System Conformance Testing

Medium Dependant Layers Tests

PL110 Physical and Link Layer Tests

8

2

3

Summary

This document contains the Physical and Link Layer test specifications for the PL110 Medium.

This document is part of the KNX Specifications v2.1.

Version 01.02.02 is a KNX Approved Standard.

Document Updates

Version	Date	Modifications
1.0	2001.12.01	Approved Standard
1.1	2005.02.25	Approved Standard – integration of AN058
1.2	2008.06.02	Integration of AN061
01.02.01	2013.10.23	Editorial updates for the publication of KNX Specifications 2.1.
01.02.02	2013.11.29	Editorial updates.

Filename: 08_02_03 System Conformance Testing - PL110 PhL and LL Tests v01.02.02 AS.docx
Version: 01.02.02
Status: Approved Standard
Savedate: 2013.11.29
Number of pages: 32

Contents

1 Foreword

The following document describes the PL110 physical layer tests only. See other documents for twisted pair and radio-frequency physical layers.

A complete set of all test-programs and helpful software mentioned below is enclosed with the PL110_TESTCD.

A detailed description of the special equipment used for the PL110 physical layer tests can be found in chapter 3.2.3.

2 Abbreviations

AC	Alternating Current
BAU	Bus Access Unit
BCD	Bus Connected Device
BCU	Bus coupling unit (Standardised BAU)
BW	Bandwidth
DC	Direct Current
DSO	Digital Storage Oscilloscope
DUT	Device under test
HB	KNX Specifications
PEI	Physical External Interface
MAU	Medium Access Unit, Part of BAU, BCD and BCU
DMM	Digital Multimeter

3 General Requirements

3.1 Environment

- Testing shall be carried out in an environment, which does not influence the test results.
- Only calibrated test equipment shall be used.
- Test set-ups shall be as small as possible (if not specified otherwise) to avoid voltage drops along the wires and parasitic induction.
- The ambient temperature shall be taken into account for testing. The operating range of the tested devices, as specified by the manufacturer in the supplied instruction sheets, shall also be taken into account.

3.2 Test-equipment

3.2.1 Test Software

To carry out the tests described later in this document, the Bus Device under Test (BDUT) must be stimulated to allow measurements at the physical layer level. The conditions for stimulation or observing the behavior are given in the test programs table. For devices providing a PEI a set of helpful programs is available. These programs are loaded into the BDUT by means of a suitable program and a serial interface (EDI). The download can be carried out using the busmonitor program stored on the KNX PL110-Test-CD. Next to the Busmonitor software, the test-CD contains a collection of other required software tools.

For devices without PEI it can be necessary to have other software or device-modification to stimulate the BDUT for the described tests. In such cases it should be stated in the test report how or by what means the BDUT was stimulated for the test. The column “BDUT without PEI” gives hints for the required stimulation of the BDUT.

For simplification the test set-ups are shown with devices providing a PEI.

The names of all test-programs are made up of 8 characters:

[medium type][program type, ‘A’ to ‘Z’][version, 01 to99]
Example: PL110B01.

Unless stated otherwise, following addresses are used in the given test-software:

1. System-ID: 01
2. Group-address: 0001
3. Physical address for Transmitters: 0001
4. Physical address for receivers 0002

Other valid addresses can be used under the condition that the error correction nibble and the check octet are calculated accordingly. See sub clause 9.1.1 for more information.

Table 1 – Test programs

DUT with PEI		DUT without PEI	Usage
Name	**Usage/Remarks**	**Description**	**Chapter**
PL110A01	Sensor No 6118 to be connected to DUT key ‘↓’ starts frequency ‘0’ key ‘↑’ starts frequency ‘1’ key ‘I’ starts ‘0011’ key ‘O’ stops transmission	Continuous transmitter for frequency ”0” Continuous transmitter for frequency ”1” Continuous transmitter for frequencies for ‘0011’ (in turns)	6.2 6.2 7.2
PL110B01	Sensor No 6118 to be connected to DUT. key ‘I’ starts cyclic transmission key ‘O’ stops transmission Repeater Flag must be set to ”0” to avoid telegram repetition. Write $EF to BCU-memory-location $101 for this purpose.	Cyclic transmission of telegrams with approx. 2 telegrams/sec. Each telegram is indicated e.g. by a flash of a LED Repeater flag must be set to ”0” to avoid telegram repetition. Write $EF to BCU-memory-location $101 for this purpose.	4.2.1 8.1.2
PL110C01	receiver for PL110B01; each received telegram is indicated by a flash of the programming LED. Do not connect any device to the receiver´s PEI-connector while testing.	Receiver for telegrams; each received telegram is indicated e.g. by flash of a LED or ACK	5.2 9.1.2
PL110C02	receiver for PL110B01; each received telegram is indicated by a flash of the programming LED and an ACK. Do not connect any device to the receiver´s PEI-connector while testing.	See PL110C01	5.2 9.1.2
PL110Dxx	Sensor No 6118 is to be connected to transmitter BCU key ‘I’ transmits one telegram without errors key ‘↑’ transmits changed telegram See chapter 9 for comprehensive details.	Transmitter for valid telegrams with changed parts within the telegram See chapter 9 for comprehensive details.	9.2
PL110Exx	Sensor No 6118 is to be connected to transmitter BCU key ‘I’ transmits one telegram without errors key ‘↑’ transmits one telegram with 1 error	Transmitter for telegrams with one or two bit errors for link-layer tests See chapter 9 for comprehensive details.	9.3

DUT with PEI		DUT without PEI	Usage
Name	**Usage/Remarks**	**Description**	**Chapter**
	key '↓' transmits one telegram with 2 errors See chapter 9 for comprehensive details.		
PL110Fxx	Transmitting telegrams for link-layer tests. See chapter 10 for comprehensive details.	Transmitting telegrams for link-layer tests. See chapter 10 for comprehensive details.	10.2 10.3 10.4

3.2.2 Test Hardware

- DSO: Digital Oscilloscope, $R_i \geq 1M\Omega$, BW min. 20 MHz
- Function Generator: Standard; $R_i = 50\ \Omega$
- DMM Digital Multi-meter, Standard, $R_i \geq 1M\Omega$
- Power meter (Real Power meter range < 5W)
- Event-counter, standard, $R_i \geq 10k\Omega$

3.2.3 Special KNX-Test-Equipment: Overview, Circuit Diagrams and Parts Listing

For the Physical Layer Test of PL110, a set of special test-equipment is necessary. The following chapters show the schematics and a detailed description of the test-modules.

Table 2 – Test Devices

Test-Device	Number	Device used for
RF-Transformer	1	Transmitter-Impedance Test Carrier-Frequency Precision Test
RF-Load	2	Transmitter-Impedance Test
Amplifier and Signal-Injector	3	Receiver-Impedance Test
RF-Chokes	4	Receiver-Impedance Test
RF-Probe	5	Receiver-Impedance Test
Attenuator	6	Receiver-Sensitivity Test
Low-Pass-Filter	7	Bit-Duration Test

