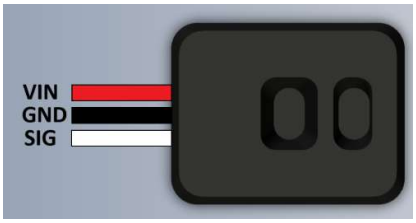
TOF Distance sensor

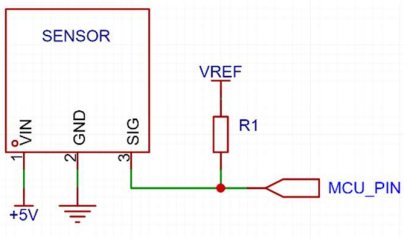
Device pinout

VIN	Connect to power supply
GND	Connect to main ground
SIG	Sensor communication open-drain input / output



Typical application

The sensor can operate from 2.8V to 5.5V, ensure that the power supply can handle up to 30mA.



The SIG pin is open drain, so for correct operation a pull-up resistor must be placed, typically between 2.4k and 10k, lower resistance means higher power loss but is needed for higher serial speed. The voltage of the pull-up resistor should be >= 2.8V, typically just connect it to the same supply as the MCU uses.

When using the sensor in serial mode, the SIG pin is half duplex UART, some microcontrollers do not have dedicated support for this mode, for example AVR microcontrollers only have full duplex (separate RX and TX pins), but this can be circumvented either by connecting the RX and TX pins together or instead using software serial. For tools like USB to UART converters simply connect RX and TX together.

Electrical characteristics

Parameter	Conditions	Min	Typical	Max	Unit
Maximum allowed voltage	At 25°C	-0.3		7	V
Operating voltage		2.8	5	5.5	V
Supply current			25	30	mA

Sensor characteristics

Parameter	Conditions	Min	Typical	Max	Unit
Sampling delay		5	33	50	ms
Maximum range	Sampling time is 50ms		1200		mm
Wavelength			940		nm
Detection field of view		18		22	°
Start-up time		10		50	ms

Device operation

As soon as the sensor starts (see Start-up time), measurement begins and data can be read. The sensor can be used to measure distance in millimetres or centimetres. Sensor can also be configured to detect some range condition, i.e. if distance is above some threshold.

Depending on the I/O configuration the senor outputs either a digital 0/1, PWM or serial, these function in the following ways:

Serial

Half duplex UART, used to read sensor registers and change configuration.

Digital 0/1

In this mode the SIG pin outputs the detection state, LOW if false, HIGH when true. Detection mode and threshold can be configured.

PWM

SIG pin outputs a PWM signal, the wave form is the same as in servo control. The period is 20ms, the pulse is 1ms – 2ms. The pulse width changes with the measured distance, 1ms = minimum distance, 2ms = maximum distance, max and min can be configured. If the distance measurement is invalid, then the pulse will be 2ms.

Device configuration

When the device is in serial mode all sensor parameters can be changed, the new values are immediately used, except for the I/O configuration these only apply after the sensor is restarted. After reset the configuration registers are set from the sensor's internal memory, configuration registers can be saved to this memory using the "save configuration" command. To restore configuration back to default, "reset configuration" command can be used.

An easy way to configure the sensor is using a USB to UART adapter. Any serial terminal, for example PuTTY or using Arduino ide's integrated terminal, see the "Serial protocol" section for how the messages are written.

Device restart

The sensor can be restarted either by disconnecting and reconnecting the power supply or using the "restart sensor" command.

Entering serial mode

If the sensor is configured in digital or PWM mode, to change to serial simply disconnect the power supply, then short the SIG pin to GND or alternatively output a LOW signal from MCU, afterwards connect the power supply and wait at least 50ms for the sensor to boot, then remove the short from SIG. The sensor will now be in serial mode with 9600 baud rate and id 0. When the sensor is reset, the mode will return to the one configured in registers.

Serial protocol

The serial protocol uses ASCII characters; numbers are in hexadecimal format. Each packet starts with the command letter and ends with a new line symbol 0x0A, or '\n' in most programming languages; the following commands are available:

Write register

Send	W	'serial id'	'register number'	'value'	'\n' (0xA)
Receive	A or F	'\n' (0xA)			

Serial id is sent in hexadecimal format as two characters, the same for the register number. Value is also in hexadecimal format but can be of variable length up to 4 characters, for example if the value is 0x0005, then you can send 5 or 0005, the leading zeroes are not mandatory. After the command is received the sensor returns A if the write was successful and F if it failed.

Examples of messages written as C strings:

Set register B0 of sensor 01 to 21: Send -> "W01B021\n" Receive <- "A\n" (success)
Set register 00 of sensor 00 to F65: Send -> "W0000F65\n" Receive <- "F\n" (Failure because register 00 is read only)

Read register

Send	R	'serial id'	'register number'	'\n' (0xA)
Receive	'register value'	'\n' (0xA)		

The returned register value is in hexadecimal format and is of variable length up to 4 characters, example if the value is 0x0080, the returned value will be 80.

