AN11135

Replacing HMC625 by NXP BGA7204

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Document information

Info	Content
Keywords	BGA7204, VGA, HMC625, cross reference, drop-in replacement, OM7922/BGA7204 Customer Evaluation Kit
Abstract	The document provides guidelines to replace the HMC625 manufactured by Hittite Microwave Corporation by the NXP BGA7204 Variable Gain Amplifier. It includes circuit, BOM and performance information.
Summary	The BGA7204 Variable Gain Amplifier can replace the HMC625 without changing any of the external components. It will yield the similar performance as the HMC625 from 700 MHz to 2850 MHz. Compared to the HMC625 the BGA7204 requires less external components, which allows for further simplification of the circuitry. The BGA7204 assumes the HMC625 SPI mode. However the BGA7204 features an extended Serial Peripheral Interface (SPI) which can be enabled by simply exchanging one SMD component.

Revision history

Rev	Date	Description
2.0	20111210	Reviewed document
1.0	20111129	Initial document

Contact information

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1. Introduction

This document describes how to replace the VGA HMC625 manufactured by Hittite Microwave Corporation by the NXP BGA7204.

The BGA7204 MMIC is an extremely linear Variable Gain Amplifier (VGA), operating from 0.4 GHz to 2.75 GHz. At minimum attenuation it has a gain of 18.5 dB, an output IP3 of 38 dBm and a noise figure of 7 dB. The attenuation range is 31.5 dB with an attenuation step of 0.5 dB.

The BGA7204 has also been designed to functionally replace the HMC625. It features the same footprint. The pin definition is compatible with the HMC625: when placed in the HMC625 application circuit, the BGA7204 will power-up with a compatible SPI (basic) interface. However the extra features (like chip temperature read out) will not be available in this mode.

2. Application Circuit for drop-in replacement

2.1 OM7922/BGA7204 Customer Evaluation Kit

In this application note the printed circuit board of the BGA7204 Customer Evaluation Kit (OM7922/BGA7204) has been used as base. It is possible to populate this printed circuit board such that it implements the HMC625 reference application circuit.

The OM7922/BGA7204 Customer Evaluation Kit can be ordered. Please contact your local NXP sales representative for further information.

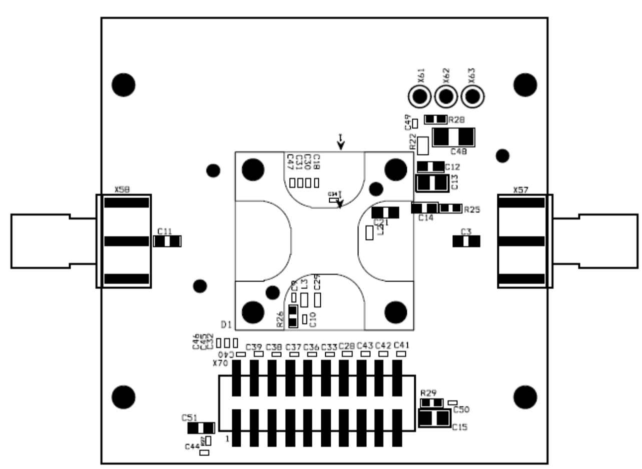

Fig 1. Top layer printed circuit board of the BGA7204 Customer Evaluation Kit (OM7922/BGA7204).

2.2 Schematic

In the picture below the BGA7204 is placed in the HMC625 reference application circuit, without changing any of the external components. Not all components are needed, but this drop-in approach could simplify the component qualification at the customer side, at the expense of placing unnecessary components.