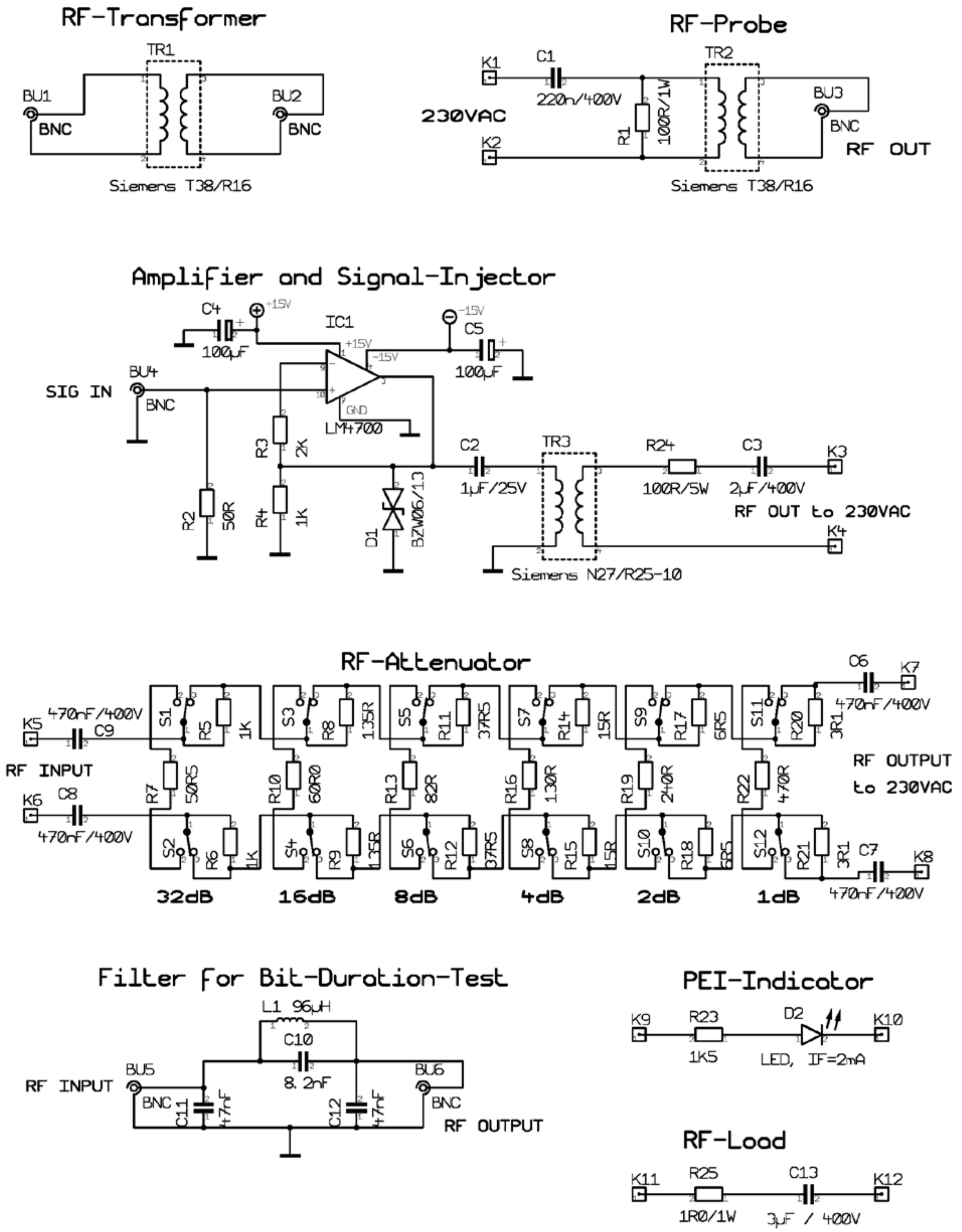

Figure 1: Circuit Diagrams of Special KNX-Test Equipment

Parts Listing for Special KNX-Test equipment

Part	Value	Part	Value
BU1	BNC-connector female	R12	37R5
BU2	BNC-connector female	R13	82R
BU3	BNC-connector female	R14	15R
BU4	BNC-connector female	R15	15R
BU5	BNC-connector female	R16	130R
BU6	BNC-connector female	R17	6R5
C1	220n/400V	R18	6R5
C10	8.2nF	R19	240R
C11	47nF	R2	50R
C12	47nF	R20	3R1
C13	3µF/400V	R21	3R1
C2	1µF/25V	R22	470R
C3	2µF/400V	R23	1k5
C4	100µF Tantal	R24	100R/5W
C5	100µF Tantal	R25	1R0/1W
C6	470nF/400V	R3	2k
C7	470nF/400V	R4	1k
C8	470nF/400V	R5	1k
C9	470nF/400V	R6	1k
D1	BZW06/13 Suppressor diode	R7	50R5
D2	LED, IF=2mA	R8	135R
IC1	LM4700	R9	135R
K1	4mm-connector female	S1	Switch
K10	0,6mm Pin	S10	Switch
K11	4mm-connector female	S11	switch
K12	4mm-connector female	S12	switch
K2	4mm-connector female	S2	switch
K3	4mm-connector female	S3	switch
K4	4mm-connector female	S4	switch
K5	4mm-connector female	S5	switch
K6	4mm-connector female	S6	switch
K7	4mm-connector female	S7	switch
K8	4mm-connector female	S8	switch
K9	0,6mm Pin	S9	switch
L1	96µH/1%	TR1	Siemens T38/R16 2x12 turns
R1	100R/1W	TR2	Siemens T38/R16 2x14 turns
R10	60R0	TR3	Siemens N27/R25-10 2x12 tns
R11	37R5		

All resistors have 1W power-dissipation and 1% tolerance unless otherwise stated.

All capacitors have 10% tolerance.

3.2.3.1 RF-Transformer

The RF-Transformer suppresses low frequency (50Hz and harmonics) disturbances as it is dimensioned for a frequency-range from 50kHz to 200kHz. The transformer is a Siemens R16 toroid of T38 ferrite with two windings of 12 turns, approx. 1mH each. A measurement-error of –1dB maximum should be taken into account.

3.2.3.2 RF-Load

The RF-Load is used for the transmitter-impedance test. It consists of a 1Ω/1W-resistor in series with a 3µF/400V capacitor.

3.2.3.3 Amplifier and Signal-Injector

This device is used for coupling RF-Signals coming from a standard function generator on the 230VAC mains line. The wideband transformer suitable for frequencies from 80kHz to 150kHz consists of a Siemens R25/10 toroid, N27 ferrite, with 2x20 turns resulting in 2x1,2mH approximately. Other ferrites such as 3C65-material may also be used. In this case core size and the number of turns has to be worked out separately.

3.2.3.4 RF-Chokes

The RF-chokes are used for impedance decoupling between the DUT and the artificial network for the receiver-impedance measurement. In each conductor, L1 and Neutral one of the following chokes is connected in series: Siemens R16 toroid, T38 ferrite, 20 turns, 3,3mH.

3.2.3.5 RF-Probe

The RF-Probe allows the measurement of the RF-Signal with the receiver impedance test where the measurement port of the CISPR16 artificial network is not accessible due to the usage of the RF-chokes. The RF-Probe has a 100Ω input-impedance and is designed for connection to a high-impedance measuring equipment of 10k or more input-impedance.
Note: The RF-Probe features no spike-protection. Disconnect the RF-Probe from the measuring device before switching the 230V mains supply.

3.2.3.6 RF-Attenuator

The RF-Attenuator is used for reduction of RF-signal-level on the 230VAC-line for the receiver-sensitivity test. It is designed for a symmetrical 50Ω-system. In case this attenuator is not terminated with 50Ω, the resulting attenuation deviates from the calculated value. This fact is unimportant as the true signal level is measured by means of a measurement receiver or a spectrum analyser. The purpose of this attenuator is the reduction of the signal level on the 230VAC-line only, a precise attenuation of each stage is not necessary.

3.2.3.7 Low-Pass-Filter

This filter is used to check the duration of high- and low-bits on the 230VAC mains. It shows a higher signal amplitude at 105kHz than at 115kHz which makes high- or low-bits visible on an oscilloscope's screen. The filter was designed with "Rudolf Saal, Handbook of Filter Design", filter no. c325/30.

4 RF-Impedance

To limit the influence of connected MAUs on the characteristic of the PL110 bus the impedance in receiving mode shall be high. For signal-injection with minimum losses the impedance in transmitting mode shall be low.

For easier measuring a load test is performed instead of a direct measurement of the impedance.

4.1 Transmitter-Impedance

4.1.1 Test Preparation

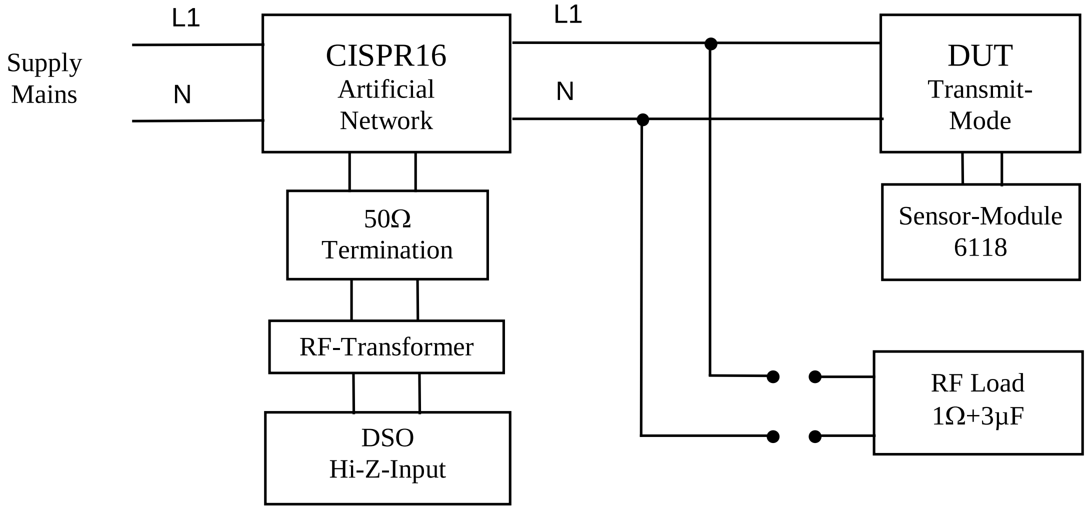

Figure 2: Test circuit transmitter impedance

Remark:

See chapter 3.2.3 for equipment details.

4.1.2 Testing

The device under test (DUT) is set to transmit mode using Test-Software PL110B01 and sensor-module 6118. Transmission is started with key “I”. The signal level is monitored with the digital storage oscilloscope (DSO). Subsequently, a load impedance consisting of 1Ω in series with 3µF / 400V is connected to the mains as shown above. The signal with and without the external load shall be recorded.

4.1.3 Requirements

The signal level without the extra load shall be at least **112 dBµV.**

With the 1Ω+3µF load the signal level shall not drop below **90dBµV**.

The maximum signal level shall not exceed **122dBµV** according EN 50065-1.

4.2 Receiver-Impedance

Similar to the transmitter impedance test, also here a load test is conducted for simplification.

