ANALOG DEVICES

## 64-Position OTP Digital Potentiometer

## FEATURES

64-position
One-time programmable (OTP) ${ }^{1}$ set-and-forget resistance setting-low cost alternative over EEMEM
Unlimited adjustments prior to OTP activation
$5 \mathrm{k} \Omega, 10 \mathrm{k} \Omega, 50 \mathrm{k} \Omega, 100 \mathrm{k} \Omega$ end-to-end resistance
Low tempco $5 \mathrm{ppm} /{ }^{\circ} \mathrm{C}$ in potentiometer mode
Low tempco $35 \mathrm{ppm} /{ }^{\circ} \mathrm{C}$ in rheostat mode
Compact standard SOT-23-8 package
Low power, $\mathrm{I}_{\mathrm{DD}}=10 \mu \mathrm{~A}$ max
Fast settling time, $\mathrm{t}_{\mathrm{s}}=5 \boldsymbol{\mu}$ styp in power-up
$I^{2} \mathrm{C}^{\ominus}$-compatible digital interface
Computer software replaces $\mu \mathrm{C}$ in factory programming applications
Full read/write of wiper register
Extra $I^{2} \mathrm{C}$ device address pin
Low operating voltage, 2.7 V to 5.5 V
OTP validation check function
Automotive temperature range $-40^{\circ} \mathrm{C}$ to $+125^{\circ} \mathrm{C}$

## APPLICATIONS

## System calibrations

Electronics level settings
Mechanical Trimmers ${ }^{\circledR}$ and potentiometer replacements
Automotive electronics adjustments
Gain control and offset adjustments
Transducer circuit adjustments
Programmable filters up to $1.5 \mathrm{MHz} \mathrm{BW}^{3}$

## GENERAL DESCRIPTION

The AD5171 is a 64-position, one-time programmable (OTP) digital potentiometer ${ }^{2}$ that uses fuse link technology to achieve the memory retention of the resistance setting function. OTP is a cost-effective alternative over the EEMEM approach for users who do not need to reprogram new memory settings in the digital potentiometer. This device performs the same electronic adjustment function as most mechanical trimmers and variable resistors. The AD5171 is programmed using a 2 -wire $\mathrm{I}^{2} \mathrm{C}$ compatible digital control. It allows unlimited adjustments before permanently setting the resistance value. During the OTP activation, a permanent fuse blown command is sent after the final value is determined, freezing the wiper position at a given setting (analogous to placing epoxy on a mechanical trimmer). When this permanent setting is achieved, the value does not change regardless of supply variations or environmental

## Rev. B

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stresses under normal operating conditions. To verify the success of permanent programming, Analog Devices patterned the OTP validation such that the fuse status can be discerned from two validation bits in read mode.

For applications that program the AD5171 in factories, Analog Devices offers device programming software that operates across Windows 95 to XP platforms, including Windows NT. This software application effectively replaces the need for external $\mathrm{I}^{2} \mathrm{C}$ controllers or host processors and therefore significantly reduces users' development time.

An AD5171 evaluation kit includes the software, connector, and cable that can be converted for factory programming applications.

The AD5171 is available in a compact SOT-23-8 package. All parts are guaranteed to operate over the automotive temperature range of $-40^{\circ} \mathrm{C}$ to $+125^{\circ} \mathrm{C}$. Besides its unique OTP feature, the AD5171 lends itself well to other general-purpose digital potentiometer applications due to its temperature performance, small form factor, and low cost.


Figure 1. Functional Block Diagram


Figure 2. Pin Configuration
${ }^{1}$ OTP allows unlimited adjustments before permanent setting.
${ }^{2}$ The terms digital potentiometer and RDAC are used interchangeably.
${ }^{3}$ Applies to $5 \mathrm{k} \Omega$ parts only.

## AD5171

## TABLE OF CONTENTS

Electrical Characteristics ..... 3
Absolute Maximum Ratings .....  6
ESD Caution .....  .6
Pin Configuration and Function Descriptions. .....  7
Typical Performance Characteristics .....  8
Theory of Operation ..... 12
One-Time Programming (OTP) ..... 12
Power Supply Considerations ..... 12
ESD Protection ..... 13
Terminal Voltage Operating Range. ..... 13
Power-Up/Power-Down Sequences ..... 14
Variable Resistance and Voltage for Rheostat Mode ..... 14
Variable Resistance and Voltage for Potentiometer Mode. ..... 15
Controlling the AD5171. ..... 16
Software Programming. ..... 16
REVISION HISTORY
1/05—Rev. A to Rev. B
Change to Features .....  1
Changes to Electrical Characteristics .....  3
Change to Table 3 ..... 6
Changes to Power Supply Considerations Section ..... 13
Changes to Level Shifting for Different Voltage Operation Section ..... 19
Added Note to Ordering Guide ..... 22
11/04—Rev. 0 to Rev. A
Changes to Specifications .....  3
Changes to Table 3 ..... 7
Changes to One-Time Programming Section ..... 11
Changes to Power Supply Consideration Section ..... 11
Changes to Figure 26 and Figure 27 ..... 12
1/04—Revision 0: Initial Version
$\mathrm{I}^{2} \mathrm{C}$ Controller Programming. ..... 17
$\mathrm{I}^{2} \mathrm{C}$-Compatible 2-Wire Serial Bus. ..... 18
Controlling Two Devices on One Bus ..... 18
Applications ..... 19
DAC. ..... 19
Gain Control Compensation ..... 19
Programmable Voltage Source with Boosted Output ..... 19
Level Shifting for Different Voltage Operation ..... 19
Resistance Scaling ..... 19
Resolution Enhancement ..... 20
RDAC Circuit Simulation Model ..... 20
Evaluation Board ..... 21
Outline Dimensions ..... 22
Ordering Guide ..... 22

## ELECTRICAL CHARACTERISTICS

$5 \mathrm{k} \Omega, 10 \mathrm{k} \Omega, 50 \mathrm{k} \Omega$, and $100 \mathrm{k} \Omega$ versions; $\mathrm{V}_{\mathrm{DD}}=3 \mathrm{~V}$ to $5 \mathrm{~V} \pm 10 \%, \mathrm{~V}_{\mathrm{A}}=\mathrm{V}_{\mathrm{DD}}, \mathrm{V}_{\mathrm{B}}=0 \mathrm{~V},-40^{\circ} \mathrm{C}<\mathrm{T}_{\mathrm{A}}<+125^{\circ} \mathrm{C}$, unless otherwise noted.
Table 1.

