KVH® CG-5100 Inertial Measurement Unit (IMU)

Technical Manual

CG-5100

CG-5100 IMU Technical Manual

This manual supports KVH Industries' CG-5100 Inertial Measurement Unit (IMU). The CG-5100 combines KVH's proprietary, highly accurate fiber optic gyros (FOGs) with industry-proven MEMS accelerometers in a single reliable, high-performance motion sensing package that is ideally suited for critical sensing applications and GPS-integrated navigation programs.

Technical and performance specifications, interface data, mounting guidelines, and a brief troubleshooting guide are included.

This manual uses the following conventions to call attention to important information:

IMPORTANT!

Be sure to read these important notices carefully to ensure proper installation and operation of the IMU.

NOTE: *Notes contain useful installation, maintenance, troubleshooting, or other information.*

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For complete warranty coverage details, refer to kvh.com/warranty.

KVH Part #54-0689 Rev. D

QUALITY CERTIFIED SYSTEM ISO 9001

KVHI™ NASDAQ LISTED

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Product Specifications

Figure 1: CG-5100 Specifications

Attribute	Rating
Performance - Gyros	
Input Limit	±375°/s
Bias Instability (constant temp.)	≤1°/hr-1σ
Bias Offset (room temp.)	±20°/hr max.
Bias Temperature Sensitivity	≤6°/hr-1σ (1°C/minute ramp)
Scale Factor (nominal)	1 ±0.2%
Scale Factor Non-linearity	≤1000 ppm-1σ
Scale Factor Temperature Sensitivity	≤500 ppm-1σ
Angle Random Walk	≤0.0667°/√hr ≤4°/hr/√Hz
Input Axis Misalignment	<8 mrad
Bandwidth (-3 dB)	≥50 Hz
Performance - Accelerometers	
Input Limit	±10 g
Bias Instability (1 year, full environment)	7.5 mg typical 25 mg max.
Bias Instability (room temp.)	≤0.25 mg-1σ
Bias Offset (room temp.)	±5 mg max.
Bias Temperature Sensitivity	≤2 mg/°C (1°C/minute ramp)
Scale Factor Non-linearity	<0.9% of full scale
Scale Factor Temperature Sensitivity	100 ppm/°C typical 250 ppm/°C max. (-40°C to +20°C)
Velocity Random Walk (room temp.)	≤0.23 ft/s/√hr ≤0.12 mg/√Hz
Input Axis Misalignment	<10 mrad
Bandwidth (-3 dB)	≥50 Hz

Attribute	Rating
Electrical	
Input Power	+9 to +18 VDC
Power Consumption	15 W max.
IMU Activation Time	5 secs max.
Odometer Power	+9 to +18 VDC, 100 mA max.
Physical	
Dimensions	6.67" L x 6.0" W x 3.5" H (16.94 cm L x 15.24 cm W x 8.89 cm H)
Weight	5 lbs (2.27 kg) nom.
Environmental	
Temperature, Operational	-40°F to +149°F (-40°C to +65°C)
Temperature, Non-operational	-58°F to +176°F (-50°C to +80°C)
Shock, Operational	7 g, 6-10 msec, 1/2 sine
Shock, Non-operational	40 g, 6-10 msec, 1/2 sine
Vibration, Operational	6 g rms, 20-2000 Hz, random
Vibration, Non-operational	8 g rms, 20-2000 Hz, random
Operating Altitude	-1,000 to 50,000 ft
Humidity	95% non-condensing
Waterproof	MIL-STD-810F, 506.4, Procedure I

