MP1015

Full System Precision CCFL Driver

Monolithic Power Systems

General Description

The MP1015 is a Power IC that offers a true complete solution for driving a Cold Cathode Fluorescent Lamps (CCFL). This Power IC converts unregulated DC voltage to a nearly pure sine wave required to ignite and operate the CCFL. Based on proprietary power topology and control techniques (patented), it greatly increases the power conversion efficiency. The MP1015 can be used with **analog** or **burst mode** dimming without any additional external components. The MP1015 offers four distinct performance advantages:

1. More light for less power
2. Smallest board implementation possible
3. Low EMI emission
4. Low cost off the shelf components

Features

- Built-in Burst Mode Oscillator and Modulator
- Built-in Analog and Burst Mode Dimming
- Built-in Current and Voltage Feedback Control
- Built-in Open/Short Lamp Protection
- Built-in Dual Mode Fault Timer
- Built-in Soft-on/Soft-off Burst Mode
- Automatic Recovery from ESD Event
- Wide Range 6 to 22V Battery Voltage with Regulated Lamp Current
- Startup at all voltages and temp without additional components
- Integrated 0.10Ω Power Switches
- Output Short Circuit Protected
- No High Voltage Ballast Capacitor
- **Evaluation Board Available**

Ordering Information

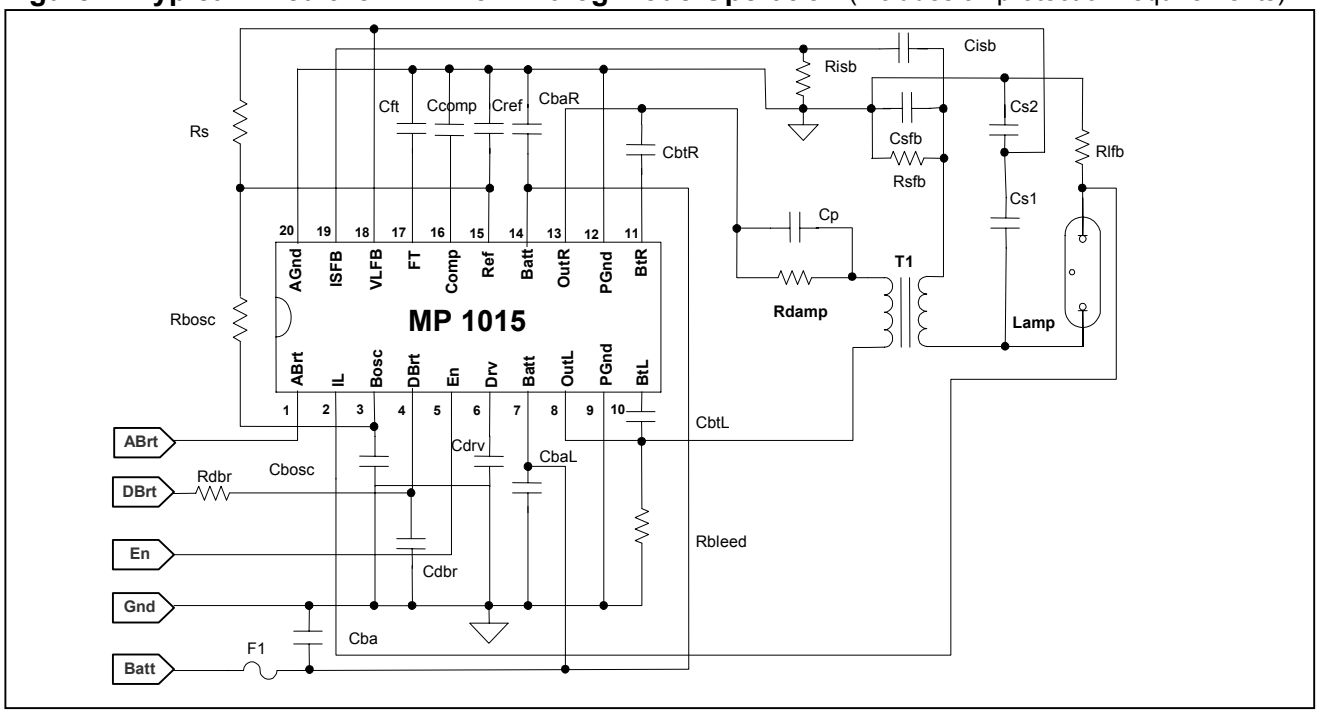
Part Number*	Package	Temperature
MP1015EM	TSSOP20	-20°C to +85°C
MP1015EF	TSSOP20F	-20°C to +85°C
EV0001	MP1015EM Evaluation Board	

