Description

The AP3068 is a white LED (WLED) driver with current balancing and dimming functions. It consists of a boost controller and 8-channel current sinks to drive WLED arrays with constant current from a wide power supply range. It can be used in middle and large-sized LCD panel backlight.

The full-scale LED current can be adjusted from 5mA to 100mA simply via a resistor. The 8 channels can be paralleled for higher current application. The AP3068 can support direct PWM dimming.

The AP3068 features LED open/short protection, Under Voltage Lockout (UVLO) protection, over output voltage protection and Over Temperature Protection (OTP).

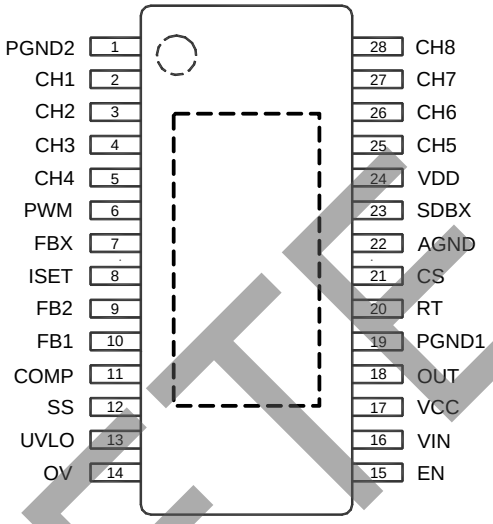
The AP3068 is available in TSSOP-28 (EDP) package.

Features

- Input Voltage Range: 6V to 27V
- Maximum Duty Cycle: 93%
- Maximum Channel Current: 100mA
- Current Matching Accuracy: ±1.5%
- Adjustable Operating Frequency: 200kHz to
- 1MHz
- Cycle-by-cycle Current Limit
- Unused LED Channel Auto-detection
- Open/Short LED Protection
- Programmable Soft-start
- Programmable UVLO Protection
- Programmable OVP
- Over Temperature Protection
- FBX and SDBX Pins Enable Parallel
- Application with AP3608E

Pin Assignments

(Top View)

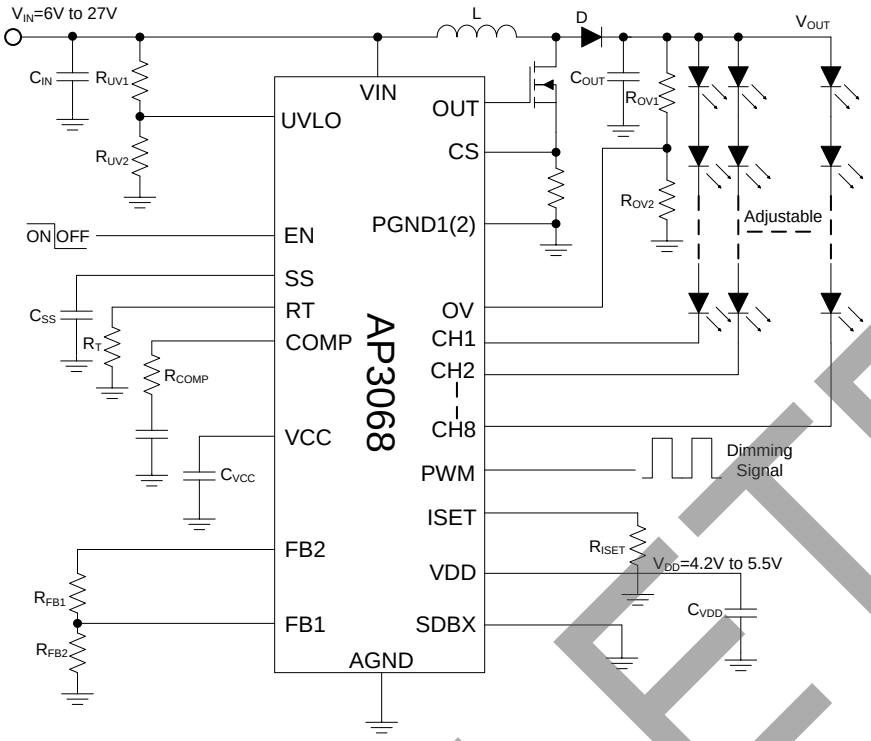


TSSOP-28 (EDP)

