ERIGrid Test Description Canvas

Title: CyDERFORT - Fortified Cyber Defense in DER Management Systems

Author: Mustafa Alparslan Zehir
Date: 20.04.22

<table>
<tr><td colspan="2">Test Objectives
To quantify the impacts of hard-to-detect cyberattacks on DER management system (DERMS) performance in distribution networks and microgrids.</td><td colspan="2">Purpose of Investigation (PoI)
Characterization of the impacts of the developed cyberattack models on DERMS and network operational parameters.</td></tr>
<tr><td>Object under Investigation (OuI)
Cyberattacks models developed by the user group.</td><td>Function(s) under Investigation (FuI)
- False Data Injection (FDI) into obtained operational parameters (voltage, current, active power, reactive power, energy and SoC),
- Replay of a formerly collected set of data,
- Change of inverter operation mode (e.g. different Volt/VAr slope or from Volt/VAr mode to Volt/Watt mode and other),
- Denial of Service (DoS) and Distributed Denial of Service (DDoS) attacks making an asset or a communication link inaccessible,
- Travelling attack -moving from one node to another-,
- Epidemic attack -spreading to other nodes-
- Contextual attack during system contingencies, instabilities or brownouts.</td><td>System under Test (SuT)
- A low voltage distribution network with controllable loads, bulk loads, AC or DC controlled power sources, photovoltaic panel group, batteries and optionally EV charging station.
- Centralized, distributed or decentralized data acquisition and control infrastructure and command library to monitor the critical points and components of the system and adjust set points/change operation modes of the controllable assets.</td><td>Functions under Test (FuT)
- Selected functions (among connect/disconnect, charge/discharge, price-based management, generation following management, peak power limiting, real and reactive power dispatch, voltage regulation, frequency regulation) of a representative distributed energy management system (DERMS), developed by the user group and if there are any existing ones in the hosting research infrastructure,
- Selected functions (among peak power limiting, voltage regulation, load following and optionally phase balancing) of a representative active distribution network management system developed by the user group and if there are any existing ones in the hosting research infrastructure,
- Selected functions of a representative microgrid primary, secondary and/or tertiary management (among primary/secondary voltage control, primary/secondary frequency control, power sharing, peak limiting, optimum energy cost minimization) system developed by the user group and if there are any existing ones in the hosting research infrastructure,</td></tr>
<tr><td colspan="2">Domain under Investigation (DuI)
Low voltage distribution network, microgrid with islanding capabilitiy.</td><td colspan="2"></td></tr>
<tr><td colspan="4">Test criteria (TCR)
Violation of upper or lower operational rms voltage limits (preferably $\pm 10\%$, optionally $\pm 5\%$ or $\pm 5\%$), violation of maximum loading limit at individual device level, at one of the network line pairs or at the trafo, violation of upper of lower operational frequency limits (preferably from 49.5 to 50.5 Hz, optionally from 47.0 to 52.0 Hz), failure of a considered DERMS service target in price-based management, peak power limiting or generation following management.</td></tr>
</table>

target metrics	**variability attributes**	**quality attributes**
- Loading at the trafo and line pairs, - rms voltage in pu at the trafo, critical points of the networks and DER buses, - Frequency - The individual or set of targets of a provided DERMS service in price-based management, peak power limiting or generation following management.	Controllable variabilitiy attributes: - Battery individual SoC levels, - Solar irradiation in case of using controlled AC or DC power source to imitate the behavior of solar panels. - Pricing rates based on the selected scenario, - Voltage at the point of common coupling of the network to the master component in islanded microgrid operation. Uncontrollable variability attributes: - Solar irradiation in case of using real PV panels, - Temperature of components, - Voltage at the point of common coupling of the network to the trafo in grid-connected operation.	- Preferably $\pm 10\%$, optionally $\pm 5\%$ or $\pm 5\%$ deviation of rms voltage at any point in the network, for longer than certain durations, - Violation of preferably 49.5 to 50.5 Hz, optionally from 47.0 to 52.0 Hz values at any point of operation, for longer than certain durations, - Violation of maximum loading limit at individual device level, at one of the network line pairs or at the trafo, based on their individual loading limits, for longer than certain durations.

