AN11299

BGA301x - 40 MHz to 1006 MHz push-pull application

Rev. 2 — 21 August 2013 Application note

Document information

Info	Content
Keywords	BGA3012, BGA3015, BGA3018, evaluation board, CATV, drop amplifier, push-pull, wideband
Abstract	This application note describes the schematic and layout requirements for using the BGA301x family as a wideband push-pull amplifier between 40 MHz and 1006 MHz.

Revision history

Rev	Date	Description
2	20130821	A correction has been made to the document title
1	20130614	First publication

Contact information

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1. Introduction

The customer evaluation boards OM7866, OM7867 and OM7868 enable the user to evaluate the performance of the BGA301x wideband CATV MMIC amplifier family in a push-pull circuit environment.

The BGA3012, BGA3015 and BGA3018 performance information is available in the available datasheets.

This application note describes the evaluation board schematic and layout requirements for using the BGA3012, BGA3015 or BGA3018 as a wideband push-pull amplifier between 40 MHz and 1006 MHz. The push-pull configuration gives a significant second order distortion improvement over a single ended solution.

The BGA301x family is fabricated in the BiCMOS process and packaged in a lead-free 3-pin SOT89 package. The amplifier MMIC comprises a two stage amplifier with internal bias network designed for a frequency range of 5 MHz to 1006 MHz with a supply voltage between 5 V and 8 V.

2. System features

- Improved OIP2 and CSO compared to single ended solution
- 75 Ω input and output impedance
- Excellent input and output return loss
- Flat gain between 40 MHz and 1006 MHz
- Unconditionally stable

3. Customer evaluation kit contents

The BGA3012 evaluation kit (OM7866) contains the following items:

- ESD safe casing
- BGA3012 push-pull evaluation board
- BGA3012 SOT89 samples

The BGA3015 evaluation kit (OM7867) contains the following items:

- ESD safe casing
- BGA3015 push-pull evaluation board
- BGA3015 SOT89 samples

The BGA3018 evaluation kit (OM7868) contains the following items:

- ESD safe casing
- BGA3018 push-pull evaluation board
- BGA3018 SOT89 samples

4. Application Information

For evaluation purposes an evaluation board is available. The evaluation circuit can be seen in figure 1 and the corresponding PCB is shown in figure 2. Table 1 shows the bill of materials.

4.1 Evaluation board circuit

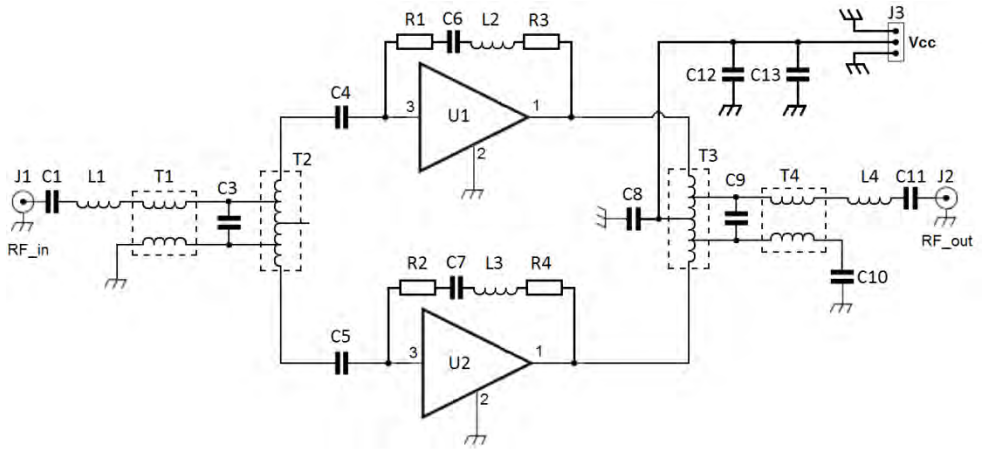


Fig 1. BGA301x Push-Pull evaluation circuit

The power supply is applied on the center pin of connector J3 and is applied to U1 and U2 via impedance transformer T3. Capacitors C12, C13 and C8 are supply decoupling capacitors.