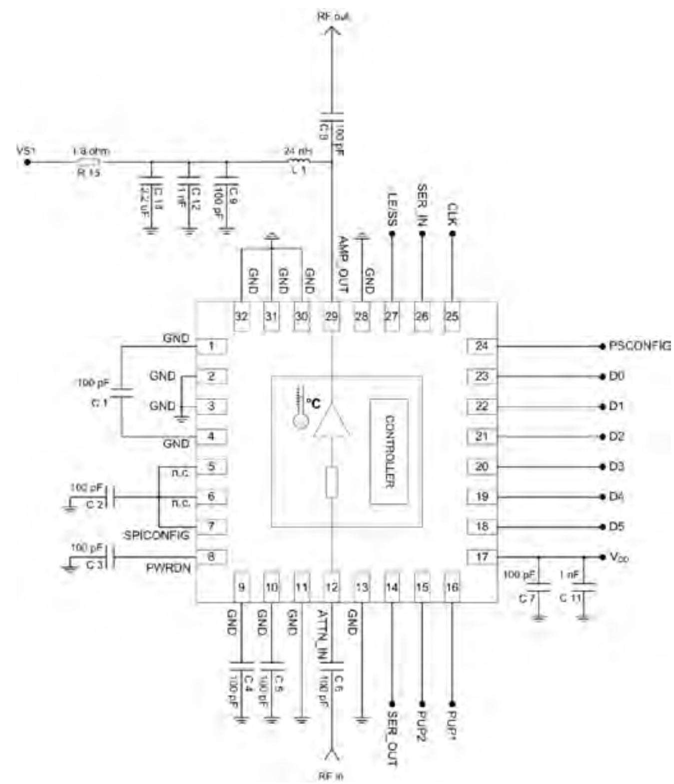

Fig 2. The HMC625 application circuit using NXP's BGA7204.

2.3 Component list

In the Table below the used components have been listed. It also contains different bill of materials, which can be used to optimize for cost or performance, see Chapter 3.

Table 1. Components values for drop-in replacement (column: HMC625), for low cost replacement (column: Low cost) and for obtaining BGA7204 performance as published in the BGA7204 data sheet (column: BGA7204 data sheet performance).

Component	HMC625	Low cost	BGA7204 data sheet performance
C1	100 pF	n.c.	n.c.
C2	100 pF	n.c.	n.c. or 0 Ω jumper[1]
C3 – C5	100 pF	n.c.	n.c.
C6	100 pF	100 pF	100 pF

Component	HMC625	Low cost	BGA7204 data sheet performance
C7	100 pF	100 pF	100 pF
C8	100 pF	100 pF	100 pF
C9	100 pF	100 pF	1 nF[2]
C11	1 nF	1 nF	47 nF
C12	1 nF	1 nF	100 pF
C14	2.2 µF	2.2 µF	4.7 µF
L1[3]	24 nH	24 nH	47 nH
R15	1.8 Ω	1.8 Ω or 0 Ω	0 Ω

[1] Place 0 Ω jumper to use the BGA7204's extended SPI mode.

[2] 1 nF decoupling capacitor C9 value will remove 300 MHz dip, see Chapter 3.

[3] Important: only use wire wound RF-choke like the Murata inductor LQW18-series.

2.4 Measurements

This paragraph plots the performance obtained using the HMC625 component values on the printed circuit board used in OM7922/BGA7204 Customer Evaluation Kit. This has been compared with the performance obtained using the NXP BGA7204 application circuit as being published in the Data Sheet.

2.4.1 S-parameters

The S-parameters depend on the used quality of the printed circuit board (etching spread and the length of the RF – tracks). Using the HMC625 BOM a resonance around 300 MHz occurs in the S-parameters. Chapter 3 describes how this can be solved.

2.4.1.1 Gain

The gain between 700 MHz and 2850 MHz is identical for both the HMC625 configuration as well as the OM7922/BGA7204 configuration.

The gain below 700 MHz drops up to 0.7 dB which is caused by the different RF-choke (24 nH instead of 47 nH).

