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BGA7350

50 MHz to 250 MHz high linearity Si variable gain amplifier; 24 dB gain range

Rev. 1 — 21 December 2011 **Product data sheet**

1. Product profile

1.1 General description

The BGA7350 MMIC is a dual independently digitally controlled IF Variable Gain Amplifier (VGA) operating from 50 MHz to 250 MHz. Each IF VGA amplifies with a gain range of 24 dB and at its maximum gain setting delivers 17 dBm output power at 1 dB gain compression and a superior linear performance.

The BGA7350 Dual IF VGA is optimized for a differential gain error of less than ±0.1 dB for accurate gain control and has a total integrated gain error of less than ±0.4 dB.

The gain controls of each amplifier are separate digital gain-control word, which is provided externally through two sets of 5 bits.

The BGA7350 is housed in a 32 pins 5 mm × 5 mm leadless HVQFN32 package.

1.2 Features and benefits

- Dual independent digitally controlled 24 dB gain range VGAs, with 5-bit control interface
- 50 MHz to 250 MHz frequency operating range
- Gain step size: 1 dB ± 0.1 dB
- 18.5 dB power gain
- Fast gain stage switching capability
- 17 dBm output power at 1 dB gain compression
- 5 V single supply operation with power-down control
- Logic-level shutdown control pin reduces supply current
- Excellent ESD protection at all pins
- Moisture sensitivity level 2
- Unconditionally stable
- Compliant to Directive 2002/95/EC, regarding Restriction of Hazardous Substances (RoHS)

1.3 Applications

- Compatible with W-CDMA / WiMAX / LTE base-station infrastructure / multi carrier systems
- Multi channel receivers
- General use for ADC driver applications

1.4 Quick reference data

Table 1. Quick reference data

A_EN = "1"; B_EN = "1" (VGA enabled). Typical values at V_{CC} = 5 V; I_{CC} = 245 mA; Tuned for f_{IF} = 172 MHz; B = 28 MHz; T_{case} = 25 °C; Differential input resistance matched to 140 Ω; Differential output resistance matched to 200 Ω; unless otherwise specified; see Section 11 "Application information".

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{CC}	supply voltage	$V_{CC(A)} + V_{CC(B)}$		4.75	5	5.25	V
I_{CC}	supply current	$I_{CC(A)} + I_{CC(B)}$					
		A_EN = "0"; B_EN = "0"		-	3	5	mA
		A_EN = "1"; B_EN = "1"		-	245	280	mA
G_p	power gain	maximum gain	[1]	17.5	18.5	19.5	dB
		minimum gain	[2]	−7	−5.5	−4	dB
$R_{i(dif)}$	differential input resistance			100	140	180	Ω
$R_{o(dif)}$	differential output resistance			160	200	240	Ω
NF	noise figure	maximum gain	[1]	-	6	8	dB
		increased rate per gain step		-	0.8	1	dB
$IP3_O$	output third-order intercept point	upper 5 gain steps	[1]	-	43	-	dBm
$P_{L(1dB)}$	output power at 1 dB gain compression	upper 5 gain steps	[1]	-	17	-	dBm
$E_{G(dif)}$	differential gain error			-	± 0.1	-	dB
$E_{\varphi(dif)}$	differential phase error	upper 12 dB gain range		-	1.5	-	deg
		per gain step (for all consecutive gain steps)		-	0.5	-	deg

[1] Maximum gain; gain code = 00000.

[2] Minimum gain; gain code = 11000.

2. Pinning information

2.1 Pinning

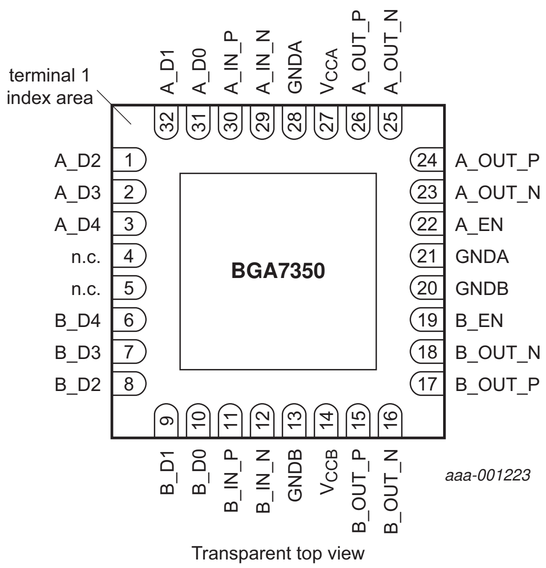

Fig 1. Pin configuration SOT617-1

2.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
A_D2	1	MSB – 2 for gain control interface of channel A
A_D3	2	MSB – 1 for gain control interface of channel A
A_D4	3	MSB for gain control interface of channel A
n.c.	4	not connected [1]
n.c.	5	not connected [1]
B_D4	6	MSB for gain control interface of channel B
B_D3	7	MSB – 1 for gain control interface of channel B
B_D2	8	MSB – 2 for gain control interface of channel B
B_D1	9	LSB + 1 for gain control interface of channel B
B_D0	10	LSB for gain control interface of channel B
B_IN_P	11	channel B positive input [2]
B_IN_N	12	channel B negative input [2]
GNDB	13, 20	ground for channel B
V_{CCB}	14	supply voltage for channel B
B_OUT_P	15, 17	channel B positive output [2]
B_OUT_N	16, 18	channel B negative output [2]
B_EN	19	power enable pin for channel B
GNDA	21, 28	ground for channel A

Table 2. Pin description *...continued*

Symbol	Pin	Description
A_EN	22	power enable pin for channel A
A_OUT_N	23, 25	channel A negative output [2]
A_OUT_P	24, 26	channel A positive output [2]
V_{CCA}	27	supply voltage for channel A
A_IN_N	29	channel A negative input [2]
A_IN_P	30	channel A positive input [2]
A_D0	31	LSB for gain control interface of channel A
A_D1	32	LSB + 1 for gain control interface of channel A
GND	GND paddle	RF ground and DC ground [3]

[1] Pin to be left open.

[2] Each channel should be independently enabled with logic HIGH and disabled with logic LOW.

[3] The center metal base of the SOT617-1 also functions as heatsink for the VGA.

3. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
BGA7350	HVQFN32	plastic thermal enhanced very thin quad flat package; no leads; 32 terminals; body 5 × 5 × 0.85 mm	SOT617-1

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4. Functional diagram

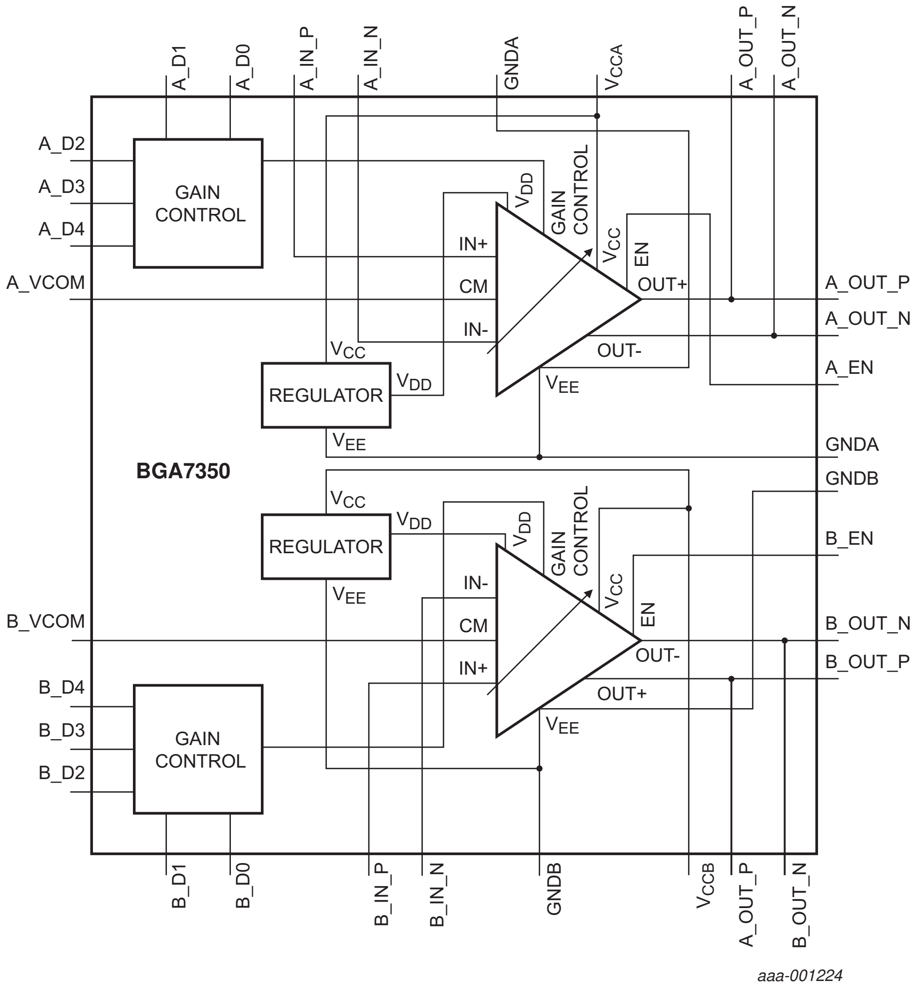


Fig 2. Functional diagram

5. Enable control

Table 4. Enable / disable control settings

Mode	Function description	Mode description	Enable		V_{EN} (V)		I_{en} (µA)	
			A_EN	B_EN	Min	Max	Min	Max
A_EN, B_EN	VGA function off	Disable	"0"	"0"	0	0.8	-	1
A_EN, B_EN	VGA in operating mode	Enable	"1"	"1"	1.6	5.25	-	1

6. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions		Min	Max	Unit
$V_{CC(A)}$	supply voltage (A)		[1]	-	6	V
$V_{CC(B)}$	supply voltage (B)		[1]	-	6	V
V_{AEN}	voltage on pin A_EN			−0.6	6	V
V_{BEN}	voltage on pin B_EN			−0.6	6	V
V_{AD0}	voltage on pin A_D0			−0.6	6	V
V_{AD1}	voltage on pin A_D1			−0.6	6	V
V_{AD2}	voltage on pin A_D2			−0.6	6	V
V_{AD3}	voltage on pin A_D3			−0.6	6	V
V_{AD4}	voltage on pin A_D4			−0.6	6	V
V_{BD0}	voltage on pin B_D0			−0.6	6	V
V_{BD1}	voltage on pin B_D1			−0.6	6	V
V_{BD2}	voltage on pin B_D2			−0.6	6	V
V_{BD3}	voltage on pin B_D3			−0.6	6	V
V_{BD4}	voltage on pin B_D4			−0.6	6	V
V_{AIN}	voltage on pin A_IN			−0.6	6	V
V_{BIN}	voltage on pin B_IN			−0.6	6	V
$P_{i(RF)}$	RF input power			-	20	dBm
T_{case}	case temperature			−40	+85	°C
T_j	junction temperature			-	150	°C
V_{ESD}	electrostatic discharge voltage	Human Body Model (HBM); According JEDEC standard 22-A114E		-	4000	V
		Charged Device Model (CDM); According JEDEC standard 22-C101B		-	2000	V
		Machine Model (MM); According JEDEC standard 22-A115		-	400	V

[1] All digital pins may not exceed V_{CC} as the internal ESD circuit can be damaged. To prevent this it is recommended that V_{AEN} and V_{BEN} are limited to a maximum of 5 mA.

7. Thermal characteristics

Table 6. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-sp)}$	thermal resistance from junction to solderpoint	T_{case} = 85 °C; V_{CC} = 5 V; I_{CC} = 245 mA	17	K/W

8. Static characteristics

Table 7. Characteristics

A_EN = "1"; B_EN = "1" (both channels enabled). Typical values at V_{CC} = 5 V; T_{case} = 25 °C; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{CC}	supply voltage	$V_{CC(A)} + V_{CC(B)}$		4.75	5	5.25	V
I_{CC}	supply current	$I_{CC(A)} + I_{CC(B)}$					
		A_EN = "0"; B_EN = "0"		-	3	5	mA
		A_EN = "1"; B_EN = "1"		-	245	280	mA
V_{IH}	HIGH-level input voltage		[1]	1.6	-	5.25	V
V_{IL}	LOW-level input voltage		[1]	-	-	0.8	V
P_L	power dissipation			-	1.2	1.5	W

[1] Voltage on the control pins.

9. Dynamic characteristics

Table 8. Characteristics

A_EN = "1"; B_EN = "1" (VGA enabled). Typical values at V_{CC} = 5 V; I_{CC} = 245 mA; Tuned for f_{IF} = 172 MHz; B = 28 MHz; T_{case} = 25 °C; Differential input resistance matched to 140 Ω; Differential output resistance matched to 200 Ω; unless otherwise specified; see Section 11 "Application information".

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
G_p	power gain	maximum gain	[1]				
		f = 50 MHz; B = 15 MHz		-	19.5	-	dB
		f = 172 MHz; B = 28 MHz		17.5	18.5	19.5	dB
		f = 250 MHz; B = 28 MHz		-	18.0	-	dB
		minimum gain	[2]				
		f = 50 MHz; B = 15 MHz		-	−4.5	-	dB
		f = 172 MHz; B = 28 MHz		−7	−5.5	−4	dB
		f = 250 MHz; B = 28 MHz		-	−6.0	-	dB
ΔG_{adj}	gain adjustment range		[1]	-	24	-	dB
G_{step}	gain step			-	1	-	
G_{flat}	gain flatness		[1]	-	0.1	-	dB
$E_{G(dif)}$	differential gain error			-	± 0.1	-	dB
$E_{G(itg)}$	integrated gain error	upper 12 dB gain range		-	± 0.3	-	dB
		full gain range		-	± 0.4	-	dB
$E_{\varphi(dif)}$	differential phase error	upper 12 dB gain range		-	1.5	-	deg
		per gain step (for all consecutive gain steps)		-	0.5	-	deg
$t_{s(step)G}$	gain step settling time	per 1.5 dB of steady state		-	5	15	ns
		per 0.1 dB of steady state		-	20	40	ns
$t_{d(grp)}$	group delay time			-	150	-	ps
t_{pu}	power-up time			-	-	1	μs

Table 8. Characteristics *...continued*

A_EN = "1"; B_EN = "1" (VGA enabled). Typical values at V_{CC} = 5 V; I_{CC} = 245 mA; Tuned for f_{IF} = 172 MHz; B = 28 MHz; T_{case} = 25 °C; Differential input resistance matched to 140 Ω; Differential output resistance matched to 200 Ω; unless otherwise specified; see Section 11 "Application information".

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$R_{i(dif)}$	differential input resistance			100	140	180	Ω
$R_{o(dif)}$	differential output resistance			160	200	240	Ω
$\alpha_{isol(ch-ch)}$	isolation between channels			50	-	-	dB
CMRR	common-mode rejection ratio			40	-	-	dB
$IP3_O$	output third-order intercept point	Upper 5 gain steps	[3]				
		f = 50 MHz	[4]	-	43	-	dBm
		f = 172 MHz	[5]	-	43	-	dBm
		f = 250 MHz	[6]	-	41	-	dBm
$IP2_O$	output second-order intercept point	Upper 5 gain steps	[3]				
		f = 50 MHz	[7]	-	85	-	dBm
		f = 172 MHz	[8]	-	70	-	dBm
		f = 250 MHz	[9]	-	70	-	dBm
$P_{L(1dB)}$	output power at 1 dB gain compression	Upper 5 gain steps	[3]				
		f = 50 MHz		-	17	-	dBm
		f = 172 MHz		-	17	-	dBm
		f = 250 MHz		-	17	-	dBm
α_{2H}	second harmonic level	maximum gain	[1][10]	-	−80	-	dBc
		gain step 12	[2][10]	-	−80	-	dBc
NF	noise figure	maximum gain	[1]	-	6	8	dB
		increase rate per gain step		-	0.8	1	dB

[1] Maximum gain; gain code = 00000.

[2] Minimum gain; gain code = 11000.

[3] Gain code = 00000, 00001, 00010, 00011, 00100.

