# Communications message formats

The SP-1 or SP-2 unit communicates via the airtalk compatible communications port.

This port consists of a shared, single wire asynchronous link. The link operates with one start bit, eight data bits and one stop bit for a total of ten bits per byte of data transmitted.

Signal levels are <0.5V for Mark and >3V for Space. Note that this is reversed polarity compared to RS232. This is the native format as used by most serial communication devices.

Data rate is 19200 baud.

A transmitting device generally pulls the line to a low state to signal a "mark" with a weak pullup provided to +5V to drive the "space" or inactive level.

The following circuit diagram shows how to construct a RS-232 to Airtalk link converter. The circuit can be built onto a DB-9 female connector that can plug directly into a serial port of a PC. Note that modem control signals should be initialized so pin 4 is set to a "high" level.
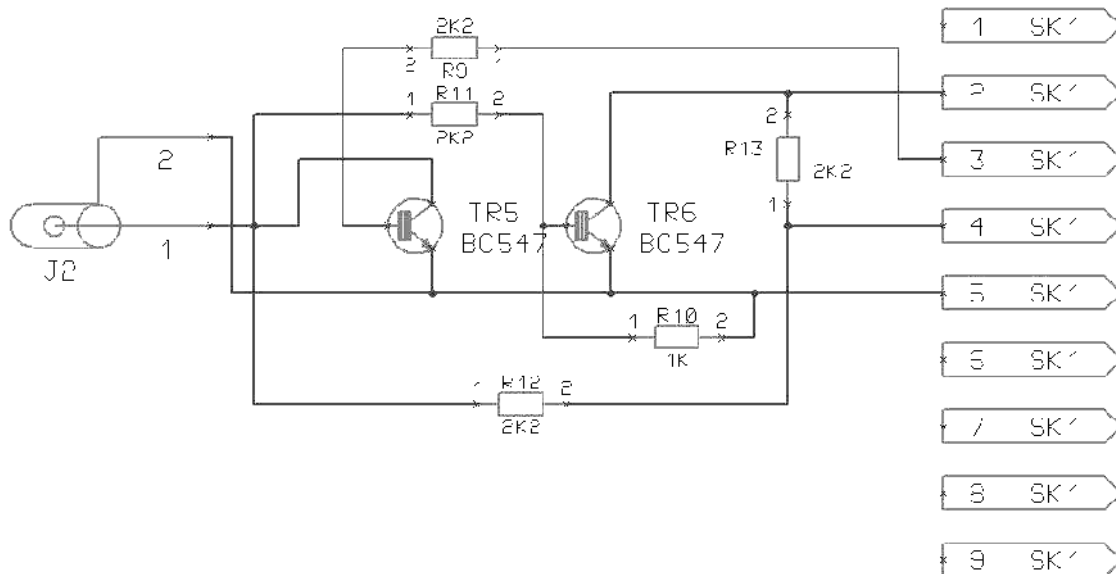


Airtalk messages have the following format:

STX, Destination, Length, message type, data[1], data[2],…,data[length-1], checksum, ETX

The byte $82 is used as STX
The byte $83 is used as ETX

Checksum is the result of all bytes in the message xor'd together with a seed of $A5. The STX,ETX and checksum itself are not included in the checksum.

As the airtalk link is a shared link with several data transmitters possible, it is required to resolve contention issues.
The basic rules for the link are simple:

a)Do not send a message if another message transmission is in progress.
b)Verify the received message for validity using the checksum. Reject any messages where the checksum does not match.

The SP-1 and SP-2 occupies the following airtalk address:

$E4    Magnetometer

Messages intended for the magnetometer should be addressed to device $E4.
Note: Message formats listed here are subject to change without notice. They are correct at release time of the SP-1 and SP-2. Future requirements may lead to messages changing or new messages added. Please contact MGL Avionics if you need to know details related to this.

