MTAG

VOLTAGE DETECTOR

OBSERVATIONS :	Name : Y. HIDAOUI
RESULT :	Signature :

DATE

10/06/2026

PLACE OF INSPECTION

FAMECA Electronics
2a rue Gutenberg
68170 Rixheim

PERSON RESPONSIBLE FOR TESTING

Yassin HIDAOUI (Product Line Manager)

INSPECTED EQUIPMENT

Device number	Device N°1	Device N°2	Device N°3
REFERENCE	MTAG		
Description	Voltage detector		
Voltage Range	16 kV SINGLE Phase		
Frequency	16.66 Hz		
Serial Number	378439-S00021J	378439-S00034J	378439-S00006J
Manufacturing Date	07/23	07/23	01/23
Fiche REX			
Fiche SRC			

EQUIPMENT USED DURING THE TESTS:

Ball-and-ring test bench in accordance with IEC 61243-1
20 kV transformer
Climatic chamber

All tests were carried out at an ambient temperature of 23°C and 60% relative humidity.

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DEVICES PICTURES

Device N°1

OBSERVATIONS :

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Device N°2

OBSERVATIONS :

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Device N°3

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CUSTOMER DIAGNOSIS

No indication of voltage presence on overhead 16kV 16.66Hz live catenary

PENTA ANALYSIS

Visual Inspection

The external condition of the devices shows some signs of wear (choc or drop of the device). Markings are also present on the devices, along with several labels, between two and three on each device.

Self Test

The self-test function operated correctly on all three devices. When the test button was pressed, the complete self-test cycle was performed successfully and ended with the illumination of the green “OK” indicator light.

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Threshold Voltage Measurement on the IEC Test Bench

IEC 61243-1 extract:

4.2.1.3 Threshold voltage

4.2.1.3.1 General

The indication "voltage present" shall appear if the voltage to earth (ground) on the part to be tested is greater than 45 % of the *nominal voltage*.

NOTE 1 45 % of the *nominal voltage* corresponds to $0{,}78U_n / \sqrt{3}$.

The indication "voltage present" shall not appear if the voltage to earth (ground) on the part to be tested is equal to or less than 10 % of the *nominal voltage*.

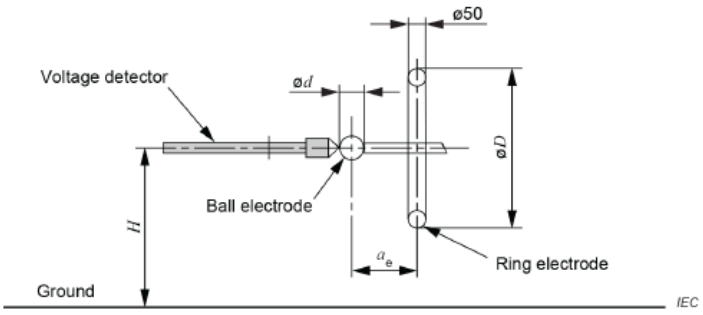
NOTE 2 10 % of the *nominal voltage* corresponds to $0{,}17U_n / \sqrt{3}$ and is the maximum phase to earth (ground) induced voltage normally encountered in the field.

To fulfil the above requirements, the *threshold voltage* U_t shall satisfy the following relationship:

$$0{,}10\ U_{n\,max} < U_t \leq 0{,}45\ U_{n\,min}$$

For *voltage detectors* with only one *nominal voltage*, $U_{n\,max}$ equals $U_{n\,min}$.

Dimensions in millimetres



U_n kV	Electrode separation distance a_e mm	H mm	D Ring diameter mm	d Ball diameter mm	W (3 times D) Wall and ceiling clearances mm
$1 < U_n \leq 12$ $12 < U_n \leq 24$ $24 < U_n \leq 52$	300	1 500	ø 550	ø 60	> 1 650
$52 < U_n \leq 170$ $170 < U_n \leq 245$	1 000	2 500	ø 1 050	ø 100	> 3 150
$245 < U_n \leq 550$	1 000	2 500	ø 1 050	ø 100	> 3 150
$550 < U_n \leq 800$	1 000	3 500	ø 1 600	ø 150	> 4 800

Figure 3b – Test set-up with ball electrode in front of the ring electrode

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According to IEC threshold formular and device voltage range of the device, threshold voltage should be:

2.77 < TV < 12.47 kV:

RESULTS:

Device number	Measured Threshold Voltage (kV) at Ambient Temperature	Result
Device n°1	4.1	**Comply**
Device n°2	4.2	**Comply**
Device n°3	4	**Comply**

OBSERVATIONS :

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Detection Tests on Overhead Power Lines

The device is attached to a bar positioned at 3.5 m. The voltage is gradually increased until the “voltage present” indication appears.

