The SF10 is a compact, lightweight laser altimeter for above-ground-level altitude measurement from small fixed wing or multi-rotor craft.

The SF10 laser altimeter is ideal for automated landings and precision hovering.

The configurable features and multiple hardware interfaces make the SF10 easy to use with different types of flight controller.

The SF10 laser altimeter uses a time-of-flight system to make accurate distance measurements to natural or artificial surfaces.

Features:

- *Very compact and lightweight - 35 grams.*
- *Accurate AGL altitude measurement on most natural and artificial surfaces.*
- *Fast update rate.*
- *Includes serial, I2C, USB and analog interfaces with programmable capabilities.*
- *Easy to configure using the built-in menu and LightWare Terminal software.*
- *Fully calibrated and ready to run.*
- *Accurate, reliable altitude measurements in sunlight or dark conditions.*
- *Not affected by: speed; wind; changes in barometric pressure; noise; ambient light; terrain or air temperature.*

www.lightware.co.za • info@lightware.co.za

Table of contents

Table of figures

www.lightware.co.za • info@lightware.co.za

Disclaimer

1. Overview

The light-weight, SF10 laser altimeter is an essential addition to any scale aircraft that needs fast, accurate and reliable AGL altitude measurements.

Operating from a regulated 5 V DC supply, the SF10 includes both analog and digital interfaces that can be easily connected to a flight controller or a standard processing platform. Each interface on the SF10 can be configured using a simple software menu that is accessible through the built-in, micro USB port.

The SF10 works by measuring the time it takes for a very short flash of laser light to travel to the ground and back again. The accuracy of the measurement is not affected by the colour or texture of the ground nor the angle of incidence of the laser beam. The SF10 is virtually immune to background light, wind and noise making it the ideal AGL altimeter for all kinds of terrain.

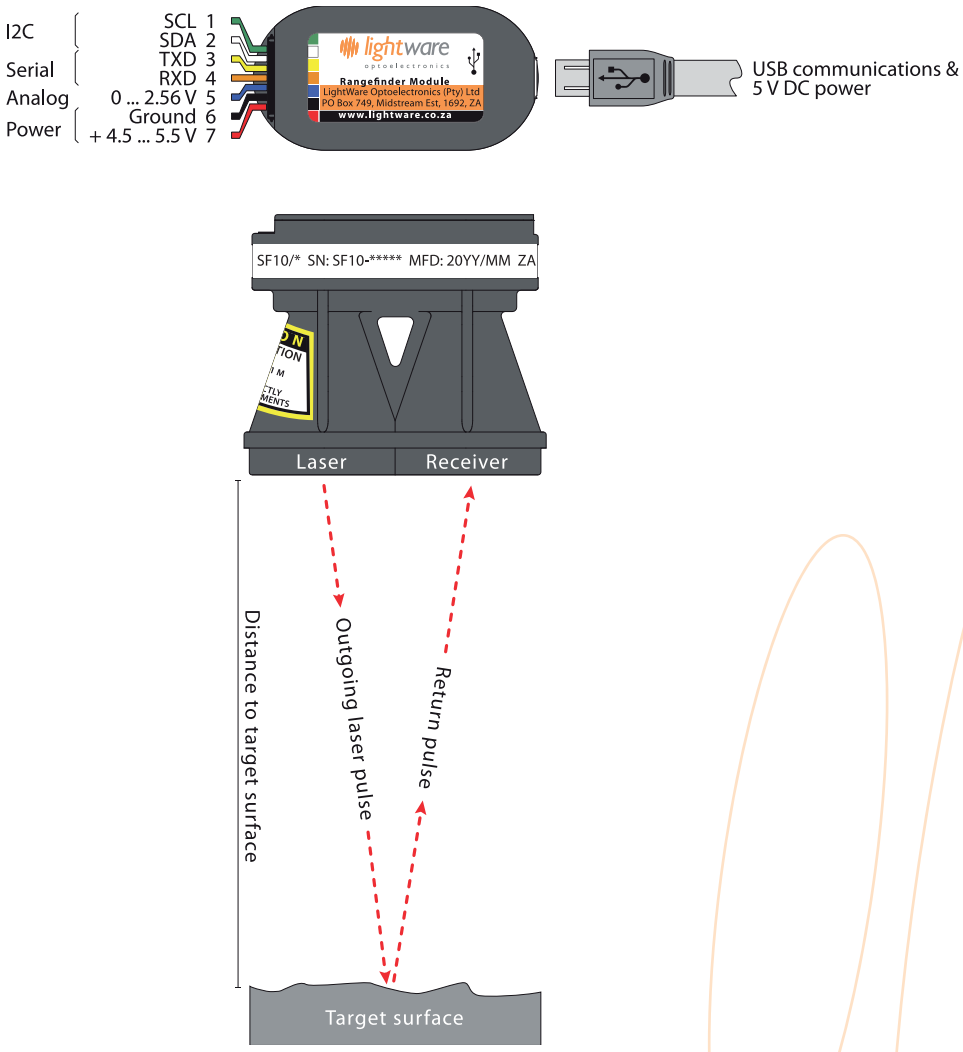


Figure 1 :: The main features of the SF10

The maximum operating altitude of the SF10 depends on the model: the SF10/A maximum range is 25 meters; the SF10/B maximum range is 50 meters; the SF10/C maximum range is 100 meters. Readings are updated 32 times per second in the SF10/A and SF10/B models, and updated 16 times per second in the SF10/C. There is a filter setting to reduce any unwanted variability in the altitude introduced by uneven terrain, bushes or long grass.

