

Upconverting WiMAX mixer provides high IP3

While many new RF capabilities are enabled by sophisticated RFICs, simple structures, such as a double-balanced quad diode mixer, can effectively perform the same signal-processing functions while also exhibiting superior electrical performance and robustness.

By Radhakrishna Setty

WiMAX (worldwide interoperability for microwave access) is a standards-based wireless technology that provides broadband connections over long and short distances. WiMAX is becoming popular as it can be used for a number of applications, including last-mile broadband connections, hotspots, cellular backhaul, and high-speed enterprise connectivity for business.

The 2.5 GHz to 2.7 GHz band is available for mobile and fixed wireless services in the United States. This band is also underused and potentially available in many countries throughout South America and Europe as well as some countries in the Asia-Pacific region. The 3.3 GHz and 3.5 GHz bands are allocated for fixed wireless services in many countries worldwide and are well-suited to WiMAX solutions for both fixed and mobile services^[1].

The company's model SIM-U432H+ is an upconverter mixer designed for WiMAX applications and is based on a combination of low-temperature co-fired ceramic (LTCC) technology, semiconductor technology, and a highly manufacturable circuit layout. This combination^[2] results in small size, high insensitivity to electrostatic discharge (ESD), excellent stability with temperature and high IP3.

The SIM-U432H+ mixer (Figure 1) is built on an LTCC substrate, suited for designs with multilayer circuits. In contrast to conventional planar circuit designs, in which all circuit elements are placed on one side of a single-layer printed circuit board, LTCC circuits can be designed and fabricated in three dimensions, even with embedded components between layers to save space. The approach results in a mixer that measures just 0.2 in. x 0.18 in. x 0.08 in. (5.1 mm x 4.6 mm x 2.1 mm), which is smaller than some commercial semiconductor-based mixers. Although the SIM-U432H+ mixer incorporates semiconductors to accomplish its non-linear frequency-translation function, it is a passive design that operates without dc bias (compared to a standard semiconductor or integrated-circuit mixer that requires the application of a constant dc bias voltage).

The SIM-U432H+ is a double-balanced mixer (Figure 2) built around a reliable diode quad. Except for the diodes, the entire structure is implemented in multiple layers of LTCC and is, therefore, inherently hermetic. By integrating components in LTCC, the mass of the mixer is minimized, making it extremely rugged in terms of withstanding shock and vibration. In fact, the entire mixer structure can withstand the environmental extremes usually experienced only by military components, in terms of temperature, humidity, vibration and mechanical shock.

The mixer is RoHS compliant, constructed without lead-based solder or other hazardous materials. It is built to withstand severe ESD scenarios under conditions normally hazardous to monolithic semiconductor mixers. The SIM-U432H+, like other members of the company's SIM mixer line, meets Class 1C ESD requirements, a level of 1000 V when tested under the human body model (HBM) conditions (compared to standard semiconductor mixers that are rated as Class 1A, 250 V for HBM testing). The SIM-U432H+ mixer also meets Class M2 ESD requirements (testing at 100 V according to the ESD machine model).

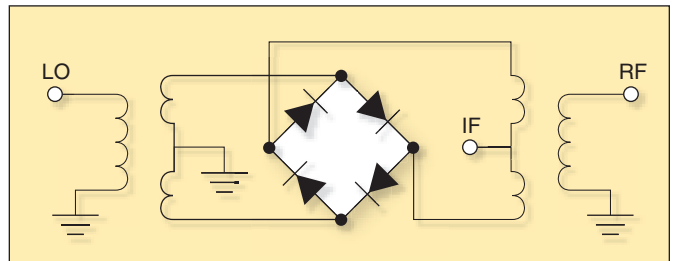


Figure 1. The SIM-U432H+ surface-mount mixer is ideal for upconverting signals in the 260 MHz to 460 MHz band to the higher 2200 MHz to 3900 MHz WiMAX band.



Figure 2. The SIM-U432H+ double-balanced mixer employs a diode quad, circuit design techniques and proven LTCC circuit materials for stable, high-ESD-immunity performance.

