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APPLICATION NOTE 5100

General Layout Guidelines for RF and Mixed-Signal PCBs

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Abstract: This application note provides guidelines and suggestions for RF printed-circuit board (PCB) design and layout, including some discussion of mixed-signal applications. The material provides "best practices" guidance, and should be used in conjunction with all other design and manufacturing guidelines that may apply to particular components, PCB manufacturers, and material sets as applicable.

This application note applies to all of Maxim's wireless products. For more information, please select a wireless or RF product.

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Click here for an overview of the wireless components used in a typical radio transceiver.

Introduction

This application note provides guidelines and suggestions for RF printed-circuit board (PCB) design and layout, including some discussion of mixed-signal applications, such as digital, analog, and RF components on the same PCB. The material is arranged by topic areas and provides "best practices" guidance. It should be used in conjunction with all other design and manufacturing guidelines that may apply to particular components, PCB manufacturers, and material sets as applicable.

RF Transmission Lines

Many of Maxim's RF components require controlled impedance transmission lines that will transport RF power to (or from) IC pins on the PCB. These transmission lines can be implemented on a exterior layer (top or bottom), or buried in an internal layer. Guidelines for these transmission lines include discussions relating to the microstrip, suspended stripline, coplanar waveguide (grounded), and characteristic impedance. It also describes transmission line bends and corner compensation, and layer changes for transmission lines.

Microstrip

This type of transmission line consists of fixed-width metal routing (the conductor), along with a solid unbroken ground plane located directly underneath (on the adjacent layer). For example, a microstrip on Layer 1 (top metal) requires a solid ground plane on Layer 2 (Figure 1). The width of the routing, the thickness of the dielectric layer, and the type of dielectric determine the characteristic impedance (typically 50Ω or 75Ω).

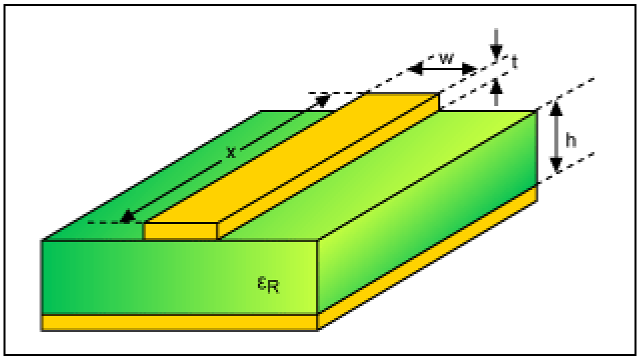


Figure 1. Microstrip example (isometric view).

Suspended Stripline

This line consists of a fixed-width routing on an inner layer, with solid ground planes above and below the center conductor. The conductor can be located midway between the ground planes (Figure 2), or it can be offset (Figure 3). This is the appropriate method for RF routing on inner layers.

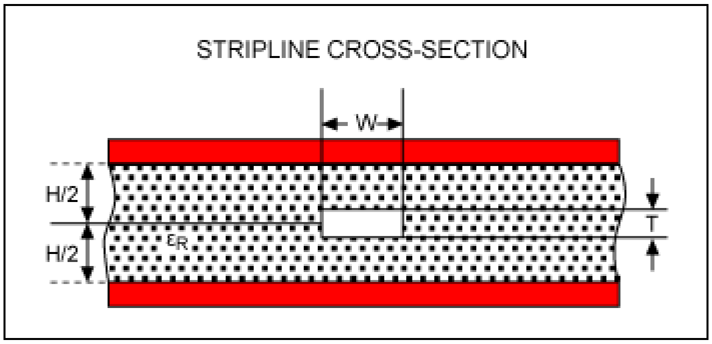


Figure 2. Suspended stripline (end view).

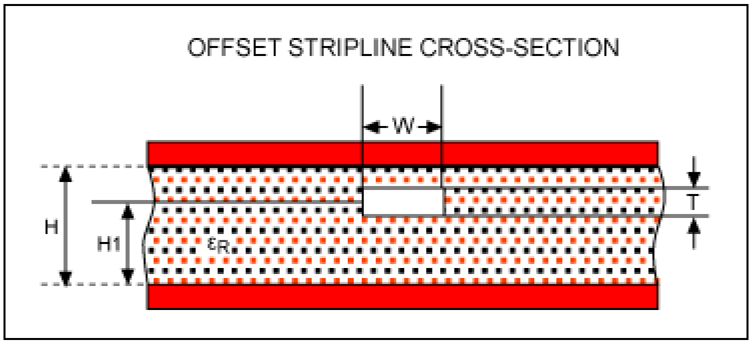


Figure 3. Offset suspended stripline. A variant of the stripline, for PCBs with unequal layer thicknesses (end view).

Coplanar Waveguide (Grounded)

A coplanar waveguide provides for better isolation between nearby RF lines, as well as other signal lines (end view). This medium consists of a center conductor with ground planes on either side and below (Figure 4).

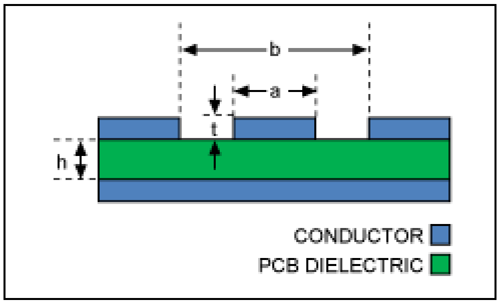


Figure 4. A coplanar waveguide provides for better isolation between nearby RF lines and other signal lines.

Via "fences" are recommended on both sides of a coplanar waveguide, as shown in Figure 5. This top view provides an example of a row of ground vias on each top metal gound plane on either side of the center conductor. Return currents induced on the top layer are shorted to the underlying ground layer.

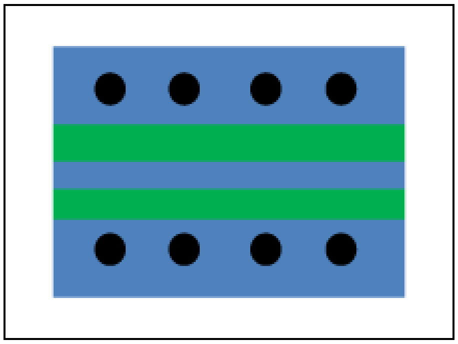


Figure 5. Via fences are recommended on both sides of a coplanar waveguide.

