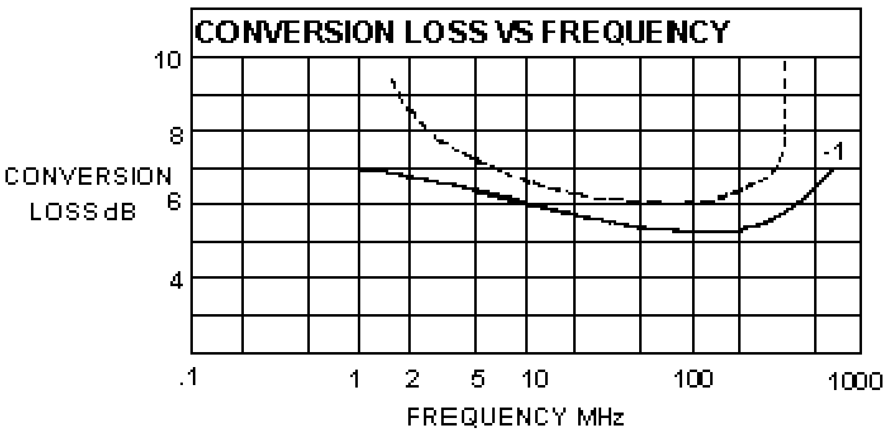
most often asked questions about mixers

Q. I have several 50-ohm DBM samples in my desk drawer and need to put together a 75-ohm prototype subsystem If I use them, what are the drawbacks?

A. Here are some rule-of-thumb guides. The high-frequency end of the DBM range might be narrowed by approximately 20 percent (for example, a 10-500 MHz model would drop to 400 MHz). At the low end, the frequency range could be narrowed by 50 percent (for example, a 1 MHz spec would become 1.5 MHz). Thus, a 50-ohm DBM rated for a given conversion loss figure over a 1-500 MHz range would maintain the same conversion loss in a 75-ohm system over a 1.5-400 MHz range.



Q. Isolation spec for LO to RF and LO to IF are generally included in mixer specs, but RF to IF isolation is often not listed. What are the typical values?

A. In a mixer application, the Rf signal level is generally ver low and thus the RF-IF isolation parameter is unimportant. However, in a phase detector application, the RF level is high and thus the RF-IF isolation becomes important. As a rule of thumb, LO-IF isolation is generally less than LO-RF isolation; -10 dB less at low frequency, 15-20 dB less at mid- and high-frequency.

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" model and actually offer lower distortion provided your design can tolerate 1 dB or so additional conversion loss. Here's the alternative: select a Mini-Circuits mixer for the LO drive you have available (with Mini-Circuits Level 7, 10, 13, 17, 23 and 27 to choose from, you can optimize for lowest distortion) and your specific frequency range of operation. Then add a 3 dB attenuator (check our low-cost AT, MAT, CAT series) to the IF output. The combination will 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; plus the 3 dB attenuator results in an overall loss of 9 dB or about 1 dB higher than the "termination-insensitive" model. If your design can tolerate this slight degradation, you have a viable alternative.

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 nominal charge of $1.00 per unit.

If your application requires other connector combinations, please contact us.

Q. My application requires a mixer with coaxial connectors and a mounting flange. What model is recommended?

A. All Mini-Circuits' connector-style mixers are available with flange mounting. The suffix letter B should be added to the basic model. For example, the ZAD-2 with mounting bracket would be ordered as a ZAD-2B.

Q. I recently purchased several Mini-Circuits mixers and noticed the marking "Hi-Rel". What does this mean?

A. In addition to all of the quality control steps taken at Mini-Circuits to ensure high-reliability mixers, additional Hi-Rel steps are taken including: (1) burn-in for 96 hours at 100C with 8 mA at 1 KHz; (a) thermal shock, and (3) gross and fine leak tests per MIL-STD-202.

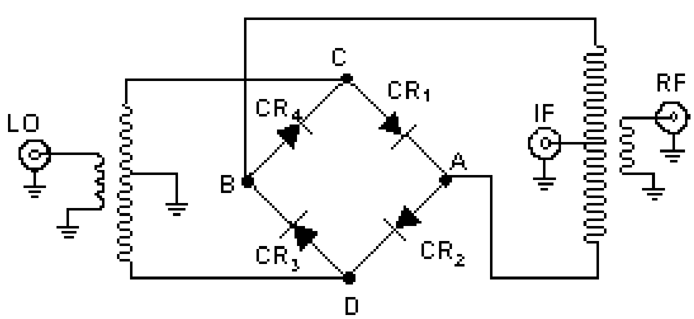
Any model may be ordered with Hi-Rel testing. Just add the suffix Hi-Rel to the model number and $1.00 per unit.