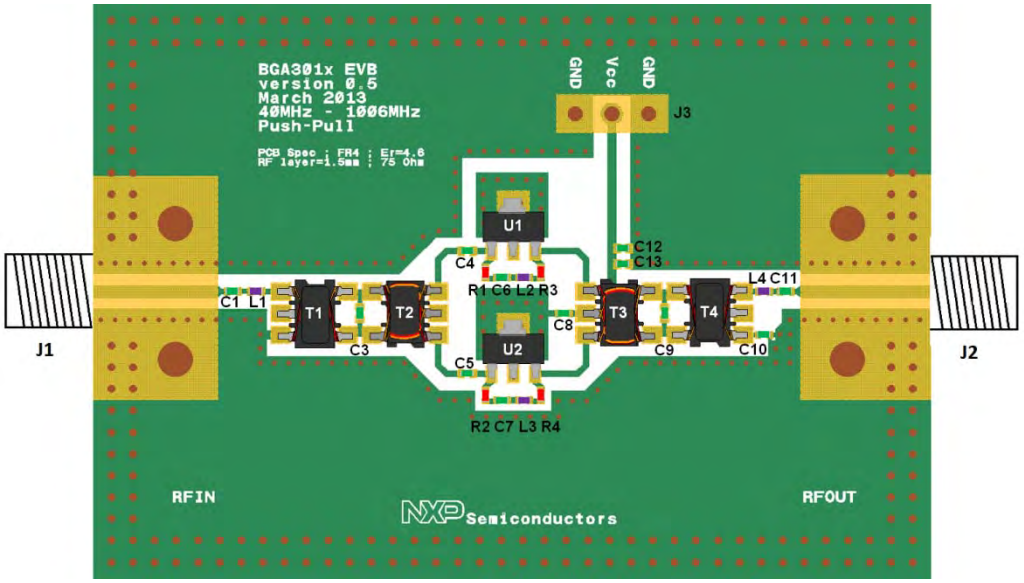
At the F-connector J1 the RF input signal is applied where capacitor C1 provides DC-blocking, followed by L1 for input matching (Z = 75 Ω). The single ended unbalanced 75 Ω signal then need to be converted into two 75 Ω balanced signals to supply both drop amplifiers U1 and U2. This is done in two steps. First the 75 Ω unbalanced signal is converted in a 75 Ω balanced signal by balun transformer T1. Second the 75 Ω balanced signal is converted into two 75 Ω balanced signals by impedance transformer T2. Both RF signals are supplied to the drop amplifiers U1 and U2 via DC-blocking capacitors C4 and C5.

The amplifier circuits and layout designs of U1 and U2 are identical. Resistors R1, R2, R3 and R4 set the gain of both amplifiers. Inductors L2 and L3 give a flat gain from 40 MHz up to 1006 MHz. Capacitors C6 and C7 provide DC-blocking between the input and output of the drop amplifiers U1 and U2.

The two 75 Ω balanced signals coming from the outputs of U1 and U2 are converted back into one 75 Ω balanced signal by transformer T3. Balun transformer T4 converts the 75 Ω balanced signal back into the needed unbalanced 75 Ω signal, where capacitor C9 and inductor L4 provide the output matching (Z = 75 Ω). Capacitor C10 and C11 are used for DC-blocking before the RF signal is available at F-connector J2.

4.2 Evaluation board layout

The evaluation board layout is the same for BGA3012, BGA3015 and BGA3018



PCB material = FR4
PCB thickness = 1.5 mm
PCB size = 40 mm x 40 mm
ε_r = 4.6
Copper thickness = 35 µm

Fig 2. BGA301x Push-Pull evaluation board layout

For optimum distortion performance it is important to have enough ground vias underneath and around the MMICs ground pins. This lowers the inductance to the ground plane. The evaluation board is made with two layer FR4 material.

4.3 Bill of materials (BoM)

All three drop amplifier boards use the same PCB board design, but use slightly different component values for each drop amplifier type.

4.3.1 BGA3012 Push-Pull BoM

Table 1. BGA3012 Push-Pull BoM

Circuit Reference	Description	Qty	Mfr	Manufacturer number	Supplier	Supplier part number
U1, U2	BGA3012	1	NXP	BGA3012	NXP	BGA3012
T1, T4	Balun	2	Toko	#617DB-1655=P3	Toko	#617DB-1655=P3
T2, T3	Transformer	2	Toko	#617PS-40369=P3	Toko	#617PS-40369=P3
C1, C4, C5, C6, C7, C8, C10, C11, C12, C13	10 nF	10	Murata	GRM155R71E103KA01D	Digikey	490-1312-1-ND
C3	NA	-	-	-	-	-
C9	0.82 pF	1	Phycomp	223886915827	RS components	616-9357
L1, L4	1.8 nH	2	Murata	LQG15HS1N8S02D	Digikey	490-2613-1-ND
L2, L3	15nH	2	Murata	LQG15HS15NJ02D	Digikey	490-2625-1-ND
R1, R2	330 Ω	2	Yageo	RC0402FR-07330RL	Digikey	311-330LRCT-ND
R3, R4	180 Ohm	2	Yageo	RC0402FR-07180RL	Digikey	311-180LRCT-ND
J1, J2	75 Ω F-connector	2	Bomar	861V509ER6	Mouser	678-861V509ER6
J3	Header 3	1	Molex	90121-0763	Digikey	WM8109-ND

