

FEATURES

Single-supply operation: 4.5 V to 16 V
Input capability beyond the rails
Rail-to-rail output swing
Continuous output current: 35 mA
Peak output current: 250 mA
Offset voltage: 10 mV
Slew rate: 6 V/ μ s
Unity gain stable with large capacitive loads
Supply current: 700 μ A per amplifier
Qualified for automotive applications

APPLICATIONS

LCD reference drivers
Portable electronics
Communications equipment
Automotive infotainment systems

GENERAL DESCRIPTION

The AD8565/AD8566/AD8567 are low cost, single-supply, rail-to-rail input and output operational amplifiers optimized for LCD monitor applications. They are built on an advanced high voltage CBCMOS process. The AD8565 contains a single amplifier, the AD8566 has two amplifiers, and the AD8567 has four amplifiers.

These LCD op amps have high slew rates, 35 mA continuous output drive, 250 mA peak output drive, and a high capacitive load drive capability. They have a wide supply range and offset voltages below 10 mV. The AD8565/AD8566/AD8567 are ideal for LCD grayscale reference buffer and V_{COM} applications.

The AD8565/AD8566/AD8567 are specified over the -40°C to $+85^{\circ}\text{C}$ temperature range. The AD8565 single is available in a 5-lead SC70 package. The AD8566 dual is available in an 8-lead MSOP package. The AD8567 quad is available in a 14-lead TSSOP package and a 16-lead LFCSP package.

The AD8566WARMZ is the automotive grade version.

PIN CONFIGURATIONS

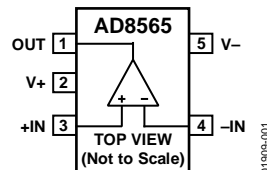


Figure 1. 5-Lead SC70 Pin Configuration

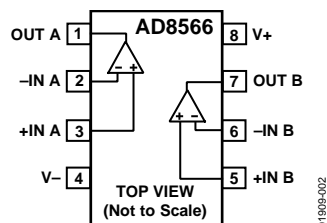


Figure 2. 8-Lead MSOP Pin Configuration

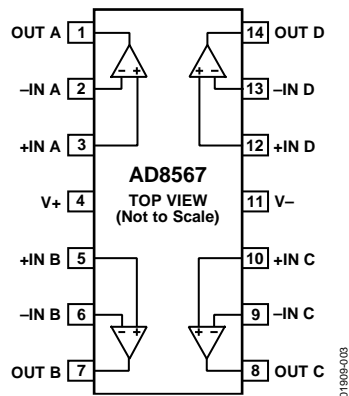
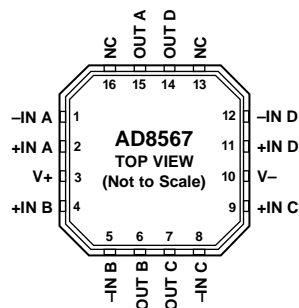


Figure 3. 14-Lead TSSOP Pin Configuration



NOTES

1. THE EXPOSED PAD MUST BE CONNECTED TO PIN 3, THAT IS, V_{+} .
2. NC = NO CONNECT.

Figure 4. 16-Lead LFCSP Pin Configuration

Rev. G

Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties that may result from its use. Specifications subject to change without notice. No license is granted by implication or otherwise under any patent or patent rights of Analog Devices. Trademarks and registered trademarks are the property of their respective owners.

TABLE OF CONTENTS

| | |
|---|---|
| Features | 1 |
| Applications | 1 |
| General Description | 1 |
| Pin Configurations | 1 |
| Revision History | 2 |
| Specifications | 3 |
| Electrical Characteristics | 3 |
| Absolute Maximum Ratings | 4 |
| Thermal Resistance | 4 |
| ESD Caution | 4 |
| Typical Performance Characteristics | 5 |

REVISION HISTORY

3/10—Rev. F to Rev. G

| | |
|---|----|
| Changes to Figure 4 | 1 |
| Changes to the Thermal Pad—AD8567 Section | 10 |

1/10—Rev. E to Rev. F

| | |
|--|----|
| Changes to Applications and General Description Sections | 1 |
| Changes to Figure 4 | 1 |
| Added Exposed Pad Notation to Outline Dimensions | 12 |
| Changes to Ordering Guide | 13 |

8/07—Rev. D to Rev. E

| | |
|-----------------------------------|----|
| Changes to Features Section | 1 |
| Changes to Phase Margin | 3 |
| Changes to Table 2 | 4 |
| Changes to Figure 30 | 10 |
| Updated Outline Dimensions | 12 |
| Changes to Ordering Guide | 13 |

2/06—Rev. C to Rev. D

| | |
|----------------------|-----------|
| Updated Format | Universal |
|----------------------|-----------|

| | |
|---|----|
| Theory of Operation | 9 |
| Input Overvoltage Protection | 9 |
| Output Phase Reversal | 10 |
| Power Dissipation | 10 |
| Thermal Pad—AD8567 | 10 |
| Total Harmonic Distortion + Noise (THD + N) | 11 |
| Short-Circuit Output Conditions | 11 |
| LCD Panel Applications | 11 |
| Outline Dimensions | 12 |
| Ordering Guide | 13 |

| | |
|--|----|
| Changes to Figure 6 and Figure 8 | 5 |
| Added the Thermal Pad—AD8567 Section | 10 |
| Changes to Ordering Guide | 13 |

3/04—Rev. B to Rev. C

| | |
|---------------------------------|---|
| Changes to Specifications | 2 |
| Changes to TPC 4 | 4 |
| Changes to TPC 10 | 5 |
| Changes to TPC 14 | 6 |
| Changes to TPC 20 | 7 |

12/03—Rev. A to Rev. B

| | |
|----------------------------------|----|
| Updated Ordering Guide | 3 |
| Updated Outline Dimensions | 11 |

10/01—Rev. 0 to Rev. A

| | |
|---|---|
| Edit to 16-Lead CSP and 5-Lead SC70 Pin Configuration | 1 |
| Edit to Ordering Guide | 3 |