Example of message:

Read register 01(distance mm) of sensor A6: Send -> "RA601\n" Receive <- "12C\n" (distance 0x12C = 300 mm)

Save configuration

Send	S	'serial id'	'\n' (0xA)
Receive	A	'\n' (0xA)	

This command saves the current configuration to the sensor memory.

Restart sensor

Send	U	'serial id'	'\n' (0xA)
Receive	A	'\n' (0xA)	

This command restarts the sensor; the reset is executed ~50ms after the sensor sends its response. After reset all registers are set to the saved configuration.

Reset configuration

Send	Z	'serial id'	'\n' (0xA)
Receive	A	'\n' (0xA)	

This command resets the sensors configuration back to the default settings.

Registers

Read-only registers:

index	Name	Min value	Max value
00	Ranging status	0	FF
Status of measurement. Bit 0 – Measurement is valid. Bit 1 – Range wraparound check not passed. Bit 2 – Range phase check not passed. Bit 3 – Signal minimum check not passed. Bit 4 – Signal threshold check not passed. Bit 5 – Sigma threshold check not passed. Bit 6 – Distance min check not passed. Bit 7 – Distance max check not passed.			
01	Distance mm	0	FFF
Measured distance in millimeters. If the measured distance is invalid the value will be FFF.			
02	Signal rate	0	FFFF
Amount of signal returned in last measurement.			
03	Ambient rate	0	FFFF
Amount of ambient light in last measurement.			
04	Sigma	0	FFFF
Measurement standard deviation in mm.			
05	SPAD count	0	FFFF
Number of photon detectors used in last measurement.			
06	Distance cm	0	FF
Measured distance in centimeters. If the measured distance is invalid the value will be FF.			
07	Detection output	0	1
The output of detection logic configured in register BA.			

Configuration registers:

Index	Name	Min	Max	Default
80	IO mode	0	2	1
IO mode selection, when changed the new value will take effect after sensor restart. Modes: 0 – Serial. 1 – Digital 0/1. 2 – PWM.				
81	Serial id	0	FF	0
Serial id when IO mode is 0.				
B0	Serial baud	0	7	0
Serial baud rates: 0 – 9600. 1 – 19200. 2 – 38400. 3 – 57600. 4 – 74880. 5 – 115200. 6 – 230400. 7 – 250000.				
83				
84				
B0	Sampling time ms	5	50	33
Sensor sampling time in milliseconds. Operation below 10ms is not guaranteed.				
B1	Offset correction	0	FFFF	0
Measurement offset correction value.				
B2	Crosstalk correction	0	FFFF	0
Measurement crosstalk correction value.				
B3	Linear correction	0	FFFF	8000
Linear correction factor, the distance mm is calculated: D = Draw * correction / 0x8000				

B4	Range checks	0	FF	F8
Various checks are performed to determine if the measurement is valid, each bit in this register corresponds to one checked condition. If a measurement passes all enabled checks, it is considered valid. All checks are always performed, and their status is written to register 0, but only those that are enabled here are used to determine validity. Bit 0 – Not used. Bit 1 – Range wraparound check. Bit 2 – Range phase check. Bit 3 – Signal minimum check. Bit 4 – Signal threshold check. Bit 5 – Sigma threshold check. Bit 6 – Distance min check. Bit 7 – Distance max check.				
B5	Signal threshold	0	FFFF	1024
Minimum amount of photons to consider a valid distance. If measured signal is below this threshold Signal threshold check is not passed.				
B6	Sigma threshold	0	FFFF	15
Standard deviation threshold in mm, if measured sigma is above this threshold Sigma threshold check is not passed.				
B7	Min distance mm	0	FFF	1
Minimum detection distance, if bit 6 in register B4 is 1, then any distance below minimum will be considered invalid.				
B8	Max distance mm	0	FFF	500
Maximum detection distance, if bit 7 in register B4 is 1, then any distance above maximum will be considered invalid.				
BA	Detection mode	0	2	0
Selects detection mode, depending on this register, the detection output value will be 1 when: 0 – Measurement is valid (status register bit 0 is 1). 1 – Distance mm is above lower threshold, register BC. 2 – Distance mm is above lower threshold and below upper threshold registers BC and BD.				
BB	Detection output invert	0	1	0
0 – Detection output normal. 1 – Detection output inverted.				
BC	Detection lower threshold mm	0	FFF	0
Detection lower threshold, for detection modes 1 and 2.				
BD	Detection upper threshold mm	0	FFF	0
Detection upper threshold, for detection modes 1 and 2.				