

# Potential of a Smart Residual Current Monitoring System for Electric Arc Recognition in PV Systems

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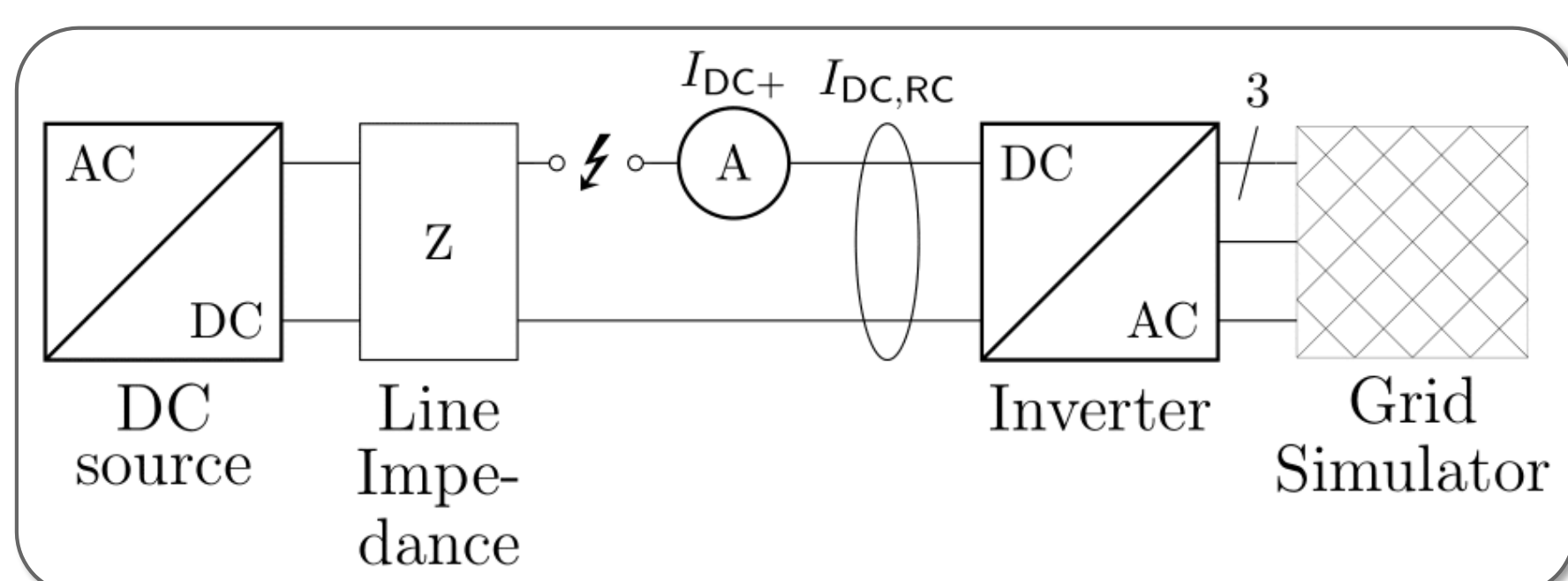
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## Introduction

- Predictive maintenance reduces O&M costs.
- PV-DiStAnS 2.0<sup>1</sup> investigates whether faults and critical states in a PV plant effect the residual current. The goal is to develop machine learning (ML) methods to detect faults at an early stage.
- This work investigates how a light arc on the DC side of a PV plant effect the behaviour of the DC residual current.

