

DIGITAL WE DAYS

2023



CREEPAGE AND CLEARANCE OF
CONNECTOR

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

TODAY'S SPEAKERS



PRESENTATION

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Field Application Engineer



MODERATION

Markus Eberle
Marketing Department

INFORMATION ABOUT THE WEBINAR

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However, you can ask us questions using the chat function.

Duration of the presentation 30 Min
Q&A: 10 – 15 Min

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WHAT IS IT ?



Source: Pixabay

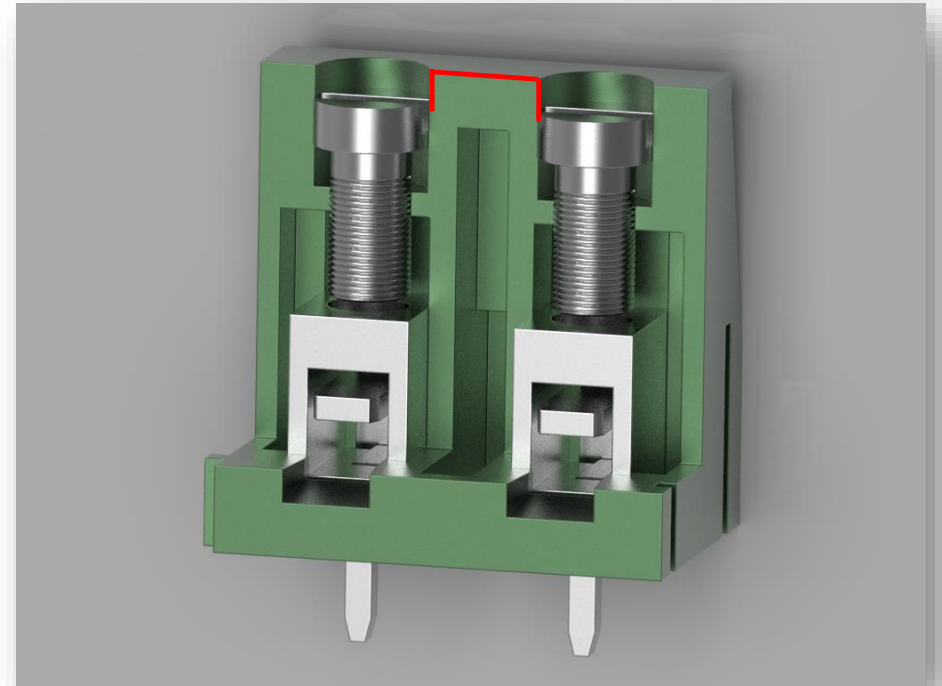
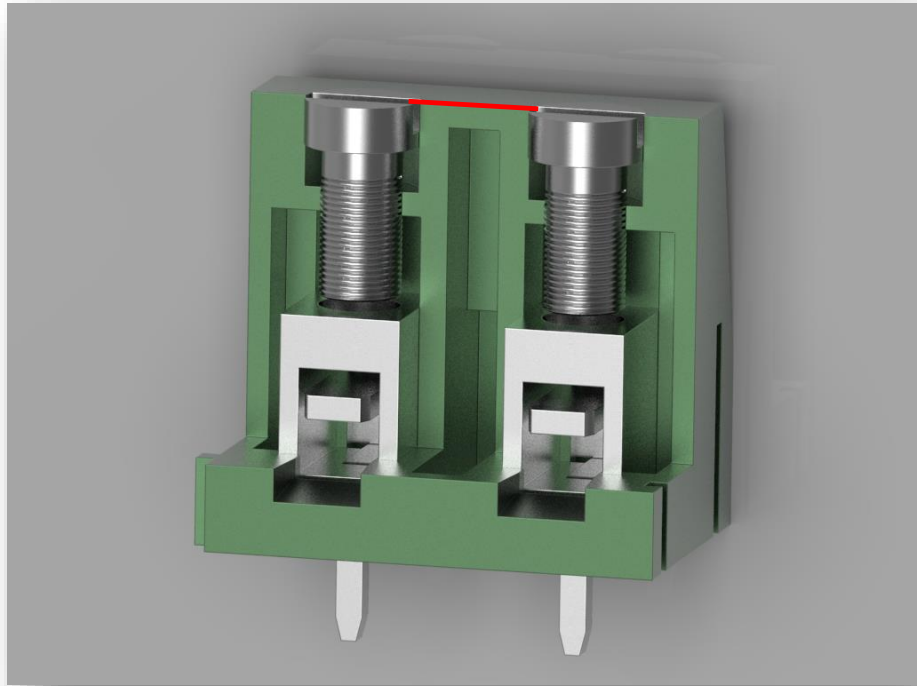
AGENDA

- What is electrical insulation
- Most common applicable standards
- Creepage and clearance rules
- Other standards
- Products limits



WHAT IS THE RIGHT
DISTANCE FOR A SPARK ON
EARTH ?

