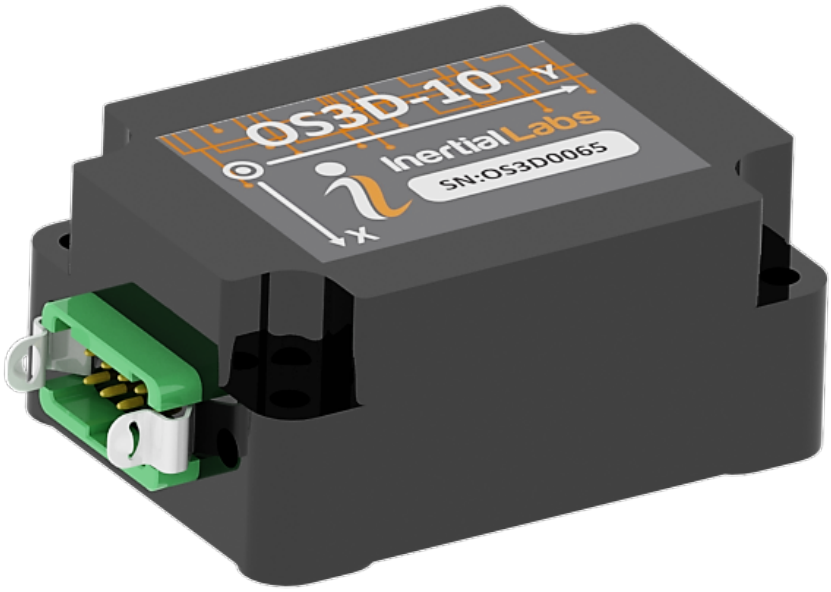
OS3D-10
MINIATURE
3D ORIENTATION SENSOR

Interface Control Document (ICD)



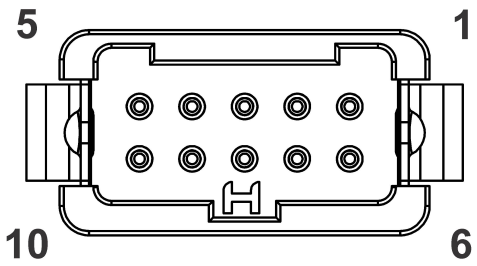
1. Hardware layer

Inertial Labs OS3D-10 is equipped with 10-pins mail receptacle (G125-MV11005L1P by HARWIN) for electrical connection to a host system. Outside view of receptacle is shown on the picture below. **OS3D-10** has 4 types of serial interfaces: RS232, RS422, RS485 and UART TTL. The first 2 can be used simultaneously with no need of hardware or firmware changes, while UART is available upon a customer request, and uses the same pins as RS232.

RS422 interface can be converted to RS485 by the following way: RS422-A and RS422-Y are tied together on the mating connector and form the RS485-A, while RS422-B tied to RS422-Z and form RS485-B.

Table 1.1 Hardware layer description.

Number	Name	Function
1	POWER	Supply voltage (see Note 1)
2	RS232-TX	RS232 Transmitter Output
3	RS232-RX	RS232 Receiver Input
4	RS422-A	RS-422 Non-Inverting Input, 120Ω
5	RS422-B	RS-422 Inverting Input, 120Ω
6	GROUND	Power Supply Return
7	TOV	3V3 TTL Time of validity output
8	EXTRIG	3V3 TTL External trigger input
9	RS422-Y	RS-422 Non-Inverting Output
10	RS422-Z	RS-422 Inverting Output



Note 1: The supply voltage range is from 4V to 15V for OS3D-10 Rev.1 and from 5V to 25V for Rev.2. Check the label of the sensor for revision.

UART, TOV and EXTRIG signals are 3V3 TTL and not 5V tolerant. All pins comply with IEC 61000-4-2 level 4 standard of ESD protection.

This document describes communication layers according to ISO/OSI model.

2. Physical layer

Table 2.1 Physical layer description.