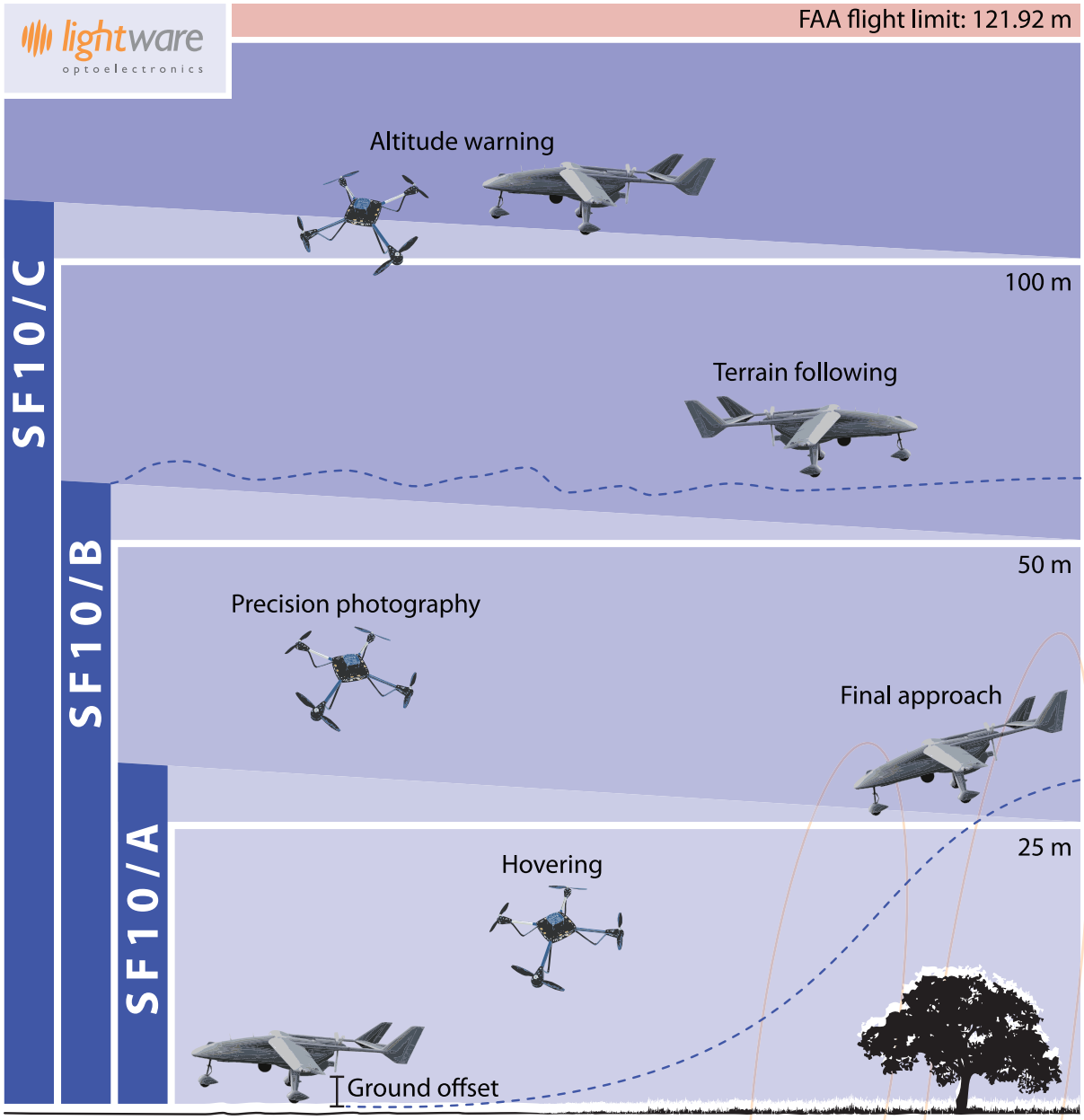


Figure 2 :: Applications

2. Quick start guide

1. CAUTION - The SF10 laser altimeter contains a laser and should never be aimed at a person or an animal. Do not look at the beam directly with optical instruments.

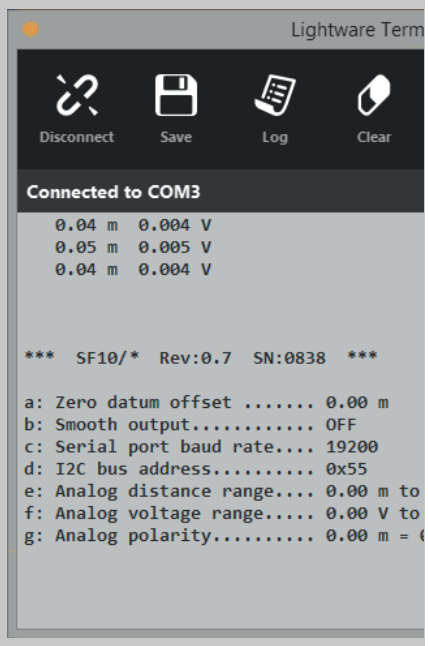
2. Download LightWare Terminal software from www.lightware.co.za > Library > Documents > Software onto your PC. Open the installer package and follow the installation instructions. Everything needed for communicating with the SF10 will automatically be installed.

3. Plug the "micro-B to type A" USB cable provided into the SF10's micro USB connector and connect the other end to your PC. This provides both power and communication to the unit.

4. Start the *LightWare Terminal* software and click the "Connect" icon to open a communications port.

5. If the connection isn't made automatically, click the "Laser" icon and select the correct USB port from the list shown.