| Parameter | Symbol | Conditions | Min | Typ ${ }^{1}$ | Max | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| DC CHARACTERISTICS RHEOSTAT MODE |  |  |  |  |  |  |
| Resistor Differential Nonlinearity ${ }^{2}$ | R-DNL | $\begin{aligned} & \mathrm{R}_{\mathrm{WB}}, \mathrm{~V}_{\mathrm{A}}=\text { no connect, } \\ & \mathrm{R}_{\mathrm{AB}}=10 \mathrm{k} \Omega, 50 \mathrm{k} \Omega \text {, and } 100 \mathrm{k} \Omega \end{aligned}$ | -0.5 | $\pm 0.1$ | +0.5 | LSB |
|  |  | $\mathrm{R}_{\mathrm{WB},}, \mathrm{V}_{\mathrm{A}}=$ no connect, $\mathrm{R}_{A B}=5 \mathrm{k} \Omega$ | -1 | $\pm 0.25$ | +1 | LSB |
| Resistor Integral Nonlinearity ${ }^{2}$ | R-INL | Rwb, $V_{A}=$ no connect, <br> $\mathrm{R}_{A B}=10 \mathrm{k} \Omega, 50 \mathrm{k} \Omega$, and $100 \mathrm{k} \Omega$ | -1.5 | $\pm 0.35$ | +1.5 | LSB |
|  |  | $\mathrm{R}_{\mathrm{WB}}, \mathrm{V}_{\mathrm{A}}=$ no connect, $\mathrm{R}_{\text {AB }}=5 \mathrm{k} \Omega$ | -1.5 | $\pm 0.5$ | +1.5 | LSB |
| Nominal Resistor Tolerance ${ }^{3}$ | $\Delta \mathrm{R}_{\text {AB }} / \mathrm{R}_{\text {AB }}$ |  | -30 |  | +30 |  |
| Resistance Temperature Coefficient | $\left(\Delta R_{A B} / R_{A B}\right) / \Delta T$ |  |  | 35 |  | ppm/ ${ }^{\circ} \mathrm{C}$ |
| Wiper Resistance | Rw | $V_{D D}=5 \mathrm{~V}$ |  | 60 | 115 | $\Omega$ |
| DC CHARACTERISTICS POTENTIOMETER DIVIDER MODE (Specifications apply to all RDACs) |  |  |  |  |  |  |
| Resolution | N |  |  |  | 6 | Bits |
| Differential Nonlinearity ${ }^{4}$ | DNL |  | -0.5 | $\pm 0.1$ | +0.5 | LSB |
| Integral Nonlinearity ${ }^{4}$ | INL |  | -1 | $\pm 0.2$ | +1 | LSB |
| Voltage Divider Temperature Coefficient | $\left(\Delta V_{W} / V_{\mathrm{w}}\right) / \Delta \mathrm{T}$ | Code $=0 \times 20$ |  | 5 |  | ppm/ ${ }^{\circ} \mathrm{C}$ |
| Full-Scale Error | $\mathrm{V}_{\text {WFSE }}$ | $\begin{aligned} & \text { Code }=0 \times 3 \mathrm{~F}, \mathrm{R}_{A B}=10 \mathrm{k} \Omega \text {, } \\ & 50 \mathrm{k} \Omega \text {, and } 100 \mathrm{k} \Omega \end{aligned}$ | -1 | -0.5 | 0 | LSB |
| Full-Scale Error | $V_{\text {wFSE }}$ | Code $=0 \times 3 \mathrm{~F}, \mathrm{R}_{\text {AB }}=5 \mathrm{k} \Omega$ | -1.5 |  | 0 | LSB |
| Zero-Scale Error | VwZSE | $\begin{aligned} & \text { Code }=0 \times 00, \mathrm{R}_{A B}=10 \mathrm{k} \Omega \text {, } \\ & 50 \mathrm{k} \Omega \text {, and } 100 \mathrm{k} \Omega \end{aligned}$ |  | 0.5 | 1 | LSB |
|  |  | Code $=0 \times 00, \mathrm{R}_{\text {AB }}=5 \mathrm{k} \Omega$ | 0 |  | 2 | LSB |
| RESISTOR TERMINALS |  |  |  |  |  |  |
| Voltage Range ${ }^{5}$ | $\mathrm{V}_{\mathrm{A}, \mathrm{B}, \mathrm{W}}$ | With respect to GND |  |  | $V_{D D}$ | V |
| Capacitance ${ }^{7}$ A, B | $C_{A, B}$ | $\mathrm{f}=1 \mathrm{MHz}$, measured to GND, Code $=0 \times 20$ |  | 25 |  | pF |
| Capacitance ${ }^{7}$ W | $C_{w}$ | $\mathrm{f}=1 \mathrm{MHz}$, measured to GND, Code $=0 \times 20$ |  | 55 |  | pF |
| Common-Mode Leakage | Ісм | $\mathrm{V}_{\mathrm{A}}=\mathrm{V}_{\mathrm{B}}=\mathrm{V}_{\mathrm{DD}} / 2$ |  | 1 |  | nA |
| DIGITAL INPUTS |  |  |  |  |  |  |
| Input Logic High (SDA and SCL) ${ }^{6}$ | $\mathrm{V}_{\mathrm{H}}$ |  | 0.7 VDD |  | $\mathrm{V}_{\mathrm{DD}}+0.5$ | V |
| Input Logic Low (SDA and SCL) ${ }^{6}$ | $\mathrm{V}_{\text {IL }}$ |  | -0.5 |  | $0.3 \mathrm{~V}_{\text {DD }}$ | V |
| Input Logic High (ADO) | $\mathrm{V}_{\text {IH }}$ | $V_{\text {DD }}=3 \mathrm{~V}$ | 3.0 |  | $V_{\text {DD }}$ | V |
| Input Logic Low (ADO) | VIL | $V_{D D}=3 \mathrm{~V}$ | 0 |  | 1.0 | V |
| Input Current | ILL | $\mathrm{V}_{\text {IN }}=0 \mathrm{~V}$ or 5 V |  |  | $\pm 1$ | $\mu \mathrm{A}$ |
| Input Capacitance ${ }^{7}$ | $\mathrm{Cl}_{\text {IL }}$ |  |  | 3 |  | pF |
| DIGITAL OUTPUTS |  |  |  |  |  |  |
| Output Logic Low (SDA) | Voı | $\mathrm{l}_{\mathrm{OL}}=6 \mathrm{~mA}$ |  |  | 0.4 | V |
| Three-State Leakage Current (SDA) | loz | $\mathrm{V}_{\mathrm{IN}}=0 \mathrm{~V}$ or 5 V |  |  | $\pm 1$ | $\mu \mathrm{A}$ |
| Output Capacitance ${ }^{7}$ | Coz |  |  | 3 |  | pF |
| POWER SUPPLIES |  |  |  |  |  |  |
| Power Supply Range | $\mathrm{V}_{\mathrm{DD}}$ |  | 2.7 |  | 5.5 | V |
| OTP Power Supply ${ }^{6,8}$ | VDD_OTP | $\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$ | 5.25 |  | 5.5 | V |
| Supply Current | ldo | $\mathrm{V}_{\mathrm{H}}=5 \mathrm{~V}$ or $\mathrm{V}_{\mathrm{IL}}=0 \mathrm{~V}$ |  | 4 | 10 | $\mu \mathrm{A}$ |
| OTP Supply Current ${ }^{6,9}$ | IDD_otp | $V_{\text {DD_OTP }}=5.5 \mathrm{~V}, \mathrm{~T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$ | 100 |  |  | mA |
| Power Dissipation ${ }^{10}$ | PDISS | $\mathrm{V}_{\mathrm{IH}}=5 \mathrm{~V}$ or $\mathrm{V}_{\mathrm{IL}}=0 \mathrm{~V}, \mathrm{~V}_{\mathrm{DD}}=5 \mathrm{~V}$ |  | 0.02 | 0.04 | mW |
| Power Supply Sensitivity | PSSR |  | -0.025 | +0.001 | +0.025 | \%/\% |

