มาตรฐานผลิตภัณฑ์อุตสาหกรรม

THAI INDUSTRIAL STANDARD

มอก. 2267 เล่ม 2 – 2549

IEC 62026 – 2(2000 – 07)

ชุดประกอบอุปกรณ์ตัดต่อและชุดประกอบอุปกรณ์ควบคุมแรงดันต่ำ – การจัดประสานส่วนควบคุมกับกลอุปกรณ์ –

เล่ม 2 : การจัดประสานแบบ AS-i

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

CONTROLLER-DEVICE INTERFACES (CDIs) –

PART 2 : ACTUATOR SENSOR INTERFACE (AS–i)

สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม

กระทรวงอุตสาหกรรม ICS 29.130.20 ISBN 974-1509-53-7

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วันที่ 28 มีนาคม พุทธศักราช 2550

เพื่อเป็นการส่งเสริมอุตสาหกรรม จึงกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรมชุดประกอบอุปกรณ์ตัดต่อและชุดประกอบ อุปกรณ์ควบคุมแรงดันต่ำ - การจัดประสานส่วนควบคุมกับกลอุปกรณ์ - เล่ม 2 : การจัดประสานแบบ AS-i ขึ้น

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นโดยรับ IEC 62026 - 2 (2000 - 07) LOW - VOLTAGE SWITCHGEAR AND CONTROLGEAR – CONTROLLER - DEVICE INTERFACES (CDIs) – Part 2 : Actuator sensor Interface (AS-i) มาใช้ในระดับเหมือนกันทุกประการ (Identical) โดยใช้ IEC ฉบับภาษาอังกฤษเป็นหลัก

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นเพื่อใช้ในการอ้างอิง และเพื่อให้ทันกับความต้องการของผู้ใช้มาตรฐาน ซึ่งจะได้แปลเป็นภาษาไทยในโอกาสอันควรต่อไป หากมีข้อสงสัยโปรดติดต่อสอบถามสำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม

คณะกรรมการมาตรฐานผลิตภัณฑ์อุตสาหกรรมได้พิจารณามาตรฐานนี้แล้ว เห็นสมควรเสนอรัฐมนตรีประกาศตามมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511

ประกาศกระทรวงอุตสาหกรรม

ฉบับที่ 3571 (พ.ศ. 2549)

ออกตามความในพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม

พ.ศ. 2511

เรื่อง กำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม

ชุดประกอบอุปกรณ์ตัดต่อและชุดประกอบอุปกรณ์ควบคุมแรงดันต่ำ –

การจัดประสานส่วนควบคุมกับกลอุปกรณ์ –

เล่ม 2 : การจัดประสานแบบ AS–i

อาศัยอำนาจตามความในมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ.2511 รัฐมนตรีว่าการกระทรวงอุตสาหกรรมออกประกาศกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม ชุดประกอบอุปกรณ์ตัดต่อและชุดประกอบอุปกรณ์ควบคุมแรงดันต่ำ – การจัดประสานส่วนควบคุมกับกลอุปกรณ์ – เล่ม 2 : การจัดประสานแบบ AS–i มาตรฐานเลขที่ มอก. 2267 เล่ม 2–2549 ไว้ ดังมีรายละเอียดต่อท้ายประกาศนี้

ประกาศ ณ วันที่ 6 พฤศจิกายน พ.ศ. 2549

โฆสิต ปั้นเปี่ยมรัษฎ์

รัฐมนตรีว่าการกระทรวงอุตสาหกรรม

มาตรฐานผลิตภัณฑ์อุตสาหกรรม
ชุดประกอบอุปกรณ์ตัดต่อและชุดประกอบอุปกรณ์ควบคุมแรงดันต่ำ – การจัดประสานส่วนควบคุมกับกลอุปกรณ์ –
เล่ม 2 : การจัดประสานแบบ AS–i

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นโดยรับ IEC 62026 - 2 (2000 - 07) LOW - VOLTAGE SWITCHGEAR AND CONTROLGEAR – CONTROLLER - DEVICE INTERFACES (CDIs) – Part 2 : Actuator sensor Interface (AS-i) มาใช้ในระดับเหมือนกันทุกประการ (Identical) โดยใช้ IEC ฉบับภาษาอังกฤษเป็นหลัก

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้ เหมาะสมที่จะใช้กับการจัดประสานอุปกรณ์วงจรควบคุมเดี่ยวเข้ากับตัวตัดต่อวงจรที่รับส่งข้อมูลและกำลังไฟฟ้าระหว่างกันด้วยสายเคเบิลเดี่ยวชนิด 2 ลวดตัวนำซึ่งไม่มีกำบังและไม่ตีเกลียวแกน

วัตถุประสงค์ของมาตรฐานเล่มนี้เพื่อกำหนดคุณลักษณะที่ต้องการต่อซีดีไอรูปแบบนี้ ดังนี้

- การจัดประสานตัวควบคุมกับตัวตัดต่อวงจร
- การทำงานสภาวะปกติของอุปกรณ์
- โครงสร้างและการทำงาน
- การทดสอบแสดงความเป็นไปตามข้อกำหนดของคุณลักษณะที่ต้องการ

เพื่อใช้เป็นข้อกำหนดเพิ่มเติมเข้ากับที่ระบุไว้ใน มอก. 2267 เล่ม 1 - 2549 (IEC 62026-1 (2000-07))

รายละเอียดให้เป็นไปตาม IEC 62026 - 2 (2000 - 07)

INTRODUCTION

The provisions of the general rules in IEC 62026-1 are applicable to this International Standard, where specifically called for. General rules clauses and subclauses thus applicable, as well as tables, figures and annexes, are identified by reference to part 1, for example subclause 7.2.4.1 of IEC 62026-1.

Where inputs and outputs (I/O) are described in this standard, their meaning is regarding the master, the meaning regarding the application is the opposite.

Clauses 1 to 8 contain the general requirements. Clause 9 contains the test specifications. Specific requirements for the various profiles of actuators, sensors, masters, etc. are given in the relevant annexes.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR – CONTROLLER-DEVICE INTERFACES (CDIs) –

Part 2: Actuator sensor interface (AS-i)

1 Scope

This International Standard applies to interfaces between low-voltage switchgear and controlgear switching elements, and controllers (e.g. programmable controllers, personal computers, etc.).

This standard specifies a bit-oriented interface-system between a single control circuit device and switching elements, connected by a nonshielded, untwisted two-wire cable, carrying data and power, and establishes a system for the interchangeability of components with such interfaces.

The object of this standard is to define, for such interfaces:

– requirements for interfaces between a slave, a master and electromechanical structures;
– normal service conditions for slaves, electromechanical devices and masters;
– constructional and performance requirements;
– tests to verify conformance to requirements.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

CISPR 11:1997, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*

IEC 60364-4-41:1992, *Electrical installations of buildings – Part 4: Protection for safety – Chapter 41: Protection against electric shock*

IEC 60947-1:1999, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-5-2:1997, *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches*

IEC 60998-2-3:1991, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-3: Particular requirements for connecting devices as separate entities with insulation piercing clamping units*

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test.* Basic EMC publication

IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test.* Basic EMC publication

IEC 61000-6-2:1999*, Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61131-2:1992, *Programmable controllers – Part 2: Equipment requirements and tests*

IEC 62026-1:2000, *Low-voltage switchgear and controlgear – Controller-device interfaces (CDIs) – Part 1: General rules*

3 Definitions, symbols and abbreviations

Alphabetical index of definitions *References*

3.1 Definitions

For the purpose of this International Standard, clause 3 of IEC 62026-1 applies with the following additions.

3.1.1
active slave
slave connected to the AS-i line and capable of communicating properly

3.1.2
Actuator Sensor interface (AS-i)
set of interfaces and serial communication method for the connection of low-voltage switchgear, controlgear and other simple devices with a controller

3.1.3
address
numerical parameter between 0 and 31 which specifies a node of an AS-i network

NOTE Address 0 is reserved for slaves which have not had an address assigned.

3.1.4
address assignment
replacement of the existing address of the AS-i slave with a new address

3.1.5
AS-i cycle
set of up to 33 transactions

NOTE A transaction may, in case of a detected fault, include one master request or slave response retransmission.

3.1.6
AS-i input
physical (external) or logical (internal) slave input port (see figure 1)

3.1.7
AS-i line
two-wire cable utilized by AS-i slaves and the AS-i master for transferring information and power

3.1.8
AS-i master
unit on the AS-i line that manages the communication between the slaves and the controller

3.1.9
AS-i network
network composed of AS-i master, slaves, power supply and line

3.1.10
AS-i output
physical (external) or logical (internal) slave output port (see figure 1)

3.1.11
AS-i power supply
combined d.c. supply and decoupling circuit needed for an AS-i network

3.1.12
AS-i slave
physical and logical means to connect the application devices (actuator, sensor or other components) to the AS-i line

NOTE A slave may be a stand alone device or part of another device.

3.1.13
bit time (effective) (T_{bit})
duration of the transmission of one bit

3.1.14
decoupling circuit
part of the AS-i power supply for decoupling the d.c. source and for conditioning the physical data transmission within the AS-i network

3.1.15
field devices
items connected to the AS-i slave, for example actuators, sensors, push-buttons, indicator lights, etc.

NOTE "Intelligent" field devices also include integrated AS-i circuitry.

3.1.16
I/O configuration (I/O code)
set of four bits which defines the direction of data flow at the four I/O ports of a slave

3.1.17
identification code (ID code)
set of four bits which defines the type of slave profile for a given I/O configuration

3.1.18
master pause
time between the last bit of a master request and the first bit of the slave response to the master

3.1.19
master request
data or parameter or function sent from the master to a single slave. The content of this master request is either data (to be moved to the output ports of the slave), parameters or a command

3.1.20
non-volatile stored data
data that remains unchanged following power interruption

3.1.21
operation address
address of the AS-i slave other than the zero address

3.1.22
output current limit I_{Lim}
output current of the power supply not to be exceeded under all environmental and load conditions

3.1.23
send pause
period after receipt of the slave response during which no subsequent transmission occurs

3.1.24
slave pause
minimum time between the last bit of a slave response and the start of the first bit of the next master request

3.1.25
slave response
message from the slave to the master after a master request has been received and processed without error. The content of this response is either data or the result of a command

3.1.26
transaction
combination of a master request, master pause, slave response and send pause (see figure 5)

3.1.27
volatile stored data
data that may change following power interruption

3.1.28
zero address
special address reserved for the online assignment of a new address to an AS-i slave

3.2 Symbols and abbreviations

APF	AS-i power failure
APM	Alternate pulse modulation
APO	AS-i power-ON
AS-i	Actuator sensor interface
T_{bit}	Bit period
TS	Transaction status
U_{b}	Power supply voltage
U_{send}	Peak value of the voltage pulses
$u(t)$	Pulse waveform

4 Classification

4.1 Overview

AS-i will usually be applied at the lowest level in a multi-level automation hierarchy. AS-i concentrates on the typical requirements to connect binary elements with a controller.

AS-i can be used as an interface physically integrated into field devices, for example actuators, sensors, or other devices and elements themselves, allowing the design of "intelligent" binary actuators, sensors, or other devices and elements. Alternatively, AS-i may be used in separate modules, each providing an interface for up to four conventional actuators and/or sensors or other devices and elements.

The AS-i structure contains two different types of interface, three logical and six physical, as shown in figure 1.

Logically, the AS-i system is a master-slave communication system composed of a single master and up to 31 slaves. The master sends data and parameters to each specific slave. The slave passes the data to the output ports or processes the requested procedure (e.g. reset_slave) and returns the input data or the result of the successfully processed procedure to the master.

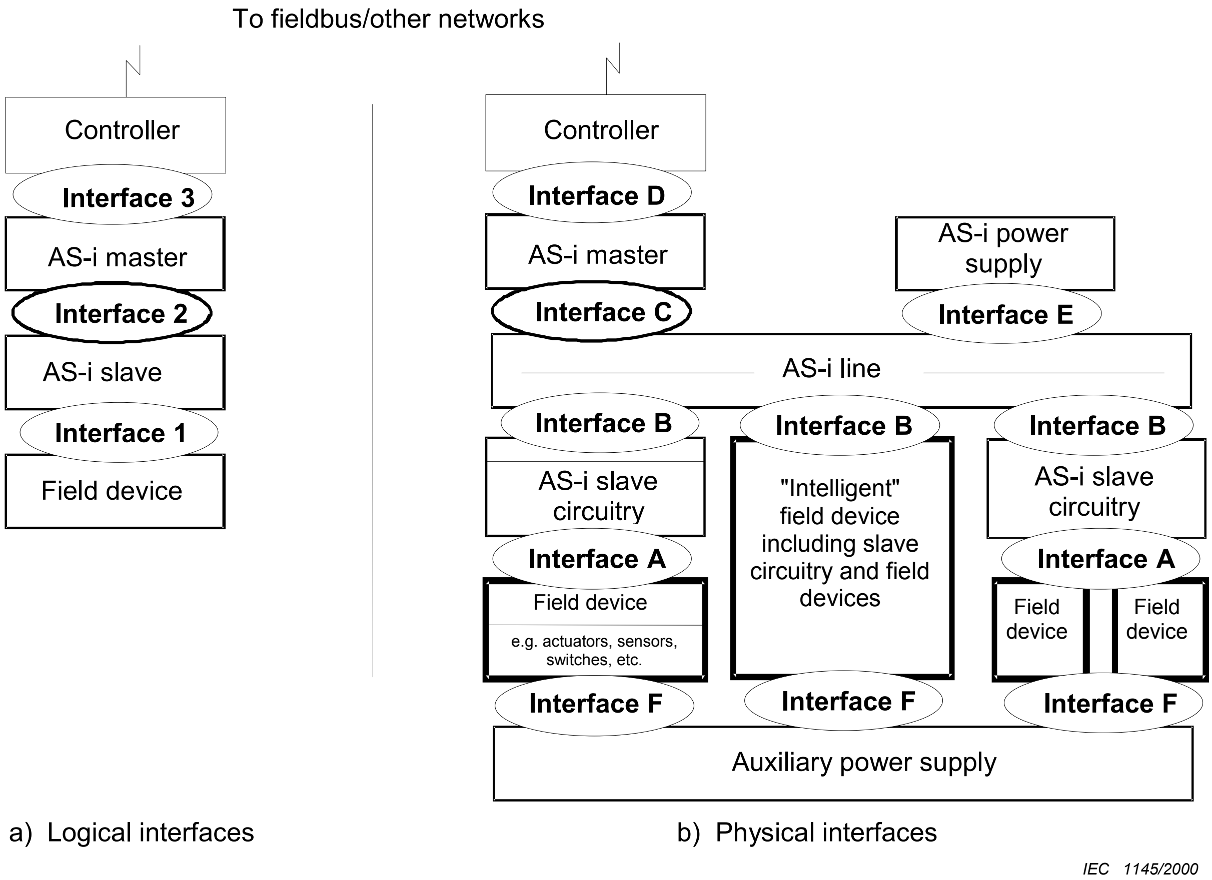


Figure 1 – AS-i components and interfaces

The AS-i concept is independent of the specific field devices. It defines the mechanisms and all the components for the communication with a controller and it offers electromechanical structures for a standardized "interconnection system" for installation of actuators, sensors, or other devices and elements.

Normally, more than one standard field device may be connected via the physical interface A to the slave.

"Intelligent field devices" contain the slave circuitry, the physical interface A and the field device itself.

The annexes define profiles for common types of field devices, that will often be used in AS-i systems.

4.2 Components and interfaces

As shown in figure 1, the AS-i system deals with components, and logical and physical interfaces.

4.2.1 Components

AS-i slave	Includes the circuitry which determines the logical and functional behaviour of the unit, and which can be accessed by the master via the AS-i line for data exchange, parameterization and monitoring. It responds to a specific request from the master and it ensures that a malfunction of the attached actuator, sensor, other device or of the slave itself shall not disturb the communication between the master and the other slaves in the network.
AS-i master	Includes the circuitry which determines the logical and functional behaviour of the unit which organizes and monitors the network, and schedules the exchange of data, parameters and commands with the AS-i slave via the AS-i line. The AS-i master sends master requests to an AS-i slave and receives slave responses from it.
AS-i power supply	Provides power to the AS-i network and includes the decoupling circuitry.
AS-i line	Provides the signalling and d.c. power connections between the AS-i devices.

4.2.2 Logical interfaces

Interface 1	The slave interface which connects the AS-i slave with the actuators, sensors, or other devices and elements. It is characterized by several ports which define the input, output or bi-directional input/output behaviour, the parameterization behaviour of the AS-i slave and the timing of the signals.
Interface 2	Provides all logical definitions required for data exchange between the AS-i master and slaves. It comprises the signalling of encoded information and the network management.
Interface 3	Provides all functions used by the controller (host) to access the AS-i master for sending and receiving data to and from slaves, sending commands to a slave, to set or to get flags and values for several lists in the master. This interface allows the controller to manage the AS-i master's behaviour and thus the behaviour of the AS-i system. Typical functions include "set_something" in the master or "get_some_information" from the master. This interface is conceptual in nature and its definition is outside the scope of this standard. The concrete representation of the interface depends on the implementation. To a large extent, it depends on the features of the specific controller system.

4.2.3 Physical interfaces

Interface A	Defines the physical connection between the field device and the AS-i slave circuitry including physical interface, signal levels and power requirements, if any.
Interface B	Defines the physical connection of the AS-i slave circuitry to the AS-i line including physical interface (mechanical/electrical), signal characteristics and power requirements.

Interface C	Defines the physical connection of the AS-i master circuitry to the AS-i line including physical interface (mechanical/electrical), signal characteristics and power requirements.
Interface D	The definition of the physical interface is outside the scope of this standard and shall be provided by the manufacturer.
Interface E	Defines the physical connection of the AS-i power supply including the signal decoupling circuit to the AS-i line.
Interface F	Defines the physical interface between the field device and an external auxiliary power supply, if any.

5 Characteristics

5.1 AS-i components

The AS-i components are described in the relevant annexes.

5.2 AS-i transmission system

5.2.1 General

The AS-i transmission system provides the communication between the AS-i slaves and the AS-i master, i.e. it represents interface 2 between a master and the slaves (see figure 1).

The AS-i system is a digital, serial, multidrop data communication with actuators and sensors including simultaneous power supply. The following specifies the transmission of data between the master and a specific slave.

5.2.2 Signal characteristics

The characteristics of the transmitted signal and the modulation are defined in this subclause.

The bit time (T_{bit}) shall be 6 µs. Thus the bit rate shall be 166 $^2/_3$ kbit/s. The maximum deviation from the nominal bit time shall not exceed ±0,2 %.

The transmission coding and encoding principle shall be as shown in figure 2. Each master request or slave response shall include a start and an end bit. The idle state shall be represented by a "1". The Master request or slave response are encoded in Manchester II format with alternate pulse modulation (APM). The duration of each bit shall be 6 µs.

A "0" shall be encoded by a period of 3 µs high level followed by a period of 3 µs low level. A "1" shall be encoded by a period of 3 µs low level followed by a period of 3 µs high level. The transmitter shall be implemented as a current sink. The amplitude of the modulation current shall be between 55 mA and 68 mA. Together with the decoupling inductances of the decoupling circuit in the power supply, this current leads to a negative voltage pulse at each rising edge and a positive voltage pulse at each falling edge. The waveform of the pulses shall be ideally:

$$u(t) \approx \pm U_{send} \times \sin^2\left(\frac{2\pi}{6\ \mu s} t\right)$$

$$U_{send} = \text{Const} \approx 2\ \text{V} \quad \text{(see figure 2)}$$

NOTE In a real AS-i system, the falling edge of the pulses is flattened due to the behaviour of the decoupling circuit and the physical properties of the AS-i line.

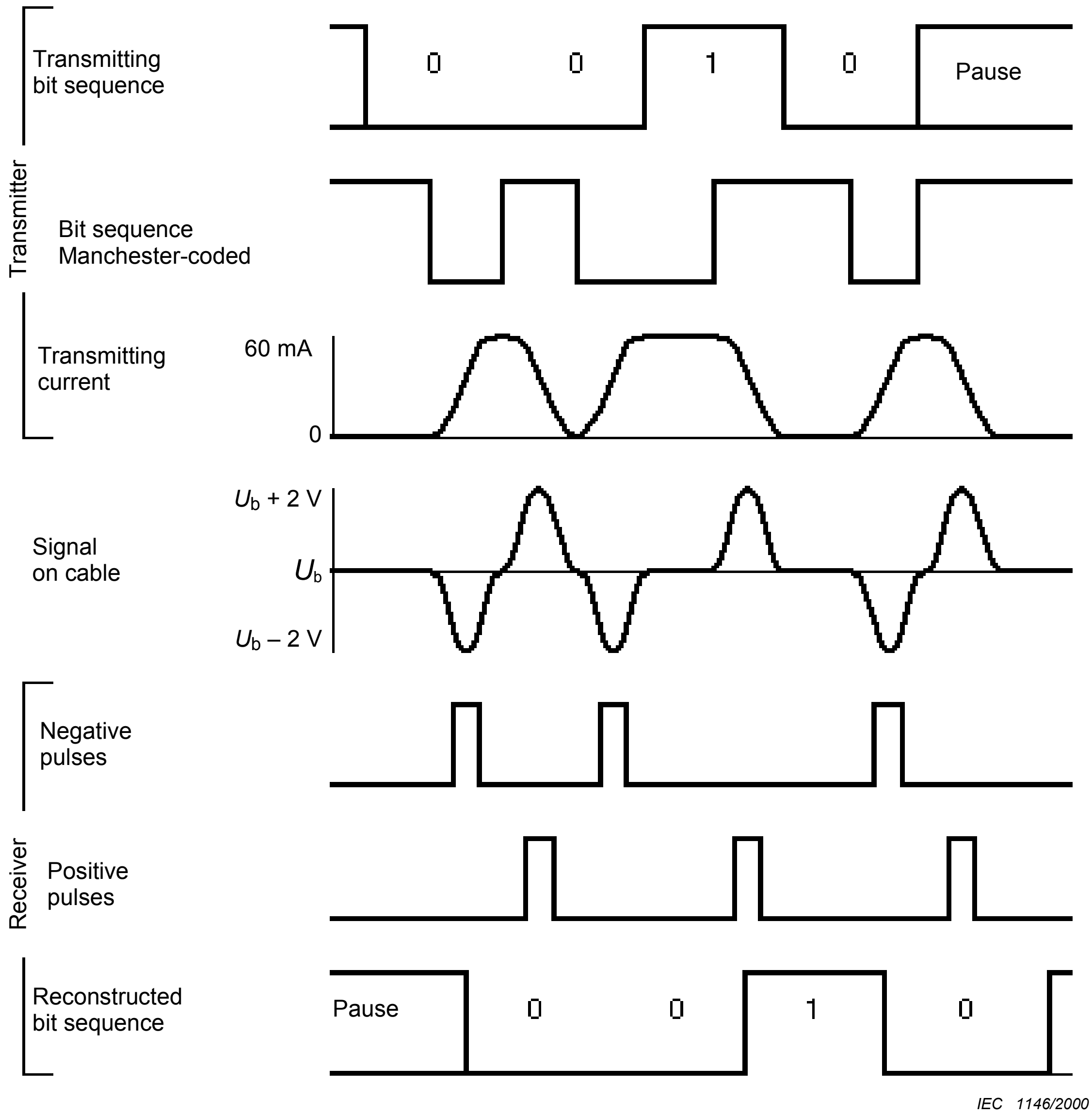


Figure 2 – Transmission coding and encoding principle

5.2.3 Power and data distribution

The simultaneous transmission of data and power on the AS-i line requires technical provisions for decoupling data and power.

