
PWM/VFM STEP-DOWN DC/DC CONVERTER WITH SYNCHRONOUS RECTIFIER

NO.EA-129-0604

OUTLINE

The R1232D Series are CMOS-based PWM step-down DC/DC converters with synchronous rectifier, low supply current. As an output capacitor, a 10 μ F or more ceramic capacitor can be used with the R1232D.

Each of these ICs consists of an oscillator, a PWM control circuit, a voltage reference unit, an error amplifier, a soft-start circuit, protection circuits, a protection against miss operation under low voltage (UVLO), PWM/VFM alternative circuit, a chip enable circuit, a synchronous rectifier, Nch. driver transistor, and so on. A low ripple, high efficiency step-down DC/DC converter can be easily composed of this IC with only a few kinds of external components, or an inductor and capacitors. (As for R1232D001x type, divider resistors are also necessary.) In terms of Output Voltage, it is fixed internally in the R1232Dxx1x types. While in the R1232D001x types, Output Voltage is adjustable with external divider resistors.

PWM/VFM alternative circuit is active with Mode Pin of the R1232D Series. Thus, when the load current is small, the operation can be switching into the VFM operation from PWM operation by the logic of MODE pin and the efficiency at small load current can be improved. As protection circuits, current limit circuit which limits peak current of L_x at each clock cycle, and latch type protection circuit which works if the term of the over-current condition keeps on a certain time in PWM mode exist. Latch-type protection circuit works to latch an internal driver with keeping it disable. To release the condition of protection, after disable this IC with a chip enable circuit, enable it again, or restart this IC with power-on or make the supply voltage at UVLO detector threshold level or lower than UVLO.

FEATURES

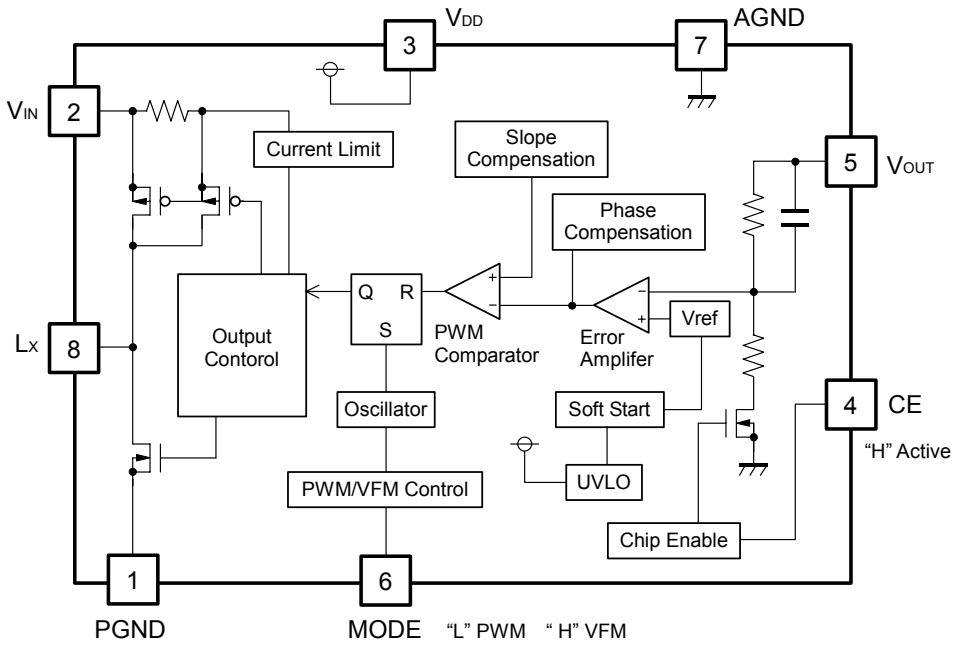
- Two choices of Oscillator Frequency 1MHz, 2.25MHz
(Small inductors can be used. 4.7 μ H for 1MHz/2.2 μ H for 2.25MHz)
- Built-in Driver ON Resistance P-channel 0.2 Ω (at V_{IN}=5.0V)
- Built-in Soft-start Function..... Typ. 1.0ms (f_{osc}=1MHz type)
- Output Voltage 0.9V to 3.3V (xx1x Type)
0.8V to V_{IN} (001x Type)
- High Accuracy Output Voltage \pm 2.0% (PWM Mode)
- Built-in Current Limit Circuit Typ. 1.4A
- Package SON-8 (t=0.9mm)

APPLICATIONS

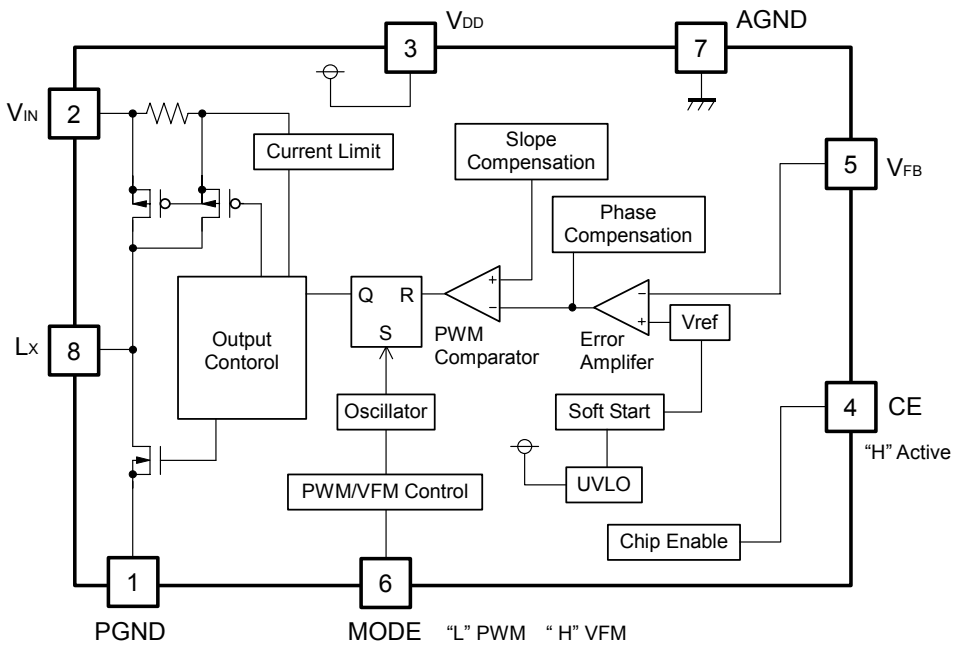
- Power source for portable equipment such as cellular, PDA, DSC, Notebook PC.
- Power source for HDD

BLOCK DIAGRAMS

R1232Dxx1A/B



R1232D001C/D



SELECTION GUIDE

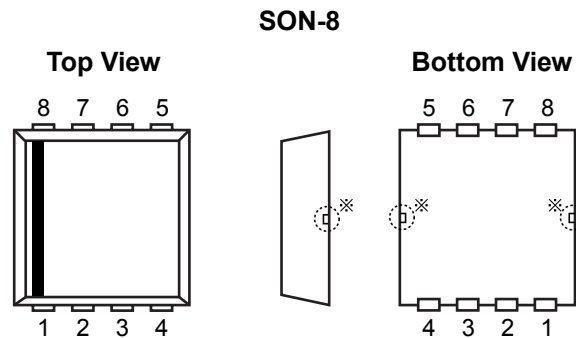
In the R1232D Series, the output voltage, the oscillator frequency, and the taping type for the ICs can be selected at the user's request.

The selection can be made with designating the part number as shown below;

R1232Dxx1x-xx ←Part Number
 ↑ ↑ ↑ ↑
 a b c d


Code	Contents
a	Setting Output Voltage(V_{OUT}): Stepwise setting with a step of 0.1V in the range of 0.9V to 3.3V is possible for fixed output version."00" is for Output Voltage Adjustable version (0.8V as the feedback voltage.)
b	1 : fixed
c	Designation of Optional Function A : 1MHz, Fixed Output Voltage B : 2.25MHz, Fixed Output Voltage C : 1MHz, Adjustable Output Voltage D : 2.25MHz, Adjustable Output Voltage
d	Designation of Taping Type; (Refer to Taping Specification)"TR" is prescribed as a standard.

PIN CONFIGURATION



PIN DESCRIPTIONS

Pin No	Symbol	Pin Description
1	PGND	Ground Pin
2	V_{IN}	Voltage Supply Pin
3	V_{DD}	Voltage Supply Pin
4	CE	Chip Enable Pin (active with "H")
5	V_{OUT}/V_{FB}	Output/Feedback Pin
6	MODE	Mode changer Pin (PWM mode at "L", VFM mode at "H".)
7	AGND	Ground Pin
8	L_X	L_X Switching Pin (CMOS Output)

* Tab in the  parts have GND level. (They are connected to the reverse side of this IC.)
Do not connect to other wires or land patterns.

ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Unit
V_{IN}	V_{IN} Supply Voltage	6.5	V
V_{DD}	V_{DD} Pin Voltage	6.5	V
V_{LX}	L_X Pin Voltage	-0.3 to $V_{IN} + 0.3$	V
V_{CE}	CE Pin Input Voltage	-0.3 to $V_{IN} + 0.3$	V
V_{MODE}	MODE Pin Input Voltage	-0.3 to $V_{IN} + 0.3$	V
V_{FB}	V_{FB} Pin Input Voltage	-0.3 to $V_{IN} + 0.3$	V
I_{LX}	L_X Pin Output Current	± 1.5	V
P_D	Power Dissipation (SON-8)* ¹	480	mW
T_{opt}	Operating Temperature Range	-40 to 85	°C
T_{stg}	Storage Temperature Range	-55 to 125	°C

*1) For Power Dissipation please refer to PACKAGE INFORMATION to be described.

