Welcome to the Texas Instruments New Product Update

We will begin promptly at 1 min past the hour- thank you for your patience
Phone lines will be muted during the presentation.

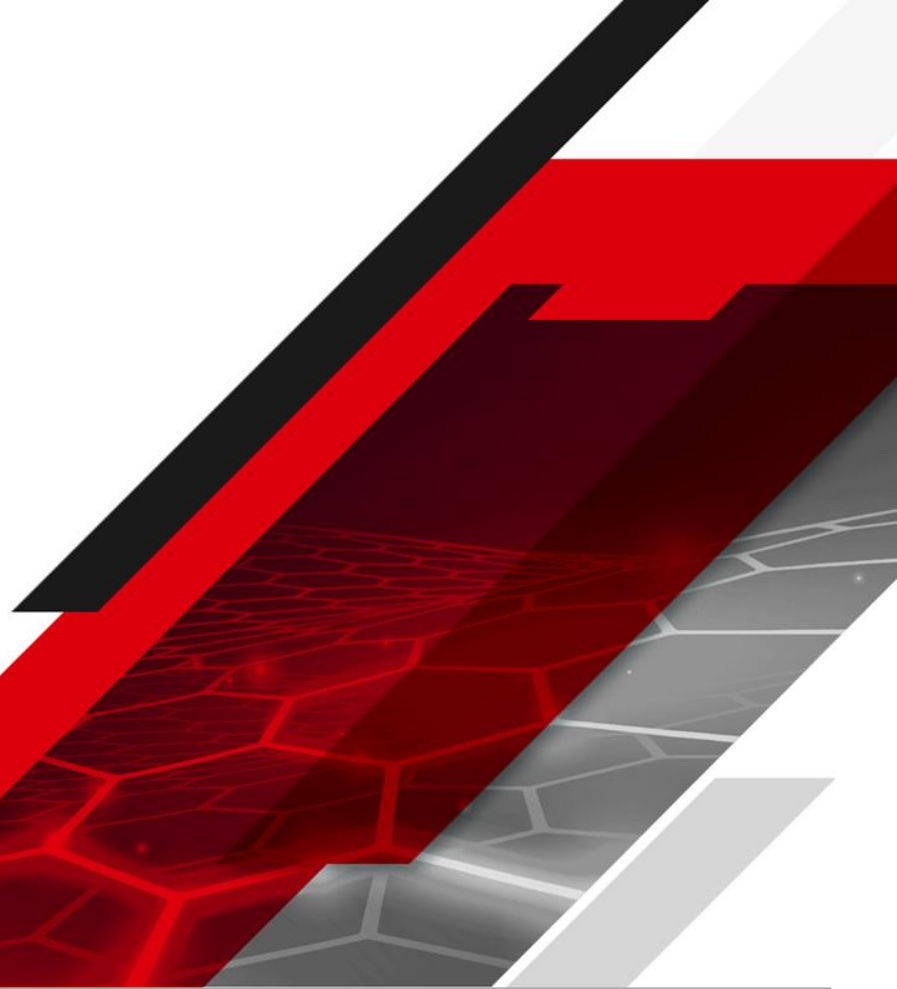
We are now using web-ex VOIP audio. There is no telephone dial in.

Please post questions on the chat Web-Ex Chat
or contact your sales person or field applications engineer

