BiSS SAFETY

Concept

Functional Safety

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OVERVIEW

The open source BiSS Interface (bidirectional/serial/synchronous) is based on a protocol which implements a realtime interface. It enables a digital, serial and secure communication between controller, sensor and actuator. The BiSS protocol is used on the lower sensor/actuator communication level in industrial applications which require transfer rates, safety, flexibility and a minimized implementation effort. In addition to its technical advantages, two conditions have established the current global standard: free BiSS license for applications and the stability and continuity of the protocol since its introduction.

BiSS Safety follows the industrial trend of fully digital communication and functional safety capabilities. Safety-critical applications targeting up to SIL3 can now be fully covered by BiSS Safety and the BiSS interface. BiSS Safety uses the BiSS protocol-specific features of the BiSS bus structure and the CRC cyclic redundancy check for a safe "Black Channel" transmission.

System components

The BiSS Safety system can be implemented in different ways: on the encoder side there are two independent position words generated by one or two sensors (BiSS slaves). The drive (BiSS master) can either be a safety drive with all needed functionality integrated or a standard drive with an additional BiSS safety monitor. This BiSS safety monitor can supervise the BiSS communication or can access relevant data.

Certification

The safety communication level "BiSS Safety" is certified by TÜV Rheinland and follows in extracts the requirements stated in DIN EN 61784-3:2011 and can be used in safety applications up to SIL3 according IEC61508:2010.

BiSS SAFETY SYSTEM STRUCTURE

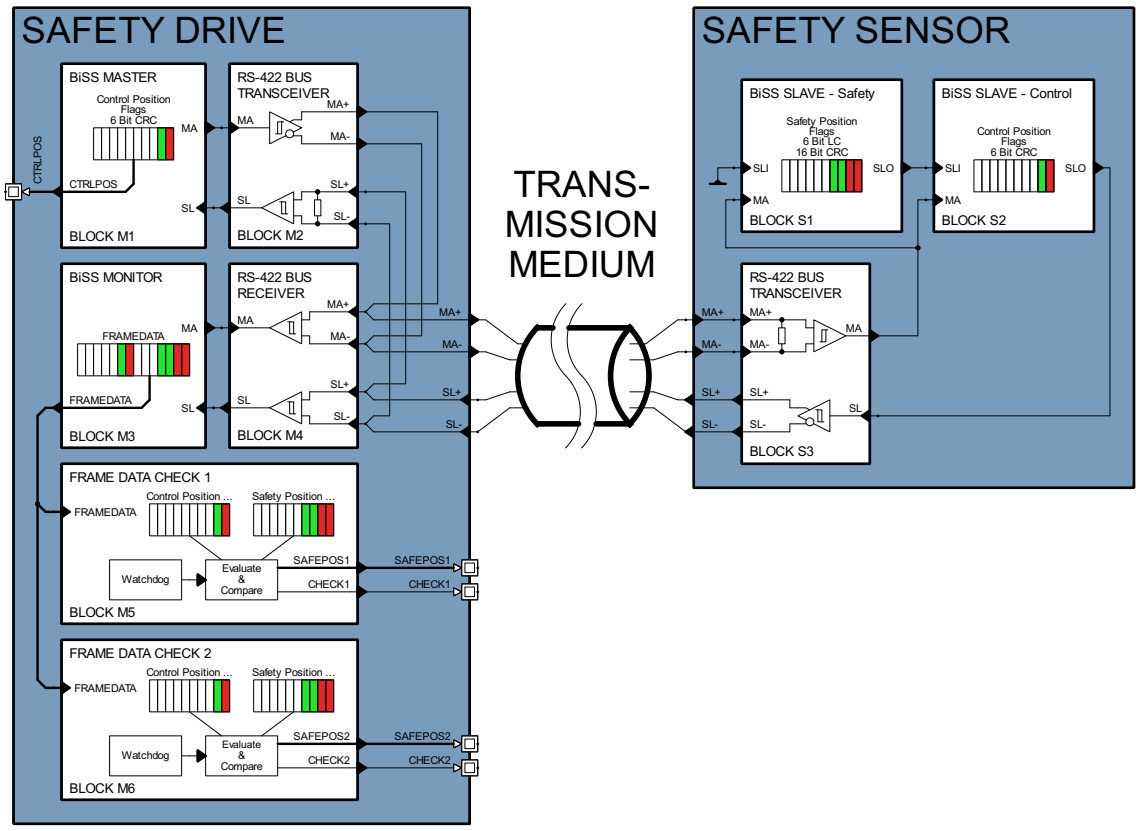

Figure 1: BiSS Safety structure based on a safety drive

Figure 1 gives an overview of a possible setup of a safety system with BiSS. The position data is sent over a single cable from the BiSS slaves on the right to the BiSS master on the left.

The standard drive consisting of the blocks "BiSS Master" and "RS-422 Bus Transceiver" is supplemented by the safety monitor (here exemplarily shown with the blocks "RS422 Bus Receiver" and "BiSS Monitor") and two instances of a frame data checker.
For integrated safety drives, a single chip consisting of the blocks "BiSS Master", "BiSS Monitor" and the RS422 interface can be used.