# Messages transmitted by the SP-1 and SP-2 unit.

Data types:

| | |
|---|---|
| byte | 8 bits unsigned integer |
| int | 16 bits signed integer LSB first |
| sint | 8 bits signed integer |
| fps | 16 bit fixed point. |
| | MSB: signed 8 bit integer. |
| | LSB: fractional part. |
| fpl | 32 bit fixed point. Lower 16 bits is fractional part, upper 16 bits is integer part. |
| fpx | 32 bit fixed point. Lower 24 bits is fractional part, upper 8 bits is integer part. |
| word | 16 bit unsigned integer |
| long | 32 bit signed integer |

### *Heading  message*

The SP-1 or SP-2 will transmit the heading message approximately 2 times per second.
This is the default message format that all Stratomaster instruments expect.
This message will be sent unconditionally.

| | | |
|---|---|---|
| $FF | byte | Destination address: All |
| 4 | byte | Message length 4 bytes |
| 50 | byte | Message type |
| heading | word | heading 0 to 359 degrees |
| MagMode | byte | Description of heading type (see below) |

MAGMODE

This byte reflects the operating mode of the heading output

1 – 2D mode
2 – 3D accelerometer tilt compensated mode

Note: Magmode is only relevant for SP-2.


## Deviation data dump

This message is sent during deviation compensation. It can be used to diagnose magnetic field related problems that may cause large deviation.

| $FF | byte | Destination address: All |
|------|------|--------------------------|
| 19   | byte | Message length 19 bytes  |
| 51   | byte | Message type             |

this is followed by 18 bytes of deviation information data as follows:

| EWMax | int | Maximum value of EW sensor |
|-------|-----|----------------------------|
| EWMin | int | Minimum value of EW sensor |
| NSMax | int | Maximum value of NS sensor |
| NSMin | int | Minimum value of NS sensor |
| EW    | int | Current value of EW sensor |
| NS    | int | Current value of NS sensor |
| ZMax  | int | Maximum value of Z axis sensor |
| ZMin  | int | Minimum value of Z axis sensor |
| Z     | int | Current value of Z axis sensor |

The above data is sent both during deviation compensation as well as during z axis calibration. Minimum and maximum readings of a sensor measured during a full rotation of the compass are recorded. These are used to calculate gain correction factors as well as cancel out sensor and amplifier offsets.

## E2 calibration dump compass

| $FF | byte | Destination address: All |
|------|------|--------------------------|
| 49   | byte | Message length 49 bytes  |
| 62   | byte | Message type             |

this is followed by 48 bytes of calibration data as stored in the E2 memory.


## Magnetic inclination

| | | |
|---|---|---|
| $FF | byte | Destination address: All |
| 6 | byte | Message length |
| 57 | byte | General information response |
| 0 | byte | response data type: Inclination |
| INCL | fpl | Inclination |

This message can be requested from SP-3hc units. It returns the last measured magnetic inclination. The value returned is relative to the magnetic south pole. Values are negative from 0 to –180 degrees. 0 degrees is the magnetic south pole, -90 degrees at the magnetic horizon and –180 degrees at the magnetic north pole.

## *Raw magnetic sensor data*

| | | |
|---|---|---|
| $FF | byte | Destination address: All |
| 17 | byte | Message length |
| 61 | byte | Magnetic data |
| X | long | value of X axis magnetometer |
| Y | long | value of Y axis magnetometer |
| Z | long | value of Z axis magnetometer |
| Pitch | integer | pitch angle from Y axis accelerometer |
| Bank | integer | bank angle from Z axis accelerometer |

This message contains raw sensor data obtained from the magnetic field sensors. Values are signed long integers.
The values are the differential of the two saturated sensor states that are used to obtain magnetic field strength with magneto resistive sensors.
Bank and pitch information is available on the SP-2 sensor only. The values are expressed in positive or negative degrees relative to straight and level being zero degrees.

This data has to be requested. Message structure for this is described further on in this document.

## *Acknowledge*

| | | |
|---|---|---|
| $FF | byte | Destination address: All |
| $02 | byte | Message length 2 bytes |
| $0A | byte | Message type |
| $00 | byte | zero byte |

This is a standard airtalk message. This message is sent by the SP-1/2 in response to the reception and/or completion of a received command that does not itself result in a response.
The transmitting node will receive this message as acknowledgement that a message sent to the SP-1/2 has been received. This message is not sent if the received message results in a response.
For example:
If you request E2 calibration data the SP-1/2 will not send an acknowledge but will send the requested data.

# Messages received by the SP-1 or 2 unit.

During normal operation, few, if any messages are sent to the SP-1 or SP-2. Most of these messages are used during device testing and calibration. Sending a message that affects the units calibration has to be done with great care. Incorrect usage of these messages will render your SP-1 or SP-2 unusable.

## *Set accelerometer X and Y to zero*

This message is relevant for the SP-2 only.
This message is used in combination with the next two (bank and pitch alignment) to calibrate the internal accelerometer. This calibration determines much of the accuracy that can be achieved during banked and/or pitch attitude of the sensor.
This message is sent with the SP-2 aligned perfectly horizontal (verify with a spirit level). This message sets the zero point for X and Y axis.

