# MAX5394

# Single, 256-Tap Volatile, SPI, Low-Voltage Linear Taper Digital Potentiometer

## General Description

The MAX5394 single, 256-tap volatile, low-voltage linear taper digital potentiometer offers three end-to-end resistance values of 10kΩ, 50kΩ, and 100kΩ. Potentiometer terminals are independent of supply for voltages up to 5.25V with single-supply operation from 1.7V to 5.5V (charge pump enabled). User-controlled shutdown modes allow the H, W, or L terminal to be opened with the wiper position set to zero-code, midcode, full-code, or the value contained in the wiper register. Ultra-low-quiescent supply current (< 1µA) can be achieved for supply voltages between 2.6V and 5.5V by disabling the internal charge pump and not allowing potentiometer terminals to exceed the supply voltage by more than 0.3V. The MAX5394 provides a low 50ppm/°C end-to-end temperature coefficient and features a SPI serial interface.

The small package size, low operating supply voltage, low supply current, and automotive temperature range of the MAX5394 make the device uniquely suited for the portable consumer market and battery-backup industrial applications.

The MAX5394 is available in a lead-free, 8-pin TDFN (2mm x 2mm) package. The device operates over the -40°C to +125°C automotive temperature range.

***Ordering Information* appears at end of data sheet.**

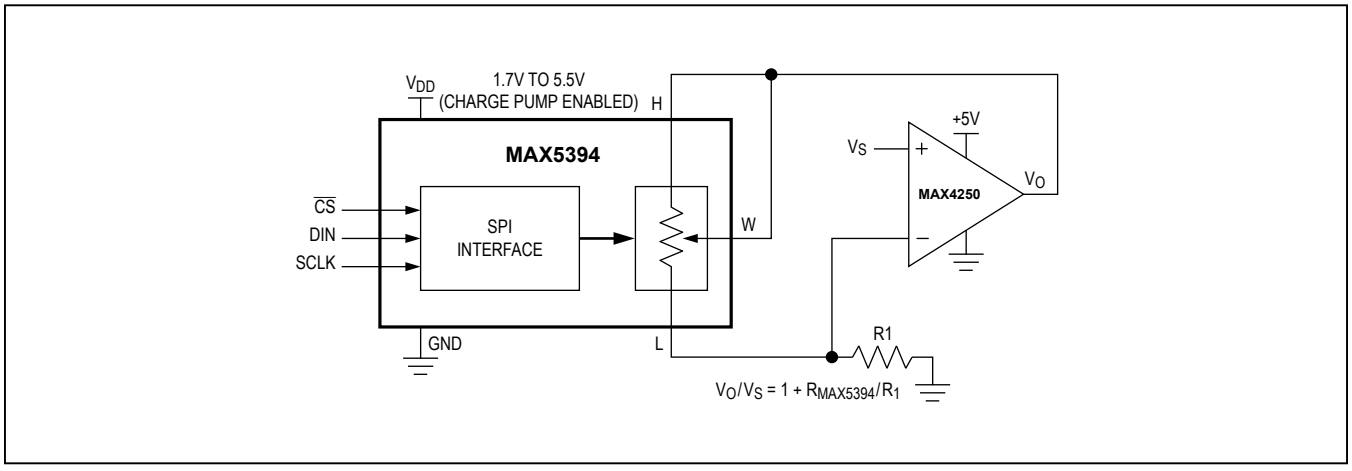
## Benefits and Features

- Single Linear Taper 256-Tap Positions
- 10kΩ, 50kΩ, and 100kΩ End-to-End Resistance
- 1.7V to 5.5V Extended Single Supply
- 0 to 5.25V H, W, L Operating Voltage Independent of $V_{DD}$
- 1µA (typ) Supply Current in Low-Power Mode
- ±1.0 LSB INL, ±0.5 LSB DNL (max) Wiper Accuracy
- Power-On Sets Wiper to Midscale
- 50ppm/°C End-to-End Temperature Coefficient
- 5ppm/°C Ratiometric Temperature Coefficient
- -40°C to +125°C Operating Temperature Range
- 2mm x 2mm, 8-Pin TDFN Package
- SPI-Compatible Serial Interface

## Applications

- Portable Electronics
- System Calibration
- Battery-Powered Systems
- Mechanical Potentiometer Replacement

## Typical Operating Circuit



## Absolute Maximum Ratings

(All voltages referenced to GND.)
$V_{DD}$ ..... -0.3V to +6V
H, W, L (charge pump enabled) ..... -0.3V to +5.5V
H, W, L (charge pump disabled) ..... -0.3V to the lower of ($V_{DD}$ + 0.3V) or +6V
All Other Pins ..... -0.3V to +6V
Continuous Current into H, W, and L
MAX5394L ..... 5mA
MAX5394M ..... 2mA
MAX5394N ..... 1mA
Maximum Current into Any Input ..... 50mA
Continuous Power Dissipation ($T_A$ = +70°C)
TDFN (derate 11.9mW/°C above +70°C) ..... 953.5mW
Operating Temperature Range ..... -40°C to +125°C
Storage Temperature Range ..... -65°C to +150°C
Junction Temperature ..... +150°C
Lead Temperature (soldering, 10s) ..... +300°C
Soldering Temperature (reflow) ..... +260°C

*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

## Package Thermal Characteristics (Note 1)

TDFN
Junction-to-Ambient Thermal Resistance ($\theta_{JA}$) ..... 83.9°C/W
Junction-to-Case Thermal Resistance ($\theta_{JC}$) ..... 37.0°C/W

**Note 1:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maximintegrated.com/thermal-tutorial**.

## Electrical Characteristics

($V_{DD}$ = 1.7V to 5.5V, $V_H$ = $V_{DD}$, $V_L$ = GND, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at $V_{DD}$ = 1.8V, $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **RESOLUTION** | | | | | | | |
| 256-Tap Family | N | | | 256 | | | Tap |
| **DC PERFORMANCE (VOLTAGE-DIVIDER MODE)** | | | | | | | |
| Integral Nonlinearity (Note 3) | INL | | | -1.0 | | +1.0 | LSB |
| Differential Nonlinearity | DNL | (Note 3) | | -0.5 | | +0.5 | LSB |
| Ratiometric Resistor Tempco | | ($DV_W/V_W$)/DT, $V_H$ = $V_{DD}$, $V_L$ = GND, no load | | | 5 | | ppm/°C |
| Full-Scale Error (Code FFh) | | Charge pump enabled, 1.7V < $V_{DD}$ < 5.5V | | -0.5 | | | LSB |
| | | Charge pump disabled, 2.6V < $V_{DD}$ < 5.5VS | MAX5394M MAX5394N | -0.5 | | | |
| | | | MAX5394L | -1.0 | | | |
| Zero-Scale Error (Code 00h) | | Charge pump enabled, 1.7V < $V_{DD}$ < 5.5V | | | | +0.5 | LSB |
| | | Charge pump disabled, 2.6V < $V_{DD}$ < 5.5V | MAX5394M MAX5394N | | | +0.5 | |
| | | | MAX5394L | | | +1.0 | |
| **DC PERFORMANCE (VARIABLE RESISTOR MODE)** | | | | | | | |
| Integral Nonlinearity (Note 4) | R-INL | Charge pump enabled, 1.7V < $V_{DD}$ < 5.5V | | -1.0 | | +1.0 | LSB |
| | | Charge pump disabled, 2.6V < $V_{DD}$ < 5.5V | MAX5394M MAX5394N | -1.0 | | +1.0 | |
| | | | MAX5394L | -1.5 | | +1.5 | |

