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

MAX2634

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 0.1µA 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

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

Features

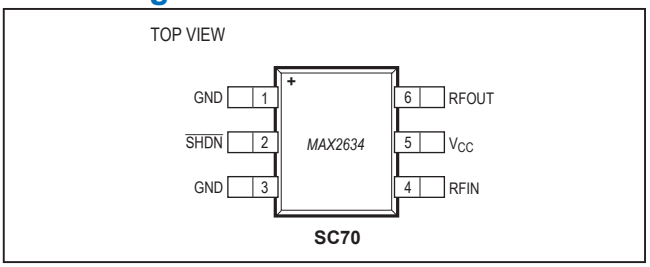
- Optimized for 308MHz, 315MHz, 418MHz, and 433.92MHz
- 2.2V to 5.5V Supply Voltage Range
- Low Operating Supply Current
  2.5mA (typ), 4mA (max)
- Logic-Controlled 1µA (max) Shutdown
- Typical Performance at 315MHz
  1.25dB Noise Figure
  -16dBm Input IP3
  15.5dB Power Gain
- Automotive Temperature Range
  -40°C to +125°C
- ESD Rating of ±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
MAX2634AXT/V+	-40°C to +125°C	6 SC70	+ADN

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

Pin Configuration



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

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Absolute Maximum Ratings

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

CAUTION! ESD SENSITIVE DEVICE

DC Electrical Characteristics

(V_{CC} = +2.2V to +5.5V, T_A = -40°C to +125°C, Typical values are at V_{CC} = +3.0V, T_A = +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	$\overline{SHDN}$ = high, TA = +25°C		2.5	4	mA
	$\overline{SHDN}$ = high, TA = -40°C to +125°C			6	mA
Shutdown Supply Current	$V_{\overline{SHDN}}$ = 0, TA = +25°C			1	µA
	$V_{\overline{SHDN}}$ = 0, TA = -40°C to +125°C			10	µA
DIGITAL CONTROL INPUTS ($\overline{SHDN}$)					
Digital Input-Voltage High		1.1			V
Digital Input-Voltage Low				0.4	V
Digital Input-Current High	$V_{\overline{SHDN}}$ = VIH			5	µA
Digital Input-Current Low	$V_{\overline{SHDN}}$ = VIL			1	µA
SHUTDOWN MODE CONTROL					
Enable Time			130		µs
Disable Time			20		µs

AC Electrical Characteristics

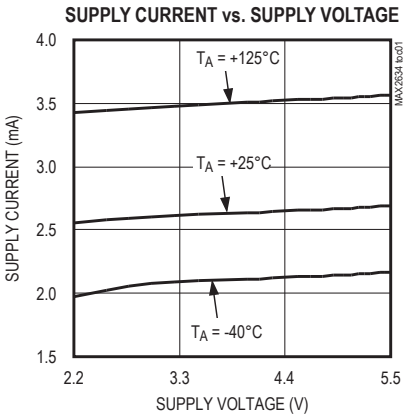
(MAX2634 EV Kit, V_{CC} = +2.2V to +5.5V, T_A = -40°C to +125°C. Typical values are at V_{CC} = +3.0V and T_A = +25°C, unless otherwise noted. P_{RFIN} = -40dBm, $\overline{SHDN}$ = high.) (Note 2)

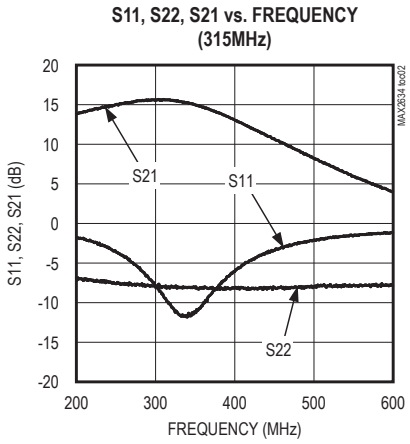
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
fRFIN = 315MHz					
Power Gain	TA = +25°C	12.5	15.5		dB
	TA = -40°C to +125°C, VCC = +3.0V	11.5			
Noise Figure	TA = +25°C		1.25		dB
Input Third-Order Intercept Point	(Note 3)		-16		dBm
Input 1dB Compression Point			-29		dBm
Input Return Loss			10		dB
Output Return Loss			8		dB
Reverse Isolation			60		dB
fRFIN = 433.92MHz					
Power Gain	TA = +25°C (Note 4)	11	13.5		dB
	TA = -40°C to +125°C, VCC = +3.0V (Note 4)	10			
Noise Figure	TA = +25°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

