DMU30 Technical Datasheet

High Performance MEMS
Inertial Measurement Unit (HPIMU)

SILICON SENSING®

www.siliconsensing.com

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 - 0.2°/hr, 0.02°/√hr
  - Linear - 30µg, 0.05m/s/√hr
- Non-ITAR
- Compact and lightweight - 68 x 61 x 62h (mm), 300g
- 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
  - Over-range output (reduced specification)
  - Additional sensor integration - GPS/Magnetometer/Barometer
  - North finding mode
  - AHRS functionality
  - Other interface protocols and specifications
  - Custom and host application integration

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

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. Planned capabilities include common mode error reduction, dynamic over-range output, low-power 'sleep' mode and performance enhanced sensor blending. Future developments will feature GPS, magnetic and ambient pressure sensing, north finding and AHRS functions.

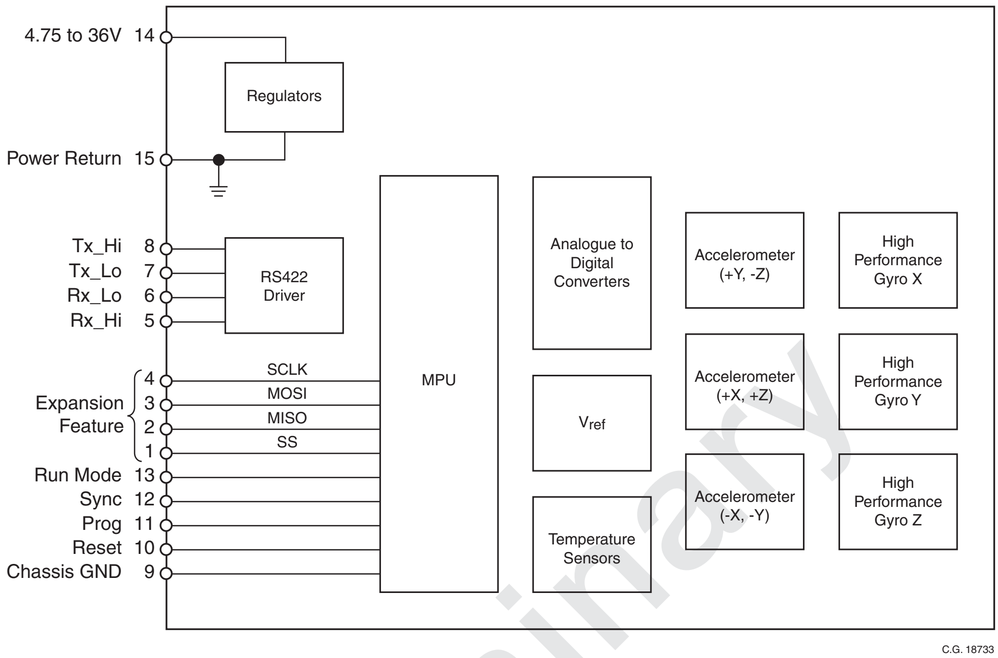
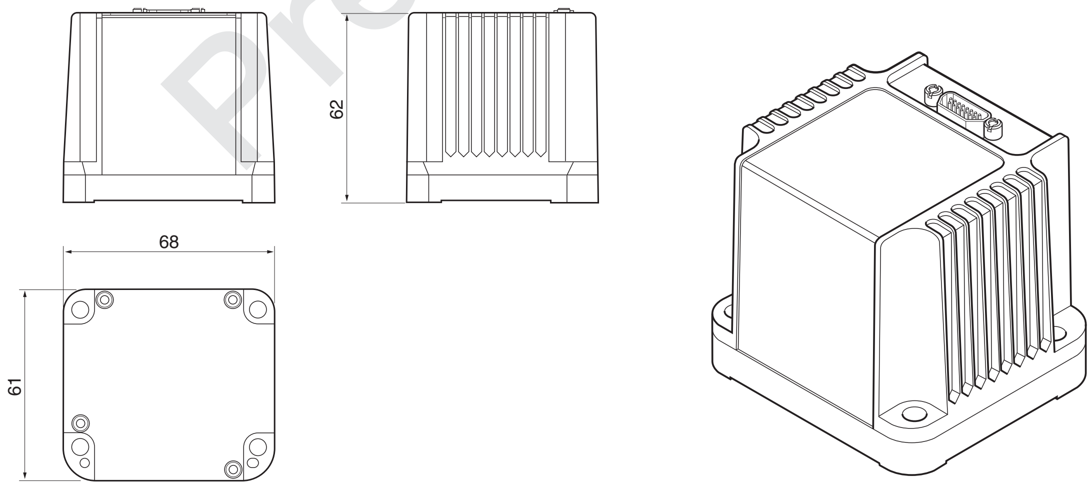