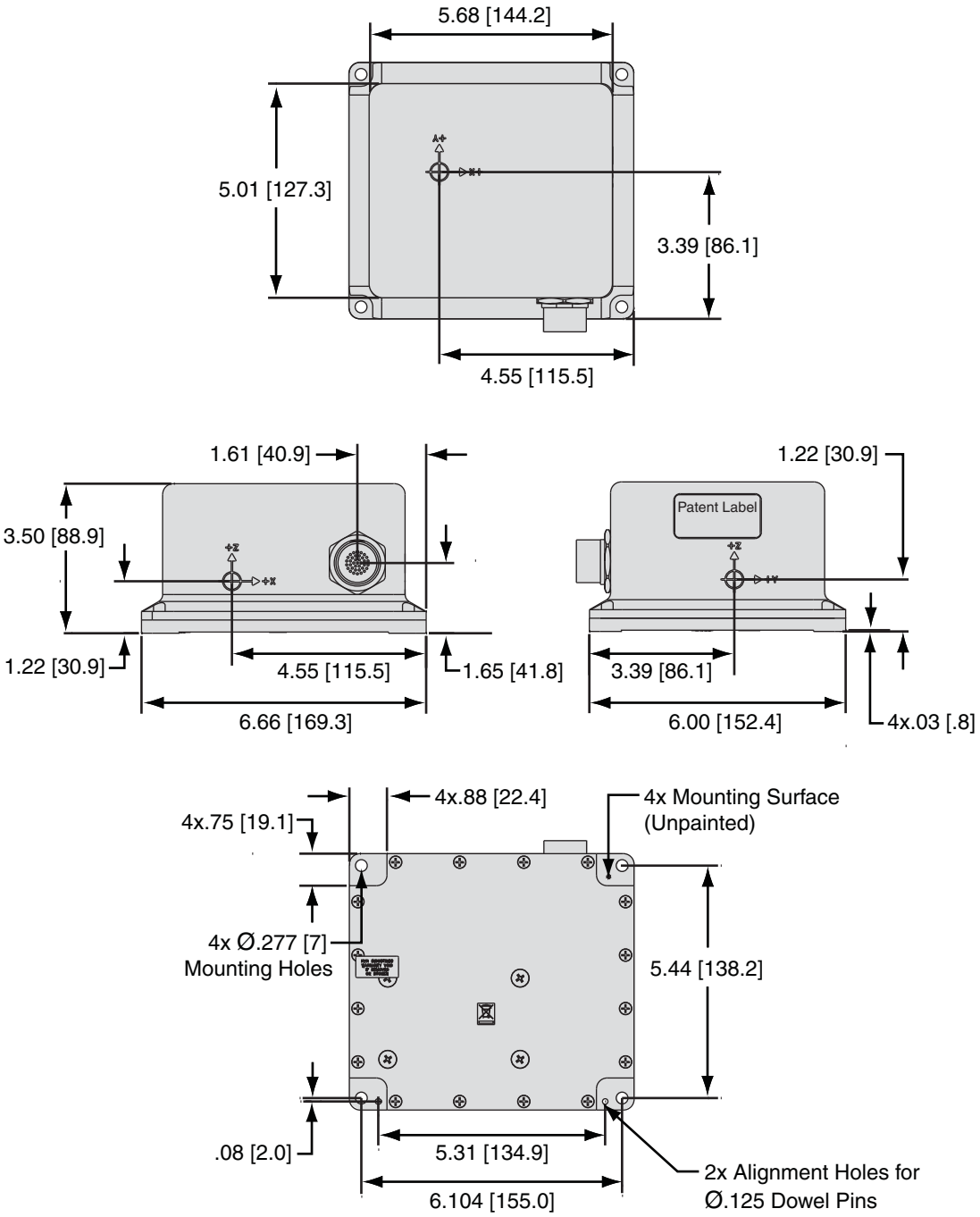
IMPORTANT!

The CG-5100 is a precision instrument. Handle the unit with care and avoid exposing it to severe static shock.

An interface control drawing (ICD) illustrating the dimensions, connector placement, and mounting holes is provided in Figure 2.