4.2.1 Test Preparation

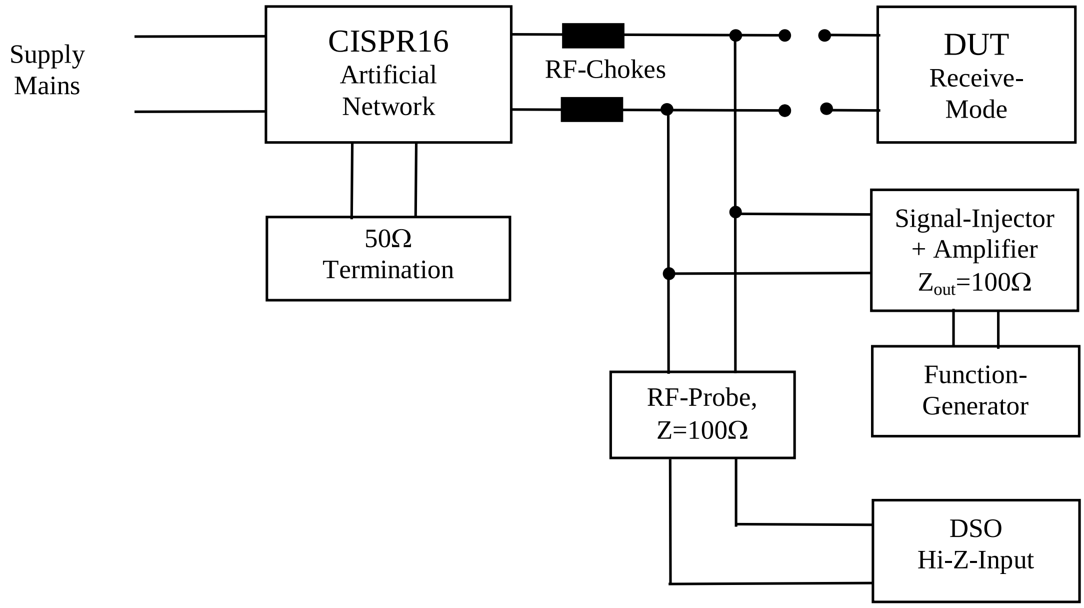

Figure 3: Test circuit receiver impedance

NOTE 1 See chapter 3.2.3 for test equipment details.

4.2.2 Testing

With the signal injector several mono-frequent sinusoidal signals are coupled on the mains line after the CISPR16 artificial network. The chokes provide an impedance-decoupling between the DUT and the artificial network.

First the chokes, the signal-injector **and** the RF-Probe are connected to the artificial mains network as shown in Figure 3. The amplitude of the signal injector shall be adjusted to **1V peak-peak** at the RF-Probe for each frequency while the **230V AC** mains supply is **ON**.

If the 230VAC causes interference the envelope signal is used for measuring.

Second the device under test (DUT) in **receiving mode** is connected to the mains as shown above. The level of the injected signal with and without the DUT connected shall be recorded.

Test-Description:

Both the signal-injector and the RF-probe have an impedance of 100Ω each at 110kHz. If the connected DUT has an impedance of 100Ω the signal seen at the DSO shows one third of the amplitude of the signal-injector without **any** load. If the measured signal is below one third of the unloaded injector the impedance of the DUT is less than 100Ω.

Note: To check the test set-up a calibration can be made using a 100Ω/0.5W-resistor in series with a 0.47µF/250VAC X7-capacitor instead of using the DUT. This test should be made with and without 230V mains supply at the artificial network.

4.2.3 Requirements

The test is conducted at 100kHz, 105kHz, 110kHz, 115kHz, 120kHz

For each frequency the injected signal shall not drop below **0,50Vpp** on connection of DUT.

5 Receiver-Sensitivity

5.1 Test Preparation

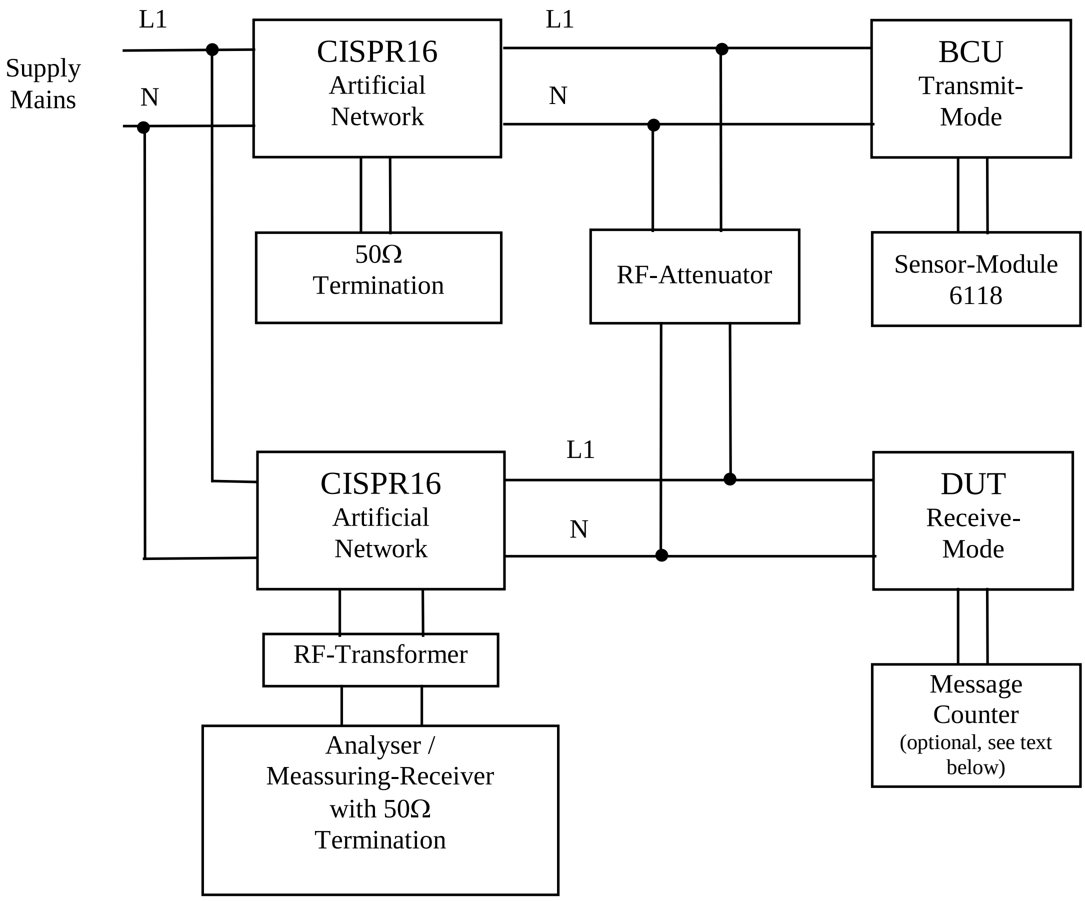

Figure 4: Test circuit receiver sensitivity

NOTE 2 See chapter 3.2.3 for details in test hardware.

5.2 Testing

The transmitter is continuously sending messages using test program PL110B01. Pressing key "I" at the connected sensor-module 6118 starts transmission. The receiver is running test-program PL110C01. The transmitter indicates each telegram with one flash of the sensor-module´s build in LED. The receiver indicates each correctly decoded telegram with one flash of the programming LED.

The signal is then reduced by the attenuator until messages are missing. The signal level where at least 98 of 100 messages are received shall be recorded.

If the connection of event-counters are desired, the indicating LEDs mentioned above are substituted by a high-amplification optocoupler like a CNY17-4 or similar. The counting signal can be taken at the collector of the optocoupler's transistor when connecting the emitter to ground and supplying the collector with a +5V-Source via a 20kΩ-Resistor.

5.3 Requirements

The sensitivity of the receiver shall be better than **60dBµV**.

6 Carrier-Frequency Precision Test

6.1 Test Preparation

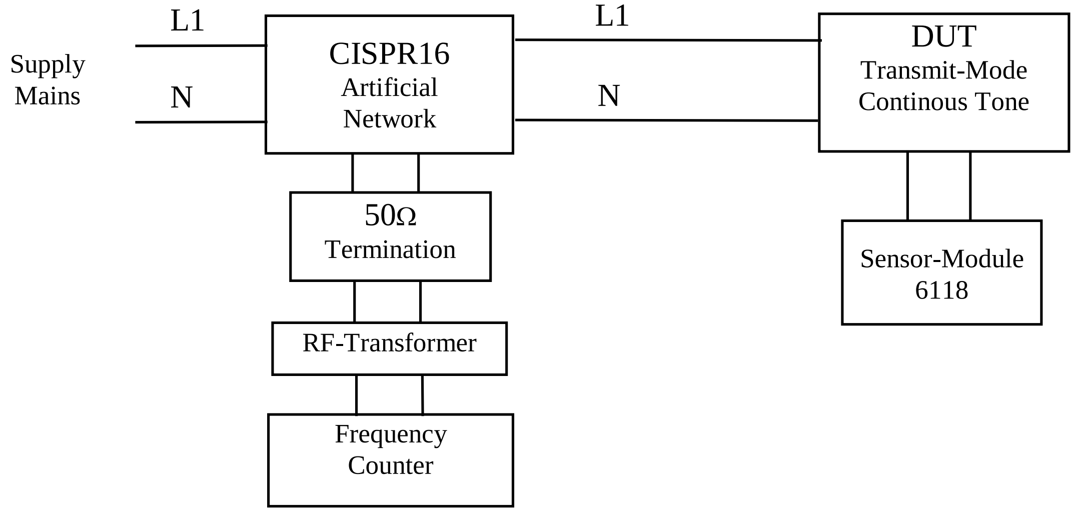

Figure 5: Test Set-up for Carrier-Frequency Precision Test

6.2 Testing

First of all test-program PL110A01 is loaded into DUT and a sensor-module 6118 is connected to the DUT's PEI Interface.

