Autonomous Technologies Conference

20% to 40% Switching and Dynamic Power Reduction Using PowerGrid or Ground PowerPad Modification in Autonomous Electric Vehicle ICs

June 27–28, 2022 | San Jose, CA

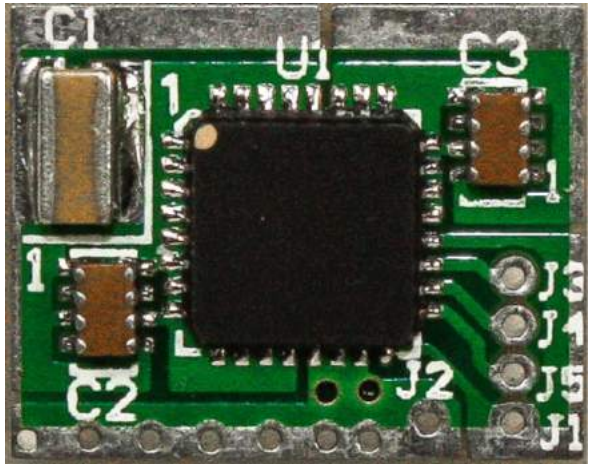
#AutonomousTechConf

CurrentRF PowerPad & PowerGrid

Current RF

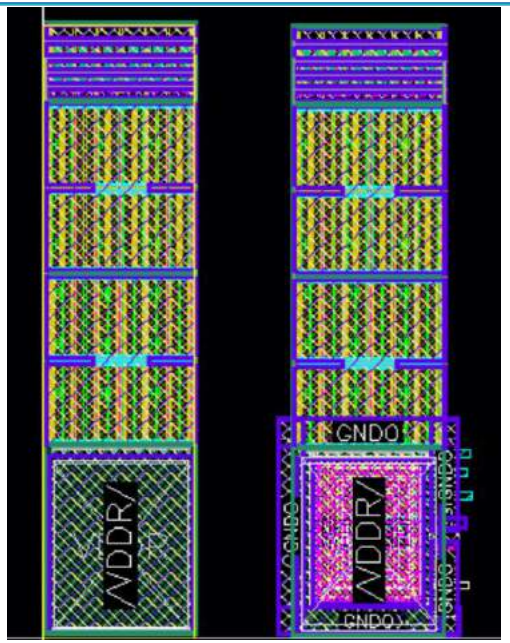
The CC-100 IC Dynamic Power Reduction Reduced to the Size and Form of a BondPad Suitable for Integration into any IC-Planar Mosfets or Finfets

Total Dynamic Power Feedback—No DC Current Draw



CC-100 IC Global Foundries
PowerPad Inside

Functionally Equivalent



XFAB XT018 BondPad

CurrentRF PowerPad

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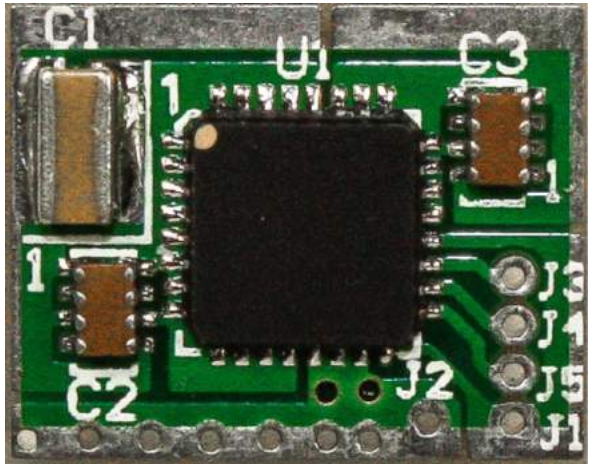

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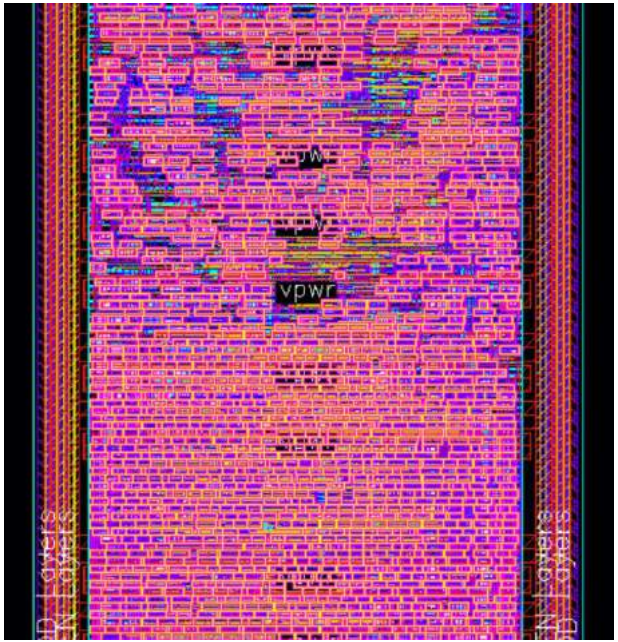

CC-100 Inserted in Digital Top Metallization

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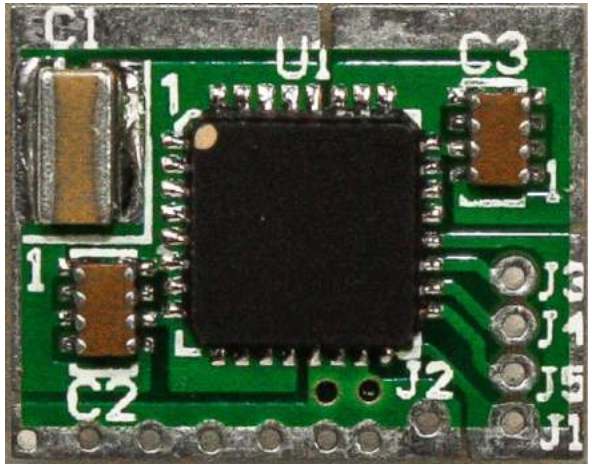

CC-100 IC Global Foundries
PowerPad Inside

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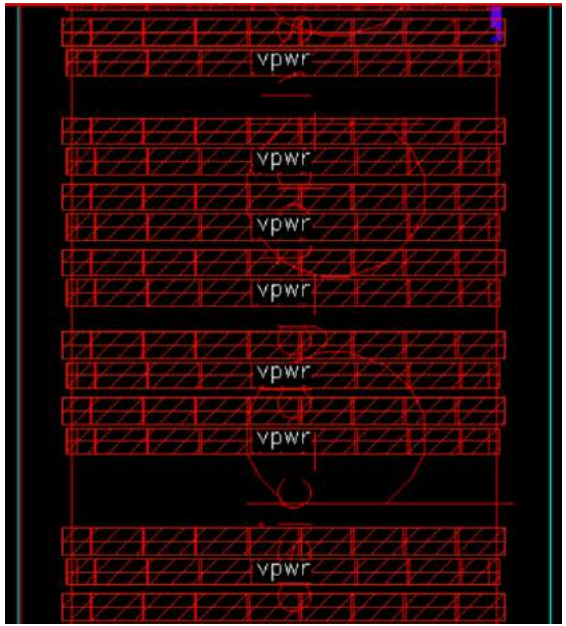
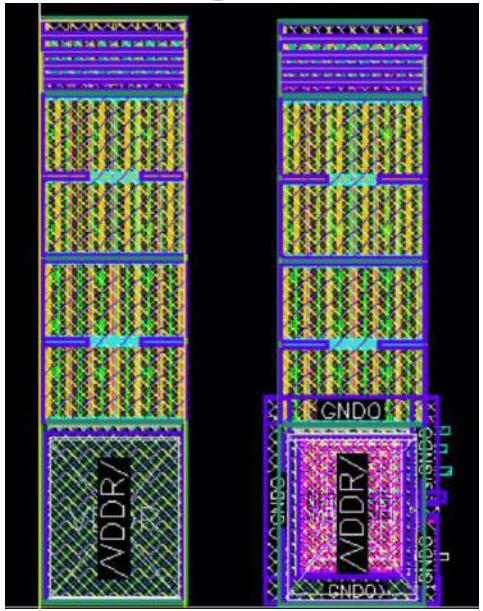