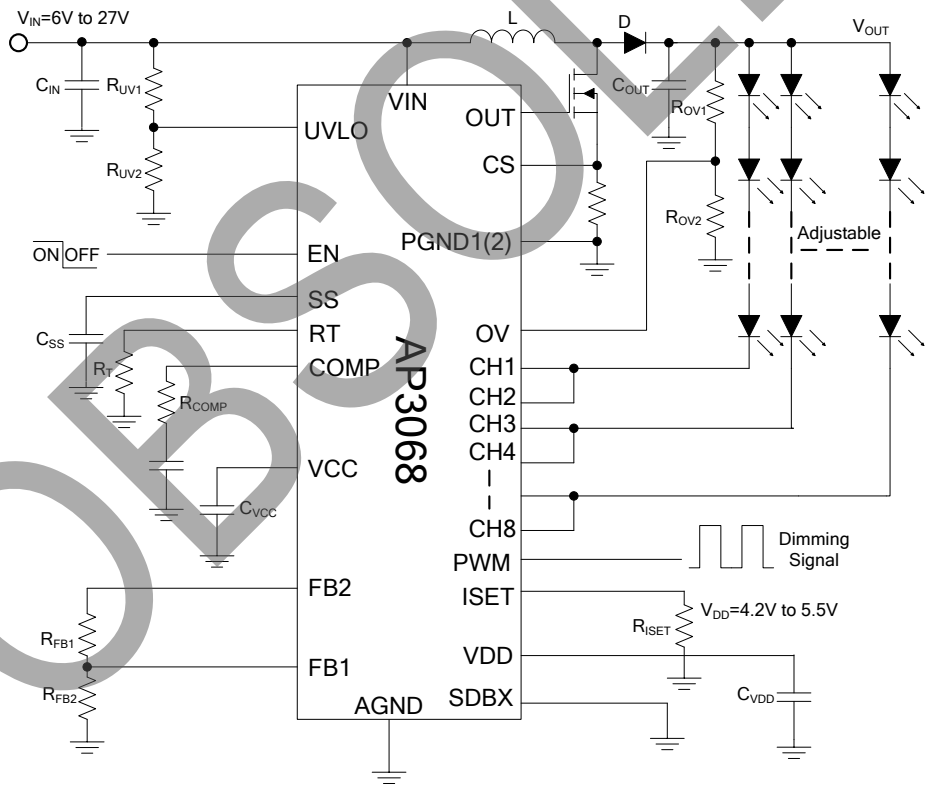
Applications

- LCD Monitor
- LCD Display Module
- LCD TV

Typical Applications Circuit



Typical Application Circuit of AP3068 (Single Channel Application)

