

## MAX2634

## 315MHz/433MHz Low-Noise Amplifier for Automotive RKE

### General Description

The MAX2634 low-noise amplifier (LNA) with low-power shutdown mode is optimized for 315MHz and 433.92MHz automotive remote keyless entry (RKE) applications. At 315MHz, the LNA achieves 15.5dB power gain and a 1.25dB noise figure while only consuming 2.5mA of supply current from a 2.2V to 5.5V power supply. An integrated logic-controlled low-power shutdown mode reduces power consumption to 0.1 $\mu$ A and replaces the two transistors typically required to implement the shutdown function in discrete-based RKE LNA solutions. The device further reduces component count by integrating the output matching and DC-blocking components, and only requires a single inductor to match the input for best noise figure and input return loss.

The device is available in a small 6-pin (2.0mm x 2.2mm x 0.9mm) lead-free SC70 package for automotive applications that require visual inspection of PCB solder connections.

### Applications

- Remote Keyless Entry (RKE)
- Tire Pressure Monitoring Systems (TPMS)
- Security
- Garage Door Openers
- Telemetry Receivers

### Features

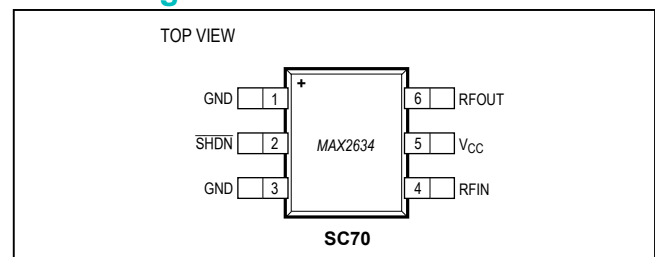
- Optimized for 308MHz, 315MHz, 418MHz, and 433.92MHz
- 2.2V to 5.5V Supply Voltage Range
- Low Operating Supply Current  
2.5mA (typ), 4mA (max)
- Logic-Controlled 1 $\mu$ A (max) Shutdown
- Typical Performance at 315MHz  
1.25dB Noise Figure  
-16dBm Input IP3  
15.5dB Power Gain
- Automotive Temperature Range  
-40°C to +125°C
- ESD Rating of  $\pm$ 2.0kV (HBM) on All Pins
- AEC-Q100 Qualification

### Ordering Information

| PART         | TEMP RANGE      | PIN-PACKAGE | TOP MARK |
|--------------|-----------------|-------------|----------|
| MAX2634AXT+  | -40°C to +125°C | 6 SC70      | +ADG     |
| MAX2634AXTV+ | -40°C to +125°C | 6 SC70      | +ADG     |

+Denotes a lead(Pb)-free/RoHS-compliant package.  
V Denotes an automotive qualified part.

### Pin Configuration



Functional Diagram/Typical Operating Circuit appears at end of data sheet.

### Performance Table

| FREQUENCY (MHz) | L1 (nH) | SUPPLY CURRENT (mA) | GAIN (dB) | NOISE FIGURE (dB) | INPUT P1dB (dBm) | INPUT IP3 (dBm) |
|-----------------|---------|---------------------|-----------|-------------------|------------------|-----------------|
| 308             | 56      | 2.5                 | 15.5      | 1.25              | -29              | -16             |
| 315             | 56      | 2.5                 | 15.5      | 1.25              | -29              | -16             |
| 418             | 33      | 2.5                 | 13.5      | 1.25              | -26              | -12             |
| 433.92          | 33      | 2.5                 | 13.5      | 1.25              | -26              | -12             |

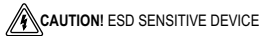
**Absolute Maximum Ratings**

V<sub>CC</sub> Pin to GND .....-0.3V to +6.0V  
 RFIN .....Pin Must Be AC-Coupled with DC-Blocking Cap  
 RFOUT,  $\overline{\text{SHDN}}$  .....-0.3V to (V<sub>CC</sub> + 0.3V)  
 RF Input Power .....+5dBm  
 Continuous Power Dissipation (T<sub>A</sub> = +70°C)  
 6-Pin SC70 (derate 3.1mW/°C above +70°C).....245mW  
 Junction-to-Case Thermal Resistance (θ<sub>JC</sub>)  
 (Note 1).....115°C/W

Junction-to-Ambient Thermal Resistance (θ<sub>JA</sub>)  
 (Note 1).....326°C/W  
 Operating Temperature Range.....-40°C to +125°C  
 Junction Temperature.....+150°C  
 Storage Temperature Range.....-65°C to +160°C  
 Lead Temperature (soldering, 10s).....300°C

**Note 1:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a 4-layer board. For detailed information on package thermal considerations, refer to [www.maximintegrated.com/thermal-tutorial](http://www.maximintegrated.com/thermal-tutorial).