6. Press the **<SPACE>** key to display the main menu. This menu includes a list of all the settings that can be changed in the SF10. A summary of the settings is given below:



Setting	Range of values	Description
a: Zero datum offset	-10.00 m … +10.00 m	Adjusts the zero point from which measurements are taken
b: Smooth output	ON / OFF	Switch on filtering to smooth the outputs
c: Serial port baud rate	9600 … 115200	Sets the baud rate for the serial port
d: I2C bus address	0 … 7F	Sets the I2C address
e: Analog distance range	SF10/A: 1.00 m … 30.00 m	Sets the distance at which the voltage output will show 2.56 V
	SF10/B: 1.00 m … 60.00 m	
	SF10/C: 1.00 m … 120.00 m	
f: Analog voltage range	0.00 V … 2.56 V or 0.00 V … 3.30 V	Selects the maximum output voltage of the analog output: either 2.56 V or 3.30 V
g: Analog polarity	0.00 m = 0.00 V | 25.60 m = 2.56 V or 25.60 m = 0.00 V | 0.00 m = 2.56 V	Selects the polarity of the analog output so that the maximum voltage selected using menu item **<f>** occurs at the maximum distance set using menu item **<e>** or at 0.00 m as required.

7. Once you have confirmed your settings, press the **<SPACE>** key to start taking distance measurements and the results will be displayed in the *Terminal* window.
8. Press the "Disconnect" icon before unplugging the USB cable.
9. There are several interface options available on the main connector. These connections are used to integrate the SF10 into your system and details of all the options are explained later in this document.

www.lightware.co.za • info@lightware.co.za

3. Making connections to the SF10

The SF10 gets power from either a regulated +5 V DC supply on the main connector or via the USB port when it is connected to a PC. There are a number of digital and analog interfaces on the main connector and either one or a combination of interfaces may be connected to a host controller. The built-in micro USB port can be used to input settings and to test the performance of the SF10.

Power supply option 1: USB

The SF10 can be powered directly from the USB port of a PC or laptop. This is particularly useful for testing the SF10 before it is installed in your system and also for changing the settings in readiness for the final application.

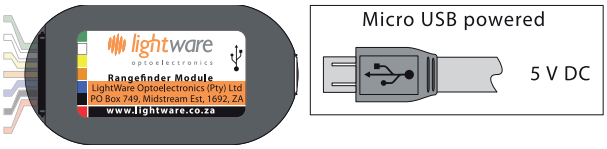


Figure 3 :: Power from the USB port

Power supply option 2: Regulated +5 V DC

The second power supply option is to connect a regulated voltage of 5 V ± 10% DC to the main connector. If the power wires are more than 30 cm long, we recommend using a decoupling capacitor, or other noise suppression components to reduce the chance interference being picked up on the power wires.

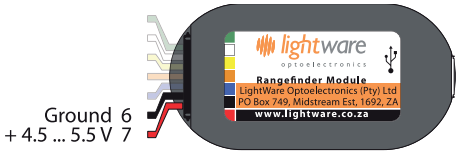


Figure 4 :: Regulated +5 V DC power supply connections

Communications using the USB port

The SF10 has a micro USB port 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 SF10. The *LightWare Terminal* software will automatically detect the USB port that is connected to the SF10 and communications can be established by clicking on the "Connect" icon. If more than one compatible device is present, click the "Laser" icon to select which USB port should be active.

Once communication has been established, settings can be changed by pressing the **<SPACE>** key to access the menu and then selecting the menu item that needs changing. Pressing the **<SPACE>** key again restarts the measuring process. If no settings are entered then the SF10 automatically restarts after two minutes. More details of the menu items are discussed in the "Menu options" section below.

If you want to use a different serial emulation program then the USB serial protocol should be set to 115200 baud with 1 stop bit and no parity or handshaking. All communications are in standard ASCII format.

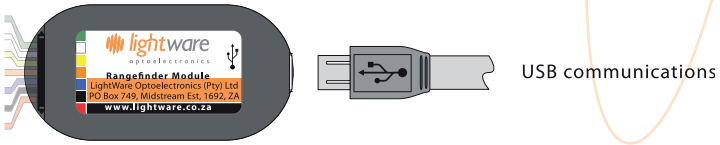


Figure 5 :: USB communications

Analog voltage interface

The analog interface on the main connector produces a linear voltage of between 0.00 V and 2.56 V that is proportional to the measured altitude. The physical altitude in meters that equates to 2.56 V can be adjusted through the USB menu system. For example, an altitude setting of 51.20 meters would produce a linear voltage output of 50 mV per meter.

Figure 6 :: Analog voltage connections

Serial interface

The serial interface on the main connector outputs the measured altitude in meters as an ASCII encoded number. This interface uses 3.3 V logic levels and can be connected directly to any similar, compatible interface. Distances are transmitted whenever the SF10 receives an ASCII character from the host controller. This character may have any value in the extended ASCII character set. The baud rate for the serial interface is selectable through the USB menu system. The maximum delay between receiving a character and returning the altitude is 25 ms.

Figure 7 :: Serial interface connections

I2C interface

The I2C interface on the main connector outputs a value that represents the altitude in centimetres. This interface operates in "slave" mode and uses 3.3 V logic levels. The I2C address can be set through the USB menu system. The host controller acts as the I2C "master" and sends the address to the SF10 as an 8 bit value (7 address bits plus 1 read bit). The SF10 then returns the altitude as a 16 bit integer. The maximum delay between receiving the address and returning the altitude is 25 ms.

Figure 8 :: I2C interface connections

www.lightware.co.za • info@lightware.co.za

4. Menu options

The SF10 can be connected through the on-board USB port to a Terminal emulation program running on a PC. The *LightWare Terminal* software is available for download from www.lightware.co.za.

