RICOH

R1700V Series

650 V Variable Output Current/Voltage ZVS PFC/LED Driver Controller

No. EA-364-200409

OVERVIEW

The R1700V is a zero-voltage switching (ZVS) PFC/LED driver controller with a variable output current/voltage. It is ideal for improving power factors of LED lightings and consumer appliances. This device features the arbitrary setting of output voltage based on buck-boost (inverting) topology. Integration of this device and the R1580N allows the two-stage architecture and a flicker-free operation in LED lighting applications.

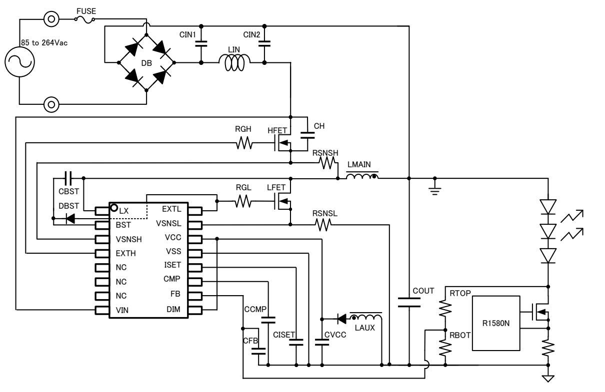
KEY BENEFITS

- Edge Resonant Control of ZVS helps to achieve Low Switching Loss and Low EMI.
- R1700V is capable of Arbitrary Setting an Output Voltage based on Buck-boost (Inverting) Topology.
- Integration of R1700V and R1580N realizes Flicker-free Operation in LED Lighting Applications.

KEY SPECIFICATIONS

- Input Voltage Range: 8 V to 650 V
- PWM Linear Dimming Control Range: 5% to 100%
- Built-in Max. 650-V Operating Regulator
- Built-in Half Bridge Gate Driver
- Corresponding Topologies
  - Buck-boost (Inverting) PFC
  - Variable Output Current PFC, Linear Dimmable
  - Variable Output Voltage PFC
  - Boost PFC
  - Buck PFC

TYPICAL APPLICATION



Buck-boost (Inverting) PFC for LED Lighting

PROTECTION FEATURES

- Overcurrent Protection (OCP)
- Thermal Shutdown (TSD)
- BST/VCC Pin Undervoltage Lockout (UVLO)
- VCC Pin Overvoltage Lockout (OVLO)
- Overvoltage Protection (FBOVP)
- Latch-type Protection (Selectable)

APPLICATIONS

- LED Lighting PFCs, Linear Dimmable
- Flicker-free LED Lighting using R1580N
- PFCs for PAM Controlled Motor Drivers
- Low Output Voltage PFCs
- DC/DC Converters

PACKAGE

SSOP-16
5.1 × 6.4 × 1.15 (mm)

OPTIONAL FUNCTIONS

Select the optional functions from below.

Product Name	Latch-type Protection	FB Pin UVD	FB Pin OVP
R1700V001A	Yes	No	Typ. 1.2 V (Rising)
R1700V001B	No		
R1700V001C	Yes	Yes	Typ. 3.65 V (Rising)
R1700V001D	No		

SELECTION GUIDE

The latch-type protection, the FB pin UVD function and the FB pin OVP voltage are user-selectable options.

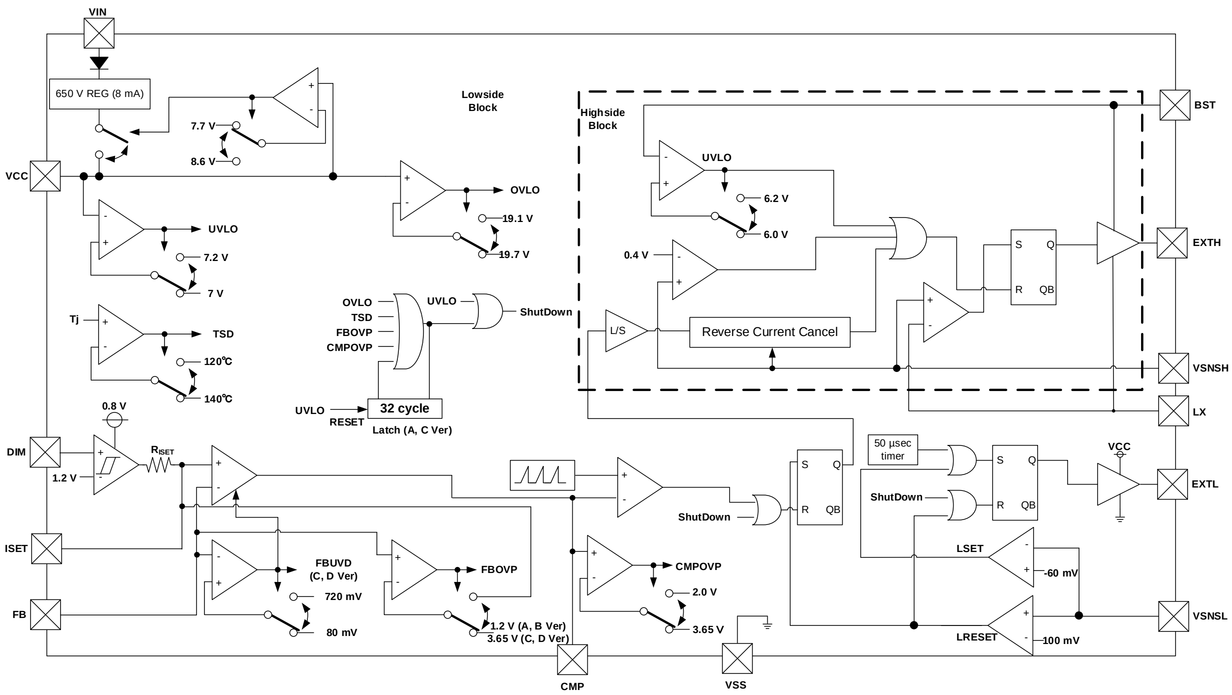
Selection Guide

Product Name	Package	Quantity per Reel	Pb Free	Halogen Free
R1700V001∗-E2-FE	SSOP-16	2,000 pcs	Yes	Yes

∗: Select the optional functions from below.

∗	Latch-type Protection	FB Pin UVD	FB Pin OVP Voltage
A	Yes	No	Typ. 1.2 V (Rising)
B	No	No	Typ. 1.2 V (Rising)
C	Yes	Yes	Typ. 3.65 V (Rising)
D	No	Yes	Typ. 3.65 V (Rising)

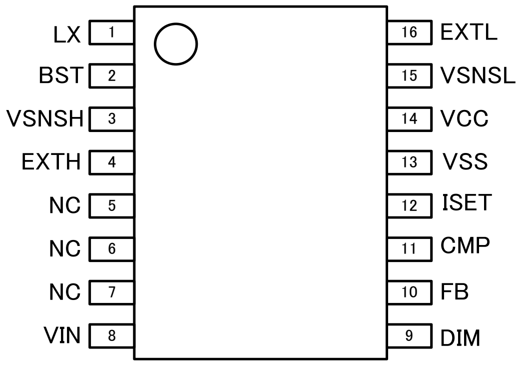
BLOCK DIAGRAM



R1700V Block Diagram

PIN DESCRIPTIONS

Top View



SSOP-16 Pin Configuration

SSOP-16 Pin Descriptions

Pin No.	Symbol	Description
1	LX	Switching Pin
2	BST	Bootstrap Pin
3	VSNSH	High-side Current Sensing Pin
4	EXTH	High-side Driver Operating Pin
5	NC	No Connection
6	NC	No Connection
7	NC	No Connection
8	VIN	Start-up Regulator Power Source Pin
9	DIM	PWM Signal Input Pin
10	FB	Feedback Pin
11	CMP	Phase Compensation Capacitance Pin
12	ISET	Current Setting Pin
13	VSS	Ground Pin
14	VCC	Power Source Pin for Controlling Circuit
15	VSNSL	Low-side Current Sensing Pin
16	EXTL	Low-side Driver Operating Pin

