System Conformance Testing

8

Medium Dependant Layers Tests

2

TP1 Physical and Link Layer Tests

2

Summary

This document contains the Physical and Link Layer tests for TP1 KNX.

Version 01.04.02 is a KNX Approved Standard.

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

Document Updates

Version	Date	Modifications
1.0	2001.03.13	- Approved Standard
1.1	2005.02.24	- Approved Standard – integration of AN003 clause 1.2, AN023, clause 2 of AN041
1.2	2009.06	- Readying document for KNX specifications V 2.0 – integration of AN084 – integration of clause 2.2.2 and 2.2.3 of AN111
1.3 RfV	2009.10	- Clarification test performance Pulse Impedance and Transmitter tests – updating of incorrect references
1.3 FV	2010.03	- Resolving comments from RfV cycle
1.3 AS	2010.08	- No comments in FV cycle
1.4 AS	2013.09	- **Integration of AN129 and AN156**
01.04.01 AS	2013.10.23	- Editorial updates for the publication of KNX Specifications 2.1.
01.04.02 AS	2013.12.11	- Correction of “Pulse Input Current” figure. - Editorial changes.

References

[01] Chapter 3/3/1 “Physical Layer General”
[02] Chapter 3/3/2 “Data Link Layer General”
[03] Part 4/1 “Safety and Environmental Requirements – General”
[04] Chapter 8/6/3 “Testing of EMI-IMI (Local Service Testing)”

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Contents

1 Foreword

The test methods are based on the assumption that the devices are black boxes and cannot be accessed internally. However for testing of the collision detection an internal auxiliary test signal is required.

When a device successfully passes the underneath TP1-256 tests, it may also be mounted in TP1-64 installations.

2 Abbreviations

AC	Alternating Current
BAU	Bus Access Unit (=integrated Bus device)
BCD	Bus Connected Device
BCU	Bus coupling unit
BDUT	Bus Device under test ;
BW	Bandwidth
Choke	KNX standardised TP 1 Choke module
CP	Current Probe
DC	Direct Current
DSO	Digital Storage Oscilloscope
EED	KNX End Device (e.g. BCU, BAU, Router)
HB	KNX Handbook Series
PB	Push Button
PEI	Physical External Interface
PSU	Power Supply Unit; DC-Source (do not confuse with standardised ***KNX*** TP1-PSU)
RVP	Reverse Voltage Protection

3 General Requirements

3.1 Environment

- Testing shall be conducted in an environment that 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 inductions.
- 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 be also taken into account.

3.2 Test Equipment

- PSU: Adjustable DC-Source ; 0-40 V; I 1 A limited; U_{PSU} (Ripple) < 10 mV
- Choke: Standard KNX-TP1 Choke-Module
- CP: Current Probe (DC-20 MHz)
- DSO: Digital Oscilloscope (BW min. 20 MHz) which is used for Voltage-Ripple and Current-Slope measurements
- Waveform Generator: programmable
- Function Generator: Standard; Ri < 50 Ω
- Amplifier: used to amplify the signals of waveform generator to bus level
- EITT: PC with KNX Interworking Test tool (for more information see manual) and RS232 Module
- Delay-Unit: Unit to delay digital signals
- Shunt Resistors

3.3 Important notes

- The underneath requirements are given for implementations with a fan-in model of up to 10 mA (see 2.5.4.1 of [03]).

  For higher fan-in models, the requirements (not the timing requirements!) of clause 4.2, 4.3 and 4.4 may be increased accordingly. In the same way, the limit and the capacitance value as given in clause 4.3.1 can be multiplied by the same factor and the resistance value may be divided by the same factor. For instance, in case of a fan in model of up to 20 mA (so twice the 10 mA fan-in model), the requirements may be doubled, the limit and the capacitance value doubled and the resistance value as given in clause 4.3.1 halved.

- When this volume requires the measurement of slopes (e.g. in the case of transmitter tests), the steepest slope shall be measured to check compliance to the requirements.

4 Power Conversion

4.1 General

A power converter is either part of a KNX-Device or a standalone unit. The main task of a power-converter is to separate the DC-Part from the bus and to convert it to a lower stabilised voltage.

A power converter may not disturb the signal voltage at the bus in any way. Fast load changes at the output of the converter shall be transformed (smoothened) to slow slopes at the input of the converter:

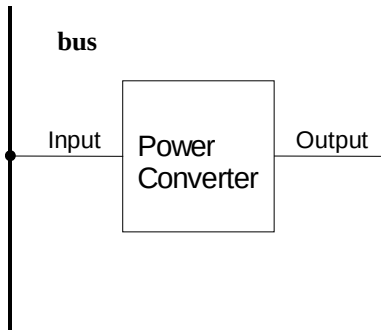

Figure 1 - Principle of a Power Converter

4.2 Power Conversion (Switch On Fast)

This test simulates the connecting of a single bus device (EED) to an operating bus segment.

4.2.1 Test Preparation

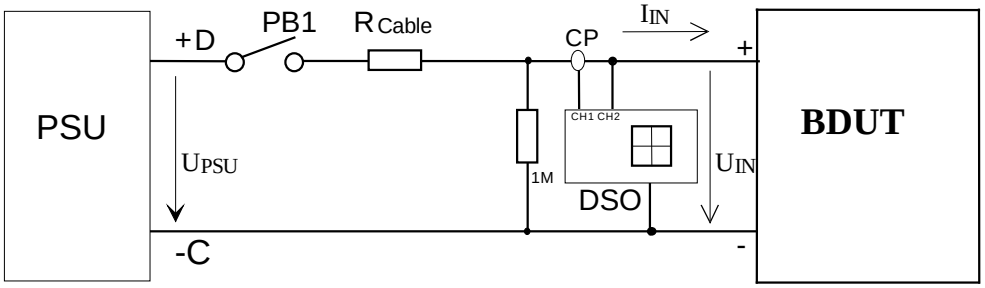

Figure 2 - Test Set-up for Switch On/Off Behaviour

PB1 is a debounced push button: to reduce the risk of side effects e.g. a FET shall be selected instead of a mechanical switch, of the maximum resistance shall be 100 mΩ.

The 1 MΩ resistor is intended to discharge the capacitors inside of BDUT before testing. The influence of this resistor to the measuring is negligible. R_{Cable} represents the ohmic part of the TP1-Cable.

4.2.2 Testing

U_{PSU} shall be tuned to both 20 V and 30 V. the push button shall be pressed and held. Testing shall be conducted at R_{Cable} =35 Ω and 0 Ω.

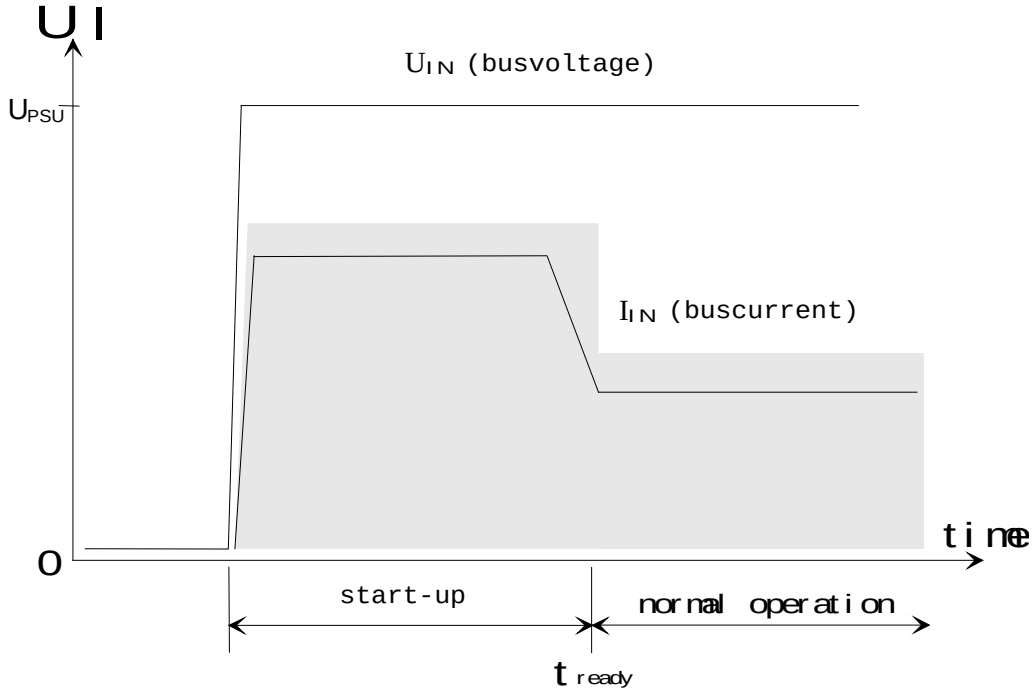

Figure 3 - Example of Switch On Graphs

4.2.3 Requirements

The BDUT shall run up properly (no latch-up may occur). The resulting graph shall be within the grey shaded area of Figure 3.

Spikes exceeding the current limit are permitted. Two types of acceptable spikes are distinguished

1. Spikes of t < 30 ms shall not exceed 45 mA
2. Spikes of t < 30 µs shall not exceed 500 mA.

The number of spikes during switch on shall not be higher than 5.

Table 1 - Ratings for Switch On Behaviour of a KNX Power Converter

Parameter	Start-Up	Operation
U_{PSU} 20/30 V		
Tstart-up [1)]	≤ 10s	
I_{IN} (TP1-64 & TP1-256)	< 30 mA	see load changes

1) Tstart-up is the time required until the DUT has become operational (normally after execution of Ureset).

4.3 Power Conversion (Switch On/Off Slow)

This test simulates the powering up of a fully equipped physical segment.

4.3.1 Test Preparation

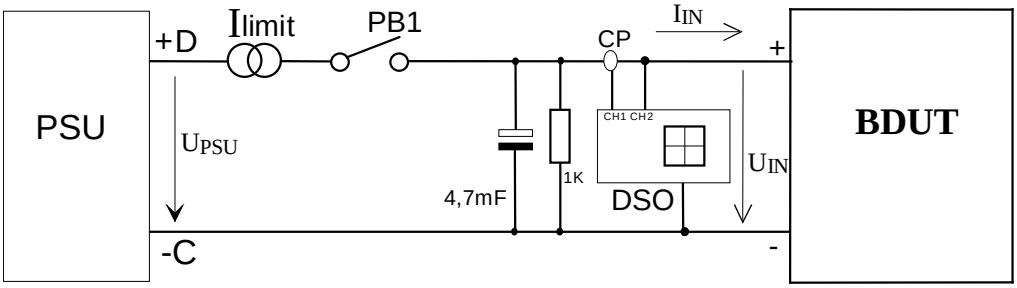

Figure 4 - Test Set-up for Switch On/Off Behaviour

PB1 is a debounced push button. The resistor, current limiter and capacitor are used to generate slow bus voltages slopes [2)].

4.3.2 Testing

UPSU shall be tuned to both 20 V and 30 V. The current limiter shall be tuned to 50 mA. Push button (PB1) shall be pressed, held and released. The time of releasing the PB1 shall be later than the time at which BDUT is in operation.

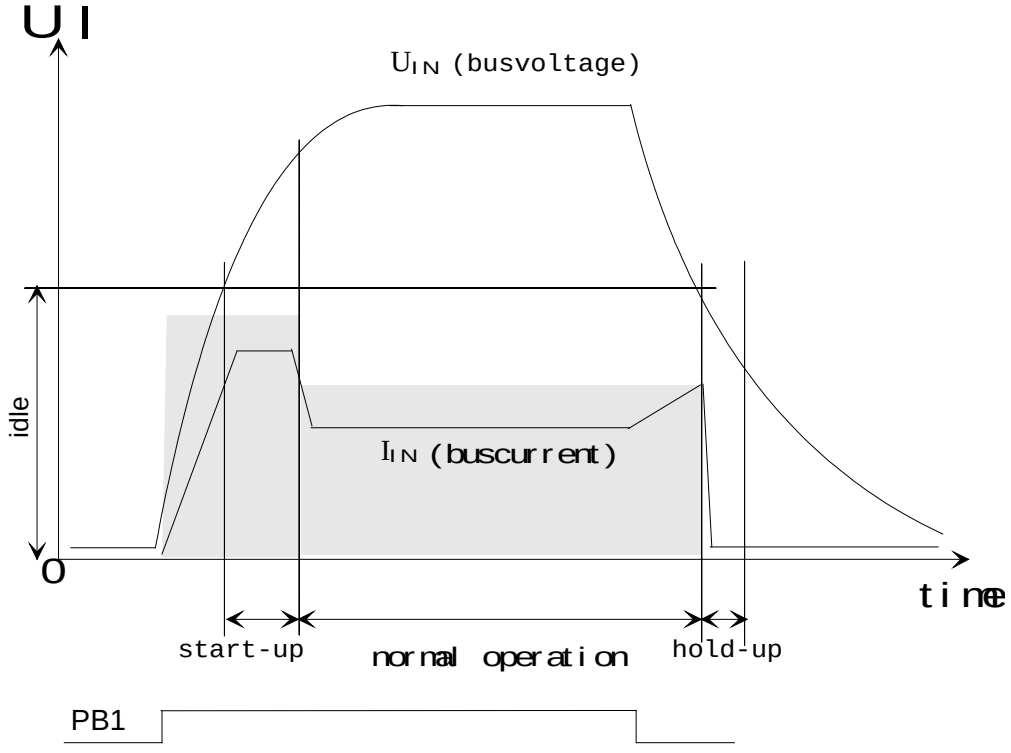

Figure 5 - Example of Switch On/Off Graph

2) The resistor and capacitor do not simulate a bus load. They can be used for testing TP1-64 as well as TP1-256 devices.

4.3.3 Requirements

The BDUT shall run up properly (i.e. no latch-up may occur). The resulting graph shall be within the grey shaded area of Figure 5.

Spikes exceeding the current limit are permitted. Two types of acceptable spikes are distinguished:

1. Spikes of t < 30 ms shall not exceed 45 mA
2. Spikes of t < 30 µs shall not exceed 500 mA.

The number of spikes during switch on shall not be higher than 5.

Table 2 - Ratings for Switch On Behaviour of a KNX Power Converter

Parameter	Start-Up	Operation	Hold-up
U_{PSU} 20/30 V			See Table 3
Tstart-up	≤ 10s		
I_{IN} (TP1-64 & TP1-256)	< 30 mA	see load changes	

4.3.4 Test Preparation for hold-up

The DUT should be loaded in that way, that the current Iin is 10 mA (FanIn=1) with Uin is 21 V.