Once the USB connection is made, the Terminal window displays the distance reading from the SF10. Pressing the **<SPACE>** key stops the measuring process and changes the display to a menu that lists all the available settings and configuration options. Pressing the **<SPACE>** key again restarts the measuring process. If no changes are made, the unit will automatically begin to measure again after two minutes.

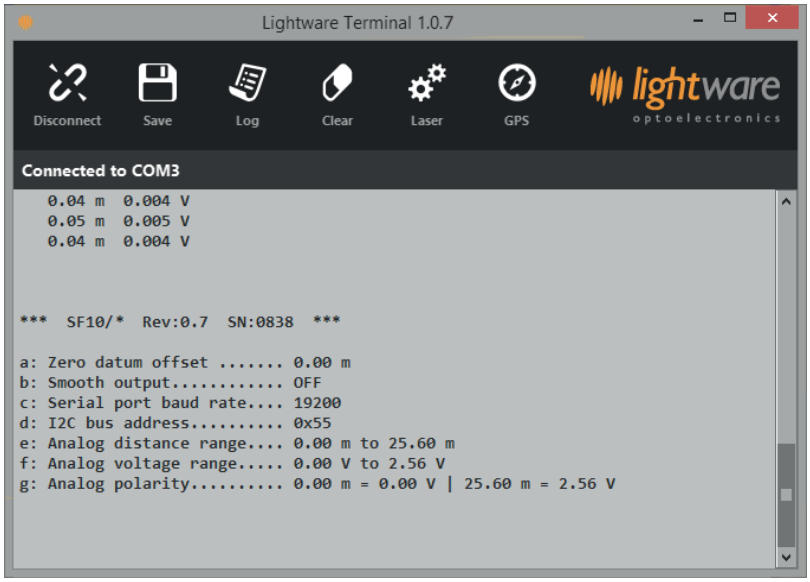


Figure 9 :: LightWare Terminal *showing menu options*

a: Zero datum offset (-10.00 m … +10.00 m)

The point from which altitude measurements are taken can be adjusted using menu item **<a>**. The range of values that can be entered are from -10.00 meter to +10.00 meters and this value is subtracted from the altitude reading before it is made available on any of the interfaces. The zero datum offset can be used to compensate for the mounting position of the SF10 in the airframe, where distance readings may best be interpreted from a suitable point on the landing gear, rather than from the front face of the SF10.

b: Smooth output - Switches ON / OFF a data filter which smoothes the outputs

Menu item **<b>** is used to reduce the effects of scrub, bushes and long grass on the mean altitude reading. Note that this filter changes the time constant of the altitude measurements and therefore the rate of response.

c: Serial port baud rate (9600 … 115200)

The serial port transmits a serial string of ASCII encoded data from the SF10 to the host controller. The baud rate of transmission is selected by menu item **<c>** and toggles through the standard baud rates from 9600 to 115200. By default, there is 1 stop bit and no parity or handshaking on this serial port.

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

"22.48\r\n"

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

\r = 0x0D
\n = 0x0A

The altitude is sent out of the serial port when any ASCII character is transmitted by the host controller to the SF10.

d: I2C bus address (0x00 … 0x7F)

The I2C bus operates in slave mode and accepts an 8 bit address (7 address bits plus 1 read bit) before responding with a 16 bit, binary coded integer that is the altitude in centimetres. The address can be set by selecting menu item **<d>** and is entered as a 7 bit, hexadecimal number.

e: Analog distance range (SF10/A: 1.00 m … 30.00 m, SF10/B: 1.00 m … 60.00 m & SF10/C: 1.00 m … 120.00 m)

The distance at which the maximum analog output of 2.56 V occurs can be set by selecting menu item **<e>**. The output voltage can be converted back into a distance by using the formula:

$$a = v / 2.56 * c$$

where:
a = measured distance
v = voltage measured by the ADC of the host
c = 2.56 V distance setting

The analog voltage output updates 16 (SF10/C) or 32 (SF10/A and SF10/B) times per second and has a 12 bit resolution.

