



# Datasheet - MAP3301C

## Single Channel LED Driver with Internal Dimming MOSFET

MAP3301C – Single Channel LED Driver with Internal Dimming MOSFET

### General Description

MAP3301C is a single channel boost type PWM driver with high efficiency. It is designed for high brightness LED driver optimized of backlighting system for LCD module.

MAP3301C provides small solution size with internal high voltage & current dimming MOSFET and internal references.

MAP3301C offers the function of accurate and fast LED dimming control using PWM interface.

MAP3301C has the input line under voltage protection, LED Open/Short protection and Power Good indication.

MAP3301C is available in SOIC-15 Pin package with Halogen-free (fully RoHS compliant).

### Features

- Wide input voltage : 8.5V ~ 33V
- Internal Dimming MOSFET
- PWM & Analog Dimming
- Current Mode Control Type
- Fixed Switching frequency : 100KHz
- Auto Restart Mode Protection
- Programmable Output Over Voltage Protection
- Programmable Input Line Voltage Protection
- LED Short Current Protection
- Power Good Indication (Open Drain)
- Small package : SOIC-15 Pin

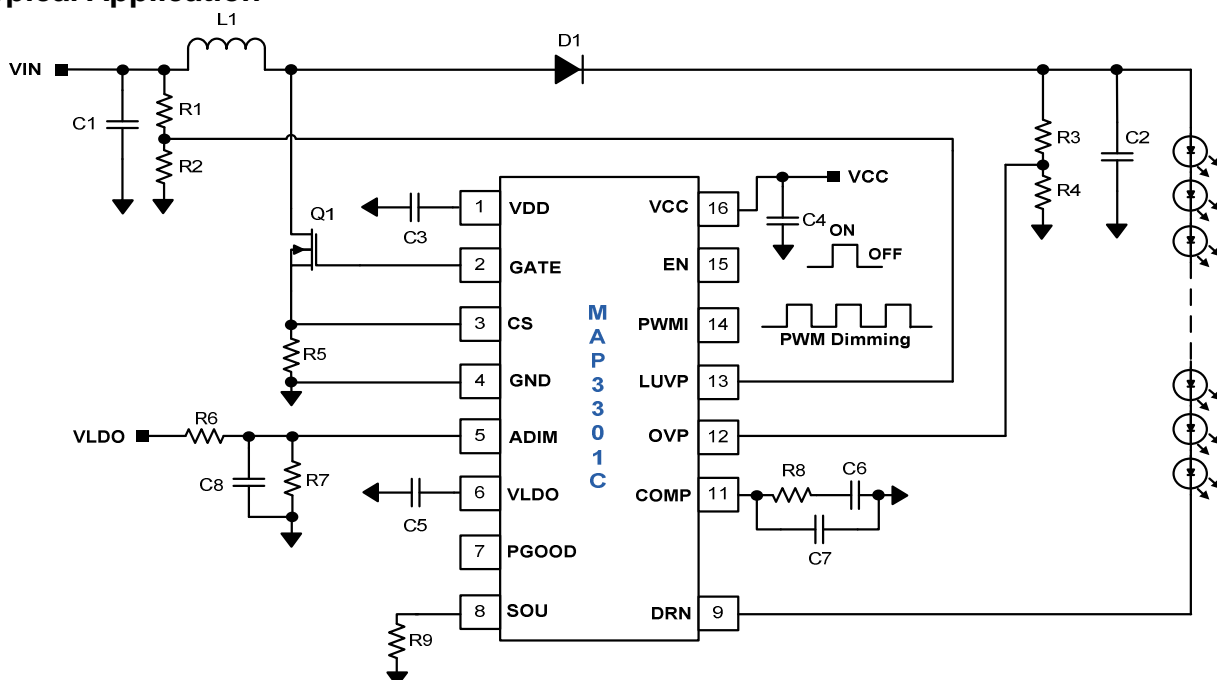
### Applications

- High Brightness white LED backlighting for LCD TVs and monitors
- General LED lighting applications

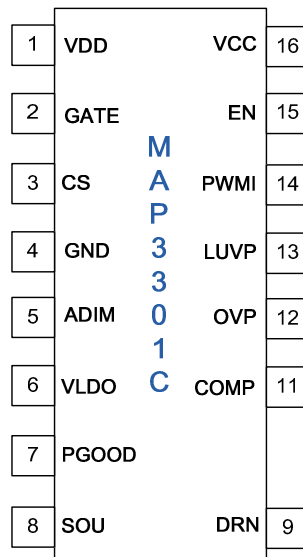
### Ordering Information

Part Number	Top Marking	Ambient Temperature Range	Package	RoHS Status
MAP3301CSIRH	MAP3301C	-40°C to +85°C	SOIC-15 Pin	Halogen Free

