

### FEATURES

- Broadband frequency range: 0.1 GHz to 20 GHz**
- Nonreflective 50 Ω design**
- Low insertion loss: 3.0 dB at 20 GHz**
- High isolation: 40 dB at 20 GHz**
- High input linearity at 250 MHz to 20 GHz**
  - P1dB: 24 dBm typical**
  - IP3: 41 dBm typical**
- High power handling**
  - 26.5 dBm through path**
  - 23 dBm terminated path**
- Integrated 2 to 4 line decoder**
- 24-lead, 4 mm × 4 mm LFCSP package**
- ESD rating: 250 V (Class 1A)**

### APPLICATIONS

- Test instrumentation**
- Microwave radios and very small aperture terminals (VSATs)**
- Military radios, radars, and electronic counter measures (ECMs)**
- Broadband telecommunications systems**

### GENERAL DESCRIPTION

The HMC641ALP4E is a general-purpose, nonreflective, single-pole, four-throw (SP4T) switch manufactured using a gallium arsenide (GaAs) process. This switch offers high isolation, low insertion loss, and on-chip termination of the isolated ports.

The switch operates with a negative supply voltage range of  $-5\text{ V}$  to  $-3\text{ V}$  and requires two negative logic control voltages.

### FUNCTIONAL BLOCK DIAGRAM

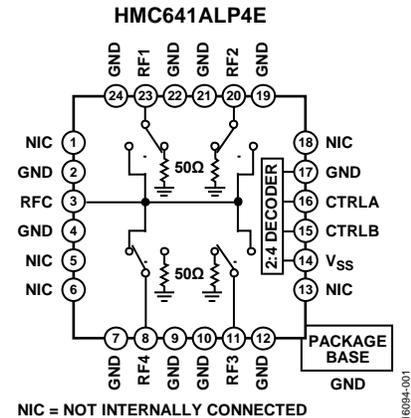


Figure 1.

The HMC641ALP4E includes an on-chip, binary 2 to 4 line decoder that provides logic control from two logic input lines. The HMC641ALP4E comes in a 4 mm × 4 mm, 24-lead LFCSP package and operates from 0.1 GHz to 20 GHz.

# HMC641ALP4E\* PRODUCT PAGE QUICK LINKS

Last Content Update: 12/18/2017

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## COMPARABLE PARTS

View a parametric search of comparable parts.

## EVALUATION KITS

- HMC641A Evaluation Board

## DOCUMENTATION

### Data Sheet

- HMC641ALP4E-DSCC: Military Data Sheet
- HMC641ALP4E: GaAs MMIC SP4T Non-Reflective Switch, DC - 20 GHz Data Sheet
- HMC641ATCPZ-EP: Enhanced Product Data Sheet

## TOOLS AND SIMULATIONS

- HMC641ALP4E S-Parameters

## REFERENCE MATERIALS

### Product Selection Guide

- RF, Microwave, and Millimeter Wave IC Selection Guide 2017

### Quality Documentation

- Semiconductor Qualification Test Report: PHEMT-J (QTR: 2013-00285)

## DESIGN RESOURCES

- HMC641ALP4E Material Declaration
- PCN-PDN Information
- Quality And Reliability
- Symbols and Footprints

## DISCUSSIONS

View all HMC641ALP4E EngineerZone Discussions.

## SAMPLE AND BUY

Visit the product page to see pricing options.

## TECHNICAL SUPPORT

Submit a technical question or find your regional support number.

## DOCUMENT FEEDBACK

Submit feedback for this data sheet.

## TABLE OF CONTENTS

Features .....	1	Interface Schematics .....	5
Applications .....	1	Typical Performance Characteristics .....	6
Functional Block Diagram .....	1	Insertion Loss, Return Loss, and Isolation .....	6
General Description .....	1	Input Power Compression and Third-Order Intercept (IP3).....	7
Revision History .....	2	Theory of Operation .....	8
Specifications.....	3	Application Information.....	9
Absolute Maximum Ratings.....	4	Evaluation Board .....	9
Power Derating Curves.....	4	Outline Dimensions .....	11
ESD Caution.....	4	Ordering Guide .....	11
Pin Configuration and Function Descriptions.....	5		

## REVISION HISTORY

This Hittite Microwave Products data sheet has been reformatted to meet the styles and standards of Analog Devices, Inc.