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 2 | byte | Message length |
| 12 | byte | Pitch/Bank zero |
| 0 | byte | Dummy byte (no function) |

## *Set accelerometer to 45 degrees bank*

This message is relevant for the SP-2 only.
This message is sent with the SP-2 aligned in a 45 degree bank (sideways tilt, X axis). The Y axis should remain at zero degrees.
.

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 2 | byte | Message length |
| 14 | byte | Bank 45 degrees |
| 0 | byte | Dummy byte (no function) |

## *Set accelerometer to 45 degrees pitch*

This message is relevant for the SP-2 only.
This message is sent with the SP-2 aligned in a 45 degree pitch (lengthwise tilt, Y axis). The X axis should remain at zero degrees.
.

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 2 | byte | Message length |
| 13 | byte | Pitch 45 degrees |
| 0 | byte | Dummy byte (no function) |

## Set deviation compensation to factory calibration

This message clears any user deviation compensation and resets back to the original compensation status as calibrated at the factory.
Factory calibration is done in an area of known magnetic field resulting in a deviation neutral setting of the calibration.
As a side effect of the calibration, sensor offsets are also measured and eliminated.

| $E4 | byte | Destination address: Compass |
|------|------|------------------------------|
| 2    | byte | Message length               |
| 52   | byte | Setup compass items          |
| 1    | byte | Function ID                  |

## Enter deviation compensation mode

After this message is received, the compass is set to deviation compensation mode. Deviation data messages are output during this mode approximately four times per second.
During deviation compensation the aircraft is turned on the ground through one or more 360 degree turns in an area with little or no external magnetic deviation (such as created by hangers or reinforced concrete aprons).
Deviation compensation can be canceled or ended with the relevant data collected stored for future use.

| $E4 | byte | Destination address: Compass |
|------|------|------------------------------|
| 2    | byte | Message length               |
| 52   | byte | Setup compass items          |
| 2    | byte | Function ID                  |

## End deviation compensation mode

After this message is received, deviation compensation mode is ended. All data collected is processed and the result is the bases for future deviation compensation.

| $E4 | byte | Destination address: Compass |
|------|------|------------------------------|
| 2    | byte | Message length               |
| 52   | byte | Setup compass items          |
| 3    | byte | Function ID                  |

## Cancel deviation compensation mode

After this message is received, deviation compensation mode is ended. All data collected is discarded, no change to existing deviation compensation data is performed.

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 2 | byte | Message length |
| 52 | byte | Setup compass items |
| 4 | byte | Function ID |

## *End deviation compensation mode and store as factory default*

After this message is received, deviation compensation mode is ended. All data collected is processed and the result is the bases for future deviation compensation. The data is also stored as factory default.
Please note that using this message will invalidate the factory default calibration, it will be lost with no possibility to retrieve it.

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 2 | byte | Message length |
| 52 | byte | Setup compass items |
| 5 | byte | Function ID |

## *Set Z axis offset*

This calibration function enters the Z axis offset compensation mode (SP-2 only).
See calibration method at end of this document.
The SP-2 will use this information to calculate the sensor offset.
Please note that there is also a similar message to set the factory default of this offset.

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 2 | byte | Message length |
| 52 | byte | Setup compass items |
| 7 | byte | Function ID |

## *Cancel Z axis offset*

After this message is received, Z axis offset measurement is canceled. No setup data is changed.

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 2 | byte | Message length |
| 52 | byte | Setup compass items |
| 9 | byte | Function ID |

## *End Z axis offset*

After this message is received, Z axis offset measurement is ended and data collected is used to calculate the sensor offset. This data is stored for future reference.

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 2 | byte | Message length |
| 52 | byte | Setup compass items |
| 8 | byte | Function ID |

## Set compass operation mode

This message selects one of three compass modes of operation:

1 – 2D mode, two axis magnetic compass
2 – 3D mode, three axis accelerometer tilt compensated compass

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 3 | byte | Message length |
| 52 | byte | Setup compass items |
| 10 | byte | Function ID |
| Mode | byte | Mode value, 1, 2 |

## Set Z axis gain

SP-2 only.
This message sets the Z axis sensor gain. The object is to set the sensor gain so the output equals that of the X/Y sensor. Gain change values are transmitted as a signed byte. Typical values sent are –1,+1, –10,+10, -50,+50. Neutral gain has a value of 1000.
The procedure to follow is to set the SP-2 on a magnetic heading of exactly 45 with the SP-2 horizontal with the SP-2 operating in mode 2 (tilt compensated compass).
Then, without changing the heading, bank the SP-2 by 45 degrees.
Should the transmitted heading now deviate from 45 degrees, send gain change values until the heading is correct.
This procedure should be carried out using a suitable, nonmagnetic jig as it is difficult to bank the unit by hand and keep the heading accurate.
Please note that there is also a similar message to set the factory default of the gain.

