**HMC877LC3**

**BROADBAND TIME DELAY & PHASE SHIFTER**

**SMT, 8 - 23 GHz**

**Typical Applications**
The HMC877LC3 is ideal for:
- Synchronization of clock and data
- Transponder design
- Broadband Test & Measurement
- RF ATE Applications

**Features**
- Very Wide Bandwidth: 8 - 23 GHz
- Continuous Adjustable Delay Range: 500° (1.4 UI\(^{[1]}\))
- Single-Ended or Differential Operation
- Adjustable Differential Output Voltage Swing: 500 - 950 mVp-p @ 16 GHz
- Delay Control Modulation Bandwidth: 2.5 GHz
- Single Supply: +3.3V
- 16 Lead Ceramic 3x3mm SMT Package: 9mm\(^2\)

**Functional Diagram**

**General Description**
The HMC877LC3 is a phase shifter/time delay with 0 to 500° (1.4 UI) continuously adjustable shift/delay range. The delay control is linearly monotonic with respect to the differential control voltage (VDCP, VDCN) and the control input has a modulation bandwidth of 2.5 GHz. The device provides a differential output voltage with constant amplitude for single-ended or differential input voltages above the input sensitivity level, while the output voltage swing may be adjusted using the VAC control pin. The HMC877LC3 features internal temperature compensation and bias circuitry to minimize delay variations with temperature. The device also features a delay control voltage range adjustment pin, LC. All RF input and outputs of the HMC877LC3 are internally terminated with 50 Ohms to Vcc, and may either be AC or DC coupled. Output pins can be connected directly to a 50 Ohm to Vcc terminated system, while DC blocking capacitors must be used if the terminated system input is 50 Ohms to a DC voltage other than Vcc. The HMC877LC3 is available in ROHS-compliant 3x3mm SMT package.

**Electrical Specifications, \(T_A = +25^\circ C\), Vcc = 3.3V, GND=ODWN = 0V**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply Voltage</td>
<td>±5 Tolerance</td>
<td>3.135</td>
<td>3.3</td>
<td>3.465</td>
<td>V</td>
</tr>
<tr>
<td>Power Supply Current</td>
<td>ODWN = 0V</td>
<td>175</td>
<td>190</td>
<td>215</td>
<td>mA</td>
</tr>
<tr>
<td>Phase Shift Range</td>
<td>@ 10 GHz</td>
<td>504</td>
<td></td>
<td></td>
<td>Deg</td>
</tr>
<tr>
<td></td>
<td>@ 16 GHz</td>
<td>498</td>
<td></td>
<td></td>
<td>Deg</td>
</tr>
<tr>
<td></td>
<td>@ 22 GHz</td>
<td>485</td>
<td></td>
<td></td>
<td>Deg</td>
</tr>
<tr>
<td>Time Delay Range</td>
<td>@ 10 GHz</td>
<td>1.4</td>
<td></td>
<td></td>
<td>UI</td>
</tr>
<tr>
<td></td>
<td>@ 16 GHz</td>
<td>1.38</td>
<td></td>
<td></td>
<td>UI</td>
</tr>
<tr>
<td></td>
<td>@ 22 GHz</td>
<td>1.35</td>
<td></td>
<td></td>
<td>UI</td>
</tr>
<tr>
<td>Delay Control Modulation Bandwidth</td>
<td>VCC-0.6 VDCP</td>
<td>2.5</td>
<td></td>
<td></td>
<td>GHz</td>
</tr>
<tr>
<td>Delay Control Voltage (VDCP)</td>
<td>VCC+0.6 VDCP</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

\[1\] The UI stands for unit interval.

