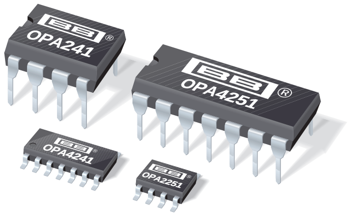
BURR - BROWN®



OPA241
OPA2241
OPA4241
OPA251
OPA2251
OPA4251

Single-Supply, *Micro*POWER OPERATIONAL AMPLIFIERS

OPA241 Family optimized for +5V supply.

OPA251 Family optimized for ±15V supply.

FEATURES

- ***Micro*POWER: I_Q = 25µA**
- **SINGLE-SUPPLY OPERATION**
- **RAIL-TO-RAIL OUTPUT (within 50mV)**
- **WIDE SUPPLY RANGE**
  Single Supply: +2.7V to +36V
  Dual Supply: ±1.35V to ±18V
- **LOW OFFSET VOLTAGE: ±250µV max**
- **HIGH COMMON-MODE REJECTION: 124dB**
- **HIGH OPEN-LOOP GAIN: 128dB**
- **SINGLE, DUAL, AND QUAD**

APPLICATIONS

- **BATTERY OPERATED INSTRUMENTS**
- **PORTABLE DEVICES**
- **MEDICAL INSTRUMENTS**
- **TEST EQUIPMENT**

DESCRIPTION

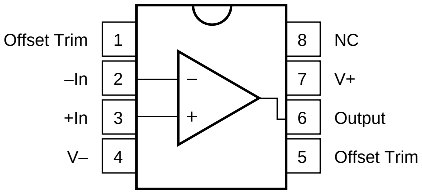
The OPA241 series and OPA251 series are specifically designed for battery powered, portable applications. In addition to very low power consumption (25µA), these amplifiers feature low offset voltage, rail-to-rail output swing, high common-mode rejection, and high open-loop gain.

The OPA241 series is optimized for operation at low power supply voltage while the OPA251 series is optimized for high power supplies. Both can operate from either single (+2.7V to +36V) or dual supplies (±1.35V to ±18V). The input common-mode voltage range extends 200mV below the negative supply—ideal for single-supply applications.

They are unity-gain stable and can drive large capacitive loads. Special design considerations assure that these products are easy to use. High performance is maintained as the amplifiers swing to their specified limits. Because the initial offset voltage (±250µV max) is so low, user adjustment is usually not required. However, external trim pins are provided for special applications (single versions only).

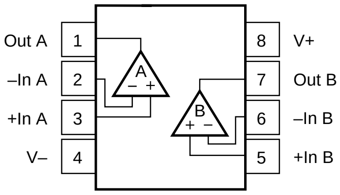
The OPA241 and OPA251 (single versions) are available in standard 8-pin DIP and SO-8 surface-mount packages. The OPA2241 and OPA2251 (dual versions) come in 8-pin DIP and SO-8 surface-mount packages. The OPA4241 and OPA4251 (quad versions) are available in 14-pin DIP and SO-14 surface-mount packages. All are fully specified from –40°C to +85°C and operate from –55°C to +125°C.

OPA241, OPA251



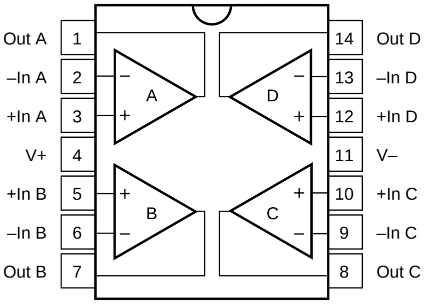
8-Pin DIP, SO-8

OPA2241, OPA2251



8-Pin DIP, SO-8

OPA4241, OPA4251



14-Pin DIP, SO-14

International Airport Industrial Park • Mailing Address: PO Box 11400, Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd., Tucson, AZ 85706 • Tel: (520) 746-1111 • Twx: 910-952-1111
Internet: http://www.burr-brown.com/ • FAXLine: (800) 548-6133 (US/Canada Only) • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

PDS-1406B
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SPECIFICATIONS: V_S = 2.7V to 5V

At T_A = +25°C, R_L = 100kΩ connected to $V_S/2$, unless otherwise noted.
Boldface limits apply over the specified temperature range, T_A = –40°C to +85°C.