The AS-i power supply shall provide the d.c. power requirements of all devices on the AS-i line. Furthermore, it shall perform the main conditioning of the physical data transmission within the system. This comprises the transmission signal forming and adaptation to the cable wave guide magnitude as well as ensuring the symmetry of the AS-i line. The adaptation is provided by a decoupling circuit.

NOTE Power distribution and data distribution are not interdependent but are combined in the AS-i line to reduce cabling requirements.

The galvanic isolation of the AS-i line from the equipment ground shall be according to figure 3. Externally connected components shall meet the PELV requirements of IEC 60364-4-41.

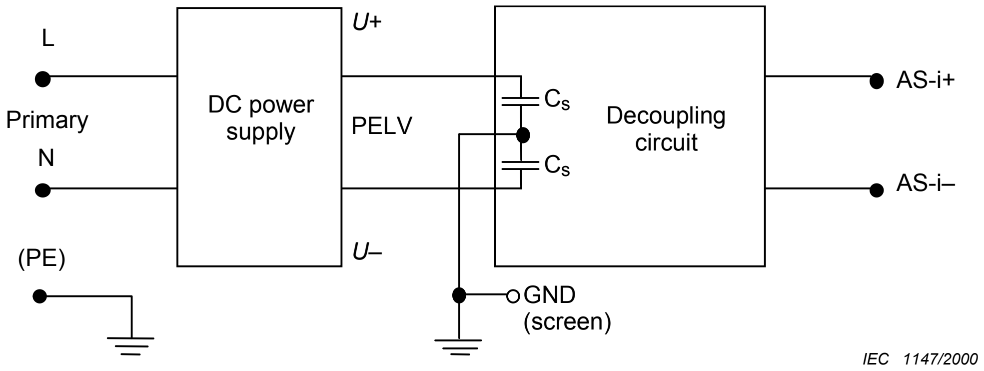


Figure 3 – AS-i power supply incorporating the decoupling circuit

5.3 AS-i topology

The AS-i system is a master-slave communication system composed of a single master and up to 31 slaves. Each slave shall have a unique address in the range 1 to 31. This address is called the operation address. The operation address shall be non-volatile.

The zero address is used during the change of a slave address. Normally, the zero address is non volatile for factory new slaves.

A single transaction shall be composed of a master request and a slave response. If a slave responds to a master request, it shall start its response within a period of 2,5 to 5,5 bit times after the end of a master request. The master shall be able to accept the start of a slave response within a period of 2,5 to 10 bit times after the end of its request to allow for propagation delay on the line and the possible use of repeaters.

A slave shall not respond if it detects an erroneous master request. The slave shall not give any negative response. The master shall interpret the absence of a slave response as a negative response.

5.4 Data transmission

A data exchange shall be realized by the processing of transactions (see figure 4). A transaction shall start with a master request (issued by the master to transfer data or a command to the slave). The master shall expect a slave response (issued by the slave to transfer data or a command result to the master) within a certain time. If the master does not receive a valid response from the slave within this time, it may retransmit the master request once. After receiving a valid response and after the send pause has elapsed, the master shall start the next transaction.

The AS-i master shall provide means for sending one master request by the master to a single slave and receiving a slave response from the slave. At a given time, the master shall process one, and only one, master request or slave response. After a transaction has been finished, the next transfer can be processed by the master. In case of failure, no more than one retransmission shall be processed in the same cycle.

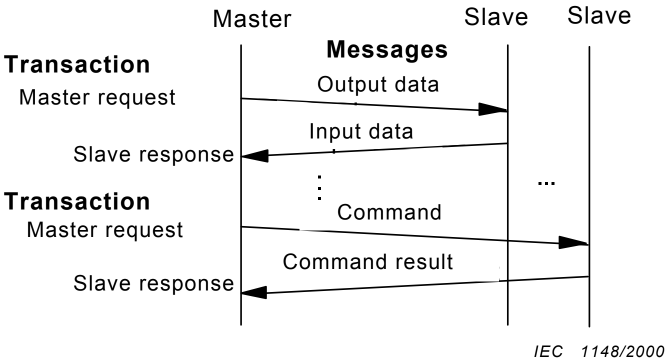


Figure 4 – Transactions

All times specified in this subclause are related to the signals on the AS-i line at the master terminals.

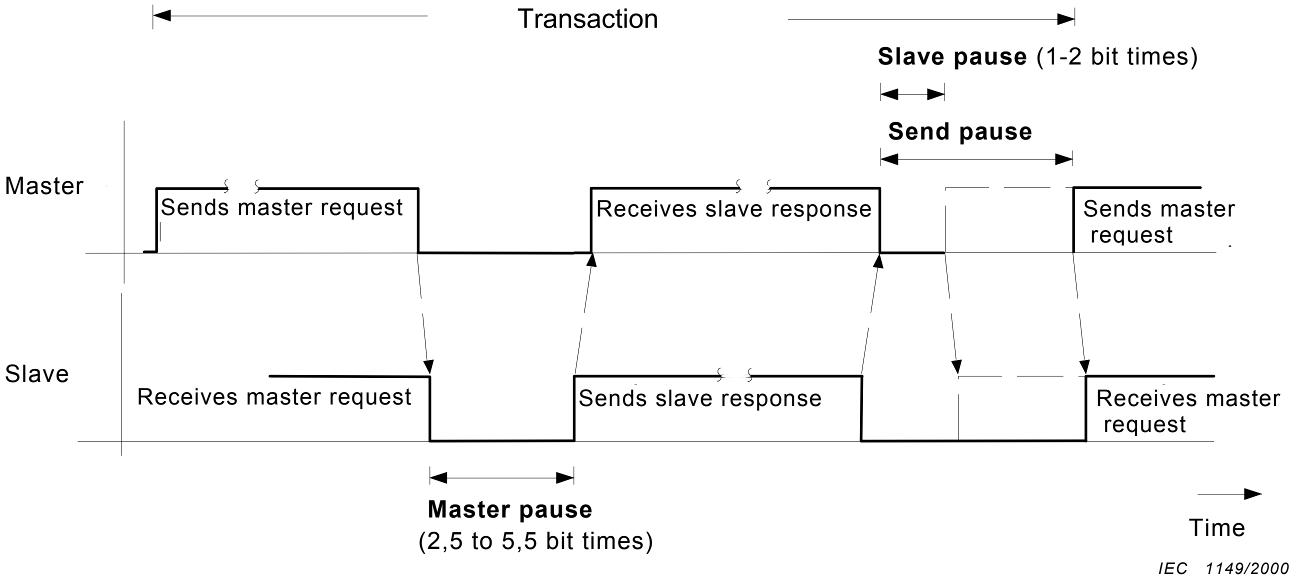


Figure 5 – Transaction cycle

A transaction shall be split into two actions (master request and slave response) and two time intervals (master pause and send pause) according to figure 5.

Master request	Sending a master request from the master to a single slave and expecting a response from the slave.
Master pause	During this time, the slave processes the requested function and produces the response data.
Slave response	Transmission of the slave data or the command result to the master.
Slave pause	After receipt of the slave response, there shall be a minimum period during which no subsequent transmission shall occur. This pause shall be 1 to 2 bit times.
Send pause	After receipt of the slave response, there shall be a minimum period during which no subsequent transmission shall occur. During normal operation with more than 30 transactions per AS-i cycle, the time of this pause shall be one slave pause. If there are 30 or less transactions per AS-i cycle, the send pause may be prolonged to a maximum of 500 µs. In this case, the AS-i cycle time shall not be longer than 5 ms.

Slave response time-out	If no response is received from the slave within a defined time (the slave response time-out) the master shall either end the transaction or repeat the transmission. This time shall be a maximum of 10 bit times. This time shall be determined by the master pause, signal propagation on the line and the repeaters. The time-out timer shall start at the end of the transmission of the master request. Within the slave response time-out, the master expects the beginning of a response frame from the slave. After this time, the transmission function determines the absence of a slave response.

During the send pause, the master shall not transmit any signal. It shall sense the AS-i line to allow the detection of an end bit error.

Subsequent data shall be transmitted only if the AS-i line was idle for at least the duration of a slave pause, after the beginning of the send pause. Every disturbance of this idle state shall cause a restart of the send pause.

A transaction shall be considered successfully processed if:

- **after** the minimum master pause and
- **before** the time of the slave response time-out + 7 T_{bit} has elapsed,
- a **valid** slave response has been received.

After Master Power-On (MPO), the master shall process a send pause.

5.5 AS-i transactions

5.5.1 AS-i transaction types

Four AS-i transaction types are defined in table 1 for data exchange, parameterization, network management and diagnostics. All master requests and slave responses have the same structure and the same length of 14 bits (master request) and 7 bits (slave response).

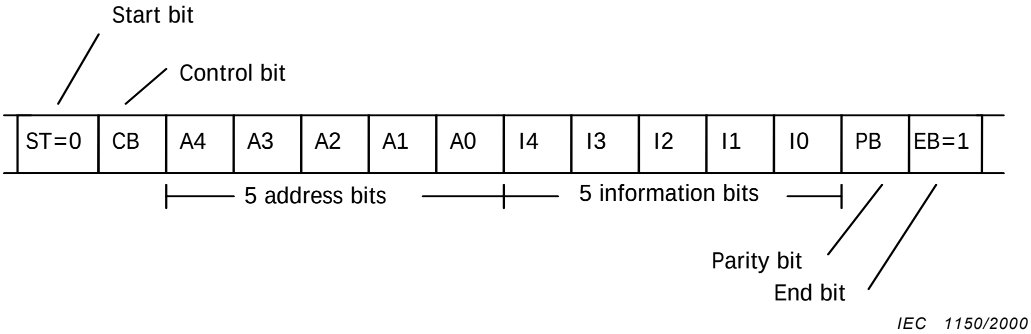
Table 1 – AS-i transaction types

Data_exchange	Delivery and/or receipt of the bit pattern to/from the data output/input ports of the slave
Write_parameter	Delivery of the bit pattern to the parameter ports of the slave
Address_assignment	Assignment of a non-volatile address (1...31) to a slave to replace a zero address
Commands	Miscellaneous functions: reset_slave delete_address read_I/O_configuration read_identification_code read_status read_reset_status reserve_R1

The master may be able to issue all or only some of the requests (according to a specific master profile), whereas any slave shall be able to respond to all master requests defined (with the possible exception of the address_assignment request).

5.5.2 Structure of the master request

The master request shall be composed as follows:



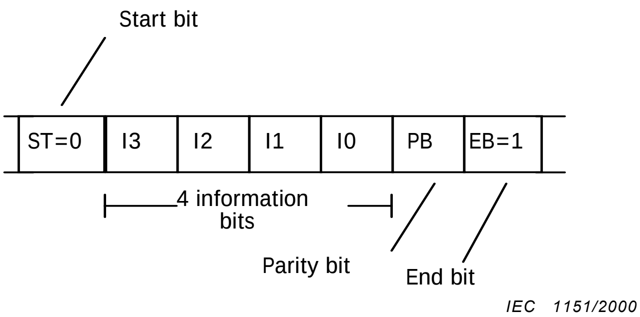
The meaning of each bit shall be as shown in table 2.

Table 2 – Master request

Bit string	Semantic	Comments
ST	Start bit	Identifies the beginning of the master request, always 0
CB	Control bit	Identifies the data/parameter transmission in the information cell 0 = data/parameter transmission/address assignment 1 = command transmission
A4..A0	Address (5 bits)	To address the listed slaves 0x00 = zero address 0x01...0x1F = slave 1 through 31
I4..I0	Information	These five bits contain the information to be transferred to the slave for every request type.
PB	Parity bit	For verification of master requests by the slave The master request has even parity. 0 = even count of 1-symbols in (CB, A4...A0, I4...I0) 1 = odd count of 1-symbols in (CB, A4...A0, I4...I0)
EB	End bit	Marks the end of the master request

5.5.3 Structure of the slave response

The slave response shall be composed as follows:



The meaning of each bit shall be as shown in table 3.

Table 3 – Slave response

Bit string	Semantic	Comments
ST	Start bit	Marks the slave response beginning
I3...I0	Information	Information of the slave response
PB	Parity bit	For verification of master requests by the slave The master request has even parity. 0 = even count of 1-symbols in (I3...I0) 1 = odd count of 1-symbols in (I3...I0)
EB	End bit	Marks of the end of the slave response

5.5.4 Individual AS-i transactions

5.5.4.1 General

This subclause describes the different transactions. The detailed functions of a slave after receiving a master request are defined in conjunction with the slave specification (slave reactions, see 8.2.1).

All other codes (bit patterns of transactions not defined in this standard) are reserved and shall not be used by any implementation.

5.5.4.2 Data_exchange

The data_exchange request shall be used by the master to transfer four bits of data (I3...I0) to the data output register of the slave and to get four bits of data from the slave input register.

The data_exchange request shall have the following structure:

ST	CB						I4	I3	I2	I1	I0		EB
=0	=0	A4	A3	A2	A1	A0	=0	D3	D2	D1	D0	PB	=1

IEC 1152/2000

The bits A4...A0 shall contain an operation address (1...31).

The slave response shall have the following structure:

ST	I3	I2	I1	I0		EB
=0	D3	D2	D1	D0	PB	=1

IEC 1153/2000

If the slave is not activated, no response shall be generated.

If the I/O configuration of the slave is 0x0F, no response shall be generated.

5.5.4.3 Write_parameter

The write_parameter request shall be used by the master to transfer the four parameter bits (I3...I0) to the parameter output register of the slave and to get four parameter bits from the slave parameter ports.

The write_parameter request shall have the following structure:

ST	CB						I4	I3	I2	I1	I0		EB
=0	=0	A4	A3	A2	A1	A0	=1	P3	P2	P1	P0	PB	=1

IEC 1154/2000

The bits A4...A0 shall contain an operation address (1...31).

The slave response shall have the following structure:

ST	I3	I2	I1	I0		EB
=0	P3	P2	P1	P0	PB	=1

IEC 1155/2000

The write_parameter request may affect the behaviour.

5.5.4.4 Address_assignment

The address_assignment request shall be used by the master to force the slave to store the given address (I4...I0) in a non-volatile form and to use this address when responding to the master requests.

The address_assignment request shall have the following structure:

ST	CB	A4	A3	A2	A1	A0	I4	I3	I2	I1	I0		EB
=0	=0	=0	=0	=0	=0	=0	=A4	=A3	=A2	=A1	=A0	PB	=1

IEC 1156/2000

The bits A4...A0 shall contain the zero address (0x00).

The slave response shall have the following structure:

ST	I3	I2	I1	I0		EB
=0	=0	=1	=1	=0	PB	=1

IEC 1157/2000

After a successful address_assignment, a slave shall respond with the new address.

5.5.4.5 Reset_AS-i_slave

The reset_AS-i_slave request shall be used by the master to reset a specific slave.

This command shall be encoded in the information part of the master request by 0x1C. The reset_AS-i_slave command shall have the following structure:

ST	CB						I4	I3	I2	I1	I0		EB
=0	=0	A4	A3	A2	A1	A0	=1	=1	=1	=0	=0	PB	=1

IEC 1158/2000

The slave response shall have the following structure:

ST	I3	I2	I1	I0		EB
=0	=0	=1	=1	=0	PB	=1

IEC 1159/2000

The reset_AS-i_slave request affects the state diagram of the slave.

5.5.4.6 Delete_address (temporary)

The delete_address request shall be used by the master to delete the operation address of a specific slave.

This command shall be encoded in the information part of the master request as 0x00. The delete_address command shall have the following structure:

ST	CB						I4	I3	I2	I1	I0		EB
=0	=1	A4	A3	A2	A1	A0	=0	=0	=0	=0	=0	PB	=1

IEC 1160/2000

The slave response shall have the following structure:

ST	I3	I2	I1	I0		EB
=0	=0	=0	=0	=0	PB	=1

IEC 1161/2000

After a successful delete_address, a slave shall respond with the zero address which is stored in a volatile form.

The delete_address request does not affect the state diagram of the slave.

A delete_address request to a slave with a zero address shall generate a slave response, but shall have no other effect.

A delete_address request shall not be issued by the master if the slave is in the process of storing its address into the non-volatile memory (processing the address_assignment request).

NOTE This is to prevent an undefined result of the storage process.

5.5.4.7 Read_I/O_configuration

The read_I/O_configuration request shall be used by the master to read the I/O configuration of a specific slave.

This command shall be encoded in the information part of the master request as 0x10. The read_I/O_configuration request shall have the following structure:

ST	CB						I4	I3	I2	I1	I0		EB
=0	=1	A4	A3	A2	A1	A0	=1	=0	=0	=0	=0	PB	=1

IEC 1162/2000

The slave response shall have the following structure:

ST	I3	I2	I1	I0		EB
=0	I3	I2	I1	I0	PB	=1

IEC 1163/2000

5.5.4.8 Read_identification_code

The command read_identification_code request shall be used by the master to read the identification code of a specific slave.

This command shall be encoded in the information part of the master request as 0x11. The read_identification_code request shall have the following structure:

ST	CB						I4	I3	I2	I1	I0		EB
=0	=1	A4	A3	A2	A1	A0	=1	=0	=0	=0	=1	PB	=1

IEC 1164/2000

The slave response shall have the following structure:

ST	I3	I2	I1	I0		EB
=0	I3	I2	I1	I0	PB	=1

IEC 1165/2000

5.5.4.9 Read_status

The read_status request shall be used by the master to read the status of a specific slave.

This command shall be encoded in the information part of the master request as 0x1E. The read_status request shall have the following structure:

ST	CB						I4	I3	I2	I1	I0		EB
=0	=1	A4	A3	A2	A1	A0	=1	=1	=1	=1	=0	PB	=1

IEC 1166/2000

The slave response shall have the following structure:

ST	I3	I2	I1	I0		EB
=0	S3	S2	S1	S0	PB	=1

IEC 1167/2000

The actual values of S0 to S3 of the status bits shall not be affected by the request.

The slave shall provide four bits for status values. These four bits are independent of each other and shall have the following semantics:

S0:	0	– address (non-volatile)
	1	– address (volatile)
S1:	0	– no parity bit error detected
	1	– parity bit error detected
S2:	0	– no end bit error detected
	1	– end bit error detected
S3:	0	– no error_reading in non-volatile memory
	1	– error_reading in non-volatile memory

The information given in the status register may be used for diagnostic purposes or for the master to determine what action can be taken to recover from a fault condition.

5.5.4.10 Read_reset_status

The read_reset_status request shall be used by the master to read the status and to reset the status bits of a specific slave.

This command shall be encoded in the information part of the master request as 0x1F. The read_reset_status request shall have the following structure:

ST	CB						I4	I3	I2	I1	I0		EB
=0	=1	A4	A3	A2	A1	A0	=1	=1	=1	=1	=1	PB	=1

IEC 1168/2000

The slave response shall have the following structure:

ST	I3	I2	I1	I0		EB
=0	S3	S2	S1	S0	PB	=1

IEC 1169/2000

After transmitting the slave response, the values of S1 to S3 of the status bits shall be 0.

The semantics of the status bits shall be the same as defined for read_status.

5.5.4.11 Reserve_R1

NOTE The reserve_R1 request is under further consideration.

This command shall be encoded in the information part of the master request as 0x12. The reserve_R1 request shall have the following structure:

ST	CB						I4	I3	I2	I1	I0		EB
=0	=1	A4	A3	A2	A1	A0	=1	=0	=0	=1	=0	PB	=1

IEC 1170/2000

The slave response shall have the following structure:

ST	I3	I2	I1	I0		EB
=0					PB	=1

IEC 1171/2000

5.6 Error detection

Any master request and slave response on the AS-i line shall be checked by the receiver in the slave or in the master for possible transmission errors including the following:

Start_bit_error	The initial pulse following a pause shall be of negative polarity. This pulse is the reference for bit decoding. The first bit detected shall be of the value 0. Violation of this rule shall be detected as start_bit_error.
Alternation_error	Two consecutive pulses shall be of different polarity. A negative pulse shall be followed by a positive pulse and vice versa. Violation of this rule shall be detected as alternation_error.
No_information_error	Within a master request or slave response, pulses (of positive or negative polarity) shall be detected within a period of ($n \times \mu s\,^{+1,0\ \mu s}_{-0,5\ \mu s}$) after the initial pulse of a master request or slave response, where n = 13 for a master request and n = 6 for a slave response. Violation of this rule shall be detected as no_information_error.
Parity_error	The sum of all information bits of the master request or slave response (excluding start and end bits, including parity bit) shall be even. Violation of this rule shall be detected as parity_error.
End_bit_error	The pulse to be detected $n \times 6\ \mu s$ after the start pulse shall be of positive polarity, where n = 13 for a master request and n = 6 for a slave response. This stop pulse shall end the master request or slave response. Violation of this rule shall be detected as end_bit_error.
Length_error	If a signal other than a pause is detected either: during the first bit time after the end pulse of a master request for synchronized slaves (during the first three bit times for non-synchronized slaves), or during the first bit time after the end pulse of a slave response (i.e. during the minimum slave pause), then a length_error shall be detected.

If any of these errors occurs, the master request or slave response shall be treated as invalid.

6 Product information

6.1 Instructions for installation, operation and maintenance

Subclause 6.1 of IEC 62026-1 applies.

6.2 Profiles

Subclause 6.2 of IEC 62026-1 applies with the following additions.

Masters and slaves shall carry the markings specified in the appropriate annex.

Markings shall be indelible and easily readable, and shall not be placed on parts normally removable in service.

6.3 Marking

Subclause 6.3 of IEC 62026-1 applies with the following additions.

6.3.1 Basic rated values

Manufacturers shall state the current ratings.

6.3.2 Connection and wiring identification

Table 4 defines the connection and wiring identification.

