

F6921

Dual-Channel Low Noise Amplifier 10.7 – 12.75 GHz

Description

The F6921 is an ultra-low power consumption, dual-channel, low noise amplifier (LNA) RFIC designed for application in Ku-Band SATCOM 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 F6921 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 on to phased array antenna panels.

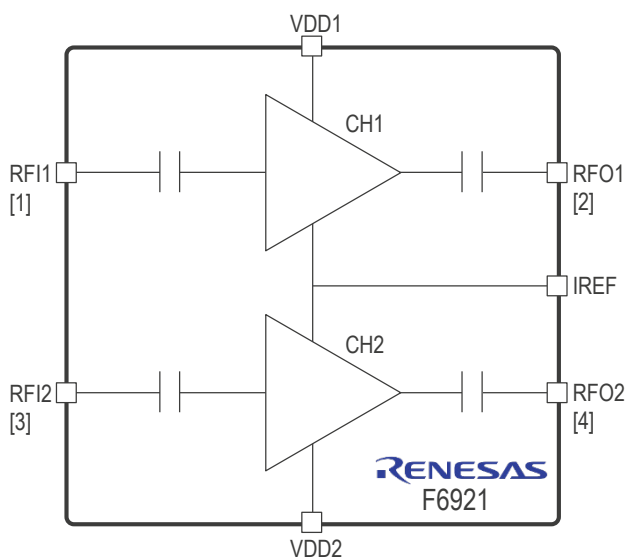


Figure 1. Block Diagram

Features

- Frequency: 10.7 – 12.75 GHz
- Gain: 19.5dB
- Noise Figure: 1.4dB
- Output P1dB: -7dBm
- Power Consumption: 12.5mW/ch
- Channel Isolation: 37dB minimum
- Supply Voltage: 0.9 – 1.0V
- Common bias control input
- Compact size for planar integration on $\lambda/2$ grid
- $2.7 \times 2.7 \times 0.9$ mm, 23-pin BGA
- -40°C to +85°C ambient operating temperature range

Note: Performance is typical at 11.7GHz. For more details, see the Specifications and Typical Performance Characteristics sections.

Applications

- Electronically Steered Phased Array Antennas (ESAs)
- Aerospace, Maritime, and Satcom-on-the-move (SOTM)
- Ku-Band SATCOM Terminals
- Communication and Radar Systems

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1. Pin Information

1.1 Pin Assignments

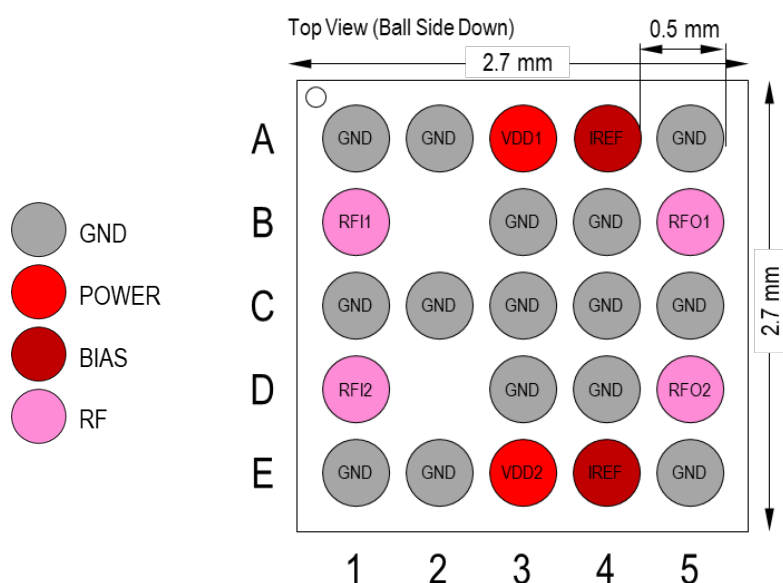


Figure 2. Pin Assignments for 2.7 × 2.7 mm 23-pin FCBGA Package – Top View

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. Channel 2 must also be enabled by powering VDD2 for channel 1 to be operable.
E3	VDD2	Power	Input	Positive supply voltage input for channel 2. For single channel operation of channel 2, channel 1 must be disabled by either floating or grounding VDD1.
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

