MAX2309/MAX2312 at 190MHz IF for W-CDMA

This report provides application data for using the MAX2309 in W-CDMA systems with an IF of 190MHz. The MAX2309 offers 110dB gain control range, and operates at 2.7V. MAX2312 in a 28-TSSOP package is compared to the MAX2309 in a 28-pin QFN package. Gain control data, IIP3 data and phase noise data are given. Demodulator phase offest and amplitude data are shown. The IF VGA input impedance is given, along with diagrams showing the test setups.

Additional Information: Wireless Product Line Page
Quick View Data Sheet for the MAX2310/MAX2312/MAX2314/MAX2316
Applications Technical Support

This report provides application data for using the MAX2309 in a W-CDMA receive-path application at 190MHz IF.

General Description of the MAX2309

The MAX2309 is an IF quadrature demodulator designed for CDMA and W-CDMA cellular-phone handsets. The signal path consists of a variable-gain amplifier (VGA) and an I/Q demodulator. The devices feature guaranteed +2.7V operation, a built-in VCO and PLL synthesizer, a variable-gain range of over 110dB, and a high IF input dynamic range (-33dBm IIP3 at 35dB gain, +1.7dBm IIP3 at -5dB gain).

The MAX2309 is a member of the MAX2310 series of single-IF and dual-IF demodulators. It is built into a 28-QFN (5x5mm) package and uses the same die as its predecessor, the MAX2312, which comes in a 28-TSSOP package. The baseband, RF, and IF performance have been determined to be identical between the two packages.

The MAX2309/2312 IF LO synthesizer's reference and RF dividers are fully programmable through a 3-wire serial bus, enabling system architectures using any common reference and IF frequency. The differential baseband I-&-Q outputs have enough bandwidth to suit both narrowband and wideband CDMA systems, and offer output levels up to 2.5Vp-p with 2.75V supply voltage.

The MAX2309 Compared to the MAX2312

The MAX2309 and the MAX2312 share the same die, so their operating functions and characteristics are the same. The parasitic packaging change from the original TSSOP-28 to the MAX2309 in the 28-pin QFN was examined carefully, but no net difference to the VCO tuning tank, IF input impedance, or common-mode isolation was found. This is largely because the practical value of VCO tank components and IF input match components are much greater than the lead-frame and bond-wire parasitics. The associated parasitic reactances are virtually unchanged between the two packages (roughly 1nH/0.5pF per lead) and have minimal circuit impact. The smaller package saves board space by as much as 50%.

The MAX2309 Pinout

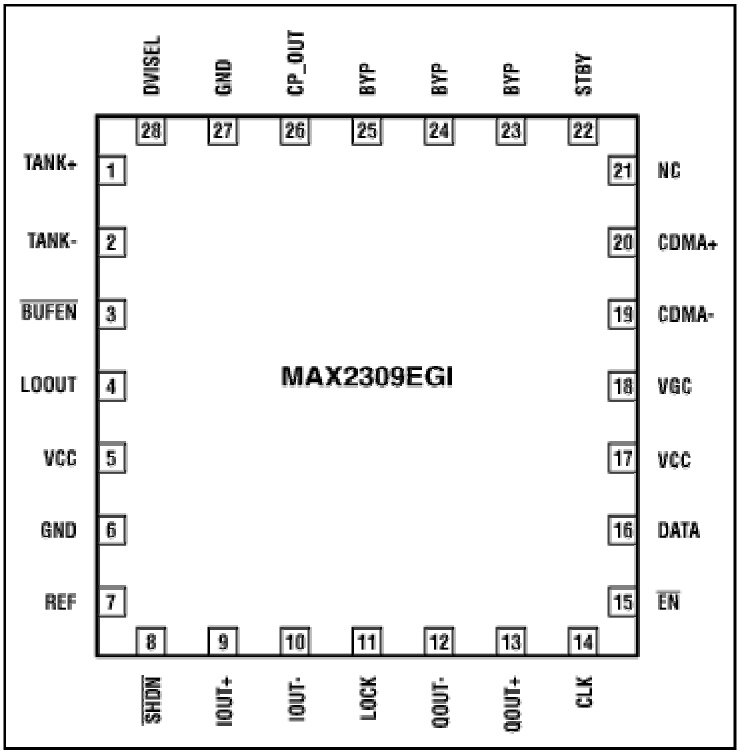


Figure 1. A 28-pin QFN, 5mm x 5mm

Measured Performance of the MAX2309

Most of the measurements that were taken were done with the MAX2312. The MAX2309 didn't have its own EV board at the time of the writing, so key electrical operating characteristics were confirmed on Maxim's CDMA Reference Design V2.0, where it has been employed using a 183.6MHz IF. The measurements were driven by a combination of system issues and certain application-specific parameters.