4.3.2 BGA3015 Push-Pull BoM

Table 2. BGA3015 Push-Pull BoM

Circuit Reference	Description	Qty	Mfr	Manufacturer number	Supplier	Supplier part number
U1, U2	BGA3015	1	NXP	BGA3015	NXP	BGA3015
T1, T4	Balun	2	Toko	#617DB-1655=P3	Toko	#617DB-1655=P3
T2, T3	Transformer	2	Toko	#617PS-40369=P3	Toko	#617PS-40369=P3
C1, C4, C5, C6, C7, C8, C10, C11, C12, C13	10 nF	10	Murata	GRM155R71E103KA01D	Digikey	490-1312-1-ND
C3	NA	-	-	-	-	-
C9	0.82 pF	1	Phycomp	223886915827	RS components	616-9357
L1, L4	1.8 nH	2	Murata	LQG15HS1N8S02D	Digikey	490-2613-1-ND
L2, L3	22nH	2	Murata	LQG15HS22NJ02D	Digikey	490-2627-1-ND
R1, R2	390 Ω	2	Yageo	RC0402FR-07390RL	Digikey	311-390LRCT-ND
R3, R4	220 Ohm	2	Yageo	RC0402FR-07220RL	Digikey	311-220LRCT-ND
J1, J2	75 Ω F-connector	2	Bomar	861V509ER6	Mouser	678-861V509ER6
J3	Header 3	1	Molex	90121-0763	Digikey	WM8109-ND

4.3.3 BGA3018 Push-Pull BoM

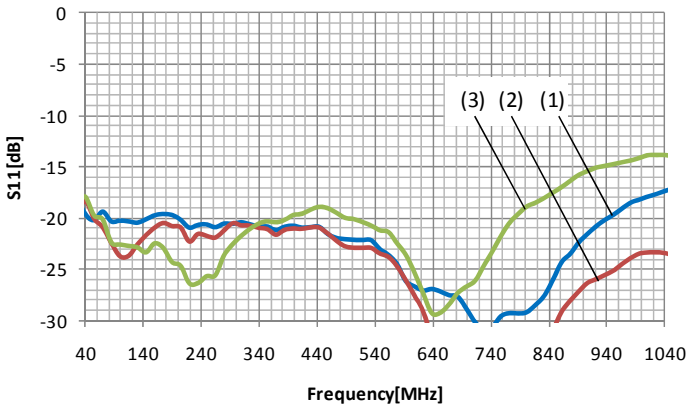
Table 3. BGA3018 Push-Pull BoM

Circuit Reference	Description	Qty	Mfr	Manufacturer number	Supplier	Supplier part number
U1, U2	BGA3018	1	NXP	BGA3018	NXP	BGA3018
T1, T4	Balun	2	Toko	#617DB-1655=P3	Toko	#617DB-1655=P3
T2, T3	Transformer	2	Toko	#617PS-40369=P3	Toko	#617PS-40369=P3
C1, C4, C5, C6, C7, C8, C10, C11, C12, C13	10 nF	10	Murata	GRM155R71E103KA01D	Digikey	490-1312-1-ND
C3	NA	-	-	-	-	-
C9	0.82 pF	1	Phycomp	223886915827	RS components	616-9357
L1, L4	1.8 nH	2	Murata	LQG15HS1N8S02D	Digikey	490-2613-1-ND
L2, L3	27nH	2	Murata	LQG15HS27NJ02D	Digikey	490-2628-1-ND
R1, R2	390 Ω	2	Yageo	RC0402FR-07390RL	Digikey	311-390LRCT-ND
R3, R4	470 Ohm	2	Yageo	RC0402FR-07470RL	Digikey	311-470LRCT-ND
J1, J2	75 Ω F-connector	2	Bomar	861V509ER6	Mouser	678-861V509ER6
J3	Header 3	1	Molex	90121-0763	Digikey	WM8109-ND

