SAND2011-8605P

Grid-tied Power Electronics

The Navajo Nation Energy Advisory Committee visit to Sandia

November 8, 2011

Stanley (Stan) Atcitty, PhD
Wind Energy Technologies Dept.

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration, under contract DE-AC04-94AL85000.

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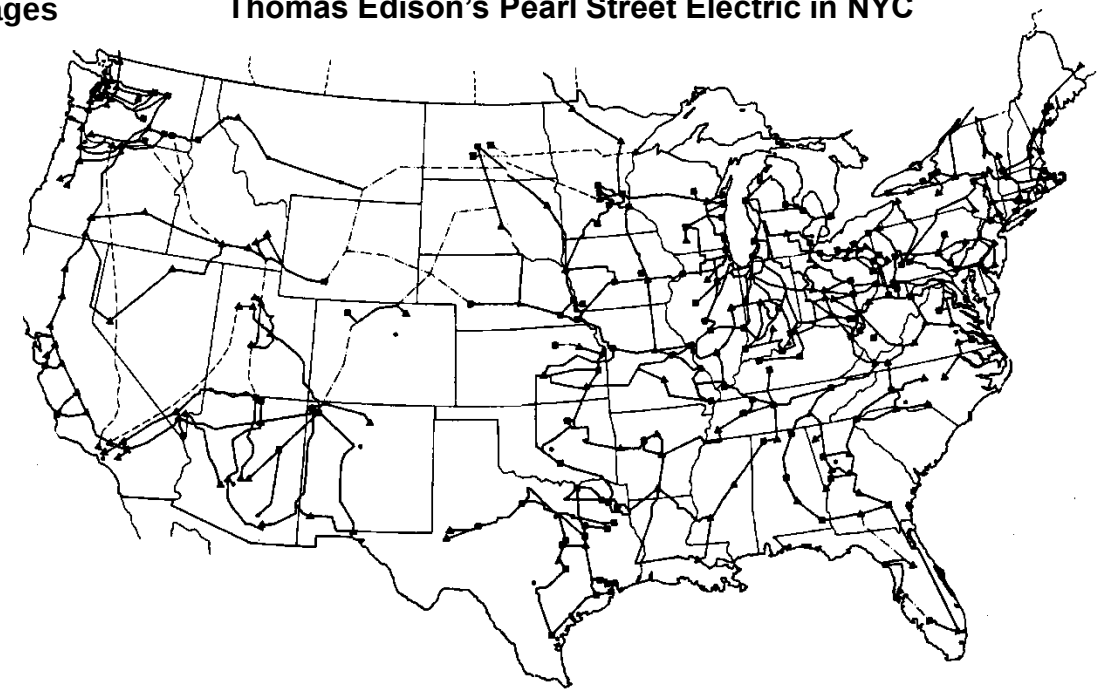
Electric Utility Background

Common AC voltages

- **Transmission**
  - 765kV
  - 500kV
  - 345kV
  - 230kV
- **Sub-Transmission**
  - 69kV
  - 30kV
- **Distribution**
  - 15kV
  - 4kV
  - 2kV
  - 600V
  - 480V
  - 240V
  - 120V

First modern electric system developed in 1882 by Thomas Edison's Pearl Street Electric in NYC



Made up of:

- **Over 150 thousand miles of transmission lines (AC & DC)**
- **10s of thousands of Generating Units totaling ~1000GW of total capacity**
- **Millions of transformers, relays, and controls**
- **100s of Billions of dollars in total investments in transmission and distribution**

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Electric Utility Major Blackouts

- **San Diego/Arizona/Baja Blackout September 2011**
  - **5M affected, HV transmission line failure from AZ to CA**
- **Northeast Power Blackout August 14, 2003**

Source: http://www.globalsecurity.org/eye/blackout_2003.htm

~ 45M people affected US, 10M Ontario Canada

~ 6B in financial losses

- **Western US Blackout August 1996**
  - **High demand, heat wave, and sagging power lines**
- **New York City Blackout July 1977**
- **Northeast Blackout November 1965**