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 3 | byte | Message length |
| 52 | byte | Setup compass items |
| 11 | byte | Function ID |
| Gain | byte | Signed byte gain change factor |

### *Send raw compass sensor data*

This message will request the SP-1 or SP-2 to send raw sensor data of the three magnetometers (two in case of the SP-1). The data is the differential of the two saturation phases used to obtain magnetic field strength with a magneto resistive sensor.

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 3 | byte | Message length |
| 52 | byte | Setup compass items |
| 15 | byte | Function ID |
| 0 | byte | Dummy byte |

### *Major axis alignment*

This consists of five messages. These are used to align the compass to the four major cardinal compass points North, South, West, East and clearing of such alignment.
These messages can be used to further cancel out minor deviations that may remain after the deviation compensation has been performed.
These messages should only be used after deviation compensation unless the required corrections are very small.
Calibration using these messages should only be performed if a very accurate reference compass system is available. Calibration is performed by aligning the SP-1 or SP-2 in each one of the four directions and then sending the related message. The SP-1 or SP-2 will then compare the internally derived heading with what it should be and calculate a suitable correction factor that will interpolate between the four directions as well.

| | | |
|---|---|---|
| $E4 | byte | Destination address: Compass |
| 3 | byte | Message length |
| 21 | byte | Setup cardinal offset |
| NSWE | byte | Direction |

NSWE:
    0       – North
    1       – South
    2       – East
    3       – West
    4       – Clear all cardinal alignment

### *Compass calibration procedure*

Note: All magnetic calibration must be performed in a known linear field line environment, i.e. no magnetic material or ferro-magnetic metals may be close

to the sensor. Verify this with a compass, also, if possible, verify that Z axis field lines correspond with magnetic inclination at your location. The magnetic field at the location of calibration should be as undistorted as possible to result in a good calibration and highest possible accuracy of the sensor.

The first, important calibration that needs to be performed is the accelerometer calibration as this is used for tilt compensation. This can be disregarded for SP-1.
Place sensor on a flat surface. Ensure tilt angles are zero, verify this with a spirit level. Once done, send the "Set accelerometer X and Y to zero" message. Place the sensor in an exact 45 degree angle of tilt around the Y axis (bank), send the "Set accelerometer to 45 degrees bank" message. Lastly, place the sensor is an exact 45 degree angle of tilt around the X axis (Pitch) and send the "Set accelerometer to 45 degrees pitch" message.
This calibration is performed at the factory and does not normally have to be performed in the field.

Normal in-field calibration consists of a deviation compensation procedure, followed optionally by alignment to the four major cardinal points North, South, West and East.
The compass is set into deviation compensation mode and it starts sending our deviation data messages. The compass should now be turned on a flat surface through 360 degrees or more. Tilt and pitch must remain at zero during this procedure (verify this with a spirit level).
End the deviation procedure to allow calculation of offset and gain correction values for future use. Cancel if you want to resume normal operation discarding any collected data. You can also reset the compass back to original factory settings.

For Z-axis calibration perform as follows:
Align compass in a North-South axis on a flat surface. Start Z axis calibration. You should now receive deviation data messages with only the Z axis data filled in. Quickly, without changing pitch angle, rotate the compass though the Y axis by 180 degrees. The compass will now be upside down, still pointing North/South. End the Z axis calibration.
This calibrates the Z axis offset.
For Z axis gain calibration, place the compass on a flat surface and rotate it such that the heading displayed is 45 degrees. Now tilt the compass around the lengthwise axis (Y axis) to an angle of 45 degrees without changing the heading. Send Z axis gain messages to increase or decrease gain so the heading reported is 45 degrees.
Check at various headings to ensure best possible tilt compensation in all directions. Aim for better than 2 degrees maximum error at tilt angles of 45 degrees.
Z-axis calibration is performed at the factory and is not normally required in the field.