International
IOR Rectifier

Patent Pending
Advanced Information* (January, 2000)

IR2167

PFC BALLAST CONTROL IC

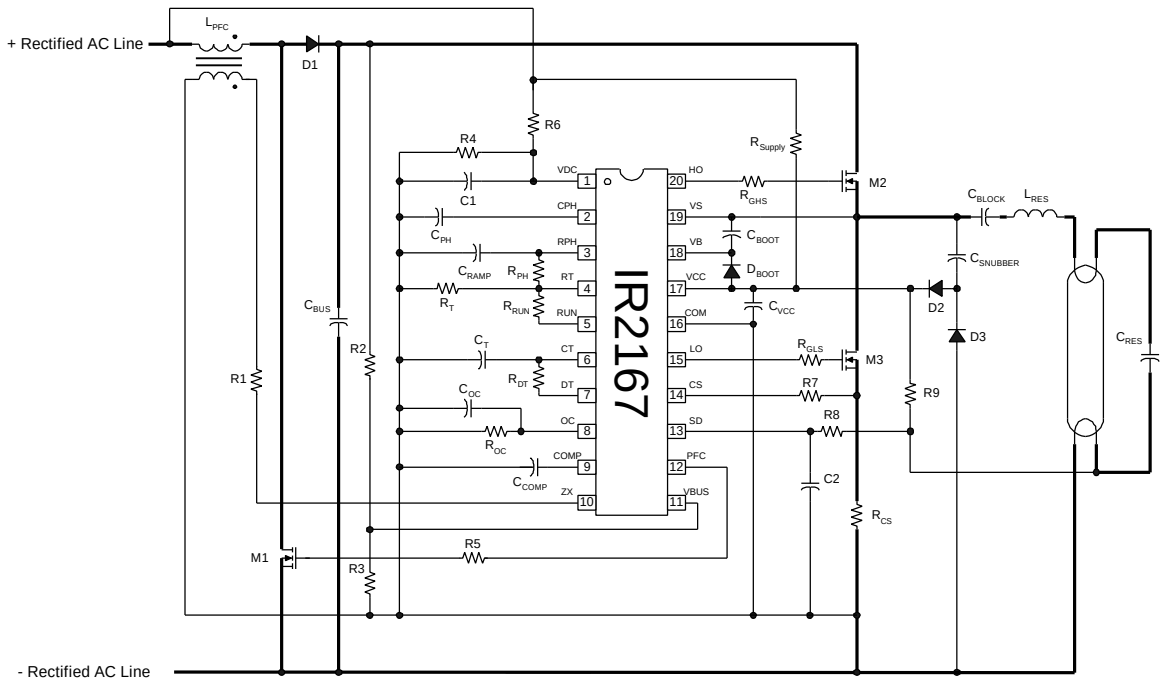
Description

The IR2167 is a fully integrated, fully protected 600V ballast control IC designed to drive virtually all types of rapid start fluorescent lamp ballasts. PFC circuitry provides for high PF, low THD and DC Bus regulation. Externally programmable features such as preheat time & frequency, ignition ramp characteristics, and running mode operating frequency provide a high degree of flexibility for the ballast design engineer. Comprehensive protection features such as protection from failure of a lamp to strike, filament failures, low AC line conditions, thermal overload, or lamp failure during normal operation, as well as an automatic restart function, have been included in the design. The heart of this control IC is a variable frequency oscillator with externally programmmable deadtime. Precise control of a 50% duty cycle is accomplished using a T-flip-flop. The IR2167 is available in both 20 pin DIP and 20 pin wide body SOIC packages.