Balun Inserted in Digital Top Metallization

Original Supply Pads and the CurrentRF PowerPad Modification

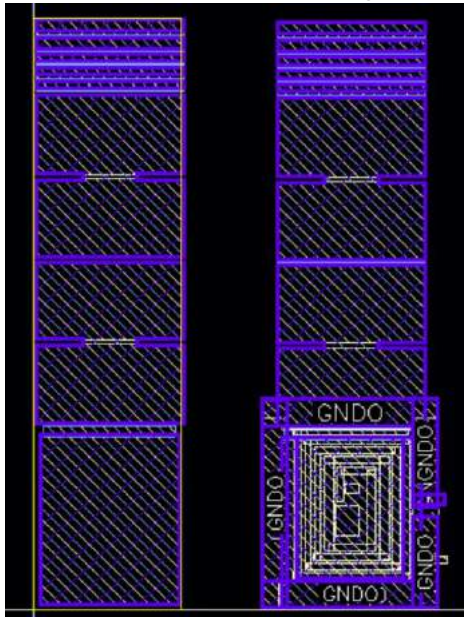
XT018 Top Metal View



XFAB XT018 BondPad **CurrentRF-XT018 PowerPad Modification**

RF Balun Embedded In a Power BondPad

XT018 Balun Secondary View

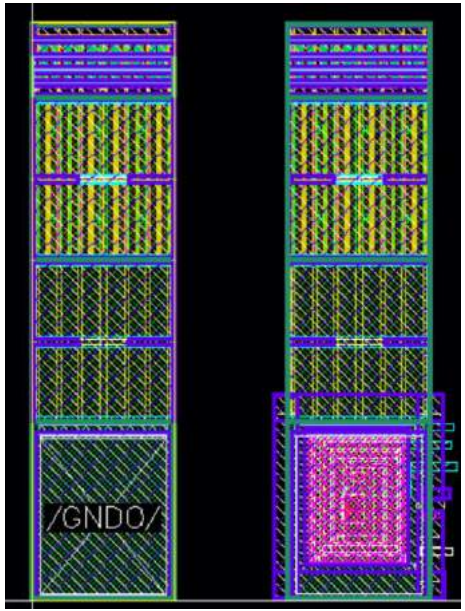


XFAB XT018 BondPad **CurrentRF-XT018 PowerPad Modification**

Original ESD Structures are Preserved with the Pad Modification

Original Ground Pads and the CurrentRF PowerPad Modification

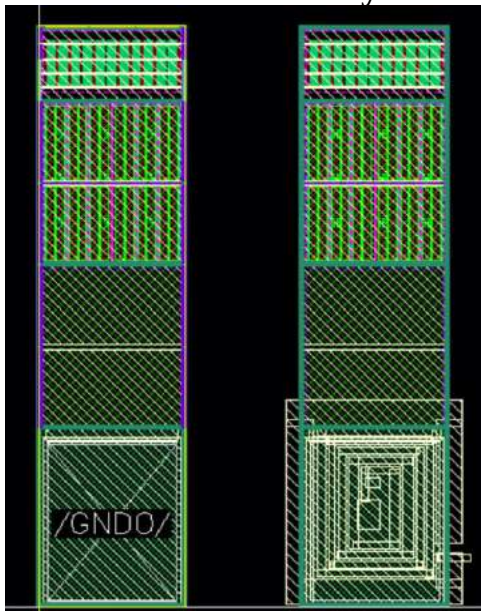
XT018 Top Metal View



XFAB XT018 BondPad **CurrentRF-XT018 PowerPad Modification**

RF Balun Embedded In a Ground BondPad

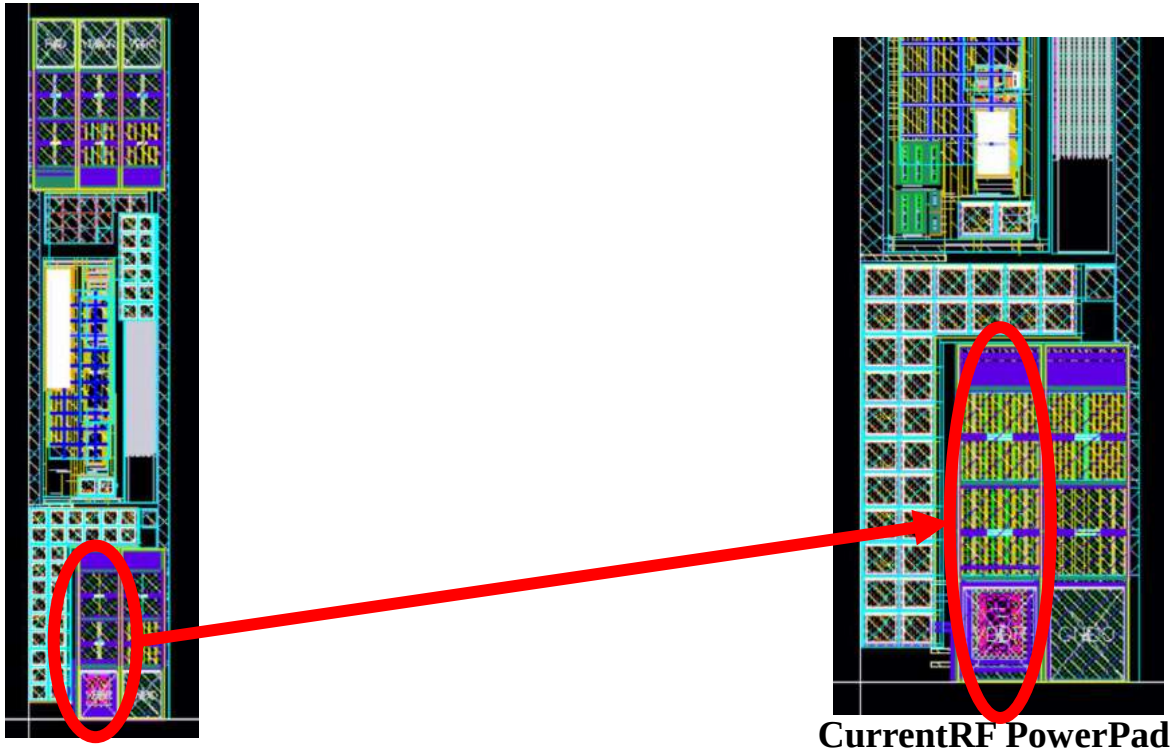
XT018 Balun Secondary View



XFAB XT018 BondPad **CurrentRF-XT018 PowerPad Modification**

Original ESD Structures are Preserved with the Pad Modification

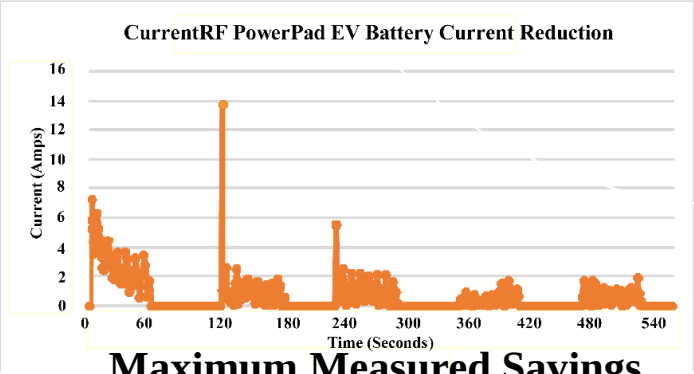
CurrentRF Supply PowerPad Integration into a 200um X 1mm Chiplet IC