Characteristic Impedance

There are several calculators available to properly set the signal conductor line width to achieve the target impedance. However, caution should be used when entering the dielectric constant of the layers. The outer laminated layers of typical PCBs often contain less glass content than the core of the board, and consequently the dielectric constant is lower. For example, FR4 core is generally given as $\varepsilon_R = 4.2$, whereas the outer laminate (prepreg) layers are typically $\varepsilon_R = 3.8$. Examples given below for reference only, metal thickness assumed for 1oz copper (1.4 mils, 0.036mm).

Table 1. Examples of Characteristic Impedance

Media	Dielectric	Layer Thickness in mils (mm)	Center Conductor in mils (mm)	Gap	Characteristic Impedance
Microstrip	Prepreg (3.8)	6 (0.152)	11.5 (0.292)	N/A	50.3
		10 (0.254)	20 (0.508)		50.0
Diff. Pair	Prepreg (3.8)	6 (0.152)	25 (0.635)	6 (0.152)	50.6
Stripline	FR4 (4.5)	12 (0.305)	3.7 (0.094)	N/A	50.0
Offset Stripline	Prepreg (3.9)	6 (0.152) upper, 10 (0.254) lower	4.8 (0.122)	N/A	50.1
Coplanar WG	Prepreg (3.8)	6 (0.152)	14 (0.35)	20 (0.50)	49.7

Transmission Line Bends and Corner Compensation

When transmission lines are required to bend (change direction) due to routing constraints, use a bend radius that is at least 3 times the center conductor width. In other words:

Bend Radius ≥ 3 × (Line Width).

This will minimize any charactericstic impedance changes moving through the bend.

In cases where a gradually curved bend is not possible, the transmission line can undergo a right-angle bend (noncurved). See Figure 6. However, this must be compensated to reduce the impedance discontinuity caused by the local increase in effective line width going through the bend. A standard compensation method is the angled miter, as illustrated below. The optimum microstrip right-angle miter is given by the formula of Douville and James:

$$M = 100\frac{x}{d}\% = \left(52 + 65e^{-\frac{27w}{20h}}\right)\%$$

Where M is the fraction (%) of the miter compared to the unmitered bend. This formula is independent of the dielectric constant, and is subject to the constraint that w/h ≥ 0.25.

Similar methods can be employed for other transmission lines. If there is any uncertaintly as to the correct compensation, the bend should be modeled using an electromagnetic simulator if the design requires high-performance transmission lines.

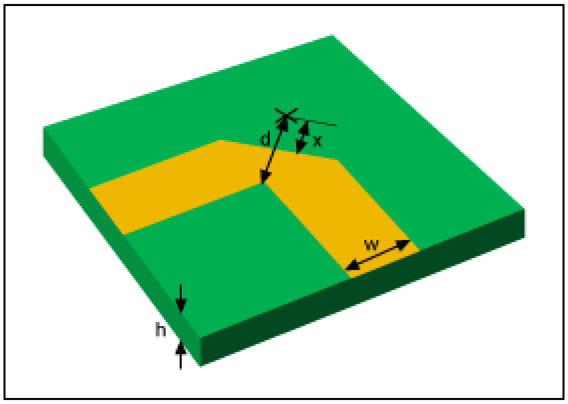


Figure 6. When a curved bend is not possible, the transmission line can undergo a right-angle bend.

Layer Changes for Transmission Lines

When layout constraints required that a transmission line move to a different layer, it is recommended that at least two via holes be used for each transition to minimize the via inductance loading. A pair of vias will effectively cut the transition inductance by 50%, and the largest diameter via should be utilized that is compatible with the transmission line width. For example, on a 15-mil microstrip line, a via diameter (finished plated diameter) of 15 mils to 18 mils would be used. If space does not permit the use of larger vias, then three transition vias of smaller diameter should be used.

Signal Line Isolation

Care must be taken to prevent unintended coupling between signal lines. Some examples of potential coupling and preventative measures:

- **RF Transmission Lines**: Lines should be kept as far apart as possible, and should not be routed in close proximity for extended distances. Coupling between parallel microstrip lines will increase with decreasing separation and increasing parallel routing distance. Lines that cross on separate layers should have a ground plane keeping them apart. Signal lines that will carry high power levels should be kept away from all other lines whenever possible. The grounded coplanar waveguide provides for excellent isolation between lines. It is impractical to achieve isolation better than approximately -45dB between RF lines on small PCBs.
- **High-Speed Digital Signal Lines**: These lines should be routed separately on a different layer than the RF signal lines, to prevent coupling. Digital noise (from clocks, PLLs, etc.) can couple onto RF signal lines, and these can be modulated onto RF carriers. Alternatively, in some cases digital noise can be up/down-converted.
- **V_{CC}/Power Lines**: These should be routed on a dedicated layer. Adequate decoupling/bypass capcitors should be provided at the main V_{CC} distribution node, as well as at V_{CC} branches. The choice of the bypass capacitances must be made based on the overall frequency response of the RF IC, and the expected frequency distribution nature of any digital noise from clocks and PLLs. These lines should also be separated from any RF lines that will transmit large amounts of RF power.

Ground Planes

The recommended practice is to use a solid (continuous) ground plane on Layer 2, assuming Layer 1 is used for the RF components and transmission lines. For striplines and offset striplines, ground planes above and below the center conductor are required. These planes must not be shared or assigned to signal or power nets, but must be uniquely allocated to ground. Partial ground planes on a layer, sometimes required by design constraints, must underlie all RF components and transmission lines. Ground planes must not be broken under transmission line routing.

Ground vias between layers should be added liberally throughout the RF portion of the PCB. This helps prevent accrual of parasitic ground inductance due to ground-current return paths. The vias also help to prevent cross-coupling from RF and other signal lines across the PCB.

