Welcome!
Texas Instruments New Product Update

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- Phone lines are muted
- Please post questions in the chat or contact your TI sales contact or field applications engineer

OPAX310: A 2-IN-1 AMPLIFIER TO IMPROVE YOUR APPLICATION'S DRIVE STRENGTH OR LOWER POWER CONSUMPTION

New Product Update

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– Systems Engineer

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– Applications Engineer

Agenda

- Device Introduction
- Product Highlight 1 & Applications
- Product Highlight 2 & Applications
- How to get started with OPAx310

Please feel free to “chat” Bhuvanesh R K, Systems Engineer or Robert Clifton, Applications Engineer, who will be available to answer any questions you have throughout this presentation.

OPAx310: OPA310 / OPA2310 / OPA4310

Released

1.5V – 5.5V Operation | 3 MHz | RRIO | High Output Current, Fast Enable Amplifier

Features

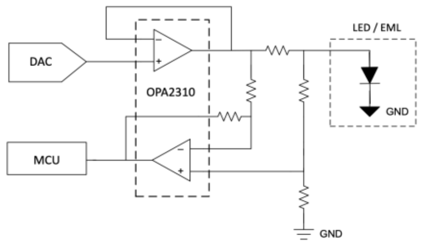
- **High Output Current**
- **Fast Enable**
- **Fail-Safe Input Structure**
- Low Offset over temp 1.4 mV (max)
- Gain Bandwidth 3 MHz (typ)
- Quiescent Current 165 µA (typ)
- Low Noise 13 nV/√Hz @10KHz (typ)
- Supply Voltage 1.5 V to 5.5 V
- **Small Size, PowerPAD Pkgs with Thermal Protection**

Benefits

- High output current helps easily bias Laser diodes, LEDs, photo diodes and drive audio pre-amplifiers, small speaker
- Low offset and Low Noise enables precision current, voltage sensing and use in signal chain applications
- EMI Filtered, Fail safe inputs with 8kV HBM ESD along with built in Power on reset ensures robust performance
- Stable across wide range of capacitive, resistive loads
- Excellent shutdown function with fast enable time for low power

Applications

- Optical Module Laser Drivers and LED Drivers
- Discrete Howland Current Pumps
- DAC Buffers & Reference Buffers
- Low-Power, High-Performance Applications
- Building Automation, Portable Electronics / Medical



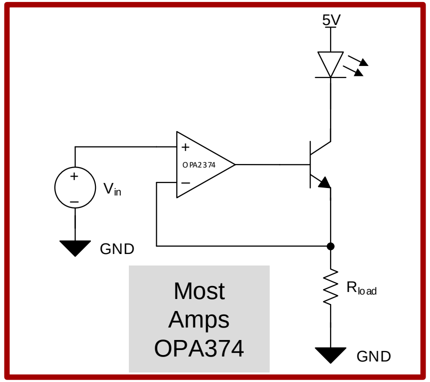
LED / EML Biasing With Current Sense

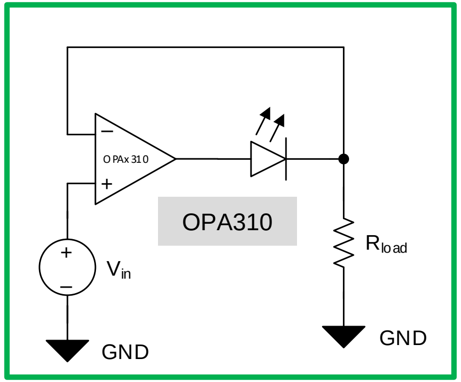
High output current applications

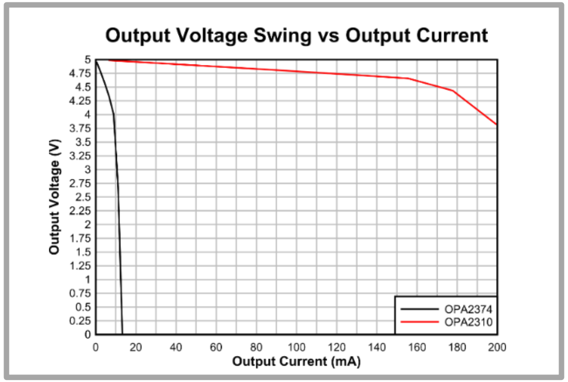
Improve drive strength

LED | Laser driver

- **Many amps require an external transistor to properly drive the LED / Laser because of,**
  - Limited output current at lower supply voltages
  - Limited output swing when directly driving the LED
- Example amp (OPAx374) has output voltage swing that is heavily limited even at a typical LED current of ±10mA requiring additional & external FET / BJT
- The OPAx310 **can drive directly various LEDs / Lasers** even at lower supply voltages with better output swing **without additional external transistor**, saving board area and cost.