## AD5171


${ }^{1}$ Typical specifications represent average readings at $25^{\circ} \mathrm{C}$ and $\mathrm{V}_{D D}=5 \mathrm{~V}$.
${ }^{2}$ Resistor position nonlinearity error, R-INL, is the deviation from an ideal value measured between the maximum resistance and the minimum resistance wiper positions. R-DNL measures the relative step change from ideal between successive tap positions. Parts are guaranteed monotonic.
${ }^{3} \mathrm{~V}_{\mathrm{AB}}=\mathrm{V}_{\mathrm{DD}}$, Wiper $\left(\mathrm{V}_{\mathrm{W}}\right)=$ no connect.
${ }^{4} I N L$ and DNL are measured at $V_{W}$ with the RDAC configured as a potentiometer divider similar to a voltage output DAC. $V_{A}=V_{D D}$ and $V_{B}=0 \mathrm{~V}$. DNL specification limits of $\pm 1$ LSB maximum are guaranteed monotonic operating conditions.
${ }^{5}$ Resistor Terminals A, B, W have no limitations on polarity with respect to each other.
${ }^{6}$ The minimum voltage requirement on the $\mathrm{V}_{\mathbb{H}}$ is $0.7 \mathrm{~V} \times \mathrm{V}_{\mathrm{DD}}$. For example, $\mathrm{V}_{\mathbb{H}} \min =3.5 \mathrm{~V}$ when $\mathrm{V}_{\mathrm{DD}}=5 \mathrm{~V}$. It is typical for the SCL and SDA resistors to be pulled up to $V_{D D}$. However, care must be taken to ensure that the minimum $V_{I H}$ is met when the SCL and SDA are driven directly from a low voltage logic controller without pull-up resistors.
${ }^{7}$ Guaranteed by design; not subject to production test.
${ }^{8}$ Different from operating power supply; power supply for OTP is used one time only.
${ }^{9}$ Different from operating current; supply current for OTP lasts approximately 400 ms for one-time need only.
${ }^{10} \mathrm{P}_{\text {DISS }}$ is calculated from (loD $\times \mathrm{V}_{D D}$ ). CMOS logic level inputs result in minimum power dissipation.
${ }^{11}$ Bandwidth, noise, and settling time depend on the terminal resistance value chosen. The lowest $R$ value results in the fastest settling time and highest bandwidth. The highest R value results in the minimum overall power consumption.
${ }^{12}$ All dynamic characteristics use $\mathrm{V}_{\mathrm{DD}}=5 \mathrm{~V}$.
${ }^{13}$ Different from the settling time after the fuse is blown. The OTP settling time occurs only once.


Figure 3. Interface Timing Diagram

## ABSOLUTE MAXIMUM RATINGS

Table 2.

| Parameter | Rating |
| :---: | :---: |
| $V_{\text {DD }}$ to GND | -0.3, +7 V |
| $\mathrm{V}_{\mathrm{A}}, \mathrm{V}_{\mathrm{B}}, \mathrm{V}_{\mathrm{w}}$ to GND | GND, VDD |
| Maximum Current |  |
| IWB, IWA Pulsed | $\pm 20 \mathrm{~mA}$ |
| Iwb Continuous (Rwb $\leq 1 \mathrm{k} \Omega$, A open) ${ }^{1}$ | $\pm 5 \mathrm{~mA}$ |
| $I_{\text {wA }}$ Continuous ( $\mathrm{Rwa}^{\text {m }} \leq 1 \mathrm{k} \Omega$, B open) ${ }^{1}$ | $\pm 5 \mathrm{~mA}$ |
| Digital Inputs and Output Voltage to GND | $0 \mathrm{~V}, \mathrm{~V}_{\mathrm{DD}}$ |
| Operating Temperature Range | $-40^{\circ} \mathrm{C}$ to $+125^{\circ} \mathrm{C}$ |
| Maximum Junction Temperature ( $\mathrm{T}_{\text {J max }}$ ) | $150^{\circ} \mathrm{C}$ |
| Storage Temperature | $-65^{\circ} \mathrm{C}$ to $+150^{\circ} \mathrm{C}$ |
| Lead Temperature (Soldering, 10 sec ) | $300^{\circ} \mathrm{C}$ |
| Vapor Phase (60 sec) | $215^{\circ} \mathrm{C}$ |
| Infrared (15 sec) | $220^{\circ} \mathrm{C}$ |
| Thermal Resistance ${ }^{2} \theta_{\mathrm{JA}}$ | $230^{\circ} \mathrm{C} / \mathrm{W}$ |

${ }^{1}$ Maximum terminal current is bounded by the maximum applied voltage across any two of the $\mathrm{A}, \mathrm{B}$, and W terminals at a given resistance; the maximum current handling of the switches, and the maximum power dissipation of the package. $\mathrm{V}_{\mathrm{DD}}=5 \mathrm{~V}$.
${ }^{2}$ Package power dissipation $=\left(\mathrm{T}_{\mathrm{J}} \max -\mathrm{T}_{\mathrm{A}}\right) / \theta_{\mathrm{JA}}$.

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.

