Power Distribution Studies for CMS Tracker

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2008-10-09

Power Distribution Studies for CMS Tracker

Current Topics of Investigation

Serial Power Distribution:

Efficiency: Current shared by multiple modules in series
Variants: Characterized by local regulation and
fault protection (shunt transistor) arrangements
Issues: Sizing of shunt transistors, isolated signaling, failure effects
System Performance
Node or Chain:
Failures
Abnormal Behavior

DC-DC Conversion

Efficiency: Magnitude of current delivered to converters
is reduced (power dissipated in cables to
tracker volume is reduced)
Variants: Switched capacitor (charge transfer), inductive
methods (air core transformer)
Issues: Switching noise, design for magnetic field environment

Proposal for Power Distribution System Studies for the CMS Tracker

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Sept. 2, 2008

Abstract

This proposal includes R&D to investigate the design of the power distribution system for the upgrades to the CMS Tracker. One purpose is to develop tools to allow engineers to identify optimal or nearly optimal architectures for delivering electrical power to the distributed detector elements. Such tools should pursue design objectives which incorporate elements of material budget, component reliability, power consumption, detector performance, and distribution system topology. Another purpose is to produce prototype hardware/software test benches using CMS Tracker components to characterize failure modes and demonstrate the techniques. These test benches will make possible investigations of the impact on detector performance due to the details of the power distribution system.

Our R&D interest is to reduce the detector material budget without compromising the reliability or performance of the semiconductor detector system. To achieve this, we will investigate the use of power delivery architectures which will produce systems which balance the requirements for performance and reliability with the goals of reduced material budget and power dissipation. These investigations will make use of techniques drawn from similar problems in fields such as power electronics, computer aided design of integrated circuits, power electronics engineering, and communications engineering. The research will result in a set of software design tools which will allow the user to define random and deterministic parameters of the system and compute solutions which attempt to minimize an objective function which incorporates these selected parameters. These design tools would not be general purpose optimization tools but rather tools focused on the types of feasible power delivery options that one would reasonably expect for the CMS tracker. These tools would allow collaborators to explore different power options and evaluate the suitability of these options for the tracker power design. These solutions will also draw from experience gained about failure modes and operating conditions during CMS running. The hardware test systems mentioned above will be made available for collaborators to use.

Power Distribution Studies for CMS Tracker

Progress Update:

Proposal Update: Recommended for Approval (Sept 30, 2008)

DC-DC Conversion:

Developing Test Systems for CMS Pixels (Based on CAPTAN)

