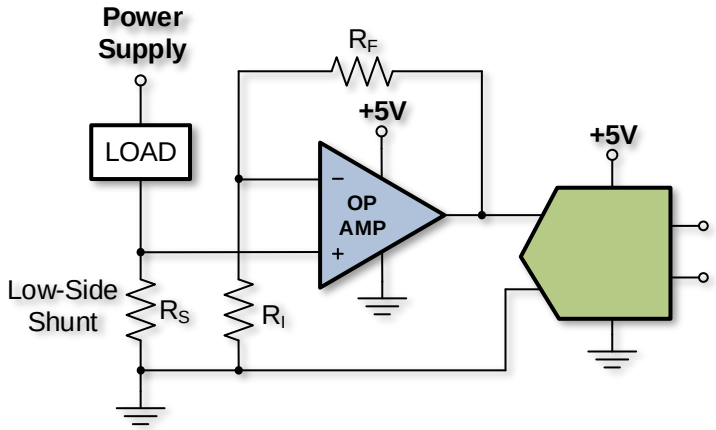
INA240

High-voltage, enhanced PWM rejection current sense amplifier for large common-mode transients

Benefits of designing with current sense amplifiers

Discrete current sensing

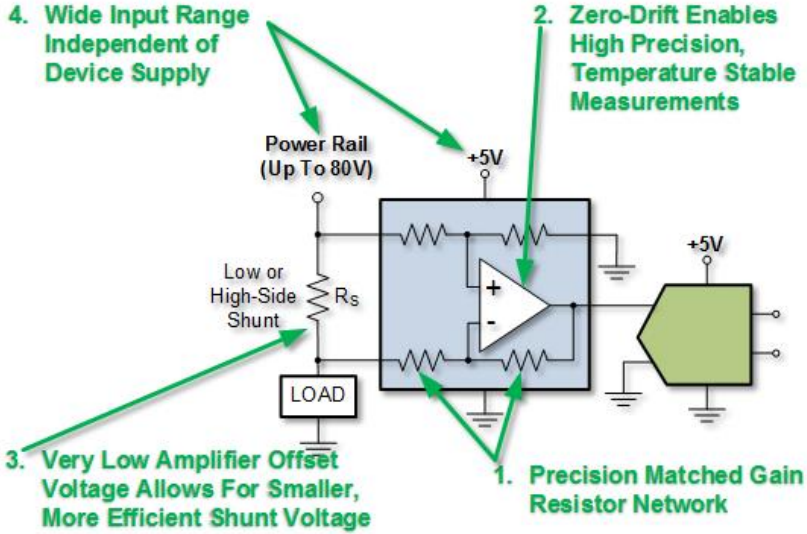


Op amp used for current sensing

External gain setting resistors

Input range limited by supply voltage

Dedicated current sense amplifier



INA240 Family

High-voltage, enhanced PWM rejection current sense amplifier for large common-mode transients

Features

- Wide common-mode : -4V to 80V
- Bi-directional
- High AC CMRR: 93dB @ 50kHz
- Enhanced PWM rejection
- High accuracy
  - Input offset voltage: 25µV (Max) with 0.25µV/°C Max Drift
  - Gain error: ±0.20% (Max) with 2.5ppm/°C Max Drift
- Available gains: 20, 50, 100, 200V/V
- Package: TSSOP-8
- ***AEC Q100 Option available in 1Q17***

Applications

- Motor control
- Solenoid/valve Control
- Power supplies

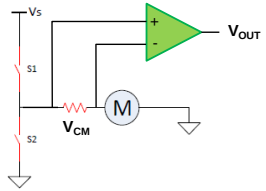
Tools & Resources

- INA240EVM gain options:
  - 20V/V, 50V/V, 100V/V, 200V/V
- INA240EVM User's Guide
- TINA-SPICE Model
- TIDA-00913 GaN half-bridge with in-line motor current sensing using INA240

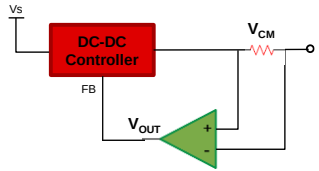
Benefits

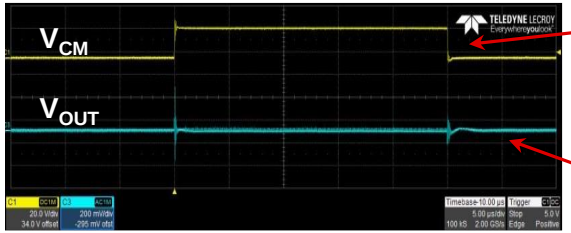
- Large input range to integrate into increasing common-mode voltage applications
- High accuracy minimizes system margins
- High CMRR allows for direct in-line motor current sensing