Features

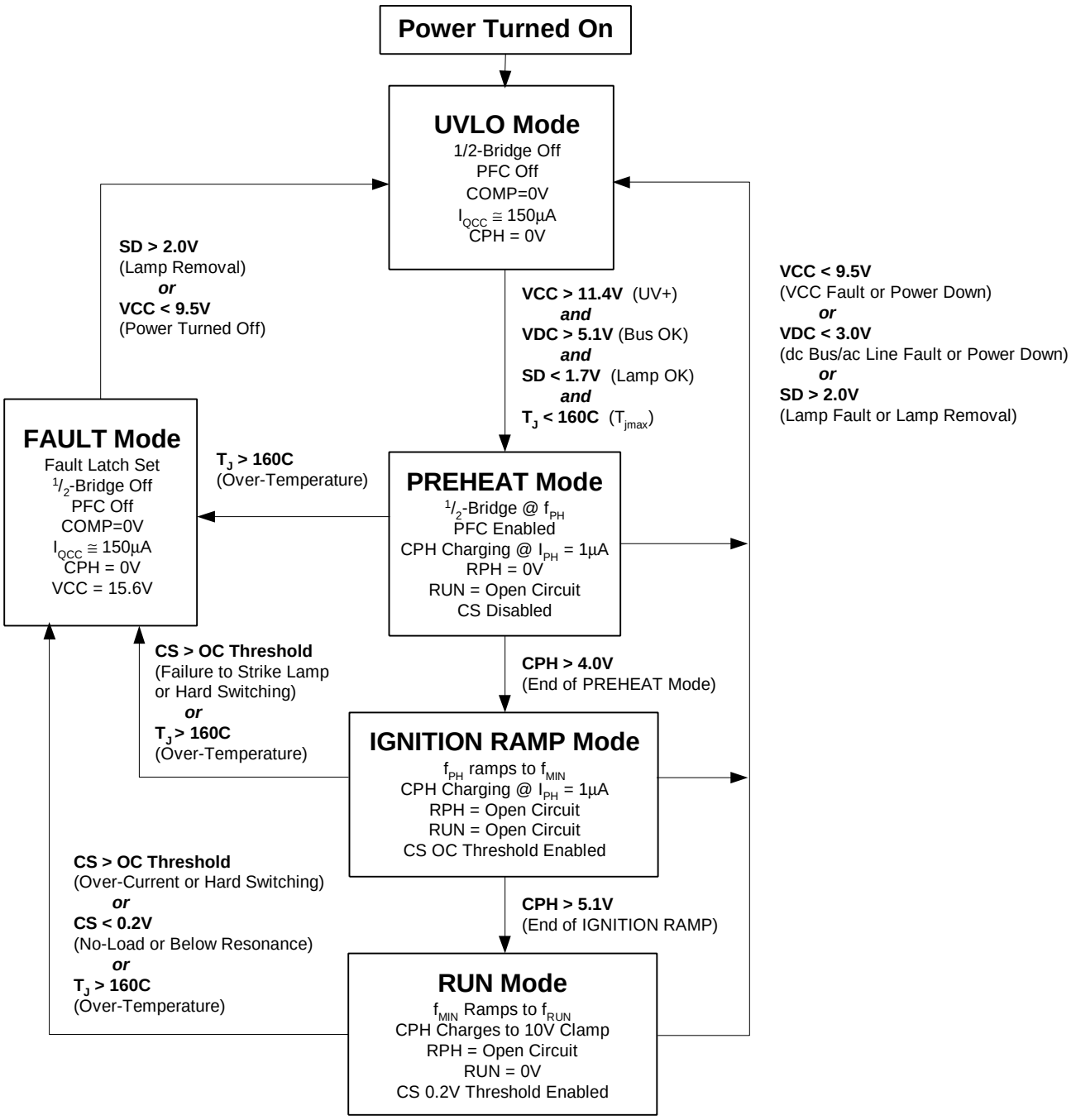
- PFC, Ballast Control and Half Bridge Driver in One IC
- Critical Conduction Mode Boost Type PFC
- No PFC Current Sense Resistor Required
- Programmable Preheat Time & Frequency
- Programmable Ignition Ramp
- Programmable Over-Current
- Lamp Filament Sensing & Protection
- Capacitive Mode Protection
- Brown-Out Protection
- Automatic Restart for Lamp Exchange
- Thermal Overload Protection
- Programmable Deadtime
- Internal 15.6V Zener Clamp Diode on V_{CC}
- Micropower Startup (150μA)
- Latch Immunity and ESD Protection

