1MHz, Precision, Rail-to-Rail I/O CMOS Operational Amplifier

1 FEATURES

- **Qualified for Automotive Applications**
- **AEC-Q100 Qualified with the Grade 1**
- **HIGH GAIN BANDWIDTH:1MHz**
- **RAIL-TO-RAIL INPUT AND OUTPUT ±2.5mV Max Vos**
- **INPUT VOLTAGE RANGE: -0.1V to +5.6V with V_S = 5.5V**
- **SUPPLY RANGE: +2.5V to +5.5V**
- **SPECIFIED UP TO +125°C**
- **Micro SIZE PACKAGES: SC70-5**

2 APPLICATIONS

- **SENSORS**
- **PHOTODIODE AMPLIFICATION**
- **ACTIVE FILTERS**
- **TEST EQUIPMENT**
- **DRIVING A/D CONVERTERS**

3 DESCRIPTIONS

The RS321BK-Q1 families of products offer low voltage operation and rail-to-rail input and output, as well as excellent speed/power consumption ratio, providing an excellent bandwidth (1MHz) and slew rate of 0.45V/us. The op-amps are unity gain stable and feature an ultra-low input bias current.

The RS321BK-Q1 has lower offset, which is guaranteed not upper than ±2.5mV at 25°C with V_S = 5V, V_{CM}= V_S/2.

The devices are ideal for sensor interfaces, active filters and portable applications. The RS321BK-Q1 families of operational amplifiers are specified at the full temperature range of −40°C to +125°C.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE(NOM)
RS321BK-Q1	SC70-5	2.10mm×1.25mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Table of Contents

4 Revision History

Note: Page numbers for previous revisions may different from page numbers in the current version.

Version	Change Date	Change Item
A.0	2023/04/06	Preliminary version completed
A.1	2023/04/25	Initial version completed
A.1.1	2024/03/07	Modify packaging naming

5 PACKAGE/ORDERING INFORMATION [(1)]

Orderable Device	Package Type	Pin	Channel	Lead finish/Ball material [(2)]	MSL Peak Temp [(3)]	Op Temp(°C)	Device Marking [(4)]	Package Qty
RS321BKXC5-Q1	SC70-5 [(5)]	5	1	NIPDAUAG	MSL1-260°-Unlimited	-40°C ~125°C	321BK	Tape and Reel,3000

NOTE:

(1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.

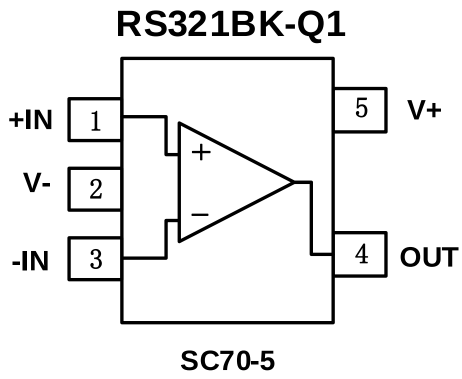
(2) Lead finish/Ball material. Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(3) MSL Peak Temp. The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the lot trace code information (data code and vendor code), the logo or the environmental category on the device.

(5) Equivalent to SOT353.

6 Pin Configuration and Functions (Top View)



Pin Description

NAME	PIN	I/O (1)	DESCRIPTION
	RS321BK-Q1		
	SC70-5		
-IN	3	I	Negative (inverting) input
+IN	1	I	Positive (noninverting) input
OUT	4	O	Output
V-	2	-	Negative (lowest) power supply
V+	5	-	Positive (highest) power supply

(1) I = Input, O = Output.

7 SPECIFICATIONS

7.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted) (1)

			MIN	MAX	UNIT
Voltage	Supply, V_S=(V+) - (V-)			7	V
	Signal input pin (2)	Common-Mode	(V-) - 0.5	(V+) + 0.5	
		Differential (7)		(V+) - (V-) + 0.2	
	Signal output pin (3)		(V-) - 0.5	(V+) + 0.5	
Current	Signal input pin (2)		-10	10	mA
	Signal output pin (3)		-10	10	mA
	Output short-circuits (4)		Continuous		
θ_{JA}	Package thermal impedance (5)	SC70-5		375	°C/W
Temperature	Operating range, T_A		-40	125	°C
	Junction, T_J (6)		-40	150	
	Storage, T_{stg}		-65	150	

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.
(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less.
(3) Output terminals are diode-clamped to the power-supply rails. Output signals that can swing more than 0.5V beyond the supply rails should be current-limited to ±10mA or less.
(4) Short-circuit to ground, one amplifier per package.
(5) The package thermal impedance is calculated in accordance with JESD-51.
(6) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$. All numbers apply for packages soldered directly onto a PCB.
(7) Differential input voltages greater than 0.5 V applied continuously can result in a shift to the input offset voltage above the maximum specification of this parameter. The magnitude of this effect increases as the ambient operating temperature rises.

