1. Device Overview

1.1 General Description
NLTL-6273SM is a MMIC non-linear transmission line (NLTL) based comb generator. This NLTL offers excellent phase noise performance over a low 0.7 to 5 GHz input frequency range with output tones to 24 GHz. NLTL-6273SM is fabricated with GaAs Schottky diode based varactors and packaged into a surface mount 5x5 mm² QFN.

1.2 Features
- Low Phase Noise
- Broadband Input Frequencies
- No External DC Bias Required

1.3 Applications
- Comb Line Generation
- High Efficiency Multiplication
- Samplers
- Phase Locked Loops

1.4 Functional Block Diagram

1.5 Part Ordering Options

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Package</th>
<th>Green Status</th>
<th>Product Lifecycle</th>
<th>Export Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLTL-6273SM</td>
<td>5mm QFN</td>
<td>SM</td>
<td>RoHS</td>
<td>Active</td>
<td>EAR99</td>
</tr>
<tr>
<td>EVAL-NLTL-6273</td>
<td>Connectorized module, QFN reflowed onto PCB</td>
<td>EVAL</td>
<td></td>
<td>Active</td>
<td>EAR99</td>
</tr>
</tbody>
</table>

1 Refer to our website for a list of definitions for terminology presented in this table.
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Revision History

<table>
<thead>
<tr>
<th>Revision Code</th>
<th>Revision Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>October 2017</td>
<td>Datasheet Initial Release</td>
</tr>
<tr>
<td>A</td>
<td>October 2017</td>
<td>Corrected typos</td>
</tr>
<tr>
<td>B</td>
<td>August 2019</td>
<td>Added DC Current Plot</td>
</tr>
</tbody>
</table>
2. Port Configurations and Functions

2.1 Port Diagram
A bottom-up view of the NLTL-6273’s SM package outline drawing is shown below. The NLTL should only be used in the forward direction, with the input and output ports given in Port Functions.

2.2 Port Functions

<table>
<thead>
<tr>
<th>Port</th>
<th>Function</th>
<th>Description</th>
<th>Equivalent Circuit for Chip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 2</td>
<td>Input</td>
<td>Pin 2 is diode connected for the SM package.</td>
<td>Pin 2</td>
</tr>
<tr>
<td>Pin 18</td>
<td>Output</td>
<td>Pin 18 is diode connected for the SM package.</td>
<td>Pin 18</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
<td>SM package ground path is provided through the ground paddle.</td>
<td>GND</td>
</tr>
</tbody>
</table>
3. Specifications

3.1 Absolute Maximum Ratings
The Absolute Maximum Ratings indicate limits beyond which damage may occur to the device. If these limits are exceeded, the device may be inoperable or have a reduced lifetime.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum Rating</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port 1 DC Current</td>
<td>TBD</td>
<td>mA</td>
</tr>
<tr>
<td>Port 2 DC Current</td>
<td>TBD</td>
<td>mA</td>
</tr>
<tr>
<td>Power Handling, at any Port</td>
<td>+TBD</td>
<td>dBm</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-55 to +100</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65 to +125</td>
<td>°C</td>
</tr>
</tbody>
</table>

3.2 Package Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESD</td>
<td>Human Body Model (HBM), per MIL-STD-750, Method 1020</td>
<td>TBD</td>
</tr>
<tr>
<td>Weight</td>
<td>S Package</td>
<td>10 g</td>
</tr>
</tbody>
</table>

3.3 Recommended Operating Conditions
The Recommended Operating Conditions indicate the limits, inside which the device should be operated, to guarantee the performance given in Electrical Specifications. Operating outside these limits may not necessarily cause damage to the device, but the performance may degrade outside the limits of the electrical specifications. For limits, above which damage may occur, see Absolute Maximum Ratings.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Nominal</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_A$, Ambient Temperature</td>
<td>-55</td>
<td>+25</td>
<td>+100</td>
<td>°C</td>
</tr>
<tr>
<td>Input Power</td>
<td>+16</td>
<td></td>
<td>+26</td>
<td>dBm</td>
</tr>
</tbody>
</table>

3.4 Sequencing Requirements
This is a passive NLTL that requires no external DC bias. Self-bias of the diodes is sufficient for operation. It is not required, but is recommended to provide a 50Ω termination to each port before applying RF power.
3.5 Electrical Specifications
The electrical specifications apply at T_A=+25°C in a 50Ω system. Typical data shown is for the NLTL used in the forward direction with a +20 dBm sine wave\(^2\) input.

Min and Max limits apply only to our connectorized units and are guaranteed at T_A=+25°C. All bare die are 100% DC tested and visually inspected.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typical</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input (Port 1) Frequency Range</td>
<td>0.7</td>
<td>5</td>
<td></td>
<td></td>
<td>GHz</td>
</tr>
<tr>
<td>Output (Port 2) Frequency Range</td>
<td>0.7</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Power</td>
<td>+16</td>
<td>+26</td>
<td></td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>Maximum Output Harmonic for given Input</td>
<td>700 MHz Input</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 GHz Input</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 GHz Input</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 GHz Input</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 GHz Input</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^2\) Square Wave input generated using the ADM1-0026-5931SM and ADM1-0026-5929SM amplifier chain at +7 V\(_\text{d/c}\)-0.5 V\(_s\) with a +12 dBm input into the amplifier.
3.6 Typical Performance Plots

