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- HMC627A Data Sheet

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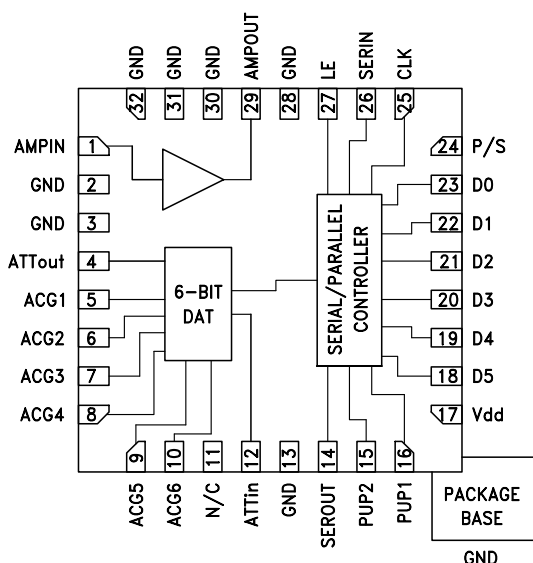
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# HMC627ALP5E

## 0.5 dB LSB GaAs MMIC 6-BIT DIGITAL VARIABLE GAIN AMPLIFIER, 50 MHz - 1 GHz

### Typical Applications

The HMC627ALP5E is ideal for:

• Cellular/3G Infrastructure

• WiBro / WiMAX / 4G

• Microwave Radio & VSAT

• Test Equipment and Sensors

• IF & RF Applications

### Features

-11.5 to 20 dB Gain Control in 0.5 dB Steps

Power-up State Selection

High Output IP3: +36 dBm

TTL/CMOS Compatible
Serial, Parallel, or latched Parallel Control

±0.25 dB Typical Gain Step Error

Single +5V Supply

32 Lead 5x5 mm SMT Package: 25 mm$^2$

### Functional Diagram



### General Description

The HMC627ALP5E is a digitally controlled variable gain amplifier which operates from 50 MHz to 1 GHz, and can be programmed to provide anywhere from 11.5 dB attenuation, to 20 dB of gain, in 0.5 dB steps. The HMC627ALP5E delivers noise figure of 4.3 dB in its maximum gain state, with output IP3 of up to +36 dBm in any state. The dual mode gain control interface accepts either three wire serial input or 6 bit parallel word. The HMC627ALP5E also features a user selectable power up state and a serial output for cascading other Hittite serially controlled components. The HMC627ALP5E is housed in a RoHS compliant 5x5 mm QFN leadless package, and requires no external matching components.

### Electrical Specifications, $T_A$ = +25° C, 50 Ohm System Vdd = +5V, Vs= +5V

| Parameter | Min. | Typ. | Max. | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|
| | 50 - 350 | | | 350 - 1000 | | | MHz |
| Gain (Maximum Gain State) | 18 | 20 | | 15 | 17.5 | | dB |
| Gain Control Range | | 31.5 | | | 31.5 | | dB |
| Input Return Loss | | 18 | | | 17 | | |
| Output Return Loss | 20 | 12 | | | 12 | | dB |
| Gain Accuracy: (Referenced to Maximum Gain State) All Gain States | 50 MHz -100MHz, 250 MHz - 350 MHz ± (0.2 + 3% of Gain Setting) Max<br><br>100 MHz - 250 MHz ± (0.1 + 2% of Gain Setting) Max | | | ± (0.3 + 3% of Gain Setting) Max | | | dB |
| Output Power for 1 dB Compression | 18 | 20 | | 16 | 20 | | dBm |
| Output Third Order Intercept Point (Two-Tone Input Power= 0 dBm Each Tone) | 33 | 36 | | 33 | 36 | | dBm |
| Noise Figure | | 4.3 | | | 4.3 | | dB |
| Switching Characteristics     tRISE, tFall (10 / 90% RF)<br>tON, tOFF (Latch Enable to 10 / 90% RF) | | 70<br>100 | | | 70<br>100 | | ns |
| Total Supply Current (Idd + Is) | | 90.5 | 110 | | 90.5 | 110 | mA |

