

F6923

Dual-Channel Low Noise Amplifier 14GHz – 17GHz

The F6923 is an ultra-low power consumption, dual-channel, low noise amplifier (LNA) RFIC designed for application in Ku-Band planar phased array antennas. The exceptional combination of low power consumption, low noise, high gain, and compact size, maximizes the antenna array G/T while minimizing overall system power dissipation. An external bias current provides gain control, standby mode, and temperature compensation.

The F6923 includes two independent gain/phase matched LNA channels in a compact 23-pin, 0.5mm pitch BGA package. All inputs and outputs are single-ended and 50Ω matched for ease of integration onto phased array antenna panels.

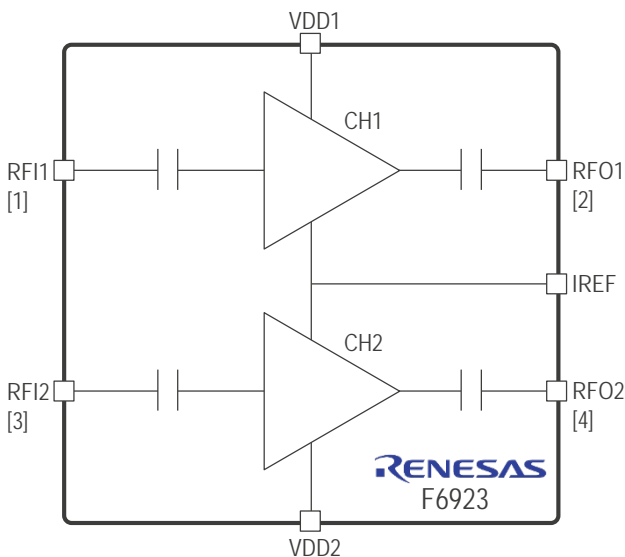


Figure 1. Block Diagram

Features

- Frequency: 14GHz - 17GHz
- Gain: 19.5 dB
- Noise figure: 1.5dB
- Output P1dB: -1.5dBm
- Power consumption: 16mW/ch
- Channel isolation: 35dB
- Supply voltage: 0.9V - 1.0V
- Common bias control input
- Compact size for planar integration on λ/2 grid
- 2.7 × 2.7 × 0.9 mm, 23-pin BGA
- -40°C to +85°C ambient operating temperature range

*Note:* Performance is typical at 15.5GHz and nominal supply voltage. For more information, see the Specifications and Typical Performance Characteristics sections.

Applications

- Electronically Steered Phased Array Antennas (ESAs)
- Ku-Band Radar, SATCOM, and Common Data Link (CDL)
- Communication and Electronic Warfare (EW) Systems

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# 1. Pin Information

## 1.1 Pin Assignments

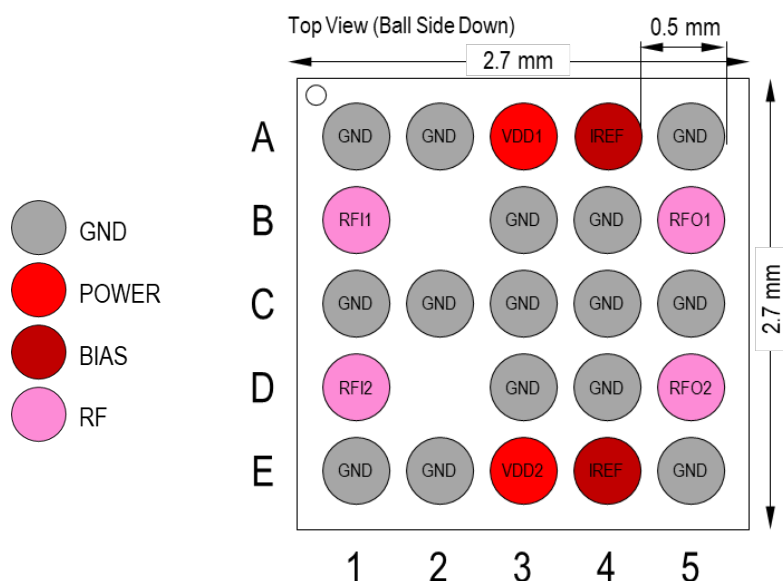


Figure 2. Pin Assignments – Top View

## 1.2 Pin Descriptions

Pin Number	Name	Type	I/O	Description
A1, A2, A5, B3, B4, C1, C2, C3, C4, C5, D3, D4, E1, E2, E5	GND	Ground	-	DC and RF ground.
A3	VDD1	Power	Input	Positive supply voltage input for channel 1.
E3	VDD2	Power	Input	Positive supply voltage input for channel 2.
A4, E4	IREF	Power	Input	Reference bias current input, tied to a common node shared by channels 1 and 2. Connect directly to a current source, voltage source through a resistor, or to the IBx pin of the F61xx.
B1	RFI1	Analog	Input	Channel 1 RF input port.
D1	RFI2	Analog	Input	Channel 2 RF input port.
B5	RFO1	Analog	Output	Channel 1 RF output port.
D5	RFO2	Analog	Output	Channel 2 RF output port.

## 2. Specifications

Exposure of the device to parameter values outside of the range listed below may reduce the operating lifetime and adversely and permanently alter the device characteristics. Furthermore, functional operation at or near absolute maximum ratings is not implied.

