



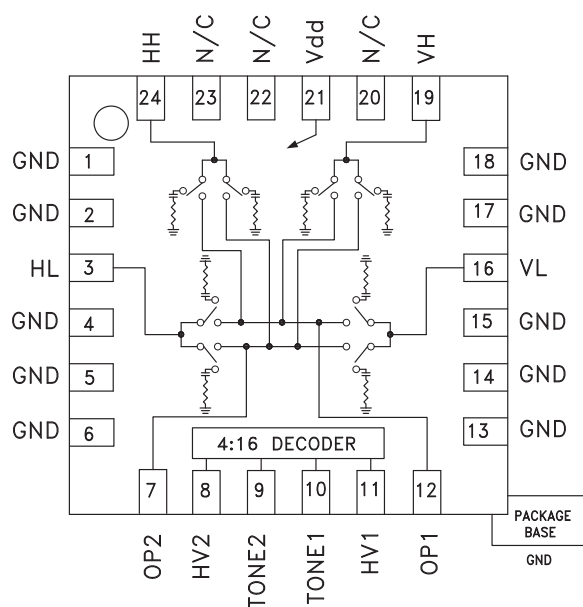
GaAs MMIC 4x2 SWITCH MATRIX, 0.2 - 3.0 GHz

Typical Applications

4x2 Switch Matrix for 0.2 - 3.0 GHz Applications:

- Cable Modem
- CATV
- Cellular Systems
- DBS

Functional Diagram



Features

- 4x2 Switch Matrix Using One IC
- 4x4 Switch Matrix Using Two ICs
- Integrated 4 Bit Decoder
- Single Positive Supply: $V_{dd} = +5V$
- QFN Leadless SMT Package, 16 mm²

General Description

The HMC276LP4 & HMC276LP4E are low-cost 4x2 switch matrices in leadless QFN 4x4 mm surface mount packages for use in RF multiplexing applications from 200 to 3000 MHz. A positive voltage controlled 4 bit decoder is integrated on the switch. The switches may be used in either 75 ohm or 50 ohm systems.

Both switch outputs (OP1 & OP2) can independently select any of the four inputs (HH, HL, VH, VL) or simultaneously select the same inputs. Note that the switch is bi-directional and input/output functionality may be interchanged. The recommended loading impedance is 62.5 ohms on each input (HH, HL, VH, VL) and 75 ohms on each output (OP1 & OP2). All data presented was measured in a 50 ohm (input/output) system.

Electrical Specifications, $T_A = +25^\circ C$, $V_{dd} = +5V$, 50 Ohm System

| Parameter | Frequency | Min. | Typ. | Max. | Units |
|-------------------------------------|--|--|----------------------|------|----------------------------|
| Insertion Loss | 200 MHz 700 - 3000 MHz | | 6.0 6.0 | 7.0 | dB dB |
| Isolation | 200 MHz 700 - 950 MHz 950 - 1450 MHz 1450 - 2150 MHz 2150 - 3000 MHz | 40 See OP1/2 Isolation Tables 33 31 | 55 44 37 35 | | dB dB dB dB dB |
| Return Loss (Input; VL, HL, VH, HH) | 200 MHz 700 - 3000 MHz | 14 | 25 18 | | dB dB |
| Return Loss (Output; OP1, OP2) | 200 MHz 700 - 3000 MHz | 16 | 20 20 | | dB dB |
| Output IP3 | 700 - 3000 MHz | 31 | 37 | | dBm |
| Input Power for 1 dB Compression | 700 - 3000 MHz | 22 | 26 | | dBm |
| Switching Speed | | | | | |
| | t_{RISE} / t_{FALL} (10/90% RF) t_{ON} / t_{OFF} (50% CTL to 10/90% RF) | 700 - 3000 MHz | 140 350 | | ns ns |

