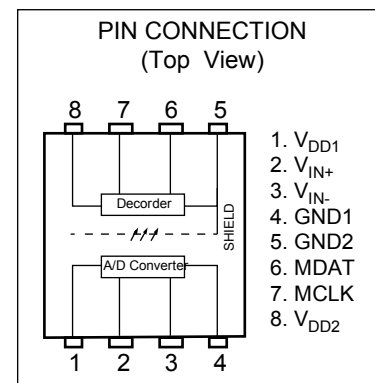# PS9352AL2

Optically Isolated Delta-Sigma Modulator

DESCRIPTION

The PS9352AL2 is an optically isolated Delta – Sigma Modulator that includes high-Accuracy A/D convertor and converts an analog voltage input into one-bit data stream. PS9352AL2 provides Effective Number of Bit (ENOB) is 12 bits (typ) with a Sinc^3 digital filter.

The PS9352AL2 is designed specifically for high common mode transient immunity (CMR) and high linearity (nonlinearity). The PS9352AL2 is suitable for current sensing and voltage sensing in motor drives.

FEATURES

- Internal Reference Voltage Tolerance (G_E = ±1% MAX.)
- Effective Number of Bit (ENOB = 12 bits TYP.)
- Operating Ambient Temperature (T_A = –40 to 110°C)
- Non-linearity (INL = 0.14% MAX.)
- Input Offset Voltage (V_{OS} = 3 mV MAX.)
- Input Offset Voltage Drift vs. Temperature ($\left| dV_{OS}/dT_A \right|$ = 2 μV/°C TYP.)
- Output Clock Frequency (f_{CLK} = 10 MHz TYP.)
- High common mode transient immunity (CMR= 15 kV/μs MIN.)
- Long creepage distance (8 mm MIN.)
- Embossed tape product: PS9352AL2-E3: 2 000 pcs/reel
- Pb-Free product
- Safety standards
  - UL approved: No. E72422
  - CSA approved: No. CA 101391 (CA5A, CAN/CSA-C22.2 60065, 60950)
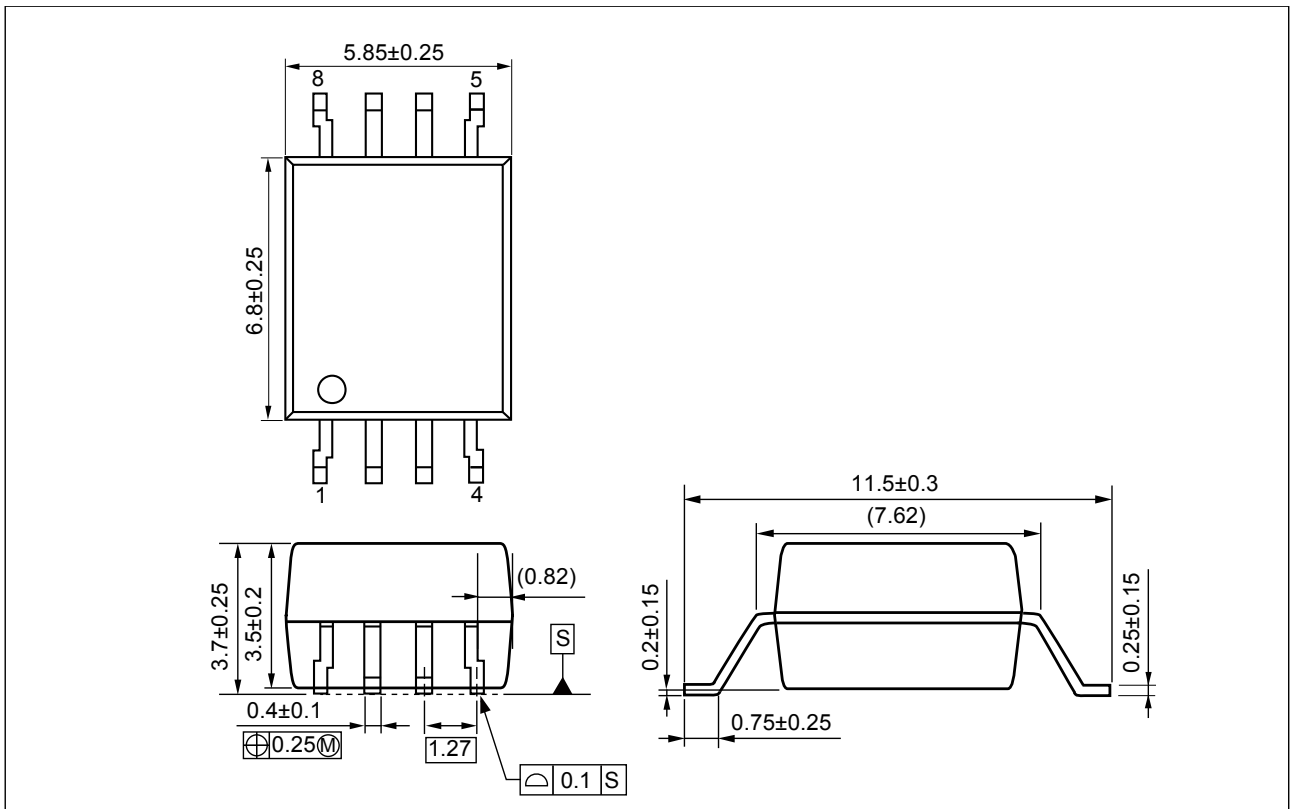 - DIN EN 60747-5-5 (VDE 0884-5) approved (Option)

PIN CONNECTION (Top View)


```
  8   7   6   5
┌──────────────────┐
│                  │
│     Decoder      │  SHIELD
│ ─ ─ ─ ─ ─ ─ ─ ─  │
│    A/D Converter │
│                  │
└──────────────────┘
  1   2   3   4
```

1. V_{DD1}
2. V_{IN+}
3. V_{IN-}
4. GND1
5. GND2
6. MDAT
7. MCLK
8. V_{DD2}

APPLICATIONS

- AC Servo, inverter
- Solar inverter
- Measurement equipment

PACKAGE DIMENSIONS (UNIT: mm)

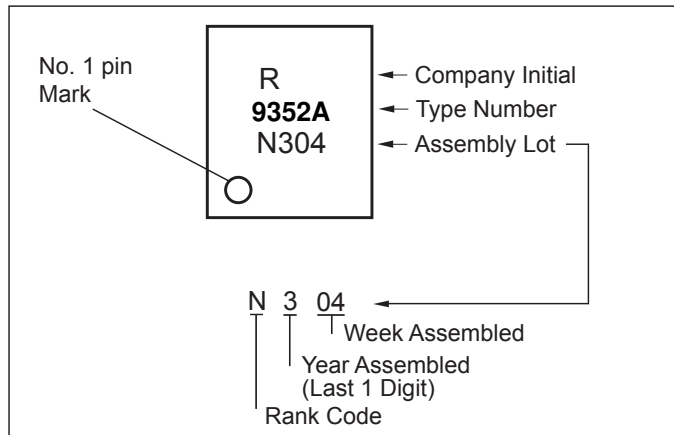**Lead Bending Type (Gull-wing) For Long Creepage Distance (Surface Mount)**

Weight: 0.316g (typ.)

PHOTOCOUPLER CONSTRUCTION

Parameter	MIN.
Air Distance	8 mm
Outer Creepage Distance	8 mm
Isolation Distance	0.4 mm

RENESAS

MARKING EXAMPLE

No. 1 pin
Mark

R
9352A
N304

← Company Initial
← Type Number
← Assembly Lot

N 3 04

Week Assembled

Year Assembled
(Last 1 Digit)

Rank Code

ORDERING INFORMATION

Part Number	Order Number	Solder Plating Specification	Packing Style	Safety Standard Approval	Application Part Number[1]
PS9352AL2	PS9352AL2-AX	Pb-Free (Ni/Pd/Au)	20 pcs (Tape 20 pcs cut)	Standard products (UL, CSA approved)	PS9352AL2
PS9352AL2-E3	PS9352AL2-E3-AX		Embossed Tape 2 000 pcs/reel		
PS9352AL2-V	PS9352AL2-V-AX		20 pcs (Tape 20 pcs cut)	UL,CSA approved, DIN EN 60747-5-5 (VDE 0884-5): 2011-11 approved (Option)	
PS9352AL2-V-E3	PS9352AL2-V-E3-AX		Embossed Tape 2 000 pcs/reel		

[1]   For the application of the Safety Standard, following part number should be used.