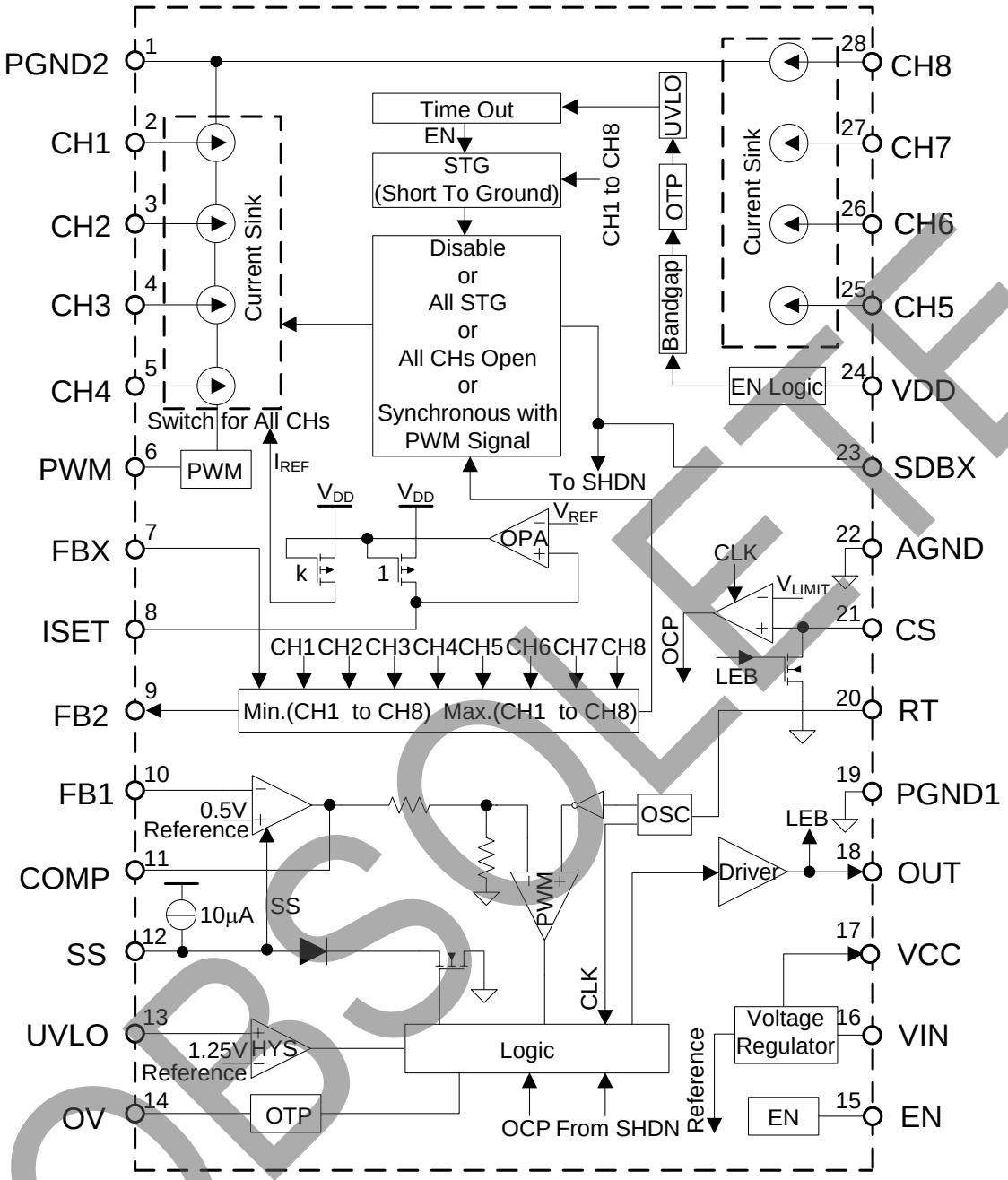


Typical Application Circuit of AP3068 (Paralleled Channel Application)

Pin Descriptions

Pin Number	Pin Name	Function
1	PGND2	Power ground pin of current sink section
2,3,4,5, 25,26,27,28	CH1 to CH8	White LED cathode connection pin. The current of each channel can be set from 5mA to 100mA. The channels can be paralleled for higher current application. These pins should be connected to GND if not used
6	PWM	PWM dimming control pin. Add a PWM signal to this pin to realize PWM dimming control
7	FBX	This pin is an interface terminal. Connect it with current sink device for parallel application. Leave it unconnected if not used
8	ISET	LED current setting pin. An external resistor can be connected to this pin to set LED current, the full-scale current can be adjusted from 5mA to100mA
9	FB2	Feedback pin. This pin is an interface terminal, which samples the voltage of each channel, and outputs the lowest voltage to DC/DC controller
10	FB1	Voltage feedback pin of the boost controller section. The reference voltage is 500mV
11	COMP	Boost controller compensation pin. This pin is the output of internal error amplifier
12	SS	Soft-start time control pin. An external soft-start time capacitor is placed between this pin and AGND, and is charged by an internal 12μA current source to control the soft-start time of regulator
13	UVLO	Under voltage lockout sense pin. The start-up and shutdown level can be set via two resistors respectively connected from this pin to AGND and VIN pin
14	OV	Over voltage sense pin
15	EN	Enable pin. Logic high enables the IC, while logic low disables the IC
16	VIN	Input supply pin of boost controller section. This pin must be locally bypassed. The input voltage ranges from 6V to 27V
17	VCC	6V linear regulator output pin. It is used to bias the gate driver for external MOSFET. If V_{IN} is less than 8.5V, V_{CC} is equal to V_{IN} minus dropout voltage across the bypass switch (V_{DROP}), in other words, $V_{CC}=V_{IN}-V_{DROP}$. This pin should be bypassed to GND (recommended to be connected to AGND pin) with a ceramic capacitor
18	OUT	External MOSFET gate driver output pin. The gate driver has 0.6A peak current capability
19	PGND1	Power ground pin of the boost controller section
20	RT	Frequency control pin. The operating frequency can be set via an external resistor placed between this pin and AGND
21	CS	Switch current sense pin. It is used for current mode control and current limit
22	AGND	Analog ground pin
23	SDBX	This pin is an interface terminal. Connect it with current sink device for parallel application. It should be connected to GND if not used
24	VDD	Input supply pin for current sink section. The input voltage ranges from 4.2V to 5.5V