RESULTS:

Device number	Measured Voltage (kV) at Ambient Temperature	Result
Device n°1	4.4	**Comply**
Device n°2	4.5	**Comply**
Device n°3	4.2	**Comply**

OBSERVATIONS :

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Climatic test according to IEC 61243-1

IEC 61243-1 extract:

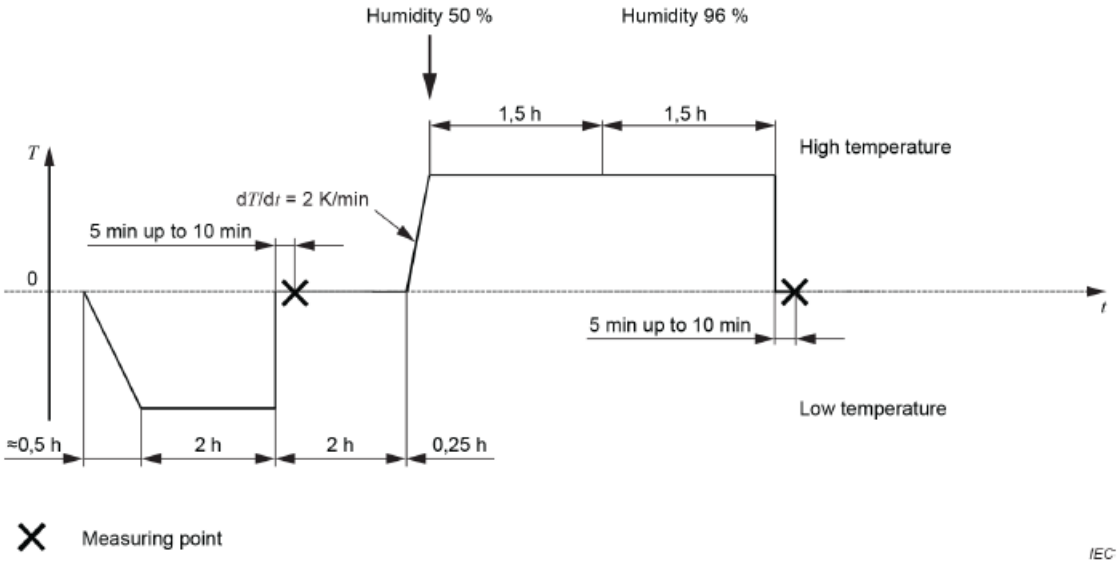

Figure 12 – Curve of test cycle for climatic dependence

Table 2 – Climatic categories

Climatic categories		Climatic conditions ranges (operation and storage)	
		Temperature °C	Humidity %
(C)	Cold	−40 to +55	20 to 96
(N)	Normal	−25 to +55	20 to 96
(W)	Warm	−5 to +70	12 to 96

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RESULTS:

As stated in the user manual, the device MUST be wiped dry whenever the housing shows signs of moisture, condensation, or water accumulation.

3. OPERATING PROCEDURE

Before use, take to care to wipe off any traces of frost or condensation.

Device number	Measured Threshold Voltage (kV) at after 2h at -25°C	Measured Threshold Voltage (kV) at after 3h at 55°C	Result
Device n°1	4.3	4	**Comply**
Device n°2	4.6	4.2	**Comply**
Device n°3	4.2	4.1	**Comply**

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FIELD TEST

Following the laboratory investigation, we carried out some field tests at a similar location to those where the customer got some issues, in order to better understand the root cause of the issue.

Several catenary lines were present, all energized at 16kV 16.66Hz.
Measurements were taken on the three outer lines, including the outermost one, which was also de-energized to allow additional readings to compare device indication (live and dead).