[4] P_L = 2 dBm per tone; spacing = 2 MHz (f_1 = 49 MHz; f_2 = 51 MHz)

[5] P_L = 2 dBm per tone; spacing = 2 MHz (f_1 = 171 MHz; f_2 = 173 MHz)

[6] P_L = 2 dBm per tone; spacing = 2 MHz (f_1 = 249 MHz; f_2 = 251 MHz)

[7] P_L = 2 dBm per tone (f_1 = 30 MHz; f_2 = 80 MHz; f_{meas} = 50 MHz)

[8] P_L = 2 dBm per tone (f_1 = 82 MHz; f_2 = 90 MHz; f_{meas} = 172 MHz)

[9] P_L = 2 dBm per tone (f_1 = 120 MHz; f_2 = 130 MHz; f_{meas} = 250 MHz)

[10] P_L = 5 dBm one tone (f = 86 MHz; f_{meas} = 172 MHz)

Table 9. Gain control

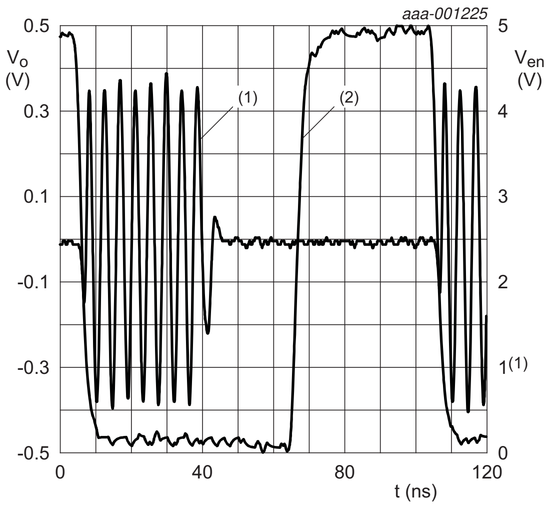
gain step	input to either A_D0 to A_D4 pins or B_D0 to B_D4 pins	nominal power gain (dB)
0	00000	18.5
1	00001	17.5
2	00010	16.5
3	00011	15.5
4	00100	14.5
5	00101	13.5
6	00110	12.5
7	00111	11.5
8	01000	10.5
9	01001	9.5
10	01010	8.5
11	01011	7.5
12	01100	6.5
13	01101	5.5
14	01110	4.5
15	01111	3.5
16	10000	2.5
17	10001	1.5
18	10010	0.5
19	10011	–0.5
20	10100	–1.5
21	10101	–2.5
22	10110	–3.5
23	10111	–4.5
24	11000	–5.5
-	> 11000	–5.5

10. Moisture sensitivity

Table 10. Moisture sensitivity level

Test methodology	Class
JESD-22-A113	2

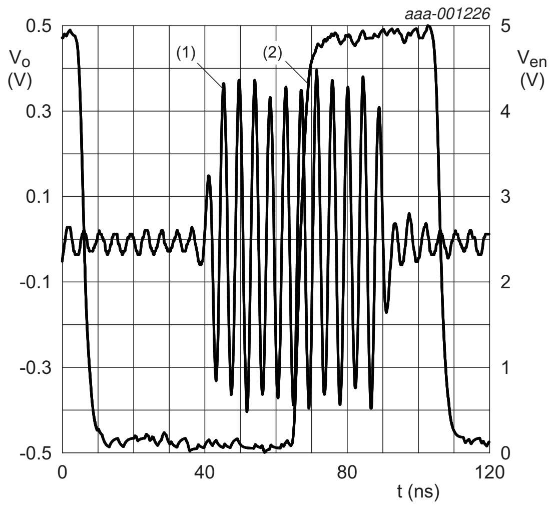
11. Application information



(1) V_O

(2) V_{en}

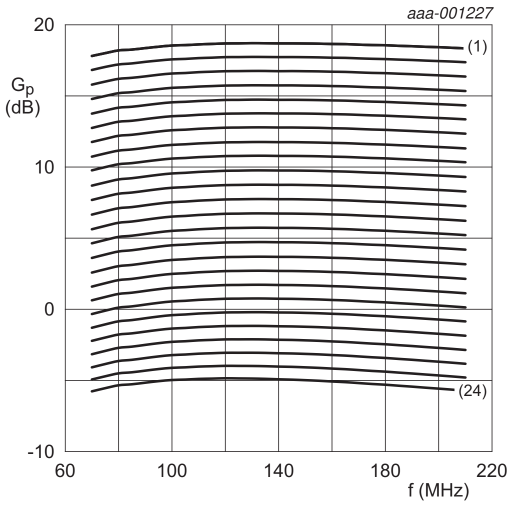
Fig 3. Enable time response



(1) V_O

(2) V_{en}

Fig 4. Gain step response

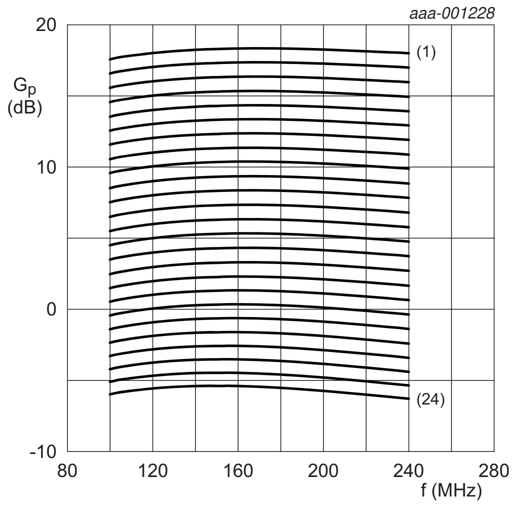


Tuned for f_{IF} = 140 MHz; P_L = 5 dBm; step size 1 dB.

(1) gain step 0 (maximum gain)

(25) gain step 24 (minimum gain)

Fig 5. Power gain as a function of frequency

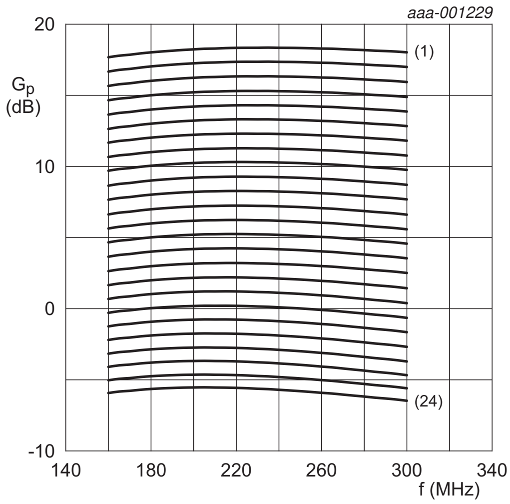


Tuned for f_{IF} = 172 MHz; P_L = 5 dBm; step size 1 dB.

(1) gain step 0 (maximum gain)

(25) gain step 24 (minimum gain)

Fig 6. Power gain as a function of frequency

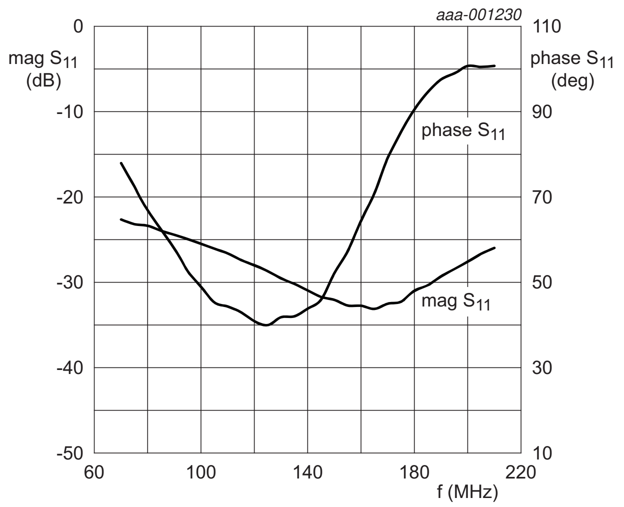


Tuned for f_{IF} = 230 MHz; P_L = 5 dBm; step size 1 dB.

(1) gain step 0 (maximum gain)

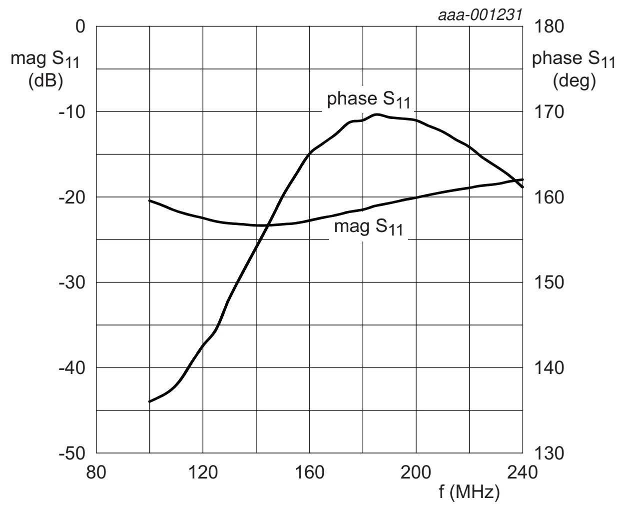
(25) gain step 24 (minimum gain)

Fig 7. Power gain as a function of frequency



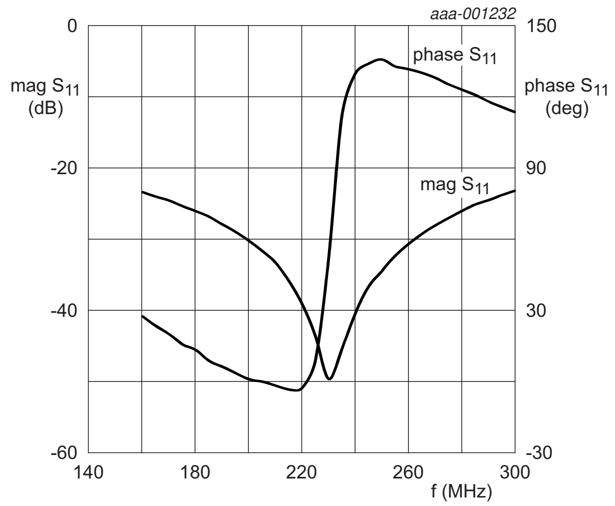
Tuned for f_{IF} = 140 MHz; measured at gain step 0 (maximum gain).

