MICROBOTICS, INC.

# MIDG IIC Message Specification for Firmware V2.1.x and Higher

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**1 Scope.** This document outlines the messages sent to and from the MIDG IIC via the serial communications port.

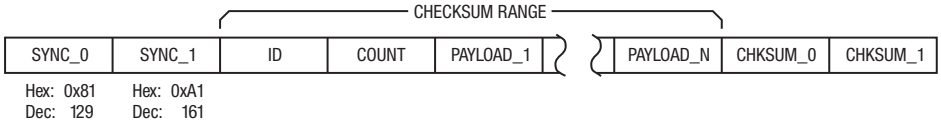
**1.1 Differences Between This Message Specification and Previous Versions.** This specification is an update to earlier Message Specifications. In particular, it addresses certain messages which are no longer supported (especially by firmware versions 2.3.1 and higher), corrects several errors, and better defines the Configuration Messages. Of particular importance are several data packets which are either no longer properly supported by the GPS module in the MIDG IIC, no longer of valid use to the client, or provide possible false information, thus the related messages should not be used in firmware versions below 2.3.x, and are no longer supported in firmware versions 2.3.1 and higher:

Satellite Ephemeris (*TIM_EPH* Message)
GPS Raw Data (*GPS_RAW* Message)
GPS 1PPS Estimate (*GPS_PPS* Message)
Time Error (*TIM_ERR* Message)
RTCM Differential Corrections (*RTCM* Message)

Additionally, the various "*VG*" Modes previously used in earlier versions are now referred by their actual operations (*STATUS* Message).

**2 Serial Interface.** Communication with the MIDG IIC occurs via an asynchronous communication port using the Microbotics Binary Interface Protocol (MBI). The Factory default is 115200 Baud, 8 data bits, no parity bit, and one stop bit (8, N, 1). The baud rate can be changed by the user via the MIDG Display/Configuration Program. The physical interface is an RS-422 differential serial link for high noise immunity.

**3 Microbotics Binary Protocol.** The MBI Protocol is a series of message packets, defined in the following sections, to communication with the host computer. These




messages provide sensor data transfer between MIDG IIC the host, as well as facilitate MIDG IIC configuration. The MBI Protocol is a standardized binary byte packet format that has the following structure:

**3.1 *SYNC* Bytes.** The two *SYNC* bytes are used to define the message packet. The first byte (*SYNC_0*) is has the hexadecimal value of 0x81, while the second byte (*SYNC_1*) has the hexadecimal value of 0xA1.

**3.2 *ID* Byte.** The *ID* byte defines the specific message.

**3.3 *COUNT* Byte.** The *COUNT* byte is the number of ***bytes*** in the payload regardless of payload formatting, zero if the message has no payload bytes.

**3.4 *PAYLOAD*.** The payload is composed of a sequence of bytes that represent data values within a message. All payload values are bit-endian, meaning the most significant byte of a multi-byte payload value is sent first. In bit field values, Bit 0 represents the least significant bit of the payload value. In the section that follows, the application messages will be defined using the nomenclature shown below to indicate the type of value represented in the payload.

| Payload Type | Description | Payload Type | Description |
|---|---|---|---|
| U1 | Unsigned, 8 bit integer (one byte) | I1 | Signed, 8 bit integer (one byte) |
| U2 | Unsigned, 16 bit integer (two bytes) | I2 | Signed, 16 bit integer (two bytes) |
| U4 | Unsigned, 32 bit integer (four bytes) | I4 | Signed, 32 bit integer (four bytes) |
| Bx | String of x bytes (x bytes) | R4 | IEEE 754 single precision (four bytes) |
| BN | Variable length string of bytes | R8 | IEEE 754 double precision (eight bytes) |

**3.5 *CHECKSUM* Bytes.** The two-byte checksum is a Fletcher checksum as defined in internet RFC 1145. It is computed over all bytes between, and including, the *ID* byte, *COUNT* byte, and all payload ***bytes***. The basic algorithm is as follows:

*CHKSUM_0* = 0
*CHKSUM_1* = 0

for each ***byte*** from *ID* to *PAYLOAD_N* (inclusive)
    *CHKSUM_0* = *CHKSUM_0* + byte  Only 8 bits maintained (modulo-256)
    *CHKSUM_1* = *CHKSUM_1* + *CHKSUM_0*  Only 8 bits maintained (modulo-256)

Once the checksum has been calculated, the low 8 bits of *CHKSUM_0* are send, followed by the low 8 bits of *CHKSUM_1*.

**4 MIDG IIC Output Messages.** The following messages are provide data output from the MIDG IIC. Any of these messages may be configured to be transmitted from the MIDG IIC at a user selectable rate from once every 5 seconds to 50Hz. Rates for these messages are set using the *CFG_SET* Message (*ID 35*) with the *MSG_DIV* Command (*ITEM_ID 5*). When a message is disabled (its output rate is set to zero), it may be polled by sending a message of the same *ID* to the MIDG IIC, but with no payload (the message payload length *COUNT* zero). Supported MIDG IIC output messages:

| | | | |
|---|---|---|---|
| | ***ID 1*** | ***STATUS*** | MIDG IIC Status |
| | ***ID 2*** | ***IMU_DATA*** | IMU Data |
| | ***ID 3*** | ***IMU_MAG*** | Magnetometer Data |
| | ***ID 10*** | ***NAV_SENSOR*** | Navigation Sensor and Attitude Data |
| | ***ID 12*** | ***NAV_PV*** | Navigation Position/Velocity Data |
| | ***ID 13*** | ***NAV_HDG*** | Navigation Heading Data |
| | ***ID 15*** | ***NAV_ACC*** | Navigation Accuracy Estimate |
| | ***ID 20*** | ***GPS_PV*** | GPS Position/Velocity Data |
| | ***ID 21*** | ***GPS_SVI*** | GPS Satellite Vehicle Data |
| ¶ | ***ID 22*** | ***GPS_RAW*** | GPS Raw Measurement Data |
| | ***ID 23*** | ***GPS_CLK*** | GPS Clock Data |
| ¶ | ***ID 24*** | ***GPS_EPH*** | Ephemeris Data (polled only) |
| | ***ID 25*** | ***TIM_UTC*** | UTC Time |
| * | ***ID 26*** | ***TIM_ERR*** | Time Error |
| * | ***ID 27*** | ***TIM_PPS*** | Time at 1 PPS |
| § | ***ID 28*** | ***TIM_TM*** | Time at Time Mark pulse in |

¶ *Due to undocumented changes in GPS modules by the manufacturer, not all MIDG IIC units support the GPS_RAW or GPS_EPH Messages correctly. As it is impossible to determine in the field if the messages are available and valid, these messages should not be used in firmware versions below 2.3.x. These messages are not available in firmware versions 2.3.1 and higher.*