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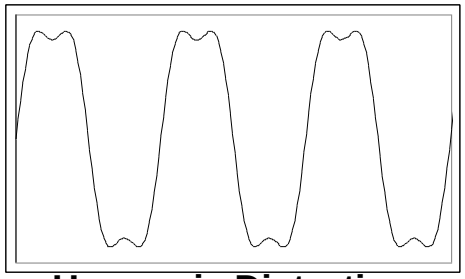
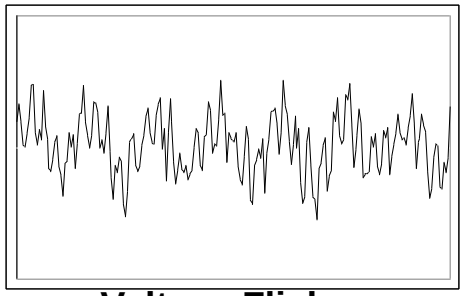
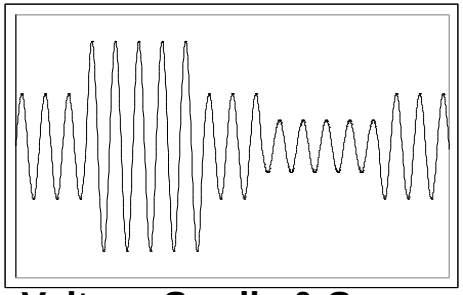
Other Electric Utility Issues



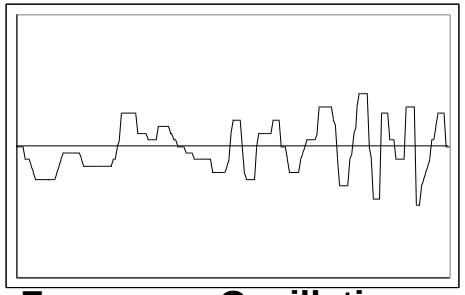
Harmonic Distortion



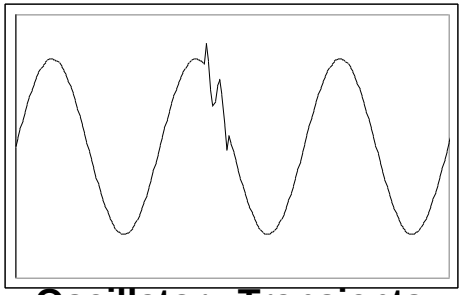
Voltage Flickers



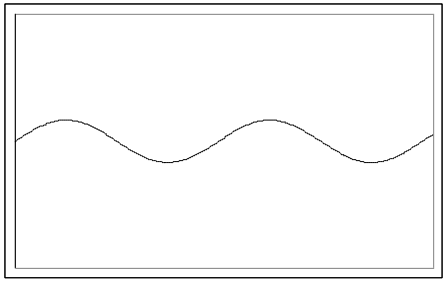
Voltage Swells & Sags



Frequency Oscillations



Oscillatory Transients



Subsynchronous Resonance

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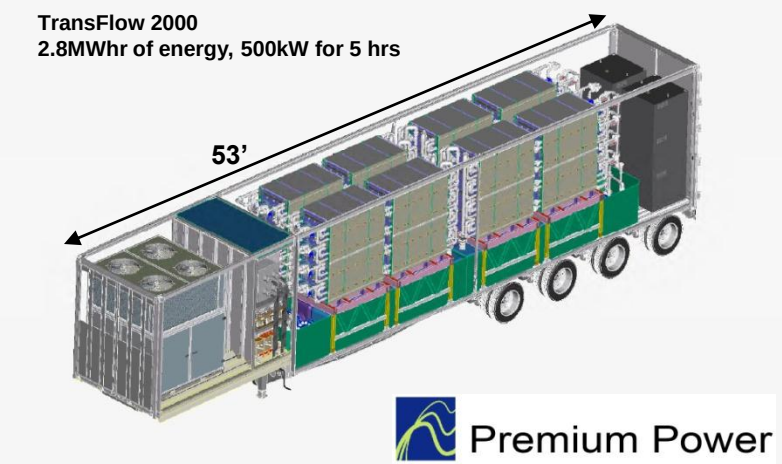
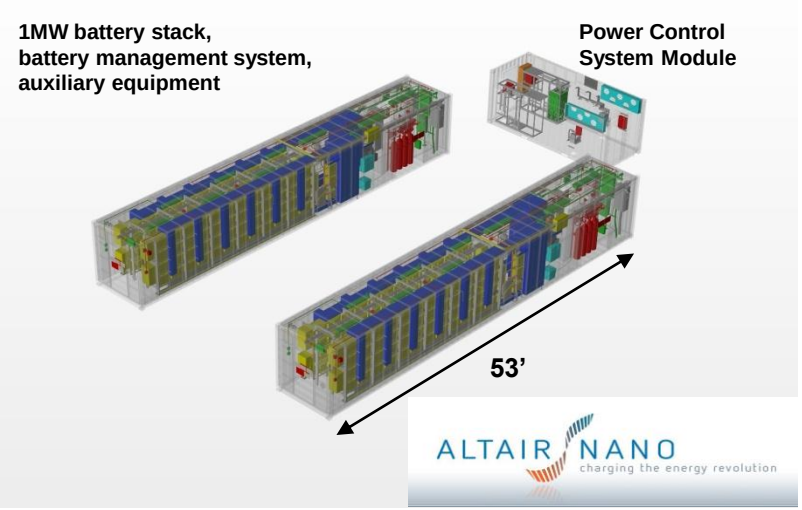
Transportable Systems