7/01—Revision 0: Initial Version

SPECIFICATIONS

ELECTRICAL CHARACTERISTICS

4.5 V ≤ V_S ≤ 16 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 | V _{OS} | | | 2 | 10 | mV |
| Offset Voltage Drift | ΔV _{OS} /ΔT | −40°C ≤ T _A ≤ +85°C | | 5 | | μV/°C |
| Input Bias Current | I _B | −40°C ≤ T _A ≤ +85°C | | 80 | 600 | nA |
| | | | | | 800 | nA |
| Input Offset Current | I _{OS} | −40°C ≤ T _A ≤ +85°C | | 1 | 80 | nA |
| | | | | | 130 | nA |
| Input Voltage Range | | Common-mode input | −0.5 | | V _S + 0.5 | V |
| Common-Mode Rejection Ratio | CMRR | V _{CM} = 0 V to V _S , −40°C ≤ T _A ≤ +85°C | 54 | 95 | | dB |
| Large Signal Voltage Gain | A _{VO} | R _L = 10 kΩ, V _O = 0.5 V to (V _S − 0.5 V) | 3 | 10 | | V/mV |
| Input Impedance | Z _{IN} | | | 400 | | kΩ |
| Input Capacitance | C _{IN} | | | 1 | | pF |
| OUTPUT CHARACTERISTICS | | | | | | |
| Output Voltage High | V _{OH} | I _L = 100 μA V _S = 16 V, I _L = 5 mA −40°C ≤ T _A ≤ +85°C | 15.85 | V _S − 0.005 15.95 | | V |
| | | V _S = 4.5 V, I _L = 5 mA −40°C ≤ T _A ≤ +85°C | 15.75 | | | V |
| | | | 4.2 | 4.38 | | V |
| | | | 4.1 | | | V |
| Output Voltage Low | V _{OL} | I _L = 100 μA V _S = 16 V, I _L = 5 mA −40°C ≤ T _A ≤ +85°C | | 5 | | mV |
| | | V _S = 4.5 V, I _L = 5 mA −40°C ≤ T _A ≤ +85°C | | 42 | 150 | mV |
| | | | | | 250 | mV |
| | | | | 95 | 300 | mV |
| | | | | | 400 | mV |
| Continuous Output Current | I _{OUT} | −40°C ≤ T _A ≤ +85°C | | 35 | | mA |
| Peak Output Current | I _{PK} | V _S = 16 V | | 250 | | mA |
| POWER SUPPLY | | | | | | |
| Supply Voltage | V _S | | 4.5 | | 16 | V |
| Power Supply Rejection Ratio | PSRR | V _S = 4 V to 17 V, −40°C ≤ T _A ≤ +85°C | 70 | 90 | | dB |
| Supply Current/Amplifier | I _{SY} | V _O = V _S /2, no load −40°C ≤ T _A ≤ +85°C | | 700 | 850 | μA |
| | | | | | 1 | mA |
| DYNAMIC PERFORMANCE | | | | | | |
| Slew Rate | SR | R _L = 10 kΩ, C _L = 200 pF | 4 | 6 | | V/μs |
| Gain Bandwidth Product | GBP | R _L = 10 kΩ, C _L = 10 pF | | 5 | | MHz |
| Phase Margin | ∅ _m | R _L = 10 kΩ, C _L = 10 pF | | 65 | | Degrees |
| Channel Separation | | | | 75 | | dB |
| NOISE PERFORMANCE | | | | | | |
| Voltage Noise Density | e _n | f = 1 kHz | | 26 | | nV/√Hz |
| | e _n | f = 10 kHz | | 25 | | nV/√Hz |
| Current Noise Density | i _n | f = 10 kHz | | 0.8 | | pA/√Hz |

ABSOLUTE MAXIMUM RATINGS

Table 2.

| Parameter | Rating |
|--------------------------------------|---|
| Supply Voltage (V_S) | 18 V |
| Input Voltage | $-0.5\text{ V to }V_S + 0.5\text{ V}$ |
| Differential Input Voltage | V_S |
| Storage Temperature Range | $-65^{\circ}\text{C to }+150^{\circ}\text{C}$ |
| Operating Temperature Range | $-40^{\circ}\text{C to }+85^{\circ}\text{C}$ |
| Junction Temperature Range | $-65^{\circ}\text{C to }+150^{\circ}\text{C}$ |
| Lead Temperature (Soldering, 60 sec) | 300°C |

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; 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 worst-case conditions, that is, for a device soldered onto a circuit board for surface-mount packages.

Table 3. Thermal Resistance

| Package Type | θ_{JA} | θ_{JC} | Unit |
|-------------------------|---------------|---------------|----------------------|
| 5-Lead SC70 (KS-5) | 376 | 126 | $^{\circ}\text{C/W}$ |
| 8-Lead MSOP (RM-8) | 210 | 45 | $^{\circ}\text{C/W}$ |
| 14-Lead TSSOP (RU-14) | 180 | 35 | $^{\circ}\text{C/W}$ |
| 16-Lead LFCSP (CP-16-4) | 38^1 | 30^1 | $^{\circ}\text{C/W}$ |

¹ DAP is soldered down to PCB.