Table 4 – Connection and wiring identification

Physical interface	Type	Function	Wire colour	Terminal number
B, C, E	AS-i line	AS-i (+) AS-i (–)	Brown Blue	1 3
A	INPUT port (with connectors according to annex D of IEC 60947-5-2)	Power supply (+) Input data 1 Power supply (–) Input data 2	1)	1 2 2) 3 4 2)
A	INPUT port solid state (with terminals)	Power supply (+) (4x) Input data (4x) Power supply (–) (4x)		11…41 12/14…42/44 13…43
A	OUTPUT port solid state (with connectors according to annex D of IEC 60947-5-2)	Power supply (+) (npn) (4x) Power supply (–) (pnp) (4x) Output, parameter, etc. (4x)		1 3 4
A	OUTPUT port relays	Change-over contact Normally closed contact (NC) Normally open contact (NO)		1 2 4
A	OUTPUT port solid state (with terminals)	Power supply (+) (npn) (4x) Power supply (–) (pnp) (4x) Output data bit (4x)		11…41 13…43 14…44
F	Auxiliary power port	Aux. power (+) Aux. power (–)	Brown Blue	1 3
B + F	AS-i line + auxiliary power port 3)	AS-i (+) AS-i (–) U_{aux} (+) (–) PE 4)	Brown Blue Black White Green/Yellow	1 3 4 2 5

1) Wire colours for proximity switches shall conform to table 3 of IEC 60947-5-2.

2) When only one INPUT pin per connector is used, the connector pins 2 and 4 shall be bridged internally.

3) When the same connector or cable is used for both voltages, the auxiliary power supply shall be of the SELV or PELV type.

4) If used.

6.3.3 AS-i standard cable

The AS-i standard cable shall be coloured yellow and the "+" and "–" conductors shall be clearly identified. If colours are used for identification, they shall be brown for + and blue for –.

6.3.4 AS-i slave

The IP protection rating of the slave shall be stated in the data sheet according to IEC 60947-1.

6.3.5 AS-i power supply

The connections of an AS-i power supply shall be as defined in table 5 if it is a single phase a.c. power supply. This marking is mandatory.

Table 5 – AS-i power supply connection markings

Power supply	Marking	Specification
Primary (a.c. type)	L	Phase
	N	Neutral
	PE	Protective earth
Secondary (Interface E)	AS-i+	AS-i line positive
	AS-i–	AS-i line negative
	GND	Equipment earth and/or shield

6.3.6 AS-i master

The type of isolation between the AS-i ports at the master and the controller shall be stated by the manufacturer.

7 Normal service, mounting and transport conditions

7.1 Normal service conditions

Subclause 7.1 of IEC 62026-1 applies with the following additions.

7.1.1 Ambient air temperature

AS-i components shall operate between the ambient temperatures of –5 °C to +40 °C if not otherwise specified, for example in conjunction with a specific actuator or sensor type. The operating characteristics shall be maintained over the permissible range of ambient temperatures.

7.1.2 Altitude

Subclause 6.1.2 of IEC 60947-1 applies.

7.2 Conditions during transport and storage

A special agreement shall be made between the user and the manufacturer if the conditions during transport and storage, for example temperature and humidity conditions, differ from those defined in 7.1.

8 Constructional and performance requirements

8.1 AS-i power supply

The AS-i power supply shall meet the requirements as defined in table 6.

Table 6 – Power supply ratings

Operating temperature range	–5 °C to +40 °C
Protection class	3 (PELV)
Output voltage range between AS-i+ and AS-i– (over the whole load range)	$U_{AS\text{-}i}$ = 29,5 V d.c. to 31,6 V d.c. at I from 0 to I_N
Rated output current	$I_e \geq 2{,}4$ A
Additional current during power-ON	$I_{ST} > 0{,}4$ A (capacitive load of 15 mF (31 × 470 µF))
Output current	$I_L = 0$ to $I_e + I_{ST}$
Current limit	$2\ I_e > I_{Lim} > I_e + I_{ST}$
Amplitude noise over the current range (measured between AS-i+ and AS-i–)	50 mV_{pp} between 10 kHz and 500 kHz
Low frequency ripple (except in the overload situation)	300 mV_{pp} in the frequency range between 0 and 10 kHz
Power-ON delay	<2 s

The AS-i power supply shall be protected against short circuits and overload. Short circuits or overload shall not lead to permanent damage of the AS-i power supply. Resetting following an overload or short circuit may be automatic.

An overload exists if the load current I reaches the current limit I_{Lim} ($I \geq I_{max}$) or if, after start up time, the AS-i voltage level does not meet the minimum required value ($U_{AS\text{-}i} < U_{AS\text{-}i\ min}$).

The rated output current I_e and the maximum current I_{Lim} shall be stated by the manufacturer.

If an overload indication is provided, either a red overload LED in steady mode or the green power ready indicator LED in a flashing mode shall be used.

Within 2 s after power-ON, the voltage level shall reach the value 26,5 V. The time between the minimum master starting voltage (22,5 V – 1 V) and the minimum AS-i voltage level (29,5 V) shall be less than 1 s (see 8.2.3.1).

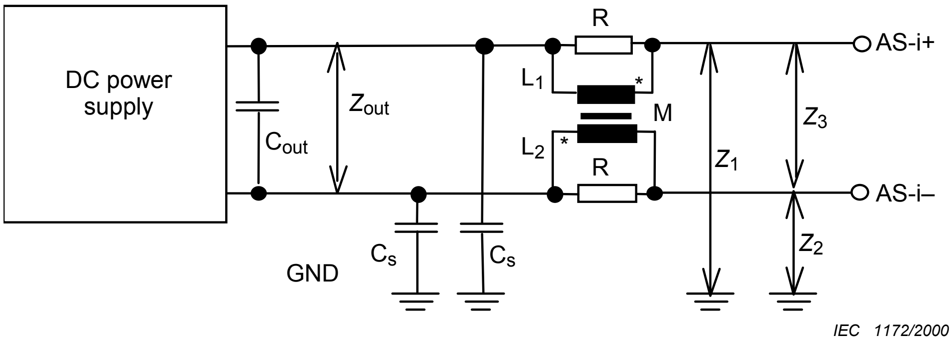
NOTE The second requirement is important because the master begins to run when the voltage exceeds its starting voltage of 22,5 V ± 1 V.

During start up, the AS-i power supply shall provide an increased current up to I_{Lim} to meet the charging process in the system. This increased current shall be 400 mA (additional load of 15 mF), for example 12,5 mA for every connected AS-i slave.

The start up shall proceed with constant load (current limit). As long as the AS-i voltage does not exceed the value of 5 V d.c., the supply current may be reduced to 0,15 I_e.

Input voltage and load current changes within the specified limits shall not affect the communication on the AS-i line; the AS-i transmission activity shall not affect the AS-i power supply.

The recommended construction of the decoupling circuit is shown in figure 6.



NOTE The balancing capacitors C_s shall be located as close as possible to L_1 and L_2. These capacitances provide impedance balance of AS-i+ and AS-i– to GND. Equal values of at least 100 nF are recommended.

The two inductances shall be manufactured as bifilar winding on a common core to provide sufficient common mode signal rejection.

Figure 6 – Recommended decoupling circuit

Table 7 shows the specific technical requirements.

Table 7 – Specific technical requirements for decoupling

Inductance between AS-i+ and AS-i–	200 µH ± 10 %; $L = L_1 + L_2 + 2\ M\ \sqrt{L_1}\ L_2$; M shall be as close as possible to 1 (I_L between 0 and rated current)
Single inductance L	50 µH ± 10 %
Resistor R	39 Ω ± 1 %
Symmetry of AS-i+/– with respect to GND	$0{,}98 \le \|Z_1\| / \|Z_2\| \le 1{,}02$ within the frequency range of 10 kHz to 300 kHz and the whole load range
Source impedance	$\|Z_{out}\| < 0{,}5\ \Omega$ in the range of 10 kHz to 300 kHz
Impedance of C_s	$\|C_s\| < 5\ \Omega$ in the range above 300 kHz

8.2 AS-i slave

8.2.1 Functions of the slave after receiving requests

8.2.1.1 General

A slave with an operating address (programmed) shall be addressable by the following master requests: data_exchange, write_parameter, and by commands.

A slave with zero address shall be addressable only by commands and address_assignment. The following master requests require slave responses, with the exception of address_assignment which is optional.

A slave shall perform the following functions in response to a particular master request.

8.2.1.2 Function of the data_exchange

In performing the data_exchange request, the slave transfers the received output bit pattern I0...I3 to the corresponding data output ports and shall signal the validity of these data bits at the data strobe output (if supported) by a pulse of 1 T_{bit} duration.

If the I/O configuration of the slave defines the data ports as "Tristate", no answer shall be generated.

NOTE When the I/O configuration is established, the data ports of the slave function as inputs or outputs, or as bi-directional inputs/outputs. Therefore, the programmed I/O configuration and the four data bits transferred by the master request determine the bit pattern which is moved to the output ports.

After the received data have been transferred to the data output ports, the slave shall load the bit pattern of the input and output ports into the transmit register.

8.2.1.3 Function of the write_parameter

In performing the write_parameter, the slave shall transfer the received bit pattern I0...I3 to the corresponding parameter output ports and shall signal the validity of these parameters at the parameter strobe port (if implemented) by a pulse of 1 T_{bit} duration.

After the received parameters have been transferred to the parameter ports, the slave shall load the bit pattern of the parameter ports into the transmit register and shall set the data_exchange_disable flag to UNTRUE.

The first parameter call after power-ON or RESET activates the slave. Until then, all outputs of the slave shall be in the default state. By disabling the data_exchange prior to the first successful write_parameter request after each RESET, it is assured that a slave will always have the expected parameters, even after an unnoticed RESET due to a brief loss of AS-i power.

8.2.1.4 Function of the address_assignment

The slave response signals to the master that the address_assignment request has been processed without error. In the case of positive address_assignment, the slave shall immediately respond with a bit pattern "0110" in the slave response.

The address shall be stored in a non-volatile memory.

If the address is reprogrammable, the process of storing data in the non-volatile memory shall take less than 15 ms. During this procedure, the status register bit S0 shall be set to HIGH.

NOTE The master may perform the read_status request to determine whether the slave has finished the storage process.

If the AS-i master did not receive a valid slave response, it shall determine whether the address_assignment process was successful or not by using the appropriate master requests.

After a valid address_assignment, the slave shall respond with the new address.

8.2.1.5 Function of the reset_AS-i_slave

This command shall initiate the routine that is also performed during power-ON or when the external reset_input is activated.

This routine performs the following processes:

- load data_output and parameter_output registers with default 0xF;
- reset the status register to 0x0;
- load address, I/O_configuration and ID_code from the non-volatile memory into the appropriate registers;
- set data_exchange_disable flag.

It is possible, therefore, with this command to reassign the previous operating address after having issued a delete_address request (e.g. for test purposes).

The reset_AS-i_slave processing shall take less than 2 ms. During this time, the slave shall not respond to any other requests issued by the master.

8.2.1.6 Function of the delete_address

The deletion of the operational address shall be done by overwriting the operational address stored in the internal address register of the slave with the zero address. The zero address shall not be stored in the non-volatile memory. The deletion of the operating address is, therefore, temporary only until the next address_assignment request or reset_AS-i_slave request is received, or the slave_reset-input is activated or a power failure occurs.

After a valid delete_address, a slave shall respond with the zero address.

After a valid address_assignment, a slave shall respond with the new address.

A delete_address request to a slave with a zero address shall generate a slave response, but shall have no other effect.

If the slave is in the process of storing its address into the non-volatile memory (processing the address_assignment request), a delete_address request shall not be issued by the master in order to prevent incorrect storage.

8.2.1.7 Function of the read_I/O_configuration

The actual I/O code of the slave shall immediately be read from the slave and transferred to the master in the slave response.

There are four types of configuration of the four-bit input/output ports:

- no configuration;
- input;
- output;
- bi-directional I/O.

In the read_I/O_configuration response, the slave shall respond with the actual I/O configuration of the input/output ports. The I/O configuration is related to the data inputs and outputs of the slave ports only.

8.2.1.8 Function of the read_identification_code

The identification code of the slave shall be read from the slave and transferred to the master in the slave response.

8.2.1.9 Function of the read_status

The current status of the slave shall be read from the slave and transferred to the master in the slave response. The actual values S1 to S3 of the status bits shall remain unchanged.

The state change of S0 (H->L) shall be valid not later than 2 ms after a read_status request. The updated status of S0 can be read with a further read_status request.

8.2.1.10 Function of the read_reset_status

The current status of the slave shall be read from the slave and transferred to the AS-i–master in the slave response.

The values of S1 to S3 of the status bits shall be reset to 0.

The state change of S0 (H->L) shall be valid not later than 2 ms after a read_reset_status request. The updated status of S0 can be read with a further read_status request.

The meaning of the status bits shall be the same as defined for the read_status request.

8.2.2 Elements of a slave

8.2.2.1 Connections and ports

The slave shall have at least two connections, AS-i+ and AS-i–, for the AS-i line. Other connections are optional. Logical ports may also exist, for example in an integrated circuit, but they need not be physically accessible. Logical ports include mandatory and optional ports.

The slave may have ports as listed in table 8.

Table 8 – Connections and logical ports of an AS-i slave

Label	Connections	Logical port	Description
AS-i+ / AS-i–	Mandatory	–	Connection to the AS-i network
D0...D3	Optional	Mandatory	Data input/output
P0...P3	Optional	Mandatory	Parameter output
RESET	Optional	–	Port to perform a forced reset
Data strobe	Optional	Optional	Data valid signalling
Parameter strobe	Optional	Optional	Parameter valid signalling
Power supply	Optional	–	Supplying the connected device
Others	Optional	Optional	

If data input/output ports D0...D3 are implemented, the input/output data of the slave response (as described in 5.5.3) shall correspond to the value of the data input/output ports. An input signal with a HIGH level at the port shall lead to a "1" of the corresponding data bit D0 to D3 in the information element of the slave response, a LOW level to a "0". A "1" in a data bit D0 to D3 in the information element of a master request shall lead to a HIGH level at the corresponding output port, a "0" to LOW level.

If data input/output ports are implemented and if they can be used for a bi-directional transmission of data, output data shall be transmitted before input data.

If data parameter output ports P0...P3 are implemented, the parameter output data of the master request correspond to the level of the parameter output ports. A "1" in a parameter bit P0...P3 in the information element of the master request write_parameter shall lead to a HIGH level at the corresponding parameter output port, a "0" to LOW level. A HIGH level at a port shall be reflected by a "1" of the corresponding data bit P0...P3 in the information element of the slave response, a LOW level by a "0".

8.2.2.2 I/O configuration

The input/output data of the slave shall correspond to the level of the data input/output ports. These input/output ports are configured to function as an input, as an output, as a bi-directionally input/output or, if unconfigured, as Tristate. This configuration depends on the environment and the required functionality and is therefore fixed by the slave. Sixteen different I/O configurations as shown in table 9 are allowed. They are identified by an I/O code which shall be stored in a non-volatile manner in the slave. The actual I/O code of a slave shall have four bits and shall be readable by the master.

NOTE I/O configuration examples are:

- four-bit input data to transmit the switching signals of four binary sensors;
- four-bit output data to activate four actuators;
- two-bit output plus two-bit input to activate a double working actuator (e.g. bi-directional pneumatic valve) and to transmit the sensor signals indicating the end positions.

Table 9 – Possible I/O configurations of a slave

I/O code	I/O configuration for			
(4-bit)	D0	D1	D2	D3
0x0	IN	IN	IN	IN
0x1	IN	IN	IN	OUT
0x2	IN	IN	IN	I/O
0x3	IN	IN	OUT	OUT
0x4	IN	IN	I/O	I/O
0x5	IN	OUT	OUT	OUT
0x6	IN	I/O	I/O	I/O
0x7	I/O	I/O	I/O	I/O
0x8	OUT	OUT	OUT	OUT
0x9	OUT	OUT	OUT	IN
0xA	OUT	OUT	OUT	I/O
0xB	OUT	OUT	IN	IN
0xC	OUT	OUT	I/O	I/O
0xD	OUT	IN	IN	IN
0xE	OUT	I/O	I/O	I/O
0xF	TRI	TRI	TRI	TRI
IN = Input; OUT = Output; TRI = Tristate; I/O = Input/Output				

8.2.2.3 ID codes

Each slave shall have an identification code (ID code) for further distinction of slaves with the same I/O configuration. The ID code shall have four bits (16 different possibilities).

Fifteen different ID codes (0x0 to 0xE) for each I/O configuration (e.g. IN-IN-IN-IN) may be assigned by the standardization body in conjunction with specific profiles (see annex A). The 16th possibility characterizes a "free profile", i.e. a usage of the slave not fixed in a particular profile. Any slave that does not use a specific profile exactly shall have the ID code ID=0xF.

The ID code shall be stored in a non-volatile manner. It shall be readable by the master. Its value depends on the implementation (the implemented profile). Therefore, it is fixed to the slave during the manufacture.

NOTE The definition of standard profiles has the goal of increasing the interchangeability of actuators and sensors on the one hand, and – with free profiles – to ensure a high degree of flexibility of the system on the other hand.

8.2.2.4 Non-volatile memory

A non-volatile memory of the slave shall contain the I/O code and the ID code. Both codes shall be factory programmed and shall only be readable into and loadable from the appropriate registers.

A non-volatile memory shall also contain the slave address. It may be realized as an electronic memory, by switches or by wiring.

The address shall be readable and loadable into the address register. If the address is reprogrammable with the address_assignment request, only the new, the old or the zero address can be assigned. This assignment shall be possible at least 10 times.

In case of manual or fixed assignment of the slave address, the zero address shall not be selectable.

All information which is stored in a non-volatile manner in a reprogrammable electronic memory shall be duplicated for data integrity reasons.

8.2.2.5 Registers and flags

The slave may have the following internal registers and flags. These are volatile memories; their contents may be lost in case of a power failure.

Address register (five bits)	Contains the address of the slave. NOTE This address register will be loaded from the non-volatile memory during power-up. It can be modified by the master request address_assignment.
I/O_configuration register (four bits)	Stores which of the data ports is configured as output, input, bi-directional I/O.
ID_code register (four bits)	Contains the ID code of the slave. NOTE I/O_configuration and ID_code registers will be loaded from the non-volatile memory during power-up. They cannot be altered.

Data_output register (four bits)	Contains the latest output information transmitted via a data_exchange request. After power-ON or a reset, the default logical values 1 should be put into the output register. NOTE It is common that the slave logical output value is the inverse of the physical device output.
Data_input register (four bits)	Contains the latest input information available in interface 1.
Parameter_output register (four bits)	Contains the latest output information transmitted via a write_parameter request. After power-ON or a reset, the default values 1 should be put into the parameter output register.
Receive register	Contains the latest received master request (start and end bit omitted).
Transmit register	Contains the slave response (start and end bits omitted).
Status register	Contains slave status information.
Sync flag	Indicates synchronization to master requests.
Data_exchange_disabled flag	Is set by RESET and reset by the first received write_parameter request.

NOTE A watchdog function may be implemented either internally in the slave circuitry between the AS-i+/– ports or externally in the connected device.

8.2.2.6 State diagram of a slave

Figure 7 shows the main states of an AS-i slave.

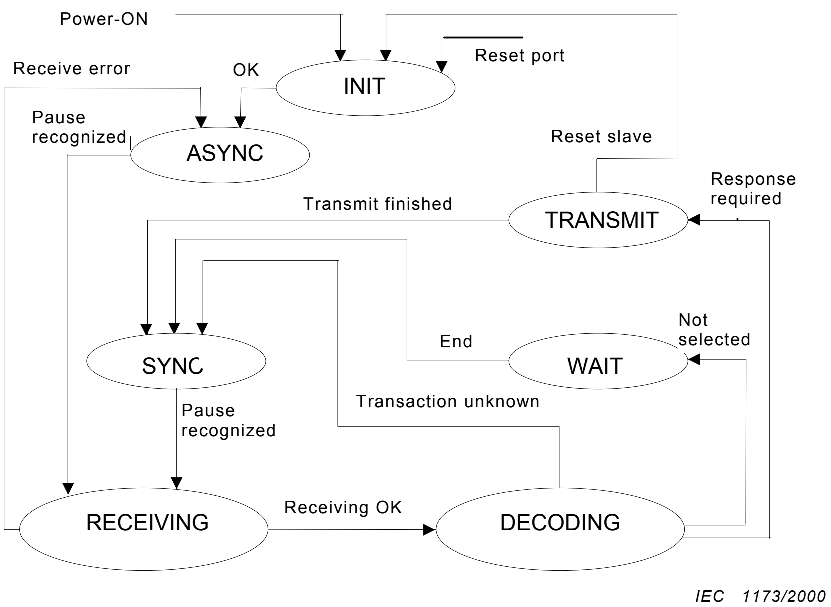


Figure 7 – Main states of a slave

After power-ON or after resetting the slave via the RESET port or after receiving a reset_AS-i_slave request, the slave shall be set to the state INIT.

In the state INIT, the following functions shall be performed:

– load data_output and parameter_output registers with default 0xF;
– reset the status register to 0x0;
– load address, I/O configuration and ID code from the non-volatile memory into the appropriate registers and check for read errors;
– set data_exchange_disabled flag to TRUE;
– change to state ASYNC.

In the state ASYNC, the following functions shall be performed:

– reset sync flag;
– poll the incoming data stream until a pause is detected;
– when a pause is detected, change state to RECEIVING.

In the state RECEIVING, the following functions shall be performed:

– wait for start bit and load master request into receive register;
– perform all error check routines;
– check master pause;
– if any error is detected, change state to ASYNC, else to DECODING.

In the state DECODING, the following functions shall be performed:

– compare received address with address register; if not equal, change state to WAIT;
– analyse information; if request unknown, change state to SYNC;
– if data_exchange_disabled flag is set and master requests data_exchange, change state to SYNC;
– perform the requested task (all defined master requests) and load appropriate response into transmit register;
– change state to TRANSMIT.

In the state WAIT, the slave shall perform the following functions:

– wait for detectable signal (from another slave response);
– if no signal detected, wait for end of response time;
– if signal detected, wait for end of slave response;
– change state to SYNC.

In the state TRANSMIT, the slave shall perform the following functions:

– wait for end of master pause (master pause shall be a minimum of three bit times, if sync flag is set; it shall be a maximum of five bit times, if sync flag is reset);
– send slave response;
– if reset_AS-i_slave request was received, change state to INIT, else to SYNC.

In the state SYNC, the slave shall perform the following functions:

– set sync flag;
– poll the incoming data stream and detect a pause;
– if a pause is detected, change state to RECEIVING.