## Electrical Characteristics (continued)

($V_{DD}$ = 1.7V to 5.5V, $V_H$ = $V_{DD}$, $V_L$ = GND, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at $V_{DD}$ = 1.8V, $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Differential Nonlinearity | R-DNL | (Note 4) | | -0.5 | | +0.5 | LSB |
| Wiper Resistance (Note 5) | $R_{WL}$ | Charge pump enabled, 1.7V < $V_{DD}$ < 5.5V | | | 25 | 50 | Ω |
| | | Charge pump disabled, 2.6V < $V_{DD}$ < 5.5V | | | | 200 | |
| **DC PERFORMANCE (RESISTOR CHARACTERISTICS)** | | | | | | | |
| Terminal Capacitance | $C_H$, $C_L$ | Measured to GND | | | 10 | | pF |
| Wiper Capacitance | $C_W$ | Measured to GND | | | 20 | | pF |
| End-to-End Resistor Tempco | $T_{CR}$ | No load | | | 50 | | ppm/°C |
| End-to-End Resistor Tolerance | | Wiper not connected | | -25 | | +25 | % |
| **AC PERFORMANCE** | | | | | | | |
| -3dB Bandwidth | BW | Code = 80h, 10pF load, $V_{DD}$ = 1.8V | 10kΩ | | 1600 | | kHz |
| | | | 50kΩ | | 340 | | |
| | | | 100kΩ | | 165 | | |
| Total Harmonic Distortion Plus Noise | THD+N | (Note 6) | | | 0.035 | | % |
| Wiper Settling Time | $t_S$ | (Note 7) | 10kΩ | | 190 | | ns |
| | | | 50kΩ | | 400 | | |
| | | | 100kΩ | | 664 | | |
| Charge-Pump Feedthrough at W | $V_{RW}$ | | | | 600 | | $nV_{RMS}$ |
| **POWER SUPPLIES** | | | | | | | |
| Supply Voltage Range | $V_{DD}$ | | | 1.7 | | 5.5 | V |
| Terminal Voltage Range (H, W, L to GND) | | Charge pump enabled, 1.7V < $V_{DD}$ < 5.5V | | 0 | | 5.25 | V |
| | | Charge pump disabled, 2.6V < $V_{DD}$ < 5.5V | | 0 | | $V_{DD}$ | |
| Supply Current (Note 8) | $I_{VDD}$ | Charge pump disabled, 1.7V | | | 0.3 | 1.4 | µA |
| | | Charge pump disabled, 2.5V | | | 0.4 | 1.7 | |
| | | Charge pump disabled, 5.5V | | | 1.0 | 4.0 | |
| | | Charge pump enabled, 1.7V < $V_{DD}$ < 5.5V | $V_{DD}$ = 5.5V | | 25 | 50 | |
| | | | $V_{DD}$ = 1.7V | | 20 | 45 | |
| **DIGITAL INPUTS** | | | | | | | |
| Minimum Input High Voltage | $V_{IH}$ | 2.6V < $V_{DD}$ < 5.5V | | 70 | | | % x $V_{DD}$ |
| | | 1.7V < $V_{DD}$ < 2.6V | | 80 | | | |
| Maximum Input Low Voltage | $V_{IL}$ | 2.6V < $V_{DD}$ < 5.5V | | | | 30 | % x $V_{DD}$ |
| | | 1.7V < $V_{DD}$ < 2.6V | | | | 20 | |
| Input Leakage Current | | | | -1 | | +1 | µA |
| Input Capacitance | | | | | 5 | | pF |

## Electrical Characteristics (continued)

($V_{DD}$ = 1.7V to 5.5V, $V_H$ = $V_{DD}$, $V_L$ = GND, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at $V_{DD}$ = 1.8V, $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **TIMING CHARACTERISTICS (Note 9)** | | | | | | | |
| SCLK Frequency | $f_{SCLK}$ | 2.6V < $V_{DD}$ < 5.5V | | | | 50 | MHz |
| | | 1.7V < $V_{DD}$ < 2.6V | | | | 25 | |
| SCLK Period | $t_{SCLK}$ | 2.6V < $V_{DD}$ < 5.5V | | 20 | | | ns |
| | | 1.7V < $V_{DD}$ < 2.6V | | 40 | | | |
| SCLK Pulse-Width High | $t_{CH}$ | | | 8 | | | ns |
| SCLK Pulse-Width Low | $t_{CL}$ | | | 8 | | | ns |
| $\overline{CS}$ Fall to SCLK Fall Setup Time | $t_{CSS0}$ | To 1st SCLK falling edge (FE) | 2.6V < $V_{DD}$ < 5.5V | 8 | | | ns |
| | | | 1.7V < $V_{DD}$ < 2.6V | 16 | | | |
| $\overline{CS}$ Fall to SCLK Fall Hold Time | $t_{CSH0}$ | Applies to inactive FE preceding 1st FE | | 0 | | | ns |
| $\overline{CS}$ Rise to SCLK Fall Hold Time | $t_{CSH1}$ | Applies to 16th FE | | 0 | | | ns |
| $\overline{CS}$ Rise to SCLK Fall | $t_{CSA}$ | Applies to 16th FE, aborted sequence | 2.6V < $V_{DD}$ < 5.5V | 12 | | | ns |
| | | | 1.7V < $V_{DD}$ < 2.6V | 16 | | | |
| SCLK Fall to $\overline{CS}$ Fall | $t_{CSF}$ | Applies to 16th FE | | 100 | | | ns |
| $\overline{CS}$ Pulse-Width High | $t_{CSPW}$ | | | 20 | | | ns |
| DIN to SCLK Fall Setup Time | $t_{DS}$ | | | 5 | | | ns |
| DIN to SCLK Fall Hold Time | $t_{DH}$ | | | 4.5 | | | ns |
| $\overline{CS}$ Pulse-Width High | $t_{CSPW}$ | | | 20 | | | ns |

**Note 2:** All devices are production tested at $T_A$ = +25°C and are guaranteed by design and characterization for $T_A$ = -40°C to +125°C.

