The

compact

LiDAR sensor

for drones,

autonomous vehicles

and robots

Features:

- *Small size laser rangefinder when weight and size are critical*
- *Long range measurements up to 100 meters to sense remote objects*
- *Up to 388 readings per second for fast detection of obstacles*
- *IP67 enclosure prevents damage from water and dust*
- *Built-in drivers to make a scanning LiDAR by adding a digital servo*
- *First and last return signals are available to suit your application.*

bsi. ISO 9001 Quality Management

FM 654831

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Product ordering codes

Model family	Model name	Model description
LW20	LW20/B (50 m)	LiDAR sensor with serial and I2C output, max 50 m
LW20	LW20/C (100 m)	LiDAR sensor with serial and I2C output, max 100 m
SF20	SF20/B (50 m)	Open frame LiDAR sensor with serial and I2C output, max 50 m
SF20	SF20/C (100 m)	Open frame LiDAR sensor with serial and I2C output, max 100 m

Disclaimer

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1. Overview of the LW20

The LW20 LiDAR is a compact laser rangefinder for use on drones, self-driving vehicles and robots. It is designed to connect to many different processors using a serial or I2C protocol and runs from a single 5 V power source.

The LW20 LiDAR offers professional grade performance in a tiny form factor. It can be used as a distance measuring sensor or attached to a servo to create LiDAR maps that sense the world as two dimensional images.

Measurements can be made to target surfaces up to 100 meters away in sunlit conditions. In scanning mode up to 388 measurements can be made each second. The data can be streamed from the communication ports or analysed internally to look for potentially hazardous alarm conditions.

The LW20 is also available as an open frame module for OEMs using part code SF20.
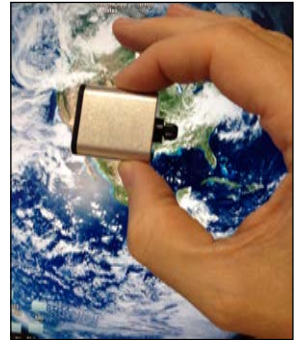
2. What can the LW20 do?

The LW20 can be used as an altimeter on multi-copter drones to measure the exact height above ground level or to set off alarms when the ground gets too close.

Height above ground

Alarm distance A

Alarm distance B
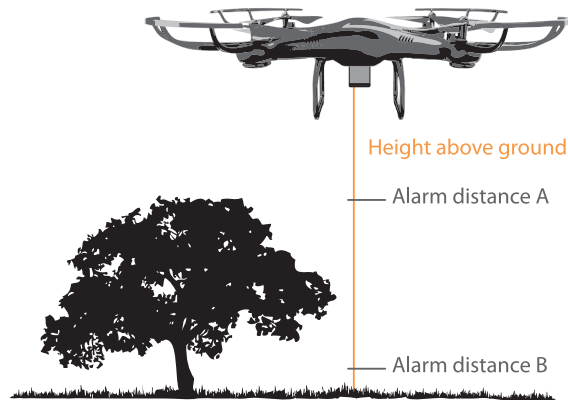
Figure 1 :: Measuring exact height above ground

With a servo attached, the LW20 becomes a low cost, lightweight collision avoidance sensor.

Scan limit

Alarm zone

Field of view

Scan limit
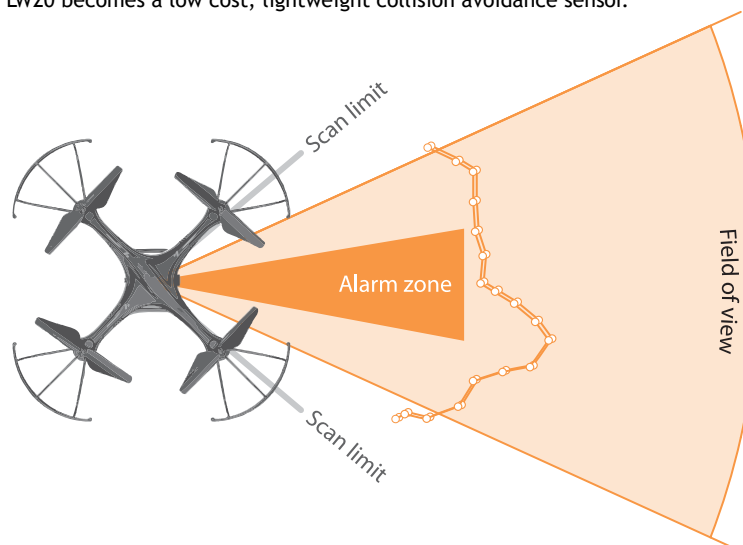
Figure 2 :: Collision avoidance zones

Used on autonomous vehicles, the LW20 can be a forwards looking obstacle sensor or can be used to create "SLAM" maps to aid in navigation.

Figure 3 :: Autonomous vehicle navigation

What's your application?

3. What are the main characteristics of the LW20?

There are two models available, the LW20 and the SF20. The LW20 is a sealed unit suitable for outdoor applications. It can easily be added onto existing products.
The SF20 is an open unit suitable for clean and dry applications or as an OEM component that is built-in as standard equipment.
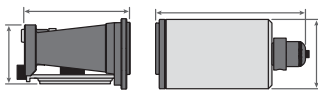
The LW20 housing measures 20 mm x 30 mm x 35 mm.
The SF20 assembly measures 20 mm x 30 mm x 32 mm.

The LW20 is waterproof to IP67 standard. It can be submerged in water to a depth of 1 meter for 15 minutes and is protected against dust ingress.
Please note that the SF20 is not waterproof.

The LW20 weighs less than 20 grams (excluding cables). This makes it ideal for applications where the low weight and small size are important.
The open frame SF20 weighs less than 10 grams. Use this module when low mass is the defining specification.

The power supply, communications and servo driver signals are connected to the LW20 / SF20 using the built-in cable.
The cable has a shield that should be earthed to reduce electrical interference.

The power supply voltage must be between 4.5 V and 5.5 V and the LW20 draws about 130 mA while measuring.
It is good practice to make sure that the power supply is able to deliver more current than need and to make sure that the voltage is stable and clean from spikes.
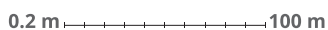
The LW20 has a maximum measuring range of 100 meters with a resolution of 1 centimeter. The accuracy of each measurement is ±10 centimeter.

New measurements are updated at a preset rate from a slowest of 48 readings per second to a maximum of 388 readings per second.
The slower speed measurements give better measuring range and are useful for laser altimeters or static distance measurements. The faster speed measurements are better for scanning applications when the LW20 is attached to a servo.

The LW20 uses a laser to take time-of-flight measurements. The laser is rated Class 1M. Do not view the laser with magnifying optics such as microscopes and telescopes.

The LW20 is able to measure the first and last return signals when there is more than one object in the laser beam.

Measuring the distance to the nearest object and the furthest object allows a drone to get information about potential collisions with trees while simultaneously following the terrain at a known height above ground.

Objects must be separated by approximately 5 meters before they are seen as separate return signals.
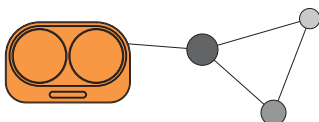
There are three different ways to communicate with the LW20:

- For machine-to-machine communication there is a built-in command set that uses ASCII mnemonics. These commands work via the serial or the I2C ports.

- For human-to-machine communication there is an internal menu system that can be accessed using a generic terminal application via the serial port. The LightWare Terminal application can be used for this.

- For interactive and graphical communication there is a GUI based Terminal application available from the LightWare website. This application also uses the serial port.

4.   Specifications of the LW20 / SF20

	LW20/B (50 m)	LW20/C (100 m)	SF20/B (50 m)	SF20/C (100 m)
Weight	20 g (excluding cables)	20 g (excluding cables)	10 g (excluding cables)	10 g (excluding cables)
Range	0.2 … 50 m (sunlit white wall, 45 readings per second)	0.2 … 100 m (sunlit white wall, 45 readings per second)	0.2 … 50 m (sunlit white wall, 45 readings per second)	0.2 … 100 m (sunlit white wall, 45 readings per second)
Resolution	1 cm	1 cm	1 cm	1 cm
Update rate	48 … 388 readings per second	48 … 388 readings per second	48 … 388 readings per second	48 … 388 readings per second
Accuracy	±10 cm	±10 cm	±10 cm	±10 cm
Outputs & interfaces	Serial and I2C (3.3 V)	Serial and I2C (3.3 V)	Serial and I2C (3.3 V)	Serial and I2C: 3.3 V
Power supply voltage	4.5 V … 5.5 V	4.5 V … 5.5 V	4.5 V … 5.5 V	4.5 V … 5.5 V
Power supply current	130 mA	130 mA	130 mA	130 mA
Laser power	<2 mW	<2 mW	<2 mW	<2 mW
Dimensions	19.5 mm x 30.2 mm x 35 mm, housing only 19.5 mm x 30.2 mm x 43 mm with cable gland	19.5 mm x 30.2 mm x 35 mm, housing only 19.5 mm x 30.2 mm x 43 mm with cable gland	19.5 mm x 30.2 mm x 32.1 mm	19.5 mm x 30.2 mm x 32.1 mm
Operating temp.	-30 .. +50˚C	-30 .. +50˚C	-30 .. +50˚C	-30 .. +50˚C
Approvals	FDA: 1710193-000 (2017/09)	FDA: 1710193-000 (2017/09)	FDA: 1710193-000 (2017/09)	FDA: 1710193-000 (2017/09)
Housing	Aluminium, ABS plastic and glass	Aluminium, ABS plastic and glass	ABS plastic and glass	ABS plastic and glass
Optical aperture	28 mm x 15 mm	28 mm x 15 mm	28 mm x 15 mm	28 mm x 15 mm
Beam divergence	0.3˚	0.3˚	0.3˚	0.3˚
Lens material	Glass	Glass	Glass	Glass
Connections	Wire tail, 5 core plus shield	Wire tail, 5 core plus shield	Wire tail, 5 core plus shield	Wire tail, 5 core plus shield
Enclosure rating	IP 67	IP 67	N/A	N/A

Cautionary note

The SF20 is an OEM module that requires the customer to provide appropriate heat sinking and EMI shielding.

