BGA758L7

BGA758L7 Low Noise Amplifier for 5-6 GHz WLAN/WiMAX Applications

Application Note AN188

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Page	Subjects (major changes since last revision)

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1 Introduction

1.1 Features

- Gain = 12.5 dB at 5.5 GHz
- High Linearity, Input P-1dB = -3.5 dBm
- Low noise figure, NF = 1.1 dB
- Output matching integrated
- DC-decoupled RF output port
- Temperature and voltage compensated internal biasing circuit
- Digital power on/off switch integrated
- Low external part count
- 1kV HBM ESD protection (including IN-pin)
- B7HFM silicon germanium technology
- Tiny TSLP-7-8 leadless package
- Pb-free (RoHS compliant) package

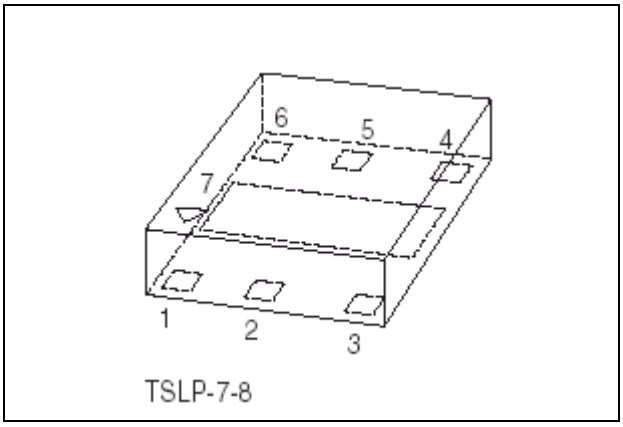

Figure 1 TSLP-7-8 Package

1.2 Applications

There is increasing number of applications in the frequency band of 5 to 6 GHz. Due to the too cloudy WLAN network at 2.4GHz, the WLAN applications at 5-6 GHz are gaining focus. Not only using WLAN for the high data rate access to the internet, but also different applications like home entertainment with wireless high-quality multimedia signal transmission and home networking amount notebooks, mass data storages and printers, implement 5-6 GHz WLAN features into their system to offer high-speed wireless connection.

In addition, high-band WiMAX is using the same frequency range. WiMAX is the upcoming emerging application for high data rate wireless communication up to 70Mbits/s which is suitable for fixed point-to-point (P2P) communication and also for portable or mobile connections.

For these kinds of high-speed, high data rate wireless communication standards, it is essential to ensure the quality of the link path. Major performance criteria of these equipments have to be fulfilled: sensitivity, strong signal capability and interference immunity.

In order to increase the system sensitivity, to put an excellent low noise amplifier in front of the receiver is mandatory, especially in the environment with very weak signal strength. A good high-gain and low noise amplifier can increase the system sensitivity by several dB. As an example, to increase the sensitivity by 5dB means doubled link distance.

In addition, string signal environment can exist when the equipment is next to the transmitter. In that case, the LNA must be “strong” enough, i.e. to have high -1dB compression point, to avoid entering into saturation and degrading the gain with increase noise figure.

The cloudy wireless environment nowadays makes the wireless system design more complicated. All kinds of interference might introduce signal distortion and reduce the real throughput data rate. To ensure that the low noise amplifier does not interfered by those signals, high linearity characteristics like IP3 is required.

Figure 2 shows a general application diagram of a WLAN system. BGA758L7 as an low noise amplifier with outstanding noise figure. Moderate gain, high -1dB compression point and high 3rd intercept point supports the reception of the WLAN transceiver to boost the system sensitivity in weak signal environment and ensures high data rate even under environment with strong interference signals. The 1kV HBM ESD robustness of BGA758L7 among the all pins helps customers’ assembly lines to avoid ESD issues during the production.

Infineon offers not only the low noise amplifier, but also the ESD systems. The ESD protection diode ESD0p2RFL has a capacitance value of only 0.2pF and can protection up to 8kV contact discharge according to IEC-61000-4-2 standard. The Power detection diode BAR63x helps the transceiver IC to get the real information about the transmission power in the Tx path.

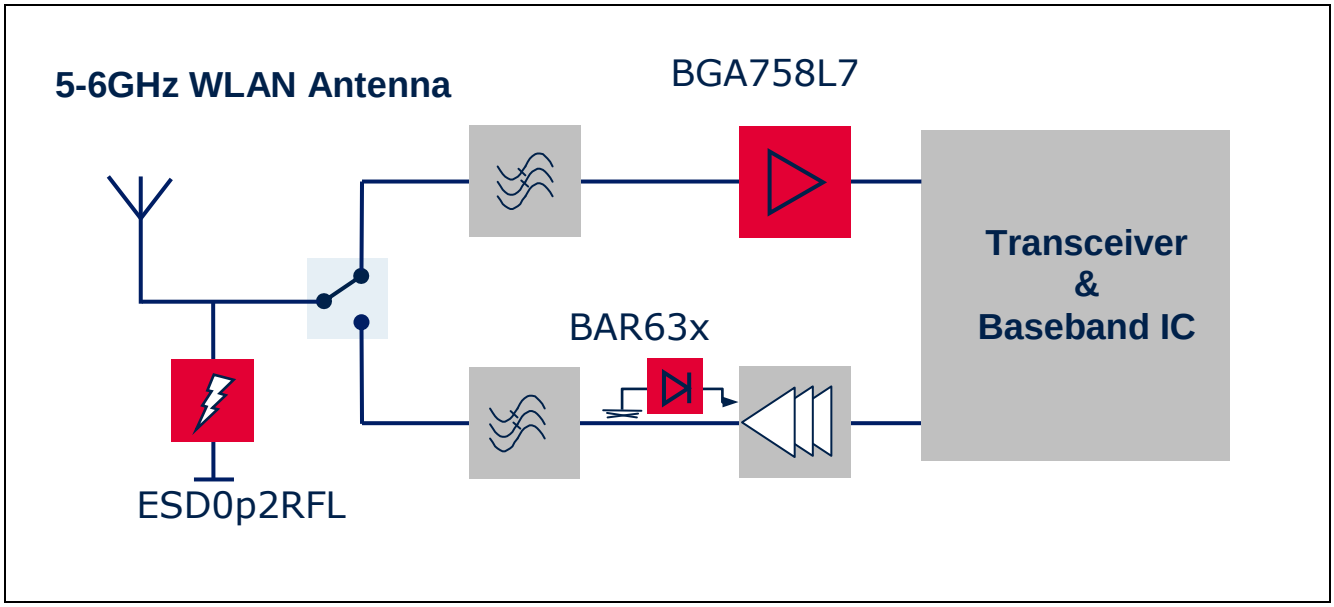

Figure 2 **5-6 GHz WLAN system with LNA BGA758L7, ESD protection diode ESD0p2RFL and power detection diode BAR63x.**

1.3 Description

The BGA758L7 is a Silicon Germanium low noise amplifier MMIC for 5 to 6GHz in the tiny TSLP-7-8 package. The LNA delivers a gain of 12.5 dB while giving an excellent noise figure of 1.3 dB in the application circuit therefore very suitable for WLAN and WiMAX applications in this frequency range. The supply current of 7.0 mA is chosen to maintain a high input -1dB compression point of -3.5 dBm to ensure the high data rate of the both applications.

