Anaren 0805 (B0809J50ATI) balun optimized for Texas Instruments CC1100/CC1101 Transceiver

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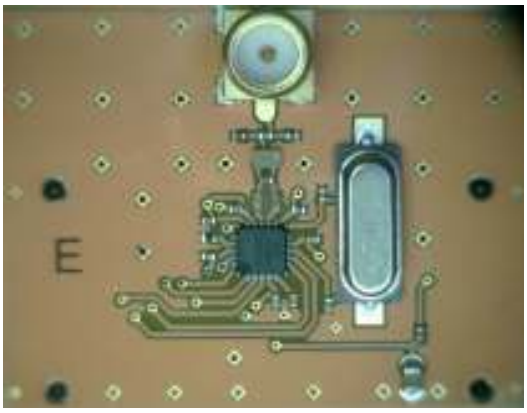


Introduction

The tradeoff between repeatability, cost and time to market plus the drive for miniaturization and integration has intensified over recent years. Designers find themselves forced to make compromises in management of the bill of materials whilst delivering the repeatability and performance metrics their marketing and management teams demand. The expectation is that the design must be robust enough to achieve good yields, but also have the lowest possible bill of materials content. Cost not only depends on the number and types of parts, but also on the size of the PCB and enclosure.

At Anaren the focus is always to develop solutions that address these design and manufacturing challenges, through the development of 100% RF tested components that increase yields and decrease product size and time to market. This application note demonstrates these objectives clearly as we present a small and simple single surface mounted balun solution optimized for use with Texas Instruments' CC1101 transceiver. The CC1101 transceiver radio is designed for a wide variety of applications from the newly ratified IEEE 802.15.4g (for smart utility networks) and 868MHz, 915MHz and 433MHz ISM applications. The balun solution presented in this application note uses only 7 components: a 2 mm by 1.25 mm (0805) Anaren multilayer matched balun, three DC blocking capacitors and three inductors for impedance matching. This results in a solution that uses 42% less components and improves performance according to the specifications in the CC1101 data sheet. The results presented in this application note cover 868MHz and 915MHz frequencies and apply to the CC1100 transceiver as well.

The CC1101 combines the excellent performance of a leading RF transceiver with an industry-standard enhanced 8051 MCU, in-system programmable flash memory, 8-KB RAM, and many other powerful features. The CC1101 comes in four different flash versions: CC1101F32/64/128/256, with 32/64/128/256 KB of flash memory, respectively. The CC1101 is highly suited for systems where ultra low power consumption is required.

For more information about this or any other products currently available in the Anaren product portfolio, please visit our website at www.anaren.com for datasheets, S parameters and general corporate information.

For more information on Low Power Wireless products from Texas Instruments please visit www.ti.com\lpw

Comparisons of Different Balun Solutions

The RF front end for the CC1101 is architecturally simple in that both receiver LNA and transmitter PA are attached to the same set of balanced pins. Hence impedance matched, balanced to single ended transformation is all that is needed.

A multitude of possible balun implementations exist. Texas Instruments provides one such reference design which uses 12 discrete components. The solution from Anaren, described in this document, uses a discrete balun, a pi filter at the antenna port and one at the balanced ports. Below is a detailed comparison of the lumped element solution and the IC balun solution.