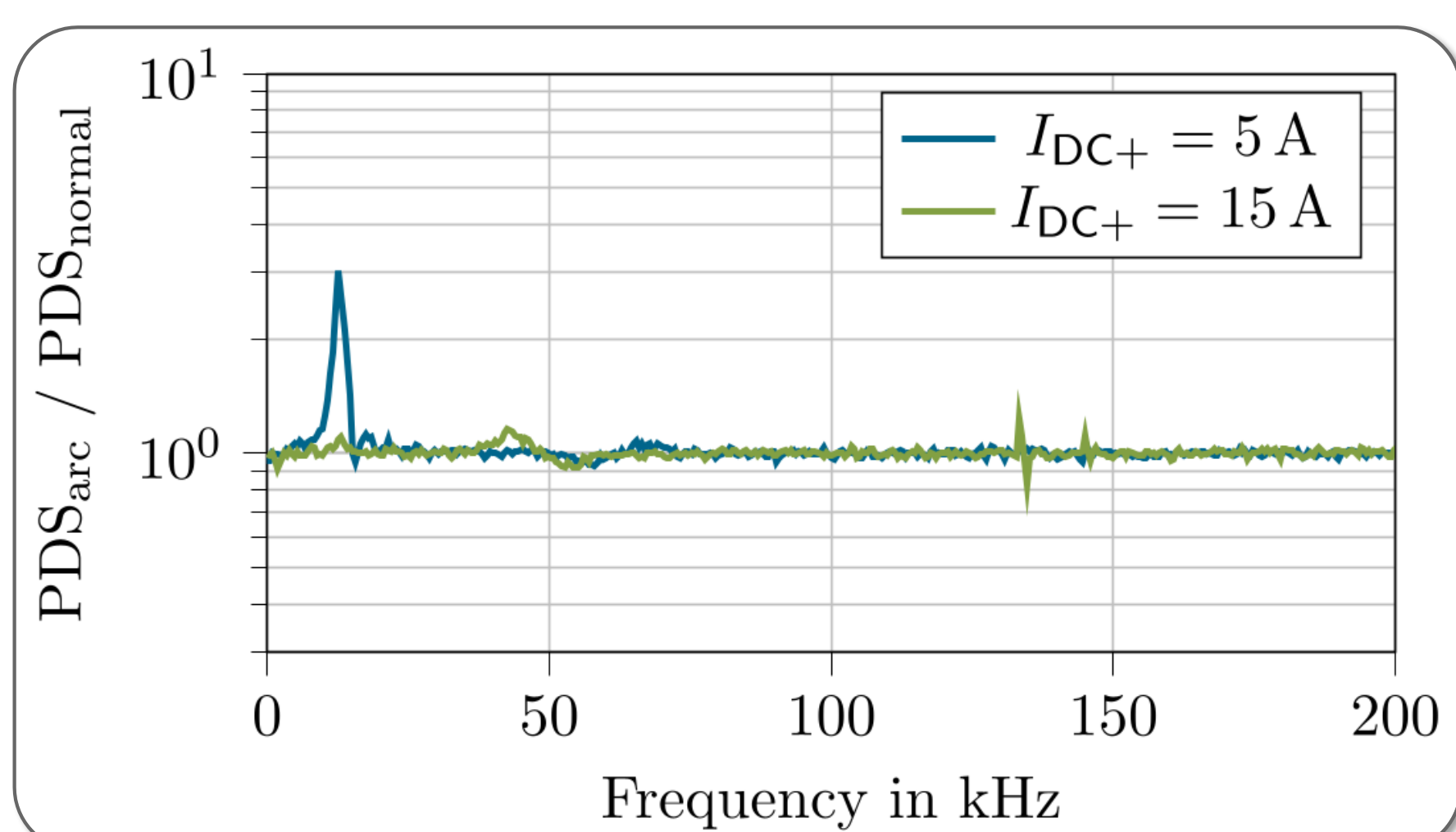
## PHIL environment

- The arc is generated manually.
- The load current  $I_{DC+}$  and the DC residual current  $I_{DC,RC}$  are measured using a DEWESoft measurement system with a sampling frequency of 1 MHz.



Schematic laboratory set-up.

