AK1221
3500MHz High Lineartity Mixer

1. Overview

The AK1221 is high linearity mixer. RF and Lo frequency range coverage is from 700 to 3500MHz and IF coverage is from 20 to 1000MHz. The RF input provides single-ended 50Ω interface. Lo ports are 50Ω matched and complementary input should be decoupled to the ground. IF output ports are differential open drain outputs. The linearity and power consumption performances can be optimized by the resistance connected to the BIAS Pin.

2. Features

- Operating Frequency: 700MHz to 3500MHz
- Linearity vs. Power selectable architecture
  Power Consumption: 45mA, IIP3: +25dBm, Gain: -0.5dB, NF: 14dB
- Lo input level: 0dBm ±5dB
- Operating Supply Voltage: 4.75 to 5.25 V
- Package: 16pin UQFN (0.5mm pitch, 3mm × 3mm × 0.60mm)
- Operating Temperature Range: -40 to 85°C

3. Applications

- Cellular BTS / Repeater
- Two-way Radios (PMR/LMR)

4. Table contents

5. Block Diagram

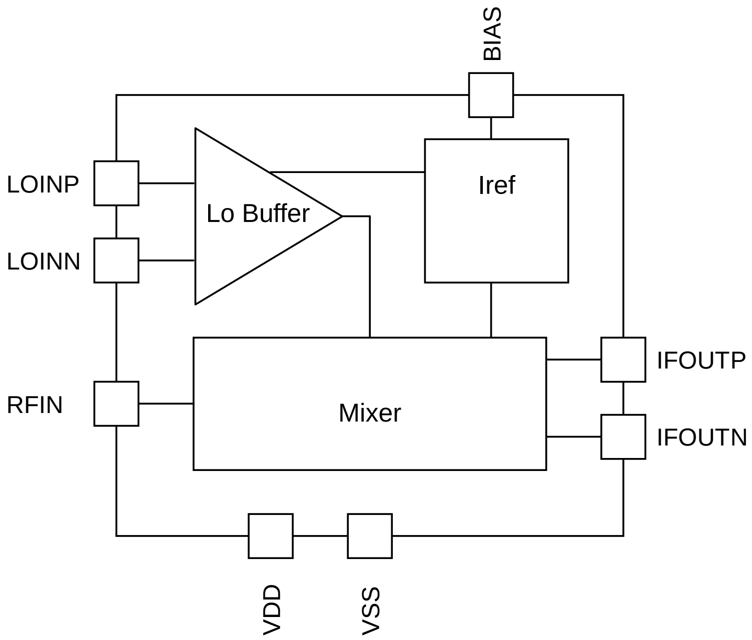


Figure 1. Block Diagram

6. System Diagram

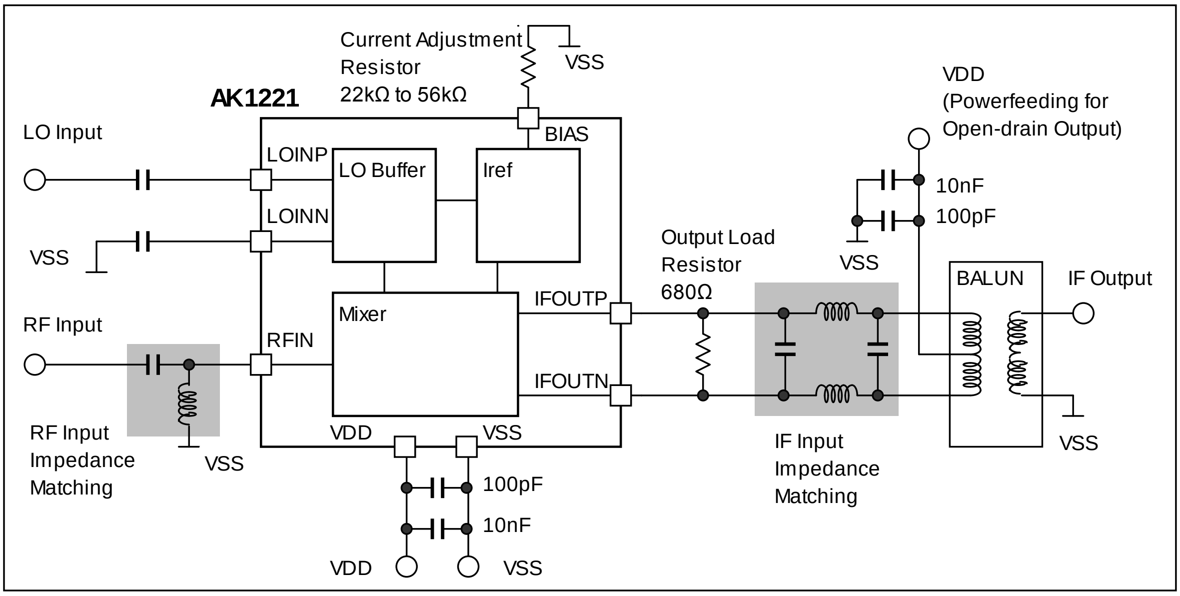


Figure 2. System Diagram

7. Pin Functional Description

Table 1 Pin Function

No.	Name	I/O	Pin Functions	Remarks
1	RFIN	AI	RF Input	Connecting an inductor between this pin and ground.
2	VSS	G	Ground pin	
3	VSS	G	Ground pin	
4	LOINN	AI	Lo Input Negative	
5	LOINP	AI	Lo Input Positive	
6	VDD	P	Power Supply	
7	VDD	P	Power Supply	
8	VDD	P	Power Supply	
9	VDD	P	Power Supply	
10	BIAS	AIO	Resistance pin for current adjustment	Connecting a resistor between this pin and ground.
11	IFOUTN	AO	IF Output Negative	This pin is open drain output. It needs power feeding via an inductor.
12	IFOUTP	AO	IF Output Positive	This pin is open drain output. It needs power feeding via an inductor.
13	VSS	G	Ground pin	
14	VSS	G	Ground pin	
15	VSS	G	Ground pin	
16	VSS	G	Ground pin	

Note) The exposed pad at the center of the backside should be connected to ground.

AI : Analog input pin	AO : Analog output pin	AIO : Analog I/O pin
P : Power supply pin	G : Ground pin	

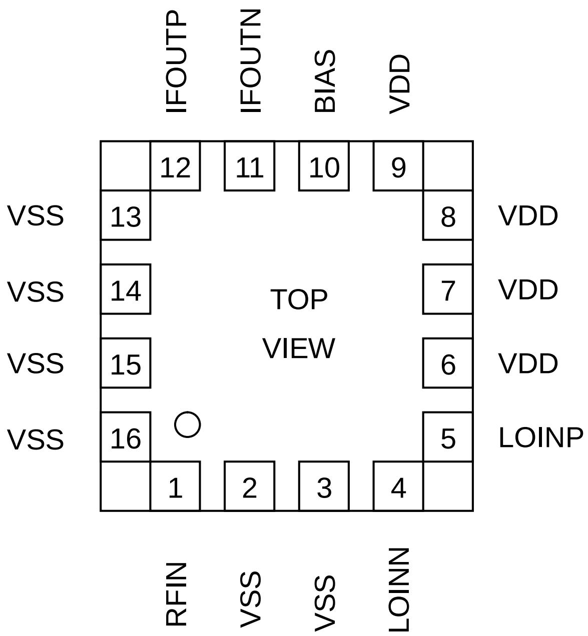


Figure 3. Package Pin Layout

8. Absolute Maximum Ratings

Table 2 Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit	Remarks
Supply Voltage	VDD	-0.3	5.5	V	
RF Input Power	RFPOW		12	dBm	
LO Input Power	LOPOW		12	dBm	
Storage Temperature	Tstg	-55	125	°C	

Exceeding these maximum ratings may result in damage to the AK1221. Normal operation is not guaranteed at these extremes.

9. Recommended Operating Range

Table 3 Recommended Operating Range

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remarks
Operating Temperature	Ta	-40		85	°C	
Supply Voltage	VDD	4.75	5	5.25	V	

The specifications are applicable within the recommended operating range (supply voltage/operating temperature).