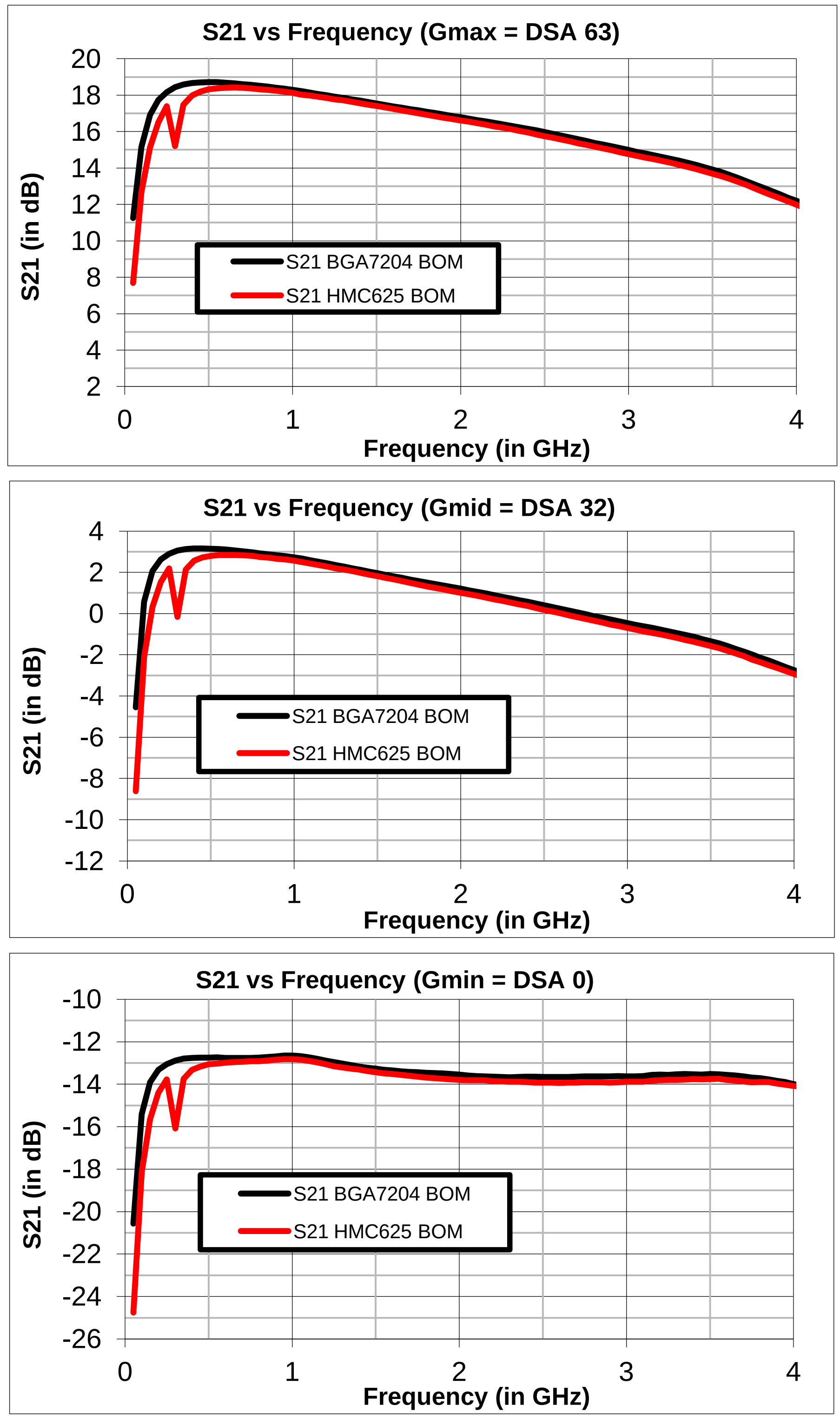

Fig 3. Gain at max, mid and min attenuation.

2.4.1.2 Input return loss

The component value of the RF choke (L1 = 24 nH instead of 47 nH) also has minor influence on the input return loss.