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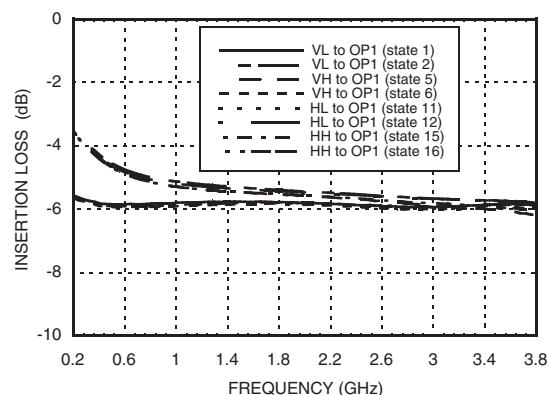
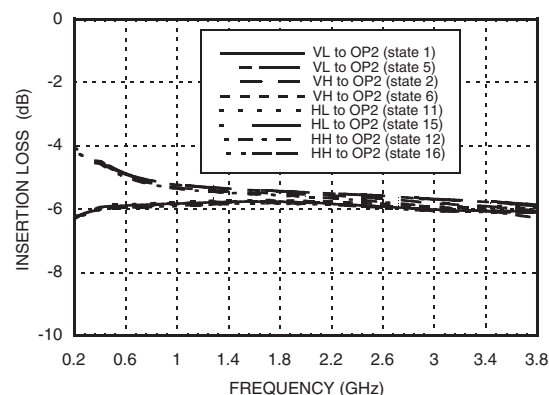
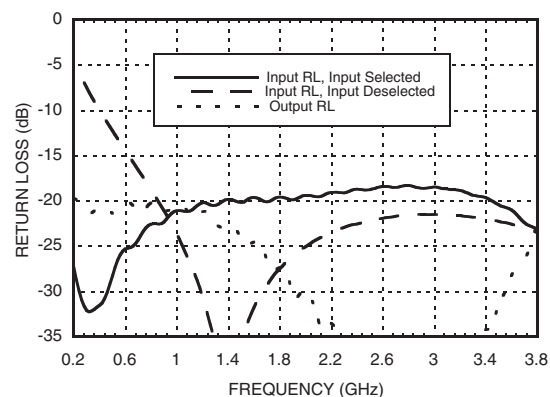
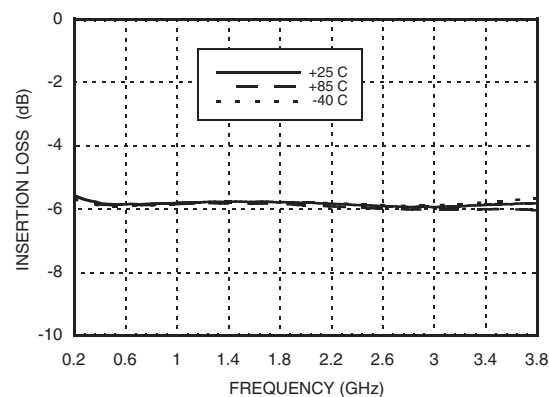
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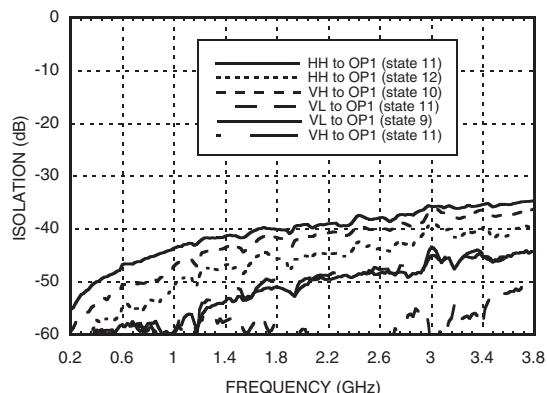
