BRITISH STANDARD

BS 6556-1: 1985

Incorporating Amendment No. 1

Low speed digital signals for use in coal mines —

Part 1: Specification for optical coupling

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Committees responsible for this British Standard

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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 largely be 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.

This Part 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.

Part 3 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 SK 17 9JN.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 6, 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.

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1 Scope

This Part of BS 6556 specifies the electrical input and output characteristics for the optical coupling of intrinsically safe transmitting and receiving circuits for use in coal mines. These form a low speed digital data transmission link in which data is transmitted using current loop techniques.

A data transmission system comprises a master and up to eight physical slaves so arranged that the transmission line is energized only from the master and galvanic isolation is achieved by optical coupling at each slave.

NOTE 1 Each physical slave may support more than one addressable logical slave as specified in Part 3 of this standard up to a maximum of 15 addressable slaves for the complete system.

This Part of BS 6556 only applies to apparatus where the circuits connected to the transmission lines are designed to be intrinsically safe in accordance with BS 1259, BS 5501-7 or BS 5501-9 as appropriate.

NOTE 2 Where apparatus, which is intended to be used in potentially explosive atmospheres, contains other circuits which are not intrinsically safe, those circuits will have to be given an alternative form of protection in accordance with BS 229, BS 4683 or BS 5501 as appropriate.

NOTE 3 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

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

2.1
duplex

the transmission of data simultaneously in opposite directions through a system

2.2
simplex

the transmission of data in one direction only

2.3
bit

the element of digital information taking the value 1 or 0

2.4
binary

having only two states (of numbers). A system of numbering where each digit has only two possible values, 0 or 1

2.5
channel

a circuit carrying information in one direction

2.6
current loop

a transmission technique where the presence or absence of current represents binary data

3 General conventions

The following conventions shall apply:

a) space = value 0 = current flow = start;

b) mark = value 1 = no current flow = idle.

4 Data link configurations

The data link shall allow data to be transmitted between a master and up to 8 slaves.

The master and slaves shall be interconnected to form data links in the following ways:

a) point-to-point simplex using a single twisted pair transmission line (see Figure 1);

b) point-to-point duplex using a four-wire transmission line (see Figure 2);

c) multi-drop duplex using a four-wire transmission line with up to 8 slaves (see Figure 3).

5 Channel allocation

Transmission from master to slave shall be via the originate channel. Transmission from slave to master shall be via the answer channel (see Figure 1 and Figure 2). For multi-drop operation the channel allocation shall be the same but with multiple slaves (see Figure 3).

6 Data rate

The data rate shall be 600 bits/s ± 0.1 %.

7 Electrical network parameters

7.1 General

Data shall be transmitted by means of current switching. The transmission lines shall be energized from the master only. Galvanic isolation shall be achieved by optical means at each slave.

The common lines of the originate and answer channels shall be connected together at the master.

7.2 Originate channel (see Figure 4)

7.2.1 *Master transmitter*. The master transmitter shall take the form of a switched source of current connected to the transmission line.

The maximum open circuit voltage at the output terminals of the transmitter shall not exceed + 12 V. The transmitter shall be capable of producing 25 mA minimum into a 260 Ω resistive load.

The mark condition current shall be less than 250 μA into a 1.2 kΩ resistive load.

The transmitter shall have a slew rate of 20 mV/μs ± 10 % between 10 % and 90 % levels across 260 Ω.

7.2.2 *Slave receiver*. The slave receiver shall monitor the transmission line current. The transmission line side of the optical link shall be a current limited light emitter.

The receiver input current shall be between 2.5 mA and 3 mA at + 4.5 V and a current of 2.5 mA or greater shall be recognized as a space condition. In this condition the receive circuit shall have an active impedance greater than 1 200 Ω.

A receiver current of less than 1 mA shall be recognized as a mark condition.

7.3 Answer channel (see Figure 5)

7.3.1 *Master receiver*. The master receiver shall supply and monitor the transmission line current.

The master receiver shall present an impedance to the line of between 150 Ω and 250 Ω. The open circuit voltage at the input terminals of the receiver shall not exceed + 10 V.

The master receiver shall recognize any current in excess of 5 mA as a space condition and any current less than 4 mA as a mark condition.

The master receiver shall be capable of delivering a minimum of 10 mA into an external resistive load of 220 Ω.