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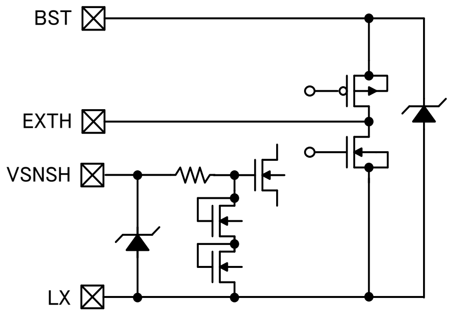
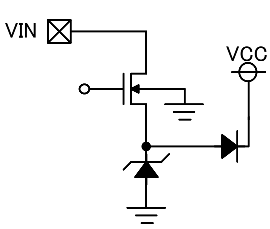
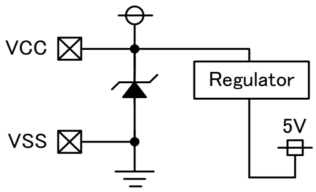
Equivalent Circuits for the Individual Terminals



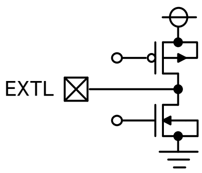
Equivalent Circuit for BST Pin, EXTH Pin, VSNSH Pin and LX Pin



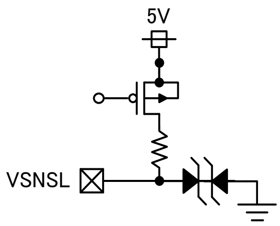
Equivalent Circuit for VIN Pin



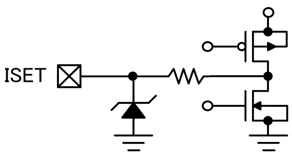
Equivalent Circuit for VCC Pin and VSS Pin



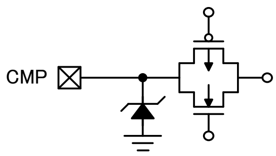
Equivalent Circuit for EXTL Pin



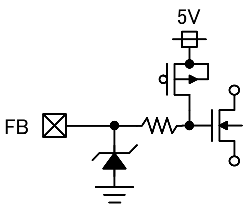
Equivalent Circuit for VSNSL Pin



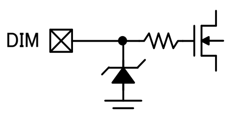
Equivalent Circuit for ISET Pin



Equivalent Circuit for CMP Pin



Equivalent Circuit for FB Pin



Equivalent Circuit for DIM Pin

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings

Symbol	Parameter			Rating	Unit
V_{IN}	VIN Pin Input Voltage			−0.3 to 650	V
V_{BST}	BST Pin Voltage			V_{LX} −0.3 to 20	V
V_{EXTH}	EXTH Pin Voltage			V_{LX} −0.3 to 20	V
V_{SNSH}	VSNSH Pin Voltage			V_{LX} −0.3 to 5.5	V
V_{LX}	LX Pin Voltage			−0.3 to 650	V
V_{EXTL}	EXTL Pin Voltage			−0.3 to 20	V
V_{SNSL}	VSNSL Pin Voltage			−0.3 to 5.5	V
V_{DIM}	DIM Pin Voltage			−0.3 to 20	V
V_{FB}	FB Pin Voltage			−0.3 to 5.5	V
V_{CMP}	CMP Pin Voltage			−0.3 to 5.5	V
V_{ISET}	ISET Pin Voltage			−0.3 to 5.5	V
V_{CC}	VCC Pin Voltage			−0.3 to 20	V
P_D	Power Dissipation(1)	SSOP-16	Standard Land Pattern	(T_{TSD1} − 25)/146	W
Tj	Junction Temperature Range			−40 to T_{TSD1}(2)	°C
Tstg	Storage Temperature Range			−55 to 150	°C

ABSOLUTE MAXIMUM RATINGS

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

RECOMMENDED OPERATING CONDITIONS

Recommended Operating Conditions

Symbol	Parameter	Rating	Unit
V_{IN}	VIN Pin Operating Input Voltage	8 to 650	V
V_{BST}	BST Pin Operating Input Voltage	6.25 to 17.6	V
V_{CC}	VCC Pin Operating Input Voltage	8.0 to 19.0	V
Ta	Operating Temperature Range	−40 to 85	°C

RECOMMENDED OPERATING CONDITIONS

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 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.

(1) Refer to *POWER DISSIPATION* for detailed information.

(2) The maximum junction temperature depends on the Thermal Shutdown Threshold Temperature listed in the *ELECTRICAL CHARACTERISTICS*.

ELECTRICAL CHARACTERISTICS

V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V unless otherwise noted.

The specifications surrounded by ☐ are guaranteed by design engineering at −40°C ≤ Ta ≤ 85°C.

R1700V Electrical Characteristics (Ta = 25°C)

Symbol	Parameter	Test Conditions/ Comments	Min.	Typ.	Max.	Unit
I_{IN1}	Supply Current 1			1.3	1.6	mA
I_{IN2}	Supply Current 2	V_{CC} = 6 V, V_{BST} = 5 V		0.43	0.55	mA
High-Side Driver Section						
V_{CZERO}	Zero Current Threshold Voltage		−7		7	mV
I_{SNSH}	VSNSH Pin Pull-up Current		−53.5	−48	−41.8	µA
V_{OCPH}	Overcurrent Protection Threshold Voltage		0.37		0.43	V
R_{ONHH}	High-side Driver High Resistance	V_{BST} = 15 V		6.7		Ω
R_{ONHL}	High-side Driver Low Resistance	V_{BST} = 15 V		2.3		Ω
V_{UVLO2_BST}	BST Pin UVLO Threshold Voltage	V_{BST} Falling	6.05	6.15	6.25	V
V_{UVLO1_BST}		V_{BST} Rising	V_{UVLO2_BST} +0.12		V_{UVLO2_BST} +0.23	V
Low-Side Driver Section						
t_{LMAXON}	Max. Low-side On Time		45		55	µsec
$t_{LMAXOFF}$	Max. Low-side Off Time		45		55	µsec
t_{LMINON}	Min. Low-side On Time		0.38		0.62	µsec
V_{REV}	Reverse Current Threshold Voltage		90	98	105	mV
V_{FOR}	Forward Current Threshold Voltage		−80	−60	−40	mV
R_{ONLH}	Low-side Driver High Resistance			5.8		Ω
R_{ONLL}	Low-side Driver Low Resistance			1.9		Ω
Protection Circuits Section						
V_{UVLO2}	VCC Pin UVLO Threshold Voltage	V_{CC} Falling	6.7	7	7.3	V
V_{UVLO1}		V_{CC} Rising	V_{UVLO2} +0.15		V_{UVLO2} +0.23	V
V_{OVLO2}	VCC Pin OVLO Threshold Voltage	V_{CC} Rising	19.1	19.7	20.3	V
V_{OVLO1}		V_{CC} Falling	V_{OVLO2} −0.64		V_{OVLO2} −0.57	V
T_{TSD1}	Thermal Shutdown Threshold Temperature	Tj Rising		140		°C
T_{TSD2}		Tj Falling		120		°C
V_{OVP2_FB}	FB Pin OVP Threshold Voltage (R1700V001A/ R1700V001B)	V_{FB} Rising	1.15		1.25	V
V_{OVP1_FB}		V_{FB} Falling		V_{ISET}		V
V_{OVP2_FB}	FB Pin OVP Threshold Voltage (R1700V001C/ R1700V001D)	V_{FB} Rising	3.55		3.80	V
V_{OVP1_FB}		V_{FB} Falling		V_{ISET}		V

ELECTRICAL CHARACTERISTICS (continued)