## 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.

## PIN CONFIGURATION AND FUNCTION DESCRIPTIONS



Figure 4. Pin Configuration

Table 3. Pin Function Descriptions

| Pin No. | Mnemonic | Description |
| :---: | :---: | :---: |
| 1 | W | Wiper Terminal W. GND $\leq \mathrm{V}_{\mathrm{w}} \leq \mathrm{V}_{\mathrm{DD}}$. |
| 2 | $V_{D D}$ | Positive Power Supply. Specified for operation from 2.7 V to 5.5 V . For OTP programming, $\mathrm{V}_{\mathrm{DD}}$ needs to be a minimum of 5.25 V and have a 100 mA driving capability. |
| 3 | GND | Common Ground. |
| 4 | SCL | Serial Clock Input. Requires a pull-up resistor. If it is driven direct from a logic controller without the pull-up resistor, ensure that $\mathrm{V}_{\mathrm{IH}} \min$ is $0.7 \mathrm{~V} \times \mathrm{V}_{\mathrm{DD}}$. |
| 5 | SDA | Serial Data Input/Output. Requires a pull-up resistor. If it is driven direct from a logic controller without a pull-up resistor, ensure that $\mathrm{V}_{\mathrm{H}}$ min is $0.7 \mathrm{~V} \times \mathrm{V}_{\mathrm{DD}}$. |
| 6 | AD0 | $1^{2} \mathrm{C}$ Device Address Bit. Allows a maximum of two AD5171s to be addressed. |
| 7 | B | Resistor Terminal B. GND $\leq \mathrm{V}_{\mathrm{B}} \leq \mathrm{V}_{\mathrm{DD}}$. |
| 8 | A | Resistor Terminal A . GND $\leq \mathrm{V}_{\mathrm{A}} \leq \mathrm{V}_{\mathrm{DD}}$. |

## AD5171

## TYPICAL PERFORMANCE CHARACTERISTICS



Figure 5. R-INL vs. Code vs. Temperature


Figure 6. R-DNL vs. Code vs. Temperature


Figure 7. INL vs. Code vs. Temperature


Figure 8. DNL vs. Code vs. Temperature


Figure 9. Full-Scale Error


Figure 10. Zero-Scale Error


Figure 11. Supply Current vs. Temperature


Figure 12. Rheostat Mode Tempco $\left(\Delta R_{A B} / R_{A B}\right) / \Delta T$ vs. Code


Figure 13. Potentiometer Mode Tempco $\left(\Delta V_{w} / V_{w}\right) / \Delta T$ vs. Code


Figure 14. Gain vs. Frequency vs. Code, $R_{A B}=5 \mathrm{k} \Omega$


Figure 15. Gain vs. Frequency vs. Code, $R_{A B}=10 \mathrm{k} \Omega$


Figure 16. Gain vs. Frequency vs. Code, $R_{A B}=50 \Omega$

## AD5171



Figure 17. Gain vs. Frequency vs. Code, $R_{A B}=100 \mathrm{k} \Omega$


Figure 18. PSRR vs. Frequency


Figure 19. Digital Feedthrough vs. Time


Figure 20. Settling Time


Figure 21. Midscale Glitch Energy


Figure 22. Power-Up Settling Time, after Fuses Blown


Figure 23. Iwb_max vs. Code

## AD5171

## THEORY OF OPERATION

The AD5171 allows unlimited 6-bit adjustments, except for the one-time programmable, set-and-forget resistance setting. OTP technology is a proven, cost-effective alternative over EEMEM in one-time memory programming applications. The AD5171 employs fuse link technology to achieve the memory retention of the resistance setting function. It has six data fuses that control the address decoder for programming the RDAC, one user mode test fuse for checking setup error, and one programming lock fuse for disabling any further programming once the data fuses are blown.

## ONE-TIME PROGRAMMING (OTP)

Prior to OTP activation, the AD5171 presets to midscale during initial power-on. After the wiper is set at the desired position, the resistance can be permanently set by programming the T bit high along with the proper coding (see Table 7 and Table 8) and one-time $\mathrm{V}_{\text {DD_отр. }}$ The fuse link technology of the AD517x family of digital potentiometers requires $\mathrm{V}_{\text {DD_отP }}$ between 5.25 V and 5.5 V to blow the fuses to achieve a given nonvolatile setting. On the other hand, $\mathrm{V}_{\mathrm{DD}}$ can be 2.7 V to 5.5 V during operation. As a result, system supply that is lower than 5.25 V requires external supply for one-time programming. Also, the user is allowed only one attempt in blowing the fuses. If the user fails to blow the fuses at the first attempt, the fuse structures may change so that they may never be blown regardless of the energy applied at subsequent events. For details, see the Power Supply Considerations section.

The device control circuit has two validation bits, E1 and E0, that can be read back to check the programming status (see Table 4). Users should always read back the validation bits to ensure that the fuses are properly blown. After the fuses have been blown, all fuse latches are enabled upon subsequent power-on; therefore, the output corresponds to the stored setting.
Table 4. Validation Status

| E1 | EO | Status |
| :--- | :--- | :--- |
| 0 | 0 | Ready for programming. |
| 0 | 1 | Test fuse not blown successfully. For factory <br> setup checking purpose only. Users should not <br> see these combinations. |
| 1 | 0 | Fatal error. Some fuses are not blown. Do not <br> retry. Dicard the unit. <br> Successful. No further programming is possible. |
| 1 | 1 |  |

This section discusses the fuse operation in detail. When the OTP T bit is set, the internal clock is enabled. The program then attempts to blow a test fuse. The operation stops if the test fuse is not properly blown. The validation bits, Bit E1 and Bit E0, show 01 . This status is intended for factory setup checking purposes only; users should not see this status. If the test fuse is
properly blown, then the data fuses can be programmed. The six data fuses are programmed in six clock cycles. The output of the fuses is compared with the code stored in the RDAC register. If they do not match, E1 and E0 of 10 are issued as fatal errors and the operation stops. Users should never try blowing the fuses more than once because the fuse structure may have changed prohibiting further programming. As a result, the unit must be discarded. This error status can also occur if the OTP supply voltage goes above or drops below the $\mathrm{V}_{\text {DD_otp }}$ requirement, the OTP supply current is limited, or both the voltage and current ramp times are slow. If the output and stored code match, the programming lock fuse is blown so that no further programming is possible. In the meantime, E1 and E0 issue 11, indicating the lock fuse is properly blown. All the fuse latches are enabled at power-on; therefore, from this point on, the output corresponds to the stored setting. Figure 24 shows a detailed functional block diagram.