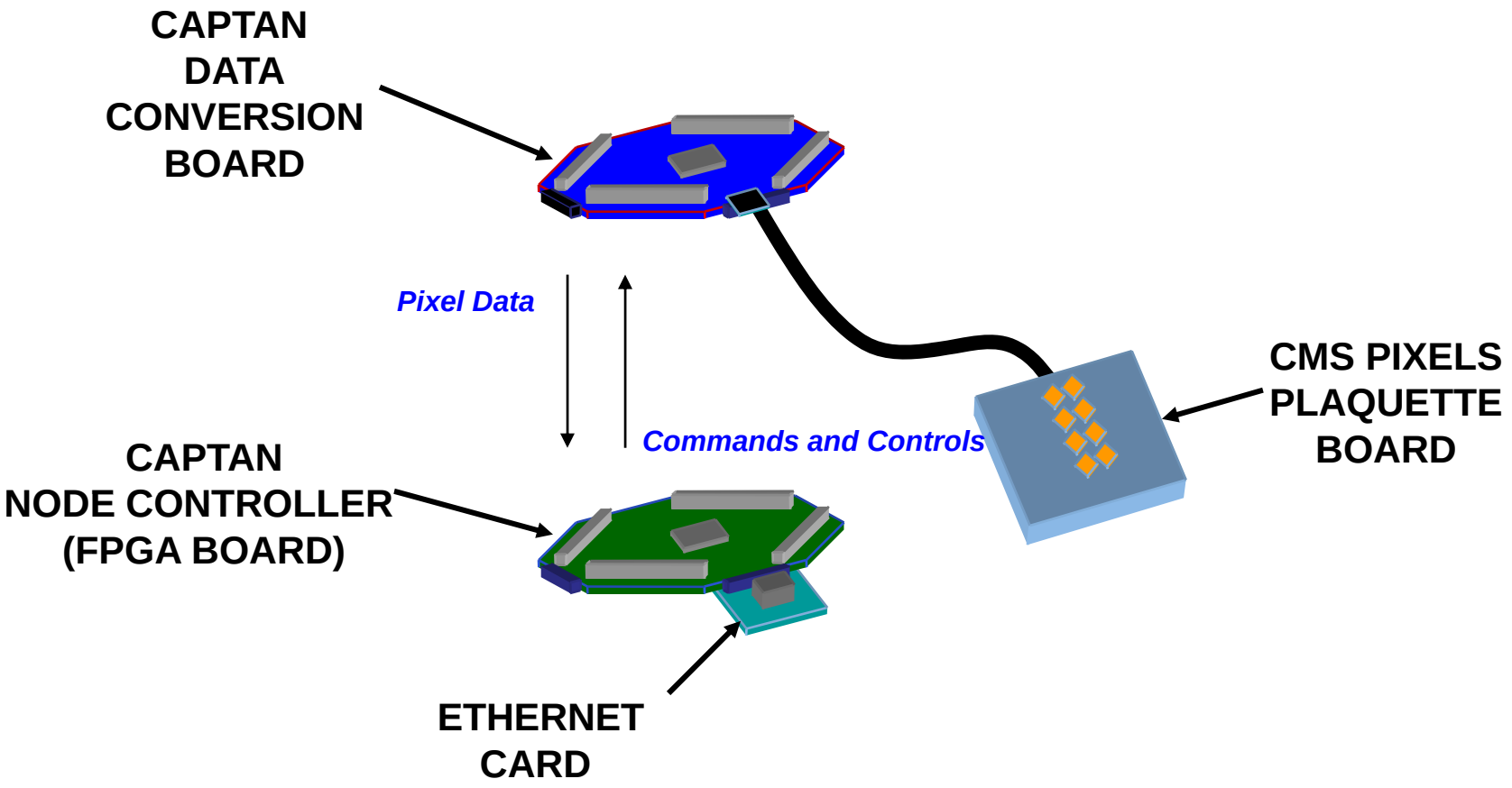
Option 1: Standard Power

Option 2: COTS DC-DC Conversion

Serial Powering:

Plan to implement a test system for CMS Pixels Using Fermilab SPI001 (Serial Powering Interface) or discrete components

Power Distribution Studies for CMS Tracker
Standard Power Configuration



Power Distribution Studies for CMS Tracker
Standard Power Configuration

Pixel Supply Voltages provided by Data Conversion Board

ADC on Data Conversion Board

No Switchers (linear regulators)