**Note 3:** DNL and INL are measured with the potentiometer configured as a voltage-divider with $V_H$ = 5.25 (QP enabled) or $V_{DD}$ (QP disabled) and $V_L$ = GND. The wiper terminal is unloaded and measured with an ideal voltmeter.

**Note 4:** R-DNL and R-INL are measured with the potentiometer configured as a variable resistor (Figure 1). H is unconnected and L = GND.
For charge pump enabled, $V_{DD}$ = 1.7V to 5.5V, the wiper terminal is driven with a source current of 400µA for the 10kΩ configuration, 80µA for the 50kΩ configuration, and 40µA for the 100kΩ configuration.
For charge pump disabled and $V_{DD}$ = 5.5V, the wiper terminal is driven with a source current of 400µA for the 10kΩ configuration, 80µA for the 50kΩ configuration, and 40µA for the 100kΩ configuration.
For charge pump disabled and $V_{DD}$ = +2.6V, the wiper terminal is driven with a source current of 200µA for the 10kΩ configuration, 40µA for the 50kΩ configuration, and 20µA for the 100kΩ configuration.

**Note 5:** The wiper resistance is the maximum value measured by injecting the currents given in Note 4 into W with L = GND. $R_W = (V_W - V_H)/I_W$.

**Note 6:** Measured at W with H driven with a 1kHz, 0V to $V_{DD}$ amplitude tone and $V_L$ = GND. Wiper at midscale with a 10pF load.

**Note 7:** Wiper-settling time is the worst-case 0-to-50% rise time, measured between tap 0 and tap 127. H = $V_{DD}$, L = GND, and the wiper terminal is loaded with 10pF capacitance to ground.

**Note 8:** Digital inputs at $V_{DD}$ or GND.

**Note 9:** Digital timing is guaranteed by design and characterization, and is not production tested.

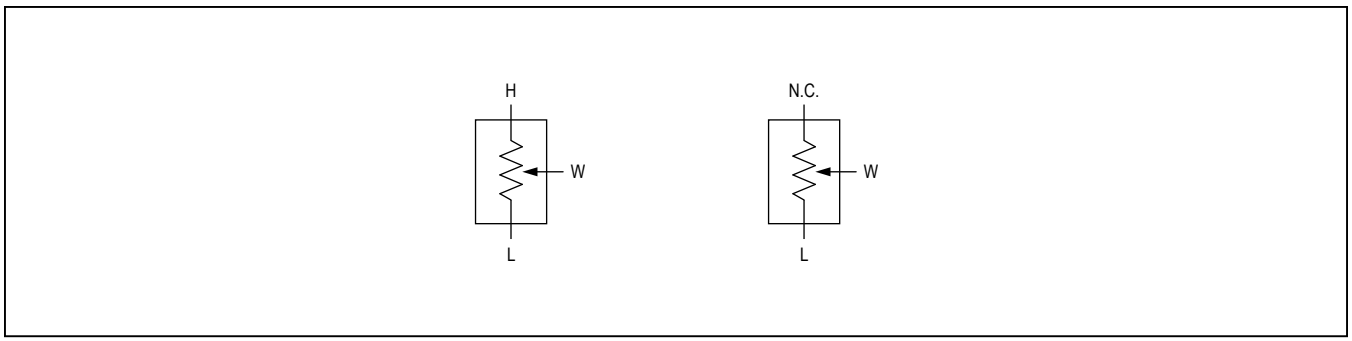



*Figure 1. Voltage-Divider and Variable Resistor Configurations*

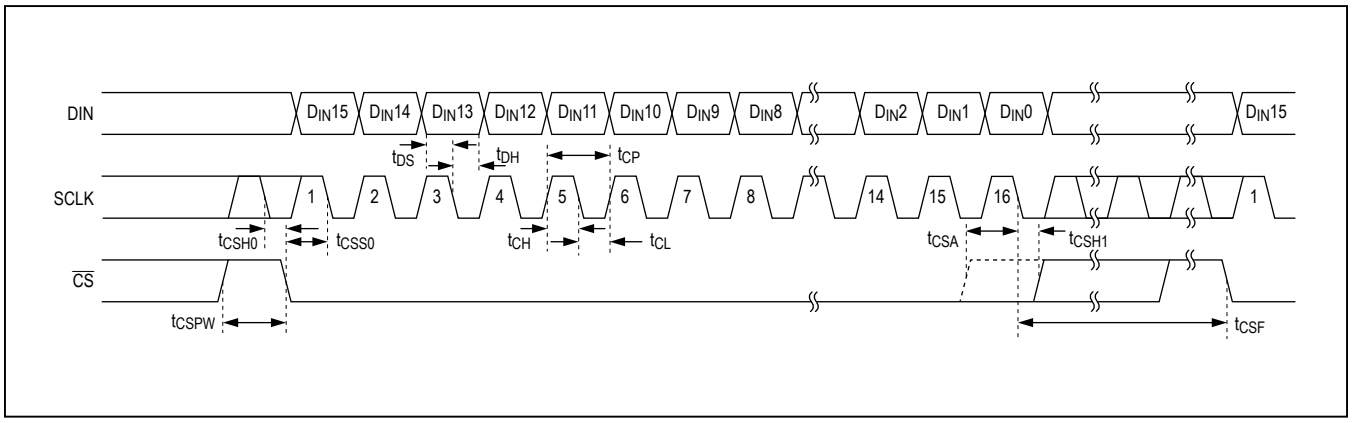
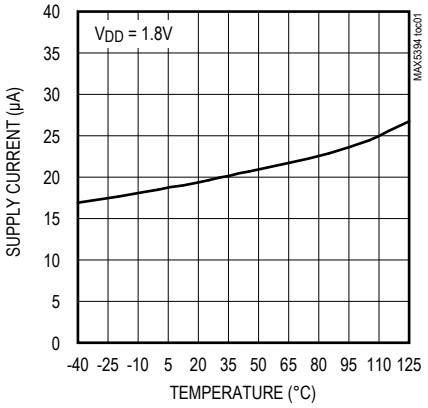



*Figure 2. SPI Timing Diagram*

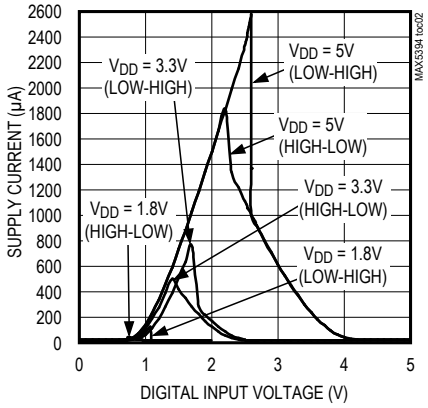
## Typical Operating Characteristics

($V_{DD}$ = 1.8V, $T_A$ = +25°C, unless otherwise noted.)

