

### Description

BP3378A is a high-precision single-stage primary side APFC controller for 90Vac-277Vac universal input application.

BP3378A adopts constant ON-time control to achieve high PF. Inherent THD optimization module can further improve THD. BP3378A operates in BCM mode to improve switching loss, EMI and transformer utilization.

BP3378A supports PWM and analog dimming signal for LED dimming application.

BP3378A is packaged in SOP-8.

### Features

- 90-277Vac Wide Input Range
- High PF and Low THD(PF>0.9, THD<15%)
- Precise Current Reference ( $\pm 3\%$  Typical)
- PWM/Analog Dimming Signal Compatible
- Excellent Line and Load Regulation
- Boundary Conduction Mode
- Low VCC Quiescent Current
- VCC UVLO Protection
- Cycle-by-Cycle OCP
- LED Open/Short Protection
- Thermal fold-back
- SOP-8 package

### Application

- Built-in or External LED Drivers
- High-performance Dimmable LED Luminaire

### Typical Application

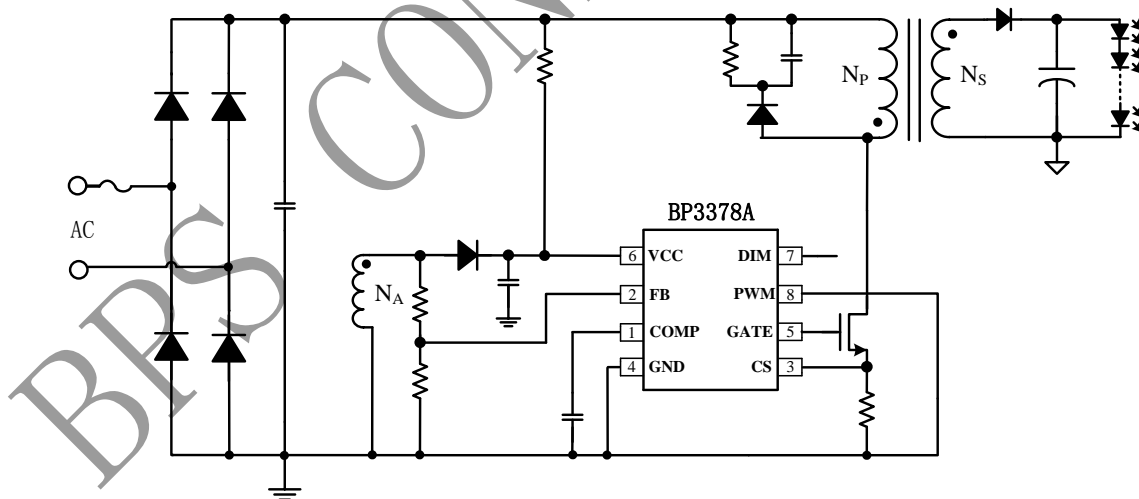


Fig.1 BP3378A Typical application with Analog Dimming Signal

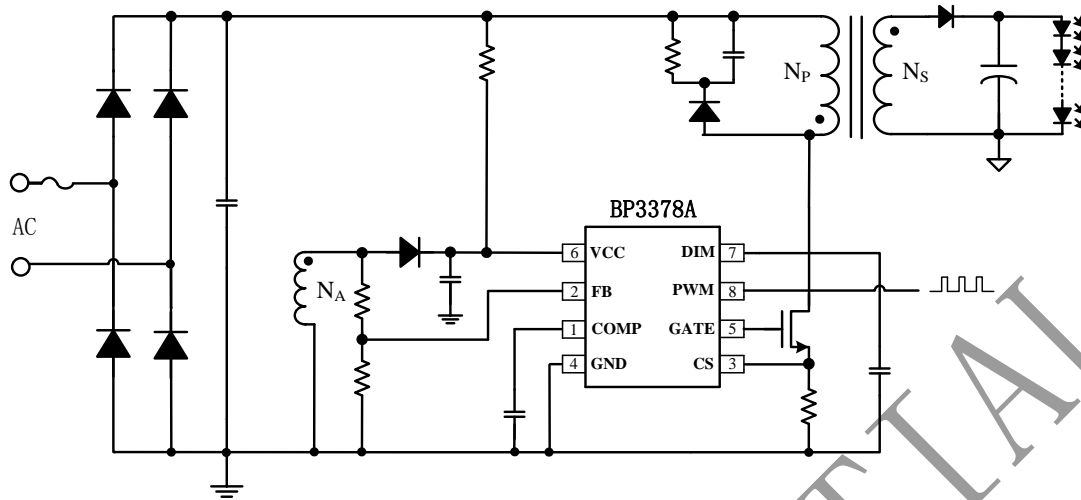
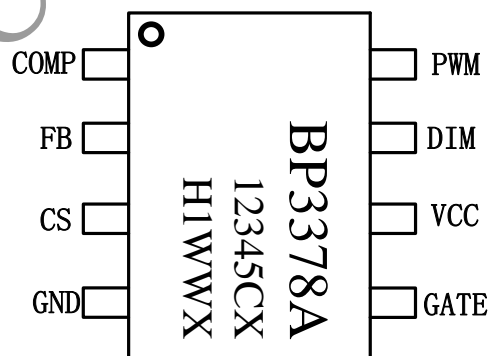


