Dear customer

ROHM Co., Ltd. ("ROHM"), on the 1st day of April, 2024,
has absorbed into merger with 100%-owned subsidiary of LAPIS Technology Co., Ltd.

Therefore, all references to "LAPIS Technology Co., Ltd.", "LAPIS Technology"
and/or "LAPIS" in this document shall be replaced with "ROHM Co., Ltd."
Furthermore, there are no changes to the documents relating to our products other than
the company name, the company trademark, logo, etc.

Thank you for your understanding.

ROHM Co., Ltd.
April 1, 2024

Downloaded from Arrow.com.

FEDL9077-06
Issue Date: Feb.29, 2024

ML9077

Power-saving energy harvesting power supply control LSI

GENERAL DESCRIPTION

ML9077 controls charging an energy harvester current to a rechargeable battery.
The control circuit is consists of a overcharge prevention circuit, a charge control circuit and a rechargeable battery voltage monitor circuit. Each circuit performs following operation.

- Overcharge prevention circuit
  When a rechargeable battery becomes FULL charge state, the current of energy harvester is drawn to VSS and the charge current for the rechargeable battery is omitted so that rechargeable battery voltage does not rise any more.
- Charge control circuit
  The voltage of energy harvester (VSC) is always compared to the voltage of rechargeable battery (VBAT) and it will have starting to charge the battery if VSC＞VBAT, and stop to charge if VSC≦BAT.
- Rechargeable battery voltage monitor circuit（BOD : Brown-Out Detector）
  The voltage of rechargeable battery (VBAT) is always supervised, and it controls VBAT low voltage detection signal (VBOD) and rechargeable battery voltage output (VDO).

APPLICATION

Consumer and Industrial equipment (e.g., Remote Controller, Electronic Shelf Labels, IoT Device, etc)

【NOTE】
This product cannot be applicable for automotive use, automatic train control systems, and railway safety systems. Please contact ROHM sales office in advance if contemplating the integration of this product into applications that requires high reliability, such as transportation equipment for ships and railways, communication equipment for trunk lines, traffic signal equipment, power transmission systems, core systems for financial terminals and various safety control devices.

FEATURES

- Self control the energy harvester current for charging a rechargeable battery.
- Direct charge energy harvester current (ISC) to a rechargeable battery.
  – [VSC＞2.0V, ISC≦1mA conditions]: Potential difference=Max 0.1V（VSC-VBAT）
  – [VSC≦2.0V, ISC≦1mA conditions]: Potential difference=Max 2.0V（VSC-VBAT）
- 2 Selectable overcharge prevention voltage.
- 2 Selectable low voltage detection voltage.
- Power supply system detects a low voltage of rechargeable battery and power off an external microcomputer.
- Low power operation
  – energy harvester current : 80nA
  – Rechargeable battery current : 80nA
- Shipment
  – 12-pin plastic WQFN
    Part number: ML9077GDZ05B
  – Chip
    Part number: ML9077WG
- Guaranteed operating range
  – Operating temperature: –20°C to 70°C
  – Operating voltage: V_{SC} = 0.0V to 3.6V, V_{BAT} = 0.0V to 3.2V

ROHM SEMICONDUCTOR

Downloaded from Arrow.com.

BLOCK DIAGRAM

ML9077 Block Diagram

Figure 1 shows ML9077 block diagram.

