

Low speed digital signals for use in coal mines —

Part 3: Specification for message protocols

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- Association of British Mining Equipment Companies
- Council for Electrical Equipment for Flammable Atmospheres (BEAMA)
- Health and Safety Executive
- National Coal Board
- National Union of Mineworkers

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Foreword

This Part of BS 6556 has been prepared under the direction of the Mining and Quarrying Requisites Standards Committee.

Control and monitoring activities below ground in coal mines require the transmission of data between items of electrical equipment supplied by different manufacturers. Data can be transmitted in analogue or alternatively digital form. For analogue, BS 5754:1980 "*Specification for electrical analogue and state signals for use in coal mines*" was produced with the purpose of promoting compatibility between transducers, recorders, indicators and data transmission systems of different manufacture and having inputs or outputs, as appropriate, in the form of d.c. voltage analogue signals or signals derived from relay contacts or a mechanical switch. This standard deals with the digital form.

A major disadvantage with control and monitoring systems employing the direct transmission of analogue signals is that since a galvanic connection is necessary between the transmitting and receiving circuits, faults, at different points of the system, particularly to earth, can seriously affect overall performance. The avoidance of such faults, on pit-wide systems, is extremely difficult. The generation of analogue signals within high voltage switchgear, and subsequent transmission for monitoring purposes, also presents difficulty in achieving the required degree of segregation between intrinsically safe and power circuits. A further disadvantage with analogue signals is that the simultaneous transmission of several signals requires either a multicore cable or separate cables.

These disadvantages can be largely overcome if the analogue or state information is transmitted in the form of serially coded digital signals. With such signals complete galvanic isolation between the transmitting and receiving circuits is possible and, within wide limits, only two wires are required for transmission in each direction irrespective of the volume of data.

If full benefit of digital signal data transmission is to be realized it is important that transmission systems of different manufacture conform to a common electrical standard and operate in a uniform manner with identical procedure (or protocol) for handling the data. This standard aims to promote such conformity. It specifies relevant requirements for a low speed digital signal link comprising a master and one or more slaves which interconnects the intrinsically safe circuits of one item of apparatus and the intrinsically safe circuits of other apparatus in such a way that units of different manufacture can be interchangeably coupled at the transmission line terminals.

This standard is published in three Parts as follows:

- *Part 1: Specification for optical coupling;*
- *Part 2: Specification for transformer coupling;*
- *Part 3: Specification for message protocols.*

Parts 1 and 2 of this standard offer alternative methods of achieving galvanic isolation between the intrinsically safe circuits of interconnected apparatus, but the two methods are not compatible.

Part 1 of this standard specifies a 600 bits/s transmission system which employs optical coupling as the means of achieving galvanic isolation. A system will comprise a master and from 1 to 8 slaves connected in point-to-point or multi-drop modes, with two cable conductors being used for each direction of transmission. Transmission from the master to a slave is achieved by the master acting as a switched current source which activates a light emitter at each slave. Transmission from slave to master is achieved by the master acting as both a current source, which is switched at the slave by a light dependent device, and a current monitor which senses the switched current.

Part 2 of this standard specifies a 600 bits/s transmission system which employs transformer coupling as the means of achieving galvanic isolation. A system will comprise a master and from 1 to 15 slaves connected in point-to-point or multi-drop modes. Transmission between master and slaves is achieved by frequency shift keying (FSK) techniques, one pair of cable conductors being used for each direction of transmission.

This Part of this standard defines the message protocols to be used by systems complying with Parts 1 or 2. It does not, however, place any restrictions on the application data contained in transmitted messages, although industry standards may exist to regulate this.

It is envisaged that for high voltage applications optical coupling will be employed due to the relative ease of meeting segregation requirements. The optical system, however, has a limit of 8 slaves and a range of 2 km while the transformer method has a greater range and can handle up to 15 slaves. For intermediate applications either system may be suitable.

In Parts 1 and 2 of this standard slaves are the physical interface between the transmission line and one or more addressable logical slaves specified in Part 3 of this standard.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations. Attention is drawn to the Health and Safety at Work etc. Act 1974, the Mines and Quarries Act 1954, the Regulations made under these Acts, and also any other appropriate statutory requirements or byelaws. These place responsibility for complying with certain specific safety requirements on the manufacturer and the user. The address of the recognized certification authority in the United Kingdom for Group 1 (coal mining) apparatus for intrinsic safety purposes is as follows:

Health and Safety Executive
HSE (M) Certification Support Unit
Harpur Hill, Buxton, Derbyshire SK17 9JN.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 18, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

0 Introduction

0.1 General

Two protocols are covered by this Part of this standard; data only protocol (DOP) and simple asynchronous protocol (SAP).

Both protocols use the same element of transmission which consists of 11 bits as follows (see Figure 1):

- a) 1 start bit;
- b) 8 data bits (a byte);
- c) an even parity bit;
- d) a stop bit.

The even parity bit contributes to error checking of the data.

Within each protocol between 1 and 128 bytes of application data, each complete with its start, stop and parity bits, can be transmitted.

0.2 Data only protocol (DOP)

DOP is a very simple protocol limited to point-to-point applications (see Figure 2).

Transmissions consist purely of application data. Separate messages are identified by a short gap. Error detection is limited to parity, framing and, in the case of MODEM systems, carrier checks.

0.3 Simple asynchronous protocol (SAP)

0.3.1 General description of SAP. SAP is a set of rules which ensures that order is maintained on the data link between the master and its slaves.

