New

DMU30

High Performance MEMS Inertial Measurement Unit (HPIMU)

Description

DMU30 is the first of a new family of High Performance MEMS IMUs (HPIMU) incorporating Silicon Sensing's tried and tested precision VSG3Q^{MAX} high-Q inductive and VSG5 low-noise PZT resonating ring gyroscopes and capacitive accelerometers.

DMU30 is a six-degree-of-freedom inertial measurement unit providing precise 3-axis outputs of angular rate and acceleration, delta angle and velocity, and temperature, at 200Hz. It uses a unique Multi-MEMS architecture to blend the inputs from dual independent MEMS sensing elements per axis to achieve benchmark all-MEMS inertial performance across the duty cycle.

DMU30 represents a realistic alternative to established FOG/RLG based IMUs due to its exceptional bias stability and low noise characteristics, yet it is comparatively compact, lightweight and offers low cost of ownership.

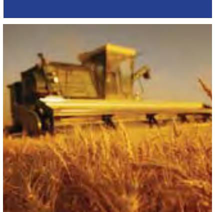
Designed specifically to meet the growing demand from high-end commercial and industrial market applications for a 'tactical' grade non-ITAR IMU, DMU30 utilises Silicon Sensing's class leading MEMS inertial sensors integrated and calibrated using an in-house state-of-the-art test facility.

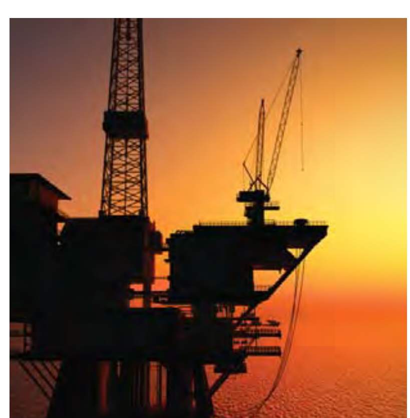
Key features

- Precision 6-DOF MEMS Inertial Measurement Unit
- Silicon Sensing's latest VSG3Q^{MAX} inductive gyro and capacitive MEMS accelerometer
- Excellent Bias Instability and Random Walk Angular - 0.1°/hr, 0.02°/√hr Linear - 15µg, 0.05m/s/√hr
- Non-ITAR
- Compact and lightweight - 68.5 x 61.5 x 65.5H (mm), 345g
- Internal power conditioning to accept 4.75V to 36V input voltage
- RS422 interfaces
- -40°C to +85°C operating temperature range
- Sealed aluminium housing (IP67)
- RoHS compliant
- In-house manufacture from MEMS fabrication to IMU calibration
- Evaluation kit and integration resources available
- First class customer technical support
- Future developments and expansion capability, e.g. magnetometer, barometer, GPS

Applications

- Hydrographic surveying
- Airborne survey and mapping
- INS (Inertial Navigation Systems)
- AHRS (Attitude and Heading Reference System)
- GPS drop-out aiding
- Maritime guidance and control
- GNSS (Global Navigation Satellite System)
- Autonomous vehicle control and ROVs
- Machine control
- MEMS alternative to FOG/RLG IMUs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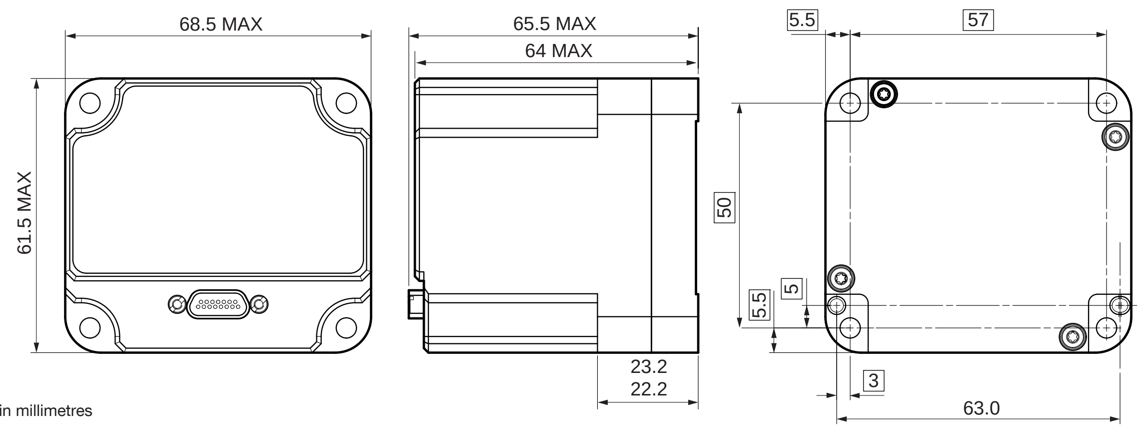

All dimensions in millimetres

Typical Data

Parameter	Specification
Gyroscope Properties	
Dynamic range	±490°/s
Scale factor over temp (±200°/s)	±250ppm
SF non-linearity (±200°/s)	±100ppm
Bias instability	<0.1°/h
Random walk	<0.02°/√h
Bias over temp	±15°/h
Noise (rms to 100Hz)	0.05°/s
Accelerometer Properties	
Dynamic range	±10g
Scale factor over temp (±1g)	±250ppm
SF non-linearity (±10g)	±1000ppm
Bias instability	<0.015mg
Random walk	<0.05m/s/√h
Bias over temp	±1.5mg
Noise (rms to 100Hz)	0.90mg
Cross Axis Sensitivity	
Over temperature	±0.20%
IMU Temperature Sensor Properties	
Range	-45 to 100°C
Accuracy at temperature	±3.0°C
IMU Properties	
Operating temperature	-40 to 85°C
Start-up-time (full performance)	<1.0s (<20s)
Power	<3W
Supply voltage	4.75 to 36V
Mass	345g

DMU30 EVK Evaluation Kit
(P/N DMU30-00-0500)

Specificationsubjecttochangewithoutnotice.

DMU30-00-0100-131 Rev 5
DCR No. 710013007

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DMU30-01 Technical Datasheet

High Performance MEMS
Inertial Measurement Unit (HPIMU)

SILICON SENSING®

Applications

- Hydrographic surveying
- Airborne survey and mapping
- INS (Inertial Navigation Systems)
- AHRS (Attitude and Heading Reference System)
- GPS drop-out aiding
- Maritime guidance and control
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- Machine control
- MEMS alternative to FOG/RLG IMUs

Features

- Precision 6-DOF MEMS Inertial Measurement Unit
- Silicon Sensing's latest VSG3Q^{MAX} inductive gyro and capacitive accelerometer MEMS
- Excellent Bias Instability and Random Walk
  - Angular - 0.1°/hr, 0.02°/√hr
  - Linear - 15µg, 0.05m/s/√hr
- Non-ITAR
- Compact and lightweight - 68.5 x 61.5 x 65.5H (mm), 345g
- Internal power conditioning to accept 4.75V to 36V input voltage
- RS422 interfaces
- -40°C to +85°C operating temperature range
- Sealed aluminium housing
- RoHS compliant
- In-house manufacture from MEMS fabrication to IMU calibration
- Evaluation kit and integration resources available
- First class customer technical support
- Future developments and expansion capability
  - Multi sensor MEMS blending
  - Low power 'sleep' mode
  - Additional sensor integration - GPS/ Magnetometer/Barometer
  - North finding mode
  - AHRS functionality
  - Other interface protocols and specifications
  - Custom and host application integration

1 General Description

DMU30 is a full six-degree-of-freedom inertial measurement unit providing precise 3-axis outputs of angular rate and acceleration, delta angle and velocity, and temperature, at 200Hz.

DMU30 is the first of a new family of High Performance MEMS IMUs (HPIMU) incorporating precision VSG3Q^{MAX} high-Q inductive resonating ring gyroscopes and capacitive accelerometers.

DMU30 represents a realistic, alternative to established FOG/RLG based IMUs due to its exceptional bias stability and low noise characteristics, yet it is comparatively compact, lightweight and offers low cost of ownership.

Designed specifically to meet the growing demand from high-end commercial and industrial market applications for a 'tactical' grade non-ITAR IMU, DMU30 utilises Silicon Sensing's class leading MEMS inertial sensors integrated and calibrated using an in-house state-of-the-art test facility.

HPIMU development takes advantage of Silicon Sensing's wide-ranging multi sensor technologies in a unique architecture to achieve a highly versatile IMU design. Future developments will feature GPS, magnetic and ambient pressure sensing, north finding and AHRS functions.