8.2.3 General requirements

8.2.3.1 Voltages

The slave and the AS-i device shall be capable of operating at any d.c. voltage in the range 26,5 V d.c. to 31,6 V d.c. applied at the AS-i+ and AS-i– connections. The slave shall communicate with the master between 18,5 V d.c. and 31,6 V d.c. If the AS-i supply voltage of the slave (measured between AS-i+ and AS-i–) drops below the limit of 18,5 V d.c., master requests may not be processed. If the voltage drops below 14,5 V d.c., no master request shall be answered and a self-reset shall be generated.

No reset shall be issued if the supply is interrupted for less than 1 ms.

If the AS-i+ and AS-i– connections to the AS-i network are reversed (e.g. because of faulty installation), the slave shall not be damaged in any way and communication between the master and other slaves of the network shall not be disturbed.

8.2.3.2 Current

The maximum value of the total current consumption (over the range 0 to 31,6 V d.c.) of the slave shall be stated in the data sheet. In normal operating conditions, the current slew rate of the slave shall not generate a noise on the AS-i line > 20 mV_{pp} in the frequency range 10 kHz to 500 kHz.

The switching of actuators from OFF state to ON state and vice versa shall be considered as a normal operation.

Overload and short-circuit conditions at external connections of the slave shall not disturb communication between the master and other slaves on the network. Under overload or short-circuit conditions at any terminals of a slave, the total current consumption from the AS-i line shall not exceed the total current consumption stated in the data sheet by more than 150 mA.

8.2.3.3 Time delay before availability

After power-ON, the operating voltage at the ports AS-i+ and AS-i– shall reach 26,5 V d.c. (U_{min} of AS-i power supply) within 2 s. Within this time, a slave shall become able to communicate with the master. This value 26,5 V d.c. shall be reached under a current equal to the maximum total current consumption (as stated in the data sheet of the slave) plus 12,5 mA.

8.2.3.4 Impedances

The input impedance of a slave, measured between the AS-i+ and the AS-i– connections under normal operating conditions with the slave installed on a grounded metal plate, shall be in accordance with the limits of the equivalent circuit given in table 10. During testing, all metal parts shall be grounded.

Table 10 – Limits for *R*, *L* and *C* of the equivalent circuit of a slave

Limits	*R*	*L*	*C*
Values for high inductance	>8 kΩ	>9 mH	<100 pF
Values for low inductance	>8 kΩ	6 mH to 9 mH	<70 pF + (*L*-6 mH) x 10 pF/mH

In the equivalent circuit, *R*, *L* and *C* are connected in parallel between AS-i+ and AS-i–. To determine their values, the values of |Z| shall be measured at the following frequencies.

If the resonant frequency of the slave is in the range of 50 kHz to 300 kHz, the impedance $|Z|$ shall be measured at 50 kHz, at the resonant frequency (if any) or 150 kHz and at 300 kHz. The values of $|Z|$ shall be converted into *R*, *L* and *C* as described in 9.3.4.3.

The impedance, measured between either AS-i+ or AS-i– and GND while the slave is mounted on a grounded metal plate, shall be not less than 250 kΩ at d.c. During testing, all metal parts shall be grounded.

For high noise immunity, it is recommended to minimize the difference of both impedances (AS-i+ to GND and AS-i– to GND) within the frequency range in which noise is expected. In the frequency range of 50 kHz to 300 kHz, the quotient $|Z_1|/|Z_2|$ of these impedances (Z_1, Z_2) shall meet the following criteria:

$$0{,}9 \le |Z_1|/|Z_2| \le 1{,}10$$

If the slave can be connected to external components (e.g. standard inductive proximity switches connected to a module) and if these may influence the impedance to GND, limits shall be stated in the data sheet of the slave. If no limits are stated, the connection of an impedance of 100 nF/10 MΩ to any of the external ports of the slave module (except AS-i+, AS-i–) and GND shall be allowed. This shall not influence the measured impedance to GND, as stated above, in such a way that the stated limits are not complied with.

8.2.3.5 Indicating means

AS-i products may incorporate one or more coloured indicator lights.

If coloured indicators are used, they shall have meanings as defined in table 11.

Table 11 – Colours of indicator lights

Continuous GREEN	Power-ON
Continuous YELLOW	INPUT/OUTPUT ON
Continuous RED	Fault
Any other continuous colour or any colour flashing mode	Other functions, e.g. short circuit

8.2.3.6 Behaviour under fault conditions

If the slave has one of the following internal failures, the communication between the master and other slaves shall not be affected.

– The slave may be disconnected from the AS-i line by, for example, a fuse. This process shall be not reversible at least until a power-ON reset.

- If, due to an internal fault of the slave, the slave tries to send data for longer than 1 ms, the slave shall be disconnected from the bus line by a self-interrupting capability (Jabber inhibit). This process shall be reset by a power-ON reset only.
- If the application (actuator or sensor) connected to a remote I/O has an internal failure, this failure shall not disturb the communication between the master and other slaves in the network (see 4.2.1).
- If the slave receives master requests which do not pass the error detection circuitry due to a detected error in the transaction, it shall not send a slave response.

  NOTE This behaviour is mandatory because the error may have occurred in the address section of the master request and the receiving slave may not be the one being addressed. Thus, multiple answers to one master request are avoided.
- If the slave receives a master request which does not pass the error detection circuitry due to a detected parity bit error, bit S1 of the status register shall be set to HIGH.
- If the slave receives a master request which does not pass the error detection circuitry due to a detected end bit error, bit S2 of the status register shall be set to HIGH.
- If, during the reset procedure (state INIT), the slave reads its address from the non-volatile memory and detects a read error, it shall load the zero address into its address register and shall set bit S3 of the status register to HIGH.

  NOTE During the process of writing its address into the non-volatile memory, a supply voltage breakdown can occur. In this case, the stored address may be invalid. The master may be able to recover from this condition by repeating the address_assignment request.
- If, during the reset procedure (state INIT), the slave reads its I/O configuration and ID code from the non-volatile memory and detects a read error, it shall load 0xF into both appropriate registers and shall set bit S3 of the status register to HIGH.

8.2.3.7 Slaves with auxiliary power supply

Optionally AS-i slaves may be powered with auxiliary power. In this case, the following conditions shall be met.

The auxiliary voltage shall be either class III protection or protective isolated from AS-i line in accordance to IEC 60947-1. The rating of the auxiliary power supply shall be stated by the manufacturer.

If an M12 connector according to annex D of IEC 60947-5-2 is used for the interconnection of the auxiliary power supply in the slave, the connector shall be of male type with the pin configuration according to table 4.

8.3 AS-i master

8.3.1 Overview

The AS-i master provides all means to exchange data between a controller and the slaves in an AS-i system (see figure 1).

A master shall poll all slaves in a cyclical order. The master works transparently and does not interpret the slave data in any way. In addition to the cyclic exchange of data with connected slaves, it organizes and monitors the network and supports the controller with diagnostic data.

The master has the structure shown in figure 8.

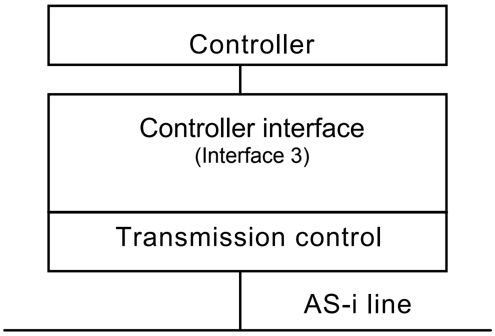


Figure 8 – Model of the master

Controller interface	Acting as the logical interface between the master and the controller. The controller uses the functions provided by the controller interface to communicate with the AS-i system. It shall be responsible for initialization of the master and the AS-i system, cyclic data exchange, acyclic commands and execution control functions.
Transmission control	Responsible for the physical transmission of data and automatic retransmission of master requests in case of failure. The AS-i master shall send and receive, respectively (i.e. request and response) as defined in 5.5.4.

NOTE The controller and the controller interface are not within the scope of this standard.

8.3.2 Master specific requirements for transmission

The following definitions contain the master specific requirements for the transmission system which are not part of the definition of the transmission system itself.

8.3.3 Line interface

An AS-i master shall conform to the specifications of the transmission given in 5.2 of this standard as long as there are no master specific definitions described in the following.

8.3.4 General requirements

8.3.4.1 Voltages

The master shall operate as specified in this standard during supply voltage interruptions shorter than or equal to 1 ms.

8.3.4.2 Current slew rate

In normal operating conditions, the current slew rate of the master shall not generate a noise on the AS-i line > 50 mV_{pp} in a frequency range of 10 kHz to 500 kHz.

8.3.4.3 Time delay before availability

After power-ON, the operating voltage at the connections AS-i+ and AS-i– shall reach 26,5 V d.c. (U_{min} of AS-i power supply), and the AS-i master shall function in less than 1 s. This value shall be reached for any current lower than the total of the maximum consumption (stated in the data sheet) plus 12,5 mA.

8.3.4.4 Impedances

The impedance Z_3 between the AS-i+ and AS-i terminals as shown in figure 9 shall be in accordance with the limits of the equivalent circuit given in table 12.

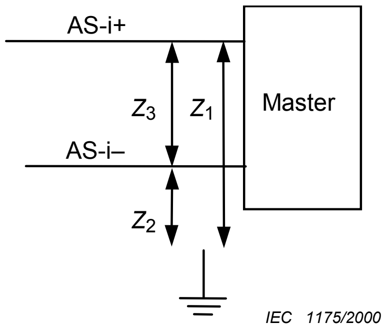


Figure 9 – Impedances

The impedance to GND, measured between either AS-i+ (Z_1) or AS-i– (Z_2) to GND or the controller's power supply while the master (and controller) is mounted on a grounded metal plate, shall not be below 250 kΩ at d.c. During testing, all metal parts of the master and the controller shall be grounded. The equivalent circuit consists of *R*, *L* and *C* connected in parallel between the measuring points.

Table 12 – Limits for *R*, *L* and *C* of the equivalent circuit of a master

Limits		
R	***L***	***C***
>5 kΩ	>3 mH	<400 pF

To determine the values of *R*, *L* and *C*, the values of $|Z|$ shall be measured at the following frequencies.

If the resonant frequency of the master is in the range of 50 kHz to 300 kHz, the impedance $|Z|$ shall be measured at 50 kHz, at the resonant frequency and at 300 kHz. The values of $|Z|$ shall be converted into *R*, *L* and *C* as described in 9.4.3.3. In the frequency range of 50 kHz to 300 kHz, the quotient $|Z_1|/|Z_2|$ of these impedances (Z_1, Z_2) shall meet the following criteria:

$$0,9 \leq |Z_1|/|Z_2| \leq 1,10$$

NOTE For high noise immunity, it is recommended to minimize the difference of both impedances (AS-i+ to GND and AS-i– to GND) within the frequency range in which noise is expected. In order to improve the noise immunity of the system, the differential impedance should be as low as possible.

The signal AS-i power-ON (APO) shall be set as long as the d.c. voltage of the AS-i line is not below the threshold of 22,5 V ± 1 V. It shall be reset if the voltage is below this threshold for more than $t_{fail} \leq 1$ ms.

8.3.4.5 Transmitter requirements

The transmitter of the master shall conform to the specification in a d.c. voltage range between 14,5 V and 31,6 V on the AS-i line.

NOTE 1 This voltage range guarantees that a slave will receive a reset_slave request in cases where voltage is low on the AS-i line.

The maximum deviation from the nominal bit time shall be less or equal to 0,1 %.

NOTE 2 This more severe requirement applies only to the master transmitter because its signal message is longer.

8.3.4.6 Receiver requirements

The master shall be able to receive and decode a slave response as described below.

The maximum pulse amplitude U_{max} of a master request or slave response shall be between 1,5 V and 4 V. The ratio of U_{max} between two slave responses at different locations on the network shall be within the range 1:1,5 to 1,5:1.

The amplitude of a valid pulse within a master request or slave response may vary from 65 % to 100 % of the maximum amplitude U_{max}.

Valid pulses shall start in a time window from ($n \times 3\ {}^{+1,0\ \mu s}_{-0,5\ \mu s}$) in relation to the initial pulse U_{init}.

Pulses (noise, ringing) of up to 30 % of U_{max} shall not disturb the master request or slave response reception.

8.3.4.7 Power fail

During the transmission of the master request and during the reception of the slave response (see figure 10), the transmission control shall sense the flag AS-i Power-ON (APO). If APO changes to FALSE during this time, the result parameter of the slave response (TS = APF) shall be set to TRUE. If a valid master request or slave response is received and APF is TRUE, the slave response shall be treated as invalid.

The transmission control shall accept and process requests from the execution control in case of APF = TRUE.

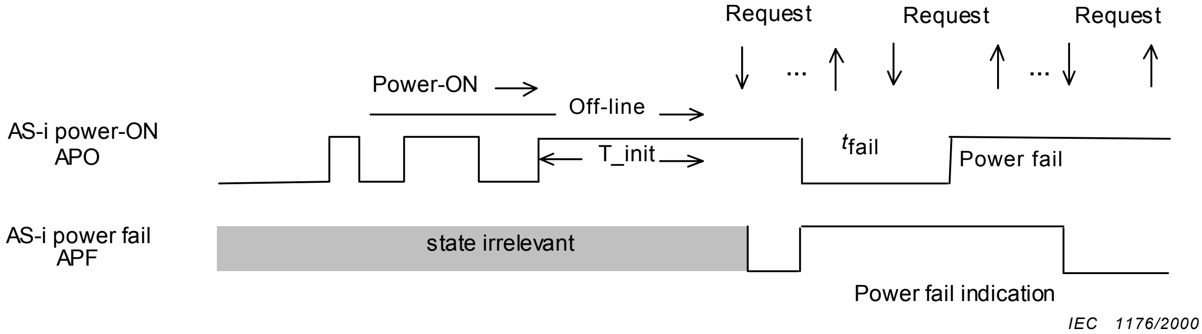


Figure 10 – AS-i power fail

8.4 Communication medium and electromechanical requirements

8.4.1 AS-i line

The AS-i transmission medium (see figure 11) may be any cable, preferably non-shielded, with the following characteristics:

at a frequency of 167 kHz: R': < 90 mΩ/m

C': < 80 pF/m

Z : 70 Ω to 140 Ω

G': ≤ 5 μS/m

The recommended cross-section is $2 \times 1{,}5$ mm^2.

For short trunk lines without further branching cables, other specifications are tolerable, if the d.c. voltage drop on these lines does not affect the function of the connected devices.

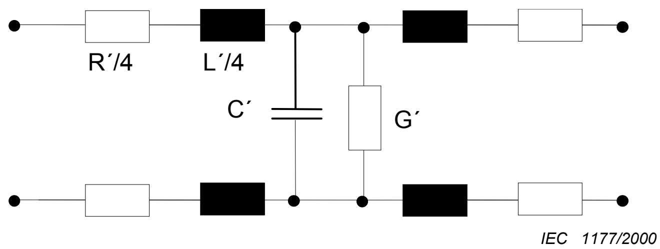
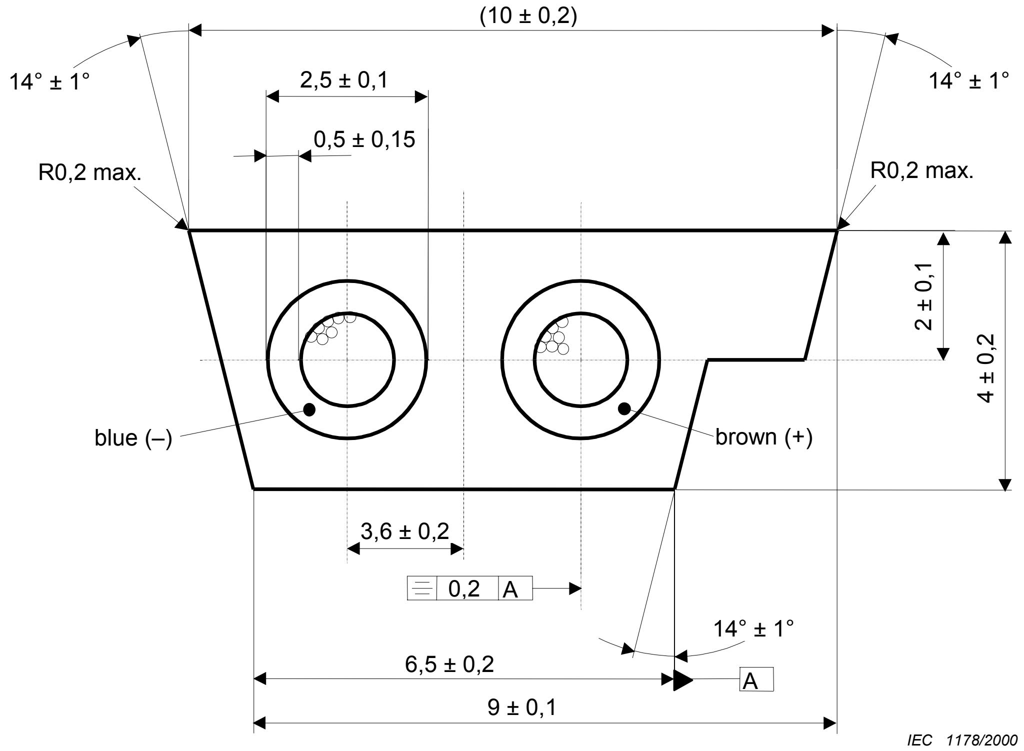


Figure 11 – Model of the AS-i transmission medium

NOTE Any cable that meets the above-mentioned data may be used as the AS-i line. Nevertheless, several requirements and tolerances of this standard are intended to meet a total voltage drop (d.c.) along the AS-i transmission medium of up to 3 V. It is recommended that a cross-sectional area be chosen so that no higher voltage drop will occur.

8.4.2 AS-i standard cable

This cable is designed for installation using insulation piercing technology (IEC 60998-2-3). Its dimensions are shown in figure 12 below.



Dimensions in millimetres

Figure 12 – AS-i standard cable

For compliance with this standard, all values shall be within the tolerances as shown.

The AS-i standard cable shall meet the following requirements:

conductor cross-section:	2 × 1,5 mm^2
conductor structure:	extra finely stranded. Conductors located in parallel
marking:	the + and – conductors shall be clearly marked. If colours are used, they shall indicate: – brown = + – blue = –
colour of cable sheath:	yellow
rated voltage:	300 V
insulation test voltage:	1,5 kV

8.4.3 Connections of the AS-i line

Any connection to the AS-i line shall meet the following requirements, whether a conventional technology or an insulation piercing technology is used:

connection cycles	minimum five cycles (if connections are detachable)
contact resistance	maximum 6 mΩ
minimum allowable current	1,5 I_{nom} (minimum 3 A for a general AS-i line) per connection
contact voltage range	10 V to 70 V d.c.
shock and vibration	according to 7.4 of IEC 60947-5-2
strain relief	according to annex E of IEC 60947-5-2

If a clamp or a screw terminal connector is used for connections, its capability shall be at least a 2 × 1,5 mm^2 cable.

8.4.4 Connections for external I/O ports on AS-i modules

If plug connectors are used, the D.2 type according to annex D of IEC 60947-5-2 is recommended.

8.4.5 Concept of profiles and electromechanical interface

Within this standard, no further restrictions for the method of interfacing the AS-i line with different components are defined in addition to the interface specified in 4.1.

Profile specifications for slaves and masters are given in annexes A and B.

8.5 Electromagnetic compatibility (EMC)

8.5.1 General

The operating characteristics of the AS-i system shall be maintained at the relevant levels of electromagnetic compatibility (EMC).

All immunity and emission tests are type tests and shall be carried out under representative conditions, both operational and environmental, using the recommended wiring practices and including all equipment necessary for communication and data transfer on the AS-i line.

This requirement can be met by the use of one master, one slave and one power supply.

100 m length of cable shall be used for the AS-i line, unless otherwise stated in the test instructions.

8.5.2 Immunity

Subclause 8.2.1 of IEC 62026-1 applies with the following modifications.

8.5.2.1 Electrostatic discharges (ESD) immunity

Performance criterion A shall apply.

8.5.2.2 Radiated radio-frequency electromagnetic fields immunity

Performance criterion A shall apply.

8.5.2.3 Conducted radio-frequency disturbances immunity

This test is not applicable, since the signal is carried on the power wires.

NOTE The operating environment of these devices using AS-i power supply with a decoupling network is considered to be well-protected against conducted radio-frequency disturbances.

8.5.2.4 Electrical fast transients immunity

The minimum test voltage shall be 2 kV and shall be applied by the capacitive coupling clamp. Performance criterion B shall apply.

The minimum test voltage shall be 1 kV and shall be applied by the capacitive coupling clamp. Performance criterion A shall apply.

8.5.2.5 Surge immunity

AS-i field devices shall not be tested for surge immunity.

The AS-i power supply shall be installed in such a way that it is not subject to line surges on the output side.

NOTE The operating environment of these devices is considered to be well-protected against surge voltages caused by lightning strikes.

In addition, due to the impedance limitations, it is impossible to protect AS-i field devices between AS-i+ and AS-i– with suitable surge supressor components because of their relatively high capacitance.

8.5.2.6 Immunity to voltage dips

See 8.1 and 8.3.4.1.

8.5.3 Emission

Subclause 8.2.2 of IEC 62026-1 applies with the following additions.

The measurement shall be made in the operating mode including grounding conditions producing the highest emission in the frequency band being investigated which is consistent with normal applications.

Each measurement shall be performed in defined and reproducible conditions.

9 Tests

9.1 Kind of tests

9.1.1 General

Clause 9 of IEC 62026-1 and subclause 8.1 of IEC 60947-1 apply with the following modifications.

This subclause specifies test requirements for logical, electrical and mechanical specifications. These test requirements specify those requirements which are not implicitly defined in the previous subclauses, for example the distance between AS-i master and AS-i slave during a specific test.

Tests are divided into three parts:

– logical testing (e.g. behaviour of the slave after receiving a message), see figure 13;
– electrical testing (e.g. testing the signals and time constraints);
– mechanical testing (e.g. AS-i standard cable).

If AS-i specifications are implemented as an integral part of a product, for example a specific actuator, the logical test is highly dependent on the behaviour of the product. To verify the compliance of the AS-i part to this standard, the specific environment in which AS-i has been integrated shall be taken into account.

Compliance to this standard does not necessarily mean compliance to a specific standard of the whole product in which AS-i is integrated. A test under specific applications of the AS-i functions is outside the scope of this standard.

If a manufacturer claims conformity of an AS-i slave to this standard, it shall be marked that the conformity comprises the conformity of the AS-i specific parts only. The conformity of, for example, a sensor is independent of the AS-i conformity testing.