Beside the Infineon's high performance RF transistor as low noise amplifier, BGA758 integrates also different useful features into it. The temperature compensated by the internal biasing circuit provides stable power consumption over the temperature range. The broadband output matching is realized by on- chip integrated LC circuits in combination with the bonding wire inductances in the package and offers outstanding matching condition to get connected with the following components. The application circuit requires only three external elements, mainly for the input matching purpose. The input matching is not integrated to ensure the best noise figure in the application. ´

In Figure 3, the block diagram of the low noise amplifier BGA758L7 is presented. The pin numbering, names and functions are described in table 1.

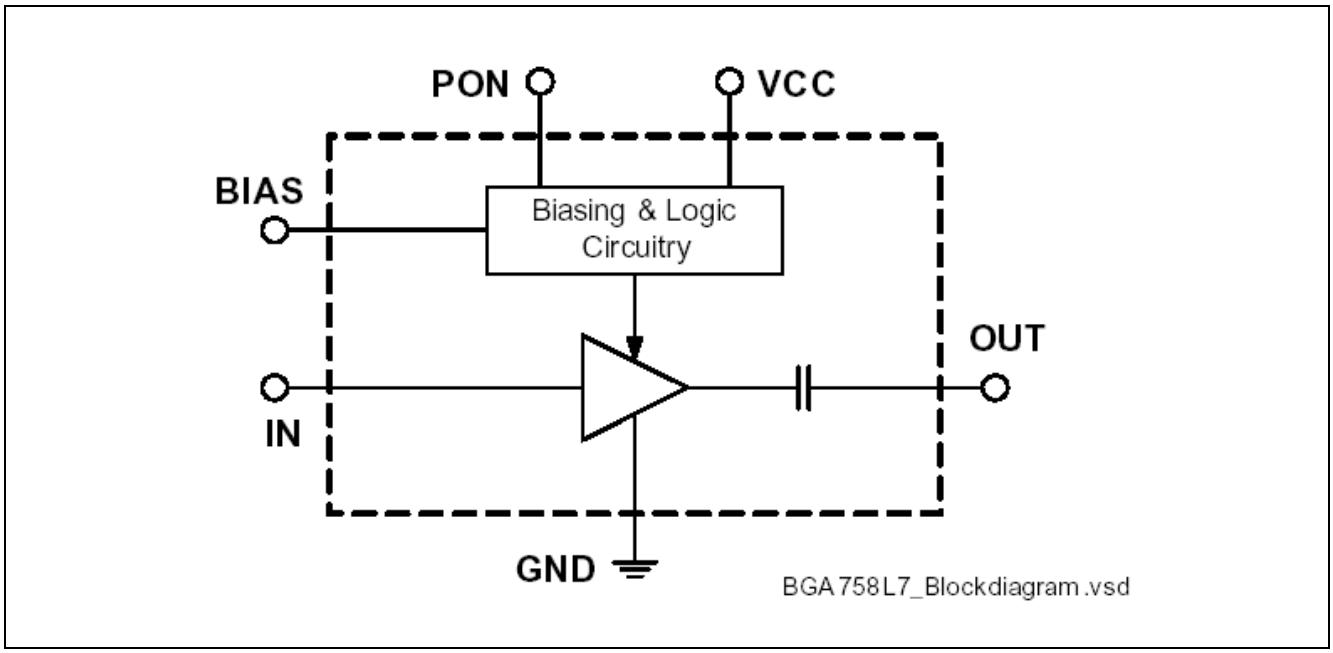

Figure 3 Block diagram of BGA758L7

Table 1 Pin Definition and Function

PIN No.	Name	Function
1	PON	Power on/off control
2	IN	RF input pin
3	BIAS	DC Bias
4	n.c	Not connected
5	VCC	DC power supply
6	OUT	RF output pin
7	GND	DC and RF ground pin

2 Application Information

In this application note, two different kinds of application circuits are described. Application 1 is the standard application circuit and optimized for the size of the application circuit and for the lowest BOM list. Application 2 is optimised for the lowest noise figure. With only one additional external element, an ultra low noise figure of 1.1 dB can be achieved.

2.1 Schematics

Figure 4 shows the proposed application circuit to get the best performance of BGA758L7. The bill-of-materials (BOM) used is shown in table 2. One inductor at input can be omitted to reduce the space used on the PCB as shown in the figure 5 and the BOM in table 3.

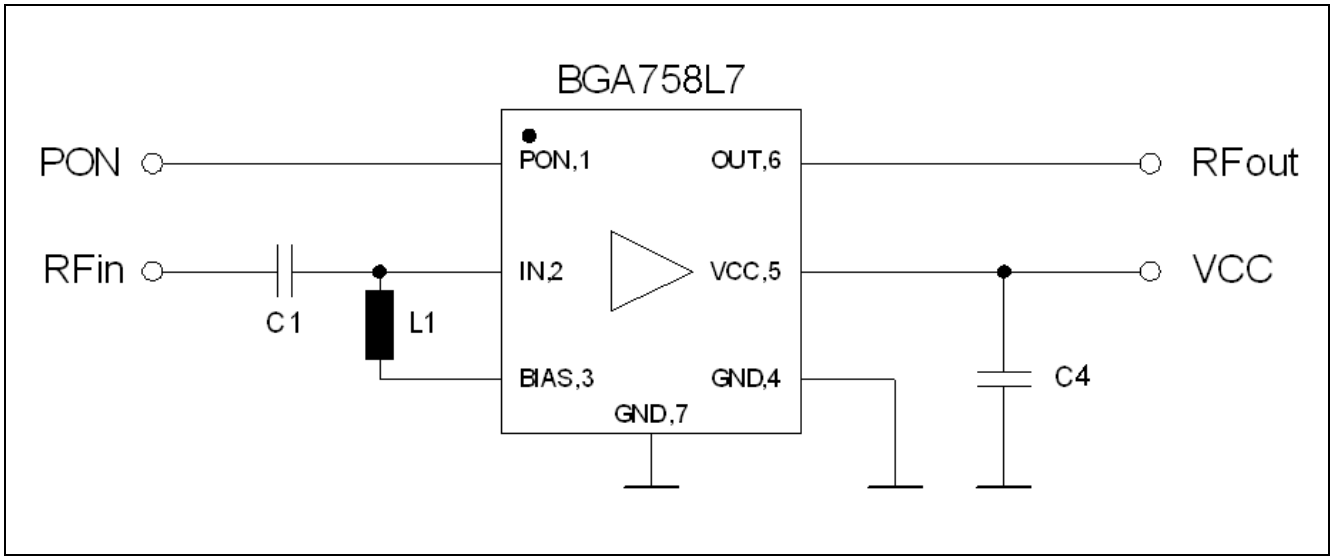

Figure 4 Schematics of the application circuit for "Application 1" (smaller PCB size)