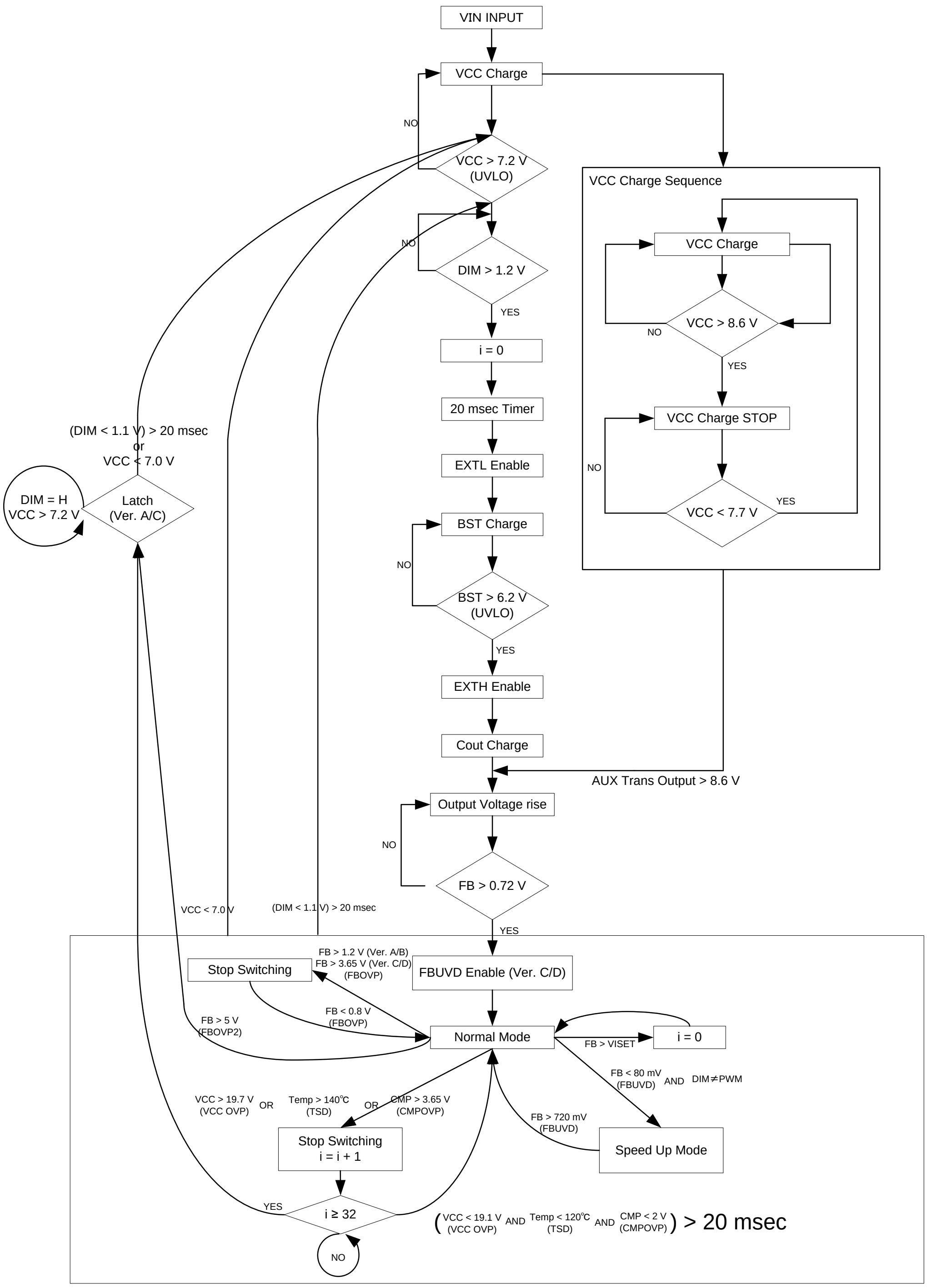
V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V unless otherwise noted.

The specifications surrounded by ☐ are guaranteed by design engineering at −40°C ≤ Ta ≤ 85°C.

R1700V Electrical Characteristics (Ta = 25°C)

Symbol	Parameter	Test Conditions/ Comments	Min.	Typ.	Max.	Unit
Protection Circuit Section (continued)						
V_{OVP1_CMP}	CMP Pin OVP Threshold Voltage	V_{CMP} Rising	3.60		3.75	V
V_{OVP2_CMP}	CMP Pin OVP Threshold Voltage	V_{CMP} Falling	1.9		2.1	V
t_{DETD}	Release Protection Delay Time		14		24	msec
C_{LAT}	Latch Protection (R1700V001A/ R1700V001C)			32		cycle
Current Control Circuit Section						
V_{OFFSET}	Error Amplifier Offset		−5		5	mV
$I_{ERSOURCE}$	Error Amplifier Source Current	V_{FB} = 0.75 V, V_{ISET} = 0.8 V V_{CMP} = 1.5 V	−4.1		−2.9	µA
I_{ERSINK}	Error Amplifier Sink Current	V_{FB} = 0.85 V, V_{ISET} = 0.8 V V_{CMP} = 1.5 V	2.9		4.1	µA
G_m	Error Amplifier Trans-conductance	V_{CMP} = 1.5 V	60		78	µS
$t_{EXTHSLOPE}$	High-side On Time Inclination	V_{CMP} = 1.3 V, 2.0 V	4.5		7.2	µsec/V
I_{FBPU}	FB Pin Pull-up Current	V_{FB} = 0 V	−2.1	−1.7	−1.0	µA
Internal Regulator Section						
I_{REG}	Internal Regulator VCC Pin Charging Current	V_{CC} = 6.8 V	9		14	mA
V_{CHGEN}	Internal Regulator VCC Pin Charge-Starting Voltage		7.4		8.0	V
V_{CHGSLP}	Internal Regulator VCC Pin Charge-Stopping Voltage		8.3		8.9	V
Variable Control Circuit Section						
V_{DIMH}	PWM Signal Threshold Voltage, High		1.13		1.25	V
V_{DIML}	PWM Signal Threshold Voltage, Low		1.09		1.18	V
f_{DIMMIN}	PWM Signal Input Frequency		0.5		100	kHz
t_{DIMMIN}	PWM Signal Input Error			±10		nsec
R_{ISETIN}	ISET Pin Impedance		263	300	342	kΩ
V_{ISETIN}	ISET Pin Controlling Voltage	PWM Duty = 100% Ta = 25°C	0.792	0.800	0.807	V
		PWM Duty = 100% −40°C ≤ Ta ≤ 85°C	0.782		0.814	
Others						
V_{UVD2_FB}	FB Pin UVD Threshold Voltage (R1700V001C/ R1700V001D)	V_{FB} Rising	695		745	mV
V_{UVD1_FB}	FB Pin UVD Threshold Voltage (R1700V001C/ R1700V001D)	V_{FB} Falling	65		95	mV
$I_{ERSOURCE\_UVD}$	Error Amplifier Source Current during UVD	V_{FB} = 0 V, V_{ISET} = 0.8 V V_{CMP} =1.5 V	−90		−44	µA

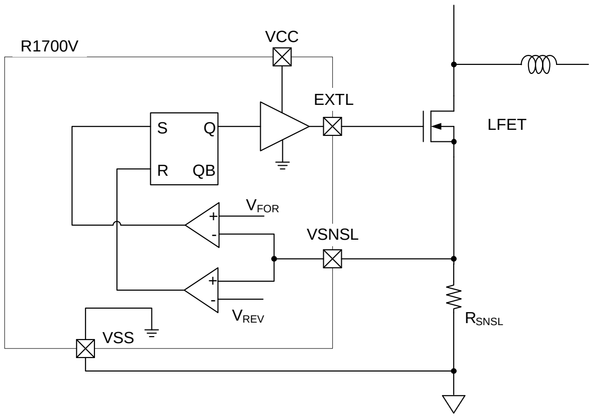
THEORY OF OPERATION



Operation Sequence Diagram

● Low-side Switching Operation

The R1700V controls the low-side switch by monitoring the voltage generated in a resistor (R_{SNSL}).