ELECTRICAL CHARACTERISTICS

• R1232DxxxA/C

T_{opt}=25°C

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V _{IN}	Operating Input Voltage		2.6		5.5	V
V _{OUT}	Step-down Output Voltage (PWM Mode)	R1232Dxx1A, MODE="L"	×0.980		×1.020	V
	Step-down Output Voltage (VFM Mode)	R1232Dxx1A, MODE="H"*1	×0.975		×1.025	V
V _{FB1}	Feedback Voltage1 (PWM Mode)	R1232D001C, MODE="L"	0.784	0.800	0.816	V
V _{FB2}	Feedback Voltage2 (VFM Mode)	R1232D001C, MODE="H"*1	0.780	0.800	0.820	V
ΔV _{OUT} /ΔT _{opt}	Step-down Output Voltage Temperature Coefficient	-40°C ≤ T _{opt} ≤ 85°C		±150		ppm/°C
fosc	Oscillator Frequency (A/C)	1MHz type V _{IN} =5.0V	0.75	1.00	1.25	MHz
I _{DD1}	Supply Current1 (A/C)	PWM mode *2, V _{FB} ="H"	70	140	190	μA
I _{DD2}	Supply Current2 (A/C)	VFM mode *3, V _{FB} ="H" *1	10	45	80	μA
I _{standby}	Standby Current	V _{CE} =0V, MODE="L"		0.0	5.0	μA
I _{LXleak}	Lx Leakage Current	V _{IN} =5.5V, V _{CE} =0V, V _{LX} =0V/5.5V	-5.0	0.0	5.0	μA
R _{ONP}	ON Resistance of Pch Transistor	V _{IN} =5.0V, I _{LX} =200mA		0.20	0.35	Ω
R _{ONN}	ON Resistance of Nch Transistor	V _{IN} =5.0V, I _{LX} =200mA		0.20	0.35	Ω
Maxduty	Oscillator Maximum Duty Cycle	V _{MODE} =0V	100			%
ton	VFM On Duty	V _{IN} =5.0V, VFM Mode	40	65	90	%
tstart	Soft-start Time (A/C)	V _{IN} =5.0V	0.5	1.0	1.4	ms
tprot	Protection Delay Time	V _{IN} =5.0V	0.1	2.0	10.0	ms
I _{LXlimit}	LX Current Limit	V _{IN} =5.0V	1.0	1.4		A
V _{UVLO1}	UVLO Detector Threshold		2.10	2.25	2.40	V
V _{UVLO2}	UVLO Released Voltage		2.20	V _{UVLO1} +0.10	2.50	V
I _{CE}	CE Input Current	V _{IN} =5.5V, V _{DD} =5.5V	-0.1	0.0	0.1	μA
I _{VFB}	VFB Input Current	V _{IN} =5.5V, V _{DD} =5.5V	-0.1	0.0	0.1	μA
I _{MODE}	Mode Input Current	V _{IN} =5.5V, V _{DD} =5.5V	-0.1	0.0	0.1	μA
V _{CEH}	CE "H" Input Voltage	V _{IN} =V _{DD} =5.5V	1.5			V
V _{CEL}	CE "L" Input Voltage	V _{IN} =V _{DD} =3.0V			0.3	V
V _{MODEH}	MODE "H" Input Voltage	V _{IN} =V _{DD} =5.5V	1.5			V
V _{MODEL}	MODE "L" Input Voltage	V _{IN} =V _{DD} =3.0V			0.3	V

*1 At VFM mode, Synchronous rectifier Nch driver is always off, therefore, an external shottky diode is necessary.

*2 V_{FB}=GND

*3 V_{FB}>V_{IN}/ internal oscillator is halted.

R1232D

• R1232DxxxB/D

T_{opt}=25°C

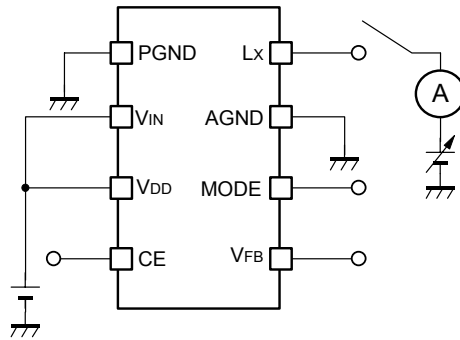
Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V _{IN}	Operating Input Voltage		2.6		5.5	V
V _{OUT}	Step-down Output Voltage (PWM Mode)	R1232Dxx1B, MODE="L"	×0.980		×1.020	V
	Step-down Output Voltage (VFM Mode)	R1232Dxx1B, MODE="H" *1	×0.975		×1.025	V
V _{FB1}	Feedback Voltage1 (PWM Mode)	R1232D001D, MODE="L"	0.784	0.800	0.816	V
V _{FB2}	Feedback Voltage2 (VFM Mode)	R1232D001D, MODE="H" *1	0.780	0.800	0.820	V
ΔV _{OUT} /ΔT _{opt}	Step-down Output Voltage Temperature Coefficient	-40°C ≤ T _{opt} ≤ 85°C		±150		ppm/°C
f _{osc}	Oscillator Frequency (B/D)	2.25MHz type V _{IN} =5.0V	1.91	2.25	2.58	MHz
I _{DD1}	Supply Current1 (B/D)	PWM mode *2, V _{FB} "H"	170	240	310	μA
I _{DD2}	Supply Current2 (B/D)	VFM mode *3, V _{FB} "H" *1	30	95	160	μA
I _{standby}	Standby Current	V _{CE} =0V, MODE="L"		0.0	5.0	μA
I _{LXleak}	L _X Leakage Current	V _{IN} =5.5V, V _{CE} =0V, V _{LX} =0V/5.5V	-5.0	0.0	5.0	μA
R _{ONP}	ON Resistance of Pch Transistor	V _{IN} =5.0V, I _{LX} =200mA		0.20	0.35	Ω
R _{ONN}	ON Resistance of Nch Transistor	V _{IN} =5.0V, I _{LX} =200mA		0.20	0.35	Ω
Maxduty	Oscillator Maximum Duty Cycle	V _{MODE} =0V	100			%
t _{on}	VFM On Duty	V _{IN} =5.0V, VFM Mode	40	65	90	%
t _{start}	Soft-start Time (B/D)	V _{IN} =5.0V	0.15	0.4	0.7	ms
t _{prot}	Protection Delay Time	V _{IN} =5.0V	0.1	2.0	10.0	ms
I _{LXlimit}	L _X Current Limit	V _{IN} =5.0V	1.0	1.4		A
V _{UVLO1}	UVLO Detector Threshold		2.10	2.25	2.40	V
V _{UVLO2}	UVLO Released Voltage		2.20	V _{UVLO1} +0.10	2.50	V
I _{CE}	CE Input Current	V _{IN} =5.5V, V _{DD} =5.5V	-0.1	0.0	0.1	μA
I _{VFB}	VFB Input Current	V _{IN} =5.5V, V _{DD} =5.5V	-0.1	0.0	0.1	μA
I _{MODE}	Mode Input Current	V _{IN} =5.5V, V _{DD} =5.5V	-0.1	0.0	0.1	μA
V _{CEH}	CE "H" Input Voltage	V _{IN} =V _{DD} =5.5V	1.5			V
V _{CEL}	CE "L" Input Voltage	V _{IN} =V _{DD} =3.0V			0.3	V
V _{MODEH}	MODE "H" Input Voltage	V _{IN} =V _{DD} =5.5V	1.5			V
V _{MODEL}	MODE "L" Input Voltage	V _{IN} =V _{DD} =3.0V			0.3	V

*1 At VFM mode, Synchronous rectifier Nch driver is always off, therefore, an external shottky diode is necessary.

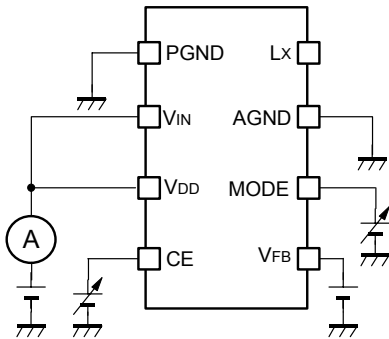
*2 V_{FB}=GND

*3 V_{FB}>V_{IN}/ internal oscillator is halted.

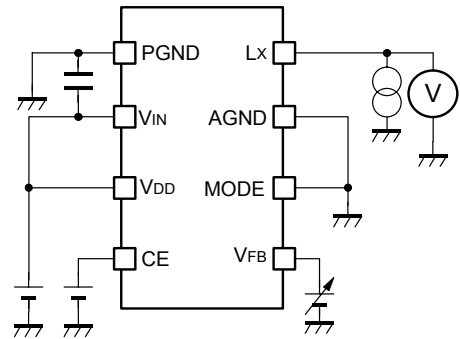
TEST CIRCUIT



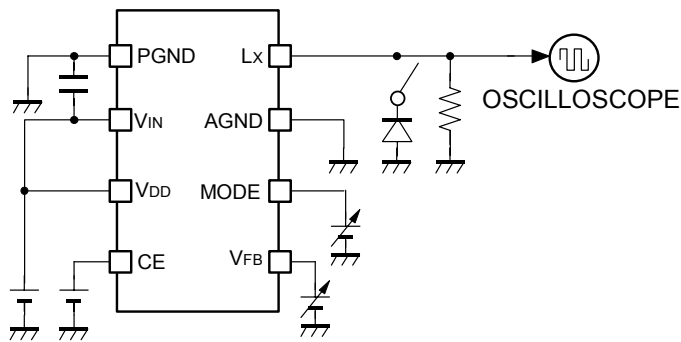
Test Circuit for Input Current and Leakage Current



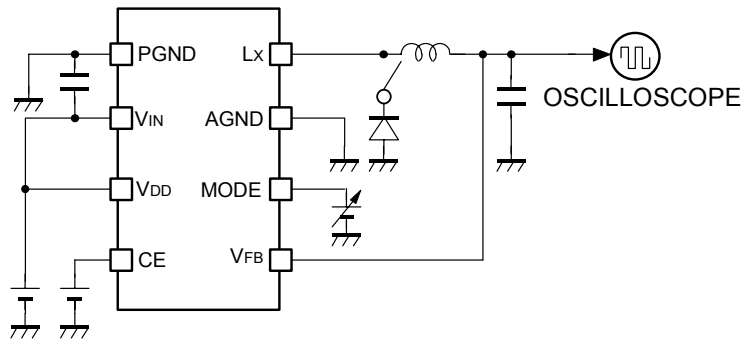
Test Circuit for Supply Current and Standby Current



Test Circuit for ON resistance of Lx



Input Voltage, Output Voltage, Frequency, Lx Current Limit, Protection Delay Time, UVLO Voltage Test Circuit

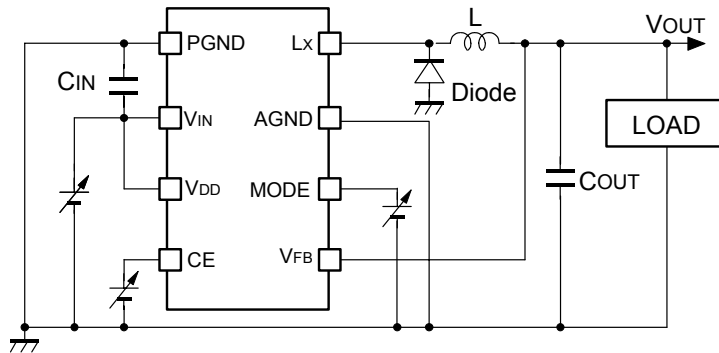


Soft Start Time Test Circuit

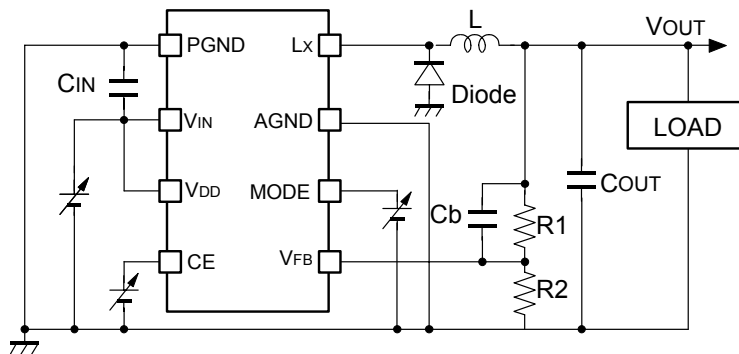
The bypass capacitor between power supply and GND is a ceramic capacitor 10 μ F.