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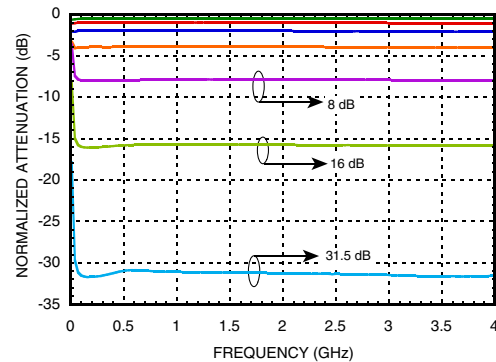Phone: 978-250-3343     Fax: 978-250-3373     Order On-line at www.hittite.com
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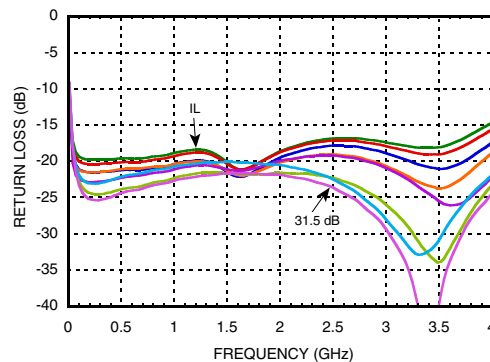*0.5 dB LSB GaAs MMIC 6-BIT DIGITAL VARIABLE GAIN AMPLIFIER, 50 MHz - 1 GHz*

**VARIABLE GAIN AMPLIFIERS - DIGITAL - SMT**

### Maximum Gain vs. Frequency [1]


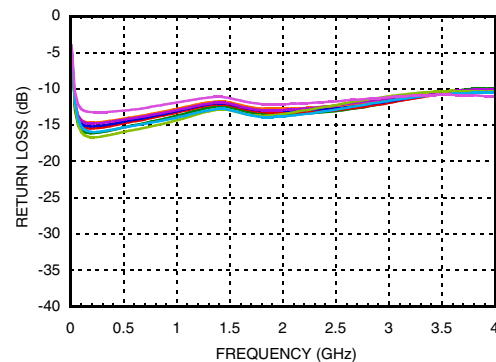
| +25 C | -40 C | +85 C |
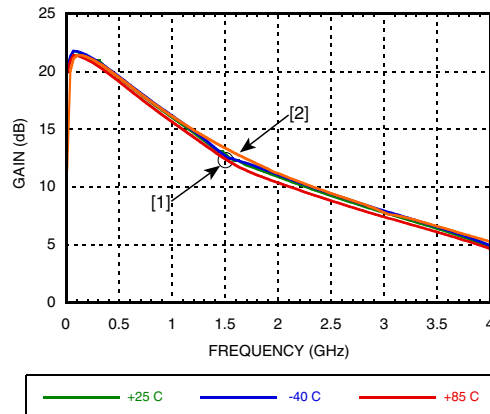
### Normalized Attenuation vs. Frequency
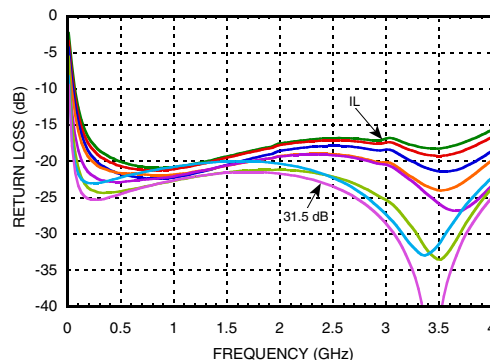*(Only Major States are Shown)*



### Input Return Loss [1]
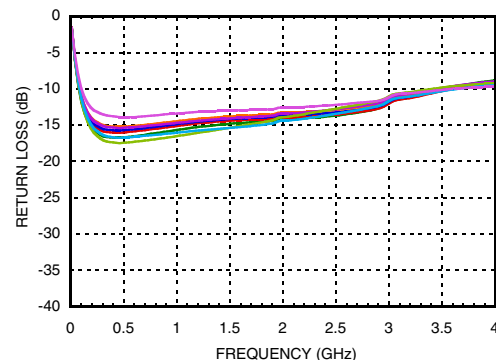*(Only Major States are Shown)*



### Output Return Loss [1]
*(Only Major States are Shown)*



### Input Return Loss [2]
*(Only Major States are Shown)*



### Output Return Loss [2]
*(Only Major States are Shown)*



[1] Tested with broadband bias tee on RF ports and C1 = 10,000 pF
[2] Tested with broadband bias tee on RF ports and C1 = 100 pF; L1 = 270 nF

