50 Ω nominal input / conjugate matched balun to ST S2-LP, 433 MHz with integrated harmonic filter

Features
- 50 Ω nominal input / conjugate matched to ST S2-LP for 433 MHz frequency operation
- Low insertion loss
- Low amplitude imbalance
- Low phase imbalance
- Small footprint
- Very low profile < 620 μm after reflow
- High RF performance
- RF BOM and area reduction
- ECOPACK® compliant component

Applications
- 433 MHz impedance matched balun filter
- Optimized for ST S2-LP sub GHz RFIC

Description
This device is an ultra-miniature balun. The BALF-SPI2-02D3 integrates matching network and harmonics filter. Matching impedance has been customized for the ST S2-LP transceiver. The BALF-SPI2-02D3 uses STMicroelectronics IPD technology on non-conductive glass substrate which optimize RF performance.
### Characteristics

#### Table 1. Absolute maximum ratings ($T_{amb} = 25 \, ^\circ C$)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{IN}$</td>
<td>Input power $RF_{IN}$</td>
<td>20</td>
<td>dBm</td>
</tr>
<tr>
<td>$V_{ESD}$</td>
<td>ESD ratings human body model (JESD22-A114), all I/O one at a time while others connected to GND</td>
<td>2000</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>ESD ratings machine model (JESD22-A115), all I/O</td>
<td>200</td>
<td>V</td>
</tr>
<tr>
<td>$T_{OP}$</td>
<td>Operating temperature</td>
<td>-40 to +105</td>
<td>°C</td>
</tr>
</tbody>
</table>

#### Table 2. Impedances ($T_{amb} = 25 \, ^\circ C$)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z_{RX}$</td>
<td>Nominal differential RX balun impedance</td>
<td>-</td>
<td>matched ST S2-LP</td>
<td>-</td>
<td>Ω</td>
</tr>
<tr>
<td>$Z_{TX}$</td>
<td>Nominal TX filter impedance</td>
<td>50</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>$Z_{ANT}$</td>
<td>Antenna impedance</td>
<td>-</td>
<td>50</td>
<td>-</td>
<td>Ω</td>
</tr>
</tbody>
</table>

#### Table 3. Electrical characteristics and RF performances ($T_{amb} = 25 \, ^\circ C$)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Test condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f$</td>
<td>Frequency range</td>
<td></td>
<td>433</td>
<td>MHz</td>
</tr>
<tr>
<td>$IL_{RX,ANT}$</td>
<td>Insertion loss in bandwidth without mismatch loss (RX balun)</td>
<td></td>
<td>1.95</td>
<td>2.20</td>
</tr>
<tr>
<td>$IL_{TX,ANT}$</td>
<td>Insertion loss in bandwidth without mismatch loss (TX filter)</td>
<td></td>
<td>3.15</td>
<td>3.60</td>
</tr>
<tr>
<td>$RL_{RX,ANT}$</td>
<td>Input return loss in bandwidth (RX balun)</td>
<td></td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>$RL_{TX,ANT}$</td>
<td>Input return loss in bandwidth (TX filter)</td>
<td></td>
<td>6.5</td>
<td>8.0</td>
</tr>
<tr>
<td>$\phi_{imb}$</td>
<td>Output phase imbalance (RX balun)</td>
<td></td>
<td>-2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>$A_{imb}$</td>
<td>Output amplitude imbalance (RX balun)</td>
<td></td>
<td>-1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Att</td>
<td>Harmonic levels (TX filter)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Attenuation at 2fo</td>
<td>52</td>
<td>58</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>Attenuation at 3fo</td>
<td>53</td>
<td>63</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>Attenuation at 4fo</td>
<td>54</td>
<td>55</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>Attenuation at 5fo</td>
<td>54</td>
<td>55</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>Attenuation at 6fo</td>
<td>55</td>
<td>56</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>Attenuation at 7fo</td>
<td>56</td>
<td>57</td>
<td>dB</td>
</tr>
</tbody>
</table>
1.1 RF measurements (Rx balun)

**Figure 1. Insertion loss**

**Figure 2. Return loss on antenna**

**Figure 3. Amplitude imbalance**

**Figure 4. Phase imbalance**
1.2 RF measurements (Tx filter)

Figure 5. Transmission

Figure 6. Insertion loss

Figure 7. Return loss on antenna
1.3 ST S2-LP application diagram example

Figure 8. ST S2-LP application diagram example
2 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com. ECOPACK® is an ST trademark.

