ARISO
CONTACTLESS COUPLER

TE Connectivity Germany GmbH
Pfnorstrasse 1
64293, Darmstadt
Germany
Tel.: +49 (0) 6151 607 0
Fax: +49 (0) 6151 607 1223
www.te.com
Link to ARISO Products in TE.com

1. SCOPE

This Specification applies to the Part Numbers of ARISO GPIO listed in the Datasheet DS 116-19004 and describes the measurement procedure for the ARISO M30 GPIO Contactless Coupler Performance Evaluation.

2. APPLICABLE DOCUMENTS

The full set of documents describing the product is listed in the Datasheet mentioned in §1.

Unless otherwise specified, the latest edition of the document applies. In the event of conflict between the requirements of this specification and the reference document, this document shall take precedence.

3. TESTS

3.1 Measuring Equipment

- A calibrated Power Analyzer (e.g. Yokogawa WT500 or Digital Multimeters for manual Power Calculations).
- A calibrated Oscilloscope (e.g. Agilent MSOX-3034A) with DSOX3MASK option.
- A calibrated DC Electronic Load (e.g. BK Precision 8500).
- A calibrated Waveform Generator (e.g. Agilent 33522A).
- Calibrated Digital Multimeters (e.g. Agilent 34410A).
- Calibrated XYZ-Table with tilt or robot with 6 degrees of freedom (X, Y, Z, Φ, Ψ, Θ).

3.2 Measurement Setup

The ARISO M30 Contactless Coupler handles Power and a Data Links.

The Data Link has 8 digital channels, GPIO-1 to GPIO-8.

Therefore, in this documents are defined test sequences for the Power Link and for the digital GPIO channels.

The following measurement conditions are possible:

1. TX powered without load on the digital data outputs, unmated.
2. TX powered without load on the digital data outputs, mated with unloaded RX.
3. TX powered without load on the digital data outputs, mated with loaded RX:
    a. No misalignment, no tilt.
    b. With misalignment, no tilt.
    c. No misalignment, with tilt.
    d. With misalignment, with tilt.
4. Switch on, mating and unmating sequences:
    a. TX and RX mated before switching on the power at TX side.
    b. TX and RX mated and powered, distance between TX and RX slowly increased.
    c. TX powered, unmated. Distance between TX and RX slowly decreased.

3.3 Parameters and default settings

During all electrical measurements, the following parameters can be set.

Table 1 - Parameters that can be set for the measurements

Parameter	Symbol	Unit	Default value
Distance between TX and RX	Δz	mm	7
Misalignment	Δr	mm	0
Tilt	$\Delta\Omega$	°	0
Medium between TX and RX	Med	-	Air
Input Voltage TX	V_{IN}	V	24.0
Mating Speed	MatSp	mm/s	0
Rotation Angle between TX and RX	Θ	°	0
Rotation speed RX with respect to TX	-	rpm	1250 (1)
Ambient temperature	T_{amb}	°C	22
Metal Clearance	MetCl	mm	> 60
Foreign Object Detection	FOD	%	0
Inter Coupler Distance	InCD	mm	> 60
Power output load	R_{LOAD}	Ω	∞
Power Output Type	PO-type	-	Resistive

Parameter	Symbol	Unit	Default value
Digital Input Waveform	DI-wav	-	Block
Digital Input Frequency	DI-freq	Hz	166
Digital Input Low Level Voltage	DI-LL	V	0
Digital Input High Level Voltage	DI-HL	V	24
Digital Output Load	DO-load	Ω	10k

Note (1) = Tested at another version

Table 2 - Parameters that can be measured

Parameter	Symbol	Unit	Min value	Max value
Input Current	I_{IN}	A	-	0.9
Input Power	P_{IN}	W	-	19
Output Voltage	V_{OUT}	V	22.8	25.2
Output Current	I_{OUT}	A	-	0.7
Output Power	P_{OUT}	W	-	12
Power Efficiency	η	%	0.72	-
Output Short Circuit Current	$I_{OUT\text{-}SHORT}$	A	-	0.7
Output Operational Readiness	t-op	ms	-	160
Housing Temperature	$T_{HOUSING}$	°C	-20	+85
Front-End Temperature	T_{FE}	°C	-20	+105
Digital Output Low Level Voltage	DO-LL	V	-	3
Digital Output High Level Voltage	DO-HL	V	5	-
Digital Output Impedance High	DO-RH	Ω	$1\cdot10^6$ (2)	-
Digital Output Impedance Low	DO-RL	Ω	-	1 (2)
Digital Output Delay Time	DO-DT	µs	-	250
Digital Output Jitter	DO-J	µs	-	500
Digital Output Bit Error Rate	DO-BER	-	-	10^{-4}
Digital Output Operational Readiness	DO-OR	ms	-	25 (3)
LED Light Output	LED	-	ON; OFF; Blinking: 1Hz or 10Hz	

Note (2) = set by design

Note (3) = after the system is powered up

3.4 Standard Measurement Setup

1) TX Test Box – Internal Connections:

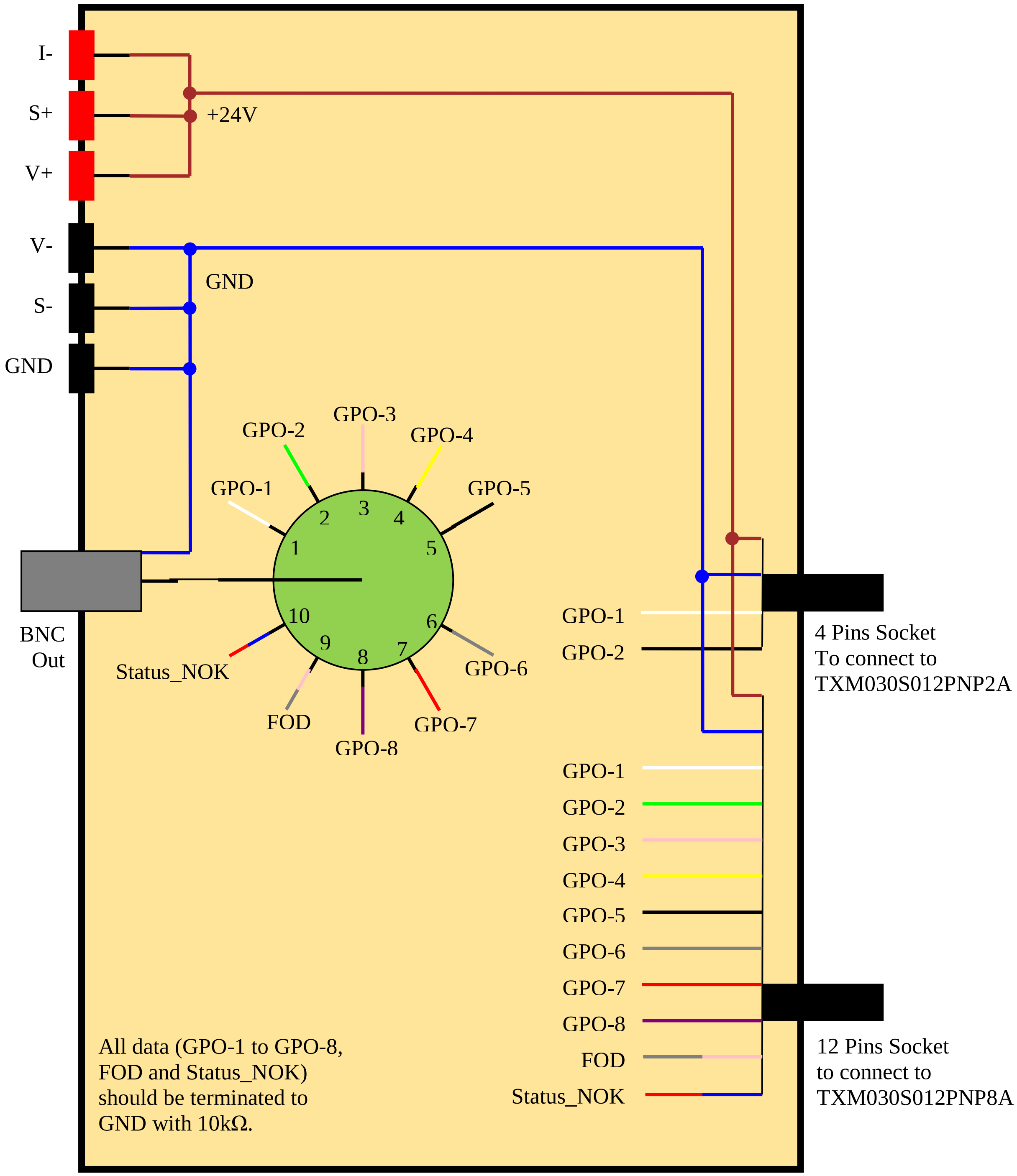


Figure 3.9.1 – TX Test Box

2) RX Test Box – Internal Connections:

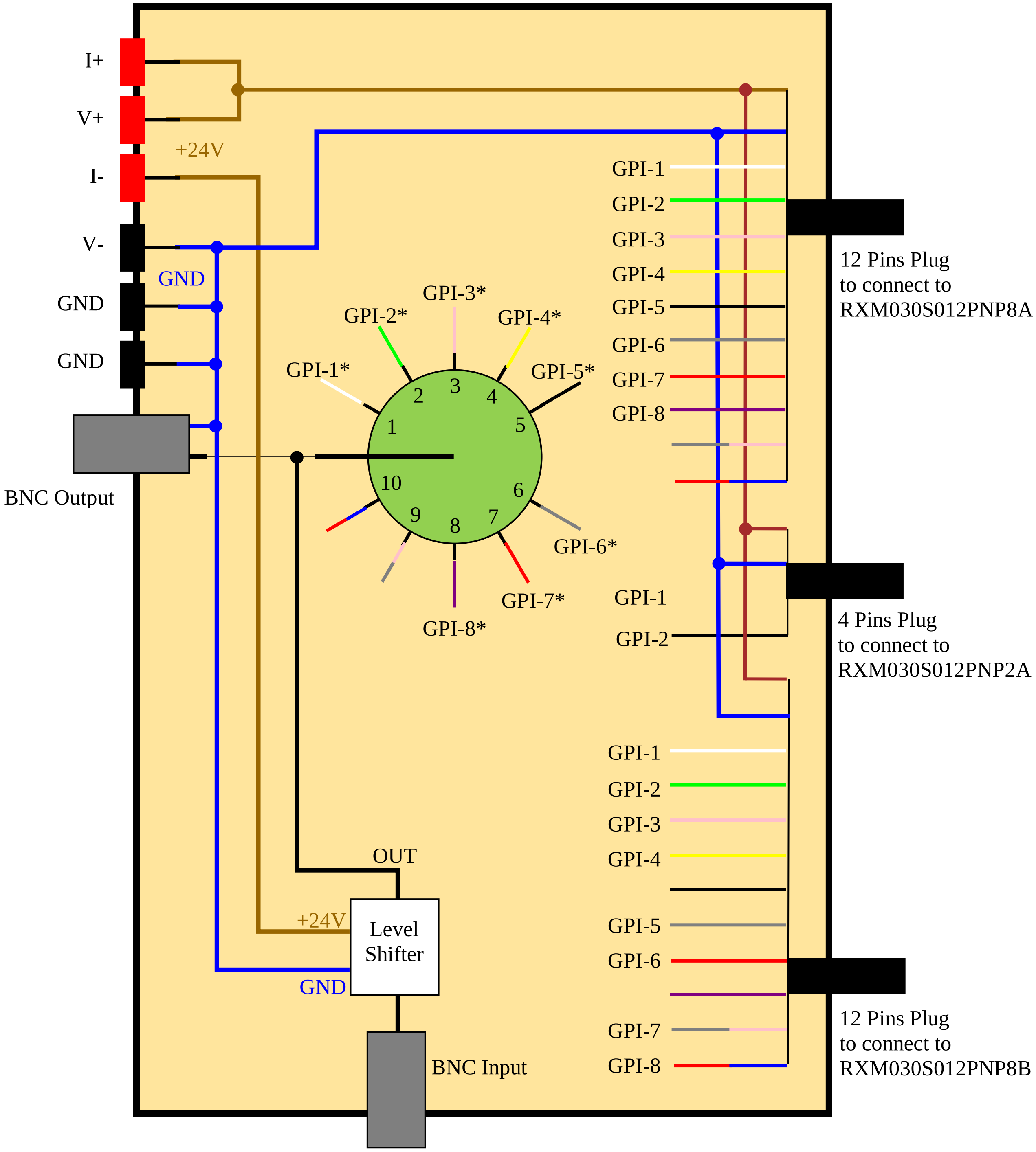


Figure 3.9.2 – RX Test Box

*The color coding of the dial is correct only for the connection of RXM030S012PNP8A cable.
For the connection of RXM030S012PNP2A and RXM030S012PNP8B cables, please follow “GPI-n” naming.

