PWM Step-up DC/DC Controller

NO.EA-134-180705

OUTLINE

The R1215D is a CMOS-based PWM step-up DC/DC controller with low supply current. The R1215D consists of an oscillator, a PWM comparator circuit, a reference voltage unit, an error amplifier, a reference current unit, a protection circuit, and an under voltage lockout (UVLO) circuit. A low ripple, high efficiency step-up DC/DC converter can be composed of this IC with some external components, or an inductor, a diode, a power MOSFET, resisters, and capacitors.

The maximum duty cycle and the soft start time are easily adjustable with external resistors and capacitors. As for the protection circuit, after the soft-starting time, if the maximum duty cycle is continued for a certain period, the R1215D latches the external driver with its off state, or the latch-type protection circuit works.

The delay time for latch the state can be set with an external capacitor.

To release the protection circuit, restart with power-on (Voltage supplier is equal or less than UVLO detector threshold level).

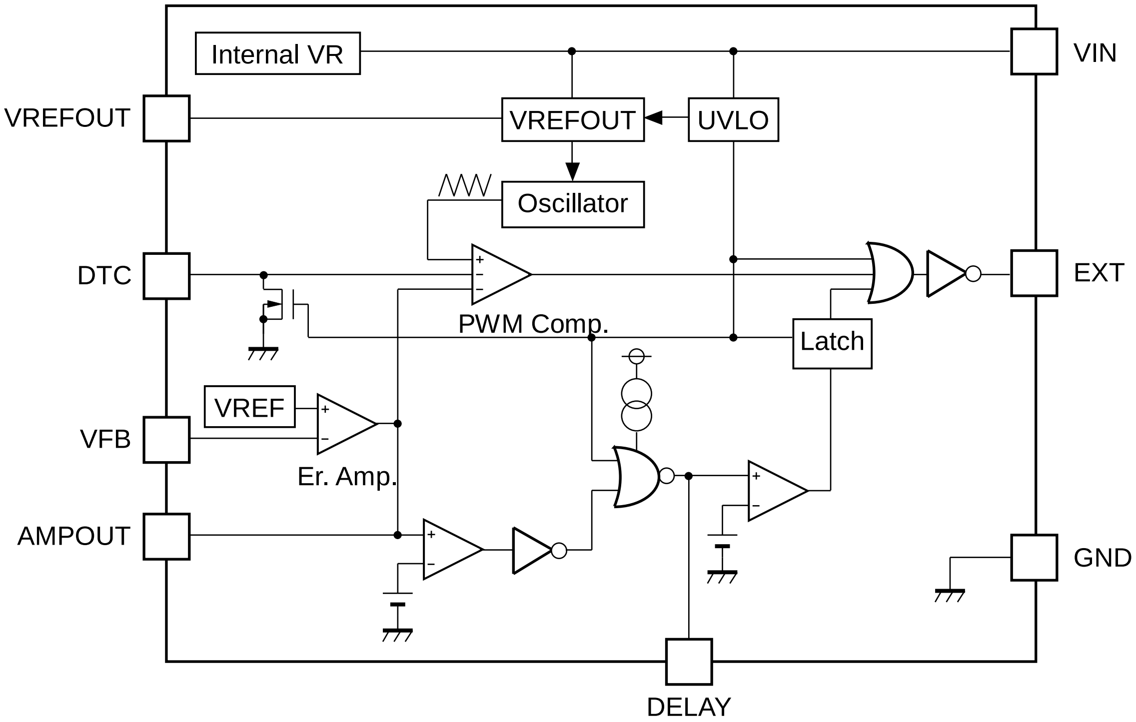
FEATURES

- Input Voltage Range .... 1.8 V to 5.5 V
- Two Options of Basic Oscillator Frequency .... Typ. 700 kHz, 1.4 MHz
- Built-in Latch-type Protection Function (Output Delay Time can be set with an external capacitor)
- Maximum Duty Cycle/Soft-start time .... Adjustable with external capacitors
- High Reference Voltage Accuracy .... ±1.5%
- UVLO Threshold level .... Typ. 1.6 V/ 1.79 V by mask option
- Small Temperature Coefficient of Reference Voltage ... Typ. ±150 ppm/°C
- Package .... SON-8 (t = Max. 0.9 mm)

APPLICATIONS

- Constant Voltage Power Source for portable equipment
- Constant Voltage Power Source for LCD and CCD

BLOCK DIAGRAM



R1215D Block Diagram

SELECTION GUIDE

In the R1215D, the oscillator frequency and UVLO detector threshold can be selected at the user's request.

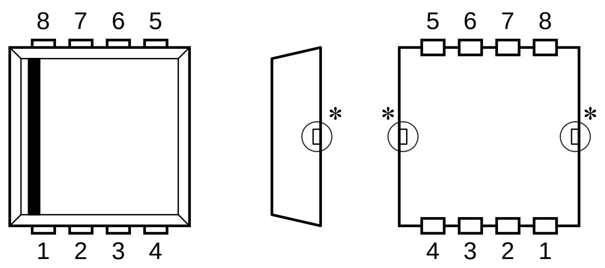
Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1215D002x-TR-FE	SON-8	3,000 pcs	Yes	Yes

x: Designation of Oscillator Frequency and Detector Threshold

Code	Oscillator Frequency	UVLO Detector Threshold
A	Typ. 700 kHz	Typ. 1.79 V
B	Typ. 1.4 MHz	Typ. 1.79 V
E	Typ. 700 kHz	Typ. 1.60 V
F	Typ. 1.4 MHz	Typ. 1.60 V

PIN CONFIGURATION



SON-8 Pin Configuration

PIN DESCRIPTION

Pin Description

Pin No	Symbol	Description
1	EXT	External FET Drive Pin (CMOS Output)
2	GND	Ground Pin
3	DTC	Pin for Setting Maximum Duty Cycle and Soft start time
4	DELAY	Pin for External Capacitor (for Setting Output Delay of Protection)
5	VFB	Feedback Pin for Monitoring Output Voltage
6	VREFOUT	Reference Voltage Output Pin
7	AMPOUT	Amplifier Output Pin
8	VIN	Power Supply Pin for the IC

∗ Tab suspension leads 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

Absolute Maximum Ratings (GND = 0 V)

Symbol	Item	Rating	Unit
V_{IN}	VIN Pin Voltage	6.5	V
V_{EXT}	EXT Pin Output Voltage	−0.3 to V_{IN} +0.3	V
V_{DLY}	DELAY Pin Voltage	−0.3 to V_{IN} +0.3	V
V_{REFOUT}	VREFOUT Pin Voltage	−0.3 to V_{IN} +0.3	V
V_{AMP}	AMPOUT Pin Voltage	−0.3 to V_{IN} +0.3	V
V_{FB}	DTC Pin Voltage	−0.3 to V_{IN} +0.3	V
V_{DTC}	VFB Pin Voltage	−0.3 to V_{IN} +0.3	V
I_{AMP}	AMPOUT Pin Current	±10	mA
I_{ROUT}	VREFOUT Pin Current	30	mA
I_{EXT}	EXT Pin Inductor Drive Output Current	±80	mA
P_D	Power Dissipation (SON-8) (Standard Test Land Pattern)*	480	mW
Topt	Operating Temperature Range	−40 to +85	°C
Tstg	Storage Temperature Range	−55 to +125	°C

∗ For Power Dissipation, please refer to PACKAGE INFORMATION to be described.

ABSOLUTE MAXIMUM RATINGS
Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the life time and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings are not assured.

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)
All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

ELECTRICAL CHARACTERISTICS

R1215D002A Electrical Characteristics (Topt = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Operating Input Voltage		2.0		5.5	V
V_{FB}	VFB Voltage Tolerance	V_{IN} = 2.5 V, Topt = 25°C	0.985	1.000	1.015	V
$\Delta V_{FB}/\Delta V_{IN}$	VFB Voltage Line Regulation	V_{IN} = 2.0 V to 5.5 V		3		mV
$\Delta V_{FB}/\Delta Topt$	VFB Voltage Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±150		ppm/°C
I_{FB}	VFB Input Current	V_{IN} = 5.5 V, V_{FB} = 0 V or 5.5 V	−0.1	0	0.1	μA
A_V	Open Loop Voltage Gain	V_{IN} = 2.5 V		100		dB
f_T	Unity Gain Frequency Band	V_{IN} = 2.5 V, A_V = 0		1.0		MHz
fosc	Oscillator Frequency	V_{IN} = 2.5 V, Topt = 25°C, V_{DLY} = V_{FB} = 0 V	595	700	805	kHz
$\Delta fosc/\Delta V_{IN}$	Oscillator Frequency Line Regulation	V_{IN} = 2.0 V to 5.5 V		50		kHz
$\Delta fosc/\Delta Topt$	Oscillator Frequency Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±0.3		kHz/°C
I_{DD1}	Supply Current 1	V_{IN} = 5.5 V, V_{DLY} = V_{FB} = 0 V		600	1000	μA
V_{REFOUT}	VREFOUT Voltage	V_{IN} = 2.5 V, I_{ROUT} = 1 mA, Topt = 25°C	1.280	1.300	1.320	V
I_{OUT}	VREFOUT Maximum Output Current	V_{IN} = 2.5 V	10			mA
$\Delta V_{REFOUT}/\Delta V_{IN}$	VREFOUT Line Regulation	V_{IN} = 2.0 V to 5.5 V		5	10	mV
$\Delta V_{REFOUT}/\Delta I_{ROUT}$	VREFOUT Load Regulation	V_{IN} = 2.5 V, I_{ROUT} = 0.1 mA to 5 mA		6	20	mV
Ilim	VREFOUT Short Current Limit	V_{IN} = 2.5 V, V_{REFOUT} = 0 V		15		mA
$\Delta V_{REFOUT}/\Delta Topt$	VREFOUT Voltage Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±150		ppm/°C
R_{EXTH}	EXT "H" ON Resistance	V_{IN} = 2.5 V, I_{EXT} = −50 mA		2.8	6.0	Ω
R_{EXTL}	EXT "L" ON Resistance	V_{IN} = 2.5 V, I_{EXT} = 50 mA		1.8	4.0	Ω
tr	EXT Rising Time	V_{IN} = 2.5 V, C_{EXT} = 1000 pF		12		ns
tf	EXT Falling Time	V_{IN} = 2.5 V,C_{EXT} = 1000 pF		8		ns
I_{DLY1}	DELAY Pin Charge Current	V_{IN} = 2.5 V, V_{DLY} = 0 V, V_{FB} = 0 V	3.0	6.0	8.5	μA
I_{DLY2}	DELAY Pin Discharge Current	V_{IN} = V_{FB} = 2.0 V, V_{DLY} = 0.1 V	0.08	0.20	0.36	mA
V_{DLY}	DELAY Pin Detector Threshold	V_{IN} = 2.5 V, V_{FB} = 0 V, V_{DLY} = 0 V→2 V	0.95	1.00	1.05	V
V_{UVLO1}	UVLO Detector Threshold	V_{IN} = 2.5 V→0 V, V_{DLY} = V_{FB} = 0 V	1.70	1.79	1.88	V
V_{UVLO2}	UVLO Released Voltage	V_{IN} = 0 V→2.5 V, V_{DLY} = V_{FB} = 0 V	1.78	1.88	1.98	V
V_{HYS}	UVLO Hysteresis Range		0.04	0.09	0.14	V
V_{DTC0}	Duty = 0% DTC Pin Voltage	V_{IN} = 2.5 V	0.28	0.38	0.48	V
V_{DTC20}	Duty = 20% DTC Pin Voltage	V_{IN} = 2.5 V		0.48		V
V_{DTC80}	Duty = 80% DTC Pin Voltage	V_{IN} = 2.5 V		0.92		V
V_{DTC100}	Duty = 100% DTC Pin Voltage	V_{IN} = 2.5 V	0.92	1.02	1.12	V
I_{AMPH}	AMP "H" Output Current	V_{IN} = 2.5 V, V_{AMP} = 1.0 V, V_{FB} = 0.9 V	1.6	3.2	5.8	mA
I_{AMPL}	AMP "L" Output Current	V_{IN} = 2.5 V, V_{AMP} = 1.0 V, V_{FB} = 1.1 V	40	85	130	μA