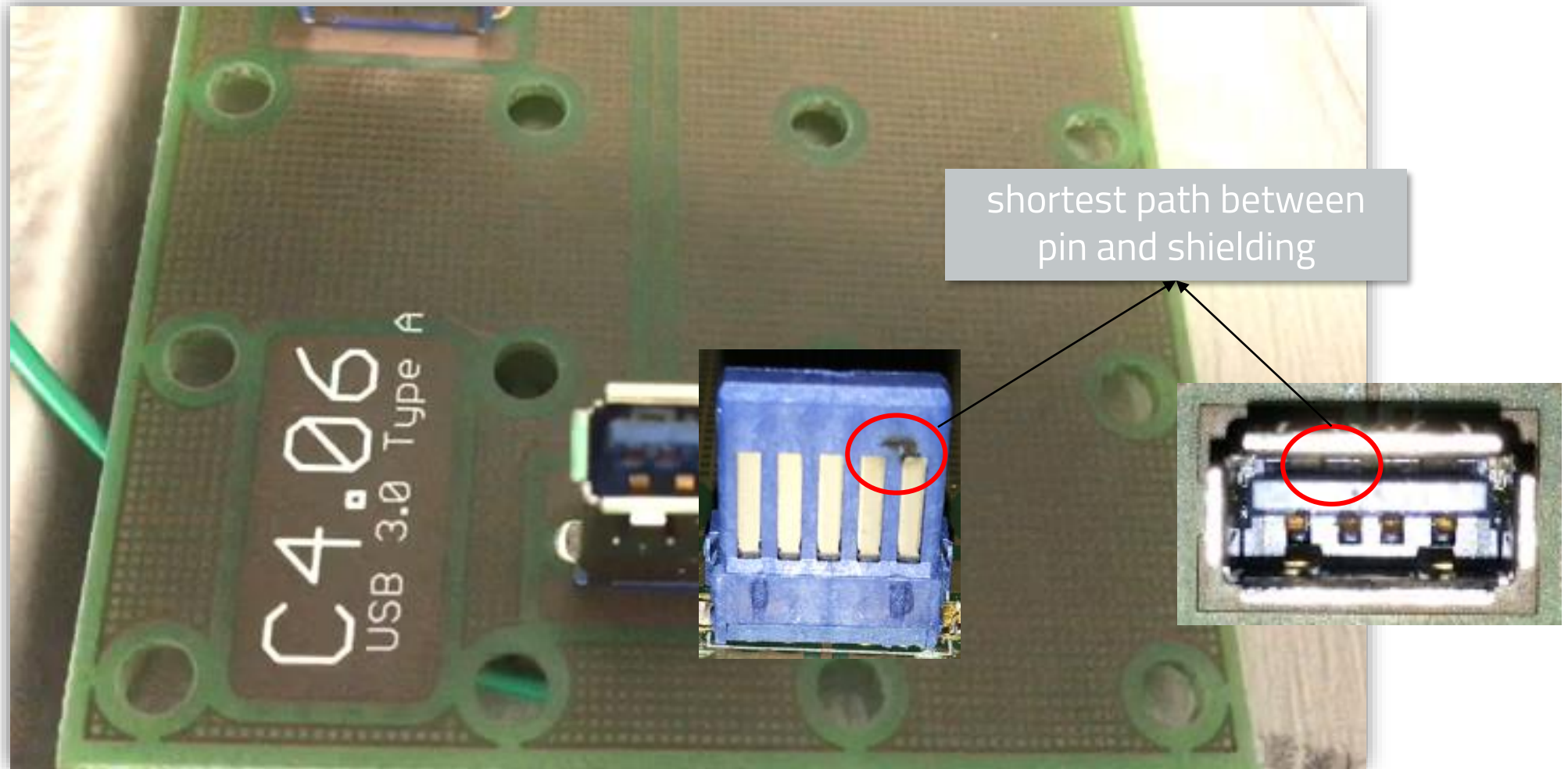
CLEARANCE DEFINITION



WE-eiCan

INCREASING CLEARANCE
WITH ANYKIND OF
MATERIAL ?

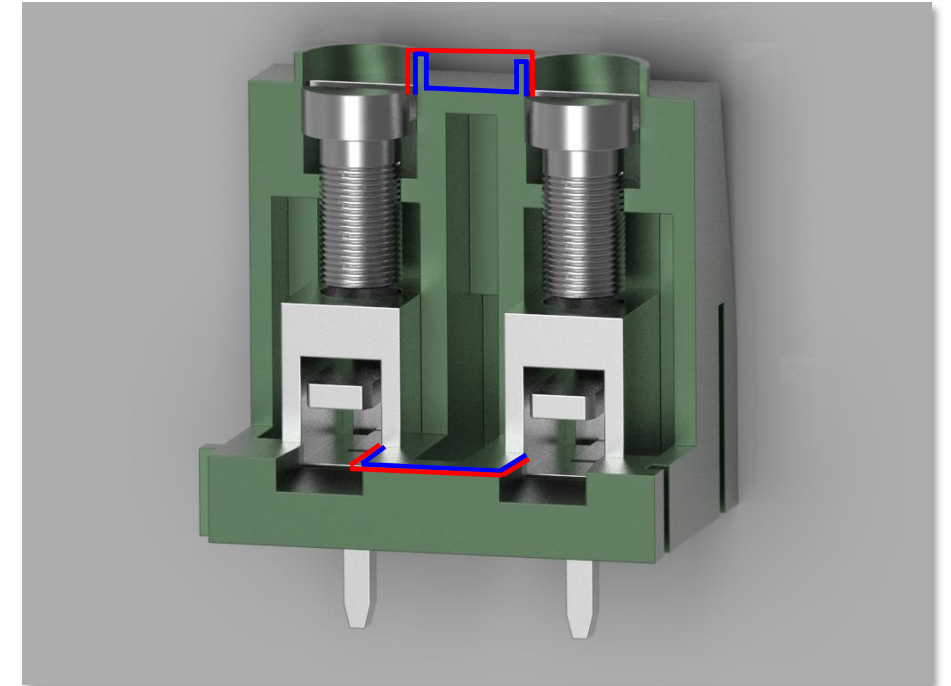
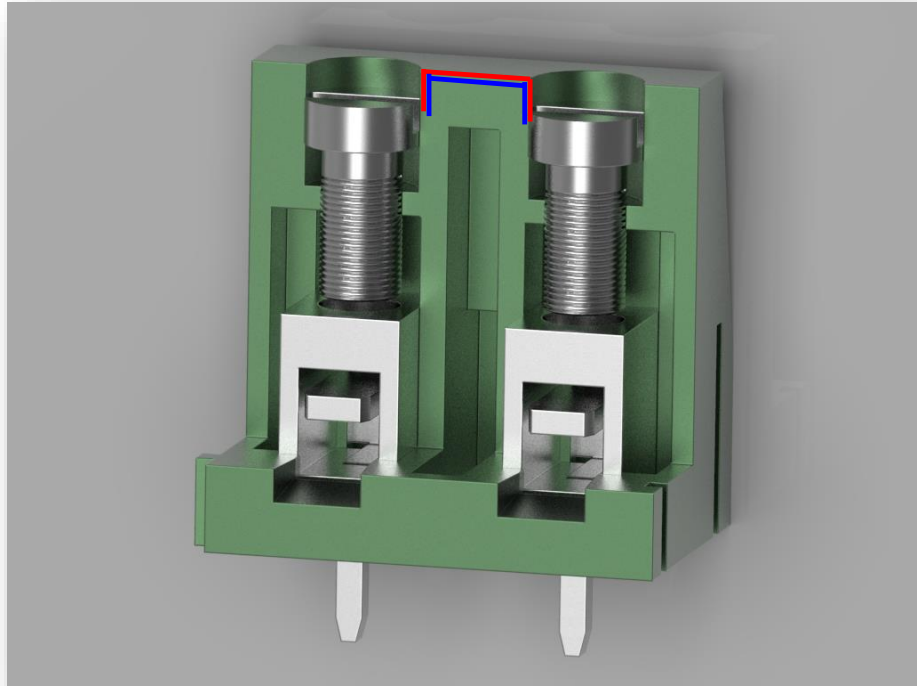
A REAL TEST ON REAL PRODUCT



All pictures: WE-eiCan

CREEPAGE DEFINITION

Clearance - Creepage



WE-eiCan

AGENDA

- What is electrical insulation
- Most common applicable standards
- Creepage and clearance rules
- Other standards
- Products limits



HOW TO CHOOSE YOUR STANDARD AND APPLICATION?



All pictures: WE-eiCan

MAIN STANDARDS APPLIED

IEC / ANSI / UL / DIN EN 60950-1

replaced by

IEC / ANSI / UL / DIN EN 62368-1

IEC / ANSI / UL / DIN EN 60947-1

IEC / DIN EN 60664-1

VDE / DIN 0110

UL / ANSI / DIN EN 804

IEC / DIN EN 61140

IEC / ANSI / UL / DIN EN 61058-1

UL / ANSI 508C

Information technology equipment – Safety

Audio/video, information and communication technology equipment – Safety requirements

Low-voltage switchgear and controlgear

Insulation coordination for equipment within low-voltage systems
Equivalent to IEC60664-1

Insulation coordination including clearances and creepage distances for electrical equipment

Protection against electric shocks – common aspect for installation and equipment

Switches for appliances

Standard for safety for power conversion equipment

PARAMETERS FOR CALCULATION

	Parameter	Clearance	Creepage
1	Pollution degree	😊	😊
2	Altitude	😊	
3	Insulator CTI		😊
4	Overvoltage category	😊	
5	Impulse withstand voltage	😊	
6	Working voltage	😊	😊