3) Level Shifter

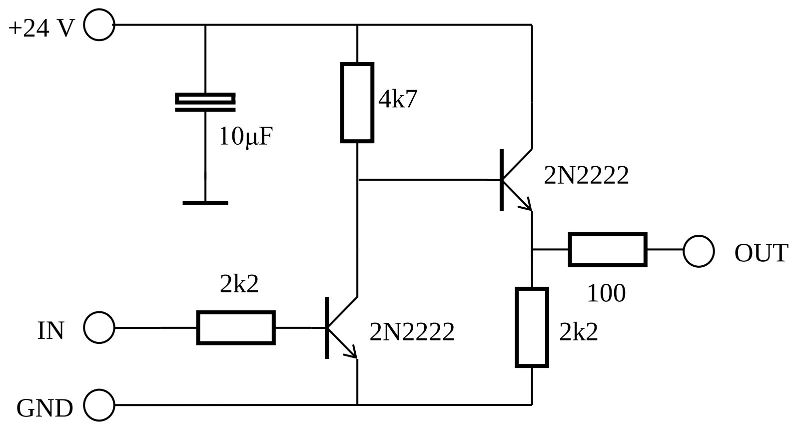


Figure 3.9.3 – Level Shifter

4) Connection diagram on TX side for manual operation:
Note: Do not connect both the TXM030S012PNP2A and TXM030S012PNP8A at the same time.

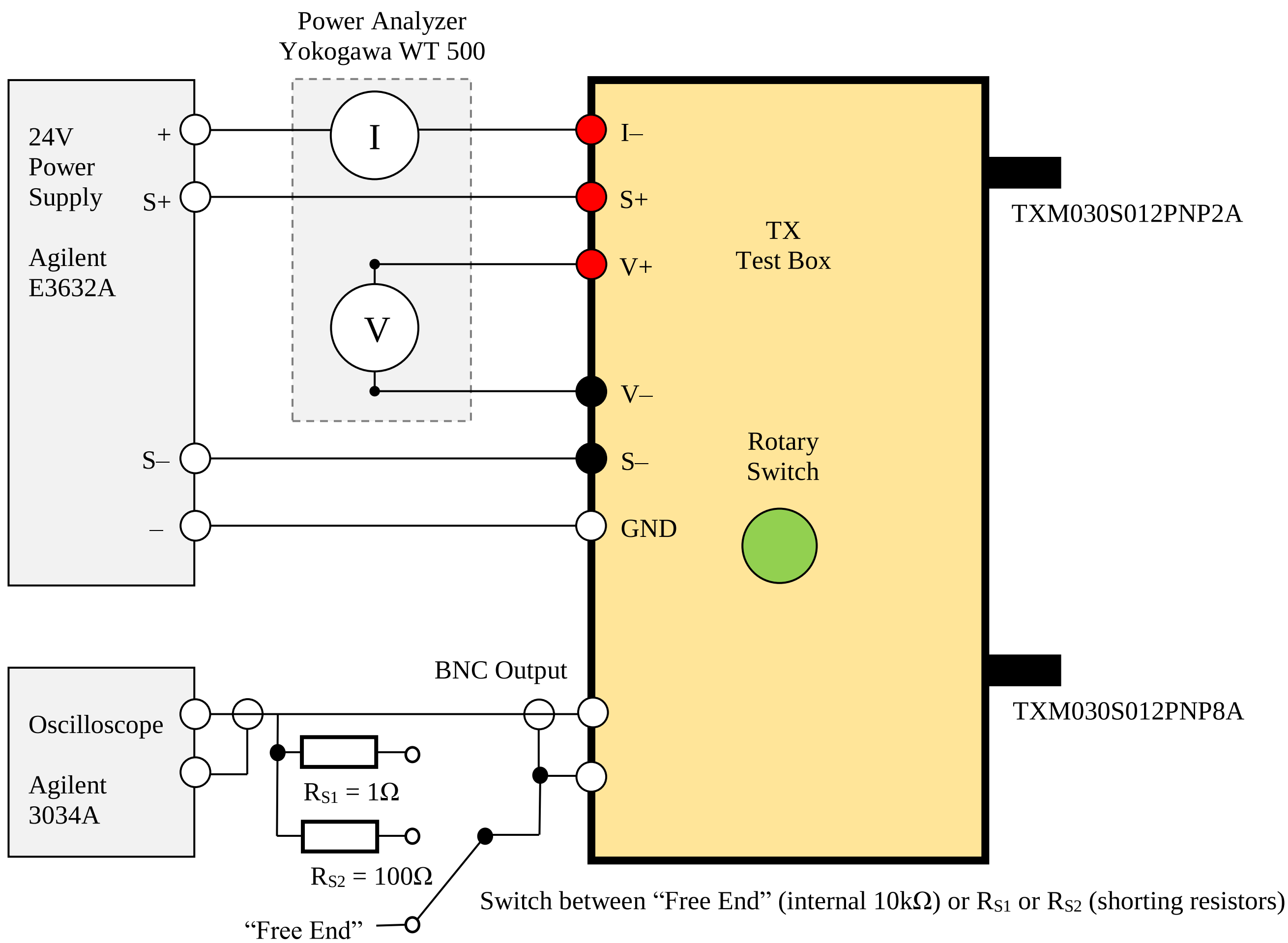


Figure 3.9.4 – Data Link Output Short Circuit Protection and Output Impedance Setup

5) Connection diagram on RX side for manual operation:

Note: Do not connect the RXM030S012PNP2A, RXM030S012PNP8A or RXM030S012PNP8B at the same time.

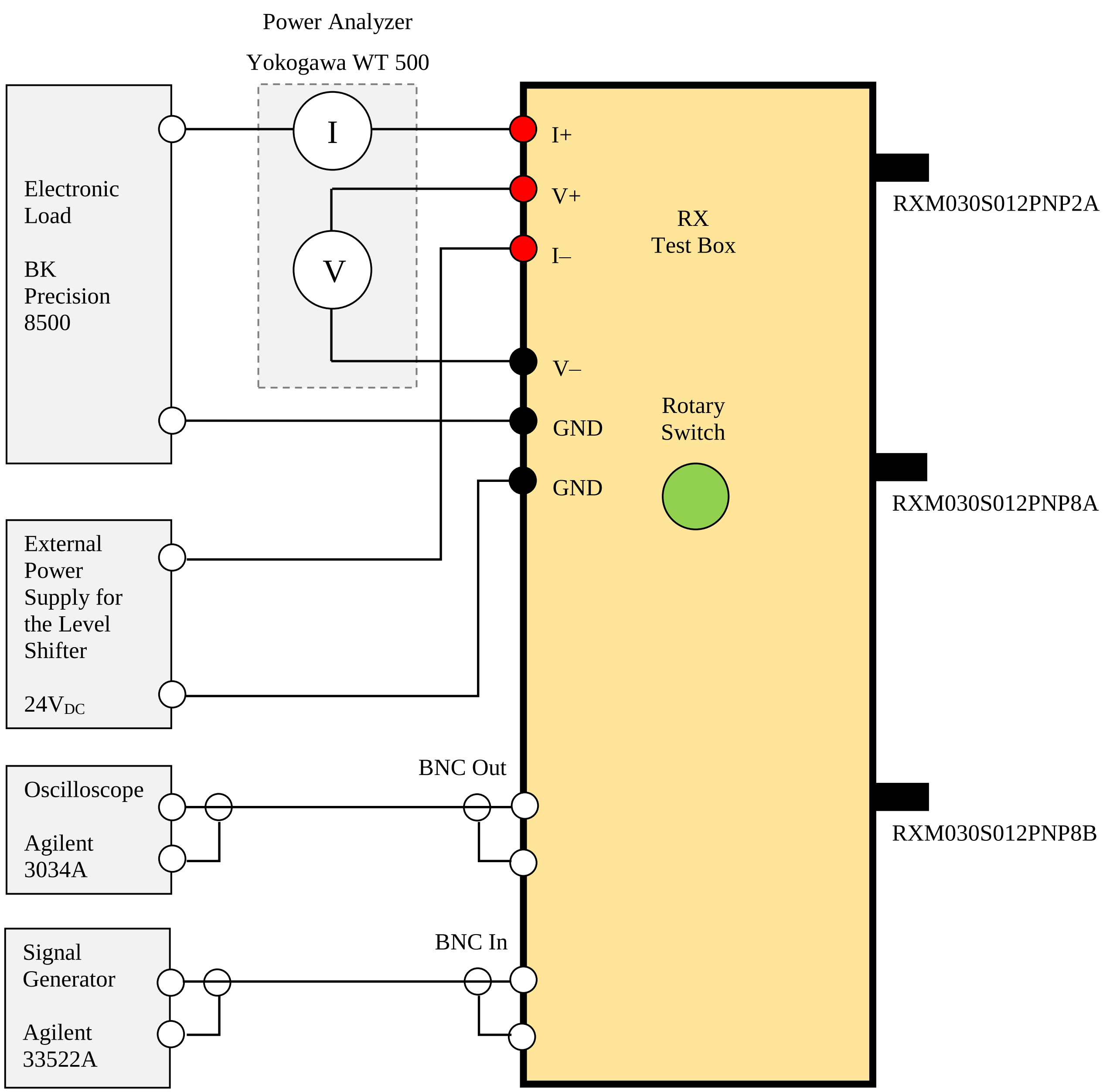


Figure 3.9.5 – RX Test Box Setup

The Power Analyzer should be set up, so that it can measures the following parameters:

- TX Input Voltage (including tolerance)
- TX Input Current (including inrush, standby and loaded)
- TX Input Power
- RX Output Voltage (also over distance)
- RX Output Current (including short circuit current)
- RX Output Power (in all situations with regard to distance, misalignment and tilt)
- TX and RX Housing and Front Cap Temperatures
- Efficiency (RX Output Power / TX Input Power)

The Oscilloscope should be able to measure the following parameters:

- Digital Input Frequency
- Digital Output Frequency
- Digital Output Low Levels
- Digital Output High Levels
- Digital Output Delay Time
- Digital Output Jitter
- Digital Output BER (Bit Error Rate)
- Digital Output Operational Readiness
- TX Input Current (including inrush, standby and loaded)
- TX Input Power

The digital input signal (at RX side) should be used as trigger source. To measure the Digital Output Operational Readiness either the TX Input Supply Voltage or the RX Output Supply Voltage should be used as trigger source.