Fig.2 BP3378A Typical Application with PWM Dimming Signal

### Ordering Information

Part Number	Package	Operating Temperature	Packing Method	Marking
BP3378A	SOP-8	-40 °C to 105 °C	4,000 Piece/Reel	BP3378A 12345CX H1WWX

### Pin Configuration



12345: Lot Number

C: Supplier

WW: Week

X: Suffix

Fig.3 Pin Configuration



# BP3378A

## 晶丰明源半导体 PWM/Analog Dimmable PSR APFC LED Controller

### Pin Definition

Pin No.	Name	Description
1	COMP	Loop Compensation.
2	FB	Feedback Voltage Input Pin. This pin detects the transformer demagnetization signal, output voltage and input voltage.
3	CS	Current Sense Pin. Connect a resistor to GND to sense the power MOSFET current.
4	GND	Grounded.
5	GATE	Gate Driver Pin.
6	VCC	Power Supply Pin.
7	DIM	Analog Dimming Signal Input Pin. Connect a filter capacitor between this pin to GND when PWM dimming signal is used.
8	PWM	PWM Dimming Signal Input Pin. Connect this pin to GND when analog dimming signal is used.

### Absolute Maximum Ratings (note 1)

Symbol	Parameters	Range	Units
I <sub>VCC_MAX</sub>	VCC pin maximum sinking current	10	mA
V <sub>GATE, PWM</sub>	GATE/PWM pin input voltage	-0.3~20	V
V <sub>IO</sub>	CS/FB/COMP/DIM input voltage	-0.3~6	V
P <sub>DMAX</sub>	Power dissipation (note 2)	0.45	W
θ <sub>JA</sub>	Thermal resistance (Junction to Ambient)	150	°C/W
T <sub>J</sub>	Operating junction temperature	-40 to 150	°C
T <sub>STG</sub>	Storage temperature range	-55 to 150	°C

**Note 1:** Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. Under “recommended operating conditions” the device operation is assured, but some particular parameter may not be achieved. The electrical characteristics table defines the operation range of the device, the electrical characteristics is assured on DC and AC voltage by test program. For the parameters without minimum and maximum value in the EC table, the typical value defines the operation range, the accuracy is not guaranteed by spec.

**Note 2:** The maximum power dissipation decrease if temperature rise, it is decided by T<sub>JMAX</sub>, θ<sub>JA</sub>, and environment temperature (T<sub>A</sub>). The maximum power dissipation is the lower one between P<sub>DMAX</sub> = (T<sub>JMAX</sub> - T<sub>A</sub>) / θ<sub>JA</sub> and the number listed in the maximum table.



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### Electrical Characteristics (note 4,5):

