GENERAL DESCRIPTION

The AD8615 are rail-to-rail, input and output, single-supply amplifiers featuring very low offset voltage, wide signal bandwidth, and low input voltage and current noise. The parts use a patented trimming technique that achieves superior precision without laser trimming. The AD8615 are fully specified to operate from 2.7 V to 5 V single supplies.

The combination of 20 MHz bandwidth, low offset, low noise, and very low input bias current make these amplifiers useful in a wide variety of applications. Filters, integrators, photodiode amplifiers, and high impedance sensors all benefit from the combination of performance features. AC applications benefit from the wide bandwidth and low distortion. The AD8615 offer the highest output drive capability of the DigiTrim™ family, which is excellent for audio line drivers and other low impedance applications.

Applications for the parts include portable and low powered instrumentation, audio amplification for portable devices, portable phone headsets, bar code scanners, and multipole filters. The ability to swing rail-to-rail at both the input and output enables designers to buffer CMOS ADCs, DACs, ASICs, and other wide output swing devices in single-supply systems.

The AD8615 are specified over the extended industrial (–40°C to +125°C) temperature range. The AD8615 is available in 5-lead TSOT-23 packages.

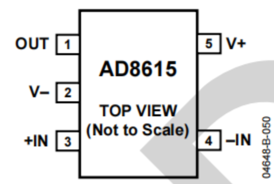


Figure 1. 5-Lead TSOT-23 (UJ-5)

FEATURES

Low offset voltage: 65 µV max
Single-supply operation: 2.7 V to 5.5 V
Low noise: 8 nV/√Hz
Wide bandwidth: >20 MHz
Slew rate: 12 V/µs
High output current: 150 mA
No phase reversal
Low input bias current: 1 pA
Low supply current: 2 mA
Unity-gain stable

APPLICATIONS

Barcode scanners
Battery-powered instrumentation
Multipole filters
Sensors
ASIC input or output amplifier
Audio
Photodiode amplification

SPECIFICATIONS

V_S =5 V, V_{CM} = V_S/2, T_A = 25°C, unless otherwise noted.

Table 1.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage AD8615	V_{OS}	V_S = 3.5 V at V_{CM} = 0.5 V and 3.0 V		23	60	µV
				23	100	µV
		V_{CM} = 0 V to 5 V		80	500	µV
		−40°C < T_A < +125°C			800	µV
Offset Voltage Drift AD8615	$\Delta V_{OS}/\Delta T$	−40°C < T_A < +125°C		1.5	7	µV/°C
				3	10	µV/°C
Input Bias Current	I_B			0.2	1	pA
		−40°C < T_A < +85°C			50	pA
		−40°C < T_A < +125°C			550	pA
Input Offset Current	I_{OS}			0.1	0.5	pA
		−40°C < T_A < +85°C			50	pA
		−40°C < T_A < +125°C			250	pA
Input Voltage Range			0		5	V
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0 V to 4.5 V	80	100		dB
Large Signal Voltage Gain	A_{VO}	R_L = 2 kΩ, V_O = 0.5 V to 5 V	105	1500		V/mV
Input Capacitance	C_{DIFF}			2.5		pF
	C_{CM}			6.7		pF
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	I_L = 1 mA	4.98	4.99		V
		I_L = 10 mA	4.88	4.92		V
		−40°C < T_A < +125°C	4.7			V
Output Voltage Low	V_{OL}	I_L = 1 mA		7.5	15	mV
		I_L = 10 mA		70	100	mV
		−40°C < T_A < +125°C			200	mV
Output Current	I_{OUT}			±150		mA
Closed-Loop Output Impedance	Z_{OUT}	f = 1 MHz, A_V = 1		3		Ω
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V_S = 2.7 V to 5.5 V	70	90		dB
Supply Current per Amplifier	I_{SY}	V_O = 0 V		1.7	2.0	mA
		−40°C < T_A < +125°C			2.5	mA
DYNAMIC PERFORMANCE						
Slew Rate	SR	R_L = 2 kΩ		12		V/µs
Settling Time	t_s	To 0.01%		<0.5		µs
Gain Bandwidth Product	GBP			24		MHz
Phase Margin	$Ø_m$			63		Degrees
NOISE PERFORMANCE						
Peak-to-Peak Noise	e_n p-p	0.1 Hz to 10 Hz		2.4		µV
Voltage Noise Density	e_n	f = 1 kHz		10		nV/√Hz
		f = 10 kHz		7		nV/√Hz
Current Noise Density	i_n	f = 1 kHz		0.05		pA/√Hz
Channel Separation	Cs	f = 10 kHz		−115		dB
		f = 100 kHz		−110		dB