*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.*



**DC Electrical Characteristics**

(V<sub>CC</sub> = +2.2V to +5.5V, T<sub>A</sub> = -40°C to +125°C, Typical values are at V<sub>CC</sub> = +3.0V, T<sub>A</sub> = +25°C, unless otherwise noted. RFIN and RFOUT are AC-coupled and terminated to 50Ω. No RF input signals at RFIN and RFOUT.) (Note 2)

| PARAMETER   | CONDITIONS  | MIN | TYP | MAX | UNITS |
|---|---|-----|-----|-----|-------|
| Operating Supply Voltage  |   | 2.2 |     | 5.5 | V     |
| Operating Supply Current  | $\overline{\text{SHDN}}$ = high, T <sub>A</sub> = +25°C           |     | 2.5 | 4   | mA    |
|   | $\overline{\text{SHDN}}$ = high, T <sub>A</sub> = -40°C to +125°C |     |     | 6   | mA    |
| Shutdown Supply Current   | V $\overline{\text{SHDN}}$ = 0, T <sub>A</sub> = +25°C            |     |     | 1   | μA    |
|   | V $\overline{\text{SHDN}}$ = 0, T <sub>A</sub> = -40°C to +125°C  |     |     | 10  | μA    |
| <b>DIGITAL CONTROL INPUTS (<math>\overline{\text{SHDN}}</math>)</b> |   |     |     |     |       |
| Digital Input-Voltage High  |   | 1.1 |     |     | V     |
| Digital Input-Voltage Low   |   |     |     | 0.4 | V     |
| Digital Input-Current High  | V $\overline{\text{SHDN}}$ = V <sub>IH</sub>                      |     |     | 5   | μA    |
| Digital Input-Current Low   | V $\overline{\text{SHDN}}$ = V <sub>IL</sub>                      |     |     | 1   | μA    |
| <b>SHUTDOWN MODE CONTROL</b>  |   |     |     |     |       |
| Enable Time   |   |     | 130 |     | μs    |
| Disable Time  |   |     | 20  |     | μs    |

AC Electrical Characteristics

(MAX2634 EV Kit,  $V_{CC} = +2.2V$  to  $+5.5V$ ,  $T_A = -40^\circ C$  to  $+125^\circ C$ . Typical values are at  $V_{CC} = +3.0V$  and  $T_A = +25^\circ C$ , unless otherwise noted.  $P_{RFIN} = -40dBm$ ,  $\overline{SHDN} = high$ .) (Note 2)

| PARAMETER                           | CONDITIONS  | MIN  | TYP  | MAX | UNITS |
|-------------------------------------|---|------|------|-----|-------|
| <b>f<sub>RFIN</sub> = 315MHz</b>    |   |      |      |     |       |
| Power Gain                          | $T_A = +25^\circ C$   | 12.5 | 15.5 |     | dB    |
|                                     | $T_A = -40^\circ C$ to $+125^\circ C$ , $V_{CC} = +3.0V$          | 11.5 |      |     |       |
| Noise Figure                        | $T_A = +25^\circ C$   |      | 1.25 |     | dB    |
| Input Third-Order Intercept Point   | (Note 3)  |      | -16  |     | dBm   |
| Input 1dB Compression Point         |   |      | -29  |     | dBm   |
| Input Return Loss                   |   |      | 10   |     | dB    |
| Output Return Loss                  |   |      | 8    |     | dB    |
| Reverse Isolation                   |   |      | 60   |     | dB    |
| <b>f<sub>RFIN</sub> = 433.92MHz</b> |   |      |      |     |       |
| Power Gain                          | $T_A = +25^\circ C$ (Note 4)                                      | 11   | 13.5 |     | dB    |
|                                     | $T_A = -40^\circ C$ to $+125^\circ C$ , $V_{CC} = +3.0V$ (Note 4) | 10   |      |     |       |
| Noise Figure                        | $T_A = +25^\circ C$   |      | 1.25 |     | dB    |
| Input Third-Order Intercept Point   | (Note 3)  |      | -12  |     | dBm   |
| Input 1dB Compression Point         |   |      | -26  |     | dBm   |
| Input Return Loss                   |   |      | 11   |     | dB    |
| Output Return Loss                  |   |      | 8    |     | dB    |
| Reverse Isolation                   |   |      | 60   |     | dB    |

