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AK1222

900MHz Low Power Mixer

1. Overview

The AK1222 is a low power mixer. RF and LO frequency range coverage from 100 to 900MHz and IF coverage is from 20 to 100MHz. The RF input provides single-ended 50Ω interface. LO ports are 50Ω matched and complementary inputs should be decoupled to the ground. IF output ports are differential open drain outputs.
The linearity and power consumption performances can optimize with the resistance connected to the BIAS pin.

2. Features

- Operating Frequency: 100 to 900MHz
- Linearity vs Power Selectable architecture
  - Power Consumption:5.3mA, IIP3:+11dBm, Gain:-2dB, NF:12dB
  - Power Consumption:2.9mA, IIP3:+2dBm, Gain:-3.5dB, NF:11.5dB
- LO input level: 0dBm±5dB
- Operating Supply Voltage: 4.75 to 5.25 V
- Package: 16pin UQFN (0.5mm pitch, 3mm x 3mm x 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

4. Table of Contents

5. Block Diagram

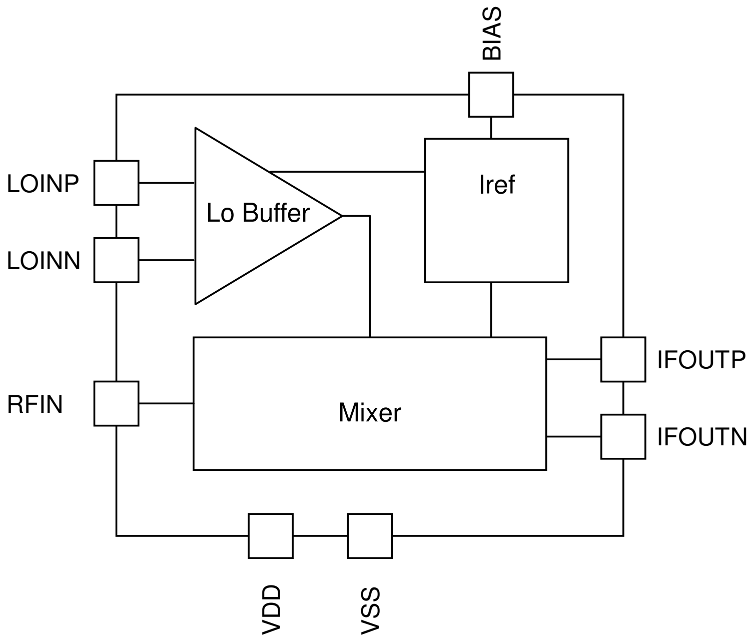


Figure 1. Block Diagram

6. System Diagram

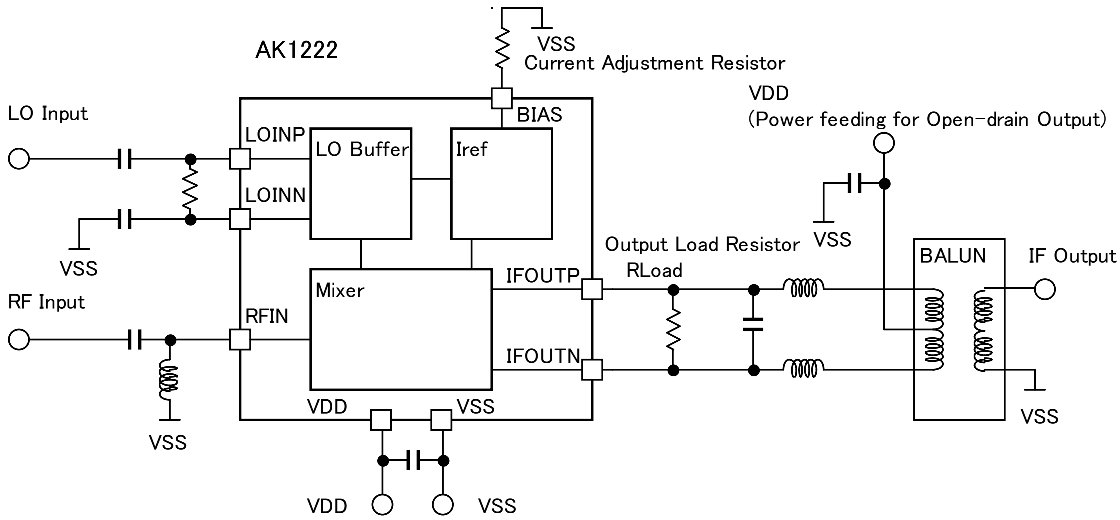


Figure 2. System Diagram

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	LOINN	AI	LO Input Negative	
4	LOINP	AI	LO Input Positive	
5	NC	-	Non Connect	
6	NC	-	Non Connect	
7	NC	-	Non Connect	
8	NC	-	Non Connect	
9	BIAS	AIO	Resistance pin for current adjustment	Connecting a resistor between this pin and ground.
10	VDD	P	Power Supply	
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	NC	-	Non Connect	
14	NC	-	Non Connect	
15	NC	-	Non Connect	
16	NC	-	Non Connect	

Note) It is recommended to connect NC pins to ground, although it will not make any impact on the electrical characteristics if the pin is open.

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

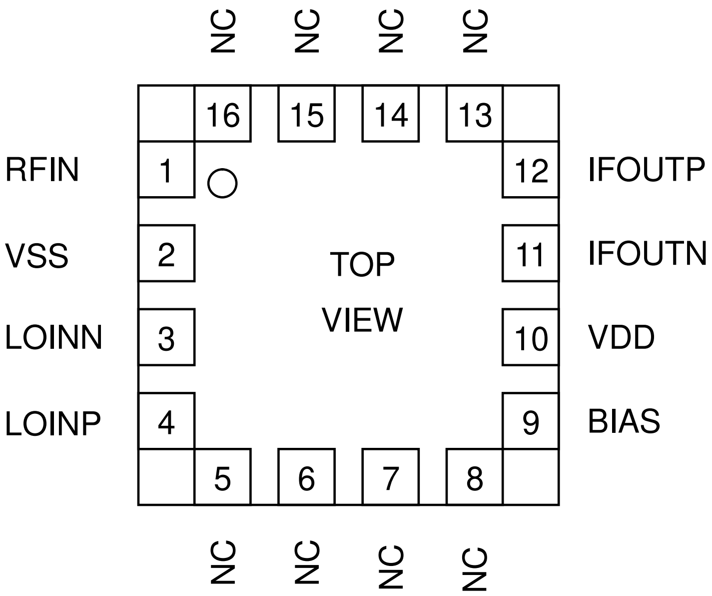


Figure 3. Package Pin Layout

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		7	dBm	
LO Input Power	LOPOW		12	dBm	
Storage Temperature	Tstg	-55	125	°C	

Exceeding these maximum ratings may result in damage to the AK1222. 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=50MHz, LO Input Level=-5dBm to +5dBm,

Output Load Resistor (RLoad)=2.2kΩ, VDD=4.75 to 5.25V, Ta=-40 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		56	kΩ	
IDD	BIAS=22kΩ		5.3	7.9	mA	The total current of VDD pin, IFOUTP pin and IFOUTN pin.
	BIAS=56kΩ		2.9	4.7	mA	
RFIN=600MHz, Output Load Resistor = 22kΩ						
Conversion Gain		-4	-2	0	dB	
SSB Noise Figure (NF)			12	14	dB	Design guarantee value
IP1dB		-3	0		dBm	
IIP3		+8	+11		dBm	
RFIN=600MHz, Output Load Resistor = 56kΩ						
Conversion Gain		-5.5	-3.5	-1.5	dB	
SSB Noise Figure (NF)			11.5	13.5	dB	Design guarantee value
IP1dB		-9	-6		dBm	
IIP3		-1	+2		dBm	

Note 1) In the shipment test, NC pins and the exposed pad on the center of the back of the package is connected to ground.

