



## 0.25 dB LSB BiCMOS MMIC 7-BIT DIGITAL ATTENUATOR, 10 - 300 MHz

### Typical Applications

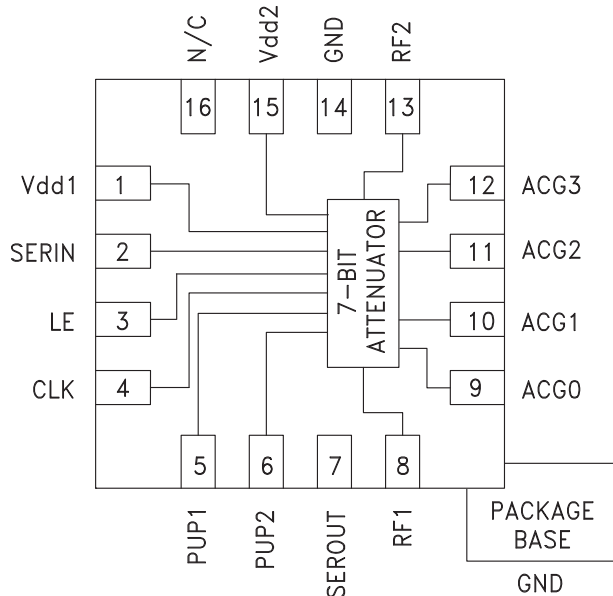
The HMC759LP3E is ideal for:

- Cellular/3G Infrastructure
- WiBro / WiMAX / 4G
- Microwave Radio & VSAT
- Test Equipment and Sensors
- IF & RF Applications

### Features

- 0.25 dB LSB Steps to 31.75 dB
- Power-Up State Selection
- High Input IP3: +40 dBm
- TTL/CMOS Compatible, Serial Control
- Excellent State & Step Accuracy  $\pm 0.25$  dB
- Single +5V Supply
- 16 Lead 3x3mm SMT Package: 9mm<sup>2</sup>

### Functional Diagram



### General Description

The HMC759LP3E is a 7-bit BiCMOS Digital Attenuator in a low cost leadless SMT package. This versatile digital attenuator incorporates off-chip AC ground capacitors for near DC operation, making it suitable for a wide variety of RF and IF applications. The control interface is CMOS/TTL compatible and accepts a three wire serial input. The HMC759LP3E features user selectable power up states and a serial output port for cascading other Hittite serial controlled components. The HMC759LP3E is housed in a RoHS compliant 3x3 mm QFN leadless package, and occupies only 9 mm<sup>2</sup>.

### Electrical Specifications

$T_A = +25^\circ\text{C}$ , 50 $\Omega$  System, with  $V_{dd1} = V_{dd2} = +5\text{V}$  &  $V_{ctl} = 0/+5\text{V}$

| Parameter                                                                      | Frequency (MHz) | Min.                                                         | Typ.  | Max. | Units         |
|--------------------------------------------------------------------------------|-----------------|--------------------------------------------------------------|-------|------|---------------|
| Insertion Loss                                                                 | 10 - 300        |                                                              | 3.3   | 4.5  | dB            |
| Attenuation Range                                                              | 10 - 300        |                                                              | 31.75 |      | dB            |
| Return Loss (RF1, RF2, All Atten. States)                                      | 10 - 300        |                                                              | 10    |      | dB            |
| Attenuation Accuracy: (Referenced to Insertion Loss)<br>All Attenuation States | 10 - 300        | $\pm (0.05 + 1.5\% \text{ of Atten. Settling}) \text{ Max.}$ |       |      | dB            |
| Input Power for 1 dB Compression                                               | 10 - 50         |                                                              | 20    |      | dBm           |
|                                                                                | 50 - 300        |                                                              | 21    |      | dBm           |
| Input Third Order Intercept Point<br>(Two-Tone Input Power = 0 dBm Each Tone)  | 10 - 50         |                                                              | 39    |      | dBm           |
|                                                                                | 50 - 300        |                                                              | >40   |      | dBm           |
| Bias Current (I <sub>dd1</sub> + I <sub>dd2</sub> )                            | 10 - 300        | 300                                                          | 650   | 1000 | $\mu\text{A}$ |
| Switching Time (50% LE to 90% RF)                                              | 10 - 300        |                                                              | 15    |      | ns            |

