

GHST Rx Public Protocol

Description

Document Cleared for Public Release

Anthony Cake, ImmersionRC Limited



Overview

This document describes the protocol used to interface a Ghost Receiver to a Flight Controller. It is similar to, but not identical to, the GHST protocol used to interface a Ghost Transmitter to a R/C Controller..

History

9-Mar-2021	Add GPS Packets
27-Jun-2021	Add RF Protocol Enum
06-Dec-2021	Add pure 12-bit path from R/C Tx to FC
02-Jan-2022	Add MSP packets for Betaflight interface
20-Sep-2022	Fix primary/secondary packet IDs, heading units, speed units

Protocol

Ghost Rx to Flight Controller

Parameter	Value	Description
GHST_RX_BAUDRATE	420000 (baud)	Baud rate used for control and telemetry data
GHST_RX_UART_WORDLENGTH	8 (bits)	8 bit UART word length
GHST_RX_UART_STOPBITS	1 (bit)	1 stop bit
GHST_RX_UART_PARITY	None	No Parity

The connection between the Flight Controller, and the Ghost Receiver, is via a single wire (half duplex), connected to the 'Tx' pin (similar to SRXL-2, and F.PORT).

Timing

Telemetry packets should be sent by the FC approx. 1ms after the reception of a valid control packet, making sure that the telemetry packet doesn't collide with the next incoming control packet. Assume that the max. Packet rate for GHST control packets will be 2ms (to allow running at 500Hz)

Endianness

All multi-byte values in the Rx-side implementation of the GHST protocol are sent little endian (low byte first).



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Addresses

The following three destination addresses are used by the Ghost Rx protocol currently.

addr	Value	Description
GHST_ADDR_FC	0x82	Flight Controller address (for control packets Rx -> FC)
GHST_ADDR_GOGGLES	0x83	Goggle address
GHST_ADDR_RX	0x89	Rx address (for telemetry packets FC->Rx)

CRC

All Ghost packets include an 8 bit CRC, computed using the The CRC-DVB S2 algorithm.

CRC data does not include addr, and len fields. It starts at index [2], type.

Control Data

Sevo data is sent as 12 bit data, with a center value of 0x7C0

Control Packet IDs

These packets are sent from the Ghost Rx to the FC. Sequencing is defined by the Ghost Rx depending upon current priorities.

type	Value	Description
GHST_UL_RC_CHANS_HS4_5TO8	0x10	Control packet with 4 primary channels + CH5-8
GHST_UL_RC_CHANS_HS4_9TO12	0x11	Control packet with 4 primary channels + CH9-12
GHST_UL_RC_CHANS_HS4_13TO16	0x12	Control packet with 4 primary channels + CH13-16
GHST_UL_RC_CHANS_RSSI	0x13	Control packet with RSSI and LQ data
GHST_UL_RC_VTX_CTRL	0x14	Goggle/FC channel changing
GHST_UL_RC_CHANS_HS4_12_5TO8	0x30	Control packet with 4 primary channels + CH5-8
GHST_UL_RC_CHANS_HS4_12_9TO12	0x31	Control packet with 4 primary channels + CH9-12
GHST_UL_RC_CHANS_HS4_12_13TO16	0x32	Control packet with 4 primary channels + CH13-16
GHST_UL_RC_CHANS_RSSI	0x33	Control packet with RSSI and LQ data
GHST_UL_VTX_SETUP	0x20	vTx Setup w/o 4 primary channels (GECO Only)
GHST_UL_MSP_REQ	0x21	MSP frame, Request
GHST_UL_MSP_WRITE	0x22	MSP frame, Write

Note that all IDs in the range **0x10** thru **0x1f** should be assumed to contain the 4 primary channels, even if the ID itself is not yet documented. This will allow additional control packets to be added in the future without causing unrecognized packets in the FC driver.

From v1.0.5.2, where a 12-bit data path from R/C Tx to FC is supported, additional packets in the range **0x30** thru **0x3f** are supported, and are just 12 bit raw versions of the original packets (or 8-bit raw versions for the upper channels).



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Control Packet (Servo Data -> FC)

Control packets are as short as possible, for minimum latency. The first 4 primary flight channels are sent in every packet, at full frame rate, with data for channels 4..12/16 being sent at a slower rate.

