Introduction

XYZ Interactive Technologies (in conjunction with SparkFun Electronics Inc.) has developed introductory ZX Sensor Models that can be used for rapid proof of concept or for sensor related applications.

These sensors consist of two transmitter(s) and one receiver mounted on one board that constitutes a short-range reflective distance measurement solution. Current design utilizes infrared technology.

The sensor may be preprogrammed to operate as a ranging device or as a gesture interface. The package includes a sensor, a USB to serial board, Mini-B USB cable, and downloadable serial software. The user can demonstrate simple position detection, distance measurement and basic gestures within minutes of opening the package.

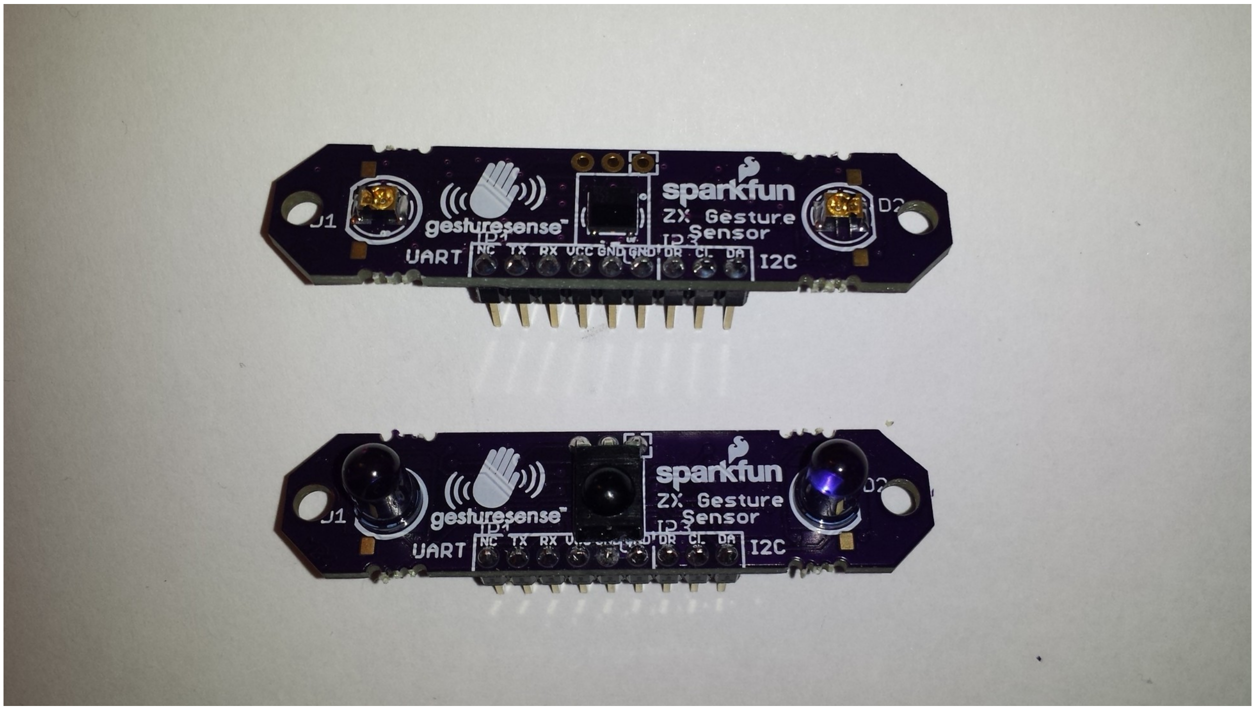
This sensor includes a UART for demo applications and I2C as a communication protocol for embedded applications like robotics and toys, or devices that have to communicate directly to a processor.