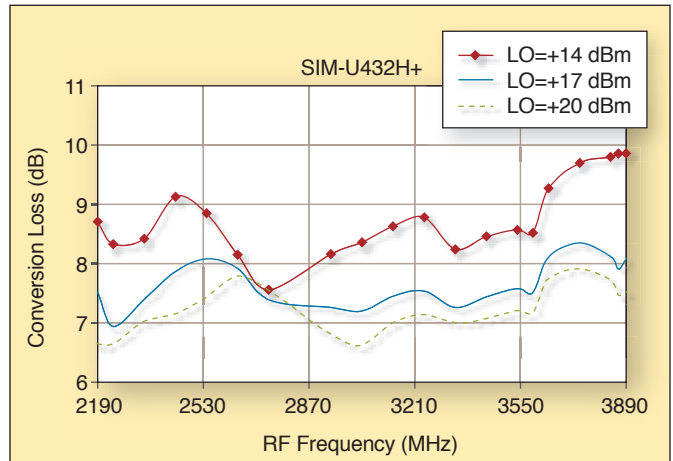


Figure 3. The SIM-U432H+ mixer exhibits well-behaved conversion loss performance with frequency over a wide range of LO drive levels. It was tested here at LO drive levels of +14 dBm, +17 dBm and +20 dBm.

Evaluating performance

The SIM-U432H+ mixer accepts intermediate-frequency (IF) signals from 260 MHz to 460 MHz and local oscillator (LO) signals from 2550 MHz to 4250 MHz at a nominal level of +17 dBm to produce RF output signals from 2200 MHz to 3900 MHz (well in excess of the WiMAX band range). It performs the frequency upconversion with typical conversion loss of 7.5 dB (Table 1). The mixer's conversion loss is well behaved with frequency even at other LO drive levels. For



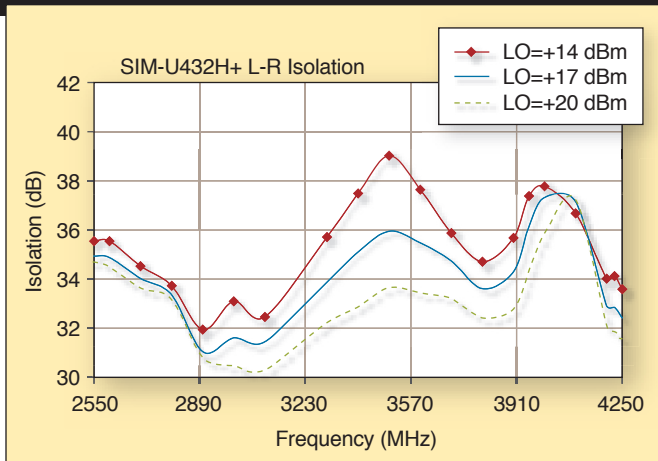


Figure 4. The isolation between the LO and RF ports was measured at typically 33 dB for three LO drive levels of +14 dBm, +17 dBm, and +20 dBm.

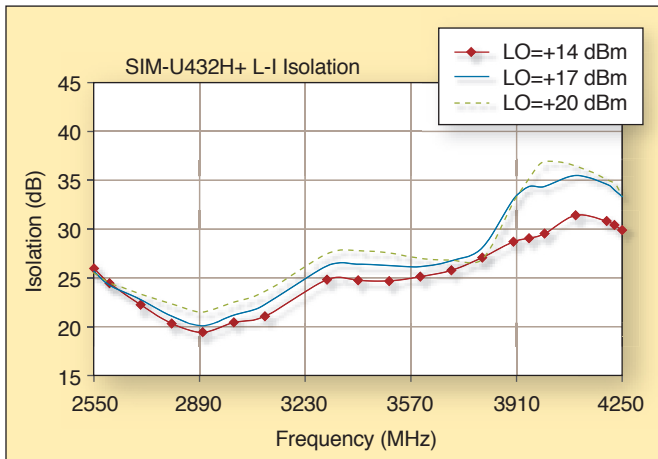


Figure 5. The isolation between the LO and IF ports was measured at typically 26 dB across the full frequency range of the SIM-U432H+ mixer.

example, the SIM-U432H+ was tested with LO drive levels of +14 dBm, +17 dBm and +20 dBm and exhibited consistent conversion-loss profiles across the 2200 MHz to 3900 MHz RF output range (Figure 3). Performing swept-frequency testing at different LO drive levels simulates the effects of variations in LO power from unit to unit as well as across wide frequency ranges. The variation with LO drive power is typically +1.5 dB/-0.5 dB across the 1700 MHz measured bandwidth.