10. Electrical Characteristics

1. Analog Circuit Characteristics

Unless otherwise noted IF output=150MHz, Lo Input Level=-5dBm to +5dBm, Output Load Resistor（RLoad）=680Ω, VDD=4.75 to 5.25V, Ta=-40°C to 85°C

Parameter		Min.	Typ.	Max.	Unit	Remarks
RF Input Frequency		700		3500	MHz	
Lo Input Frequency		700		3500	MHz	
IF output Frequency		20		1000	MHz	
Lo Input Power		-5	0	+5	dBm	
Current Adjustment Resistor(BIAS)		22		56	kΩ	
IDD	BIAS=22kΩ		64	87	mA	The total current of VDD pin, IFOUTP pin and IFOUTN pin.
	BIAS=33kΩ		45	64	mA	
	BIAS=56kΩ		30	44	mA	
RFIN=2500MHz, Current Adjustment Resistor =33kΩ						
Conversion Gain		-2.5	-0.5	1.5	dB	
SSB Noise Figure			14	16.5	dB	Design guarantee value
IP1dB		7	10		dBm	
IIP3		21	25		dBm	Design guarantee value

11. Typical Performance

Unless otherwise noted, RF input =2500MHz, Lo input =2350MHz, IF output =150MHz, Output Load Resistor (RLoad)=680Ω

1. Current Adjustment Resistor vs. IIP, NF, P1dB, Gain, IDD

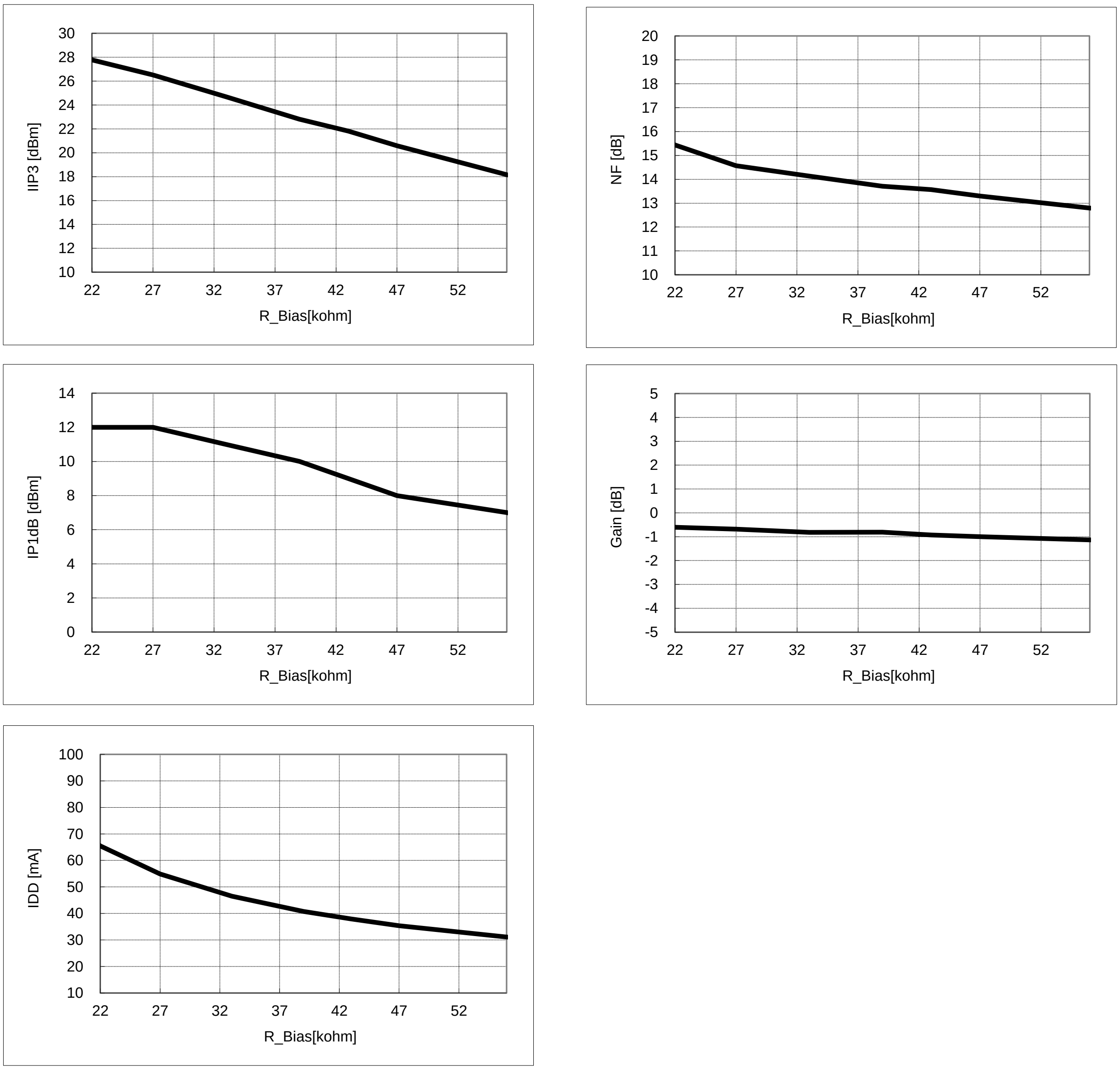


Figure 4. Current Adjustment Resistor vs. IIP3, NF, P1dB, Gain, IDD

Note) A resistor with 5% tolerance are used.

