AN11228

BGA301x Wideband Variable Gain Amplifier Application

Rev. 1 — 22 October 2012 Application note

Document information

Info	Content
Keywords	BGA3015, BGA3018, CATV, Line-up, VGA, Evaluation board
Abstract	This application note describes the schematic and layout requirements for using the BGA3015 and BGA3018 drop amplifiers in a CATV VGA application.

Revision history

Rev	Date	Description
v.1	20121022	First publication

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1. Introduction

With the use of NXP's BGA301x drop amplifiers and the BAP70Q quad pin diode attenuator a wideband Variable Gain Amplifier (VGA) has been made which can be used as line-up amplifier in CATV networks.

The combination of NXP's BGA301x amplifiers and BAP70Q pin diode parts a high gain amplifier with low noise figure and wide dynamic range can be made.

This application note describes the evaluation board schematic and layout requirements, and shows the test results.

2. System features

- 75 Ω input and output impedance
- Gain control dynamic range of 20 dB
- Flat gain between 40 MHz and 1003 MHz
- Unconditionally stable
- Excellent input and output return loss

3. Customer evaluation kit contents

The evaluation kit contains the following items:

- ESD safe casing
- BGA301x VGA evaluation board

4. Application Information

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

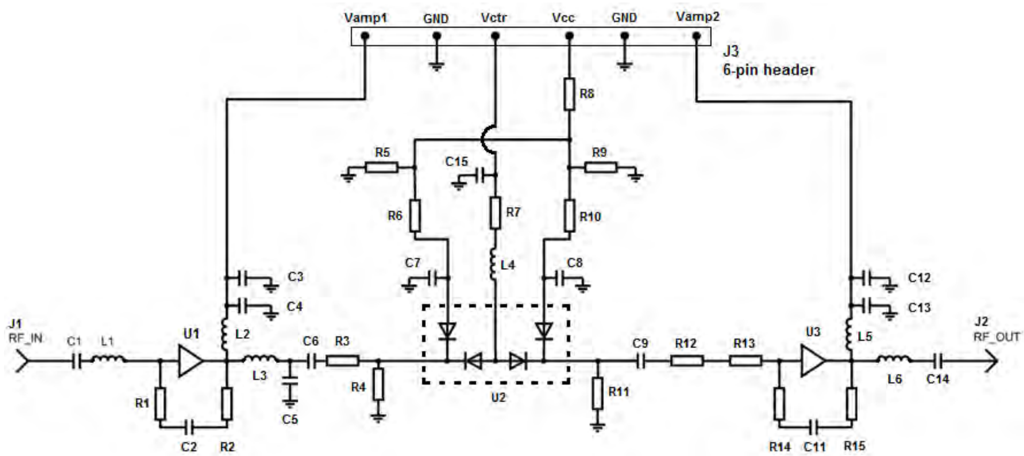


Fig 1. VGA evaluation circuit

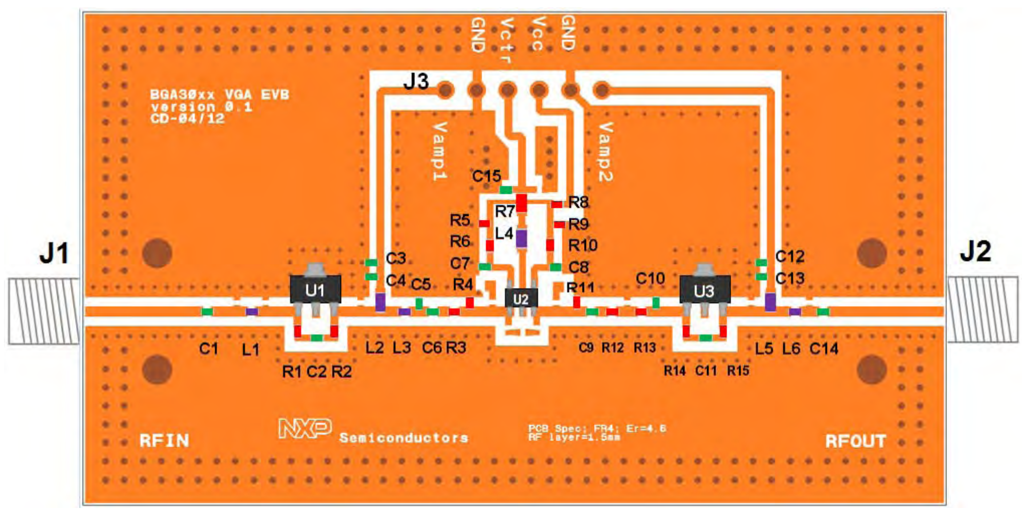
The connector pinning is as followed:

- "GND" : Ground pins
- "Vamp1" : +8 V power supply for amplifier U1
- "Vamp2" : +8 V power supply for amplifier U3
- "Vcc" : +8 V power supply for pin diode attenuator U2
- "Vctr" : Pin diode attenuator control voltage (1 … 3 V)

At connector J1 the RF signal from an external optical receiver is applied, where C1 provides DC-blocking, followed by L1 for S11 matching of the BGA3018 amplifier (U1). The feedback of amplifier U1 is provided via R1 & R2 with C2 for DC-blocking between the input and output pins of the amplifier. Two resistors are used to lower the influence of the parasitic capacitance from the circuit board. The output of amplifier U1 is matched with L3 and C5 and C6 provides the DC-blocking towards pin-diode attenuator U2.

The signal out of the first amplifier has a large dynamic range and with use of the BAP70Q pin diode attenuator (U2) the RF signals can be attenuated in such a way that a stable RF signal will be available at the output of the pin-diode attenuator. The stable output signal is amplified again by the BGA3015 amplifier (U3).The output of amplifier U2 is matched for S22 with L6 and C14 provides the DC-blocking towards the output connector J2.

4.2 Evaluation board layout



PCB material = FR4
PCB thickness = 1.5 mm
PCB size = 40 mm x 70 mm
ε_r = 4.6
Copper thickness = 35 µm

Fig 2. VGA 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.

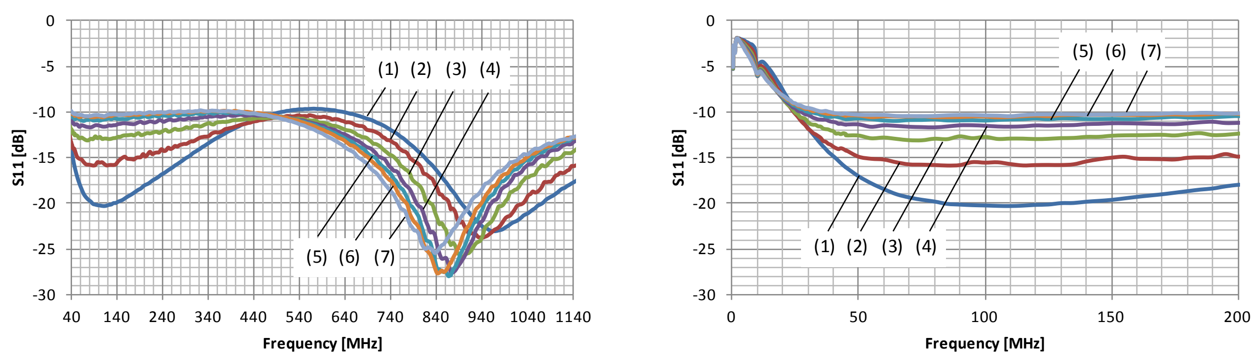
4.3 Bill of materials

Table 1. Evaluation board BOM

Circuit Reference	Description	Qty	Mfr	Manufacturer number	Supplier	Supplier part number
U1	BGA3018	1	NXP	BGA3018	NXP	BGA3018
U2	BAP70Q	1	NXP	BAP70Q	NXP	BAP70Q
U3	BGA3015	1	NXP	BGA3015	NXP	BGA3015
C1, C2, C4 C6, C7, C8 C11, C13, C14	10 nF	9	Murata	GRM155R71E103KA01D	Digikey	490-1312-1-ND
C3, C12, C15	100 pF	3	Murata	GRM1555C1H101JZ01D	Digikey	490-3458-1-ND
C9	270 pF	1	Murata	GRM1555C1H271JA01D	Digikey	490-1294-1-ND
C5, C10	0.5 pF	2	Murata	GRM1555C1HR50CZ01D	Digikey	490-1263-1-ND
L1, L3, L6	3.9 nH	3	Murata	LQG15HS3N9S02D	Digikey	490-2617-1-ND
L2, L4, L5	Choke	3	Murata	BLM18HE152SN1D	Digikey	490-5216-1-ND
R1, R4, R11	470 Ω	3	Yageo	RC0402FR-07470RL	Digikey	311-470LRCT-ND
R2, R14, R15	300 Ω	3	Yageo	RC0402FR-07300RL	Digikey	311-300LRCT-ND
R3, R6, R10, R12, R13	0 Ω (Jumper)	5	Yageo	RC0402FR-070RL	Digikey	311-0.0LRCT-ND
R7	0 Ω (Jumper)	1	Yageo	RC0603FR-070RL	Digikey	RC0603FR-070RL-ND
R5, R9	1200 Ω	2	Yageo	RC0402FR-071K2L	Digikey	311-1.20KLRCT-ND
R8	2200 Ω	1	Yageo	RC0402FR-072K2L	Digikey	311-2.20KLRCT-ND
J1, J2	75Ω F-connector	2	Bomar	861V509ER6	Mouser	678-861V509ER6
J3	Header 6	1	Molex	90121-0766	Digikey	WM8112-ND