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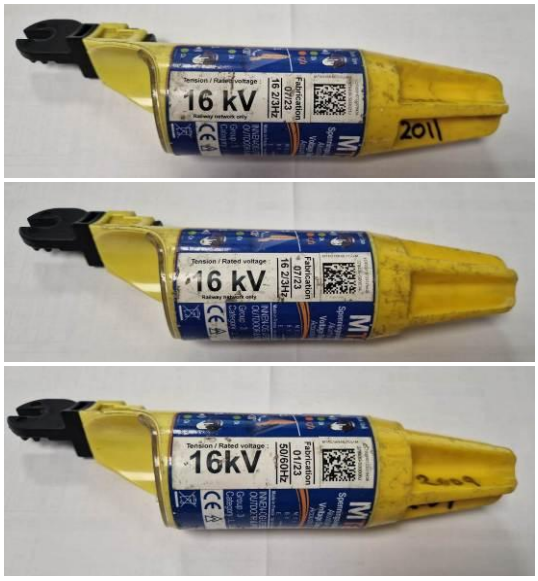
The measurements were performed using several instruments, listed below.

- The 3 devices involved in detection issues



- The MVI

- The MTAG BLE

The MTAG BLE and the MVI are diagnostic tools that allow us to carry out investigations by transmitting the measurements recorded in the field. They provide valuable insight into the values measured by the capacitive voltage detectors, helping us better understand and analyze their behavior under actual operating conditions.

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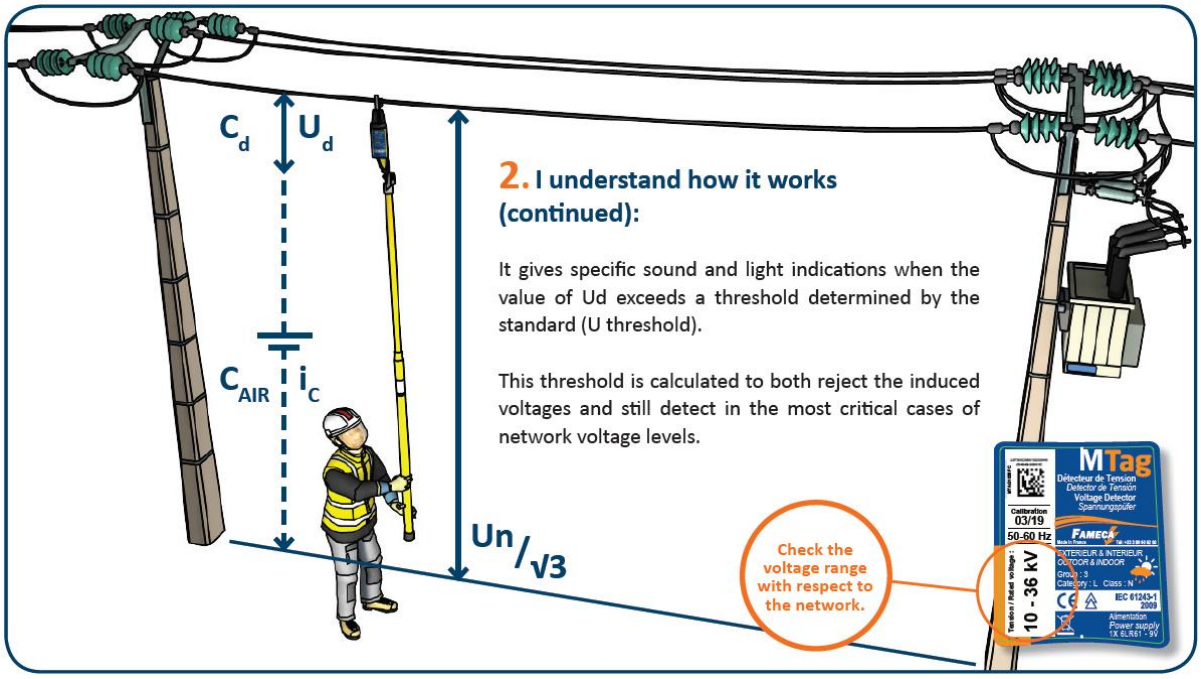
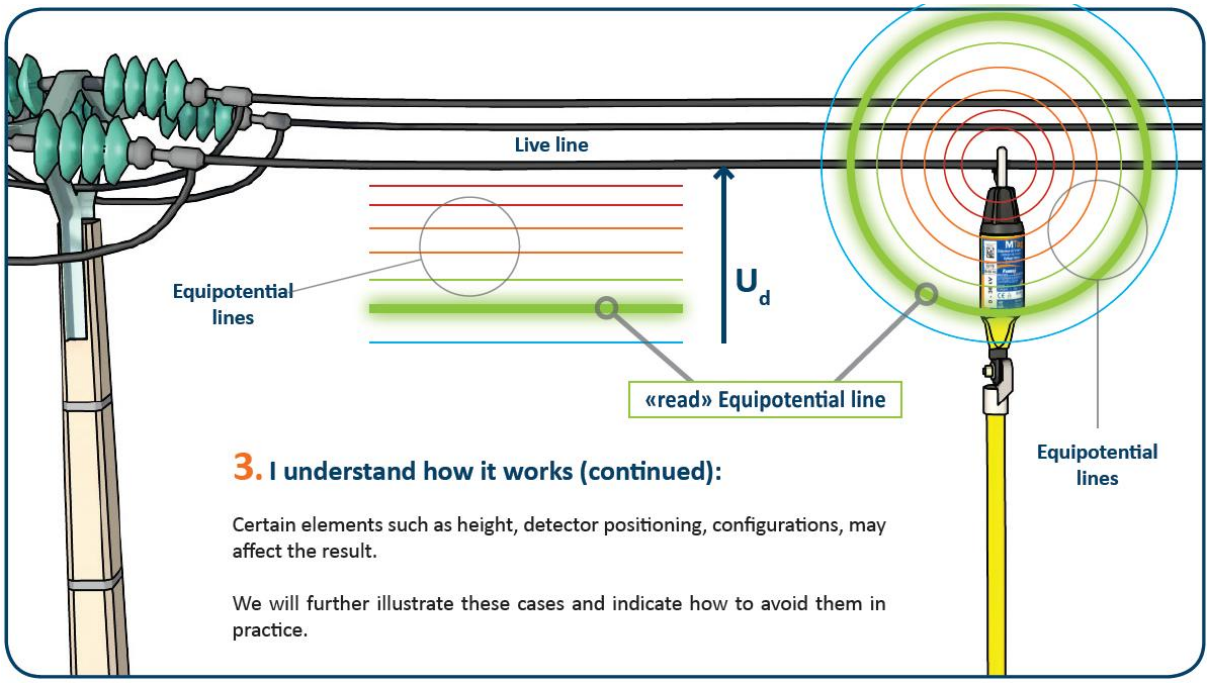
Below a short remind to explain how works a capacitive voltage detector :