5. BGA301x Push-Pull measurement results

5.1 BGA301x measurement results at Vcc = 8 V

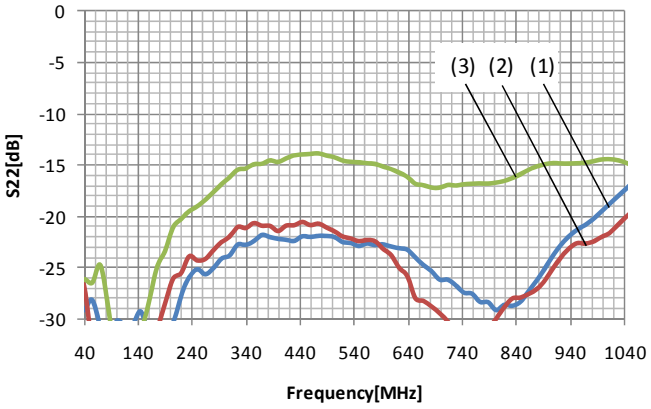
5.1.1 S-Parameters



Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

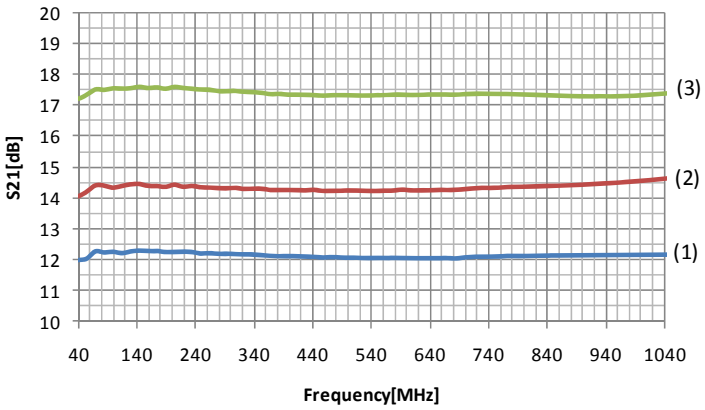
Fig 3. Input matching (S11); Vcc = 8 V



Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

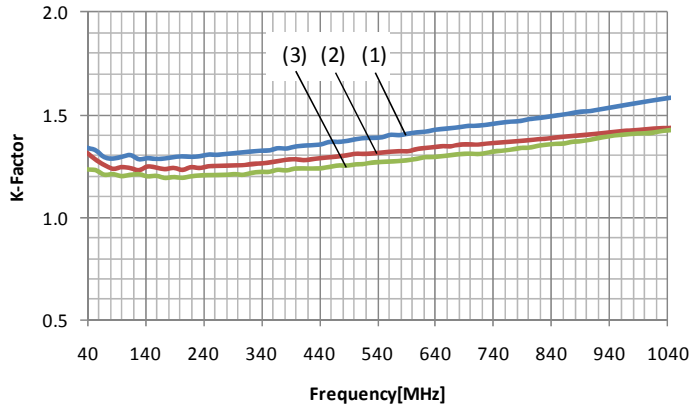
Fig 4. Output matching (S22); Vcc = 8 V



Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 5. Gain (S21); Vcc = 8 V

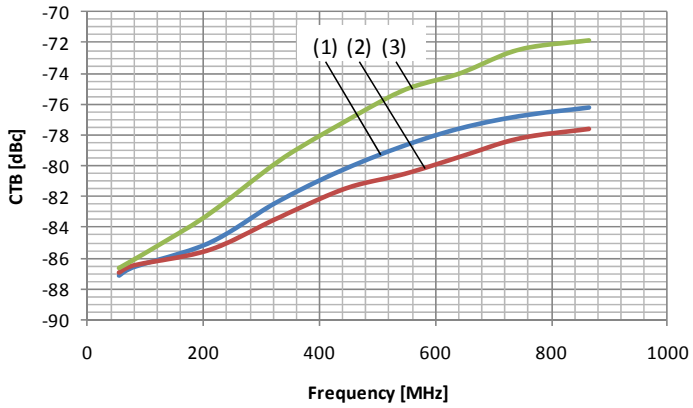


Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 6. K-factor; Vcc = 8 V

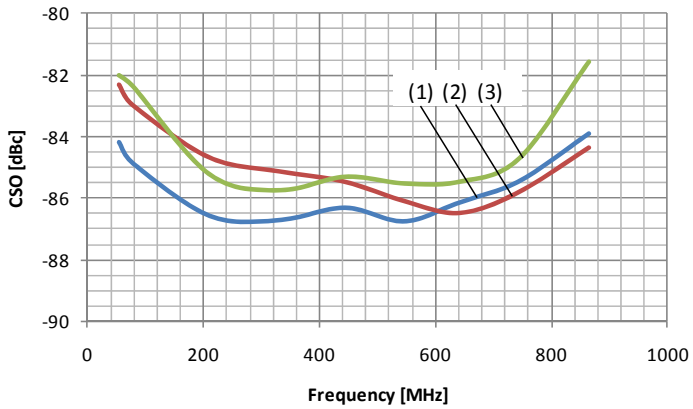