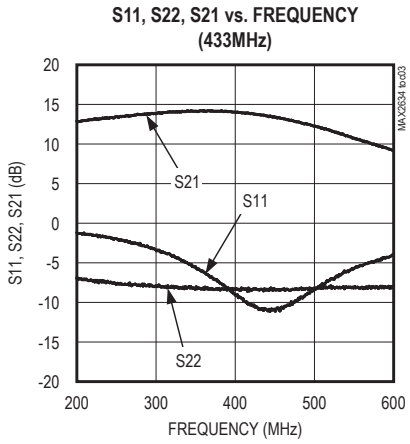
Note 2: Guaranteed by production test at T_A = +25°C. Guaranteed by design and characterization at T_A = -40°C and T_A = +125°C.
Note 3: Measured with two tones located at 315MHz and 316MHz or 433MHz and 434MHz at -40dBm/tone.
Note 4: Guaranteed by design and characterization.

Typical Operating Characteristics

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



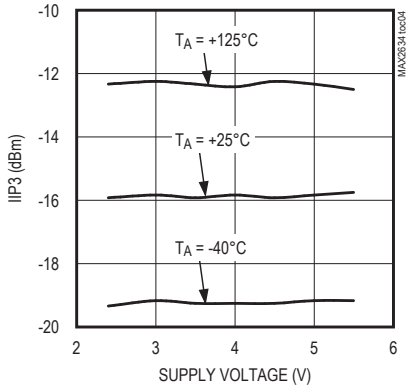




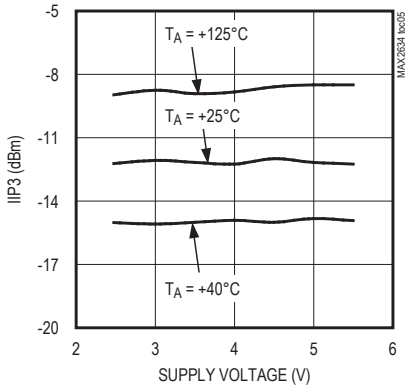
Typical Operating Characteristics (continued)

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

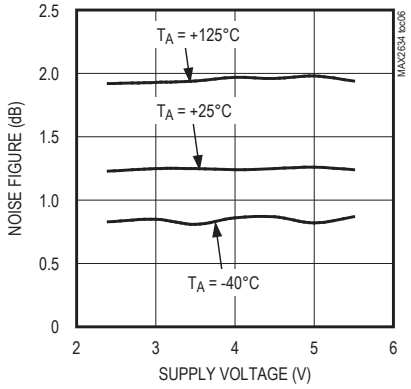
IIP3 vs. SUPPLY VOLTAGE (315MHz)



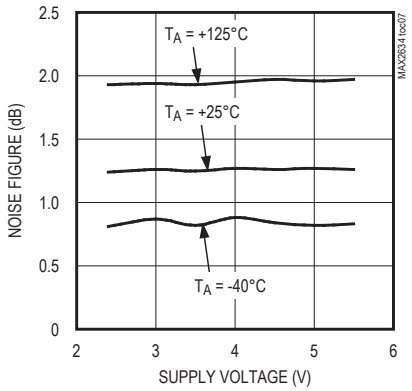
IIP3 vs. SUPPLY VOLTAGE (433MHz)



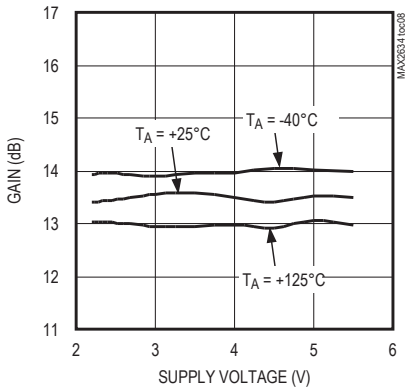
NOISE FIGURE vs. SUPPLY VOLTAGE (433MHz)



