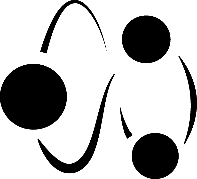
**SMARTBALL v1.x/v2**

Datagram specifications v0.4

last update – 16/10/2022

# INTRODUCTION

Smartballs send and receive specific UDP Datagrams, this choice has been made over OSC, Artnet or other kind of existing protocol to save bandwidth as much as possible. This protocol is still in active development and will likely to evolve during the alpha and beta test phase.

This document is compatible with the following release:

* hardware v1.x  : <https://github.com/siteswapjuggler/smartball-hardware/tree/v1.2>
* firmware dev branch : <https://github.com/siteswapjuggler/smartball-firmware/tree/dev>
* externals v0.3 beta 1 : <https://github.com/siteswapjuggler/smartball-externals/tree/v0.3-beta.1> (apart GSC)

# VERSION NOTE

Structure change:

* Packet format updated to take advantage of UDP packet informations

Command updates:

* Stream now has a flag to describe the data content of the stream
* IMU flag has new bits for Fusion algorithm feedback

New commands:

* Set config settings
* Save config settings

Removed commands:

* DeepSleep

SUMMARY

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# DATAGRAM STRUCTURE

## UPSTREAM PACKETS

Upstream datagram are made as described below:

* Command 1 byte
* Data (optional)

### CMD – Command

Commands byte is unique to every message.

### DATA (optional)

Data depends on each command and is optional. See command description below for further information.

## DOWNSTREAM PACKETS

Downstream datagram are made as described below:

* Id number 2 bytes
* Serial number 2 bytes
* Command 1 byte
* Data depending on length

### ID – ID Number

Two bytes uint16 serial number.

### SN – Serial Number

Two bytes uint16 serial number.

### CMD – Command

Commands byte is unique to every message.

### DATA (optional)

Data depends on each command and is optional. See command description below for further information.

# UPSTREAM COMMANDS

## PING

Ping command trigger a pong answer.

|  |
| --- |
| CMD |
| 0x01 |

## REBOOT

Reboot command trigger the reboot of the ball (*does not work on first boot after firmware update*).

|  |
| --- |
| CMD |
| 0x02 |

## FACTORY SETTINGS

Factory settings command sets new factory settings value. Factory settings includes a serial number, a device flag and an adc scaling factor.

|  |  |
| --- | --- |
| CMD | DATA |
| 0x10 | 5 bytes |

Data structure:

* serial number: uint16 value from 0 to 65535
* device flag: 16 bits flag describing available devices
* adc scaling factor: unsigned Q15.1 value from 0.0 to 6553.5

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SN\_MSB | SN\_LSB | FLAG\_MSB | FLAG\_LSB | SCL\_MSB | SCL\_LSB |

DEVICE FLAG structure:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| - | - | - | - | - | - | - | - | - | - | - | BUZ | MOT | IRL | IMU | RGB |

## SAVE FACTORY SETTINGS

Save factory command trigger EEPROM writing of the factory settings.

|  |
| --- |
| CMD |
| 0x11 |

## GENERAL SETTINGS

General settings command sets new general settings value. General settings includes the id number.

|  |  |
| --- | --- |
| CMD | DATA |
| 0x12 | 1 bytes |

Data structure:

* id number: uint8 value from 0 to 255

|  |
| --- |
| ID |

## SAVE GENERAL SETTINGS

Save general settings command trigger EEPROM writing of the general settings.

|  |
| --- |
| CMD |
| 0x13 |

## COLOUR (FOREGROUND)

Colour command change current colours according to the number of RGB values sent. To be clearer data length will implicitly tell the ball which colour mode to apply, see options below:

* 3 values: 1 colour mode
* 6 values: 2 colours mode (1 per hemisphere)
* 9 values: 3 colours mode (3 pairs of opposite leds)
* 18 values: 6 colours mode (6 individual leds)

|  |  |
| --- | --- |
| CMD | DATA |
| 0x20 | variable |

Data structure:

* Colour 1 Red value : uint8 value from 0 to 255
* Colour 1 Green value : uint8 value from 0 to 255
* Colour 1 Blue value : uint8 value from 0 to 255
* (optional) colour 2/3/4/5/6 RGB values

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| R1 | G1 | B1 | (R2) | (G2) | (B2) | and so on… |

## COLOUR (BACKGROUND)

Background colour command change the current background colours according to the number of RGB values sent. Background colour is the second colour of the stroboscopic effect. Data structures and options are the as the foreground colour command.

|  |  |
| --- | --- |
| CMD | DATA |
| 0x22 | variable |

## STREAM

Stream command act almost the same way as colour command apart that you can address multiple balls at one time. Doing this you need to add one extra data byte to precise the number of colours sent for each ball. Balls will change colours according to its id numbers modulo the number of channels sent in the stream.

|  |  |
| --- | --- |
| CMD | DATA |
| 0x21 | variable |

Data structure:

* Flag : describe the data sent in the stream
* Offset : id offset of the stream
* Series of data 1
* (optional) Series of data 2, etc…

STREAM FLAG structure:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| LOOP | - | - | - | - | GSC | MOT | IRL | STB | MST | N\_COL2 | | | N\_COL1 | | |

Data structure EXAMPLE:

Even serial number balls goes red & blue while odd serial number balls goes black & white:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| FLAG | OFFSET | RGB1.1 | RGB1.2 | RGB2.1 | RGB 2.2 |
| 0x00 0x02 | 0x00 | 0xFF 0x00 0x00 | 0x00 0x00 0xFF | 0xFF 0xFF 0xFF | 0x00 0x00 0x00 |

This command has been design for the first 30 balls during the alpha tests. Future firmware will use customisable id values instead of serial numbers.