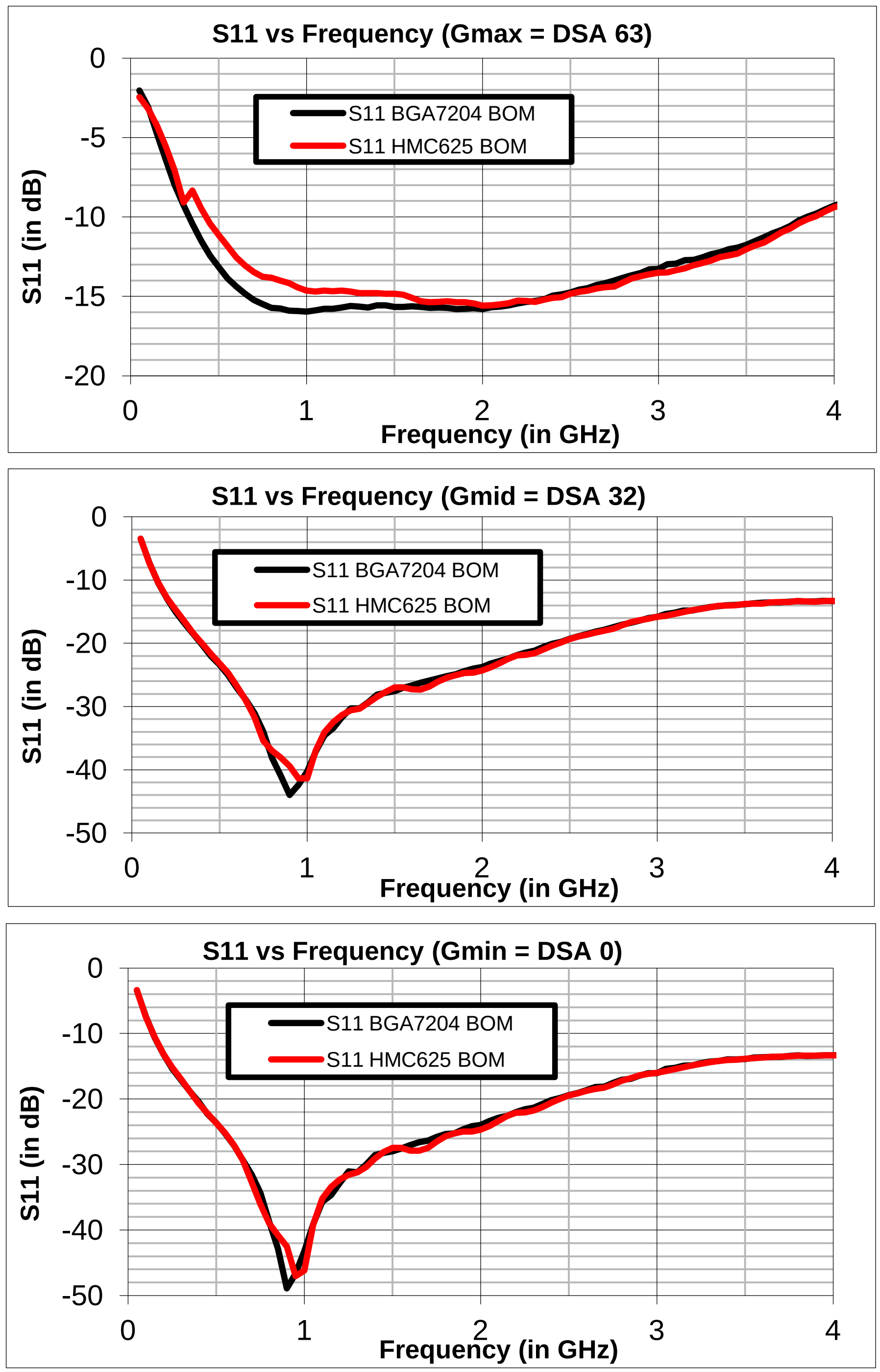

Fig 4. Input return loss at max, mid and min attenuation

2.4.1.3 Output return loss

The component value of the RF choke (L1 = 24 nH) has influence on the output return loss. For frequencies below 700 MHz it might make sense to improve this by changing the component value of the RF choke (L1 = 47 nH instead of 24 nH), see Chapter 3.