Typical Application Diagram

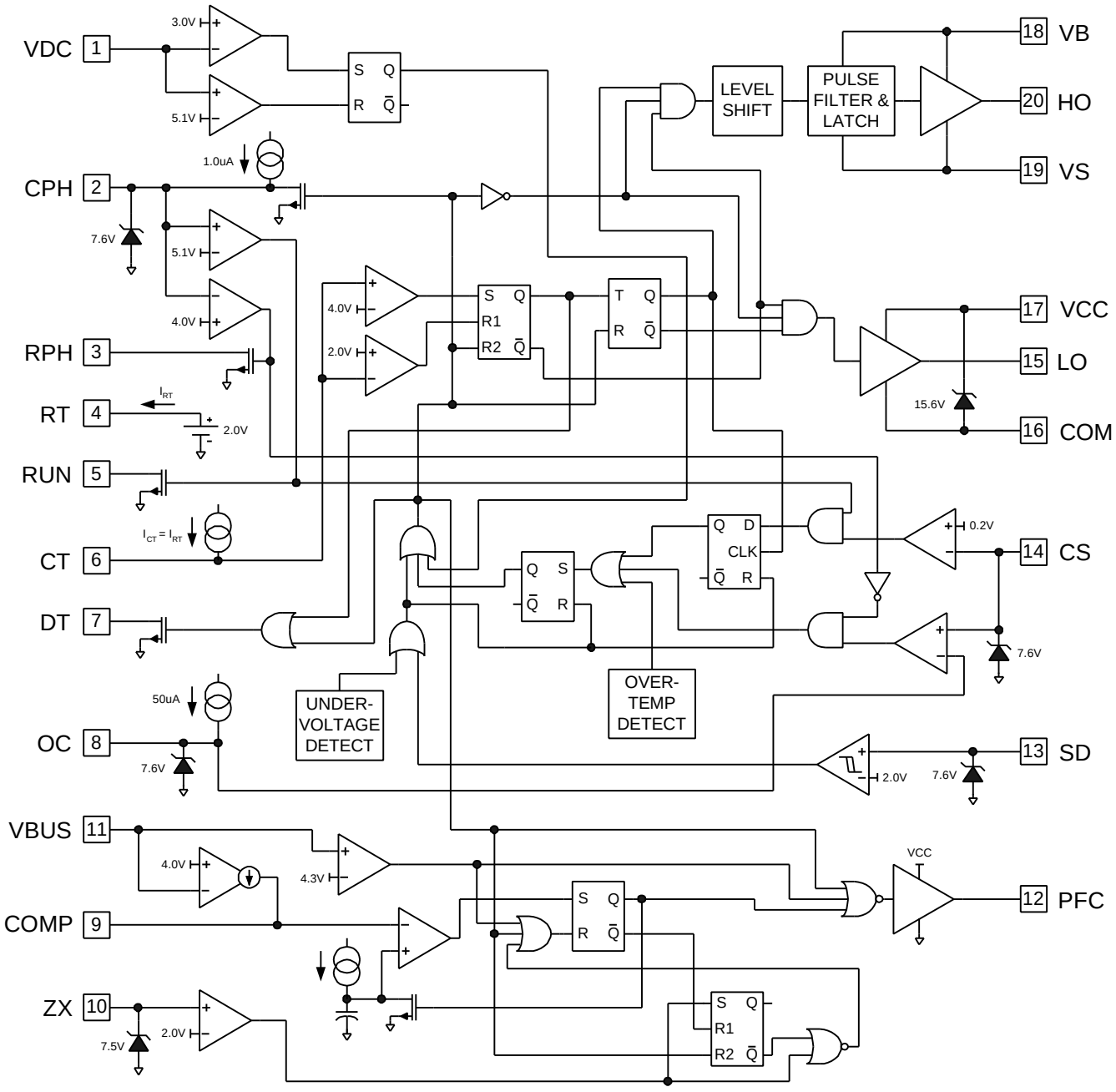


**** Please note that this datasheet contains advanced information which could change before the product is released to production.***