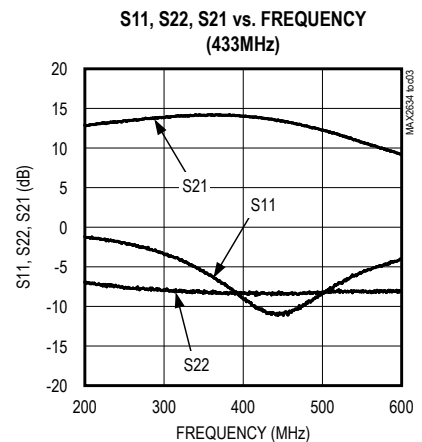
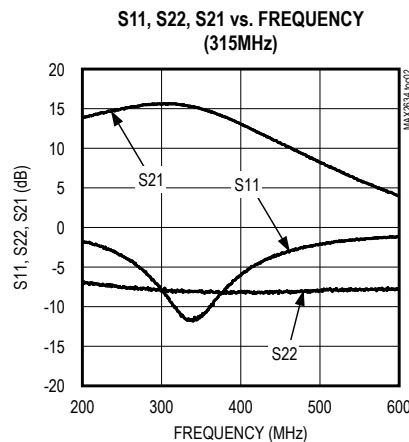
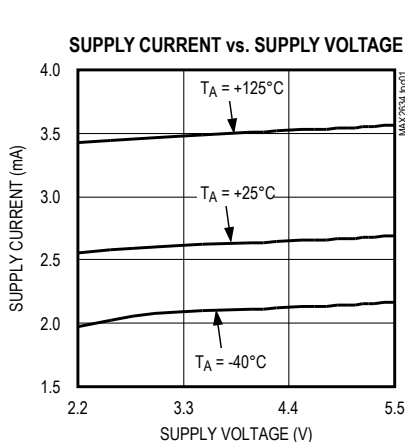
**Note 2:** Guaranteed by production test at  $T_A = +25^\circ C$ . Guaranteed by design and characterization at  $T_A = -40^\circ C$  and  $T_A = +125^\circ C$ .