* For Tape & Reel use suffix - Z (e.g. MP1015EM-Z)

Applications

- LCD Backlight inverter for notebook computers, Web Pads, GPS, or desktop display

Figure 1: Typical Circuit for PWM or Analog Mode Operation (includes all protection requirements)



Absolute Maximum Ratings

Input Voltage (V_{Batt})	25V
IL, ISFB Input Voltages (V_{IL}, V_{ISFB})	+/-6V
VLFB Input Voltage (V_{VLFB})	-0.3 to 12V
Logic Input Voltages	-0.3 to 6.8V
Power Dissipation	1.0W
Operating Frequency	150KHz
Junction Temperature	150°C
Lead Temperature (Solder)	260°C
Storage Temperature	–55°C to 150°C

Recommended Operating Conditions

Input Voltage (V_{Batt})	6 to 22V
Analog Brightness Voltage (V_{ABrt})	0 to 1.9V
Digital Brightness Voltage (V_{DBrt})	0 to 1.8V
Enable (V_{En})	0 to 5V
Operating Frequency (Typical)	60KHz
Ambient Operating Temperature	-20°C to +85°C

Thermal Characteristics

Thermal resistance θ_{JA} (TSSOP)	140°C/W
Thermal resistance θ_{JA} (TSSOPF)	110°C/W

Electrical Characteristics (Unless otherwise specified V_{Batt}=12V, T_A=25°C)

Parameters	Symbol	Condition	Min	Typ	Max	Units
Reference Voltage						
Output Voltage	V_{Ref}	I_{Ref} = 3mA	4.75	5.0	5.25	V
Reference Current	I_{Ref}				3.0	mA
Line Regulation		6.5V < V_{Batt}< 22V			30	mV
Load Regulation		0 < I_{Ref}< 3.0mA			30	mV
Battery Supply						
Supply Current (disabled)	I_{Batt}				10	µA
Supply Current (enabled)	I_{Batt}	6.0V < V_{Batt}< 22V		1.6	2.5	mA
Shutdown Logic						
Fault Timer Threshold	$V_{(TH)FT}$		1.1	1.2	1.3	V
Fault Timer Sink Current		V_{VLFB}>0, V_{ISFB}<1.2V		1		µA
Fault Timer Source Current						
Open Lamp		V_{VLFB}<0, V_{ISFB}<1.2V		1		µA
Secondary Overload		V_{ISFB}>1.2V		120		µA
Enable Voltage Low	$V_{(L)En}$				0.5	V
Enable Voltage High	$V_{(H)En}$		2.0			V
Output Drivers						
Switch On Resistance	$R_{(ON)OutL,OutR}$	**(Note 1)**	0.085	0.12	0.15	Ω
Short Circuit Current	I_{SC}			4		A
Ton(min)		V_{Comp}=0V, V_{Batt}=22V		435	550	ns
Ton(min)		V_{Comp}=0V, V_{Batt}=6V		1750	2100	ns
Brightness Control						
Sense full Brightness	V_{IL}	V_{ABrt}= 2.0V	360	379	400	mV
Sense full Dim	V_{IL}	V_{ABrt}= 0V	105	117	130	mV
Lamp Current regulation		7V < V_{Batt}< 22V		2	5	%
Burst Oscillator Sink Current	I_{Bosc}			380		µA
Burst Oscillator Peak Voltage	V_{Bosc}		1.7	1.8	1.9	V
Digital Brightness Offset Voltage	$V_{(OS)\ DBrt}$		-50	5	50	mV
Fault Loop Control						
Open Lamp Threshold	$V_{(TH)VLFB}$			0		V
Secondary Current Threshold	$V_{(TH)ISFB}$			1.2		V
Fault Mode Comp Current	I_{Comp}	V_{VLFB}<0V, V_{ISFB}>1.2V		475		µA

Note 1: This parameter is guaranteed by design.