New Innovations in Current & Magnetic Sensing

Accurately measure the real world

May 30, 2019

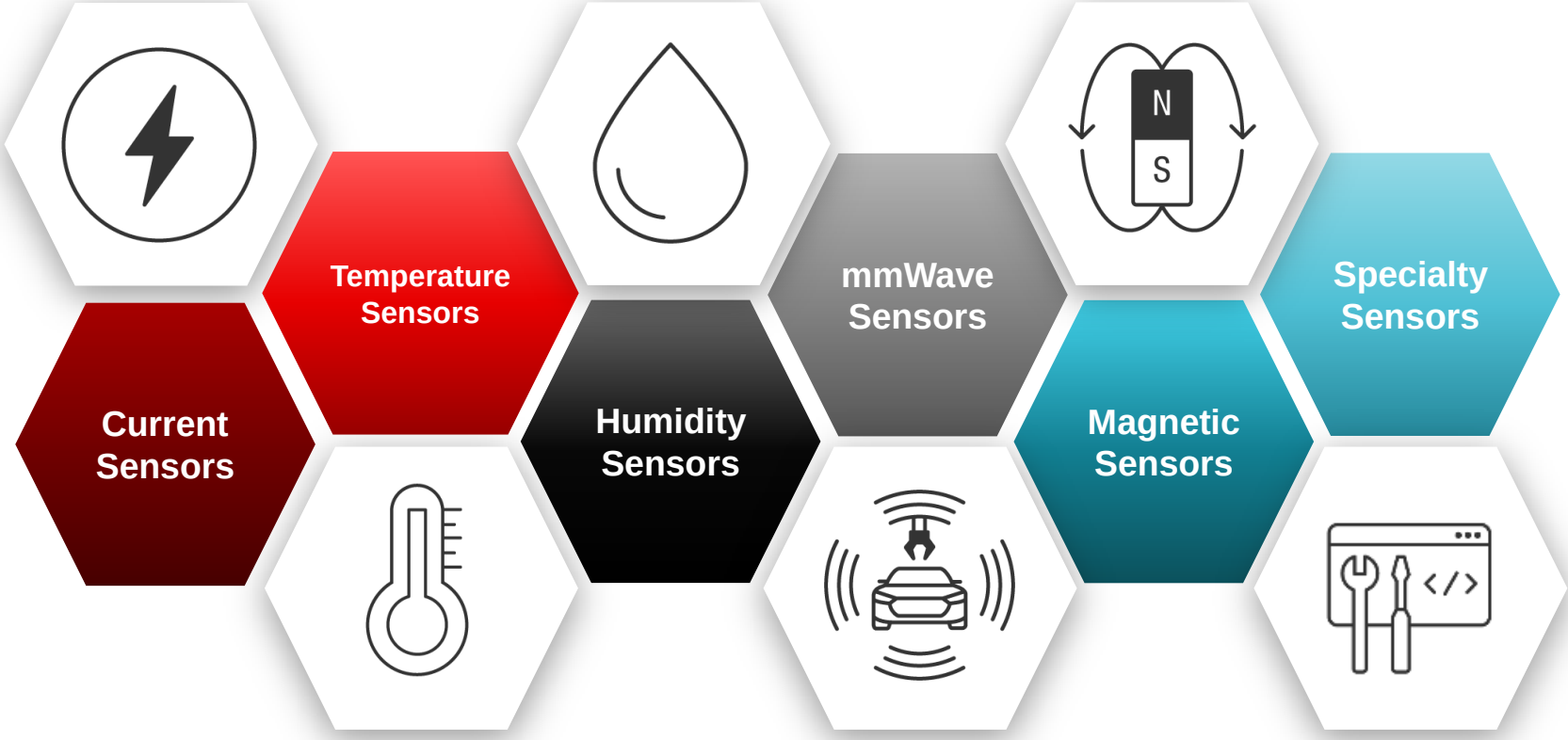


Agenda

- Hall sensing solutions:
  - High performance Hall switches, latches and linear sensors
- Current sensing solutions:
  - High-accuracy, low-input bias current sense amplifiers
  - Smallest surface-mount current sense amplifier
  - Integrated-shunt current sense amplifiers

Sensors to accurately measure the real world

Design intelligent systems with highly accurate, small-size sensors



Magnetic sensors

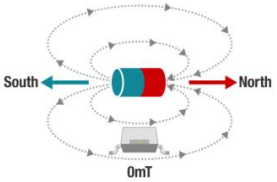
Magnetic Hall effect sensors

Low power, highly reliable, cost-optimized solutions for magnetic position sensing

Why use TI magnetic hall effect sensors?

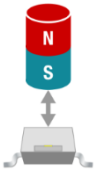
Known for robust durability and dependable operation, TI magnetic Hall effect sensors are the simplest solution for any position sensing application. Whether simply detecting the closing of a lid/surface or performing complex motor commutation, TI's Hall effect sensors will reliably and accurately sense the position in any system.

TI's magnetic hall effect sensors



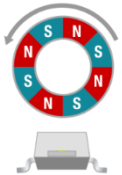
Position measurement

Precise absolute position of linear and angular movements using linear hall sensors



Proximity detection

Detect presence or absence of a magnetic field for simple on/off or open/close applications using hall effect switches



Rotational sensing

Speed and direction for rotary encoding and rotor position for motor commutation using hall effect latches or linear hall sensors

Key applications

Automotive

- Body motors
- Buttons & Switches
- Electric power steering
- LIDAR

Industrial

- Cordless garden/power tools
- E-meters
- Door & window sensors
- Motor drive

Featured products

DRV5013	DRV5015	DRV5032	DRV5055
2.5V to 38V hall effect latch	2mT, 5.5V hall effect latch	Ultra-low power 1.65V to 5.5V hall effect switch	High accuracy 3.3V or 5V bipolar linear hall effect sensor

Links to get started

Design support | Hall effect sensor training | Application notes | Competitor-cross reference

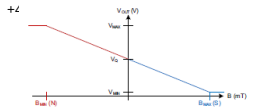
Hall-effect portfolio

Absolute Position

Proximity Detection & Rotational Sensing

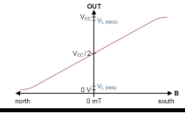
DRV5053
High-Voltage Linear

- 30kHz Signal Bandwidth
- Multiple Sensitivity Options
  - -11mV/mT, -23mV/mT, -45mV/mT, -90mV/mT, +23mV/mT,



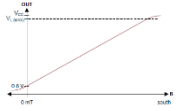
DRV5055
Radiometric Bipolar Linear

- 20kHz Signal Bandwidth
- Multiple Sensitivity Options:
  - 12.5mV/mT, 25mV/mT, 50mV/mT, 100mV/mT
- 5% Sensitivity Accuracy
- 0.12%/°C Magnet Temp Compensation