PARAMETER	CONDITION	OPA241UA, PA OPA2241UA, PA OPA4241UA, PA			OPA251UA, PA OPA2251UA, PA OPA4251UA, PA			UNITS
		MIN	TYP[1]	MAX	MIN	TYP[1]	MAX	
OFFSET VOLTAGE								
Input Offset Voltage V_{OS}			±50	±250		±100		µV
T_A = –40°C to +85°C			**±100**	**±400**		**±130**		µV
vs Temperature dV_{OS}/dT	**T_A = –40°C to +85°C**		**±0.4**			**±0.6**		µV/°C
vs Power Supply PSRR	V_S = 2.7V to 36V		3	30		∗	∗	µV/V
T_A = –40°C to +85°C	V_S = 2.7V to 36V			**30**			∗	µV/V
Channel Separation (dual, quad)			0.3			∗		µV/V
INPUT BIAS CURRENT								
Input Bias Current[2] I_B			–4	–20		∗		nA
T_A = –40°C to +85°C				**–25**				nA
Input Offset Current I_{OS}			±0.1	±2		∗		nA
T_A = –40°C to +85°C				**±2**				nA
NOISE								
Input Voltage Noise, f = 0.1Hz to 10Hz			1			∗		µVp-p
Input Voltage Noise Density, f = 1kHz e_n			45			∗		$nV/\sqrt{Hz}$
Current Noise Density, f = 1kHz i_n			40			∗		$fA/\sqrt{Hz}$
INPUT VOLTAGE RANGE								
Common-Mode Voltage Range V_{CM}		–0.2		(V+) –0.8				V
Common-Mode Rejection Ratio CMRR	V_{CM} = –0.2V to (V+) –0.8V	80	106			∗		dB
T_A = –40°C to +85°C	V_{CM} = 0V to (V+) –0.8V	**80**						dB
INPUT IMPEDANCE								
Differential			$10^7 \parallel 2$			∗		$\Omega \parallel$ pF
Common-Mode			$10^9 \parallel 4$			∗		$\Omega \parallel$ pF
OPEN-LOOP GAIN								
Open-Loop Voltage Gain A_{OL}	R_L = 100kΩ, V_O = (V–)+100mV to (V+)–100mV	100	120			∗		dB
T_A = –40°C to +85°C	R_L = 100kΩ, V_O = (V–)+100mV to (V+)–100mV	**100**						dB
	R_L = 10kΩ, V_O = (V–)+200mV to (V+)–200mV	100	120			∗		dB
T_A = –40°C to +85°C	R_L = 10kΩ, V_O = (V–)+200mV to (V+)–200mV	**100**						dB
FREQUENCY RESPONSE								
Gain-Bandwidth Product GBW			35			∗		kHz
Slew Rate SR	V_S = 5V, G = 1		0.01			∗		V/µs
Overload Recovery Time	$V_{IN} \cdot G = V_S$		60			∗		µs
OUTPUT								
Voltage Output Swing from Rail[3] V_O	R_L = 100kΩ to $V_S/2$, A_{OL} ≥ 70dB		50			∗		mV
	R_L = 100kΩ to $V_S/2$, A_{OL} ≥ 100dB		75	100		∗		mV
T_A = –40°C to +85°C	R_L = 100kΩ to $V_S/2$, A_{OL} ≥ 100dB			**100**				mV
	R_L = 10kΩ to $V_S/2$, A_{OL} ≥ 100dB		100	200		∗		mV
T_A = –40°C to +85°C	R_L = 10kΩ to $V_S/2$, A_{OL} ≥ 100dB			**200**				mV
Short-Circuit Current I_{SC}								
Single Versions			–24/+4			∗		mA
Dual, Quad Versions			–30/+4			∗		mA
Capacitive Load Drive C_{LOAD}			See Typical Curve			∗		
POWER SUPPLY								
Specified Voltage Range V_S			+2.7 to +5			∗		V
Operating Voltage Range	**T_A = –40°C to +85°C**	**+2.7**		**+36**	∗		∗	V
Quiescent Current (per amplifier) I_Q	I_O = 0		±25	±30		∗		µA
T_A = –40°C to +85°C	I_O = 0			**±36**				µA
TEMPERATURE RANGE								
Specified Range		–40		+85	∗		∗	°C
Operating Range		–55		+125	∗		∗	°C
Storage Range		–55		+125	∗		∗	°C
Thermal Resistance θ_{JA}								
8-Pin DIP			100			∗		°C/W
SO-8 Surface Mount			150			∗		°C/W
14-Pin DIP			80			∗		°C/W
SO-14 Surface Mount			100			∗		°C/W

∗ Specifications the same as OPA241UA, PA.

NOTES: (1) V_S = +5V. (2) The negative sign indicates input bias current flows out of the input terminals. (3) Output voltage swings are measured between the output and power supply rails.

SPECIFICATIONS: V_S = ±15V

At T_A = +25°C, R_L = 100kΩ connected to ground, unless otherwise noted.
Boldface limits apply over the specified temperature range, T_A = –40°C to +85°C.

PARAMETER	CONDITION	OPA241UA, PA OPA2241UA, PA OPA4241UA, PA			OPA251UA, PA OPA2251UA, PA OPA4251UA, PA			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
OFFSET VOLTAGE								
Input Offset Voltage V_{OS}			±100			±50	±250	μV
T_A = –40°C to +85°C			**±150**			**±100**	**±300**	μV
vs Temperature dV_{OS}/dT	**T_A = –40°C to +85°C**		**±0.6**			**±0.5**		μV/°C
vs Power Supply PSRR	V_S = ±1.35V to ±18V		*	*		3	30	μV/V
T_A = –40°C to +85°C	V_S = ±1.35V to ±18V			*			**30**	μV/V
Channel Separation (dual, quad)			*			0.3		μV/V
INPUT BIAS CURRENT								
Input Bias Current[(1)] I_B			*			–4	–20	nA
T_A = –40°C to +85°C							**–25**	nA
Input Offset Current I_{OS}			*			±0.1	±2	nA
T_A = –40°C to +85°C							**±2**	nA
NOISE								
Input Voltage Noise, f = 0.1Hz to 10Hz			*			1		μVp-p
Input Voltage Noise Density, f = 1kHz e_n			*			45		$nV/\sqrt{Hz}$
Current Noise Density, f = 1kHz i_n			*			40		$fA/\sqrt{Hz}$
INPUT VOLTAGE RANGE								
Common-Mode Voltage Range V_{CM}					(V–) –0.2		(V+) –0.8	V
Common-Mode Rejection Ratio CMRR	V_{CM} = –15.2V to 14.2V		*		100	124		dB
T_A = –40°C to +85°C	V_{CM} = –15V to 14.2V				**100**			dB
INPUT IMPEDANCE								
Differential			*			10^7 || 2		Ω || pF
Common-Mode			*			10^9 || 4		Ω || pF
OPEN-LOOP GAIN								
Open-Loop Voltage Gain A_{OL}	R_L = 100kΩ, V_O = –14.75V to +14.75V		*		100	128		dB
T_A = –40°C to +85°C	R_L = 100kΩ, V_O = –14.75V to +14.75V				**100**			dB
	R_L = 20kΩ, V_O = –14.7V to +14.7V		*		100	128		dB
T_A = –40°C to +85°C	R_L = 20kΩ, V_O = –14.7V to +14.7V				**100**			dB
FREQUENCY RESPONSE								
Gain-Bandwidth Product GBW			*			35		kHz
Slew Rate SR	G = 1		*			0.01		V/μs
Overload Recovery Time	V_{IN} • G = V_S		*			60		μs
OUTPUT								
Voltage Output Swing from Rail[(2)] V_O	R_L = 100kΩ, A_{OL} ≥ 70dB		*			50		mV
	R_L = 100kΩ, A_{OL} ≥ 100dB		*			75	250	mV
T_A = –40°C to +85°C	R_L = 100kΩ, A_{OL} ≥ 100dB						**250**	mV
	R_L = 20kΩ, A_{OL} ≥ 100dB		*			100	300	mV
T_A = –40°C to +85°C	R_L = 20kΩ, A_{OL} ≥ 100dB						**300**	mV
Short-Circuit Current I_{SC}								
Single Versions			*			–21/+4		mA
Dual Versions			*			–50/+4		mA
Capacitive Load Drive C_{LOAD}			*			See Typical Curve		
POWER SUPPLY								
Specified Voltage Range V_S			*			±15		V
Operating Voltage Range	**T_A = –40°C to +85°C**	*		*	**±1.35**		**±18**	V
Quiescent Current (per amplifier) I_Q	I_O = 0		*			±27	±38	μA
T_A = –40°C to +85°C	I_O = 0						**±45**	μA
TEMPERATURE RANGE								
Specified Range		*		*	–40		+85	°C
Operating Range		*		*	–55		+125	°C
Storage Range		*		*	–55		+125	°C
Thermal Resistance θ_{JA}								
8-Pin DIP			*			100		°C/W
SO-8 Surface Mount			*			150		°C/W
14-Pin DIP			*			80		°C/W
SO-14 Surface Mount			*			100		°C/W

* Specifications the same as OPA251UA, PA.