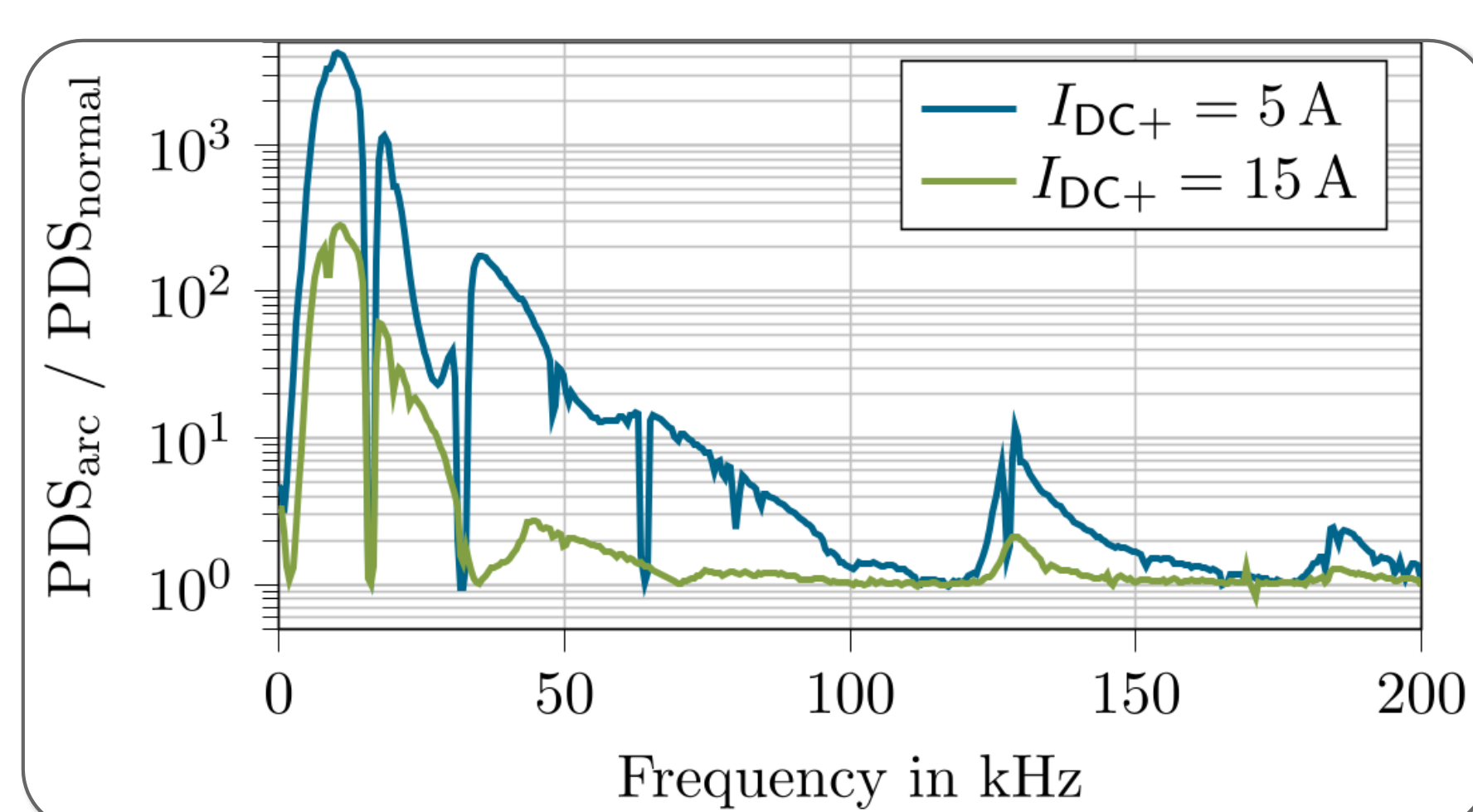
## DC residual current



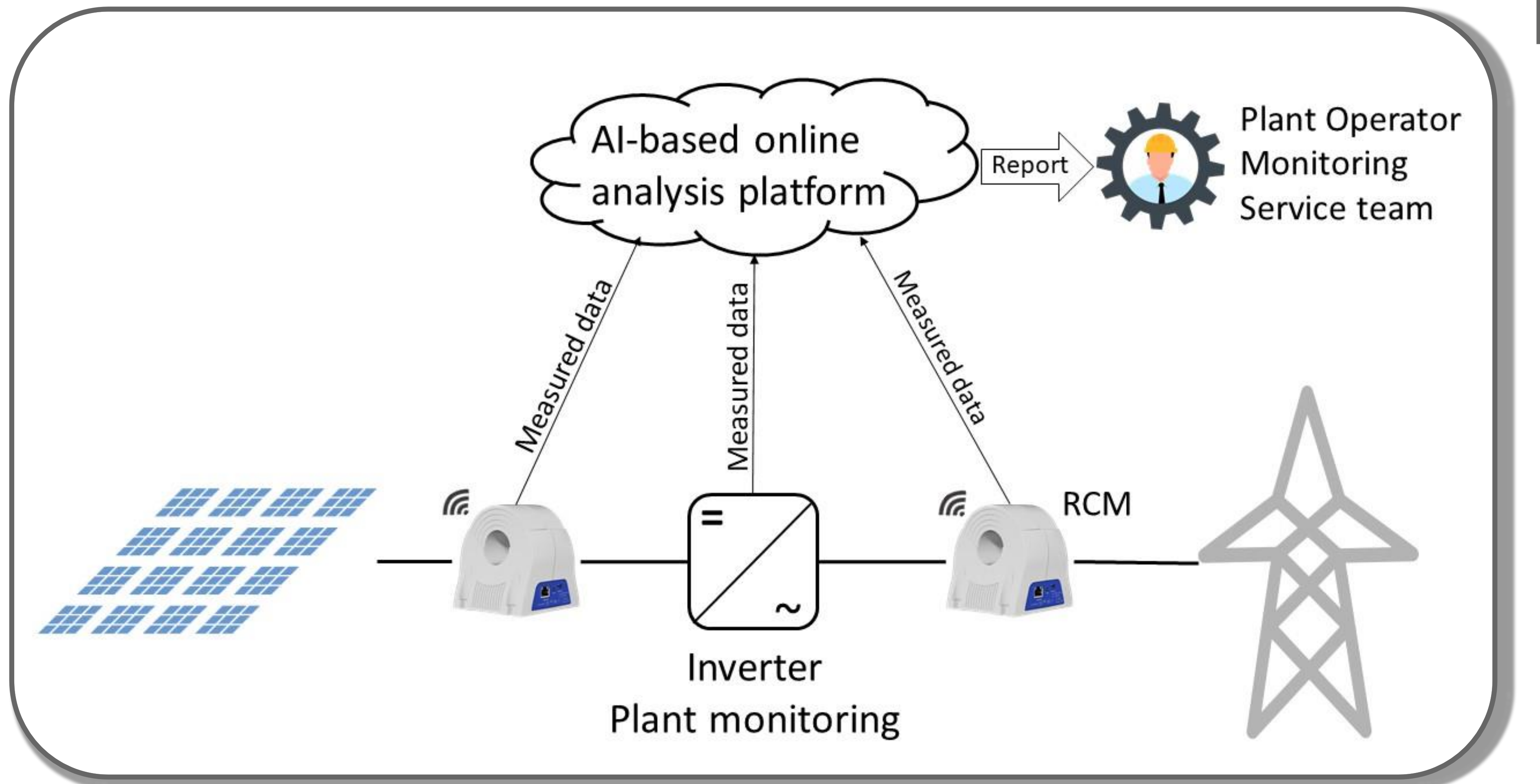
Normalized PDS of the residual current  $I_{DC,RC}$  of the PHIL set-up for different load current amplitudes.

- The change of the power density spectrum (PDS) during arcing is visible for  $I_{DC+} = 5 A$  at the inverter switching frequency of 16 kHz with the normalized PDS tripling.

## DC load current



Normalized PDS of the load current  $I_{DC+}$  of the PHIL set-up for different load current amplitudes.



Main principle of the smart analysis system.