V_S = 2.7 V, V_{CM} = V_S/2, T_A = 25°C, unless otherwise noted.

Table 2.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage AD8615	V_{OS}	V_S = 3.5 V at V_{CM} = 0.5 V and 3.0 V		23	65	µV
				23	100	µV
		V_{CM} = 0 V to 2.7 V		80	500	µV
		−40°C < T_A < +125°C			800	µV
Offset Voltage Drift AD8615	$\Delta V_{OS}/\Delta T$	−40°C < T_A < +125°C		1.5	7	µV/°C
				3	10	µV/°C
Input Bias Current	I_B			0.2	1	pA
		−40°C < T_A < +85°C			50	pA
		−40°C < T_A < +125°C			550	pA
Input Offset Current	I_{OS}			0.1	0.5	pA
		−40°C < T_A < +85°C			50	pA
		−40°C < T_A < +125°C			250	pA
Input Voltage Range			0		2.7	V
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0 V to 2.7 V	80	100		dB
Large Signal Voltage Gain	A_{VO}	R_L = 2 kΩ, V_O = 0.5 V to 2.2 V	55	150		V/mV
Input Capacitance	C_{DIFF}			2.5		pF
	C_{CM}			7.8		pF
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	I_L = 1 mA	2.65	2.68		V
		−40°C < T_A < +125°C	2.6			V
Output Voltage Low	V_{OL}	I_L = 1 mA		11	25	mV
		−40°C < T_A < +125°C			30	mV
Output Current	I_{OUT}			±50		mA
Closed-Loop Output Impedance	Z_{OUT}	f = 1 MHz, A_V = 1		3		Ω
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V_S = 2.7 V to 5.5 V	70	90		dB
Supply Current per Amplifier	I_{SY}	V_O = 0 V		1.7	2	mA
		−40°C < T_A < +125°C			2.5	mA
DYNAMIC PERFORMANCE						
Slew Rate	SR	R_L = 2 kΩ		12		V/µs
Settling Time	t_s	To 0.01%		< 0.3		µs
Gain Bandwidth Product	GBP			23		MHz
Phase Margin	$Ø_m$			42		Degrees
NOISE PERFORMANCE						
Peak-to-Peak Noise	e_n p-p	0.1 Hz to 10 Hz		2.1		µV
Voltage Noise Density	e_n	f = 1 kHz		10		nV/√Hz
		f = 10 kHz		7		nV/√Hz
Current Noise Density	i_n	f = 1 kHz		0.05		pA/√Hz
Channel Separation	Cs	f = 10 kHz		−115		dB
		f = 100 kHz		−110		dB

ABSOLUTE MAXIMUM RATINGS

Table 3.

Parameter	Rating
Supply Voltage	6 V
Input Voltage	GND to V_S
Differential Input Voltage	±3 V
Output Short-Circuit Duration to GND	Indefinite
Storage Temperature	−65°C to +150°C
Operating Temperature Range	−40°C to +125°C
Lead Temperature Range (Soldering 60 sec)	300°C
Junction Temperature	150°C

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

THERMAL RESISTANCE

θ_{JA} is specified for the worst-case conditions, that is, θ_{JA} is specified for device soldered in circuit board for surface-mount packages.

Table 4.

Package Type	θ_{JA}	θ_{JC}	Unit
5–Lead TSOT-23 (UJ)	207	61	°C/W

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

APPLICATIONS

INPUT OVERVOLTAGE PROTECTION

The AD8615 have internal protective cir-cuitry that allows voltages exceeding the supply to be applied at the input.