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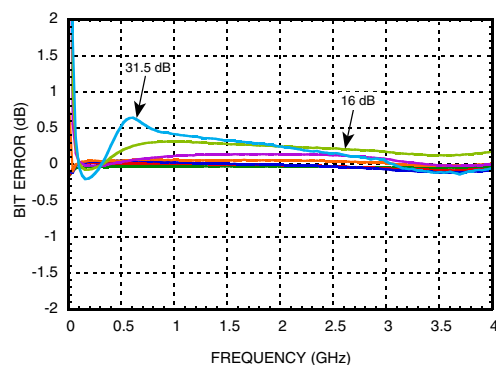*Application Support: Phone: 978-250-3343  or  apps@hittite.com*
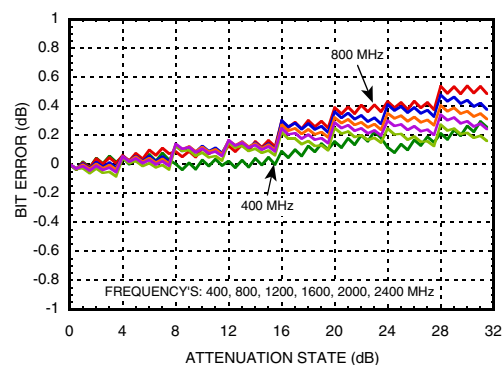
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### *0.5 dB LSB GaAs MMIC 6-BIT DIGITAL VARIABLE GAIN AMPLIFIER, 50 MHz - 1 GHz*

## *Bit Error vs. Frequency [2]*
*(Only Major States are Shown)*



## *Bit Error vs. Attenuation State [2]*



## *Normal Relative Phase vs. Frequency [2]*
*(Only Major States are Shown)*



## *Step Error vs. Frequency [2]*
*(Only Major States are Shown)*



## *Maximum Gain vs. Frequency [3]*



## *Normalized Attenuation vs. Frequency [3]*
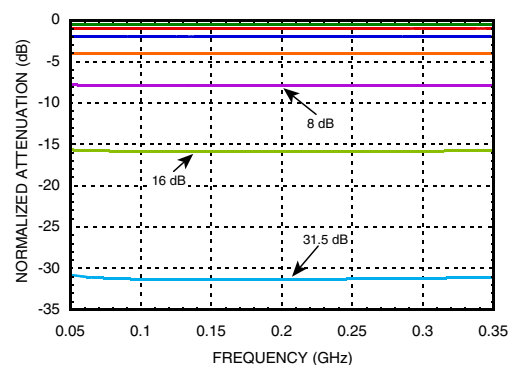


[2]  Tested with broadband bias tee on RF ports and C1 = 100 pF, L1 = 270 nF
[3] Tested with broadband bias tee on RF ports and C1 = 3300 pF; C3, C4 & C5 = 330 pF; L1 = 560 nH

