

# INN2904 InnoSwitch-EP Family

Off-Line CV/CC Flyback Switcher IC with Integrated 900 V MOSFET,  
Sync-Rect Feedback with Advanced Protection

**PRELIMINARY**

## Product Highlights

### Highly Integrated, Compact Footprint

- Incorporates flyback controller, 900 V MOSFET, secondary-side sensing and synchronous rectification driver
- FluxLink™ integrated, HIPOT-isolated, feedback link
- Exceptional CV accuracy, independent of transformer design or external components
- Excellent multi-output cross regulation with weighted SSR feedback and synch FETs

### EcoSmart™ – Energy Efficient

- <10 mW no-load at 230 VAC when supplied by transformer bias winding
- Easily meets all global energy efficiency regulations

### Advanced Protection / Safety Features

- Primary sensed output OVP
- Secondary sensed output overshoot clamp
- Secondary sensed output OCP to zero output voltage
- Hysteretic thermal shutdown
- Input voltage monitor with accurate brown-in/brown-out and overvoltage protection

### Full Safety and Regulatory Compliance

- 100% production HIPOT compliance testing equivalent to 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

- Appliance, industrial, and smart lighting

### Description

The InnoSwitch™-EP family of ICs dramatically simplify the development and manufacturing of low-voltage, high current power supplies, particularly those in compact enclosures or with high efficiency requirements. The InnoSwitch-EP 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, enable the system to achieve less than 10 mW no-load to maximize efficiency in standby.

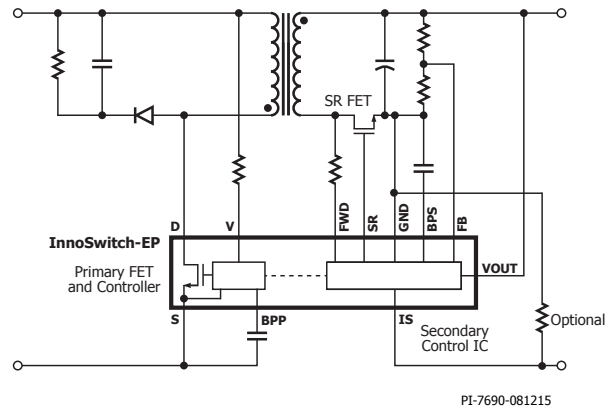


Figure 1. Typical Application/Performance.



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

## Output Power Table

Product <sup>3</sup>	230 VAC ±15%	85-265 VAC
	Peak or Open Frame <sup>1,2</sup>	Peak or Open Frame <sup>1,2</sup>
<b>INN2904K</b>	27 W	20 W

Table 1. Output Power Table.

Notes:

1. Minimum continuous power in a typical non-ventilated enclosed typical size adapter measured at 40 °C ambient. Max output power is dependent on the design. With condition that package temperature must be <= 125 °C.
2. Minimum peak power capability.
3. Package: K: eSOP-R16B.