Table 1. Gain Measurements

Pin (dBm)	Vin_RMS (mV)	Vagc (V)	Differential Vop-p (Q) (mV)	Gain (dB)
-5	397.63536	1.21400	50	-27.04
-10	223.60680	1.24900	50	-22.04
-15	125.74334	1.28800	50	-17.04
-20	70.71068	1.32800	50	-12.04
-25	39.76354	1.36800	50	-7.04
-30	22.36068	1.40000	50	-2.04
-35	12.57433	1.43600	50	2.96
-40	7.07107	1.47400	50	7.96
-45	3.97635	1.51200	50	12.96
-50	2.23607	1.55000	50	17.96
-55	1.25743	1.59100	50	22.96
-60	0.70711	1.64100	50	27.96
-70	0.22361	1.75200	50	37.96
-80	0.07071	1.86400	50	47.96
-90	0.02236	1.98300	50	57.96
-100	0.00707	2.10000	50	67.96

Table 2. IIP3 Measurements

Pin/Tone (dBm)	Pin Total (dBm)	Vin_RMS (mV)	Vagc (V)	Differential Vop-p (Q) (mV)	Gain (dB)	IIP3 (dBm)
-15	-12.0	177.6172	1.246	50	-20.04	1.45
-30	-27.0	31.5853	1.355	50	-5.04	-2.6
-15	-12.0	177.6172	1.327	150	-10.50	-4.67
-30	-27.0	31.5853	1.43	150	4.50	-6.4
-60	-57	0.9988	1.684	150	34.5	-29.73
-15	-12	177.6172	1.348	200	-8	-5.75
-30	-27	31.5853	1.444	200	7	-7.08
-60	-57	0.9988	1.713	200	37	-32.08