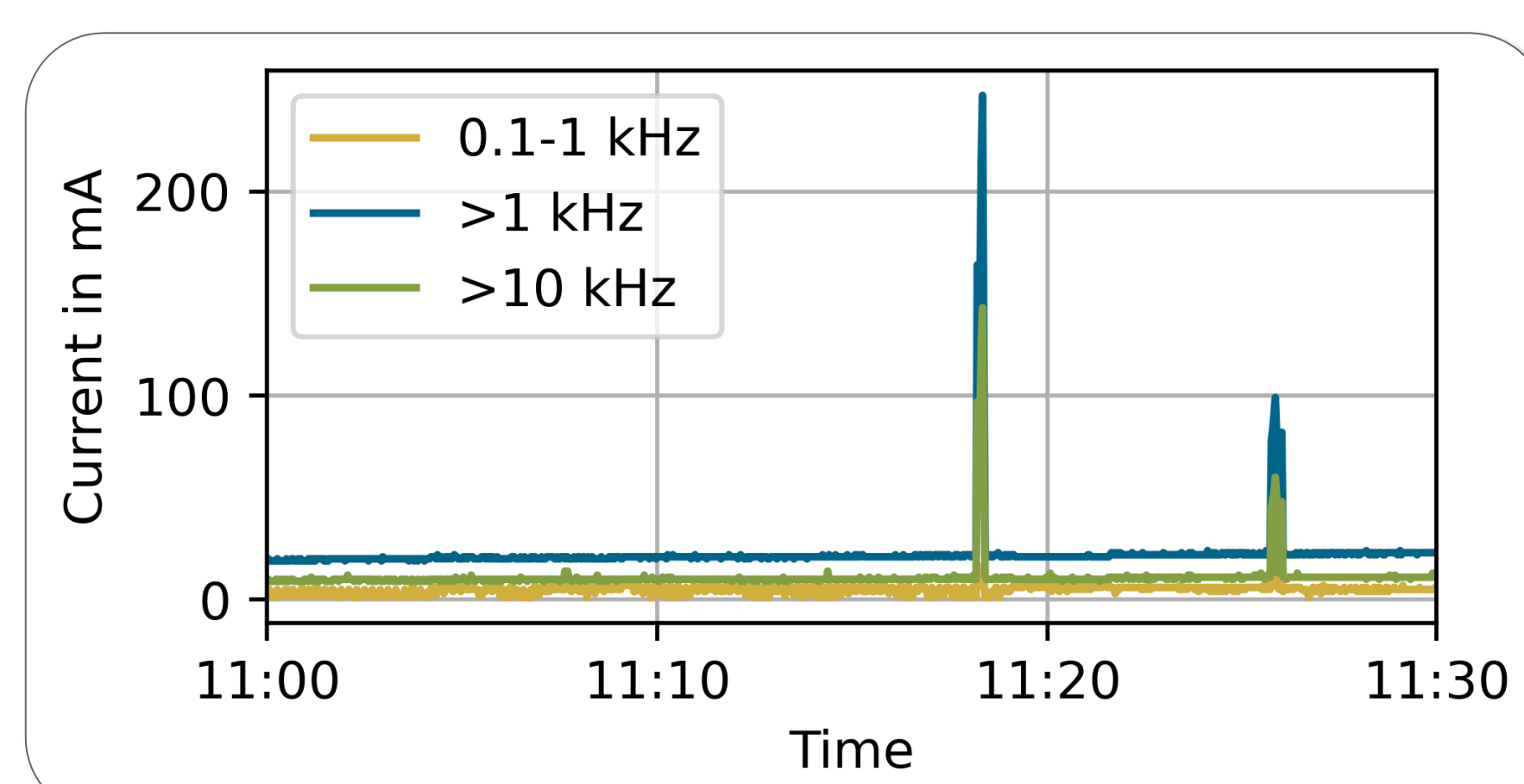
- The  $1/f^2$ -noise of the light arc is visible especially between 0-100 kHz.
- The PDS changes during arcing by a factor of >2000 and >3000 respectively.

## Smart Analysis System

- Residual current monitor (RCM)<sup>2</sup> that inherits analogue frequency filters measuring 0-100 kHz.
- Cloud database with a 1 s resolution
- One RCM for DC residual current
- Second RCM misplaced in the DC load current path due to the results obtained by the DEWESoft measurement
- Data analysis through ML methods

