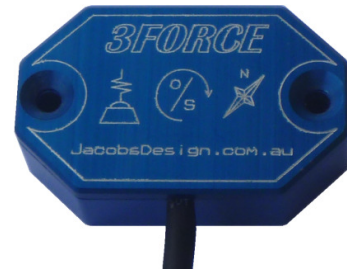


3Force Sensor

The 3Force sensor is compact and economical, offering triple axis measurement of G-Force, Gyroscopic Force and Magnetic Field. The sensing range of each sensor has been tailored to suit a wide range of applications characterised by high levels of dynamic motion. The sensor has four wire connection to provide power supply and CAN bus allowing easy integration into existing data acquisition systems.



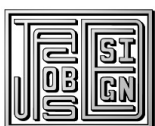
1. Features

- Rugged anodised aluminium enclosure. (Al 6016-T6)
- The loom is constructed with Mil Spec wiring and Raychem DR25 heat shrink.
- Measurement of gravitational force (g-force), gyroscopic force (gyro) and magnetic field (compass) in a single sensor.
- G-force measurements are triple axis in the range -16g to +16g.
- Gyro measurements are triple axis in the range -500°/s to +500°/s.
- Compass measurements are triple axis and suited to the earth's magnetic field.
- Sensor communicates via CAN bus.
- The base CAN address is programmable to allow multiple sensors on the same CAN bus.
- Supports CAN bus baud rates up to 1M baud.
- Internal sample rate of sensors is 6KHz for G-force, 800Hz for Gyro and 75Hz for Compass.
- Each triple axis parameter is transmitted in a dedicated CAN bus message.
- The transmit rate of each CAN bus message can be independently set in the range of 1Hz to 1000Hz.
- The sensor features automatic digital filtering to achieve the best possible result to match the CAN transmit rate.
- Sensor is compact at only 52 x 32 x 15mm.
- Sensor is light weight at only 55 grams.
- Operational temperature range is -20°C to +85°C.



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2. Specifications

General Parameters	Min	Typical	Max	Units
Supply Voltage ^{*1}	5	-	24	V
Supply Current	-	50	-	mA
Length	-	52	-	mm
Width	-	32	-	mm
Depth	-	15	-	mm
Weight	-	55	-	g
Operational Temperature ^{*2}	-20	+35	+85	°C

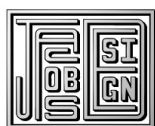
^{*1} The supply voltage must be from a load dump protected source.

^{*2} Although untested at the extremes, the operational temperature range has been designed into the product by part selection.

G-Force Parameters	Min	Typical	Max	Units
Dynamic Range	-	16	-	g
Resolution	-	1	-	mg
Sample Rate (Internal to Sensor)	-	800	-	Hz
Default Reporting Rate (CAN bus)	-	100	-	Hz

Gyroscope Parameters	Min	Typical	Max	Units
Dynamic Range	-	500	-	°/s
Resolution	-	0.1	-	°/s
Sample Rate (Internal to Sensor)	-	800	-	Hz
Default Reporting Rate (CAN bus)	-	100	-	Hz

Compass Parameters	Min	Typical	Max	Units
Sample Rate (Internal to Sensor)	-	75	-	Hz
Default Reporting Rate (CAN bus)	-	100	-	Hz

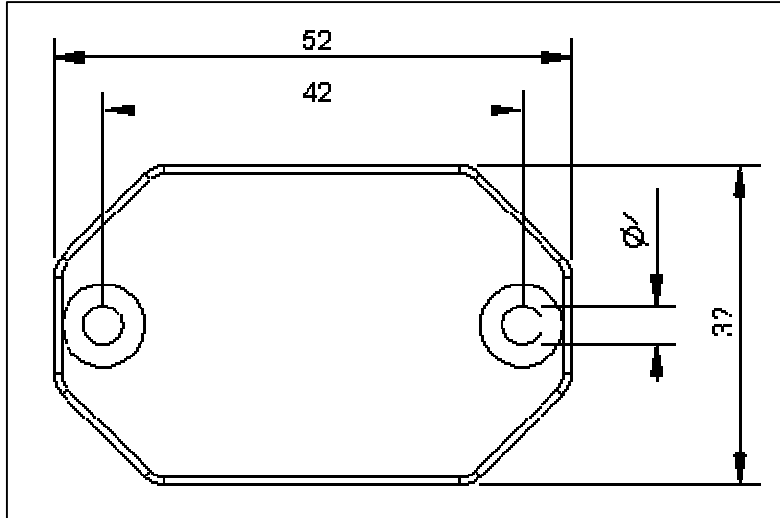


3. Installation – Mechanical

Two options are possible:

- Rigid Mounting (using M4 countersunk bolts) for when a more direct coupling is required. Excessive vibration may swamp the g-force measurements.
- Flexible Mounting (using double sided tape or velcro) for when an amount of shock "filtering" is required.

Both methods of mounting have been successfully used.



The above figure shows the dimensions of the top view of the sensor.

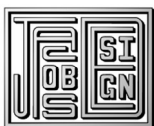
4. Installation – Electrical

The sensor requires a supply voltage of 5 to 10 Volts, which must be from a load dump protected source. **DO NOT connect this sensor directly to vehicle battery.** No CAN bus termination is included in this device, but should be included as part of the overall CAN bus design.

Sensor wiring is as per the following table:

Wire Colour	Function
Red	Supply Voltage: +5 Volts to +10 Volts
Black	0 Volt Reference
Green	CAN+
Blue	CAN-

The connecting wire is approximately 150mm long, and is supplied unterminated. The green and blue wires (CAN bus wires) are twisted together in a clockwise twist underneath the heat shrink, with the sensor loom sufficiently short to be connected as a spur onto existing CAN busses.



5. CAN Bus Communications

General CAN Details

The CAN (Car Area Network) bus is a communications system designed for the fault tolerant transmission of data in harsh electrical environments. There is a lot of further general information about CAN bus topology and layout available on the Internet.

All of the messages used by the 3Force sensor are based on standard CAN data packets which has a fixed mailbox address and up to eight bytes of payload. The default base CAN bus address of the 3Force sensor is 0x610; with all examples being shown referenced to that address.

The following representation is used for all CAN messages:

CAN Address	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
-------------	--------	--------	--------	--------	--------	--------	--------	--------

The 3Force CAN bus protocol has the following messages:

CAN Address	Purpose
0x610	G-Force Data – Sent from 3Force
0x611	Gyro Data – Sent from 3Force
0x612	Compass Data – Sent from 3Force
0x613	Reserved – Sent from 3Force
0x614	Request Calibration / Configuration Parameter – Sent to 3Force
0x615	Reply Calibration / Configuration Parameter – Sent from 3Force
0x616	Set Calibration / Configuration Parameter – Sent to 3Force
0x617	Commit / Abort Configuration Changes – Sent to 3Force

0x610 (Base + 0) – G-Force Values

3Force – Transmit Only.

The format of the G-Force message is: (Only 6 data bytes used)

0x610	X-Axis Data	Y-Axis Data	Z-Axis Data
-------	-------------	-------------	-------------

The X, Y and Z values are all signed 16 bit data. The high-byte of the data precedes the low-byte. The G-Force sensor has a nominal sensing range of $\pm 16g$. The data has a resolution of 1mg. The output value is as follows:

Measured G-Force	Output Value
-16g	-16000
-1g	-1000
0g	0
1g	1000
16g	16000

If connecting to a MoTeC data logger then set the G-Force CAN channels as:

Parameter	Value
Multiplier	1
Divider	10
Adder ^{*1}	0

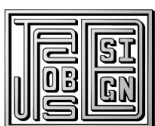
^{*1} The Adder can be used to offset the zero value of the sensor in lieu of a sensor calibration.

0x611(Base + 1) – Gyro Values

3Force – Transmit Only.

The format of the Gyro message is: (Only 6 data bytes used)

0x611	X-Axis Data	Y-Axis Data	Z-Axis Data
-------	-------------	-------------	-------------



The X, Y and Z values are all signed 16 bit data. The high-byte of the data precedes the low-byte. The Gyroscopic sensor has a nominal sensing range of $\pm 500^\circ/\text{s}$. The data has a resolution of $0.1^\circ/\text{s}$. The output value is as follows:

Measured Gyro Rate	Output Value
$-500^\circ/\text{s}$	-5000
$-1^\circ/\text{s}$	-10
$0^\circ/\text{s}$	0
$1^\circ/\text{s}$	10
$500^\circ/\text{s}$	5000

If connecting to a MoTeC data logger then set the Gyro CAN channels as:

Parameter	Value
Multiplier	1
Divider	1
Adder ^{*1}	0

^{*1} The Adder can be used to offset the zero value of the sensor in lieu of a sensor calibration.