Special Consideration on Bias and Ground Layers

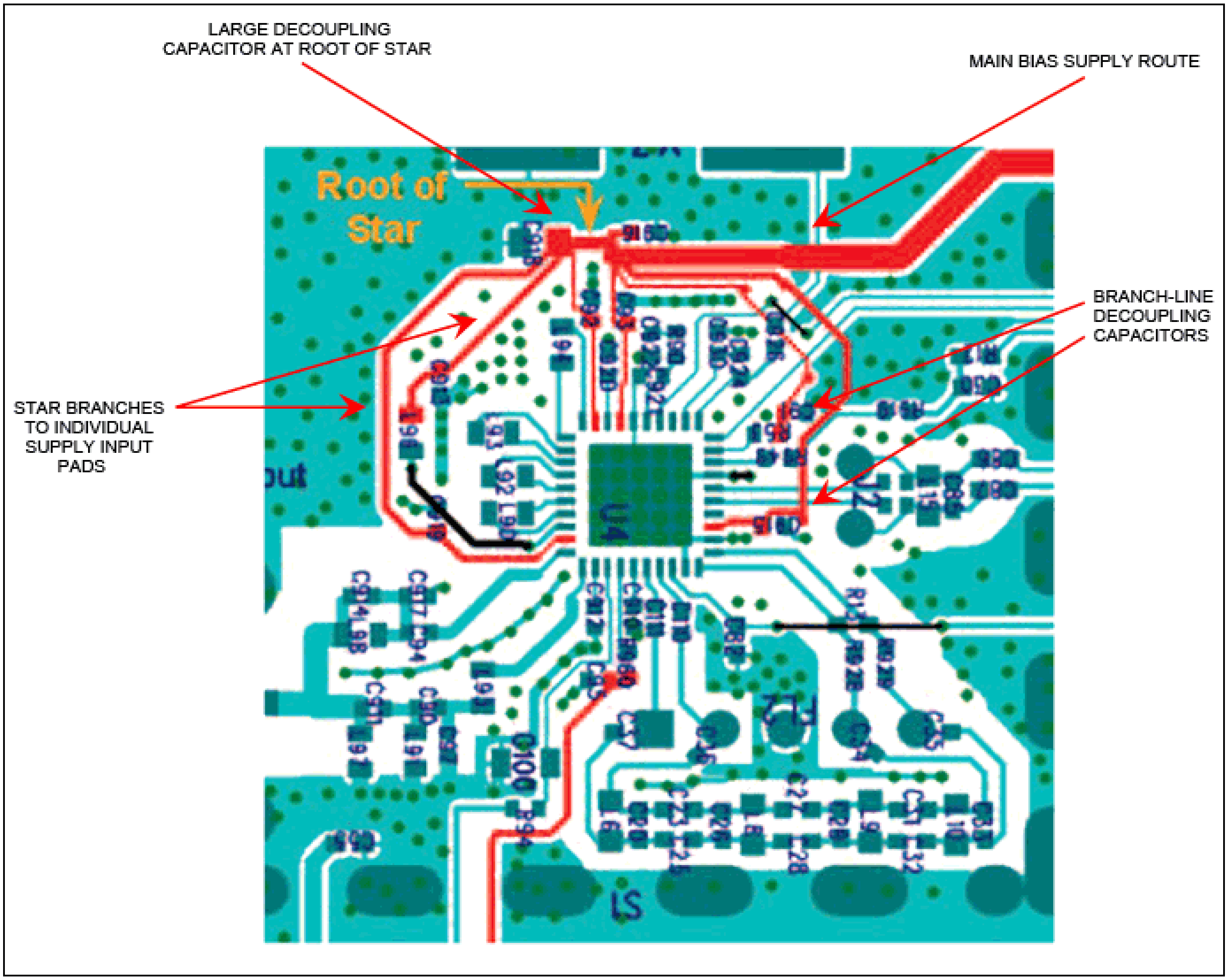
The layers assigned to system bias (DC supply) and ground must be considered in terms of the return current for the components. The general guidance is to not have signals routed on layers between the bias layer and the ground layer.

Figure 7. Incorrect layer assignment: there are signal layers between the bias layer and ground-current return path on ground layer. Bias line noise can be coupled to the signal layers.

Figure 8. Better layer assignment: there are no signal layers between the bias and ground return layers.

Power (Bias) Routing and Supply Decoupling

A common practice is to use a "star" configuration for the power-supply routes, if a component has several supply connections (Figure 9). A larger decoupling capacitor (tens of µFds) is mounted at the "root" of the star, and smaller capacitors at each of the star branches. The value of these latter capacitors depends on the operating frequency range of the RF IC, and their specific functionality (i.e., interstage vs. main supply decoupling). An example is shown below.



More detailed image (PDF, 2MB)

Figure 9. If a component has several supply connections, the power-supply routes can be arranged in a star configuration.

The "star" configuration avoides long ground return paths that would result if all the pins connected to the same bias net were connected in series. A long ground return path would cause a parasitic inductance that could lead to unintended feedback loops. The key consideration with supply decoupling is that the DC supply connections must be electrically defined as AC ground.

Selection of Decoupling or Bypass Capacitors

Real capacitors have limited effective frequency ranges due to their self-resonant frequency (SRF). The SRF is available from the manufacturer, but sometimes must be characterized by direct measurement. Above the SRF, the capacitor is inductive, and therefore will not perform the decoupling or bypass function. When broadband decoupling is required, standard practice is to use several capacitors of increasing size (capacitance), all connected in parallel. The smaller value capacitors normally have higher SRFs (for example, a 0.2pF value in a 0402 SMT package with an SRF = 14GHz), while the larger values have lower SRFs (for example, a 2pF value in the same package with an SRF = 4GHz). A typical arrangement is depicted in Table 2.

Table 2. Useful Frequency Ranges of Capacitors

Component	Capacitance	Package	SRF	Useful Frequency Range*
Ultra-High Range	20pF	0402	2.5GHz	800MHz to 2.5GHz
Very High Range	100pF	0402	800MHz	250MHz to 800MHz
High Range	1000pF	0402	250MHz	50MHz to 250MHz
Midrange	1µF	0402	60MHz	100kHz to 60MHz
Low Range	10µF	0603	600kHz	10kHz to 600kHz

*Low end of useful frequency range defined as less than 5Ω of capacitive reactance.

Bypass Capacitor Layout Considerations

Since the supply lines must be AC ground, it is important to minimize the parasitic inductance added to the AC ground return path. These parasitic inductances can be caused by layout or component orientation choices, such as the orientation of a decoupling capacitor's ground. There are two basic methods, shown in Figure 10 and Figure 11.

