

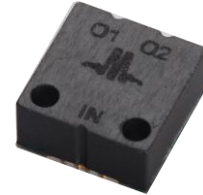
## LEAD-FREE / RoHS-COMPLIANT

### SURFACE-MOUNT BROADBAND BALUN

### BAL-0006SMG

#### Features

- 500 kHz to 6 GHz 1:2 Balun (Balanced to Unbalanced Transformer)
- Transforms 50  $\Omega$  Input to 100  $\Omega$  Differential (50 Ohm Single) Output
- Tuned for Optimal Phase/Amplitude Balance
- Applications: Analog to Digital Converters, Balanced Receivers, Baseband Digital Modulation, Signal Integrity
- [BAL-0006SMG.s3p](#)



**Electrical Specifications** - Specifications guaranteed from -55 to +100°C, measured in a 50 $\Omega$  system.

| Parameter                               | Frequency Range  | Min | Typ | Max |
|---|------------------|-----|-----|-----|
| Insertion Loss as a mode converter (dB) | 500 kHz to 6 GHz |     | 4   | 5.5 |
| Nominal Phase Shift (Degrees)           |                  |     | 180 |     |
| Amplitude Balance (dB)                  |                  |     | 0.4 | 1.2 |
| Phase Balance (Degrees)                 |                  |     | 3   | 10  |
| Common Mode Rejection (dB)              |                  | 20  | 30  |     |
| Isolation (dB)                          |                  |     | 8   |     |
| VSWR                                    |                  |     | 1.5 |     |
| Total Input Power (W)                   |                  |     |     | 1   |
| Risetime /Falltime (ps) <sup>1</sup>    |                  |     |     | 17  |

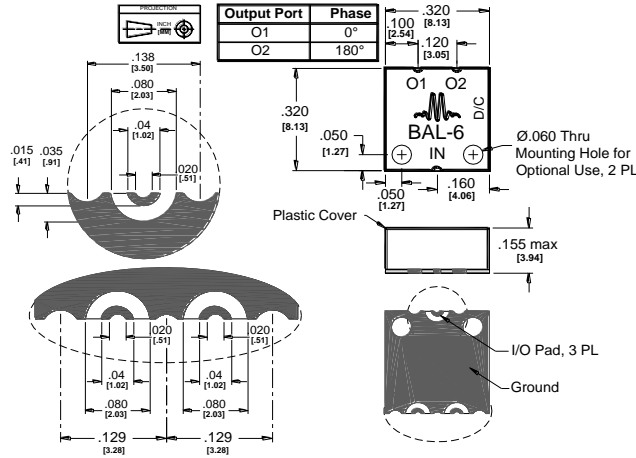
<sup>1</sup>Specified as 90%/10%. Calculated from  $\tau_{\text{balun}}^2 = (\tau_{\text{out}}^2 - \tau_{\text{in}}^2)$

| Model Number  | Description  |
|---------------|--|
| BAL-0006SMG   | 500 kHz to 6 GHz Balun, Surface Mount, <b>LEAD-FREE/RoHS COMPLIANT</b> |
| EVAL-BAL-0006 | Connectorized Evaluation Fixture, <b>LEAD-FREE/RoHS COMPLIANT</b>      |

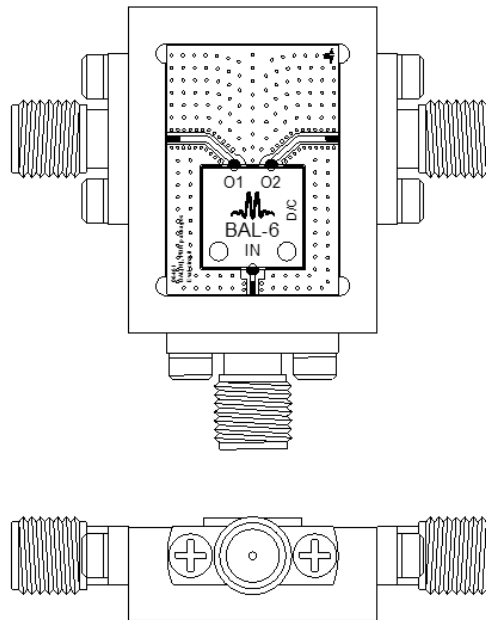
**SURFACE-MOUNT BROADBAND BALUN**

**BAL-0006SMG**

Page 2



Substrate material is 8-mil thick Rogers 4003, 1 Oz Electrodeposited Cu. I/O Pads & Ground Plane Finish is Gold Flash, 5 to 10 μ-inches, over Electroplated Nickel, 100-200 μ-inches, over Cu. See [BALSMG-PCB](#) for suggested PCB layout.