POLLUTION DEGREE

Pollution degree	Not conductive pollution	Conductive pollution due to condensation	Rain/snow	Application example
1	possible	no	no	Sealed components White room
2	yes	temporary	no	Laboratories Office environment
3	yes	permanent	no	Industrial Farming Unheated rooms
4	yes	permanent	yes	Outdoor

POLLUTION DEGREE

examples

Pollution degree 1: Computer power supply



Pollution degree 2: Lab oven



Pollution degree 3: Workshop systems



Pollution degree 4: Outdoor electric vehicle connector



All pictures: WE-eiCan

ALTITUDE



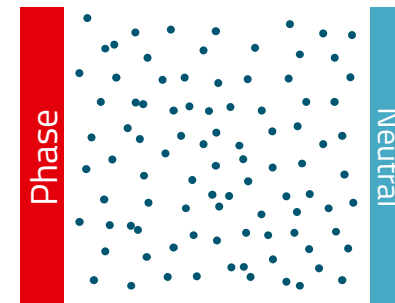
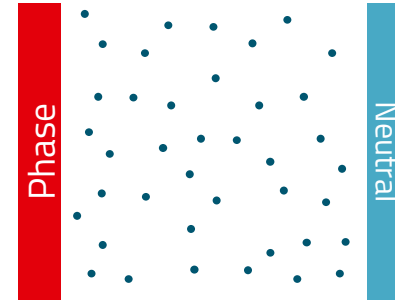
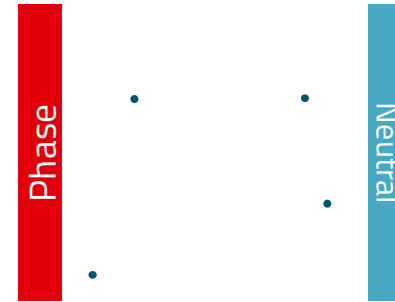
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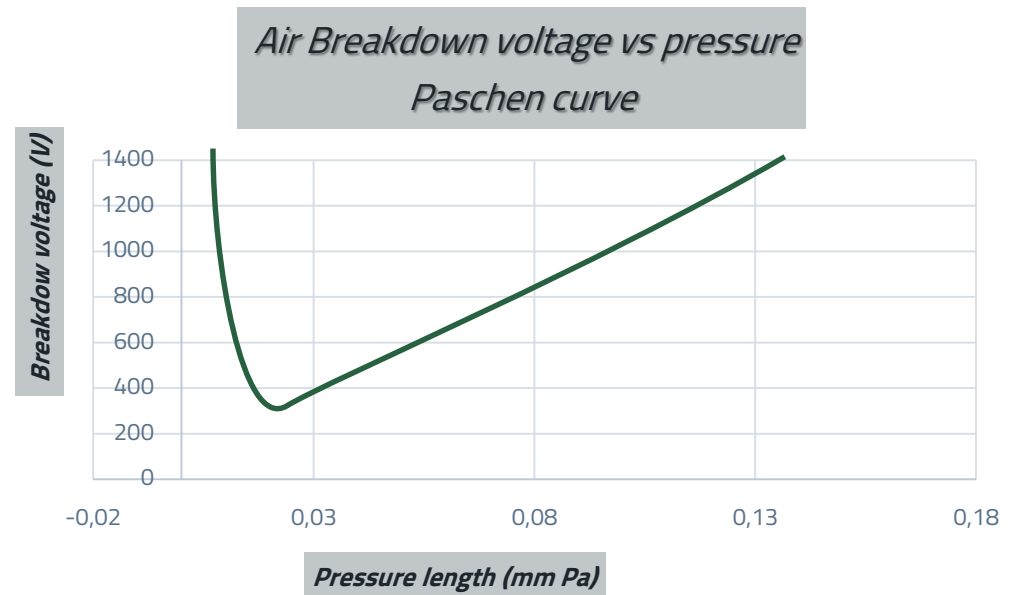
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ALTITUDE



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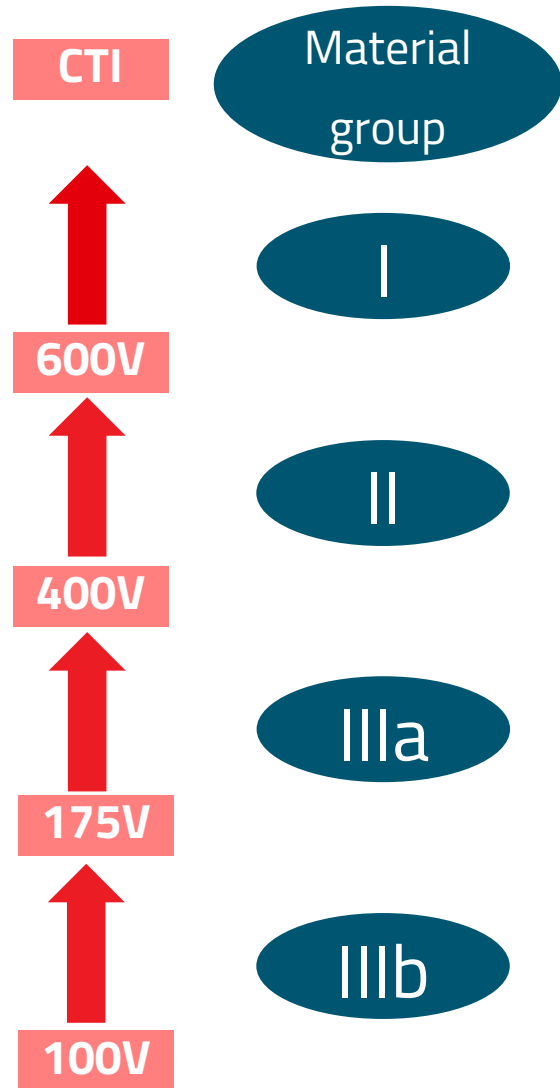