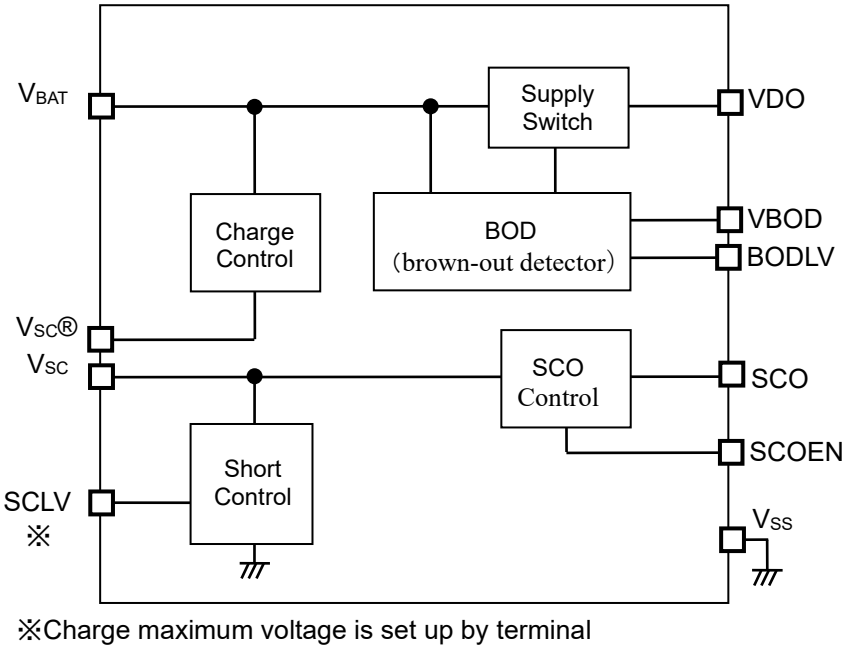
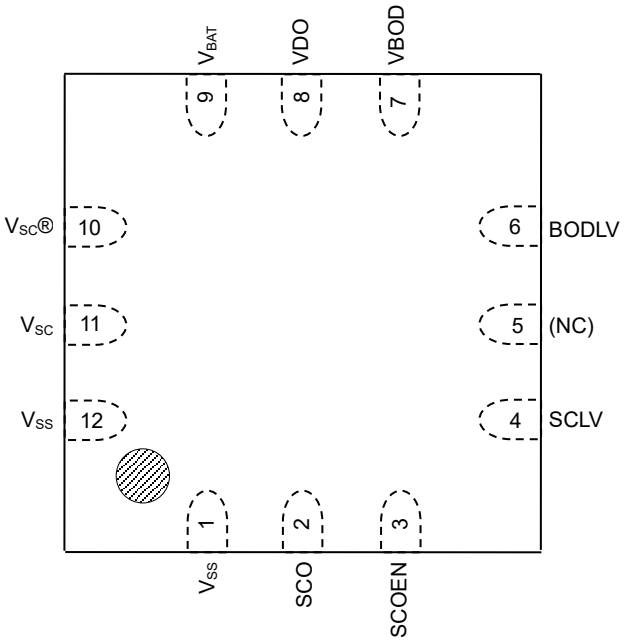


Figure 1 ML9077 Block Diagram

PIN CONFIGURATION

ML9077 WQFN12 Pin Layout

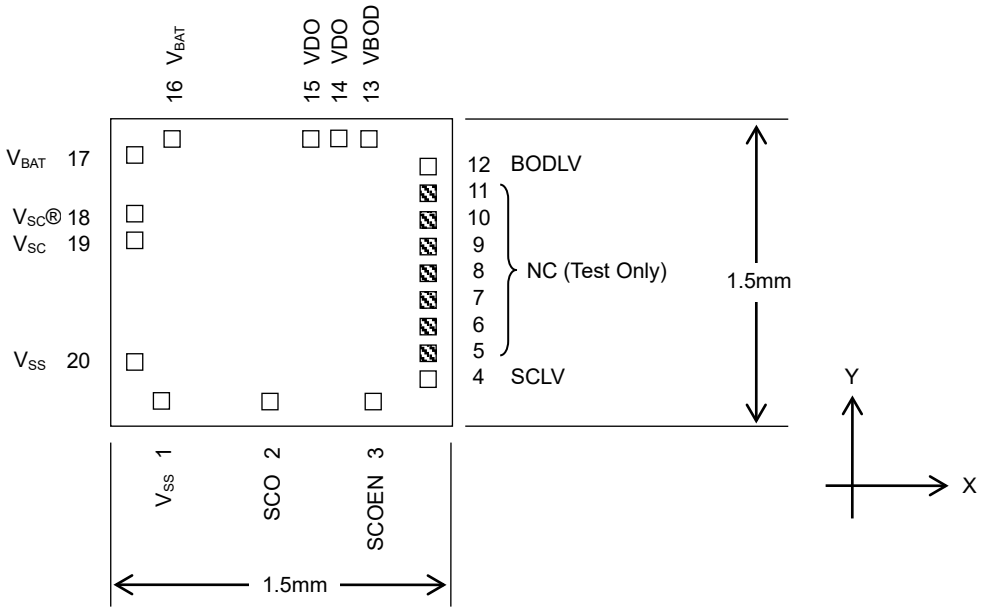


(NC): No Connection

Figure 2 ML9077 WQFN12 Pin Configuration

Downloaded from Arrow.com.