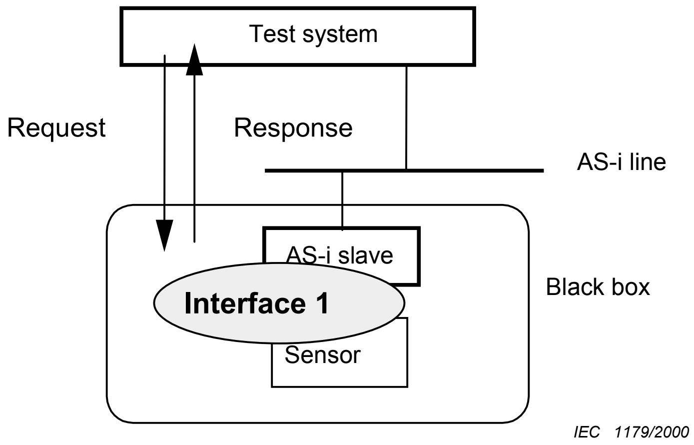


Figure 13 – AS-i interfaces

The test system shall only test if the response sent by the slave is correct. Because interface 1 is conceptual in nature, the concrete representation of the interface depends mainly on the environment in which it is used. The logical tests shall be restricted to the test of the AS-i slave treated as a black box.

All measurements of the electrical and mechanical tests shall be at an accuracy of ±1 %, if not otherwise stated.

9.1.2 Type tests

Type tests are intended to verify compliance with this standard.

These are:

– test of the AS-i power supply (9.2);
– test of an AS-i slave (9.3);
– test of an AS-i master (9.4);
– test of electromechanical components (9.5).

9.2 Test of the AS-i power supply

9.2.1 Impedance

This test determines the impedance of an AS-i decoupling network which is in an operating state.

The absolute impedance is not measured, but the accuracy or deviation from the required values is determined.

9.2.1.1 Test circuits

The test shall be performed with the decoupling network connected to a test circuit as shown in the figure 14.

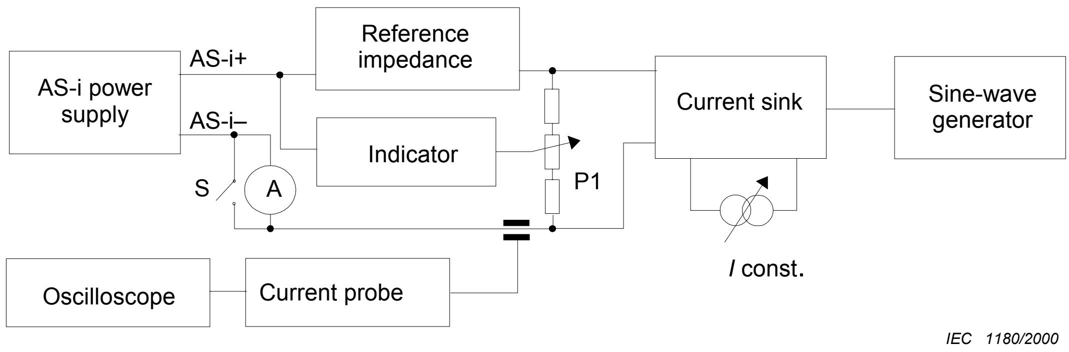


Figure 14 – Test circuit for the measurement of the impedance

The reference impedance shall be 100 µH || 78 Ω ± 1 %.

The constant current sink, indicator and display module shall have the same characteristics as the circuits shown in figures 15, 16 and 17 as guidelines.

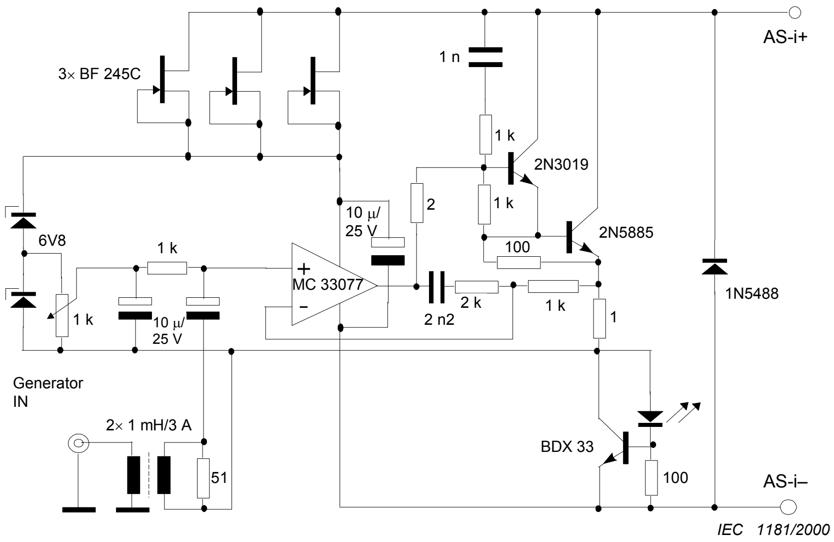


Figure 15 – Constant current sink

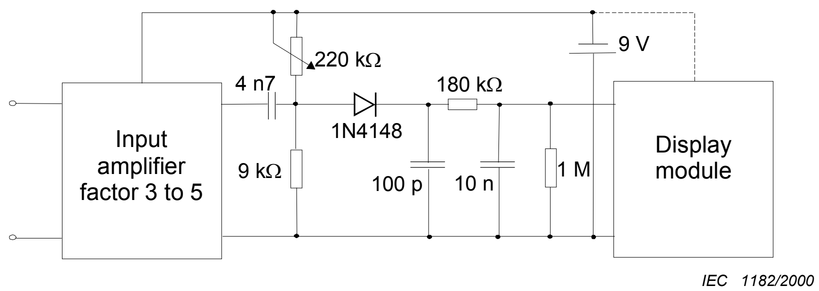


Figure 16 – Indicator

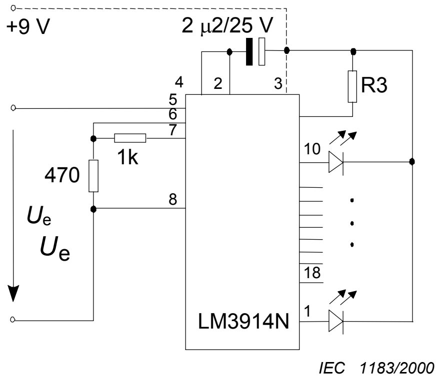


Figure 17 – Display module

9.2.1.2 Test procedure

The following steps shall be carried out:

1) by means of the constant current sink, a current of 0,1 A or I_e shall be set. The modulation amplitude and frequency of the current sink shall be set to 75 mA_{pp} and a frequency of 50 kHz;
2) the ammeter shall be replaced by a short circuit;
3) the bridge circuit shall be balanced to an accuracy within ±10 %;
4) repeat of steps 1 to 3 but at a modulation frequency of 300 kHz.

9.2.1.3 Evaluation of test results

It shall be possible to balance the bridge circuit for all four combinations of current and frequency shown in table 13.

Table 13 – Current and frequency for impedance determination

Current (A)	0,1	I_e	0,1	I_e
Frequency (kHz)	50	50	300	300

9.2.2 Symmetry

9.2.2.1 Test circuit

The test shall be performed with the decoupling network connected to a test circuit having the same characteristics as those shown in figures 14 to 17.

9.2.2.2 Test procedure

The following steps shall be carried out:

1) by means of the constant current sink, a current of 0,1 A or I_e shall be set. The modulation amplitude and frequency of the current sink shall be set to 75 mA_{pp} at 50 kHz;
2) the ammeter shall be replaced by a short circuit;
3) the bridge circuit shall be balanced to an accuracy within ±1 %;
4) steps 1 to 3 shall be repeated but at modulation frequencies of 160 kHz and 300 kHz.

9.2.2.3 Evaluation of test results

The bridge circuit shall be balanced for all six combinations of current and frequency shown in table 14.

Table 14 – Current and frequency for symmetry determination

Current (A)	0,1	I_e	0,1	I_e	0,1	I_e
Frequency (kHz)	50	50	160	160	300	300

9.2.3 Noise

9.2.3.1 Test circuit

The test shall be performed with the AS-i power supply (decoupling network) connected to a test circuit as shown in figure 18. The AS-i network is in steady-state operation.

The accuracy of the measurements shall be within ±5 %.

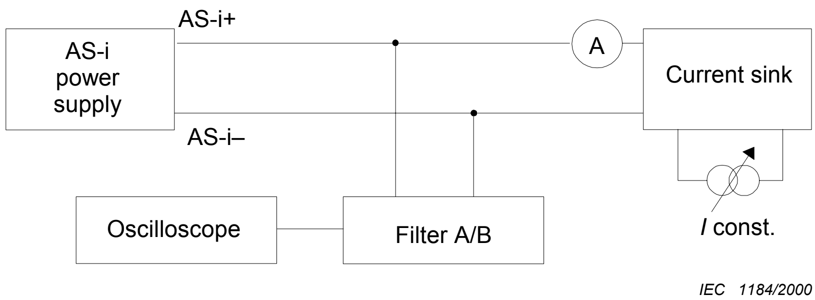


Figure 18 – Test circuit

The filter A, the filter B and the connected oscilloscope shall have the same characteristics as the circuits/oscilloscope shown in figures 19 and 20.

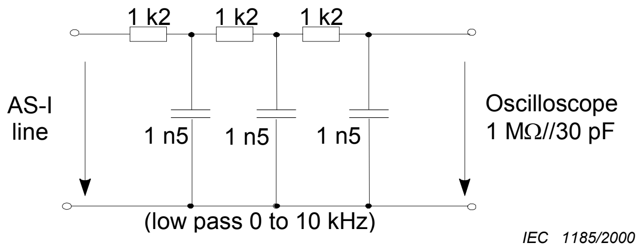


Figure 19 – Filter A

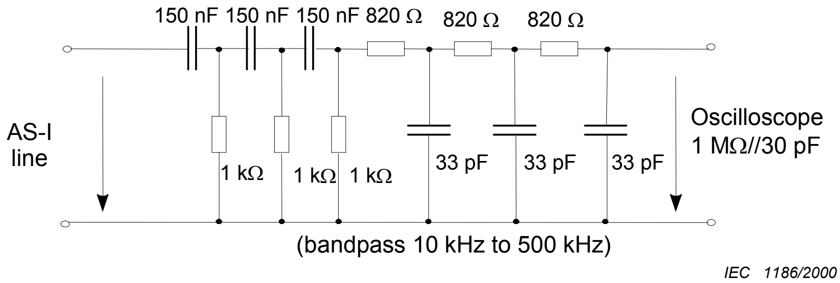


Figure 20 – Filter B

9.2.3.2 Test procedure

1) The constant current shall be varied from 0,1 A to I_e following a ramp function.
2) The emissions shall be monitored in the frequency range 0 to 10 kHz using filter A and in the frequency range 10 kHz to 500 kHz using filter B.

9.2.3.3 Evaluation of test results

The emissions between AS-i+ and AS-i– shall not exceed the values shown in table 15.

Table 15 – Current and frequency for emissions

Frequency range (kHz)	0 to 10	10 to 500
Maximum emission level (mV_{pp})	300	50

9.2.4 Power-ON behaviour

9.2.4.1 Test circuit

The test shall be performed with the AS-i power supply (decoupling network) at a maximum load of I_L connected to a test circuit shown in figure 21.

The accuracy of the measurements shall be within ±5 %.

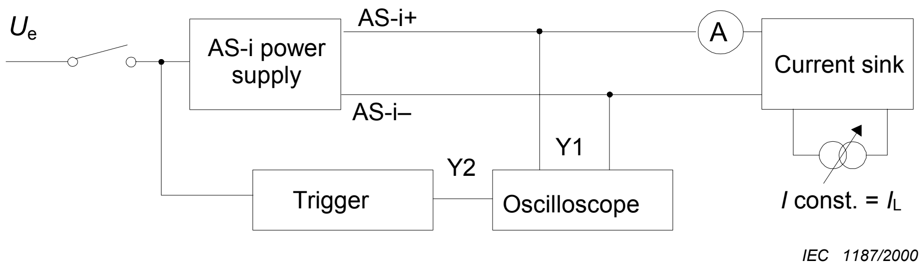


Figure 21 – Test circuit

9.2.4.2 Test procedure

The rise time of the voltage from zero to the steady-state value after power-ON shall be determined.

1) The current sink shall be set to the constant value of I_L according to figure 21.
2) The AS-i voltage value and slope shall be recorded.

9.2.4.3 Evaluation of test results

The voltage rise time for the two voltage ranges shall not exceed the values shown in table 16.

Table 16 – Voltage rise time determination

Voltage (V)	0,0 to 26,5	23,5 to 29,5
Maximum time (s)	2	1

9.3 Test of an AS-i slave

9.3.1 Logical test

9.3.1.1 Test circuit

The slave shall be connected to the test system (master) as shown in figure 22.

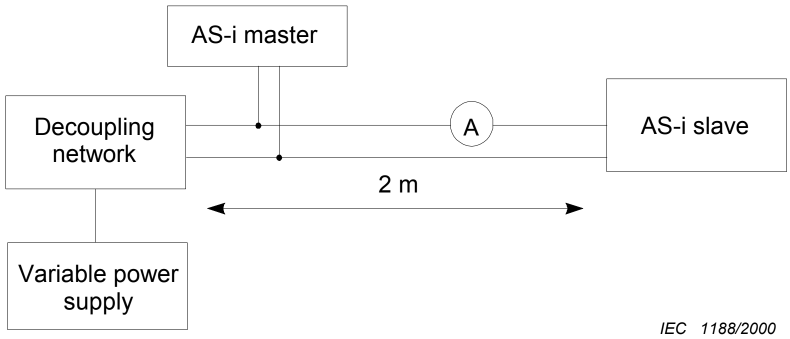


Figure 22 – Test circuit

The voltage shall be measured near to the slave.

NOTE If an AS-i slave is implemented as an integral part of a product, for example a specific actuator, the logical test is highly dependent on the behaviour of the product which includes the AS-i slave. To verify the compliance of the slave, the specific environment in which the slave has been integrated is taken into account.

9.3.1.2 Test procedure

The master shall issue an AS-i message. The correctness of the slave response shall be verified. These tests shall run for all mandatory messages and under the following four voltages:

– 31,6 V;
– 26,5 V;
– 18,5 V, and
– the minimum voltage stated by the manufacturer at which the slave still functions correctly as shown in table 17.

The logical test shall be processed under all four voltages for the following messages (m = mandatory, o = optional), i.e. 32 mandatory test cases shall be processed:

– data_exchange (m);
– write_parameter (m);
– address_assignment (o);
– reset_AS-i_slave (m);
– delete_address (temporary) (m);
– read_I/O_configuration (m);
– read_identification_code (m);
– read_status (m);
– read_reset_status (m).

During each test, the communication function (correct slave response sent by the slave) and the device function shall be tested. The device function as stated by the manufacturer shall be tested if possible.

NOTE The device function test requires that the manufacturer indicates how to determine the correctness of the device function.

9.3.1.3 Evaluation of test results

For each of the above-listed messages, the test result shall be marked in table 17.

Table 17 – Logical test determination

Voltage (V)	31,6	26,5	18,5	Minimum voltage stated by the manufacturer
Is the tested communication correct ?	Yes/No	Yes/No	Yes/No	Yes/No
Communication required	Yes	Yes	Yes	Yes
Is the tested device function correct ?	Yes/No	Yes/No	Yes/No	Yes/No
Correct device function required	Yes	Yes	Yes/No	Yes/No

The test is successful if the tested and required values are identical. If the minimum voltage stated by the manufacturer is greater than 18,5 V, then the device function is not required to be tested at 18,5 V. If the device function cannot be determined, this result should be marked as not testable.

9.3.2 Current consumption

9.3.2.1 Test circuit

The slave shall be connected to the test system (master) as shown in figure 23.

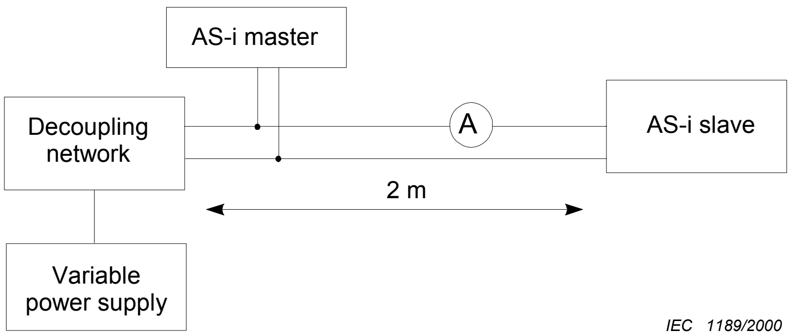


Figure 23 – Test circuit

The voltage shall be measured near to the slave.

9.3.2.2 Test procedure

The master shall issue an AS-i message valid for the slave under test. The current at the AS-i line shall be measured. These tests shall be run under the following four voltages:

- 31,6 V;
- 26,5 V;
- 18,5 V, and
- the minimum voltage stated by the manufacturer at which the slave still functions correctly as shown in table 18.

9.3.2.3 Evaluation of test results

The current shall be less than the maximum current stated by the manufacturer.

Table 18 – Maximum current consumption

Voltage (V)	31,6	26,5	18,5	Minimum voltage stated by the manufacturer
Current (A)				

9.3.3 Noise generated by slave device

9.3.3.1 Test circuit

The test shall be performed with the AS-i slave in the steady-state operation and connected to a test circuit as shown in figure 24. The inputs and/or outputs of the AS-i slave shall be connected to their nominal load.

The accuracy of the measurements shall be within ±5 %.

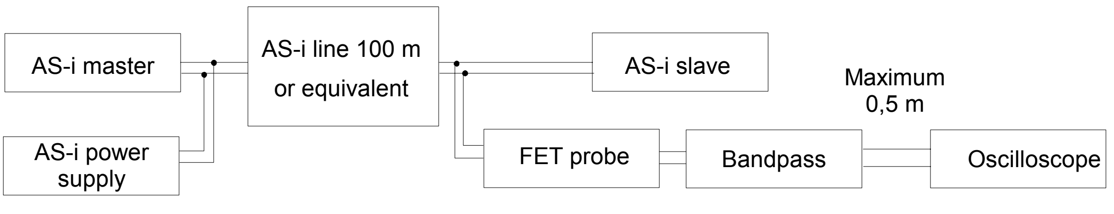


Figure 24 – Test circuit

The bandpass filter used shall have the same characteristics as the circuit shown in figure 25.

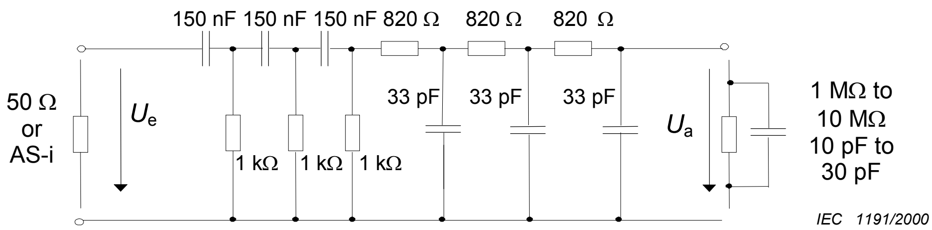


Figure 25 – Test circuit (bandpass 10 kHz to 500 kHz)

9.3.3.2 Test procedure

The emissions shall be determined with and without the AS-i slave connected.

9.3.3.3 Evaluation of test results

The difference of the emissions between AS-i+ and AS-i– measured without and with the AS-i slave connected to the AS-i line shall not exceed 20 mV_{pp}.

9.3.4 Impedance

9.3.4.1 Test circuit

The test shall be performed with the AS-i slave connected to a test circuit having the same characteristics as the circuit shown in figure 26.

An a.c. signal with an internal resistance $R_i \le 1\ \Omega$ shall be superimposed on the AS-i d.c. voltage. The a.c. voltage and a.c. current shall be determined.

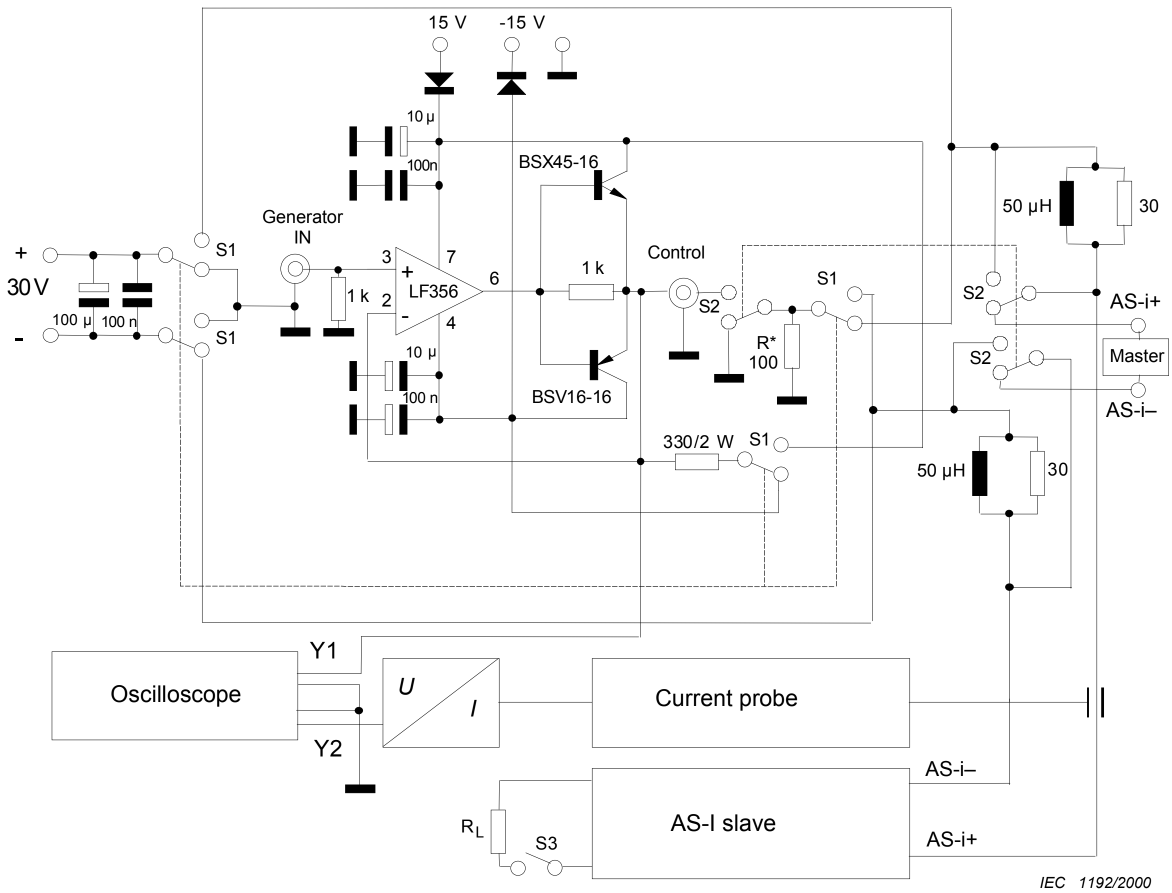


Figure 26 – **Test circuit**

Switch S1 allows selection of the a.c. ground. The depicted position is AS-i– = GND. Switch S3 allows the maximum load I_L according to the data sheet of the manufacturer. Switch S2 allows to provide the AS-i slave with the d.c. at time of switching.