CTI - COMPARATIVE TRACKING INDEX

Comparative Tracking
Index
(CTI)
ASTM D3638
IEC 60112
UL 746A-24

With kind authorization of
 **ELTEK**
International Laboratories
elteklabs.com

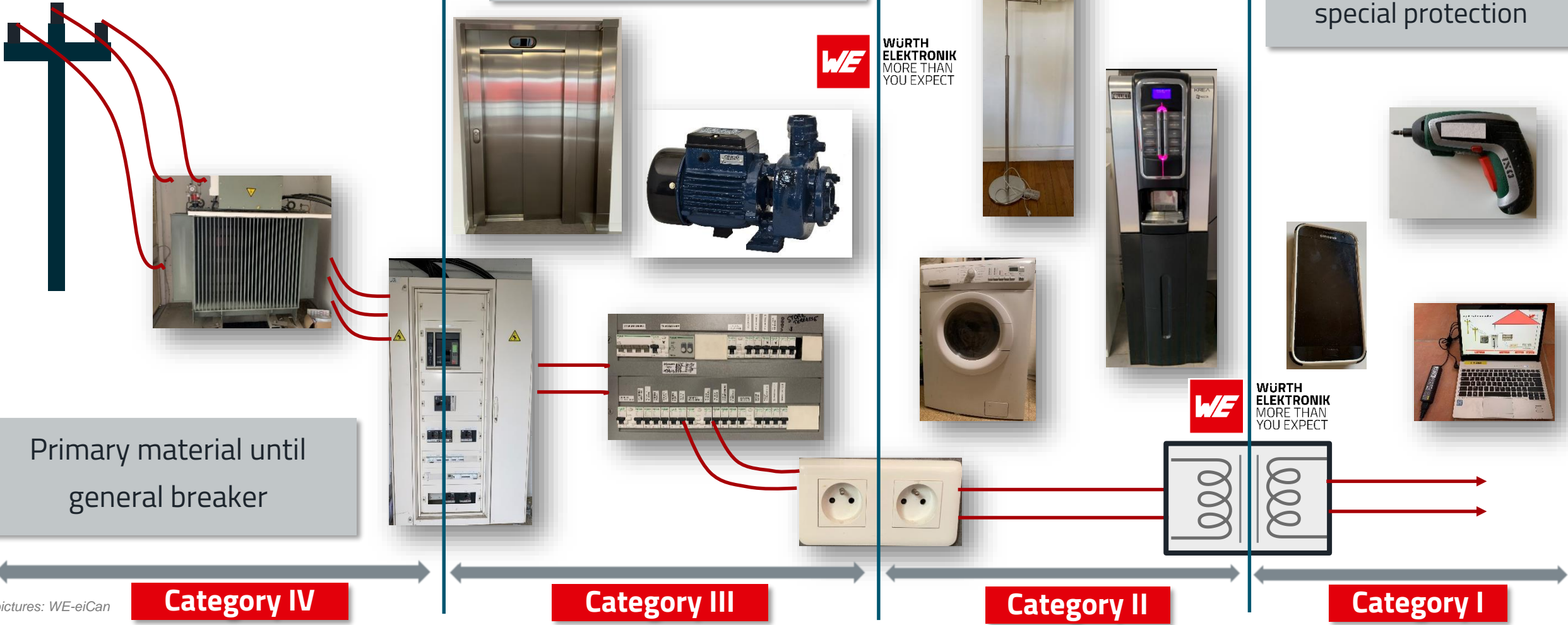
CTI - COMPARATIVE TRACKING INDEX



Examples

	Material	CTI (V)	Material group
For information – Numbers could vary	PA	600	I
	PTFE (Teflon)	600	I
	PBT	400	II
	PC	250	IIIa
	LCP	145	IIIb

OVERVOLTAGE CATEGORY



Industrial machinery
Electrical distribution

Electrical products
after outlets

Electrical products with
special protection

Primary material until
general breaker

Category IV

Category III

Category II

Category I



All pictures: WE-eiCan



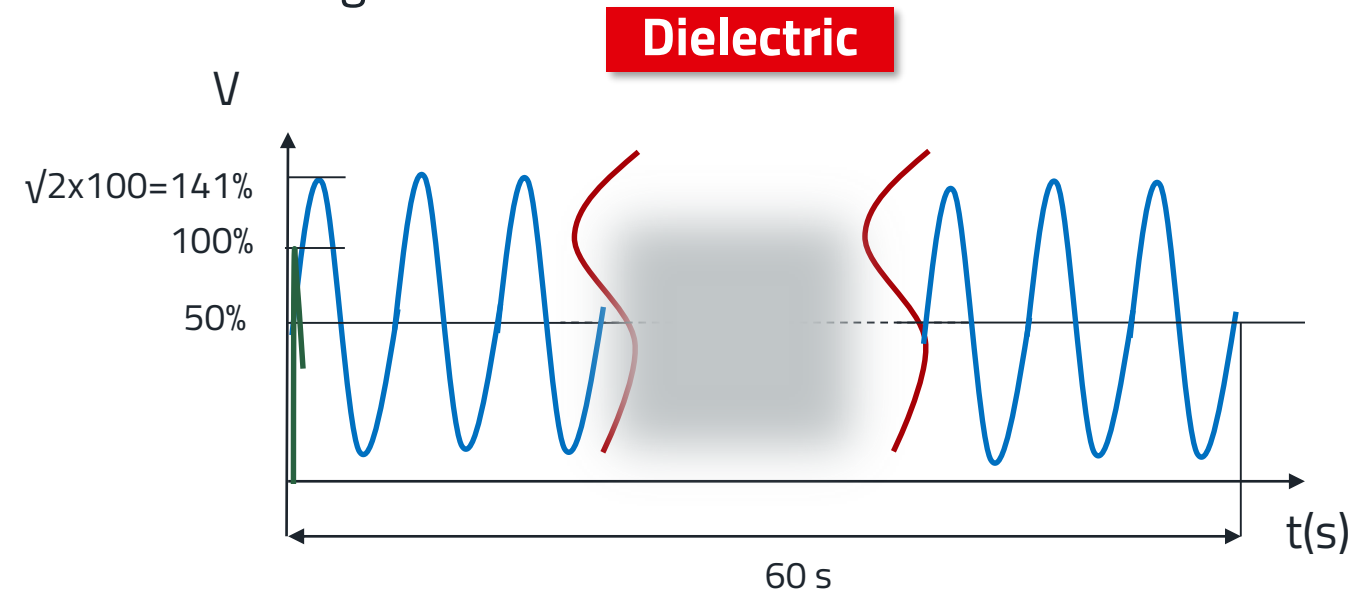
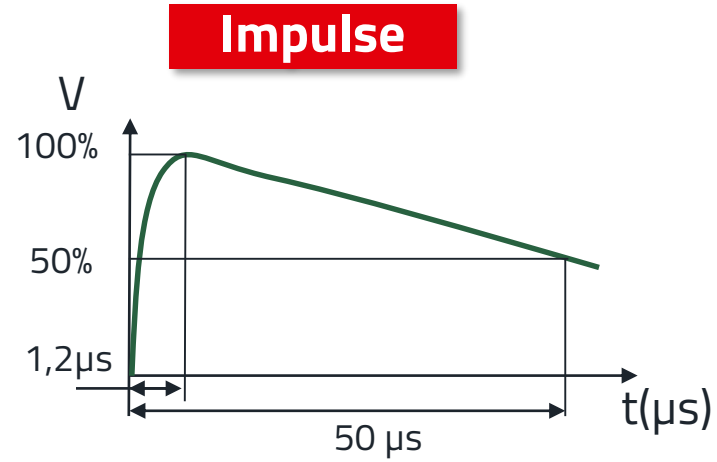
OVERVOLTAGE CATEGORY - IMPULSE WITHSTAND VOLTAGE

➤ Standard table extract to find overvoltage

Voltage AC rms or DC	Rated impulse voltage Overvoltage category			
	I kV	II kV	III kV	IV kV
50	0,33	0,5	0,8	1,5
100	0,5	0,8	1,5	2,5
150	0,8	1,5	2,5	4
300	1,5	2,5	4	6
600	2,5	4	6	8
1000	4	6	8	12

IMPULSE WITHSTAND VOLTAGE

➤ Impulse withstand voltage vs dielectric withstand voltage



**Impulse vs dielectric :
1 page / 1200 pages**

IMPULSE WITHSTAND VOLTAGE

➤ How to handle with WE products:



Mechanical Properties

Wire Strip Length	6 (mm)
Screw	M3

Packaging Properties

Packaging	Box
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Kind Properties

Pitch	5.08 mm
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General Information