Caution: 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	250	μA
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.	θ_{JB}	14	$^{\circ}C/W$
Theta JC. Junction to case. (case top)	θ_{JC}	108	$^{\circ}C/W$
Theta JA. Junction to ambient.	θ_{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}	10.7	-	12.75	GHz
Power Supply Voltage	V_{DD}	0.9	0.95	1.0	V
Reference Bias Current at -40°C	I_{REF}	43	50	58	μA
Reference Bias Current at +25°C		102	120	138	μA
Reference Bias Current at +85°C		156	184	212	μA
Ambient Temperature	T_A	-40	-	85	°C
RF Pin Load Impedance	Z_{RF}	-	50	-	Ω

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}	$V_{DD} = 0.95V$, $I_{REF} = 120\mu A$	-	13	-	mA
Supply Current, Idle-state ^[1]	I_{DD_IDLE}	$I_{REF} = 0\mu A$	-	1	-	μA

1. IREF pin may be grounded or floating to achieve idle-state.

2.4.2. RF Electrical Specifications

Unless stated otherwise, all specifications are for $V_{DD} = 0.95V$, $I_{REF} = 120\mu A$, $T_{AMB} = 25^{\circ}C$, $Z_S = Z_L = 50\Omega$, $f_{RF} = 11.7GHz$.

Parameter	Symbol	Condition	Minimum	Typical	Maximum	Unit
Gain	G	-	-	19.5	-	dB
Gain Flatness vs. Frequency	G_{VAR_FREQ}	$f_{RF} = 10.7 - 12.75 GHz$	-	0.9	-	dB
		Within any 250MHz	-	0.16	-	dB
Noise Figure	NF	-	-	1.4	-	dB
Output 1dB Compression Point	OP1dB	-	-	-7	-	dBm
Output 3 rd Order Intercept Point	OIP3	Pin = -35 dBm/tone, $\Delta f = 1MHz$	-	2	-	dBm
Input Return Loss	IRL	-	-	22	-	dB
Output Return Loss	ORL	-	-	12	-	dB
Reverse Isolation	ISO	-	-	35	-	dB
Channel-to-channel Isolation	ISO_{CH-CH}	$f_{RF} = 10.7 - 12.75 GHz$	37	-	-	dB

3. Typical Application Circuit

Figure 3 shows two typical application circuits for biasing the F6921.

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. Refer to Figure 13 for the typical relationship between V_{iref} and I_{ref} .

The bottom circuit uses the programmable IDAC of the Renesas F61XX beamforming IC to provide the reference current directly to the F6921.