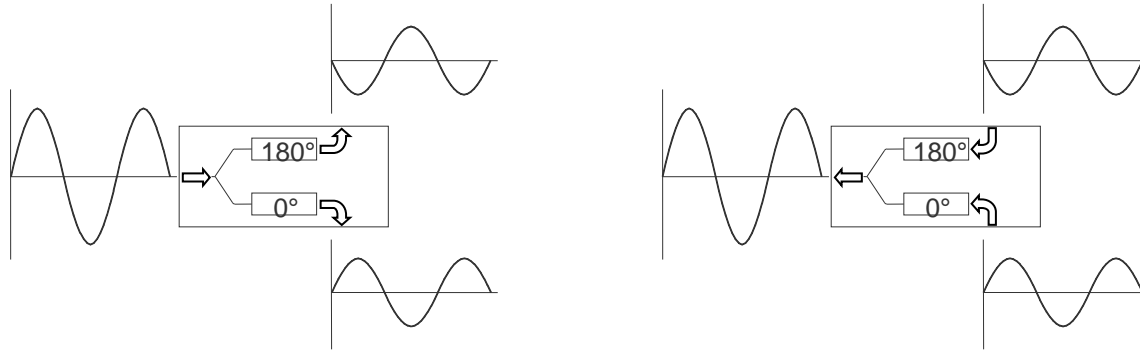
**Evaluation Board outline**

# SURFACE-MOUNT BROADBAND BALUN

# BAL-0006SMG

Page 3

## Block Diagram



Single ended to differential

Differential to single ended

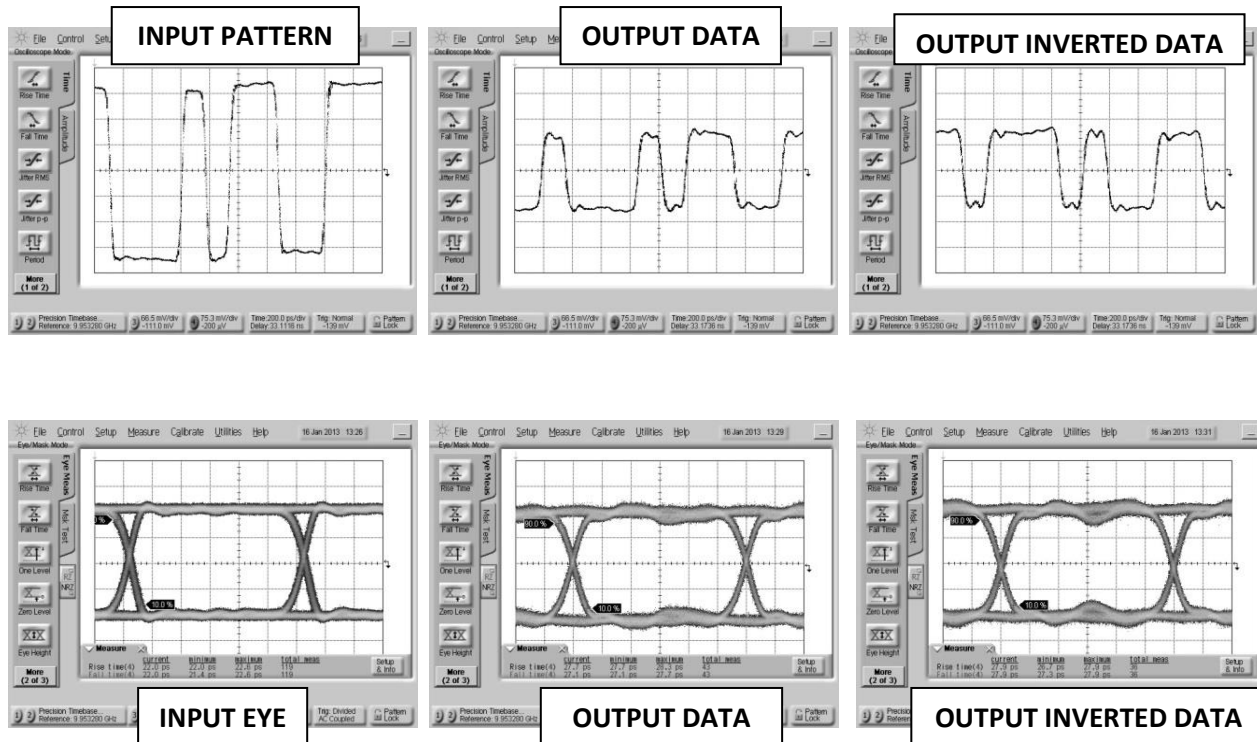


Fig. 1. Oscilloscope measurements of the BAL-0006SMG with a 6 Gb/s PRBS pattern. Bit pattern is measured with a  $2^7-1$  PRBS input demonstrating extremely good pulse fidelity for both inverted and non-inverted output. Eye diagrams are taken with a  $2^{31}-1$  PRBS input demonstrating minimal eye distortion/closure afforded by the extremely low frequency operation of the balun (<500 kHz).

## SURFACE-MOUNT BROADBAND BALUN

## BAL-0006SMG

Page 4

### Mixed Mode Scattering Parameters

Mixed mode scattering parameters are used to characterize differential circuits. For baluns, this means that the  $0^\circ$  and  $180^\circ$  ports become a single  $100\Omega$  differential port and the common port remains the same  $50\Omega$  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: Sds12 is the differential output response given a single ended input.

