Introduction to ACEINNA

January 2021

www.aceinna.com

Company Overview

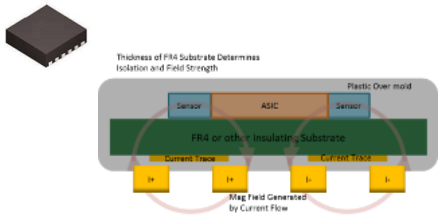
Company Profile

- Leading precision sensor and sensing integration products.
- ACEINNA started in 2017 as a spin-off from MEMSIC, Inc. (founded in 1999, a maker of consumer MEMS-based sensors products)
- State-of-the-art inertial navigation systems, AMR magnetic current sensors and flow sensors
- HQ is in Andover, MA. R&D in San Jose, Chicago, and Andover. Manufacturing in Wuxi, China.

Technology Leadership (Field Proven)

- Invented and brought to market unique thermal MEMS accelerometer
  - >30M shipped into Automotive ECS and rollover applications (Ford, GM, Land Rover, Volvo, Jaguar, Hyundai, Nissan etc)
- First to offer MEMS-based FAA-certified AHRS and a leading supplier of IMU's to Heavy Equipment Market
  - Hundreds of thousand IMUs installed in precision agriculture market
- First to bring high performance AMR sensor to mobile phone and shipped >500Mu into e-compass
- IP and knowhow developed over 15 years in designing and manufacturing AMR magnetic thin film sensors
- IP and expertise in MEMS and AMR sensor, ASIC, calibration and packaging to achieve high performance
- Shipped 1B units accelerometers in 2016

Product Lines and Applications

Technology / Product Lines		Application Markets	
	**Inertial System & Solution** ➢ IMUs (6 / 9 DOF) ➢ VG / AHRS ➢ GNSS / INS / RTK ➢ Static / Dynamic Tilt	• Precision AG • Construction Equip. • Unmanned Vehicles / • Platform Stabilization • Mapping / Surveying • Robotics & Control	
	**Current Sensors** ➢ Isolated Magnetic Sensing • High Bandwidth • High Accuracy	• Server / Power Supply • DC / DC Conversion • Electric Motors • Invertors • Power Factor Correction	
	**Flow and Pressure Sensors** ➢ Thermal MEMS Based • Clean Gas Flow • Differential Pressure	• Natural and other Gas • Industrial Processing • Mass Airflow • HVAC • Medical	

Advanced Magnetic Current Sensors

Current Sensors for Next Generation Power Conversion & Management

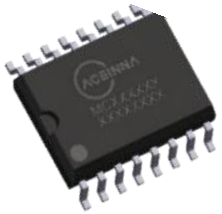
Khagendra S Thapa

January 2021

ACEINNA's Current Sensors for Next Gen. Power Conversions

Powerful Sensing Solutions

- **Award winning, simple to use, All-in-One single chip solutions (MCx1101 Series)**
- **MCx1101 leads the market for "accuracy + bandwidth + response time" in a single chip solution**
- **ACEINNA's products have 1.5MHz bandwidth – highest in the industry**
- **Key performances to support fast switching wide-bandgap SiC and GaN power stage**



- **Popular current solutions technology vs ACEINNA AMR current sensors**

COMPARISON

Desired Feature	Aceinna AMR	Hall IC	Current Transformer	Sense Resistor
Accuracy	✓	✗	✓/✗	✓/✗
DC->1MHz 3dB BW to 5MHz 3dB BW	✓	✗	✗	✓
Isolated	✓	✓	✓	✗
Small Size	✓	✓/✗	✗	✗

ACEINNA MCx1101 AMR Current Sensors

(available in ±5A, ±20A, ±50A, fixed gain or ratiometric gain)