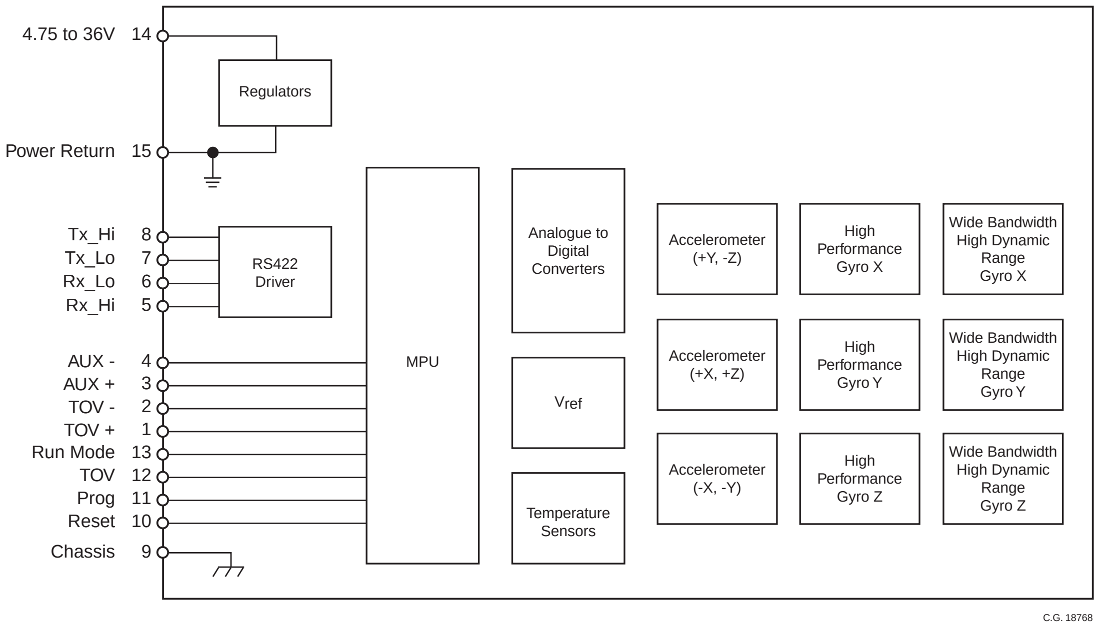
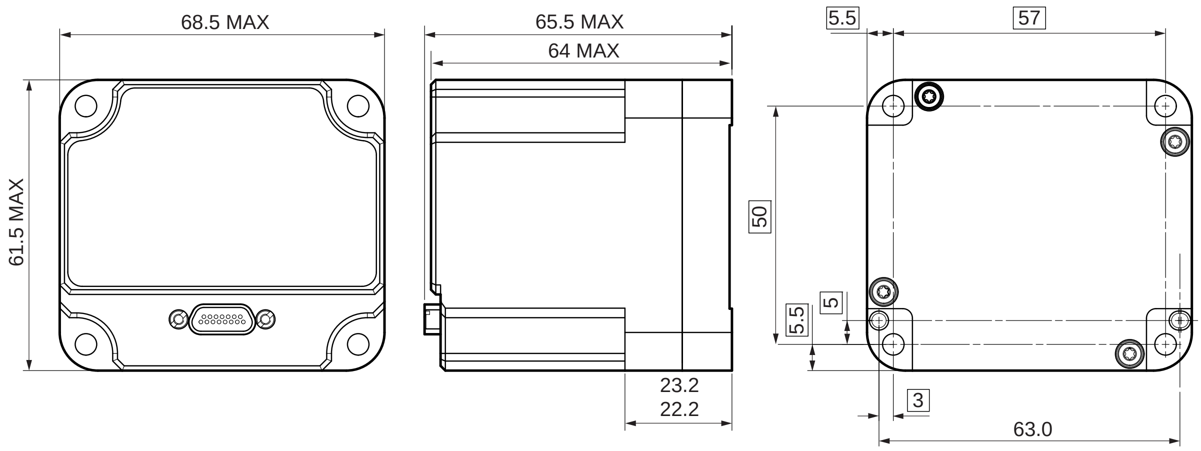


Figure 1.1 DMU30 Functional Block Diagram



All dimensions in millimetres.

Figure 1.2 DMU30 Unit Overall Dimensions

2 Ordering Information

Item	Description	Overall Dimensions	Part Number
		mm	
 DMU30-01 IMU	High Performance MEMS Inertial Measurement Unit	68.5 x 61.5 x 65.5H	DMU30-01-0100
 DMU30 Evaluation Kit	Customer Evaluation Kit (EVK) comprising a RS422 to USB Connector, USB Driver and Data Logging Software, Cables and Connectors, Instruction Manual (DMU30 is NOT included)	Not Applicable	DMU30-00-0500
 DMU30 Mating Connector	Mating connector plug and cable for DMU30	Length 450mm	Glenair MWDM2L-15P-6E5-18 or equivalent

3 Specification

Parameter	Minimum	Typical	Maximum	Notes
Angular (Roll, Pitch, Yaw)				
Dynamic Range (°/s)	-490	–	+490	Clamped at ±495°/s during over-range
Scale Factor Error (ppm) Over Life	-700 (-1500)	±500	+700 (+1500)	Up to ±200°/s (over life) (between ±200°/s and ±490°/s)
Scale Factor Non-Linearity Error (ppm)	-500 (-1500)	±100 (±500)	+500 (+1500)	Up to ±200°/s factory fresh test (between ±200°/s and ±490°/s)
Bias (°/hr)	-20	±15	+20	Over operating temperature range factory fresh test
Bias Instability (°/h)	–	< 0.1	0.2	As measured using the Allan Variance method.
Random Walk (°/√h)	–	< 0.02	0.04	
Bias Repeatability (°/h)	–	20	100	$Bias\ Repeatability = \sqrt{(Bias_{warmup})^2 + (Bias_{toto})^2 + (Bias_{ageing})^2 + (Bias_{temperature})^2}$
Gyro Cross Coupling (%)	-0.40	±0.20	+0.40	Over operating temperature range
Sensor Level Bandwidth (Hz)	–	150	–	-3dB point
IMU Level Bandwidth (Hz)	>77	–	–	-3dB point
Noise (°/s rms)	–	0.05	0.1	Wide band noise
VRE (°/s/g² rms)	-0.006	±0.002	+0.006	4.2g rms stimulus 20Hz to 2,000Hz
g Sensitivity (°/hr/g)	-0.1	±0.05	+0.1	Tested over ±10g

3 Specification Continued

Parameter	Minimum	Typical	Maximum	Notes
Linear (X, Y, Z)				
Dynamic Range (g)	-10	–	+10	Clamped at ±11.0g during over-range
Scale Factor Error (ppm)	-500	±250	+500	Maximum error at ±1g (9.80665m/s/s) factory fresh test
Scale Factor Error (ppm) Over Life	-1000	±500	+1000	Maximum error at ±1g (9.80665m/s/s) over life
Scale Factor Non-Linearity Error (ppm)	-5000	±1000	+5000	Maximum error from best straight line calculated at ±1g (over ±10g range)
Bias (mg)	-5.00	±1.50	+5.00	Over operating temperature range, factory fresh test
Bias Instability (µg)	–	15	30	As measured using the Allan Variance method.
Random Walk (m/s/√h)	–	0.05	0.06	
Bias Repeatability (mg)	–	3.5	7	$Bias\ Repeatability = \sqrt{(Bias_{warmup})^2 + (Bias_{toto})^2 + (Bias_{ageing})^2 + (Bias_{temperature})^2}$
Acc Cross Coupling (%)	-0.40	±0.20	+0.40	Over operating temperature range
Sensor Level Bandwidth (Hz)	–	250	–	-3dB point
IMU Level Bandwidth (Hz)	>77	–	–	-3dB point
Noise (mg rms)	–	0.9	1.4	Wide band noise
VRE (mg/g² rms)	-0.15	±0.10	+0.15	4.2g rms stimulus 20Hz to 2,000Hz when measured with zero g background acceleration
Temperature Output				
Range (°C)	-45	–	100	Note that this exceeds operational temperature range
Accuracy (°C)	–	±3	–	Represents the internal DMU30 temperature

4 Environment, Power and Physical

4.1 Normal Operation

Parameter	Minimum	Typical	Maximum	Notes
Environment				
Operating Temperature Range (°C)	-40	–	+85	Full specification
Storage Temperature Range (°C)	-55	–	+100	–
Operational Shock (g)	–	–	95	6ms, half sinewave
Operational Shock (g) (powered survival)	–	–	1,000	1.0ms, half sinewave. This is a survival test. After subjection to this shock profile the performance of the DMU30 may degrade by a factor of two
Operational Random Vibration (g rms)	–	–	4.2	20Hz to 2KHz
Non-Operational Random Vibration (g rms)	–	–	10	20Hz to 2KHz
Humidity (% rh)	–	–	85	Non-condensing
Sealing	IP67	–	–	The DMU30 is sealed and tested to IP67
Environmental Protection				
Audio Frequency Conducted Susceptibility (power inputs)	–	Section 18 Category Z	–	RTCA/DO-160G (Note 1)
RF Susceptibility (radiated and conducted)	–	Section 20 Category SS	–	RTCA/DO-160G
Emission of RF Energy	–	Section 21 Category B	–	RTCA/DO-160G
Electrical and Interface				
Communication Protocol (standard)	–	RS-422	–	Full duplex communication
Data Rate (Hz)	–	200 (default)	–	User programmable (future feature)
Baud Rate (BPS)	–	460,800 (default)	–	User programmable (future feature)
Startup Time (s) (operational output)	–	< 1.0	1.2	Time to operational output

Note 1: DMU30 has been tested in accordance with RTCA/DO-160G section 18 category Z. The DMU30 is sensitive to frequencies matching the internal resonator frequencies which are 13500Hz to 14500Hz, plus the submultiples of 1/2 and 1/3.

