are discussed in the “Menu options” section below.

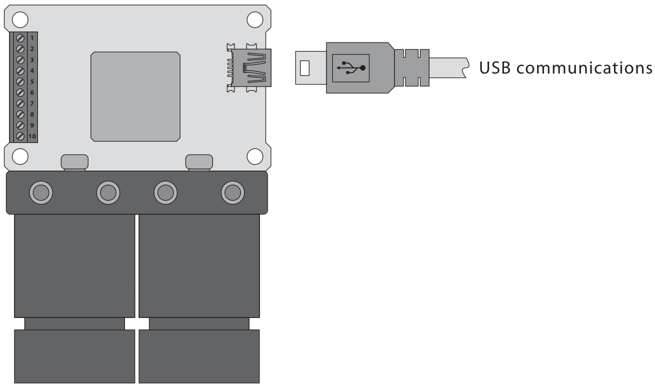

Figure 6 :: USB communications

Analog voltage output

The analog voltage interface on screw terminal 7 produces a linear voltage of between 0.0 V and 3.3 V that is proportional to the measured distance. The actual distances of the 0.0 V and 3.3 V end points can be adjusted through the menu system. The analog voltage can be measured by the host controller using any available analog-to-digital-converter (ADC). The voltage is updated 12 times per second and has 10 bit resolution.

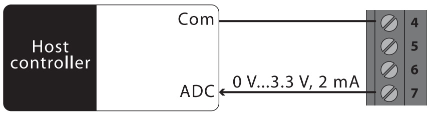

Figure 7 :: Analog interface, Analog voltage output

Alarm output

The alarm output on screw terminal 6 is a digital warning signal that becomes active when an object is closer than a preset distance. The alarm distance can be set using the menu system. The alarm is active high with an output of 3.3 V. This alarm signal can be connected to an available digital port pin on the host controller and read as: low = safe and high = alarm.

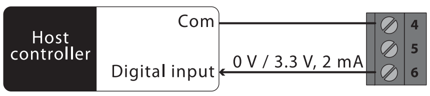

Figure 8 :: Digital interface, Digital alarm output

Auxiliary serial port

The auxiliary serial port on screw terminals 8 and 9 outputs an ASCII encoded string as a floating point representation of the distance measured. The serial port uses 0 V / 3.3 V logic and is designed for direct connection to a similar serial port on the host controller. The baud rate is selectable using the menu system.

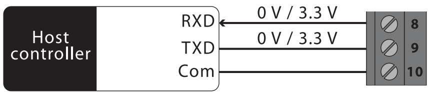

Figure 9 :: Serial interface, Auxiliary serial port basic connection

The time when distance data is transmitted from the auxiliary serial port is controlled by one of two triggers. The first is a software trigger provided by the host controller through its serial port and consists of the ASCII code for the letter <D>. When the SF02 receives this character it outputs the next available distance result which will happen in less than 100 ms.

There is an alternative hardware trigger on screw terminal 5 that can be controlled by a digital port pin on the host controller. This trigger is active low and can be either a negative going pulse or can be held low in order to get a continuous stream of distance data from the auxiliary serial port.

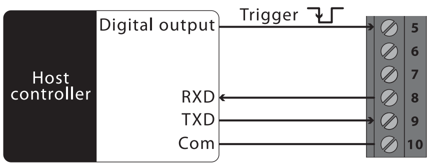

Figure 10 :: Serial interface, Auxiliary serial port with hardware trigger

3. Menu options

The SF02 can be connected through the on-board USB port to a Terminal emulation program running on a PC. LightWare provides a free Terminal program available for download from its website at http://www.lightware.co.za/index.php/lib-docs

Once the USB connection is made, the Terminal window displays the distance reading from the SF02. Pressing the <SPACE> bar stops the measuring process and changes the display to a menu that lists all the available settings and configuration options. Pressing the <SPACE> bar again restarts the measuring process.

Figure 11 :: LightWare Terminal *showing menu options*

Analog voltage output settings

Menu items <1> and <2> relate to the analog voltage output and are used to set the end point distances that correspond to the 0.0 V and 3.3 V output voltages. These voltages are read by the ADC of the host controller and can be converted back into a distance by using the formula:

$$d = v / 3.3 * (DH - DL) + DL$$

where:
d = measured distance
v = voltage measured by the ADC of the host
DL = 0.0V distance
DH = 3.3V distance

The range of values for both distance settings is from 0.00 meters to 40.00 meters. The analog voltage output updates at 12 readings per second and has a 10 bit resolution.