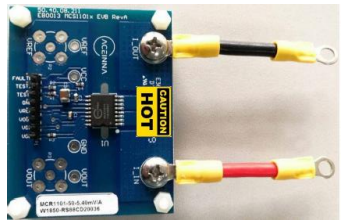
Powerful Sensing Solutions

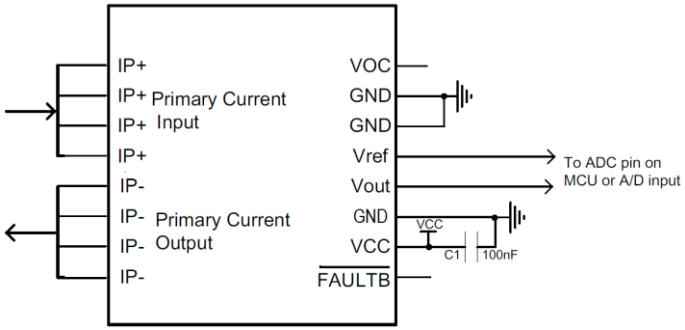
Features

- **Excellent accuracy and over temperature:**
  - 20A: Total error of **0.6% of RD** typ @25°C and **2.0% max @ 85°C**
  - 50A: Total error of **0.7% of RD** typ @25°C and **2.5% max @ 85°C**

    Note: above error is total error as **% of Reading (vs % of Full Scale)**
- **Very High Frequency Response:**
  - 1.5 MHz bandwidth (3dB) with low phase delay
- **Fast output step response time: 300ns typical**
- **Integrated fast over-current-detection: 200ns typical**
- **3.3V/5V Supply with low quiescent current (4.5/6.5mA typ)**
- **Low Primary Resistance (0.9 mΩ typ for 50A)**
- **-40 to +105°C Operating Temp Range**
- **4.8kV galvanic isolation**
- **SOIC 16 package (RoHS/REACH compliant)**
- **UL/IEC/EN60950-1 Certified**
- **Easy to use**

Part	Current (A)	Output Type	VCC (V)	Accuracy (Total Error as % of Reading) Typ @ 25C, Max at 85C
MCA1101-50-3	±50	Fixed Gain	3.3	0.7% typ, 2.5% max
MCR1101-50-3	±50	Ratiometric	3.3	0.7% typ, 2.5% max
MCA1101-20-3	±20	Fixed Gain	3.3	0.6% typ, 2% max
MCR1101-20-3	±20	Ratiometric	3.3	0.6% typ, 2% max
MCA1101-5-3	±5	Fixed Gain	3.3	1% typ, 2% max
MCR1101-5-3	±5	Ratiometric	3.3	1% typ, 2% max
MCA1101-50-5	±50	Fixed Gain	5	1.5% typ, 2.5% max
MCR1101-50-5	±50	Ratiometric	5	1.5% typ, 2.5% max
MCA1101-20-5	±20	Fixed Gain	5	0.6% typ, 2% max
MCR1101-20-5	±20	Ratiometric	5	0.6% typ, 2% max
MCA1101-5-5	±5	Fixed Gain	5	1% typ, 2% max
MCR1101-5-5	±5	Ratiometric	5	1% typ, 2% max





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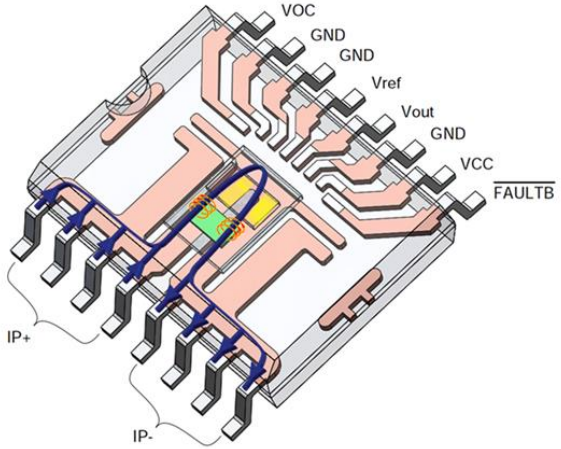
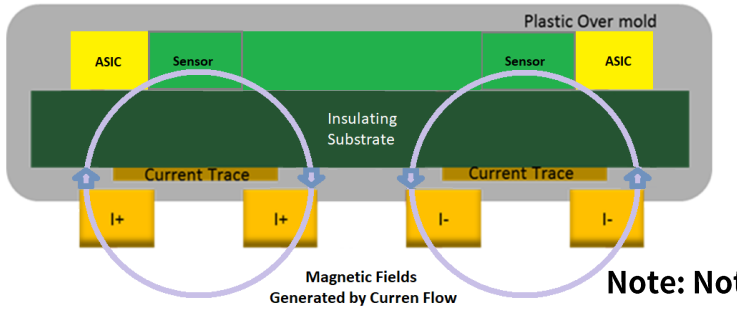
Electronic Products PRODUCT OF THE YEAR 2019 AWARD WINNER