### 7/2017—Rev. 00.1013 to Rev. A

Changes to Features Section, Applications Section, General Description Section, and Figure 1 .....	1
Deleted Truth Table, Bias Voltage and Current Table, and TTL/CMOS Control Voltages Table .....	3
Changes to Table 1 .....	3
Added Power Derating Curves Section and Figure 2; Renumbered Sequentially.....	4
Changes to Table 2.....	4
Added Figure 4.....	5
Changes to Figure 3, Table 3, and Figure 5 .....	5
Deleted GND Interface Schematic.....	5
Changes to Typical Performance Characteristics Section.....	6
Added Theory of Operation Section and Table 4; Renumbered Sequentially .....	8
Added Applications Information Section and Figure 14 .....	9
Changes to Table 5.....	9
Added Figure 16.....	10
Updated Outline Dimensions .....	11
Changes to Ordering Guide .....	11

## SPECIFICATIONS

$V_{SS} = -3\text{ V}$  or  $-5\text{ V}$ ,  $V_{CTRL} = 0\text{ V}$  or  $V_{SS}$ ,  $T_{CASE} = 25^\circ\text{C}$ ,  $50\ \Omega$  system, unless otherwise noted.

Table 1.

Parameter	Symbol	Test Conditions/Comments	Min	Typ	Max	Unit
FREQUENCY RANGE	f		0.1		20	GHz
INSERTION LOSS						
Between RFC and RF1 to RF4 (On)		0.1 GHz to 12 GHz		2.0		dB
		12 GHz to 20 GHz		3.0		dB
ISOLATION						
Between RFC and RF1 to RF4 (Off)		0.1 GHz to 12 GHz	30	42		dB
		12 GHz to 20 GHz	30	40		dB
RETURN LOSS						
RFC and RF1 to RF4 (On)		0.1 GHz to 12 GHz		18		dB
		12 GHz to 20 GHz		17		
RF1 to RF4 (Off)		0.1 GHz to 20 GHz		13		dB
SWITCHING						
Rise and Fall Time	$t_{RISE}, t_{FALL}$	10% to 90% of radio frequency (RF) output		30		ns
On and Off Time	$t_{ON}, t_{OFF}$	50% $V_{CTL}$ to 90% of RF output		100		ns
INPUT LINEARITY <sup>1</sup>		250 MHz to 20 GHz				
1 dB Power Compression	P1dB	$V_{SS} = -5\text{ V}$	20	24		dBm
		$V_{SS} = -3\text{ V}$		22		dBm
Third-Order Intercept	IP3	10 dBm per tone, 1 MHz spacing				
		$V_{SS} = -5\text{ V}$		41		dBm
		$V_{SS} = -3\text{ V}$		41		dBm
SUPPLY		$V_{SS}$ pin				
Voltage	$V_{SS}$		-5		-3	V
Current	$I_{SS}$			1.7	5	mA
DIGITAL CONTROL INPUTS		CTRLA and CTRLB pins				
Voltage	$V_{CTL}$					
Low	$V_{INL}$	$V_{SS} = -5\text{ V}$	-3		0	V
		$V_{SS} = -3\text{ V}$	-1		0	V
High	$V_{INH}$	$V_{SS} = -5\text{ V}$	-5		-4.2	V
		$V_{SS} = -3\text{ V}$	-3		-2.2	V
Current	$I_{CTL}$					
Low	$I_{INL}$			30		$\mu\text{A}$
High	$I_{INH}$			0.5		$\mu\text{A}$

<sup>1</sup> Input linearity performance degrades at frequencies less than 250 MHz.

## ABSOLUTE MAXIMUM RATINGS

For recommended operating conditions, see Table 1.

Table 2.

