OptoForce Ltd.
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OptoForce custom DAQ specification - SPI

Version 1.0

The SPI interface is compatible with Motorola® SPI and SIOP interfaces.
The pinout and color code of the SPI interface cable is the following:

Power		
	Red	Supply (6-24V)
	Blue	Ground
	Copper shield	Ground
SPI		
	Brown	SPI Data In
	Green	SPI Data Out
	Yellow	SPI Clock
	White	SPI Chip Select (active-low)

The SPI interface pins only support 3.3V.
Higher than 3.6V can cause permanent damage!

The device is configured to be a SLAVE with maximum clock speed of 10 MHz.
The Input data sampled at middle of data output time.
Idle state for clock is a low level; active state is a high level.
Serial output data changes on transition from Idle clock state to active clock state.

After the device has been selected (by pulling the Chip Select pin low) the device is ready to clock out the DATA packet (34 bytes).

After reading from the device it does not require to be deselected, but can be deselected if multiple devices shares the same SPI bus.

The device is configured to have an internal sampling and update rate of 1 kHz. The device operates in free-run mode and does not require the SPI clock for its operation. That means it updates the DATA packet at each 1 ms with the most current sensor values.

However, please note that if the previous DATA packet has not been completely read within 1ms the update will be skipped. Therefore, it is recommended to read the device within <1ms (e.g.: 0.8ms) in order to get all the 1000 packets in each second.

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The format of the DATA packet is the following:

DATA packet bytes																																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Header (170,7,8,28)				Sample Counter		Status		Fx_1		Fy_1		Fz_1		Fx_2		Fy_2		Fz_2		Fx_3		Fy_3		Fz_3		Fx_4		Fy_4		Fz_4		Checksum
								Channel 1						Channel 2						Channel 3						Channel 4						

Please note that the force values (Fx,Fy,Fz) are signed INT16 values.

The *Sample counter* is a UINT16 type variable incremented each time the DAQ completes an internal sampling (fixed at 1 kHz).

The *Status* UINT16 indicates the current status of the sensor. *The detailed description will be discussed later.*

The *Checksum* (UINT16) can be used to check the integrity of the packet. The checksum is a sum of the preceding bytes starting from the header (170 + 7+ 8 + 28 + ……).

During clocking out the Data packet the device is also clocking in the bytes sent from the host. Therefore, please make sure to send 0x00 bytes during reading from the device, to prevent accidental misconfiguration.

The device requires a multiple of 8 bytes to be read. It is recommended to read 64 bytes from the device at a time in order to make sure that a complete DATA packet has been received.

If the device has been started to be read the first bytes sent (at least 8) are leading zeros (due to the internal buffer mechanism). These zeros can be ignored until the header bytes (170,7,8,28) are received.

Then the actual DATA packet are sent, that can be verified by checking the checksum. After the DATA packet the sent bytes are all zeros.

Here is an example :

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Example of the received 64 SPI bytes