## *0.5 dB LSB GaAs MMIC 6-BIT DIGITAL VARIABLE GAIN AMPLIFIER, 50 MHz - 1 GHz*

### Input Return Loss [3]
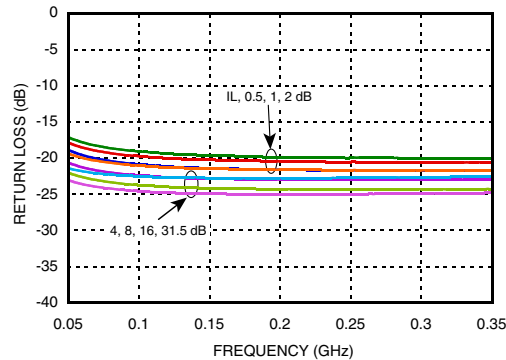


### Output Return Loss [3]
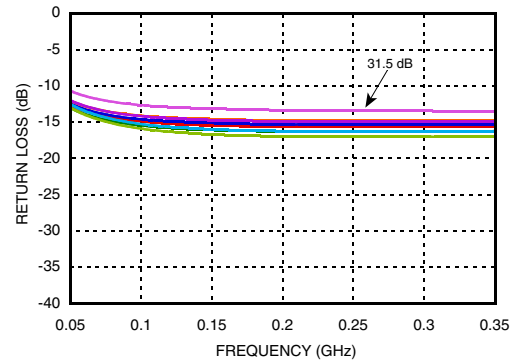


### Bit Error vs. Frequency [3]
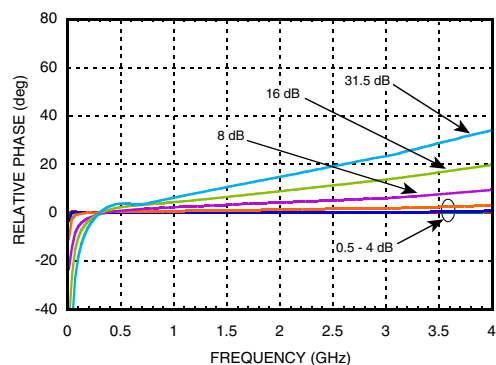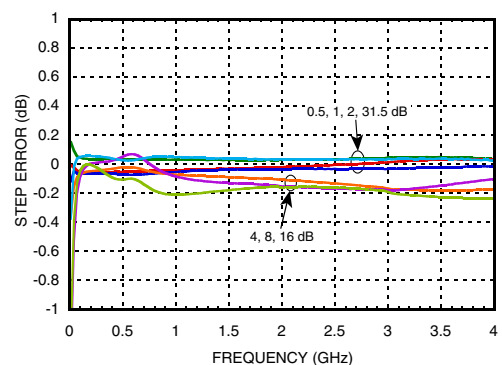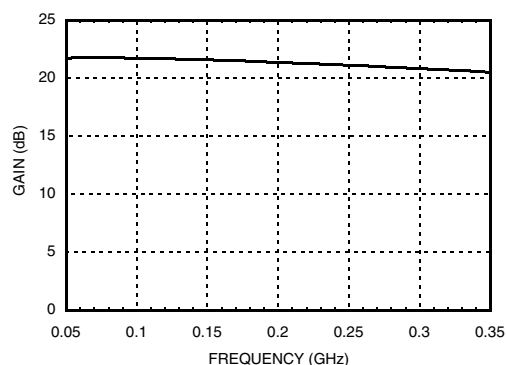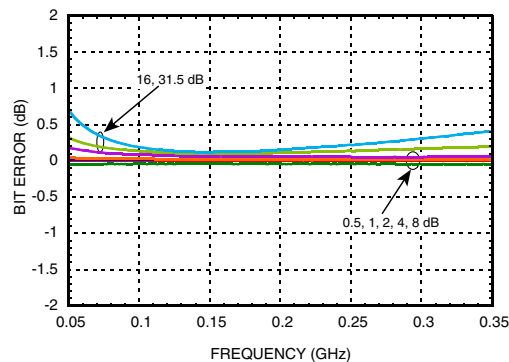


