

RV1S9355A

R08DS0315EJ0100

Rev. 1.00

20MHz Internal Clock High SNR Optically Isolated Delta-Sigma Modulator

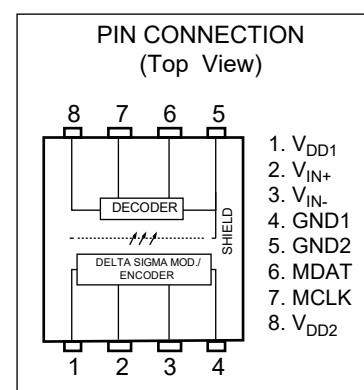
Feb. 05, 2025

DESCRIPTION

The RV1S9355A is an optically isolated Delta – Sigma Modulator that includes high-Accuracy A/D converter with 20 MHz internal clock and converts an analog voltage input into one-bit data stream. The RV1S9355A provides an Effective Number of Bit (ENOB) is 14 bits (TYP.) with a Sinc³ digital filter. The RV1S9355A is designed specifically for high common mode transient immunity (CMTI), high SNR and high linearity (Low nonlinearity). The RV1S9355A is suitable for the motor current sensing of the industrial instrument and enables high-precision measurement in the harsh noise environment.

FEATURES

- High SNR (88 dB TYP.)
- Gain Error (GE = $\pm 0.5\%$ @25 °C)
- Operating ambient temperature (T_A = -40 to 125 °C)
- Non-linearity (INL = ± 15 LSB)
- Input offset voltage (V_{OS} = ± 1 mV)
- Input offset voltage drift vs. temperature ($|dV_{OS}/dT_A| = 1.0 \mu V/^{\circ}C$ MAX.)
- Output clock frequency (f_{MCLK} = 20 MHz TYP.)
- High common mode transient immunity (CMTI = 50 kV/ μ s MIN.)
- Long creepage distance (8 mm MIN.)
- Embossed tape product: RV1S9355ACCSP-120x#KC0: 2 000 pcs/reel
- Pb-free product
- Safety standards
 - UL approved: No. UL1577, Double protection
 - VDE approved: DIN EN IEC 60747-5-5, DIN EN IEC 62368-1, Reinforced insulation (Option)



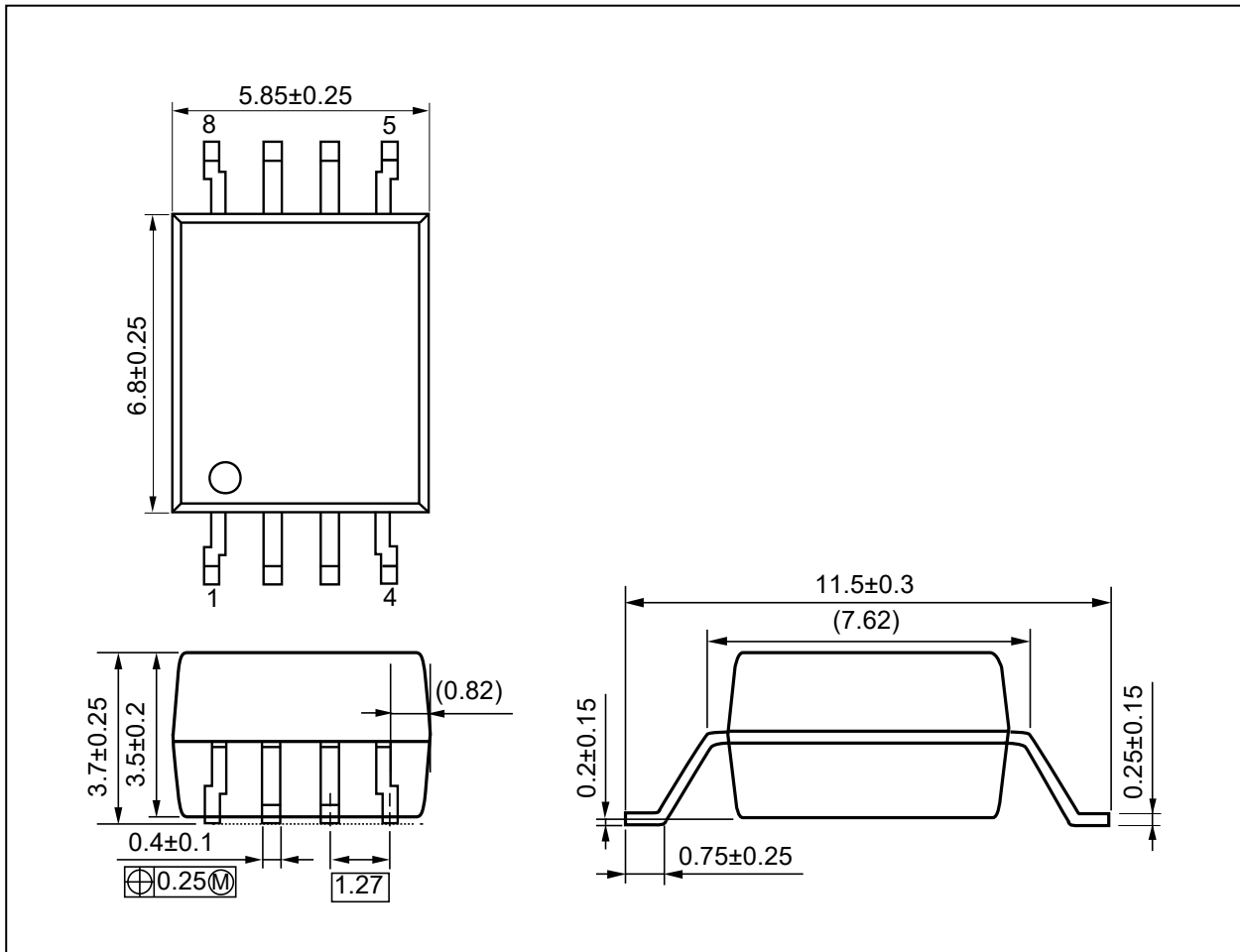
APPLICATIONS

- AC Servo, inverter
- Solar inverter
- Measurement equipment

Start of mass production
Dec. 2024

PACKAGE DIMENSIONS (UNIT: mm)

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

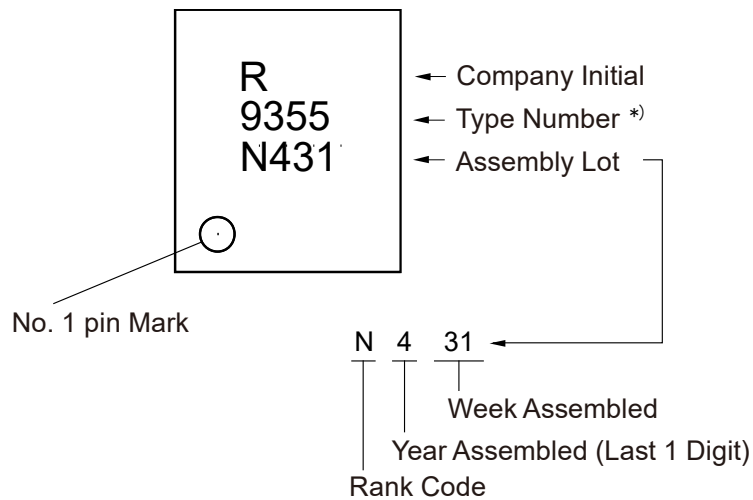


Weight : 0.316 g (TYP.)

