



The Future of Analog IC Technology®

# MP1026

## CCFL Driver

### For Handheld Display Applications

### DESCRIPTION

The MP1026 is a Power IC that offers a complete solution for driving a Cold Cathode Fluorescent Lamp (CCFL). This Power IC converts unregulated DC voltage to a nearly pure sine wave required to ignite and operate the CCFL.

The MP1026 greatly increases power conversion efficiency and supports both analog and burst mode dimming, simplifying the module implementation. The MP1026 offers the following distinct performance advantages:

- More light for less power
- Small board implementation
- Low RF emission
- Low external components cost

The MP1026 is suitable for 2-Cell Li-Ion battery applications using 5V, 9V, or 12V adapters as the power source.

### FEATURES

- 4.5V to 14V Power Input ( $V_{Batt}$ )
- Increase Transformer Reliability
- Open Lamp Timer and Regulation
- Current and Voltage Feedback Control
- Logic Level Burst Mode Control
- Supports Open/Short Lamp Protection
- Soft-Start
- Outputs are Short Circuit Protected
- Allows Burst-Mode Operation
- Improved Line Transient Response
- Tightened Lamp Current Accuracy

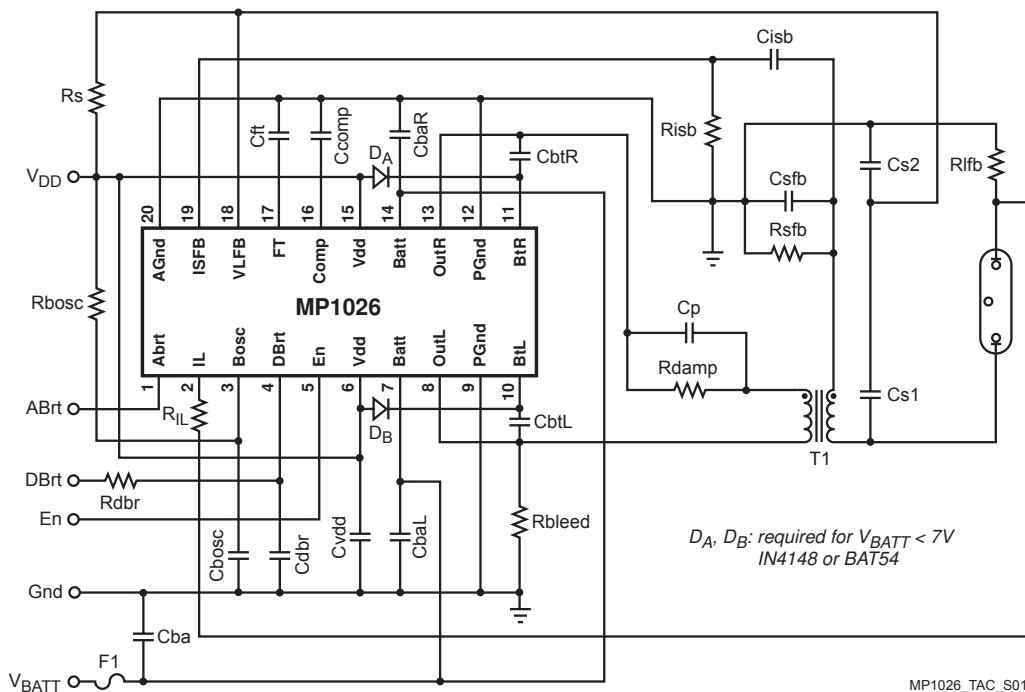
### APPLICATIONS

- Portable DVD Players
- PDAs
- Camcorders
- Digital Cameras

"MPS" and "Monolithic Power Systems" are Registered Trademarks of Monolithic Power Systems, Inc.