Index	Len	Name	Description	Value
0	u8	addr	GHST_ADDR_FC	0x82
1	u8	len	Length including type, and crc	0x0c
2	u8	type	RC_CHANS_HS4_5TO8	0x10 (or 0x30 for 12-bit mode)
3	u12	ch1	Control data, CH1 (high resolution, high rate)	
	u12	ch2	Control data, CH2 (high resolution, high rate)	
6	u12	ch3	Control data, CH3 (high resolution, high rate)	
	u12	ch4	Control data, CH4 (high resolution, high rate)	
9	u8	chaa	Control data, CH5, CH9, or CH13, depending upon ID	
10	u8	chbb	Control data, CH6, CH10, or CH14, depending upon ID	
11	u8	chcc	Control data, CH7, CH11, or CH15, depending upon ID	
12	u8	chdd	Control data, CH8, CH12, or CH16, depending upon ID	
13	u8	crc	CRC-DVB S2 CRC algorithm	
total	112		Total: 14 bytes	

GHST_UL_RC_CHANS_HS4_RSSI

RSSI packets contain the first 4 primary flight channels, at full rate, along with RSSI/Mode/LQ data.

Index	Len	Name	Description	Value
0	u8	addr	GHST_ADDR_FC	0x82
1	u8	len	Length including type, and crc	0x0c
2	u8	type	GHST_UL_RC_CHANS_HS4_RSSI	0x13 (or 0x33 for 12-bit mode)
3	u12	ch1	Control data, CH1 (high resolution, high rate)	
	u12	ch2	Control data, CH2 (high resolution, high rate)	
6	u12	ch3	Control data, CH3 (high resolution, high rate)	
	u12	ch4	Control data, CH4 (high resolution, high rate)	
9	u8	lq	Lq in range 0-100	
10	u8	rssi	Rssi in range 0..-128dBm, sign inverted	
11	u8	protocol	RF Protocol (Normal, Race, etc.)	
12	s8	txPwr	Tx Power (Ghost, not Tramp) in dBm	
13	u8	crc	CRC-DVB S2 CRC algorithm	
total	112		Total: 14 bytes	



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Protocol							
7	6	5	4	3	2	1	0
Future Use	AltScale	Telem	Prot4	Prot3	Prot2	Prot1	Prot0

AltScale: 0 = Classic Scaling, 1 New Scaling

Telem 0 = No Telemetry, 1 = Telemetry Required

Prot RF Protocol, 0-31

Protocol Enums

protocol	Description	Bidirectional?	Frame Rate
5	Normal	Yes	55Hz
6	Race	Yes	160Hz
7	PureRace	No	250Hz
8	Long Range	Yes	19Hz
10	Race250	Yes	250Hz
11	Race500	No	500Hz
12	Solid150	No	150Hz
13	Solid250	No	250Hz

vTx Control Packet (Ghost Rx -> Goggles)

Special packet sent from the Ghost Rx (bound with a RxId of Goggle1) to the goggles via the GECO interface.

Index	Len	Name	Description	Value
0	u8	addr	GHST_ADDR_MODULE	0x80
1	u8	len	Length including type, and crc	0x0c
2	u8	type	GHST_UL_VTX_SETUP	0x20
3	u8	vtxFlags	vTx Flags	
4	u16	vtxFreq	vTx Frequency (in MHz)	
6	u16	vtxPwr	vTx Power (in mW), with 0 = vTx Off	
8	u8	vtxBandChan	vTx Band and Channel (4 bits of each)	
9	u8	tbd1	Not yet used	
10	u8	tbd2	Not yet used	
11	u8	tbd3	Not yet used	
12	u8	tbd4	Not yet used	
13	u8	crc	CRC-DVB S2 CRC algorithm	
total	96		Total: 12 bytes	



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Telemetry Packets (FC -> Rx)

Packet IDs

Parameter	Value	Description
GHST_DL_PACK_STAT	0x23	Battery Status
GHST_DL_GPS_PRIMARY	0x25	Primary GPS Data
GHST_DL_GPS_SECONDARY	0x26	Secondary GPS Data
GHST_DL_MAGBARO	0x27	Magnetometer, Barometer (and Vario) Data
GHST_DL_MSP_RESP	0x28	MSP Response

Telemetry packets are fixed length (14 bytes) and contain packet type-specific data.
For example, type 0x23 contains battery pack voltage/current/mAh data.

Index	Len	Name	Description	Value
0	u8	addr	GHST_ADDR_RX	0x89
1	u8	len	Length including type, and crc	0x0c
2	u8	type	RC_CHANS_HS4_5TO8	0x23
3	u8 x 10		Packet-specific data	
13	u8	crc	CRC-DVB S2 CRC algorithm	
total	112		Total: 14 bytes	

Flight Pack Data : GHST_DL_PACK_STAT

Flight Pack data includes flight pack voltage/current/mAh data.