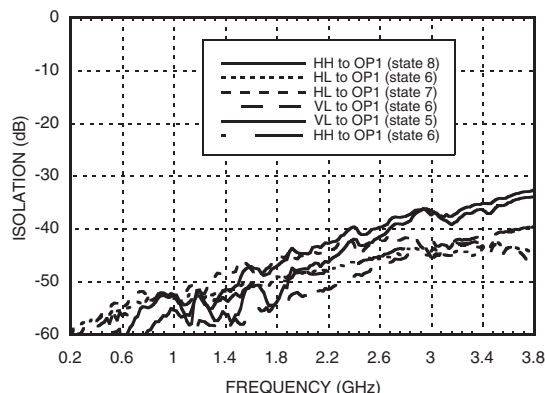
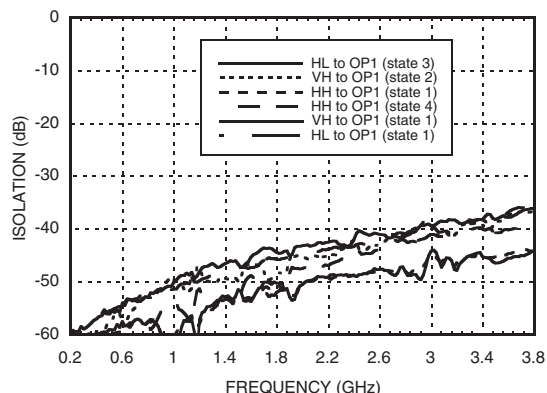
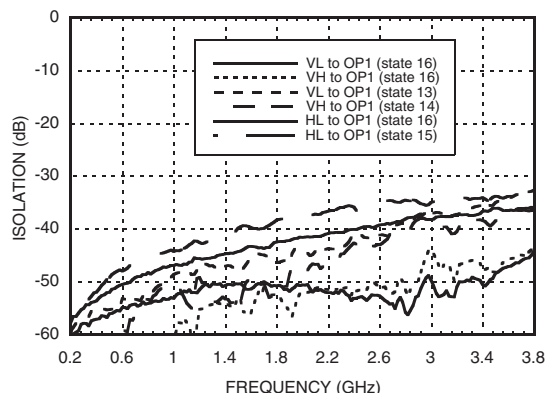
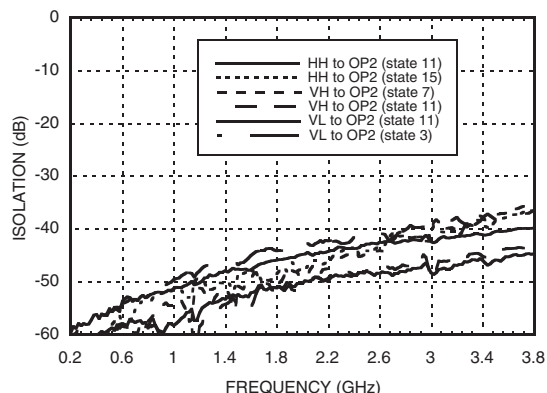
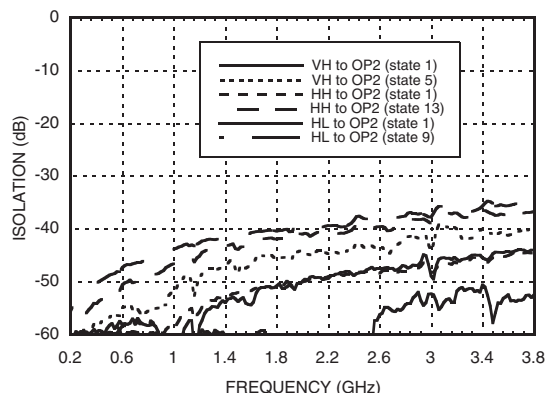
OP1 Isolation 950 - 1450 MHz

