

## 1. Overview

The AK1224 is a high linearity and low noise mixer. RF frequency range coverage is from 100 to 900MHz and IF coverage is from 20 to 100MHz. AK1224 can be driven by a single ended RF input and a low-power differential LO input that can be driven with a differential or single ended LO signal. IF output ports are differential open drain outputs. The analog circuit characteristics and power consumption performances can be optimized by the resistance connected to the BIAS Pin.

## 2. Feature

- Operating Frequency: 100MHz to 900MHz
- Linearity vs. Power selectable architecture:  
Current consumption:21mA, IIP3:+16dBm, Gain:5.5dB, NF:8.5dB
- Lo input level: 0dBm  $\pm$ 5dB
- Operating Supply Voltage: 4.75 to 5.25 V
- Package: 16pin UQFN(0.5mm pitch, 3mm  $\times$  3mm  $\times$  0.60mm)
- Operating Temperature Range -40 to 85°C

## 3. Applications

- Two-way Radios (PMR/LMR)
- Radio Communications for disaster prevention
- Marine Radios
- Amateur Radios

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**5. Block Diagram**

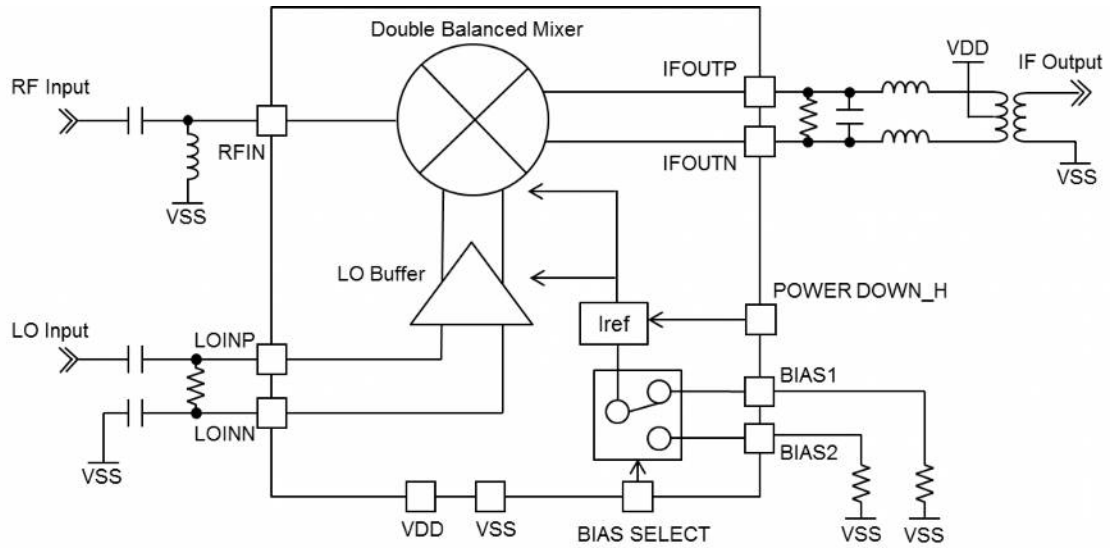


Figure 1. Block Diagram

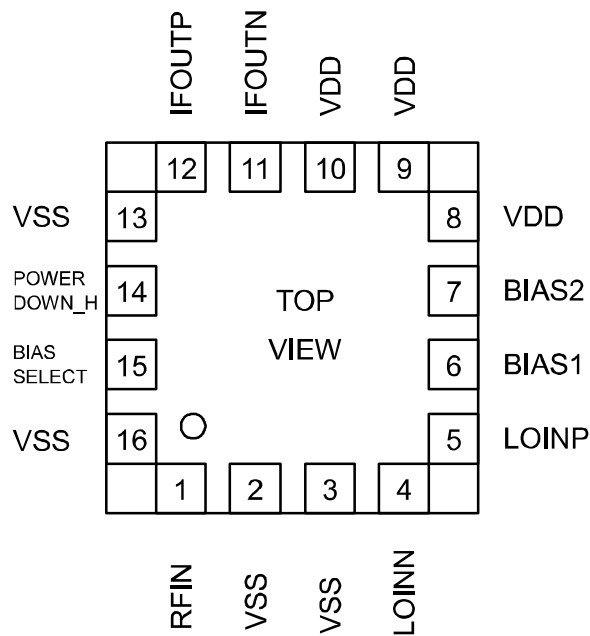


Figure 2. Package Pin Layout

## 6. Pin Function Description

Table 1 Pin Function

No.	Name	I/O	Pin Function	Remarks
1	RFIN	AI	RF Input	Connecting a 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	BIAS1	AIO	Resistance pin for current adjustment	Connecting a resistor between this pin and ground.
7	BIAS2	AIO	Resistance pin for current adjustment	Connecting a resistor between this pin and ground.
8	VDD	P	Power Supply	VDD
9	VDD	P	Power Supply	VDD
10	VDD	P	Power Supply	VDD
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	POWER DOWN_H	DI	Power Down control pin	High : Power OFF Low : Power ON
15	BIAS SELECT	DI	Bias Resistance select pin	High : Bias2 pin is enable Low : Bias1pin is enable
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	DI: Digital input pin

## 7. 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 AK1224. Normal operation is not guaranteed at these extremes.

## 1. 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).

## 8. Electrical Characteristics

### 1. Analog Circuit Characteristics

Unless otherwise noted IF output=50MHz, Lo Input Level=-5dBm to +5dBm,  
Output Load Resistor (R<sub>Load</sub>)=2.2kΩ, VDD=4.75 to 5.25V, Ta=-40°C to 85°C

Parameter	Min.	Typ.	Max.	Unit	Remarks
RF Input Frequency	100		900	MHz	
Lo Input Frequency	100		900	MHz	
IF output Frequency	20		100	MHz	
Lo Input Power	-5	0	+5	dBm	
Current Adjustment Resistor(BIAS)	22		100	kΩ	
IDD (BIAS=22kΩ)	20	26	36	mA	The total current of VDD pin, IFOUTP pin and IFOUTN pin.
IDD (BIAS=27kΩ)	16	21	30	mA	
IDD (BIAS =100kΩ)	4.5	6	8.5	mA	
IDD (POWERDOWN_H=VDD)		1	10	uA	
<b>RFIN=600MHz, Current Adjustment Resistor=27kΩ</b>					
Conversion Gain	3.5	5.5	7.5	dB	
SSB Noise Figure		8.5	11	dB	Design guarantee value
IP1dB	-3	0		dBm	
IIP3	13	16		dBm	

### 2. Digital Circuit Characteristics

This table is for **POWER DOWN\_H** pin and **BIAS SELECT** pin.