How it Works





Note: Not to scale

- **Primary current (IP+, IP-) flows through package lead frame**
  - A magnetic field is generated inside the package
- **Current sensor provides voltage output relative to the magnetic field detected**
  - AMR sensors form a resistive bridge to sense the magnetic field.
  - Two AMR sensors used for external field cancellation
  - Proprietary ASIC with performance provides gain, calibration, compensation over operating temperature, features
- **A insulating substrate separates the electronics to provide isolation**

ACEINNA's AMR Technology

ACEINNA Current Sensors – based on AMR technology

MCx1101

Electronic PRODUCTS PRODUCT OF THE YEAR 2019 AWARD WINNER

ACEINNA AMR vs Hall Effect

- Better Accuracy over temperature & range
- Higher Bandwidth & Lower Phase Shift
- Lower Offset (Up to 1/10th)
- Lower Noise (Up to ½)

ACEINNA AMR vs Transformer

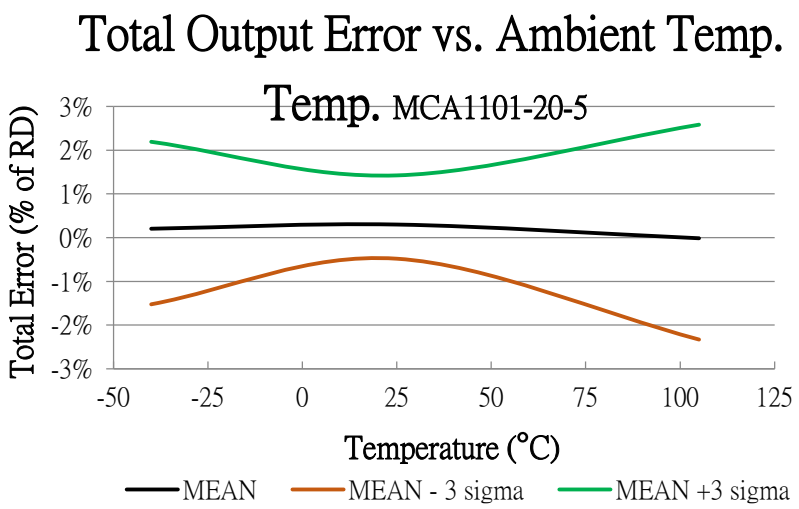
- Response to DC and AC
- No core saturation effects
- Much smaller size
- Faster/Simpler to design

ACEINNA AMR vs Shunt Resistor

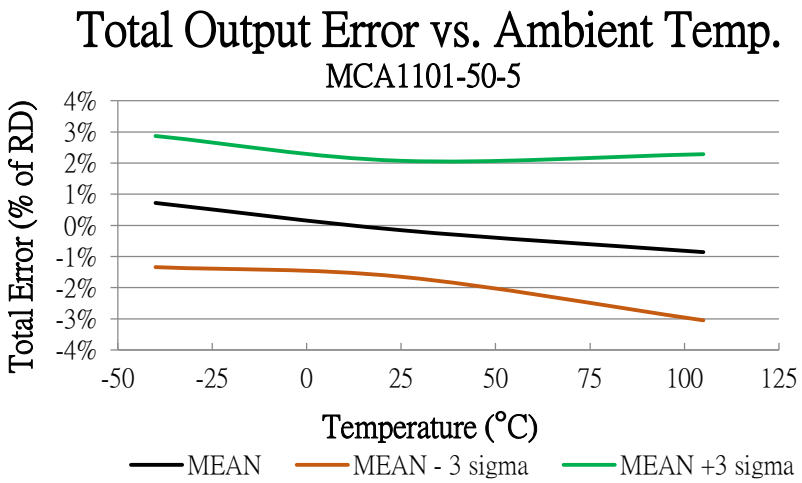
- Inherent Isolation
- Improved Accuracy vs Power Loss
- Less Components, Space Savings, Cost Savings
- Faster/Simpler design