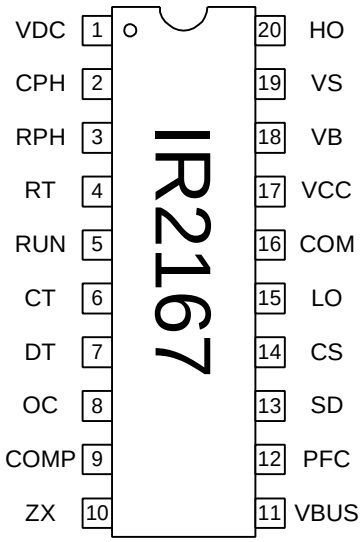
IR2167 State Diagram



IR2167 Block Diagram



Pin Assignments



Pin #	Symbol	Description
1	VDC	DC Bus Sensing Input
2	CPH	Preheat Timing Capacitor
3	RPH	Preheat Frequency Resistor & Ignition Capacitor
4	RT	Oscillator Timing Resistor
5	RUN	Run Frequency Resistor
6	CT	Oscillator Timing Capacitor
7	DT	Deadtime Programming
8	OC	Over-current (CS+) Threshold Programming
9	COMP	Error Amplifier Compensation
10	ZX	Zero-Crossing, PFC Inductor
11	VBUS	Bus Voltage Sense Input
12	PFC	PFC Gate Driver Output
13	SD	Shutdown Input
14	CS	Current Sensing Input
15	LO	Low-Side Gate Driver Output
16	COM	IC Power & Signal Ground
17	VCC	Logic & Low-Side Gate Driver Supply
18	VB	High-Side Gate Driver Floating Supply
19	VS	High Voltage Floating Return
20	HO	High-Side Gate Driver Output

Absolute Maximum Ratings

Absolute Maximum Ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are absolute voltages referenced to COM, all currents are defined positive into any lead. The Thermal Resistance and Power Dissipation ratings are measured under board mounted and still air conditions.

Parameter				
Symbol	Definition	Min.	Max.	Units
V_B	High Side Floating Supply Voltage	-0.3	625	V
V_S	High Side Floating Supply Offset Voltage	V_B - 25	V_B + 0.3	V
V_{HO}	High-Side Floating Output Voltage	V_S - 0.3	V_B + 0.3	V
V_{LO}	Low-Side Output Voltage	-0.3	V_{CC} + 0.3	V
V_{PFC}	PFC Gate Driver Output Voltage	-0.3	Vcc + 0.3	V
I_{OMAX}	Maximum Allowable Output Current (HO, LO, PFC) Due to External Power Transistor Miller Effect	-500	500	mA
I_{RT}	R_T Pin Current	-5	5	mA
V_{CT}	C_T Pin Voltage	-0.3	6.5	V
V_{DC}	VDC Pin Voltage	-0.3	V_{cc} + 0.3	V
I_{CPH}	CPH Pin Current	-5	5	mA
I_{RPH}	RPH Pin Current	-5	5	mA
I_{RUN}	RUN Pin Current	-5	5	mA
I_{DT}	Deadtime Pin Current	-5	5	mA
V_{CS}	Current Sense Pin Voltage	-0.3	6.5	V
I_{CS}	Current Sense Pin Current	-5	5	mA
I_{OC}	Over-Current Threshold Pin Current	-5	5	mA
I_{SD}	Shutdown Pin Current	-5	5	mA
V_{BUS}	DC Bus Sensing Input Voltage	-0.3	Vcc	V
I_{ZX}	PFC Inductor Current, Zero Crossing Detection Input	-5	5	mA

Absolute Maximum Ratings (Continued)

Absolute Maximum Ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are absolute voltages referenced to COM, all currents are defined positive into any lead. The Thermal Resistance and Power Dissipation ratings are measured under board mounted and still air conditions.