PHOTOCOUPLER CONSTRUCTION

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

MARKING EXAMPLE



*Applicable type numbers are listed below.

RV1S 9355 ACCSP-120x

Marking type number. "RV1S" and "ACCSP-120x" are omitted from original type number.

ORDERING INFORMATION

Part Number	Order Number	Solder Plating Specification	Packing Style	Safety Standard Approval	Application Part Number *1
RV1S9355ACCSP-120C	RV1S9355ACCSP-120C#SC0	Pb-Free (Ni/Pd/Au)	Embossed Tape 20 pcs	UL Approved	RV1S9355A
	RV1S9355ACCSP-120C#KC0		Embossed Tape 2 000 pcs/reel		
RV1S9355ACCSP-120V	RV1S9355ACCSP-120V#SC0		Embossed Tape 20 pcs	UL, VDE Approved	
	RV1S9355ACCSP-120V#KC0		Embossed Tape 2 000 pcs/reel		

Notes : *1. For the application of the safety standard, the following part number should be used.

ABSOLUTE MAXIMUM RATINGS ($T_A = 25\text{ }^{\circ}\text{C}$, unless otherwise specified)

Parameter	Symbol	Ratings	Unit
Operating Ambient Temperature	T_A	-40 to +125	$^{\circ}\text{C}$
Storage Temperature	T_{stg}	-55 to +150	$^{\circ}\text{C}$
Supply Voltage	$V_{\text{DD1}}, V_{\text{DD2}}$	-0.5 to +6.0	V
Input Voltage ^{*1}	$V_{\text{IN+}}, V_{\text{IN-}}$	-2 to $V_{\text{DD1}} + 0.5$	V
Instantaneous Input Voltage ^{*1, 2}	$V_{\text{IN+}}, V_{\text{IN-}}$	-6 to $V_{\text{DD1}} + 0.5$	V
Output Voltage ^{*3}	MCLK, MDAT	-0.5 to $V_{\text{DD2}} + 0.5$	V
Isolation Voltage ^{*4}	BV	5 000	Vr.m.s.

Notes : *1. The input voltage of $V_{\text{IN+}}$ and $V_{\text{IN-}}$ terminals is less than 6 V.

*2. Duration of time is within 2 seconds.

*3. The input voltage of MCLK and MDAT terminals is less than 6 V.

*4. AC voltage for 1 minute at $T_A = 25\text{ }^{\circ}\text{C}$, 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		125	$^{\circ}\text{C}$
Supply Voltage	V_{DD1}	4.5		5.5	V
Supply Voltage	V_{DD2}	3		5.5	V
Input Voltage (Accurate and Linear) ^{*1}	$V_{\text{IN+}}, V_{\text{IN-}}$	-250		250	mV

Notes : *1. Avoid using $V_{\text{IN-}}$ of 2.5 V or more, because the internal test mode is activated when the voltage $V_{\text{IN-}}$ reaches more than 2.5 V.

ELECTRICAL CHARACTERISTICS

(TYP.: $T_A = 25\text{ }^{\circ}\text{C}$, $V_{IN+} = -250\text{ to }+250\text{ mV}$, $V_{IN-} = 0\text{ V}$, $V_{DD1} = 5\text{ V}$, $V_{DD2} = 3.3\text{ V}$,
MIN., MAX.: refer to RECOMMENDED OPERATING CONDITIONS, unless otherwise specified)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Primary-side Supply Current *1	I_{DD1}	$V_{IN+} = -320\text{ to }+320\text{ mV}$		12	15	mA
Secondary-side Supply Current *1	I_{DD2}	$V_{DD2} = 3.0\text{ to }3.6\text{ V}$		7.5	10.5	mA
		$V_{DD2} = 4.5\text{ to }5.5\text{ V}$		9	11.5	mA
Input Bias Current *1	I_{IN}	$V_{IN+} = 0\text{ V}$		-30		μA
Equivalent Input Resistance	R_{IN}	$V_{IN+} = -250\text{ to }+250\text{ mV}$		13		$\text{k}\Omega$
Low Level Saturated Output Voltage	V_{OL}	$I_{OUT} = +4\text{ mA}$			0.5	V
High Level Saturated Output Voltage	V_{OH}	$V_{DD2} = 3.3\text{ V}$, $I_{OUT} = -4\text{ mA}$	$V_{DD2} - 0.5$	$V_{DD2} - 0.1$		V
		$V_{DD2} = 5\text{ V}$, $I_{OUT} = -4\text{ mA}$				
Output Clock Frequency	f_{MCLK}	$C_L = 15\text{ pF}$	19	20	21	MHz
Isolation Capacitance	C_{I-O}	$f = 1\text{ MHz}$		0.7		pF
Data Hold Time *2	t_h	$C_L = 15\text{ pF}$	5	12		ns
Set Up Time	t_s		18	35		ns
RisingTime	t_r			2		
FallingTime	t_f			2		
Start Up Time *3	t_{START}			1	10	μs
Common Mode Transient Immunity *4	CMTI	$V_{CM} = 1.0\text{ kV}$, $T_A = 25\text{ }^{\circ}\text{C}$	50	100		$\text{kV}/\mu\text{s}$

Notes :

*1. The polarity of the current flowing from the external circuit to the RV1S9355A is positive.

*2. The data hold time (t_h) is that the data (MDAT) will stay stable following the rising edge of the clock (MCLK).

Timing chart is shown in the below timing chart.

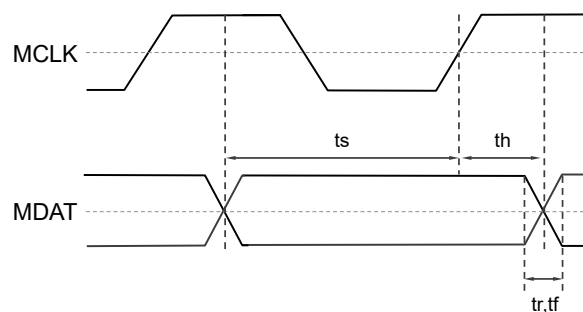


Fig. Timing Chart

*3. The start-up time is from the time V_{DD1} is applied with V_{DD2} applied to the output of normal signals (MCLK, MDATA).

*4. Common-mode transient immunity CMTI measurements apply steep rise/fall time voltage steps between GND1 (4-pin) on the input side and GND2 (5-pin) on the output side. The determination is performed after 1 μs after the voltage step is applied.