It is recommended, however, not to apply voltages that exceed the supplies by more than 1.5 V at either input of the amplifier. If a higher input voltage is applied, series resistors should be used to limit the current flowing into the inputs.

The input current should be limited to <5 mA. The extremely low input bias current allows the use of larger resistors, which allows the user to apply higher voltages at the inputs. The use of these resistors adds thermal noise, which contributes to the overall output voltage noise of the amplifier.

For example, a 10 kΩ resistor has less than 13 nV/√Hz of thermal noise and less than 10 nV of error voltage at room temperature.

OUTPUT PHASE REVERSAL

The AD8615 are immune to phase inversion, a phenomenon that occurs when the voltage applied at the input of the amplifier exceeds the maxi-mum input common mode.

Phase reversal can cause permanent damage to the ampli-fier and can create lock-ups in systems with feedback loops.

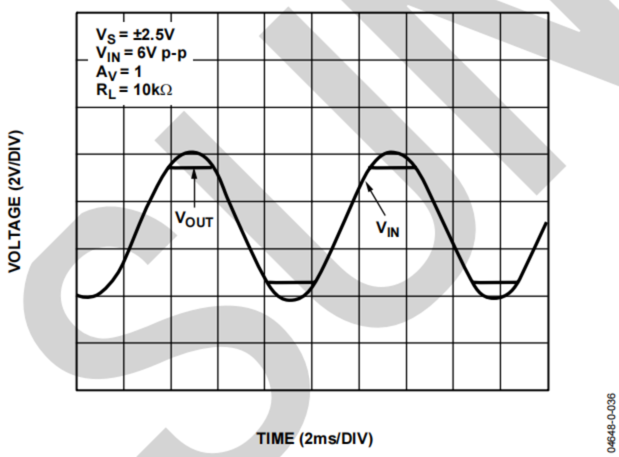


Figure 1. No Phase Reversal

DRIVING CAPACITIVE LOADS

Although the AD8615 are capable of driving capacitive loads of up to 500 pF without oscillating, a large amount of overshoot is present when operating at frequencies above 100 kHz. This is especially true when the amplifier is configured in positive unity gain (worst case). When such large capacitive loads are required, the use of external compensation is highly recommended. This reduces the overshoot and minimizes ringing, which in turn improves the frequency response of the AD8615. One simple technique for compensation is the snubber, which consists of a simple RC network. With this circuit in place, output swing is maintained and the amplifier is stable at all gains.

Figure 3 shows the implementation of the snubber, which reduces overshoot by more than 30% and eliminates ringing that can cause instability. Using the snubber does not recover the loss of bandwidth incurred from a heavy capacitive load.