Figure 24. Detailed Functional Block Diagram

## POWER SUPPLY CONSIDERATIONS

To minimize the package pin count, both the one-time programming and normal operating voltage supplies share the same $\mathrm{V}_{\mathrm{DD}}$ terminal of the AD5171. The AD5171 employs fuse link technology that requires 5.25 V to 5.5 V for blowing the internal fuses to achieve a given setting, but normal $V_{D D}$ can be anywhere between 2.7 V and 5.5 V after the fuse programming process. As a result, dual voltage supplies and isolation are needed if system VDD is lower than the required VDd_otp. The fuse programming supply (either an on-board regulator or rack-mount power supply) must be rated at 5.25 V to 5.5 V and able to provide a 100 mA current for 400 ms for successful onetime programming. Once fuse programming is complete, the $\mathrm{V}_{\text {DD_OTP }}$ supply must be removed to allow normal operation at 2.7 V to 5.5 V; the device then consumes current in the $\mu \mathrm{A}$ range. Figure 25 shows the simplest implementation to meet the dual-voltage requirement with a jumper. This approach saves one voltage supply, but draws additional current and requires manual configuration.


Figure 25. Power Supply Requirement
An alternate approach in 3.5 V to 5.25 V systems adds a signal diode between the system supply and the OTP supply for isolation, as shown in Figure 26.


Figure 26. 5.5 V OTP Supply Isolated From the 3.5 V to 5.25 V Normal Operating Supply. The VD_otp supply must be removed once OTP is complete.


Figure 27. 5.5 V OTP Supply Isolated From the 2.7 V Normal Operating Supply. The VDD_otp supply must be removed once OTP is complete.

When operating at 2.7 V , use of the bidirectional low threshold P-Ch MOSFETs is recommended for the supply's isolation. As shown in Figure 27, this assumes that the 2.7 V system voltage is applied first, and the P1 and P2 gates are pulled to ground, thus turning on P1 and, subsequently, P2. As a result, $V_{D D}$ of the AD5171 approaches 2.7 V . When the AD5171 setting is found, the factory tester applies the $V_{\text {DD_otp }}$ to both the $V_{D D}$ and the MOSFETs gates, thus turning off P1 and P2. The OTP command should be executed at this time to program the AD5171 while the 2.7 V source is protected. Once the fuse programming is complete, the tester withdraws the VD__otp and the AD5171's setting is permanently fixed.

AD5171 achieves the OTP function through blowing internal fuses. Users should always apply the 5.25 V to 5.5 V one-time program voltage requirement at the first fuse programming attempt. Failure to comply with this requirement may lead to a change in the fuse structures, rendering programming inoperable.

Care should be taken when SCL and SDA are driven from a low voltage logic controller. Users must ensure that the logic high level is between $0.7 \mathrm{~V} \times \mathrm{V}_{\mathrm{DD}}$ and $\mathrm{V}_{\mathrm{DD}}$. Refer to the Level Shifting for Different Voltage Operation section.

Poor PCB layout introduces parasitics that may affect the fuse programming. Therefore, it is recommended that a $10 \mu \mathrm{~F}$ tantalum capacitor be added in parallel with a 1 nF ceramic capacitor as close as possible to the $V_{D D}$ pin. The type and value chosen for both capacitors are important. This combination of capacitor values provides both a fast response and larger supply current handling with minimum supply droop during transients. As a result, these capacitors increase the OTP programming success by not inhibiting the proper energy needed to blow the internal fuses. Additionally, C1 minimizes transient disturbance and low frequency ripple while C 2 reduces high frequency noise during normal operation.

## ESD PROTECTION

Digital inputs SDA and SCL are protected with a series input resistor and parallel Zener ESD structures (Figure 28).


Figure 28. ESD Protection of Digital Pins

## TERMINAL VOLTAGE OPERATING RANGE

There are also ESD protection diodes between $V_{D D}$ and the RDAC terminals; therefore, the $\mathrm{V}_{\mathrm{DD}}$ of the AD5171 defines their voltage boundary conditions (see Figure 29). Supply signals present on Terminal A, Terminal B, and Terminal W that exceed $\mathrm{V}_{\mathrm{DD}}$ are clamped by the internal forward-biased diodes and should be avoided.


Figure 29. Maximum Terminal Voltages Set by $V_{D D}$

## AD5171

## POWER-UP/POWER-DOWN SEQUENCES

Similarly, because of the ESD protection diodes, it is important to power $V_{D D}$ first before applying any voltages to Terminal $A$, Terminal B, and Terminal W. Otherwise, the diode is forwardbiased such that $V_{D D}$ is powered unintentionally and may affect the remainder of the users' circuits. The ideal power-up sequence is in the following order: GND, $\mathrm{V}_{\mathrm{DD}}$, digital inputs, and $V_{A} / V_{B} / V_{w}$. The order of powering $V_{A}, V_{B}, V_{W}$, and the digital inputs is not important as long as they are powered after VDD. Similarly, VDD should be powered down last.

## VARIABLE RESISTANCE AND VOLTAGE FOR RHEOSTAT MODE

If only the W -to- B or W -to-A terminals are used as variable resistors, the unused terminal can be opened or shorted with Terminal W. This operation is called rheostat mode (Figure 30).


Figure 30. Rheostat Mode Configuration
The nominal resistance ( $\mathrm{R}_{A B}$ ) of the RDAC has 64 contact points accessed by the wiper terminal, plus the B terminal contact if $\mathrm{R}_{\text {wB }}$ is considered. The 6-bit data in the RDAC latch is decoded to select one of the 64 settings. Assuming that a $10 \mathrm{k} \Omega$ part is used, the wiper's first connection starts at Terminal B for data $0 x 00$. Such a connection yields a minimum of $60 \Omega$ resistance between Terminal W and Terminal B due to the $60 \Omega$ wiper contact resistance. The second connection is the first tap point, which corresponds to $219 \Omega\left(R_{W B}=1 \times R_{A B} / 63+R_{W}\right)$ for data $0 x 01$, and so on. Each LSB data value increase moves the wiper up the resistor ladder until the last tap point is reached at $10060 \Omega\left(63 \times R_{A B} / 63+R_{W}\right)$. Figure 31 shows a simplified diagram of the equivalent RDAC circuit. The general equation determining $R_{W B}$ is

$$
\begin{equation*}
R_{W B}(D)=\frac{D}{63} \times R_{A B}+R_{W} \tag{1}
\end{equation*}
$$

where:
$D$ is the decimal equivalent of the 6-bit binary code.
$R_{A B}$ is the end-to-end resistance.
$R_{W}$ is the wiper resistance contributed by the on-resistance of the internal switch.