4.1 Normal Operation Continued

Parameter	Minimum	Typical	Maximum	Notes
Startup Time (s) (full performance)	–	–	20	Time to full performance (mounting dependent)
Power (watts)	–	< 3	4	With 120 Ω RS422 termination resistor
Supply Voltage (V)	+4.75	+12	+36	Unit is calibrated at 12V Note that operation at 4.75V requires a low impedance supply with short interconnects
Physical				
Size (mm)	–	68.5 x 61.5 x 65.5H	–	–
Mass (grams)	–	345g	350g	–

Notes:

DMU30 is designed for immersion in water (IP67). To maintain integrity around the connector, it is essential that the mating connector is a sealed type, or a suitable sealing compound should be applied around the connectors.

The in-rush current required for start up increases with decreasing supply voltage. Therefore, for low supply voltages a supply with a low source impedance is required. Also short cables are recommended.

4.2 Absolute Minimum/Maximum Ratings

	Minimum	Maximum
Electrical:		
Vdd	Reverse voltage protected	+37V
ESD protection	–	IEC 61000-4-2 with chassis externally connected to 0V
Life:		
Operational life	5 years	–
MTTF	20,000 hours	–

Notes:

Improper handling, such as dropping onto hard surfaces, can generate every high shock levels in excess of 10,000g. The resultant stresses can cause permanent damage to the sensor.

Exposure to the Absolute Maximum Ratings for extended periods may affect performance and reliability.

5 Typical Performance Characteristics

This section shows the typical performance of DMU30, operating from a 12V power supply.

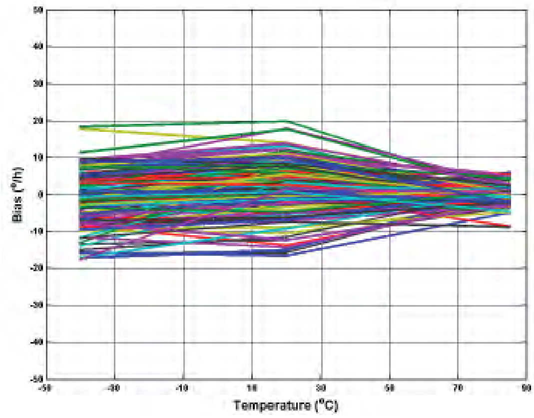


Figure 5.1 Gyro Bias Error (°/h) over Temperature

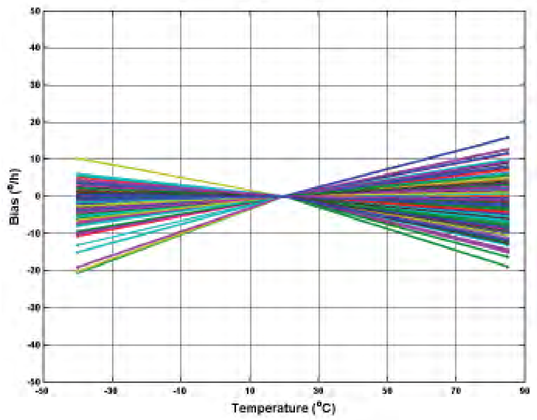


Figure 5.2 Normalised Gyro Bias Error (°/h) over Temperature

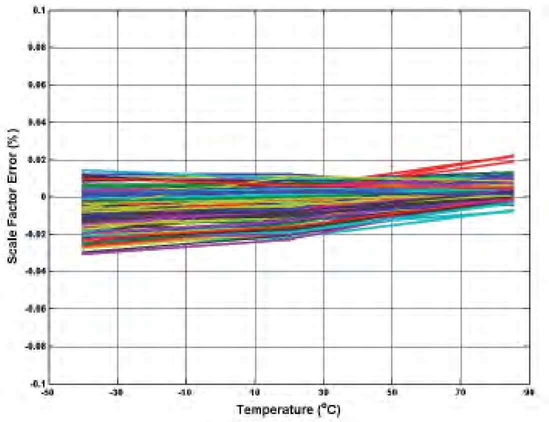


Figure 5.3 Gyro Scale Factor Error over Temperature

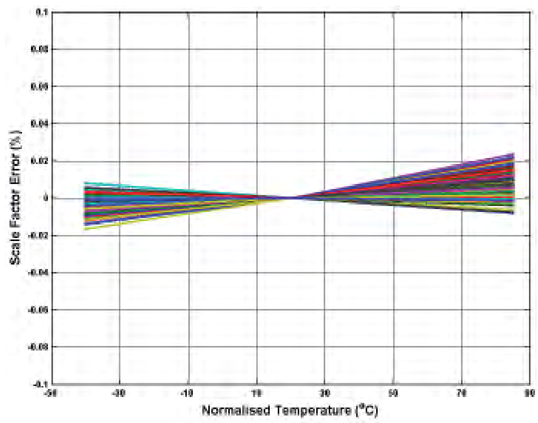


Figure 5.4 Normalised Gyro Scale Factor Error over Temperature

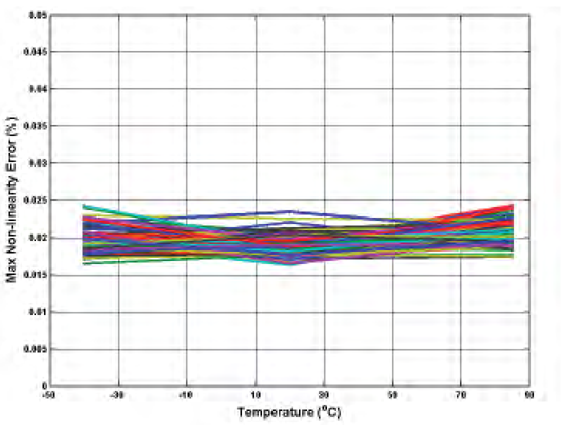


Figure 5.5 Gyro Max Non-Linearity Error (±490°/s range) over Temperature

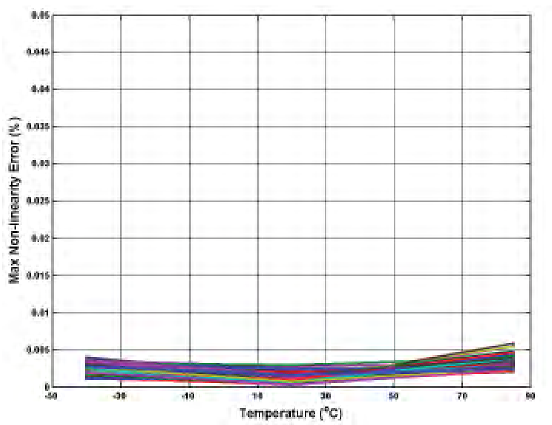


Figure 5.6 Gyro Max Non-Linearity Error (±200°/s range) over Temperature

5 Typical Performance Characteristics Continued

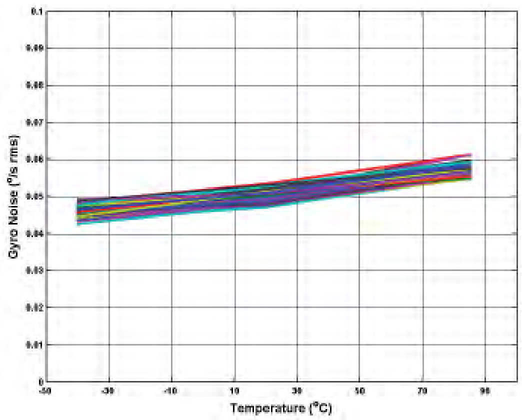


Figure 5.7 Gyro Noise (°/srms) vs Test Chamber Temperature

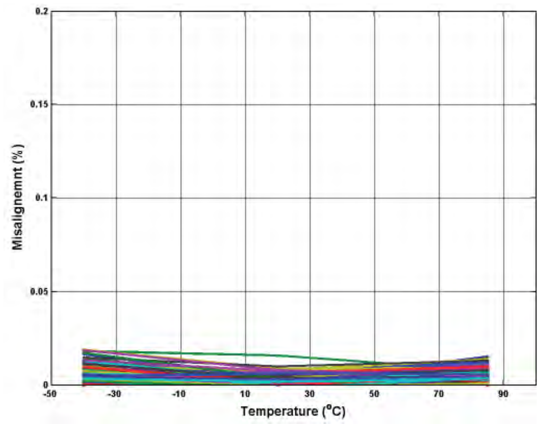


Figure 5.8 Gyro Misalignments and Crosscoupling (±200°/s range) over Chamber Temperature