R1215D002B Electrical Characteristics (Topt = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Operating Input Voltage		2.0		5.5	V
V_{FB}	VFB Voltage Tolerance	V_{IN} = 2.5 V, Topt = 25°C	0.985	1.000	1.015	V
$\Delta V_{FB}/\Delta V_{IN}$	VFB Voltage Line Regulation	V_{IN} = 2.0 V to 5.5 V		3		mV
$\Delta V_{FB}/\Delta Topt$	VFB Voltage Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±150		ppm/°C
I_{FB}	VFB Input Current	V_{IN} = 5.5 V, V_{FB} = 0 V or 5.5 V	−0.1	0	0.1	μA
A_V	Open Loop Voltage Gain	V_{IN} = 2.5 V		100		dB
f_T	Unity Gain Frequency Band	V_{IN} = 2.5 V, A_V = 0		1.0		MHz
fosc	Oscillator Frequency	V_{IN} = 2.5 V, Topt = 25°C , V_{DLY} = V_{FB} = 0 V	1.190	1.400	1.610	MHz
$\Delta fosc/\Delta V_{IN}$	Oscillator Frequency Line Regulation	V_{IN} = 2.0 V to 5.5 V		100		kHz
$\Delta fosc/\Delta Topt$	Oscillator Frequency Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±0.6		kHz/°C
I_{DD1}	Supply Current 1	V_{IN} = 5.5 V, V_{DLY} = V_{FB} = 0 V		900	1800	μA
V_{REFOUT}	VREFOUT Voltage	V_{IN} = 2.5 V, I_{ROUT} = 1 mA, Topt = 25°C	1.280	1.300	1.320	V
I_{OUT}	VREFOUT Maximum Output Current	V_{IN} = 2.5 V	10			mA
$\Delta V_{REFOUT}/\Delta V_{IN}$	VREFOUT Line Regulation	V_{IN} = 2.0 V to 5.5 V		5	10	mV
$\Delta V_{REFOUT}/\Delta I_{ROUT}$	VREFOUT Load Regulation	V_{IN} = 2.5 V, I_{ROUT} = 0.1 mA to 5 mA		6	20	mV
Ilim	VREFOUT Short Current Limit	V_{IN} = 2.5 V, V_{REFOUT} = 0 V		15		mA
$\Delta V_{REFOUT}/\Delta Topt$	VREFOUT Voltage Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±150		ppm/°C
R_{EXTH}	EXT "H" ON Resistance	V_{IN} = 2.5 V, I_{EXT} = −50 mA		2.8	6.0	Ω
R_{EXTL}	EXT "L" ON Resistance	V_{IN} = 2.5 V, I_{EXT} = 50 mA		1.8	4.0	Ω
tr	EXT Rising Time	V_{IN} = 2.5 V, C_{EXT} = 1000 pF		12		ns
tf	EXT Falling Time	V_{IN} = 2.5 V, C_{EXT} = 1000 pF		8		ns
I_{DLY1}	DELAY Pin Charge Current	V_{IN} = 2.5 V, V_{DLY} = 0 V, V_{FB} = 0 V	3.0	6.0	8.5	μA
I_{DLY2}	DELAY Pin Discharge Current	V_{IN} = V_{FB} = 2.0 V, V_{DLY} = 0.1 V	0.08	0.20	0.36	mA
V_{DLY}	DELAY Pin Detector Threshold	V_{IN} = 2.5 V, V_{FB} = 0 V, V_{DLY} = 0 V→2 V	0.95	1.00	1.05	V
V_{UVLO1}	UVLO Detector Threshold	V_{IN} = 2.5 V→0 V, V_{DLY} = V_{FB} = 0 V	1.70	1.79	1.88	V
V_{UVLO2}	UVLO Released Voltage	V_{IN} = 0 V→2.5 V, V_{DLY} = V_{FB} = 0 V	1.78	1.88	1.98	V
V_{HYS}	UVLO Hysteresis Range		0.04	0.09	0.14	V
V_{DTC0}	Duty = 0% DTC Pin Voltage	V_{IN} = 2.5 V	0.28	0.38	0.48	V
V_{DTC20}	Duty = 20% DTC Pin Voltage	V_{IN} = 2.5 V		0.47		V
V_{DTC80}	Duty = 80% DTC Pin Voltage	V_{IN} = 2.5 V		0.93		V
V_{DTC100}	Duty = 100% DTC Pin Voltage	V_{IN} = 2.5 V	0.92	1.02	1.12	V
I_{AMPH}	AMP "H" Output Current	V_{IN} = 2.5 V, V_{AMP} = 1.0 V, V_{FB} = 0.9 V	1.6	3.2	5.8	mA
I_{AMPL}	AMP "L" Output Current	V_{IN} = 2.5 V, V_{AMP} = 1.0 V, V_{FB} = 1.1 V	40	85	130	μA

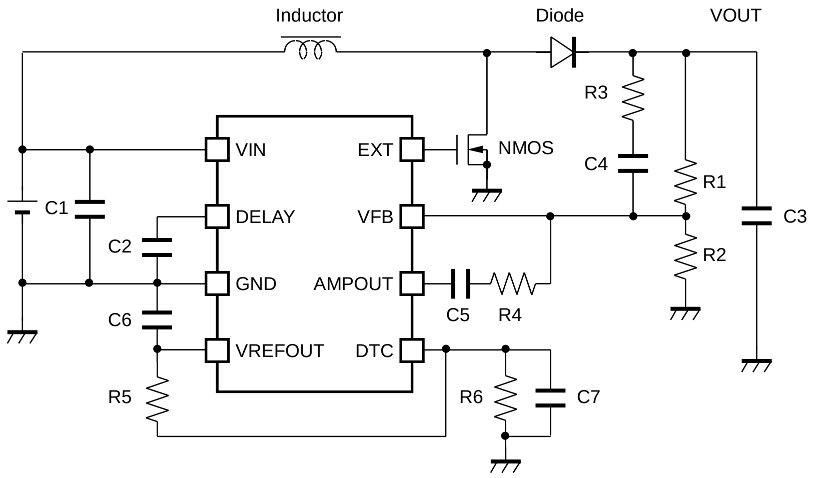
R1215D002E Electrical Characteristics (Topt = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Operating Input Voltage		1.8		5.5	V
V_{FB}	VFB Voltage Tolerance	V_{IN} = 2.5 V, Topt = 25°C	0.985	1.000	1.015	V
$\Delta V_{FB}/\Delta V_{IN}$	VFB Voltage Line Regulation	V_{IN} = 1.8 V to 5.5 V		3		mV
$\Delta V_{FB}/\Delta Topt$	VFB Voltage Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±150		ppm/ °C
I_{FB}	VFB Input Current	V_{IN} = 5.5 V, V_{FB} = 0 V or 5.5 V	−0.1	0	0.1	μA
A_V	Open Loop Voltage Gain	V_{IN} = 2.5 V		100		dB
f_T	Unity Gain Frequency Band	V_{IN} = 2.5 V, A_V = 0		1.0		MHz
fosc	Oscillator Frequency	V_{IN} = 2.5 V, Topt = 25°C , V_{DLY} = V_{FB} = 0 V	595	700	805	kHz
$\Delta fosc/\Delta V_{IN}$	Oscillator Frequency Line Regulation	V_{IN} = 2.0 V to 5.5 V		50		kHz
$\Delta fosc/\Delta Topt$	Oscillator Frequency Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±0.3		kHz/ °C
I_{DD1}	Supply Current 1	V_{IN} = 5.5 V, V_{DLY} = V_{FB} = 0 V		600	1000	μA
V_{REFOUT}	VREFOUT Voltage	V_{IN} = 2.5 V, I_{ROUT} = 1 mA, Topt = 25°C	1.280	1.300	1.320	V
I_{OUT}	VREFOUT Maximum Output Current	V_{IN} = 2.5 V	10			mA
$\Delta V_{REFOUT}/\Delta V_{IN}$	VREFOUT Line Regulation	V_{IN} = 1.8 V to 5.5 V		5	10	mV
$\Delta V_{REFOUT}/\Delta I_{ROUT}$	VREFOUT Load Regulation	V_{IN} = 2.5 V, I_{ROUT} = 0.1 mA to 5 mA		6	20	mV
Ilim	VREFOUT Short Current Limit	V_{IN} = 2.5 V, V_{REFOUT} = 0 V		15		mA
$\Delta V_{REFOUT}/\Delta Topt$	VREFOUT Voltage Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±150		ppm/ °C
R_{EXTH}	EXT "H" ON Resistance	V_{IN} = 2.5 V, I_{EXT} = −50 mA		2.8	6.0	Ω
R_{EXTL}	EXT "L" ON Resistance	V_{IN} = 2.5 V, I_{EXT} = 50 mA		1.8	4.0	Ω
tr	EXT Rising Time	V_{IN} = 2.5 V, C_{EXT} = 1000 pF		12		ns
tf	EXT Falling Time	V_{IN} = 2.5 V, C_{EXT} = 1000 pF		8		ns
I_{DLY1}	DELAY Pin Charge Current	V_{IN} = 2.5 V, V_{DLY} = 0 V, V_{FB} = 0 V	3.0	6.0	8.5	μA
I_{DLY2}	DELAY Pin Discharge Current	V_{IN} = V_{FB} = 1.8 V, V_{DLY} = 0.1 V	0.08	0.18	0.36	mA
V_{DLY}	DELAY Pin Detector Threshold	V_{IN} = 2.5 V, V_{FB} = 0 V, V_{DLY} = 0 V→2 V	0.95	1.00	1.05	V
V_{UVLO1}	UVLO Detector Threshold	V_{IN} = 2.5 V→0 V, V_{DLY} = V_{FB} = 0 V	1.50	1.60	1.70	V
V_{UVLO2}	UVLO Released Voltage	V_{IN} = 0 V→2.5 V, V_{DLY} = V_{FB} = 0 V	1.56	1.67	1.78	V
V_{HYS}	UVLO Hysteresis Range		0.03	0.07	0.11	V
V_{DTC0}	Duty = 0% DTC Pin Voltage	V_{IN} = 2.5 V	0.28	0.38	0.48	V
V_{DTC20}	Duty = 20% DTC Pin Voltage	V_{IN} = 2.5 V		0.48		V
V_{DTC80}	Duty = 80% DTC Pin Voltage	V_{IN} = 2.5 V		0.92		V
V_{DTC100}	Duty = 100% DTC Pin Voltage	V_{IN} = 2.5 V	0.92	1.02	1.12	V
I_{AMPH}	AMP "H" Output Current	V_{IN} = 2.5 V, V_{AMP} = 1.0 V, V_{FB} = 0.9 V	1.6	3.2	5.8	mA
I_{AMPL}	AMP "L" Output Current	V_{IN} = 2.5 V, V_{AMP} = 1.0 V, V_{FB} = 1.1 V	40	85	130	μA