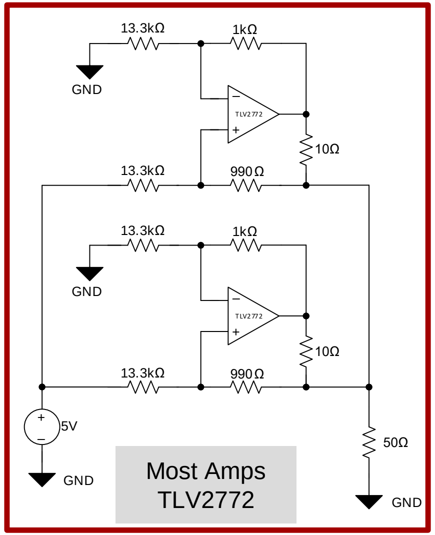


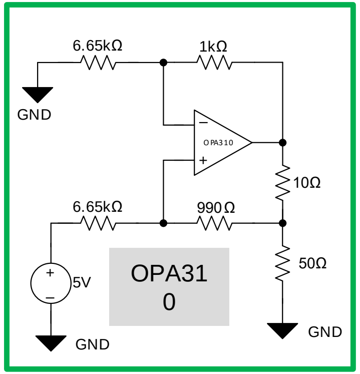
Howland current pump

- For building current sources, higher output current amplifier helps **reduce the need for higher channel count** to drive the same load (with better voltage compliance)

- In this example, a 50Ω load requires 75mA of current (4.5V at the amplifier output → 1V Headroom at Supply voltage of 5V)
  - **Most amps require two channels in parallel**
  - Single amp of OPAx310 drives this load

- **OPAx310 Solution Benefits:**
  - Saves cost : Cheaper
  - Saves board area : Smaller