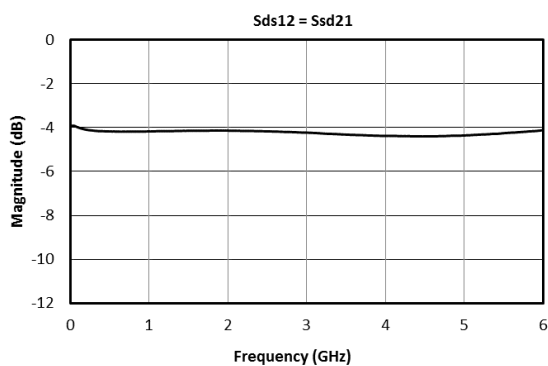


Fig. 2. Insertion loss as a mode converter

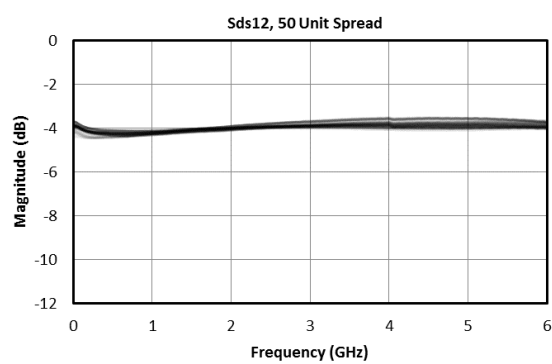


Fig. 3. Insertion loss as a mode converter across 50 units

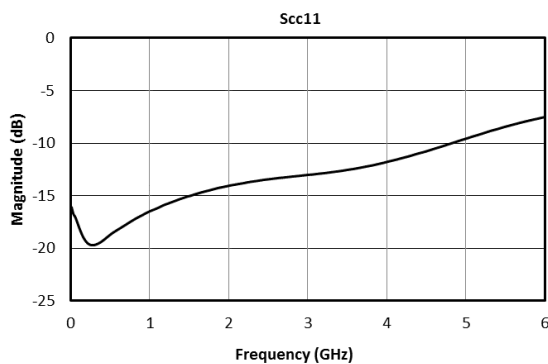


Fig. 4. Return loss of a common mode signal

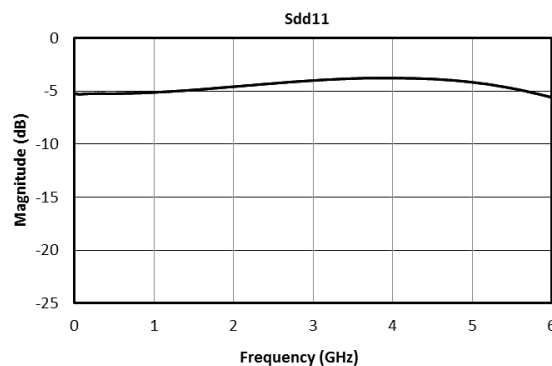


Fig. 5. Return loss of a differential signal

**SURFACE-MOUNT BROADBAND BALUN**

**BAL-0006SMG**

Page 5

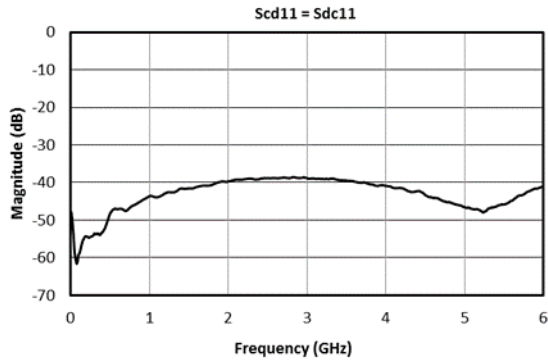


Fig. 6. Reflection converted between differential and common modes

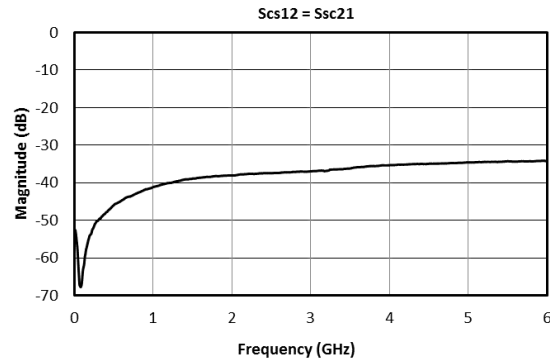


Fig. 7. Insertion loss of a common mode signal