Table 2 Bill-of-Materials of Application Circuit 1

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	2.7	pF	0402	various	
C4	1	nF	0402	various	
L1	3.9	nH	0402	Murata	LQW15 series
Q1	BGA758L7		TSLP-7-8	Infineon	

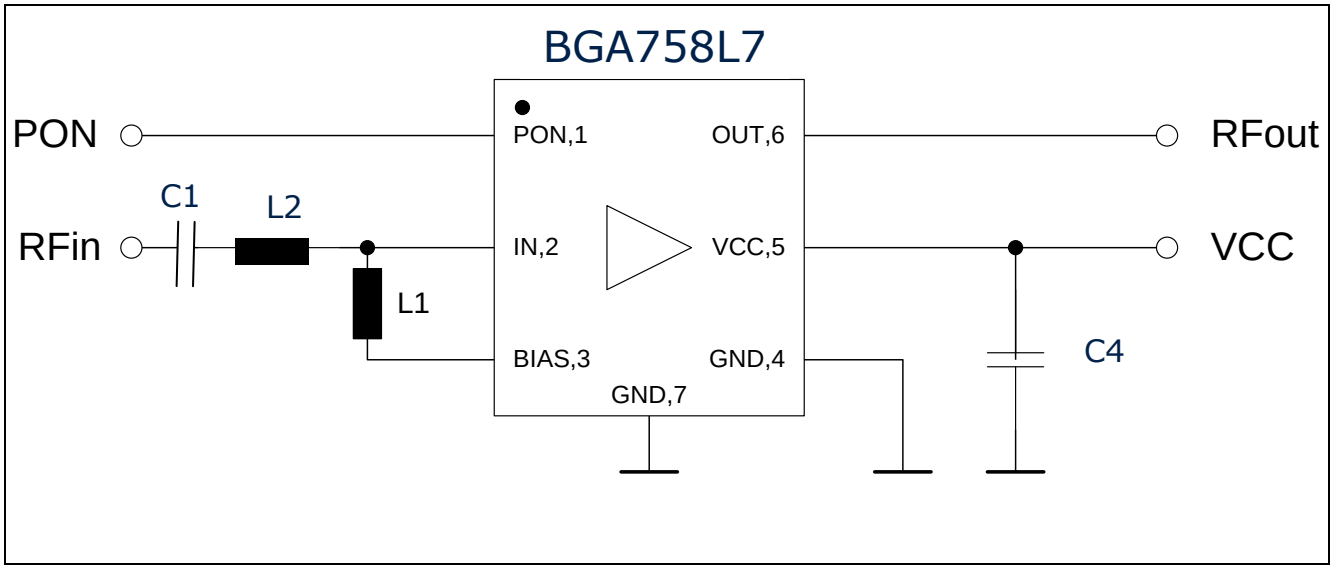

Figure 5 Schematics of the application circuit for "Application 2" (best performance)

Table 3 Bill-of-Materials of Application Circuit 2

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	2.7	pF	0402	various	
C4	1	nF	0402	various	
L1	3.9	nH	0402	Murata	LQW15 series
L2	1.3	nH	0402	Murata	LQW15 series
Q1	BGA758L7		TSLP-7-8	Infineon	

3 Measurement Results

Table 4 shows the measurement results of **BGA758L7 with the application circuit 1** measured at 3.3 V and 6.8 mA. The insertion gain is 12.7 dB at 5.5 GHz with excellent noise figure of 1.32 dB. The input and output are broadband matched to 50 Ohm. With its optimized design, BGA758L7 offers high input -1dB compression point of -4 dBm and input 3rd-order intercept point of +8 dBm to ensure the system not to have interference issues in the filed tests. The circuit of BGA758L7 is unconditionally stable measured up to 10GHz.

Table 4 Electrical Characteristics (measured at room temperature), Application Circuit 1

Parameter	Symbol	Value	Unit	Comment/Test Condition
Frequency Range	Freq	5-6	GHz	
DC Voltage	Vcc	3.3	V	
DC Current	Icc	6.8	mA	
Gain	G	12.7	dB	f=5.5GHz
Noise Figure	NF	1.32	dB	f=5.5GHz, input line loss of 0.1dB is deembedded
Input Return Loss	RLin	-18	dB	f=5.5GHz
Output Return Loss	RLout	-18	dB	f=5.5GHz
Reverse Isolation	IRev	-22	dB	f=5.5GHz
Input P1dB	IP1dB	-4.0	dBm	f=5.5GHz
Output P1dB	OP1dB	7.7	dBm	f=5.5GHz
Input IP3	IIP3	8.0	dBm	f=5.5GHz, Δf=1MHz, Pin=-30dBm
Output IP3	OIP3	20.7	dBm	f=5.5GHz, Δf=1MHz, Pin=-30dBm
Stability	k	>1	--	Unconditionally stable up to 10 GHz

Table 5 shows the measurement results of **BGA758L7 with the application circuit 2** measured at 3.3 V and 6.8 mA. The insertion gain is 12.7 dB at 5.5 GHz with excellent noise figure of 1.13 dB. The input and output are broadband matched to 50 Ohm. With its optimized design, BGA758L7 offers high input -1dB compression point of -4 dBm and input 3rd-order intercept point of +8 dBm to ensure the system not to have interference issues in the filed tests. The circuit of BGA758L7 is unconditionally stable measured up to 10 GHz.

Table 5 Electrical Characteristics (measured at room temperature), Application Circuit 2

Parameter	Symbol	Value	Unit	Comment/Test Condition
Frequency Range	Freq	5-6	GHz	
DC Voltage	Vcc	3.3	V	
DC Current	Icc	6.8	mA	
Gain	G	12.7	dB	f=5.5GHz
Noise Figure	NF	1.13	dB	f=5.5GHz, input line loss of 0.15dB is deembedded
Input Return Loss	RLin	-14	dB	f=5.5GHz
Output Return Loss	RLout	-15	dB	f=5.5GHz
Reverse Isolation	IRev	-22	dB	f=5.5GHz
Input P1dB	IP1dB	-4.1	dBm	f=5.5GHz
Output P1dB	OP1dB	7.6	dBm	f=5.5GHz
Input IP3	IIP3	8.0	dBm	f=5.5GHz, Δf=1MHz, Pin=-30dBm
Output IP3	OIP3	20.7	dBm	f=5.5GHz, Δf=1MHz, Pin=-30dBm
Stability	k	>1	--	Unconditionally stable up to 10 GHz