Parameter		Min.	Max.	Units
Symbol	Definition			
I_{COMP}	PFC Error Amplifier Compensation Current	-5	5	mA
I_{CC}	Supply Current (Note 1)	-20	20	mA
dV/dt	Allowable Offset Voltage Slew Rate	-50	50	V/ns
P_D	Package Power Dissipation @ $T_A \leq +25^oC$ (20-Pin DIP)	---	1.50	W
P_D	Package Power Dissipation @ $T_A \leq +25^oC$ (20-Pin SOIC)	---	1.25	W
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient (20-Pin	---	85	$^oC/W$
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient (20-Pin	---	90	$^oC/W$
T_J	Junction Temperature	-55	150	^oC
T_S	Storage Temperature	-55	150	
T_L	Lead Temperature (Soldering, 10 seconds)	---	300	

Note 1: This IC contains a zener clamp structure between the chip V_{CC} and COM which has a nominal breakdown voltage of 15.6V. Please note that the Vcc pin should not be driven by a DC, low impedance voltage source greater than the V_{CLAMP} specified in the Electrical Characteristics section.

Recommended Operating Conditions

For proper operation the device should be used within the recommended conditions. All voltage parameters are absolute voltages referenced to COM, all currents are defined positive into any lead.

Parameter		Min.	Max.	Units
Symbol	Definition			
V_{BS}	High Side Floating Supply Voltage	V_{CC} - 0.7	V_{CLAMP}	V
V_S	Steady State High Side Floating Supply Offset Voltage	-3.0	600	V
V_{CC}	Supply Voltage	V_{CCUV+}	V_{CLAMP}	V
I_{CC}	Supply Current	Note 2	10	mA
V_{DC}	VDC Pin Voltage	0	V_{CC}	V
C_T	CT Pin Capacitance	220	---	pF
R_{DT}	Deadtime Resistance	1.0	---	kΩ
I_{RT}	R_T Pin Current (Note 3)	-500	-50	µA
I_{RPH}	RPH Pin Current (Note 3)	0	450	µA
I_{RUN}	RUN Pin Current (Note 3)	0	450	µA
I_{SD}	Shutdown Pin Current	-1	1	mA
I_{CS}	Current Sense Pin Current	-1	1	mA
I_{ZX}	Zero Crossing Detection Pin Current	-1	1	mA
T_J	Junction Temperature	-40	125	^oC

Note 2: Sufficient current should be supplied to the VCC pin to keep the internal 15.6V zener clamp diode on this pin regulating its voltage.

Note 3: Due to the fact that the RT pin is a voltage-controlled current source, the total RT pin current is the sum of all of the parallel current sources connected to that pin. For optimum oscillator current mirror performance, this total current should be kept between 50µA and 500µA. During the preheat mode, the total current flowing out of the RT pin consists of the RPH pin current plus the current due to the RT resistor. During the run mode, the total RT pin current consists of the RUN pin current plus the the current due to the RT resistor.

Electrical Characteristics

V_{CC} = V_{BS} = V_{BIAS} = 14V +/- 0.25V, R_T = 40.0 kΩ, C_T = 470 pF, RPH and RUN pins no connection, V_{CPH} = 0.0 V, R_{DT} = 6.1 kΩ, R_{OC} = 20.0 kΩ, V_{CS} = 0.5 V, V_{SD} = 0.0 V, C_L = 1000pF unless otherwise specified.

