Simple Approach to Isolated High-Current Measurement Webinar

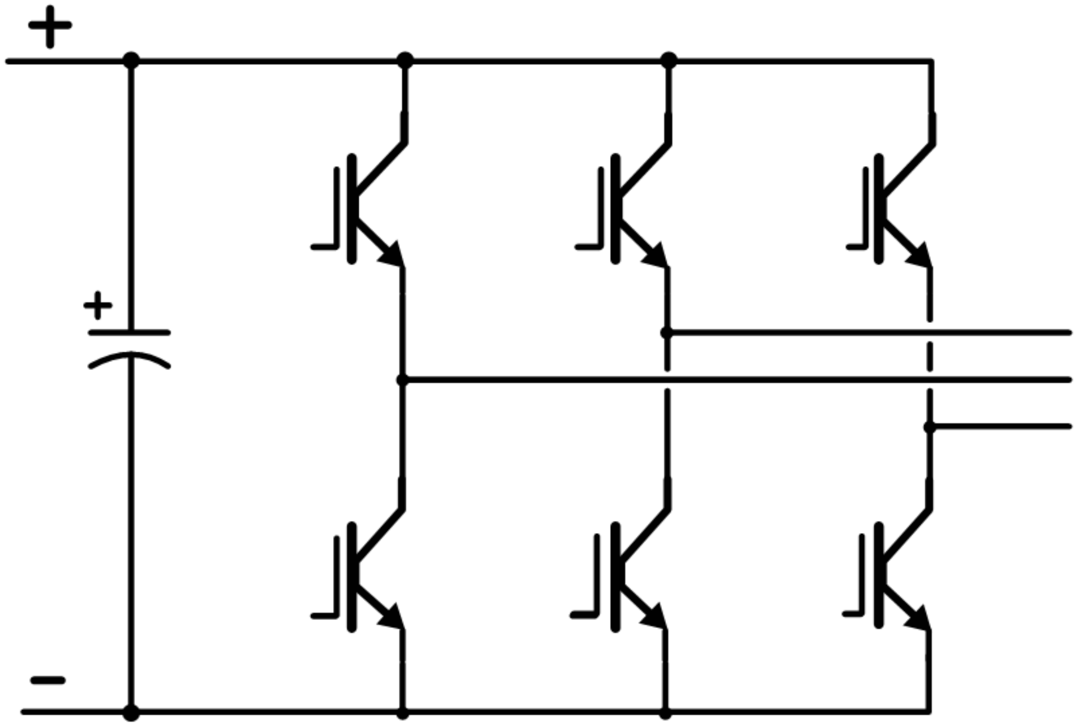
June 15th, 2021

Presenter: Ted Smith

Agenda

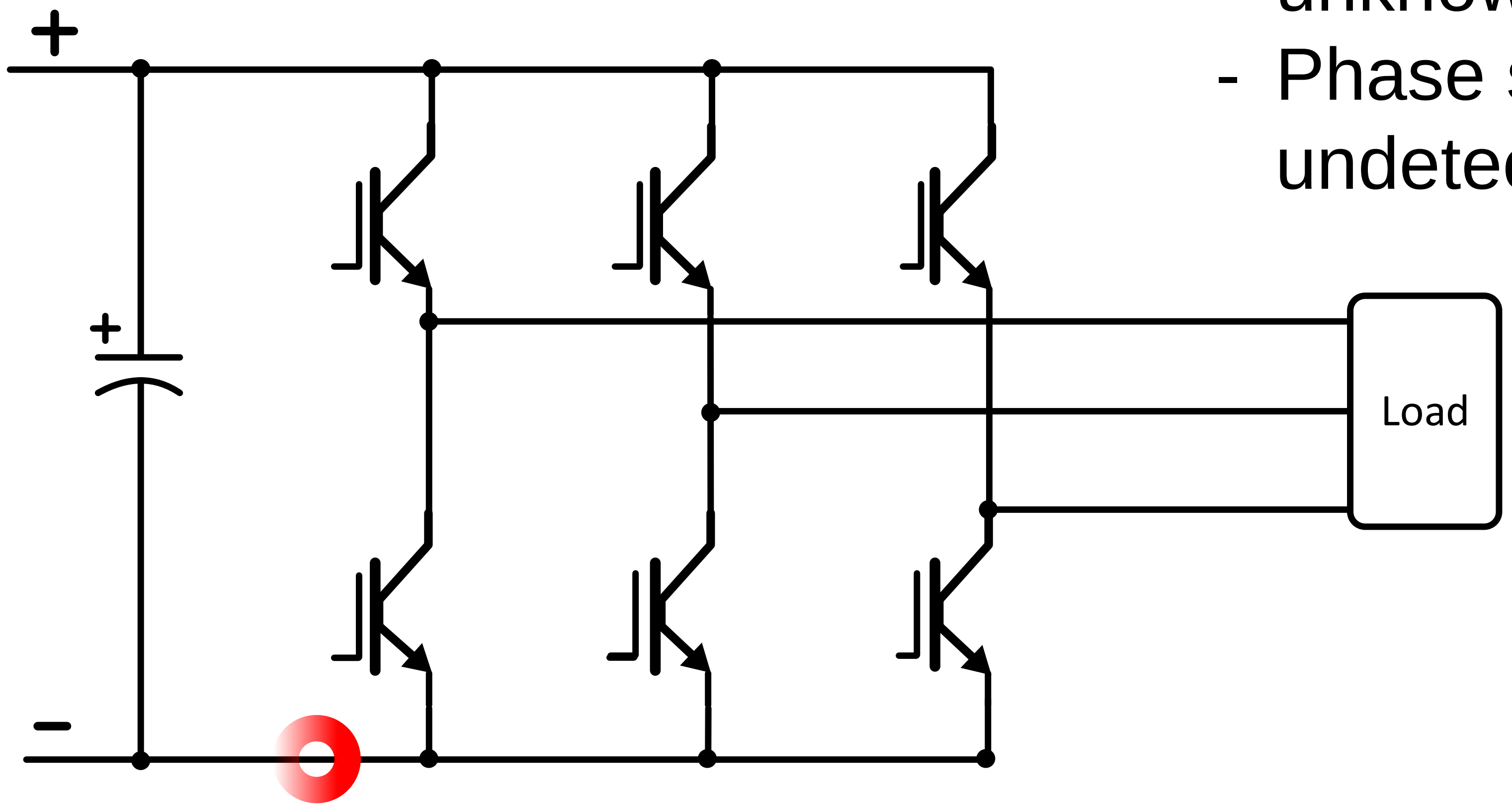
- Current Sensing System Level Perspective Overview
- Achieving Cost Effective Isolation
- Differential Hall Principle
- Solving Thermal Challenges
- Managing Noise While Maximizing Bandwidth
- Easy Implementation Techniques

Inverter as an example



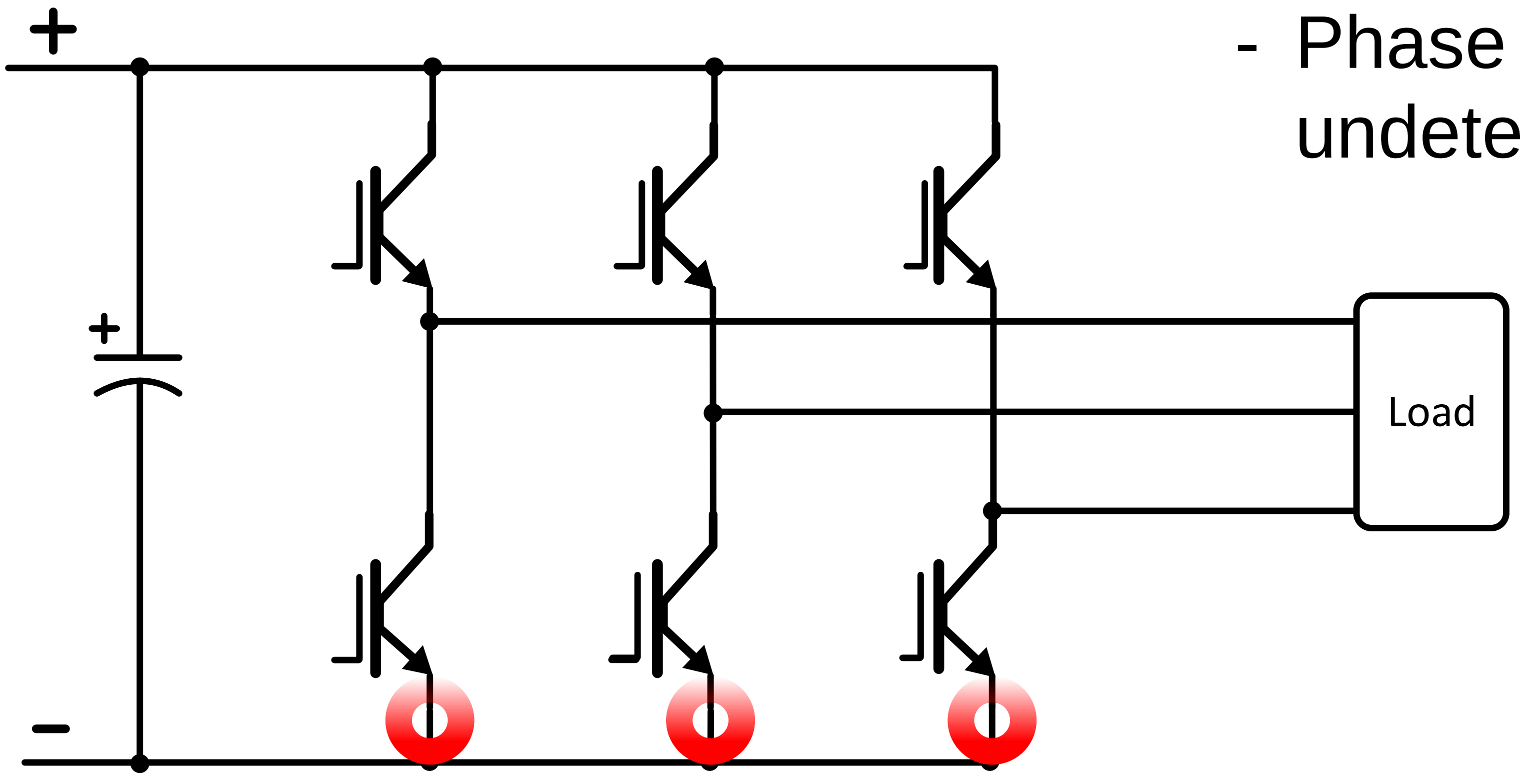
3 Phase Inverter Low Side Current Sensing