Low-side Switch Turn-on Operation

The forward current of inductor flows R_{SNSL} through the body diode of the low-side switch due to the high-side switch turned off. This leads the VSNSL voltage drops to the forward current threshold voltage (V_{FOR}) or lower, and the low-side switch is turned on.

The R1700V uses a bootstrap method which enables to use Nch MOSFET as a high-side switch. The ceramic capacitor (C_{BST}) between LX and BST needs to be charged during the low-period of LX.

The charging current of C_{BST} pulls up the LX. If the low-side's power source V_{CC} is the charging source, the VSNSL voltage does not go below V_{FOR} when the peak current of inductor is not enough at a light load. This may cause a low-side switch cannot be turned on.

As this countermeasure, set the charging source of C_{BST} as EXTL, and make a structure of charging C_{BST} after the low-side switch is turned on.

Low-side Switch Turn-off Operation

The R1700V makes the inductor current flow reverse to perform a zero-voltage-switching (ZVS) which can significantly reduce switching loss and switching noise. The reverse current of inductor should be set to enable ZVS when the maximum input voltage is applied. The reverse current of inductor (I_{REV}) can be calculated as follows.

$I_{REV} = V_{REV}/R_{SNSL}$

V_{REV} = 98 [mV] Typ.

Figure 1 shows the resonant operation waveform and Figure 2 shows the off-resonant operation waveform.

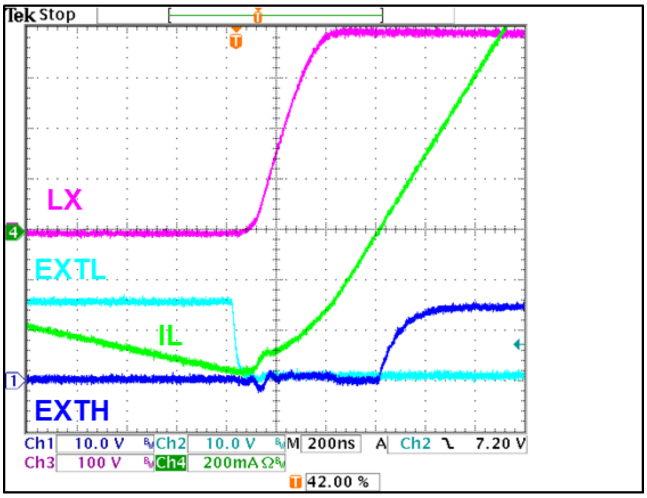


Figure 1. The Resonant Operation Waveform

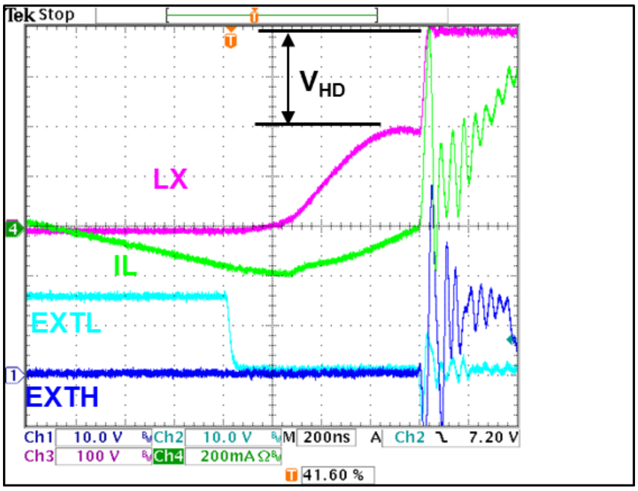


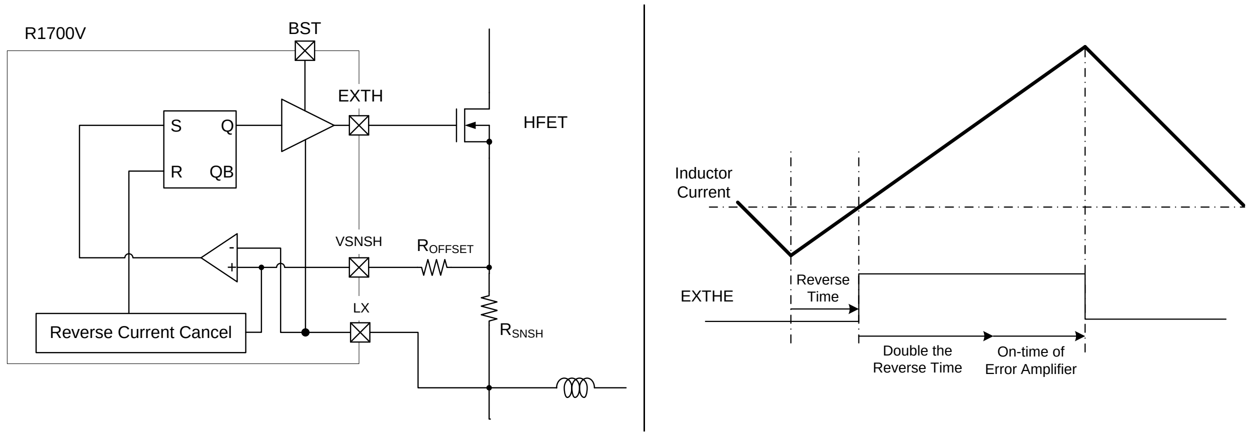
Figure 2. The Off-resonant Operation Waveform

Figure 1 shows that the high-side switch is turned on with ZVS after Vds (V_{IN} - LX) = 0 V.

Figure 2 shows that the reverse current of inductor is not enough, so the high-side switch is turned on when Vds of high-side switch is V_{HD}. In this case, high-side switch produces a switching loss: fosc x 1 / 2 x Cds x V_{HD}^2. Cds is the sum of drain-source capacities of high-side switch and low-side switch. For example, if fosc = 500 kHz, Cds = 100 pF, and V_{HD} = 200 V, the switching loss will be 1.0 W. The switching noise increases when ZVS cannot be performed, and it may cause a malfunction.

● High-side Switching Operation

The R1700V controls the high-side switch by monitoring the voltage generated in a resistor (R_{SNSH}).



High-side Switch Turn-on Operation

The reverse current of inductor flows input side through the body diode of the high-side switch due to the low-side switch turned off. At this timing, when the VSNSH voltage exceeds zero (V_{CZERO}), that is when the inductor current becomes zero, the high-side switch is turned on.

The pull-up current (I_{SNSH}) flows constantly from the VSNSH pin. The turn-on timing of the high-side switch can be changed by setting the offset resistor (R_{OFFSET}) between the high-side switch source and the VSNSH pin. Harmonics can be changed by adding this offset resistor to make the cancel time of reverse current adjustable.

High-side Switch On-Time

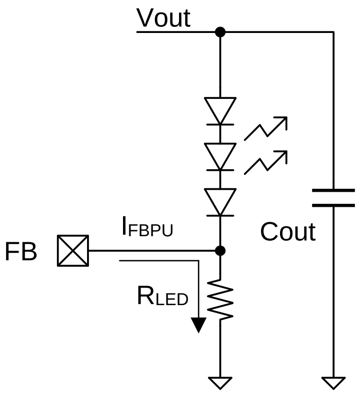
The R1700V uses a critical current mode for improving power factor. However, the device makes the inductor current flow reverse to achieve a zero-voltage-switching (ZVS). The reverse flowing inductor current causes a period which generally cannot supply power to the output, therefore the power factor deteriorates. As this countermeasure, the double the time of flowing reverse current is added to the fixed on-time determined by an error amplifier. It cancels the reverse current and improves power factors. The previously mentioned R_{OFFSET} allows the reverse current flowing time adjustable. This enables a countermeasure for the frequency drop at a low input and the change of harmonic.