3.5 Setup for Power Link Operational Readiness and Inrush Current Measurements

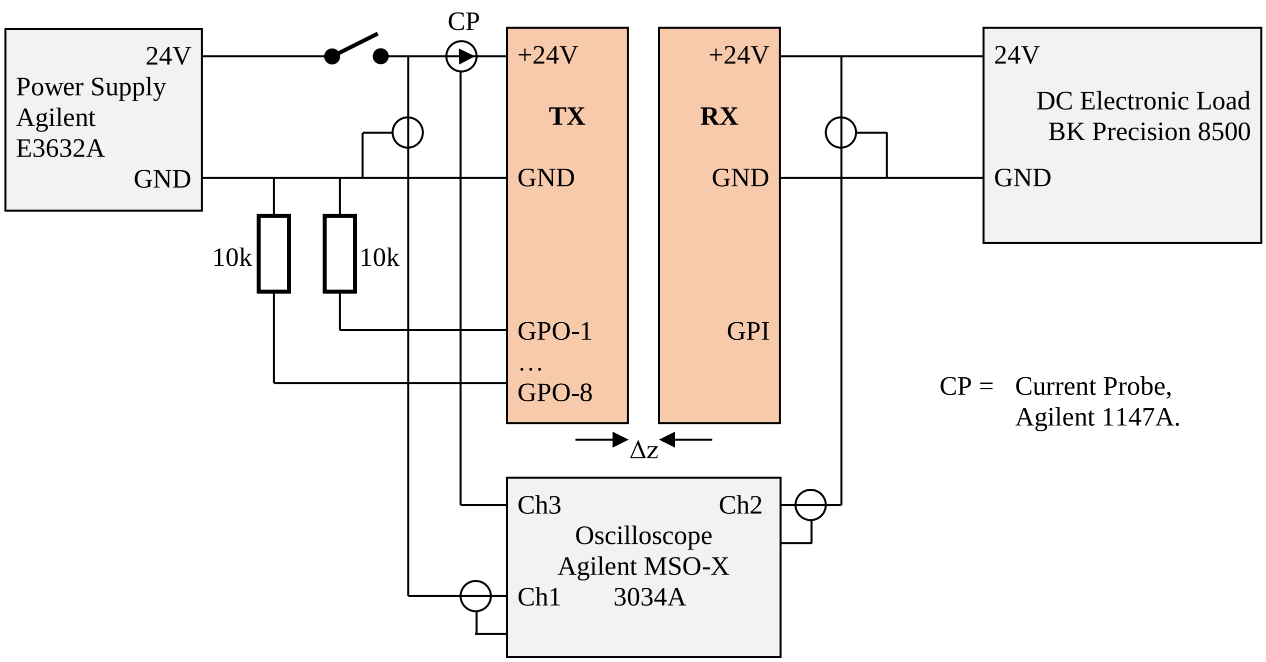


Figure 3.10.1 – Power Link Operational Readiness and Inrush Current Setup

Oscilloscope settings: Trigger at Ch1, Trigger Level 21.6V
Power Link Operational Readiness can be measured with Ch2
Inrush Current can be measured with Ch3

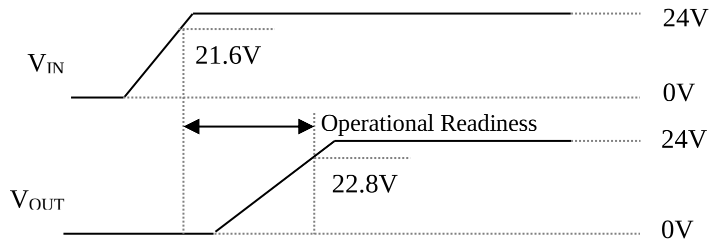


Figure 3.10.2 – Operational Readiness

3.6 Setup for Power Link Ripple and Noise Measurements

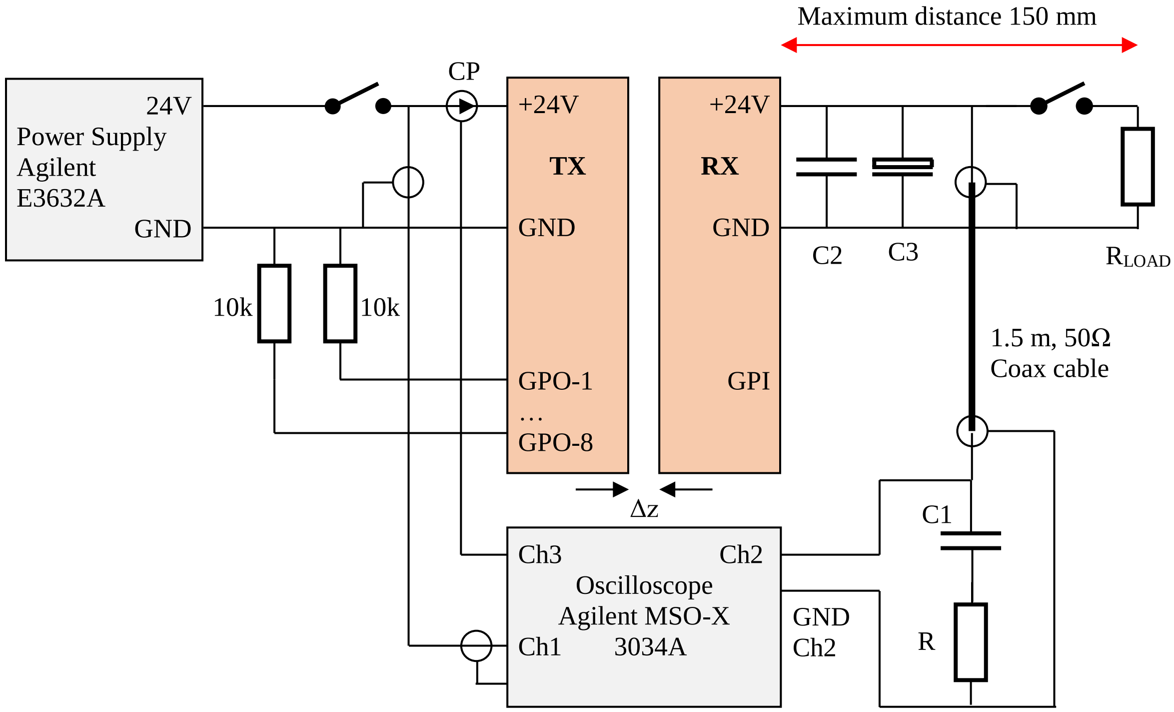


Figure 3.11.1 – Power Link Ripple and Noise Setup

R	= 50Ω
R_{LOAD}	= 50Ω (50W) or ∞
C1	= 4700 pF
C2	= 0.47 µF (film type)
C3	= 22 µF (electrolytic type)

3.7 Setup to measure the capability to handle the Output Inrush Current

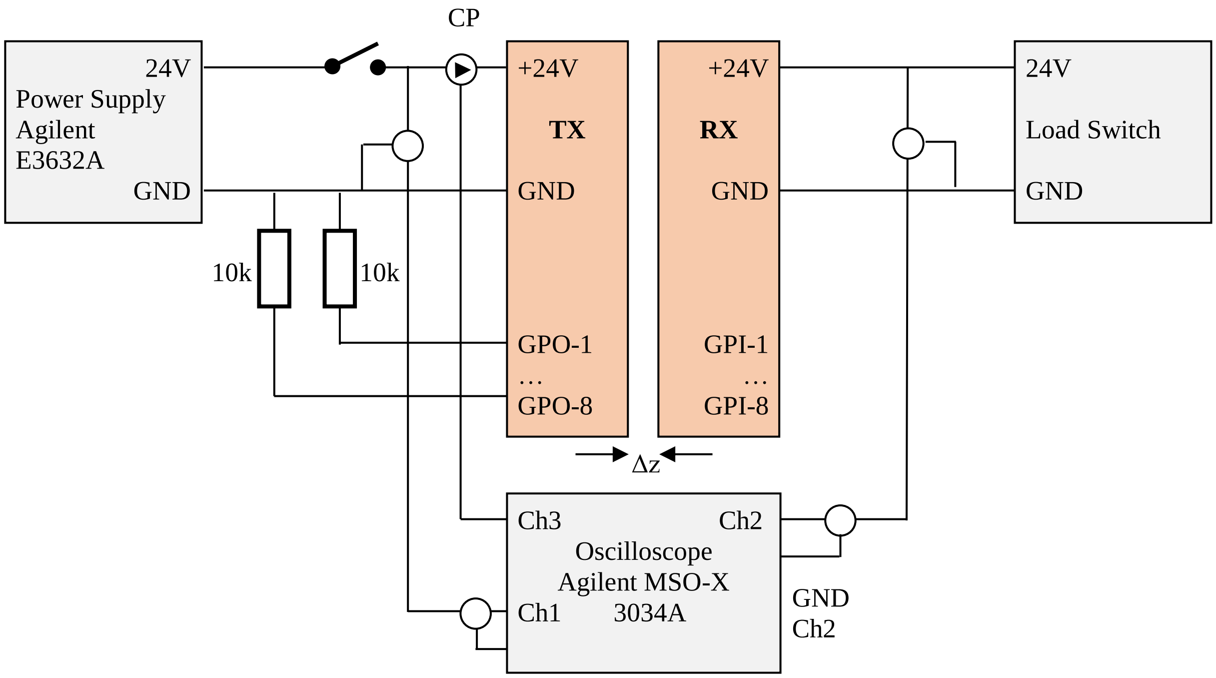


Figure 3.12.1 – Output Inrush Current Setup

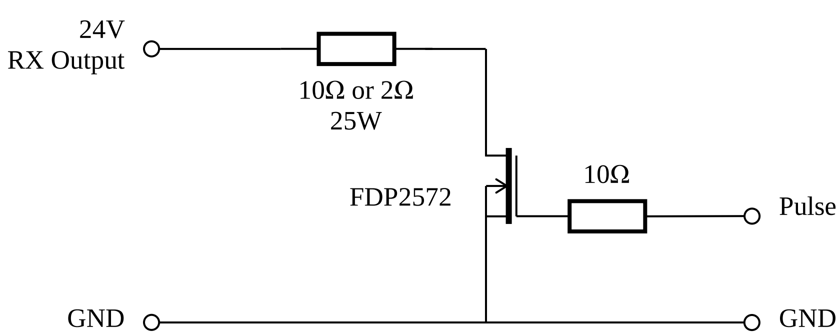


Figure 3.12.2

Pulse characteristics

Pulse width	100 µs / 20 µs
Repetition frequency	1 Hz
Low voltage level	0V
High voltage level	10V

3.8 Setup for Power Input Stress Tests

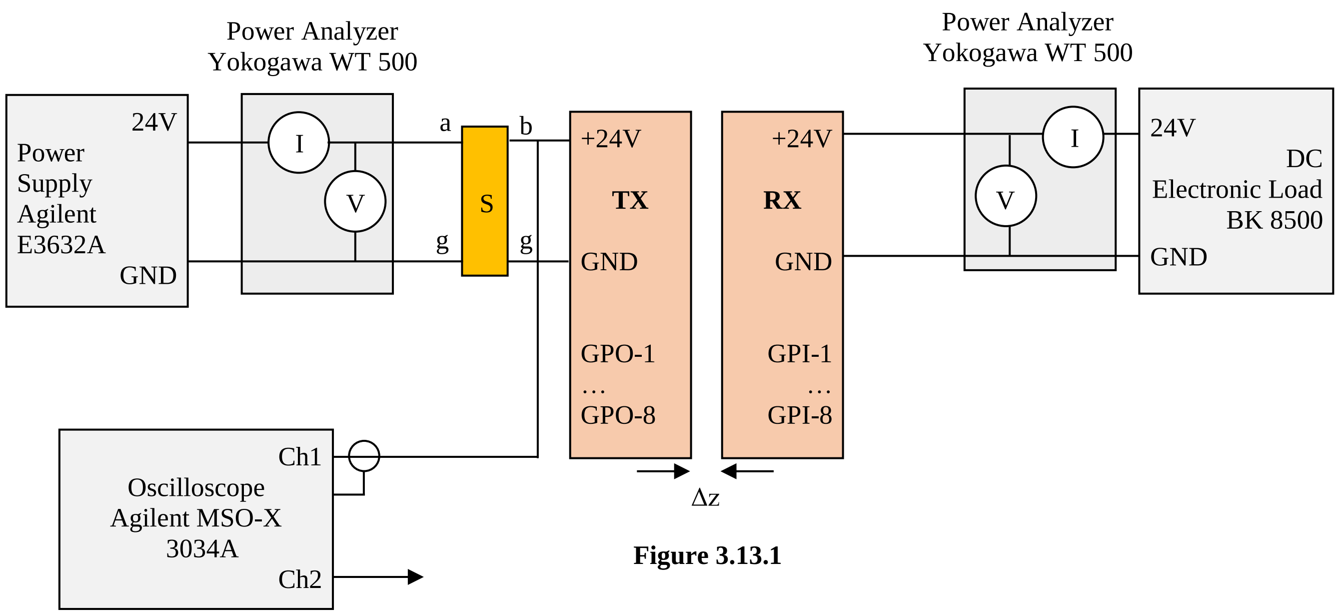


Figure 3.13.1

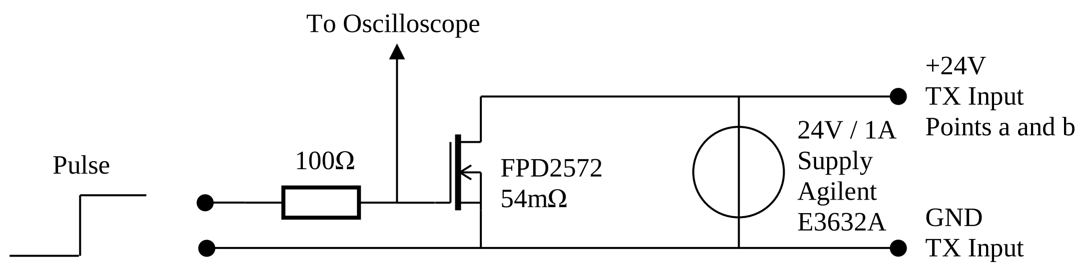


Figure 3.13.2 – Shorting Power Supply

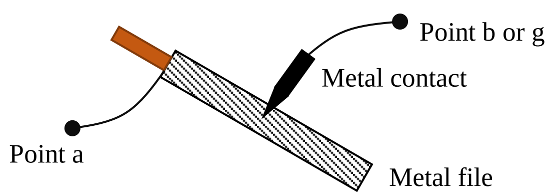


Figure 3.13.1 - C

Figure 3.13.3 – Simulation of Power Disturbances

Measurement setup:

