

# Study of Communication Boundaries of Primal-Dual-Based Distributed Energy Resource Management Systems (DERMS)

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## Abstract

As the coordination of distributed energy resources (DERs) becomes increasingly necessary with distributed energy resource management systems (DERMS), studying the communication requirements for successful real-world, low-cost implementation becomes increasingly important. Specifically, this paper studies the necessary communication time resolutions between the different system components for a primal-dual-based DERMS, a highly developed DERMS framework. We design a metric to evaluate the functionality of a DERMS with respect to providing grid services. Using numerical simulations based on a real-world feeder in Colorado, we show that the upper bound on the time resolutions is on the order of minutes instead of the previously assumed order of seconds.

## Motivation

A primal-dual-based DERMS is a **distributed feedback controller** to provide grid services, such as:

- Voltage support
- Virtual power plant (VPP)
- Line current constraints.



Relies on **communication infrastructure**, which **could be expensive**, depending on its communication requirements.

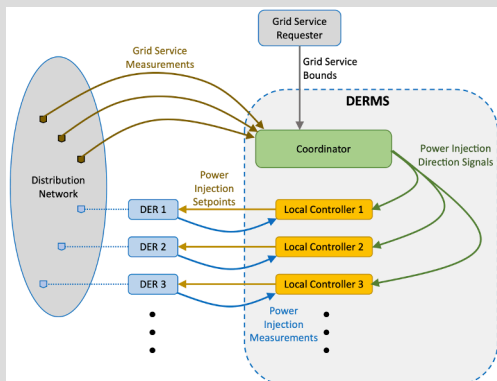
Research question:

- What are the **upper bounds on the communication time resolution** for a functional DERMS?

Answers will **reduce the uncertainty to commercialize DERMS** and possibly allow for **less expensive communication equipment**.

## DERMS Communication

### Primal-Dual-Based DERMS Communication Architecture



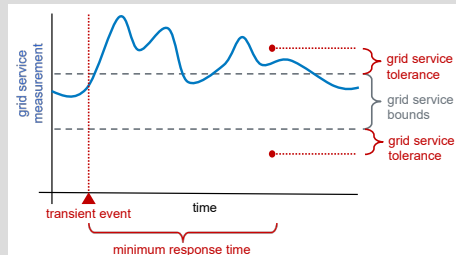
Communication channel categories:

1. Grid service measurements to DERMS coordinator
2. DERMS coordinator to local controllers
3. Local controller and DER(s).

## Evaluation Metrics

To determine if the DERMS is functional:

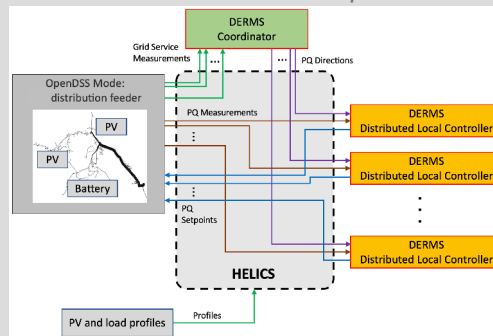
- Does the DERMS keep the grid service measurements near or within bounds after a transient event?



The DERMS is functional if every grid service measurement is within the tolerances by the minimum response time.

## Evaluation Setup

### Co-Simulation Communication Setup in HELICS



DERMS grid services:

- VPP
- Voltage support.

Distribution feeder:

- 4.6-MW peak load
- ~2,000 nodes
- 163 measurement nodes.

DERs:

- 163 PV generators
- 140 energy storage batteries.

Time resolutions:

- PV generation data = 1 minute
- Load data = 15 minutes
- Power flow calculation (OpenDSS) = 2 seconds
- DERMS coordinator update = 1 minute
- Default communication within HELICS = 2 seconds.

Evaluation metric settings:

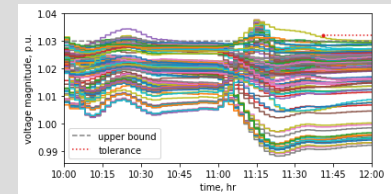
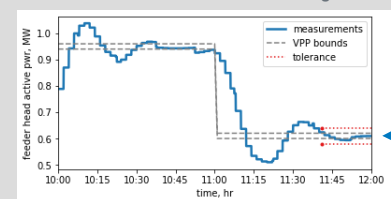
- Transient event = step change in VPP settings
- VPP tolerance = 0.02 MW
- Voltage tolerance = 0.002 p.u.
- Minimum response time = 40 minutes.

## Numerical Results

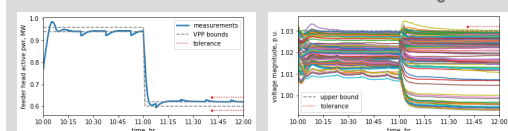
### Upper Bounds on the Communication Time Resolution

Communication Channel Category	Time Resolution Upper Bound	Limiting Grid Service
Grid service measurements to DERMS coordinator	2 minutes	Voltage support, VPP Phase B
DERMS coordinator to local controllers	2 minutes	Voltage support
Local controller and DER(s)	2 minutes	Voltage support, VPP Phase C
<b>All categories together</b>	<b>2 minutes</b>	<b>Voltage support, VPP Phase C</b>

### 2-Minute Time Resolution for All Categories



### Benchmark: 2-Second Time Resolution for All Categories



## Conclusions

This paper studied the communication time resolution bounds among the system components for primal-dual-based DERMS with the intention of informing the DERMS industry with:

- A metric based on the minimum response time after a transient event was designed to evaluate the functionality of a DERMS with respect to the grid services it is tasked to provide.
- Numerical simulations with a real-world feeder and load data show that the time resolution can be increased from seconds to 2 minutes when using a minimum response time of 40 minutes.