SC1223K
InnoSwitch™ Family

Off-Line CV/CC Flyback Switcher IC with Integrated MOSFET, Sync-Rect and Feedback

Product Highlights

Highly Integrated, Compact Footprint
- Incorporates flyback controller, 650 V MOSFET, secondary-side sensing and synchronous rectification
- Integrated, HIPOT-isolated, feedback link
- Exceptional CV/CC accuracy, independent of transformer design or external components
- Instantaneous transient response ±5% CV with 0-100-0% load step

EcoSmart™– Energy Efficient
- <10 mW No-load @ 230 VAC with optional bias winding
- Easily meets all global energy efficiency regulations
- Low heat dissipation

Advanced Protection / Safety Features
- Primary sensed output OVP with optional bias winding
- Secondary sensed output overshoot clamp
- Secondary sensed output OCP to zero output voltage
- Hysteretic thermal shutdown

Full Safety and Regulatory Compliance
- 100% production HIPOT compliance testing at 6 kV DC/1 sec
- Reinforced insulation
- Isolation voltage = 3,500 VAC
- UL1577 and TUV (EN60950) safety approved
- EN61000-4-8 (100 A/m) and EN61000-4-9 (1000 A/m) compliant

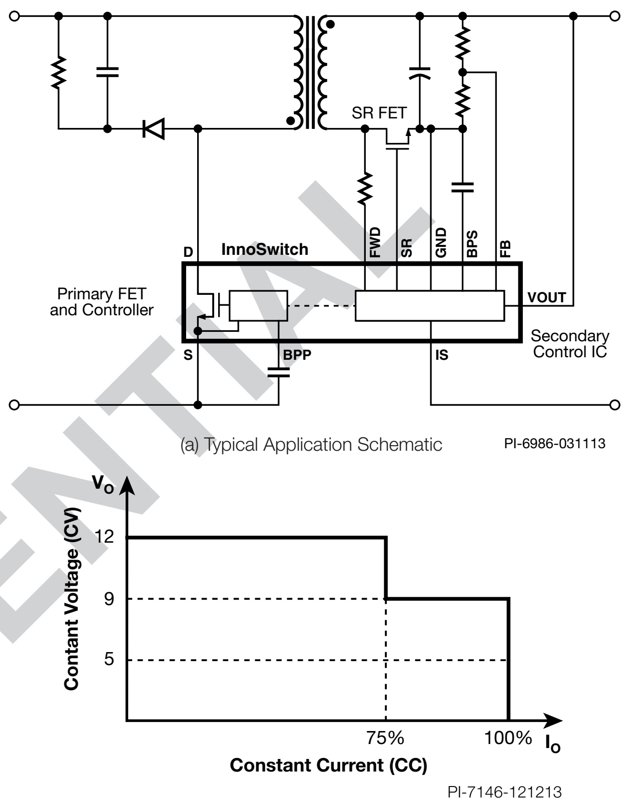
Green Package
- Halogen free and RoHS compliant

Applications
- Chargers and adapters for smart mobile devices
- LED lighting
- High efficiency, low voltage, high current power supplies

Description

The InnoSwitch family of ICs dramatically simplifies the development and manufacturing of low voltage, high current power supplies, particularly those in compact enclosures or with high efficiency requirements. The InnoSwitch architecture is revolutionary in that the devices incorporate both primary and secondary controllers, with sense elements and a safety-rated feedback mechanism into a single IC.

Close component proximity and innovative use of the integrated communication link permit accurate control of a secondary-side synchronous rectification MOSFET and optimization of primary-side switching to maintain high efficiency across the entire load range. Additionally, the minimal DC bias requirements of the link, enables the system to achieve less than 10 mW no-load in challenging applications such as smart-mobile device chargers.



(a) Typical Application Schematic

(b) Output Characteristic

Figure 1. Typical Application/Performance.

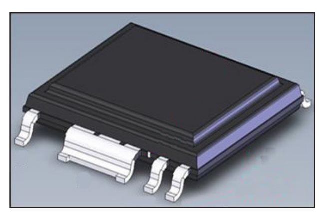


Figure 2. High Creepage, Safety-Compliant eSOP Package.

Output Power Table

Product[3]	230 VAC ±15%		85-265 VAC	
	Adapter[1]	Peak or Open Frame[2]	Adapter[1]	Peak or Open Frame[2]
SC1223K	18 W	22 W	18 W	22 W

Table 1. Output Power Table.

Notes:
1. Minimum continuous power in a typical non-ventilated enclosed adapter measured at 40 °C ambient. Assumes +12 V output.
2. Minimum peak power capability.
3. Package: KR: eSOP-R16B.

PRELIMINARY

This document contains information on a new product. Specifications and information herein are subject to change without notice.

