INTERNATIONAL STANDARD

# ISO/IEC 14908-3

First edition
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# Information technology — Control network protocol —

## Part 3: Power line channel specification

*Technologies de l'information — Protocole de réseau de contrôle —*

*Partie 3: Spécification de canal de courants porteurs*



Reference number
ISO/IEC 14908-3:2012(E)

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# Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

ISO/IEC 14908-3 was prepared by CEN/TC 247 and was adopted, under a special “fast-track procedure”, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval by the national bodies of ISO and IEC.

ISO/IEC 14908 consists of the following parts, under the general title *Information technology — Control network protocol*:

— *Part 1: Protocol stack*

— *Part 2: Twisted pair communication*

— *Part 3: Power line channel specification*

— *Part 4: IP communication*

# Introduction

This part of ISO/IEC 14908 specifies the Control Network Power Line (PL) Channel and serves as a companion document to ISO/IEC 14908-1. Its purpose is to present the information necessary for the development of a PL physical network and nodes to communicate and share information over that network. This is one of a series of documents covering the various media that comprise the CNP standard.

This part of ISO/IEC 14908 covers the complete physical layer (OSI layer 1) including the interface to the Medium Access Control (MAC) Sub-Layer and the interface to the medium. It includes parameters specific to the PL channel type, even though the parameters may be controlled at an OSI layer other than layer 1. This part of ISO/IEC 14908 also provides a set of guideline physical and electrical specifications for the power line environment as an aid in developing products for that environment.

This part of ISO/IEC 14908 has been prepared to provide mechanisms through which various vendors of local area control networks may exchange information in a standardised way. It defines communication capabilities.

This part of ISO/IEC 14908 is used by all involved in design, manufacture, engineering, installation and commissioning activities and has been made in response to the essential requirements of the Constructive Products Directive.

The CNP specification model is based on the OSI 7-layer model Reference Model. There are also important extensions to the OSI Reference Model. Figure 1 shows the scope of this specification in reference to the entire CNP model. In this International Standard, only the parts of the model relevant to power line communication are specified. Anything outside this boundary is covered in other parts of the standard. Similar specifications exist for other CNP media.

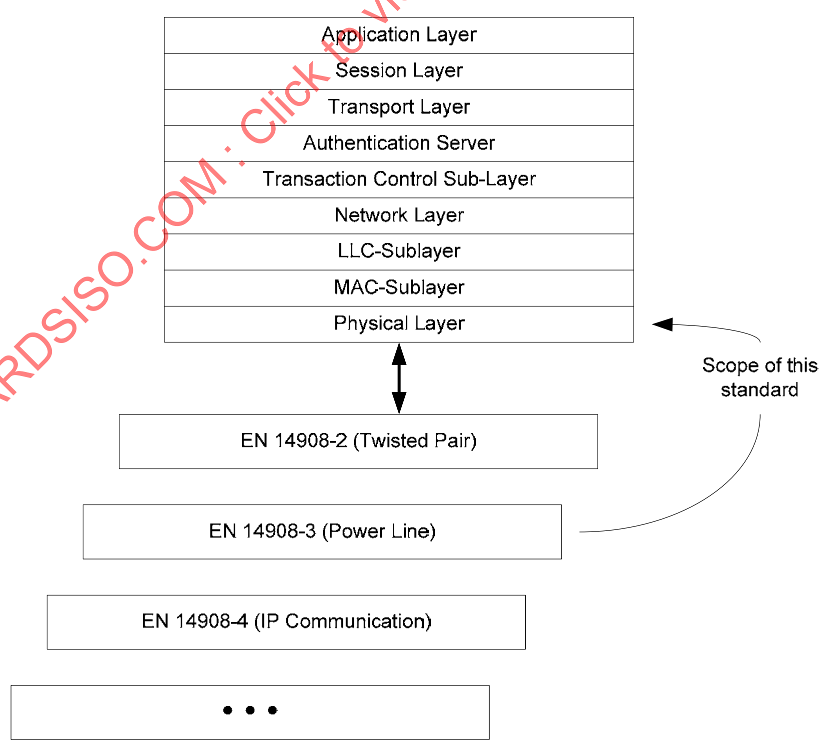



**Figure 1 — Relationship of CNP 3 specification to the CNP 1 specification**

The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this International Standard may involve the use of patents held by Echelon Corporation.