ELECTRICAL CHARACTERISTICS

(TYP.: $T_A = 25\text{ }^{\circ}\text{C}$, $V_{IN+} = -250\text{ to }+250\text{ mV}$, $V_{IN-} = 0\text{ V}$, $V_{DD1} = 5\text{ V}$, $V_{DD2} = 3.3\text{ V}$,
MIN., MAX.: refer to RECOMMENDED OPERATING CONDITIONS, unless otherwise specified)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Integral Non-Linearity *5	INL+	$T_A = -40\text{ to }125\text{ }^{\circ}\text{C}$, $V_{IN+} = -250\text{ to }+250\text{ mV}$		3	15	LSB
	INL-		-15	-3		
Differential Non-Linearity *6	DNL	$T_A = -40\text{ to }125\text{ }^{\circ}\text{C}$, $V_{IN+} = -250\text{ to }+250\text{ mV}$	-0.9		0.9	LSB
Input Offset Voltage *7	V_{OS}	$T_A = -40\text{ to }125\text{ }^{\circ}\text{C}$, $V_{IN+} = V_{IN-} = 0\text{ V}$	-1	0	1	mV
Input Offset Voltage Drift vs. Temperature	$ dV_{OS}/dT_A $	$V_{DD1} = 5\text{ V}$		0	1	$\mu\text{V}/^{\circ}\text{C}$
Input Offset Voltage Drift vs. Supply Voltage	$ dV_{OS}/dV_{DD1} $			40		$\mu\text{V}/\text{V}$
Gain Error *8	GE	$T_A = 25\text{ }^{\circ}\text{C}$ $V_{IN+} = -250\text{ to }+250\text{ mV}$ $V_{IN-} = 0\text{ V}$	-0.5		0.5	%
		$T_A = -40\text{ to }125\text{ }^{\circ}\text{C}$ $V_{IN+} = -250\text{ to }+250\text{ mV}$ $V_{IN-} = 0\text{ V}$	-1.0		1.0	
Gain Error Drift vs. Temperature *9	$ dGE/dT_A $			20	40	ppm/ $^{\circ}\text{C}$
Gain Error Drift vs. Supply Voltage *10	$ dGE/dV_{DD1} $			410		ppm/V
Common-Mode Rejection Ratio *11	CMRR_{IN}	$V_{IN} = \pm 250\text{ mV}$, Diff-G/Com-G		90		dB

*5. INL (Integral Non-Linearity) is the maximum deviation on the positive side (INL+) and the maximum deviation on the negative side (INL-) of the actual conversion value relative to the best-fit straight line obtained by the least squares method from the actual conversion value output for the differential input voltage ($V_{IN+} - V_{IN-}$: $V_{IN+} = -250\text{ mV}$ to 250 mV , $V_{IN-} = 0\text{ V}$) in LSB. Since 16 bits ($2^{16} = 65536$) are assigned to the full scale of 640 mV ($-320\text{ to }320\text{ mV}$), the minimum resolution of 1 LSB (Least Significant Bit) is $9.76\text{ }\mu\text{V}$ in voltage.

*6. DNL (Differential Non-Linearity) is the difference between a measured code width and ideal 1 LSB in the ADC transfer curve.

*7. V_{OS} means the difference between the ideal mid-scale code (32,768 at the 16-bit level) when the input voltage is 0 V ($V_{IN+} = V_{IN-} = 0\text{ V}$). This LSB difference is converted to a voltage and expressed.

*8. GE (Gain Error) is the deviation between the slope of the best-fit line of the measured digital code output within the input voltage range ($V_{IN+} = -250\text{ to }+250\text{ mV}$) and the slope of the ideal conversion line.

*9. $|dGE/dT_A|$ is calculated as the maximum temperature range change $\{(Gain @ 125\text{ }^{\circ}\text{C} - Gain @ 25\text{ }^{\circ}\text{C}) / Gain @ 25\text{ }^{\circ}\text{C}\} / (125\text{ }^{\circ}\text{C} - 25\text{ }^{\circ}\text{C})$ and the minimum temperature range change $\{(Gain @ -40\text{ }^{\circ}\text{C} - Gain @ 25\text{ }^{\circ}\text{C}) / Gain @ 25\text{ }^{\circ}\text{C}\} / \{(-40\text{ }^{\circ}\text{C}) - 25\text{ }^{\circ}\text{C}\}$ based on $25\text{ }^{\circ}\text{C}$. The unit is ppm/ $^{\circ}\text{C}$. The maximum and minimum temperature changes are compared and the larger change is used as the maximum value. The GE change based on $25\text{ }^{\circ}\text{C}$ will not exceed this maximum value as long as it is within the maximum and minimum temperature range.

*10. $|dGE/dV_{DD1}|$ is calculated by the maximum voltage range change amount $\{(Gain @ 5.5\text{ V} - Gain @ 5.0\text{ V}) / Gain @ 5.0\text{ V}\} / (5.5\text{ V} - 5.0\text{ V})$ and the minimum voltage range change amount $\{(Gain @ 4.5\text{ V} - Gain @ 5.0\text{ V}) / Gain @ 5.0\text{ V}\} / (4.5\text{ V} - 5.0\text{ V})$ based on 5.0 V . The unit is ppm/V.

*11. CMRR_{IN} (Common-Mode Rejection Ratio) is the Gain ratio between the differential input ($V_{IN+} = -250\text{ mV}$ to 250 mV , $V_{IN-} = 0\text{ V}$) and the common-mode input ($V_{IN+} = V_{IN-} = -250\text{ mV}$ to 250 mV : both input pins connected). Expressed in dB, it is defined by the following formula: $\text{CMRR}_{IN} [\text{dB}] = 20 \log (G_{do}/G_{co})$
 G_{do} = Differential Input Gain
 G_{co} = Common-mode input gain

ELECTRICAL CHARACTERISTICS (Tested with Sinc³ filter, 256 decimation ratio.)(TYP.: $T_A = 25\text{ }^{\circ}\text{C}$, $V_{IN+} = -250\text{ to }+250\text{ mV}$, $V_{IN-} = 0\text{ V}$, $V_{DD1} = 5\text{ V}$, $V_{DD2} = 3.3\text{ V}$,