* *The TIM_ERR Message is a legacy message from the earliest MIDG-Series units, and provides no data useable to the user. This message is not available in firmware versions 2.3.1 and higher. TIM_PPS Message is a legacy message from when the MIDG-Series did not have 1PPS Time Pulse outputs. As communications latencies can cause errors, this message should not be used for estimating the Time Pulse timing. This message is not available in firmware versions 2.3.1 and higher.*

§ *The TIM_TM Message is available only in MIDG IIC units with the Time Mark Option (Microbotics Part Number SIS90031C-SR).*

**4.1** Message: **STATUS** Message ID: **1 (0x01)** Payload Length: **8 Bytes (0x08)**
Description: Status Information Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Timestamp |
| 4 | U2 | Bit field | System Status:<br>Bits 8..15: (N/A, read zero)<br>Bit 7: NV Configuration Valid<br>Bit 6: Timestamp is GPS time<br>Bit 5: DGPS (SBAS – WAAS, EGNOS, MSAS)<br>Bit 4: (N/A, reads zero)<br>Bits 3..0: Current operational mode: (1)<br>0 = (N/A)<br>1 = IMU Mode<br>2 = Initialize Alignment<br>3 = Coarse Alignment<br>4 = Medium Alignment<br>5 = Fine Alignment<br>6 = Vertical Gyro Mode<br>7 = INS Mode |
| 6 | I2 | 0.01 °C | Internal Temperature |

***Notes:***

(1) *Operational mode definitions:*

| *Current Designation* | *Previously Called* | *Defiinition* |
|---|---|---|
| *IMU Mode* | *IMU Mode* | *IMU operational mode: only sensor data available, Kalman Filter not active* |
| *Initialize Alignment* | *VG Init* | *Sensor alignment initialization* |
| *Coarse Alignment* | *VG Fast* | *Sensor coarse alignment* |
| *Medium Alignment* | *VG Medium* | *Sensor medium alignment* |
| *Fine Alignment* | *VG Slow* | *Sensor fine alignment* |
| *Vertical Gyro Mode* | *VG SE* | *Vertical Gyro operational mode: all data available, Kalman Filter active without using GPS data* |
| *INS Mode* | *INS Mode* | *INS operational mode: all data available, Kalman Filter active using GPS data* |

**4.2** Message: **IMU_DATA** Message ID: **2 (0x02)** Payload Length: **23 Bytes (0x17)**
Description: Inertial Measurements Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Timestamp |
| 4 | I2 | .01 °/s | X-Axis Angular Rate (1) |
| 6 | I2 | .01 °/s | Y-Axis Angular Rate |
| 8 | I2 | .01 °/s | Z-Axis Angular Rate |
| 10 | I2 | milli-g | X-Axis Acceleration (1,2) |
| 12 | I2 | milli-g | Y-Axis Acceleration |
| 14 | I2 | milli-g | Z-Axis Acceleration |
| 16 | I2 | Relative units | X-Axis Magnetic Field (3) |
| 18 | I2 | Relative units | Y-Axis Magnetic Field |
| 20 | I2 | Relative units | Z-Axis Magnetic Field |
| 22 | U1 | Bit field | Flags:<br>Bit 7: GPS 1PPS flag<br>Bit 6: Timestamp is GPS time<br>Bits 5..0: (N/A, read zero) |

***Notes:***

(1) *The sensor readings are calibrated values not compensated by the Kalman Filter.*

(2) *"1 g" is defined as 9.799096177 m/sec$^2$.*

(3) *The magnetometer outputs are scaled so that the magnitude of the local field at MIDG IIC calibration is 5000 counts.*

**4.3** Message: **IMU_MAG** Message ID: **3 (0x03)** Payload Length: **11 Bytes (0x0B)**
Description: Magnetometer Measurements Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Timestamp |
| 4 | I2 | Relative units | X-Axis Magnetic Field (1) |
| 6 | I2 | Relative units | Y-Axis Magnetic Field |
| 8 | I2 | Relative units | Z-Axis Magnetic Field |
| 10 | U1 | Bit field | Flags:<br>Bit 7: (N/A, reads zero)<br>Bit 6: Timestamp is GPS time<br>Bits 5..0: (N/A, read zero) |

***Notes:***

(1) *The magnetometer outputs are scaled so that the magnitude of the local field at MIDG IIC calibration is 5000 counts.*

**4.4** Message: **NAV_SENSOR** Message ID: **10 (0x0A)** Payload Length: **39 Bytes (0x27)**
Description: Navigation Sensor Data Applicable Modes: VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Timestamp |
| 4 | I2 | .01 °/s | X-Axis Angular Rate (1) |
| 6 | I2 | .01 °/s | Y-Axis Angular Rate |
| 8 | I2 | .01 °/s | Z-Axis Angular Rate |
| 10 | I2 | milli-g | X-Axis Acceleration (1,2) |
| 12 | I2 | milli-g | Y-Axis Acceleration |
| 14 | I2 | milli-g | Z-Axis Acceleration |
| 16 | I2 | 0.01deg | Yaw, Local Frame Z-Axis Attitude (3) |
| 18 | I2 | 0.01deg | Pitch, Local Frame Y-Axis Attitude |
| 20 | I2 | 0.01deg | Roll, Local Frame X-Axis Attitiude |
| 22 | I4 | $2^{-30}$ | Orientation Quaternion *Qw* (4) |
| 26 | I4 | $2^{-30}$ | Orientation Quaternion *Qx* |
| 30 | I4 | $2^{-30}$ | Orientation Quaternion *Qy* |
| 34 | I4 | $2^{-30}$ | Orientation Quaternion *Qz* |
| 38 | U1 | Bit field | Flags:<br>Bit 7: INS Mode<br>Bit 6: Timestamp is GPS time<br>Bit 5: DGPS<br>Bit 4: Magnetometer measurement applied<br>Bit 3: External heading measurement applied<br>Bit 2: External position measurement applied (5)<br>Bit 1: External velocity measurement applied<br>Bit 0: External air data measurement applied (5) |

***Notes:***

(1) *The sensor readings are compensated by the Kalman Filter.*

(2) *"1 g" is defined as 9.799096177 m/sec$^2$.*

(3) *Rotation sequence is taken Yaw, Pitch, Roll.*

(4) *The elements of the Orientation Quaternion must be multiplied by $2^{-30}$ ($9.31322574615 \times 10^{-10}$) to get a unit quaternion.*

(5) *External Position and External Air Data aiding have not been implemented, bits read zero.*