Parameter	Rating
Negative Supply Voltage ( $V_{SS}$ )	-7 V
Digital Control Input Voltage	$V_{SS} - 0.5 \text{ V}$ to +1 V
RF Input Power <sup>1</sup> ( $f = 250 \text{ MHz}$ to 20 GHz, $T_{CASE} = 85^\circ\text{C}$ )	
$V_{SS} = -5 \text{ V}$	
Through Path	26.5 dBm
Terminated Path	23 dBm
Hot Switching	20 dBm
$V_{SS} = -3 \text{ V}$	
Through Path	21 dBm
Terminated Path	20 dBm
Hot Switching	17 dBm
Temperature	
Junction, $T_J$	150°C
Storage	-65°C to +150°C
Reflow (MSL1 Rating) <sup>2</sup>	260°C
Junction to Case Thermal Resistance, $\theta_{JC}$	
Through Path	201°C/W
Terminated Path	321°C/W
Electrostatic Discharge (ESD) Sensitivity	
Human Body Model (HBM)	250 V (Class 1A)

<sup>1</sup> For power derating at frequencies less than 250 MHz, see Figure 2.

<sup>2</sup> See the Ordering Guide section.

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

### POWER DERATING CURVES

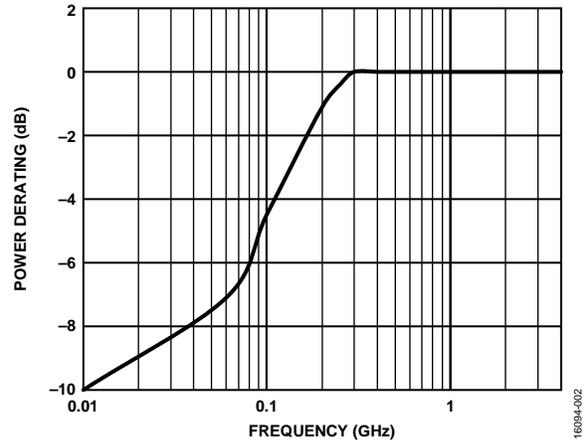


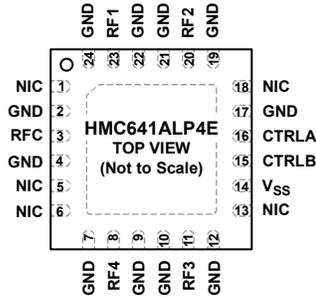
Figure 2. Power Derating at Frequencies Less than 250 MHz

### ESD CAUTION



**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

# PIN CONFIGURATION AND FUNCTION DESCRIPTIONS



NOTES  
 1. NIC = NOT INTERNALLY CONNECTED. THE PINS ARE NOT CONNECTED INTERNALLY; HOWEVER, ALL DATA SHOWN IN THIS DATA SHEET IS MEASURED WITH THESE PINS CONNECTED TO RF/DC GROUND EXTERNALLY.  
 2. EXPOSED PAD. THE EXPOSED PAD MUST BE CONNECTED TO THE RF/DC GROUND OF THE PCB.

16094-002

Figure 3. Pin Configuration

Table 3. Pin Function Descriptions

Pin No.	Mnemonic	Description
1, 5, 6, 13, 18	NIC	Not Internally Connected. The pins are not connected internally; however, all data shown in this data sheet is measured with these pins connected to RF/dc ground externally.
2, 4, 7, 9, 10, 12, 17, 19, 21, 22, 24	GND	Ground. These pins must be connected to the RF/dc ground of the printed circuit board (PCB).
3	RFC	RF Common Port. This pin is dc-coupled and matched to 50 Ω. A dc blocking capacitor is required if the RF line potential is not equal to 0 V dc.
8	RF4	RF4 Port. This pin is dc-coupled and matched to 50 Ω. A dc blocking capacitor is required if the RF line potential is not equal to 0 V dc.
11	RF3	RF3 Port. This pin is dc-coupled and matched to 50 Ω. A dc blocking capacitor is required if the RF line potential is not equal to 0 V dc.
14	V <sub>ss</sub>	Negative Supply Voltage Pin.
15	CTRLB	Control Input 2 Pin. See Table 4 for the control voltage truth table.
16	CTRLA	Control Input 1 Pin. See Table 4 for the control voltage truth table.
20	RF2	RF2 Port. This pin is dc-coupled and matched to 50 Ω. A dc blocking capacitor is required if the RF line potential is not equal to 0 V dc.
23	RF1	RF1 Port. This pin is dc-coupled and matched to 50 Ω. A dc blocking capacitor is required if the RF line potential is not equal to 0 V dc.
	EPAD	Exposed Pad. The exposed pad must be connected to the RF/dc ground of the PCB.