Functional Block Diagram



Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Value	Unit
V_{IN}	Input Voltage	30	V
V_{DX}	CH1 to CH8 Voltage (Note 2)	-0.3 to 40	V
V_{EN}	EN Pin Voltage	-0.3 to 30	V
V_{DD}	VDD Pin Voltage	-0.3 to 6	V
V_{ISET}	ISET Pin Voltage	-0.3 to 6	V
V_{PWM}	PWM Pin Voltage	-0.3 to 6	V
V_{COMP}	COMP Pin Voltage	-0.3 to 6	V
V_{SS}	SS Pin Voltage	-0.3 to 6	V
V_{UVLO}	UVLO Pin Voltage	-0.3 to 7	V
V_{VCC}	VCC Pin Voltage	-0.3 to 10	V
V_{OUT}	OUT Pin Voltage	-0.3 to 10	V
V_{CS}	CS Pin Voltage	-0.3 to 7	V
V_{RT}	RT Pin Voltage	-0.3 to 7	V
V_{OV}	OV Pin Voltage	-0.3 to 7	V
T_J	Operating Junction Temperature	+150	°C
T_{STG}	Storage Temperature	-65 to +150	°C
T_{LEAD}	Lead Temperature (Soldering, 10 sec)	+260	°C
_	ESD (Machine Model)	200	V
_	ESD (Human Body Model)	2000	V

Notes: 1. Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "Recommended Operating Conditions" is not implied. Exposure to "Absolute Maximum Ratings" for extended periods may affect device reliability.
2. Breakdown Voltage.

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V_{IN}	Input Voltage 1	6	27	V
V_{DD}	Input Voltage 2	4.2	5.5	V
f_O	Operating Frequency	0.2	1	MHz
I_{CHX}	LED Channel Current	5	100	mA
f_{PWM}	PWM Dimming Frequency	0.1	25	kHz
T_A	Operating Temperature	-40	+85	°C

Electrical Characteristics (V_{IN} =12V, V_{DD}=5V, T_A=+25°C, unless otherwise specified.)

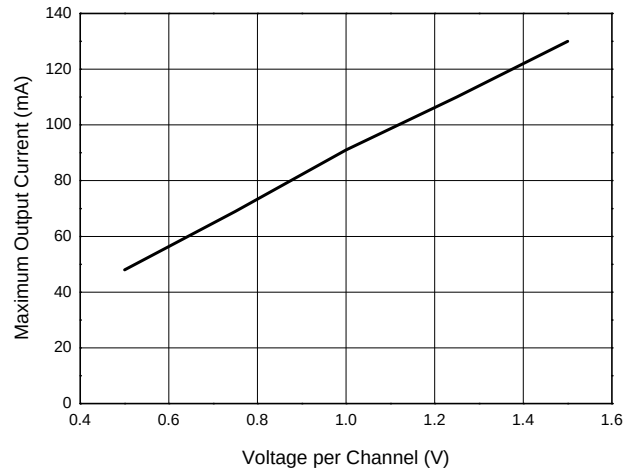
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
INPUT SECTION						
V_{IN}	Input Voltage	_	6	_	27	V
I_Q	Quiescent Current	No Switching	_	3	5	mA
I_{SHTD}	Shutdown Supply Current	V_{EN} =V_{DD}=0V	_	1	2	μA
V_{UVLO}	VIN UVLO Threshold	Rising Edge	1.22	1.25	1.28	V
I_{HYS}	VIN UVLO Hysteresis Current Source	_	16	20	24	μA
VCC SECTION						
V_{CC}	VCC Voltage	6V≤V_{IN}≤9V	5	_	_	V
		9V≤V_{IN}≤27V	5.5	6	6.5	V
I_{VCC_LIM}	VCC Current Limit	_	_	50	_	mA
V_{DROP}	Dropout Voltage Across Bypass Switch	I_{CC}=0mA, f_{OSC}≤400kHz, 6V≤V_{IN}≤8.5V	_	300	_	mV
V_{BYP_HI}	Bypass Switch Turn-off Threshold	V_{IN} Rising	_	8.7	_	V
V_{BYP_HYS}	Bypass Switch Threshold Hysteresis	V_{IN} Falling	_	260	_	mV
V_{CC_UVLO}	VCC UVLO Threshold	Rising Edge	_	4.7	_	V
V_{CC_HYS}	VCC UVLO Hysteresis	_	_	300	_	mV
BOOST CONTROLLER SECTION						
V_{RT}	RT Voltage	_	1.20	1.25	1.30	V
f_O	Operating Frequency	Adjustable	0.2	_	1	MHz
g_M	Error Amplifier Transconductance	_	_	470	_	μA/V
R_O	Error Amplifier Output Resistance	_	_	1	_	Ω
V_{CS}	Current Limit Threshold Voltage	_	0.09	0.11	0.13	V
D_{MAX}	Maximum Duty Cycle	_	90	93	_	%
I_{SS}	Soft-start Current Source	_	_	12	_	μA
t_{RISING}	OUT Pin Rising Time	1nF Load	_	20	_	ns
$t_{FALLING}$	OUT Pin Falling Time	1nF Load	_	20	_	ns
V_{OUT_H}	Output High Voltage Level (V_{CC}-V_{OUT})	I_{OUT}=50mA	_	0.25	0.75	V
V_{OUT_L}	Output Low Voltage Level	I_{OUT}=100mA	_	0.25	0.75	V
V_{OV}	OV Threshold	_	_	1.25	_	V
I_{OV_HYS}	OV Hysteresis Current Source	_	16	20	24	μA