NOTE: *All dimensions are shown in inches [millimeters] format.*

Figure 2: Interface Control Drawing



Storage and Handling

The CG-5100 may be stored in a location with an environmental temperature between -58°F and +176°F (-50°C and +80°C). Ideally, the unit should be stored at a room temperature of approximately 70°F (21°C).

The CG-5100 is a sensitive measuring device. Take normal safety precautions when handling to ensure the integrity of the device. During unpacking and installation, proper ESD handling procedures should be enforced.

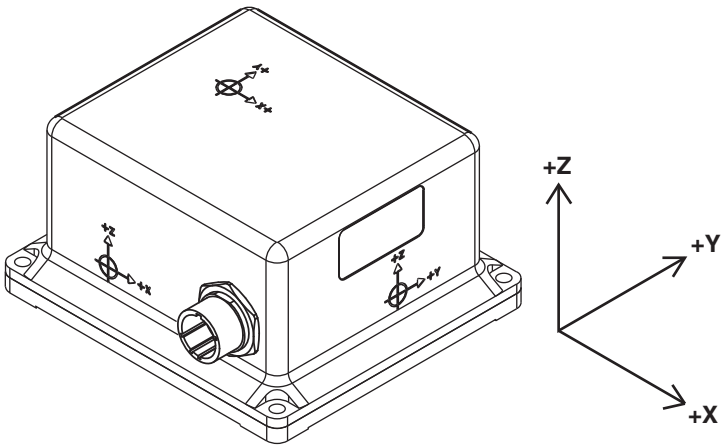
Maintenance

The CG-5100 is supplied as a sealed unit; there are no field maintainable components. Opening the enclosure will void the warranty and may violate the contract under which the unit was supplied.

Output Orientation

The CG-5100 senses rotation on three axes, X, Y, and Z, as shown in Figure 3. These axes are marked on the enclosure. For navigation applications, mount the unit such that its positive Z-axis arrow points upward and its Y-axis arrow points forward along the direction of travel.

Figure 3: Output Orientation



Interface Connector

The CG-5100 is equipped with a 37-pin interface connector of the following type: MIL-DTL-38999 Series 3 (Part Number D38999/24FD35PA). Figure 4 shows the connector location and Figure 5 describes the function of each pin.

Figure 4: Interface Connector Location

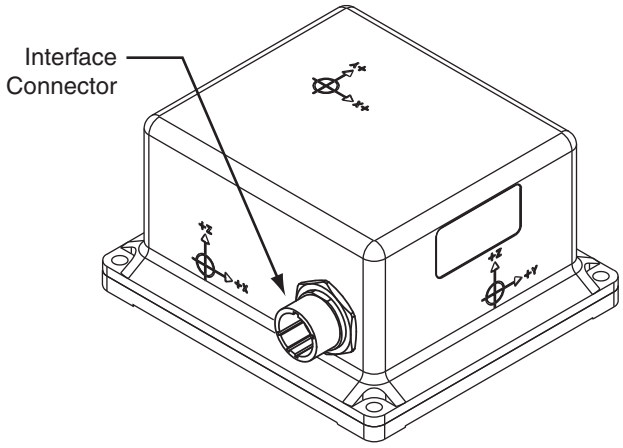


Figure 5: Interface Connector Pins

Pin	Type	Description
1	Power (-)	Power Return
2	Power (+)	9-18 VDC Power Input
3-12	-	Not connected
13	Odometer	Odometer Power (9-18 VDC, 100 mA max.)
14	Odometer	Odometer Power Return
15	Odometer	SIGA
16	Odometer	SIGA Inverted
17	Odometer	SIGB
18	Odometer	SIGB Inverted
19-20	-	Not connected
21	IMU	RS422 TX+
22	IMU	RS422 TX-
23-24	-	Not connected
25	IMU	RS422 Signal Ground

Pin	Type	Description
26	IMU	RS232 TX
27	-	Not connected
28	IMU	RS232 Signal Ground
29-34	-	Not connected
35	TTL	Time of Validity (TOV) Output
36	TTL	External Clock Input (Optional)
37	Ground	Chassis Ground