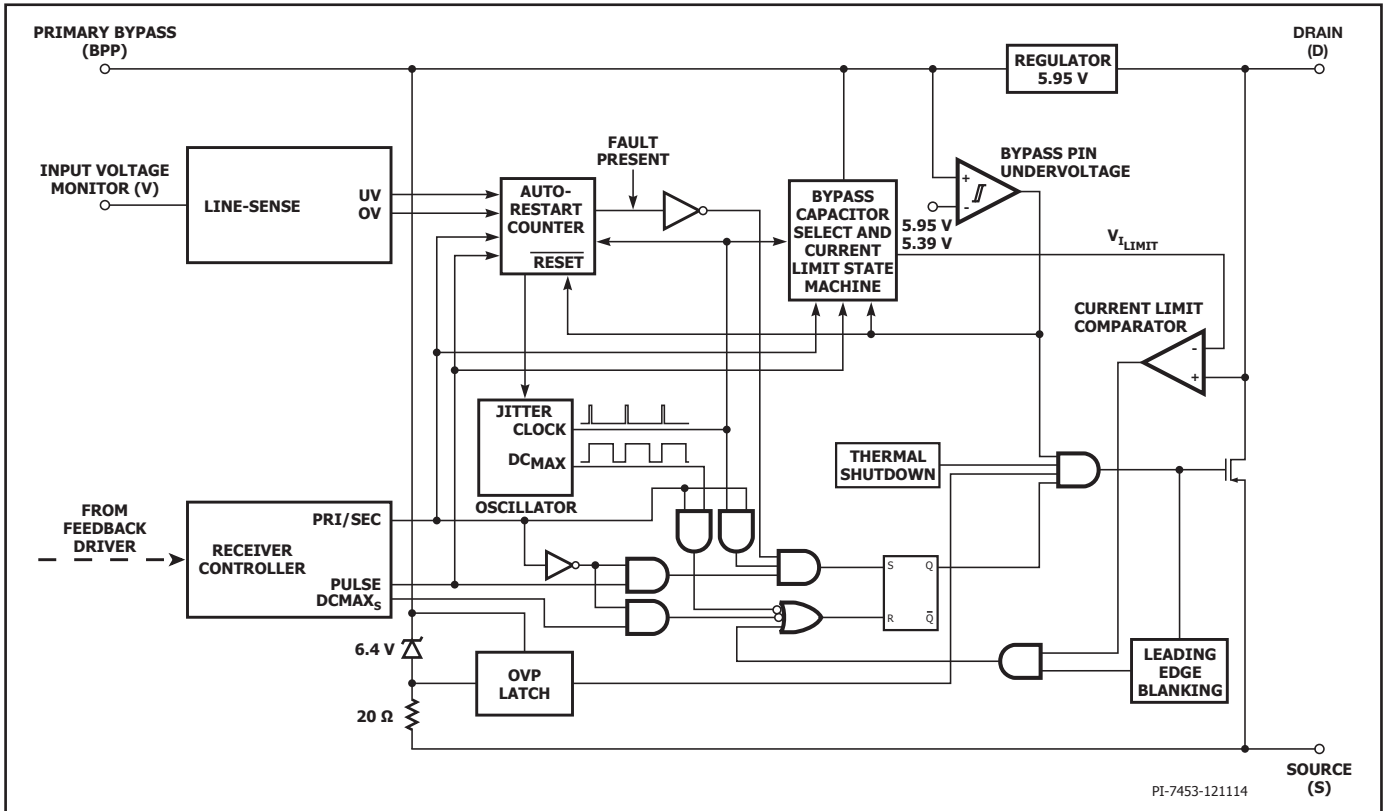


Figure 3. Primary-Side Controller Block Diagram.