0x612 (Base + 2) – Compass Values

3Force – Transmit Only.

The format of the Compass message is: (Only 6 data bytes used)

0x612	X-Axis Data	Y-Axis Data	Z-Axis Data
-------	-------------	-------------	-------------

The X, Y and Z values are all signed 16 bit data. The high-byte of the data precedes the low-byte. The Compass sensor measures magnetic field in units of gauss. The measured value is affected by the presence of ferrous materials as well as geophysical effects. Because of these reasons, the most meaningful way to use the compass sensor is to consider the output as unit-less and to calculate the trigonometric relationship between the values in the plane of interest – typically the horizontal plane. The Compass sensor has a nominal range of ± 1000 units.

If connecting to a MoTeC data logger then set the G-Force CAN channels as:

Parameter	Value
Multiplier	1
Divider	10
Adder ^{*1}	See Note

^{*1} The Adder value should be set on a per installation basis, since the 3Force sensor is affected by its mounting environment.

0x613 (Base + 3) – Reserved

3Force – Transmit Only.

The format of the Reserved message is: (Only 6 data bytes used)

0x613	X-Axis Data	Y-Axis Data	Z-Axis Data
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The X, Y and Z values are all signed 16 bit data. The high-byte of the data precedes the low-byte.

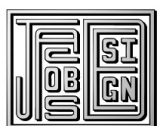
0x614 (Base + 4) – Request Calibration / Configuration Parameter

3Force – Receive Only.

The general format of the Request message is:

0x614	Group	Value
-------	-------	-------

If the 3Force sensor receives a valid Group / Value pair, then the associated configuration / calibration value(s) will be transmitted on the CAN bus using the 0x615 (Base + 5) message. Messages with an invalid Group / Value pair will result in no response from the 3Force sensor. The following Group / Value pairs are supported:



Group	Value	Usage
0	0	The number of general options. (Group 0)
0	1	Configuration Format Version. (Read Only)
0	2	CAN Base Address. (Default is 0x610)
0	3	Hardware Identifier. (Read Only)
0	4	Serial Number. (Read Only)
0	5	Firmware Version. (Read Only)
1	0	The number of G-Force options. (Group 1)
1	1	G-Force CAN Message Transmission Rate.
1	2	G-Force X-Axis Offset and Scaling.
1	3	G-Force Y-Axis Offset and Scaling.
1	4	G-Force Z-Axis Offset and Scaling.
2	0	The number of Gyro options. (Group 2)
2	1	Gyro CAN Message Transmission Rate.
2	2	Gyro X-Axis Offset and Scaling.
2	3	Gyro Y-Axis Offset and Scaling.
2	4	Gyro Z-Axis Offset and Scaling.
3	0	The number of Compass options. (Group 3)
3	1	Compass CAN Message Transmission Rate.
3	2	Compass X-Axis Offset and Scaling.
3	3	Compass Y-Axis Offset and Scaling.
3	4	Compass Z-Axis Offset and Scaling.

0x615 (Base + 5) – Transmit Calibration / Configuration Parameter

3Force – Transmit Only.

The general format of the Request message is:

0x615	Group	Value	Parameters
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The messages sent are grouped by functionality.

Number of Options

0x615	0	0	5
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Number of General options

0x615	1	0	4
-------	---	---	---

Number of G-Force options

0x615	2	0	4
-------	---	---	---

Number of Gyro options

0x615	3	0	4
-------	---	---	---

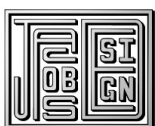
Number of Compass options

These messages are of no general use other than informational to support configuration tools.

Misc. Items

0x615	0	1	2
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Configuration Format Version (Read Only)



The configuration format versions indicates the internal format of the configuration parameters. All later version numbers are backward compatible with earlier version numbers. Configurations are automatically updated to later versions without loss of calibration / configuration data.