High Accuracy Over Temperature

±20A Current Sensor



±50A Current Sensor

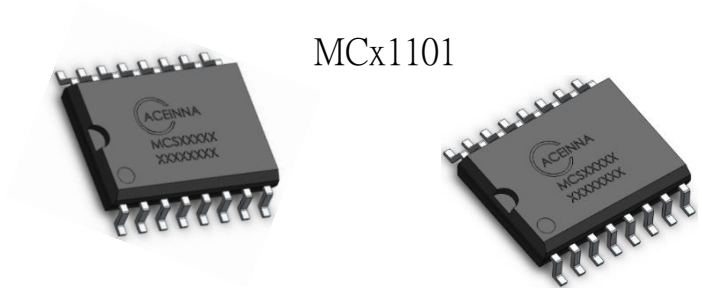


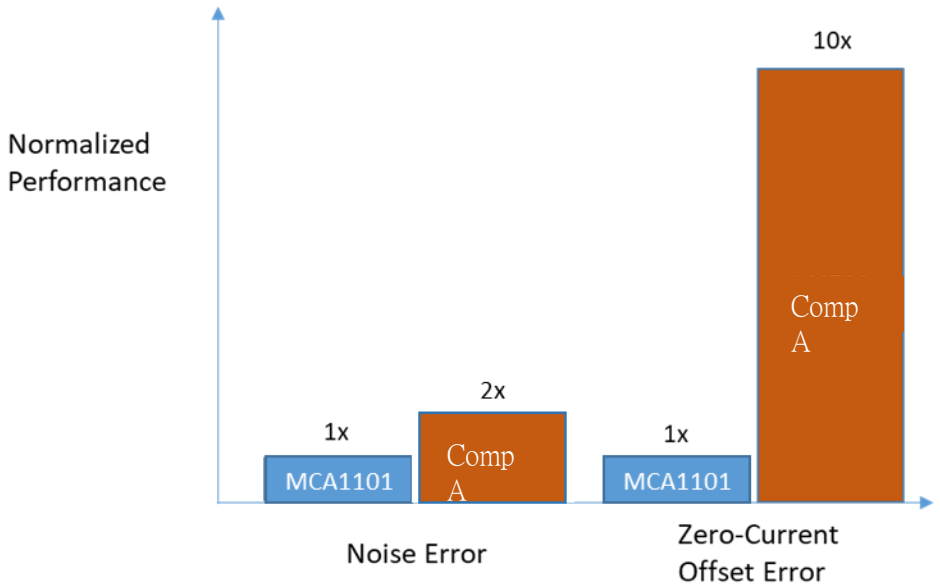
- ACEINNA AMR technology provides excellent accuracy over temperature vs Hall Effect competitors
- With lower noise and offset, ACEINNA AMR current sensors provide higher accuracy over the current dynamic range vs Hall Effect competitors

