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

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

BLOCK DIAGRAM

ML9077 Block Diagram

Figure 1 shows ML9077 block diagram.

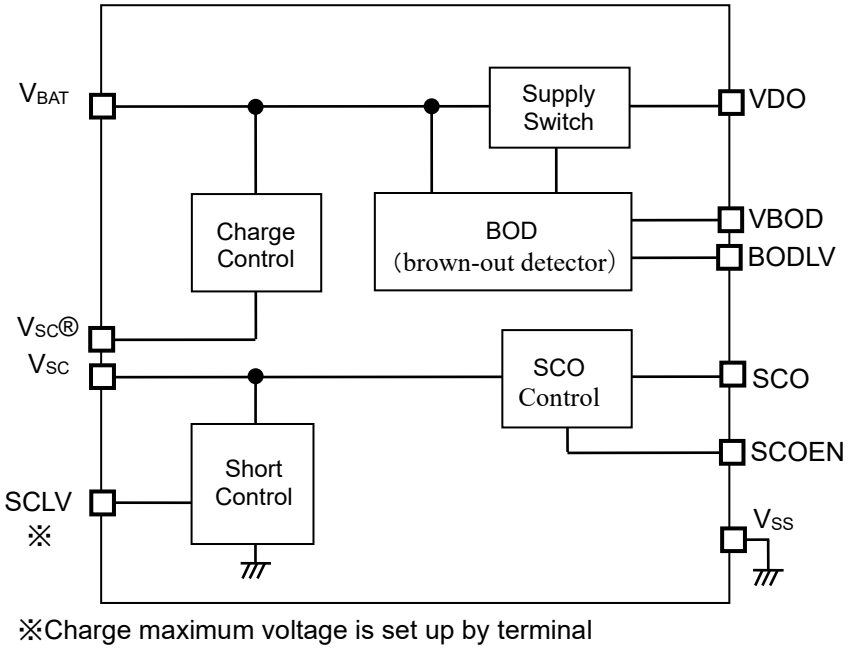
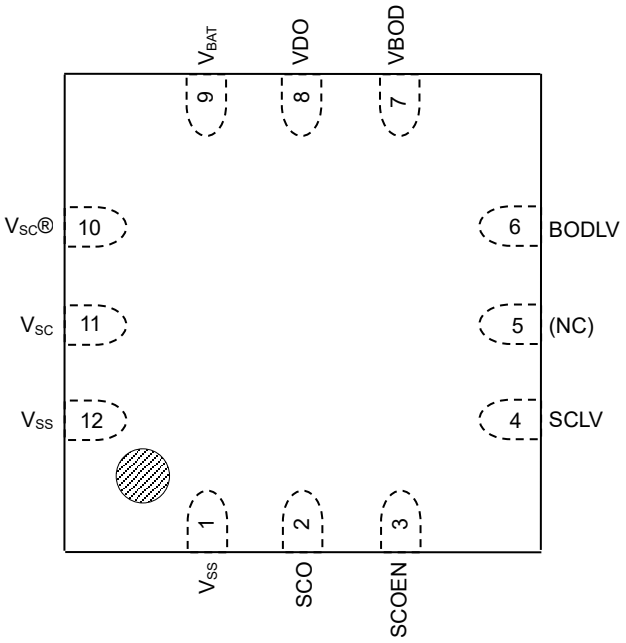