1. Supply — +24V, 1A Maximum Current.
2. Electronic load — 12W (constant Power) or 50Ω

3.9 Setup for Operation in External Magnetic Field Measurements

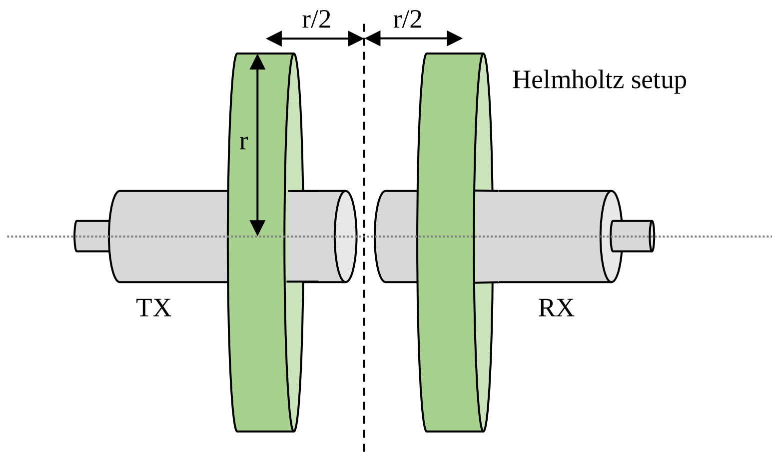


Figure 3.14.1 – External Magnetic Field Measurements Setup

3.10 Setup for Data Link Operational Readiness

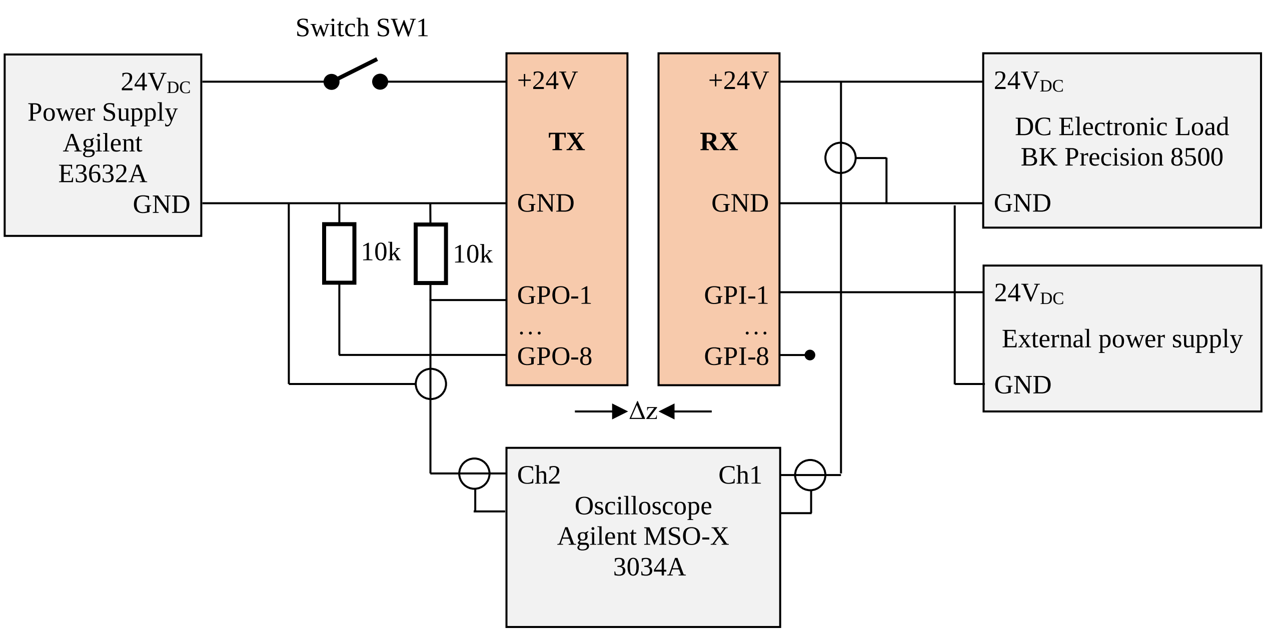


Figure 3.15.1 – Setup for Data Link Operational Readiness

Only GPI-1 is connected to the external Power Supply, while the other channels are open-ended.

3.11 Setup for Power Link Vibration Performance Measurements

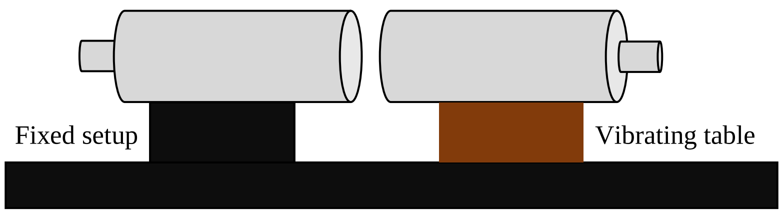


Figure 3.16.1 – Power Link Vibration Performance Measurements Setup

3.12 Setup for Digital Link Stability Test – Bit Error Rate (BER)

Setup description	TX powered, mated with RX
Settings	Power link V_{IN} = 24.0V, Δz = 7 mm, with R_{LOAD} = 50Ω
Measurement Setup	Acc. Figure 3.9.4 and Figure 3.9.5

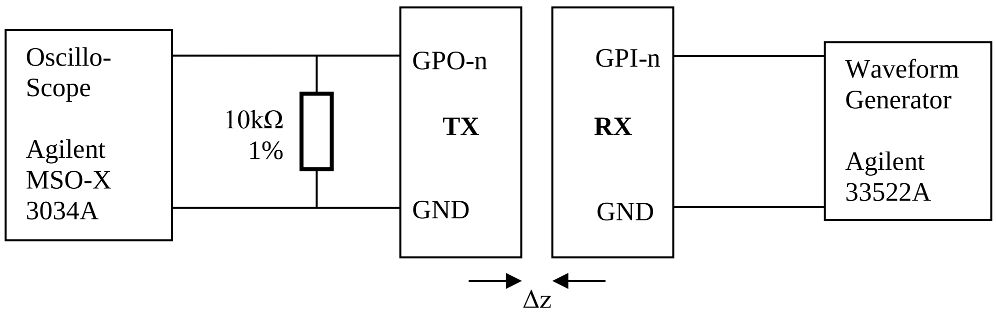


Figure 3.18.1 – Setup for Digital Link Stability Test

Note that the power transmitter TX is receiving data from the RX and put this data onto the 8 GPIO-n Digital Outputs.

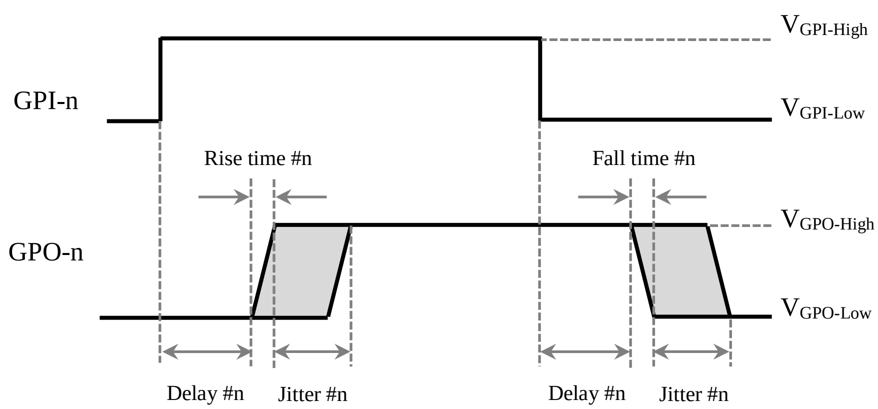


Figure 3.18.2 – Definition of Delay and Jitter for GPIO Link

The Bit-Error-Rate is measured via the MASK option of the Oscilloscope: the oscilloscope is triggered by Input-n and a MASK is set around GPIO-n, see next figure.

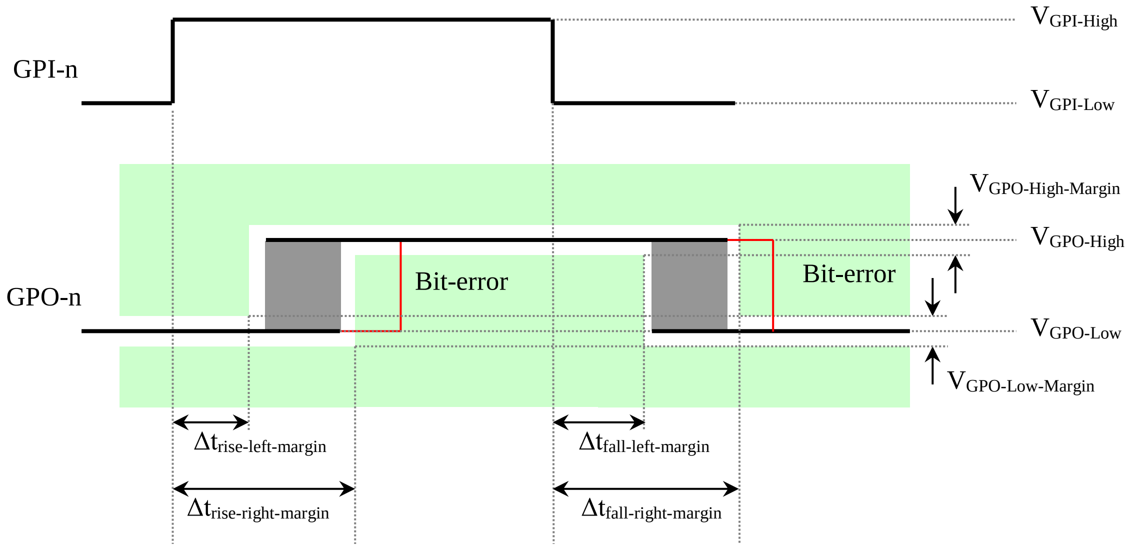


Figure 3.18.3 – Definition of Margins for Bit Error Rate (BER) – GPIO Link Measurements

$V_{GPO\text{-}High\text{-}Margin} = \pm 2.5$ V	$\Delta t_{rise\text{-}left\text{-}margin} = 250$ µs	$\Delta t_{fall\text{-}left\text{-}margin} = 250$ µs
$V_{GPO\text{-}Low\text{-}Margin} = \pm 2.5$ V	$\Delta t_{rise\text{-}right\text{-}margin} = 750$ µs	$\Delta t_{fall\text{-}right\text{-}margin} = 750$ µs