Pin Description

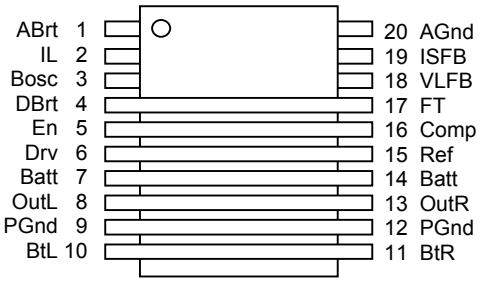
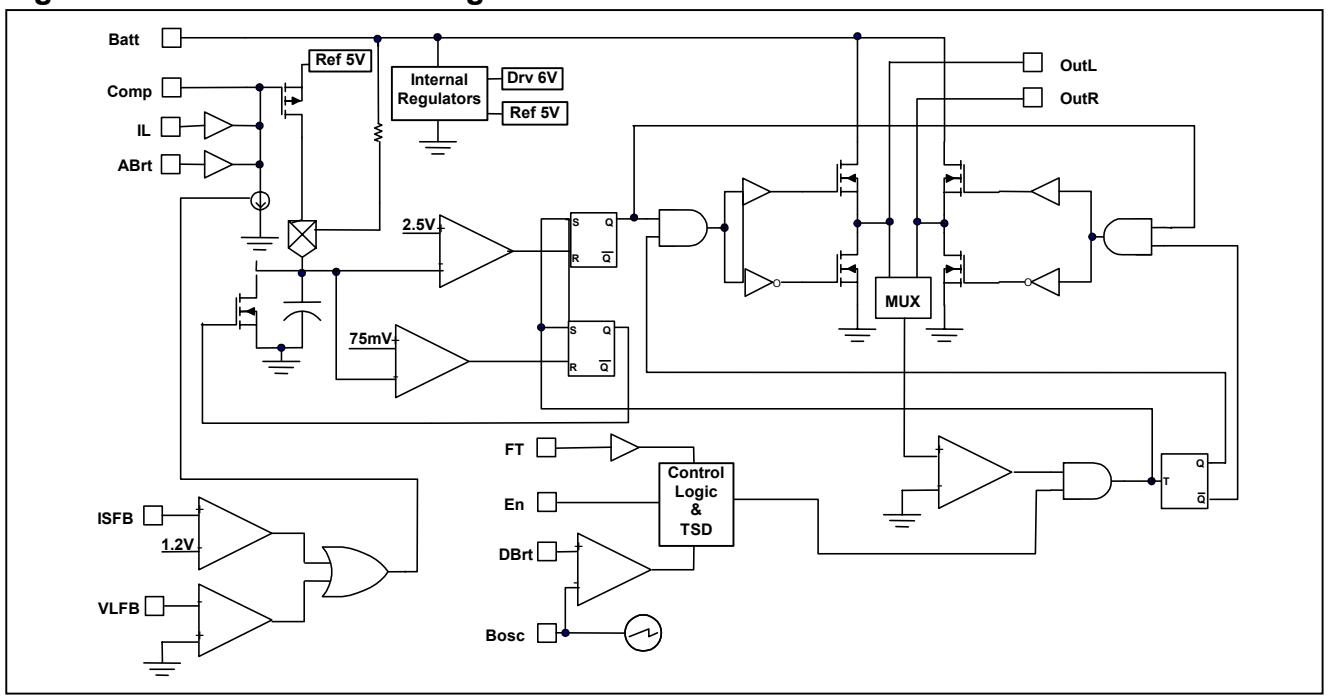