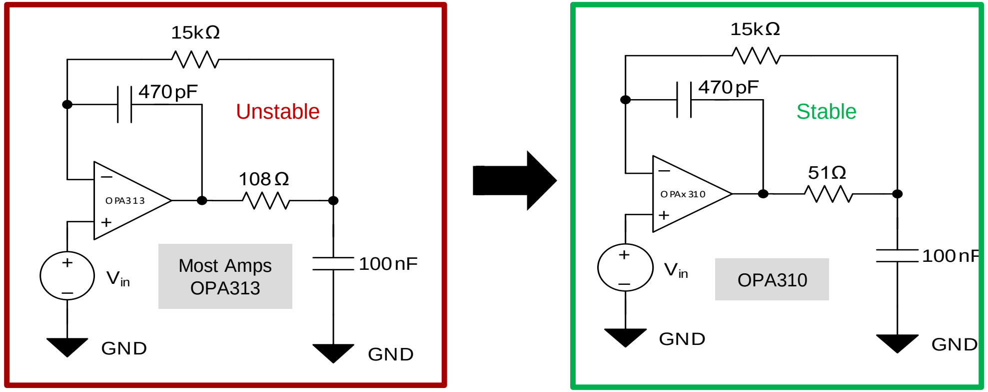


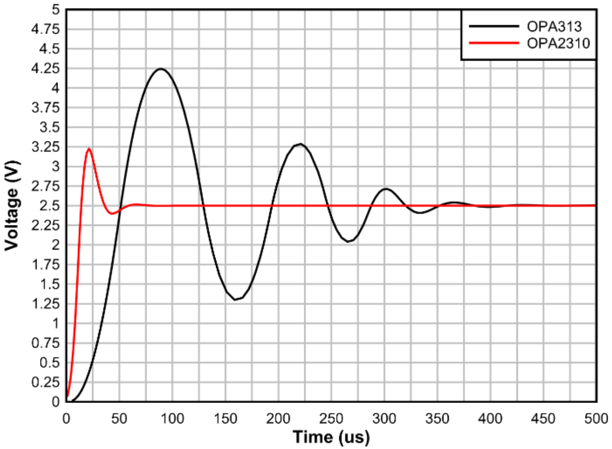


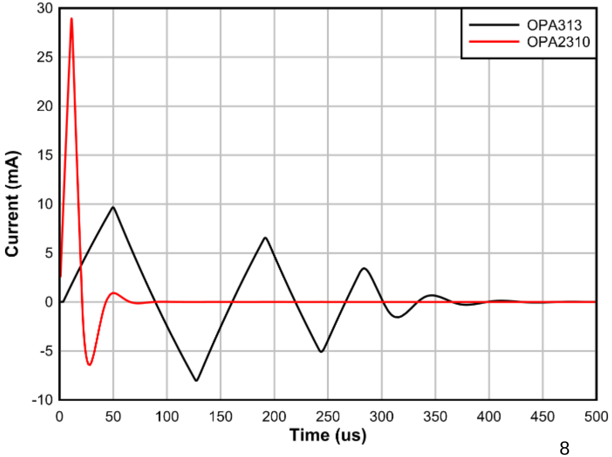
Texas Instruments

Reference buffer | shield amplifiers

- Amplifiers can struggle when driving large value capacitors that can experience switching voltage or current transients
  - These transients drive amp **into current limit (non-linear operation)** when used as reference buffers or guard / shield amps
- With OPA310's high output current & fast slew rate the application can have:
  - **Linear operation (does not enter current limiting)**
  - Less overshoot & **Faster settling time**







Electrical characteristics | Drive strength

1. Tested Swing with 50mA :

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
A_{OL}	Open-loop voltage gain [6]	V_S = 3.3 V, (V–) + 0.25 V < V_O < (V+) – 0.25 V, I_L = ±50 mA	T_A = 25°C	80	102		dB

2. Short Circuit Current :

- 5.5V Supply : 110-mA (minimum) and 150-mA (typical)
- 1.8V Supply : 6-mA (minimum over temp) and 20-mA (typical)

3. Voltage Swing Closer to Rails :

				MIN	TYP	MAX	UNIT
V_{OH}	Voltage output swing from positive rail	V_S = 1.8 V, R_L = 2 kΩ to V_S / 2			10	21	mV
		V_S = 1.8 V, R_L = 10 kΩ to V_S / 2			2	11	
		V_S = 1.8 V, R_L = 2 kΩ to V_S / 2	T_A = –40°C to 125°C			51	
		V_S = 1.8 V, R_L = 10 kΩ to V_S / 2	T_A = –40°C to 125°C			26	
		V_S = 5.5 V, R_L = 2 kΩ to V_S / 2			3.5	20	
		V_S = 5.5 V, R_L = 10 kΩ to V_S / 2			0.75	9	
		V_S = 5.5 V, R_L = 2 kΩ to V_S / 2	T_A = –40°C to 125°C			30	
		V_S = 5.5 V, R_L = 10 kΩ to V_S / 2	T_A = –40°C to 125°C			14	

Typical characteristic curves | Drive strength

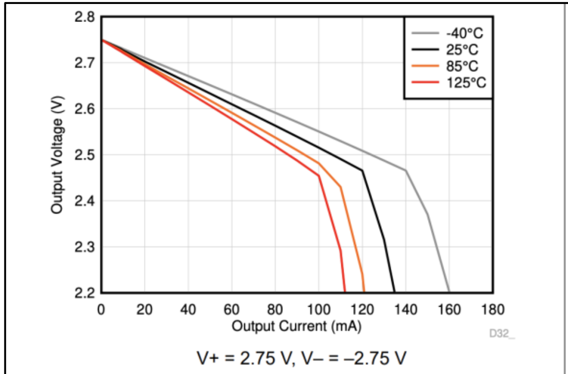


Figure 7-21. Output Voltage Swing vs Output Current (Sourcing)