| Input to Output State | Interfering Signal | State | Min. (dB) | Typ. (dB) |
|-----------------------|--------------------|------------------|-----------|-----------|
| HL to OP1 | VL to OP1 | 9 | 38 | 41 |
| | All Other States | All Other States | 40 | >43 |
| VL to OP1 | All States | All States | 43 | >46 |
| VH to OP1 | All States | All States | 43 | >46 |
| HH to OP1 | HL to OP1 | 15 | 38 | 41 |
| | All Other States | All Other States | 41 | >44 |

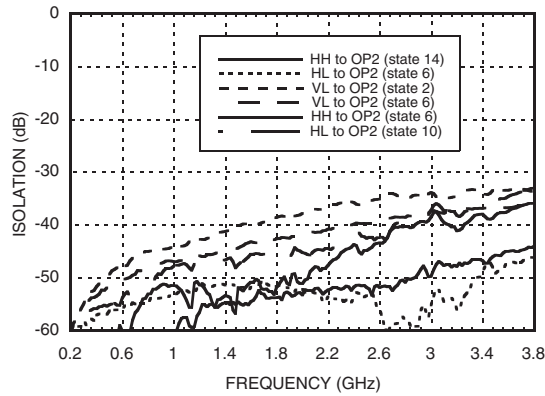
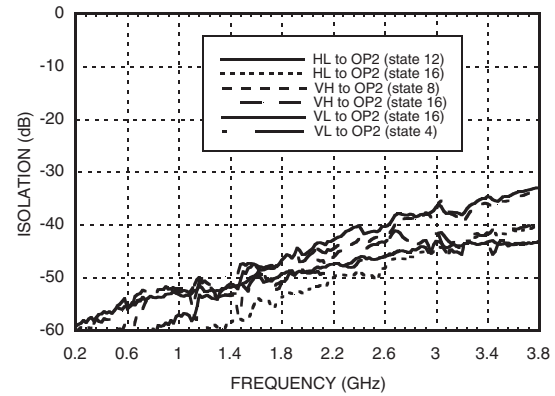
OP2 Isolation 950 - 1450 MHz

| Input to Output State | Interfering Signal | State | Min. (dB) | Typ. (dB) |
|-----------------------|--------------------|------------------|-----------|-----------|
| HL to OP2 | All States | All States | 42 | >45 |
| VH to OP2 | VL to OP2 | 2 | 38 | 41 |
| | All Other States | All Other States | 41 | >44 |
| VL to OP2 | HL to OP2 | 9 | 38 | 41 |
| | All Other States | All Other States | 40 | >43 |
| HH to OP2 | All States | All States | 45 | >48 |

Insertion Loss on OP1

Insertion Loss on OP2

Return Loss

Typical Insertion Loss vs. Temperature


Isolation When HL is Connected to OP1*

Isolation When VH is Connected to OP1*

Isolation When VL is Connected to OP1*

Isolation When HH is Connected to OP1*

Isolation When HL is Connected to OP2*

Isolation When VL is Connected to OP2*


* Isolation is recorded above insertion loss & measured at output of switch.

Isolation When VH is Connected to OP2*

Isolation When HH is Connected to OP2*

Output Third Order Intercept Point

| Path | State | F1 Pout (dBm) | Pout Intermod (dBm) | IMR (dBc) | Output IP3 (dBm) |
|---|-------|------------------|------------------------|--|---------------------|
| VL to OP1 | 1 | -12 | -106 | 94 | 35 |
| VL to OP2 | 1 | -12 | -114 | 102 | 39 |
| HL to OP1 | 11 | -12 | -108 | 96 | 36 |
| HL to OP2 | 11 | -12 | -110 | 98 | 37 |
| VH to OP1 | 6 | -12 | -115 | 103 | 39.5 |
| VH to OP2 | 6 | -12 | -115 | 103 | 39.5 |
| HH to OP1 | 16 | -12 | -116 | 104 | 40 |
| HH to OP2 | 16 | -12 | -114 | 102 | 39 |
| Test Conditions Temperature = +25° C F1 = 2150 (MHz): -12 dBm at the Output F2 = 2151 (MHz): -12 dBm at the Output | | | | Vdd = +5V VCTL Low = 0V, High = +5V | |

* Isolation is recorded above insertion loss & measured at output of switch.