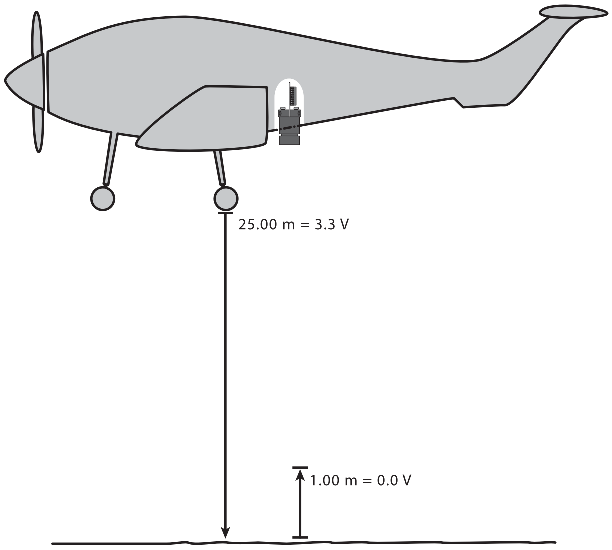

Figure 12 :: Height above ground represented by the analog voltage output

Alarm settings

The digital alarm output goes high whenever an object is detected that is closer than the distance setting shown in menu item <3>. This distance can be set from 0.00 meters to 40.00 meters and the alarm output is updated 12 times per second. To prevent multiple switching of the alarm output, menu item <4> provides for hysteresis on the alarm distance. This will change the alarm activation and deactivation distances to:

activation distance = alarm distance - hysteresis
deactivation distance = alarm distance + hysteresis

The hysteresis can be adjusted up to 1.00 meters.

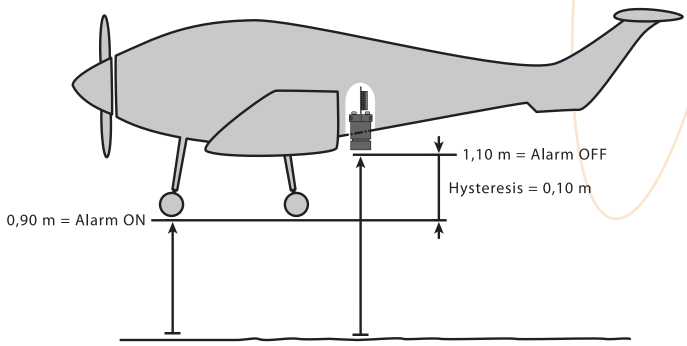

Figure 13 :: Ground proximity alarm warning

Auxiliary serial port (UART)

The auxiliary serial port, or UART, transmits a serial string of ASCII encoded data from the SF02 to the host controller. The baud rate of transmission is selected by menu item <5> and can be any of the standard baud rates from 4800 to 115200. By default, there is one stop bit and no parity or handshaking on this serial port.

The ASCII string representing the distance is in floating point format with two decimal places followed by carriage return and line feed, as follows:

"22.48\r\n"

where carriage return and line feed are given by the hexadecimal ASCII characters:

\r = 0x0D
\n = 0x0A

Data is sent out of the auxiliary serial port whenever a "trigger" notification is received. The ASCII character <D> acts as a trigger when transmitted by the host controller to the SF02. Additionally, there is an active low, hardware trigger that can be controlled by a digital port pin on the host controller.

Measuring speed

The measuring speed can be selected by menu item <6> to be either fast or slow. In fast mode the readings update 12 times per second. In slow mode, a four point rolling average filter is applied to the distance readings giving a smoother output. The slow mode is for making more precision measurements.

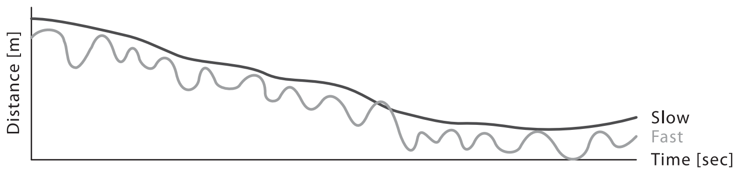

Figure 14 :: Measuring speed

Zero point

The point from which distance measurements are taken can be adjusted using menu item <7>. The range of values that can be entered are from -1.00 meters to +1.00 meters. This zero point adjustment can be used to compensate for the mounting position of the SF02 in the final system, where distance readings may best be interpreted from a suitable point on the system rather than from the front face of the SF02.