**Note 3:** Measured with two tones located at 315MHz and 316MHz or 433MHz and 434MHz at -40dBm/tone.

**Note 4:** Guaranteed by design and characterization.

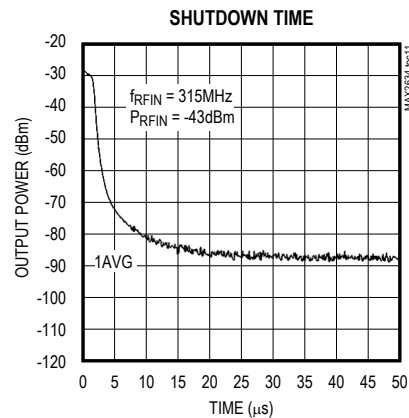
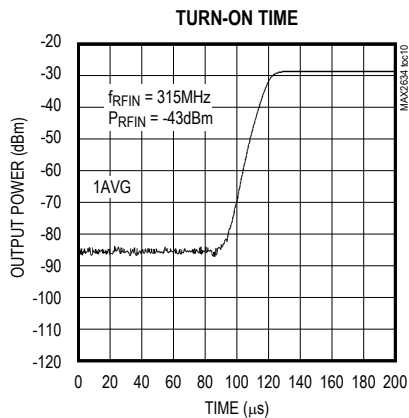
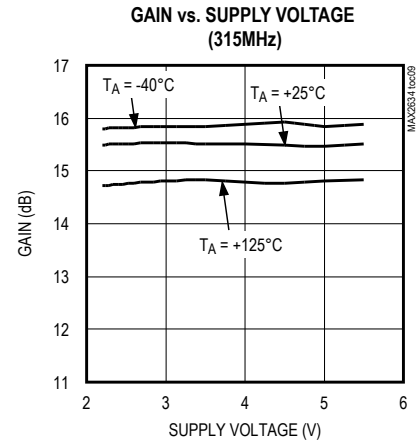
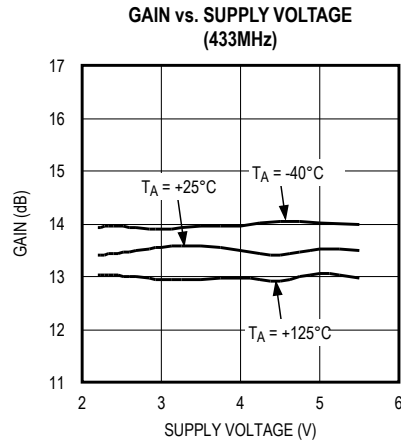
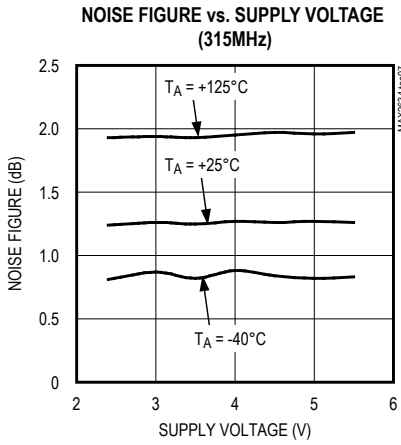
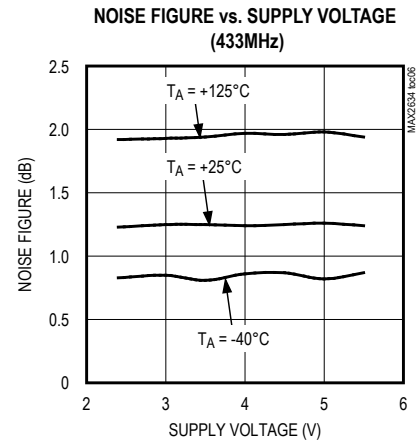
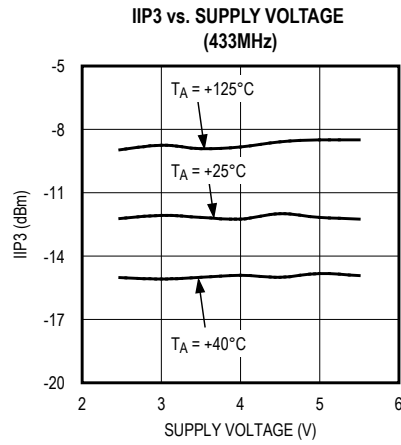
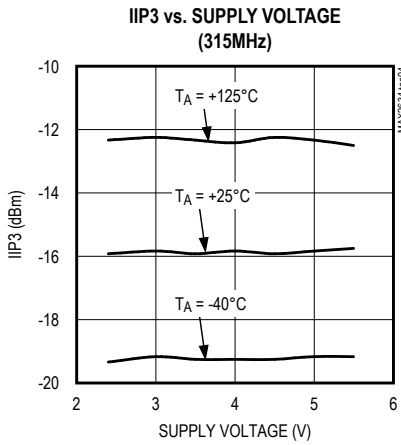
Typical Operating Characteristics

(MAX2634 EV Kit,  $V_{CC} = +2.2V$  to  $+5.5V$ ,  $T_A = -40^\circ C$  to  $+125^\circ C$ . Typical values are at  $V_{CC} = +3.0V$  and  $T_A = +25^\circ C$ , unless otherwise noted.  $f_{RFIN} = 315MHz/433MHz$ ,  $P_{RFIN} = -40dBm$ ,  $\overline{SHDN} = high$ .)



Typical Operating Characteristics (continued)

(MAX2634 EV Kit,  $V_{CC} = +2.2V$  to  $+5.5V$ ,  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$ . Typical values are at  $V_{CC} = +3.0V$  and  $T_A = +25^{\circ}C$ , unless otherwise noted.  $f_{RFIN} = 315MHz/433MHz$ ,  $P_{RFIN} = -40dBm$ ,  $\overline{SHDN} = high$ .)