5. How to communicate with the LW20 using the graphical interface

To use the graphical interface to setup and test the LW20 you will need to connect the serial port of the LW20 to the USB port on a PC. This is done using a serial-to-usb converter such as the TTL-232R-3V3-WE converter cable from FTDI (http://www.ftdichip.com/Products/Cables/USBTTLSerial.htm). This converter provides both the signals and power supply to the LW20.

Figure 4 :: Connection to a USB converter cable

Once the converter is wired up to the LW20, prepare the Terminal application on the PC as follows:

- Download and instal the latest Terminal application from the LightWare website
- Open the Terminal application
- Select the "Settings" icon
- Set the baud rate to 115200
- You can tick the "Remember settings" box if you intend to use this configuration again
- Apply the change to close the dialog window
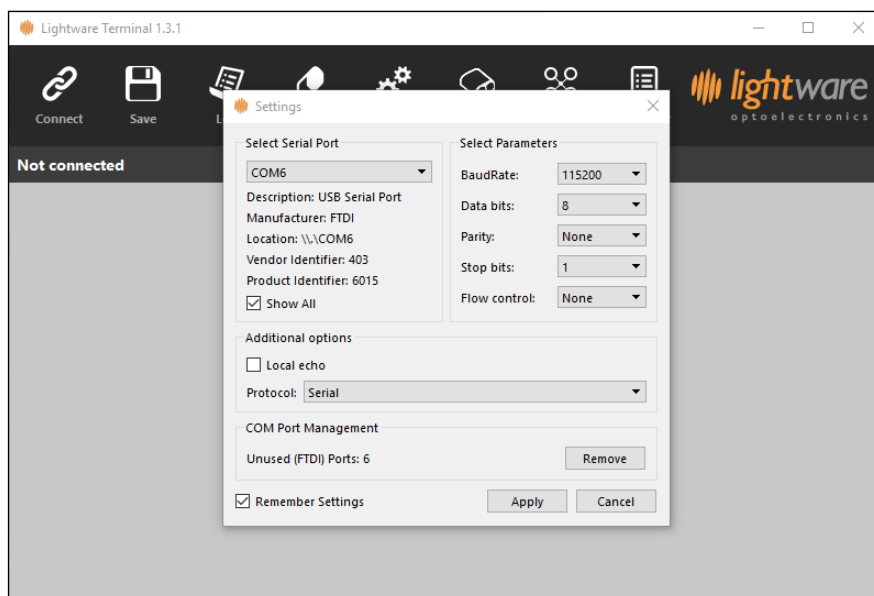

Figure 5 :: Setting the baud rate for LW20 communications

To establish communication between the LW20 and the graphical interface:

- Plug the LW20 converter into a USB port on the PC
- Click the "Connect" icon - a notice of the connection and its associated USB port number should become visible on the toolbar
- Press the "LW20" icon - this opens the graphical interface home screen

There are four tabs at the top of the home screen. Each one provides a visualization of the settings inside the LW20 and guides you through the setup process as follows:

- The "Home" tab shows the welcome screen with shortcuts to other screens shown near the bottom
- The "Setup" tab is for checking or entering settings with graphical indicators showing the effect of any changes
- The "Parameters" tab gives a tabulated summary of all the settings
- The "Operate" tab is a graphical display that shows the LW20 working with the settings that you have entered
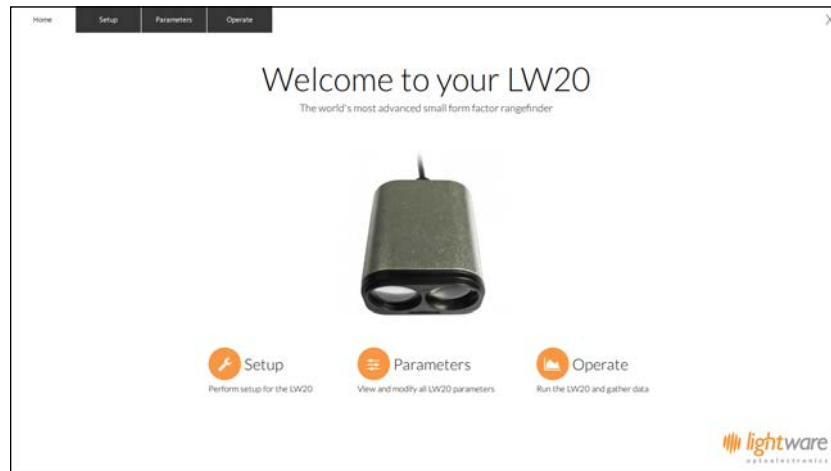
Figure 6 :: The graphical interface Home screen

The "Setup" tab is divided into three functional areas. On the left there are four buttons that group related settings together. In the middle column the names and values of each setting are shown in editable boxes. On the right of the screen there is a graphic visualizing the group of settings.

The four Setup buttons have the following features:

- The "Laser" button is for settings that relate to distance measurement, communication and encoding
- The "Servo" button is to configure the physical parameters of servo chosen for scanning
- The "Sweep" button defines the software limits of the scan
- The "Alarm" button is used to create software controlled, two dimensional alarms
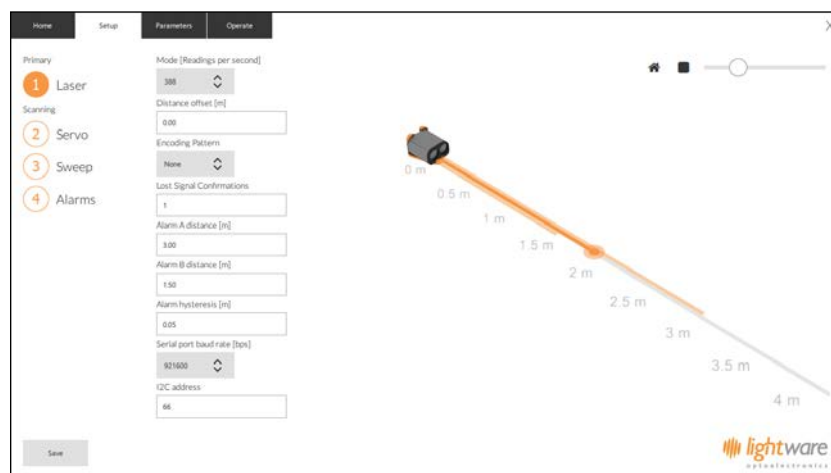
Figure 7 :: The graphical interface Setup screen

Details of each button and how to use the settings are given later in this manual.

Note that any settings changes are not automatically saved. The "Save" button must be pressed if you want to keep the changes. The graphics can be manipulated to alter their position and angle of view using the left and right mouse keys. There is a scale slider in the top right hand corner along with icons to return to the default isometric view or change to a view from above.

The "Parameters" tab gives a summary of all the available settings, grouped into columns to match the buttons on the "Setup" tab. This tab is useful to users who are familiar with effects of each setting and know what values to enter for their application.
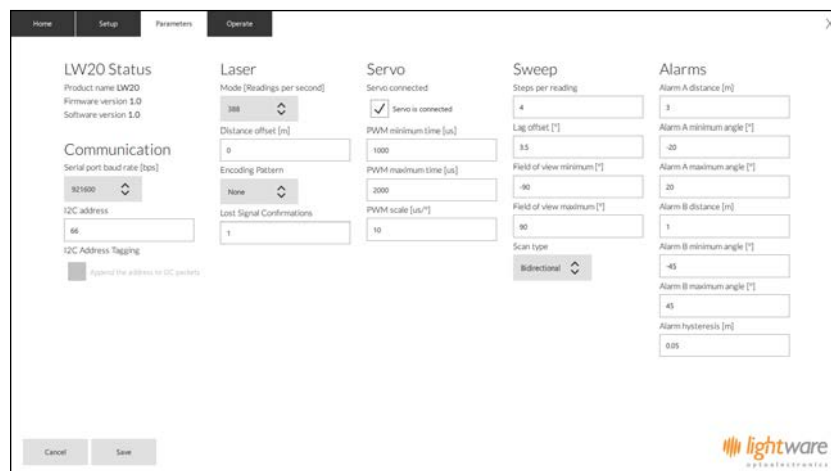
Figure 8 :: The graphical interface Parameters screen