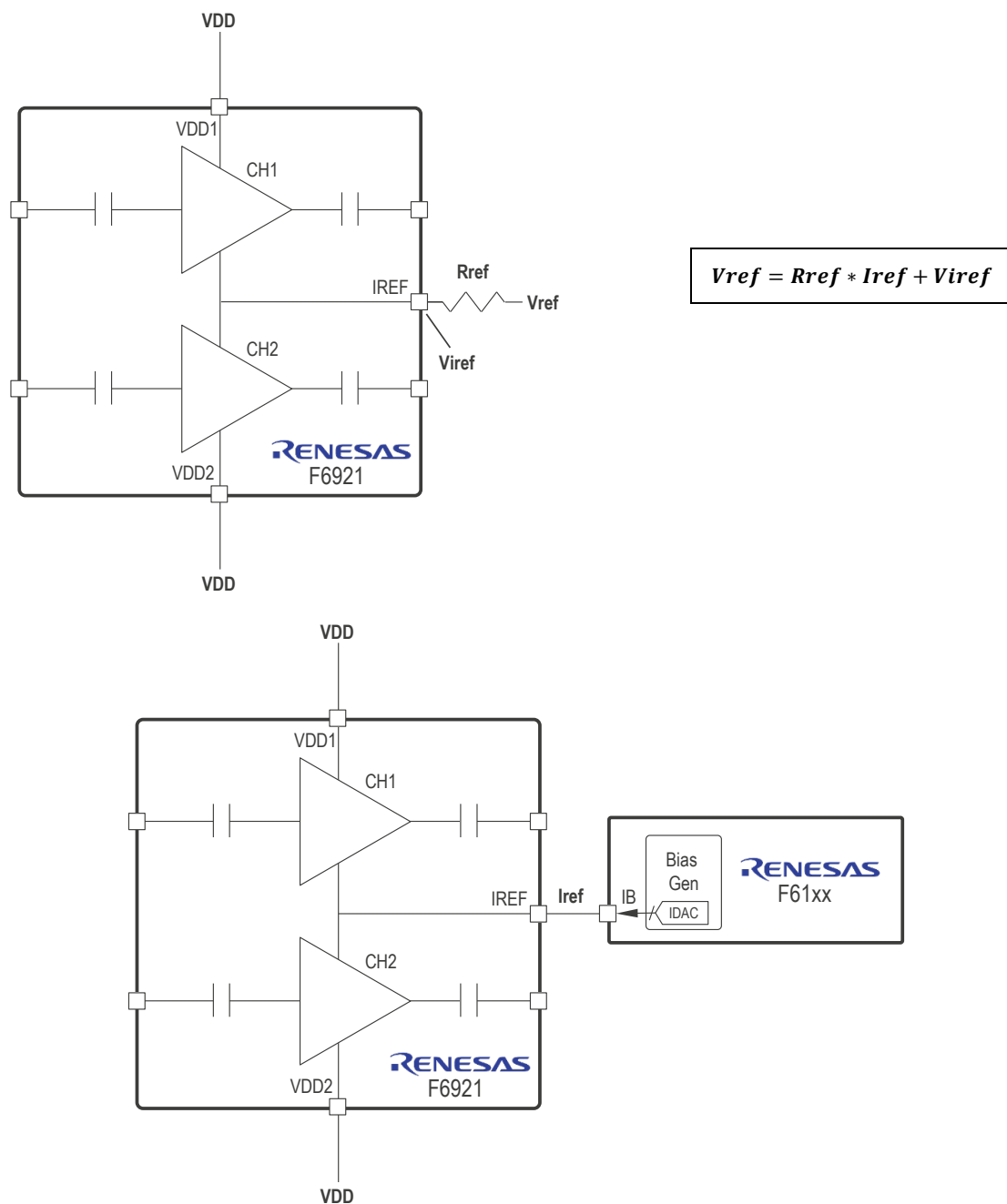


Figure 3. Typical Application Circuits

4. Typical Performance Characteristics

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

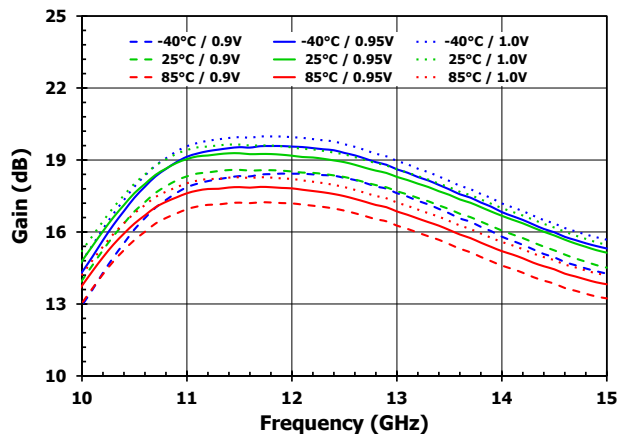


Figure 4. Gain

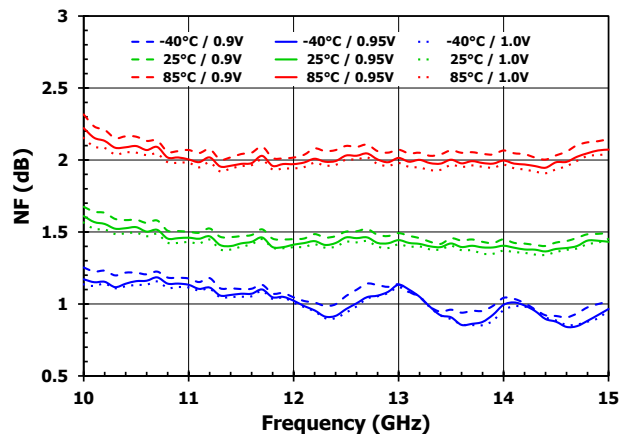


Figure 5. Noise Figure

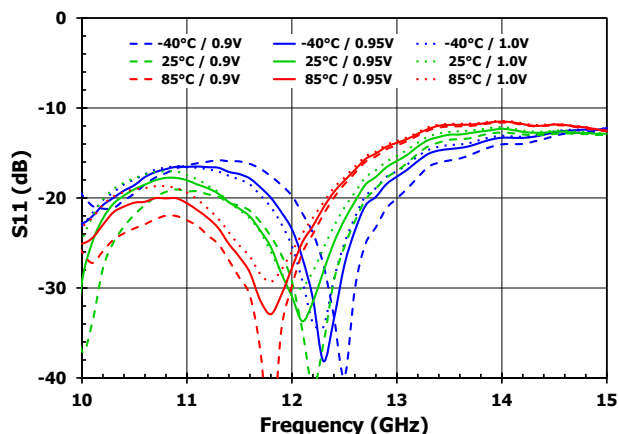


