BRITISH STANDARD

BS 6556-2: 1985

Incorporating Amendment Nos. 1, 2 and 3

Low speed digital signals for use in coal mines —

Part 2: Specification for transformer coupling

Confirmed January 2011

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Mining and Quarrying Requisites Standards Committee (MQE/-) to Technical Committee MQE/25 upon which the following bodies were represented:

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

This British Standard, having been prepared under the direction of the Mining and Quarrying Requisites Standards Committee, was published under the authority of the Board of BSI and comes into effect on
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The following BSI references relate to the work on this standard:
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6205	February 1992	
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Contents

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.

This Part 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 14, 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 transformer 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 frequency shift keying techniques.

A data transmission system comprises a master and up to 15 physical slaves. The circuits of all stations are galvanically isolated from the line circuits by transformers.

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
MODEM

a combined modulator demodulator

2.7
ready for sending (RFS)

an output from the modulator

2.8
receive line signal detected (RLSD)

an output from the demodulator

2.9
request to send (RTS)

a control input of the modulator

2.10
frequency shift keying (FSK)

a method of transmitting information by different frequencies

2.11
dBm

power level referenced to 1 mW

2.12
isochronous distortion

deviation of received bits from their nominal period expressed as a percentage of the nominal bit period

3 General conventions

The following conventions shall apply:

a) space = value 0 = low frequency = start;

b) mark = value 1 = high frequency = idle.

4 Data link configurations

4.1 General

The data link shall allow data to be transmitted between a master and up to 15 slaves.

Each transmitting and receiving station shall be galvanically isolated from the transmission lines by coupling transformers.

NOTE The connections between the transformer and the transmission line may have to include safety components to meet the requirements of clause **14**.

The modulator and demodulator shall be inter-connected 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 two-pair or twisted quad transmission line (see Figure 2);

c) multi-drop duplex using a two-pair or twisted quad transmission line with up to 15 slaves (see Figure 3).

4.2 Termination rules

In multi-drop configuration the following line termination rules shall apply.

a) When the transmission line is looped into each MODEM, all MODEMs, except those at each end, shall have the line termination switched out. The end MODEMs shall have the line termination switched in.

b) Where the length of a spur is less than 1 km the line termination of MODEMs on the spur shall be switched out.

c) Where the length of a spur is greater than 1 km, the node shall be a symmetrical resistive splitter (see Figure 4). In this case the final MODEM on each spur shall have the line termination switched in. All other MODEMs on the spur shall have the line termination switched out.

d) Impedance switching in any one MODEM on both modulator and demodulator line terminations shall be by a single actuator.

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 Modulation parameters

The modulation method shall be phase continuous frequency shift keying (FSK) (see Figure 5).

The master modulator and slave demodulator shall operate in the following frequency band:

originate channel: 1 170 ± 100 Hz,
i.e. mark 1 270 Hz, space 1 070 Hz.

The master demodulator and slave modulator shall operate in the following frequency band:

answer channel: 2 125 ± 100 Hz,
i.e. mark 2 225 Hz, space 2 025 Hz.

The tolerance on the centre frequency, i.e. 1 170 Hz or 2 125 Hz shall be ± 5 Hz.

The tolerance on the difference between mark frequency and space frequency shall be ± 10 Hz.

8 Line spectrum

The spectrum of the transmitted signal with the line termination switched in and with 600 Ω connected across the line terminals shall comply with Figure 6 for the originate channel and with Figure 7 for the answer channel.

9 Modulator

9.1 General

The modulator shall accept serial binary data at the specified data rate and convert it to audio frequency signals for transmission via a transformer to line (see Figure 8). The modulator shall be controlled by the interface signal "request to send" (RTS) and shall output the signal "ready for sending" (RFS).

9.2 Transmit levels

The transmitted signal measured at the line terminals with the line termination switched in and with 600 Ω connected across the line terminals shall be 0 ± 1 dBm.

9.3 Modulator line interface

The interface between the modulator and the transmission line shall be a transformer to provide galvanic isolation and a balanced line signal (see Figure 8).

The transformer shall be designed such that the line terminals have intrinsically safe segregation from the power supply of the apparatus.

The modulator shall be operated in current driving mode and present an impedance to the line in excess of 5 kΩ. Means shall be provided for terminating the line with an impedance of 600 Ω ± 10 % (see **4.2**).

The degree of balance of the transformer at the line terminals shall be better than 40 dB.

9.4 Ready for sending delay

The modulator shall operate the RFS signal in response to changes in the RTS signal as given in Table 1.

Table 1 — Manner of modulator operation

RTS	RFS	Delay
OFF to ON	OFF to ON	20 ± 2 ms
ON to OFF	ON to OFF	⩽ 2 ms

During the interval between the OFF to ON transition of RTS and the OFF to ON transition of RFS the modulator shall transmit the signal corresponding to binary one data. During the time that RTS is OFF the line signal shall be reduced to less than – 60 dBm.

9.5 Modulator delay

The delay between inputting data and the line signal changing shall be less than 1 ms.

9.6 Inhibit

The slave modulator shall be provided with a control circuit which, independent of the state of RFS and RTS, inhibits the operation of the modulator if it transmits continuously for a period in excess of 5 s. Inhibit OFF shall allow normal operation of the modulator. Inhibit ON shall reduce the line signal level to less than – 60 dBm and shall latch in this condition and be indicated on the equipment.