- No isolation needed
- Load current is detected, but individual phase currents unknown
- Phase short circuit goes undetected



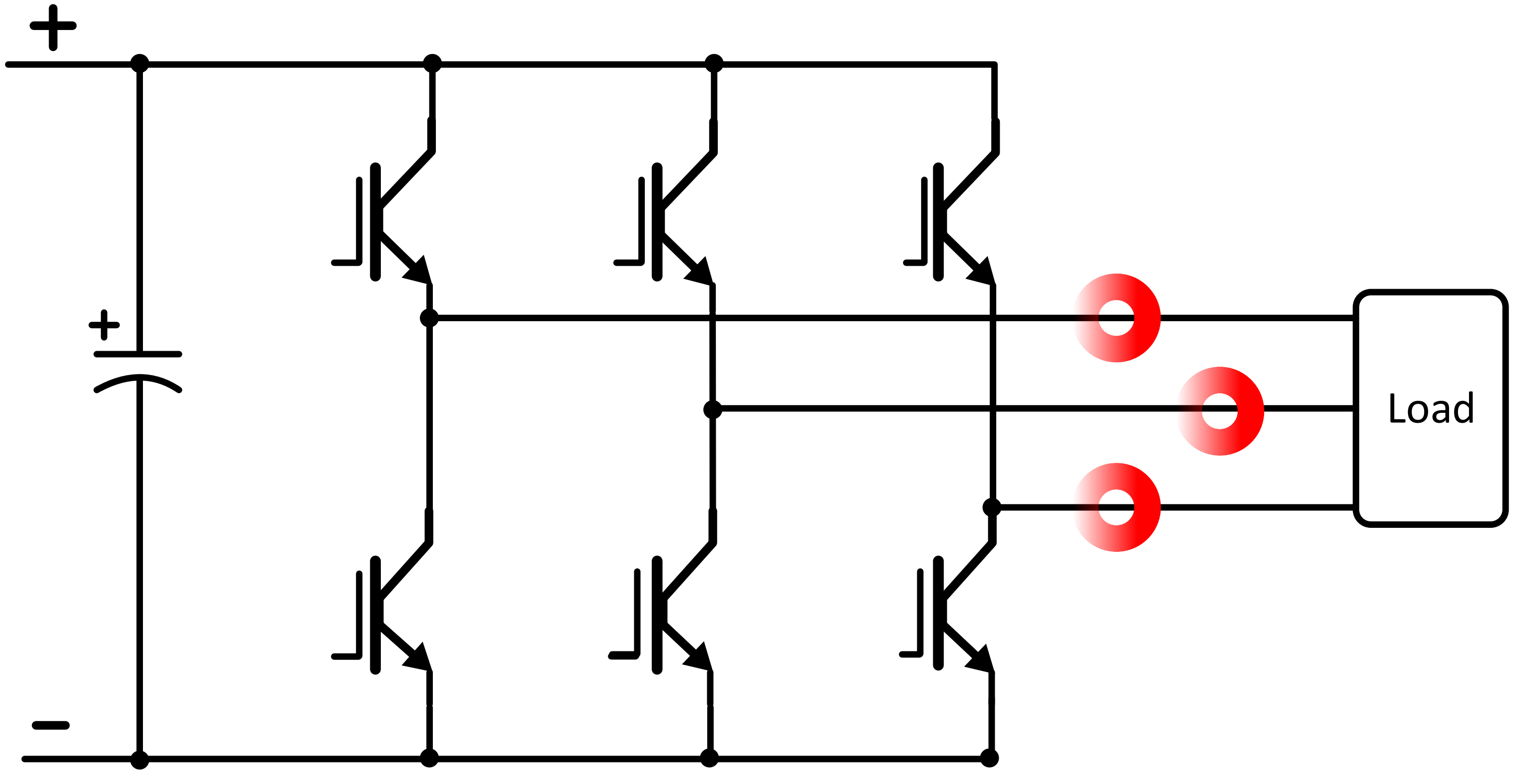
3 Phase Inverter Low Side Current Sensing

- No isolation needed
- Phase currents can be reconstructed in microcontroller with some difficulty
- Phase short circuit goes undetected