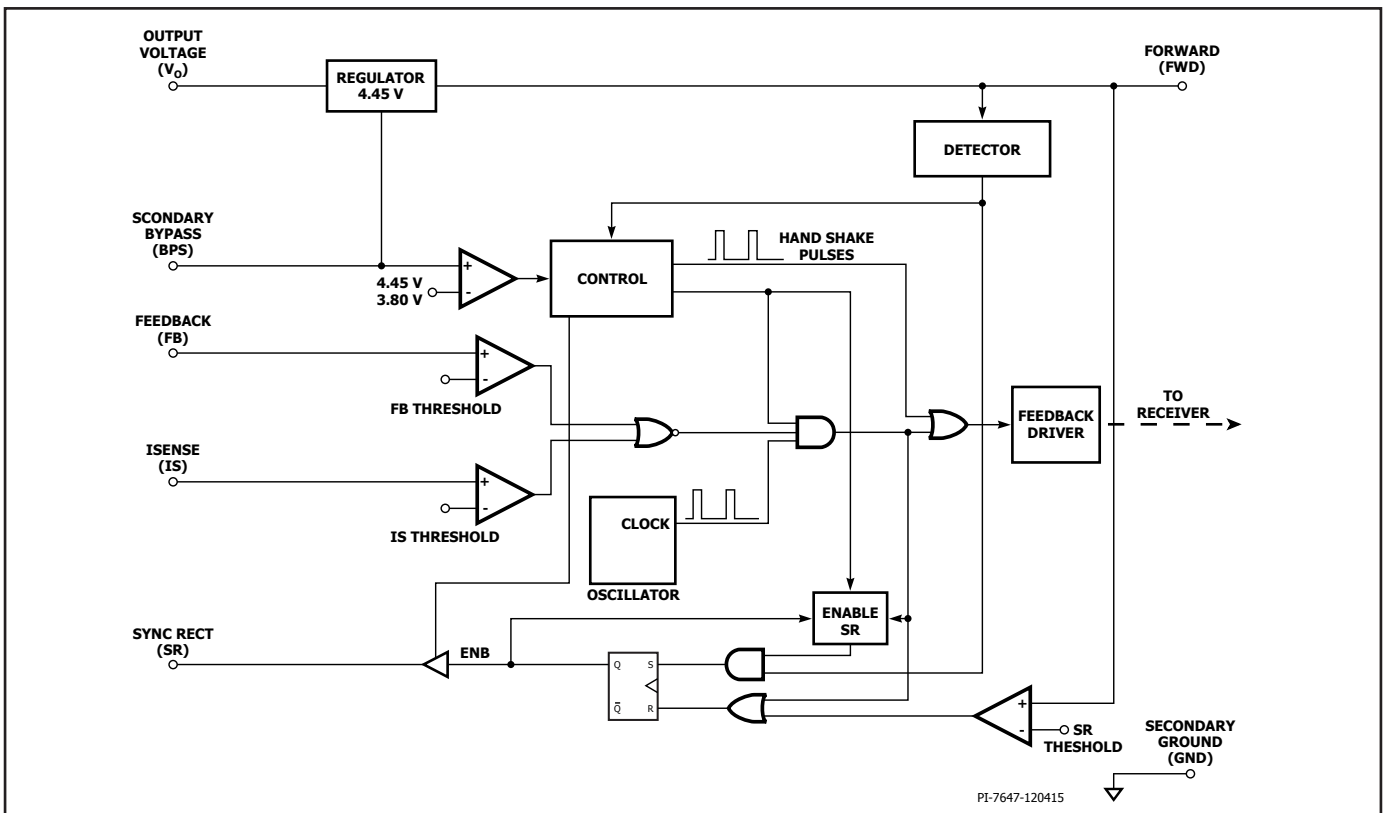


Figure 4. Secondary-Side Controller Block Diagram.

## Pin Functional Description

### DRAIN (D) Pin (Pin 1)

This pin is the power MOSFET drain connection.

### SOURCE (S) Pin (Pin 3-6)

This pin is the power MOSFET source connection. It is also the ground reference for the PRIMARY BYPASS pin.

### PRIMARY BYPASS (BPP) Pin (Pin 7)

It is the connection point for an external bypass capacitor for the primary-side controller IC supply.

### INPUT VOLTAGE MONITOR (V) Pin (Pin 8)

A 8 M $\Omega$  resistor is tied between the pin and the input bulk capacitor to provide input under and overvoltage protection.

### 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-side controller supply.

### FEEDBACK (FB) Pin (Pin 14)

This pin connects to an external resistor divider to set the power supply CV voltage regulation threshold.

### SECONDARY GROUND (GND) (Pin 15)

Ground connection for the secondary IC.

### ISENSE (IS) Pin (Pin 16)

Connection to the power supply output terminals. An external current sense resistor is connected between this pin and the SECONDARY GROUND pin.

If secondary current sense is not required, the ISENSE pin should be connected to the SECONDARY GROUND pin.

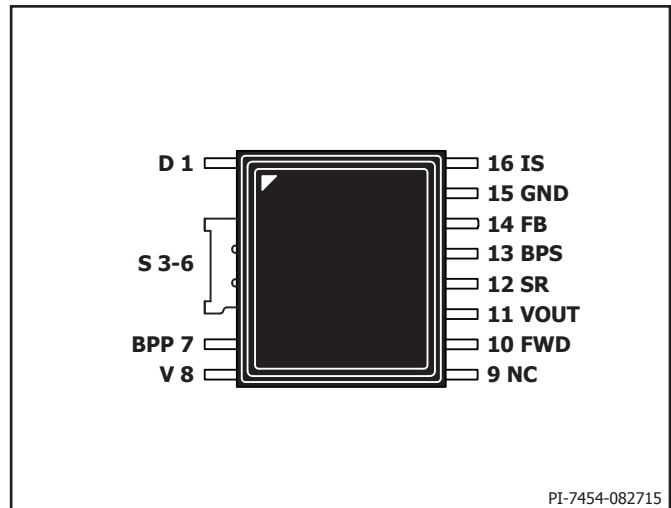


Figure 5. Pin Configuration.