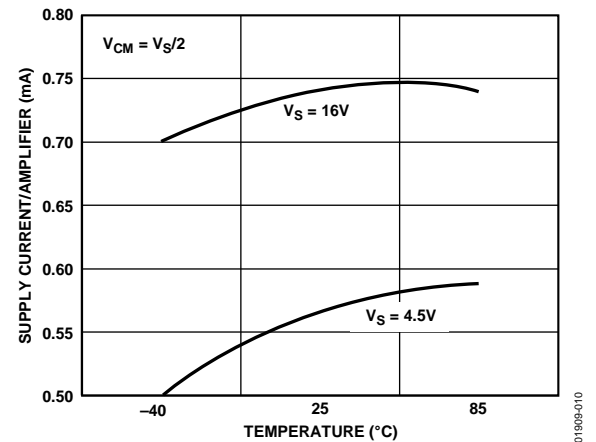
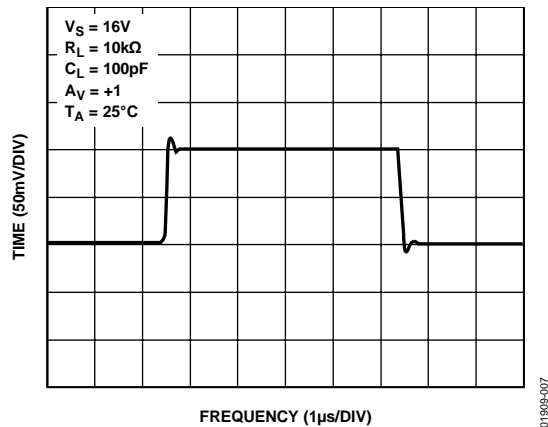
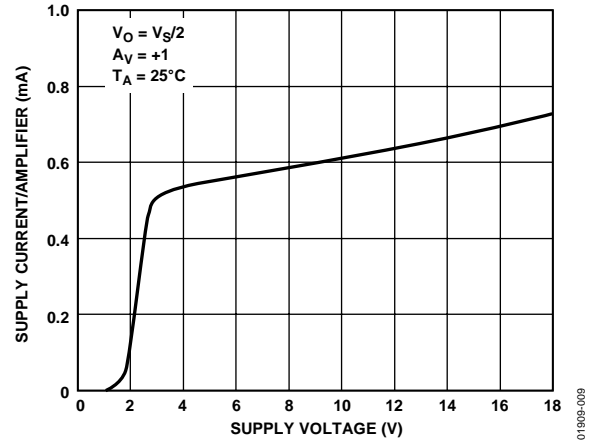
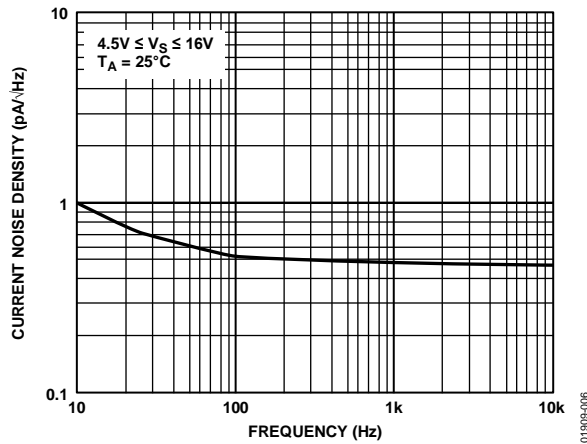
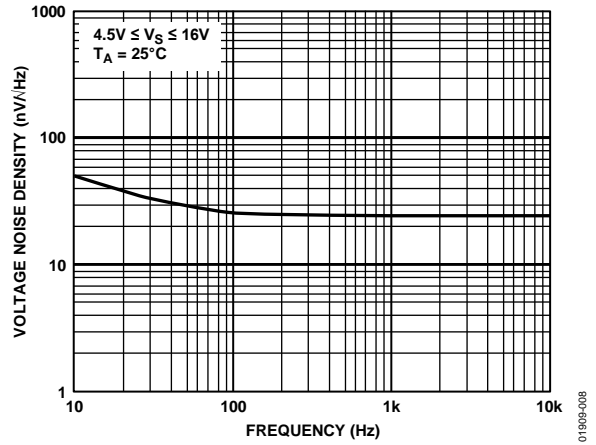
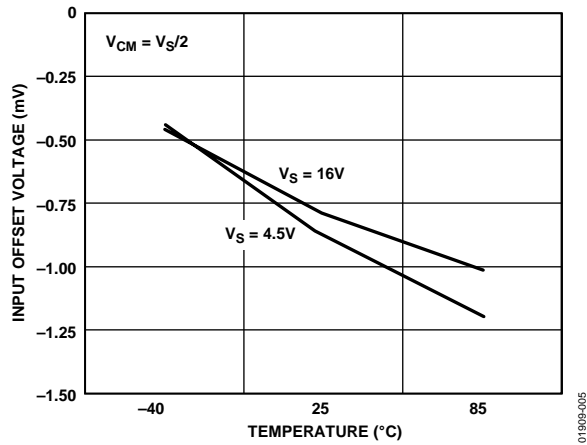
ESD CAUTION



ESD (electrostatic discharge) sensitive device.

Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

TYPICAL PERFORMANCE CHARACTERISTICS



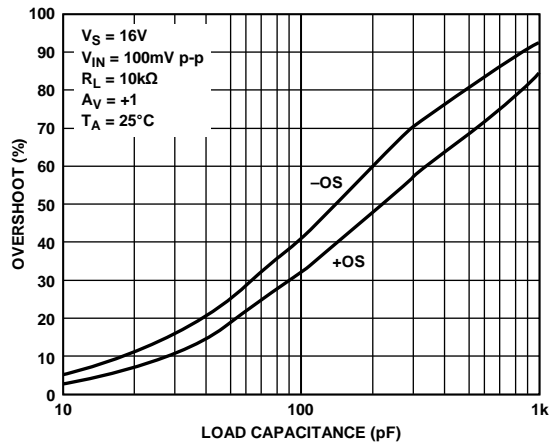


Figure 11. Small Signal Overshoot vs. Load Capacitance

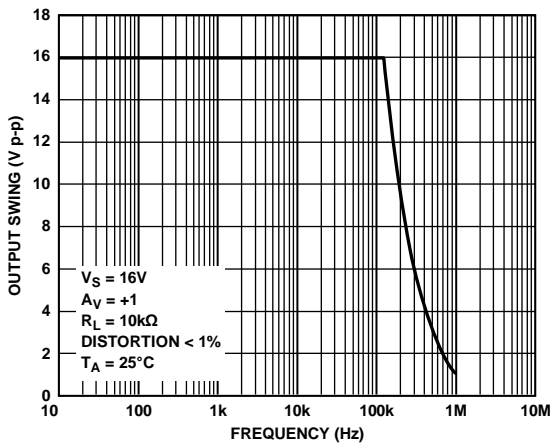


Figure 12. Closed-Loop Output Swing vs. Frequency

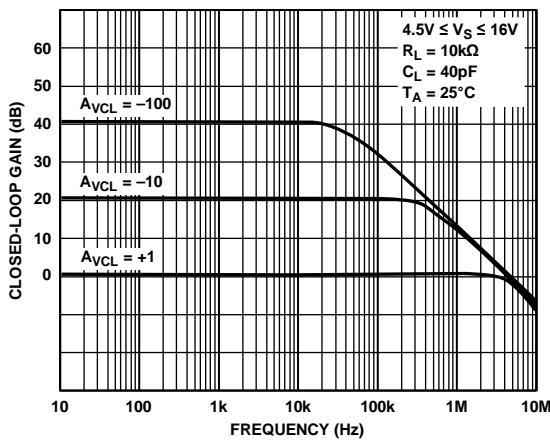


Figure 13. Closed-Loop Gain vs. Frequency

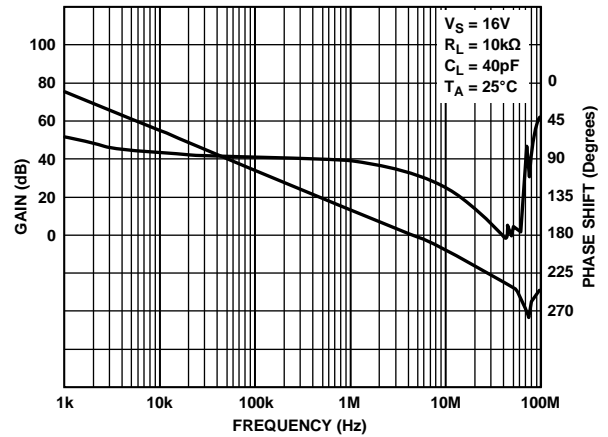


Figure 14. Open-Loop Gain and Phase Shift vs. Frequency

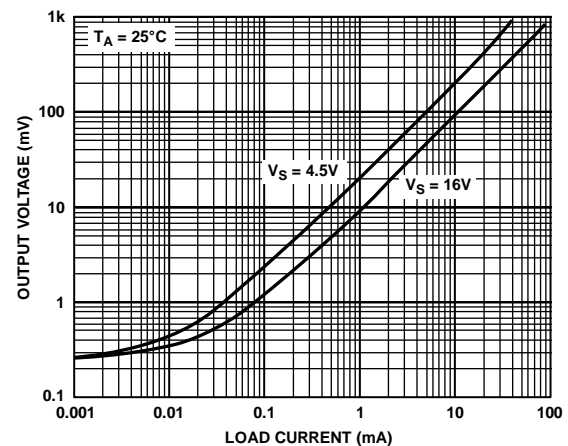


Figure 15. Output Voltage to Supply Rail vs. Load Current

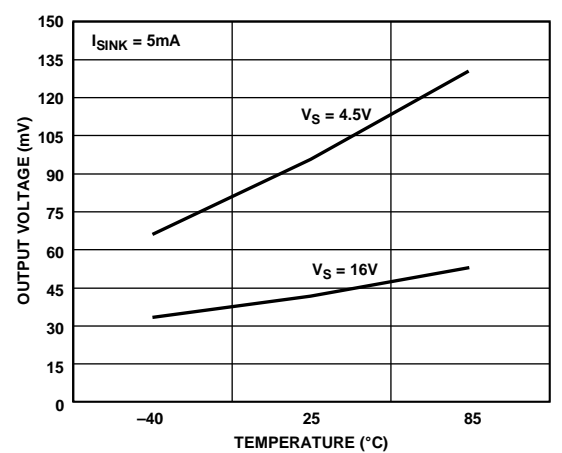


Figure 16. Output Voltage Swing to Rail vs. Temperature

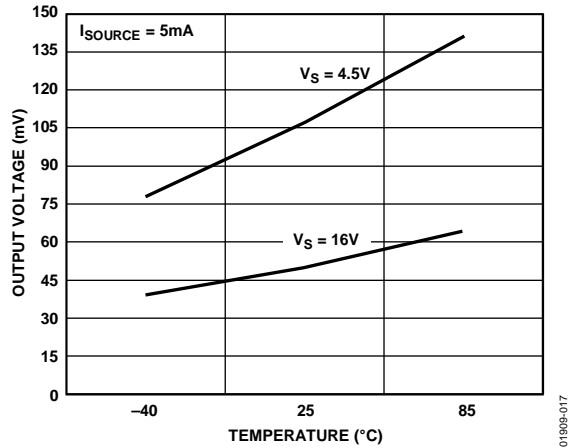


Figure 17. Output Voltage Swing to Rail vs. Temperature

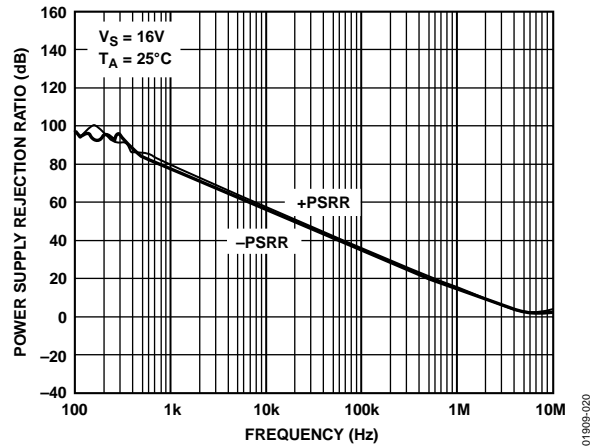