R1215D002F Electrical Characteristics (Topt = 25°C)

Symbol	Item	Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Operating Input Voltage		1.8		5.5	V
V_{FB}	VFB Voltage Tolerance	V_{IN} = 2.5 V, Topt = 25°C	0.985	1.000	1.015	V
$\Delta V_{FB}/\Delta V_{IN}$	VFB Voltage Line Regulation	V_{IN} = 1.8 V to 5.5 V		3		mV
$\Delta V_{FB}/\Delta Topt$	VFB Voltage Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±150		ppm/°C
I_{FB}	VFB Input Current	V_{IN} = 5.5 V, V_{FB} = 0 V or 5.5 V	−0.1	0	0.1	μA
A_V	Open Loop Voltage Gain	V_{IN} = 2.5 V		100		dB
f_T	Unity Gain Frequency Band	V_{IN} = 2.5 V, A_V = 0		1.0		MHz
fosc	Oscillator Frequency	V_{IN} = 2.5 V, Topt = 25°C , V_{DLY} = V_{FB} = 0 V	1.190	1.400	1.610	MHz
$\Delta fosc/\Delta V_{IN}$	Oscillator Frequency Line Regulation	V_{IN} = 1.8 V to 5.5 V		100		KHz
$\Delta fosc/\Delta Topt$	Oscillator Frequency Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±0.6		KHz/°C
I_{DD1}	Supply Current 1	V_{IN} = 5.5 V, V_{DLY} = V_{FB} = 0 V		900	1800	μA
V_{REFOUT}	VREFOUT Voltage	V_{IN} = 2.5 V, I_{ROUT} = 1 mA, Topt = 25°C	1.280	1.300	1.320	V
I_{OUT}	VREFOUT Maximum Output Current	V_{IN} = 2.5 V	10			mA
$\Delta V_{REFOUT}/\Delta V_{IN}$	VREFOUT Line Regulation	V_{IN} = 1.8 V to 5.5 V		5	10	mV
$\Delta V_{REFOUT}/\Delta I_{ROUT}$	VREFOUT Load Regulation	V_{IN} = 2.5 V, I_{ROUT} = 0.1 mA to 5 mA		6	20	mV
Ilim	VREFOUT Short Current Limit	V_{IN} = 2.5 V, V_{REFOUT} = 0 V		15		mA
$\Delta V_{REFOUT}/\Delta Topt$	VREFOUT Voltage Temperature Coefficient	−40°C ≤ Topt ≤ 85°C		±150		ppm/°C
R_{EXTH}	EXT "H" ON Resistance	V_{IN} = 2.5 V, I_{EXT} = −50 mA		2.8	6.0	Ω
R_{EXTL}	EXT "L" ON Resistance	V_{IN} = 2.5 V, I_{EXT} = 50 mA		1.8	4.0	Ω
tr	EXT Rising Time	V_{IN} = 2.5 V, C_{EXT} = 1000 pF		12		ns
tf	EXT Falling Time	V_{IN} = 2.5 V, C_{EXT} = 1000 pF		8		ns
I_{DLY1}	DELAY Pin Charge Current	V_{IN} = 2.5 V, V_{DLY} = 0 V, V_{FB} = 0 V	3.0	6.0	8.5	μA
I_{DLY2}	DELAY Pin Discharge Current	V_{IN} = V_{FB} = 1.8 V, V_{DLY} = 0.1 V	0.08	0.18	0.36	mA
V_{DLY}	DELAY Pin Detector Threshold	V_{IN} = 2.5 V, V_{FB} = 0 V, V_{DLY} = 0 V→2 V	0.95	1.00	1.05	V
V_{UVLO1}	UVLO Detector Threshold	V_{IN} = 2.5 V→0 V, V_{DLY} = V_{FB} = 0 V	1.50	1.60	1.70	V
V_{UVLO2}	UVLO Released Voltage	V_{IN} = 0 V→2.5 V, V_{DLY} = V_{FB} = 0 V	1.56	1.67	1.78	V
V_{HYS}	UVLO Hysteresis Range		0.03	0.07	0.11	V
V_{DTC0}	Duty = 0% DTC Pin Voltage	V_{IN} = 2.5 V	0.28	0.38	0.48	V
V_{DTC20}	Duty = 20% DTC Pin Voltage	V_{IN} = 2.5 V		0.47		V
V_{DTC80}	Duty = 80% DTC Pin Voltage	V_{IN} = 2.5 V		0.93		V
V_{DTC100}	Duty = 100% DTC Pin Voltage	V_{IN} = 2.5 V	0.92	1.02	1.12	V
I_{AMPH}	AMP "H" Output Current	V_{IN} = 2.5 V, V_{AMP} = 1.0 V, V_{FB} = 0.9 V	1.6	3.2	5.8	mA
I_{AMPL}	AMP "L" Output Current	V_{IN} = 2.5 V, V_{AMP} = 1.0 V, V_{FB} = 1.1 V	40	85	130	μA

TYPICAL APPLICATIONS AND TECHNICAL NOTES



Typical Application

<Output Voltage Setting: 9 V>

Inductor	VLF504012MT-100M (TDK: 10 µH)		
NMOS	CPH6415 (Sanyo)		
Diode	CRS10I30A (Toshiba)		
C1	1.0 µF	R1	160 kΩ
C2	1.0 µF	R2	20 kΩ
C3	15 µF	R3	1 kΩ
C4	1000 pF	R4	4.7 kΩ
C5	2200 pF	R5	68 kΩ
C6	0.1 µF	R6	240 kΩ
C7	0.1 µF		

- Output Voltage Setting Method and Phase Compensation Making Method

  The feedback voltage is controlled into 1.0 V. The output voltage can be set with divider resistors for voltage setting, R1 and R2 as shown in typical application of the previous page. Refer to the next formula.

  Output Voltage = V_{FB} x (R1 + R2) / R2

  Output Voltage is adjustable with setting various resistor values combination.

  R1 + R2 should be equal or less than 500 kΩ.

  As for the DC/DC converter, depending on the load current and external components such as L and C, phase may loss around 180°. In such case, phase margin becomes less and may be unstable. To avoid this situation, make the phase margin more. The pole is made with external components L and C.

  Fpole ~ 1 / {2 x π x √ (L x C3)}

  C4, C5, R3, and R4 shown in the diagram are for making phase compensation. The gain of the system can be set with using these resistors and capacitors. Each value in the diagram is just an example.

  R4 and C5 make zero (the backward phase).

  Fzero ~ 1 / (2 x π x R4 x C5)

  Choose the R4 and C5 value so as to make the cutoff frequency of this zero point close to the cutoff frequency of the pole by external components, L and C.

  For example, supposed that L = 10 µH and C_{OUT} (C3) = 15 µF, the cutoff frequency of the pole is approximately 13 kHz. Therefore make the cutoff frequency of the zero point close to 13 kHz. Then R4 = 4.7 kΩ and C5 = 2200 pF are appropriate values.

  As for setting the gain, the ratio of the composite resistor (RT: RT = R1 x R2 / (R1 + R2)) to R4 is the key.

  If the R4 against the composite resistor, RT, is large, the gain becomes also large. If the gain is large, the response characteristic is improved, however, too large gain makes the system be unstable.

  If the spike noise of V_{OUT} may be large, the spike noise may be picked into VFB pin, and the unstable operation may result. In this case, a resistor R3, shown in typical application of the previous page. The recommended resistance value of R3 is in the range from 1 kΩ to 5 kΩ. Then, noise level will be decreased.