Fig 8. S_{11} as a function of frequency



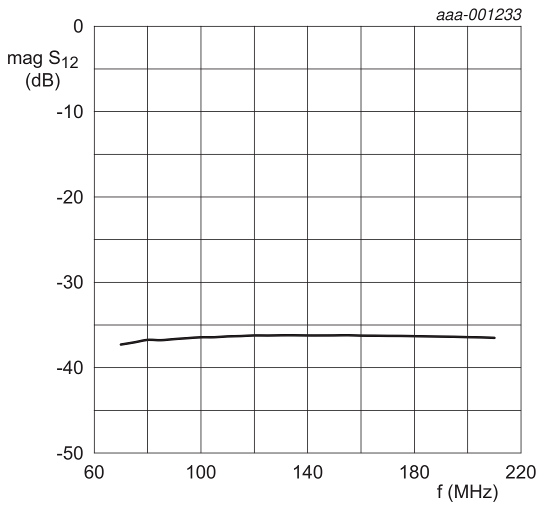
Tuned for f_{IF} = 172 MHz; measured at gain step 0 (maximum gain).

Fig 9. S_{11} as a function of frequency



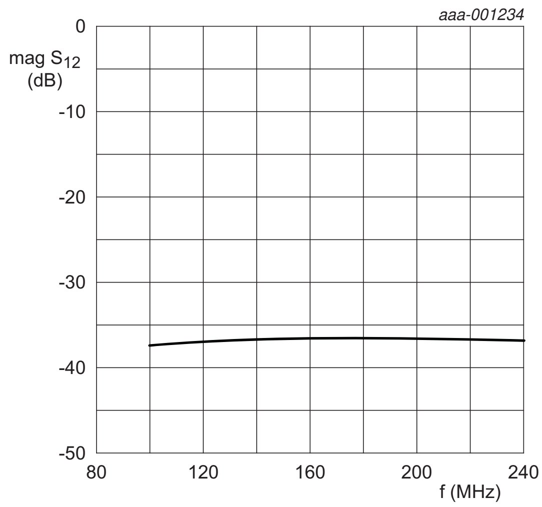
Tuned for f_{IF} = 230 MHz; measured at gain step 0 (maximum gain).

Fig 10. S_{11} as a function of frequency



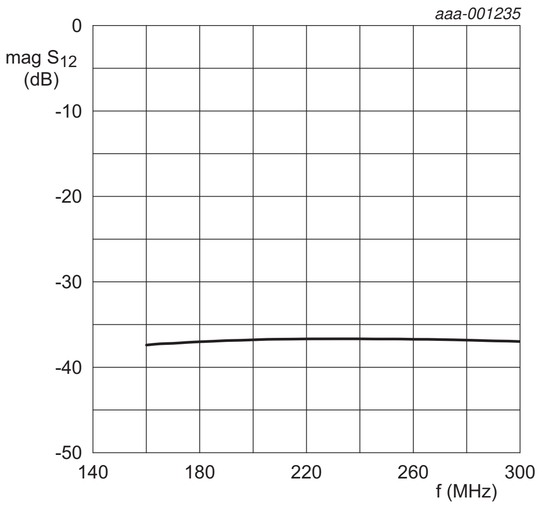
Tuned for f_{IF} = 140 MHz; measured at gain step 0 (maximum gain).

Fig 11. S_{12} as a function of frequency



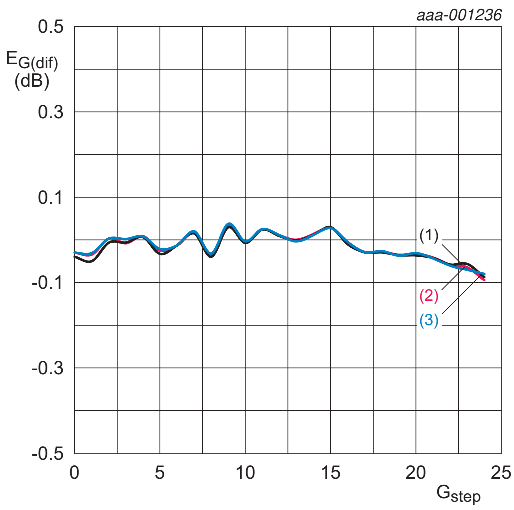
Tuned for f_{IF} = 172 MHz; measured at gain step 0 (maximum gain).

Fig 12. S_{12} as a function of frequency



Tuned for f_{IF} = 230 MHz; measured at gain step 0 (maximum gain).

Fig 13. S_{12} as a function of frequency



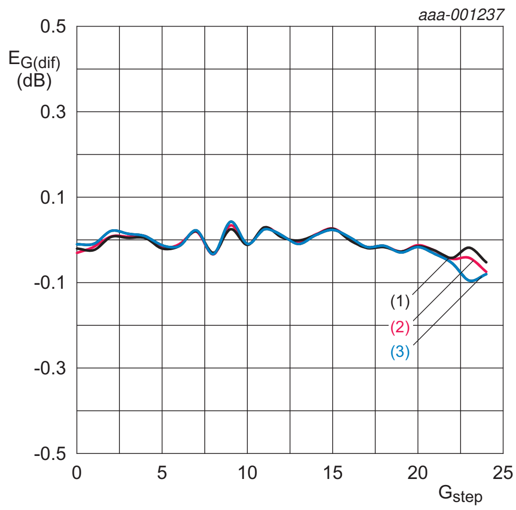
Tuned for f_{IF} = 140 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 14. Differential gain error as a function of gain step



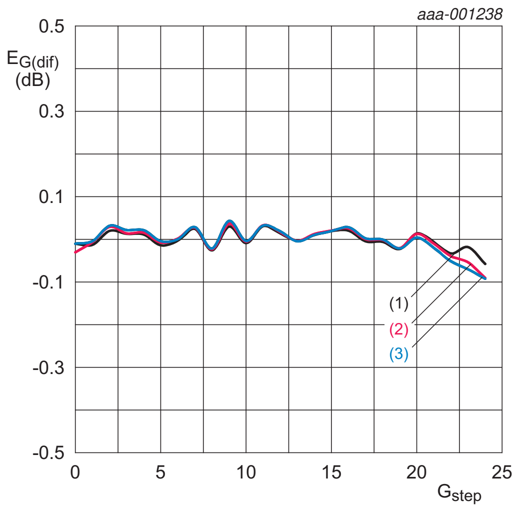
Tuned for f_{IF} = 172 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 15. Differential gain error as a function of gain step



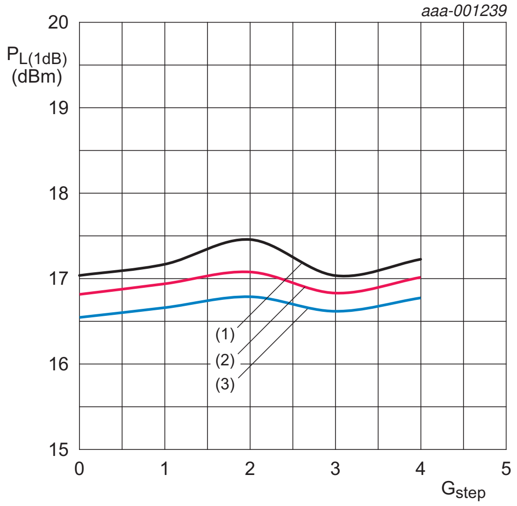
Tuned for f_{IF} = 230 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 16. Differential gain error as a function of gain step