Peak Shaving, Demand Response, T&D Deferral, etc.



Grid Stabilization/Renewable Integration

Wind farm dynamic VAR compensation

Benefits

- Lower Installation Cost
- Less Time from Installation to Operation
- Use at Multiple Sites Optimizes Overall System Use

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Benefits of Electricity Storage

- **Maintain quality power and reliability**
- **Provide customer services — cost control, flexibility and convenience**
- **Improve T&D stability**
- **Enhance asset utilization and defer upgrades**
- **Increase the value of intermittent renewable generation**

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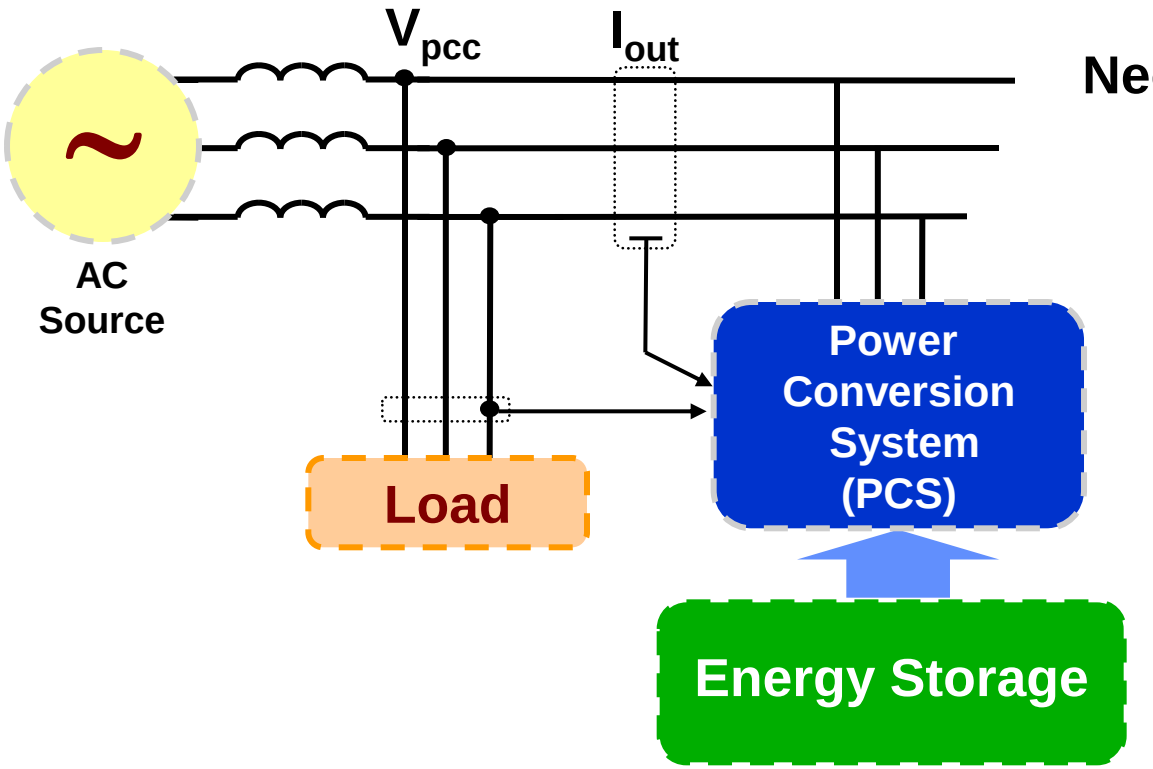
Why is DOE/Sandia interested in power electronics?