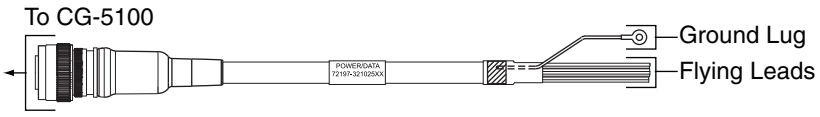
Interface Cable

A 5-ft (1.5 m) interface cable with a mating connector (part number D38999/26FD35SA) at one end and flying leads at the other is supplied with the unit (see Figure 6). Each flying lead is labeled with its associated pin number.

IMPORTANT!

Be sure to snip and insulate any unused wires from the cable to avoid the possibility of a short.

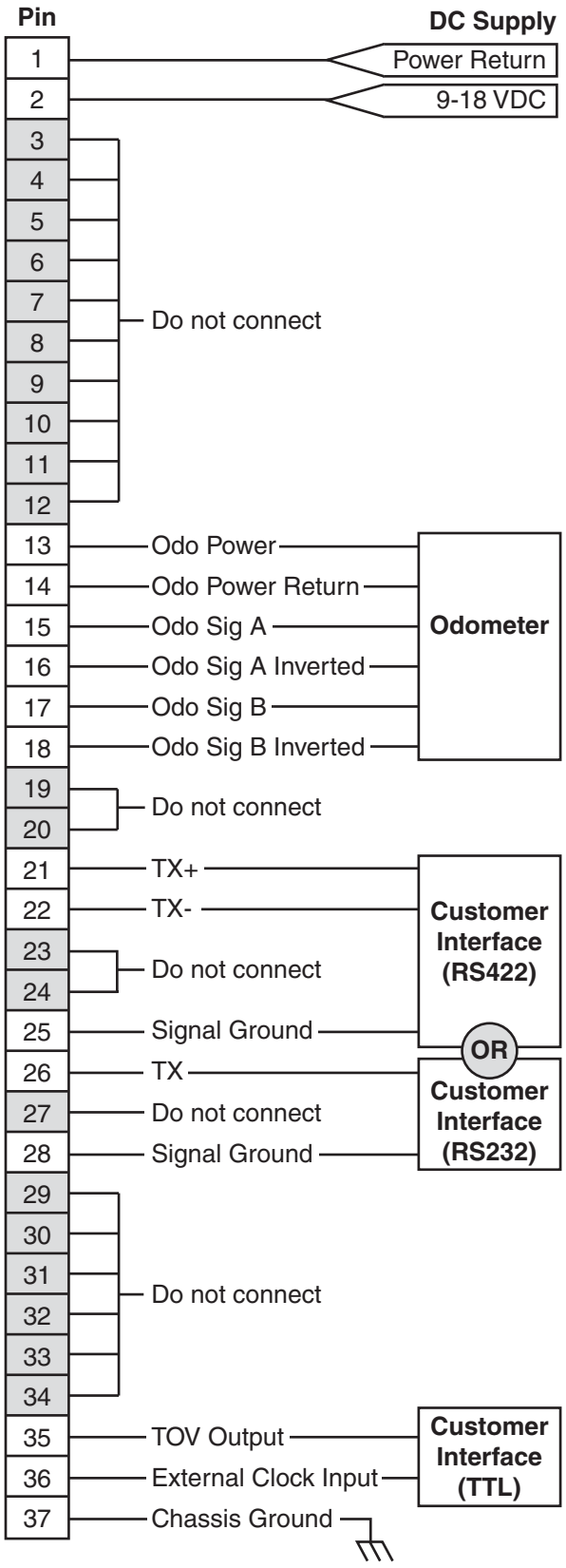
Figure 6: Supplied Interface Cable



Wiring the IMU

Use Figure 7 as a guide to connect the IMU to your application.