**4.5** Message: **NAV_PV** Message ID: **12 (0x0C)** Payload Length: **29 Bytes (0x1D)**
Description: Navigation Position and Velocity Solution Applicable Modes: VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Timestamp |
| 4 | I4 | cm, $10^{-7}$ deg | X-Axis Position (ECEF X, Relative Position East, or Longitude) (1) |
| 8 | I4 | cm, $10^{-7}$ deg | Y-Axis Position (ECEF Y, Relative Position North, or Latitude) |
| 12 | I4 | cm | Z-Axis Position (ECEF Z, Relative Position Up, or Altitude) |
| 16 | I4 | cm/s | X-Axis Velocity (ECEF Vx, or Relative Veast) (2) |
| 20 | I4 | cm/s | Y-Axis Velocity (ECEF Vy, or Relative Vnorth) |
| 24 | I4 | cm/s | Z-Axis Velocity (ECEF Vz, or Relative Vup) |
| 28 | U1 | Bit field | Solution Details:<br>Bit 7: Position estimate invalid<br>Bit 6: Timestamp is GPS time<br>Bit 5: DGPS (SBAS – WAAS, EGNOS, MSAS)<br>Bit 4: Velocity estimate invalid<br>Bits 3..2: Position Format<br>0 = ECEF<br>1 = ENU Relative (3)<br>2,3 = LLA<br>Bit 1: Velocity Format<br>0 = ECEF<br>1 = ENU<br>Bit 0: ENU position relative to first fix (3) |

***Notes:***

(1) *Position format: ECEF or ENU Relative in cm; Longitude and Latitude in $10^{-7}$ deg, Altitude in cm.*

(2) *Velocity Format is either ECEF or ENU.*

(3) *If Position Format is ENU Relative, position is relative to either the first GPS fix or location specified in configuration.*

**4.6** Message: **NAV_HDG** Message ID: **13 (0x0D)** Payload Length: **17 Bytes (0x11)**
Description: Navigation Heading Information Applicable Modes: INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Timestamp |
| 4 | I2 | 0.01 deg | Magnetic Heading |
| 6 | I2 | 0.01 deg | Magnetic Declination (1) |
| 8 | I2 | 0.01 deg | Magnetic Dip |
| 10 | I2 | 0.01 deg | Course Over Ground (2) |
| 12 | U2 | cm/s | Speed Over Ground |
| 14 | I2 | cm/s | Vertical Velocity |
| 16 | U1 | Bit field | Flags:<br>Bit 7: Declination and dip valid<br>Bit 6: Timestamp is GPS time<br>Bits 5..0: (N/A, read zero) |

***Notes:***

(1) *Magnetic Declination and Magnetic Dip are taken from the World Magnetic Model, which requires initialization with the current location. As a result, these values are not valid until position is known and Bit 7 is set in the Flags bit field.*

(2) *Course Over Ground, Speed Over Ground, and Vertical Velocity are calculated from the navigation solution data and correspond to the velocities presented in the NAV_PV message.*

**4.7** Message: **NAV_ACC** Message ID: **15 (0x0F)** Payload Length: **17 Bytes (0x11)**
Description: Navigation Solution Accuracy Estimate Applicable Modes: INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Timestamp |
| 4 | U2 | cm | Horizontal position accuracy estimate (1) |
| 6 | U2 | cm | Vertical position accuracy estimate |
| 8 | U2 | cm/s | Horizontal velocity accuracy estimate (1) |
| 10 | U2 | cm/s | Vertical velocity accuracy estimate |
| 12 | U2 | 0.01 deg | Tilt accuracy estimate (1) |
| 14 | U2 | 0.01 deg | Heading accuracy estimate |
| 16 | U1 | Bit field | Flags:<br>Bit 7: Content valid<br>Bit 6: Timestamp is GPS time<br>Bit 5: DGPS (SBAS – WAAS, EGNOS, MSAS)<br>Bits 4..0: (N/A, read zero) |

***Notes:***

(1) *Values represents the probable standard deviation of error.*

**4.8** Message: **GPS_PV** [1] Message ID: **20 (0x14)** Payload Length: **38 Bytes (0x26)**
Description: GPS Position and Velocity Solution Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | GPS Time |
| 4 | U2 | Count | GPS week |
| 6 | U2 | Bit field | Solution Details:<br>Bits 15..12: Number of satellites used in solution<br>Bits 11..8: GPS Fix Type:<br>0 = No Fix<br>1 = Dead reckoning only<br>2 = 2D Fix<br>3 = 3D Fix<br>4 = GPS + dead reckoning combined<br>Bit 7: Time of week valid<br>Bit 6: Week number valid<br>Bit 5: Differential solution (WAAS, EGNOS, MSAS)<br>Bit 4: GPS Fix valid<br>Bits 3..2: Position Format:<br>0 = ECEF<br>1 = ENU Relative [2]<br>2,3 = LLA<br>Bit 1: Velocity Format:<br>0 = ECEF<br>1 = ENU<br>Bit 0: ENU Relative Position relative to first fix |
| 8 | I4 | cm, $10^{-7}$ deg | X Axis Position (ECEF X, Relative East, or Longitude) [3] |
| 12 | I4 | cm, $10^{-7}$ deg | Y Axis Position (ECEF Y, Relative North, or Latitude) |
| 16 | I4 | cm | Z Axis Position (ECEF Z, Relative Up, or Altitude) |
| 20 | I4 | cm/s | X Axis Velocity (ECEF Vx, or Relative Veast) [4] |
| 24 | I4 | cm/s | Y Axis Velocity (ECEF Vy, or Relative Vnorth) |
| 28 | I4 | cm/s | Z Axis Velocity (ECEF Vz, or Relative Vup) |
| 32 | U2 | 0.01 | Position DOP |
| 34 | U2 | cm | Position Accuracy [5] |
| 36 | U2 | cm/s | Speed Accuracy |

***Notes:***

[1] *This message is provided at the selected rate only if data is produced by the GPS receiver.*

[2] *If Position Format is ENU Relative, position is relative to either the first GPS fix or location specified in configuration.*

[3] *Position Format: ECEF or ENU Relative in cm; Longitude and Latitude in $10^{-7}$ deg, Altitude in cm.*

[4] *Velocity Format is either ECEF or ENU.*

[5] *Accuracy is the square root of the variance in the filtered estimate.*

**4.9** Message: **GPS_SVI** [1] Message ID: **21 (0x15)** Payload Length: **(8 * NCh) + 6 Bytes** [2]
Description: GPS Satellite Vehicle Information Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | GPS Time |
| 4 | U1 | | (Reserved, value indeterminate) |
| 5 | U1 | Count | Number of satellites to follow (1..16) |

After the 6 bytes above are sent, the following block is repeated *NCh* times (once for each satellite, 8 bytes per block) [3]:

| | | | |
|---|---|---|---|
| (8 * $N_i$) + 6 | U1 | Count | Receiver channel number (1..16) |
| (8 * $N_i$) + 7 | U1 | Address | Satellite ID on this receiver channel |
| (8 * $N_i$) + 8 | U1 | $dB_{Hz}$ | Carrier to Noise ratio |
| (8 * $N_i$) + 9 | U1 | Bit field | Information regarding the satellite:<br>Bits 7..5: (N/A, value indeterminate)<br>Bit 4: Satellite is unhealthy, will not be used<br>Bit 3: Orbit information is ephemeris<br>Bit 2: Orbit information available for this satellite<br>Bit 1: DGPS data available for this satellite<br>Bit 0: Satellite used for navigation |
| (8 * $N_i$) + 10 | I1 | Value | Information regarding the receiver channel:<br>7: Code/carrier locked, receiving 50bps data<br>5,6: Code and carrier locked<br>4: Code locked<br>3: Signal detected but unusable<br>1,2: Channel is searching<br>0: Channel is idle |
| (8 * $N_i$) + 11 | I1 | deg | Satellite Elevation |
| (8 * $N_i$) + 12 | I2 | deg | Satellite Azimuth |