RENESAS

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Ratings	Unit
Operating Ambient Temperature	T_A	−40 to +110	°C
Storage Temperature	T_{stg}	−55 to +125	°C
Supply Voltage	V_{DD1}, V_{DD2}	0 to 5.5	V
Input Voltage	V_{IN+}, V_{IN-}	−2 to V_{DD1} +0.5	V
2 Seconds Transient Input Voltage	V_{IN+}, V_{IN-}	−6 to V_{DD1} +0.5	V
Output Voltage	V_{OUT+}, V_{OUT-}	−0.5 to V_{DD2} +0.5	V
Isolation Voltage[1]	BV	5 000	Vr.m.s.

*1 AC voltage for 1 minute at T_A = 25°C, RH = 60% between input and output.
Pins 1-4 shorted together, 5-8 shorted together.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	MIN.	TYP.	MAX.	Unit
Operating Ambient Temperature	T_A	−40		110	°C
Supply Voltage	V_{DD1}, V_{DD2}	4.5	5	5.5	V
Input Voltage (Accurate and Linear) [1]	V_{IN+}, V_{IN-}	−200		200	mV

*1 Using V_{IN-} = 0 V (to be connected to GND1) is recommended. Avoid using V_{IN-} of 2.5 V or more, because the internal test mode is activated when the voltage V_{IN-} reaches more than 2.5 V.

ELECTRICAL CHARACTERISTICS

(TYP.: $T_A = 25°C$, $V_{IN+} = V_{IN-} = 0$ V, $V_{DD1} = V_{DD2} = 5$ V,
MIN., MAX.: refer to RECOMMENDED OPERATING CONDITIONS, unless otherwise specified)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Input Supply Current	I_{DD1}	$V_{IN+} = 350$ mV		12.6	15	mA
Output Supply Current	I_{DD2}	$V_{IN+} = -350$ mV		7	13	mA
Input Bias Current	I_{IN}		-5	-0.6	5	μA
Low Level Saturated Output Voltage	V_{OL}	$I_{OUT} = 1.6$ mA		0.1	0.6	V
High Level Saturated Output Voltage	V_{OH}	$I_{OUT} = -100\ \mu$A	3.9	4.9		V
Output Short-circuit Current	$|I_{OSC}|$	$V_{OUT} = V_{DD2}$ or $V_{OUT} = GND2$		20	40	mA
Equivalent Input Resistance	R_{IN}			450		kΩ
Output Clock Frequency	f_{CLK}		8.2	10	13.2	MHz
Isolation Resistance	R_{I-O}	$V_{I-O} = 1$ kV$_{DC}$, $T_A = 25°C$	10^{11}			Ω
Isolation Capacitance	C_{I-O}	$f = 1$ MHz		0.7		pF
Data Hold Time [1]	t_{HDDAT}		4	10	16	ns
Common Mode Transient Immunity [2]	CMR	$V_{CM} = 1$ kV, $T_A = 25°C$	15			kV/μs

[1]   The data hold time (t_{HDDAT}) is that the data (MDAT) will stay stable following the rising edge of the clock (MCLK). t_{HDDAT} is shown in the below timing chart.
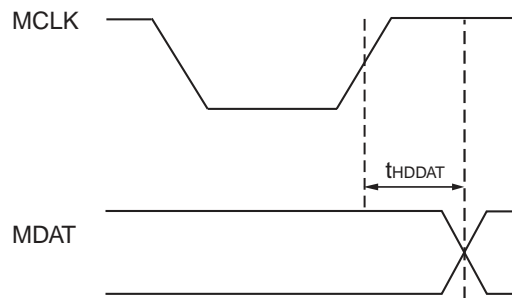

Fig. Timing Chart

[2]   Common Mode Transient Immunity (CMR) is specified by the rate of rise / fall of a pulse applied between GND1 on the input side and GND2 on the output side (pins 4 and 5) by using the circuit shown in **Fig. 6 CMR Test Circuit**. CMR is defined at the point that clock signals are corrupted.

ELECTRICAL CHARACTERISTICS (Tested with Sinc3 filter, 256 decimation ratio.)

(TYP.: TA = 25°C, VIN+ = VIN− = 0 V, VDD1 = VDD2 = 5 V,
MIN., MAX.: refer to RECOMMENDED OPERATING CONDITIONS, unless otherwise specified)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Integral Non-linearity *3	INL	−200 mV ≤ VIN+ ≤ 200 mV		3	30	LSB
				0.01	0.14	%
Differential Non-linearity *4	DNL	−200 mV ≤ VIN+ ≤ 200 mV			1	LSB
Input Offset Voltage *5	VOS		−3	0	3	mV
Input Offset Voltage Drift vs. Temperature	|dVOS/dTA|			2	10	μV/°C
Input Offset Voltage Drift vs. Supply Voltage	|dVOS/dVDD1|			0.1		mV/V
Internal Reference Voltage *6	VREF			320		mV
Absolute Internal Reference Voltage Tolerance	GE	TA = 25°C	−1		1	%
		TA = −40 to 110°C	−3		3	%
Internal Reference Voltage Drift vs. Temperature	|dVREF/dTA|			60		ppm/°C
Internal Reference Voltage Drift vs. Supply Voltage	|dVREF/dVDD1|			0.2		mV/V
Input DC Common-Mode Rejection Ratio *7	CMRRIN			70		dB

***3** Integral non-linearity (INL) is the maximum deviation between the ideal conversion line (best-fit line) and measured points. The best-fit line is obtained by using the least-squares method from the differential input voltage ($V_{IN+} − V_{IN-}$: V_{IN+} = −200 mV to 200 mV, V_{IN-} = 0 V) and the output data that is measured under the circuit shown in **Fig. 7 INL Test Circuit**. INL is defined as the ratio (%) obtained by dividing [Half of the peak to peak value of the deviation] by [full-scale differential input voltage 400 mV].
For example, if the differential input voltage is V_{IN+} = −200 mV to 200 mV, and the peak to peak value of the deviation is 1.12 mV, Integral non-linearity is obtained as follows:
INL = 1.12 mV/(2 × 400 mV) = 0.14%
And Input Full-Scale 640 mV (−320 to 320 mV) of PS9352AL2 is assigned 15 bits (2^{15} = 32768).
Therefore, Least Significant Bit (LSB) is 19.5 μV.
By LSB indication, above-mentioned INL is 1.12 mV/(2 × 0.0195 mV) = 29 LSBs.

***4** Differential non-linearity (DNL) is the difference between a measured code width and ideal 1 LSB in the ADC transfer curve.

***5** Input offset voltage (V_{OS}) is a measured value after Sinc³ digital filter when the input voltage is 0 V (V_{IN+} = V_{IN-} = 0 V).

***6** Absolute Internal Reference Voltage Tolerance (G_E) is the gap rate between the ideal conversion line slope (Slope = 1) and a best-fit line slope that provided by the least-squares method from a real conversion level output for the differential input voltage ($V_{IN+} − V_{IN-}$: V_{IN+} = −200 mV to 200 mV, V_{IN-} = 0 V).

***7** Input DC Common-Mode Rejection Ratio ($CMRR_{IN}$) is the ratio of the differential signal (V_{IN+} = −200 mV to 200 mV, V_{IN-} = 0 V) to the common-mode signal (V_{IN+} = V_{IN-} = −200 mV to 200 mV: Both input pins are connected). $CMRR_{IN}$ is defined as follows,

CMRRIN (dB) = 20log (Vdo/Vco)
    Vdo : Output voltage when the differential signal voltage input
    Vco : Output voltage when the common-mode signal voltage input

ELECTRICAL CHARACTERISTICS (Tested with Sinc^3 filter, 256 decimation ratio.)