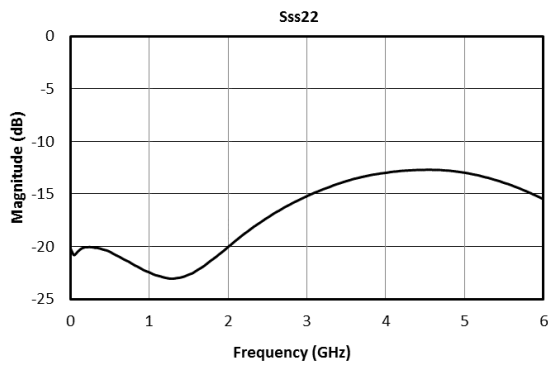


Fig. 8. Unbalanced port return loss

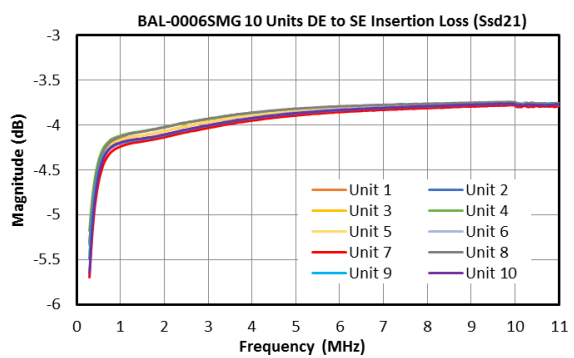


Fig. 9. Low frequency Insertion loss as a mode converter across 10 units

## SURFACE-MOUNT BROADBAND BALUN

## BAL-0006SMG

Page 6

### Typical Performance Scattering Parameters

Three port scattering parameters measured as three single-ended 50Ω ports showing relationship between any two ports. For example: S<sub>21</sub> and S<sub>31</sub>, often referred to as insertion loss of a balun, is the output response on ports 2 and 3 with an input stimulus on port 1.