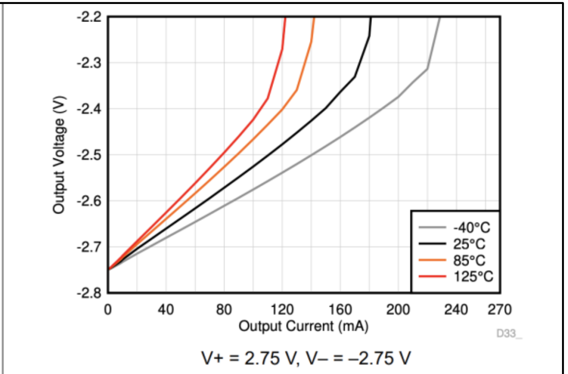


Figure 7-22. Output Voltage Swing vs Output Current (Sinking)

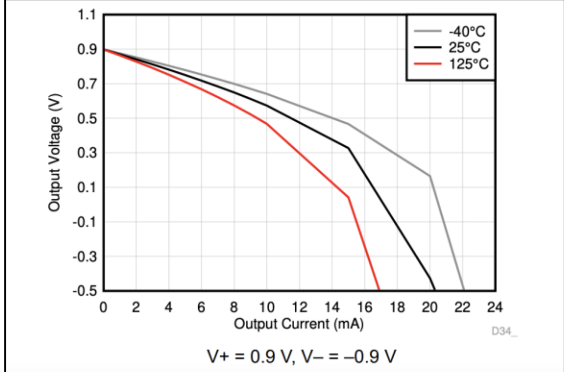


Figure 7-23. Output Voltage Swing vs Output Current (Sourcing)

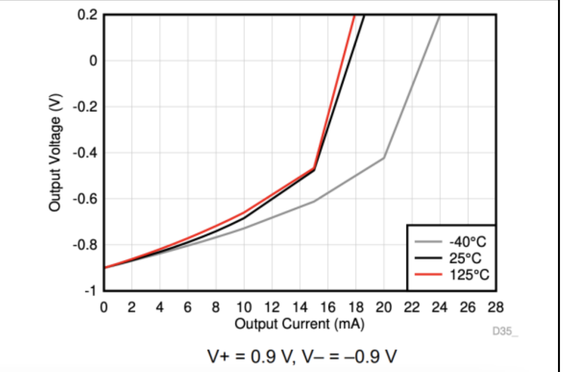


Figure 7-24. Output Voltage Swing vs Output Current (Sinking)

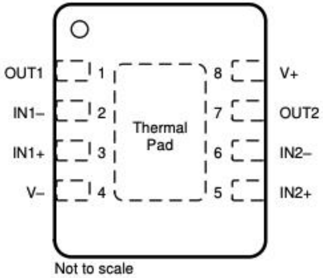
Enables much higher load currents at 5.5V

- 100mA I_{load} with 0.3V to rails (typical)
- −20% I_{load} accounts for process variations

Enables greater output swing at lower supply voltages of 1.8V

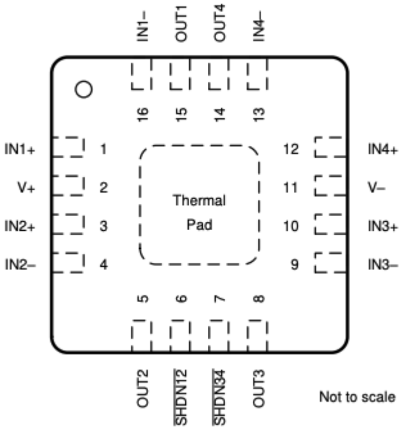
- 5mA I_{load} with 0.2V to rails (typical)
- −20% I_{load} accounts for process variations

OPAx310 PowerPAD | Small size packages



Connect exposed thermal pad to V–. See Section 8.3.10 for more information.

Figure 6-7. OPA2310 DSG Package 8-Pin WSON with Exposed Thermal Pad (Top View)



Connect thermal pad to V–.