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Test Objectives
To validate cyberattack detection methods developed for identifying hard-to-detect attacks on DERMS, active distribution network management system and microgrid control system.

Purpose of Investigation *(PoI)*
Validation of the performance, accuracy and robustness of the developed cyberattack detection methodologies.

Object under Investigation (*OuI*)
Cyberattacks detection solutions developed by the user group.

Function(s) under Investigation (*FuI*)
- False Data Injection (FDI) attack detection,
- Replay attack detection,
- Hijacking attack detection,
- Denial of Service (DoS) and Distributed Denial of Service (DDoS) attacks detection,
- Travelling attack -moving from one node to another- detection,
- Epidemic attack -spreading to other nodes- detection,
- Contextual attack detection during system contingencies, instabilities or brownouts.

Domain under Investigation (*DuI*)
Low voltage distribution network, microgrid with islanding capabilitiy.

System under Test (*SuT*)
- A low voltage distribution network with controllable loads, bulk loads, AC or DC controlled power sources, photovoltaic panel group, batteries and optionally EV charging station.
- Centralized, distributed or decentralized data acquisition and control infrastructure and command library to monitor the critical points and components of the system and adjust set points/change operation modes of the controllable assets.

Functions under Test (*FuT*)
- Cyberattack models quantified in Test Case-1,
- Selected functions (among connect/disconnect, charge/discharge, price-based management, generation following management, peak power limiting, real and reactive power dispatch, voltage regulation, frequency regulation) of a representative distributed energy management system (DERMS), developed by the user group and if there are any existing ones in the hosting research infrastructure,
- Selected functions (among peak power limiting, voltage regulation, load following and optionally phase balancing) of a representative active distribution network management system developed by the user group and if there are any existing ones in the hosting research infrastructure,
- Selected functions of a representative microgrid primary, secondary and/or tertiary management (among primary/secondary voltage control, primary/secondary frequency control, power sharing, peak limiting, optimum energy cost minimization) system developed by the user group and if there are any existing ones in the hosting research infrastructure,

Test criteria *(TCR)*
Attack detection time, attack detection accuracy, attack detection robustness to randomized attacks and uncertainty of prices and renewable generation. Computational burden during detection of attacks.

target metrics	**variability attributes**	**quality attributes**
- Loading at the trafo and line pairs, - rms voltage in pu at the trafo, critical points of the networks and DER buses, - Frequency, - The rate of change of any metrics listed above, - The time series similarity of a set of any metrics listed above with historical recordings, - DER simultaneity, - RAM use per detection, - Processor use per detection, - The individual or set of targets of a provided DERMS service in price-based management, peak power limiting or generation following management.	Controllable variability attributes: - Attacked target node, component, communication link, - Attacking time, - Number of attacks in a given time period, - Battery individual SoC levels, - Solar irradiation in case of using controlled AC or DC power source to imitate the behavior of solar panels. - Pricing rates based on the selected scenario, - Voltage at the point of common coupling of the network to the master component in islanded microgrid operation. Uncontrollable variability attributes: - Solar irradiation in case of using real PV panels, - Temperature of components, - Voltage at the point of common coupling of the network to the trafo in grid-connected operation.	- Attack detection accuracy preferably over the highest available in similar studies in the literature, optionally over the average of similar studies in the literature, - Attack detection time preferably below the lowest available in similar studies in the literature, optionally below the average of similar studies in the literature, - Attack detection robustness preferably over the best available in similar studies in the literature, optionally over the average of similar studies in the literature, - Computatonal burden preferably below the lowest available in similar studies in the literature, optionally below the average of similar studies in the literature,