NOTE The inhibit circuit should isolate the modulator as close to the output as possible. Normally the latch should be reset by application of power or a switch on the equipment or by remote command.

10 Demodulator

10.1 General

The demodulator shall accept the audio frequency signals from the transmission line and convert them in to serial binary data (see Figure 9) and shall output the signal "receive line signal detected" (RLSD).

10.2 Demodulator line interface

The interface between the demodulator and the transmission line shall be a transformer to provide galvanic isolation and a balanced load to the line (see Figure 9). The transformer shall be designed such that the line terminals have intrinsically safe segregation from the power supply of the apparatus.

The demodulator shall present an impedance to the line in excess of 5 kΩ. Means shall be provided for terminating the line with an impedance of 600 Ω ± 10 % (see clause **4**).

The degree of balance of the transformer at the line terminals shall be better than 40 dB.

10.3 Received line signal detector

The demodulator shall monitor the average level of the received line signal and operate in band interface signal RLSD as given in Table 2.

Table 2 — Manner of demodulator operation

Signal level range	RLSD
> – 35 dBm	ON
< – 40 dBm	OFF

There shall be at least 2 dBm hysteresis between the ON and OFF levels. RLSD shall respond within 15 ms to valid ON and OFF levels measured at the line terminals.

The detector shall not respond to signals lasting less than 5 ms nor to loss of signal for less than 5 ms.

The demodulator data output shall be binary 1 during the time that RLSD is OFF.

10.4 Demodulator delay

The delay between frequency change at the line terminals and outputting data shall be less than 3 ms.

11 System performance

11.1 Transmission impairment checks

Combinations of modulators and demodulators, when interconnected in the required configurations, shall be capable of satisfactory operation in the presence of transmission impairments in the form of noise and injected tones. The required performance shall be checked by the tests given in Table 3. Tests 1 to 8 shall be carried out using a 511 bit pseudo-random sequence (see Figure 11).

NOTE In order to demonstrate this the configuration shown in Figure 10 may be used.

11.2 System checks

Masters and slaves shall be capable of operating with data link configurations comprising 14 slaves at a distance of 10 km from the master and one slave, using cable as specified in Appendix A.

12 Cable connections

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

13 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.

Table 3 — Performance tests

Test no.	Impairment	Test network	Result
1	None	None	No errors over a 2 h period sampled in the bit centre
2	None	None	Isochronous distortion < 10 % over 10^5 bits
3	None	10 km cable	No errors over a 2 h period sampled in the bit centre
4	None	10 km cable	Isochronous distortion < 10 % over 10^5 bits
5	Injected tone at – 10 dBm and at 50 Hz, 1 600 Hz, 2 750 Hz (separately)	None	No errors over a 2 h period sampled in the bit centre
6	Injected tone at – 10 dBm and at 50 Hz, 1 600 Hz, 2 750 Hz (separately)	None	Isochronous distortion < 15 % over 10^5 bits
7	Injected constant power density (white) noise over the bandwidth 0 to 20 kHz at – 12 dBm	10 km cable	Bit error rate < 1 in 10^5 sampled in the bit centre
8	Injected constant power density (white) noise over the bandwidth 0 to 20 kHz at – 12 dBm	10 km cable	Isochronous distortion < 15 % over 10^5 bits
9	Inject the originate channel frequency into the master receiver at – 12 dBm with modulator off	None	No response from RLSD
10	Inject answer channel frequency into the slave receiver at –12 dBm with modulator off	None	No response from RLSD

NOTE The cable may be simulated in tests 3, 4, 7 and 8.

14 Line circuit parameters

14.1 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:

V_{oc} = 5 V; I_{sc} = 0.4 A; C_{eq} = 0; 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.

The capacitance of zener diodes shall not be taken into consideration in determining the value of C_{eq}.

14.2 Maximum input power

The maximum input power from the transmission line shall be taken as 2 W. This value shall be used in addition to the maximum power available from the apparatus under the fault conditions defined in clause 4 of BS 5501-7:1977 for category "ia" apparatus when determining the rating of the components in the line output circuit.

15 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 6556-2:1985[1)] and "MASTER" or "SLAVE" as appropriate.

[1)] Marking BS 6556-2:1985 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. 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 shall be marked "BS 6556-2:1985".

The line termination actuator shall be marked "Line termination" and the positions shall be marked "IN" and "OUT" as appropriate.

The resistive node circuit shall be marked "Resistive node BS 6556-2:1985" and appropriately marked to facilitate installation.

16 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.