ML9077 Chip Pin Layout & Dimension



(NC): No Connection

[Note]
There may be some causions for assembly condition (To Be Noted)

Chip size:	1.5mm×1.5mm
PAD count:	20 pins（Test Only PAD count：7pins）
Minimum PAD pitch:	120 μm
PAD aperture:	90 μm × 90 μm
Chip thickness:	350 μm
Voltage of the rear side of chip:	V_{SS} level

Figure 3 ML9077 Chip Layout & Dimension

ML9077 Pad Coordinates

Table 1 ML9077 Pad Coordinates

Chip Center: X=0,Y=0

PAD No.	Pad Name	ML9077	
		X (μm)	Y (μm)
1	VSS	-442.0	-632.0
2	SCO	-94.0	-632.0
3	SCOEN	337.0	-632.0
4	SCLV	632.0	-565.0
5	NC	632.0	-445.0
6	NC	632.0	-325.0
7	NC	632.0	-205.0
8	NC	632.0	-85.0
9	NC	632.0	35.0
10	NC	632.0	155.0

PAD No.	Pad Name	ML9077	
		X (μm)	Y (μm)
11	NC	632.0	275.0
12	BODLV	632.0	395.0
13	VBOD	484.0	632.0
14	VDO	364.0	632.0
15		244.0	632.0
16	VBAT	-479.0	632.0
17		-632.0	534.0
18	VSC®	-632.0	275.0
19	VSC	-632.0	155.0
20	VSS	-632.0	-532.0

[Note]
※The following PADs is the same signal, please bonding it to one of PAD.
PAD No. 1 and 20、PAD No. 14 and 15、PAD No. 16 and 17
※The directions for VSC®.
When charging current limitation resistance is required, it connects with VSC through resistance, please short to VSC except it.

Downloaded from Arrow.com.

PIN DESCRIPTION

Pin name	I/O	Description	Logic
Power supply			
V_{SS}	—	Negative power supply pin	—
V_{BAT}	—	Rechargeable battery positive power supply pin	—
V_{SC}	—	Energy harvester positive power supply pin	—
V_{SC}®	—	Energy harvester positive power supply pin to have a charging current limitation resistor. When the charge current limitation is needed for an energy harvester, connect the positive power(+) of energy harvester to VSC pin and connect the positive power(+) to VSC® through the current limitation register. When the charge current limitation is Not needed for an energy harvester, connect the positive power(+) of energy harvester to both VSC pin and VSC® pin.	—
Energy harvester current monitor terminal			
SCOEN	I	Energy harvester current monitor enable pin	Positive
SCO	O	Output for energy harvester current monitor	—
BOD voltage setting input			
BODLV		Brown-out detector voltage select pin	Positive
Fault charge detection voltage setting input			
SCLV	I	Overcharge prevention voltage select pin	Positive
BOD output terminal			
VBOD	O	Brown-out detector output for rechargeable battery low voltage	—
Rechargeable battery output			
VDO	O	Rechargeable battery voltage output	—

TERMINATION OF UNUSED PINS

Table 2 shows methods of terminating the unused pins.

Table 2 Termination of Unused Pins

Pin	Recommended pin termination
VDO	Open
VBOD	Open
BODLV	V_{BAT} or V_{SS}
SCLV	V_{BAT} or V_{SS}
SCOEN	Open
SCO	Open

Downloaded from Arrow.com.