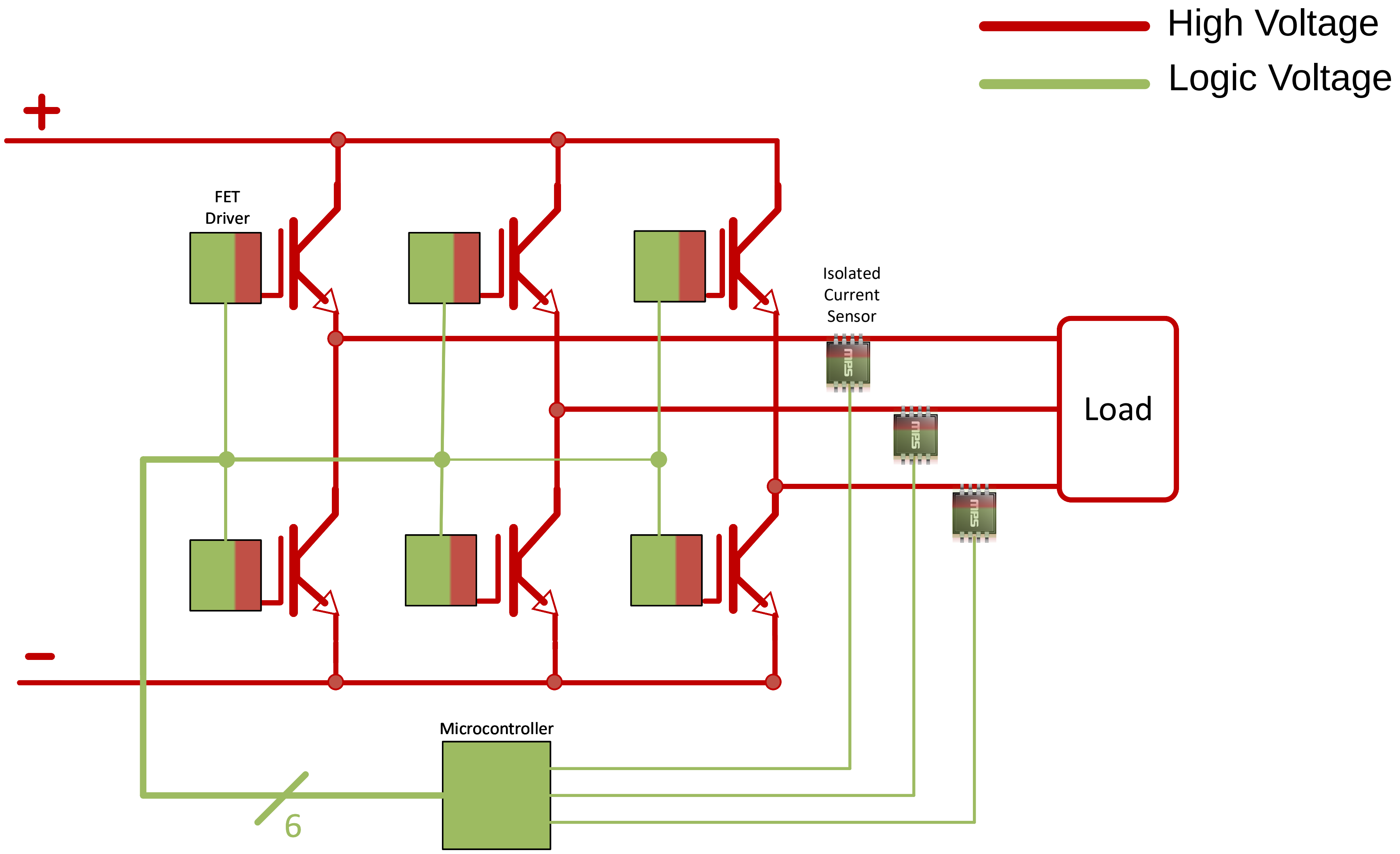


3 Phase Inverter Phase Current Sensing

- Phase currents are known
- Load shorts are detected
- Isolation required



3 Phase Inverter Isolation



Current Sensing Design Options

Current Transformers

PRO

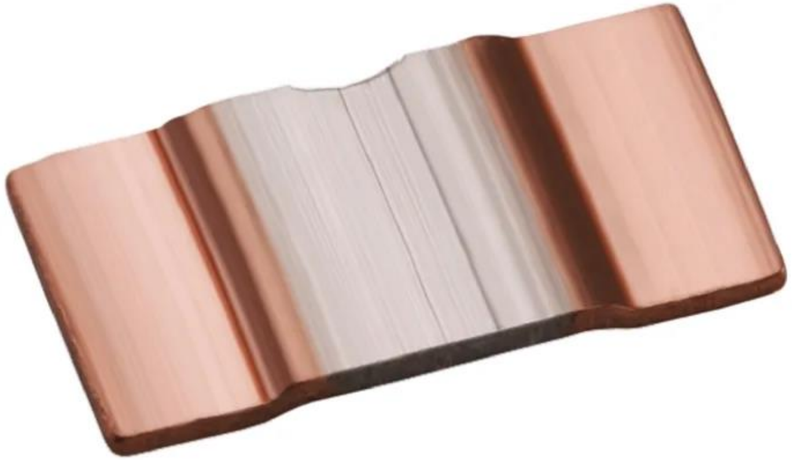
- Accurate
- Isolation included

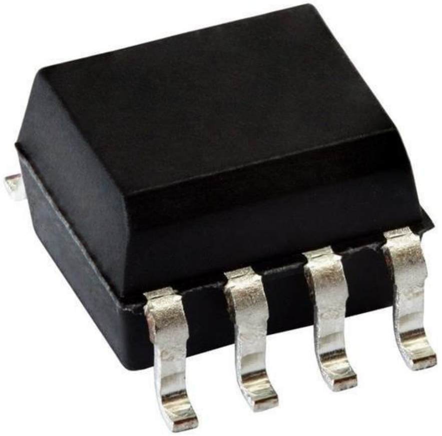
CON

- AC only
- Large Footprint (XYZ)
- Expensive

Current Sensing Design Options

Shunt + Amplifier



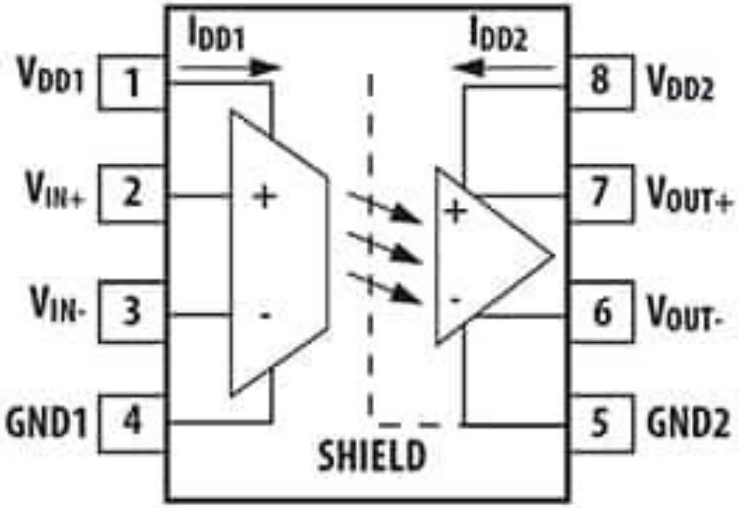


PRO

- Simple V = iR

CON

- Multiple Components/Large Footprint
- Isolated Amplifier Required
- Large footprint (shunt + iso amp + Kelvin connections)
- Power dissipation



Current Sensing Design Options

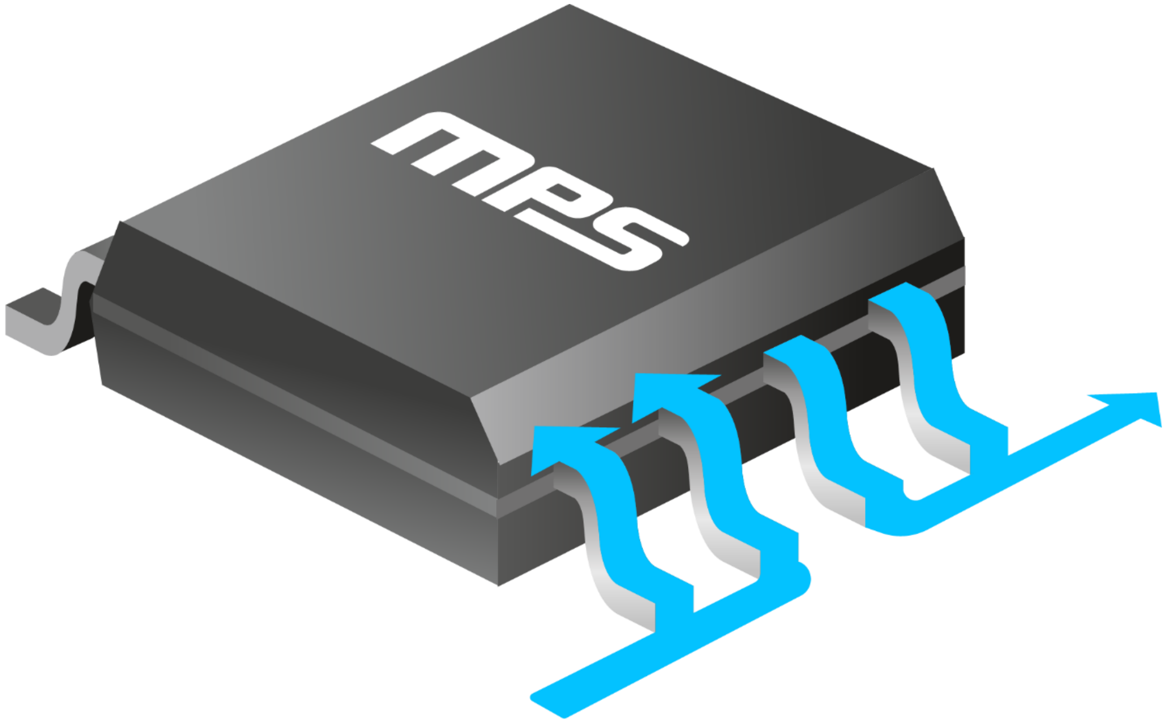
PRO

- Complete isolated current sensor in SOIC
- Single IC – easy design in
- Smallest solution footprint
- Senses up to 50 A
- 0.9 mΩ primary – power efficient
- Cost Effective

CON

- Sensing limited to 50 A primary current
- Max current limited by thermal dissipation of SOIC-8

MPS (Hall Sensor Based)



Isolation in Detail

Working Voltage

- Lifetime continuous operating voltage
- Determines limit to prevent long-term degradation of insulation
- Viorm = 250 VRMS

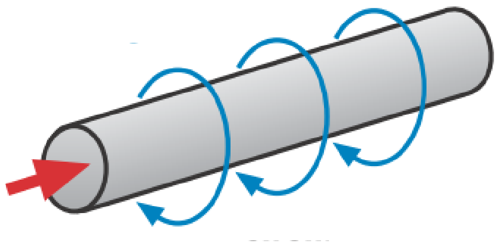
Peak Isolation

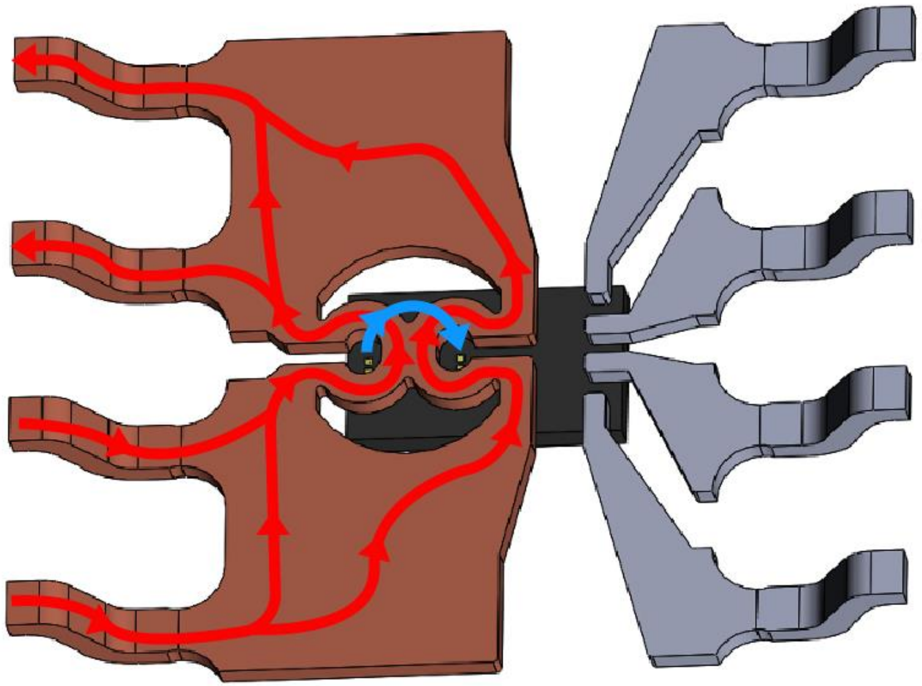
- One time overvoltage for example, electrical spike
- Viso = 2200 Vpeak (min)