NOTES: (1) The negative sign indicates input bias current flows out of the input terminals. (2) Output voltage swings are measured between the output and power supply rails.

ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage, V+ to V–	36V
Input Voltage[2]	(V–) –0.5V to (V+) +0.5V
Output Short Circuit to Ground[3]	Continuous
Operating Temperature	–55°C to +125°C
Storage Temperature	–55°C to +125°C
Junction Temperature	150°C
Lead Temperature (soldering, 10s)	300°C

NOTES: (1) Stresses above these ratings may cause permanent damage. (2) Input terminals are diode-clamped to the power supply rails. Input signals that can swing more that 0.5V beyond the supply rails should be current-limited to 5mA or less. (3) One amplifier per package.

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION

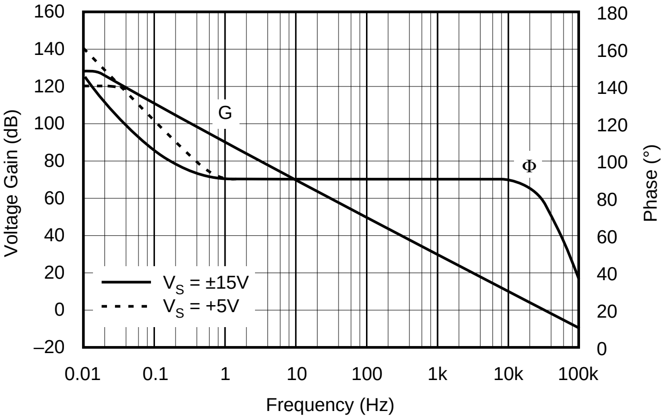
PRODUCT	SPECIFIED VOLTAGE	OPERATING VOLTAGE RANGE	PACKAGE	PACKAGE DRAWING NUMBER[1]	SPECIFICATION TEMPERATURE RANGE
OPA241 SERIES					
Single					
OPA241PA	2.7V to 5V	2.7V to 36V	8-Pin DIP	006	–40°C to +85°C
OPA241UA	2.7V to 5V	2.7V to 36V	SO-8 Surface Mount	182	–40°C to +85°C
Dual					
OPA2241PA	2.7V to 5V	2.7V to 36V	8-Pin DIP	006	–40°C to +85°C
OPA2241UA	2.7V to 5V	2.7V to 36V	SO-8 Surface Mount	182	–40°C to +85°C
Quad					
OPA4241PA	2.7V to 5V	2.7V to 36V	14-Pin DIP	010	–40°C to +85°C
OPA4241UA	2.7V to 5V	2.7V to 36V	SO-14 Surface Mount	235	–40°C to +85°C
OPA251 SERIES					
Single					
OPA251PA	±15V	2.7V to 36V	8-Pin DIP	006	–40°C to +85°C
OPA251UA	±15V	2.7V to 36V	SO-8 Surface Mount	182	–40°C to +85°C
Dual					
OPA2251PA	±15V	2.7V to 36V	8-Pin DIP	006	–40°C to +85°C
OPA2251UA	±15V	2.7V to 36V	SO-8 Surface Mount	182	–40°C to +85°C
Quad					
OPA4251PA	±15V	2.7V to 36V	14-Pin DIP	010	–40°C to +85°C
OPA4251UA	±15V	2.7V to 36V	SO-14 Surface Mount	235	–40°C to +85°C

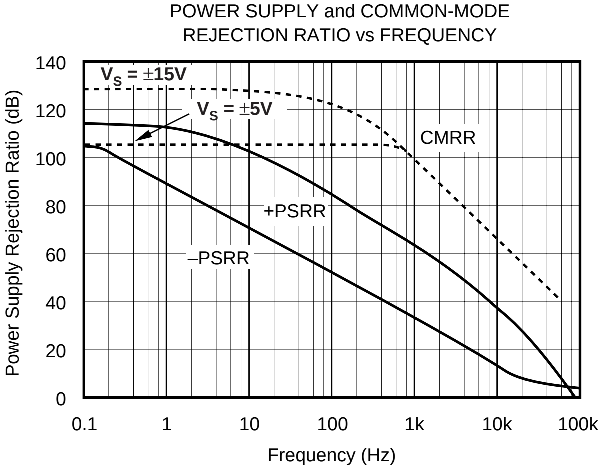
NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.

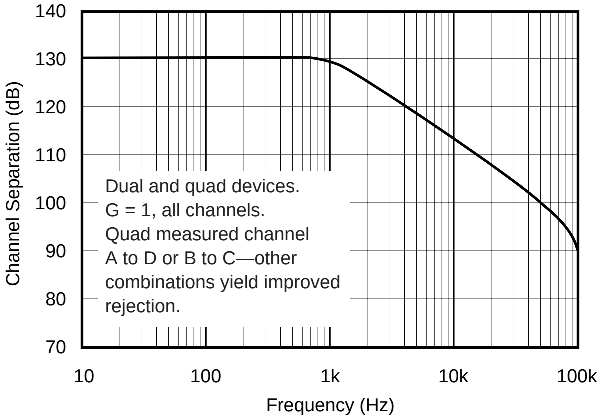
TYPICAL PERFORMANCE CURVES

At T_A = +25°C, and R_L = 100kΩ connected to V_S/2 (ground for V_S = ±15V), unless otherwise noted.