The usage of the test-program is explained in chapter 3.2.1.

The two carrier frequencies are measured with the frequency counter. The signal is taken via the RF-transformer to eliminate unwanted 50kHz and harmonics.

6.3 Requirements

Frequency 1 is 105,5990 kHz **±100ppm (±10,6Hz)**

Frequency 2 is 115,1989 kHz **±100ppm (±11,5Hz)**

7 Bit-Timing

With this test both the duration of one bit and the delay between the mains zero crossing and the start of a bit is checked.

7.1 Test Preparation

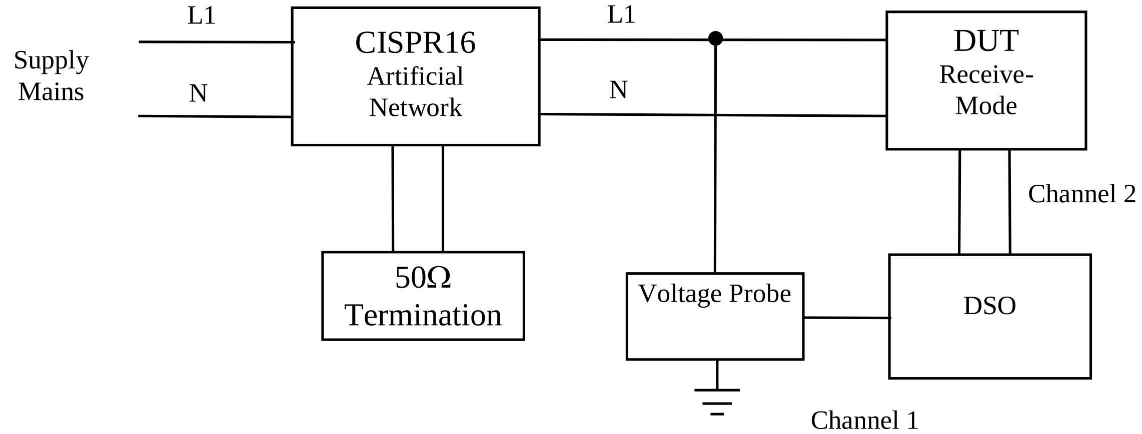

Figure 6: Test Set-up for Bit Delay Test

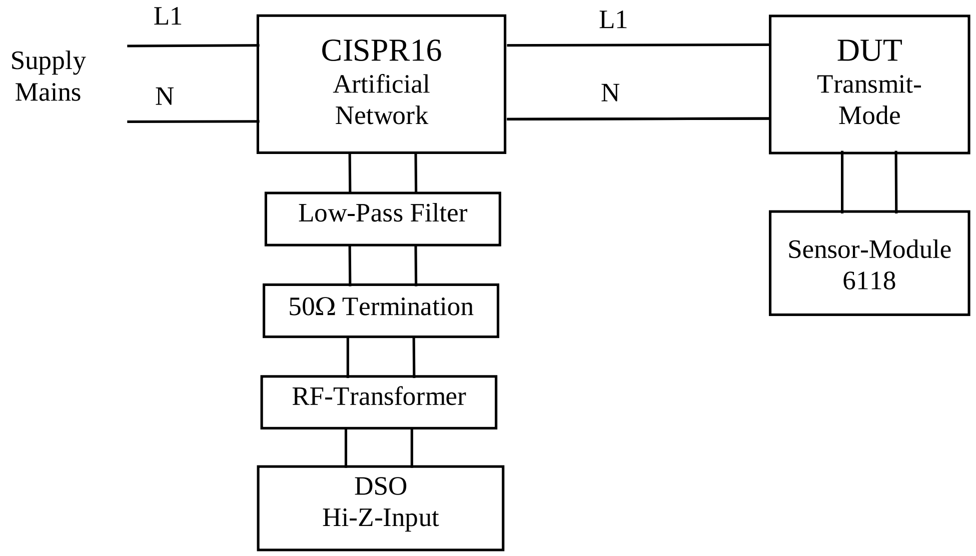

Figure 7: Test Set-up for Bit-Duration Test

NOTE 3 See Chapter 3.2.3 for test hardware details.

7.2 Testing

Testing Delay:

With the DSO the time is measured between the mains zero-crossing (rising edge) and the beginning of a bit. If no bit-clock signal is available a port pin shall provide this signal.

This test has to be carried out with a BCU in receive-mode without communication on the line.

Testing Bit Duration:

Test-program PL110A01 is loaded into the DUT and the transmission of a 00110011-endless-bit sequence is initiated by pressing key ‘I’ of the connected sensor-module 6118. See chapter 3.2.1 for software-details.

The duration for both 1- and 0- bits is measured with the digital storage oscilloscope.

Due to the filter the amplitudes of the two FSK-signals are different.

The transmitter sends two 0- and two 1-bits in turns in order to continuously get 0011 or 1100- transition. This allows a more precise measuring than with single 10- or 01-transitions. Consequently the resulting times for 0- and 1-bits have to be divided by two.

7.3 Requirements

The delay between a bit sequence and the mains zero-crossing shall be less than **100µs**.

The bit-duration for one shall be **833µs ± 8µs**.

8 Power-Test

8.1 230V Power-Dissipation

8.1.1 Test Preparation

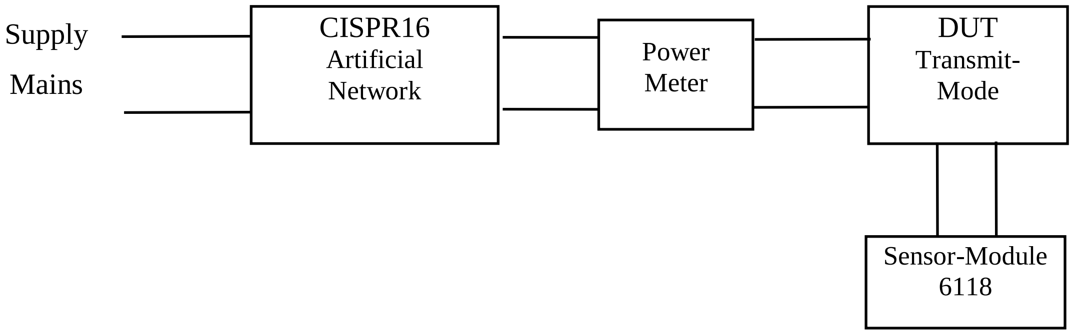

Figure 8: Test setup for power consumption test

NOTE 4 See chapter 3.2.3. for equipment details.

8.1.2 Testing

The value of the real power consumption is recorded in receive and transmit mode.

For this test the mains voltage should be 230V ± 1% and no additional application hardware is connected to the DUT.

In transmitting mode a continuous data stream is required. To ensure this the DUT is loaded with the software PL110B01. Connecting a sensor-module 6118 to the DUT and pressing key “I” starts data transmission.

8.1.3 Requirements

8.1.3.1 Transmit-Mode

The power consumption shall be less than **2W**.

8.1.3.2 Receive-Mode

The power consumption shall be less than **1.5 W**.

8.2 DC-Power-Output

With this test the DC-power-output of the PEI-connector is checked. KNX-applications like switches, displays e.g. are supplied via this connector.

8.2.1 Test Preparation

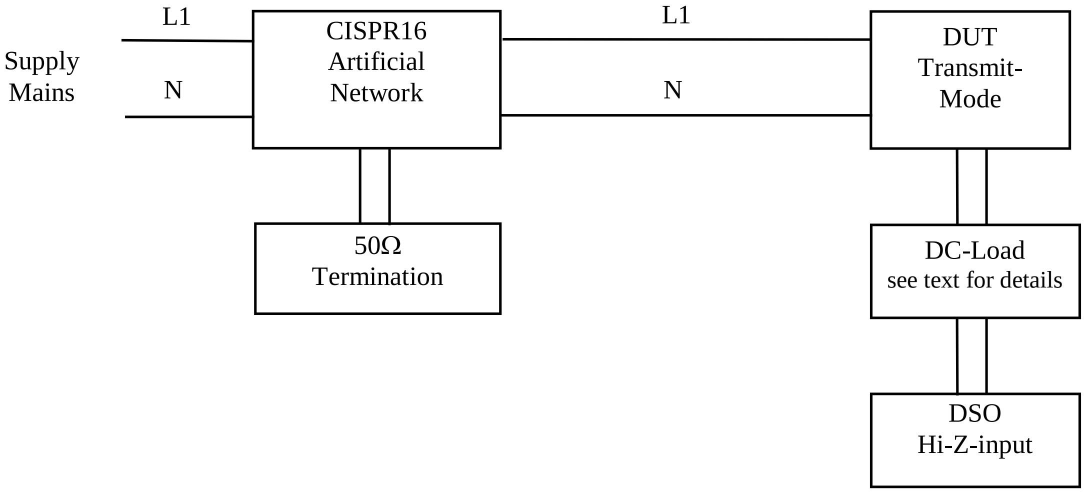

Figure 9: Test setup for DC-Power-out-test

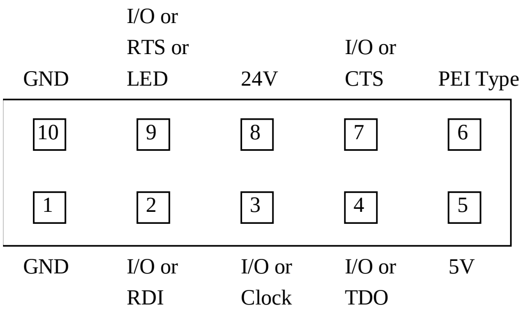

Figure 10: PEI-Connector

8.2.2 Testing

The DUT is set in receive-mode. A 510Ω-resistor is connected between the 5V and ground PEI-terminals. The voltage at the 510Ω-resistor shall be recorded by the DMM .