Accuracy Over Dynamic Range

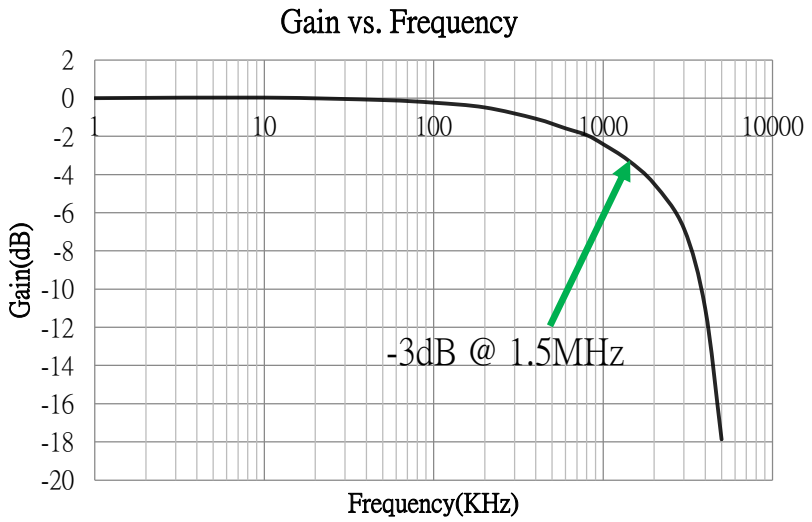
Low Offset, Low Noise

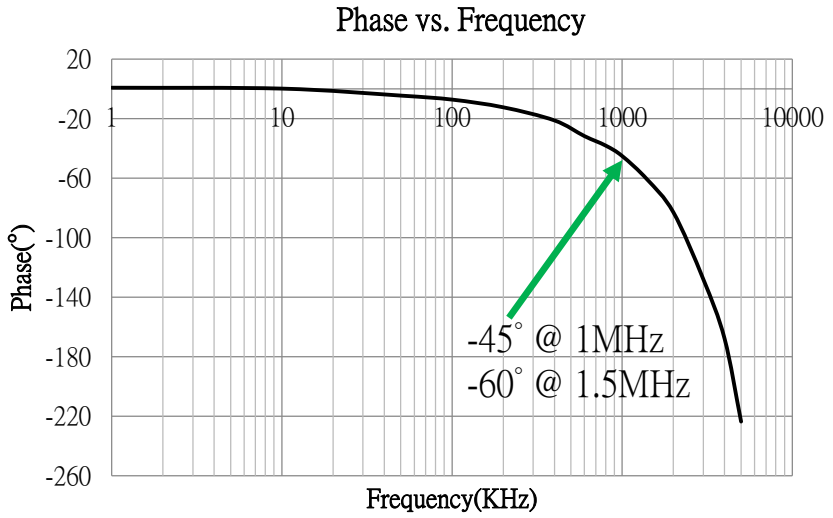
- Many current sensor applications require high accuracy over a dynamic range
- At low currents, offset errors remain fixed and can dramatically increase total error as a percentage.
- ACEINNA's High bandwidth AMR technology offers a clear advantage in accuracy at the lower end of the current range vs Hall Effect.





Frequency Response, Best –In-Class





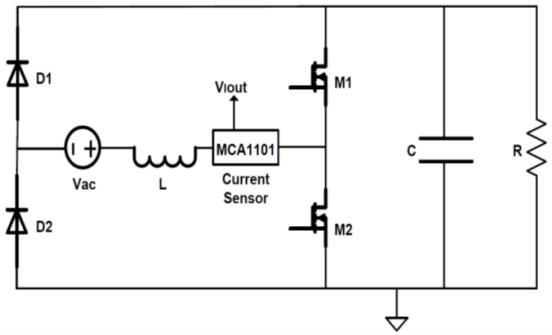
High Bandwidth is Needed for Wide Bandgap Transistors

Silicon Carbide (SiC) and Galium Nitride (GaN) are starting to replace Silicon MOSFETs

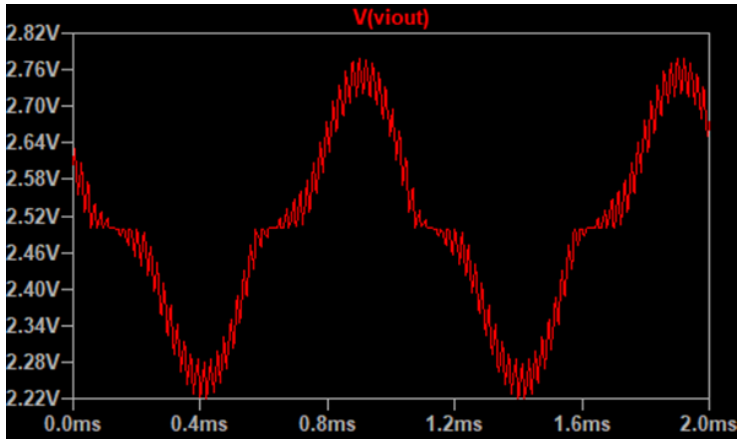
These new transistors are enabling higher frequency systems with better efficiency and smaller size. With higher frequencies, you need:

- A higher bandwidth current sensor for the current control loop.
  - Totem pole PFC requires fast switching ripple current measurement.
  - Motor and inverter apps also require fast ripple current measurement.
- A higher bandwidth sensor to enable fast step response in protection circuits.