4 Measured Graphs

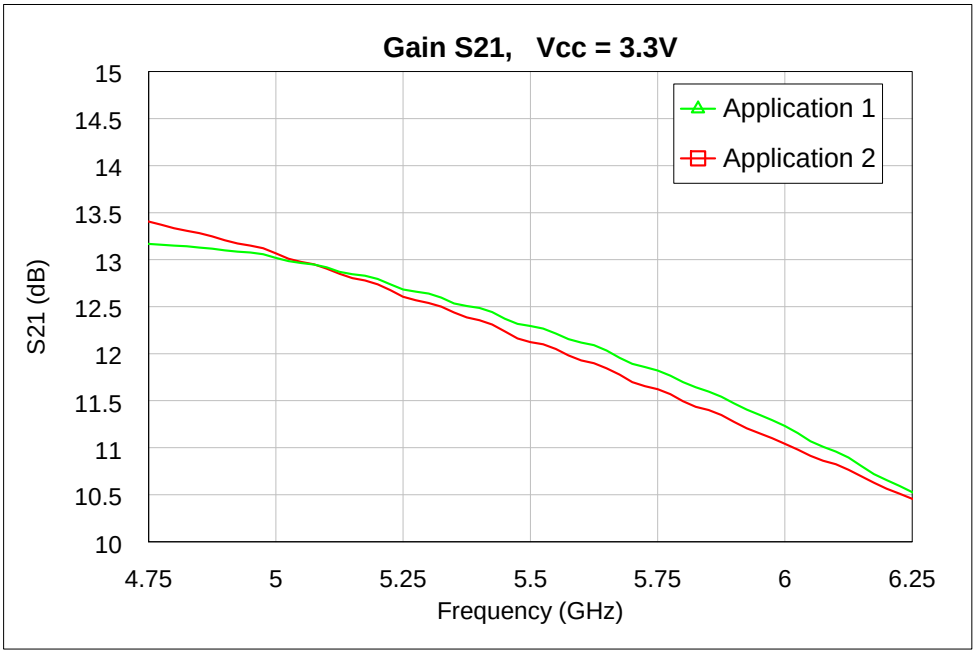

Figure 6 Insertion gain of the both BGA758L7 application circuits

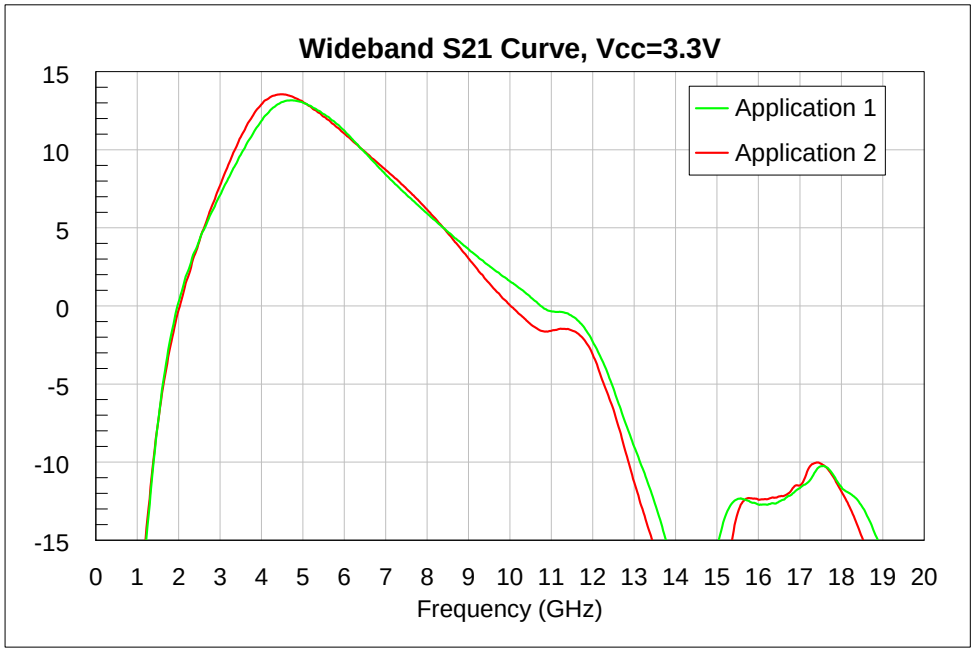

Figure 7 Wideband insertion gain curves of BGA758L7 application circuits

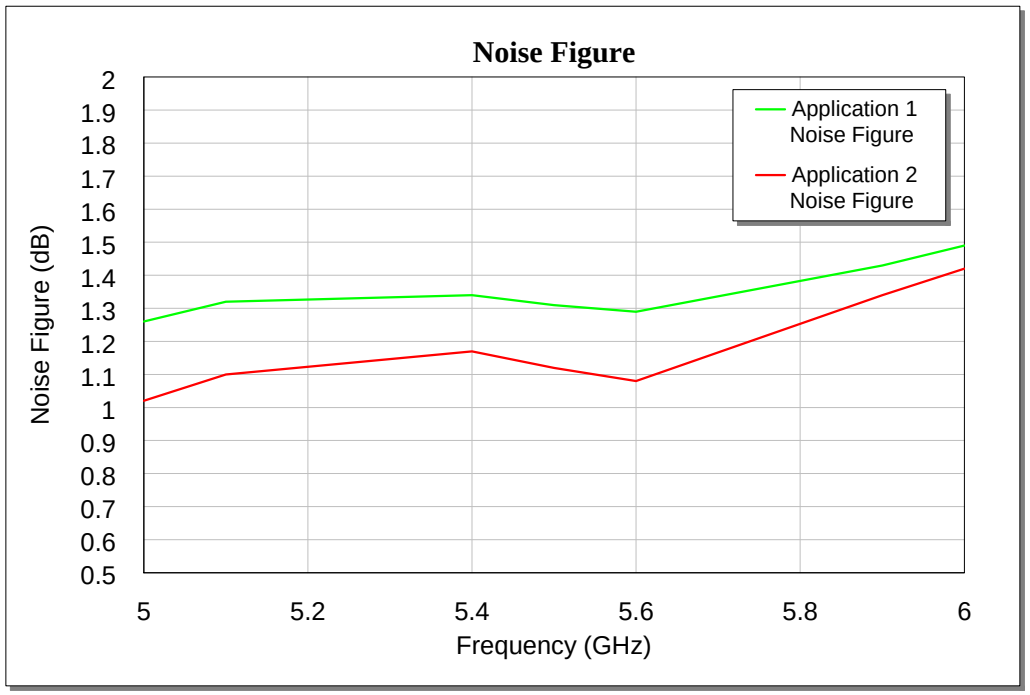

Figure 8 Noise figure curves of the both BGA758L7 application circuits