Subsequently, the 510Ω-resistor is removed and a 12kΩ-resistor is connected between the 24V and the ground-terminal of the PEI-connector. The voltage at the 12kΩ resistor shall be recorded by the DMM.

8.2.3 Requirements

With the 510Ω-test the 5V-output shall not drop below **4.75V**.

With the 12kΩ-test the 24V-output shall not drop below **20V**.

9 Link Layer Tests

9.1 Test preparation

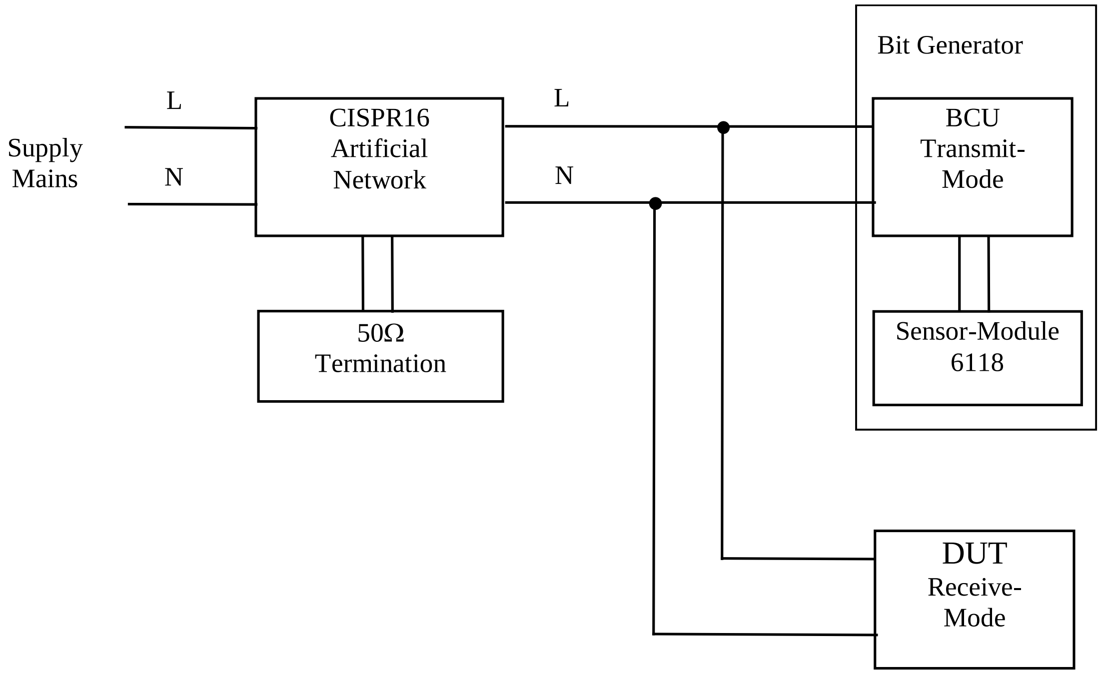

Figure 11: Test setup for error-correction test

9.1.1 Test setup

The bit-generator and the DUT are connected to an artificial network according CISPR 16. The bit-generator can be build up in different ways. To perform the tests described below the bit-generator should be able to generate telegrams containing invalid parts e.g. error correction, checksum, control-field etc. This can be done by using a waveform generator connected via the amplifier and signal-injector (test device no. 3) to the mains. Frequencies and bit timing shall be chosen from Vol. 3 Part 2 Chapter 3 Clause 1. The calculation of the error correction must be done manually according Vol. 3 Part 2 Chapter 3 Clause 1.7.5. The check octet byte is calculated according Vol. 3 Part 2 Chapter 2 Clause 2.1.3.6.

As an alternative a bit-generator using a PL110 BCU, an application module 6118 and a set of software can be used. The software is loaded into the BCU of the bit-generator. The contents of the telegrams transmitted for the tests is located at the following memory-locations and are assigned to the 3 push buttons connected to the PEI:

I : (transition from high to low at PEI pin 2) memory-location $01C5_h$ to $01D6_h$ (last 4 bits unused)

↑: (transition from high to low at PEI pin 3) memory-location $01D7_h$ to $01E8_h$ (last 4 bits unused)

↓: (transition from high to low at PEI pin 7) memory-location $01E9_h$ to $01FA_h$ (last 4 bits unused)

For each test the basic telegram is given at memory location from $01C5_h$ to $01D6_h$.

The telegram with modifications is located in the memory from $01D7_h$ to $01E8_h$.

For bit error tests the telegram with single bit error is located in memory from $01D7_h$ to 01E. Telegram with double bit error is located in memory from $01E9_h$ to $01FA_h$.

The modified parts are underlined

When modifying, it shall be taken into account that the error correction and the check octet must be calculated manually. The contents of those telegrams can be directly exchanged in the memory at the above given locations using EITT or other tools.

For simplification the method using the bit generator (BCU, Application module and test software) is described in the test given below.

9.1.2 Indication of the test result:

The DUT shall be able to indicate the correct reception and interpretation of a received telegram as a positive result. This can be done by transmitting an ACK (program PL110C02) or by a flash of the programming LED (program PL110C01).

Positive result: The tests mentioned below will indicate a positive result by a flash of the programming LED at the DUT (PL110C01) or transmitting an ACK (PL110C02).

Negative result: A negative test is considered if the programming LED of the DUT remains dark or no ACK is transmitted, depending on the loaded test program (PL110C01 or PL110C02).

9.1.3 Single and double bit errors

The telegrams given below are examples and can be modified accordingly provided the error correction nibble and the checksum octet are calculated. The single bit or double bit errors must be chosen very carefully in a bit by bit method. The change from 01 to 03 is a single bit error while the change from 01 to 02 will lead to a double bit error:

01: 0000 0001 basic value
02: 0000 0010 double bit error (0 changed to 1 and 1 changed to 0)
03: 0000 0011 single bit error (0 changed to 1)
To calculate the value for the error correction nibble the program PL110EC.EXE can be used.

9.2 Valid Telegrams without bit-errors

Each test-program of the PL110Dxx series transmits a valid telegram when pressing key 'I' at the sensor-module. This allows a quick check of the correct test-setup. The transmitter sends a valid but partly changed telegram when pressing key '↑'. The DUT shall acknowledge this as described in the tests given below.

The changed parts within the telegrams are underlined.

9.2.1 Basic test-telegram used for checking test-set up

Test-program PL110D01 is loaded into the transmitter BCU. Pressing ‚I'-key at the sensor-module transmits the basic telegram:

A B0 B0 *B0***2** *00***0** *01***C** *00***0** *01***C** *E1***C** *00***0** *81***F** 2F**2** 01**C**

A	Training sequence	No error correction
B0 B0	Preamble	No error correction
B0	LL Control field	Error correction nibble **2**
00 01	Source address	Error correction nibbles **0**, **C**
00 01	Group Address	Error correction nibbles **0**, **C**
E1	NL Control field	Error correction nibble **C**
00	TL Control field	Error correction nibble **0**
81	AL Control field	Error correction nibble **F**
2F	Check octet *	Error correction nibble **2**
01	System –ID	Error correction nibble **C**

* The check octet is calculated only for the part printed in italic characters.

Transmitting of this telegram shall cause a **positive** result at the DUT.

9.2.2 Test-telegram with changed destination (group) address

Test-program PL110D02 is loaded into the transmitter BCU. Pressing ‚↑'-key at the sensor-module transmits the telegram:

A B0 B0 B0**2** 00**0** 01**C** 00**0** 02**B** E1**C** 00**0** 81**F** 2C**5** 01**C**

Transmitting of this telegram shall cause a **negative** result at the DUT.

9.2.3 Test-telegram with changed system-ID

Test-program PL110D03 is loaded into the transmitter BCU. Pressing ‚↑‘-key at the sensor-module transmits the telegram:

A B0 B0 B0**2** 00**0** 01**C** 00**0** 01**C** E1**C** 00**0** 81**F** 2F**2** 02**B**

Transmitting of this telegram shall cause a **negative** result at the DUT.

9.2.4 Telegram with a modified training sequence

Test-program PL110D04 is loaded into the transmitter BCU. Pressing ‚↑‘-key at the sensor-module transmits the telegram:

5 B0 B0 B0**2** 00**0** 01**C** 00**0** 01**C** E1**C** 00**0** 81**F** 2F**2** 01**C**

Transmitting of this telegram shall cause a **positive** result at the DUT because the training sequence is not communication relevant.