### 2.1 Absolute Maximum Ratings

Parameter	Symbol	Conditions	Minimum	Maximum	Unit
Supply Voltage	$V_{DD}$		-0.3	1.2	V
Reference Current	$I_{REF}$		0	200	$\mu A$
Input RF Pin DC Voltage	$V_{DC\_RFI}$		-0.3	1.0	V
Output RF Pin DC Voltage	$V_{DC\_RFO}$		-0.3	1.2	V
RF Input Power	$P_{IN}$	$V_{DD} = 1.0V, VSWR < 2:1$		0	dBm
Junction Temperature	$T_J$			125	$^{\circ}C$
ESD – Human Body Model	$V_{HBM}$	JS-001-2012		750	V
ESD – Charged Device Model	$V_{CDM}$	JESD22-C101		250	V

### 2.2 Thermal Information

Parameter	Symbol	Value	Unit
Theta JB. Junction to board	$\theta_{JB}$	14	$^{\circ}C/W$
Theta JC. Junction to case. (case top)	$\theta_{JC}$	108	$^{\circ}C/W$
Theta JA. Junction to ambient	$\theta_{JA}$	47	$^{\circ}C/W$
Storage Temperature	$T_{STOR}$	-40 to +150	$^{\circ}C$
Lead Temperature (soldering, 30s)	$T_{LEAD}$	260	$^{\circ}C$

## 2.3 Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Unit
RF Frequency Range	$f_{RF}$	14		17	GHz
Power Supply Voltage	$V_{DD}$	0.9	0.95	1.0	V
Reference Bias Current at -40°C	$I_{REF}$	71	83	95	$\mu A$
Reference Bias Current at +25°C		94	110	127	$\mu A$
Reference Bias Current at +85°C		115	135	155	$\mu A$
Ambient Temperature	$T_A$	-40		85	°C
RF Pin Load Impedance	$Z_{RF}$		50		$\Omega$

## 2.4 Electrical Specifications

Specifications apply when operated at  $T_{AMB} = +25^\circ C$ .

### 2.4.1. DC Electrical Specifications

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Unit
Supply Current, Per Channel	$I_{DD}$	$V_{DD} = 0.95V, I_{REF} = 110\mu A$		17		mA
Supply Current, Idle-state <sup>[1]</sup>	$I_{DD\_IDLE}$	$I_{REF} = 0\mu A$		1		$\mu A$

- $I_{REF}$  pin can be grounded or floating to achieve idle-state.

### 2.4.2. RF Electrical Specifications

Unless stated otherwise, all specifications are for  $V_{DD} = 0.95V, I_{REF} = 110\mu A, T_{AMB} = 25^\circ C, Z_S = Z_L = 50\Omega, f_{RF} = 15.5GHz$ .

Parameter	Symbol	Condition	Minimum	Typical	Maximum	Unit
Gain	G			19.5		dB
Gain Flatness vs. Frequency	$G_{VAR\_FREQ}$	$f_{RF} = 14GHz - 17GHz$		2		dB
		Within any 250MHz		0.2		dB
Noise Figure	NF			1.5		dB
Output 1dB Compression Point	OP1dB			-1.5		dBm
Output 3 <sup>rd</sup> Order Intercept Point	OIP3	Pin = -35 dBm/tone, $\Delta f = 1MHz$		10		dBm
Input Return Loss	IRL			21		dB
Output Return Loss	ORL			15		dB
Reverse Isolation	ISO			35		dB
Channel-to-Channel Isolation	$ISO_{CH-CH}$	S21-S41. $f_{RF} = 14 - 17 GHz$	35			dB

### 3. Typical Application Circuits

Figure 3 shows two typical application circuits for biasing the F6923.

The top circuit uses a voltage source  $V_{ref}$  to supply the bias reference current  $I_{REF}$  through an external resistor  $R_{ref}$ .  $V_{ref}$  should be set to achieve the recommended  $I_{REF}$  bias currents per the indicated formula. For the typical relationship between  $V_{ref}$  and  $I_{REF}$ , see Figure 13.

The bottom circuit uses the programmable IDAC of the Renesas F61xx beamforming device to provide the reference current directly to the F6923.