The ISO and IEC take no position concerning the evidence, validity and scope of this patent right. The holder of this putative patent right has assured the ISO and IEC that they are willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of the putative patent rights is registered with the ISO and IEC. Information may be obtained from:

> Echelon Corporation, 4015 Meridian Avenue, San Jose, CA 94304, USA, phone +1-408-938-5234, fax: +1-408-790-3800 http://www.echelon.com.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights other than those identified above. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

# INFORMATION TECHNOLOGY – CONTROL NETWORK PROTOCOL –

# Part 3: Power line channel specification

## 1 Scope

This International Standard specifies all the information necessary to facilitate the exchange of data and control information over the power line medium for networked control systems used in conjunction with ISO/IEC 14908-1.

This International Standard establishes a minimal set of rules for compliance. It does not rule out extended services to be provided, given that the rules are adhered to within the system. It is the intention of the standard to permit extended services (defined by users) to coexist.

Certain aspects of this standard are defined in other documents. These documents are referenced where relevant. In the case where a referenced standard conflicts with this International Standard, this part of ISO/IEC 14908 will prevail.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 14908-1, *Information technology – Control network protocol – Part 1: Protocol stack*

EN 50065-1, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz — Part 1: General requirements, frequency bands and electromagnetic disturbances*

EN 50065-2-1, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz —Part 2-1: Immunity requirements for mains communications equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in residential, commercial and light industrial environments*

EN 50065-2-2, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz — Part 2-2: Immunity requirements for mains communications equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in industrial environments*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 14908-1 and the following, specifically with the power line medium and physical layer shown in Figure 1, apply.

**3.1**
**PL node**
user node attached to the power line medium at a tap that meets the requirements of this specification

**3.2**
**line cord**
cable not part of the power line network that allows a node located away from the power line network to be connected to the network

**3.3**
**power line network**
communication network based on power distribution lines ("power lines"), from the final distribution transformer to and including all homes served by that transformer, including all wiring in those homes

**3.4**
**non-network-powered node**
compatible node that attaches to the power line network but does not draw any power from the network

## 4 General description

### 4.1 Electrical safety

This clause gives several recommendations related to safety concerns with respect to this International Standard.

This discussion is not complete, nor does it address all possible safety issues. The designer is urged to consult, among other things, the relevant local and national electrical codes for the country of intended use. Local codes may supplement national electrical codes and impose additional safety related requirements.

Products conforming to this International Standard shall be designed, constructed, assembled, tested and installed following recognised safety provisions appropriate to products covered by the standard.

Power line network cables are subject to at least five direct electrical safety hazards during their use:

- high-energy transients coupled into the power line network from external environmental sources;
- possible differences between safety grounds to which network components are connected;
- possible high voltages on neutral or ground wiring;
- possible open safety grounds;
- high short-circuit current levels available at interface.

These electrical safety hazards should be alleviated for the network to perform properly. In addition to provisions for properly handling these faults in an operational system, special measures should be taken to maintain the intended safety features during changes of an existing network.

All wire and wiring to which nodes connect should conform to wiring standards of the appropriate national code for the country of intended use and should have been inspected to comply with that code.

### 4.2 Functional partitioning of PL specification

This specification divides the complete power line environment into two basic parts: the powerline medium and the node physical access specification.

The medium specification concerns the capabilities and properties of the physical medium. This encompasses such items as its bandwidth, frequency allocation, electrical and physical specifications, connectors etc.

The node physical access specification deals with the physical properties of that part of the node that makes contact with the medium. Also described is the interface between the physical layer and the symbol-encoding sub-layer.

# 5 Power Line Medium specifications

## 5.1 Power

The nodes should not rely on the line frequency for timing or synchronisation to perform communications. AC power may be used to power the interface and application needs of a node.

## 5.2 Data channel

The channel occupies bandwidth from 125 kHz to 140 kHz frequency band, as defined in EN 50065-1, as a Binary Phase Shift Keyed (BPSK) modulated carrier. This channel is used to send protocol messages containing control, status, configuration and diagnostic information. The rules established in the CNP Medium Access Control (MAC) Layers and above shall be followed. The signalling characteristics of the channel are described in Clause 6.