Figure 6. Input Match

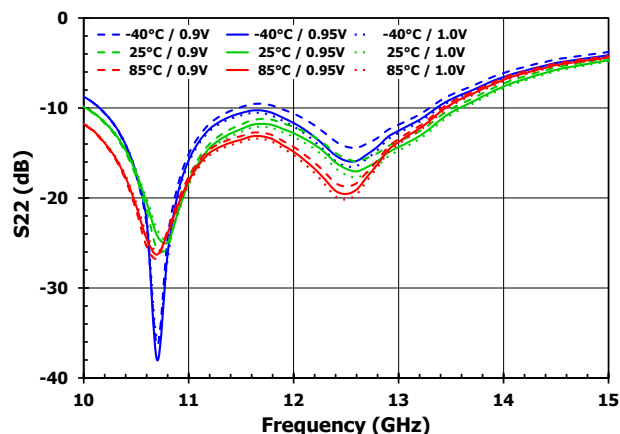


Figure 7. Output Match

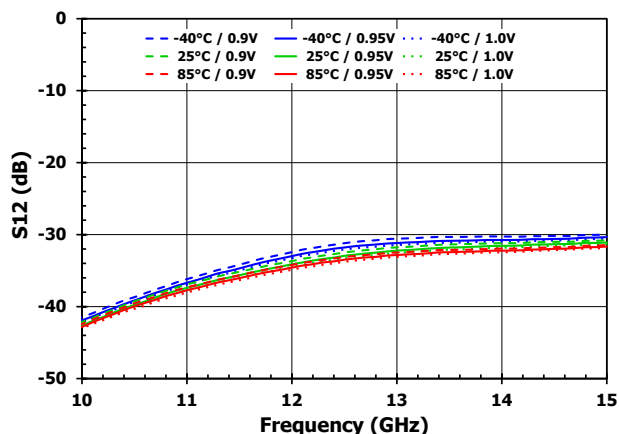


Figure 8. Input-to-Output Isolation

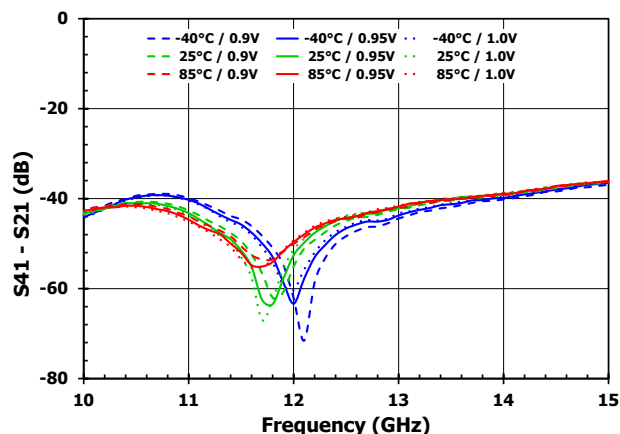


Figure 9. Ch-to-Ch Isolation

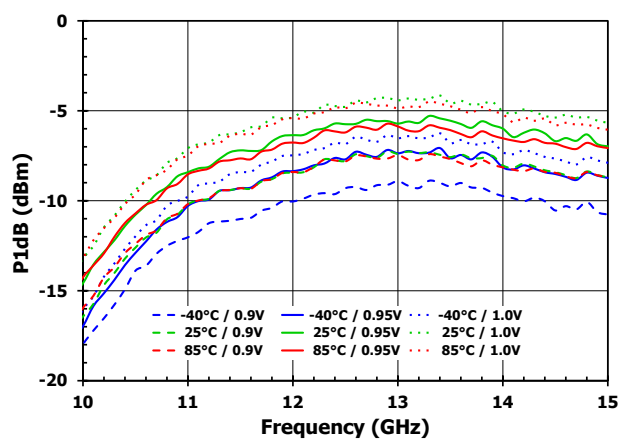


Figure 10. Output 1dB Compression

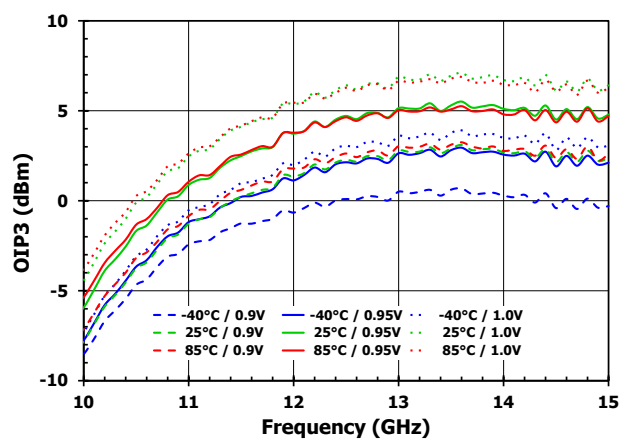