Symbol	Description	Condition	Min.	Typ	Max.	Unit
<b>Supply Voltage (VCC)</b>						
V <sub>CC_CLAMP</sub>	V <sub>CC</sub> Clamp Voltage	1mA		17	19	V
V <sub>CC_ON</sub>	V <sub>CC</sub> Turn On Threshold	V <sub>CC</sub> Rising	13.5	15	16.5	V
V <sub>CC_UVLO</sub>	V <sub>CC</sub> Turn On Threshold	V <sub>CC</sub> Falling		7.5		V
I <sub>OP</sub>	V <sub>CC</sub> Operating Current	F <sub>OP</sub> =70KHz			0.27	mA
<b>Error Amplifier (COMP)</b>						
G <sub>m</sub>	EA Transconductance			60		uA/V
V <sub>COMP</sub>	COMP Linear Range		1.5		4.5	V
V <sub>REF</sub>	Internal Reference Voltage		194	200	206	mV
<b>Current Sensing (CS)</b>						
V <sub>CS_TH</sub>	CS Peak Voltage Limitation		0.9	1	1.1	V
T <sub>LEB</sub>	Leading Edge Blanking Time			300		ns
T <sub>DELAY</sub>	Switch off Propagation Delay			200		ns
<b>Dimming (DIM)</b>						
V <sub>DIM_ON</sub>	Dimming On Threshold			75		mV
V <sub>DIM_OFF</sub>	Dimming Off Threshold			37.5		mV
V <sub>DIM</sub>	Dimming Range		0.075		1.4	V
<b>PWM Dimming (PWM)</b>						
V <sub>PWM_ON</sub>	PWM Effective High Level	PWM Rising		1.5		V
V <sub>PWM_OFF</sub>	PWM Effective Low Level	PWM Falling		1.4		V
<b>Demagnetization Detection and OVP (FB)</b>						
V <sub>FB_FALL</sub>	FB Falling Edge Threshold	FB Falling		0.1		V
V <sub>FB_HYS</sub>	FB Hysteresis Voltage	FB Rising		0.1		V
V <sub>FB_OVP</sub>	FB OVP protection Threshold		1.4	1.5	1.6	V
<b>Internal Timing</b>						
T <sub>ON_MAX</sub>	Maximum On Time			20		us
T <sub>OFF_MIN</sub>	Minimum Off Time			4.5		us
T <sub>OFF_MAX</sub>	Maximum Off Time			130		us
<b>Gate Driver (GATE)</b>						
I <sub>SOURCE</sub>	Maximum Sourcing Current			200		mA
I <sub>SINK</sub>	Maximum Sinking Current			600		mA
<b>Thermal Regulation</b>						
T <sub>REG</sub>	Thermal Regulation Temp.			150		°C

**Note 4:** production testing of the chip is performed at 25°C.

**Note 5:** the maximum and minimum parameters specified are guaranteed by test, the typical value is guaranteed by design, characterization and statistical analysis.