Parameter	Value	Units
Standard	TIA/EIA−485A (half-duplex)	-
	TIA/EIA−422B (full-duplex)	-
	TIA/EIA−232 (+ optional UART)	-
Default Baud Rate	1000000	bps
Configurable Baud Rate	2400-3M (RS422, RS485, UART)	bps
	2400-1M (RS232)	bps
Byte Size	8	Bits
Stop Bits	1	Bits
Parity	No	-

3. Transport layer

The communications protocol is optimized to work with 16-bit words. Each word consists of two bytes, the first byte is the least significant, and the second is the most significant one. If the pause between bytes in packet is longer than 10uS, this packet is ignored by sensor.

Table 3.1 Transport layer description.

Index	Name	Description	Value
1	Header	Packet header	-
2	Length	Packet length in bytes (from Header to CS)	8-65534
3	Data1	Data	various types
XX	DataXX	Data	various types
N+2	DataN	Data	various types
N+3	CS	Checksum (Sum from Header to DataN)	0-65535
-	Pause	The pause allows a sensor to parse a packet	>20uS

In a request packet coming from an application host to a sensor the Header field could take on two values:
Header = 0x55AA if broadcasting packet;
Header = (Address*256) + (255-Address) if packet is intended to the sensor with certain address.

Address can take on values from 0 to 255. Address = 85 is broadcast address, because it corresponds to broadcasting header. **Header** value is defined in **Status Buffer** of the sensor (see below).

In a response packet coming from a sensor to an application host the packet header is always 0x55AA;

4. Application layer

4.1 Reset command is issued by the application host to reset the device.

Table 4.1 Reset command structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0xFF00	unsigned word	Packet type

Response: this command doesn't have a response. As the result the sensor is in the initial state: output stream is stopped.

4.2 GetIden command is issued by the application host to request the sensor's ID string.

Table 4.2.1 GetIden request structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0100	unsigned word	Packet type

Response: the sensor returns its identification string.

Table 4.2.2 GetIden response structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0110	unsigned word	Command type
Data2...257	ID[256]		Char	ID string

ID string example: "OS3D10_1.0.0.0 May 25 2017"

4.3 GetData command is issued by the application host to request the data from sensor. The application host can request the different combinations of the orientation data using the following GetData subtypes:

GetDataR command is issued by the application host to request the raw data form ADC (not calibrated).

Table 4.3.1 GetDataR request structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0200	unsigned word	Packet type

Response:

Table 4.3.2 GetDataR response structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0210	unsigned word	Command type
Data2	Cntr*	0-65535	unsigned word	Packet counter
Data3	Acc1	±32767	signed word	Raw acc. ch.1
Data4	Acc2	±32767	signed word	Raw acc. ch.2
Data5	Acc3	±32767	signed word	Raw acc. ch.3
Data6	Gyro1	±32767	signed word	Raw gyro ch.1
Data7	Gyro2	±32767	signed word	Raw gyro ch.2
Data8	Gyro3	±32767	signed word	Raw gyro ch.3
Data9	Mag1	±32767	signed word	Raw mag. ch.1
Data10	Mag2	±32767	signed word	Raw mag. ch.2
Data11	Mag3	±32767	signed word	Raw mag. ch.3
Data12	Temp	±32767	signed word	Raw temp.

***** Cntr is incremented each time the data packet is transferred.

GetDataQ command is issued by the application host to request the orientation quaternion.

Table 4.3.3 GetDataQ request structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0201	unsigned word	Packet type

Response:
The estimated attitude quaternion. The first part is the scalar value. The attitude is given as the body frame with respect to the local East North Up (ENU) frame.

Table 4.3.4 GetDataQ response structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0211	unsigned word	Command type
Data2	Cntr	0-65535	unsigned word	Packet counter
Data3	QuatW	-1.0 - 0.99997	fixed point*	Quaternion W
Data4	QuatX	-1.0 - 0.99997	fixed point*	Quaternion X
Data5	QuatY	-1.0 - 0.99997	fixed point*	Quaternion Y
Data6	QuatZ	-1.0 - 0.99997	fixed point*	Quaternion Z

* Fixed point signed 1.15 format

GetDataD command is issued by the application host to request calibrated data & temperature.