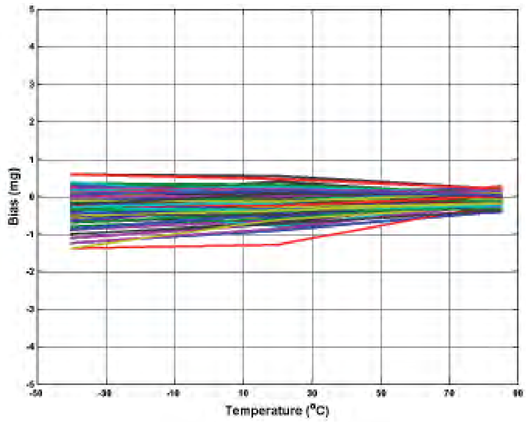


Figure 5.9 Accelerometer Bias Error (mg) over Temperature

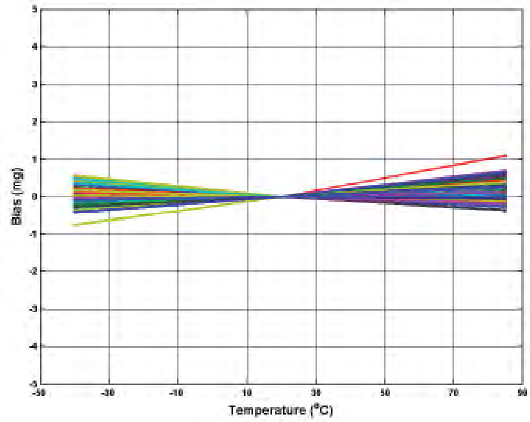


Figure 5.10 Normalised Accelerometer Bias Error (mg) over Temperature

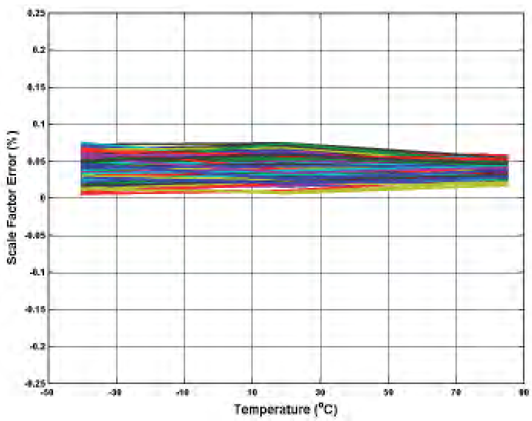


Figure 5.11 Accelerometer Scale Factor Error (±1g range) over Temperature (Plymouth g = 9.81058m/s/s)

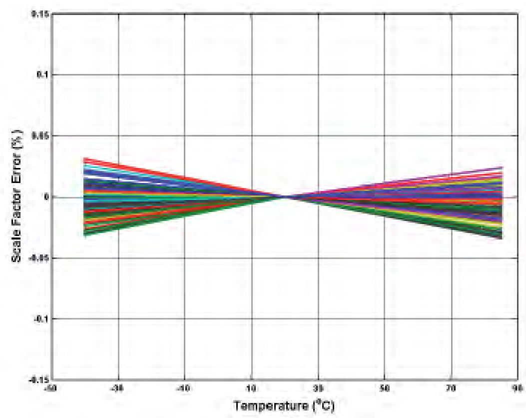


Figure 5.12 Normalised Accelerometer Scale Factor Error (±1g range) over Temperature

5 Typical Performance Characteristics Continued

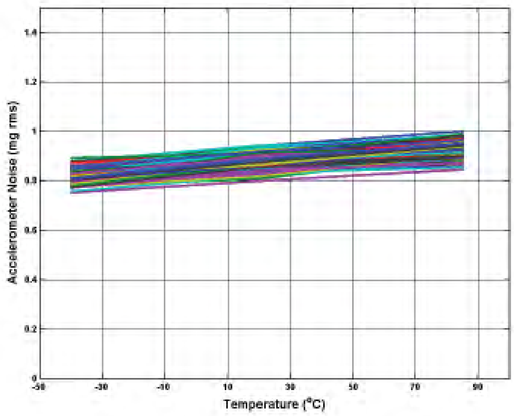


Figure 5.13 Accelerometer Noise vs Test Chamber Temperature

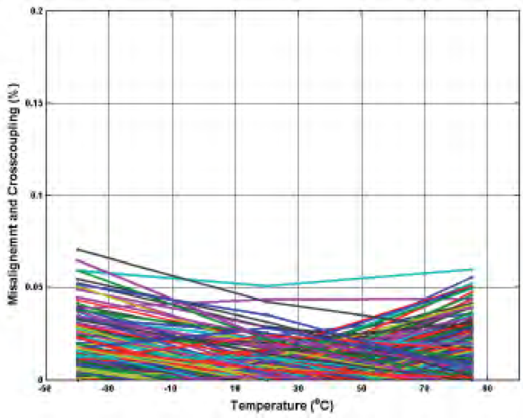


Figure 5.14 Accelerometer Misalignments and Crosscoupling over Temperature

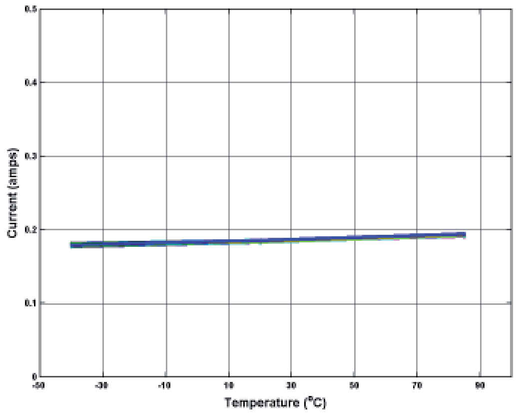


Figure 5.15 current Consumption vs Chamber Temperature (12V supply)

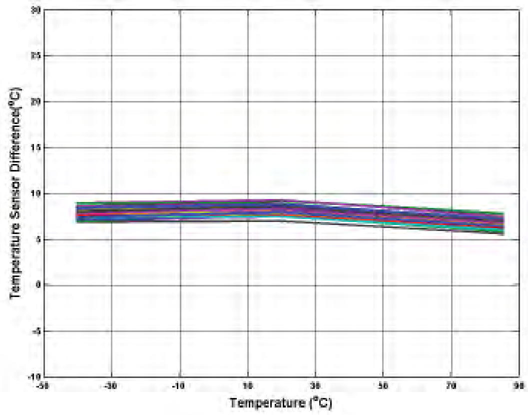


Figure 5.16 DMU30 Temperature Output Difference (°/C) vs Test Temperature (self heating)