Operating Temperature	-30 up to +120 °C
Compliance	Lead free / RoHS

Electrical Properties

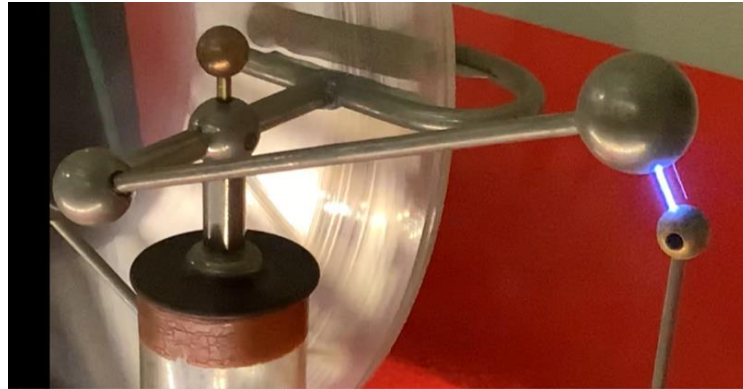
I _{R UL}	20 A
I _{R VDE}	20 A
Working Voltage [UL]	300 V (AC)
Working Voltage [VDE]	450 V (AC)
Withstanding Voltage [UL]	1600 V (AC)
Withstanding Voltage [VDE]	2500 V (AC)
Contact Resistance	20 mΩ

Examples

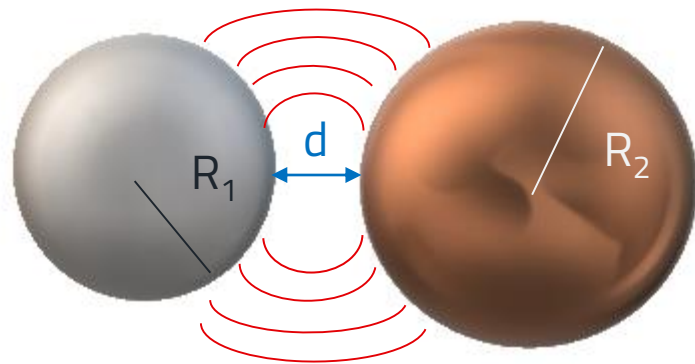
Neutral – phase voltage derived from the AC or DC voltage	Rated impulse voltage Overvoltage category
	I kV
50	0,33
100	0,5
150	0,8
300	1,5
600	2,5
1000	4

$$2500 \times \sqrt{2} \approx 3,5 \text{ kV}$$

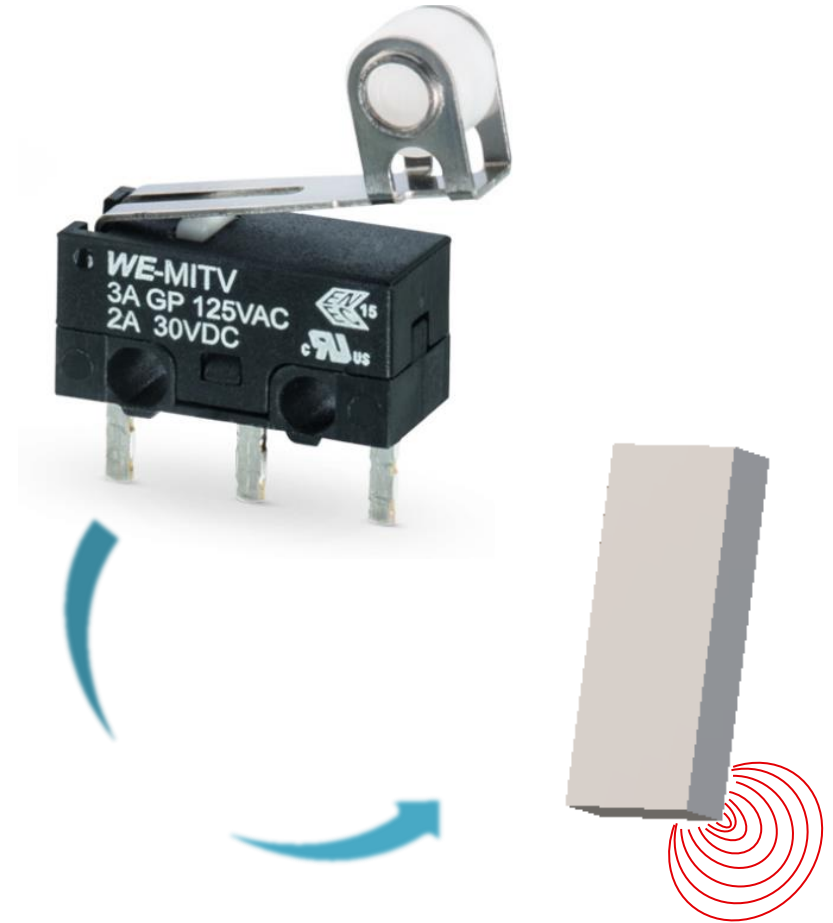
CLEARANCE CALCULATION



WE-eiCan



Homogeneous field
 $d < R_1 \text{ \& \ } R_2$



Inhomogeneous field

CLEARANCE CALCULATION

Minimum Clearance at altitude 2000m above sea level in mm								
Required impulse withstand voltage kV	Case A Inhomogeneous field				Case B Homogeneous field			
	Pollution degree				Pollution degree			
	1	2	3	4	1	2	3	4
0,33	0,01				0,01			
0,4	0,02				0,02			
0,5	0,04				0,04			
0,6								
0,8	0,10				0,1			
1	0,15			1,6	0,15			
1,2	0,25	0,25			0,2			
1,5	0,5	0,5			0,3			
2	1	1	1		0,45			
2,5	1,5	1,5	1,5		0,6			
3	2	2	2	2	0,8			
4	3	3	3	3	1,2			
5	4	4	4	4	1,5			
6								
8								
10	11	11	11	11	3,5	3,5		
12	14	14	14	14	4,5	4,5	4,5	4,5

Voltage AC rms or DC	I kV
50	0,33
100	0,5
150	0,8
300	1,5
600	2,5

CREEPAGE

CTI > 600
Material group = I

Minimum creepage distances in mm

Voltage rms V	Printed wiring material		Pollution degree											
	1	2	1	2										
	All material groups	All material groups except IIIb	All material groups	Material group I	Material group II	Material group III								
200	0,4	0,63	0,42	1	1,4	2								
250	0,56	1	0,56	1,25	1,8	2,5								
320	0,75	1,6	0,75	1,6	2,2	3,2	4	4,5	6,3	8	10			
400	1	2	1	2	2,8	4	5	5,6	6,3	8	10	12,5		
1000	3,2	5	3,2	5	7,1	10	12,5	14	16	20	25	32		



Mechanical Properties

Wire Strip Length	6
Screw	M3

Packaging Properties

Kind Properties

Pitch	5.08 mm
-------	---------

General Information

Operating Temperature	-30 up to +120 °C
Compliance	RoHS

Electrical Properties

$I_{R\ cULus}$	14 A
$I_{R\ VDE}$	14 A
Working Voltage [cULus]	300 V (AC)
Working Voltage [VDE]	250 V (AC)

Material Properties

Insulator Material	PA66
Insulator Flammability Rating	UL94 V-0
Contact Material	Copper Alloy
Contact Plating	Tin over Nickel
Terminal Screw Material	Steel
Terminal Screw Plating	Zinc
Wire Guard Material	Copper Alloy
Certification	
cULus Approval	E150931
VDE Approval	40021366