4.3.5 Requirements for hold-up (under consideration)

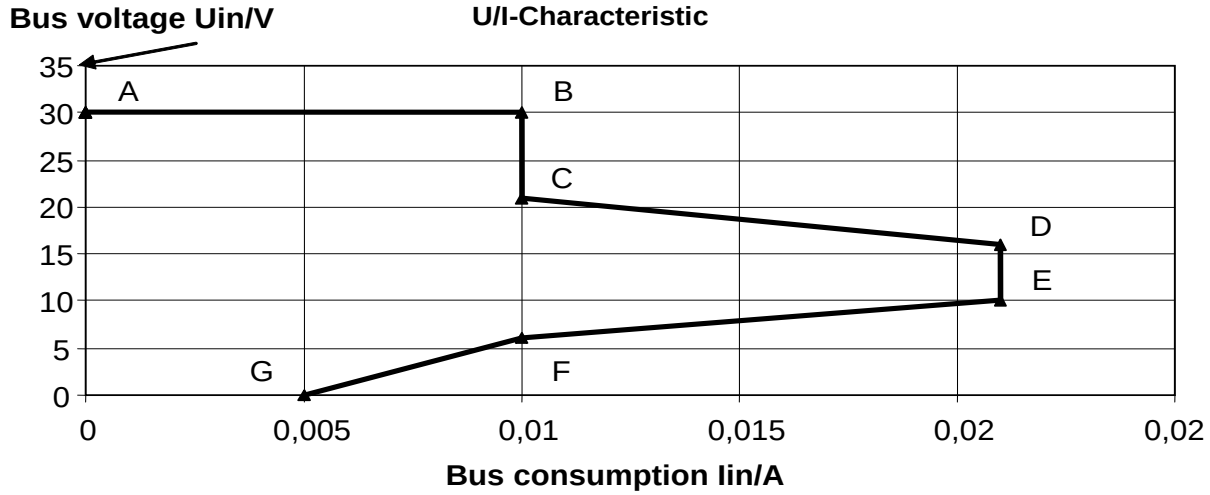

Figure 6 - U/I Characteristic

Table 3 - Requirements

Point	Uin/V	Iin/mA
A	31	0
B	31	10
C	21	10
D	16	21
E	10	21
F	6	10
G	0	5

4.4 Power Conversion (Load Changes)

Switching from minimal to maximal load and vice versa simulates the changing of load. Maximum load is manufacturer specific and specified as the maximum load that can be connected to the PEI. The maximum bus current of 12 mA that may be drawn by the device shall hereby not be exceeded. The bus current I_{IN} shall be monitored with a storage oscilloscope. A steep slope of the output current (I_{OUT}) shall be transferred to a flat slope of input current (I_{IN}).

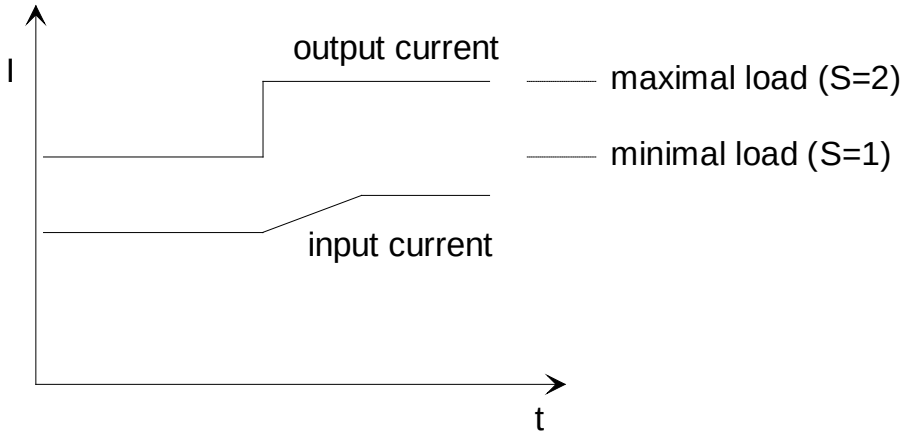

Figure 7 - Output Load Changes

4.4.1 Test Preparation

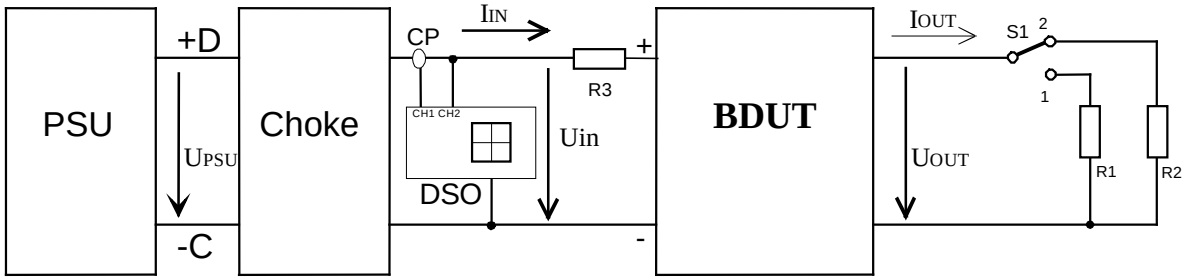

Figure 8 - Test Set-up for Switch on/off and static behaviour

R1& R2: Two resistors are used for load simulation: R1 represents minimum load and R2 maximum load. R3 = 100 Ω

S1: Is a two-way switch, which is used for evaluating load changes.

4.4.2 Testing

The bus current shall be monitored while switching from max to min load and vice versa. At both positions, the static bus current and the AC-Part of U_{IN} shall be measured.

4.4.3 Requirements (TP1-64 & TP1-256)

Table 4 - Ratings for Load Change Behaviour of a KNX Power Converter

Parameter	Values
DC input current (any load) [3)]	TP1-64: max. 12 mA for $U_{IN=}$ 20-30 V TP1-256: max. 12 mA for $U_{IN=}$ 20-30 V
slope of input current	max. 0.5 mA/1 ms
slope of input current for manually operated devices (e.g. push buttons)	max. 2.5 mA/1 ms

4.5 Power Conversion (RVP)

Transceivers that do not support free connection of bus polarity for normal operation shall provide a protection unit (RVP) for reverse polarity connection.

In case of reverse connection of a bus device, this device may neither have a negative influence to the bus, nor shall it be damaged, no matter how long this reverse connection lasts.

During reverse connection the BCU current shall be lower than or equal to the current for normal connection.

4.5.1 Test Preparation and Testing

See 4.2 - Power Conversion (Switch On Fast).

The polarity of the BDUT shall be exchanged.

4.5.2 Requirements

Values shall be lower or equal to “Switch On” limits.

4.6 Power Conversion (Impedance)

See 5.1 - Pulse-Impedance.

3) Currents that are higher than the specified one, are permitted under the condition, that a factor is provided. For details see the PhL-Specification in [01], under “Non-standardised EEDs”.

5 Receiver

A receiver can be part of an integrated bus device or can be a standalone device. The task of a receiver is to convert the analogue coded signal from the bus into a digital signal. The value of the impedance is not constant; it depends on the shape of the bus voltage. A special test method is provided to check the input impedance of a KNX device. Impedance matching is important to ensure that both signal damping is not too high and following bits are not distorted by equalisation procedure of preceding bits.

5.1 Pulse-Impedance

5.1.1 Test Preparation

The combination of waveform generator and PSU shall provide the following signal at BDUT (U_{IN})

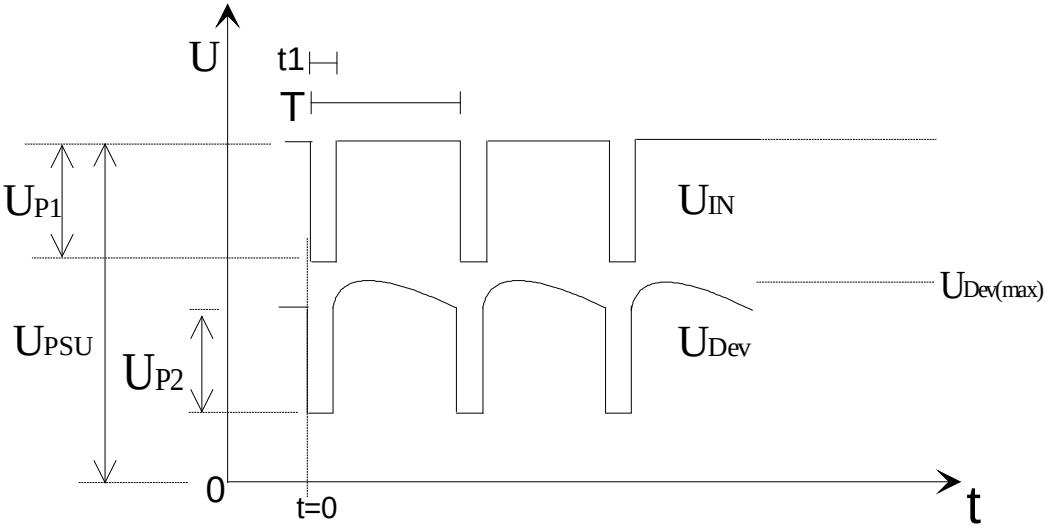

Figure 9 - Pulse Test voltage

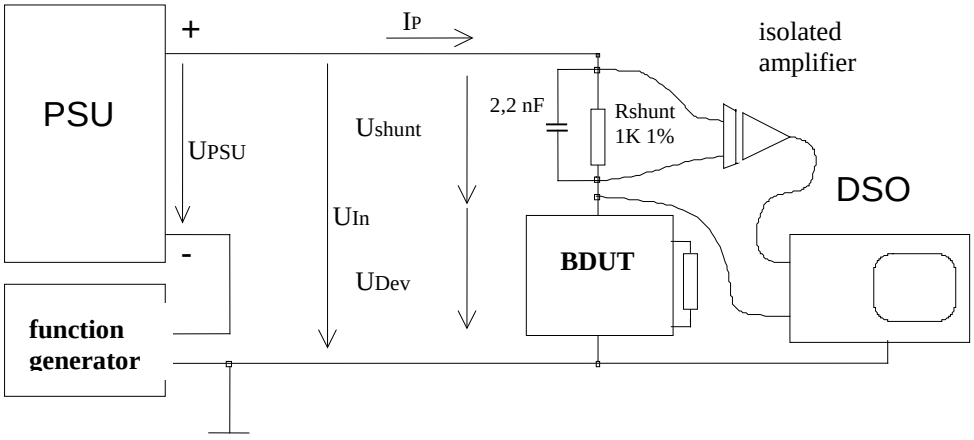

Figure 10 - Test-Set up for Pulse-Impedance

The BDUT shall be configured in such a way, that the maximum load current is consumed permanently. This state can also be evaluated by connecting a load resistor in parallel to the internal power source of the bus device. The value of U_{PSU} shall be tuned to set the maximum level of U_{Dev} to about 25 V. Only one test voltage of U_{PSU} is designated to simplify this test.

5.1.2 Testing

The expected waveform of U_{Shunt} is shown below. The diagram indicates the course of the current. The current is U_{Shunt} / R_{Shunt}

A1 [0 - t_1] and A2 [t_1 - T] are the areas which are comprised by the curve.

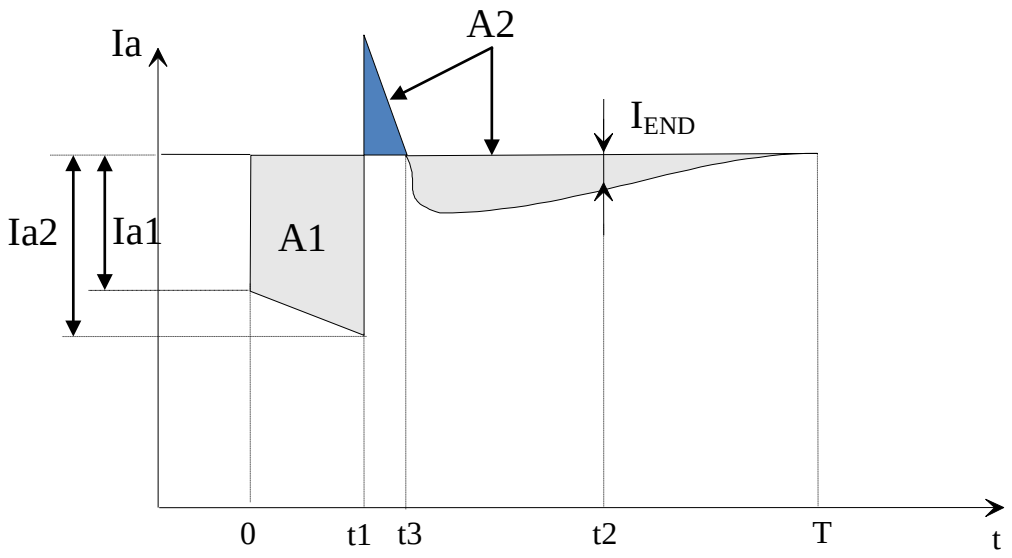

Figure 11 - Pulse Input Current

NOTE 1 In the case where an overshoot is established in the equalisation phase, i.e. on time t1, the area of A2 above the 0 reference shall be subtracted from the value of A2 below the reference to come to the final value of A2.

Table 5 - Test Conditions for Pulse Impedance

Parameter	Value
UPSU	shall be tuned until $U_{DEV(max)}$ = 25 V
UP1	shall be tuned until UP2 = 6 V
f	t1=35 µs, t2=104 µs; T=300 µs, t3 = 45 µs

5.1.3 Requirements (TP1-64)

Table 6 - Impedance limits for TP1- 64

Parameter	min	typ	max
A1 / A2	0.7	1.5	3
Ia1 [mA]	3	4	4,5
Ia2 [mA]	3,5	5	5,5
I_{END} / Ia2	0	0,2	0,28

5.1.4 Requirements (TP1-256)

Table 7 - Impedance limits for TP1-256

	min	typ	max
A1/A2	1,1	2	4
Ia1 [mA]	0,3	1,4	1,9
Ia2 [mA]	0,32	1,4	2
I_{END} / Ia2	0	0,05	0,18

5.2 Sensitivity

This test is used to check the thresholds and the sensitivity of the receiver. The receiver shall be able to detect both strong and weak analogue data signals.

Because of the fact, that the output signal of a receiver cannot be accessed within a bus device, an indication element shall be provided at the bus device. The purpose of an indication element is to signal whether the bus device has received a certain telegram or not. An indication element can be a port of the PEI, an LED, an ACK telegram, or any other element that can be used for human or electrical checking.

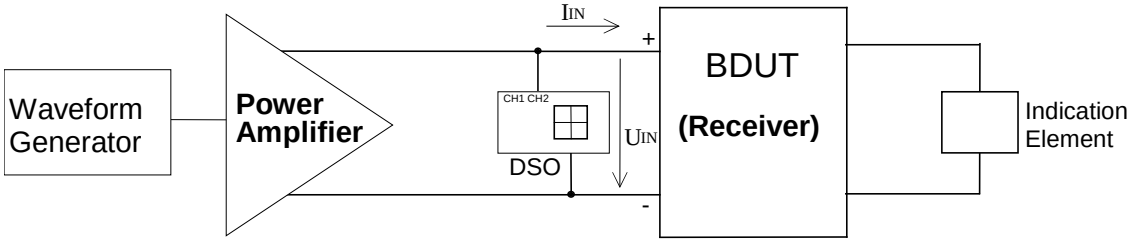

Figure 12 - Test Set-up for Receiver

5.2.1 Test Preparation

The waveform generator shall deliver a telegram signal that is similar to that of normal bus devices transmitting a KNX DPT 1.001 ON command. The following coding shall be observed:

BC	10	01	10	01	E1	00	81	4)
Control	Individual Address		Group Address		NPCI	TPCI	APCI	Parity

Figure 13 -'DPT 1.001 coding'

See also paragraph 6.5 - Coding Rules.

The combination of waveform generator and amplifier shall provide the test signal at the BDUT (U_{IN}). For shape and timing of a logical '0' the following adjustment shall be carried out.

4) Calculation of Parity Byte see [01].