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Measurements with both MTAG BLE and MVI devices were carried out with and without the rail electrode extension specifically designed for dense railway environments.

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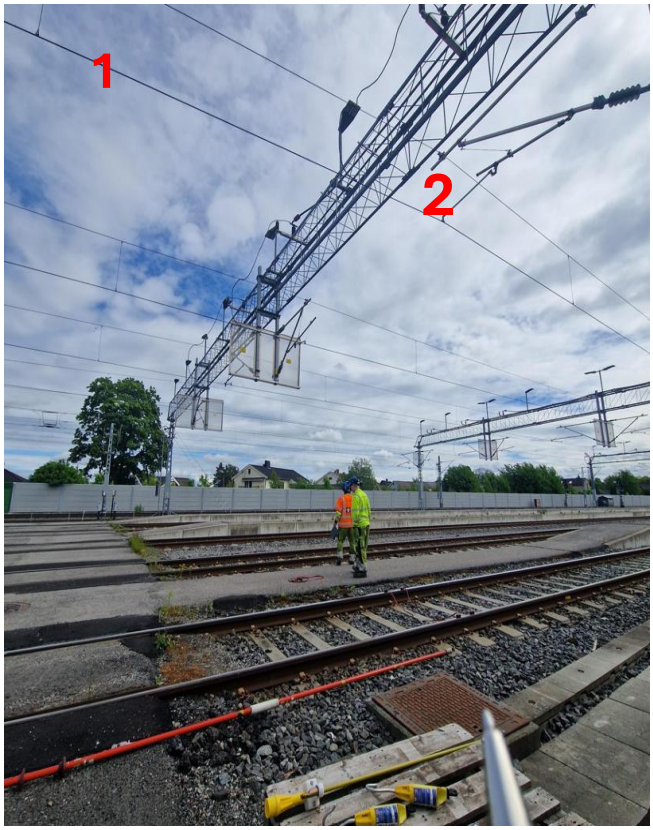
RESULTS:

TEST n°1 : Test performed with all catenary lines energized.