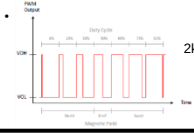
DRV5056
Radiometric Unipolar Linear

- 20kHz Signal Bandwidth
- Multiple Sensitivity Options:
  - 25mV/mT, 50mV/mT, 100mV/mT, 200mV/mT
- 5% Sensitivity Accuracy
- 0.12%/°C Magnet Temp Compensation



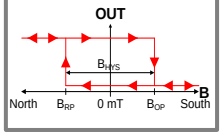
DRV5057
Bipolar Linear w/ PWM Output

- 20kHz Signal Bandwidth
- Multiple Sensitivity Options:
  - 2%D/mT, 1%D/mT, 0.5%D/mT, 0.25%D/mT
- 5% Sensitivity Accuracy
- ıensation
- 2kHz Clock Freq



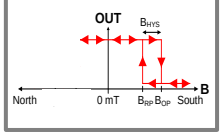
DRV5013
High-BW Latch

- 4 Magnet Threshold Options
  - 3.4mT, 5mT, 9mT, 18mT
- 30kHz BW



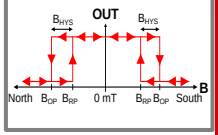
DRV5023
High-BW Switch

- 3 Magnet Threshold Options
  - 6.8mT, 12mT, 24mT
- Unipolar
- Open-Drain Output



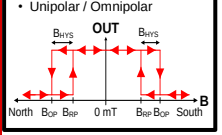
DRV5033
High-BW Switch

- 3 Magnet Threshold Options
  - 3.5mT, 6.9mT
- Omnipolar
- Open-Drain Output



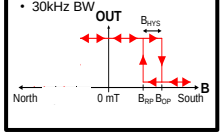
DRV5032
Low-Power, **Low-Cost** Switch

- 4 Magnet Threshold Options
  - 3.9mT, 4.8mT, 9.5mT, 63mT
- Open-Drain / Push-Pull
- Unipolar / Omnipolar



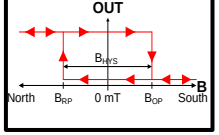
DRV5021
High-BW, Low-Voltage Switch

- 3 Magnet Threshold Options
  - 2.9mT, 9.2mT, 17.9mT
- Unipolar
- 2.5V or 5.5 V operation
- 30kHz BW



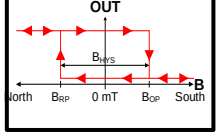
DRV5012
Low-Power, Low-Voltage Latch

- Low-Power operation:
  - 1.6µA @ 20Hz
  - 153µA @ 2.5kHz
- Low-Voltage: 2.5 V or 5.5V



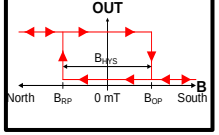
DRV5011
Smallest Latch in the Industry

- 2mT magnetic sensitivity
- 30kHz BW
- Tiny package options:
  - 1.1 x 1.1 mm X2SON
  - 0.8 x 0.8 mm DSBGA



DRV5015
High-BW, **Low-Cost** Latch

- Inverted output option
- 2.5V or 5.5 V operation
- 30kHz BW



1st Generation

2nd Generation

High Voltage: Up To 38V Supply Voltage

Automotive Grade Available

Texas Instruments

DRV5013 & DRV5013-Q1 Family

2.5V to 38V Digital Hall Effect Latch

Features

- 2.5V to 38V operating supply voltage
- Tolerates -22V and 40V reverse battery and load dump
- Four different threshold options (max over temp)
  - FA: ±3.4mT, most sensitive
  - AD: ±5mT
  - AG: ±9mT
  - BC: ±18mT
- 30kHz bandwidth
- AEC-Q100 Grade 0, Grade 1, and Industrial options
  - 175°C max operating junction temperature
- Two package options: SOT-23 and TO-92

Applications

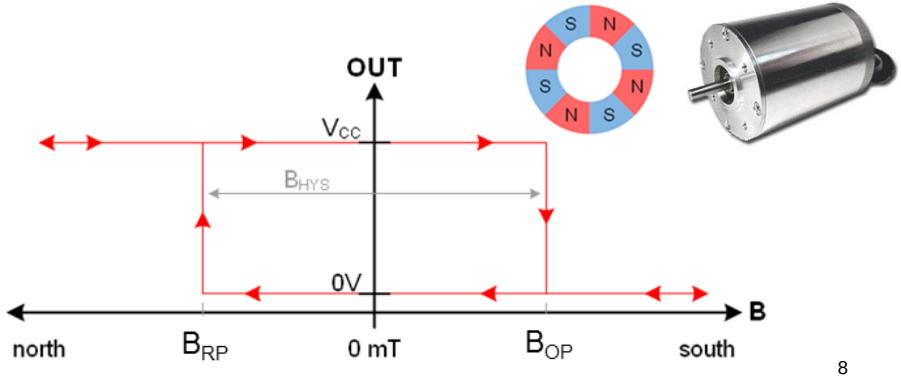
- Power Tools
- Flow Meters
- Valve & Solenoid Status
- BLDC Motors, Rotary Encoding
- Proximity Sensing
- Tachometers