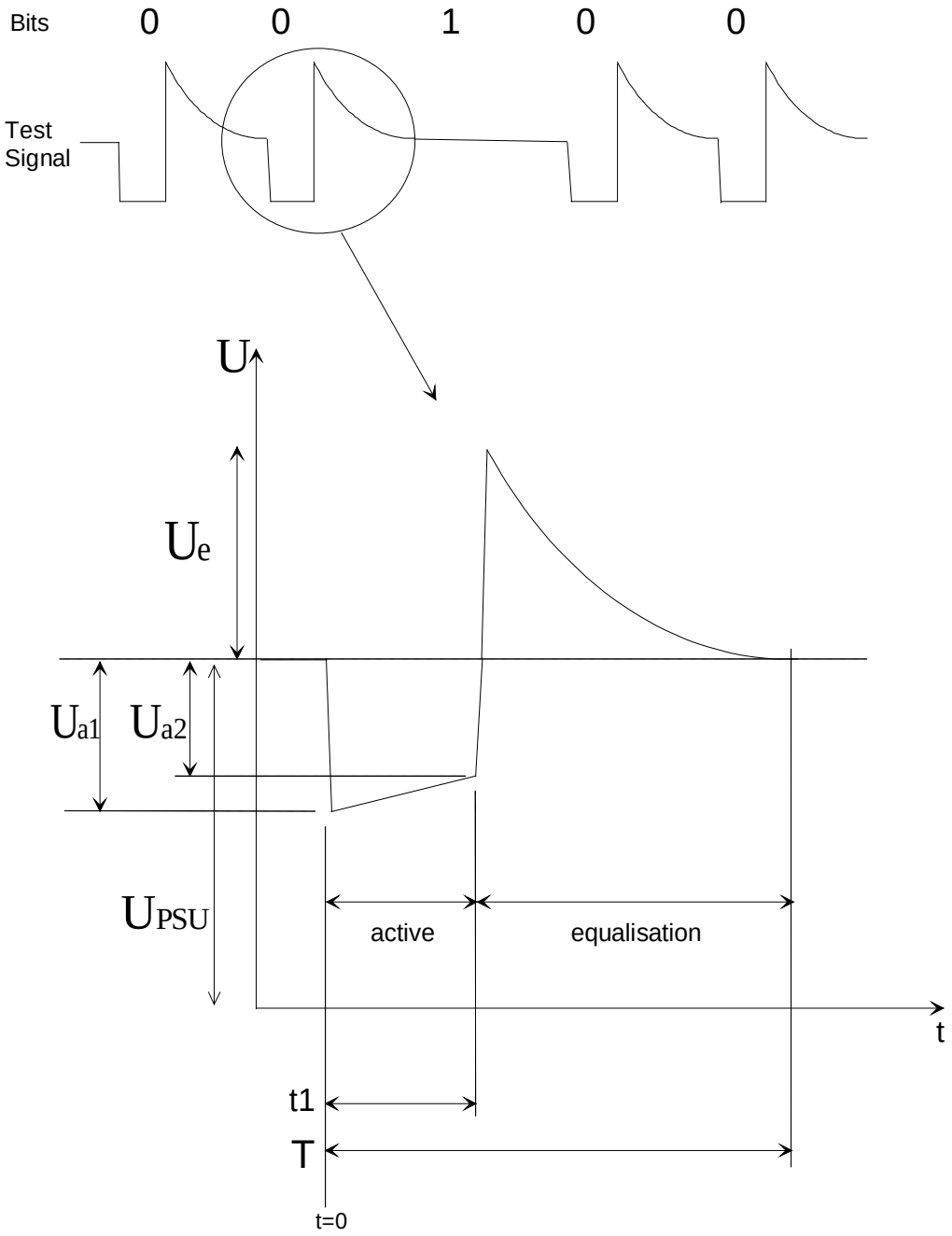

Figure 14 - UIN Pulse Test Voltage

Table 8 - Pulse Test Voltage

"0" Coding	
UPSU	20 V / 30 V(see testing)
Ua1 & Ua2	see requirements , Ue = Ua1
f	t1=35 µs; T=104 µs
U [0] (active)	UPSU - Ua1
U [t1] (active)	UPSU - Ua2
U [t1 -T] (equalisation)	UPSU + Ue* $e^{-((t-t1)/15\mu s))}$
rising and falling slopes	1 ≤ V/µs ≤ 60

"1" Coding	
U [0 - T]	U_{PSU}

5.2.2 Testing

Testing shall be conducted in several steps. Each test step shall be conducted with 20 V and 30 V. The signal test voltages and the limits for the thresholds are defined in Table 9. Always the same telegram with different voltages shall be sent while observing the BDUT. The analysis of the indication element determines whether a telegram was understood by the BDUT or not.

5.2.3 Requirements

Table 9 - Requirements for Receiver Sensitivity

step	Ua1 [V]	Ua2 [V]	Receiving
1	9	9	Yes
2	0,7	0,5	Yes
3	0,2	0,2	No

5.3 Decoding Rules

This test is carried out to check the function of the receiver and the decoding software. It shall be tested whether a bus device is able to interpret the bus-signals with their associated distortions correctly.

Owing to the fact, that the output signal of a receiver cannot be accessed within a bus device, an indication element shall be provided at the bus device. The purpose of an indication element is to signal whether the bus device has received a certain telegram or not. An indication element can be a port of the PEI, or an LED or any other element that can be used for human or electrical checking.

Use Figure 12: Test Set-up for Receiver.

5.3.1 Test Preparation

The waveform-generator shall deliver a telegram signal that is similar to that of normal bus devices transmitting a KNX DPT1.001 On/Off command. The following coding shall be observed:

BC	10	01	10	01	E1	00	81	
Control	Individual Address		Group Address		NPCI	TPCI	APCI+D	Parity

Figure 15 - DPT 1.001 Telegram

See also paragraph 6.5 - Coding Rules.

The combination of waveform generator and amplifier shall provide the bus-signal at BDUT (U_{IN}). For details see Figure 14 and step1 of Table 9. The bus-signal shall be modified concerning timing. The Figure below shows the timing definition within a telegram.

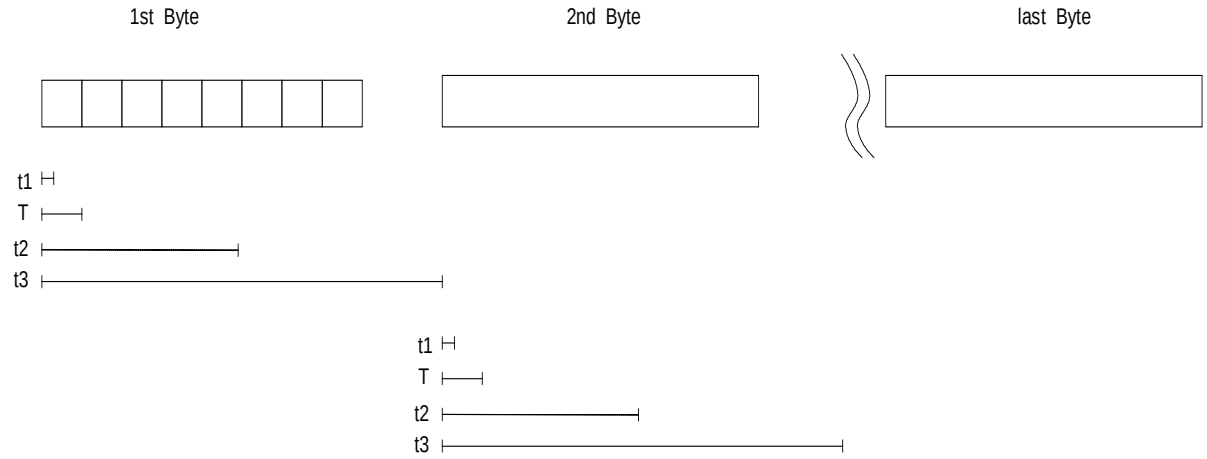

Figure 16 - Telegram Timing

Symbol	Meaning	min	typ	max
t1	0-Bit active time	25µs	35µs	70µs
T	Bit-time		104µs	
t2	time from 1st start-bit to following bits (bit-time)	(n bit times) - 7µs	n * T	(n bit times) +33µs
t3	time from start-bit to start-bit of consecutive byte	typ - 30µs	13 * T	typ +30µs

Figure 17 - Decoding Tolerance

NOTE 2 The indicated variation of the time t1 shall be applied only to the start bit in each character. Tests with other bits are strongly recommended

The indicated variation of the time t2 shall

– First be applied to between the start bit and the next bit in each character

– Secondly to a random bit in each character

The above indicated time variation shall be applied for a random byte.

In all cases the time t3 is kept unchanged, i.e. the second character starts at the normal time.

5.3.2 Testing & Requirements

Testing shall be conducted in several steps:

Table 10 - Requirements for Decoding

test-step	t1	t2	t3
1	typ	typ	typ
2 a/b	min / max	typ	typ
3 a/b	typ	min / max	typ
4 a/b	typ	typ	min / max

6 Transmission

The objective of this test (current test) is to check the ability of the transmitter to generate proper signals at different busloads.

In order to transmit a logical ´0´, the transmitter of a bus device shall draw a current from the bus to cause a certain voltage drop U_a of the analogue signal with a duration of t_{active}. During the following equalisation time, the energy consumed during the active time can be recharged back to the bus and the connected devices. Owing to free topology of the KNX TP1- System, the transmitter shall support different line impedances to ensure proper signal amplitudes.

6.1 Transmitter Test (Normal Current) - Test 1

This test represents the sending of one device to the bus, which is equipped only with a few bus-devices.

6.1.1 Test Preparation

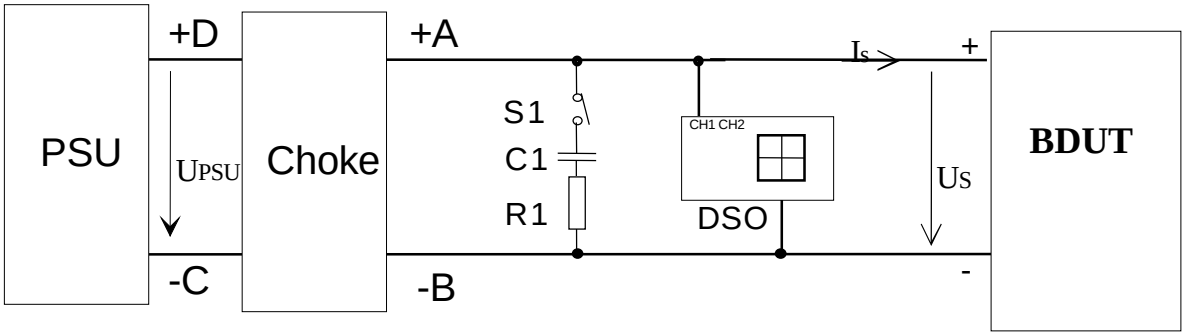

Figure 18 - Test Set-up for Transceiver (Normal & Max)

The BDUT shall be configured in such a way that the device transmits an DPT 1.001 telegram (definition see Figure 15). Transmission can be initiated automatically or manually.

A telegram repetition, as a consequence of the missing ACK, does not affect the test. S1 shall be open. R1=22 Ω and C1=1000 µF [5)].

The resulting voltages for the AC-Part are based on the definitions given in Figure 19. The test is carried out at U_{PSU} = 20 and 30 V_{DC}

6.1.2 Testing

An oscilloscope shall monitor the voltage at BDUT. The relating values can be read out from the curves. The limits are valid for all zero bits of a telegram. Voltages shall comply with the values in table of chapter 6.1.3.

The reference for measuring Ua shall be the DC bus voltage level at the beginning of the telegram. This is the common reference, from which all further amplitudes Ua shall be measured. “Uref” is thus only taken once for the test.

The following curves are expected by using the configuration of Figure 18: Test Set-up for Transceiver (Normal & Max).

5) R1 and C1 serve for simulating a bus load to the sending device.

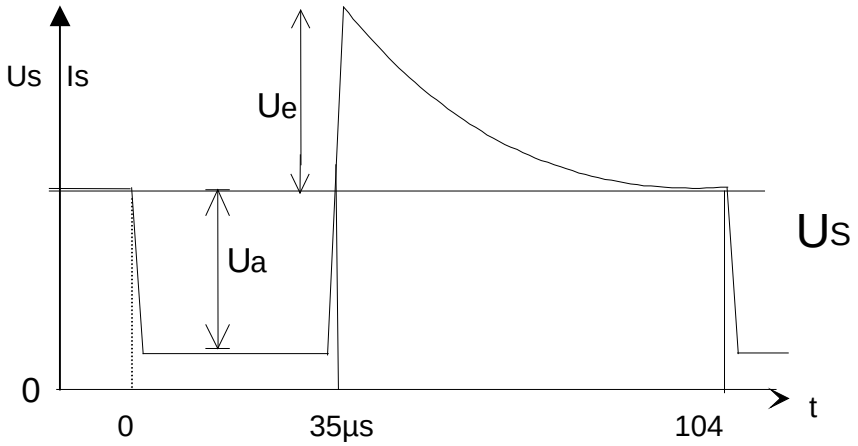

Figure 19 - Analogue Signal of Logical ´0´

6.1.3 Requirements

Values shall be within the grey shaded area.

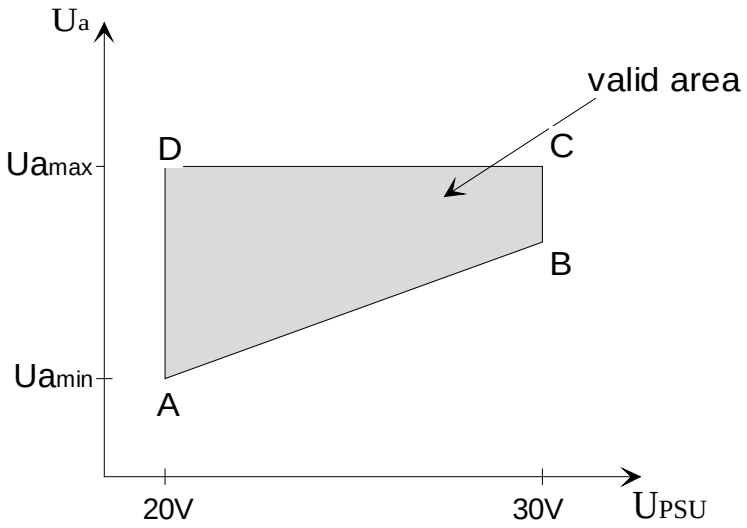

Figure 20 - Global Tolerance Pattern for Transmitter

Table 11 - Ua Limits of a Transmitter (TP1-64) {Nominal Current}

	A [V]	**B [V]**	**C [V]**	**D [V]**
U_{PSU}	**20V**	**30V**	**30V**	**20V**
Ua	4,5V	6V	9V	9V
Ua (rising and falling slopes)	1 < slope < 100 [V/µs]			

Table 12 - Ua Limits of a Transmitter (TP1-256) {Nominal Current}

Corners	A [V]	B [V]	C [V]	D [V]
U_{PSU}	**20V**	**30V**	**30V**	**20V**
Ua	6V	6V	9V	9V
Ua (rising and falling slopes)	1 < slope < 100 [V/µs]			

6.2 Transmitter Test (Normal Current) - Test 2

6.2.1 Test Preparation

Test set-up identical to 6.1.

The BDUT shall be configured in such a way that the device transmits a MAXDATA telegram with the maximum allowed number of 0 bit. Transmission can be initiated automatically or manually.