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit	Remark
High level input voltage	V <sub>ih</sub>		0.8×VDD			V	
Low level input voltage	V <sub>il</sub>				0.2×VDD	V	
High level input current	I <sub>ih</sub>	V <sub>ih</sub> = VDD=5.25V	-1		1	μA	
Low level input current	I <sub>il</sub>	V <sub>il</sub> = 0V, VDD1=5.25V	-1		1	μA	

### 9. Typical Performance

Unless otherwise noted, RF input =600MHz, Lo input =550MHz, IF output =50MHz,  
Output Load Resistor (R<sub>Load</sub>)=2.2kΩ

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

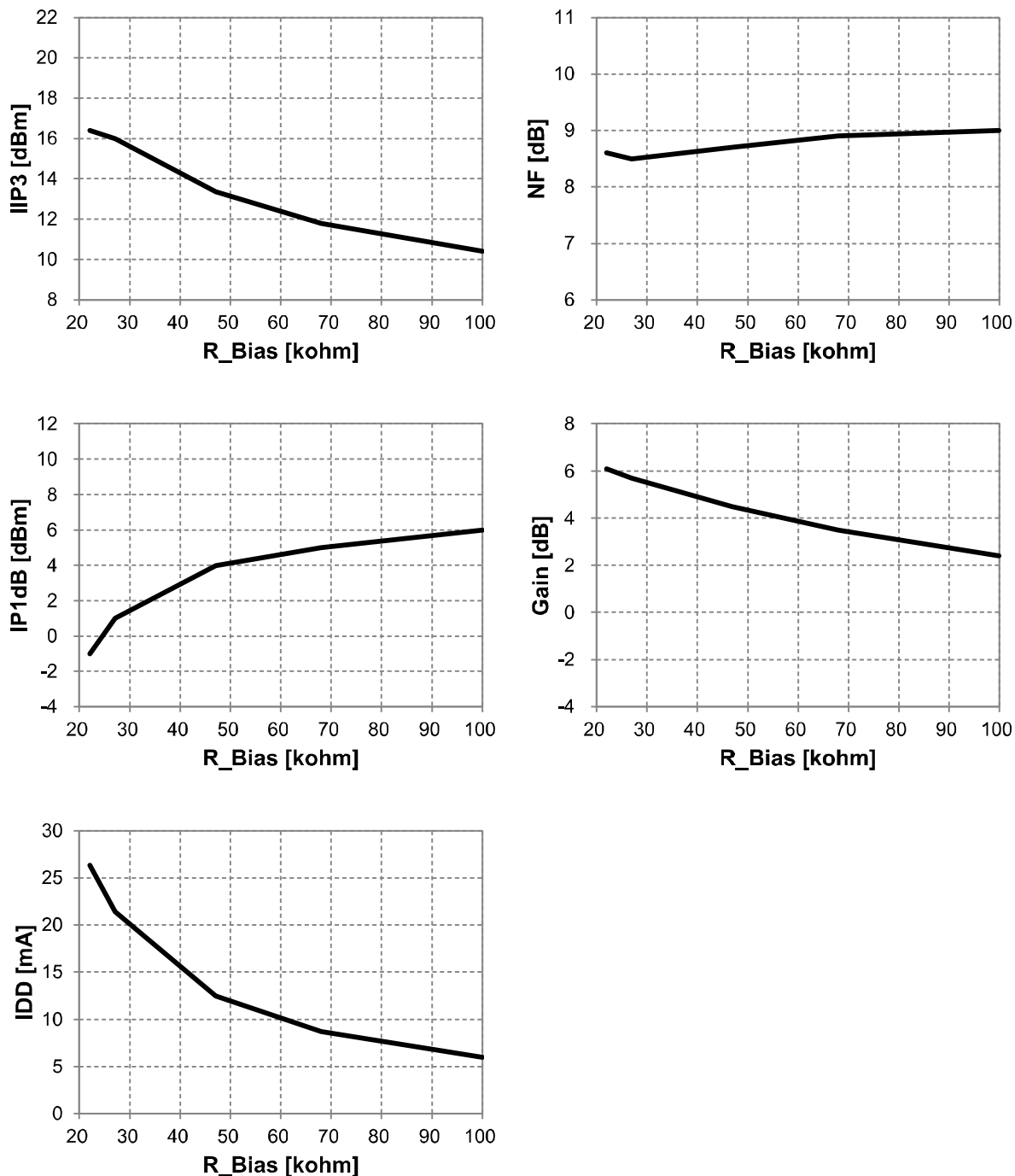


Figure 3. Current Adjustment Resistor vs. IIP3, NF, P1dB, Gain, IDD

Note ) A resistor with 5% tolerance are used.