11. Typical Performance

Unless otherwise noted, RF input =600MHz, LO input =550MHz, IF output =50MHz,

Output Load Resistor (RLoad)=2.2kΩ

1. Current Adjustment Resistor vs. IIP3, NF, IP1dB, Gain, IDD

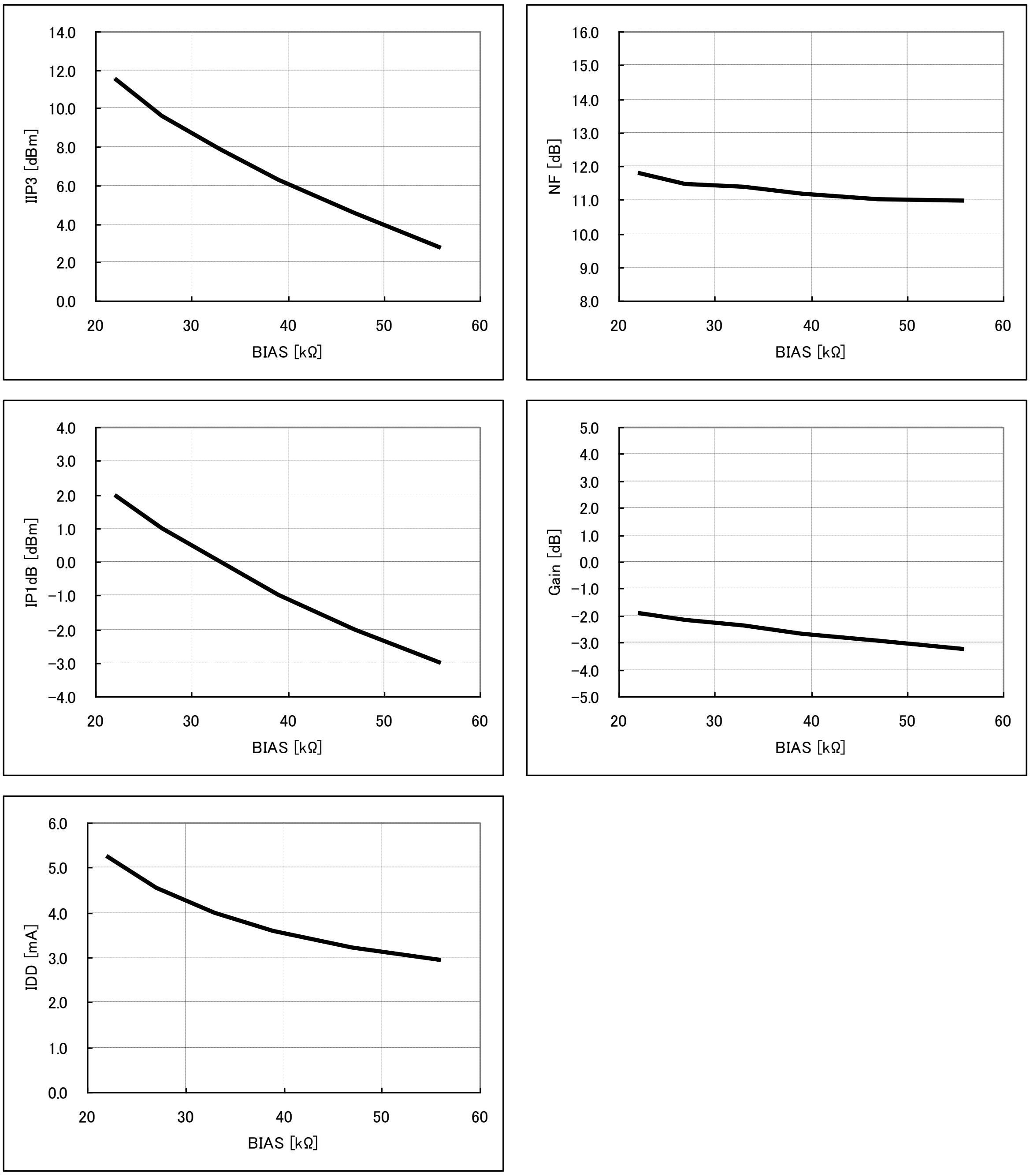


Figure 4. Current Adjustment Resistor vs. IIP3, NF, IP1dB, Gain, IDD

Note 1) A resistor with 5% tolerance are used.