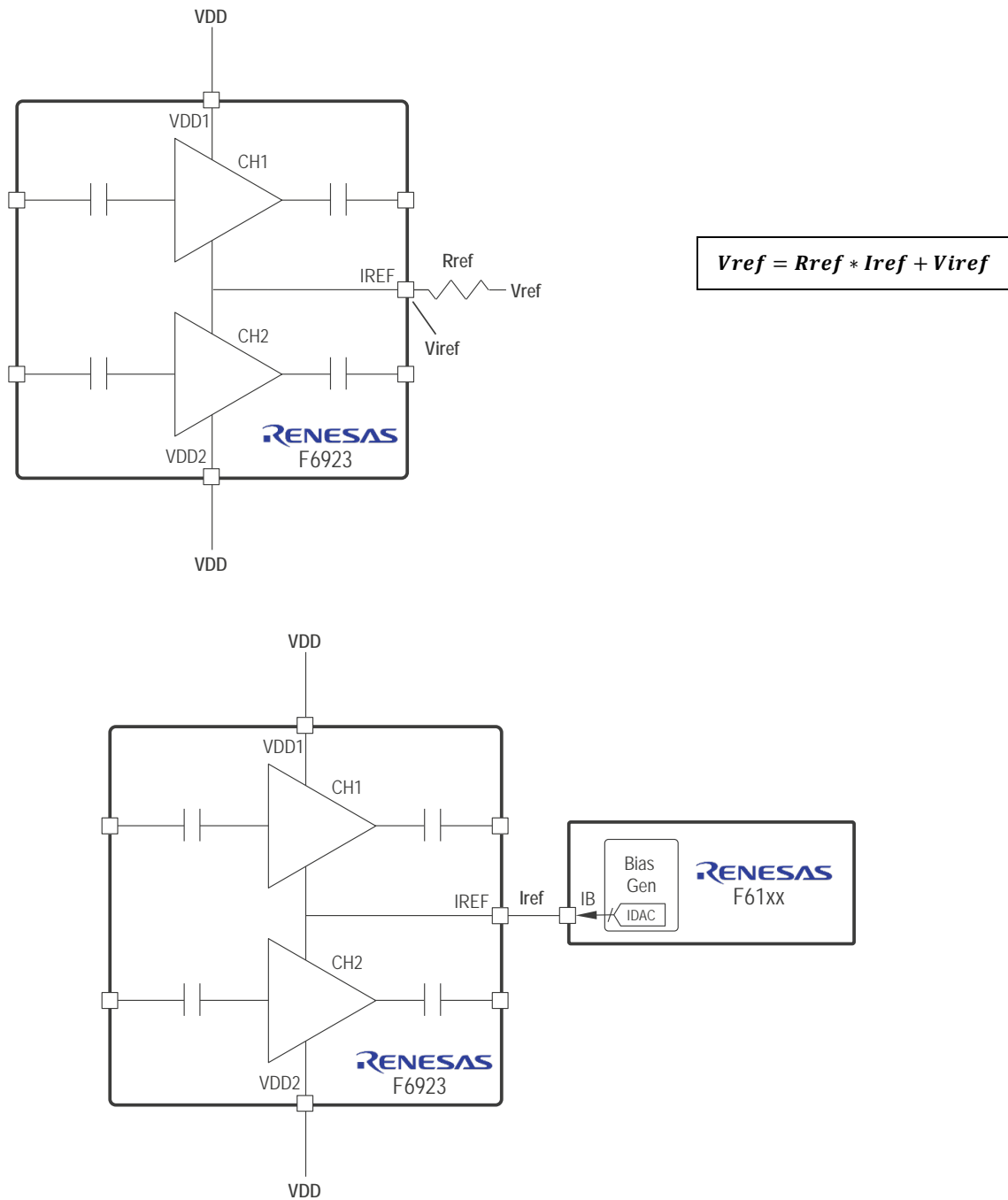


Figure 3. Typical Application Circuits

## 4. Typical Performance Characteristics

Unless stated otherwise,  $Z_S = Z_L = 50\Omega$  on all RF ports,  $V_{DD} = 0.95V$ , and  $T_{AMB} = 25^\circ C$ .