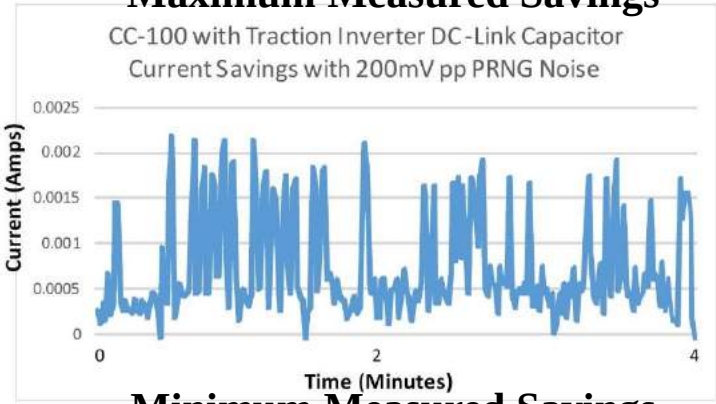
CurrentRF PowerPad

The CurrentRF PowerPad Can Be Inserted into the Power ESD Cells of any IC

CurrentRF PowerPad Current Savings Dynamic Range



Maximum Measured Savings



Minimum Measured Savings

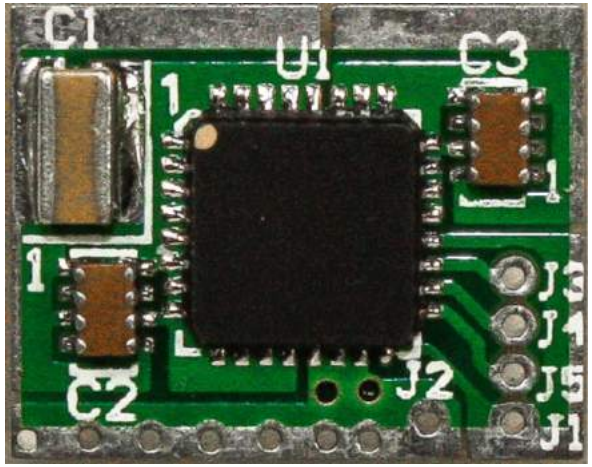
Electric Vehicle Solution—60 Amp Nominal Battery Current Draw
Average Savings--> 3 Amps—5% Savings
Maximum Surge Savings→14 Amps—23% savings
Applications→ EV Traction Inverter DC Link Caps
EV Battery Packs
EV Battery Management Systems

Digital and Mixed Signal IC Solution—5mA Nominal Current Draw
Average Savings--> 500 Micro-Amps—10% savings
Maximum Surge Savings→ 2.1mA---42% savings
Applications→ Micro and Nano Power Digital ICs
Micro and Nano Power Mixed Signal ICs
PLLs
Any IC that consumes Dynamic Power from Supplies

EV Solutions

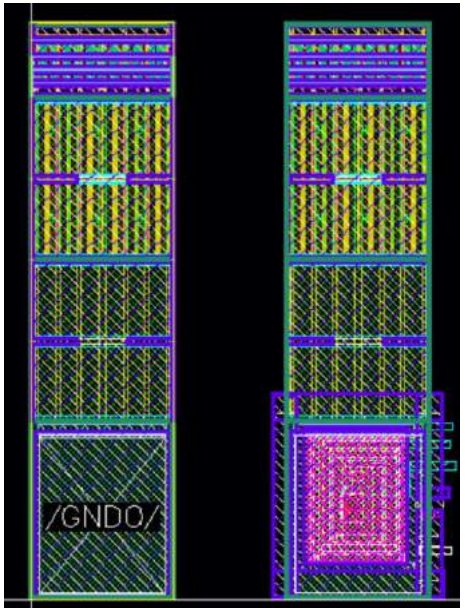
The CC-100 IC Dynamic Power Reduction Reduced to the Size and Form of a BondPad Suitable for Integration into any IC-Planar Mosfets or Finfets

Total Dynamic Power Feedback—No DC Current Draw



CC-100 IC Global Foundries
PowerPad Inside

Functionally Equivalent

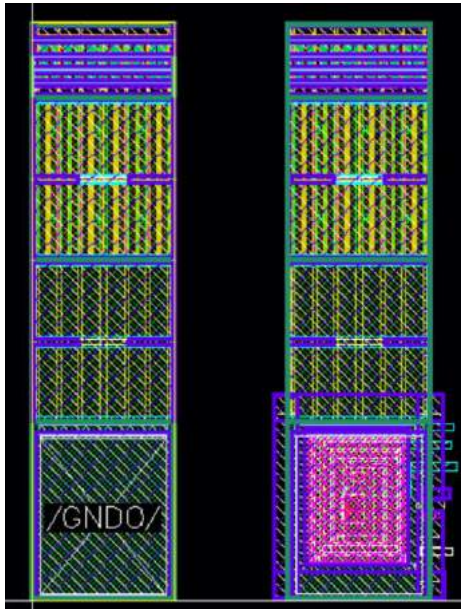


XFAB XT018 BondPad

CurrentRF PowerPad

Original Ground Pads and the CurrentRF PowerPad Modification

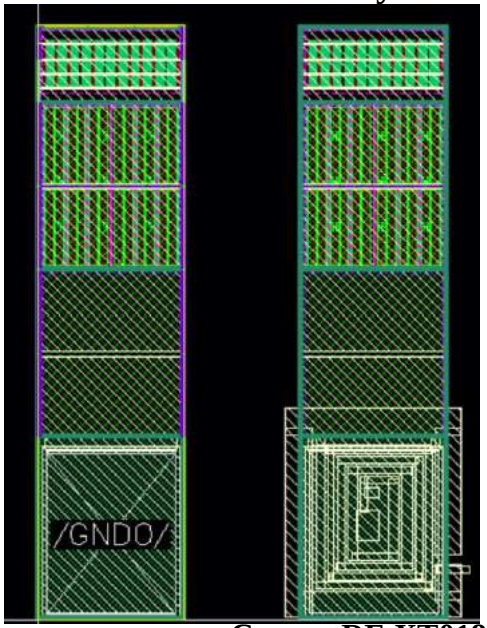
XT018 Top Metal View



XFAB XT018 BondPad **CurrentRF-XT018 PowerPad Modification**

RF Balun Embedded In a Ground BondPad

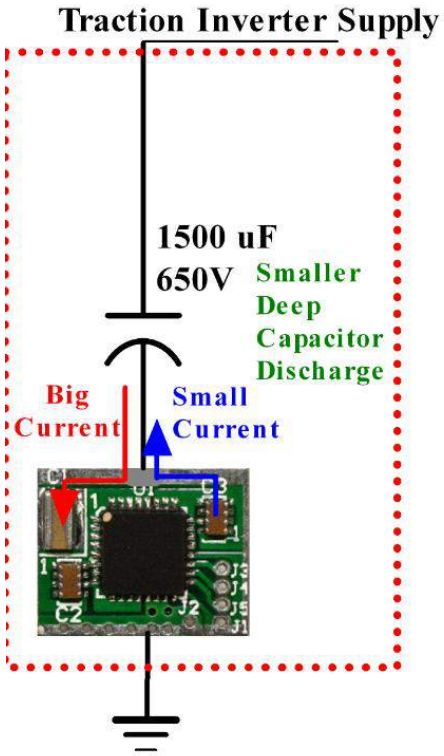
XT018 Balun Secondary View



XFAB XT018 BondPad **CurrentRF-XT018 PowerPad Modification**

Original ESD Structures are Preserved with the Pad Modification

Top Level –How the CurrentRF PowerPad Works With EV DC-Link Capacitors



Kirchoff's Current Law For AC Currents

CurrentRF Powerpad Enhanced DC-Link Capacitors

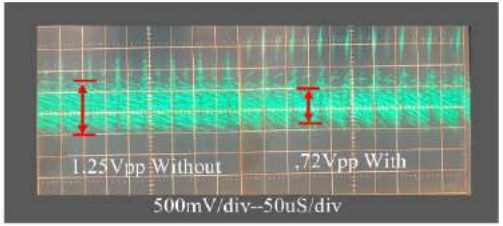
Patent # 10,666,089

Electric Vehicles are Electrically Noisy-PowerPad Battery Current Reduction

Shielded EV Cables

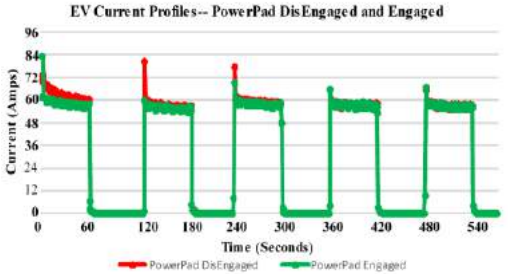
Why do This?