A telegram repetition, as a consequence of the missing ACK, does not affect the test. S1 shall be open.

The resulting voltages for the AC-Part are based on the definitions given in Figure 19. The test is carried out at U_{PSU} = 20 and 30 V_{DC}

6.2.2 Testing

Testing identical to 6.1

6.2.3 Requirements

Values shall be within the grey shaded area. The values shall be checked for the last bit in the MAXDATA telegram.

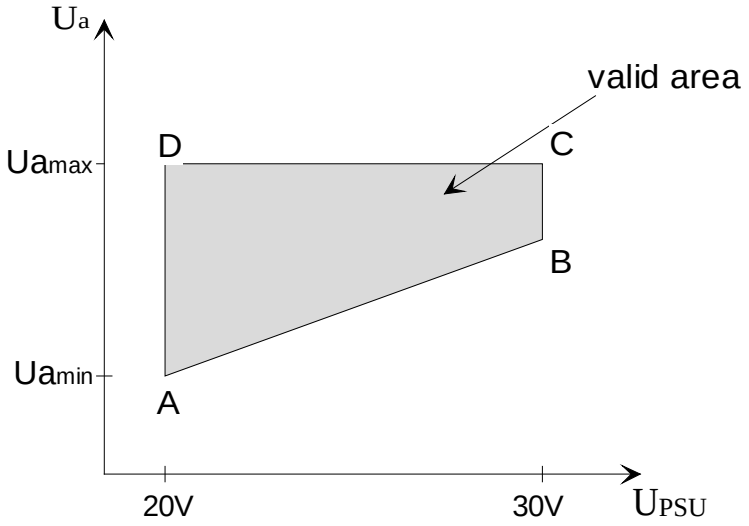

Figure 21 - Global Tolerance Pattern for Transmitter

Table 13 - Ua Limits of a Transmitter (TP1-64) {Nominal Current} Test 2

	A [V]	B [V]	C [V]	D [V]
U_{PSU}	**20V**	**30V**	**30V**	**20V**
Ua	4.5V	7V	10.5V	10.5V

Table 14 - Ua Limits of a Transmitter (TP1-256) {Nominal Current} Test 2

Corners	A [V]	B [V]	C [V]	D [V]
U_{PSU}	**20V**	**30V**	**30V**	**20V**
Ua	6V	6V	10.5V	10.5V

6.3 Transmitter Test (Maximal Current)

This test represents the sending of one device to the bus, which is equipped with maximal number of bus-devices (EED's).

6.3.1 Test Preparation

Use Figure 18. S1 shall be closed.

The BDUT shall be configured in such a way that the device transmits a DPT 1.001 telegram (definition see Figure 13). Transmission can be initiated automatically or manually.

A telegram repetition, as a consequence of the missing ACK, does not affect the test.

The resulting voltages for the AC-Part are based on the definitions given in Figure 19. The test is carried out at U_{PSU} = 20 and 30 V_{DC}.

6.3.2 Testing

An oscilloscope shall monitor the voltage Ua at BDUT. The relating values can be readout from the curves. The limits shall be measured for the first 0 bit of the first character of a telegram. Voltages shall comply with the values in table of chapter 6.3.3.

For establishing the values of the rising and falling slopes of Ua the steepest part of the slope shall be taken into account.

The curves of Figure 19 are expected.

6.3.3 Requirements

Table 15 - Ua Limits of a Transmitter (TP1-64) {Maximal Current}

Corners	A [V]	B [V]	C [V]	D [V]
U_{PSU}	**20V**	**30V**	**30V**	**20V**
Ua	3V	4.5V	9V	9V
Ua (rising and falling slopes)	1 < slope < 100 [V/µs]			

Table 16 - Ua Limits of a Transmitter (TP1-256) {Maximal Current}

Corners	A [V]	B [V]	C [V]	D [V]
U_{PSU}	**20V**	**30V**	**30V**	**20V**
Ua	3V	4.5V	9V	9V
Ua (rising and falling slopes)	1 < slope < 100 [V/µs]			

6.4 Transmitter Test (Minimal Current)

This test represents the simultaneous sending of maximum number device at a bus-segment.

This case occurs if e.g. an ACK is transmitted by all bus-devices. Auxiliary devices are used to draw a certain transmit current. The resulting transmit current (Is) is divided in BDUT current (Is1) and AUX current (Is2).

6.4.1 Test Preparation

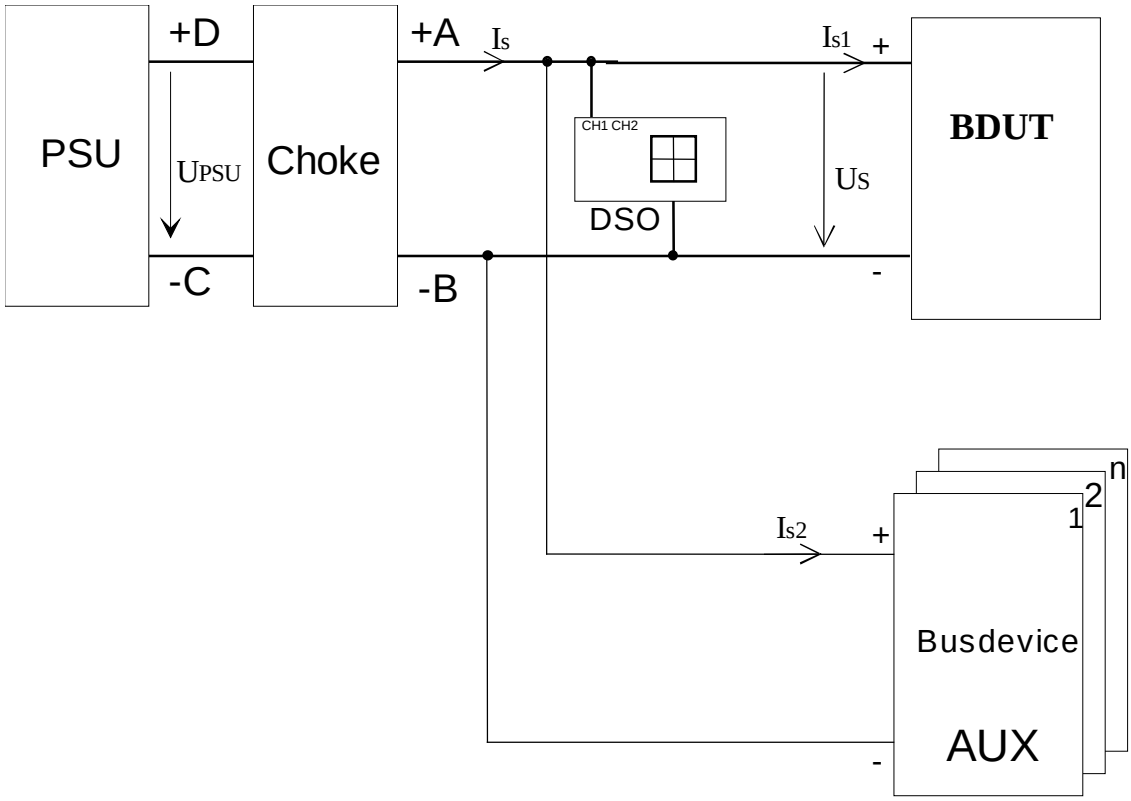

Figure 22 - Test Set-up for Transceiver (Minimal)

The BDUT and AUX shall be configured in such a way that the devices transmit a KNX telegram simultaneously (e.g. ACK). Transmission can be initiated automatically or manually or by another bus device.

The resulting voltages for the AC-Part are based on the definitions given in Figure 19. The test is carried out at U_{PSU} = 25 $V_{DC.}$

6.4.2 Testing

An oscilloscope shall monitor the voltage at BDUT and AUX. The relating values can be read out from the curves. The limits are valid for all zero bits of a telegram. Voltages shall comply with the values in table of chapter 6.4.3. As the current depends predominantly on the used components, during this test it is not measured.

The reference for measuring Ua shall be the DC bus voltage level at the beginning of the telegram. This is the common reference, from which all further amplitudes Ua shall be measured. “Uref” is thus only taken once for the test.

The curves of Figure 19 are expected.

6.4.3 Requirements

Table 17 - Voltage Limits of a Transmitter (TP1-64)

U_{PSU}	Ua (min)	Ua (max)	Ue (min)	Ue (max)
25V	4,5	10,5	3,0	14,5

Table 18 - Voltage Limits of a Transmitter (TP1-256)

U_{PSU}	Ua (min)	Ua (max)	Ue (min)	Ue (max)
25V	6	10,5	4,0	14,5

6.5 Coding Rules

Purpose of this test is to examine the correct timing of a bus device transmitting a telegram on the bus.

6.5.1 Test preparation

Testing is conducted with a KNX minimal configuration. The BDUT shall be configured in such a way that the device transmits an EIS-1 Telegram (definition see Figure 13). Transmission can be initiated automatically or manually.

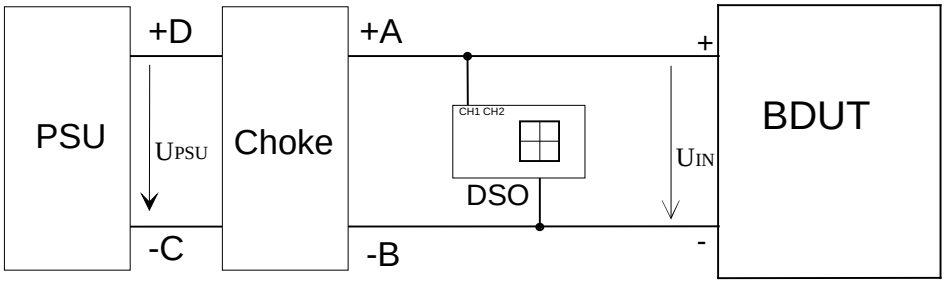

Figure 23 - Test Set-up 1: Time Coding

6.5.2 Testing

The resulting signals of the transmitter caused by the sending of BDUT shall be monitored with the DSO. The values for timing shall be read out from the graphs of the DSO. Figure 24 shows how the analogue signal shall be interpreted for this test. It is also possible to use a logic analyser for this test, with a special receiver. The task of this auxiliary receiver is, to convert KNX analogue signals into standardised TTL-signals. Take also the properties of the auxiliary receiver into account for measured time values.

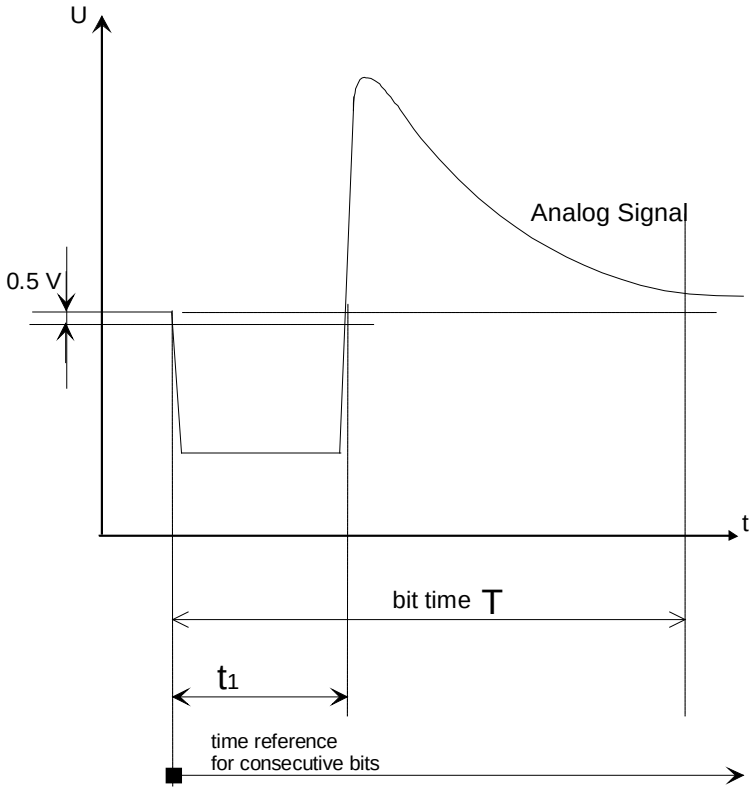

Figure 24 - Signal Assessment

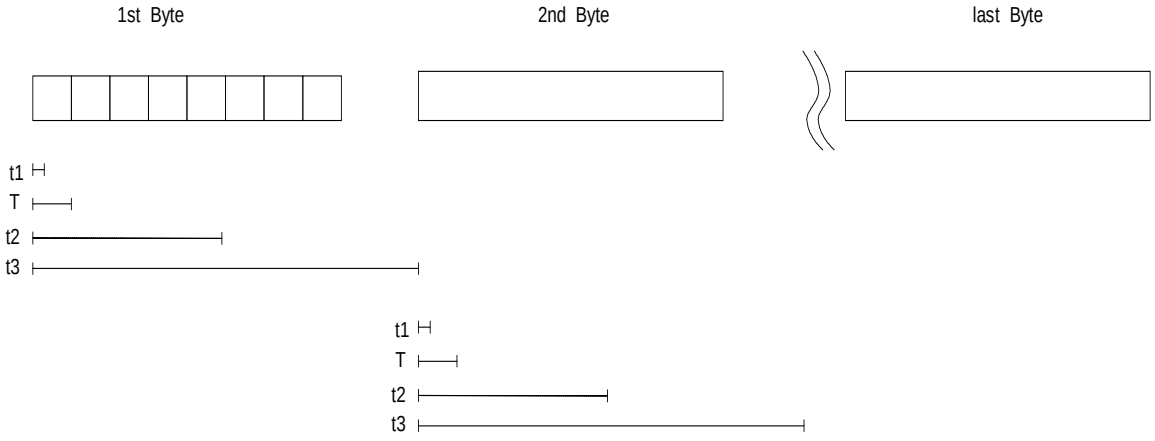

Figure 25 - Telegram Timing

6.5.3 Requirements

Table 19 - Timing Tolerances for Coding

Symbol	Meaning	min	typ	Max
t1	0 bit active time	34µs	35µs	37µs
T	Bit-time		104µs	
t2	time from start-bit to following bits (bit-time)	typ - 2µs	n * T	typ +2µs
t3	time from start-bit to start-bit of consecutive byte	typ - 2µs	13 * T	typ +5µs

7 Transceiver

A bus device can be regarded as a device consisting normally of two functional blocks: the transceiver and the micro-controller. If a bus device build with a KNX certified micro-controller and a non-certified transceiver, it is possible to test only the transceiver properties. The voluminous collision tests are not mandatory in case of combination of a successful tested transceiver and a KNX certified controller.

Transceiver testing includes 4 sub-tests

1. Power converter test (see 4 - Power Conversion)
2. Receiver test (see 5.1 - Pulse-Impedance & 5.2 - Sensitivity)
3. Transmitter test (see 6.1 & 6.4 Transmitter Current Tests)
4. Propagation delay test (see 7.1 - Propagation Delay (Transmitter))

7.1 Propagation Delay (Transmitter)

The objective of the test is to check the internal delay of transmitter. If this delay exceeds a given value, the bus-devices (BDUT) will not work properly in case of telegram collision with other bus-devices.