**GaAs MMIC 4x2 SWITCH
MATRIX, 0.2 - 3.0 GHz**
Truth Table

| State | Control Input | | | | Output to Input State | | RF Path State | | | | | | | |
|-------|---------------|--------|------|--------|-----------------------|-----|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | HV 1 | Tone 1 | HV 2 | Tone 2 | OP1 | OP2 | VL to OP1 | HL to OP1 | VH to OP1 | HH to OP1 | VL to OP2 | HL to OP2 | VH to OP2 | HH to OP2 |
| 1 | 0 | 0 | 0 | 0 | VL | VL | LOSS | ISOL | ISOL | ISOL | LOSS | ISOL | ISOL | ISOL |
| 2 | 0 | 0 | 0 | 1 | VL | VH | LOSS | ISOL | ISOL | ISOL | ISOL | ISOL | LOSS | ISOL |
| 3 | 0 | 0 | 1 | 0 | VL | HL | LOSS | ISOL | ISOL | ISOL | ISOL | LOSS | ISOL | ISOL |
| 4 | 0 | 0 | 1 | 1 | VL | HH | LOSS | ISOL | ISOL | ISOL | ISOL | ISOL | ISOL | LOSS |
| 5 | 0 | 1 | 0 | 0 | VH | VL | ISOL | ISOL | LOSS | ISOL | LOSS | ISOL | ISOL | ISOL |
| 6 | 0 | 1 | 0 | 1 | VH | VH | ISOL | ISOL | LOSS | ISOL | ISOL | ISOL | LOSS | ISOL |
| 7 | 0 | 1 | 1 | 0 | VH | HL | ISOL | ISOL | LOSS | ISOL | ISOL | LOSS | ISOL | ISOL |
| 8 | 0 | 1 | 1 | 1 | VH | HH | ISOL | ISOL | LOSS | ISOL | ISOL | ISOL | ISOL | LOSS |
| 9 | 1 | 0 | 0 | 0 | HL | VL | ISOL | LOSS | ISOL | ISOL | LOSS | ISOL | ISOL | ISOL |
| 10 | 1 | 0 | 0 | 1 | HL | VH | ISOL | LOSS | ISOL | ISOL | ISOL | ISOL | LOSS | ISOL |
| 11 | 1 | 0 | 1 | 0 | HL | HL | ISOL | LOSS | ISOL | ISOL | ISOL | LOSS | ISOL | ISOL |
| 12 | 1 | 0 | 1 | 1 | HL | HH | ISOL | LOSS | ISOL | ISOL | ISOL | ISOL | ISOL | LOSS |
| 13 | 1 | 1 | 0 | 0 | HH | VL | ISOL | ISOL | ISOL | LOSS | LOSS | ISOL | ISOL | ISOL |
| 14 | 1 | 1 | 0 | 1 | HH | VH | ISOL | ISOL | ISOL | LOSS | ISOL | ISOL | LOSS | ISOL |
| 15 | 1 | 1 | 1 | 0 | HH | HL | ISOL | ISOL | ISOL | LOSS | ISOL | LOSS | ISOL | ISOL |
| 16 | 1 | 1 | 1 | 1 | HH | HH | ISOL | ISOL | ISOL | LOSS | ISOL | ISOL | ISOL | LOSS |

Control Voltages

HV1, Tone1, HV2, Tone2

| State | Bias Condition |
|----------|---------------------------------------|
| Low (0) | 0 to 0.8 Vdc @ 5 μ A Typical |
| High (1) | +2.0 to +5.0 Vdc @ 25 μ A Typical |

Bias Voltage

| Vdd Range = +5.0 Vdc \pm 10 % | | |
|---------------------------------|-----------------|-----------------|
| Vdd (Vdc) | Idd (Typ.) (mA) | Idd (Max.) (mA) |
| +5.0 | 1 | 1.5 |

DC Blocking And Decoupling Capacitors

The HMC276LP4 requires DC blocks on all 6 RF ports (OP1, OP2, VL, HL, VH, HH). Characterization on the HMC276LP4 was done using 0402 size 330pF capacitors on all RF ports. A 1,000 pF DC decoupling capacitor (0603 size) is recommended for the Vdd pin.