The "Operate" tab shows a graphic that can be used for display purposes. Different elements can be added or removed from the image using the tick boxes and the view can be changed to represent either single point distance measurement or two dimensional LiDAR scanning.
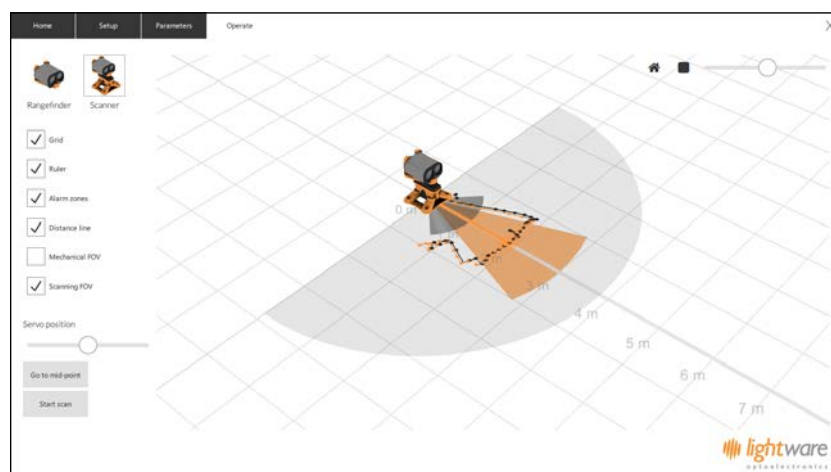
Figure 9 :: The graphical interface Operate screen

6. How to communicate with the LW20 using a terminal emulator

To use a terminal emulation application to setup and test the LW20 you will need to connect the serial port of the LW20 to the USB port on a PC. This is done using a serial-to-usb converter such as the TTL-232R-3V3-WE converter cable from FTDI (http://www.ftdichip.com/Products/Cables/USBTTLSerial.htm). This converter provides both the signals and power supply to the LW20.

Figure 10 :: Connection to a USB converter cable

Once the converter is wired up to the LW20, prepare the Terminal application on the PC as follows:

- Download and instal the Terminal application from the LightWare website
- Other terminal emulation programs with the correct communication parameters will also work
- Open the Terminal application
- Select the "Laser" icon
- Set the baud rate to 115200
- You can tick the "Remember settings" box if you intend to use this configuration again
- Apply the change to close the dialog window
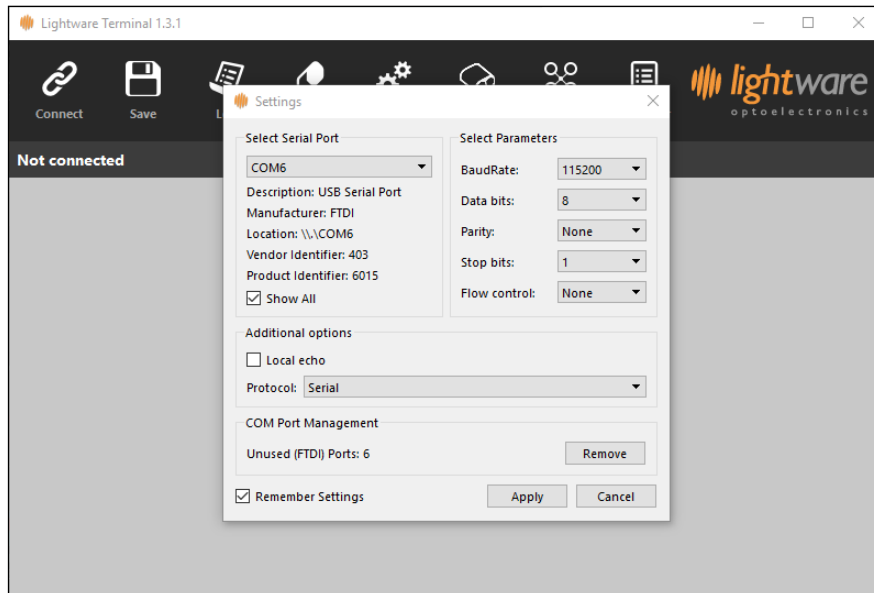
Figure 11 :: Setting the baud rate for LW20 communications

To establish communication between the LW20 and the Terminal application:

- Plug the LW20 converter into a USB port on the PC
- Click the "Connect" icon - a notice of the connection and its associated USB port number should become visible on the toolbar
- Press the **<up arrow>** to engage serial communication mode. The LW20 will reply with a product code.
- The LW20 is now running in machine-to-machine mode and will respond to the set of machine commands
- Press the **<?>** key followed by **<CR>**. The LW20 will reply with the product code, hardware revision and software revision

In this mode, the LW20 will respond to the command set normally used by a controller to communicate using either the serial or I2C ports. The "**?**" command mentioned above is the command used to identify the LW20. The full command listing can be found in Appendix C.

Pressing the **<ESC>** key switches the LW20 into human-to-machine mode providing data and menus in an easy to read format. You can navigate between the menus and live data streams using the arrow keys. There are four screens available, two show the LW20 setup and two show the setup of the servo if it is attached.
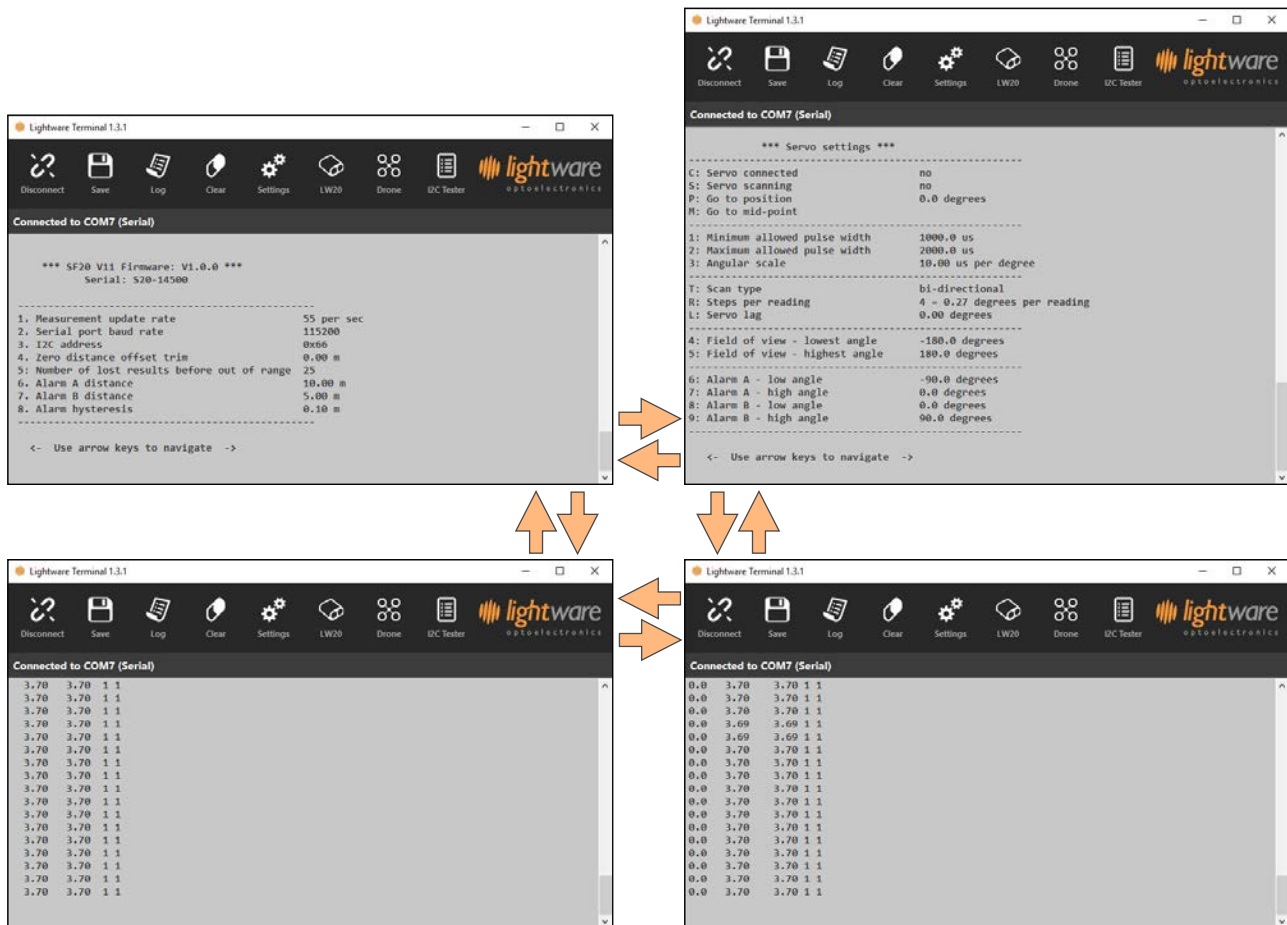
Figure 12 :: Arrangement of screens in terminal emulation mode

Each item on a menu screen can be selected and changed by pressing the number or letter adjacent to the description. Some of the values are numeric while others will toggle between the available options. Note that any changes made here are stored immediately in permanent memory and will remain valid after the power is removed.

