Low-voltage switchgear and controlgear — Controller and device interface systems — Actuator Sensor interface (AS-i)

The European Standard EN 50295:1999 has the status of a
British Standard

ICS 29.130.20

National foreword

This British Standard is the English language version of EN 50295:1999.

The UK participation in its preparation was entrusted by Technical Committee PEL/17, Switchgear, controlgear, and HV-LV co-ordination, to Subcommittee PEL/17/2, Low-voltage switchgear and controlgear, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Attention is drawn to the fact that this standard is subject to certain patent rights. Details are given in the EN foreword.

Textual error

The textual error set out below was discovered when the English language version of EN 50295 was adopted as the national standard. It has been reported to CEN in a proposal to amend the text of the European Standard.

In Figure 27 the supply rails to AS-i slave have their polarity incorrectly indicated. The note defining V_1 and V_2 gives the correct voltage polarities. The circuit in Figure 28 shows the correct rail polarities.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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Summary of pages

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Descriptors: low-voltage switchgear, control equipment, automatic systems, interfaces sensor-actuator, definition, classification, marking, performance evaluation, equipment specification, tests

English version

Low-voltage switchgear and controlgear —
Controller and device interface systems —
Actuator Sensor interface (AS-i)

Appareillage à basse tension —   Niederspannungsschaltgeräte Steuerungs - und
Systèmes d'interface appareil de commande - appareils —   Geräte-Interface Systeme —
Interface capteur-actionneur (AS-i)   Aktuator Sensor Interface (AS-i)

This European Standard was approved by CENELEC on 1998-12-01.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B-1050 Brussels

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Page 2
EN 50295:1999

Foreword

This European Standard was prepared by Technical Committee CENELEC TC 17B, Low-voltage switchgear and controlgear including dimensional standardization.

The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 50295 on 1998-12-01.

There are patent rights linked to EN 50295:1999. The patent holder, SIEMENS Aktiengesell-schaft has declared to grant licences to these patents and corresponding patent applications under fair and reasonable terms in accordance with CEN/CENELEC Memorandum 8.

The following dates were fixed:

— latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	1999-12-01
— latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	1999-12-01

Annexes designated ''normative'' are part of the body of the standard.

In this standard, both annexes A and B are normative.

Contents

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1 Scope

This standard specifies requirements for a bit-oriented interface system between a single controlling device and control circuit devices or switching elements as defined in EN 60947-1, connected by an unshielded, untwisted two-wire cable carrying data and power. It also enables the interchangeability of components which have such interfaces.

This standard specifies:

— requirements for interfaces and for electromechanical structures for slaves and masters;

— performance of slaves, electromechanical structures and masters under normal service conditions;

— constructional and performance requirements;

— tests to verify conformance to the requirements.

Specific requirements for the various profiles for slaves and masters are given in annexes A and B.

NOTE 1 The standardized low-voltage switchgear and controlgear products covered by the EN 60947 series are:

— EN 60947-1: *General rules*;

— EN 60947-2: *Circuit-breakers*;

— EN 60947-3: *Switches, disconnectors, switch-disconnectors and fuse-combination units*;

— EN 60947-4: *Contactors and motor-starters*;

— EN 60947-5: *Control-circuit devices and switching elements*;

— EN 60947-6: *Multiple function equipment*;

— EN 60947-7: *Ancillary equipment*.

NOTE 2 Where inputs and outputs (I/O) are described in this standard, their meaning is relative to the master. The meaning relative to the application is the opposite.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 55011:1998, *Industrial, scientific and medical (ISM) radio-frequency equipment — Radio disturbance characteristics — Limits and methods of measurement.*
EN 60947-1:1997, *Low-voltage switchgear and controlgear — Part 1: General rules.*
EN 60947-5-1:1997, *Low-voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices.*
EN 60947-5-2:1997, *Low-voltage switchgear and controlgear — Part 5: Control circuit devices and switching elements — Section 2: Proximity switches.*
EN 60998-2-3:1993, *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.*
EN 61000-4-2:1995, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 2: Electrostatic discharge immunity test.*
EN 61000-4-3:1996, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 3: Radiated, radio-frequency, electromagnetic field immunity test.*
EN 61000-4-4:1995, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 4: Electrical fast transient/burst immunity test.*
EN 61131-2:1994, *Programmable controllers — Part 2: Equipment requirements and tests.*
HD 384.4.41 S2:1996, *Electrical installation of buildings — Part 4: Protection for safety — Chapter 41: Protection against electric shock.*
(IEC 60364-4-41:1992, mod)

3 Definitions, symbols and abbreviations

3.1 Definitions
The following terms and definitions apply to this standard.

3.1.1
active slave
slave connected to the AS-i line and capable of communicating as specified in this standard

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 to 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 of connecting 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)
duration of the transmission of one bit (T_{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

NOTE 1 Examples are actuators, sensors, push-buttons, indicator lights.

NOTE 2 "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 at the master

3.1.19
master request
data or parameter or function sent from the master to a single slave

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 which cannot be exceeded under all environmental and load conditions

3.1.23
send pause
period after receipt of the slave response during which no 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 time
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 is usually 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 e.g. actuators, sensors, or other devices and elements themselves, allowing 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 five 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
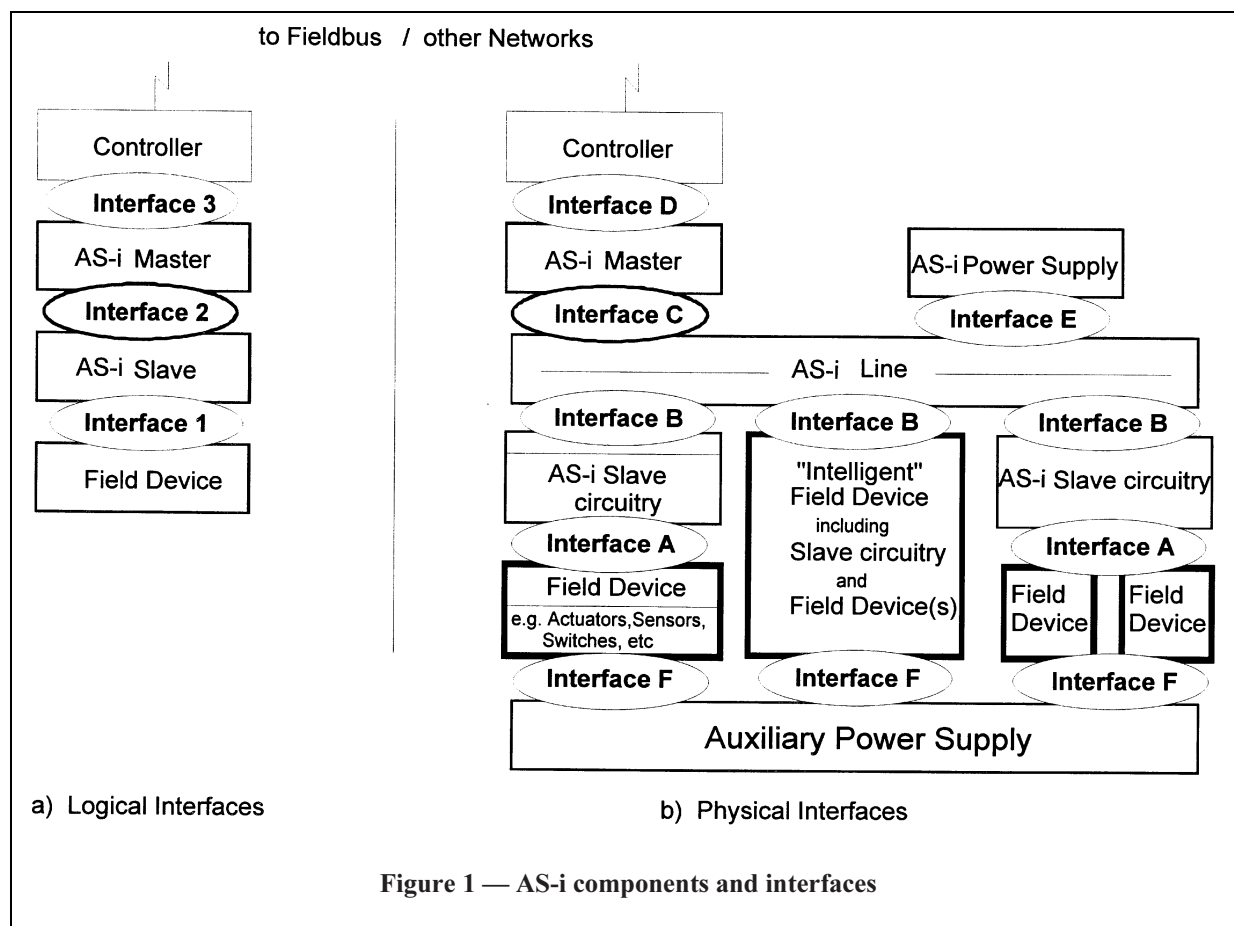
The AS-I concept is independent of the specific field devices. It defines the mechanisms and all the components for the communication with a controlling device and it offers electromechanical structures for a standardized ''interconnection system'' for installation of actuators, sensors, or other devices and elements.

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.

Annexes A and B define profiles for common types of devices that can be used in AS-i systems.

4.2 Components and interfaces (see Figure 1)

4.2.1 *Components*

4.2.1.1 *AS-i slave*

The AS-i slave includes the circuitry that 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 or other device or of the slave itself does not disturb the communication between the master and the other slaves in the network.

4.2.1.2 *AS-i master*

The AS-i master includes the circuitry that determines the logical and functional behaviour of the unit that 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.

4.2.1.3 *AS-i power supply*

The AS-i power supply provides power to the AS-i network and includes the decoupling circuitry.

4.2.1.4 *AS-i line*

The AS-i line provides the signalling and d.c. power connections between the AS-i devices.

4.2.2 *Logical interfaces*

4.2.2.1 *Interface 1*

Interface 1 is the slave interface that 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.

4.2.2.2 *Interface 2*

Interface 2 provides all logical definitions required for data exchange between the AS-i master and slaves. It comprises signalling of encoded information and the network management.

4.2.2.3 *Interface 3*

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 of the scope of this standard. The concrete representation of the interface depends on the implementation. To a large extent, it depends on features of the specific controller system.

4.2.3 *Physical interfaces*

4.2.3.1 *Interface A*

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.

4.2.3.2 *Interface B*

Interface B defines the physical connection of the AS-i slave circuitry to the AS-i line including physical interface (mechanical and electrical), signal characteristics and power requirements.

4.2.3.3 *Interface C*

Interface C defines the physical connection of the AS-i master circuitry to the AS-i line including physical interface (mechanical and electrical), signal characteristics and power requirements.

4.2.3.4 *Interface D*

The definition of the physical interface between the AS-i master and the controller (interface D) is outside of the scope of this standard and shall be provided by the manufacturer.

4.2.3.5 *Interface E*

Interface E defines the physical connection of the AS-i power supply including the signal decoupling circuit, to the AS-i line.

4.2.3.6 *Interface F*

Interface F defines the physical interface between the field device and an external auxiliary power supply if any.

5 Characteristics

5.1 AS-i transmission system

5.1.1 *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. Subclause **5.1.2** specifies the transmission of data between the master and a specific slave.

5.1.2 *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''. Master request or slave response shall be 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 will lead to a negative voltage pulse at each rising edge and a positive voltage pulse at each falling edge. The ideal waveform of the pulses is:

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

where U_{send} is a constant approximately equal to 2 V (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.
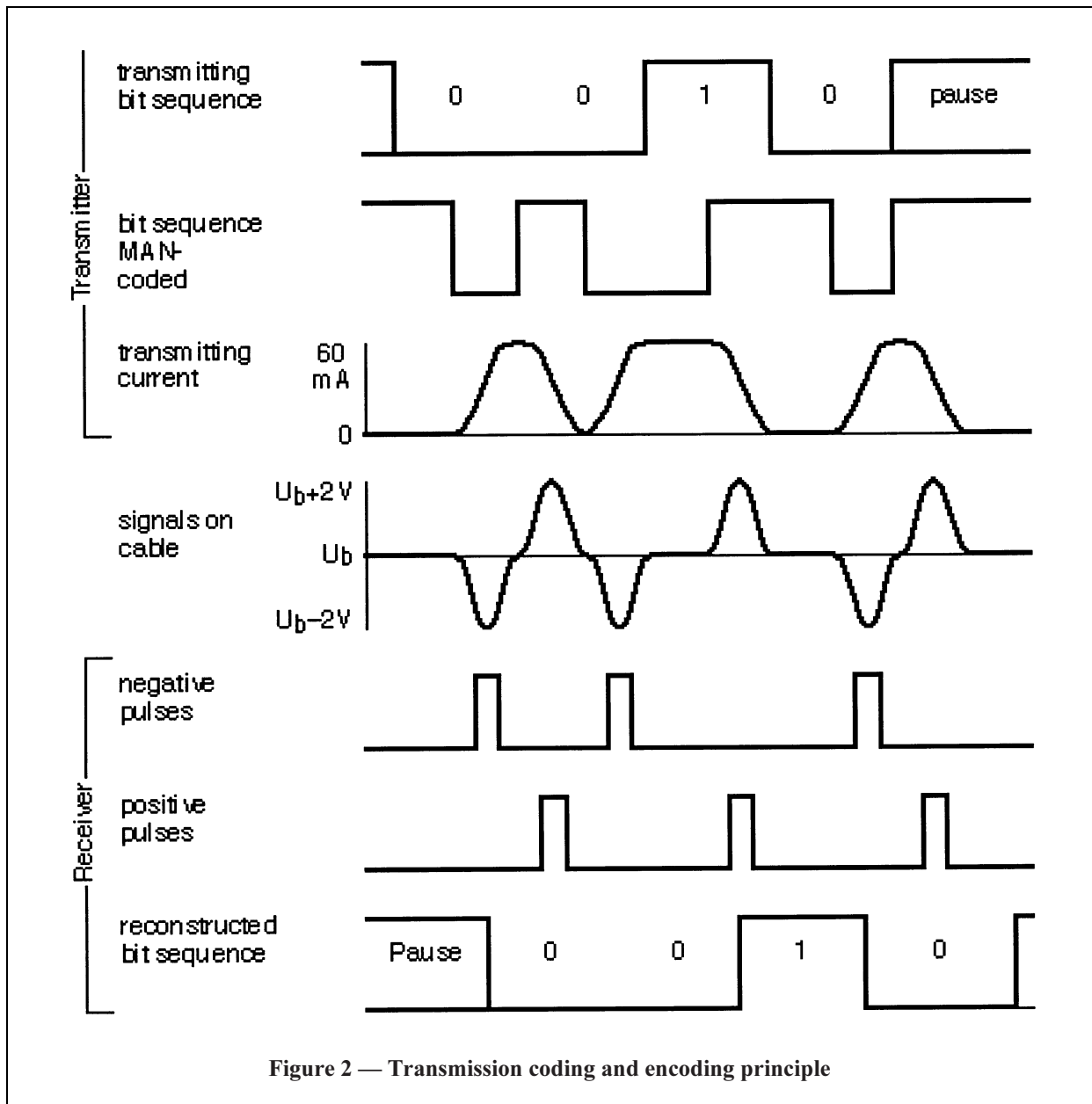
Figure 2 — Transmission coding and encoding principle

5.1.3 *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 provides d.c. power to devices on the AS-i line. Futhermore, it shall perform the main conditioning of physical data transmission within the system. This comprises the transmission signal forming and adaptation to the cable as well as ensuring the symmetry of the AS-i line. The adaptation is provided by a decoupling circuit.