2. Over temperature vs. IIP3, NF, P1dB, Gain, IDD

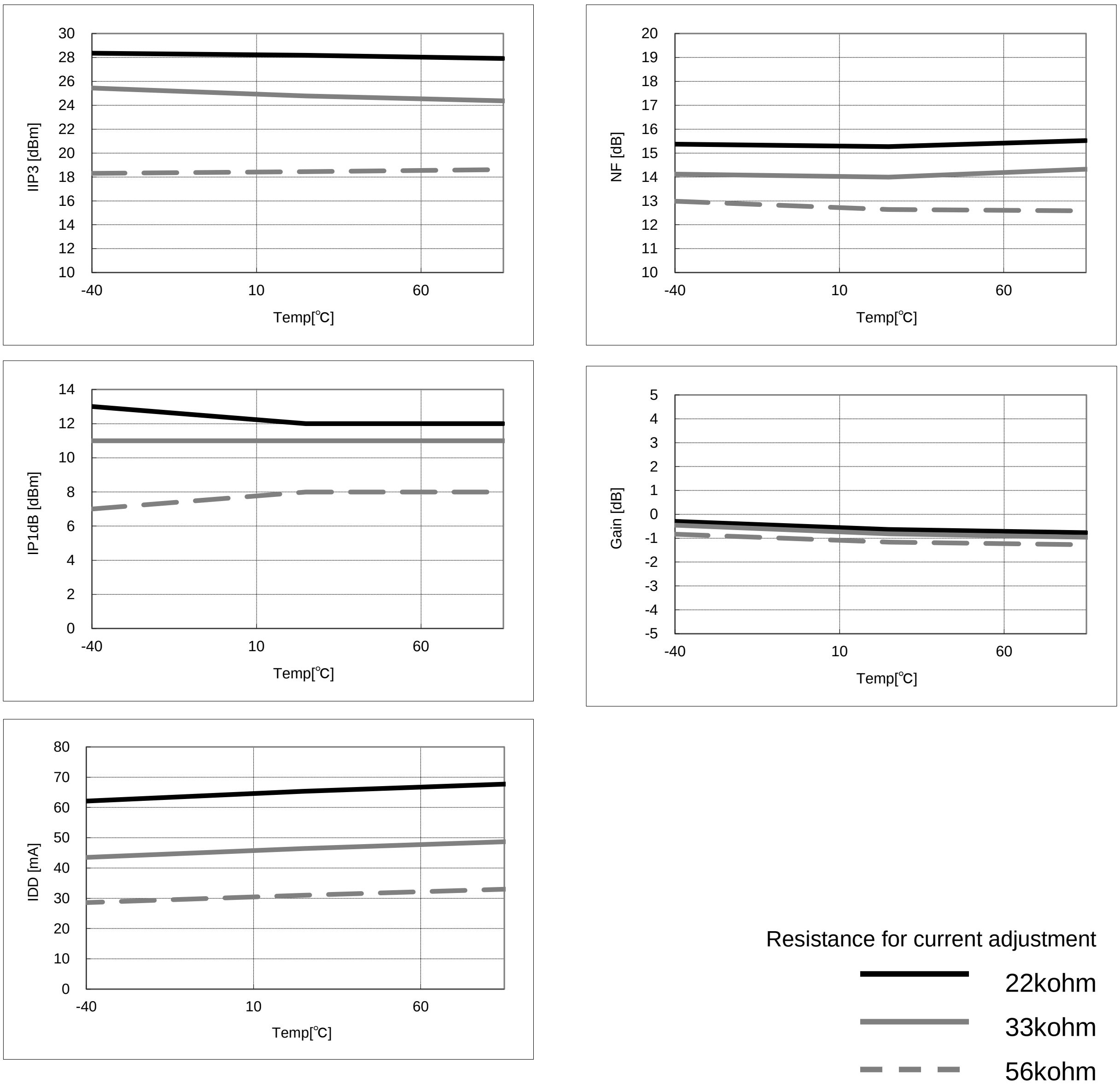


Figure 5. Over temperature vs. IIP3, NF, IP1dB, Gain, IDD

3. Supply voltage vs. IIP3, NF, P1dB, Gain, IDD

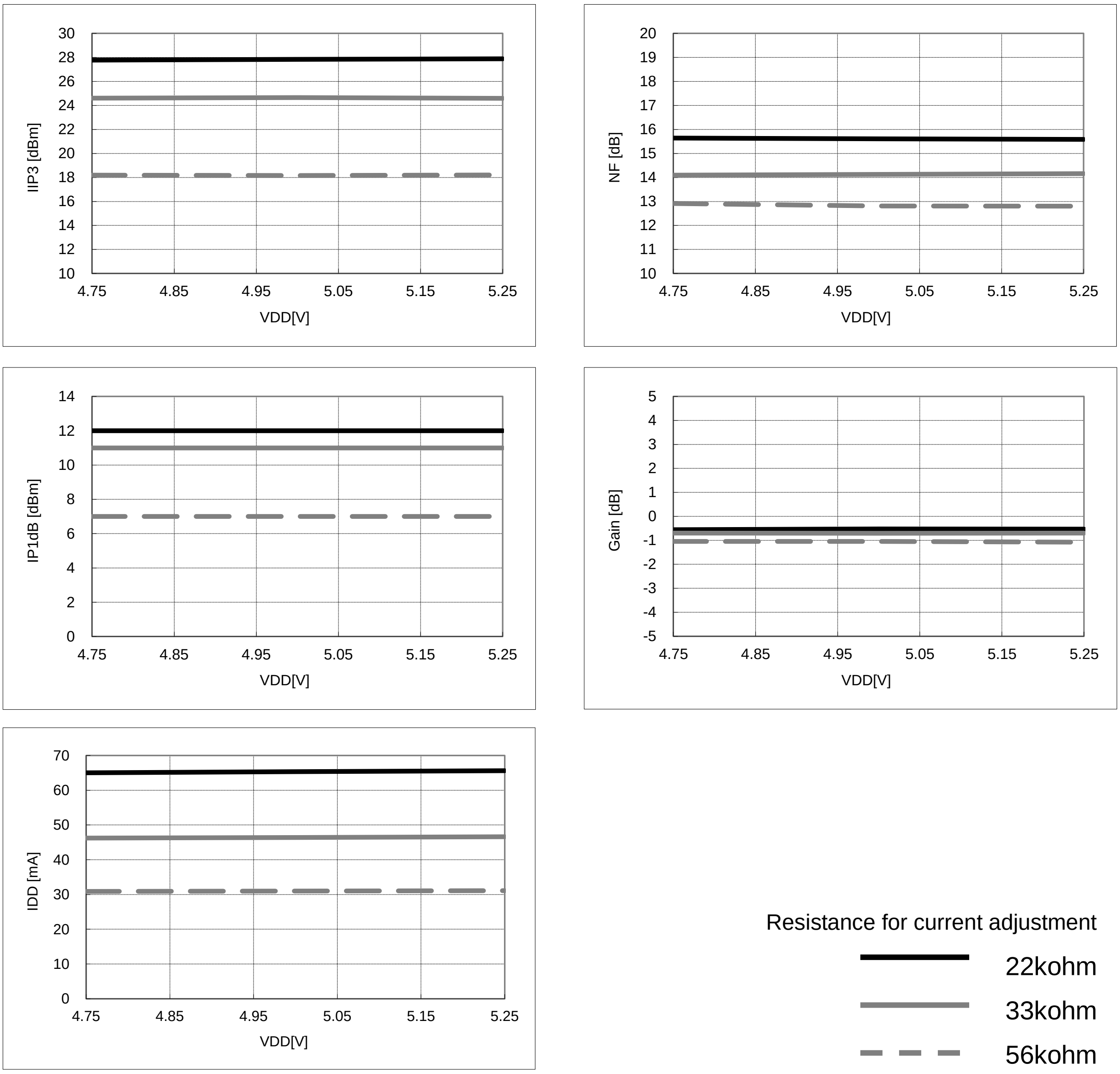


Figure 6. Supply voltage vs. IIP3, NF, IP1dB, Gain, IDD

4. RF input frequency vs. IIP3, NF, Gain

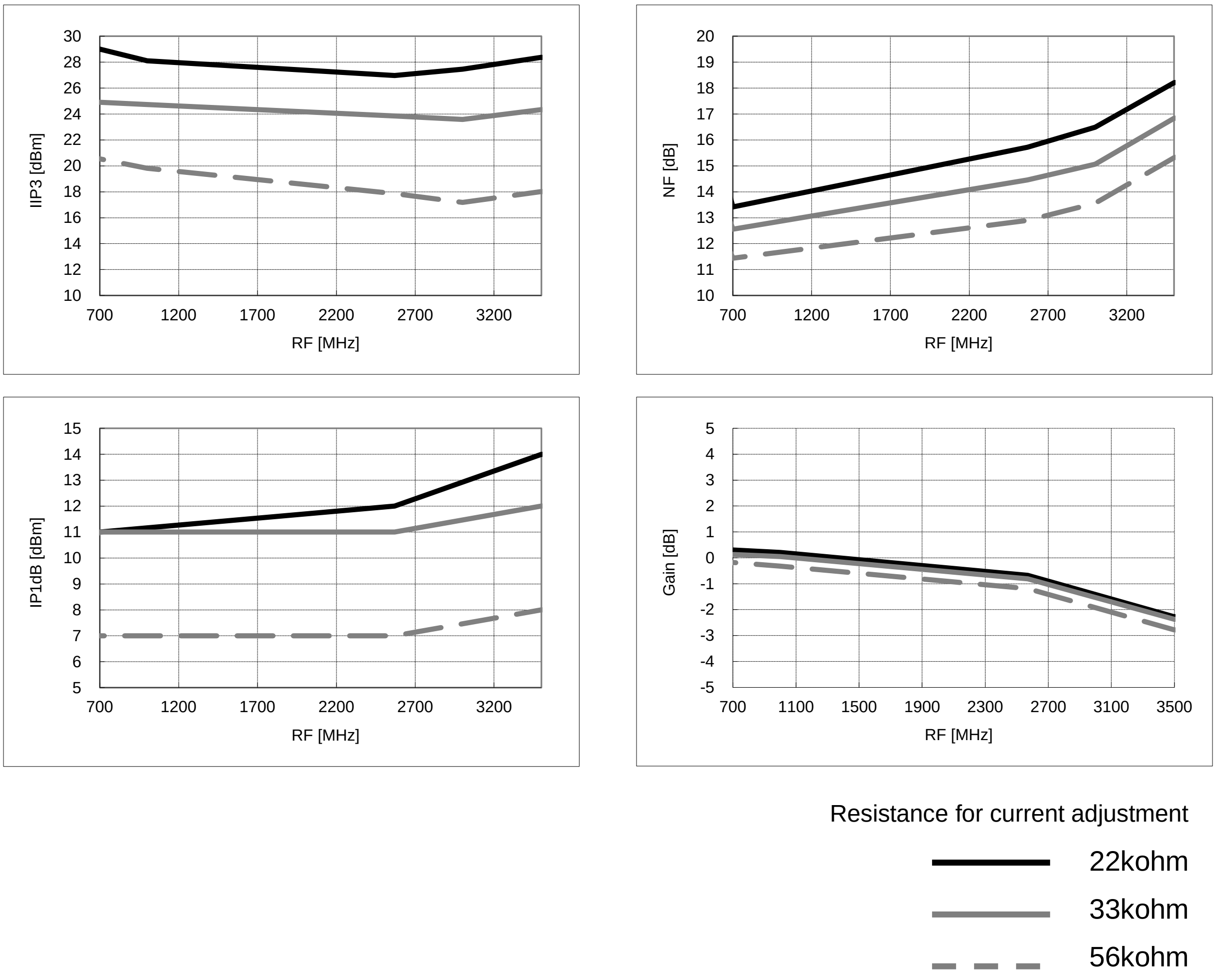


Figure 7. RF input frequency vs. IIP3, NF, Gain

5. IF input frequency vs. IIP3, NF, Gain

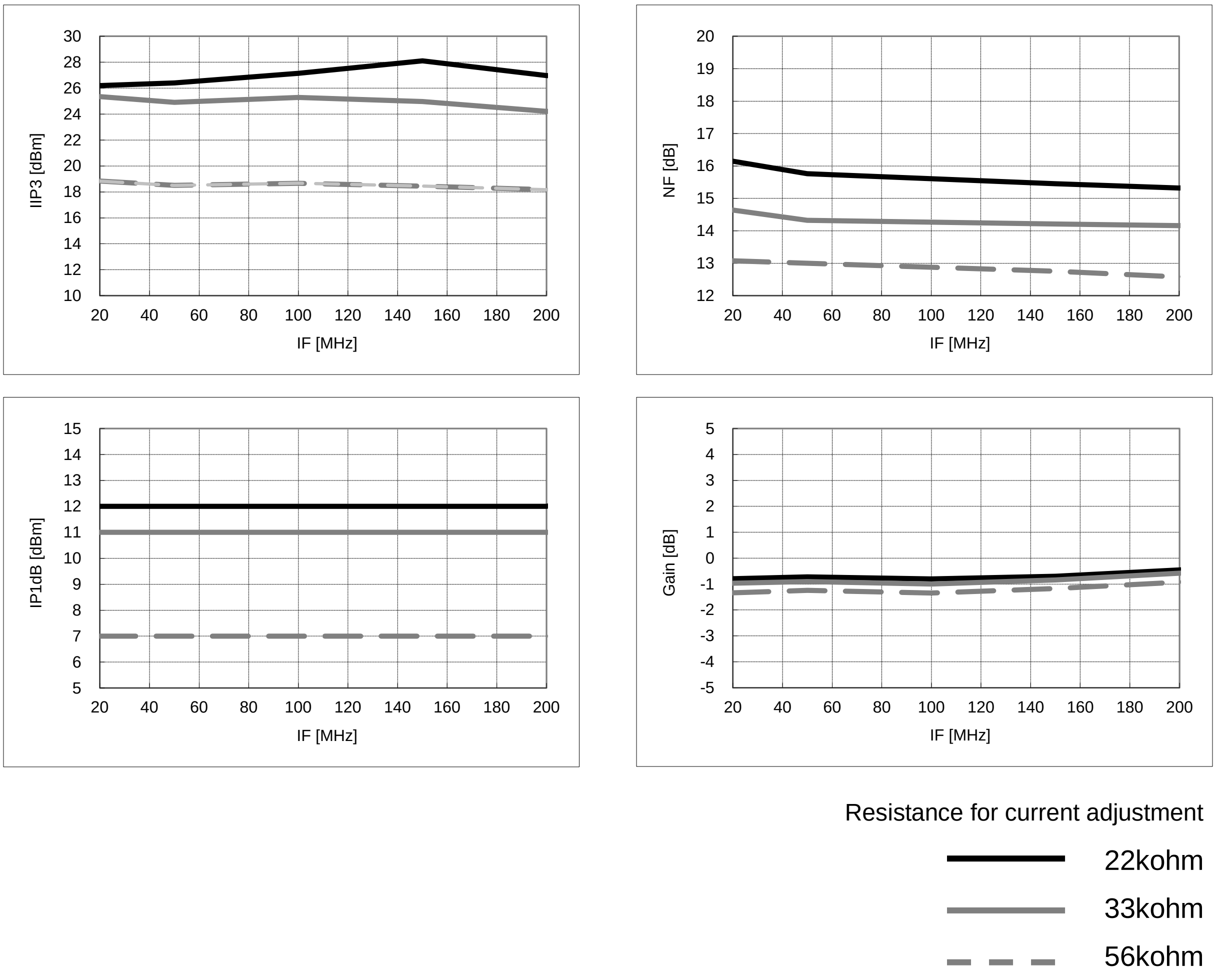


Figure 8. IF input frequency vs. IIP3, NF, Gain

6. Lo input power vs. IIP3, NF, Gain