2. Over temperature vs. IIP3, NF, IP1dB, Gain, IDD

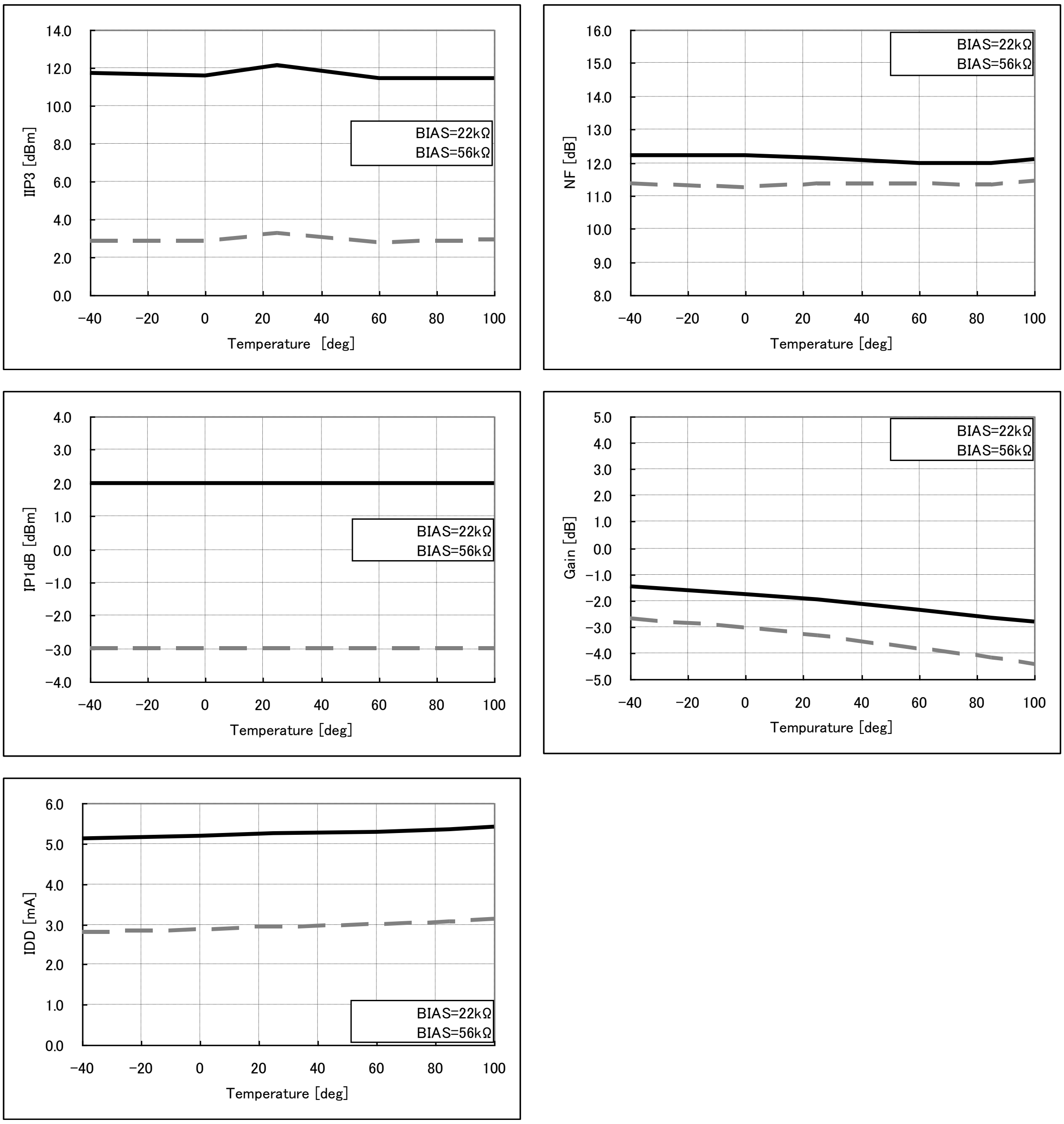


Figure 5. Over temperature vs. IIP3, NF, IP1dB, Gain, IDD

3. Supply voltage vs. IIP3, NF, IP1dB, Gain, IDD

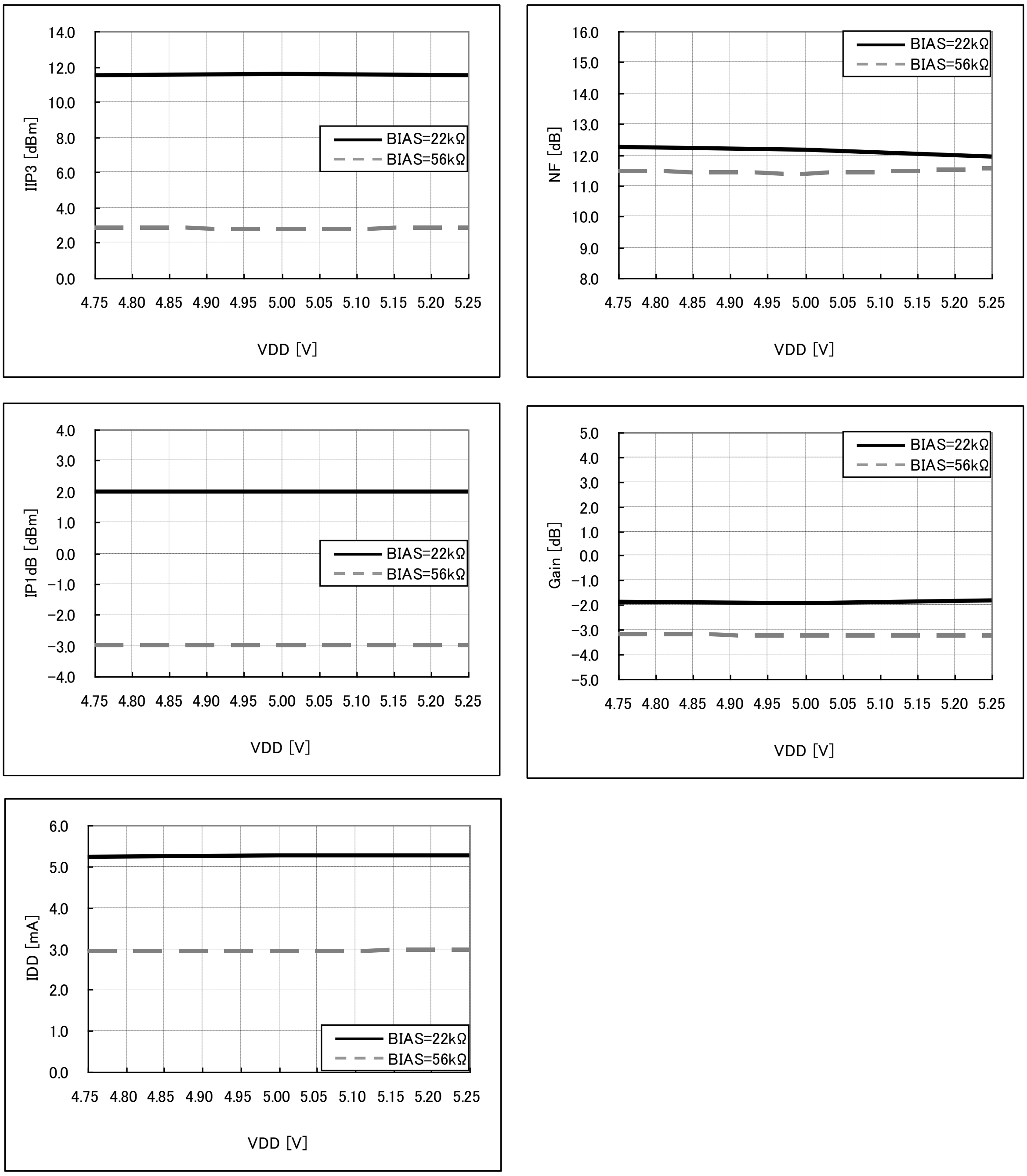


Figure 6. Supply voltage vs. IIP3, NF, IP1dB, Gain, IDD

4. RF input frequency vs. IIP3, NF, IP1dB, Gain