TYPICAL APPLICATION AND TECHNICAL NOTES

• Fixed Output Voltage Type



• Adjustable Output Type



C _{IN}	10 μ F C2012JB0J106MT (TDK), 10 μ F CM21B106M06AB (Kyocera)
C _{OUT}	10 μ F C2012JB0J106MT (TDK), 10 μ F CM21B106M06AB (Kyocera)
L	4.7 μ H/2.2 μ H VLP5610-4R7MR90, VLP5610-2R7M1R0 (TDK)
SD	RB491D (Rohm), MA721 (Panasonic)

At VFM mode used with an external diode in between Lx and GND.

As for PWM mode, an external diode is not necessary.

In terms of setting R1, R2, Cb, refer to the technical notes.

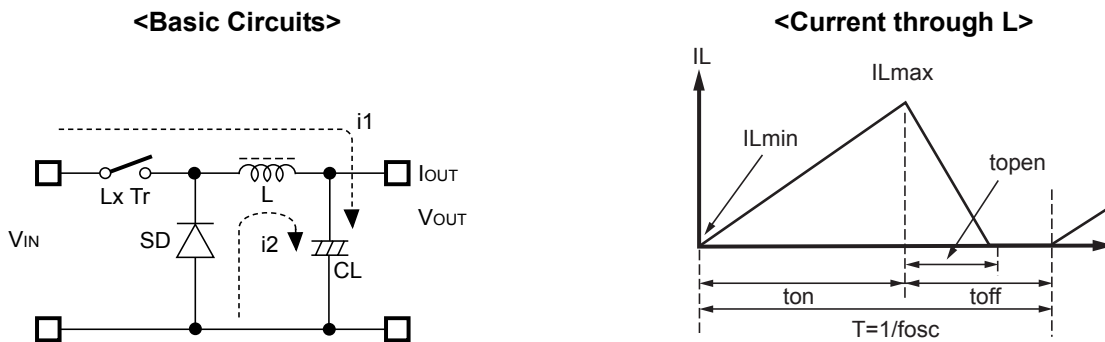
When you use these ICs, consider the following issues;

- Input the same voltage into power supply pins, V_{IN} and V_{DD} . Set the same level as AGND and PGND.
- When you control the CE pin and MODE pin by another power supply, do not make its "H" level more than the voltage level of V_{IN} / V_{DD} pin.
- Set external components such as an inductor, C_{IN} , C_{OUT} as close as possible to the IC, in particular, minimize the wiring to V_{IN} pin and PGND pin.
- At stand by mode, (CE="L"), the LX output is Hi-Z, or both P-channel transistor and N-channel transistor of Lx pin turn off.
- In terms of VFM mode, the synchronous rectifier Nch Driver is always off, therefore, if the VFM mode is necessary, add an external Schottky diode.
- In terms of the protection circuits, current limit for the peak current of each cycle of Lx, and the latch protection circuit, which works if the over-limit current flows continuously for a certain time exist. To release the protection, once make this IC into be standby mode with chip enable pin, or make the supply voltage be down to UVLO threshold level or less.
- At VFM mode, (MODE="H"), Latch protection circuit does not operate.
- If the mode is switched over into PWM mode from VFM mode during the operation, change the mode at light load current. If the load current is large, output voltage may decline.
- Reinforce the V_{IN} , PGND, and V_{OUT} lines sufficiently. Large switching current may flow in these lines. If the impedance of V_{IN} and PGND lines is too large, the internal voltage level in this IC may shift caused by the switching current, and the operation might be unstable.

The performance of power source circuits using these ICs extremely depends upon the peripheral circuits. Pay attention in the selection of the peripheral circuits. In particular, design the peripheral circuits in a way that the values such as voltage, current, and power of each component, PCB patterns and the IC do not exceed their respected rated values.

OPERATION of step-down DC/DC converter and Output Current

The step-down DC/DC converter charges energy in the inductor when L_x transistor is ON, and discharges the energy from the inductor when L_x transistor is OFF and controls with less energy loss, so that a lower output voltage than the input voltage is obtained. The operation will be explained with reference to the following diagrams:



Step 1 : P-channel Tr. turns on and current $I_L (=i_1)$ flows, and energy is charged into C_L . At this moment, I_L increases from $I_{Lmin} (=0)$ to reach I_{Lmax} in proportion to the on-time period (t_{on}) of P-channel Tr.

Step 2 : When P-channel Tr. turns off, Synchronous rectifier N-channel Tr. turns on in order that L maintains I_L at I_{Lmax} , and current $I_L (=i_2)$ flows.

Step 3 : $I_L (=i_2)$ decreases gradually and reaches $I_L = I_{Lmin} = 0$ after a time period of t_{open} , and N-channel Tr. Turns off. Provided that in the continuous mode, next cycle starts before I_L becomes to 0 because t_{off} time is not enough. In this case, I_L value increases from this $I_{Lmin} (>0)$.

In the case of PWM control system, the output voltage is maintained by controlling the on-time period (t_{on}), with the oscillator frequency (f_{osc}) being maintained constant.

• Discontinuous Conduction Mode and Continuous Conduction Mode

The maximum value (ILmax) and the minimum value (ILmin) of the current flowing through the inductor are the same as those when P-channel Tr. turns on and off.

The difference between ILmax and ILmin, which is represented by ΔI ;

$$\Delta I = I_{Lmax} - I_{Lmin} = V_{OUT} \times t_{open} / L = (V_{IN} - V_{OUT}) \times t_{on} / L \dots\dots\dots \text{Equation 1}$$

Where, $t = 1/f_{osc} = t_{on} + t_{off}$

$$\text{duty (\%)} = t_{on} / t \times 100 = t_{on} \times f_{osc} \times 100$$

$$t_{open} \cong t_{off}$$

In Equation 1, $V_{OUT} \times t_{open} / L$ and $(V_{IN} - V_{OUT}) \times t_{on} / L$ are respectively shown the change of the current at ON, and the change of the current at OFF.

When the output current (I_{OUT}) is relatively small, $t_{open} < t_{off}$ as illustrated in the above diagram. In this case, the energy is charged in the inductor during the time period of t_{on} and is discharged in its entirety during the time period of t_{off} , therefore I_{Lmin} becomes to zero ($I_{Lmin} = 0$). When I_{OUT} is gradually increased, eventually, t_{open} becomes to t_{off} ($t_{open} = t_{off}$), and when I_{OUT} is further increased, I_{Lmin} becomes larger than zero ($I_{Lmin} > 0$). The former mode is referred to as the discontinuous mode and the latter mode is referred to as continuous mode.

In the continuous mode, when Equation 1 is solved for t_{on} and assumed that the solution is t_{onc}

$$t_{onc} = t \times V_{OUT} / V_{IN} \dots\dots\dots \text{Equation 2}$$

When $t_{on} < t_{onc}$, the mode is the discontinuous mode, and when $t_{on} = t_{onc}$, the mode is the continuous mode.

OUTPUT CURRENT AND SELECTION OF EXTERNAL COMPONENTS

When P-channel Tr. of L_X is ON:

(Wherein, Ripple Current P-P value is described as I_{RP} , ON resistance of P-channel Tr. and N-channel Tr. of L_X are respectively described as R_{ONP} and R_{ONN} , and the DC resistor of the inductor is described as R_L .)

$$V_{IN} = V_{OUT} + (R_{ONP} + R_L) \times I_{OUT} + L \times I_{RP} / t_{on} \dots\dots\dots \text{Equation 3}$$

When P-channel Tr. of L_X is "OFF" (N-channel Tr. is "ON"):

$$L \times I_{RP} / t_{off} = V_{IN} - V_{OUT} + R_{ONN} \times I_{OUT} \dots\dots\dots \text{Equation 4}$$

Put Equation 4 to Equation 3 and solve for ON duty of P-channel transistor, $D_{ON} = t_{on} / (t_{off} + t_{on})$,

$$D_{ON} = (V_{OUT} - R_{ONN} \times I_{OUT} + R_L \times I_{OUT}) / (V_{IN} + R_{ONN} \times I_{OUT} - R_{ONP} \times I_{OUT}) \dots\dots\dots \text{Equation 5}$$

Ripple Current is as follows;

$$I_{RP} = (V_{IN} - V_{OUT} - R_{ONP} \times I_{OUT} - R_L \times I_{OUT}) \times D_{ON} / f_{osc} / L \dots\dots\dots \text{Equation 6}$$

wherein, peak current that flows through L, and L_X Tr. is as follows;

$$I_{Lmax} = I_{OUT} + I_{RP} / 2 \dots\dots\dots \text{Equation 7}$$

Consider I_{Lmax} , condition of input and output and select external components.

★ The above explanation is directed to the calculation in an ideal case in continuous mode.

How to Adjust Output Voltage and about Phase Compensation

As for Adjustable Output type, feedback pin (V_{FB}) voltage is controlled to maintain 0.8V.

Output Voltage, V_{OUT} is as following equation;

$$V_{OUT} R1+R2=V_{FB}:R2$$
$$V_{OUT}=V_{FB}\times(R1+R2)/R2$$

Thus, with changing the value of R1 and R2, output voltage can be set in the specified range.

In the DC/DC converter, with the load current and external components such as L and C, phase might be behind 180 degree. In this case, the phase margin of the system will be less and stability will be worse. To prevent this, phase margin should be secured with proceeding the phase. A pole is formed with external components L and C_{OUT} .

$$f_{pole} \sim 1/2\pi\sqrt{LC_{OUT}}$$

A zero (signal back to zero) is formed with R1 and Cb.

$$\cong f_{zero} \sim 1/(2\pi\times R1\times Cb)$$

First, choose the appropriate value of R1, R2 and Cb.
Set $R1+R2$ value 100k Ω or less.

For example, if $L=4.7\mu H$, $C_{OUT}=10\mu F$, the cut off frequency of the pole is approximately 23kHz.

To make the cut off frequency of the zero by R1, R2, and Cb be higher than 23kHz,
set $R1=33k\Omega$ and $Cb=100pF$. If V_{OUT} is set at 2.0V, $R2 = 22k\Omega$ is appropriate.

External Components

1. Inductor

Select an inductor that peak current does not exceed I_{Lmax} . If larger current than allowable current flows, magnetic saturation occurs and makes transform efficiency be worse.

Supposed that the load current is at the same, the smaller value of L is used, the larger the ripple current is.