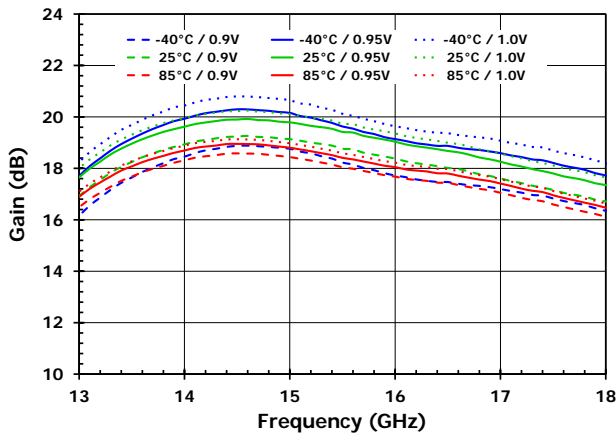


Figure 4. Gain

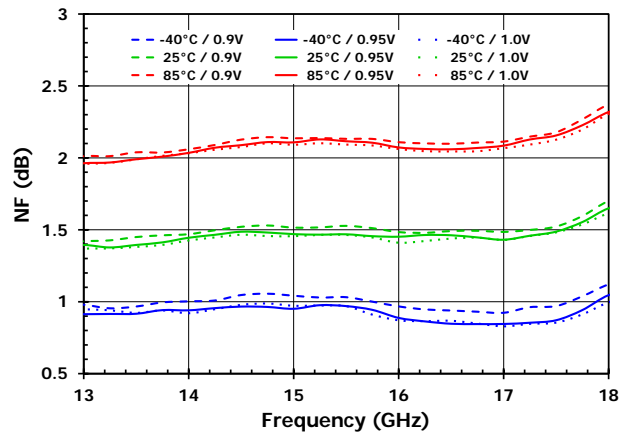


Figure 5. Noise Figure

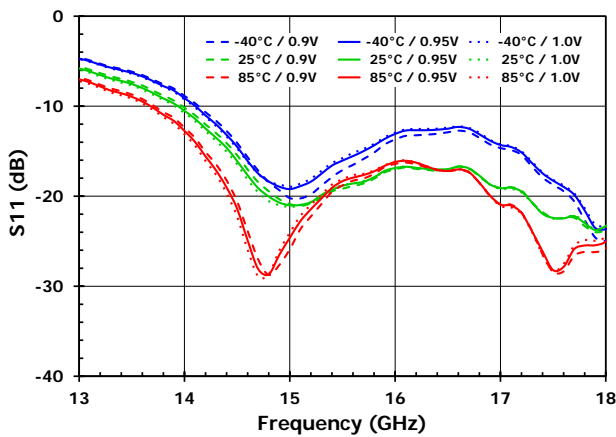


Figure 6. Input Match

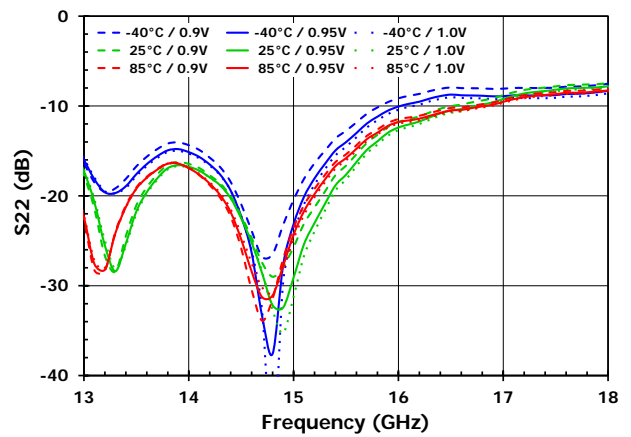


Figure 7. Output Match

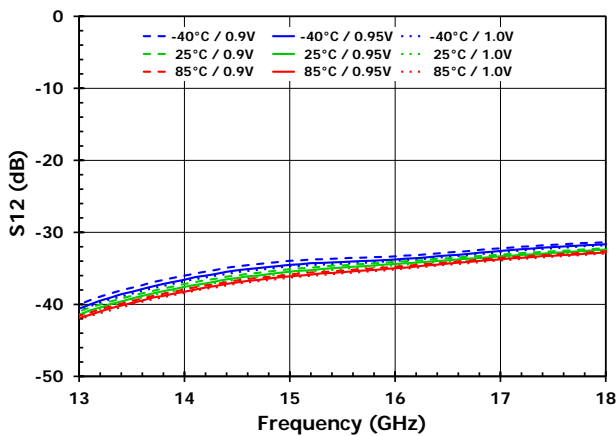


Figure 8. Input-to-Output Isolation

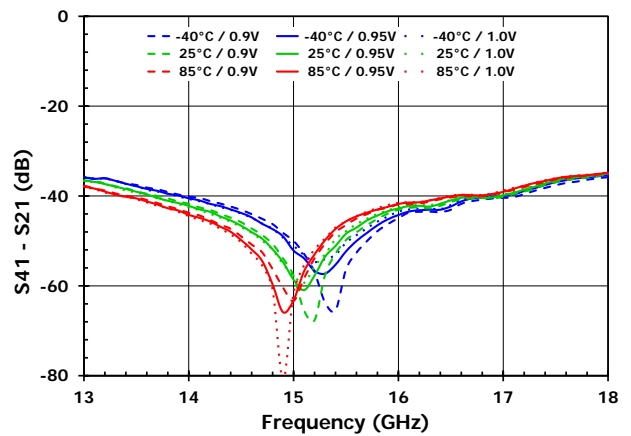


Figure 9. Channel-to-Channel Isolation

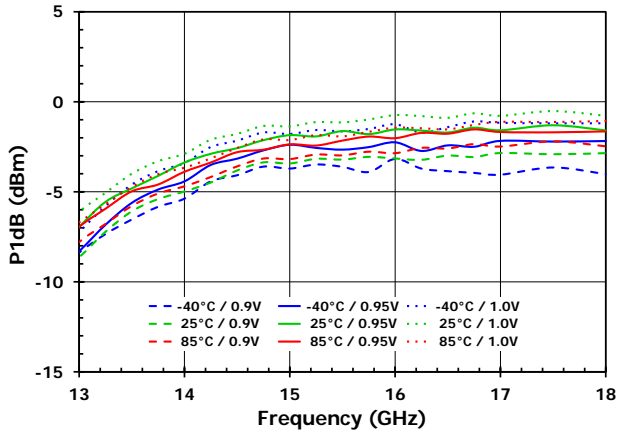