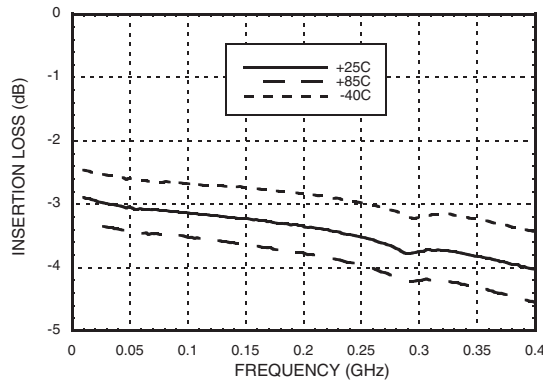
Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties that may result from its use. Specifications subject to change without notice. No license is granted by implication or otherwise under any patent or patent rights of Analog Devices. Trademarks and registered trademarks are the property of their respective owners.

For price, delivery, and to place orders: Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106  
Phone: 781-329-4700 • Order online at [www.analog.com](http://www.analog.com)  
Application Support: Phone: 1-800-ANALOG-D

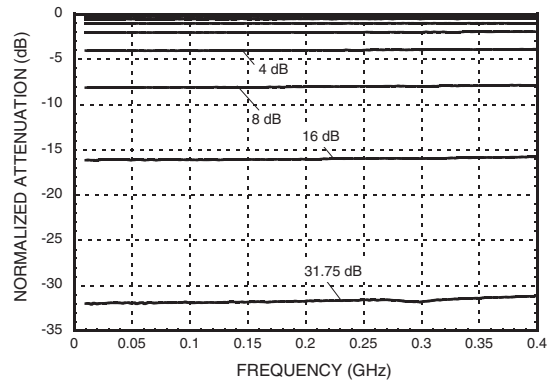


**0.25 dB LSB BiCMOS MMIC 7-BIT DIGITAL ATTENUATOR, 10 - 300 MHz**

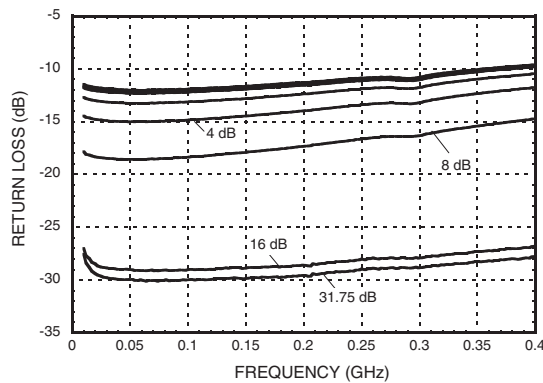
**Insertion Loss vs. Temperature<sup>[1]</sup>**



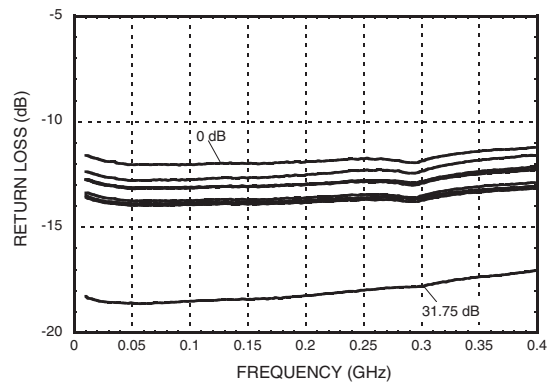
**Normalized Attenuation<sup>[1]</sup>**  
(Only Major States are Shown)



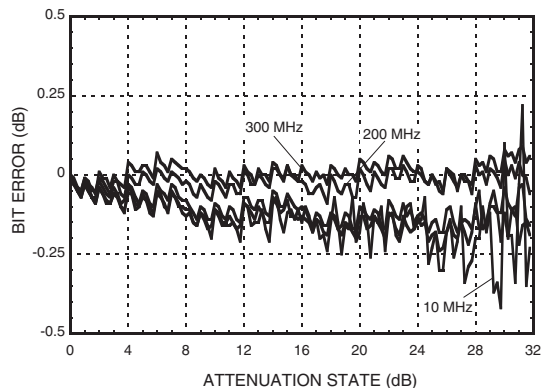
**Input Return Loss<sup>[1]</sup>**  
(Only Major States are Shown)