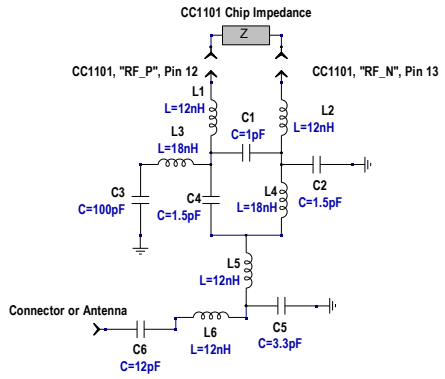


Figure 1 Schematic of Lumped element implementation

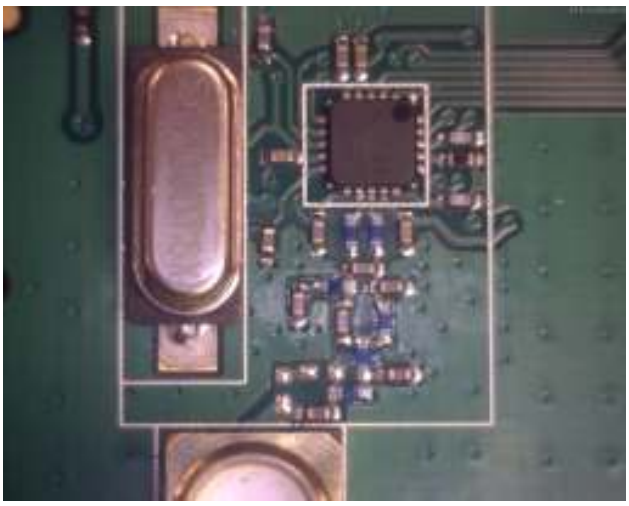


Figure 2 Layout of Lumped element implementation

The lumped element implementation shown in Figure 1 and Figure 2 uses 6 capacitors and 6 inductors. The PCB real estate taken up is significant and the performance is sensitive to changes in component vendor, component placement, PCB thickness and variation in the PCB material.

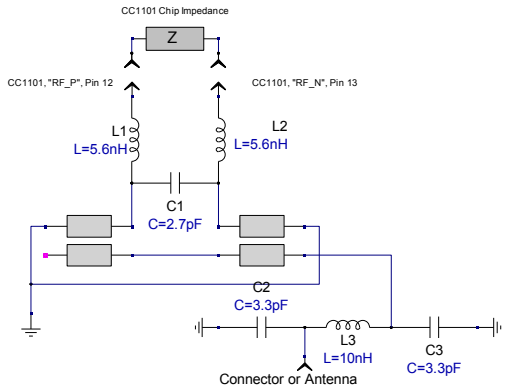


Figure 3 Schematic of the Anaren balun implementation with 0402 matching components

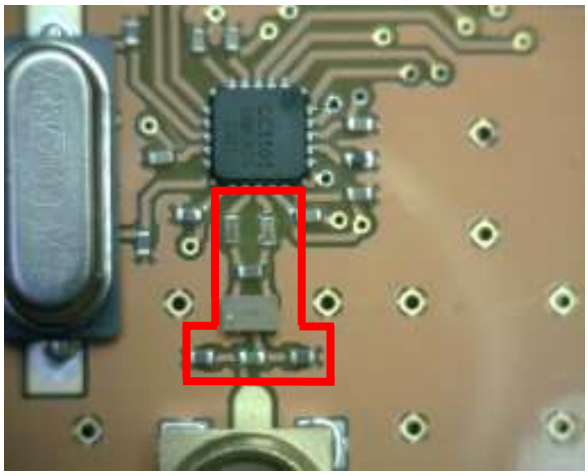


Figure 4 Layout of the Anaren balun implementation with 0402 matching components

The Anaren solutions shown in Figure 4 take up significantly less number of external matching components which make them less susceptible to the discrete component tolerance/variation.

The recommended Anaren solutions are:

B0809J50ATI balun with 0402 matching components: 10nH (MurataLQG15HS10NJ02D), two 5.6nH (MurataLQP15MN5N6B02), two 3.3pF (MurataGRM1555C1H3R3CZ01D), and a 2.7pF (MurataGRM1555C1H2R7CZ01D).

Table 1 demonstrates the significant reduction in component count achieved with the Anaren 0805 balun solution.

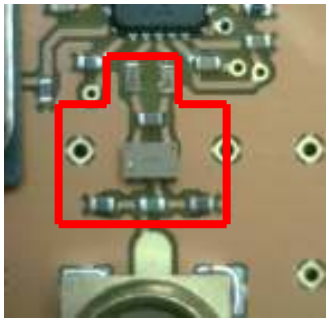
Lumped element design	Anaren balun 0402 matching components
	
12 Total 6 Capacitors 6 Inductors	7 Total 1 Balun 3 Inductor 3 Capacitor

Table 1 Comparison of the different implementations

Care should be taken using alternate vendors especially on the inductor as they do not have the same performance. Each vendor of inductors and capacitors has their own way of realizing the parts with associated differences in parasitic values. Even within a single vendor, different component series are made differently, with significantly different parasitic. Also from one value to the next in the same series there can be parasitic differences. It is highly recommended to use the same parts as mentioned in this application note.