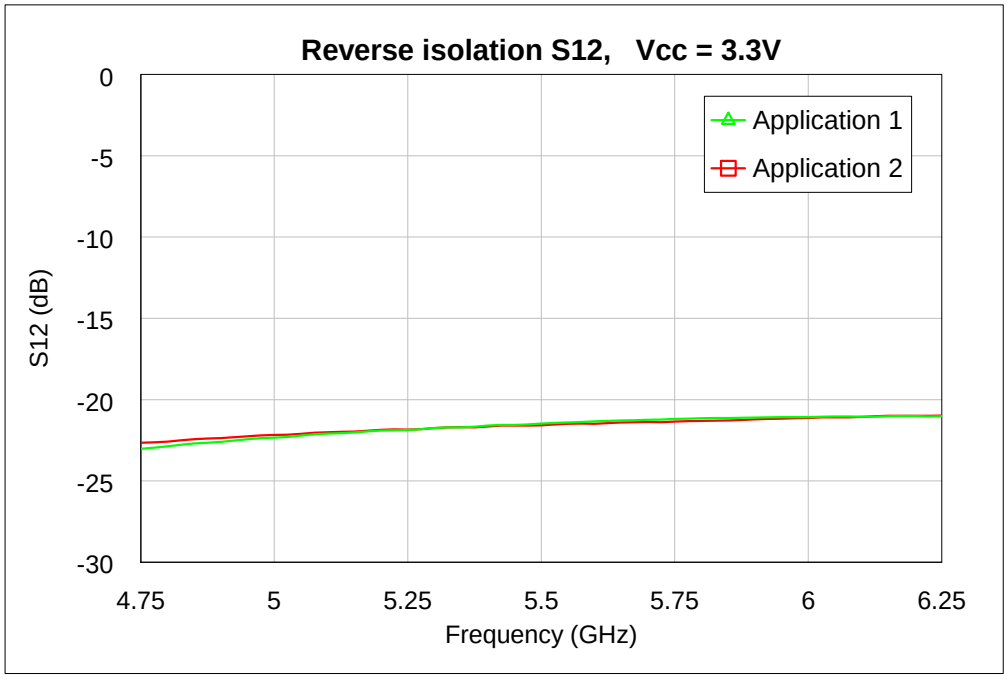

Figure 9 Wideband insertion gain curves of BGA758L7 application circuits

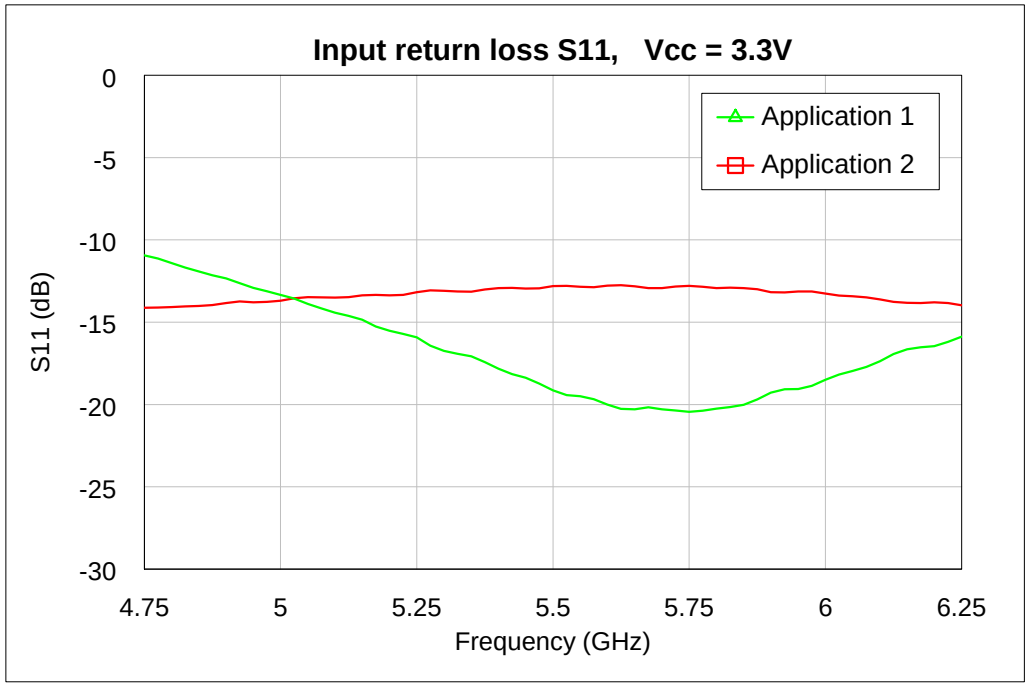

Figure 10 Input return loss curves of the both BGA758L7 application circuits

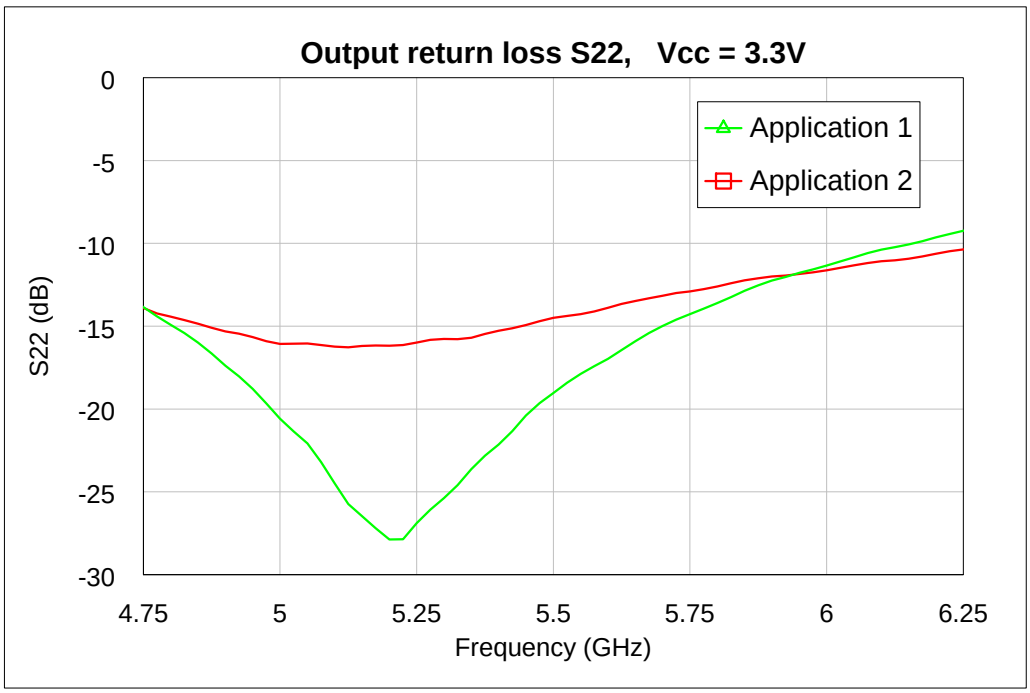

Figure 11 Output return loss curves of the both BGA758L7 application circuits

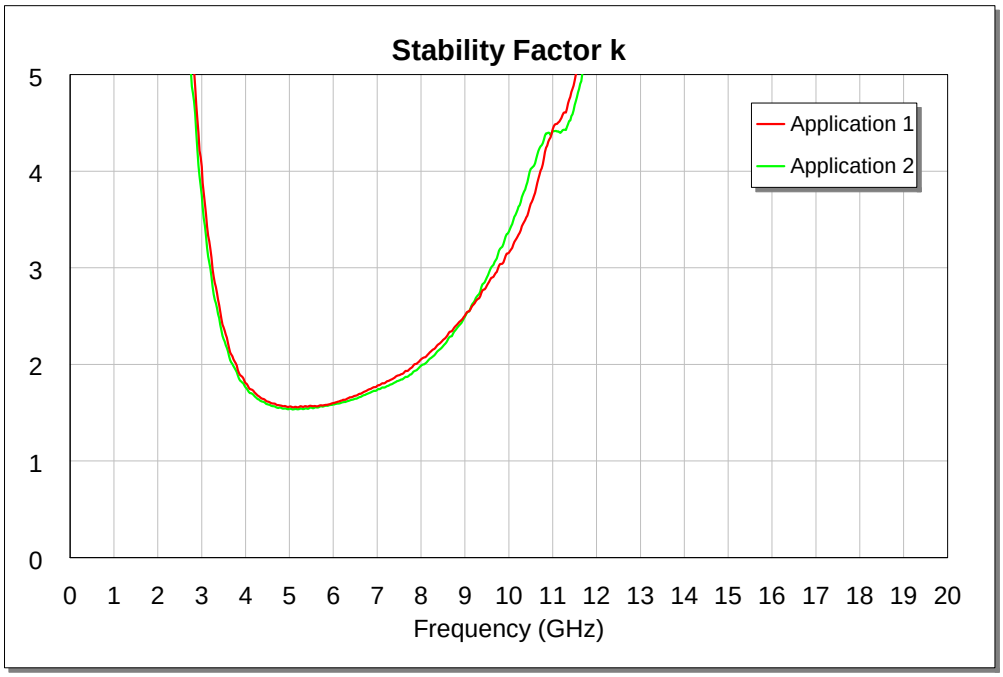