Tools & Resources

- TI Designs
- TechNotes
- DRV50x3 Demonstration Unit (available through Marketing contact)

Benefits

- Most robust operating voltage range in the industry, to withstand transient voltage spikes and reversed-battery
- Different threshold options prevent false-positives due to interfering magnetic fields
  - Minimal magnetic threshold change across temperature
- Fast sampling enables use in high-rpm BLDC motors.
- Suitable for the harshest automotive Grade 0 environments
- Highly reliable magnetic sensors that are immune to wear, environmental contaminants, dirt, and RF noise versus mechanical switches



DRV5015 & DRV5015-Q1

Low-Voltage Digital Hall Effect Latch

Features

- Max magnetic threshold options:
  - A1: 2 mT, 2.9 mT
  - A2: 3.7 mT, 3.85 mT
  - A3: 3.7 mT, 3.85 mT (inverted output)
- 2.5V to 5.5V operating supply voltage
- 30kHz bandwidth
- -40°C to 150°C AEC-Q100 Grade 0
- Open-drain output with 20mA capability
- 2.3 mA typical supply current

Applications

- Automotive BLDC motors
- Incremental Rotary Encoding
- Flow Transmitter
- RPM meter

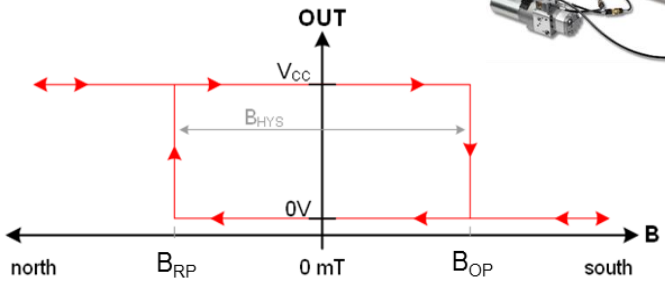
Tools & Resources

- TI Designs
- TechNotes
- HALL-ADAPTER-EVM

SOT-23

Benefits

- High sensitivity reduces the required magnet size or increases the allowable air gap.
- Voltage range compatible with many battery types and traditional MCUs
- Fast sampling enables use in high-rpm BLDC motors.
- Consistent performance across wide temperature range
- Requires external pull-up, allowing for more flexible implementation.
- Low power consumption for battery-powered applications.
- Highly reliable magnetic sensor that's immune to wear, environmental contaminants, dirt, and RF noise when compared to mechanical switches.



DRV5032 Family
Ultra-Low-Power Digital Hall Effect Switch

Features

- **Industry-leading ultra-low power consumption**
  - 5Hz version: **0.54µA** with 1.8V
  - 20Hz versions: **1.6µA** with 3V
- 1.65V to 5.5V operating supply voltage
- Magnetic threshold options (over temp):
  - FA,FB,FC,FD: 1.5 to 4.8mT, high sensitivity
  - DU: 1.2 to 3.9mT, high sensitivity
  - AJ: 4 to 9.5mT, medium sensitivity
  - ZE: 33 to 63mT, low sensitivity
- Omnipolar or unipolar magnetic response
- Push-pull or open-drain output options
- SOT-23, **Ultra-small 1.1 x 1.4 x 0.37mm** X2SON package
- -40°C to 85°C operating temperature range

Applications

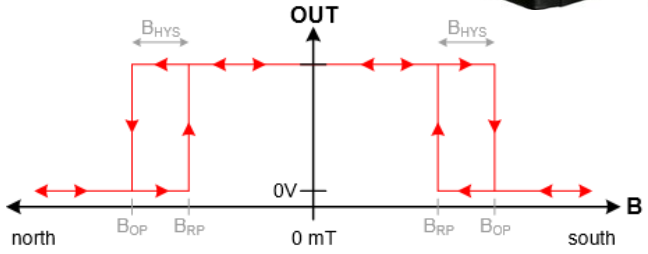
- Battery-critical position sensing
- E-meter tamper detection
- E-locks, smoke detectors
- IoT, medical devices
- Phone, laptop, tablet case sensing

Tools & Resources

- TI Designs
- TechNotes
- DRV5032-SOLAR-EVM

Benefits

- Low power consumption maximizes battery life
- Voltage range compatible with many battery types and traditional MCUs
- Various threshold options prevent false-positives due to interfering magnetic fields
- Numerous magnetic response options allows for flexibility in system design and BOM selections
- Push-pull output removes the need and power drain of an external pullup resistor
- Extremely small and thin X2SON package option for space constrained applications
- Highly reliable magnetic sensor that's immune to wear, environmental contaminants, dirt, and RF noise versus mechanical switches



DRV5055 & DRV5055-Q1 Family

Ratiometric Linear Hall Effect Sensor

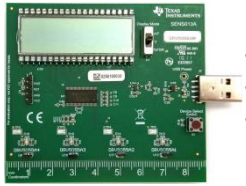
Features

- Operating supply voltages of **3V–3.6V** and **4.5V–5.5V**
- Flexible magnetic sensitivity options (at 5V):
  - 12.5 mV/mT (±171 mT range)
  - 25 mV/mT (±86 mT range)
  - 50 mV/mT (±43 mT range)
  - 100 mV/mT (±22 mT range)
- ±5% sensitivity accuracy at 25°C
- Low ±10 mV output noise (50 mV/mT version)
- 0.12 %/°C **magnet temperature compensation**
- -40°C to 150°C **AEC-Q100 Grade 0** temperature range