The Anaren recommended layouts with 0402 matching components are fabricated on a 31.5mil (0.8mm) thick FR4 board. If a multilayer board is used it is recommended that internal power/GND planes be opened such that the effective height to GND is roughly 0.8mm, as illustrated in Figure 5. If it is not possible to open up internal layers then follow recommendations in Table 2 for changes to the transmission lines identified in Figure 6. The differential lines are identified with red arrows and the single ended connection identified with a blue arrow.

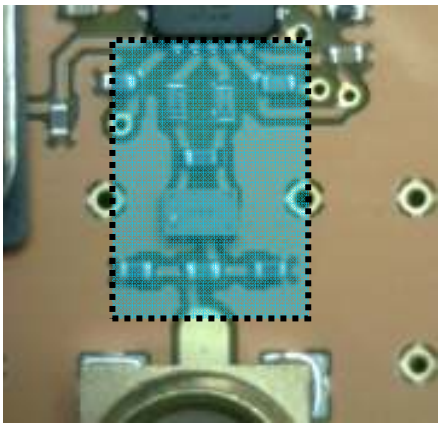


Figure 5 Opening in power/GND planes below RF circuitry

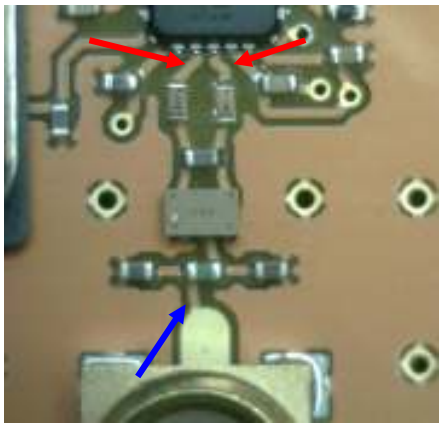


Figure 6 Differential (red) connecting lines and single ended (blue) connecting line

Distance between ground and circuit layer mil (mm)	Differential line width Width/Length mil(mm)/mil(mm)	Single ended line width Width/Length mil(mm)/mil(mm)
5 (0.127), PI	8(0.203)/170(4.318)	24(0.61)/100(2.54)
8 (0.203), Ro4350	8(0.203)/170(4.318)	24(0.61)/100(2.54)
10 (0.254), FR4	10(0.254)/154(3.912)	24(0.61)/100(2.54)
20 (0.508), FR4	10(0.254)/100(2.54)	55(1.397)/195(4.953)
31.5 (0.699), FR4	10(0.254)/40(1.016)	55(1.397)/195(4.953)
40 (1.016), FR4	10(0.254)/40(1.016)	55(1.397)/195(4.953)
60 (1.524), FR4	10(0.254)/40(1.016)	55(1.397)/195(4.953)

Table 2 : Differential line and single ended line width/length for various substrate heights based on Anaren 0805 balun with 0402 matching components

The above mentioned line lengths and widths are for B0809J50ATI Anaren balun with 0402 matching components only. The line length will change for Anaren balun with 0201 matching components. The values in table1 are simulated results only, except the row highlighted in green.

Changing the placement or value of the components and the dimensions of the PCB traces could affect the performance. It is therefore recommended to keep the DC block capacitor and the inductor for impedance matching close to the balun. The layout of the transmission lines connected to the balun should follow the recommendations in Table 2.

The value of the inductor and the capacitor also depends on the length of the transmission line used between the CC1101 chip and the balun. If the length of the transmission line between the chip and the balun is increased then the inductor and the capacitor values should be decreased and vice versa if the length of the line is decreased.

The SMA on the reference design can be replaced with an antenna or a different SMA connector. It is important in such cases to implement a 50 ohm trace between the balun and the antenna to achieve proper performance.

The lumped elements usually have 5% tolerance each and the discrete solution put together with 12 components will lead to very large variation in the performance but Anaren balun is consistent and tolerant to PCB manufacturing tolerances.