Figure 10. Output 1dB Compression

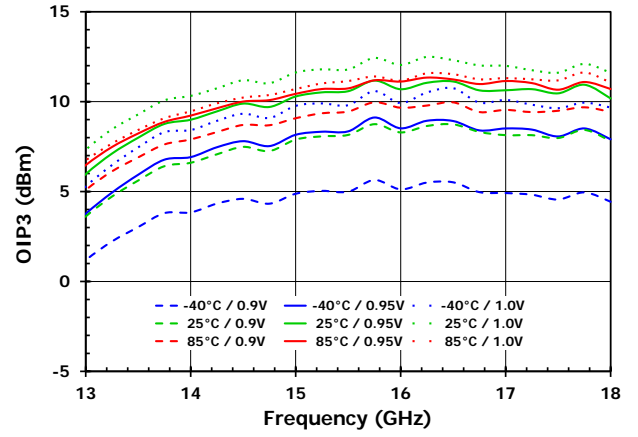


Figure 11. Output Third Order Intercept

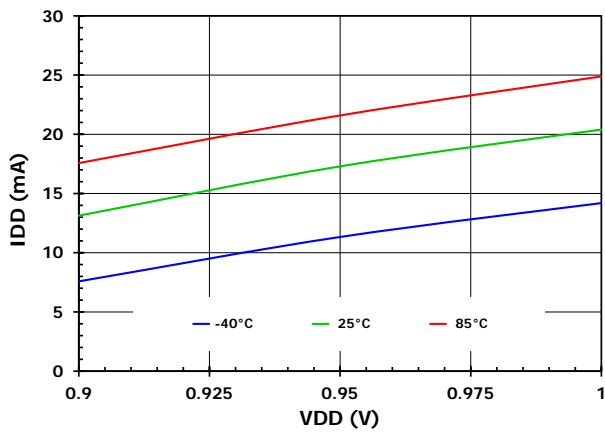


Figure 12. Supply Current, Per Channel

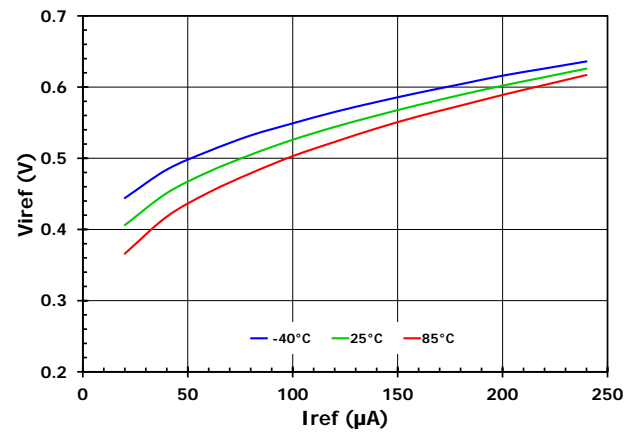


Figure 13. IREF Pin Voltage vs Current



## 5. Evaluation Board

For more information about the evaluation board, see the *F69xx Evaluation Board Manual* on the [F6923](#) product page.