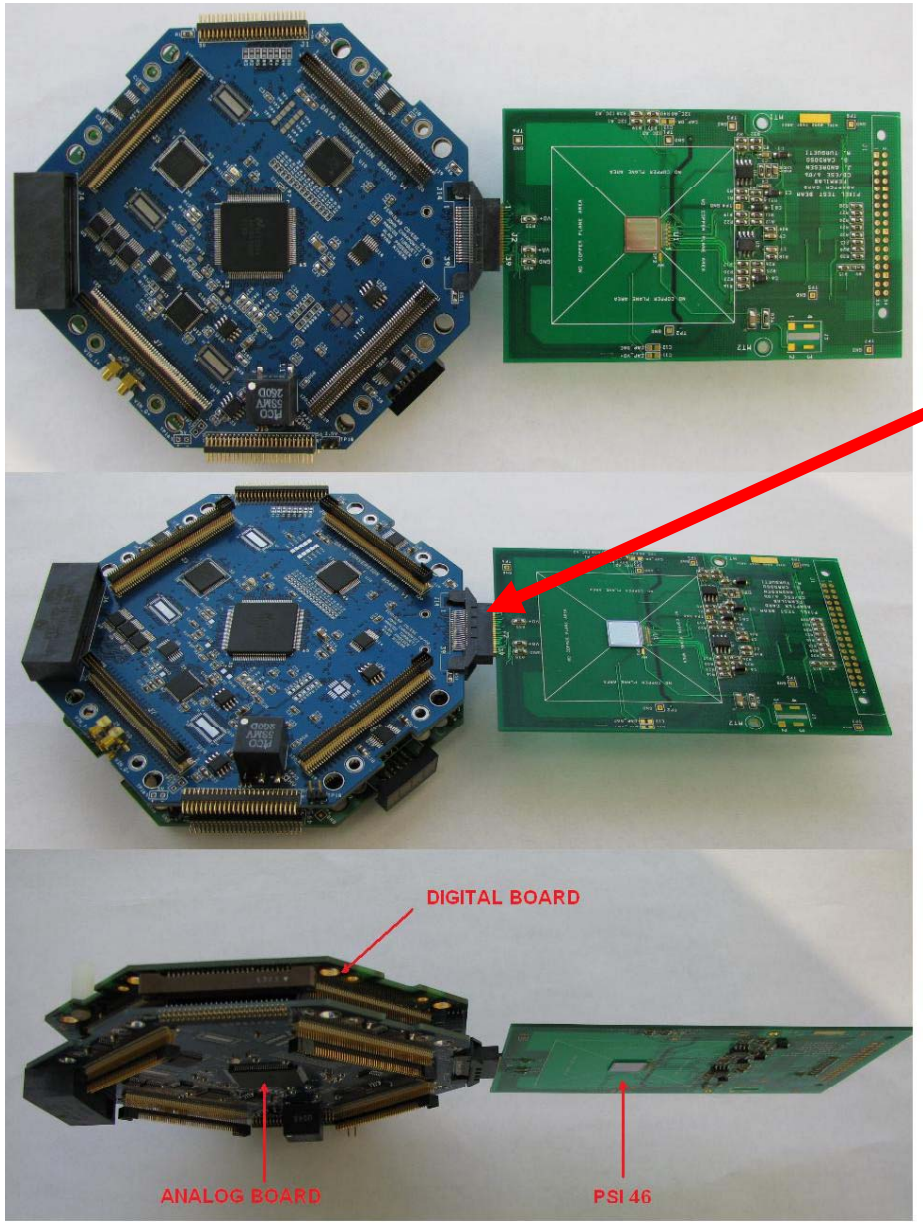
Single Chip Version Operating at Fermilab (ESE Dept test-stand)