## 5.3 Physical and electrical specifications

Physical and electrical specifications for the PL medium are not formally given in this International Standard since: 1) the PL medium is assumed to already exist in any environment using power line communications and; 2) this specification lacks control over the installation of the power line medium, its physical properties, topology, or other devices connected to the medium.

## 5.4 Connectors and coupling

If a connector is used to attach a CNP node to the power line network (as opposed to a direct connection), then the connector shall meet the following requirements:

- the connector shall impose a negligible signal loss (less than 0,1 dB) from the power line network and the attached node;
- the connector shall not impose any signal or voltage loss (greater than 0,1 dB) to the power line network (with or without a node connected to the connector).

Single-phase power line node connectors are assumed to fit standard electrical outlets appropriate for the country of use and may or may not include a connection to the protective conductor of such outlets if present. Signalling shall only be between phase and neutral conductors and no functional connection shall be made to the protective conductor.

Multi-phase powerline nodes may use any of the connection schemes given in EN 50065-1 permitting signalling between all phases simultaneously and the neutral conductor or between any of the phase conductors individually and the neutral conductor. No functional connection shall be made to the protective conductor.

## 5.5 Signal coupling between phases

Signal coupling between phases in multi-phase installations may be achieved by using phase couplers according to EN 50065-4-1.

### 5.6 Surge protection and related devices

Certain surge protection and related frequency selective protection devices may be installed on the power network. These devices may attenuate the CNP channel waveform sufficiently to prevent operation in part or the entire network. Precautions should be taken such that the device chosen does not substantially attenuate the signals in the 125 kHz to 140 kHz range.

## 6 PL Node specifications

### 6.1 Compliance

PL nodes shall comply with the requirements of EN 50065-1 and with either EN 50065-2-1 or EN 50065-2-2 depending upon the intended field of application of the nodes.

PL nodes shall comply with the additional requirements given in Clause 5 and 6.2 to 6.6.

### 6.2 Interface to MAC sub-layer

The data is passed from the MAC sub-layer to the PL transceiver in an 8 bit byte format containing a L2Hdr byte, the NPDU and a 16 bit CRC as described in 6.3, 6.4 and 6.5 of ISO/IEC 14908-1. The PL transceiver encodes each byte of data into an 11 bit word and adds a bit sync pattern, a word sync word and an End-of-Frame consisting of two EndofPacket (EOP) words. The entire packet is shown below in Figure 2. The bit sync pattern consists of 24 bits of alternating "10". The word sync word is "11001111011". The EndofPacket word is "11100110011". The bit sync pattern provides clock timing information. The word sync pattern provides bit polarity and word boundary information.

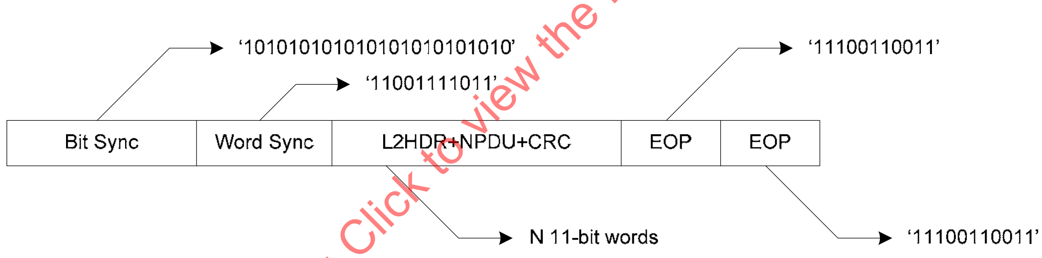



**Figure 2 — Power line packet format**

### 6.3 Word encoding

Each 8-bit byte in the L2Hdr, the NPDU and the CRC is encoded into an 11-bit word as follows. The first 8 bits of the 11-bit word are the 8 bits of data that are transmitted in NRZ format (uncoded). Bit 9 is an even parity bit P for the first 9 bits. Bits 10 and 11 are the last two bits and are always '01'. A data word is shown in Figure 3.

| | | | |
|---|---|---|---|
| MSB **8 bit word from MAC layer** LSB | **P** | **0** | **1** |

**Figure 3 — 11-bit word format**

### 6.4 PL packet timing

As described in ISO/IEC 14908-1, the protocol uses an interpacket spacing defined as a Beta1 time and randomising slots defined as Beta2 times. Beta1 is measured from the end of a packet to the beginning of the first Beta2 slot. The CNP protocol and PL transceiver in combination shall produce a Beta1 time of 3,4 ms ± 0,1 ms and B2 times of 2,0 ms ± 0,1 ms each. For optimum communication between nodes, there should be 8 priority Beta2 slots. In addition, the transceiver shall meet the timing parameters defined below and specified in Table 1.