5.1.2 Distortion



Tamb = +25 °C ; 132 channels NTSC , Vo = 30 dBmV

(1) BGA3012
(2) BGA3015
(3) BGA3018

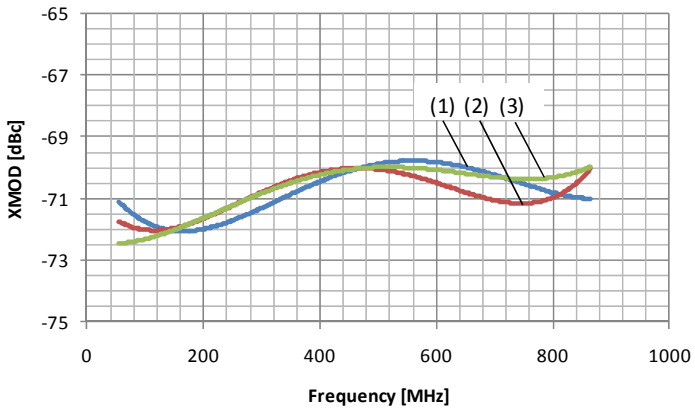
Fig 7. Composite triple beat (CTB); Vcc = 8 V



Tamb = +25 °C ; 132 channels NTSC , Vo = 30 dBmV

(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 8. Composite second order (CSO); Vcc = 8 V

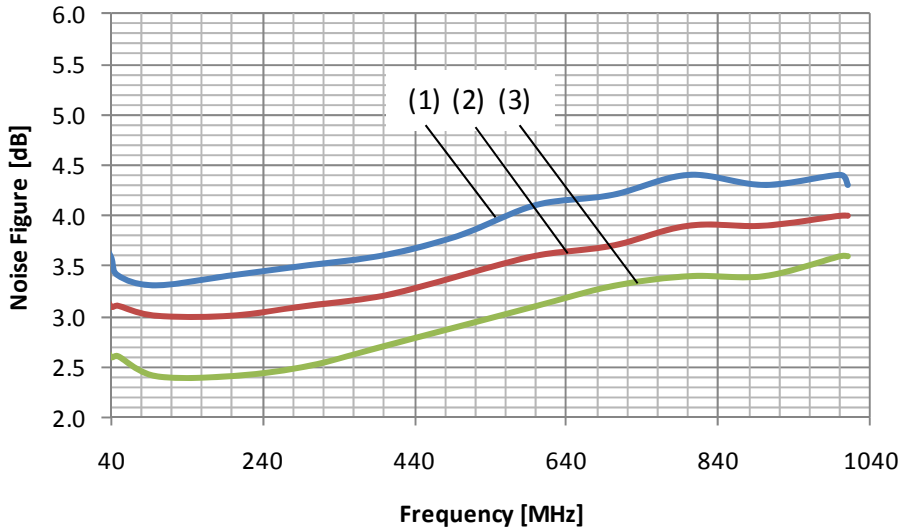


Tamb = +25 °C ; 132 channels NTSC , Vo = 30 dBmV

(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 9. Cross modulation (XMOD); Vcc = 8V

5.1.3 Noise figure

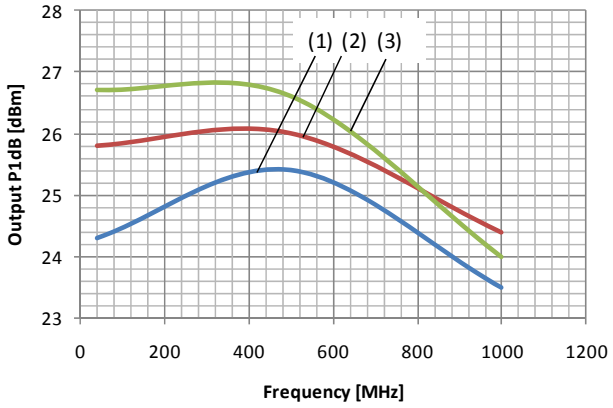


Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 10. Noise figure; Vcc = 8 V