To Suppress EV Transmitted Noise

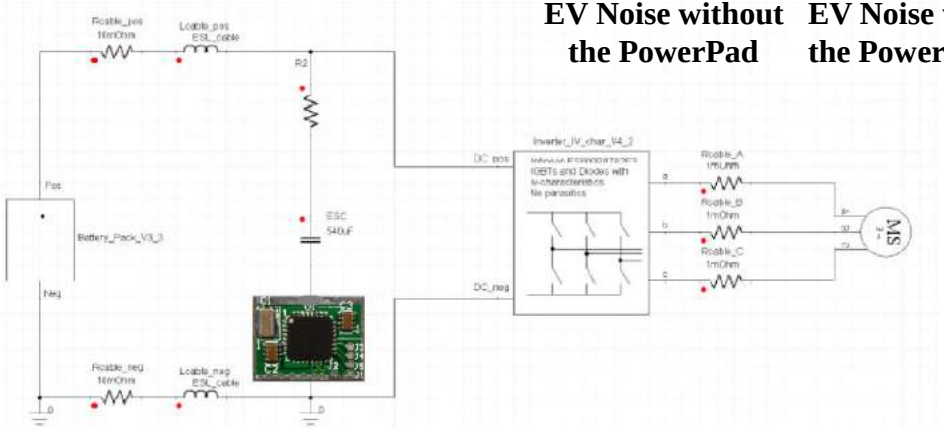


EV Noise without the PowerPad

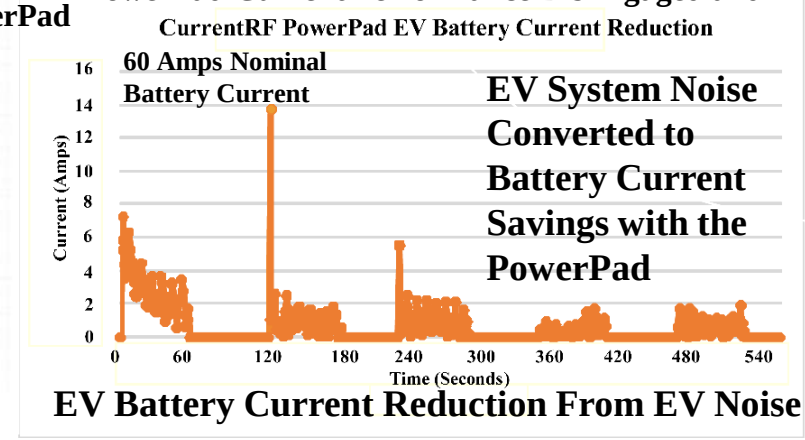
EV Noise with the PowerPad



PowerPad Current Performance DisEngaged and Engaged



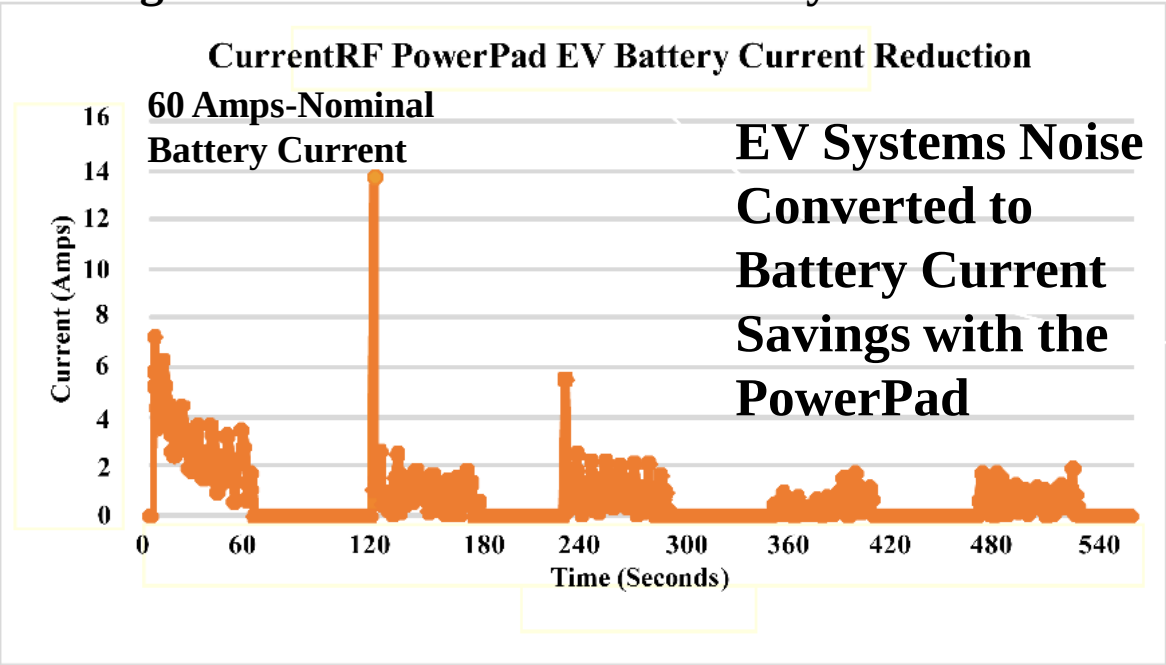
PowerPad Insertion on the Ground Side of a DC-Link Capacitor



EV Battery Current Reduction From EV Noise

-Maximum Current Savings Application-
DC Link Capacitors in Traction Inverters Driving EVs

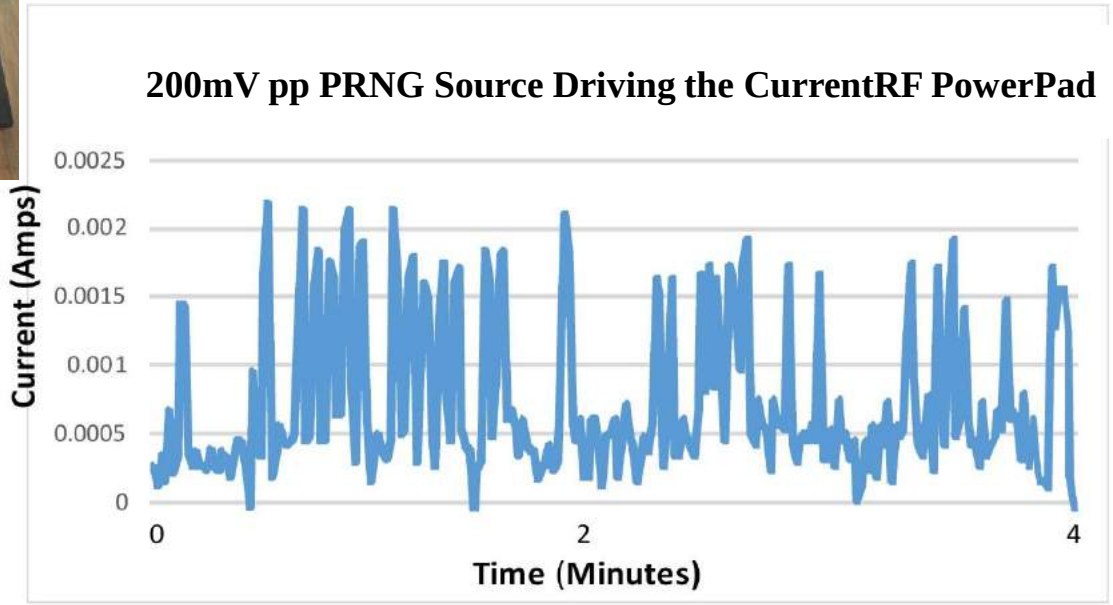
- 10% Increase in EV Mileage (Town and Country)
- Surge Reduction Extends EV Battery Pack Lifetimes