### Bit Error vs. Attenuation State [3]
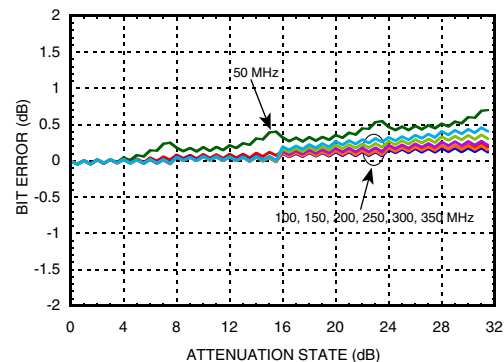


### Normal Relative Phase vs. Frequency [3]
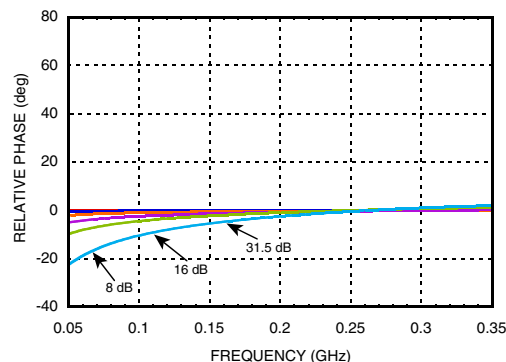


### Step Error vs. Frequency [3]
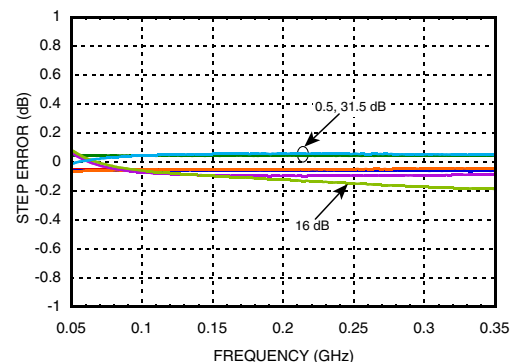


[3] Tested with broadband bias tee on RF ports and C1 = 3300 pF; C3, C4 & C5 = 330 pF; L1 = 560 nH

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## Serial Control Interface

The HMC627ALP5E contains a 3-wire SPI compatible digital interface (SERIN, CLK, LE). It is activated when P/S is kept high. The 6-bit serial word must be loaded MSB first. The positive-edge sensitive CLK and LE requires clean transitions. If mechanical switches were used, sufficient debouncing should be provided. When LE is high, 6-bit data in the serial input register is transferred to the attenuator. When LE is high CLK is masked to prevent data transition during output loading.

When P/S is low, 3-wire SPI interface inputs (SERIN, CLK, LE) are disabled and serial input register is loaded asynchronously with parallel digital inputs (D0-D5). When Le is high, 6-bit parallel data is transferred to the attenuator.

For all modes of operations, the DVGA state will stay constant while LE is kept low.



| Parameter | Typ. |
|---|---|
| Min. serial period, $t_{SCK}$ | 100 ns |
| Control set-up time, $t_{CS}$ | 20 ns |
| Control hold-time, $t_{CH}$ | 20 ns |
| LE setup-time, $t_{LN}$ | 10 ns |
| Min. LE pulse width, $t_{LEW}$ | 10 ns |
| Min LE pulse spacing, $t_{LES}$ | 630 ns |
| Serial clock hold-time from LE, $t_{CKN}$ | 10 ns |
| Hold Time, $t_{PH.}$ | 0 ns |
| Latch Enable Minimum Width, $t_{LEN}$ | 10 ns |
| Setup Time, $t_{PS}$ | 2 ns |
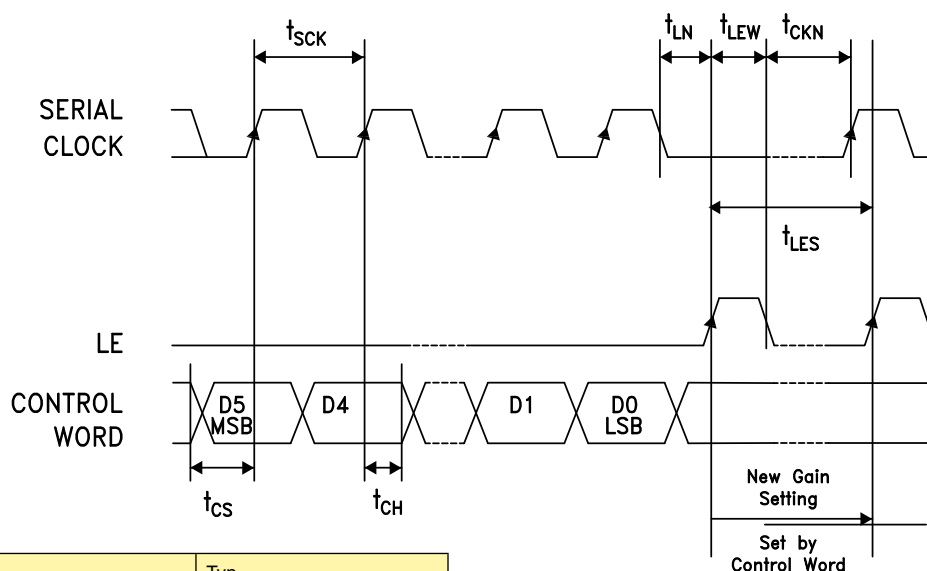
**Timing Diagram** *(Latched Parallel Mode)*
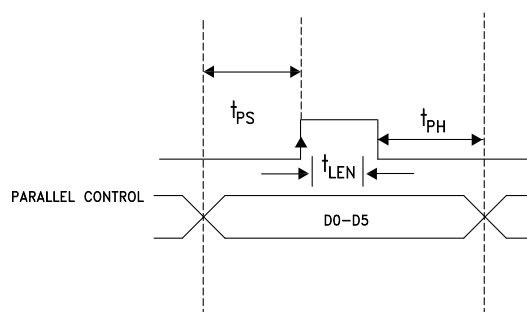