Figure 1.1 DMU30 Functional Block Diagram



All dimensions in millimetres.

Figure 1.2 DMU30 Unit Overall Dimensions

2 Ordering Information

Item	Description	Overall Dimensions	Part Number
		mm	
 DMU30 IMU	High Performance MEMS Inertial Measurement Unit.	68 x 61 x 62H	DMU30-01-0100
 DMU30 Evaluation Kit	Customer Evaluation Kit (EVK) comprising a DMU30-01-0100, RS422 to USB Connector, USB Driver and Data Logging Software, Cables and Connectors, Instruction Manual.	Not Applicable	DMU30-01-0500
 DMU30 Mating Connector	Mating connector plug and cable for DMU30	Length 600mm	DMU30-01-TBD

3 Specification

Parameter	Minimum	Typical	Maximum	Notes
Angular (Roll, Pitch, Yaw)				
Dynamic Range (°/s)	-200	–	+200	Clamped at ±205°/s during over-range
Scale Factor Error (ppm)	-500	±100	+500	Factory fresh test
Scale Factor Non-Linearity Error (ppm)	-500	±100	+500	Factory fresh test
Bias (°/hr)	-20	±15	+20	Over operating temperature range factory fresh test
Bias Instability (°/h)	–	< 0.2	0.4	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 (%)	-0.7	±0.35	+0.7	Over operating temperature range
Gyro Bandwidth (Hz)	10	85	90	-3dB point User programmable
Noise (°/s rms)	–	0.15	0.25	Wide band noise at 100Hz bandwidth
VRE (°/s/g² rms)	-0.006	±0.002	+0.006	10g rms stimulus 20Hz to 2,000Hz

3 Specification Continued

Parameter	Minimum	Typical	Maximum	Notes
Linear (X, Y, Z)				
Dynamic Range (g)	-10	–	+10	Clamped at ±10.01g during over-range
Scale Factor Error (ppm)	-500	±100	+500	–
Scale Factor Non-Linearity Error (ppm)	-500	±100	+500	Maximum error from best straight line over ±10g
Bias (mg)	-5.00	±1.50	+5.00	Over operating temperature range
Bias Instability (mg)	–	0.03	0.05	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 (%)	-0.70	±0.35	+0.70	Over operating temperature range
Acc Bandwidth (Hz)	10	85	150	-3dB point User programmable
Noise (mg rms)	–	1.00	2.30	Wide band noise at 100Hz bandwidth
VRE (mg/g² rms)	-0.15	±0.10	+0.15	3g rms stimulus 20Hz to 2,000Hz
Temperature Output				
Range (°C)	-45	–	100	Note that this exceeds operational temperature range
Accuracy (°C)	–	±3	–	In the operational temperature range

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
Operational Random Vibration (g rms)	–	–	3.0	20Hz to 2KHz
Non-Operational Random Vibration (g rms)	–	–	10	20Hz to 2KHz
Humidity (% rh)	–	–	85	Non-condensing
Immersion Depth (m)	–	–	1	IMU is sealed
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
Startup Time (s) (full performance)	–	< 5	20	Time to full performance (mounting dependent)
Power (watts)	–	< 3	4	With 120 Ω RS422 termination resistor
Supply Voltage (V)	+4.75	+8	+36	Unit is calibrated at 8 volts
Physical				
Size (mm)	–	68 x 61 x 62H	–	–
Mass (grams)	–	300g	–	TBC

Notes:

DMU30 is designed for 1m 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.