Figure 6-12. OPA4310S RTE Package 16-Pin WQFN With Exposed Thermal Pad (Top View)

2CH : 2mm x 2mm

$R_{\theta JA}$ – 90.1 ℃ / W

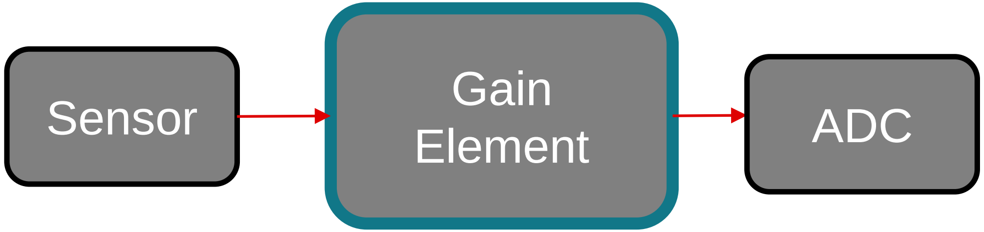
4CH : 3mm x 3mm

$R_{\theta JA}$ – 57.6 ℃ / W

Lower power consumption

How to lower power consumption

- Typical amplifier signal chain consists of Sensor / Gain Element / ADC



- Sensors have longer latency and are usually left on
- ADC can be operated in burst mode to save power
- How to reduce amplifier power ?

Use case for fast shutdown

- **Straight forward way to reduce amp power is to use low power amp**

Amplifier	Quiescent Current when powered-on (nA)	Bandwidth (kHz)	Noise at 10kHz (nV/rt-Hz)	Output Impedance at 10kHz (Ohms)
TLV8541	500	8	264	8000
TLV379	1000	90	83	28000
TLV9041	10000	350	65	7500

Disadvantages : Lower bandwidth, Higher Noise, Hard to stabilize

- **Better Approach**: **Use fast enable amplifier with better performance & turn off amplifier when not in use to lower power**
  - Turn on amplifier just before ADC conversion start with enough time to account for enable time & settling time. *OPAx310 is optimized for faster settling after enable*
  - Example in the next slide comparing average power in 1ms for OPAx310 vs Other Amps

Use case for fast shutdown

OPAx310 achieves lowest duty cycle for 1ms example with fast enable & settling

Amplifier	Enable time (μs)	Settling time 0.01% (μs)	Total ON time over 1ms (μs)	Total SHDN time over 1ms (μs)	Minimum Duty Cycle D (%)
TLV9041	160	30	190	810	19
TLV9001	70	3	73	927	7.3
TLV9061	10	1	11	989	1.1
OPA310	1	1.6	2.6 = (1 + 1.6)	997.4 = (1000 – 2.6)	0.26 = (2.6 / 1000)

OPAx310 consumes lowest current in shutdown while providing faster enable time

Amplifier	Bandwidth (MHz)	Enable time (μs)	Quiescent Current when powered-on Q_ON (μA)	Quiescent Current in shut down Q_OFF (μA)
TLV9041	0.35	160	10	0.750
TLV9001	1	70	60	0.500
TLV9061	10	10	538	0.500
OPA310	3	1	165	0.265

1ms average quiescent current vs performance

Type	Amplifier	Average Quiescent current in 1ms (μA)	Thermal noise floor (nV/rt-Hz)	Output Impedance at 10 kHz (Ohms)
Always ON	TLV8541	0.50	264	8000
ON / OFF	TLV9041	1.96	65	7500
ON / OFF	TLV9001	4.84	27	1200
ON / OFF	TLV9061	6.41	10	100
ON / OFF	OPA310	**0.69** (165*0.0026 + 0.265*0.9974)	**13**	**1000**

OPAx310 enables duty cycling to achieve good power-performance balance,

- Lower Noise
- Better Stability
- Lower Power

Electrical characteristics | Shutdown response

Fast Enable Time:

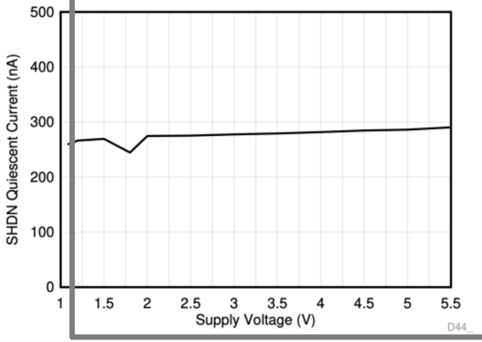
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{ON}	Amplifier enable time (full shutdown) [7] [1]	G = +1, $V_{CM} = V_S / 2$, $V_O = 0.9 \times V_S / 2$, R_L connected to V–		1	1.6	μs
t_{OFF}	Amplifier disable time [7]	G = +1, $V_{CM} = V_S / 2$, $V_O = 0.1 \times V_S / 2$, R_L connected to V–		1		μs