Table 5. $\mathrm{R}_{\mathrm{WB}}$ vs. Codes: $\mathrm{R}_{\mathrm{AB}}=10 \mathrm{k} \Omega$; Terminal A Open

| $\mathbf{D}$ (Dec) | RwB $^{(\boldsymbol{\Omega})}$ | Output State |
| :--- | :--- | :--- |
| 63 | 10060 | Full-scale $\left(\mathrm{R}_{\text {AB }}+\mathrm{R}_{\mathrm{w}}\right)$ |
| 32 | 5139 | Midscale |
| 1 | 219 | 1 LSB |
| 0 | 60 | Zero-scale (wiper contact resistance) |

Since a finite wiper resistance of $60 \Omega$ is present in the zeroscale condition, care should be taken to limit the current flow between Terminal W and Terminal B in this state to a maximum pulse current 20 mA . Otherwise, degradation or possible destruction of the internal switch contact can occur.

Similar to the mechanical potentiometer, the resistance of the RDAC between the wiper (Terminal W) and Terminal A also produces a complementary resistance, $\mathrm{R}_{\mathrm{WA}}$. When these terminals are used, Terminal B can be opened or shorted to Terminal W. Setting the resistance value for Rwa starts at a maximum value of resistance and decreases as the data loaded in the latch increases in value. The general equation for this operation is

$$
\begin{equation*}
R_{W A}(D)=\frac{63-D}{63} \times R_{A B}+R_{W} \tag{2}
\end{equation*}
$$

Table 6. R $\mathrm{R}_{\mathrm{WA}}$ vs. Codes: $\mathrm{R}_{\mathrm{AB}}=10 \mathrm{k} \Omega$;Terminal B Open

| D (Dec) | Rwa $\boldsymbol{( \Omega )}$ | Output State |
| :--- | :--- | :--- |
| 63 | 60 | Full-scale |
| 32 | 4980 | Midscale |
| 1 | 9901 | 1 LSB |
| 0 | 10060 | Zero-scale |

The typical distribution of the resistance tolerance from device to device is process-lot dependent; it is possible to have $\pm 30 \%$ tolerance.


Figure 31. AD5171 Equivalent RDAC Circuit

## VARIABLE RESISTANCE AND VOLTAGE FOR POTENTIOMETER MODE

If all three terminals are used, the operation is called the potentiometer mode. The most common configuration is the voltage divider operation (Figure 32).


Figure 32. Potentiometer Mode Configuration
Ignoring the effect of the wiper resistance, the transfer function is simply

$$
\begin{equation*}
V_{W}(D)=\frac{D}{63} V_{A} \tag{3}
\end{equation*}
$$

A more accurate calculation, which includes the wiper resistance effect, yields

$$
\begin{equation*}
V_{W}(D)=\frac{\frac{D}{63} R_{A B}+R_{W}}{R_{A B}+2 R_{W}} V_{A} \tag{4}
\end{equation*}
$$

Unlike in rheostat mode where the absolute tolerance is high, potentiometer mode yields an almost ratio-metric function of $\mathrm{D} / 63$ with a relatively small error contributed by the $\mathrm{R}_{\mathrm{W}}$ terms; thus, the tolerance effect is almost cancelled. Although the thin film step resistor $\left(\mathrm{R}_{s}\right)$ and CMOS switches resistance $\left(\mathrm{R}_{\mathrm{w}}\right)$ have very different temperature coefficients, the ratiometric adjustment also reduces the overall temperature coefficient effect to $5 \mathrm{ppm} /{ }^{\circ} \mathrm{C}$, except at low value codes where Rw dominates.

Potentiometer mode includes other operations such as op amp input, feedback resistor networks, and voltage scaling applications. Terminal A, Terminal W, and Terminal B can, in fact, be input or output terminals provided that $\left|\mathrm{V}_{\mathrm{AB}}\right|,\left|\mathrm{V}_{\mathrm{WA}}\right|$, and $\left|\mathrm{V}_{\mathrm{wB}}\right|$ do not exceed VDD to GND.

## CONTROLLING THE AD5171

There are two ways of controlling the AD5171. Users can either program the devices with computer software or employ external $\mathrm{I}^{2} \mathrm{C}$ controllers.

## SOFTWARE PROGRAMMING

Due to the advantage of the one-time programmable feature, users may consider programming the device in the factory before shipping it to end users. ADI offers device programming software that can be implemented in the factory on PCs running Windows 95 to Windows XP platforms. As a result, external controllers are not required, which significantly reduces development time.

The program is an executable file that does not require the user to know any programming languages or programming skills. It is easy to set up and use. Figure 33 shows the software interface. The software can be downloaded from www.analog.com.


Figure 33. Software Interface

## Write

The AD5171 starts at midscale after power-up prior to the OTP programming. To increment or decrement the resistance, move the scrollbar on the left. To write any specific values, use the bit pattern control in the upper screen and click Run. The format of writing data to the device is shown in Table 7. Once the desired setting is found, click Program Permanent to blow the internal fuse links for permanent setting. The user can also set the programming bit pattern in the upper screen and click Run to achieve the same result.

## Read

To read the validation bits and data from the device, click Read. The user may also set the bit pattern in the upper screen and click Run. The format of reading data out from the device is shown in Table 8.

To apply the device programming software in the factory, users need to modify a parallel port cable and configure Pin 2, Pin 3, Pin 15, and Pin 25 for SDA_write, SCL, SDA_read, and DGND, respectively, for the control signals (Figure 34). Also lay out the PCB of the AD5171 with SCL and SDA pads, as shown in Figure 35, such that pogo pins can be inserted for the factory programming.


Figure 34. Parallel Port Connection. Pin $2=$ SDA_write, Pin $3=S C L$, Pin $15=$ SDA_read, and Pin $25=$ DGND.


Figure 35. Recommended AD5171 PCB Layout. The SCL and SDA pads allow pogo pins to be inserted so that signals can be communicated through the parallel port for programming (Figure 34).