**Absolute Maximum Ratings<sup>1,2</sup>**

DRAIN Pin Voltage.....	-0.3 V to 900 V
DRAIN Pin Peak Current <sup>3</sup> .....	1360 (2550) mA
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 <sup>7</sup> V
FEEDBACK/CURRENT SENSE Pin Voltage.....	-0.3 to 9 V
SR/P Pin Voltage.....	-0.3 to 9 V <sup>6</sup>
OUTPUT VOLTAGE Pin Voltage.....	-0.3 to 15 <sup>8</sup> V
Storage Temperature .....	-65 to 150 °C
Operating Junction Temperature <sup>4</sup> .....	-40 to 150 °C
Ambient Temperature .....	-40 to 105 °C
Lead Temperature <sup>5</sup> .....	260 °C

**Notes:**

- All voltages referenced to Source and Secondary Ground, T<sub>A</sub> = 25 °C.
- 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.
- Higher peak Drain current is allowed while the Drain voltage is simultaneously less than 400 V.
- Normally limited by internal circuitry.
- 1/16" from case for 5 seconds.
- 1.8 V for a duration of ≤500 nsec. See Figure 23.
- The maximum current out of the FORWARD pin when the FORWARD pin is below Ground is -40 mA.
- Maximum current into VOUT pin at 15 V should not exceed 10 mA.

**Thermal Resistance**

Thermal Resistance: K Package:

(θ <sub>JA</sub> ).....	65 °C/W <sup>2</sup> , 69 °C/W <sup>1</sup>
(θ <sub>JC</sub> ).....	12 °C/W <sup>3</sup>

**Notes:**

- Solder to 0.36 sq. in (232 mm<sup>2</sup>), 2 oz. (610 g/m<sup>2</sup>) copper clad.
- Solder to 1 sq. in (645 mm<sup>2</sup>), 2 oz. (610 g/m<sup>2</sup>) copper clad.
- The case temperature is measured at the plastic surface at the top of the package.

Parameter	Conditions	Rating	Units
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**Ratings for UL1577 (Adapter power rating is derated power capability)**

<b>Primary-Side Current Rating</b>	Current from pin (3-6) to pin 1	1.5	A
<b>Primary-Side Power Rating</b>	T <sub>AMB</sub> = 25 °C (Device mounted in socket resulting in T <sub>CASE</sub> = 120 °C)	1.35	W
<b>Secondary-Side Current Rating</b>	Current from pin 16 to pin 15	N/A	
<b>Secondary-Side Power Rating</b>	T <sub>AMB</sub> = 25 °C (Device mounted in socket)	0.125	W

Parameter	Symbol	Conditions SOURCE = 0 V T <sub>JT</sub> = -40 °C to +125 °C (Note C) (Unless Otherwise Specified)	Min	Typ	Max	Units
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**Control Functions**

<b>Output Frequency Applies to Both Primary and Secondary Controllers</b>	f <sub>OSC</sub>	T <sub>J</sub> = 25 °C	Average	93	100	107	kHz
			Peak-to-Peak Jitter		6		
<b>Maximum Duty Cycle</b>	DC <sub>MAX</sub>	T <sub>J</sub> = 0 °C to 125 °C	60				%

Parameter	Symbol	Conditions SOURCE = 0 V $T_{JI} = -40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$ (Unless Otherwise Specified)	Min	Typ	Max	Units
<b>Control Functions (cont.)</b>						
<b>PRIMARY BYPASS Pin Supply Current</b>	$I_{S1}$	$T_J = 25\text{ }^{\circ}\text{C}$ , $V_{BPP} + 0.1\text{ V}$ (MOSFET not Switching) See Note B		260		$\mu\text{A}$
	$I_{S2}$	$T_J = 25\text{ }^{\circ}\text{C}$ , $V_{BPP} + 0.1\text{ V}$ (MOSFET Switching at $f_{OSC}$ ) See Note A, C		740		
<b>PRIMARY BYPASS Pin Charge Current</b>	$I_{CH1}$	$T_J = 25\text{ }^{\circ}\text{C}$ , $V_{BP} = 0\text{ V}$ See Notes D, E		-4.5		$\text{mA}$
	$I_{CH2}$	$T_J = 25\text{ }^{\circ}\text{C}$ , $V_{BP} = 4\text{ V}$ See Notes D, E		-2.8		
<b>PRIMARY BYPASS Pin Voltage</b>	$V_{BPP}$	See Note D	5.70	5.95	6.15	V
<b>PRIMARY BYPASS Pin Voltage Hysteresis</b>	$V_{BPP(H)}$		0.40	0.56	0.70	V
<b>PRIMARY BYPASS Shunt Voltage</b>	$V_{SHUNT}$	$I_{BPP} = 2\text{ mA}$	6.15	6.45	6.75	V
<b>Line Fault Protection</b>						
<b>UV/OV Pin Brown-In Threshold</b>	$I_{UV+}$	$T_J = 25\text{ }^{\circ}\text{C}$ See Note F		12.3		$\mu\text{A}$
<b>UV/OV Pin Brown-Out Threshold</b>	$I_{UV-}$	$T_J = 25\text{ }^{\circ}\text{C}$ See Note A, F, G, H		$0.87 \times I_{UV+}$		
<b>Brown-Out Delay Time</b>	$t_{UV-}$	See Note F, H		32		ms
<b>UV/OV Pin Line Over-voltage Threshold</b>	$I_{OV+}$	$T_J = 25\text{ }^{\circ}\text{C}$		117		$\mu\text{A}$
<b>UV/OV Pin Line Ovevoltage Recovery Threshold</b>	$I_{OV-}$			$0.96 \times I_{OV+}$		
<b>UV/OV Pin Overvoltage Deglitch Filter</b>	$t_{OV+}$			5		$\mu\text{s}$
<b>VOLTAGE MONITOR Pin Threshold Voltage</b>	$V_V$			3.7		V
<b>Circuit Protection</b>						
<b>Standard Current Limit (BPP) Capacitor = 0.1 <math>\mu\text{F}</math></b>	$I_{LIMIT}$ See Note E	$di/dt = \text{TBD mA}/\mu\text{s}$ $T_J = 25\text{ }^{\circ}\text{C}$		1000		mA