Figure 11. Output Third Order Intercept

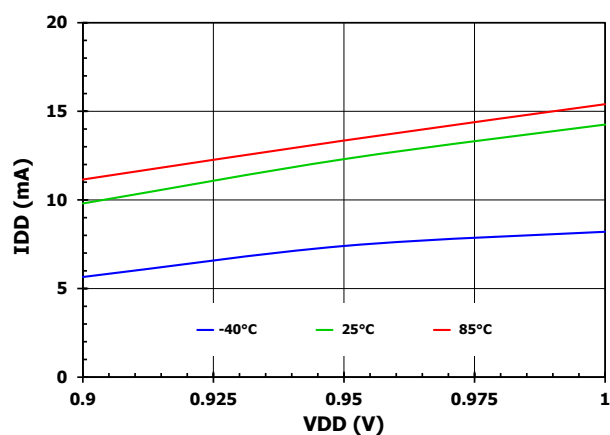


Figure 12. Supply Current, Per Channel

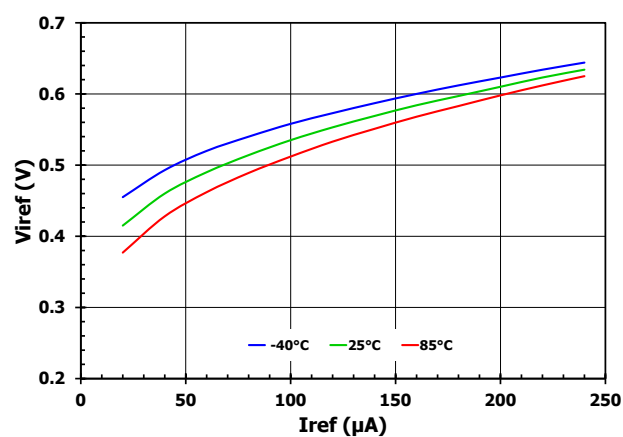


Figure 13. IREF Pin Voltage vs Current

5. Evaluation Board

For more information about the evaluation board, see the *F69xx Evaluation Board Manual* on the [F6921](#) product page.

