Texas Instruments

New Product Update

Precision Hall-effect current sensor with ±1100 V reinforced isolation working voltage

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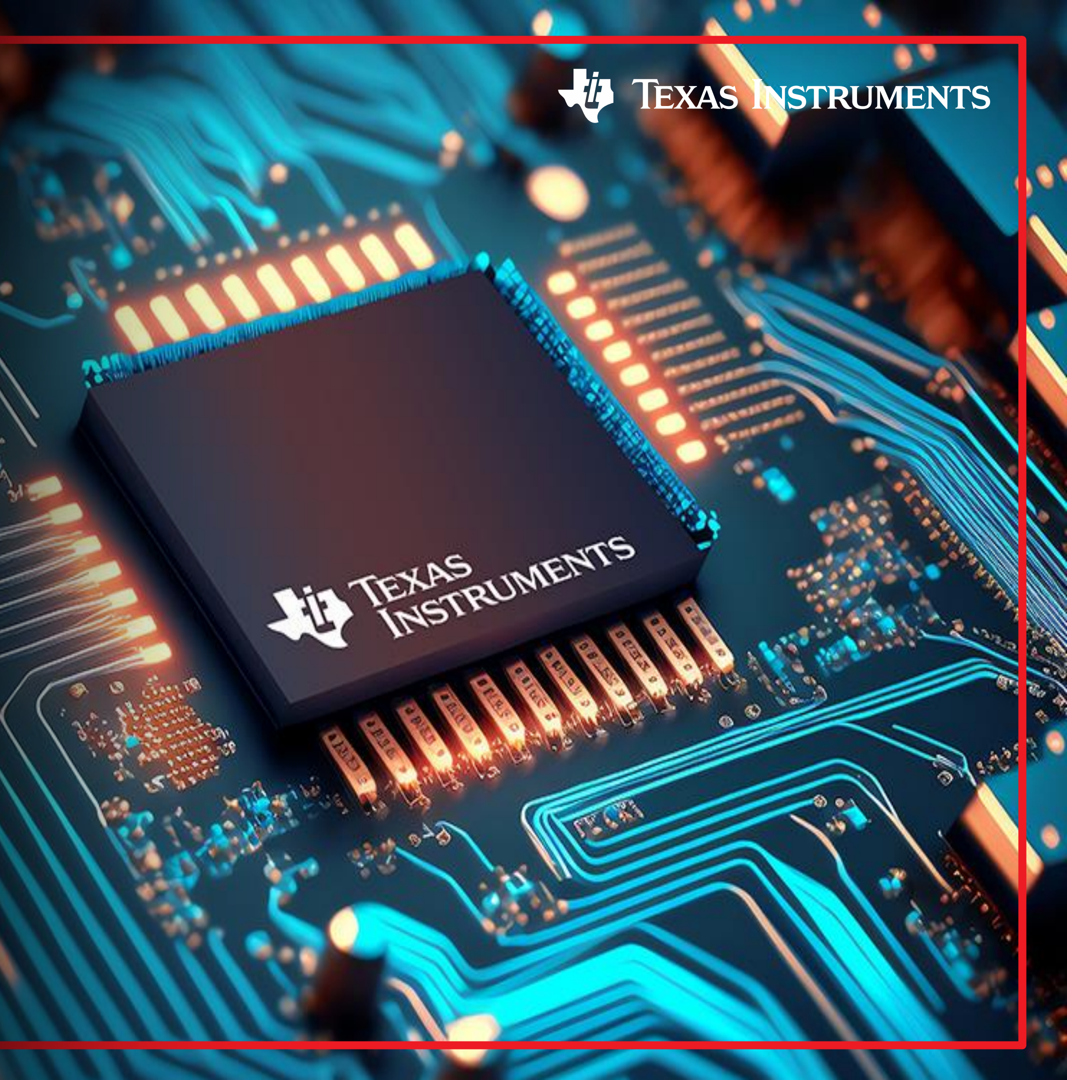
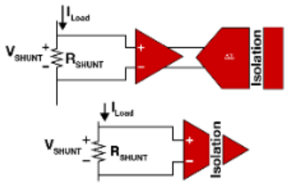
Product marketing engineer