Figure 7: Wiring Diagram



Digital Data Output

The IMU provides a digital, low-voltage interface with the following characteristics:

Figure 8: Interface Characteristics

Parameter	Value
Type	RS422 (pins 21, 22, 25) or RS232 (pins 26, 28)
Baud Rate	115,200
Parity	None
Data Bits	8
Stop Bits	1
Flow Control	None

Each character in the output message contains a total of 11 bits that have the following functions:

Figure 9: Character Format

Function	Total # Bits	Values
Start	1	Space, binary 0
Data	8	1 message byte, starting with LSB
Stop	2	Mark, binary 1

An idle line is always marking (in a binary 1 state). Thirty-six characters in sequence constitute a basic message.

Message Structure

The output message contains 36 bytes, excluding start and stop bits. The most significant **byte** is sent first; and the least significant **bit** of each byte is sent first. Figure 10 and Figure 11 define the format of the message.

Figure 10: Message Format

Function	Total # Bytes	Description
Header	4	Always 0xFE81FF55; this value will never occur anywhere else
Message data	30	See Figure 11 for details
Checksum	2	Computed as follows: Each byte in the message data is treated as an unsigned, 8-bit integer; the checksum is the least significant two bytes of the accumulated data

Figure 11: Message Data

Function	Byte Number(s)	Data Type*	Output Range	Notes
X angle	1,2,3,4	SPFP	±0.66 radians	Assumes 100 Hz TOV
Y angle	5,6,7,8	SPFP	±0.66 radians	Assumes 100 Hz TOV
Z angle	9,10,11,12	SPFP	±0.66 radians	Assumes 100 Hz TOV
X velocity	13,14,15,16	SPFP	±1 m/sec	Assumes 100 Hz TOV
Y velocity	17,18,19,20	SPFP	±1 m/sec	Assumes 100 Hz TOV
Z velocity	21,22,23,24	SPFP	±1 m/sec	Assumes 100 Hz TOV
Odometer pulses	25,26,27,28	SPFP	45 kHz	
Status	29	DISC	1=valid; 0=invalid	See Figure 12 for details
Sequence #	30	UINT8	0-127	Increments for each message and resets to 0 after 127

* See Figure 13 for data type details.

Figure 12: Status Byte Format

Function	Bit #	Notes
Gyro X status	0	LSB
Gyro Y status	1	
Gyro Z status	2	
Not used	3	Set to 0
Accelerometer X status	4	
Accelerometer Y status	5	
Accelerometer Z status	6	
Not used	7	Set to 0

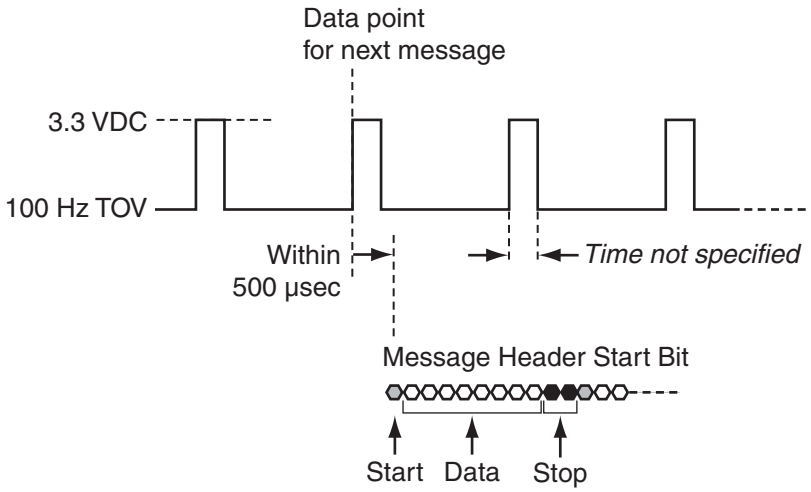
Figure 13: Data Types

Data Type	Description	Notes
SPFP	Single-precision floating point	Defined in the IEEE-754 standard
DISC	Discrete value	Indicates status: Logic 1 = valid Logic 0 = invalid
UINT8	8-bit unsigned number	Ranging from 0 to 255