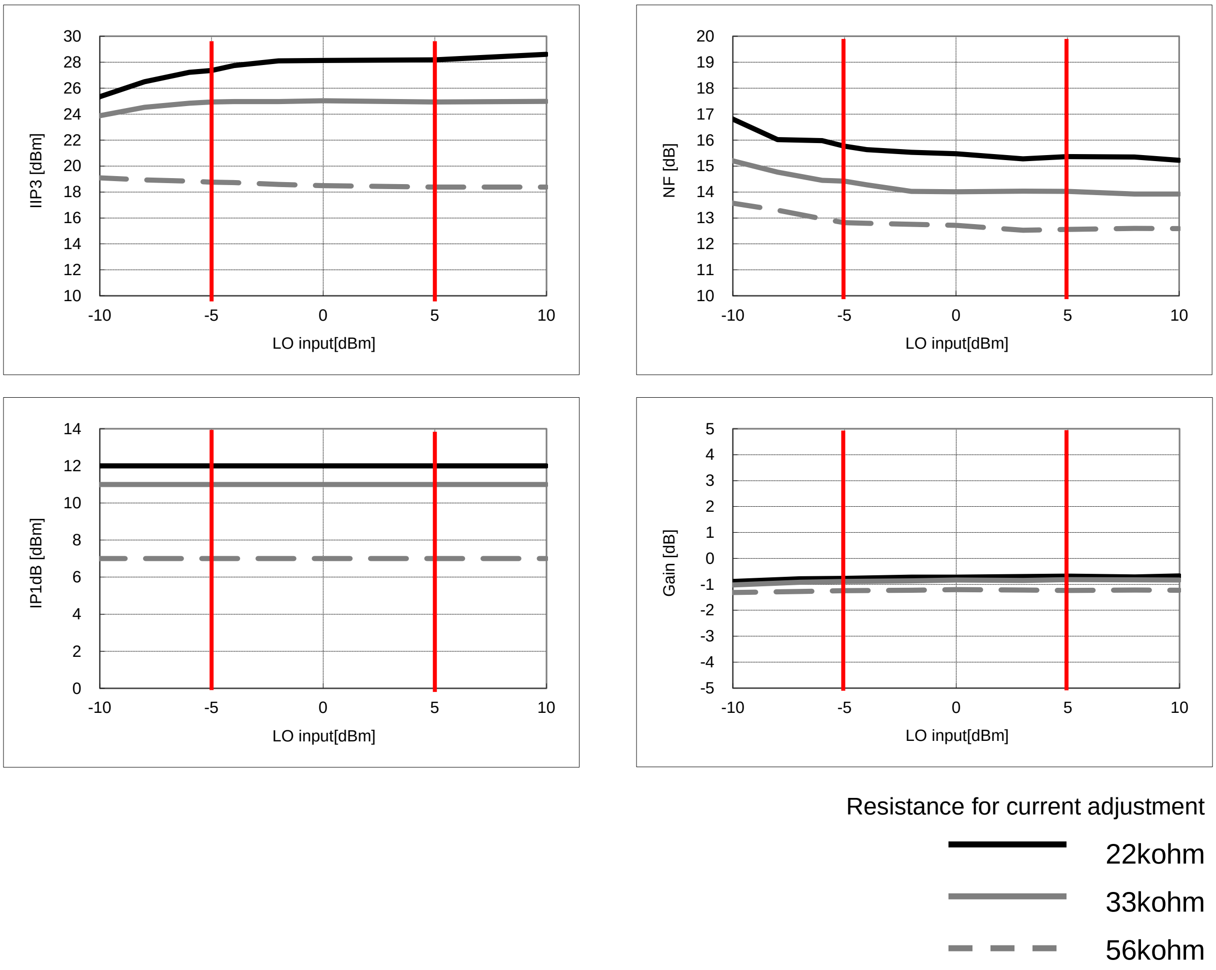


Figure 9. Lo input power vs. IIP3, NF, Gain

7. Output Load Resistor（RLoad） vs. IIP3, NF, Gain

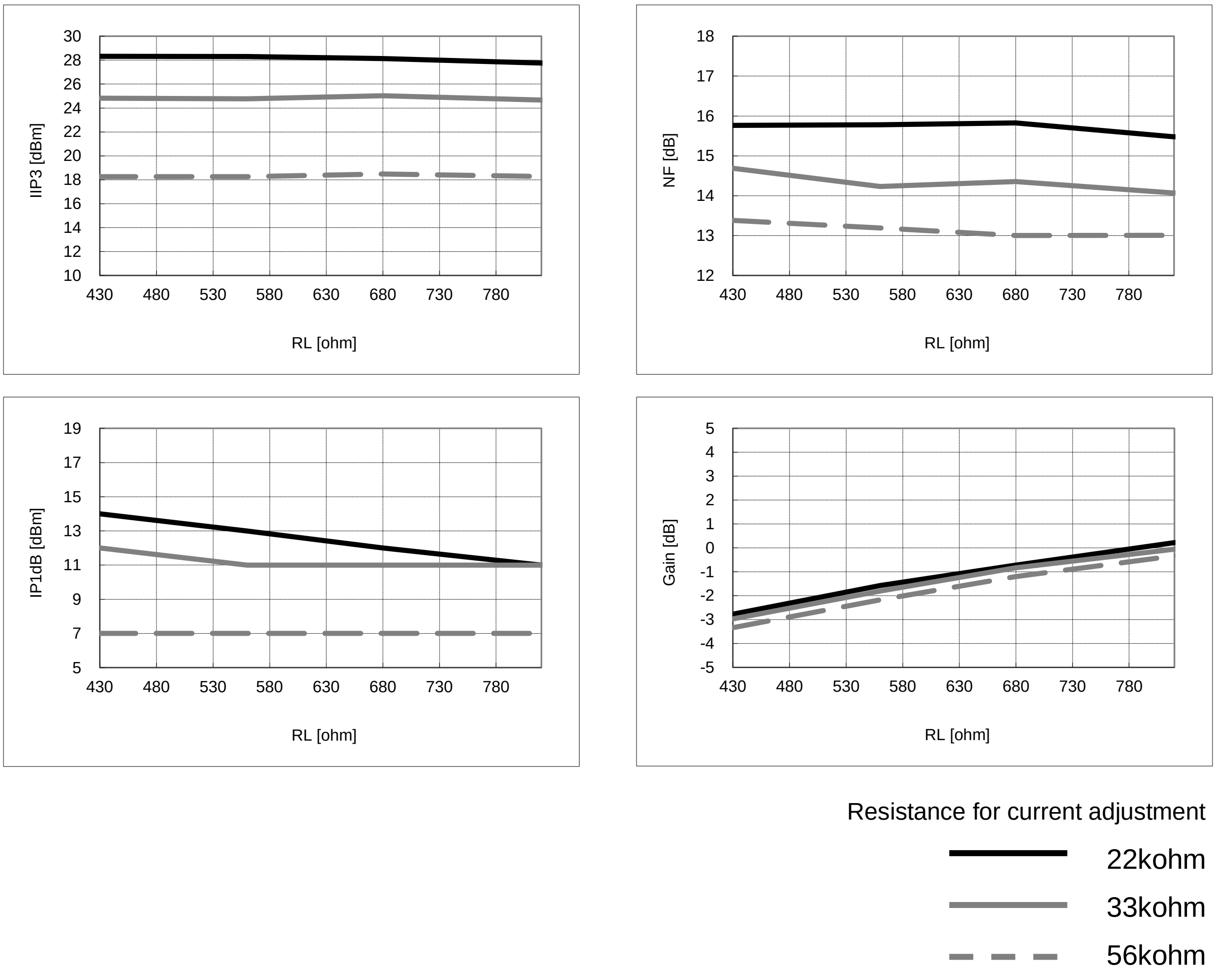


Figure 10. Output Load Resistor（RLoad） vs. IIP3, NF, Gain

8. Leakage

RFIN=2500MHz,-20dBm,LO input=2350MHz,0dBm,RLoad=680Ω,Ta=25℃ VDD=5V

Parameter	BIAS	Typ.	Unit
RF – LO Leakage	22kΩ	-36	dBc
	56kΩ	-36	dBc
RF – IF Leakage	22kΩ	-61	dBc
	56kΩ	-57	dBc
LO – RF Leakage	22kΩ	-44	dBc
	56kΩ	-44	dBc
LO – IF Leakage	22kΩ	-58	dBc
	56kΩ	-66	dBc

12. Typical Evaluation Board Schematic

1. Typical Evaluation Board Schematic