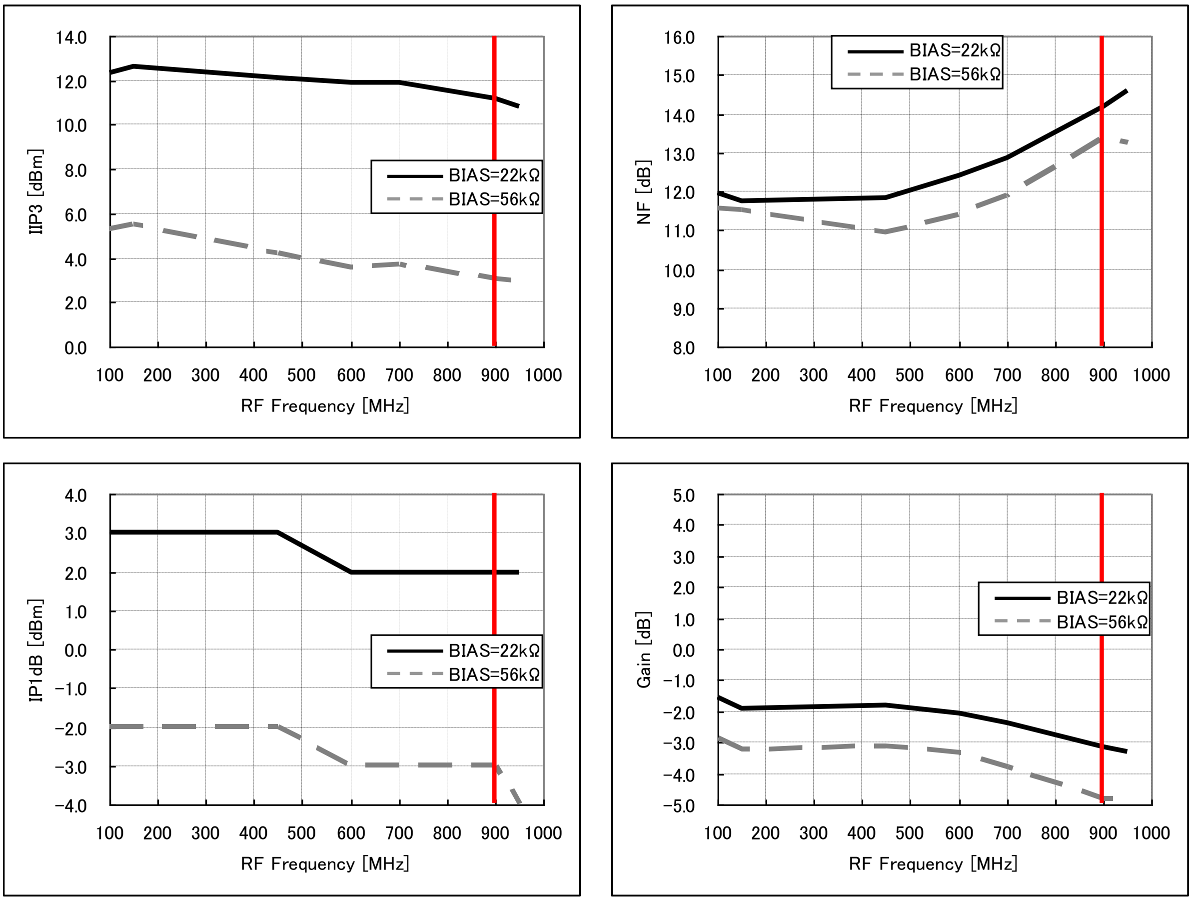


Figure 7. RF input frequency vs. IIP3, NF, IP1dB, Gain

Note 1) AK1222 supports 100MHz to 900MHz RF Input.

5. IF output frequency vs. IIP3, NF, IP1dB, Gain

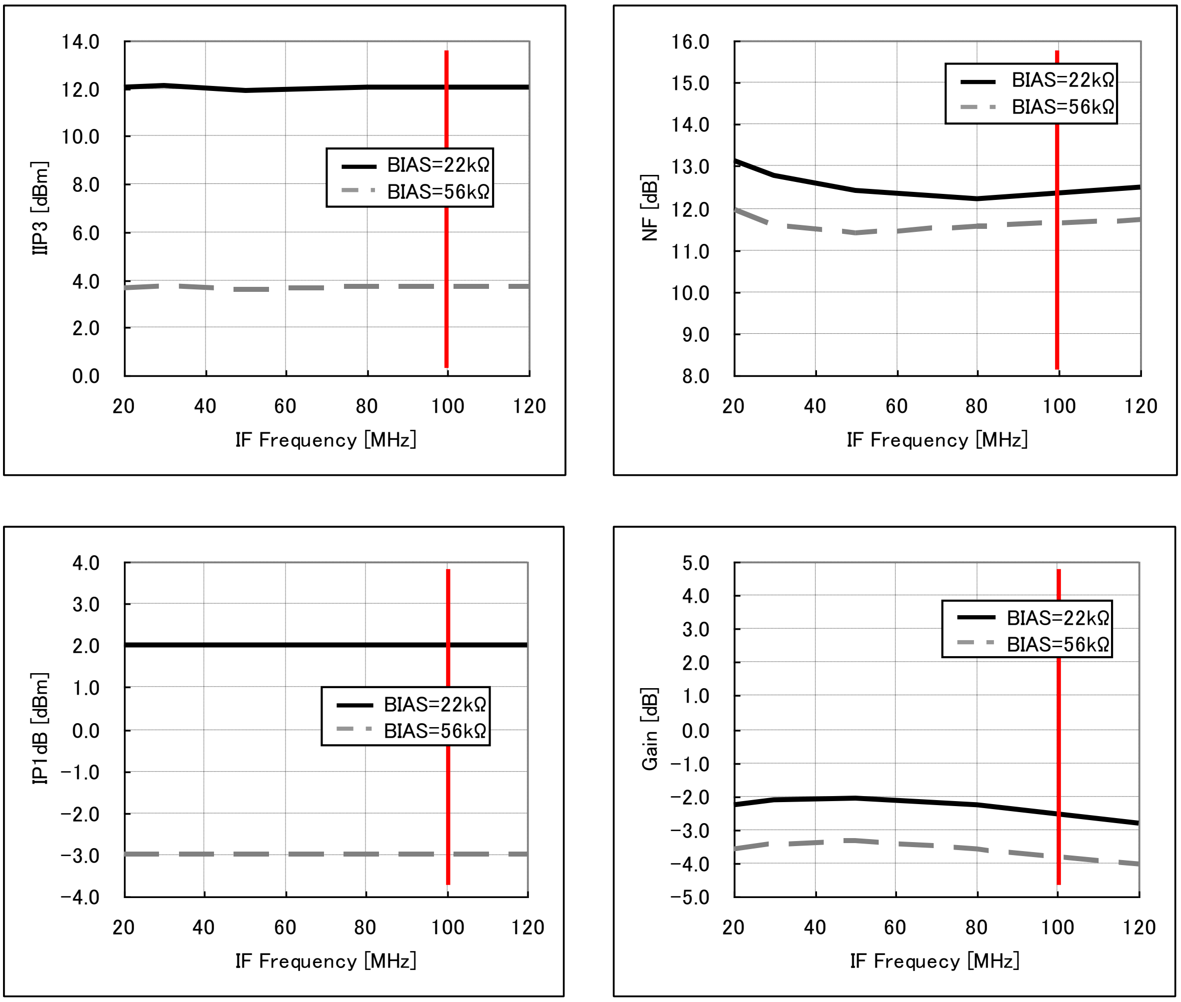


Figure 8. IF output frequency vs. IIP3, NF, IP1dB, Gain

Note 1) AK1222 supports 20MHz to 100MHz IF Output.