## INTERFACE SCHEMATICS

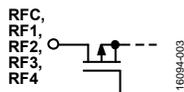


Figure 4. RFC to RF4 Interface Schematic

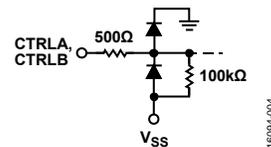


Figure 5. CTRLA and CTRLB Interface Schematic

**TYPICAL PERFORMANCE CHARACTERISTICS**  
**INSERTION LOSS, RETURN LOSS, AND ISOLATION**

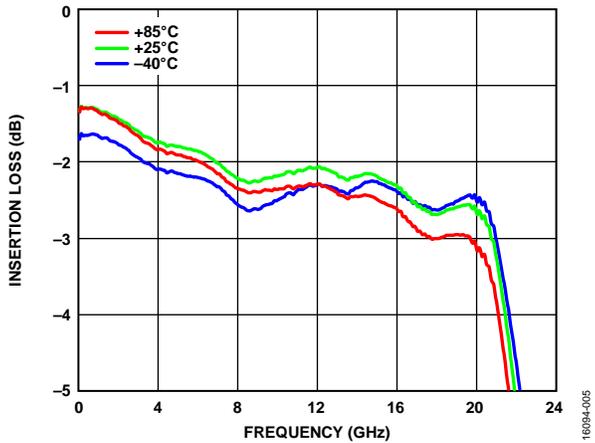


Figure 6. Insertion Loss Between RFC and RF1 vs. Frequency at Various Temperatures