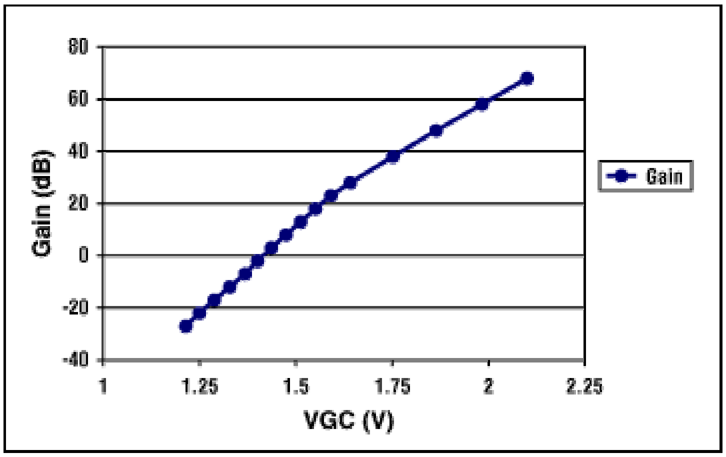


Figure 2. MAX2312 voltage gain vs. VGC, constant Vo = 50mV p-p

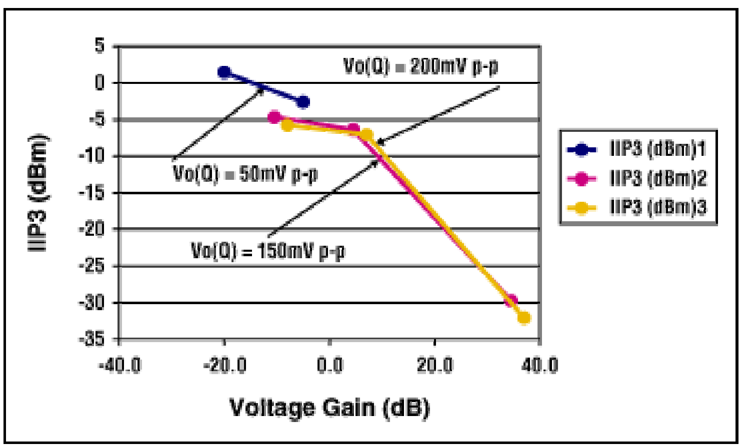


Figure 3. MAX2309/12 IIP3 vs. voltage gain

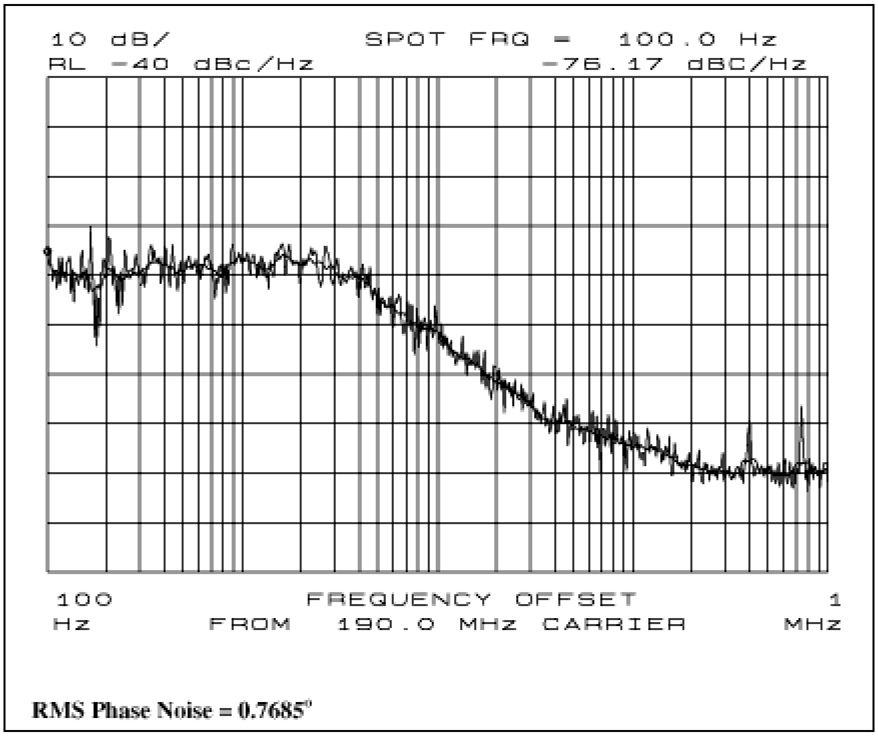


Figure 4. Phase noise vs. frequency offset

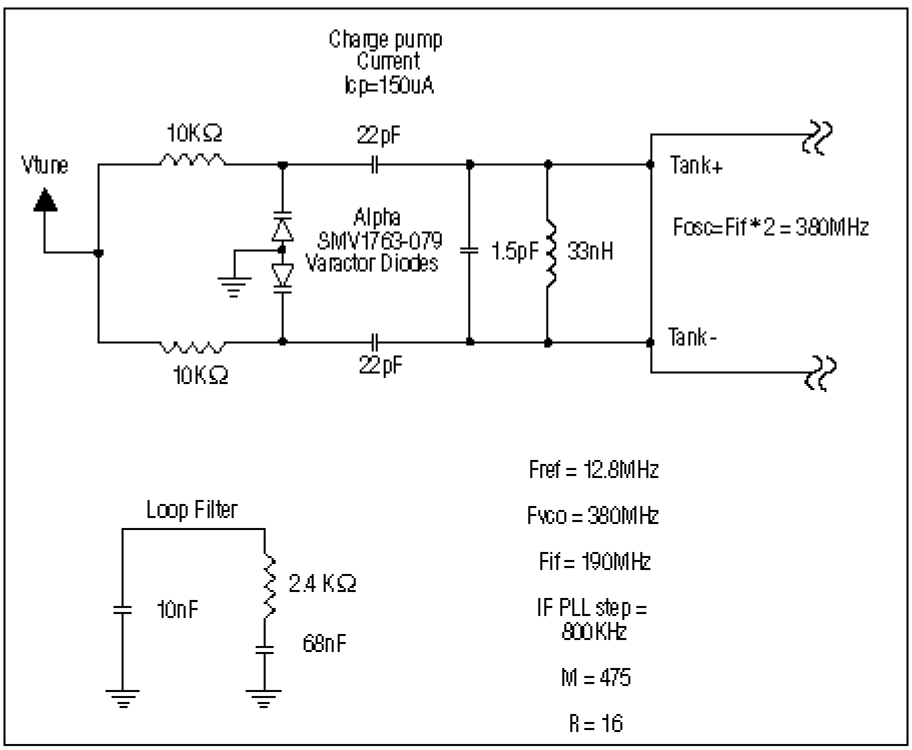


Figure 5. MAX2309/2312 VCO tank circuit and loop filter

Baseband I-and-Q Output Circuit

The MAX2309/2312 use a traditional Gilbert cell with emitter-follower output buffers for differential baseband I-and-Q outputs. Figure 6 identifies OUTN and OUTP for the differential output pins driven by Q8 and Q7.