● DIM Pin Input

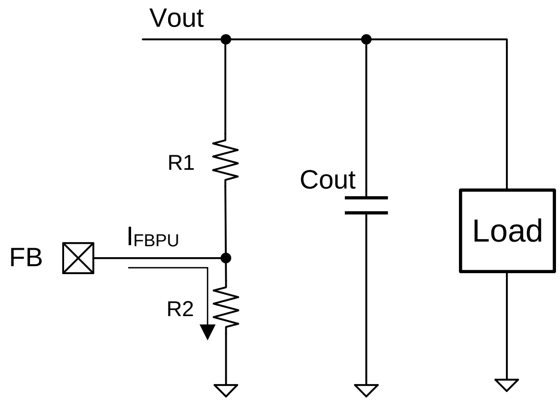
The R1700V outputs the ISET pin voltage according to the high duty of PWM signal to the DIM Pin. To minimize the influence by the PWM signal input error (t_{DIMMIN}), use a low PWM frequency of 500 Hz or more. When using the device for dimmable LED lighting, it is recommended to use a PWM frequency from 1 kHz to 10 kHz. The ISET pin voltage is the smoothed PWM Duty with a capacitor (C_{ISET}). The R1700V varies the output current/voltage by according the FB pin voltage and the ISET pin voltage. Connect a large enough C_{ISET} to the ISET pin to avoid a ripple voltage problem. The low PWM signal should be lower than the low PWM signal threshold voltage (V_{DIML}), and the high PWM signal should be higher than the PWM signal threshold voltage (V_{DIMH}). The R1700V can be shut down by applying a low signal to the DIM pin for 25 msec or more typically. If the control by PWM signal to DIM pin or a shutdown function is not needed, connect the DIM pin to the VCC pin.

- **Output Setting**

Current Variable Type



Voltage Variable Type



Current Variable Type (LED Driver)

The R1700V adjusts the source voltage of resistor (R_{LED}) connected between LED and VSS to the ISET pin output voltage (V_{ISET}) level. V_{ISET} can be calculated as follows.

$V_{ISET} = V_{ISETIN}$ x PWM Duty

V_{ISETIN} = 0.8 [V] Typ.

LED current can be calculated by using R_{LED}.

Where V_{OFFSET} is the offset votage of error amplifier and I_{FBPU} is the pull-up current of FB pin.

$I_{LED} = (V_{ISET} + V_{OFFSET}) / R_{LED} + I_{FBPU}$

$V_{OFFSET} = \pm 5$ [mV]

$I_{FBPU} = -1.7$ [µA] Typ.

The offset voltage (V_{OFFSET}) can be affected if V_{ISET} is low, so it should be taken into account if low-dimming-control is necessary.

Voltage Variable Type

As for the constant voltage output, the R1700V sets the output voltage by the ratio of the resistor (R1/R2) connected between V_{OUT} and VSS. The output voltage (V_{OUT}) is calculated as follows.

$V_{OUT} = (V_{ISET} + V_{OFFSET})$ x $(R1 + R2) / R2 + R1$ x I_{FBPU}

The pull-up current of FB pin (I_{FBPU}) can be affected by high resistance of R1, so it should be taken into account when setting R1/R2.

As similar to the current variable type, the V_{ISET} can be changed by the PWM signal to the DIM pin. The V_{CC} varies according to the output voltage when supplying V_{CC} with the auxiliary winding, therefore set the output voltage within the operating range of V_{CC} or supply the V_{CC} with the external power source.

● Oscillation Frequency

The oscillation frequency (fosc) can be determined by input voltage (V_{IN}), output voltage (V_{OUT}), LED current (I_{LED}), inductance (L), and inductor reverse current (I_{REV}).

Buck Converter
fosc = V_{OUT} x (V_{IN} – V_{OUT}) / (V_{IN} x L x (I_{LED} + I_{REV}) x 2)

Boost Converter
fosc = (1 − V_{IN} / V_{OUT}) / (((I_{REV} + V_{OUT} x I_{LED} / Vin / (1 − V_{IN} / V_{OUT})) x 2) x L/ V_{IN})

Buck-boost (Inverting) Converter
fosc = V_{OUT} x V_{IN} / (2 x L x (V_{OUT} + V_{IN}) x (I_{LED} x (V_{OUT} + V_{IN}) / V_{IN} + I_{REV}))

● Power Source

At start-up, the high-voltage internal regulator connected to the VIN pin starts charging the VCC pin. When the VCC pin voltage becomes higher than the UVLO threshold voltage (V_{UVLO1}) and the BST pin voltage becomes higher than the BST pin UVLO threshold voltage (V_{UVLO1_BST}), the R1700V starts operation. If the VCC pin voltage becomes higher than the internal regulator VCC pin charge-stopping voltage (V_{CHGSLP}), V_{CHGSLP} = 8.6 V (Typ.), the high-voltage internal regulator stops the operation, and the auxiliary power source (auxiliary winding, inductor divided voltage, external power source) starts up. If power is supplied to the VCC pin through the auxiliary power source, the high-voltage internal regulator maintains the off state to save the consumption current of R1700V. If the external power source is not activated yet, the VCC pin voltage drops. If it drops below the internal regulator VCC pin charge-starting voltage (V_{CHGEN}), the high-voltage internal regulator restarts the operation and charges the VCC pin.

● Low Voltage Detection on FB Pin: R1700V001C/ R1700V001D

The R1700V increases the operation speed of error amplifier when the FB pin voltage goes below the FB pin UVD threshold voltage (V_{UVD1_FB}), so it can quickly respond to the sudden drop in input voltage or the sudden increase in the load. The R1700V increases the operation speed until the FB pin voltage exceeds the FB pin UVD threshold voltage (V_{UVD2_FB}). This low voltage detection is disabled at start up because it is enabled only when the FB pin voltage exceeds V_{UVD1_FB}. If a PWM signal is inputted to the DIM pin, this detection is disabled.

● Overcurrent Protection Setting

The R1700V monitors the inductor current when the high-side switch is turned on by the voltage generated at a resistor (R_{SNSH}) connected between the high-side switch and the LX pin. The overcurrent protection current (I_{OCP}) can be calculated as follows.
I_{OCP} = V_{OCPH} / R_{SNSH}
V_{OCPH} = 0.4 [V] Typ.
I_{OCP} should be set at the rated crrent of inductor or lower.

● Overvoltage Protection on VCC Pin

The R1700V stops the switching operation if the VCC pin goes beyond the OVLO threshold voltage (V_{OVLO2}) and restarts the switching operation after the release protection delay time (t_{DETD}) if the VCC pin drops below the OVLO threshold voltage (V_{OVLO1}). The overvoltage protection is effective during LED open mode when there is an auxiliary power source which is dependent on V_{OUT} such as auxiliary windings and inductor dividing voltage.

● **Thermal Shutdown**

The R1700V stops the switching operation if the junction temperature goes beyond the thermal shutdown threshold temperature (T_{TSD1}) and restarts the switching operation after t_{DETD} if the junction temperature drops below the thermal shutdown threshold temperature (T_{TSD2}).

● **Overvoltage Detection on FB Pin**

The R1700V stops the switching operation if the FB pin voltage exceeds the FB pin OVP threshold voltage (V_{OVP2_FB}). Once the FB pin voltage goes below the FB pin OVP threshold voltage (V_{OVP1_FB}), it restarts the switching operation.