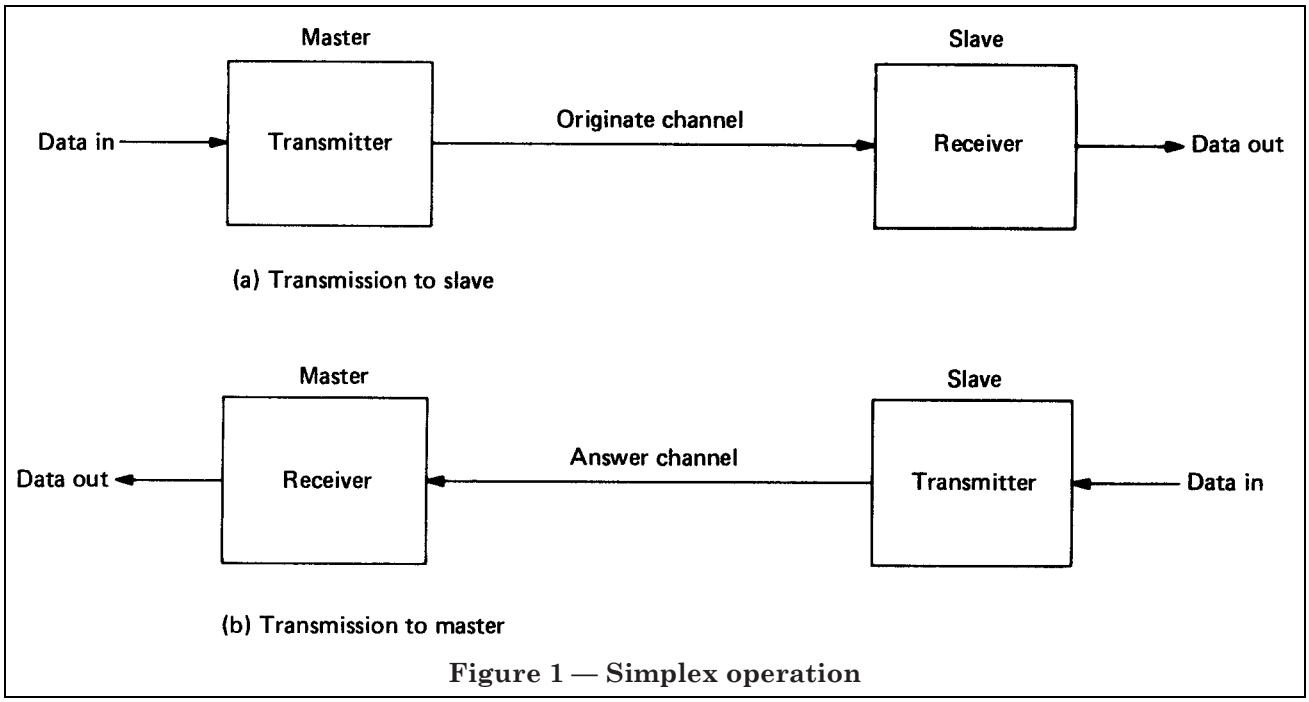


Figure 1 — Simplex operation

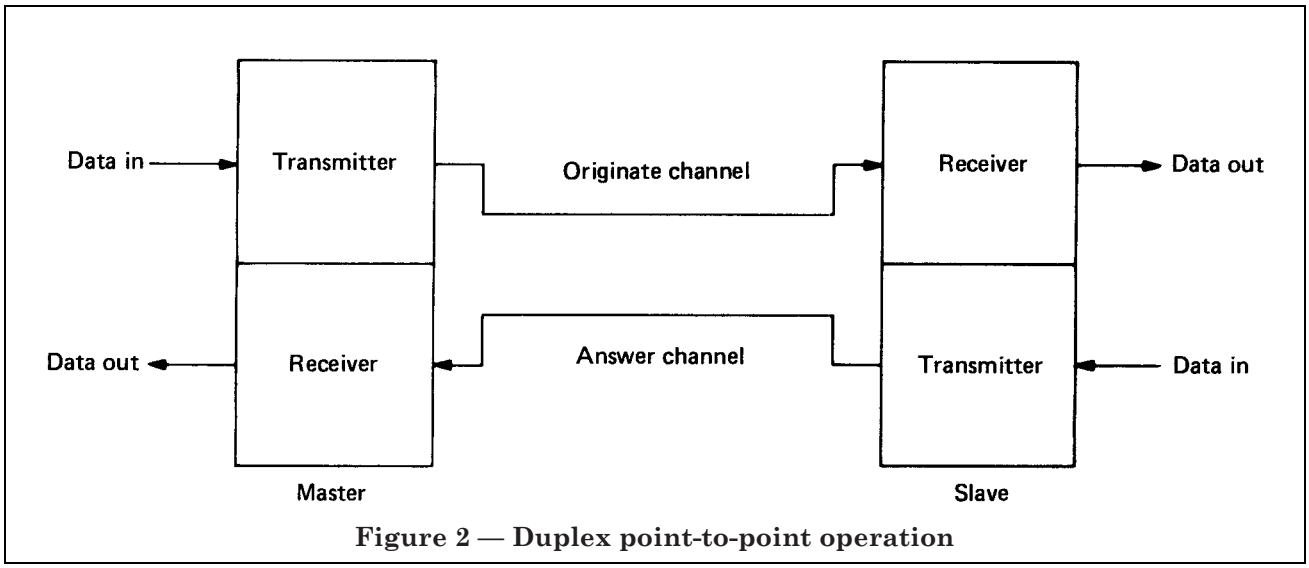
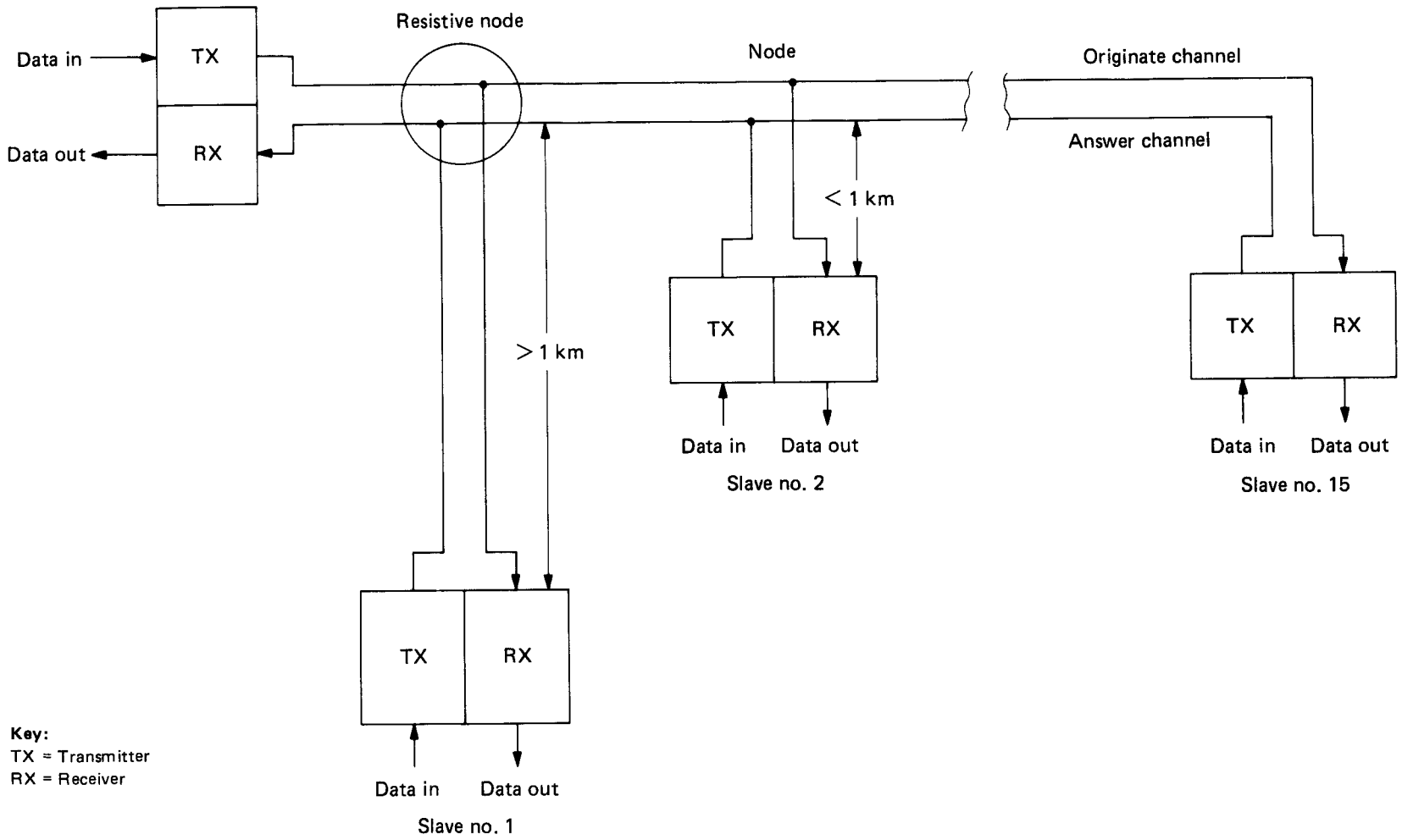
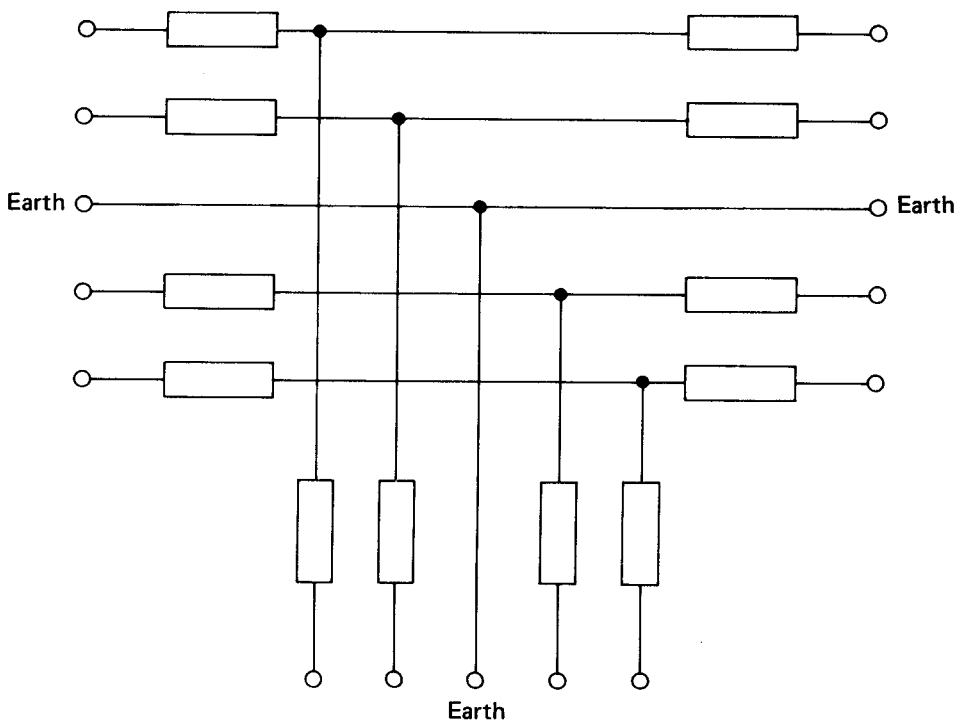


Figure 2 — Duplex point-to-point operation



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

Figure 3 — Multi-drop operation



NOTE All resistors 100 Ω ± 5 %.

