HORIZON HOBBY, LLC.

Specification for Spektrum® X-Bus Telemetry Sensors

Enabling Use of Non-Spektrum Sensors

Rev M

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Specification for communicating on the X-Bus so that data from non-Spektrum devices can be displayed on the AirWare™ -based transmitters.

Specification for Spektrum® X-Bus Telemetry Sensors

1 INTRODUCTION

With the advent of third-party display (J-Link), annunciation (vSpeak), and data display systems (Robo-Software and TLMViewer.com), we feel it is in everybody's best interests to open the telemetry system by sharing correct implementation data. With that mindset, the purpose of this document is to enable third-party telemetry sensors, both commercial and hobbyists, that can use the Spektrum X-Bus telemetry system as a data transport mechanism for custom sensors including items such as:

- an ESC,
- fuel flow meter,
- high-current battery "fuel gauge" (mAh),
- digital status (for example, landing gear status lights),
- thrust/strain gauge,
- air tank pressure, or
- an individual cell monitor for LiPo batteries.

The intent is that publication of this document will ensure that these third-party devices can inter-operate with one another and with Spektrum products in a non-interfering, cooperative manner. Spektrum will provide an interface to allow generic data display and alarms on certain levels of transmitter products, although they obviously cannot be as thoroughly integrated into the radios as Spektrum products are.

2 AUDIENCE

This document is intended for non-Horizon personnel to be able to develop sensors which function correctly in the Spektrum X-Bus Air Telemetry System. This document includes sufficient information to allow a sensor to be created such that it reports data useful to the users.

This document does not provide information that can be used to access data contained in a Spektrum telemetry file (.TLM). The STi application provides this capability for Apple iPhone and related products. Robo-Software has developed a Windows- and Mac-based shareware product which provides excellent capabilities for post-flight data analysis.

3 RELATED DOCUMENTATION

All necessary technical information is contained within this document, including diagrams and source code guidance.

4 LEGAL INFORMATION

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7. Severability. If any provision of this Agreement is illegal or unenforceable under applicable law, the remainder of the provision will be amended to achieve as closely as possible the effect of the original term and all other provisions of this Agreement will continue in full force and effect.

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9. Waiver. No failure to exercise, and no delay in exercising, on the part of either party, any right or any power hereunder shall operate as a waiver thereof, nor shall any single or partial exercise of any right or power hereunder preclude further exercise of that or any other right hereunder. In the event of a conflict between this Agreement and any applicable purchase or other terms, the terms of this Agreement shall govern.

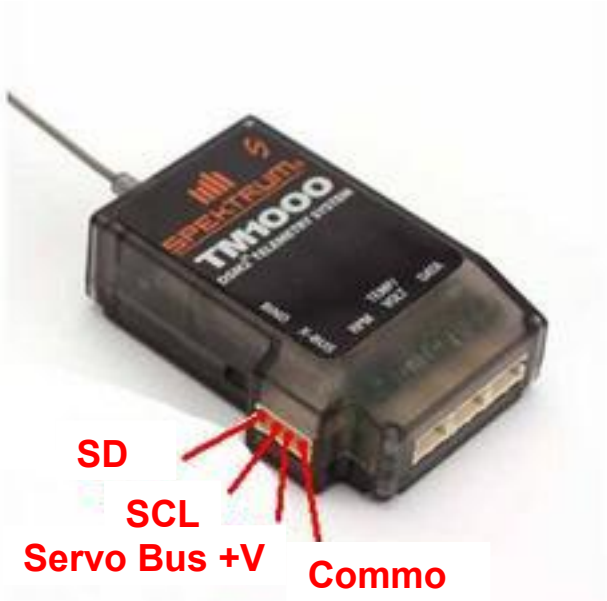
All correspondence regarding this document shall be through the Horizon Hobby legal department:

Horizon Hobby, LLC
Legal Department
4105 Fieldstone Road
Champaign, IL 61822 USA

5 ELECTRICAL DATA

All sensors are powered by the X-Bus. The X-Bus port bus provides the servo bus voltage (3.5 to 9.6V) at a current limited by the JST contact rating (1A). The operational limit in an application may be quite a bit lower, depending upon the method of powering the servo bus.