Production average and worst case data for the B0809J50ATI are illustrated in Figure 7 Balun Performance

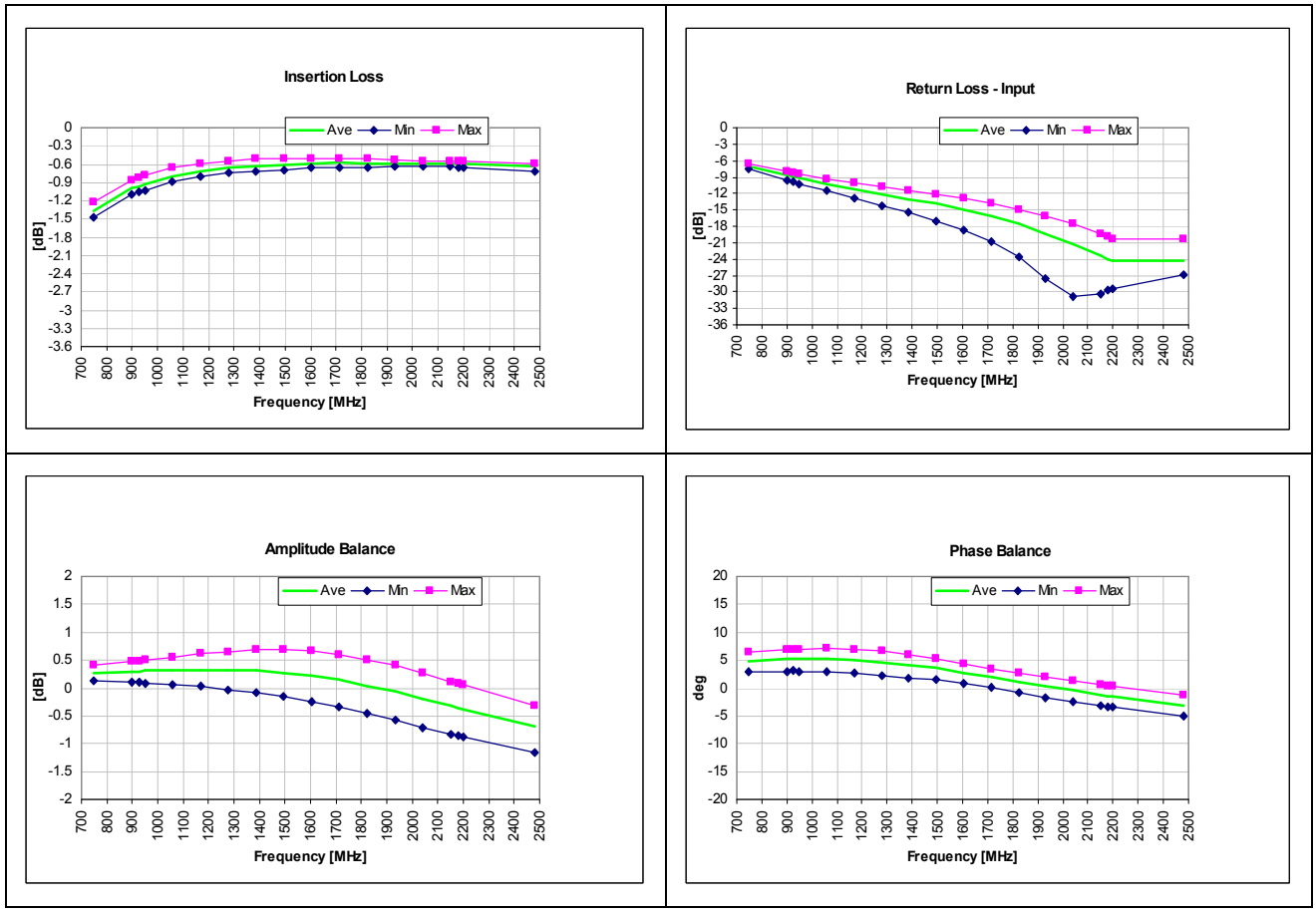


Figure 7 Balun Performance