When the receiver line terminals are short circuited the resulting current shall not exceed 40 mA.

7.3.2 *Slave transmitter*. The slave transmitter shall switch the transmission line current. In the space condition the slave terminal voltage shall be less than 1.5 V when sinking 6 mA.

The leakage current in the mark condition shall not exceed 250 μA with + 10 V applied at the line terminals.

8 System performance

Master and slaves shall be capable of operating on a data link configuration comprising 8 slaves on a single cable at a distance of 2 km from the master, using cable as specified in Appendix A, with zero bit errors over a test period of 2 h.

9 Cable connections

The cable connections shall be designed to allow the electrical continuity of the armouring or screens to be maintained.

10 Environment

The equipment shall be able to operate within an ambient temperature range of – 5 °C to + 40 °C in humidity up to 95 % normally not condensing.

Other environmental conditions of temperature and humidity may be specified by agreement between supplier and purchaser and shall be deemed to comply with this standard, provided that the requirements of all other clauses are met and that the agreed conditions shall be so marked on the equipment.

NOTE Condensation may form when, for example, the equipment is first installed and this should not permanently affect the operation of the equipment.

11 Maximum output parameters

The maximum output parameters and limiting characteristics measured at the line terminals under the fault conditions of clause **4** of BS 5501-7:1977 for category "ia" apparatus shall be:

a) for the combined outputs of the master's transmitting and receiving circuits:

V_{oc} = 17 V; I_{sc} = 200 mA; C_{eq} = 100 nF; L_{eq} = 0

b) for the slave:

V_{oc} = 0; I_{sc} = 0; C_{eq} = 100 nF; L_{eq} = 0

where

V_{oc} is open circuit voltage;

I_{sc} is short circuit current;

C_{eq} is equivalent capacitance;

L_{eq} is equivalent inductance.

12 Marking

In addition to any marking required by a certifying authority, apparatus having input or output circuits complying with this standard shall be marked externally with the number and date of this standard, i.e. BS 6556-1:1985[1)] and "MASTER" or "SLAVE" as appropriate.

[1)] Marking BS 6556-1:1985 on or in relation to a product is a claim by the manufacturer that the product has been manufactured to the requirements of the standard. The accuracy of such a claim is therefore solely the manufacturer's responsibility. Enquiries as to the availability of third party certification to support such claims should be addressed to the Director, Quality Assurance Division, BSI, Maylands Avenue, Hemel Hempstead, Herts HP2 4SQ for certification marks administered by BSI or to the appropriate authority for other certification marks.

Where terminals are used they shall be marked "originate transmit", "answer receive", "originate receive", "answer transmit" and "earth" as appropriate. Transmit and receive terminals shall also be marked with "common" and "+" as appropriate. Where terminals relating to Parts 1 and 2 of this standard are within a single terminal chamber, each group of terminals shall be marked "BS 6556-1:1985" or "BS 6556-2:1985" as appropriate.

Plug and socket outlets to line shall be marked "BS 6556-1:1985".

13 Documentation

The supplier of the equipment specified in this Part of BS 6556 shall produce and make available such information as is necessary for the safe and correct use of the equipment.