Electrical Characteristics (Cont. V_{IN} =12V, V_{DD}=5V, T_A=+25°C, unless otherwise specified.)

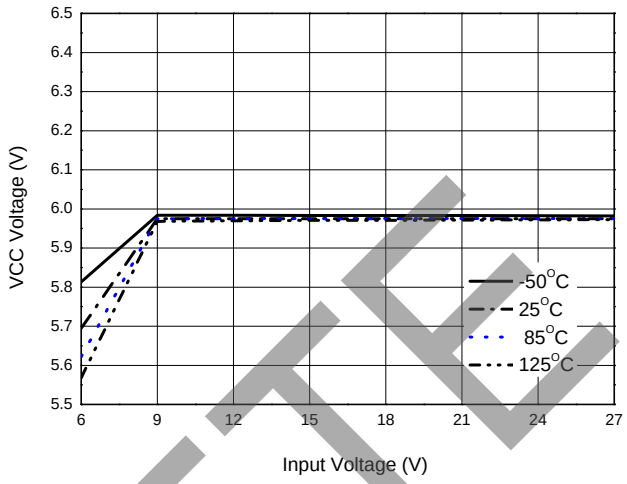
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
CURRENT SINK SECTION						
V_{DD}	Input Voltage	_	4.2	_	5.5	V
I_Q	Quiescent Current	No Load	_	0.5	1	mA
V_{ISET}	ISET Reference Voltage	_	1.17	1.194	1.218	V
k	Output/ISET Current Multiplication Ratio	_	370	400	430	_
$I_{CHX-MAX}$	Maximum Output Current per Channel	V_{CHX}=0.5V	23	45	_	mA
		V_{CHX}=1V	65	70	_	
		V_{CHX}=1.5V	110	120	_	
$I_{CH-MATCH}$	Current Matching Accuracy Between Each Channel	I_{CHX}=60mA V_{CHX}=1V	-1.5	_	1.5	%
V_{CHX}	Current Sink Saturation Voltage per Channel	I_{CHX}=20mA	_	_	0.45	V
		I_{CHX}=60mA	_	_	0.8	
		I_{CHX}=100mA	_	_	1.2	
$\Delta I_{CH}/(I_{CH} \times \Delta V_{DD})$	Output Current Line Regulation	V_{DD}=4.2V to 5.5V	_	_	2	%/V
_	Output Current Load Regulation	V_{CHX}=0.5V to 2.8V	_	_	4	%
V_{D_OPEN}	LED Open Detecting Voltage	_	_	3	_	V
ENABLE AND PWM DIMMING SECTION						
V_{IH_EN}	EN High Level Threshold Voltage	_	2.0	_	_	V
V_{IL_EN}	EN Low Level Threshold Voltage	_	_	_	0.5	V
V_{IH_PWM}	PWM High Level Threshold Voltage	_	1.8	_	_	V
V_{IL_PWM}	PWM Low Level Threshold Voltage	_	_	_	0.8	V
f_{PWM}	PWM Dimming Frequency	_	0.1	_	25	kHz
D_{PWM_MIN}	Minimum PWM Duty Cycle	_	0.35	_	_	%
TOTAL DEVICE						
T_{OTSD}	Thermal Shutdown Temperature	_	_	+160	_	°C
T_{HYS}	Thermal Shutdown Hysteresis	_	_	+20	_	°C

Performance Characteristics (V_{IN} =12V, V_{EN}=V_{DD}=5V, R_{IEST}=20kΩ, T_A=+25°C, unless otherwise specified.)