Figure 1 ML9077 Block Diagram

PIN CONFIGURATION

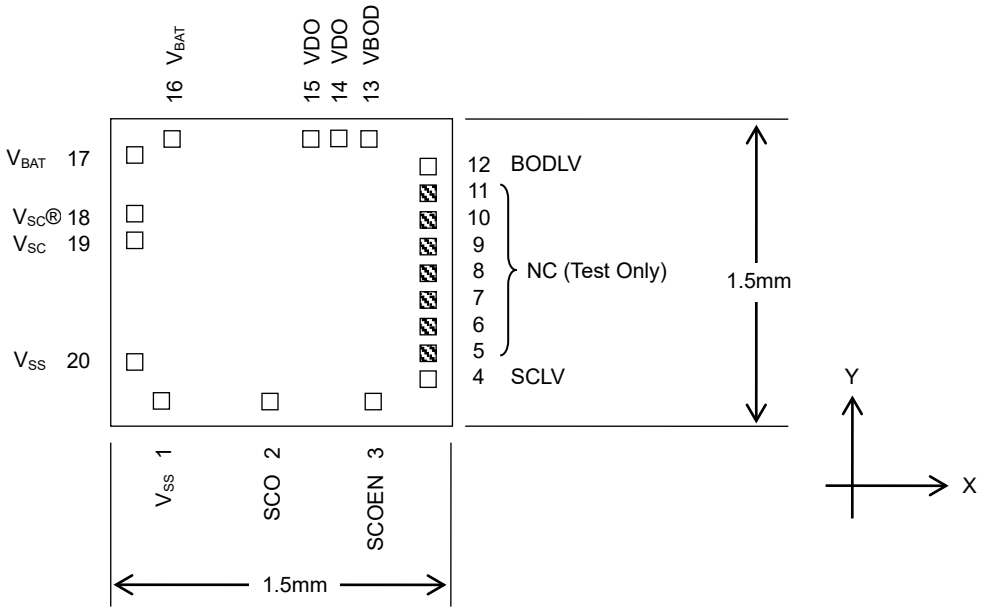
ML9077 WQFN12 Pin Layout



(NC): No Connection

Figure 2 ML9077 WQFN12 Pin Configuration

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.

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

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)

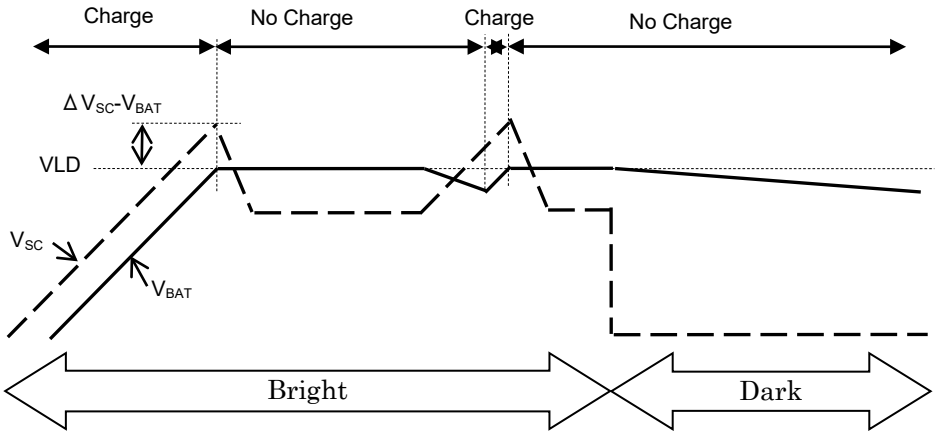
Parameter	Symbol	Condition	Rating			Unit	Measuring circuit
			Min.	Typ.	Max.		
Input voltage (BODLV,SCLV) (SCOEN)	VIH	V_{BAT}=1.3 to 3.6V	0.7 ×V_{BAT}	—	V_{BAT}	V	1
		V_{BAT}=1.1 to 3.6V	0.7 ×V_{BAT}	—	V_{BAT}		
	VIL	V_{BAT}=1.3 to 3.6V	0	—	0.3 ×V_{BAT}		
		V_{BAT}=1.1 to 3.6V	0	—	0.2 ×V_{BAT}		
Input 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	—	—		

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)