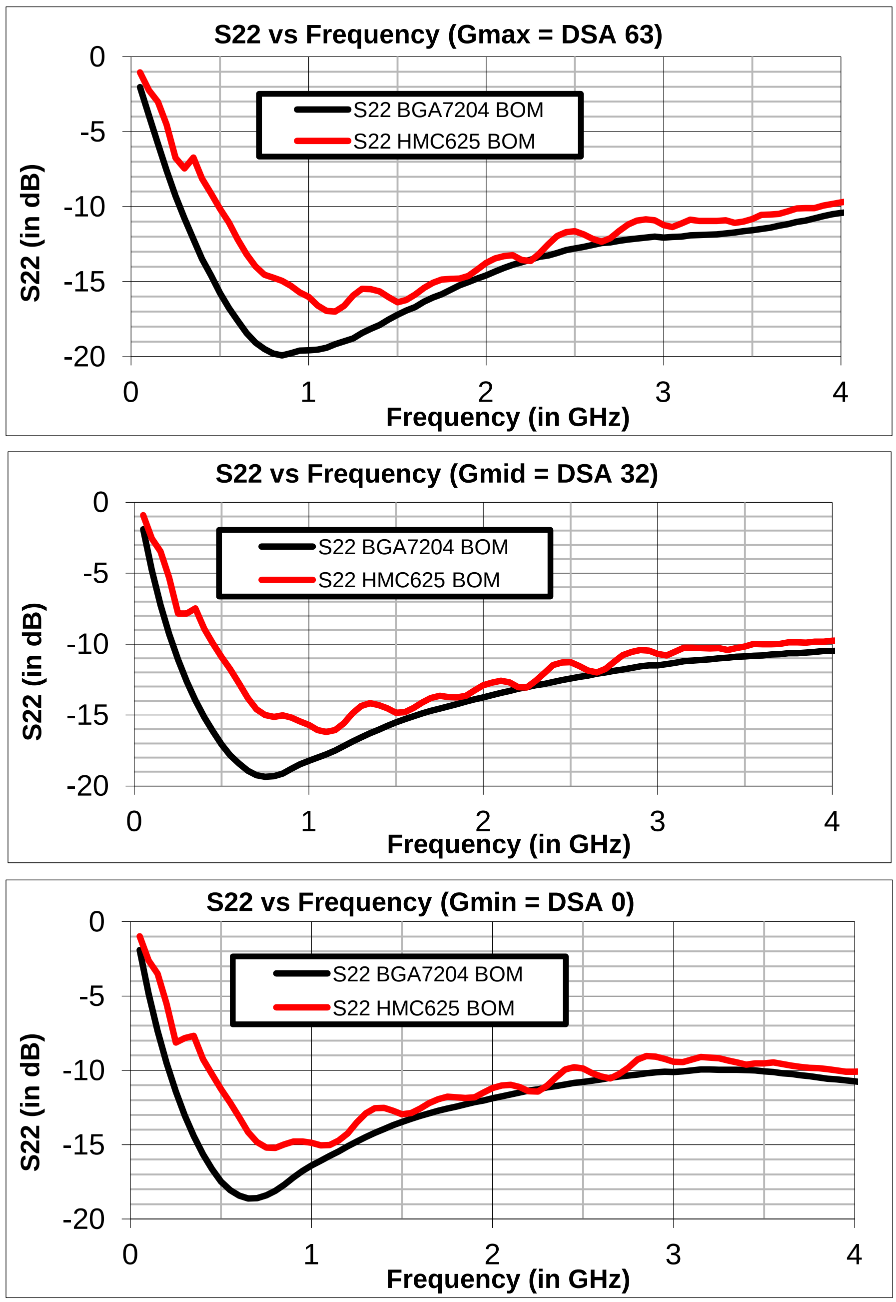

Fig 5. Output return loss at max, mid and min attenuation

2.4.2 Output third order intercept point

No degradation on OIP3 for frequencies above 700 MHz by using the HMC625 bill of material.