(TYP.: T_A = 25°C, V_{IN+} = V_{IN-} = 0 V, V_{DD1} = V_{DD2} = 5 V,
MIN., MAX.: refer to RECOMMENDED OPERATING CONDITIONS, unless otherwise specified)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Signal to Noise Ratio [8]	SNR	V_{IN+} = 35 Hz, 400 mVpk-pk (141 mVr.m.s.) sine wave	62	74		dB
Total Harmonic Distortion [9]	THD			−80		dB
Signal to Noise and Distortion Ratio [10]	SNDR		51	72		dB
Effective Number of Bit [11]	ENOB		10	12		bits

[8] Signal to Noise Ratio (SNR) is the ratio of the AC signal power to the noise power that excludes harmonic signals and DC. SNR is defined as follows,

SNR (dB) = $10\log(P_S/P_N)$
    P_S: Signal power (fundamental)
    P_N: Noise power (excluding harmonic signals and DC)

[9] Total Harmonic Distortion (THD) is the ratio of the AC signal power (fundamental) to the sum of harmonic signals that are occurred by the non-linearity. THD is defined as follows,

THD (dB) = $10\log((P_{H2} + P_{H3} + ... + P_{H5})/P_S)$
    P_S: Signal power (fundamental)
    $P_{H2}, P_{H3} ... P_{H5}$: Second through fifth harmonics power

[10] Signal to Noise and Distortion ratio (SNDR) is the ratio of the AC signal power (fundamental) to the noise power plus distortion power. SNDR is defined as follows,

SNDR (dB) = $10\log(P_S/(P_N + P_{H2} + P_{H3} + ... + P_{H5}))$
    P_S: Signal power (fundamental)
    P_N: Noise power (excluding harmonic signals and DC)
    $P_{H2}, P_{H3} ... P_{H5}$: Second through fifth harmonics power

[11] Effective Number of Bit (ENOB) is the effective resolution of ADC that is considered the noise. ENOB is defined as follows,

ENOB (bits) = $(SNR-1.76)/6.02$

TEST CIRCUIT

Fig.1 I$_{DD1}$ Test Circuit

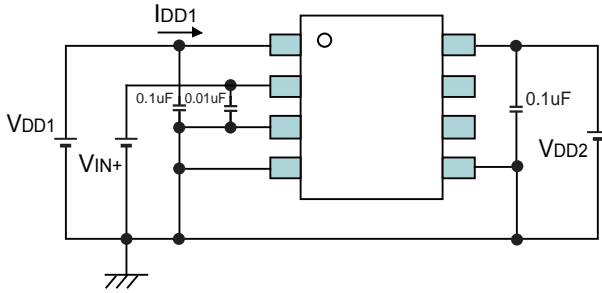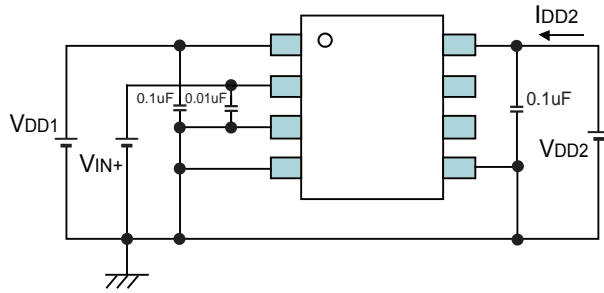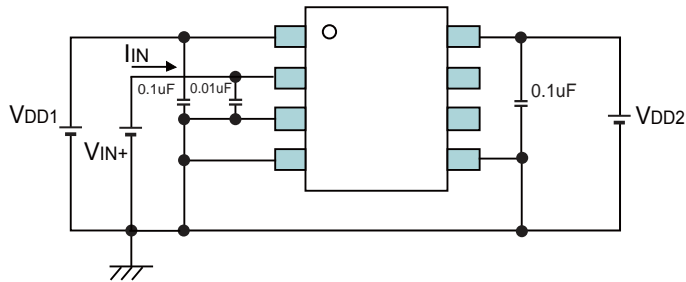Fig.2 I$_{DD2}$ Test Circuit

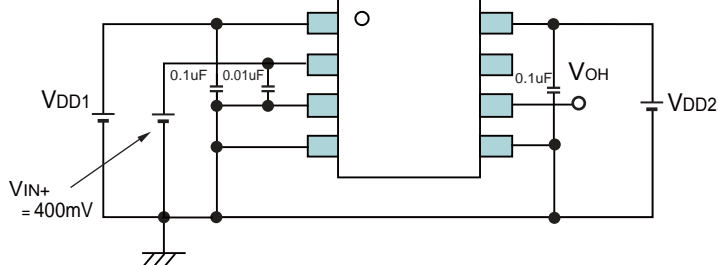Fig.3 I$_{IN}$ Test Circuit

Fig.4 Vout Test Circuit

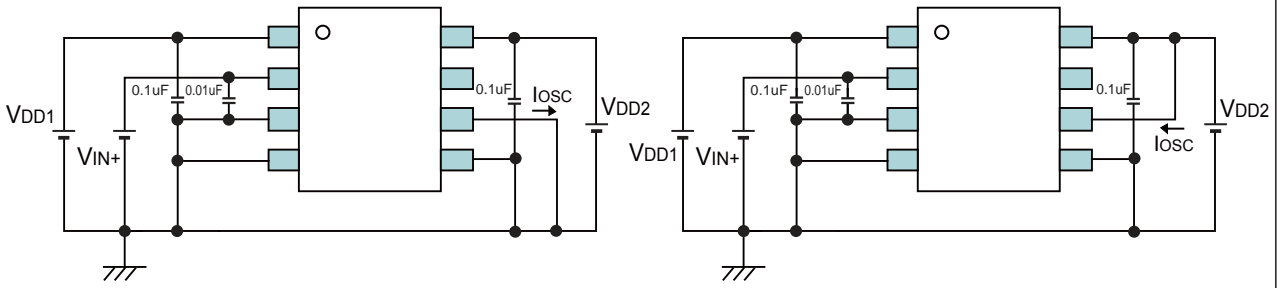（V$_{OL}$）
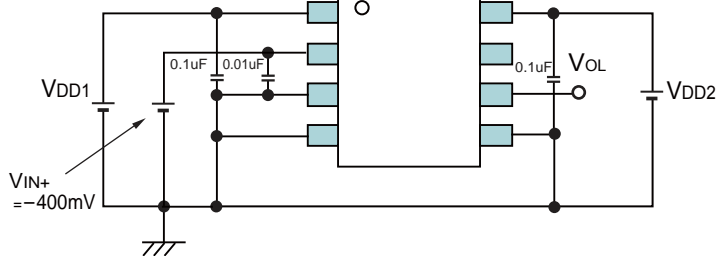
（V$_{OH}$）

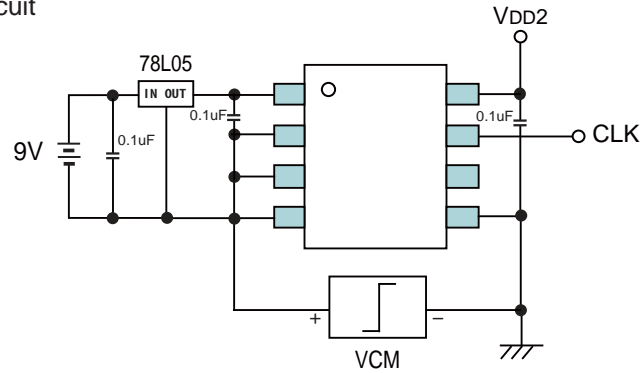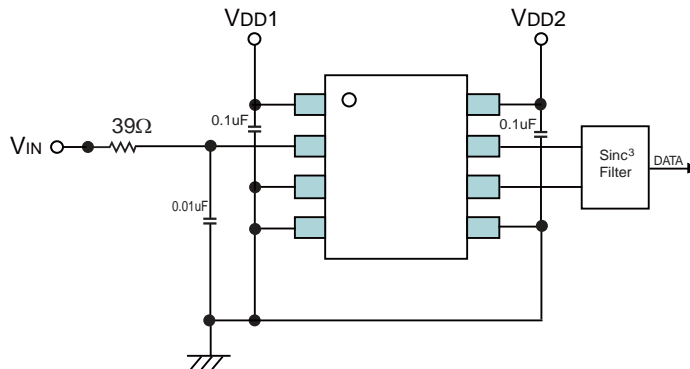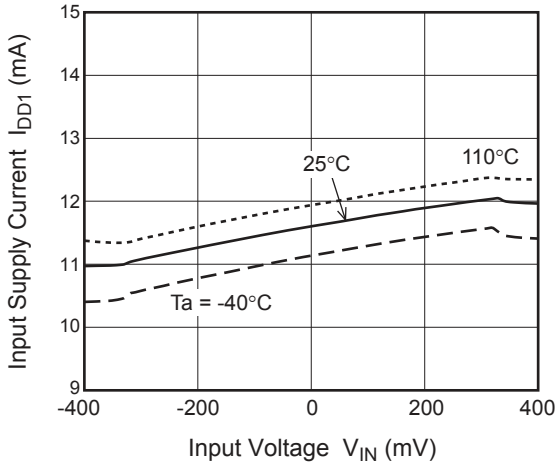Fig.5 I$_{OSC}$ Test Circuit