Parameter	Symbol	Conditions SOURCE = 0 V $T_{JI} = -40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$ (Unless Otherwise Specified)	Min	Typ	Max	Units
<b>Circuit Protection (cont.)</b>						
<b>Reduced Current Limit (BPP) Capacitor = 10 <math>\mu\text{F}</math></b>	$I_{\text{LIMIT-1}}$ See Note E	$di/dt = \text{TBD mA}/\mu\text{s}$ $T_J = 25\text{ }^{\circ}\text{C}$		850		mA
<b>Increased Current Limit (BPP) Capacitor = 1 <math>\mu\text{F}</math></b>	$I_{\text{LIMIT+1}}$ See Note E	$di/dt = \text{TBD mA}/\mu\text{s}$ $T_J = 25\text{ }^{\circ}\text{C}$		1150		mA
<b>Power Coefficient</b>	$I^2f$	Standard Current Limit, $I^2f = I_{\text{LIMIT(TYP)}}^2 \times f_{\text{OSC(TYP)}}$ See Note A	$0.87 \times I^2f$	$I^2f$	$1.15 \times I^2f$	A <sup>2</sup> Hz
		Reduced Current Limit, $I^2f = I_{\text{LIMITred(TYP)}}^2 \times f_{\text{OSC(TYP)}}$ See Note A	$0.84 \times I^2f$	$I^2f$	$1.18 \times I^2f$	
		Increased Current Limit, $I^2f = I_{\text{LIMITinc(TYP)}}^2 \times f_{\text{OSC(TYP)}}$ See Note A	$0.84 \times I^2f$	$I^2f$	$1.18 \times I^2f$	
<b>Initial Current Limit</b>	$I_{\text{INIT}}$	$T_J = 25\text{ }^{\circ}\text{C}$ See Note A	$0.75 \times I_{\text{LIMIT(TYP)}}$			mA
<b>Leading Edge Blanking Time</b>	$t_{\text{LEB}}$	$T_J = 25\text{ }^{\circ}\text{C}$ See Note A	170	250		ns
<b>Current Limit Delay</b>	$t_{\text{ILD}}$	$T_J = 25\text{ }^{\circ}\text{C}$ See Note A, F		170		ns
<b>Thermal Shutdown</b>	$T_{\text{SD}}$	See Note A	135	142	150	$^{\circ}\text{C}$
<b>Thermal Shutdown Hysteresis</b>	$T_{\text{SD(H)}}$	See Note A		75		$^{\circ}\text{C}$
<b>PRIMARY BYPASS Pin Shutdown Threshold Current</b>	$I_{\text{SD}}$		5.6	7.6	9.6	mA
<b>Primary Bypass Power-Up Reset Threshold Voltage</b>	$V_{\text{BPP(RESET)}}$	$T_J = 25\text{ }^{\circ}\text{C}$		3.8		V
<b>Auto-Restart On-Time at <math>f_{\text{OSC}}</math></b>	$t_{\text{AR}}$	$T_J = 25\text{ }^{\circ}\text{C}$ See Note G		60		ms
<b>Auto-Restart Trigger-Skip Time</b>	$t_{\text{AR(SK)}}$	$T_J = 25\text{ }^{\circ}\text{C}$ See Note A, G		1		s