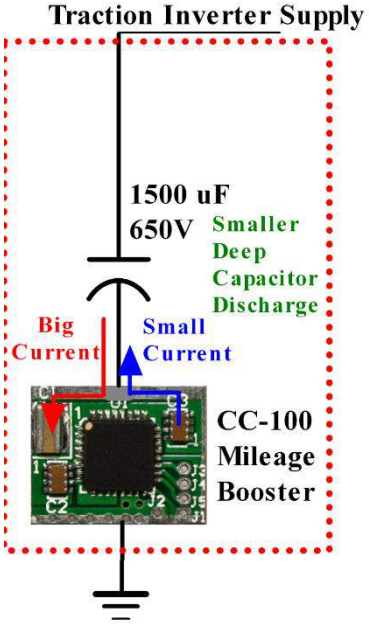


CurrentRF PowerPad- Minimum EV Noise Sensitivity Test Results

A Pseudo Random Noise Generator (PRNG) was Utilized to Generate a Controlled Noise Source for these Tests

The Current Feedback Mechanism inside the CurrentRF PowerPad Lessens the Capacitor Deep Discharge, thus less re-charge from System Batteries



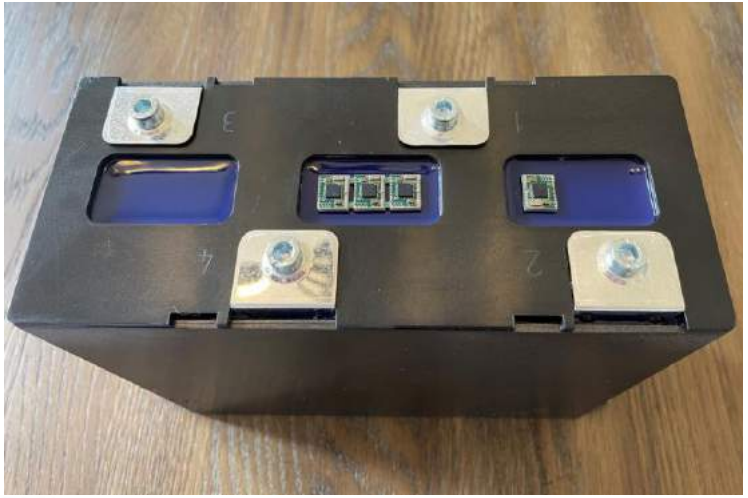


CurrentRF PowerPad Inserted into the Ground Side of a DC-Link Capacitor

EV Applications

- **PowerPad Insertion into DC-Link Capacitors/Traction Inverters**
- **PowerPad Insertion into EV Battery Packs**
- **PowerPad Insertion into EV Battery Management Systems**
- **PowerPad Insertion into EV Gate Drivers**
- **PowerPad Insertion into EV Control ICs**

DC-Link Capacitor CurrentRF PowerPad IP Enhancements in Electric Vehicles



Current RF

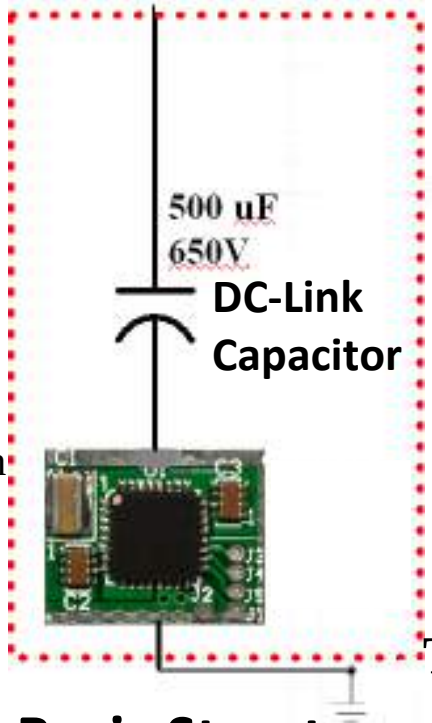
CurrentRF PowerPad Enhanced DC-Link Capacitors

Patent # 10,666,089

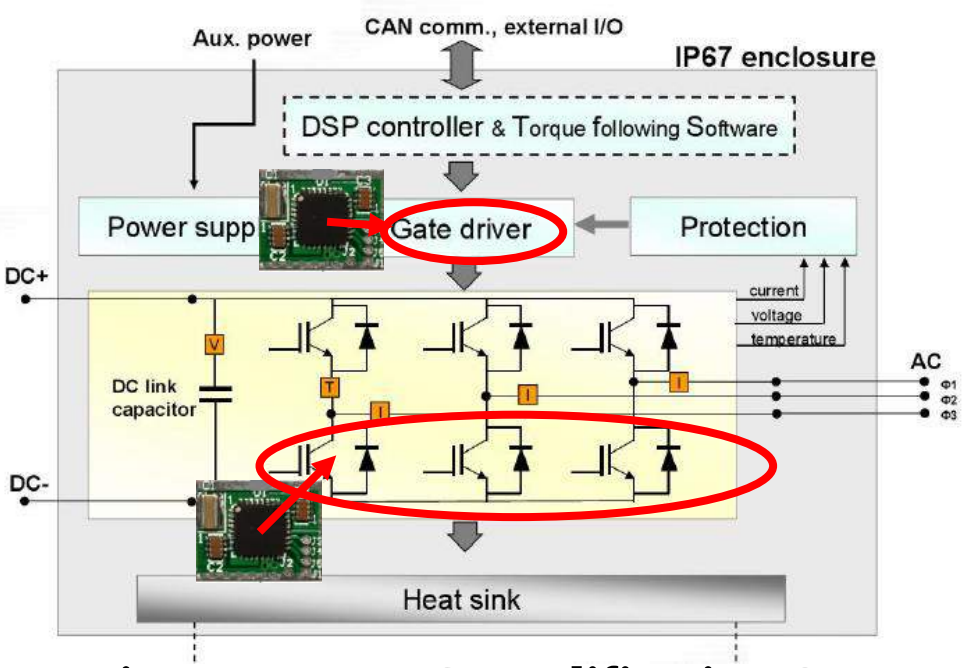
The CurrentRF PowerPad IP can be Inserted in Hybrid Form or as a Scalable IP Pad in Various Locations in the EV System

CurrentRF PowerPad IP Integration Opportunities:

The CurrentRF Powerpad can be inserted in Hybrid form in SiC Power MOSFETs, and/or in the Gate Driver ICs that drive the SiC Power MOSFETs in Traction Inverters



Basic Structure

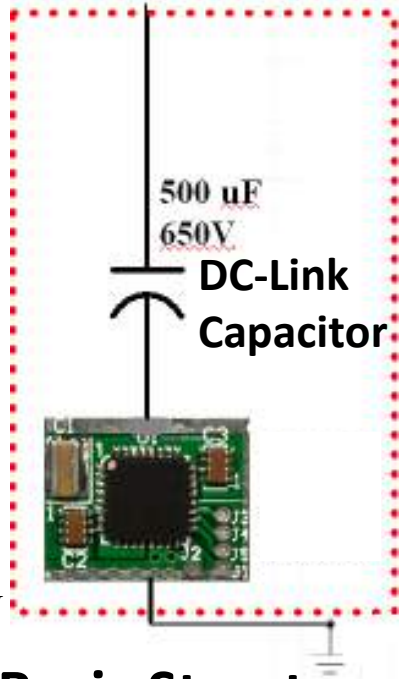


Traction Inverter IC Modification Opportunities

The CurrentRF PowerPad IP can be Inserted Into Standard CMOS SiC Gate Driver ICs

Traction Inverter Gate Driver Modification:

The CurrentRF PowerPad can be included in the low voltage side of Gate Driver ICs. A simple pin connection to the ground side of the Traction Inverter DC-Link cap is all that is needed for EV Mileage Increase performance