Table 1: Pin Designators

Pin Number	Pin Name	Pin Function
1	ABrt	Analog Dimming
2	IL	Lamp Current Feedback Sense Input
3	Bosc	Burst Oscillator Timing
4	DBrt	Burst Mode Dimming
5	En	Chip Enable. ***Do not float this pin.***
6	Drv	Internally Generated MOSFET Gate Drive Supply Voltage (6V)
7	Batt	Power Supply Input
8	OutL	Output to Load (tank circuit)
9	PGnd	Power Ground
10	BtL	Regulated Output Voltage for Bootstrap Capacitor on Phase L
11	BtR	Regulated Output Voltage for Bootstrap Capacitor on Phase R
12	PGnd	Power Ground
13	OutR	Output to Load (tank circuit)
14	Batt	Power Supply Input
15	Ref	Internally Generated Reference Voltage Output (5V)
16	Comp	Loop Compensation Capacitor
17	FT	Fault Timer
18	VLFB	Open Lamp Detect (Lamp Voltage Feedback.)
19	ISFB	Shorted Lamp Detect (Secondary Current Feedback)
20	AGnd	Small Signal Ground (Note 1)

Note 1: For the MP1015EF, connect the exposed paddle to AGND (Pin 20).

Figure 2: Functional Block Diagram



Feature Description

Brightness Control

The MP1015 can operate in three modes: Analog Mode, Burst Mode with a DC input, or Burst Mode with an external PWM. The three modes are dependent on the pin connections as per Table 1. Choosing the required burst repetition frequency can be achieved by an RC combination, as defined in component selection. The MP1015 has a soft on and soft off feature to reduce noise, when using burst mode dimming.

Table 2: Function Mode

Function	Pin Connection		
	Pin 1	Pin 4	Pin 3
	ABrt	DBrt	Bosc
Analog Mode	0 – 1.9V	V_{Ref}	AGnd
Burst Mode with DC input voltage	V_{Ref}	0 – 1.8V	Rbosc Cbosc
Burst Mode from external source	V_{Ref}	PWM	1.5V

Brightness Polarity:

Burst: 100% duty cycle is at 1.8V
Analog: 1.9V is maximum brightness

Fault Protection

Open Lamp: The VLFB pin (#18) is used to detect whether an open lamp condition has occurred. During normal operation the VLFB pin is typically at 5V DC with an AC swing of +/- 2V. If an open lamp condition exists then the AC voltage on the VLFB line will swing below zero volts. When that occurs, the IC regulates the VLFB voltage to 10V p-p and a 1µA current source will inject into the FT pin. If the voltage at the FT pin exceeds 1.2V, then the chip will shut down.

Excessive Secondary Current (Shorted Lamp and UL safety specs): The ISFB pin (#19) is used to detect whether excessive secondary current has occurred. During normal operation the ISFB voltage is a 1V p-p AC signal centered at zero volts D.C. If a fault condition occurs that increases the secondary current, then the voltage at ISFB will be greater than 1.2V. When that occurs, the IC regulates the ISFB voltage to 2.4V p-p and a 120µA current source will inject into the FT pin. If the voltage at the FT pin exceeds 1.2V, then the chip will shut down.

Feature Description (continued)

Fault Timer: The timing for the fault timer will depend on the sourcing current, as described above, and the capacitor on the FT pin. The user can program the time for the voltage to rise before the chip detects a "real" fault. When a fault is triggered, then the internal drive voltage (V_{Drv}) will collapse from 6.2V to 0V. The reference voltage will stay high at 5.0V.

Lamp Startup

The strike voltage of the lamp will always be guaranteed at any temperature because the MP1015 uses a resonant topology for switching the outputs. The device will continue to switch at the resonant frequency of the tank until the strike voltage is achieved. This eliminates the need for external ramp timing circuits to ensure startup.

Chip Enable

The chip has an on / off function, which is controlled by the En pin (#5). The enable signal goes directly to a Schmitt trigger. The chip will turn ON with an En = High and OFF with an En = Low.