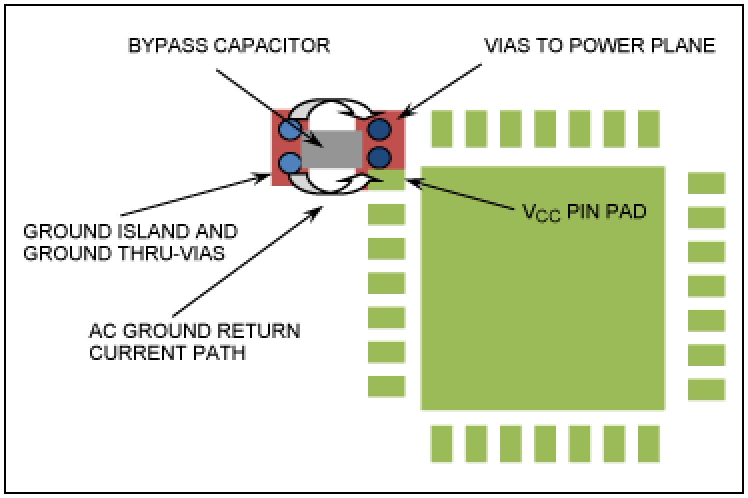


Figure 10. This configuration presents the smallest total footprint for the bypass capcitor and related vias.

In this configuration, the vias connecting the V_{CC} pad on the top layer to the inner power plane (layer) poentially impede the AC ground current return, forcing a longer return path with resulting higher parasitic inductance. Any AC current flowing into the V_{CC} pin passes through the bypass capcitor to its ground side before returning on the inner ground layer. This configuration presents the smallest total footprint for the bypass capcitor and related vias.

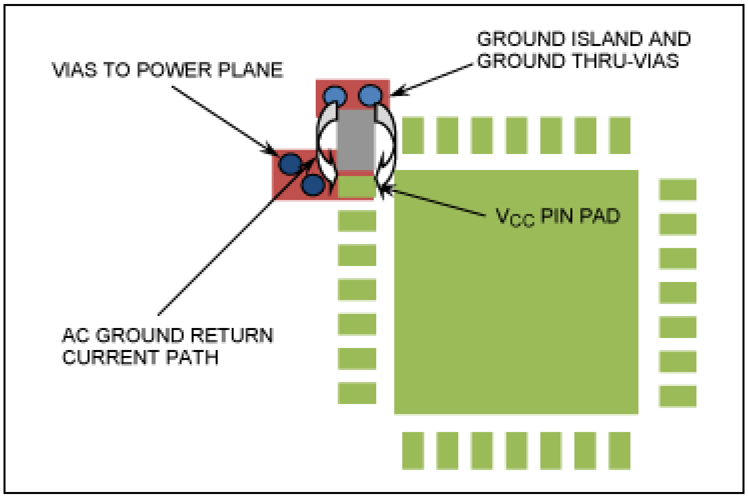


Figure 11. This configuration requires more PCB area.

In this alternate configuration, the AC ground return paths are not blocked by the power-plane vias. Generally this configuration requires somewhat more PCB area.

Grounding of Shunt-Connected Components

For shunt-connected (grounded) components (such as power-supply decoupling capacitors), the recommended practice is to use at least two grounding vias for each component (Figure 12). This reduces the effect of via parasitic inductance. Via ground "islands" can be used for groups of shunt-connected components.

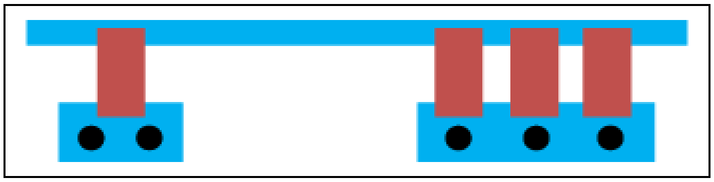


Figure 12. Using at least two grounding vias for each components reduces the effect of via parasitic inductance.

IC Ground Plane ("Paddle")

Most ICs require a solid ground plane on the component layer (top or bottom of PCB) directly underneath the component. This ground plane will carry DC and RF return currents through the PCB to the assigned ground plane. The secondary function of this component "ground paddle" is to provide a thermal heatsink, so the paddle should include the maximum number of thru vias that are allowed by the PCB design rules. The example below shows a 5 × 5 array of via holes embedded in the central ground plane (on the component layer) directly under the RF IC (Figure 13). The maximum number of vias that can be accomodated by other layout considerations should be used. These vias are ideally thru-vias (i.e., penetrate all the way through the PCB), and must be plated. If possible, the vias should be filled with thermally conductive paste to enhance the heatsink (the paste is applied after via plating and prior to final board plating).

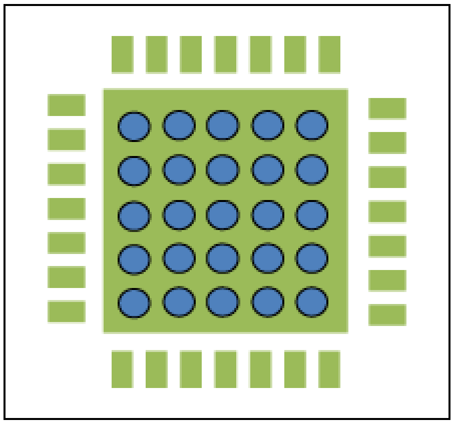


Figure 13. A 5 × 5 array of via holes embedded in the central ground plane directly under the RF IC.

Please see our Wireless and RF Products page for more information.

Related Parts

DS1870	LDMOS RF Power-Amplifier Bias Controller	-- Free Samples
DS4026	10MHz to 51.84MHz TCXO	-- Free Samples
MAX12000	1575MHz GPS Front-End Amplifier	-- Free Samples
MAX12005	Satellite IF Switch	-- Free Samples
MAX1385	Dual RF LDMOS Bias Controllers with I²C/SPI Interface	-- Free Samples
MAX1386	Dual RF LDMOS Bias Controllers with I²C/SPI Interface	
MAX1470	315MHz Low-Power, +3V Superheterodyne Receiver	-- Free Samples
MAX1471	315MHz/434MHz Low-Power, 3V/5V ASK/FSK Superheterodyne Receiver	-- Free Samples
MAX1472	300MHz-to-450MHz Low-Power, Crystal-Based ASK Transmitter	-- Free Samples
MAX1473	315MHz/433MHz ASK Superheterodyne Receiver with Extended Dynamic Range	-- Free Samples
MAX1479	300MHz to 450MHz Low-Power, Crystal-Based +10dBm ASK/FSK Transmitter	-- Free Samples
MAX19692	12-Bit, 2.3Gsps Multi-Nyquist DAC	
MAX19790	250MHz to 4000MHz Dual, Analog Voltage Variable Attenuator	-- Free Samples
MAX19985	Dual, SiGe, High-Linearity, High-Gain, 700MHz to 1000MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX19985A	Dual, SiGe, High-Linearity, High-Gain, 700MHz to 1000MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX19993	Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX19993A	Dual, SiGe, High-Linearity, 1200MHz to 2000MHz Downconversion Mixer with	