Fig.6 CMR Test Circuit

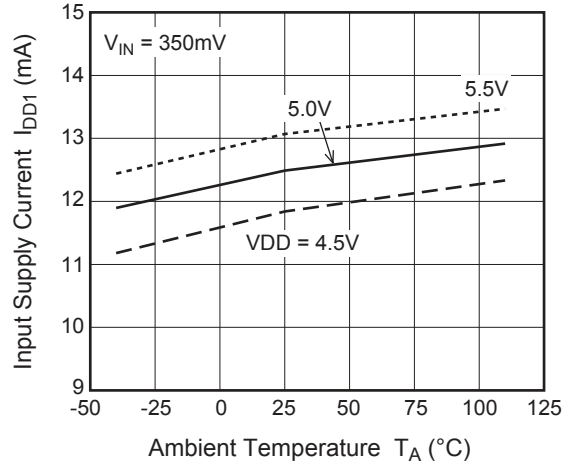Fig.7 Vos, INL, DNL, G$_E$, SNR, THD, SNDR, ENOB Test Circuit

TYPICAL CHARACTERISTICS (TA = 25°C, VIN+ = VIN− = 0 V, VDD1 = VDD2 = 5 V, tested with Sinc3 filter, 256 decimation ratio, unless otherwise specified)
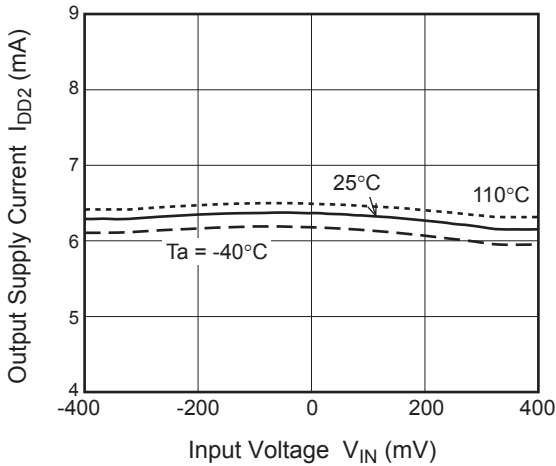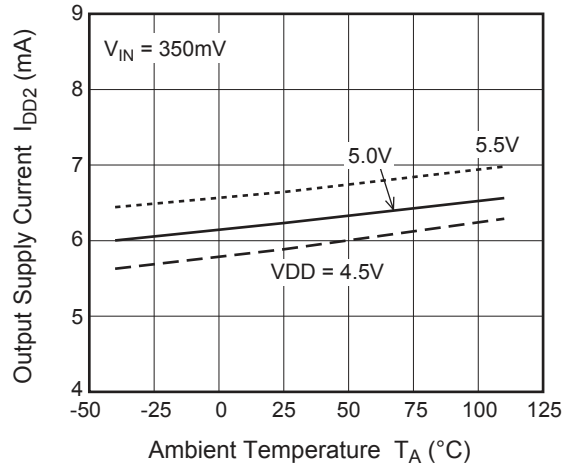
INPUT SUPPLY CURRENT vs.
INPUT VOLTAGE

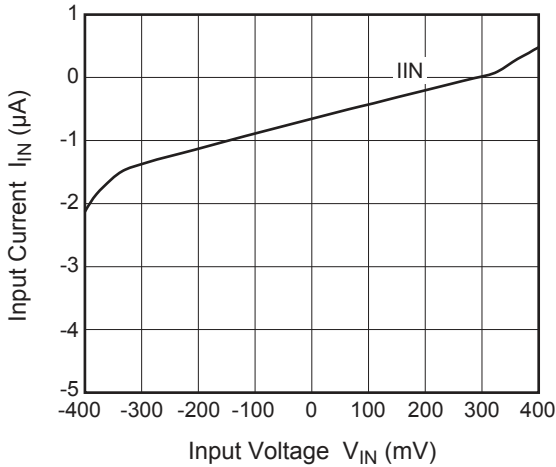INPUT SUPPLY CURRENT vs.
AMBIENT TEMPERATURE
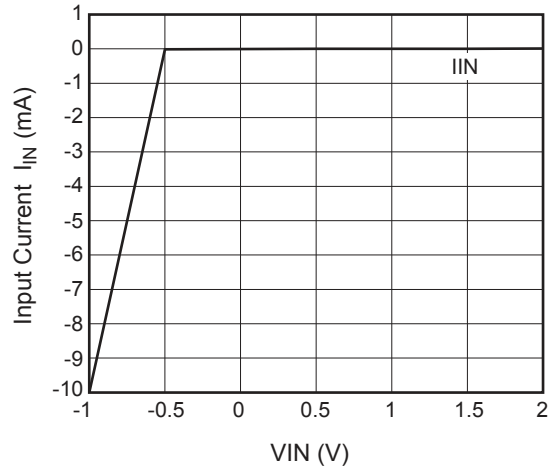
OUTPUT SUPPLY CURRENT vs.
INPUT VOLTAGE

OUTPUT SUPPLY CURRENT vs.
AMBIENT TEMPERATURE
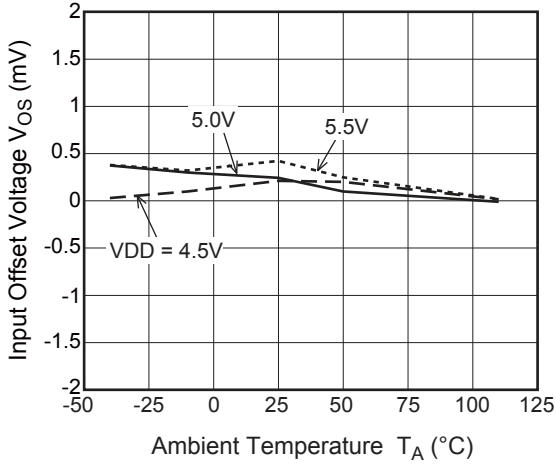
INPUT CURRENT vs. INPUT VOLTAGE

INPUT CURRENT vs. INPUT VOLTAGE

Remark The graphs indicate nominal characteristics.