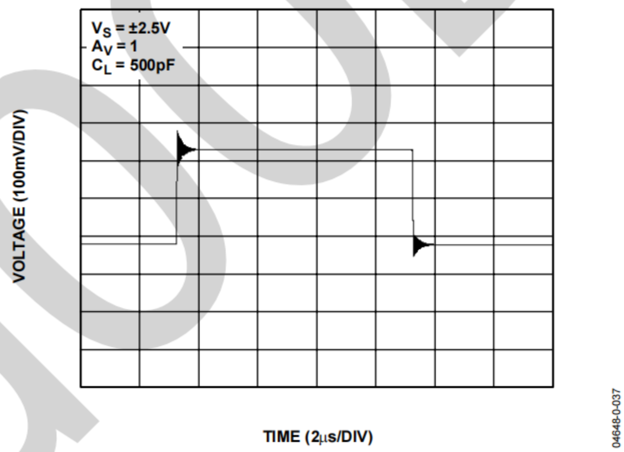


Figure 2. Driving Heavy Capacitive Loads Without Compensation

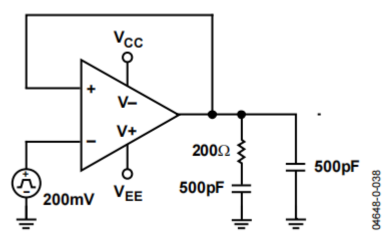


Figure 3. Snubber Network

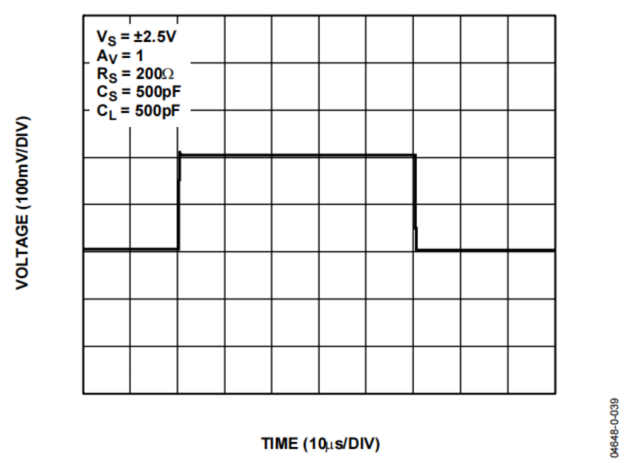


Figure 4. Driving Heavy Capacitive Loads Using the Snubber Network

HIGH SPEED PHOTODIODE PREAMPLIFIER

The AD8615 are excellent choices for I-to-V conversions. The very low input bias, low current noise, and high unity-gain bandwidth of the parts make them suitable, especially for high speed photodiode preamps.

In high speed photodiode applications, the diode is operated in a photoconductive mode (reverse biased). This lowers the junction capacitance at the expense of an increase in the amount of dark current that flows out of the diode.

The total input capacitance, C1, is the sum of the diode and op amp input capacitances. This creates a feedback pole that causes degradation of the phase margin, making the op amp unstable. Therefore, it is necessary to use a capacitor in the feedback to compensate for this pole.

To get the maximum signal bandwidth, select

$$C2 = \sqrt{\frac{C1}{2\pi R2 f_U}}$$

where f_U is the unity-gain bandwidth of the amplifier.

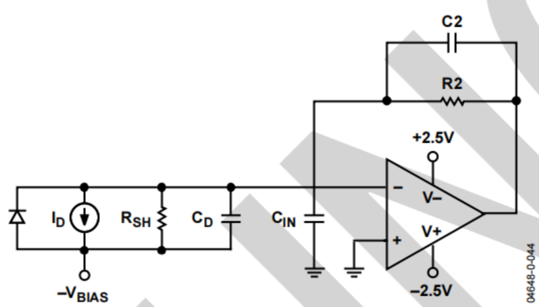


Figure 5. High Speed Photodiode Preamplifier

POWER DISSIPATION

Although the AD8615 are capable of providing load currents up to 150 mA, the usable output, load current, and drive capability is limited to the maximum power dissipation allowed by the device package.

In any application, the absolute maximum junction temperature for the AD8615 is 150°C. This should never be exceeded because the device could suffer premature failure.

Accurately measuring power dissipation of an integrated circuit is not always a straightforward exercise.

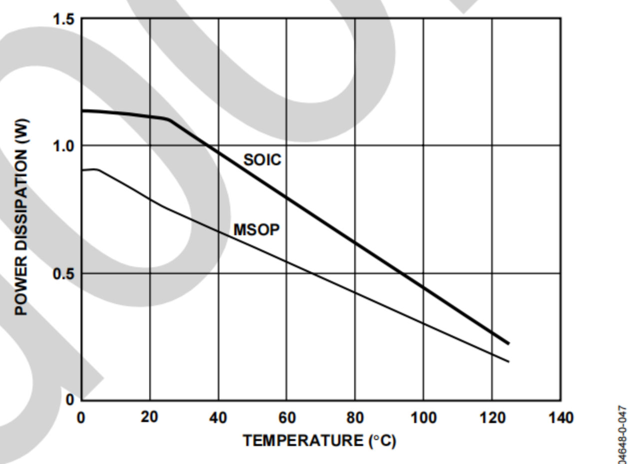


Figure 6. Maximum Power Dissipation vs. Ambient Temperature

These thermal resistance curves were determined using the AD8615 thermal resistance data for each package and a maximum junction temperature of 150°C. The following formula can be used to calculate the internal junction temperature of the AD8615 for any application:

$$T_J = P_{DISS} \times \theta_{JA} + T_A$$

where:

T_J = junction temperature
P_{DISS} = power dissipation
θ_{JA} = package thermal resistance, junction-to-case
T_A = ambient temperature of the circuit

To calculate the power dissipated by the AD8615, use

$$P_{DISS} = I_{LOAD} \times (V_S - V_{OUT})$$

where:

I_{LOAD} = output load current
V_S = supply voltage
V_{OUT} = output voltage

The quantity within the parentheses is the maximum voltage developed across either output transistor.