The master controls all link activity. There is only one master and from 1 to 15 slaves. The slaves are connected in multi-drop as shown in Figure 3.

The master can send a message to one or all slaves. Slaves may only send messages to the master.

SAP allows the use of four message types as follows:

- a) an application data message (ADM) (see Figure 4);
- b) a link control message (LCM) (see Figure 5);
- c) a broadcast message (BRO) (see Figure 4);
- d) an initialization message (IM) (see Figure 5).

Each message begins with a start of message byte (SMB) by which it is identified (see Table 1). The second byte is always the address byte (AB) which contains the slave address.

The LCM and IM consist simply of the SMB and AB and are used for link control purposes only.

The ADM and BRO are data messages and contain the application data field (ADF) which may be between 1 and 128 bytes in length. The ADF may exceed this length where byte stuffing is necessary (see 0.3.6).

0.3.2 Normal link operation. A link control message (LCM) is used by the master to poll each active slave in a designated polling sequence.

A slave polled by an LCM may respond by transmitting one of the following:

- a) an application data message (ADM) if there is application data to send;
- b) an LCM if there is no application data to send;
- c) an initialization message (IM) if the slave requires initialization.

Reception of a poll is the only condition which allows a slave to transmit a message. Only one slave is allowed to transmit over the link at any one time.

The master sends application data to a single slave by means of an ADM or to all slaves by means of a broadcast message (BRO).

0.3.3 Initialization. Initialization of stations is achieved by the exchange of initialization messages (IM). An IM from the master is a poll that is substituted in the polling sequence in place of an LCM where a slave requires initialization.

0.3.4 Message loss. The protocol includes facilities which detect when an application data message (ADM) has been lost. Each ADM to and from each slave is designated as either ODD or EVEN by assigning unique start of message bytes (SMB) to each type (see Table 1).

A master or slave receiving an ADM acknowledges its reception and type (ODD or EVEN) by the use of an acknowledge bit (ACK-BIT) contained in the address byte (AB). The ACK-BIT acts as a toggle which is set and reset only by the reception of a valid in-sequence ADM. Failure of the ACK-BIT to toggle as expected will cause a re-transmission.

To ensure that a datum point is established after initialization, messages before the reception of a valid ADM will have the acknowledge bits (ACK-BITs) equal to one and the first ADM to and from each slave will be EVEN.

0.3.5 Broadcast message. A broadcast facility is provided to allow the master to transmit to every slave. An address is reserved for this purpose. This message is received simultaneously by all slaves and is not acknowledged.

0.3.6 Byte stuffing. As the codes 80H, 81H, 83H, 85H and 87H are reserved for link control, it is necessary to ensure that these codes are not transmitted when they occur in application data. To prevent this, data having the same code as a reserved code is transmitted as two bytes, a stuff byte (STF), reserved value 80H, and a byte derived by subtracting 80H from the data byte. The receiving station on recognizing 80H adds this to the following byte to restore the original data (see Table 3).

0.3.7 Message priority and length. Facilities are provided for assigning higher priority to selected ADMs and BROs. This is achieved by a priority bit contained in the applications data description byte (ADD). The remaining bits in this byte are used to represent the number of bytes in the application data field (ADF).

0.3.8 Error checking. Additional to the parity, framing and, in the case of the MODEM system, carrier checks within the transmission element, there are two further checks used within the protocol.

The address byte (AB) contains its own error detection bits so that a slave recognizing its address (or a broadcast) is assured of its validity and can prepare to receive the remainder of the message.

The check field (CF) at the end of each ADM and BRO allows the integrity of data to be checked before it is used. This is a 16 bit cyclic redundancy check.

0.3.9 Link failure. Link failures are detected by stations being unable to gain correct responses after re-transmissions.

Slaves considered by the master to have failed are polled at less regular intervals defined by the polling sequence.

0.3.10 Poll insertion. To improve link efficiency, a master transmitting an ADM may insert a poll within the ADM. This facility is used when there is no reply outstanding. An ADM may have many polls inserted. Such polls override the normal order of transmission and may appear anywhere in an ADM including immediately following the SMB or an STF or between the two bytes of the CF.

1 Scope

This Part of BS 6556 specifies two message protocols employed with particular low speed digital signals systems for use in coal mines, using either optical coupling (see BS 6556-1) or transformer coupling (see BS 6556-2). Either protocol can be employed in either transmission system.

The protocols require only limited station intelligence for successful implementation. One protocol, known as simple asynchronous protocol, is designed to work in point-to-point or multi-drop configurations. The other protocol, known as data only protocol, will only work in point-to-point configurations.

Protocol for the applications data is not specified by this standard although industry standards will exist to regulate this.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions and abbreviations

2.1 Definitions

For the purposes of this Part of BS 6556 the following definitions apply.

2.1.1

bit

the element of digital information taking the value 1 or 0

2.1.2

bit period

the time taken to transmit a single bit

2.1.3

parity bit

a check bit which is derived from a number of data bits and provides a degree of checking for corruption

2.1.4

byte

a group of 8 bits d_0 to d_7 , with d_0 being the least significant bit and d_7 being the most significant bit

2.1.5

byte period

the time taken to transmit a single byte along with its associated start, stop and parity bits

2.1.6

current loop link

a transmission technique complying with BS 6556-1

2.1.7

MODEM

a combined modulator demodulator complying with BS 6556-2

2.1.8

receive line signal detected (RLSD)

an output from a demodulator complying with BS 6556-2

2.1.9

request to send (RTS)

a control input of a modulator complying with BS 6556-2