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	1	93	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	0	0	10	0	1	0	0	0	11	1	113	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	1	153	4	12	255	255	0	0	0	12	0	0	0	0	0	12	0	0	0	1	0	10	0	0	0	0	0	11	3	171	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	1	223	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	1	0	9	0	0	0	0	0	11	1	242	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	2	27	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	1	0	9	0	0	0	1	0	11	1	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	2	97	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	1	0	10	0	1	0	1	0	11	1	120	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	2	157	4	12	255	255	0	0	0	12	0	0	0	0	0	12	0	0	0	0	0	10	0	0	0	0	0	11	3	175	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	2	227	4	12	255	255	0	0	0	12	0	0	0	0	0	12	0	0	0	0	0	9	255	255	0	0	0	10	5	241	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	3	41	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	0	0	9	0	1	0	0	0	10	1	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	3	101	4	12	255	255	0	0	0	12	0	0	0	0	0	12	0	0	0	1	0	9	0	0	0	0	0	10	3	119	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	3	171	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	1	0	9	0	0	0	1	0	11	1	193	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	3	231	4	12	0	0	0	0	0	12	0	0	0	0	0	11	0	0	0	0	0	9	0	0	0	0	0	12	1	251	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	4	45	4	12	255	255	0	0	0	12	255	255	0	0	0	12	0	0	0	2	0	10	0	0	0	0	0	11	5	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	4	105	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	1	0	10	0	1	0	1	0	11	1	130	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	4	175	4	12	255	255	0	0	0	12	0	0	0	0	0	12	0	0	0	0	0	9	0	1	255	255	0	10	5	192	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	4	235	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	0	0	9	0	0	0	1	0	11	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	5	49	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	0	0	9	0	0	0	0	0	10	1	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	5	119	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	0	0	9	0	0	0	0	0	10	1	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	5	179	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	1	0	9	0	0	0	2	0	11	1	204	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	5	249	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	0	0	10	0	0	0	0	0	11	2	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	6	53	4	12	255	255	0	0	0	12	0	0	0	0	0	12	0	0	0	1	0	9	255	255	0	0	0	10	5	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	6	123	4	12	255	255	0	0	0	12	255	255	0	0	0	12	0	0	0	1	0	10	0	0	0	0	0	11	5	144	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	6	183	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	0	0	10	0	0	0	0	0	11	1	207	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	6	253	4	12	255	255	0	0	0	12	0	0	0	0	0	12	0	0	0	0	0	9	0	0	0	0	0	10	4	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	7	8	28	7	57	4	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0	1	0	9	0	0	0	1	0	10	1	82	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Leading zeros

Actual packet

Zeros at the end of the packet

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The description of the STATUS word is the following:

STATUS Word															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

ERROR		OVERLOAD						Multiple sensor selection	
DAQ type	Sensor type	Fx	Fy	Fz	Tx	Ty	Tz	Single/Multiple	Sensor number
000 = No error 001 = DAQ error 010 = Communication error 011 = Reserved 100 = Reserved 101 = Reserved 110 = Reserved 111 = Reserved	000 = No error 001 = The sensor has not been detected 010 = Sensor failure 011 = Temperature error 100 = Reserved 101 = Reserved 110 = Reserved 111 = Reserved	0 = The axis has not been overloaded 1 = The axis has been overloaded			These are not used in case of force only sensors			0 = Only a single sensor has error (or no error) 1 = Multiple sensors have error /This case, only the first sensor # has been indicated/	000 = No sensor has error 001 = Sensor #1 010 = Sensor #2 011 = Sensor #3 100 = Sensor #4 101 = Reserved 110 = Reserved 111 = Reserved

Example: a decimal 514 equal to 0b0000001000000010 would imply an overload condition of axis Fx of the sensor #2 (channel 2).

The default bandwidth is 15Hz. The device can be configured via sending the following CONFIG packet (9 bytes):
Please note that the configuration will reset on power reset, and the sent bytes must be a multiple of 8 bytes. It is recommended to expand the number of bytes to 16 (with seven 0x0 bytes at the end).

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CONFIG bytes								
1	2	3	4	5	6	7	8	9

Header (170,0,50,3)	Speed	Filter	Zero	Checksum

The *Checksum* (UINT16) needs to be calculated according to the value of the Speed,Filter and Zero.

$$Checksum = 170 + 0 + 50 + 3 + Speed + Filter + Zero$$

The *Speed* byte sets the update speed.

Speed (decimal)	Update frequency
0	Stops the transmission
1	1000 Hz (default)
3	333 Hz
10	100 Hz
33	30 Hz
100	10 Hz

The internal filtering can be configured by setting the Filter byte.

Filter (decimal)	Cut-off frequency
0	No filtering
1	500 Hz
2	150Hz
3	50 Hz
4	15 Hz (default)
5	5 Hz
6	1.5 Hz

In order to clear the sensors offset the sensor can be zeroed by setting the ZERO byte to 255 (decimal). It can be restored to the original values by setting it to 0.

Example: In order to set 1000 Hz update rate and 500Hz cut-off frequency and cancel the offset (by zeroing) the 16 bytes to be sent should be the following:

170 0 50 3 1 1 255 1 224 0 0 0 0 0 0 0