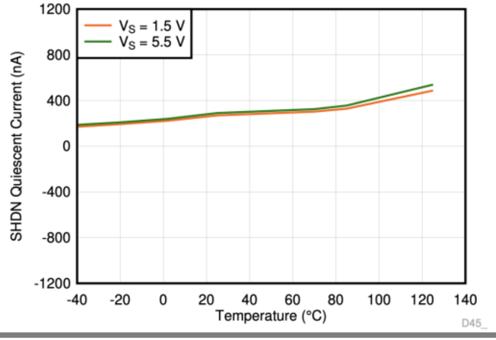
Lower Shutdown Quiescent Current:

I_{Q_SHDN}	Shutdown current per amplifier	All amplifiers disabled, $\overline{SHDN}$ = V–, OPA4310S	0.100	0.150	μA
		All amplifiers disabled, $\overline{SHDN}$ = V–, OPA310S	0.265	0.475	μA
I_{Q_SHDN}	Shutdown current per amplifier	All amplifiers disabled, $\overline{SHDN}$ = V–, OPA2310S	0.200	0.375	μA
I_{Q_SHDN}	Shutdown current per amplifier [1]	All amplifiers disabled, $\overline{SHDN}$ = V–, T_A = –40°C to 85°C, OPA4310S		0.300	μA
		All amplifiers disabled, $\overline{SHDN}$ = V–, T_A = –40°C to 85°C, OPA310S		0.700	μA
I_{Q_SHDN}	Shutdown current per amplifier [1]	All amplifiers disabled, $\overline{SHDN}$ = V–, T_A = –40°C to 85°C, OPA2310S		0.600	μA
Z_{OUT_SHDN}	Output impedance during shutdown	Amplifier disabled	43 || 11.5		GΩ || pF

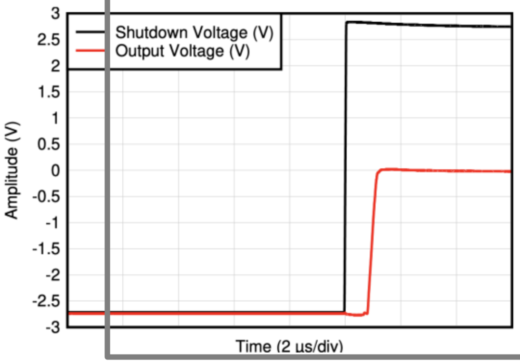
Typical characteristics | Shutdown response

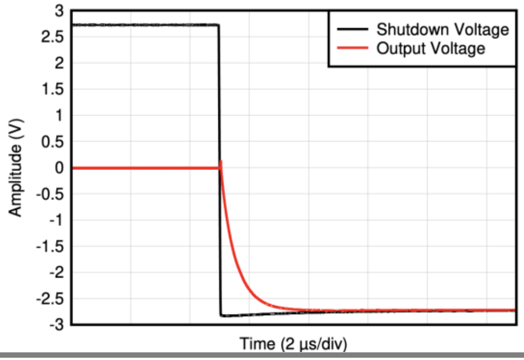
SHDN Quiescent Current, 1CH



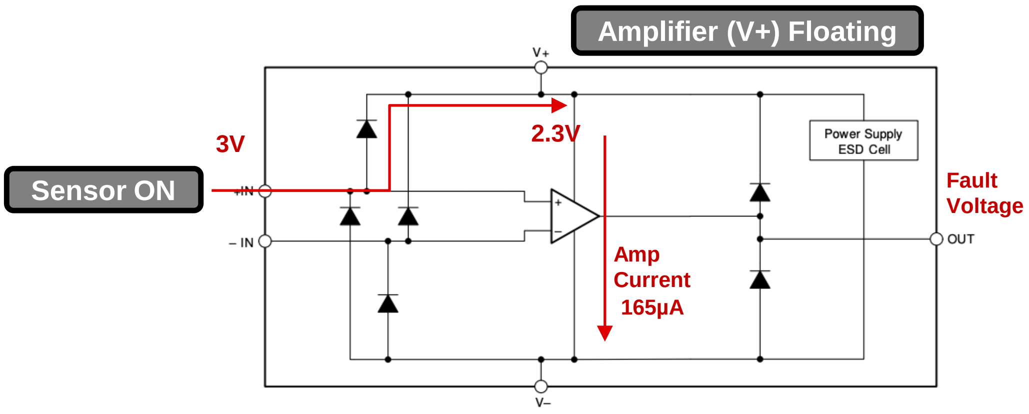


Enable / Disable Response





Problem scenario | Why fail safe ESD ?