2.1 Flip-Chip 6 bumps package information

Table 4. Flip-Chip 6 bumps dimensions (in mm)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.580</td>
<td>0.630</td>
<td>0.680</td>
</tr>
<tr>
<td>A1</td>
<td>0.180</td>
<td>0.205</td>
<td>0.230</td>
</tr>
<tr>
<td>A2</td>
<td>0.380</td>
<td>0.400</td>
<td>0.420</td>
</tr>
<tr>
<td>b</td>
<td>0.230</td>
<td>0.255</td>
<td>0.280</td>
</tr>
<tr>
<td>D</td>
<td>2.050</td>
<td>2.100</td>
<td>2.150</td>
</tr>
<tr>
<td>D1</td>
<td></td>
<td>1.210</td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td></td>
<td>0.500</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td>1.500</td>
<td>1.600</td>
</tr>
<tr>
<td>E1</td>
<td></td>
<td>1.060</td>
<td></td>
</tr>
<tr>
<td>fD1</td>
<td></td>
<td>0.195</td>
<td></td>
</tr>
<tr>
<td>fD2</td>
<td></td>
<td>0.195</td>
<td></td>
</tr>
<tr>
<td>fE1</td>
<td></td>
<td>0.195</td>
<td></td>
</tr>
<tr>
<td>fE2</td>
<td></td>
<td>0.295</td>
<td></td>
</tr>
</tbody>
</table>
2.2 Flip-chip 6 bumps packing information

**Figure 10. Marking**

Dot, ST logo
- ECOPACK grade
- xx = marking
- z = manufacturing location
- yww = datecode

**Figure 11. Flip Chip tape and reel specifications**

Dot identifying Pin A1 location
All dimensions are typical values in mm
User direction of unreeling
3 PCB assembly recommendations

3.1 Land pattern

Figure 12. Recommended balun land pattern

![Recommended Balun Land Pattern](image)

Note: (*) Clearances 250 µm is needed to ensure good sensitivity.
(**) 1000 µm length between S2-LP & balun (between center QFN pads to center IPD pads).

Figure 13. PCB stack-up recommendations

```
Top plane

Mid Layer

Bottom plane

GND plane
```

35um + 31um
305um
31um
432um
35um + 31um
900um
3.2 Stencil opening design

**Figure 14. Footprint - 3 mils stencil - non solder mask defined**
- Copper pad diameter:
  - 220 µm recommended
  - 180 µm minimum
  - 260 µm maximum
- Solder mask opening:
  - 320 µm recommended
  - 300 µm minimum
  - 340 µm maximum
- Solder stencil opening:
  - 220 µm recommended

**Figure 15. Footprint - 3 mils stencil - solder mask defined**
- Copper pad diameter:
  - 220 µm recommended
  - 180 µm minimum
  - 260 µm maximum
- Solder mask opening:
  - 320 µm recommended
  - 300 µm minimum
- Solder stencil opening:
  - 220 µm recommended

**Figure 16. Footprint - 5 mils stencil - non solder mask defined**
- Copper pad diameter:
  - 220 µm recommended
  - 180 µm minimum
  - 260 µm maximum
- Solder mask opening:
  - 320 µm recommended
  - 300 µm minimum
  - 340 µm maximum
- Solder stencil opening:
  - 330 µm recommended*

*depending on paste, it can go down to 270 µm

**Figure 17. Footprint - 5 mils stencil - solder mask defined**
- Copper pad diameter:
  - 220 µm recommended
  - 180 µm minimum
  - 260 µm maximum
- Solder mask opening:
  - 320 µm recommended
  - 300 µm minimum
- Solder stencil opening:
  - 330 µm recommended*

*depending on paste, it can go down to 270 µm

3.3 Solder paste

1. Halide-free flux qualification ROL0 according to ANSI/J-STD-004.
2. "No clean" solder paste is recommended.
3. Offers a high tack force to resist component movement during high speed.
4. Use solder paste with fine particles: powder particle size 20-38 µm.
3.4 Placement

1. Manual positioning is not recommended.
2. It is recommended to use the lead recognition capabilities of the placement system, not the outline centering.
3. Standard tolerance of ±0.05 mm is recommended.
4. 1.0 N placement force is recommended. Too much placement force can lead to squeezed out solder paste and cause solder joints to short. Too low placement force can lead to insufficient contact between package and solder paste that could cause open solder joints or badly centered packages.
5. To improve the package placement accuracy, a bottom side optical control should be performed with a high resolution tool.
6. For assembly, a perfect supporting of the PCB (all the more on flexible PCB) is recommended during solder paste printing, pick and place and reflow soldering by using optimized tools.

3.5 PCB design preference

1. To control the solder paste amount, the closed via is recommended instead of open vias.
2. The position of tracks and open vias in the solder area should be well balanced. A symmetrical layout is recommended, to avoid any tilt phenomena caused by asymmetrical solder paste due to solder flow away.

3.6 Reflow profile

![Figure 18. ST ECOPACK® recommended soldering reflow profile for PCB mounting](image)

Note: Minimize air convection currents in the reflow oven to avoid component movement.

Note: More information is available in the application note:
- AN2348 Flip-Chip: “Package description and recommendations for use”
4 Ordering information

Table 5. Ordering information

<table>
<thead>
<tr>
<th>Order code</th>
<th>Marking</th>
<th>Package</th>
<th>Weight</th>
<th>Base qty.</th>
<th>Delivery mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>BALF-SPI2-02D3</td>
<td>TN</td>
<td>Flip-Chip 6 bumps</td>
<td>3.4 mg</td>
<td>5000</td>
<td>Tape and reel</td>
</tr>
</tbody>
</table>
Revised by

Table 6. Document revision history

<table>
<thead>
<tr>
<th>Date</th>
<th>Revision</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>02-May-2018</td>
<td>1</td>
<td>Initial release.</td>
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