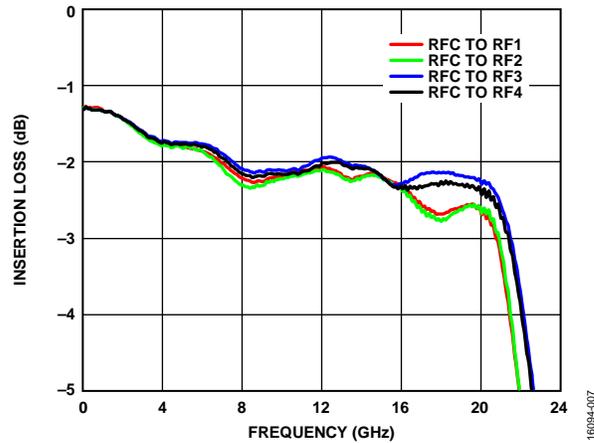


Figure 8. Insertion Loss Between RFC to RFx vs. Frequency

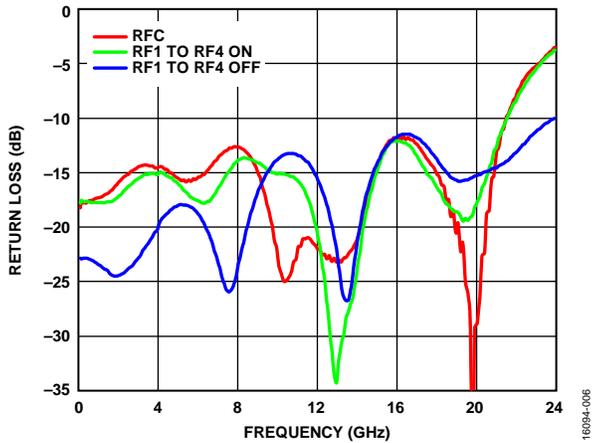


Figure 7. Return Loss for RFC, RF1 to RF4 On, and RF1 to RF4 Off vs. Frequency

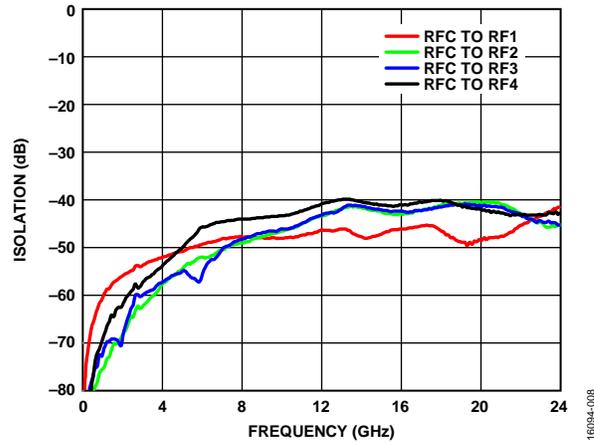


Figure 9. Isolation Between RFC and RFx vs. Frequency

**INPUT POWER COMPRESSION AND IP3**

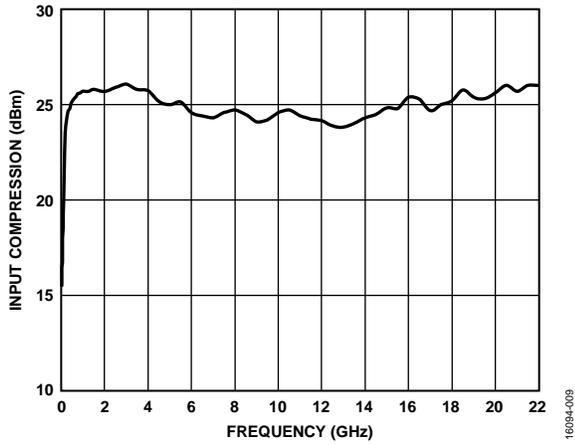


Figure 10. Input Compression vs. Frequency at Room Temperature,  $V_{SS} = -5V$

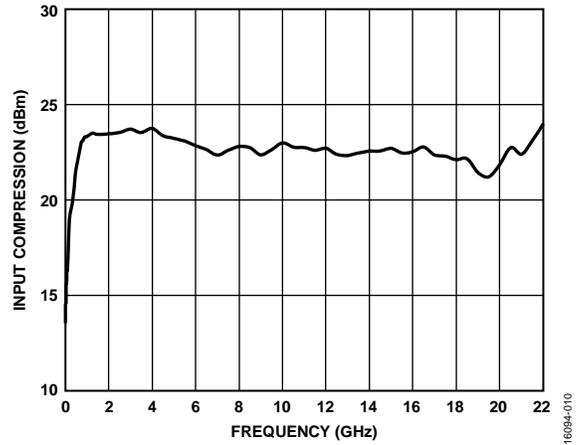


Figure 12. Input Compression vs. Frequency at Room Temperature,  $V_{SS} = -3V$

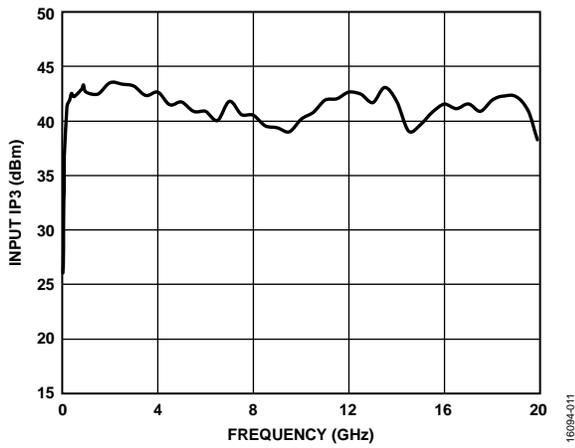


Figure 11. Input IP3 vs. Frequency at Room Temperature,  $V_{SS} = -5V$

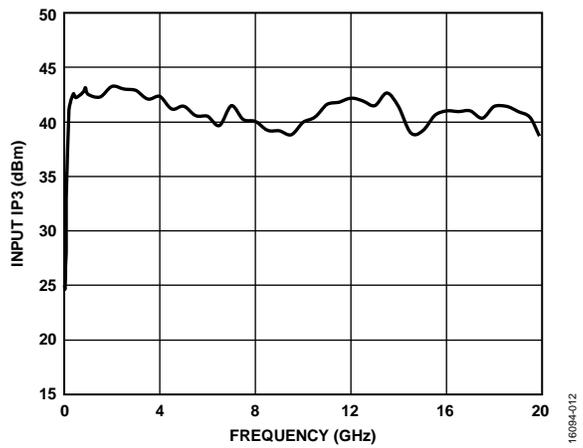


Figure 13. Input IP3 vs. Frequency at Room Temperature,  $V_{SS} = -3V$

## THEORY OF OPERATION

The HMC641ALP4E requires a negative supply voltage at the  $V_{SS}$  pin and two logic control inputs at the CTRLA and CTRLB pins to control the state of the RF paths.