## RCM resolution

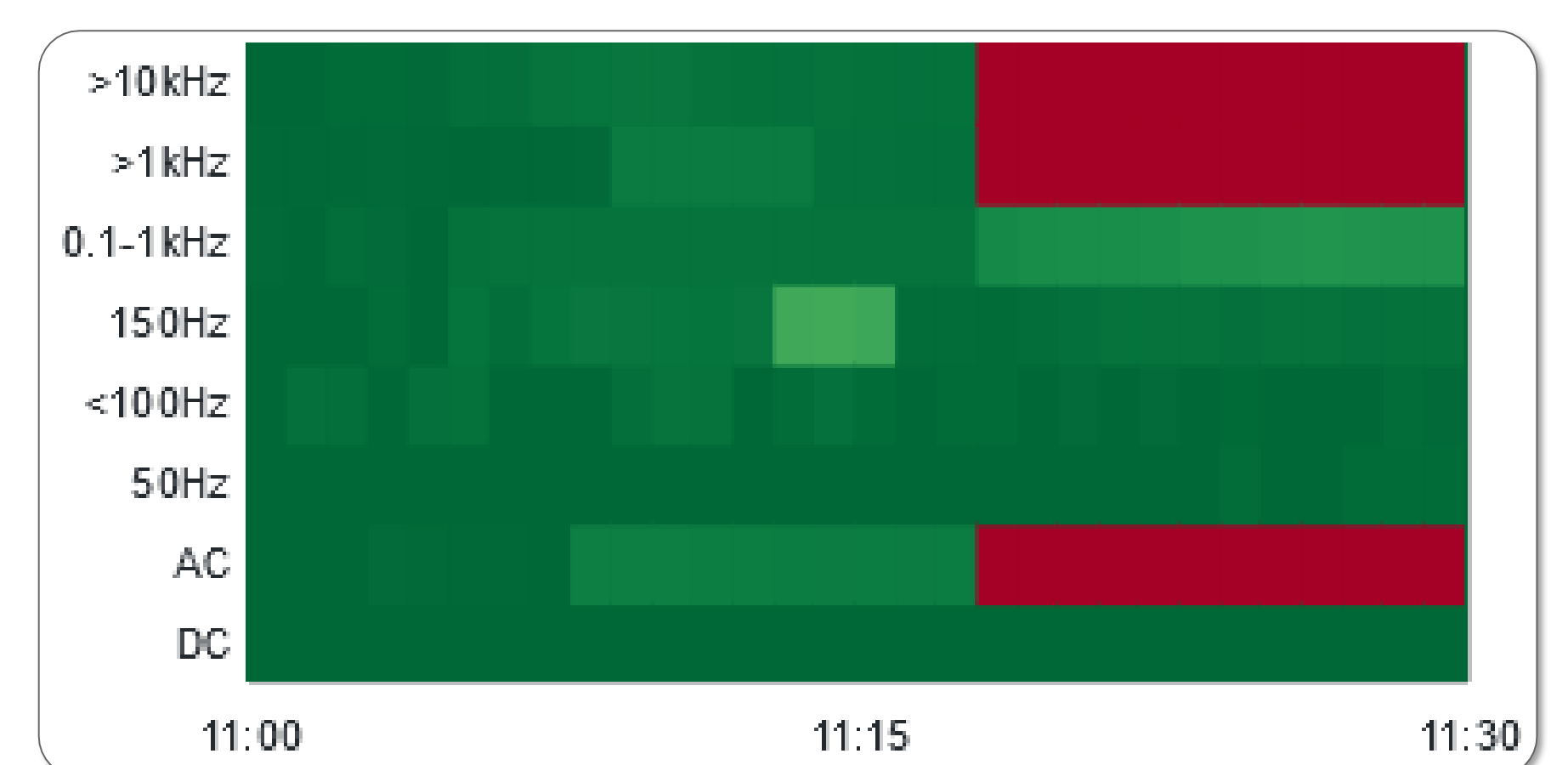
- The RCM data of the residual current show no change during arcing due to a lower sampling frequency and the analogue filter ranges.
- During arcing the measured current amplitude rises for frequencies >1 kHz and >10 kHz.



Load current measured by the RCM with two light arc events.