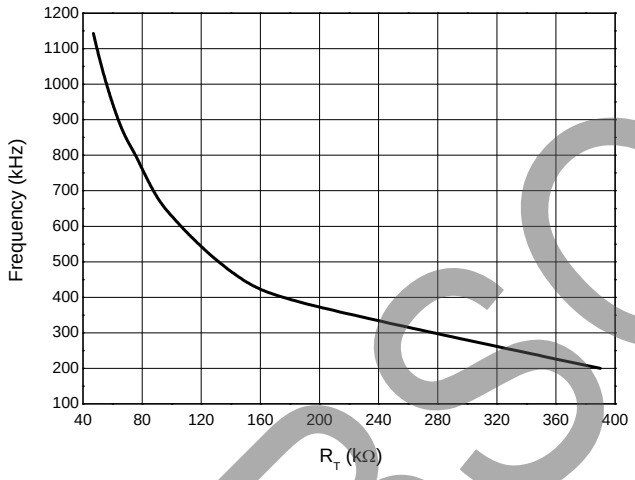
Maximum Output Current vs. Voltage per Channel



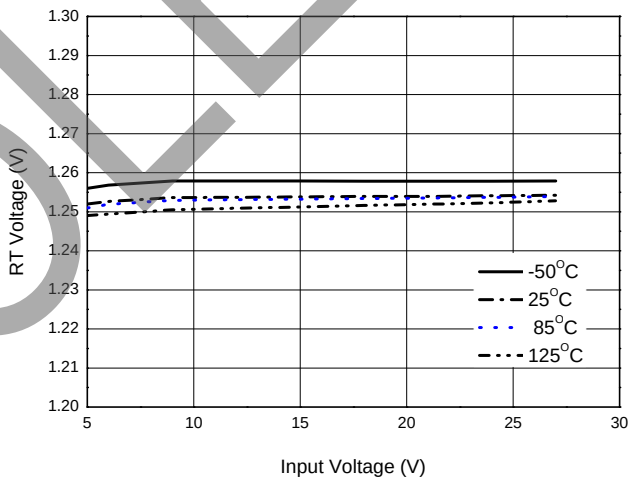
VCC Voltage vs. Input Voltage



Frequency vs. R_T



RT Voltage vs. Input Voltage



Application Information

1. Input Under-voltage Detector

The AP3068 integrates an UVLO circuit. Two resistors R_{UV1} and R_{UV2} are respectively connected from UVLO pin to GND and VIN pin. The resistor divider (R_{UV1} and R_{UV2}) must be designed such that the voltage on UVLO pin is higher than 1.25V when V_{IN} is in the desired operating range. If the voltage on UVLO pin is below the under voltage threshold, all functions of AP3068 will be disabled, while the system will remain in a low-power standby state. The UVLO hysteresis is realized through an internal 22μA current source, which switched on or off 22μA current flowed into the set-point divider. The current source will be instantly activated to raise the voltage on the UVLO pin (V_{UVLO}) when the UVLO threshold (T_{UVLO}) is exceeded, and will be turned off to lower V_{UVLO} when V_{UVLO} falls below T_{UVLO}. The formulas of UVLO can be expressed as blow:

$$V_{IN\_THRESHOLD} = \frac{(R_{UV1} + R_{UV2}) \times 1.25V}{R_{UV2}} \qquad V_{IN\_HYSTERESIS} = R_{UV1} \times 22\mu A$$

Where $V_{IN\_THRESHOLD}$ is the input threshold voltage and $V_{IN\_HYSTERESIS}$ is the input hysteresis voltage.

2. Over Voltage Protection

The AP3068 integrates an OVP circuit. The OV pin is connected to the center tap of voltage-divider (R_{OV1} and R_{OV2}) that placed between high voltage output and GND. If the voltage on OV pin exceeds 1.25V, which may results from open loop or excessive output voltage, all the functions of AP3068 will be disabled with output voltage falling. The OVP hysteresis is realized by an internal 22μA current source and its operation mode behaves the same as UVLO. The formulas of OVP can be expressed as blow:

$$V_{OVP} = \frac{(R_{OV1} + R_{OV2}) \times 1.25V}{R_{OV2}} \qquad V_{OVP\_HYSTERESIS} = R_{OV1} \times 22\mu A$$

Where V_{OVP} is the OVP voltage and $V_{OVP\_HYSTERESIS}$ is the OVP hysteresis voltage.