The X-Bus uses I2C to communicate. Termination resistors are in the TM1000. The pins are defined according to this picture:



Every device shall be responsible to regulate the supply to a level useful for its operation. The I2C signals must be 3.3V logic, and the pins in open drain mode so as to not interfere with the logic levels.

In order to maintain compatibility with other products, it is strongly urged that any sensors include two X-Bus ports to allow them to be daisy-chained in the same manner as Spektrum sensors.

The connector used in the TM1000 and all Spektrum sensors is JST part number S4B-ZR(LF)(SN) or Digikey part 455-1671-ND.

6 HARDWARE-LEVEL PROTOCOL

The TM1000 is an I2C master device talking at 100kHz to the slaves. For best future compatibility, devices should support 400kHz as well.

Every device shall reply to a poll with a 16-byte message, the first byte of which is always the polled I2C address. The remaining bytes are defined in the section on the telemetry header file.

Shortly after the TM1000 starts, it polls all addresses on the bus. During this enumeration phase, the attached devices must reply with their address as the first byte of the reply. The remainder of the first message will be discarded by the TM1000, but the full 16-byte message must be available for the TM1000 to clock in. If a device does not answer the enumeration correctly, the TM1000 will not poll it any more. It is therefore of utmost importance that the first I2C message be answered correctly. The TM1000 allows clock stretching per the I2C specification, which allows slow-to-start devices to enumerate properly in the system. If your device will be slow to start, it is recommended that you first select a higher address, and second that you use the stretched clock.

The TM1000 transmits data to the ground at a rate of one message per 22ms. The time between polls for any single device is dependent upon the number of sensors which enumerated on the bus. Note that the TM1000 reserves two addresses for its internal use, so the maximum rate at which a device is polled will be no less than 44ms. If timing is a critical function for a particular device, it is necessary that the device provide its own clock source and not utilize the X-Bus for timing.

7 ADDRESSING & DEVICE TYPES

The Appendix includes the telemetry header file used by all Spektrum AirWare-based transmitters. It defines the device type codes for all Spektrum products and known reserved values. The device type codes are used as I2C bus addresses by default, but the protocol also provides a means for them to differ.

Spektrum reserves the right to use addresses not listed as we deem necessary. We do not intend to interfere with other products, and therefore urge anybody making a device to provide a mechanism to select different addresses should the need arise. Commercial vendors are urged to contact Spektrum in order to coordinate addresses and prevent interference.

Note that Spektrum is the owner of all address assignments, and does not guarantee that any unused address will be available in the future. Only addresses specifically assigned are guaranteed not to change. Addresses 0x09 and below shall not be used by any third-party devices.

For each of the messages in the header file it should be noted that they begin with the fields *identifier* and *sID*. The *identifier* field is always under all circumstances an exact match to the I2C address, and needs to be the first byte of any reply as noted in the hardware-level section. The second byte, *sID*, serves as a way to allow either multiple devices of the same type to live on the bus, or for a device to retain its type code when there is a conflict of the addresses. At this time, none of the AirWare radios properly display data from multiple instances of the same device type.

Use of the sID field is quite simple:

When sID is zero, then the device type (TELE_DEVICE_xxx) is the same as the bus address *identifier*. This is the norm for all Spektrum products. If *sID* is non-zero, then *sID* is the device type and *identifier* serves only to provide a unique I2C address.

8 DATA FORMATS

All third-party sensors shall report their data in big-endian format (MSB at lower address) if they are to be displayed on the transmitter screens. All data shall binary 8, 16 or 32 bits. Spektrum uses BCD for JetCat and GPS but does not support these formats for third-party products.

The TM1100 module notifies the transmitter that it is in use by setting the high bit of the *identifier* field. This is informational-only to the transmitter and does not affect operation.

The DSMX Ultra Micro receivers provide Flight Log data only, using the standard QoS record structure. The receiver voltage field is fixed at 0xFFFF, indicating “no data” to the transmitter.

The transmitter uses two sentinel values to indicate that there is “no data” for a field. For an unsigned value, a value with all bits set to one (ie, 0xFFFF or 0xFFFFFFFF) indicates this. For a signed value the “no data” value is denoted by all bits set except the sign bit, i.e. 0x7FFF or 0x7FFFFFFF.