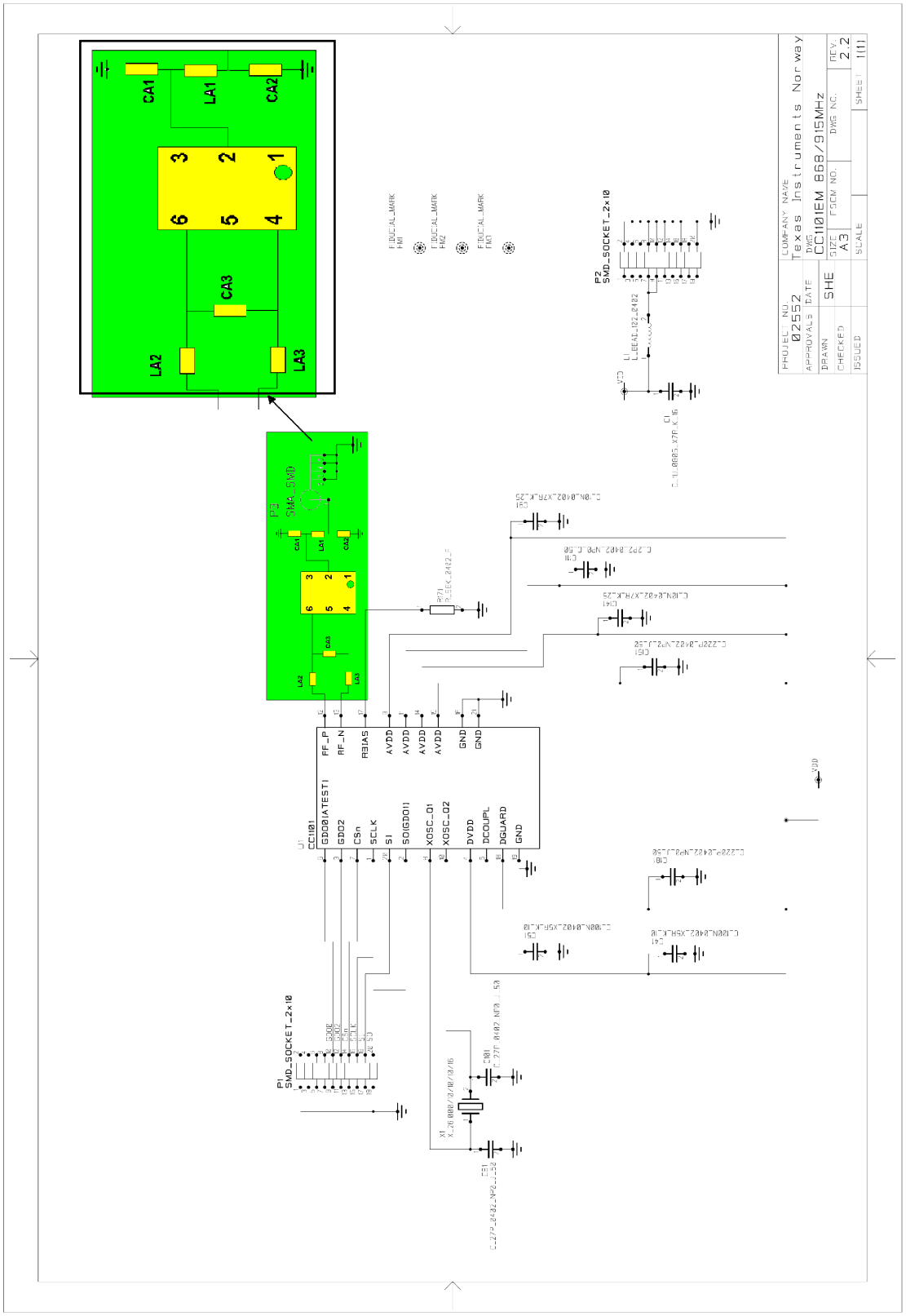


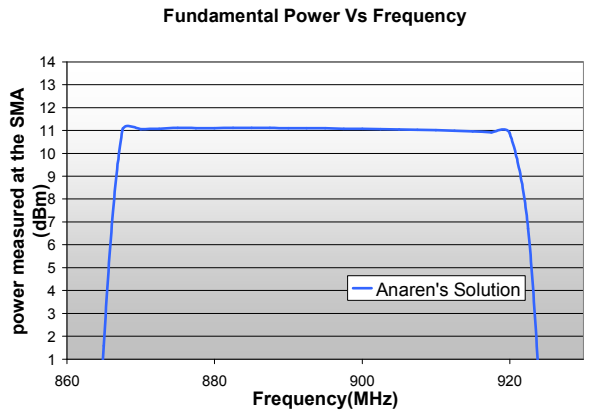
Figure 8 Evaluation daughter board schematic with the Anaren balun