Ex: In-line Motor Current Sensing



Ex: High-side DC-DC Current Sensing



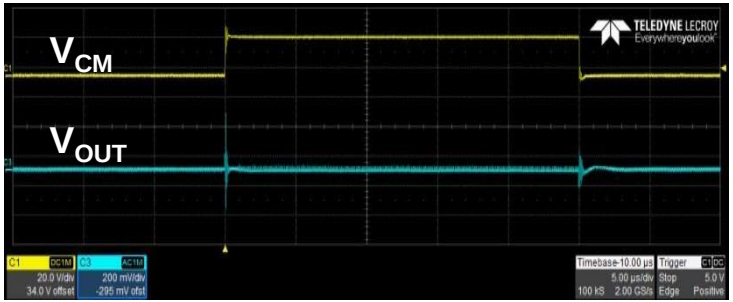


Large, high slew rate input V_{CM}

Stable V_{OUT}!

Enhanced PWM Rejection

- **What is it?**
  - Active circuitry which monitors the input common-mode signals.
  - If a fast transition is detected, will suppress the signal to minimize the “glitch” to be propagated through the device’s output.

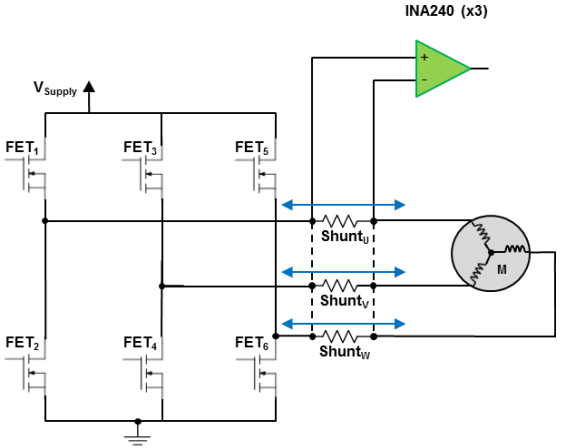


- **How do other solutions tackle this problem?**
  - Competitive solutions typically utilize high-bandwidth amplifiers to settle the output as quickly as possible.
  - Problem with this approach is it may incur added delay due to the settling time.

- **What system-level benefit is there with Enhanced PWM Rejection?**
  - “Blanking time” is reduced substantially!
  - Can measure accurately at lower duty cycles!

Why is in-line motor sensing important?

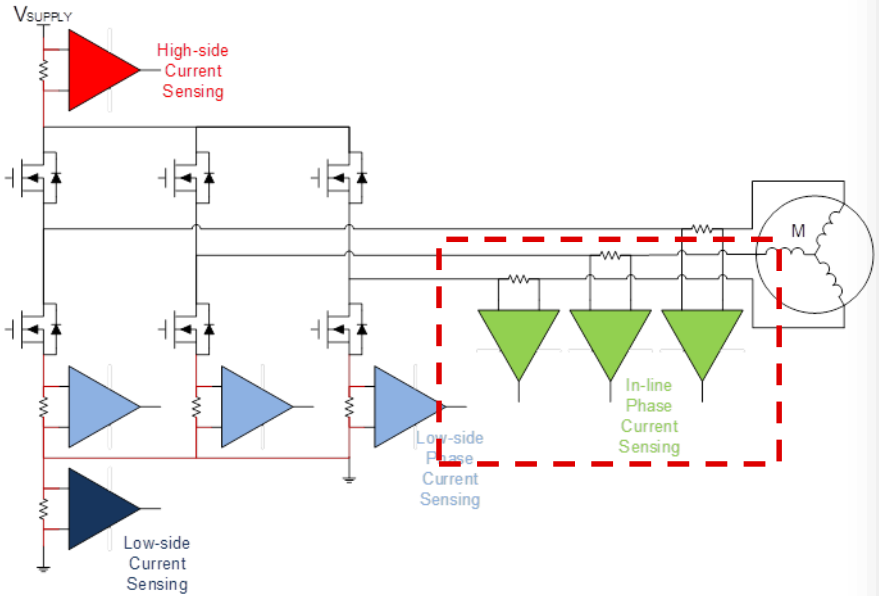
- **Why measure current in a motor?**
  - Fault protection
  - Input into motor control algorithm



- **Why measure current in-line vs. low-side?**
  - Low-side is a proven approach with a large customer base and perceived to have a lower system cost, but has difficulty to scaling to higher precision and lower drift
  - Low-side creates a non-linear output signal that must be post-processed to extract the proportional base current information
  - In-line provides a faster response, higher precision, and the ability to have less drift over a wide temperature range
  - In-line reproduces a continuous proportional signal of the phase current which does not need further processing