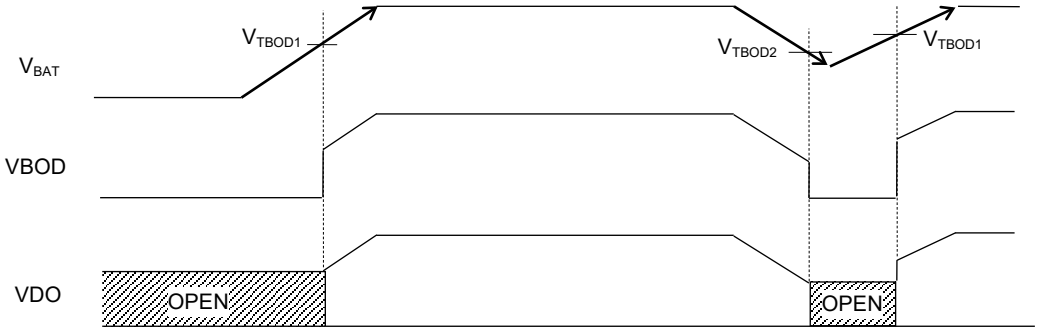
Parameter	Symbol	Condition	Rating Min.	Rating Typ.	Rating Max.	Unit	Measuring circuit
Output current (SCO)	ISCO1	V_{SC}=1.2V,SCO=1.1V, SCOEN="H"	—	—	-10	μA	2
	ISCO2	V_{SC}=3.4V, SCO=0V, SCOEN="L"	-0.05	—	—		

DC CHARACTERISTICS (Brown-out detection)

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

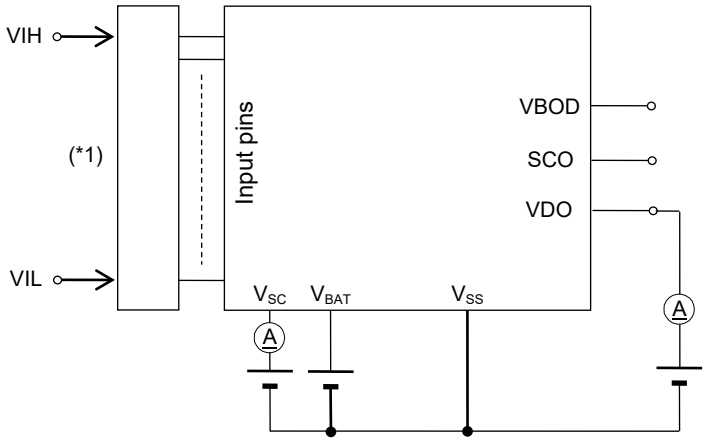
Parameter	Symbol	Condition		Rating Min.	Rating Typ.	Rating Max.	Unit	Measuring circuit
Reversal voltage (BOD) *1	V_{TBOD1}	V_{BAT}="L"⇒"H"	BODLV="L"	1.0	1.15	1.25	V	3
			BODLV="H"	1.7	1.8	1.9		
	V_{TBOD2}	V_{BAT}="H"⇒"L"		V_{TBOD1} -0.25	—	V_{TBOD1} -0.1		
Temperature characteristics (BOD)	T_{BOD}	In 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.