	MTAG 378439-S00021J	MTAG 378439-S00034J	MTAG 378439-S00006J	MTAG BLE	MTAG BLE with electrode extension	MVI	MVI with electrode extension
Position 1	Voltage presence indication	Voltage presence indication	Voltage presence indication	10.7 kV	12 kV	11.3 kV	14.5 kV
Position 2	Voltage presence indication	Voltage presence indication	Voltage presence indication	10.2 kV	11.4 kV	11 kV	14 kV

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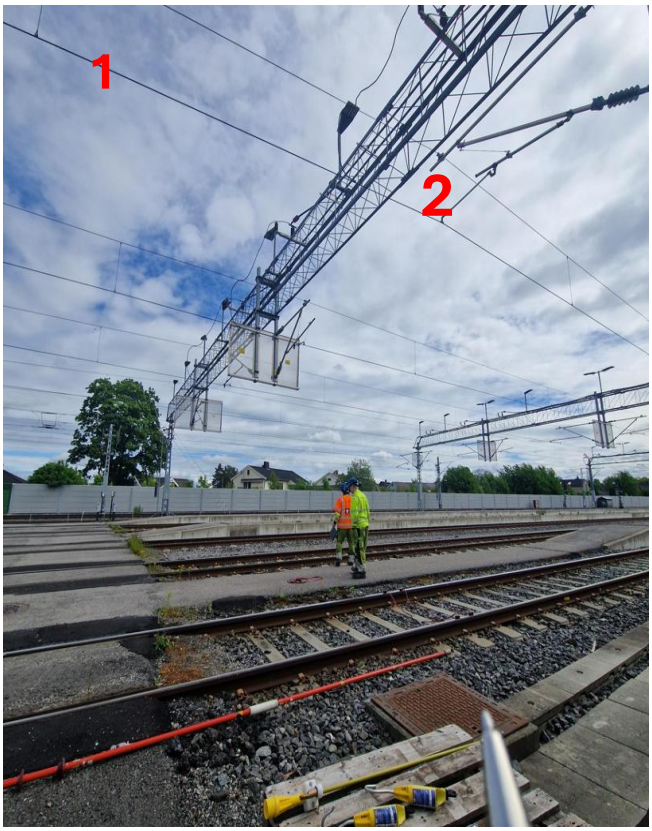
TEST n°2 : The test was performed with all catenary lines energized, except for the outermost one, which was de-energized.



	MTAG 378439-S00021J	MTAG 378439-S00034J	MTAG 378439-S00006J	MTAG BLE	MTAG BLE with electrode extension	MVI	MVI with electrode extension
Position 1	No indication of Voltage presence	No indication of Voltage presence	No indication of Voltage presence	0 kV	0 kV	0 kV	0 kV
Position 2	No indication of Voltage presence	No indication of Voltage presence	No indication of Voltage presence	0 kV	0 kV	0 kV	0 kV

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TEST n°3 : Test performed with all catenary lines energized.

	MVI
Line 1	11.3 kV
Line 2	11 kV
Line 3	11 kV

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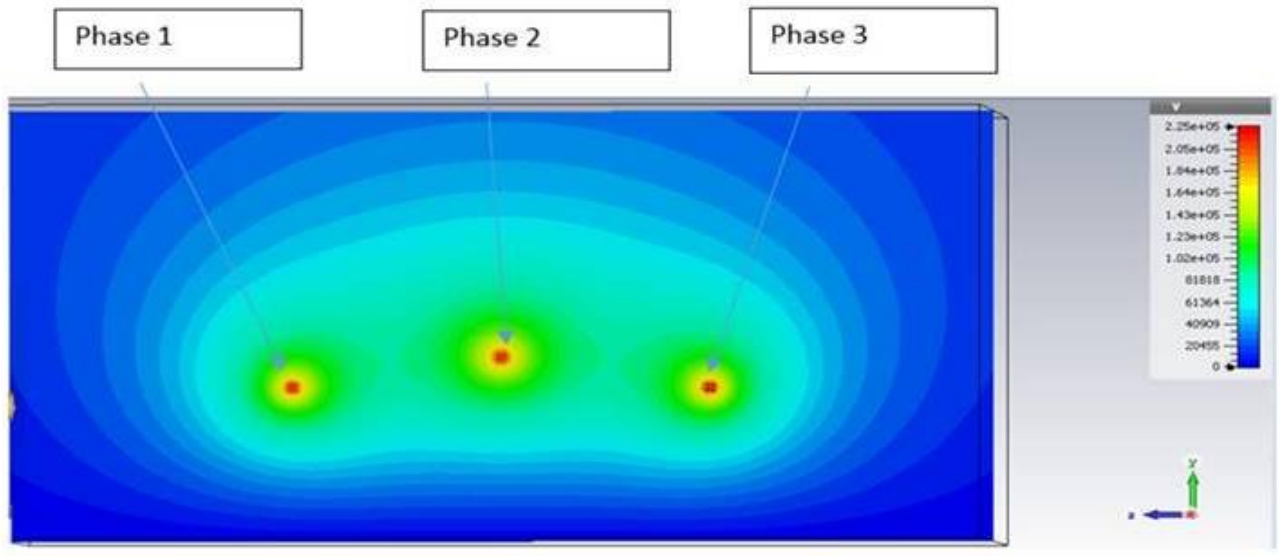
REMINDER