INPUT OFFSET VOLTAGE vs. AMBIENT TEMPERATURE

INPUT OFFSET VOLTAGE CHANGE vs. AMBIENT TEMPERATURE
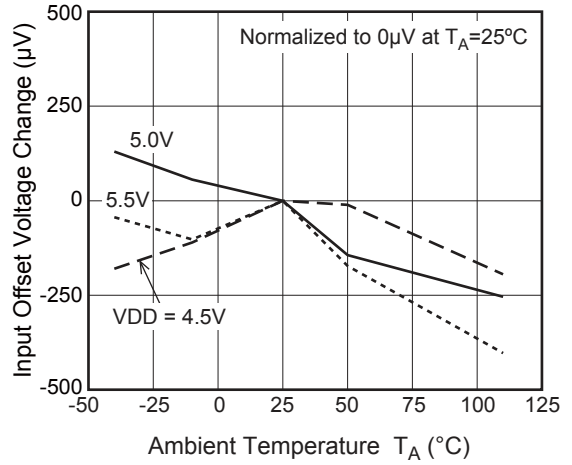
ABSOLUTE INTERNAL REFERENCE VOLTAGE TOLETANCE vs. AMBIENT TEMPERATURE

OUTPUT CLOCK FREQUENCY vs. AMBIENT TEMPERATURE

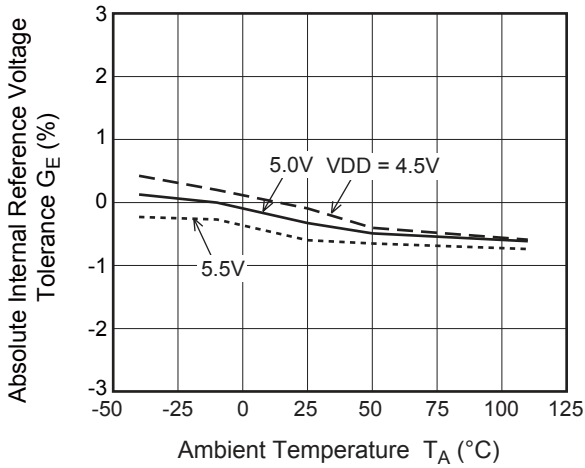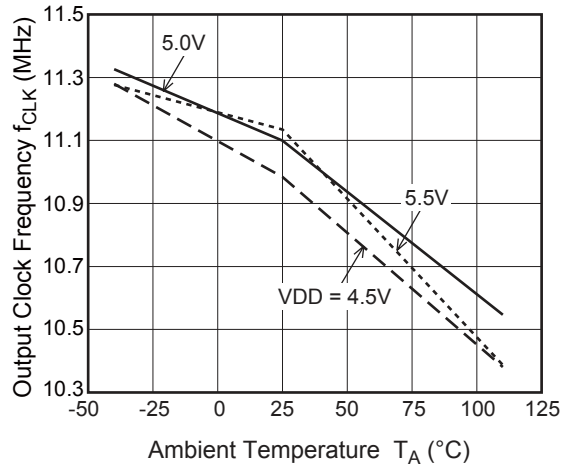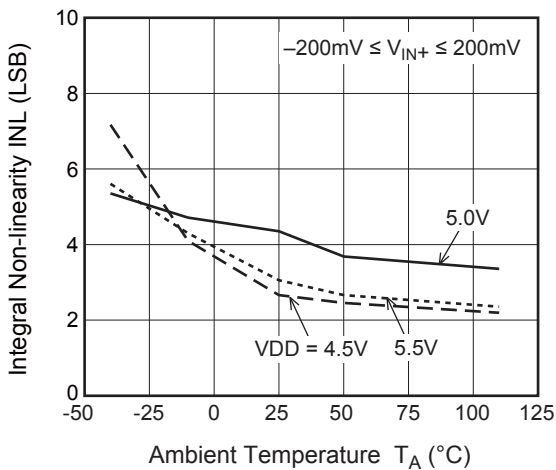### INTEGRAL NON-LINEARITY(LSB) vs. AMBIENT TEMPERATURE

INTEGRAL NON-LINEARITY(%) vs. AMBIENT TEMPERATURE
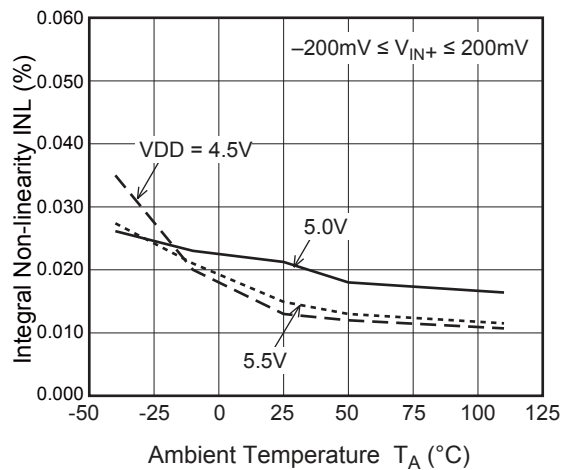
Remark The graphs indicate nominal characteristics.

SIGNAL TO NOISE RATIO vs.
AMBIENT TEMPERATURE

Signal to Noise Ratio SNR (dB)

VDD = 4.5V

5.0V

5.5V

V_{IN+} = 35Hz,400mV pk-pk
(141mVr.m.s.) sine wave

Ambient Temperature T_A (°C)
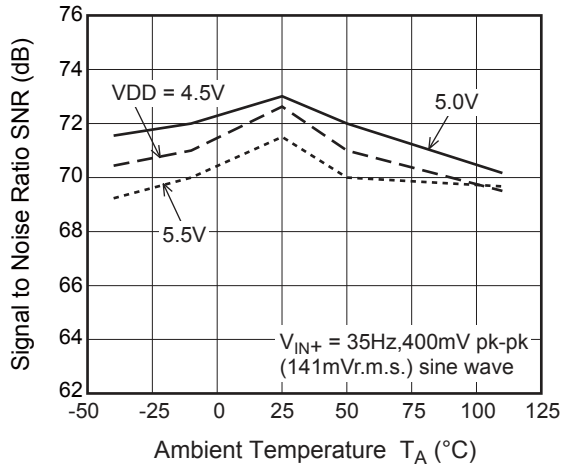
SIGNAL TO NOISE AND DISTORTION
RATIO vs. AMBIENT TEMPERATURE

Signal to Noise and Distortion Ratio SNDR (dB)

VDD = 4.5V

5.0V

5.5V

V_{IN+} = 35Hz,400mV pk-pk
(141mVr.m.s.) sine wave

Ambient Temperature T_A (°C)
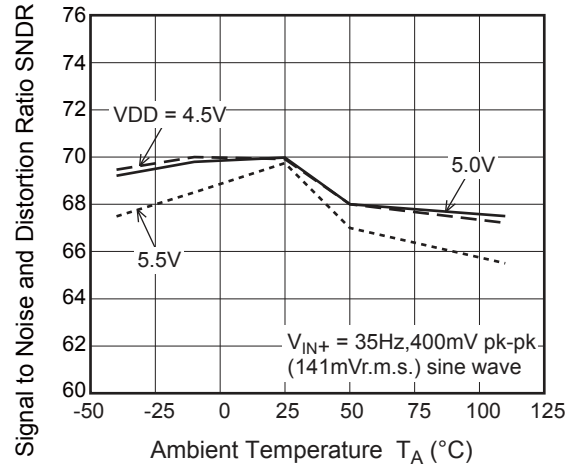
EFFECTIVE NUMBER OF BIT vs.
AMBIENT TEMPERATURE

Effective Number of Bit ENOB (bits)

VDD = 4.5V

5.0V

5.5V

V_{IN+} = 35Hz,400mV pk-pk
(141mVr.m.s.) sine wave

Ambient Temperature T_A (°C)
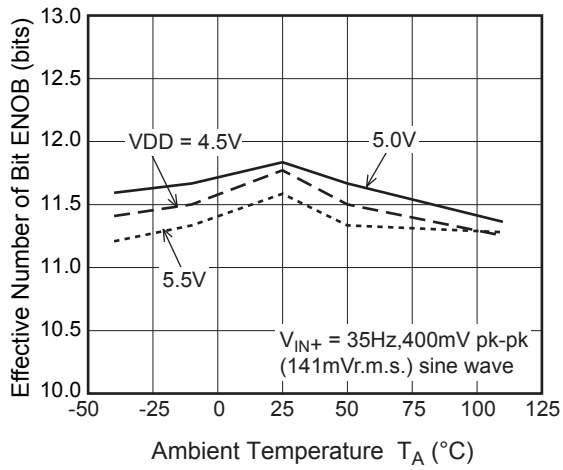
Remark The graphs indicate nominal characteristics.