***Notes:***

[1] *This message is provided at the selected rate only if data is produced by the GPS receiver. The values in this message are data provided directly by the GPS module and passed to the output message without any intervening processing.*

[2] *"NCh" is number of receiver channels in this message.*

[3] *"$N_i$" goes from zero to (NCh - 1).*

**4.10** Message: **GPS_RAW** [1,2] Message ID: **22 (0x16)** Payload Length: **(24 * nSVs) + 8 Bytes** [3]
Description: GPS Raw Measurement Data Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | GPS Time |
| 4 | U2 | Count | GPS week |
| 6 | U1 | | (Reserved, value indeterminate) |
| 7 | U1 | Count | Number of satellites to follow (up to 10) |

After the 8 bytes above are sent, the following block is repeated *nSVs* times (once for each satellite, 24 bytes per block) [4]**:**

| | | | |
|---|---|---|---|
| (24 * $N_i$) + 8 | R8 | cycles | Carrier Phase |
| (24 * $N_i$) + 16 | R8 | m | Pseudo Range |
| (24* $N_i$) + 24 | R4 | Hz | Doppler Measurement |
| (24* $N_i$) + 28 | U1 | Address | Satellite ID |
| (24* $N_i$) + 29 | I1 | Value | Information regarding the receiver channel:<br>7: Code/carrier locked, receiving 50bps data<br>5,6: Code and carrier locked<br>4: Code locked<br>3: Signal detected but unusable<br>1,2: Channel is searching<br>0: Channel is idle |
| (24 * $N_i$) + 30 | U1 | $dB_{Hz}$ | Carrier to Noise ratio |
| (24 * $N_i$) + 31 | U1 | | Loss of link indicator (RINEX definition) |

***Notes:***

(1) *Due to undocumented changes in GPS modules by the manufacturer, not all MIDG IIC units support the GPS_RAW Message. As it is impossible to determine in the field if the Raw Data are available from the GPS module, this message should not be used. The values in this message are data provided directly by the GPS module and passed to the output message without any intervening processing.*

(2) *This message is provided at the selected rate only if data is produced by the GPS receiver.*

(3) *"nSVs" is number of satellites in this message.*

(4) *"$N_i$" goes from zero to (nSVs - 1).*

**4.11** Message: **GPS_CLK** [1] Message ID: **23 (0x17)** Payload Length: **20 Bytes (0x14)**
Description: GPS Receiver Clock Solution Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | GPS Time |
| 4 | I4 | ns | Clock bias |
| 8 | I4 | ns/s | Clock drift |
| 12 | U4 | ns | Time accuracy estimate |
| 16 | U4 | ps/s | Frequency accuracy estimate |

***Notes:***

(1) *This message is provided at the selected rate only if data is produced by the GPS receiver. The values in this message are data provided directly by the GPS module and passed to the output message without any intervening processing.*

**4.12** Message: **GPS_EPH** [1,2] Message ID: **24 (0x19)** Payload Length: **77 Bytes (0x4D)** [3]
Description: GPS Satellite Ephemeris Data Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | Address | Satellite ID [3] |
| 1 | U4 | | GPS Handover word |

After the 5 bytes above are sent, the following element is repeated 24 times. Each element is a 24-bit word of the GPS Navigation Message (see *ICD-GPS-200*). The 8 words following the Telemetry and Handover Words of Sub-frames 1 through 3 are included. Each word is arranged most significant byte first (big-endian):

| | | | |
|---|---|---|---|
| 5 + ($N_i$ * 3) | U3 | 24-Bit Word | Navigation Words from Sub-frames 1 through 3 [4,5] |

***Notes:***

(1) *Due to undocumented changes in GPS modules by the manufacturer, not all MIDG IIC units support the GPS_EPH Message correctly (the Navigation Words contents may be invalid). As it is impossible to determine in the field if the Ephemeris Data are available from the GPS module or if the message contents are valid, this message should not be used in firmware versions below 2.3.x. This message is not available in firmware versions 2.3.1 and higher.*

(2) *This message does not have a configurable message rate. Ephemeris data is polled for a satellite by sending a message to the MIDG IIC with ID = 24 (GPS_EPH) and a single payload byte which is the Satellite ID for the satellite for which ephemeris data is being requested. In order to prevent overrunning the MIDG IIC output queue, requests are cached and ephemeris messages are sent at a rate of only one ephemeris message per second.*

(3) *If no valid ephemeris data is available for a satellite, this message will have a single byte payload, the Satellite ID, and the Handover Word and Navigation Words will not be included. In this case, the Payload Length will be 1.*

(4) *"$N_i$" goes from zero to 23.*

(5) *Each these elements are 24-bit (3-byte) words. Since the Navigation Words require significant byte splitting and parsing, no effort is made to align the 24-bit words on 4-byte boundaries.*

**4.13** Message: **TIM_UTC** [1] Message ID: **25 (0x19)** Payload Length: **16 Bytes (0x10)**
Description: UTC Time Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | GPS Time |
| 4 | I4 | ns | Nanoseconds of Second (-5 x $10^8$ to +5 x $10^8$, UTC) |
| 8 | U2 | Value | Year (1999..2099, UTC) |
| 10 | U1 | Value | Month (1..12, UTC) |
| 11 | U1 | Value | Day of Month (1..31, UTC) |
| 12 | U1 | Value | Hour of Day (0..23, UTC) |
| 13 | U1 | Value | Minute of Hour (0..59, UTC) |
| 14 | U1 | Value | Second of Minute (0..59, UTC) |
| 15 | U1 | Bit field | Time information validity:<br>Bits 7..3: (Reserved, value indeterminate)<br>Bit 2: Valid UTC (leap seconds known)<br>Bit 1: Week number valid<br>Bit 0: Time of week valid |

***Notes:***

(1) *This message is provided at the selected rate only if data is produced by the GPS receiver. The values in this message are data provided directly by the GPS module and passed to the output message without any intervening processing.*

**4.14** Message: **TIM_ERR** [1]
Description: Time Error Information

Message ID: **26 (0x1A)**

Payload Length: **7 Bytes (0x07)**
Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | GPS Time |
| 4 | I1 | Counts | Time timer bias |
| 5 | I1 | Counts | Data timer bias |
| 6 | U1 | Bit field | Flags: |
| | | | Bit 7: (N/A, reads, zero) |
| | | | Bit 6: Timestamp is GPS time |
| | | | Bits 5..0: (N/A, read zero) |