Figure 20. Power Supply Rejection Ratio vs. Frequency

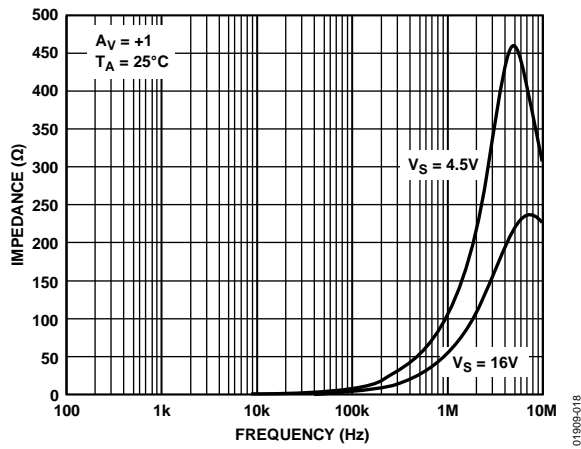


Figure 18. Closed-Loop Output Impedance vs. Frequency

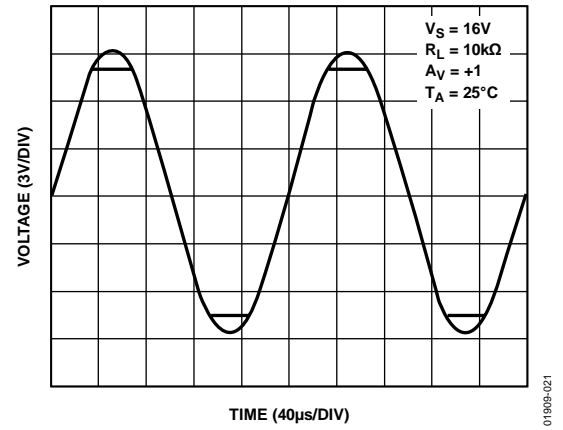


Figure 21. No Phase Reversal

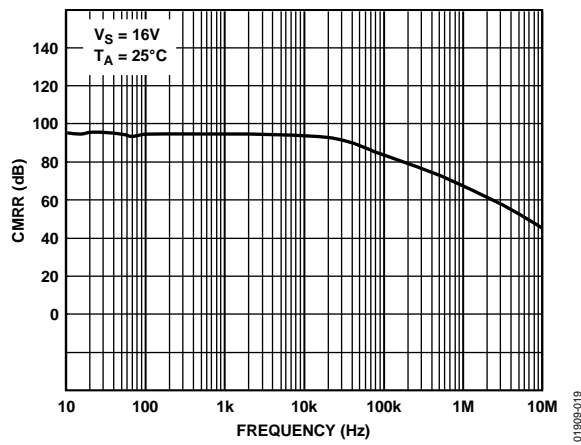


Figure 19. Common-Mode Rejection Ratio (CMRR) vs. Frequency

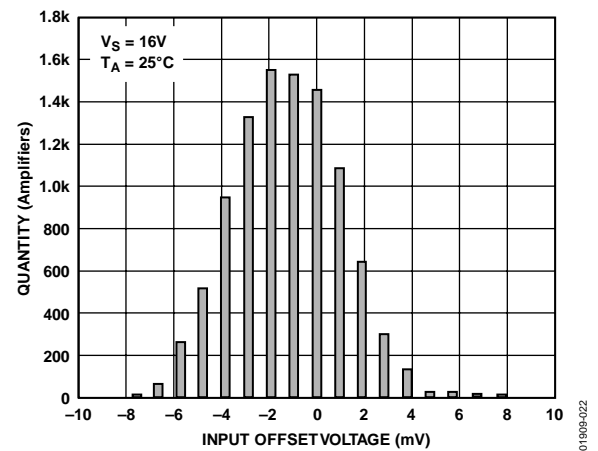


Figure 22. Input Offset Voltage Distribution

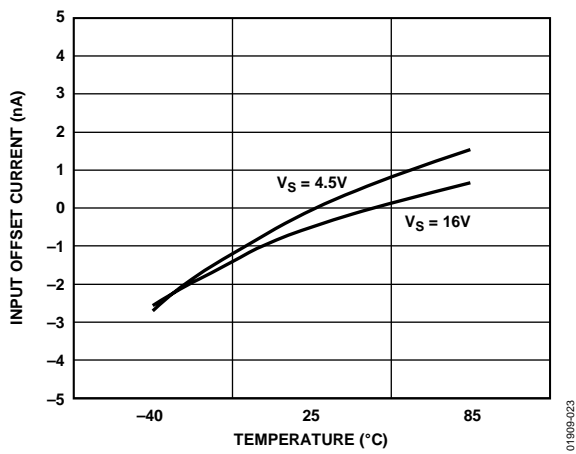


Figure 23. Input Offset Current vs. Temperature

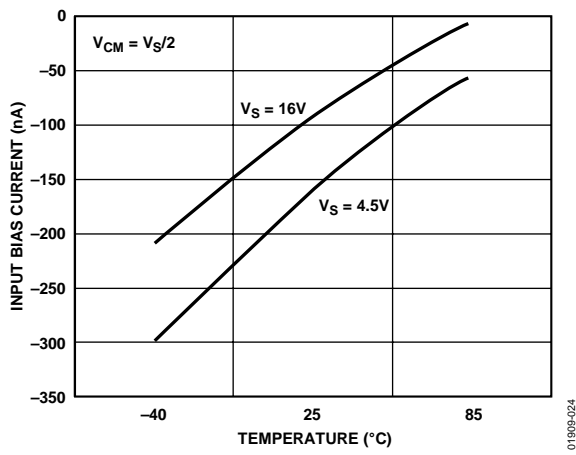


Figure 24. Input Bias Current vs. Temperature

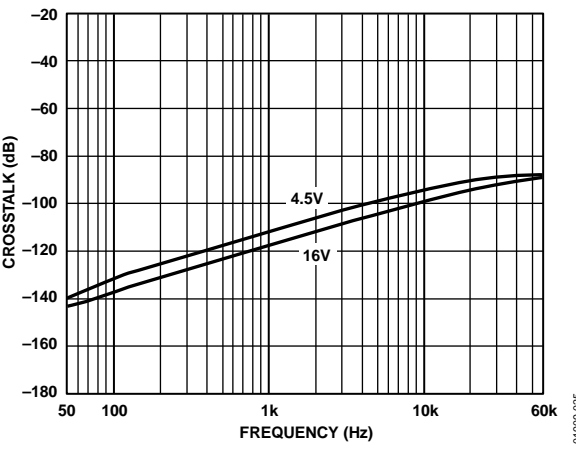


Figure 25. Channel A vs. Channel B Crosstalk

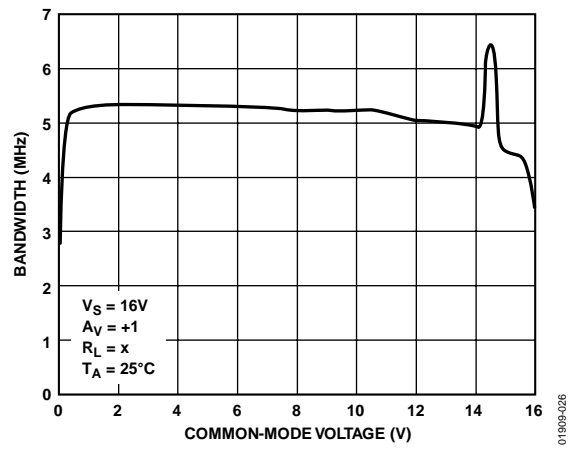


Figure 26. Frequency vs. Common-Mode Voltage ($V_S = 16 V$)