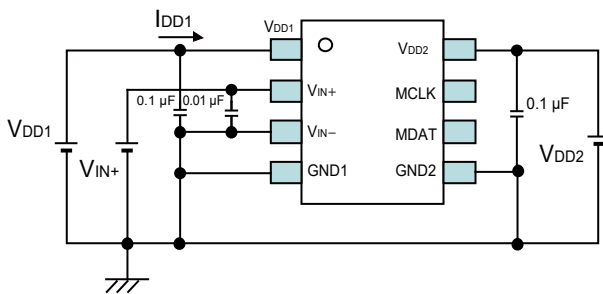
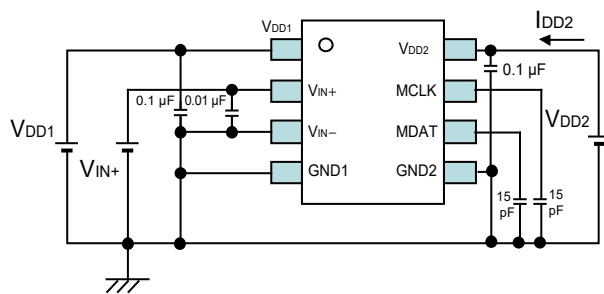
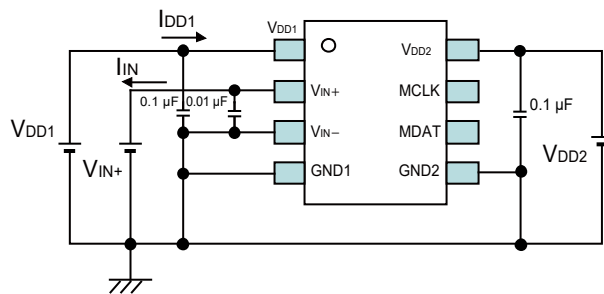
MIN., MAX.: refer to RECOMMENDED OPERATING CONDITIONS, unless otherwise specified)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Signal-to-Noise Ratio	SNR	$V_{IN+} = 35\text{ Hz}$, 500 mVpp sine wave	83	88		dB
Signal-to-(Noise + Distortion) Ratio	SNDR		78	84		dB
Effective Number of Bit	ENOB		13.5	14.0		bits
Total Harmonics Distortion	THD			-92		dB

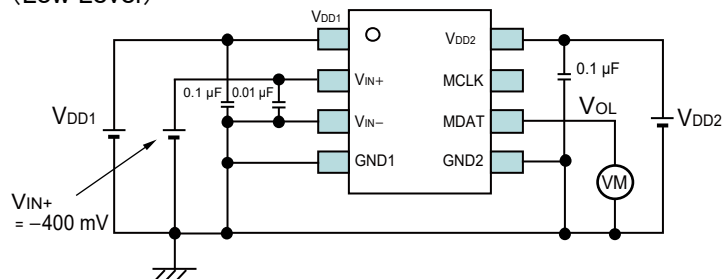
AD CONVERSION TABLE

Analog Input	Input Voltage mV	ADC Code 16-bit Unsigned Decimation
+Full scale	+320	65,535
+ side Recommended input signal	+250	58,367
Input 0	0	32,768
- side Recommended input signal	-250	7,167
- Full scale	-320	0

TEST CIRCUIT

Fig.1 I_{DD1} Test CircuitFig.2 I_{DD2} Test CircuitFig.3 I_{IN} Test CircuitFig.4 V_{OUT} Test Circuit

(Low Level)



(High Level)

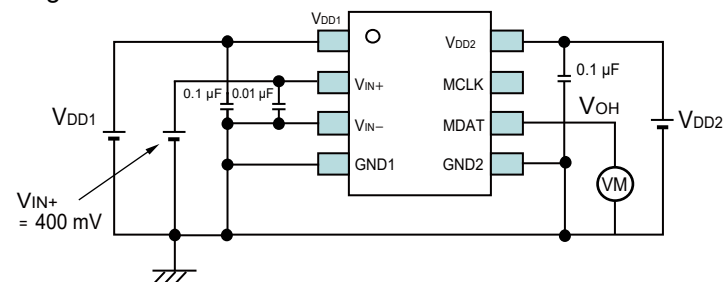


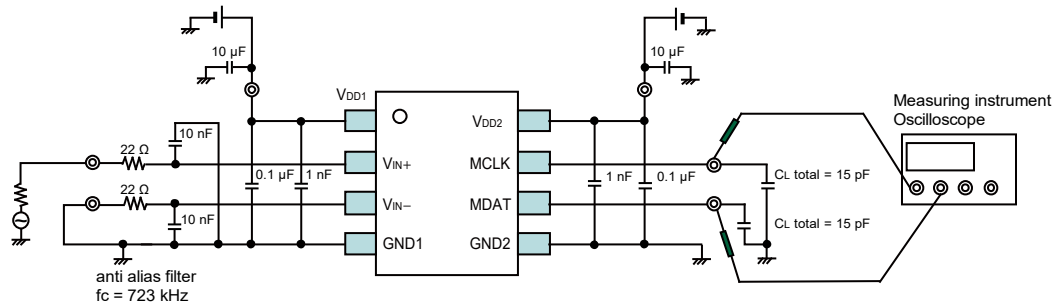
Fig.5 t_h , t_s , t_r , t_f Test Circuit

Fig.6 CMTI Test Circuit

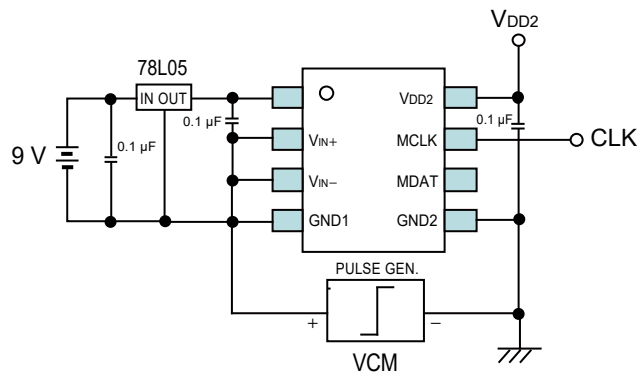
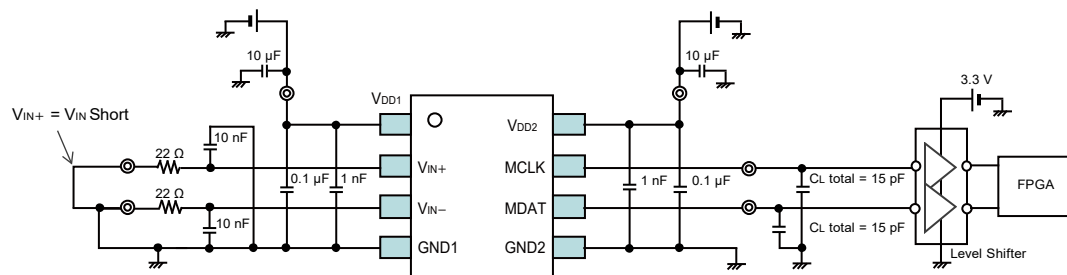
Fig.7 V_{os} Test Circuit