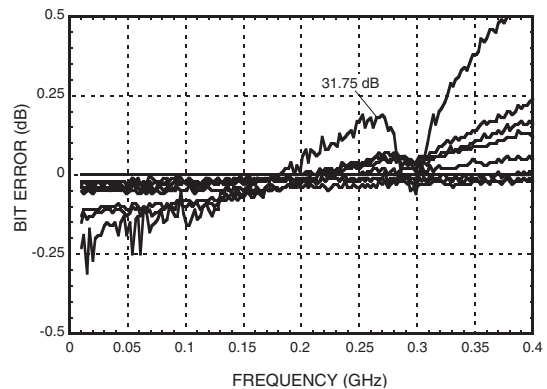
**Output Return Loss<sup>[1]</sup>**  
(Only Major States are Shown)



**Bit Error vs. Attenuation State<sup>[2]</sup>**



**Bit Error vs. Frequency<sup>[2]</sup>**  
(Only Major States are Shown)



[1] Data taken with broadband DC blocking on RF input and output ports.

[2] C1, C2 = 10nF

Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties that may result from its use. Specifications subject to change without notice. No license is granted by implication or otherwise under any patent or patent rights of Analog Devices. Trademarks and registered trademarks are the property of their respective owners.

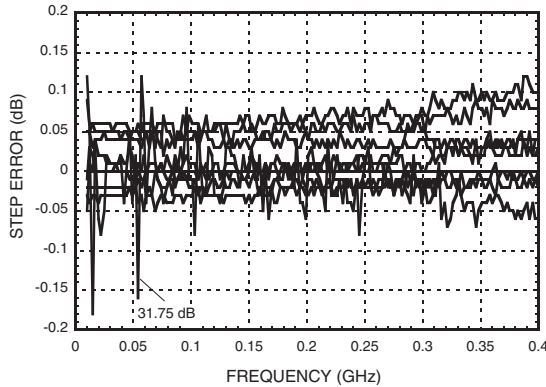
For price, delivery, and to place orders: Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106 Phone: 781-329-4700 • Order online at [www.analog.com](http://www.analog.com) Application Support: Phone: 1-800-ANALOG-D



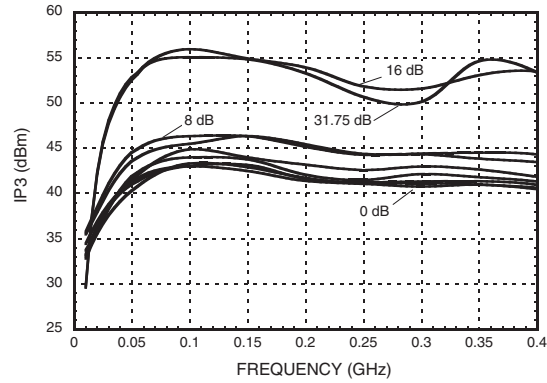
**0.25 dB LSB BiCMOS MMIC 7-BIT DIGITAL ATTENUATOR, 10 - 300 MHz**



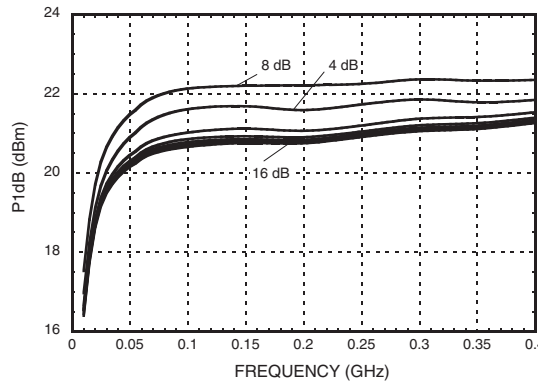
**Worst Case Step Error Between Successive Attenuation States [1]**