The OIP3 at 400 MHz drops 0.7 dB, resulting from the gain drop at frequencies below 700 Mhz. The component value of the RF choke (L1 = 24 nH) causes the gain drop. This can be improved, see Chapter 3.

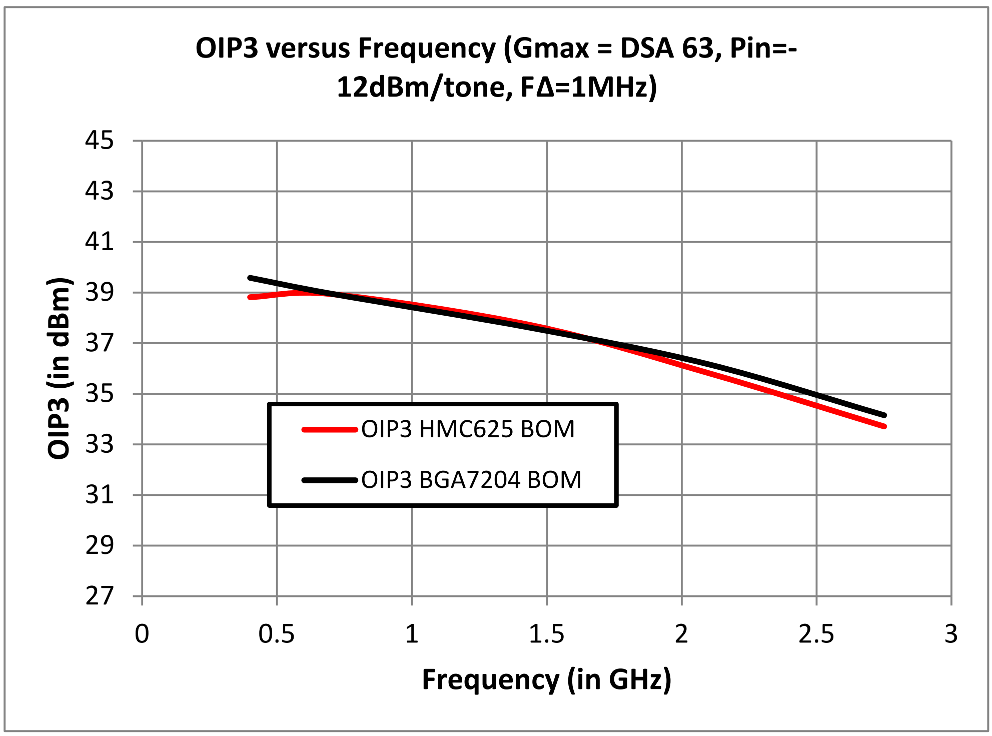

Fig 6. OIP3, BGA7204 using the BGA7204 BOM and the HMC625 BOM

2.4.3 Output power at 1 dB gain compression

No significant change in OP1dB performance has been measured.