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

(V_{SS}= 0V)

Parameter	Symbol	Condition	Rating	Unit
Power supply voltage 1	V_{BAT}	Ta=25℃	-0.3 to +3.7	V
Power supply voltage 2	V_{SC}	Ta=25℃	-0.3 to +3.7	V
Power supply voltage 3	VDO	Ta=25℃	-0.3 to +3.7	V
Input voltage	V_{IN}	Ta=25℃	-0.3 to V_{BAT}+0.3	V
Output voltage	V_{OUT}	Ta=25℃	-0.3 to V_{BAT}+0.3	V
Output current 1	I_{OUT1}	VDO、Ta=25℃	30	mA
Output current 2	I_{OUT2}	VBOD、Ta=25℃	-4 to +4	mA
Power dissipation	PD	Ta=25℃	0.88	W
Storage temperature	T_{STG}	—	-40 to +125	℃

RECOMMENDED OPERATING CONDITIONS

(V_{SS}= 0V)

Parameter	Symbol	Condition	Range	Unit
Operating temperature	T_{OP}	-	-20 to +70	℃
Operating voltage	V_{SC}	Tj=-20℃to 70℃	0.0 to 3.6	V
	V_{BAT}		0.0 to 3.2	

DC CHARACTERISTICS (Input)

(V_{BAT}=1.1 to 3.6V, V_{SS}=0V, Ta=-20 to +70℃ unless otherwise specified)

Parameter	Symbol	Condition	Rating			Unit	Measuring circuit
			Min.	Typ.	Max.		
Input voltage (BODLV,SCLV) (SCOEN)	VIH	V_{BAT}=1.3 to 3.6V	0.7 ×V_{BAT}	—	V_{BAT}	V	1
		V_{BAT}=1.1 to 3.6V	0.7 ×V_{BAT}	—	V_{BAT}		
	VIL	V_{BAT}=1.3 to 3.6V	0	—	0.3 ×V_{BAT}		
		V_{BAT}=1.1 to 3.6V	0	—	0.2 ×V_{BAT}		
Input current (1) SCOEN	IIH1	VIH=V_{BAT}	5	30	50	μA	3
	IIL1	VIL=0V	-0.1	—	—		
Input current (2) BODLV, SCLV	IIH2	VIH=V_{BAT}	—	—	0.1	μA	-
	IIL2	VIL=0V	-0.1	—	—		

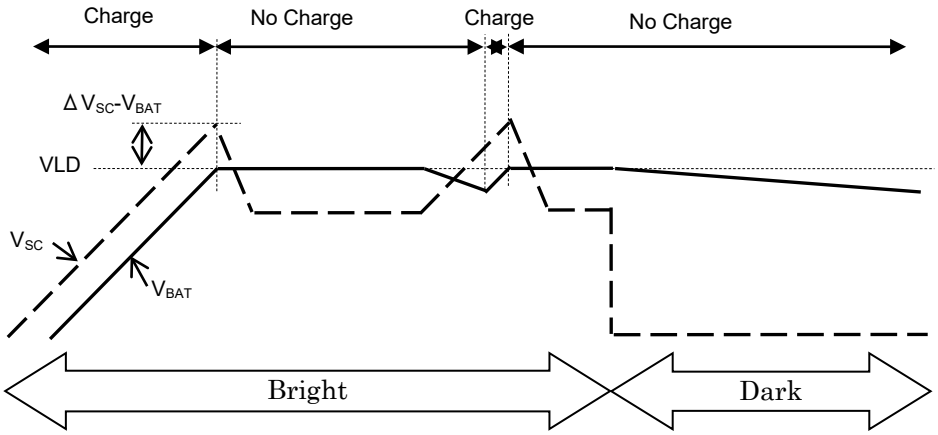
Downloaded from Arrow.com.