### 5.1 Evaluation Board Photos

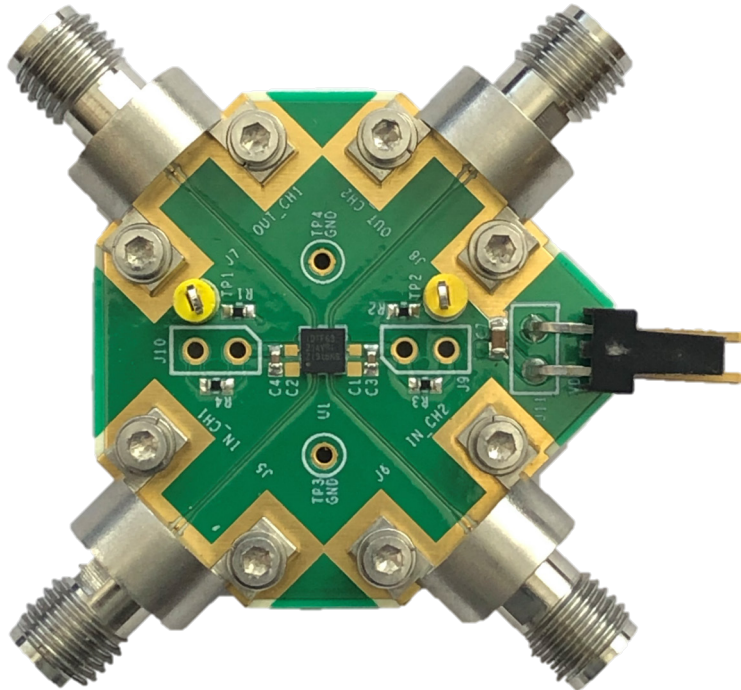


Figure 14. Evaluation Board – Top View

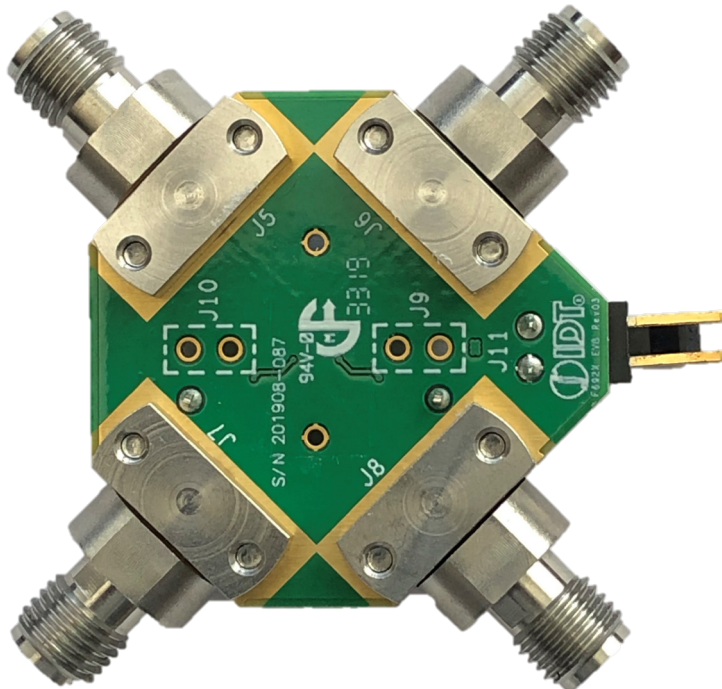


Figure 15. Evaluation Board – Bottom View

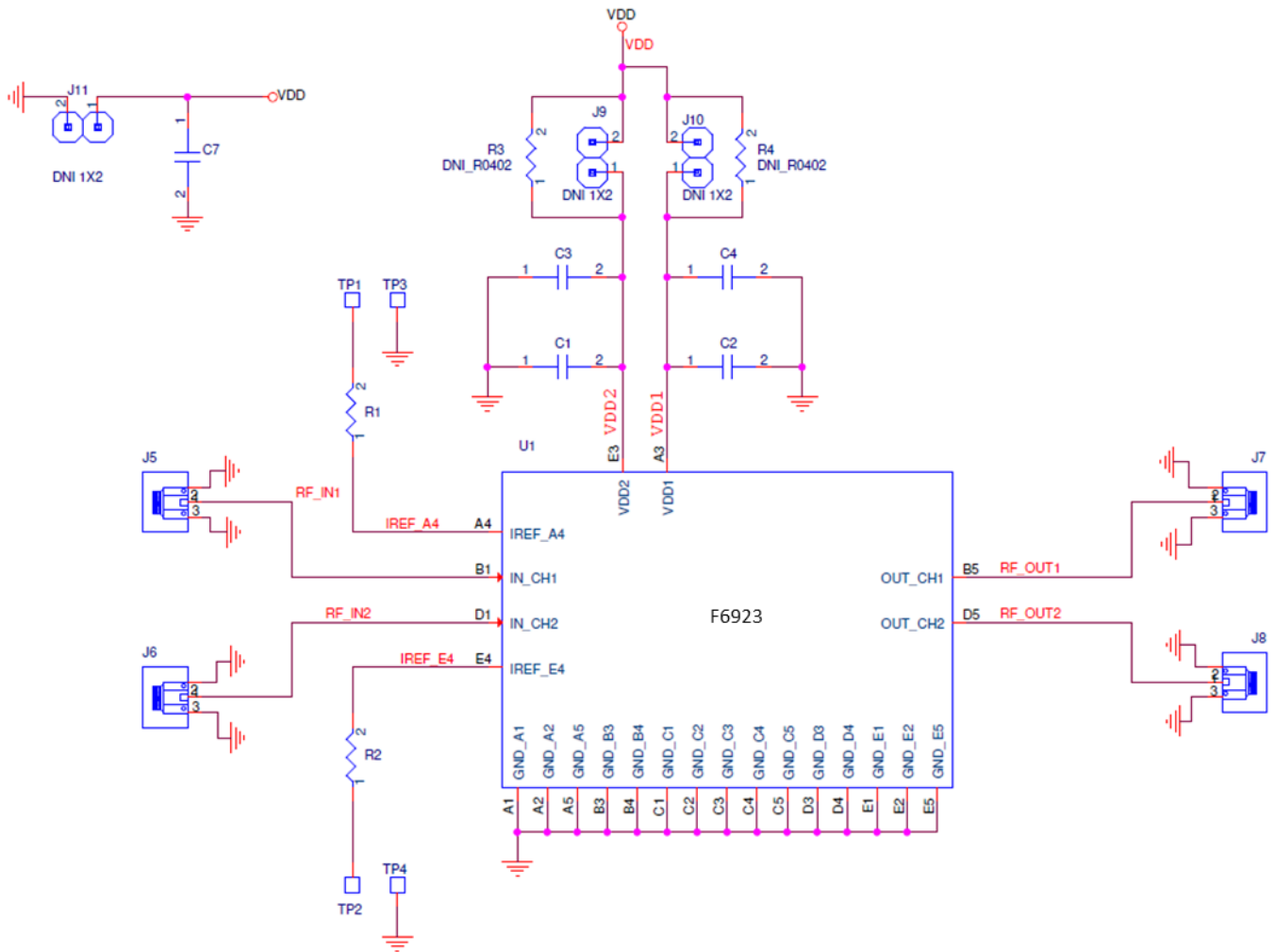


Figure 16. Evaluation Board – Schematic

Table 1. Bill of Material (BOM)

Part Ref.	QTY	Description	Manufacturer Part #	Manufacturer
C1, C2	2	33pF ±5%, 50V, C0G Ceramic Capacitor (0402)	GRM1555C1H330J	MURATA
C3, C4	2	1µF ±10%, 16V, X6S Ceramic Capacitor (0402)	GRM155C81C105K	MURATA
C7	1	10µF ±20%, 16V, X6S Ceramic Capacitor (0603)	GRM188C81C106M	MURATA
R1	1	3.4kΩ ±1%, 1/16W, Resistor (0402)		
R2	1	DNI		
R3, R4	2	0Ω Resistors (0402)	ERJ-2GE0R00X	PANASONIC
J5-J8	4	Edge Launch 2.92mm 40GHz	ELF-40-002	SIGNAL MICROWAVE
TP1, TP2	2	Test Point Yellow	5004	Keystone Electronics
J11	1	CONN HEADER R/A 2POS 2.54MM	1718571002	MOLEX

## 5.2 Evaluation Board Operation

This section provides basic information on operating the F6923 evaluation board. For more information about the evaluation board, see the *F69xx Evaluation Board Manual* on the [F6923](#) product page.