Parameter		T_A = 25ºC				
Symbol	**Definition**	**Min**	**Typ**	**Max**	**Units**	**Test Conditions**
Supply Characteristics						
V_{CCUV+}	V_{CC} Supply Undervoltage Positive Going Threshold	---	11.4	---		V_{CC} rising from 0V
V_{UVHYS}	V_{CC} Supply Undervoltage Lockout Hysteresis	---	1.8	---		
I_{QCCUV}	UVLO Mode Quiescent Current	---	150	---	µA	V_{CC} < V_{CCUV-}
I_{QCCFLT}	Fault-Mode Quiescent Current	---	200	---	µA	SD = 5V, CS = 2V, or Tj > T_{SD}
I_{QCC}	Quiescent VCC Supply Current	---	3.8	---	mA	RT no connection, CT connected to
I_{QCC50k}	VCC Supply Current, f = 50kHz	---	4.5	---	mA	R_T=36K ohm, R_{DT}= 5.6K ohm, C_T=220pF
V_{CLAMP}	V_{CC} Zener Clamp Voltage	---	15.6	---	V	I_{CC} = 10mA
Floating Supply Characteristics						
I_{QBS0}	Quiescent V_{BS} Supply Current	---	0	---	µA	V_{HO} = V_S
I_{QBS1}	Quiescent V_{BS} Supply Current	---	30	---		V_{HO} = V_B
V_{BSMIN}	Minimum required V_{BS} Voltage for proper HO functionality	---	4	5	V	
I_{LK}	Offset Supply Leakage Current	---	---	50	µA	V_B = V_S = 600V
PFC Error Amplifier Characteristics						
V_{VBUS}	VBUS Sense Input Threshold	---	4.0	---	V	
I_{VBUS}	VBUS Sense Input Bias Current	---	---	0.1	µA	
gm	Error Amplifier Transconductance	---	100	---	µmho	
I_{SOURCE}	Error Amplifier Output Current Sourcing	---	60	---	µA	V_{VBUS} = 3.2V
I_{SINK}	Error Amplifier Output Current Sinking	---	60	---	µA	V_{VBUS} = 4.8V
$V_{OH(EA)}$	Error Amplifier Output Voltage Swing (High State)	---	10	---	V	V_{VBUS} = 3.2V
$V_{OL(EA)}$	Error Amplifier Output Voltage Swing (Low State)	---	1	---	V	V_{VBUS} = 4.8V
PFC Overvoltage Comparator						
V_{OV}	Overvoltage Comparator Threshold	---	4.3	---	V	
PFC Zero Current Detector						
V_{ZX}	ZX Pin Comparator Threshold Voltage	---	2.0	---	V	
V_{ZXhys}	ZX Pin Comparator Hysterisis	---	120	---	mV	
$V_{ZXclamp+}$	ZX Pin Clamp Voltage (High State)	---	7.5	---	V	I_{ZX} = 2mA

Electrical Characteristics (Continued)

V_{CC} = V_{BS} = V_{BIAS} = 14V +/- 0.25V, R_T = 40.0 kΩ, C_T = 470 pF, RPH and RUN pins no connection, V_{CPH} = 0.0 V, R_{DT} = 6.1 kΩ, R_{OC} = 20.0 kΩ, V_{CS} = 0.5 V, V_{SD} = 0.0 V, C_L = 1000pF unless otherwise specified.