Table 4.3.5 GetDataD request structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0202	unsigned word	Packet type

Response:

Table 4.3.6 GetDataD response structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0212	unsigned word	Command type
Data2	Cntr	0-65535	unsigned word	Packet counter
Data3	AccX	-1.0 - 0.99997	fixed point[1]	Acc. X[2]
Data4	AccY	-1.0 - 0.99997	fixed point[1]	Acc. Y[2]
Data5	AccZ	-1.0 - 0.99997	fixed point[1]	Acc. Z[2]
Data6	MagX	-1.0 - 0.99997	fixed point[1]	Mag. X[3]
Data7	MagY	-1.0 - 0.99997	fixed point[1]	Mag. Y[3]
Data8	MagZ	-1.0 - 0.99997	fixed point[1]	Mag. Z[3]
Data9	GyroX	-1.0 - 0.99997	fixed point[1]	Gyro X[4]
Data10	GyroY	-1.0 - 0.99997	fixed point[1]	Gyro Y[4]
Data11	GyroZ	-1.0 - 0.99997	fixed point[1]	Gyro Z[4]
Data12	Temp	-1.0 - 0.99997	fixed point[1]	Temperature[5]

1 – Fixed point signed 1.15 format;
2 – Conversion factor: 0.0625 = 1g;
3 – Conversion factor: 0.0625 ≈ 0.5 Gauss;
4 – Conversion factor: pi/5760 = 1dps;
5 – Conversion formula: T°C = 100.27*Temp + 24.

GetDataF command is issued by the application to request the quaternion, calibrated data & temperature.

Table 4.3.7 GetDataF request structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0203	unsigned word	Packet type

Response:
Table 4.3.8 GetDataF response structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0213	unsigned word	Command type
Data2	Cntr	0-65535	unsigned word	Packet counter
Data3	QuatW	-1.0 - 0.99997	fixed point[1]	Quaternion W[2]
Data4	QuatX	-1.0 - 0.99997	fixed point[1]	Quaternion X[2]
Data5	QuatY	-1.0 - 0.99997	fixed point[1]	Quaternion Y[2]
Data6	QuatZ	-1.0 - 0.99997	fixed point[1]	Quaternion Z[2]
Data7	AccX	-1.0 - 0.99997	fixed point[1]	Acc. X[3]
Data8	AccY	-1.0 - 0.99997	fixed point[1]	Acc. Y[3]
Data9	AccZ	-1.0 - 0.99997	fixed point[1]	Acc. Z[3]
Data10	MagX	-1.0 - 0.99997	fixed point[1]	Mag. X[4]
Data11	MagY	-1.0 - 0.99997	fixed point[1]	Mag. Y[4]
Data12	MagZ	-1.0 - 0.99997	fixed point[1]	Mag. Z[4]
Data13	GyroX	-1.0 - 0.99997	fixed point[1]	Gyro X[5]
Data14	GyroY	-1.0 - 0.99997	fixed point[1]	Gyro Y[5]
Data15	GyroZ	-1.0 - 0.99997	fixed point[1]	Gyro Z[5]
Data16	Temp	-1.0 - 0.99997	fixed point[1]	Temperature[6]

1 – Fixed point signed 1.15 format;

2 – The estimated attitude quaternion, see GetDataQ command for details;
3 – Conversion factor: 0.0625 = 1g;
4 – Conversion factor: 0.0625 ≈ 0.5 Gauss;
5 – Conversion factor: pi/5760 = 1dps;
6 – Conversion formula: T°C = 100.27*Temp + 24.

GetDataE command is issued by the application to request the Euler angles.

Table 4.3.9 GetDataE request structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0204	unsigned word	Packet type

Response:

The estimated attitude Yaw, Pitch, and Roll angles measured in modified physical units: 1.0 = 180 deg. The attitude is given as a 3,1,2 Euler angle sequence describing the body frame with respect to the local East North Up (ENU) frame.

Table 4.3.10 GetDataE response structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0214	unsigned word	Command type
Data2	Cntr	0-65535	unsigned word	Packet counter
Data3	Yaw	-1.0 - 0.99997	fixed point[1]	Euler yaw angle[2]
Data4	Pitch	-0.5 - 0.5	fixed point[1]	Euler pitch angle[2]
Data5	Roll	-1.0 - 0.99997	fixed point[1]	Euler roll angle[2]

1 - Fixed point signed 1.15 format;
2 - In modified physical units: 1.0 = 180 deg.