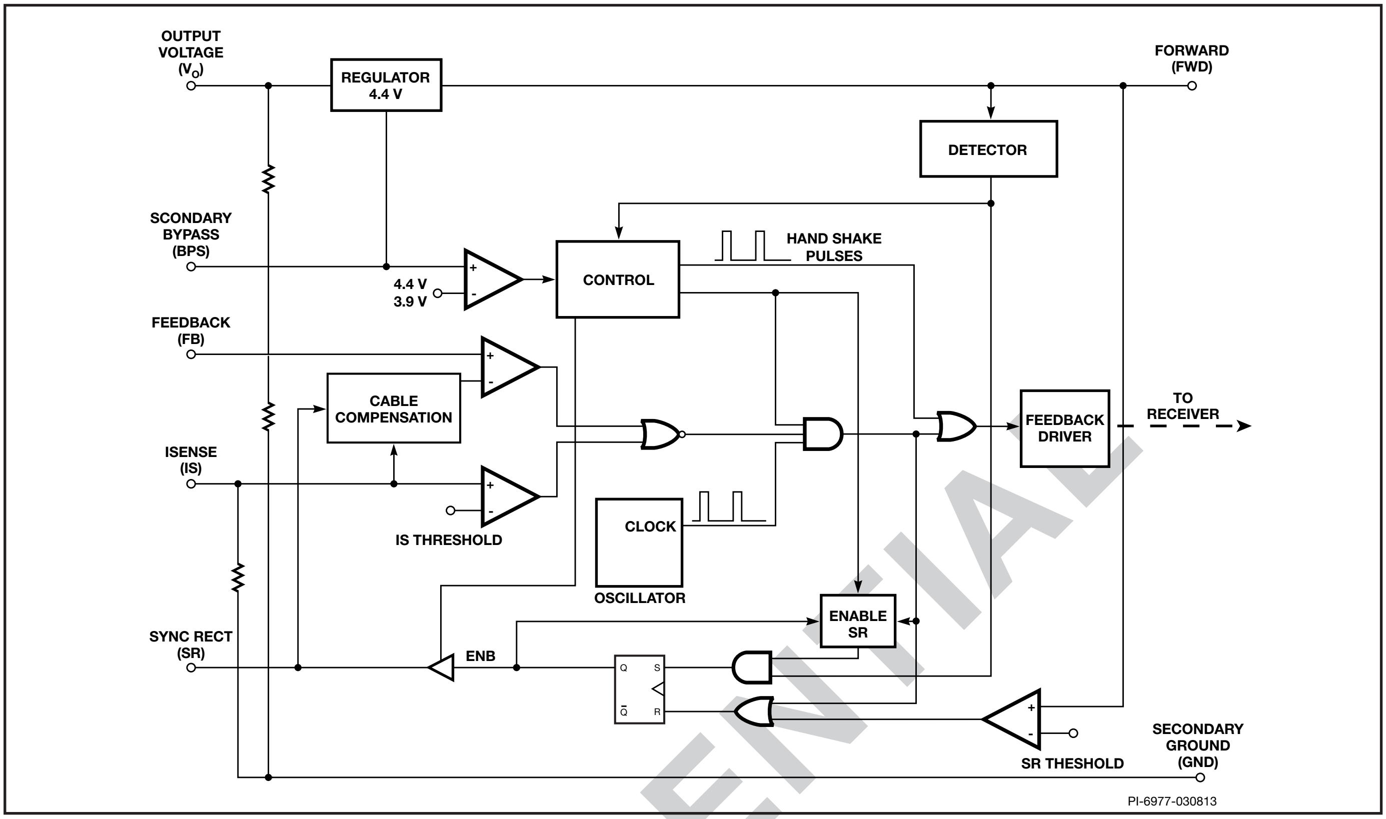


Figure 3. Secondary-Side Controller Block Diagram.