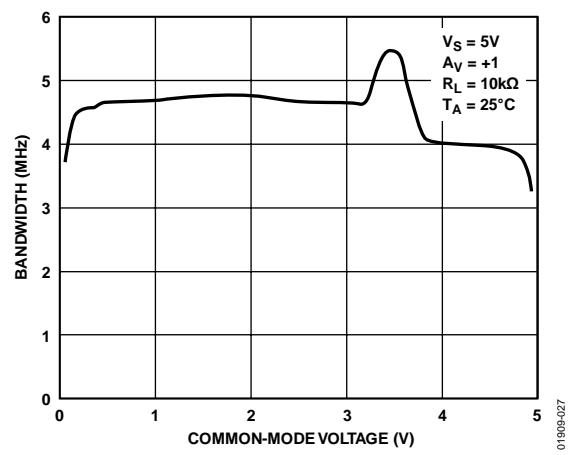


Figure 27. Frequency vs. Common-Mode Voltage ($V_S = 5 V$)

THEORY OF OPERATION

The AD8565/AD8566/AD8567 are designed to drive large capacitive loads in LCD applications. They have high output current drive and rail-to-rail input/output operation and are powered from a single 16 V supply. They are also intended for other applications where low distortion and high output current drive are needed.

Figure 28 shows a simplified equivalent circuit for the AD8565/AD8566/AD8567. The rail-to-rail bipolar input stage is composed of two PNP differential pairs, Q4 to Q5 and Q10 to Q11, operating in series with diode protection networks, D1 to D2. Diode network D1 to D2 serves as protection against large transients for Q4 to Q5 to accommodate rail-to-rail input swing. D5 to D6 protect Q10 to Q11 against Zenering. In normal operation, Q10 to Q11 are off, and their input stage is buffered from the operational amplifier inputs by Q6 to D3 and Q8 to D4.

Operation of the input stage is best understood as a function of applied common-mode voltage: when the inputs of the AD8565/AD8566/AD8567 are biased midway between the supplies, the differential signal path gain is controlled by resistive loads Q4 to Q5 (via R9, R10). As the input common-mode level is reduced toward the negative supply (V_{NEG} or GND), the input transistor current sources, I1 and I2, are forced into saturation, thereby forcing the Q6 to D3 and Q8 to D4 networks into cutoff. However, Q4 to Q5 remain active, providing input stage gain.

Inversely, when common-mode input voltage is increased toward the positive supply, Q4 to Q5 are driven into cutoff, Q3 is driven into saturation, and Q4 becomes active, providing bias to the Q10 to Q11 differential pair. The point at which the Q10 to Q11 differential pair becomes active is approximately equal to ($V_{POS} - 1$ V).

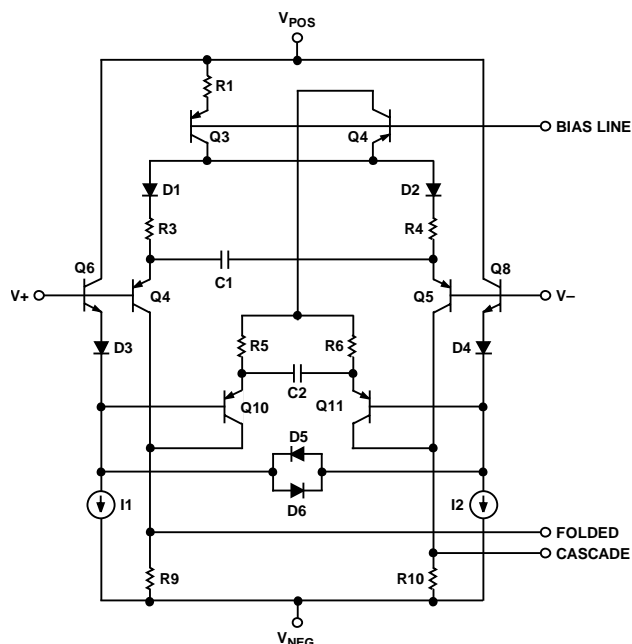


Figure 28. AD8565/AD8566/AD8567 Equivalent Input Circuit

The benefit of this type of input stage is low bias current. The input bias current is the sum of base currents of Q4 to Q5 and Q6 to Q8 over the range from ($V_{NEG} + 1$ V) to ($V_{POS} - 1$ V). Outside this range, the input bias current is dominated by the sum of base currents of Q10 to Q11 for input signals close to V_{NEG} and of Q6 to Q8 (Q10 to Q11) for signals close to V_{POS} . From this type of design, the input bias current of the AD8565/AD8566/AD8567 not only exhibits different amplitude but also exhibits different polarities. Figure 29 provides the characteristics of the input bias current vs. the common-mode voltage. It is important to keep in mind that the source impedances driving the inputs are balanced for optimum dc and ac performance.

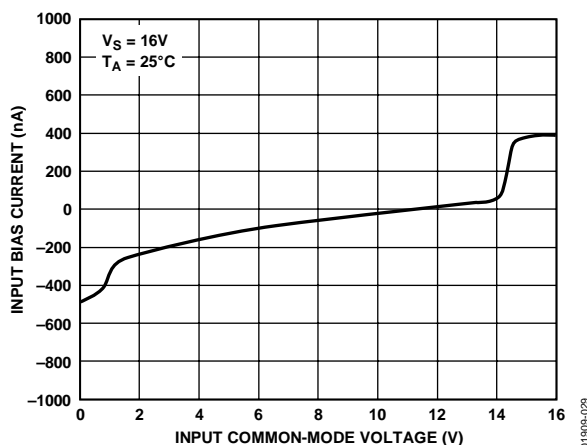


Figure 29. AD8565/AD8566/AD8567 Input Bias Current vs. Common-Mode Voltage

To achieve rail-to-rail output performance, the AD8565/AD8566/AD8567 design uses a complementary common-source (or gmRL) output. This configuration allows output voltages to approach the power supply rails, particularly if the output transistors are allowed to enter the triode region on extremes of signal swing, which are limited by V_{GS} , the transistor sizes, and output load current. In addition, this type of output stage exhibits voltage gain in an open-loop gain configuration. The amount of gain depends on the total load resistance at the output of the AD8565/AD8566/AD8567.