***Notes:***

**(1)** *This message is a legacy message that actually provides no useful data to the user as the message only defines information used internally by the MIDG-Series units. This message is not available in firmware versions 2.3.1 and higher.*

**4.15** Message: **TIM_PPS** [1,2]
Description: Time Pulse Information

Message ID: **27 (0x1B)**

Payload Length: **16 Bytes (0x10)**
Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | GPS time of next pulse |
| 4 | U4 | msec / $2^{32}$ | Fractional millisecond of next pulse |
| 8 | I4 | ps | Quantization error of next pulse [3] |
| 12 | U2 | | GPS week number of next pulse |
| 14 | U1 | Bit field | Flags: |
| | | | Bits 7..3: (N/A, read zero) |
| | | | Bit 1: UTC is available |
| | | | Bit 0: Time base is (0=GPS, 1=UTC) |
| 15 | U1 | | (Reserved, value indeterminate) |

***Notes:***

**(1)** *This message is a legacy from when the MIDG-Series units did not have a Time Pulse output signal (1PPS), and indicates the estimated time of the next GPS time pulse. This message is just passed through from the GPS module by the MIDG IIC, via two serial data transmissions with uncertain latencies. Thus the data in this message may be incorrect for the next pulse being output by the GPS module. As the 1PPS Time Pulse output signal is available at the MIDG IIC output connector, use of this message is not recommended. This message is not available in firmware versions 2.3.1 and higher.*

**(2)** *The Time Pulse output signal is present only when the receiver is able to calculate a position solution. Accuracy of the Time Pulse output signal available at the MIDG IIC output connector is 50 $ns_{rms}$, with 99% < 100 ns error.*

**(3)** *The time pulse signal is aligned to a 23.104 MHz clock, which results in a resolution of 43 ns. The resulting quantization is considered in the time accuracy estimation of the receiver.*

**4.16** Message: **TIM_TM** [1] Message ID: **28 (0x1C)** Payload Length: **8 Bytes (0x08)**
Description: Time Mark Information Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | GPS time of received pulse rising edge |
| 4 | U2 | Count | GPS week number of received pulse rising edge |
| 6 | U2 | | (Reserved, value indeterminate) |

***Notes:***

**(1)** *This message is only available on MIDG IIC units that have the Time Mark Option (Microbotics Part Number SIS90031C-SR) supporting an external pulse input at Pin 8 of the MIDG IIC output connector. The MIDG IIC records the GPS time of the rising edge of the received pulse (+/- 1 ms), and sends this message at the first 50 Hz update slot of MIDG IIC processing (maximum update of 50 Hz). If multiple pulses are received in a 50 Hz period, only the time of the most recent rising edge is reported.*

**5 MIDG IIC External Aiding Input Messages.** The MIDG IIC messages defined in this section provide a mechanism for aiding the MIDG IIC Kalman filter with external measurements, including heading, magnetic vector, position, velocity, and air data. The MIDG IIC supports the following input aiding messages:

| | | | |
|---|---|---|---|
| | ***ID 31*** | ***HDG_MEAS*** | Heading Aiding |
| | ***ID 32*** | ***AID_MAG*** | Magnetometer Vector Aiding |
| § | ***ID 37*** | ***AID_POS*** | Position Aiding |
| | ***ID 38*** | ***AID_VEL*** | Velocity Aiding |
| § | ***ID 39*** | ***AID_AIR*** | Airspeed Aiding |

§ *The AID_POS and AID_AIR Messages have not yet been implemented and are non-functioning. While the HDG_MEAS, AID_MAG, and AID_VEL Messages have been implemented, they have not been fully tested, nor are their effects, especially with invalid entries, fully known at this time. The user accepts any and all risks and consequences when using any aiding message.*

**5.1** Message: **HDG_MEAS** Message ID: **31 (0x1F)** Payload Length: **8 Bytes (0x08)**
Description: Heading Measurements Applicable Modes: INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Time (1) |
| 4 | U2 | Bit fields | Details and vertical position standard deviation:<br>Bit 15: Time value format (1)<br>1 = GPS Time<br>0 = Estimated delay<br>Bits 14..12: (Reserved, send as zero) |
| | | 0.1 deg | Bits 11..0: Heading Standard Deviation (2) |
| 6 | I2 | 0.1 deg | Heading Measurement. Valid range is -1800 to +3600 (3) |

***Notes:***

(1) *The Time value is either the GPS Time of the measurement, or the estimated delay of the measurement from the time when the aiding message is sent and measurement was valid. The convention used depends on a Bit 15 of the Details field. If time delay is used (Bit 15 is zero), then the delay value is taken from the least significant byte of the Time value for a maximum delay of 255 milliseconds.*

(2) *The Heading Standard Deviation is used by the Kalman filter to merge the Heading Measurement into the final solution. A deviation value of zero causes the message to be ignored. A deviation value too small for the current heading estimates may cause instability in the final heading results.*

(3) *The Heading Measurement is in True Heading with North at 0 degrees and East at +90 degrees.*

**5.2** Message: **AID_MAG** Message ID: **32 (0x20)** Payload Length: **12 Bytes**
Description: Magnetometer Vector Applicable Modes: INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Time [1] |
| 4 | U2 | Bit field | Details:<br>Bit 15: Time value format [1]<br>1 = GPS Time<br>0 = Estimated delay<br>Bits 14..0: (Reserved, send as zero) |
| 6 | I2 | Relative units | X magnetic component [2] |
| 8 | I2 | Relative units | Y magnetic component |
| 10 | I2 | Relative units | Z magnetic component |

***Notes:***

[1] *The Time value is either the GPS Time of the measurement, or the estimated delay of the measurement from the time when the aiding message is sent and measurement was valid. The convention used depends on a Bit 15 of the Details field. If time delay is used (Bit 15 is zero), then the delay value is taken from the least significant byte of the Time value for a maximum delay of 255 milliseconds.*

[2] *Units for the magnetic components may be selected arbitrarily. The maximum vector value should be high enough to provide good resolution, but low enough to avoid saturating the 16-bit signed integer field. A scaled range of ±10000 counts would be a good choice. Internally, the MIDG IIC will convert the vector components to a normalized unit vector for use as a measurement.*

**5.3** Message: **AID_POS** [1] Message ID: **37 (0x25)** Payload Length: **20 Bytes** [3]
Description: Position Aiding Applicable Modes: INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Time [2] |
| 4 | U2 | Bit fields | Details and Vertical Position Standard Deviation:<br>Bit 15: Time value format [2]<br>1 = GPS Time<br>0 = Estimated delay<br>Bit 14: Measurement reference coordinates [3]<br>1 = ECEF<br>0 = Altitude/Lon/Lat<br>Bit 13: Calculate altitude bias [4]<br>Bit 12: (Reserved, send as zero) |
| | | 0. 1 m | Bits 11..0: Vertical Standard Deviation [5] |
| 6 | U2 | 0.1 m | Horizontal Standard Deviation [3,5] |
| 8 | I4 | cm | ECEF X, or Altitude [3] |
| 12 | I4 | cm, $10^{-7}$ deg | ECEF Y, or Longitude |
| 16 | I4 | cm, $10^{-7}$ deg | ECEF Z, or Latitude |