4.2 Absolute Minimum/Maximum Ratings

	Minimum	Maximum
Electrical:		
Vdd	-0.3V	+37V
ESD protection	–	2kV HBM
Environmental:		
Shock (non-operational)	–	6,500g 0.1ms 1/2 sine
Life:		
Unpowered	15 years	–
Powered	12,000 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.

5.1 Performance Characteristics

This section will include comprehensive test result statistics of all main IMU performance parameters.

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

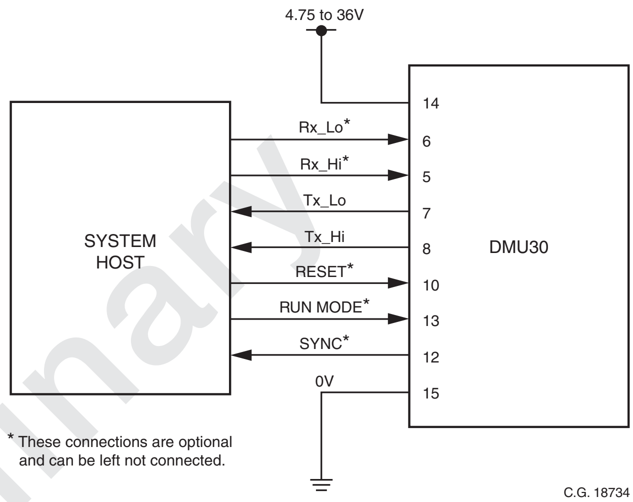


Figure 7.1 Required Connections for RS422 Communications with DMU30

7.2 Physical Interface

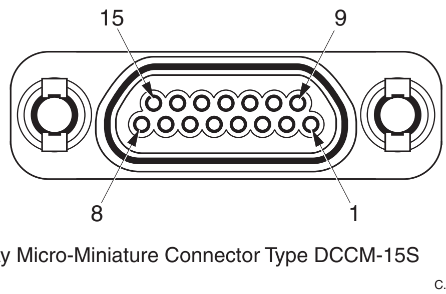


Figure 7.2 DMU30 Socket Connector

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 (Part Number DMU30-01-TBD).

7.4 Pin Information

Pin	Label	Signal	In/Out
1, 2, 3, 4	Future	A SPI® comm port for future expansion	I/O
5	Rx_Hi	The positive receive connection required for the RS422 communication	I
6	Rx_Lo	The negative receive connection required for the RS422 communication	I
7	Tx_Lo	The negative transmit connection required for the RS422 communication	O
8	TX_Hi	The positive transmit connection required for the RS422 Communication	O
9	Chassis GND	Chassis ground	I
10	Reset	Microprocessor reset. Pin is pulled low to reset the device. Suggested implementation using TTL logic	I
11	Factory Use	Used by SSSL for programming purposes and should not be interfaced with	N/A
12	Sync	Output signal that can be used by an external system to synchronise with DMU30	O
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
14	+Volts	Input voltage to the DMU30. Can be between 4.75V and 36V	I
15	GND	Ground connected to the DMU30	I

Table 7.1 Pin Information

7.5 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.

7.6 Operational Message Output

The Output Message is output on a RS422 Serial output at 460,800 baud using a non-return to zero protocol. 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 33 words (66 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.

7.7 Sensor Sampling and Synchronisation

The inertial sensors within DMU30 are all sampled at 1,000Hz. The 'Sync Pulse' on the connector is set HIGH at the start of the sampling and returned to LOW when the last inertial sensor is sampled. Pulses are therefore seen on the connector at 1,000Hz.

The inertial sensor measurements are then filtered with a 2nd order low pass filter, also running at 1000Hz. The factory default setting for this filter has a corner frequency of > 85Hz.

The internal sequence for DMU30 is:

- Cycle 1: Sample Sensors, 2nd order Filter
- Cycle 2: Sample Sensors, 2nd order Filter, Calculate Sensor Compensation
- Cycle 3: Sample Sensors, 2nd order Filter, Apply Sensor Compensation
- Cycle 4: Sample Sensors, 2nd order Filter, Calculate Delta Theta and Vels
- Cycle 5: Sample Sensors, 2nd order Filter, Transmit Message

The message is transmitted after the 'Sync Pulse' associated with Cycle 5 has returned LOW. The inertial data included in the message is generated when the 'Sync Pulse' associated with Cycle 3 is HIGH. This enables the external equipment to synchronise with the time when the inertial data is valid.