INPUT OVERVOLTAGE PROTECTION

As with any semiconductor device, whenever the input exceeds either supply voltages, attention needs to be paid to the input overvoltage characteristics. As an overvoltage occurs, the amplifier could be damaged, depending on the voltage level and the magnitude of the fault current. When the input voltage exceeds either supply by more than 0.6 V, internal positive-negative (pn) junctions allow current to flow from the input to the supplies.

AD8565/AD8566/AD8567

This input current is not inherently damaging to the device as long as it is limited to 5 mA or less. If a condition exists using the AD8565/AD8566/AD8567 where the input exceeds the supply more than 0.6 V, an external series resistor should be added. The size of the resistor can be calculated by using the maximum over-voltage divided by 5 mA. This resistance should be placed in series with either input exposed to an overvoltage.

OUTPUT PHASE REVERSAL

The AD8565/AD8566/AD8567 are immune to phase reversal. Although device output does not change phase, large currents due to input overvoltage could damage the device. In applications where the possibility of an input voltage exceeding the supply voltage exists, overvoltage protection should be used as described in the Input Overvoltage Protection section.

POWER DISSIPATION

The maximum allowable internal junction temperature of 150°C limits the maximum power dissipation of AD8565/AD8566/AD8567 devices. As the ambient temperature increases, the maximum power dissipated by AD8565/AD8566/AD8567 devices must decrease linearly to maintain maximum junction temperature. If this maximum junction temperature is exceeded momentarily, the device still operates properly once the junction temperature is reduced below 150°C. If the maximum junction temperature is exceeded for an extended period, overheating could lead to permanent damage of the device.

The maximum safe junction temperature, T_{JMAX} , is 150°C. Using the following formula, the maximum power that an AD8565/AD8566/AD8567 device can safely dissipate as a function of temperature can be obtained:

$$P_{DISS} = T_{JMAX} - T_A / \theta_{JA}$$

where:

P_{DISS} is the AD8565/AD8566/AD8567 power dissipation.

T_{JMAX} is the AD8565/AD8566/AD8567 maximum allowable junction temperature (150°C).

T_A is the ambient temperature of the circuit.

θ_{JA} is the AD8565/AD8566/AD8567 package thermal resistance, junction-to-ambient.

The power dissipated by the device can be calculated as

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

where:

V_S is the supply voltage.

V_{OUT} is the output voltage.

I_{LOAD} is the output load current.

Figure 30 shows the maximum power dissipation vs. temperature. To achieve proper operation, use the previous equation to calculate P_{DISS} for a specific package at any given temperature or use Figure 30.

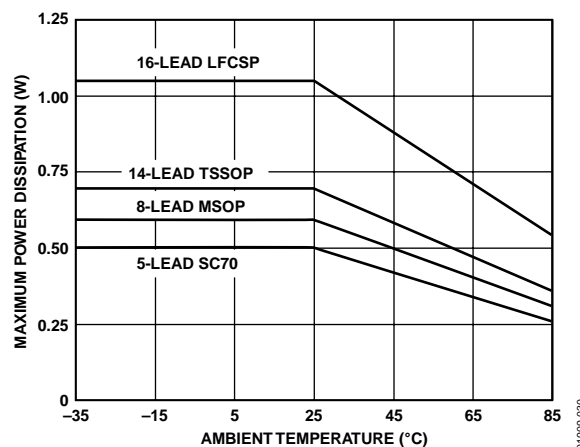


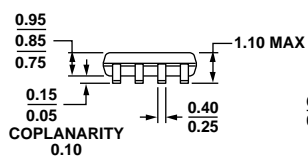
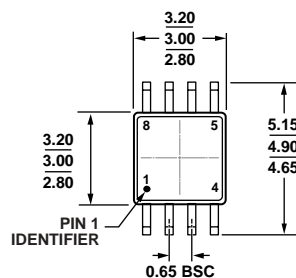
Figure 30. Maximum Power Dissipation vs. Temperature for 5-Lead SC70, 8-Lead MSOP, 14-Lead TSSOP, and 16-Lead LFCSP Packages

THERMAL PAD—AD8567

The AD8567 LFCSP comes with a thermal pad that is attached to the substrate. This substrate is connected to the most positive supply, that is, Pin 3 in the LFCSP package and Pin 4 in the TSSOP package. To be electrically safe, the thermal pad should be soldered to an area on the board that is electrically isolated or connected to V_{DD} . Attaching the thermal pad to ground adversely affects the performance of the part.

Soldering down this thermal pad dramatically improves the heat dissipation of the package. It is necessary to attach vias that connect the soldered thermal pad to another layer on the board. This provides an avenue to dissipate the heat away from the part. Without vias, the heat is isolated directly under the part.

OUTLINE DIMENSIONS

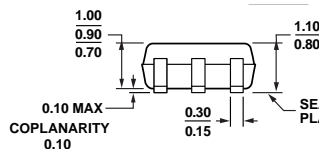
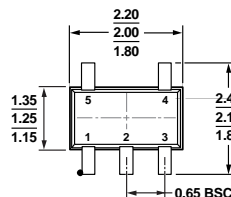


COMPLIANT TO JEDEC STANDARDS MO-187-AA

Figure 34. 8-Lead Mini Small Outline Package [MSOP] (RM-8)