***Notes:***

**(1)** *This message has not yet been implemented and is non-functioning. It is presented for reference only, and is subject to change without notice.*

**(2)** *The Time value is either the GPS Time of the measurement, or the estimated delay of the measurement from the time when the aiding message is sent and measurement was valid. The convention used depends on a Bit 15 of the Details field. If time delay is used (Bit 15 is zero), then the delay value is taken from the least significant byte of the Time value for a maximum delay of 255 milliseconds.*

**(3)** *If Bit 14 of Details is set (ECEF coordinates), the message must be full length. If it is cleared (Altitude/Lon/Lat), then a short message that includes a Horizontal Standard Deviation of zero and ends with the Altitude field ($8^{th}$..$11^{th}$ bytes of the Payload) is accepted. The Payload Length in this case is 12 bytes.*

**(4)** *If Bit 13 of Details is set, the MIDG IIC assumes it must calculate a bias for the altitude measurement when internal GPS data is available.*

**(5)** *The Standard Deviation values are used by the Kalman filter to merge the Position Measurement(s) into the final solution. A deviation value too small for the current heading estimates may cause instability in the final position results. If a Standard Deviation field is zero, it indicates that the associated measurement should not receive an update: e.g., a packet that updates the Latitude and Longitude, but not the Altitude, would set the Vertical Standard Deviation (Bits 11..0 of Details) to zero.*

**5.4** Message: **AID_VEL** Message ID: **38 (0x26)** Payload Length: **14 Bytes (0x0E)** [2]
Description: Velocity Aiding Applicable Modes: INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Time [1] |
| 4 | U2 | | Details and speed standard deviation:<br>Bit 15: Time value format [1]<br>1 = GPS Time<br>0 = Estimated delay<br>Bit 14: Speed only [2]<br>Bits 13..12: (Reserved, send zero) |
| | | 0.1 m/s | Bits 11..0: Vertical Speed Standard Deviation [2,3] |
| 6 | I2 | cm/s | Up Velocity (or total Velocity Magnitude if Bit 14 is set) [2] |
| 8 | I2 | cm/s | East Velocity |
| 10 | I2 | cm/s | North Velocity |
| 12 | U2 | 0.1 m/s | Horizontal Speed Standard Deviation [3] |

***Notes:***

[1] *The Time value is either the GPS Time of the measurement, or the estimated delay of the measurement from the time when the aiding message is sent and measurement was valid. The convention used depends on a Bit 15 of the Details field. If time delay is used (Bit 15 is zero), then the delay value is taken from the least significant byte of the Time value for a maximum delay of 255 milliseconds.*

[2] *Bit 14 of Details set indicates the Up Velocity is actually the absolute value of the total speed through space, and Bits 11-0 are the Standard Deviation of this speed measurement. If Bit 14 of Details is set, then all elements of the message after Up Velocity are ignored, and may be omitted by the sender. The Payload Length in this case is 8 bytes.*

[3] *The Standard Deviation values are used by the Kalman filter to merge the Velocity Measurement(s) into the final solution. A deviation value too small for the current heading estimates may cause instability in the final velocity results. If a Standard Deviation field is zero, it indicates that the associated measurement should not receive an update: e.g., a packet that updates the East and North velocities, but not the Up Velocity, would set the Horizontal Speed Standard Deviation to zero; if Bits 11..0 of Details are zero, then the Up Velocity is not used in the measurement update.*

**5.5** Message: **AID_AIR** [1] Message ID: **39 (0x27)** Payload Length: **12 Bytes (0x0C)**
Description: Air Data Aiding Applicable Modes: INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | msec | Time [2] |
| 4 | U2 | Bit fields | Details and airspeed standard deviation<br>Bit 15: Time value format [2]<br>1 = GPS Time<br>0 = Estimated delay<br>Bits 14..12: (Reserved, send as zero) |
| | | 0.1 m/s | Bits 11..0: True Airspeed Standard Deviation [3] |
| 6 | U2 | 0.1 m/s | True Airspeed [4] |
| 8 | U2 | Bit fields | Angle of Attack Details:<br>Bits 15..12: Standard Deviation [5]<br>Bits 11..0: Angle of Attack [6] |
| 10 | U2 | Bit fields | Angle of Slip Details:<br>Bits 15..12: Standard Deviation [5]<br>Bits 11..0: Angle of Slip [6] |

***Notes:***

[1] *This message has not yet been implemented and is non-functioning. It is presented for reference only, and is subject to change without notice.*

[2] *The Time value is either the GPS Time of the measurement, or the estimated delay of the measurement from the time when the aiding message is sent and measurement was valid. The convention used depends on a Bit 15 of the Details field. If time delay is used (Bit 15 is zero), then the delay value is taken from the least significant byte of the Time value for a maximum delay of 255 milliseconds.*

[3] *The Standard Deviation value for True Airspeed is used by the Kalman filter to merge the Speed Measurement into the final solution. A deviation value too small for the current speed estimates may cause instability in the final velocity results. If a Standard Deviation field is zero, it indicates that the measurement should not receive an update.*

[4] *The provided airspeed is expected to be the ground speed plus the current wind, so that if the actual wind is estimated and removed from this measurement, it will be equivalent to the ground speed.*

[5] *The Standard Deviation fields for Angle of Attack and Angle of Slip represent the standard deviations of the angle measurement. The actual deviation applied with the measurement is the deviation 4-bit value times 2 plus 1. A deviation value of 0 = 1 degree, 1 = 3 degrees, 2 = 5 degrees, … , 15 = 31 degrees.*

[6] *The Angle of Attack and Angle of Slip are represented as 12-bit scaled signed integesr that represents approximately ±90 degrees. The scale factor is 90/2048, which gives slightly better than 0.05 degree resolution. For example, 123 = 5.4 degrees.*

**6 Miscellaneous MIDG IIC Input Messages.** Several message are provided for commanding and providing information to the MIDG IIC. Miscellaneous input messages are:

| | | | |
|---|---|---|---|
| ¶ | ***ID 30*** | ***RTCM*** | RTCM differential correction data |
| | ***ID 99*** | ***RESET*** | System reset |

¶ *Due to undocumented changes in GPS modules by the manufacturer, not all MIDG IIC units support the RTCM Message. As it is impossible to determine in the field if the message is available, this message should not be used in firmware versions below 2.3. This message is not available in firmware versions 2.3.1 and higher.*

**6.1** Message: **RTCM** (1) Message ID: **30 (0x1E)** Payload Length: **Variable**
Description: RTCM DGPS corrections Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | BN | | RTCM data for differential GPS corrections (2) |