Time of Validity (TOV) Output

The CG-5100 provides a 100 Hz, low-voltage TTL time of validity (TOV) output to indicate the precise timing of the IMU's measurement data. The data output after the rising edge of the 3.3 VDC TTL logic waveform corresponds to the most recent 2 kHz filter update that occured due to the TOV active edge. The start bit of the output message header is transmitted within 500 µsec of this active edge.

Figure 14: TOV Output Timing



External Clock Input (Optional)

The CG-5100 can accept a customer-supplied TTL square wave clock signal at a 45-50% duty cycle to initiate the IMU's sensor sampling. The input signal must be 2 MHz ±0.0625% (or ±1.25 kHz). This signal is then reduced to 2 kHz within the IMU.

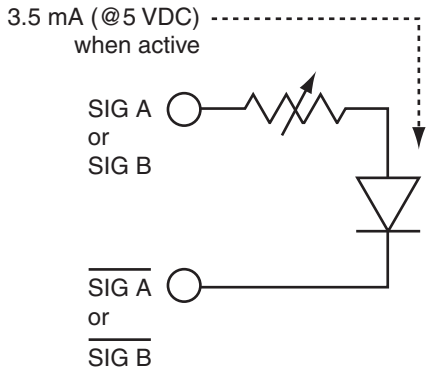
The external clock signal is phase-locked to an internally generated 2 MHz clock. If no external clock signal is present on pin 36, the IMU will automatically revert to using its internal 2 MHz clock. Therefore, an external clock is not required for operation.

Connecting a Wheel Sensor (Optional)

The CG-5100 can accept input pulses from an external quadrature encoded or pulse and direction wheel sensor. With a wheel sensor connected, the CG-5100 calculates pulse counts and reports the number of pulses in the output message.

Connect your wheel sensor to pins 13-18 of the interface connector (see Figure 5 on page 5), using Figure 15 as a conceptual guide. The CG-5100 will power the wheel sensor (9-18 VDC, 100 mA max.) through pins 13 and 14.

Figure 15: Conceptual Electrical Diagram for Wheel Sensor Interface



The wheel sensor must meet the following requirements for compatibility with the CG-5100:

Figure 16: Wheel Sensor Requirements

Attribute	Rating
Input Range	45 kHz max.
Input Duty Cycle	40-60% symmetric
Active Voltage	≥ 2.5 VDC
Inactive Voltage	≤ 1 VDC
Maximum Input Voltage	50 VDC
Input Current	3.5 mA @ 5 VDC, typical 5 mA @ 50 VDC, max.

Connecting Power

The CG-5100 requires a 12 VDC (nominal) input voltage. Consider the following guidelines to connect the CG-5100 to a power supply:

- Be sure to observe the correct polarity when connecting power. Power input pins are located at the IMU's interface connector:
  Pin 1 = Power return
  Pin 2 = +12 VDC (9-18 VDC)

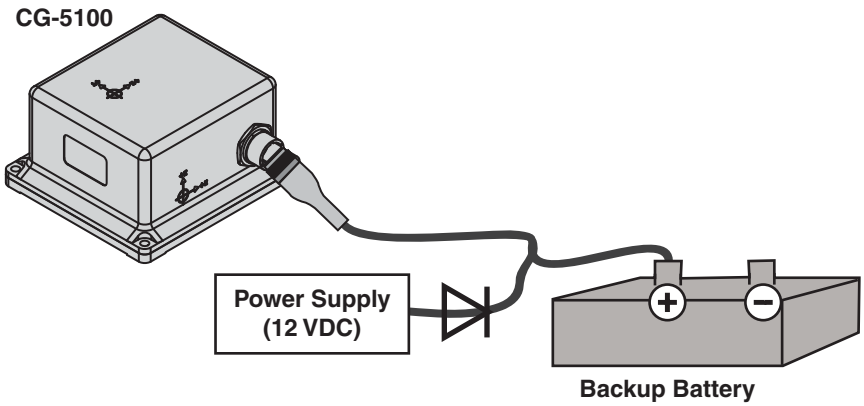
- Ensure the power supply meets minimum specifications (12 VDC nominal, 1.1 amps min.).