Provided that the allowable current is large in that case and DC current is small, therefore, for large output current, efficiency is better than using an inductor with a large value of L and vice versa.

2. Capacitor

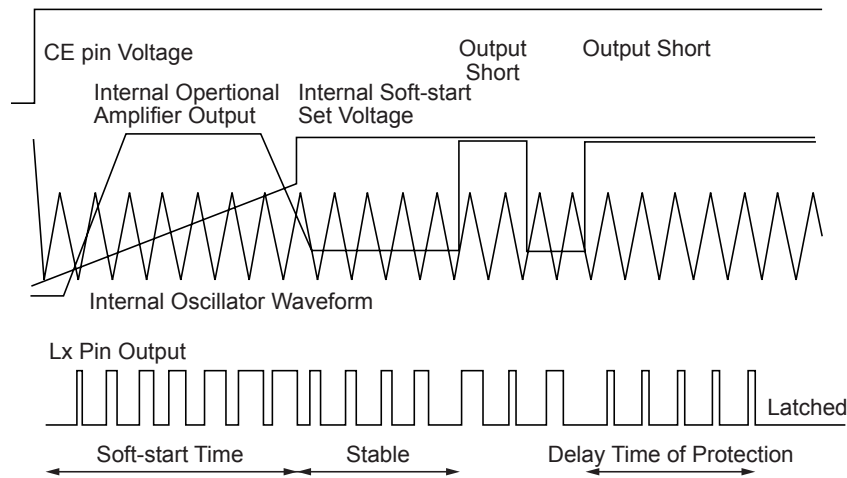
As for C_{IN} , use a capacitor with low ESR (Equivalent Series Resistance) Ceramic type of a capacity at least 10 μF for stable operation.

C_{OUT} can reduce ripple of Output Voltage, therefore as much as 10 μF ceramic type is recommended.

3. Diode

If VFM mode is chosen at light load, use a Schottky diode with small V_F . A diode with small V_F makes the efficiency of the circuit improved. Small reverse direction current, I_R is an important factor, however, V_F has more important priority than I_R .

TIMING CHART



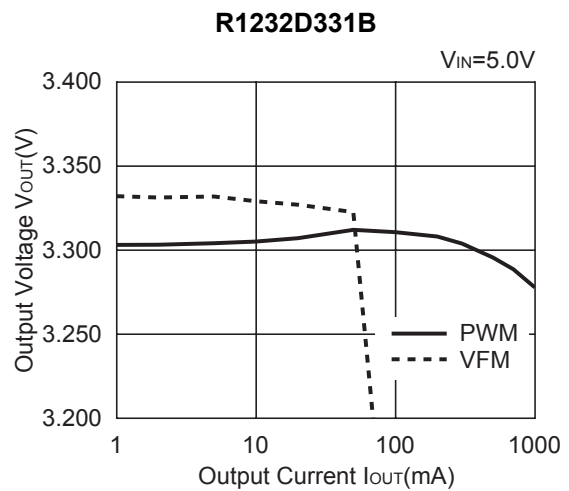
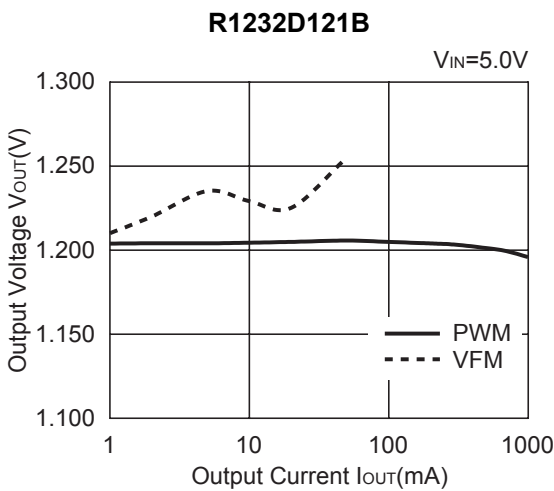
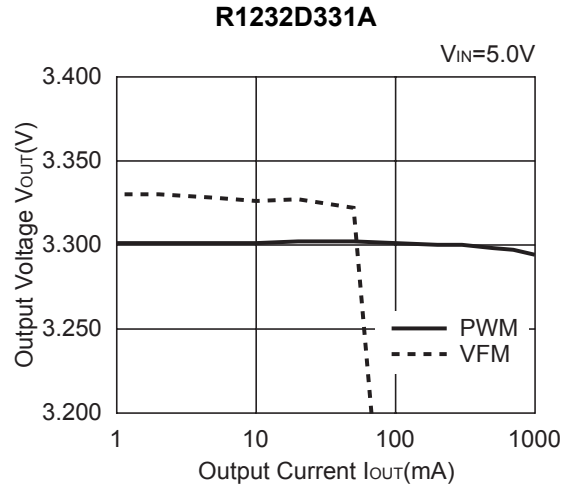
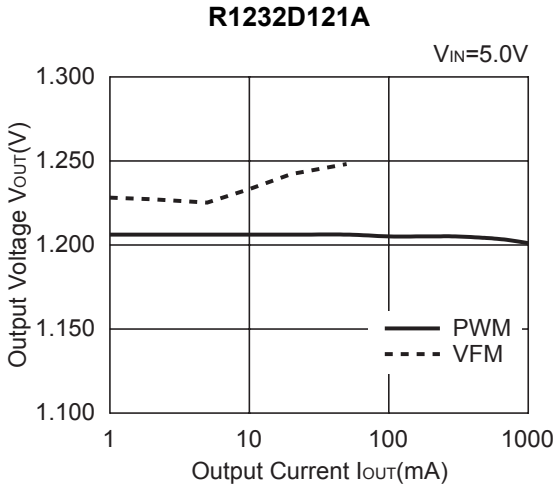
The timing chart as shown above describes the waveforms starting from the IC is enabled with CE and latched with protection. During the soft-start time, until the level is rising up to the internal soft-start set voltage, the duty cycle of L_x is gradually wider and wider to prevent the over-shoot of the voltage. During the term, the output of amplifier is "H". After the output voltage reaches the set output voltage, they are balanced well. Herein, if the output pin would be short circuit, the output of amplifier would become "H" again, and the condition would continue for 2.0ms (Typ.), latch circuit would work and the output of L_x would be latched with "OFF". (Output ="High-Z")

If the output short is released before the latch circuit works (within 2ms after output shorted), the output of amplifier is balanced in the stable state again.

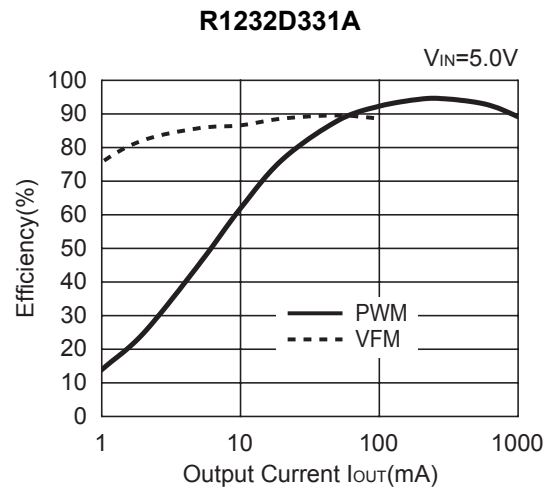
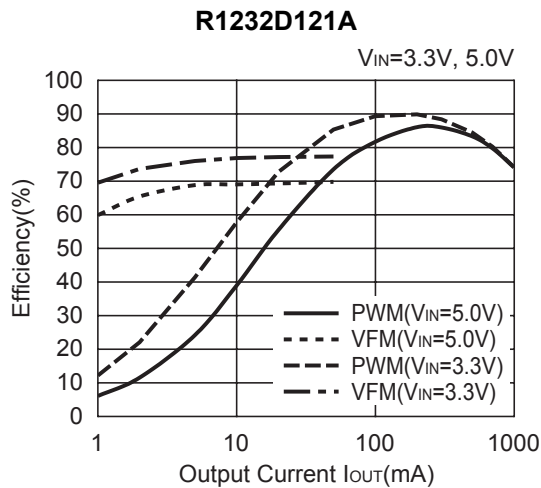
Once the IC is latched, to release the protection, input "L" with CE pin, or make the supply voltage at UVLO level or less.

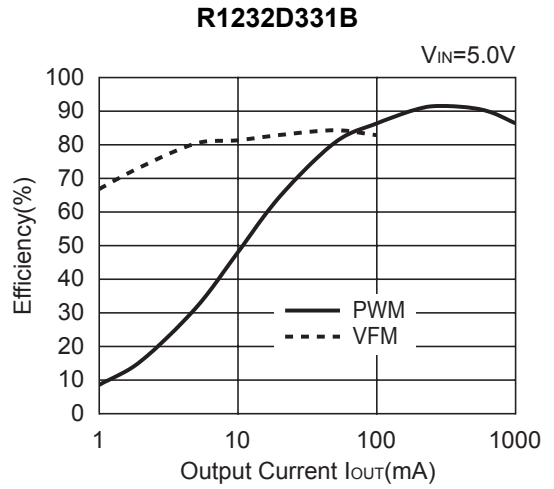
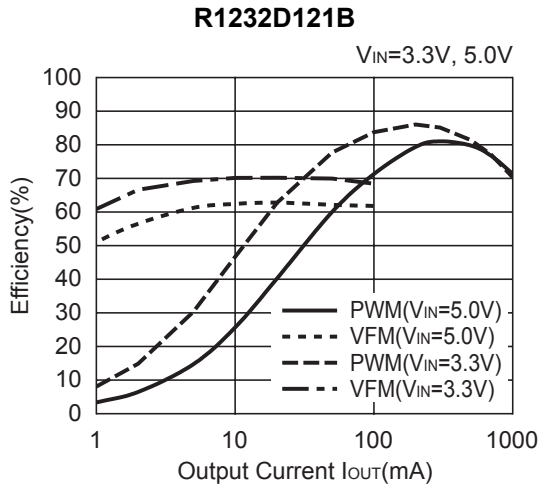
TYPICAL CHARACTERISTICS

1) Output Voltage vs. Output Current ($L = 4.7\mu\text{H}$, $C_{\text{IN}} = 10\mu\text{F}$, $C_{\text{OUT}} = 10\mu\text{F}$)