5.1 Evaluation Board Photos

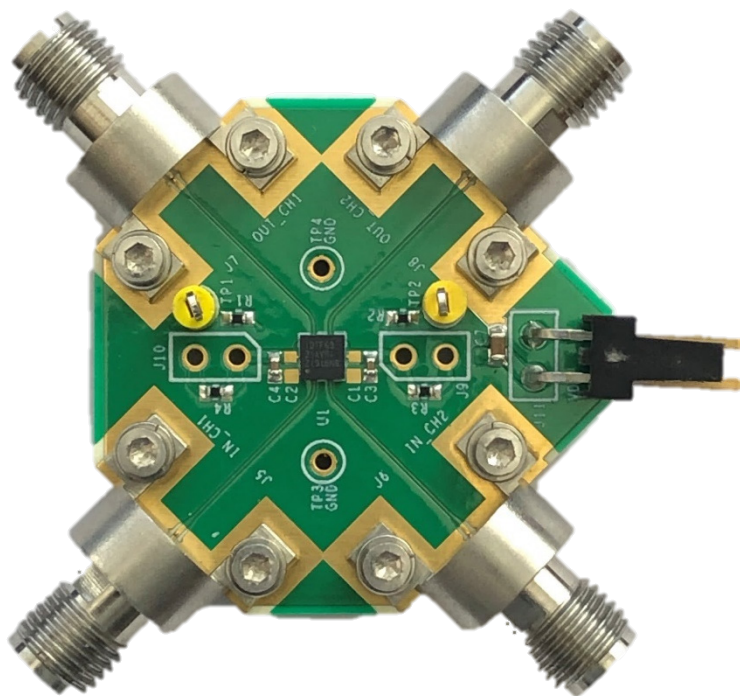


Figure 14. Evaluation Board - Top View

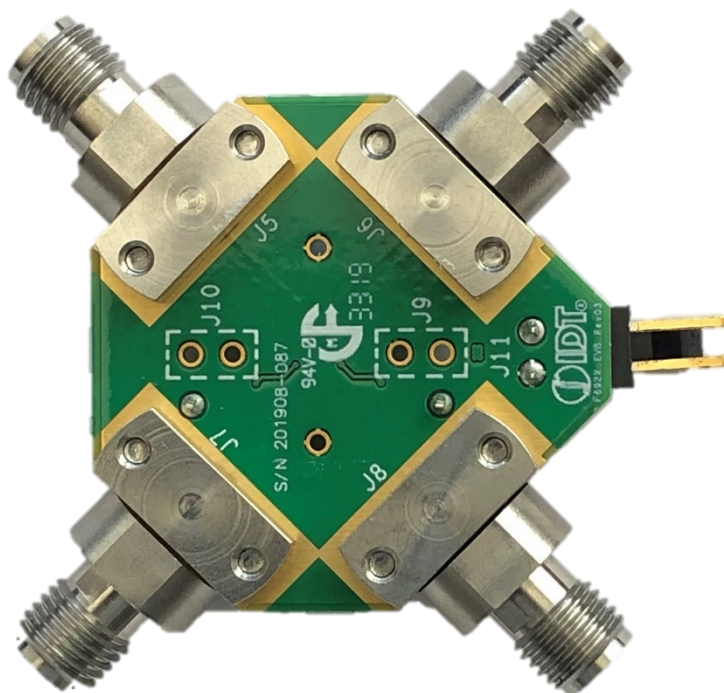


Figure 15. Evaluation Board - Bottom View

5.2 Evaluation Board Schematic

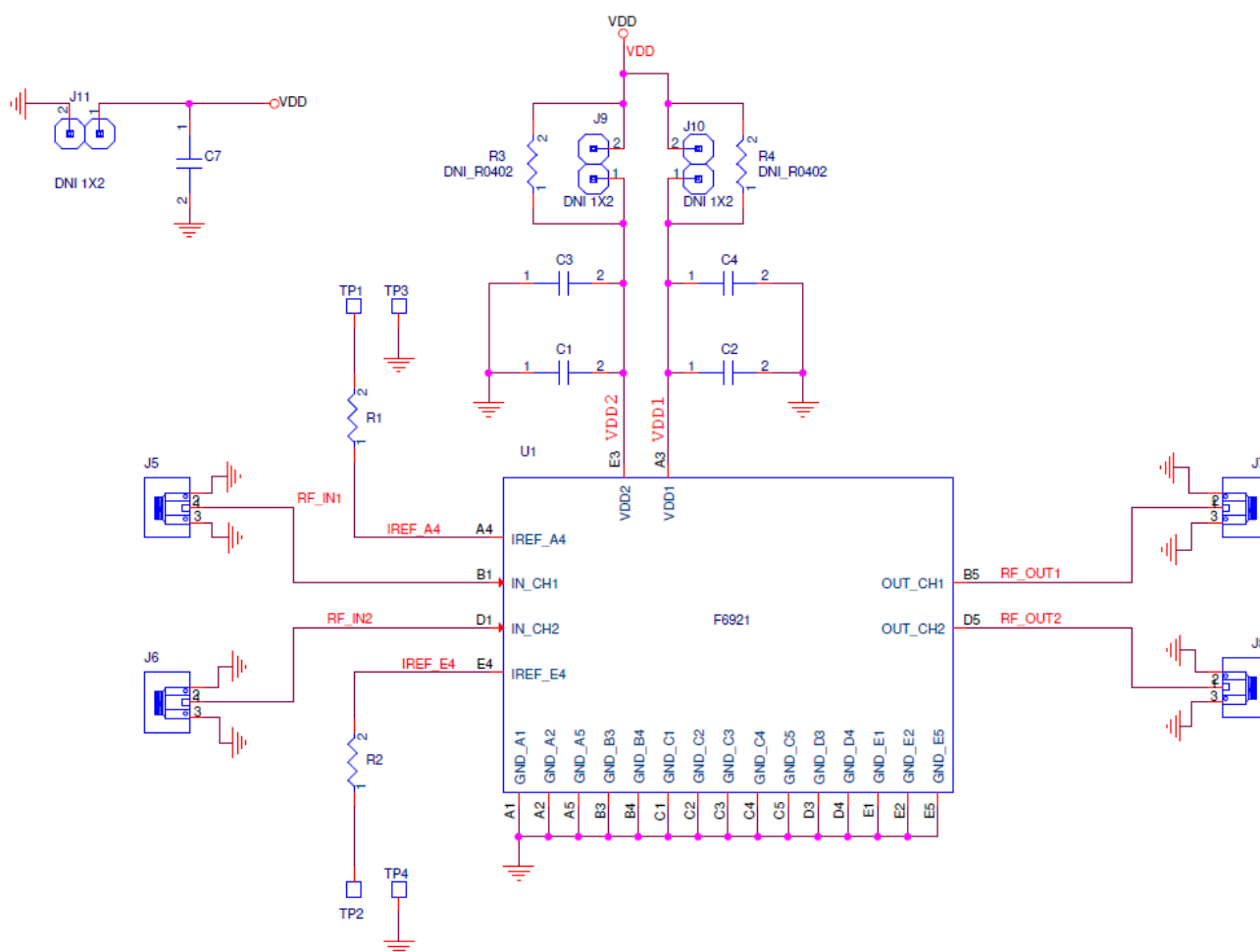


Figure 16. Evaluation Board Schematic

Table 1. Bill of Material (BOM)

Part Reference	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	3.2kΩ ±1%, 1/16W, Resistor (0402)	-	-
R2	1	DNI	-	-
R3, R4 ^[1]	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

1. For single channel operation of Ch2, remove R4 to disconnect VDD1 from the VDD supply pin.

5.3 Evaluation Board Operation

This section provides basic information on operating the F6921 evaluation board. For more information about the evaluation board, see the *F69xx Evaluation Board Manual* on the [F6921](#) product page.

5.3.1. 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 F6921 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 24mA).

5.3.2. Independent VDD and IREF Bias Control

5.3.2.1. 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 24mA).

5.3.2.2. Voltage Source and Current Source