The columns on the live data screens show the distances (first and last signals) and alarm status. The live data screen associated with the servo setup also includes the aiming angle of each reading in the first column.

Pressing the **<~>** key switches back into machine-to-machine mode.

6.1 How to communicate with the LW20 using the Devantech USB to I2C module
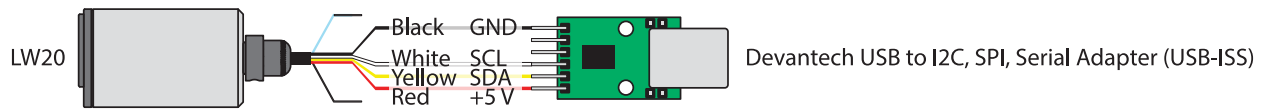
Figure 13 :: Connection to a Devantech USB-ISS module

The I2C interface is designed for machine-to-machine communications with multiple devices over a small network. In order to test the I2C interface on the LW20, an I2C to USB converter can be connected and a limited number of commands can be sent to the LW20 using the LightWare Terminal application.
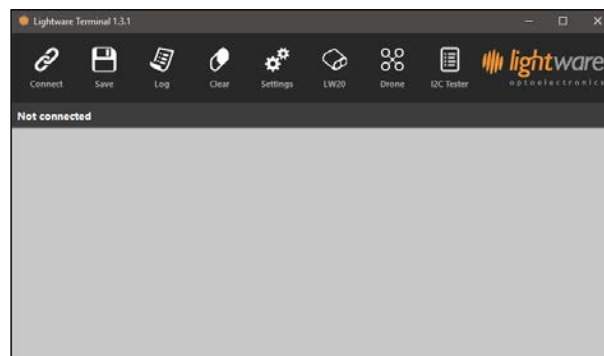
Figure 14 :: The LightWare Terminal application top level window showing the toolbar

Select the correct protocol using the "Settings" icon on the toolbar of the LightWare Terminal. This should match the I2C converter being used and in this example the Devantech USB-ISS adaptor is shown.
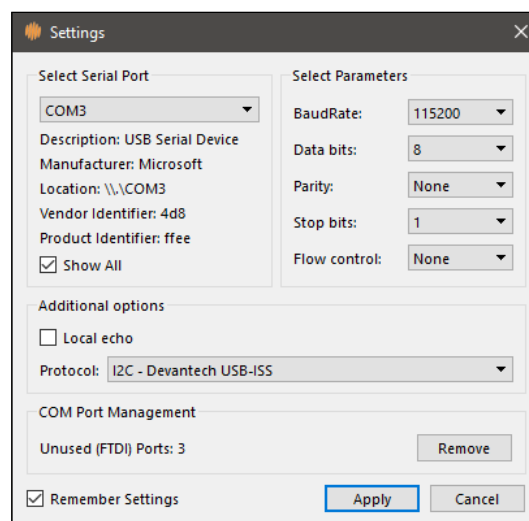
Figure 15 :: Selecting the Devantech I2C-ISS converter

Once the correct setting is applied, commands can be sent and results viewed by selecting the "I2C Tester" icon and pressing the one of the test buttons available in the dialog box.
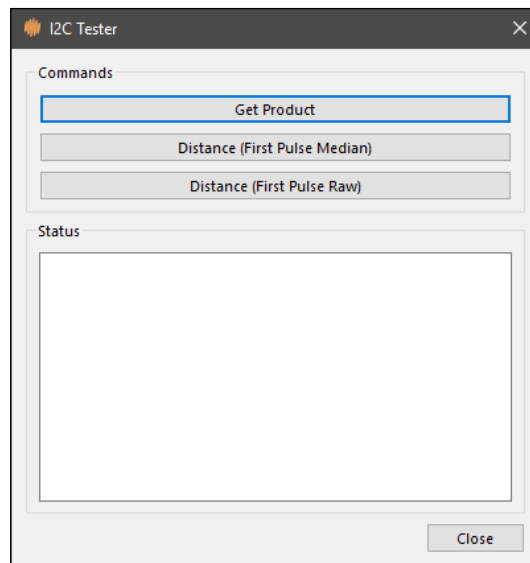
Figure 16 :: I2C test dialog box showing command buttons

The factory default I2C bus address is **0x66**.

7. How to communicate with the LW20 using a controller

The LW20 is designed to communicate with a host controller. This controller can be a single board computer, flight controller or a PC.

There are two communications interfaces available, serial and I2C. The LW20 will wait for the first command to confirm which communication mode to select (serial or I2C). The first command will not get a response.

The serial port is a one-to-one protocol that lets a single LW20 talk to a single host controller. The serial interface uses 3.3 V logic to transmit results and receive commands.

Multiple LW20's with an I2C port can be connected onto an I2C bus. The I2C interface uses 3.3 V logic to receive commands from a master device.

The communication language for both the serial and I2C ports is based on ASCII commands and messages. Command strings take the form of simple mnemonics and results are provided as text strings.

A command string is made up of:

- A directive that indicates what action to take
- A channel that represents a functional block containing related information
- An index that determines which value is being acted on
- A numeric value if needed
- **<CR><LF>** indicates the end of the command

There are four different directives, each using a single ASCII character:

?	Fetch a value
#	Write a value
$	Stream live results
%	Save changes

There are six channels available inside the LW20:

|	
P	The Product channel contains product related information
L	The Laser channel contains all laser related information
S	The Servo channel contains all servo related information
C	The Communication channel handles serial and I2C data
A	The Alarm channel provides alarm status information

A typical command sent by the host controller would be:

?PN<CR><LF>

Which means: What is your Product Name?

The LW20 / SF20 would reply with:

PN:LW20 <CR><LF>

Which means: Product Name : LW20

Full details of the communication language are given in Appendix C.

8. How to do an initial setup of the LW20

Using the GUI, Terminal or machine commands the measuring characteristics of the LW20 can be tailored to suit different applications. The primary settings can be found by pressing the "Laser" button under the "Setup" tab of the GUI or on the main menu screen of the terminal.
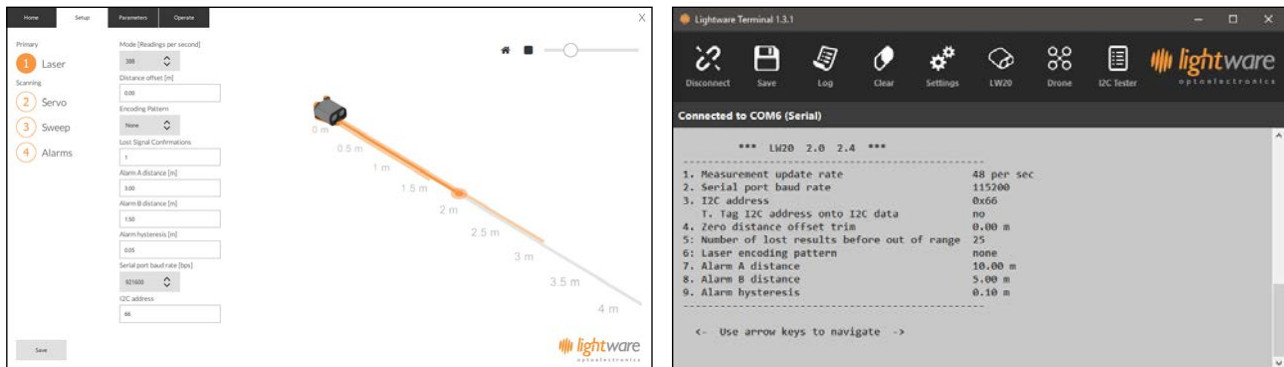
Figure 17 :: Initial setup using the GUI or terminal emulation

Details of the initial settings are given in the table below.

Setting name	Range of values	Description
Mode (update rate)	48 … 388 readings per second	Sets the rate at which distances are measured.
Zero distance offset	-10.00 … 10.00 meters	Moves the point at which the measured distance reads zero. This is to correct for errors introduced by the mounting position.
Lost signal confirmation	1 … 250	Sets the number of readings that must be taken before a lost signal or out-of-range condition is reported. This value prevents brief losses of signal from affecting the distance results.
Alarm A distance	0 … 100 meters	Sets the activation distance of alarm A. This is the distance below which the alarm changes state from '0' to '1'.
Alarm B distance	0 … 100 meters	Sets the activation distance of alarm B. This is the distance below which the alarm changes state from '0' to '1'.
Alarm hysteresis	0 … 10 meters	The alarm hysteresis prevents the alarms from switching rapidly between states when the target surface is at the activations distance. Activation occurs at the set distance minus the hysteresis distance and deactivation occurs at the set distance plus the hysteresis distance.
Serial port baud rate	9600 … 921600	Select the baud rate for the serial communication port. Note that new values take effect after they are saved and power is cycled, the factory default is 115200.
I2C address	0x00 … 0x7F	The address of the LW20 on the I2C bus, the factory default is 0x66.

9. How to set up a scanning LiDAR using a digital servo

The LW20 can be converted into a scanning LiDAR by attaching it to a digital servo and using the built-in servo driver hardware and software. The LiDAR data can be streamed live or used to activate two internal alarms. This makes a useful SLAM mapping device or a collision sensor.