AGENDA

- What is electrical insulation
- Most common applicable standards
- Creepage and clearance rules
- Other standards
- Products limits



SPECIFIC STANDARDS APPLIED

UL 1977

Components connectors for use in Data, Signal, Control and power applications

UL / ANSI 1059

Terminal blocks

CSA C22.2 n° 158-10

Terminal blocks



**WÜRTH
ELEKTRONIK**
MORE THAN
YOU EXPECT

IPC 2221

Generic standards of printed board design

IEC / DIN EN 60598-1

Luminaires – General requirements and tests

UL1059 – CSA C22.2 N° 158-10 : TERMINAL BLOCKS

Application

Service – including dead-front, switchboards, panel boards

Commercial appliances, including business equipment, electronic, data processing equipment

Industrial general

Industrial with limited ratings

Terminal blocks above 600V



Mechanical Properties

Wire Strip Length 6 (mm)

Screw

Packaging Properties

Packaging Box

Kind Properties

Pitch 5.08 mm

General Information

Operating Temperature -30 up to +120 °C

Electrical Properties

I_{RUL} 20 A

I_{RVDE} 20 A

Working Voltage [UL] 300 V (AC)

Working Voltage [VDE] 450 V (AC)

Withstanding Voltage [UL] 1600 V (AC)

Withstanding Voltage [VDE] 2500 V (AC)

Contact Resistance ≤ 10 mΩ

1000 - 1500

17,8

30,5



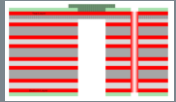
WURTH ELEKTRONIK
MORE THAN YOU EXPECT



PCB STANDARD – IPC2221 GENERIC STANDARDS OF PRINTED BOARD DESIGN

Minimum spacing IPC2221 mm

Table 10

Voltage between conductors (DC or AC peaks)	Equivalent Vac rms	Bare Printed Board		Assembly				
		B1	B2	B3	B4	A5	A6	A7
		internal conductors	external conductors	external conductors	external conductors	external conductors	External component lead	External component lead
			uncoated sea level ≤3050m	uncoated >3050m	permanent coating any elevation	permanent coating any elevation	uncoated sea level ≤3050m	permanent coating any elevation
0 – 15	0 – 11	0,05	0,1	0,1	0,05	0,13	0,13	0,13
16 – 30	12 – 21	0,05	0,1	0,1	0,05	0,13	0,25	0,13
31 – 50	22 – 35	0,1	0,64	0,64	0,13	0,13	0,4	0,13
51 – 100	36 – 71	0,1	0,1	1,5	0,13	0,13	0,5	0,13
101 – 150	71 – 107	0,1	0,1	1,5	0,13	0,13	0,5	0,4
151 – 170	107 – 122	0,1	0,1	1,5	0,13	0,13	0,5	0,4
171 – 250	122 – 178	0,1	0,1	1,5	0,13	0,13	0,5	0,4
251 – 300	178 – 212	0,2	1,25	12,5	0,4	0,4	0,8	0,8
301 – 500	213 – 354	0,25	2,5	12,5	0,8	0,8	1,5	0,8
≥ 500	≥ 355	0,0025/V	0,005/V	0,025/V	0,00305/V	0,00305/V	0,00305/V	0,00305/V



WHAT TO REMIND?

Choose carefully your standard

Most common used:

- IEC/UL for products
- IPC2221 for PCB

AGENDA

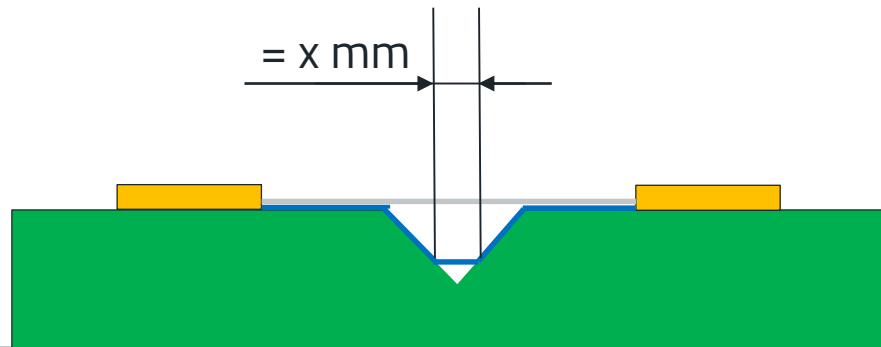
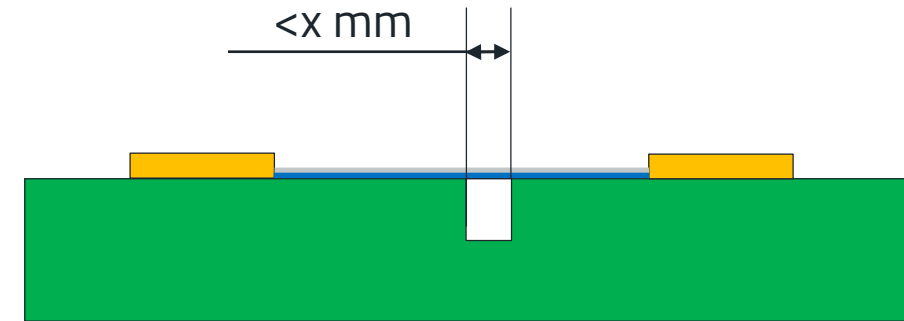
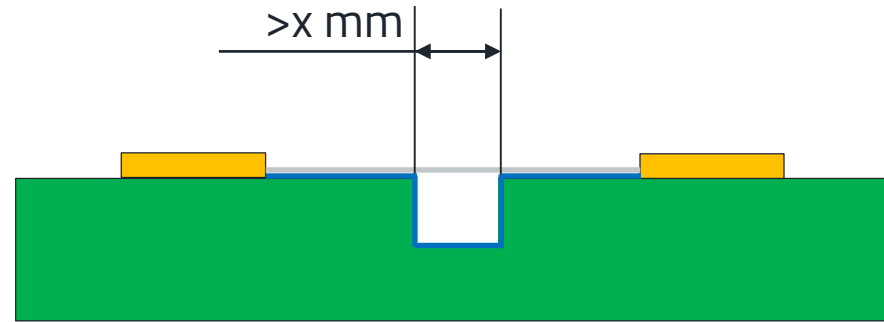
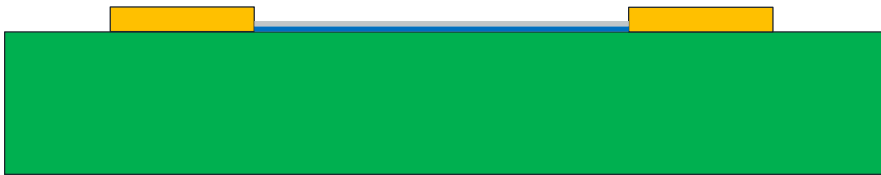
- What is electrical insulation
- Most common applicable standards
- Creepage and clearance rules
- Other standards
- Tricks and advices
- Products limits



HOW TO SOLVE CLEARANCE AND CREEPAGE ISSUES ?