NOTE   Power 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 HD 384.4.41 S2.
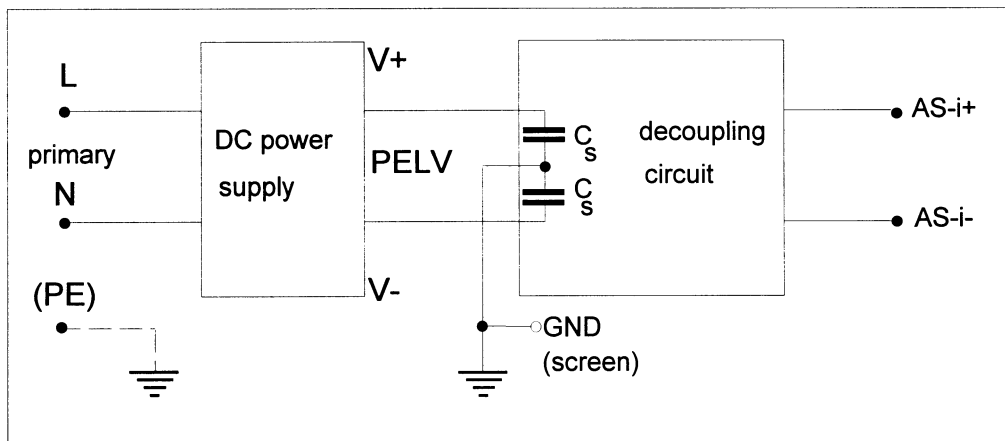
Figure 3 — AS-i power supply incorporating the decoupling circuit

5.2 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.

5.3 Data transmission

A data exchange shall be realised 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 re-transmission shall be processed in the same cycle.
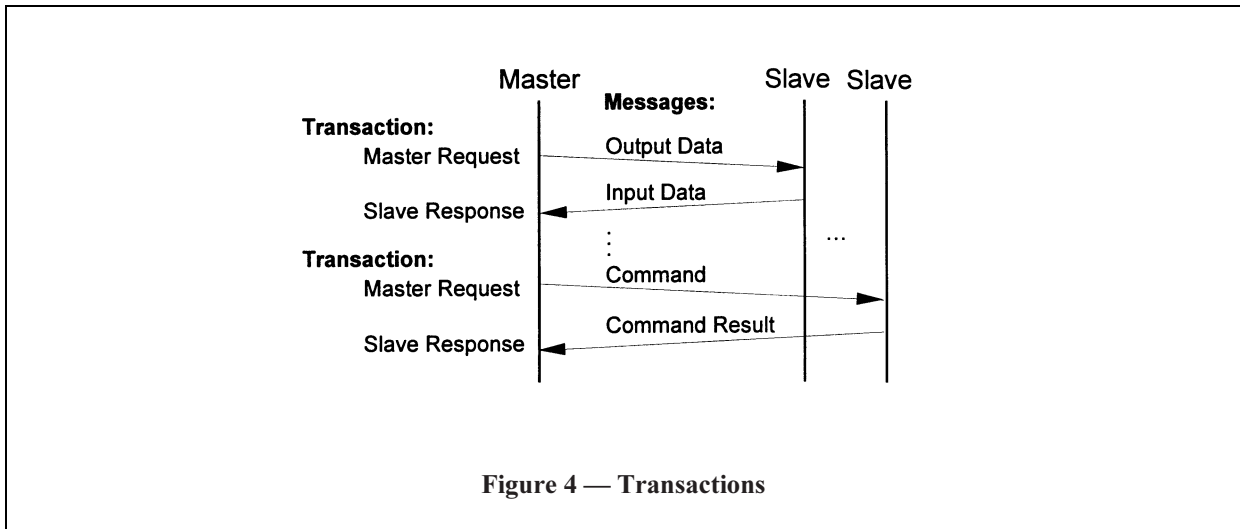
Figure 4 — Transactions

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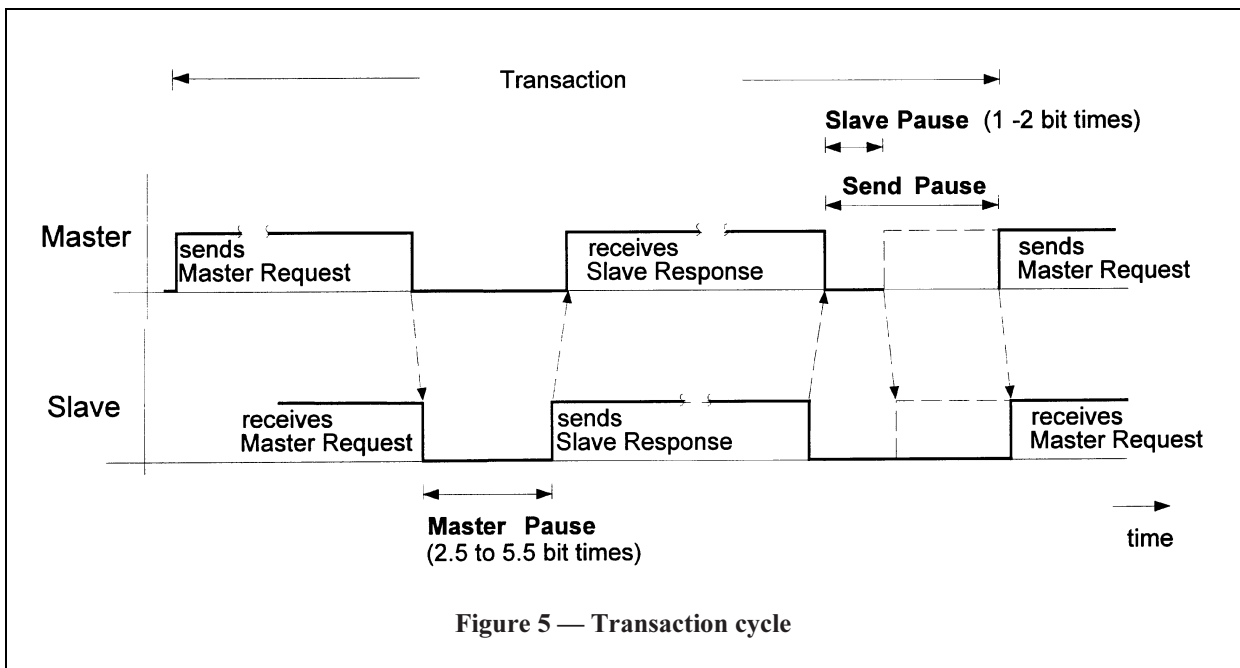

Figure 5 — Transaction cycle

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. These actions and intervals consist of the following.

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 slave 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 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.

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 bit)	To address the listed slaves. 0×00 = zero address. $0 \times 01...0 \times 1F$ = slave 1 through 31.
I4..I0	Information	These 5 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 the 1-symbols in (CB, A4...A0, I4...I0).
EB	End bit	Marks the end of the master request.

5.4.3 *Structure of the slave response*

The slave response shall be composed as follows.
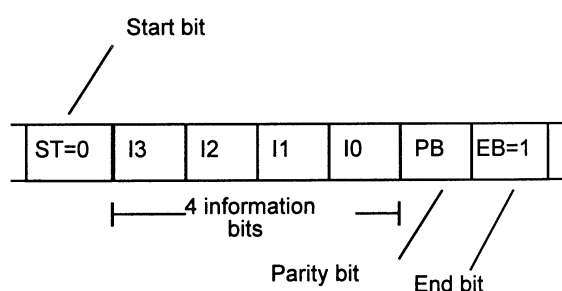
The meaning of the each bit shall be as shown in Table 3.

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 the 1-symbols in (I3...I0).
EB	End bit	Marks of the end of the slave response.

5.4.4 *Individual AS-i transactions*

5.4.4.1 *General*

Subclause **5.4.4** specifies requirements for the different transactions. The detailed functions of a slave after receiving a master request are defined in **8.2**.

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

5.4.4.2 *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

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

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

If the I/O configuration of the slave is $0 \times 0F$, no response shall be generated.

5.4.4.3 *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

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

The write_parameter request may affect the behaviour of the slave.

5.4.4.4 *Address_assignment*

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

The bits A4...A0 shall contain the zero address (0 × 00).

The slave response shall have the following structure.

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

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

5.4.4.5 *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 0 × 1C. 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

The slave response shall have the following structure.

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

The reset_AS-i_slave request affects the slave's state machine.

5.4.4.6 *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 0 × 00. 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

The slave response shall have the following structure.

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

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 slave's state machine.

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.

5.4.4.7 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 0×10. 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

The slave response shall have the following structure.

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

5.4.4.8 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 0×11. 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

The slave response shall have the following structure.

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

5.4.4.9 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 $0 \times 1E$. 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

5.5 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 a 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 $(n \times 6\,\mu s)^{+1.0\,\mu s}_{-0.5\,\mu s}$ 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 an end_bit_error.

Length_error: a length_error shall be detected 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.

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

6 Product information

6.1 Nature of information

The following information shall be given by the manufacturer.

6.1.1 *Instructions for installation, operation and maintenance*

The manufacturer shall specify in his documents or catalogues the conditions for installation, operation and maintenance of the interface components.

6.1.2 *Identification*

a) The manufacturer's name or trade mark.

b) A type designation or other marking which makes it possible to identify the product and to get the relevant information from the manufacturer or his catalogue.

c) Reference to this standard if the manufacturer claims compliance.

Basic rated values and utilization

d) Current ratings.

e) Connection and wiring identification as specified in Table 4.

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 EN 60947-5-2)	Power supply (+) Input data 1 Power supply (−) Input data 2	*)	1 2[1] 3 4[1]
A	INPUT port solid state (with terminals)	Power supply (+) (4×) Input data (4×) Power supply (−) (4×)		11...41 12/14...42/44 13...43
A	OUTPUT port solid state (with connectors. according to annex D of EN 60947-5-2)	Power supply (+) (npn) (4×) Power supply (−) (pnp) (4×) Output, parameter, etc. (4×)		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) (4×) Power supply (−) (pnp) (4×) Output data bit (4×)		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 [2]	AS-i (+) AS-i (−) U_{aux} (+) (−) PE [3]	Brown Blue Black White Green/Yellow	1 3 4 2 5

*) Wire colours for proximity switches shall conform to Table 3 of EN 60947-5-2.
[1] When only one INPUT pin per connector is used, the connector pins 2 and 4 shall be bridged internally.
[2] When the same connector or cable is used for both voltages, the auxiliary power supply shall be of the SELV or PELV type.
[3] If used.

6.2 Marking

6.2.1 *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 = + and blue = −.

6.2.2 *AS-i slave*

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

6.2.3 *AS-i power supply*

The connections of an AS-i power supply shall be identified as specified 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

6.2.4 *AS-i master*

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

6.2.5 *Profiles and all other AS-i components*

Masters and slaves shall be marked in order to permit the unambiguous identification of master and slave profiles as defined in annexes A and B.

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

7 Normal service, mounting and transport conditions

7.1 Normal service conditions

7.1.1 *General*

Unless otherwise specified in this standard, AS-i components shall be capable of operating under the conditions specified in **7.1.2** to **7.1.4**.

If the conditions for operation differ from those given in this standard, the user shall state the deviation from the following conditions and consult the manufacturer on the suitability for use under such conditions.

7.1.2 *Ambient air temperature*

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

7.1.3 *Altitude*

Subclause **6.1.2** of EN 60947-1 applies.

7.1.4 *Climatic conditions*

7.1.4.1 *Humidity*

AS-i components shall maintain the operating characteristics specified in this standard at a relative humidity (RH) of the air of up to 50 % at 40 °C. Higher relative humidities may occur at lower temperatures, e.g. 90 % at +20 °C.

NOTE Special measures may be necessary if occasional condensation is likely to occur due to variations in temperature.

7.1.4.2 *Pollution degree*

Unless otherwise stated by the manufacturer, an AS-i component directly connected to or incorporated into an actuator or sensor shall maintain the operating characteristics specified in this standard under environmental conditions of pollution degree 3 as defined in **6.1.3.2** of EN 60947-1.

NOTE Operating capability at other pollution degrees can be necessary, depending upon the micro-environment.

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, e.g. 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 ... +40 °C
Protection class	3 (PELV)
Output voltage range between AS-i+ and AS-i– (over the whole load range)	U_{AS-i} = 29,5 V d.c. ... 31,6 V d.c. at I from 0... 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	$I_L = 0...I_e + I_{ST}$
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 after start up time the AS-i voltage level does not meet the minimum required value ($U_{AS-i} < U_{AS-i\ min}$).

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

If overload indication is provided, it shall consist of either a red overload LED in steady mode or the green power ready indicator LED in a flashing mode.

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), e.g. 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 an impedance balance of AS-i+ and AS-i- to GND. Equal values of at least 100 nF are recommended.

The two inductances L_1 and L_2 should 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 for the recommended decoupling circuit.

Table 7 — Specific technical requirements for decoupling circuit

Inductance between AS- i+/AS-i-	100 μH ± 10 % (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	$0,98 \leq |Z_1| / |Z_2| \leq 1,02$ within the frequency range of 10 kHz to 300 kHz and the whole load range
Source impedance	$|Z_{out}| < 0,5$ Ω in the range of 10 kHz to 300 kHz
Impedance of C_S	$|C_S| < 5$ Ω 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 commands.

A slave with zero address shall be addressable only by commands and address_assignment.

The master requests stated in **8.2.1.2** to **8.2.1.10** require slave responses, except for the address_assignment which is optional.

