



#### **Typical Applications**

The HMC631LP3(E) is ideal for:

- Cellular/3G & WiMAX Systems
- Wireless Infrastructure HPA & MCPA Error Correction
- Pre-Distortion or Feed-Forward Linearization
- Beam Forming & Nulling Circuits

#### **Functional Diagram**



### Electrical Specifications, $T_A = +25^{\circ} C$ , Vcc= +8V

# HMC631LP3 / 631LP3E

### GaAs HBT VECTOR MODULATOR 1.8 - 2.7 GHz

#### Features

Continuous Phase Control: 360° Continuous Gain Control: 40 dB Output Noise Floor: -160 dBm/Hz Input IP3: +35 dBm 16 Lead 3x3mm SMT Package: 9mm<sup>2</sup>

#### **General Description**

The HMC631LP3 & HMC631LP3E are high dynamic range Vector Modulator RFICs which are targeted for RF predistortion and feed-forward cancellation circuits, as well as RF cancellation, beam forming and amplitude/phase correction circuits. The I & Q ports of the HMC631LP3(E) can be used to continuously vary the phase and amplitude of RF signals by up to 360 degrees and 40 dB respectively, while supporting a 3 dB modulation bandwidth of 200 MHz. With an output IP3 of +26 dBm and output noise floor of -160 dBm/Hz (at maximum gain setting), the IP3/noise floor ratio is 186 dB.

Parameter	Min.	Тур.	Max.	Min.	Тур.	Max.	Units
Frequency Range		1.8 - 2.2			2.2 - 2.7		GHz
Maximum Gain <sup>[1]</sup>	-11	-9			-11		dB
Gain Variation Over Temperature		0.016	0.025		0.016		dB / °C
Gain Flatness Across Any 60 MHz Bandwidth		0.15			0.4		dB
Gain Range		40			40		dB
Input Return Loss		9			9		dB
Output Return Loss		13			10		dB
Input Power for 1dB Compression (P1dB)	15	18			21		dBm
Input Third Order Intercept (IP3)		35			37		dBm
Output Noise		-160			-160		dBm/Hz
Control Port Bandwidth (-3 dB)		200			200		MHz
Control Port Impedance		1.45k			1.45k		Ohms
Control Port Capacitance		0.22			0.22		pF
Control Voltage Range		+0.5 to +2.5			+0.5 to +2.5		Vdc
Group Delay Variation Over 60 MHz Bandwidth		20			20		ps
Supply Current (Icq)		93			93		mA

Unless otherwise noted, measurements are made @ max. gain setting and 45° phase setting. See application circuit for details. <sup>[1]</sup>Includes loss of input balun (0.8 dB typ.)

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#### Maximum Gain vs. Temperature



Gain vs. Phase Settings @ F= 2 GHz



Input Return Loss vs. Temperature





GaAs HBT VECTOR MODULATOR 1.8 - 2.7 MHz



Phase vs. Phase Settings @ F= 2 GHz vs. Various Gain Settings



#### **Output Return Loss vs. Temperature**



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#### **Output Noise vs. Temperature**



Input P1dB vs. Temperature



Group Delay





### GaAs HBT VECTOR MODULATOR 1.8 - 2.7 MHz



Input IP3 vs. Temperature



Linear Gain vs. Phase Setting



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#### Typical Supply Current vs. Vcc

Vcc (V)	Icc (mA)
7.6	88
8.0	93
8.4	99

Note:

Modulator will operate over full voltage range shown above.



ELECTROSTATIC SENSITIVE DEVICE **OBSERVE HANDLING PRECAUTIONS** 

#### **Outline Drawing**





NOTES:

SQUARE

1.95

.077 .059

0.30 0.18

1.56 1.44

1. LEADFRAME MATERIAL: COPPER ALLOY

2. DIMENSIONS ARE IN INCHES [MILLIMETERS].

BOTTOM VIEW

PIN 16

U 

3. LEAD SPACING TOLEBANCE IS NON-CUMULATIVE

- 4. PAD BURR LENGTH SHALL BE 0.15mm MAXIMUM.
- PAD BURR HEIGHT SHALL BE 0.05mm MAXIMUM. 5. PACKAGE WARP SHALL NOT EXCEED 0.05mm.