DC CHARACTERISTICS (Charge control)

(V_{BAT}=1.1 to 3.6V, V_{SS}=0V, Ta=-20 to +70℃ unless otherwise specified)

Parameter	Symbol	Condition		Rating Min.	Rating Typ.	Rating Max.	Unit	Measuring circuit
Overcharge non-prevention *1(V_{BAT})	VSCL	I_{SC}≦150nA,Ta=-20 to +70℃		1.55	—	—	V	1
Overcharge prevention voltage (V_{BAT}) (Rechargeable battery clamp voltage)	VLD	I_{SC}=0.15uA~ 6mA Ta=25℃	SCLV="H"	3.0	3.1	3.2		
			SCLV="L"	2.5	2.6	2.7		
Overcharge prevention voltage Temperature characteristics	T_{VLD}	Ta=-20℃ to 70℃		-1.2	—	1.2	mV/℃	
Supply current (V_{SC})	IDD_{SC}	V_{BAT}=VLD(min),V_{SC}=V_{BAT}-0.05V Ta=25℃		—	—	80	nA	
Potential difference (V_{SC}-V_{BAT})	Δ V_{SC}-V_{BAT}	V_{SC}>2.0V, ISC≦1mA		—	—	0.1	V	
		V_{SC}≦2.0V, ISC≦1mA		—	—	2		

*1 : The overcharge prevention circuit does not work when the energy harvester voltage (V_{SC}) is less than 1.55V even if the rechargeable battery becomes FULL charge state.



DC CHARACTERISTICS (Energy harvester current monitor)

(V_{BAT}=1.1 to 3.6V, V_{SS}=0V, Ta=-20 to +70℃ unless otherwise specified)

Parameter	Symbol	Condition	Rating Min.	Rating Typ.	Rating Max.	Unit	Measuring circuit
Output current (SCO)	ISCO1	V_{SC}=1.2V,SCO=1.1V, SCOEN="H"	—	—	-10	μA	2
	ISCO2	V_{SC}=3.4V, SCO=0V, SCOEN="L"	-0.05	—	—		

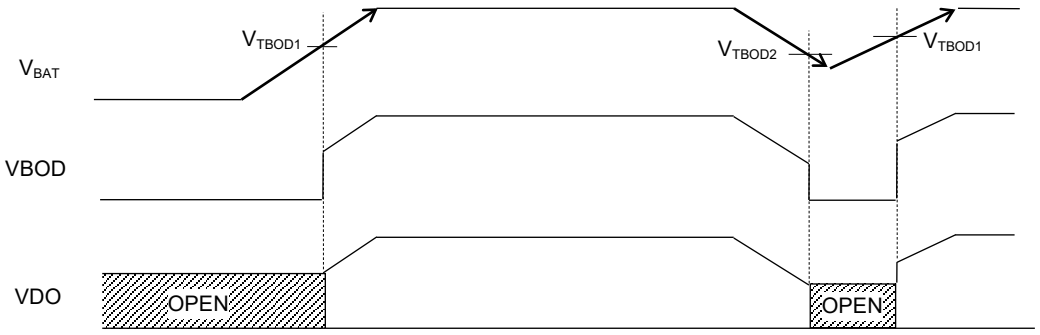
Downloaded from Arrow.com.

DC CHARACTERISTICS (Brown-out detection)

(V_{BAT}=1.1 to 3.6V, V_{SS}=0V, Ta=-20 to +70℃ unless otherwise specified)

Parameter	Symbol	Condition		Rating Min.	Rating Typ.	Rating Max.	Unit	Measuring circuit
Reversal voltage (BOD) *1	V_{TBOD1}	V_{BAT}="L"⇒"H"	BODLV="L"	1.0	1.15	1.25	V	3
			BODLV="H"	1.7	1.8	1.9		
	V_{TBOD2}	V_{BAT}="H"⇒"L"		V_{TBOD1} -0.25	—	V_{TBOD1} -0.1		
Temperature characteristics (BOD)	T_{BOD}	In the state of reversal voltage Ta=-20℃～60℃		-1.5	—	1.5	mV/℃	
Supply current (V_{BAT})	IDD_{BAT}	-		—	—	80	nA	
Output voltage (VBOD)	VOH1	IOH1=-0.5mA, V_{BAT}=1.8～3.6V		V_{BAT} -0.5	—	—	V	
		IOH1=-0.1mA, V_{BAT}=1.3～3.6V		V_{BAT} -0.3	—	—		
		IOH1=-0.03mA, V_{BAT}=1.1 to 3.6V		V_{BAT} -0.3				
	VOL1	IOL1=+0.5mA, V_{BAT}=1.8 to 3.6V		—	—	0.5		
		IOL1=+0.1mA, V_{BAT}=1.3 to 3.6V		—	—	0.5		
		IOL1=+0.03mA, V_{BAT}=1.1 to 3.6V				0.3		
Output current (VDO)	IVDO1	V_{BAT}=V_{TBOD1}~1.8V, VDO=V_{BAT}-0.05V		—	—	-5	mA	
	IVDO2	V_{BAT}=1.8~3.6V, VDO=V_{BAT}-0.05V		—	—	-20		
	IVDO3	V_{BAT}=0.0~V_{TBOD1}, VDO=0.0~V_{BAT}		-0.05	—	—	μA	