### 5.2.1. Single Power Supply Operation

Connect the positive and negative outputs of a power supply ( $V_{DD}$ ) to J11. In addition, connect the positive output of the  $V_{DD}$  supply to TP1. While there are two  $I_{REF}$  pins on the F6923 device (which are individually accessible via TP1 and TP2 on the evaluation board), these pins (A4 and E4) are internally connected to the same node on the IC, simultaneously controlling the bias of channels 1 and 2. Set the power supply to 0.95V and enable the power supply output. Monitor the  $V_{DD}$  supply output current to confirm the nominal bias point is set correctly (approximately 34mA).

### 5.2.2. Independent VDD and IREF Bias Control

#### 5.2.2.1. Two Voltage Sources

Connect the positive and negative outputs of a power supply ( $V_{DD}$ ) to J11. In addition, connect the positive output of a second supply ( $V_{REF}$ ) to TP1 and the negative output to the negative output of the  $V_{DD}$  supply. Set both power supplies to 0.95V and enable the power supply outputs. Monitor the  $I_{DD}$  of the  $V_{DD}$  supply to confirm the nominal bias point is set correctly (approximately 34mA).

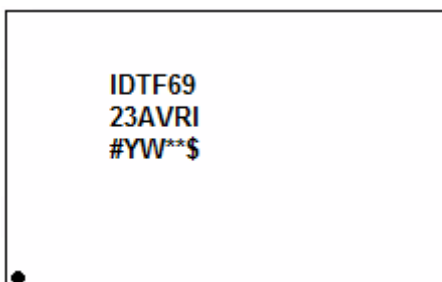
#### 5.2.2.2. Voltage Source and Current Source

Connect the positive and negative outputs of a power supply ( $V_{DD}$ ) to J11. In addition, connect an independent current supply ( $I_{REF}$ ) to TP1 and the ground of the current supply to the negative terminal of the  $V_{DD}$  supply. Set  $V_{DD}$  to 0.95V,  $I_{REF}$  to 110 $\mu$ A and enable the power supply outputs. Monitor the  $I_{DD}$  of the  $V_{DD}$  supply to confirm the nominal bias point is set correctly (approximately 34mA).

## 6. Package Outline Drawings

The package outline drawings are located at the end of this document and are accessible from the Renesas website (see Ordering Information for POD links). The package information is the most current data available and is subject to change without revision of this document.