Further, R1 and C4 makes another zero point (the backward phase).

Fzero ~ 1 / (2 x π x R1 x C4)

Make the cutoff frequency of this zero point be lower than the cutoff frequency of the pole by external components, or, L and C. Herein, R1 = 160 kΩ and C4 = 1000 pF are appropriate values.

- Soft-start Time and the Maximum Duty Cycle Setting Method
  The soft-start time and the maximum duty cycle can be set with R5, R6, and C7 values connected to the VREFOUT pin and the DTC pin. (Refer to the timing chart: Soft-start operation.)

- In terms of the capacitor for setting delay time of the latch protection, C2 is shown in typical application above. Latch delay time depends on this C2 value. Refer to the Latch Protection Operation Timing Chart. Set the C2 GND as close as possible to the IC GND.

- Use a 1 µF or more capacitance value of bypass capacitor between VIN pin and GND, C1 as shown in the typical application above. Connect the capacitor as short as possible to the IC.

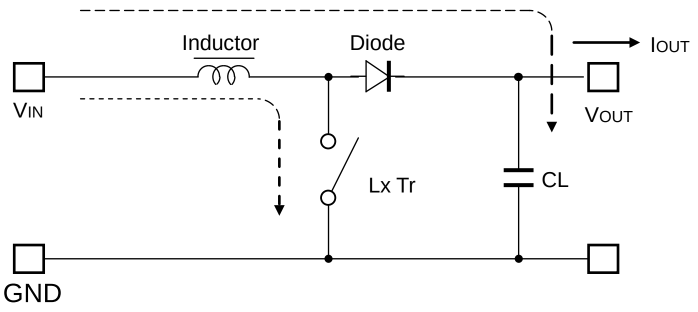
- Connect a capacitor between VREFOUT and GND, C6 as shown in typical application of the previous page. The capacitance value of C6 is between 0.1 µF and 1.0 µF.

- Connect a 1 µF or more value of capacitor between VOUT and GND, C3 as shown in typical application above. (10 µF to 22 µF is the capacitance recommendation range.) If the operation of the composed DC/DC converter may be unstable, use a tantalum type capacitor instead of ceramic type.

- Select the Power MOSFET, the diode, capacitors and the inductor within ratings (Voltage, Current, Power) of this IC. Choose the power MOSFET with low threshold voltage depending on the input voltage to be able to turn on the FET completely.

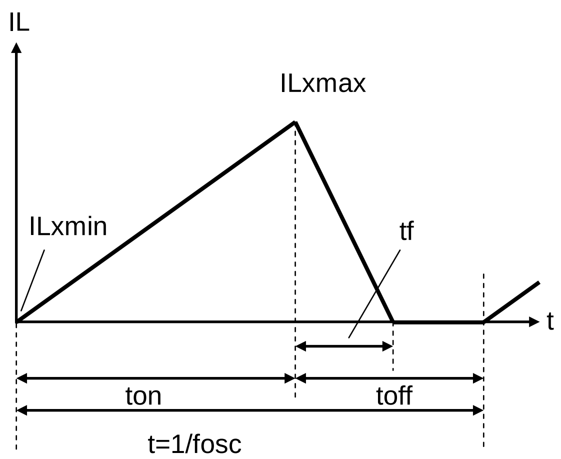
- Choose the diode with low VF such as Shottky type with low reverse current IR, and with fast switching speed. When an external transistor is switching, spike voltage may be generated caused by an inductor, therefore recommended voltage tolerance of capacitor connected to VOUT is twice as much as the setting voltage or more.

OUTPUT CURRENT AND SELECTION OF EXTERNAL COMPONENTS

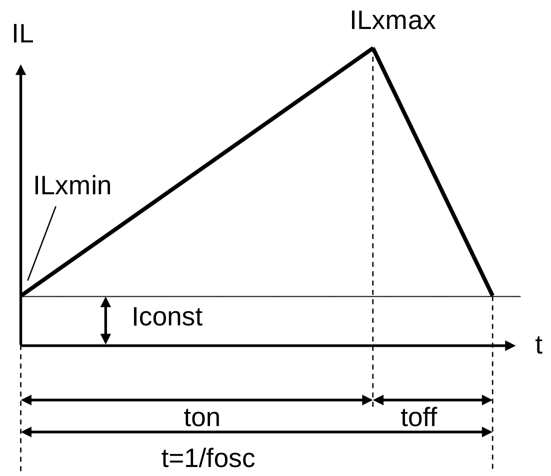


R1215D Typical Application

Current Flowing through L



Discontinuous Mode



Continuous Mode

There are two modes, or discontinuous mode and continuous mode for the PWM step-up switching regulator depending on the continuous characteristic of inductor current. During on time of the transistor, when the voltage added on to the inductor is described as V_{IN}, the current is V_{IN} x t / L. Therefore, the electric power, P_{ON}, which is supplied with input side, can be described as in next formula.

$P_{ON} = \int_0^{ton} V_{IN}^2 \times t/L\ dt$ .... Formula 1

With the step-up circuit, electric power is supplied from power source also during off time. In this case, input current is described as (V_{OUT} − V_{IN}) x t / L, therefore electric power, P_{OFF} is described as in next formula.

$P_{OFF} = \int_0^{tf} V_{IN} \times (V_{OUT} - V_{IN}) \times t/L\ dt$ .... Formula 2

In this formula, tf means the time of which the energy saved in the inductance is being emitted. Thus average electric power, or P_{AV} is described as in the next formula.

$$P_{AV} = 1/(t_{ON} + t_{OFF}) \times \{\int_0^{ton} V_{IN}^2 \times t / L \; dt + \int_0^{tf} V_{IN} \times (V_{OUT} - V_{IN}) \times t / L \; dt\} \quad \text{Formula 3}$$

In PWM control, when tf = toff is true, the inductor current becomes continuous, then the operation of switching regulator becomes continuous mode.

In the continuous mode, the deviation of the current is equal between on time and off time.

$$V_{IN} = t_{ON} / L = (V_{OUT} - V_{IN}) \times toff / L \quad \text{Formula 4}$$

Further, the electric power, P_{AV} is equal to output electric power, V_{OUT} x I_{OUT}, thus,

$$I_{OUT} = f_{OSC} \times V_{IN}^2 \times t_{ON}^2 / \{2 \times L \times (V_{OUT} - V_{IN})\} = V_{IN}^2 \times t_{ON} / (2 \times L \times V_{OUT}) \quad \text{Formula 5}$$

When I_{OUT} becomes more than formula 5, the current flows through the inductor, then the mode becomes continuous. The continuous current through the inductor is described as Iconst, then,

$$I_{OUT} = f_{OSC} \times V_{IN}^2 \times t_{ON}^2 / \{2 \times L \times (V_{OUT} - V_{IN})\} + V_{IN} \times Iconst / V_{OUT} \quad \text{Formula 6}$$

In this moment, the peak current, ILxmax flowing through the inductor and the driver Tr. is described as follows:

$$ILx\max = Iconst + V_{IN} \times t_{ON} / L \quad \text{Formula 7}$$

With the formula 4, 6, and ILxmax is,

$$ILx\max = V_{OUT} / V_{IN} \times I_{OUT} + V_{IN} \times t_{ON} / (2 \times L) \quad \text{Formula 8}$$

Therefore, peak current is more than I_{OUT}. Considering the value of ILxmax, the condition of input and output, and external components should be selected. In the formula 7, peak current ILxmax at discontinuous mode can be calculated. Put Iconst = 0 in the formula.

The explanation above is based on the ideal calculation, and the loss caused by Lx switch and external components is not included. The actual maximum output current is between 50% and 80% of the calculation. Especially, when the I_{LX} is large, or V_{IN} is low, the loss of V_{IN} is generated with the on resistance of the switch. As for V_{OUT}, Vf (as much as 0.3 V) of the diode should be considered.

TIMING CHART

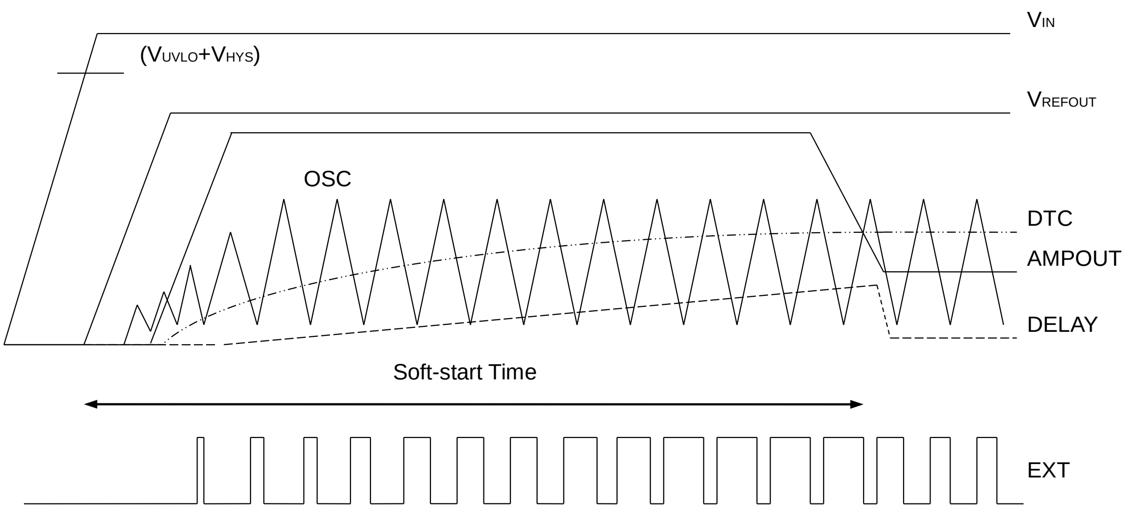
Soft-start Operation

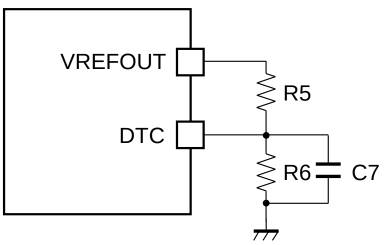
The timing chart below describes the state of each pin from the power-on until the IC entering the stable operation. By raising the voltage of the DTC pin slowly, the switching duty cycle is limited, and prevent the drastic voltage rising (over-shoot) and inrush current.