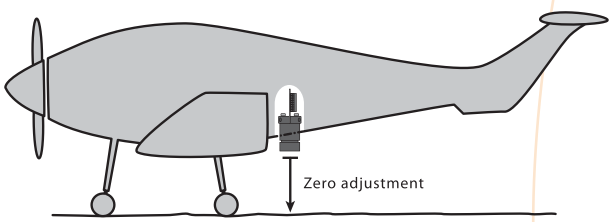

Figure 15 :: Compensating for the height of the landing gear

4. Instructions for safe use

The SF02 is a laser range finder that emits ionizing laser radiation. The level of the laser emission is Class 1M which indicates that the laser beam is safe to look at with the unaided eye but must not be viewed using binoculars or other optical devices at a distance of less than 15 meters. Notwithstanding the safety rating, avoid looking into the beam and switch the unit off when working in the area.

CAUTION -- The use of optical instruments with this product will increase eye hazard.

The SF02 should not be disassembled or modified in any way. The laser eye safety rating depends on the mechanical integrity of the optics and electronics so if these are damaged do not continue using the SF02. There are no user serviceable parts and maintenance or repair must only be carried out by the manufacturer or a qualified service agent.

No regular maintenance is required for the SF02 but if the lenses start to collect dust then they may be wiped with suitable lens cleaning materials. Make sure that the SF02 is switched OFF before looking into the lenses.

The SF02 should be mounted using the four holes provided in the circuit board. Do not hold or clamp the lens tubes as this may cause damage and adversely affect the laser safety rating.

Laser radiation information and labels

Specification	Value / AEL	Notes
Laser wavelength	850 nm	
Pulse width	< 30 ns	
Pulse frequency	< 16 kHz	
Peak power	< 10 W / 15.96 W	50 mm aperture at 2 m
Average power	<0.6 mW / 0.78 mW	7 mm aperture
Average energy per pulse	<0.15 nj / 200 nj	
NOHD	<15 m	Distance beyond which binoculars with may be used safely

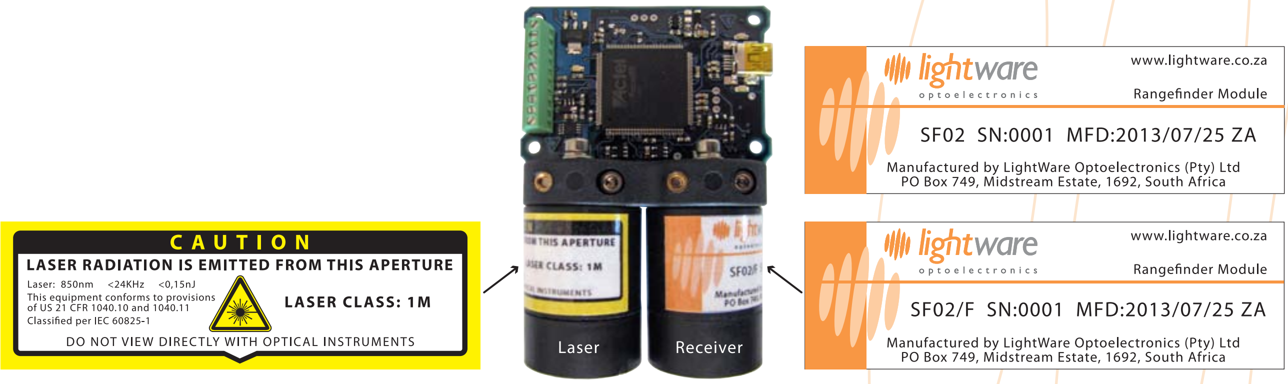

Figure 16 :: Labeling on the SF02

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Appendix A :: Specifications