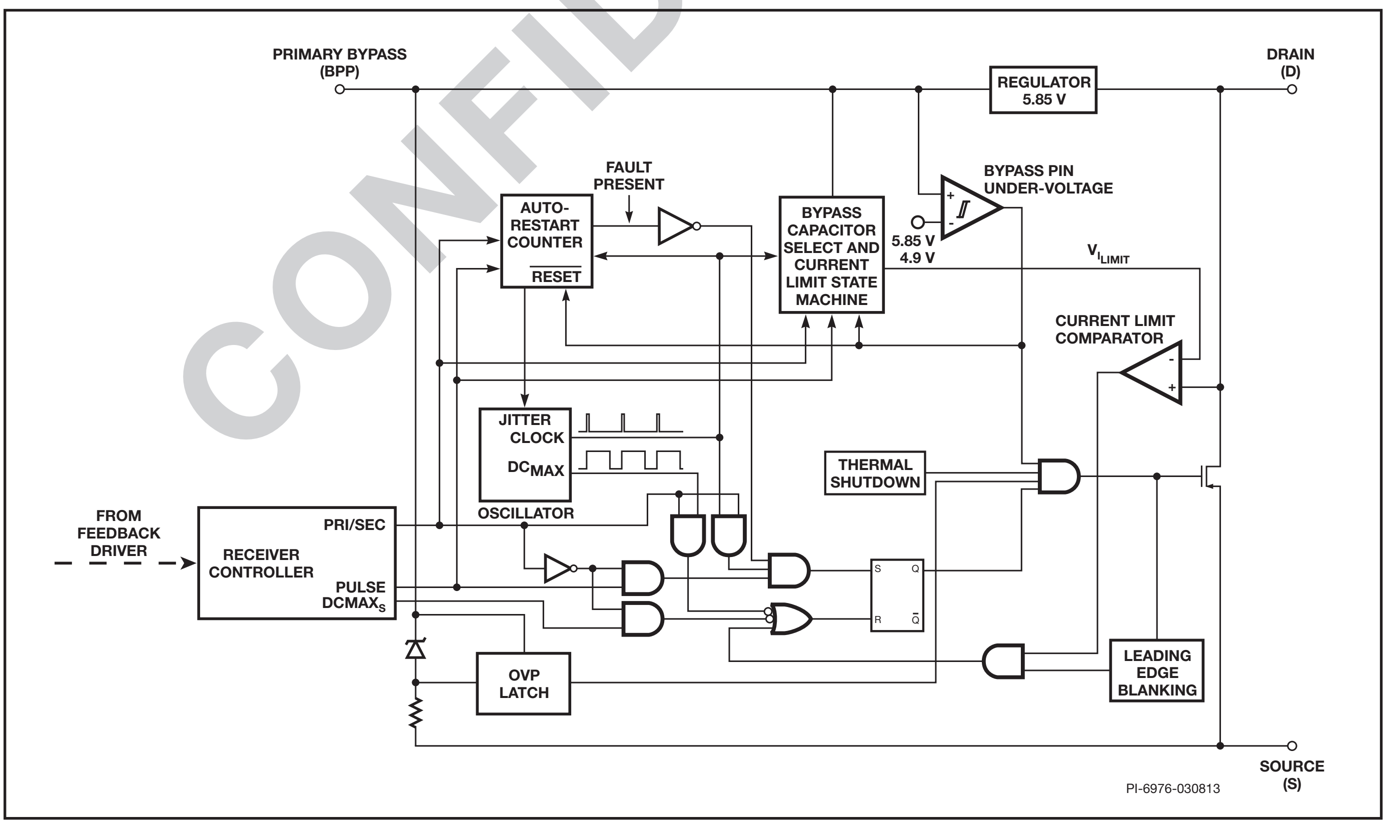


Figure 4. Primary-Side Controller Buck Diagram.

PRELIMINARY

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Pin Functional Description

Drain (D) Pin: (Pin 1)
This pin is the power MOSFET drain connection.

PRIMARY BYPASS (BPP) Pin: (Pin 7)
It is the connection point for an external bypass capacitor for the primary IC supply.

FEEDBACK (FB) Pin: (Pin 14)
This pin connects to an external resistor divider to set the power supply CV voltage regulation threshold.

FORWARD (FWD) Pin: (Pin 10)
The connection point to the switching node of the transformer output winding for sensing and other functions.

OUTPUT VOLTAGE (VOUT) Pin: (Pin 11)
This pin is connected directly to the output voltage of the power supply to provide bias to the secondary IC.

SYNCHRONOUS RECTIFIER DRIVE (SR) Pin: (Pin 12)
Connection to external SR FET gate terminal.

SECONDARY BYPASS (BPS) Pin: (Pin 13)
It is the connection point for an external bypass capacitor for the secondary IC supply.

SECONDARY GROUND (GND): (Pin 15)
Ground connection for the secondary IC.

ISENSE (IS) Pin: (Pin 16)
Connection to the power supply output terminals. Internal current sense is connected between this pin and the SECONDARY GROUND pin.

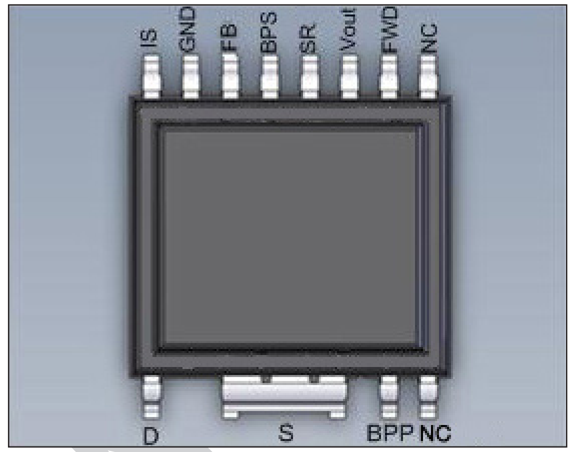


Figure 5. Pin Configuration.