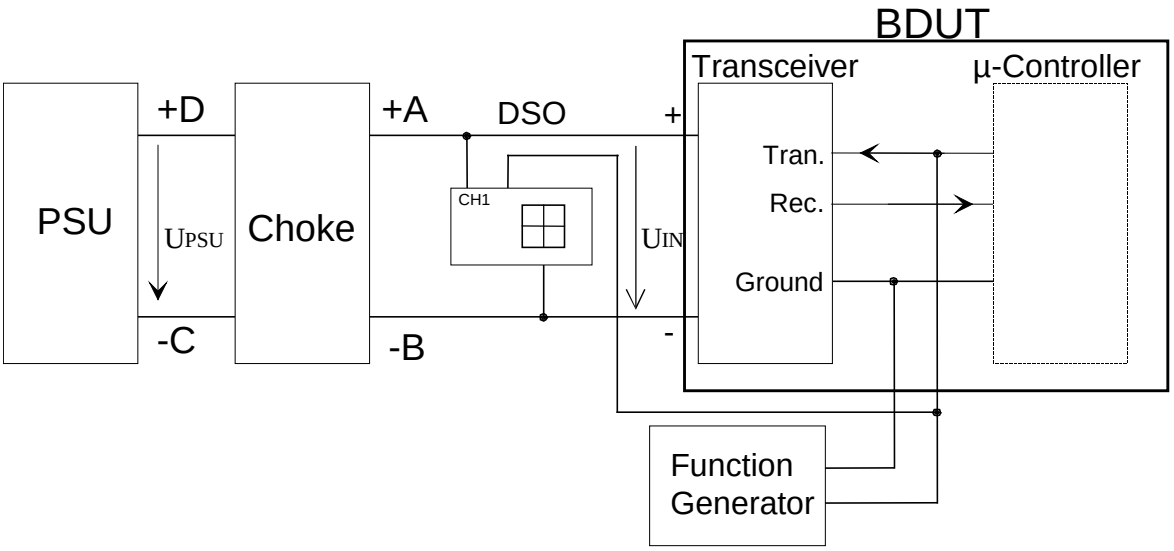

Figure 26 - Transceiver (Transmitter-Part)

7.1.1 Test Preparation

The function generator shall deliver a signal which is equal to a series of transmitted zero bits.

The following signals are expected.

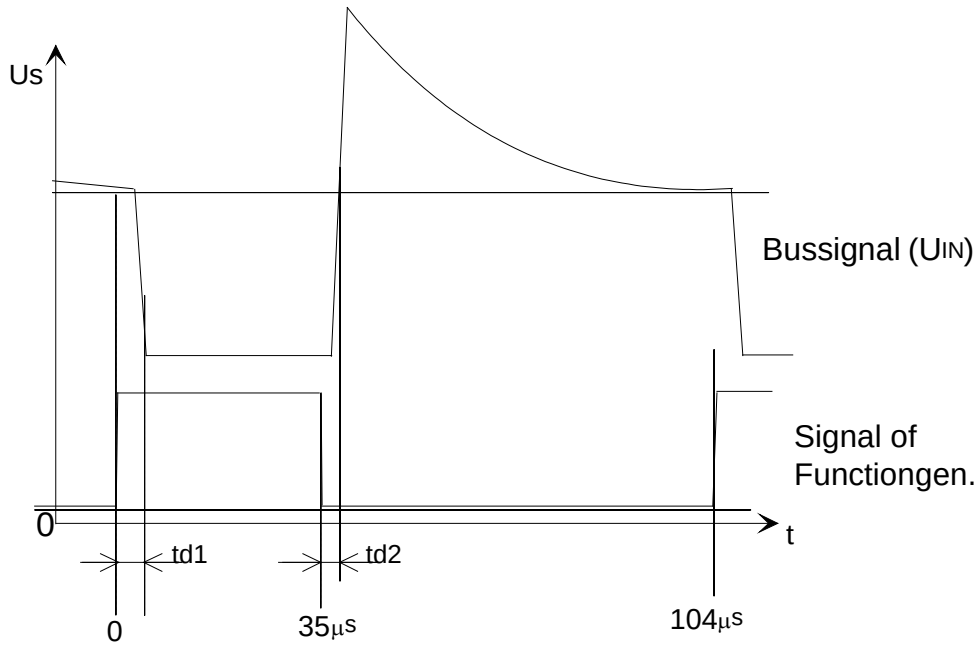

Figure 27 - Transmit Delay

7.1.2 Testing

Testing shall be conducted with DSO. The values of td (rising and falling) shall be readout and compared to those of requirements.

UPSU shall be tuned to 30 V and 20 V.

7.1.3 Requirements

Table 20 - Requirements for Transmitter Delay

Parameter UPSU =[20 V-30 V]	Value
td1	< 1 µs
td2	< 3 µs

Td1 is measured from the rising edge of signal of the function generator (rise time can be disregarded) to the start of the active part of the bus signal (i.e. excluding the falling edge of Ua).

Td2 is measured from the falling edge of the signal of the function generator (fall time can be disregarded) to the start of the rising edge of the active part of the bus signal (i.e. excluding the rising edge of Ua).

7.2 Propagation Delay (Receiver)

The objective of the test is to check the internal delay of receiver. If the delay exceeds a given value, the bus device (BDUT) will not work properly in case of telegram collision with other bus-devices.

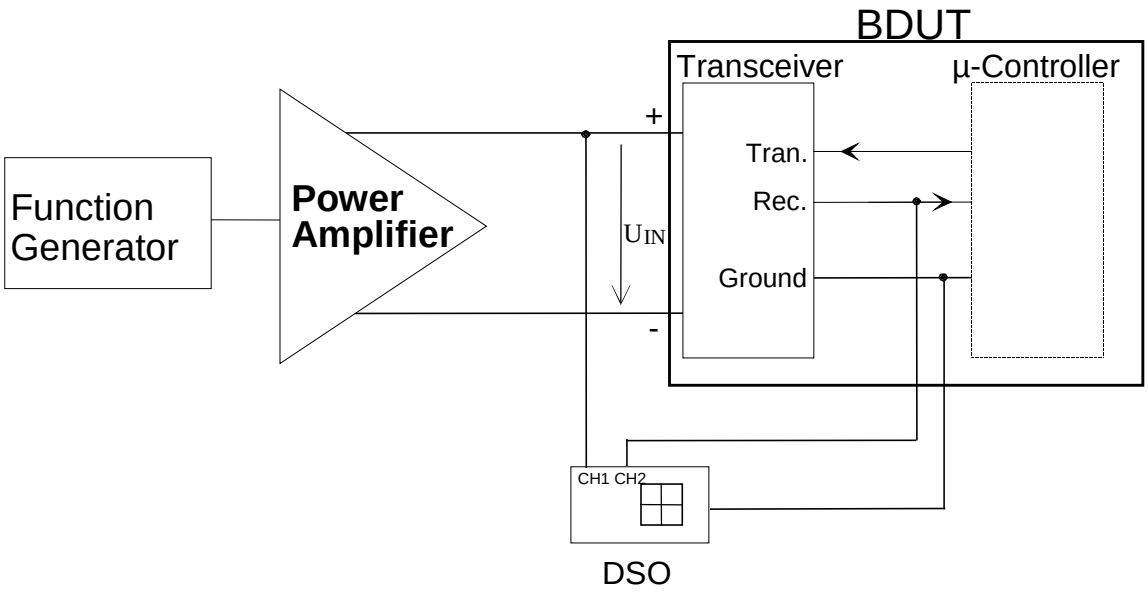

Figure 28 - Transceiver (Receiver-Part)

7.2.1 Test Preparation

An auxiliary device (function generator & power amplifier) is used to generate a continuous series of zero bits at the bus. This device has the property to vary the signal amplitude (Ua) of zero bits. Make sure to avoid ground loops with the DSO. Use e.g. isolated amplifiers.

The following signals are expected.

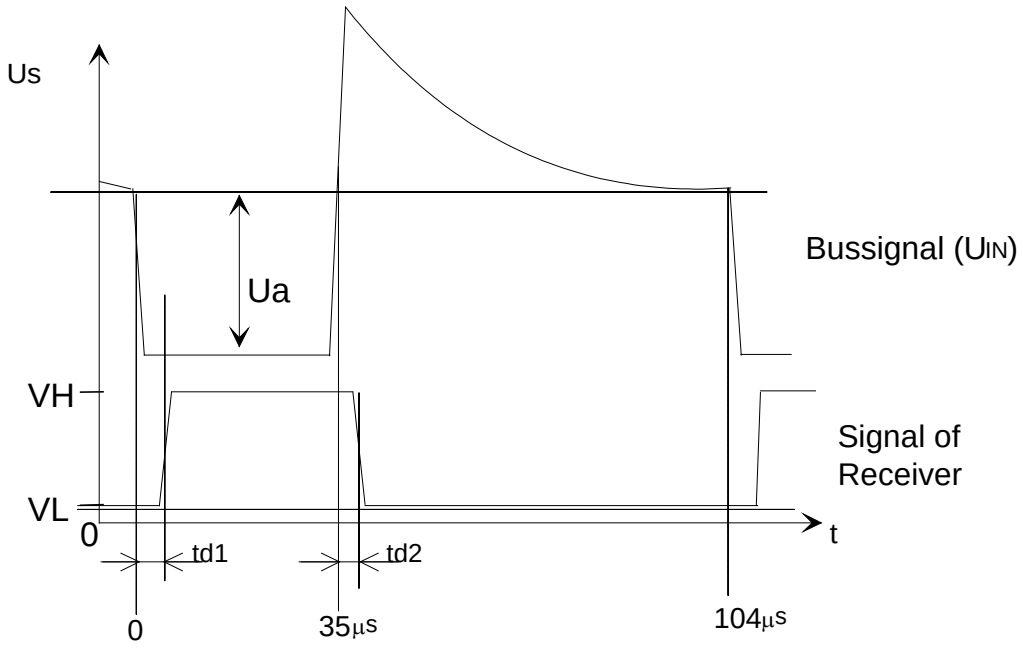

Figure 29 - Receiver Delay

7.2.2 Testing

UPSU shall be tuned to 25 V. Testing shall be conducted with Ua=10V and Ua = 0.7 V signal amplitude.

The values of td1 (rising slope) and td2 (falling slope) shall be readout from the DSO and compared to those of requirements. The output voltages (VH and VL) of receiver shall be measured.

7.2.3 Requirements

Table 21 - Requirements for Receiver Sensitivity

Parameter	Value at Ua=0.7V	Value at Ua=10V
td1 (rising slope)	< 5 µs	< 3 µs
td2 (falling slope)	< 3 µs	< 3 µs

Td1 is measured from the bus signal Ua = -0.7V to 50% of the rising edge of the receiver signal.

Td2 is measured from the bus signal Ua = -0.2V to 50% of the falling edge of the receiver signal.

8 Collision

8.1 General

Collision test is a comprehensive test. With this test a lot of sub test are included.

Collision test integrates:

- Physical and data link layer properties
- Sampling of data signal
- Signal dynamic behaviour
- Bus cable delays
- Internal delays
- Arbitrary and priority properties

This test is very important, owing to the CSMA/CA bus access of the KNX Twisted Pair system, to check whether bus devices behave properly if they are sending simultaneously.

A mechanism shall be included in the collision tests, which shall prevent that the BDUT in the event of a collision infinitely tries to send the collided telegram on the bus, which then in turn again collides with the one sent by the Waveform Generator.

8.2 Bus free detection (Delay Stepping)

This test checks the decoding and arbitrary functions of a bus device. An auxiliary bus device is needed to generate a fixed telegram, which has a certain delay referring to telegram of the BDUT. The contents (structure) of these two telegrams are equal.

8.2.1 Test Preparation

The BDUT shall be configured in such a way that the device transmits a DPT 1.001 telegram (definition see Figure 13). Transmission can be initiated automatically or manually. Telegram repetition (in case of no ACK) shall be switched off. It is mandatory that there is an auxiliary preceding signal at BDUT accessible, which indicates, that the BDUT is going to send a telegram after a fixed time (td1 > 50µs). If it is ensured, that there is always a constant delay (td2) between the initiating of a telegram and sending, the initiating signal can be used instead of the preceding signal.

NOTE 3 The test condition, that the BDUT shall send a telegram after a fixed time, may require a modified source code of its link layer. The manufacturer shall therefore declare that while allowing this possibility, the physical layer functionality remains unchanged.

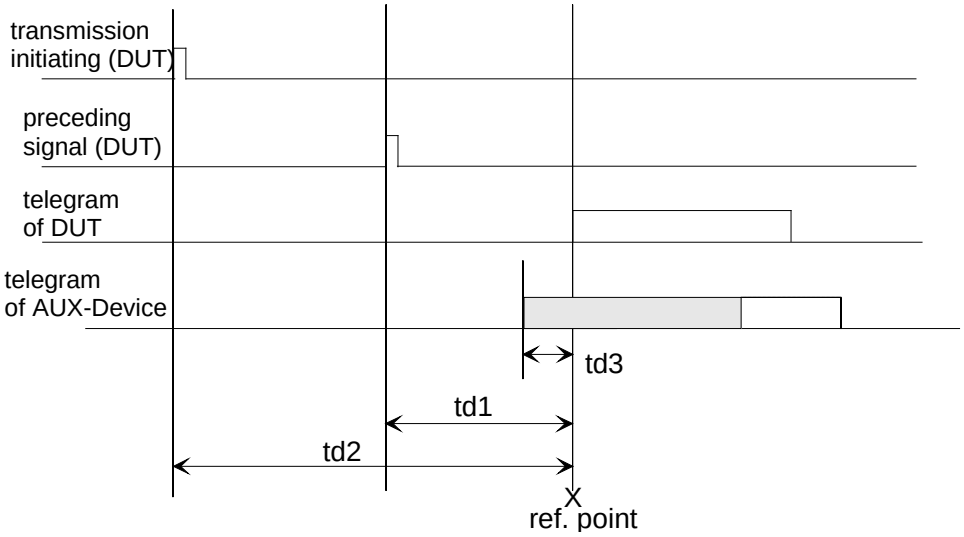

Figure 30 - Delays for Telegram Sending

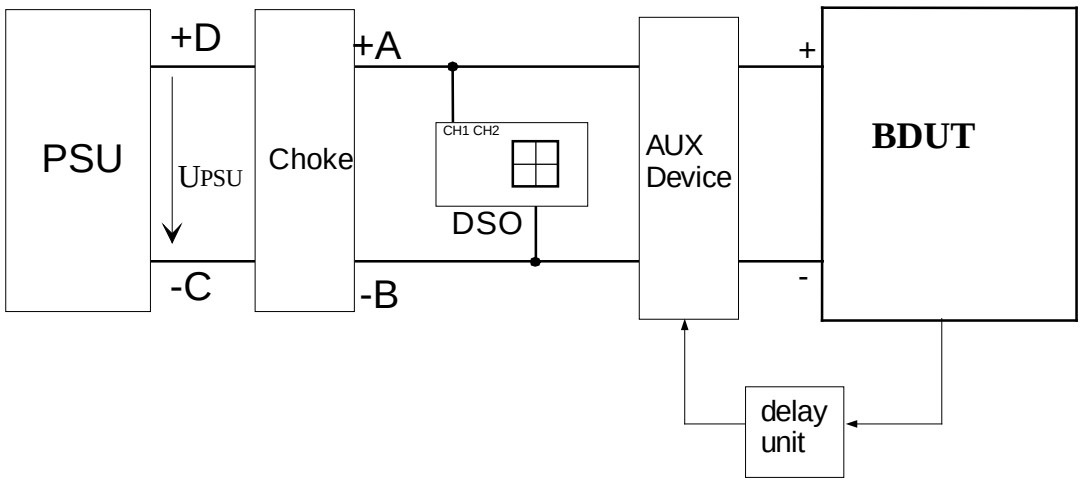

Figure 31 - Bus free detection Test (Delay stepping)

8.2.2 Testing & Requirements

Table 22 - Delayed Stepping of Telegrams

Delay	Required behavior of BDUT
td3 < -7 µs	No sending (BDUT shall recognize that the bus is occupied)
-7 µs < td3 < 0	BDUT may recognize that the bus is occupied or may send in parallel
0 < td3 < 32 µs	BDUT shall send in parallel with AUX

8.2.3 Collision of Acknowledge Frame

The same delay stepping test shall be executed for the BDUT sending an acknowledge frame. It shall be checked, whether the BDUT sends its acknowledge frame (ACK, NACK or BUSY) also if the bus is not free (because of another acknowledge frame).