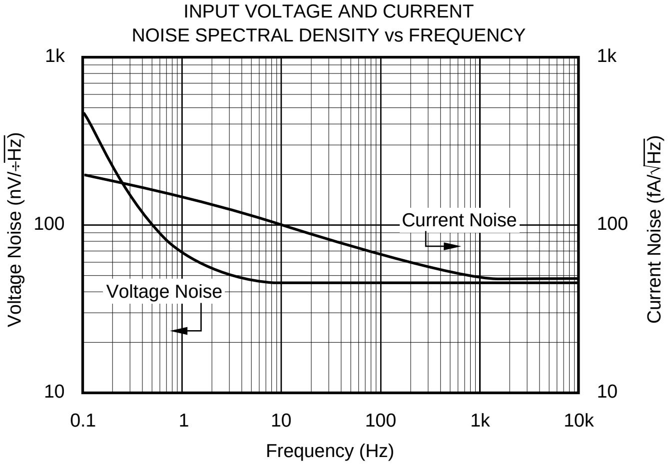
Curves apply to OPA241 and OPA251 unless specified.

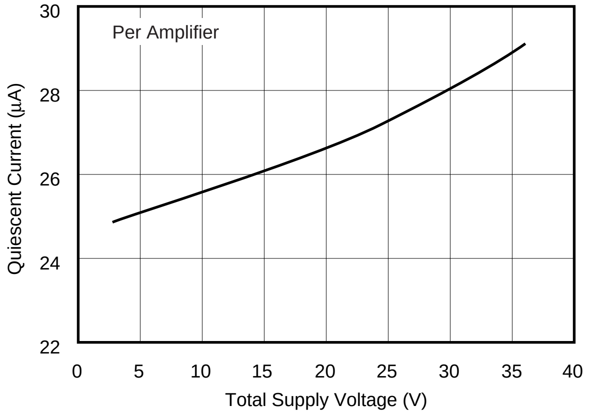

OPEN-LOOP GAIN/PHASE vs FREQUENCY

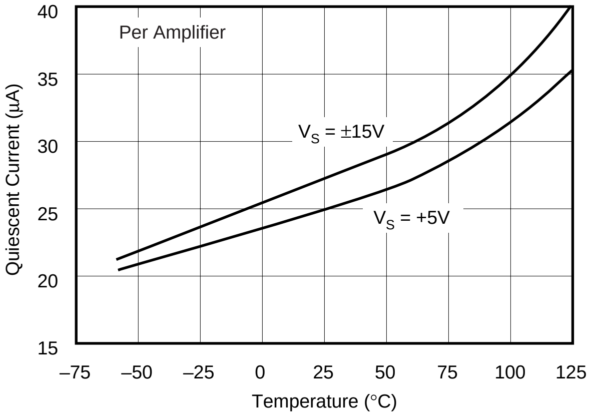

POWER SUPPLY and COMMON-MODE REJECTION RATIO vs FREQUENCY


CHANNEL SEPARATION vs FREQUENCY

Dual and quad devices.
G = 1, all channels.
Quad measured channel
A to D or B to C—other
combinations yield improved
rejection.


INPUT VOLTAGE AND CURRENT NOISE SPECTRAL DENSITY vs FREQUENCY


QUIESCENT CURRENT vs SUPPLY VOLTAGE

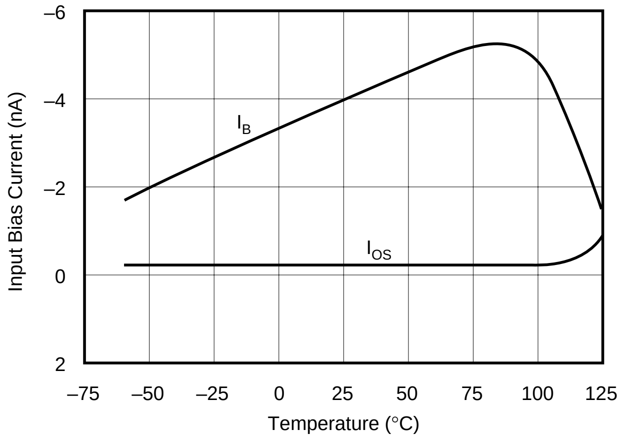

QUIESCENT CURRENT vs TEMPERATURE

TYPICAL PERFORMANCE CURVES (CONT)

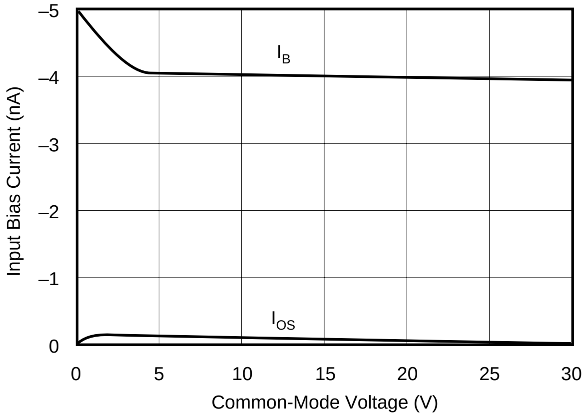
At T_A = +25°C, and R_L = 100kΩ connected to $V_S/2$ (ground for V_S = ±15V), unless otherwise noted.

Curves apply to OPA241 and OPA251 unless specified.

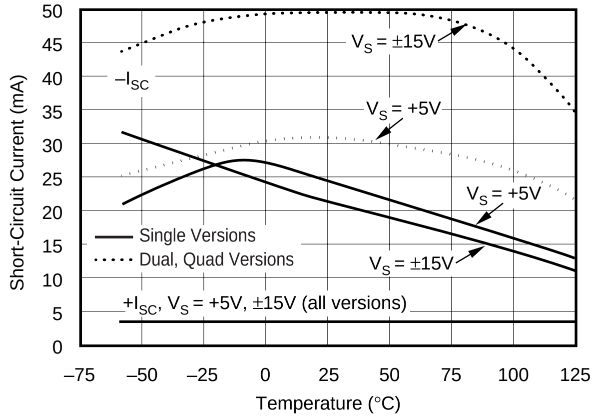
INPUT BIAS CURRENT vs TEMPERATURE



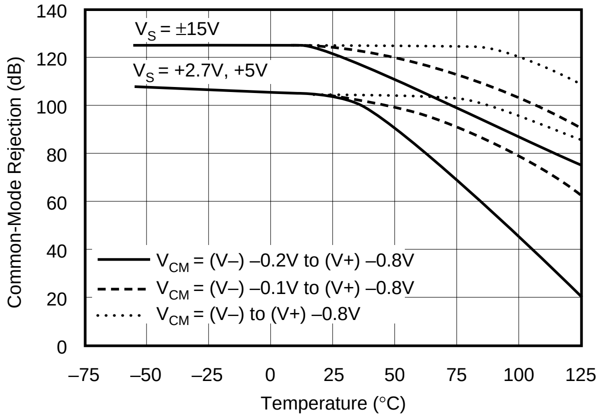
INPUT BIAS CURRENT vs INPUT COMMON-MODE VOLTAGE



