Advantages of MMIC Mixers

WJ Communications is now offering a new family of mixers, the MH series, which are ideally suited for base station and repeater applications. These MMIC mixers are intended to replace the older diode mixers and offer the following key advantages:

***Lower price** - $2.25-$2.95 at 10K compared to $5.00-$7.00 for a comparable diode mixers
***Higher IP3** – 1-3 dB higher performance
***Industry standard packaging** – easy to assemble packages using standard SMT assembly procedures
***MMIC** construction for the highest of reliability

Table 1: List of Diode and MMIC Mixers from WJ Communications

Model	Description	CL, (dB)	IP3 (dBm)	L-I Isol (dB)	LO (dBm)	Frequency (MHz)			Price @10K	Other Comp*	Total Price
						RF	LO	IF			
MH1A	PCS FET Mixer	8.3	35	38	+17	1700-2000	1450-1950	50-250	$2.25	0	$2.25
MH103A	UMTS FET Mixer	8.2	34	37	+17	1900-2200	1600-2150	50-300	$2.25	0	$2.25
MH203A	Cellular FET Mixer	7.3	34	60	+17	800-960	1000-1310	200-350	$2.25	$0.30	$2.55
MH205A	Cellular FET Mixer	7.0	35	55	+17	800-915	700-845	70-120	$2.25	$0.30	$2.55
MH302	PCS/UMTS Quad FET Mixer	7.5	27	32	+13	1800-2000	1540-1740	200-300	$2.95	$1.11	$4.06
MH303	Cellular Quad FET Mixer	7.5	28	44	+13	750-820	820-920	20-100	$2.95	$1.11	$4.06
SME1400B-17	Diode Mixer	6.5	27	22	+17	1-2200	1-2200	1-2000	$5-7	0	$5-7
SME1400B-13	Diode Mixer	6.5	22	22	+13	1-2200	1-2200	1-2000	$5-7	0	$5-7
SME1400B-10	Diode Mixer	6.2	19	22	+10	1-2200	1-2200	1-2000	$5-7	0	$5-7
SME1900-17	Diode Mixer	7.4	29	30	+17	1600-2400	1400-2390	10-250	$5-7	0	$5-7

* Cost of other components required to make the mixer operate normally

Replacing a diode mixer with an MH series FET mixer

Mixers are used to down-convert from a received radio-frequency (RF) signal at high frequency to an intermediate (IF) signal at a lower frequency, at which filtering and amplification are more convenient, and to perform the reverse operation for transmission. Mixers based on high-frequency Schottky diodes, generally connected in groups of four to form a "quad", are well-known and have been in wide use in microwave and cellular communications for decades. These mixers can have excellent performance but require balanced-unbalanced transformers (baluns); surface-mount versions are relatively large and expensive.

Recently, monolithic microwave integrated circuit (MMIC) FET mixers with performance similar to diode mixers have become available from WJ Communications. The MMIC mixers incorporate baluns for the local oscillator (LO) input on chip, fabricated using conventional planar technology. The use of integrated passive elements saves considerable space and eliminates assembly operations in mixer manufacturing. Thus, MMIC mixers are smaller and less expensive than diode mixers, though in general MMIC mixers configured in this fashion must be optimized for relatively narrower bands on all ports compared to similar diode mixers.

When a diode mixer is replaced with a MMIC mixer, minor changes in circuit design and performance can be expected. In this applications note, the reader will find guidance in selecting and applying MMIC mixers to replace diode mixers for typical mobile infrastructure applications, reducing size and cost of the resulting boards.

Selection Guide

In table 2 we provide guidance on selecting MMIC mixers to replace older WJ Communications diode mixer models, depending on the bands in use.

Table 2: MMIC replacements for Diode Mixers

Diode mixer	RF band	LO band	IF band	MMIC replacement	Benefits	Challenges
SME1400B-17	800-960	1000-1310	200-350	MH203A	Reduced cost, size; 4-6 dB add'l IP3	1 dB add'l conversion loss
	800-915	700-845	70-120	MH205A	Reduced cost, size; 4-6 dB add'l IP3	1 dB add'l conversion loss
	1700-2000	1450-1950	50-250	MH1A	Reduced cost, size; add'l 4-6 dB IP3	2 dB add'l conversion loss
	1950-2200	1600-2150	50-300	MH103A	Reduced cost, size; add'l 4-6 dB IP3	2 dB add'l conversion loss
SME1400B-13	820-920	750-850	70	MH303	Reduced cost, size; 1-2 dB addl IP3	1 dB add'l conversion loss
	1800-2000	1540-1740	260	MH302	Reduced cost, size; 1-2 dB addl IP3	1 dB add'l conversion loss
SME1900-17	1700-2000	1450-1950	50-250	MH1A	Reduced cost, size; add'l 4-6 dB IP3	2 dB add'l conversion loss
	1950-2200	1600-2150	50-300	MH103A	Reduced cost, size; add'l 4-6 dB IP3	2 dB add'l conversion loss
	2200-2400	1900-2350	50-300	MH103A	Reduced cost, size; add'l 4-6 dB IP3	2 dB add'l conversion loss