0x615	0	2	0x610	CAN Base Address (Read / Write)
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All CAN bus communications are relative to this address. Updating the CAN bus base address allows multiple 3Force sensors on the same CAN bus. The other reason to update the CAN base address is to resolve conflicts with other devices on the CAN bus.

0x615	0	3	'J'	'D'	'L'	'1'	Hardware Version (Read Only)
-------	---	---	-----	-----	-----	-----	------------------------------

The hardware version of the product is a Jacobs Design internal company identifier.

0x615	0	4	'0'	'1'	'6'	'0'	Serial Number (Read Only)
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The serial number is the same as the one etched into the side of the sensor.

0x615	0	5	'L'	'E'	'0'	'1'	Firmware Version (Read Only)
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'A' = 2001. Thus 'L' = 2012.

'A' = January. Thus 'E' = May.

The firmware version in this instance is 1 May 2012.

CAN Message Rate

0x615	1	1	100 (Default)	G-Force Message Rate
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The message rate resolution is 0.1ms. Default to 10.0ms (100Hz).

0x615	2	1	100 (Default)	Gyro Message Rate
-------	---	---	---------------	-------------------

The message rate resolution is 0.1ms. Default to 10.0ms (100Hz).

0x615	3	1	100 (Default)	Compass Message Rate
-------	---	---	---------------	----------------------

The message rate resolution is 0.1ms. Default to 10.0ms (100Hz).

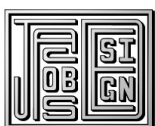
Offset and Scaling

G-Force Offset and Scaling

0x615	1	2	Offset	Scale	X-Axis
0x615	1	3	Offset	Scale	Y-Axis
0x615	1	4	Offset	Scale	Z-Axis

Gyroscope Offset and Scaling

0x615	2	2	Offset	Scale	X-Axis
0x615	2	3	Offset	Scale	Y-Axis
0x615	2	4	Offset	Scale	Z-Axis



Compass Offset and Scaling

0x615	3	2	Offset	Scale	X-Axis
0x615	3	3	Offset	Scale	Y-Axis
0x615	3	4	Offset	Scale	Z-Axis

The general equation for offset and scaling is:

$$TxValue = \left(MeasuredValue + \frac{Offset}{16} \right) \times \left(\frac{Scale}{8192} \right)$$

If the value from the sensor did not require any calibration, then the calibration values are:

Offset = 0 and Scale = 8192.

The Range of Offset and Scale is -32768 to +32768.

The data can be Offset in the range -2000 to +2000.

The data can be Scaled in the range 0.0 to ±4.0.

If using a MoTeC data logging system, then offset and scaling can be supplemented by the multiplier, divider and adder parameters that are part of the CAN message setups.

0x616 (Base + 6) – Set Calibration / Configuration Parameter

3Force – Receive Only.

The general format of the Request message is:

0x616	Group	Value
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If the 3Force sensor receives a valid Group / Value pair, then the associated configuration / calibration value will be updated. The reception of this message is confirmed by sending a CAN bus 0x615 (Base + 5) message with the new updated value.

NB: Any changes made to the sensor using command will be lost if the sensor loses power. Use the 0x617 (Base + 7) command to commit the changes to permanent storage in the sensor.

0x617 (Base + 7) – Commit / Abort Configuration Changes

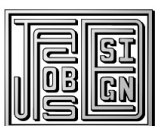
3Force – Receive Only.

The format of this message is:

0x617	B_High	B_Low
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If B_High and B_Low match the CAN base address of the sensor, then any changes made to the sensor configuration will be written to a permanent storage area in the sensor. If B_High and B_Low do not match the CAN base address of the sensor, then the previous configuration will be reloaded.

For a base address of 0x610: B_High = 0x06 and B_Low = 0x10 would commit the configuration to permanent storage.



6. Sensor Part Number

The orderable part number of this sensor is as follows:

3Force	This part is the combined G-Force / Gyro / Compass.
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7. Company Information

Jacobs Design (Aust) Pty Ltd incorporated in July 2000. Since then the company has been involved in the development of custom hardware and software solutions. The company has also supplied a data analysis support service to the V8 Supercars since its inception.