Also, observe that INN and INP are internal differential inputs from the variable-gain IF amplifier and that LON and LOP are internal differential local oscillator inputs from the on-chip IF VCO.

With Vcc at approximately 3.0VDC, the quiescent output voltage at Q7 and Q8 is set by the 250µA bias current through the 3.1kohm collector loads (around a 0.75-volts drop), summed with the Vbe drop (around 0.7 volts).

Output DC source capability should be around 7mA to 10mA shorted to ground, and sink is around 250µA pulled to Vcc. Each pin output resistance should be around 120 ohms, resulting in approximately 240-ohm differential drive impedance.

Using Figure 6, note the following tolerance data:

The general value of Vout: At any of the I or Q outputs, with Vcc = 2.85, unloaded, you should measure around 1.35-Vout DC, which is due to the drop from Vcc of 0.77 volts across the 3.1k collector loads plus the Q7/8Vbe of around 0.73-volts DC.

Vout unloaded varies by:

- +/-60mV over process variations, at constant 25 degrees C
- +/-90mV over temperature range, given the nominal process
- +/-150mV over all temperature plus process variations (that is, worst-case boundary "corners")

The variation in the output 250?A current sources (more properly called "sinks"):

- 204µA to 317µA over process variations, at constant 25 degrees C
- 168µA to 350µA over temperature range, given the nominal process
- 138µA to 459µA over all temperature plus process variations (that is, worst-case boundary "corners")