Applications

- Automotive position sensing
- Brake, acceleration, clutch pedals
- Gear shifters and transmission
- Torque sensor
- Industrial automation and robotics
- Keyboards, gamepads, triggers
- Home appliances
- Medical devices
- E-meter tampering

Tools & Resources



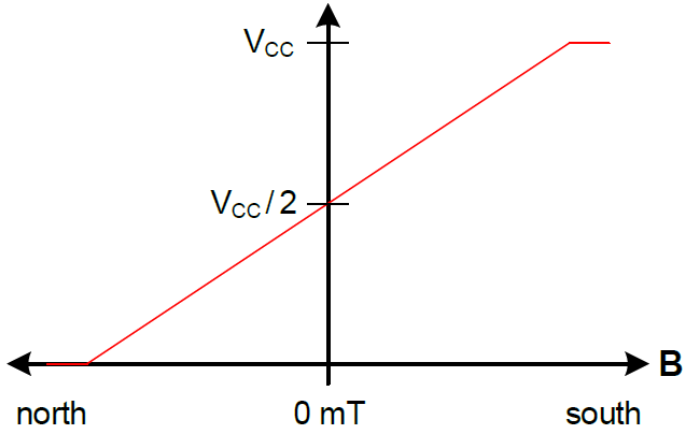
- TI Designs
- TechNotes
- DRV505xEVM

SOT-23

TO-92

Benefits

- Voltage range compatible with many battery types and traditional MCUs
- Comprehensive range of magnetic sensitivity options
- Enables precise system measurement
- Ratiometric output eliminates error due to VCC
- Eliminates error due to magnet shifting over temperature
- Suitable for the harshest automotive Grade 0 environments



Current sensing

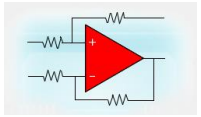
Current & power monitoring solutions

High precision, cost-optimized solutions for current and power sensing

Why use TI current sensing?

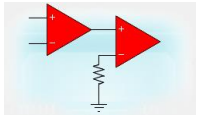
Current sensing products enable higher system efficiency, real-time system protection, and responsive control feedback in both isolated and non-isolated system topologies. Whether simply detecting a fault condition or performing a precise measurement, TI's current sensors will reliably and accurately sense the current or power in any system.

TI's current & power monitoring solutions



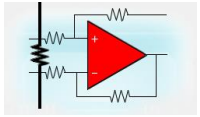
Analog Output

Integrates the full analog signal processing and provide a voltage or current output



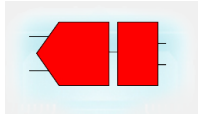
Comparator

Provides a simple ALERT signal when the load current exceeds a threshold along with analog or digital out



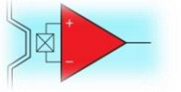
In-package Shunt

Offers a low-drift, precision shunt resistor element in-package with either analog or digital out



Digital Monitor

Integrates the full signal conditioning path and utilize a standard 2-wire digital interface



In-package Hall

Offers precision isolated Hall through-package current measurement.

Ambient Field Sensor

On-chip sensor measures the magnetic field flux density and generates a voltage output proportional to the field strength

Key applications

Automotive

- HEV/EV DC-DC
- Electronic power steering
- Body Control Modules
- Premium Audio

Industrial

- Power delivery
- Test & Measurement
- Factory Automation
- Medical

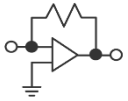
Featured products

INA240	INA381	INA190	INA253
80V Analog Out with enhanced PWM Rejection	Cost effective Analog out with integrated comparator	40V, High-precision analog out with µA bias current	Integrated shunt with enhanced PWM rejection

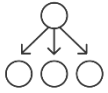
Links to get started

Design support

Current sense training



Filter Design Tool



Competitor-cross reference

Texas Instruments

INA190

High Accuracy, Bidirectional, Low- and High-Side, Current-Shunt Monitor with picoAmp Bias Current and Enable Option

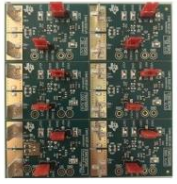
Features

- Common Mode Voltage Range: **-0.1V to 40V**
- High Accuracy
  - **Voltage offset: +/-15uV (0.13uV/C)**
  - **0.3% gain error (max over temp)**
- Low power
  - **Low quiescent current @ 25C (65uA max)**
  - **Low disable current (0.1uA max)**
  - **Low bias current (500pA typ)**
- Five gain options 25, 50, 100, 200 500 V/V
- Independent Supply Voltage of 1.7V to 5.5V
- Temp Range: -40 to 125C
- **AEC-Q100 options for 2019 (SC70 Package)**