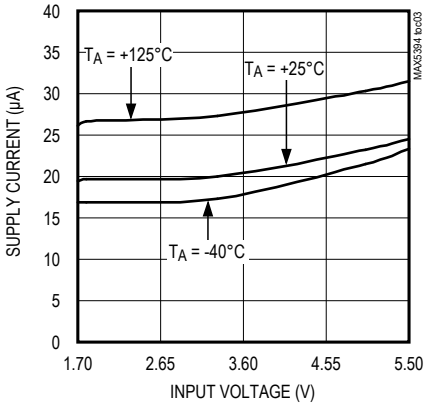
**SUPPLY CURRENT vs. TEMPERATURE**



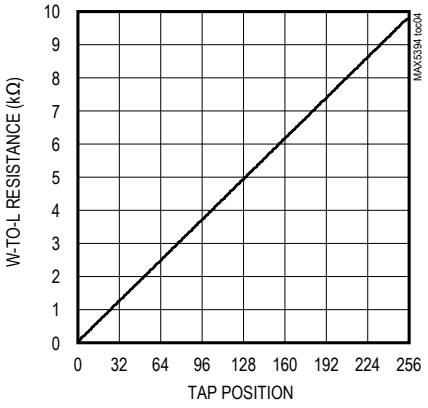

**SUPPLY CURRENT vs. DIGITAL INPUT VOLTAGE**



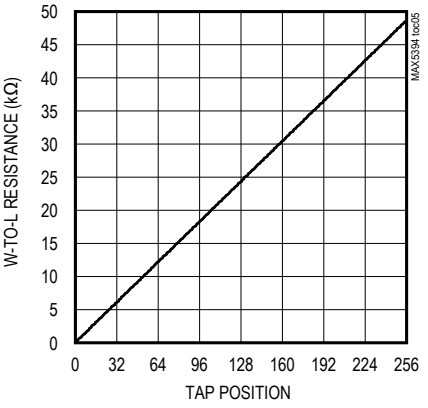

**SUPPLY CURRENT vs. INPUT VOLTAGE**



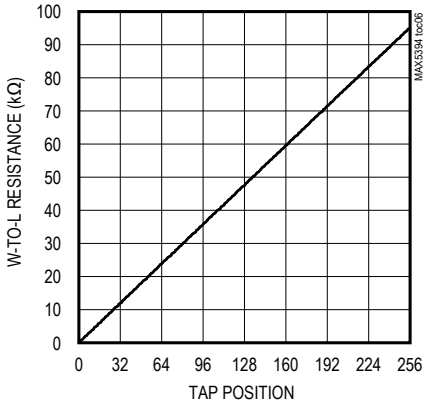

**RESISTANCE (W-TO-L) vs. TAP POSITION (10kΩ)**



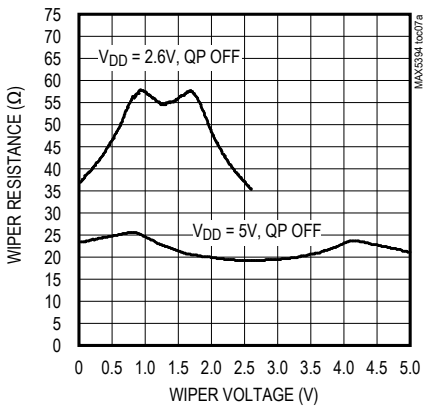

**RESISTANCE (W-TO-L) vs. TAP POSITION (50kΩ)**



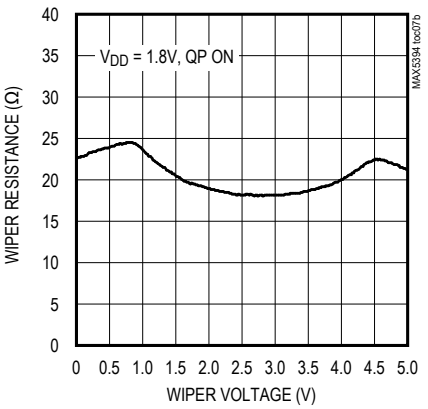

**RESISTANCE (W-TO-L) vs. TAP POSITION (100kΩ)**



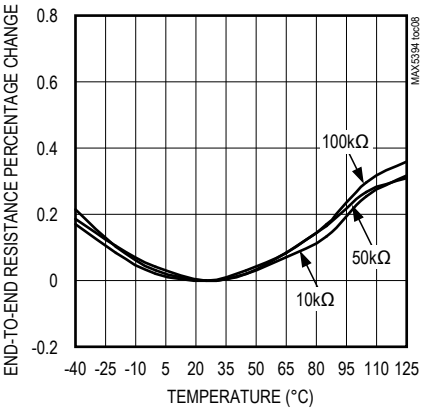

**WIPER RESISTANCE vs. WIPER VOLTAGE**




**WIPER RESISTANCE vs. WIPER VOLTAGE**



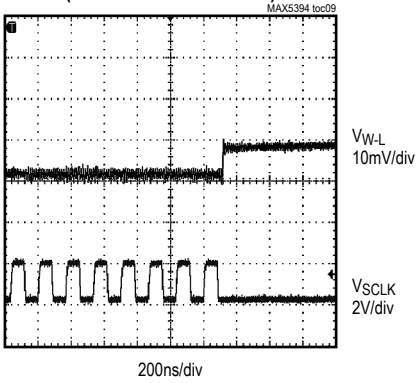

**END-TO-END RESISTANCE PERCENTAGE CHANGE vs. TEMPERATURE**



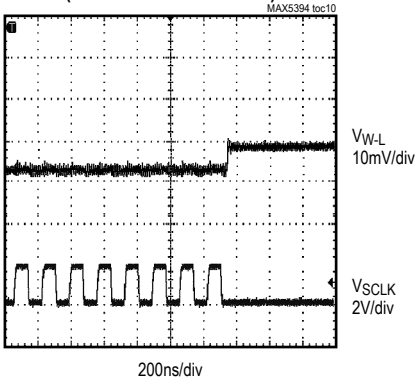
## Typical Operating Characteristics (continued)

($V_{DD}$ = 1.8V, $T_A$ = +25°C, unless otherwise noted.)