InnoSwitch Operation

InnoSwitch devices operate in the current limit mode. When enabled, the oscillator turns the power MOSFET on at the beginning of each cycle. The MOSFET is turned off when the current ramps up to the current limit or when the DC_{MAX} limit is reached. Since the highest current limit level and frequency of a InnoSwitch design are constant, the power delivered to the load is proportional to the primary inductance of the transformer and peak primary current squared. Hence, designing the supply involves calculating the primary inductance of the transformer for the maximum output power required. If the InnoSwitch is appropriately chosen for the power level, the current in the calculated inductance will ramp up to current limit before the DC_{MAX} limit is reached.

InnoSwitch senses the output voltage on the FEEDBACK pin using a resistive voltage divider to determine whether or not to proceed with the next switching cycle. The sequence of cycles is used to determine the current limit. Once a cycle is started, it

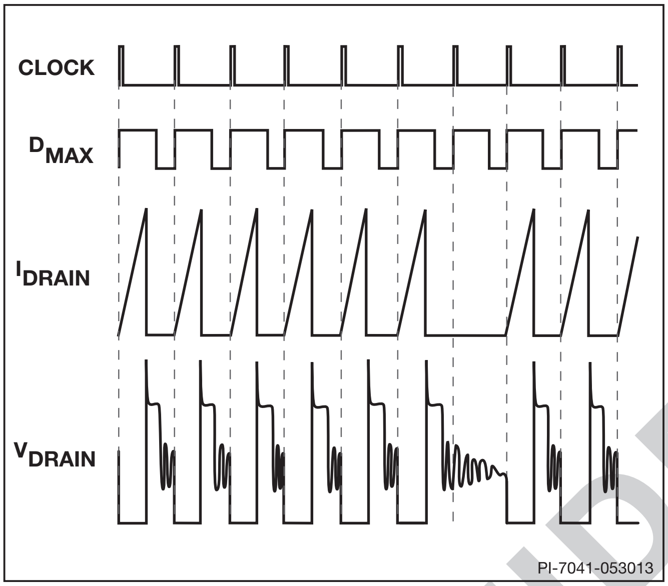


Figure 6. Operation at Near Maximum Loading.

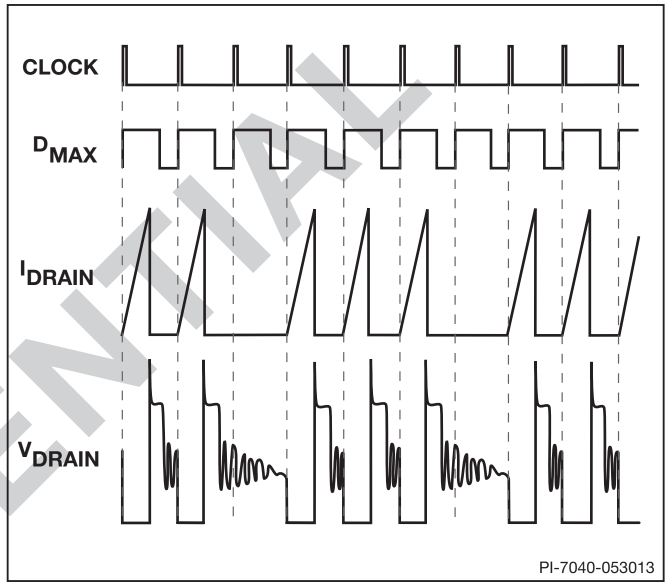


Figure 7. Operation at Moderately Heavy Loading.

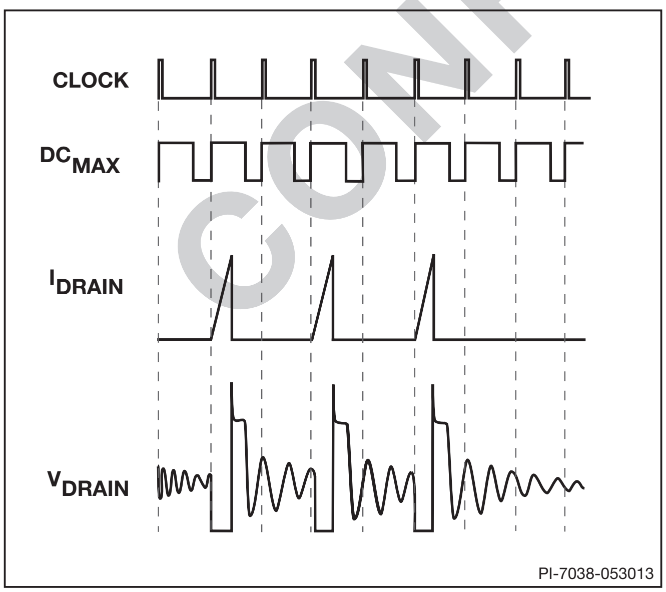


Figure 8. Operation at Medium Loading.