Totem Pole Circuit



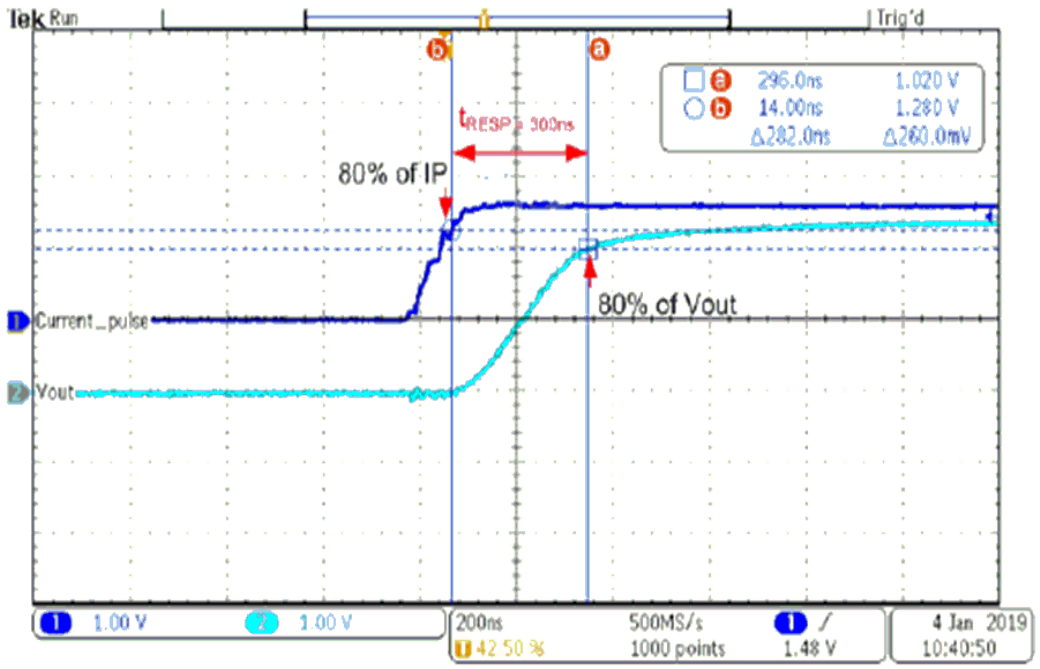
Current sine wave with ripple



Output Response Time, Best-In-Class

Response Time

Output response time is the time interval from 80% if the input IP to 80% of the output Vout



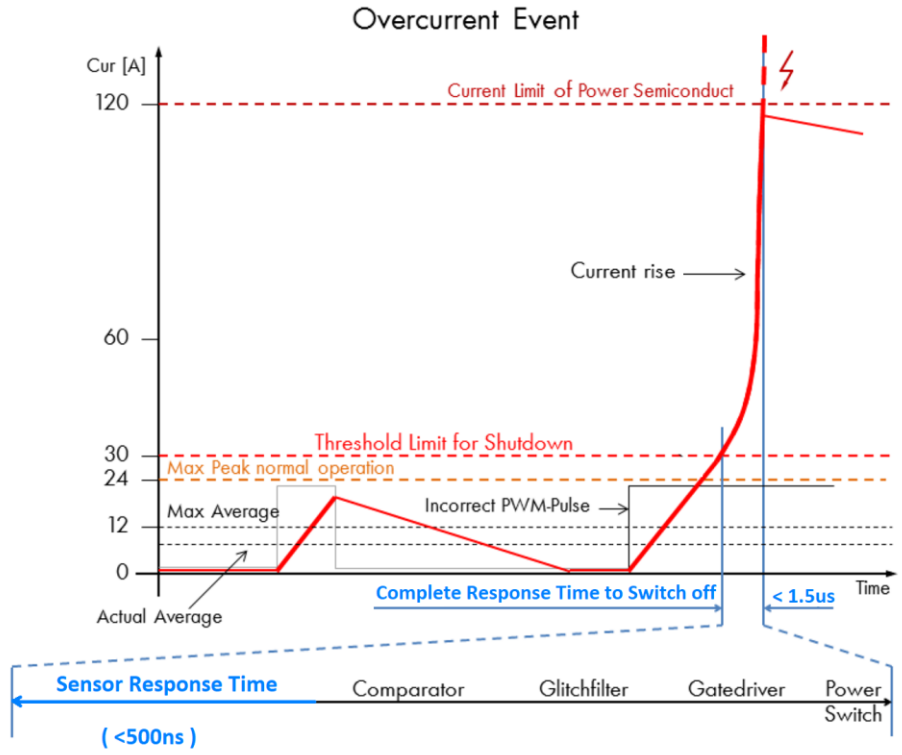
- Scope shows 45A input step with fast 100ns rise time
- Output response time 300ns

Output Response Time, Best-In-Class

Current sensors are often used in protection circuits to help shut down the power system when there is a problem. Fast current sensor response time and high bandwidth is often critical in these applications.