7.8 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 7.2 Operational Message Data Output Definitions

7.9 System BIT Flags

7.9.1 System Startup BIT Flags

TBA

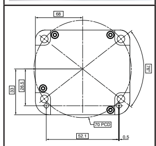
7.9.2 System Operation BIT Flags

TBA

7.9.3 System Error Indication BIT Flags

TBA

8 Design Tools and Resources Available

Item	Description of Resource	Part Number	Order/Download
	**DMU30 Brochure:** A one page sales brochure describing the key features of the DMU30 Inertial Measurement Unit.	DMU30-00-0100-131	Download (www.siliconsensing.com)
	**DMU30 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.	DMU30-00-0100-132	Download (www.siliconsensing.com)
	**DMU30 Evaluation Kit:** DMU30 delivered with an RS422 to USB interface, plug-and-play real time display and logging software and two interface cabling solutions DMU30-01-0100 unit included.	DMU30-01-0500	Order (www.siliconsensing.com) (sales@siliconsensing.com)
	**DMU30 Presentation:** A useful presentation describing the features, construction, principles of operation and applications for the DMU30 Inertial Measurement Unit.	–	Download (www.siliconsensing.com)
	**Solid Model CAD files for DMU30 Inertial Measurement Unit:** Available in .STP and .IGS file formats.	DMU30-01-0100-408	Download (www.siliconsensing.com)
	**DMU30 Plug and Cable:** A mating plug and 600mm long cable.	DMU30-01-TBD	Order (www.siliconsensing.com) (sales@siliconsensing.com)
	**DMU30 Installation Drawing:** CAD file containing host interface geometry. Available in .STP and .IGS file formats.	DMU30-01-0100-TBD	Download (www.siliconsensing.com)
RoHS	**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.	–	Download (www.siliconsensing.com)

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 DMU30-01-0500) contains the following:

DMU30 IMU (part number DMU30-01-0100).

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

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® Windows® XP (SP3 or greater), Vista®, Windows 7 or Windows 8 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;

WWYYXXXX R where:

WW = Manufacturing week number
YY = Manufacturing year number
XXXX = Serial number
R = Revision

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

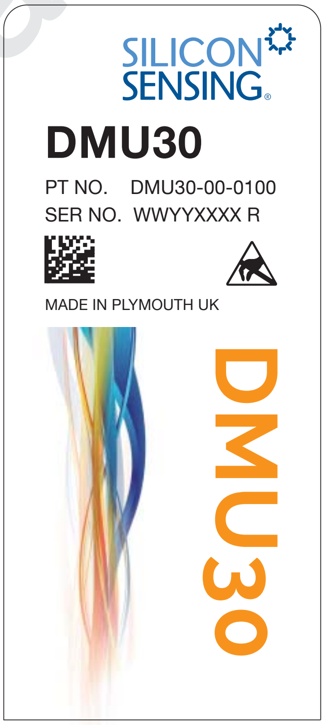


Figure 9.1 DMU30 Label

10 Installation Details

Figures 10.1 show the installation drawing for the DMU30.

The DMU30 is designed for 4 point mounting using M5.0 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 M5.0 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.