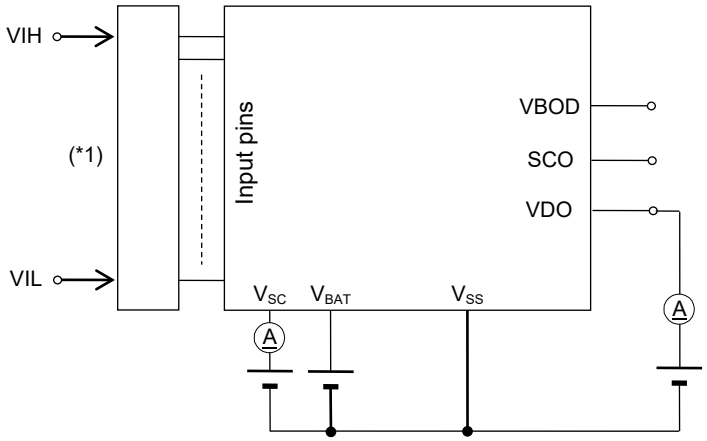
*1 : If VBAT voltage turns into below BOD reversal voltage, a VBOD output will serve as a VSS level, if a VDO terminal will be in an open state and VBAT voltage becomes more than BOD reversal voltage, a VBOD output will serve as a VBAT level and a VBAT level will be outputted from a VDO terminal.



Downloaded from Arrow.com.

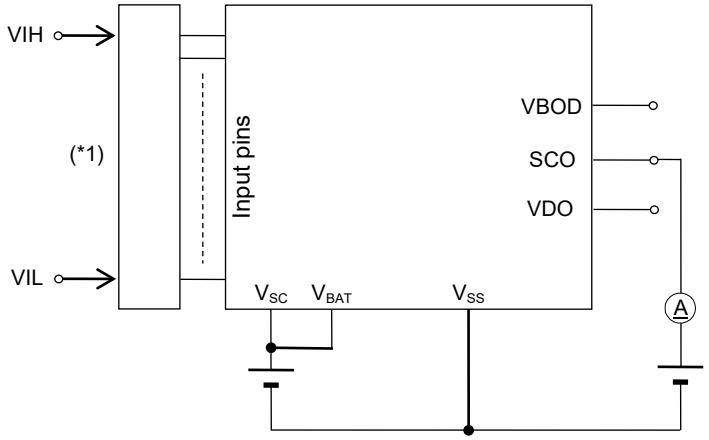
MEASURING CIRCUITS

MEASURING CIRCUIT 1



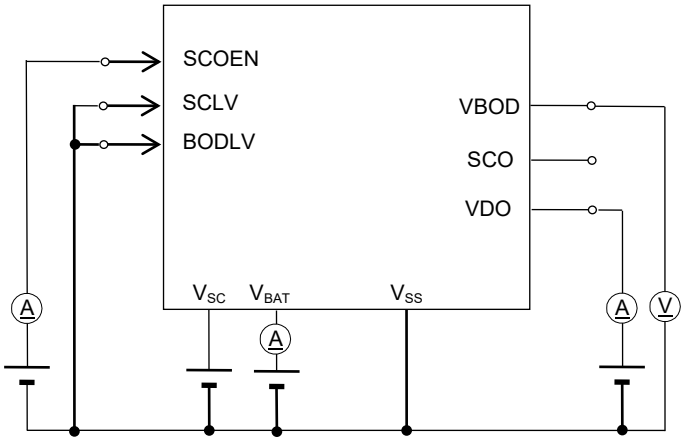
(*1) Input logic circuit to determine the specified measuring conditions.