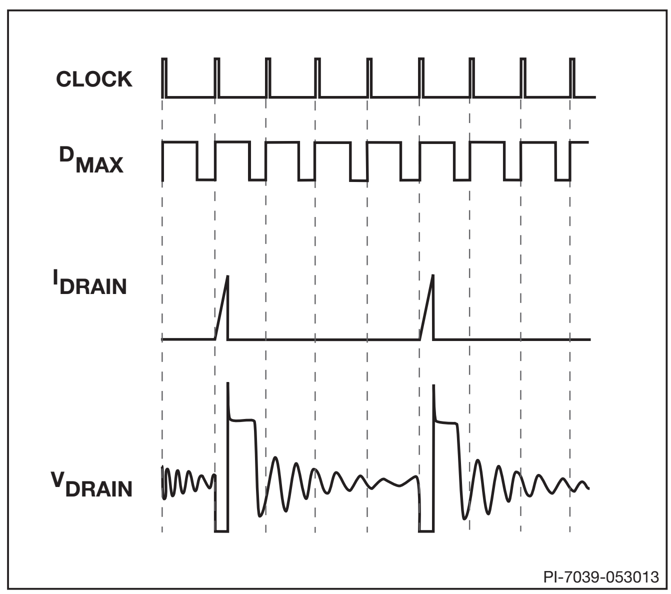


Figure 9. Operation at Very Light Load.

always completes the cycle. This operation results in a power supply in which the output voltage ripple is determined by the output capacitor, and the amount of energy per switch cycle.

ON/OFF Operation with Current Limit State Machine

The internal clock of the InnoSwitch runs all the time. At the beginning of each clock cycle, the voltage comparator on the FEEDBACK pin decides whether or not to implement a switch cycle, and based on the sequence of samples over multiple cycles, it determines the appropriate current limit. At high loads, the state machine sets the current limit to its highest value. At lighter loads, the state machine sets the current limit to reduced values.

At near maximum load, InnoSwitch will conduct during nearly all of its clock cycles (Figure 6). At slightly lower load, it will “skip” additional cycles in order to maintain voltage regulation at the power supply output (Figure 7). At medium loads, cycles will be skipped and the current limit will be reduced (Figure 8). At very light loads, the current limit will be reduced even further (Figure 9). Only a small percentage of cycles will occur to satisfy the power consumption of the power supply.

The response time of the ON/OFF control scheme is very fast compared to PWM control. This provides tight regulation and excellent transient response.

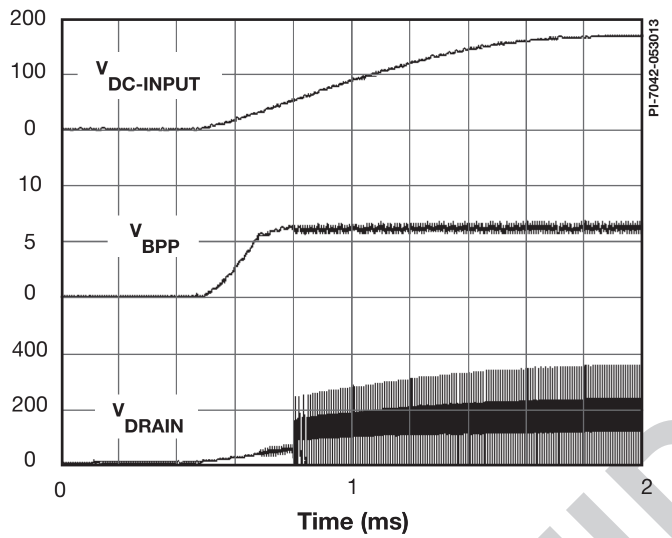


Figure 10. Power-Up.

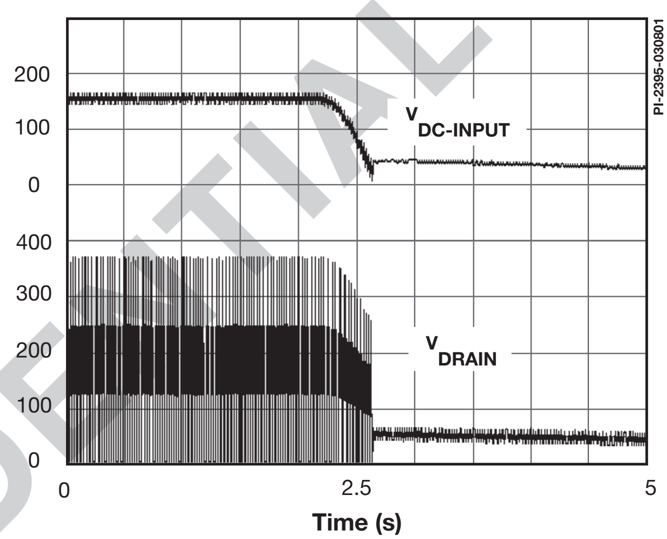


Figure 11. Normal Power-Down Timing.