Agenda

- TI current sensing solutions
- TMCS fundamentals of operation
- Benefits of designing with TMCS
- TMCS overview
- Getting started

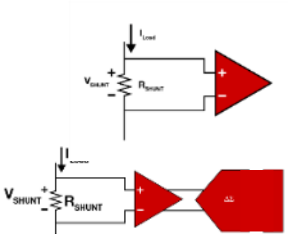
TI current sensing solutions

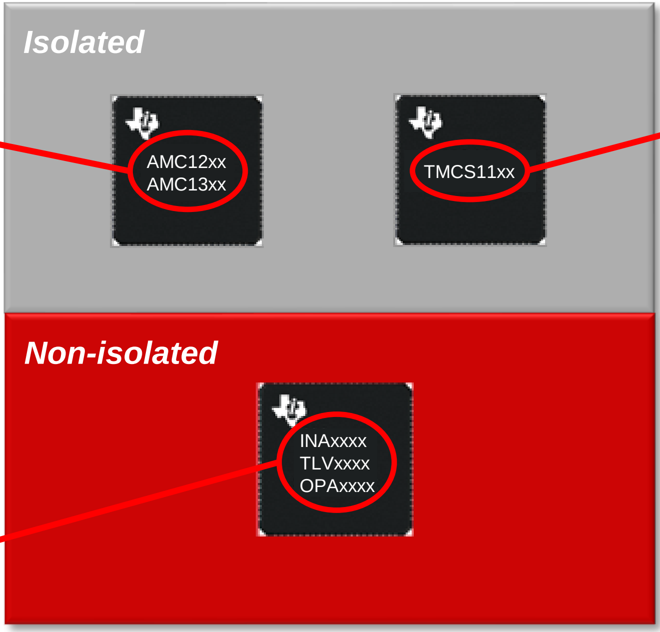


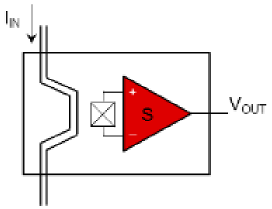
Isolated shunt options

Directly measures the current through a relatively small ohmic valued (shunt) resistor.

Non-isolated shunt options





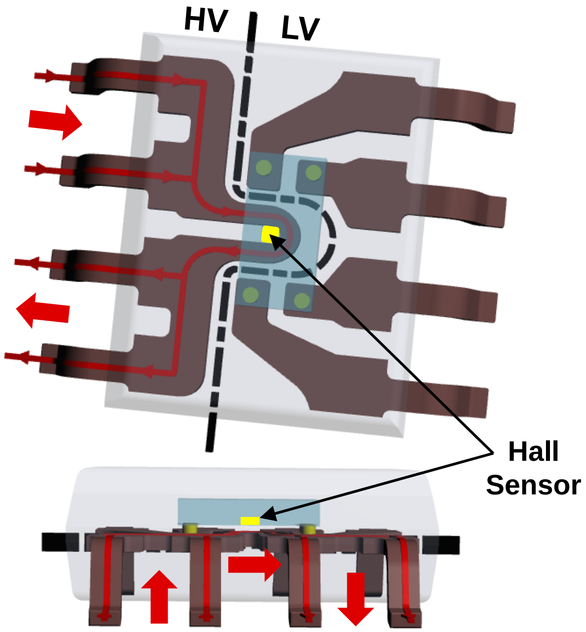


In-package magnetic options

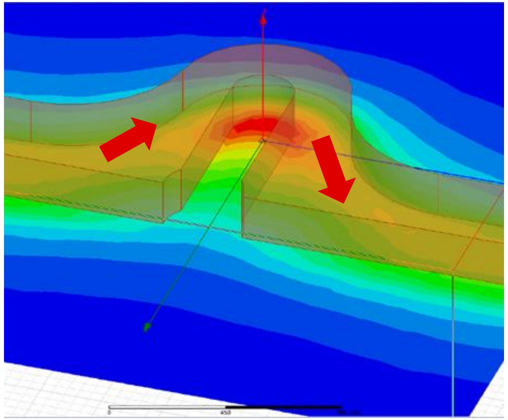
Magnetic sensing indirectly measures the load current by measuring the magnetic field produced by a current running through a conductor.