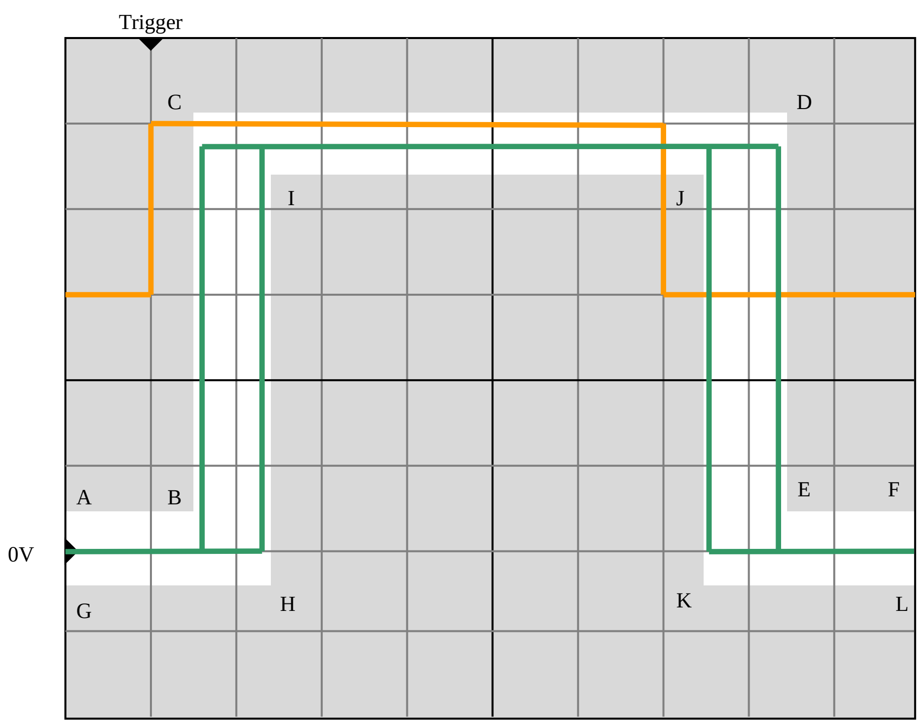


Figure 3.17.4

Figure 3.18.4 – Definition of Mask for Bit Error Rate (BER) measurements

Legend

Input	Block wave	
	Frequency =	166Hz
	Low Level =	0V
	High Level =	24V
	Duty Cycle =	50%
Screen	5 ms / div	
	5V / div for GPO-n, 10V / div for GPI-n	
	Trigger at rising edge GPI	
	Yellow line = GPI	
	Green line = GPO	

Mask Points	A =	(–500µs, +2.5V)	G =	(–500µs, –2.5V)
	B =	(+250µs, +2.5V)	H =	(+750µs, –2.5V)
	C =	(+250µs, +26.5V)	I =	(+750µs, +21.5V)
	D =	(+3250µs, +26.5V)	J =	(+3250µs, +21.5V)
	E =	(+3750µs, +2.5V)	K =	(+3750µs, –2.5V)
	F =	(+4500µs, +2.5V)	L =	(+4500µs, –2.5V)

All measurement points outside the white mask area / inside the gray mask area will be denoted as a Bit Error (BE).

The Bit-Error-Rate (BER) is defined as the ratio Number of Bit-Errors / Number of Measurements, being the Number of Measurements at least 20.000.

A maximum of one Bit Error is allowed within 20.000 measurement samples, measured at one data channel, leading to a BER less than 10^{-4}.

Have a look to the Figure 3.9.4 for the TX Setup.

3.13 Setup for Data Input / Output Stress Tests

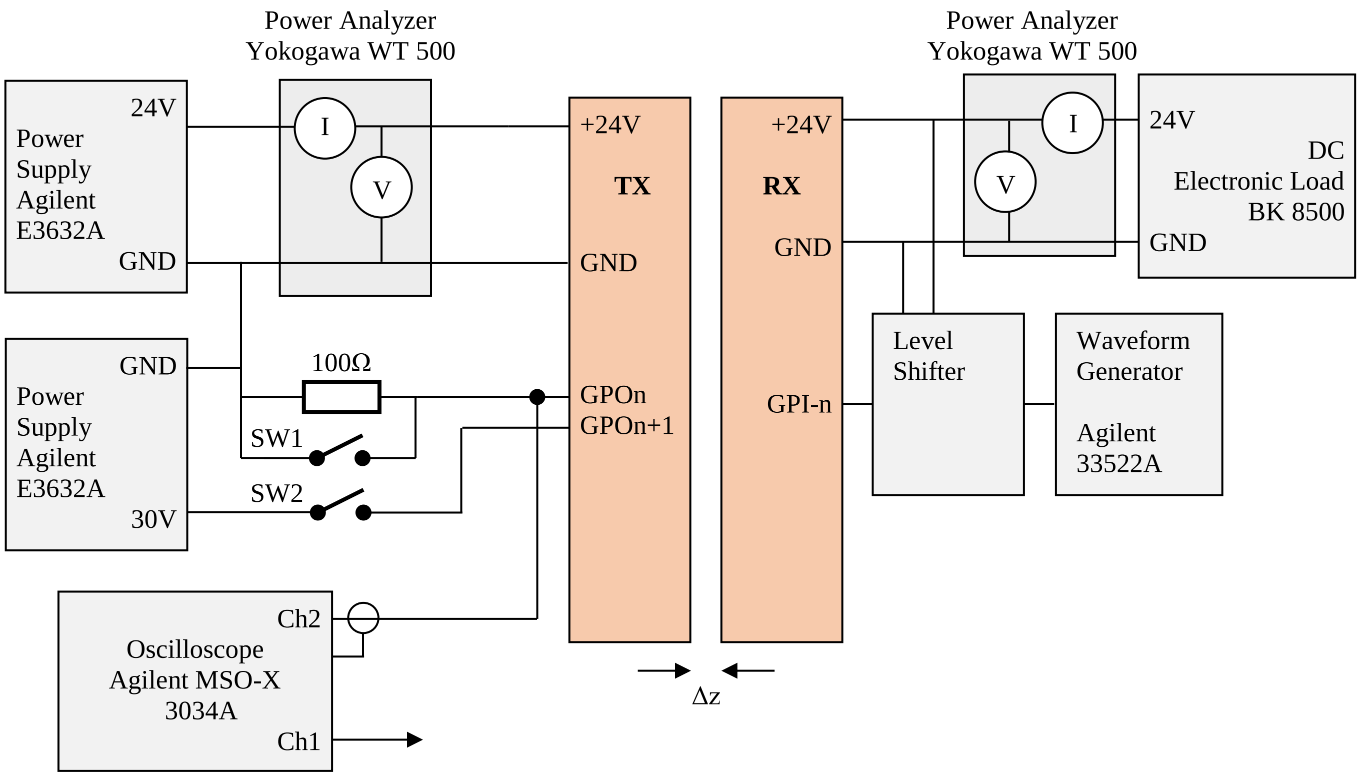


Figure 3.19.1 – Data Input / Output Stress Tests

Refer to Figure 3.9.4 for the TX Setup.

TEST DEFINITIONS FOR FUNCTIONAL ELECTRICAL TESTS

4. TEST DEFINITIONS OF POWER LINK MEASUREMENTS

In following sections are described the different tests. All unspecified settings need to be equal to the default value. The mentioned test numbers refer to the tests described in the Product Specification (PS). The Default Load is 50Ω.

4.1.1 Visual and dimensional examination

Test number	1.01 of the Product Specification			
Setup description	TX turned OFF and ON, mated and unmated with the RX			
Purpose	Determine correct LED functionality			
Parameters to measure				
Power Link	V_{IN} = 24.0V, R_{LOAD} = 50Ω			
Data Link	Default Load at GPOs			
Measurement Setup	Acc. Figures 3.2.1, 3.2.2, 3.2.3, 3.4.1, 3.6.1, 3.6.2			
Parameters to measure	**TX**	**Δz [mm]**	**Condition**	**LED**
LED Light Output according to the table on the right	OFF	25	-	OFF
	ON	25	Normal unmated condition	Blinking at 10Hz
	ON	7	Metal Plate between TX and RX (FOD)	Blinking at 1Hz
	ON	7	Over Temperature	Blinking at 10Hz
	ON	7	Normal Operation	ON
Note	A 1Hz blinking LED refers to internal failure and is difficult to provoke from the outside.			

4.1.2 Power Link Unmated Standby Power

Test number	1.02 of the Product Specification
Setup description	TX powered, unmated with RX
Purpose	Determine Unmated Standby Power
Settings	
Power Link	V_{IN} = 24.0V, Δz > 25 mm (unmated situation)
Data Link	Default Load at GPOs
Measurement Setup	Acc. Figure 3.9.4
Parameters to measure	I_{IN} ; P_{IN} ; LED Output

4.1.3 Power Link Mated Standby Power

Test number	1.03 of the Product Specification
Setup description	TX powered, mated with RX
Purpose	Determine Mated Standby Power
Settings	
Power Link	V_{IN} = 24.0V, Δz = 0, 2, 4, 7, 8 mm, no Load at RX side
Data Link	GPIs set to Low and default Load at GPO
Measurement Setup	Acc. Figures 3.9.4, 3.9.5
Parameters to measure	I_{IN} ; P_{IN} ; LED Output

4.1.4 Power Link Input Voltage Tolerance Sensitivity and Output Voltage Tolerance and Regulation

Test number		1.04 of the Product Specification
Setup description		TX powered, mated with RX
Purpose		Determine Sensitivity to Input Voltage and Output Load Variations
Settings		
Power Link		
	1st run	$R_{LOAD} = \infty$ (no power Load at RX side)
		V_{IN} = 19.60V, increase Δz = 0, 2, 4, 5, 7, 8 mm
		V_{IN} = 20.00V, increase Δz = 0, 2, 4, 5, 7, 8 mm
		V_{IN} = 21.60V, increase Δz = 0, 2, 4, 5, 7, 8 mm
		V_{IN} = 26.40V, increase Δz = 0, 2, 4, 5, 7, 8 mm
	2nd run	$R_{LOAD} = 192\Omega$ Load
		V_{IN} = 19.60V, increase Δz = 0, 2, 4, 5, 7mm
		V_{IN} = 20.00V, increase Δz = 0, 2, 4, 5, 7 mm
		V_{IN} = 21.60V, increase Δz = 0, 2, 4, 5, 7 mm
		V_{IN} = 26.40V, increase Δz = 0, 2, 4, 5, 7 mm
	3rd run	$R_{LOAD} = 96\Omega$ Load
		V_{IN} = 19.60V, increase Δz = 0, 2, 4, 5, 7mm
		V_{IN} = 20.00V, increase Δz = 0, 2, 4, 5, 7 mm
		V_{IN} = 21.60V, increase Δz = 0, 2, 4, 5, 7 mm
		V_{IN} = 26.40V, increase Δz = 0, 2, 4, 5, 7 mm
	4th run	$R_{LOAD} = 50\Omega$
		V_{IN} = 19.60V, increase Δz = 0, 2, 4, 5, 7mm
		V_{IN} = 20.00V, increase Δz = 0, 2, 4, 5, 7 mm
		V_{IN} = 21.60V, increase Δz = 0, 2, 4, 5, 7 mm
		V_{IN} = 26.40V, increase Δz = 0, 2, 4, 5, 7 mm
Data Link		Default Loading, Inputs Low
Measurement Setup		Acc. Figures 3.9.4, 3.9.5
Parameters to measure		I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output
Notes		At $V_{IN} \leq$ 19.60V the output voltage (V_{OUT}) should be 0V
		At $V_{IN} \geq$ 20.00V and $\Delta z \leq$ 8 mm the output voltage (V_{OUT}) should be 24.0V ± 5%
		Check if Hysteresis is present

4.1.5 Power Link Continuous Output Power and Efficiency over distance

Version A

Test number	1.05 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Power and Efficiency Over Distance
Settings	
Power Link	V_{IN} = 24.00V
	Decrease Δz from 10mm to 0mm in steps of 2mm
	For Δz > 7mm determine Maximum Load for Stable Output of 24.0V
	For Δz = 7mm Output Voltage should be 24.0V with R_{LOAD} = 50Ω
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figures 3.9.4, 3.9.5
Parameters to measure	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output