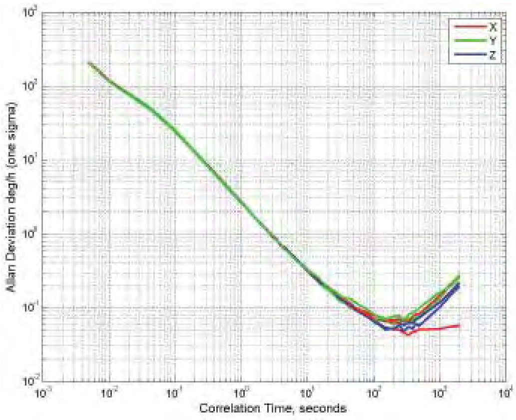


Figure 5.17 Gyro Allan Variance

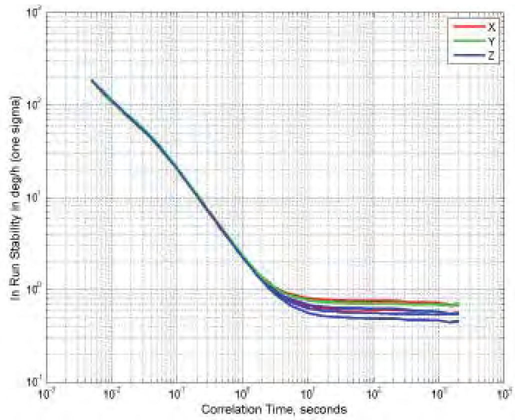


Figure 5.18 Gyro In Run Stability

5 Typical Performance Characteristics Continued

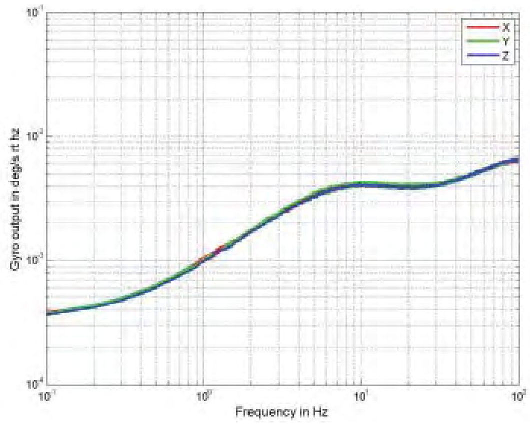


Figure 5.19 Gyro Spectral Data

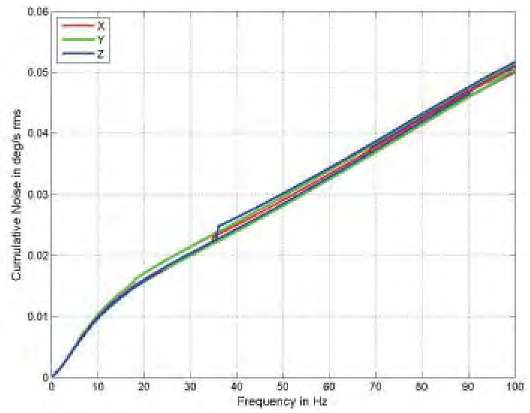


Figure 5.20 Gyro Cumulative Noise

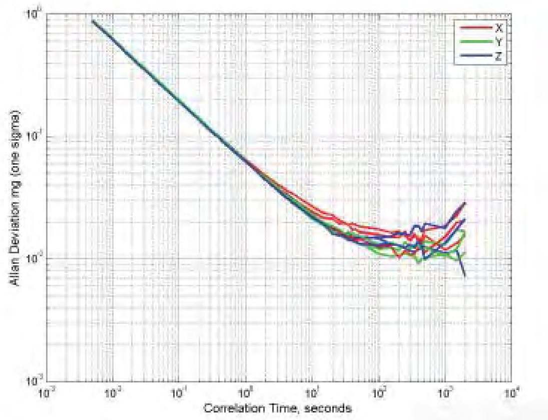


Figure 5.21 Accelerometer Allan Variance

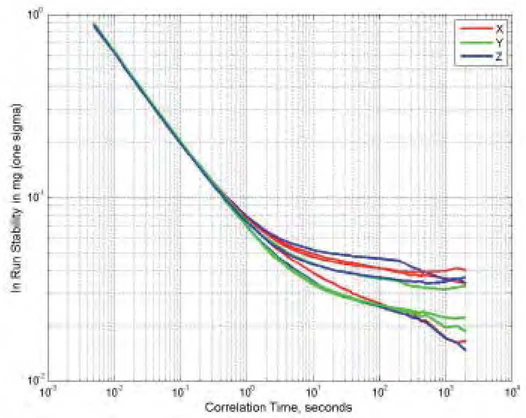


Figure 5.22 Accelerometer In Run Stability

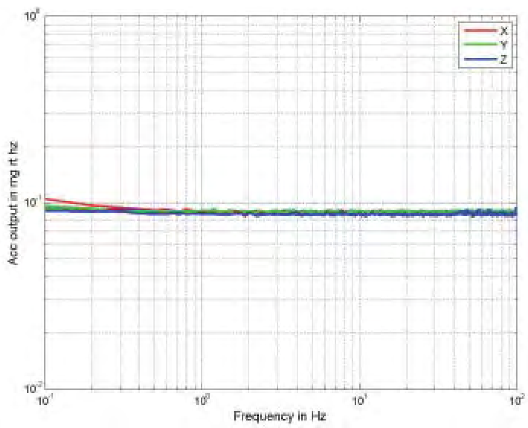


Figure 5.23 Accelerometer Spectral Data

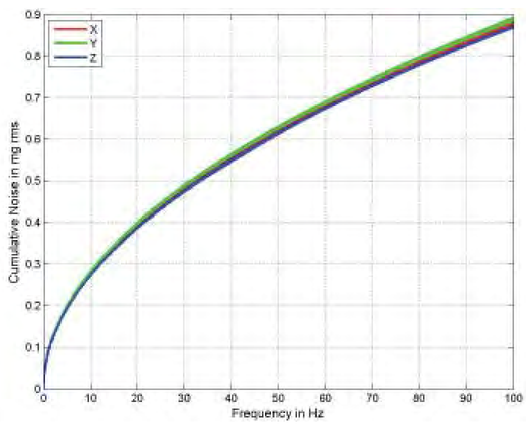


Figure 5.24 Accelerometer Cumulative Noise

6 Glossary of Terms

ADC	Analogue to Digital Converter
ARW	Angle Random Walk
AWG	American Wire Gauge
BPS	Bits Per Second (or Baud Rate)
BW	Bandwidth
C	Celsius or Centigrade
DAC	Digital to Analogue Converter
DPH	Degrees Per Hour
DPS	Degrees Per Second
DRIE	Deep Reactive Ion Etch
EMC	Electro-Magnetic Compatibility
ESD	Electro-Static Damage
F	Farads
h	Hour
HBM	Human Body Model
HPIMU	High Performance MEMS Inertial Measurement Unit
Hz	Hertz, Cycles Per Second
K	Kilo
MDS	Material Datasheet
MEMS	Micro-Electro Mechanical Systems
mV	Milli-Volts
NEC	Not Electrically Connected
NL	Scale Factor Non-Linearity
OEM	Original Equipment Manufacturer
OT	Over Temperature
PD	Primary Drive
PP	Primary Pick-Off
RC	Resistor and Capacitor filter
RT	Room Temperature
s	Seconds
SF	Scale Factor
SMT	Surface Mount Technology
SOG	Silicon On Glass
SD	Secondary Drive
SP	Secondary Pick-Off
TBA	To Be Advised
TBC	To Be Confirmed
TBD	To Be Determined
V	Volts

7 Interface

Physical and electrical inter-connect and RS422 message information

7.1 Electrical Interface

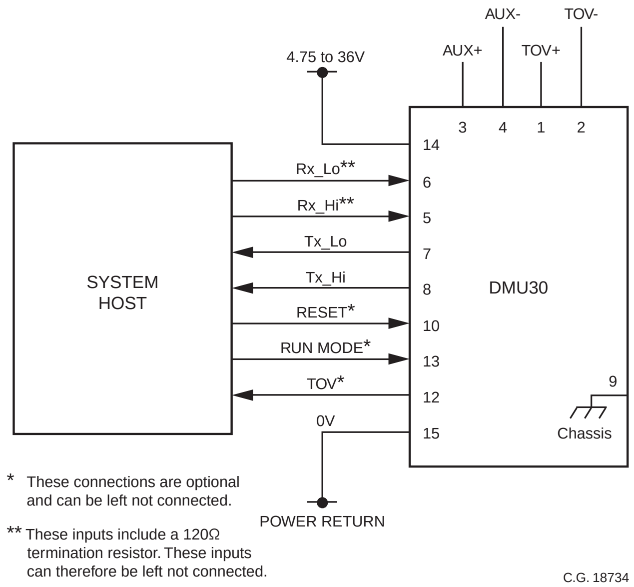


Figure 7.1 Required Connections for RS422 Communications with DMU30

7.2 Physical Interface

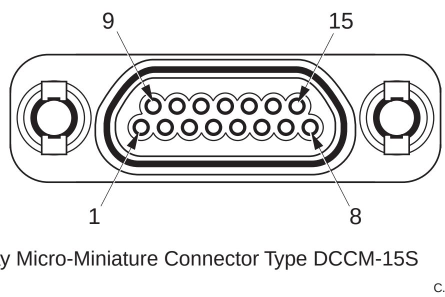


Figure 7.2 DMU30 Socket Connector

7.3 Connector Specification

DMU30 uses a 15 way socket connector which is the micro-miniature 'D' type range of connectors, produced by Cinch, Glenair and others.

The DMU30 plug mating connector is a 15 way plug, for example DCCM-15P (DCCM-15P6E518).

Silicon Sensing can supply a mating plug and cable to interface to DMU30 or they are available from electronic component distributors.

