

**FEATURES**

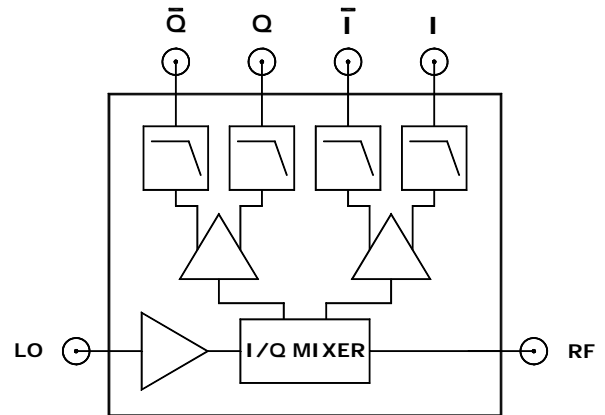
LO/RF Frequency:	9 – 12 GHz
I/Q Bandwidth:	275 MHz
Input IP3:	+23 dBm
Input P1dB:	+13 dBm
Amplitude Imbalance:	±0.1 dB
Phase Error:	-1 Degree
LO Power:	+5 dBm
DC Supplies:	+5V @ 110 mA, -5V @ 40 mA



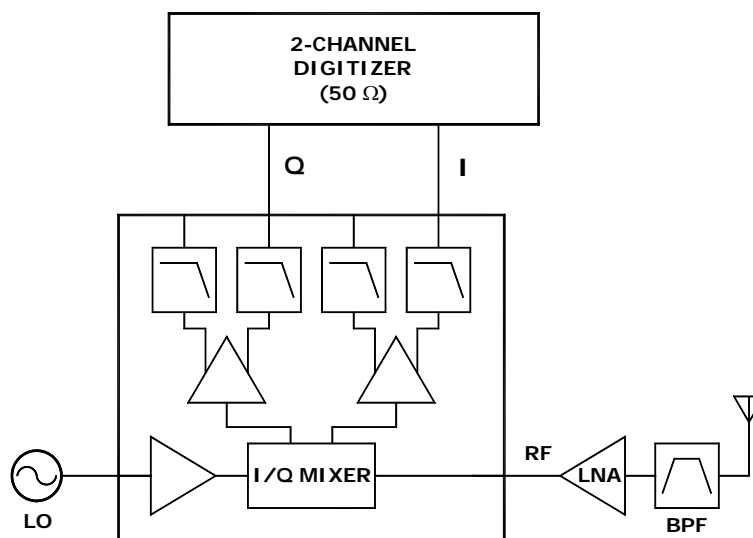
**DESCRIPTION**

When a LO signal is applied, the AD90120B converts the RF input signal centered at the LO frequency directly to baseband I and Q outputs. Integral low pass filters provide I and Q anti-alias filtering. The AD90120B's differential I and Q outputs can be directly connected to 50 Ω digitizers or instrumentation.

The AD90120B can be easily interfaced with differential high-speed analog-to-digital converters (ADCs). For more information, please refer to the **APPLICATIONS** section of this datasheet.