### Internal Block Diagram

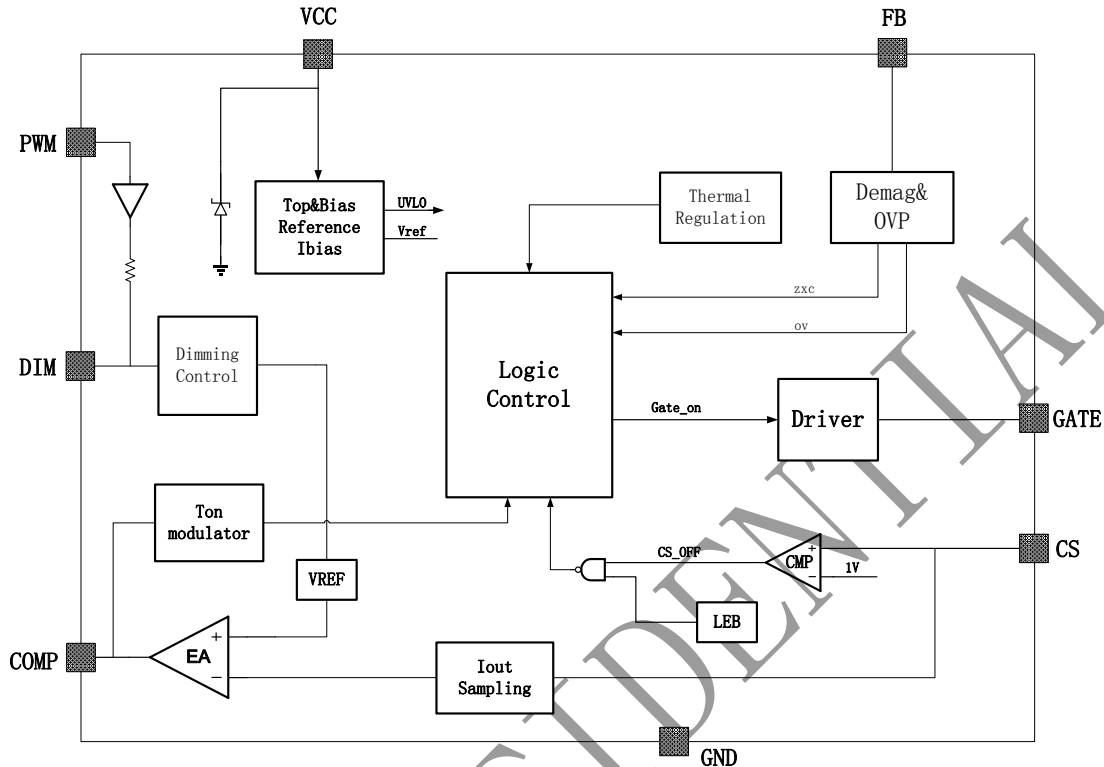


Fig.4 BP3378A Internal Diagram Block

### Application Information

BP3378A is a dimmable high-precision primary-side single stage Active PFC controller targeting isolated Flyback and non-isolated Buck-Boost constant current topologies. The controller is compatible with PWM/Analog dimming signal, especially suitable for the application of 90Vac-277Vac universal input voltage.

#### 1 Start Up

After system powered up, the VCC pin capacitor is charged up by the startup resistor. When the VCC pin voltage reaches the turn on threshold, the internal circuits start working. The COMP pin voltage is pulled up to 1.7V quickly, and then BP3378A starts to switch the MOSFET. The system works around about 7kHz frequency at the beginning to raise the output voltage

gradually. If FB pin detects that the voltage is above 0.4V when MOSFET is off, the controller begins to regulated the output current according to the voltage of DIM pin, and close-loop control is established after then.

#### 2 Constant Current Control

BP3378A adopts proprietary primary side current sensing scheme. It can precisely control the LED current without secondary side sense and feedback circuit.

The current in LED can be calculated by the equation:

$$I_{out} \approx \frac{V_{REF}}{2 \times R_{cs}} \times \frac{N_P}{N_S}$$

Where,

V<sub>REF</sub>: Internal reference voltage

$N_p$ : Turns of primary winding

$N_s$ : Turns of secondary winding

$R_{cs}$ : Resistance of current sensing resistor

### 3 Feedback Network

BP3378A senses the output current zero crossing information through the feedback network, the FB falling threshold voltage is set to 0.1V with 0.1V hysteresis. FB pin is also used to detect input voltage and turn-on time of MOSFET is extended according to input voltage.

Upper resistor of the divider is set as:

$$R_{FBH} \approx \frac{\sqrt{2} \times V_{AC\_max}}{420\mu A} \times \frac{N_A}{N_P}$$

Where,

$V_{AC\_max}$ : RMS value of maximum AC input voltage.

$N_p$ : Turns of primary winding

$N_A$ : Turns of auxiliary winding

The FB pin is also used for OVP. The threshold voltage is 1.5V. The ratio of FB upper resistor to lower resistor can be set as:

$$\frac{R_{FBL}}{R_{FBL} + R_{FBH}} \approx \frac{1.5V}{V_{OVP\_FB}} \times \frac{N_S}{N_A}$$

Where,

$R_{FBL}$ : lower divider resistor of FB network

$R_{FBH}$ : upper divider resistor of FB network

$V_{OVP\_FB}$ : maximum output voltage when OVP

$N_s$ : Turns of secondary winding

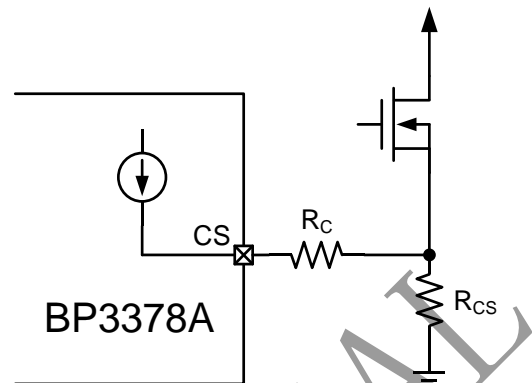
$N_A$ : Turns of auxiliary winding

### 4 Line Regulation Compensation

BP3378A provides line regulation compensation.