Applications

- Notebook Computers
- Cell Phones
- Battery-powered devices
- Telecom Equipment
- Power Management
- Battery Chargers

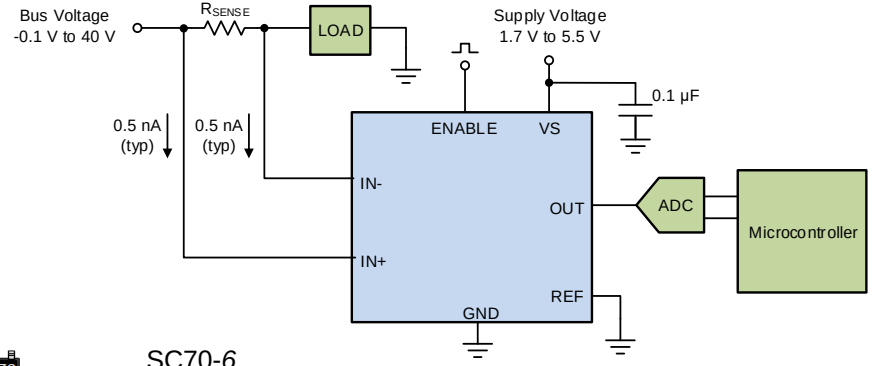
Tools & Resources



- INA190EVM
- PSpice Model
- TINA-TI Reference Design
- TINA-TI Spice Model
- TI Designs Pending

Benefits

- Common mode range supports low- and high-side up to 40V applications
- Smaller error margins needed in design
- Ideal for low power and space sensitive applications
- Small bias current allows for measurement of small µA currents
- Independent supply voltage enables device to interface with 1.8V ADC



ENABLE Pin only available in QFN-10 Package

SC70-*6*
(2.0 mm x 2.1 mm)

UQFN-*10*
(1.8 mm x 1.4 mm)

INA191

High Accuracy, Low- and High-Side, Current-Shunt Monitor with PicoAmp Bias Current and Enable

Features

- Common Mode Voltage Range:
  - **-0.1V to 40V**
- High Accuracy
  - **Voltage offset: +/-15uV (0.13uV/C)**
  - **0.3% gain error (max over temp)**
  - **25V/V, 50V/V, 100V/V, 200V/V, 5000 V/V**
- Low power
  - **Low quiescent current (70uA max)**
  - **Low disable current (0.1uA typ)**
  - **Low bias current (500pA typ)**
- Independent Supply Voltage of +1.7V to +5.5V
- Temp Range: -40 to 125C

Applications

- Notebook Computers
- Cell Phones
- Battery-powered devices
- Telecom Equipment
- Power Management
- Battery Chargers

Tools & Resources

- INA191EVM
- PSpice Model
- TINA-TI Reference Design
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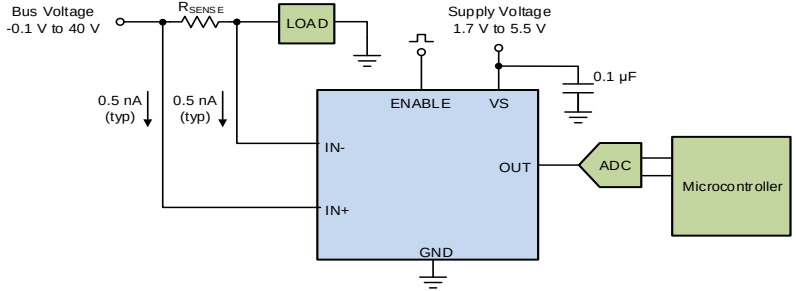
- Small bias current allows for measurement of small µA currents
- Independent supply voltage enables device to interface with 1.8V ADC



WCSP
(1.2 mm x 0.8 mm)

INA186

40V Bidirectional, Low- and High-Side, Current-Shunt Monitor with PicoAmp Bias Current and Enable Option

Features

- Common Mode Voltage Range:
  - **Survivability from -0.3V to 42V**
  - Performance specified from -0.1V to 40V
- Low power
  - **Low quiescent current (70uA max)**
  - **Low disable current (0.1uA typ)**
  - **Low bias current (500pA typ)**
- Accuracy
  - **Voltage offset: +/-50uV (0.50µV/C)**
  - **1.0% gain error (max over temp)**
- Independent Supply Voltage of +1.7V to +5.5V
- **AEC-Q100 options planned**

Applications

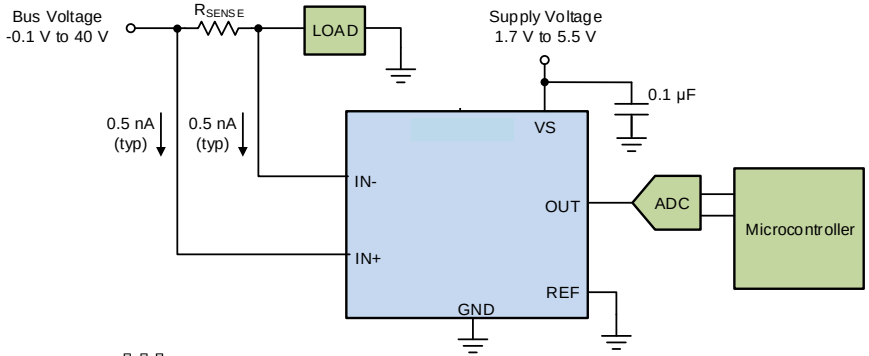
- Telematics Equipment
- Battery Management Systems
- eCall Battery Status