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Electrical Specifications, $T_A = +25^\circ C$, $Vcc = 3.3V$, GND=ODWN = 0V (Continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Amplitude Control Voltage (VAC)</td>
<td>Single-Ended, peak-to-peak @ 10 GHz</td>
<td>0.65</td>
<td>1.5</td>
<td>1.8</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Single-Ended, peak-to-peak @ 16 GHz</td>
<td>490</td>
<td>648</td>
<td></td>
<td>mVp-p</td>
</tr>
<tr>
<td></td>
<td>Single-Ended, peak-to-peak @ 22 GHz</td>
<td>420</td>
<td>520</td>
<td></td>
<td>mVp-p</td>
</tr>
<tr>
<td>Input Amplitude Range</td>
<td>Differential</td>
<td>200</td>
<td>1200</td>
<td>mVp-p</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Single-Ended</td>
<td>100</td>
<td>600</td>
<td>mVp-p</td>
<td></td>
</tr>
<tr>
<td>Harmonic Suppression*</td>
<td>VDCP=VDCN=3.3 V @ 22 GHz</td>
<td>26</td>
<td>48</td>
<td>dBC</td>
<td></td>
</tr>
<tr>
<td>$f_0$ is fundemental frequency</td>
<td>VDCP=VDCN=3.3 V @ 8 GHz</td>
<td>28</td>
<td>62</td>
<td>dBC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VDCP=VDCN=3.3 V @ 16 GHz</td>
<td>30</td>
<td>32</td>
<td>36</td>
<td>dBC</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>frequency &lt; 23 GHz</td>
<td></td>
<td></td>
<td>12</td>
<td>dB</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>frequency &lt; 23 GHz</td>
<td></td>
<td></td>
<td>6</td>
<td>dB</td>
</tr>
<tr>
<td>RMS Jitter</td>
<td>$\oplus$ 16 GHz</td>
<td></td>
<td></td>
<td>0.45</td>
<td>ps</td>
</tr>
<tr>
<td>Rise Time, tr</td>
<td>$\oplus$ 16 GHz</td>
<td></td>
<td></td>
<td>10</td>
<td>ps</td>
</tr>
<tr>
<td>Fall Time, tf</td>
<td>$\oplus$ 16 GHz</td>
<td></td>
<td></td>
<td>11</td>
<td>ps</td>
</tr>
<tr>
<td>Time Delay Temperature Sensitivity</td>
<td>$\oplus$ 16 GHz</td>
<td></td>
<td></td>
<td>0.05</td>
<td>deg/°C</td>
</tr>
<tr>
<td>Propagation Delay, td</td>
<td>VDCP=2.7V, VDCN=3.3V@ 16GHz</td>
<td></td>
<td></td>
<td>140</td>
<td>ps</td>
</tr>
</tbody>
</table>

* Harmonic suppression measurements are taken for single-ended inputs and outputs.

Time Delay vs. Frequency $[^{[1][2][3]}$

Time Delay vs. Bias Voltage $[^{[2][3][4]}$

[1] VCC = 3.3V
[2] ODWN= 0 V, VDCN=VCC
[3] On the x-axis differential control voltage represents VDCP-VDCN voltage
[4] Input Frequency: 20 GHz

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**Time Delay vs. Temperature**

![Time Delay vs. Temperature Graph](image)

**Time Delay vs. Control Voltage**

@ VDCP=2.7V to 3.9V with 0.1V step

![Time Delay vs. Control Voltage Graph](image)

**Time Delay vs. Temperature @ VDCP=3.3V**

(Relative to VDCP=VCC-0.6V)

![Time Delay vs. Temperature at VDCP=3.3V Graph](image)

**Phase Shift vs. Frequency**

![Phase Shift vs. Frequency Graph](image)

**Phase Shift vs. Bias Voltage**

![Phase Shift vs. Bias Voltage Graph](image)

**Phase Shift vs. Temperature**

![Phase Shift vs. Temperature Graph](image)

[1] VCC = 3.3V
[2] ODWN= 0 V, VDCN=VCC
[3] On the x-axis differential control voltage represents VDCP-VDCN voltage
[4] Input Frequency: 20 GHz
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---

**Phase Shift vs. Control Voltage**

@ VDCP=2.7V to 3.9V with 0.1V step \(1\)[2][3]

---

**Phase Shift vs. Temperature @VDCP=3.3V**

(Relative to VDCP=VCC-0.6V) \(1\)[2]

---

**Phase Error vs. Control Voltage**

@ Fmean=16 GHz \(1\)[2][3][4]

---

**Phase Shift vs. Control Voltage**

@ 10 GHz \(1\)[2][3][4]

---

**Phase Shift vs. Control Voltage**

@ 22 GHz \(1\)[2][3][4]