Version B

Test number	1.05 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Power and Efficiency Over Distance
Settings	
Power Link	V_{IN} = 24.00V
1st Sequence	Increase Δz from 0mm to 10mm in steps of 0.1mm
	Till Δz = 7mm, Output Voltage should be 24.0V with R_{LOAD} = 50Ω (± 0.5 %)
	For Δz > 7 mm determine Maximum Load for stable Output Voltage of 24.0V
2nd Sequence	Decrease Δz from 10mm to 0mm in steps of 0.1mm
	For Δz > 7mm determine Maximum Load for stable Output Voltage of 24.0V
	For Δz = 7mm Output Voltage should be 24.0V with R_{LOAD} = 50Ω
Measurement setup	Acc. Figures 3.9.4, 3.9.5
Parameters to measure	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output
Notes	Table mentioned in Product Specification contains a subset of above measured parameters

4.1.6 Power Link Sensitivity to XYZ and Tilt misalignment Sensitivity

Test number	1.06 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Power and Efficiency Over Misalignment
Settings	
Power Link	V_{IN} = 24.00V
(Δz, Δr, $\Delta\Omega$)	(0, ±5, 0.0), (2, ±5, 0.0), (2, 0, 7.5), (2, ±5, 8.5), (4, ±5, 0.0), (4, 0, 15.0), (4, ±5, 17.5) (5, ±3, 0.0), (5, 0, 20.0), (5, ±3, 22.5), (7, ±2, 0.0), (7, 0, 25.0), (7, ±2, 32.5) Output Voltage should be 24.0V with R_{LOAD} = 50Ω
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figures 3.2.2, 3.9.4, 3.9.5
Parameters to measure	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output

4.1.7 Power Link Output Short Circuit Protection and Reverse Polarity Protection

Test number	1.07 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Short Circuit Output Current and Recovery after removal of Short Circuit
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm
1st Step	R_{LOAD} = 50Ω
2nd Step	R_{LOAD} = 1Ω
3rd Step	R_{LOAD} = 50Ω
4th Step	Reverse Polarity of Input Voltage
Digital Data Link	Default Loading, Inputs Low
Measurement setup	Acc. Figures 3.9.4, 3.9.5
Parameters to measure	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output
Notes	Normal operational Output should appear once Short Circuit is removed or Input Polarity is normal. Furthermore, in both cases (50Ω or 1Ω Loads) the Output Current should be stable

4.1.8 Power Link Rotational Freedom

Test number	1.08 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Rotational Freedom of the Power Link
Settings	
Power Link	$V_{IN} = 24.00V$, $\Delta z = 7mm$, $R_{LOAD} = 50\Omega$
1st Step	TX angle $\Theta = 0°, 90°, 180°$ and $270°$ with respect to RX
2nd Step	TX fixed, dynamic rotation of RX at 1250rpm
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figures 3.4.1, 3.9.4, 3.9.5
Parameters to measure	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output

4.1.9 Power Link Operational Readiness

Test number	1.09 of the Product Specification
Setup description	TX switched from unpowered to powered, mated with loaded RX
Purpose	Determine Delay between Input Voltage and stable Output Voltage
Settings	
Power Link	$V_{IN} = 24.00V$, $\Delta z = 7mm$, $R_{LOAD} = 50\Omega$
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figure 3.10.1
Parameters to measure	
Power Link	Time between $V_{IN} = 21.6V$ and $V_{OUT} \geq 22.8V$

4.1.10 Power Link Inter Coupler Distance

Test number	1.10 of the Product Specification
Setup description	Two normal operating Couplers in close proximity
Purpose	Determine stable operation of two Couplers in close proximity
Settings	
Power Link	$V_{IN} = 24.00V$, $\Delta z = 7mm$, $R_{LOAD} = 50\Omega$ for both Couplers
	Inter Coupler Distance = 60 mm
Data Link	Default Loading, Inputs Low
	Acc. Figures 3.3.1, 3.9.4, 3.9.5
Parameters to measure	
Power Link Pair 1	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output
Power Link Pair 2	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output
Notes	Two setups should be tested: TX_1 aside TX_2 and TX_1 aside RX_2

4.1.11 Power Link Metal Clearance

Test number	1.11 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine stable operation of Couplers in a Metal Enclosure
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω Metal Clearance = 15 mm
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figures 3.5.1, 3.9.4 and 3.9.5
Parameters to measure	
Power Link	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output

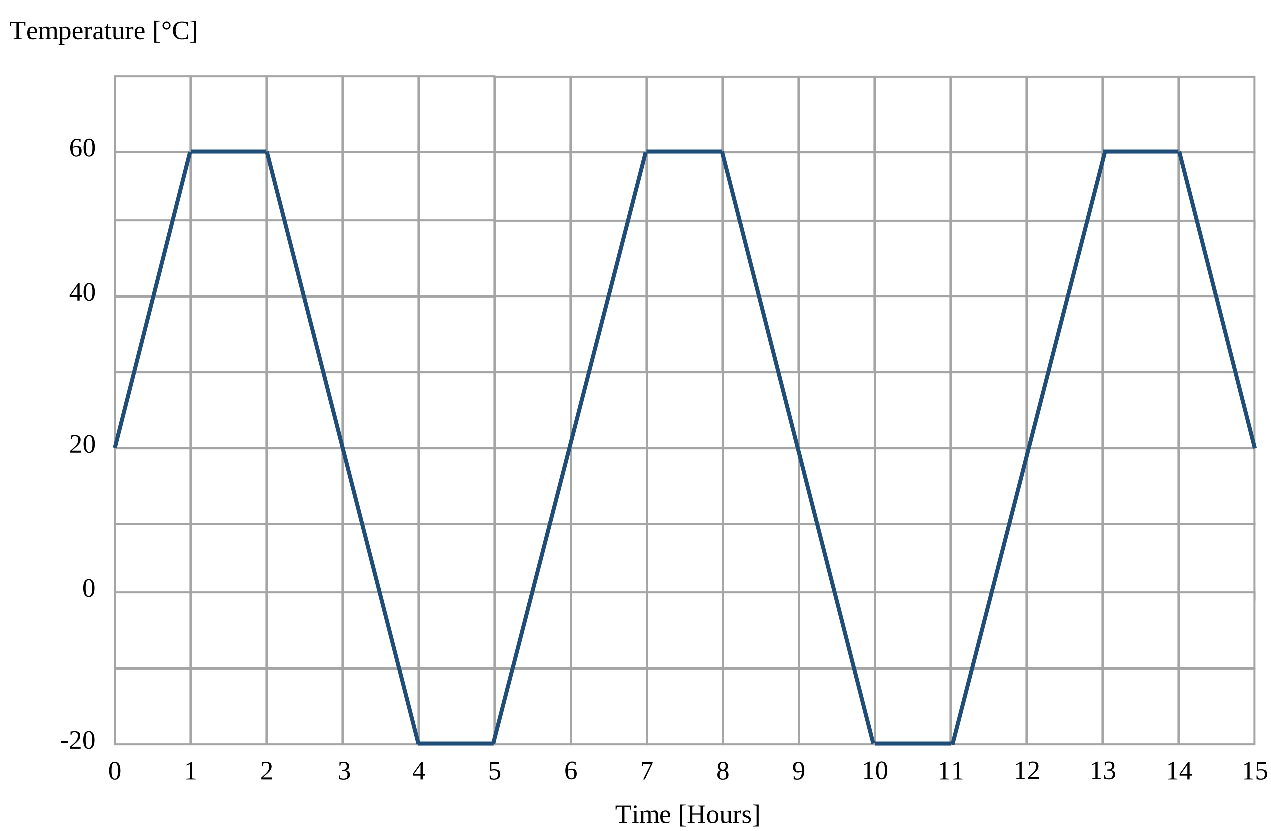
4.1.12 Power Link Vibration Performance

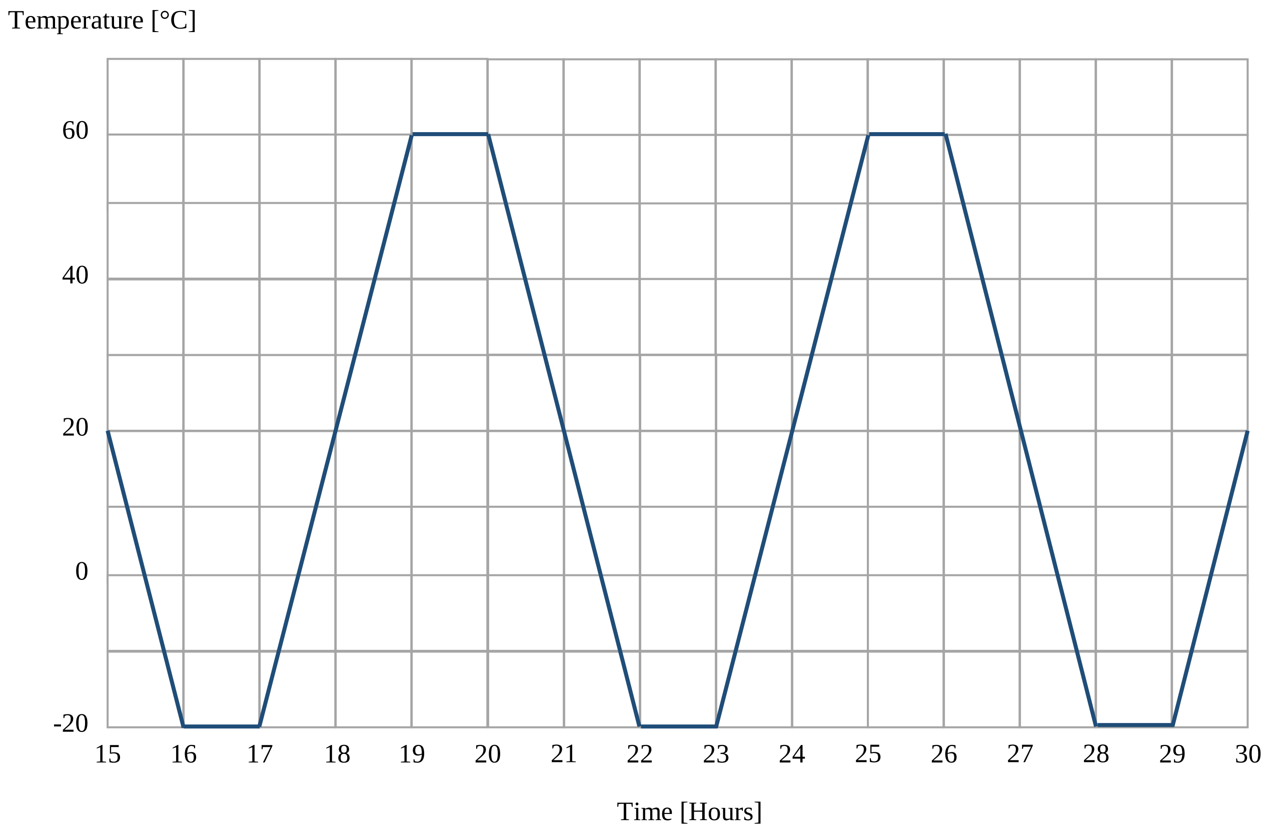
Test number	1.12 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine stable operation when the RX vibrates with respect to the TX
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω TX should be fixed, RX vibrating with respect to TX Vibration should be Sine with 2mm amplitude in X, Y and Z Directions and Frequency 10Hz
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figures 3.9.4, 3.9.5, 3.16.1
Parameters to measure	
Power Link	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output

4.1.13 Power Link Temperature Cycling operational

Test number	1.13 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine stable operation with cyclic Temperature
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Digital Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figures 3.9.4, 3.9.5
	Cycling profile see figure below: Ramp from +20 °C up to +60 °C in 1 hour Stay at +60 °C for 1 hour Ramp from +60 °C down to -20 °C in 2 hours Stay at –20 °C for 1 hour Ramp from –20 °C up to +60 °C in 2 hours Repeat the cycle 5 times
Parameters to measure	
Power Link	Ambient Temperature, TX Housing Temperature, V_{OUT}
Notes	Forced Air Flow