Fig.8 GE, INL, DNL Test Circuit

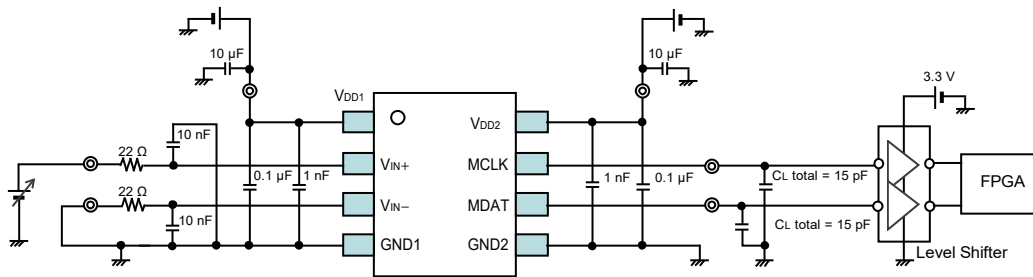
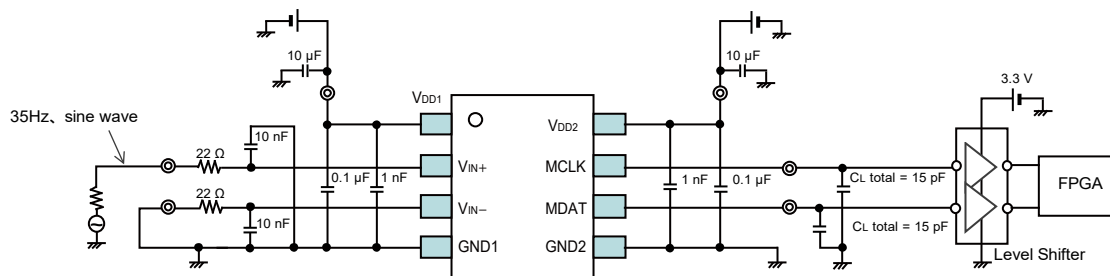


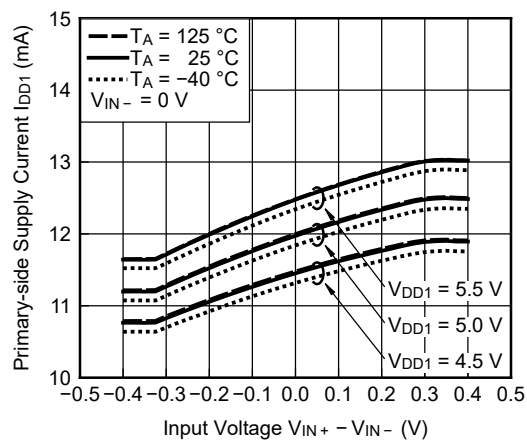
Fig.9 SNR, SNDR Test Circuit



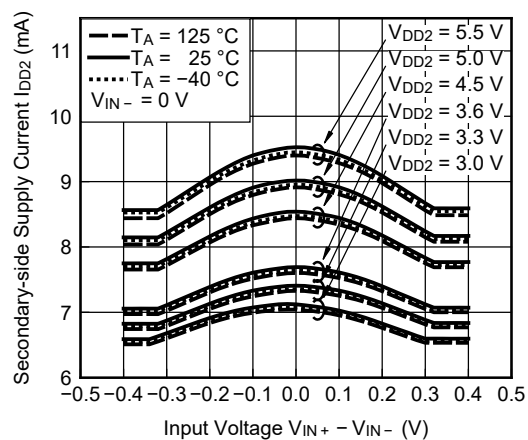
TYPICAL CHARACTERISTICS

($T_A = 25\text{ }^{\circ}\text{C}$, $V_{IN+} = V_{IN-} = 0\text{ V}$, $V_{DD1} = V_{DD2} = 5\text{ V}$, unless otherwise specified)

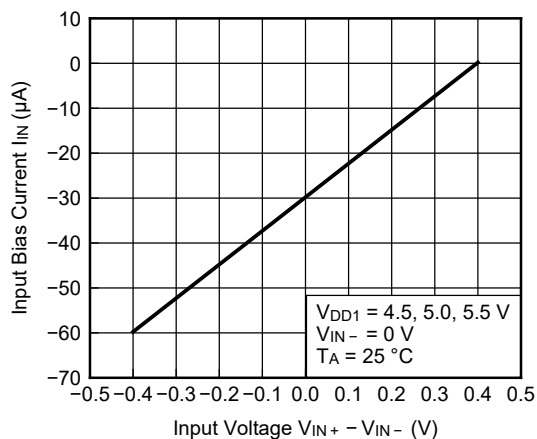
PRIMARY-SIDE SUPPLY CURRENT vs. INPUT VOLTAGE



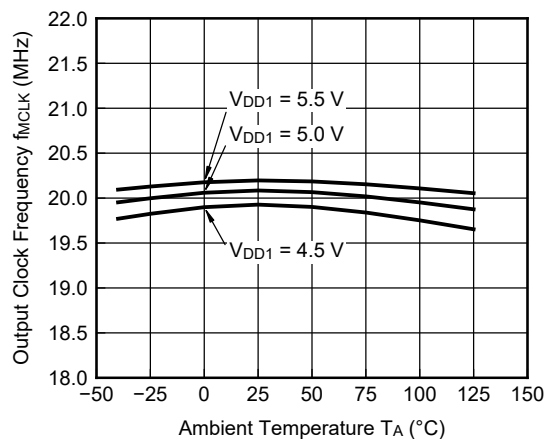
SECONDARY-SIDE SUPPLY CURRENT vs. INPUT VOLTAGE



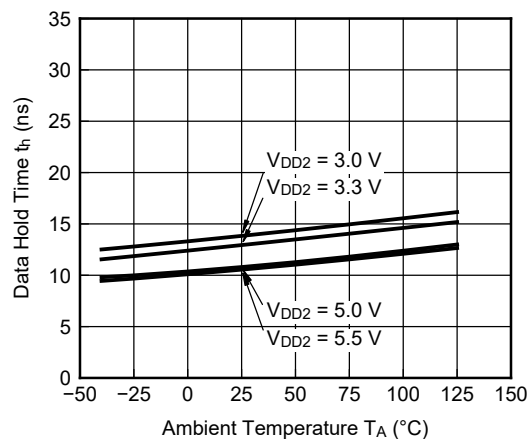
INPUT BIAS CURRENT vs. INPUT VOLTAGE



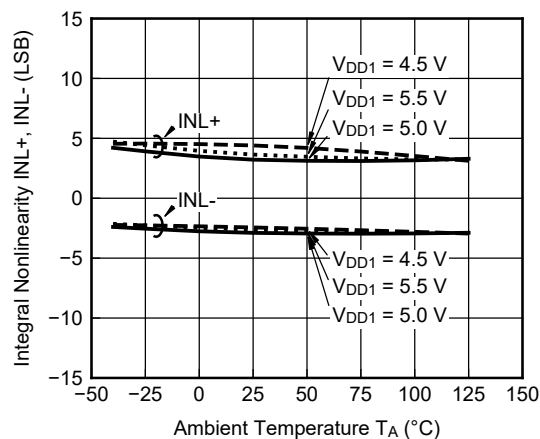
OUTPUT CLOCK FREQUENCY vs. AMBIENT TEMPERATURE