The servo driver works with most standard digital servos. Note that analog servos are not compatible as they respond too slowly to the control signals produced by the LW20. The LW20 is connected to the servo as shown in the diagram below:
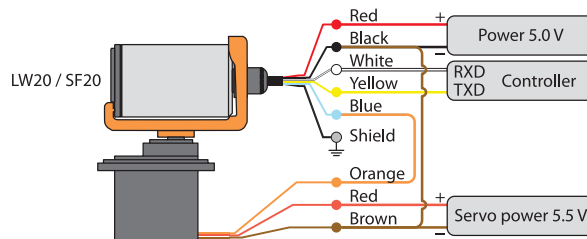
Figure 18 :: Servo connections

To reduce the chances of power supply spikes affecting the performance of the LW20, it is important to run the servo from a separate power supply. Check the servo specifications for the correct voltage and current ratings and make sure that there is a common connection to the negative rails of the LW20 and servo power supplies.

Communications to the LW20 and the servo can be made through either the serial port or via an I2C bus. In this guide we will use the serial port and the GUI interface to set up the servo parameters and configure automatic scanning.

Select the "Servo" button under the "Setup" tab to access the initial servo configuration graphic.
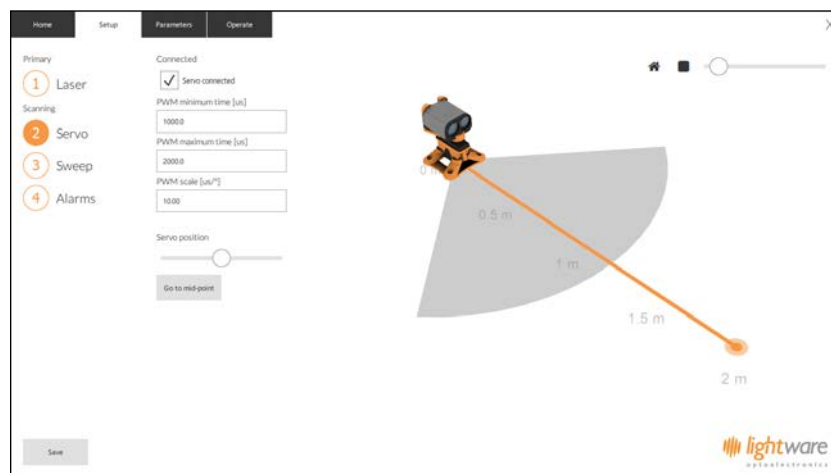
Figure 19 :: Setting up the electrical and mechanical characteristics of the servo

With the LW20 connected to the GUI, settings can be entered and saved even without the servo attached. This is useful if you already know what values to enter for your chosen servo. If the servo is connected, then ticking the "Connected" box and entering settings through the GUI will result in live movements of the servo, allowing you to see the effect of the new values.

The servo position is controlled by a pulse-width modulated (PWM) signal coming from the blue control line of the LW20. This signal can change in width from 0us to 3000 us in steps of 0.7us and updates 333 times per second. A given servo will be limited to a specific range of PWM widths, corresponding to the physical limits of rotary motion.

By default the minimum PWM width is set to 1000 us and the maximum PWM width to 2000 us. This is suitable for most servos but new values can be entered if needed. If a new value beyond the capabilities of the servo is entered, the servo may draw too much power, get hot or buzz.

> **CAUTION:** Setting PWM values outside the specified range of the servo may cause damage to the servo.

When viewed from above, the lower PWM setting turns the servo shaft to the extreme left position and the higher PWM setting turns it to the extreme right. The midpoint position corresponds to the PWM value that is halfway between the two end settings.
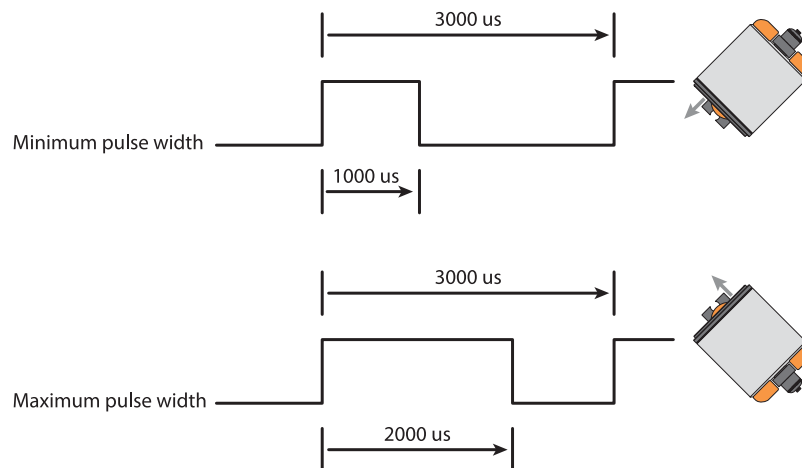
Figure 20 :: Setting the servo's limits of motion using the PWM values

For each degree of motion by the servo, the PWM pulse width needs to change by a specific number of us. This "PWM scale" can usually be found on the data sheet of the servo. Alternatively, you can measure how many degrees the servo moves for a 1000 us change in PWM pulse width and calculate the PWM scale from this result. The default scale value is 10.00 us per degree as shown in the picture below:
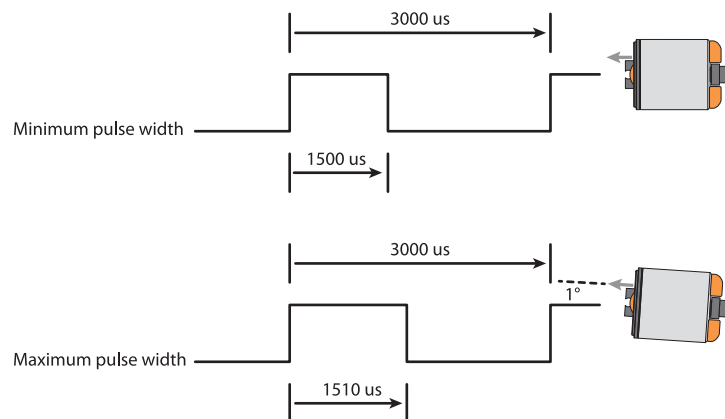
Figure 21 :: Setting the servo's PWM scale

Once the settings have been entered, the servo can be manually positioned using the slider near the bottom of the graphic page. This slider works in 5 degree increments. The central or middle position can be checked by pressing the "Go to midpoint" button. The midpoint should be lined up with the forward direction of whatever the servo is mounted on. In the graphic, the physical range of angular motion of the servo is shown as a grey segment.

Note that settings will only be saved to the LW20 once the "Save" button in the bottom left corner of the screen has been pushed.

Once the electrical characteristics of the servo have been entered using the method above, the servo can be used to aim the LW20 in a specific direction or autonomously scan the LW20 to produce LiDAR maps and provide collision warning alarms.

Configuring the scanning motion is done by selecting the "Sweep" button under the "Setup" tab. Note that the settings entered here are limited by the physical and electrical characteristics of the servo. Only the first return signal is shown on the graphic.
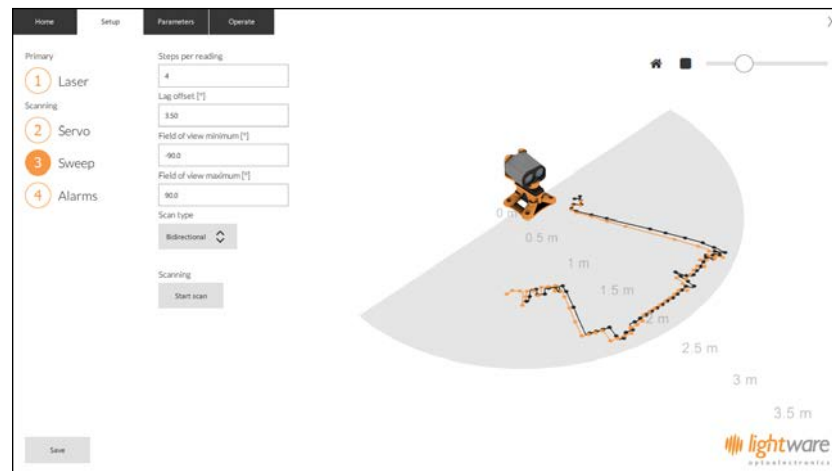
Figure 22 :: Setting up the servo's scanning characteristics

The speed of the scan is determined by how fast the LW20 updates and the number of steps that the servo moves with each reading. The "Steps per reading" box increases or decreases this speed as does the update rate setting in the "Laser" section. Running the servo faster increases its power consumption but provides a faster response to changes in measurements. If the servo moves too fast its range of motion may be decreased.

Each direction of the scan is indicated in a different color on the graphic. This is to emphasize the effect of "servo lag" that most servos exhibit when moving at a constant speed. Servo lag comes about because servos are designed to aim in a fixed direction and their control systems are optimized for this type of action. When the servo moves continuously, the control loop isn't able to catch up with the aiming direction and always lags behind.