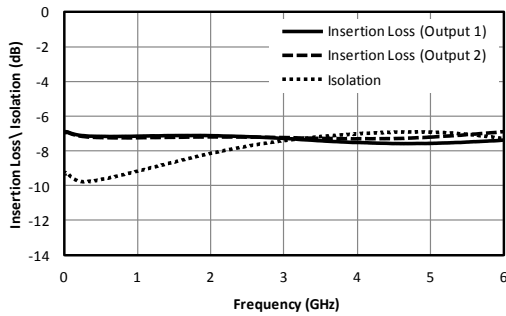


Fig. 10. Common to output port insertion loss and output to output port Isolation.

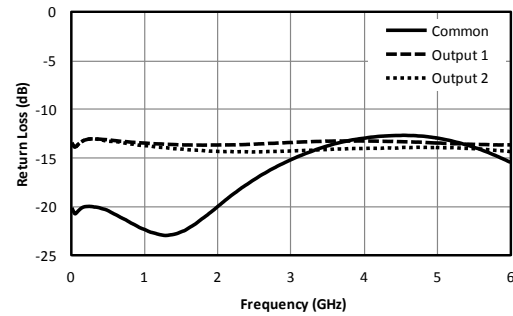


Fig. 11. Return loss for common port and output ports.

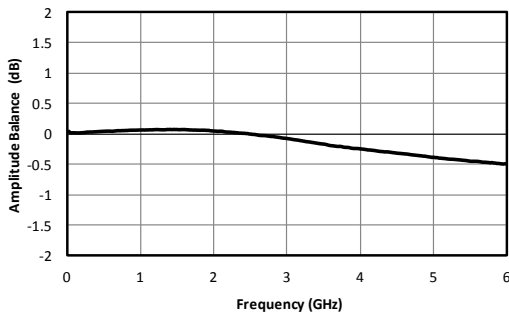


Fig. 12. Amplitude balance between output ports.

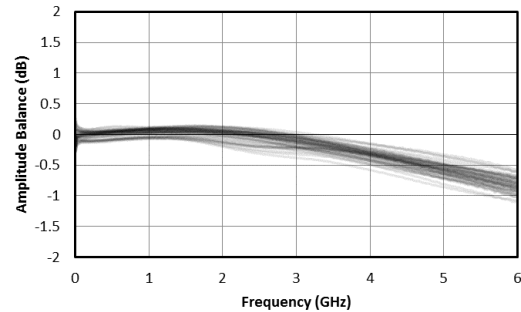


Fig. 13. Amplitude balance, 50 unit spread.

**SURFACE-MOUNT BROADBAND BALUN**

**BAL-0006SMG**

Page 7

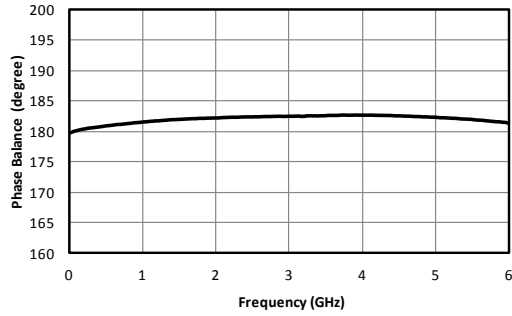


Fig. 14. Phase balance between output ports

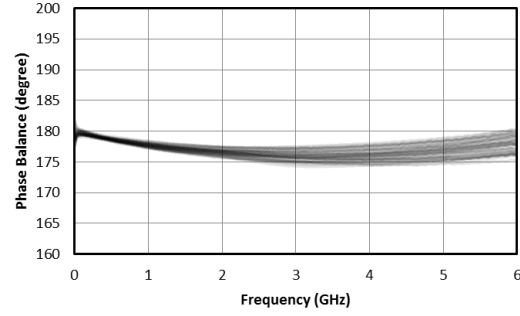


Fig. 15. Phase balance, 50 unit spread

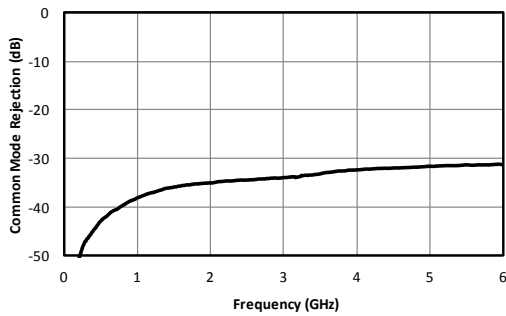


Fig. 16. Common mode rejection.