6. LO input power vs. IIP3, NF, IP1dB, Gain

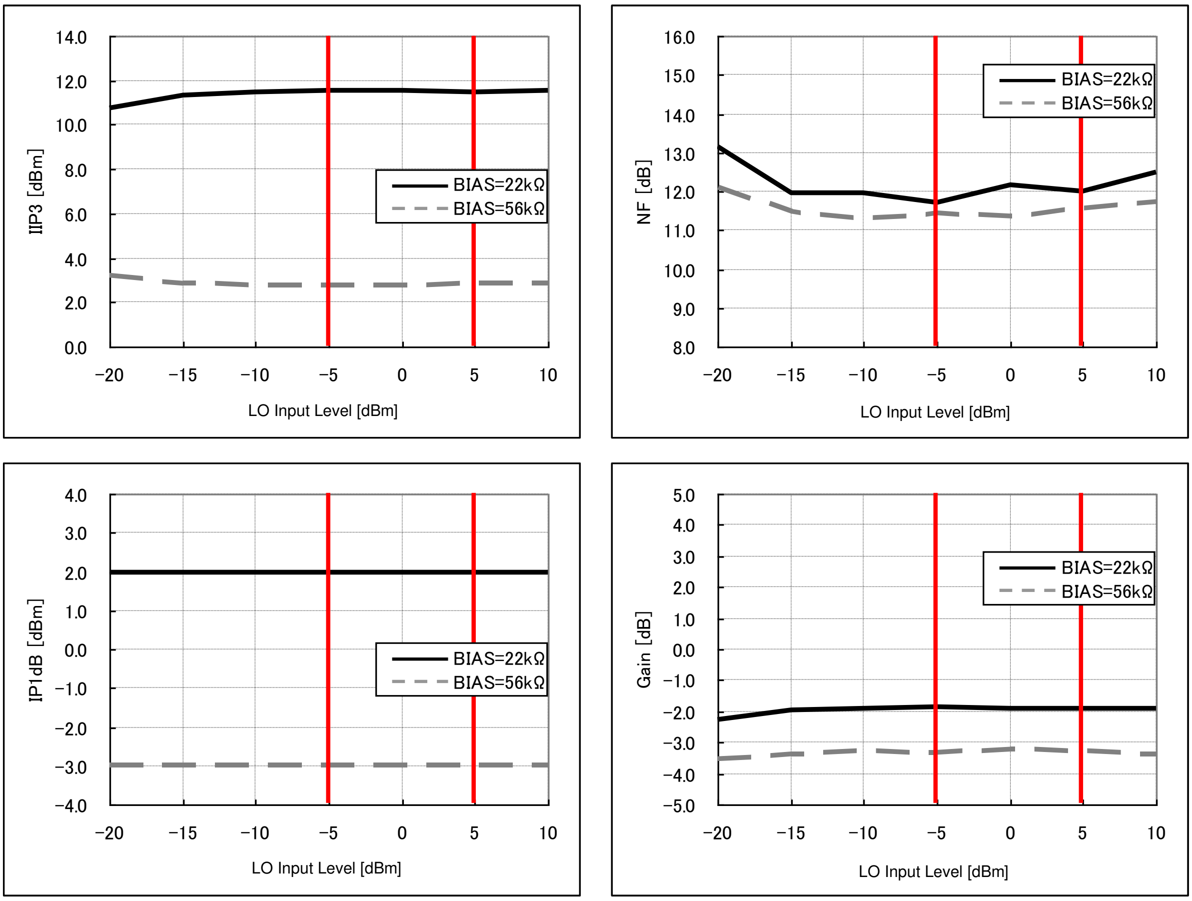


Figure 9. LO input power vs. IIP3, NF, IP1dB, Gain

Note 1) AK1222 supports -5dBm to 5dBm LO input power.

7. Output Load Resistor (RLoad) vs. IIP3, NF, IP1dB, Gain

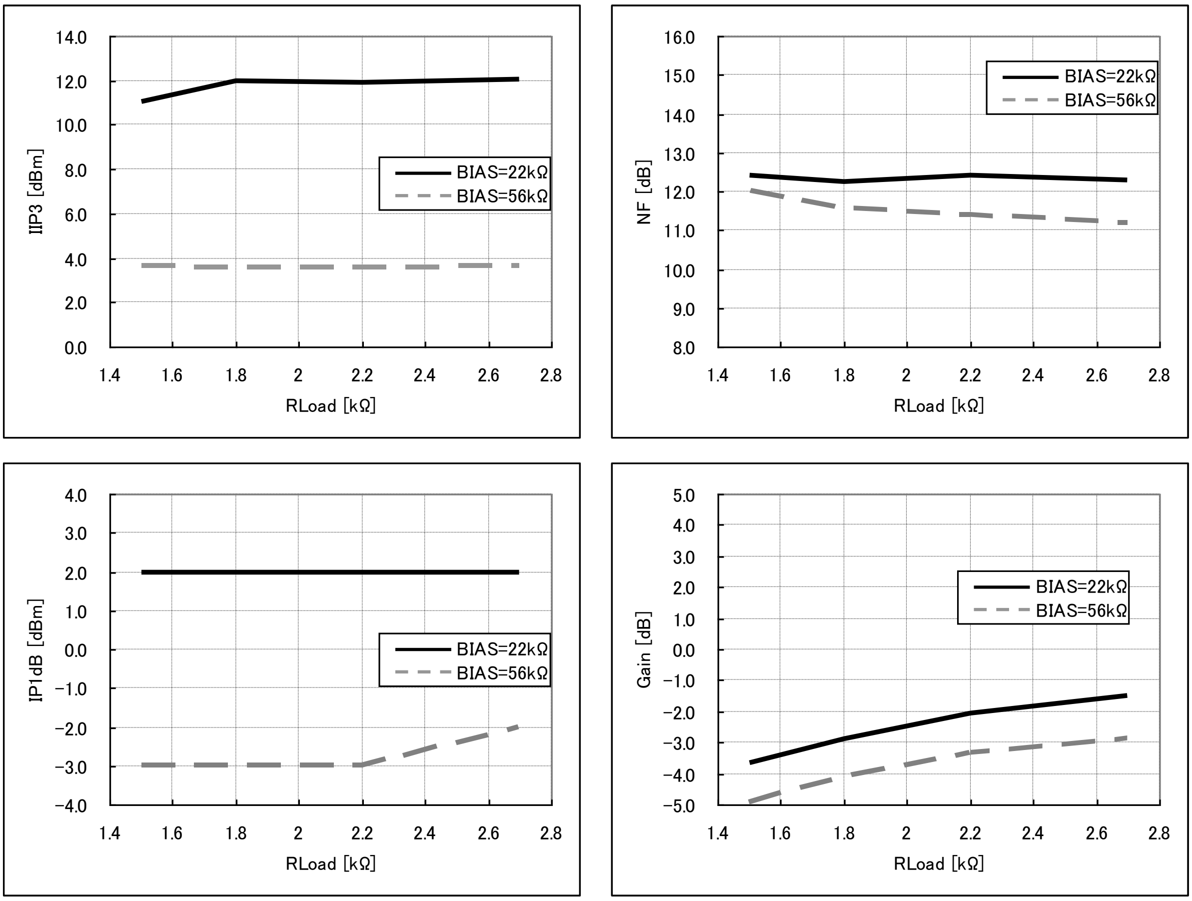


Figure 10. Output Load Resistor（RLoad）vs. IIP3, NF, IP1dB, Gain

8. Leakage

RF input=600MHz, -20dBm, LO input=600MHz, 0dBm, Ta=25°C VDD=5V

Parameter	BIAS	Typ.	Unit
RF – LO Leakage	22kΩ	-50	dBc
	56kΩ	-50	dBc
RF – IF Leakage	22kΩ	-80	dBc
	56kΩ	-80	dBc
LO – RF Leakage	22kΩ	-50	dBc
	56kΩ	-50	dBc
LO – IF Leakage	22kΩ	-80	dBc
	56kΩ	-80	dBc

12. Typical Evaluation Board Schematic

1. Typical Evaluation Board Schematic

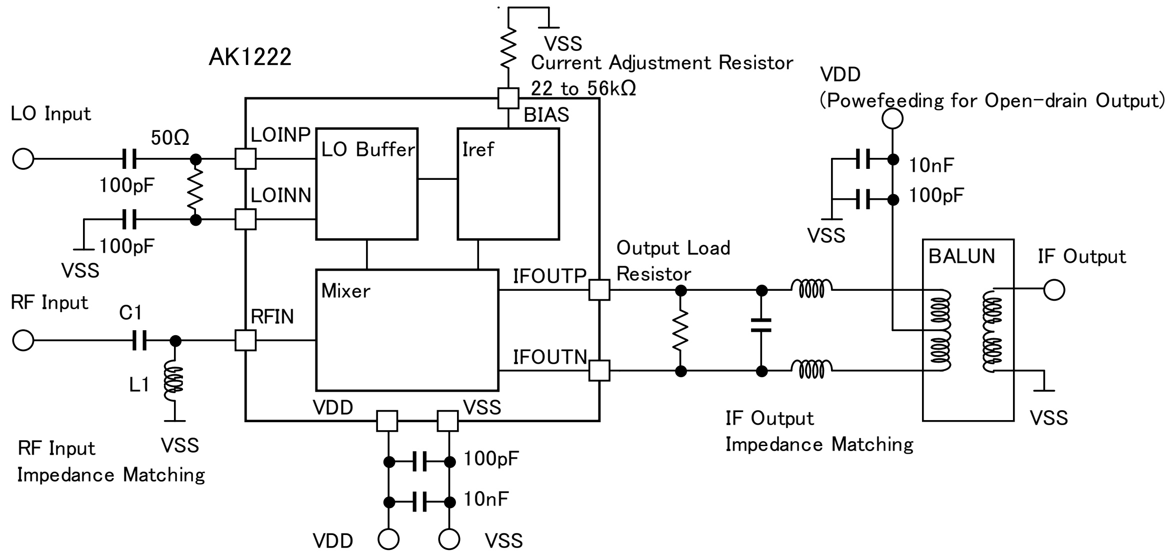


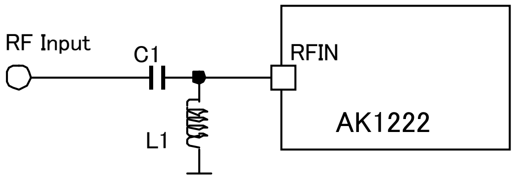
Figure 11. Typical Evaluation Board Schematic