Q. My application requires a rugged, low-cost mixer with high reliability. What model would you recommend?

A. We recommend the SBL-1 for a rugged, industrial application. It is the lowest cost mixer in the world (only #3.95 in small quantity lost) with over millions of units operating reliably in the field today.

Q. A couple of diodes can be hooked up as a phase detector. Why go to the trouble and expense of using a double-balanced mixer(DBM) for the same function?

A. A DBM is an ideal device for phase detection since it offers high isolation between all three ports - the reference (LO), input signal (RF) and output (IF). Furthermore, the DBM provides very low DC offset or residual voltage at the IF output.



Double-Balanced Mixer Schematic

Q. I've tried using a DBM as a phase detector and have experienced an odd result. What am I doing wrong?

A. Perhaps you added an op amp without considering the op amp DC input voltage, impedance matching and/or proper filtering.

Another source of erratic results can be a defective diode in the DBM. To check, measure the LO to RF isolation at a fairly low frequency. If isolation does not meet or exceed published specs, a diode is probably defective.

Q. Why must the DBM be operated in a saturated mode when used as a phase detector?

A. When sufficiently high input level signals are applied to the LO and RF ports, the DBM operates in a saturated mode (as a limiter) and thus the IF output becomes independent of input signal level variations. Thus, the IF output of the DBM would have a DC voltage proportional only to te phase difference between LO and RF inputs.

Q. Why is DC offset so important?

A. In many phase detector applications, one of the two signals may be 90. Thus, the lower the DC offset voltage, the more accurately the phase detector performs its function.

Q. Data sheets from most phase detector manufacturers indicate both input signals, RF and LO, should be equal in amplitude. Suppose they are not?

A. If the signal inputs to the LO and RF ports are of sufficient magnitude, the phase detector will operate in a saturated mode and provide a DC output proportional to the phase difference between the two signals. However, if the LO signal is of sufficient amplitude but the RF signal is low in amplitude, the output of the phase detector will be proportional to the amplitude as well as the phase of the RF input.

To operate the DBM in the required saturated mode, the RF signal level should be at least:
+1 dBm for Standard Level (+7 dBm LO) mixers
+10 dBm for High Level (+17 dBm LO) mixers
+15 dBm for Very High Level (+23 dBm LO) mixers.

Q. I've selected a mixer that will provide the IM products to meet my design requirements. However, I'm concerned that LO power variations my get me into trouble. How can I be sure of my design?

A. Mini-circuits exclusive CAPD data is your salvation. Detailed point-by-point data are available for a given RF input level and frequency with LO drive a variable. For example, let's consider an SRA-1 mixer with RF input at -10 dBm and 400 MHz, and LO at 370 MHz. Here's how LO drive variation affects the 3 × 1 product (third harmonic of RF mixing with LO): with LO at + 4 dBm, the 3 × 1 product is 40 dB below IF; at + 7 dBm LO, 56 dB down; and at + 10 dBm LO, 63 dB below IF. This indicates a rather substantial change in I level with Lo drive variation. There's no need to gamble or guess... take advantage of Mini-Circuits exclusive CAPD service for these and similar unusual design situations.