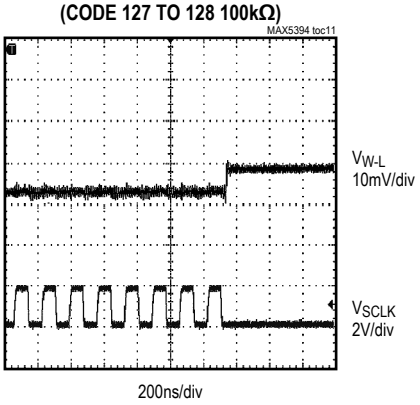
**TAP-TO-TAP SWITCHING TRANSIENT (CODE 127 TO 128 10kΩ)**



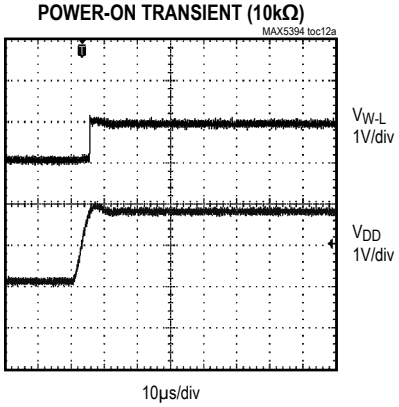

**TAP-TO-TAP SWITCHING TRANSIENT (CODE 127 TO 128 50kΩ)**



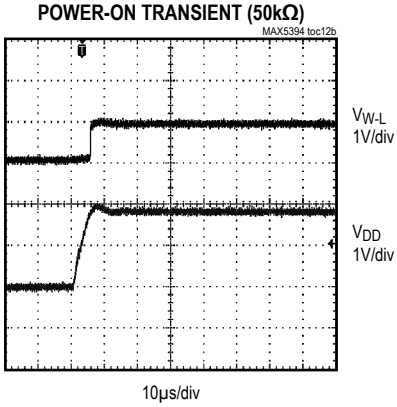

**TAP-TO-TAP SWITCHING TRANSIENT (CODE 127 TO 128 100kΩ)**



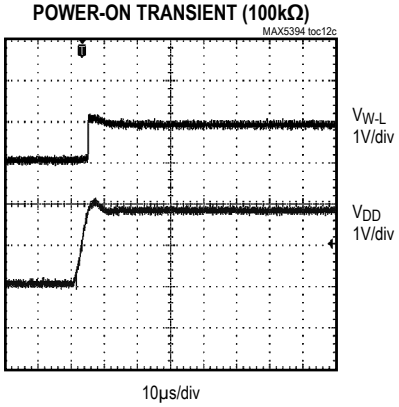

**POWER-ON TRANSIENT (10kΩ)**




**POWER-ON TRANSIENT (50kΩ)**



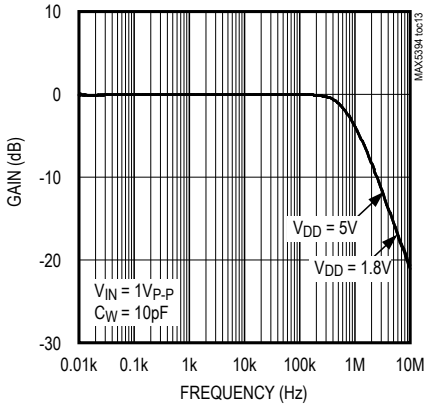

**POWER-ON TRANSIENT (100kΩ)**



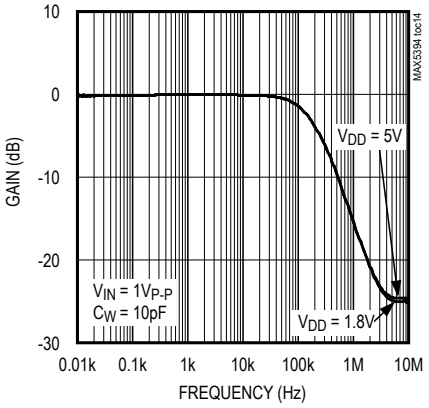
## Typical Operating Characteristics (continued)

($V_{DD}$ = 1.8V, $T_A$ = +25°C, unless otherwise noted.)

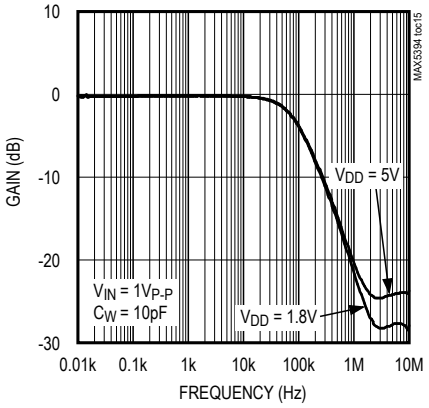
MIDSCALE FREQUENCY RESPONSE (10kΩ)



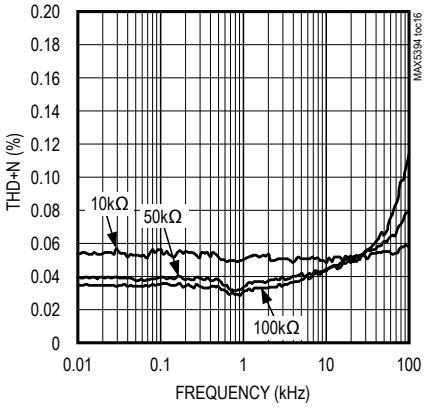

MIDSCALE FREQUENCY RESPONSE (50kΩ)



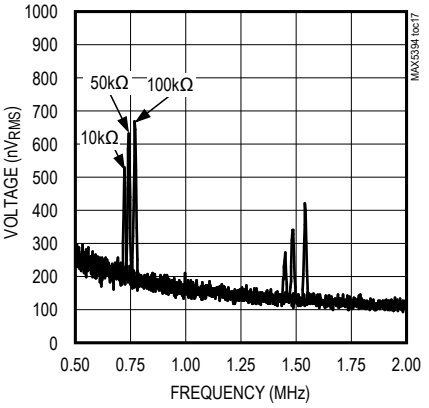

MIDSCALE FREQUENCY RESPONSE (100kΩ)