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

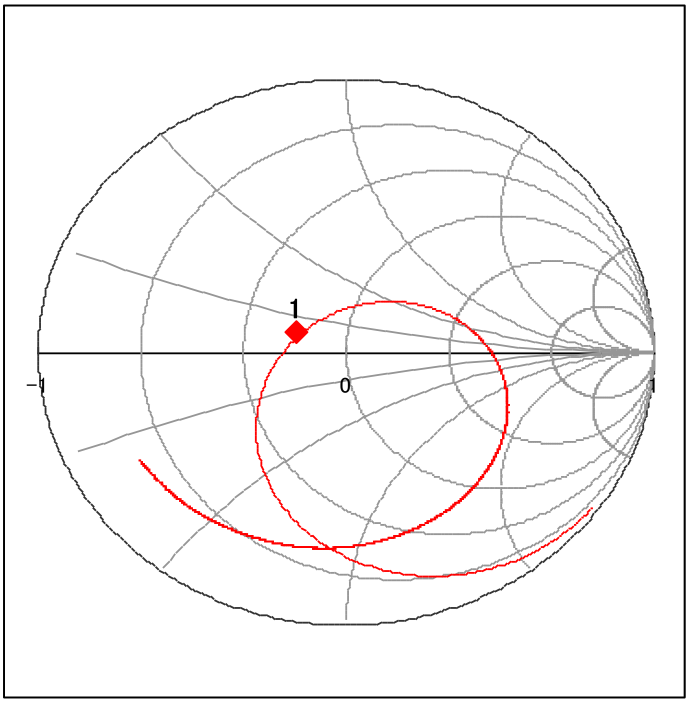
Note 2) It is necessary to adjust impedance matching as to its setting frequency. (RF input and IF output)