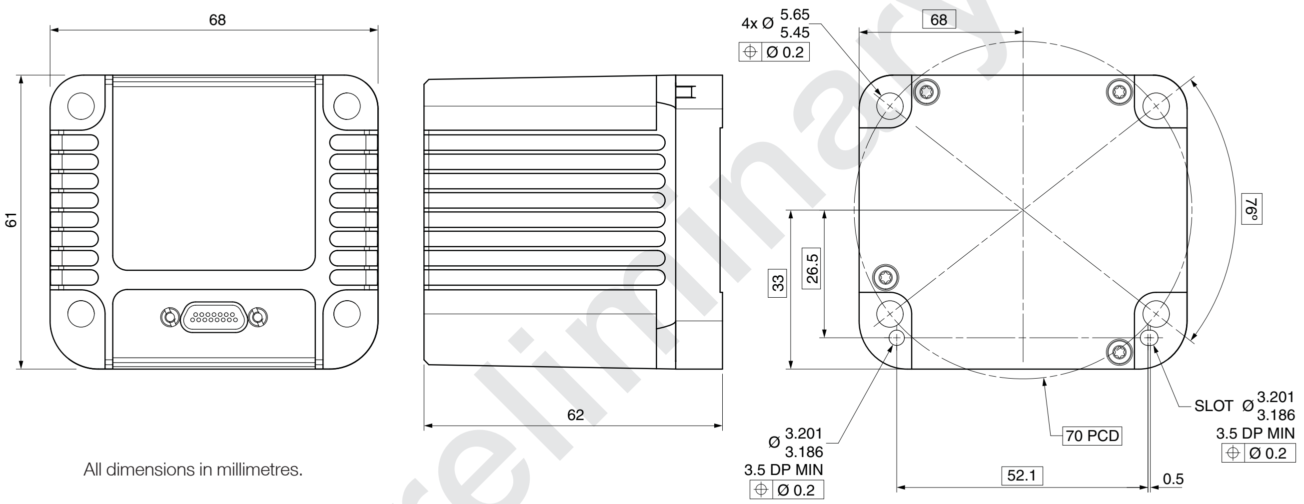


Figure 10.1 DMU30 Installation Drawing

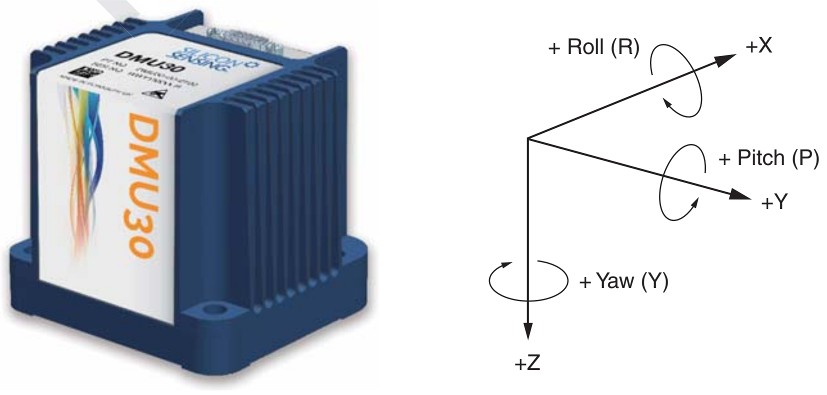


Figure 10.2 Axis Definitions

11 Packaging

Full packaging specification including package labelling (TBD).

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.

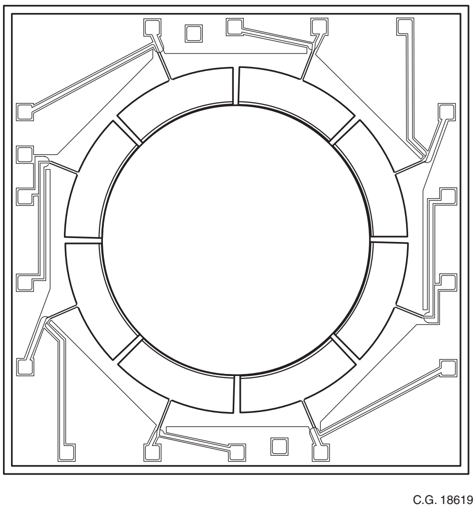


Figure 12.1 Silicon MEMS Ring

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'.

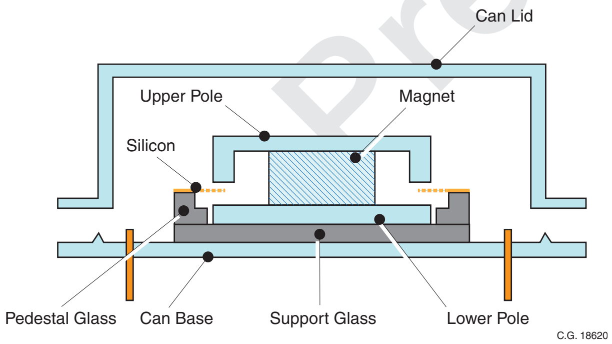


Figure 12.2 MEMS VSG3Q^{MAX} Sensor

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.