Application Information

Pin 19 (ISFB) : Rsfb, Csfb , Risb and Cisb
(Secondary Short Protection)

The Rsfb and Csfb combination is used for feedback to the IS pin to detect excessive secondary current. *These resistors have to be +/- 5% tolerance components*. The value for Rsfb is approximately 1.7KΩ and Csfb is approximately 82nF. This will ensure that the voltage at the ISFB pin is typically 1.0V during steady state operation. The maximum value for Csfb is 93nF to ensure that the chip will meet the UL1950 specification. Risb and Cisb components are used as a high pass filter.

Pin 18 (VLFB): Cs1, Cs2 and Rs
(Open Lamp protection)

The regulated open lamp voltage is proportional to the Cs1 and Cs2 ratio. Cs1 has to be rated at 3KV and is typically between 5 to 22pF. The value of Cs1 is typically 15pF and is chosen for a specified maximum frequency. The value of Cs2 is set by the Customer to achieve the required open lamp voltage detection value, typically 4nF.

$$Cs2=Cs1 * V(max)rms/ 3.5Vrms)$$

The value of Rs is typically 300KΩ (not critical).

Pin 17 (FT): Cft

The Cft cap is used to set the fault timer. This capacitor will determine when the chip will reach the fault threshold value. The user can choose the cap value to set the time out value.

Open Lamp Time

$$Cft\ (nF) = T(open\ lamp)\ (1\mu A)/\ 1.2\ V$$

For a Cft= 820nF, then the time out for open lamp will be 0.98 sec.

Secondary Short Turn Off time

Because the sourcing current for a secondary short is approx. 120µA, then the off time when a resistive short occurs across the lamp will be approx 100 times faster than the open lamp time.

To reduce the turn off time even further, then by modifying the connection at the FT node to:

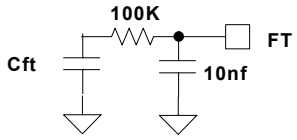


Figure 3: Turn Off Time Adjustment

For a Cap=10nF, then the time out for secondary short will be 0.11ms. The turn off time for the secondary short will be reduced by an additional 100 times.

Note: The open lamp time will remain the same value as defined by Cft.

Pin 16 (Comp): Ccomp

This cap is the system compensation cap that connects between comp and AGnd. A 1.5nf or 2.2nF cap is recommended. This cap should be X7R ceramic with a voltage rating sufficient for 5V biasing. The value of Ccomp affects the soft-on rise time and soft-off fall time.

Application Information (Continued)

Pin 15 (Cref):

Cref is the bypass cap for the internal 5.0V supply. This capacitor must be placed as close as possible to the pin. A maximum of 100 mils is recommended between the cap and the IC. The value of the cap is typically 0.47µF

Pin 14, Pin 7 & Pin 9 (Batt & PGnd): CbaR/L, Cba

These caps are used as the bypass caps for the battery voltage supply line. These capacitors will absorb most of the input switching current of the inverter and will require adequate ripple rating. The typical current rating for Cba is > 500mArms. Typically CbaR and CbaL are 1µF and Cba is equal to 2 caps of 2.2µF.

Pin 13 & Pin 8 (OutL & OutR): Cp1, Rdamp, Rbleed

The primary transformer current flows through this capacitor. Its value is typically 1µF and its voltage rating is sufficient for a 5V bias. The capacitor should be ceramic and have a ripple current rating greater than the primary current (typically 0.8Arms). It is more optimal to use two parallel 0.47µF ceramic caps for minimal ESR losses.

Rdamp and Rbleed are used to ensure that the bridge outputs are at 0V prior to startup. Typically Rbleed = 4.3KΩ and Rdamp = 1KΩ.

Pin 11 and Pin 10 (BtL and BtR): Cbtl and Cbtr

These are the reservoir caps for the upper switches' gate drive. They should be 10nF and made of X7R ceramic material and have a voltage rating for 6.6V
biasing.