The number of degrees of lag is different for different servos, at different speeds and at different power supply voltages. To correct for this lag enter a value in the "Lag offset" box. This is typically between 0.5 degrees and 10 degrees depending upon the torque, speed and quality of the servo. By making small adjustments to the lag offset the images from each direction of scan can be made to coincide, as seen in the picture below.
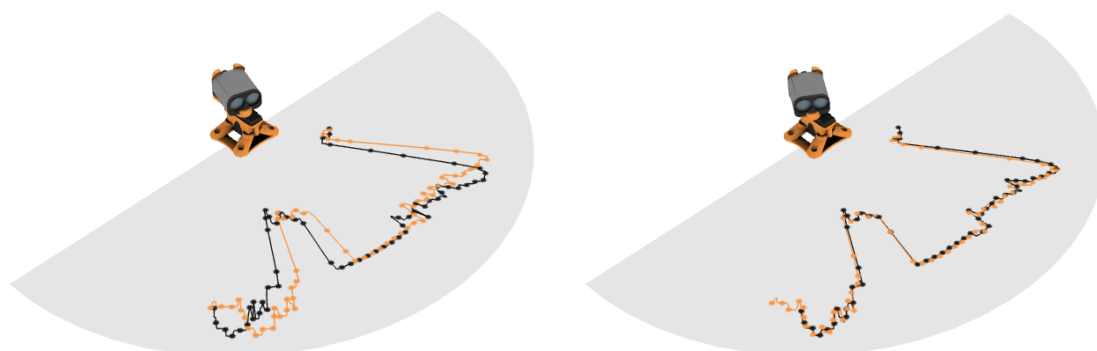
Figure 23 :: The effect of servo lag with no correction and after applying a 2.5 degree correction

Once the servo lag has been corrected, the mechanical motion of the servo will remain consistent. From time to time the settings should be checked in case wear on the gears or changes to the power supply have affected the servo.

In most applications, the field of view of the scanning pattern will need to be reduced. This could be because of fixed objects inside the scanning area or to remove errors at the edges of the scan caused by the servo changing direction.

Changing the field of view does not affect the physical motion of the servo as this would upset the PWM and servo lag settings. Instead, the field of view cuts out unwanted data from the edges of the scanned image. The left and right edge settings of the field of view can be changed independently.
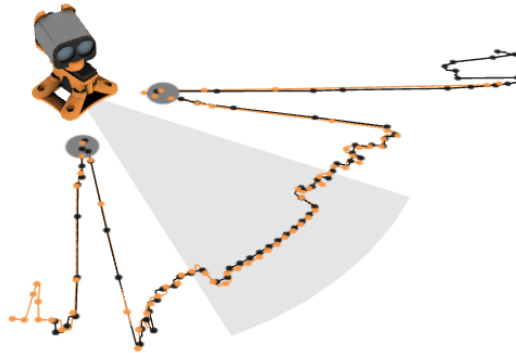
Figure 24 :: Reducing the field of view to avoid detecting the landing legs on a drone

For high precision scanning, the servo can be made to scan in one direction only. The resulting image has higher angular repeatability at the expense of increased power consumption by the servo when returning to the start of the scan. Switching from bi-directional to uni-direction scans is done using the "Scan type" selection box.
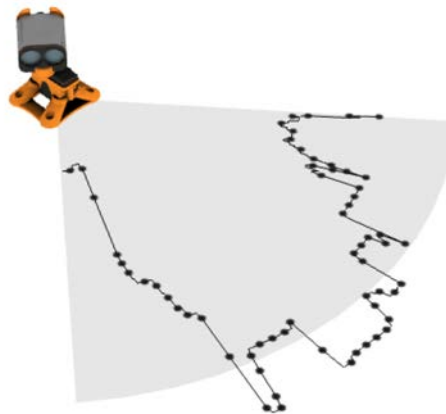
Figure 25 :: Uni-directional scanning for higher precision

10. How to set up the alarms

The LW20 has two alarms, A and B, that be can used to warn when objects get too close. The alarm changes from a 0 state to a 1 state when an object is detected closer than the set distance. The alarms are updated every time a new distance measurement is taken.

The alarm distances and hysteresis can be set using the "Laser" button found under the "Setup" tab. The alarms settings are indicated on the graphic along side the distance measurement.
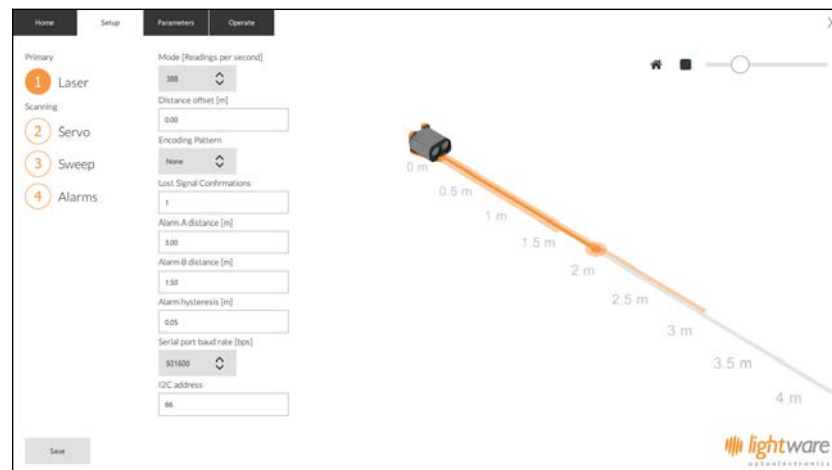
Figure 26 :: Setting the alarms to warn of nearby objects

The alarms can also be used in scanning mode when the LW20 is attached to a servo. In this case, the alarms become two dimensional with distance and angle settings. Two dimensional alarms update at the ends of each sweep and remain in a fixed state for the duration of the sweep, giving the host controller time to check the alarm status.

The two dimensional alarm settings can be found using the "Alarms" button under the "Setup" tab. The segment representing alarm A is indicated in orange and alarm B is indicated in grey. The colored areas flash when an object is detected inside the alarm zone.
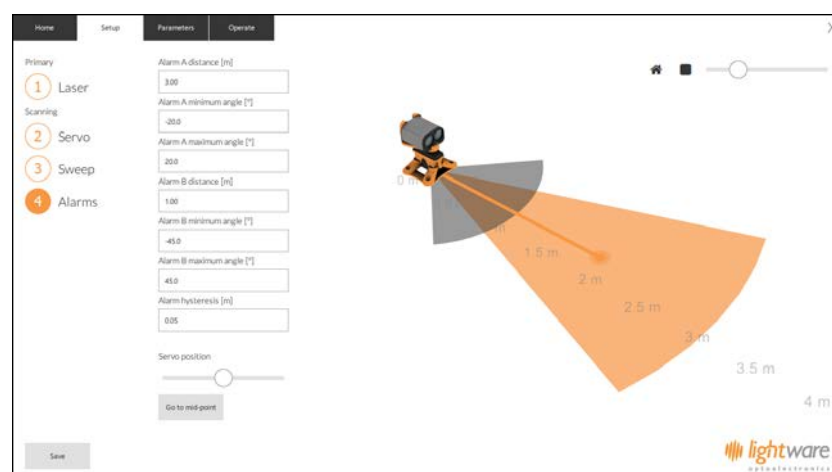
Figure 27:: Setting two dimensional alarms

You can use the position slider to check the activation of the alarms at different scanning angles.

11. Limitations

The maximum range can be reached on white painted walls that have high reflectivity and a large surface area. Surfaces that are darker in color or smaller in size can only be measured at shorter ranges.

12. Instructions for safe use

The LW20 is a laser based altimeter 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 0.5 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 LW20 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 LW20. 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 LW20 but if the lenses start to collect dust then they may be wiped with suitable lens cleaning materials. Make sure that the LW20 is switched OFF before looking into the lenses.

Laser warning label · Company and product identification labels
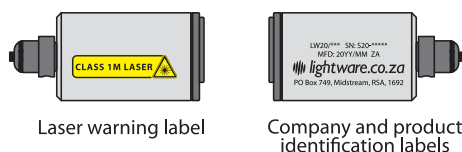
Figure 28 :: Laser radiation information and labels

Specification	Value / AEL	Notes
Eye safety classification	Class 1M	
Laser wavelength	905 nm	
Pulse width	15 ns	
Pulse frequency	10 kHz	
Peak energy	160 nJ	
Average power	< 1.2 mW	7 millimeter aperture
NOHD	0.5 m	Distance beyond which binoculars with may be used safely

Appendix A :: Dimension drawings
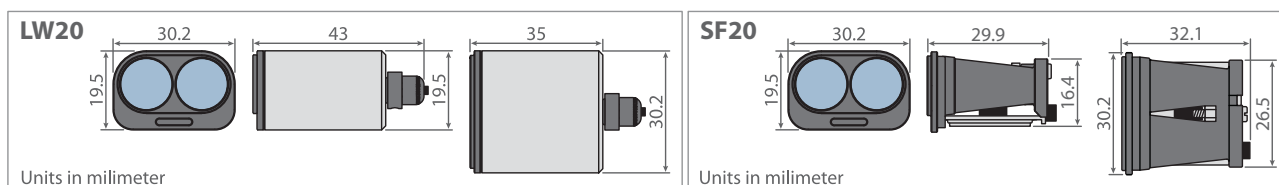
Figure 29 :: Dimension drawings of the LW20 and SF20
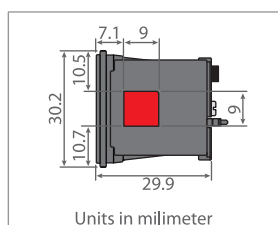
Figure 30 :: Heat sink contact area

Appendix B :: Cables and connections

Figure 31 :: Serial and power cable

	Part no.	Manufacturer part no.	Description
1	DK: 455-2177-ND	JST Sales America 08SUR-32S	Conn Rcpt 8 Pos 0.8mm Male
2		Daburn 2752/5	Sub-Miniature Shielded Cable 32 AWG, black
3	DK: 490-11141-ND	Murata FSRH044C00RNB00B	Ferrite Core 40 OHM Solid 1.5mm

NOTE: Wire colours are critical. Do not deviate.