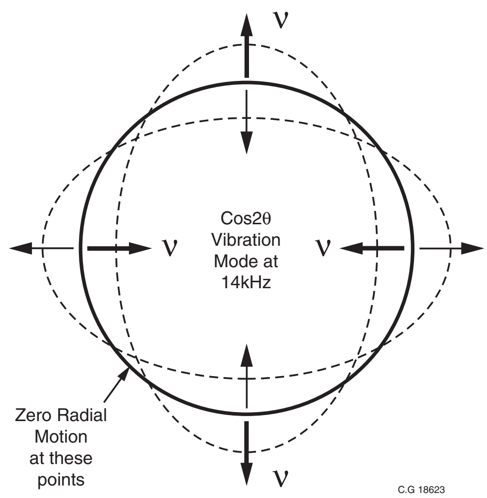


Figure 12.3 Primary Vibration Mode

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.

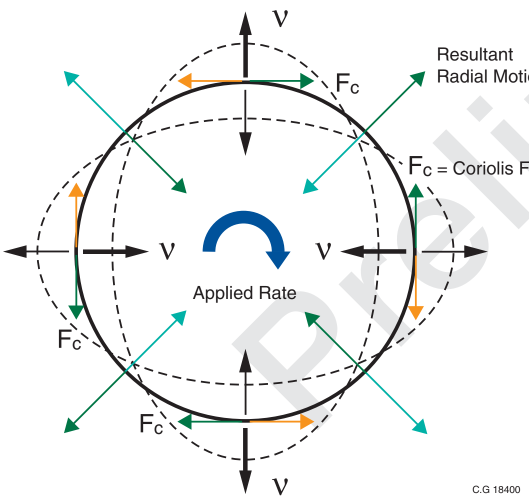


Figure 12.4 Secondary Vibration Mode

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.

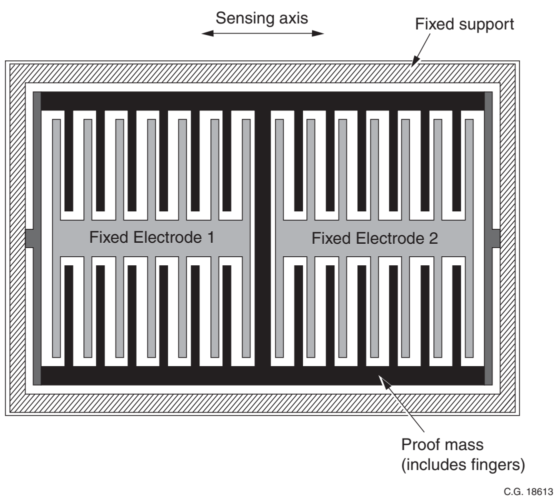


Figure 12.5(a) Schematic of Accelerometer Structure

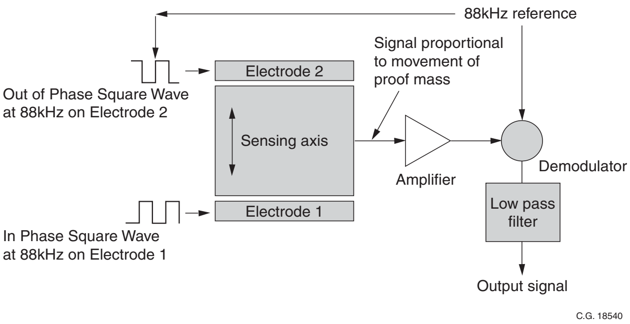


Figure 12.5(b) Schematic of Accelerometer Control Loop

Notes

Silicon Sensing Systems Limited
Clittaford Road Southway
Plymouth Devon
PL6 6DE United Kingdom
T: +44 (0)1752 723330
F: +44 (0)1752 723331
E: sales@siliconsensing.com
W: siliconsensing.com

Silicon Sensing Systems Japan Limited
1-10 Fuso-Cho
Amagasaki
Hyogo 6600891 Japan
T: +81 (0)6 6489 5868
F: +81 (0)6 6489 5919
E: sssj@spp.co.jp
W: siliconsensing.com

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