**Carrier Detect** - The time from when the beginning of the packet is at the receiver's input until the receiver has detected carrier and caused P_Channel_Active to be set to true.

**Transmit Start Delay** - The time from when P_Data_request is activated to when the beginning of the packet is initiated onto the power line.

**Table 1 — Transceiver timing specifications**

| Parameter | Specification |
|---|---|
| Carrier Detect | 1,7 ms max. |
| Transmit Start Delay | 100 µs max. |

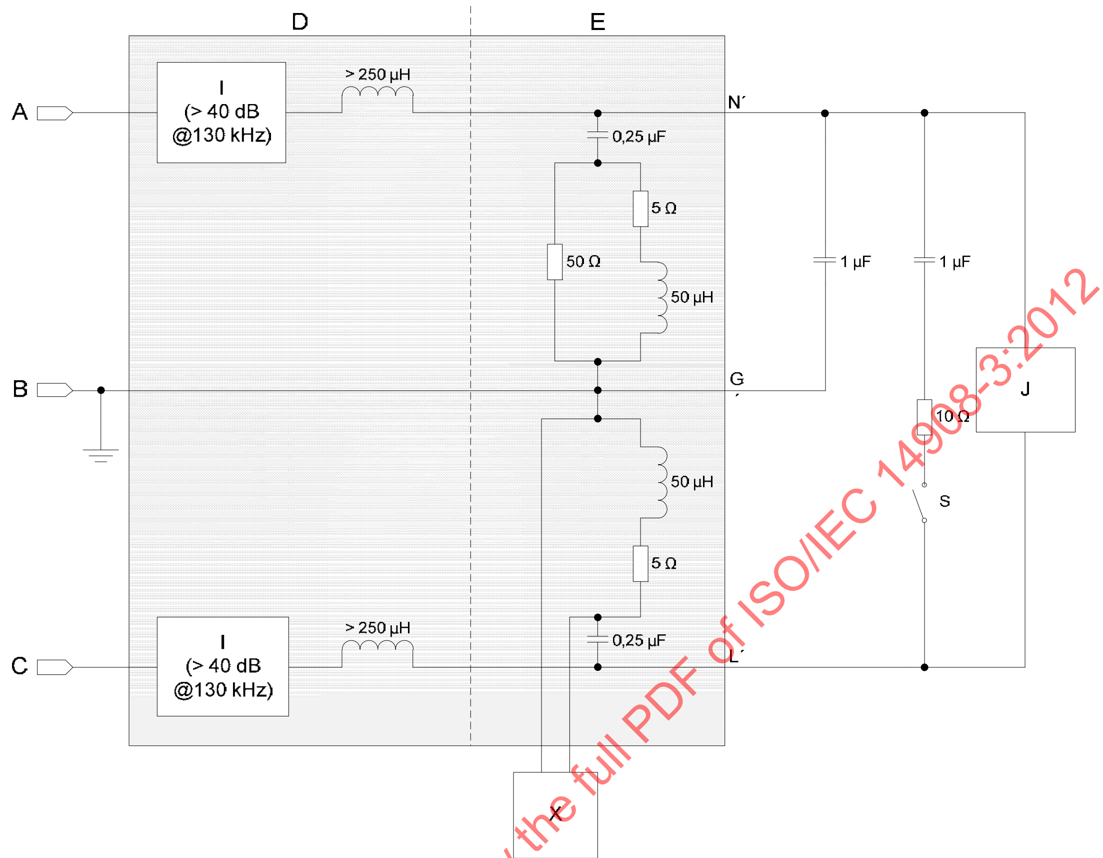
## 6.5 Transmitter characteristics

### 6.5.1 Carrier modulation

The transmitter shall be a differential driver capable of driving the specified signal on the PL network. Each bit is sent as NRZ data BPSK modulated on to a carrier. The carrier frequency is 131,579 kHz with a tolerance of ± 0,02 %. The symbol rate is 5 482,45 symbols/s with a tolerance of ± 0,02 %. Note that appropriate shaping shall be performed on the modulated waveform to meet the requirements in EN 50065-1 for conducted emissions.