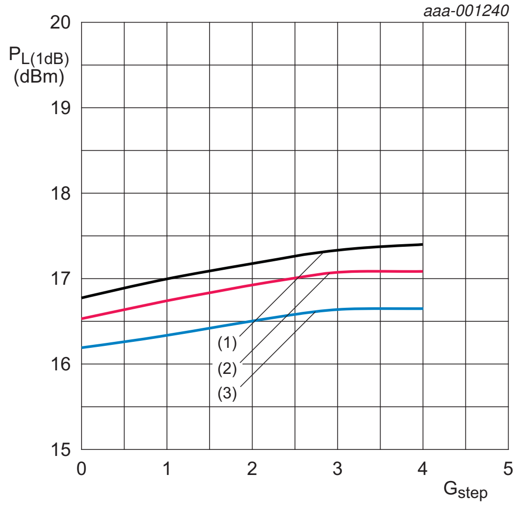
Tuned for f_{IF} = 140 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 17. output power at 1 dB gain compression as a function of gain step



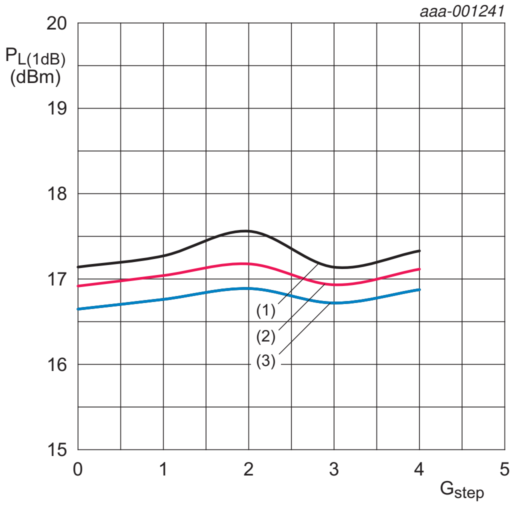
Tuned for f_{IF} = 172 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 18. output power at 1 dB gain compression as a function of gain step



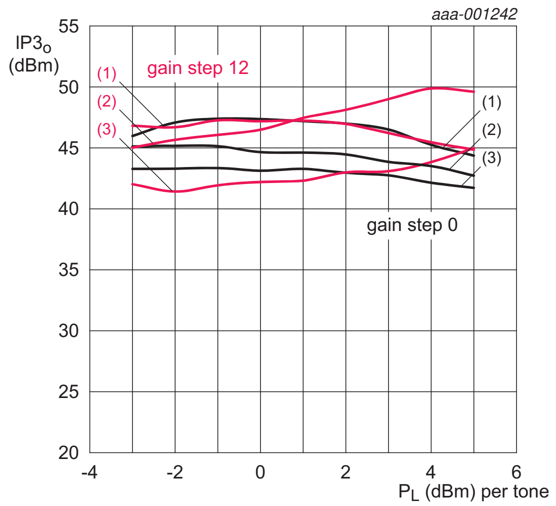
Tuned for f_{IF} = 230 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 19. output power at 1 dB gain compression as a function of gain step



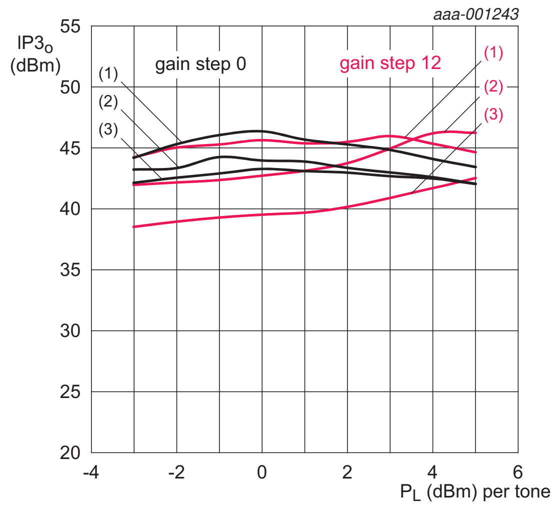
Tuned for f_{IF} = 140 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 20. Output third order intercept point as a function of output power per tone



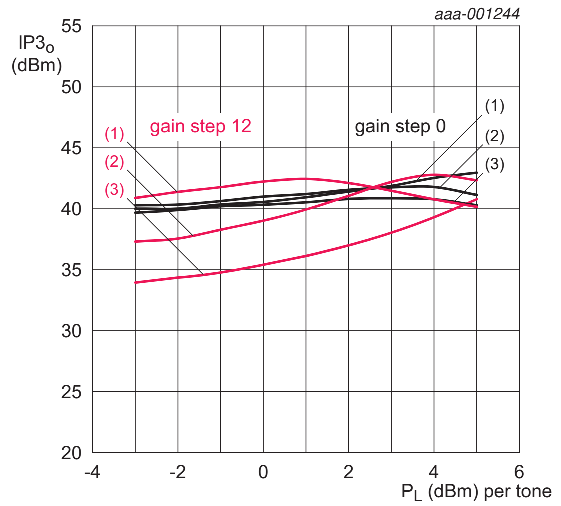
Tuned for f_{IF} = 172 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 21. Output third order intercept point as a function of output power per tone



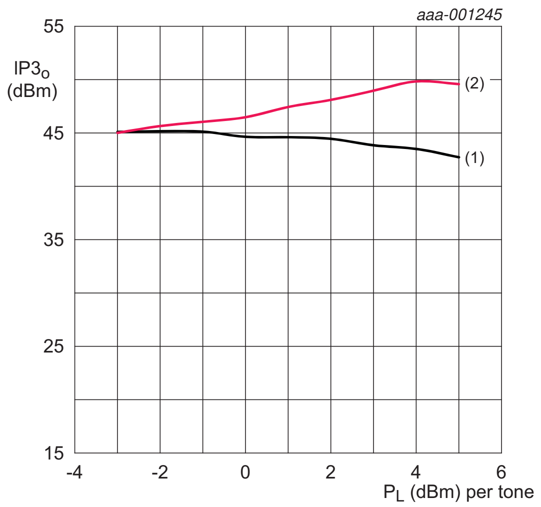
Tuned for f_{IF} = 230 MHz.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 22. Output third order intercept point as a function of output power per tone

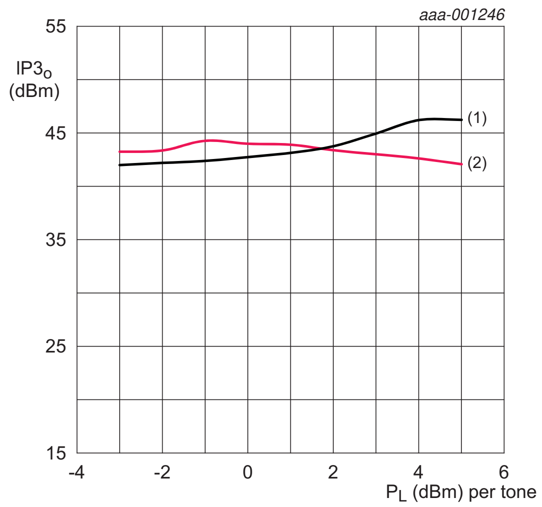


Tuned for f_{IF} = 140 MHz.

(1) gain step 0

(2) gain step 12

Fig 23. Output third order intercept point as a function of output power per tone

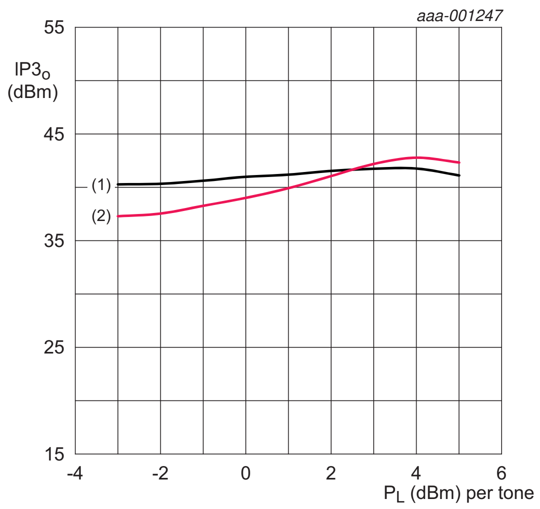


Tuned for f_{IF} = 172 MHz.

(1) gain step 0

(2) gain step 12

Fig 24. Output third order intercept point as a function of output power per tone

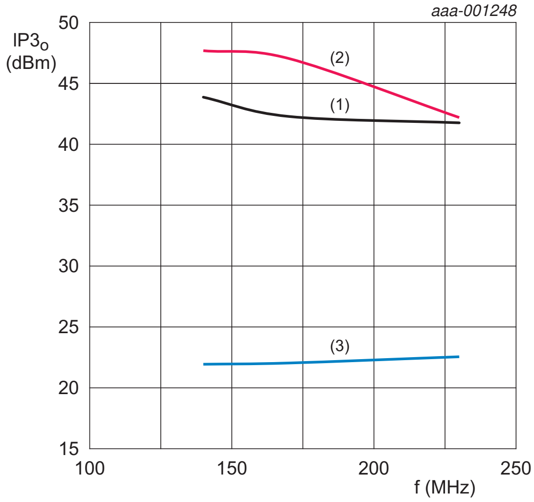


Tuned for f_{IF} = 230 MHz.