Multi-Module Version Depends on CMS Pixels Plaquette Board in Design

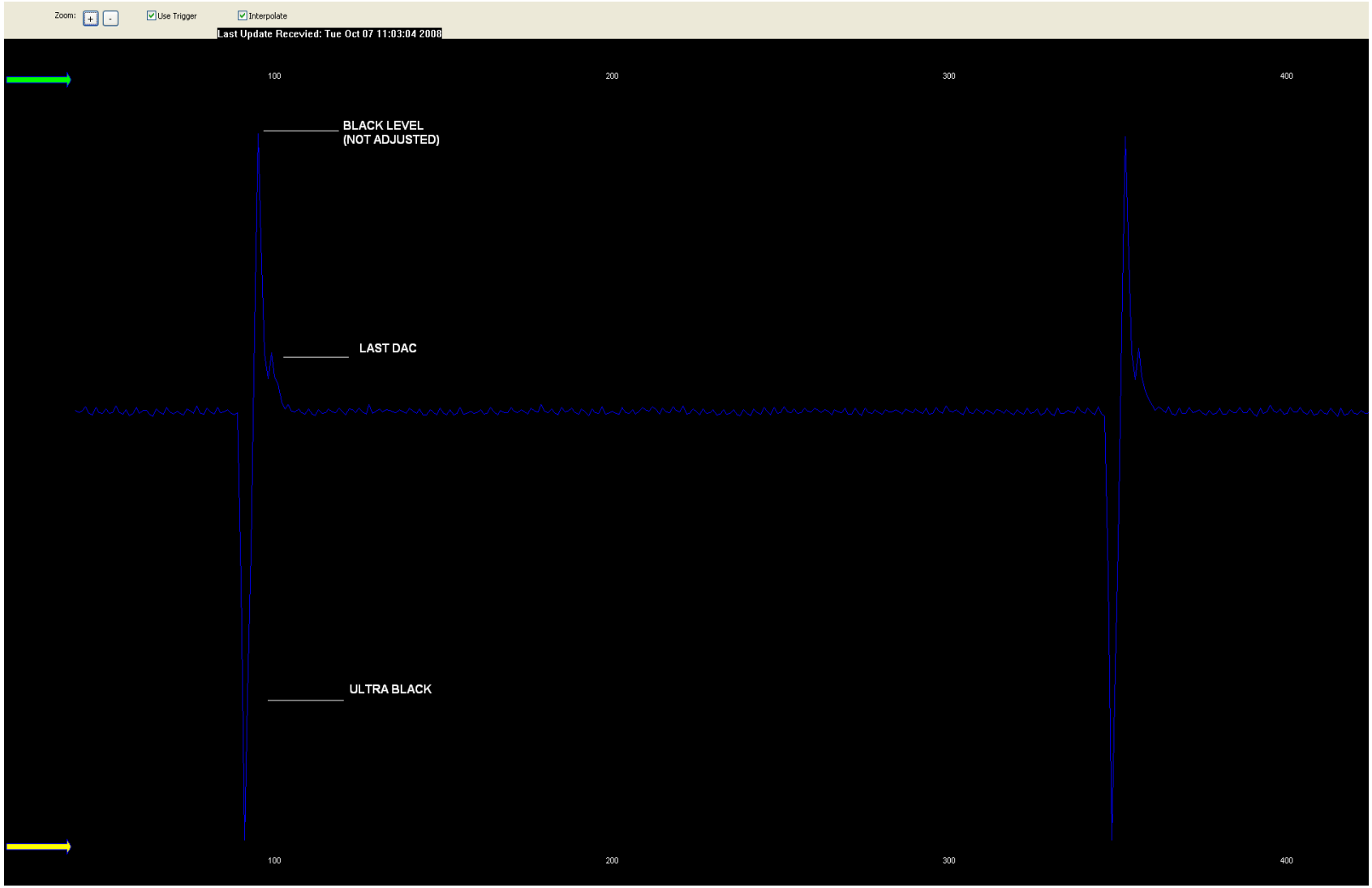
Operating with Gigabit Ethernet Link

CAPTAN Stack

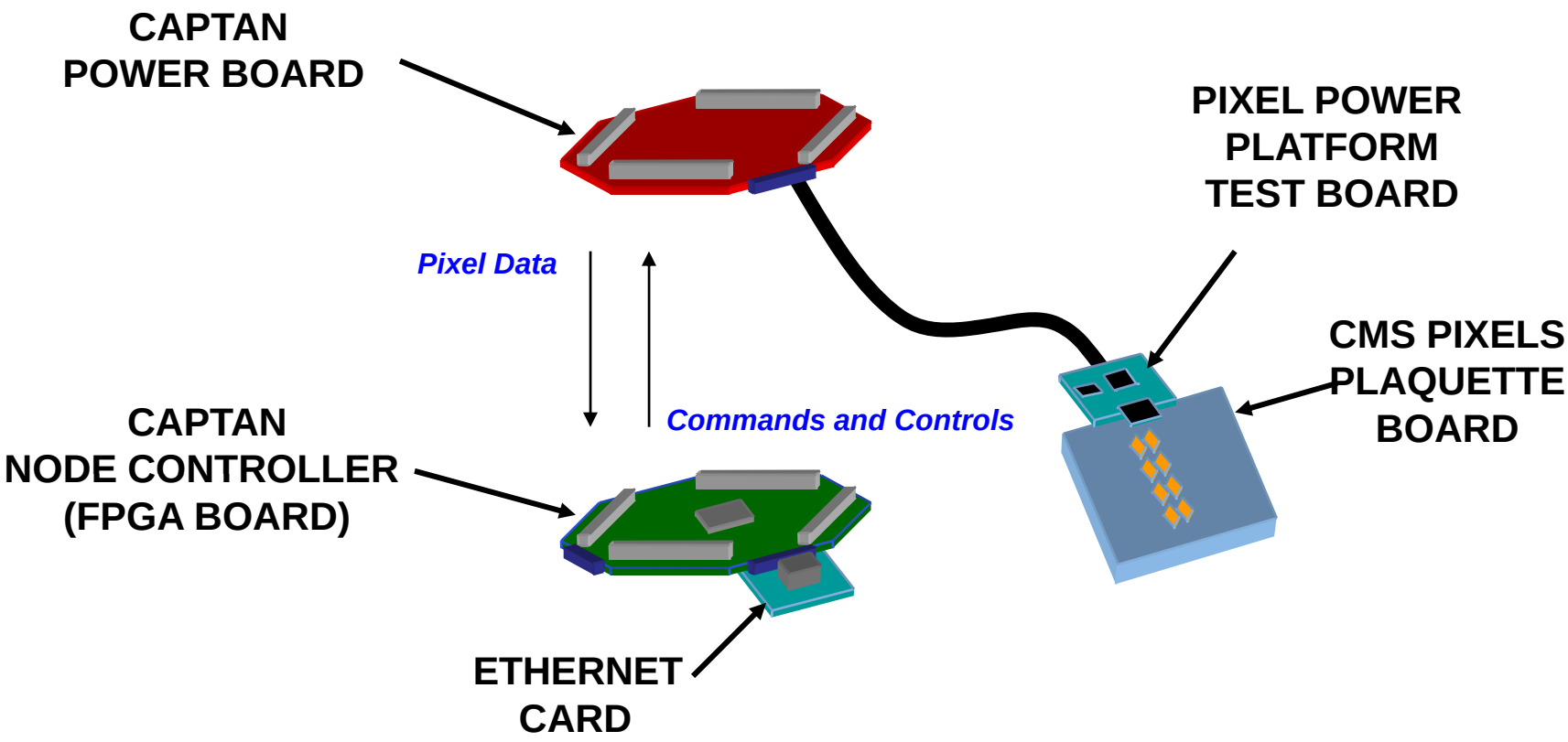
Node Controller + Data Conversion Board with Current CMS Pixels Board



Power Distribution Studies for CMS Tracker
Single PSI46 Test



Power Distribution Studies for CMS Tracker
DC-DC Conversion Configuration



Power Distribution Studies for CMS Tracker
DC-DC Conversion Configuration

High Voltage (50 V) Provided by CAPTAN Power Board

Pixel Supply Voltages provided by Pixel Power Platform Test Board

COTS Switching Power Supplies

+

COTS Low Drop Out Regulators

ADC on Pixel Power Platform Test Board

Digitizes Pixel Readout

CPLD on Pixel Power Platform Test Board

Decodes Command Stream (Modulated Power Line from Power Board)

Carries Data Stream from Readout Chip (Directly to Node Controller)