### 6.5.2 Waveform amplitude

The amplitude of the carrier output voltage during packet transmission should be measured at 23 ºC ± 3 ºC using the test circuit shown in Figure 4. The V-network is an artificial network of (50 Ω/(50 µH+5 Ω)) conforming to 8.2.1 of CISPR 16. The amplitude is measured using the tuned receiver at a frequency of 131,5 kHz with a peak detector and a 30 kHz resolution bandwidth. The tuned receiver using its peak detector should read the rms value of a sinusoid. The amplitude limits shall be met both with switch closed and with the switch open. The transmit voltage will be calculated using the following formula $V_{pp}=2{,}828xV_{measured}$ and $dBV=20\times\log_{10}(V_{measured})$. The transmit voltage $V_{measured}$ shall be greater than 0 dBV (2,828 $V_{pp}$) and less than 11 dBV (10,0 $V_{pp}$) when the switch is open and greater than –12 dBV (0,7 $V_{pp}$) when the switch is closed.




**Key:**

A Neutral
B Ground
C Line
D Filter
E V-Network
I Power line filter
J Power line transceiver under test
S Switch

**Figure 4 — Test circuit for determining transmit amplitude**



### 6.5.3 Device coupling

The devices will couple the control channel signal to the power line in various ways depending on which lines are available and what local electrical code restrictions apply.

### 6.5.4 Single phase coupling

A power line node shall only be coupled to phase and neutral conductors. No connection shall be made to the protective (earth) conductor for signalling purposes although such connection may be made for other protective or functional purposes.

### 6.5.5 Multiple phase coupling

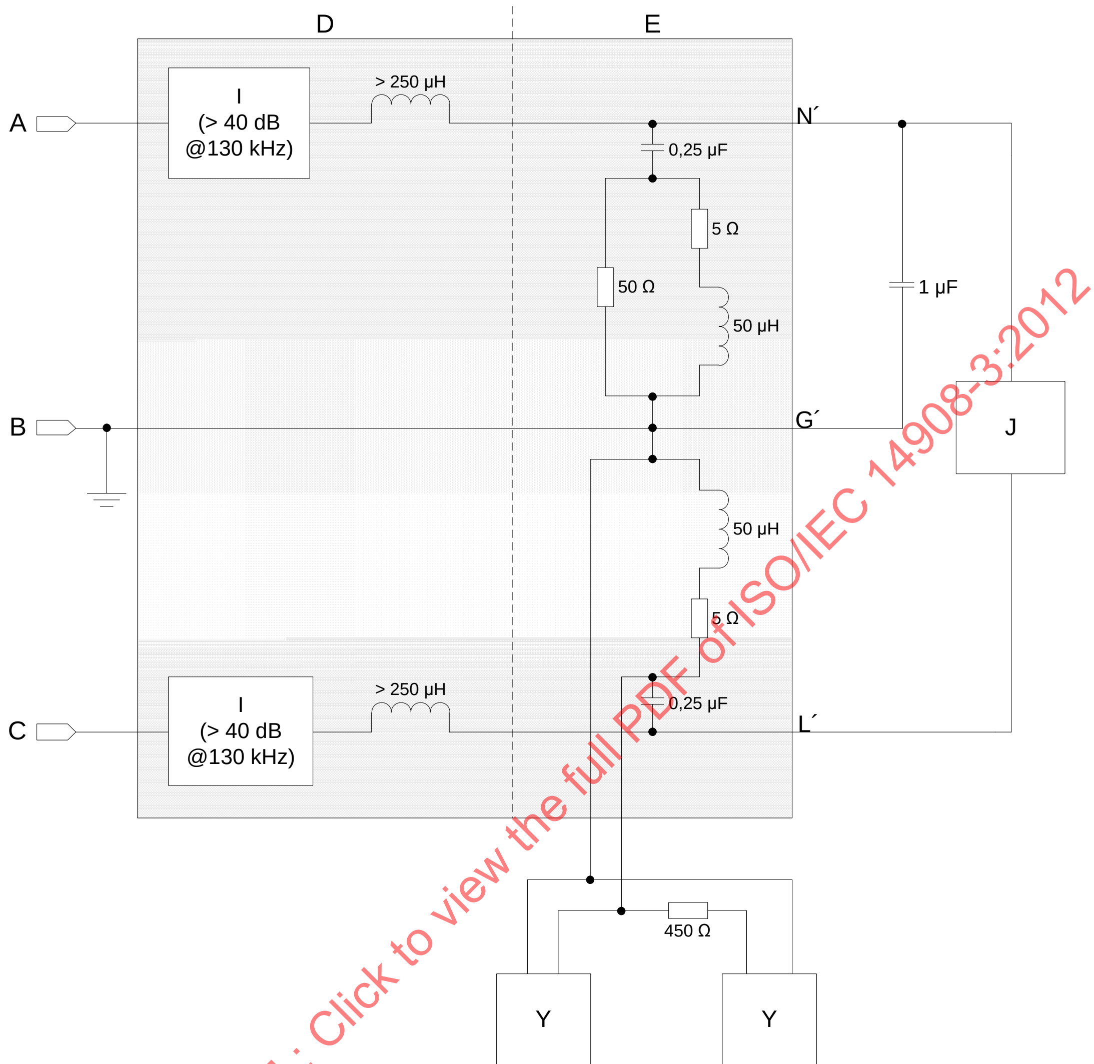
If a power line node has access to more than one phase and neutral then any or all phases may be used to couple with respect to neutral as described in EN 50065-1. No connection shall be made to the protective (earth) conductor for signalling purposes although such connection may be made for other protective or functional purposes.