7.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-Body Model (HBM), per AEC Q100-002 (1)	±2000	V
		Charged-Device Model (CDM), per AEC Q100-011	±500	
		Latch-Up (LU), per AEC Q100-004	±100	mA

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

ESD SENSITIVITY CAUTION

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

7.3 Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
Supply voltage，V_S= (V+) - (V-)	Single-supply	2.5		5.5	V
	Dual-supply	±1.25		±2.75	

7.4 ELECTRICAL CHARACTERISTICS

(At T_A = +25°C, V_S=5V, R_L = 10kΩ connected to V_S/2, and V_{OUT} = V_S/2, V_{CM}= V_S/2, Full [9] = -40°C to +125°C, unless otherwise noted.) [1]

PARAMETER		CONDITIONS	T_J	RS321BK-Q1			
				MIN[2]	TYP[3]	MAX[2]	UNIT
POWER SUPPLY							
V_S	Operating Voltage Range		25°C	2.5		5.5	V
I_Q	Quiescent Current Per Amplifier		25°C		65	120	uA
			Full			180	
PSRR	Power-Supply Rejection Ratio	V_S=2.5V to 5.5V, V_{CM}=(V-)	25°C	70	75		dB
			Full	64			
INPUT							
V_{OS}	Input Offset Voltage	V_{CM}=0V to 3.0V	25°C	-2.5	±0.8	2.5	mV
			Full	-3		3	
V_{OS} TC	Input Offset Voltage Average Drift		Full		±2		uV/°C
IB	Input Bias Current [4] [5]		25°C		±1	±10	pA
I_{OS}	Input Offset Current [5]		25°C		±1	±10	pA
V_{CM}	Common-Mode Voltage Range	V_S= 5.5V	Full	-0.1		5.6	V
CMRR	Common-Mode Rejection Ratio	V_S= 5.5V, V_{CM} =-0.1V to 3.5V	25°C	73	85		dB
			Full	72			
		V_S= 5.5V, V_{CM} =-0.1V to 5.6V	25°C	55	80		
			Full	54			
OUTPUT							
A_{OL}	Open-Loop Voltage Gain	R_L=10KΩ, Vo=0.1V to 4.9V	25°C	105	110		dB
			Full	95			
	Output Swing From Rail	R_L=10KΩ	25°C		10	20	mV
			Full			30	
I_{OUT}	Output Short-Circuit Current [6] [7]		25°C	±70	±100		mA
			Full	±50			
FREQUENCY RESPONSE							
SR	Slew Rate [8]		25°C		0.45		V/us
GBP	Gain-Bandwidth Product		25°C		1		MHz
t_S	Settling Time,0.1%	V_S=±2.5V, G=+1, C_L=100pF, Step=2V	25°C		7		us
t_{OR}	Overload Recovery Time	V_{IN}·Gain≥V_S	25°C		5		us
NOISE							
En	Input Voltage Noise	f = 0.1Hz to 10Hz, V_S=±2.5V	25°C		4.5		uV_{PP}

NOTE:

(1) Electrical table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device.
(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.
(3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.
(4) Positive current corresponds to current flowing into the device.
(5) This parameter is ensured by design and/or characterization and is not tested in production.
(6) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{θJA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is PD = ($T_{J(MAX)}$ - T_A) / $R_{θJA}$. All numbers apply for packages soldered directly onto a PCB.
(7) Short circuit test is a momentary test.
(8) Number specified is the slower of positive and negative slew rates.
(9) Specified by characterization only.

7.5 TYPICAL CHARACTERISTICS

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.
At T_A = +25°C, V_S=5V, R_L = 10kΩ connected to $V_S/2$, V_{OUT} = $V_S/2$, unless otherwise noted.