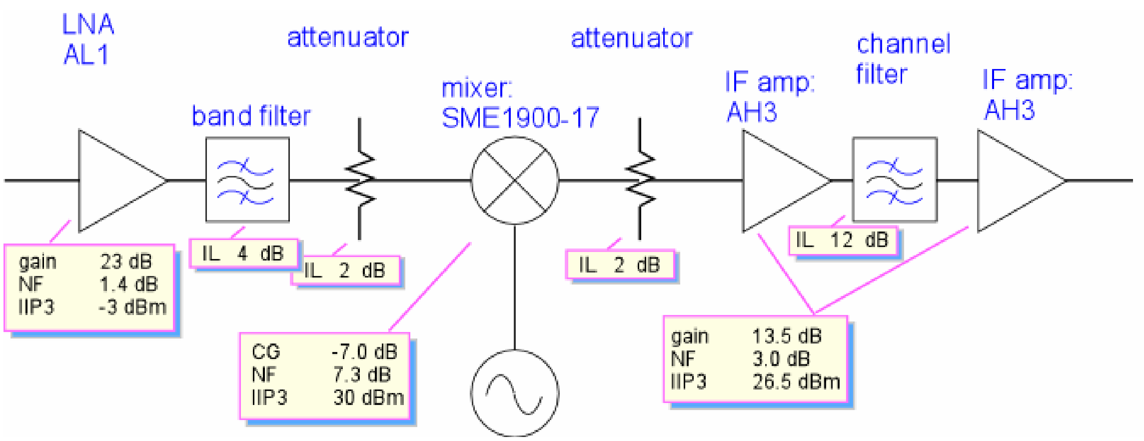
In the remainder of this note we discuss a typical example and examine what changes are encountered when the suggested substitutions are implemented.

Example 1: 1930-1990 RX Front End [US PCS Band]

Assume the following typical RF front-end requirements:

RF Frequency:	1930-1990 MHz
IF Frequency:	120 MHz
Minimum input signal:	-110 dBm
Maximum input signal:	-35 dBm
Dynamic range:	75 dB
Gain:	20 dB
IIP3:	-5 dBm

Assume we have an existing circuit employing an SME1900-17 diode mixer for this application. Let's realize this circuit with the following block diagram:



Analysis of the chain gives the following overall performance:

Stage Description	Stage Gain (dB)	Stage Noise Fig (dB)	Stage IIP3 (dBm)	Cum. Gain (dB)	Cum. Noise Fig (dB)	Cum. Noise Pow (dBm)	Cum. IIP3 (dBm)	Carrier / Noise Ratio (dB)	Spur Free Dyn Range (dB)	Min Dis Signal (dBm)
LNA	23.00	1.40	-3.00	23.00	1.40	-89.60	-3.00	80.60	-77.07	-112
Filter	-4.00	4.00	100.00	19.00	1.42	-93.58	-3.00	80.58	-77.05	-112
Attenuator	-2.00	2.10	100.00	17.00	1.45	-95.55	-3.00	80.55	-77.03	-112
SME1400B-17	-7.00	7.30	30.00	10.00	1.71	-102.29	-3.11	80.29	-76.93	-112
Attenuator	-2.00	2.10	100.00	8.00	1.89	-104.11	-3.11	80.11	-76.81	-112
IF Amp: AH3	13.50	3.00	26.50	21.50	2.31	-90.19	-3.14	79.69	-76.55	-111
Filter	-12.00	12.20	100.00	9.50	2.58	-101.92	-3.14	79.42	-76.37	-111
IF Amp: AH3	13.50	3.00	26.50	23.00	2.84	-88.16	-3.18	79.16	-76.22	-111