The "BiSS Monitor" translates the BiSS data into a serial data stream that can easily be read by a microprocessor. Furthermore the monitor supervises the BiSS timeout and signals an error to a higher level safety-PLC if a slave does not answer in a valid time frame.
The position data, the CRC values and the sign-of-life-counter are evaluated in the two independent frame checkers. Each of them checks the data integrity by verifying the CRC values and comparing the two position words for consistency. Furthermore they evaluate the sign-of-life counter in order to detect missing or reordered position values. Both frame checkers signal their results and the safe position value to the safety-PLC.

The encoder in the safety application has to be able to transmit two independently generated position values. Both words are transmitted over the same physical cable to the BiSS master. The two sensors that generate the two position words can be two separate encoder-iCs, connected in daisy-chain as described in the BiSS Safety Implementation Handbook, or a single chip solution that generates two independent position words.

BiSS SAFETY COMMUNICATION FORMAT

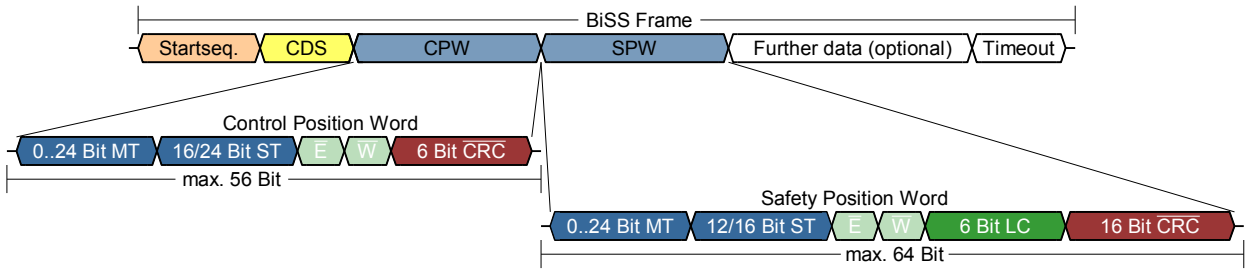

Figure 2: BiSS Safety communication profile

The "Control Position Word" (CPW), used for motor control can be of high resolution and is protected against transmission errors with a standard 6-bit CRC (HD = 3).

The "Safety Position Word" (SPW) is strongly protected with a safety capable 16-bit CRC (HD = 6). Additionally an integrated 6-bit sign-of-life counter helps to detect missing or reordered position values. The resolution of the safety word can be lower than the resolution of the control word. Its purpose is to ensure the validity of the control word. The arrangement of the "Control Position Word" and the "Safety Position Word" within the BiSS frame may be rearranged.

ERROR DETECTION

The following operations are required to detect an error during data transmission via BiSS.

Cyclic redundancy check
The CRCs of both the CPW and the SPW have to be checked separately. Mandatory polynomials are 0x43 for the CPW and 0x190D9 for the SPW.

Sign-of-life counter (LC)
The sign-of-life counter is incremented for every BiSS Safety Frame. The corresponding bits can be compared to an expected counter value.

+/- 1 LSB comparison
The comparison of the CPW and SPW positions allows a +/- 1 LSB tolerance at the MSB bit count ACC_{MIN}.

PRESELECTION OF CONFIGURATIONS

This preselection covers popular configurations. Those configuration represent a combination of bit length and resulting detectabilities for required residual error rates.

Encoder	Type	MT_{CPW}	MT_{SPW}	ST_{CPW}	ST_{SPW}	ACC_{MIN}	SCT_{min}
Rotary Singleturn	RXM	0	0	16	12	9	31.25 µs
Rotary Singleturn	RXH	0	0	24	16	13	31.25 µs
Rotary Multiturn	RSM	12	12	16	12	9	31.25 µs
Rotary Multiturn	RSH	12	12	24	16	13	62.50 µs
Rotary Multiturn	RLM	24	24	16	12	9	62.50 µs
Rotary Multiturn	RLH	24	24	24	16	13	62.50 µs
Rotary Multiturn	RUM	12	0	16	12	9	31.25 µs
Rotary Multiturn	RUH	12	0	24	16	13	62.50 µs
Linear	LMM	16	16	16	16	11	62.50 µs

Table 1: Suitable configurations for SIL3

Further configurations are possible but require individual calculations. Further SCD content needs to be considered as a possible but modified configuration and will also require individual calculations. For linear encoder the total bit count results by adding the MT and ST bit count each position word. The BiSS Protocol and the BiSS Safety Profile allow short safety cycles down to 31.25 µs respectively 62.5 µs as stated in the BiSS Safety Profile.

DEFINITIONS

Abbr.	Description
CPW	Control Position Word
SPW	Safety Position Word
ACC_{min}	Minimum required accuracy for the bit comparison
SCT_{min}	Minimum Safety Cycle Time
SCD	Single Cycle Data
MT	Multiturn position
ST	Singleturn position
E	Error status bit, part of status
W	Warning status bit, part of status
LC	Sign-of-life counter, part of status
CRC	Cyclic redundancy check sum
HD	Hamming distance

Table 2: Explanations