Dimensions shown in millimeters

100708-B

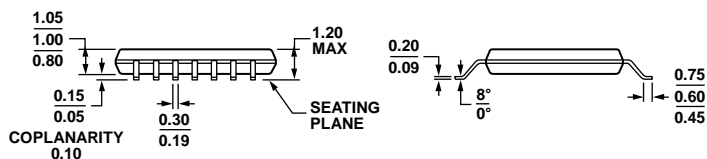
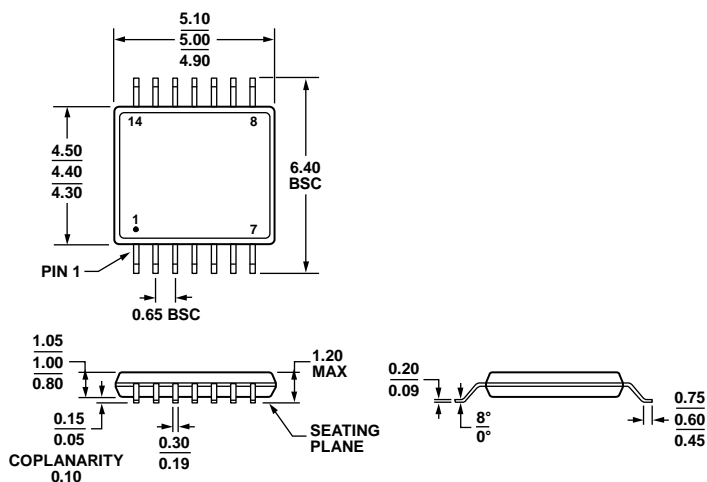


COMPLIANT TO JEDEC STANDARDS MO-203-AA

Figure 35. 5-Lead Thin Shrink Small Outline Transistor Package [SC70] (KS-5)

Dimensions shown in millimeters

072809-A

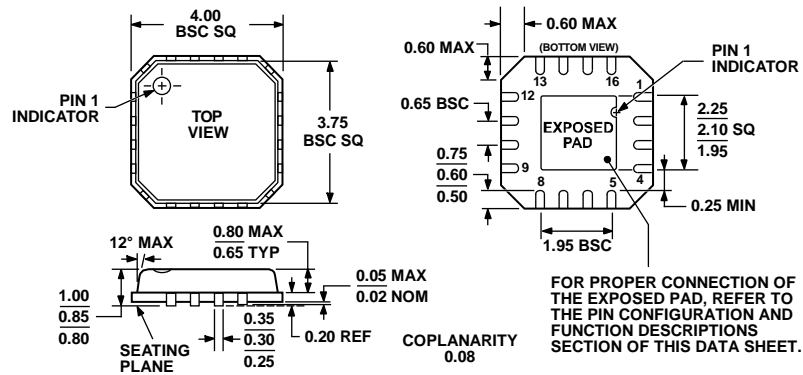


COMPLIANT TO JEDEC STANDARDS MO-153-AB-1

Figure 36. 14-Lead Thin Shrink Small Outline Package [TSSOP] (RU-14)

Dimensions shown in millimeters

061900-A



COMPLIANT TO JEDEC STANDARDS MO-220-VGGC

Figure 37. 16-Lead Lead Frame Chip Scale Package [LFCSP_VQ]
 4 mm × 4 mm Body, Very Thin Quad
 (CP-16-4)
 Dimensions shown in millimeters

072808-A

ORDERING GUIDE

| Model ¹ | Abs Max (V) | Temperature Range | Package Description | Package Option | Branding |
|-------------------------------|-------------|-------------------|--|----------------|----------|
| AD8565AKSZ-REEL7 | 18 | −40°C to +85°C | 5-Lead Thin Shrink Small Outline Transistor Package (SC70) | KS-5 | A0N |
| AD8566ARM-R2 | 18 | −40°C to +85°C | 8-Lead Mini Small Outline Package (MSOP) | RM-8 | ATA |
| AD8566ARM-REEL | 18 | −40°C to +85°C | 8-Lead Mini Small Outline Package (MSOP) | RM-8 | ATA |
| AD8566ARMZ-R2 | 18 | −40°C to +85°C | 8-Lead Mini Small Outline Package (MSOP) | RM-8 | ATA# |
| AD8566ARMZ-REEL | 18 | −40°C to +85°C | 8-Lead Mini Small Outline Package (MSOP) | RM-8 | ATA# |
| AD8566WARMZ-REEL ² | 18 | −40°C to +85°C | 8-Lead Mini Small Outline Package (MSOP) | RM-8 | LG3 |
| AD8567ARU | 18 | −40°C to +85°C | 14-Lead Thin Shrink Small Outline Package (TSSOP) | RU-14 | |
| AD8567ARU-REEL | 18 | −40°C to +85°C | 14-Lead Thin Shrink Small Outline Package (TSSOP) | RU-14 | |
| AD8567ARUZ | 18 | −40°C to +85°C | 14-Lead Thin Shrink Small Outline Package (TSSOP) | RU-14 | |
| AD8567ARUZ-REEL | 18 | −40°C to +85°C | 14-Lead Thin Shrink Small Outline Package (TSSOP) | RU-14 | |
| AD8567ACP-R2 | 18 | −40°C to +85°C | 16-Lead Lead Frame Chip Scale Package (LFCSP_VQ) | CP-16-4 | |
| AD8567ACP-REEL7 | 18 | −40°C to +85°C | 16-Lead Lead Frame Chip Scale Package (LFCSP_VQ) | CP-16-4 | |
| AD8567ACPZ-R2 | 18 | −40°C to +85°C | 16-Lead Lead Frame Chip Scale Package (LFCSP_VQ) | CP-16-4 | |
| AD8567ACPZ-REEL | 18 | −40°C to +85°C | 16-Lead Lead Frame Chip Scale Package (LFCSP_VQ) | CP-16-4 | |
| AD8567ACPZ-REEL7 | 18 | −40°C to +85°C | 16-Lead Lead Frame Chip Scale Package (LFCSP_VQ) | CP-16-4 | |

¹ Z = RoHS Compliant Part.² Qualified for automotive applications.

AD8565/AD8566/AD8567

NOTES

NOTES

NOTES

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Analog Devices Inc.:](#)

[AD8565AKSZ-REEL7](#) [AD8566ARMZ-R2](#) [AD8567ARUZ](#) [AD8566ARMZ-REEL](#) [AD8567ACPZ-R2](#) [AD8567ACPZ-REEL](#) [AD8567ARUZ-REEL](#) [AD8567ACPZ-REEL7](#)