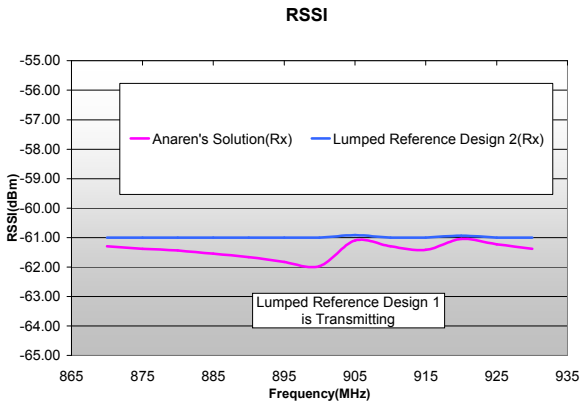
Application Verification

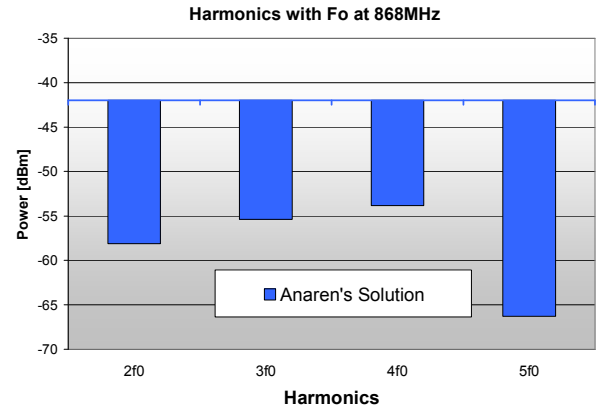
Measurements verify that the reference design presented in this application note has the same performance as represented in the data sheet. These measurements include;

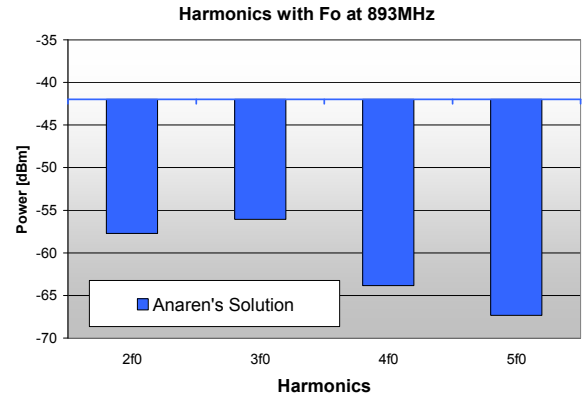
- Transmit Power
- Receive Sensitivity
- Harmonics

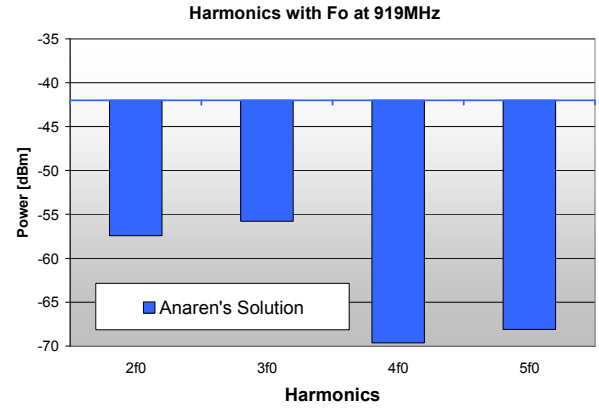
Performance plots at 10dB power level selected at TI's RFstudio tool











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Sales Desk Europe: Voice: **(+44) 2392 232392** Fax: **(+44) 2392 251369**

References

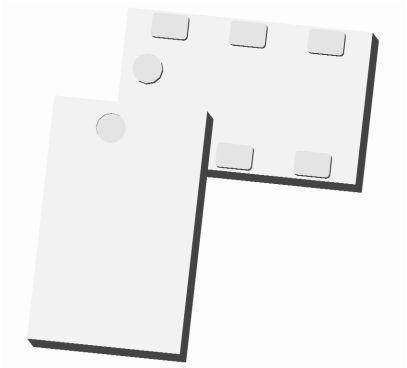
1. http://focus.ti.com/docs/prod/folders/print/cc1101.html - CC1101EM Reference Design
2. http://focus.ti.com/docs/prod/folders/print/cc1101.html - CC1101 Development kit user manual

Please contact Anaren questions/enquiries or visit www.anaren.com for gerber files of the recommended layout.

http://www.anaren.com/pages/index.cfm?id=162&page=appnotes

Impedance Matched Ultra Low profile 0805 Balun for TI CC1101/1100 chipset

(Anaren Application Note Ann-2005)



Description

The B0809J50ATI is a low cost, low profile sub-miniature unbalanced to balanced transformer specifically designed for differential inputs and output locations Texas Instruments CC1100 and CC1101 SoC Solution in an easy to use surface mount package. The B0809J50ATI is ideal for high volume manufacturing and delivers higher performance than traditional ceramic baluns. This transformation enables single ended signals to be applied to differential ports on the CC1100/CC1101. The output ports have equal amplitude (-3dB) with 180 degree phase differential. The B0809J50ATI is available on tape and reel for pick and place high volume manufacturing.