## IMU SETTINGS

IMU settings command will change current IMU feedback settings.

|  |  |
| --- | --- |
| CMD | FLAG |
| 0x30 | variable |

Data structure:

* IMU flag: 8 bits flag describing available feedbacks.

DEVICE FLAG structure:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| STA | WLD | QUA | VEC | TMP | MAG | GYR | ACC |

## ACCELEROMETER RANGE

Accelerometer range command will change current accelerometer full-scale range settings.

|  |  |
| --- | --- |
| CMD | PAR |
| 0x32 | variable |

Data structure:

* Full-scale parameter: 8 bits parameter.

PARAMETER VALUEs:

* 0x00: -2g / +2g.
* 0x01: -4g / +4g.
* 0x02: -8g / +8g.
* 0x03: -16g / +16g (default).

## GYROSCOPE RANGE

Gyroscope range command will change current gyroscope full-scale range settings.

|  |  |
| --- | --- |
| CMD | PAR |
| 0x33 | variable |

Data structure:

* Full-scale parameter: 8 bits parameter.

PARAMETER VALUEs:

* 0x00: -250dps / +250dps.
* 0x01: -500dps / +500dps.
* 0x02: -1000dps / +1000dps.
* 0x03: -2000dps / +2000dps (default).

## SAVE IMU SETTINGS

Save IMU command trigger EEPROM writing of the IMU settings.

|  |
| --- |
| CMD |
| 0x031 |

## INFRARED

Infrared command change the current value of the infrared channel PWM.

|  |  |
| --- | --- |
| CMD | DATA |
| 0x40 | 2 bytes |

Data structure:

* value : uint16 value from 0 to 1023

|  |  |
| --- | --- |
| VAL\_MSB | VAL\_LSB |

## MOTOR

Motor command change the current value of the motor channel PWM.

|  |  |
| --- | --- |
| CMD | DATA |
| 0x50 | 2 bytes |

Data structure:

* value : uint16 value from 0 to 1023

|  |  |
| --- | --- |
| MSB | LSB |

## STROBE

Strobe command change the current interval of the inner stroboscopic effect. Using this effect switch between foreground and background colour every *n* milliseconds. Values are stored as 10 µs per less significant bit.

|  |  |
| --- | --- |
| CMD | DATA |
| 0x60 | 2 bytes |

Data structure:

* interval (ms) : value from 0. to 500.

## MASTER

Master command is a global dimmer for every colour channel. The dimmer value does not affect the colours memory it only change the amount of colours forwarded to the RGB Leds. Values are stored as 1/100th unit per less significant bit.

|  |  |
| --- | --- |
| CMD | DATA |
| 0x70 | 2 bytes |

Data structure:

* dimmer: value from 0. to 100.

# DOWNSTREAM COMMANDS

## PONG

Pong is answering the ping command.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ID | | SN | | CMD |
| MSB | LSB | MSB | LSB | 0x01 |

## BATTERY VALUE

Battery feedback transmit Vshare voltage value stored as 1/100th Volts per LSB.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ID | | SN | | CMD | DATA |
| MSB | LSB | MSB | LSB | 0x00 | 2 bytes |

Data structure:

* value: value from 0 to 5.2V, this value is adjusted by the adc scaling factory setting.

|  |  |
| --- | --- |
| VAL\_MSB | VAL\_LSB |

## IMU VALUES

IMU feedback transmit IMU values according to the current IMU flag.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ID | | SN | | CMD | DATA |
| MSB | LSB | MSB | LSB | 0x30 | variable |

Data structure:

* IMU flag: 8 bits flag describing available feedbacks (see IMU settings for description)
* (optional) accelerometer: 6 bytes containing the XYZ values of the accelerometer 1/100th m.s-2
* (optional) gyroscope: 6 bytes containing the XYZ 1/100 values of the gyroscope 1/100th d.s-1
* (optional) magnetometer: 6 bytes containing the XYZ values of the magnetometer 1/100th.µT
* (optional) temperature: temperature value 1/100th °C
* (optional) magnitude: 6 bytes containing values of the acc, gyr & mag magnitude 1/100th
* (optional) quaternion: 8 bytes containing the WXYZ values of the quaternion 1/10000th
* (optional) world: 6 bytes containing the XYZ values of the real world acceleration 1/100th m.s-2
* (optional) special states: 1 byte flag for filter state detection (work in progress)

Data structure EXAMPLE:

Optional data stacks after directly after the flag depending on enable bits order.

|  |  |  |
| --- | --- | --- |
| FLAG | GYR\_XYZ | TEMP |
| 0x0A | 6 bytes | 2 bytes |

|  |  |
| --- | --- |
| document version | |
| v1.0 | Initial release |
| v1.1 | Loop bit correction in stream flag |
| v1.2 | IMU Flag correction in IMU Settings, fixed point value correction, summary correction |
| v1.3 | GSC bit in the stream flag |