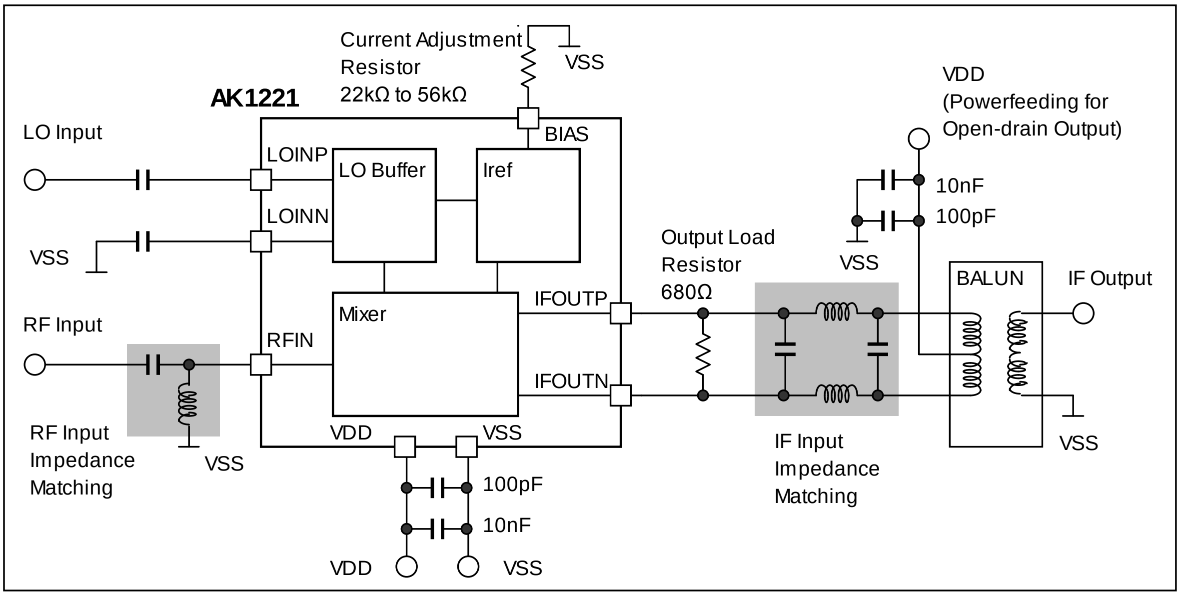


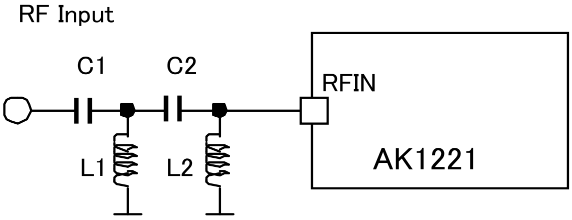
Figure 11. Typical Evaluation Board Schematic

Note 1) The open drain output needs power feeding via a inductor. (IFOUTP pin and IFOUTN pin)

Note 2) It is necessary to adjust impedance matching as to its setting frequency. (RF input and IF output)

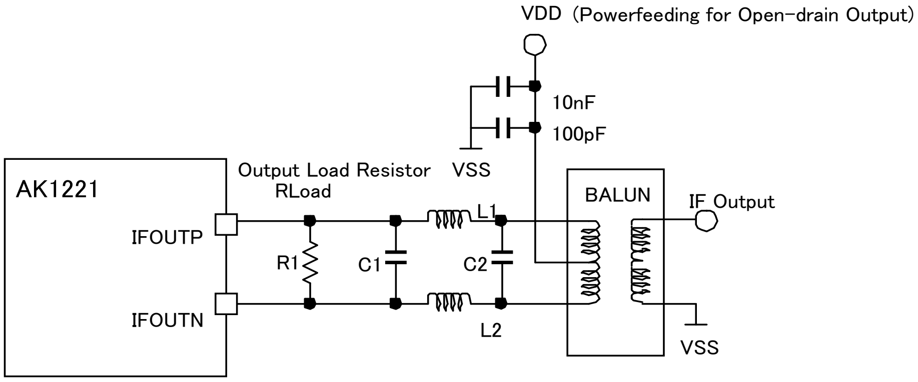
2. Example of impedance matching

2 -1 RFIN



Frequency[MHz]	C1[pF]	C2[pF]	L1[nH]	L2[nH]	Impedance[ohm]
700	none	20	none	39	42.9 - j5.4
2500	39	2.2	1.8	10	61.2 - j12.8
3500	39	1.0	1.0	10	40.7 - j5.1