5.1.4 Output P1dB

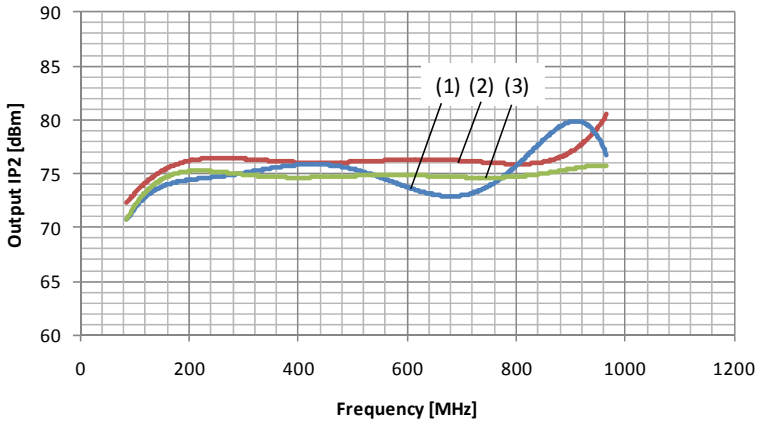


Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 11. Output P1dB; Vcc = 8V

5.1.5 Output IP2

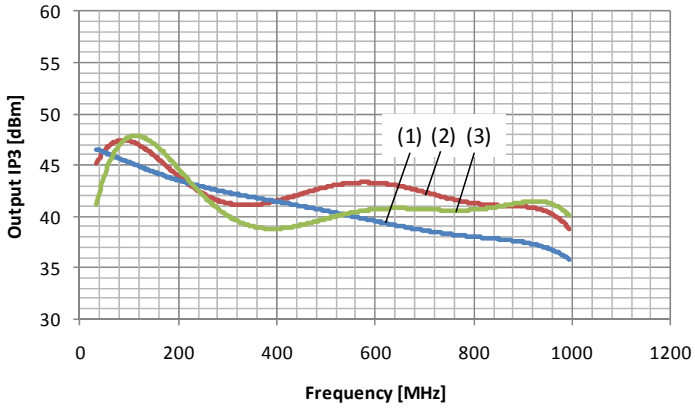


Tamb = +25 °C
f2 = f1 ± 6MHz

(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 12. Output IP2; Vcc = 8 V

5.1.6 Output IP3



Tamb = +25 °C

f2 = f1 ± 6MHz

(1) BGA3012

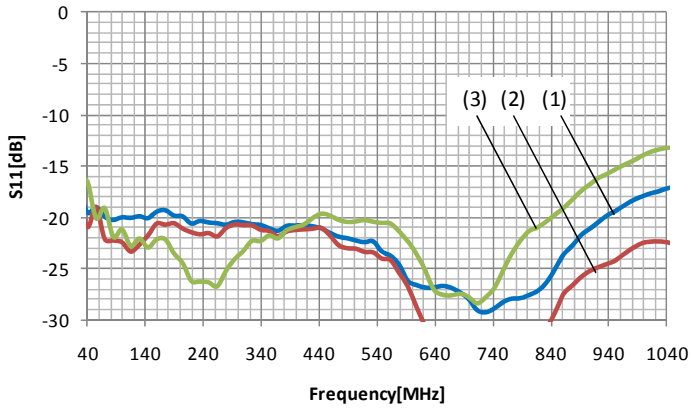
(2) BGA3015

(3) BGA3018

Fig 13. Output IP3; Vcc = 8 V

5.2 BGA301x measurement results at Vcc = 5 V

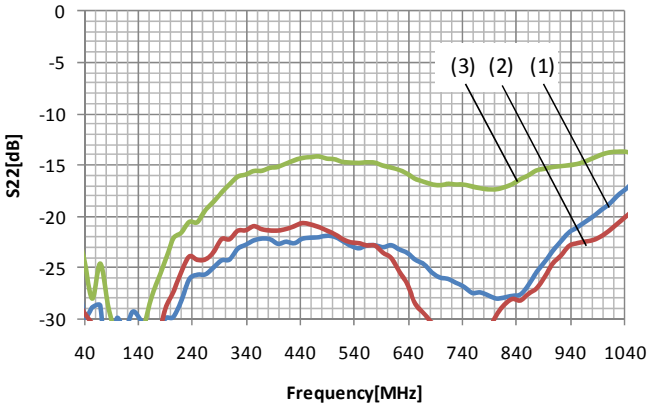
5.2.1 S-Parameters



Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