## Parallel Mode *(Direct Parallel Mode & Latched Parallel Mode)*

**Note:** The parallel mode is enabled when P/S is set to low.

**Direct Parallel Mode** - The attenuation state is changed by the Control Voltage Inputs directly. The LE (Latch Enable) must be at a logic high to control the attenuator in this manner.

**Latched Parallel Mode** - The attenuation state is selected using the Control Voltage Inputs and set while the LE is in the Low state. The attenuator will not change state while LE is Low. Once all Control Voltage Inputs are at the desired states the LE is pulsed. See timing diagram above for reference.

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## Power-Up States

If LE is set to logic LOW at power-up, the logic state of PUP1 and PUP2 determines the power-up state of the part per PUP truth table. If the LE is set to logic HIGH at power-up, the logic state of D0-D5 determines the power-up state of the part per truth table. The DVGA latches in the desired power-up state approximately 200 ms after power-up.

## Power-On Sequence

The ideal power-up sequence is: GND, Vdd, digital inputs, RF inputs. The relative order of the digital inputs are not important as long as they are powered after Vdd / GND

## Absolute Maximum Ratings

| RF Input Power [1] (At Max Gain Setting) | 11.5 dBm (T = +85 °C) |
|---|---|
| Digital Inputs (Reset, Shift Clock, Latch Enable & Serial Input) | -0.5V to Vdd +0.5V |
| Bias Voltage (Vdd) | 5.6V |
| Collector Bias Voltage (Vcc) | 5.5V |
| Channel Temperature | 150 °C |
| Continuous Pdiss (T = 85 °C) (derate 9 mW/°C above 85 °C) [2] | 0.59 W |
| Thermal Resistance [3] | 110 °C/W |
| Storage Temperature | -65 to +150 °C |
| Operating Temperature | -40 to +85 °C |

[1] The maximum RF input power increases by the same amount the gain is reduced. The maximum input power at any state is no more than 28 dBm.

[2] This value is the total power dissipation in the amplifier.

[3] This is the thermal resistance for the amplifier.

## PUP Truth Table

| LE | PUP1 | PUP2 | Gain Relative to Maximum Gain |
|---|---|---|---|
| 0 | 0 | 0 | -31.5 |
| 0 | 1 | 0 | -24 |
| 0 | 0 | 1 | -16 |
| 0 | 1 | 1 | Insertion Loss |
| 1 | X | X | 0 to -31.5 dB |

Note: The logic state of D0 - D5 determines the power-up state per truth table shown below when LE is high at power-up.

## Truth Table

| Control Voltage Input | | | | | | Gain Relative to Maximum Gain |
|---|---|---|---|---|---|---|
| D5 | D4 | D3 | D2 | D1 | D0 | |
| High | High | High | High | High | High | 0 dB |
| High | High | High | High | High | Low | -0.5 dB |
| High | High | High | High | Low | High | -1 dB |
| High | High | High | Low | High | High | -2 dB |
| High | High | Low | High | High | High | -4 dB |
| High | Low | High | High | High | High | -8 dB |
| Low | High | High | High | High | High | -16 dB |
| Low | Low | Low | Low | Low | Low | -31.5 dB |

Any combination of the above states will provide a reduction in gain approximately equal to the sum of the bits selected.