3. Frequency Selection

An external resistor R_T, placed between RT pin and GND, can be used to set the operating frequency. The operating frequency ranges from 200kHz to 1MHz. The high frequency operation optimizes the regulator for the smallest- sized component application, while low frequency operation can help to reduce switch loss.

R_T (kΩ)	Operating Frequency (kHz)
390	200
147	400
95	600
68	800
51	1000

4. Soft-start

The AP3068 integrates a soft-start circuit to limit the inrush current during start-up. The time of soft-start can be controlled by an internal 12μA current source and an external soft-start capacitor C_{SS} placed between SS pin and GND. The effective C_{SS} voltage for soft-start ranges from 0V to 2.3V, and the time of soft-start can be expressed as below:

$$t_{SS} = \frac{C_{SS} \times 2.3V}{12\mu A}$$

Where t_{SS} is the time of soft-start.

Application Information (Cont.)

5. VCC Pin Application Description

The AP3068 includes an internal low-dropout linear regulator with an output pin VCC. This pin is used to power the internal PWM controller, control logic and MOSFET driver. On condition that V_{IN}≥8.5V, the regulator will generate a 6V supply; On condition that 6V≤V_{IN}≤8.5V, V_{CC} is equal to V_{IN} minus dropout voltage across bypass switch (V_{DROP}), in other words, $V_{CC}=V_{IN}-V_{DROP}$; On condition that V_{IN}≤6V, connect VCC pin to VIN pin directly.

6. LED Current Setting

The maximum LED current per channel can be adjusted up to 100mA via ISET pin. When ≥100mA current is needed in application, two or more channels can be paralleled to provide larger drive current. Connect a resistor R_{ISET} between ISET pin and GND to set the reference current I_{SET}, and I_{SET} can be expressed as below:

$$I_{SET} = \frac{1.194V}{R_{ISET}}$$

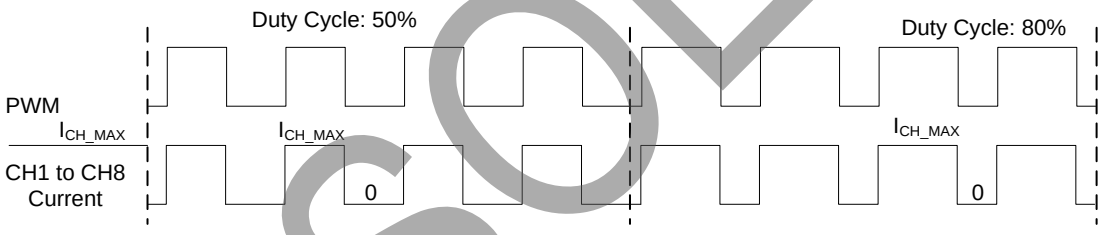
This reference current is multiplied internally with a gain (k) of 400, and then be mirrored onto all enabled channels, which can set the maximum LED current, referred to as 100% current (I_{CHX_MAX}). And I_{CHX_MAX} can be expressed as below:

$$I_{CHX\_MAX} = k \times I_{SET}$$

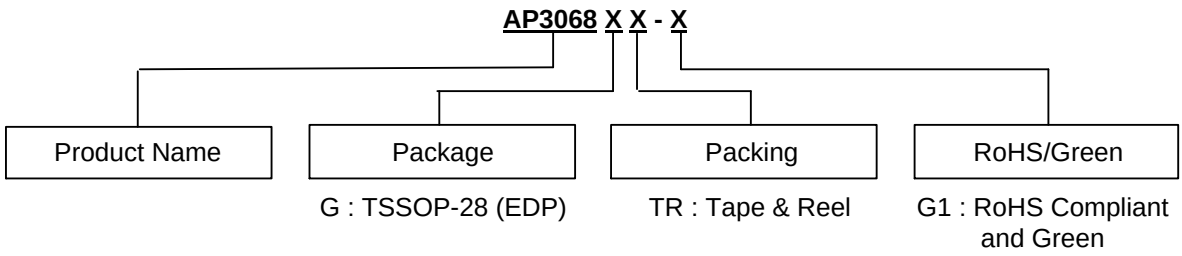
The LED current can be reduced from 100% by PWM dimming control.

7. PWM Dimming Mode

Applying a PWM signal to PWM pin to adjust the LED current, that means, the LED current of all enabled channels can be adjusted at the same time and the LED brightness can be adjusted from 1%× I_{CHX_MAX} to 100%×I_{CHX_MAX}. During the “high level” period of PWM signal, the LED is turned on and 100% of the current flows through LED, while during the “low level” period of the PWM signal, the LED is turned off and almost no current flows through the LED, thus changing the average current through LED and finally adjusting LED brightness. The external PWM signal frequency applied to PWM pin is allowed to be 100Hz or higher.