2 - 2 IFOUT

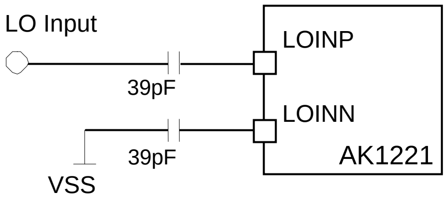


Frequency [MHz]	R1 [ohm]	C1 [pF]	C2 [pF]	L1 [nH]	L2 [nH]	Impedance[ohm]
20	680	15	none	1200 *1	1200 *1	56.6 – j4.5
150	680	1	None	180 *2	180 *2	52.6 + j1.6
200	680	none	none	150 *2	150 *2	47.0 – j11.9
500	440	0.2	1.8	43 *2	43 *2	49.2 – j2.3
750	440	0.3	1.3	20 *2	20 *2	51.7 + j3.4
1000	440	0.1	1.2	12 *2	12 *2	53.2 – j4.9

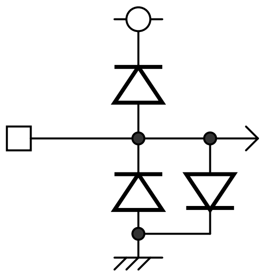
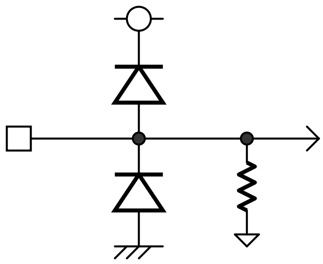
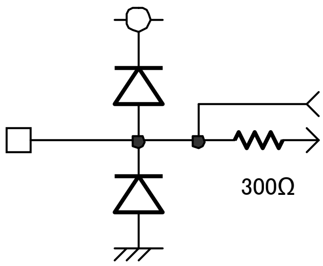
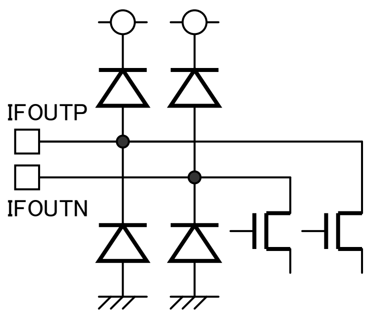
*1)Murata LQW21A series

*2)Murata LQW18A series

2 – 3 LOINP/LOINN



13. LSI Interface Schematic

No.	Name	I/O	Function
1	RFIN	I	**RF Input pin** 
4	LOINN	I	**Lo Input pins** 
5	LOINP		
10	BIAS	I/O	**Analog I/O pin** 
11	IFOUTN	O	**IF Output pins** 
12	IFOUTP		

14. Application Information

•Impedance matching network with LC

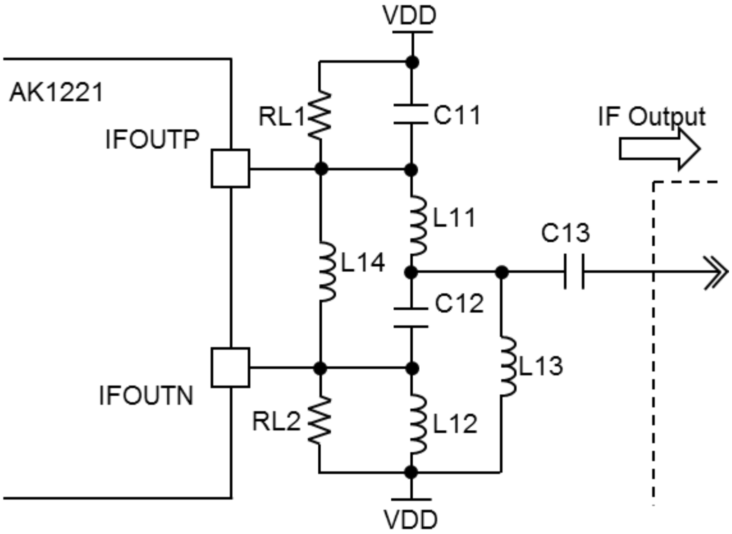


Figure 12. Impedance matching network with LC

Impedance matching network with LC is shown in Figure 12. AK1221 has open drain outputs, so RL1 + RL2 is output load resistance. C11 and L11 compose lowpass filter. C12 and L12 are for highpass filter. C13 is DC blocking capacitor and L13 is RF choke. IFOUTP and IFOUTN pins need power feeding via L11, L12 and L13.

The differential voltage from IFOUTP/N can be converted to a single-ended by L11, L12, C11 and C12 properly. The differential impedance (RL1 + RL2) is converted to single-ended output terminating impedance Ro.

L11, C11, L12 and C12 are calculated as below. f_{out} is IF output frequency.

$$C_{11} = C_{12} = \frac{1}{2\pi * f_{\mathrm{OUT}} * \sqrt{(R_{\mathrm{L1}} + R_{\mathrm{L2}}) * R_{\mathrm{O}}}}$$

$$L_{11} = L_{12} = \frac{\sqrt{(R_{\mathrm{L1}} + R_{\mathrm{L2}}) * R_{\mathrm{O}}}}{2\pi * f_{\mathrm{OUT}}}$$

For example, in the case of IF Output = 50MHz, Output Load Resistor (Rload) = 660Ω in 50Ω interface, L11, C11, L12 and C12 are calculated as below.

$$C_{11} = C_{12} = \frac{1}{2\pi*(150*10^{\wedge}6)*\sqrt{660*50}} = 5.84\text{pF}$$

$$L_{11} = L_{12} = \frac{\sqrt{660*50}}{2\pi*(150*10^{\wedge}6)} = 193\text{nH}$$

L13 and C13 should be large enough not to affect the impedance at IF output frequency. In some cases the impedance matching can be optimized by L13 and C13.

For example, in the case of IF Output = 150MHz, Output Load Resistor (Rload) = 660Ω in 50Ω interface, it is recommended to choose 2200nH and 1000pF as L13 and C13. If any correction is needed, it can be adjusted by reducing the value of L13 and C13.

In some cases L14 can be selected to resonate with IF output capacitance. The typical differential output impedances for several frequencies are below. In the case of IF Output = 150MHz, it is recommended to choose 1000nH as L14.

	Differential Output Impedance		Matching Element
IF Output Frequency [MHz]	R[ohm]	jX[ohm]	L14 [nH]
20	2300	-J4083	OPEN
50	711	-J2448	OPEN
70	419	-J1873	OPEN
100	244	-J1420	2200
150	109	-J932	1000
180	77	-J788	750
200	62	-J706	560
250	38	-J566	360
300	28	-J470	240
400	16	-J346	150
500	15	-J270	82
600	13	-J223	62
700	10	-J188	43
800	9	-J159	33
900	7	-J138	24

These calculated values are approximation. In some cases, some correction is needed due to the effect of parasitic capacitance of external parts or/and PCBs. The impedance matching network components should be decided through enough evaluation on AK1221.

Typical Performance using impedance matching network with LC is below. RF Input = 2500MHz, IF Output = 150MHz, LO Input = 2350MHz, Output Load Resistor (Rload) = 660Ω, Vdd = 5V, Ta = 25°C, LO Input Level = 0dBm, current adjustment resistor =33kΩ.

Ref.	Value	Size	Part Number
RL1, RL2	330Ω	1005	KOA RK73B1ETTP331
L11, L12	200nH	1608	Murata LQW18ANR20G00
C11, C12	6pF	1005	Murata GJM1552C1H6R0DB01
L13	2200nH	2012	Murata LQW21HN2R2J00
C13	1000pF	1005	Murata GRM1552C1H102JA01
L14	1000nH	2012	Murata LQW21HN1R0J00

Parameter	Min. Typ. Max.	Unit
Conversion Gain	-1.1	dB
SSB Noise Figure (NF)	13.8	dB
IP1dB	11.6	dBm
IIP3	24.8	dBm

The phase and amplitude balance is achieved at IF Output frequency by using impedance matching network with LC. The port-to-port leakage is improved with the phase and amplitude balance is achieved at RF, LO, and IF frequency with wide band balun.