Figure 4 — Resistive node

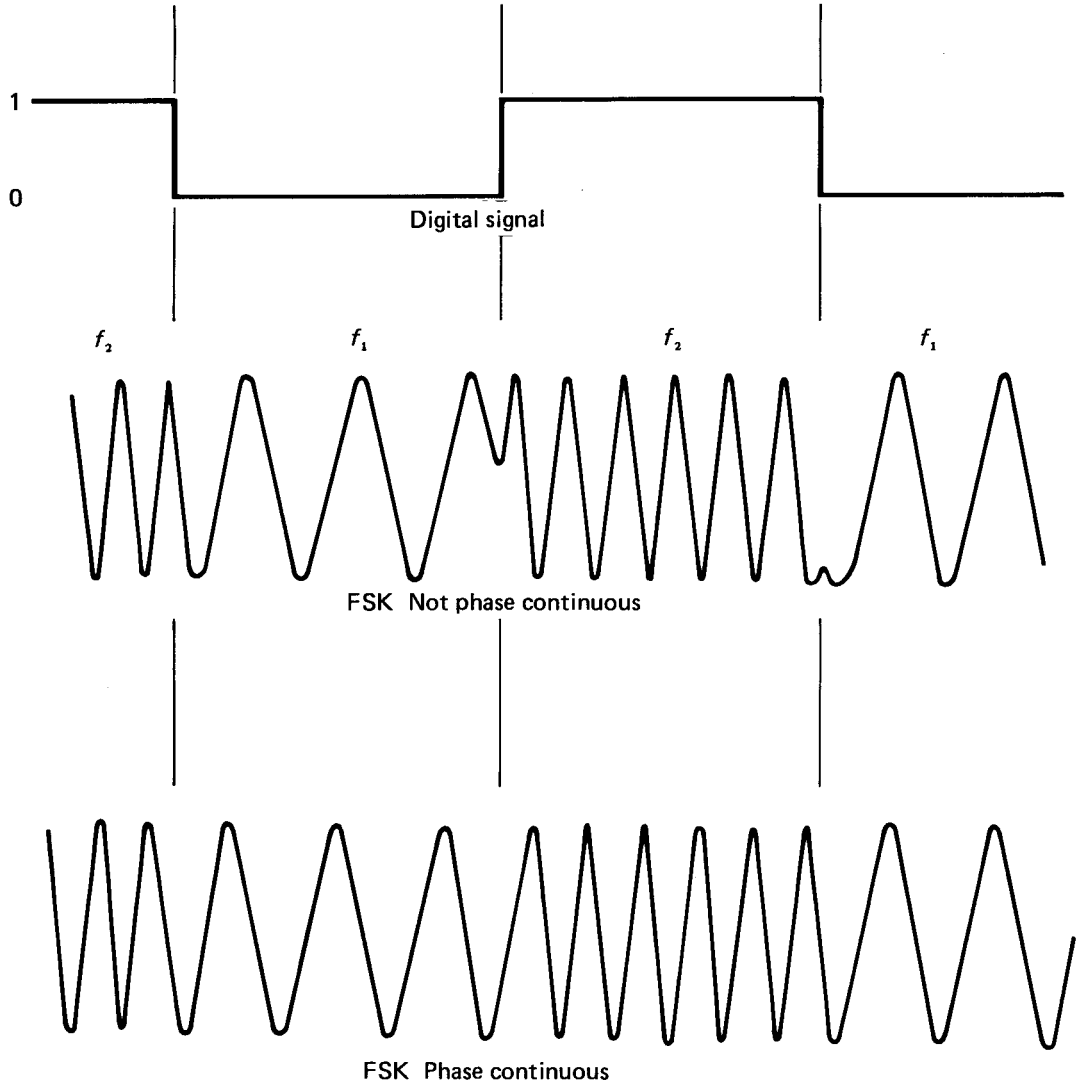