(1) gain step 0

(2) gain step 12

Fig 25. Output third order intercept point as a function of output power per tone



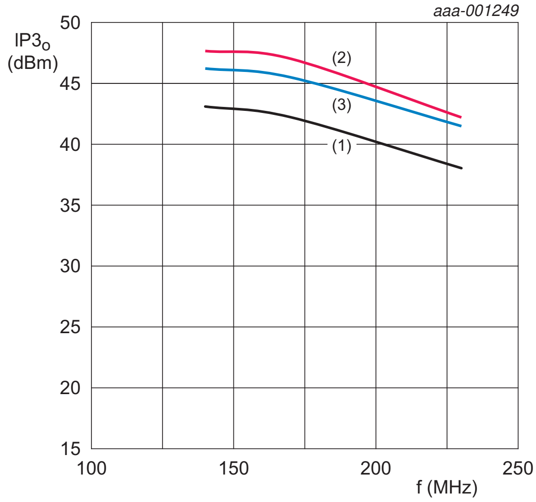
P_L = 3 dB per tone; T_{amb} = 25 °C.

(1) gain step 0

(2) gain step 12

(3) gain step 24

Fig 26. Output third order intercept point as a function of frequency



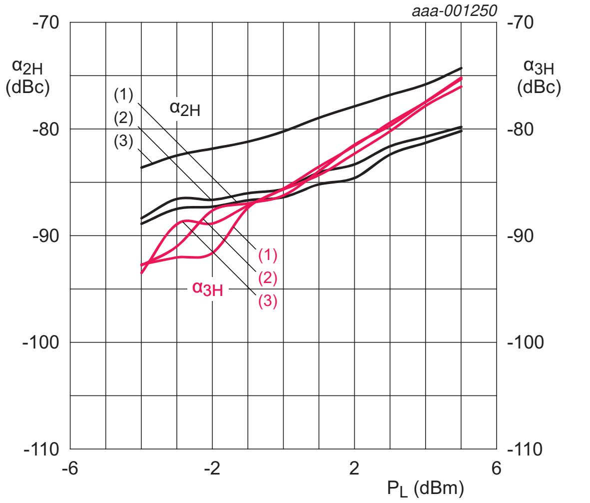
P_L = 3 dB per tone; gain step 12.

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 27. Output third order intercept point as a function of frequency



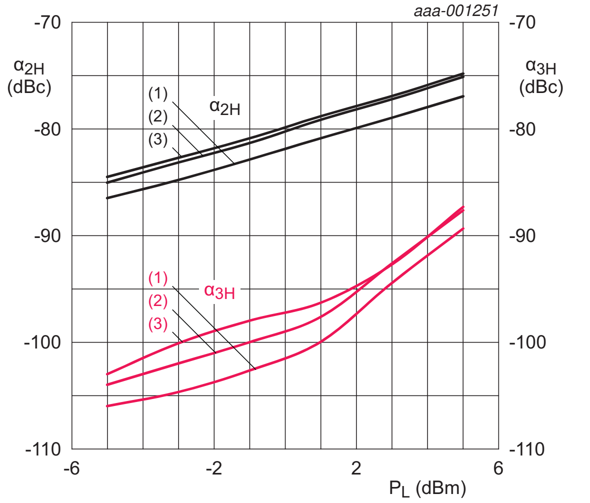
Tuned for f_{IF} = 86 MHz; f_{2H} = 172 MHz; f_{3H} = 258 MHz; gain step 0 (maximum gain).

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 28. Second harmonic level and third harmonic level as a function of output power



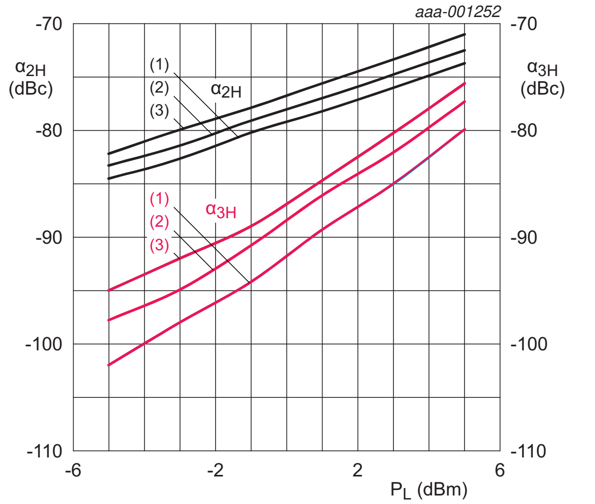
Tuned for f_{IF} = 140 MHz; f_{2H} = 280 MHz; f_{3H} = 420 MHz; gain step 0 (maximum gain).

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 29. Second harmonic level and third harmonic level as a function of output power



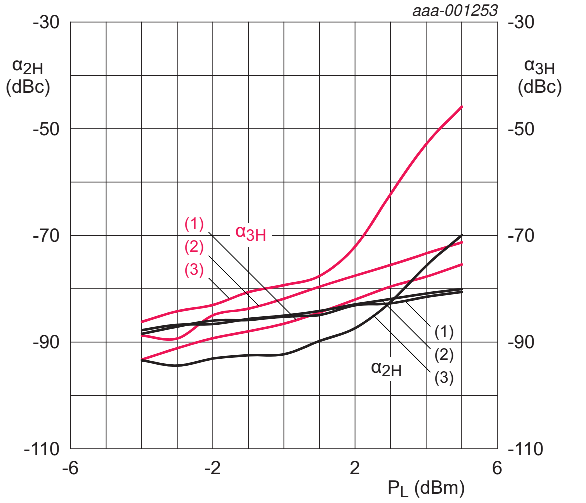
Tuned for f_{IF} = 230 MHz; f_{2H} = 460 MHz; f_{3H} = 690 MHz; gain step 0 (maximum gain).

(1) T_{amb} = −40 °C

(2) T_{amb} = +25 °C

(3) T_{amb} = +85 °C

Fig 30. Second harmonic level and third harmonic level as a function of output power



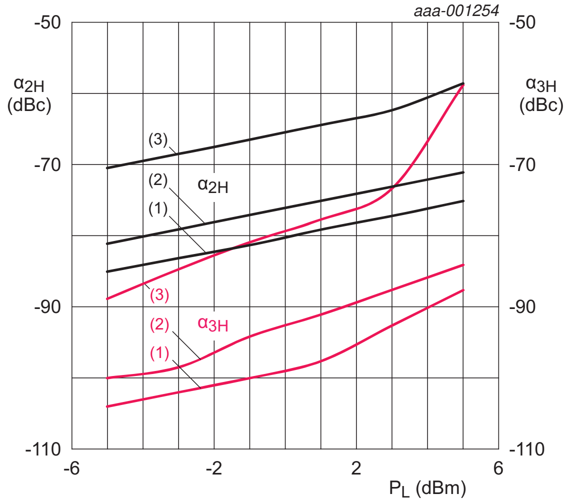
Tuned for f_{IF} = 86 MHz; f_{2H} = 172 MHz; f_{3H} = 358 MHz; T_{amb} = 25 °C.

(1) gain step 0

(2) gain step 12

(3) gain step 24

Fig 31. Second harmonic level and third harmonic level as a function of output power



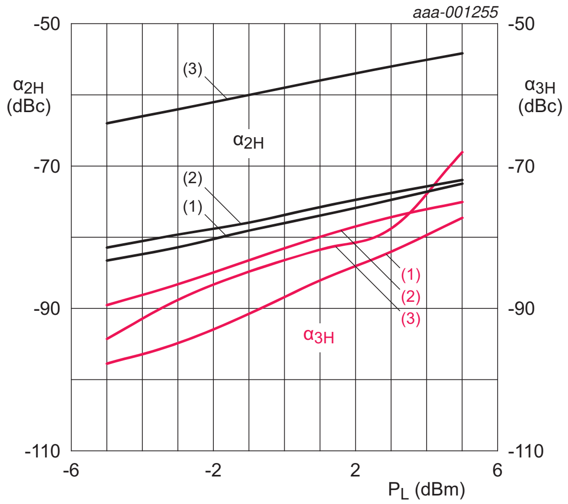
Tuned for f_{IF} = 140 MHz; f_{2H} = 280 MHz; f_{3H} = 420 MHz; T_{amb} = 25 °C.