TAPING SPECIFICATIONS (UNIT: mm)

Outline and Dimensions (Tape)

2.0±0.1

4.0±0.1

$\phi 1.5 ^{+0.1}_{-0}$

1.75±0.1

4.5 MAX.

11.5±0.1

$24.0 ^{+0.3}_{-0.1}$

12.0±0.1

$\phi 2.0 ^{+0.1}_{-0}$

8.0±0.1

6.35±0.1

4.05±0.1

0.35

Tape Direction

PS9352AL2-E3

Outline and Dimensions (Reel)

2.0±0.5

2.0±0.5

$\phi 13.0$±0.2

$\phi 330$±2.0

$\phi 100$±1.0

R 1.0

$\phi 21.0$±0.8

25.5±1.0

29.5±1.0

23.9 to 27.4
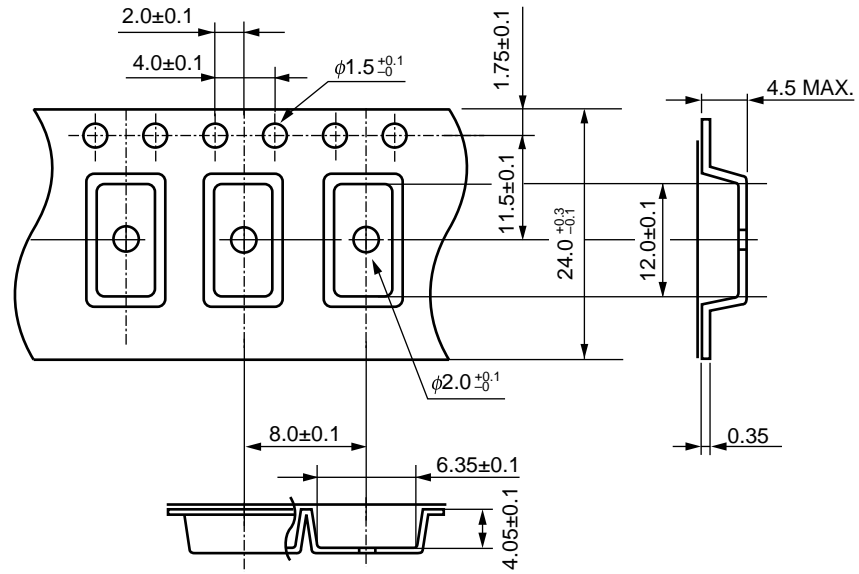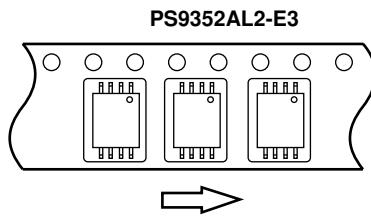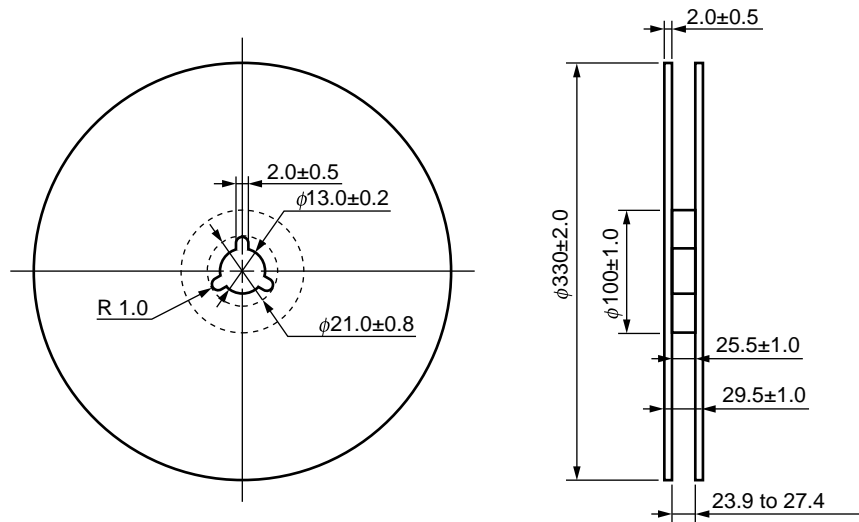
Packing: 2 000 pcs/reel

RECOMMENDED MOUNT PAD DIMENSIONS (UNIT: mm)

Part Number	Lead Bending	A	B	C	D
PS9352AL2	lead bending type (Gull-wing) for long creepage distance (surface mount)	10.2	1.27	0.8	2.2
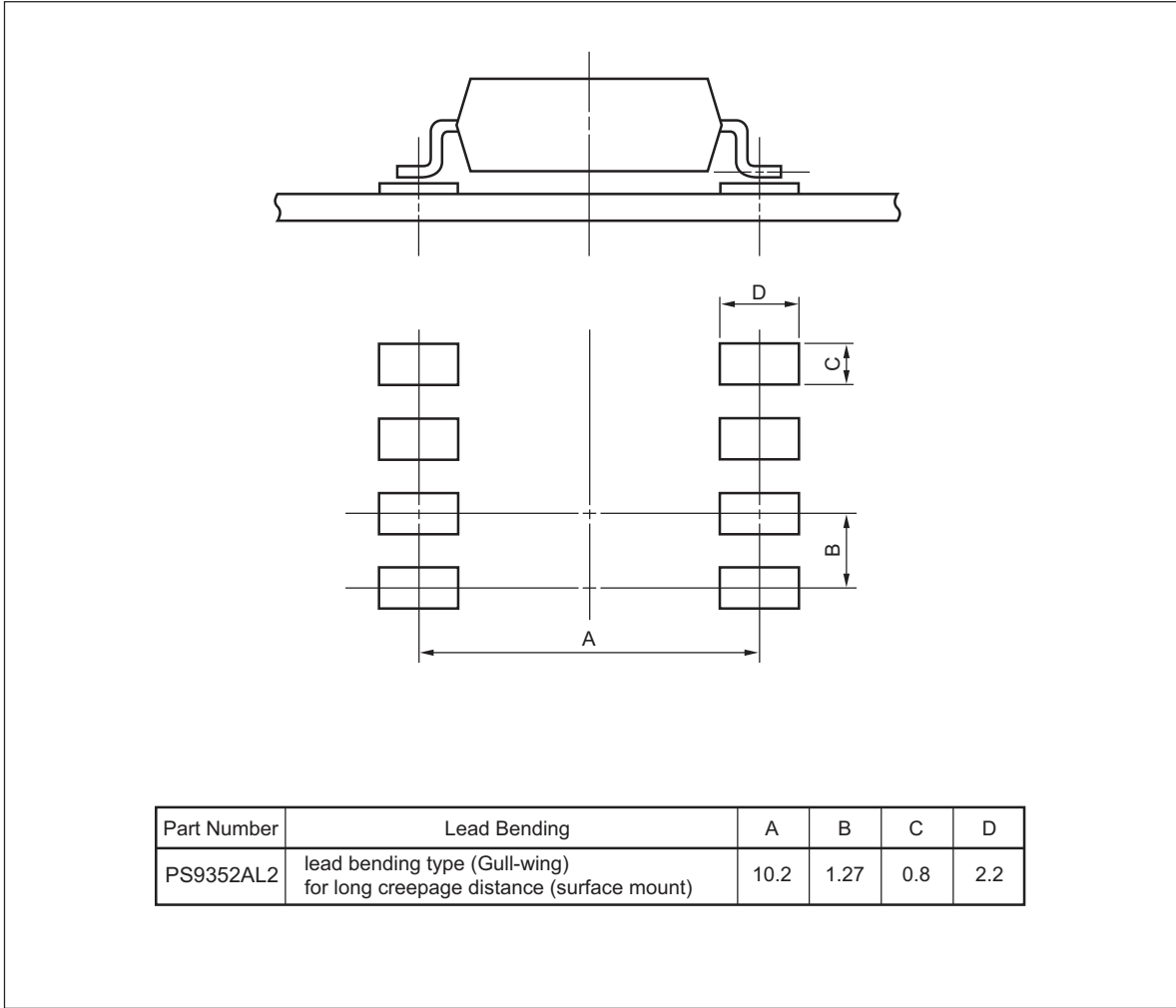
NOTES ON HANDLING

1. Recommended soldering conditions

(1) Infrared reflow soldering

- Peak reflow temperature   260°C or below (package surface temperature)
- Time of peak reflow temperature   10 seconds or less
- Time of temperature higher than 220°C   60 seconds or less
- Time to preheat temperature from 120 to 180°C   120±30 s
- Number of reflows   Three
- Flux   Rosin flux containing small amount of chlorine (The flux with a maximum chlorine content of 0.2 Wt% is recommended.)