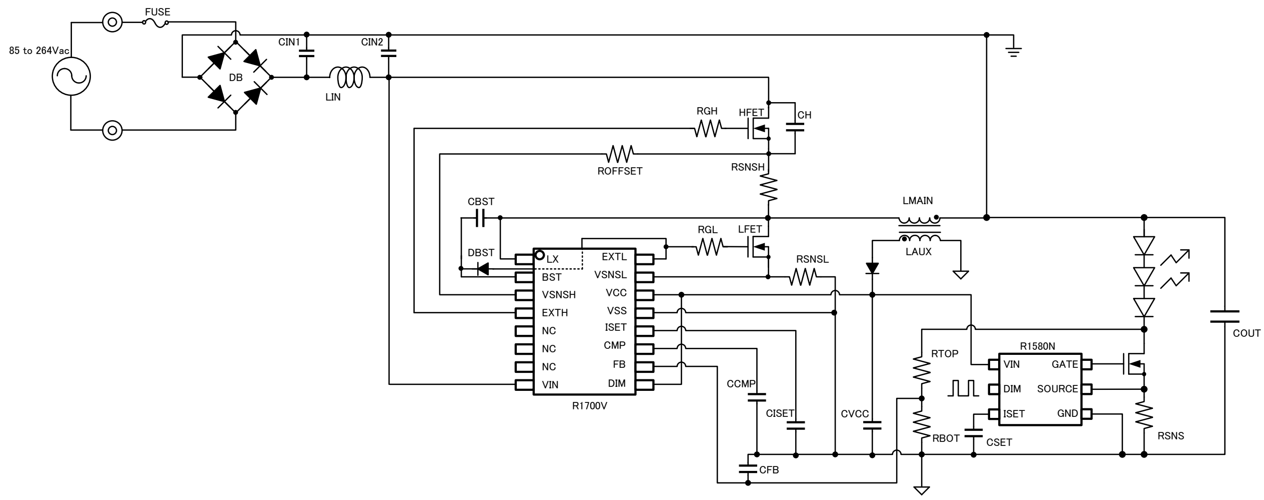
● **Overvoltage Detection on CMP Pin**

The R1700V stops the switching operation if the CMP pin voltage exceeds the CMP pin OVP threshold voltage (V_{OVP1_CMP}). Once the CMP pin goes below the CMP pin OVP threshold voltage (V_{OVP2_CMP}), it restarts the switching operation after t_{DETD}.

● **Latch-type Protection: R1700V001A/R1700V001C**

The R1700V stops the operation if an abnormal state is counted for thirty two times; C_{LAT} = 32 [cycle]. The activation of the following detection can be counted as an abnormal state: the VCC pin overvoltage detection, the thermal shutdown, or the CMP pin overvoltage detection. The FB pin overvoltage detection is not included. The R1700V returns to the normal operation if the FB pin voltage becomes the ISET pin output voltage (V_{ISET}) level, and resets the counter; C_{LAT} = 0 [cycle]. To release the latch-type protection, make the VCC pin voltage below the VCC pin UVLO threshold voltage (V_{UVLO2}) or make the device shutdown using the DIM pin. Refer to the *Operation Sequence Diagram* for detailed information.

APPLICATION INFORMATION



R1700V + R1580N Typical Application Circuit, Buck-boost (Inverting) Converter

Integration of R1700V and R1580N

The integration of R1700V and R1580N allows a smaller flicker-free operation in LED lighting applications than a conventional two-stage architecture.
The above system controls LED current by using R1580N consisting of constant current circuit in the cathode side of LED. In the constant current circuit, it generates loss due to the LED current and the potential difference between cathode voltage of LED and VSS.
Set the cathode voltage of LED as low as possible in a range of the bottom cathode voltage of LED is not below the minimum operation voltage of the constant current circuit.

● Corresponding Topologies

The R1700V can be used as a buck converter, a boost converter or a buck-boost (inverting) converter.

Buck Converter

In the buck converter, the inductor current constantly flows into the load, so that the converter can operate with high efficiency. The output voltage needs to be lower than the input voltage.

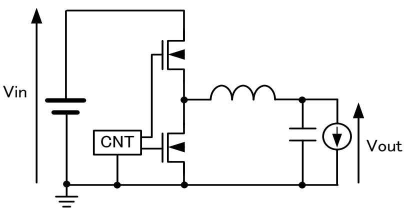
Boost Converter

In the boost converter, the inductor current flows into the load only during the off-cycle, which means low-side switch is conducted, so that the current ripple of inductor increases. This is one of the reasons why the boost converter is not as efficient as the buck converter. It is necessary that the output voltage should be set higher than the input voltage. The inrush current flows through the body diode of low-side switch at power-on. To prevent this, it may require a bypass circuit between the input and output of the converter.

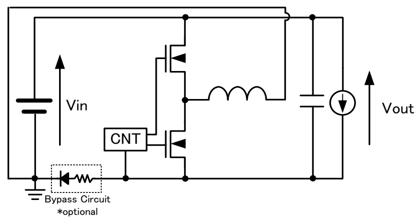
Buck-boost (Inverting) Converter

In the buck-boost (inverting) converter, the inductor current flows into the load only during the off-cycle, which means low-side switch is conducted, that is same as the boost converter, so that the current ripple of inductor increases. This is one of the reasons why the buck-boost (inverting) converter is not as efficient as the buck converter. This converter can be used effectively for input voltages and for power factor improvement because it can independently supply energy to the output (load) no matter what the input voltage is. Also, unlike the boost converter, it does not require any bypass circuit since there is no inrush current. The LX pin switches at $V_{OUT} + V_{IN}$ voltage, so take the device breakdown voltage into account.

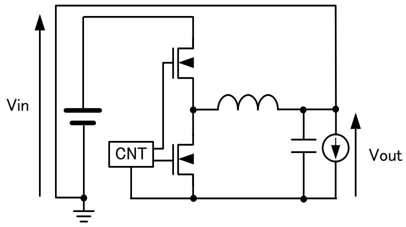
Buck Converter



Boost Converter



Buck-boost (Inverting) Converter



● Power Factor Correction

The R1700V can be used to improve the power factor by a structure including a buck converter, a boost converter, and a buck-boost (inverting) converter. Connect a 1.0-μF or more ceramic capacitor (C_{CMP}) to the CMP pin for a 50-Hz or more line frequency. For use in an LED lighting, a harmonic standard IEC 61000-3-2 Class C is applied. The buck converter structure may not conform to the standard due to the input and output voltage relationship. For use in a boost converter and a buck-boost (inverting) converter is recommended.

● Notes on Selecting Components

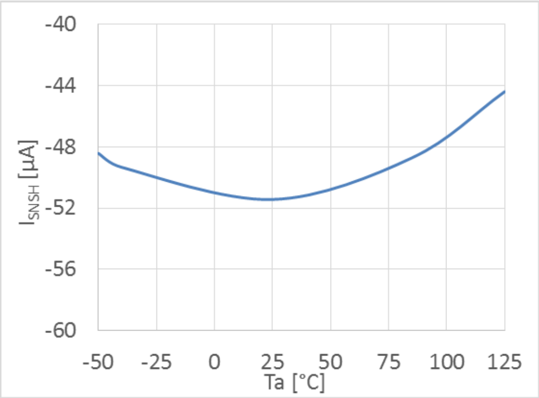
The R1700V has two power source pins: the VCC pin for low-side operation and the BST pin for high-side operation. Connect a 1.0-μF or more ceramic capacitor (C_{VCC}) between the VCC and VSS pins, a 1.0-μF or more ceramic capacitor (C_{BST}) between the BST and LX pins, and a bootstrap diode between the BST and EXTL pins.