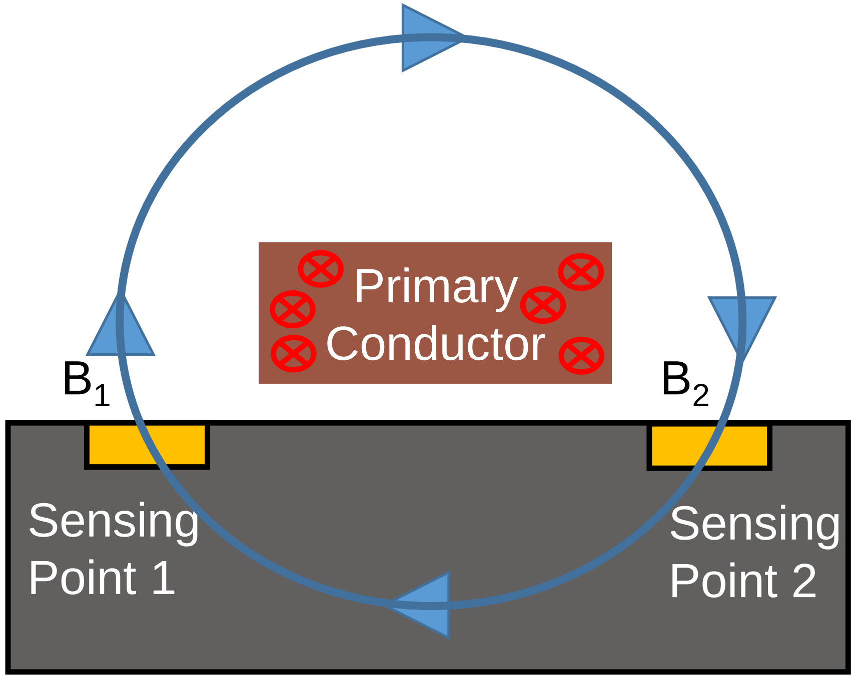
Design Perspective

- Able to operate continuously at or below Viorm
- No guardband / margin required

Technical Detail About Differential Hall-Based Sensing







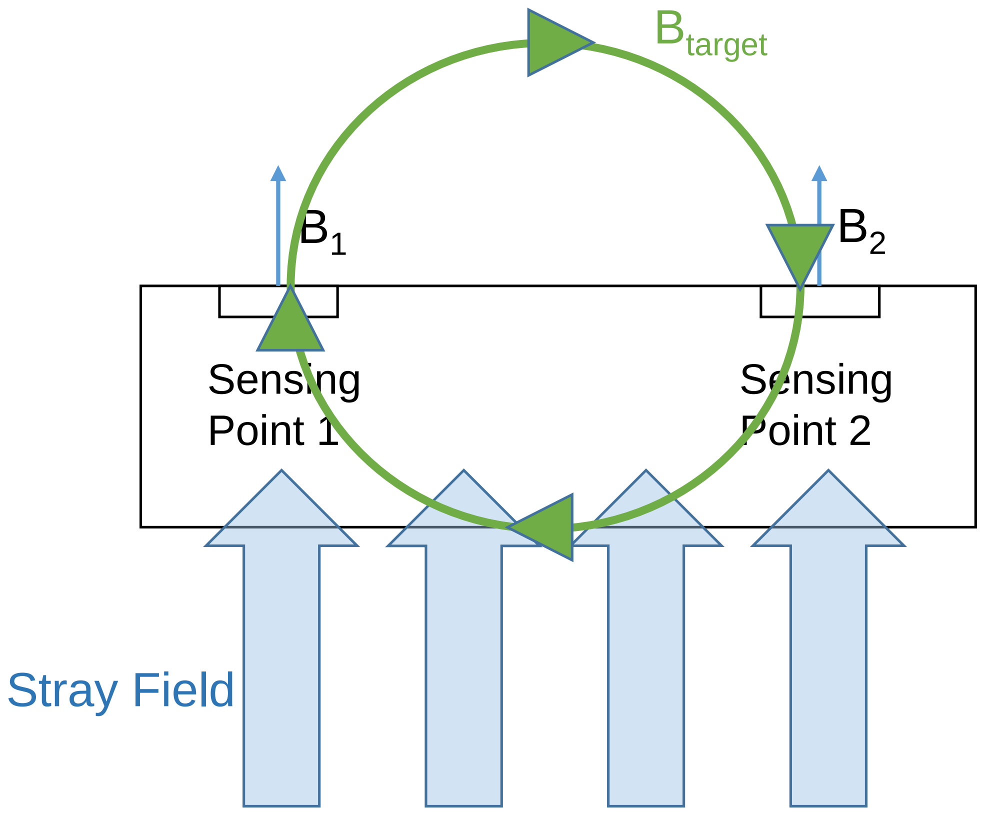
Ampere's Law: $B \propto I$

$$B_{measure} = B_1 - B_2$$

Differential Sensing Results in Stray Field Immunity

- Adjacent Load Currents Can Cause Stray Magnetic Fields
- Differential Sensing Results Stray Field Immunity
- Output Voltage Proportional to Measured Field Difference:

$B_1 – B_2 = 0$ Stray Field is Removed



$$B_1 – (\mathbf{-B_2}) = B_{target}$$

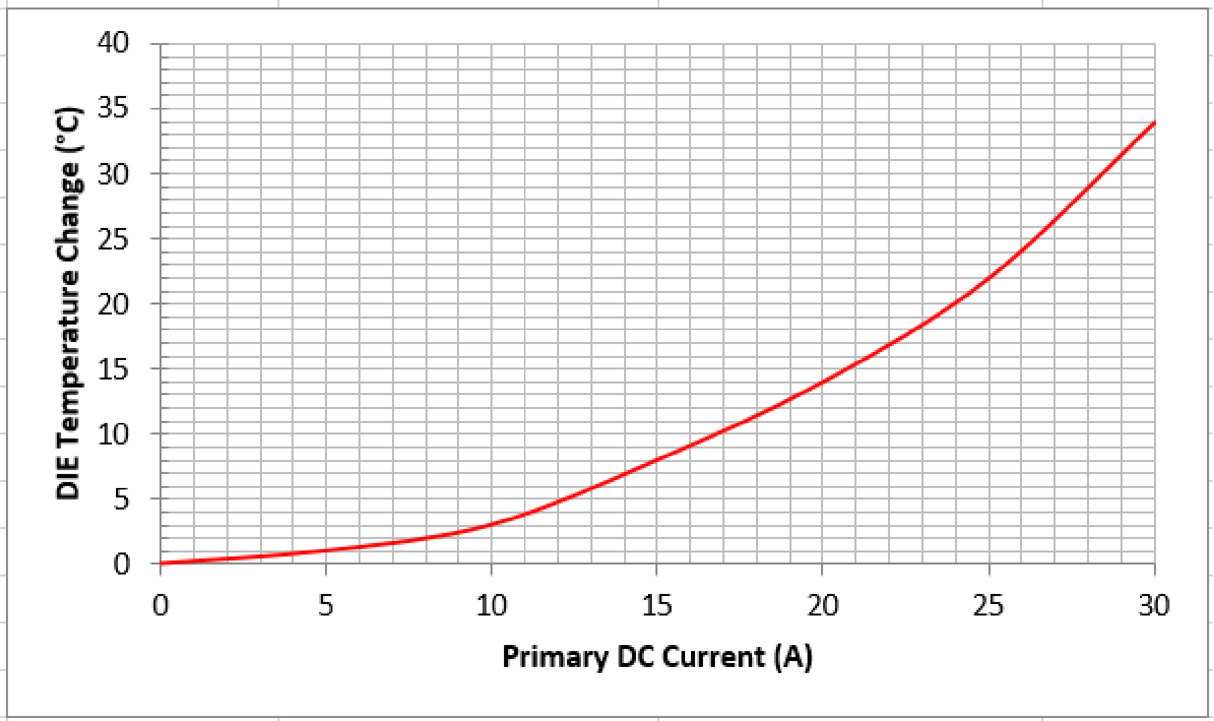
Solving Thermal Challenges

- Current Sensor
  - Lower Internal Resistor is Better: 0.9mΩ

- Example: 30 A_{rms} Load

- $P = 0.9\ m\Omega * 30\ A * 30\ A = 0.81\ W$

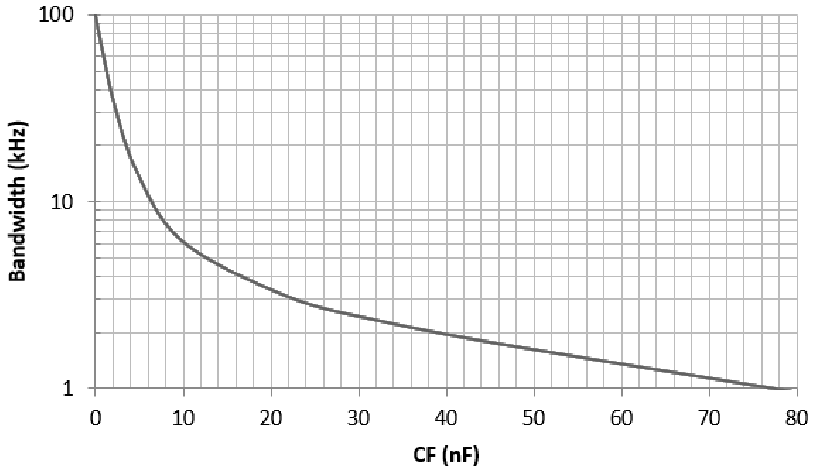
- Die temp change < 35°

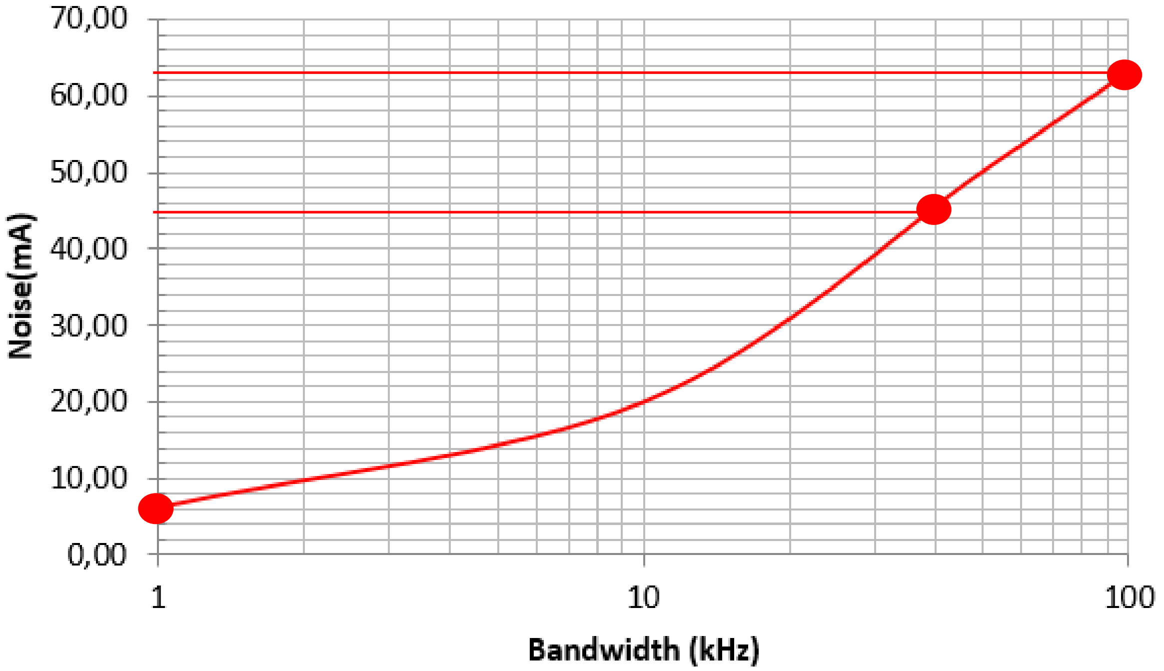


Bandwidth Control for ADC Interface

- Pin Configurable Bandwidth Range: 1 kHz … 100 kHz
- Reduction of Sensors Bandwidth
  - Simple Single Small Passive Capacitor
- Designs which don‘t require full bandwidth can benefit from lower noise

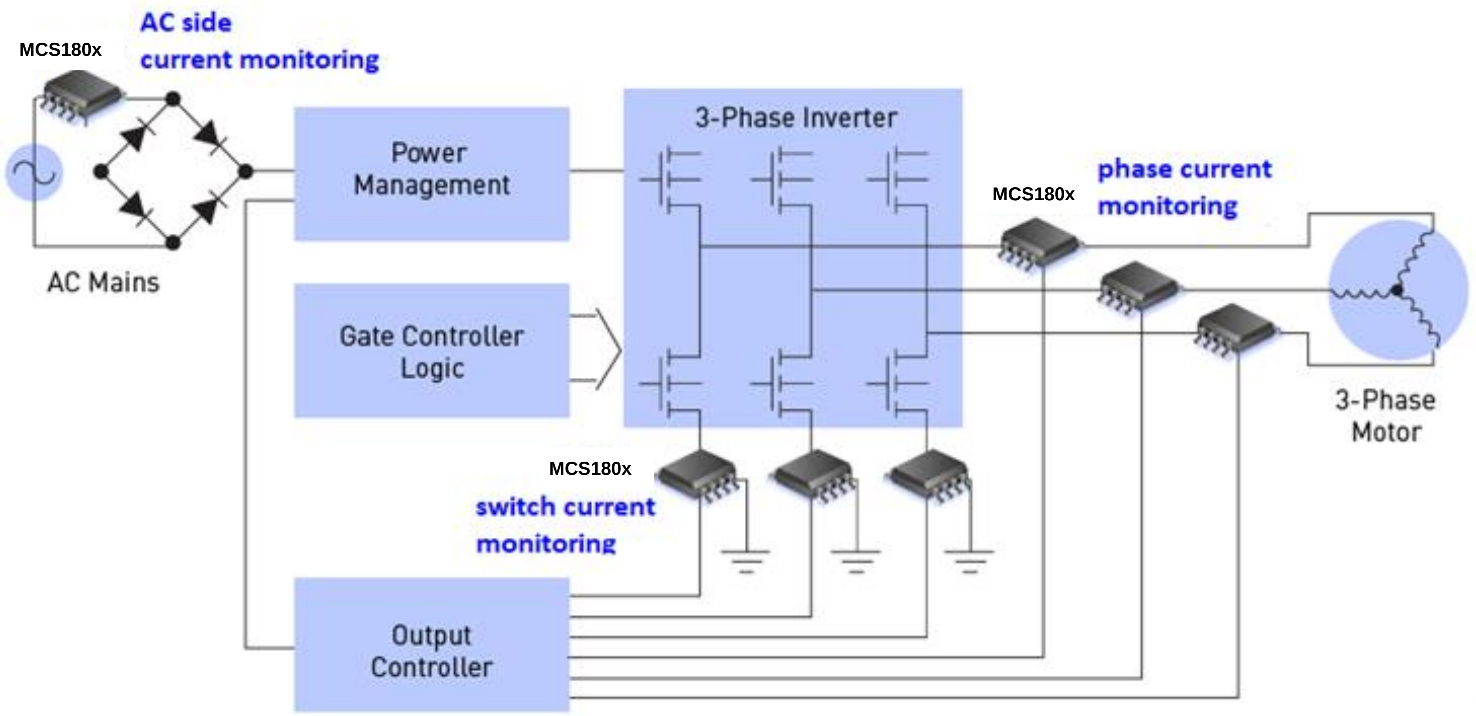
- Examples:
  - Full bandwidth - 63 mA noise
  - 20 kHz switching – set BW to 40 kHz – 45 mA noise
  - DC current sense – only 5 mA noise