The distance between AS-i slave and AS-i master shall be 20 cm. The d.c. resistance between AS-i+, AS-i– and all the metallic parts of the slave (with the exception of the outer connections) shall be ≥ 250 kΩ.

9.3.4.2 Test procedure

The accuracy of the measurements shall be within ±3 %.

The following steps shall be carried out:

1) switch S1: position AS-i– to GND;
2) switch S2: position data transmission;
3) set data and parameter bit combination according to the manufacturer's data sheet to that combination at which the value of the impedance is the minimum and at which the symmetry is the minimum;
4) change switch S2 to the position impedance measurement;
5) close switch S3 (only in case that AS-i modules are used which are connected to the auxiliary power supply of the AS-i system with the nominal load of I_L);

6) determination of the a.c. current at an a.c. voltage of 6 V_{pp} at the frequencies 50 kHz, 300 kHz and at the resonant frequency if it is in the range between 50 kHz and 300 kHz.

9.3.4.3 Evaluation of test results

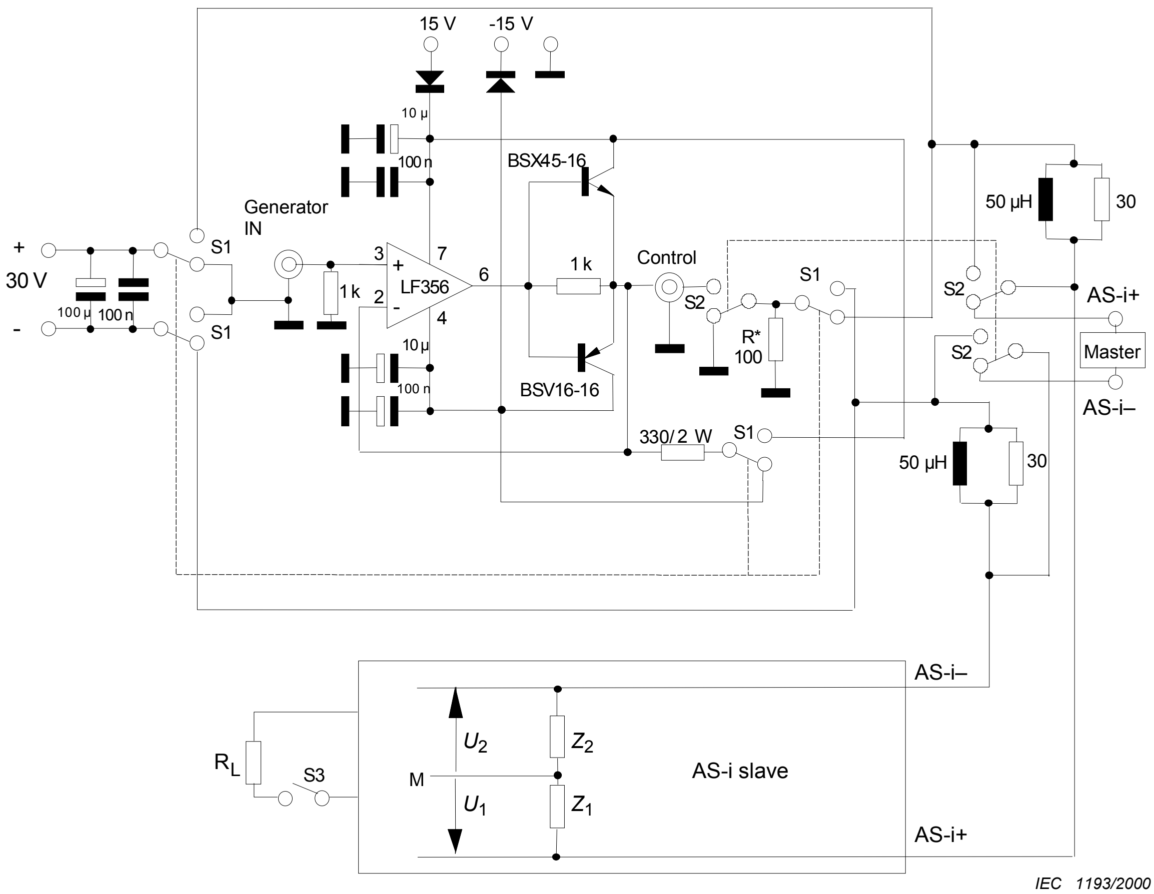
According to 8.2.3.4, the values of *R*, *L* and *C* of the corresponding equivalent circuit shall be determined as the solution of the system of three equations for the absolute value of the impedance $|Z|$ at the frequencies given in 8.2.3.4.

$$|Z| = \frac{1}{\sqrt{\frac{1}{R^2} + \left(\omega C - \frac{1}{\omega L}\right)^2}}$$

9.3.5 Symmetry

9.3.5.1 Test circuit

The test shall be performed with the operating AS-i slave connected to a test circuit having the same characteristics as the test circuit shown in figures 27, 28 and 29.



U_1: Voltage between M and AS-i+ (AS-i+ = GND)

U_2: Voltage between M and AS-i– (AS-i – = GND)

NOTE For AS-i slaves with external connections, the measurement point M may be the galvanically coupled power supply. For AS-i slaves with integrated AS-i ASIC, the measurement point M may be their metal housing. For AS-i slaves with a plastic package, the measurement point M may be the metallic part on which the plastic package is installed.

Figure 27 – Test circuit

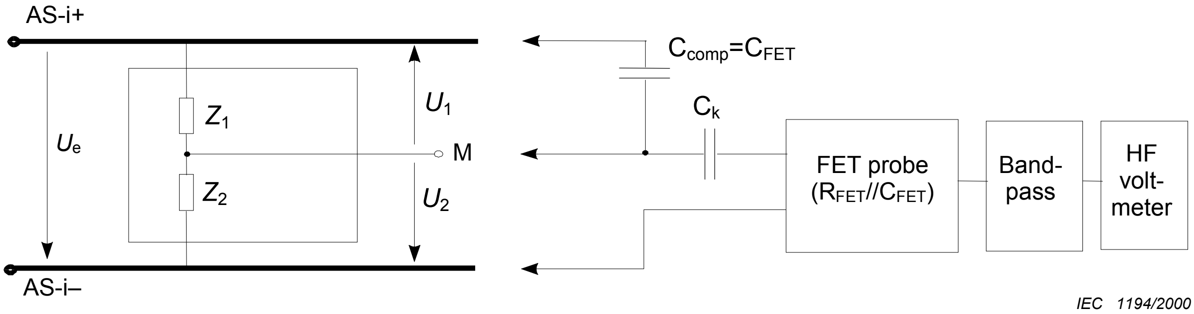


Figure 28 – **Details of test circuit – Galvanic coupling between AS-i+ (AS-i–) and the measurement point M (d.c. resistance ≤ 250 kΩ)**

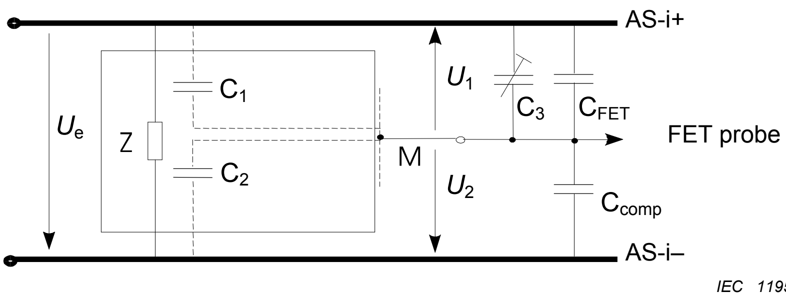


Figure 29 – **Details of test circuit – Electrical isolation between AS-i+ (AS-i–) and the measurement point M (d.c. resistance > 250 kΩ)**

9.3.5.2 Test procedure

The accuracy of the measurements shall be 3 %.

a) For galvanic coupling

1) Calibrate the value of the measurement of the r.m.s. voltage to 2,0 V at a frequency of 160 kHz.
2) Set data and parameter bit combination according to data sheet of the manufacturer to that combination at which the value of the impedance is the minimum and at which the symmetry is the minimum.
3) AS-i+ to GND: measure $|U_1|$ at the frequencies of 50 kHz, 100 kHz, 125 kHz, 160 kHz, 200 kHz and 300 kHz.
4) AS-i– to GND: measure $|U_2|$ at the frequencies of 50 kHz, 100 kHz, 125 kHz, 160 kHz, 200 kHz and 300 kHz.

b) For electrical isolation

1) Determine the voltage $|U_1|$ and $|U_2|$ at a frequency of 300 kHz without C_3.
2) If either $|U_1| / |U_2| > 0,9$ or $|U_1| / |U_2| < 1,1$, add C_3 between the measurement point M and AS-i+ or AS-i–. Calibrate the value of C_3 such that $|U_1| = |U_2| = U_e/2$ at the frequency of 300 kHz.
3) Determine the voltage $|U_1|$ and $|U_2|$, without changing C_3, for each of the other frequencies: 50 kHz, 100 kHz, 125 kHz, 160 kHz and 200 kHz.

9.3.5.3 Evaluation of test results

a) For galvanic coupling, and
b) For electrical isolation:

the following condition shall be met, depending on the value of C_3:

– for $C_3 = 0$ $0{,}9 < |U_1| / |U_2| = |Z_1| / |Z_2| < 1{,}1$

– for $C_3 \leq 15$ pF $0{,}8 \leq |U_1| / |U_2| \leq 0{,}9$ or $1{,}10 \leq |U_1| / |U_2| \leq 1{,}20$

– for $C_3 \leq 30$ pF $|U_1| / |U_2| \leq 0{,}8$ or $1{,}20 \leq |U_1| / |U_2|$

9.3.6 Power-ON behaviour

9.3.6.1 Test circuit

All AS-i slave inputs and/or outputs shall be connected with their rated load.

Current consumption:

Test with constant current source with I = (I stated by the manufacturer + 12,5) mA.

NOTE No monitoring of the communication is possible, because the current source prevents the communication.

The test shall be performed with the AS-i slave connected to a test circuit as shown in figure 30.

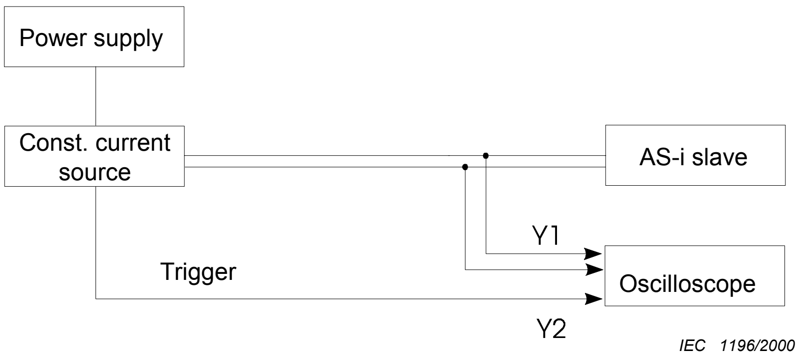


Figure 30 – Test circuit

9.3.6.2 Test procedure

The accuracy of the measurement shall be better than ±3 %.

Current consumption:

The time t_1 from connecting the AS-i slave to the AS-i line up to the time where the minimum voltage of 26,5 V has been reached shall be determined.

9.3.6.3 Evaluation of test results

The time t_1 shall be less than or equal to 1 s.

9.3.7 Test of total current consumption under short-circuit conditions

9.3.7.1 Test circuit

The test shall be performed with the AS-i slave connected to a test circuit as shown in figure 31.

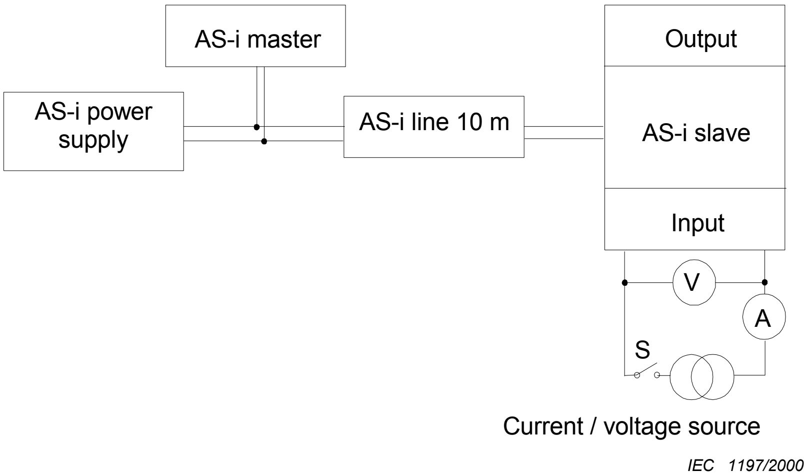


Figure 31 – Test circuit

9.3.7.2 Test procedure

No specific test requirements.

9.3.7.3 Evaluation of test results

Under overload or short-circuit conditions at all the terminals of a slave, the total current consumption from the AS-i line shall not exceed the total current consumption stated by the manufacturer plus 150 mA.

9.3.8 Verification of the voltage reversal withstand

9.3.8.1 Test set-up

The test shall be performed with an AS-i circuit consisting of one master, two slaves and one power supply.

9.3.8.2 Test procedure

Connect the slave under test with inverted polarity to the AS-i circuit. Verify that the other slave can communicate with the master.

Reconnect the slave under test with the proper polarity.

9.3.8.3 Evaluation of test results

With the slave under test inverted, the master and the other slave shall communicate correctly. After reconnecting the slave under test with the proper polarity, it shall communicate and function within its specification.

9.3.9 Verification of the electromagnetic compatibility

9.3.9.1 Test conditions

Unless otherwise stated, the tests shall be carried out at an ambient air temperature of 23 °C ± 5 °C.

The tests shall be performed under the following conditions.

1) The AS-i device mounted in free air shall be connected to the AS-i line and supplied with its rated operational voltage (U_e); terminals and connectors, if any, shall be connected to the intended sensors or actuators according to the manufacturer's instructions. Any connecting leads for external sensors or actuators shall be at least 2 m. For devices not having integral cables, the type of cable used shall be specified by the manufacturer and recorded in the test report.
2) The test shall be performed:

   For sensors:

   a) with the target set at a position such that the switching element is in the OFF-state;
   b) with the target set at a position such that the switching element is in the ON-state.

   For actuators:

   a) with the actuator in the ON-state;
   b) with the actuator in the OFF-state.

   For remote I/Os:

   a) with the I/Os activated;
   b) with the I/Os deactivated.

   For master:

   According to 9.4, without repetition of any message in case of a fault.

   The master shall have provisions for detecting disturbed messages.

For the test of 8.5.2.4, the following additional mounting conditions apply.

Metal enclosures of AS-i devices, if any, shall be connected to the reference ground plane.

AS-i devices with non-metallic enclosures shall be mounted on a metal plate which shall be connected to the reference ground plane.

The method of connection to the reference ground plane shall be in accordance with the manufacturer's instructions, if given, and shall be recorded in the test report.

9.3.9.2 Electrostatic discharges immunity

The test is performed according to IEC 61000-4-2 and 8.5.2.1 and shall be repeated ten times at each measuring point, with a minimum time interval of 1 s between pulses.

9.3.9.3 Radiated radio-frequency electromagnetic fields immunity

The test is performed according to IEC 61000-4-3 and 8.5.2.2.

9.3.9.4 Electrical fast transients immunity

The test shall be performed according to IEC 61000-4-4 and 8.5.2.4, with all the connecting leads placed in the capacitive coupling clamp. The test voltage for the auxiliary power ports shall be applied via the coupling network.

9.3.9.5 Emission requirements

The test shall be performed according to CISPR 11, group 1, class A, and to 8.5.3.

9.3.9.6 Test results and test report

The test results shall be documented in a comprehensive test report. The test report shall present the objective, the results and all relevant information of the tests. The test report shall define the AS-i device under test, including the cable layout, the necessary auxiliary equipment and the target position, if any. Any deviation from the test plan shall be mentioned.

Where a range of AS-i devices is made according to the same principle and design, and using the same type of components, tests may be performed on representative samples. Furthermore, based on first results, the testing laboratory may limit the tested frequency range for radiation or conduction tests; then, it shall include the frequency range used in the report.

9.4 Test of a master

9.4.1 Current consumption

9.4.1.1 Test circuit

The test shall be performed with the AS-i master connected to a test circuit as shown in figure 32.

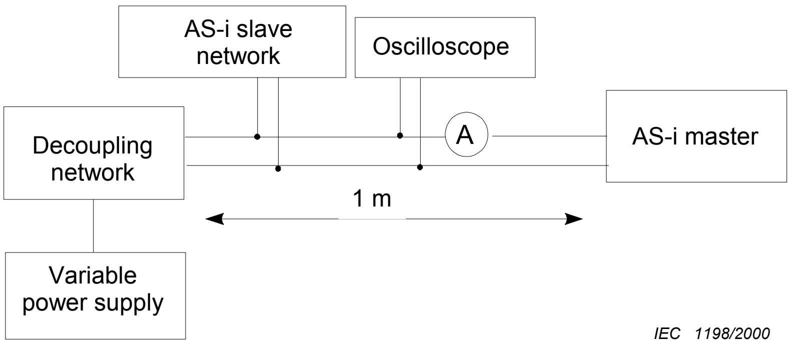


Figure 32 – Test circuit

9.4.1.2 Test procedure

1) Operate the master under normal conditions.
2) Determine the master function using a master message on the AS-i line at the following voltages: 31,6 V, 26,5 V, 23,5 V, 21,5 V, and again at 23,5 V.
3) Determine the maximum current consumption.

9.4.1.3 Evaluation of test results

With the exception of 21,5 V, the communication shall be active at voltages according to table 19. The maximum current shall not exceed the value (I_{st}) stated in the data sheet of the product by more than 12,5 mA.

Table 19 – Current consumption determination

Voltage (V)	31,6	26,5	23,5	21,5	23,5
Current (mA)	$< I_{st} + 12{,}5$	$< I_{st} + 12{,}5$	$< I_{st} + 12{,}5$	$< I_{st} + 12{,}5$	$< I_{st} + 12{,}5$
Communication active	Yes	Yes	Yes	No communication allowed	Yes

9.4.2 Noise of an AS-i master on the AS-i network in the power fail condition

9.4.2.1 Test circuit

The test shall be performed with the AS-i master connected to a test circuit as shown in figure 33. The input and/or output of the AS-i master shall be connected with the nominal load.

The accuracy of the measurements shall be within ±5 %.

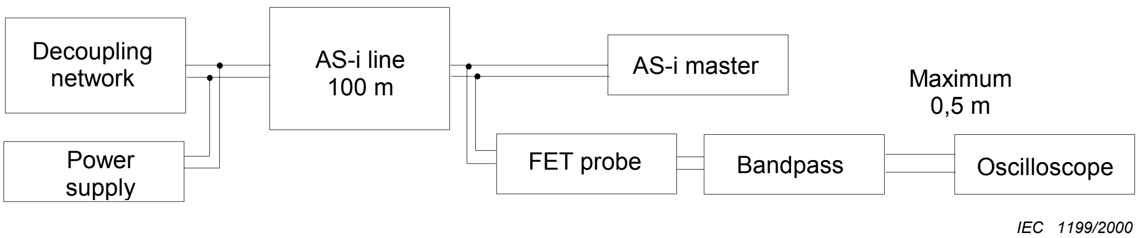


Figure 33 – Test circuit

The bandpass filter used shall have the same characteristics as the circuit shown in figure 25.

9.4.2.2 Test procedure

1) The voltage of the AS-i line shall be calibrated to 21 V (AS-i master not connected).
2) Determine the emissions at the AS-i line during a period of 60 s.
3) Connect the AS-i master to the AS-i line.
4) Check the power fail condition of the AS-i master.
5) Determine the emissions at the AS-i line during a period of 60 s.

9.4.2.3 Evaluation of test results

The difference of the emissions between AS-i+ and AS-i– measured without and with the AS-i master connected to the AS-i line under the power fail condition shall not exceed 50 mV_{pp}.

9.4.3 Impedance

9.4.3.1 Test circuit

The test shall be performed with the operating AS-i master connected to a test circuit having the same characteristics as the circuit shown in figure 34.

An a.c. signal with an internal resistance of $R_i \leq 20\ \Omega$ shall be superimposed on the AS-i d.c. voltage. The a.c. voltage and a.c. current shall be determined.

The d.c. voltage shall be calibrated to 21 V (the AS-i master shall be off-line at this voltage).