## 7. Marking Diagram



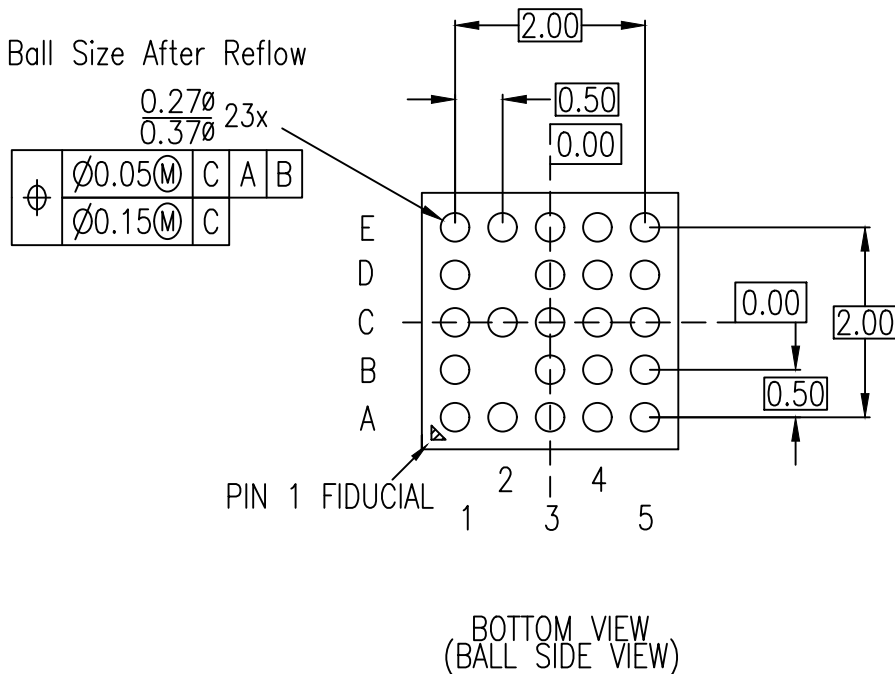
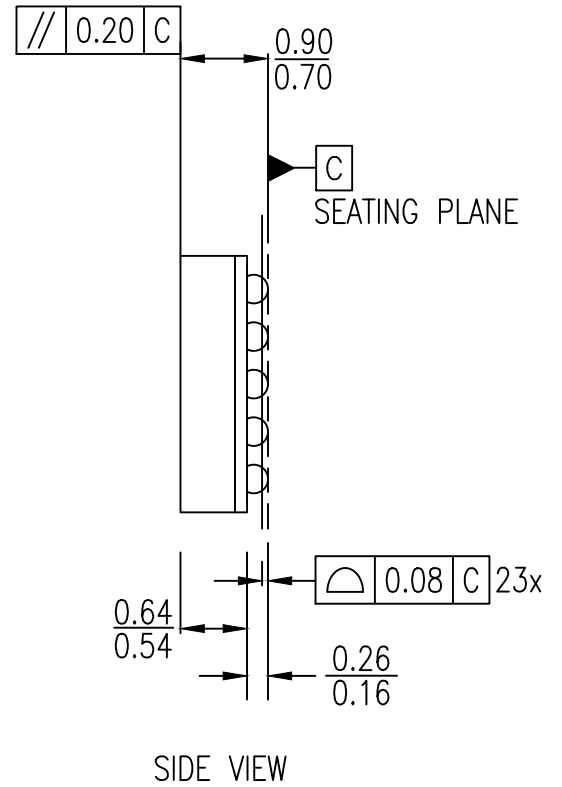
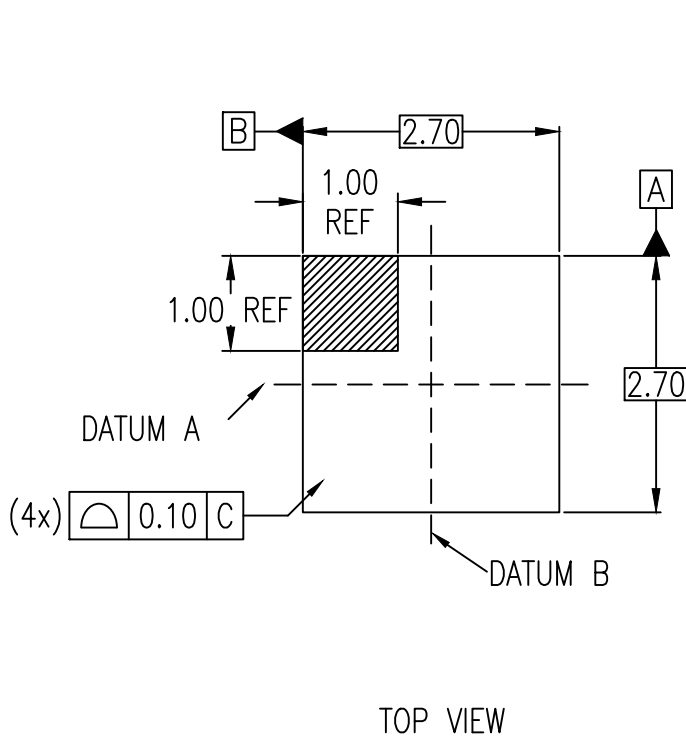
- Lines 1 and 2: Renesas part number
- Line 3:
  - “#” is the device step
  - “YW” is the last digit of the year and workweek code
  - “\*\*” is the lot sequential code
  - “\$” is the mark location code

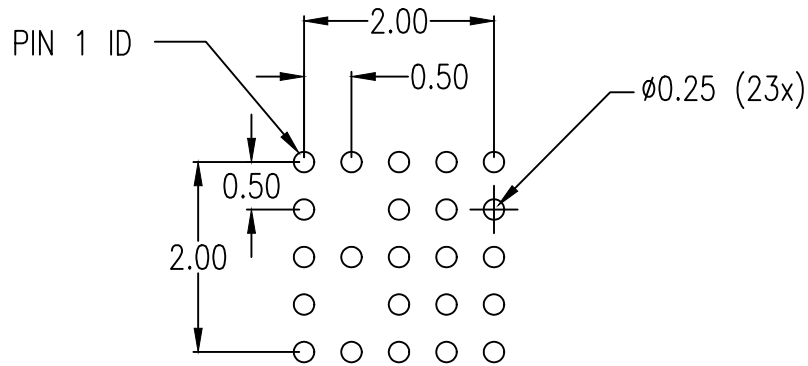
## 8. Ordering Information

Part Number	Package	MSL Rating	Carrier Type	Temperature Range
F6923AVRI	2.7 × 2.7 × 0.9 mm <a href="#">23-BGA</a>	3	Tray	-40°C to +85°C
F6923AVRI8	2.7 × 2.7 × 0.9 mm <a href="#">23-BGA</a>	3	Reel	-40°C to +85°C
F6923EVB	F6923 Evaluation Board			

## 9. Revision History

Revision	Date	Description
1.0	Jul 6, 2021	Initial release.





RECOMMENDED LAND PATTERN DIMENSION  
(TOP VIEW)

NOTES:

1. ALL DIMENSION ARE IN MM. ANGLES IN DEGREES.
2. TOP DOWN VIEW. AS VIEWED ON PCB.
3. LAND PATTERN RECOMMENDATION PER IPC-7351B GENERIC REQUIREMENT FOR SURFACE MOUNT DESIGN AND LAND PATTERN.

Package Revision History		
Date Created	Rev No.	Description
Dec. 6, 2018	Rev 00	Initial Release