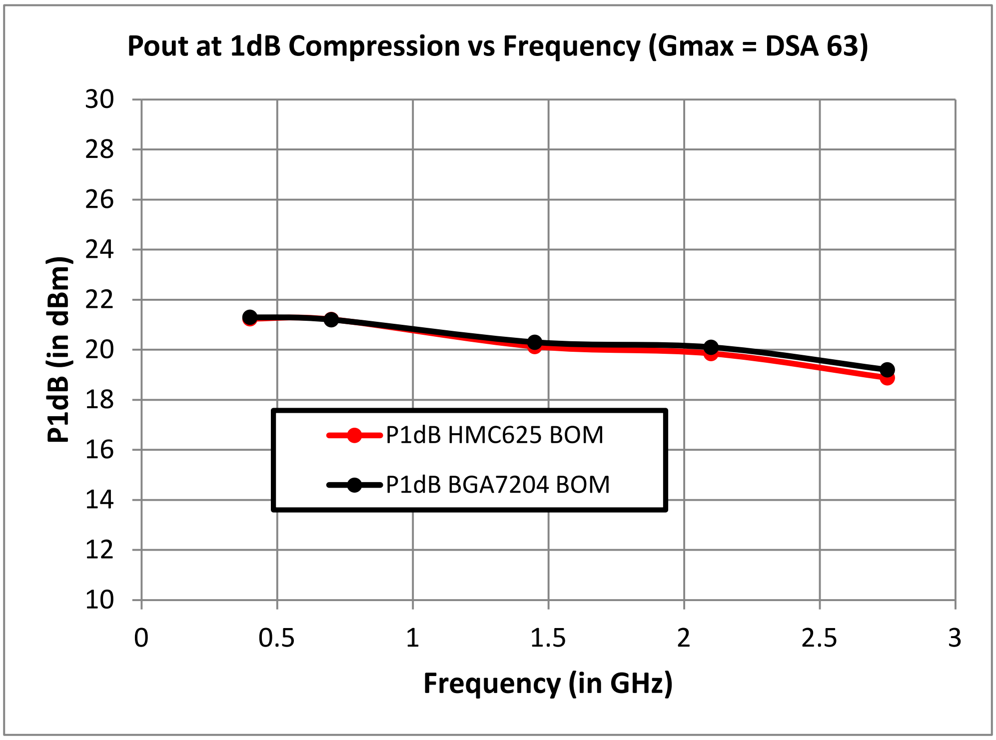

Fig 7. P1dB out, BGA7204 using BGA7204 BOM and the HMC625 BOM

3. Tips and tricks

The application circuitry described in Chapter 2 leaves the bill of material of the HMC625 reference application circuitry intact. This means that unnecessary external components are being placed. Also this limits features and performance of the BGA7204. This chapter describes how to optimize the performance and features using the HMC625 reference board.

3.1 Saving on external components

Not all components needed for the HMC625 are required for the BGA7204. In the table of paragraph 2.3 the 'low cost' column shows which components can be omitted.

3.2 Restoring low frequency performance

The NXP VGA BGA7204 can handle frequencies down to 400MHz. The RF choke (L1) must be changed from 24 nH to 47 nH to extend the frequency range down to 400 MHz. See the table of paragraph 2.3 component list column 'BGA7204 Data Sheet performance.'

3.3 Using extended SPI mode

The BGA7204 can be set to extended SPI mode which allows extra features (like chip temperature read out), to use this mode some changes on the BOM has to be done. The position on the printed circuit board for the capacitor C2 needs to be used to ground pin 7, by placing a 0 Ω jumper. See also the table of paragraph 2.3 component list column 'BGA7204 Data Sheet performance.'

When pin 7 is not grounded it will pull-up to logic high, yielding the HMC625 compatible mode (basic mode). Please refer to the Data Sheet for the features of the extended mode. Also mind the fact that in extended mode daisy chaining of multiple devices is not possible.

3.4 Removing the 300 MHz dip

The S-parameter graphs reveal a dip around 300 MHz (gain, output return loss). This is caused by the position of the RF de-coupling capacitors (C9, C12 and C14) relative to the RF choke (L1). The exact frequency and magnitude of the dip is therefore depending on the layout of the components on the printed circuit. The dip is also visible when using the HMC625.

The dip can be avoided by placing the RF-decoupling capacitors (C9, C12 and C14) close to the RF choke (L1), although this is not always possible due to keep out areas for component placement machine.

Another option is to change the position of the RF-decoupling capacitors, putting the 1 nF capacitor nearby the RF choke (L1) by swapping the component values of C9 and C12. C9 becomes 1 nF and C12 becomes 100 pF, see also the table of paragraph 2.3 component list column 'BGA7204 Data Sheet performance.'