Detailed Electrical Specifications: Specifications subject to change without notice.

Features:

- **850 – 915 MHz**
- **Matched to TI CC1100 & CC1101 SoC**
- **0.7mm Height Profile**
- **Low Insertion Loss**
- **Surface Mountable**
- **Tape & Reel**
- **Non-conductive Top Surface**
- **RoHS Compliant**
- **Zigbee, RF4CE**
- **Halogen Free**

Parameter	ROOM (25°C) Min.	Typ.	Max	Unit
Frequency	850		915	MHz
Unbalanced Port Impedance*		50		Ω
Balanced Port Impedance*		Matched		Ω
Return Loss*	15.3	18.0		dB
Insertion Loss**		0.5	0.6	dB
Power Handling			2.0	Watts
Operating Temperature	-55		+85	*°C*

*Specification based on performance of unit properly installed on microstrip printed circuit boards according to Anaren application note Ann-2005.

** Insertion Loss stated at room temperature (Insertion Loss is approximately 0.1dB higher at +85°C

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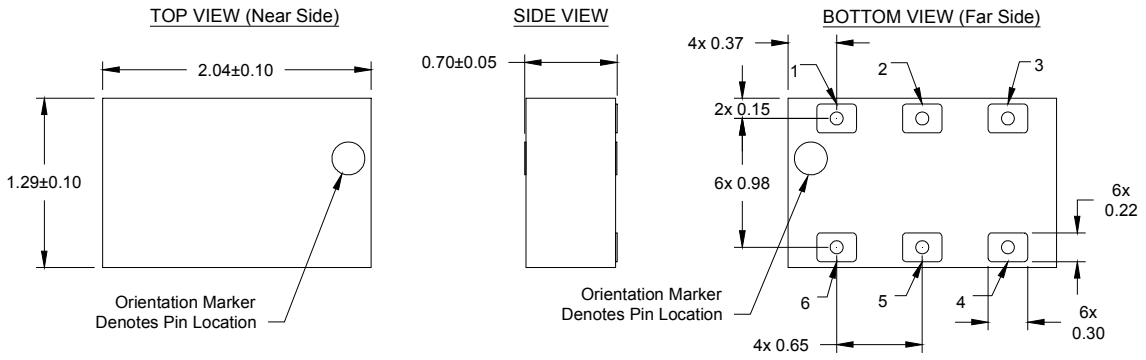
Outline Drawing



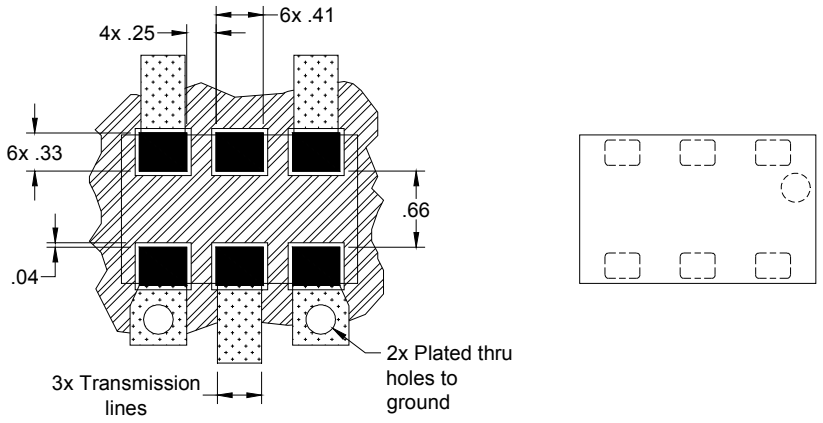
Pin	Designation
1	GND
2	Unbalanced Port
3	GND
4	Balanced Port
5	NC
6	Balanced Port

Mechanical Outline
-Dimensions are in Millimeters

Mounting Configuration:

In order for Xinger surface mount components to work optimally, the proper impedance transmission lines must be used to connect to the RF ports. If this condition is not satisfied, insertion loss, Isolation and VSWR may not meet published specifications.