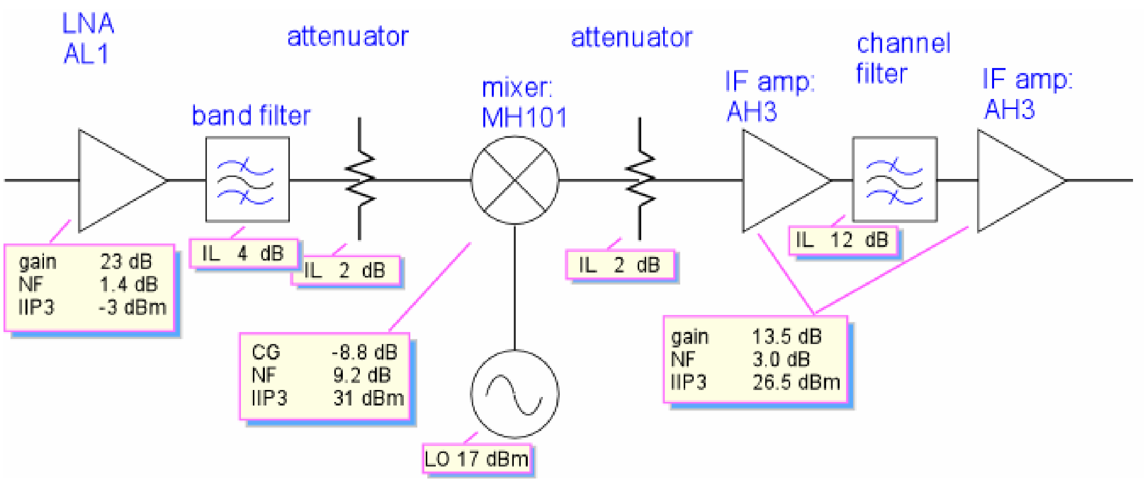
We see that the overall system noise figure of 2.9 dB, gain of 23 dB, and IIP3 of –3.2 dBm meet the specification. The spur-free dynamic range of 76 dB is also compliant with the minimum- and maximum-signal requirements.

We could lower the cost of this radio chain if we substituted a MMIC mixer for the diode mixer. By reference to table 2 we see that the appropriate substitution is the MH1A. The performance of these two mixers in the relevant RF band, using low-side injection with an IF frequency of 120 MHz, is compared in table 3.

Table 3: SME1900-17 and MH101 performance, for RF=1930-1990 MHz, LO = 1810-1870 MHz, IF=120 MHz

Parameter	SME1900-17	MH103A
Conversion loss (dB)	7	8.2
IIP3 (dBm)	30	36
LO power (dBm)	17	17
LO return loss (dB)	12	13
IF return loss (dB)	16	20
RF return loss (dB)	12	14
LO-IF isolation (dB)	31	38
LO-RF isolation (dB)	27	30

The block diagram becomes:



The chain analysis gives:

Stage Description	Stage Gain (dB)	Stage Noise Fig (dB)	Stage IIP3 (dBm)	Cum. Gain (dB)	Cum. Noise Fig (dB)	Cum. Noise Pow (dBm)	Cum. IIP3 (dBm)	Carrier / Noise Ratio (dB)	Spur Free Dyn Range (dB)	Min Dis Signal (dBm)
LNA	23.00	1.40	-3.00	23.00	1.40	-89.60	-3.00	80.60	-77.07	-112
Filter	-4.00	4.00	100.00	19.00	1.42	-93.58	-3.00	80.58	-77.05	-112
Attenuator	-2.00	2.10	100.00	17.00	1.45	-95.55	-3.00	80.55	-77.03	-112
MH103A	-8.20	8.70	36.00	8.80	1.83	-103.37	-3.03	80.17	-76.80	-112
Attenuator	-2.00	2.10	100.00	6.80	2.06	-105.14	-3.03	79.94	-76.65	-111
IF Amp: AH3	13.50	3.00	26.50	20.30	2.59	-91.11	-3.05	79.41	-76.31	-111
Filter	-12.00	12.20	100.00	8.30	2.92	-102.78	-3.05	79.08	-76.09	-111
IF Amp: AH3	13.50	3.00	26.50	21.80	3.24	-88.96	-3.08	78.76	-75.90	-110

The cumulative gain has fallen by 1.2dB, while the cumulative noise figure has been degraded by a modest 0.4dB. IIP3 has improved by 0.1 dB, and thus the spurious-free dynamic range has lost only 0.3dB.

If we wish to make up for the additional conversion loss by adding 2 dB of gain to the RF path (by e.g. removing the attenuator in front of the mixer, since the MMIC mixer has a somewhat better match to 50 ohms than the diode mixer), we find that IP3 and the dynamic range are the same value as in before the with SME mixer and that the noise figure improves to 2.6 dB. The design remains spec compliant, with reduced cost and size requirements.