POWER CALCULATIONS FOR VARYING OR UNKNOWN LOADS

Often, calculating power dissipated by an integrated circuit to determine if the device is being operated in a safe range is not as simple as it might seem. In many cases, power cannot be directly measured. This may be the result of irregular output waveforms or varying loads. Indirect methods of measuring power are required.

There are two methods to calculate power dissipated by an integrated circuit. The first is to measure the package temperature and the board temperature. The second is to directly measure the circuits supply current.

Calculating Power by Measuring Ambient and Case Temperature

The two equations for calculating junction temperature are

$$T_J = T_A + P\ \theta_{JA}$$

where:

T_J = junction temperature
T_A = ambient temperature
θ_{JA} = the junction-to-ambient thermal resistance

$$T_J = T_C + P\ \theta_{JC}$$

where T_C is case temperature and θ_{JA} and θ_{JC} are given in the data sheet.

The two equations for calculating P (power) are

$$T_A + P\ \theta_{JA} = T_C + P\ \theta_{JC}$$

$$P = (T_A - T_C)/(\theta_{JC} - \theta_{JA})$$

Once power has been determined, it is necessary to recalculate the junction temperature to ensure that it has not been exceeded.

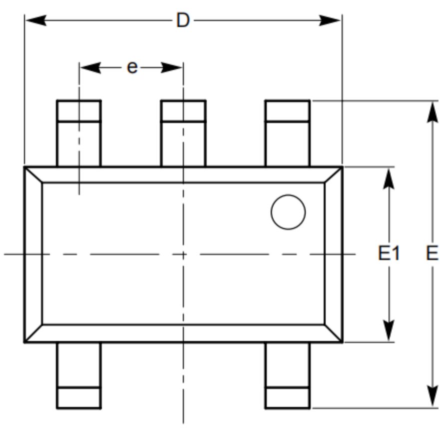
The temperature should be measured directly on and near the package, but not touching it. Measuring the package can be difficult. A very small bimetallic junction glued to the package can be used, or an infrared sensing device can be used if the spot size is small enough.

Calculating Power by Measuring Supply Current

Power can be calculated directly if the supply voltage and current are known. However, the supply current can have a dc component with a pulse directed into a capacitive load, which could make the rms current very difficult to calculate. This difficulty can be overcome by lifting the supply pin and inserting an rms current meter into the circuit. For this method to work, make sure the current is delivered by the supply pin being measured. This is usually a good method in a single-supply system; however, if the system uses dual supplies, both supplies may need to be monitored.

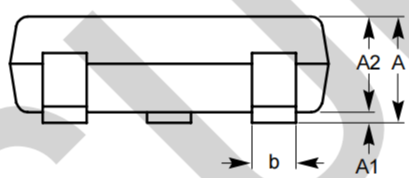
PACKAGE OUTLINE DRAWING

SOT-23-5

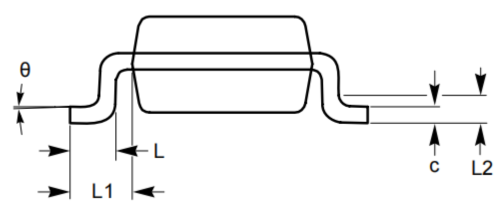


TOP VIEW

SYMBOL	MIN	NOM	MAX
A			1.00
A1	0.01	0.05	0.10
A2	0.80	0.87	0.90
b	0.30		0.45
c	0.12	0.15	0.20
D		2.90 BSC	
E		2.80 BSC	
E1		1.60 BSC	
e		0.95 TYP	
L	0.30	0.40	0.50
L1		0.60 REF	
L2		0.25 BSC	
θ	0º		8º



SIDE VIEW



END VIEW