## 6.6 Receiver characteristics

### 6.6.1 Receive mode effective input impedance

The receive-mode effective input impedance shall be measured using the test circuit shown in Figure 5 and at an ambient temperature of 23 ºC ± 3 ºC. The V-network is an artificial network of (50 Ω/(50 μH+5 Ω)) conforming to 8.2.1 of CISPR 16. The receiver impedance is measured as follows. Set the signal generator to a sine wave of amplitude 5 V peak-to-peak at a frequency of 131,5 kHz. All measurements are made with a tuned receiver using a peak detector and a 30 kHz resolution bandwidth. The tuned receiver using its peak detector should read the rms value of a sinusoid. With the transceiver unplugged, measure the voltage ($V_{oc}$) on the V-network 50 Ω resistor (the signal generator provides this resistor with its internal termination) with the tuned receiver. The voltage $V_{oc}$ should be 5,5 dBV ± 1 dB (5,3 $V_{pp}$ ± 10 %) where dBV is defined as dBV=20×log$_{10}$($V_{pp}$/2,828). Next, with the transceiver plugged in and powered up in receive mode measure the voltage ($V_{ic}$) on the V-network 50 Ω resistor. The effective receive input impedance is calculated with the following formula where $Z_e$ is the effective receiver input impedance, $Z_n$ is a constant value of 29,0 $V_{oc}$ and $V_{ic}$ are the two voltages measured as described above (they shall be corrected for the 1/10 divider). The calculated value for $Z_e$ shall be greater than or equal to 200.

$$Z_e \equiv 50 \times V_{ic} \times \frac{Z_n}{V_{oc}(50 + Z_n) - V_{ic}(50 + Z_n)} \qquad (1)$$




**Key**

A Neutral
B Ground
C Line
D Filter
E V-Network
I Power line filter
J Power line transceiver under test
Y Signal Generator (50 Ω)