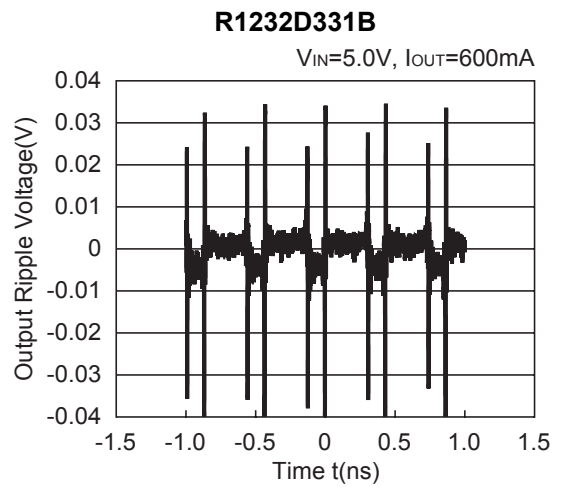
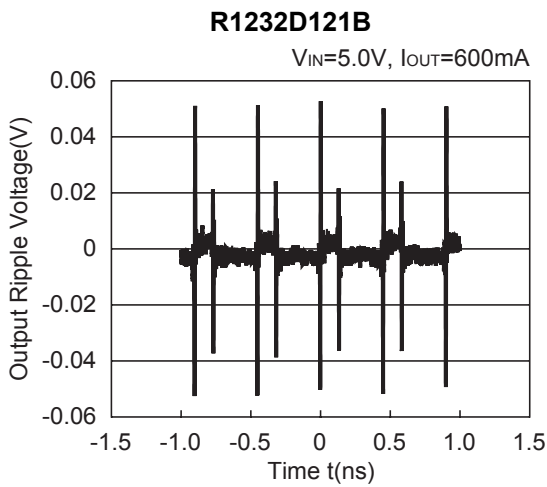
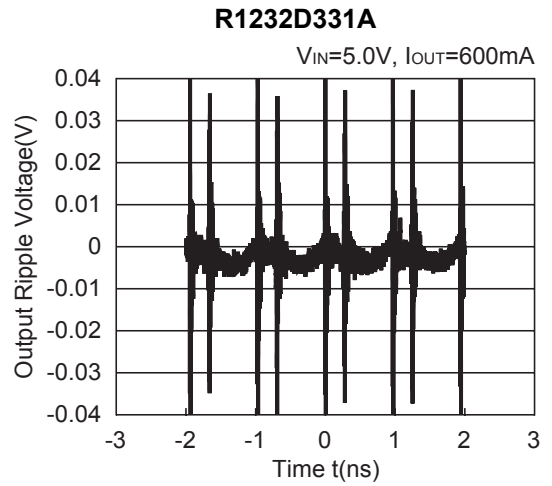
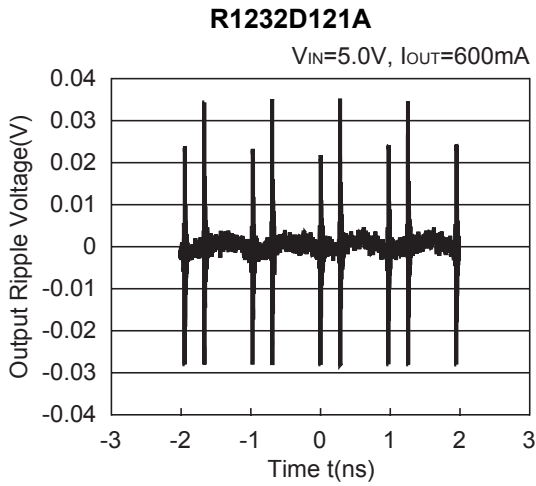


2) Efficiency vs. Output Current ($L = 4.7\mu\text{H}$, $C_{\text{IN}} = 10\mu\text{F}$, $C_{\text{OUT}} = 10\mu\text{F}$)