IMPORTANT!

Make sure the power supply is monotonic *(does not drop in voltage)* during startup to ensure the CG-5100 initializes properly.

- If the CG-5100 is installed on a vehicle, KVH recommends that you install a backup battery between the CG-5100 and its power supply as a power buffer (see Figure 17). When the engine starts up, power can dip to 9.6 VDC or cut out to ancillary equipment.

Figure 17: Backup Battery Connection



- Be sure to connect the interface cable's ground lug to a suitable ground for EMI compliance (see "Interface Cable" on page 6).

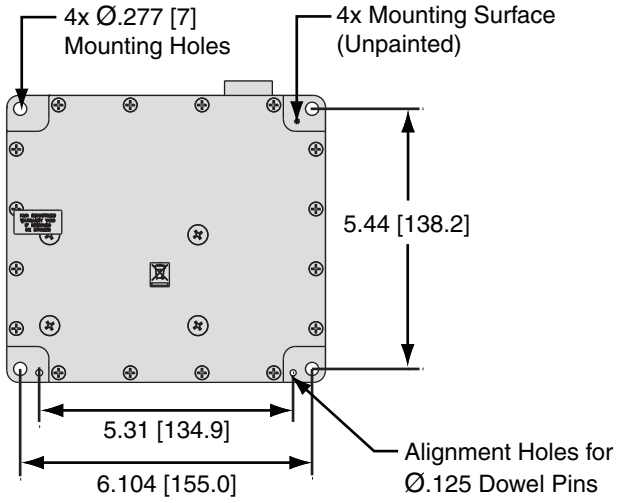
- If you are using your own interface cable, be sure to use the appropriate gauge wire to compensate for the voltage drop across the length of the cable. For example, a power cable longer than 7 ft (2.1 m) connecting to a 12 VDC supply should have a wire diameter no smaller than 24 AWG.

The power module within the CG-5100 filters and regulates the supply voltage, protects against over-voltage, over-current, and high-temperature conditions, and provides automatic reset circuit protection.

Mounting the IMU

The CG-5100 is easily mounted to a structure using the four ∅.277" (∅7 mm) mounting holes on the base of the enclosure (see Figure 18). Two ∅.125" (∅3.175 mm) holes are provided at the front edge of the enclosure for alignment purposes. You may also use the edge of the enclosure itself for alignment.

Figure 18: Mounting Holes (Bottom View)



Troubleshooting

This chapter explains how to diagnose basic problems.

IMPORTANT!

The CG-5100 is supplied as a sealed unit. Breaking the QA seals voids the warranty and may violate the contract under which the unit was supplied. The warranty does not apply if the unit has been damaged by misuse or as the result of service or modification other than by KVH Industries.

Figure 19: Basic Troubleshooting

Problem	Solution
Power is applied to the unit, but it is not making any sound.	This is normal. The CG-5100 uses fiber optic gyros, not ring laser or mechanical gyros.
The unit does not power up.	Check the input power supply. 12 VDC (nominal) is recommended for stable performance. The supply should also output less than 15 W over the entire operating temperature range. If the power supply is OK, check the power cable and wiring.
Incoherent data is streaming.	Ensure the baud rate of your interface port is set to 115,200 baud.

Technical Support

For technical support, please e-mail your question or a description of your problem to fogsupport@kvh.com.

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