It is important to remind that 16 kV railway overhead line systems are supplied with single-phase AC power. In environments where several catenary lines are present, the distribution of the electric fields differs significantly from that encountered in conventional three-phase power networks. As a result, the electric field detected by the device may be affected by the surrounding infrastructure, leading to behavior that differs from that observed under standard operating conditions.

In this context, the positioning of the detector is particularly important. Compliance with the manufacturer's installation and operating recommendations is essential to ensure reliable detection and the proper functioning of the device. Any deviation from the prescribed positioning may affect the detector's performance and lead to unreliable detection results.

3 phases system overhead line



The electric field level is very strong near the line then drops very quickly.
Around a 3 phase system overhead line the electrical field decrease with a 1/d law (d=distance).
Meaning the maximum decrease is concentrated around the phase conductor.
The IEC Voltage detectors class L are designed for that configuration.

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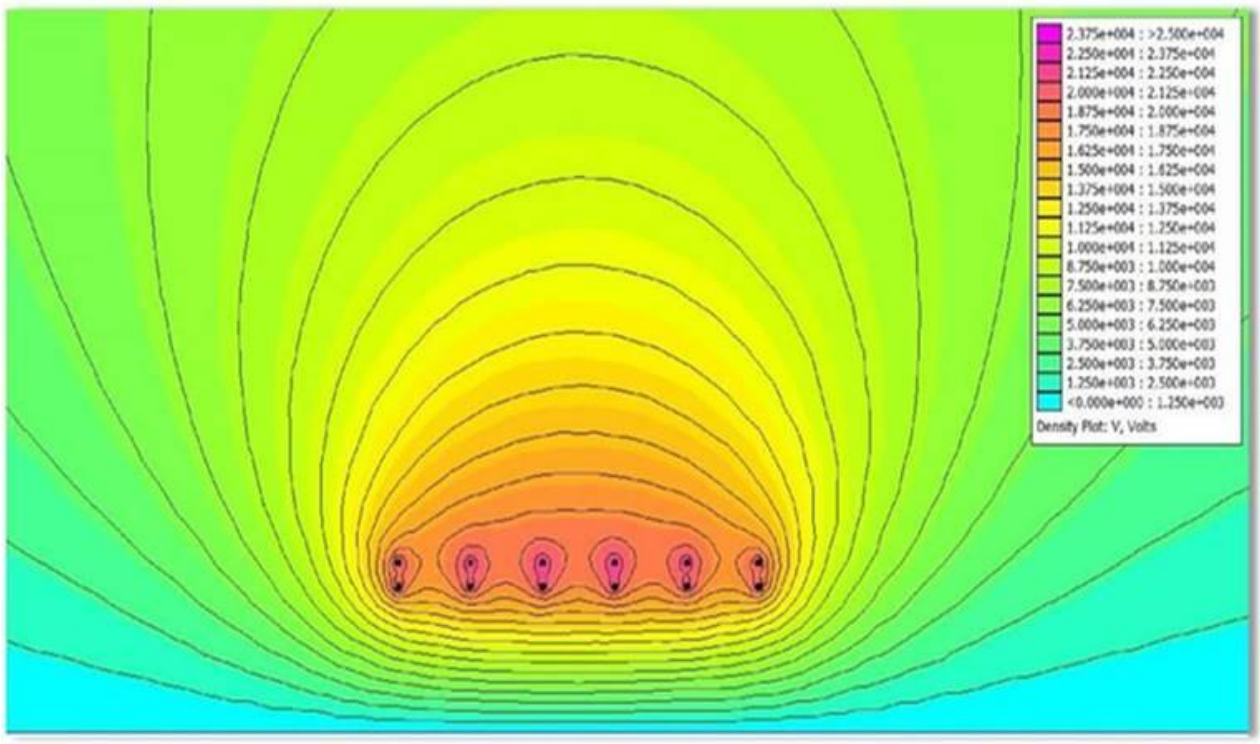
Single phase Railways catenaries circuits