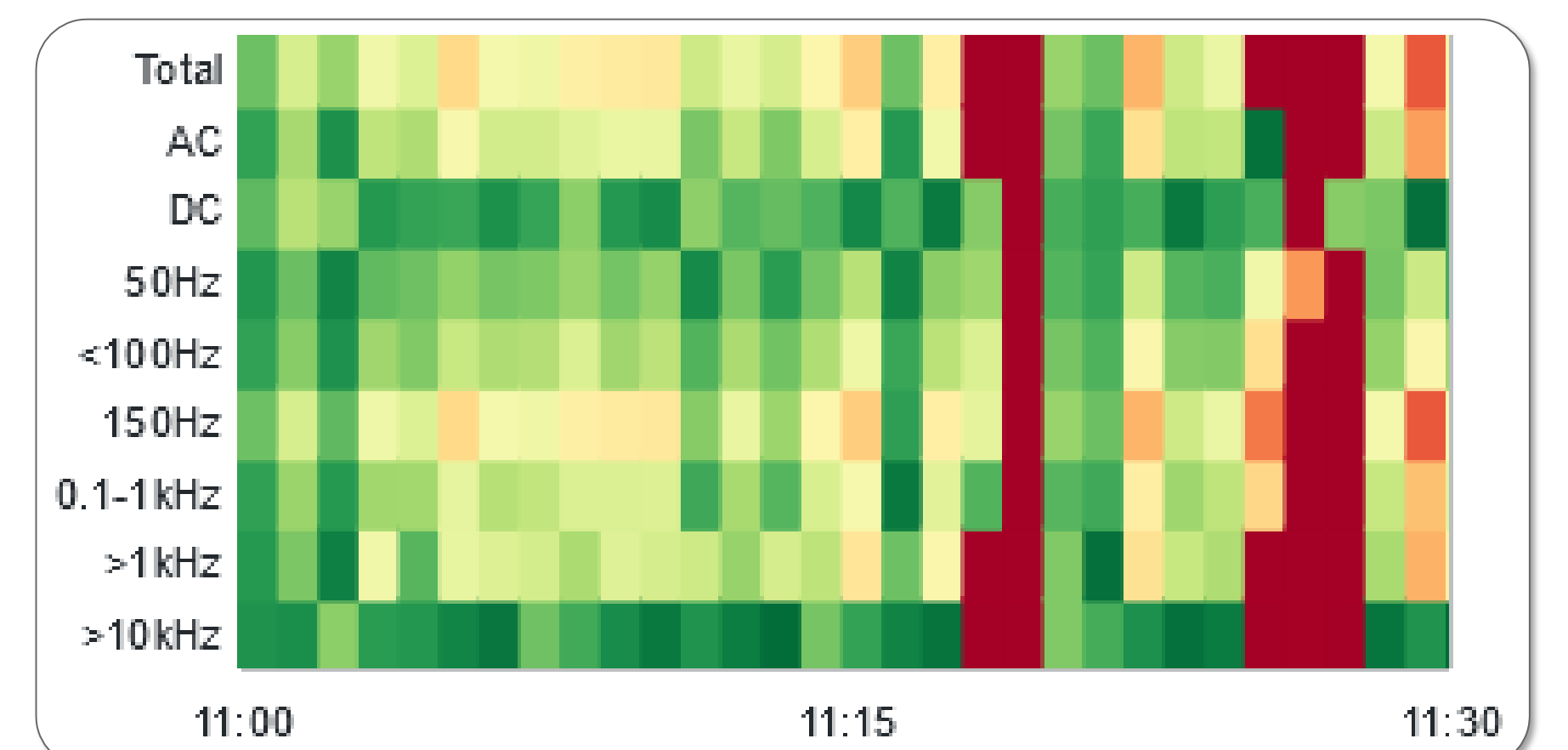
## ML-based detection

- The pattern recognition method expresses incidents via an anomaly factor.



Pattern recognition results in a heatmap with red indicating a high anomaly factor.

- State estimator method expresses incidents via a reconstruction error.



State estimator results in a heatmap with red indicating a high reconstruction error.

## Conclusion

- The electric arc has a small effect on the residual current.
- The RCM can detect the arc in the load current however not in the residual current.
- The ML methods can detect an anomaly provoked by the arcing.
- Further work will investigate the behaviour in a real PV plant due to assumptions made for the PHIL setup.

## Acknowledgements

This work would not have been possible without the help of the project partners Doepke Schaltgeräte GmbH and twingz development GmbH including Anže Javornik, as well as the funding provided by the Funk Stiftung.

<sup>1</sup>PV-DifferenzStromAnalyseSystem

<sup>2</sup>DCTR B-X Hz 035-PoE from Doepke Schaltgeräte GmbH