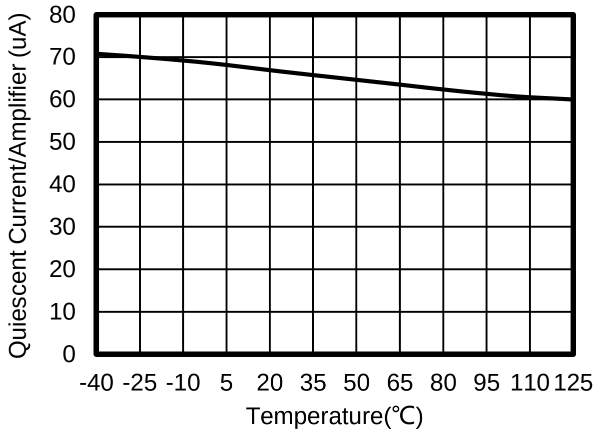


Figure 1. Quiescent Current vs Temperature

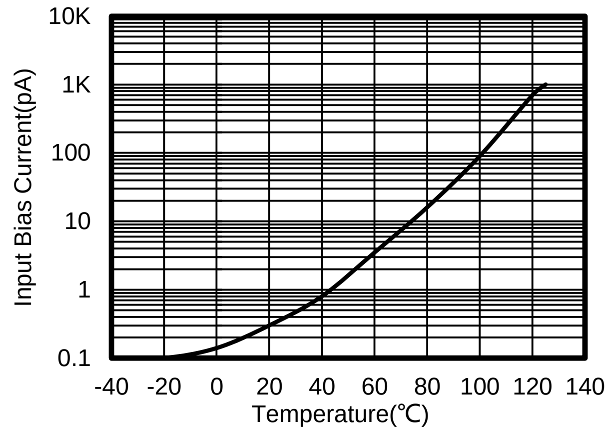


Figure 2. Input Bias Current vs Temperature

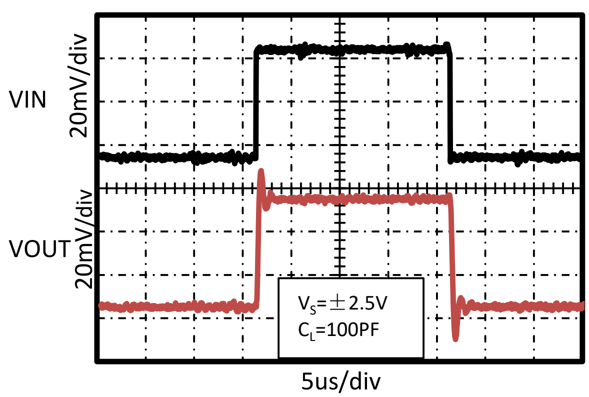


Figure 3. Small-Signal Step Response

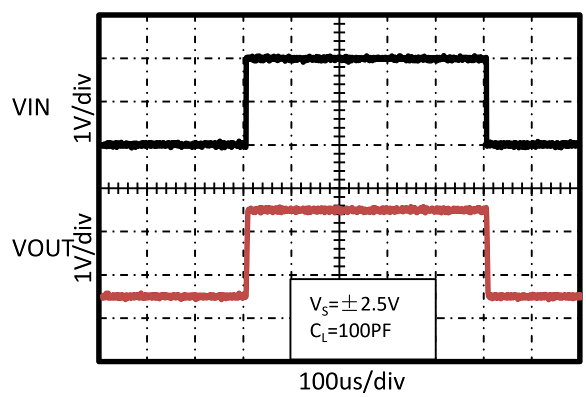


Figure 4. Large-Signal Step Response

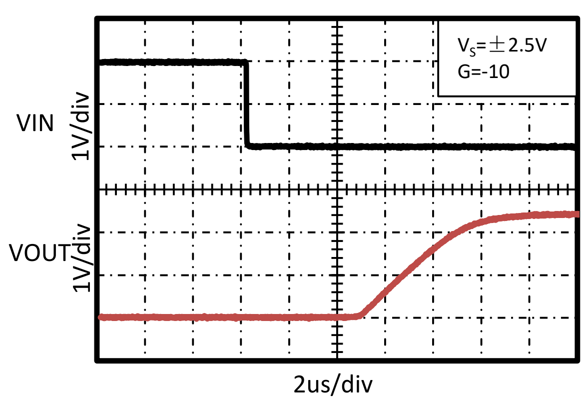


Figure 5. Negative Overvoltage Recovery

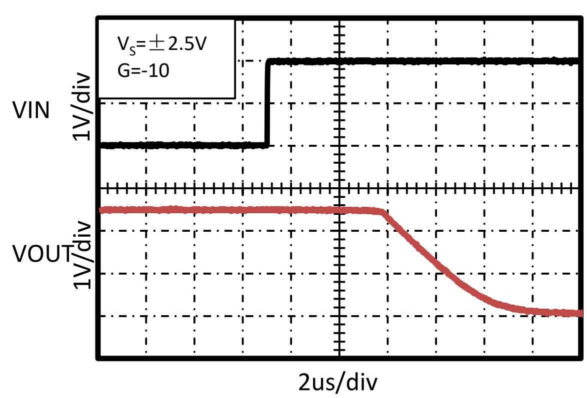


Figure 6. Positive Overvoltage Recovery

TYPICAL CHARACTERISTICS

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

At T_A = +25°C, V_S=5V, R_L = 10kΩ connected to V_S/2, V_{OUT} = V_S/2, unless otherwise noted.