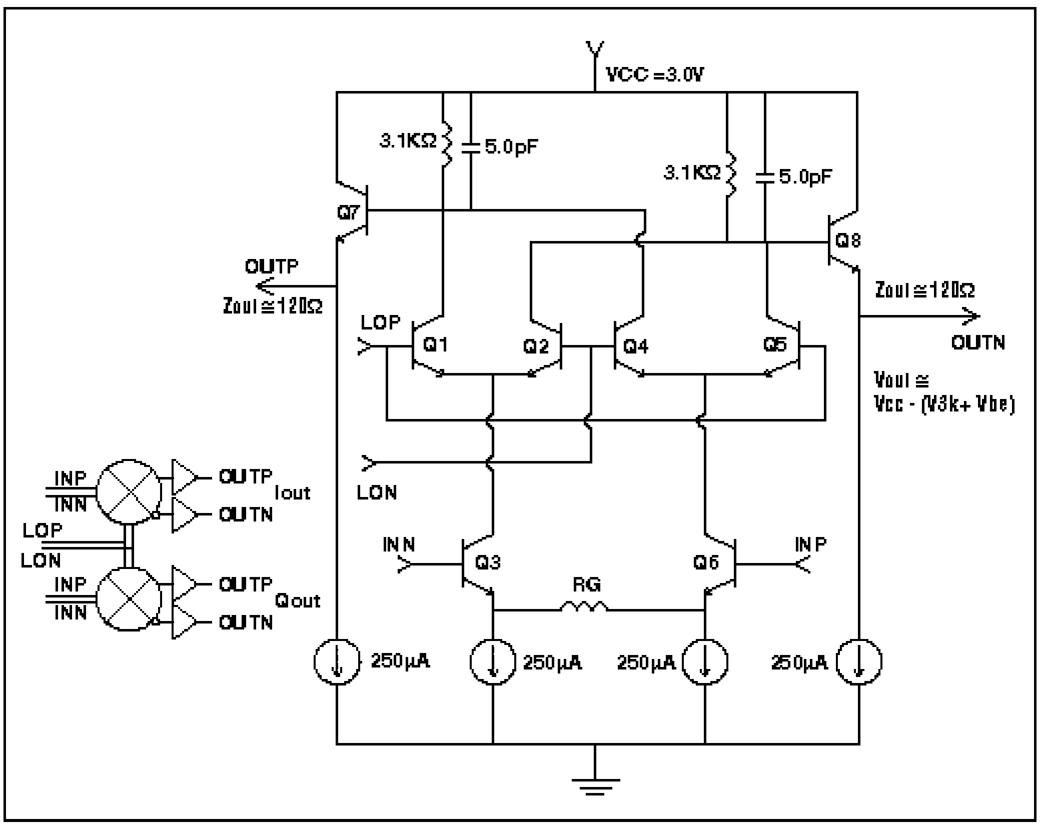


Figure 6. MAX2309/2312 baseband I-and-Q output circuit

Table 3. I-&-Q Amplitude and Phase Imbalance Using Flo = 190MHz

Frequency (MHz)	I-&-Q Phase Offset Phase (deg)	I-&-Q Phase |Δ| from 90 deg (deg)	I-&-Q Amplitude Imbalance (dB)
185.0	89.93	0.07	0.12
186.0	90.20	0.20	0.08
187.0	90.45	0.45	0.09
188.0	90.24	0.24	0.09
189.0	90.14	0.14	0.09
189.9	90.26	0.26	0.13
190.1	89.80	0.20	0.20
191.0	90.20	0.20	0.04
192.0	90.40	0.40	0.09
193.0	90.40	0.40	0.10
194.0	90.46	0.46	0.09
195.0	90.72	0.72	0.13

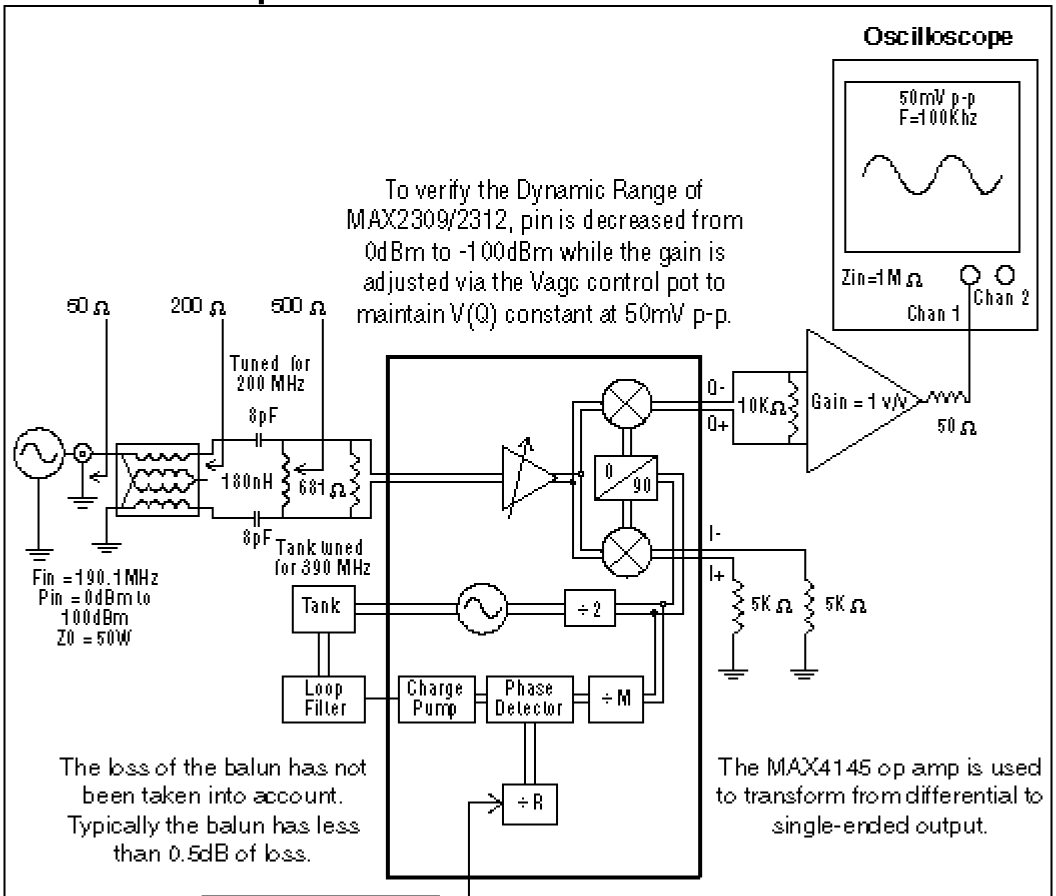
Approximate Model of the Input Impedance Zin

The input impedance of the IF VGA is challenging to measure using a 50-ohm S-parameter test set because of its high impedance. The intended operation uses an external parallel resistor across the differential input, forming a broadband IF match. For SAW filters, this typically is 300 ohms to 600 ohms. It was determined experimentally that the equivalent [Rpar || Cpar] input network for low and medium IF have the following approximate values:

Table 4. Approximate Values

IF Frequency (MHz)	Rin Parallel (kΩ)	Cin Parallel (pF)
85	2.02	0.45
90	2.09	0.42
95	2.08	0.44
100	2.00	0.42
105	2.10	0.42
110	1.98	0.42
115	2.10	0.39
120	2.01	0.42
125	1.98	0.39
130	1.95	0.40
135	1.91	0.39
140	2.00	0.41
145	1.95	0.38
150	2.02	0.40
155	2.01	0.38
160	2.03	0.38
165	1.97	0.39
170	1.85	0.39
175	2.06	0.39
180	2.02	0.41
185	1.93	0.40
190	1.95	0.38
195	1.93	0.42
200	1.95	0.40
205	1.88	0.41
210	1.99	0.39
215	1.92	0.41
220	1.98	0.42
225	1.93	0.41
230	1.82	0.40
235	1.95	0.40
240	1.79	0.42
245	1.83	0.42
250	1.81	0.42
255	1.78	0.42
260	1.85	0.41
265	1.89	0.43
270	1.84	0.42
275	1.78	0.42
280	1.84	0.44
285	1.84	0.43
290	1.76	0.42
295	1.72	0.44
300	1.89	0.43

Measurement Setup



$$\mathrm{Vin(RMS)} = \sqrt{\left[\frac{\mathrm{RIN}}{1000}\right] * 10^{\left[\frac{\mathrm{Pin(dBm)}}{10}\right]}}$$

$$\mathrm{Gain} = 20 \log\left(\frac{\mathrm{V(Q)outp-p}}{2\sqrt{2} * \mathrm{Vin(RMS)}}\right)$$

RIN = 500Ω

The amplitude imbalance is less than ±0.2dB at 100KHz, and the phase imbalance is 180 deg ±0.3 deg for V(Q+) and V(Q-).

The amplitude imbalance is less than ±0.25dB at 100KHz, and the phase imbalance is 90 deg ±0.3 deg for V(Q) and V(I).