## Control Voltage Table

| State | Vdd = +3V | Vdd = +5V |
|---|---|---|
| Low | 0 to 0.5V @ <1 µA | 0 to 0.8V @ <1 µA |
| High | 2 to 3V @ <1 µA | 2 to 5V @ <1 µA |

## Bias Voltage

| Vdd (V) | Idd (Typ.) (mA) |
|---|---|
| +5 | 2.5 |
| Vs (V) | Is (mA) |
| +5 | 88 |
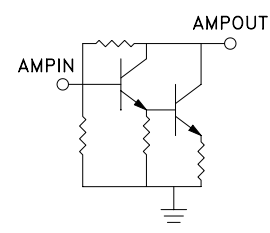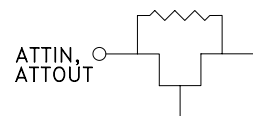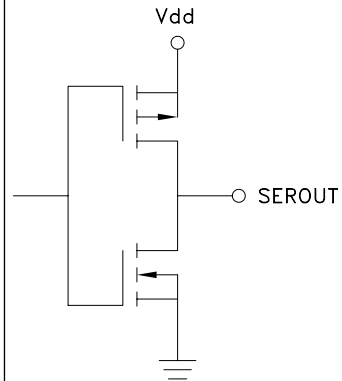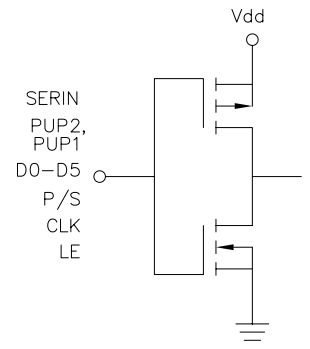
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## 0.5 dB LSB GaAs MMIC 6-BIT DIGITAL VARIABLE GAIN AMPLIFIER, 50 MHz - 1 GHz

### Outline Drawing



NOTES:
1. LEADFRAME MATERIAL: COPPER ALLOY
2. DIMENSIONS ARE IN INCHES [MILLIMETERS]
3. LEAD SPACING TOLERANCE 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
   LAND PATTERN.

### Package Information

| Part Number | Package Body Material | Lead Finish | MSL Rating | Package Marking [2] |
|---|---|---|---|---|
| HMC627ALP5E | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 [1] | H627A XXXX |

[1] Max peak reflow temperature of 260 °C
[2] 4-Digit lot number XXXX

## Pin Descriptions

| Pin Number | Function | Description | Interface Schematic |
|---|---|---|---|
| 1 | AMPIN | This pin is DC coupled. An off chip DC blocking capacitor is required. |  |
| 29 | AMPOUT | RF output and DC bias (Vcc) for the output stage of the amplifier. | |
| 2, 3, 13, 28, 30 - 32 | GND | These pins and package bottom must be connected to RF/DC ground. |  |
| 12, 4 | ATTIN, ATTOUT | These pins are DC coupled and matched to 50 Ohms. Blocking capacitors are required. Select value based on lowest frequency of operation. |  |
| 5 - 10 | ACG1 - ACG6 | External capacitors to ground is required. Select value for lowest frequency of operation. Place capacitor as close to pins as possible. | |
| 11 | N/C | No Connection | |
| 14 | SEROUT | Serial input data delayed by 6 clock cycles. |  |
| 15, 16 | PUP2, PUP1 | |  |
| 18 - 23 | D5, D4, D3, D2, D1, D0 | | |
| 24 | P/S | | |
| 25 | CLK | | |
| 26 | SERIN | | |
| 27 | LE | | |
| 17 | Vdd | Supply Voltage | |

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*0.5 dB LSB GaAs MMIC 6-BIT DIGITAL
VARIABLE GAIN AMPLIFIER, 50 MHz - 1 GHz*

VARIABLE GAIN AMPLIFIERS - DIGITAL - SMT

## Application Circuit



## Components for Selected Frequencies

| Tuned Frequency | 50 -350 MHz | 350 - 1000 MHz |
|---|---|---|
| Evaluation PCB | 121394-HMC627ALP5 | 118329-HMC627ALP5 |
| C1, C6, C8 | 3300 pF | 100 pF |
| C3, C4, C5 | 330 pF | 100 pF |
| L1 | 560 nH | 270 nH |