When the VIN voltage becomes equal or more than the UVLO released voltage (V_{UVLO} + V_{HYS}), VREFOUT operation starts. Following with the increase of the voltage level of VREFOUT, the internal oscillator begins to operate, then the DTC voltage is also rising, then, soft-start operation starts. When the DTC voltage crosses the chopping wave level inside the IC, EXT pin starts switching, then, step-up operation begins. During this term, the output voltage does not reach the set output voltage. Therefore the output of the amplifier is "H". Besides, the protection circuit may work and the IC charges the DELAY pin. Because of this, the soft-start time should be set shorter than the latch protection delay time.

After the initial stage, when the output voltage reaches the set output voltage, the level of AMPOUT becomes the normal state. In other words, the level is determined with the input voltage, the output voltage, and the output current. When the level of AMPOUT becomes falling, charging the DELAY pin stops and discharges to the GND. The soft-start time (the time for the DTC pin voltage becoming to V_{DTC} level) can be estimated with the next formula.

$t \cong 1 / \alpha \times \ln (V_{DTC} \times \alpha / \beta + 1)$, herein, $\alpha = -1 / C_7 \times (1 / R_5 + 1 / R_6)$, $\beta = V_{REFOUT} / (C_7 \times R_5)$



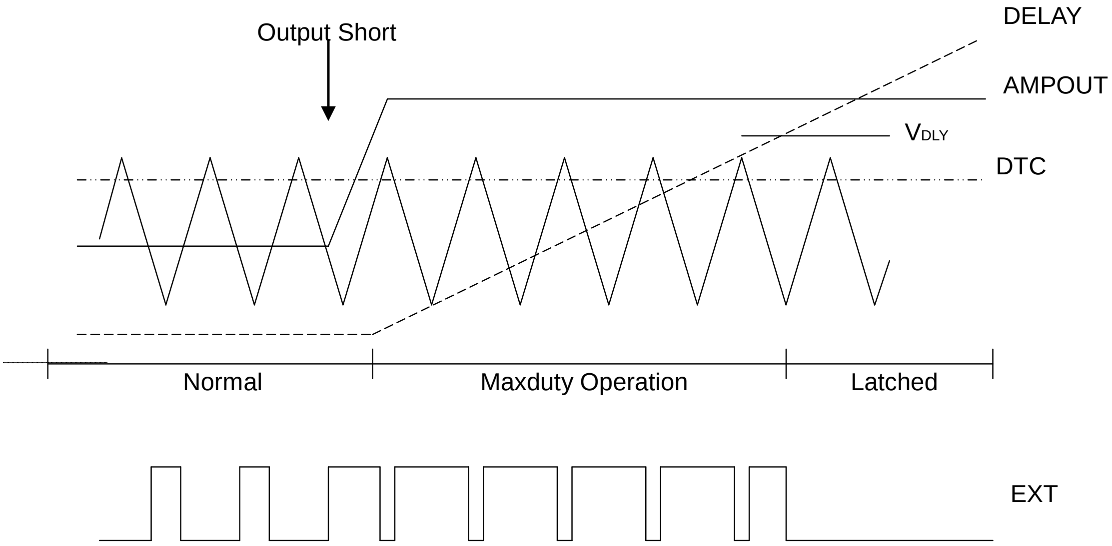


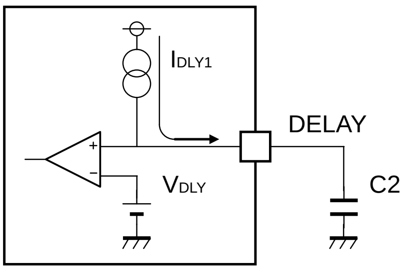
Latch Protection Operation

The operation of Latch protection circuit is as follows: When AMPOUT becomes "H" and the IC detects maximum duty cycle, charge to an external capacitor, C2 of DELAY pin starts. The maximum duty cycle continues and the voltage of DELAY pin reaches delay voltage detector threshold, V_{DLY}, outputs "L" to EXT pin and turns off the external power MOSFET. To release the latch protection operation, make the supply voltage down to UVLO detector threshold or lower, and make it rise up to the normal input voltage. The delay time of latch protection can be calculated with C2, V_{DLY}, and the delay pin charge current, I_{DLY1}, as in the next formula.

$t = C2 \times V_{DLY} / I_{DLY1}$

Once after becoming the maximum duty cycle, if the duty cycle decreases before latch operation works, the charging the capacitor stops immediately, and the DELAY pin voltage is fixed at GND level with I_{DLY2}.





TEST CIRCUITS

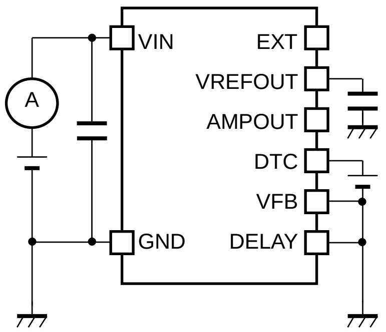


Fig.1 Consumption Current Test Circuit

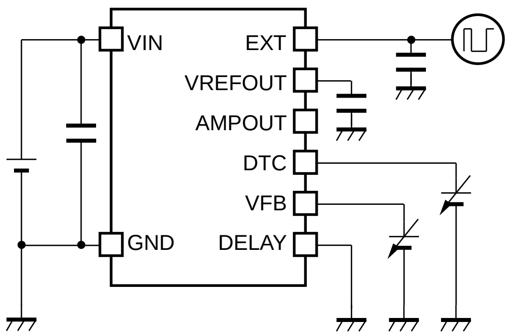


Fig.2 Oscillator Frequency, VFB Voltage,
Duty Cycle, EXT Rising Time/ Falling Time Test Circuit