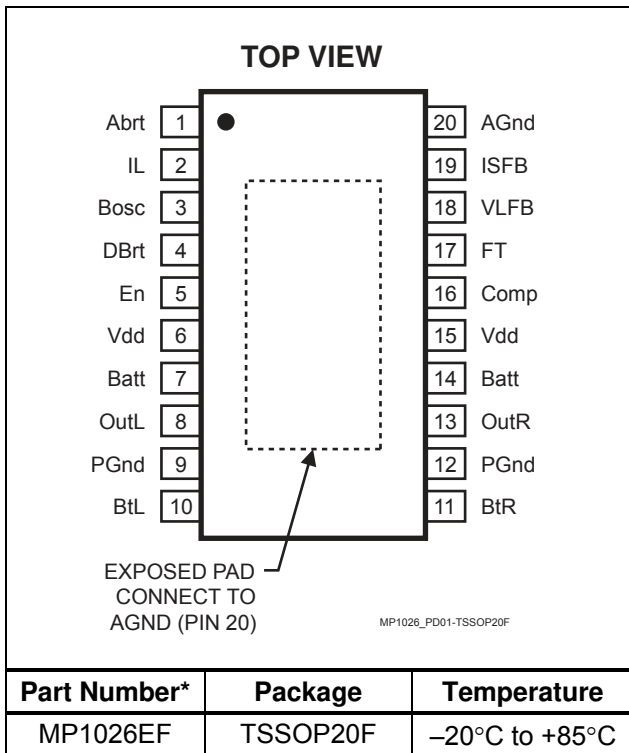
The MP1026 is covered by US Patents 6,316,881 and 6,114,814.

### TYPICAL APPLICATION



MP1026\_TAC\_S01

## PACKAGE REFERENCE



## ABSOLUTE MAXIMUM RATINGS <sup>(1)</sup>

Input Voltage ( $V_{BATT}$ )	16V
Power Dissipation	1.0W
Logic Inputs	0.3V to 6.0V
IL, ISFB Inputs	+6V / -2V
Junction Temperature	150°C
Lead Temperature (Solder)	260°C
Operating Frequency	150KHz
Storage Temperature	-55°C to +150°C

## Recommended Operating Conditions <sup>(2)</sup>

Battery Voltage $V_{BATT}$	4.5V to 14V
Input Voltage $V_{DD}$	4.5V to 5.5V
Enable Voltage $V_{EN}$	0V to 5.0V
Brightness Voltage	0V to 2.0V
Operating Frequency	60KHz
Operating Temperature	-20°C to +85°C

Thermal Resistance <sup>(3)</sup>	$\theta_{JA}$	$\theta_{JC}$
TSSOP20F	40	6

### Notes:

- Exceeding these ratings may damage the device.
- The device is not guaranteed to function outside of its operating conditions.
- Measured on approximately 1" square of 1 oz copper.

Part Number*	Package	Temperature
MP1026EF	TSSOP20F	-20°C to +85°C

\* For Tape & Reel, add suffix -Z (eg. MP1026EF-Z)  
For Lead Free, add suffix -LF (eg. MP1026EF-LF-Z)

## ELECTRICAL CHARACTERISTICS

**Batt = 14V,  $V_{DD}$  = 5V,  $T_A$  = +25°C, unless otherwise noted.**

Parameter	Symbol	Condition	Min	Typ	Max	Units
<b>Voltage Supply</b>						
Vdd Off Current	I <sub>dd(off)</sub>	Enable = 0V			400	μA
Batt Off Current	I <sub>Batt(off)</sub>	enable = 0V			20	μA
Vdd Current (operating)	I <sub>dd(on)</sub>			1.2	1.8	mA
<b>Shutdown Logic</b>						
Fault Timer Threshold	V <sub>th(FT)</sub>			1.2		V
Fault Timer Sink Current		V(VLFB) > 0, V(ISFB) < 1.2		1		μA
Fault Timer Source Current						
Open Lamp		V(VLFB) > 0, V(ISFB) < 1.2		1		μA
Secondary Overload		V(ISFB) > 1.2		115		μA
Enable Voltage Low	V <sub>L(En)</sub>				0.6	V
Enable Voltage High	V <sub>H(En)</sub>		1.5			V

**ELECTRICAL CHARACTERISTICS** *(continued)*
**Batt = 14V, V<sub>DD</sub> = 5V, T<sub>A</sub> = +25°C, unless otherwise noted.**