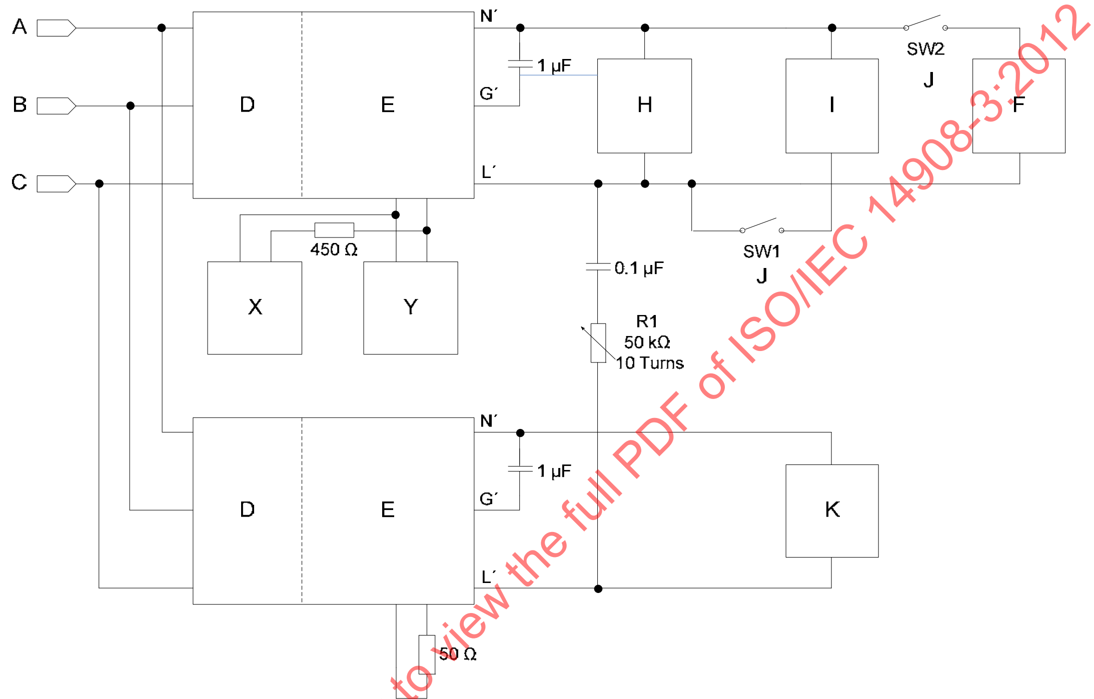
**Figure 5 — Test circuit for determining effective receiver impedance**

### 6.6.2 Receiver performance

There are four receiver performance specifications. The performance is measured under various conditions as described in the following sections for each of the four tests. The performance metric used is packet error rate (PER%) which is defined by the equation below where $P_r$ is packets received and $P_s$ is packets sent. The number of packets sent ($P_s$) shall be more than 1 000.

$$\mathrm{PER\%} = 100 \times \left(1 - \frac{P_r}{P_s}\right) \tag{2}$$

The test circuit for all of the receiver performance tests is shown in Figure 6. The V-networks shown shall conform to the same standard as described in 6.6.1. The tuned receiver should be using a peak detector, a resolution bandwidth of 10 kHz (10 kHz is wide enough to encompass the power line signal and is a commonly available filter bandwidth in standard measuring equipment) and a video bandwidth of 30 Hz. The tuned receiver using its peak detector should read the rms value of a sinusoid. Note that the tuned receiver is measuring 1/10 of the actual voltage on the 50 Ω resistor of the V-network. When a test does not use the signal generator's output care shall be taken to insure that the 50 Ω termination is still present. In this case, the signal generator can be either set to 0 amplitude or can be removed and replaced with a 50 Ω termination.




**Key:**

A Neutral
B Ground
C Line
D Filter
E V-Network
F Dimmer Circuit
T Turn
H Receiver under test
I Notch circuit
J Switch
K Transmitter
X Measuring Receiver(50 Ω)
Y Signal Generator(50 Ω)

**Figure 6 — Test circuit for receiver performance**



### 6.6.3 Receiving on a quiet line

The quiet line test is performed using the test set-up shown in Figure 6. Switches SW1 and SW2 are open. The packet error rate is measured when there are no impairments and the received signal level ranges from –60 dBV (2,828 $mV_{pp}$) to at least 9 dBV (8 $V_{pp}$). (8 V is chosen as a reasonable compromise between node design complexity, performance and ease of testing). The received signal level is measured across the V-network 50 Ω resistor using the measuring receiver while the transmitter is sending packets. Adjusting R1 sets the received level. The verification procedure is to check performance at each endpoint i.e. at -60 dBV and ≥ 9 dBV where the PER% shall be < 0,1 %.