GetDataEG command is issued by the application to request the Euler angles and compensated gyros.

Table 4.3.11 GetDataEG request structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0205	unsigned word	Packet type

Response:
The estimated attitude Yaw, Pitch, and Roll angles measured in modified physical units: 1.0 = 180 deg. The attitude is given as a 3,1,2 Euler angle sequence describing the body frame with respect to the local East North Up (ENU) frame.

Table 4.3.12 GetDataE response structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0215	unsigned word	Command type
Data2	Cntr	0-65535	unsigned word	Packet counter
Data3	Yaw	-1.0 - 0.99997	fixed point	Euler yaw angle[3]
Data4	Pitch	-0.5 - 0.5	fixed point	Euler pitch angle[3]
Data5	Roll	-1.0 - 0.99997	fixed point	Euler roll angle[3]
Data6	C_GyroX	-1.0 - 0.99997	fixed point	Comp. gyro X[6]
Data7	C_GyroY	-1.0 - 0.99997	fixed point	Comp. gyro Y[6]
Data8	C_GyroZ	-1.0 - 0.99997	fixed point	Comp. gyro Z[6]

GetDataFE command is issued by the application to request the quaternion, Euler angles, calibrated data & temperature.

Table 4.3.11 GetDataFE request structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0206	unsigned word	Packet type

Response:
Table 4.3.12 GetDataFE response structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0216	unsigned word	Command type
Data2	Cntr	0-65535	unsigned word	Packet counter
Data3	QuatW	-1.0 - 0.99997	fixed point[1]	Quaternion W[2]
Data4	QuatX	-1.0 - 0.99997	fixed point[1]	Quaternion X[2]
Data5	QuatY	-1.0 - 0.99997	fixed point[1]	Quaternion Y[2]
Data6	QuatZ	-1.0 - 0.99997	fixed point[1]	Quaternion Z[2]
Data7	Yaw	-1.0 - 0.99997	fixed point[1]	Euler yaw angle[3]
Data8	Pitch	-0.5 - 0.5	fixed point[1]	Euler pitch angle[3]
Data9	Roll	-1.0 - 0.99997	fixed point[1]	Euler roll angle[3]
Data10	AccX	-1.0 - 0.99997	fixed point[1]	Acc. X[4]
Data11	AccY	-1.0 - 0.99997	fixed point[1]	Acc. Y[4]
Data12	AccZ	-1.0 - 0.99997	fixed point[1]	Acc. Z[4]
Data13	MagX	-1.0 - 0.99997	fixed point[1]	Mag. X[5]
Data14	MagY	-1.0 - 0.99997	fixed point[1]	Mag. Y[5]
Data15	MagZ	-1.0 - 0.99997	fixed point[1]	Mag. Z[5]
Data16	GyroX	-1.0 - 0.99997	fixed point[1]	Gyro X[6]
Data17	GyroY	-1.0 - 0.99997	fixed point[1]	Gyro Y[6]
Data18	GyroZ	-1.0 - 0.99997	fixed point[1]	Gyro Z[6]
Data19	Temp	-1.0 - 0.99997	fixed point[1]	Temperature[7]

1 – Fixed point signed 1.15 format;
2 – The estimated attitude quaternion, see GetDataQ command for details;
3 – In modified physical units: 1.0 = 180 deg;
4 – Conversion factor: 0.0625 = 1g;
5 – Conversion factor: 0.0625 ≈ 0.5 Gauss;
6 – Conversion factor: pi/5760 = 1dps;
7 – Conversion formula: T°C = 100.27*Temp + 24.

4.4 GetStat command is issued by the application host to request the **Status Buffer.**

Table 4.4.1 GetStat request structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0300	unsigned word	Packet type

Response:

Table 4.4.2 GetStat response structure.

Transport	Name	Value	Notation	Description
Data1	Cmd	0x0310	unsigned word	Command type
Data2... Data257	StatBuff[256]	0-65535	unsigned word	Status buffer

Status Buffer contents the following status variables:

Table 4.4.3 Status Buffer structure.