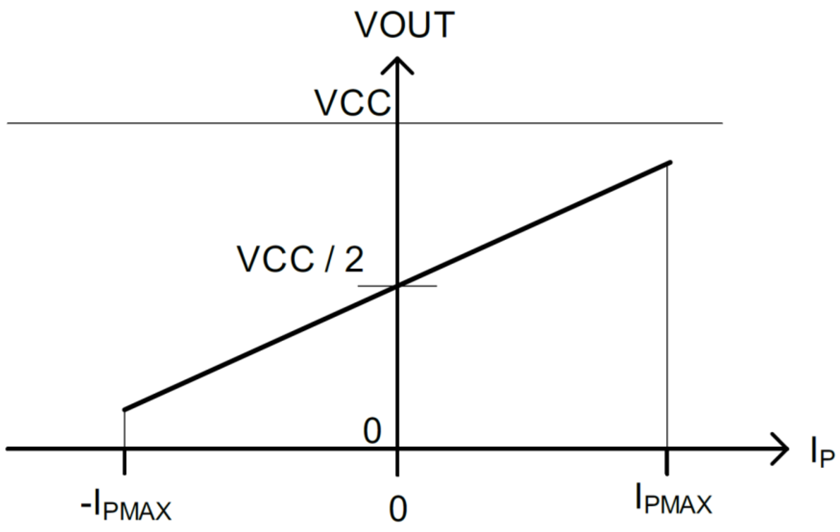




System Interfacing with Ratiometric Output

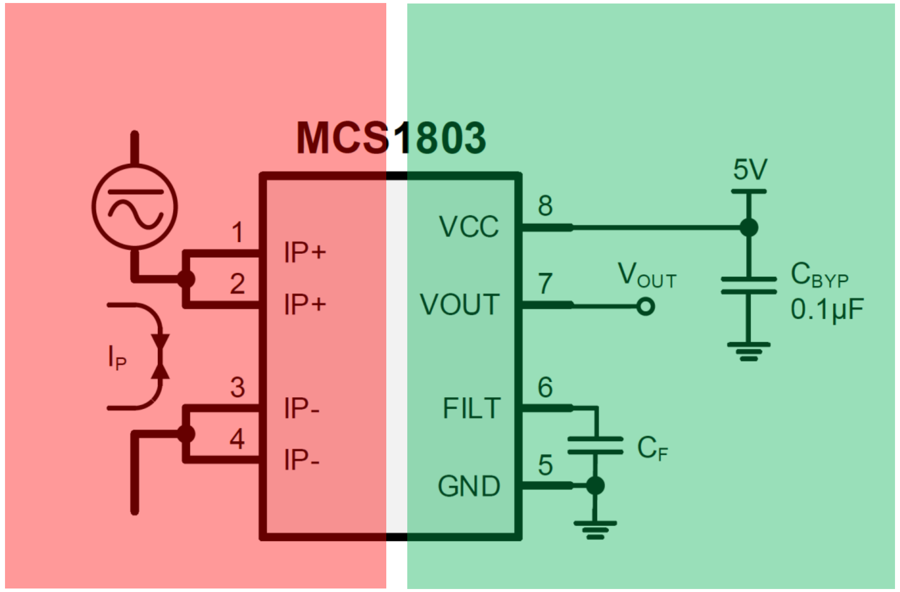
- Analog Ratiometric Signals
  - No extra external reference
- Covers AC & DC Currents
  - 0 A defined at VCC/2
- Bandwidth up to 100 kHz

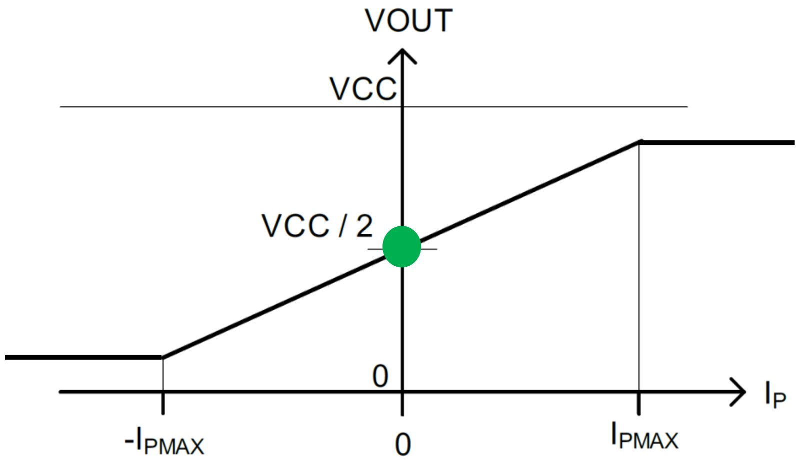




Isolated Current Sensing Board Level Solution

Ipmax = 5 A, 10 A, 20 A, 30 A, 40 A, or 50 A





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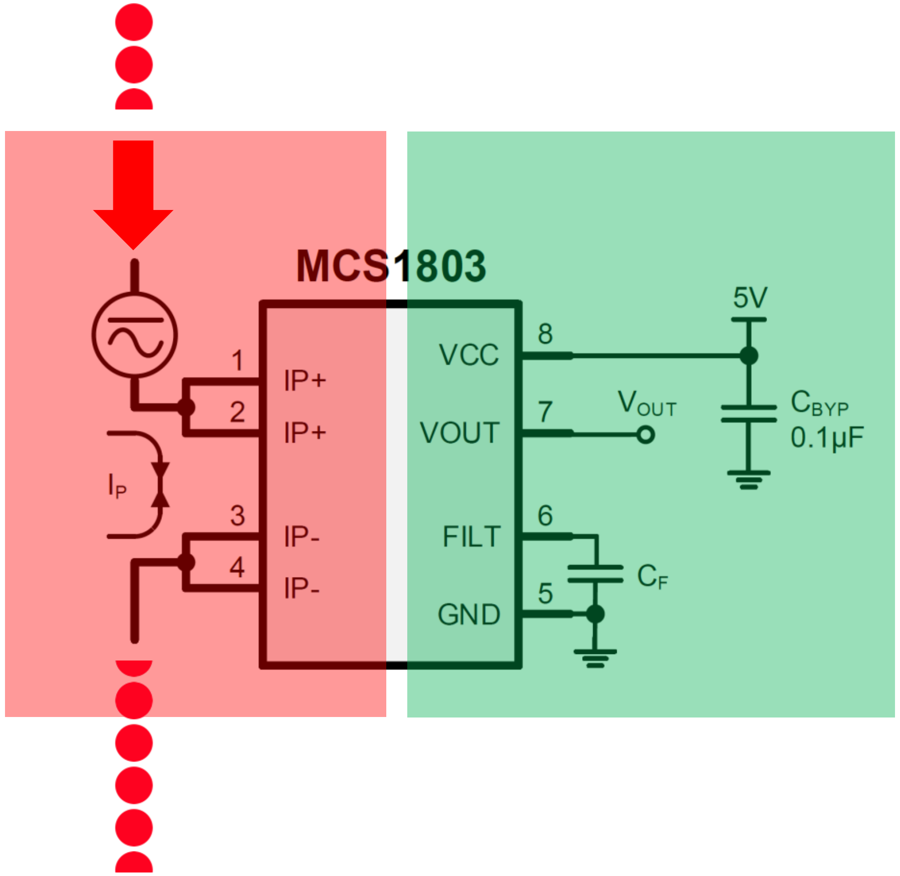

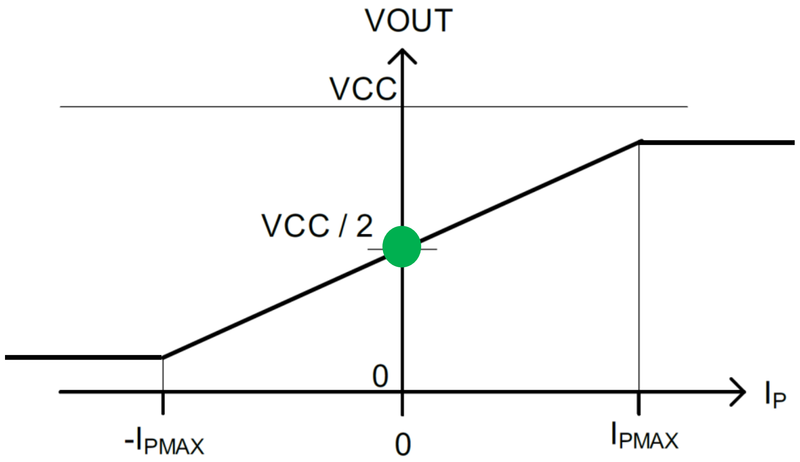

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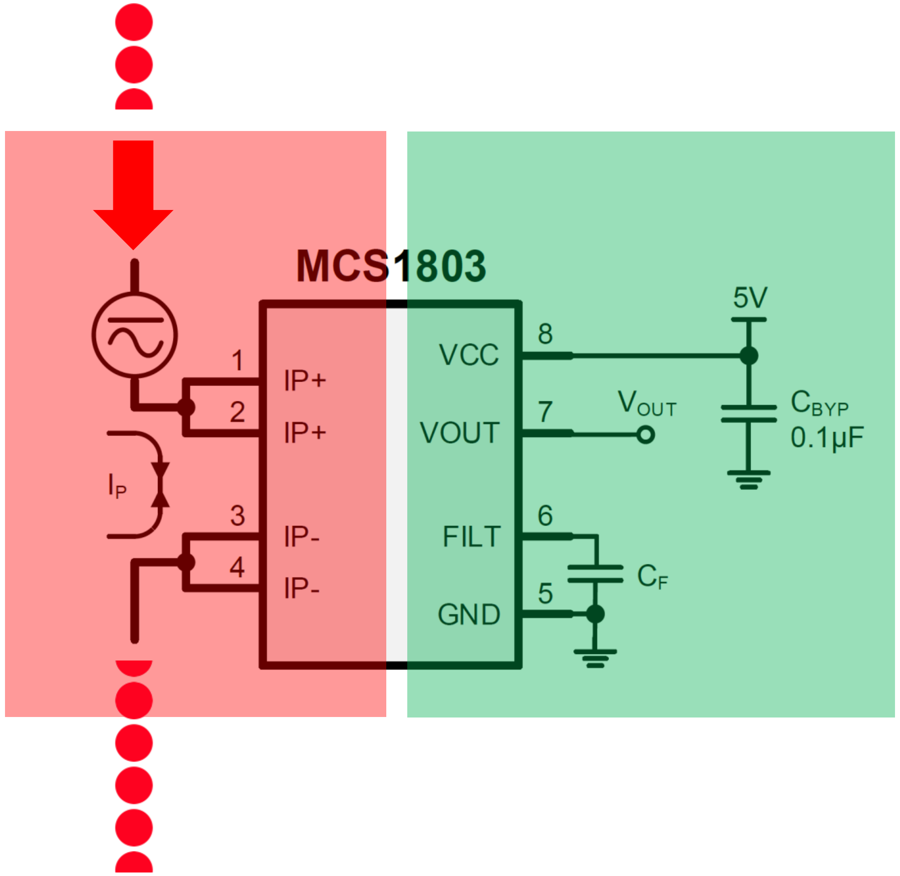