## Pin Description

| PIN  | NAME            | FUNCTION  |
|------|-----------------|---|
| 1, 3 | GND             | Ground. Use minimum path to ground plane to minimize inductance.  |
| 2    | SHDN            | Shutdown Input. A logic-level high enables the LNA, and a logic-level low disables the LNA.   |
| 4    | RFIN            | RF Input. Requires an inductor to match the input for best noise figure and return loss. A DC-blocking capacitor is required if the RFIN input will see a DC voltage or ground. See the <i>Functional Diagram/Typical Operating Circuit</i> . |
| 5    | V <sub>CC</sub> | Supply Voltage. Bypass to ground with a 0.01μF capacitor as close as possible to the pin.   |
| 6    | RFOUT           | RF Output. Internally matched to 50Ω and incorporates an internal DC-blocking capacitor.  |

**Table 1. Typical Input and Output Impedances in R+jX Format**

(V<sub>CC</sub> = +3.0V, T<sub>A</sub> = +25°C.)

| FREQUENCY (MHz) | INPUT IMPEDANCE |      | OUTPUT IMPEDANCE |       |
|-----------------|-----------------|------|------------------|-------|
|                 | R               | X    | R                | X     |
| 100             | 58              | -438 | 92               | -94   |
| 200             | 43              | -216 | 92.1             | -50   |
| 308             | 29              | -139 | 91.2             | -35.8 |
| 315             | 29.4            | -137 | 91               | -35   |
| 418             | 29.2            | -101 | 90.5             | -30   |
| 434             | 28.5            | -96  | 89.5             | -29.3 |
| 500             | 26.4            | -83  | 91               | -28.2 |
| 600             | 26.7            | -69  | 87.5             | -27.3 |

## Detailed Description

The MAX2634 LNA with low-power shutdown mode is optimized for 308MHz, 315MHz, 418MHz, and 433MHz automotive RKE applications, which are required to operate over the -40°C to +125°C automotive temperature range. The device reduces component count by integrating the output matching and DC-blocking components, and only requires a single inductor to match the input for best noise figure and input return loss. An integrated logic-controlled low-power shutdown mode reduces power consumption to 0.1μA and replaces the two transistors typically required to implement the shutdown function in discrete-based RKE LNA solutions.

## Input Matching

The MAX2634 requires an off-chip input matching network. The *Functional Diagram/Typical Operating Circuit* shows the recommended input-matching network component values for operation at 315MHz and 433MHz. These values are optimized for the best simultaneous gain, noise figure, and return loss performance. Table 1 lists typical input and output impedances.

### RF Input Coupling Capacitor Input IP3 vs. Enable Time

The value of the coupling capacitor affects input IP3 and turn-on time. A larger coupling capacitor results in higher input IP3 at the expense of longer turn-on time. See Table 3 for the typical amount of trade-off.

### Integrated Output Matching Network and DC-Block

The MAX2634 integrates the output matching network and DC-block, eliminating the need for external matching components while providing a broadband match. See the *Functional Diagram/Typical Operating Circuit* for component values.

### Shutdown

The MAX2634 features a shutdown pin to disable the entire chip. Apply a logic-high to the  $\overline{\text{SHDN}}$  pin to place the part in the active mode, and a logic-low to place the part in the shutdown mode.

### Power-Supply Bypassing

Bypassing the  $V_{CC}$  line is necessary for optimum gain/linearity performance. See the *Functional Diagram/Typical Operating Circuit* for bypassing capacitor values.

### Layout Information

A properly designed PCB is essential to any RF/microwave circuit. Use controlled-impedance lines on all high-frequency inputs and outputs. Bypass with decoupling capacitors located close to the device's  $V_{CC}$  pin. For long  $V_{CC}$  lines, it may be necessary to add additional decoupling capacitors. These additional capacitors can be located farther away from the device package. Proper grounding of the GND pins is essential. If the PCB uses a topside RF ground, connect it directly to all GND pins. For a board where the ground plane is not on the component layer, the best technique is to connect the GND pins to the board with a plated through-hole located close to the package.