**IP3 vs. Attenuation States [1]**  
(Only Major States are Shown)

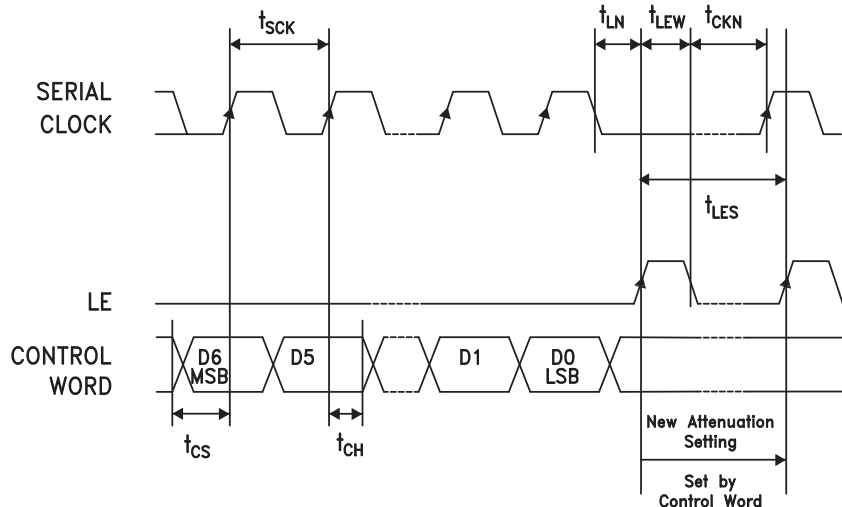


**Input P1dB vs. Attenuation States [1][2]**  
(Only Major States are Shown)



**Serial Control Interface**

The HMC759LP3E contains a 3-wire SPI compatible digital interface (SERIN, CLK, LE). The 7-bit serial word must be loaded MSB first. The positive-edge sensitive CLK and LE requires clean transitions. If mechanical switches are used, sufficient debouncing should be provided. When LE is high, 7-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.



[1] C1, C2 = 10nF

[2] Part does not enter 1 dB compression at 31.75 dB max attenuation up to 25 dBm input power.

Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties that may result from its use. Specifications subject to change without notice. No license is granted by implication or otherwise under any patent or patent rights of Analog Devices. Trademarks and registered trademarks are the property of their respective owners.

For price, delivery, and to place orders: Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106 Phone: 781-329-4700 • Order online at [www.analog.com](http://www.analog.com) Application Support: Phone: 1-800-ANALOG-D


**0.25 dB LSB BiCMOS MMIC 7-BIT  
DIGITAL ATTENUATOR, 10 - 300 MHz**
**Bias Voltage**

| Vdd (V) | I <sub>dd</sub> (Typ.) (μA) |
|---------|-----------------------------|
| 4.5     | 580                         |
| 5.0     | 650                         |
| 5.5     | 710                         |

**Control Voltage Table**

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

| Parameter                                        | Typ.   |
|--------------------------------------------------|--------|
| Min. serial period, t <sub>SCK</sub>             | 100 ns |
| Control set-up time, t <sub>CS</sub>             | 20 ns  |
| Control hold-time, t <sub>CH</sub>               | 20 ns  |
| LE setup-time, t <sub>LN</sub>                   | 10 ns  |
| Min. LE pulse width, t <sub>LEW</sub>            | 10 ns  |
| Min LE pulse spacing, t <sub>LES</sub>           | 630 ns |
| Serial clock hold-time from LE, t <sub>CKN</sub> | 10 ns  |

**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 kept high at power up, power up state will be indeterminate therefore is not recommended.

**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

**PUP Truth Table**

| LE | PUP1 | PUP2 | Relative Attenuation |
|----|------|------|----------------------|
| 0  | 0    | 0    | -31.75               |
| 0  | 1    | 0    | -24                  |
| 0  | 0    | 1    | -16                  |
| 0  | 1    | 1    | Insertion Loss       |
| 1  | X    | X    | Indeterminate        |

**Truth Table**

| Control Voltage Input |      |      |      |      |      |      | Reference Insertion Loss (dB) |
|-----------------------|------|------|------|------|------|------|-------------------------------|
| D6                    | D5   | D4   | D3   | D2   | D1   | D0   |                               |
| High                  | High | High | High | High | High | High | 0                             |
| High                  | High | High | High | High | High | Low  | 0.25                          |
| High                  | High | High | High | High | Low  | High | 0.5                           |
| High                  | High | High | High | Low  | High | High | 1                             |
| High                  | High | High | Low  | High | High | High | 2                             |
| High                  | High | Low  | High | High | High | High | 4                             |
| High                  | Low  | High | High | High | High | High | 8                             |
| Low                   | High | High | High | High | High | High | 16                            |
| Low                   | Low  | Low  | Low  | Low  | Low  | Low  | 31.75                         |

Any combination of the above states will provide an attenuation equal to the sum of the bits selected.