Depending on the logic level applied to the CTRLA pin and the CTRLB pin, one RF path is in the insertion loss state while the other three paths are in an isolation state (see Table 4). The insertion loss path conducts the RF signal between the RF throw pin and RF common pin while the isolation paths provide high loss between RF throw pins terminated to internal 50  $\Omega$  resistors and the insertion loss path.

The ideal power-up sequence is as follows:

1. Ground to the die bottom.
2. Power up  $V_{SS}$ .
3. Power up the digital control inputs. The relative order of the logic control inputs is not important. However, powering the digital control inputs before the  $V_{SS}$  supply can inadvertently become forward-biased and damage the internal ESD protection structures.
4. Apply an RF input signal. The design is bidirectional; the RF input signal can be applied to the RFC pin while the RF throw pins are the outputs, or the RF input signal can be applied to the RF throw pins while the RFC pin is the output. All of the RF pins are dc-coupled to 0 V, and no dc blocking is required at the RF pins when the RF line potential is equal to 0 V.

The power-down sequence is the reverse of the power-up sequence.

**Table 4. Control Voltage Truth Table**

Digital Control Input		RF Paths			
CTRLA	CTRLB	RFC to RF1	RFC to RF2	RFC to RF3	RFC to RF4
High	High	Insertion loss (on)	Isolation (off)	Isolation (off)	Isolation (off)
Low	High	Isolation (off)	Insertion loss (on)	Isolation (off)	Isolation (off)
High	Low	Isolation (off)	Isolation (off)	Insertion loss (on)	Isolation (off)
Low	Low	Isolation (off)	Isolation (off)	Isolation (off)	Insertion loss (on)

# APPLICATION INFORMATION

## EVALUATION BOARD

The EV1HMC641ALP4 is a 4-layer evaluation board. Each copper layer is 0.5 oz (0.7 mil) and separated by dielectric materials. Figure 14 shows the stack up for this evaluation board.

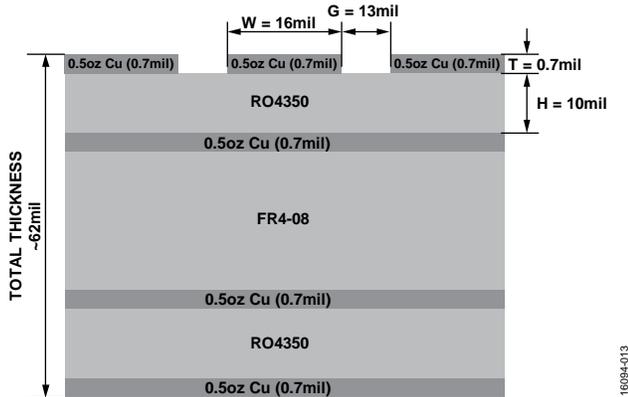


Figure 14. The EV1HMC641ALP4 Evaluation Board (Cross Sectional View)

All RF and dc traces are routed on the top copper layer whereas the inner and bottom layers are grounded planes that provide a solid ground for the RF transmission lines. Top dielectric material is a 10 mil Rogers RO4350. The middle and bottom dielectric materials provide mechanical strength. The overall board thickness is approximately 62 mil, allowing the subminiature version A (SMA) launchers to be connected at the board edges.

The RF transmission lines were designed using a coplanar waveguide (CPWG) model, with trace width of 16 mil and ground clearance of 13 mil for a characteristic impedance of 50 Ω. For optimal RF and thermal grounding, arrange as many plated through vias as possible around transmission lines and under the exposed pad of the package.

Figure 15 shows the layout of the EV1HMC641ALP4 evaluation board with component placement. Power supply port is connected to the V<sub>SS</sub> test point, J8, and control voltages, CTRLA and CTRLB, are connected to the A and B test points, J6 and J7, and the ground reference is connected to the GND test point, J9. On the supply trace, V<sub>SS</sub>, use a 1000 pF bypass capacitor to filter high frequency noise.

The RF input and output ports (RFC, RF1, RF2, RF3, and RF4) are connected through 50 Ω transmission lines to the SMA launchers, J1 to J5. These SMA launchers are soldered onto the board. A through calibration line connects the unpopulated J10 and J11 launchers; this transmission line estimates the loss of the PCB over the environmental conditions being evaluated, as shown in Figure 16.

Table 5 shows the evaluation board components.