Parameter	Symbol	Condition	Min	Typ	Max	Units
<b>Output Drivers</b>						
Switch On Resistance <sup>(4)</sup>	R <sub>(ON)OUTL,O</sub> UTR		0.085	0.12	0.15	Ω
Ton(min) Vdd = 5V		Batt = 4.5V, Vcomp = 0V		1800		ns
Ton(min) Vdd = 5V		Batt = 14V, Vcomp = 0V		350		ns
First Pulse Ton(min) Vdd = 5V		Batt = 4.5V		8300		ns
First Pulse Ton(min) Vdd = 5V		Batt = 14V		1300		ns
<b>Brightness Control</b>						
Sense Full Brightness	V(IL)	V(Abrt) = 2.0V	360	385	410	mV
Sense Full Dim	V(IL)	V(Abrt) = 0V	100	115	130	mV
Lamp Current Regulation		4.5v < V(Batt) < 14V		3		%
Burst Oscillator Sink Current	I(Bos)			370		μA
Burst Oscillator Peak Voltage	V(Bos)			1.8		V
<b>Fault Loop Control</b>						
Open Lamp Threshold	Vth(VLFB)			0		V
Secondary Current Threshold	Vth(ISFB)			1.2		V
Fault Mode Comp Current	I(Cmp)	V(VLFB) < 0V, V(ISFB) > 1.2V		460		μA

**Note:**

4) This parameter is guaranteed by design.

**PIN FUNCTIONS**

Pin #	Name	Description
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	Vdd	Supply Voltage.
7	Batt	Power Supply Input.
8	OutL	Output to Load (Tank Circuit).
9	PGnd	Power Ground.
10	BtL	Regulated Output Voltage for Bootstrap Cap on Phase L.
11	BtR	Regulated Output Voltage for Bootstrap Cap on Phase R.
12	PGnd	Power Ground.
13	OutR	Output to Load (Tank Circuit).
14	Batt	Power Supply Input.
15	Vdd	Supply Voltage.
16	Comp	Loop Compensation Cap.
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 (Connect the Exposed Pad to Pin 20).