## 0.25 dB LSB BiCMOS MMIC 7-BIT DIGITAL ATTENUATOR, 10 - 300 MHz

8

ATTENUATORS - DIGITAL - SMT

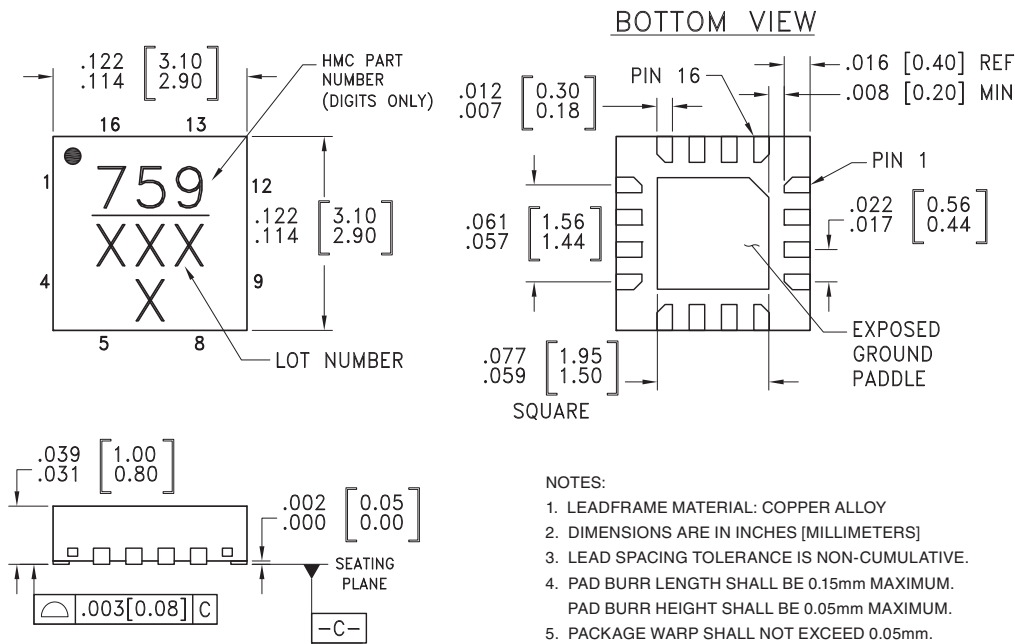
### Absolute Maximum Ratings

|                                                                         |                     |
|-------------------------------------------------------------------------|---------------------|
| RF Input Power (RF1, RF2)                                               | 20 dBm (T = +85 °C) |
| Digital Inputs (SERIN LE, CLK, PUP1, PUP2)                              | -0.5 to Vdd +0.5V   |
| Bias Voltage (Vdd)                                                      | 5.6V                |
| Channel Temperature                                                     | 125 °C              |
| Continuous P <sub>diss</sub> (T = 85 °C) (derate 9.8 mW/°C above 85 °C) | 0.29 W              |
| Thermal Resistance (channel to ground paddle)                           | 138 °C/W            |
| Storage Temperature                                                     | -65 to +150 °C      |
| Operating Temperature                                                   | -40 to +85 °C       |
| ESD Sensitivity (HBM)                                                   | Class 1A            |



ELECTROSTATIC SENSITIVE DEVICE  
OBSERVE HANDLING PRECAUTIONS

### Outline Drawing



- NOTES:
- LEADFRAME MATERIAL: COPPER ALLOY
  - DIMENSIONS ARE IN INCHES [MILLIMETERS]
  - LEAD SPACING TOLERANCE IS NON-CUMULATIVE.
  - PAD BURR LENGTH SHALL BE 0.15mm MAXIMUM.  
PAD BURR HEIGHT SHALL BE 0.05mm MAXIMUM.
  - PACKAGE WARP SHALL NOT EXCEED 0.05mm.
  - ALL GROUND LEADS AND GROUND PADDLE MUST BE SOLDERED TO PCB RF GROUND.
  - REFER TO HITTITE APPLICATION NOTE FOR SUGGESTED LAND PATTERN.