mixer harmonic intermodulation

model SRA-1 *(Relative to desired IF output)*

		RF CAL	LO at +4 dBm							LO at +7 dBm							LO at +10 dBm						
Harmonic RF Order	0	0	-	36	17	24	24	29	33	-	31	17	27	22	28	30	-	26	13	25	16	21	21
	1	0	18	-	33	18	35	31	45	17	-	37	11	33	37	47	19	-	42	10	30	30	39
	2	74	42	49	41	63	45	57	57	48	47	50	52	49	60	56	63	53	71	59	58	62	58
	3	78	66	40	51	35	54	38	57	66	56	58	46	57	44	68	69	63	70	69	73	64	72
	4	79	68	72	66	69	63	69	63	71	71	72	70	3	69	70	72	73	74	2	3	3	74
	5	78	72	71	72	65	68	59	60	73	73	72	73	73	71	72	72	72	74	74	74	72	73
	6	77	70	71	71	72	73	72	73	73	71	2	71	73	73	73	71	72	73	72	73	73	72
	7	78	72	71	71	71	71	72	71	73	71	72	71	73	73	73	72	72	71	73	72	73	73
	8	78	72	71	71	70	71	71	70	74	72	72	71	74	74	73	72	71	72	72	72	74	73
	9	80	72	72	68	70	71	71	72	74	72	73	72	72	72	73	74	71	71	71	72	73	73
	10	80	71	72	71	70	72	71	71	73	74	73	71	73	73	73	73	73	72	72	74	72	73
	11	79	71	72	72	72	71	70	70	71	73	73	72	72	72	71	73	73	72	73	73	73	71
	12	79	71	71	72	71	72	71	71	73	73	72	74	72	73	72	73	73	73	73	73	73	72
	13	78	71	71	71	70	72	71	71	73	73	73	73	72	73	73	73	73	74	72	73	72	73
	14	80	72	71	72	71	71	71	71	73	72	73	73	73	73	73	72	73	72	74	74	74	73
	15	73	66	73	71	71	71	71	72	66	73	72	73	73	73	73	66	73	73	73	72	73	73
			0	1	2	3	4	5	6	0	1	2	3	4	5	6	0	1	2	3	4	5	6
			Harmonic LO Order							Harmonic LO Order							Harmonic LO Order						

test conditions
RF = 400.1 MHz at -10 dBm **LO** = 370.01 MHz
For other test frequencies, contact factory.

Q. I need a mixer that can perform with an Lo level of 0 dBm or even lower, What can you suggest?

A. Mini-Circuits' model UNCL-L1 includes a built-in amplifier between the LO input and the mixer, so excellent performance over 0.5 to 500 MHz can be achieved with LO input as low as -4 dBm. Also consider the Level 3 RMS series of +3 dBm LO mixers that perform well even at 0 dBm.

Q. My new design will require surface-mount mixers. What SMT models are available from Mini-Circuits?

A. We offer a wide variety of off-the-shelf surface-mount packages in plastic or metal cases. All catalog models can be obtained in surface-mount configurations; contact our Applications Engineering department.

Q. Input noise is a critical factor in my receiver design. Which mixer would you recommend?

A. There are many factors to consider in addition to conversion loss and noise figure. The article "How to Select a Mixer" will lead you to a model best suited for your application and you can then choose from the wide variety offered by Mini-Circuits.

Q. What makes it possible for Mini-Circuits to offer a five-year guarantee on its Ultra-Rel^{TM} mixers?

A. The key factor is an improved monolithic processing technique, developed jointly by Mini-Circuits and H-P, for producing Ultra-Rel diodes that meet and exceed MIL-STD-883 tests with ease. When these devices were exposed to a brutal accelerated high-temperature test of 250C for 981 hours, none failed; even at a sizzling 300C, none failed. Conventional diodes could not endure such punishment.

Others test applied to these Ultra-Rel diodes include grueling mechanical shock and vibration, thermal cycling, autoclave, and 85/85 (85C at 85% humidity for 168 hours with no bias). Since the reliability of a mixer is closely linked to its diodes, the five-year guarantee for Ultra-Rel mixers is actually conservative.

Q. OK ... so Ultra-Rel^{TM} mixers can take the brutal punishment you describe. What does it mean to me when my application doesn't face anywhere near the extremes discussed?

A. You're quite correct that the majority of applications do not require the demanding levels of endurance offered by Ultra-Rel^{TM} mixers. But recent studies among design engineers indicate quality is the number-one factor today in selecting a vendor ad his product line, with price second, and prompt delivery third. With this in mind, consider how Ultra-RelTM mixers in your product design and production will enhance your product's reliability and thus strongly influence your firm's reputation and your customer's satisfaction.