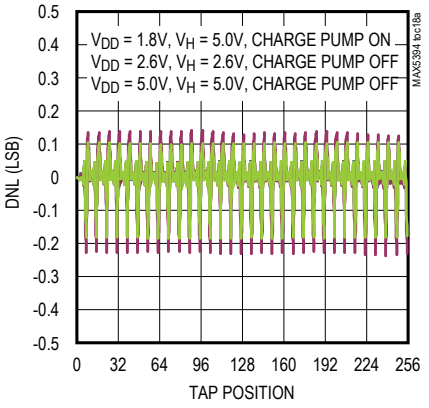

TOTAL HARMONIC DISTORTION PLUS NOISE vs. FREQUENCY



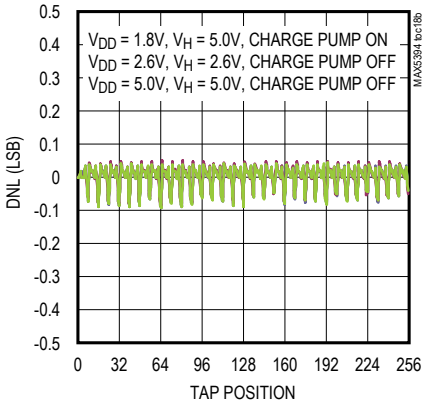

CHARGE-PUMP FEEDTHROUGH AT W



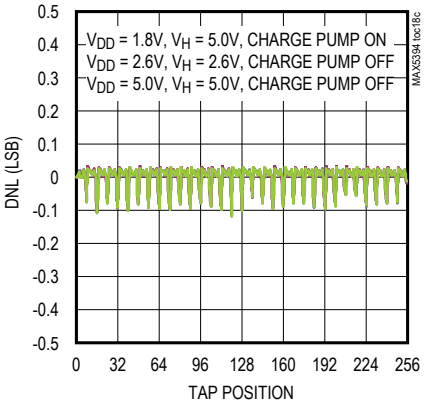

VARIABLE-RESISTOR DNL vs. TAP POSITION (10kΩ)



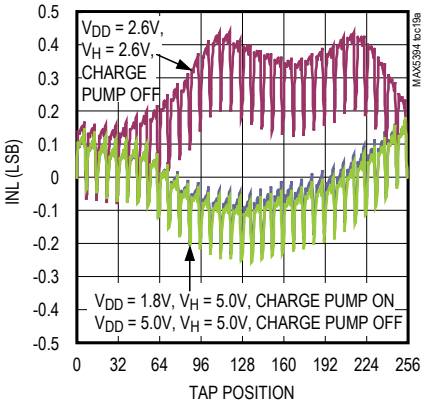

VARIABLE-RESISTOR DNL vs. TAP POSITION (50kΩ)




VARIABLE-RESISTOR DNL vs. TAP POSITION (100kΩ)



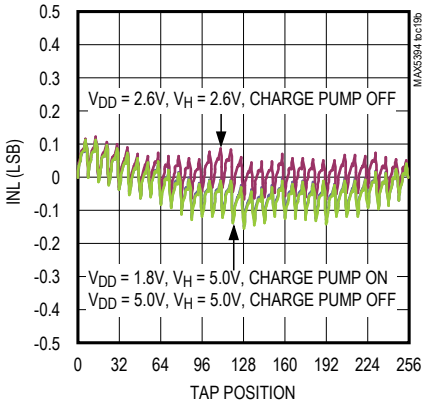

VARIABLE-RESISTOR INL vs. TAP POSITION (10kΩ)



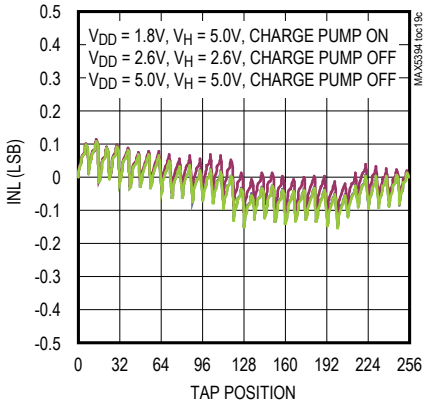
## Typical Operating Characteristics (continued)

($V_{DD}$ = 1.8V, $T_A$ = +25°C, unless otherwise noted.)

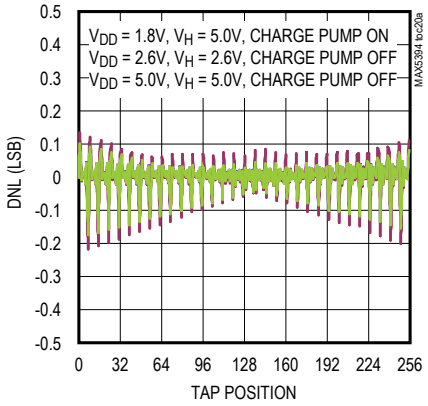
**VARIABLE-RESISTOR INL vs. TAP POSITION (50kΩ)**