### Package Information

| Part Number | Package Body Material                              | Lead Finish   | MSL Rating          | Package Marking <sup>[1]</sup> |
|-------------|----------------------------------------------------|---------------|---------------------|--------------------------------|
| HMC759LP3E  | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 <sup>[2]</sup> | 759<br>XXXX                    |

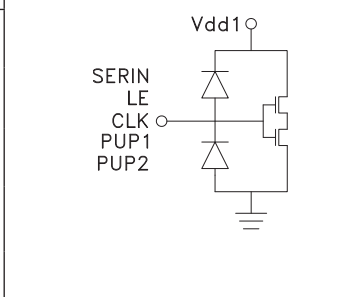
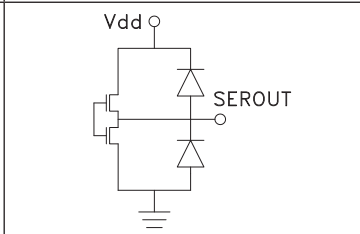
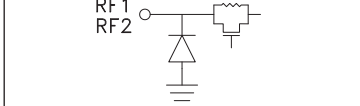
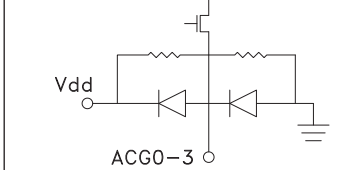
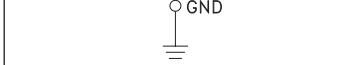
[1] 4-Digit lot number XXXX

[2] Max peak reflow temperature of 260 °C



## 0.25 dB LSB BiCMOS MMIC 7-BIT DIGITAL ATTENUATOR, 10 - 300 MHz

### Pin Descriptions

| Pin Number | Function | Description                                                                                                                           | Interface Schematic                                                                   |
|------------|----------|---------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 1          | Vdd1     | This pin should be pulled high to Vdd through a 39 kΩ resistor.                                                                       |    |
| 2          | SERIN    | See Truth Table, Control Voltage Table and Timing Diagram.                                                                            |                                                                                       |
| 3          | LE       |                                                                                                                                       |                                                                                       |
| 4          | CLK      |                                                                                                                                       |                                                                                       |
| 5          | PUP1     |                                                                                                                                       |                                                                                       |
| 6          | PUP2     |                                                                                                                                       |                                                                                       |
| 7          | SEROUT   | Serial input data delayed by 7 clock cycles.                                                                                          |   |
| 8, 13      | RF1, RF2 | This pin is DC coupled and matched to 50 Ohms. Blocking capacitors are required.                                                      |  |
| 9 - 12     | ACG0 - 3 | External capacitors to ground are required. Place these capacitors close to the package.                                              |  |
| 14         | GND      | This pin and package bottom must be connected to RF/DC ground.                                                                        |  |
| 15         | Vdd2     | Supply voltage.                                                                                                                       |                                                                                       |
| 16         | N/C      | This pin is not connected internally; however, all data shown herein was measured with this pin connected to RF/DC ground externally. |                                                                                       |