Parameter	Symbol	Conditions		Min	Typ	Max	Units
		SOURCE = 0 V T <sub>J1</sub> = -40 °C to +125 °C (Unless Otherwise Specified)					
<b>Circuit Protection (cont.)</b>							
<b>Auto-Restart Off-Time at f<sub>osc</sub></b>	t <sub>AR(OFF)</sub>	T <sub>J</sub> = 25 °C See Note G				2	s
<b>Short Auto-Restart Off-Time at f<sub>osc</sub></b>	t <sub>AR(OFF)SH</sub>	T <sub>J</sub> = 25 °C See Note A, G			0.5		s
<b>Output</b>							
<b>ON-State Resistance</b>	R <sub>DS(ON)</sub>	I <sub>D</sub> = 850 mA	T <sub>J</sub> = 25 °C		3.5		Ω
			T <sub>J</sub> = 100 °C See Note A				
<b>OFF-State Drain Leakage Current</b>	I <sub>DSS1</sub>	V <sub>BPP</sub> = 6.2 V, V <sub>DS</sub> = 560 V, T <sub>J</sub> = 125 °C See Note H				200	μA
<b>OFF-State Drain Leakage Current</b>	I <sub>DSS2</sub>	V <sub>BPP</sub> = 6.2 V, V <sub>DS</sub> = 325 V, T <sub>J</sub> = 25 °C See Note A, H			15		μA
<b>Breakdown Voltage</b>	BV <sub>DSS</sub>	V <sub>BPP</sub> = 6.2 V T <sub>J</sub> = 25 °C See Note I		900			V
<b>Drain Supply Voltage</b>				50			V
<b>Secondary</b>							
<b>FEEDBACK Pin Voltage</b>	V <sub>FB</sub>	T <sub>J</sub> = 25 °C at V <sub>O</sub> = 5 V		1.250	1.265	1.280	V
<b>OUTPUT VOLTAGE Pin Auto-Restart Threshold</b>	V <sub>OUT(AR)</sub>				V <sub>OUT</sub> -2 V		
<b>SECONDARY BYPASS Pin Current at No-Load</b>	I <sub>SNL</sub>	T <sub>J</sub> = 25 °C			300		μA
<b>SECONDARY BYPASS Pin Voltage</b>	V <sub>BPS</sub>			4.25	4.45	4.65	V
<b>SECONDARY BYPASS Pin Undervoltage Threshold</b>	V <sub>BPS(UVLO)</sub>			3.45	3.8	4.15	V
<b>SECONDARY BYPASS Pin Undervoltage Hysteresis</b>	V <sub>BPS(HYS)</sub>			0.10	0.65	1.2	V
<b>Output (IS Pin) Current Limit Voltage Threshold</b>	IS <sub>VTH</sub>	T <sub>J</sub> = 25 °C			35		mV
<b>VOUT Pin Auto-Restart Timer</b>	t <sub>VOUT(AR)</sub>			8			ms
<b>FEEDBACK Pin Short-Circuit</b>	V <sub>FB(OFF)</sub>				0.1		V

Parameter	Symbol	Conditions		Min	Typ	Max	Units
		SOURCE = 0 V T <sub>J1</sub> = -40 °C to +125 °C (Unless Otherwise Specified)					
<b>Synchronous Rectifier<sup>1</sup></b>							
<b>SYNCHRONOUS RECTIFIER Pin Threshold</b>	V <sub>SRTH</sub>	T <sub>J</sub> = 25 °C		-19	-24	-29	mV
<b>SYNCHRONOUS RECTIFIER Pin Pull-Up Current</b>	I <sub>SRPU</sub>	T <sub>J</sub> = 25 °C C <sub>LOAD</sub> = 2 nF, f <sub>s</sub> = 100 kHz			162		mA
<b>SYNCHRONOUS RECTIFIER Pin Pull-Down Current</b>	I <sub>SRPD</sub>	T <sub>J</sub> = 25 °C C <sub>LOAD</sub> = 2 nF, f <sub>s</sub> = 100 kHz			280		mA
<b>SYNCHRONOUS RECTIFIER Pin Drive Voltage</b>	V <sub>SR</sub>	See Note A		4.2	4.4	4.6	V
<b>Rise Time</b>	t <sub>R</sub>	T <sub>J</sub> = 25 °C C <sub>LOAD</sub> = 2 nF See Note A	0-100%		71		ns
			10-90%		40		
<b>Fall Time</b>	t <sub>F</sub>	T <sub>J</sub> = 25 °C C <sub>LOAD</sub> = 2 nF See Note A	0-100%		32		ns
			10-90%		15		
<b>Output Pull-Up Resistance</b>	R <sub>PU</sub>	T <sub>J</sub> = 25 °C, V <sub>SPS</sub> = 4.4 V I <sub>SR</sub> = 10 mA, See Note A			11.5		Ω
<b>Output Pull-Down Resistance</b>	R <sub>PD</sub>	T <sub>J</sub> = 25 °C, V <sub>SPS</sub> = 4.4 V I <sub>SR</sub> = 10 mA, See Note A			3.5		Ω