***Notes:***

(1) *Due to undocumented changes in GPS modules by the manufacturer, not all MIDG IIC units support the RTCM Message. As it is impossible to determine in the field if the message is available, this message should not be used in firmware versions below 2.3. This message is not available in firmware versions 2.3.1 and higher.*

(2) *RTCM corrections are provided to the MIDG IIC as a stream of bytes. Typically, GPS ground stations that create differential GPS corrections provide a serial stream of these corrections to the user. The contents of this stream must be encapsulated in this packet and provided to the MIDG IIC. The MIDG IIC accepts RTCM message types 1, 2, 3, and 9.*

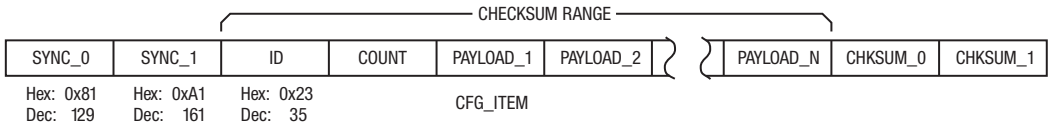
**6.2** Message: **RESET** Message ID: **99 (0x63)** Payload Length: **4 Bytes (0x04)**
Description: Software Reset Command Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U4 | Reset Code | Value must be **0x01310655** for the reset to occur |

**7 Configuration.** Configuration messages provide access to the setup information of the MIDG IIC. This includes the selected mode of operation, message rates, output formats, etc. Configuration operations use two MBI messages: *CFG_SET* (Message 35) and *CFG_QUERY* (Message 36).

**7.1 Configuration Set Message (*CFG_SET*).** The *CFG_SET* Message is used to set parameters of the MIDG IIC internal configuration. The general form of this message is:




The *ID* for the *CFG_SET* Message is 35 (0x23), with the first byte of the Payload being the specific *CFG_ITEM* being set. The balance of the Payload is configuration specific to the *CFG_ITEM*. The details for each *CFG_ITEM* are outlined in the sections below.

The MIDG IIC responds to each *CFG_SET* Message with either an Configuration Acknowledge Message (*CFG_ACK*) if the *CFG_ITEM* operation has been successful, or a Configuration Not-Acknowledge Message (*CFG_NAK*) if the operation was not successful.

**7.1.1** Message: **CFG_ACK** Message ID: **40 (0x28)** Payload Length: **2 Bytes (0x02)**
Description: Acknowledge (sent by MIDG IIC upon success) Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *Message_ID* | ***ID = 35 (0x23)***, indicating this is a reply to *CFG_SET* |
| 1 | U1 | *CFG_ITEM* | *CFG_ITEM* number that was successfully changed |

**7.1.2** Message: **CFG_NAK** Message ID: **41 (0x29)** Payload Length: **3 Bytes (0x03)**
Description: Not-Acknowledge (sent by MIDG IIC upon failure) Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *Message_ID* | ***ID = 35 (0x23)***, indicating this is a reply to *CFG_SET* |
| 1 | U1 | *CFG_ITEM* | *CFG_ITEM* number that was unsuccessfully changed |
| 2 | U1 | Code | Failure codes:<br>1 Wrong number of parameters<br>2 Bad *CFG_ITEM* number<br>3 Invalid request<br>4 Change would exhaust the serial port bandwidth<br>5 Subsystem busy – retry message |

**7.1.3** Message: **CFG_SET: BAUD_RATE** [1] Message ID: **35 (0x23)** Payload Length: **2 Bytes (0x02)**
Description: Set serial communication baud rate Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 1 (0x01)*** |
| 1 | U1 | Code | Baud Rate:<br>0 = 115200<br>1 = 57600<br>2 = 38400<br>3 = 19200<br>4 = 9600 |

***Notes:***

**(1)** *Changes take effect on reset.*

**7.1.4** Message: **CFG_SET: PROTOCOL** [1] Message ID: **35 (0x23)** Payload Length: **2 Bytes (0x02)**
Description: Set serial communication protocol Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 2 (0x02)*** |
| 1 | U1 | Code | Protocol [1]<br>0 = Microbotics Binary Interface Protocol (only valid protocol) |

***Notes:***

**(1)** *Changes take effect on reset. The only valid protocol is Microbotics Binary Interface Protocol.*

**7.1.5** Message: **CFG_SET: FORMAT** Message ID: **35 (0x23)** Payload Length: **2 Bytes (0x02)**
Description: Set output format for position and velocity Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 3 (0x03)*** |
| 1 | U1 | Bit field | Solution Status:<br>Bits 4-7: (Reserved, send zero)<br>Bits 2-3: Position Format<br>0 = ECEF<br>1 = ENU Relative (1)<br>2,3 = LLA<br>Bit 1: Velocity Format<br>0 = ECEF<br>1 = ENU<br>Bit 0: ENU position relative to first fix (1) |

***Notes:***

(1) *If ENU Relative is selected for Position Format, the position will be relative to either the first GPS fix (Bit 0 set) since reset or a location specified in configuration (Bit 0 cleared).*

**7.1.6** Message: **CFG_SET: RUN_MODE** Message ID: **35 (0x23)** Payload Length: **2 Bytes (0x02)**
Description: Set MIDG IIC Run Mode Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 4 (0x04)*** |
| 1 | U1 | Code | Run Mode select value:<br>0 = *IMU Mode*<br>1 = *Vertical Gyro Mode*<br>2 = *INS Mode* |

**7.1.7** Message: **CFG_SET: MSG_DIV** Message ID: **35 (0x23)** Payload Length: **3 Bytes (0x03)**
Description: Set message interval divider Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 5 (0x05)*** |
| 1 | U1 | Value | Output Message *ID* for which the divisor is to be set |
| 2 | U1 | Value | Message Rate Divisor: 0, 1..255 **(1)** |

***Notes:***

**(1)** *If the Message Rate Divisor is non-zero, the update rate will be (50 / Message Rate Divisor) Hz. If the Message Rate Divisor is zero, the specific message requested will be disabled, although it may still be queried.*

**7.1.8** Message: **CFG_SET: POS_REF** Message ID: **35 (0x23)** Payload Length: **16 Bytes (0x10)**
Description: Set *ENU Relative* position reference Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 6 (0x06)*** |
| 1 | U1 | | (Reserved, send zero) |
| 2 | U2 | | (Reserved, send zero) |
| 4 | I4 | cm | X Position, ECEF coordinates **(1)** |
| 8 | I4 | cm | Y Position, ECEF coordinates |
| 12 | I4 | cm | Z Position, ECEF coordinates |

***Notes:***

**(1)** *The specified location is used as the reference point against which relative ENU Relative position is calculated.*

**7.1.9** Message: **CFG_SET: XFORM** Message ID: **35 (0x23)** Payload Length: **8 Bytes (0x08)**
Description: Set Transform from Platform to MIDG IIC Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 10 (0x0A)*** |
| 1 | U1 | | (Reserved, send zero) |
| 2 | I2 | 0.01 deg | Transform Yaw [(1)] |
| 4 | I2 | 0.01 deg | Transform Pitch |
| 6 | I2 | 0.01 deg | Transform Roll |