Table 5. Evaluation Board Components

Component	Default Value	Description
J1 to J5		PCB mount SMA connector
J6 to J9		DC pin
J10, J11	Do not insert	PCB mount SMA connector
C1	1000 pF	Capacitor, C0402 package
U1		HMC641ALP4E SP4T switch
PCB	600-00782-00-1	Evaluation PCB

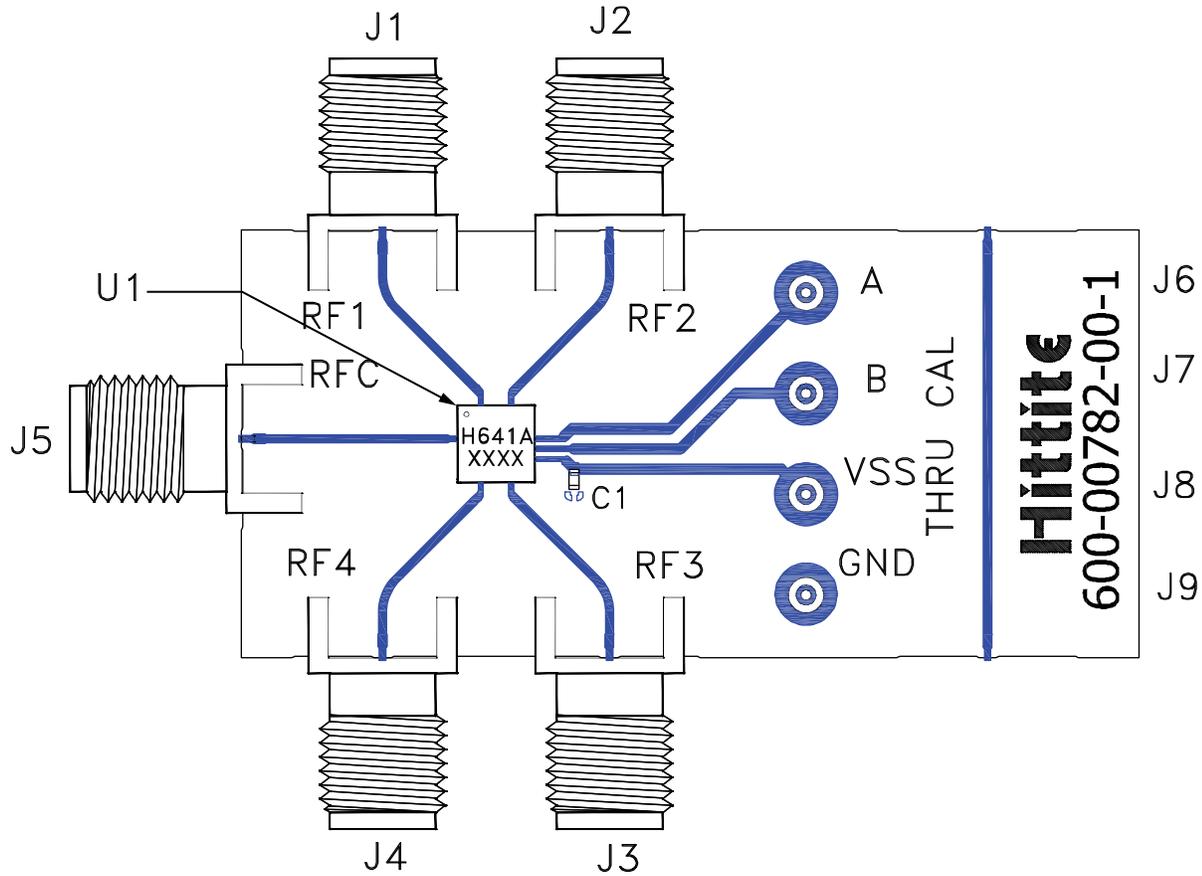


Figure 15. The EV1HMC641ALP4 Evaluation Board Component Placement

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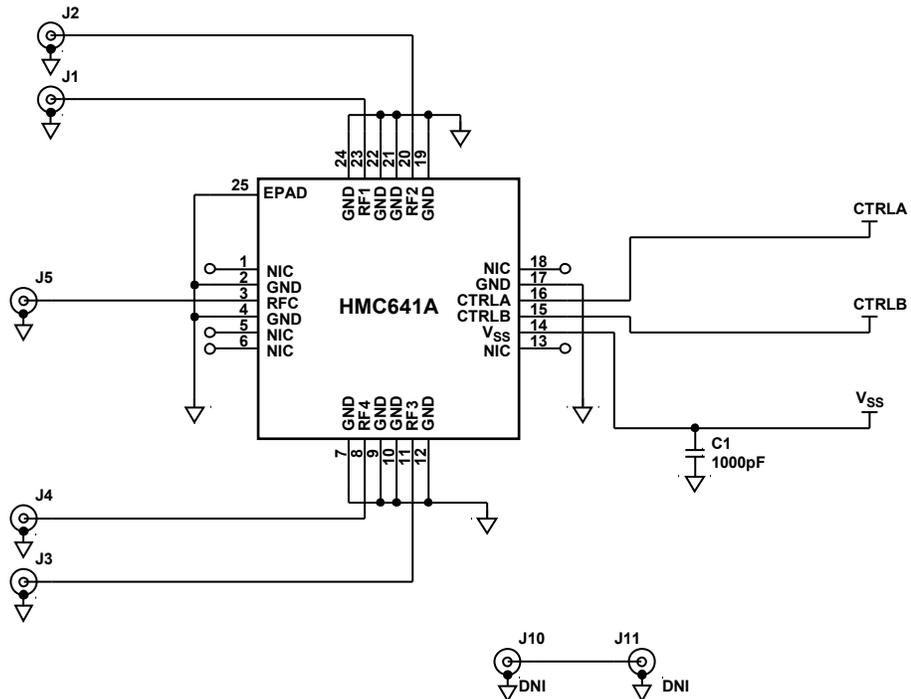


Figure 16. The EV1HMC641ALP4 Evaluation Board Schematic

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# OUTLINE DIMENSIONS

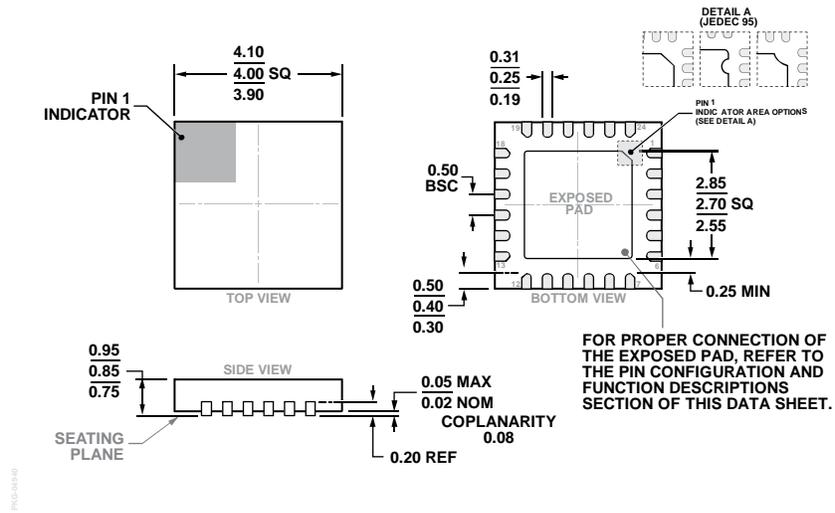


Figure 17. 24-Terminal Lead Frame Chip Scale Package [LFCSP]  
 4 mm x 4 mm Body and 0.90 mm Package Height  
 (HCP-24-3)  
 Dimensions shown in millimeters

## ORDERING GUIDE

Model <sup>1</sup>	Temperature Range	MSL Rating <sup>2</sup>	Package Description	Package Option	Branding <sup>3</sup>
HMC641ALP4E	-40°C to +85°C	MSL1	24-Terminal Lead Frame Chip Scale Package [LFCSP]	HCP-24-3	H641A XXXX
HMC641ALP4ETR	-40°C to +85°C	MSL1	24-Terminal Lead Frame Chip Scale Package [LFCSP]	HCP-24-3	H641A XXXX
EV1HMC641ALP4			Evaluation Board		

<sup>1</sup> E = RoHS Compliant Part.

<sup>2</sup> See the Absolute Maximum Ratings section.

<sup>3</sup> XXXX is the 4 digit lot number.

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