	SF02	SF02/F
Range	10 m (natural targets) indoor use	40 m (natural targets) indoor and outdoor use
Resolution	1 cm	1 cm
Update rate	12 readings per second	12 readings per second
Accuracy	See Figure 17 below	See Figure 17 below
Power supply voltage	6.5 V .. 9.0 V or 5.0 V ± 0.5 V DC	6.5 V .. 9.0 V or 5.0 V ± 0.5 V DC
Power supply current	150 mA (maximum)	150 mA (maximum)
Outputs & interfaces	Analog, serial and digital	Analog, serial and digital
Dimensions	27 x 59 x 86 mm	27 x 59 x 86 mm
Weight	69 g (2.43 oz)	69 g (2.43 oz)
Mounting	4 x M3 (3.2 mm diameter)	4 x M3 (3.2 mm diameter)
Connections	Screw terminal: 0.1 in. pitch header	Screw terminal: 0.1 in. pitch header
Laser power	14 W (peak), 6 mW (average), Class 1M	14 W (peak), 6 mW (average), Class 1M
Operating temperature	0 ... 40°C	0 ... 40°C
Approvals	FDA accession number: 1310953-000 (2013/12)	FDA accession number: 1310953-000 (2013/12)

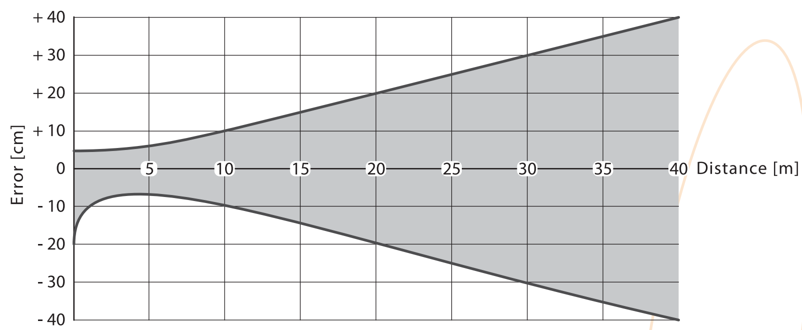

Figure 17 :: Accuracy profile

SF02

Appendix B :: Dimensions

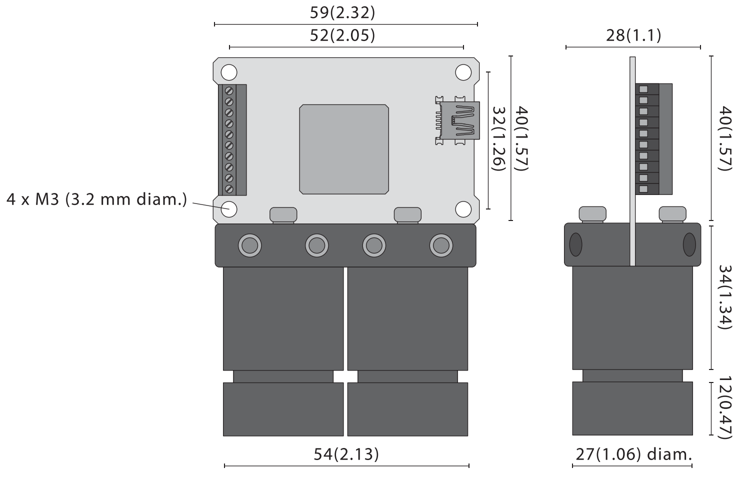

Figure 18 :: Dimension drawings of the SF02

Revision history

Version	Date	Authors	Comments
Rev 6	2014/02/11	TLP	Corrected: "There is an alternative hardware trigger on screw terminal **5**" (page 8). Updated "Appendix A :: Specifications" (page 13).
Rev 5	2014/01/12	TLP	Included "SF02" module on page 1 and Appendix A :: Specifications table (page 13). Amended Appendix A :: Specifications "Dimensions" (page 13).
Rev 4	2014/01/05	JEP	Corrected the hexadecimal ASCII characters: \r = 0x0D and \n = 0x0A (page 11).
Rev 3	2013/12/18	TLP	"Appendix A :: Specifications" (page 13) include "Approvals" information regarding FDA accession number "1310953-000"
Rev 2	2013/09/30	TLP	"Appendix A :: Specifications" (page 13) corrected "Measuring range" to read "40 m".
Rev 1	2013/09/12	TLP	Move section "1. Overview" to page 3. Include "-" and "+" symbols in Figures 3, 4 and 5. Update UAV image in Figures 12, 13 and 15.
Rev 0	2013/09/03	JEP	First edition