1 Device Overview

1.1 General Description

MBAL-1445 is a high isolation MMIC balun. Passive GaAs MMIC technology allows production of smaller constructions that replace larger form factor circuit board constructions. Tight fabrication tolerances result in less unit to unit variation than traditional balun technologies, allowing for accurate simulations using the provided S3P file taken from measured production units. Baluns are passive reciprocal devices allowing either single ended to differential or differential to single ended conversion. Applications include high-speed track-and-hold amplifiers, analog-to-digital converters, digital-to-analog converters, balanced amplifiers, and signal integrity. The MBAL-1445SM is available as a 4 X 4 mm QFN package. Evaluation boards are also available.

1.2 Features
- 14GHz to 45GHz Balun (Balanced to Unbalanced Transformer)
- High Isolation
- High CMRR
- 1:2 Impedance Ratio
- RoHS Compliant
- S3P data MBAL-1445.zip

1.3 Functional Block Diagram

![Functional Block Diagram](image)

1.4 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>MBAL-1445SM</td>
<td>4 X 4 mm QFN</td>
<td>SM</td>
<td>RoHS</td>
<td>Active</td>
<td>EAR99</td>
</tr>
<tr>
<td>EVAL-MBAL-1445</td>
<td>Connectorized Evaluation Fixture</td>
<td>Eval</td>
<td>RoHS</td>
<td>Active</td>
<td>EAR99</td>
</tr>
</tbody>
</table>

1 Refer to our [website](https://www.markimicrowave.com) 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>June 2020</td>
<td>Initial Datasheet Release</td>
</tr>
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</table>
2 Port Configurations and Functions

2.1 Port Diagram
A bottom-up view of the MBAL-1445SM’s SM package outline drawing is shown below. The MMIC baluns are passive reciprocal devices allowing either single ended to differential or differential to single ended conversion.

2.2 Port Functions

<table>
<thead>
<tr>
<th>Port</th>
<th>Function</th>
<th>Description</th>
<th>Equivalent Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 1</td>
<td>Differential/ 0° Balanced</td>
<td>The 0° port is DC short to ground.</td>
<td>Pin 1</td>
</tr>
<tr>
<td>Pin 5</td>
<td>Differential / 180° Balanced</td>
<td>The 180° port is DC short to ground.</td>
<td>Pin 5</td>
</tr>
<tr>
<td>Pin 13</td>
<td>Unbalanced/ Single ended</td>
<td>The common port is DC open to ground.</td>
<td>Pin 13</td>
</tr>
<tr>
<td>Pad</td>
<td>Ground</td>
<td>SM package ground path is provided through the ground paddle.</td>
<td>Pad</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>Common Port DC Current</td>
<td>N/A</td>
<td>mA</td>
</tr>
<tr>
<td>Differential Port 1 DC Current</td>
<td>TBD</td>
<td>mA</td>
</tr>
<tr>
<td>Differential 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>N/A</td>
</tr>
</tbody>
</table>

3.3 Electrical Specifications¹
The electrical specifications apply at $T_A=+25°C$ in a 50Ω system.

Min and Max limits are guaranteed at $T_A=+25°C$.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Frequency (GHz)</th>
<th>Min</th>
<th>Typ.</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode conversion Loss</td>
<td>14-45</td>
<td></td>
<td>4.5</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Nominal Phase Shift</td>
<td></td>
<td></td>
<td>180</td>
<td></td>
<td>Degrees</td>
</tr>
<tr>
<td>Amplitude Balance</td>
<td>14-40</td>
<td>0.2</td>
<td>1</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>40-45</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase Balance</td>
<td></td>
<td></td>
<td>2.5</td>
<td>10</td>
<td>Degrees</td>
</tr>
<tr>
<td>Common Mode Rejection</td>
<td>14-45</td>
<td>19</td>
<td>33</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Isolation between differential ports</td>
<td></td>
<td>10</td>
<td>18</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>VSWR</td>
<td></td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impedance</td>
<td></td>
<td>50</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
</tbody>
</table>

¹ All measured data is taken from the eval board without de-embedding of the connectors and traces.
3.4 Typical Performance Plots

3.4.1 Mixed Mode Scattering Parameters

Mixed mode scattering parameters are used to characterize differential circuits. For baluns, this means that the 0° and 180° ports become a single 100Ω differential port and the common port remains the same 50Ω common port. The two-port s-parameters of the balun are then characterized based on differential (d), common mode (c), or single-ended (s) signals. For example: Scs21 is the Common output response given a single ended input.

Fig. 1. Insertion loss as a mode converter
Fig. 2. Unbalanced port return loss
Fig. 3. Return loss of differential Signal
Fig. 4. Insertion loss of a common mode signal
Fig. 5. Reflection converted between differential and common modes
Fig. 6. Return loss of a common mode signal
3.4.2 Typical Performance Scattering Parameter

Three port scattering parameters measured as three single-ended 50Ω ports showing relationship between any two ports.

![Graph 1: Insertion Loss](image1)

**Fig. 7.** Common to output port insertion loss

![Graph 2: Return Loss](image2)

**Fig. 8.** Return loss for common port and output ports.

![Graph 3: Isolation](image3)

**Fig. 9.** Isolation between differential ports

![Graph 4: Common Mode Rejection](image4)

**Fig. 10.** Common Mode Rejection Ratio.

![Graph 5: Phase Balance](image5)

**Fig. 11.** Phase balance between output ports.

![Graph 6: Amplitude Balance](image6)

**Fig. 12.** Amplitude balance between output ports.
4  Mechanical Data

4.1  SM Package Outline Drawing

Notes:

1. Substrate material is LCP.
2. I/O Leads and Ground Paddle plating is (from base to finish):
   Ni: 0.5um MIN
   Pd: 0.02um MIN
   Au: 0.05um MAX
3. All unconnected pins should be connected to PCB RF ground.

4.2  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.
4.3 Evaluation Board outline

<table>
<thead>
<tr>
<th>Port</th>
<th>Connector Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1</td>
<td>2.40mm Female</td>
</tr>
<tr>
<td>O2</td>
<td>2.40mm Female</td>
</tr>
<tr>
<td>IN</td>
<td>2.40mm Female</td>
</tr>
</tbody>
</table>

Note: Eval Package Connectors are not removable.

All measurements are typical.

- Edge Mount Connector 2.40 Female, 3PL
- Backside Label

DATASHEET NOTES:

2. $S_{dd22}$: differential return loss of the differential port driven with a differential signal
   $S_{dc22}$: differential return loss of the differential port driven with a common signal
   $S_{ds21}$: insertion loss from a single ended input to a differential output
   $S_{cc22}$: common mode return loss of the differential port driven with a common signal
   $S_{cd22}$: common mode return loss of the differential port driven with a differential signal
   $S_{cs21}$: insertion loss from a single ended input to a common output
   $S_{ss11}$: single ended return loss
   $S_{sd12}$: insertion loss from a differential signal to single ended output
   $S_{sc12}$: insertion loss from a common signal to single ended output

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