A slave shall perform the functions specified in **8.2.1.2** to **8.2.1.10** in response to each specific 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.

NOTE 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 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 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, a 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-up or when the external reset_input is activated.

This routine performs the following processes:

— load data_output and parameter_output registers with default $0 \times F$;

— reset the status register to 0×0;

— 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*

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 4-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 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, e.g. in an integrated circuit, but they need not be physically accessible. Logical ports include mandatory and optional ports.

The connections and logical ports are 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 **5.4.3**) 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 shall lead 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'' shall lead to a LOW level.

If data input/output ports are implemented and if they can be used for 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 shall 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'' shall lead to a 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 shall be reflected 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 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. 16 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:

    — 4-bit input data to transmit the switching signals of 4 binary sensors;

    — 4-bit output data to activate four actuators;

    — 2-bit output plus 2-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
0×0	IN	IN	IN	IN
0×1	IN	IN	IN	OUT
0×2	IN	IN	IN	I/O
0×3	IN	IN	OUT	OUT
0×4	IN	IN	I/O	I/O
0×5	IN	OUT	OUT	OUT
0×6	IN	I/O	I/O	I/O
0×7	I/O	I/O	I/O	I/O
0×8	OUT	OUT	OUT	OUT
0×9	OUT	OUT	OUT	IN
$0 \times A$	OUT	OUT	OUT	I/O
$0 \times B$	OUT	OUT	IN	IN
$0 \times C$	OUT	OUT	I/O	I/O
$0 \times D$	OUT	IN	IN	IN
$0 \times E$	OUT	I/O	I/O	I/O
$0 \times F$	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).

15 different ID codes (0×0 to $0 \times E$) 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 = $0 \times F$.

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 if a power failure occurs.

Address register (5 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 (4 bits): stores which of the data ports is configured as output, input, bi-directional I/O.

ID_code register (4 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 (4 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 (4 bits): contains the latest input information available in interface 1.

Parameter_output register (4 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 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
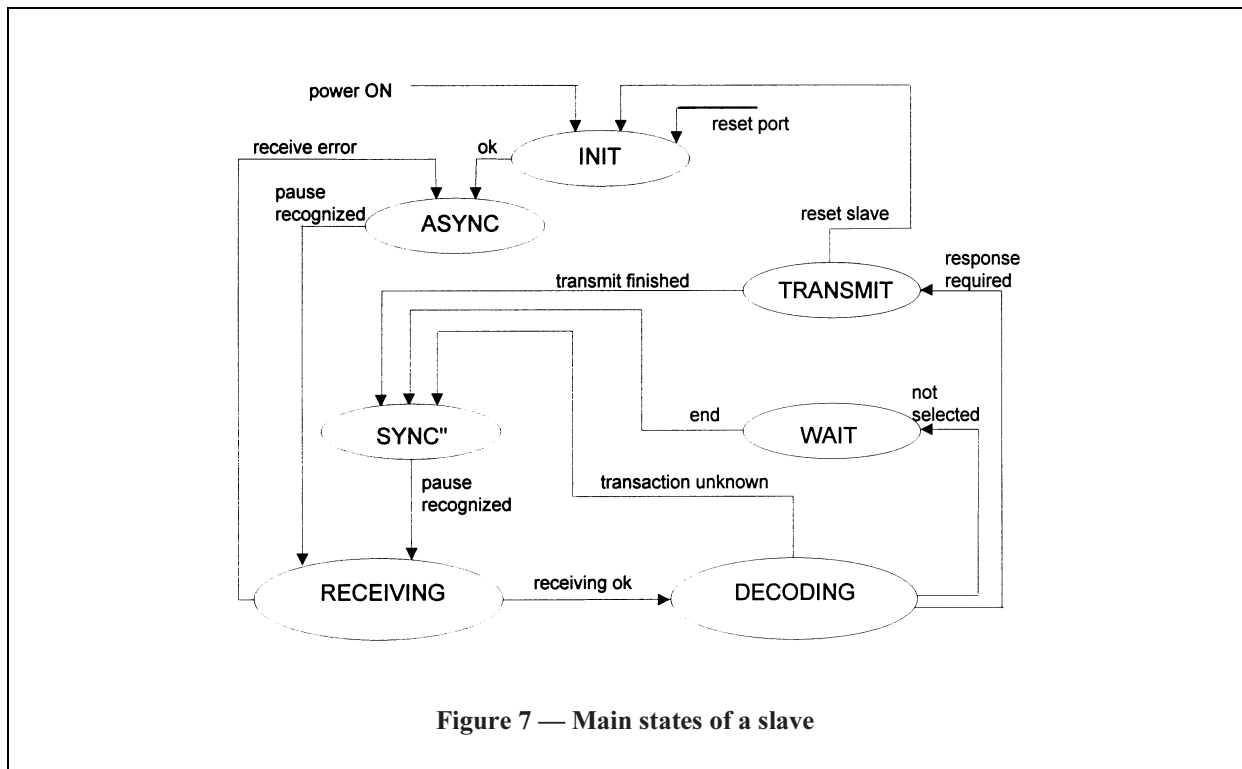
After power-ON or after resetting the slave via the RESET port or after receiving a reset_AS-i_slave request the slave shall be set to the state INIT.

In the state INIT the following functions shall be performed:

— load data_output and parameter_output registers with default $0 \times F$;

— reset the status register to 0×0;

— 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_disable 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_disable 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 3 bit times, if sync flag is set; it shall be a maximum of 5 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 pause 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. to 31,6 V d.c. If the AS-i supply voltage (measured between AS-i+ and AS-i-) of the slave drops below the limit of 18,5 V d.c., it is possible that master requests will 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 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 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 peak-to-peak 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 equivalent circuit limits 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

Inductance level	R	L	C
High inductance	>8 kΩ	>9 mH	<100 pF
Low inductance	>8 kΩ	6 to 9 mH	<70 pF + (L-6 mH) × 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 the impedance |Z| shall be measured.

The impedance |Z| shall be measured at the following frequencies:

— 50 kHz;

— the resonant frequency (if between 50 kHz and 300 kHz) or 150 kHz;

— 300 kHz.

The values of $\left|Z\right|$ shall be converted into *R*, *L* and *C* as described in **9.3.4**.

The impedance, measured between either AS-i+ or AS-i- to GND while the slave is mounted on a grounded metal plate, shall not be less than 250 kΩ. 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 $\left|Z_1\right|/\left|Z_2\right|$ of these impedances (Z_1, Z_2) shall meet the following criteria:

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

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.

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8.2.3.5 *Indicating means*

AS-i products may incorporate one or more coloured indicators.

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

Table 11 — Colours of indicator lights

Colour and mode	Meaning
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 not be 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 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 $0 \times F$ into both appropriate registers and shall set bit S3 of the status register to HIGH.

8.2.3.7 *Slaves with auxiliary power supply*

If an AS-i slave is powered with auxiliary power, the auxiliary voltage shall either have class III protection or have protective isolation from AS-i line in accordance with EN 60947-1. The rating of the auxiliary power supply shall be stated by the manufacturer.

If an M12 connector according to annex D of EN 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 structure of the master is shown in Figure 8.

Figure 8 — Model of the master
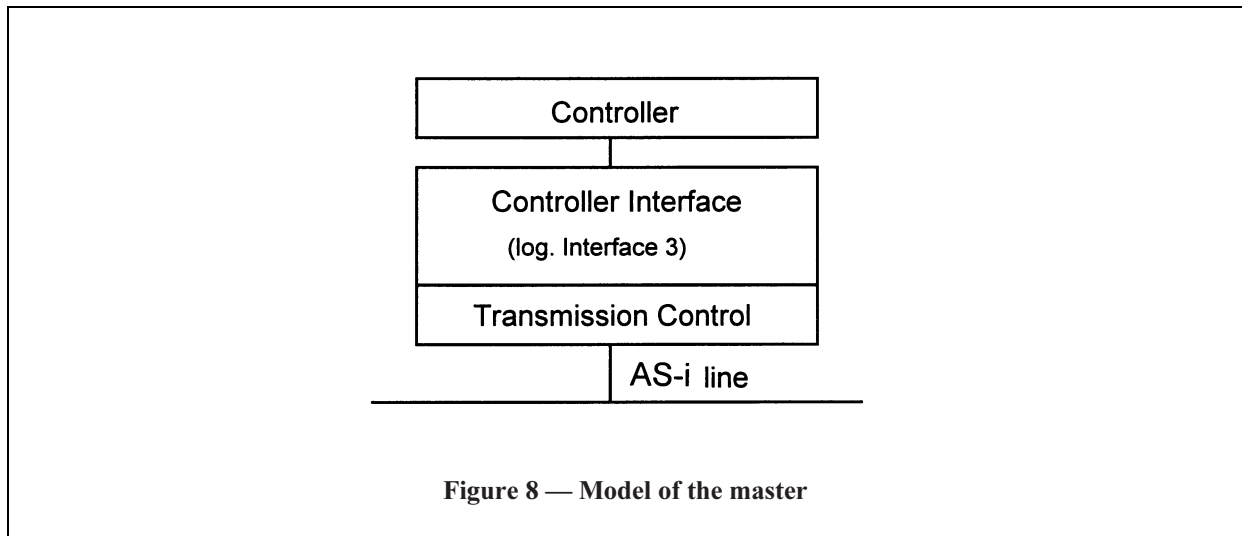
The controller interface acts as the logical interface between the master and the controller.

The controller uses the functions provided by the controller interface to communicate with the AS-i system. It is responsible for initialization of the master and the AS-i system, cyclic data exchange, acyclic commands and execution control functions.

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

The transmission control function is 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 (i.e. request and response) as defined in **5.4.4**.

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 **5.1** as long as there are no master specific definitions described in the following.

8.3.4 *General requirements*

8.3.4.1 *Voltages interruptions*

The master shall continue to 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 peak-to-peak 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 within 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
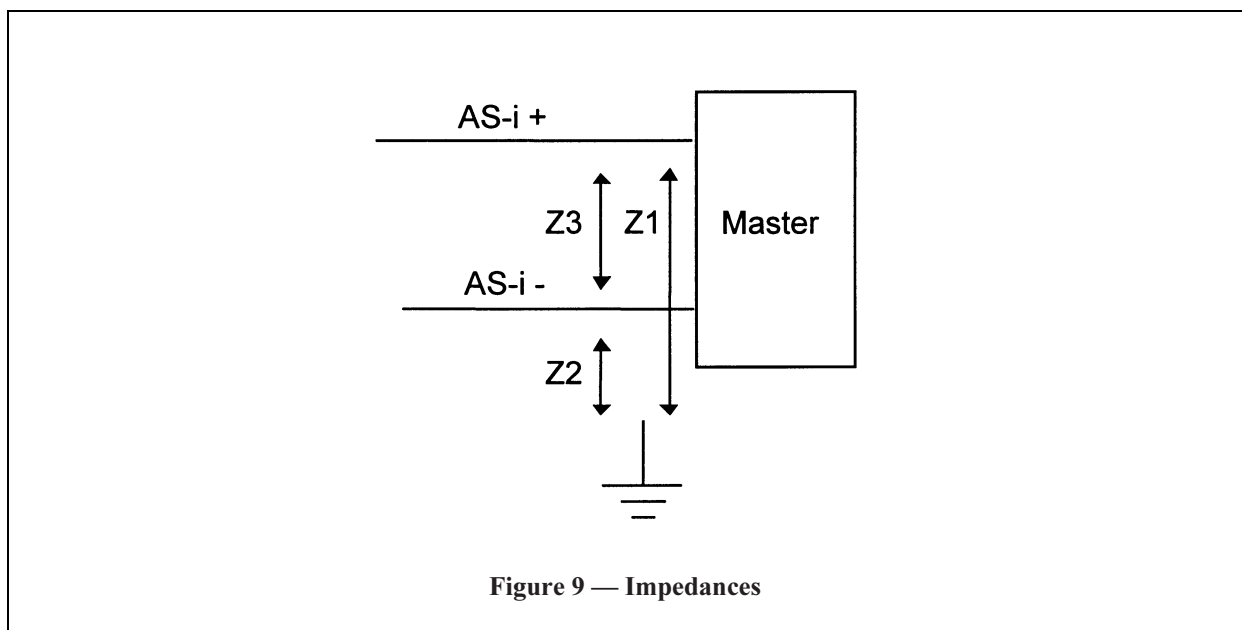
The impedance to GND, measured between either AS-i+ (Z_1) or AS-i- (Z_2) to GND or to the controlling device's power supply, while the master (and controlling device) is mounted on a grounded metal plate, shall not be less than 250 kΩ. During testing, all metal parts of the master and the controller device 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

R	*L*	*C*
>5 kΩ	>3 mH	<400 pF

To determine the values of R, L and C, the values of the impedance $|Z|$ shall be measured.

The impedance $|Z|$ shall be measured at the following frequencies:

— 50 kHz;

— the resonant frequency (if between 50 kHz and 300 kHz);

— 300 kHz.

The values of $|Z|$ shall be converted into R, L and C as described in **9.4.3**.

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 $t_{\text{fail}} \leq 1$ 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 than or equal to 0,1 %.

NOTE 2 This more severe requirement applies only to the master transmitter because its signal message length 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 V_{max} of a master request or slave response shall be between 1,5 V and 4 V. The ratio of V_{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 shall be between 65 % to 100 % of the maximum amplitude V_{max}.

Valid pulses shall start within a time window from $(\text{n} \times 3\mu s)^{+1.0\,\mu s}_{-0.5\,\mu s}$ in relation to the initial pulse V_{init}.

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

8.3.4.7 *Power failure*

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 the case of APF = TRUE.