Output Power vs Input Power: 0.7 GHz Sine Wave Input (dBm)

0.7 GHz +24 dBm Sine Wave Input

NTL Output for 0.7 GHz +24 dBm Sine Wave Input

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Output Power vs Input Power: 1 GHz Sine Wave Input (dBm)

1 GHz +22 dBm Sine Wave Input

NTL Output for 1 GHz +22 dBm Sine Wave Input

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Output Power vs Input Power: 1 GHz Square Wave Input (dBm)

Output Frequency (GHz)

Output Power vs Input Power: 2 GHz Sine Wave Input (dBm)

Output Frequency (GHz)

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This space intentionally left blank
This space intentionally left blank

Output Power vs Input Power: 2 GHz Square Wave Input (dBm)

Output Power vs Input Power: 4 GHz Sine Wave Input (dBm)

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NLTL Output for 2GHz +25 dBm Square Wave Input

NLTL Output for 4GHz +24 dBm Sine Wave Input
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3.6.1 Typical Performance Plots: Residual Phase Noise

![Residual Phase Noise: 1 GHz Sine Wave Input, 5th Harmonic (dBc/Hz)](chart)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typical</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hz Offset</td>
<td>-120</td>
<td></td>
<td></td>
<td>dBc/Hz</td>
</tr>
<tr>
<td>10 Hz Offset</td>
<td>-130</td>
<td></td>
<td></td>
<td>dBc/Hz</td>
</tr>
<tr>
<td>100 Hz Offset</td>
<td>-140</td>
<td></td>
<td></td>
<td>dBc/Hz</td>
</tr>
<tr>
<td>1 KHz Offset</td>
<td>-150</td>
<td></td>
<td></td>
<td>dBc/Hz</td>
</tr>
<tr>
<td>10 KHz Offset</td>
<td>-160</td>
<td></td>
<td></td>
<td>dBc/Hz</td>
</tr>
<tr>
<td>100 KHz Offset</td>
<td>-170</td>
<td></td>
<td></td>
<td>dBc/Hz</td>
</tr>
<tr>
<td>1 MHz Offset</td>
<td></td>
<td>Thermal Floor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. Application Information

4.1 Detailed Description
NLTL-6273SM belongs to Marki Microwave’s NLTL family of multipliers and non-linear transmission lines. The NLTL product line consists of passive GaAs MMIC non-linear transmission lines designed and fabricated with GaAs Schottky diode based varactors. NLTLs take an input signal and create an impulse train of harmonics. Harmonic outputs up to and beyond 24 GHz are generated by the NLTL. The NLTL-6273SM is the packaged 5 mm QFN version of the NLTL-6273CH.

Port 1 supports L and S band input signals. Port 2 will output integer multiples of the input signal (i.e., x2, x3, x4, …, x24) up to the 24th output harmonic or a maximum of 24 GHz. Higher harmonics can be generated but will be at a lower efficiency.

The operating conditions of the NLTL are extremely important to optimize performance. High power inputs will increase the output power observed; however, the conversion efficiency will decrease. This is increasingly true for higher input frequencies and at input powers above the recommended limit. Optimal conversion efficiency of the NLTL is achieved using a square wave input with a fast rise time. Doing so causes a degradation in the 2nd output harmonic but otherwise improves the conversion efficiency at all other harmonics.

NLTL-6273SM requires no external DC bias. The self-bias of the diodes caused by the rectified RF input signal is sufficient for operation. For the best performance, optimization of the DC return path is recommended for each specific application to optimize the harmonic output power distribution.

The phase noise of a non-linear transmission line is outstanding. If verification of performance is necessary, the application circuit used and input conditions are extremely important. NLTLs are AM sensitive. If there is excessive AM noise on the input of the NLTL, observing the output of the NLTL will show excessive PM/phase noise because of the high AM to PM conversion property of NLTLs.
4.2 Application Circuit

DC Path to Ground — An RF choke followed by a 15 Ω resistor should be used to provide a DC path to ground on the input port of the NLTL. A shunt 1 μF capacitor is used to filter noise generated by the resistor. This forms the circuit which self-biases the NLTL. The DC return to ground removes DC rectified current created by high power RF signal injection. The DC path to ground is provided within the S package. A conical coil inductor is recommended to push the self-resonance frequency of the inductor past the operating bandwidth of the NLTL. The recommended inductance value of the conical coil inductor is 50nH or higher.

Blocking Capacitor — A DC blocking capacitor on the output of the NLTL-6273SM’s integrated circuit is necessary to prevent unwanted DC current flow from or to the output. If there is a DC signal on the input, place a DC block on the input to avoid disrupting the self-biasing of the diodes.
5. Mechanical Data

5.1 SM Package Outline Drawing

1. Substrate material is ceramic.
2. I/O Leads and Ground Paddle plating is (from base to finish):
   - Ni: 8.89µm MAX 1.27µm MIN
   - Pd: 0.17µm MAX 0.07µm MIN
   - Au 0.254µm MAX 0.03µm MIN
3. All unconnected pads should be connected to PCB RF ground.

5.2 SM Package Footprint

QFN-Package Surface-Mount Landing Pattern
Click here for a DXF of the above layout.
Click here for leaded solder reflow.  Click here for lead-free solder reflow
5.3 Evaluation Board Outline Drawing

- SMA Connector, 2 pi

Dimensions:
- 1.75 [44.45]
- 1.00 [25.40]
- 0.50 [12.70]