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## Evaluation PCB
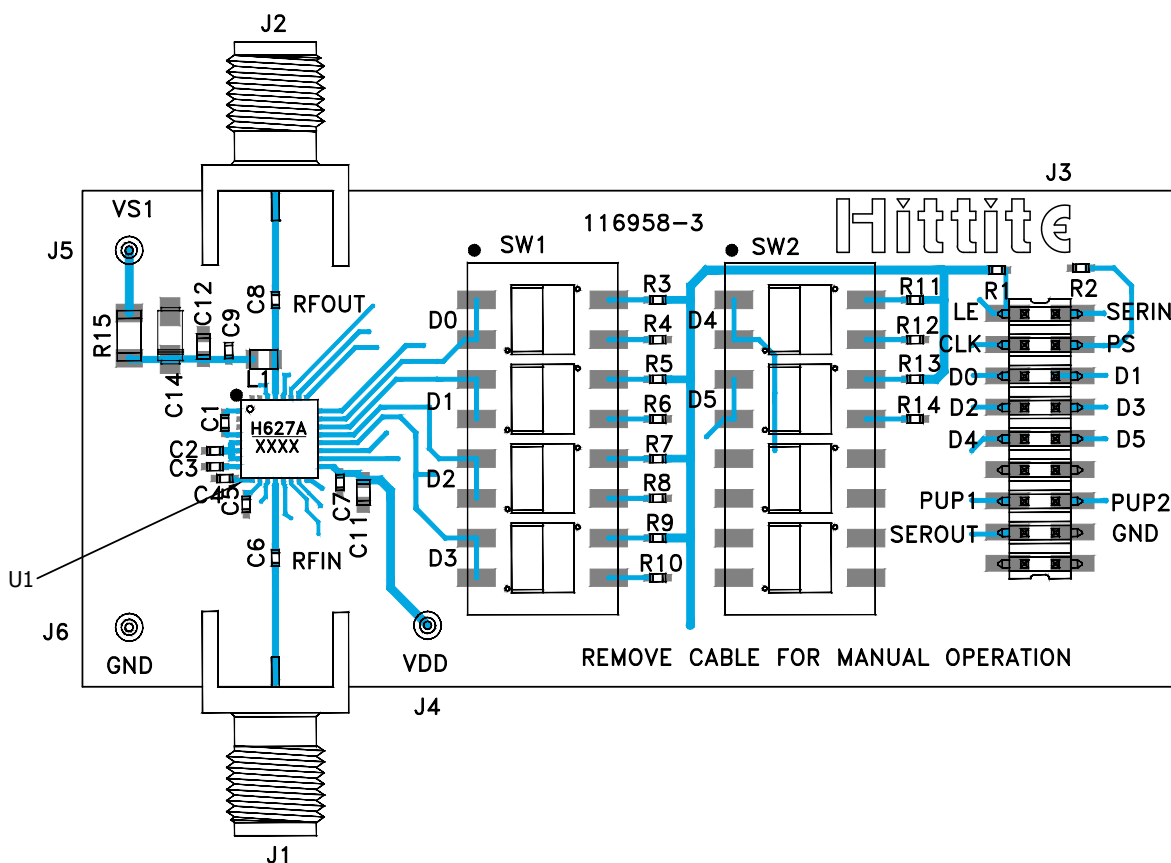


## List of Materials for Evaluation PCB [3]

| Item | Description |
|------|-------------|
| J1 - J2 | PCB Mount SMA Connectors |
| J3 | 18 Pin DC Connector |
| J4 - J6 | DC Pin |
| C1, C3 - C6, C8 | Capacitor, 0402 Pkg.[3] |
| C2, C7. C9 | 100 pF Capacitor. 0402 Pkg. |
| C11 - C12 | 1000 pF Capacitor, 0402 Pkg. |
| C14 | 2.2 µF Capacitor, CASE A Pkg. |
| R1 - R14 | 100 kOhm Resistor, 0402 Pkg. |
| R15 | 1.8 Ohm Resistor, 1206 Pkg. |
| L1 | Inductor, 0603 Pkg. [3] |
| SW1, SW2 | SPDT 4 Position DIP Switch |
| U1 | HMC627ALP5E Variable Gain Amplifier |
| PCB [2] | 116958 Evaluation PCB |

[1] Reference this number when ordering complete evaluation PCB
[2] Circuit Board Material: Arlon 25FR, FR4
[3] Please reference Components for Selected Frequencies Table

The circuit board used in the 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 circuit board shown is available from Hittite upon request.

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