Note that Rx voltage is present in this packet, but it is inserted by the Rx before sending up to the Ghost Tx. No need for the FC to insert it.

Idx	Len	Name	Description	Step	Range	Value
0	u8	addr	GHST_ADDR_RX			0x89
1	u8	len				0x0c
2	u8	type	GHST_DL_PACK_STAT			0x23
3	u16	packVolts	Pack Voltage	10mV	0-655.35V	
5	u16	packAmps	Instantaneous Current	10mA	0-655.35A	
7	u16	packmAh	Consumed mAh	10mAh	0-655.35Ah	
9	u8	rxVolts	Rx Voltage	100mV	0-25.5V	
10	u8					
11	u8					
12	u8					
13	u8	crc				
	112		Total: 14			



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GPS Data : GHST_DL_GPS_PRIMARY

GPS Primary data includes the 3D position, Latitude, Longitude, Altitude.

NOTE: Only send this packet type from the FC if GPS data is currently being acquired.

Index	Len	Name	Description	Step	Range	Value
0	u8	addr	GHST_ADDR_RX			0x89
1	u8	len	Length including type, and crc			0x0c
2	u8	type	GHST_DL_GPS_PRIMARY			0x25
3	u32	gpsLat	GPS Latitude	1e-7 degrees	-90 -> +90 degrees	
7	u32	gpsLong	GPS Longitude	1e-7 degrees	-180 -> +180 degrees	
11	s16	gpsAlt	GPS Altitude	1 meter	-32,768 to 32,767	
13	u8	crc	CRC-DVB S2 CRC algorithm			
total	112		Total: 14 bytes			

GPS Data : GHST_DL_GPS_SECONDARY

GPS Secondary data includes auxiliary GPS position data.

NOTE: Only send this packet type from the FC if GPS data is currently being acquired.

Index	Len	Name	Description	Step	Range	Value
0	u8	addr	GHST_ADDR_RX			0x89
1	u8	len	Length including type, and crc			0x0c
2	u8	type	GHST_DL_GPS_SECONDARY			0x26
3	u16	gpsGroundSpeed	Ground Speed	1 cm/s		
5	u16	gpsGroundCourse	Ground Course (heading)	0.1 degree	0-3600 deci-degrees	
7	u8	gpsNumSats	Number of satellites	0..n		
8	u16	gpsHomeDist	Distance to home, units of 10m	10m	0-655,350m	
10	u16	gpsHomeDir	Direction to home, units of deci-degrees	0.1 degree	0-3600 deci-degrees	
12	u8	gpsFlags			GPS_FLAGS_FIX 0x01 GPS_FLAGS_FIX_HOME 0x02	
13	u8	crc	CRC-DVB S2 CRC algorithm			
total	112		Total: 14 bytes			



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Misc Data : GHST_DL_MAGBARO

This packet includes magnetometer, barometer, and vario data.

Index	Len	Name	Description	Step	Range	Value
0	u8	addr	GHST_ADDR_RX			0x89
1	u8	len	Length including type, and crc			0x0c
2	u8	type	GHST_DL_MAGBARO			0x27
3	u16	magHeading	Magnetometer Heading	0.1 degree	-1800 to 1800	
5	s16	baroAltitude	Barometric Altitude	1 meter	-32000 to 32000	
7	s16	vario	Variometer	cm/s	-32767 to 32767	
9		TBD				
10		TBD				
11		TBD				
12	u8	miscFlags			MISC_FLAGS_MAGHEAD 0x01 MISC_FLAGS_BAROALT 0x02 MISC_FLAGS_VARIO 0x04	
13	u8	crc	CRC-DVB S2 CRC algorithm			
total	112		Total: 14 bytes			

Misc Data : GHST_DL_MSP_RESP

MSP Response

Index	Len	Name	Description	Step	Range	Value
0	u8	addr	GHST_ADDR_RX			0x89
1	u8	len	Length including type, and crc			0x0c
2	u8	type	GHST_DL_MSP_RESP			0x28
3	u8	msp0	MSP Payload, 6 bytes			
4	u8	msp1				
5	u8	msp2				
6	u8	msp3				
7	u8	msp4				
8	u8	msp5				
9	u8	tbd0	Not yet used (not sent OTA)			
10	u8	tbd1				
11	u8	tbd2				
12	u8	tbd3				
13	u8	crc	CRC-DVB S2 CRC algorithm			
total	112		Total: 14 bytes			