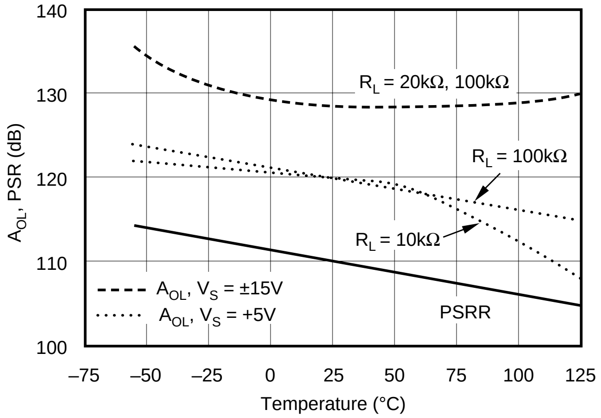
SHORT-CIRCUIT CURRENT vs TEMPERATURE



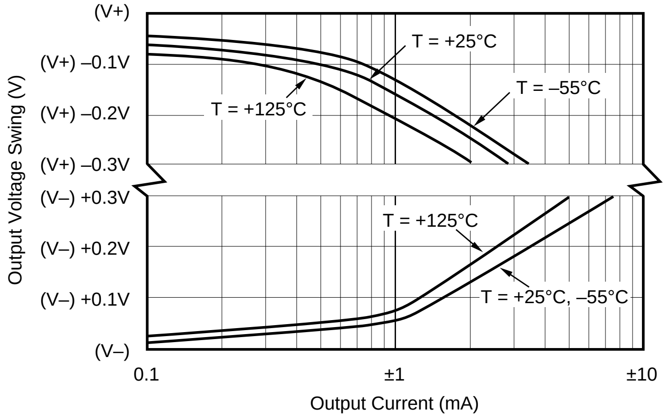
COMMON-MODE REJECTION vs TEMPERATURE



OPEN-LOOP GAIN AND POWER SUPPLY REJECTION vs TEMPERATURE



OUTPUT VOLTAGE SWING vs OUTPUT CURRENT

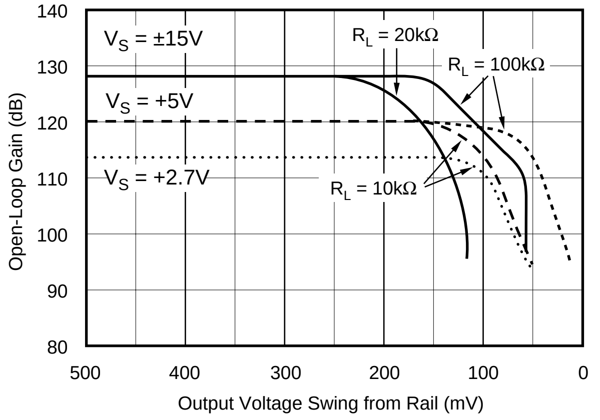


TYPICAL PERFORMANCE CURVES (CONT)

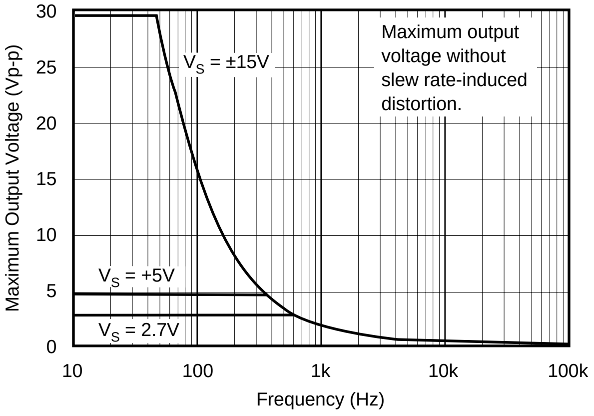
At T_A = +25°C, and R_L = 100kΩ connected to $V_S/2$ (ground for V_S = ±15V), unless otherwise noted.

Curves apply to OPA241 and OPA251 unless specified.