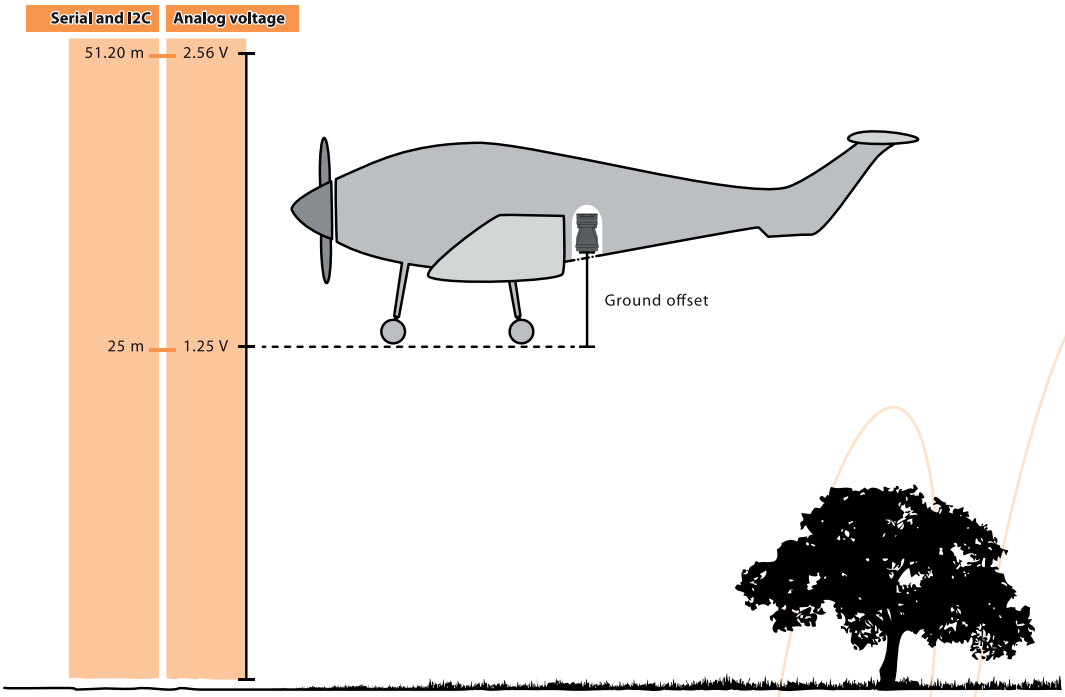


Figure 10 :: Altitude represented by distance (Serial / I2C) and analog voltage

f: Analog voltage range (0.00 V … 2.56 V or 0.00 V … 3.30 V)

Selects the maximum output voltage of the analog output - either 2.56 V or 3.30 V - by selecting menu item <f>.

g: Analog polarity (0.00 m = 0.00 V | 25.60 m = 2.56 V or 25.60 m = 0.00 V | 0.00 m = 2.56 V)

Selects the polarity of the analog output so that the maximum voltage selected using menu item <f> occurs at the maximum distance set using menu item <e> or at 0.00 m as required.

www.lightware.co.za • info@lightware.co.za

5. Instructions for safe use

The SF10 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 SF10 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 SF10. 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 SF10 but if the lenses start to collect dust then they may be wiped with suitable lens cleaning materials. Make sure that the SF10 is switched OFF before looking into the lenses.

The SF10 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	905 nm	
Pulse width	< 20 ns	
Pulse frequency	< 36 kHz	
Peak power	< 10 W	50 millimeter aperture at 2 meters
Average power	< 0.6 mW	7 millimeter aperture
Average energy per pulse	< 300 nj	
NOHD	15 m	Distance beyond which binoculars with may be used safely

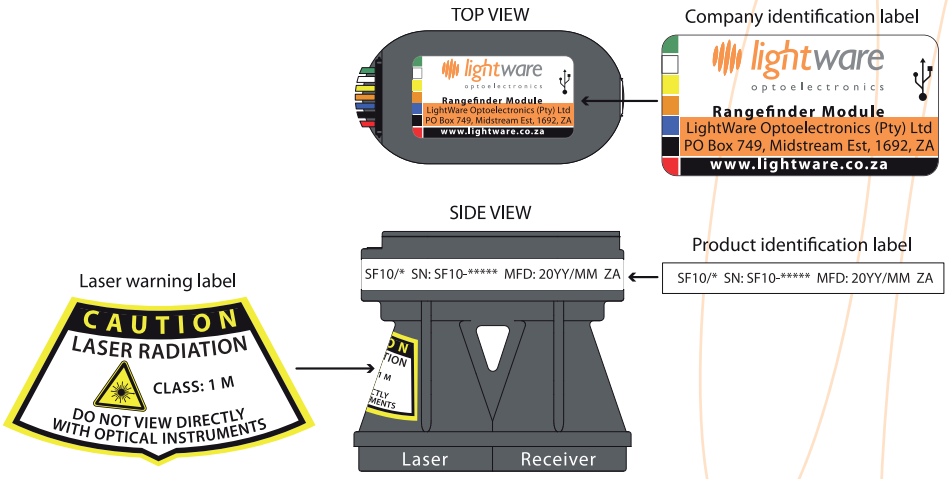


Figure 11 :: Labelling on the SF10

Appendix A :: Specifications

	SF10/A (25 m)	SF10/B (50 m)	SF10/C (100 m)
Range	0 … 25 meters (natural targets)	0 … 50 meters (natural targets)	0 … 100 meters (natural targets)
Resolution	1 centimeter	1 centimeter	1 centimeter
Update rate	32 readings per second	32 readings per second	16 readings per second
Accuracy	±0.05 meter (70% reflective target @ 20°C)	±0.05 meter (70% reflective target @ 20°C)	±0.1 meter (70% reflective target @ 20°C)
Power supply voltage	5.0 V ± 0.5 V DC	5.0 V ± 0.5 V DC	5.0 V ± 0.5 V DC
Power supply current	125 mA (maximum)	150 mA (maximum)	150 mA (maximum)
Outputs & interfaces	Serial, I2C (up to 400 kHz) & analog with maximum latency of 25 ms	Serial, I2C (up to 400 kHz) & analog with maximum latency of 25 ms	Serial, I2C (up to 400 kHz) & analog with maximum latency of 25 ms
Dimensions	30 x 56.5 x 50 millimeters	30 x 56.5 x 50 millimeters	30 x 56.5 x 50 millimeters
Weight	35 grams (excluding cables)	35 grams (excluding cables)	35 grams (excluding cables)
Connections	Plug & socket, micro USB	Plug & socket, micro USB	Plug & socket, micro USB
Laser power	4 W (peak), 5 mW (average), Class 1M	20 W (peak), <15 mW (average), Class 1M	20 W (peak), <15 mW (average), Class 1M
Optical aperture	51 millimeters	51 millimeters	51 millimeters
Beam divergence	0.4°	0.2°	0.2°
Operating temp.	0 … 40°C	0 … 40°C	0 … 40°C
Approvals	FDA accession number: 1410968-002 (2016/01)	FDA accession number: 1410968-002 (2016/01)	FDA accession number: 1410968-002 (2016/01)