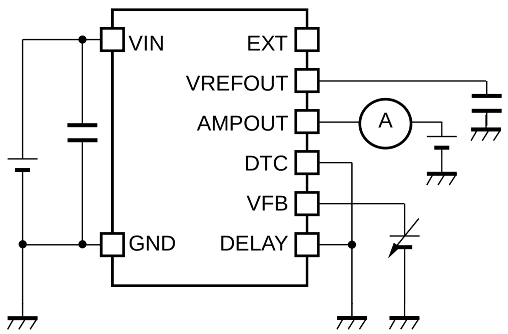


Fig.3 AMP "L" Output Current "H" Output Current Test Circuit

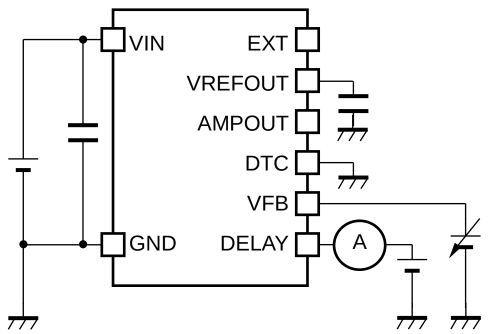


Fig.4 DELAY Pin Charge Current/ Discharge Current Test Circuit

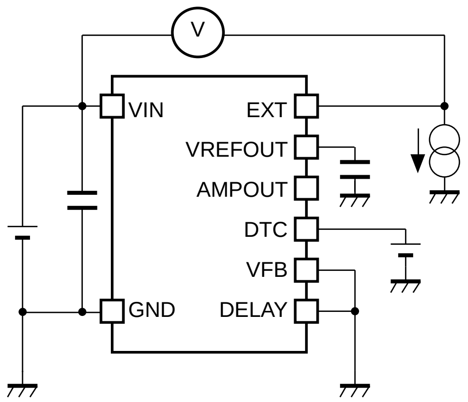


Fig.5 EXT "H" ON Resistance Test Circuit

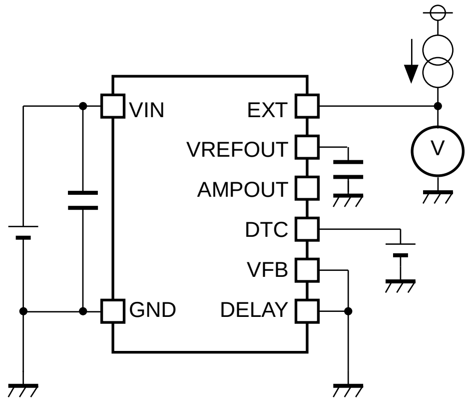


Fig.6 EXT "L" ON Resistance Test Circuit

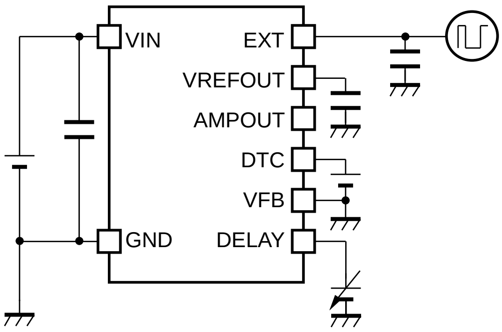


Fig.7 DELAY Pin Detector Threshold Test Circuit

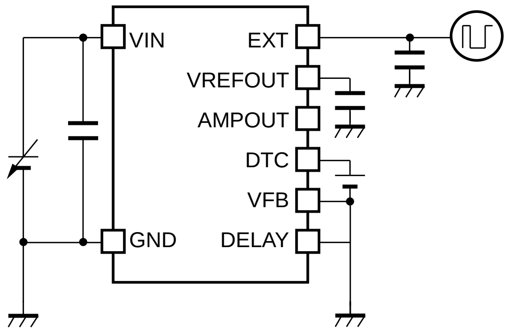


Fig.8 UVLO Detector Threshold/ Released Voltage Test Circuit

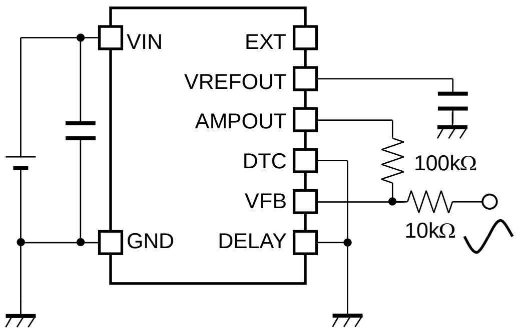


Fig.9 Error AMP Gain/ Phase Test Circuit

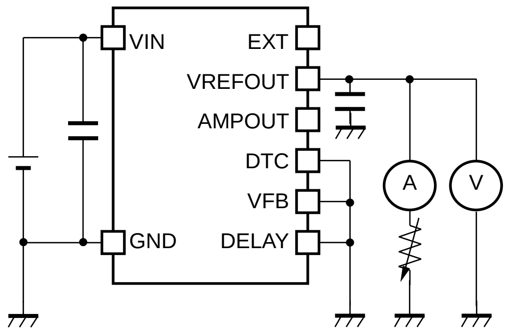


Fig.10 VREFOUT Voltage Test Current

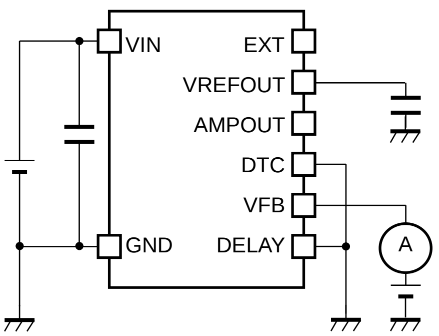
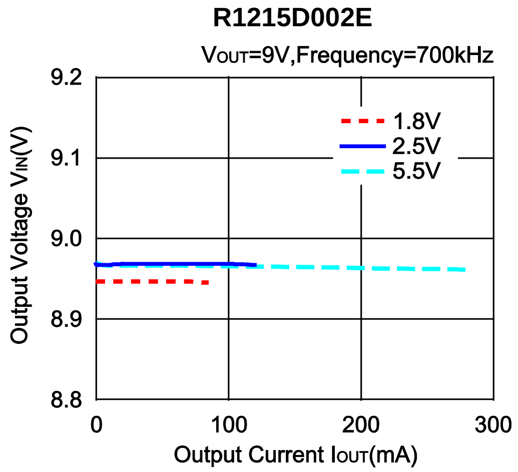


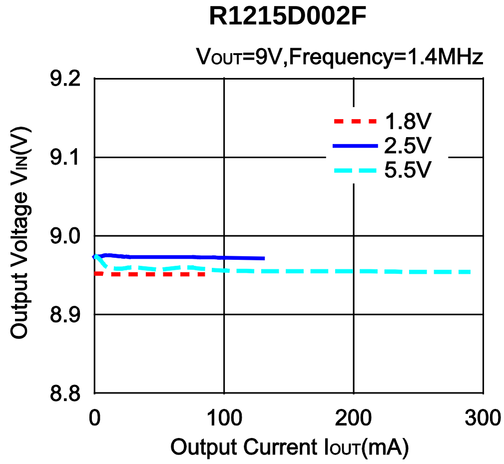
Fig.11 VFB Leakage Current Test Circuit

RICOH

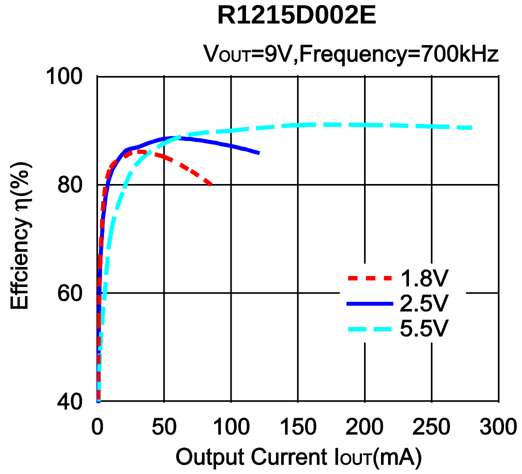
TYPICAL CHARACTERISTICS

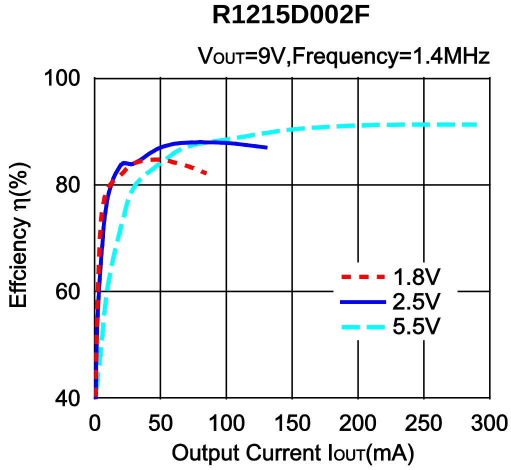
1) Output Voltage vs. Output Current (Topt = 25°C)



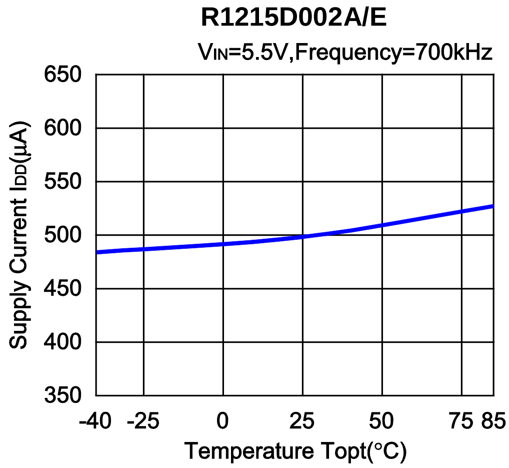


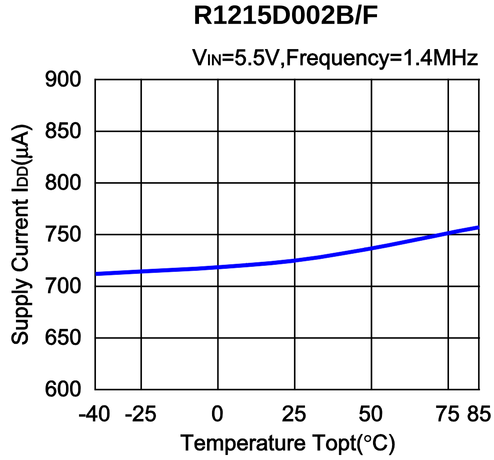
2) Efficiency vs. Output Current (Topt = 25°C)