(1) gain step 0

(2) gain step 12

(3) gain step 24

Fig 32. Second harmonic level and third harmonic level as a function of output power



Tuned for f_{IF} = 230 MHz; f_{2H} = 460 MHz; f_{3H} = 690 MHz; T_{amb} = 25 °C.

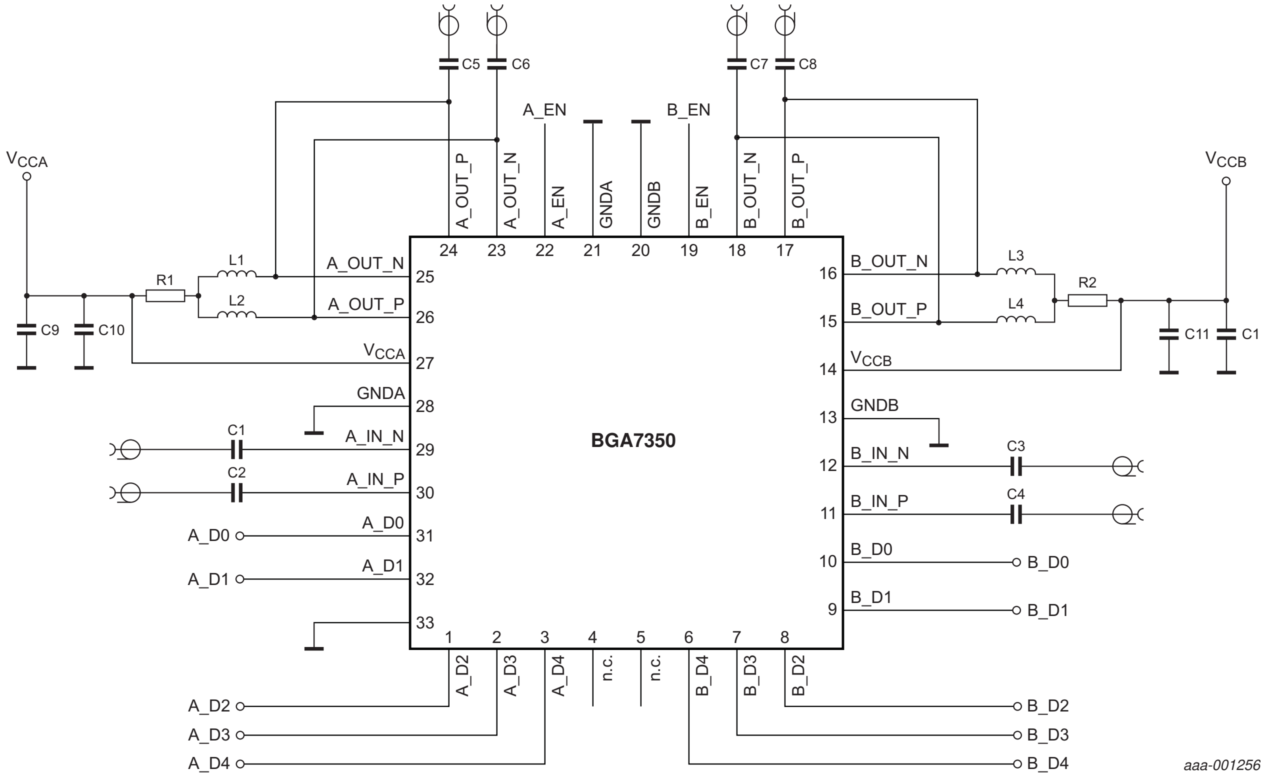
(1) gain step 0

(2) gain step 12

(3) gain step 24

Fig 33. Second harmonic level and third harmonic level as a function of output power

11.1 Schematic dual VGA



For a list of components see Table 11.

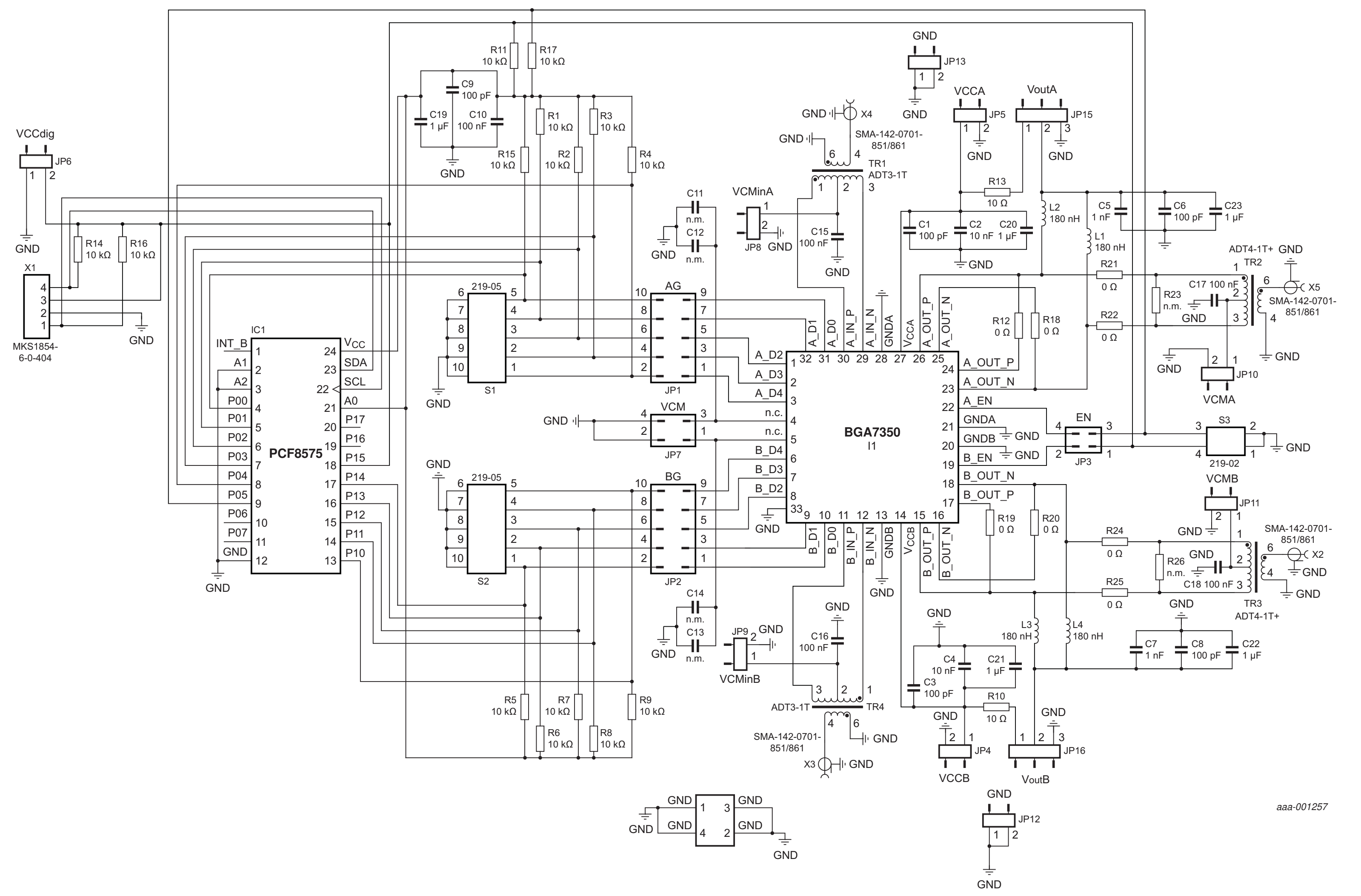
Fig 34. Schematic dual VGA

Table 11. List of components

For schematic see Figure 34.