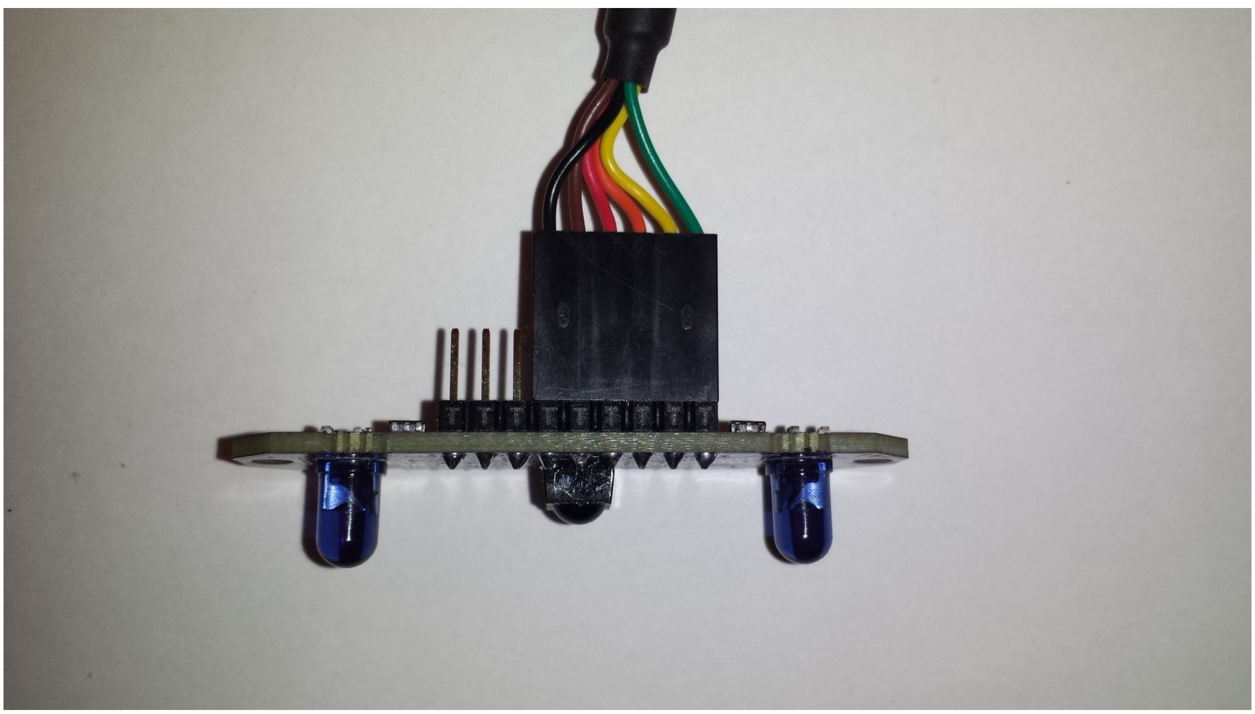
ZX Sensor

The following describes the ZX sensor. There are two types of the ZX sensor available (as shown). The ZX sensor is available as versions with 1) Through-Hole parts (TH ZX sensor) which allows sensing solutions that have longer range because of lensing on the emitter snd receiver, and 2) SMT parts (SMT ZX sensor) which allows sensing solutions that are more compact and may be hidden under IR transmissible plastic.

The ZX sensor is designed with the following characteristics:

1. UART at 115200 baud (see UART details below)
2. I2C interface (see I2C details below)
3. Continuous data output at a rate of 50 samples/sec
4. Simultaneous UART/I2C data output
5. 3D object detection in depth and in the periphery
6. On-board gesture detection and output (swipes, hand-push, etc.)
7. Optional on-board pull-down resistors for I2C
8. Support for up to two ZX sensors on one I2C bus
9. Optional I2C ID’s as 20 (unsoldered plug) and 22 (soldered plug)





The ZX/SP sensor has labeled connections with UART and I2C separated. This makes it easy to connect ready-made connectors (like the FTDI UART connector) directly to the ZX sensor pins (as shown). Similarly, the I2C connection pins may connect to any two-wire interface using the ZX sensor as the I2C slave, and any embedded or external processor as the I2C master.

Note the labeled connections are shown here– it is important that the FTDI cable goes is connected to the UART portion of the pin-out. I2C connections are for only the 3 pins on the right, as well as using VCC and GND connections to power the sensor.

ZX Sensor Pin-out

The ZX sensor board contains two emitters and one receiver module, to determine the position of a reflector in the Z X space, and is powered externally using a 4-pin standard 0.025-inch dip connector. The following is the pin configuration:

1. Pin 1 : NC
2. pin 2 : Input voltage (5.0 volts DC)
3. Pin 3 : RX for connection to an external UART serial transmitter (TX) line
4. Pin 4 : TX for connection to an external UART serial receiver (RX) line
5. Pin 5 : GND for ground.
6. Pin 6 : GND for ground.
7. Pin 7 : DR (Data Ready) for the I2C interface.
8. Pin 8: CL (or the SCL) clock signal for the I2C interface.
9. Pin 9: DA (or SDA) data signal for the I2C Interface.

The input voltage to the board must be between 4.8 to 5.2 volts maximum, and the voltage is NOT regulated on the sensor board itself. This was done purposefully to allow the user to apply any power source from an external board supporting the serial I/O from the receiver board for further control processing. Currently the RXD line does not support any serial data input to the sensor board. Note that the sensor can function at lower voltages like 3.3 V but the lower emitter brightness will cause the sensor to have reduced ranging performance.

X is determined by measuring the differential illumination of the two optical elements (emitter-receiver pair). When the reflecting object (reflector) is precisely above the sensor, both optical elements are equally illuminated, thus producing a zero brightness differential. By definition this position is referred to as X origin, or X = 0. When the reflector is not centered, the receiver gets more reflected light from one emitter and less from the other; hence one can determine reflector's location based on the degree that the light reception is not balanced.

The Z range is a measure of the direct illumination of both receivers. Accurate Z ranging is possible when the reflector is positioned directly above the sensing element (or IR receiver).

Output X and Z coordinate values are directly calculated by the sensor and presented to the serial link to be included in the serial output. See section 6 for how the serial output is displayed in the demo program. The actual calibrated Range (or Z) value may be calculated using an external serial program that uses a sensor-output to actual range look-up table, to increase ranging accuracy. Such a table could use a Linear-Spline calculation (for example) to improve the ranging resolution. The Range value represents the actual distance as shown in the following geometric representation:

In the current design, the Range value output is limited between zero and +80 cm, designed for "arm's-length" use cases where low-power consumption is desired, and where the IR receiver senses little reflective IR beyond the 80 cm range in this design. The limit is also imposed because the edge of the sensor's IR beam creates nonlinear effects when the reflector is partially within the beam directly ahead of the sensor. Longer range sensors can operate at greater distances but require higher power to achieve the IR reflectivity.