Figure 10 — AS-i Power failure
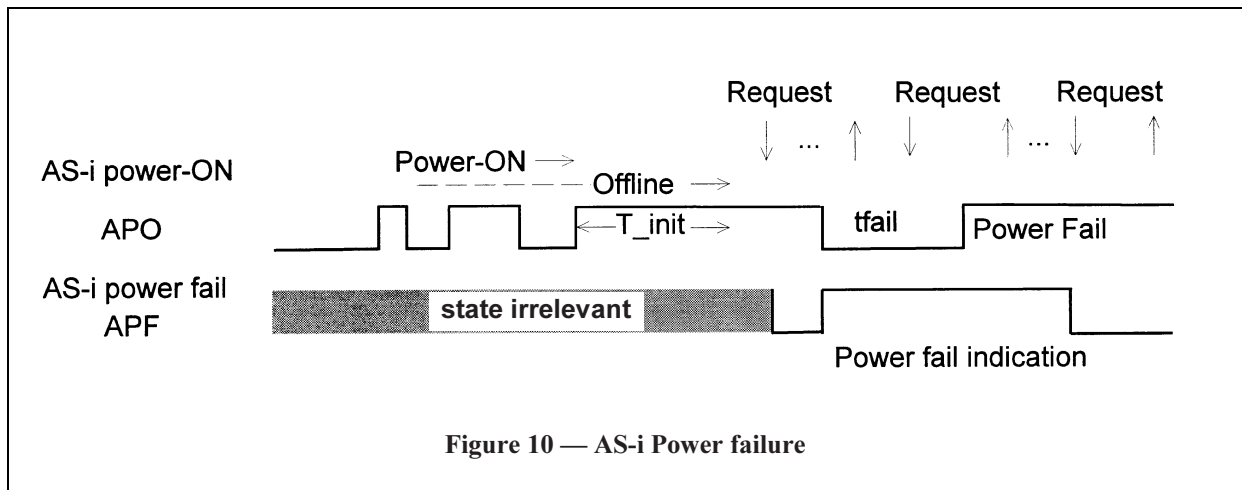
8.4 Electromechanical requirements

8.4.1 *AS-i line*

The AS-i transmission medium (see Figure 11) may be any cable, preferably non-shielded, and shall have 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 with 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
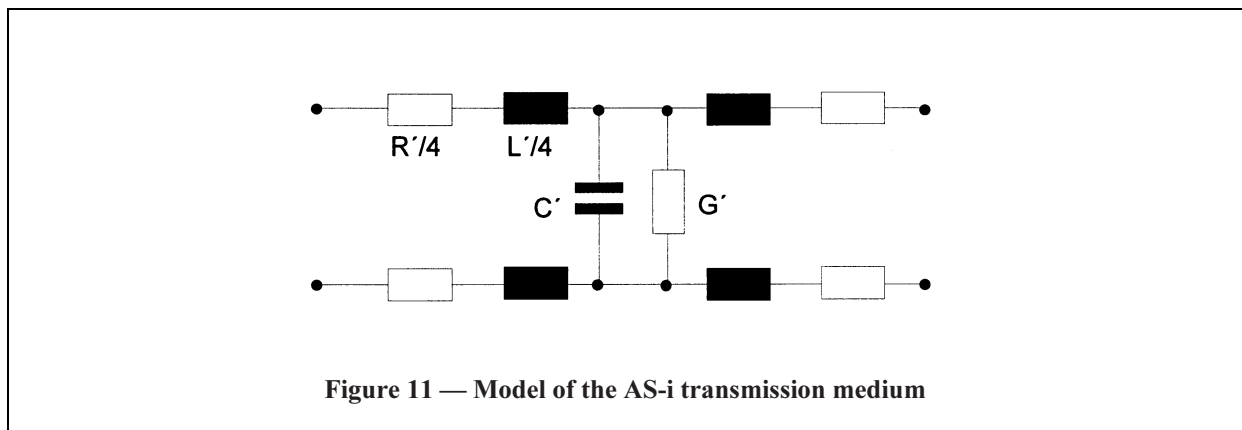
NOTE Any cable that meets the above mentioned data may be used as the AS-i line. Nevertheless, several requirements and tolerances of this standard are intended to meet a total voltage drop (d.c.) along the AS-i transmission medium of no more than 3 V. It is recommended that a cross-sectional area be 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 in accordance with EN 60998-2-3.

The dimensions and tolerances of the AS-i standard cable shall conform to Figure 12.
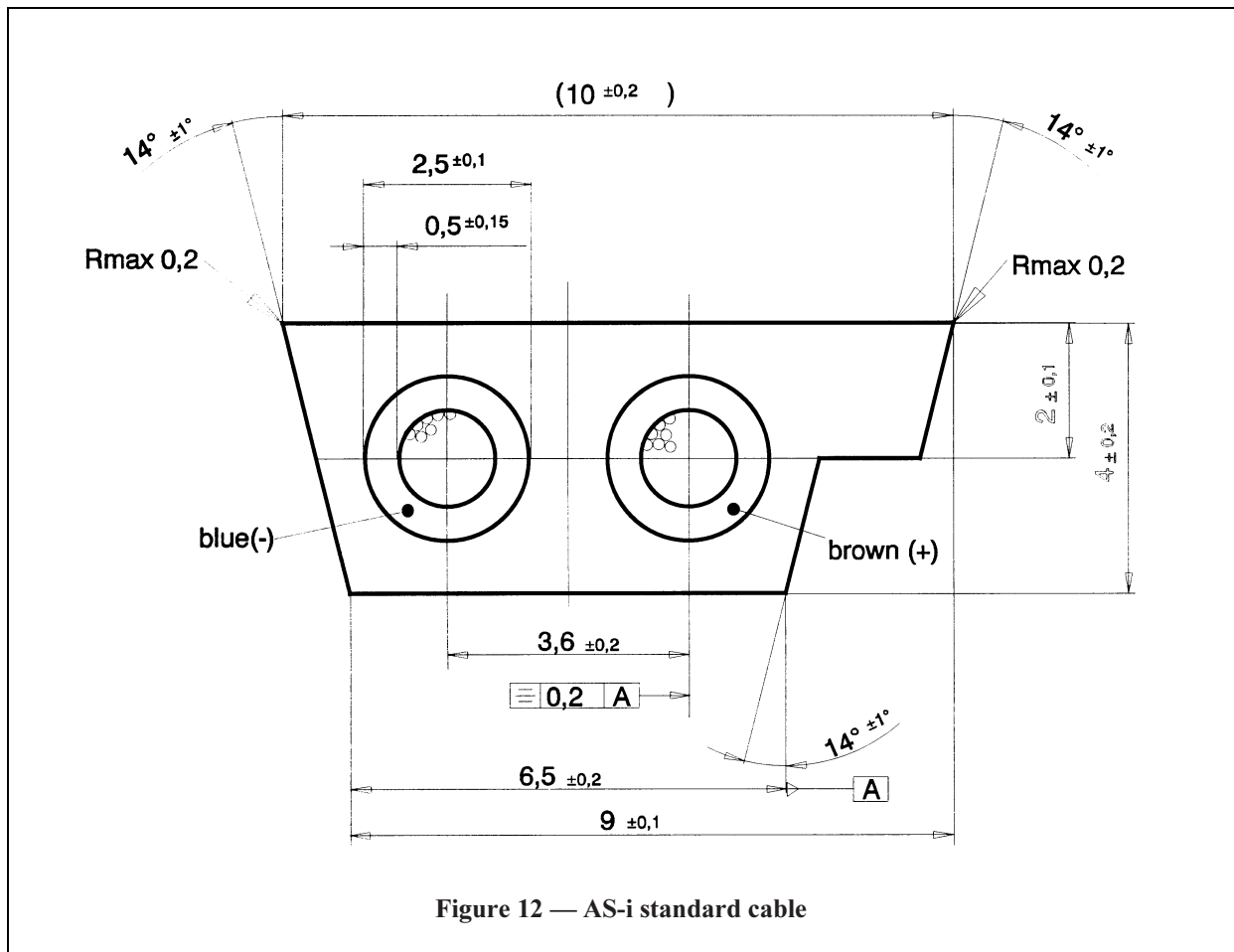
Figure 12 — AS-i standard cable

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

conductor cross section:	$2 \times 1,5$ 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 times (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 EN 60947-5-2
strain relief:	according to annex E of EN 60947-5-2

If a clamp or a screw terminal connector is used for connections, its capability shall be at least a $2 \times 1,5$ mm² cable.

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

If plug connectors are used, the type specified in **D.2** of EN 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 the 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).

The immunity and emission tests specified in **8.5.2** and **8.5.3** are type tests and shall be carried out under representative conditions, both operational and environmental, using the manufacturer's 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.

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

8.5.2 *Immunity*

8.5.2.1 *Performance criteria*

The test results are specified using the following performance criteria.

A: normal performance within the specification limits and statistical maximum of one disturbed master request or slave response per 30 transactions.

B: during the tests a temporary loss of the data communication may occur; thereafter, the device shall continue to operate as intended. No change of actual operating state or stored data shall occur.

The AS-i device to be tested shall have all the essential design details of the type which it represents and shall be in a clean and new condition.

Maintenance or replacement of parts during or after a testing cycle is not permitted.

8.5.2.2 *Electrostatic discharge (ESD) immunity*

The test shall be performed in accordance with EN 61000-4-2.

10 positive and 10 negative pulses shall be applied to each selected point.

The test voltage shall be applied by the contact discharge method to AS-i devices with metallic enclosures at a minimum test voltage of 4 kV.

The test voltage shall be applied by the air gap discharge method to AS-i devices with non-metallic enclosures at a minimum test voltage of 8 kV.

Performance criterion A shall apply.

8.5.2.3 *Radiated radio frequency electromagnetic field immunity*

The test shall be performed in accordance with EN 61000-4-3.

The minimum test field strength shall be 10 V/m.

The frequency band shall be 80 MHz to 1 000 MHz, amplitude modulated.

Performance criterion A shall apply.

8.5.2.4 *Conducted radio frequency disturbance 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.

8.5.2.5 *Electrical fast transient immunity*

The test shall be performed in accordance with EN 61000-4-4, as follows.

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.

8.5.2.6 *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 suppressor components because of their relatively high capacitance.

8.5.2.7 *Immunity to voltage dips*

See **8.1** and **8.3.4.1**.

8.5.3 *Emission*

8.5.3.1 *Conditions during measurement*

The measurement shall be made in the operating mode, including grounding conditions, which produces, in the relevant frequency band, the highest emission consistent with normal applications.

Each measurement shall be performed in defined and reproducible conditions.

Descriptions of the tests, test methods and set-ups are given in the standards listed in Table 13. Additional information needed for the practical application of the tests is given in this standard.

8.5.3.2 *Emission limits*

The emission of the AS-i device shall be within the limits specified in Table 13.

Table 13 — Emission limits for AS-i devices

Port	Frequency range	Limits	Standard
Enclosure	30 to 230 MHz 230 to 1 000 MHz	40 dB(μV/m) quasi peak, measured at 10 m distance 47 dB(μV/m) quasi peak, measured at 10 m distance	EN 55011
a.c. power	0,15 to 0,50 MHz 0,50 to 30 MHz	79 dB (μV) quasi peak 66 dB (μV) average 73 dB (μV) quasi peak 60 dB (μV) average	EN 55011

These limits are given for AS-i devices exclusively used in an industrial environment. When they may be used in a domestic environment, the following warning shall be included in the instructions for use.

Warning

This is a class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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9 Tests

9.1 Kind of tests

9.1.1 *General*

Subclause **8.1** of EN 60947-1 applies.

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, e.g. 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, e.g. a specific actuator, the logical test is highly dependent on the behaviour of the product. To verify the conformity of the AS-i part to this standard, the specific environment in which AS-i has been integrated shall be taken into account.

Conformity of an AS-i device to this standard does not necessarily mean conformity to a specific standard of the whole product in which AS-i is integrated. A test of the AS-i functions in specific applications 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, e.g. a sensor, is independent of the AS-i conformity testing.
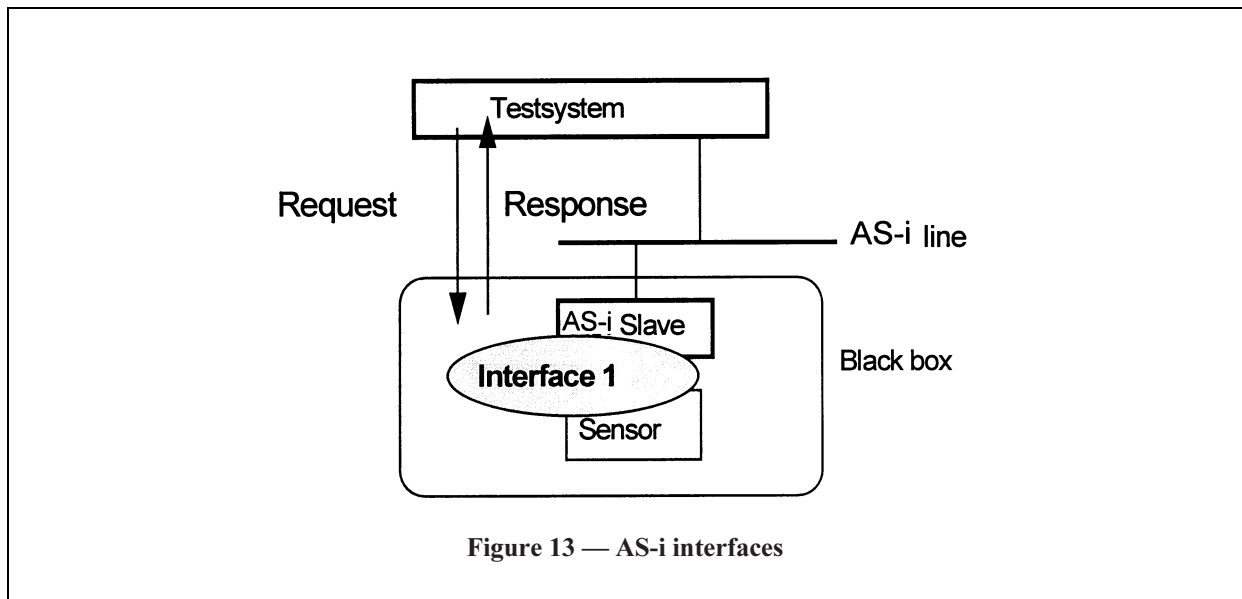
Figure 13 — AS-i interfaces

The test system shall only test the response sent by the slave. Because interface 1 (see Figure 13) is conceptual in nature, the physical 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 in 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*

9.2.1.1 *General*

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

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

9.2.1.2 *Test circuits*

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

Figure 14 — Test circuit for the measurement of the impedance
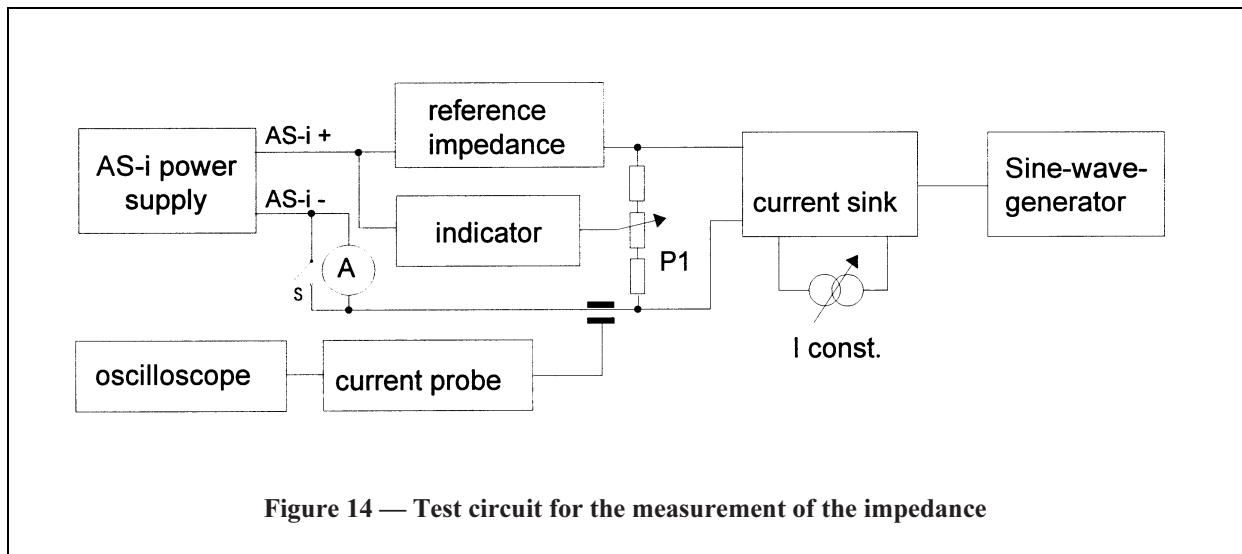
The reference impedance shall be 100 µH || 78 Ω ± 1%.