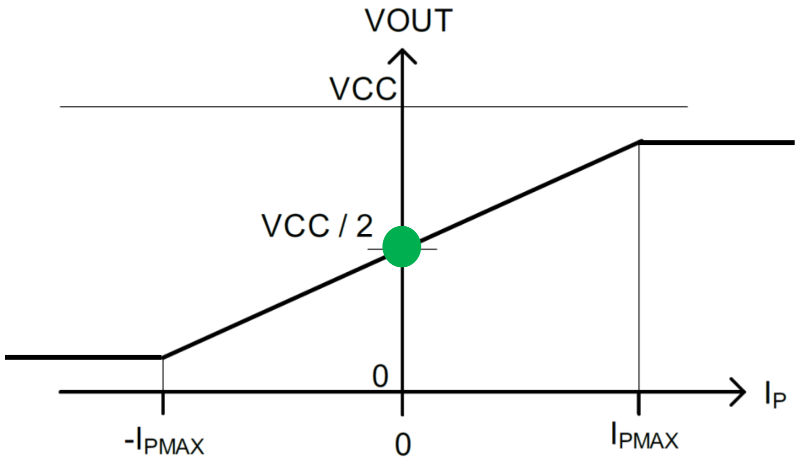

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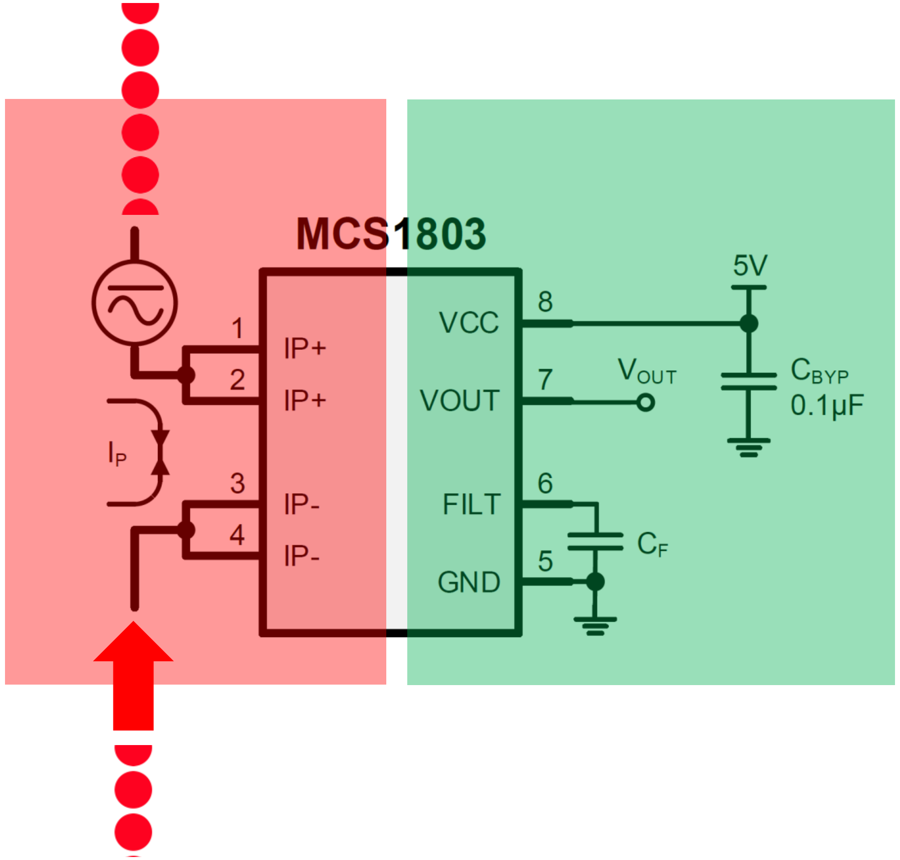