Parameter		T_A = 25ºC				
Symbol	**Definition**	**Min**	**Typ**	**Max**	**Units**	**Test Conditions**
Oscillator, Ballast Control, I/O Characteristics						
f_{OSC}	Oscillator Frequency	---	30	---	kHz	R_T = 32 kΩ, R_{DT} = 6.1kΩ, C_T = 470 pF
		---	100	---		R_T = 6.1 kΩ, R_{DT} = 6.1kΩ, C_T = 470 pF
df/dV	Oscillator Frequency Voltage Stability	---	0.5	---	%/V	V_{CCUV+} < VCC < 15V
df/dT	Oscillator Frequency Temperature Stability	---	0.02	---	%/C	-40°C < Tj < 125°C
d	Oscillator Duty Cycle		50		%	
V_{CT+}	Upper C_T Ramp Voltage Threshold	---	4.0	---	V	
V_{CT-}	Lower C_T Ramp Voltage Threshold	---	2.0	---		
V_{CTFLT}	Fault-Mode C_T Pin Voltage	---	0	---	mV	SD = 5V, CS = 2V, or Tj > T_{SD}
V_{RT}	RT Pin Voltage	---	2.0	---	V	
V_{RTFLT}	Fault-Mode R_T Pin Voltage	---	0	---	mV	SD = 5V, CS = 2V, or Tj > T_{SD}
tdlo	LO Output Deadtime	---	2.0	---	µsec	
tdho	HO Output Deadtime	---	2.0	---	µsec	
dtd/dV	Deadtime Voltage Stability		0.5		%/V	V_{CCUV+} < V_{CC} < 15V
dtd/dT	Deadtime Temperature Stability		0.02		%/C	-40°C < Tj < 125°C
Preheat Characteristics						
I_{CPH}	CPH Pin Charging Current	---	1.0	---	µA	V_{CPH} = 0V
V_{CPHIGN}	CPH Pin Ignition Mode Threshold Voltage	---	4.0	---		
V_{CPHRUN}	CPH Pin Run Mode Threshold Voltage	---	5.15	---	V	
V_{CPHCLM}	CPH Pin Clamp Voltage		10			I_{CPH} = 1µA
V_{CPHFLT}	Fault-Mode CPH Pin Voltage	---	0	---	mV	SD = 5V, CS = 2V, or Tj > T_{SD}
RPH Characteristics						
I_{RPHLK}	Open Circuit RPH Pin Leakage Current	---	0.1	---	µA	V_{RPH} = 5V, V_{PH} = 6V
V_{RPHFLT}	Fault-Mode RPH Pin Voltage	---	0	---	mV	SD = 5V, CS = 2V, or Tj > T_{SD}
RUN Characteristics						
I_{RUNLK}	Open Circuit RUN Pin Leakage Current	---	0.1	---	µA	V_{RUN}=5V
V_{RUNFLT}	Fault-Mode RUN Pin Voltage	---	0	---	mV	SD = 5V, CS = 2V, or Tj > T_{SD}

Electrical Characteristics (Continued)

V_{CC} = V_{BS} = V_{BIAS} = 14V +/- 0.25V, R_T = 40.0 kΩ, C_T = 470 pF, RPH and RUN pins no connection, V_{CPH} = 0.0 V, R_{DT} = 6.1 kΩ, R_{OC} = 20.0 kΩ, V_{CS} = 0.5 V, V_{SD} = 0.0 V, C_L = 1000pF unless otherwise specified.

Parameter		T_A = 25ºC				
Symbol	**Definition**	**Min**	**Typ**	**Max**	**Units**	**Test Conditions**
Protection Circuitry Characteristics						
V_{SDTH+}	Rising Shutdown Pin Threshold Voltage	---	2.0	---	V	
V_{SDHYS}	Shutdown Pin Threshold Hysteresis		150		mV	
V_{CSTH_+}	Over-Current Sense Threshold Voltage	---	1.0	---	V	
V_{CSTH-}	Under-Current Sense Threshold Voltage	---	0.2	---	V	
t_{cs}	Over-Current Sense Propogation Delay	---	160	---	nsec	Delay from CS to LO
V_{DC+}	Low V_{BUS}/Rectified Line Input Upper Threshold	---	5.15	---	V	
V_{DC-}	Low V_{BUS}/Rectified Line Input Lower Threshold	---	3.0	---	V	
T_{SD}	Thermal Shutdown Junction Temperature	---	160	---	ºC	Note 4
Gate Driver Output Characteristics						
V_{OL}	Low-Level Output Voltage		0	100	mV	I_O = 0
V_{OH}	High-Level Output Voltage		0	100		V_{BIAS} - V_O , I_O = 0
t_r	Turn-On Rise Time		85	150	nsec	
t_f	Turn-Off Fall Time		45	100		

Note 4: When the IC senses an overtemperature condition (T_j > 160ºC), the IC is latched off. In order to reset this Fault Latch, the SD pin must be cycled high and then low, or the VCC supply to the IC must be cycled below the falling undervoltage lockout threshold (V_{CCUV-}).

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Data and specifications subject to change without notice.

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