Figure 12 Stability factor k of the both BGA758L7 application circuits

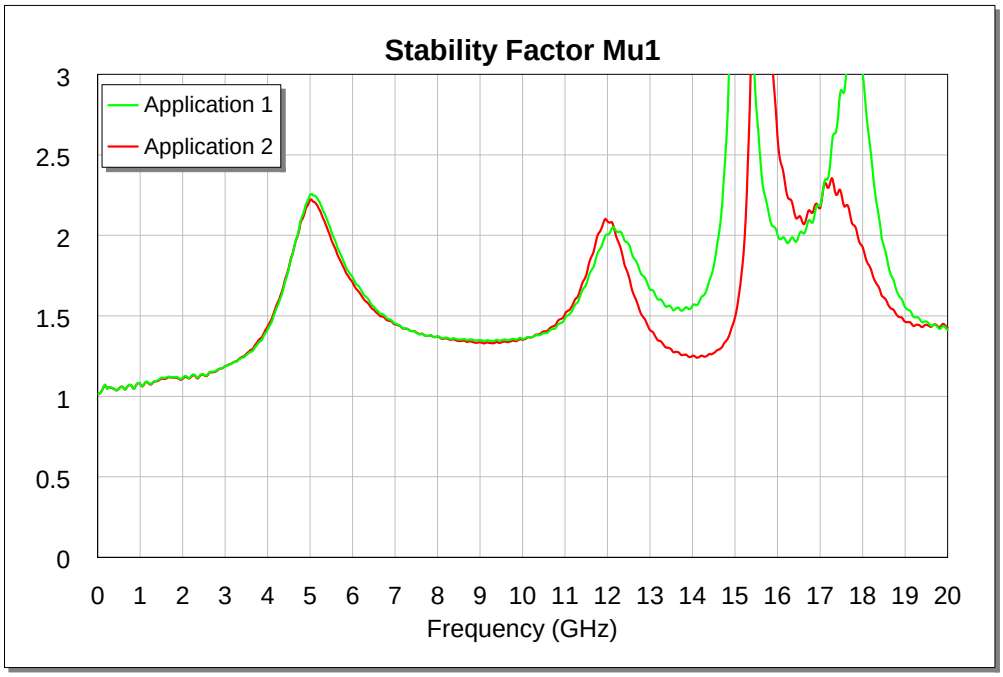

Figure 13 Input stability factor µ1 of the both BGA758L7 application circuits

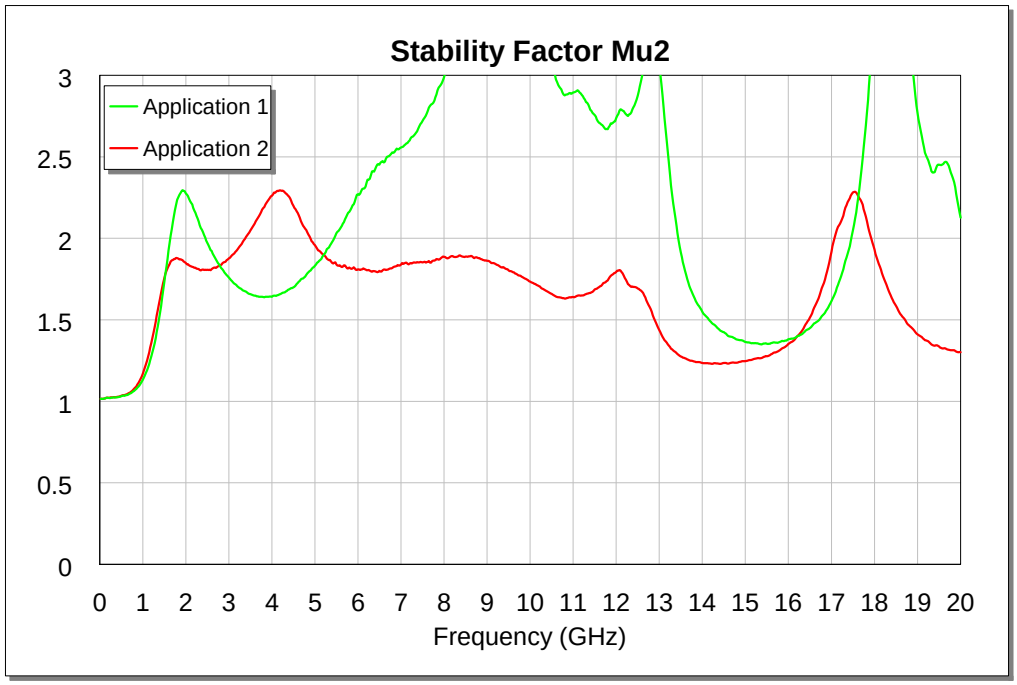

Figure 14 Output stability factor µ2 of the both BGA758L7 application circuits

5 Evaluation Board and layout Information