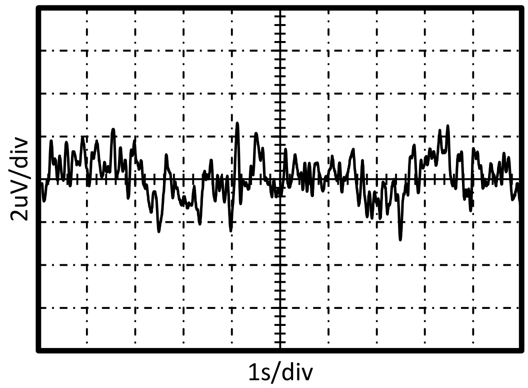


Figure 7. 0.1Hz to 10Hz Input Voltage Noise

8 Detailed Description

8.1 Overview

The RS321BK-Q1 are high precision, rail-to-rail operational amplifiers that can be run from a single-supply voltage 2.5V to 5.5V (±1.25V to ±2.75V). Supply voltages higher than 7V (absolute maximum) can permanently damage the amplifier. Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications. Good layout practice mandates use of a 0.1uF capacitor place closely across the supply pins.

8.2 Phase Reversal Protection

The RS321BK-Q1 family has internal phase-reversal protection. Many op amps exhibit phase reversal when the input is driven beyond the linear common-mode range. This condition is most often encountered in noninverting circuits when the input is driven beyond the specified common-mode voltage range, causing the output to reverse into the opposite rail. The input of the RS321BK-Q1 prevents phase reversal with excessive common-mode voltage. Instead, the appropriate rail limits the output voltage. This performance is shown in figure 8.

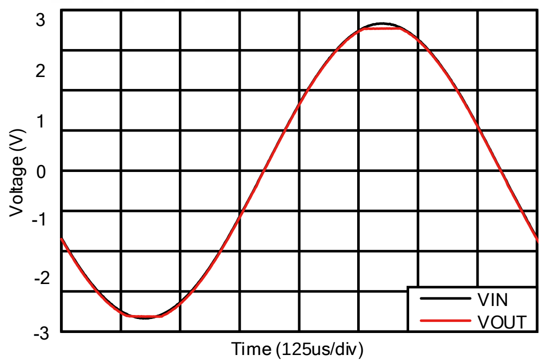


Figure 8. Output Waveform Devoid of Phase Reversal During an Input Overdrive Condition

9 LAYOUTS

9.1 Layout Guidelines

Attention to good layout practices is always recommended. Keep traces short. When possible, use a PCB ground plane with surface-mount components placed as close to the device pins as possible. Place a 0.1uF capacitor closely across the supply pins.
These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the EMI susceptibility.

9.2 Layout Example

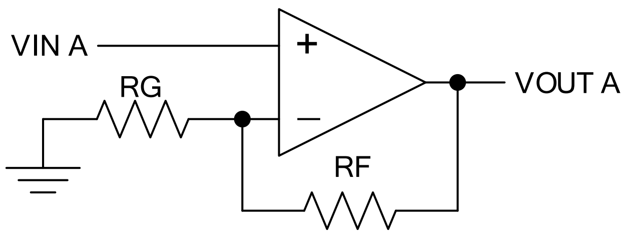
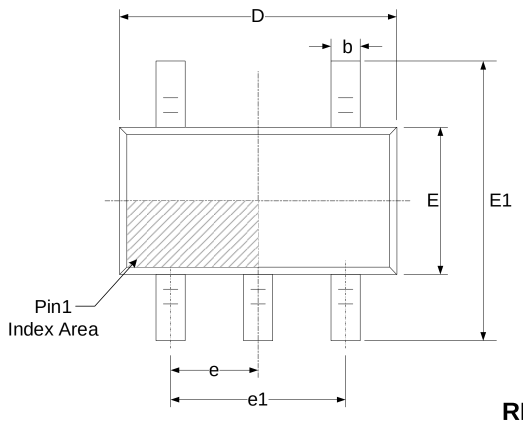
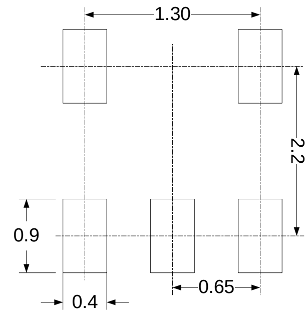