7.4 Pin Information

Pin	Label	Signal	In/ Out	Nominal Range	Absolute Max
1	TOV+	Time of Validity positive differential positive output	O	±5V	±15V
2	TOV-	Time of Validity positive differential negative output	O	±5V	±15V
3	AUX+	Auxiliary signal positive differential input	I	-9V to +9V	-9V to +9V
4	AUX-	Auxiliary signal negative differential input	I	-9V to +9V	-9V to +9V
5	Rx_Hi	The positive receive connection required for the RS422 communication	I	±5V	±15V
6	Rx_Lo	The negative receive connection required for the RS422 communication	I	±5V	±15V
7	Tx_Lo	The negative transmit connection required for the RS422 communication	O	±5V	±15V
8	TX_Hi	The positive transmit connection required for the RS422 communication	O	±5V	±15V
9	Chassis	Chassis	I	0V	+6V
10	Reset	Microprocessor reset. Pin is pulled low to reset the device.	I	0V to +5V	-0.3V to +7.3V
11	Factory Use	Used by SSSL for programming purposes and should not be interfaced with	N/A	0V to +5V	-0.3V to +7.3V
12	TOV	Time of Validity (see section 7.7)	O	0V to +5V	-0.3V to +7.3V
13	Run Mode	Device Enable/Disable. Pin is pulled high or not connected to enable the device. Pin is pulled low to disable the device. Suggested implementation using TTL logic	I	0V to +5V	-0.3V to +7.3V
14	+Volts	Input voltage to the DMU30. Can be between 4.75V and 36V with respect to GND	I	+4.75V to +36V	-37V to +37V
15	0V	Power return for the DMU30	I	–	–

Table 7.1 Pin Information

7.5 Chassis

The chassis of DMU30 is not internally connected to the 0V power return. The chassis shall be electrically connected to the system 0V by a low impedance connection. Note that the base of the DMU30 has not been anodised in order to facilitate this connection. If the mount is isolated, Pin 9 should be used to ground the chassis.

7.6 Communications with DMU30

The Run Mode pin on the connector is used to control the output from the DMU30. The "Free Run" or "Enabled" mode is active when the Pin is floating (not connected), and the output will be enabled.

The DMU30 output is disabled when the "Run Mode" Pin is pulled low. Note that the Rx_Hi and Rx_Lo lines include a 120Ω termination resistor.

7.7 Operational Message Output

The Output Message is output on a RS422 Serial output at 460,800 baud using a non-return to zero protocol. Note the RS422 lines are not trislated between messages Each byte contains a start bit (logic 0), 8 data bits and 2 stop bits (logic 1). Data is output in big endian format by default.

Data is output at a rate of 200 messages per second.

Each message contains 34 words (68 bytes) as described in Table 7.2. The message is transmitted if the "Run Mode" Pin is floating/HIGH.

If the "Run Mode" Pin changes to a LOW (Disable output), while the message is being transmitted, the message is completed before the output is disabled.

7.8 Sensor Sampling and Synchronisation

The DMU30 includes a 'Time of Validity (TOV)' output for synchronisation purposes.

The 'TOV' on the connector is normally set HIGH. It is set low, for 1.0ms, half way through the sampling sensor process. It therefore indicates the reference point in time when the data output in the next message was collected. The 'TOV' pulses are therefore seen on the connector at 200Hz.

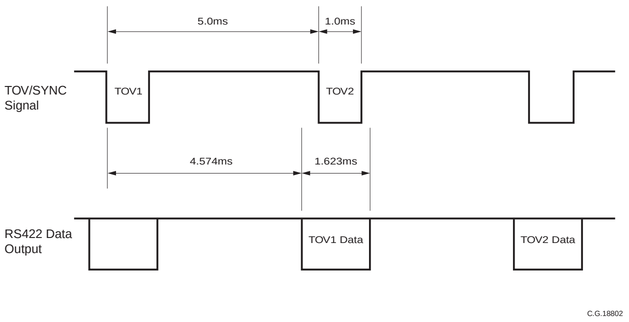


Figure 7.3 Timing Diagram

Time of Validity Parameters	Requirement
Time of Validity Signal Frequency	200Hz
TOV Logic	Active Low
TOV Pulse Width	1ms
TOV Declared Accuracy	<0.5ms
TOV Jitter	<50µs
Delay to Start of Message from TOV Low	<5ms (3.37ms Typical)
Format	RS422 Differential from Pins 1 and 2, Single Ended from Pin 12

Table 7.2 Time of Validity Parameters

The message from the DMU30 is transmitted after the 'Time of Validity'. This enables the external equipment to synchronise with the time when the Inertial Data was valid.

7.9 Auxiliary Input

A differential auxiliary input is provided and is capable of accepting voltage inputs of up to ±9V.

7.10 Operational Message Definitions

The data output message has the content and sequence as shown in the table below:

Item	Word	Data Item	Value / Unit
0	0	Header	16 Bit, 0x55AA
1	1	Message Count	16 Bit, 0 to 65535 decimal
2	2-3	Axis X Rate	32 Bit Single Precision FP, (°/s)
3	4-5	Axis X Acceleration	32 Bit Single Precision FP, (g)
4	6-7	Axis Y Rate	32 Bit Single Precision FP, (°/s)
5	8-9	Axis Y Acceleration	32 Bit Single Precision FP, (g)
6	10-11	Axis Z Rate	32 Bit Single Precision FP, (°/s)
7	12-13	Axis Z Acceleration	32 Bit Single Precision FP, (g)
8	14-15	Aux Input Voltage	32 Bit Single Precision FP, (volts)
9	16-17	Average IMU Temperature	32 Bit Single Precision FP, (°C)
10	18-19	Axis X Delta Theta	32 Bit Single Precision FP, (°)
11	20-21	Axis X Delta Vel	32 Bit Single Precision FP, (m/s)
12	22-23	Axis Y Delta Theta	32 Bit Single Precision FP, (°)
13	24-25	Axis Y Delta Vel	32 Bit Single Precision FP, (m/s)
14	26-27	Axis Z Delta Theta	32 Bit Single Precision FP, (°)
15	28-29	Aux Z Delta Vel	32 Bit Single Precision FP, (m/s)
16	30	System Startup BIT Flags	16 Bit decimal value
17	31	System Operation BIT Flags	16 Bit decimal value
18	32	Error Operation BIT Flags	16 Bit decimal value
19	33	Checksum	16 Bit 2's Complement of the 16 Bit Sum of the Previous 0-18 data items

Table 7.3 Operational Message Data Output Definitions

7.11 System BIT Flags

Built in Test functions are indicated during start up and operation. The Bit Flag Error indication word provides details of affected axes if a fault is detected.

7.11.1 System Start up BIT Flags

BIT	System Start Up Flags
0	Extendable Checksum Fail
1	NVM Coefficient Checksum Fail
2	Sensor Start Up Error
3	Internal Processor Error
4	Invalid NVM Coefficient
5	Reserved
6	Reserved
7	Reserved
8	Reserved
9	Reserved
10	Reserved
11	Reserved
12	Reserved
13	Reserved
14	Reserved
15	Reserved

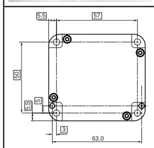
7.11.2 System Operation BIT Flags

BIT	System Operation Flags
0	Voltage Regulator Range Error
1	Scheduler Slot Extended
2	Output Message Missed
3	Internal Processor Error
4	Sensor Operation Error
5	Output Over Range
6	Accelerometer Plausibility Error
7	Reserved
8	Reserved
9	Reserved
10	Reserved
11	Reserved
12	Reserved
13	Reserved
14	Reserved
15	Reserved

7.11.3 System Error Indication BIT Flags

BIT	BIT Flag Error Indication
0	Axis X Rate
1	Axis X Acceleration
2	Axis Y Rate
3	Axis Y Acceleration
4	Axis Z Rate
5	Axis Z Acceleration
6	Aux Input Voltage
7	Average IMU Temperature
8	Axis X Delta Theta
9	Axis X Vel
10	Axis Y Delta Theta
11	Axis Y Vel
12	Axis Z Delta Theta
13	Axis Z Vel
14	Reserved
15	Reserved

8 Design Tools and Resources Available

Item	Description of Resource	Part Number	
	**DMU30 Brochure:** A one page sales brochure describing the key features of the DMU30 Inertial Measurement Unit.	DMU30-01-0100-131	
	**DMU30-01 Datasheet:** Full technical information on all DMU30 Dynamic Measurement Unit part number options. Specification and other essential information for assembling and interfacing to DMU30 Inertial Measurement Unit, and getting the most out of it.	DMU30-01-0100-132	
	**DMU30 Evaluation Kit:** Delivered with an RS422 to USB interface, plug-and-play real time display and logging software and two interface cabling solutions DMU30 unit NOT included.	DMU30-00-0500	
	**DMU30 Presentation:** A useful presentation describing the features, construction, principles of operation and applications for the DMU30 Inertial Measurement Unit.	–	
	**Solid Model CAD files for DMU30 Inertial Measurement Unit:** Available in .STP and .IGS file formats.	DMU30-00-0100-408	
	**DMU30 Plug and Cable:** A mating plug and 450mm long cable.	Glenair MWDM2L-15P-6E5-18 or equivalent	
	**DMU30 Installation Drawing:** CAD file containing host interface geometry. Available in .STP and .IGS file formats.	DMU30-00-0100-403	
	**RoHS compliance statement for DMU30:** DMU30 is fully compliant with RoHS. For details of the materials used in the manufacture please refer to the MDS Report.	–	

8.1 DMU30 Evaluation Kit

The DMU30 Evaluation Kit enables the output data from the DMU30 to be viewed and logged for testing and evaluation purposes.