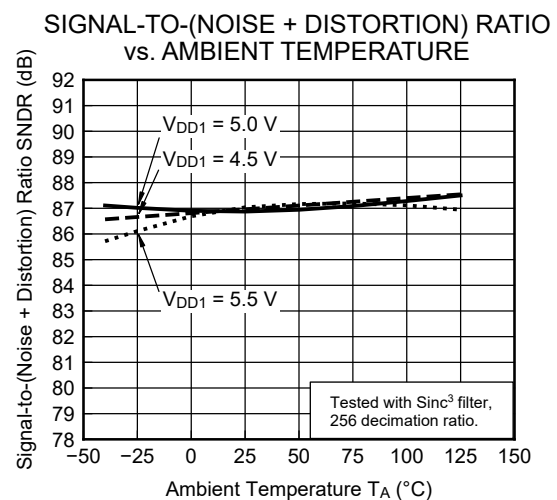
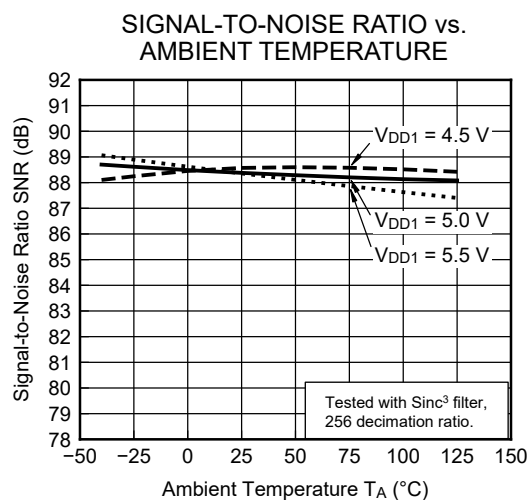
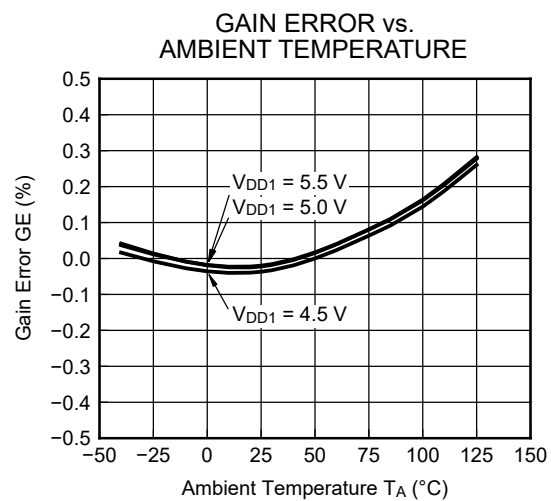
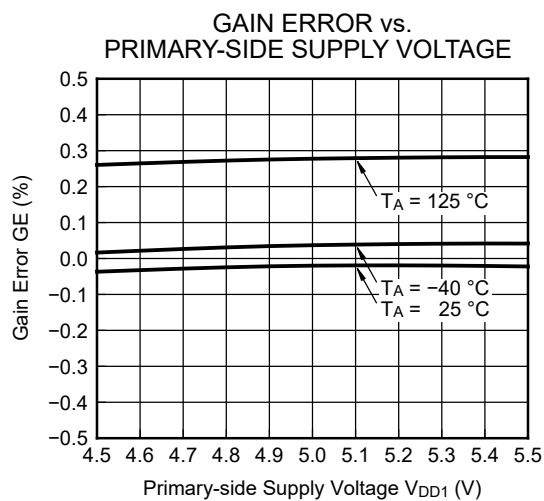
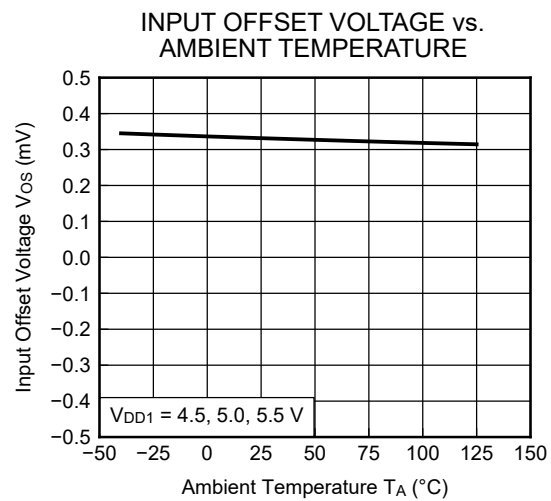
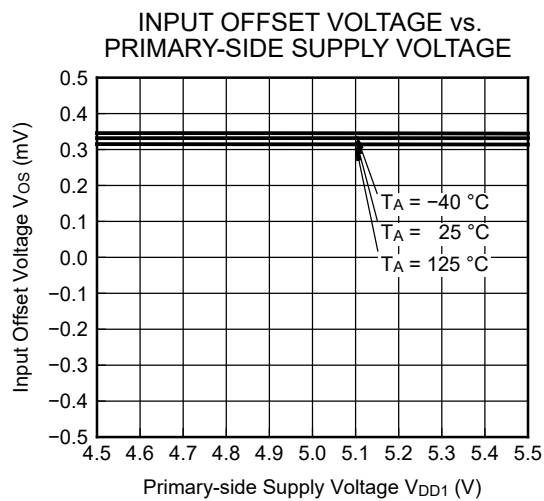
DATA HOLD TIME vs. AMBIENT TEMPERATURE



INTEGRAL NONLINEARITY vs. AMBIENT TEMPERATURE



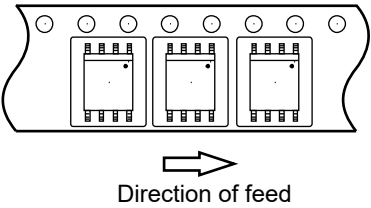
Remark The graphs indicate nominal characteristics.



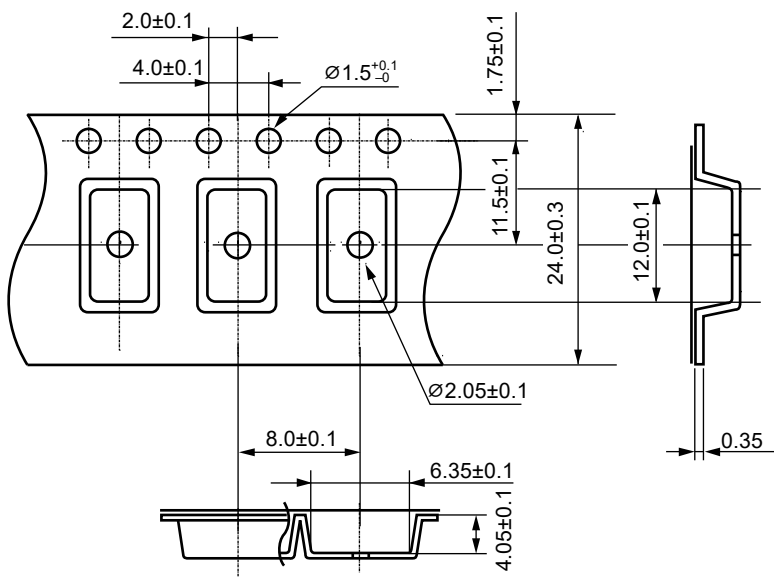
Remark The graphs indicate nominal characteristics.