Absolute Maximum Ratings[1,2]

DRAIN Pin Voltage .... -0.3 V to 650 V
DRAIN Pin Peak Current .... 1710 (3200) mA[3]
PRIMARY BYPASS/SECONDARY BYPASS Pin
Voltage.. -0.3 V to 9 V
PRIMARY BYPASS/SECONDARY BYPASS Pin
Current .... 100 mA
FORWARD Pin Voltage....................................... -1.5 V to 150 V
FEEDBACK Pin Voltage .... -0.3 to 9 V
SR/P Pin Voltage .... -0.3 to 9 V
OUTPUT VOLTAGE Pin Voltage.............................. -0.3 to 15 V
Storage Temperature ....-65 to 125 °C
Operating Junction Temperature[4]..........................-40 to 125 °C
Ambient Temperature... -40 to 85 °C
Lead Temperature ....260 °C

Notes:

1. All voltages referenced to Source and Secondary Ground, T_A = 25 °C.
2. Maximum ratings specified may be applied one at a time without causing permanent damage to the product. Exposure to Absolute Maximum Ratings conditions for extended periods of time may affect product reliability.
3. Higher peak Drain current is allowed while the Drain voltage is simultaneously less than 400 V.
4. Normally limited by internal circuitry.
5. 1/16" from case for 5 seconds.

Thermal Resistance

Thermal Resistance: K Package:
(θ_{JA}).....................................65 °C/W[2], 69 °C/W[3]
(θ_{JC})...12 °C/W[2]

Notes:

1. Measured on the SOURCE pin close to the plastic interface.
2. Solder to 0.36 sq. in (232 mm^2), 2 oz. (610 g/m^2) copper clad.
3. Solder to 1 sq. in (645 mm^2), 2 oz. (610 g/m^2) copper clad.
4. The case temperature is measured at the bottom-side exposed pad.

Parameter	Conditions	Rating	Units
Ratings for UL1577 (Adapter power rating is derated power capability)			
Primary-Side Current Rating	Current from pin (3-6) to pin 1	1.5	A
Primary-Side Power Rating	T_{AMB} = 25 °C (Device mounted in socket resulting in T_{CASE} = 120 °C)	1.35	W
Secondary-Side Current Rating	Current from pin 16 to pin 15	2.0	A
Secondary-Side Power Rating	T_{AMB} = 25 °C (Device mounted in socket)	0.125	W

Parameter	Symbol	Conditions SOURCE = 0 V T_{JI} = -40 °C to +125 °C (Note C) (Unless Otherwise Specified)		Min	Typ	Max	Units
Control Functions							
Output Frequency Applies to Both Primary and Secondary Controllers	f_{OSC}	T_J = 25 °C	Average		100		kHz
			Peak-to-Peak Jitter		8		
Maximum Duty-Cycle	DC_{MAX}			60			%

Parameter	Symbol	Conditions SOURCE = 0 V T_{JI} = -40 °C to +125 °C (Unless Otherwise Specified)	Min	Typ	Max	Units
Control Functions (cont.)						
PRIMARY BYPASS Pin Supply Current	I_{S1}	V_{BPP} = 6.2 V (MOSFET not Switching) See Note 2		270		µA
	I_{S2}	T_J = 25 °C, V_{BPP} = 6.2 V (MOSFET Switching at f_{OSC}) See Note 1,3		990		
PRIMARY BYPASS Pin Charge Current	I_{CH1}	T_J = 25 °C, V_{BP} = 0V See Notes 4, 5		-4.7		mA
	I_{CH2}	T_J = 25 °C, V_{BP} = 4 V See Notes 4, 5		-3.0		
PRIMARY BYPASS Pin Voltage	V_{BPP}	See Note 4		5.95		V
PRIMARY BYPASS Pin Voltage Hysteresis	$V_{BPP(H)}$			0.57		V
PRIMARY BYPASS Shunt Voltage	V_{SHUNT}	I_{BPP} = 2 mA		6.4		V
Circuit Protection						
Standard Current Limit (BPP) Capacitor = 0.1 µF	I_{LIMIT} See Note 5	di/dt = 213 mA/µs T_J = 25 °C	883	990	1102	mA
Reduced Current Limit (BPP) Capacitor = 1 µF	$I_{LIMIT-1}$ See Note 5	di/dt = 213 mA/µs T_J = 25 °C	790	890	918	mA
Increased Current Limit (BPP) Capacitor = 10 µF	$I_{LIMIT+1}$ See Note 5	di/dt = 213 mA/µs T_J = 25 °C	976	1050	1134	mA
Power Coefficient	I^2f	Standard Current Limit $I^2f = I_{LIMIT(TYP)}{}^2 \times f_{OSC(TYP)}$, T_J = 25 °C	0.9 × I^2f	I^2f	1.12 × I^2f	A^2Hz
		Reduced Current Limit $I^2f = I_{LIMIT-1(TYP)}{}^2 \times f_{OSC(TYP)}$, T_J = 25 °C	0.9 × I^2f	I^2f	1.16 × I^2f	
		Increased Current Limit $I^2f = I_{LIMIT+1(TYP)}{}^2 \times f_{OSC(TYP)}$, T_J = 25 °C	0.9 × I^2f	I^2f	1.16 × I^2f	
Initial Current Limit	I_{INIT}	T_J = 25 °C See Note 1	0.75 × $I_{LIMIT(TYP)}$			mA
Leading Blank Time	t_{LEB}	T_J = 25 °C See Note 1	170	250		ns
Current Limit Delay	t_{ILD}	T_J = 25 °C See Note 1, 6		170		ns
Thermal Shutdown	T_{SD}		135	142	150	°C