	LO Buffer/Switch	
MAX19994	Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch	
MAX19994A	Dual, SiGe, High-Linearity, 1200MHz to 2000MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX19995	Dual, SiGe, High-Linearity, 1700MHz to 2200MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX19995A	Dual, SiGe, High-Linearity, 1700MHz to 2200MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX19996	SiGe, High-Linearity, High-Gain, 2000MHz to 3000MHz Downconversion Mixer with LO Buffer	-- Free Samples
MAX19996A	SiGe, High-Linearity, 2000MHz to 3900MHz Downconversion Mixer with LO Buffer	-- Free Samples
MAX19997A	Dual, SiGe High-Linearity, High-Gain, 1800MHz to 2900MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX19998	SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer	-- Free Samples
MAX19998A	SiGe, High-Linearity, High-Gain, 3200MHz to 3900MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX19999	Dual, SiGe High-Linearity, 3000MHz to 4000MHz Downconversion Mixer with LO Buffer	-- Free Samples
MAX2009	1200MHz to 2500MHz Adjustable RF Predistorter	-- Free Samples
MAX2010	500MHz to 1100MHz Adjustable RF Predistorter	-- Free Samples
MAX2014	50MHz to 1000MHz, 75dB Logarithmic Detector/Controller	-- Free Samples
MAX2015	0.1GHz to 3GHz, 75dB Logarithmic Detector/Controller	-- Free Samples
MAX2016	LF-to-2.5GHz Dual Logarithmic Detector/Controller for Power, Gain, and VSWR Measurements	-- Free Samples
MAX2021	High-Dynamic-Range, Direct Up-/Downconversion, 750MHz to 1200MHz Quadrature Modulator/Demodulator	-- Free Samples
MAX2022	High-Dynamic-Range, Direct Upconversion 1500MHz to 2500MHz Quadrature Modulator	-- Free Samples
MAX2023	High-Dynamic-Range, Direct Up-/Downconversion 1500MHz to 2300MHz Quadrature Mod/Demod	-- Free Samples
MAX2027	IF Digitally Controlled Variable-Gain Amplifier	
MAX2029	High-Linearity, 815MHz to 1000MHz Upconversion/Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX2030	Dual, SiGe, High-Linearity, 700MHz to 1000MHz Up/Downconversion Mixer with LO Buffer/Switch	
MAX2030A	Dual, SiGe, High-Linearity, 700MHz to 1000MHz Up/Downconversion Mixer with LO Buffer/Switch	
MAX2031	High-Linearity, 650MHz to 1000MHz Upconversion/Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX2032	High-Linearity, 650MHz to 1000MHz Upconversion/Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX2039	High-Linearity, 1700MHz to 2200MHz Upconversion/Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX2040	Dual, SiGe, High-Linearity, 1700MHz to 2200MHz Up/Downconversion Mixer with LO Buffer/Switch	
MAX2040A	Dual, SiGe, High-Linearity, 1700MHz to 3000MHz Up/Downconversion Mixer with LO Buffer/Switch	
MAX2041	High-Linearity, 1700MHz to 3000MHz Upconversion/Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX2042	SiGe High-Linearity, 2000MHz to 3000MHz Upconversion/Downconversion Mixer with LO Buffer	-- Free Samples
MAX2042A	SiGe, High-Linearity, 1600MHz to 3900MHz Upconversion/Downconversion Mixer with LO Buffer	
MAX2043	1700MHz to 3000MHz High-Linearity, Low LO Leakage Base-Station Rx/Tx Mixer	-- Free Samples
MAX2044	SiGe, High-Linearity, 2300MHz to 4000MHz Upconversion/Downconversion Mixer with LO Buffer	-- Free Samples