3) Supply Current vs. Temperature

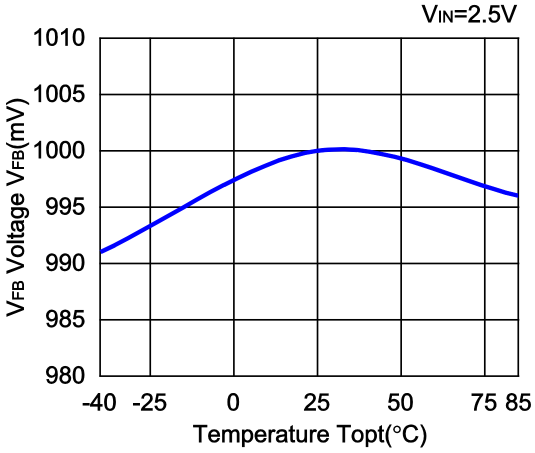




RICOH

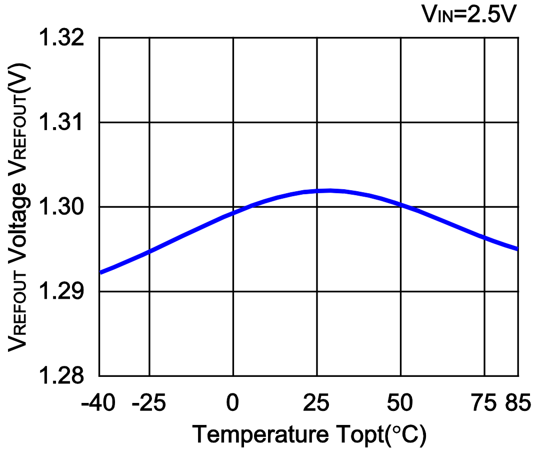
4) VFB Voltage vs. Temperature

R1215D002x



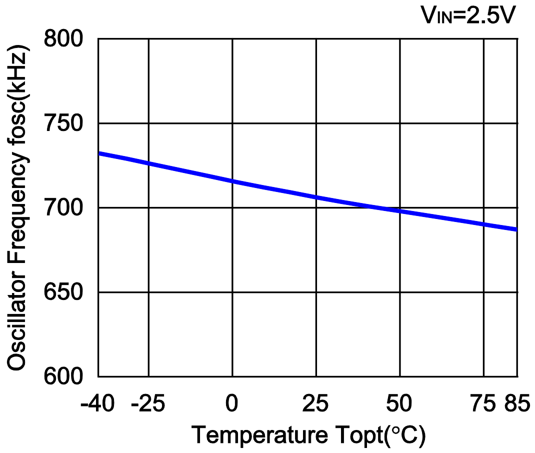
5) VREFOUT Voltage vs. Temperature

R1215D002x

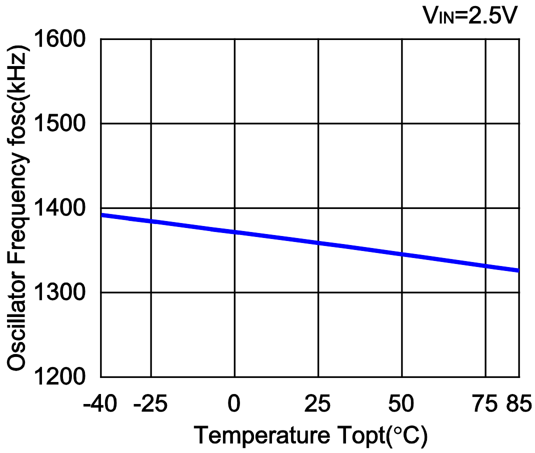


6) Oscillator Frequency vs. Temperature

R1215D002A/E

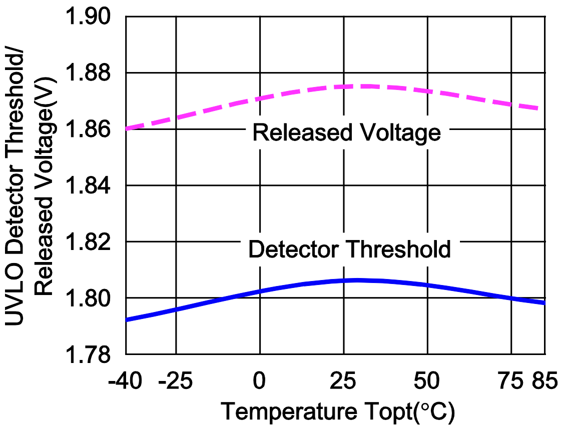


R1215D002B/F

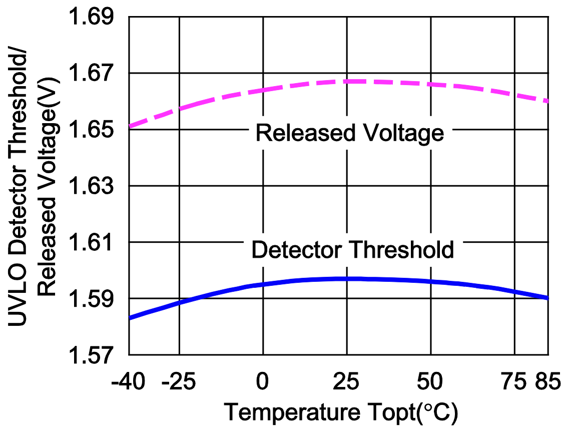


7) UVLO Detector Threshold / Released Voltage vs. Temperature

R1215D002A/B



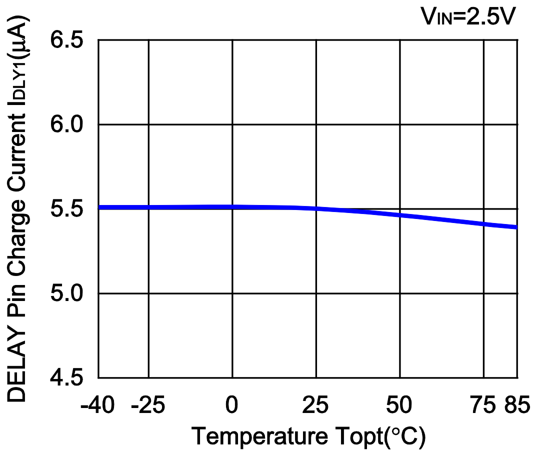
R1215D002E/F



RICOH

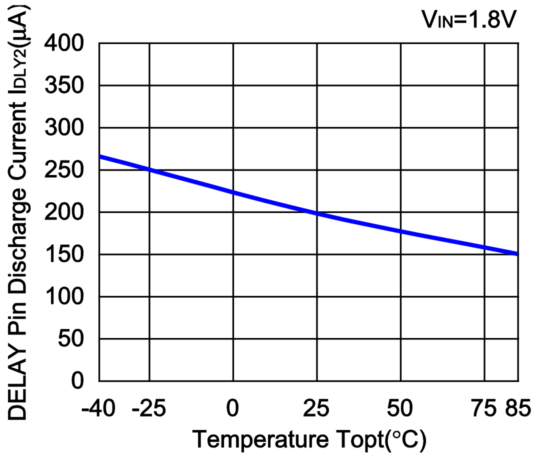
8) DELAY Pin Charge Current vs. Temperature

R1215D002x



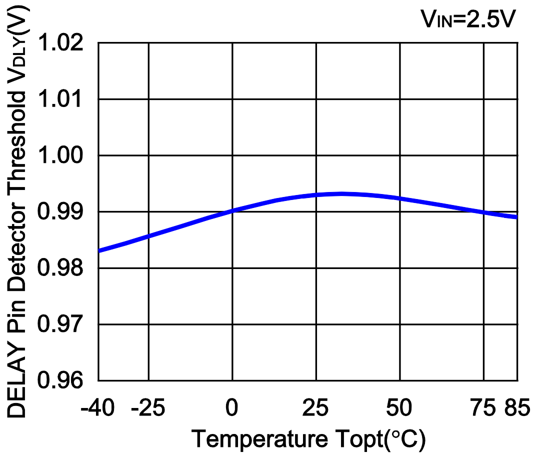
9) DELAY Pin Discharge Current vs. Temperature

R1215D002x



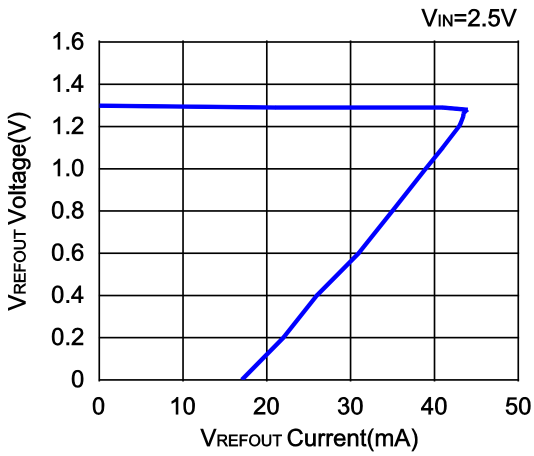
10) DELAY Pin Detector Threshold vs. Temperature

R1215D002x



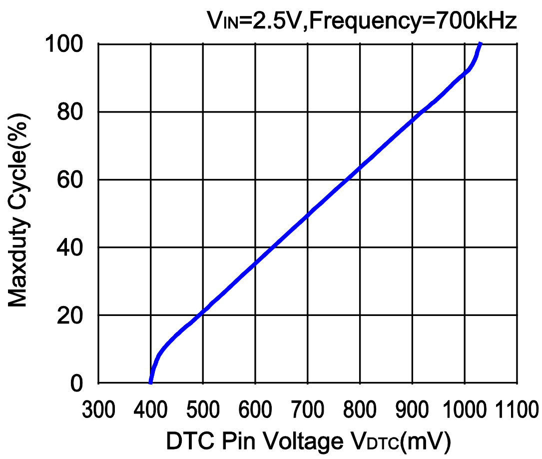
11) VREFOUT Voltage vs. VREFOUT Current

R1215D002x

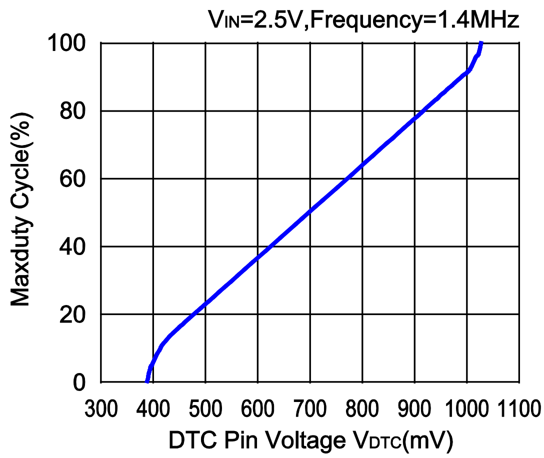


12) Maximum Duty Cycle vs. DTC Pin Voltage (Topt = 25°C)

R1215D002A/E

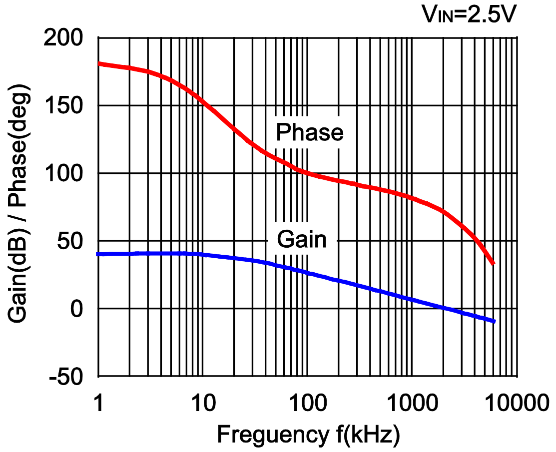


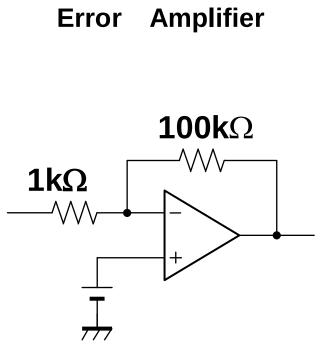
R1215D002B/F



13) Error Amplifier Frequency (Topt = 25°C)

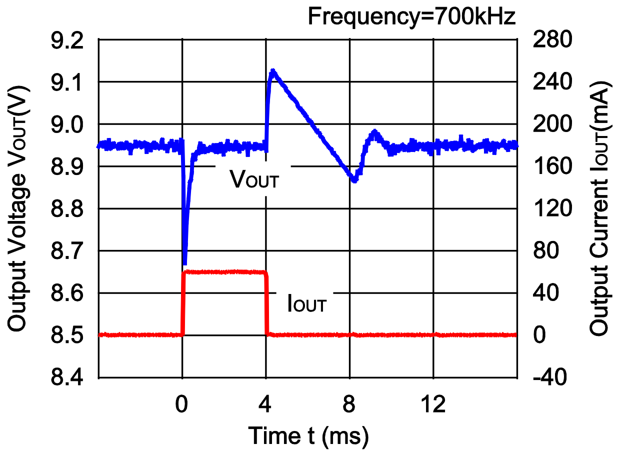
R1215D002x



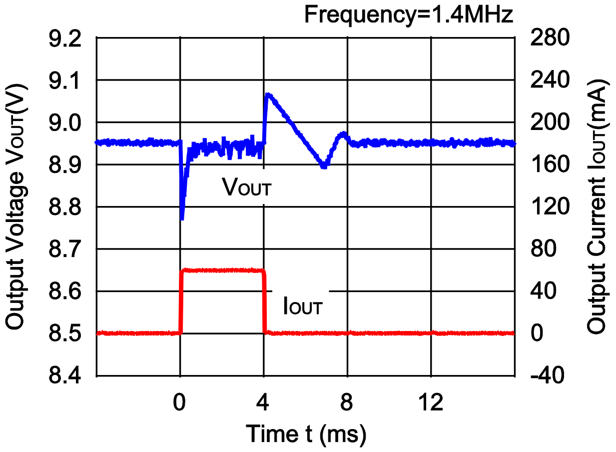


14) Load Transient Response (V_{IN} = 2.5 V, Topt = 25°C)