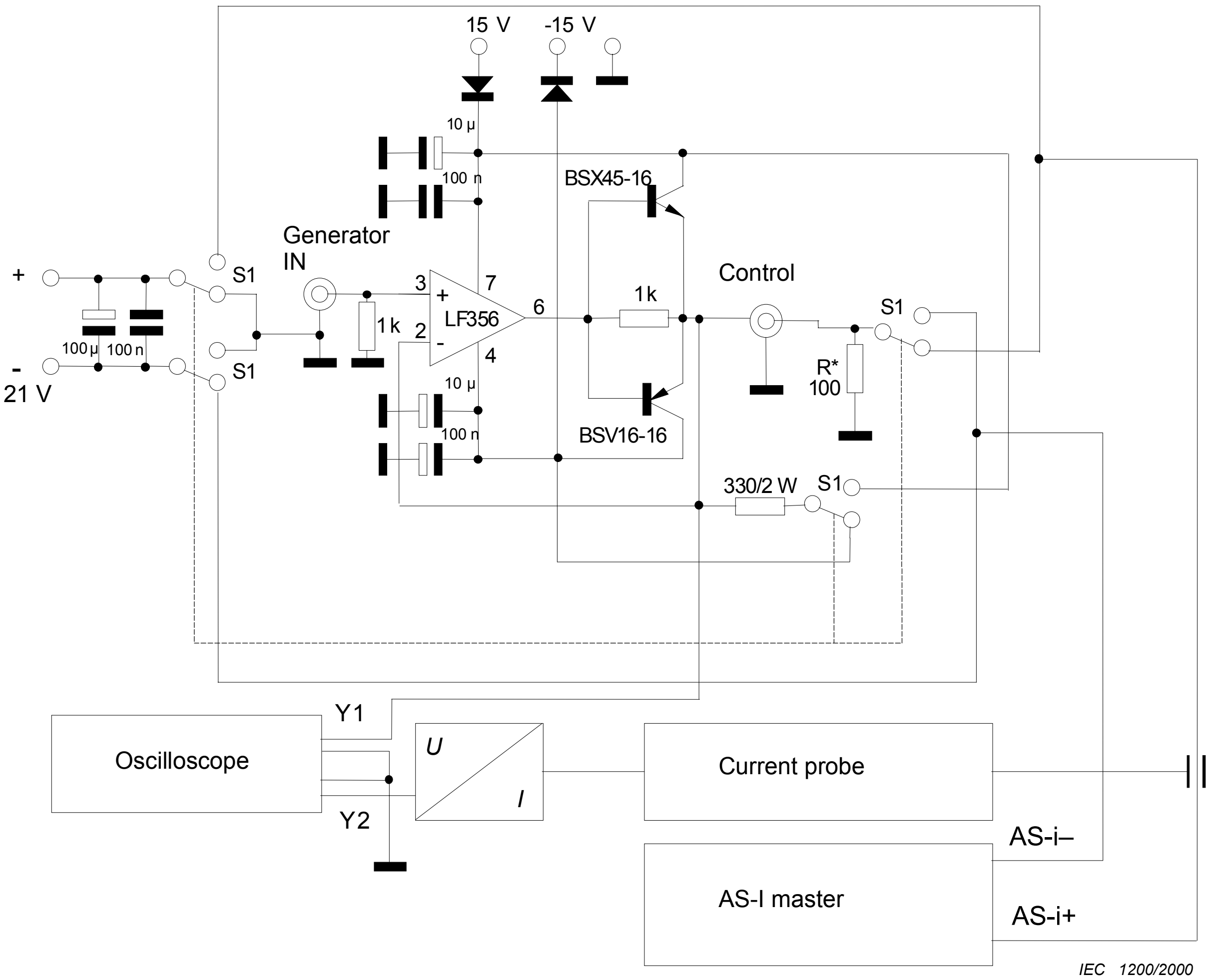


Figure 34 – Test circuit

Switch S1 allows selection of the connection to the ground. The depicted position is AS-i– to GND.

The resistance between AS-i+, AS-i– and all the metallic parts of the master (with the exception of the outer connections) shall be ≥ 250 kΩ.

9.4.3.2 Test procedure

The test shall be carried out according to figure 34. The AS-i master under test shall be placed in the appropriate position.

The accuracy of the measurements shall be within ±3 %.

The following steps shall be carried out.

1) Switch S1: position AS-i– to GND.
2) Determine the a.c. current at an a.c. voltage of 6 V_{pp} at the frequency 50 kHz, the resonant frequency and 300 kHz.

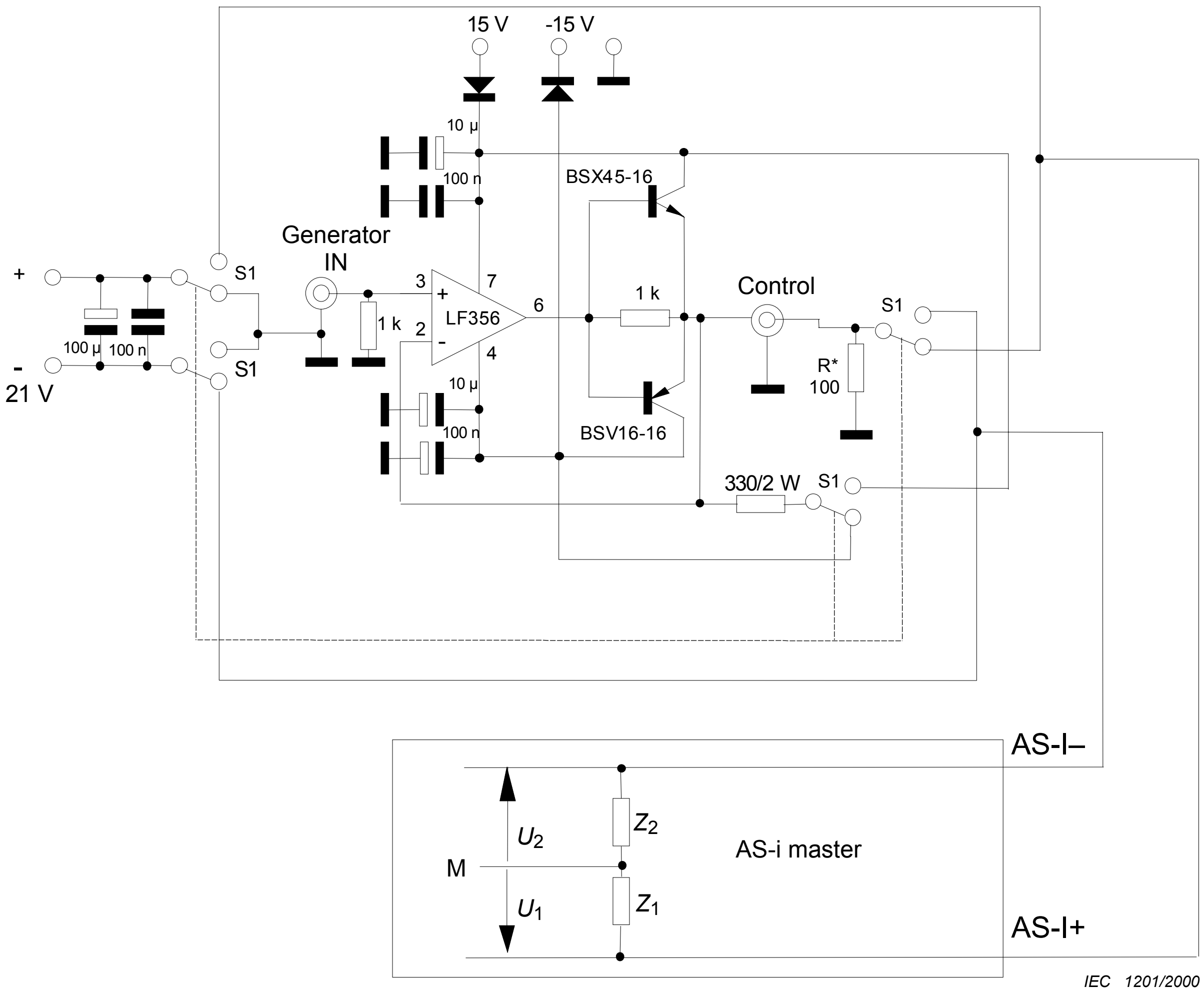
9.4.3.3 Evaluation of test results

According to 8.3.4.4, the values of *R*, *L* and *C* of the corresponding equivalent circuit shall be determined as the solution of the system of three equations for the absolute value of the impedances $|Z|$ at the frequencies given in 8.3.4.4. The formula for their calculation is given in 9.3.4.3.

9.4.4 Symmetry

9.4.4.1 Test circuit

The test shall be performed with the operating AS-i master connected to a test circuit as shown in figure 35.



An asymmetry of 10 % is determined as follows:

U_1: Voltage between M and AS-i+ (AS-i+ = GND)

U_2: Voltage between M and AS-i– (AS-i– = GND)

NOTE For AS-i masters, the measurement point M may be the metal housing or the metallic part on which the AS-i master is installed. It is connected with the external supply line of the AS-i master or the controller.

Figure 35 – Test circuit

Test circuit details:

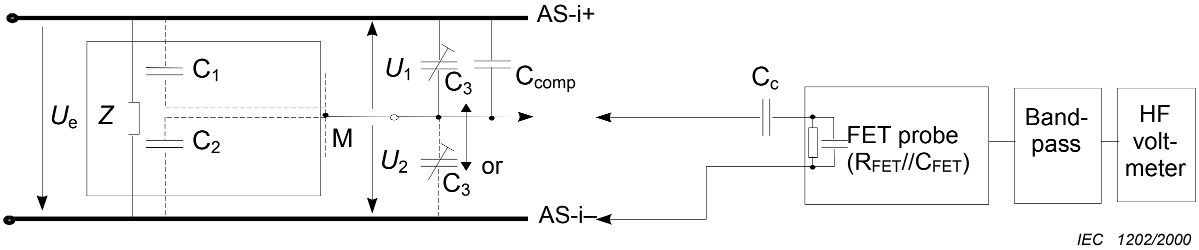


Figure 36 – Test circuit for symmetry

9.4.4.2 Test procedure

The bandpass filter according to figure 25 shall be used.

The accuracy of the measurements shall be within ±3 %.

1) Determine the voltages $|U_1|$ and $|U_2|$ at a frequency of 300 kHz without C_3.
2) If either $|U_1| / |U_2| > 0{,}9$ or $|U_1| / |U_2| < 1{,}1$, add C_3 between the measurement point M and AS-i+ or AS-i–. Calibrate the value of C_3 such that $|U_1| = |U_2| = U_e/2$ at the frequency of 300 kHz.
3) Determine the voltages $|U_1|$ and $|U_2|$, without changing C_3, for each of the other frequencies: 50 kHz, 100 kHz, 125 kHz, 160 kHz and 200 kHz.

9.4.4.3 Evaluation of test results

The following condition, depending on the value of C_3, shall be met:

– for $C_3 = 0$ $0{,}9 < |U_1| / |U_2| = |Z_1| / |Z_2| < 1{,}1$

– for $C_3 \leq 15$ pF $0{,}8 \leq |U_1| / |U_2| \leq 0{,}9$ or $1{,}10 \leq |U_1| / |U_2| \leq 1{,}20$

– for $C_3 \leq 30$ pF $|U_1| / |U_2| \leq 0{,}8$ or $1{,}20 \leq |U_1| / |U_2|$

9.4.5 Behaviour during power-ON

9.4.5.1 Power-ON communication behaviour

The AS-i master shall be connected to a constant voltage source.

The time T_1 from connecting the AS-i master to the AS-i line up to the time where the AS-i master requests a message (e.g. read_I/O code) shall be determined with an accuracy of ±3 %.

9.4.5.2 Current consumption

The test shall be performed with the AS-i master connected to a test circuit as shown in figure 37.

The constant current shall be $I = (I_{st} + 12{,}5)$ mA.

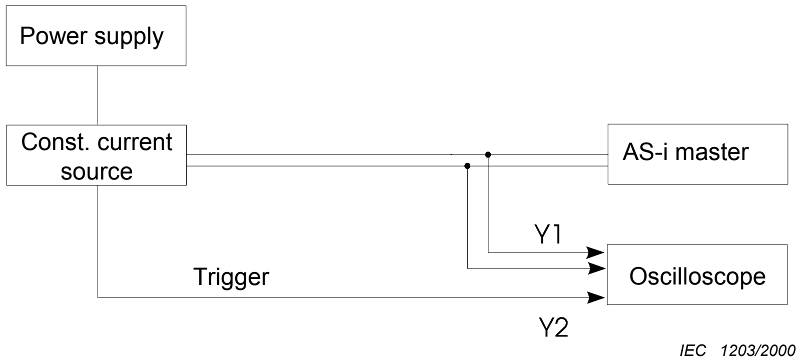


Figure 37 – Test circuit

The time T_2 from connecting the AS-i master to the AS-i line to the time where the minimum voltage of 26,5 V has been reached shall be determined with an accuracy of ±3 %.

9.4.5.3 Evaluation of test results

a) The time T_1 shall be greater than 1 s.

b) The time T_2 shall be less than 1 s.

c) The sum of times T_1 and T_2 shall be less than 2 s.

9.5 Test of electromechanical components

Tests of electromechanical components comprise the test of the AS-i standard cable (dimensions and connection).

The dimensions of the AS-i standard cable shall be verified according to figure 12.

Annex A
(normative)

Slave profiles

This annex states specific information about the definition of profiles for the AS-i slaves. It explains the concept of profile and states the particular features for the individual slave profiles.

A.1 Introduction

The AS-i system supports the communication of four I/O data bits and four parameter bits between the master and individual slaves. For each slave, there are sixteen different configurations for the I/O data bits, i.e. the bits may be defined as input, output, bidirectional, or, if non-configured, tristate. Furthermore, two particular slaves with the same I/O configuration may have different meanings of the data and parameter bits.

To facilitate usage in applications, AS-i defines profiles for the slaves. Slave profiles define the use of the data and parameter values for the most common applications and assign specific meanings to them.

A slave profile contains all the additional definitions and restrictions needed for a slave in a specified application.

A slave profile contains the following well-defined and fixed data:

– I/O configuration (I/O code) with meanings for the I/O data and parameter values;
– identification code (ID code);
– definition of meanings of the levels (HIGH or LOW) of the I/O data and parameters;
– list of minimum requirements for the physical implementation.

The installation of slaves according to specific slave profiles may be supported by standard function blocks (if available) in the controller. Replacing a slave with another having the same slave profile shall need no changes in the application software, provided the physical specification of the old slave and the replacement slave is identical in the application.

The ID code of the slave is used to distinguish between different slave profiles with the same I/O code. The ID code is stored within the slave in a non-volatile and irreversible format.

A.2 Definitions

I/O type	Each I/O data port of a slave is configured as input, output, bidirectional, or, if unconfigured, tristate type.
Controller level	The representation of the logic level (0/1) of inputs or outputs at the interface between the AS-i master and the controller.

AS-i level — The logic level (LOW/HIGH) within the AS-i system is called "AS-i level".

NOTE The logic level for the I/O output bits is inverted at the inputs of the AS-i master, i.e. for I/O output bits the AS-i level is the inverse of the controller level.

Default levels — The default for the AS-i levels of the I/O data bits and parameter bits is HIGH.

Physical signal — In some slave profiles, the definition of "meaning" uses the terms "physical signal detected" and "physical signal not detected". In this context, the "physical signal detected" is defined for several different groups of binary sensors.

For photoelectric and ultrasonic sensors: light or sound is detected on the detecting element within the specified range of geometry, intensity or time window.

For inductive or capacitive sensors: the frequency or the amplitude of the internal oscillator is changed due to the presence of an object within the specified range.

For pressure sensors: the higher of two pressure values is detected by the switch.

For flow sensors: the higher of two flow rates is detected by the switch.

A.3 Overview of existing slave profiles

An overview of the existing slave profiles and their combinations of the configuration (I/O code) and profile identification (ID code) is given in table A.1. The detailed definitions of the slave profiles are described in A.4.

Table A.1 – Overview of existing slave profiles

<table>
<tr><th colspan="3" rowspan="2">AS-i profiles</th><th colspan="16">ID code</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td rowspan="16">I/O code</td><td>0</td><td>I, I, I, I</td><td rowspan="9">X.0</td><td>0.1</td><td rowspan="15" colspan="13">Reserved</td><td rowspan="13">Free profile</td></tr>
<tr><td>1</td><td>I, I, I,O</td><td>1.1</td></tr>
<tr><td>2</td><td>I, I, I,B</td><td></td></tr>
<tr><td>3</td><td>I,I,O,O</td><td></td></tr>
<tr><td>4</td><td>I,I,B,B</td><td></td></tr>
<tr><td>5</td><td>I,O,O,O</td><td></td></tr>
<tr><td>6</td><td>I,B,B,B</td><td></td></tr>
<tr><td>7</td><td>B,B,B,B</td><td>7.1</td></tr>
<tr><td>8</td><td>O,O,O,O</td><td></td></tr>
<tr><td>9</td><td>O,O,O,I</td><td>R</td><td></td></tr>
<tr><td>A</td><td>O,O,O,B</td><td>X.0</td><td></td></tr>
<tr><td>B</td><td>O,O,I,I</td><td>R</td><td>B.1</td></tr>
<tr><td>C</td><td>O,O,B,B</td><td>X.0</td><td></td></tr>
<tr><td>D</td><td>O, I,I, I</td><td>R</td><td>D.1</td><td rowspan="2">X.F</td></tr>
<tr><td>E</td><td>O,B,B,B</td><td>X.0</td><td></td></tr>
<tr><td>F</td><td>T,T,T,T</td><td colspan="15">NOT USED</td><td>V</td></tr>
<tr><td colspan="19">Configuration: I = Input, O = Output, B = Bidirectional, T = Tristate
Profiles: V = Virgin, R = Reserved</td></tr>
</table>

Existing slave profiles are stated in table A.2.

Table A.2 – Short description of existing slave profiles

I/O code	ID code	Description	Slave	I/O	ID
I/O = X	ID = F	Free profiles	S	X	F
I/O = 0	ID = 1	Two dual-signal sensors	S	0	1
I/O = 1	ID = 1	Single sensor with extended control	S	1	1
I/O = B	ID = 1	Dual actuator with feedback	S	B	1
I/O = D	ID = 1	Single actuator with monitoring	S	D	1
I/O = X	ID = 0	Remote I/O ports	S	X	0
I/O = 7	ID = 1	Profile for the transfer of 6- to 18-bit signals	S	7	1
I/O = F	ID = F	Virgin slaves	S	F	F

If there is an error in transferring the codes from the non-volatile to the volatile memory, the codes I/O = F and ID = F shall be stored in the volatile memory of a slave.

A.4 Slave profiles

A.4.1 Free profiles S-X.F

A.4.1.1 Definition

Slaves with free profiles are those slaves which do not have a particular defined profile. These may be slaves with special communication functions, or physical realizations for a unique application.

A.4.1.2 Codes

The I/O code may have any value between Hex 0 and Hex E.

The ID code shall be Hex F.

A.4.1.3 Meanings of I/O data and parameters

Meanings for the I/O data and parameter values are not defined.

A.4.1.4 Additional requirements

There are no additional requirements for these slaves.

A.4.2 Remote I/O ports S-X.0

A.4.2.1 Definition

These profiles collect all the AS-i–slaves which are used as remote I/O ports with no particular meaning of the I/O data bits. Each I/O data bit is an individual remote I/O bit and there is no particular relationship between the single bits. The remote I/O ports may be used to connect, for example, conventional actuators, two- or three-wire sensors, and other devices and elements to an AS-i network. These profiles allow free access to the I/O data at interface 1 between the field device and the AS-i–slave, as it is described in figure 1. Remote I/O devices may also have ports for power supply from the AS-i line.

A.4.2.2 Codes

The I/O code may have any value between Hex 0 and Hex E, except Hex 9, B and D.

The ID code shall be Hex 0.

A.4.2.3 Meanings of I/O data

The meanings of the I/O data bits are summarized in table A.3.

Table A.3 – Meanings of data

Bit	Type	Function	Controller level	AS-i level	Meaning
D0	–	Remote I/O	0	–	–
			1	–	–
D1	–	Remote I/O	0	–	–
			1	–	–
D2	–	Remote I/O	0	–	–
			1	–	–
D3	–	Remote I/O	0	–	–
			1	–	–

For D0 to D3, no particular meaning exists. Each I/O data bit is an individual remote I/O bit and there is no particular relationship between the single bits.

A.4.2.4 Meanings of parameters

The meanings of the parameter bits are summarized in table A.4.

Table A.4 – Meanings of parameters

Bit	Type	Function	Controller level	AS-i level	Meaning
P0	Parameter	To be defined	0	LOW	To be defined
			1	HIGH	To be defined
P1	Parameter	To be defined	0	LOW	To be defined
			1	HIGH	To be defined
P2	Parameter	To be defined	0	LOW	To be defined
			1	HIGH	To be defined
P3	Parameter	To be defined	0	LOW	To be defined
			1	HIGH	To be defined

The meanings of P0 to P3 are reserved for future use and shall not be used in this profile.

A master request on parameter bits not used shall always yield an AS-i HIGH level.

A.4.2.5 Ports and connectors

A.4.2.5.1 Port to the AS-i line

There shall be two contacts for the connection of the AS-i slave to the AS-i line (AS-i+/AS-i–).

A.4.2.5.2 Input data port

If a 12 mm or 8 mm connector according to annex D of IEC 60947-5-2 is used for the connection, the connector shall be female with the following pin identification:

1	=	(+) power supply
2	=	input data bit
3	=	(–) power supply
4	=	input data bit

Pins 2 and 4 of such a 12 mm or 8 mm connector shall be electrically bridged. The bridging connection shall be made in such a way that it cannot be removed with simple tools.

If terminals are used, then for the input data bits D0 to D3, the terminals shall be numbered as follows:

11 to 41	=	(+) power supply for sensors 1 to 4
13 to 43	=	(–) power supply for sensors 1 to 4
12/14 to 42/44	=	input data bits 1 to 4

A.4.2.5.3 Output data port

If a 12 mm or 8 mm connector according to annex D of IEC 60947-5-2 is used for the connection, for an active output (including power for e.g. an actuator) the plug shall be female with the following identification:

1	=	(+) power supply in the case of a npn logic
2	=	not connected
3	=	(–) power supply in the case of a pnp logic
4	=	output, parameter, etc.

For a passive output (e.g. relay contacts), the connector shall be male with the following pin identification:

1	=	change-over contact
2	=	normally closed (NC) contact
4	=	normally open (NO) contact

If terminals are used, then for the output data bits D0 to D3 the terminals shall be numbered as follows:

11 to 41	=	(+) power supply for actuators 1 to 4 in the case of npn logic
13 to 43	=	(–) power supply for actuators 1 to 4 in the case of pnp logic
14 to 44	=	output data bits 1 to 4

A.4.2.5.4 Power port

If a 12 mm or 8 mm connector according to annex D of IEC 60947-5-2 is used for the connection of the auxiliary power or the power from the AS-i line, the connector shall be male for power input and female for power output with the following pin identification:

1	=	(+) power
2	=	not used
3	=	(–) power
4	=	not used

If terminals are used, then they shall be numbered as follows:

1	=	(+) power
3	=	(–) power

A.4.2.6 Marking

The remote I/O ports shall have a clear identification of the available ports on the enclosure such as I/O data bits and power supply from the AS-i system, as well as a clear identification of the pnp or npn logic used for the ports.

The ports for the four I/O data bits D0 to D3 shall be marked with the numbers 1 to 4. In addition to the numbers, the ports of bidirectional I/Os shall be marked with the capital letter B. In general, for the unique identification of the ports, a single letter may be used, such as I for input data, O for output data, etc. Only capital letters shall be used. The letters A, B and P are reserved for complementary (antivalent) I/Os, bidirectional I/Os and parameter outputs respectively.

A.4.2.7 Additional requirements

The voltage levels and currents at the ports of a remote I/O device shall be in accordance with IEC 61131-2.

The value of the time delay for an I/O signal between the arrival at the port of a remote I/O device and the availability on the AS-i line shall be less than 5 ms for input data and less than 20 ms for output data. The actual value of the time delay shall be stated by the manufacturer.