---

**DC Current vs. Temperature** \(2\)[5]

---

---

\[1\] VCC = 3.3V  
\[2\] O/DWN= 0 V, VDCN=VCC  
\[3\] 25°C  
\[4\] VDCP-VDCN=-0.6V is taken as reference level  
\[5\] VDCP=3.3V and input frequency is 20 GHz

---

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**Single-Ended Output Swing vs. Supply Voltage** [1][2][3]

**Single-Ended Output Swing vs. Frequency** [1][3][4]

**Single-Ended Output Swing vs. Control Voltage** [1][4][5]

**Duty Cycle Distortion @ 16 GHz** [1][4][5]

**Single-Ended Output Swing vs. Amplitude Control Voltage** [1][3][4][6]

---

[1] ODWN = 0V, VDCN = VCC

[2] Input Frequency: 20 GHz

[3] VCC = 3.3V

[4] VCC = 3.3V

[5] On the x-axis differential control voltage represents VDCP-VDCN voltage

[6] The input frequency is 10 GHz

---

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**RMS Jitter vs. Temperature**  
@ 16 GHz [1][2][3]

---

**RMS Jitter vs. Bias Voltage**  
@ 16 GHz [1][3][4]

---

**P_{fin} - P_{\text{fin}/2} Output Power Difference**  
vs. Control Voltage [1][2][5]

---

**P_{fin} - P_{\text{3fin}/2} Output Power Difference**  
vs. Control Voltage [1][2][5]

---

[1] ODWN= 0V, VDCN=VCC  
[2] VCC=3.3V  
[3] On the x-axis differential control voltage represents VDCP-VDCN voltage  
[4] Source jitter was not deembedded  
[5] fin is the fundamental frequency

---

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Second Harmonic vs. Control Voltage

Input Return Loss vs. Frequency

Output Return Loss vs. Frequency

Modulation Signal Bandwidth vs. Temperature

[1] VCC= 3.3 V, ODWN=0V
[2] fin is the fundamental frequency
[3] -6.8 dBm input power was applied to VDCP, VDCN is 50 Ohms terminated and fin=15 GHz
[4] VDCP=VDCN=VCC

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Output Eye Diagram Snapshot for 15 GHz Input Signal

Time Scale: 10 ps/div  
Amplitude Scale: 81.8 mV/div

Test Conditions:  
VCC=3.3 V, ODWN=0 V  
VDCP = 300 mVpp @ 1 MHz  
VDCN is 50 Ohms terminated

Measurement Results:  
RMS Jitter: 0.3 ps  
Peak to peak Jitter: 1.78 ps  
Rise Time: 11.78 ps  
Fall Time: 11.78 ps

Output Eye Diagram Continuous Snapshot for 15 GHz Input Signal

Time Scale: 10 ps/div  
Amplitude Scale: 81.8 mV/div

Test Conditions:  
VCC=3.3 V, ODWN=0 V  
VDCP = 300 mVpp @ 1 MHz  
VDCN is 50 Ohms terminated

Measurement Result:  
26.8 ps (0.4 UI )
### Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply Voltage (Vcc)</td>
<td>-0.5V to +3.75V</td>
</tr>
<tr>
<td>Input Voltage (V_{IN}), Output Voltage (V_{OUT})</td>
<td>Vcc -1.2V to Vcc+0.6V</td>
</tr>
<tr>
<td>Control Voltage (V_{DCP}), Delay Control Voltage Range Adjustment (L_{D})</td>
<td>0 to Vcc+0.6V</td>
</tr>
<tr>
<td>Amplitude Control Voltage (V_{AC})</td>
<td>- Vcc+0.6V</td>
</tr>
<tr>
<td>Channel Temperature (Tc)</td>
<td>125 °C</td>
</tr>
<tr>
<td>Continuous Pdiss (T = 85 °C) (derate 35.8 mW/°C above 85 °C)</td>
<td>1.43 W</td>
</tr>
<tr>
<td>Thermal Resistance (junction to ground paddle)</td>
<td>27.9 °C/W</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65 to +125 °C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40 to +85°C</td>
</tr>
<tr>
<td>ESD Sensitivity (HBM)</td>
<td>Class 1A</td>
</tr>
</tbody>
</table>