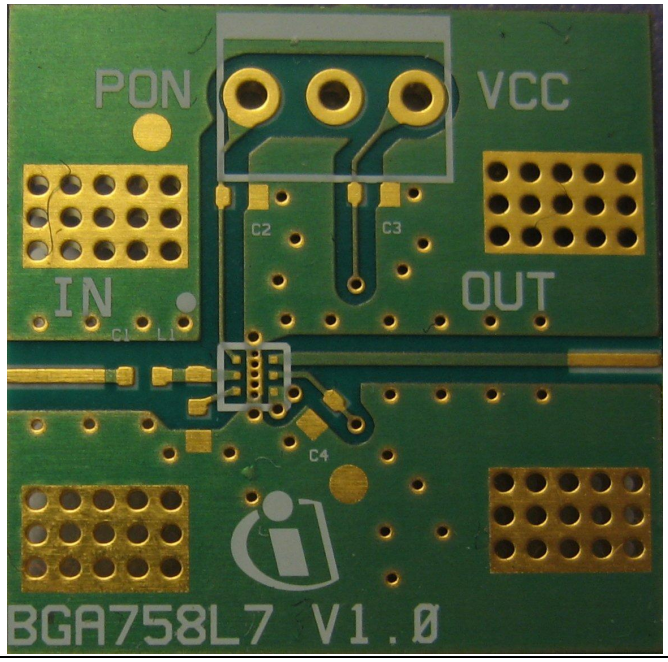

Figure 15 Photo picture of the unpopulated evaluation board of BGA758L7

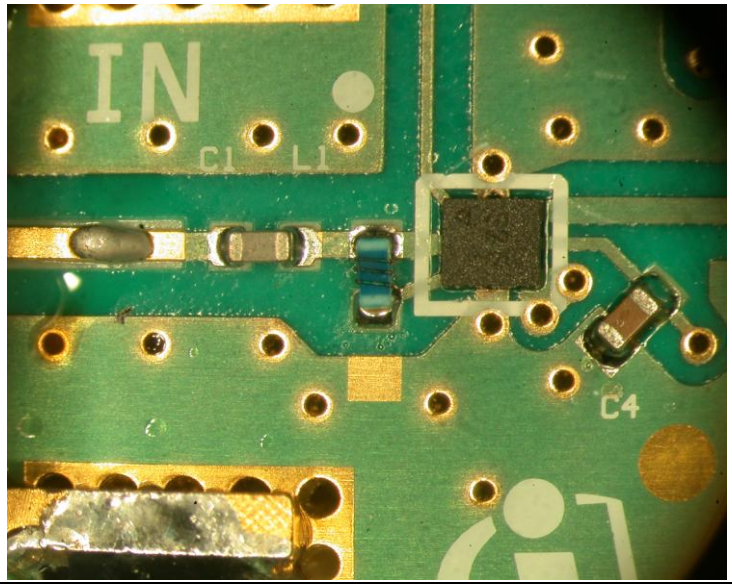

Figure 16 Photo picture of the populated evaluation board for BGA758L7 “Application 1”

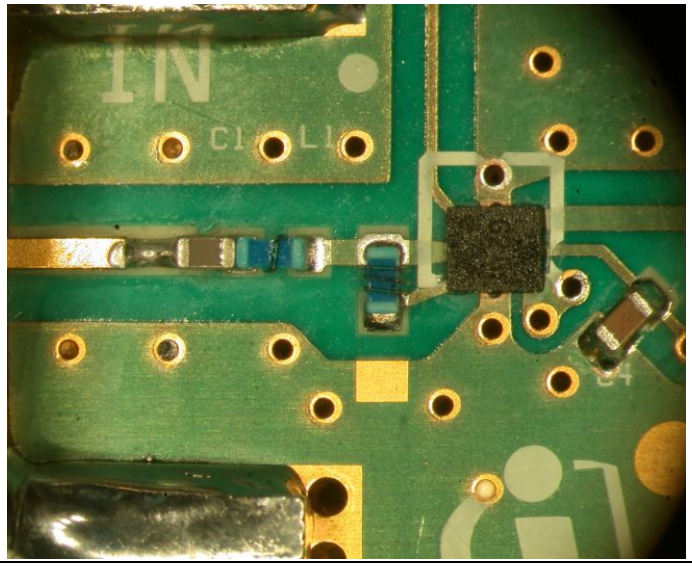

Figure 17 Photo picture of the evaluation board for BGA758L7 “Application 2”