**TYPICAL APPLICATION: DIRECT CONVERSION RECEIVER**



## ELECTRICAL SPECIFICATIONS

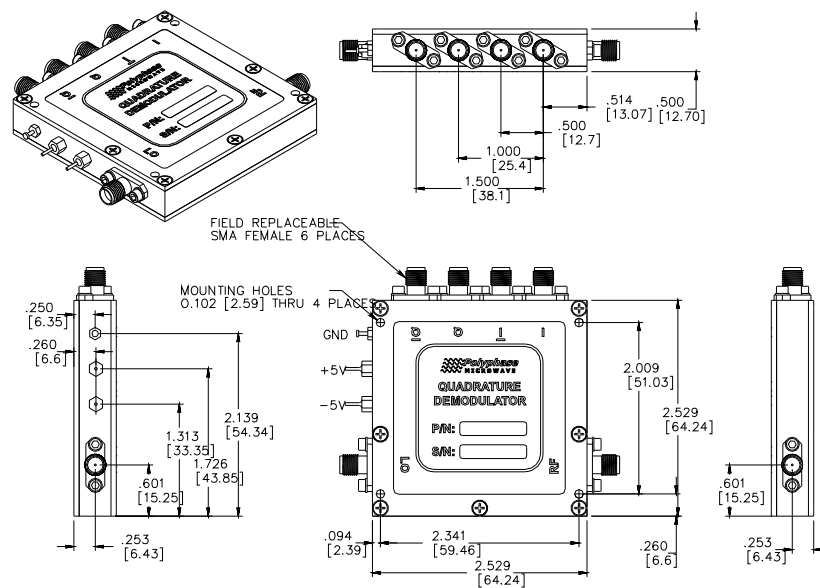
Test Conditions: +25°C, LO = +5 dBm, RF input = +0 dBm @ LO+100 kHz unless otherwise noted.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
LO/RF Frequency Range <sup>1</sup>		9.0		12.0	GHz
+5V DC Supply Range		+4.9	+5.0	+5.2	V
-5V DC Supply Range		-5.2	-5.0	-4.9	V
+5V DC Supply Current			110		mA
-5V DC Supply Current			40		mA
LO Power		+3	+5	+7	dBm
LO VSWR			1.5:1		Ratio
RF VSWR			2.5:1		Ratio
I/Q Baseband Filter Bandwidth <sup>2</sup>	<1 dB Flatness	DC		275	MHz
I/Q Baseband Filter Stop Band <sup>2</sup>	>25 dB Rejection	450		7000	MHz
I/Q Differential Output Impedance			100		Ω
I/Q DC Offset		-8	-4	+8	mV
Conversion Loss			8	10	dB
Noise Figure			8.5		dB
Input IP3	2-Tone, Δf = 1 MHz		+23		dBm
Input P1dB			+13		dBm
LO-RF Isolation	No RF input drive		45		dB
LO-I/Q Isolation	No RF input drive		60		dB
Amplitude Imbalance		-0.5	±0.1	+0.5	dB
Quadrature Phase Error		-5.0	-1.0	+3.0	Degree
Operating Temperature Range		-40		+85	°C
LO/RF Input Power w/o Damage				+15	dBm

### Notes:

- When RF > LO frequency: I = cos(), Q = sin()
- Standard low pass filters. Contact factory for other options.

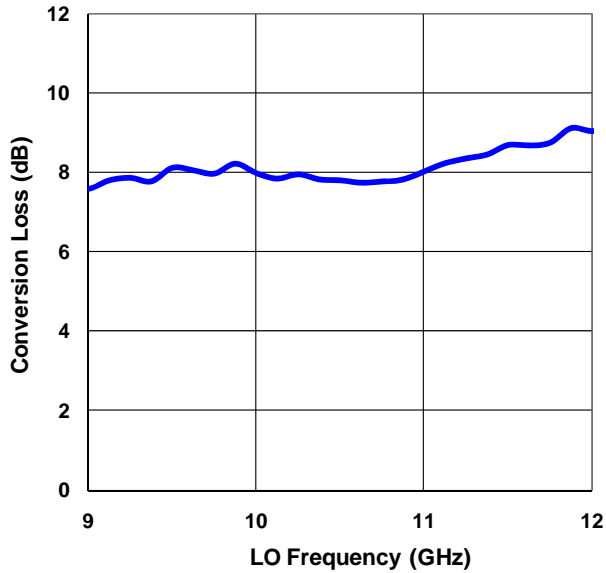
## DIMENSION DRAWING



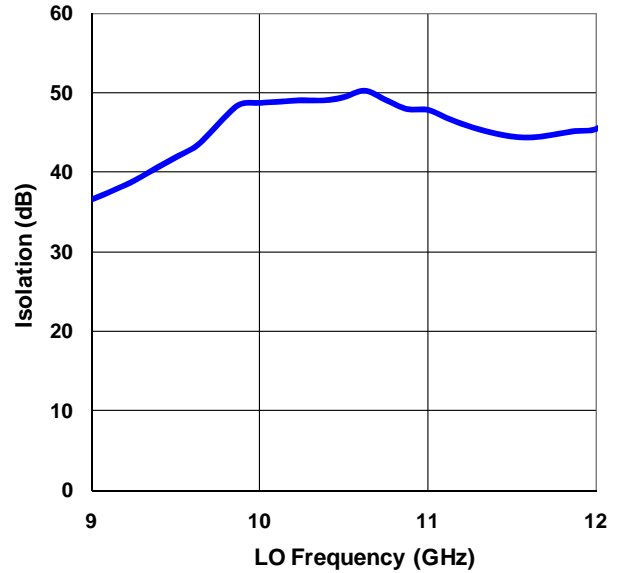
**TYPICAL PERFORMANCE CHARACTERISTICS**

Standard Test Conditions: +25°C, LO = +5 dBm, RF = +0 dBm @ LO+100 kHz.