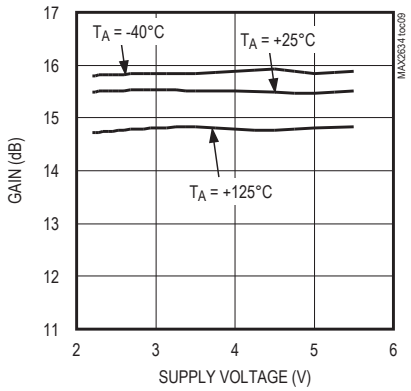
NOISE FIGURE vs. SUPPLY VOLTAGE (315MHz)



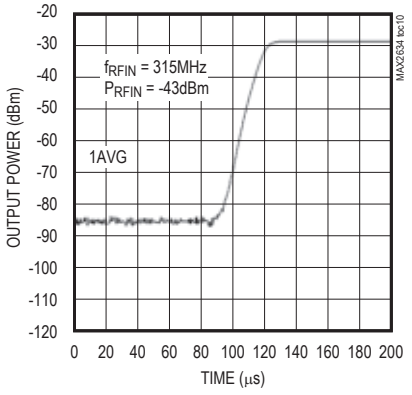
GAIN vs. SUPPLY VOLTAGE (433MHz)



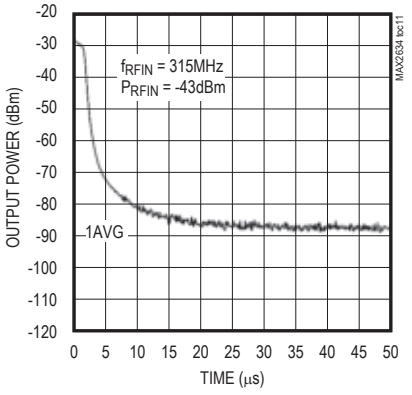
GAIN vs. SUPPLY VOLTAGE (315MHz)



TURN-ON TIME



SHUTDOWN TIME



Pin Description

PIN	NAME	FUNCTION
1, 3	GND	Ground. Use minimum path to ground plane to minimize inductance.
2	$\overline{SHDN}$	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 *Functional Diagram/ Typical Operating Circuit*.
5	VCC	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_{CC} = +3.0V, T_A = +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 $\overline{SHDN}$ 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°C.)

FREQUENCY (MHz)	FMIN (dB)	$\lvert\Gamma_{OPT}\rvert$	$\lvert\Gamma_{OPT}\rvert$ ANGLE	RN (Ω)
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

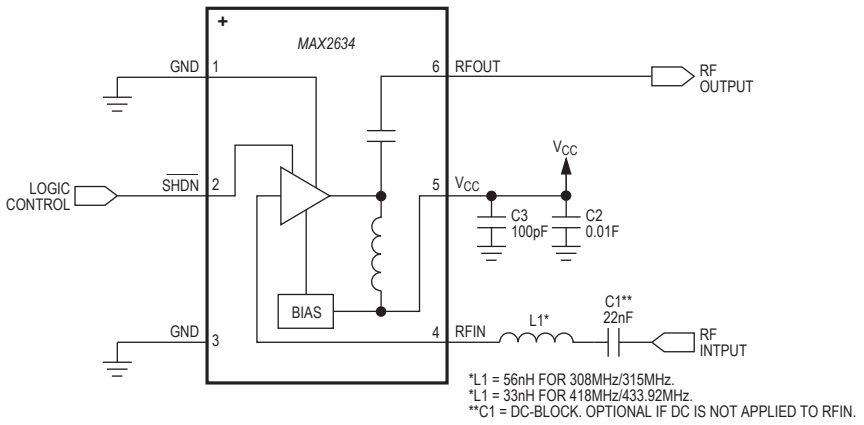
Table 3. RF Input Coupling Capacitor Input IP3 vs. Enable Time

INPUT DC-BLOCKING CAPACITOR, C1 (nF)	ENABLE TIME (µs)	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.analog.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	21-0077	90-0189

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	10/08	Initial release	—
1	3/09	Updated the *Features*, *Performance Table*, *Electrical Characteristics*, and *Typical Operating Characteristics* sections.	1, 3, 4
2	2/14	Added automotive grade package to *Ordering Information*	1
3	11/15	Updated package code in *Package Information* section	7
4	8/25	Updated the top mark in the *Ordering Information* table	1

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