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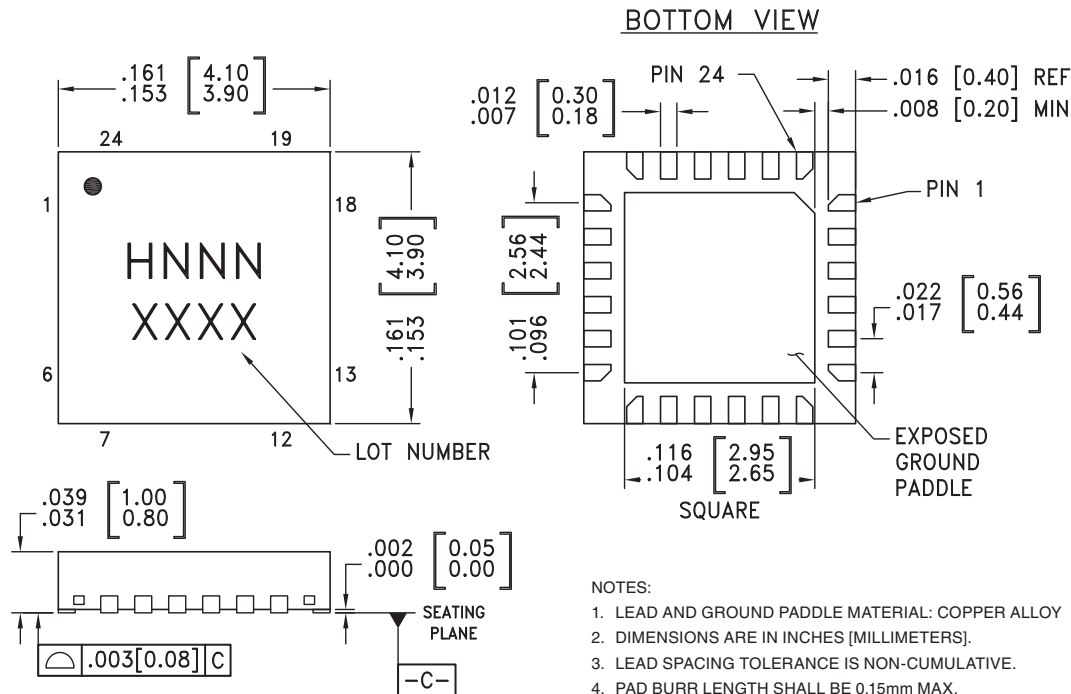
Absolute Maximum Ratings

| | |
|--|--------------------------|
| Bias Voltage Range (Vdd) | +8.0 Vdc |
| Control Voltage Range (All Logic Lines) | Vdd +0.5 to -0.2V Vdc |
| Channel Temperature | 150 °C |
| Thermal Resistance | 325 °C/W |
| Storage Temperature | -65 to +150 °C |
| Operating Temperature | -40 to +85 °C |
| Maximum Input Power (Each Input) | +23 dBm (200 - 2150 MHz) |



ELECTROSTATIC SENSITIVE DEVICE
OBSERVE HANDLING PRECAUTIONS

Outline Drawing



Package Information

| Part Number | Package Body Material | Lead Finish | MSL Rating | Package Marking [3] |
|-------------|--|---------------|------------|---------------------|
| HMC276LP4 | Low Stress Injection Molded Plastic | Sn/Pb Solder | MSL1 [1] | H276 XXXX |
| HMC276LP4E | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 [2] | H276 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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Switch Application Circuit for 4x4 Switch Matrix

The HMC276LP4 switch can operate as a 4x4 switch by connecting the 4 inputs of two switches directly together.

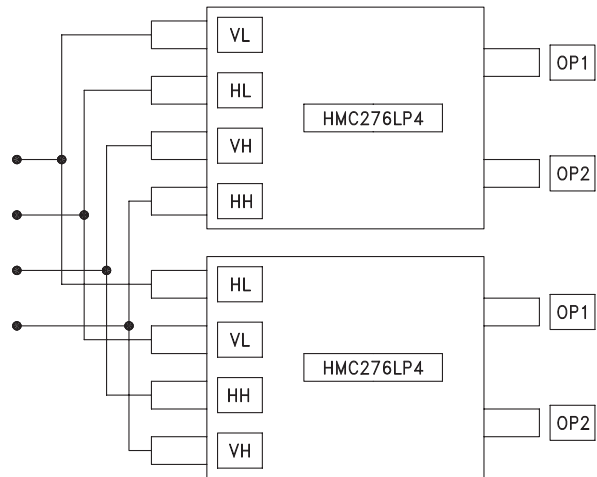
The VL, VH, HL, and HH inputs of the first switch should be connected to the second switch, as illustrated.

Mirror image switch performance can be realized by inverting the HV1 & HV2 logic control signals of one of the HMC276LP4 switches.