**Table 2. MAX2634 Typical Noise Parameters**

( $V_{CC} = +3.0V$ ,  $T_A = +25^\circ C$ .)

| FREQUENCY (MHz) | FMIN (dB) | $ \Gamma_{OPT} $ | $ \Gamma_{OPT} $ ANGLE | $R_N (\Omega)$ |
|-----------------|-----------|------------------|------------------------|----------------|
| 308             | 0.64      | 0.50             | 27.0                   | 9.78           |
| 315             | 0.65      | 0.49             | 27.7                   | 9.78           |
| 418             | 0.78      | 0.44             | 37.4                   | 9.87           |
| 434             | 0.80      | 0.44             | 38.9                   | 9.88           |

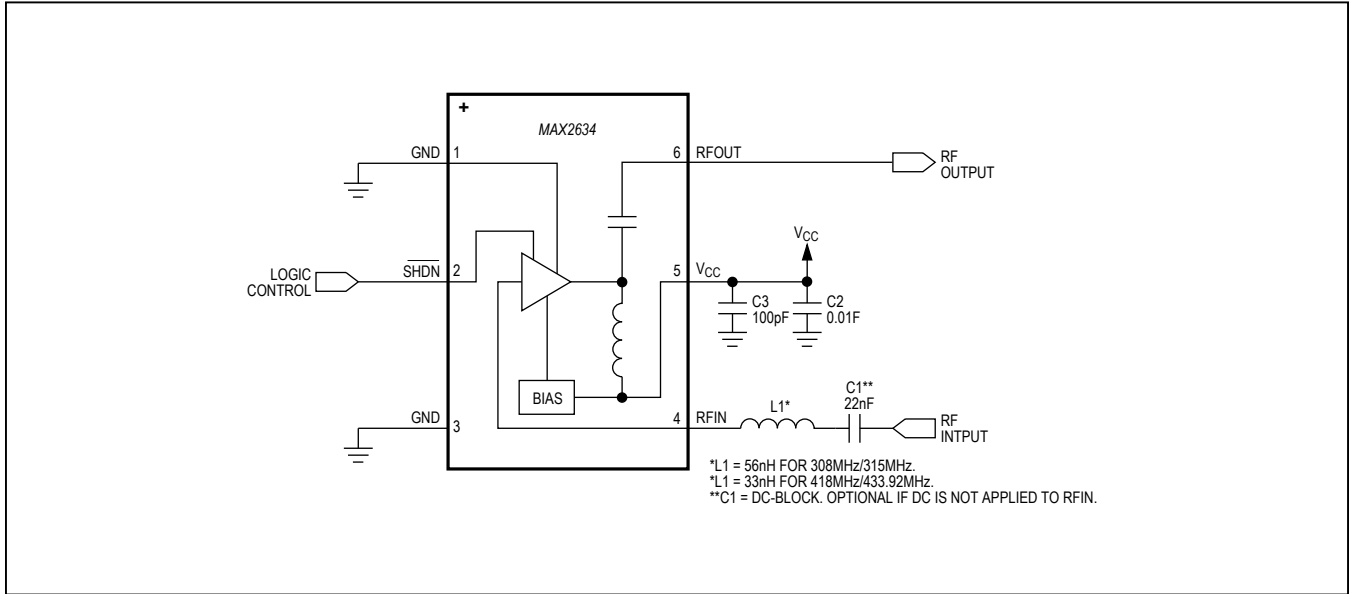
**Table 3. RF Input Coupling Capacitor  
Input IP3 vs. Enable Time**

| INPUT DC-BLOCKING CAPACITOR, C1 ( | ENABLE TIME ( $\mu s$ ) | INPUT IP3 AT 315MHz (dBm) |
|-----------------------------------|-------------------------|---------------------------|
| 1                                 | 6                       | -19                       |
| 3.3                               | 20                      | -14                       |
| 22                                | 130                     | -12                       |
| 100                               | 600                     | -11                       |
| 1000                              | 6000                    | -11                       |

### Chip Information

PROCESS: SiGe BiCMOS

Functional Diagram/Typical Operating Circuit



Package Information

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://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.        |
|--------------|--------------|-------------------------|-------------------------|
| 6 SC70       | X6SN+1       | <a href="#">21-0077</a> | <a href="#">90-0189</a> |

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION   | PAGES CHANGED |
|-----------------|---------------|---|---------------|
| 0               | 10/08         | Initial release   | —             |
| 1               | 3/09          | Updated the <i>Features</i> , <i>Performance Table</i> , <i>Electrical Characteristics</i> , and <i>Typical Operating Characteristics</i> sections. | 1, 3, 4       |
| 2               | 2/14          | Added automotive grade package to <i>Ordering Information</i>   | 1             |
| 3               | 11/15         | Updated package code in <i>Package Information</i> section  | 7             |

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated's website at [www.maximintegrated.com](http://www.maximintegrated.com).

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