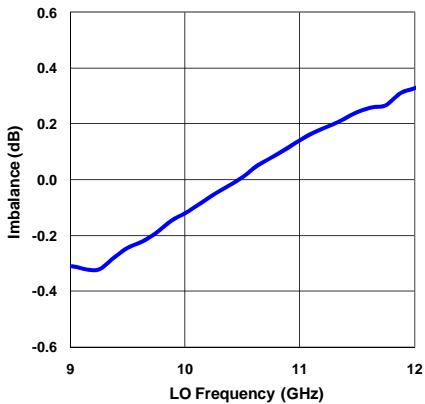
**Conversion Loss**



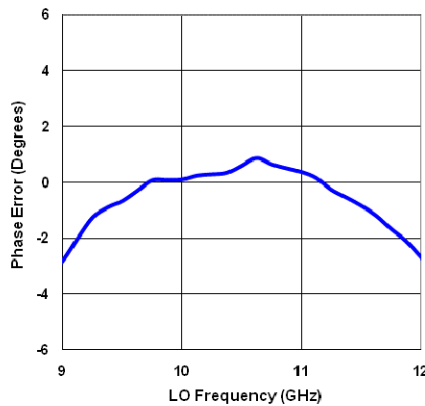
**LO-RF Isolation**



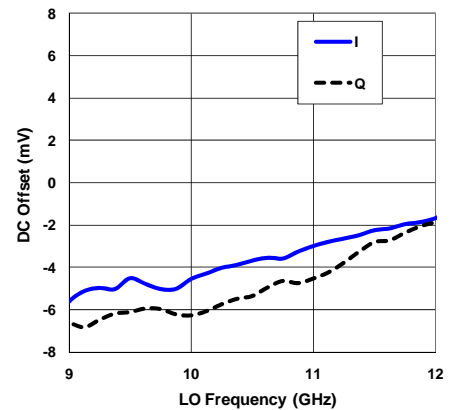
**Amplitude Imbalance**



**Quadrature Phase Error**



**DC Offsets**



## APPLICATIONS

### LO Input Drive Requirements

The AD90120B requires an LO signal be applied at +5 dBm nominal to demodulate the RF input. If the LO is pulsed, the I and Q outputs will be valid approximately 15 ns after the LO pulse is applied.

### Interfacing with Differential ADCs

The AD90120B's differential I and Q outputs can be interfaced with differential high-speed analog-to-digital converters (ADCs). The AD90120B's I and Q outputs are DC-coupled with a common-mode voltage of 0 V (ground). Most ADCs have a positive input common-mode voltage requirement between 0.8 V and 2.5 V.

Series DC blocking capacitors can be used to float the I and Q signals to the ADC's common-mode voltage. Figure 1 shows the AD90120B interfaced to a dual ADC with differential inputs.

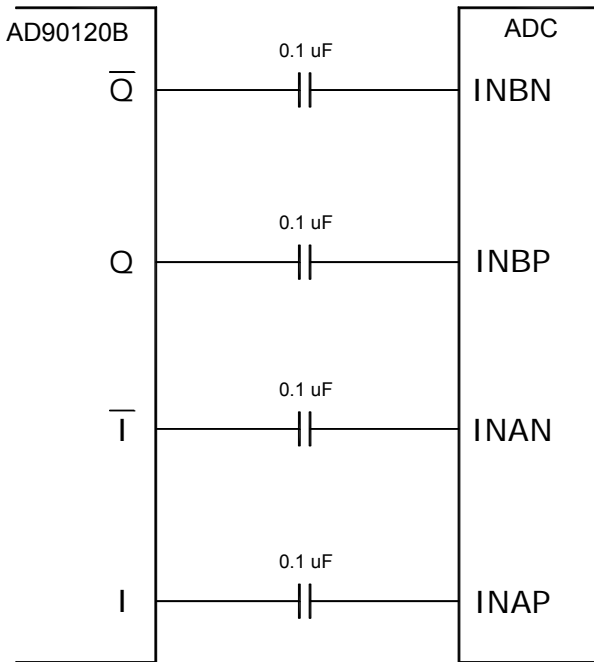


Figure 1. Differential ADC Interface

## I/Q DEMODULATION

The AD90120B converts an RF signal centered at the LO frequency into I and Q baseband outputs. To understand the process of I/Q demodulation, first consider the case of an ideal demodulator. The original RF signal is defined using the complex envelope representation:

$$z(t) = \mathbf{R} \left[ A(t) e^{j(2\pi f_c t + \phi(t))} \right] \quad (1)$$

$z(t)$  is the real time-domain signal present at the RF port of the demodulator centered at frequency  $f_c$ .  $z(t)$  has amplitude  $A(t)$  in volts and phase  $\phi(t)$  in radians. Both  $A(t)$  and  $\phi(t)$  are time-dependent.  $\mathbf{R}[\ ]$  denotes taking only the real part of the expression.