MAX2044A	SiGe, High-Linearity, 3000MHz to 4000MHz Upconversion/Downconversion Mixer with LO Buffer	
MAX2045	High-Gain Vector Multipliers	-- Free Samples
MAX2046	High-Gain Vector Multipliers	-- Free Samples
MAX2047	High-Gain Vector Multipliers	-- Free Samples
MAX2051	SiGe, High-Linearity, 850MHz to 1550MHz Up/Downconversion Mixer with LO Buffer	-- Free Samples
MAX2055	Digitally Controlled, Variable-Gain, Differential ADC Driver/Amplifier	
MAX2056	800MHz to 1000MHz Variable-Gain Amplifier with Analog Gain Control	-- Free Samples
MAX2057	1300MHz to 2700MHz Variable-Gain Amplifier with Analog Gain Control	-- Free Samples
MAX2058	700MHz to 1200MHz High-Linearity, SPI-Controlled DVGA with Integrated Loopback Mixer	-- Free Samples
MAX2059	1700MHz to 2200MHz, High-Linearity, SPI-Controlled DVGA with Integrated Loopback Mixer	-- Free Samples
MAX2062	Dual 50MHz to 1000MHz High-Linearity, Serial/Parallel-Controlled Analog/Digital VGA	-- Free Samples
MAX2063	Dual 50MHz to 1000MHz High-Linearity, Serial/Parallel-Controlled Digital VGA	-- Free Samples
MAX2064	50MHz to 1000MHz, High-Linearity, Serial/Analog-Controlled VGA	-- Free Samples
MAX2065	50MHz to 1000MHz High-Linearity, Serial/Parallel-Controlled Analog/Digital VGA	-- Free Samples
MAX2066	50MHz to 1000MHz High-Linearity, Serial/Parallel-Controlled Digital VGA	-- Free Samples
MAX2067	50MHz to 1000MHz High-Linearity, Serial/Analog-Controlled VGA	-- Free Samples
MAX2112	Complete, Direct-Conversion Tuner for DVB-S2 Applications	-- Free Samples
MAX2114	DBS Direct Downconverter	
MAX2117	Complete, Direct-Conversion Tuner for MMDS Applications	-- Free Samples
MAX2120	Complete, Direct-Conversion Tuner for DVB-S and Free-to-Air Applications	-- Free Samples
MAX2121	Complete Direct-Conversion L-Band Tuner	-- Free Samples
MAX2135A	ISDB-T/DVB-T Diversity Tuner	-- Free Samples
MAX2136	ISDB-T/DVB-T Low-IF Tuner	-- Free Samples
MAX2140	Complete SDARS Receiver	-- Free Samples
MAX2141	Low-Power XM Satellite Radio Receiver	-- Free Samples
MAX2150	Wideband I/Q Modulator with Sigma-Delta Fractional-N Synthesizer	-- Free Samples
MAX2160	ISDB-T Single-Segment Low-IF Tuners	-- Free Samples
MAX2160EBG	ISDB-T Single-Segment Low-IF Tuners	
MAX2161	ISDB-T 1- and 3-Segment Low-IF Tuners	-- Free Samples
MAX2161S	ISDB-T 1- and 3-Segment Low-IF Tuners	
MAX2162	ISDB-T 1- and 3-Segment Low-IF Tuners	-- Free Samples
MAX2162S	ISDB-T 1- and 3-Segment Low-IF Tuners	
MAX2165	Single-Conversion DVB-H Tuner	-- Free Samples
MAX2169	Multiband Tuner for Mobile Multimedia Applications	-- Free Samples
MAX2170	Direct-Conversion to Low-IF Tuners for Digital Audio Broadcast	-- Free Samples
MAX2171	Direct-Conversion to Low-IF Tuners for Digital Audio Broadcast	-- Free Samples
MAX2172	Direct-Conversion to Low-IF Tuner for Digital Audio Broadcast	-- Free Samples
MAX2180	AM/FM Car Antenna Low-Noise Amplifier	-- Free Samples
MAX2202	RMS Power Detector	
MAX2203	RMS Power Detector	-- Free Samples
MAX2204	RF Power Detector	-- Free Samples
MAX2205	RF Power Detectors in UCSP	
MAX2206	RF Power Detectors in UCSP	-- Free Samples
MAX2207	RF Power Detectors in UCSP	
MAX2208	RF Power Detectors in UCSP	
MAX2209	RF Power Detector	-- Free Samples
MAX2209A	RF Power Detector with Shutdown Control	
MAX2232	900MHz ISM-Band, 250mW Power Amplifiers with Analog or Digital Gain Control	-- Free Samples
MAX2233	900MHz ISM-Band, 250mW Power Amplifiers with Analog or Digital Gain Control	-- Free Samples
MAX2235	+3.6V, 1W Autoramping Power Amplifier for 900MHz Applications	-- Free Samples
MAX2240	2.5GHz, +20dBm Power Amplifier IC in UCSP Package	
MAX2242	2.4GHz to 2.5GHz Linear Power Amplifier	

MAX2265	2.7V, Single-Supply, Cellular-Band Linear Power Amplifiers	-- Free Samples
MAX2306	CDMA IF VGAs and I/Q Demodulators with VCO and Synthesizer	-- Free Samples
MAX2308	CDMA IF VGAs and I/Q Demodulators with VCO and Synthesizer	-- Free Samples
MAX2309	CDMA IF VGAs and I/Q Demodulators with VCO and Synthesizer	-- Free Samples
MAX2335	450MHz CDMA/OFDM LNA/Mixer	-- Free Samples
MAX2338	Triple/Dual-Mode CDMA LNA/Mixers	-- Free Samples
MAX2370	Complete 450MHz Quadrature Transmitter	-- Free Samples
MAX2371	LNAs with Step Attenuator and VGA	-- Free Samples
MAX2373	LNAs with Step Attenuator and VGA	-- Free Samples
MAX2410	Low-Cost RF Up/Downconverter with LNA and PA Driver	-- Free Samples
MAX2411A	Low-Cost RF Up/Downconverter with LNA and PA Driver	-- Free Samples
MAX2470	10MHz to 500MHz, VCO Buffer Amplifiers with Differential Outputs	-- Free Samples
MAX2471	10MHz to 500MHz, VCO Buffer Amplifiers with Differential Outputs	-- Free Samples
MAX2472	500MHz to 2500MHz, VCO Buffer Amplifiers	-- Free Samples
MAX2473	500MHz to 2500MHz, VCO Buffer Amplifiers	-- Free Samples
MAX2500B	Complete Cellular Baseband-to-RF Transmitter with PA	
MAX2510	Low-Voltage IF Transceiver with Limiter RSSI and Quadrature Modulator	-- Free Samples
MAX2511	Low-Voltage IF Transceiver with Limiter and RSSI	-- Free Samples
MAX2547	WCDMA/HSPA Band I RF-to-Bits Femto-Basestation Radio Receiver	-- Free Samples
MAX2548	Quad-Band TDD-WCDMA RF-to-Bits Radio Receiver	-- Free Samples
MAX2550	Complete Single-Chip Femtocell Radio Transceiver	
MAX2557	Multiband, Multimode RF-to-Bits Femto-Basestation Radio Receiver	-- Free Samples
MAX2557A	Multiband, Multimode RF-to-Bits CDMA Femto-Basestation Radio Receiver	-- Free Samples
MAX2597	Femto-Basestation Bits-to-RF Radio Transmitter	-- Free Samples
MAX2598	Quad-Band TDD-WCDMA Bits-to-RF Radio Transmitter	-- Free Samples
MAX2599	Femto Basestation Bits-to-RF Radio Transmitter	-- Free Samples
MAX2601	3.6V, 1W RF Power Transistors for 900MHz Applications	-- Free Samples
MAX2602	3.6V, 1W RF Power Transistors for 900MHz Applications	-- Free Samples
MAX2605	45MHz to 650MHz, Integrated IF VCOs with Differential Output	-- Free Samples
MAX2606	45MHz to 650MHz, Integrated IF VCOs with Differential Output	-- Free Samples
MAX2607	45MHz to 650MHz, Integrated IF VCOs with Differential Output	-- Free Samples
MAX2608	45MHz to 650MHz, Integrated IF VCOs with Differential Output	-- Free Samples
MAX2609	45MHz to 650MHz, Integrated IF VCOs with Differential Output	-- Free Samples
MAX2611	DC-to-Microwave, Low-Noise Amplifier	-- Free Samples
MAX2620	10MHz to 1050MHz Integrated RF Oscillator with Buffered Outputs	-- Free Samples
MAX2622	Monolithic Voltage Controlled Oscillators	-- Free Samples
MAX2623	Monolithic Voltage Controlled Oscillators	-- Free Samples
MAX2624	Monolithic Voltage Controlled Oscillators	-- Free Samples
MAX2630	VHF-to-Microwave, +3V, General-Purpose Amplifiers	-- Free Samples
MAX2631	VHF-to-Microwave, +3V, General-Purpose Amplifiers	
MAX2632	VHF-to-Microwave, +3V, General-Purpose Amplifiers	-- Free Samples
MAX2633	VHF-to-Microwave, +3V, General-Purpose Amplifiers	-- Free Samples
MAX2634	315MHz/433MHz Low-Noise Amplifier for Automotive RKE	-- Free Samples
MAX2640	300MHz to 2500MHz SiGe Ultra-Low-Noise Amplifiers	-- Free Samples
MAX2641	300MHz to 2500MHz SiGe Ultra-Low-Noise Amplifiers	-- Free Samples
MAX2642	900MHz SiGe, High-Variable IP3, Low-Noise Amplifier	-- Free Samples
MAX2643	900MHz SiGe, High-Variable IP3, Low-Noise Amplifier	
MAX2644	2.4GHz SiGe, High IP3 Low-Noise Amplifier	-- Free Samples
MAX2645	3.4GHz to 3.8GHz SiGe Low-Noise Amplifier/PA Predriver	-- Free Samples
MAX2650	DC-to-Microwave, +5V Low-Noise Amplifier	-- Free Samples
MAX2654	1575MHz/1900MHz Variable-IP3 Low-Noise Amplifiers	-- Free Samples
MAX2655	1575MHz/1900MHz Variable-IP3 Low-Noise Amplifiers	-- Free Samples
MAX2656	1575MHz/1900MHz Variable-IP3 Low-Noise Amplifiers	-- Free Samples
MAX2657	GPS/GNSS Low-Noise Amplifiers	
MAX2658	GPS/GNSS Low-Noise Amplifiers	
MAX2659	GPS/GNSS Low-Noise Amplifier	-- Free Samples
MAX2660	400MHz to 2.5GHz Upconverters	-- Free Samples
MAX2661	400MHz to 2.5GHz Upconverters	-- Free Samples
MAX2663	400MHz to 2.5GHz Upconverters	-- Free Samples
MAX2664	VHF/UHF Low-Noise Amplifiers	