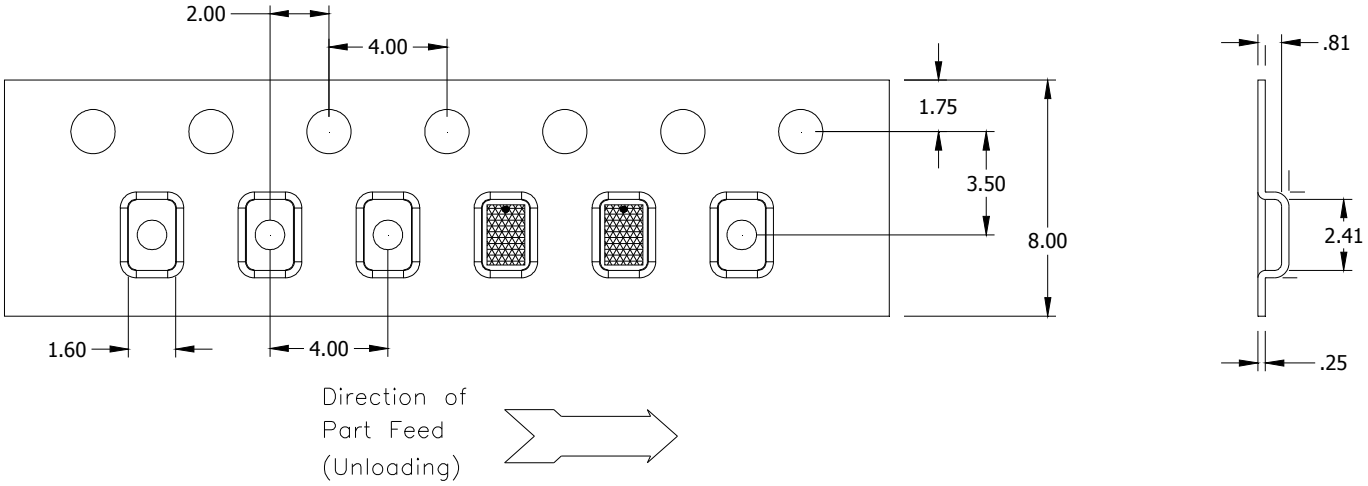
All of the Xinger components are constructed from organic PTFE based composites which possess excellent electrical and mechanical stability. Xinger components are compliant to a variety of ROHS and Green standards and ready for Pb-free soldering processes. Pads are Gold plated with a Nickel barrier.



Dimensions are in Millimeters
Mounting Footprint

Packaging and Ordering Information

Parts are available in reel and are packaged per EIA 481-2. Parts are oriented in tape and reel as shown below. Minimum order quantities are 4000 per reel. See Model Numbers below for further ordering information.



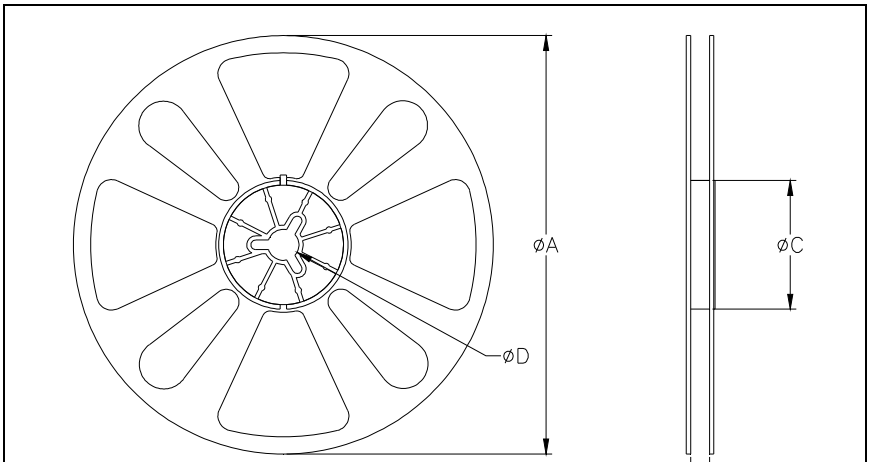


TABLE 1		
QUANTITY/REEL	REEL DIMENSIONS mm	
4000	øA	177.80
	B	8.00
	øC	50.80
	øD	13.00