2. Example of impedance matching

・RFIN



Frequency[MHz]	C1[pF]	L1[nH]
150	15	82
450	5.1	22
600	3.6	15
900	3.9	6.8



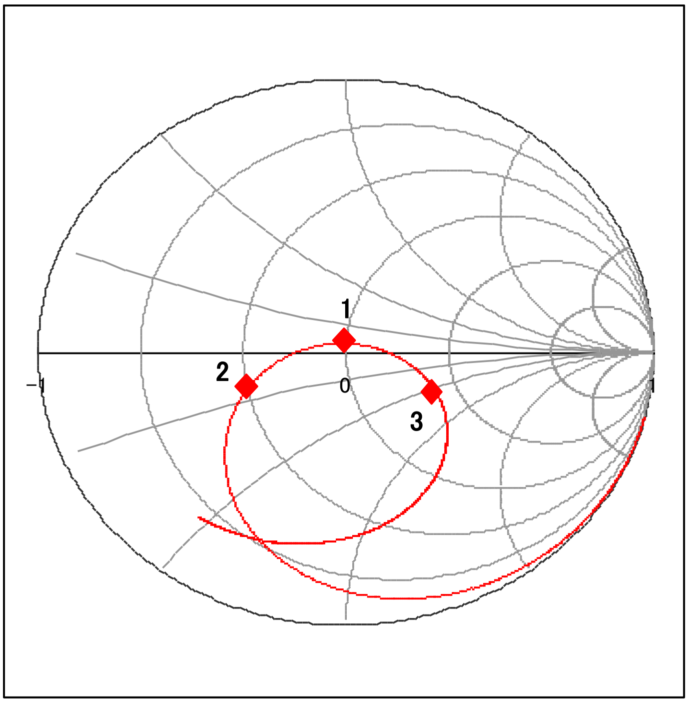
Frequency[MHz]	C1[pF]	L1[nH]
150	15	82

Start 50MHz, Stop 1GHz

Marker 1

150MHz: 36.1Ω 4.2Ω

Figure 12. RFIN 150MHz example of impedance matching



Frequency[MHz]	C1[pF]	L1[nH]
450	5.1	22

Start 50MHz, Stop 1GHz

Marker 1

450MHz: 51.1Ω 3.3Ω

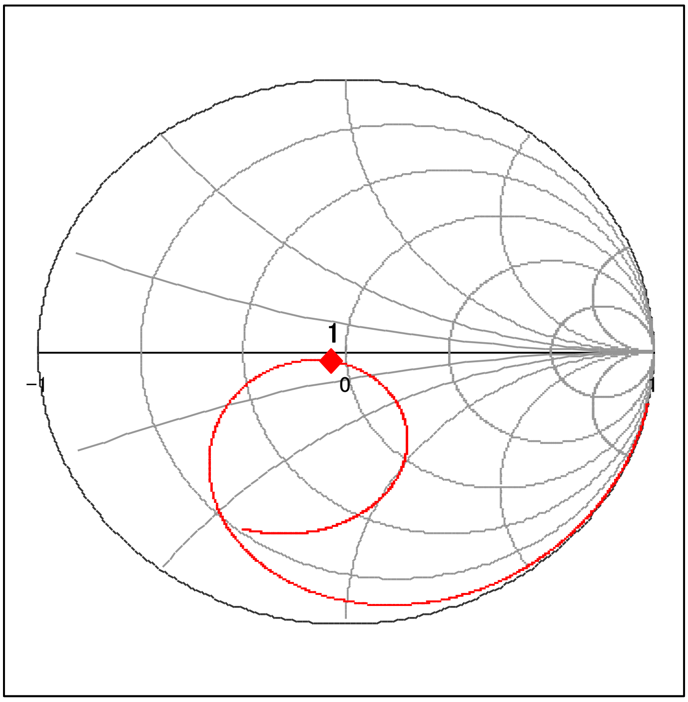
Marker 2

394MHz: 25.1Ω -7.6Ω

Marker 3

524MHz: 85.6Ω -30.1Ω

Figure 13. RFIN 450MHz example of impedance matching



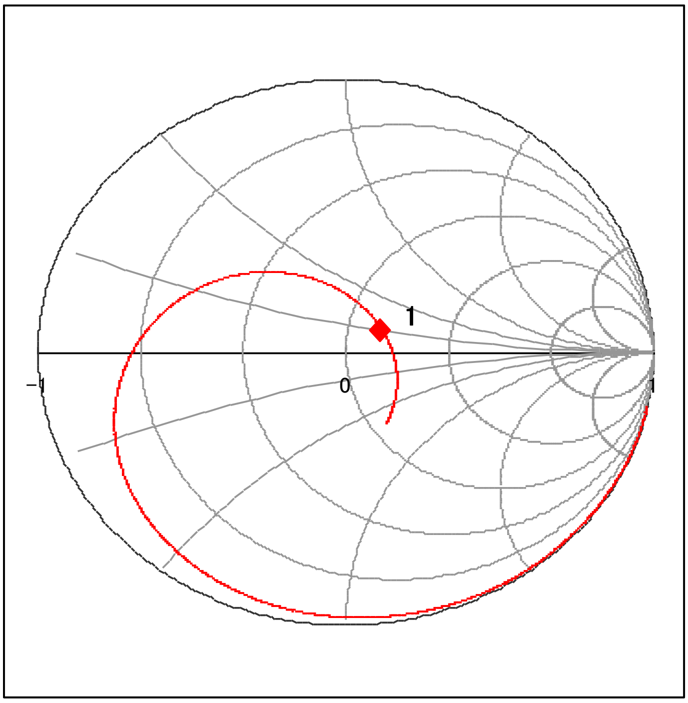
Frequency[MHz]	C1[pF]	L1[nH]
600	3.6	15

Start 50MHz, Stop 1GHz

Marker 1

600MHz: 46.2Ω -3.3Ω

Figure 14. RFIN 600MHz example of impedance matching



Frequency[MHz]	C1[pF]	L1[nH]
900	3.9	6.8

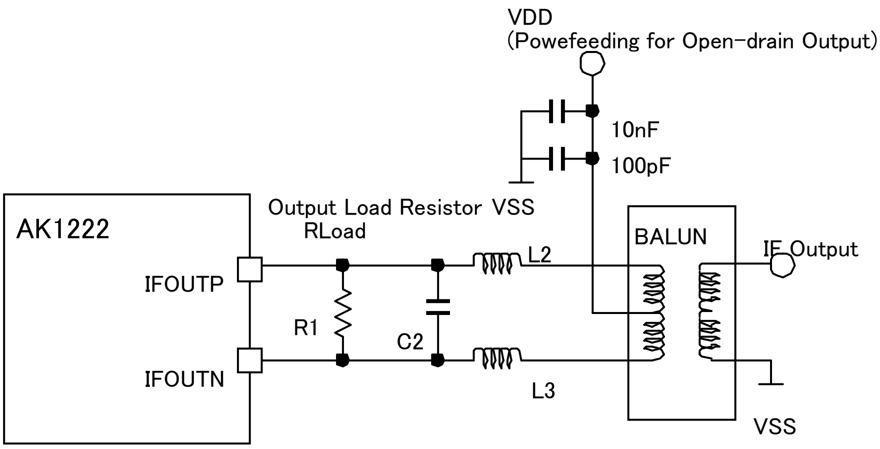
Start 50MHz, Stop 1GHz

Marker 1

900MHz: 61.8Ω 11.0Ω

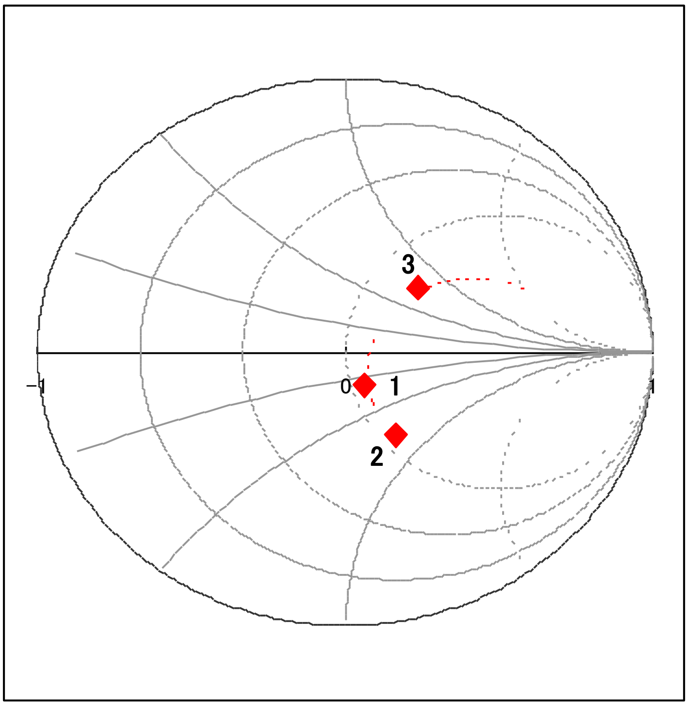
Figure 15. RFIN 900MHz example of impedance matching

・IFOUT



Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
30	2.2	3.9	1800	1800
50	2.2	2.0	1000	1000
60	2.2	0.5	1000	1000
80	2.2	N/A	680	680
100	2.2	N/A	470	470

1800nH : Murata LQW21HN1R8J00L
1000nH : Murata LQW21HN1R0J00L
680nH : Murata LQW21HNR68J00L
470nH : Murata LQW21HNR47J00L
BALUN:Mini-Circuits ADT4-6T+

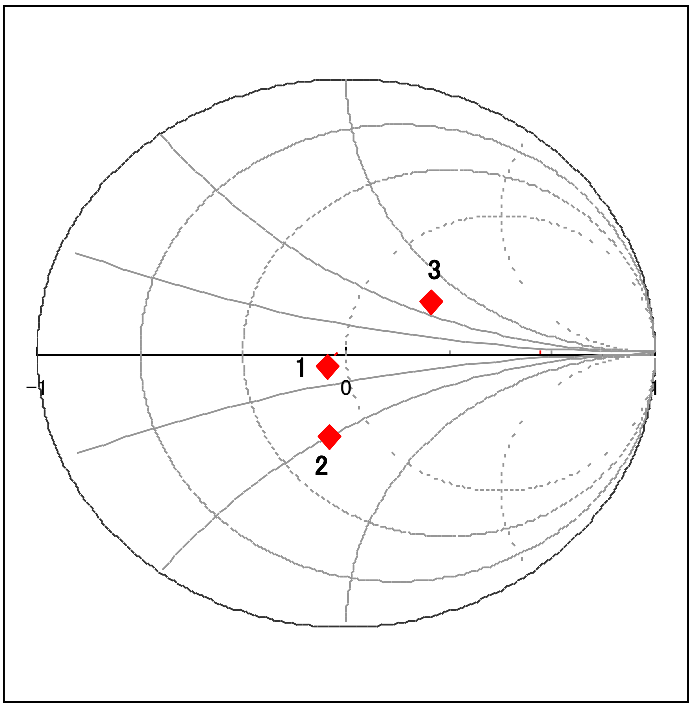


Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
30	2.2	3.9	1800	1800

Start 10MHz, Stop 140MHz

Marker 1
30MHz: 55.5Ω -19.7Ω
Marker 2
28MHz: 55.7Ω -37.3Ω
Marker 3
36MHz: 72.8Ω 38.4Ω