➤ Increasing creepage

Clearance
Creepage



Pollution degree	Minimum dimension x mm
1	0,25
2	1,0
3	1,5
4	2,5

HOW TO INCREASE POLLUTION DEGREE ?

Question: find pluggable 5,08mm TBL with a pollution degree 3

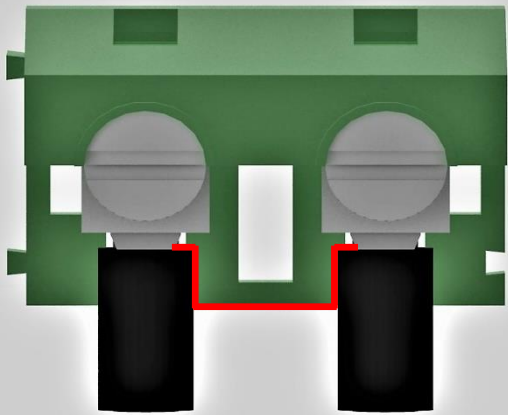


Minimum creepage distances

Voltage rms	Printed wiring material		Pollution degree						
	1	2	1	2			3		
	All material groups	All material groups except IIIb	All material groups	Material group I	Material group II	Material group III	Material group I	Material group II	Material group III
	mm	mm	mm	mm	mm	mm	mm	mm	mm
50	0,025	0,040	0,18	0,60	0,85	1,20	1,50	1,70	1,90
63			0,20	0,63	0,90	1,25	1,60	1,80	2,00
80			0,22	0,67	0,95	1,30	1,70	1,90	2,10
100			0,25	0,71	1,00	1,40	1,80	2,10	2,30
250	0,560	1,0	0,56	1,25	1,80	2,50	3,20	3,60	4,00
320	0,75	1,6	0,75	1,60	2,20	3,20	4,00	4,50	5,00

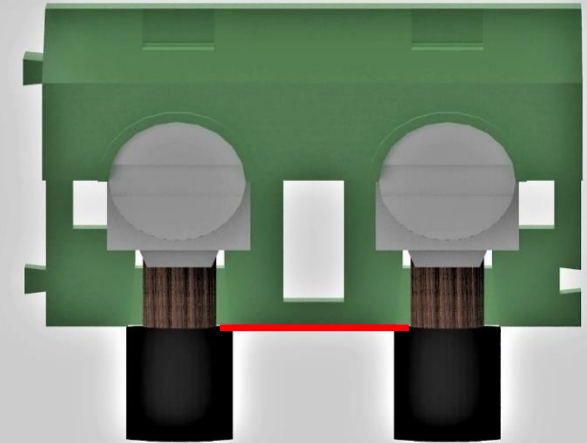
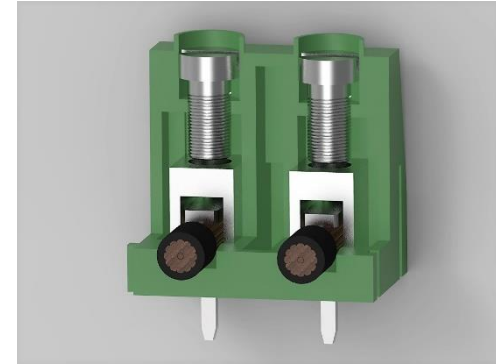
RESPECT STRIP LENGTH

Datasheet strip length



630V

Wrong strip length



320V

Loss of 50% of the
creepage and
clearance

AGENDA

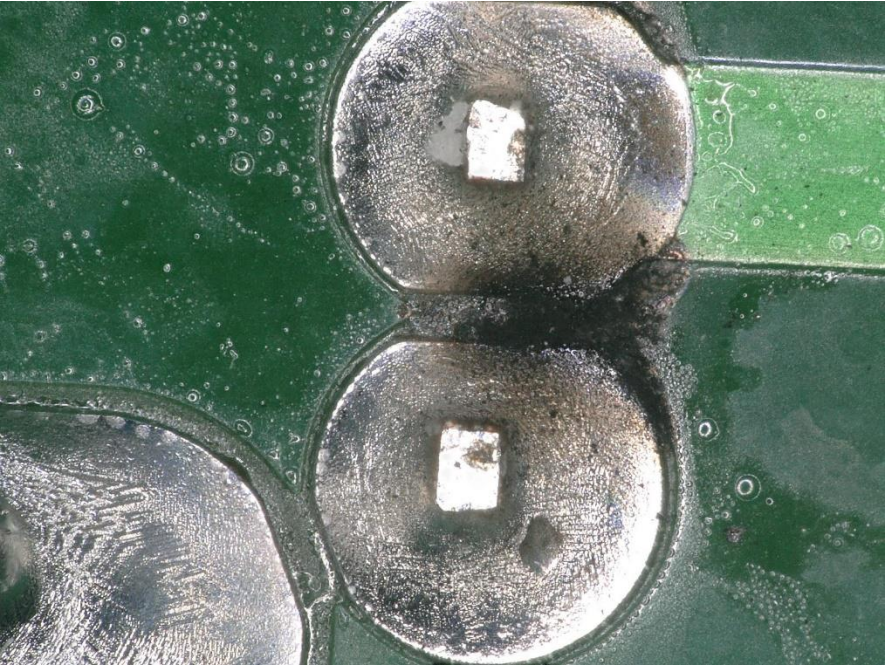
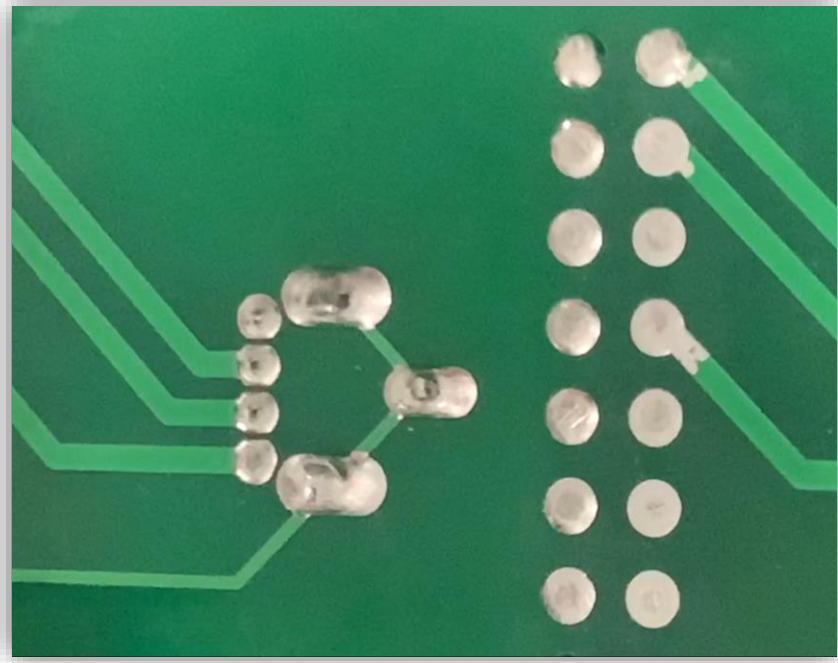
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USB2.0 TYPE A THT BREAKDOWN