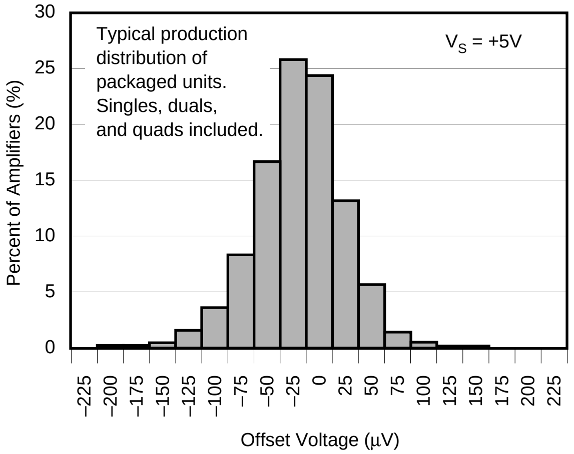
OPEN-LOOP GAIN vs OUTPUT VOLTAGE SWING



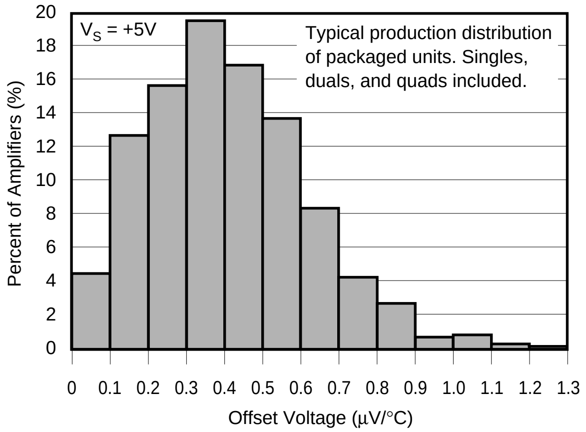
MAXIMUM OUTPUT VOLTAGE vs FREQUENCY



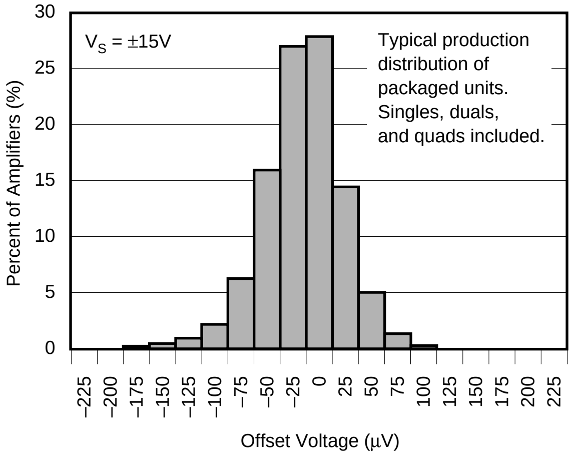
OPA241 SERIES OFFSET VOLTAGE PRODUCTION DISTRIBUTION



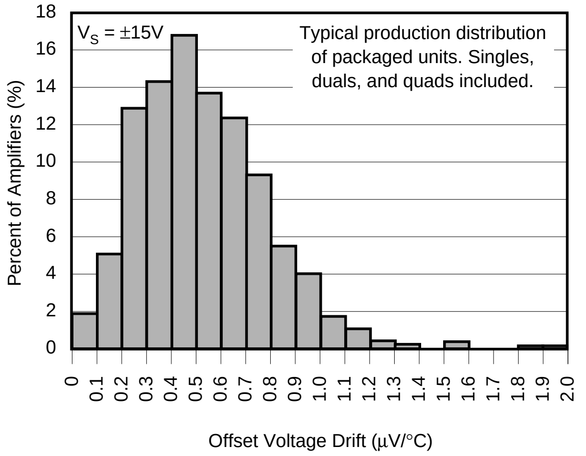
OPA241 SERIES OFFSET VOLTAGE DRIFT PRODUCTION DISTRIBUTION



OPA251 SERIES OFFSET VOLTAGE PRODUCTION DISTRIBUTION



OPA251 SERIES OFFSET VOLTAGE DRIFT PRODUCTION DISTRIBUTION

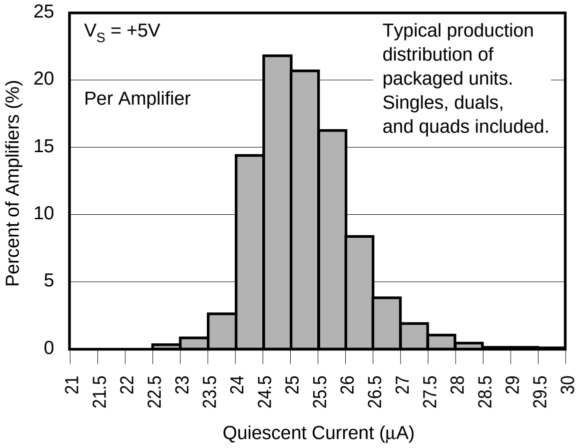


TYPICAL PERFORMANCE CURVES (CONT)

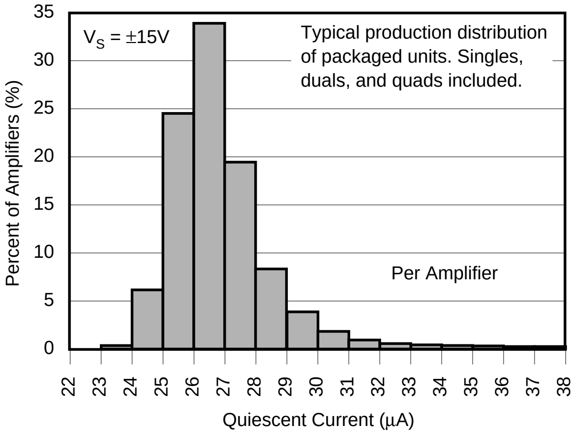
At T_A = +25°C, and R_L = 100kΩ connected to $V_S/2$ (ground for V_S ±15V), unless otherwise noted.

Curves apply to OPA241 and OPA251 unless specified.

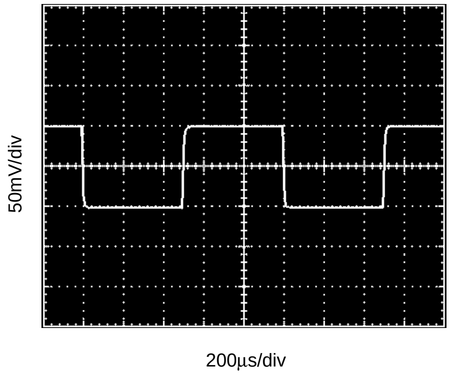
QUIESCENT CURRENT
PRODUCT DISTRIBUTION



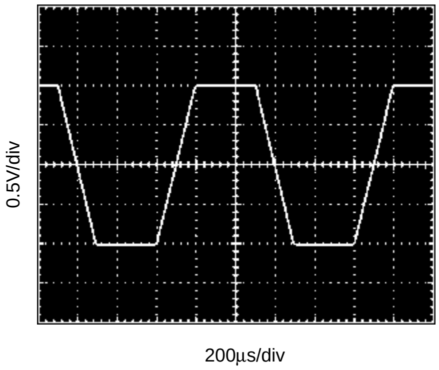
QUIESCENT CURRENT
PRODUCTION DISTRIBUTION



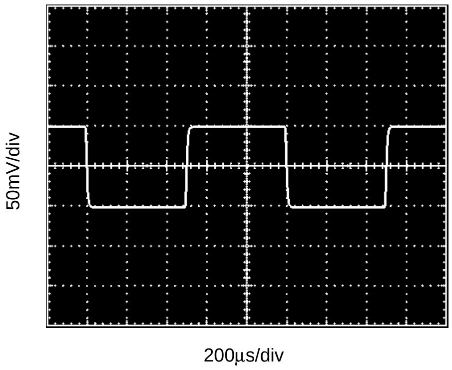
OPA241
SMALL-SIGNAL STEP RESPONSE
V_S = +5V, G = +1, R_L = 100kΩ, C_L = 100pF