These values and standards are also utilized by post-flight systems to properly display logged data.

9 ELECTRONIC SPEED CONTROL

The AirWare-based transmitters include support for a generic Electronic Speed Control (ESC) device. Spektrum does not sell a device which conforms to this telemetry standard, but is instead providing a common interface which may be supported by ESC manufacturers.

The ESC configuration screen provides the same functions available to other devices, that is, whether the status is actively monitored on the display. Alarms are available for the following conditions:

- Input Voltage too low
- Motor current too high
- FET temperature too high

The units and ranges for each of the fields in the telemetry message are found in the appendix in the definition for the ESC structure. The transmitter does not provide any filtering of data for any ESC fields.

10 FUEL FLOW METER

The AirWare-based transmitters may include support for a generic fuel flow and capacity metering device. Spektrum does not sell a device which conforms to this telemetry standard, but is instead providing a common interface which may be supported by third-party manufacturers.

The "Fuel" configuration screen provides the same functions available to other devices, that is, whether the status is actively monitored on the display. Alarms may be available for some of the following conditions:

- Tank 1 capacity consumed > user-defined value
- Tank 2 capacity consumed > user-defined value
- Fuel flow 1 too low
- Fuel flow 1 too high
- Fuel flow 2 too low
- Fuel flow 2 too high
- Temperature 1 too low
- Temperature 1 too high
- Temperature 2 too low
- Temperature 2 too high

The units and ranges for each of the fields in the telemetry message are found in the appendix in the definition for the FUEL structure. The transmitter does not provide any filtering of data for any fields.

11 HIGH-CURRENT BATTERY CAPACITY

The AirWare-based transmitters include support for a generic battery current and capacity metering device. Spektrum SPMA9605 provides this function, alarming and reporting only the first set of message data (address 0x34) at this time. SPMA9604 provides similar capabilities for low-current applications using address 0x18. PowerSafe receivers use both channels of reporting in the low-current

record (0x18 type) for each input power source.

The units and ranges for each of the fields in the telemetry message are found in the appendix in the definition for the MAH structures. The transmitter does not provide any filtering of data for any fields.

12 DIGITAL INPUT AND AIR PRESSURE SENSOR

The AirWare-based transmitters may include support for a generic digital input and air pressure metering device. Spektrum does not sell a device which conforms to this telemetry standard, but is instead providing a common interface which may be supported by third-party manufacturers.

The "Air" configuration screen provides the same functions available to other devices, that is, whether the status is actively monitored on the display. Alarms may be available for the following conditions:

- Digital Bit set (bits 0-16)
- Digital Bit clear (bits 0-16)
- Pressure too low
- Pressure too high

The units and ranges for each of the fields in the telemetry message are found in the appendix in the definition for the DIGITAL_AIR structure. The transmitter does not provide any filtering of data for any fields.

13 THRUST/STRAIN GAUGE

The AirWare-based transmitters may include support for a generic thrust or strain metering device. Spektrum does not sell a device which conforms to this telemetry standard, but is instead providing a common interface which may be supported by third-party manufacturers.

The "Strain" configuration screen provides the same functions available to other devices, that is, whether the status is actively monitored on the display. Alarms may be available for the following conditions:

- Single Strain too high (any input above threshold)
- Sum Strain too high (sum of active strains above threshold)
- Strain Imbalance (delta of min/max strains on active inputs is above threshold)

The units and ranges for each of the fields in the telemetry message are found in the appendix in the definition for the STRAIN structure. The transmitter does not provide any filtering of data for any fields.

14 INDIVIDUAL CELL MONITOR

The AirWare-based transmitters include support for generic multi-tap voltage monitoring devices in both 6S and 14S combinations. Spektrum does not sell a device which conforms to this telemetry standard, but is instead providing a common interface which may be supported by third-party manufacturers.

NOTE: The Common (Ve-) connection of the X-Bus is connected to the receiver, which in an electric model is likely connected directly to the negative terminal in the battery string. It is strongly recommended that the voltage measurements be galvanically isolated from the battery pack being measured so as to prevent short circuits and ground loops. This isolation also permits battery packs of more than 6 cells to be monitored accurately and without concern for wiring problems.