Name	Notation	Description
AutoTx	unsigned word	AutoTx = 0xFFFF turns the sensor to auto transfer mode
ModeA	unsigned word	Defines the output data type in auto transfer mode
Period	unsigned word	Defines the data transferring period in auto transfer mode
Header	unsigned word	Device packet header (see the Table 3.1)
SN_H	unsigned word	MSW of the device's 32-bit serial number
SN_L	unsigned word	LSW of the device's 32-bit serial number
……..	unsigned word	Other variables defined by firmware

The period of data transferring in auto transfer mode is defined by **Period** variable in the following way Time(us) = **Period**. Valid range for **Period** is 500-65535 (2KHz - 15.26Hz);

The output data type is defined by the **ModeA** in the following way:

1000 (decimal value) – raw data (see **GetDataR response**);
1001 (decimal value) - quaternion (see **GetDataQ response**);
1002 (decimal value) - calibrated data & temperature (see **GetDataD response**);
1003 (decimal value) - quaternion, calibrated data & temperature (see **GetDataF response**);
1004 (decimal value) - Euler angles (see **GetDataE response**);
1005 (decimal value) - Euler angles and compensated gyros (see **GetDataEG response**);
1006 (decimal value) - quaternion, Euler angles, calibrated data & temp. (see **GetDataFE response**);

5 SetVar command is issued by the application host to define the variables in status buffer.

Table 4.5.1 SetVar command structure.

Transport	Name	Value	Notation	Description
Data1	Cmd+Addr*	0x0400+0x00XX	unsigned word	Pack.type+Addr
Data2	Value	0-65535	unsigned word	Variable value

*Addr is the address of status variable in Status Buffer, for ex.: the Addr = 0 for AutoTx.

Response: this command doesn't have a response.

5. Software examples

5.1 The example of correct parsing the data packets

```
while(!Device->Stop)
{
	if( !ReadFile(hCom, CurBuf, 1, &Cntr, NULL ) || Cntr != 1 )
	{
		ClearCommError(hCom, &ldwErrors, &lCOMSTAT );
		continue;
	}

	/* parse byte read */
	switch(InCnt)
	{
	case 0 : // Idenf AA
		if( CurBuf[0] != 0xAA )
		{
			//printf("\n0xAA byte not found!");
			reset = true;
		}
		break;

	case 1 : // Idenf 55
		if( CurBuf[0] != 0x55 )
		{
			//printf("\n0x55 byte not found!");
			reset = true;
		}
		break;

	case 2 : // LenL
		{
			MessLen = CurBuf[0];
			break;
		}

	case 3 : // LenH
		{
			MessLen += (CurBuf[0] << 8);
			break;
		}

	default:
		{
			If( InCnt != ( MessLen - 1 ) )
			{
				break;
			}
```

```
                        /* message reception completed, process the message */
                        MessLen = (MessLen/2) - 1;
                        CSumm = 0;


                        /* checksum */
                        for( unsigned int i = 0; i < MessLen; i++ )
                        {
                                CSumm += WBuf[i];
                        }
                        if( CSumm != WBuf[MessLen] )
                        {
                                printf( "\nCheckSum failed" );
                                reset = true;
                                break;
                        }
                }

                if( reset )
                {
                        CurBuf = Buf;
                        CSumm = 0;
                        InCnt = 0;
                        reset = false;
                }
                else
                {
                        InCnt++;
                        CurBuf++;
                }
        }
}
```

5.2 The example of sending commands to sensor

- Send the "**Reset**" command to the sensor:
  {0xAA,0x55,0x08,0x00,0x00,0xFF,0xB2,0x54}
- Pause 1 S;
- Set the **GetDataQ** as the output data type in auto transfer mode:
  {0xAA,0x55,0x0A,0x00,0x01,0x04,0xE9,0x03,0x9E,0x5D}
- Pause 25 uS;
- Turn the sensor to auto transfer mode:
  {0xAA,0x55,0x0A,0x00,0x00,0x04,0xFF,0xFF,0xB3,0x59}
- Pause 25 uS;

Result: the sensor transfers a quaternion data packet.