$z(t)$  can be written in terms of two orthogonal signals,  $I(t)$  and  $Q(t)$ :

$$z(t) = I(t) \cos(2\pi f_c t) - Q(t) \sin(2\pi f_c t) \quad (2)$$

where

$$A(t) = \sqrt{I^2(t) + Q^2(t)} \quad (3)$$

and

$$\phi(t) = \arctan(Q(t), I(t)) \quad (4)$$

An ideal quadrature demodulator extracts the  $I(t)$  and  $Q(t)$  signals defined in (2). A real demodulator introduces several linear distortions including conversion loss, amplitude imbalance, quadrature phase error, I-axis phase rotation, and I/Q DC offsets. After applying these linear distortions, the real measured I and Q output signals are obtained:

$$\hat{I}(t) = C_I (\cos \theta_R I(t) - \sin \theta_R Q(t)) + B_I \quad (5)$$

$$\hat{Q}(t) = C_Q (\cos \theta_R \cos \theta_E Q(t) - \sin \theta_E I(t) + \sin \theta_R I(t)) + B_Q \quad (6)$$

$C_I$  is the I channel conversion loss factor,  $C_Q$  is the Q channel conversion loss factor,  $\theta_R$  is the I-axis phase rotation in radians,  $B_I$  is the I channel DC offset in volts,  $B_Q$  is the Q channel DC offset in volts, and  $\theta_E$  is the quadrature phase error in radians.

When the LO and RF frequencies are not equal,  $\theta_R$  can be set to 0 to simplify (5) and (6):

$$\hat{I}(t) = C_I I(t) + B_I \quad (7)$$

$$\hat{Q}(t) = C_Q (\cos \theta_E Q(t) - \sin \theta_E I(t)) + B_Q \quad (8)$$

$\theta_R$  is only important in applications when the phase difference between the RF and LO signals must be known (i.e. phase detector).

**Example:** Apply a 10 GHz CW LO signal at +5 dBm and a 10.001 GHz CW RF signal at -2 dBm. To estimate the AD90120B's  $\hat{I}(t)$  and  $\hat{Q}(t)$  signals, start by determining all the parameters in (7) and (8).

$C_I$  and  $C_Q$  are determined by the conversion loss and amplitude imbalance of the AD90120B. From the datasheet's typical performance plots at 10 GHz, use 8 dB conversion loss and -0.12 dB amplitude imbalance to find  $C_I$  and  $C_Q$  :

$$\frac{C_I + C_Q}{2} = 10^{(-8/20)} = 0.3981 \quad (9)$$

$$20 \log\left(\frac{C_Q}{C_I}\right) = -0.12 \quad (10)$$

$$C_I = 0.4008 \quad C_Q = 0.3954 \quad (11), (12)$$

Quadrature phase error and DC offsets are also obtained from the typical performance plots at 10 GHz:

$$\theta_E = 0.1 \text{ Deg.} = -0.0017 \text{ Radians} \quad (13)$$

$$B_I = -0.0045 \text{ V} \quad B_Q = -0.0062 \text{ V} \quad (14), (15)$$

The next step in estimating  $\hat{I}(t)$  and  $\hat{Q}(t)$  is to calculate the ideal  $I(t)$  and  $Q(t)$  from the RF input signal. Given that the RF signal frequency is 1 kHz greater than the LO frequency,  $I(t)$  and  $Q(t)$  define an upper sideband tone of 1 kHz having a constant amplitude of:

$$\frac{A^2}{0.1} = 10^{(-2.0/10)} \quad (16)$$

$$A = 0.2512 \text{ V} \quad (17)$$

From (3) and (17) we know:

$$I(t) = 0.1776 \cos(2\pi 1000t) \quad (18)$$

and

$$Q(t) = 0.1776 \sin(2\pi 1000t) \quad (19)$$

The final step in estimating  $\hat{I}(t)$  and  $\hat{Q}(t)$ , the demodulator's real I and Q outputs signals, is to insert (11), (12), (13), (14), (15), (18), and (19) into (7) and (8) giving the final result:

$$\hat{I}(t) = 0.071 \cos(2\pi 1000t) - 0.0045$$

$$\hat{Q}(t) = 0.070 \sin(2\pi 1000t - 0.0017) - 0.0062$$