Tools & Resources

- INA186EVM
- PSpice Model
- TINA-TI Reference Design
- TINA-TI Spice Model
- TI Designs Pending

Benefits

- Common mode range supports low- and high-side up to 40V applications
- Smaller error margins needed in design
- Ideal for low power and space sensitive applications
- Small bias current allows for measurement of small µA currents
- Independent supply voltage enables device to interface with 1.8V ADC
- Enable pin reduces power consumption (SOT23 package)



SC70-*6*
(2.0 mm x 2.1 mm)

INA185

26V, Bidirectional, Low-/High-Side, Current Sense Amplifier, in Industry's smallest leaded SOT563 package

Features

- Integrated Gain-setting Resistors
- Multiple Gain Offerings V/V: 20 (A1), 50 (A2), 100 (A3), 200 (A4)
- Exceptional performance for the value
  - **Max Gain Error: 0.3%, -40°C to 125°C (All variants)**
  - **CMRR: 100 dB Minimum, 120 dB (typ) (A2- A4 devices)**
  - **Max Input V_{OS} @ VCM = 0 V: 60µV / 0.5µV/°C drift (A2-A4 devices)**
  - **Max Input V_{OS} @ VCM = 12 V: 100µV / 0.5µV/°C drift (A2-A4 devices)**
- Wide Bandwidth and High Slew Rate
  - **Slew Rate: 2 V/µs**
  - **BW = 210kHz @ Gain=50**
- **Ultra-small 1.6mm x 1.6mm SOT563 package**

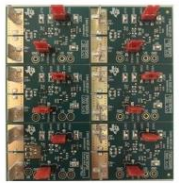
Benefits

- Integrated gain-setting resistors enable the use of small shunt resistances
  - Enhances power efficiency without sacrificing measurement accuracy
- Multiple gain options conveniently scales input signals to match output voltage requirements
- Bi-directional capability simplifies circuit design by reducing the number of external components
- High bandwidth and slew rate allow for reliable measurements in fast switching applications

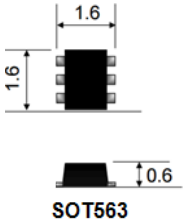
Applications

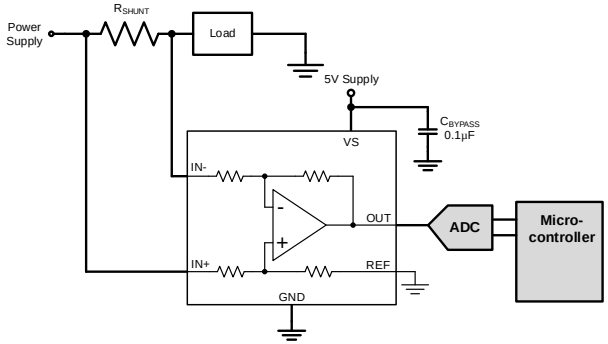
- Notebooks
- Telecom
- Solar Inverters
- Power Supply
- Test equipment
- Servers

Tools & Resources



- INA185EVM
- PSpice Model
- TINA-TI Reference Design
- TINA-TI Spice Model
- TI Designs Pending





INA253 Family

High-Voltage, Enhanced PWM Rejection Current Sense Amplifier w/ Precision Integrated Low-Inductive 2mΩ Internal Shunt

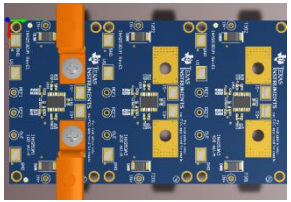
Features

- Precision Integrated Shunt Resistor
  - **0.1% Integrated 2mΩ Shunt Resistor with 15ppm/°C across full temperature range**
  - **Low-inductance 3nH Shunt**
  - **Up to ±15A @ -40°C to 85°C**
  - **Kelvin connection guaranteed**
- High Accuracy (Current Sense Amplifier and Shunt Resistor)
  - Input Offset Current: 12.5mA (Max) & Offset Drift: 125µA/°C (Max)
  - Gain Error: ±0.5% (Max) & Gain Drift: 25ppm/°C (Max)
  - High AC CMRR: 93dB @ 50kHz
- Wide Common-Mode **: -4V to 80V**
- Package: TSSOP-20
- **AEC Q100 Option planned**