・Evaluation Board

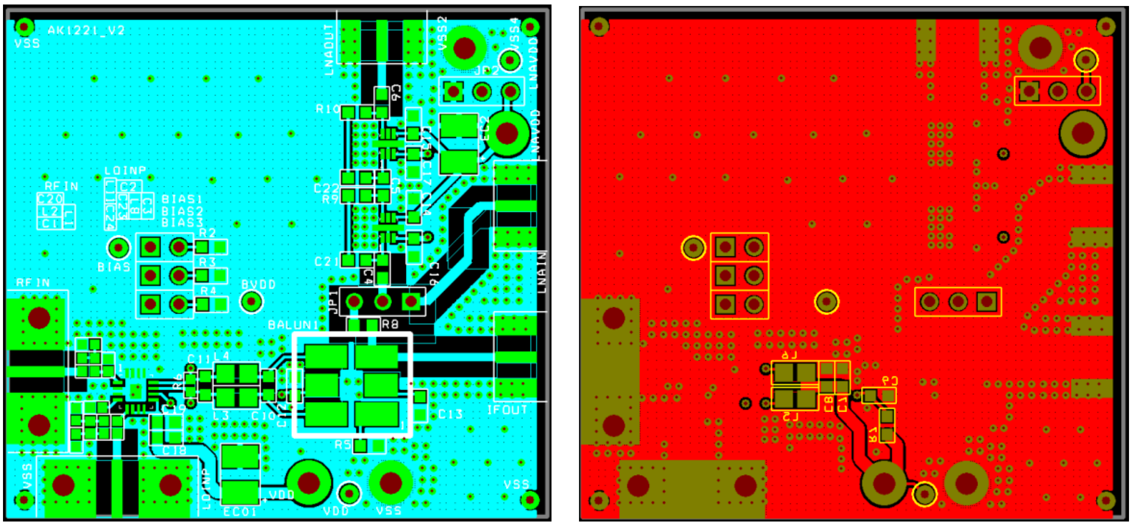


Figure 13. AK1221 Evaluation Board (Balun)

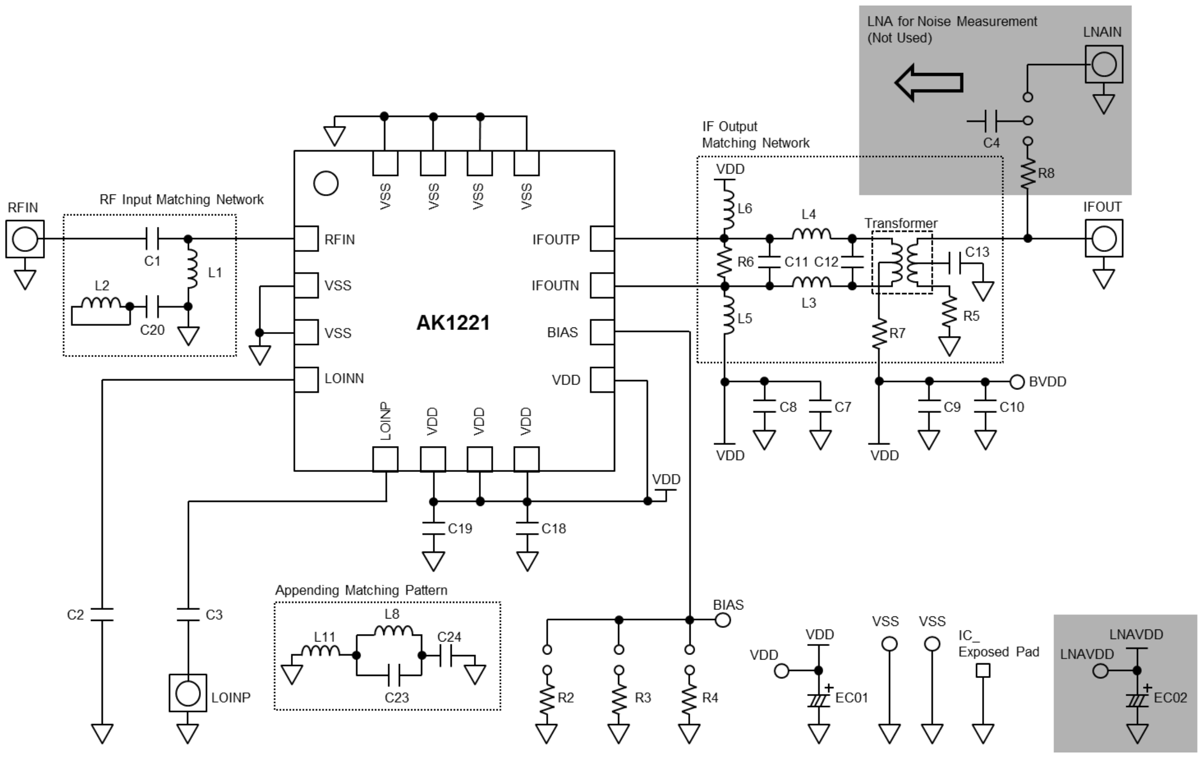


Figure 14. AK1221 Evaluation Board Schematic (Balun)

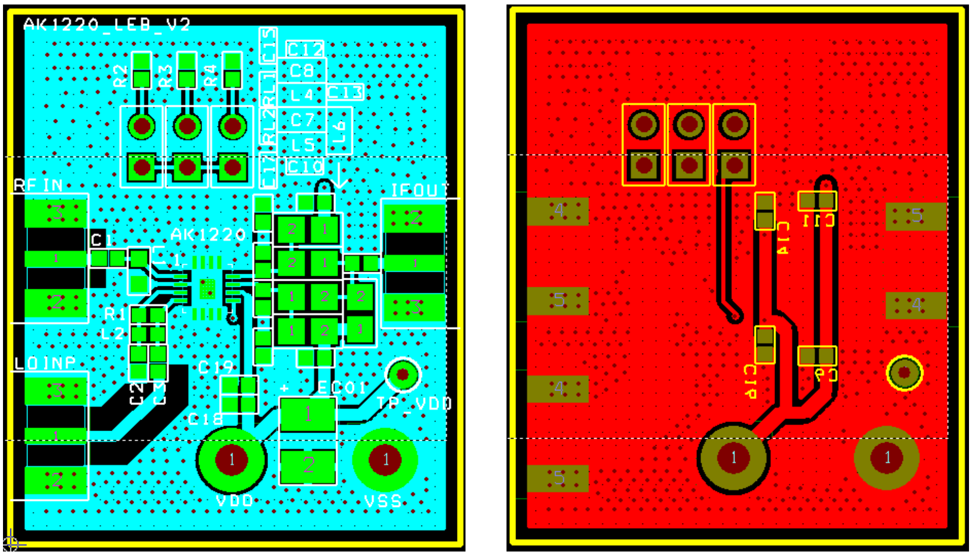


Figure 15. AK1221 Evaluation Board (matching network with LC)

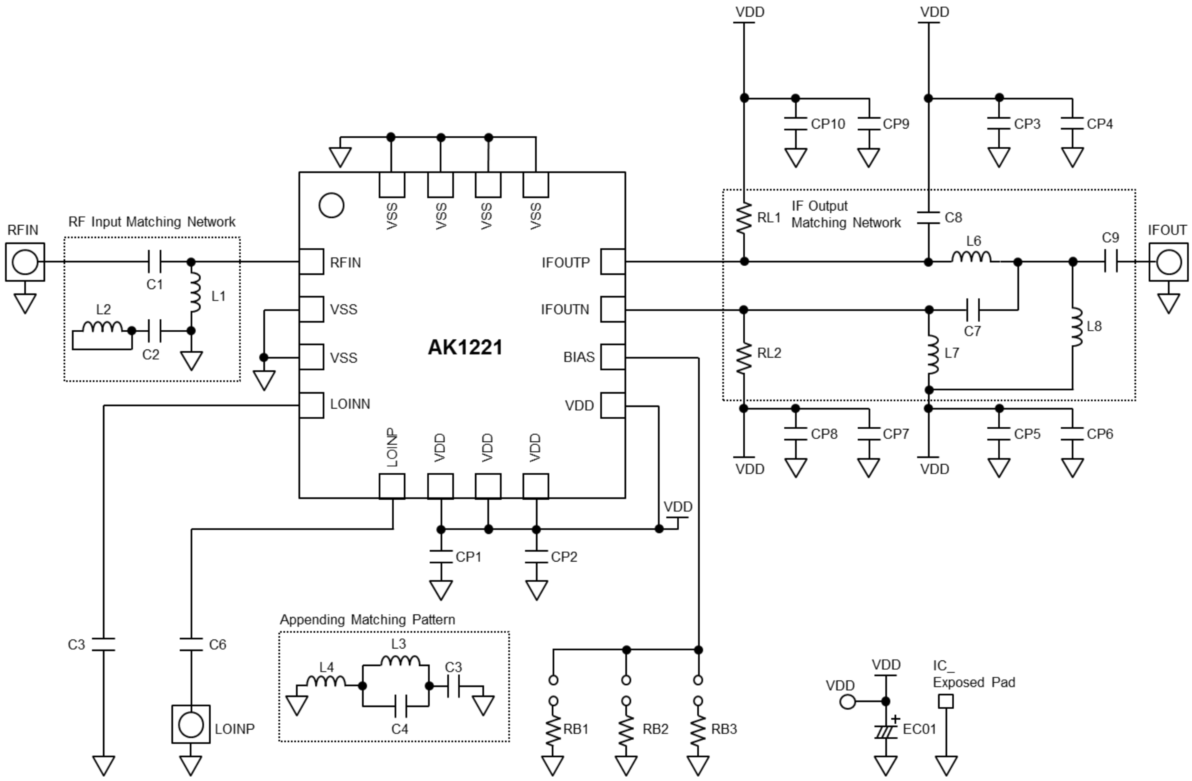


Figure 16. AK1221 Evaluation Board Schematic (matching network with LC)