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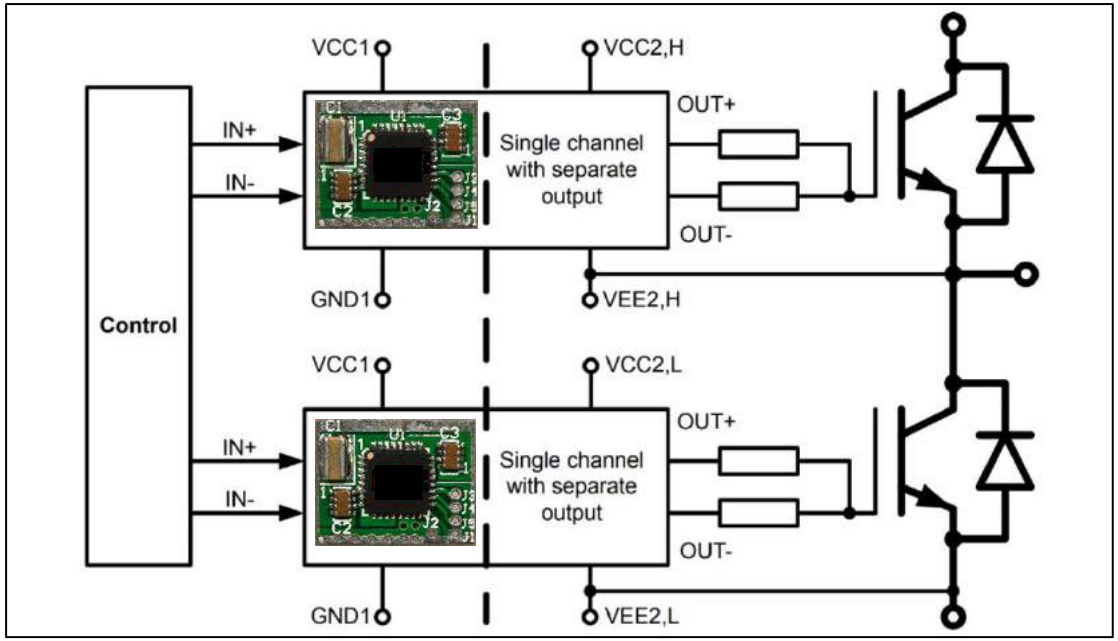
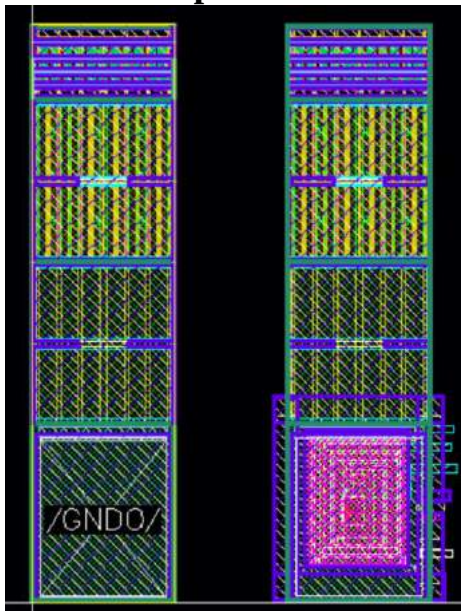


CurrentRF PowerPad Gate Driver Modification Opportunities

Standard Digital/Mixed Signal Solutions (Planar Mosfets or FinFet Technologies)

Original Ground Pads and the CurrentRF PowerPad Modification

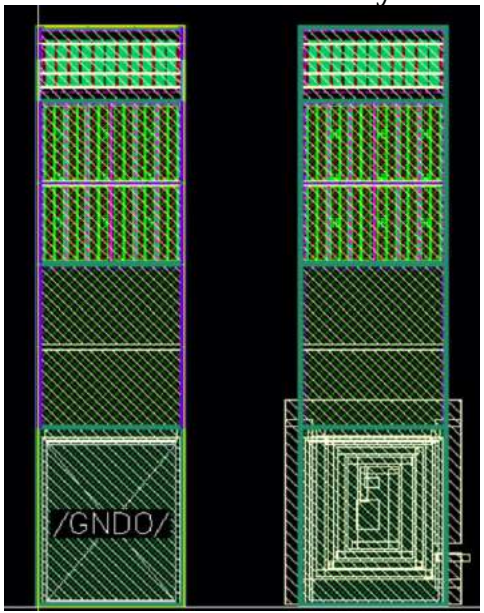
XT018 Top Metal View



XFAB XT018 BondPad **CurrentRF-XT018 PowerPad Modification**

RF Balun Embedded In a Ground BondPad

XT018 Balun Secondary View



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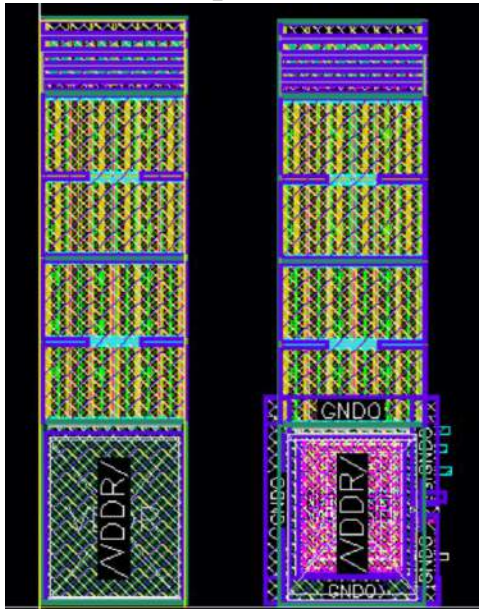

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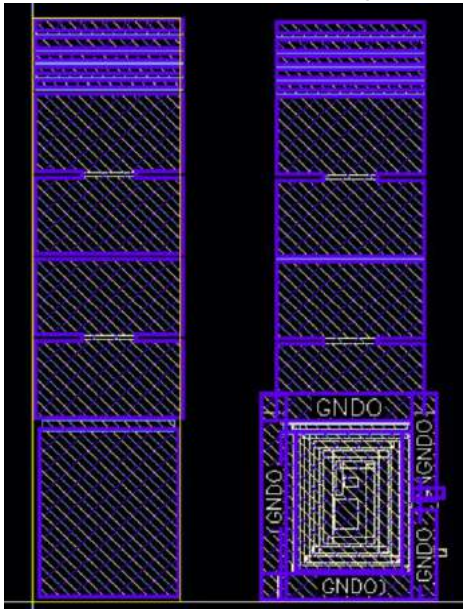

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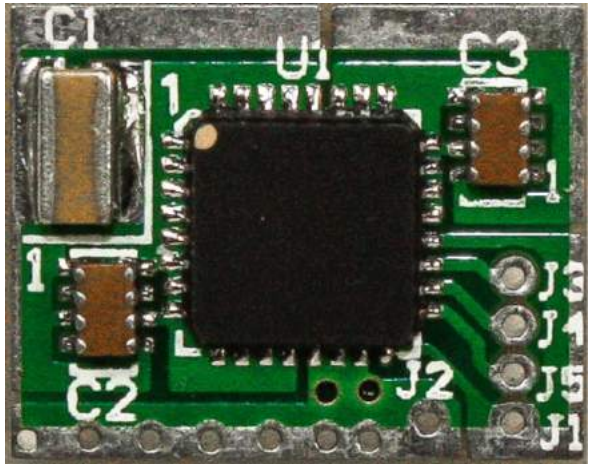
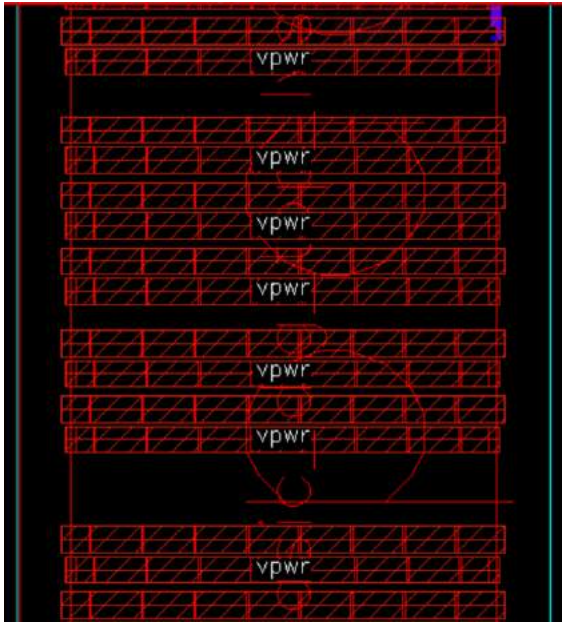