MEASURING CIRCUIT 2



(*1) Input logic circuit to determine the specified measuring conditions.

MEASURING CIRCUIT 3

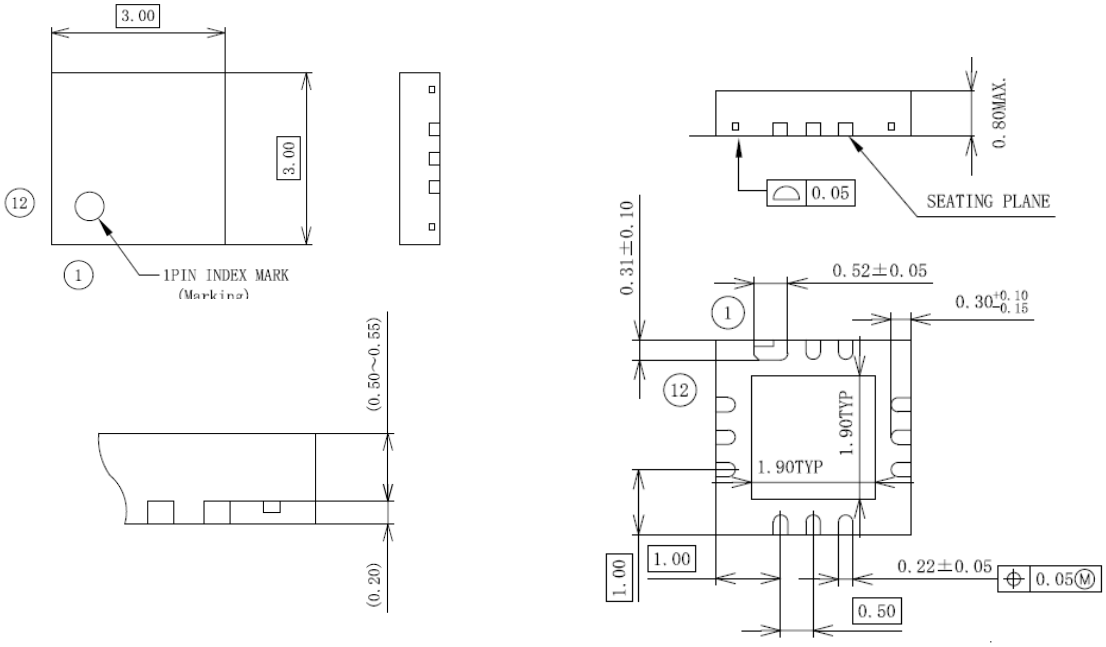


Downloaded from Arrow.com.

PACKAGE DIMENSIONS

(Unit: mm)

P-WQFN12-0303-0.50-63



Package material	Epoxy resin
Lead frame material	Cu alloy
Lead finish	Ni/Pd/Au
Solder thickness	Au/Pd Max0.01/Max0.15
Package weight (g)	0.01980typ.
Rev. No./Last Revised	3 / Oct. 07,2010

LAPIS Technology Co.,Ltd.

Notes for Mounting the Surface Mount Type Package

The surface mount type packages are very susceptible to heat in reflow mounting and humidity absorbed in storage. Therefore, before you perform reflow mounting, contact our responsible sales person for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).

Downloaded from Arrow.com.

REVISION HISTORY

Document No.	Date	Page		Description
		Previous Edition	Current Edition	
FEDL9077-01	Jan.30,2012	–	–	First edition
FEDL9077-02	Dec.07,2012	5	5	＜DC CHARACTERISTICS (Input)＞ Change of “Iput current”
FEDL9077-03	Apr.21.2023	1-11	1-11	Logo changed to “LAPIS Technology Co.,Ltd.”
		1	1	< FEATURES> Correction of inequality
		2	2	<PIN CONFIGURATION> Correction of terminal name
		6	6	<Overcharge prevention voltage(VBAT)> Add Typical Rating
		11	11	<Notes> Update to Notes
FEDL9077-04	Apr.24.2023	1	1	< FEATURES> Correction of Chip Part number
		9	9	< PACKAGE DIMENSIONS> Correction of Package code
FEDL9077-05	Jun.26.2023	1-11	1-11	Change “solar panel/cell” to “energy harvester”
		4	4	<TERMINATION OF UNUSED PINS> Correction of Table number
		9	9	< PACKAGE DIMENSIONS> Correction of Package code
FEDL9077-06	Feb.29.2024	1	1	<Application> Add Application
		9	9	<PACKAGE DIMENSIONS> Correction of Figure
		11	11	<Notes> Update to Notes