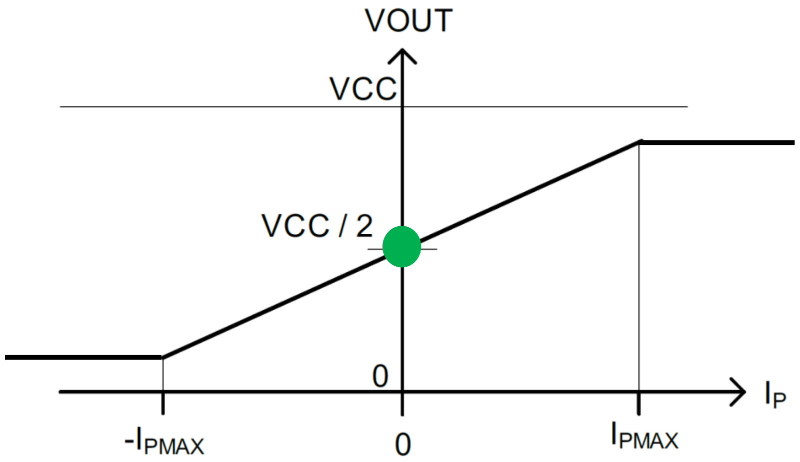

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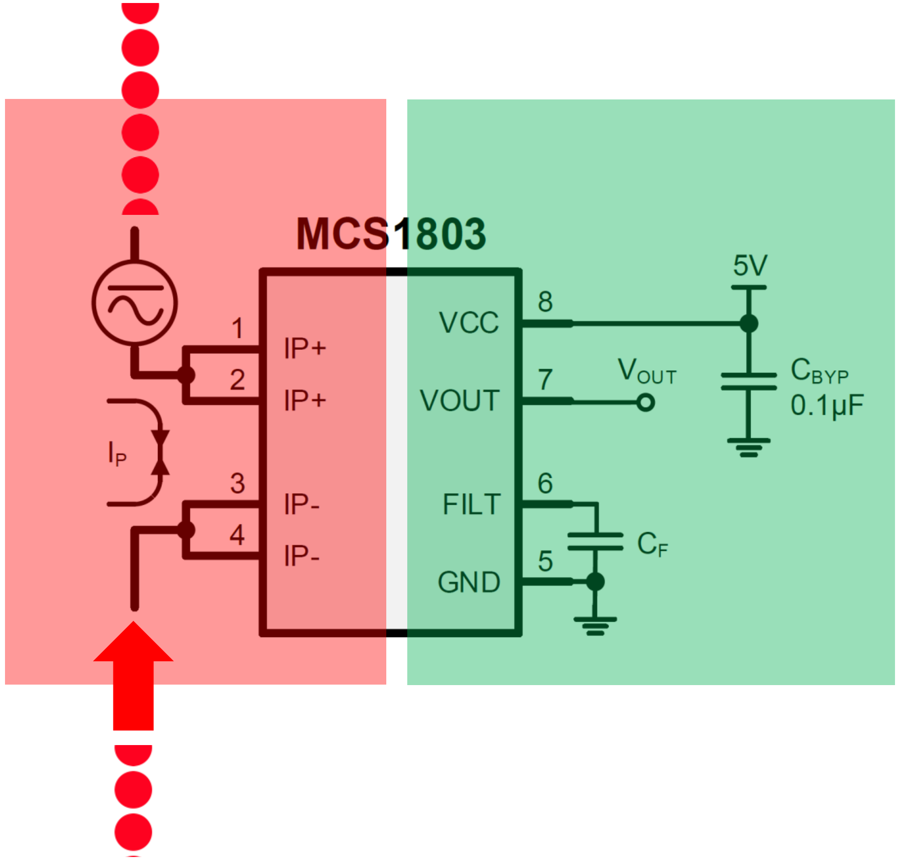
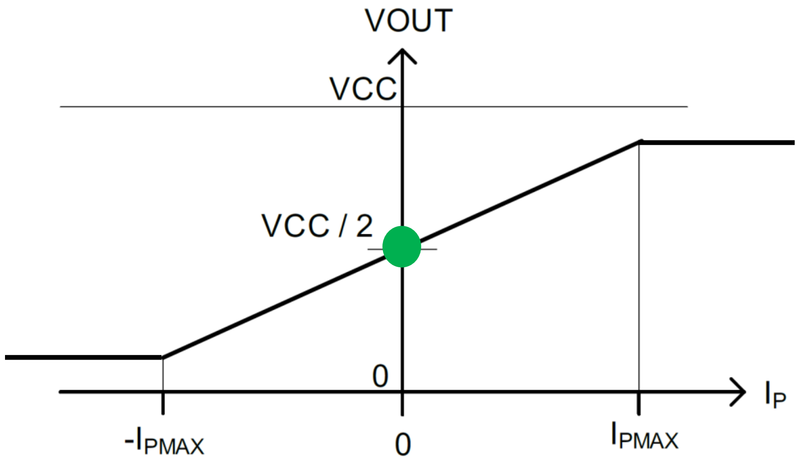
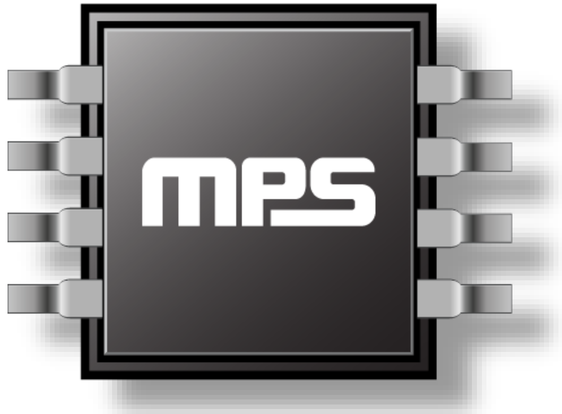
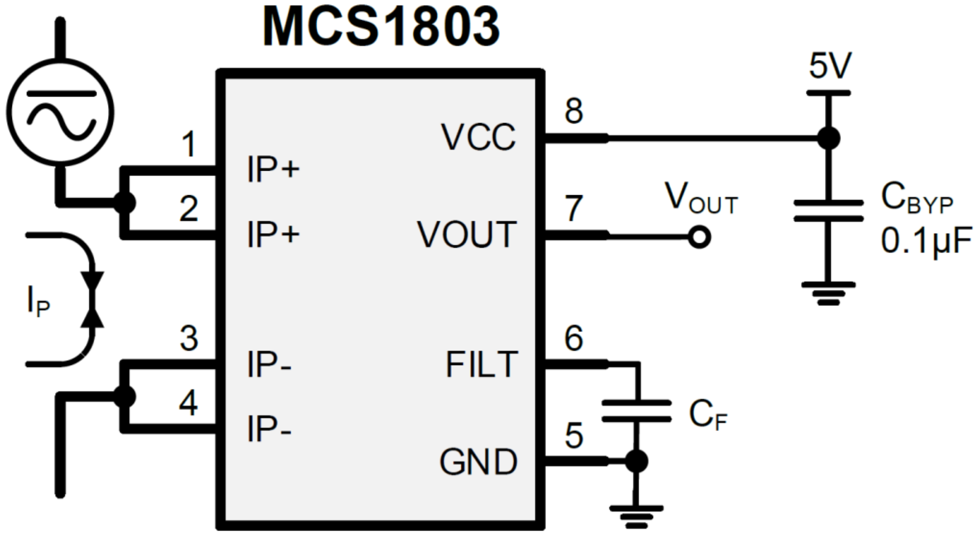




Cost Effective Isolated Current Sensing

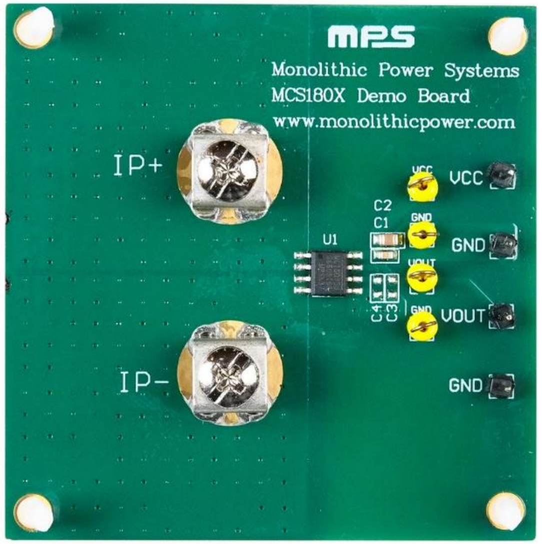
- Single IC Solution
- Standard SOIC-8
- Smallest Solution Footprint
- Integrated True Galvanic Isolation





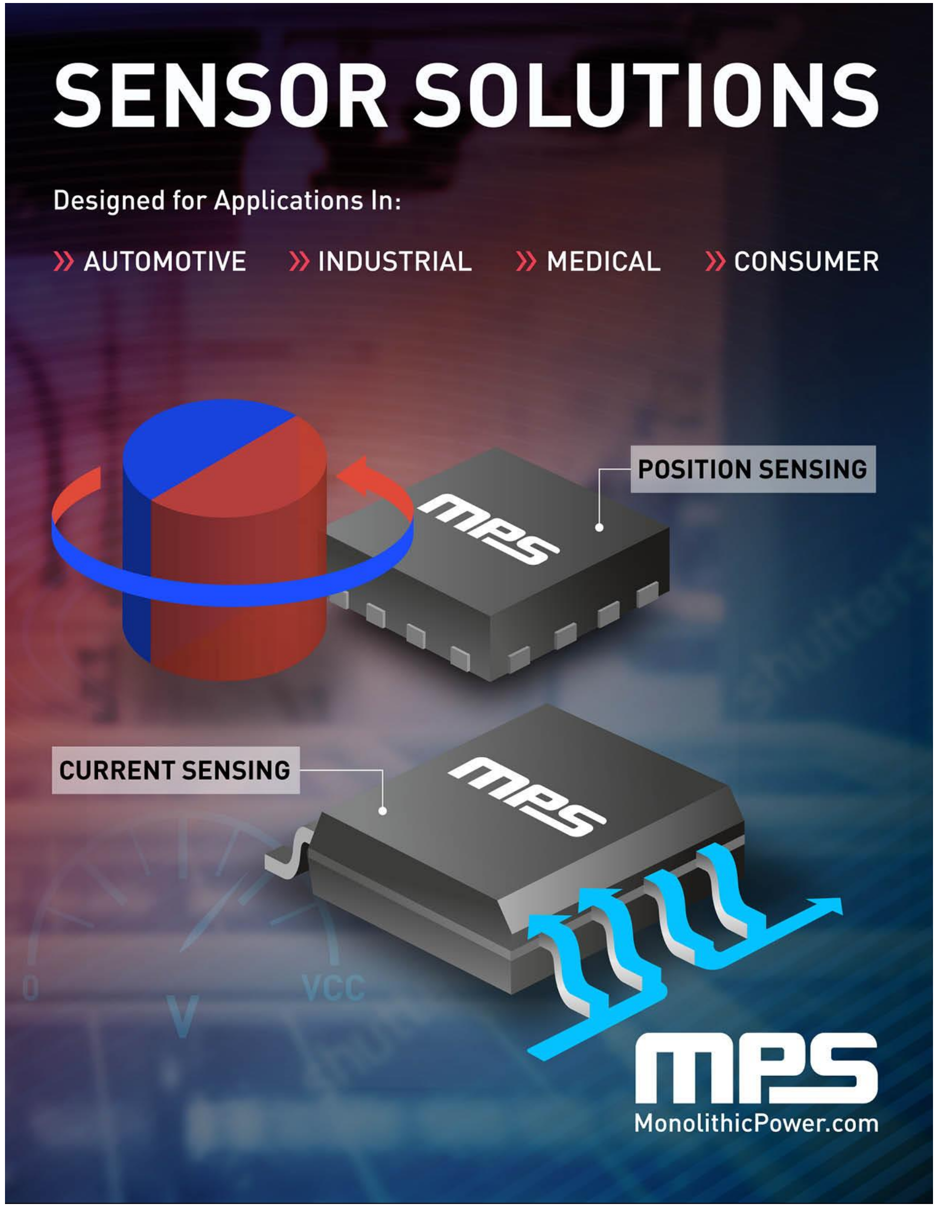
Get Started with Evaluation Boards

Part Number	Supply (Vcc)	Current Options	Accuracy	Isolation
MCS1800	3.3V	±12.5A, ±25A	3%	1000V
MCS1801	5V			
MCS1802	3.3V	±5, ±10, ±20, ±30, ±40, ±50A	2.5%	2200V
MCS1803	5V			



- Visit https://www.monolithicpower.com/en/products/sensors/current-sensors.html
- Datasheets available online
- Product is released to production

Thank You – Q&A



For more information, contact:
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Check out our Sensor Solutions brochure at **MonolithicPower.com**