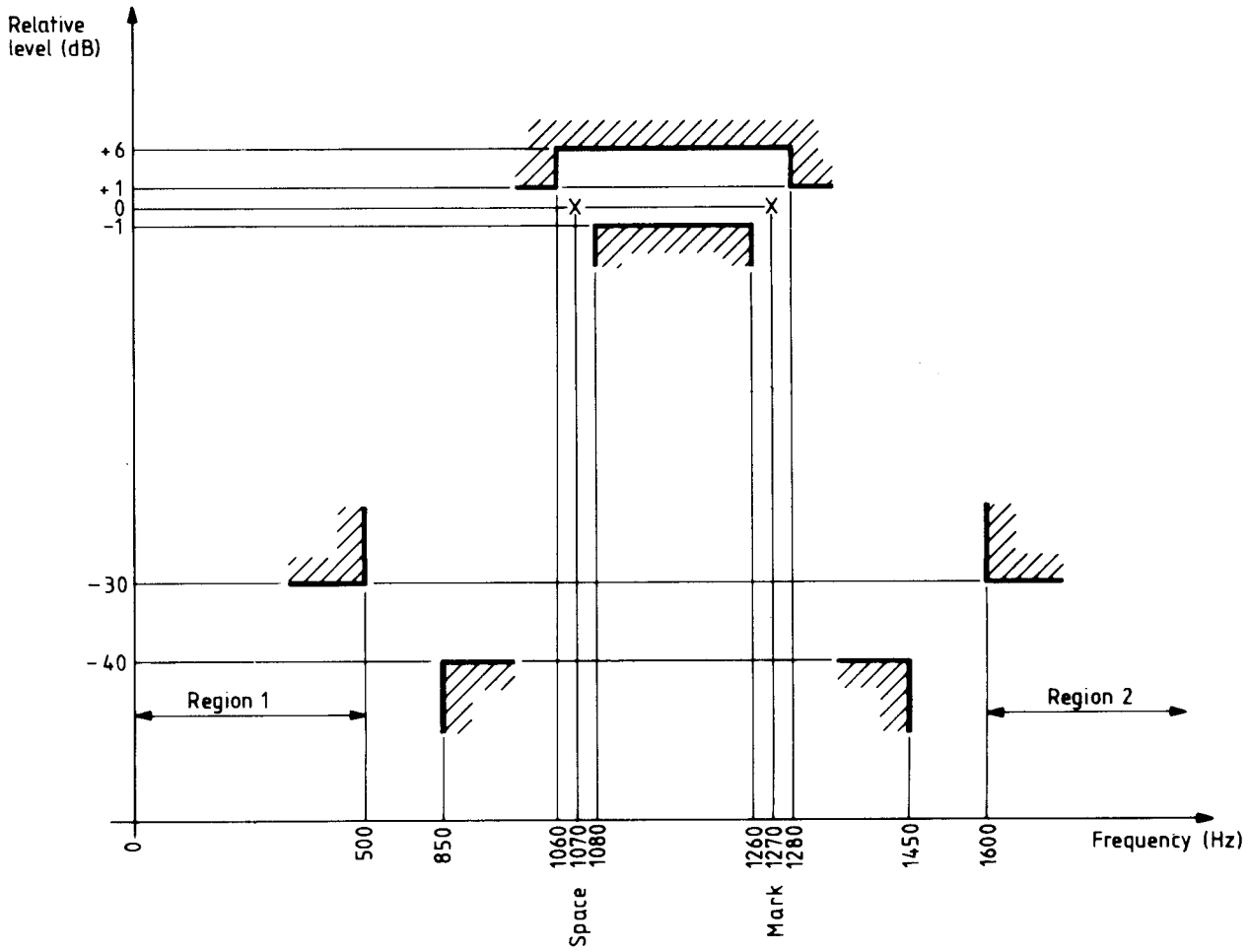
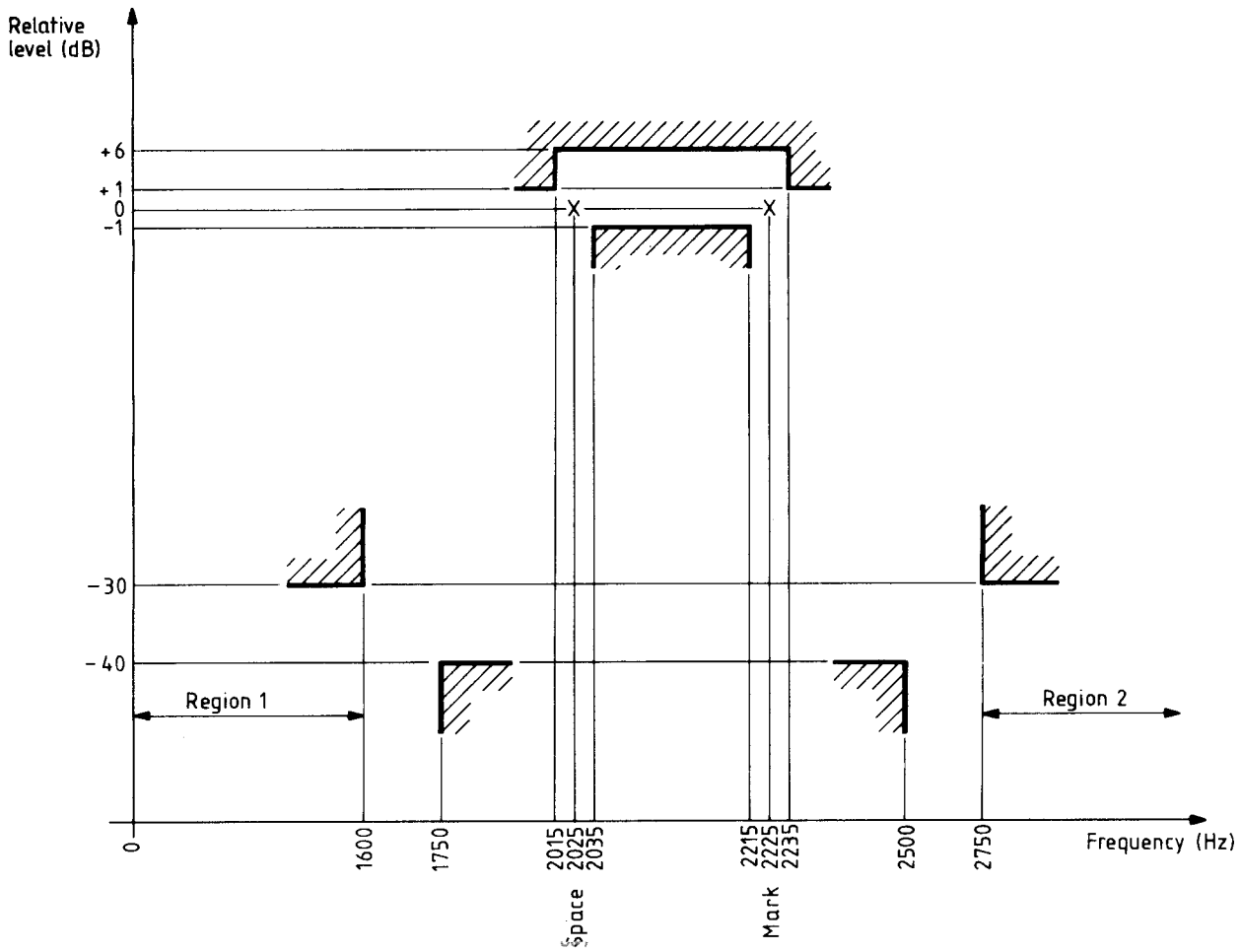