9.2.5 Telegram with invalid Control Field

Test-program PL110D05 is loaded into the transmitter BCU. Pressing ‚↑‘-key at the sensor-module transmits the telegram:

A B0 B0 A0**5** 00**0** 01**C** 00**0** 01**C** E1**C** 00**0** 81**F** 3F**5** 01**C**

Transmitting of this telegram shall cause a **negative** result at the DUT.

9.2.6 Telegram with invalid length information

Test-program PL110D06 is loaded into the transmitter BCU. Pressing ‚↑‘-key at the sensor-module transmits the telegram:

A B0 B0 B0**2** 00**0** 01**C** 00**0** 01**C** E2**B** 00**0** 81**F** 2C**5** 01**C**

Transmitting of this telegram shall cause a **negative** result at the DUT.

9.2.7 Telegram with invalid Group Address range

Test-program PL110D07 is loaded into the transmitter BCU. Pressing ‚↑‘-key at the sensor-module transmits the telegram:

A B0 B0 B0**2** 00**0** 01**C** 80**3** 01**C** E1**B** 00**0** 81**F** AF**1** 01**C**

Transmitting of this telegram shall cause a **negative** result at the DUT.

9.3 Telegrams modified by bit-errors

Each test-program of the PL110Exx-series transmits a valid telegram when pressing key ‘I’ at the sensor-module. This allows a quick check of the correct test-setup.

The transmitter sends a telegram with one 1-bit-error when pressing key ‘↑’

The transmitter sends a telegram with one 2-bit-error when pressing key ‘↓’.

The modified bytes within the telegrams are underlined.

9.3.1 Telegram with preamble byte modified by bit-error

Test-program PL110E01 is loaded into the transmitter BCU. Pressing ‚↓‘-key at the sensor-module transmits the telegram:

A B3 B0 B0**2** 00**0** 01**C** 00**0** 01**C** E1**C** 00**0** 81**F** 2F**2** 01**C**

Transmitting of this telegram shall cause a **negative** result at the DUT.

9.3.2 Telegram with data byte modified by bit-error

9.3.2.1 Single Bit-Error Test

Test-program PL110E02 is loaded into the transmitter BCU. Pressing ‚↑‘-key at the sensor-module transmits the telegram:

A B0 B0 B0**2** 00**0** 01**C** 00**0** 03**C** E1**C** 00**0** 81**F** 2F**2** 01**C**

Transmitting of this telegram shall cause a **positive** result at the DUT.

9.3.2.2 Double Bit-Error Test

Test-program PL110E02 is loaded into the transmitter BCU. Pressing ‚↓‘-key at the sensor-module transmits the telegram:

A B0 B0 B0**2** 00**0** 01**C** 00**0** 02**C** E1**C** 00**0** 81**F** 2F**2** 01**C**

Transmitting of this telegram shall cause a **negative** result at the DUT.

9.3.3 Telegram with 4-bit error-correction of one data byte modified by bit-error

9.3.3.1 Single Bit-Error Test

Test-program PL110E03 is loaded into the transmitter BCU. Pressing ‚↑‘-key at the sensor-module transmits the telegram:

A B0 B0 B0**2** 00**0** 01**C** 00**0** 01**C** E1**4** 00**0** 81**F** 2F**2** 01**C**

Transmitting of this telegram shall cause a **positive** result at the DUT.

9.3.3.2 Double Bit-Error Test

Test-program PL110E03 is loaded into the transmitter BCU. Pressing ‚↓‘-key at the sensor-module transmits the telegram:

A B0 B0 B0**2** 00**0** 01**C** 00**0** 01**C** E1**A** 00**0** 81**F** 2F**2** 01**C**

Transmitting of this telegram shall cause a **negative** result at the DUT.

9.3.4 Telegram with checksum-byte modified by bit-error

9.3.4.1 Single Bit-Error Test

Test-program PL1120E04 is loaded into the transmitter BCU. Pressing ‚↑‘-key at the sensor-module transmits the telegram:

A B0 B0 B0**2** 00**0** 01**C** 00**0** 01**C** E1**C** 00**0** 81**F** 2E**2** 01**C**

Transmitting of this telegram shall cause a **positive** result at the DUT.

9.3.4.2 Double Bit-Error Test

Test-program PL110E04 is loaded into the transmitter BCU. Pressing ‚↓‘-key at the sensor-module transmits the telegram:

A B0 B0 B0**2** 00**0** 01**C** 00**0** 01**C** E1**C** 00**0** 81**F** 25**2** 01**C**

Transmitting of this telegram shall cause a **negative** result at the DUT.

9.3.5 Telegram with system-ID-byte modified by bit-error

9.3.5.1 Single Bit-Error Test

Test-program PL110E05 is loaded into the transmitter BCU. Pressing ‚↑‘-key at the sensor-module transmits the telegram:

A B0 B0 B0**2** 00**0** 01**C** 00**0** 01**C** E1**C** 00**0** 81**F** 2F**2** 11**C**

Transmitting of this telegram shall cause a **positive** result at the DUT.

9.3.5.2 Double Bit-Error Test

Test-program PL110E05 is loaded into the transmitter BCU. Pressing ‚↓‘-key at the sensor-module transmits the following telegram:
A B0 B0 B0**2** 00**0** 01**C** 00**0** 01**C** E1**C** 00**0** 81**F** 2F**2** 51**C**
Transmitting of this telegram shall cause a **negative** result at the DUT.

10 Telegram Timing Tests

10.1 Test preparation

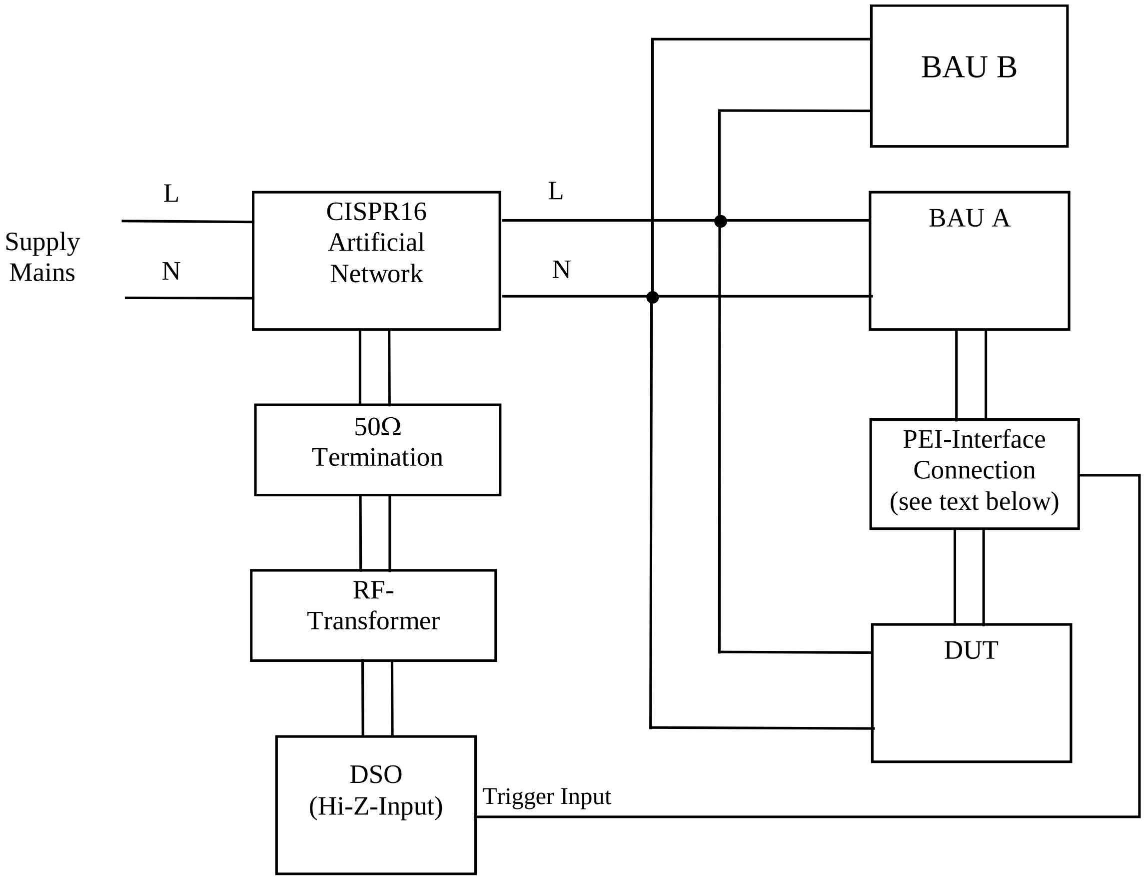

Figure 12: Test setup for telegram timing test

The devices used in the test setup for measuring of telegram timing shall be able to influence each other to provoke transmissions. This can be achieved by synchronizing the BAU A and the DUT as specified in the timing diagram below. If there is a PEI available at the DUT as well as at BAU, the following connections can be made. In combination with the software mentioned in the test below the telegrams are transmitted in the required manner.