Parameter	Symbol	Conditions SOURCE = 0 V T_{JI} = -40 °C to +125 °C (Unless Otherwise Specified)		Min	Typ	Max	Units
Circuit Protection (cont.)							
Thermal Shutdown Hysteresis	$T_{SD(H)}$				75		°C
PRIMARY BYPASS Pin Shutdown Threshold Current	I_{SD}				7.6		mA
Primary Bypass Power-up Reset Threshold Voltage	$V_{BPP(RESET)}$	T_J = 25 °C			3.0		V
Auto-Restart On-time at f_{osc}	t_{AR}	T_J = 25 °C See Note 7			75		ms
Auto-Restart Trigger Skip Time	$t_{AR(SK)}$	T_J = 25 °C See Note 7			1		s
Auto-Restart Off-time at f_{osc}	$t_{AR(OFF)}$	T_J = 25 °C See Note 7			2		s
Output							
ON-State Resistance	$R_{DS(ON)}$	I_D = 1050 mA	T_J = 25 °C		1.55		Ω
			T_J = 100 °C		2.32		
Off-State Drain Leakage Current	I_{DSS1}	V_{BPP} = 6.2 V V_{DS} = 560 V T_J = 125 °C See Note 8				200	µA
	I_{DSS1}	V_{BPP} = 6.2 V V_{DS} = 325 V T_J = 25 °C See Notes 1, 8			15		µA
Breakdown Voltage	BV_{DSS}	V_{BPP} = 6.2 V T_J = 25 °C See Note 9		650			V
Drain Supply Voltage				50			V

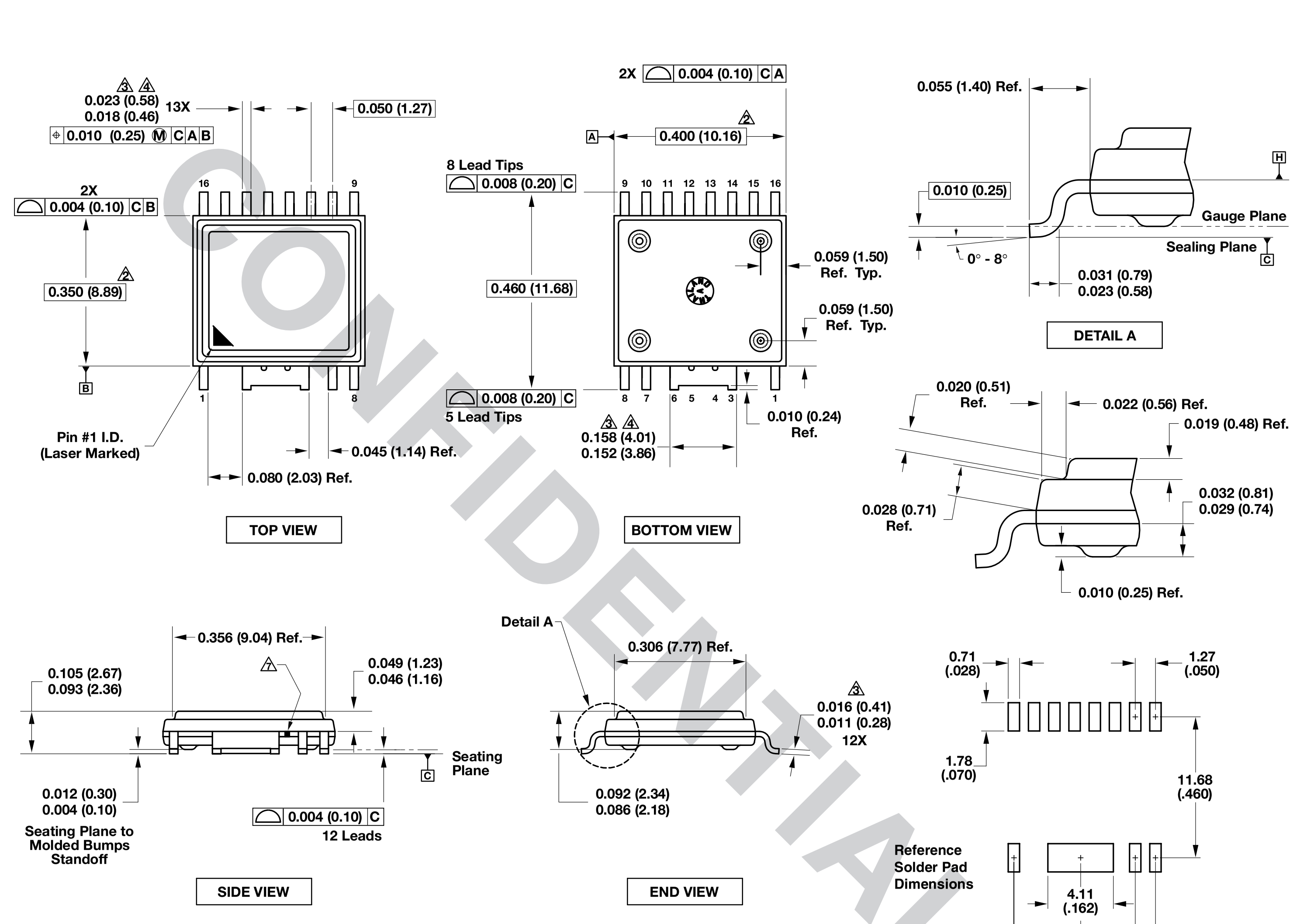
Parameter	Symbol	Conditions SOURCE = 0 V T_{JI} = -40 °C to +125 °C (Unless Otherwise Specified)	Min	Typ	Max	Units
Secondary						
FEEDBACK Pin Voltage	V_{FB}	T_J = 25 °C	1.240	1.265	1.290	V
FEEDBACK Pin Voltage at Turn-Off Voltage	$V_{FB(AR)}$			0.65 × V_{FB}		
Cable Drop Compensation Factor	ϕ_{CD}	T_J = 25 °C		1.06		
SECONDARY BYPASS Pin Current at No-Load	I_{SNL}	T_J = 25 °C			270	µA
SECONDARY BYPASS Pin Voltage	V_{BPS}	T_J = 25 °C		4.44		V
SECONDARY BYPASS Pin Undervoltage Threshold	$V_{BPS(UVLO)}$	T_J = 25 °C		3.85	3.95	V
SECONDARY BYPASS Pin Undervoltage Hysteresis	$V_{BPS(HYS)}$	T_J = 25 °C		0.65		V
Output (IS Pin) Current Limit Voltage Threshold	IS_{VTH}	T_J = 25 °C		33		mV
SR/P Pin Voltage Threshold	V_{SRTH}	T_J = 25 °C		-24		mV
SR/P Pin Pull-Up Current	I_{SRPU}	T_J = 25 °C		165		mA
SR/P Pin Pull-Down Current	I_{SRPD}	T_J = 25 °C		265		mA
Constant-Current Regulation Threshold	I_{CC}	T_J = 25 °C	2.0			A