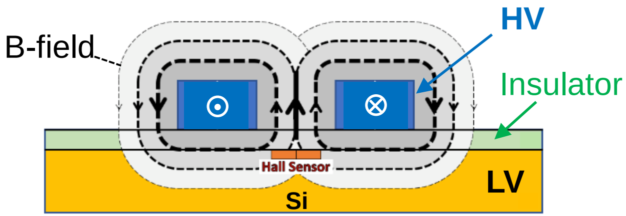
In-package MCS fundamentals of operation

Current flows through lead frame, electrically isolated from die



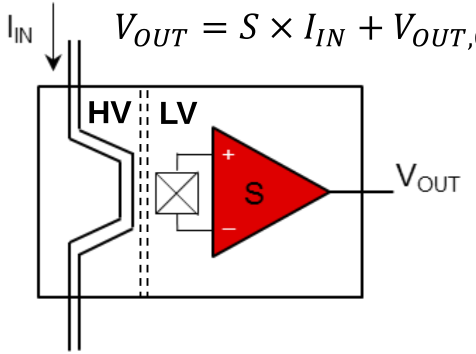
Lead frame loop generates magnetic field proportional to current





Precision Hall sensor converts magnetic field to voltage signal

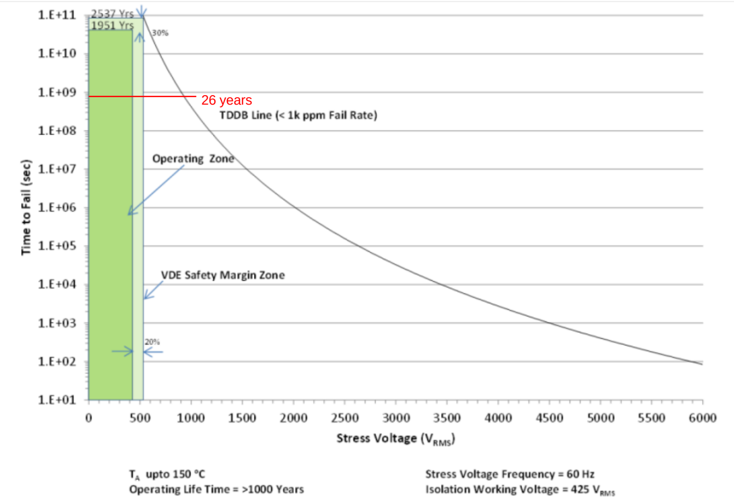
$$V_{OUT} = S \times I_{IN} + V_{OUT,0A}$$



Benefits of designing with TI TMCS portfolio

Isolation: built-in quality & reliability

TMCS1100 600V lifetime insulation



- Only supplier to provide insulation lifetime (TDDB)
- Devices specified and tested per VDE 0884-11
- Specified with margin, tested aggressively:
  - 100% TMCS1100 3.6 kV Production test (900 V standard)

Solving system level challenges

TMCS1100 (R in 2020)

- ±600 V_{PK} working voltage in SOIC-8
- 30 A_{RMS} at 25°C
- <1% error over temp, <0.7% lifetime drift

TMCS1123 (RTM in 2023)

- Reinforced ±1100 V_{PK} working voltages
- 75 A_{RMS} at 25°C with 0.67 mΩ conductor
- ±1.75% total error across temp and lifetime
- Enhancing system safety with 1 µs OC and integrated diagnostics

TMCS1123

Samples on TI.com now
Releasing 4Q23

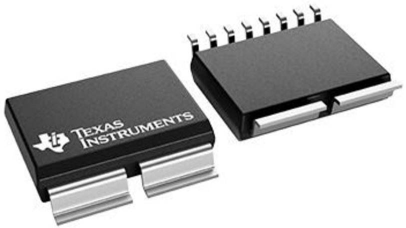
Precision Hall-effect current sensor with ambient field rejection, configurable over-current and fault detection