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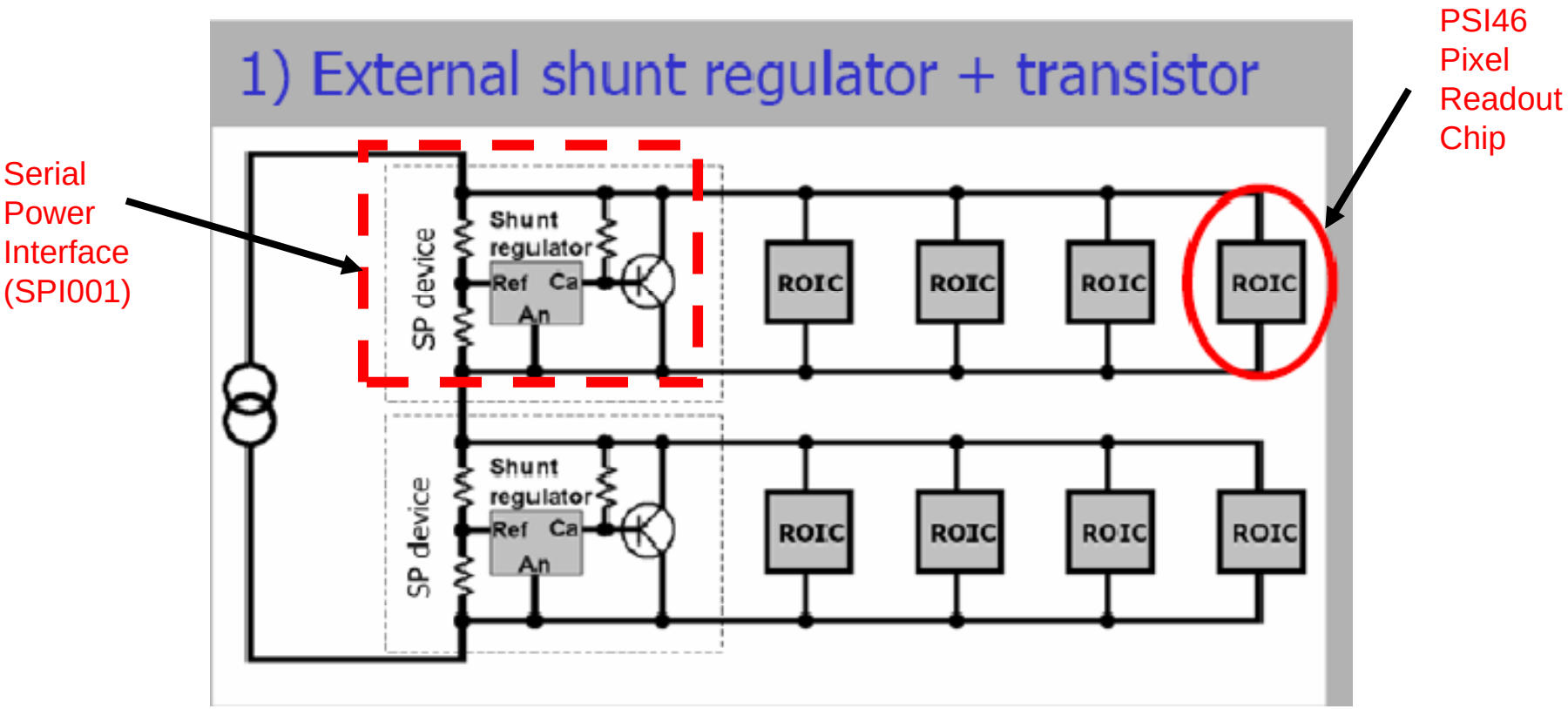
Serial Powering Interface Testing



From "The SPI as an integrated power management device for serial powering", M. Trimpl, TWEPP 2008, Naxos, Greece

Power Distribution Studies for CMS Tracker

Additional Topics for Investigation

- Learn From Operation of Current Pixels and Strips Detectors
- System Performance Measurements:
  - Threshold dispersion (how is it related to distribution scheme?)
  - EMC, EMI (how does noise couple throughout the system?)
  - Failure Mode Analysis (how do components fail and with what impact?)
- System Modeling:
  - Topology and regulation options
  - Reliability studies (Monte Carlo based on FMA discoveries)
  - Noise Modeling
  - Evolution of the Network (how do failures propagate?)

Power Distribution Studies for CMS Tracker

Work plan:

First results by the end of the year
Collaboration with University of Iowa, University of Mississippi

Study Current State of Power Distribution in CMS Tracker

Understand the constraints

Identify critical areas

Identify opportunities for improvement

Implement various power distribution prototypes for limited system studies & analysis

Make test - systems available for collaborators

Use test results for simulations and optimization of scaled system model