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

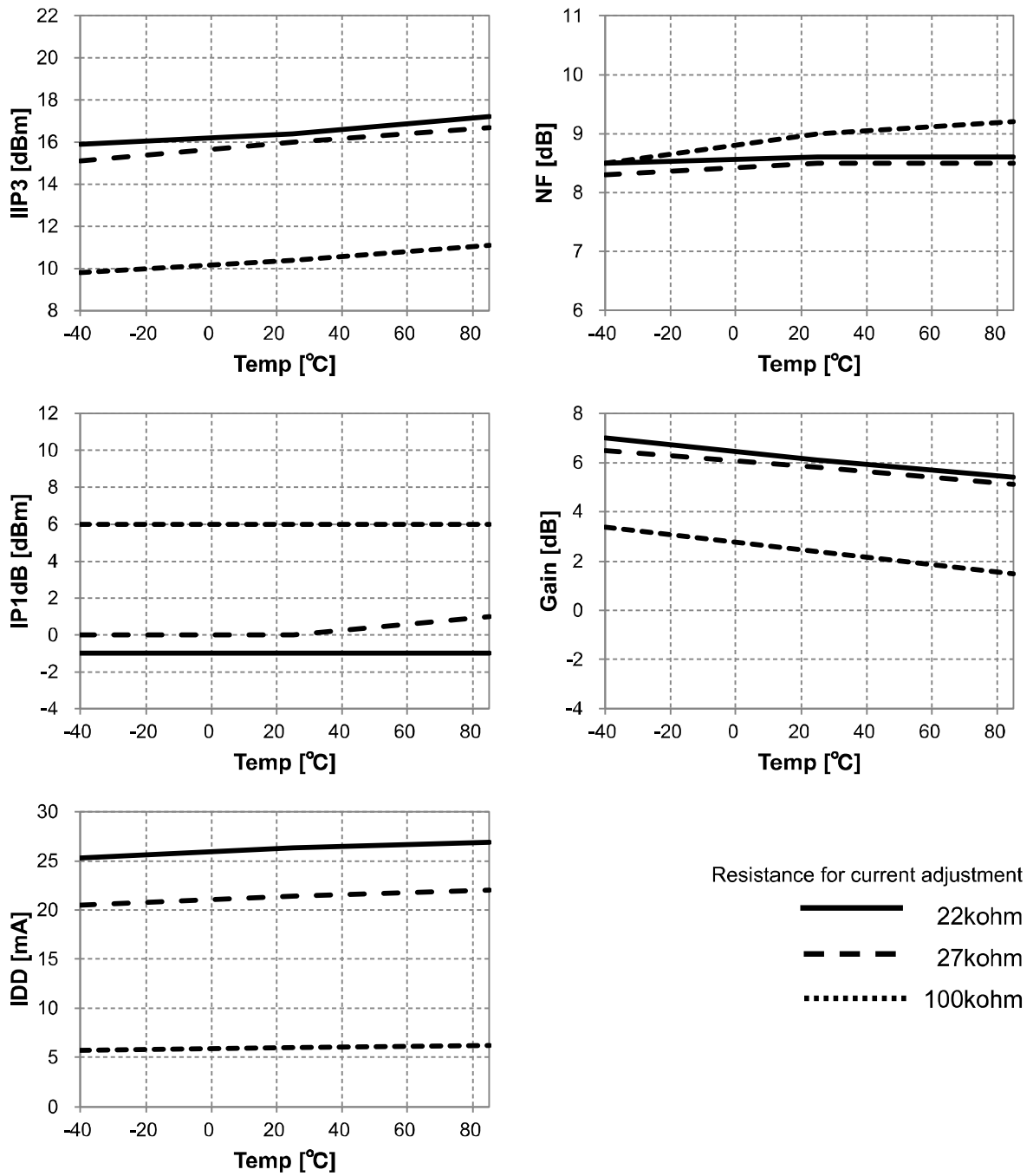


Figure 4. Over temperature vs. IIP3, NF, IP1dB, Gain, IDD



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

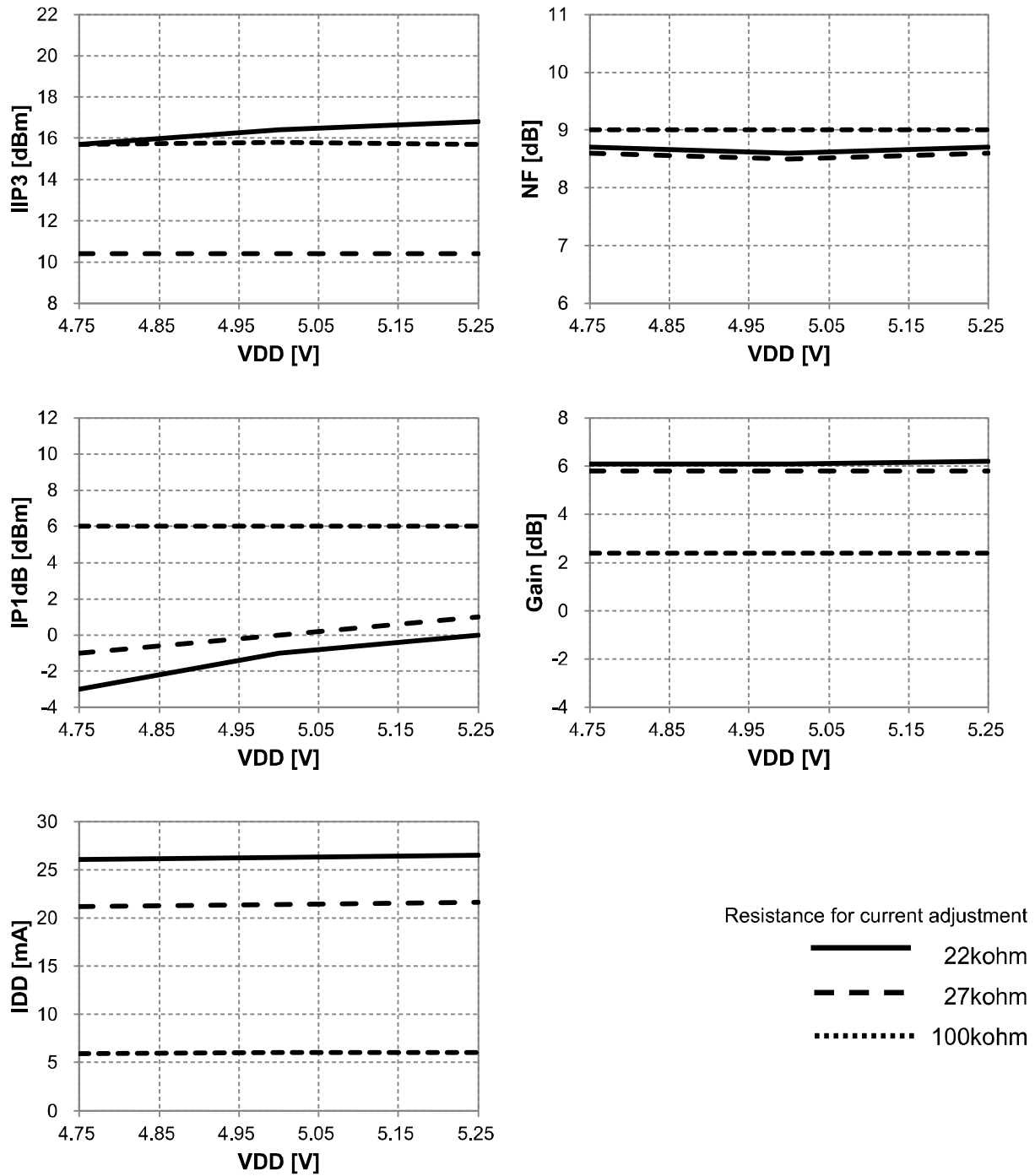


Figure 5. Supply voltage vs. IIP3, NF, IP1dB, Gain, IDD

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

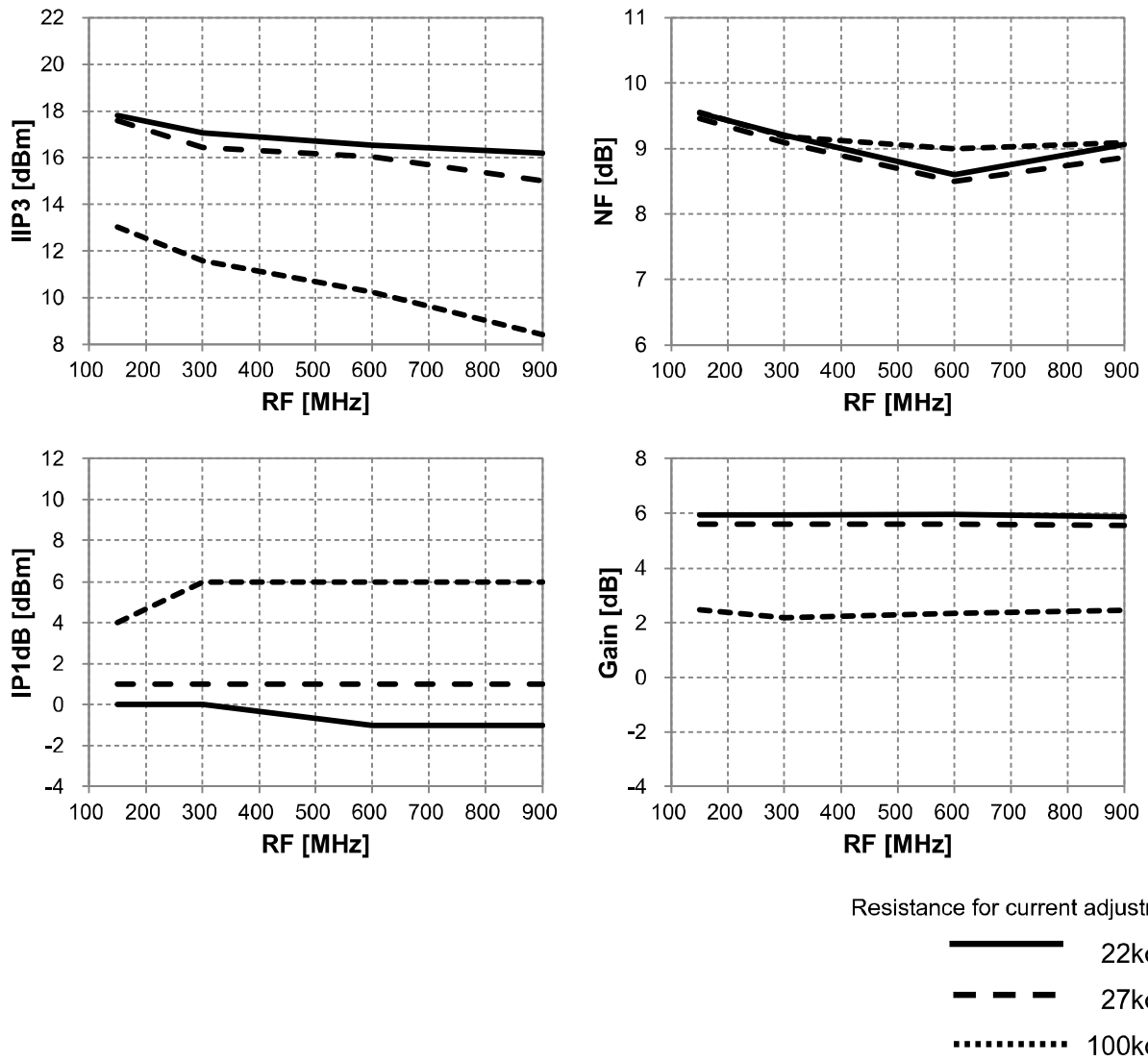


Figure 6. RF input frequency vs. IIP3, NF, Gain

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

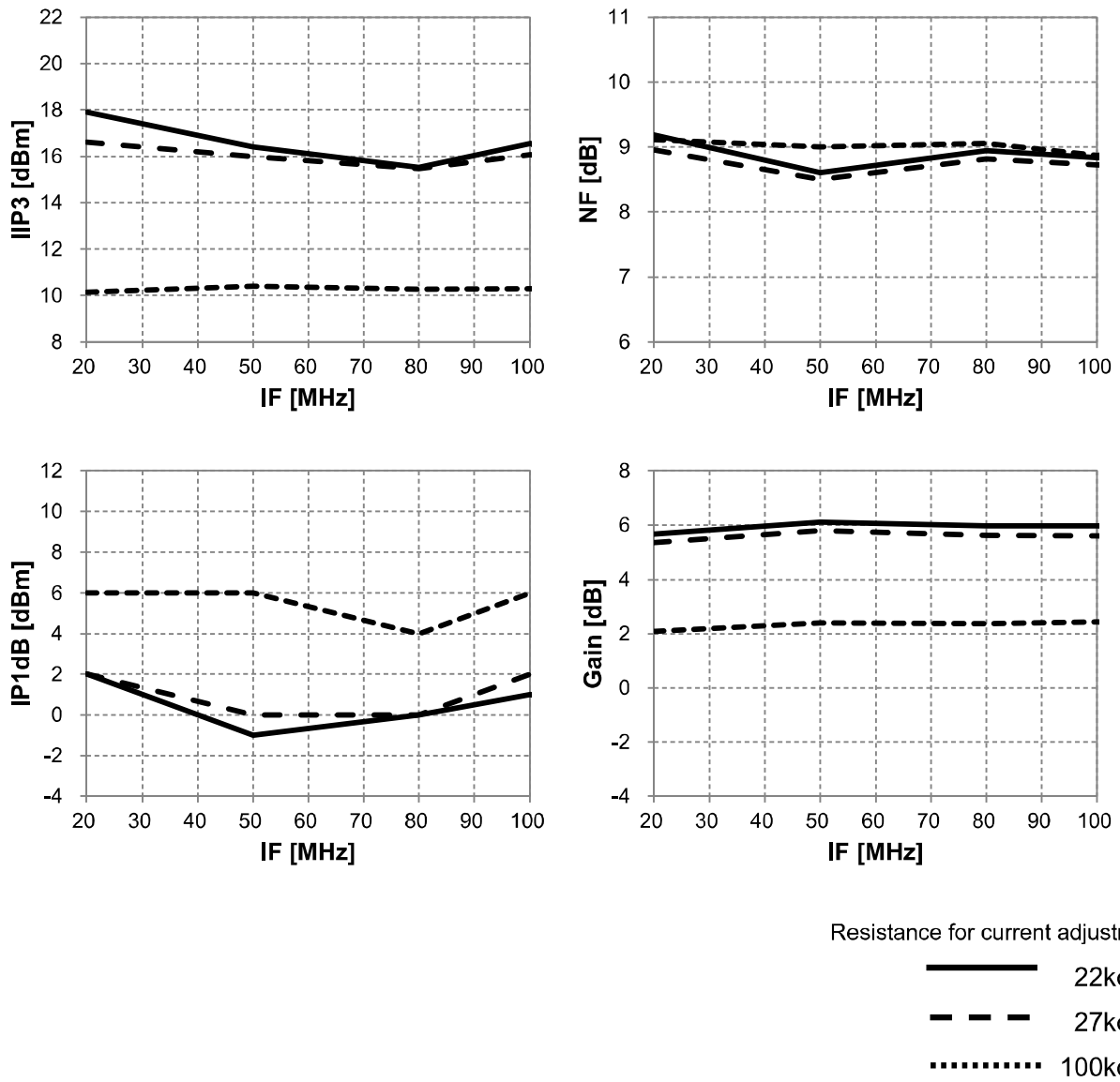