Procedure: trigger Waveform Generator with send line of BDUT to generate an ACK frame a time td3 before the BDUT sends an ACK frame.

Acceptance:

For devices inhibiting bus free detection only 35 µs before acknowledge Frame transmission:

Table 23 - Collision of acknowledge frame

	Action	comment
WG on bus before BDUT sends acknowledge frame -35 µs < td3 < 0µs	BDUT sends ack frame	BDUT sends ack frame even if the bus is not free during the specified time.

8.3 Collision (Remote Test)

This test supplementary checks the combination of weak and strong data signals, which occur if two devices simultaneously send telegrams with different contents. The sending (=BDUT) device is coded receding (with a '1' at a determined position). An auxiliary bus device (=AUX) is needed to generate the same telegram with the exception of coding a '0' at a determined position (= dominant coding). This can be achieved by triggering a Waveform Generator via the send line of the BDUT. Collision shall be carried out with telegrams with maximum length, in which all bits before and including the source address are tested and after the source address only one arbitrary bit of each octet.

Additionally the bus-line shall be equipped with the maximum possible number of bus-devices according to the declared TP1 class (64 or 256) minus three to evaluate maximum segment configuration. The devices included in the test set-up shall be copies of the to be certified implementation.

Alternatively and in order to avoid that the bus line of the test set-up has to be equipped with the maximum possible number of bus devices minus three to evaluate maximum segment configuration, the 'remote test' may be carried out with telegrams (as sent by the Waveform Generator) in which the maximum deviations of paragraph 5.3 (Figure 17 and Table 10) are inserted (bit or byte wise). In all cases, these telegrams shall cause the BDUT to detect collision. The BDUT shall retract and repeat the original message up to three times. This alternative test method is not allowed for devices based on a non-certified physical layer implementation.

In case the to be certified physical layer is of a higher fan-in class, the settings of the devices should be such that from a signalling point of view the devices are connected to the bus but it is avoided that they consume maximum power. If this is - for whatever reason - not possible, the number of devices may be reduced but this shall then be stated in the resulting product documentation to inform the installer that the number of devices on a line segment must be reduced accordingly.

8.3.1 Test Preparation

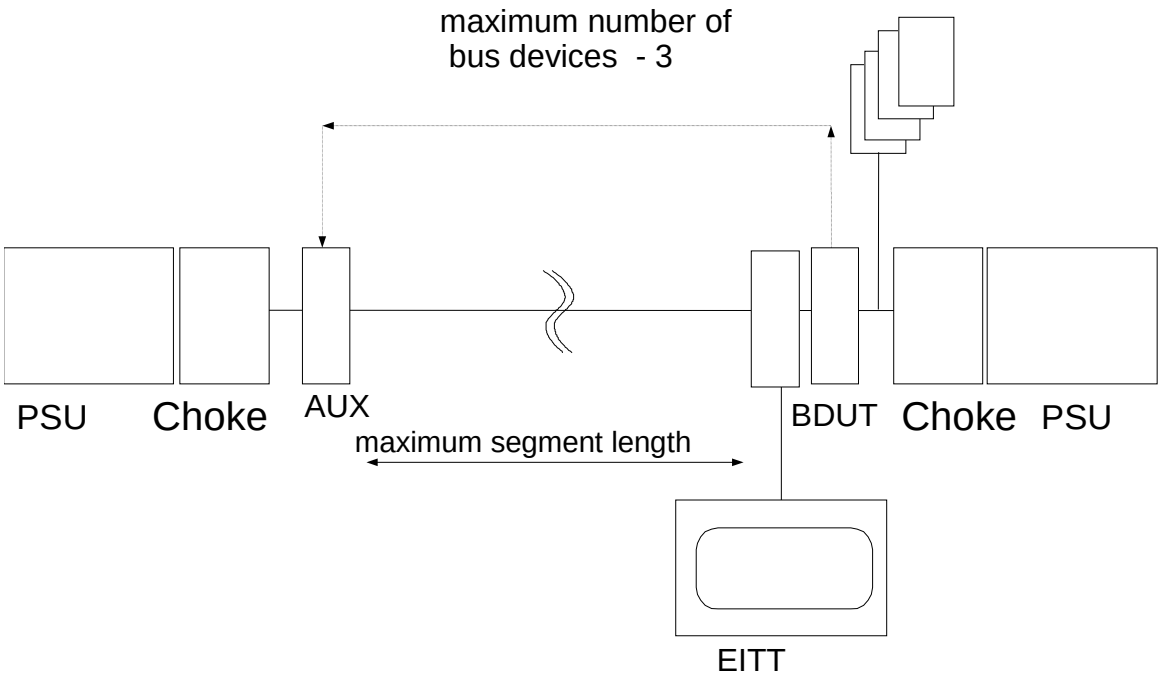

Figure 32 - Test set-up for Collision remote Test

8.3.2 Testing

It shall be ensured, that BDUT and AUX are sending simultaneously.

8.3.3 Requirements

The BDUT shall recognise, that another simultaneous sending device (dominant coded) has overwritten the determined '1' by a '0' [6)]. The BDUT shall draw back at once. The resulting telegram at the EITT shall be the one sent by the AUX device.

[6)] Naturally in the control field, only those bits can be manipulated, which form part of a control field supported by the BDUT.

8.4 Collision (System Test)

This test checks the handling of received telegrams. All devices except one shall respond with an ACK and one device with an NACK or BUSY [7)].

The bus-line shall be equipped with the maximum possible number of bus-devices according to the declared TP 1 class (64 or 256) minus three to evaluate maximum segment configuration. The devices included in the test set-up shall be copies of the to be certified implementation.

Alternatively and in order to avoid that the bus line of the test set-up has to be equipped with the maximum possible number of bus devices minus three to evaluate maximum segment configuration, the 'system test' may be carried out with NACK respectively Busy telegrams (as sent by the Waveform Generator) in which the maximum deviations of paragraph 5.3 (Figure 17 and Table 10) are inserted. These shall then be collided with the ACK signal. In all cases, the BDUT shall recognize a NACK respectively Busy and repeat the original message up to three times.

This alternative test method is not allowed for devices based on a non-certified physical layer implementation.

In case the to be certified physical layer is of a higher fan-in class, the settings of the devices should be such that from a signalling point of view the devices are connected to the bus but it is avoided that they consume maximum power. If this is - for whatever reason - not possible, the number of devices may be reduced but this shall then be stated in the resulting product documentation to inform the installer that the number of devices on a line segment must be reduced accordingly.

8.4.1 Test Preparation

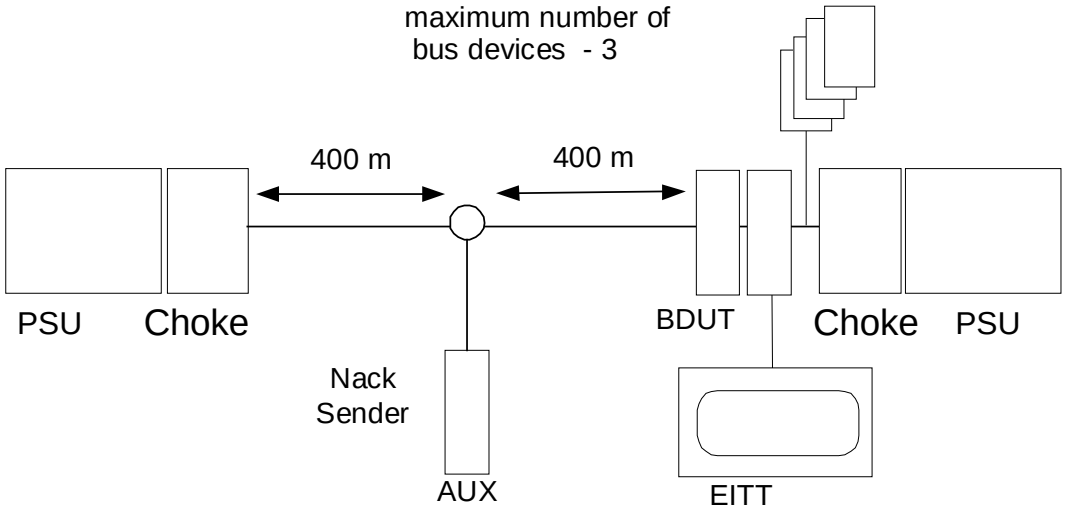

Figure 33 - Test Set-up for Collision Receipt Test

It shall be ensured that the BDUT sends a group telegram to the other devices. AUX shall be configured in such a way, that a NACK or BUSY will be sent back in case of receiving the related group address (e.g. by triggering a Waveform Generator via the BDUT send line).

8.4.2 Testing

The BDUT sends a group telegram to the other devices.

8.4.3 Requirements

The BDUT shall recognise that one of the other devices (special coded) has responded with NACK or BUSY. BDUT shall repeat the message normally 3 times (configurable).

[7)] It is not mandatory to test both NACK and Busy

9 Certification of high impedance power converter

9.1 General

When a high impedance power converter is added in parallel to a certified physical layer to draw more current from the bus, the requirements for clause 5.1 continue to apply. If a power converter is submitted separately to certification (in order for it to be combinable with any certified physical layer), the underneath requirements shall be met.

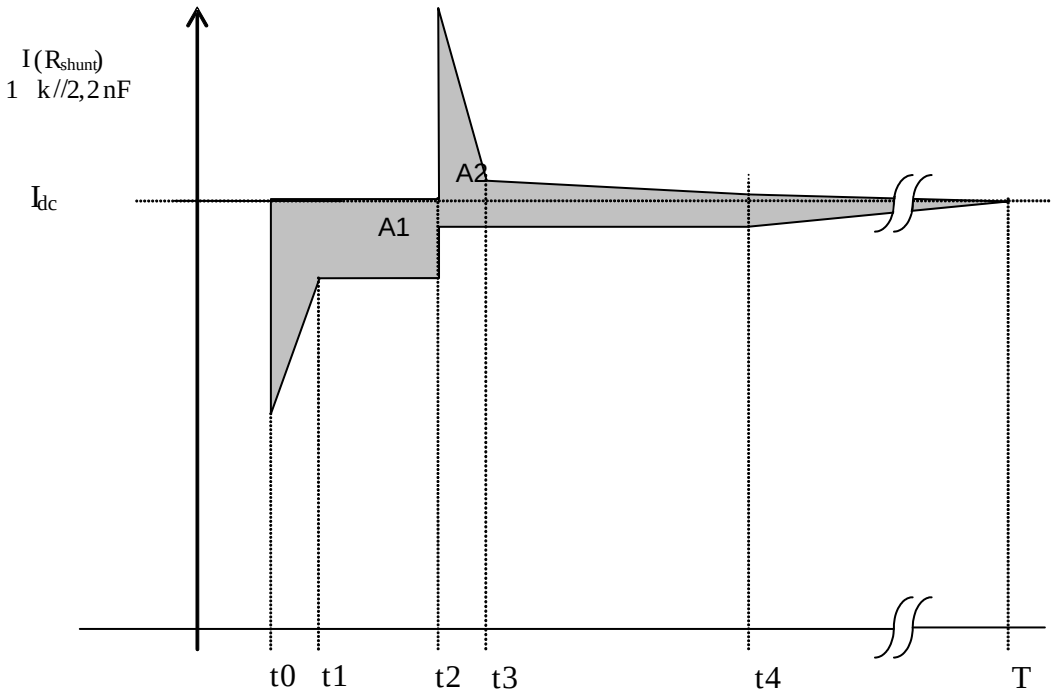

Figure 34 - Acceptable current tolerances

t0 = 0; t1 = 10µs; t2 = 35µs; t3 = 45µs; t4 = 104µs; T = 300µs

Idc = i(T) => shall be configured in that way, that the max load current is consumed permanently.

Table 24 - Impedance limits for high impedance power converter TP1-64

Parameter	Min	typ	Max
Area ratio, A1 / A2	-	-	-
i(t0)	Idc – 3mA		Idc
i(t1 ≤ t < t2)	Idc – 1mA		Idc
i(t2)	Idc – 0,2mA		Idc +2mA
i(t3)	Idc – 0,2mA		Idc+0,15mA
i(t4)	Idc – 0,2mA		Idc+0,08mA
I(T)		Idc	

Table 25 - Impedance limits for high impedance power converter TP1-256

Parameter	Min	typ	Max
Area ratio, A1 / A2	-	-	-
i(t0)	Idc – 1,4mA		Idc
i(t1 ≤ t < t2)	Idc – 0,3mA		Idc
i(t2)	Idc – 0,1mA		Idc +1,1mA
i(t3)	Idc – 0,1mA		Idc+0,05mA
i(t4)	Idc – 0,1mA		Idc+0,03mA
I(T)		Idc	

It shall be borne in mind that the fan-in of a high impedance power converter is handled in the same way as that of a normal BCU. The fan-ins of all - BCUs and high impedance power converter – shall be added up and the sum may never exceed 256.

Next to the above tests, the power converter shall meet the requirements of clauses 4.2 to 4.6 respectively 8.3 and 8.4, for the latter two tests, in conjunction with a certified physical layer implementation. All other tests from this volume can be skipped.