TYPICAL CHARACTERISTICS

Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

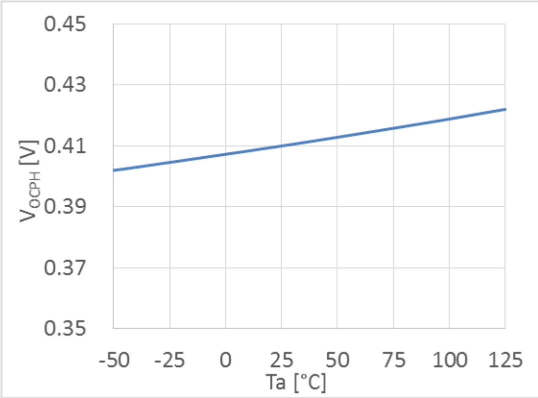
VSNSH Pin Pull-up Current

V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V



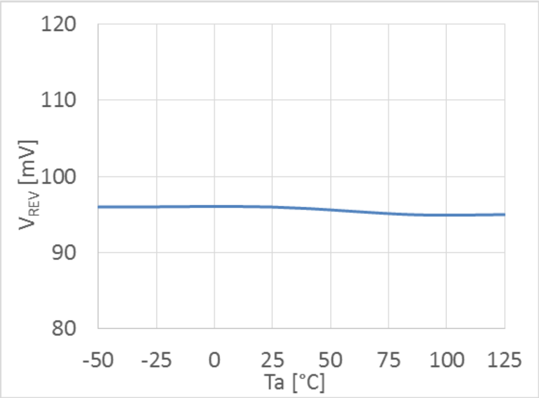
Overcurrent Protection Threshold Voltage

V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V



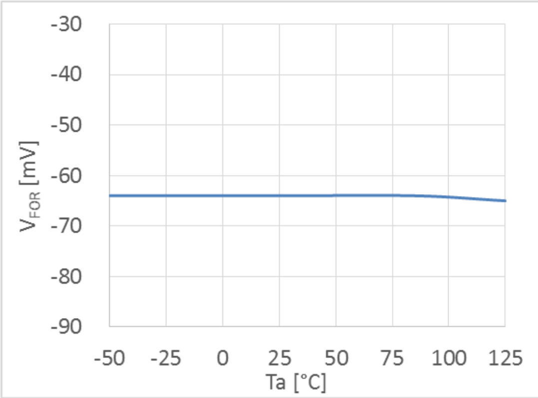
Reverse Current Threshold Voltage

V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V



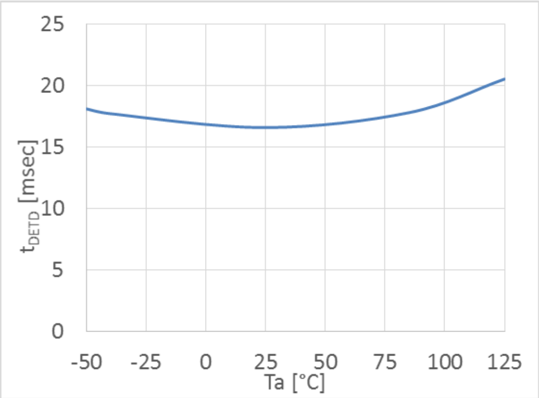
Forward Current Threshold Voltage

V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V



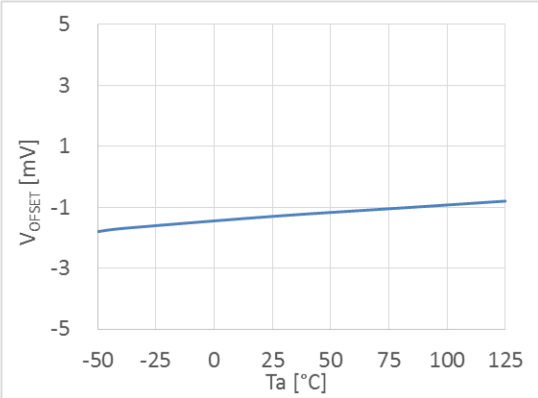
Release Protection Delay Time

V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V



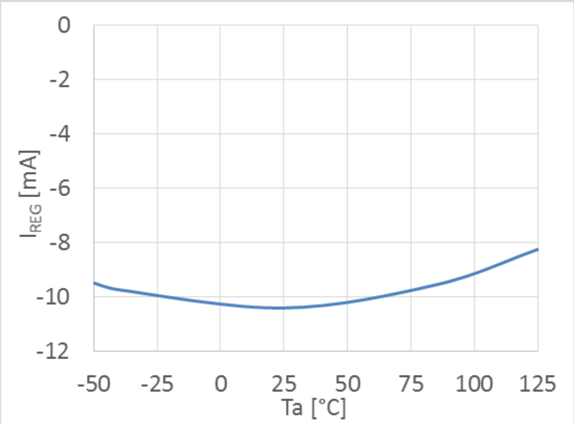
Error Amplifier Offset

V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V



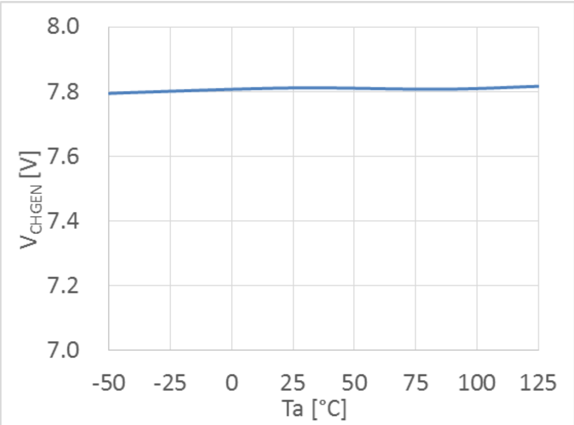
Internal Regulator VCC Pin Charging Current

V_{IN} = 30 V, V_{CC} = 6.8 V, V_{BST} = 15 V



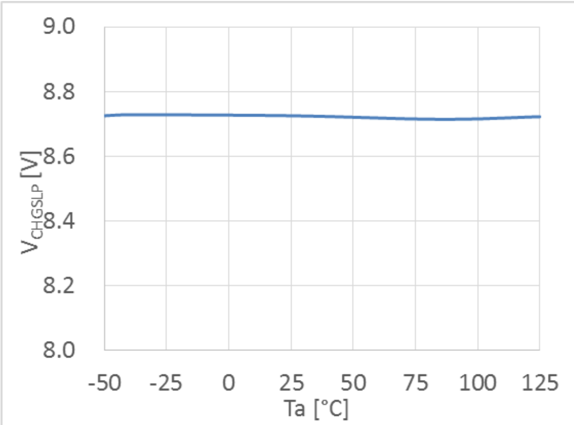
Internal Regulator VCC Pin Charge-Starting Voltage

V_{IN} = 30 V, V_{CC} = Sweep down, V_{BST} = 15 V



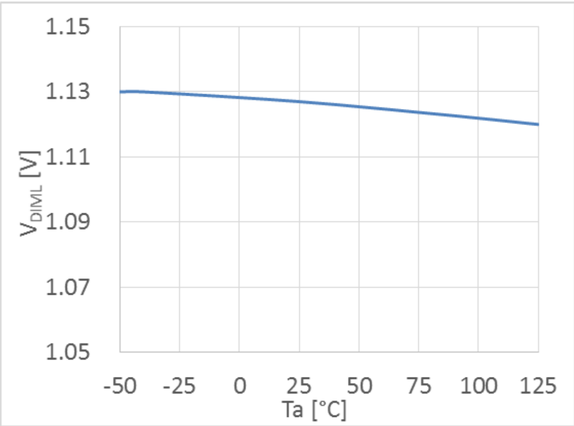
Internal Regulator VCC Pin Charge-Stopping Voltage