The graph below depicts the effect on swapping both capacitors (C9 versus C12) on the OM7922/BGA7204 printed circuit board. On this board the distance between those capacitors are much larger than on the HMC625 board making the dip more pronounced[1]. The blue graph shows the performance using the HMC625 component values; the red graph shows the performance after swapping C9 and C12.

[1] The RF-decoupling capacitors are placed far from the RF choke to allow for the placement of a test socket.

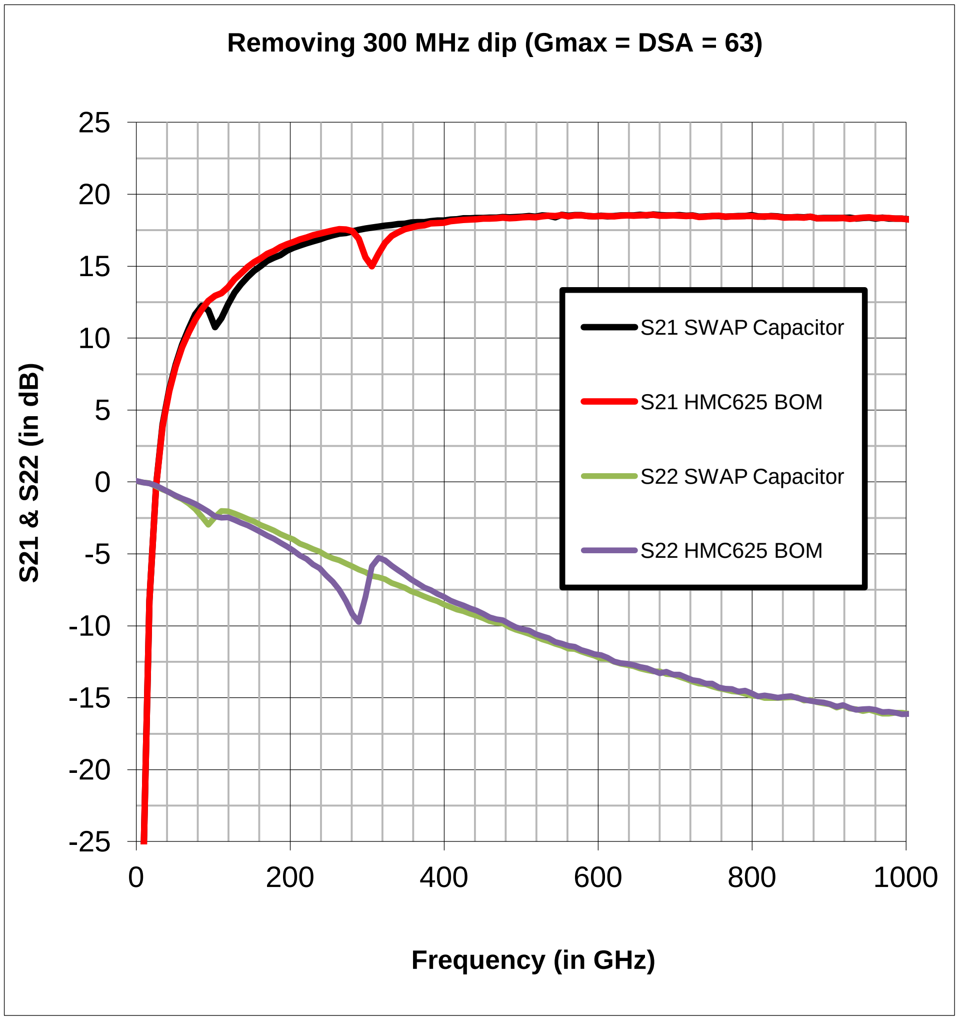

Fig 8. Gain and output return loss at minimum attenuation of the BGA7204 using the printed circuit board of the OM7922/BGA7204 Customer Evaluation Kit. The effect of swapping C9 and C12 is shown, see text.

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