Features

- 5 kV_{RMS} Withstand Isolation Voltage, 8mm creepage
- ± 1100 V_{PK} Reinforced Working Voltage
- 0.67 mΩ conductor, 75 A_{RMS} continuous current @ 25°C
- Measurable current ranges up to ±100 A (+200 A)
- 250 kHz signal bandwidth
- Configurable over-current detection threshold with < 1 µs response time
- < 1.75% accuracy across temperature (-40 to 125°C) and lifetime
- Differential Hall element sensing rejects ambient magnetic fields
- Internal fixed reference for bi- or uni-directional sensing
- Internal thermal and sensor diagnostics
- 16-pin SOIC-W package (16 DW)
- 75 kV/us CMTI (minimum)

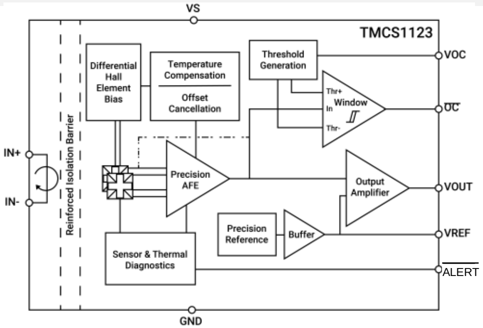
Applications

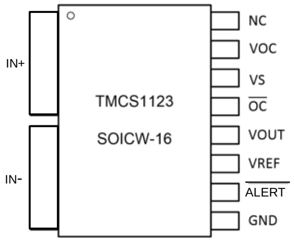
- Motor control
- PV string inverters
- Switching converters
- Overcurrent protection
- Power monitoring



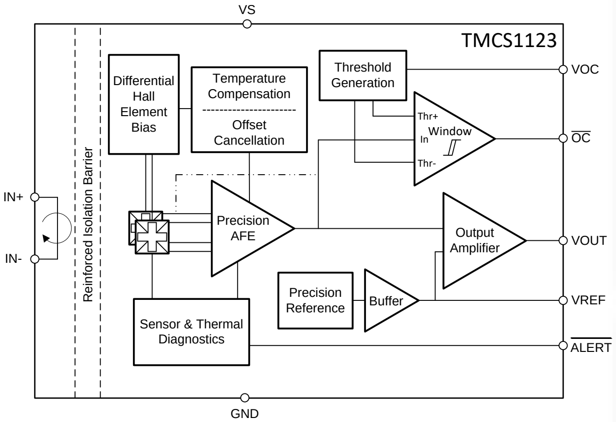
Benefits

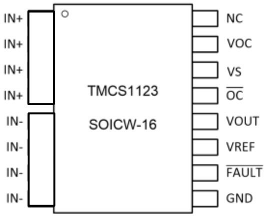
- Industry leading reinforced isolation with highest working voltages
- Wide range of measurable current ranges
- Enhanced thermal performance enables higher current capabilities within system thermal boundaries
- Fast hardware control for fault protection of inverters and power switches
- Thermal diagnostics and ambient field rejection simplify two main design challenges of magnetic sensors
- Precision signal chain delivers the highest accuracy and most linear Hall current sensing device available, stable across temperature.
- Internal reference and fixed architecture provide high PSRR and output immunity from noisy environments
- Sensor fault diagnostics enhance system-level safety





TMCS family feature set | ambient field rejection





Feature capability

Value proposition: reject interference from external magnetic fields due to adjacent high current traces or other magnetic fields

- Magnetic rejection ratio (BRR) limited by Hall matching and coupling of leadframe.