Figure 16. IFOUT 30MHz example of impedance matching



Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
50	2.2	2	1000	1000

Start 10MHz, Stop 140MHz

Marker 1

50MHz: 43.2Ω -7.5Ω

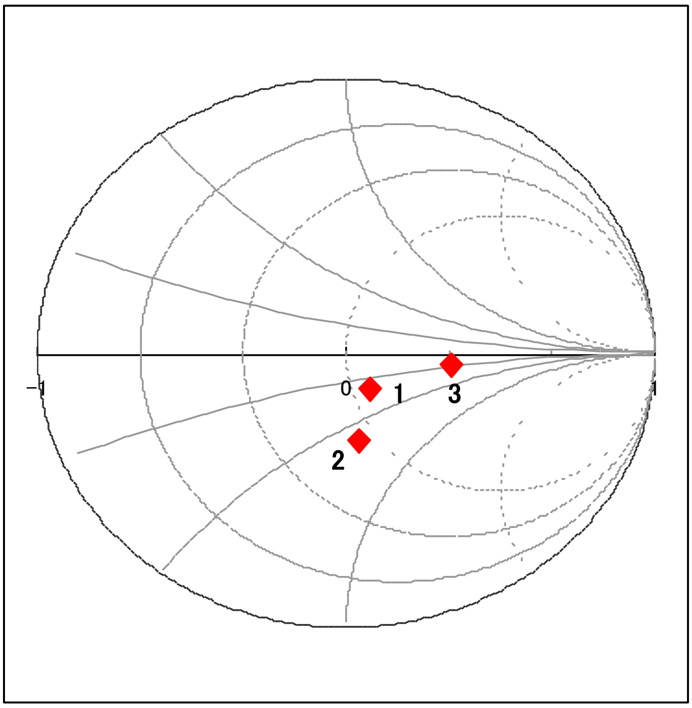
Marker 2

45MHz: 37.3Ω -28.6Ω

Marker 3

59MHz: 81.6Ω 34.6Ω

Figure 17. IFOUT 50MHz example of impedance matching



Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
60	2.2	0.5	1000	1000

Start 10MHz, Stop 140MHz

Marker 1

60MHz: 52.7Ω -19.0Ω

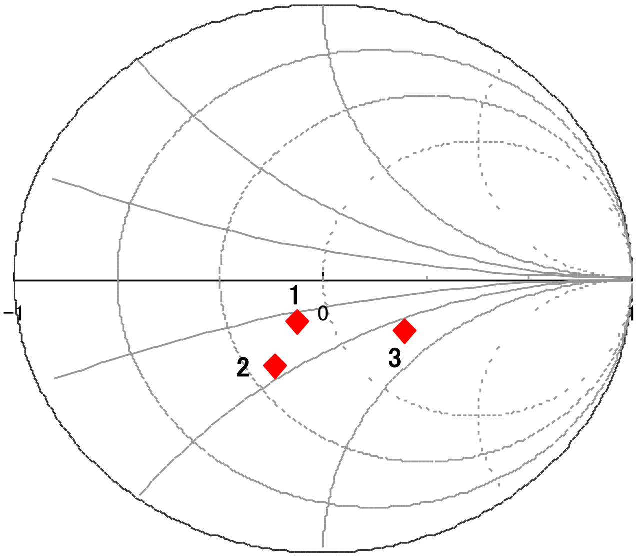
Marker 2

54MHz: 43.4Ω -33.1Ω

Marker 3

70MHz: 100.7Ω -8.4Ω

Figure 18. IFOUT 60MHz example of impedance matching



Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
80	2.2	N/A	680	680

Start 10MHz, Stop 140MHz

Marker 1

80MHz: 38.5Ω -14.5Ω

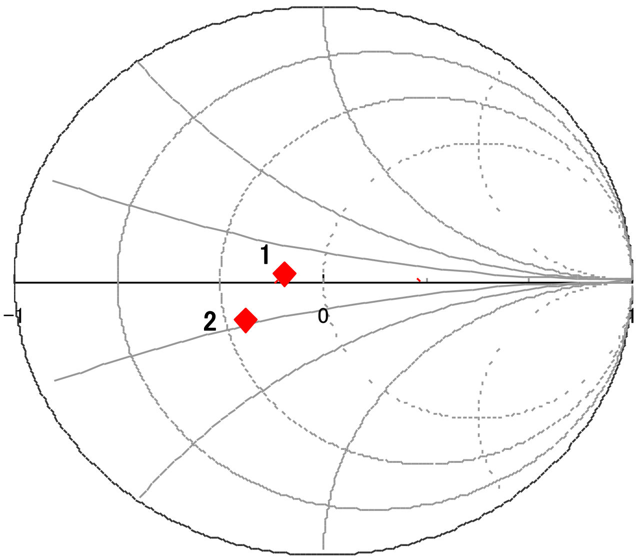
Marker 2

75MHz: 31.2Ω -21.3Ω

Marker 3

95MHz: 78.7Ω -33.8Ω

Figure 19. IFOUT 80MHz example of impedance matching



Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
100	2.2	N/A	470	470

Start 10MHz, Stop 140MHz

Marker 1

100MHz: 38.9Ω 1.6Ω

Marker 2

90MHz: 26.9Ω -12.2Ω

Figure 20. IFOUT 100MHz example of impedance matching

・LOINP/LOINN

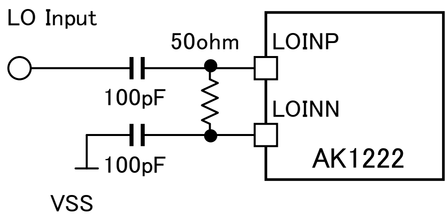
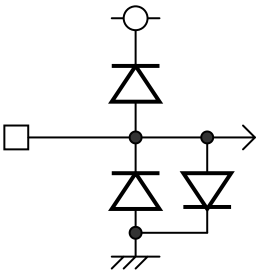
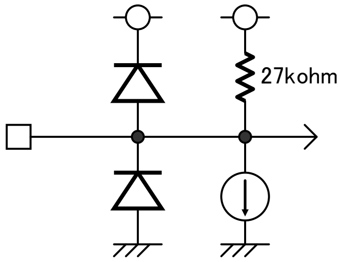
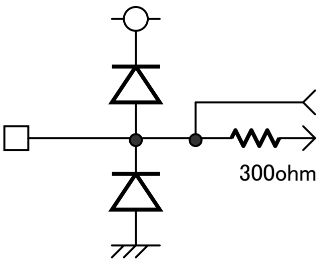
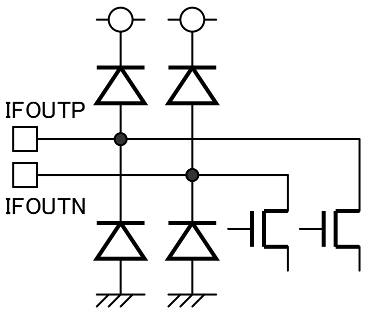


Figure 21. LOINP/LOINN example of impedance matching

13. IC Interface Schematic

No.	Name	I/O	Function
1	RFIN	I	**RF input pin** 
3	LOINN	I	**LO input pins** 
4	LOINP	I	
9	BIAS	I/O	**Analog I/O pin** 
11	IFOUTN	O	**IF output pins** 
12	IFOUTP	O	

14. Application Information

•Impedance matching network with LC

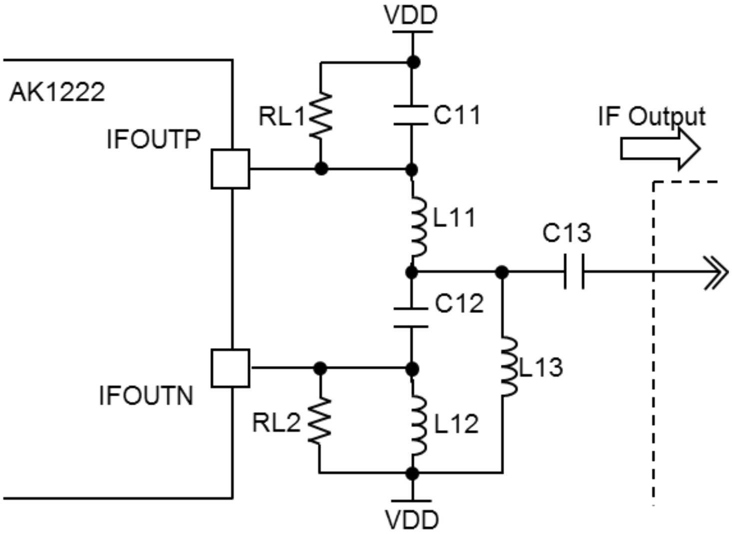


Figure 22. Impedance matching network with LC

Impedance matching network with LC is shown in Figure 22. AK1222 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) = 2.2kΩ in 50Ω interface, L11, C11, L12 and C12 are calculated as below.