Figure 7. IF input frequency vs. IIP3, NF, Gain

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

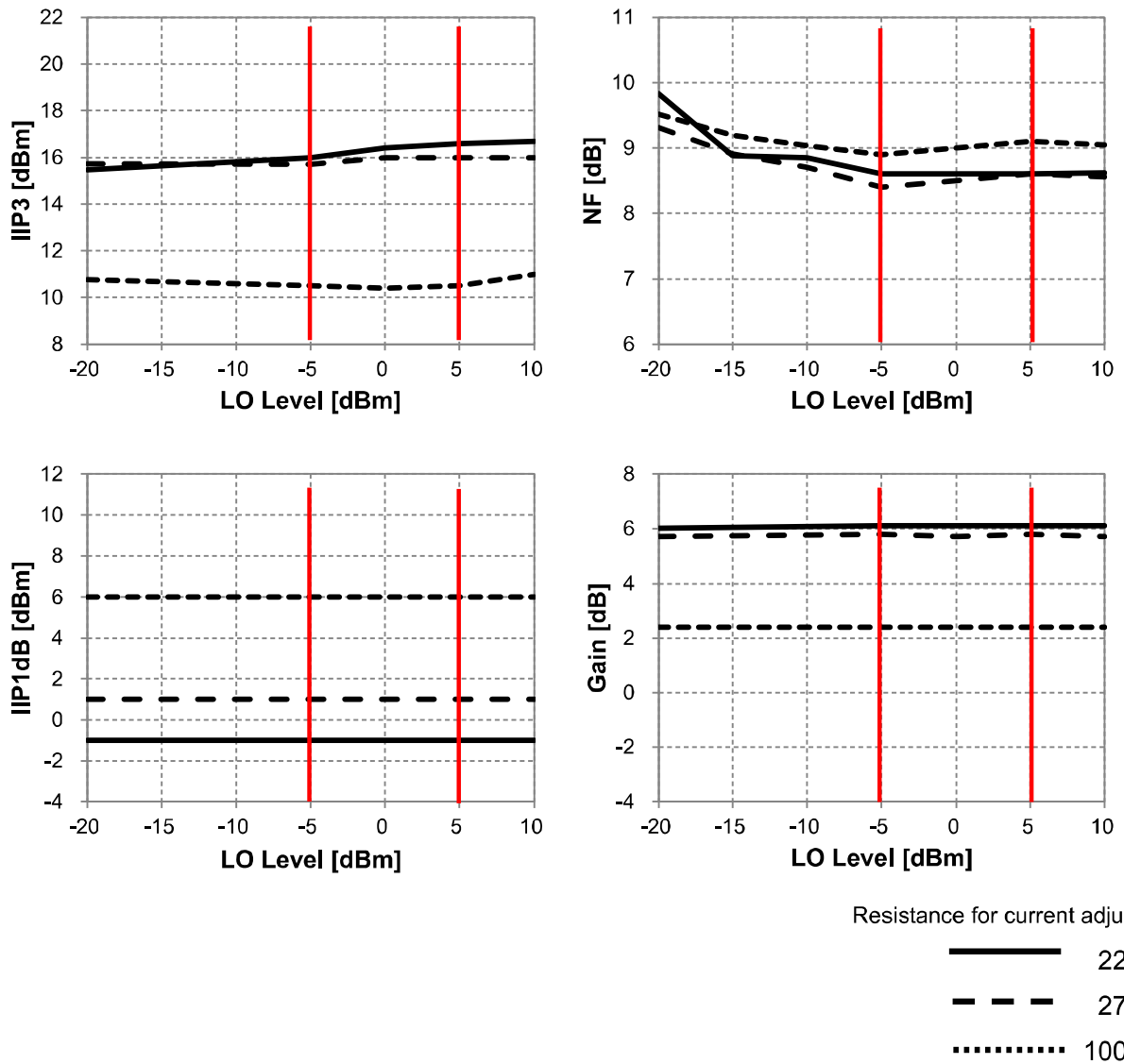


Figure 8. Lo input power vs. IIP3, NF, Gain

7. Output Load Resistor (R<sub>Load</sub>) vs. IIP3, NF, Gain

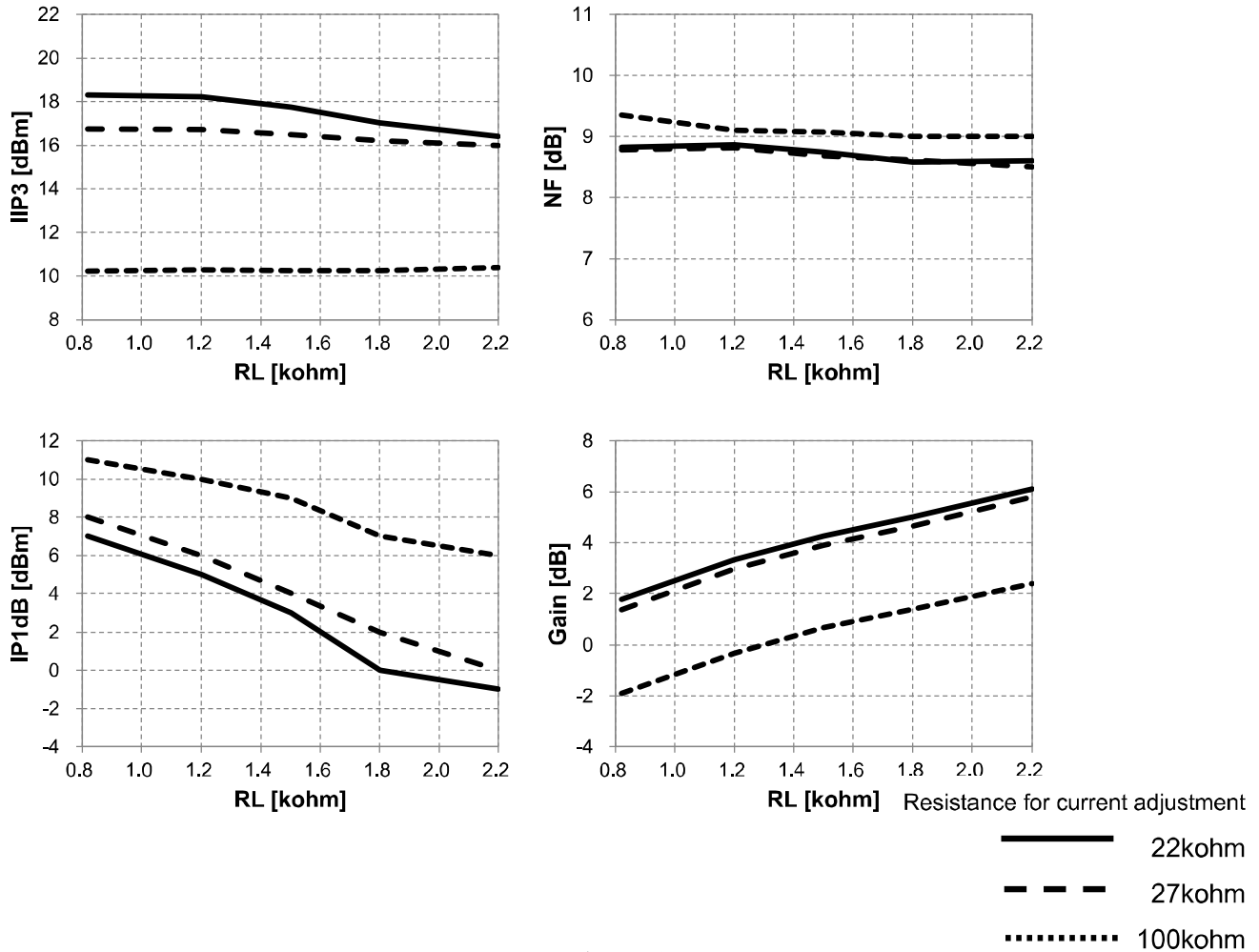


Figure 9. Output Load Resistor (R<sub>Load</sub>) vs. IIP3, NF, Gain

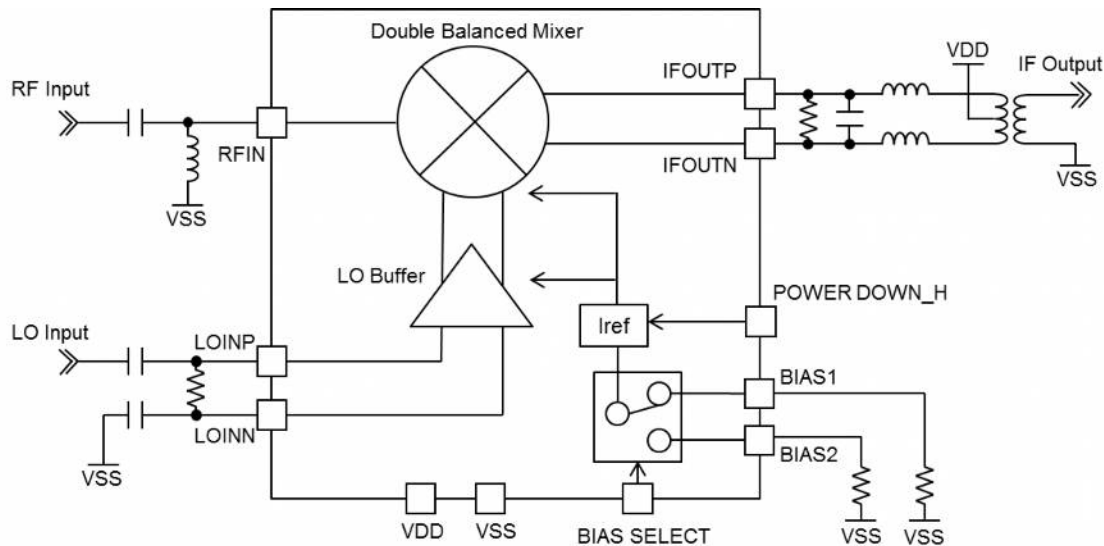
8. Leakage

RFIN=600MHz,-20dBm, LO input=550MHz,0dBm, RLoad=2.2kΩ, Ta=25°C VDD=5V

Parameter	BIAS	Typ.	Unit
RF – LO Leakage	22kΩ	-60	dBc
	100kΩ	-58	dBc
RF – IF Leakage	22kΩ	-59	dBc
	100kΩ	-60	dBc
LO – RF Leakage	22kΩ	-52	dBc
	100kΩ	-55	dBc
LO – IF Leakage	22kΩ	-57	dBc
	100kΩ	-56	dBc

**10. Typical Evaluation Board Schematic**

1. Typical Evaluation Board Schematic

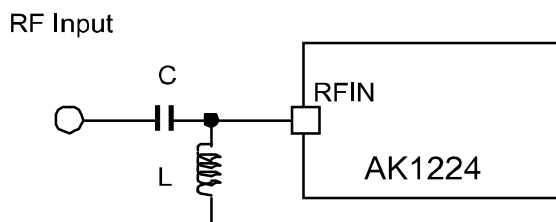


**Figure 10. Typical Evaluation Board Schematic**

- Note) The exposed pad at the center of the backside should be connected to ground.
- Note) The open drain output needs power feeding via an inductor. (IFOUTP pin and IFOUTN pin)
- Note) It is necessary to adjust impedance matching as to its setting frequency. (RF input and IF output)