Downloaded from Arrow.com.

Notes

1) When using LAPIS Technology Products, refer to the latest product information and ensure that usage conditions (absolute maximum ratings*1, recommended operating conditions, etc.) are within the ranges specified. LAPIS Technology disclaims any and all liability for any malfunctions, failure or accident arising out of or in connection with the use of LAPIS Technology Products outside of such usage conditions specified ranges, or without observing precautions. Even if it is used within such usage conditions specified ranges, semiconductors can break down and malfunction due to various factors. Therefore, in order to prevent personal injury, fire or the other damage from break down or malfunction of LAPIS Technology Products, please take safety at your own risk measures such as complying with the derating characteristics, implementing redundant and fire prevention designs, and utilizing backups and fail-safe procedures.
   *1: Absolute maximum ratings: a limit value that must not be exceeded even momentarily.

2) The Products specified in this document are not designed to be radiation tolerant.

3) Descriptions of circuits, software and other related information in this document are provided only to illustrate the standard operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. And the peripheral conditions must be taken into account when designing circuits for mass production. LAPIS Technology disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, and other related information.

4) No license, expressly or implied, is granted hereby under any intellectual property rights or other rights of LAPIS Technology or any third party with respect to LAPIS Technology Products or the information contained in this document (including but not limited to, the Product data, drawings, charts, programs, algorithms, and application examples, etc.). Therefore, LAPIS Technology shall have no responsibility whatsoever for any dispute, concerning such rights owned by third parties, arising out of the use of such technical information.

5) LAPIS Technology intends our Products to be used in a way indicated in this document. Please be sure to contact a ROHM sales office if you consider the use of our Products in different way from original use indicated in this document. For use of our Products in medical systems, please be sure to contact a LAPIS Technology representative and must obtain written agreement. Do not use our Products in applications which may directly cause injuries to human life, and which require extremely high reliability, such as aerospace equipment, nuclear power control systems, and submarine repeaters, etc. LAPIS Technology disclaims any and all liability for any losses and damages incurred by you or third parties arising by using the Product for purposes not intended by us without our prior written consent.

6) All information contained in this document is subject to change for the purpose of improvement, etc. without any prior notice. Before purchasing or using LAPIS Technology Products, please confirm the latest information with a ROHM sales office. LAPIS Technology has used reasonable care to ensure the accuracy of the information contained in this document, however, LAPIS Technology shall have no responsibility for any damages, expenses or losses arising from inaccuracy or errors of such information.

7) Please use the Products in accordance with any applicable environmental laws and regulations, such as the RoHS Directive. LAPIS Technology shall have no responsibility for any damages or losses resulting non-compliance with any applicable laws or regulations.

8) When providing our Products and technologies contained in this document to other countries, you must abide by the procedures and provisions stipulated in all applicable export laws and regulations, including without limitation the US Export Administration Regulations and the Foreign Exchange and Foreign Trade Act.

9) Please contact a ROHM sales office if you have any questions regarding the information contained in this document or LAPIS Technology's Products.

10) This document, in part or in whole, may not be reprinted or reproduced without prior consent of LAPIS Technology.

(Note) “LAPIS Technology” as used in this document means LAPIS Technology Co., Ltd.

Copyright 2012 - 2024 LAPIS Technology Co., Ltd.

LAPIS Technology Co.,Ltd.
2-4-8 Shinyokohama, Kouhoku-ku, Yokohama 222-8575, Japan
https://www.lapis-tech.com/en/

Downloaded from Arrow.com.