BLOCK DIAGRAM

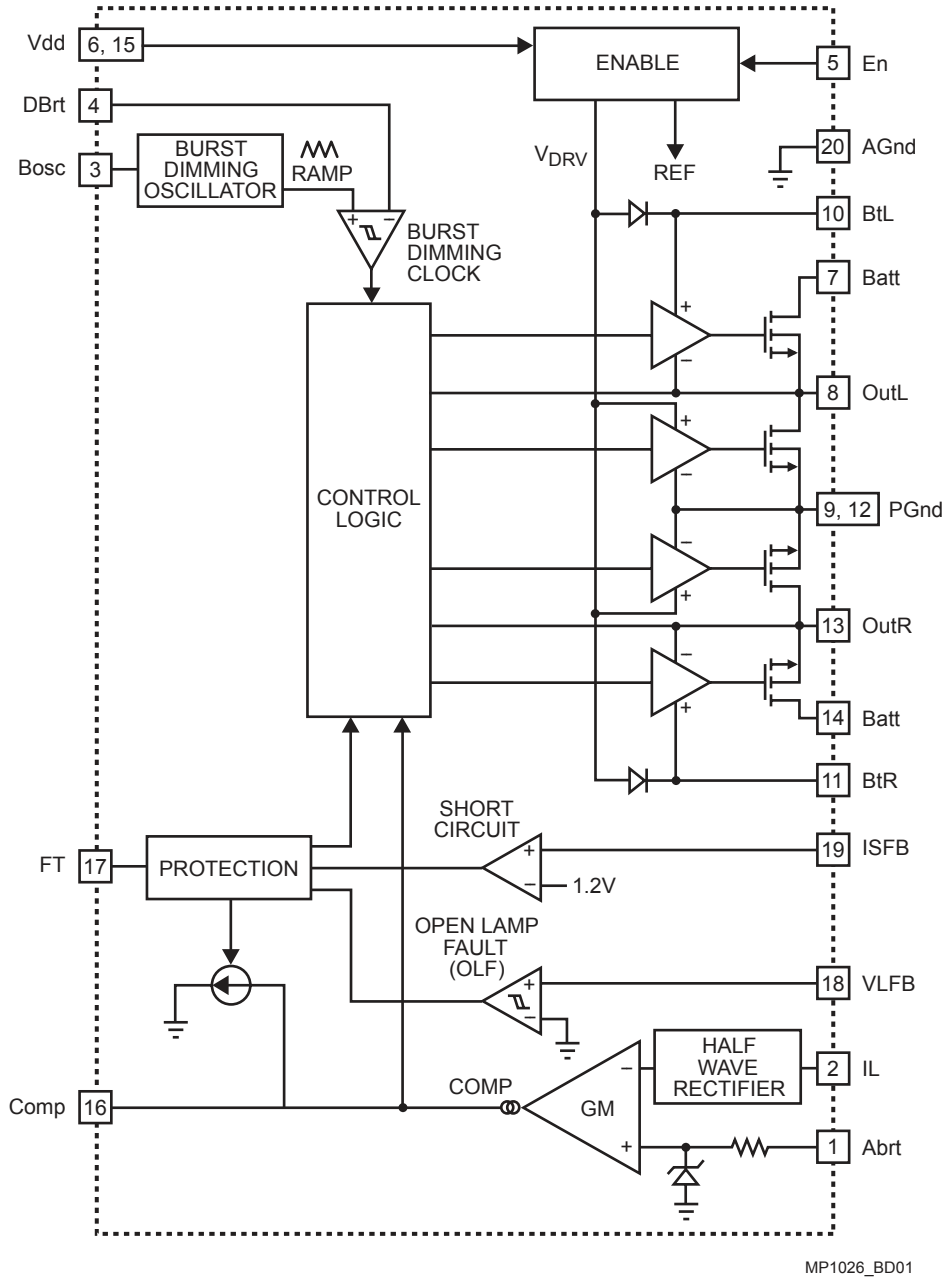


Figure 1—Functional Block Diagram

## APPLICATION INFORMATION

### Brightness Control

The MP1026 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 below. The MP1026 has a soft on and soft off feature to reduce noise, when using burst mode dimming.

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:

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

3. Select a burst frequency and find  $T_{TOTAL}$  where:

$$T_{TOTAL} = 1/\text{burst frequency.}$$

Then determine Cbosc by the formula:

$$C_{bosc} = \frac{(1 - D_{MIN})}{0.42 \times R_{bosc} \times f_{bosc}}$$

Where  $f_{bosc}$  is burst frequency rate in Hz and  $T_{min}$  is the Minimum burst time in sec.

In a typical application,  $R_{bosc}=470k\Omega$  and  $C_{bosc}=22nF$ .

**Table 1—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  $\pm 2.5V$ . 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  $1\mu A$  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 peak ISFB voltage is below 1.2V. If a fault condition occurs that increases the secondary current, then the voltage at ISFB will be greater than 1.2V. When that occurs, a  $120\mu A$  current source will inject into the FT pin. If the voltage at the FT pin exceeds 1.2V, then the chip will shut down.

The following is the design reference for the secondary winding current.

Sensing network: Rsfb, Risb, Csfb and Cisb.

$$R_{sfb} > \frac{1.2V}{0.7mA} = 1.7k\Omega$$

The recommended value is 3.9k $\Omega$  to 10k $\Omega$  (typically 4.7k $\Omega$ ).

$$C_{sfb} < \frac{0.7mA / KHz}{1.2V \times 2\pi} = 93nF$$

Select a capacitor with less than 93nF capacitance for Csfb and make the FB pin voltage peak value around 0.9V in normal operation.

The 0.7mA DC and 0.7mA/KHz AC current values are taken from the UL60950 safety requirement.

C<sub>isb</sub> and R<sub>isb</sub> make up a high-pass filter, wherein the corner frequency should be between 1KHz and 2KHz so as to minimize the attenuation of the AC signal.

The recommended value for R<sub>isb</sub> is 100kΩ.

$$1.6\text{nF} = \frac{1}{2\pi \times R_{isb} \times 1\text{KHz}} > C_{isb}$$

$$C_{isb} > \frac{1}{2\pi \times R_{isb} \times 2\text{KHz}} = 0.8\text{nF}$$

A typical value for C<sub>isb</sub> is 1.2nF.

**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<sub>Drv</sub>) will collapse from V<sub>DD</sub> to 0V.

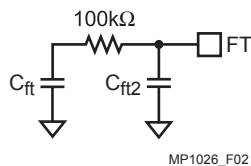
For open lamp time:

$$T(\text{open\_lamp}) = \frac{C_{ft}(\mu\text{F}) \times 1.2\text{V}}{1\mu\text{A}}$$

For secondary short turn off time:

$$T(\text{short}) = \frac{C_{ft}(\mu\text{F}) \times 1.2\text{V}}{120\mu\text{A}}$$

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 2—Turn Off Time Adjustment**

There is no impact on the open lamp time. The secondary short turn off time is:

$$T(\text{short}) = \frac{C_{ft2}(\mu\text{F}) \times 1.2\text{V}}{120\mu\text{A}}$$

With a smaller capacitor value for C<sub>ft2</sub> (when compared to C<sub>ft</sub>), the turn off time for the secondary short will be further reduced.