10 Link Layer Tests

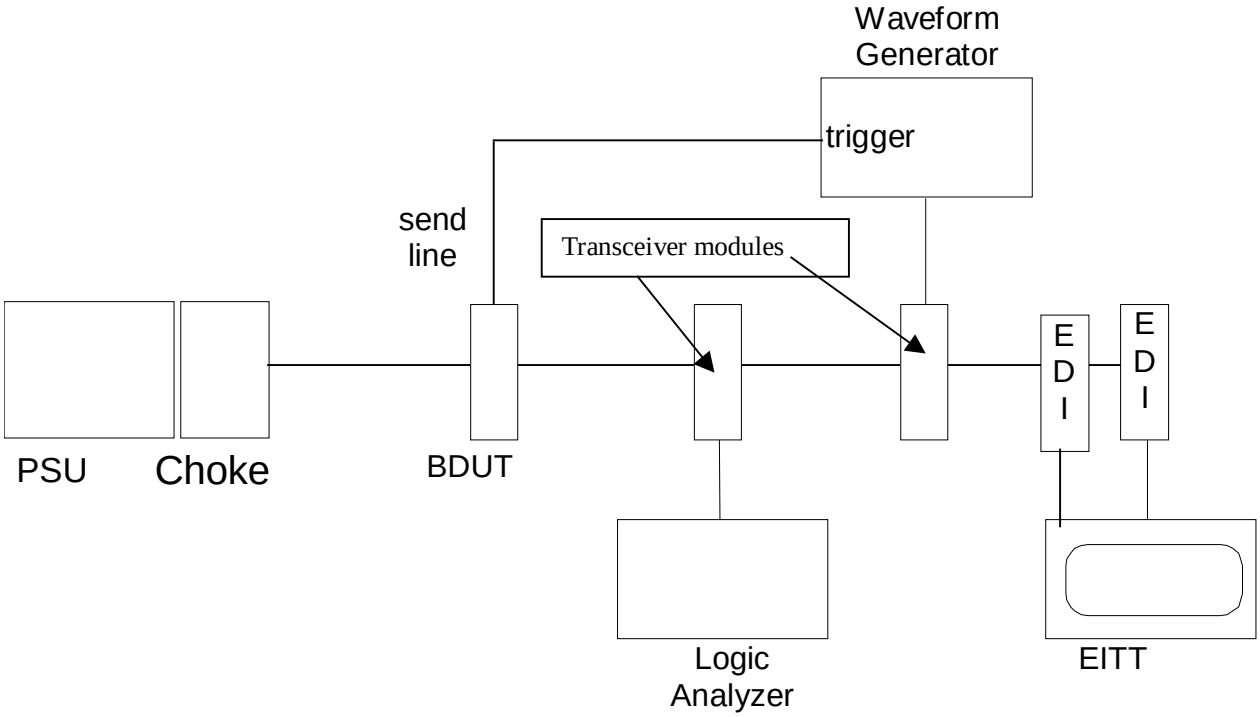

Figure 35 - Test set-up for link layer test

The following test equipment is required.

- A power supply unit and choke.
- A PC running EITT (version 2.3 or upward compatible), connected to the bus by two EDI's (KNX Data Interface) both based on BCU2 technology (allowing polling). For the data part of Link Layer, one of the EDI's is replaced by a terminal BCU. This EDI is based on BIM112 Technology, with a special application program allowing faulty telegram transmission. A copy of the application program can be obtained from the KNX association.
- A Logic Analyser connected to the bus by a transceiver module.
- A Waveform Generator connected to the bus by a transceiver module.

The BDUT shall have the individual address 1001h and the group address 1002h. If the BDUT can be configured as a polling slave, it shall respond to polling group 1003h.

NOTE 4 The wording 'stimulate BDUT to send frame' signifies in case of a BCU (with available PEI) that the BDUT shall be stimulated via local services, whereas in case of a BAU (without available PEI) the BDUT shall be stimulated according to the manufacturer's PIXIT. The underneath telegrams are merely examples (based on the case where the BDUT is a BCU) and may be replaced by appropriate other frames.

10.1 Physical Part of Link Layer

10.1.1 Data block

10.1.1.1 Transceiver Fault

Purpose Check that the BDUT does not send a telegram in case of a transceiver fault

Procedure Disconnect transceiver receive line from BDUT. Stimulate BDUT to send telegram (e.g. switch to Link layer and send a L_DATA.req).

Result No telegram shall appear on the bus (the BDUT shall at the latest stop transmission after the first byte)

10.1.1.2 Parity Bit

Purpose Check reaction of BDUT to incorrect parity bit

Procedure Send telegram addressed to the device with correct and incorrect parity bit in the check sum octet (via Waveform Generator) and check with EITT if BDUT sends ACK or NACK. This test shall be carried out once with a physical addressed and once with a group addressed frame.

IN BC AFFE 1001 60 80 :T-Connect(Addr=1001)

IN BC AFFE 1002 E1 00 80 : ValueWrite (Grp=1002, 00)

Result BDUT sends NACK if at least one parity bit in the frame was incorrect and an ACK if all parity bits in the sent frame were correct. Check that the BDUT does not update the sent value (in the case of an actuator by visual check or in the case of a sensor by reading out the value of the addressed object)

10.1.1.3 Stop Bit

Purpose Check reaction of BDUT to incorrect stop bit

Procedure Send telegram addressed to the device with correct and incorrect stop bit in the check sum octet (via Waveform Generator)p and check with EITT if BDUT sends ACK or NACK. This test shall be carried out once with a physical addressed and once with a group addressed frame.

IN BC AFFE 1001 60 80 :T-Connect(Addr=1001)

IN BC AFFE 1002 E1 00 80 : ValueWrite (Grp=1002, 00)

Result BDUT sends NACK if at least one stop bit in the frame was incorrect and an ACK if all stop bits in the sent frame were correct. Check that the BDUT does not update the sent value (in the case of an actuator by visual check or in the case of a sensor by reading out the value of the addressed object)

10.1.1.4 Send Telegram

Purpose Check correct setting of parity and stop bits if BDUT sends telegram.

Procedure Stimulate BDUT to send a physical and group addressed telegram

OUT BC 1001 1002 E1 00 80 ValueWrite (Grp=1002, 00)

OUT BC 1001 AFFE 64 42 41 01 16 01 :MemoryResponse(Count=01, Addr=0116, Data=01)

Result Parity and Stop bits shall be set correctly (Logic Analyser) in the entire frame (including check octet).

10.1.2 Data packet frame and priorities

10.1.2.1 Start of Low and Normal priority Frame: Send

Purpose Check that start of telegram (with low and normal priority) is sent at least 53 bit times after preceding telegram frame

Procedure Stimulate BDUT to send telegram, which triggers the Waveform Generator via the send line of the BDUT to send a valid frame on the bus. BDUT detects collision and sends its frame with a delay after the bus is free again. Check this delay with the Logic Analyser.

Result BDUT waits at least 53 bit times after the Waveform Generator has terminated its transmission [8)].

10.1.2.2 Start of Repeated/Polling/System/Alarm Frame: Send

Purpose Check that a repeated telegram, polling telegram and a telegram with system/alarm priority is sent at least 50 bit times after preceding telegram frame.

Procedure Stimulate BDUT to send an unacknowledged telegram. Check time between first frame and repeated frame with the Logic Analyser.

Stimulate BDUT to send an unacknowledged telegram, which triggers via the send line of the BDUT the Waveform Generator to send a valid frame after a delay corresponding to the duration of the frame sent by the BDUT plus 50 bit times. Check that the BDUT detects collision and waits to send its repeated frame at least 50 bit times after the Waveform Generator has terminated its transmission.

Stimulate BDUT to send polling telegram / telegram with system/alarm priority, which shall trigger the Waveform Generator via the send line of BDUT to send a valid frame on the bus. Check that the BDUT detects collision and waits to send its frame at least 50 bit times after the Waveform Generator has terminated its transmission.

Result BDUT waits at least 50 bit times after the Waveform Generator has terminated its transmission.

[8)] The time between the end of a telegram and the start of a telegram of normal/low priority is 53 bit times, including the two separation characters. In other words, measurements have to be done of the time between the addressed stop bit of the preceding telegram and the start bit of the following telegram with normal/low priority and this time shall be at least 53 bit times.

10.1.2.3 Start of Frame: Receive (optional)

Purpose Check that BDUT rejects a repeated telegram, a polling telegram or a telegram with system/alarm priority telegram when received less than 40 bit times after preceding telegram frame

Procedure Stimulate Waveform Generator to send two consecutive frames (polling frames, repeated telegram frame, frame with system /alarm priority) on the bus of which the second is addressed to the BDUT. Repeated telegram frames and frames with system/alarm priority shall be sent once physically addressed and once group addressed. The delay time between both frames is less than 40 bit times.

CASE 1 Physical addressed

IN BC AFFE 1004 60 80 :T-Connect(Addr=1004)

IN 9C AFFE 1001 60 80 :T-Connect(Addr=1001) (repeated)

IN BC AFFE 1001 60 80 :T-Connect(Addr=1001) (Low)

IN B4 AFFE 1001 60 80 :T-Connect(Addr=1001) (High)

IN B8 AFFE 1001 60 80 :T-Connect(Addr=1001) (Alarm)

IN B0 AFFE 1001 60 80 :T-Connect(Addr=1001) (System)

CASE 2 Group addressed

IN BC AFFE 1005 E1 00 80 ValueWrite (Grp=1005, 00)

IN 9C AFFE 1002 E1 00 80 ValueWrite (Grp=1002, 00) (repeated)

IN BC AFFE 1002 E1 00 80 ValueWrite (Grp=1002, 00) (Low)

IN B4 AFFE 1002 E1 00 80 ValueWrite (Grp=1002, 00) (High)

IN B8 AFFE 1002 E1 00 80 ValueWrite (Grp=1002, 00) (Alarm)

IN B0 AFFE 1002 E1 00 80 ValueWrite (Grp=1002, 00) (System)

CASE 3 Polling

IN F0 AFFE 1001 01 :Polling request

IN F0 AFFE 1003 01 :Polling request

Result BDUT does not react on the frame (sends no ACK / fills no polling slots).

10.1.2.4 Start of Frame after BUSY resp. overlapping Busy/Nack [9]: Send

Purpose Check that start of telegram is sent at least 150 bit times after preceding BUSY or overlapping Busy/NACK

Procedure Stimulate BDUT to send telegram, which triggers via its send line the Waveform Generator to answer with a Busy-frame or overlapping Busy/Nack. The BDUT repeats the previously sent frame after a delay. Check this delay with the Logic Analyser. The test shall be carried out with physically addressed, group addressed and frames with different priorities and repeated frames (if supported by the BDUT).

Result BDUT shall not repeat its frame before 150 bits after the Waveform Generator has terminated its transmission.

[9] This overlapping Busy and Nack may occur in case devices deactivate CSMA/CA detection during transmission of ACK telegrams. This is currently the case in TP1 BCU1.

10.1.2.5 Separation of characters inside a frame: Send

Purpose Check that characters inside a frame sent by the BDUT are separated by at least two bit times

Procedure Stimulate BDUT to send physically addressed, group addressed and frames with different priorities and repeated frames (if supported by the BDUT).

Result Check timing between characters in frame sent by BDUT: these shall be separated by at least two bit times.

10.1.2.6 Separation of characters inside a frame: Receive (optional)

Purpose Check that frames are rejected by the BDUT, in which the characters are separated by less than two bit times

Procedure Send frame to BDUT via Waveform Generator, in which the characters are separated by less than two bit times.

Result If supported, a frame may be interpreted with less than 2 bit times between two characters if the deviation does not exceed 1 bit time.

10.1.2.7 ACK timing: Send

Purpose Check that ACK is sent at least 15 bit times after preceding telegram (allowed deviation +20/- 5 µs)

Procedure Send physically and group addressed frame from EITT to BDUT. Check time between end of frame to ACK sent by BDUT with Logic Analyser.

IN BC AFFE 1001 60 80 :T-Connect(Addr=1001)

IN BC AFFE 1002 E1 00 80 :ValueWrite(Grp=1002, 00)

Result BDUT waits 15 bit times (allowed deviation +20/- 5 µs) after end of frame to send ACK.

10.1.2.8 ACK timing: Receive (optional)

Purpose Check if device rejects acknowledge telegram when

a) Before 15 bit times - 5 µs after preceding telegram

b) After 15 bit times + 30 µs after preceding telegram

Procedure Stimulate BDUT to send frame, which triggers the Waveform Generator via the send line of BDUT to transmit an ACK frame

a) less than 15 bit times – 5 µs after end of BDUT frame.

b) More than 15 bit times + 30 µs after and of BDUT frame

Result BDUT does not accept ACK (repeats frame).

10.1.2.9 BDUT is polling slave

Purpose Check that slave sends polling data after 5 bit times (allowed deviation +/- 50 µs) after end of polling request frame, preceding polling data or fill character

Procedure Switch the EDI to link layer via EITT and stimulate EDI to send L_Polldata.req with length 5.

IN A9 00 18 34 56 78 0A (PEI_Switch.req)

IN 13 00 00 00 10 03 05 (L_Polldata.req)

Configure BDUT to answer in first polling slot, in a slot after a master fill byte, and in a slot following the answer of another slave configured for the same polling group.

Check timing with Logic Analyser.

Result BDUT answers in all cases after a delay of 5 bit times (allowed deviation +/- 50 µs).

10.1.2.10 BDUT is polling master (Send)

Purpose a) Check that master sends fill data 6 bit times (allowed deviation +/- 50 µs) after end of polling request frame, preceding polling data or fill character (in case of missing polling data)

b) Check that master sends polling data 5 bit times (allowed deviation +/- 50 µs) if it is configured to additionally act as a polling slave (if supported).

Procedure a) Stimulate BDUT to send polling master frame with length 5 (in case of BCU with PEI via local services, otherwise see PIXIT).
Configure polling slave to answer in third slot.

b) Stimulate BDUT to send polling master frame with length 5 (in case of BCU with PEI via local services, otherwise see PIXIT).
Configure BDUT to answer in second polling slot (in case of BCU with PEI via local services, otherwise see PIXIT).

Check timing with Logic Analyser.

Result a) BDUT answers in all slots except 3 with fill byte FEh after a delay of 6 bit times (allowed deviation +/- 50 µs)

b) BDUT answers in all slots except 2 with fill byte FEh after a delay of 6 bit times (allowed deviation +/- 50 µs) and in slot 2 after a delay of 5 bit times (allowed deviation +/- 50 µs).

10.1.2.11 BDUT is polling master (Receive - optional)

Purpose Check that BDUT rejects the answer of a polling slave if the latter is sent with incorrect timing

Procedure Stimulate BDUT to send polling master frame with length 5 (in case of BCU with PEI via local services, otherwise see PIXIT), which triggers the Waveform Generator via the send line of the BDUT to transmit a polling value in slot 2

a) starting 5 bit times – 30 µs after the first fill byte

b) starting 6 bit times + 30 µs after the first fill byte

Result The BDUT rejects in all cases the answer of the polling slave (in case of a BCU, check the L_polldata.con, in case of a BAU check reaction according PIXIT)

10.2 Data part of Link Layer

10.2.1 Control field

10.2.1.1 Valid and Invalid Control field - Receive

Purpose Verify if BDUT rejects frames with invalid or unsupported control fields (including rejection of telegrams with Ack control field)

Verify if BDUT acknowledges frames with valid or supported control fields (e.g. correct priorities, repetition flag set, polling request…)

Procedure Send Group Value Read telegrams [10)] via Interface supporting sending of Raw Frames to the BDUT with valid and invalid control fields to a supported group address – observe a waiting time of 1 seconds between telegrams to check BDUT reaction

IN 00 AFFE 1001 E1 00 00 :Value Read

IN 01 AFFE 1001 E1 00 00 :Value Read

…

IN B0 AFFE 1001 E1 00 00 :Value Read

IN B4 AFFE 1001 E1 00 00 :Value Read

IN B8 AFFE 1001 E1 00 00 :Value Read

IN BC AFFE 1001 E1 00 00 :Value Read

….

IN 90 AFFE 1001 E1 00 00 :Value Read

…

IN 98 AFFE 1001 E1 00 00 :Value Read

…..

IN FF AFFE 1001 E1 00 00 :Value Read

Result BDUT does not send ACK for invalid/unsupported control fields

BDUT sends ACK for valid control fields (including control fields with repetition flag set) and returns a Value Response [11)].
The control fields that shall be interpreted as valid by the BDUT are given in the KNX specifications and in the product documentation.

10.2.1.2 Priorities: Send

Purpose Check that the BDUT can send telegrams with all priorities

Procedure Stimulate BDUT to send telegrams with all priorities

a) in case of BCU with PEI : switch to Link Layer and send L_Data.req-services with different priorities.