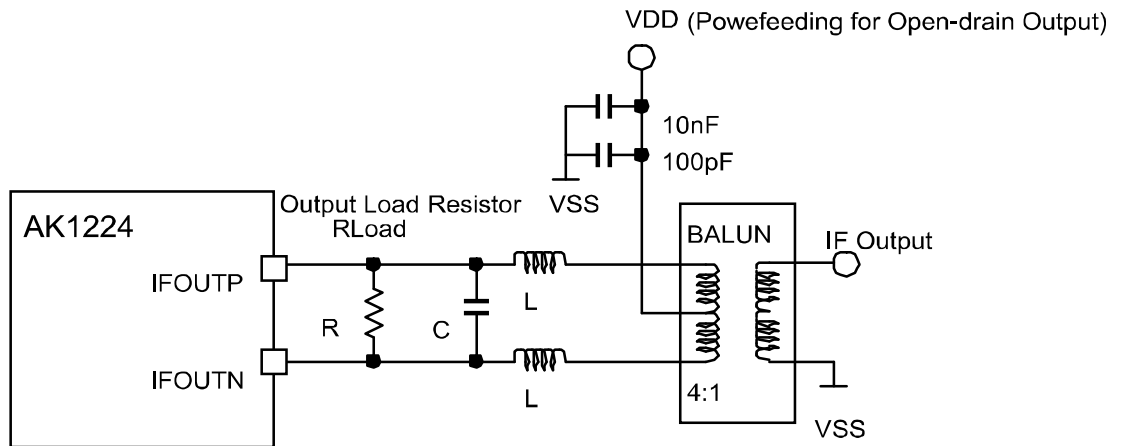
2. Example of impedance matching

•RFIN



Frequency[MHz]	C1[pF]	L[nH]	Impedance[ohm]
100	68	220	49.3 - j5.4
600	15	22	48.3 - j0.7
900	12	12	44.48 - j1.0

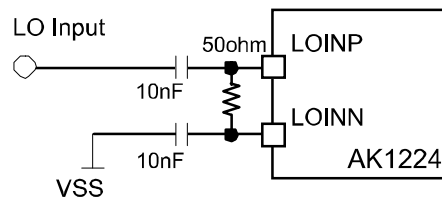
·IFOUT



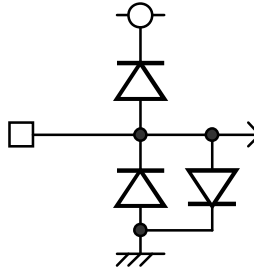
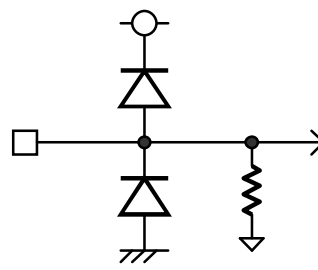
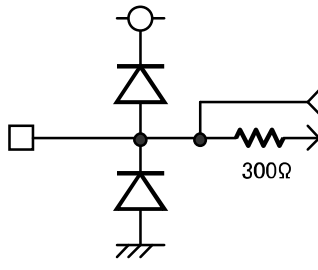
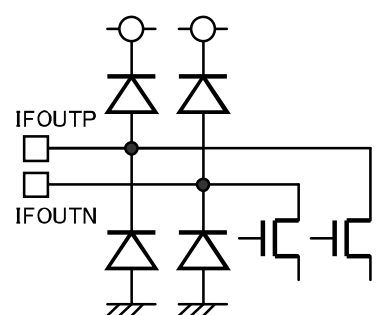
Frequency [MHz]	R1 [kohm]	C [pF]	L [nH]	Impedance[ohm]
20	2.2	10	2200 <sup>*1</sup>	51.2 – j11.6
50	2.2	3.3	1000 <sup>*1</sup>	51.6 – j0.6
100	2.2	1.2	470 <sup>*1</sup>	48.6 – j5.7

\*1)Murata LQW series

·LOINP/LOINN



**11. LSI Interface schematic**

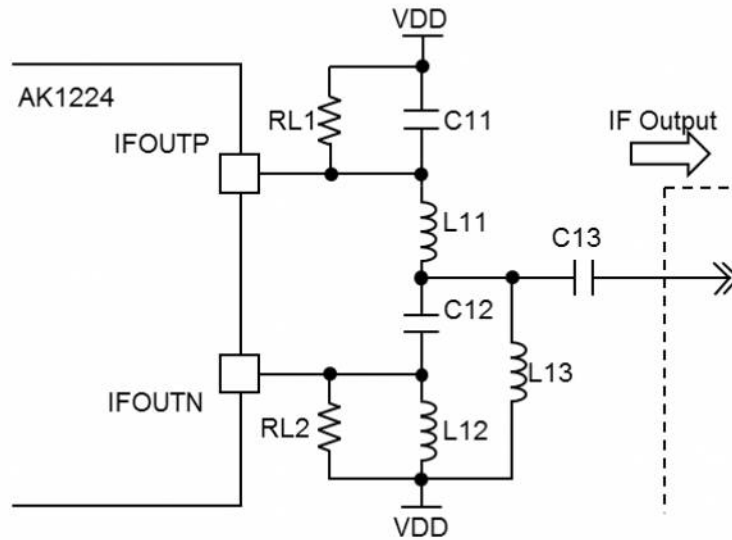
No.	Name	I/O	Function
1	RFIN	I	RF Input pin 
4	LOINN	I	LO Input pins 
5	LOINP		
6	BIAS1	I/O	Analog I/O pins 
7	BIAS2		
11	IFOUTN	O	IF Output pins 
12	IFOUTP		



14	Power Down_H	I	Digital Input pins
15	BIAS Select		

## 12. Application Information

### • Impedance matching network with LC



**Figure 11. Impedance matching network with LC**

Impedance matching network with LC is shown in Figure 11. AK1224 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  $R_o$ .

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

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

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

For example, in the case of IF Output = 50MHz, Output Load Resistor ( $R_{load}$ ) = 2.2k $\Omega$  in 50 $\Omega$  interface,  $L11$ ,  $C11$ ,  $L12$  and  $C12$  are calculated as below.

$$C_{11} = C_{12} = \frac{1}{2\pi * (50 * 10^6) * \sqrt{(2.2 * 10^3) * 50}} = 9.6\text{pF}$$

$$L_{11} = L_{12} = \frac{\sqrt{(2.2 * 10^3) * 50}}{2\pi * (50 * 10^6)} = 1056\text{nH}$$

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 = 50MHz, Output Load Resistor (Rload) = 2.2kΩ 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.

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 AK1224

Typical Performance using impedance matching network with LC is below. RF Input = 600MHz, IF Output = 50MHz, LO Input = 550MHz, Output Load Resistor (Rload) = 2.2kΩ, Vdd = 5V, Ta = 25°C, LO Input Level = 0dBm, Current Adjustment Resistor=27kΩ.

Ref.	Value	Size	Part Number
RL1, RL2	1.1kΩ	1005	KOA RK73K1ETP112
L11, L12	1000nH	2012	Murata LQW21HN1R0J00
C11, C12	10pF	1005	Murata GRM1552C1H100JA01
L13	2200nH	2012	Murata LQW21HN2R2J00
C13	150pF	1005	Murata GRM1552C1H151JA01

Parameter	Min.	Typ.	Max.	Unit
Conversion Gain		5.1		dB
SSB Noise Figure (NF)		8.6		dB
IP1dB		2.0		dBm
IIP3		16.3		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