The PCS is a key component of the energy storage system—it can represent 20-60% of the total system cost.



Needs:

- Reduce install cost/kW
- Decrease size & weight especially for transportable systems
- Improve integration control
- Increase reliability
- Increase efficiency

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Daniel B. Poneman,
Deputy Secretary*
Melvin G. Williams Jr
Associate Deputy Secretary

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- Federal Energy Regulatory Commission
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Thomas P. D'Agostino
Under Secretary for Nuclear Security

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Under Secretary for Science

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Under Secretary

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- Assistant Secretary for Fossil Energy
- Assistant Secretary for Electricity Delivery and Energy Reliability
- Assistant Secretary for Nuclear Energy
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* The Deputy Secretary also serves as the Chief Operating Officer

06 Oct 11

DOE Energy Storage Program

DOE Office of Electricity Program Manager – Dr. Imre Gyuk

Mission:

Develop, in partnership with industry, advanced electricity storage and power conversion system technologies, for modernizing and expanding the electric supply to improve the quality, reliability, flexibility, and cost effectiveness of the existing system.

The Program is led by Sandia National Laboratories.

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Energy Storage Systems Program Goals

- **Develop and evaluate integrated energy storage systems**
- **Develop batteries, SMES, flywheels, ECs and other advanced energy storage devices**
- ***Improve multi-use power conversion system, controls, and communications components***
- **Analyze and compare technologies and application requirements**
- **Encourage program participation by industry, academia, research organizations, and regulatory agencies**

In short, develop a broad portfolio of demonstrated storage technologies for a wide spectrum of applications.

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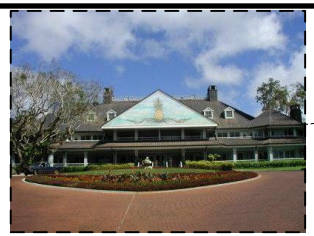
Lanai Grid Energy Storage Control Project



Koehle Lodge

Well Pumps

Lanai City

(City #1 CKT)

(City #2 CKT)

(Harbor CKT)

(Hotel CKT)

Harbor

Airport

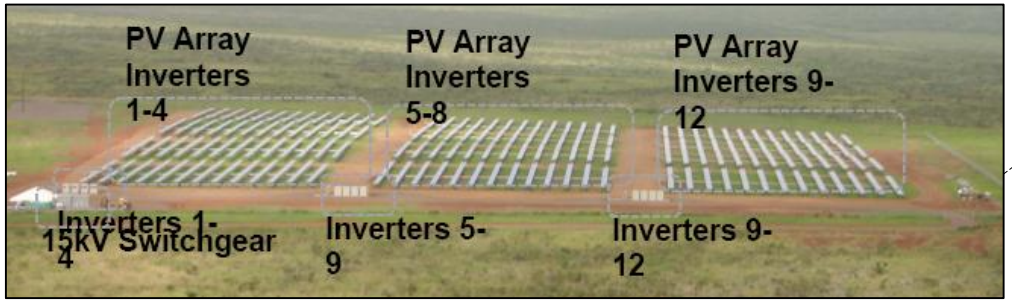
Miko Power Plant (10.4 MW)

PV Plant (1.2 MW)

(Hotel CKT)