Pin 6 (Drv): Cdrv

This bypasses the 6.2V gate supply for the lower switches. The value should be 100nF ceramic Y5V or X7R material.

Pin 5: (En)

This pin will enable and disable the chip. Do not float this pin.

Pin 4 (DBrt) : Rdbr, Cdbr

This pin is used for burst brightness control. The DC voltage on this pin will control the burst percentage on the output. The signal is filtered for optimal operation. The active range is approximately 0.1V to 1.8V. The value of Rdbr and Cdbr is not critical.

Pin 3 (Bosc): Cbosc, Rbosc

The Cbosc and Rbosc will set the burst repetition rate and the minimum Ton. Set T_{min} to achieve the minimum required system brightness. Ensure that T_{min} is long enough that the lamp does not extinguish. These values are determined by the following steps:

1) Select a Minimum Duty Cycle (D_{MIN}). This is the ratio T_{FALL} / (T_{FALL} + T_{RISE}) for the burst oscillator. For example: 10%

2) Determine Rbosc by the formula:

$$Rbosc = \frac{\left[\frac{1.68 * [(1 / D_{MIN}) - 1]}{0.42}\right] + 4}{350 * 10^{-6}}$$

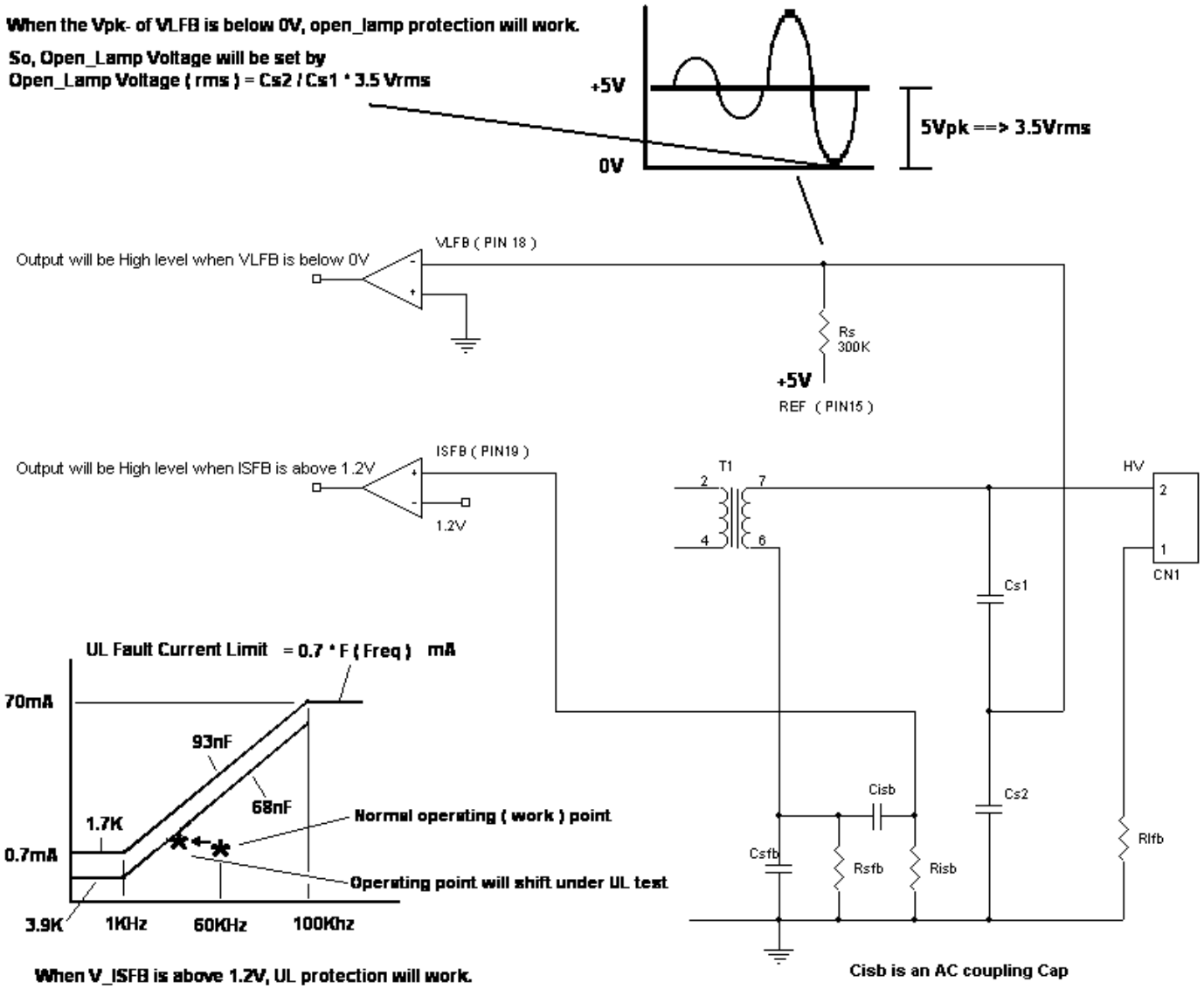
3) Select a burst frequency and find T_{TOTAL} where T_{TOTAL} = 1/burst frequency. Then determine Cbosc by the formula:

$$Cbosc = \frac{(1-D_{MIN})}{0.42 * Rbosc * f_{bosc}}$$

Where:

f_{bosc}= burst frequency rate in Hz
T_{min}= Minimum burst time in sec

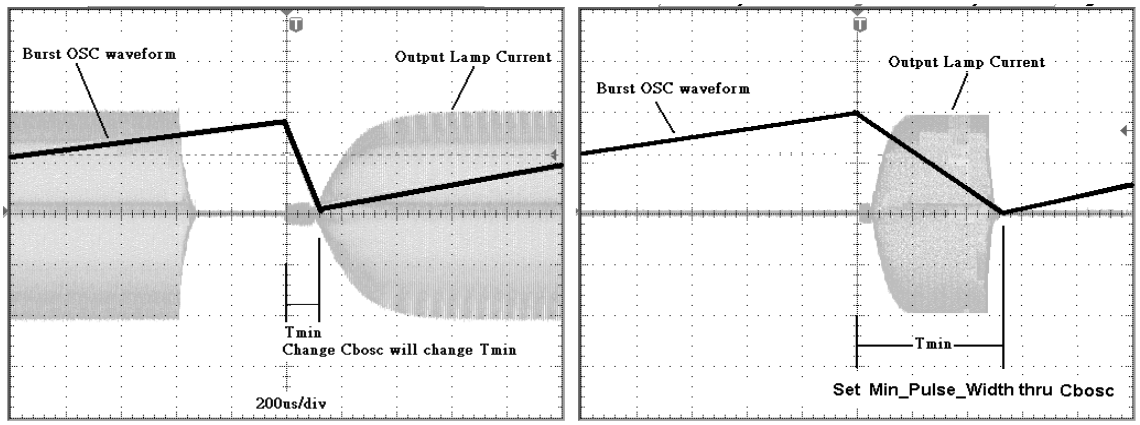
Figure 4: Open_Lamp Voltage Setup and UL Test Protection Application Information



So, Xcsfb = E / I = Epk / Ipk = 1.2V / 70mA
Xcsfb = 1 / (2 * 3.14 * F* Csfb) , F = 100K
Csfb = 1/ (2 * 3.14 * 100K * Xcsfb) = 70mA / (2 * 3.14 * 100K * 1.2V) = 93nF
Get Csfb_max = 93nF , therefore Csfb is selected below 93nF approx 75nF or 68nF.

Rsfb = E / I = 1.2V / 0.7mA = 1.7K
Get Rsfb_min = 1.7K , therefore Rsfb is selected above 1.7K approx 12K ~ 3.9K.

Figure 5: Burst Oscillator Waveform versus Output Lamp Current



Packaging Information

TSSOP20 or TSSOP20F (Exposed Paddle **)