Table 7. SDA Write Mode Bit Format


Table 8. SDA Read Mode Bit Format

| S | 0 | 1 | 0 | 1 | 1 | 0 | AD0 | 1 | A | E1 | E0 | D5 | D4 | D3 | D2 | D1 | D0 | A | P |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | Slave Address Byte |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | Data Byte |  |

Table 9. SDA Bits Definitions and Descriptions

| Bit | Description |
| :--- | :--- |
| S | Start Condition. |
| P | Stop Condition. |
| A | Acknowledge. |
| AD0 | I $^{2}$ C Device Address Bit. Allows a maximum of two AD5171s to be addressed. |
| X | Don't Care. |
| T | OTP Programming Bit. Logic 1 programs the wiper position permanently. |
| D5, D4, D3, D2, D1, D0 | Data Bits. |
| E1, E0 | OTP Validation Bits. |
| 0,0 | Ready to Program. |
| 0,1 | Test Fuse Not Blown Successfully. For factory setup checking purpose only. Users should not see these |
| 1,0 | combinations. |
| 1,1 | Fatal Error. Do not retry. Discard the unit. |

## $I^{2}$ C CONTROLLER PROGRAMMING

## Write Bit Patterns



Figure 37. Activating One-Time Programming

## Read Bit Pattern



Figure 38. Reading Data from RDAC Register

## AD5171

## $I^{2}$ C-COMPATIBLE 2-WIRE SERIAL BUS

For users who prefer to use external controllers, the AD5171 can be controlled via an $\mathrm{I}^{2} \mathrm{C}$-compatible serial bus; the part is connected to this bus as a slave device. Referring to Figure 36, Figure 37, and Figure 38, the 2 -wire $\mathrm{I}^{2} \mathrm{C}$ serial bus protocol operates as follows:

1. The master initiates data transfer by establishing a start condition, which is when SDA goes from high to low while SCL is high (Figure 36 and Figure 37). The following byte is the slave address byte, which consists of the 6 MSBs as a slave address defined as 010110 . The next bit is AD0, which is an $I^{2} \mathrm{C}$ device address bit. Depending on the states of their AD0 bits, two AD5171s can be addressed on the same bus (Figure 39). The last LSB is the $\mathrm{R} / \overline{\mathrm{W}}$ bit, which determines whether data is read from, or written to, the slave device.

The slave address corresponding to the transmitted address bit responds by pulling the SDA line low during the $9^{\text {th }}$ clock pulse (this is termed the Acknowledge bit). At this stage, all other devices on the bus remain idle while the selected device waits for data to be written to, or read from, its serial register.
2. The write operation contains one instruction byte more than the read operation. The instruction byte in the write mode follows the slave address byte. The MSB of the instruction byte labeled T is the one-time programming bit. After acknowledging the instruction byte, the last byte in the write mode is the data byte. Data is transmitted over the serial bus in sequences of nine clock pulses (eight data bits followed by an Acknowledge bit). The transitions on the SDA line must occur during the low period of SCL and remain stable during the high period of SCL (Figure 36).
3. In read mode, the data byte follows immediately after the acknowledgment of the slave address byte. Data is transmitted over the serial bus in sequences of nine clock pulses (note the slight difference from the write mode; there are eight data bits followed by a No Acknowledge bit). Similarly, the transitions on the SDA line must occur during the low period of SCL and remain stable during the high period of SCL (Figure 38).
4. When all data bits have been read or written, a stop condition is established by the master. A stop condition is defined as a low-to-high transition on the SDA line while SCL is high. In the write mode, the master pulls the SDA line high during the $10^{\text {th }}$ clock pulse to establish a stop condition (Figure 36 and Figure 37). In the read mode, the master issues a No Acknowledge for the $9^{\text {th }}$ clock pulse, i.e., the SDA line remains high. The master then brings the SDA line low before the $10^{\text {th }}$ clock pulse, which goes high to establish a stop condition (Figure 38).

A repeated write function gives the user flexibility to update the RDAC output a number of times, except after permanent programming, addressing, and instructing the part only once. During the write cycle, each data byte updates the RDAC output. For example, after the RDAC has acknowledged its slave address and instruction bytes, the RDAC output updates after these two bytes. If another byte is written to the RDAC while it is still addressed to a specific slave device with the same instruction, this byte updates the output of the selected slave device. If different instructions are needed, the write mode has to be started with a new slave address, instruction, and data bytes. Similarly, a repeated read function of the RDAC is also allowed.

## CONTROLLING TWO DEVICES ON ONE BUS

Figure 39 shows two AD5171 devices on the same serial bus. Each has a different slave address since the state of each AD0 pin is different. This allows each device to be independently operated. The master device output bus line drivers are opendrain pull-downs in a fully $\mathrm{I}^{2} \mathrm{C}$-compatible interface.


Figure 39. Two AD5171 Devices on One Bus

## APPLICATIONS

## DAC

It is common to buffer the output of the digital potentiometer as a DAC unless the load is much larger than $\mathrm{R}_{\text {wB. }}$. The buffer can impede conversion and deliver higher current, if needed.


Figure 40. Programmable Voltage Reference (DAC)

## GAIN CONTROL COMPENSATION

The digital potentiometers are commonly used in gain controls (Figure 41) or sensor transimpedance amplifier signal conditioning applications. To avoid gain peaking, or in worst-case oscillation due to step response, a compensation capacitor is needed. In general, C2 in the range of a few picofarads to a few tenths of a picofarad is adequate for the compensation.


Figure 41. Typical Noninverting Gain Amplifier

## PROGRAMMABLE VOLTAGE SOURCE WITH BOOSTED OUTPUT

For applications that require high current adjustment, such as a laser diode driver or tunable laser, a boosted voltage source can be considered (Figure 42).


Figure 42. Programmable Booster Voltage Source
In this circuit, the inverting input of the op amp forces the Vout to be equal to the wiper voltage set by the digital potentiometer. The load current is then delivered by the supply via the $\mathrm{N}-\mathrm{Ch}$ FET $\mathrm{N}_{1} . \mathrm{N}_{1}$ power handling must be adequate to dissipate
$\left(\mathrm{V}_{\mathrm{I}}-\mathrm{V}_{\mathrm{O}}\right) \times \mathrm{I}_{\mathrm{L}}$ power. This circuit can source a maximum of 100 mA with a 5 V supply. For precision applications, a voltage reference such as the ADR421, ADR03, or ADR370 can be applied at Terminal A of the digital potentiometer.

## LEVEL SHIFTING FOR DIFFERENT VOLTAGE OPERATION

If the SCL and SDA signals come from a low voltage logic controller and are below the minimum $\mathrm{V}_{\mathrm{IH}}$ level $\left(0.7 \mathrm{~V} \times \mathrm{V}_{\mathrm{DD}}\right)$, level shift the signals for read/write communications between the AD5171 and the controller. Figure 43 shows one of the implementations. For example, when the SDA1 is at $2.5 \mathrm{~V}, \mathrm{M} 1$ turns off, and the SDA2 becomes 5 V . When the SDA1 is at 0 V , M1 turns on, and the SDA2 approaches to 0 V . As a result, proper level shifting is established. M1 and M2 should be low threshold N-Ch power MOSFETs, such as FDV301N.