Telegram Timing:

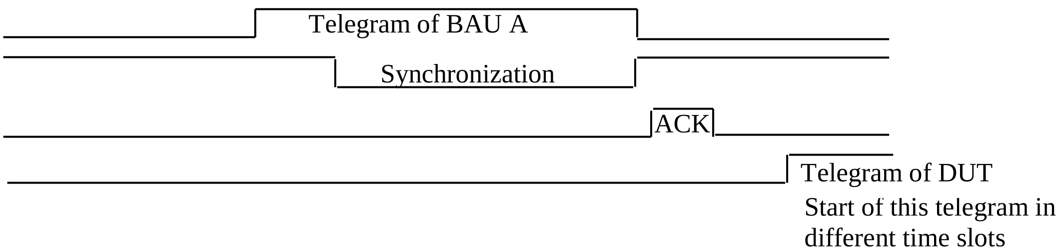

Table 3 - PEI-Connections between BAU A and DUT (see 8.2.1 for PEI-connector details)

BAU A Pin	DUT Pin	Remark
1	1	ground wire
9	2	wire, connect to DSO-trigger input also
5,6	-	430kΩ PEI-Type-Resistor BCU; no connection to DUT allowed from these pins
-	5,6	430kΩ PEI-Type-Resistor DUT; no connection to BCU allowed from these pins.

10.2 Time slot for ACK telegram

10.2.1 Test Preparation

The test-setup used is shown in Figure 12. For this test BAU B is omitted.

10.2.2 Testing

BAU A is loaded with test program PL110F02 and DUT is loaded with test program PL110C02. With the DSO the time between the transmitted telegram and ACK shall be recorded.

10.2.3 Requirements

The time between the telegram and ACK shall be between 1 and 5 bit times (0.833 ms up to 4.167 ms).

10.3 Time between two communication cycles

10.3.1 Telegram with system priority

10.3.1.1 Test Preparation

The test-setup used is shown in Figure 12.

10.3.1.2 Testing

BAU A is loaded with test program PL110F02, BAU B is loaded with test program PL110C02 and DUT is loaded with test program PL110F03.

BAU A sends a telegram. BAU B confirms the receipt with an ACK. The DUT is triggered by an impulse via a connection between BAU A and the DUT. This will start a new communication cycle with system priority (PL110F03).

With the DSO the time between the ACK of the first cycle and the telegram of the new cycle shall be recorded.

10.3.1.3 Requirements

The time between the ACK and the new telegram shall be 22 ± 2 bit times (16.67 ms up to 20 ms).

10.3.2 Telegrams with low priority

10.3.2.1 Test Preparation

The test-setup used is shown in Figure 12.

10.3.2.2 Testing

BAU A is loaded with test program PL110F02, BAU B is loaded with test program PL110C02 and DUT is loaded with test program PL110F04.

BAU A sends a telegram. BAU B will send an ACK. The DUT is triggered by an impulse via a connection between BAU A and the DUT. This will start a new communication cycle with low priority (PL110F04).

With the DSO the time between the ACK of the first cycle and the telegram of the new cycle shall be recorded.

10.3.2.3 Requirements

The telegrams must be recorded according the following structure:

The first valid time slot for the telegram start of a new communication cycle is at 38 ± 2 bit times (30 ms up to 33.33 ms). The telegram start shall be within a grid of at least 7 different positions each separated by at least 16 bit times (13.33 ms). The different positions shall appear at a random order. See also Fig. 27 of Vol. 3, Part 2, Chapter 3 for additional information.

10.4 Time between telegram and repeated telegram

10.4.1 Test Preparation

The test-setup used is shown in Figure 12. BAU A and BAU B are omitted.

10.4.2 Testing

The DUT is loaded with test program PL110F03.

The DUT sends a telegram and a repeated telegram e.g. started with a high to low transition at PEI pin 2. With the DSO the delay between telegrams shall be recorded.

10.4.3 Requirements

The delay time between the first and the repeated telegram must be 40 ± 2 bit times (31.5 ms up to 35 ms).

11 Repeater Test

11.1 General Test Set-UP

11.1.1 Hardware

The test set-up is depicted in the underneath figure and consists of:

- one repeater as Bus Device Under Test (BDUT)
- one additional BAU used as acknowledge generator (BAU B)
- the KNX Interworking Test Tool, hereafter called EITT running on a PC, which is connected to the bus via BAU A by an EDI (KNX data interface, PEI-Type 16)
- an artificial network 50Ω / 50µH + 5Ω according CISPR 16 (Second Edition, Clause 8.2.1) shall be installed next to the BDUT.
- two attenuators, see description below for details
- two KNX RF-Probes as described in clause 3.2.3
- one RF-transformer as described in clause 3.2.3
- one Digital Storage Oscilloscope (DSO) with at least 3 independent differential input channels for measuring

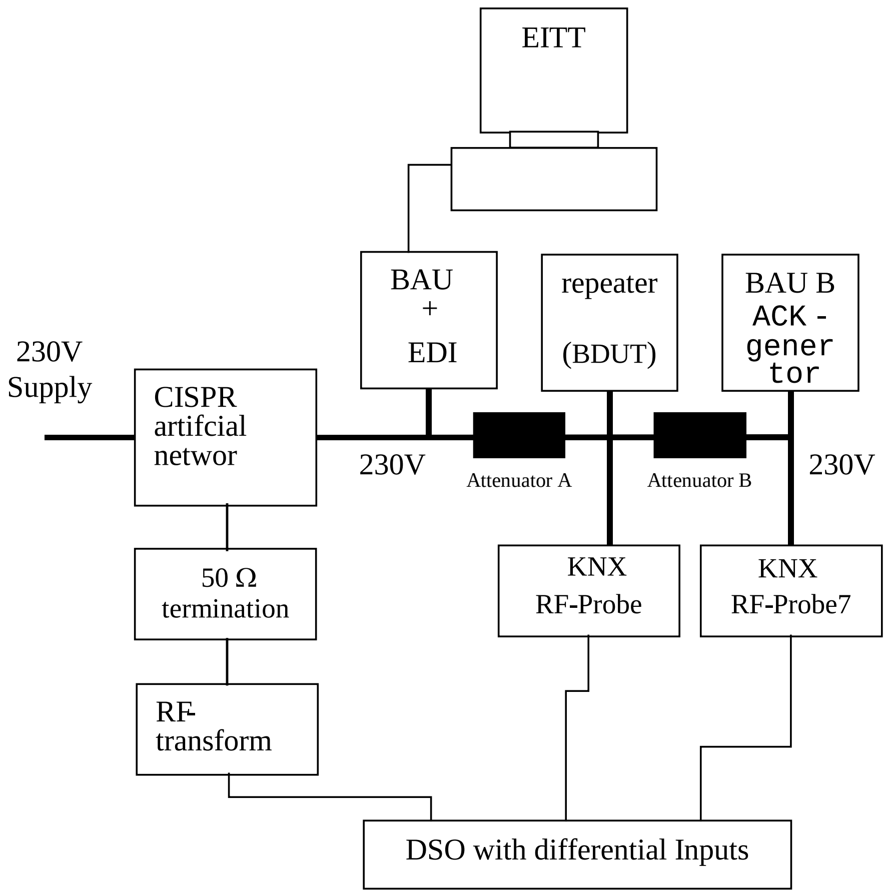

Figure 13: Test Set-up for a repeater black-box test

DSO differential inputs:

Connecting three KNX RF-probes to an ordinary oscilloscope as shown above can reduce the effect of the attenuators.

To avoid this unwanted effect, differential inputs or differential probes should be used.

Details of the attenuators:

The two attenuators mentioned above can be implemented as line filter sections of switched power supplies. The value of the actual attenuation is unimportant – it should be high enough to prevent direct communication between BAU A and BAU B. On the other hand BAU A and BAU B need to communicate with the repeater (BDUT).

Schematic of an example of one attenuator

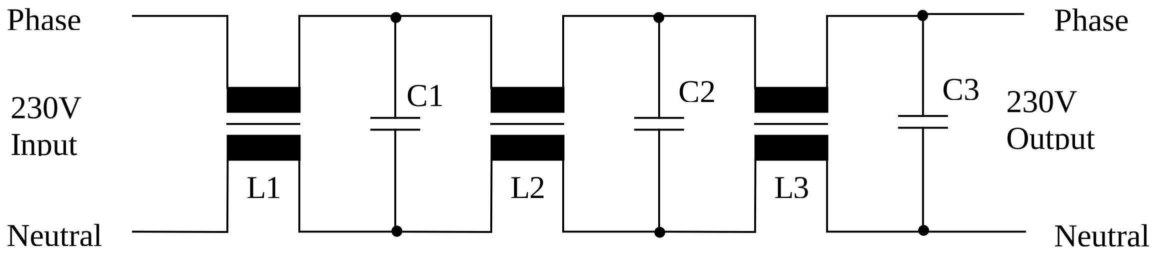

Figure 14: Example of an attenuator

Typical values for L1 = L2 = L3 = 2x6,8mH current compensated coil, C1 = 1µF, C2 = C3 = 220nF, X2 foil capacitors, 275V AC rated voltage. These values may be altered to reach the desired attenuation.