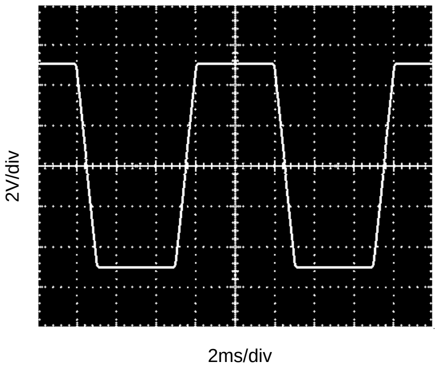
OPA241
LARGE-SIGNAL STEP RESPONSE
V_S = +5V, G + 1, R_L = 100kΩ, C_L = 100pF



OPA251
SMALL-SIGNAL STEP RESPONSE
V_S = ±15V, G = +1, R_L = 100kΩ, C_L = 500pF



OPA251
LARGE-SIGNAL STEP RESPONSE
V_S = ±15V, G = +1, R_L = 100kΩ, C_L = 500pF



APPLICATIONS INFORMATION

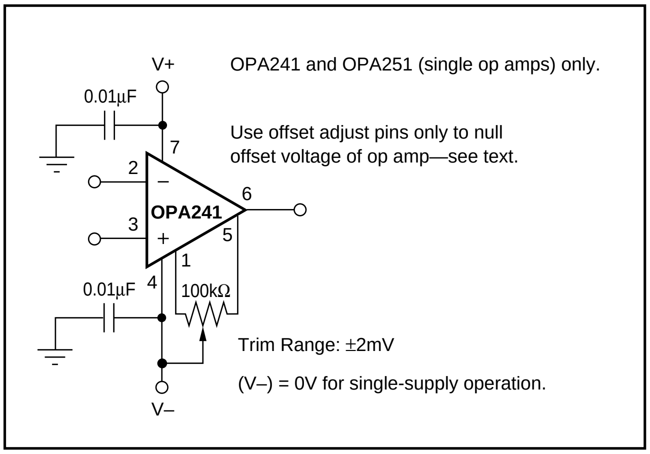
The OPA241 and OPA251 series are unity-gain stable and suitable for a wide range of general purpose applications. Power supply pins should be bypassed with 0.01µF ceramic capacitors.

OPERATING VOLTAGE

The OPA241 series is laser-trimmed for low offset voltage and drift at low supply voltage (V_S = +5V). The OPA251 series is trimmed for ±15V operation. Both products operate over the full voltage range (+2.7V to +36V or ±1.35V to ±18V) with some compromises in offset voltage and drift performance. However, all other parameters have similar performance. Key parameters are guaranteed over the specified temperature range, –40°C to +85°C. Most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage or temperature are shown in typical performance curves.

OFFSET VOLTAGE TRIM

As mentioned previously, offset voltage of the OPA241 series is laser-trimmed at +5V. The OPA251 series is trimmed at ±15V. Because the initial offset is so low, user adjustment is usually not required. However, the OPA241 and OPA251 (single op amp versions) provide offset voltage trim connections on pins 1 and 5. Offset voltage can be adjusted by connecting a potentiometer as shown in Figure 1. This adjustment should be used only to null the offset of the op amp, not to adjust system offset or offset produced by the signal source. Nulling offset could degrade the offset drift behavior of the op amp. While it is not possible to predict the exact change in drift, the effect is usually small.



OPA241 and OPA251 (single op amps) only.

Use offset adjust pins only to null offset voltage of op amp—see text.

Trim Range: ±2mV

(V–) = 0V for single-supply operation.

FIGURE 1. OPA241 and OPA251 Offset Voltage Trim Circuit.

CAPACITIVE LOAD AND STABILITY

The OPA241 series and OPA251 series can drive a wide range of capacitive loads. However, all op amps under certain conditions may be unstable. Op amp configuration, gain, and load value are just a few of the factors to consider when determining stability.

Figures 2 and 3 show the regions where the OPA241 series and OPA251 series have the potential for instability. As shown, the unity gain configuration with low supplies is the most susceptible to the effects of capacitive load. With V_S = +5V, G = +1, and I_{OUT} = 0, operation remains stable with load capacitance up to approximately 200pF. Increasing supply voltage, output current, and/or gain significantly improves capacitive load drive. For example, increasing the supplies to ±15V and gain to 10 allows approximately 2700pF to be driven.

One method of improving capacitive load drive in the unity gain configuration is to insert a resistor inside the feedback loop as shown in Figure 4. This reduces ringing with large capacitive loads while maintaining dc accuracy. For example, with V_S = ±1.35V and R_S = 5kΩ, the OPA241 series and OPA251 series perform well with capacitive loads in excess of 1000pF. Without the series resistor, capacitive load drive is typically 200pF for these conditions. However, this method will result in a slight reduction of output voltage swing.

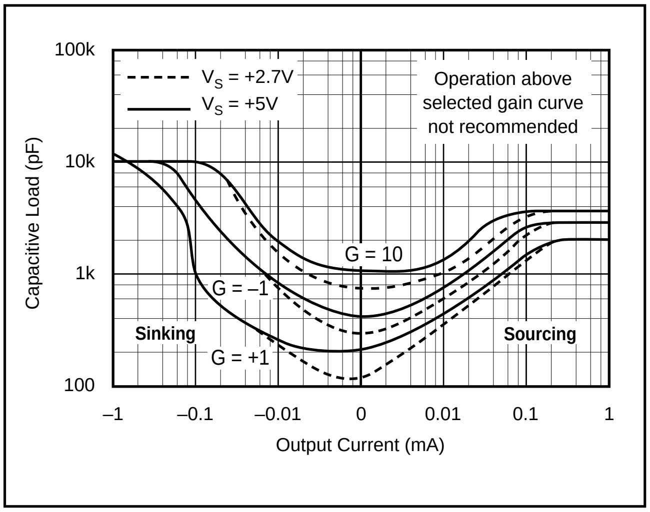


FIGURE 2. Stability—Capacitive Load versus Output Current for Low Supply Voltage.