The electrical field around the circuit shapes a pretty flat layer, especially below, with a concentration on the edges.
Equipotential line gradient (the way it decreases) is quite linear from line to ground.
The type of detector designed for 3 phase system overhead lines are not 100% adapted as they will cross much less equipotential lines, this happen mainly when you approach station or dispatch area with many many parallel lines. This is the main reason why the IEC Standard IEC 61243-1 ask for some restriction for railways installation voltage detection. However, appropriate measures can be taken to overcome or minimize the effects of this issue.

In particularly complex railway environments, where several catenary lines are located in close proximity to one another, the distribution of electric fields can differ significantly from standard configurations and may affect the detector's sensitivity and behavior.

To address this situation, PENTA developed a solution consisting of the addition of a 1.2 m electrode extension. This extension positions the detector in a more favorable electric field environment, allowing it to:

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• measure a greater number of equipotential lines generated by an energized catenary, thereby increasing detection sensitivity;

• remain outside the area most affected by edge effects from adjacent energized catenaries, reducing the risk of incorrect indications.

This solution has been successfully implemented by many customers and has provided complete satisfaction in daily operation. More than 1,500 devices equipped with this configuration are currently used every day under operational railway conditions.

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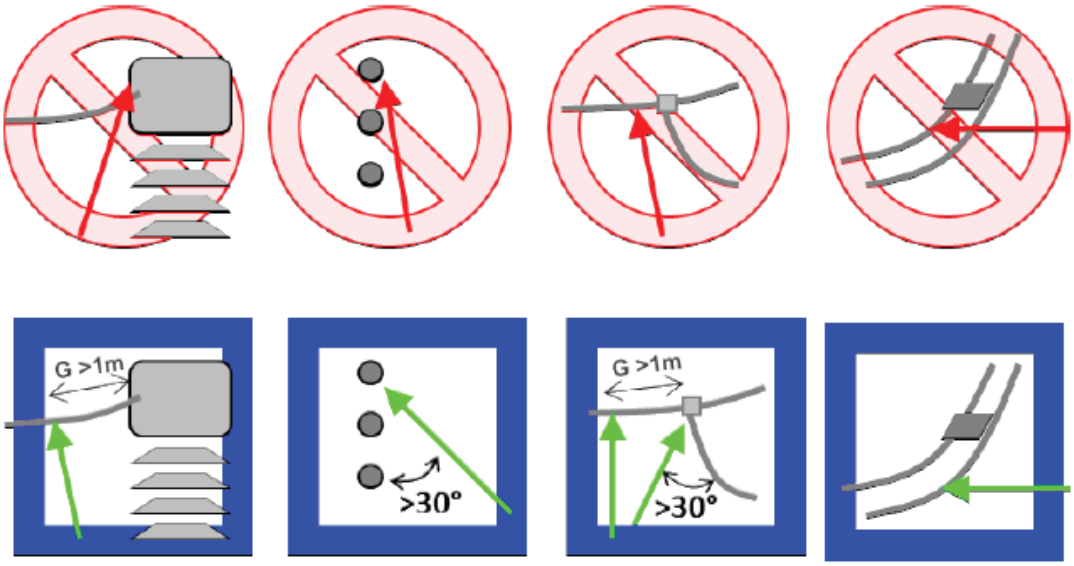
CONCLUSION

Following all the test results, which were compliant, we hereby confirm that all laboratory tests and field test/measure were successfully passed. Despite the presence of some impact marks and many labels on the device, all voltage tests were compliant.

We would nevertheless like to remind the importance of the device's positioning in relation to the various elements of its environment during use, which is crucial for the proper functioning of a capacitive voltage detector.



As also stated in the device manual, maintenance particularly wiping the device before use is very important. Any traces of frost must be removed. The use of a silicone cloth during use in rainy conditions is strongly recommended.

Considering the complexity of the electrical environment involved, it would be advisable to have a 1.2 m electrode extension available for future investigations. If a similar event were to occur, comparative testing with and without the extension could be carried out to evaluate its effectiveness under the specific catenary configuration and to further validate the proposed solution.

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