NOTES:

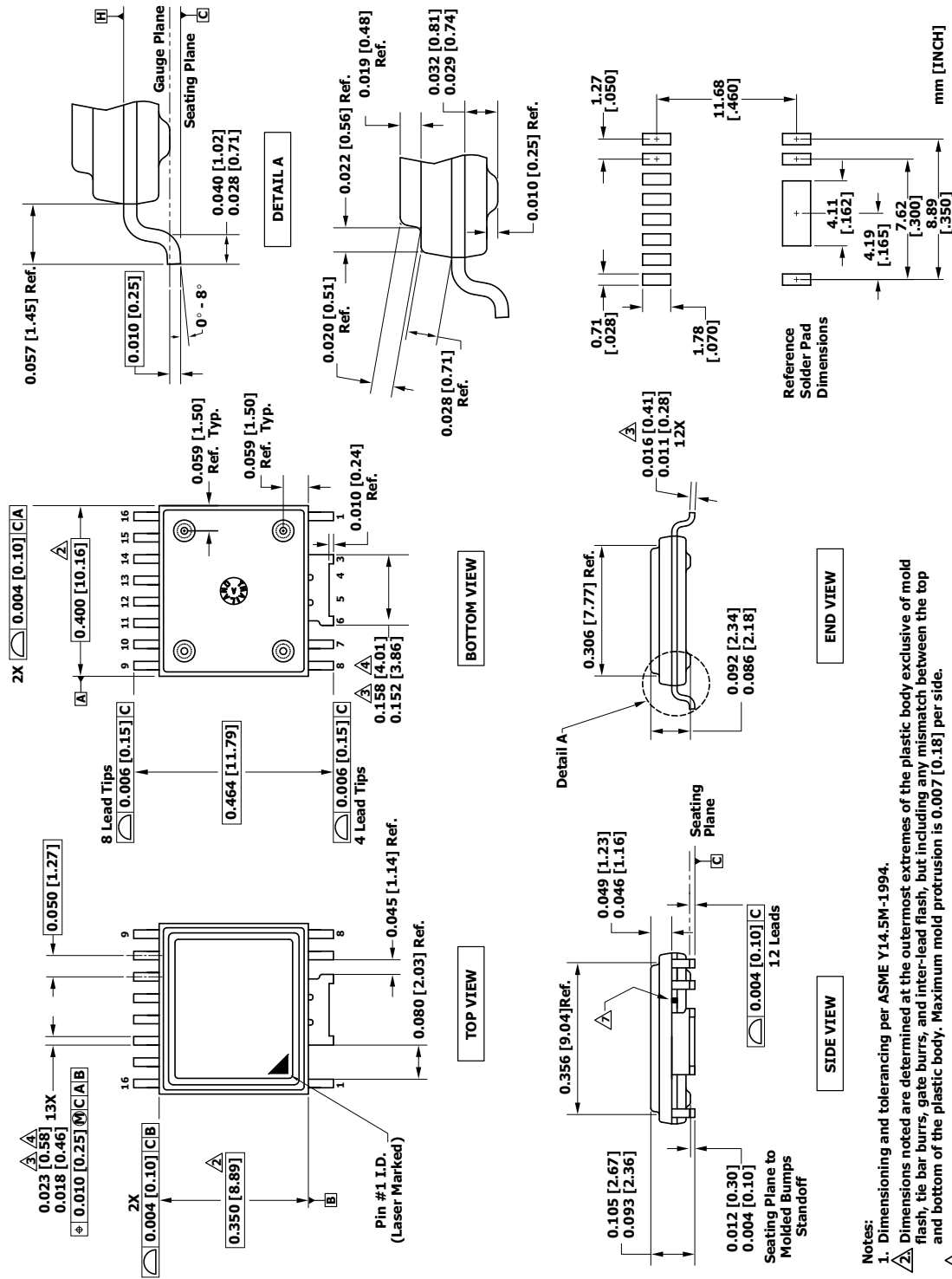
- A. This parameter is derived from characterization.
- B. I<sub>S1</sub> is an estimate of device current consumption at no-load, since the operating frequency is so low under these conditions. Total device consumption at no-load is sum of I<sub>S1</sub> and I<sub>DSS2</sub> (this does not include secondary losses)
- C. 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.
- D. The PRIMARY BYPASS pin is not intended for sourcing supply current to external circuitry.
- E. 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