TAPING SPECIFICATIONS (UNIT: mm)

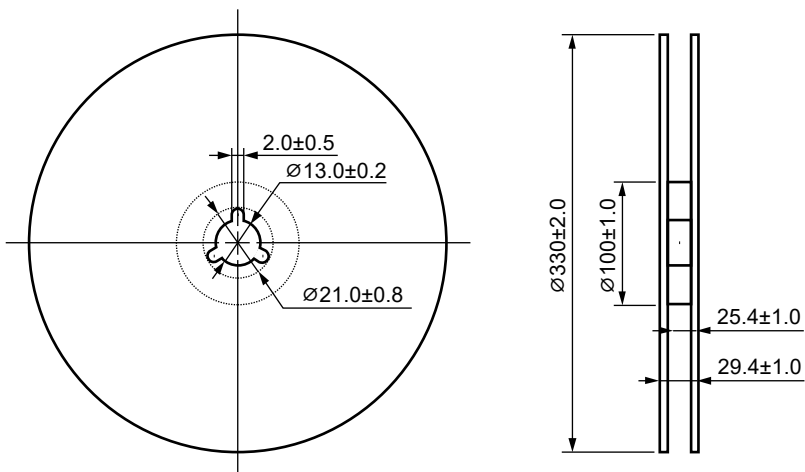
Taping Direction



Outline and Dimensions (Tape)

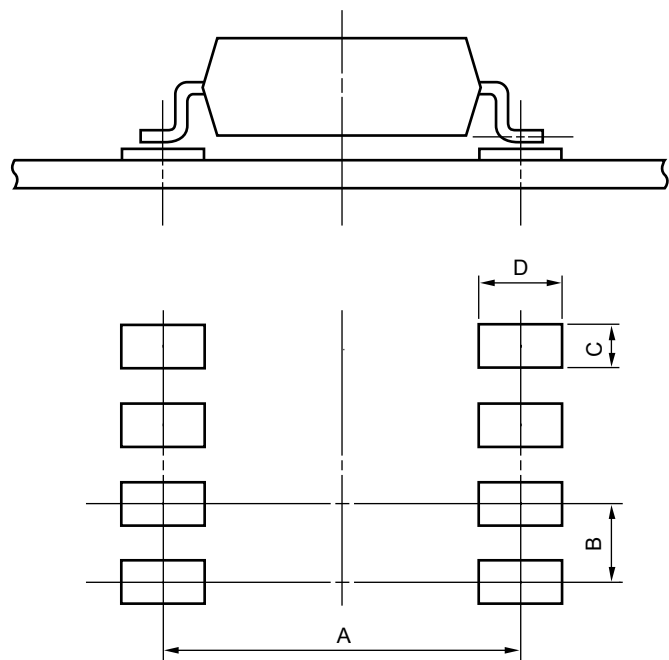


Outline and Dimensions (Reel)



Packing : 2 000 pcs/reel

RECOMMENDED MOUNT PAD DIMENSIONS (UNIT: mm)



Part Number	Lead Bending	A	B	C	D
RV1S9355A	lead bending type (Gull-wing) for long creepage distance (surface mount)	10.2	1.27	0.8	2.2

Remark All dimensions in this figure must be evaluated before use.

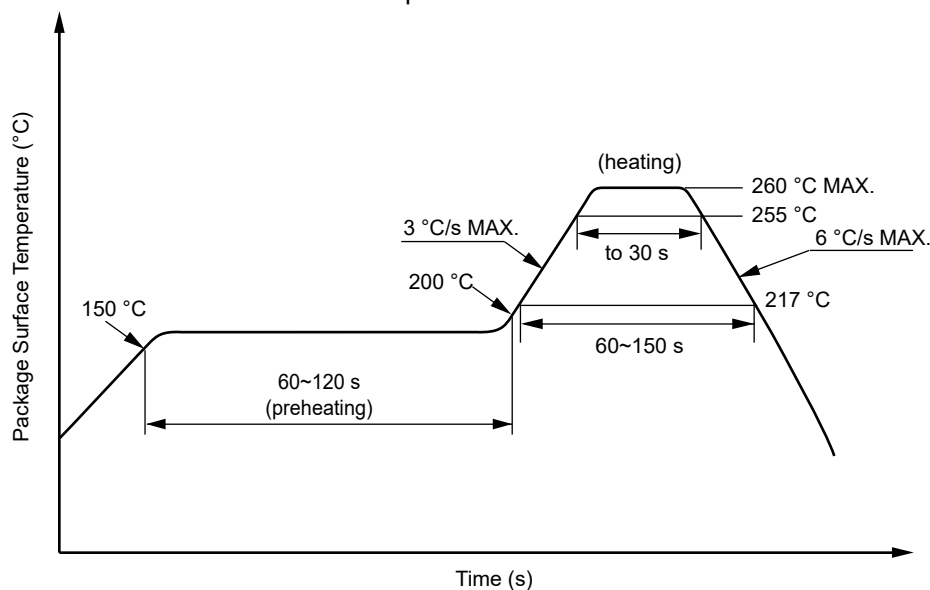
NOTES ON HANDLING

1. Recommended soldering conditions

(1) Infrared reflow soldering

- Peak reflow temperature 260 °C or below (package surface temperature)
- Time of peak reflow temperature $-5\text{ }^{\circ}\text{C}$ (255 °C) 30 seconds or less
- Time of temperature higher than 217 °C 60 to 150 seconds
- Time to preheat temperature from 150 to 200 °C 60 to 120 seconds
- 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



JEDEC J-STD-020E compliant soldering conditions

(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 (per one side) 3 s or less
- Flux Rosin flux containing small amount of chlorine
(The flux with a maximum chlorine content of 0.2 Wt % is recommended.)
- Place 1.5 to 2.0 mm or more away from the root of the lead

(4) Cautions

- Flux cleaning Avoid cleaning with Freon- or halogen-based (chlorinated etc.) solvents.
- Fixing/Coating Do not use fixing agents or coatings containing halogen-based substances.

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.

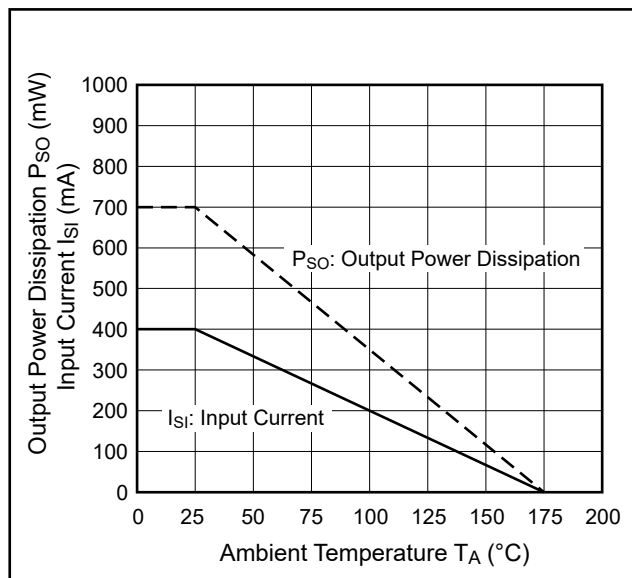
USAGE CAUTIONS

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) By-pass capacitor of more than 0.1 μ F 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.
 - (2) 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.
 - (3) When the primary power supply (V_{DD1}) is off and only the secondary power supply (V_{DD2}) is being applied ($V_{DD1} = 0$ V and $V_{DD2} = 5$ V), MCLK and MDAT output a high level (MCLK = MDAT = 5.0 V typ.), regardless of the input voltages (V_{IN+} and V_{IN-}).
 - (4) When V_{DD1} is lower than 4.5 V that is the outside of the 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.