TI solutions for 3-phase DC Motor Control

Current meas. options in 3-phase DC motor



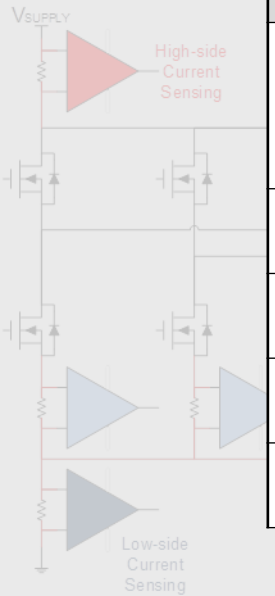
TI 3-phase DC motor current measurement solutions

In-line Phase Current							
Device	**V_{CM} Range**	**V_{OS}**	**V_{OS} Drift**	**Gain**	**Gain Error**	**Gain Error Drift**	**Comment**
INA240	–4V to +80V	25µV	0.25µV/°C	20, 50, 100, 200	0.2%	2.5ppm/°C	Enhanced PWM Rejection
Low-side Phase Current							
Device	**V_{CM} Range**	**V_{OS}**	**V_{OS} Drift**	**Gain**	**Gain Error**	**Gain Error Drift**	**Comment**
INA303	0V to +36V	35µV	0.1µV/°C	20, 50, 100	0.10%	10ppm/°C	Integrated Window Comparator
High-side Motor Current Monitoring for Over-Current Protection							
Device	**V_{CM} Range**	**V_{OS}**	**V_{OS} Drift**	**Gain**	**Gain Error**	**Gain Error Drift**	**Comment**
INA240	–4V to +80V	25µV	0.25µV/°C	20, 50, 100, 200	0.2%	2.5ppm/°C	Ultra-high Precision
LMP8640HV	–2V to +76V	900µV	2.6µV/°C	20, 50, 100	0.25%	26.2ppm/°C	High Bandwidth
INA200	–16V to +80V	2.5mV	5µV/°C (typ)	20, 50, 100	1%	-	Over-current
Low-side Motor Current Monitoring for Over-Current Protection							
Device	**V_{CM} Range**	**V_{OS}**	**V_{OS} Drift**	**Gain**	**Gain Error**	**Gain Error Drift**	**Comment**
INA199	–0.3V to +26V	150µV	0.1µV/°C	50, 100, 200	1.40%	10ppm/°C	Low-cost Current Sense Amplifier
INA301	0V to +36V	35µV	0.1µV/°C	20, 50, 100	0.10%	10ppm/°C	Integrated Fast Comparator

TI solutions for 3-phase DC motor control

Current Meas. options in 3-phase DC Motor

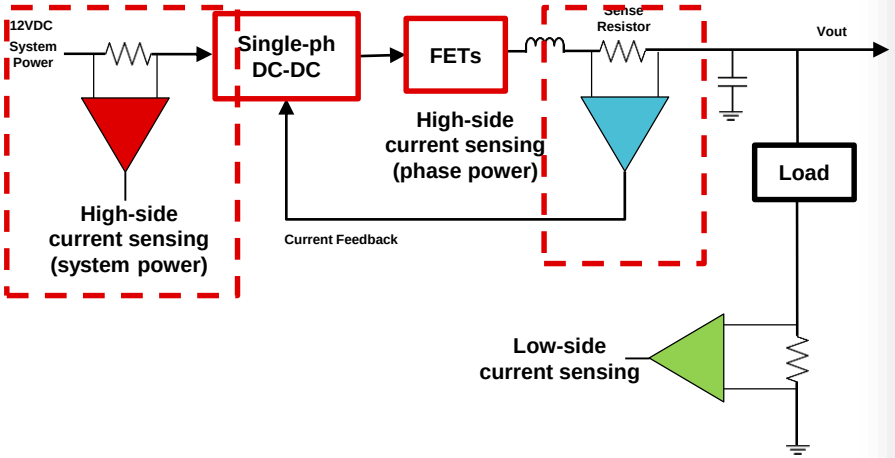
TI 3-phase DC Motor Current Measurement Solutions



System benefits gained from using INA240
Most accurate phase current representation with in-line phase current sensing
Algorithm optimization
Reduced blanking time
Possible elimination of galvanic isolation
Increased motor efficiency

