Mini-Circuits®

Frequently asked questions about mixers

Scope of this application note, and related sources of Questions and Answers:

The Q&As below cover general topics on the use of frequency mixers. Q&As relating to the process of selecting a mixer from among the many that are available are included in another application note entitled, "How to Select a Mixer". Additionally, please refer to application note, "Frequently Asked Questions about Phase Detectors", which includes Q&As relating to the use of mixers as phase detectors.

Q. I have an application requiring mixers with coaxial connectors; a female BNC for the RF and LO input and a male BNC for the IF output. Is such a mixer available?
A. Not as a standard model. However, you may specify a BNC male connector at the IF port, at an additional charge. Generally, a connector change requires feasibility evaluation and assignment of a special model number. Please contact us if your application requires connectors other than those shown on our website.

Q. My application requires a mixer with coaxial connectors and a mounting bracket. What model is recommended?
A. Most Mini-Circuits connector-style mixers are available with a mounting bracket. Some, such as the ZX05 series, have a bracket integral with the case design. Generally, the data sheet identifies a suffix added to the basic model number when that is necessary for ordering. For example, ZAD-2+ with mounting bracket would be ordered as ZAD-2B+ or ZAD-2BR+ depending upon the bracket configuration.

Q. I've selected a mixer whose Harmonics table on the website shows its (m × LO) ± (n × RF) products will meet my design requirements. However, I'm concerned that LO power variations may get me into trouble. How can I be sure of my design?
A. Upon request, Mini-Circuits can test the mixer you want to use at LO power pertinent to the variation you anticipate in your application, and provide you with the data.

Q. I need a mixer that can perform with LO level of 0 dBm or even lower. What can you suggest?
A. Mini-Circuits has mixers that include a built-in amplifier in the LO input path, so excellent performance can be achieved with LO input as low as -6 dBm. Examples, with their nominal LO levels, are: MACA-242H+ (-3 dBm, 750 – 2400 MHz), MACA-63H+ (0 dBm, 2 – 6 GHz), and UNCL-L1 (-4 dBm, 10 – 500 MHz). Also, consider the Level 3 series of +3 dBm LO mixers that perform well even at 0 dBm, without requiring DC power.

Q. Data sheets of mixers list IP3 (third-order intermodulation intercept) in the specifications. Does this refer to the input or the output of the mixer?

A. IP3 of down-converting mixers such as LAVI-17VH+ is referred to the RF input. IP3 of up-converting mixers such as LAVI-U252VH+ is referred to the IF input.

Q. My application dictates a welded metal-case mixer, and my manufacturing process requires components to be surface-mount. What would you recommend?

A. Consider Mini-Circuits TUF-SM series, the most rugged metal-case surface-mount mixers in the world, with all welded internal and external construction. The 0.5 by 0.2 by 0.25-inch TUF-SM units employ only four gull-wing leads to simplify lead placement on PC boards.

Q. I see ads for mixers that are "termination insensitive". They are quite expensive and frankly, I can't afford them in my current design assignment. Do I have any alternatives?

A. Yes, you do. It involves a trade-off, which in fact could lower your costs by as much as 10:1 over a "termination-insensitive" mixer and actually offer lower distortion, provided your system design can tolerate 1 dB or so additional conversion loss. Here's the alternative: Select a Mini-Circuits mixer with LO level that provides acceptable distortion performance (refer to our application note, How to Select a Mixer), and meets your other requirements. Then, add a 3-dB attenuator – our low-cost GAT, LAT, PAT series (surface-mount), or HAT, UNAT, VAT series (coaxial) – to the IF output. The combination performs as well as the "termination-insensitive" model at a lower price and, in addition, is optimized by LO drive level for minimum distortion and fits your frequency range. What's the catch? The Mini-Circuits mixer you selected probably has a conversion loss of 6 dB; adding the 3-dB attenuator results in an overall loss of 9 dB. This is about 1 dB higher than a typical "termination-insensitive" mixer. If your design can tolerate this slight degradation, you have a viable alternative.

Q. I am a digital designer, dealing with pulses rather than sine waves. Is it necessary to furnish only sine waves to a double-balanced mixer?

A. No. A double-balanced mixer operates as a switching device; pulses are fine, and may even reduce distortion.

Q. I see mixer specs given in normalized frequency ranges. Can you clarify such terms as: one octave from band-edge, lower band-edge to one decade higher, and upper band-edge to one octave lower?