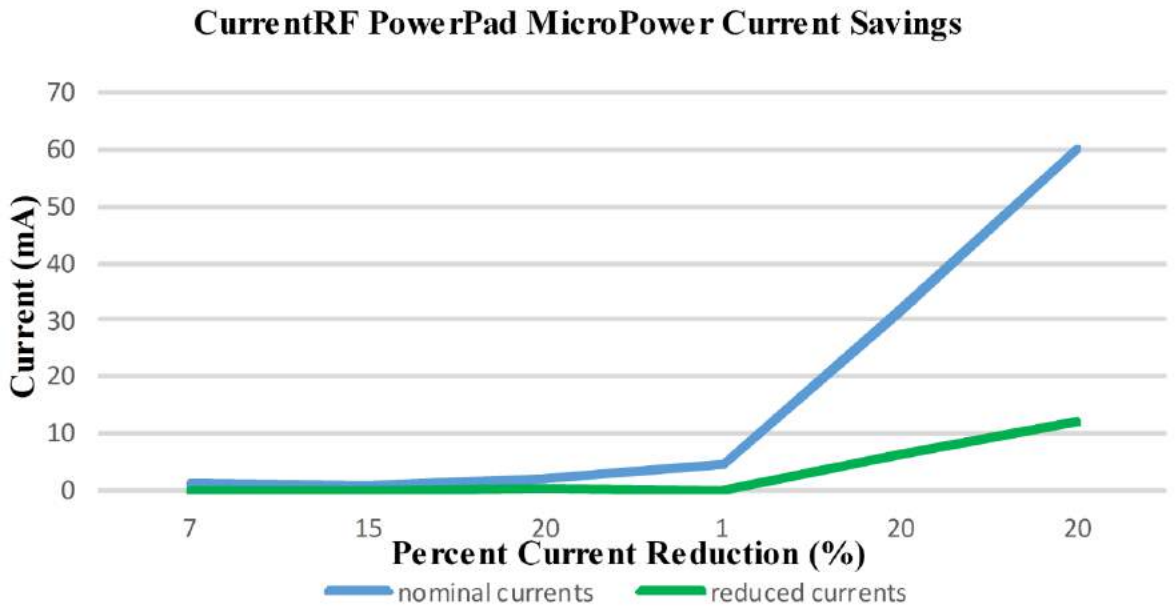
CC-100 IC Global Foundries
PowerPad Inside

Functionally Equivalent

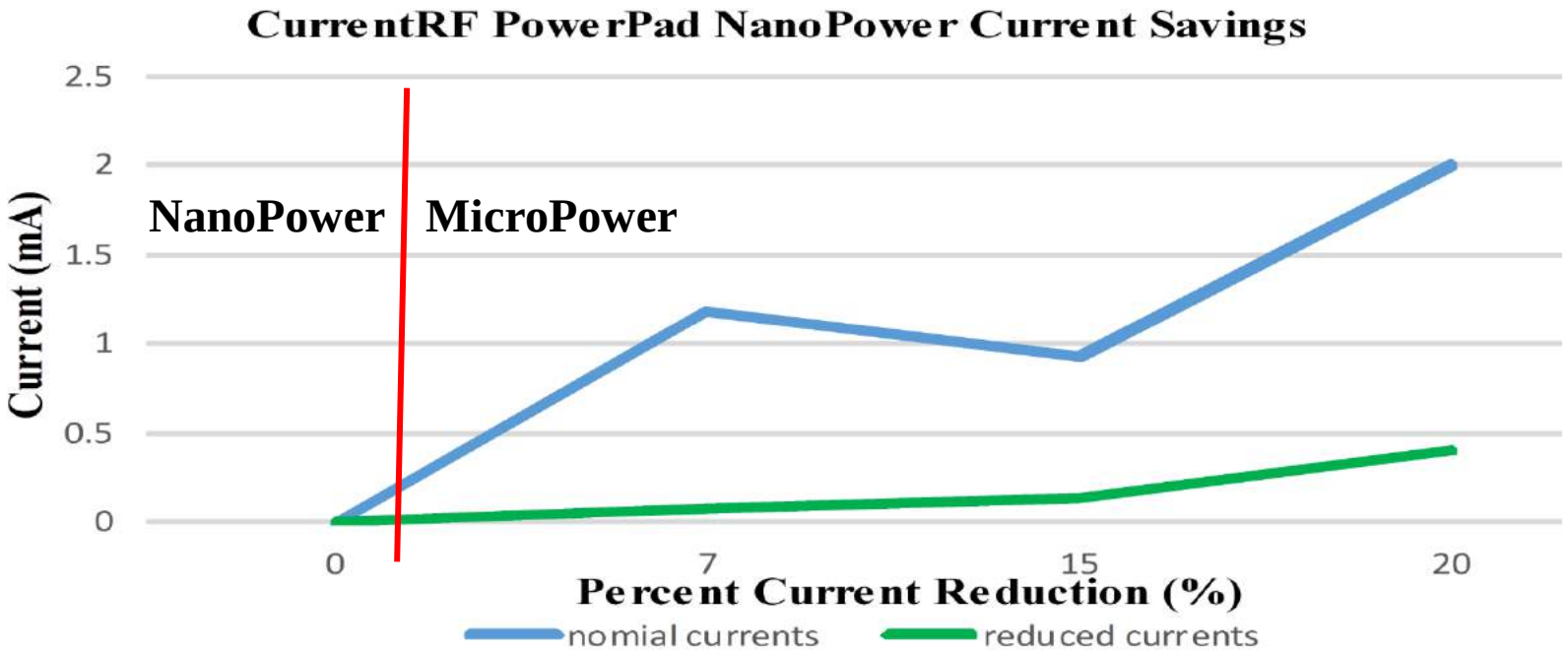


Balun Inserted in Digital Top Metallization

CurrentRF PowerPad and PowerGrid—Absolute Minimum MicroPower Sensitivity



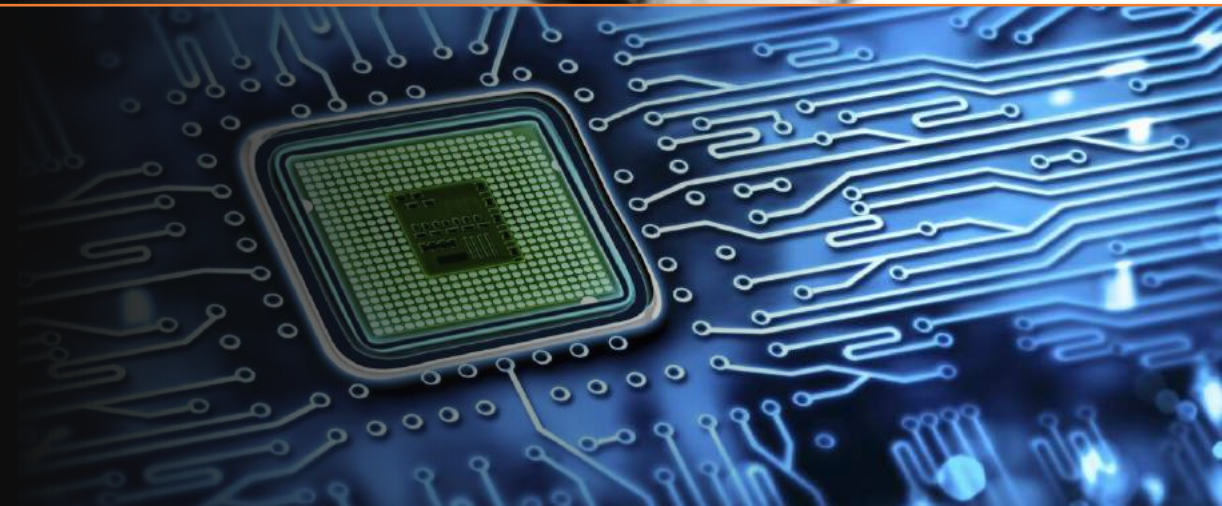
CurrentRF PowerPad and PowerGrid Absolute Minimum NanoPower Sensitivity