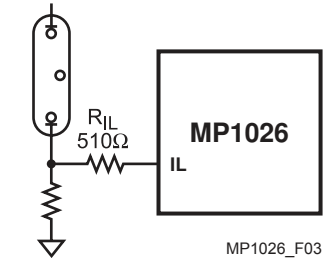
**Lamp Startup**

The strike voltage of the lamp will always be guaranteed at any temperature because the MP1026 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.

**ESD Resistor**

It is recommended that a resistor (R<sub>IL</sub>=470Ω~1kΩ) be added in series with the lamp current feedback as shown in Figure 3.

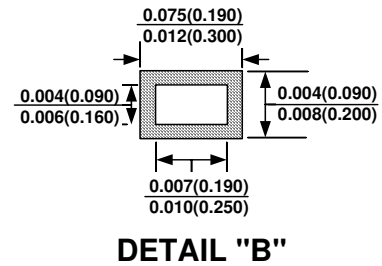
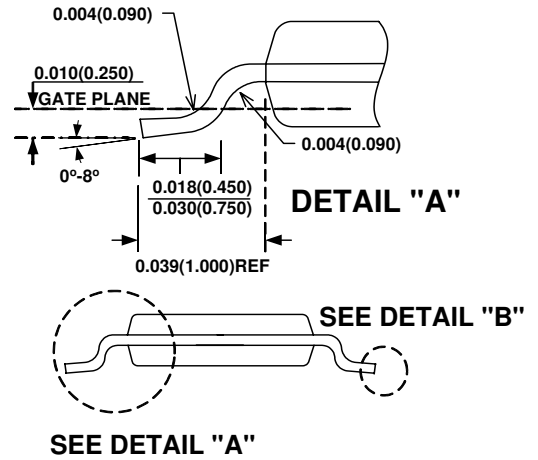
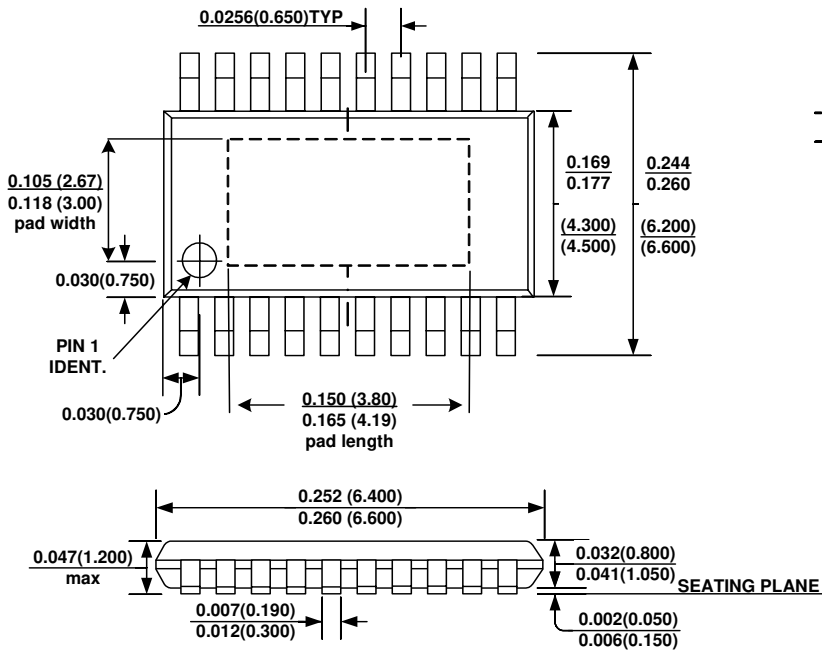
The addition of this resistor helps minimize the possibility of ESD damage in case of mishandling of the IC during board level assembly and test.



**Figure 3—ESD Resistor**

PACKAGE INFORMATION

TSSOP20F



**NOTE:**  
1) Control dimension is in inches. Dimension in bracket is millimeters.

**NOTICE:** The information in this document is subject to change without notice. Please contact MPS for current specifications. Users should warrant and guarantee that third party Intellectual Property rights are not infringed upon when integrating MPS products into any application. MPS will not assume any legal responsibility for any said applications.