5. Measurement results

5.1 S-Parameters



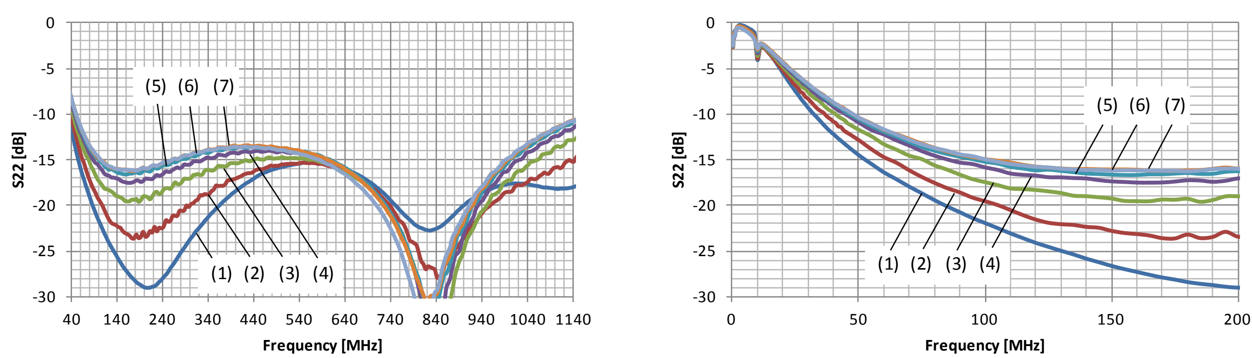
a. S11: 40 MHz – 1140 MHz

(1): Vctr = 2.13 V
(2): Vctr = 1.80 V
(3): Vctr = 1.64 V
(4): Vctr = 1.50 V
(5): Vctr = 1.39 V
(6): Vctr = 1.29 V
(7): Vctr = 1.12 V

b. S11: 300 kHz – 200 MHz

(1): Vctr = 2.13 V
(2): Vctr = 1.80 V
(3): Vctr = 1.64 V
(4): Vctr = 1.50 V
(5): Vctr = 1.39 V
(6): Vctr = 1.29 V
(7): Vctr = 1.12 V

Fig 3. Input matching (S11); typical



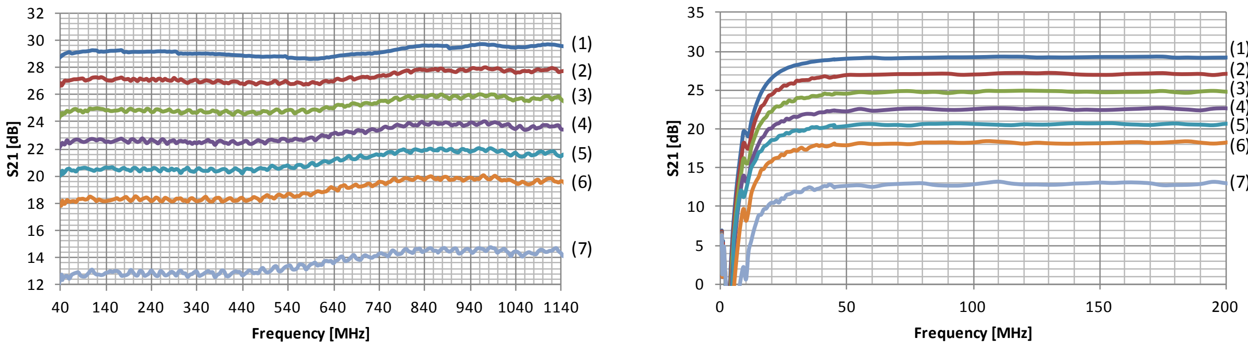
a. S22: 40 MHz – 1140 MHz

(1): Vctr = 2.13 V
(2): Vctr = 1.80 V
(3): Vctr = 1.64 V
(4): Vctr = 1.50 V
(5): Vctr = 1.39 V
(6): Vctr = 1.29 V
(7): Vctr = 1.12 V