Applications

- Solenoid/Valve Control
- Pressure Regulator
- Motor Control
- Power Management

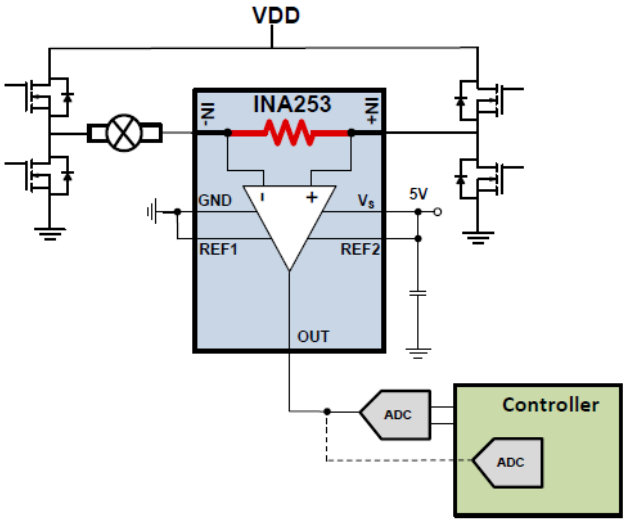
Tools & Resources



- INA253EVM
- PSpice Model
- TINA-TI Spice Model
- TI Designs Pending

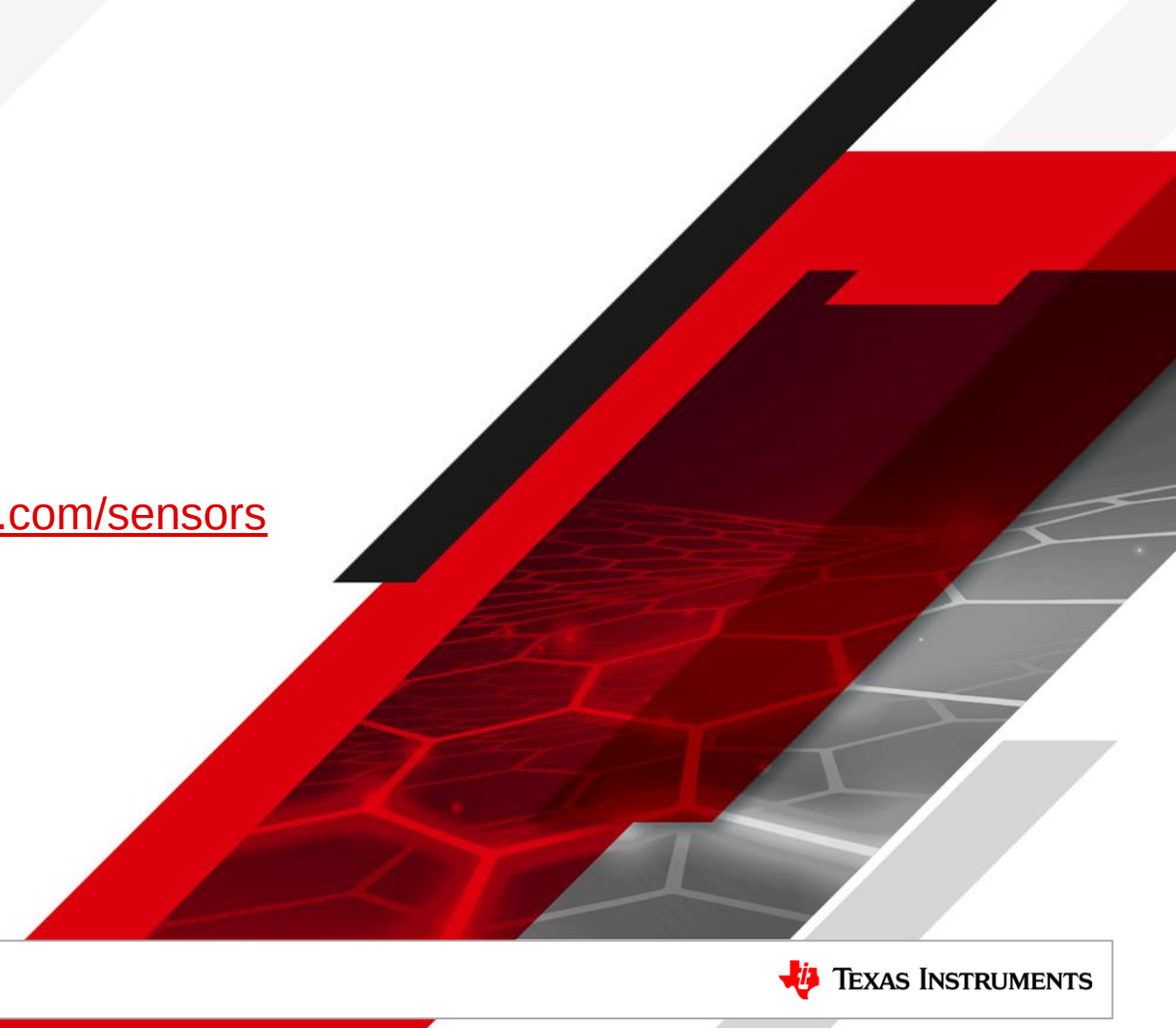
Benefits

- High accuracy minimizes system margins and potentially eliminates system-level calibration
- High CMRR allows for direct in-line motor current sensing
- Low inductance reduces PWM spikes and improves measurement accuracy
- Simplifies system design allowing for faster time to market



Thank you

For more information, visit ti.com/sensors



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