6. ALL GROUND LEADS AND GROUND PADDLE MUST BE SOLDERED TO PCB RF GROUND.

7. REFER TO HITTITE APPLICATION NOTE FOR SUGGESTED PCB LAND PATTERN.

#### Package Information

Part Number	Package Body Material	Lead Finish	MSL Rating	Package Marking <sup>[3]</sup>
HMC631LP3	Low Stress Injection Molded Plastic	Sn/Pb Solder	MSL1 <sup>[1]</sup>	631 XXXX
HMC631LP3E	RoHS-compliant Low Stress Injection Molded Plastic	100% matte Sn	MSL1 <sup>[2]</sup>	<u>631</u> XXXX

[1] Max peak reflow temperature of 235 °C

[2] Max peak reflow temperature of 260 °C

[3] 4-Digit lot number XXXX

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# HMC631LP3 / 631LP3E

**GaAs HBT VECTOR** MODULATOR 1.8 - 2.7 MHz

#### Absolute Maximum Ratings

RF Input (Vcc = +8V)	27 dBm
Supply Voltage (Vcc)	+10V
I & Q Input	-0.5V to +5V
Junction Temperature (Tc)	135 °C
Continuous Pdiss (T = 85°C) (Derate 34 mW/°C above 85°C)	1.7 W
Thermal Resistance (R <sub>th</sub> ) (junction to ground paddle)	29.6 °C/W
Storage Temperature	-65 to +150 °C
Operating Temperature	-40 to +85 °C

-.016 [0.40] REF

PIN 1

EXPOSED

GROUND

PADDLE

.022 .017

Г

.008 [0.20] MIN

 $0.56 \\ 0.44$ 



# HMC631LP3 / 631LP3E

## GaAs HBT VECTOR MODULATOR 1.8 - 2.7 MHz



#### **Pin Description**

Pin Number	Function	Description	Interface Schematic	
1, 4, 10 - 12	N/C	No connection. These pins may be connected to RF ground. Performance will not be affected		
2, 3	IN, IN	Differential RF inputs, 100 Ohms differential impedance. (i.e. each pin is 50 Ohms to ground). Must be DC blocked.	IN O	
5, 15	I	In-phase control input. Pins 5 and 15 are redundant. Either input can be used.	ι,(Q) 15,(16) 6.3kΩ	
6, 16	Q	Quadrature control input. Pins 6 and 16 are redundant. Either input can be used.	I,(Q) 5,(6) 1.88ko = = =	
7, 8, 13, 14	Vcc	Supply Voltage, pins are DC connected on-chip. It is only nec- essary to supply Vcc to any 1 of the 4 pins, but all 4 pins must be bypassed to ground. (See application circuit).		
9	RFOUT	RF Output: Must be DC blocked.	RFOUT	
	GND	Ground: Backside of package has exposed metal ground paddle which must be connected to RF/DC ground.		

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# HMC631LP3 / 631LP3E

### GaAs HBT VECTOR MODULATOR 1.8 - 2.7 MHz



**Application Circuit** 



\* Pins 15 & 16 are redundant I & Q inputs.

Gain and Phase control are applied through the I and Q control ports. For a given linear gain (G) and phase ( $\theta$ ) setting, the voltages applied to these ports in all measurements are calculated as follows:

$$I(G,\theta) = Vmi + 1.0V \frac{G}{G \max} Cos(\theta)$$
$$Q(G,\theta) = Vmq + 1.0V \frac{G}{G \max} Sin(\theta)$$

Where Vmi and Vmq are the I and Q voltage settings corresponding to maximum isolation at room temperature and F = 2 GHz. Note that  $G=10^x$  and  $Gmax = 10^y$  where  $x = \frac{Gain Setting (dB)}{20}$  and  $y = \frac{Max Gain Setting(dB)}{20}$ . Nominally Vmi = Vmq = 1.5V, Gmax = 0.316.

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# HMC631LP3 / 631LP3E

v00.1007

### GaAs HBT VECTOR MODULATOR 1.8 - 2.7 MHz



#### **Evaluation PCB**



#### List of Materials for Evaluation PCB 117201 <sup>[1]</sup>

Item	Description	
J1 - J4	PCB Mount SMA Connector	
J5	2 mm DC Header	
C1	4.7 µF Capacitor, Tantalum	
C2 - C5	100 pF Capacitor, 0402 Pkg.	
T1	Balun, 0805 Pkg. ANAREN BD1722J50100A	
L1	330 nH Inductor, 0805 Pkg.	
U1	HMC631LP3(E) Vector Modulator	
PCB [2]	117196 Evaluation PCB	

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: Rogers 4350, Er = 3.48

The circuit board used in the final application should use RF circuit design techniques. Signal lines should have 50 ohm impedance while the package ground leads and exposed paddle should be connected directly to the ground plane similar to that shown. A sufficient number of via holes should be used to connect the top and bottom ground planes. The evaluation board should be mounted to an appropriate heat sink. The evaluation circuit board shown is available from Hittite upon request.

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GaAs HBT VECTOR MODULATOR 1.8 - 2.7 MHz



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