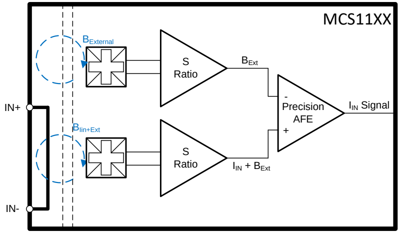
  20 A Trace 10 mm away ≈ 400 µT

  20 A input ≈ 20 mT

  BRR = 100 (40dB)

  Error = 0.02%

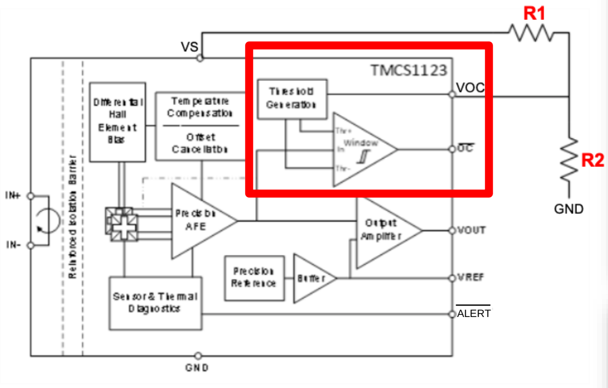
$$e_{B_{Ext}}(\%) = 100\% \times \left[\frac{\frac{B_{Ext}}{BRR}}{B_{IN}}\right] = 100\% \times \left[\frac{\frac{B_{Ext}}{G \times BRR}}{I_{IN}}\right]$$

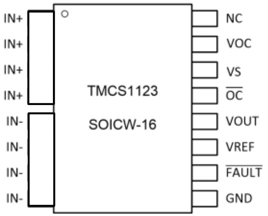


Discovery questions

- What nearby high current traces or other magnetic interference do you expect?
  - What is the highest frequency of these large current signals?
  - How large are they relative to your current of interest?
- What is your system-level accuracy target across the full temperature range?
- Do you have any experience or comfortability with magnetic shielding?

TMCS family feature set | over-current detection



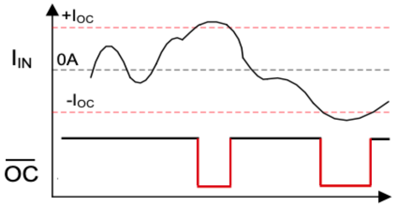


Feature capability

Value proposition: integrated over-current detection provides fast hardware protection capability for short circuit and over current events

$VOC = S \times I_{OC}/2.5$

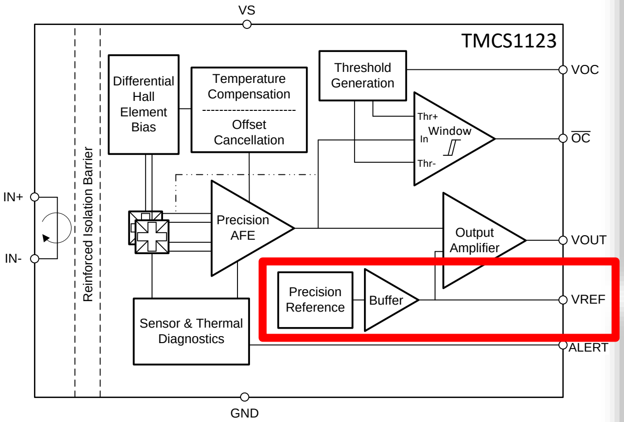
- **1us integrated OCP** for protection @ up to 2.5x measurable full-scale current (I_{FS})
- External voltage on VOC pin sets window comparator thresholds (I_{OC}), OC is active low open-drain output
- Ex: Sensitivity, S = 50 mV/A with 5 V supply, I_{FS} = ± 50 A For Ioc = ±75 A, set VOC = 1.5 V

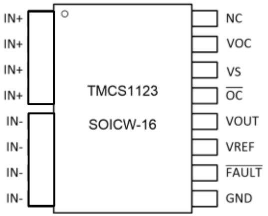


Discovery questions

- What types of events do you need an integrated OC detection for?
- How much of your system response time do you allow for current sense?
- Relative to measurable range, what is your detection threshold?
  - How much does this vary between platforms / products?
- How accurate do you need OC detection to be?