A. To normalize frequency on spec sheets, the frequency range of wide-band mixers is divided into three parts, L, M and U. The lower frequency range, L, covers the lowest specified frequency to one decade higher (ten times the lowest frequency). The upper frequency range, U, covers the highest frequency to one octave lower (one-half the highest frequency). The mid-range, M, covers the high end of the low-frequency range to the low end of the high-frequency range. For example, a mixer covering 0.5-500 MHz would have the following divisions: L = 0.5 to 5 MHz, M = 5 to 250 MHz, and U = 250 to 500 MHz. Many mixer specs distinguish a “mid-frequency” range m (lower-case) covering 2 times the lowest frequency to one-half the highest frequency, 1 to 250 MHz in this example.

Q. Double-balanced mixers don't seem to be cluttered with bulky and expensive filters. How come?

A. The inherent isolation between LO, IF and RF ports make filters unnecessary. Thus, double-balanced mixers can be operated over a wide bandwidth with very high isolation; 50 dB is typical at lower frequencies.

Q. I'm dealing with low-level 1000 MHz signals and low distortion is a must. I have a 70 MHz IF amplifier following the mixer. Should I be concerned with the amplifier input impedance?

A. If the amplifier input does not appear as 50-ohms, there will be reflections back to the IF port of the mixer that can cause distortion products.

Q. I need to attenuate low frequencies, from 1 kHz to 2 MHz, and PIN diode attenuators won't do the job. Can I use a double-balanced mixer for this application?

A. Yes. A DC current flowing through the IF port can provide isolation or attenuation between the LO and RF ports. With no current through the IF port, maximum attenuation (50 dB or more) exists between the LO and RF ports. As IF port current flow increases, attenuation decreases to about 2 dB.

Q. A basic double-balanced mixer uses four or more diodes in a symmetrical arrangement. How can I diagnose a defective mixer?

A. Measure the LO-RF isolation at the low end of the frequency range (10 MHz or lower). If isolation is less than 45 or 50 dB, one of the diodes is probably shorted or leaky. Then, check conversion loss. A leaky diode would increase the conversion loss by 0.5 dB; and an open diode by as much as 2 dB.

Q. I need a phase detector that operates at frequencies higher than the phase detector models Mini-Circuits offers, and I see that there are mixers covering the higher frequencies. Can I use a mixer as a phase detector?

A. Yes, provided attention is paid to certain details. These are dealt with in the application note “Frequently asked questions” listed under Phase Detectors on our website.

Q. Is it safe to test the diodes in a double-balanced mixer using a digital multimeter?

A. Yes. When the multimeter polarity back-biases a diode, it simultaneously forward-biases other diodes that protect the back-biased diode.

Q. What is the thermal resistance and maximum junction temperature of a mixer, such as ADE-1L?

A. The semiconductor diodes in Model ADE-1L have a power derating curve of 300 mW total at 25°C to zero at 150°C. From this, the thermal resistance can be taken nominally as the inverse of the derating: (150 - 25) / 0.3W = 417°C per watt. Maximum operating temperature of ADE-1L is 85°C, and maximum input power (LO plus RF) is 50 mW. Using the above value of thermal resistance, maximum junction temperature rating is 85°C + 0.05W x 417°C per watt = 106°C.

Q. I have a signal around 2.45 GHz that I want to up-convert to 4.9 GHz. Can I use an LO frequency of 2.45 GHz to do this? On receive, can I use a 2.45 GHz LO to down-convert the 4.9 GHz signal back to its original frequency? What problems could occur?

A. In the up-conversion the second harmonic of the LO will fall on the RF signal frequency. Using a SIM-83+ mixer for example with +7 dBm LO and -4 dBm IF input, the LO 2nd harmonic will be only about 20 dB below the RF output and too close in frequency to be filtered.

In the down-conversion, suppose -10 dBm RF at 4.9 GHz is being received, and with 6 dB conversion loss and 23 dB LO-IF isolation, the IF output is -10dBm - 6dB = -16 dBm, and the LO leakage is +7dBm - 23dB = -16 dBm: the same level as the desired IF! It would be better to use 7.35 GHz LO for the down-conversion and avoid this problem.

Q. Mini-Circuits mixers are characterized in a 50-ohm system. I need to put together a 75-ohm prototype subsystem. What performance difference am I likely to see?

A. Typical conversion loss characteristics of two mixers are shown below as examples. They indicate that performance may be useful in 75-ohm applications, but differences should be expected. In the ADE-1+ graph the conversion loss is less with 75 ohms than with 50 ohms, while for ADE-11X the reverse is true. This is caused by differences in the impedances looking into the mixer ports and how they react with the external terminating impedance.