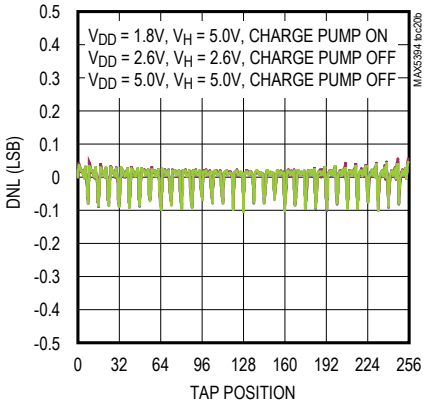

**VARIABLE-RESISTOR INL vs. TAP POSITION (100kΩ)**



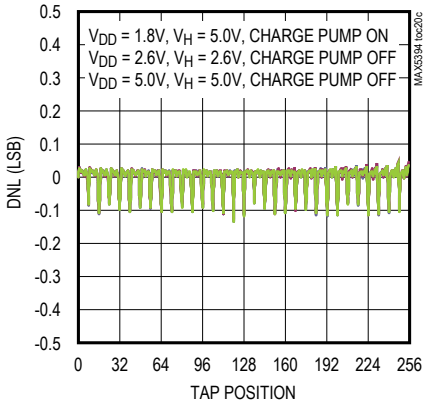

**VOLTAGE-DIVIDER DNL vs. TAP POSITION (10kΩ)**



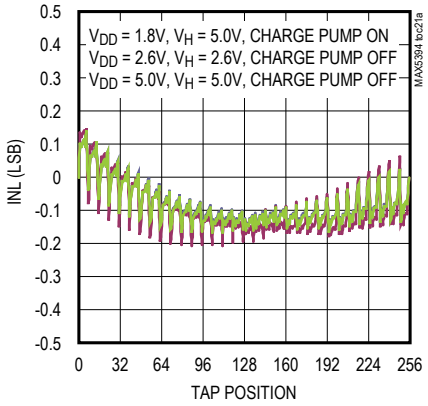

**VOLTAGE-DIVIDER DNL vs. TAP POSITION (50kΩ)**



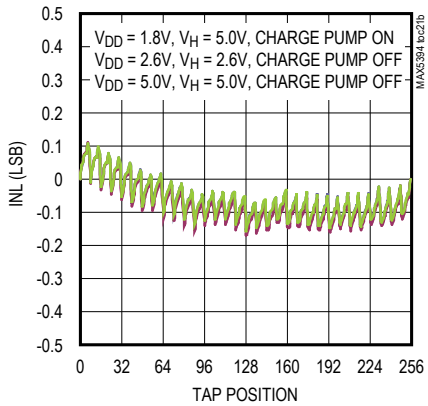

**VOLTAGE-DIVIDER DNL vs. TAP POSITION (100kΩ)**



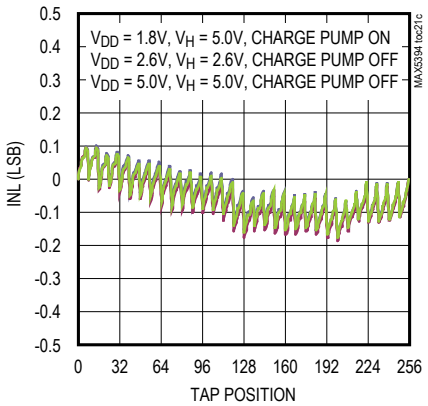

**VOLTAGE-DIVIDER INL vs. TAP POSITION (10kΩ)**



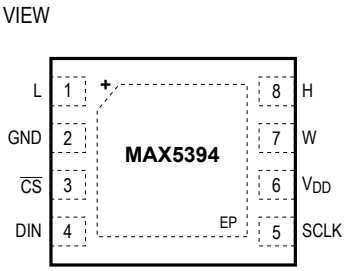

**VOLTAGE-DIVIDER INL vs. TAP POSITION (50kΩ)**




**VOLTAGE-DIVIDER INL vs. TAP POSITION (100kΩ)**



## Pin Configuration

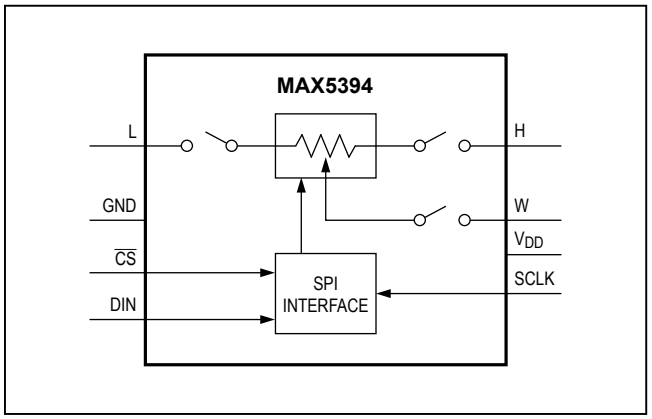



**TDFN**

## Pin Description

| PIN | NAME | FUNCTION |
|---|---|---|
| 1 | L | Low Terminal. The voltage at L can be greater than or less than the voltage at H. Current can flow into or out of L. |
| 2 | GND | Ground |
| 3 | $\overline{CS}$ | Active-Low Chip-Select Digital Input |
| 4 | DIN | Serial-Interface Data Input |
| 5 | SCLK | Serial-Interface Clock Input |
| 6 | $V_{DD}$ | Power Supply |
| 7 | W | Wiper Terminal |
| 8 | H | High Terminal. The voltage at H can be greater than or less than the voltage at L. Current can flow into or out of H. |
| — | EP | Exposed Pad. Internally connected to GND. Connected to ground. |

## Functional Diagram




## Detailed Description

The MAX5394 single, 256-tap volatile, low-voltage linear taper digital potentiometer offers three end-to-end resistance values of 10kΩ, 50kΩ, and 100kΩ. Potentiometer terminals are independent of supply for voltages up to +5.25V with single-supply operation from 1.7V to 5.5V (charge pump enabled). User-controlled shutdown modes allow the H, W, or L terminals to be opened with the wiper position set to zero-code, midcode, full-code, or the value contained in the wiper register. Ultra-low-quiescent supply current (< 1µA) can be achieved for supply voltages between 2.6V and 5.5V by disabling the internal charge pump and not allowing potentiometer terminals to exceed the supply voltage by more than 0.3V. The MAX5394 provides a low 50ppm/°C end-to-end temperature coefficient and features a SPI serial interface.

The small package size, low supply operating voltage, low supply current, and automotive temperature range of the MAX5394 make the device uniquely suited for the portable consumer market and battery-backup industrial applications.

### Charge Pump

The MAX5394 contains an internal charge pump that guarantees the maximum wiper resistance, $R_{WL}$, to be less than 50Ω (25Ω typ) for supply voltages down to 1.7V and allows pins H, W, and L to be driven between GND and 5.25V independent of $V_{DD}$. Minimal charge-pump feedthrough is present at the terminal outputs and is illustrated by the Charge-Pump Feedthrough at W vs. Frequency graph in the *Typical Operating Characteristics*. The charge pump is on by default but can be disabled with QP_OFF and enabled with the QP_ON commands (Table 1). The MAX5394 minimum supply voltage with charge pump disabled is limited to 2.6V and terminal voltage cannot exceed -0.3V to ($V_{DD}$ + 0.3V).

### SPI Interface

The digital interface is powered from $V_{DD}$, not the internal charge-pump voltage. Therefore the $V_{IH}$ and $V_{IL}$ logic thresholds will follow $V_{DD}$ as specified in the *Electrical Characteristics* table.

The SPI digital interface uses a 3-wire serial data interface to control the wiper tap position. This write-only interface contains three inputs: Chip Select ($\overline{CS}$), Data In (DIN), and Data Clock (SCLK). When $\overline{CS}$ is taken low, data from the DIN pin is synchronously loaded into the serial shift register on each falling edge of each SCLK pulse (Figure 3). After all the data bits have been shifted in, they are latched into the potentiometer control register. Data written to a memory register immediately updates the wiper position.

Keep $\overline{CS}$ low during the entire data stream to prevent the data from being terminated. The power-on default position of the wiper is midscale (D[7:0] = 80H).