Timing budget for current sensor in protection circuits is often tight.
Example shown is for inverter application:

- Protection: <1.5us total for full switch off time (includes time for other items in path to react as well)
- Current Sensor Response time needs to be well below 500ns
- ACEINNA current sensor step response time is 300ns typical

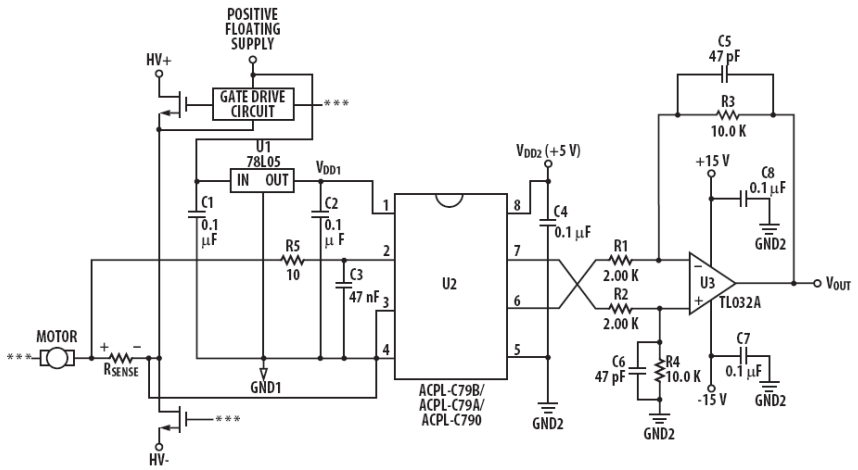


Courtesy of SMA GmbH

Isolated Shunt vs Isolated Magnetic Sensor: Simplicity

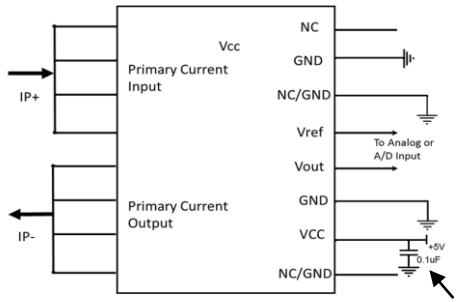
Shunt Solution, Isolated (Typical)

- Many components, Higher dissipation, BW limited by isolator



Isolated Magnetic Current Sensor Solution

- Greatly simplified solution with high performance



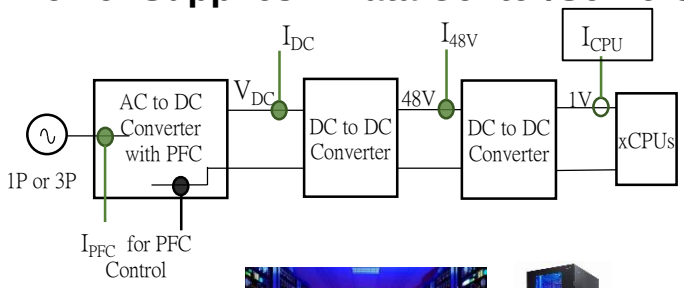
Only decoupling capacitors

ACEINNA Isolated Magnetic Current Sensor benefits over Shunt solutions

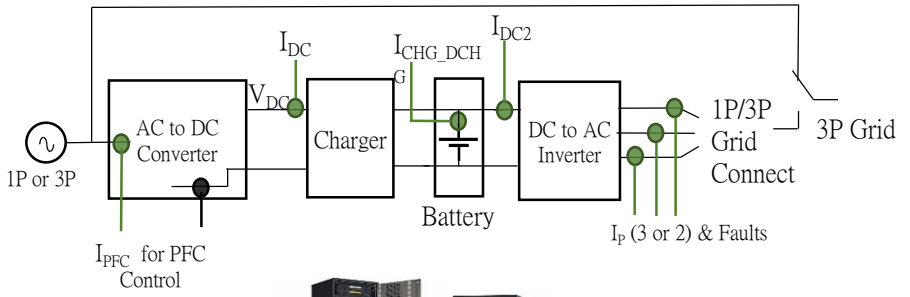
- Small, Simple Isolated (4.8kV) Solution -> Vastly minimizes components, board space and failure risks
- Low power dissipation / consumption and no need for power supply for both side of isolation
- High bandwidth (1.5MHz) provides fast response with low phase delay; Includes ultra fast OCD