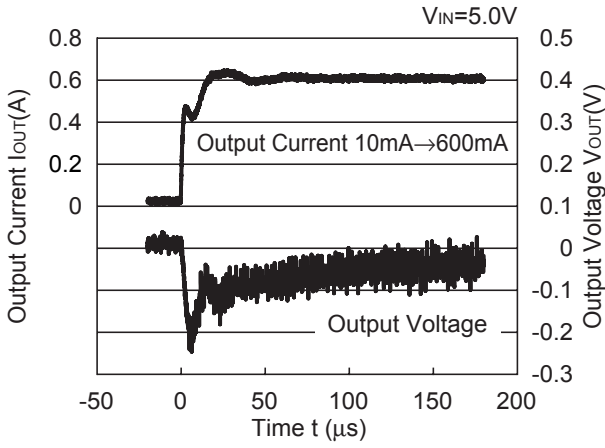


3) Output Waveform

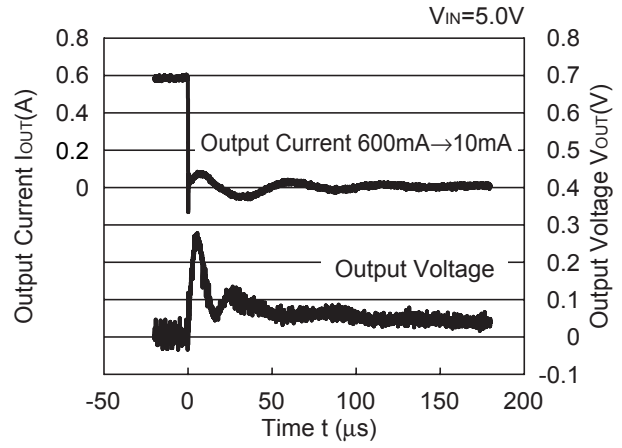


4) Load Transient Response

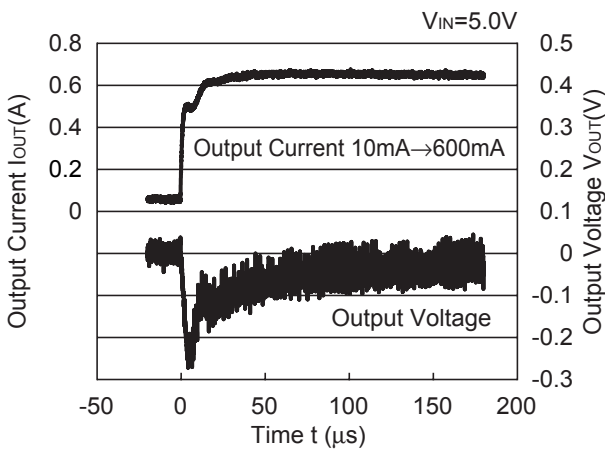
R1232D121A



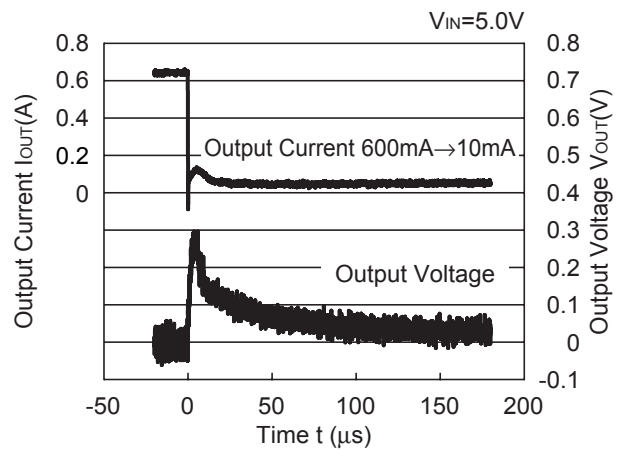
R1232D121A



R1232D121B

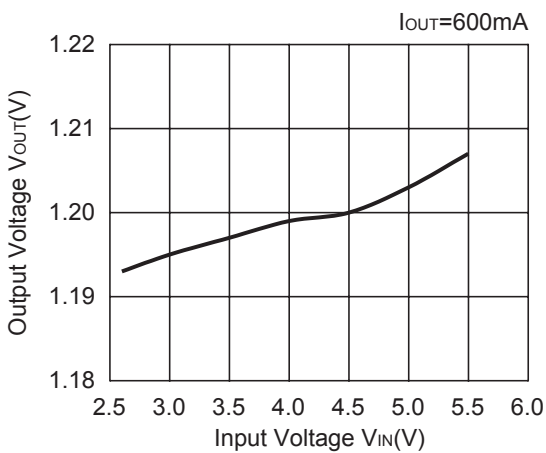


R1232D121B

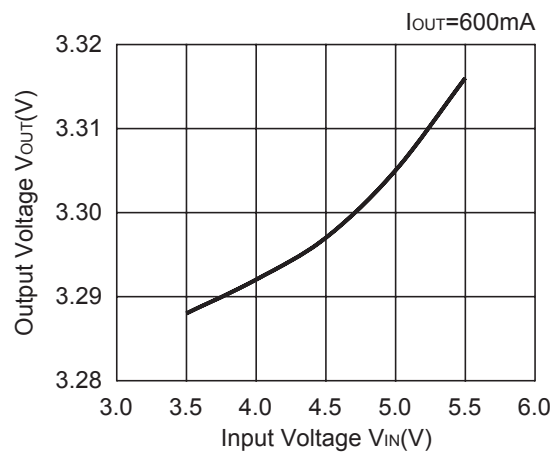


5) Output Voltage vs. Input Voltage

R1232D121A

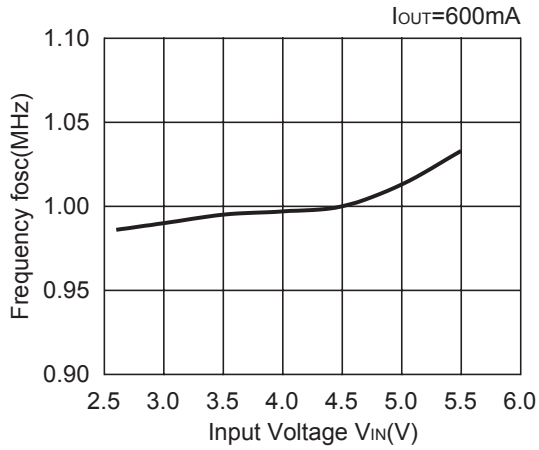


R1232D331A

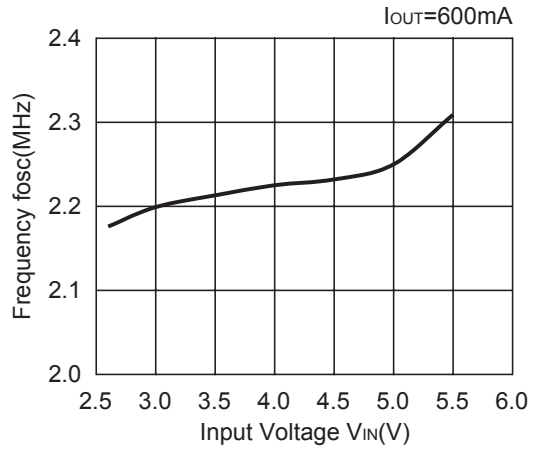


6) Oscillator Frequency vs. Input Voltage

R1232D121A

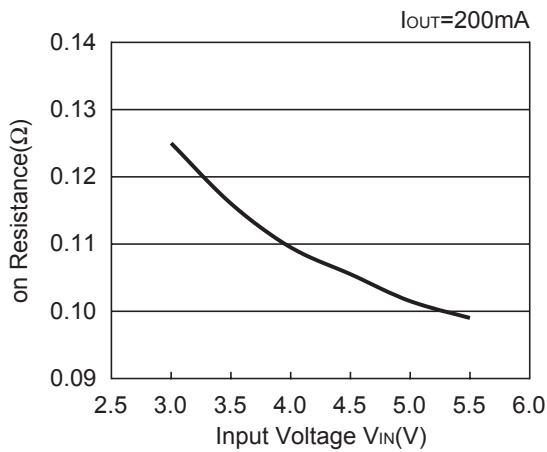


R1232D121B

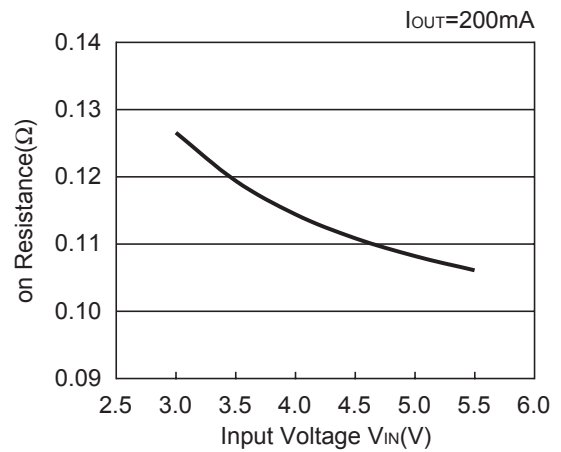


7) Lx Transistor On Resistance vs. Input Voltage

Switching Tr. Pch on Resistance



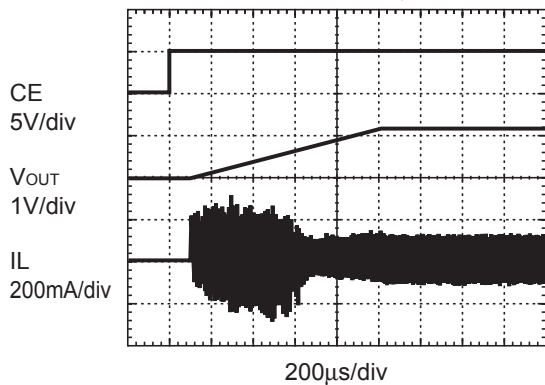
Synchronous Rectifier Tr. Nch on Resistance



8) Turn-on speed by CE pin

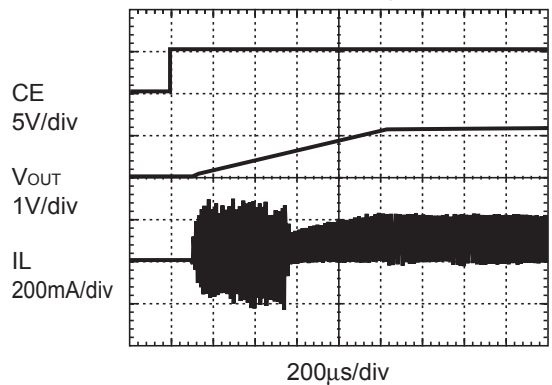
R1232D121A

$V_{IN}=5.0V, L=4.7\mu H, R_{load}=0\Omega$



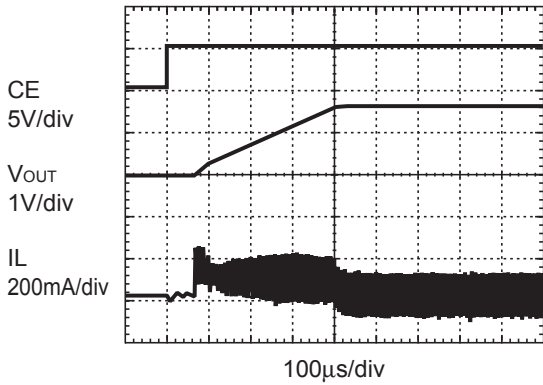
R1232D121A

$V_{IN}=5.0V, L=4.7\mu H, R_{load}=12\Omega$



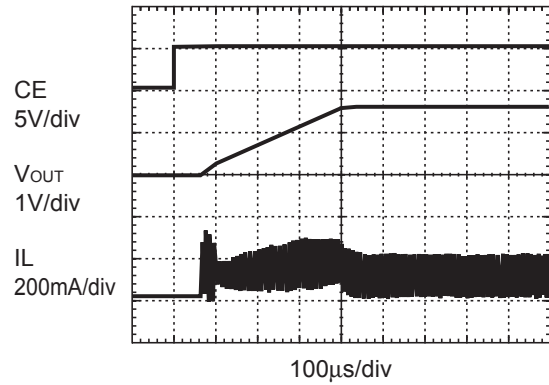
R1232D331B

$V_{IN}=5.0V$, $L=2.7\mu H$ $R_{load}=0\Omega$



R1232D331B

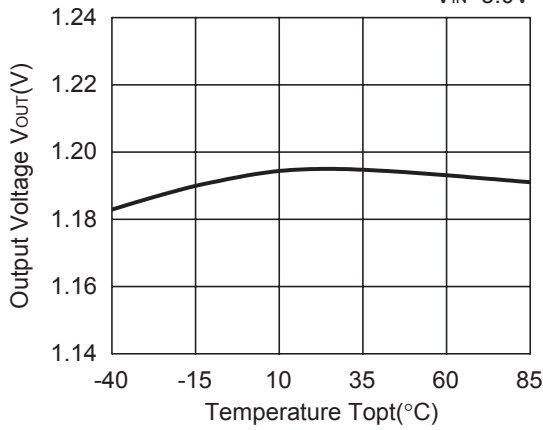
$V_{IN}=5.0V$, $L=2.7\mu H$ $R_{load}=33\Omega$



9) Output Voltage vs. Temperature

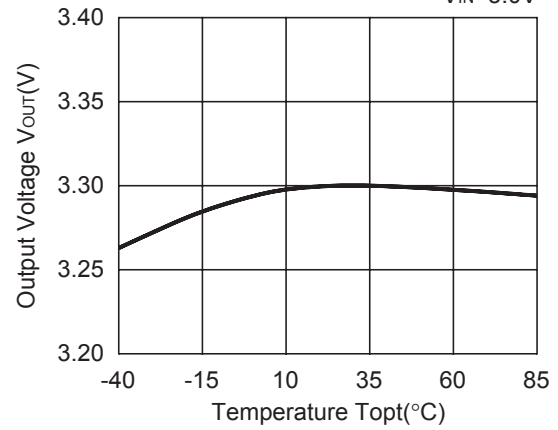
R1232D121A

$V_{IN}=5.0V$



R1232D331A

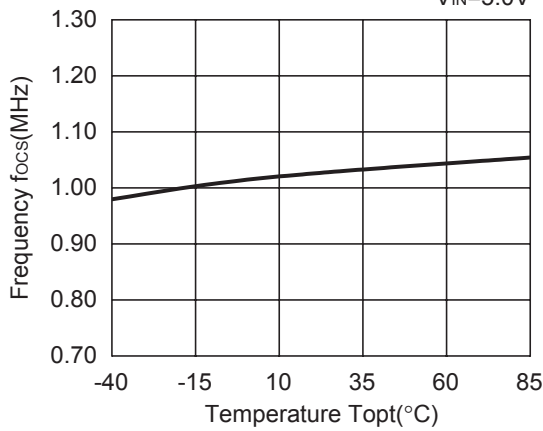
$V_{IN}=5.0V$



10) Oscillator Frequency vs. Temperature

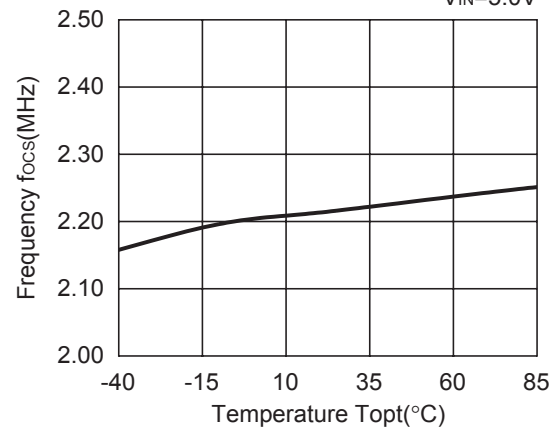
R1232D121A

$V_{IN}=5.0V$

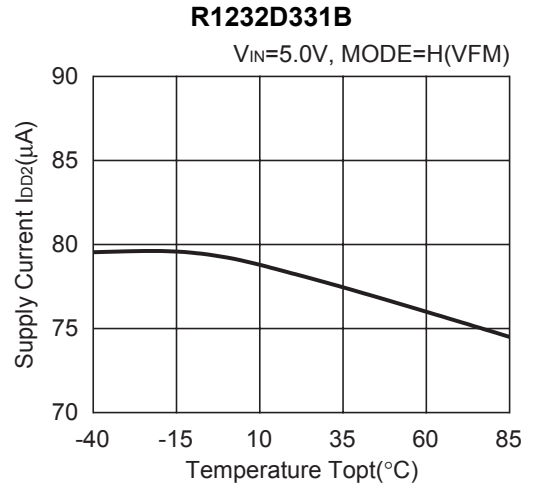
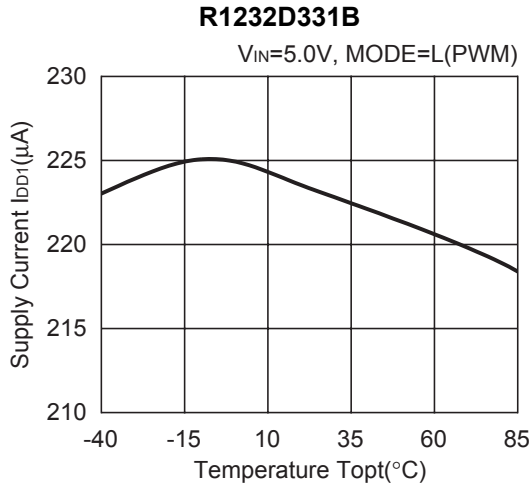
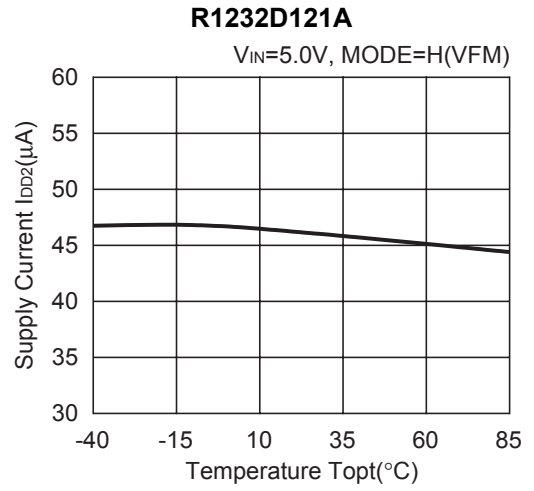
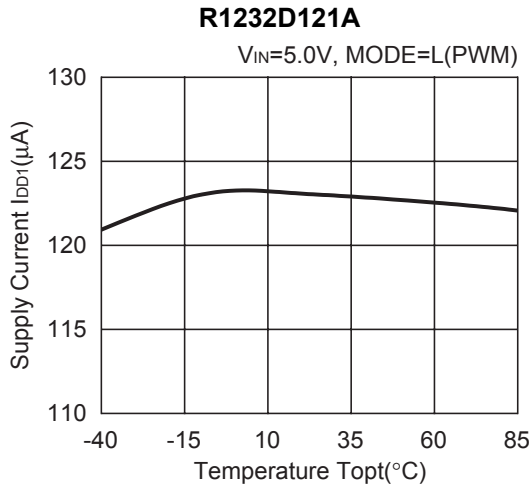