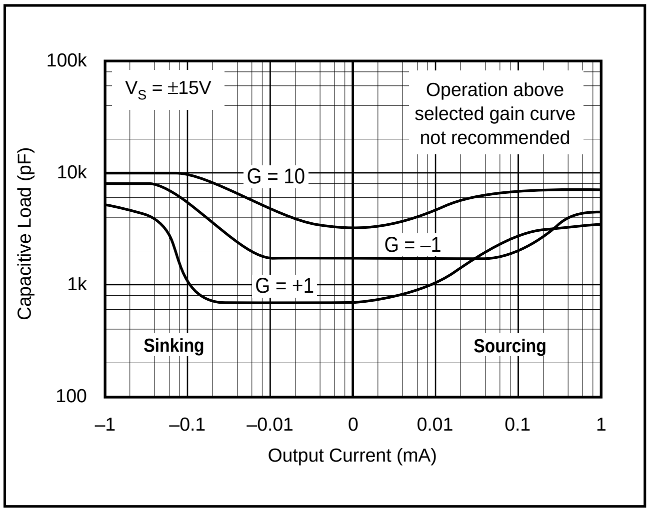


FIGURE 3. Stability—Capacitive Load versus Output Current for ±15V Supplies.

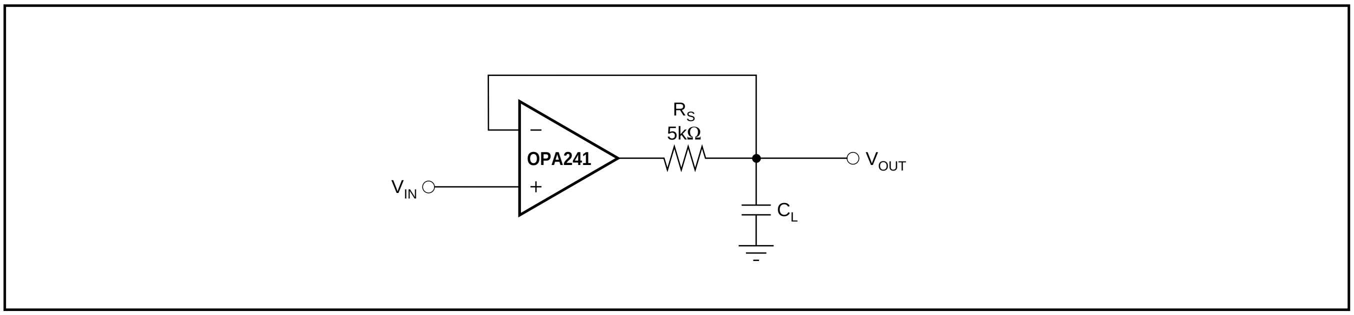


FIGURE 4. Series Resistor in Unity Gain Configuration Improves Capacitive Load Drive.

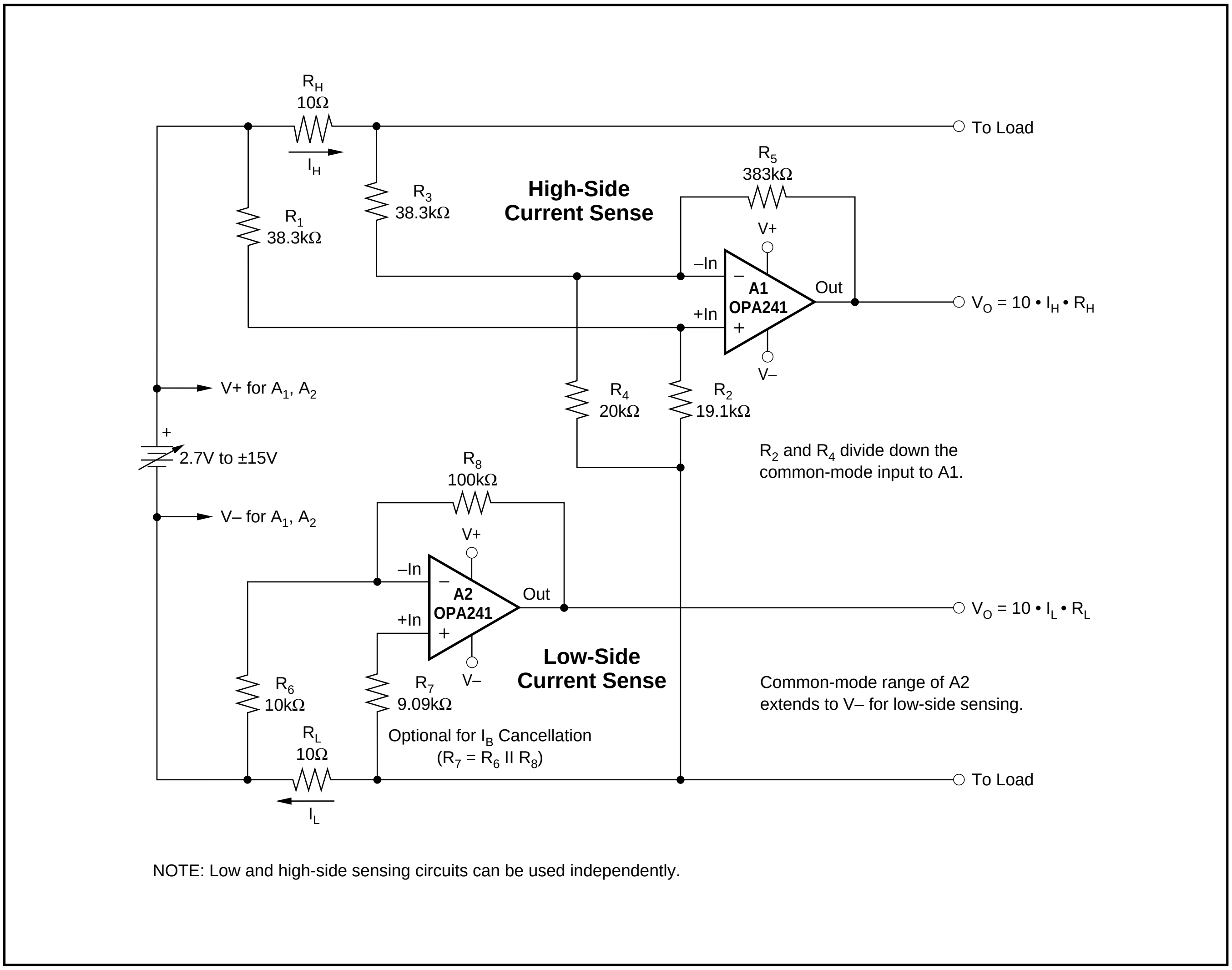


FIGURE 5. Low and High-Side Battery Current Sensing.

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