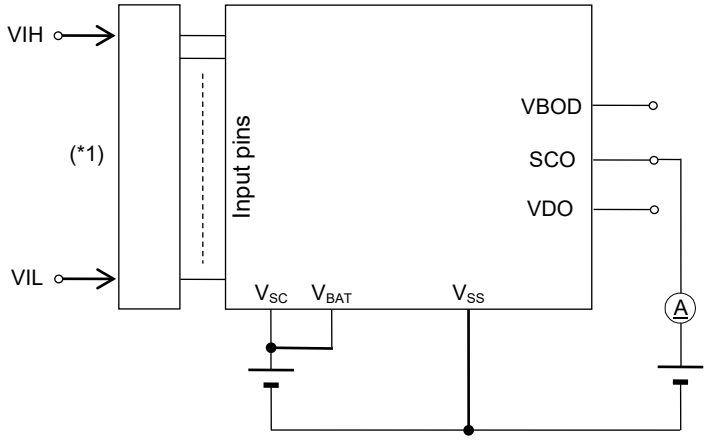
MEASURING CIRCUITS

MEASURING CIRCUIT 1



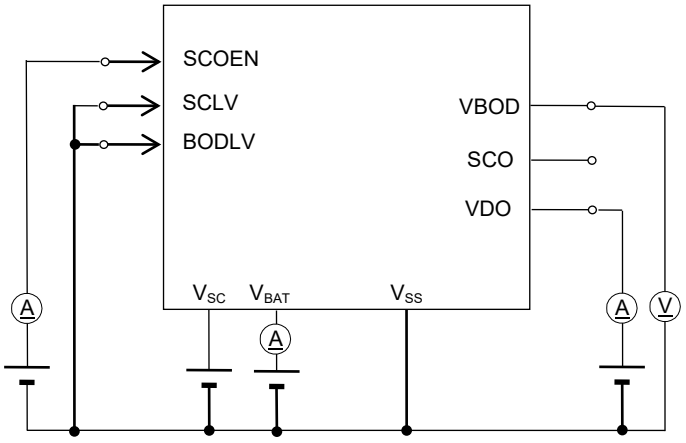
(*1) Input logic circuit to determine the specified measuring conditions.

MEASURING CIRCUIT 2



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

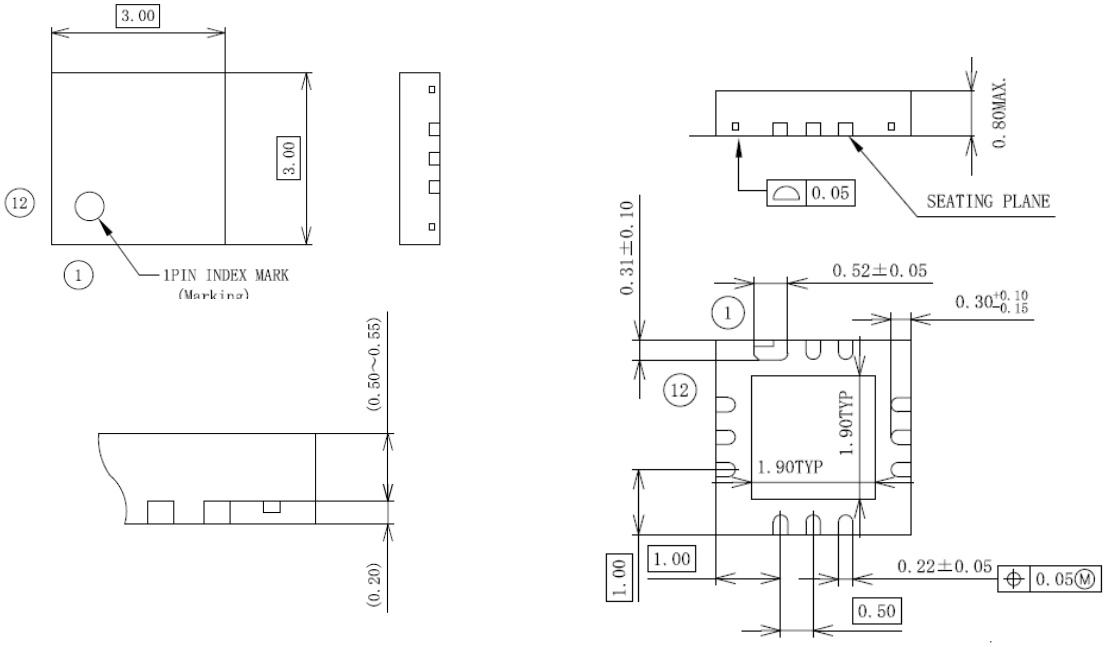
MEASURING CIRCUIT 3



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).

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

Notes

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