Figure 5 — Frequency shift keying (FSK)



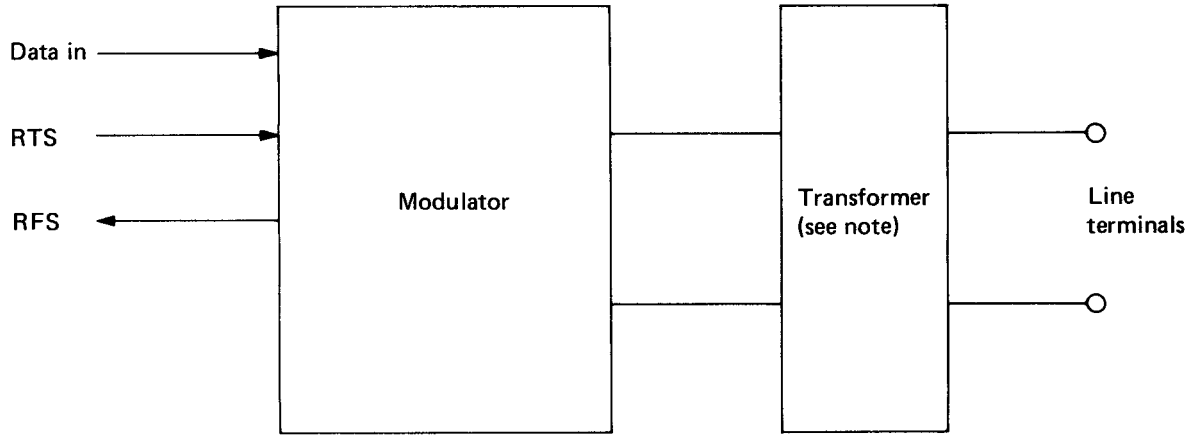
NOTE 1 Reference level at mark frequency.
NOTE 2 Roll off ⩾ 20 dB/DEC in regions 1 and 2.
NOTE 3 See also absolute limits on mark and space amplitude as specified in clause **9**.
NOTE 4 The spectrum should pass between the hatched corners of the diagram.
NOTE 5 The spectrum should be measured at the line terminals whilst transmitting a 511 bit pseudo-random sequence (see Figure 11).

Figure 6 — Originate channel spectrum limits



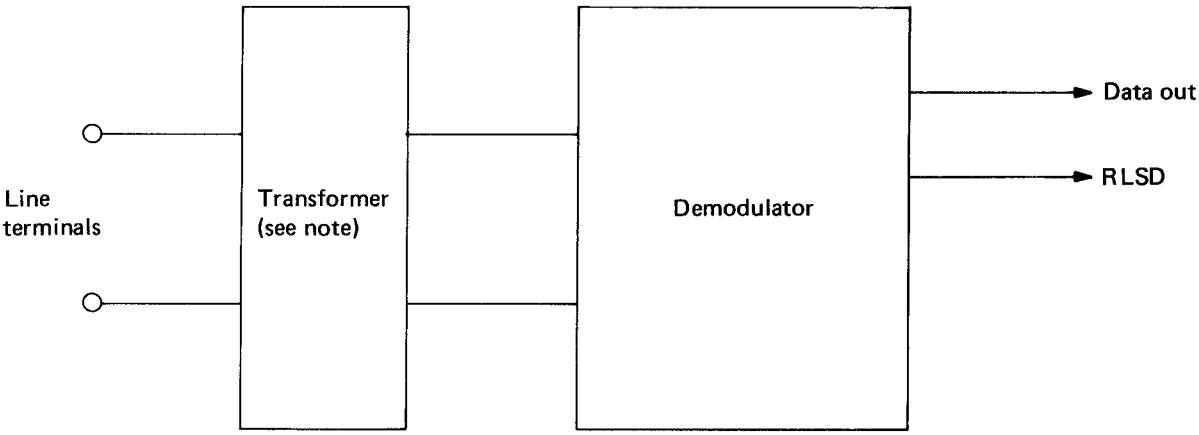
NOTE 1 Reference level at mark frequency.
NOTE 2 Roll off $\geqslant$ 20 dB/DEC in regions 1 and 2.
NOTE 3 See also absolute limits on mark and space amplitude as specified in clause **9**.
NOTE 4 The spectrum should pass between the hatched corners of the diagram.
NOTE 5 The spectrum should be measured at the line terminals whilst transmitting a 511 bit pseudo-random sequence (see Figure 11).

Figure 7 — Answer channel spectrum limits



NOTE The connections between the transformer and the transmission line may have to include safety components to meet the requirements of clause **14**.

Figure 8 — Modulator configuration



NOTE The connections between the transformer and the transmission line may have to include safety components to meet the requirements of clause **14**.