Recommended Temperature Profile of Infrared Reflow

(2) Wave soldering

- Temperature   260°C or below (molten solder temperature)
- Time   10 seconds or less
- Preheating conditions   120°C or below (package surface temperature)
- Number of times   One (Allowed to be dipped in solder including plastic mold portion.)
- Flux   Rosin flux containing small amount of chlorine (The flux with a maximum chlorine content of 0.2 Wt% is recommended.)
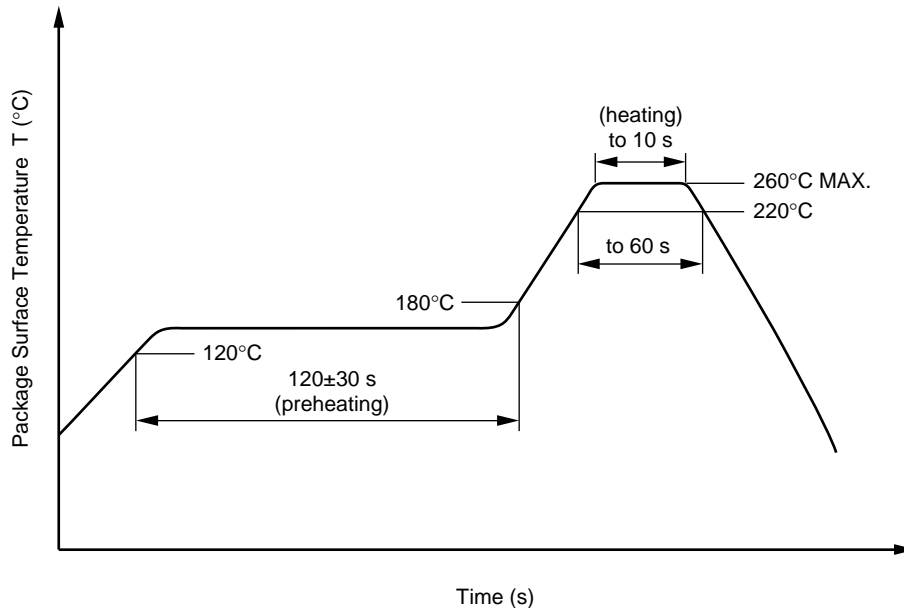
(3) Soldering by Soldering Iron

- Peak Temperature (lead part temperature)   350°C or below
- Time (each pins)   3 seconds or less
- Flux   Rosin flux containing small amount of chlorine (The flux with a maximum chlorine content of 0.2 Wt% is recommended.)

  (a) Soldering of leads should be made at the point 1.5 to 2.0 mm from the root of the lead

(4) Cautions
  • Fluxes
    Avoid removing the residual flux with freon-based and chlorine-based cleaning solvent.

2. Cautions regarding noise
    Be aware that when voltage is applied suddenly between the photocoupler's input and output at startup, the output transistor may enter the on state, even if the voltage is within the absolute maximum ratings.

USAGE CAUTIONS

1. This product is weak for static electricity by designed with high-speed integrated circuit so protect against static electricity when handling.
2. Board designing
    (1) Below figure shows a typical application circuit where the PS9352A is used. A digital filter (Sinc^3 filter) reduces high frequency quantization noise from the PS9352A and convers from one-bit data stream to 3-wire serial data.
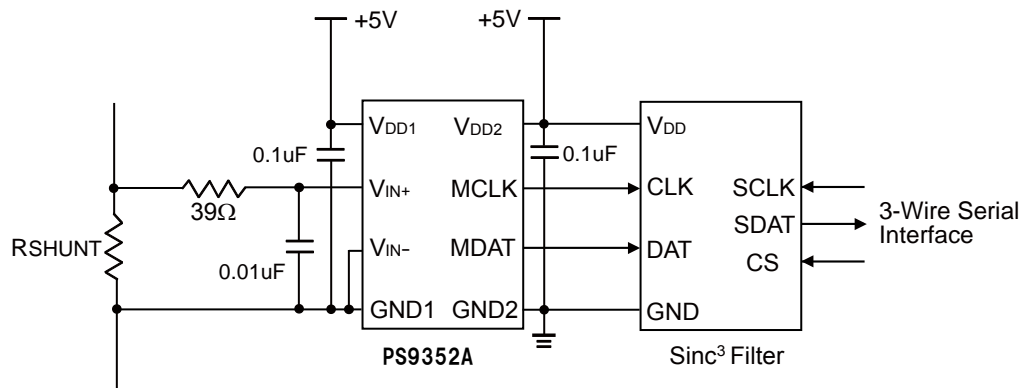

Fig. PS9352A Typical application circuit

    (2) By-pass capacitor of more than 0.1 μF is used between V$_{DD}$ and GND near device. Also, ensure that the distance between the leads of the photocoupler and capacitor is no more than 10 mm.
    (3) Keep the pattern connected the input (V$_{IN+}$, V$_{IN-}$) and the output (MCLK, MDAT), respectively, as short as possible. MCLK and MDAT are digital signal, but when the lines between the photocoupler and a digital filter are long, the digital filter might not read the data.
      When using long lines, use a line driver between the photocoupler and the digital filter, and keep the pattern between the output (MCLK, MDAT) and the line driver as short as possible.
    (4) Do not connect any routing to the portion of the frame exposed between the pins on the package of the photocoupler. If connected, it will affect the photocoupler's internal voltage and the photocoupler will not operate normally.
    (5) Because the maximum frequency of the signal input to the photocoupler must be lower than the allowable frequency band, be sure to connect an anti-aliasing filter (an RC filter with R = 39 Ω and C = 0.01 μF, for example).
    (6) When VDD is lower than 4.5 V that is the outside of recommended operating condition, the output (MCLK, MDAT) of this product is unstable, and this might produce undesirable operation. Be sure to check the operation of an IC that is connected to this product during Power-up and Power-down process. And we recommend to use a disable function (shutdown function) of the connected IC or a reset IC to avoid this undesirable operation.

3. Avoid storage at a high temperature and high humidity.

SPECIFICATION OF VDE MARKS LICENSE DOCUMENT

Parameter	Symbol	Spec.	Unit
Climatic test class (IEC 60068-1/DIN EN 60068-1)		40/110/21	
Dielectric strength maximum operating isolation voltage Test voltage (partial discharge test, procedure a for type test and random test) $U_{pr} = 1.6 \times U_{IORM}$, $P_d < 5$ pC	U_{IORM} U_{pr}	1 130 1 808	V_{peak} V_{peak}
Test voltage (partial discharge test, procedure b for all devices) $U_{pr} = 1.875 \times U_{IORM}$, $P_d < 5$ pC	U_{pr}	2 119	V_{peak}
Highest permissible overvoltage	U_{TR}	8 000	V_{peak}
Degree of pollution (DIN EN 60664-1 VDE 0110 Part 1)		2	
Comparative tracking index (IEC 60112/DIN EN 60112 (VDE 0303 Part 11))	CTI	175	
Material group (DIN EN 60664-1 VDE 0110 Part 1)		III a	
Storage temperature range	T_{stg}	−55 to +125	°C
Operating temperature range	T_A	−40 to +110	°C
Isolation resistance, minimum value $V_{IO} = 500$ V dc at $T_A = 25°C$ $V_{IO} = 500$ V dc at T_A MAX. at least 100°C	Ris MIN. Ris MIN.	10^{12} 10^{11}	Ω Ω
Safety maximum ratings (maximum permissible in case of fault, see thermal derating curve) Package temperature Current (input current I_F, Psi = 0) Power (output or total power dissipation) Isolation resistance $V_{IO} = 500$ V dc at $T_A = Tsi$	Tsi Isi Psi Ris MIN.	175 400 700 10^9	°C mA mW Ω