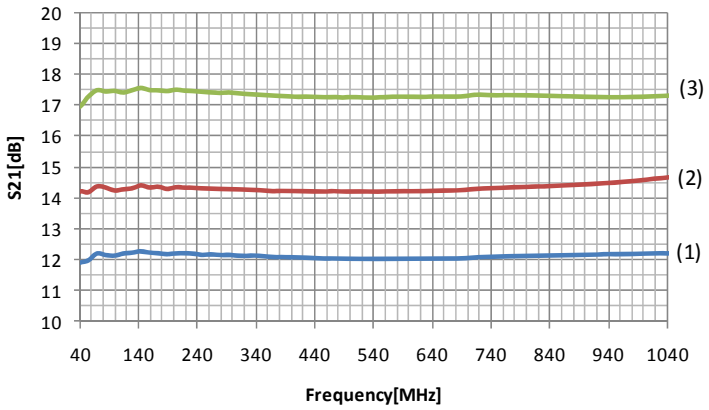
Fig 14. Input matching (S11); Vcc = 5 V



Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

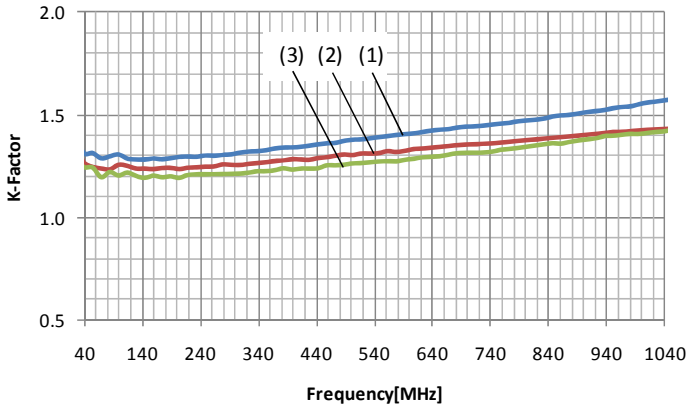
Fig 15. Output matching (S22); Vcc = 5 V



Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 16. Gain (S21); Vcc = 5 V

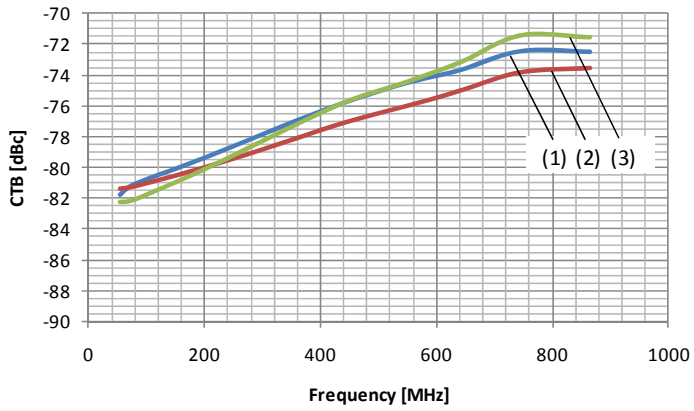


Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

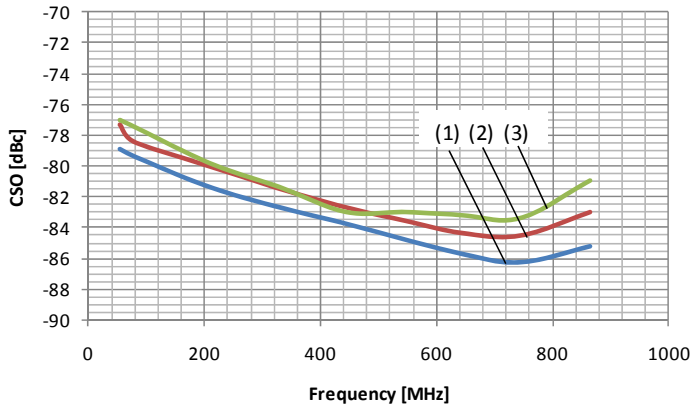
Fig 17. K-factor; Vcc = 5 V

5.2.2 Distortion



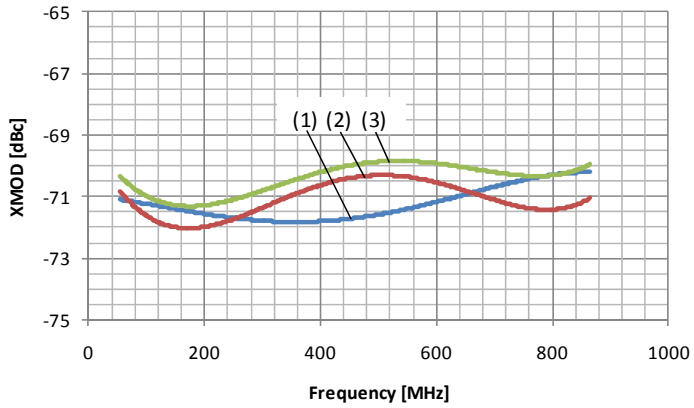
(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 18. Composite triple beat (CTB); Vcc = 5 V