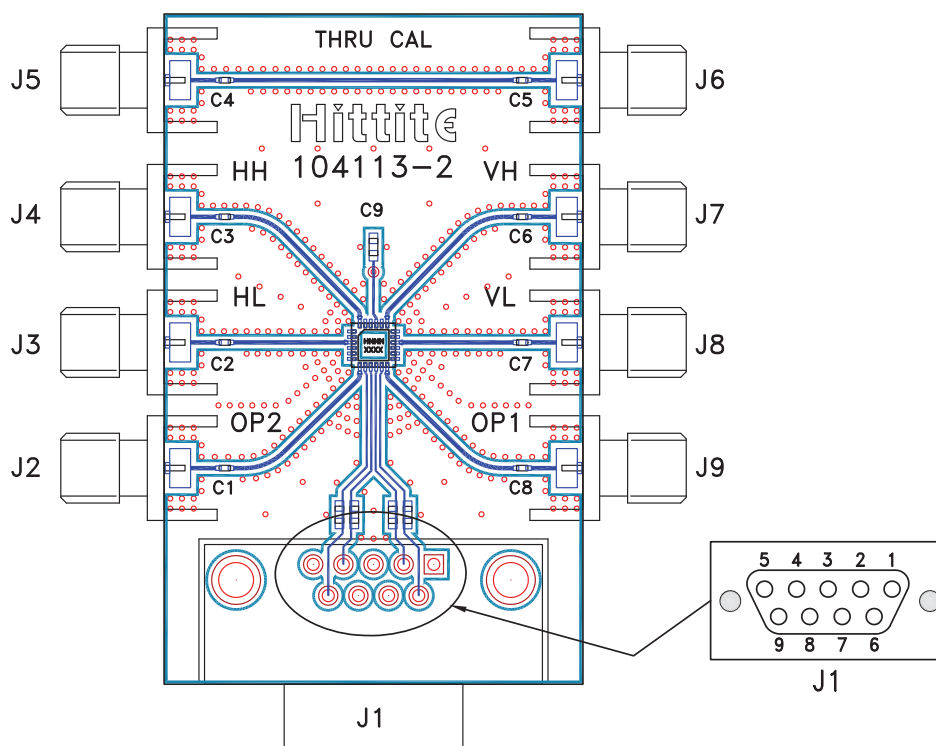
The input loading impedance of two switches in parallel should be 31.25 ohms. The output loading impedance on each output should be 75 ohms. The interconnect RF line between the switch's inputs should be an RF trace with a characteristic impedance of 62.5 ohms. This will allow the switch to remain matched in all possible switch states.

The HMC276LP4 does not provide output to output (OP1 to OP2) isolation. For this reason, it is recommended that external amplifiers should be used at each output. The amplifier's reverse isolation will provide output to output isolation, if this is necessary.

Each HMC276LP4 requires DC blocking capacitors on ALL RF input and output ports.



Evaluation PCB



The circuit board used in the final application should be generated with proper RF circuit design techniques. Signal lines at the RF port should have 50 ohm impedance and the package ground leads and exposed paddle should be connected directly to the ground plane similar to that shown above. A generous number of ground vias should be used to interconnect top/bottom ground planes. The evaluation circuit board shown above is available from Hittite Microwave Corporation upon request.

List of Materials for Evaluation PCB 104130 ^[1]

| Item | Description |
|--------------------|---|
| J2 - J9 | PCB Mount SMA RF Connector |
| J1 | DC Connector |
| C1 - C8 | 330 pF Capacitor, 0402 Pkg. |
| C9 | 1,000 pF Capacitor, 0603 Pkg. |
| U1 | HMC276LP4 / HMC276LP4E 4x2 Switch Matrix |
| PCB ^[2] | 104113 Eval Board |

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: Rogers 4350

Multi Pin DC Interface (J1)

| Pin | Line |
|-----|--------|
| 1 | Vdd |
| 2 | Tone 1 |
| 3 | GND |
| 4 | Tone 2 |
| 5 | GND |
| 6 | HV1 |
| 7 | N/C |
| 8 | N/C |
| 9 | HV2 |