DATA INTERFACE CONTROL DOCUMENT

TWINKLE STAR TRACKER

Release information

	Name	Function	Signature	Date
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Version Control

Version	Author	Date	Change Log	Sections
1.0	T. Delabie	07/09/2021	Initial version	All

Applicable Documents

ID	Document Title	Document Reference	Version
AD01			

Reference Documents

ID	Document Title	Document Reference	Version
RD01	Twinkle Star Tracker User Manual	TWK_ARC_ENG_0002	1.0

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1 Introduction

This document describes the data interfaces of the Twinkle star tracker. The Twinkle star tracker is a high accuracy, extremely compact star tracker that fits within CubeSat dimensions, but is also suitable for larger satellites. It delivers arc second range pointing knowledge with a minimal strain on the power, volume and mass budget.

2 Data interfaces

The different layers of the data interface are described below.

2.1 Physical layer

The star tracker uses an RS485 interface. A 120 ohm termination resistor is installed on the star tracker. This can be adapted on request.

The communication parameters are:

Bit rate	115200 bps
Stop bits	1
Word length	8 bits

The bit rate can be increased up to 2Mbit/s. This can speed up the download of partial images. The bit rate is configured during manufacturing. To discuss other communication parameters, please contact us.

The RS485 interface uses a separate up and downlink pair.

RS485-A	RX: positive
RS485-B	RX: inverted
RS485-Y	TX: positive
RS485-Z	TX: inverted

We recommend to not share the RS485 bus with other devices.

2.2 CSP protocol

The star tracker uses the CSP Kiss protocol to communicate with the satellite bus.

CSP address	5

The CSP address can be changed during manufacturing.

The star tracker implements the standard CSP ping and CSP functionality. Other functionality such as memory and process information is not available.

The star tracker communication protocol is implemented with the following parameters.

CSP port	20
Maximum frame size	1200 bytes
Transport Layer	UDP

2.3 Application Layer

This section describes what goes in the variable length body of the UDP CSP frame.

There are three categories:

1. Parameters: This is usually a setting that you want to load each time you start the star tracker. An example is the exposure time of the star tracker. You can consider this a type of configuration of the star tracker. Parameters only go one way from the platform to the star tracker. The star tracker only confirms if it could accept the parameter or not.
2. Actions: These perform an action on the star tracker. To change the time on the star tracker or download a part of the image for example, you need to execute an action. An action can send values from the star tracker to the OBC. For each action, the star tracker returns an action reply. An action reply can also include several values.
3. Telemetry: Several types of telemetry are generated on the star tracker. The one that will be used most in nominal operations is probably the star tracker solution, but also other housekeeping data (like temperatures) can be requested. A telemetry value is always time stamped at the time it was generated.

By default, the star tracker works in a synchronous mode. For each frame that is sent to the star tracker, a single frame is returned. As a result, the platform must always poll the star tracker for new data. For many situations this works fine and eases the implementation on the platform.

If you want to have the lowest possible latency between telemetry generation and acceptance by the platform (and want to avoid polling the star tracker at a high frequency), you can 'subscribe' to a telemetry. At this point the star tracker will send the telemetry data without request. If several star trackers are on the same RS485 bus, avoiding collisions and data corruption can be difficult in such a setup.

In total 9 different type of frames exist.

Type	Description
0x00	Set parameter (SC to ST)
0x80	Set parameter reply (ST to SC)
0x01	Request parameter (SC to ST)
0x81	Parameter reply (ST to SC)
0x02	Request telemetry (SC to ST)
0x82	Telemetry reply (ST to SC)
0x03	Action (SC to ST)
0x83	Action reply (ST to SC)
0x84	Asynchrounous Telemetry reply

In the following sections the different types of frames are described.

2.3.1 Set Parameter

The 'set parameter' telecommand sets a parameter on the star tracker. The id is the id of the parameter. Parameter data is a variable length field and depends of the type of parameter.

Parameter id	Parameter data
uint8_t	N

The parameter data is described in RD1.

The parameters are only available in run mode and not in bootloader mode.

2.3.2 Set Parameter reply

The star tracker replies to the set parameter command with a 'set parameter reply'. It contains the parameter_id of the set parameter and a result code.

Parameter_id	Result
uint8_t	uint8_t

The parameter id is the same as described in the TMTC table.

Result code	Description
0	ok
1	Not implemented
2-255	parameter dependent error

2.3.3 Parameter request

This is used to request a parameter

Parameter id
1 byte uint8_t

The parameter id is described in the TMTC table.

2.3.4 Parameter reply

Parameter reply is the response of the star tracker to a requested parameter. The parameter data has the same data structure as the corresponding set parameter data.

The parameter id is described in the TMTC table.

Parameter_id	Parameter data
uint8_t	N

2.3.5 Request Telemetry

Request a telemetry from the star tracker.

Telemetry_id
1 byte uint8_t

The available telemetries are listed in RD1

2.3.6 Telemetry reply/Asynchronous Telemetry Reply

Telemetry reply is the response of the star tracker to a telemetry request. The telemetry id is the id of the requested telemetry. Ticks contains an internal counter when the telemetry was generated. TS contains a timestamp when the telemetry was generated. TS is a unix time in microseconds. Both ticks and TS correspond to the generated timestamp of the data and not the timestamp of the communication.

Telemetry_id	Status	Ticks	TS	Telemetry data
uint8_t	status	uint32_t	uint64_t	N

Telemetry reply status	Description
0	ok
1	not implemented
2-255	telemetry dependent error

A telemetry reply can be generated either by a 'Request Telemetry' command or by setting the subscription parameter. In the first case it will use the id 0x82. In the second case it will use the id 0x84. This id can be used to distinguish between synchronous and asynchronous communication.

2.3.7 Action Request

An action request results in an immediate action of the star tracker (e.g. reboot, frame request etc).

Action_id	Action data
uint8_t	N

RD1 describes which actions are available in Boot and Run mode.

The action data fields are described in an external machine-readable document.

2.3.8 Action reply

The action reply contains the id of the action, a result code and, optionally, some response data.

Action_id	Action status	Action response data
uint8_t	uint8_t	N

The action reply uses the same id as the action request.

Action status	Description
0	ok
1	not implemented
2-255	parameter dependent error

The action response data fields are described in an external machine-readable document.

3 Boot loader

The star trackers boots in a bootloader mode. The bootloader provides the following functionality

- Boot the primary or secondary main star tracker firmware
- Read the star tracker firmware
- Checksum the star tracker firmware
- Erase part the flash memory
- Write part the flash memory

There are four memory regions available in the star tracker:

Region id	Contents	Size	Code
0	Bootloader	128K	0x625a1d81
1	Star tracker	896KB	0x28bd2af3
2	Free	128K	0x453928ab
3	Free	896KB	0x90bc2ea1

To erase or write to a region, the region must first be unlocked. The unlock codes are listed in the table. We recommend to use the unlock codes to implement extra safety on the platform software to avoid accidental change of the firmware software.

In normal operations, you only have to use the bootloader to boot the star tracker image (region 1). This can be done using the boot command.

3.1 Firmware upgrade

We recommend implementing the other features of the bootloader on the OBC. This allows you to reprogram the star tracker in case of an issue in orbit.

To upgrade the firmware, the following sequence needs to be followed:

1. Unlock the region
2. Erase the region
3. Upload the new firmware
4. Verify the checksum of the firmware

It is also possible to reprogram the bootloader itself. Warning: If a problem occurs during the upgrade, the unit can be in an irrecoverable state.

A firmware image is linked to a certain region. It is not possible to use a firmware in a different region.