Figure 8.1 DMU30 Evaluation Kit

8.1.1 DMU30 Evaluation Kit Contents

The DMU30 Evaluation Kit (part number DMU30-00-0500) contains the following:

- MEV RS485i to USB converter.
- CD containing the MEV drivers.
- USB memory stick containing the data logging software.
- Mating plug and cable.
- User manual.

Note: DMU30 is NOT included in the evaluation kit.

8.1.2 System Requirements

The DMU30 Evaluation Kit requires a PC with a USB port. The requirements for the PC are as follows:

- Microsoft® Vista®, Windows 7, Windows 8 or Windows 10, Operating Systems. The software has not been tested on any other Operating System and therefore correct functionality cannot be guaranteed.
- Minimum of 500Mb of RAM.
- 500Mb of free hard drive space plus space for logged data (typical data rate ≈ 50kbit/s).
- High power or self-powered USB 2.0 Port.

9 Part Markings

DMU30 is supplied with an adhesive label attached. The label displays readable DMU30 part and part identification numbers.

The part identification number is a numeric code;

YYWWXXXX CC where:

- YY = Manufacturing year number
- WW = Manufacturing week number
- XXXX = Serial number
- CC = Revision

A 4x4 data matrix barcode containing the part identification number is also displayed on the label.

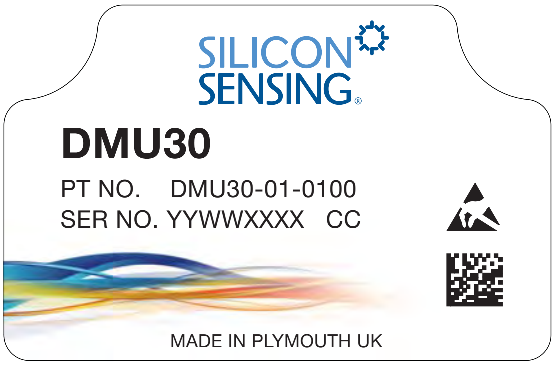


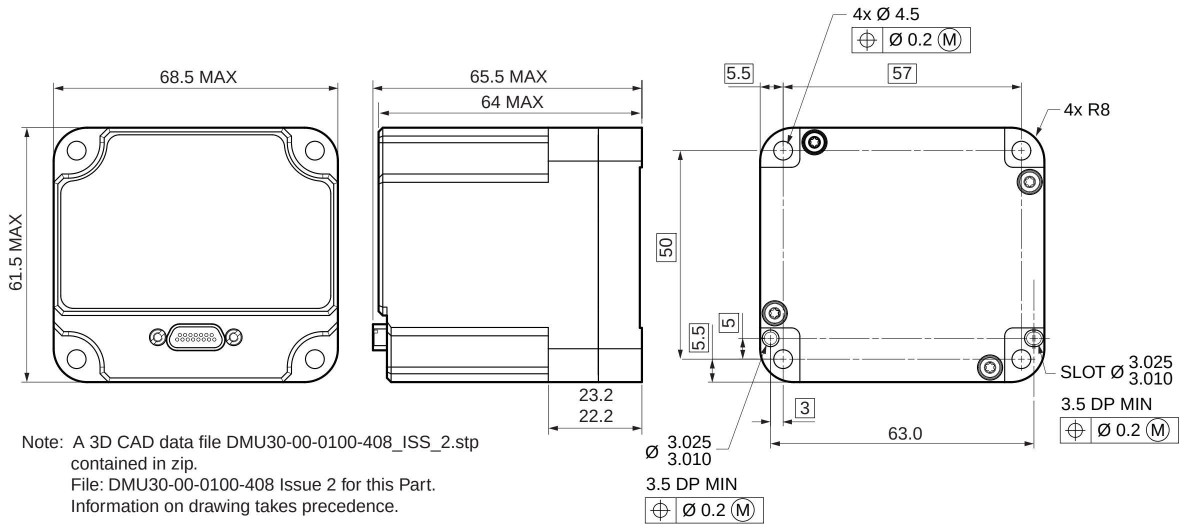
Figure 9.1 DMU30 Label

10 Installation Details

Figures 10.1 show the installation drawing for the DMU30.

The DMU30 is designed for 4 point mounting using M4.0 screws. During calibration alignment is achieved using two external reference dowel holes on the base of the DMU30. The dowel holes are designed to be used with two Ø3mm (in accordance with BS EN ISO 8734 or BS EN ISO 2338) dowel pins provided by the host.

The DMU30 mounting screw torque settings will be dependent on the host application; it will for example vary depending on the specification of the screw, the material of the host structure and whether a locking compound is used. When securing a DMU30 to the host system using steel M4.0 screws and a thread locking compound the suggested torque setting is 0.2Nm for securing to an aluminium host structure. This information is provided for guidance purposes only, the actual torque settings are the responsibility of the host system designer.



All dimensions in millimetres.

Figure 10.1 DMU30 Installation Drawing

11 Axis Definitions and Sensing Points

The DMU30 uses 6 gyroscopes and 6 accelerometers in a paired configuration to optimise performance for each axis. Figure 11.1 shows the axis definitions for the DMU30.

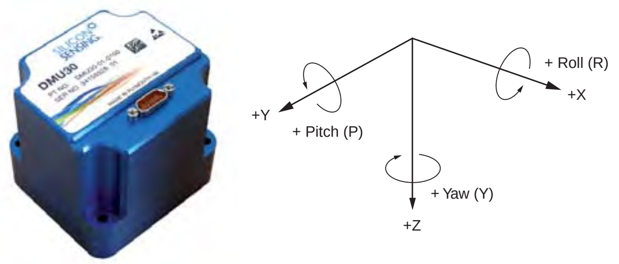


Figure 11.1 Axis Definitions

In order to minimise the requirement for size effect compensation the accelerometer seismic masses have been located as close as possible to the centre of the DMU30 (the inertial reference point shown in Figure 11.2).

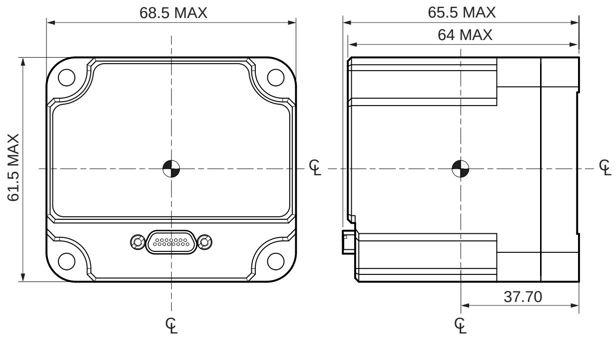


Figure 11.2 Position of the Inertial Reference Point

There are two accelerometers per axis within the DMU30. These are located as close to the Inertial Reference point as possible, constrained by the physical size of the devices. The sensors which are used in each axis are configured in a "back to back" orientation to reduce common mode errors and improve noise. Table 11.1 shows the effective mid-point position of the pairs of accelerometers used for each axis. Size effect compensation is not carried out within the DMU30 and these values will enable to user to provide external size effect compensation should this become necessary within the application.

Accelerometer	Sensing Element Position (Relative to Inertial Reference Point), mm		
	X	Y	Z
X Accelerometer	3.725	-0.435	1.625
Y Accelerometer	3.83	0.015	-3.425
Z Accelerometer	-0.445	-0.41	0

Table 11.1 Accelerometer Sensing Positions

12 DMU30 Construction and Theory of Operation

12.1 IMU Construction

DMU30 is an aluminium alloy assembly comprising base, housing, sensor block, sensor assemblies and IMU electronics.

The base and housing are sealed using a self-forming gasket and secured by four machine screws to provide a waterproof enclosure. A micro-miniature 'D' type socket connector located on the top face of the housing provides the electrical interface to the host system. The top face of the housing displays the DMU30 part marking information.

DMU30 is aligned to the host system using two Ø3mm dowels in the host platform which locate with matching dowel holes in the bottom face of the base. The IMU is secured to the host using M5.0 machine screws.

A precision machined aluminium 3-Axis Sensor Block, secured to the DMU30 Base by machine screws provides accurate alignment and support for the DMU30 MEMS inertial sensor assemblies and IMU electronics. Internally generated heat from the sensor assemblies and IMU electronics is absorbed into the sensor block and surrounding housing and conducted to the host via the base and to the ambient atmosphere via convection cooling fins in the housing.

The IMU electronics is a triple-stack PCB assembly which is affixed to the sensor block by six spacers and machine screws to provide stable and precise alignment between the sensor assemblies.

12.2 Sensor Construction and Theory of Operation

Silicon MEMS Inductive Ring Gyroscope

The silicon MEMS ring is 6mm diameter by 100µm thick, fabricated by Silicon Sensing Systems using a DRIE (Deep Reactive Ion Etch) bulk silicon process. The ring is supported in free-space by sixteen pairs of symmetrical legs which isolate the ring from the supporting structure on the outside of the ring.