Q. My application dictates a rugged surface-mount mixer but price is critical. What would you recommend?

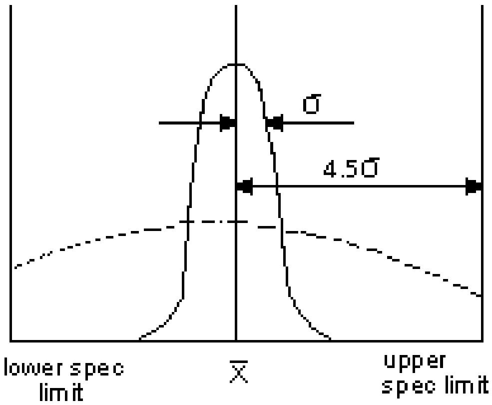
A. Consider Mini-Circuits' TUF-series, the most rugged surface-mount mixers in the world, with all-welded internal and external construction. The 0.5 by 0.2 by 0.25 in. metal case TUF- units employ only four gull wings to simplify lead placement on pc boards. And priced low ... from $3.95 each in 10 quantity.

Q. I need a "termination insensitive" mixer but most advertised models are too expensive for my current application. Any thoughts?

A. For 1-1500 MHz operation, consider Mini-Circuits' UNCL-X1 or -X1MH which provides a built-in buffer amplifier between the mixer and the following IF amplifier stage. The excellent 50-ohm match of the internal amplifier is responsible for the termination insensitivity of the mixer. And prices start from only $23.95.

Q. Your ads highlight "4.5 sigma guaranteed". Without overwhelming me with statistical processing equations, can you briefly describe what this means to me and my company's design and production efforts.

A. By applying powerful statistical process-control techniques, Mini-Circuits can guarantee "skinny" sigma with spec limits 4.5 sigma from the mean value (process capability C_{PK} of 1.5). That's the brief mathematical description.



Sigma(σ) is a statistical measure of the Gaussian variability around a mean value $\bar{X}$. In a normal Gaussian distribution (dotted line), 68% of the units fall within one standard deviation or one sigma. With a 4.5 sigma criteria, only 4 units in a million-lot production run approach the spec limit.

Here's what this mean to you and your company in terms of design and production. We guarantee that production units sent to you today, tomorrow, and next year will very closely match the performance of units supplied for your initial evaluation and prototypes. Such product uniformity translates to substantial reductions in cost by trimming manufacturing throughput time, rework, specialized test equipment, troubleshooting, report paperwork, and inspection personnel. This all results in cost savings to you.

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

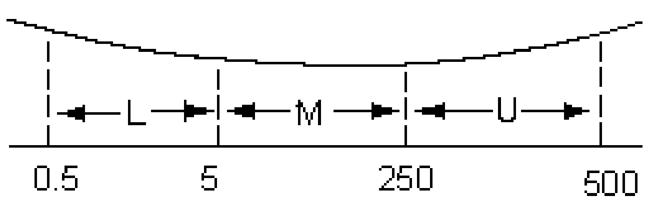
A. No. A DBM operates as a switching device ... pulses are fine (and may even lower distortion).

Q. I see 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 mixer frequency range is divided into three parts, L, M and U.

The lower frequency range, L, covers the lowest specified frequency to one decade higher (or ten times the lowest frequency). The upper frequency range, U, covers the highest frequency to one octave lower (or one-half the highest frequency). The mid-range, M, covers the highest 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:



Q. DBMs 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, DBMs 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 IF port does not appear as 50-ohms, there will be reflections causing 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 DBM for this application?

A. Yes. A DC current flowing thought 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 DBM uses four diodes in a symmetrical arrangement. How can I diagnose a defective mixer?

A. Most mixer failures can be traced to defective diodes. Measure the LO-RF isolation at the low-frequency end of the DBM 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. Your ads mention CAPD (computer-Automated Performance Data). What's its significance to me, the design engineer?

A. Most mixer manufacturers merely supply a spec sheet for each model. Mini-Circuits has developed and introduced its exclusive Computer-Automated Performance Data (CAPD) software, using computer-controlled test set-ups. Here's how you, the designer, benefits:

- no more guesswork on how the mixer interacts with filters
- clearly shows how critical parameters vary with frequency
- quickly indentifies in-band spurious responses
- indicates how LO drive variations affect VSWR, conversion loss, isolation and intermod. And offers perhaps the only published data on how LO drive affects VSWR and intermod.

Quite significant, CAPD allows you to obtain specific data at the frequencies you are concentrating on rather than arbitrary frequencies selected by a manufacturer. Need specific information? Just contact our Engineering Applications department, let us know what models you are interested in and your frequencies of interest - we'll fulfill your request and supply you with appropriate CAPD data.

Last Updated: 09/08/1999