LightWare Optoelectronics (Pty) Ltd | LA 000_093: LW/SF20 Serial & power cable | Rev: 2

Figure 32 :: Pinout diagram

Appendix C :: Complete command set for machine-to-machine communications

The LW20 has either a serial or an I2C communication port. Commands can be sent that read values, change settings or alter the performance of the LW20. Distances are in meters and temperatures in degrees celsius.

Commands are sent and responses received in ASCII format (human readable). These ASCII strings have a maximum of 32 characters.

NOTE: There are some special commands to make the LW20 compatible with older systems and these are in binary format.

Once a command has been sent a single reply will be returned. To continuously update the reply without re-sending the command the streaming ($) command can be used.

> **Note**
>
> The first command sent after power up will be used to detect if the LW20 is running in Serial or I2C mode, and therefore will not get a response.

Command string format:
  <command type><channel><parameter><index><,><numeric value><CR><LF>

Command types:
?   Read a value once. This can be either a result or a setting.
Change a setting. All settings can be changed.
$ Stream a value continuously. Update a result or a setting every time it changes.
%   Save a setting. The setting becomes permanent even after the power is switched off.

Channels:
P   Product channel - provides product specific information
L   Laser channel - provides distance measurements and related settings
S   Servo channel - relates to servo position and settings
A   Alarm channel - shows the status of alarms
C   Communications channel - handles serial and I2C settings

Examples:
?LDF,0   Read the median value of the distance to the first return signal
#LO,0.23 Move the measurement zero datum further away by 0.23 meters
$1LT   Stream the internal temperature in the first column
%P   Save all settings to permanent memory

Command list

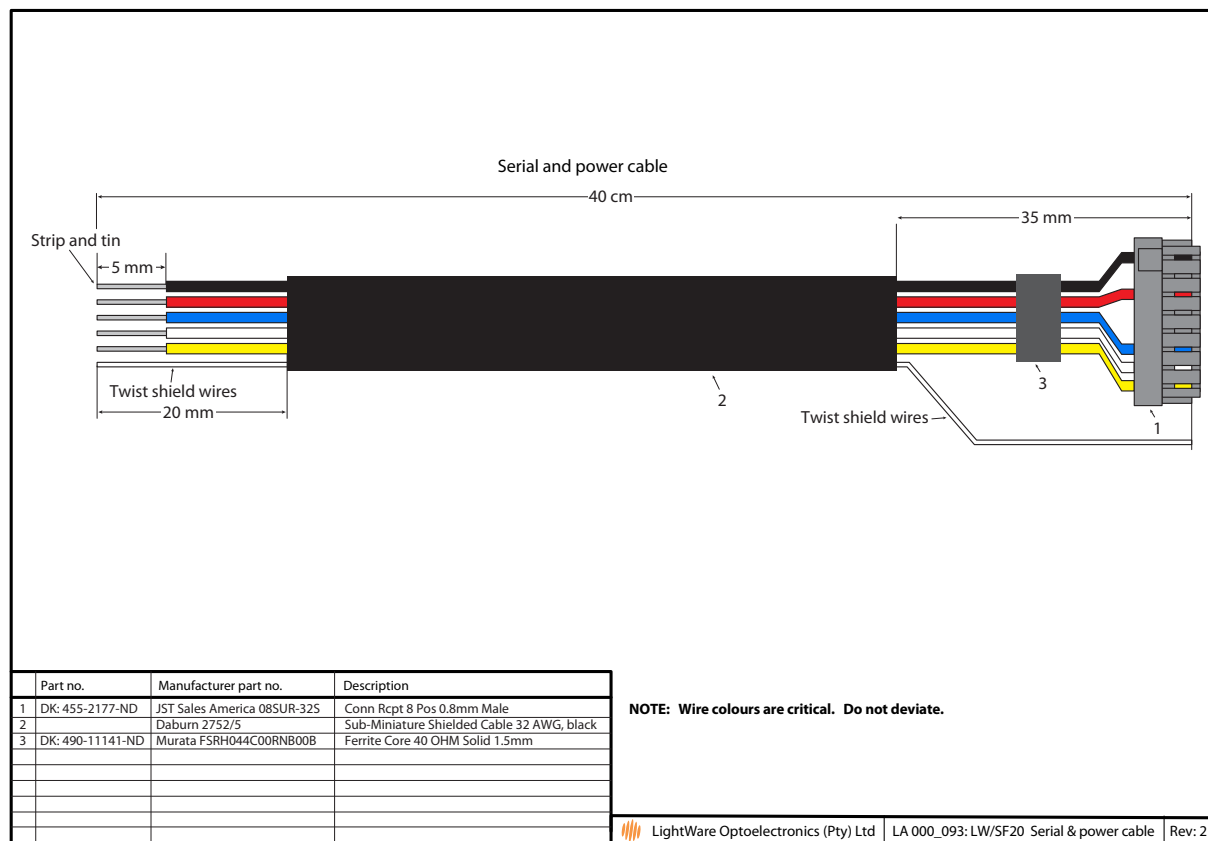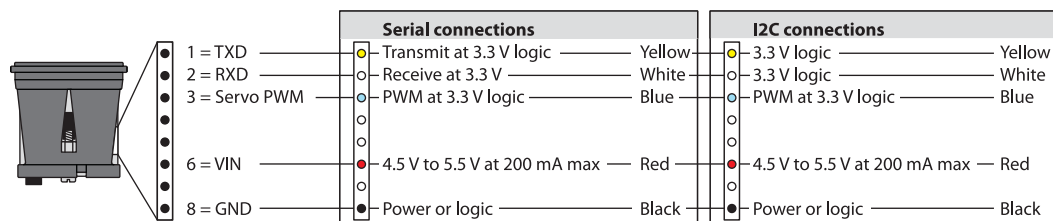| Command	Typical return	Description
		Product channel commands
? ?P	p:SF20,1.0.0,11	Product name, firmware version, hardware version
?PN	pn:SF20	Product name
?PF	pf:11	Hardware version
?PS	ps:1.0.0	Firmware version
%P	%p:	Save all new settings to permanent memory
		Laser channel commands
?L ?LD	l:3.35 ld,0:23.67	Default raw distance Default median distance
?LDF ?LDF,0 ?LDF,1 ?LDF,2 ?LDF,3	ldf,0:56.98 ldf,0:45.32 ldf,1:32.78 ldf,2:65.12 ldf,3:34.23	Median distance to the first return Median distance to the first return Raw distance to the first return Closest distance to the first return Furthest distance to the first return
?LDL ?LDL,0 ?LDL,1 ?LDL,2 ?LDL,3	ldl,0:56.98 ldl,0:45.32 ldl,1:32.78 ldl,2:65.12 ldl,3:34.23	Median distance to the last return Median distance to the last return Raw distance to the last return Closest distance to the last return Furthest distance to the last return

Command	Typical return	Description
?LH ?LHF ?LHL	lhf:100 lhf:100 lhl:78	Signal strength of first default signal (%) Signal strength of first return (%) Signal strength of last return (%)
?LO #LO,0.56	lo:0.14 lo:0.56	Read distance measurement datum offset Change to a new datum offset: Adjustment range = -10.00 ... 10.00
?LA ?LAA #LAA,5.00	laa:3.00 laa:3.00 laa:5.00	Read the first alarm distance Read the first alarm distance Change the first alarm distance: Adjustment range = 0.00 ... 100.00
?LAB #LAB,6.00	lab:3.00 lab:6.00	Read the second alarm distance Change the second alarm distance: Adjustment range = 0.00 ... 100.00
?LAH #LAH,0.05	lh:0.00 lh:0.05	Read the alarm hysteresis value Change the alarm hysteresis value: Adjustment range = 0.00 ... 10.00

?LM
#LM,1
	lm:5
	lm:1
		Check which measuring mode (update rate) is active
		Change to a new measuring mode (update rate):
		    1 = 388 readings per second
		    2 = 194 readings per second
		    3 = 129 readings per second
		    4 = 97 readings per second
		    5 = 78 readings per second
		    6 = 65 readings per second
		    7 = 55 readings per second
		    8 = 48 readings per second

?LF
#LF,0
	lf:1
	lf:0
		Check if the laser is running
		Change the laser state:
		    0 = laser is off
		    1 = laser is running

