APPLICATION NOTE

SKY12212-478LF: Low Frequency Tuning

Introduction
The SKY12212-478LF is a high power handling, Single-Pole, Double-Throw (SPDT) silicon PIN diode switch. The device operates over the 50 MHz to 2.7 GHz band. It features low insertion loss, excellent power handling, and superb linearity with low DC power consumption. The SKY12212-478LF is well-suited for use as a high power transmit/receive switch in a variety of telecommunication systems such as Sat-Com, Cable TV, WiMAX, TD-SCDMA, or LTE base stations. The device is provided in a 4 x 4 mm, 16-pin Quad Flat No-Lead (QFN) package. The SKY12212-478LF block diagram is shown in Figure 1.

![SKY12212-478LF Block Diagram](image)

Abstract
The operating range specified in the standard data sheet for the SKY12212-478LF is 50 MHz to 2.7 GHz. The part has the capability to operate at lower frequencies with high input power. With modifications to the external bias circuitry, the SKY12212-478LF can operate from 20 MHz to 2700 MHz with low insertion loss, high isolation and 100 W power handling capability.

Theory of Operation
Operating at frequencies below 200 MHz presents problems not seen at higher frequencies. The series transmit diode has a characteristic to self-rectify at low RF frequencies and high power levels. In the transmit mode, high harmonic content is observed at input power levels above 42 dBm. This requires an innovative solution to reduce harmonic levels and maintain low TX insertion loss and high RX isolation up to 100 Watts.

The solution is to create an innovative bias decoupling network that reduces the harmonic distortion at low frequencies and high power levels.

At high power levels, a high harmonic content occurs because the RF input frequency is close to the SRF of the RF choke/DC bias inductors. As a result, the switch goes into an early compression state at power levels > 42 dBm. The bias inductors provide the RF choking on the DC bias lines without degrading the input and output VSWR. The inductor value must be selected properly as it affects the RF match. The solution is to modify the bias network by adding an additional inductor that has an SRF above the RF input.

The inductors are positioned in series to each other with the highest value inductor placed next to the switch. This provides the highest RF reactance for the best RF blocking and best match at lower operating frequencies. The evaluation board schematic diagram for the SKY12212-478LF for low frequency operation is shown in Figure 2. The low frequency tuned evaluation board is shown in Figure 3. The bill of materials is shown in Table 1.
Figure 2. SKY12212-478LF Evaluation Board Schematic for Low Frequency Tuning Diagram

Notes:
- R1 value set for 5 V, 100 mA bias
- R2 and R3 values set for 28 V, 100 mA bias

Figure 3. SKY12212-478LF Evaluation Board Layout for Low Frequency Tuning
Table 1. SKY12212-478LF Evaluation Board Bill of Materials

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
<th>Units</th>
<th>Size</th>
<th>Manufacturer</th>
<th>Mfr Part Number</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C2, C7, C9, C10, C11, C12</td>
<td>10000</td>
<td>pF</td>
<td>0603</td>
<td>Murata</td>
<td>GRM188R7H103K</td>
<td>X7R, 50 V, ±5%</td>
</tr>
<tr>
<td>C13</td>
<td>1</td>
<td>µF</td>
<td>0603</td>
<td>Murata</td>
<td>GRM188R71C105K</td>
<td>X7R, 16 V, ±10%</td>
</tr>
<tr>
<td>L3, L8, L9</td>
<td>1800</td>
<td>nH</td>
<td>0805</td>
<td>Coil Craft</td>
<td>0805LS-182XJLB</td>
<td>±5%, SRF 246 MHz</td>
</tr>
<tr>
<td>L4, L7, L10</td>
<td>390</td>
<td>nH</td>
<td>0805</td>
<td>TOKO</td>
<td>LL2012-FR39K</td>
<td>±10%, SRF 330 MHz</td>
</tr>
<tr>
<td>L6</td>
<td>820</td>
<td>nH</td>
<td>0603</td>
<td>Coil Craft</td>
<td>00603LS-821XJLB</td>
<td>±5%, SRF 410 MHz</td>
</tr>
<tr>
<td>R1</td>
<td>33</td>
<td>Ω</td>
<td>1206</td>
<td>Panasonic</td>
<td>ERJ8ENF33R0V</td>
<td>250 mW, 1%</td>
</tr>
<tr>
<td>R2, R3</td>
<td>560</td>
<td>Ω</td>
<td>2512</td>
<td>Multicomp</td>
<td>MCPWR12FTEA5600</td>
<td>1.5 W, 1%</td>
</tr>
<tr>
<td>U1</td>
<td>4 x 4 x 1.5 mm</td>
<td>Stock works</td>
<td>SKY12212-478LF</td>
<td>EVB</td>
<td>EN33-D785-001</td>
<td></td>
</tr>
</tbody>
</table>

Typical Performance Characteristics
(Top = +25°C, Pin = 0 dBm, ANT_DC = 5 V, TX_DC, RX_BIAS and RX_DC= 0/28 V, Characteristic Impedance [Zo] = 50 Ω, Unless Otherwise Noted)

![Figure 4. Insertion Loss vs Frequency](image1)

![Figure 5. Return Loss vs Frequency](image2)

![Figure 6. Isolation vs Frequency](image3)

![Figure 7. Insertion Loss vs CW Input Power vs Frequency](image4)
Summary

Operating high power PIN diode switches at frequencies below 200 MHz presents problems not seen at higher frequencies. In the transmit mode, high harmonic content is observed at input power levels above 42 dBm. The solution is to create an innovative bias decoupling network with two series RF chokes to reduce the harmonic distortion observed at low frequencies and high power levels.