Manele Hotel

12-135kW SatCon Inverters



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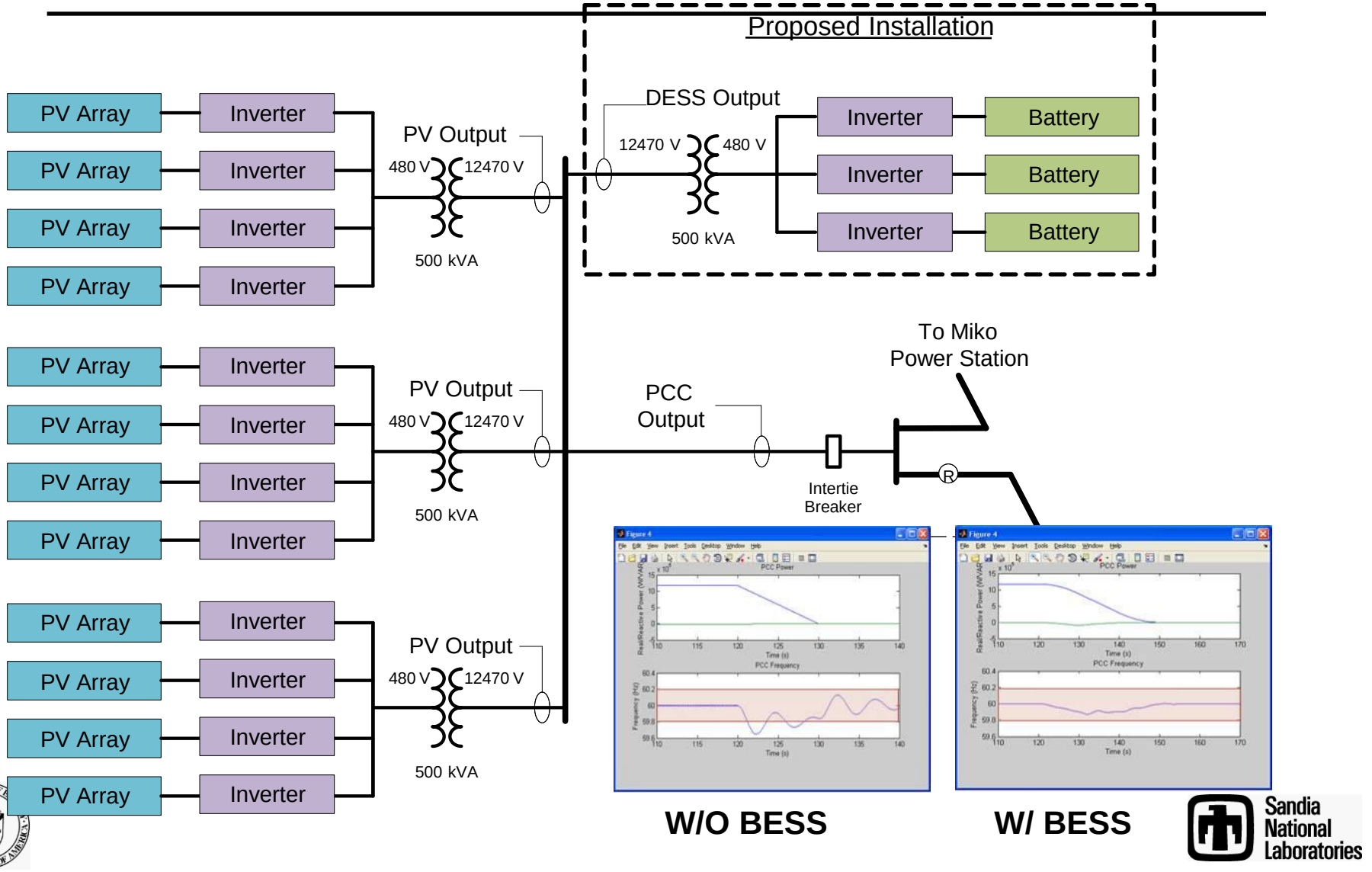
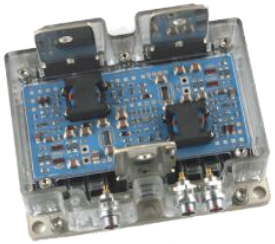
Lanai Grid Energy Storage Control Project



DOE Energy Storage Power Electronics Program Accomplishments

GeneSiC Semiconductor, Inc.
SiC Thyristors
– 2011 Winner



APEI, Inc.
SiC Power Module
– 2009 Winner

4 R&D 100 Awards

"The winning of an R&D 100 Award provides a mark of excellence known to industry, government, and academia as proof that the product is one of the most innovative ideas of the year." – R&D Magazine

Virginia Tech
Emitter Turn-off Thyristor
– 2003 Winner

Airak, Inc.
Fiber Optic Electrical Current Transducer
– 2003 Winner

In addition,

- **Three U.S. Patents (7,567,060 – July 2009, 7,239,044 – June 2007, 6,353,304 – March 2002, one pending)**
- **Over 40 technical publications**

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For Additional Information Contact

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Principal Member of Technical Staff

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