Figure 7. MAX2309/MAX2312 gain measurement setup for W-CDMA application

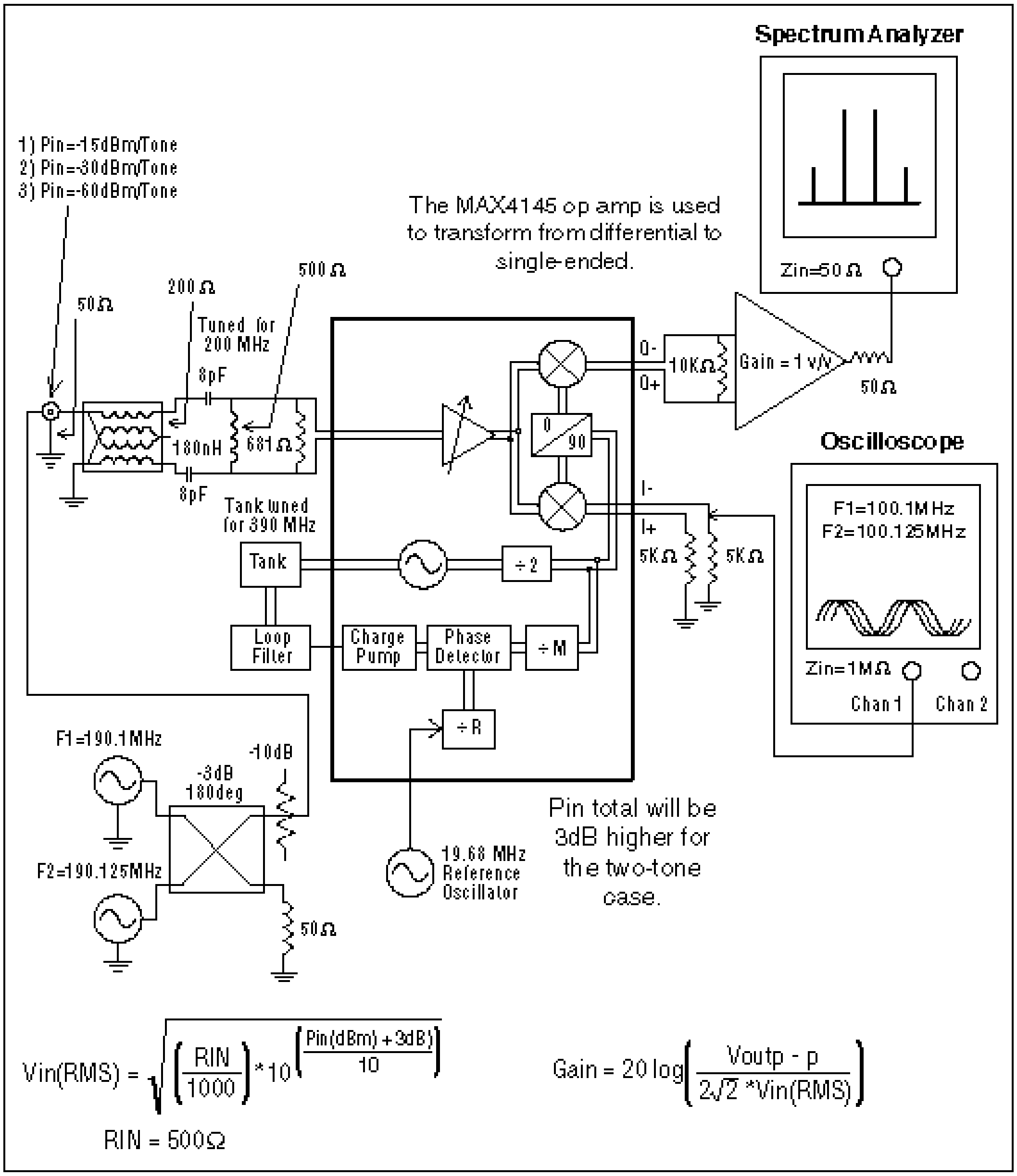


Figure 8. MAX2309/2312 IIP measurement setup for W-CDMA application

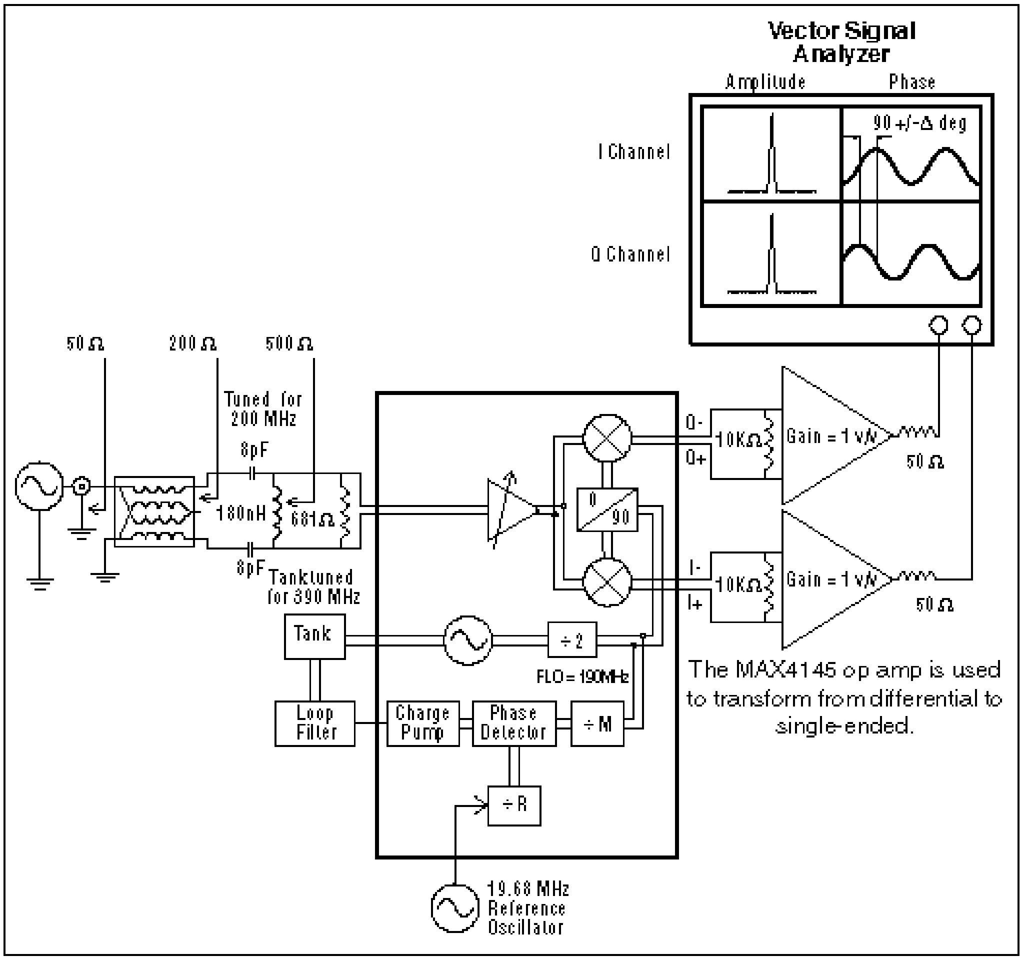
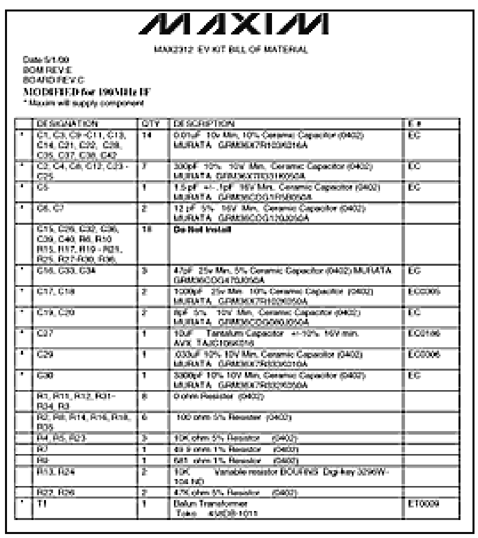