R1232D331B

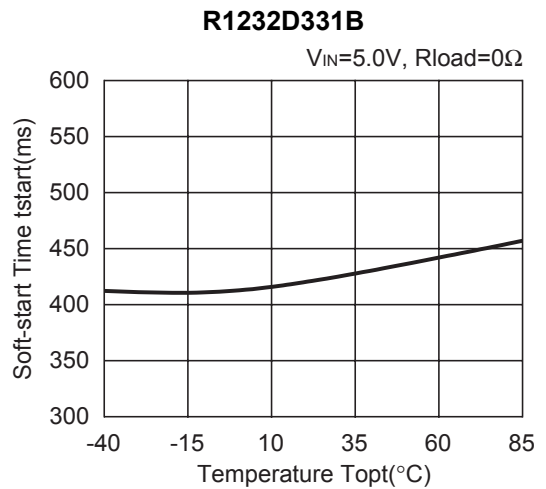
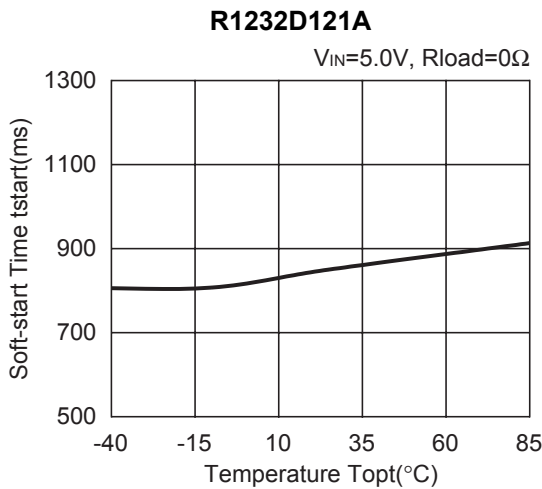
$V_{IN}=5.0V$