As an option, remote I/O output ports may have an integrated watchdog function monitoring the continuity of the communication. Such a watchdog function shall not have a response time less than 20 ms. In the product documentation, it shall be stated whether or not the remote I/O ports contain a watchdog function.

For remote I/O ports with an auxiliary power supply, the availability, overload, short circuit, etc. of the auxiliary power may be monitored by electronic means. If such a monitor function is used, it shall use the local reset function of the slave to inhibit the communication to the master. The use of this monitor function in the remote I/O ports shall be stated in the product documentation.

A.4.3 Two dual-signal sensors S-0.1

A.4.3.1 Definition

This slave profile comprises the applications of one or two binary sensors which have two data signals each. The slave profile offers the possibility to use a single monitor function for each sensor, such as a warning, a failure message, a breakdown signal, etc. The slave profile also includes remote I/O devices for the connection of conventional antivalent output sensors to the AS-i line.

A.4.3.2 Codes

The I/O code shall be Hex 0.

The ID code shall be Hex 1.

A.4.3.3 Meanings of I/O data

The meanings of the I/O data bits are summarized in table A.5.

Table A.5 – Meanings of data with monitoring function

Bit	Type	Function	Controller level	AS-i level	Meaning
D0	Input	Sensor 1	0	LOW	Physical signal not detected
			1	HIGH	Physical signal detected
D1	Input	Monitor signal 1	0	LOW	Warning/failure
			1	HIGH	Normal operation
D2	Input	Sensor 2	0	LOW	Physical signal not detected
			1	HIGH	Physical signal detected
D3	Input	Monitor signal 2	0	LOW	Warning/failure
			1	HIGH	Normal operation

D0 and D2 shall only be used as input signals from the switching elements of sensors 1 and 2 respectively, the term "physical signal" in the column "meaning" being defined in A.2. If the slave is a remote I/O port to which the two sensors may be connected, then the terms "physical signal detected" and "physical signal not detected" shall be replaced by "switching element in the (external) sensor closed" and "switching element in the (external) sensor open" respectively.

D1 and D3 shall only be used as monitor signals for sensors 1 and 2 respectively. The monitor signals may indicate, for example, when the corresponding sensor has a reduced functionality, is in a critical state or broken down, gives a warning, needs an inspection, etc.

The monitor signals D1 and D3 may also be the inverted signals to the sensor function signals D0 and D2, respectively. If so, the meanings of the data bits shall be as listed in table A.6.

Table A.6 – Meanings of data with exclusive-OR ports

Bit	Type	Function	Controller level	AS-i level	Meaning
D0	Input	Sensor 1	0	LOW	Physical signal not detected
			1	HIGH	Physical signal detected
D1	Input	Sensor 1	0	LOW	Physical signal detected
			1	HIGH	Physical signal not detected
D2	Input	Sensor 2	0	LOW	Physical signal not detected
			1	HIGH	Physical signal detected
D3	Input	Sensor 2	0	LOW	Physical signal detected
			1	HIGH	Physical signal not detected

If the slave is a remote I/O port to which the two sensors may be connected, then the terms "physical signal detected" and "physical signal not detected" shall be replaced by "switching element in the (external) sensor closed" and "switching element in the (external) sensor open" respectively.

A.4.3.4 Meanings of parameters

The meanings of the parameter bits are summarized in table A.7

Table A.7 – Meanings of parameters

Bit	Type	Function	Controller level	AS-i level	Meaning
P0	Parameter	To be defined	0	LOW	To be defined
			1	HIGH	To be defined
P1	Parameter	To be defined	0	LOW	To be defined
			1	HIGH	To be defined
P2	Parameter	To be defined	0	LOW	To be defined
			1	HIGH	To be defined
P3	Parameter	To be defined	0	LOW	To be defined
			1	HIGH	To be defined

The meanings of P0 to P3 are reserved for future use and shall not be used for this profile. A master request on parameter bits not used shall always yield an AS-i HIGH level.

A.4.3.5 Requirements for ports of remote I/O devices

The slave profile may also comprise remote I/O devices to connect conventional sensors with an antivalent output or other dual-signal sensors to the AS-i system. For the ports of such remote I/O devices, the following requirements apply.

If a 12 mm or 8 mm connector according to annex D of IEC 60947-5-2 is used, the connector shall be female with the following pin identification:

1	=	(+) power supply
2	=	input signal (normally closed), or monitor signal
3	=	(–) power supply
4	=	input signal (normally open)

If terminals are used, they shall be numbered as follows:

11 and 21	=	(+) power supply for sensors 1 and 2
12 and 22	=	input data (normally closed) of sensors 1 and 2, or monitor signal of sensors 1 and 2
13 and 23	=	(–) power supply for sensors 1 and 2
14 and 24	=	input data (normally open) of sensors 1 and 2

The voltage levels and currents at the ports shall be according to IEC 61131-2.

The value of the time delay for a signal between its arrival at the port and its availability on the AS-i line shall be less than 5 ms. The actual value of the time delay shall be stated by the manufacturer.

The ports for sensors 1 and 2 shall be clearly marked as "1/2" and "3/4" respectively. The sensor output logic (npn or pnp) for which the ports may be used shall also be marked on the enclosure.

A.4.4 Single sensor with extended control S-1.1

A.4.4.1 Definition

This profile collects the applications of single binary sensors with an increased functionality, i.e. the profile offers the possibility to use different sensor monitor and control functions, and allows a binary parameterizing of the sensor.

A.4.4.2 Codes

The I/O code shall be Hex 1.

The ID code shall be Hex 1.

A.4.4.3 Meanings of I/O data

The meanings of the I/O data bits are summarized in table A.8.

Table A.8 – Meanings of data

Bit	Type	Function	Controller level	AS-i level	Meaning
D0	Input	Sensor function	0	LOW	Physical signal not detected
			1	HIGH	Physical signal detected
D1	Input	Warning	0	LOW	Warning on
			1	HIGH	Warning off
D2	Input	Availability	0	LOW	Not available
			1	HIGH	Available
D3	Output	Test	0	HIGH	Test function inactive
			1	LOW	Test function active

D0 shall only be used as input for the status of the switching element in the sensor, the term "physical signal" in the column "meaning" being defined in A.2. If the slave is a remote I/O port to which the two sensors may be connected, then the terms "physical signal detected" and "physical signal not detected" shall be replaced by "switching element in the (external) sensor closed" and "switching element in the (external) sensor open" respectively.

D1 shall only be used as a warning signal. It indicates that the sensor is working but has a reduced functionality or needs an inspection.

D2 shall monitor the availability of the sensor only. A breakdown of the device may be signalled by this bit.

D3 shall only initiate a functional test of the sensor.

A master request on data bits not used shall always yield an AS-i HIGH level.

A.4.4.4 Meanings of parameters

A.4.4.4.1 Inductive proximity switches

For inductive proximity switches, the meanings of the parameter bits are summarized in table A.9.

Table A.9 – Meanings of parameter bits for inductive proximity switches

Bit	Type	Function	Controller level	AS-i level	Meaning
P0	Parameter	Timer	0	LOW	Timer function ON
			1	HIGH	Timer function OFF
P1	Parameter	Inversion of D0	0	LOW	Inversion of D0
			1	HIGH	D0 as specified
P2	Parameter	Range	0	LOW	Low range
			1	HIGH	High range
P3	Parameter	Special function	0	LOW	Special function
			1	HIGH	Basic function

P0 shall only be used to activate a timer function.

P1 shall only be used to invert the meaning of D0.

P2 shall only be used to select between two different ranges of the sensor, for example between single and double distance ranges.

P3 shall only be used to set a special function of the sensor. Such a function may be for example a special mode, a teach-in, a reset of the sensor, etc.

A master request on parameter bits not used shall always yield an AS-i HIGH level.

A.4.4.4.2 Photoelectric proximity switches

For photoelectric proximity switches, meanings of the parameter bits are summarized in table A.10.

Table A.10 – Meanings of parameters bits for photoelectric proximity switches

Bit	Type	Function	Controller level	AS-i level	Meaning
P0	Parameter	Modulation frequency	0	LOW	Low modulation frequency
			1	HIGH	High modulation frequency
P1	Parameter	Inversion of D0	0	LOW	Inversion of D0
			1	HIGH	D0 as specified
P2	Parameter	Timer	0	LOW	Timer function ON
			1	HIGH	Timer function OFF
P3	Parameter	Special function	0	LOW	Special function
			1	HIGH	Basic function

P0 shall only be used to change the modulation frequency of the sensor.

P1 shall only be used to invert the meaning of D0.

P2 shall only be used to activate a timer function.

P3 shall only be used to set a special function of the sensor. Such a function may be, for example, a special mode, a teach-in, a reset of the sensor, etc.

A master request on parameter bits not used shall always yield an AS-i HIGH level.

A.4.4.4.3 Other sensors

Other sensors shall not use parameters P0 to P3 and a master request on parameter bits shall always yield an AS-i HIGH level.

A.4.4.5 Additional requirements

The detailed functions of the single data bits and parameter bits used for a particular sensor shall be stated in the product documentation of the sensor.

A.4.5 Dual actuator with feedback S-B.1

A.4.5.1 Definition

This slave profile collects the applications of dual actuators with feedback signals, such as two-directional pneumatic or hydraulic cylinders, two-directional motors, etc. The actual position or movement of the actuator is indicated by two feedback signals.

A.4.5.2 Codes

The I/O code shall be Hex B.

The ID code shall be Hex 1.

A.4.5.3 Meanings of I/O data

The meanings of the I/O data bits are summarized in table A.11.

Table A.11 – Meanings of data

Bit	Type	Function	Controller-level	AS-i level	Meaning
D0	Output	Command actuator 1	0	HIGH	Set actuator 1 de-energized
			1	LOW	Set actuator 1 energized
D1	Output	Command actuator 2	0	HIGH	Set actuator 2 de-energized
			1	LOW	Set actuator 2 energized
D2	Input	Feedback from 1	0	LOW	Actuator 1 is de-energized
			1	HIGH	Actuator 1 is energized
D3	Input	Feedback from 2	0	LOW	Actuator 2 is de-energized
			1	HIGH	Actuator 2 is energized

D0 and D1 shall only be used as command outputs for the actuators 1 and 2 respectively.

D2 and D3 shall only be used for the feedback signals of actuators 1 and 2 respectively.

A.4.5.4 Meanings of parameters

The meanings of the parameter bits are summarized in table A.12.

Table A.12 – Meanings of parameters

Bit	Type	Function	Controller level	AS-i level	Meaning
P0	Parameter	Watchdog function	0	LOW	Watchdog enabled
			1	HIGH	Watchdog disabled
P1	Parameter	Interlock 1 and 2	0	LOW	1 and 2 interlocked
			1	HIGH	No interlock
P2	Parameter	Remote reset	0	LOW	Start remote reset
			1	HIGH	Normal operation
P3	Parameter	Special function	0	LOW	Special function
			1	HIGH	Basic function

P0 shall only be used to enable a watchdog function monitoring the continuity of the communication activity of the slave. The watchdog function shall have a response time greater than 20 ms and shall de-energize the actuators following a communication failure.

P1 shall only be used to activate an interlock of the actuators 1 and 2. If P1 is in operation and set to its AS-i LOW level, it shall be prohibited to set both actuators active at the same time. An attempt to energize both actuators simultaneously shall result in de-energizing both actuators.

P2 shall only be used as a remote reset. A remote reset may, for example, restart the actuator out of a fault state, set the actuator to a defined initial state/position, etc.

P3 shall only be used to activate special functions, such as timer, speed-up, test, etc.

A master request on parameter bits shall always yield an AS-i HIGH level.

A.4.5.5 Additional requirements

The detailed functions of the single data bits and parameter bits used shall be stated in the product documentation.

A.4.6 Single actuator with monitoring S-D.1

A.4.6.1 Definition

This slave profile collects the applications of single actuators with extended monitor functions, such as for motor feeders, etc. The state of the actuator may be monitored by up to three bits of information.

A.4.6.2 Codes

The I/O code shall be Hex D.

The ID code shall be Hex 1.

A.4.6.3 Meanings of I/O data

The meanings of the I/O data bits are summarized in table A.13.

Table A.13 – Meanings of data

Bit	Type	Function	Controller level	AS-i level	Meaning
D0	Output	Command	0	HIGH	Set actuator de-energized
			1	LOW	Set actuator energized
D1	Input	Feedback	0	LOW	Actuator in de-energized position
			1	HIGH	Actuator in energized position
D2	Input	Fault	0	LOW	Fault
			1	HIGH	No fault
D3	Input	Availability	0	LOW	Not available
			1	HIGH	Available

D0 shall only be used as a command output for the actuator.

D1 shall only be used for the feedback signals of the actuator.

D2 shall only be used to indicate a fault condition. The fault messages are the reaction of a protection device and may indicate overload, overtemperature, overcurrent, tripping of a motor, etc.

D3 shall monitor the availability of the actuator only.

A.4.6.4 Meanings of parameters

The meanings of the parameter bits are summarized in table A.14.

Table A.14 – Meanings of parameters

Bit	Type	Function	Controller level	AS-i level	Meaning
P0	Parameter	Watchdog function	0	LOW	Watchdog enabled
			1	HIGH	Watchdog disabled
P1	Parameter	Timer	0	LOW	Timer enabled
			1	HIGH	Timer disabled
P2	Parameter	Remote reset	0	LOW	Start remote reset
			1	HIGH	Normal operation
P3	Parameter	Special function	0	LOW	Special function
			1	HIGH	Basic function

P0 shall only be used to enable a watchdog function monitoring the continuity of the communication activity of the slave. The watchdog function shall have a response time greater than 20 ms and shall de-energize the actuators following a communication fault.

P1 shall only be used to activate a timer function in the actuator.

P2 shall only be used as a remote reset. A remote reset may restart the actuator out of a fault state, set the actuator to a defined initial state/position, etc.

P3 shall only be used to activate special functions, such as speed-up, test, etc.

A master request on parameter bits not used shall always yield an AS-i HIGH level.

A.4.6.5 Additional requirements

The detailed functions of the single data bits and parameter bits used shall be stated in the product documentation.

Annex B
(normative)

Master profiles

B.1 Introduction

The AS-i master specification defines a list of functions to ensure the expected behaviour at the AS-i line.

AS-i masters need not provide all these functions, but those functions which are provided shall comply with this standard.

The object of this annex is to define the profiles for the AS-i master to prevent confusion between different AS-i masters from different manufacturers. It is also necessary to ensure the interoperability between master and slaves by well-defined and clear profile definitions.

B.2 Type of profiles

An AS-i master shall have one of the following profiles.

Table B.1 – Master profiles

Profile identifier	Name	Remark
M0	Minimum master	Only for data I/O
M1	Full master	Full data I/O, parameter and all other functions
M2	Reduced master	Full data I/O and minimum parameter functions

All profiles define the functionality of the AS-i master at the interface to the user.

The implementation of the function at the user interface according to the specific profile depends on the type of AS-i master.

B.3 Behaviour of the master according to the profiles

A master shall have a well-defined behaviour for start-up, running and shutdown, as described in this standard.

The required behaviour, the start-up and shutdown are defined in 8.3 and shall be implemented according to that definition.

Error reporting of AS-i masters shall be the same for all masters. At least the flag config_OK shall be available. This flag may be combined with other status or error information. The flag config_OK need not be evaluated in configuration mode if it is combined with other flags.

If there are several controller interfaces, for example a front panel with switches and lights combined with software calls interface, the error flag shall be accessible on all controller interfaces of the AS-i master.

B.4 List of functions and profile assignment

Table B.2 shows the names, results and functionality of the functions in abbreviated form. They are described in the manner of software calls.

A Protocol Implementation Conformance Statement (PICS) according to the profile assignment shall be included in the product documentation. The PICS describes the mapping between the functions defined in the AS-i master specification and the functions available at the controller or user interface.

The declaration of the AS-i cycle time is part of the PICS and shall be included in the product documentation. It shall allow for the calculation of the cycle time depending on the number of activated slaves under the following assumption:

master request = 14 T_{bit};

master pause = 3 T_{bit};

slave response = 7 T_{bit};

slave pause = 2 T_{bit};

one inclusion phase per AS-i cycle.

Example:

AS-i cycle time:	up to 19 activated slaves:	3 ms
	20 to 31 activated slaves:	(1 + number of activated slaves) × 156 µs

Table B.2 – Profile assignment list

No.	Function or call at controller interface		Data transfer/function	M0	M1	M2
1	Image, Status =	Read_IDI ()	IDI -> Controller	M	M	M
2	Status =	Write_OD (Image)	Controller -> OD	M	M	M
3	Status =	Set_permanent_parameter (Addr, Param)	Controller -> PP[x]	O	M	O
4	Param, Status =	Get_permanent_parameter (Addr)	PP[x] -> Controller	O	M	O
5	Status, Param =	Write_parameter (Addr, Param)	Controller -> Slave[x]	O	M	M
6	Status, Param =	Read_parameter (Addr)	Pa[x] -> Controller	O	M	O
7	Status =	Store_actual_parameters ()	Pa -> Pp	O	M	M
8	Status =	Set_permanent_configuration (Addr, Config)	Controller -> PCD[x]	O	M	O
9	Status, Config =	Get_permanent_configuration (Addr)	PCD[x] -> Controller	O	M	O
10	Status =	Store_actual_configuration ()	CDI -> PCD	M	M	M
11	Status, Config =	Read_actual_configuration (Addr)	CDI[x] -> Controller	O	M	O
12	Status =	Set_LPS (List31)	Controller -> LPS	O	M	O
13	Status, List31 =	Get_LPS ()	LPS -> Controller	O	M	O
14	Status, List31 =	Get_LAS ()	LAS -> Controller	O	M	O
15	Status, List32 =	Get_LDS ()	LDS -> Controller	O	M	O
16.0	Status, Flags =	Get_flags ()	Flags -> Controller	O	M	O
16.1	Status, Flag =	Get_flag_config_OK ()	Flag -> Controller	M	M	M
16.2	Status, Flag =	Get_flag_LDS.0 ()	Flag -> Controller	O	M	O
16.3	Status, Flag =	Get_flag_auto_address_assign ()	Flag -> Controller	O	M	O
16.4	Status, Flag =	Get_flag_auto_prog_available ()	Flag -> Controller	O	M	O
16.5	Status, Flag =	Get_flag_configuration_active ()	Flag -> Controller	O	M	O
16.6	Status, Flag =	Get_flag_normal_operation_active ()	Flag -> Controller	O	M	O
16.7	Status, Flag =	Get_flag_APF ()	Flag -> Controller	O	M	O
16.8	Status, Flag =	Get_flag_offline_ready ()	Flag -> Controller	O	M	O
17	Status =	Set_operation_mode (Mode)	Controller -> OM-Flag	M	M	M
18	Status =	Set_offline_mode (Mode)	Controller -> Offline-Flag	O	M	O
19	Status =	Activate_data_exchange (Mode)	Controller -> DE-Flag	O	O	O
20	Status =	Change_slave_address (Addr1, Addr2)	Controller -> Slave	O	M	O
21.1	Status =	Set_auto_address_enable (Mode)	Controller -> AE-Bit	O	O	O
21.2	Mode =	Get_auto_address_enable ()	Controller <- AE-Bit	O	O	O
22.1	Status, Resp =	Cmd_reset_AS-i_slave (Addr, Reset)	Controller -> Slave	O	O	O
22.2	Status, Resp =	Cmd_read_I/O_configuration (Addr, Conf)	Controller -> Slave	O	O	O
22.3	Status, Resp =	Cmd_read_identification_code (Addr, ID_cod)	Controller -> Slave	O	O	O
22.4	Status, Resp =	Cmd_read_status (Addr, Stat)	Controller -> Slave	O	O	O
22.5	Status, Resp =	Cmd_read_reset_status (Addr, Stat_res)	Controller -> Slave	O	O	O
22.6	Status, Resp =	Cmd_R1 (Addr, R1_code)	Controller -> Slave	O	O	O

NOTE 1 Explanation of symbols: M: mandatory; O: optional.

NOTE 2 The functions 22.1 to 22.6 inclusive make use of the execution control function execute_command (addr, info).

AS-i Protocol Implementation Conformance Statement (PICS)

Manufacturer:	
Product name:	
Order No.:	
Release:	
Date:	

Table B.3 – List of implemented functions

No.	Function or call at controller interface		3	Remark/implemented by
1	Image, Status =	Read_IDI ()		
2	Status =	Write_OD (Image)		
3	Status =	Set_permanent_parameter (Addr, Param)		
4	Param, Status =	Get_permanent_parameter (Addr)		
5	Status, Param =	Write_parameter (Addr, Param)		
6	Status, Param =	Read_parameter (Addr)		
7	Status =	Store_actual_parameters ()		
8	Status =	Set_permanent_configuration (Addr, Config)		
9	Status, Config =	Get_permanent_configuration (Addr)		
10	Status =	Store_actual_configuration ()		
11	Status, Config =	Read_actual_configuration (Addr)		
12	Status =	Set_LPS (List31)		
13	Status, List31 =	Get_LPS ()		
14	Status, List31 =	Get_LAS ()		
15	Status, List32 =	Get_LDS ()		
16.0	Status, Flags =	Get_flags ()		
16.1	Status, Flag =	Get_flag_config_OK ()		
16.2	Status, Flag =	Get_flag_LDS.0 ()		
16.3	Status, Flag =	Get_flag_auto_address_assign ()		
16.4	Status, Flag =	Get_flag_auto_prog_available ()		
16.5	Status, Flag =	Get_flag_configuration_active ()		
16.6	Status, Flag =	Get_flag_normal_operation_active ()		
16.7	Status, Flag =	Get_flag_APF ()		
16.8	Status, Flag =	Get_flag_offline_ready ()		
17	Status =	Set_operation_mode (Mode)		
18	Status =	Set_offline_mode (Mode)		
19	Status =	Activate_data_exchange (Mode)		
20	Status =	Change_slave_address (Addr1, Addr2)		
21.1	Status =	Set_auto_address_enable (Mode)		
21.2	Mode =	Get_auto_address_enable ()		
22.1	Status, Resp =	Cmd_reset_AS-i_slave (Addr, Reset)		
22.2	Status, Resp =	Cmd_read_I/O_configuration (Addr, Conf)		
22.3	Status, Resp =	Cmd_read_identification_code (Addr, ID_Cod)		
22.4	Status, Resp =	Cmd_read_status (Addr, Stat)		
22.5	Status, Resp =	Cmd_read_reset_status (Addr, StatRes)		
22.6	Status, Resp =	Cmd_R1 (Addr, R1_code)		
NOTE In column 3, the symbol X means that the function is implemented and the absence of the symbol means that the function is not available.				