Appendix B :: Dimensions

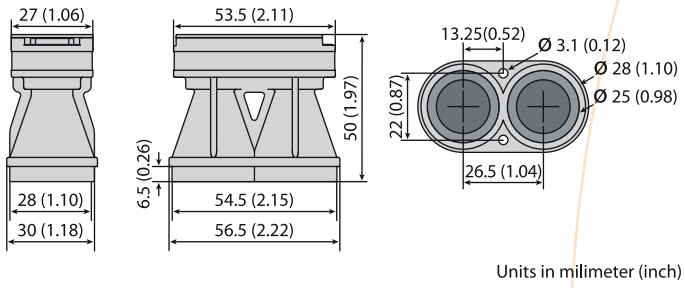
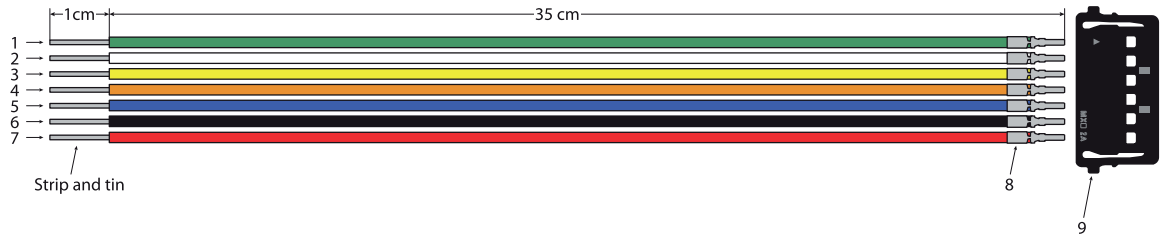


Figure 12 :: Dimension drawings of the SF10

Appendix C :: Main cable type 1, 35 cm



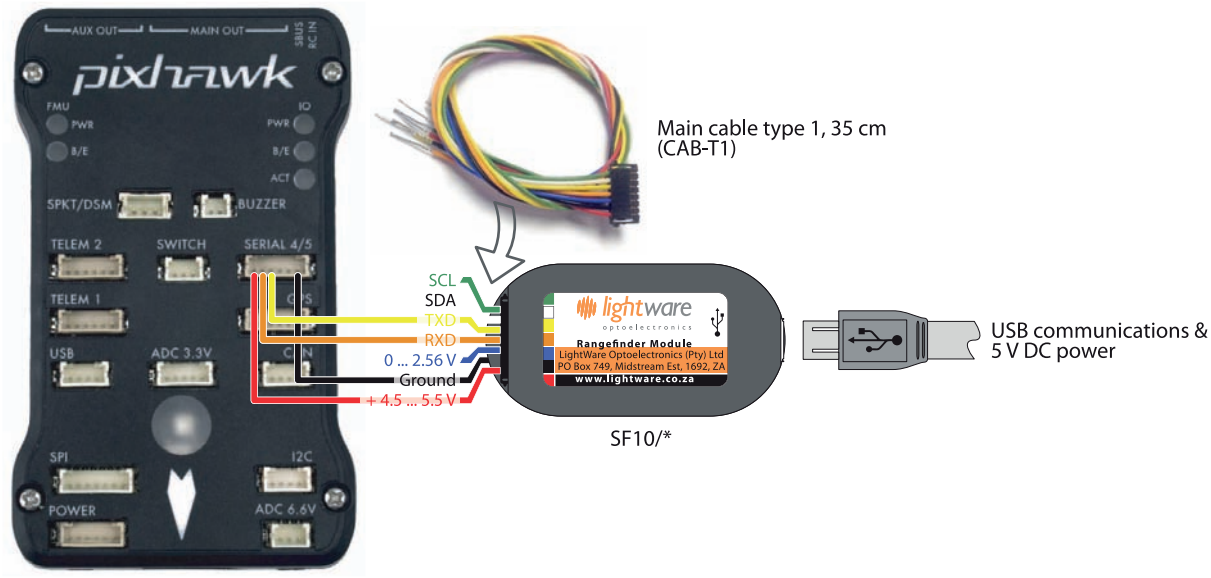
	RS part no.	Manufacturer part no.	Description
1	RS: 177-0867	Alpha Wire: 5853 GR005	Hookup-Wire TFE Teflon Insulation, 26 AWG - Green
2	RS: 177-0839	Alpha Wire: 5853 WH005	Hookup-Wire TFE Teflon Insulation, 26 AWG - White
3	RS: 177-0889	Alpha Wire: 5853 YL005	Hookup-Wire TFE Teflon Insulation, 26 AWG - Yellow
4	RS: 177-0918	Alpha Wire: 5853 OR005	Hookup-Wire TFE Teflon Insulation, 26 AWG - Orange
5	RS: 177-0895	Alpha Wire: 5853 BL005	Hookup-Wire TFE Teflon Insulation, 26 AWG - Blue
6	RS: 177-0845	Alpha Wire: 5853 BK005	Hookup-Wire TFE Teflon Insulation, 26 AWG - Black
7	RS: 177-0851	Alpha Wire: 5853 RD005	Hookup-Wire TFE Teflon Insulation, 26 AWG - Red
8	RS: 789-8378	Molex: 504052-0098	Pico-Lock contact terminal 24-28 AWG
9	RS: 789-8371 P	Molex: 504051-0701	Pico-Lock wire to board housing 7 way

NOTE: Wire colours are critical. Do not deviate.