Notes:
1. This parameter is derived from characterization.
2. I_{S1} is an estimate of device current consumption at no-load, since the operating frequency is so low under these conditions. Total device consumption at no-load is sum of I_{S1} and I_{DSS2} (this does not include secondary losses)
3. Since the output MOSFET is switching, it is difficult to isolate the switching current from the supply current at the Drain. An alternative is to measure the PRIMARY BYPASS pin current at 6.2 V.
4. The PRIMARY BYPASS pin is not intended for sourcing supply current to external circuitry.
5. To ensure correct current limit it is recommended that nominal 0.1 μF/1 μF/10 μF capacitors are used. In addition, the BPP capacitor value tolerance should be equal or better than indicated below across the ambient temperature range of the target application. The minimum and maximum capacitor values are guaranteed by characterization.

Nominal PRIMARY BYPASS Pin Capacitor Value	**Tolerance Relative to Nominal Capacitor Value**	
	Minimum	Maximum
0.1 μF	-60%	+100%
1 μF	-50%	+100%
10 μF	-50%	N/A

6. This parameter is derived from the change in current limit measured at 1X and 4X of the di/dt shown in the I_{LIMIT} specification.
7. Auto-restart on-time has same temperature characteristics as the oscillator (inversely proportional to frequency).
8. I_{DSS1} is the worst-case OFF state leakage specification at 80% of BV_{DSS} and the maximum operating junction temperature. I_{DSS2} is a typical specification under worst-case application conditions (rectified 265 VAC) for no-load consumption calculations.
9. Breakdown voltage may be checked against minimum BV_{DSS} specification by ramping Drain voltage up to but not exceeding minimum BV_{DSS}.

eSOP-R16B (KR Package)



Notes:
1. Dimensioning and tolerancing per ASME Y14.5M-1994.
2. Dimensions noted are determined at the outermost extremes of the plastic body exclusive of mold flash, tie bar burrs, gate burrs, and inter-lead flash, but including any mismatch between the top and bottom of the plastic body. Maximum mold protrusion is 0.007 (0.18) per side.
3. Dimensions noted are inclusive of plating thickness.
4. Does not include inter-lead flash or protrusions.
5. Controlling dimensions in inches (mm).
6. Datums A and B to be determined in Datum H.
7. Exposed metal at the plastic package body outline/surface between leads 2 and 3, connected internally to lead 2.

PI-6995-021814

Revision	Notes	Date
A	Preliminary	02/14

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