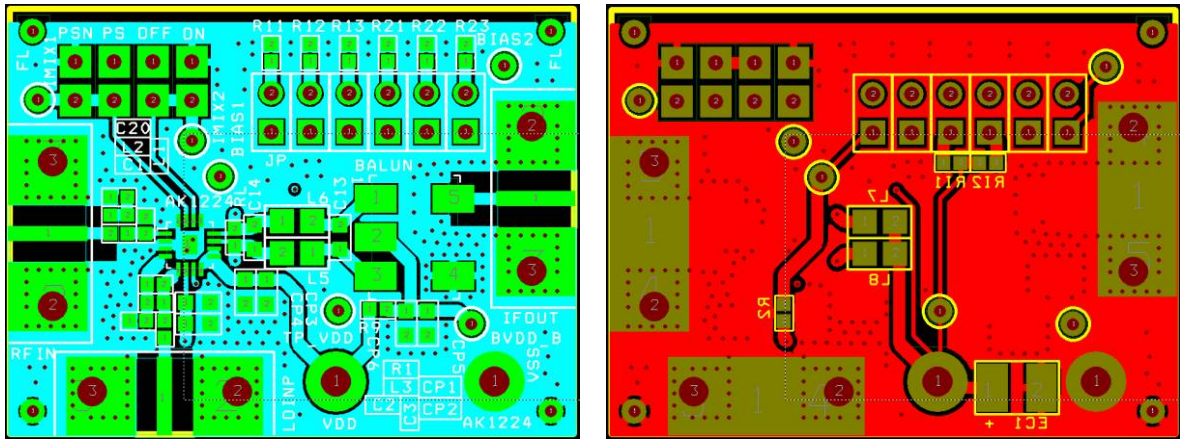


Figure 12. AK1224/AK1228 Evaluation Board (Balun)

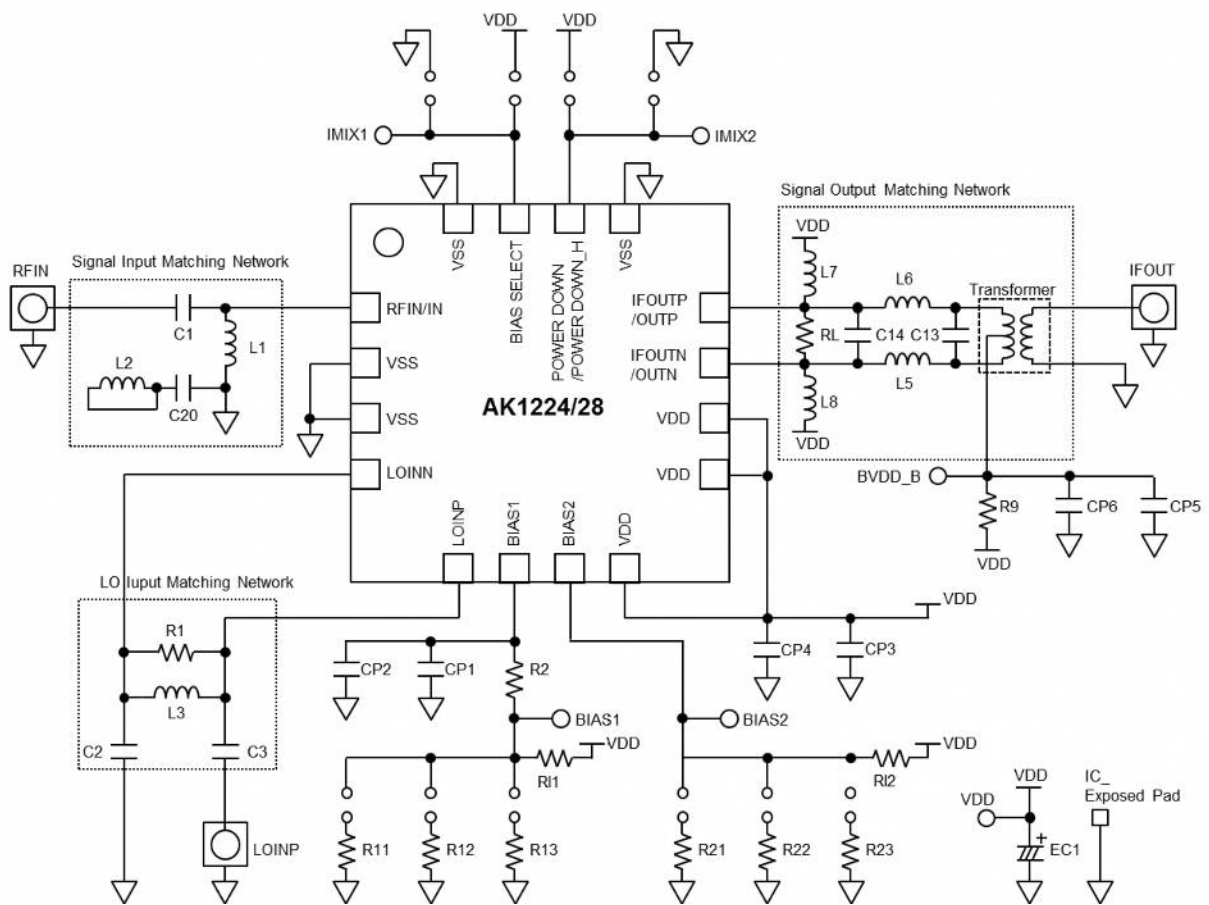


Figure 13. AK1224/AK1228 Evaluation Board Schematic (Balun)

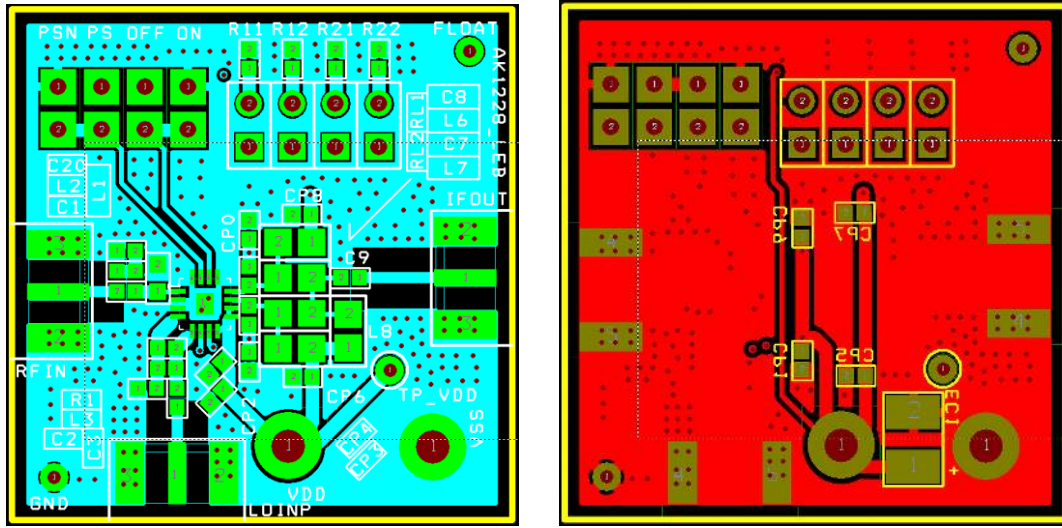


Figure 14. AK1224/AK1228 Evaluation Board (matching network with LC)