The integrity of the mixer's circuit design is most evident in the port-to-port isolation. High isolation is instrumental in achieving good performance in dual-mixer in-phase (I) and quadrature (Q) modulators. Also, a mixer with high isolation requires less additional external filtering to reduce unwanted signal content, such as LO feedthrough. The LO-to-RF isolation of the SIM-U432H+ mixer was also evaluated at the three LO drive levels used for the conversion-loss tests, to compare performance at different LO levels and to understand the effects of variations in LO power on isolation. As Figure 4 shows, the LO-to-RF isolation is high (typically 33 dB) and well behaved at all three LO drive levels. Variations in isolation as a function of LO power are typically ± 2 dB.

Similarly, the LO-to-IF port isolation was evaluated at the three LO drive levels. While isolation between these two ports is less critical in an upconverter applications (where a greater concern is feedthrough of LO signals to the RF output port), the SIM-U432H+ mixer nonetheless exhibited typically 26 dB across a LO frequency range of 2550 MHz to 4250 MHz (Figure 5).

Since wide dynamic range is important in many WiMAX-band applications, the input third-order intercept point (IP3) of the SIM-U432H+ mixer was also evaluated at the three LO drive lev-

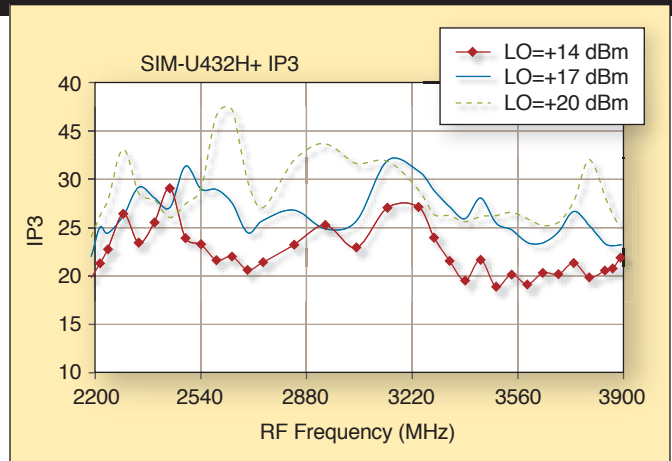


Figure 6. The measured input third-order intercept performance of the SIM-U432H+ mixer was in excess of +8 dBm and typically +11 dBm at all frequencies.

Parameter	
IF range (input)	260 MHz to 460 MHz
RF range (output)	2200 MHz to 3890 MHz
LO range (input)	2550 MHz to 4250 MHz
LO power (nominal)	17 dBm
Conversion loss (typical)	7.5 dB
LO-RF isolation (typical)	33 dB
LO-to-IF isolation (typical)	26 dB
Compression point (1 dB)	14 dBm
Operating temperature range	-40 °C to 85 °C
IP3 (typical)	26 dBm
Storage temperature range	-55 °C to 100 °C
Size	0.2 in. x 0.18 in. x 0.08 in.

Table 1. A summary of the SIM-U432H+ mixer's performance.

els (+14 dBm, +17 dBm and +20 dBm) and an RF output range of 2200 MHz to 3900 MHz. The mixer's input IP3 is consistently about +26 dBm across most of that range for the output (Figure 6).

The LTCC double-balanced mixer features typical LO port return loss of 12 dB. The return loss measured at the RF port is 10 dB typical in the WiMAX band of frequencies while the return loss at the IF port is typically 10 dB to 15 dB across the full IF band.

For WiMAX applications the SIM-U432H+ double-balanced mixer provides an extremely compact, high-performance solution based on a stable LTCC process. The mixer supports conventional surface-mount applications, and can be supplied in tape and reel formats for use with automated assembly equipment. The RoHS-compliant mixer fills a range of global WiMAX applications and is designed to withstand high levels of ESD mishandling compared to more sensitive, and larger, semiconductor mixers. **RFD**

References

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2. United States Patent No. 7,027,795 (2006).

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