OUT BC 1001 AFFE 60 80 :T-Connect(Addr=AFFE)

10) For devices not supporting Group Value Read, send TL-Connect and observe minimum 6 seconds between telegrams to check for TL-Disconnect messages in case of valid or supported control fields (same behaviour also applies to devices with TL connection oriented minimal implementations).

11) The TP1 BCU with mask 1.2 reacts on LL telegrams with the invalid control field ‘AC’ (and also updates values in AL). This is not allowed for future implementations.

OUT B4 1001 AFFE 60 80 :T-Connect(Addr=AFFE)

OUT B8 1001 AFFE 60 80 :T-Connect(Addr=AFFE)

OUT B0 1001 AFFE 60 80 :T-Connect(Addr=AFFE)

b) in case of a BAU without PEI : send Value Read to implemented communication objects (config flags to be set to ensure generation of a response).

Result BDUT sends frames with

a) Priorities according to those set in the L_Data.req-services

b) Priorities corresponding to those set in the Value Read frames

10.2.1.3 Repetition flag : send

See clause 10.2.6.2

10.2.1.4 Repetition flag : receive

Purpose Check handling of telegrams with repetition flag set.

Procedure Send a frame to the BDUT, in which the repetition flag is not set, followed by the same frame with repetition flag set. Check whether the BDUT writes the value when receiving the first frame and does not again write the value when receiving the second frame.

Result The BDUT writes the value when receiving the first frame and ignores the second [12)]

10.2.2 Source address

Purpose Check the correct setting of the source address in a frame sent by the BDUT.

Procedure Stimulate BDUT to send a frame.

OUT BC 1001 AFFE 60 80 :T-Connect(Addr=AFFE)

Result The source address corresponds to the individual address of the BDUT.

10.2.3 Destination Address

10.2.3.1 Individual Address

Purpose Check the acceptance of individually addressed telegrams by the BDUT.

Procedure Use EITT to send the following frame addressed to the BDUT:

IN BC AFFE 1001 60 80 :T-Connect(Addr=1001)

Result BDUT accepts the frame (sends ACK).

10.2.3.2 Unused Individual Address

Purpose Check the rejection of telegrams not addressed to the BDUT.

Procedure Use EITT to send the following frame addressed to the BDUT:

IN BC AFFE 1002 60 80 :T-Connect(Addr=1001)

Result BDUT does not accept the frame (sends no ACK).

[12)] The verification whether the BDUT only writes the value when receiving the first frame and not in case of the second frame can only be checked in case of BCU's (in view of availability of External Message Interface) and not in case of closed devices.

10.2.3.3 Used Group Address

Purpose Send telegram with used group address or broadcast and check if ACK is sent by BDUT.

Procedure Use EITT to send the following frames addressed to the BDUT:

IN BC AFFE 1002 E1 00 81

IN BC AFFE 0000 E3 00 C0 12 34 :SetPhysAddr(Addr=1234)

Result BDUT accepts the frames (sends ACK).

10.2.3.4 Unused Group Address

Purpose Send telegram with unused group address and check if ACK is not sent

Procedure Ensure that the group address 2222h is not contained in the BDUT's address table.

Use EITT to send the following frame addressed to the BDUT:

IN BC AFFE 2222 E1 00 81

Result BDUT does not accept the frame (sends no ACK).

10.2.3.5 Send telegrams

Purpose Check that BDUT can send a group telegram and (if implemented) a broadcast and an individually addressed telegram.

Procedure Stimulate BDUT to send a group telegram, a broadcast telegram and an individually addressed telegram. Check telegrams with EITT.

OUT BC 1001 1002 E1 00 81

OUT BC 1001 0000 E3 00 C0 12 34 :SetPhysAddr(Addr=1234)

OUT B0 1001 AFFE 60 80 :T-Connect(Addr=AFFE)

Result BDUT sends all telegrams correctly.

10.2.3.6 BDUT is a Router

Purpose Check routing of telegrams.

Procedure Send an individually addressed telegram to the BDUT.

Send a group addressed telegram to the BDUT.

Send a broadcast telegram to the BDUT.

Result BDUT routes the individually addressed frame according to its own individual address, the group telegram according to the setting of the filter tables, and the broadcast telegram in any case.

(Examples of Test sequences : to be completed)

10.2.4 Information length

10.2.4.1 Info Length: Send

Purpose Check that BDUT can send frames with different (minimum and maximum supported) info lengths.

Procedure Stimulate BDUT to send a

a) T-Disconnect

b) A memory response with maximum info length (check with EITT):

OUT BC 1001 AFFE 60 81 (T-Disconnect)

OUT BC 1001 AFFE 6F 42 52 01 16 01 02 03 04 05 06 07 08 09 00A 0B OC (Memory Response, Count =12, Addr=0116, Data : 01 02 03 04 05 06 07 08 09 0A 0B OC)

Result BDUT creates frames with information length set correctly.

10.2.4.2 Info Length: Receive

Purpose Check that BDUT receives frames with different (minimum and maximum supported) info lengths.

Procedure Send frames from EITT to BDUT with different info lengths:

IN BC AFFE 1001 60 80 (T-Connect)

IN BC AFFE 1001 6F 42 52 01 16 01 02 03 04 05 06 07 08 09 00A 0B OC (Memory Response, Count =12, Addr=0116, Data : 01 02 03 04 05 06 07 08 09 0A 0B OC):

Result BDUT accepts frames (sends ACK).

10.2.4.3 Incorrect Info Length: Receive (Optional)

Purpose Check that BDUT does not accept frames with incorrectly set info length.

Procedure Send frames from EITT to BDUT with information length not corresponding to number of sent data:

IN BC AFFE 1002 EF 00 81

IN BC AFFE 1002 E2 00 80 00 00 00 00 00 00 00 00 00 00 00 00 00 00 :

Result BDUT does not accept frames (sends no ACK).

10.2.5 Check Octet

10.2.5.1 Checksum: Send

Purpose Check if BDUT sets the checksum byte correctly when sending a frame.

Procedure Stimulate BDUT to send a frame. Use the BCU Terminal connected to EITT to check the correct calculation of the checksum.

OUT BC 1001 1002 E1 00 81

Result BDUT sets checksum correctly.

10.2.5.2 Checksum: Receive

Purpose Check if BDUT rejects a frame with incorrect checksum.

Procedure Use Waveform Generator to send a frame addressed to the BDUT with incorrect checksum.

OUT BC 1001 1002 E1 00 81

Result BDUT sends NACK. Check that the BDUT does not update the sent value (in the case of an actuator by visual check or in the case of a sensor by reading out the value of the addressed object)

10.2.6 Confirmation Field

10.2.6.1 Sending of Ack, Nack, Busy

Purpose Check if BDUT is always able to respond to frames addressed to it by means of the appropriate acknowledge frame (ACK, Nack or Busy [13)]. This shall be ensured for physically and group addressed frames.

Procedure Send frame to BDUT and check correct generation of acknowledge frame. Check in PICS under which conditions which a Busy signal is transmitted (e.g. in case of BCU2 device: program EEPROM and send group telegram addressed to BDUT)

Result BDUT sends correct acknowledgement frame.

10.2.6.2 Repetition

Purpose Check if BDUT is able to repeat a frame.

Procedure Stimulate BDUT to send telegram, which triggers via the sent line of the BDUT the Waveform Generator to send

a) a NACK

b) Busy

c) no frame

d) overlapping NACK and Busy

Result BDUT repeats frame with the repetition flag set.

10.2.6.3 Receive ACK

Purpose Check if BDUT does not repeat a frame if it receives an ACK.

Procedure Stimulate BDUT to send a frame to which another device responds with ACK.

Result BDUT does not repeat frame.

[13)] The applicant shall declare in the supplied PICS-proforma how a busy signal can be invoked. In some cases (e.g. the use of sufficiently fast microprocessors), the generation of a Busy might never be possible. However, the fact that a device does not send a busy, does not imply that it shall not repeat messages when receiving a busy. This is tested in clause 10.2.6.2.

10.2.7 Polling Frames: BDUT is Master

10.2.7.1 Sending legal Length

Purpose Check if BDUT generates valid master frames with different lengths and no slave answers.

Procedure Stimulate BDUT to send master frames to non-existing polling group.

OUT F0 1001 1004 00

OUT F0 1001 1004 01 FE

...

OUT F0 1001 1004 0F FE FE FE FE FE ...

Result BDUT sends frames correctly and fills all slots with the fill byte FEh.

10.2.7.2 Slave sends FEh

Purpose Check if BDUT does not evaluate the value FEh as a slave answer.

Procedure Stimulate BDUT to send polling request on existing polling group with number of expected poll data = 1. A slave sends the value FEh in the first slot.

Result BDUT treats the answer identical to a master fill byte.

10.2.8 Polling Frames: BDUT is Slave

10.2.8.1 Other polling group

Purpose Check if BDUT does not answer on a master frame with a polling group not supported by the BDUT.

Procedure Generate master frames with polling group not supported by the BDUT.

IN F0 1001 1005 00

IN F0 1001 1005 01 FE

...

IN F0 1001 1005 0F FE FE FE FE FE ...

Result BDUT does not answer in any slot.

10.2.8.2 Length = 0

Purpose Check if BDUT does not answer to a master frame with number of slots = 0.

Procedure Generate master frames with number of slots = 0.

IN F0 1001 1004 00

Result BDUT does not answer.

10.2.8.3 Length > 0

Purpose Check if BDUT does not answer to a master frame with number of slots lower than own slot number (e.g. requested number of poll data from master is 6 and slave's slot number is 6). Note that the slot number is counted from 0 to 14 whereas the number of requested slots from 1 to 15.

Procedure Generate master frames with number of slots = 6.

IN F0 1001 1004 06

Result BDUT does not answer.

10.2.8.4 Length > 15

Purpose Check if BDUT does not answer to a master frame with number of slots > 15.

Procedure Generate master frames with number of slots = 16.

IN F0 1001 1004 11

Result BDUT does not answer.

10.2.8.5 Legal Length

Purpose Check if BDUT answers to a master frame with legal length.

Procedure Generate master frames with number of slots = 1 ... 15. BDUT answers in the slot for which it was configured (e.g. in underneath example configured for slot number 0).

IN F0 1001 1004 01

OUT FF

IN F0 1001 1004 02

OUT FF FE

IN F0 1001 1004 0F

OUT FF FE FE FE FE FE FE FE FE FE FE FE FE FE FE

Result BDUT answers correctly.

10.3 Busmonitor Mode of the Link Layer

The Busmonitor mode is tested in [04].

11 Bus Load tests

11.1.1 Requirements for end devices

It shall be ensured that bus devices can cope with a minimum busload and do not disturb bus by e.g. generating unneeded L2-BUSY characters. Busload shall be generated and measured using the formula given in [02]. Appropriate software tools that do so are currently manufacturer specific.

11.1.1.1 Requirements when device is receiving

A device shall be able to receive high busload. There shall be no different behaviour for different busload types.

Table 26 - Testing high busload only receiving

	Busload type	Busload level	Busload composition	Expected behaviour	Test objective
1	Uniform	High	Point to Point (device is not addressed)	IGNORE [14)]	Device shall not disturb on-going point to point communication if it is not addressed
2	Uniform	High	Multicast (device is not addressed)	ACK [15)]/ IGNORE	Device shall not disturb on-going multicast communication, if it is not addressed.
3	Uniform	High	Point to Point (device is not addressed) in addition to 1 frame Point to Point (device is addressed)	IGNORE (only for not addressed/ ACK (only for addressed frames)	Device shall not disturb on-going point to point communication if it is not addressed even when it is evaluating a point-to-point frame.
4	Uniform	High	Multicast (device is not addressed) in addition to 1 frame Multicast (device is addressed)	ACK [14)]/ IGNORE (only if not addressed)	Device shall not disturb on-going multicast communication, if it is not addressed even when it is evaluating a multicast frame
5	Uniform	High	Multicast (device is not addressed) in addition to 1 frame Broadcast (device is addressed)	IGNORE (only if not addressed)/ ACK [14)]	Device shall not disturb on-going multicast communication, if it is not addressed even when it is evaluating a Broadcast frame

[14)] IGNORE: DUT sends no Acknowledge frame

[15)] Devices are allowed to send Data Link Layer acknowledge frames on multicast traffic in a non-selective way.

11.1.1.2 Requirements when device is receiving and transmitting

At medium busload level the device shall be able to send during on-going bus traffic.

Table 27 - Testing receiving and transmitting at medium busload

	Busload type	Busload level	Busload composition	Expected behaviour	Test objective
1	Uniform	Medium	Point to Point (device is not addressed) in addition to 1 frame Point to Point (device is addressed and answers to this frame)	ACK / IGNORE (only if not addressed) + answer	Device shall not disturb on-going point to point communication, if it is not addressed. It shall be able to evaluate 1frame point to point communication without generating BUSY. It shall be able to send point to point frames at medium busload.
2	Uniform	Medium	Multicast (device is not addressed) in addition to 1 frame Multicast (device is addressed and answers to this frame, e.g. value read)	ACK / IGNORE (only if not addressed) + answer	Device shall not disturb on-going multicast communication, if it is not addressed. It shall be able to evaluate 1frame multicast communication without generating BUSY. It shall be able to send multicast frames at medium busload.
3	Uniform	Medium	Multicast (device is not addressed) in addition to 1 frame Broadcast (device is addressed and answers to this frame, e.g. PH Address read and device is in programming mode)	ACK / IGNORE (only if not addressed) + answer	Device shall not disturb on-going multicast communication, if it is not addressed. It shall be able to evaluate 1frame broadcast communication without generating BUSY. It shall be able to send broadcast frames at medium busload.

11.1.2 Requirements on Couplers

11.1.2.1 Common requirements

In addition to the test suite for normal end devices, a coupler shall fulfil the additional requirements given in this clause.

11.1.2.2 Requirements receiving and transmitting

A coupler is required to route a high busload to its other side if the medium of the other line has the same or a bigger speed. For all tests the coupler never needs to send repetitions because of missing L2-ACK on the other side of the coupler. This can be done by either putting an L2-ACK generator on the other side of the coupler or by setting the parameters to “no repetitions on routing” if this is possible.

Table 28 - Receiving and transmitting at high busload

	Busload type	Busload level	Busload composition	Expected behaviour	Test objective
1	Uniform	High (on one side)	Point to Point (device is not addressed)	ACK + frame sent to other line	Coupler shall route point to point communication at high busload without generating BUSY
2	Uniform	High (on one side)	Multicast (device is not addressed)	ACK + frame sent to other line	Coupler shall route multicast communication at high busload without generating BUSY
3	Uniform	Both sides 35 % (frames must be routed). This leads to a doubled busload on both sides.	Point to Point (device is not addressed)	ACK + frame sent to other line	Coupler shall route point to point communication from both sides simultaneously without generating BUSY if total busload exceeds not the maximum busload for the media
4	Uniform	Half of the high busload at both sides (frames must be routed). This leads to a doubled busload on both sides.	Multicast (device is not addressed)	ACK + frame sent to other line	Coupler shall route multicast communication from both sides simultaneously without generating BUSY if total busload exceeds not the maximum busload for the media

12 Applicable tests for devices with integrated certified system components

In the case where devices are submitted to the KNX certification process containing a certified system component realizing the TP1 Physical Layer and/or (part of) the Data Link Layer, the KNX certification department shall be contacted to obtain a list of the tests from this volume part that still need to be performed for the used system component.