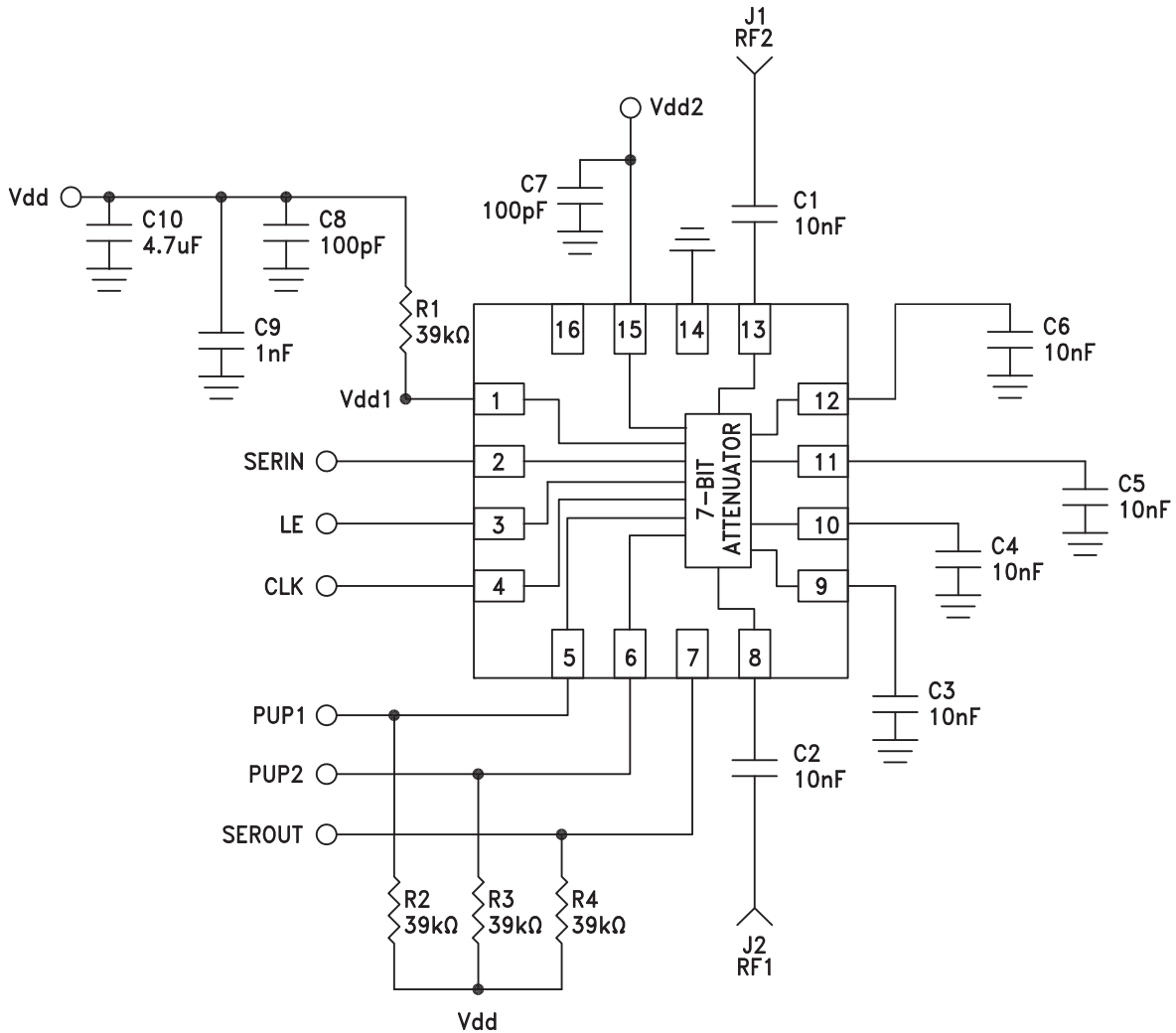
Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties that may result from its use. Specifications subject to change without notice. No license is granted by implication or otherwise under any patent or patent rights of Analog Devices. Trademarks and registered trademarks are the property of their respective owners.

For price, delivery, and to place orders: Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106  
 Phone: 781-329-4700 • Order online at [www.analog.com](http://www.analog.com)  
 Application Support: Phone: 1-800-ANALOG-D