V_{IN} = 30 V, V_{CC} = Sweep up, V_{BST} = 15 V



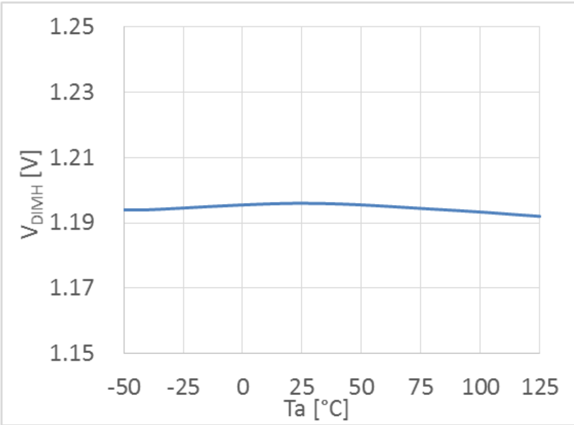
PWM Signal Threshold Voltage, Low

V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V



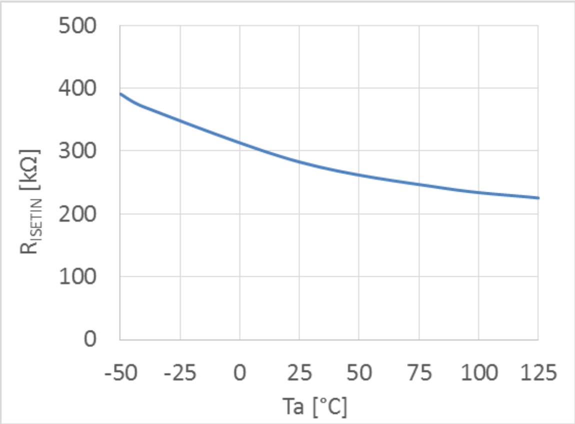
PWM Signal Threshold Voltage, High

V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V



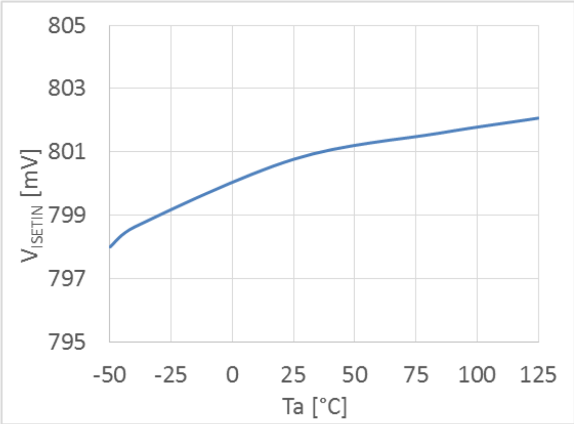
ISET Pin Impedance

V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V



ISET Pin Controlling Voltage

V_{IN} = 30 V, V_{CC} = 15 V, V_{BST} = 15 V, PWM Duty = 100%



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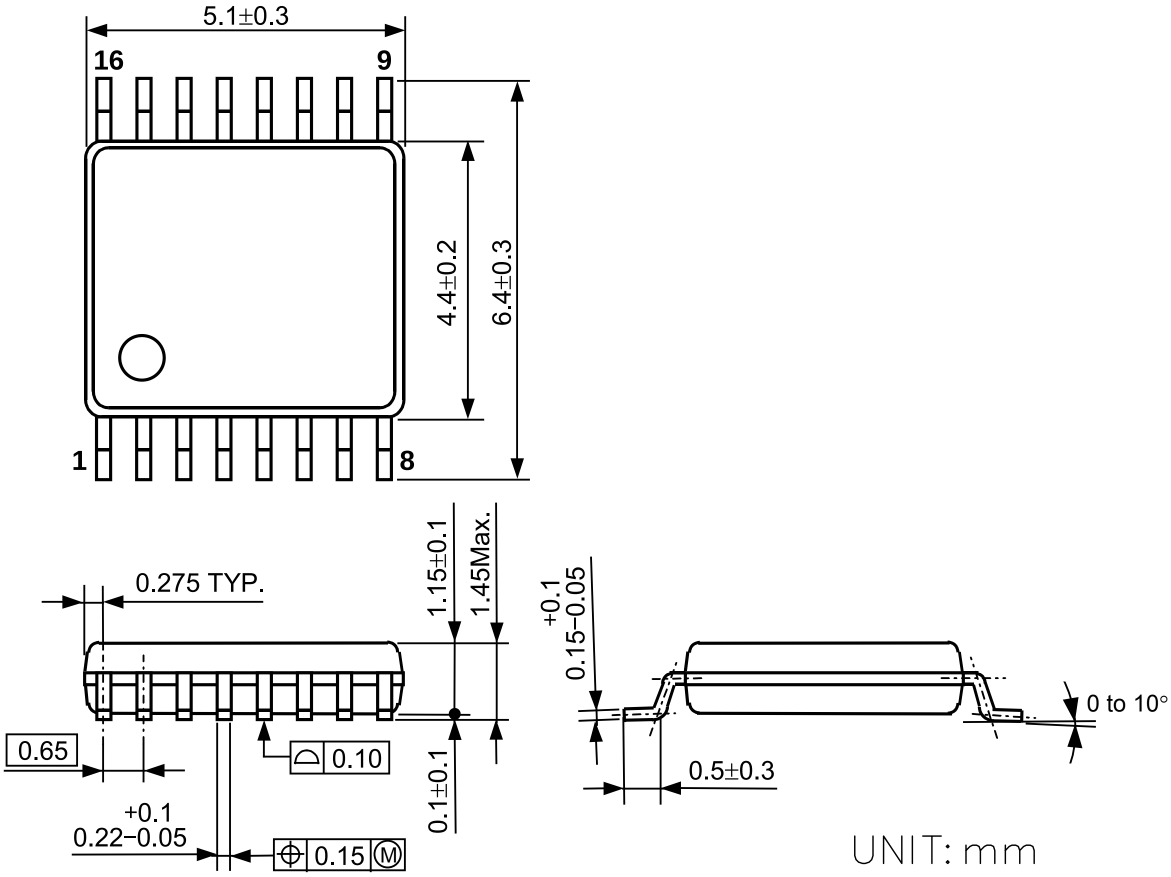


SSOP-16 Package Dimensions

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

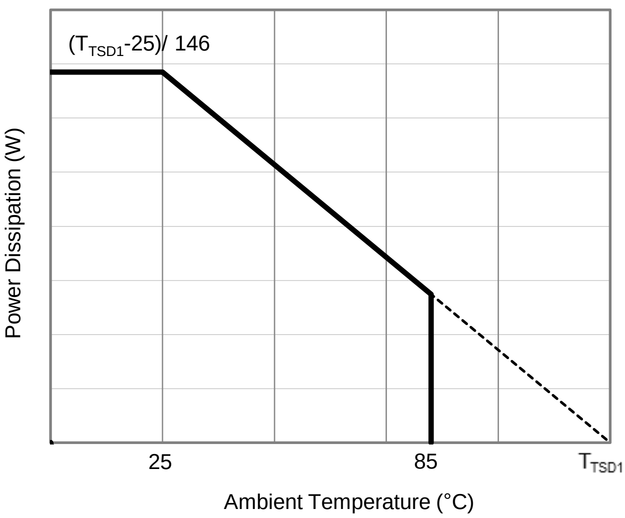
Item	Standard Land Pattern
Environment	Mounting on Board (Wind Velocity = 0 m/s)
Board Material	Glass Cloth Epoxy Plastic (Double-Sided Board)
Board Dimensions	40 mm × 40 mm × 1.6 mm
Copper Ratio	Top Side: Approx. 50% Bottom Side: Approx. 50%
Through-holes	ϕ 0.5 mm × 44 pcs

Measurement Result ($Ta = 25°C$, $Tjmax = T_{TSD1}°C$)

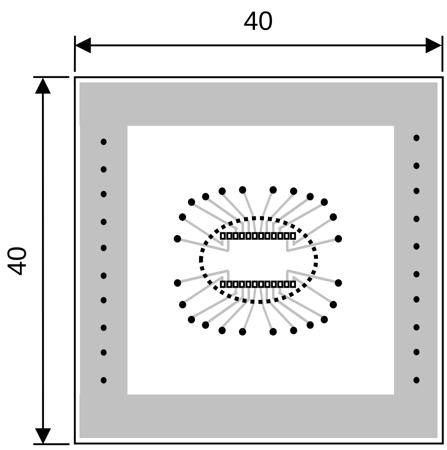
Item	Standard Land Pattern
Power Dissipation	$(T_{TSD1}-25)/ 146$ W
Thermal Resistance (θja)	$\theta ja = 146°C/W$
Thermal Characterization Parameter (ψjt)	$\psi jt = 22°C/W$

θja: Junction-to-Ambient Thermal Resistance

ψjt: Junction-to-Top Thermal Characterization Parameter



Power Dissipation vs. Ambient Temperature



Measurement Board Pattern

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