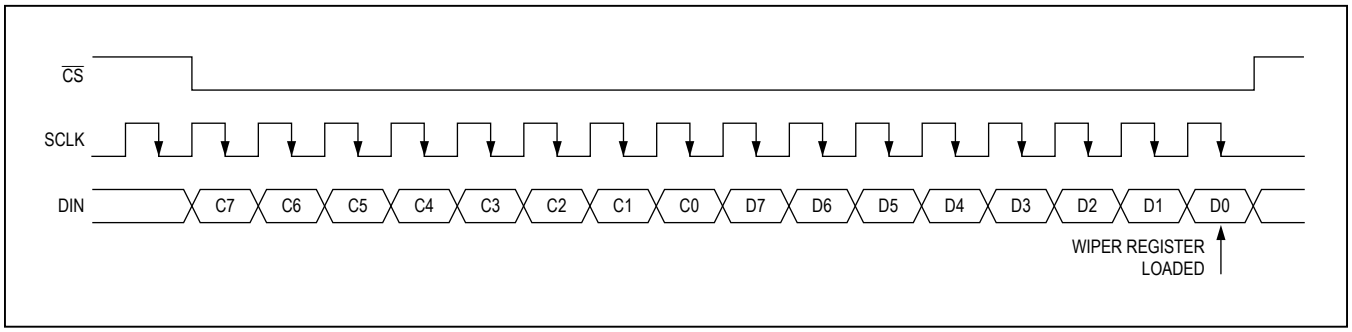



*Figure 3. SPI Digital Interface Format*

## Table 1. SPI Write Command Byte Summary

| COMMAND | COMMAND BYTE | | | | | | | | DATA BYTE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C7 | C6 | C5 | C4 | C3 | C2 | C1 | C0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| WIPER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| SD_CLR | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | X | X | X | X | X | X | X | X |
| SD_H_WREG | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | X | X | X | X | X | X | X | X |
| SD_H_ZERO | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | X | X | X | X | X | X | X | X |
| SD_H_MID | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | X | X | X | X | X | X | X | X |
| SD_H_FULL | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | X | X | X | X | X | X | X | X |
| SD_L_WREG | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | X | X | X | X | X | X | X | X |
| SD_L_ZERO | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | X | X | X | X | X | X | X | X |
| SD_L_MID | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | X | X | X | X | X | X | X | X |
| SD_L_FULL | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | X | X | X | X | X | X | X | X |
| SD_W | 1 | 0 | 0 | 0 | 0 | 1 | X | X | X | X | X | X | X | X | X | X |
| QP_OFF | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | X | X | X | X | X | X | X | X |
| QP_ON | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | X | X | X | X | X | X | X | X |
| RST | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | X | X | X | X | X | X | X | X |

### WIPER Command

The data byte writes to the wiper register and the potentiometer moves to the appropriate position. D[7:0] indicates the position of the wiper. D[7:0] = 0x00 moves the wiper to the position closest to L. D[7:0] = 0xFF moves the wiper closest to H. D[7:0] = 0x80 following power-on.

### SD_CLR Command

Removes any existing shutdown condition. Connects all potentiometer terminals and returns the wiper to the value stored in the wiper register. The command does not affect the current status of the charge pump.

### SD_H_WREG Command

Opens the H terminal and maintains the wiper at the wiper register location. Writes cannot be made to the wiper register while shutdown mode is engaged. Clearing shutdown mode will close the H terminal and allow the wiper register to be written. A RST will also deassert shutdown mode and return the wiper to midscale (0x80). This command does not affect the charge-pump status.

### SD_H_ZERO Command

Moves wiper to zero-scale position (0x00) and opens the H terminal. The wiper register remains unaltered. Writes cannot be made to the wiper register while shutdown mode is engaged. Clearing shutdown mode will return the wiper to the position contained in the wiper register and close the H terminal. A RST will also deassert shutdown mode and return the wiper to midscale (0x80). This command does not affect the charge-pump status.

### SD_H_MID Command

Moves wiper to midscale position (0x80) and opens the H terminal. The wiper register remains unaltered. Writes cannot be made to the wiper register while shutdown mode is engaged. Clearing shutdown mode will return the wiper to the position contained in the wiper register and close the H terminal. A RST will also deassert shutdown mode and return the wiper to midscale (0x80). This command does not affect the charge-pump status.

### SD_H_FULL Command

Moves wiper to full-scale position (0xFF) and opens H terminal. The wiper register remains unaltered. Writes cannot be made to the wiper register while shutdown mode is engaged. Clearing shutdown mode will return the wiper to the position contained in the wiper register and close the H terminal. A RST will also deassert shutdown mode and return the wiper to midscale (0x80). This command does not affect the charge-pump status.

### SD_L_WREG Command

Opens the L terminal and maintains the wiper at the wiper register location. Writes cannot be made to the wiper register while shutdown mode is engaged. Clearing shutdown mode will close the L terminal and allow wiper

register to be written. A RST will also deassert shutdown mode and return the wiper to midscale (0x80). This command does not affect the charge-pump status.

### SD_L_ZERO Command

Moves wiper to zero-scale position (0x00) and opens the L terminal. The wiper register remains unaltered. Writes cannot be made to the wiper register while shutdown mode is engaged. Clearing shutdown mode will return the wiper to the position contained in the wiper register and close the L terminal. A RST will also deassert shutdown mode and return the wiper to midscale (0x80). This command does not affect the charge-pump status.

### SD_L_MID Command

Moves wiper to midscale position (0x80) and opens the L terminal. The wiper register remains unaltered. Writes cannot be made to the wiper register while shutdown mode is engaged. Clearing shutdown mode will return the wiper to the position contained in the wiper register and close the L terminal. A RST will also deassert shutdown mode and return the wiper to midscale (0x80). This command does not affect the charge-pump status.

### SD_L_FULL Command

Moves wiper to full-scale position (0xFF) and opens the L terminal. The wiper register remains unaltered. Writes cannot be made to the wiper register while shutdown mode is engaged. Clearing shutdown mode will return the wiper to the position contained in the wiper register and close the L terminal. A RST will also deassert shutdown mode and return the wiper to midscale (0x80). This command does not affect the charge-pump status.

### SD_W Command

Opens the W terminal keeping the internal tap position the same as the wiper register. Writes cannot be made to the wiper registers while shutdown mode is engaged. Clearing shutdown mode will return the wiper to the position contained in the wiper register and close W terminal. A RST will also deassert shutdown mode and return the wiper to midscale (0x80). This command does not affect the charge-pump status.

### QP_ON Command

Enables the onboard charge pump to allow low-supply voltage operation. This is the power-on default condition. Low supply voltage is 1.7V.

### QP_OFF Command

Disables the on-board charge pump and places device in low power mode. Low supply voltage is limited to 2.6V.

### RST Command

Returns device to power-on default conditions. Resets the wiper register to midscale (0x80), enables charge pump, and deasserts any shutdown modes.

## Ordering Information

| PART | PIN-PACKAGE | INTERFACE | TAPS | END-TO-END RESISTANCE (kΩ) |
|---|---|---|---|---|
| MAX5394LATA+T | 8 TDFN-EP* | SPI | 256 | 10 |
| MAX5394MATA+T | 8 TDFN-EP* | SPI | 256 | 50 |
| MAX5394NATA+T | 8 TDFN-EP* | SPI | 256 | 100 |

***Note:*** *All devices operate over the -40°C to +125°C temperature range.*

*+Denotes a lead(Pb)-free/RoHS-compliant package.*

**EP = Exposed pad.*

## Chip Information

PROCESS: BiCMOS

## Package Information

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO. | LAND PATTERN NO. |
|---|---|---|---|
| 8 TDFN-EP | T822+2 | 21-0168 | 90-0065 |

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 7/12 | Initial release | — |
| 1 | 9/12 | Revised the *Absolute Maximum Ratings* | 2 |
| 2 | 10/14 | Removed automotive reference from data sheet | 1, 11 |
| 3 | 1/16 | Updated *Supply Current* specification in *Electrical Characteristics* table | 3 |

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