TI solutions for embedded DC-DC power

Current measurement in Embedded DC-DC



TI Solutions for Embedded DC-DC

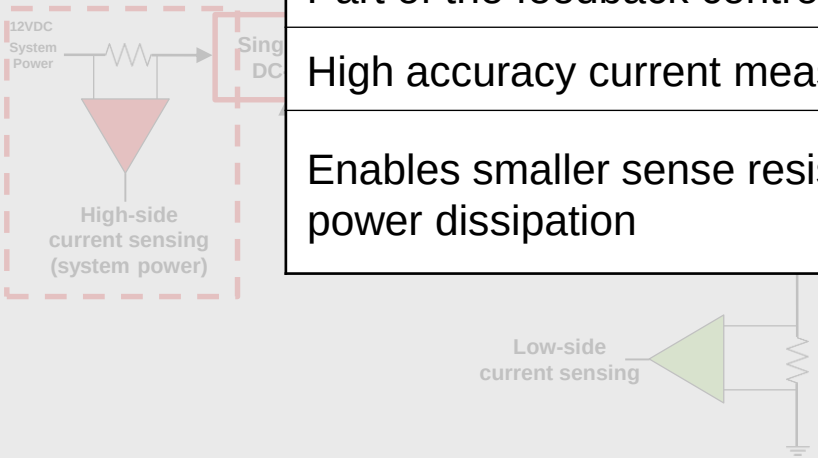
High-side Current Sensing (system power)							
Device	V_{CM} Range	V_{OS}	V_{OS} Drift	Gain	Gain Error	Gain Error Drift	Comment
INA240	-4V to +80V	25µV	0.25µV/°C	20, 50, 100, 200	0.2%	2.5ppm/°C	Ultra-high Precision
INA210	-0.3V to +26V	35µV 60µV 100µV	0.1µV/°C	50, 75, 100, 200, 500	0.9%	10ppm/°C	High Performance
INA301	0V to +36V	35µV	0.1µV/°C	20, 50, 100	0.10%	10ppm/°C	Fast Comparator
INA302	0V to +36V	35µV	0.1µV/°C	20, 50, 100	0.10%	10ppm/°C	Over/Under Current
High-side Current Sensing (phase power)							
Device	V_{CM} Range	V_{OS}	V_{OS} Drift	Gain	Gain Error	Gain Error Drift	Comment
INA240	-4V to +80V	25µV	0.25µV/°C	20, 50, 100, 200	0.2%	2.5ppm/°C	PWM Rejection
INA210	-0.3V to +26V	35µV 60µV 100µV	0.1µV/°C	50, 75, 100, 200, 500	0.9%	10ppm/°C	High Performance
LMP8645	-2V to +42V	1000µV	7µV/°C	Adjustable	2%	140ppm/°C	High Bandwidth
Low-side Current Sensing							
Device	V_{CM} Range	V_{OS}	V_{OS} Drift	Gain	Gain Error	Gain Error Drift	Comment
INA210	-0.3V to +26V	35µV 60µV 100µV	0.1µV/°C	50, 75, 100, 200, 500	0.9%	10ppm/°C	High Performance
INA199	–0.3V to +26V	150µV	0.1µV/°C	50, 100, 200	1.40%	10ppm/°C	Low-cost
INA301	0V to +36V	35µV	0.1µV/°C	20, 50, 100	0.10%	10ppm/°C	Fast Comparator
INA302	0V to +36V	35µV	0.1µV/°C	20, 50, 100	0.10%	10ppm/°C	Warning/ Shutdown

TI solutions for embedded DC-DC power

Current measurement in Embedded DC-DC

TI Solutions for Embedded DC-DC

System benefits gained from using INA240
Part of the feedback control loop for DC-DC controllers
High accuracy current measurement
Enables smaller sense resistor value which lowers overall system power dissipation



Device	V_{CM} Range	V_{OS}	V_{OS} Drift	Gain	Gain Error	Gain Error Drift	Comment
						2.5ppm/°C	Ultra-high Precision
						10ppm/°C	High Performance
						10ppm/°C	Fast Comparator
						10ppm/°C	Over/Under Current
						Gain Error Drift	Comment
						2.5ppm/°C	PWM Rejection
						10ppm/°C	High Performance
LMP8645	-2V to +42V	1000µV	7µV/°C	Adjustable	2%	140ppm/°C	High Bandwidth

Low-side Current Sensing

Device	V_{CM} Range	V_{OS}	V_{OS} Drift	Gain	Gain Error	Gain Error Drift	Comment
INA210	-0.3V to +26V	35µV 60µV 100µV	0.1µV/°C	50, 75, 100, 200, 500	0.9%	10ppm/°C	High Performance
INA199	–0.3V to +26V	150µV	0.1µV/°C	50, 100, 200	1.40%	10ppm/°C	Low-cost
INA301	0V to +36V	35µV	0.1µV/°C	20, 50, 100	0.10%	10ppm/°C	Fast Comparator
INA302	0V to +36V	35µV	0.1µV/°C	20, 50, 100	0.10%	10ppm/°C	Warning/ Shutdown

Thank you for joining!