Figure 9. MAX2309/2312 I-&-Q amplitude and phase imbalance measurement setup for W-CDMA application



MAXIM

MAX2312 EV KIT BILL OF MATERIAL

Date 5/1/00
BOM REV E
BOARD REV C
MODIFIED for 190MHz IF
* Maxim will supply component

	DESIGNATION	QTY	DESCRIPTION	E #
*	C1, C3, C9-C11, C13, C14, C21, C22, C28, C35, C37, C38, C42	14	0.01uF 10v Min, 10% Ceramic Capacitor (0402) MURATA [illegible]	EC
*	C2, C4, C8, C12, C23 - C25	7	330pF 10% 10V Min, Ceramic Capacitor (0402) MURATA [illegible]	EC
*	C5	1	1.5pF +/-.1pF 16V Min, Ceramic Capacitor (0402) MURATA [illegible]	EC
*	C6, C7	2	12 pF 5% 16V Min, Ceramic Capacitor (0402) MURATA [illegible]	
	C15, C26, C32, C36, C39, C40, R6, R10 R15, R17, R19 - R21, R25, R27-R30, R36,	18	**Do Not Install**	
*	C16, C33, C34	3	47pF 25v Min, 5% Ceramic Capacitor (0402) MURATA [illegible]	EC
*	C17, C18	2	1000pF 25v Min 10% Ceramic Capacitor (0402) MURATA [illegible]	EC0005
*	C19, C20	2	8pF 5% 10V Min, Ceramic Capacitor (0402) MURATA [illegible]	EC
*	C27	1	10uF Tantalum Capacitor +/-10% 16V min. AVX TAJC106K016	EC0186
*	C29	1	.033uF 10% 10V Min, Ceramic Capacitor (0402) MURATA [illegible]	EC0006
*	C30	1	3300pF 10% 10V Min, Ceramic Capacitor (0402) MURATA [illegible]	EC
	R1, R11, R12, R31-R34, R3	8	0 ohm Resistor (0402)	
	R2, R8, R14, R16, R18, R35	6	100 ohm 5% Resistor (0402)	
	R4, R5, R23	3	10K ohm 5% Resistor (0402)	
	R7	1	49.9 ohm 1% Resistor (0402)	
	R9	1	681 ohm 1% Resistor (0402)	
	R13, R24	2	10K Variable resistor BOURNS Digi-key 3296W-104 ND	
	R22, R26	2	47K ohm 5% Resistor (0402)	
*	T1	1	Balun Transformer Toko [illegible]	ET0009

[Larger Image (PDF, 12K)]

Figure 10. Bill of Materials for 190MHz IF

MAX2309/2312, March 2001

MORE INFORMATION

MAX2309:	QuickView	-- Full (PDF) Data Sheet (304k)	-- Free Sample
MAX2312:	QuickView	-- Full (PDF) Data Sheet (344k)	-- Free Sample