Dependence of maximum safety ratings with package temperature
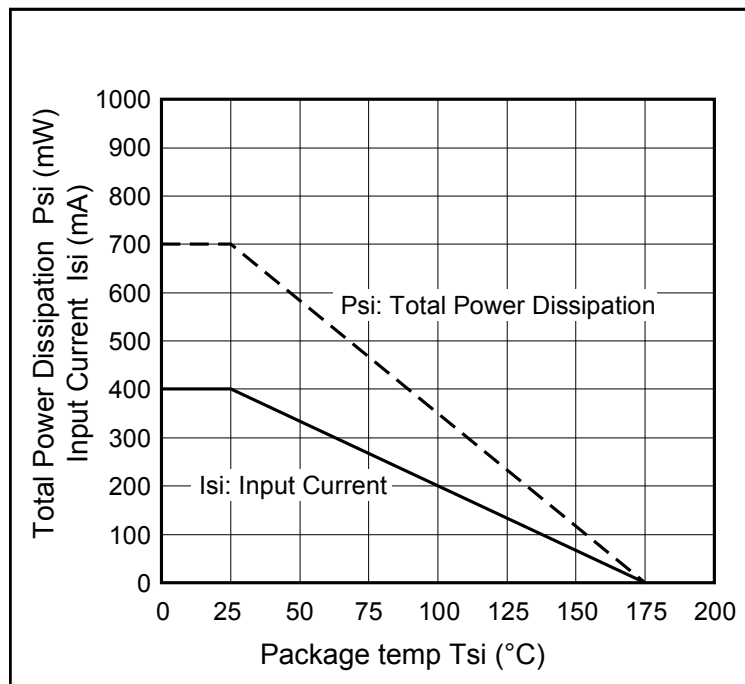
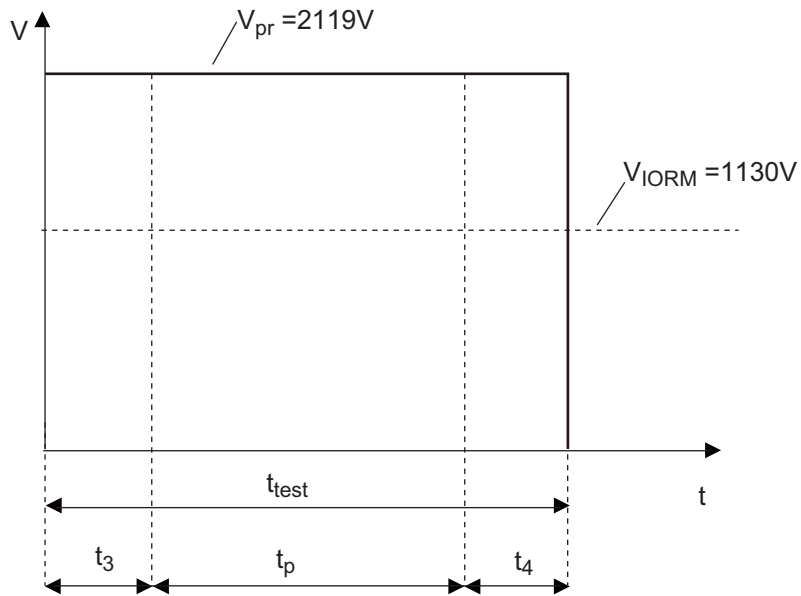## Method a Destructive Test, Type and Sample Test
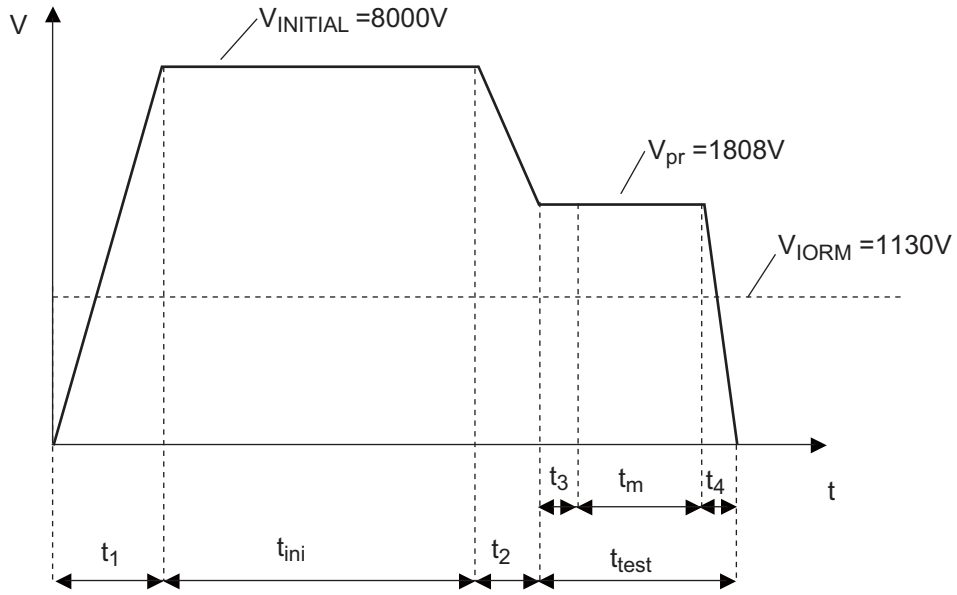
t_1, t_2 = 1 to 10 sec
t_3, t_4 = 1 sec
$t_{m(PARTIAL\ DISCHARGE)}$= 10 sec
t_{test} = 12 sec
t_{ini} = 60 sec

Method b Non-destructive Test, 100% Production Test

t_3, t_4 = 0.1 sec
$t_{m(PARTIAL\ DISCHARGE)}$= 1.0 sec
t_{test} = 1.2 sec

		This product uses gallium arsenide (GaAs). GaAs vapor and powder are hazardous to human health if inhaled or ingested, so please observe the following points.

Caution	GaAs Products	• Follow related laws and ordinances when disposing of the product. If there are no applicable laws and/or ordinances, dispose of the product as recommended below.
		
		  1. Commission a disposal company able to (with a license to) collect, transport and dispose of materials that contain arsenic and other such industrial waste materials.
		
		  2. Exclude the product from general industrial waste and household garbage, and ensure that the product is controlled (as industrial waste subject to special control) up until final disposal.
		
		• Do not burn, destroy, cut, crush, or chemically dissolve the product.
		
		• Do not lick the product or in any way allow it to enter the mouth.

Rev.	Date	Description		
		Page	Summary	
1.00	Aug 24, 2015	−	First edition issued	

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.

2. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.

3. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

4. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from such alteration, modification, copy or otherwise misappropriation of Renesas Electronics product.

5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The recommended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots etc.

   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; and safety equipment etc.

   Renesas Electronics products are neither intended nor authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems, surgical implantations etc.), or may cause serious property damages (nuclear reactor control systems, military equipment etc.). You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application for which it is not intended. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for which the product is not intended by Renesas Electronics.

6. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.

7. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or systems manufactured by you.

8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

9. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You should not use Renesas Electronics products or technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. When exporting the Renesas Electronics products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations.

10. It is the responsibility of the buyer or distributor of Renesas Electronics products, who distributes, disposes of, or otherwise places the product with a third party, to notify such third party in advance of the contents and conditions set forth in this document, Renesas Electronics assumes no responsibility for any losses incurred by you or third parties as a result of unauthorized use of Renesas Electronics products.

11. This document may not be reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.

12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

RENESAS

Renesas Electronics Corporation

http://www.renesas.com

SALES OFFICES

Refer to "http://www.renesas.com/" for the latest and detailed information.

California Eastern Laboratories, Inc.
4590 Patrick Henry Drive, Santa Clara, California 95054-1817, U.S.A.
Tel: +1-408-919-2500, Fax: +1-408-988-0279

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HALII Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141