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

Figure 15 — Constant current sink
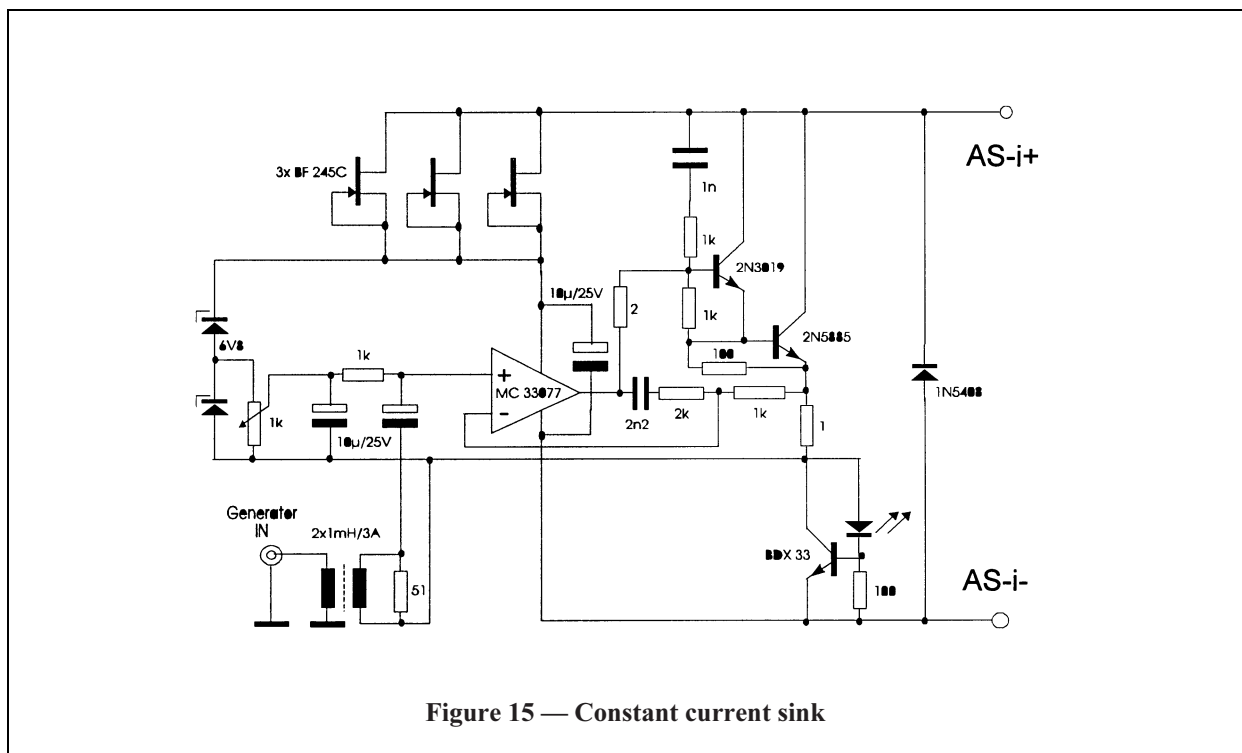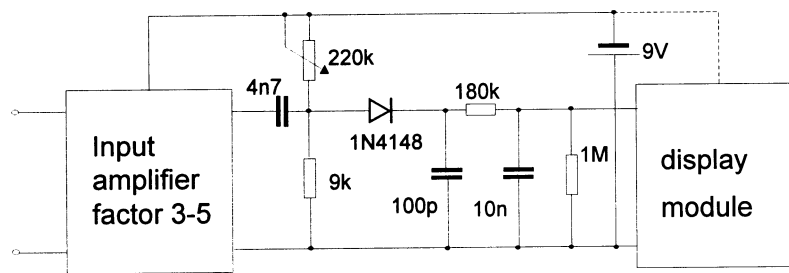
Figure 16 — Indicator

Figure 17 — Display module

9.2.1.3 *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 peak-to-peak 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 steps 1 to 3, but at a modulation frequency of 300 kHz.

9.2.1.4 *Evaluation of test results*

It shall be possible to balance the bridge circuit for all four combinations of current and frequency shown in Table 14.

Table 14 — 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 *General*

This test determines the symmetry of an AS-i coupling network that is in an operating condition.

The accuracy or deviation from the required values is determined.

9.2.2.2 *Test circuits*

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 of **9.2.1.1**.

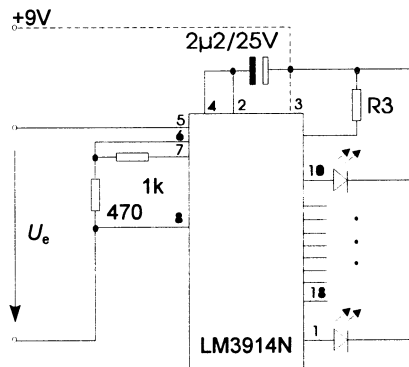**9.2.2.3** *Test procedure*

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 peak-to-peak 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.

9.2.2.4 *Evaluation of test results*

It shall be possible to balance the bridge circuit for all six combinations of current and frequency shown in Table 15.

Table 15 — 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*

This test determines the noise of an AS-i network that is in steady-state operation.

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 accuracy of the measurements shall be within ±5 %.
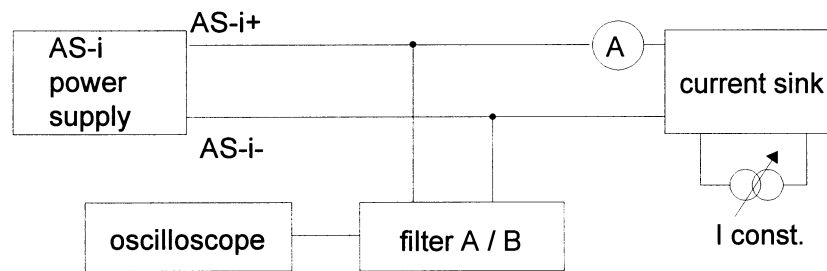
Figure 18 — Test circuit

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

(Low pass 0 Hz to 10 KHz)

Figure 19 — Filter A

(Band pass 10 KHz to 500 KHz)
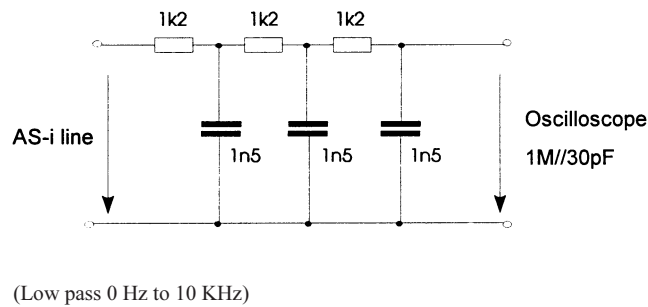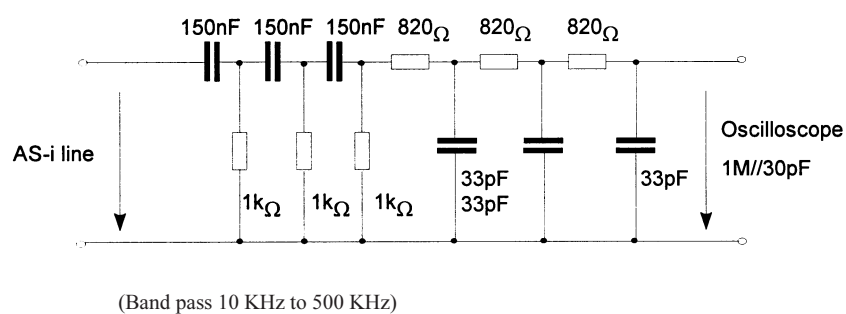
Figure 20 — Filter B

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 Hz 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 16.

Table 16 — Current and frequency for emissions

Frequency range (kHz)	0 to 10	10 to 500
Maximum emission level peak-to-peak (mV)	300	50

9.2.4 *Power-ON behaviour*

This test determines the power-ON behaviour of an AS-i power supply at a maximum load of I_L.

9.2.4.1 *Test circuit*

The test shall be performed with the AS-i power supply (decoupling network) connected to a test circuit shown in Figure 21.

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

Figure 21 — Test circuit
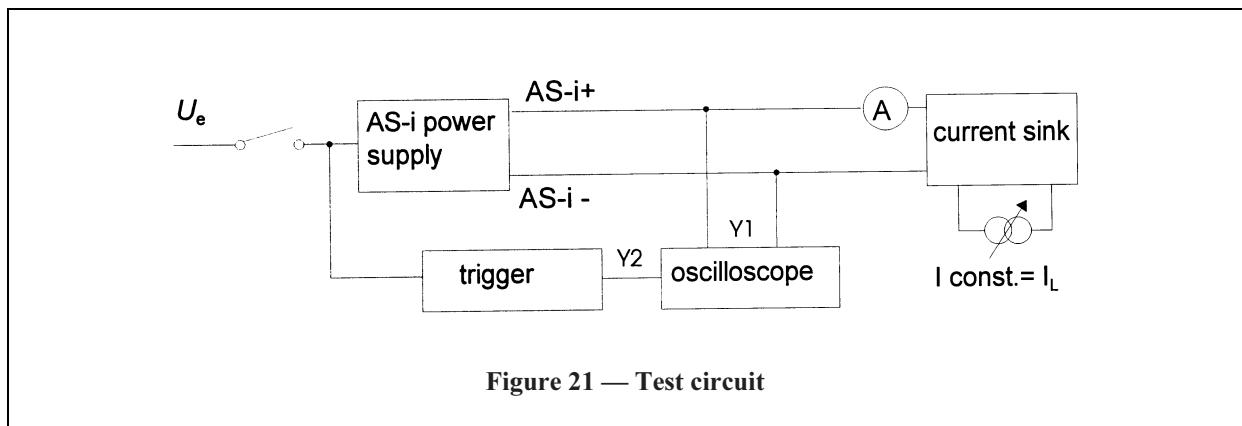
9.2.4.2 *Test procedure*

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 as shown in Table 17.

Table 17 — 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 *General*

This test allows determination of the logical behaviour of an AS-i slave.

During the logical test all mandatory AS-i messages shall be exchanged between AS-i master and AS-i slave. The slave shall be treated as a black box.

NOTE If an AS-i slave is implemented as an integral part of a product, e.g. a specific actuator, the logical test is highly dependent on the behaviour of the product which includes the AS-i slave. When verifying conformity of the slave, the specific environment in which the slave has been integrated should be taken into account.

9.3.1.2 *Test circuit*

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

Figure 22 — Test circuit
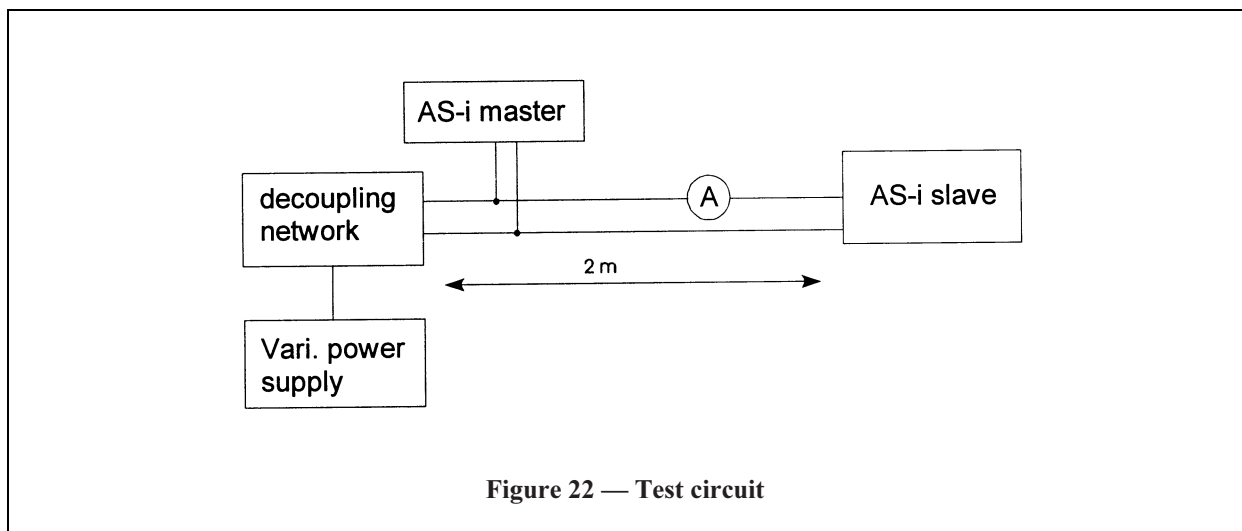
The voltage shall be measured near to the slave.

9.3.1.3 *Test procedure*

The master shall issue an AS-i message. The correctness of the slave response shall be verified. These tests shall be performed for all mandatory messages and at the following four voltages (see Table 18):

— 31,6 V;

— 26,5 V;

— 18,5 V; and

— the minimum voltage stated by the manufacturer at which the slave still functions correctly.