?LT	lt:35.7	Read the internal temperature
?LN	ln:0.5	Read the level of background noise
?LC #LC,16	lc:8 lc:16	Read the number of lost signal confirmations Change the number of lost signal confirmations: Adjustment range = 1 …. 250
?LB #LB,1.00	lb:0.00 lb:1.00	Read the gain boost value Change the gain boost value: Adjustment range = -20.00 ... 5.00
%L	%l:	Save all new settings to permanent memory
	Servo channel commands	
?S ?SC #SC,1	s:0 sc:0 sc:1	Check if a servo is connected Check if a servo is connected Connect the servo
?SS #SS,1 $1SS	ss:0 ss:1 ss:30.5,15.56,27.43	Check if the servo is scanning Turn on servo scanning Stream servo scanning data: ss:angle, first return, last return
?SP #SP,20.5	sp:0.0 sp:20.5	Read the current servo position in degrees Move the servo to a new position: Adjustment range = -180 ... 180
?SM #SM	sm:15.0 sm:0.0	Read the current servo position in degrees Move the servo to the middle position
?SWL #SWL,1100.0	swl:1000.0 swl:1100.0	Read the minimum allowed PWM time in us Change the minimum allowed PWM time: Adjustment range = 0.0 ... 2999.0
?SWH #SWH,1900	swh:2000.0 swh:1900.0	Read the maximum allowed PWM time in us Change the maximum allowed PWM time: Adjustment range = 0.0 ... 2999.0
?SWS #SWS,10.00	sws:9.00 sws:10.00	Read the us per degree scale of the servo Change the us per degree scale of the servo: Adjustment range = 0.1 ... 1000.0

Command	Typical return	Description

?ST
#ST,0
	st:1
	st:0
		Read the type of scan being used
		Change the type of scan:
		   0 = bidirectional scan
		   1 = unidirectional scan

?SR #SR,8	sr:4 sr:8	Read the number of servo steps per reading Change the number of servo steps per reading: Adjustment range = 1 … 32
?SL #SL,2.57	sl:1.32 sl:2.57	Read the servo lag angle in degrees Change the servo lag angle: Adjustment range = 0.00 … 90.00
?SFL #SFL,-30.0	sfl:-45.0 sfl:-30.0	Read the lower angle of the field of view Change the lower angle of the field of view: Adjustment range = -180.0 … 180.0
?SFH #SFH,30.0	sfh:45.0 sfh:30.0	Read the higher angle of the field of view Change the higher angle of the field of view: Adjustment range = -180.0 … 180.0
?SAL #SAL,-15.0	sal:-45.0 sal:-15.0	Read the lower angle for alarm A Change the lower angle for alarm A: Adjustment range = -180.0 … 180.0
?SAH #SAH,0.0	sah:45.0 sah:0.0	Read the higher angle for alarm A Change the higher angle for alarm A: Adjustment range = -180.0 … 180.0
?SBL #SBL,0.0	sbl:-45.0 sbl:0.0	Read the lower angle for alarm B Change the lower angle for alarm B: Adjustment range = -180.0 … 180.0
?SBH #SBH,15.0	sbh:45.0 sbh:15.0	Read the higher angle for alarm B Change the higher angle for alarm B: Adjustment range = -180.0 … 180.0
%S	$s:	Save all new settings to permanent memory
Alarm channel commands		
?A ?AA ?AB	a:0,1 aa:0 ab:1	Read the states of both alarms Read the state of alarm A Read the state of alarm B
Communications channel commands		

?CB
#CB,6
	cb:7
	cb:6
		Read the serial port baud rate
		Change the serial port baud rate:
		   0 = 9600
		   1 = 19200
		   2 = 38400
		   3 = 57600
		   4 = 115200
		   5 = 230400
		   6 = 460800
		   7 = 921600

?CI #CI,0x78	ci:0x66 ci:0x78	Read the I2C address in hexadecimal Change the I2C address: Adjustment range = 0 … 0x7F
%C	%c:	Save all new settings to permanent memory
Legacy commands for the serial port		
D' or 'd'	78.32	Output the current distance once only

?SU
#SU,1
	su:0
	su:1
		Check if distance streaming is active
		Switch distance streaming on or off:
		   0 = off
		   1 = on

0'	No response	Enable I2C legacy distance streaming
Legacy commands for the I2C port		
0' or 0 or 1 or 129	78.23	Enable output binary coded distance in centimeters Send any other command to disable

Data streaming

The LW20 can stream up to five read commands (?).

Set a stream using the format: **<$><stream num><,><parameter name><CR>**

For example:

To stream the median distance to the first return, on stream one: **$1,ldf<CR>**

To stream the signal strength of first return, on stream two: **$2,lhf<CR>**

You can clear an individual stream by using: **$<stream num><CR>**

You can clear all streams by sending **$<CR>**

Streams are considered a settable parameter like any other in the LW20, therefore you can save the stream to persist through boot up. The command **%p<CR>** will save all settings.

Note: Saving parameters in the LW20 happens on flash memory, which has limited writes. This is not a problem for everyday use, but don't call the save command in a tight loop, as you could exhaust the flash if you accidentally call it a few hundred thousand times.

Revision history

Version	Date	Author	Comments
Rev 9	2018/07/23	TLP	Included "Figure 30 :: Heat sink contact area" (page 22).
Rev 8	2018/07/04	TLP	Removed feature "Remove feature: "Encoded laser pulses prevent interference for other lasers" (pages 1, 6). Removed feature "Power saving mode to save energy when not in use" (page 1). Updated power supply current to "130 mA" (pages 5, 7). Added "Objects must be separated by approximately 5 meters before they are seen as separate return signals." (page 6). Include cautionary note "The SF20 is an OEM module that requires the customer to provide appropriate heat sinking and EMI shielding" (page 7). Changed "Select the "Laser" icon" to "Select the "Settings" icon" (page 8). Added new instruction "Press the up arrow to engage serial communication mode. The LW20 will reply with a product code" (page 11). Removed <~> key option to go back into machine-to-machine mode (page 11). Updated "Figure 12 :: Arrangement of screens in terminal emulation mode" (page 11). Update "The LW20 will wait for the first command to confirm which communication mode to select (serial or I2C). The first command will not get a response (page 15). Remove the "E - The Energy channel controls power usage" channel (pages 15, 24, 26). Remove the setting "Encoding pattern" from the table (page 16). Correct the serial port baud rate to "9600 … 921600" (page 16). Updated "Figure 31 :: Pinout diagram" (page 23). Added note "The first command sent after power up will be used to detect if the LW20 is running in Serial or I2C mode, and therefore will not get a response" (page 24). Replace "%C - Save the latest communications settings to permanent memory" with "%P - Save all settings to permanent memory" (page 24). Updated "Command list" table (pages 24, 25, 26).
Rev 7	2018/04/26	TLP	Added new model variations for "LW20/B", "LW20/C", "SF20/B" and "SF20/C" to replace obsolete "LW20/SER", "LW20/I2C" and "SF20" models (pages 2, 7, 15). Units now ship a single I2C and serial communication cable (pages 7, 15, 17, 24). Updated "Figure 10 :: Connection to a USB converter cable" (page 11). Updated "Figure 4 :: Connection to a USB converter cable" (page 8) and "Figure 13 :: Connection to a Devantech USB-ISS module" (page 13). Removed sentences "5 V logic should also work without any level shifters." and "In some cases, 5 V logic will also work but this is not guaranteed." (page 15). Included cautionary note "Ensure that adequate ventilation or heat sinking is provided if the SF20 is incorporated into a custom enclosure, as heat build-up could occur." (page 22). Removed "Figure 31 :: I2C and power cable". Updated "Figure 31 :: Pinout diagram" by removing reference to "or 5 V logic" on RXD pin (page 22).
Rev 6	2018/04/05	TLP	Updated "4. Specifications of the LW20 / SF20" item "Range" to "0.2 … 100 m (sunlit white wall, 45 readings per second)" (pages 4, 5). "4. Specifications of the LW20 / SF20" item "Beam divergence" to "0.3°" (page 5). Updated "Figure 13 :: Connection to a Devantech USB-ISS module" to reflect an LW20/I2C model (page 11).
Rev 5	2017/07/27	TLP	Added "Figure 32 :: Pinout diagram (page 22).
Rev 4	2017/05/25	TLP	Highlighted the factory default I2C bus address as 0x66 (pages 12, 14). Highlighted the factory default serial baud rate as 115200 (page 12).
Rev 3	2017/05/05	TLP	Changed baud rate setting from 921600 to 115200 (pages 6, 9). Updated "Figure 13 :: Connection to a Devantech USB-ISS module" (page 11). Updated LightWare Terminal screens to version 1.3.1 (pages 6, 9, 10, 11, 14). Included "Data streaming" section into "Appendix C" (page 25).
Rev 2	2017/04/10	TLP	Include new section "6.1 How to communicate with the LW20 using the Devantech USB to I2C module" (pages 11, 12).
Rev 1	2017/03/03	JEP	Updated "4. Specifications of the LW20 / SF20" to include the approval "FDA: 1710193-000 (2017/02)" (page 5). Update "Figure 26 :: Serial and power cable" (Rev 2) and "Figure 27 :: I2C and power cable" (Rev 2) to include a Ferrite Core component (page 19).
Rev 0	2017/02/20	JEP	First edition

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