Current Sensors in Isolated High Power Conversion Applications

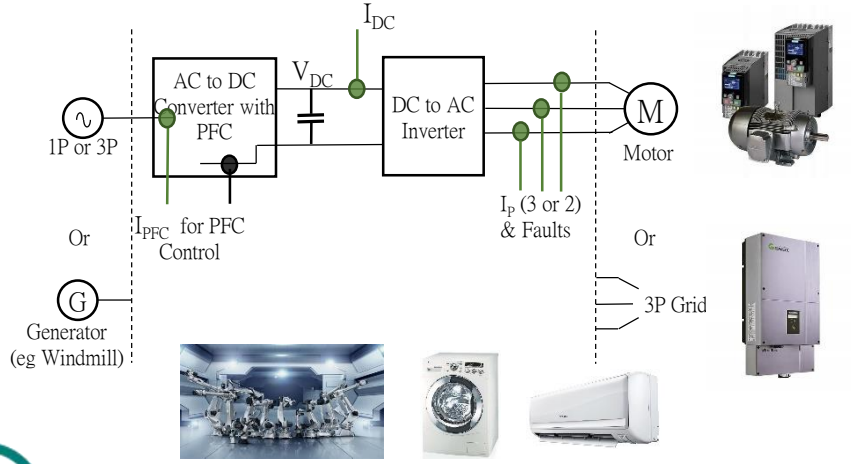
Power Supplies – Data Center/Servers/Telecom



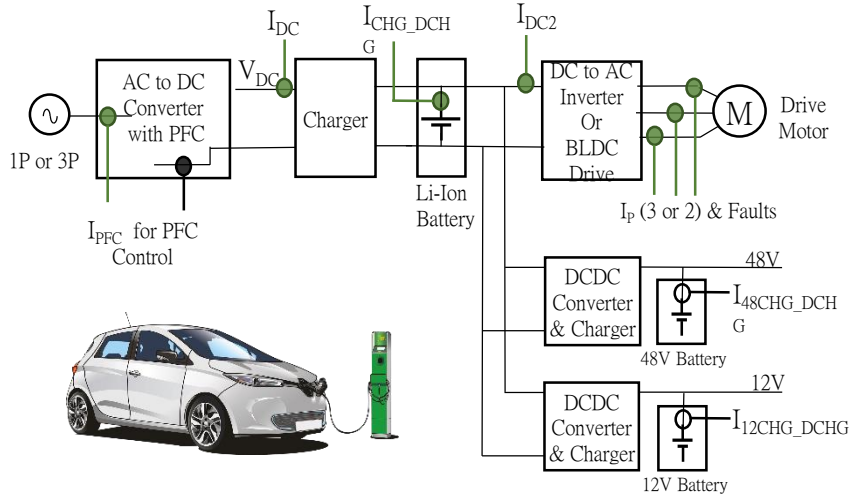
Uninterruptible Power Supplies (UPS)



Motor Drives and Inverters



Electric Vehicle Motor Drive /Battery Management



ACEINNA's Current Sensor Products

- **Benchmark Frequency Response (Bandwidth, 1.5MHz)**
  - Enables SiC/GaN advantages
    - Higher frequency,
    - Smaller system size,
    - Better efficiency systems
- **Benchmark Step Response Time (300ns)**
  - Minimizes protection timing budget for current sensor
  - Enables the protection of higher frequency SiC/GaN switches
- **Benchmark Accuracy (0.6% typ) over temperature for ICs**
  - Better control and regulation to improve efficiency and reliability
  - Low offset and low noise provides high accuracy across the dynamic range
- **Simple to use**
  - Easy to design, small single chip isolated current sensing solution
  - Only a decoupling capacitor needed

Electronic PRODUCTS
PRODUCT OF THE YEAR
2019
AWARD WINNER

Product of the Year 2019

Thank You