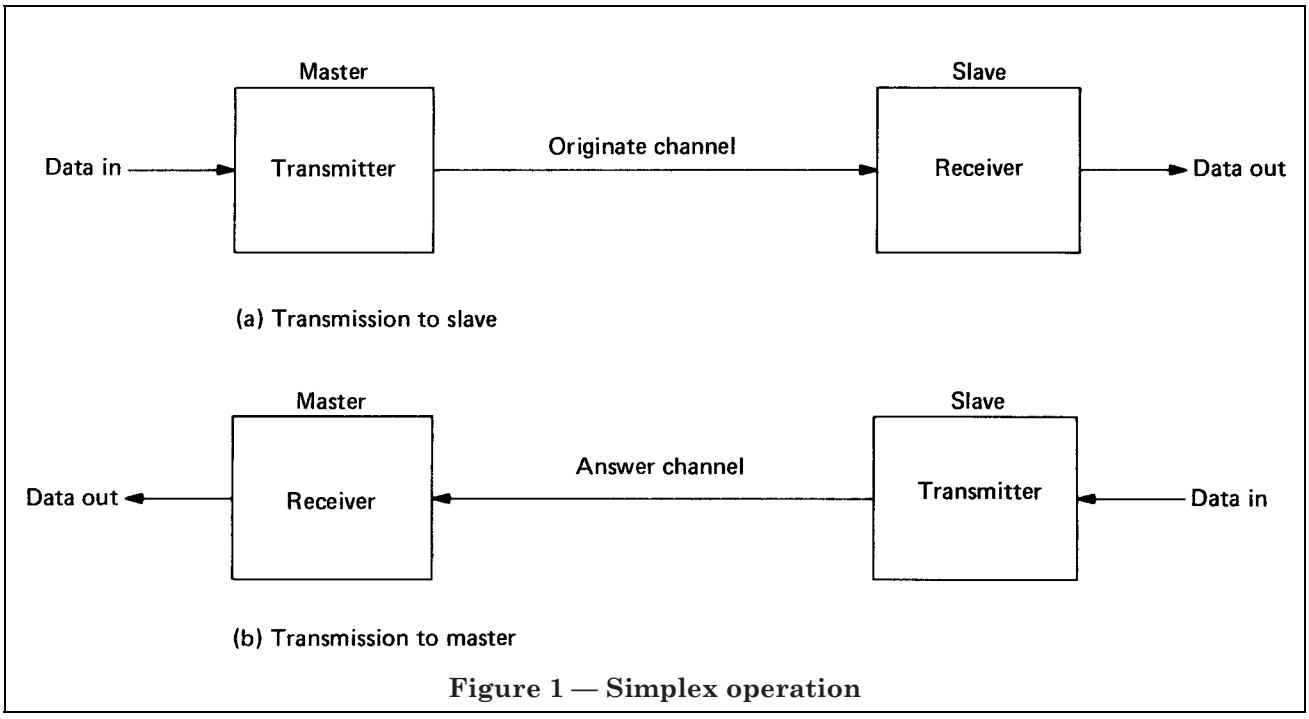


Figure 1 — Simplex operation

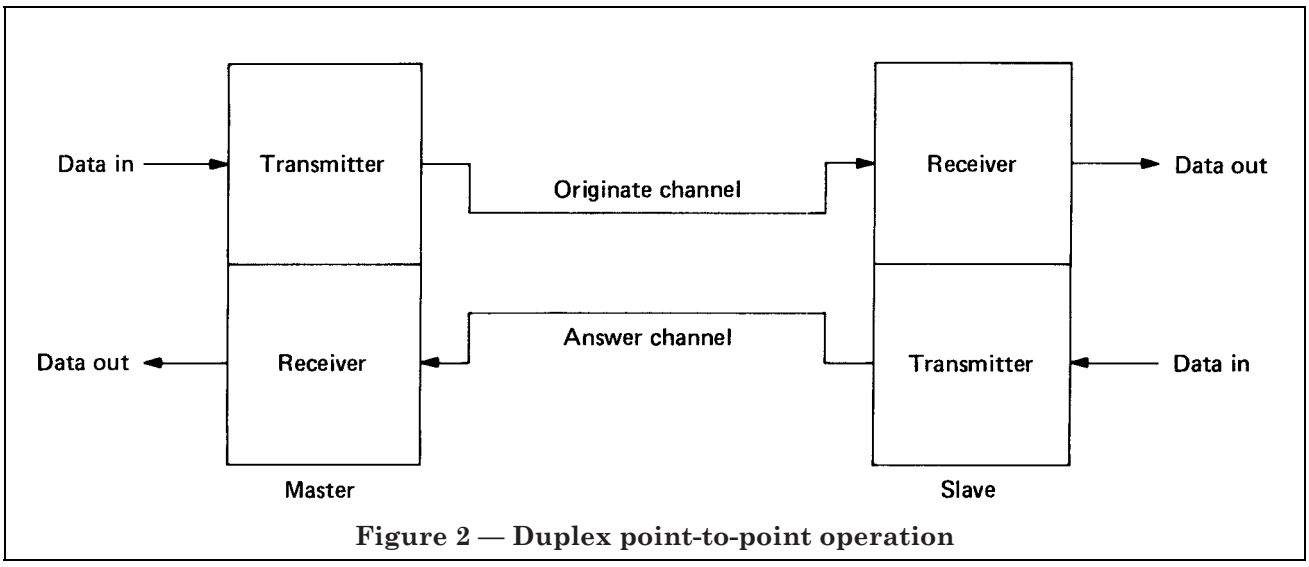
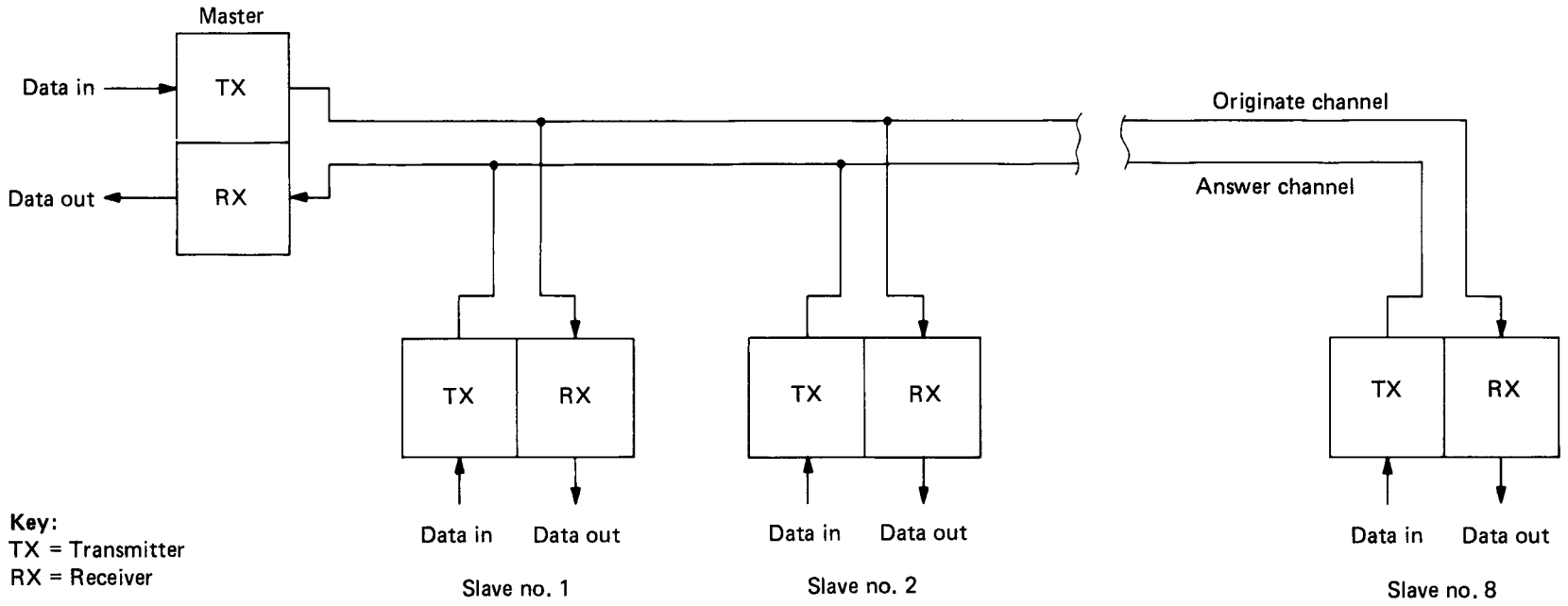


Figure 2 — Duplex point-to-point operation



NOTE Each physical slave may support more than one addressable logical slave as specified in BS 6556-3 up to a maximum of 15 addressable slaves for the complete system.