**0.25 dB LSB BiCMOS MMIC 7-BIT DIGITAL ATTENUATOR, 10 - 300 MHz**

**Application Circuit**



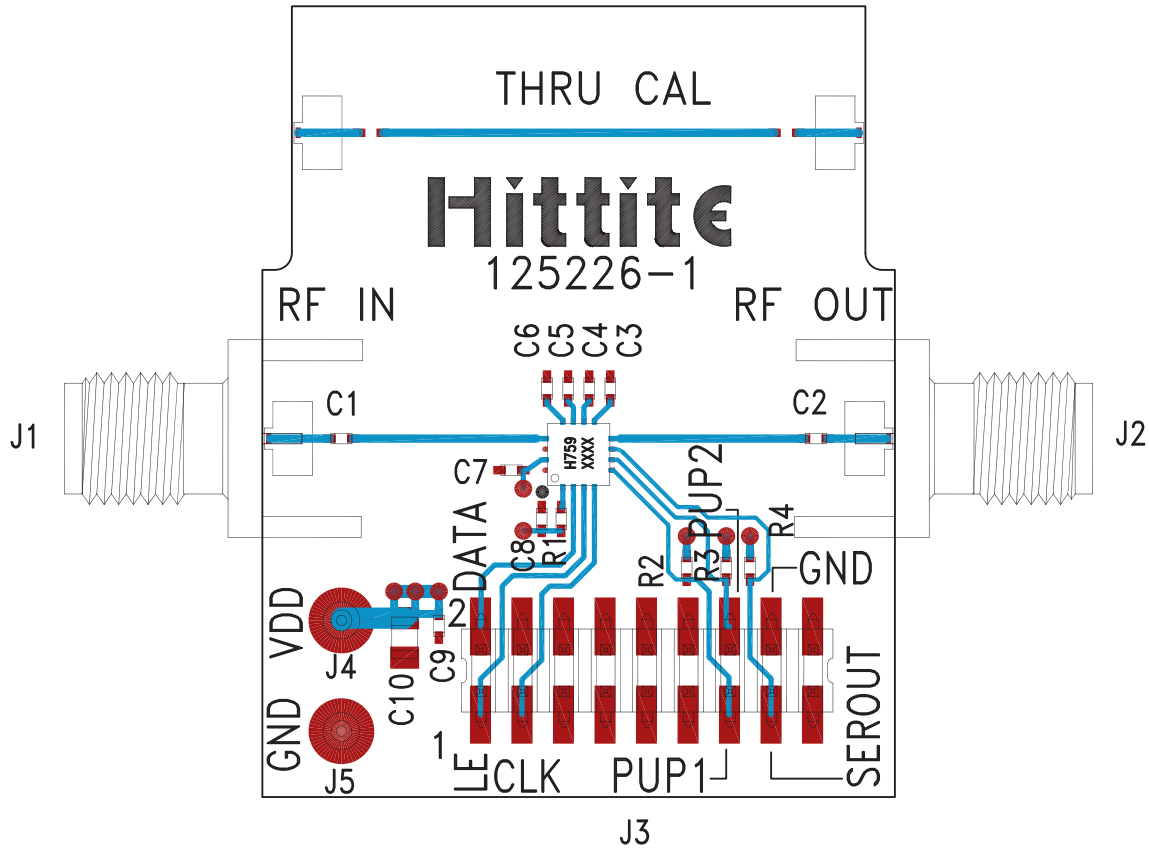
Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties that may result from its use. Specifications subject to change without notice. No license is granted by implication or otherwise under any patent or patent rights of Analog Devices. Trademarks and registered trademarks are the property of their respective owners.

For price, delivery, and to place orders: Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106 Phone: 781-329-4700 • Order online at [www.analog.com](http://www.analog.com) Application Support: Phone: 1-800-ANALOG-D



**0.25 dB LSB BiCMOS MMIC 7-BIT  
DIGITAL ATTENUATOR, 10 - 300 MHz**

**Evaluation PCB**



**List of Materials for Evaluation PCB 125228 [1]**

| Item    | Description                      |
|---------|----------------------------------|
| J1, J2  | PCB Mount SMA Connector          |
| J3      | 18 Pin DC Connector              |
| J4, J5  | DC Pin                           |
| C1 - C6 | 10 nF Capacitor, 0402 Pkg.       |
| C7, C8  | 100 pF Capacitor, 0402 Pkg.      |
| C9      | 1 nF Capacitor, 0402 Pkg.        |
| C10     | 4.7 $\mu$ F Capacitor, 0805 Pkg. |
| R1 - R4 | 39K Ohm Resistor, 0402 Pkg.      |
| U1      | HMC759LP3E Digital Attenuator    |
| PCB [2] | 125226 Evaluation PCB            |

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: Arlon 25FR or Rogers 4350

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 circuit board shown is available from Hittite upon request.