The reflecting surface can be any surface or object that has reflective properties varying from as little as 18% (i.e. the reflectance of a Kodak grey card) to 100% (i.e. or 95% for white paper).

UART Communication Protocol

Physical Interface:

The sensor reports periodically over an asynchronous serial interface (UART) using the following configuration:

Baud-rate =115200   Data bits = 8   Parity = None   No Handshaking

Data are reported only when a reflecting object is detected. The data refresh rate is approximately 50 samples per second.

Communication Protocol:

Data are reported as a binary frame with the following format:

Msg. Code (0xF1 to 0xFF)	Data Payload

- Each message frame starts with a Message Code (1 byte) followed by a certain data payload
- Each message type is identified by a unique Message Code
- All message codes are larger than 0xF0.

- All data bytes are unsigned 8 bit integers smaller or equal than 0xF0 (decimal 240)

Note: signed data are represented with a 120 bias.

Examples:

0 → 120

120 → 240

-120 → 0

X = -55 is represented as 65

X = 75 is represented as 195

The following messages are reported:

Table 1: Message Types

Message Code	**Message**	**Payload Size** [bytes]	**Description**
0xFF	Pen Up	0	Indicates that the reflector moved out of range. Mark the end of a data stream.
0xFE	Ranges	2	Each range is represented by 1 unsigned byte with a range between 0 to 240
0xFA	X Coordinate	1	X coordinate is represented as a signed byte with a 120 bias.
0xFB	Z Coordinate	1	Z coordinate is represented as an unsigned byte between 0 to 240
0xFC	Gesture Event	2	The first byte represents the gesture code. The additional byte encode parameters associated with the gesture (i.e. speed)
0xF1	ID	3	This message is used for sensor type identification. 1-st byte = sensor type. 2-nd byte = hardware version 3-rd byte = firmware version

Table 2: Gestures

The 0xFC message indicates that a gesture event has been detected. The following gesture events are supported (for the ZX sensor this is indicated by the ‘Y’ in the ZX column):

#	Gesture Event	ZX	Gesture Code	2-nd byte	Comments
1	Swipe Right	Y	0x01	Speed	Swipe is the simplest gestural interaction: the reflector moves in a certain direction over the sensor. Speed is reported as a normalized value between 1 to 10 1 = slow 10 = fast
2	Swipe Left	Y	0x02		
3	Swipe Down	Y	0x03		
4	Swipe Up		0x04		
5	Air Push		0x05	0	The reflector moves “down” and “up” without hovering over the sensor.
6	Hover (Enter)		0x11	Position	This message is sent when a “hover” condition is detected. Position = 0 ⟶ Center Position = 1 ⟶ Right Position = 2 ⟶ Left
7	Hover (Exit)		0x12	Z	This message is sent when the reflector exit a “hover” condition. Parameter: last steady Z
8	Hover & Move	Y	0x15	Position	This gesture is sent when the reflector stops (hover) over the sensor for few seconds, then moves in a certain direction. Position = 0 ⟶ Center Position = 1 ⟶ Right Position = 2 ⟶ Left
9	Circle Clockwise		0x21		Circular motion is sensed as a double swipe in the same direction.
10	Circle Counter-clockwise		0x22		
11	Wave (Right / Left)		0x23		A wave gesture is sensed as a double swipe in opposite directions.
12	Wave (Left / Right)		0x24		

Note: the simplest gestural device is the ZX sensor, thus it implements only a reduced set of gestures. The gestures currently supported by the ZX sensor are marked by “Y” in the ZX column.

Note: for convenience all ZX supported gestures have a payload of 2 bytes.

I2C Communication Protocol

The following register map defines the addresses used by the ZX SP sensor I2C protocol.

GestureSense XZ01 Sensor I2C Register Map

Version 1

Last update: 20140728

Address	Name	Description
0x00	STATUS	Sensor and Gesture Status
0x01	DRE	Data Ready Enable Bitmap
0x02	DRCFG	Data Ready Configuration
0x04	GESTURE	Last Detected Gesture
0x05	GSPEED	Last Detected Gesture Speed
0x06	DCM	Data Confidence Metric
0x08	XPOS	X Coordinate
0x0a	ZPOS	Z Coordinate
0x0c	LRNG	Left Emitter Ranging Data
0x0e	RRNG	Right Emitter Ranging Data
0xfe	REGVER	Register Map Version
0xff	MODEL	Sensor Model ID

Note that this is a high level description of the data available for the I2C protocol. More details of the ZX sensor I2C specification may be obtained from the GestureSense ZX Sensor I2C Register Map spreadsheet. This spreadsheet is available for advanced I2C users and may be consulted for programming the I2C interface requiring the details of the pin assignments including the DR pin.

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