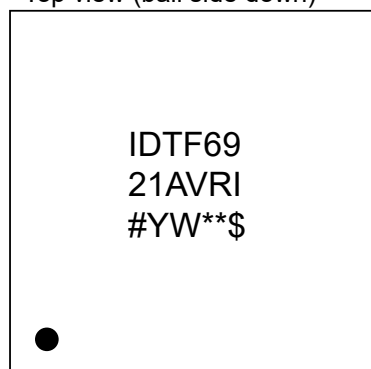
Connect the positive and negative outputs of a power supply (V_{DD}) to J11. In addition, connect an independent current supply (I_{REF}) to TP1 and the ground of the current supply to the negative terminal of the V_{DD} supply. Set V_{DD} to 0.95V, I_{REF} to 120 μ A and enable the power supply outputs. Monitor the I_{DD} of the V_{DD} supply to confirm the nominal bias point is set correctly (approximately 24mA).

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

Top view (ball side down)



- 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 and mark location code

8. Ordering Information

Orderable Part Number	Package	MSL Rating	Carrier Type	Temperature Range
F6921AVRI	2.7 × 2.7 × 0.9 mm 23-BGA	3	Tray	-40°C to +85°C
F6921AVRI8	2.7 × 2.7 × 0.9 mm 23-BGA	3	Reel	-40°C to +85°C
F6921EVB	F6921 Evaluation Board			

9. Revision History

Revision	Date	Description
1.02	Nov 14, 2024	Updated Applications section on page 1.
1.01	Sep 17, 2024	▪ Updated VDD1 and VDD2 pin descriptions in section 1.2. ▪ Added EVB BOM note about single channel operation in Table 1.
1.00	Apr 8, 2021	Initial release.