LightWare Optoelectronics (Pty) Ltd	Main cable type 1 assembly	Rev: 0

www.lightware.co.za • info@lightware.co.za

Appendix D :: Connecting to Pixhawk Autopilot using “serial 4”

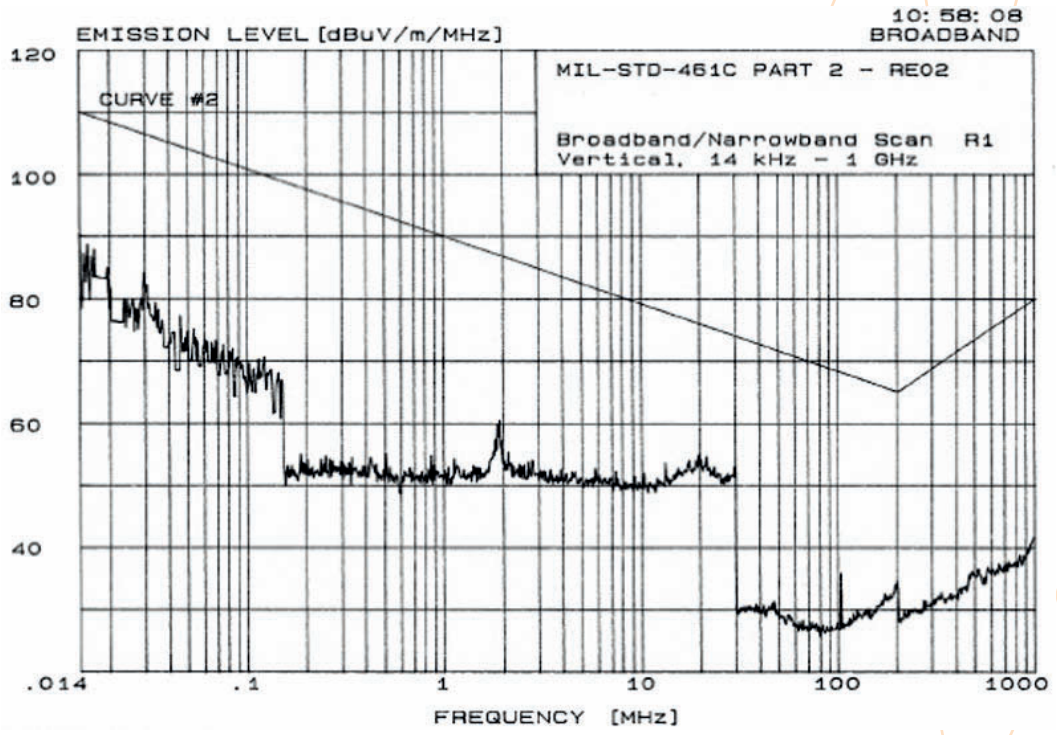


Pixhawk Autopilot

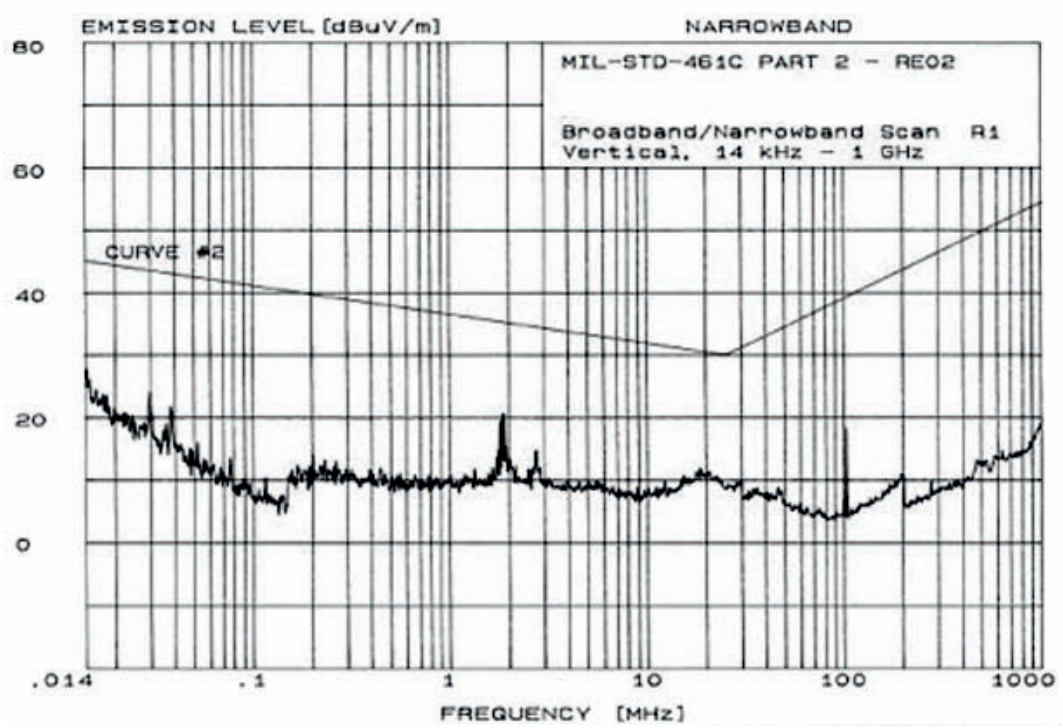
Appendix E :: Electromagnetic interference (EMI) graphs

The SF10 family has been tested for radio frequency interference in accordance with MIL-STD-451C. The results are well within the required limits so that neither direct radiation nor secondary radiation from wiring should cause interference to on-board systems such as GPS and optical flow.