MAX2665	VHF/UHF Low-Noise Amplifiers	
MAX2666	Tiny Low-Noise Amplifiers for HSPA/LTE	-- Free Samples
MAX2667	GPS/GNSS Ultra-Low-Noise-Figure LNAs	
MAX2668	Tiny Low-Noise Amplifiers for HSPA/LTE	-- Free Samples
MAX2669	GPS/GNSS Ultra-Low-Noise-Figure LNAs	
MAX2670	GPS/GNSS Front-End Amplifier	
MAX2671	400MHz to 2.5GHz Upconverters	-- Free Samples
MAX2673	400MHz to 2.5GHz Upconverters	-- Free Samples
MAX2674	GPS/GNSS LNAs with Antenna Switch and Bias	
MAX2676	GPS/GNSS LNAs with Antenna Switch and Bias	
MAX2680	400MHz to 2.5GHz, Low-Noise, SiGe Downconverter Mixers	-- Free Samples
MAX2681	400MHz to 2.5GHz, Low-Noise, SiGe Downconverter Mixers	
MAX2682	400MHz to 2.5GHz, Low-Noise, SiGe Downconverter Mixers	-- Free Samples
MAX2685	Low-Cost, 900MHz, Low-Noise Amplifier and Downconverter Mixer	-- Free Samples
MAX2686	GPS/GNSS Low-Noise Amplifiers	
MAX2686L	GPS/GNSS Low-Noise Amplifier with Integrated LDO	
MAX2687	GPS/GNSS Low-Noise Amplifiers	
MAX2687L	GPS/GNSS Low-Noise Amplifier with Integrated LDO	
MAX2688	GPS/GNSS Low-Noise Amplifiers	
MAX2689	GPS/GNSS Low-Noise Amplifier	
MAX2690	Low-Noise, 2.5GHz Downconverter Mixer	-- Free Samples
MAX2691	GPS/GNSS Low-Noise Amplifier for L2 Band	
MAX2692	WLAN/WiMax Low-Noise Amplifiers	
MAX2693	GPS/GNSS Low-Noise Amplifier	
MAX2694	GPS/GNSS Low-Noise Amplifiers	
MAX2695	WLAN/WiMax Low-Noise Amplifiers	
MAX2740	Integrated GPS Receiver and Synthesizer	
MAX2745	Single-Chip Global Positioning System Front-End Downconverter	-- Free Samples
MAX2750	2.4GHz Monolithic Voltage-Controlled Oscillators	-- Free Samples
MAX2750AUA	2.4GHz Monolithic Voltage-Controlled Oscillator for Automotive	
MAX2751	2.4GHz Monolithic Voltage-Controlled Oscillators	-- Free Samples
MAX2752	2.4GHz Monolithic Voltage-Controlled Oscillators	-- Free Samples
MAX2769	Universal GPS Receiver	-- Free Samples
MAX2769B	Universal GPS Receiver	-- Free Samples
MAX2828	Single-/Dual-Band 802.11a/b/g World-Band Transceiver ICs	-- Free Samples
MAX2829	Single-/Dual-Band 802.11a/b/g World-Band Transceiver ICs	-- Free Samples
MAX2830	2.4GHz to 2.5GHz 802.11g/b RF Transceiver with PA and Rx/Tx/Diversity Switch	
MAX2831	2.4GHz to 2.5GHz, 802.11g RF Transceivers with Integrated PA	
MAX2832	2.4GHz to 2.5GHz, 802.11g RF Transceivers with Integrated PA	-- Free Samples
MAX2837	2.3GHz to 2.7GHz Wireless Broadband RF Transceiver	-- Free Samples
MAX2838	3.3GHz to 3.8GHz Wireless Broadband RF Transceiver	-- Free Samples
MAX2839	2.3GHz to 2.7GHz MIMO Wireless Broadband RF Transceiver	-- Free Samples
MAX2839AS	2.3GHz to 2.7GHz MIMO Wireless Broadband RF Transceiver	
MAX2842	3.3GHz to 3.9GHz MIMO Wireless Broadband RF Transceiver	-- Free Samples
MAX2850	5GHz, 4-Channel MIMO Transmitter	-- Free Samples
MAX2851	5GHz, 5-Channel MIMO Receiver	-- Free Samples
MAX2852	5GHz Receiver	-- Free Samples
MAX2900	200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands	-- Free Samples
MAX2901	200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands	-- Free Samples
MAX2902	200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands	-- Free Samples
MAX2903	200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands	-- Free Samples
MAX2904	200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands	-- Free Samples
MAX2990	10kHz to 490kHz OFDM-Based Power Line Communications Modem	-- Free Samples
MAX3518	DOCSIS 3.0 Upstream Amplifier	-- Free Samples
MAX3524	Low-Noise, High-Linearity Broadband Amplifier	-- Free Samples
MAX3541	Complete Single-Conversion Television Tuner	-- Free Samples
MAX3542	Complete Single-Conversion Television Tuner	-- Free Samples
MAX3543	Multiband Analog and Digital Television Tuner	-- Free Samples
MAX3544	Multiband Digital Television Tuner	-- Free Samples