Figure 9 — Demodulator configuration

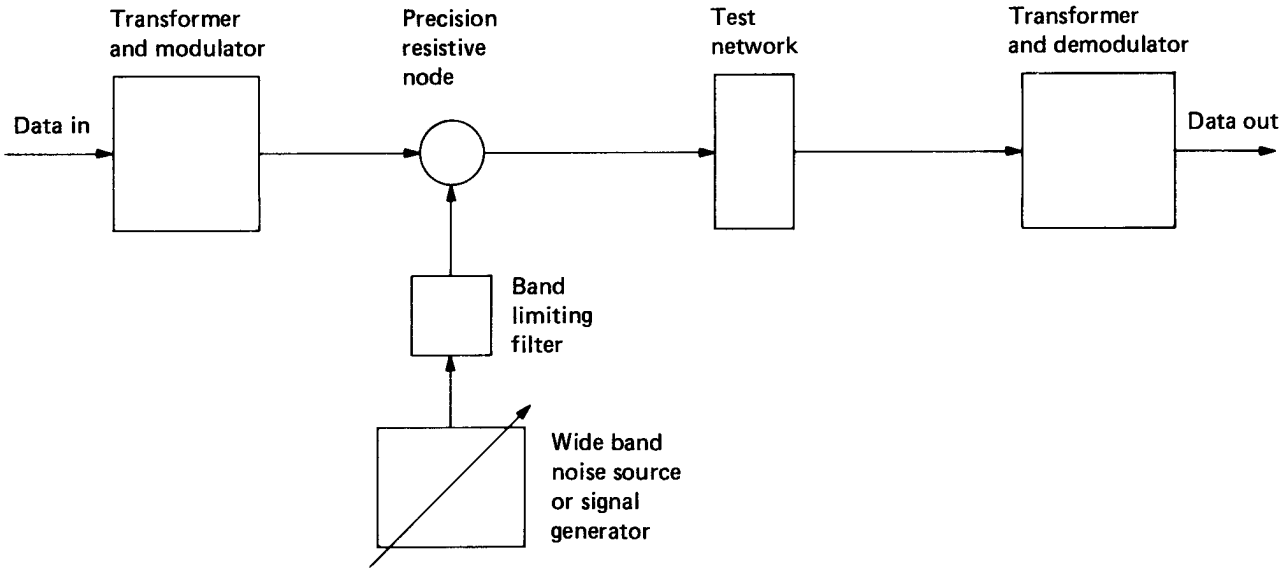


Figure 10 — Performance test configuration

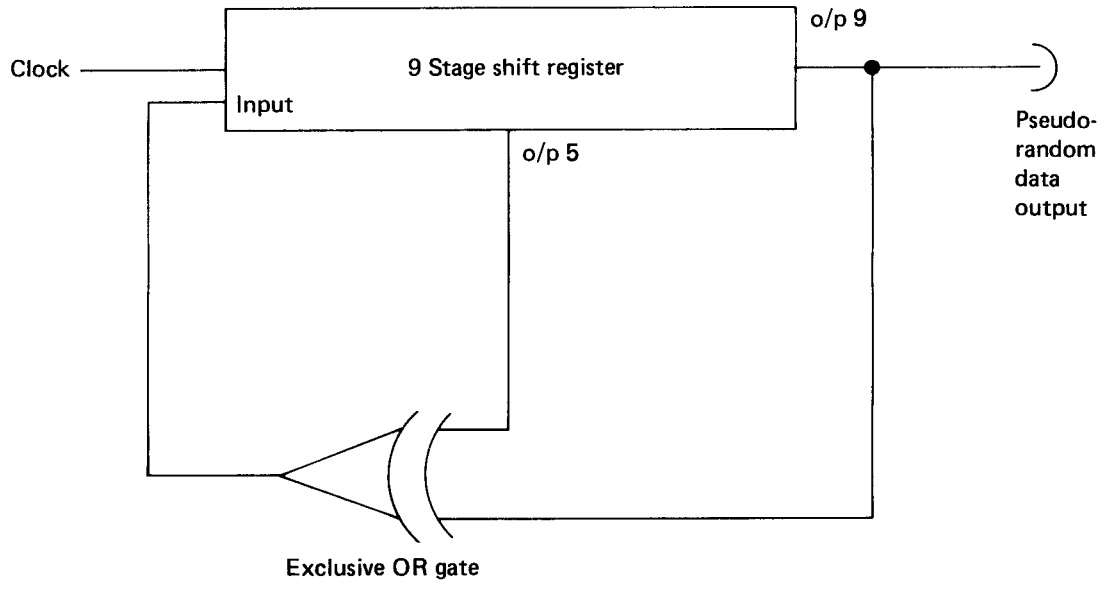


Figure 11 — Generator of 511 bit pseudo-random data

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 the core configuration shown in Figure 12;

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.

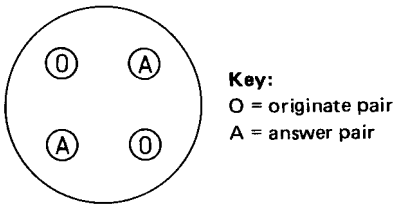


Figure 12 — Core configuration of cable

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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 instrinsically 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 6556-1, *Specification for optical coupling.*
BS 6556-3, *Specification for message protocols*[2)].

[2)] Referred to in the foreword only.

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