15. Outer Dimensions

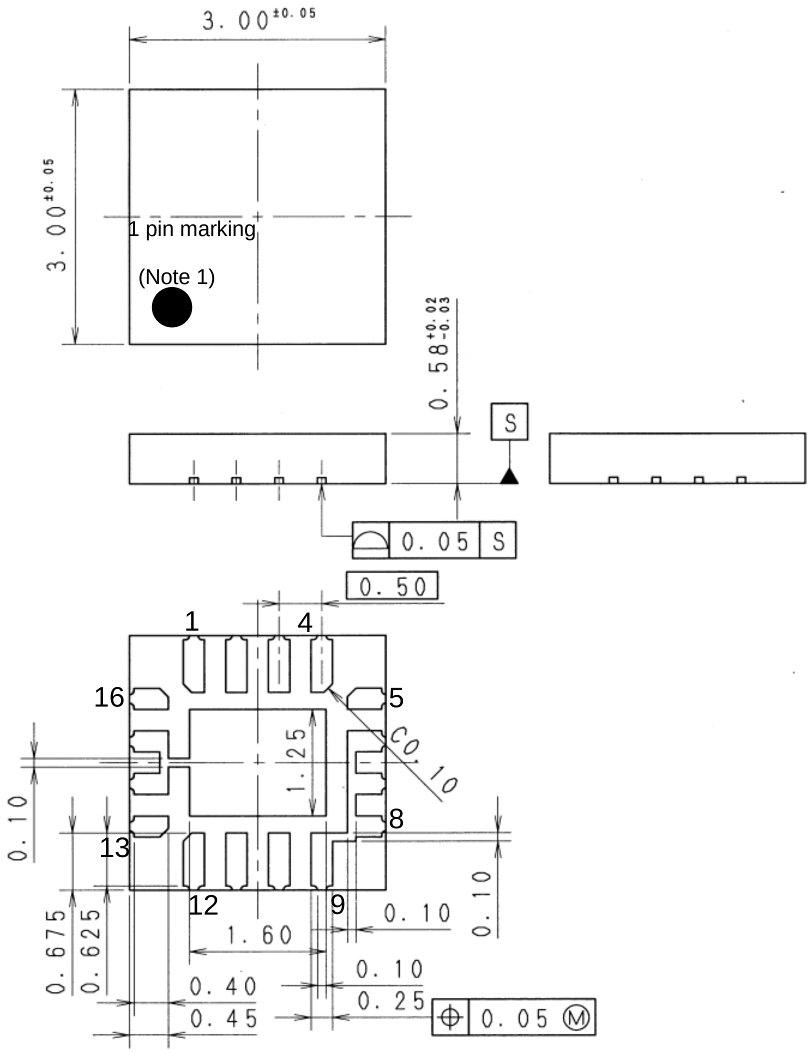


Figure 17. Outer Dimensions

Note 1. 1 pin marking is only a reference for the 1 pin location on the top of package.

16. Marking

(a) Style	:	UQFN	
(b) Number of pins	:	16	
(c) 1 pin marking:	:	○	
(d) Product number	:	1221	
(e) Date code	:	YWWL (4 digits)	
		Y :	Lower 1 digit of calendar year (Year 2012 → 2, 2013 → 3 ...)
		WW :	Week
		L :	Lot identification, given to each product lot which is made in a week → LOT ID is given in alphabetical order (A, B, C…).

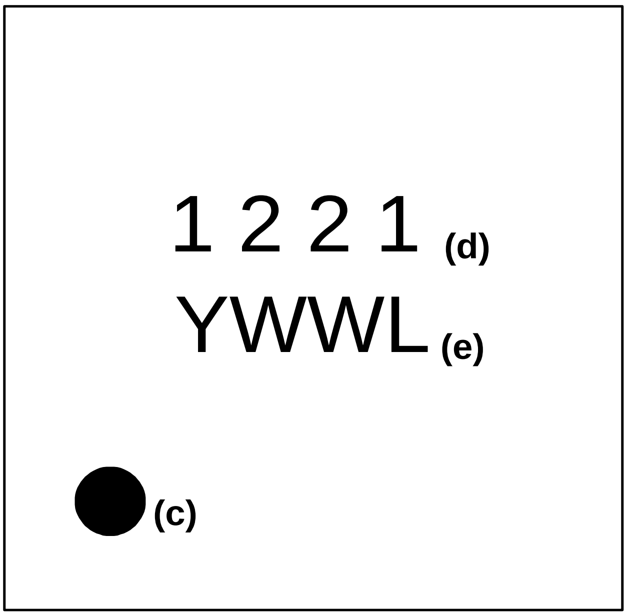


Figure 18. Marking

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•Related Parts

Part#	Discription	Comments
Mixer		
AK1220	100MHz~900MHz High Linearity Down Conversion Mixer	IIP3:+22dBm
AK1222	100MHz~900MHz Low Power Down Conversion Mixer	IDD:2.9mA
AK1224	100MHz~900MHz Low Noise, High Liniarity Down Conversion Mixer	NF:8.5dB, IIP3:+18dBm
AK1228	10MHz~2GHz Up/Down Conversion Mixer	3V Supply, NF:8.5dB
AK1221	0.7GHz~3.5GHz　High Linearity Down Conversion Mixer	IIP3:+25dBm
AK1223	3GHz~8.5GHz High Linearity Down Conversion Mixer	IIP3:+13dB, NF:15dB
PLL Synthesizer		
AK1541	20MHz~600MHz Low Power Fractional-N Synthesizer	IDD:4.6mA
AK1542A	20MHz~600MHz Low Power Integer-N Synthesizer	IDD:2.2mA
AK1543	400MHz~1.3GHz Low Power Fractional-N Synthesizer	IDD:5.1mA
AK1544	400MHz~1.3GHz Low Power Integer-N Synthesizer	IDD:2.8mA
AK1590	60MHz~1GHz Fractional-N Synthesizer	IDD:2.5mA
AK1545	0.5GHz~3.5GHz Integer-N Synthesizer	16-TSSOP
AK1546	0.5GHz~3GHz Low Phase Noise Integer-N Synthesizer	Normalized C/N:-226dBc/Hz
AK1547	0.5GHz~4GHz Integer-N Synthesizer	5V Supply
AK1548	1GHz~8GHz Low Phase Noise Integer-N Synthesizer	Normalized C/N:-226dBc/Hz
IFVGA		
AK1291	100~300MHz Analog Signal Control IF VGA w/ RSSI	Dynamic Range:30dB
integrated VCO		
AK1572	690MHz~4GHz Down Conversion Mixer with Frac.-N PLL and VCO	IIP3:24dBm, -111dBc/Hz@100kHz
AK1575	690MHz~4GHz Up Conversion Mixer with Frac.-N PLL and VCO	IIP3:24dBm, -111dBc/Hz@100kHz
IF Reciever (2nd Mixer + IF BPF + FM Detector)		
AK2364	Built-in programmable AGC+BPF, FM detector IC	IFBPF:±10kHz ~ ±4.5kHz
AK2365A	Built-in programmable AGC+BPF, IFIC	IFBPF:±7.5kHz ~ ±2kHz
Analog BB for PMR/LMR		
AK2345C	CTCSS Filter, Encoder, Decoder	24-VSOP
AK2360/ AK2360A	Inverted frequency(3.376kHz/3.020kHz) scrambler	8-SON
AK2363	MSK Modem/DTMF Receiver	24-QFN
AK2346B	0.3-2.55/3.0kHz Analog audio filter, Emphasis, Compandor, scrambler, MSK Modem	24-VSOP
AK2346A		24-QFN
AK2347B	0.3-2.55/3.0kHz Analog audio filter Emphasis, Compandor, scrambler, CTCSS filter	24-VSOP
AK2347A		24-QFN
Function IC		
AK2330	8-bit 8ch Electronic Volume	VREF can be selected for each channel
AK2331	8-bit 4ch Electronic Volume	VREF can be selected for each channel