Fault Scenarios

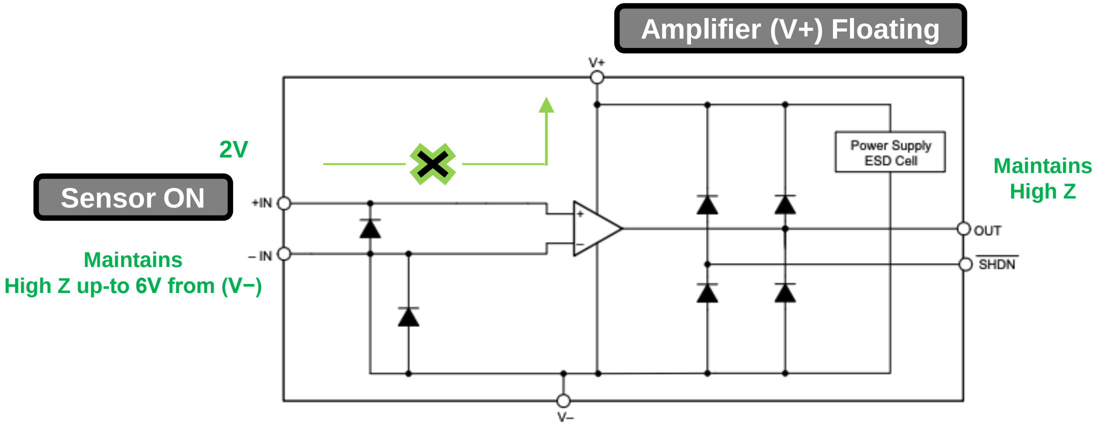
- Separate power supplies between Amp & Sensor
- Power Sequencing

Most Amps : ESD diodes to V+

Fault Scenarios if Sensor output voltage is present before amplifier supply voltage

Amplifier "back-powering", sensor loading & fault signal at output

OPAx310 fail safe ESD



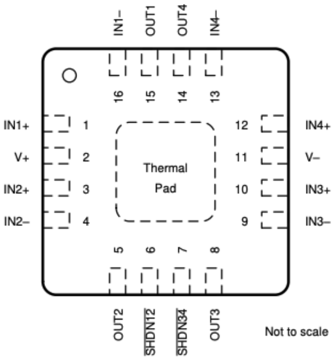
Robust Performance

- ❑ 8kV ESD HBM
- ❑ Fail-safe ESD Inputs

OPAx310 uses modified ESD Structure with No ESD diodes to V+ rails

- **No Sensor Loading :** Maintains High Z at inputs up to 6V from (V-)
- **No Back Powering & Output Faults** to ADC / Microcontroller

OPAx310S shutdown packages



Connect thermal pad to V–.

Figure 6-12. OPA4310S RTE Package 16-Pin WQFN With Exposed Thermal Pad (Top View)

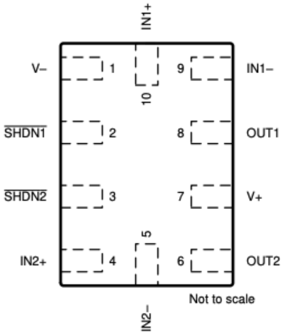


Figure 6-8. OPA2310S RUG Package 10-Pin X2QFN (Top View)

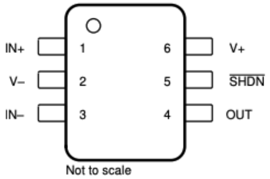


Figure 6-5. OPA310S DCK Package 6-Pin SC70 (Top View)

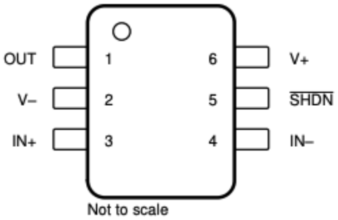


Figure 6-4. OPA310S DBV Package 6-Pin SOT-23 (Top View)