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 case the communication function (correct slave response sent by the slave) shall be tested. The device function, as stated by the manufacturer, shall be tested if the manufacturer indicates a method of determining its correctness.

9.3.1.4 *Evaluation of test results*

For each of the messages listed in **9.3.1.3** the test result shall be recorded in Table 18.

Table 18 — 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 test results meet the requirements. 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*

This test allows measurement of the maximum current consumption of the AS-i slave.

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
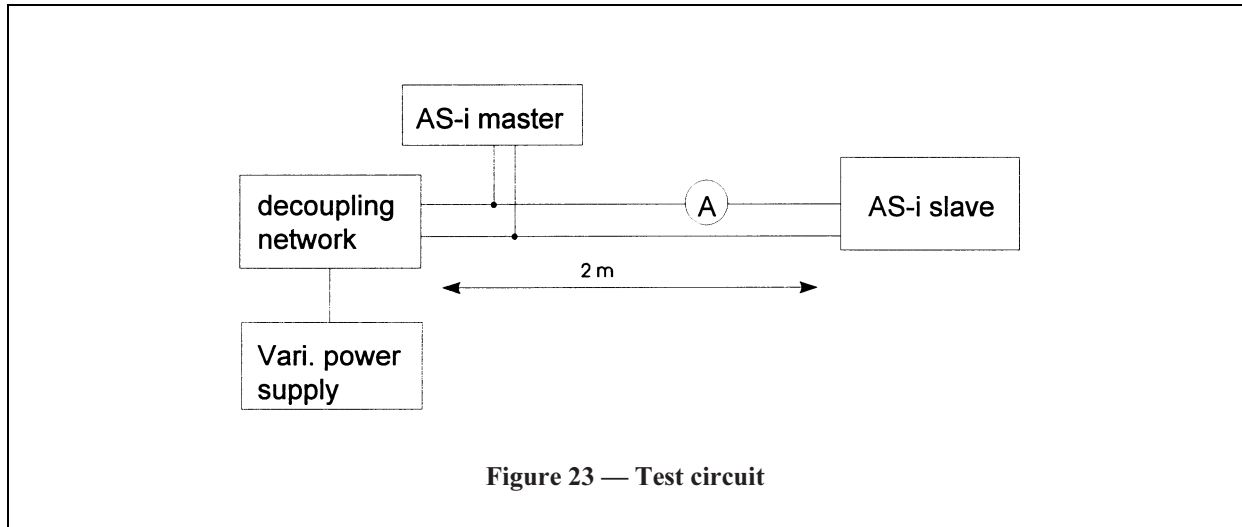
The voltage shall be measured near to the slave.

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 performed at the following four voltages (see Table 19).

— 31,6 V;

— 26,5 V;

— 18,5 V; and

— the minimum voltage stated by the manufacturer at which the slave still functions correctly.

9.3.2.3 *Evaluation of test results*

At each test voltage, the current shall not be greater than the maximum current stated by the manufacturer.

Table 19 — Logical test determination

Voltage (V)	31,6	26,5	18,5	Minimum voltage stated by the manufacturer
Current (A)	Not greater than the current stated by the manufacturer			

9.3.3 *Noise*

This test determines the noise of an AS-i slave on the AS-i network in the steady-state operation of the slave.

9.3.3.1 *Test circuit*

The test shall be performed with the AS-i slave 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 %.
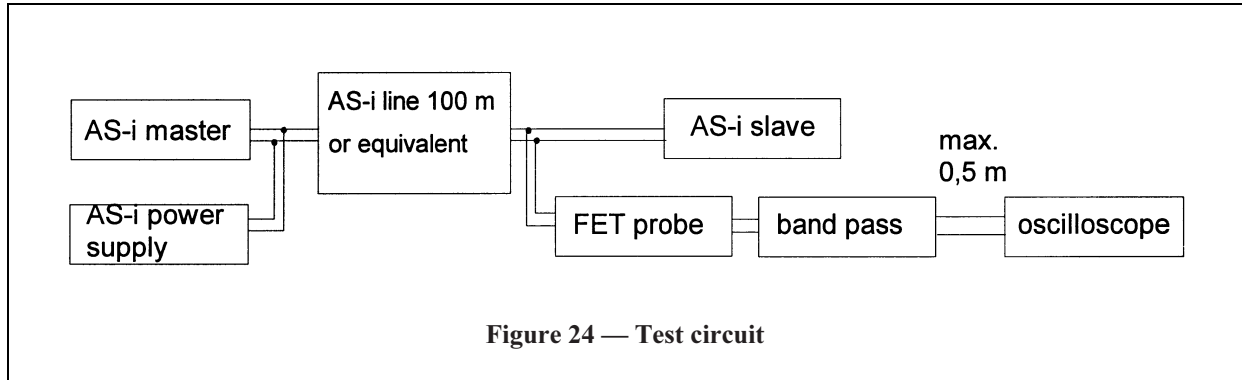
Figure 24 — Test circuit

The bandpass filter used shall have the same characteristics as the circuit shown in Figure 25.
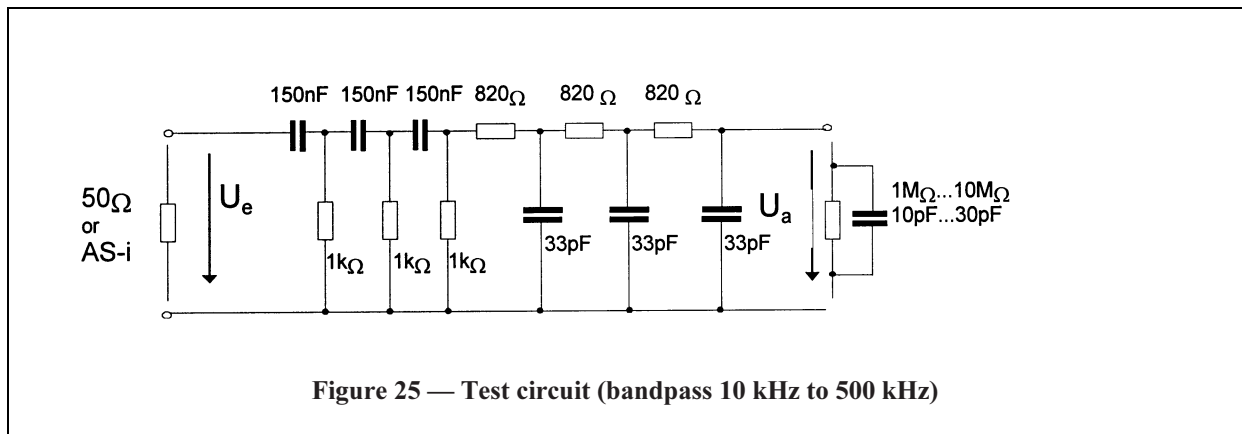
Figure 25 — Test circuit (bandpass 10 kHz to 500 kHz)

9.3.3.2 *Test procedure*

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

9.3.3.3 *Evaluation of test results*

The difference of the emission between AS-i+ and AS-i- measured without and measured with the AS-i slave connected to the AS-i line shall not exceed 20 mV peak-to-peak.

9.3.4 *Impedance*

This test determines the impedance of an AS-i slave that is operating.

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 $R_i \leq 1 \ \Omega$ shall be superimposed on the AS-i d.c. voltage. The a.c. voltage and a.c. current shall be determined.
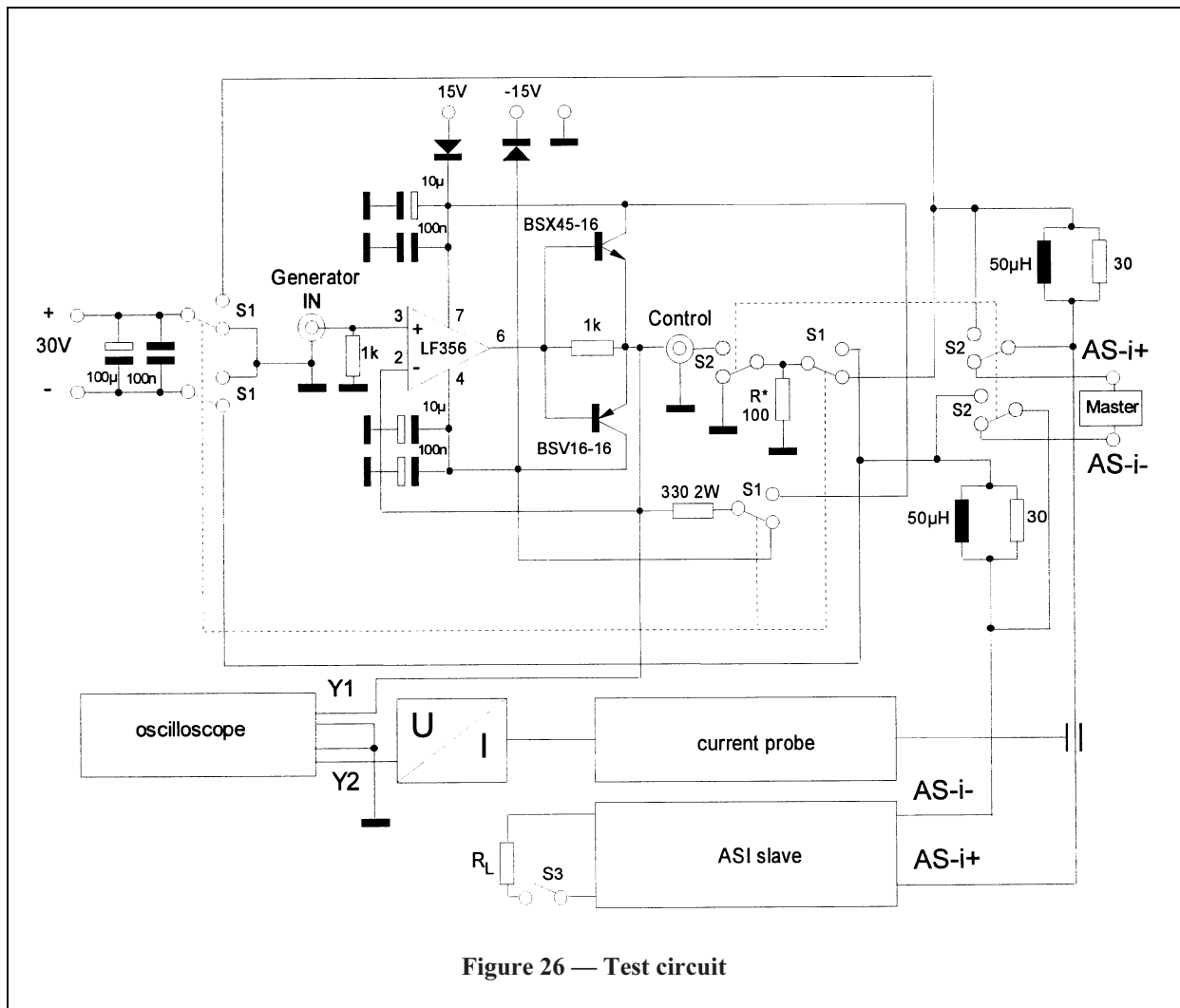
Figure 26 — Test circuit

Switch S1 allows selection of the a.c. ground. The depicted position is AS-i- to 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 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 that case where 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 peak-to-peak 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 $\left|Z\right|$ at the frequencies given in **8.2.3.4**.

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

9.3.5 *Symmetry*

This test determines the symmetry in AS-i slave that is operating.

9.3.5.1 *Test circuit*

The test shall be performed with the AS-i slave connected to a test circuit having the same characteristics as the test circuit shown in Figure 27.

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-AS-iC 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

Test circuit details:

1) galvanic coupling between AS-i+ (AS-i-) and the measurement point M (d.c. resistance ≤ 250 kΩ).

Figure 28 — Test circuit
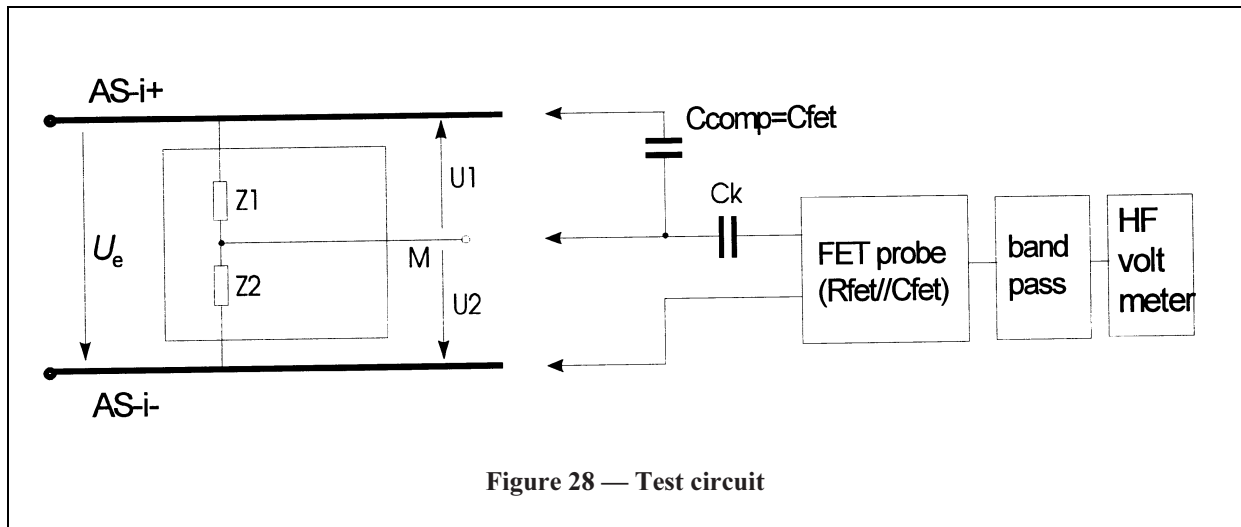
2) electrical isolation between AS-i+ (AS-i-) and the measurement point M (d.c. resistance > 250 kΩ).