Figure 3 — Multi-drop operation

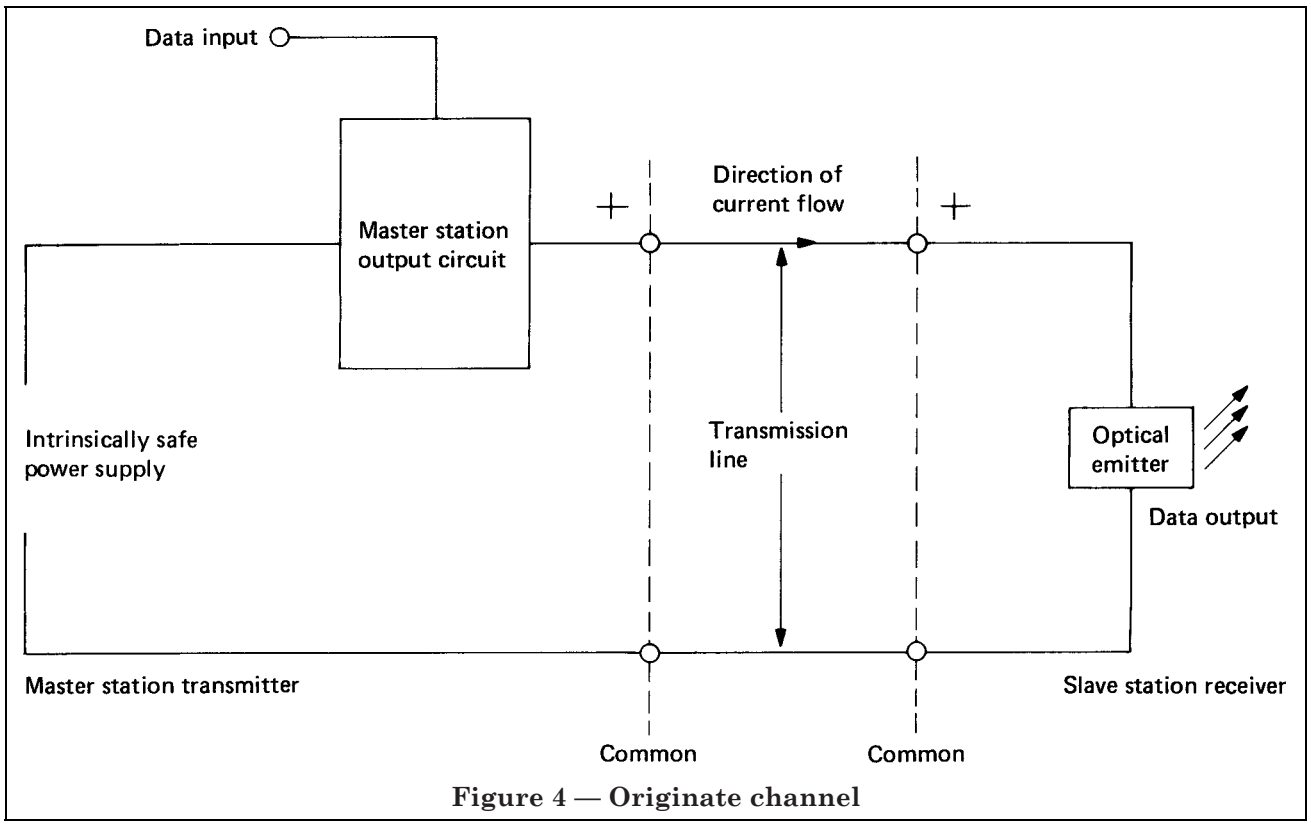


Figure 4 — Originate channel

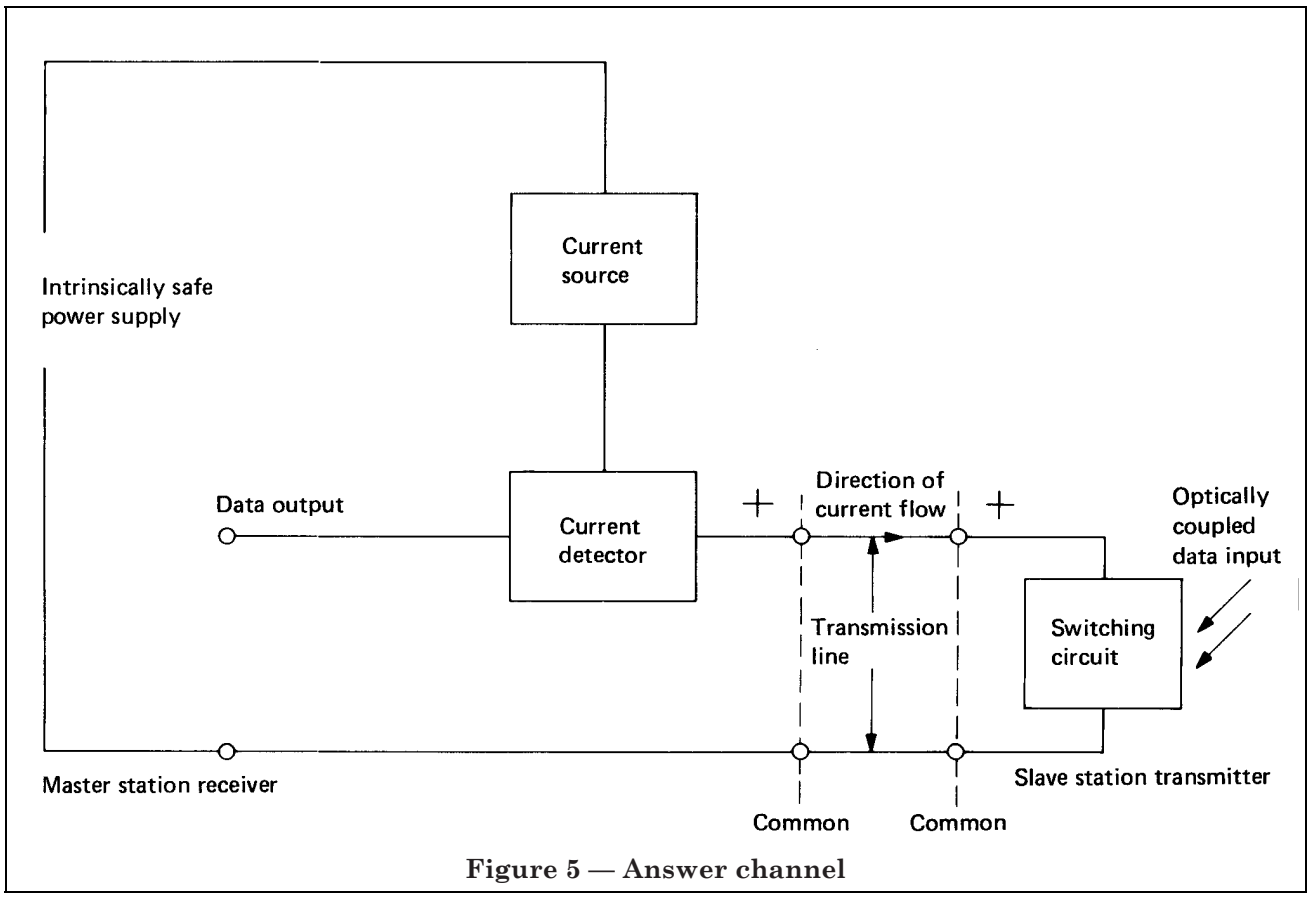


Figure 5 — Answer channel

Appendix A Cable parameters used for system performance test

The following cable parameters shall be used in a system performance test:

a) four-core cable laid up to form a symmetrical star quad using two adjacent cores for each channel as shown in Figure 6;

b) armouring consisting of a single or double layer of galvanized steel wires complying with BS 1442;

c) the conductor loop resistance up to, but not exceeding, 28 Ω/km of cable at 20 °C;

d) the ratio of inductance to resistance up to, but not exceeding, 65 μH/Ω;

e) the insulation resistance measured at 500 V d.c. after steady electrification for 1 min at 20 °C shall be not less than 10 MΩ for 1 km;

f) the cable capacitance shall not exceed 200 nF/km;

g) the cable characteristic impedance shall be greater than 130 Ω at 1 kHz.

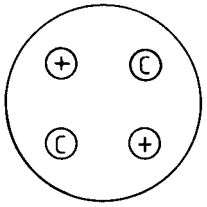


Figure 6 — Core configuration of cable

Publications referred to

BS 229, *Flameproof enclosure of electrical apparatus.*
BS 1259, *Intrinsically safe electrical apparatus and circuits for use in explosive atmospheres.*
BS 1442, *Galvanized mild steel wire for armouring cables.*
BS 4683, *Electrical apparatus for explosive atmospheres.*
BS 5501, *Electrical apparatus for potentially explosive atmospheres.*
BS 5501-7, *Intrinsic safety "i".*
BS 5501-9, *Specification for intrinsically safe electrical systems "i".*
BS 5754, *Specification for electrical analogue and state signals for use in coal mines*[2)].
BS 6556, *Low speed digital signals for use in coal mines.*
BS 6556-2, *Specification for transformer coupling.*
BS 6556-3, *Specification for message protocols.*

[2)] Referred to in the foreword only.

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