MAX3580	Direct-Conversion TV Tuner	-- Free Samples
MAX3654	47MHz to 870MHz Analog CATV Transimpedance Amplifier	-- Free Samples
MAX4000	2.5GHz 45dB RF-Detecting Controllers	-- Free Samples
MAX4001	2.5GHz 45dB RF-Detecting Controllers	-- Free Samples
MAX4002	2.5GHz 45dB RF-Detecting Controllers	-- Free Samples
MAX4987AE	Overvoltage-Protection Controller with USB ESD Protection	-- Free Samples
MAX4987BE	Overvoltage-Protection Controller with USB ESD Protection	
MAX5879	14-Bit, 2.3Gsps Direct RF Synthesis DAC with Selectable Frequency Response	
MAX5894	14-Bit, 500Msps, Interpolating and Modulating Dual DAC with CMOS Inputs	-- Free Samples
MAX66901-K00	High-Frequency Developers Kit for ISO 14443B and ISO 15693 RFID Keys	
MAX7030	Low-Cost, 315MHz, 345MHz, and 433.92MHz ASK Transceiver with Fractional-N PLL	-- Free Samples
MAX7031	Low-Cost, 308MHz, 315MHz, and 433.92MHz FSK Transceiver with Fractional-N PLL	-- Free Samples
MAX7032	Low-Cost, Crystal-Based, Programmable, ASK/FSK Transceiver with Fractional-N PLL	-- Free Samples
MAX7033	315MHz/433MHz ASK Superheterodyne Receiver with AGC Lock	-- Free Samples
MAX7034	315MHz/434MHz ASK Superheterodyne Receiver	-- Free Samples
MAX7036	300MHz to 450MHz ASK Receiver with Internal IF Filter	-- Free Samples
MAX7042	308MHz/315MHz/418MHz/433.92MHz Low-Power, FSK Superheterodyne Receiver	-- Free Samples
MAX7044	300MHz to 450MHz High-Efficiency, Crystal-Based +13dBm ASK Transmitter	-- Free Samples
MAX7049	High-Performance, 288MHz to 945MHz ASK/FSK ISM Transmitter	-- Free Samples
MAX7057	300MHz to 450MHz Frequency-Programmable ASK/FSK Transmitter	-- Free Samples
MAX7058	315MHz/390MHz Dual-Frequency ASK Transmitter	-- Free Samples
MAX7060	280MHz to 450MHz Programmable ASK/FSK Transmitter	-- Free Samples
MAX8805	600mA/650mA PWM Step-Down Converters in 2mm x 2mm WLP for WCDMA PA Power	
MAX8805W	600mA/650mA PWM Step-Down Converters in 2mm x 2mm WLP for WCDMA PA Power	
MAX8805X	600mA/650mA PWM Step-Down Converters in 2mm x 2mm WLP for WCDMA PA Power	
MAX8805Y	600mA/650mA PWM Step-Down Converters in 2mm x 2mm WLP for WCDMA PA Power	
MAX8805Z	600mA/650mA PWM Step-Down Converters in 2mm x 2mm WLP for WCDMA PA Power	
MAX9930	2MHz to 1.6GHz 45dB RF-Detecting Controllers and RF Detector	-- Free Samples
MAX9931	2MHz to 1.6GHz 45dB RF-Detecting Controllers and RF Detector	-- Free Samples
MAX9932	2MHz to 1.6GHz 45dB RF-Detecting Controllers and RF Detector	-- Free Samples
MAX9933	2MHz to 1.6GHz 45dB RF-Detecting Controllers and RF Detector	-- Free Samples
MAX9947	AISG Integrated Transceiver	-- Free Samples
MAX9957	Fast Dual Driver for ATE with Waveform Shaping	-- Free Samples
MAX9981	825MHz to 915MHz, Dual SiGe High-Linearity Active Mixer	-- Free Samples
MAX9982	825MHz to 915MHz, SiGe High-Linearity Active Mixer	-- Free Samples
MAX9984	SiGe High-Linearity, 400MHz to 1000MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX9985	Dual, SiGe, High-Linearity, 700MHz to 1000MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX9985A	Dual, SiGe, High-Linearity, 700MHz to 1000MHz Downconversion Mixer with LO Buffer/Switch	
MAX9986	SiGe High-Linearity, 815MHz to 995MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX9986A	SiGe High-Linearity, 815MHz to 1000MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX9987	+14dBm to +20dBm LO Buffers/Splitters with ±1dB Variation	-- Free Samples
MAX9988	+14dBm to +20dBm LO Buffers/Splitters with ±1dB Variation	-- Free Samples
MAX9989	+14dBm to +20dBm LO Buffers with ±1dB Variation	-- Free Samples
MAX9990	+14dBm to +20dBm LO Buffers with ±1dB Variation	-- Free Samples
MAX9993	High-Linearity 1700MHz to 2200MHz Down-Conversion Mixer with LO Buffer/Switch	-- Free Samples

MAX9994	SiGe High-Linearity, 1400MHz to 2200MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX9995	Dual, SiGe, High-Linearity, 1700MHz to 2700MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples
MAX9995A	Dual, SiGe, High-Linearity, 1700MHz to 2200MHz Downconversion Mixer with LO Buffer/Switch	
MAX9996	SiGe High-Linearity, 1700MHz to 2200MHz Downconversion Mixer with LO Buffer/Switch	-- Free Samples

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