Figure 29 — Test circuit
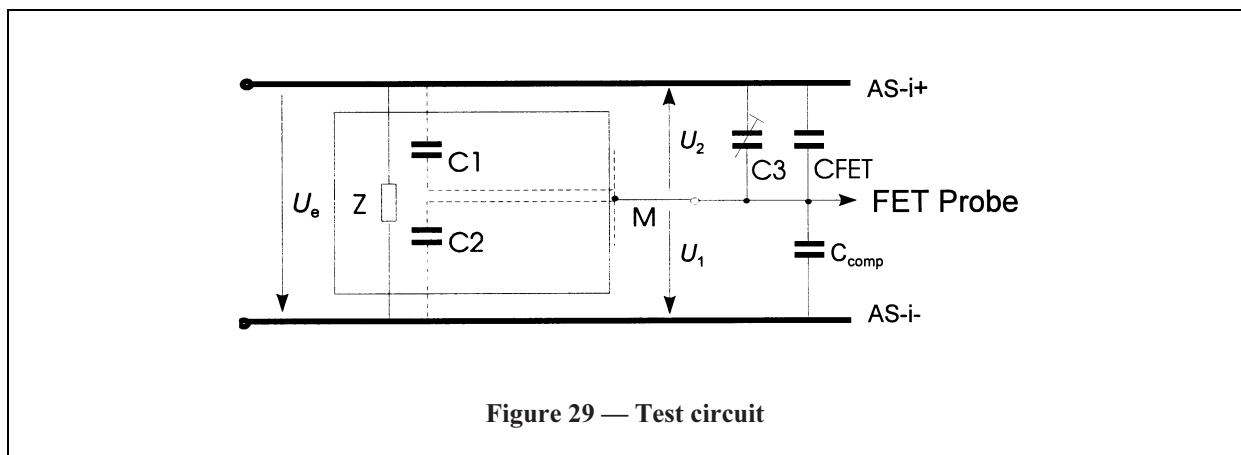
9.3.5.2 *Test procedure*

The accuracy of the measurements shall be 3 %.

a) For galvanic coupling.

1) Calibrate the value of the measurement voltage to 2,0 V_{rms} 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 other frequency: 50 kHz, 100 kHz, 125 kHz, 160 kHz and 200 kHz.

9.3.5.3 *Evaluation of test results*

   1) For galvanic coupling; and

   2) 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.
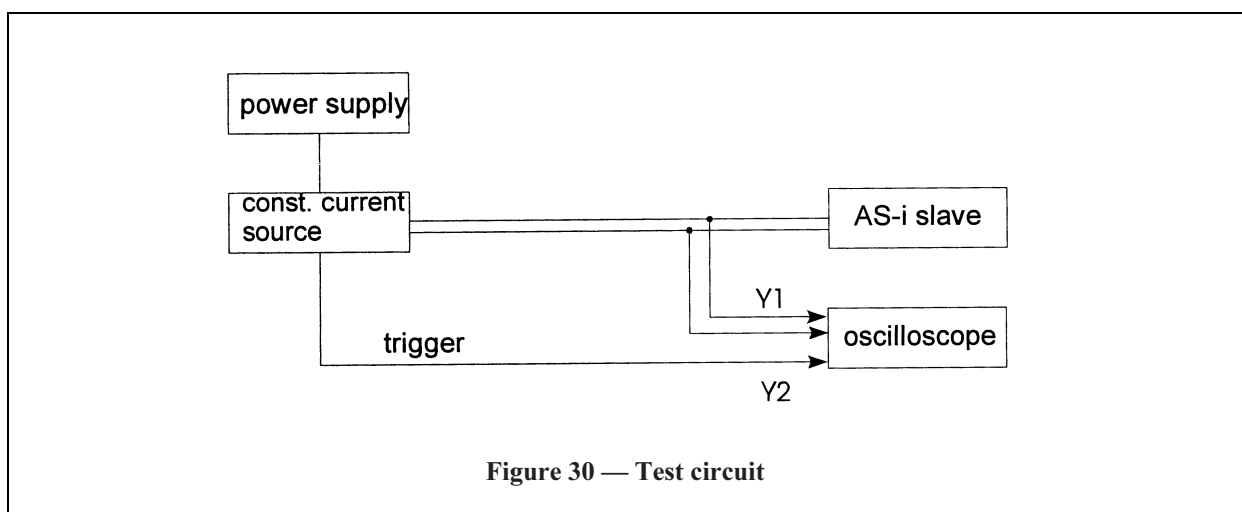
Figure 30 — Test circuit

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.
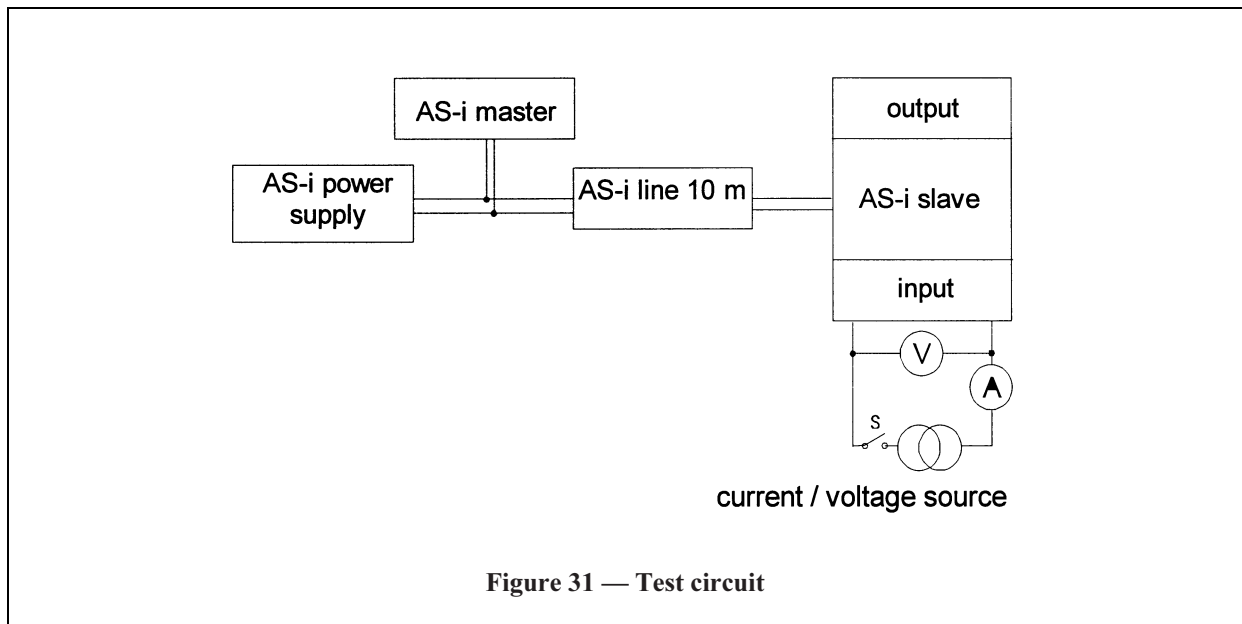
Figure 31 — Test circuit

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 electromagnetic compatibility*

9.3.8.1 *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 beat 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.

NOTE The master shall have provisions for detecting disturbed messages.

For the test of **8.5.2.5** 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.

9.3.8.2 *Electrostatic discharge immunity*

The test is performed according to EN 61000-4-2 and **8.5.2.2** and shall be repeated ten times at each measuring point, with a minimum time interval of 1 s between pulses.

9.3.8.3 *Radiated radio frequency electromagnetic field immunity*

The test is performed according to EN 61000-4-3 and **8.5.2.3**.

9.3.8.4 *Electrical fast transient immunity*

The test shall be performed according to EN 61000-4-4 and **8.5.2.5**, 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.

9.3.8.5 *Emission requirements*

The test shall be performed according to EN 55011 group 1, class A, and to **8.5.3**.

9.3.8.6 *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 in the report the frequency range used.

9.4 Test of a master

9.4.1 *Current consumption*

This test allows the determination of the maximum current consumption of an AS-i master.

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.
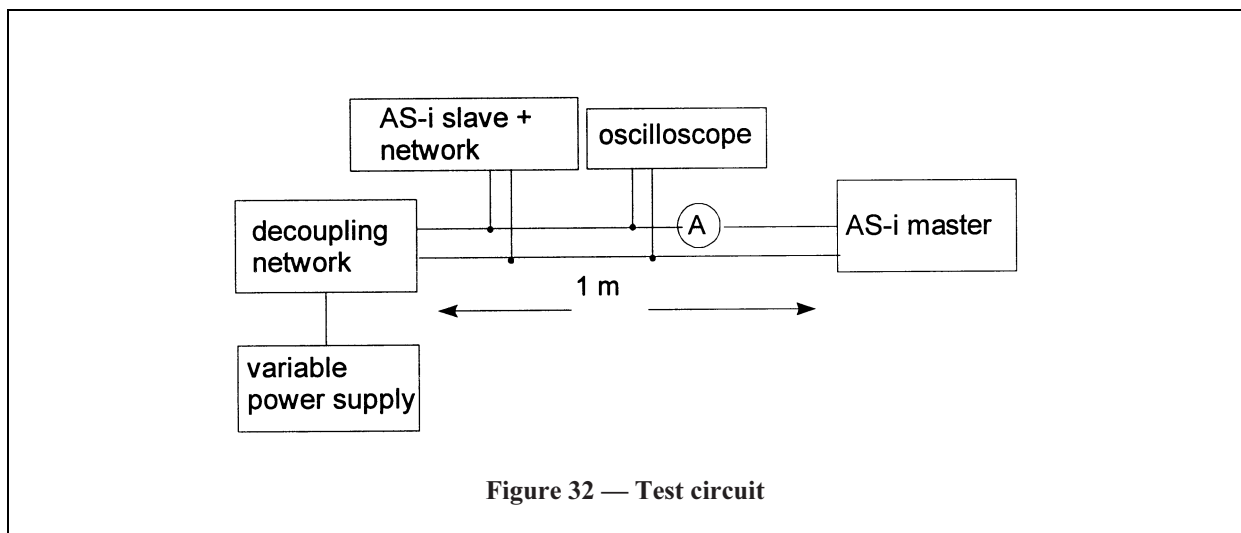
Figure 32 — Test circuit

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 20. The maximum current shall not exceed the value stated in the data sheet (I_{st}) of the product by more than 12,5 mA.

Table 20 — 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*

This test determines the 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 %.
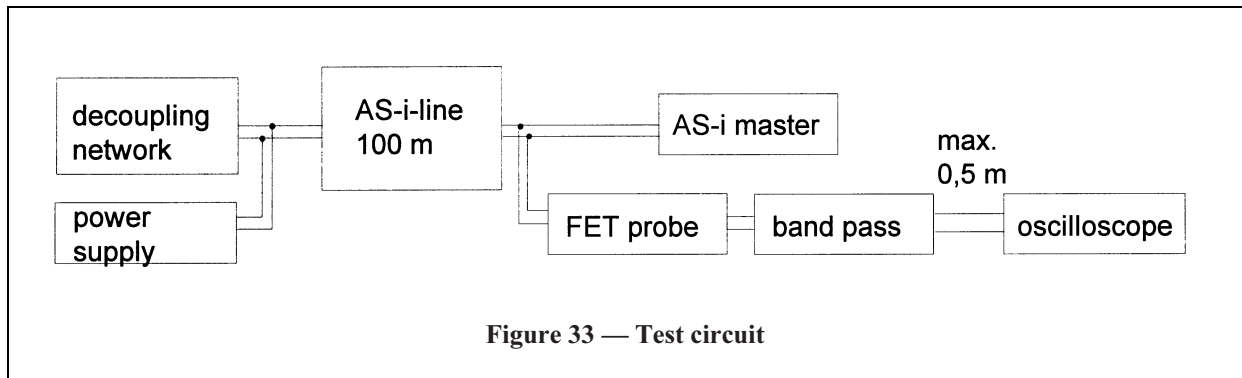
Figure 33 — Test circuit

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 emission 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 emission at the AS-i line during a period of 60 s.

9.4.2.3 *Evaluation of test results*

The difference of the emission between AS-i+ and AS-i- measured without and measured with the AS-i master connected to the AS-i line under the power fail condition shall not exceed 50 mV peak-to-peak.

9.4.3 *Impedance*

This test determines the impedance of an AS-i master which is operating.

9.4.3.1 *Test circuit*

The test shall be performed with the 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 (AS-i master shall be off-line at this voltage).
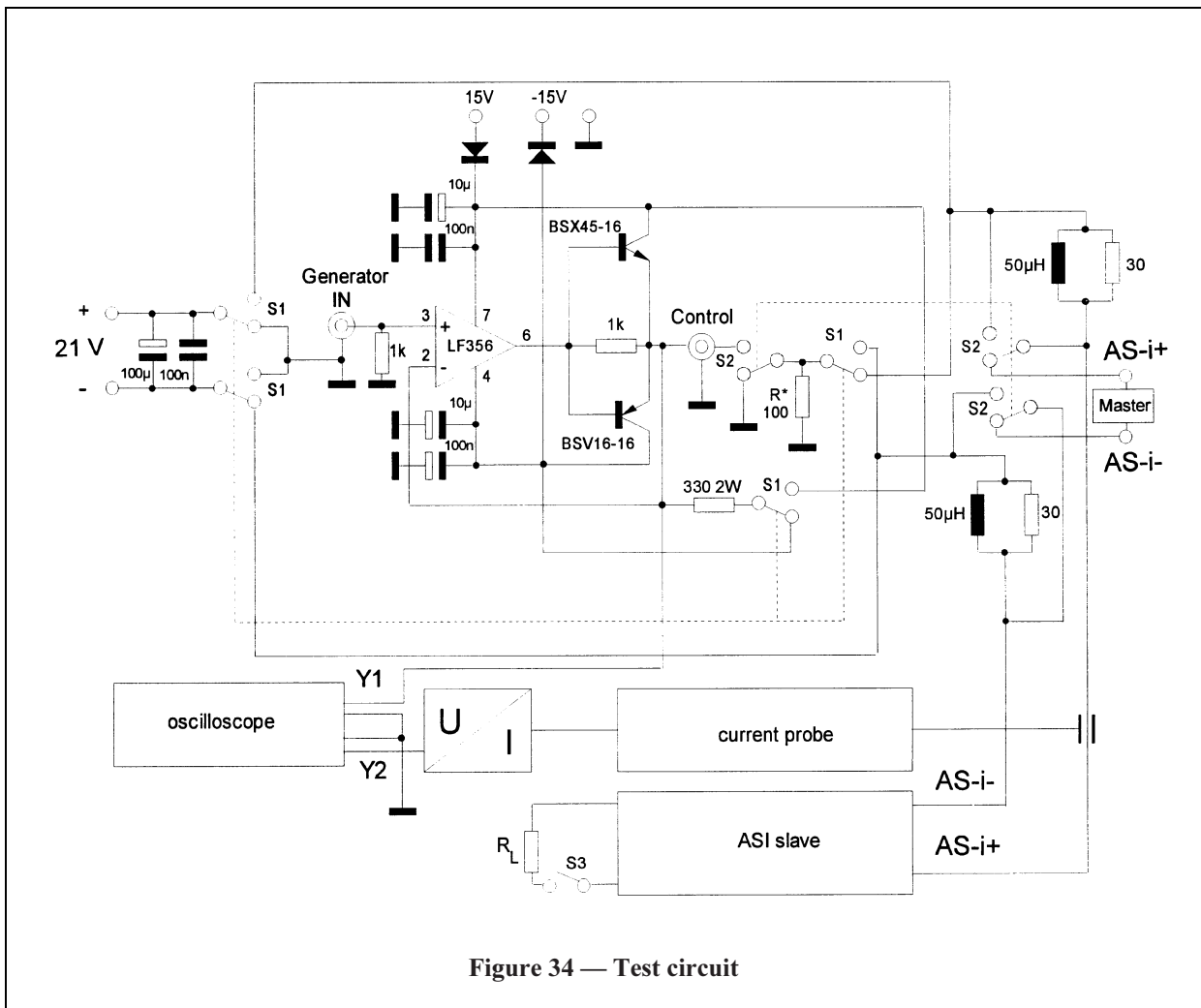
Figure 34 — Test circuit

Switch S1 allows selection of the connection to the ground. The depicted position is AS-i- to GND. Switch S3 allows the maximum load I_L according to the manufacturer's data sheet. Switch S2 connects the AS-i slave to the d.c. supply.