11.1.2 Software

During the test the only tool used is the KNX Interworking Test Tool (EITT)

By means of EITT (in send mode) the BDUT and the BAU B are stimulated. The timing between stimulus and reply telegram can be observed via a DSO.

Before carrying out the various tests or test steps, several values have to be set in the BDUT by means of EITT. These relate amongst others to:

- the individual address of the BDUT shall be set to 1101_{hex}
- the BAU A (EDI) shall have the individual address 1102_{hex}
- the BAU B shall have the individual address 1103_{hex}
- the domain address FEh shall be loaded into BAU A, BAU B and the BDUT
- specific data (e.g. repeater mode), which has to be downloaded into a fixed memory area of the BDUT

NOTE 5 The actual application software stored inside of BAU A, BAU B, and BDUT has to be provided with the corresponding test report.

11.2 Repeater Idle Test

A stimulus is sent by the EDI (group oriented communication).

The time between the end of the stimulus and the beginning of the acknowledgement shall be measured.

11.2.1 Test preparation

- BCU B shall be loaded with the address-table, association-table and group object table
- Remove Attenuation A and Attenuation B

11.2.2 Testing

The following telegrams shall be used:

DPT 1.001 telegram, source address 1102, destination address 1001, system priority:

```
IN    B0 1102 1001 E1 00 81
```

DPT 1.001 telegram, source address 1102, destination address 1001, low priority:

```
IN    BC 1102 1001 E1 00 81
```

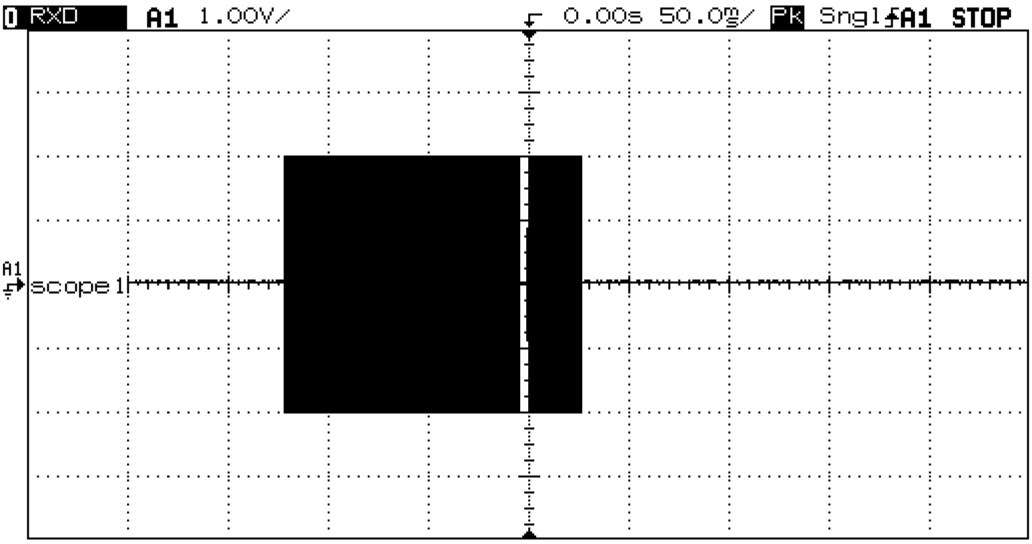

Figure 15: Stimulus without repetition with acknowledge

11.2.3 Requirements

The BAU B shall start an acknowledgement frame within 5 bit times after the reception of the stimulus.

The BDUT shall not react!

11.3 Test Repeated and Acknowledged Frame

A stimulus is sent by the EDI (group oriented communication).

The time between the end of the stimulus and the beginning of the repeated telegram shall be measured as well as the time between the end of the repeated telegram and the beginning of the acknowledgement frame.

11.3.1 Test preparation

Install the attenuation A and the attenuation B.

11.3.2 Testing

DPT 1.001 telegram, source address 1102, destination address 1001, system priority:

`IN    B0 1102 1001 E1 00 81`

DPT 1.001 telegram, source address 1102, destination address 1001, low priority:

`IN    BC 1102 1001 E1 00 81`

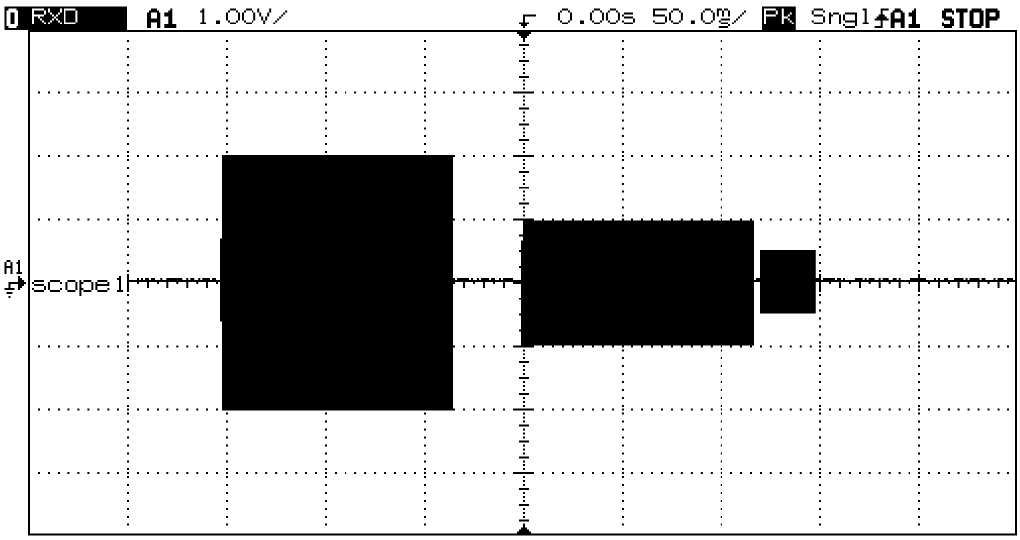

Figure 16: Stimulus with repetition and acknowledge

11.3.3 Requirements

The BDUT shall start the repetition of the stimulus after 40±2 bit times. The BAU B shall start an acknowledgement frame within 5 bit times after the reception of the repeated stimulus. A Not Acknowledgement frame shall not be sent by the BDUT.

11.4 Test Repeated and Not Acknowledged Frame

A stimulus is sent by the EDI (group oriented communication). The BDUT shall start the repetition of the stimulus. The BAU B shall not react. A not acknowledgement frame shall be sent by the BDUT.

11.4.1 Test preparation

Remove BAU B, remove attenuation A and attenuation B.

11.4.2 Testing

DPT 1.001 telegram, source address 1102, destination address 1001, system priority:

`IN    B0 1102 1001 E1 00 81`

DPT 1.001 telegram, source address 1102, destination address 1001, low priority:

`IN    BC 1102 1001 E1 00 81`

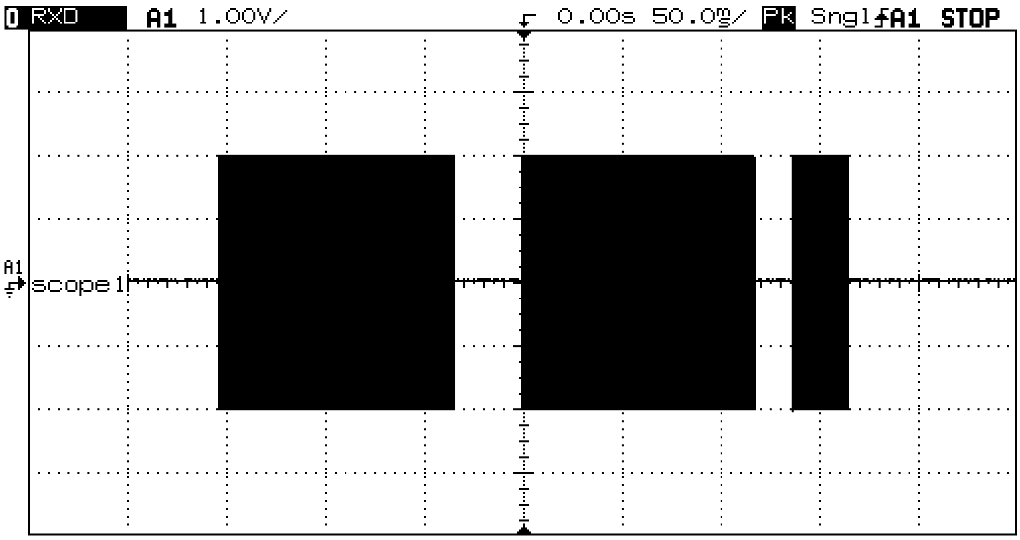

Figure 17: Stimulus with repetition and not acknowledge

11.4.3 Requirements

The BDUT shall repeat the stimulus within 40±2 bit times and send a not acknowledgement frame within 22±2 bit times.

11.5 Group Speaker Test

The usage of group speakers minimizes the number of acknowledges necessary when a group of BCUs is addressed

11.5.1 Test Preparation

For testing the group speaker functionality the test described in chapter 11.2 can be used where an acknowledge frame is sent by BCU B.

The second test is done with group speaker functionality disabled.

11.5.2 Requirements

With the group speaker functionality enabled an acknowledge frame is to be transmitted as described in chapter 11.2.

With the group speaker functionality disabled an acknowledgement frame may not be sent.