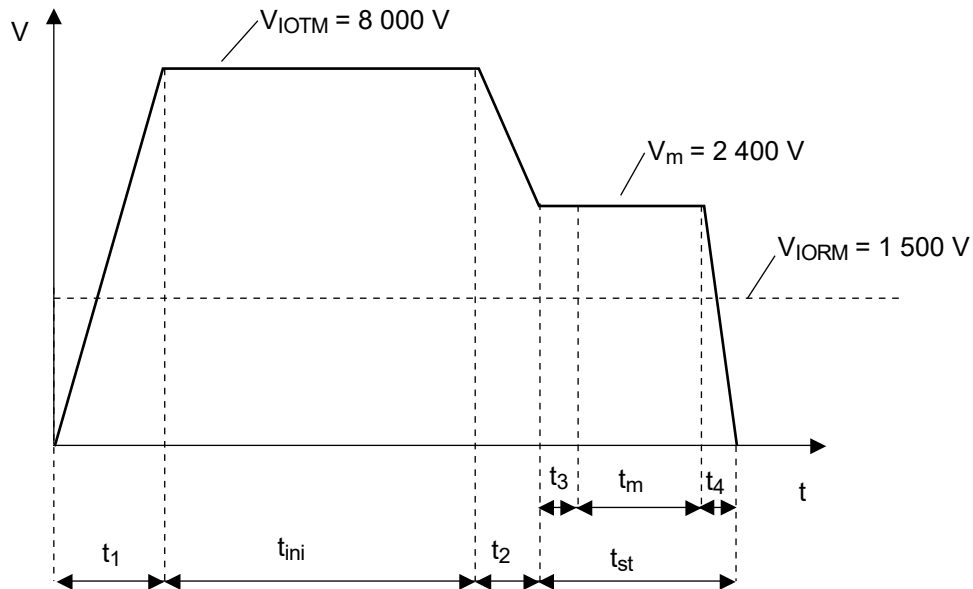
SPECIFICATION OF VDE MARKS LICENSE DOCUMENT

Parameter	Symbol	Rating	Unit
Climatic test class (IEC 60068-1/DIN EN 60068-1)		40/125/21	
Dielectric strength			
maximum operating isolation voltage	V_{IORM}	1 500	V_{peak}
Test voltage (partial discharge test, procedure a for type test and random test)	V_m	2 400	V_{peak}
$V_m = 1.6 \times V_{IORM}$, $q_{pd} < 5 \text{ pC}$			
Test voltage (partial discharge test, procedure b for all devices)	V_m	2 813	V_{peak}
$V_m = 1.875 \times V_{IORM}$, $q_{pd} < 5 \text{ pC}$			
Highest permissible overvoltage	V_{IOTM}	8 000	V_{peak}
Degree of pollution (IEC 60664-1/DIN EN 60664-1 (VDE 0110-1))		2	
Comparative tracking index (IEC 60112/DIN EN 60112 (VDE 0303-11))	CTI	175	
Material group (IEC 60664-1/DIN EN 60664-1 (VDE 0110-1))		III a	
Storage temperature range	T_{stg}	-55 to +150	°C
Operating temperature range	T_A	-40 to +125	°C
Isolation resistance, minimum value			
$V_{I-O} = 500 \text{ V dc}$, $T_A = 25 \text{ °C}$	$R_{I-O} \text{ MIN.}$	10^{12}	Ω
$V_{I-O} = 500 \text{ V dc}$, $T_A = \text{maximum temperature of rating, at least } 100 \text{ °C}$	$R_{I-O} \text{ MIN.}$	10^{11}	Ω
Safety maximum ratings (maximum permissible in case of fault, see thermal derating curve)			
Maximum ambient temperature	T_S	175	°C
Maximum input current	I_{SI}	400	mA
Maximum output power dissipation	P_{SO}	700	mW
Isolation resistance, minimum value at $V_{I-O} = 500 \text{ V dc}$, $T_A = T_S$	$R_{I-O} \text{ MIN.}$	10^9	Ω

Dependence of maximum safety ratings on ambient temperature

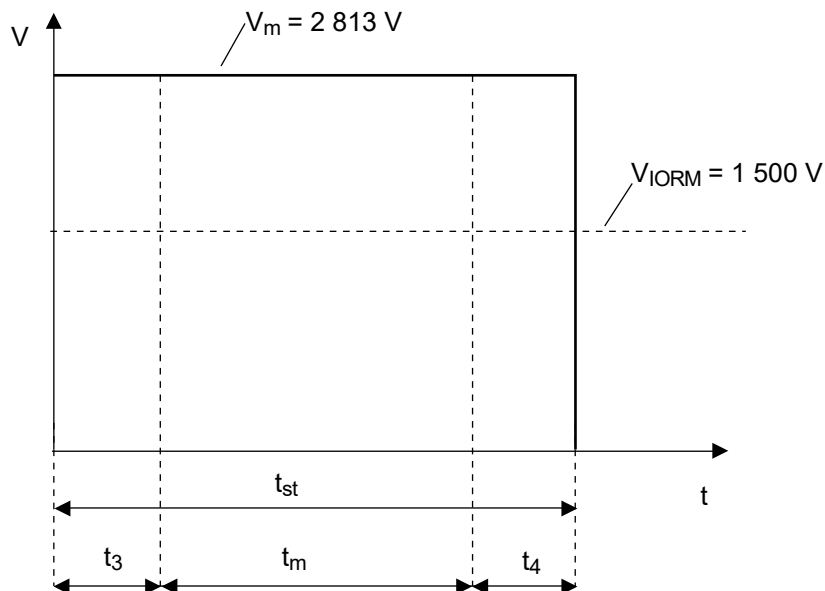


Method a) Destructive Test, Type and Sample Test



$t_1, t_2 = 1\text{ to }10\text{ sec}$
 $t_3, t_4 = 1\text{ sec}$
 $t_m = 10\text{ sec}$
 $t_{st} = 12\text{ sec}$
 $t_{ini} = 60\text{ sec}$

Method b) Non-destructive Test, 100% Production Test



$t_3, t_4 = 0.1\text{ sec}$
 $t_m = 1.0\text{ sec}$
 $t_{st} = 1.2\text{ sec}$

Caution

GaAs Products

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.

- 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.

All trademarks and registered trademarks are the property of their respective owners.

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 or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving 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, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. 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 shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended 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; industrial robots; etc.

"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or 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 damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION ("Vulnerability Issues"). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, 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 and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall 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 shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/