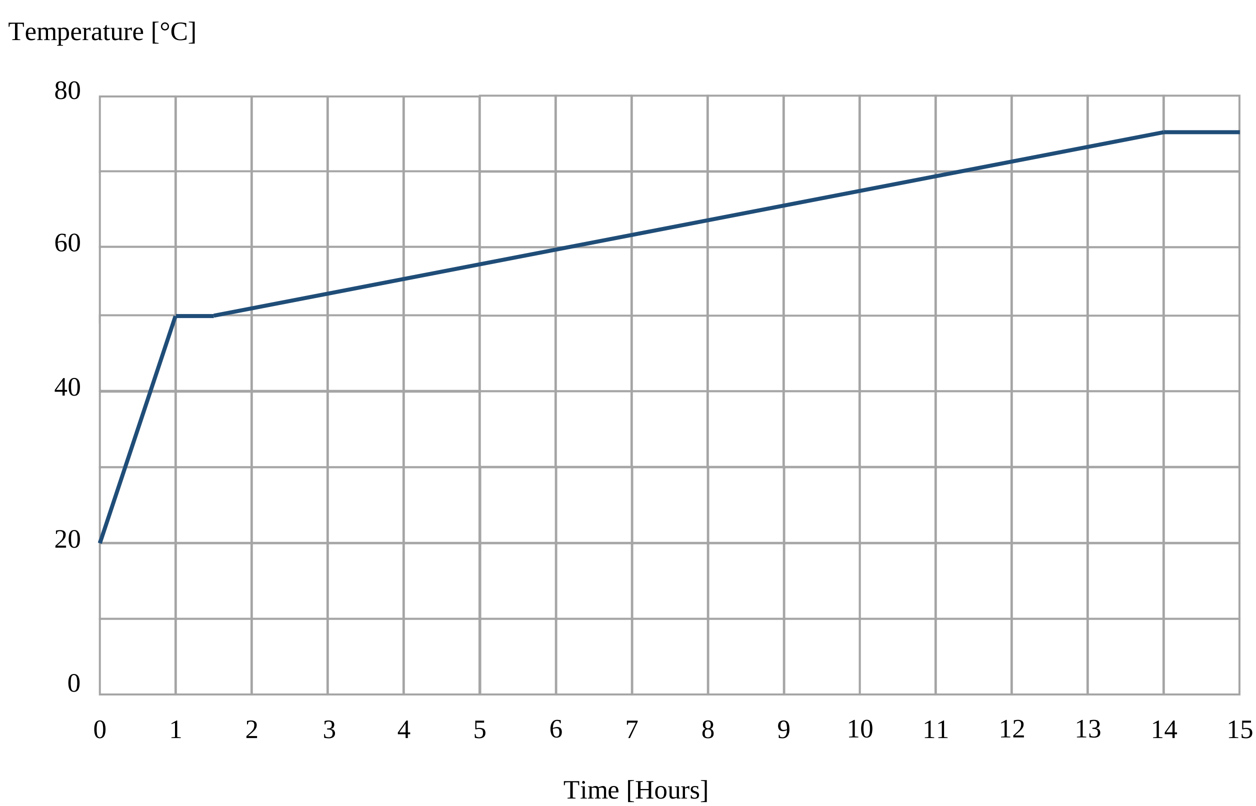
Cyclic Profile

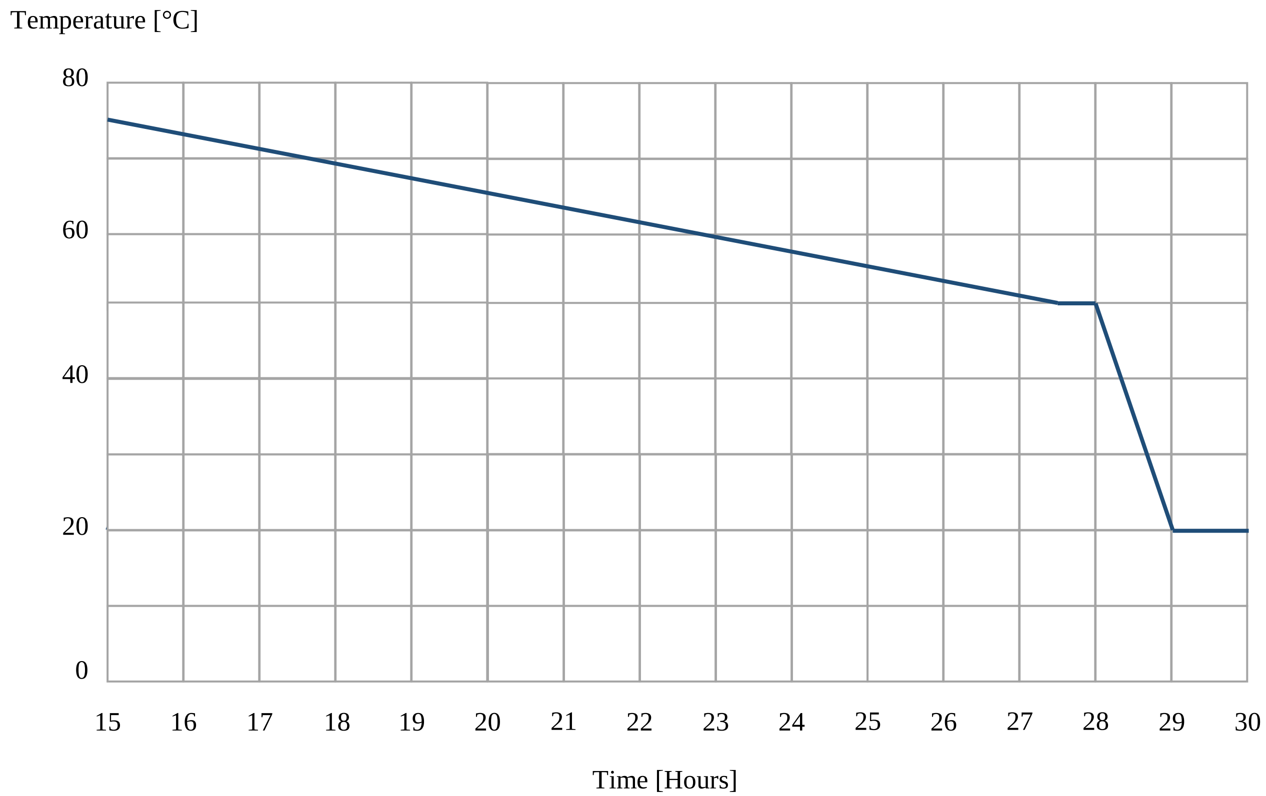



Temperature [°C]
60
40
20
0
-20
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
Time [Hours]

4.1.14 Power Link Over Temperature Protection (OTP) Threshold

Test number	1.14 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine stable OTP Threshold Level at Rising and Falling Temperatures
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figures 3.9.4, 3.9.5
	Maximum Ambient Temperature Change ≤ 5 °C / hour First Ramp from +20°C to +50°C in 1 hour Stay at +50°C for 30 minutes to stabilize Ramp from +50°C to +75°C with a speed of 2°C / hour Stay at +75°C for 1 hour Ramp Down from +75°C to +50°C with a speed of 2°C / hour Stay at +50°C for 30 minutes Ramp Down from +50°C to +50°C in 1 hour
Parameters to measure	
Power Link	Ambient Temperature, V_{OUT}
Notes	Record Temperature, during slow Temperature Rise, at which V_{OUT} is switched off. Record Temperature, during slow Temperature Fall, at which V_{OUT} is switched on again. Some Hysteresis should be observed. Forced air flow





4.1.15 Power Link Foreign Object Detection (FOD)

Test number	1.15 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine FOD Threshold
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
	Metal Plate of 0.5mm Thickness between TX and RX
	Increase X from 0.0mm to 30.0mm in steps of 0.5mm
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figures 3.6.1, 3.6.2, 3.9.4 and 3.9.5
Parameters to measure	
Power Link	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output

4.1.16 Power Link Temperature Rating

Test number	1.16 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Temperature Raise in Housing and Cap for Normal Operation and determine Maximum Output Power as function of Ambient Temperature
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm
1st Step	R_{LOAD} = 50Ω
2nd Step	Ambient Temperature increased from 50°C to 75°C in steps of 5°C
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figures 3.9.4, 3.9.5
Parameters to measure	
1st Step: Temperatures	Ambient Temperature TX Housing and TX Cap Temperatures RX Housing and TX Cap Temperatures
2nd Step: Maximum Load	Determine Maximum Load for stable 24.0V Output Voltage
Notes	Forced Air Flow

4.1.17 Power Link Operational Robustness

Test number	1.17 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Robustness of Power Link
Settings	
Power Link	R_{LOAD} = 50Ω
1st Sequence	Decrease V_{IN} from 24.0V down to 21.0V in 10s, Maximum Step Size 0.1V Increase V_{IN} from 21.0V up to 27.0V in 20s, Maximum Step Size 0.1V Decrease V_{IN} from 27.0V down to 24.0V in 10s, Maximum Step Size 0.1V All at Ambient Temperature of 20°C and Δz = 7mm
2nd Sequence	Increase Δz from 1mm to 20mm in 10s, Maximum Step Size 0.1mm Decrease Δz from 20mm down to 1mm in 10s, Maximum Step Size 0.1mm All at V_{IN} = 24.0V and Ambient Temperature of 20°C
3rd Sequence	Increase Δz from 1mm to 20mm in 0.10s Decrease Δz from 20mm down to 1mm in 0.10s All at V_{IN} = 24.0V and Ambient Temperature of 20°C
4th Sequence	Insert slowly a Metal Plate between TX and RX Caps Move along X Direction from 0mm to 30mm and from 30mm down to 0mm All at V_{IN} = 24.0V, Δz = 7mm and Ambient Temperature of 20°C
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figures 3.9.4, 3.9.5
Parameters to measure	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η ; LED Output
Notes	Normal Operating Conditions: V_{IN} = 24.0V ± 10%, $T_{amb} \leq 55$ °C and no Metal Plate between TX and RX. Power Link should startup without instabilities when parameters are (come) within Normal Operating Conditions

4.1.18 Power Link Inrush current

Test number	1.18 of the Product Specification
Setup description	TX switched from unpowered to powered, mated with loaded RX
Purpose	Determine Inrush Current
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm
	$R_{LOAD} = \infty$ and $R_{LOAD} = 50\Omega$
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figure 3.10.1
Parameters to measure	
Power Link	I_{INRUSH}

4.1.19 Power Link Output Ripple and Noise and Load Variation Regulation

Test number	1.19 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Output Ripple and Noise and Load Variation Regulation
Settings	
Power Link	V_{IN} = 24.00V
1st Step	Δz = 4mm and 7 mm, $R_{LOAD} = \infty$ and 50Ω
2nd Step	Δz = 4mm and 7 mm, R_{LOAD} switched from ∞ to 50Ω and from 50Ω to ∞
Data Link	Default Loading, Inputs Low
Measurement Setup	Acc. Figure 3.11.1
Parameters to measure	
1st Step	$V_{RIPPLE+NOISE}$ = Output Voltage and Noise
2nd Step	ΔV_{OUT} = Variations of the Output Voltage

4.1.20 Power Link Stress Tests

Test number		1.20 of the Product Specification
Setup description		TX powered, mated with loaded RX
Purpose		Determine stable Operation after stress
Settings		
Power Link		
	1st Step	Connect a and b in Figure 3.13.1, TX unmated. Set Power supply to V_{IN} = 50.00V, I_{IN_MAX} = 100mA Switch-on the Power Supply for about 1s Set Power Supply to V_{IN} = 24.00V, I_{IN_MAX} = 1A
	2nd Step	Connect a and b as shown in Figures 3.13.1 and 3.13.2 V_{IN} = 26.40V, I_{IN_MAX} = 1A, Δz = 7mm, R_{LOAD} = 50Ω
	3rd Step	Connect a and b as shown in Figures 3.13.1 and 3.13.2 V_{IN} = 24.00V, I_{IN_MAX} = 1A, Δz = 7mm, R_{LOAD} = 50Ω Power Input shorted at least 10 times
	4th Step	Connect a to the metal file and b to the metal contact as shown in Figures 3.13.1 and 3.13.3 V_{IN} = 24.00V, I_{IN_MAX} = 1A, Δz = 7mm, R_{LOAD} = 50Ω Slide the contact over the file for at least 1 minute while the system is running. After 1 minute contact should be connected to the file
	5th Step	Short circuit a and b and connect them to the metal file. Connect g to the metal contact. Refer to Figures 3.13.1 and 3.13.3 V_{IN} = 24.00V, I_{IN_MAX} = 1A, Δz = 7mm, R_{LOAD} = 50Ω Slide the contact over the file for at least 1 minute while the system is running. After 1 minute, disconnect contact from file.
Data Link		Default Loading, Inputs Low
Measurement Setup		Acc. Figure 3.13.1
Parameters to measure		Power Link
	1st Step	Monitor V_{IN} and I_{IN} during the time the power supply is on. I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η after V_{IN} is set to 24.00V again.
	2nd Step	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η
	3rd Step	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η after Power Input Short
	4th Step	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η after file test
	5th Step	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η after file test

4.2 Test Definitions of Data Link Measurements

In following sections are described the different tests. All unspecified settings need to be equal to the default value.
The mentioned test numbers refer to the tests described in the Product Specification (PS).