**ELECTROSTATIC SENSITIVE DEVICE**

**OBSERVE HANDLING PRECAUTIONS**
HMC877LC3

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Outline Drawing

**NOTEs:**
1. PACKAGE BODY MATERIAL: ALUMINA
2. LEAD AND GROUND PADDLE PLATING: 30-80 MICROINCHES GOLD OVER 50 MICROINCHES MINIMUM NICKEL.
3. DIMENSIONS ARE IN INCHES [MILLIMETERS].
4. LEAD SPACING TOLERANCE IS NON-CUMULATIVE.
5. CHARACTERS TO BE BLACK INK MARKED WITH .018"MIN to .030"MAX HEIGHT REQUIREMENTS. UTILIZE MAXIMUM CHARACTER HEIGHT BASED ON LID DIMENSIONS AND BEST FIT. LOCATE APPROX. AS SHOWN.
6. PACKAGE WARP SHALL NOT EXCEED 0.05mm DATUM -C-
7. ALL GROUND LEADS AND GROUND PADDLE MUST BE SOLDERED TO PCB RF GROUND.

Package Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package Body Material</th>
<th>Lead Finish</th>
<th>MSL Rating</th>
<th>Package Marking [2]</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMC877LC3</td>
<td>Alumina, White</td>
<td>Gold over Nickel</td>
<td>MSL3 [1]</td>
<td>H877 XXXX</td>
</tr>
</tbody>
</table>

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

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### Pin Descriptions

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Function</th>
<th>Description</th>
<th>Interface Schematic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 4-5, 8-9, 12</td>
<td>GND</td>
<td>Signal grounds should be connected to 0V. Ground paddle must be connected to DC ground.</td>
<td>![Interface Schematic 1]</td>
</tr>
<tr>
<td>2, 3, 6, 7</td>
<td>INP, INN, VDCP, VDCN</td>
<td>Differential signal inputs.</td>
<td>![Interface Schematic 2]</td>
</tr>
<tr>
<td>10, 11</td>
<td>QN, QP</td>
<td>Differential signal outputs.</td>
<td>![Interface Schematic 3]</td>
</tr>
<tr>
<td>13</td>
<td>VAC</td>
<td>The output amplitude control pin.</td>
<td>![Interface Schematic 4]</td>
</tr>
<tr>
<td>14</td>
<td>ODWN</td>
<td>Enable pin of the output. It should be connected to GND to enable the part. When it is connected to VCC or floated the output is set to VCC.</td>
<td>![Interface Schematic 5]</td>
</tr>
<tr>
<td>15</td>
<td>VCC</td>
<td>The supply voltage of the part.</td>
<td>![Interface Schematic 6]</td>
</tr>
</tbody>
</table>
## Pin Descriptions (Continued)

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>LC</td>
<td>This pin enables the control of the linearity level of Control Voltage vs. Phase Shift/Time Delay. Compromise is between linearity level and wideness of the Phase Shift/Time Delay tuning range. For optimum tuning range and linearity balance, R2=R3 are chosen as 4.7 kOhms.</td>
</tr>
</tbody>
</table>

### Application Circuit

![Application Circuit Diagram]

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**Evaluation PCB**

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 board should be mounted to an appropriate heat sink. The evaluation circuit board shown is available from Hittite upon request.

**List of Materials for Evaluation PCB EVAL01-HMC877LC3**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1 - J2, J5-J6</td>
<td>K Connector</td>
</tr>
<tr>
<td>J3-J4</td>
<td>SMA Connector</td>
</tr>
<tr>
<td>TP1-TP5</td>
<td>DC Pin</td>
</tr>
<tr>
<td>C1-C3</td>
<td>1000 pF Capacitor, 0402 Pkg.</td>
</tr>
<tr>
<td>C5-C7</td>
<td>0.1 µF Capacitor, 0402 Pkg.</td>
</tr>
<tr>
<td>C8-C9</td>
<td>4.7 µF Capacitor, Tantalum</td>
</tr>
<tr>
<td>R2-R3</td>
<td>4.7 kOhm Resistor, 0402 Pkg.</td>
</tr>
<tr>
<td>U1</td>
<td>HMC877LC3 Analog Phase Shifter/ Broadband Time Delay</td>
</tr>
<tr>
<td>PCB [2]</td>
<td>600-00064-00 Evaluation Board</td>
</tr>
</tbody>
</table>

[1] Reference this number when ordering complete evaluation PCB

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