R1215D002A/E

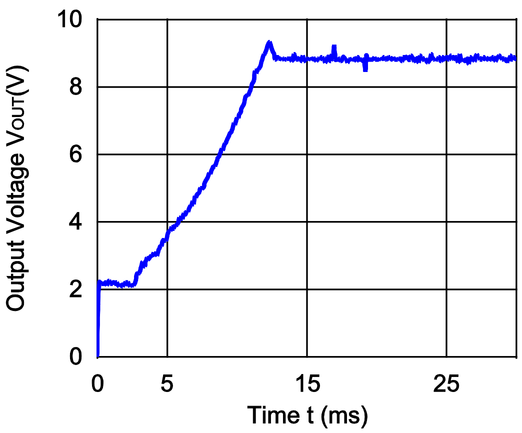


R1215D002B/F

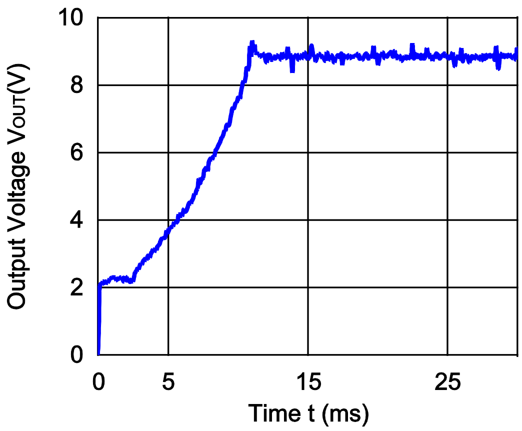


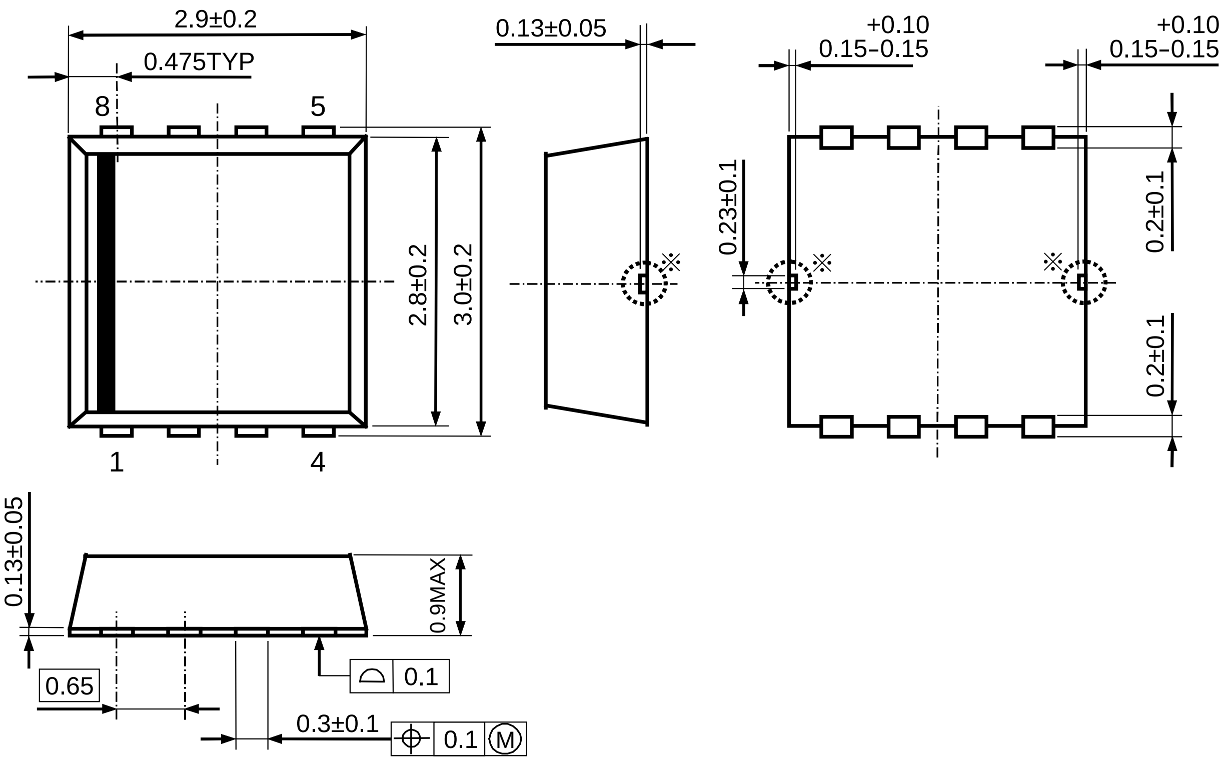
15) Power On Response (V_{IN} = 2.5 V, Topt = 25°C, R_{OUT} = 150 Ω)

R1215D002A/E



R1215D002B/F





SON-8 Package Dimensions (Unit: mm)

* The tab suspension leads on the bottom of the package is substrate level (GND/ V_{DD}). It is recommended that the tab suspension leads be connected to the ground plane / the VDD pin on the board, or otherwise be left floating. Also, the tab suspension leads should not connect to other wires or land patterns.

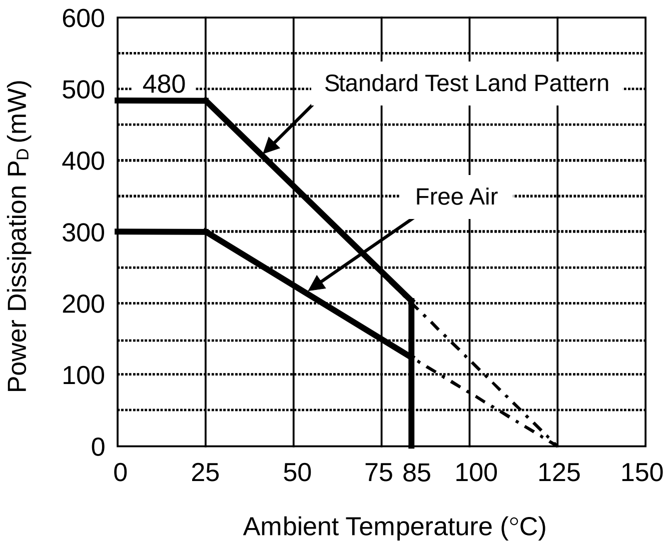
The power dissipation of the package is dependent on PCB material, layout, and environmental conditions. The following conditions are used in this measurement.

Measurement Conditions

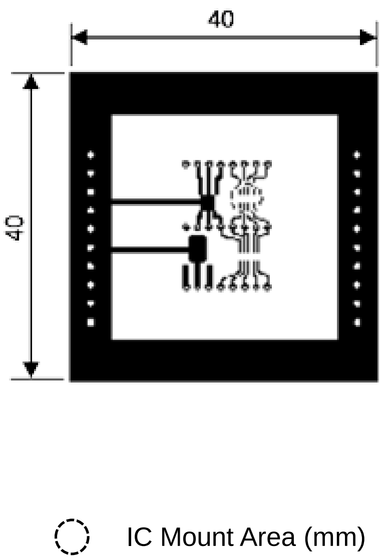
	Standard Test Land Pattern
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Double-Sided Board)
Board Dimensions	40 mm × 40 mm × 1.6 mm
Copper Ratio	Top Side: Approx. 50% Bottom Side: Approx. 50%
Through-holes	f 0.5 mm × 44 pcs

Measurement Result (Ta = 25°C, Tjmax = 125°C)

	Standard Test Land Pattern	Free Air
Power Dissipation	480 mW	300 mW
Thermal Resistance	qja = (125 − 25°C) / 0.48 W = 208°C/W	333°C/W



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

RoHS Compliant
Halogen Free

Ricoh is committed to reducing the environmental loading materials in electrical devices with a view to contributing to the protection of human health and the environment.
Ricoh has been providing RoHS compliant products since April 1, 2006 and Halogen-free products since April 1, 2012.

RICOH ELECTRONIC DEVICES CO., LTD.

https://www.e-devices.ricoh.co.jp/en/

Sales & Support Offices

Ricoh Electronic Devices Co., Ltd.
Shin-Yokohama Office (International Sales)
2-3, Shin-Yokohama 3-chome, Kohoku-ku, Yokohama-shi, Kanagawa, 222-8530, Japan
Phone: +81-50-3814-7687 Fax: +81-45-474-0074

Ricoh Americas Holdings, Inc.
675 Campbell Technology Parkway, Suite 200 Campbell, CA 95008, U.S.A.
Phone: +1-408-610-3105

Ricoh Europe (Netherlands) B.V.
Semiconductor Support Centre
Prof. W.H. Keesomlaan 1, 1183 DJ Amstelveen, The Netherlands
Phone: +31-20-5474-309

Ricoh International B.V. - German Branch
Semiconductor Sales and Support Centre
Oberrather Strasse 6, 40472 Düsseldorf, Germany
Phone: +49-211-6546-0

Ricoh Electronic Devices Korea Co., Ltd.
3F, Haesung Bldg, 504, Teheran-ro, Gangnam-gu, Seoul, 135-725, Korea
Phone: +82-2-2135-5700 Fax: +82-2-2051-5713

Ricoh Electronic Devices Shanghai Co., Ltd.
Room 403, No.2 Building, No.690 Bibo Road, Pu Dong New District, Shanghai 201203, People's Republic of China
Phone: +86-21-5027-3200 Fax: +86-21-5027-3299

Ricoh Electronic Devices Shanghai Co., Ltd.
Shenzhen Branch
1205, Block D(Jinlong Building), Kingkey 100, Hongbao Road, Luohu District, Shenzhen, China
Phone: +86-755-8348-7600 Ext 225

Ricoh Electronic Devices Co., Ltd.
Taipei office
Room 109, 10F-1, No.51, Hengyang Rd., Taipei City, Taiwan
Phone: +886-2-2313-1621/1622 Fax: +886-2-2313-1623