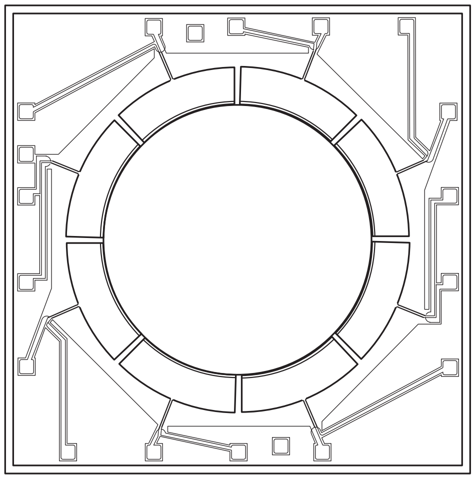


Figure 12.1 Silicon MEMS Ring

The bulk silicon etch process and unique patented ring design enable close tolerance geometrical properties for precise balance and thermal stability and, unlike other MEMS gyros, there are no small gaps to create problems of interference and stiction. These features contribute significantly to DMU30's bias and scale factor stability over temperature, and vibration immunity. Another advantage of the design is its inherent immunity to acceleration induced rate error, or 'g-sensitivity'.

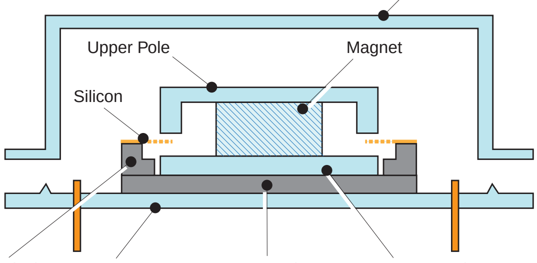


Figure 12.2 MEMS VSG3Q^{MAX} Sensor

The ring is essentially divided into 8 sections with two conductive tracks in each section. These tracks enter and exit the ring on the supporting legs. The silicon ring is bonded to a glass pedestal which in turn is bonded to a glass support base. A magnet, with upper and lower poles, is used to create a strong and uniform magnetic field across the silicon ring. The complete assembly is mounted within a hermetic can.

The tracks along the top of the ring form two pairs of drive tracks and two pairs of pick-off tracks. Each section has two loops to improve drive and pick-off quality.

One pair of diametrically opposed tracking sections, known as the Primary Drive PD section, is used to excite the cos2θ mode of vibration on the ring. This is achieved by passing current through the tracking and, because the tracks are within a magnetic field, causes motion on the ring. Another pair of diametrically opposed tracking sections are known as the Primary Pick-off PP section are used to measure the amplitude and phase of the vibration on the ring. The Primary Pick-off sections are in the segments 90° to those of the Primary Drive sections. The drive amplitude and frequency is controlled by a precision closed loop electronic architecture with the frequency controlled by a Phase Locked Loop (PLL), operating with a Voltage Controlled Oscillator (VCO), and amplitude controlled with an Automatic Gain Control (AGC) system. The primary loop therefore establishes the vibration on the ring and the closed loop electronics is used to track frequency changes and maintain the optimal amplitude of vibration over temperature and life. The loop is designed to operate at about 14kHz.

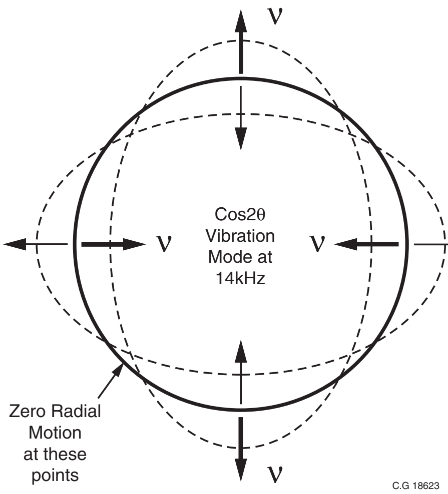


Figure 12.3 Primary Vibration Mode

Having established the cos2θ mode of vibration on the ring, the ring becomes a Coriolis Vibrating Structure Gyroscope. When the gyroscope is rotated about its sense axis the Coriolis force acts tangentially on the ring, causing motions at 45° displaced from the primary mode of vibration. The amount of motion at this point is directly proportional to the rate of turn applied to the gyroscope. One pair of diametrically opposed tracking sections, known as the Secondary Pick-off SP section, is used to sense the level of this vibration. This is used in a secondary rate nulling loop to apply a signal to another pair of secondary sections, known as the Secondary Drive SD. The current applied to the Secondary Drive to null the secondary mode of vibration is a very accurate measure of the applied angular rate. All of these signals occur at the resonant frequency of the ring. The Secondary Drive signal is demodulated to baseband to give a voltage output directly proportional to the applied rate in free space.

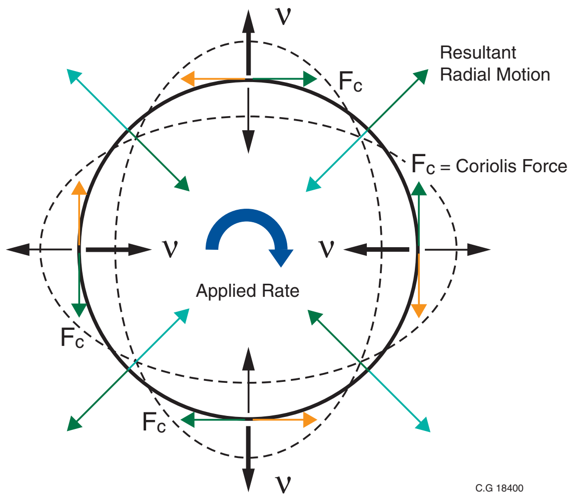


Figure 12.4 Secondary Vibration Mode

The closed loop architecture of both the primary and secondary loops results in excellent bias, scale factor and non-linearity control over a wide range of operating environments and life. The dual loop design, introduced into this new Sensor Head design, coupled with improved geometric symmetry results in excellent performance over temperature and life. The discrete electronics employed in DMU30 ensures that performance is not compromised.

Silicon MEMS Capacitive Accelerometer

The accelerometer contains a seismic 'proof mass' with multiple fingers suspended via a 'spring', from a fixed supporting structure. The supporting structure is anodically bonded to the top and bottom glass substrates and thereby fixed to the sensor package base.

When the accelerometer is subjected to a linear acceleration along its sensitive axis, the proof mass tends to resist motion due to its own inertia, therefore the mass and its fingers become displaced with respect to the interdigitated fixed electrode fingers (which are also fixed to glass substrates). Air between the fingers provides a damping effect. This displacement induces a differential capacitance between the moving and fixed silicon fingers which is proportional to the applied acceleration.

Capacitor plate groups are electrically connected in pairs at the top and bottom of the proof mass. In-phase and out of phase waveforms are applied by the ASIC separately to the 'left' and 'right' finger groups. The demodulated waveforms provide a signal output proportional to linear acceleration.

Figures 12.5(a) and 12.5(b) provide schematics of the accelerometer structure and control loop respectively.

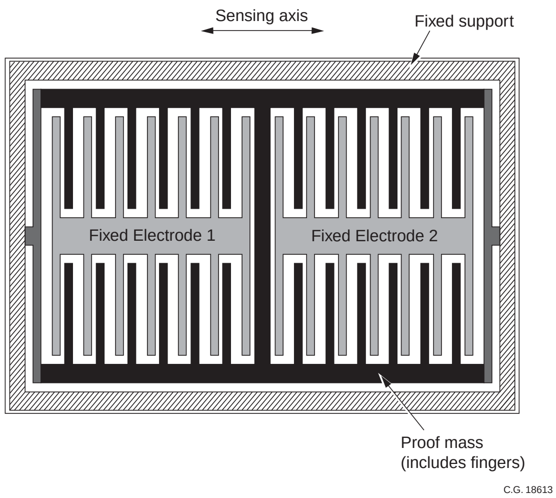


Figure 12.5(a) Schematic of Accelerometer Structure

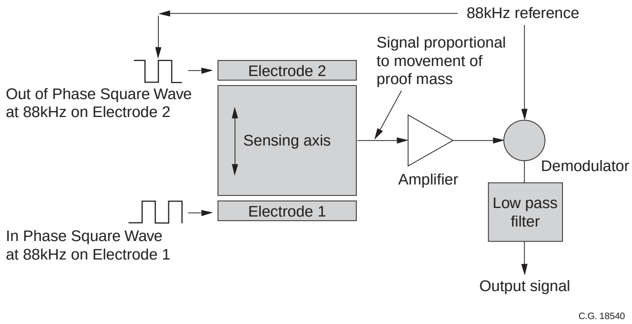


Figure 12.5(b) Schematic of Accelerometer Control Loop