c. S22: 300 kHz – 200 MHz

(1): Vctr = 2.13 V
(2): Vctr = 1.80 V
(3): Vctr = 1.64 V
(4): Vctr = 1.50 V
(5): Vctr = 1.39 V
(6): Vctr = 1.29 V
(7): Vctr = 1.12 V

Fig 4. Output matching (S22); typical



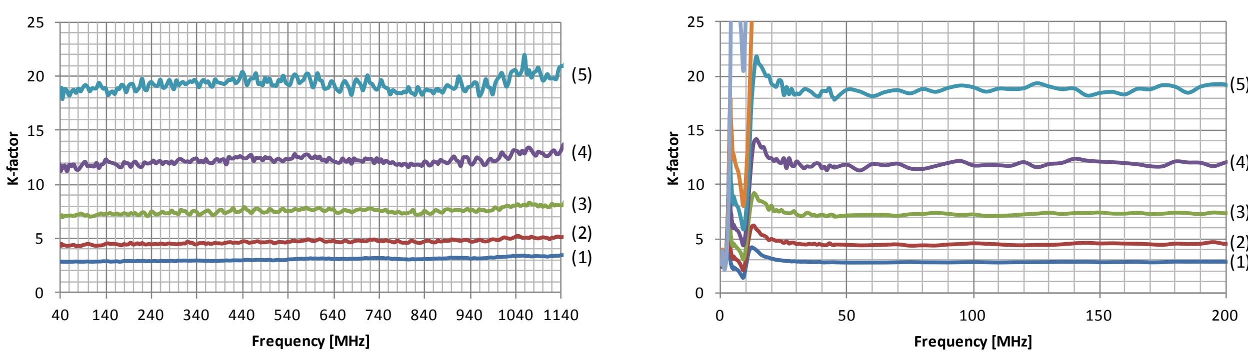
a. S21: 40 MHz – 1140 MHz

(1): Vctr = 2.13 V
(2): Vctr = 1.80 V
(3): Vctr = 1.64 V
(4): Vctr = 1.50 V
(5): Vctr = 1.39 V
(6): Vctr = 1.29 V
(7): Vctr = 1.12 V

d. S21: 300 kHz – 200 MHz

(1): Vctr = 2.13 V
(2): Vctr = 1.80 V
(3): Vctr = 1.64 V
(4): Vctr = 1.50 V
(5): Vctr = 1.39 V
(6): Vctr = 1.29 V
(7): Vctr = 1.12 V

Fig 5. Gain (S21); typical



a. K-factor: 40 MHz – 1140 MHz

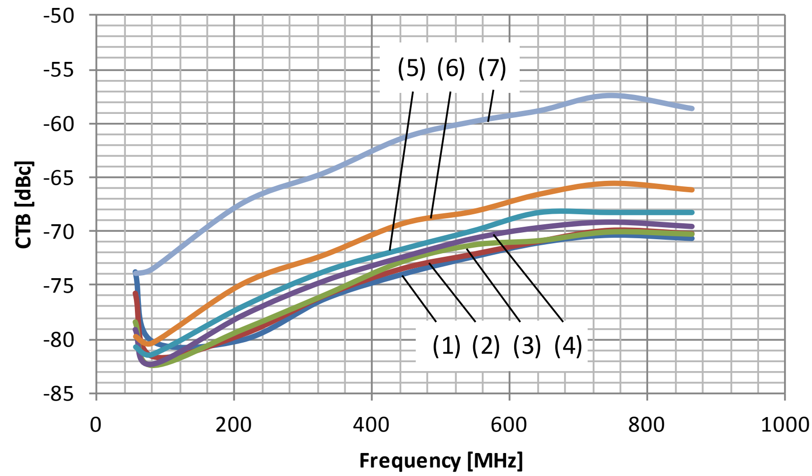
(1): Vctr = 2.13 V
(2): Vctr = 1.80 V
(3): Vctr = 1.64 V
(4): Vctr = 1.50 V
(5): Vctr = 1.39 V
(6): Vctr = 1.29 V
(7): Vctr = 1.12 V

b. K-factor: 300 kHz – 200 MHz

(1): Vctr = 2.13 V
(2): Vctr = 1.80 V
(3): Vctr = 1.64 V
(4): Vctr = 1.50 V
(5): Vctr = 1.39 V
(6): Vctr = 1.29 V
(7): Vctr = 1.12 V