Figure 9. Schematic Representation

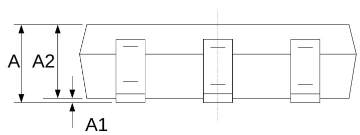
10 PACKAGE OUTLINE DIMENSIONS

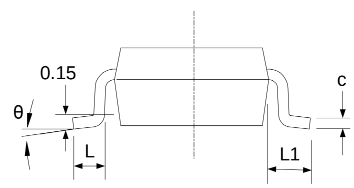
SC70-5





RECOMMENDED LAND PATTERN (Unit: mm)





Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.850	1.050	0.033	0.041
A1	0.000	0.100	0.000	0.004
A2	0.800	1.000	0.031	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D	2.020	2.120	0.079	0.084
E	1.250	1.350	0.049	0.053
E1	2.200	2.400	0.087	0.094
e	0.650(BSC)		0.026(BSC)	
e1	1.300(BSC)		0.051(BSC)	
L	0.280	0.380	0.011	0.015
L1	0.500(REF)		0.020(REF)	
θ	0°	8°	0°	8°

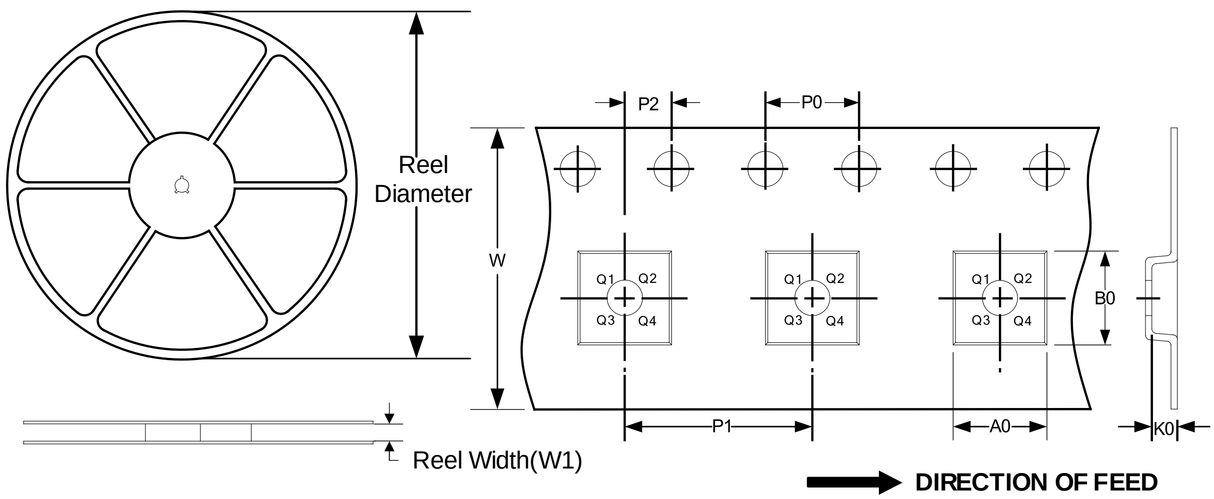
NOTE:

A. All linear dimension is in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. BSC: Basic Dimension. Theoretically exact value shown without tolerances.
E. REF: Reference Dimension, usually without tolerance, for information purposes only.

11 TAPE AND REEL INFORMATION

REEL DIMENSIONS

TAPE DIMENSION



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SC70-5	7''	9.5	2.25	2.55	1.20	4.0	4.0	2.0	8.0	Q3

NOTE:
1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

IMPORTANT NOTICE AND DISCLAIMER

Jiangsu RUNIC Technology Co., Ltd. will accurately and reliably provide technical and reliability data (including data sheets), design resources (including reference designs), application or other design advice, WEB tools, safety information and other resources, without warranty of any defect, and will not make any express or implied warranty, including but not limited to the warranty of merchantability Implied warranty that it is suitable for a specific purpose or does not infringe the intellectual property rights of any third party.

These resources are intended for skilled developers designing with RUNIC products You will be solely responsible for: (1) Selecting the appropriate products for your application; (2) Designing, validating and testing your application; (3) Ensuring your application meets applicable standards and any other safety, security or other requirements; (4) RUNIC and the RUNIC logo are registered trademarks of RUNIC INCORPORATED. All trademarks are the property of their respective owners; (5) For change details, review the revision history included in any revised document. The resources are subject to change without notice. Our company will not be liable for the use of this product and the infringement of patents or third-party intellectual property rights due to its use.