The d.c. resistance between AS-i+, AS-i- and all metallic parts of the master (with the exception of the outer connections) shall be $\geq 250\ \text{k}\Omega$.

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 $\pm 3\ \%$.

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 peak-to-peak at the frequencies 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*

This test determines the symmetry of an AS-i master which is operating.

9.4.4.1 *Test circuit*

The test shall be performed with the 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 shall be connected with the external supply line of the AS-i master or the controller.

Figure 35 — Test circuit
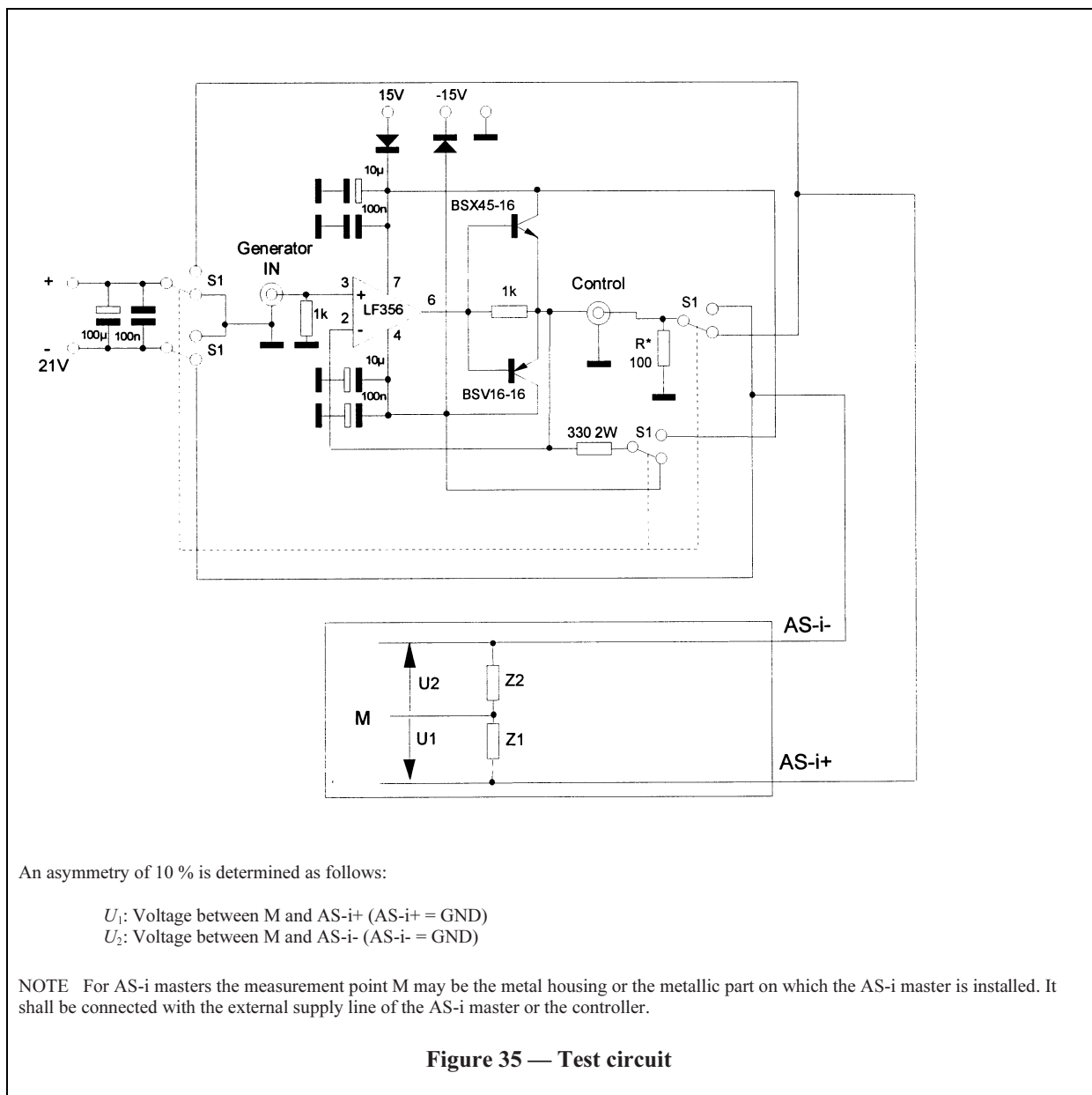
Test circuit details.
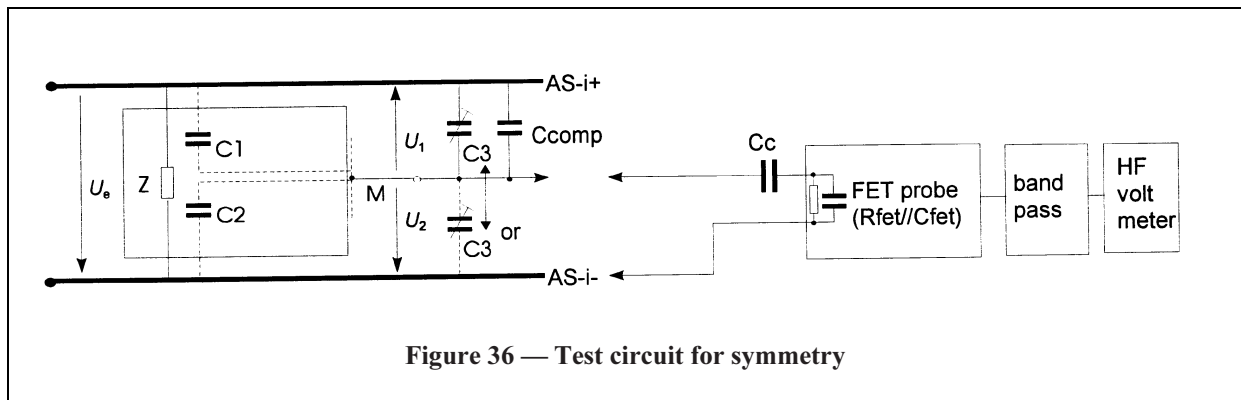
Figure 36 — Test circuit for symmetry

9.4.4.2 *Test procedure*

The bandpass 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 other frequency:
> 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.
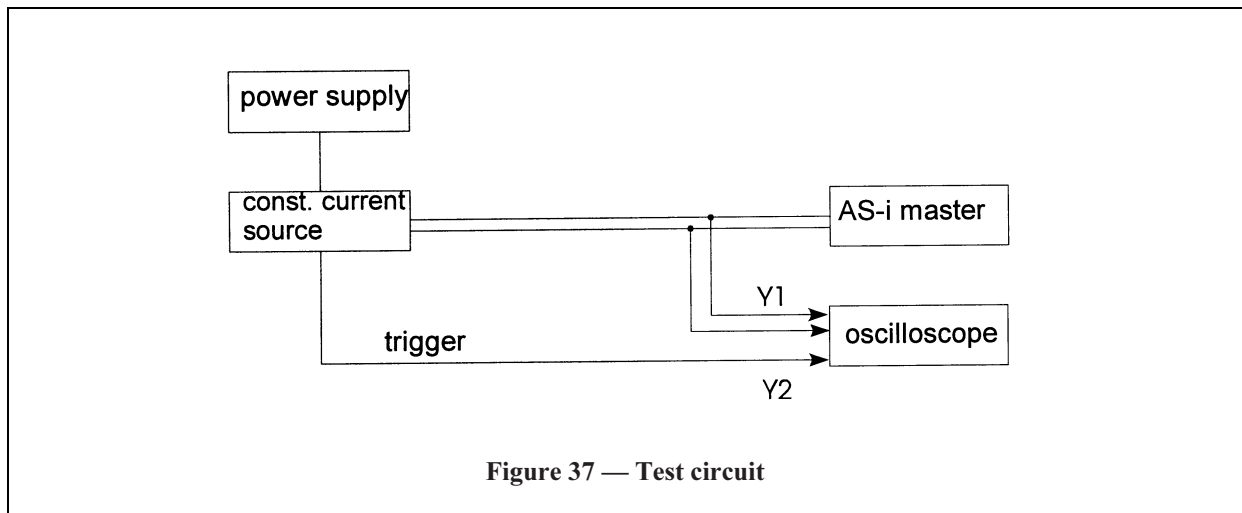
Figure 37 — Test circuit

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

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

Annex A (normative)
Slave profiles

A.1 Introduction

This annex specifies requirements relating to individual profiles of AS-i slaves. It also explains the concept of profiles and how they are configured.

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, bi-directional, or if unconfigured, 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 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 and the replacement slave are identical in the application.

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

A.2 Definitions

A.2.1
I/O type
classification of each I/O data port of a slave according to its configuration as input, output, bi-directional, or if unconfigured, tristate type

A.2.2
controller level
representation of the logic level (0/1) of inputs or outputs at the interface between the AS-i master and the controller

A.2.3
AS-i level
logic level (LOW/HIGH) within the AS-i system

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 inverse of the controller level.

A.2.4
default levels
the default for the AS-i levels of the I/O data bits and parameter bits is HIGH

A.2.5
physical signal
in some slave profiles the ''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 one of two pressure values is detected by the switch.

For flow sensors the higher one 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. Requirements relating to the slave profiles are given in **A.4**.

Table A.1 — Overview of existing slave profiles

AS-i profiles			ID code															
			0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
	0	I, I, I, I		0.1														f
	1	I, I, I,O		1.1														r
	2	I, I, I,B																e
	3	I,I,O,O																e
I/	4	I ,I ,B,B																
O	5	I,O,O,O	X.0															p
	6	I,B,B,B																r
c	7	B,B,B,B		7.1			Reserved											o
o	8	O,O,O,O																f
d	9	O,O,O,I	R															i
e	A	O,O,O,B	X.0															l
	B	O,O,I ,I	R	B.1														e
	C	O,O,B,B	X.0															
	D	O, I ,I, I	R	D.1														X.F
	E	O,B,B,B	X.0															
	F	T,T,T,T					NOT USED											V

Configuration: I=input, O=output, B= bi-directional, T= tristate
Profiles: V = virgin, R = reserved

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	I/D
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 e.g. conventional actuators, 2 or 3 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.

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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 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 EN 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 EN 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 EN 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 on the enclosure a clear identification of the available ports, 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 bi-directional 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 (anti-valent) I/Os, bi-directional 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 EN 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 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, availability, overload, or 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 e.g. a warning, a failure message, a breakdown signal, etc. The slave profile includes also remote I/O devices for the connection of conventional anti-valent output sensors to the AS-i line.

Page 70
EN 50295:1999

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 1and 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.

D_1 and D_3 shall only be used as monitor signals for sensors 1 and 2 respectively. The monitor signals may indicate e.g. 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 anti-valent 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 EN 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 EN 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 monitors 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 meaning of the parameter bits are summarized in Table A.9.

Table A.9 — Meanings 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.

P_1 shall only be used to invert the meaning of D0.

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

P3 shall only be used to set a special function of the sensor. Such a function may be e.g. 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 the meanings of the parameter bits are summarized in Table A.10.

Table A.10 — Meanings 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 e.g. 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 e.g. 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 not be possible 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 remote reset. A remote reset may be used, for example, to restart the actuator out of a fault state, or to set the actuator to a defined initial state/position.

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

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. 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 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 faults such as overload, over-temperature, overcurrent and tripping of a motor.

D3 shall only be used to monitor the availability of the actuator.

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 (if such a function is implemented) which monitors 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 remote reset. A remote reset may be used, for example to restart the actuator out of a fault state, or to set the actuator to a defined initial state/position.

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

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

A.4.6.5 *Additional requirements*

The detailed function 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 of this standard gives a list of functions to ensure the expected behaviour at the AS-i line.

AS-i maters need not provide all these functions, but those functions which are provided shall conform to this standard.

This annex specifies profiles for the AS-i master, to prevent confusion between different AS-i masters from different manufacturers and to ensure the inter-operability between master and slaves.

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 for each 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 this definition.

Error reporting by AS-i masters shall be the same for all masters. As a minimum, 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, e.g. 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, the 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 PICS shall include a declaration of the AS-i cycle time. This shall allow the calculation of the cycle time depending on the number of activated slaves, based on the following assumptions:

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. |

Page 78
EN 50295:1999

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, RParam =	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_adress_enable (Mode)	Controller → AE-Bit	O	O	O
21.2	Mode =	Get_auto_adress_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_IO_configuration (Addr, CONF)	Controller → Slave	O	O	O
22.3	Status, Resp =	Cmd_read_identification_code (Addr,IDCOD)	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, TATRES)	Controller → Slave	O	O	O
22.6	Status, Resp =	Cmd_R1 (Addr, R1CODE)	Controller → Slave	O	O	O

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

Key to the symbols:

Sign	Meaning
M	Mandatory
O	Optional

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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, RParam =	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_IO_configuration (Addr, CONF)		
22.3	Status, Resp =	Cmd_read_identification_code (Addr, IDCOD)		
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, R1CODE)		

Key to the symbols for column 3:

Sign	Meaning
X	Implemented
	Not available

Figure B.1 — PICS model

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