Fig 6. K-factor; typical

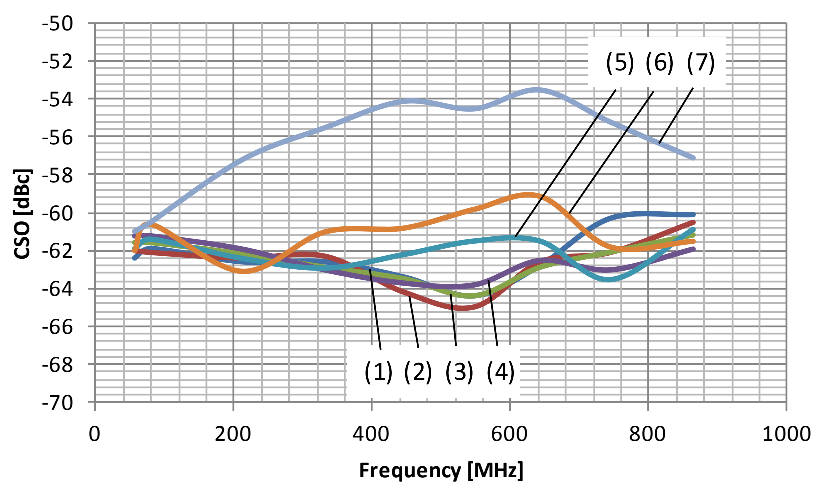
5.2 Distortion



(1): Vctr = 2.13 V (5): Vctr = 1.50 V
(2): Vctr = 1.80 V (6): Vctr = 1.39 V
(3): Vctr = 1.64 V (7): Vctr = 1.29 V

132 channels NTSC , Vo = 30dBmV

Fig 7. Composite triple beat (CTB) at different gain settings

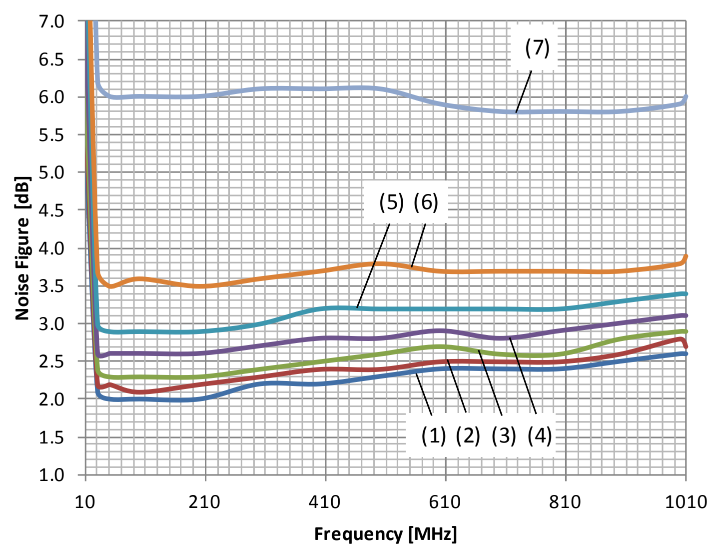


(1): Vctr = 2.13 V (5): Vctr = 1.50 V
(2): Vctr = 1.80 V (6): Vctr = 1.39 V
(3): Vctr = 1.64 V (7): Vctr = 1.29 V

132 channels NTSC , Vo = 30dBmV

Fig 8. Composite second order (CSO) at different gain settings

5.3 Noise figure



(1): Vctr = 2.13 V
(2): Vctr = 1.80 V
(3): Vctr = 1.64 V
(5): Vctr = 1.50 V
(6): Vctr = 1.39 V
(7): Vctr = 1.29 V

Fig 9. Noise figure at different gain settings

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
PCB	Printed Circuit Board
RF	Radio Frequency
SMD	Surface Mounted Device

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