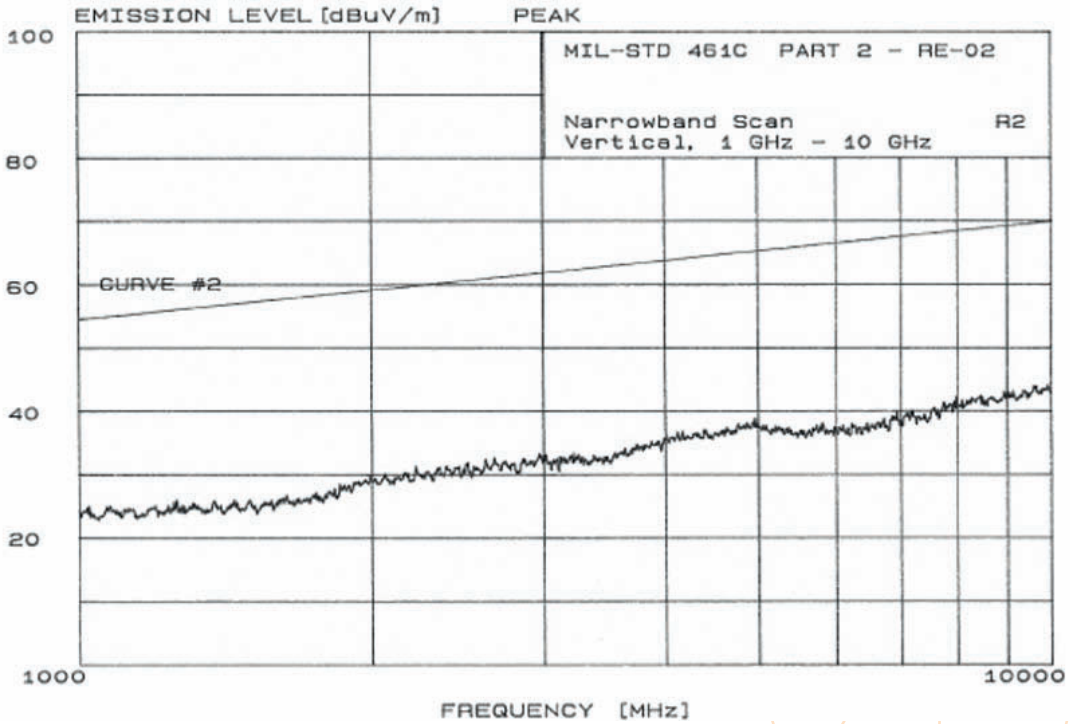
1. 14 kHz to 1 GHz - narrowband



2. 14 kHz to 1 GHz - broadband



3. 1 GHz to 10 GHz - narrowband



Revision history

Version	Date	Authors	Comments
Rev 10	2016/03/07	TLP	Update I2C feature “up to 400 kHz” in “Appendix A :: Specifications” (page 11).
Rev 9	2016/01/29	TLP	Update FDA accession number “1410968-002 (2016/01)” in “Appendix A :: Specifications” (page 11). Include “Appendix D :: Connecting to Pixhawk Autopilot using “serial 4” (page 13).
Rev 8	2015/09/18	TLP	Update FDA accession number “FDA: 1410968-001 (2015/09)” in “Appendix A :: Specifications” (page 11). Added clarifications regarding the “I2C interface” 8 bit value consisting of “7 address bits plus 1 read bit” (pages 7 & 9). Update “Figure 9 :: LightWare Terminal showing menu options” (page 8). Updated menu option “c: Serial port baud rate (9600 … 115200)” (pages 5 & 8). Updated menu option “d: I2C bus address” (pages 5 & 9). Updated menu option “Analog 2.56 V distance” to “e: Analog distance range” (pages 5 & 9). Include new menu item “f: Analog voltage range” (pages 5 & 9). Include new menu item “g: Analog polarity” (pages 5 & 9).
Rev 7	2015/06/09	TLP	Updated product part code “Main cable type 1, 35 cm” (page 12).
Rev 6	2015/01/26	TLP	Updated value: I2C bus address is entered as an “8” bit, hexadecimal number (page 9). Include “Appendix C :: SF10 Communications cable assembly” (page 12). Include “Appendix D :: Electromagnetic interference (EMI) graphs” (page 13).
Rev 5	2014/11/19	TLP	Update product code references: “SF10/A” to “SF10/B (50 m)”; “SF10/B” to “SF10/C (100 m)” and “SF10/C” to “SF10/A (25 m)”. Update “2. Quick start guide” software menu item references for: “Ground offset” to “Zero datum offset”; “Altitude filter” to “Smooth output”; and “Analog 2.56 V altitude” to “Analog 2.56 V distance” (page 5). Amend “2. Quick start guide” I2C bus address to “0 … FF” (page 5). Update “a: Zero datum offset” range from “0.00 m … +10.0 m” to “-10.00 m … +10.00 m” (page 5 & 8) Include FDA accession number “FDA: 1410968-000 (2014/10)” in “Appendix A :: Specifications” (page 11).
Rev 4	2014/09/30	TLP	Include “Figure 2 :: Applications” (page 4).
Rev 3	2014/09/29	TLP	Include maximum range specifications and update rate for the SF10/B and SF10/C modules (page 3). Updated “Summary of the settings” to include SF10/B model (page 4). Include information and specifications for SF10/B model (page 10).
Rev 2	2014/09/25	TLP	Include information and specifications for SF10/C model (page 10). Updated references to “Damping” to “Altitude filter”. Update quick start settings table (page 4). Updated “Figure 8 :: LightWare Terminal showing menu options” (page 7). Update “Appendix A :: Specifications” (page 10).
Rev 1	2014/08/25	TLP	Update reading rate to “32” per second (pages 1, 3, 8 & 10). Update accuracy specification to “±0.04 meter (70% reflective target @ 20°C)” (page 10).
Rev 0	2014/07/12	JEP	First edition

www.lightware.co.za • info@lightware.co.za