TMCS family feature set | internal reference





Feature capability

Value proposition:

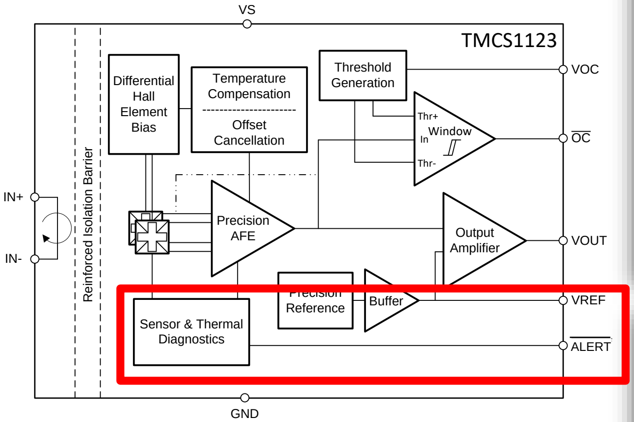
- Internal reference voltage compatible with 3-V & 5-V full scale ADC
  - 2.5-V, 1.65-V, & 0.33-V orderables
- Increases system PSRR & simplifies implementation

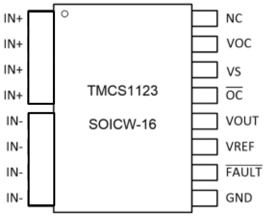
PARAMETERS		TEST CONDITIONS	MIN	TYP	MAX	UNIT
	V_{REF} Output Voltage Error	TA = 25°C		±0.04	±0.2	%
	V_{REF} Output Voltage Error	TA = –40°C to 125°C		8	40	ppm/°C
	V_{REF} PSRR	VS = 3 V to 5.5 V		±20	±200	uV/V

Discovery questions

- What full-scale ADC range does your customer require? Relative to Analog Supply?
- Do you typically do a single point calibration?
- Is there value add to make Vref externally driven?
- Do you use differential or pseudo-differential ADC? Is there an intermediate buffer / level shift stage?

TMCS family feature set | sensor diagnostics





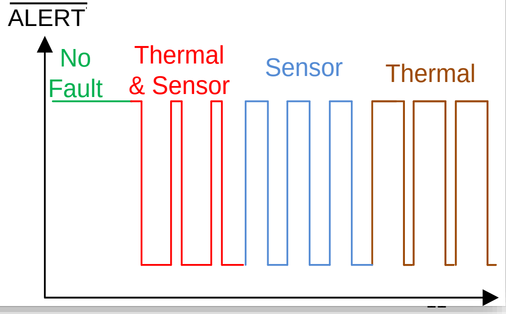
Feature capability

Value proposition: sensor alerts system if operating conditions might invalidate output signal, and simplifies thermal monitoring of sensor device

- Hall sensitivity out of range alert
  - Device continuously monitors health of the Hall sensor, compares to factory limits
- Over-temperature alert
  - Die can be significantly heated by high currents through leadframe
  - ALERT occurs if die temperature exceeds maximum junction temperature

Discovery questions

- Are there key system safety behaviors that you have experienced before with magnetic sensors?
- What other fault or safety conditions would be beneficial for the sensor to tolerate / diagnose?
- Is PWM encoding acceptable?



Getting started

You can start evaluating this device leveraging the following:

Content type	Content
Product folder	Precision Hall-effect current sensor with ±1100-V reinforced isolation working voltage
End equipment diagrams	DC Fast Charging Station , DC Wallbox Charger, Micro Inverter & String Inverter
Customer training series or webinar session	Precision labs series: Magnetic sensors
Technical blog content or white paper	Simplifying high-voltage sensing with Hall-effect current sensors
Product overview	Current Sensing With Isolated Magnetic Hall-Effect Current Sensors
Development tool or evaluation kit	TMCS1123EVM & TMCS1123EVM User Guide

Visit www.ti.com/npu

For more information on the New Product Update series, calendar and archived recordings