- F. This parameter is derived from the change in current limit measured at 1X and 4X of the di/dt shown in the I<sub>LIMIT</sub> specification.
- G. Auto-restart on-time has same temperature characteristics as the oscillator (inversely proportional to frequency).
- H. I<sub>DSS1</sub> is the worst-case OFF-state leakage specification at 80% of BV<sub>DSS</sub> and the maximum operating junction temperature. I<sub>DSS2</sub> is a typical specification under worst-case application conditions (rectified 230 VAC) for no-load consumption calculations.
- I. Breakdown voltage may be checked against minimum BV<sub>DSS</sub> specification by ramping Drain voltage up to but not exceeding minimum BV<sub>DSS</sub>.
- J. For reference only. This is the total range of current limit threshold which corrects for variations in the current sense bond wire. Both of which are trimmed to set the normalized output constant current.



# eSOP-R16B

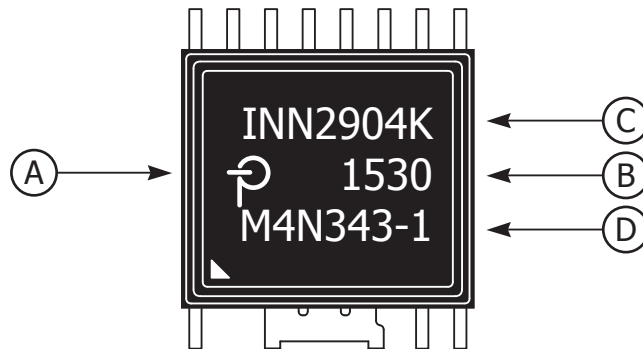


- Notes:**
1. Dimensioning and tolerancing per ASME Y14.5M-1994.
  2. Dimensions noted are determined at the outermost extremes of the plastic body exclusive of mold flash, tie bar burrs, gate burrs, and inter-lead flash, but including any mismatch between the top and bottom of the plastic body. Maximum 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 6 and 7, connected internally to wide lead 3/4/5/6.

PI-6995-010615  
POD-eSOP-R16B Rev B

**PACKAGE MARKING**

**eSOP-R16B**



- A. Power Integrations Registered Trademark
- B. Assembly Date Code (last two digits of year followed by 2-digit work week)
- C. Product Identification (Part #/Package Type)
- D. Lot Identification Code

PI-7802-111915

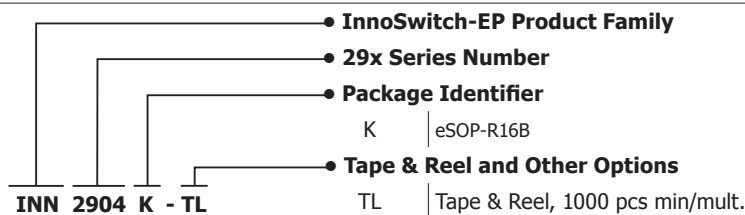
**MSL Table**

Part Number	MSL Rating
INN2904	3

**ESD and Latch-Up Table**

Test	Conditions	Results
Latch-up at 125 °C	JESD78D	> ±100 mA or > 1.5 V (max) on all pins
Human Body Model ESD	ANSI/ESDA/JEDEC JS-001-2014	> ±2000 V on all pins
Machine Model ESD	JESD22-A115C	> ±200 V on all pins

**Part Ordering Information**



Revision	Notes	Date
A	Preliminary.	12/15

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