Demonstration of a Heliostat Solar Field Wireless Control System

SolarDynamics LLC
Concentrating on a new energy future

Objective: de-risk the adoption of wireless communication systems used to control heliostats in CSP power plants.

- ➢ Problem – No public performance data on existing systems.
  - Stakeholder risk is high for new plants.
  - ✓ Solution - Build & operate a demonstration system.
    - Publicly document operational performance and detailed engineering (hardware and software) of the system.
- ✓ Develop CSP solar field wireless system analytical tools.
  - Predict wireless performance of reference CSP power plant solar field using a 'tuned' wireless computer RF propagation model.
- ✓ Reduce the installation cost of heliostat solar fields.
  - Detailed Bill of Materials for reference CSP power plant.

Task #1

Demonstrate a 200+ heliostat solar field wireless control system.

✓ Use commercially available, standards-based, industrial technology

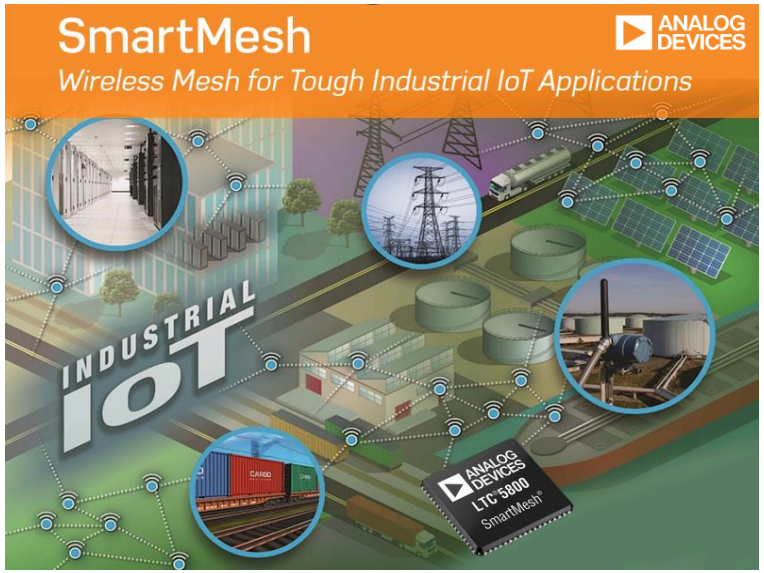

Fig 1 – SmartMesh overview picture. Taken from "SmartMesh Brochure" 7/3/2023, ©2017 Analog Devices, Inc.

- IEEE
  - 802.3 (Ethernet)
  - 802.11 (Wi-Fi)
  - 802.15.4 (LR-WPAN)
- IPv6
- TCP/IP
- 6LoWPAN
- Redundancy
- Reliability
- Response
- Large, dense networks

Task #2

Computer model of the Radio Frequency (RF) links between the wireless nodes in the heliostat solar field.

REMCOM Wireless InSite® 3D

1. 3D ray-tracing simulation of demonstration wireless system (details radio behavior and RF propagation).
2. 'Tune' model such that real-world and simulated performance match (RSSI vs distance, Packet Success Ratio, path stability).
3. Extend the tuned model to a reference CSP power plant solar field with 20,000 – 50,000 heliostats.

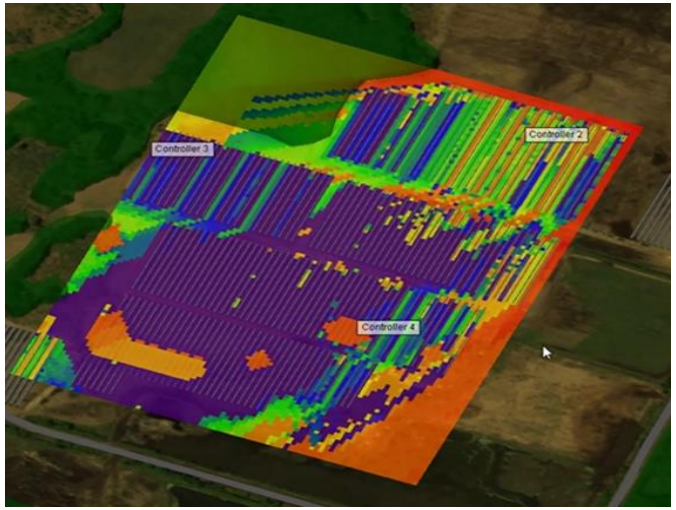

Fig 2 – Predicted RSSI heat map of PV Solar Field created with Wireless InSite 3D. Used with permission 7/3/2023. REMCOM.

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SmartMesh Key Details for Solar Field Application

- Time Synchronized, Channel Hopping (TSCH), multi-hop mesh network, operating in 2.4GHz frequency band.
  - TDMA eliminates RF self-interference and ensures adequate bandwidth
  - Mesh topology provides redundant paths for changing RF environments
  - Increases network bandwidth due to spatial diversity
  - Frequency hopping to avoid blocked channels (device coexistence)
  - No licensing fees, world-wide ISM band
- Robust security features for mission-critical applications
  - End-to-end message encryption, authentication, and integrity checks.
  - Device authentication, network key establishment and exchange.
- Scalable to 50,000 nodes for large heliostat solar fields.
- Up to 10 messages/second/node for responsive solar field control.
- Diagnostics and self-optimization.
- A complete wireless solution – no network stack development. Only need to develop the application.
- Field proven in tough wireless RF environments such as mines, refineries, data centers, & street parking systems.
- Over 76,000 networks in 120 countries. Used in products from leading manufactures. FCC certified PCB radio modules.

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SmartMesh Performance Testing To-date by Solar Dynamics

- Test #1 – 30-node test in heliostat solar field.
- Test #2 – 500-node test in Photovoltaic (PV) solar field.
- Key testing results:
  - System worked "out of the box"
  - Validate network response predictions (≤10 seconds) using evaluation products
  - Confirm effective solar field radio transmission range
  - Prove reliable wireless data communication in actual RF environment

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