***Notes:***

[(1)] *The Yaw, Pitch, and Roll indicate the Euler angles that define the direction cosine matrix to rotate a vector in the vehicle coordinates to a vector in the MIDG IIC sensor coordinates. The rotation is taken Yaw, Pitch, Roll*

**7.1.10** Message: **CFG_SET: HDG** Message ID: **35 (0x23)** Payload Length: **8 Bytes (0x08)**
Description: Set Transform from Platform to MIDG IIC Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 11 (0x0B)*** |
| 1 | U1 | Bit fields | Magnetometer operation settings:<br>Bit 7: (Reserved, send zero)<br>Bits 6-4: Internal magnetometer aiding Threshold Level [(1)]<br>Bit 3: Use velocity vector for heading even when turning<br>Bit 2: Use velocity vector for heading [(2)]<br>Bit 1: Enable internal magnetometer in *VG Mode*<br>Bit 0: Enable internal magnetometer in *INS Mode* |
| 2 | I2 | Relative units | X axis magnetometer bias [(3)] |
| 4 | I2 | Relative units | Y axis magnetometer bias |
| 6 | I2 | Relative units | Z axis magnetometer bias |

***Notes:***

[(1)] *The internal magnetometer will not be used if the current heading accuracy is better than the selected Threshold Level. The Threshold Levels correspond to 1 sigma error estimates as follows:*

| *Threshold Level* | *Error Estimate (1 sigma)* |
|---|---|
| *0* | *0.5 degree* |
| *1* | *1.0 degree* |
| *2* | *2.0 degrees* |
| *3* | *4.0 degrees* |
| *4* | *8.0 degrees* |
| *5* | *12.0 degrees* |
| *6* | *20.0 degrees* |
| *7* | *30.0 degrees* |

[(2)] *Bit 2 allows the velocity vector, from the GPS or an external measurement, to be used as heading aiding. This assumes that the MIDG IIC is aligned with the vehicle such that heading is equivalent to direction of motion, and is generally applicable for ground vehicles. If the velocity vector is different from heading when turning, select Bit 3 also.*

[(3)] *The provided bias values are subtracted from the magnetometer data.*

**7.1.11** Message: **CFG_SET: CFG_SAVE** [1] Message ID: **35 (0x23)** Payload Length: **1 Byte (0x01)**
Description: Save configuration to NV memory Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 100 (0x64)*** |

***Notes:***

**(1)** *This configuration message must be issued for any configuration changes to be preserved across resets.*

**7.1.12** Message: **CFG_SET: CFG_LOAD** [1] Message ID: **35 (0x23)** Payload Length: **1 Byte (0x01)**
Description: Load configuration from NV memory Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 101 (0x65)*** |

***Notes:***

**(1)** *This configuration message resets the MIDG IIC configuration information to the values stored in NV memory.*

**7.1.13** Message: **CFG_SET: CFG_ERASE** [1] Message ID: **35 (0x23)** Payload Length: **1 Byte (0x01)**
Description: Erase configuration in NV memory, reset to default Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 102 (0x66)*** |

***Notes:***

**(1)** *This configuration message erases the configuration in the non-volatile memory and resets the configuration in the MIDG IIC to its Factory default values. This erasure also forces the NV Configuration Valid flag in the STATUS Message (Bit 7) to remain reset until a new configuration is saved via a CFG_SET: CFG_SAVE Message.*

**7.2 Configuration Query Message (*CFG_QUERY*).** The *CFG_QUERY* Message is used to query the parameters of the MIDG IIC internal configuration. The message takes on two forms: *CFG_QUERY: GENERAL* where a specific *CFG_ITEM* is being queried, or the *CFG_QUERY: INFO* where MIDG IIC Product Information is being queried.

The MIDG IIC responds to each *CFG_QUERY: GENERAL* Message with either an Query Acknowledge Message (*QUERY_ACK*) if the operation has been successful, or a Query Not-Acknowledge Message (*QUERY_NAK*) if the operation was not successful. The MIDG IIC responds to each *CFG_QUERY: INFO* Message with an Information Acknowledge Message (*INFO_ACK*).

**7.2.1** Message: **CFG_QUERY: GENERAL** Message ID: **36 (0x24)** Payload Length: **1 Byte (0x01)**
Description: Query status of *CFG_ITEM* Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | *CFG_ITEM* number being queried (See *CFG_SET* Messages above) |

**7.2.2** Message: **QUERY_ACK** Message ID: **36 (0x24)** Payload Length: **Variable** (1)
Description: Acknowledge (sent by MIDG IIC upon success) Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | *CFG_ITEM* number that was successfully queried (1) |
| 1 | BN | | Configuration data for the *CFG_ITEM* queried (1) |

***Notes:***

(1) *The Payload of a successful CFG_QUERY: GENERAL message has the same format as the corresponding CFG_SET Message for the specific CFG_ITEM requested, with the data indicating the actual values present in the MIDG IIC internal configuration.*

**7.2.3** Message: **QUERY_NAK** Message ID: **36 (0x24)** Payload Length: **3 Bytes (0x03)**
Description: Not-Acknowledge (sent by MIDG IIC upon failure) Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *Message_ID* | ***ID = 36 (0x24)***, indicating this is a reply to *CFG_QUERY: GENERAL* |
| 1 | U1 | *CFG_ITEM* | *CFG_ITEM* number that was unsuccessfully queried |
| 2 | U1 | Code | Failure code:<br>2 Bad *CFG_ITEM* number |

**7.2.4** Message: **CFG_QUERY: INFO** Message ID: **36 (0x24)** Payload Length: **2 Bytes (0x02)**
Description: Query Product Information from the MIDG IIC Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 20 (0x14)***, indicating this is a query for *CFG_QUERY: INFO* |
| 1 | U1 | Code | Product ID queried:<br>0 = Manufacturer<br>1 = Product<br>2 = Part Number<br>3 = Serial Number<br>4 = Support Key<br>5 = Firmware Version |

**7.2.5** Message: **INFO_ACK** Message ID: **36 (0x24)** Payload Length: **Variable** [1]
Description: Product Information (sent by the MIDG IIC) Applicable Modes: IMU, VG, INS

**Payload Contents**

| Byte Offset | Number Format | Units | Purpose / Comment |
|---|---|---|---|
| 0 | U1 | *CFG_ITEM* | ***CFG_ITEM = 20 (0x14)***, indicating this is a reply to *CFG_QUERY: INFO* |
| 1 | U1 | Code | *Product ID* queried |
| 2 | BN | ASCII string | Information requested returned as a NULL-terminated ASCII string [1] |

***Notes:***

[1] *The requested information is returned after the Product ID byte as a NULL-terminated string. If the requested Product ID is not recognized, or the information is not available, the reply will be a NULL string (a single byte of 0x00).*