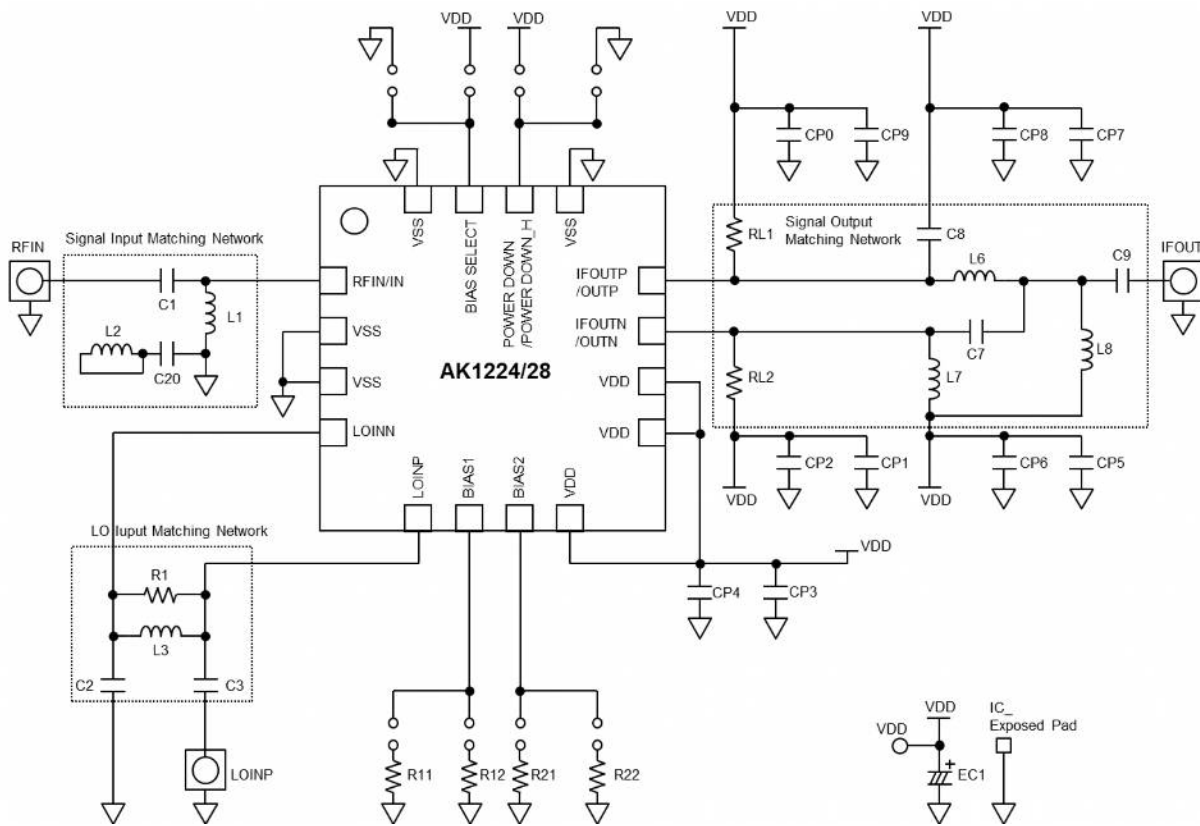
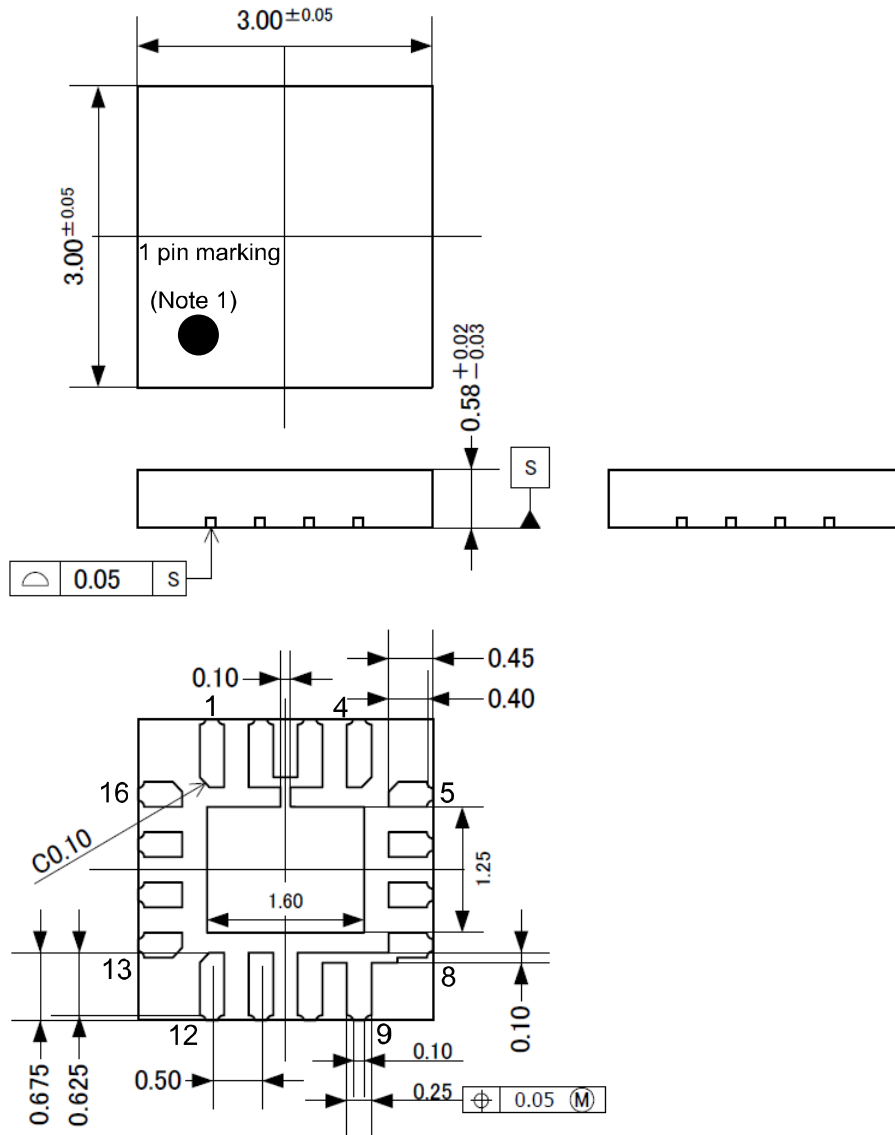


Figure 15. AK1224/AK1228 Evaluation Board Schematic (matching network with LC)

**13. Outer Dimensions**

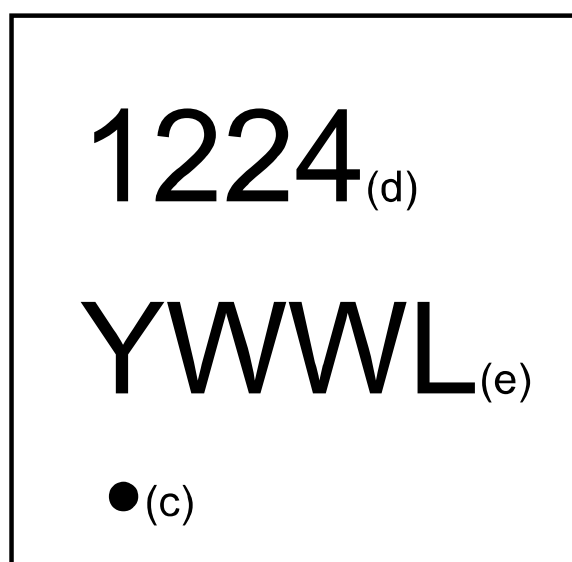


**Figure 16. Outer Dimensions**

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

**14. Marking**

(a) Style	:	UQFN
(b) Number of pins	:	16
(c) 1 pin marking	:	○
(d) Product number	:	1224
(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 17. Marking**



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### ●Related Parts

Part#	Discription	Comments
<b>Mixer</b>		
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
<b>PLL Synthesizer</b>		
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
<b>IFVGA</b>		
AK1291	100~300MHz Analog Signal Control IF VGA w/ RSSI	Dynamic Range:30dB
<b>integrated VCO</b>		
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
<b>IF Reciever (2nd Mixer + IF BPF + FM Detector)</b>		
AK2364	Built-in programmable AGC+BPF, FM detector IC	IFBPF:±10kHz ~ ±4.5kHz
AK2365A	Built-in programmable AGC+BPF, IFIC	IFBPF:±7.5kHz ~ ±2kHz
<b>Analog BB for PMR/LMR</b>		
AK2345	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,	24-VSOP
AK2346A	Emphasis, Compandor, scrambler, MSK Modem	24-QFN
AK2347B	0.3-2.55/3.0kHz Analog audio filter	24-VSOP
AK2347A	Emphasis, Compandor, scrambler, CTCSS filter	24-QFN
<b>Function IC</b>		
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

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