11) Supply Current vs. Temperature

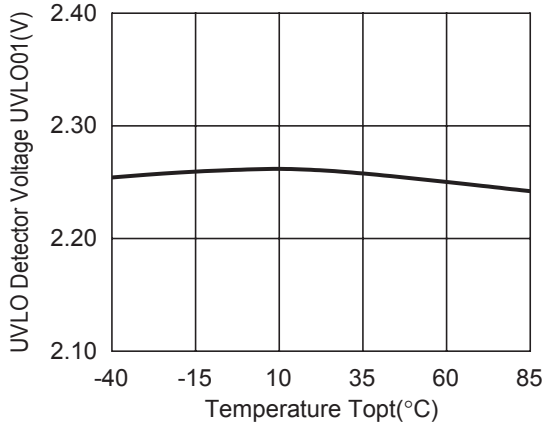


12) Soft-start time vs. Temperature

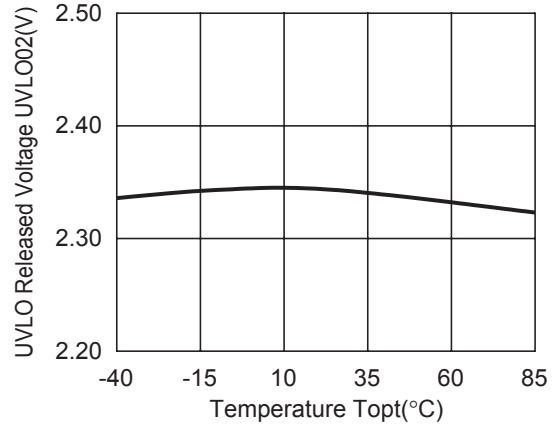


13) UVLO Voltage vs. Temperature

R1232D121A



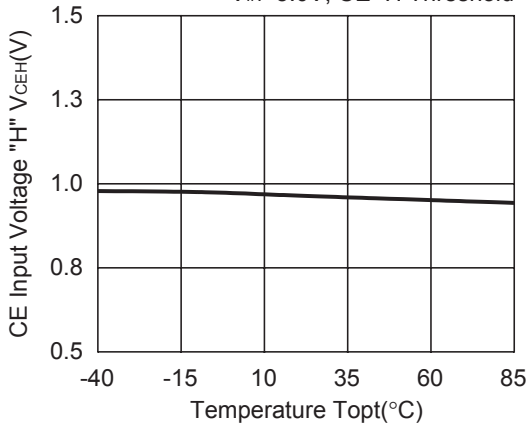
R1232D121A



14) CE Input Voltage vs. Temperature

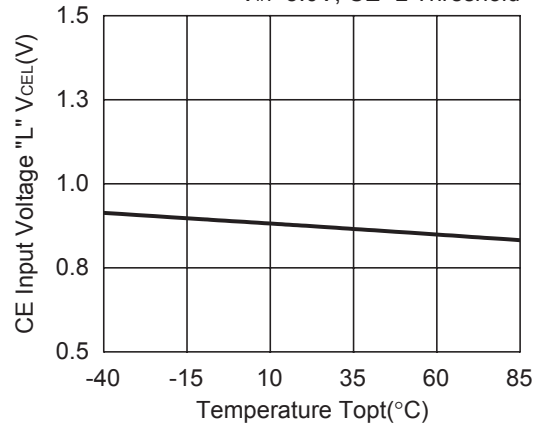
R1232D121A

V_{IN}=5.0V, CE=H Threshold



R1232D121A

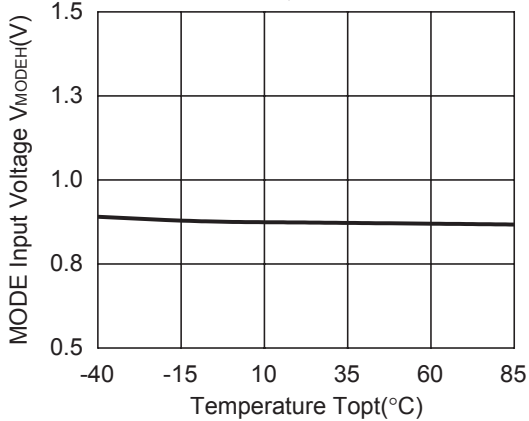
V_{IN}=5.0V, CE=L Threshold



15) Mode Input Voltage vs. Temperature

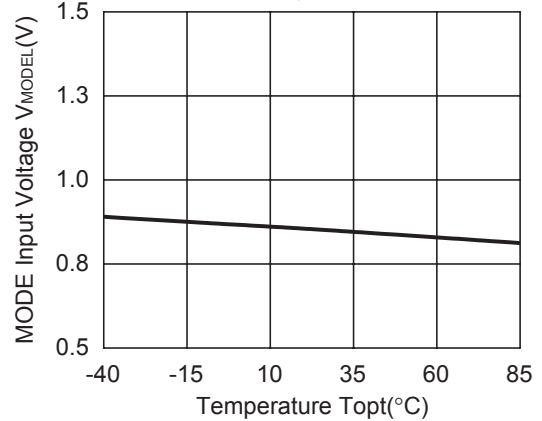
R1232D121A

V_{IN}=5.0V, MODE=H Threshold



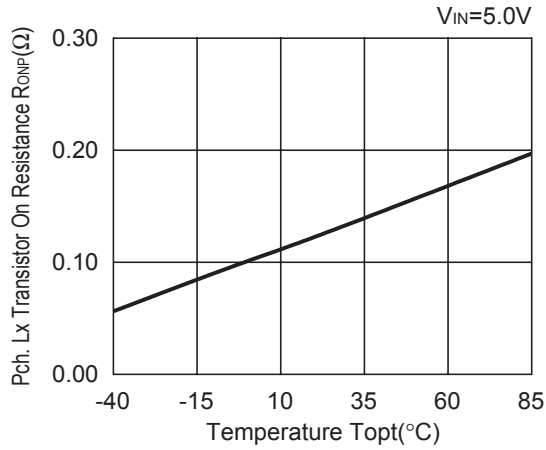
R1232D121A

V_{IN}=5.0V, MODE=L Threshold

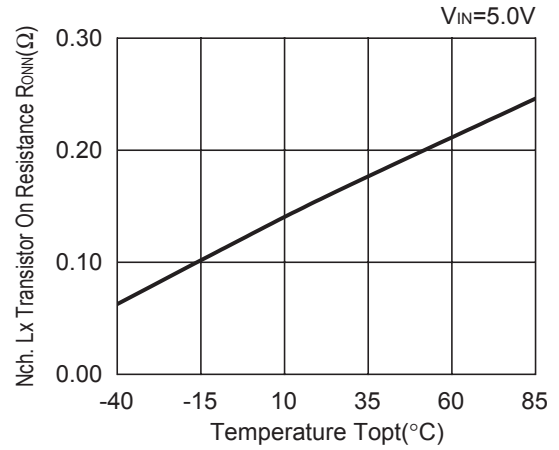


16) Lx Transistor On Resistance vs. Temperature

Driver Tr. Pch ON Resistance

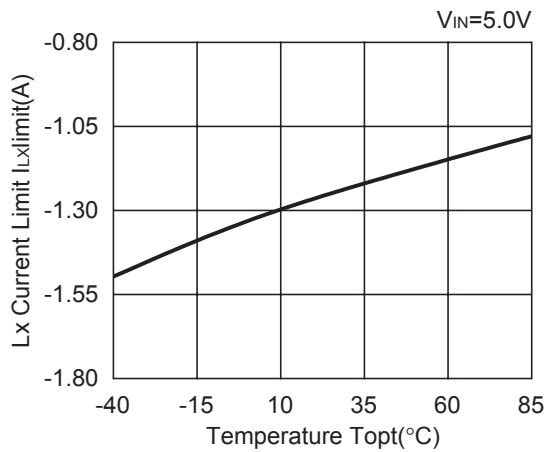


Rectifier Tr.Nch ON Resistance

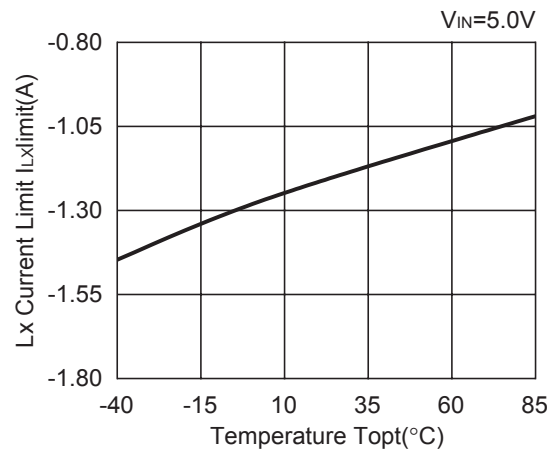


17) Current Limit vs. Temperature

R1232D121A

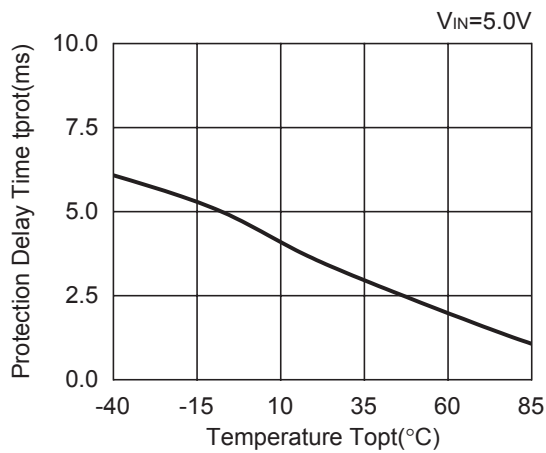


R1232D331B

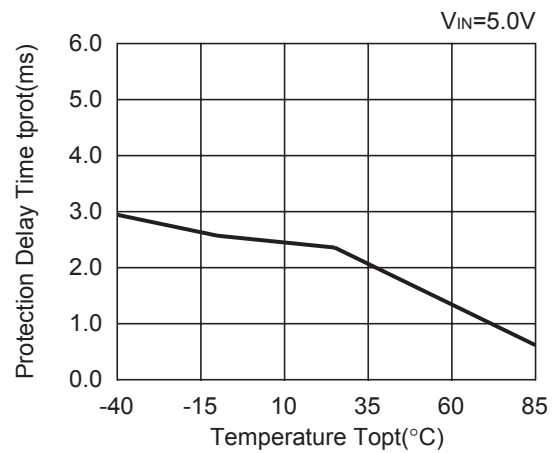


18) Protection Delay Time vs. Temperatures

R1232D121A



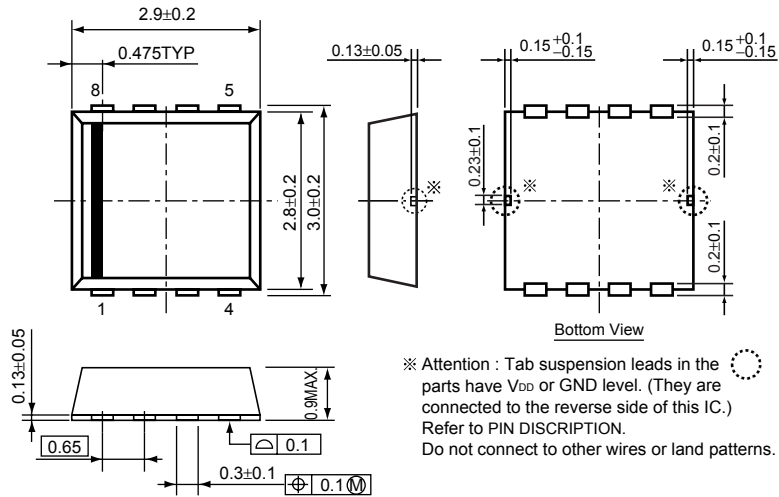
R1232D331B



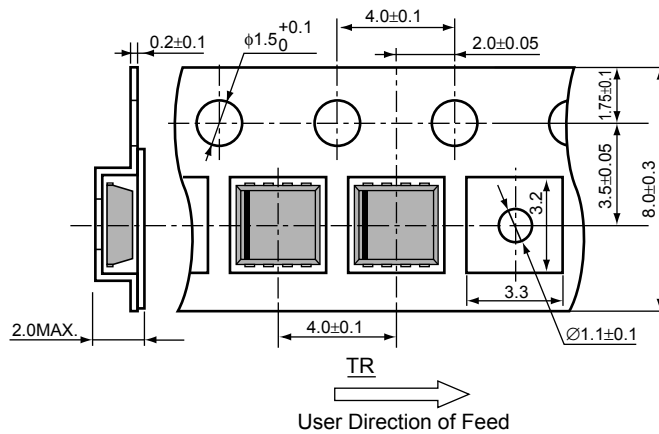
• SON-8

Unit: mm

PACKAGE DIMENSIONS

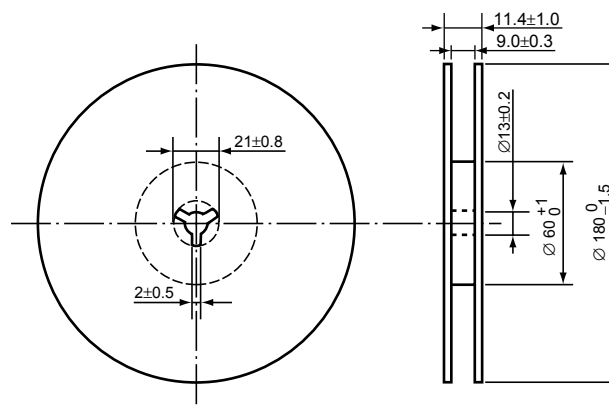


TAPING SPECIFICATION



TAPING REEL DIMENSIONS

(1reel=3000pcs)



POWER DISSIPATION (SON-8)

This specification is at mounted on board. Power Dissipation (P_D) depends on conditions of mounting on board. This specification is based on the measurement at the condition below:

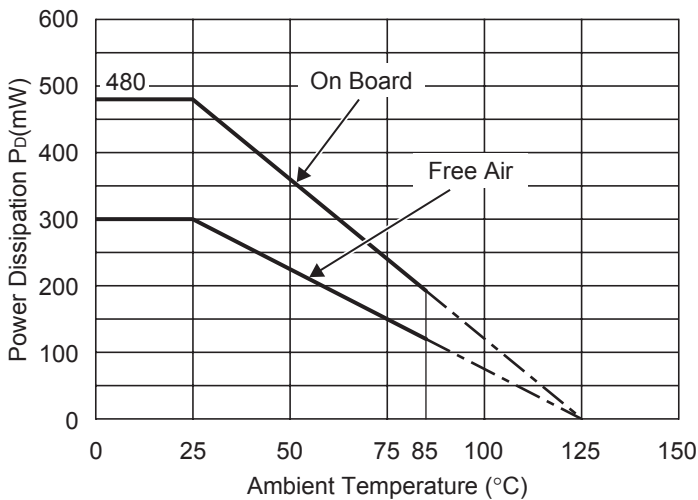
Measurement Conditions

	Standard Land Pattern
Environment	Mounting on Board (Wind velocity=0m/s)
Board Material	Glass cloth epoxy plactic (Double sided)
Board Dimensions	40mm × 40mm × 1.6mm
Copper Ratio	Top side : Approx. 50% , Back side : Approx. 50%
Through-hole	φ0.5mm × 44pcs

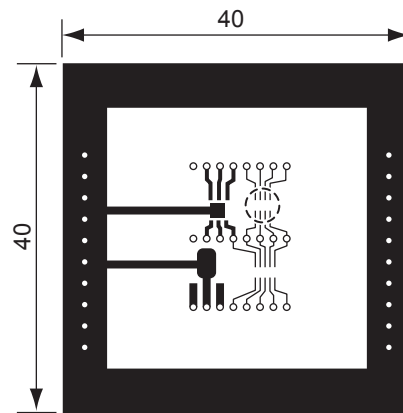
Measurement Result

($T_{opt}=25^{\circ}C, T_{jmax}=125^{\circ}C$)

	Standard Land Pattern	Free Air
Power Dissipation	480mW	300mW
Thermal Resistance	$\theta_{ja}=(125-25^{\circ}C)/0.48W=208^{\circ}C/W$	333 $^{\circ}C/W$



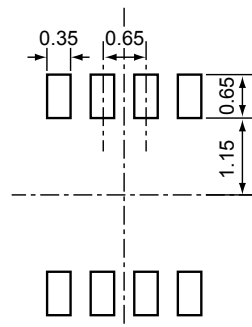
Power Dissipation



Measurement Board Pattern

○ IC Mount Area (Unit : mm)

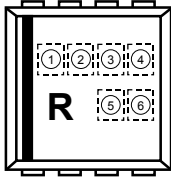
RECOMMENDED LAND PATTERN



(Unit: mm)

R1232D SERIES MARK SPECIFICATION

• SON-8



① to ④ : Product Code (refer to Part Number vs. Product Code)

⑤, ⑥ : Lot Number

• Part Number vs. Product Code

Part Number	Product Code			
	①	②	③	④
R1232D091A	K	0	9	A
R1232D101A	K	1	0	A
R1232D111A	K	1	1	A
R1232D121A	K	1	2	A
R1232D131A	K	1	3	A
R1232D141A	K	1	4	A
R1232D151A	K	1	5	A
R1232D161A	K	1	6	A
R1232D171A	K	1	7	A
R1232D181A	K	1	8	A
R1232D191A	K	1	9	A
R1232D201A	K	2	0	A
R1232D211A	K	2	1	A
R1232D221A	K	2	2	A
R1232D231A	K	2	3	A
R1232D241A	K	2	4	A
R1232D251A	K	2	5	A
R1232D261A	K	2	6	A
R1232D271A	K	2	7	A
R1232D281A	K	2	8	A
R1232D291A	K	2	9	A
R1232D301A	K	3	0	A
R1232D311A	K	3	1	A
R1232D321A	K	3	2	A
R1232D331A	K	3	3	A

Part Number	Product Code			
	①	②	③	④
R1232D091B	K	0	9	B
R1232D101B	K	1	0	B
R1232D111B	K	1	1	B
R1232D121B	K	1	2	B
R1232D131B	K	1	3	B
R1232D141B	K	1	4	B
R1232D151B	K	1	5	B
R1232D161B	K	1	6	B
R1232D171B	K	1	7	B
R1232D181B	K	1	8	B
R1232D191B	K	1	9	B
R1232D201B	K	2	0	B
R1232D211B	K	2	1	B
R1232D221B	K	2	2	B
R1232D231B	K	2	3	B
R1232D241B	K	2	4	B
R1232D251B	K	2	5	B
R1232D261B	K	2	6	B
R1232D271B	K	2	7	B
R1232D281B	K	2	8	B
R1232D291B	K	2	9	B
R1232D301B	K	3	0	B
R1232D311B	K	3	1	B
R1232D321B	K	3	2	B
R1232D331B	K	3	3	B

Part Number	Product Code			
	①	②	③	④
R1232D001C	K	0	1	C
R1232D001D	K	0	1	D