Figure 43. Level Shifting for Different Voltage Operation

## RESISTANCE SCALING

The AD5171 offers $5 \mathrm{k} \Omega, 10 \mathrm{k} \Omega, 50 \mathrm{k} \Omega$, and $100 \mathrm{k} \Omega$ nominal resistances. For users who need to optimize the resolution with an arbitrary full range resistance, the following techniques can be used. By paralleling a discrete resistor (Figure 44), a proportionately lower voltage appears at Terminal A to Terminal B, which is applicable only to the voltage divider mode.

This translates into a finer degree of precision because the step size at Terminal W is smaller. The voltage can be found as

$$
\begin{equation*}
V_{W}(D)=\frac{\left(R_{A B} \| R 2\right)}{R 3+R_{A B} \| R 2} \times \frac{D}{64} \times V_{D D} \tag{5}
\end{equation*}
$$



Figure 44. Lowering the Nominal Resistance

For log taper adjustment, such as volume control, Figure 45 shows another way of resistance scaling. In this circuit, the smaller the R 2 with respect to $\mathrm{R}_{A B}$, the more it behaves like the pseudo log taper characteristic. The wiper voltage is simply

$$
\begin{equation*}
V_{W}(D)=\frac{\left(R_{W B} \| R 2\right)}{R_{W A}+R_{W B} \| R 2} \times V_{I} \tag{6}
\end{equation*}
$$



Figure 45. Resistor Scaling with Log Adjustment Characteristics

## RESOLUTION ENHANCEMENT

The resolution can be doubled in the potentiometer mode of operation by using three digital potentiometers. Borrowed from ADI's patented RDAC segmentation technique, users can configure three AD5171s (Figure 46) to double the resolution. First, U3 must be parallel with a discrete resistor, $\mathrm{R}_{\mathrm{P}}$, which is chosen to be equal to a step resistance $\left(\mathrm{R}_{\mathrm{P}}=\mathrm{R}_{A B} / 64\right)$. Adjusting U 1 and U2 together forms the coarse 6-bit adjustment, and adjusting U3 alone forms the finer 6-bit adjustment. As a result, the effective resolution becomes 12-bit.


[^0]
## RDAC CIRCUIT SIMULATION MODEL

The internal parasitic capacitances and the external capacitive loads dominate the ac characteristics of the digital potentiometers. Configured as a potentiometer divider, the -3 dB bandwidth of the AD5171 ( $5 \mathrm{k} \Omega$ resistor) measures 1.5 MHz at half scale. Figure 14 to Figure 17 provide the large signal BODE plot characteristics of the four available resistor versions: $5 \mathrm{k} \Omega$, $10 \mathrm{k} \Omega, 50 \mathrm{k} \Omega$, and $100 \mathrm{k} \Omega$. A parasitic simulation model is shown in Figure 47. Listing 1 provides a macro model net list for the $10 \mathrm{k} \Omega$ device.


Figure 47. Circuit Simulation Model for $R D A C=10 \mathrm{k} \Omega$

## Listing 1. Macro Model Net List for RDAC

```
.PARAM D=64, RDAC=10E3
*
.SUBCKT DPOT (A,W,B)
*
CA A 0 25E-12
RWA A W {(1-D/64)*RDAC+60}
CW W 0 55E-12
RWB W 
*
.ENDS DPOT
```


## EVALUATION BOARD



Figure 48. Evaluation Board Schematic

The AD5171 evaluation board comes with a dual op amp AD822 and a 2.5 V reference ADR03. Users can configure many building block circuits with minimum components needed. Figure 49 shows one of the examples. There is space available on the board where users can build additional circuits for further evaluations as shown in Figure 50.


Figure 50. Evaluation Board
Figure 49. Programmable Voltage Reference

## AD5171

## OUTLINE DIMENSIONS



Figure 51. 8-Lead Small Outline Transistor Package [SOT-23]
(RJ-8)
Dimensions shown in millimeters

## ORDERING GUIDE

| Model ${ }^{1}$ | $\mathrm{R}_{\mathrm{AB}}(\mathrm{k} \Omega$ ) | Package Code | Package Description | Full Container Quantity | Branding |
| :---: | :---: | :---: | :---: | :---: | :---: |
| AD5171BRJ5-R2 | 5 | RJ-8 | SOT-23-8 | 250 | D12 |
| AD5171BRJ5-RL7 | 5 | RJ-8 | SOT-23-8 | 3000 | D12 |
| AD5171BRJZ5-R2 ${ }^{2}$ | 5 | RJ-8 | SOT-23-8 | 250 | D12 |
| AD5171BRJZ5-R7 ${ }^{2}$ | 5 | RJ-8 | SOT-23-8 | 3000 | D12 |
| AD5171BRJ10-R2 | 10 | RJ-8 | SOT-23-8 | 250 | D13 |
| AD5171BRJ10-RL7 | 10 | RJ-8 | SOT-23-8 | 3000 | D13 |
| AD5171BRJZ10-R2 ${ }^{2}$ | 10 | RJ-8 | SOT-23-8 | 250 | D13 |
| AD5171BRJZ10-R7 ${ }^{2}$ | 10 | RJ-8 | SOT-23-8 | 3000 | D13 |
| AD5171BRJ50-R2 | 50 | RJ-8 | SOT-23-8 | 250 | D14 |
| AD5171BRJ50-RL7 | 50 | RJ-8 | SOT-23-8 | 3000 | D14 |
| AD5171BRJZ50-R2 ${ }^{2}$ | 50 | RJ-8 | SOT-23-8 | 250 | D14 |
| AD5171BRJZ50-R7 ${ }^{2}$ | 50 | RJ-8 | SOT-23-8 | 3000 | D14 |
| AD5171BRJ100-R2 | 100 | RJ-8 | SOT-23-8 | 250 | D15 |
| AD5171BRJ100-RL7 | 100 | RJ-8 | SOT-23-8 | 3000 | D15 |
| AD5171BRJZ100-R2 ${ }^{2}$ | 100 | RJ-8 | SOT-23-8 | 250 | D15 |
| AD5171BRJZ100-R7 ${ }^{2}$ | 100 | RJ-8 | SOT-23-8 | 3000 | D15 |
| AD5171EVAL ${ }^{3}$ | 10 |  | Evaluation Board | 1 |  |

[^1]A05171 NOTES

## AD5171

## NOTES


[^0]:    Figure 46. Doubling the Resolution

[^1]:    ${ }^{1}$ Parts have a YWW or \#YWW marking on the bottom of the package. \# stands for Pb-free part. Y shows the year that the part was made, for example, $\mathrm{Y}=5$ for 2005 . WW shows the work week that the part was made.
    ${ }^{2} Z=P b$-free part.
    ${ }^{3}$ The evaluation board is shipped with three pieces of $10 \mathrm{k} \Omega$ parts. Users should order extra samples or different resistance options if needed.