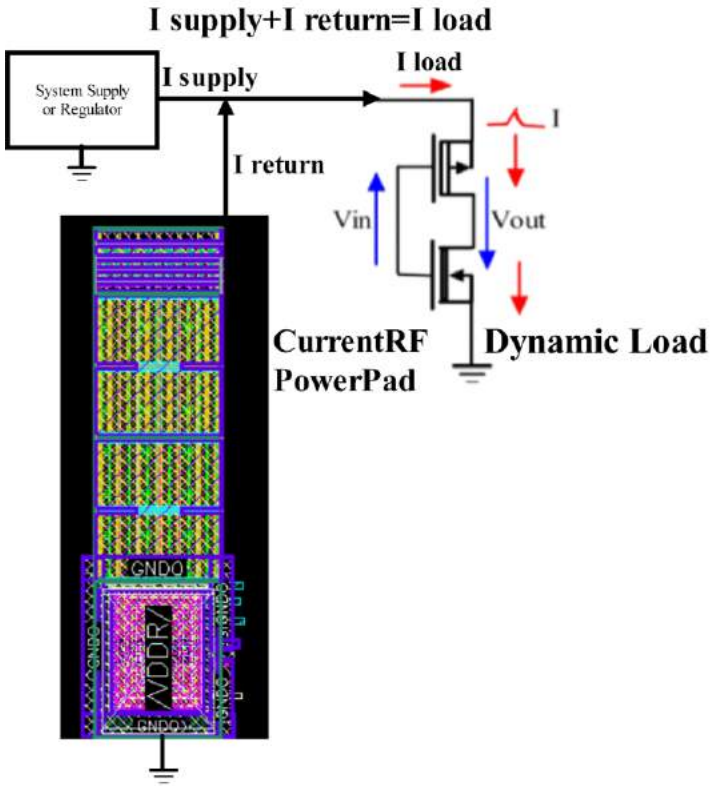
Digital and Mixed Signal Applications

- **PowerPad Insertion into the Pad Cells of Microprocessor ICs**
- **PowerPad Insertion into the Pad Cells of any Mixed Signal IC**
- **PowerPad Insertion into the Pad Cells of Sensor ICs**
- **PowerPad Insertion into the Pad Cells of PLLs**
- **PowerPad Insertion into the Pad Cells of Memory ICs**
- **PowerGrid Insertion into the Power Grid of Microprocessor ICs**
- **PowerGrid Insertion into the Power Grid of any Mixed Signal IC**
- **PowerGrid Insertion into the Power Grid of Sensor ICs**
- **PowerGrid Insertion into the Power Grid of PLLs**
- **PowerGrid Insertion into the Power Grid Of Memory ICs**
- **PowerPad or PowerGrid Insertion has Power Saving Benefits for any IC**

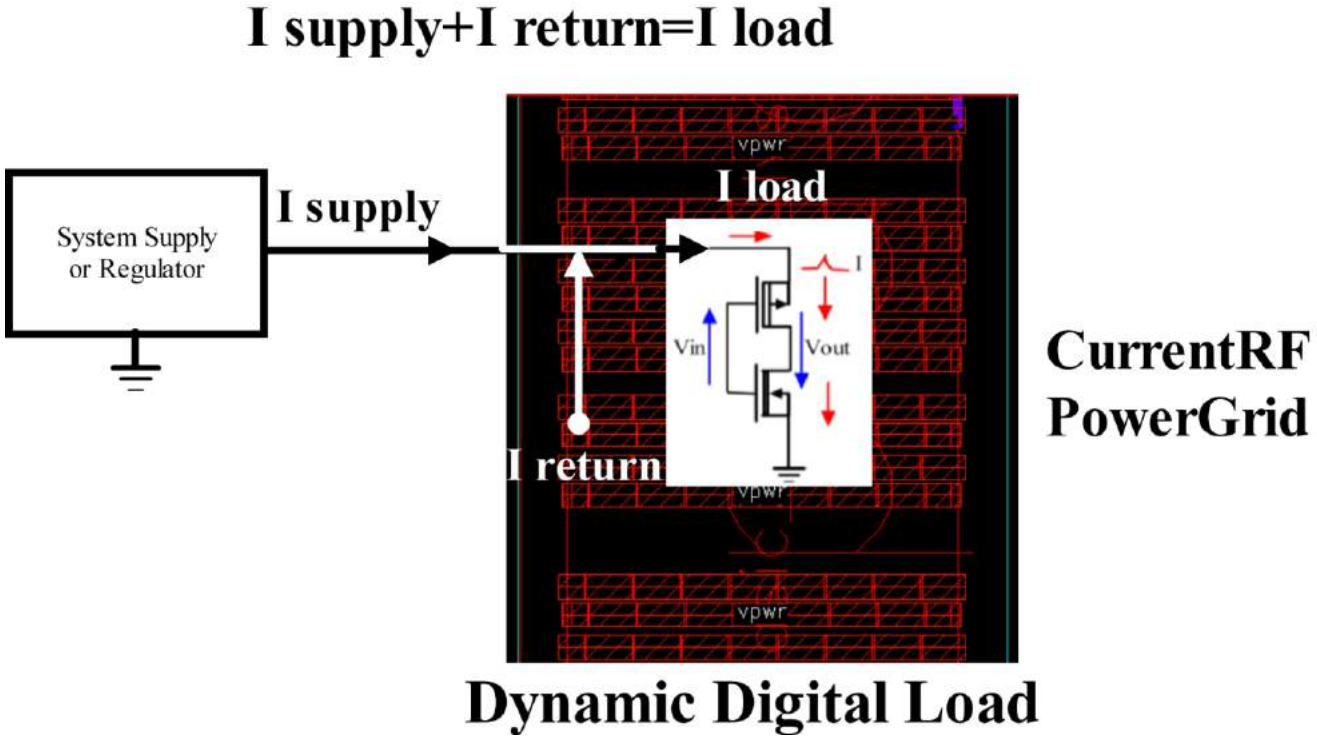
Applications



How the CurrentRF PowerPad Works in Typical Digital Solutions (Kirchoff's Current Law for AC Currents)



How the CurrentRF PowerGrid Works in Typical Digital Solutions (Kirchoff's Current Law for AC Currents)



Conclusions

- **PowerPad Insertion Fits Into the Footprint of Any IC Supply or Ground Bondpad**
- **PowerGrid Insertion Fits Into the Footprint of Any IC Supply or Ground Routing**
- **PowerPad/PowerGrid Insertion Re-Cycles the Overlap Current in Digital and Switching Circuits**
- **PowerPad/PowerGrid Insertion Saves Up to 40% of Total Digital, Switching, and Dynamic Current**
- **PowerPad Insertion Extends EV Driving Range (Town and Country)**
- **PowerPad Insertion Extends EV Battery Pack Lifetimes**
- **PowerPad/PowerGrid Insertion Reduces Digital and Mixed Signal Power Dissipation**
- **PowerPad/PowerGrid Insertion Reduces Dynamic Power at the Micro and Nano Power Levels**

Current RF

8558 Maul Oak Drive

West Jordan, Utah

84081

www.CurrentRF.com

(209)-914-2305

Michael.Hopkins@CurrentRF.com