(1) BGA3012
(2) BGA3015
(3) BGA3018

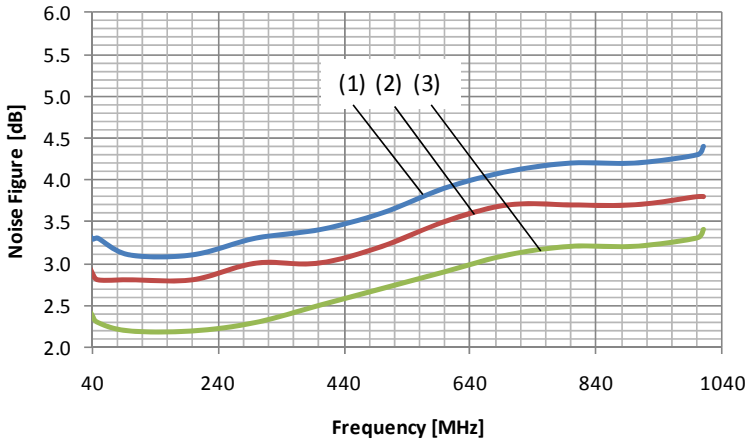
Fig 19. Composite second order (CSO); Vcc = 5 V



(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 20. Cross modulation (XMOD); Vcc = 5 V

5.2.3 Noise figure

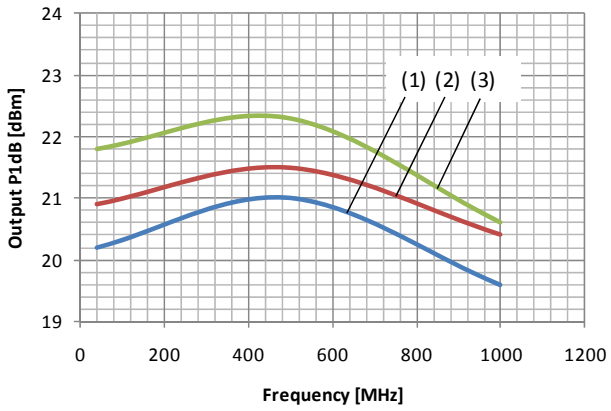


Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 21. Noise figure; Vcc = 5 V

5.2.4 Output P1dB

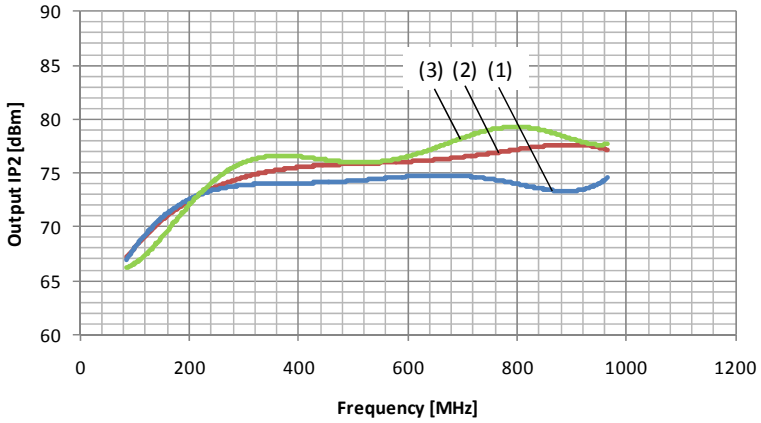


Tamb = +25 °C

(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 22. Output P1dB; Vcc = 5 V

5.2.5 Output IP2

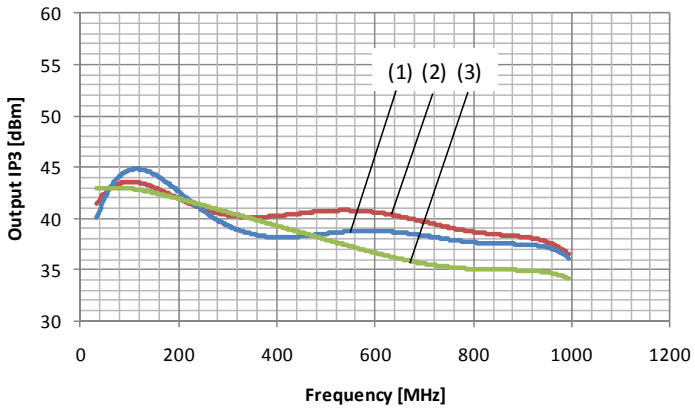


Tamb = +25 °C
f2 = f1 ± 6MHz

(1) BGA3012
(2) BGA3015
(3) BGA3018

Fig 23. Output IP2; Vcc = 5 V

5.3 Output IP3



Tamb = +25 °C

f2 = f1 ± 6MHz

(1) BGA3012

(2) BGA3015

(3) BGA3018

Fig 24. Output IP3; Vcc = 5 V

6. Abbreviations

Table 2. Abbreviations

Acronym	Description
AC	Alternating Current
CATV	Community Antenna TeleVision
DC	Direct Current
ESD	Electro Static Discharge
MMIC	Monolithic Microwave Integrated Circuit
NTSC	National Television Standards Committee
PCB	Printed Circuit Board
RF	Radio Frequency
SMD	Surface Mounted Device

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