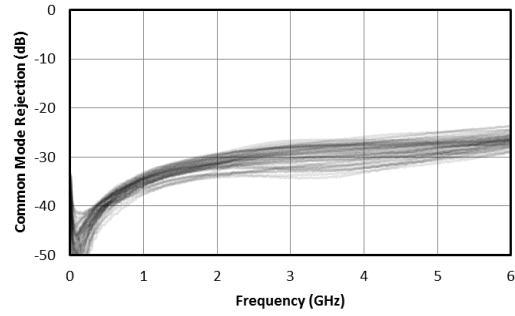


Fig. 17. Common mode rejection, 50 unit spread

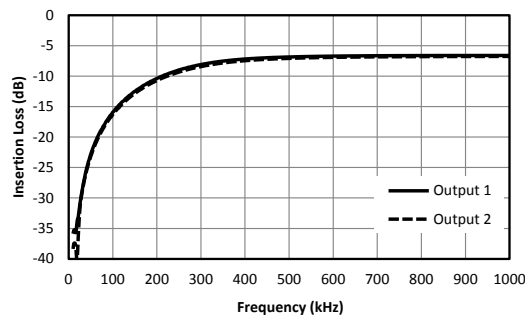



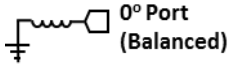
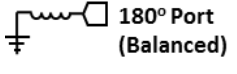
Fig. 18. Low Frequency Response

**SURFACE-MOUNT BROADBAND BALUN**

**BAL-0006SMG**

Page 8

**DC Interface**

| Port                          | Description                            | DC Interface Schematic  |
|-------------------------------|--|---|
| Common Port / In (Unbalanced) | The common port is DC short to ground. |  <p>Common Port (Unbalanced)</p> |
| Out 1 / 0° Port (Balanced)    | The 0° port is DC short to ground.     |  <p>0° Port (Balanced)</p>       |
| Out 2 / 180° Port (Balanced)  | The 180° port is DC short to ground.   |  <p>180° Port (Balanced)</p>     |

| Absolute Maximum Ratings |                 |
|--------------------------|-----------------|
| Parameter                | Maximum Rating  |
| DC Current               | TBD             |
| RF Power Handling        | 33 dBm          |
| Operating Temperature    | -55°C to +100°C |
| Storage Temperature      | -65°C to +125°C |





## SURFACE-MOUNT BROADBAND BALUN

**BAL-0006SMG**

Page 9

### DATASHEET NOTES:

1. Specified as 90%/10%. Calculated from  $\tau_{\text{balun}}^2 = (\tau_{\text{out}}^2 - \tau_{\text{in}}^2)$  with a 6 Gb/s input pattern.
2. Sdd22: differential return loss of the differential port driven with a differential signal  
Sdc22: differential return loss of the differential port driven with a common signal  
Sds21: insertion loss from a single ended input to a differential output  
Scc22: common mode return loss of the differential port driven with a common signal  
Scd22: common mode return loss of the differential port driven with a differential signal  
Scs21: insertion loss from a single ended input to a common output  
Sss11: single ended return loss  
Ssd12: insertion loss from a differential signal to single ended output  
Ssc12: insertion loss from a common signal to single ended output

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### Revision History

| Revision code | Revision Date | Comment   |
|---------------|---------------|---|
| -             | February 2013 | Datasheet initial Release                           |
| A             | March 2019    | Evaluation board outline added                      |
| B             | October 2019  | Mixed Mode Scattering Parameters added              |
| C             | April 2020    | Unit Spread Graphs Added                            |
| D             | July 2020     | Update Specs table & low frequency Ssd21 plot added |
| E             | October 2020  | Update Specs table                                  |

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