4.2.1 Digital Data Link Functionality

Test number	2.01 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Data Link Connections and Functionality of the GPIO-1 to GPIO-8 Channels (Voltage Levels and Bit Error Rate within specification)
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Data Link	Default Loading
1st Step	GPI Channel 1 toggling with 166Hz, all other Channel Inputs Low
2nd Step	GPI Channel 2 toggling with 166Hz, all other Channel Inputs Low
…	…
8th Step	GPI Channel 8 (1) toggling with 166Hz, all other Channel Inputs Low
Measurement Setup	Acc. Figures 3.9.4, 3.9.5, 3.18.1, 3.18.2, 3.18.3, 3.18.4
Parameters to measure	Data Link
1st Step	GPO Channel 1 toggling with 166Hz, all other Channel Inputs Low
2nd Step	GPO Channel 2 toggling with 166Hz, all other Channel Inputs Low
…	…
8th Step	GPO Channel 8 (1) toggling with 166Hz, all other Channel Inputs Low
	The signal of an active Channel should be within mask as given by Fig. 3.18.2, 3.18.3, 3.18.4 Bit Error Rate (BER) should be $\leq 10^{-4}$
Notes	Number of samples to be measured ≥ 20.000 Maximum number of errors = 1

4.2.2 Digital Data Link Latency and Jitter

Test number	2.02 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Data Link Latency and Jitter
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Data Link	Default Loading, Inputs toggling at 166Hz
Measurement Setup	Acc. Figures 3.9.4, 3.9.5, 3.18.1, 3.18.2, 3.18.3, 3.18.4
Parameters to measure	Rise and Fall Times according to Figure 3.18.3 Latency and Jitter according to Figure 3.18.3

Note (1): The Number of GPIO Lines depends on the product´s type

4.2.3 Digital Data Link Sensitivity to XYZ and Tilt Misalignment

Test number	2.03 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Data Link Sensitivity to XYZ and Tilt Misalignment
Settings	
Power Link	V_{IN} = 24.00V
1st Sequence	(Δz, Δr, $\Delta\Omega$) = (0, 5, 0), (2, 4, 0), (2, 0, 10), (5, 3, 0), (5, 0, 20) Δz = 7mm, R_{LOAD} = 50Ω
2nd Sequence	(Δz, Δr, $\Delta\Omega$) = (7, 2, 0), (7, 0, 30) Load at RX according to measurements of Test 1.06
Data Link	Default Loading, Inputs toggling at 166Hz
Measurement Setup	Acc. Figures 3.2.2, 3.9.4, 3.9.5, 3.18.1, 3.18.2, 3.18.3, 3.18.4
Parameters to measure	Bit Error Rate of GPO Channels
Notes	Number of samples to be measured ≥ 20.000 Maximum number of errors = 1

4.2.4 Digital Data Link Output Short Circuit Protection and Output Impedance

Test number	2.04 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Short Circuit Output Current and Recovery after Removal of Short Circuit situation of Data Links
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Digital Data Link	Inputs toggling with 166Hz
	Switch Load at GPO-1 to GPO-8 (1) (TX side) from 10kΩ to 1Ω and back
Measurement Setup	Acc. Figures 3.9.4, 3.9.5, 3.18.1, 3.18.2, 3.18.3, 3.18.4
Parameters to measure	Data Link
1st Step	Short Circuit Current and Recovery at GPO-1 to GPO-8 (1) (TX side), R_{S1} = 1Ω Load
2nd Step	Voltage Drop at GPO-1 to GPO-8 (1) (TX side) between 10kΩ Load and R_{S2} = 100Ω Load
Notes	In the 2nd Step, the Output Impedance can be determined Maximum drop in output voltage between 10kΩ and 100Ω should be less than 1V

Note (1): The Number of GPIO Lines depends on the product´s type

4.2.5 Digital Data Link Rotational Freedom

Test number	2.05 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine Rotational Freedom of the Data Link
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Digital Data Link	Default Loading, Inputs toggling with 166Hz
1st Step	TX angle Θ = 0°, 90°, 180° and 270° with respect to RX
2nd Step	TX fixed, dynamic rotation of RX at 1250rpm
Measurement Setup	Acc. Figures 3.4.1, 3.9.4, 3.9.5, 3.18.1, 3.18.2, 3.18.3, 3.18.4
Parameters to measure	Bit Error Rate of GPO Channels
Notes	Number of samples to be measured ≥ 20.000 Maximum number of errors = 1

4.2.6 Digital Data Link Operational Readiness

Test number	2.06 of the Product Specification
Setup description	TX powered through switch SW1, mated with loaded RX
Purpose	Determine Operational Readiness
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Digital Data Link	GPI-1 = 24.00V
Measurement Setup	Acc. Figure 3.15.1
Parameters to measure	
Power Link	Trigger at Output Voltage ≥ 22.8V
Data Link	Time between Output Voltage ≥ 22.8V and First Edge at GPO

4.2.7 Digital Data Link Inter Coupler Distance

Test number	2.07 of the Product Specification
Setup description	Two normal operating Couplers in close proximity
Purpose	Determine stable operation of two Couplers in close proximity
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω for both Couplers, Inter Coupler Distance = 60mm
Digital Data Link	Default Loading, Inputs toggling with 166Hz
Measurement Setup	Acc. Figures 3.3.1, 3.9.4, 3.9.5, 3.18.1, 3.18.2, 3.18.3, 3.18.4
Parameters to measure	
Data Link Pair 1	Bit Error Rate of GPO Channels ≤ 10^{-4}
Data Link Pair 2	Bit Error Rate of GPO Channels ≤ 10^{-4}
Notes	Number of samples to be measured ≥ 20.000 Maximum number of errors = 1

4.2.8 Digital Data Link Metal Clearance

Test number	2.08 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine stable operation of Couplers in Metal Enclosure
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω Metal Clearance = 30mm
Digital Data Link	Default Loading, Inputs toggling with 166Hz
Measurement Setup	Acc. Figures 3.5.1, 3.9.4, 3.9.5, 3.18.1, 3.18.2, 3.18.3, 3.18.4
Parameters to measure	Data Link: Bit Error Rate of GPO Channels
Notes	Number of samples to be measured ≥ 20.000 Maximum number of errors = 1

4.2.9 Digital Data Link Vibrational Performance

Test number	2.09 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine stable operation when RX vibrates with respect to TX
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω TX should be fixed, RX vibrating with respect to TX Vibration should be Sine with 2mm amplitude in X, Y and Z Directions and Frequency 10Hz
Digital Data Link	Default Loading, Inputs toggling with 166Hz
Measurement Setup	Acc. Figures 3.9.4, 3.9.5, 3.16.1, 3.18.1, 3.18.2, 3.18.3, 3.18.4
Parameters to measure	Data Link: Bit Error Rate of GPO Channels
Notes	Number of samples to be measured ≥ 20.000 Maximum number of errors = 1

4.2.10 Digital Data Link Temperature Cycling operational

Test number	2.10 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine stable operation with cyclic Temperature
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Digital Data Link	Default Loading, Inputs toggling with 166Hz
Measurement Setup	Acc. Figures 3.9.4, 3.9.5, 3.18.1, 3.18.2, 3.18.3, 3.18.4 Temperature profile acc. to §4.1.13
Parameters to measure	Data Link: Bit Error Rate of GPO Channels
Notes	Number of samples to be measured ≥ 20.000 Maximum number of errors = 1

4.2.11 Digital Data Link Operational Robustness

Test number	2.11 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine stable mating connection during mating and unmating cycles
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Digital Data Link	Default Loading, Inputs toggling with 166Hz
Measurement Setup	Acc. Figures 3.9.4, 3.9.5, 3.18.1, 3.18.2, 3.18.3, 3.18.4 Maximum ambient temperature change ≤ 5 °C / hour
Parameters to measure	166Hz Output Signal at GPO-1 to GPO-8 (1) must appear within 2s after mating
Notes	Number of mating cycles = 10 Time between unmating and mating again at least 5s

4.2.12 Digital Data Link Output Status

Test number	2.12 of the Product Specification
Setup description	TX powered, unmated and mated with loaded RX
Purpose	Determine default Digital Output Status
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Digital Data Link	All GPI connected to +24V_{DC}
Measurement Setup	Acc. Figure 3.15.1
Parameters to measure	Digital Data Link
1st Test	GPIO-1 to GPIO-8 (1) levels after unmated TX is powered – SW1 ON
2nd Test	GPIO-1 to GPIO-8 (1) levels after mated TX is powered – SW1 ON
3rd Test	GPIO-1 to GPIO-8 (1) levels after mated TX is powered – SW1 ON and slowly unmated

4.2.13 Digital Data Link Salt Water Test

Test number	2.13 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine BER with Coupler operational in Salt Water
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Digital Data Link	Default Loading, Inputs toggling with 166Hz TX and RX submerged in Salt Water (4% NaCl dissolved in water)
Measurement Setup	Acc. Figures 3.9.4, 3.9.5, 3.18.1, 3.18.2, 3.18.3, 3.18.4
Parameters to measure	Data Link: Bit Error Rate of GPO Channels
Notes	Number of samples to be measured ≥ 20.000 Maximum number of errors = 1

Note (1): The Number of GPIO Lines depends on the product´s type

4.2.14 Digital Data Link Stress Test

Test Number	2.14 of the Product Specification
Setup description	TX powered, mated with loaded RX
Purpose	Determine stable operation after stress test
Settings	
Power Link	V_{IN} = 24.00V, Δz = 7mm, R_{LOAD} = 50Ω
Digital Data Link	
1st Step	GPIn connected to 166Hz, GPOn connected to 100Ω – SW1 OFF, GPOn+1 not connected to +30V – SW2 OFF
2nd Step	GPIn connected to 166Hz, GPOn connected to Ground – SW1 ON, GPOn+1 not connected to +30V – SW2 OFF
3rd Step	GPIn connected to 166Hz, GPOn connected to 100Ω – SW1 OFF, GPOn+1 connected to +30V – SW2 ON
4th Step	GPIn connected to 166Hz, GPOn connected to Ground – SW1 ON, GPOn+1 connected to +30V – SW2 ON
Measurement Setup	Acc. Figure 3.19.1
Parameters to measure	Data Link
1st and 3rd Steps	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η BER of GPOn channel
2nd and 4th Steps	I_{IN} ; P_{IN} ; V_{OUT} ; I_{OUT} ; P_{OUT} ; η BER of GPOn channel after removing short to Ground
Notes	n = 1…8 (in case n = 8 then n+1 = 1) All four steps should be run for at least 1 hour each Number of samples to be measured ≥ 20.000 Maximum number of errors = 1