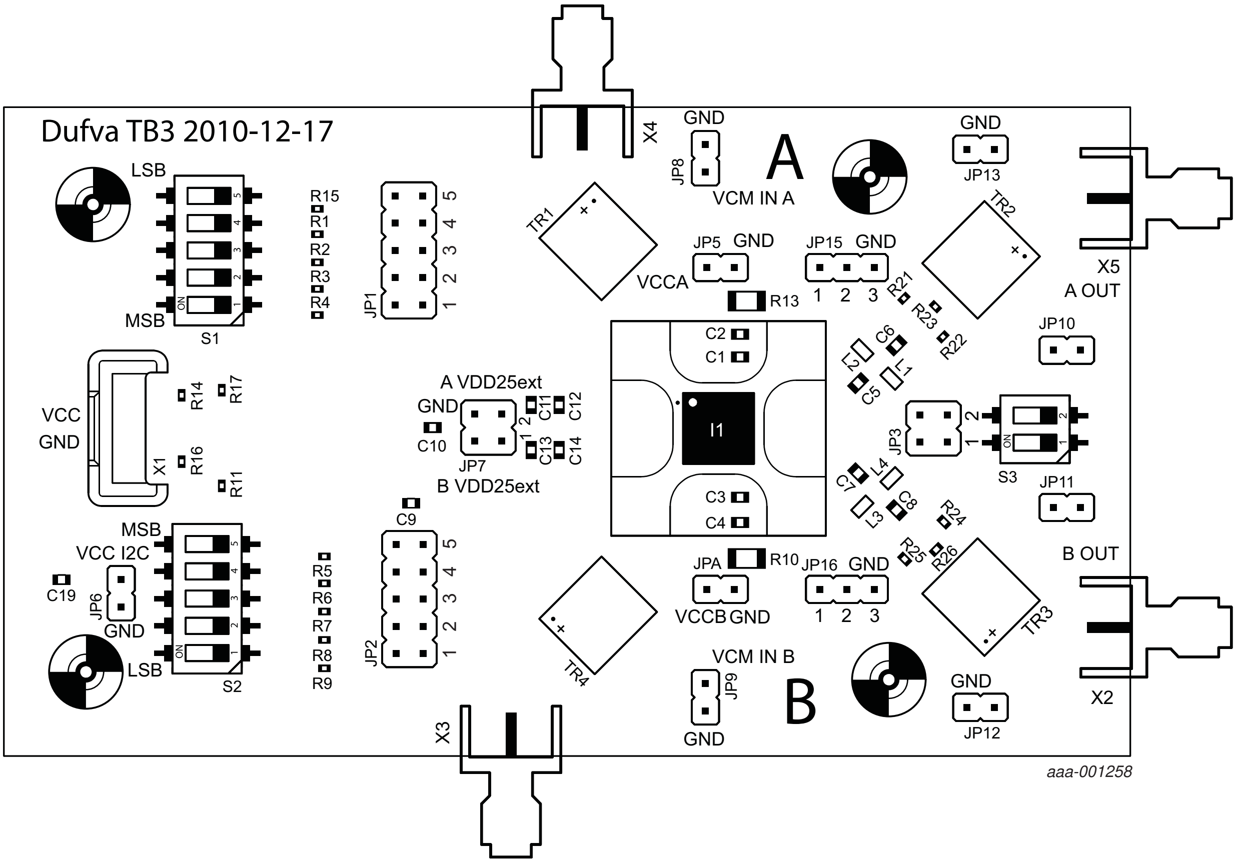
Component	Description	Conditions	Value	Remarks
C1, C2, C3, C4, C5, C6, C7, C8, C9, C11	capacitor		1 nF	
C10, C12	capacitor		100 pF	
L1, L2, L3, L4	inductor	f = 50 MHz	1200 nH	0603LS
		f = 172 MHz	120 nH	0603LS
		f = 250 MHz	56 nH	0603LS
R1, R2	resistor		0 Ω	

11.2 Application PCB



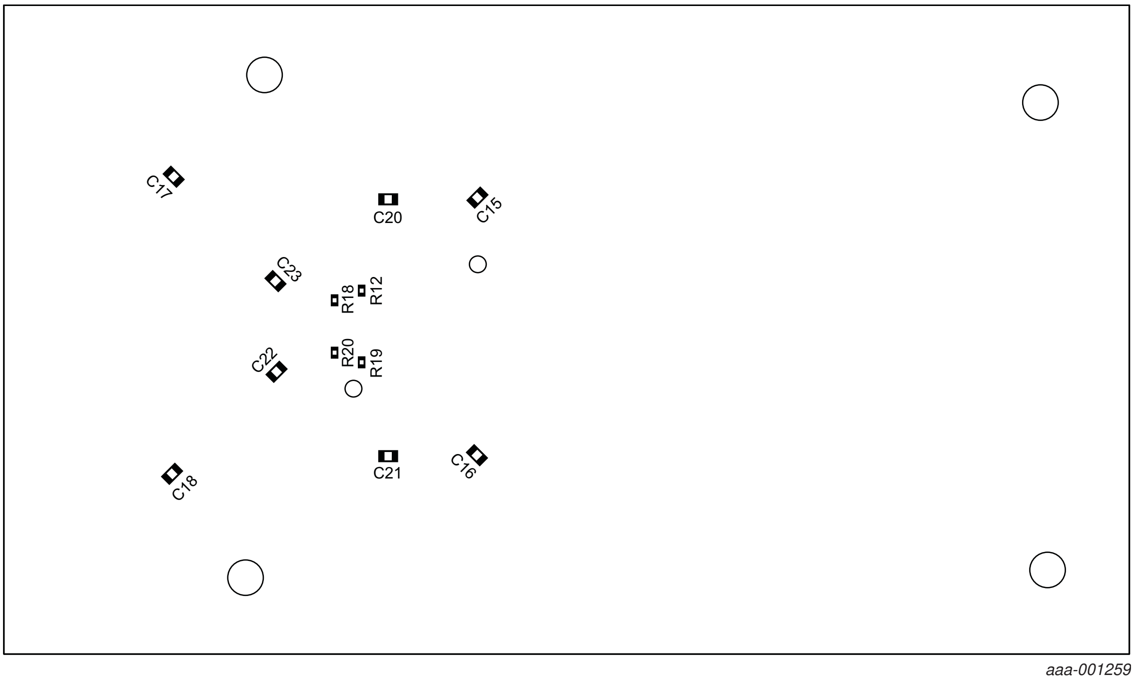
For a list of components see Table 12.

Fig 35. Schematic



For a list of components see Table 12.

Fig 36. Components top side



For a list of components see Table 12.

Fig 37. Components bottom side

Table 12. List of components

See Figure 35, Figure 36 and Figure 37.

Component	Description	Conditions	Value	Size	Remarks
C1, C3, C6, C8, C9	capacitor		100 pF	0603	
C2, C4	capacitor		10 nF	0603	
C5, C7	capacitor		1 nF	0603	
C10, C15, C16, C17, C18	capacitor		100 nF	0603	
C11	capacitor		-	0603	not mounted
C12	capacitor		-	0603	not mounted
C13	capacitor		-	0603	not mounted
C14	capacitor		-	0603	not mounted
C19, C20, C21, C22, C23	capacitor		1 μF	0603	
I1	BGA7350		-		
JP1	jumper		-	JP5	AG
JP2	jumper		-	JP5	BG
JP3	jumper		-	JP2	EN
JP4	jumper		-	JP2	VCCB
JP5	jumper		-	JP2	VCCA
JP6	jumper		-	JP2	VCCdig
JP7	jumper		-	JP2	VCM
JP8	jumper		-	JP2	VCMinA

Table 12. List of components
See Figure 35, Figure 36 and Figure 37.

Component	Description	Conditions	Value	Size	Remarks
JP9	jumper		-	JP2	VCMinB
JP10	jumper		-	JP2	VCMA
JP11	jumper		-	JP2	VCMB
JP12	jumper		-	JP2	GND
JP13	jumper		-	JP2	GND
JP15	jumper		-	JP3	VoutA
JP16	jumper		-	JP3	VoutB
L1, L2, L3, L4	inductor	f_{IF} = 140 MHz	150 nH	0603	dependent on PCB layout
		f_{IF} = 172 MHz	100 nH	0603	dependent on PCB layout
		f_{IF} = 230 MHz	56 nH	0603	dependent on PCB layout
R1	resistor		10 Ω	0402	
R2	resistor		10 Ω	0402	
R3	resistor		10 Ω	0402	
R4	resistor		10 Ω	0402	
R5	resistor		10 Ω	0402	
R6	resistor		10 Ω	0402	
R7	resistor		10 Ω	0402	
R8	resistor		10 Ω	0402	
R9	resistor		10 Ω	0402	
R10	resistor		10 Ω	1206	
R11	resistor		10 Ω	0402	
R12	resistor		0 Ω	0402	
R13	resistor		10 Ω	1206	
R14	resistor		10 Ω	0402	
R15	resistor		10 Ω	0402	
R16	resistor		10 Ω	0402	
R17	resistor		10 Ω	0402	
R18	resistor		0 Ω	0402	
R19	resistor		0 Ω	0402	
R20	resistor		0 Ω	0402	
R21	resistor		0 Ω	0402	
R22	resistor		0 Ω	0402	
R23	resistor		-	0402	not mounted
R24	resistor		0 Ω	0402	
R25	resistor		0 Ω	0402	not mounted
R26	resistor		-	0402	
S1	DIP-switch		-		CTS-219-05
S2	DIP-switch		-		CTS-219-05
S3	DIP-switch		-		CTS-219-02
TR1	1:3 transformer		-		Mini Circuits ADT3-1T+