4CH : 3mm x 3mm

2CH : 2mm x 1.5mm

1CH : 2mm x 1.25mm

1CH : 2.9mm x 1.6mm

Getting started

You can start evaluating this device leveraging the following:

Content type	Content title	Link to content or more details
Product folder	OPAx310 product folder	https://www.ti.com/product/OPA310 https://www.ti.com/product/OPA4310 https://www.ti.com/product/OPA2310
Samples	Sampling page for OPA310, OPA2310, OPA4310	https://www.ti.com/product/OPA310#order-quality https://www.ti.com/product/OPA4310#order-quality https://www.ti.com/product/OPA2310#order-quality
Technical blog content or white paper	Various articles: • Op Amp ESD Protection Structures • Analysis of Improved Howland Current Pump • Fast Enable Amplifier with Fail Safe Input ESD • Benefits of Op-Amps with High Output Current	https://www.ti.com/lit/pdf/slvaex7 https://www.ti.com/lit/pdf/sboa437 To be published soon To be published soon
Selection and design tools and models	Spice models with Reference Design	https://www.ti.com/lit/tsc/sbomc55
Development tool or evaluation kit	SMALL-AMP-DIP-EVM evaluation module SURFACE-MOUNT-ADAPTER-EVM	https://www.ti.com/tool/SMALL-AMP-DIP-EVM https://www.ti.com/tool/SURFACE-MOUNT-ADAPTER-EVM

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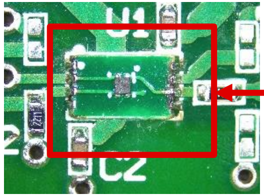
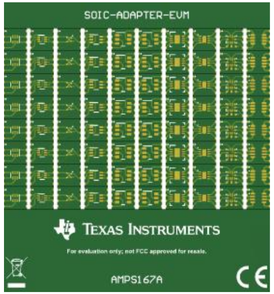
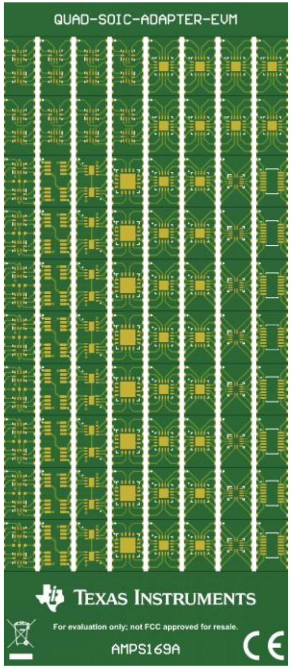
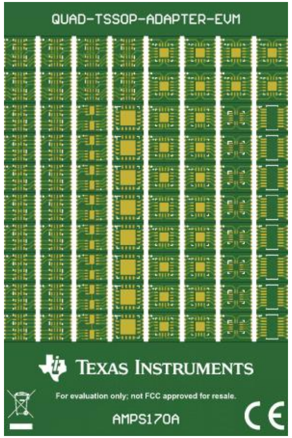
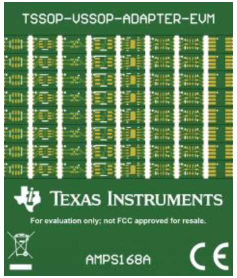


The Four Board Variants



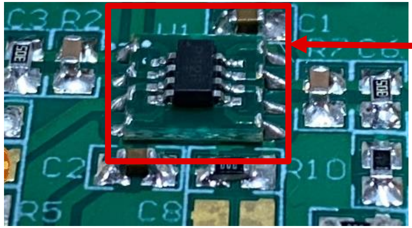






Features:

- Four boards to choose from: SOIC-8, TSSOP-8/VSSOP-8, SOIC-14/16, and TSSOP-14/16
- 42 adaption combinations
  - Examples: SOT-23, X2SON, WSON, etc.
- Optimized PCB designed to reduce parasitics
- PCB layout can be referenced for dual footprint designs
- Allow customer to evaluate devices in their system when specific package is not available
- Help transition from larger packages to new small modern ones



TEXAS INSTRUMENTS