It is recommended that the user familiarize himself with the balance and voltage limit reporting functions within the two cell monitor support screens.

The units and ranges for each of the fields in the telemetry message are found in the appendix in the definition for the LIPOMON structure. The transmitter does not provide any filtering of data for any fields.

15 ATTITUDE & MAGNETIC COMPASS

The AirWare-based transmitters may include a facility to display data from an attitude and magnetic compass. This is currently envisioned as an information-only device which may be of use in certain applications but unable to generate alarms. Data which is unavailable due to limitations of the sensor hardware shall report a value of 0x7FFF to indicate "No data available."

16 3-AXIS GYRO

The AirWare-based transmitters include a facility to display data from a 3-axis gyro system. This currently is envisioned as an information-only device which may be of use in certain applications, but unable to generate alarms. Data which is unavailable due to limitations of the sensor hardware shall report a value of 0x7FFF to indicate "No data available."

17 USER-DEFINED DEVICES IN THE TX

The AirWare-based transmitters include a facility to display data from user-defined sensors according to four "user" structures defined in the Appendix. The four structures are associated with four different *identifier* field values.

Transmitters may have generic screens to show the data for each structure type. The transmitters would allow the user to specify a short title for the screen, but not for individual fields, nor would it allow specification of units. Display of individual fields may be only turned on or off using the configuration screen. It is up to the user to know the representation of each field shown on the transmitter for these custom devices.

These devices do not have any alarm capability.

The transmitter does not provide any filtering of data for any fields.

18 USER TEXT DEVICE

The AirWare-based transmitters include a facility to display text data directly on the screen in a

formatted manner. This message would typically be used in conjunction with a serial interface telemetry module such as the SPM4649T attached to a flight controller (FC) for purposes of configuring the FC using transmitter stick inputs (aka “Stick Programming”).

APPENDIX – HEADER FILE DATA

Note that some device types cannot be used by third-party devices, in particular voltage (0x01) and temperature (0x02), as these are reserved for internal use within the transmitter. The text below has been re-formatted for tabs that look good on the page. If you copy/paste them into your code, you will probably want to re-tab them.

Header file has been made into a separate file which can be found here.
https://github.com/SpektrumFPV/SpektrumDocumentation/blob/master/Telemetry/spektrumTelemetrySensors.h

REVISION HISTORY

Rev	Date	Author	Description
P0	2013-03-28	AK	For initial review.
P1	2013-04-04	AK	Fix address in JetCat_2 struct definition.
P2	2013-07-08	AK	Add RF data type/struct (Bug MD 1000).
P3	2013-07-10	AK	Add Gyro and Attitude/Compass info.
P4	2013-07-16	AK	Add 0x43 as reserved address. Correct text on TM1000.
P5	2013-11-19	AK	Change Dual Energy and MAH structs. Reserved addresses 0x30 and 0x32 for internal sensors, reassigned devices to 0x20 and 0x22.
P6	2014-03-31	AK	Correct ESC struct .currentBEC units to 100mA
P7	2014-05-05	AK	Revise ESC struct for powerOut and No Data sentinels
A	2015-01-16	AK	Release to the public.
B	2015-01-23	AK	Update temp resolution for ESC.
B’	2015-11-24	TB	Legal Information added for public release
C	2015-12-28	AK	Annotate Turbine fields as BCD per code.
D	2015-12-30	AK	Expand/Correct Turbine Status code values for more ECUs.
E	2016-02-16	AK	Integrate B’ into published document.
F	2016-03-06	AK	Correct Pbox ID in struct area, add Alpha6, add reference to SPMA9604/5.
G	2016-03-26	AK	Revise 6S, Add 14S LiPo Monitors
H	2016-07-28	AK	Add Lap Timer, Text Generator
I	2016-08-26	AK	Add dBm fields to RPM record
J	2016-08-30	AK	Update Lap Timer
K	2016-10-28	AK	Add RTC report device
L	2016-11-03	AK	Add Text description, update status of some sensors per Tx.
M	2016-12-16	MFA	Removed header file. Now a separate referenced file.