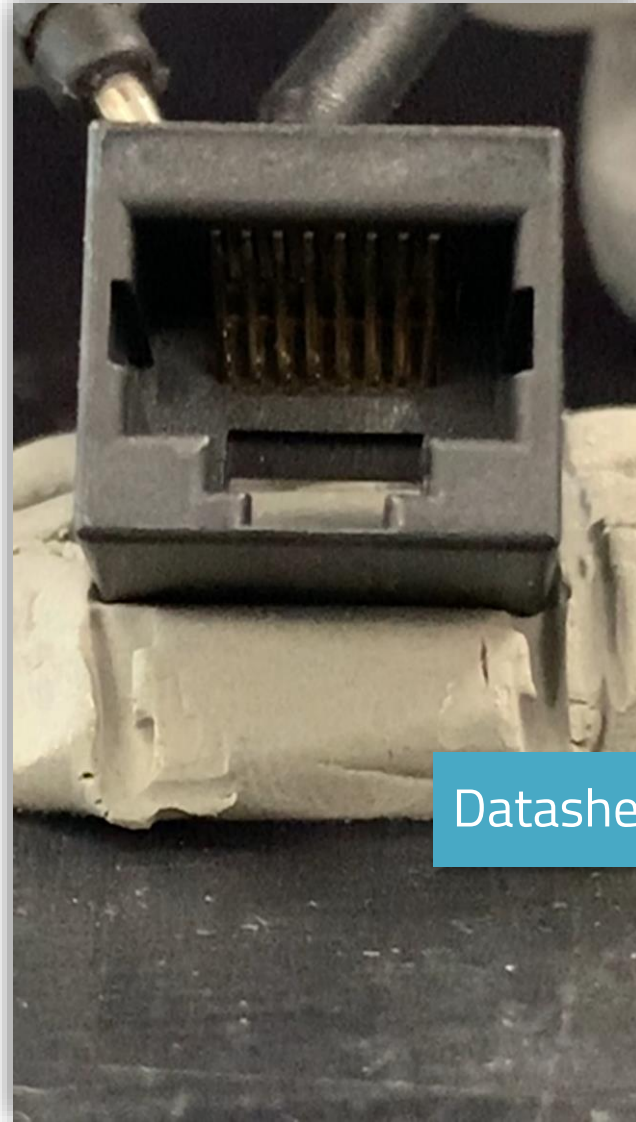
Carbon path after breakdown



Datasheet : **500V/mn** → real breakdown **1000V**






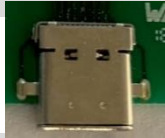
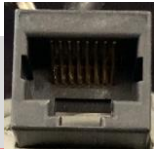
All pictures: WE-eiCan

MODULAR JACK UNSHIELDED SMT BREAKDOWN



Datasheet : **1000V/mn** → real breakdown **1700V**

WHAT ABOUT WE PRODUCTS ?

Product	Picture	Working voltage	Dielectric withstanding voltage	Breakdown voltage
Mini module		100 V	500 Vac/mn	1800 V
Box header		250 V	500 Vac/mn	1500 V
Switch		12 V	500 Vac/mn	1500 V
USB type A 2.0		30 V	500 Vac/mn	1000 V
USB type A 3.1		20V	100 Vac/mn	2000 V
USB type C		20V	100 Vac/mn	1000 V
Modular Jack		125V	1000 Vac/mn	1700 V

All pictures: WE-eiCan

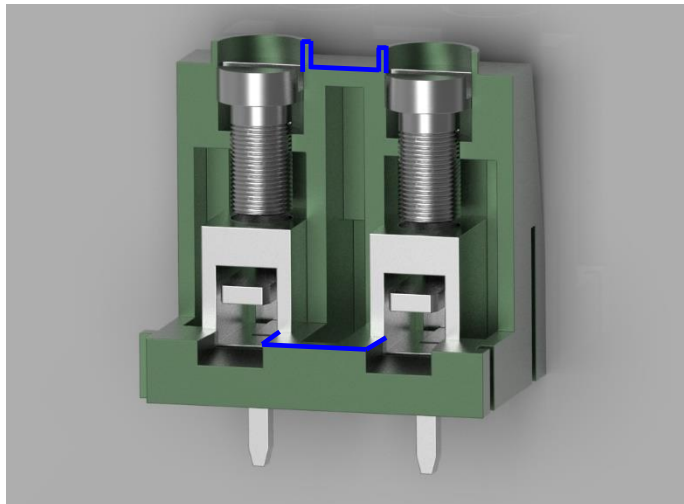
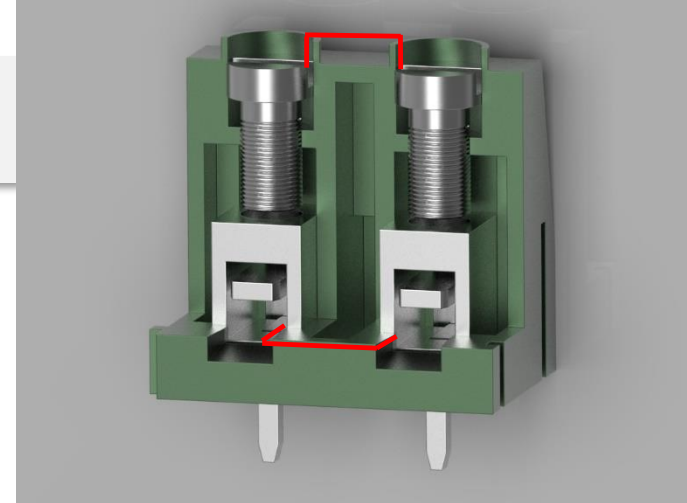
AGENDA

➤ What to remind



WHAT TO REMIND?

- **Clearance:** shortest distance through the air



- **Creepage:** shortest distance over surface

WHAT TO REMIND?

- **Clearance:** prevents from overvoltage coming from storm lightening or internal system

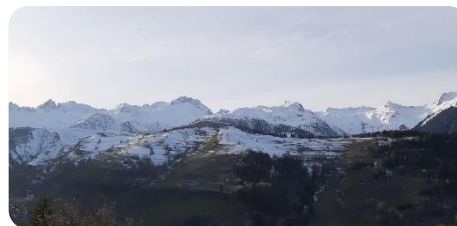


Pixabay

- **Creepage:** prevents from electric arc within the time.



Pollution degree



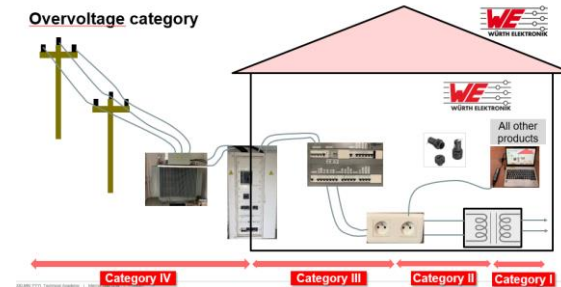
Altitude



elteklabs.com

CTI

Overvoltage category



WHAT TO REMIND ?

- Product application → applicable standard
- Define your application parameters
- Use standards tables to define creepages and clearances
- Choose your products
- Design your PCB

- WE products have big voltage security margin before breakdown
- Breakdown brings low destruction for WE products.

Choose carefully your standard

Most common used:

- IEC/UL for products
- IPC2221 for PCB

Questions

& Answers



We are here for you now!
Ask us directly via our chat or via E-Mail.

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