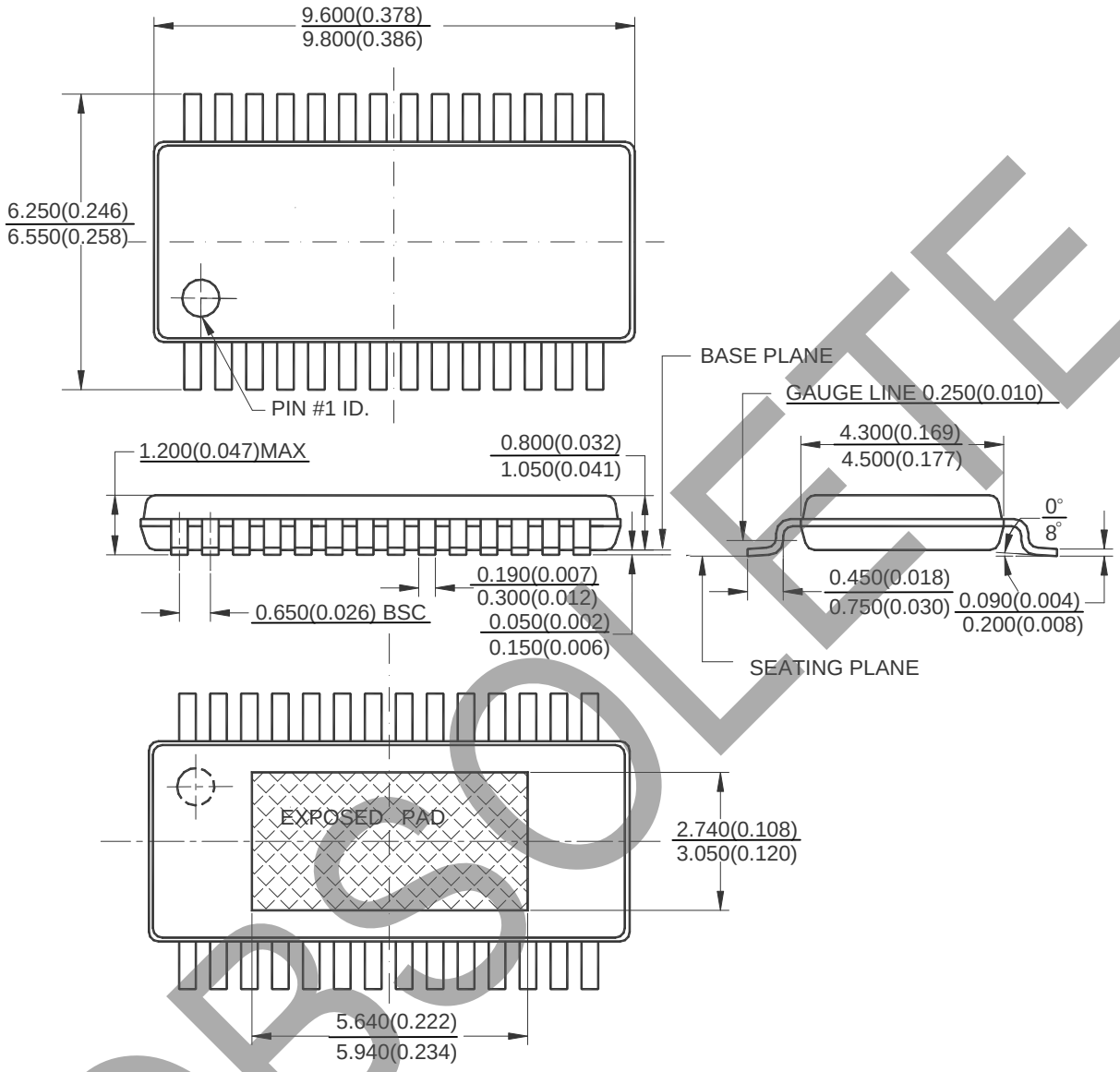
Ordering Information



Package	Temperature Range	Part Number	Marking ID	Packing
TSSOP-28 (EDP)	-40 to +85°C	AP3068GTR-G1	AP3068G-G1	Tape & Reel

Package Outline Dimensions (All dimensions in mm(inch).)

(1) Package Type: TSSOP-28 (EDP)



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