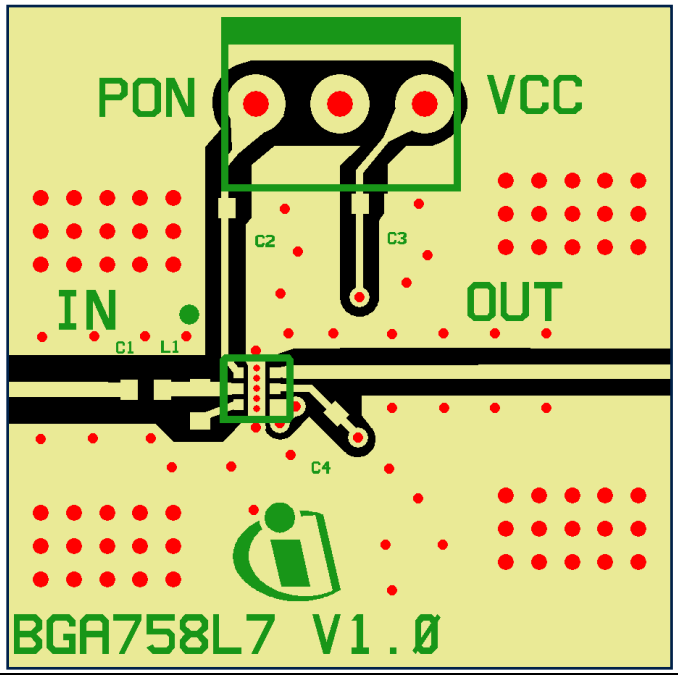

Figure 18 Layout of top layer metal of the evaluation board with via holes

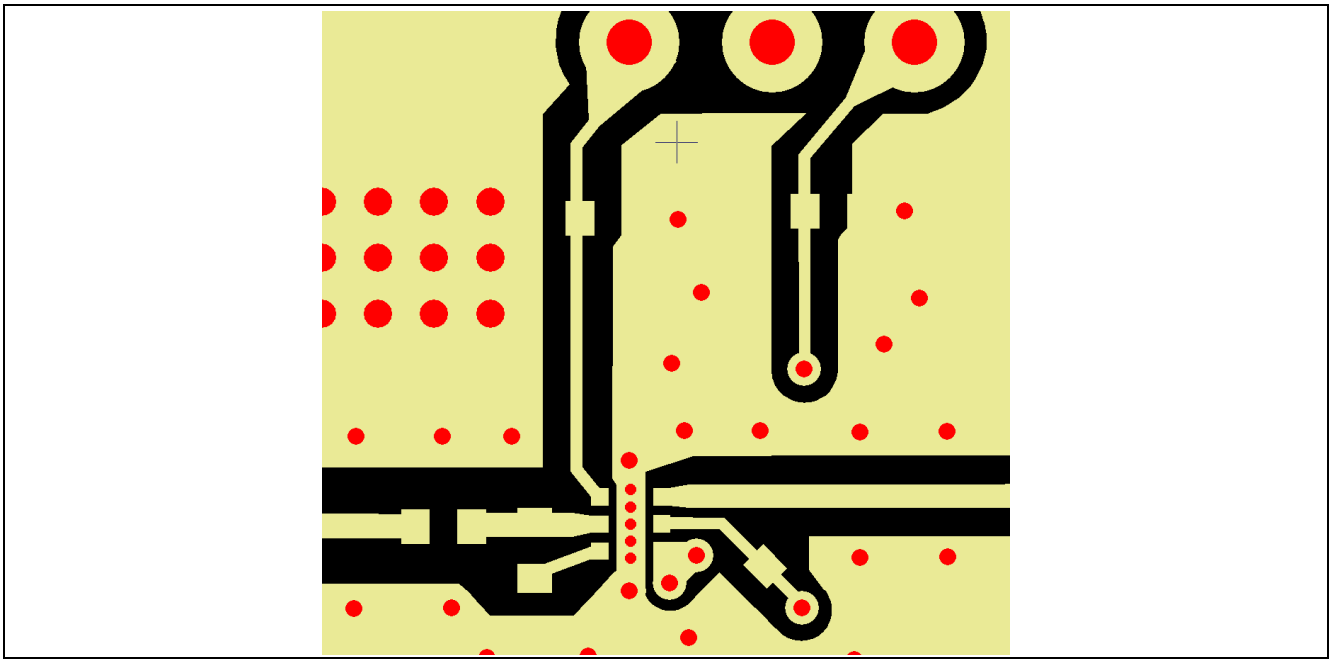

Figure 19 Layout of top layer metal of the evaluation board with via holes (detailed view)

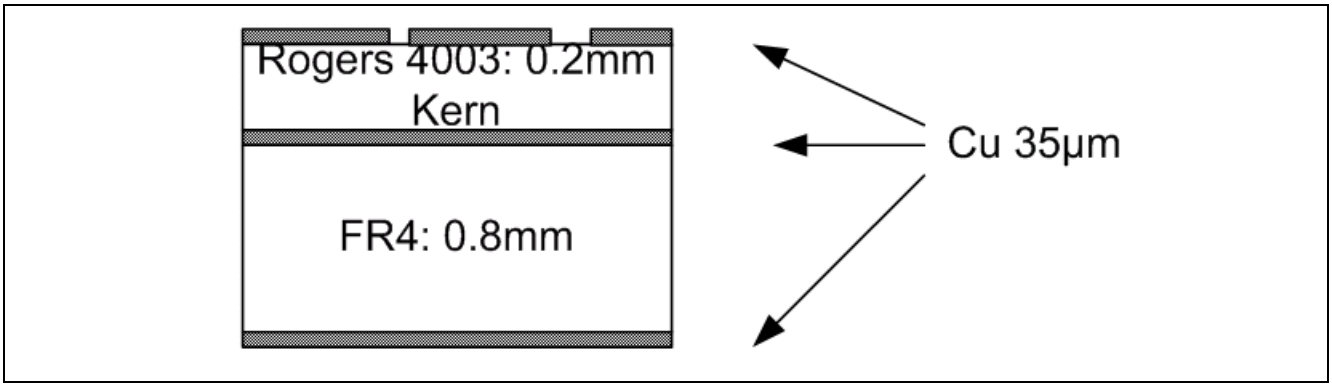

Figure 20 PCB layer information

6 Simulation Tool

Please find in the following attached file the S-parameter file with noise parameter for the simulation purpose. Please note that the S-parameter is measured from 10MHz up to 10GHz. The noise parameter covers only from 5 to 6 GHz. Figure 21 describes how the S-parameter file with the noise parameter is measured and the reference plane used in the file. A Jumper is used instead of C1 on the board. The biasing inductor L1 is not used. The BGA758L7 is biased through the external bias-T together with Vcc and PON connected to 3.3V. The phase shift introduced by the transmission lines at the input and the output are deembedded through the port extension so that the reference plane of the S-parameter file is directly at the Input and the output pins of BGA758L7. But the losses of the input line of 0.15dB and of the output line of 0.3dB are not deembedded.

S-Parameter file with the noise parameter (please right click the symbol and save the file)

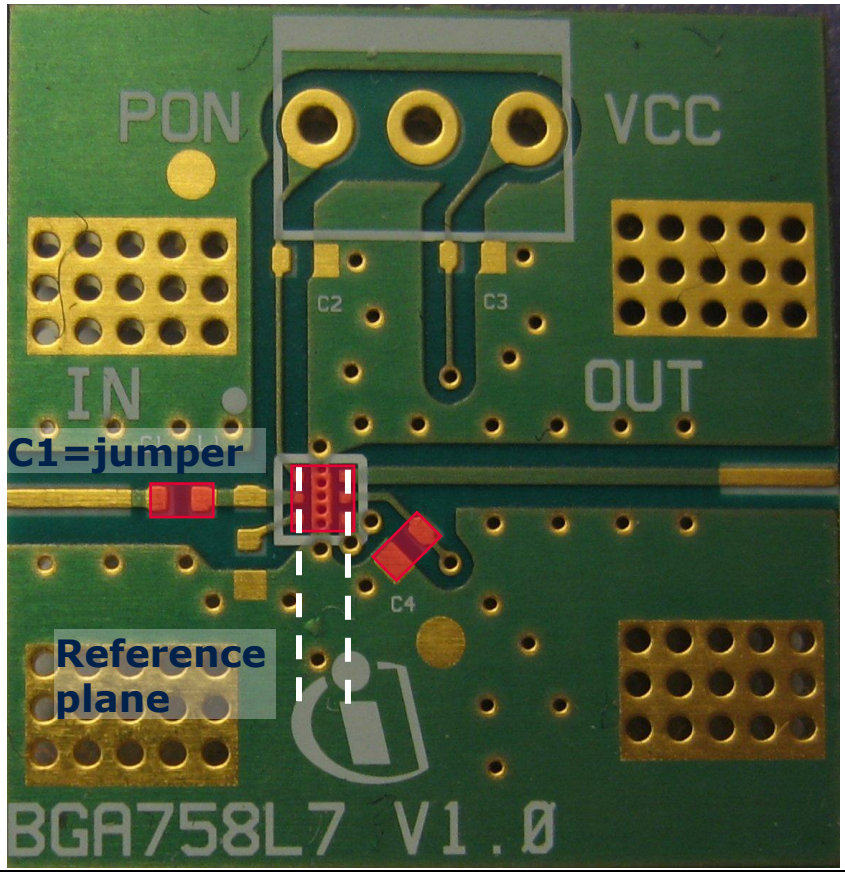

Figure 21 Photo picture of the unpopulated evaluation board of BGA758L7

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