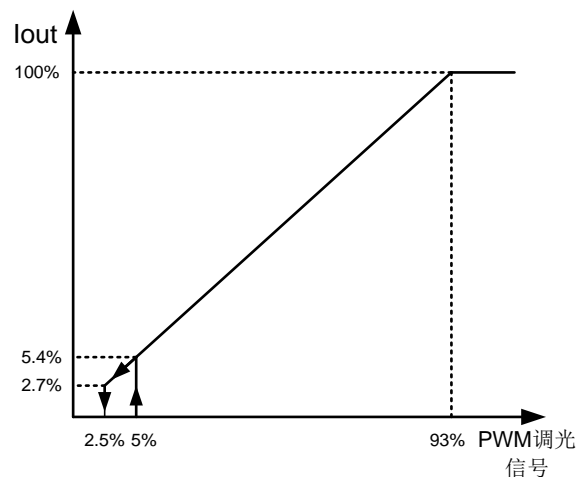
For wide input voltage application, one resistor

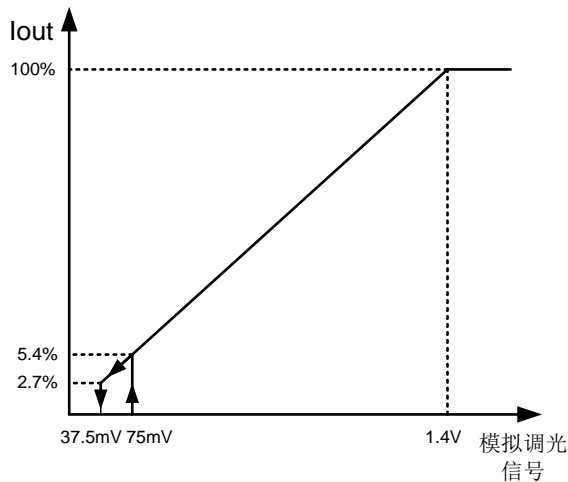
$R_C$  connected between CS pin and current sensing resistor is used to compensate the current difference at different line voltage.



### 5 PWM Dimming and Analog Dimming

BP3378A accepts PWM or Analog signal for dimming. If PWM signal is provided via PWM pin, one ceramic capacitor should be connected to DIM pin to act as a filter together with an internal capacitor between PWM pin and DIM pin. If analog signal is used for dimming, it is better to ground the PWM pin. No matter PWM or analog signal is used, output current is controlled by changing the internal reference voltage. The voltage range of DIM pin is 0-1.5V. Detailed dimming curve is as follows:





### Thermal Regulation

BP3378A integrates thermal regulation function. When the system is over temperature, the output current is gradually reduced; the output power and thermal dissipation are also reduced. The system temperature is regulated and the system reliability is improved.

the thermal regulation temperature is set to 150°C internally.

### 6 Protections

BP3378A integrates with multiple protections to assure system reliability.

When LED is open, output voltage increases gradually, causing the voltage detected by FB pin also increases. When FB voltage is higher than 1.5V OVP threshold, OVP protection is triggered. The controller stops switching and enters into fault protection.

When LED is shorted, demagnetizing signal is failed to be detected, the controller will work around 7kHz. After 100 consecutive switching pulse, if LED short is not removed, the controller will enter into LED short fault protection.

In case of fault protection, VCC voltage is discharged by an internal current source. If VCC

is below UVLO threshold, the control will restart.

When LED is shorted or the transformer is saturated, CS peak voltage will be high. When CS voltage is higher than OCP threshold 1V, the MOSFET will be turned off immediately. The cycle-by-cycle is helpful to protect MOSFET, transformer and freewheeling diodes at secondary side.

### 7 PCB Layout

The following guidelines should be followed in BP3378A PCB layout:

#### Bypass Capacitor

The bypass capacitor on VCC pin should be as close as possible to the VCC and GND pins.

#### Ground Path

The power ground path for current sense resistor should be short and wide, and it should be as close as possible to the IC ground (pin 4), otherwise the LED output current accuracy maybe affected. Resistor connected to CS pin for line regulation compensation should be placed close to CS pin as possible. Furthermore, Ground for COMP and FB should be connected to IC GND pin with short traces and should be away from the power ground path.

#### The Area of Power Loop

The area of main current loop should be as small as possible to reduce EMI radiation, such as the primary current loop, the snubber circuit and the secondary rectifying loop.

#### FB Pin

The feedback resistor divider should be as close as possible to the FB pin, and the trace must keep away from dynamic node of the transformer and MOSFET DRAIN trace, otherwise OVP may be triggered unexpectedly by the system noise.

### Physical Dimensions