### Typical Application



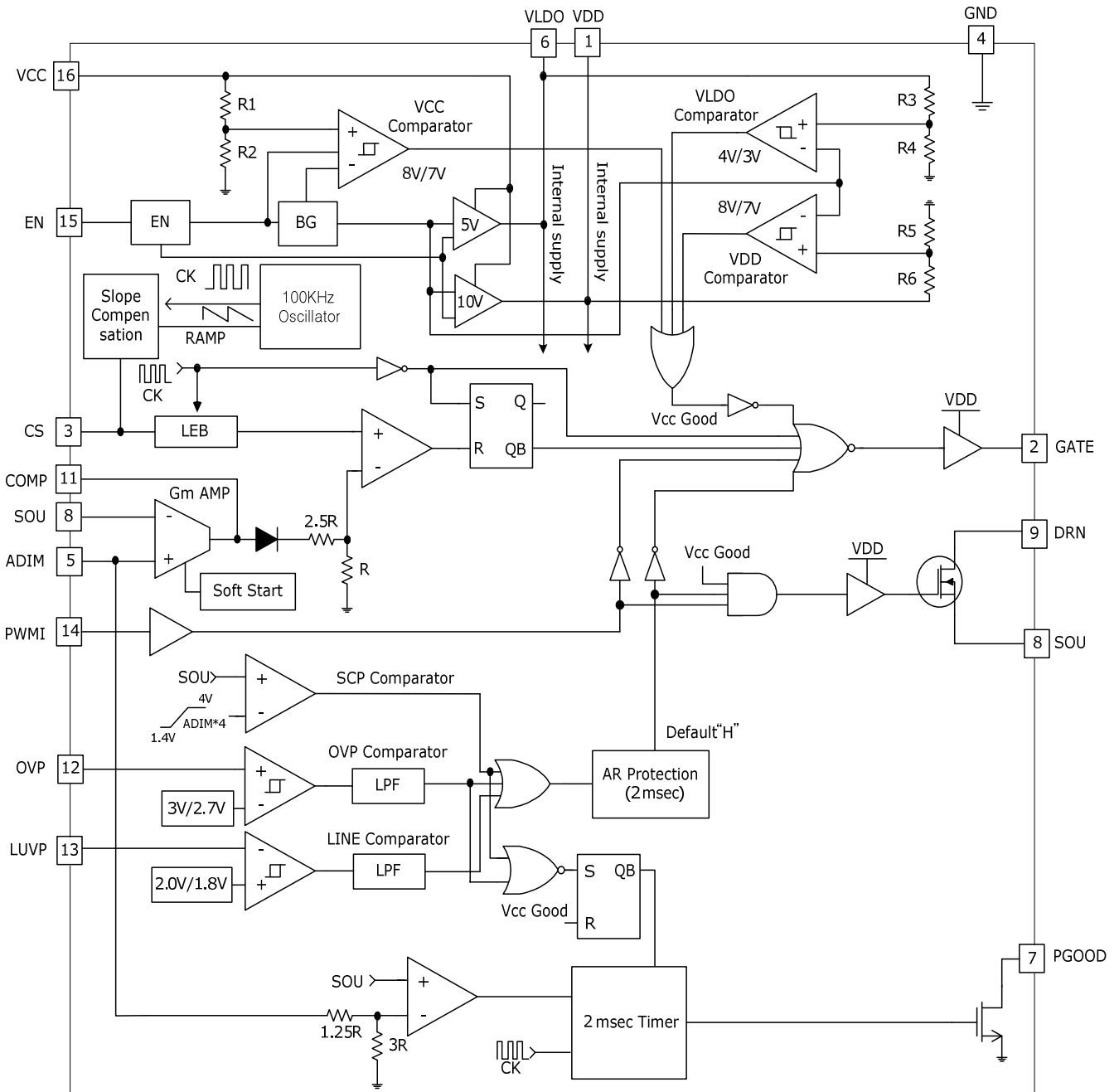
## Pin Configuration



## Pin Description

PIN NO	Description
1	VDD Output for Gate drive voltage
2	GATE Gate drive Output for Boost Convert
3	CS Current sense of the Boost Convert
4	GND Ground
5	ADIM Analog Dimming using DC voltage level
6	VLDO Reference voltage
7	PGOOD Output power good indication (Open-Drain status output, Normal : Open, Protection : Internal GND)
8	SOU Internal Dim MOSFET Source
9	DRN Internal Dim MOSFET Drain
11	COMP Error Amp. Compensation
12	OVP Over Voltage Protection
13	LUV Input Line Under Voltage Protection
14	PWMI PWM Dimming Input
15	EN Enable
16	VCC Input Power Supply

**Functional Block Diagram**



### Absolute Maximum Ratings

PARAMETER	VALUE	UNIT
VCC	-0.3 ~ 36	V
GATE, PWMI, LUVF, VDD	-0.3 ~ 20	V
VLDO, CS, COMP, ADIM, PGOOD, SOU, OVP, EN	-0.3 ~ 5	V
DRN Voltage	250	V
DRN Current	6.2	A
Operating Junction Temperature Range	-40 ~ 125	°C
Absolute Temperature Range(1)	-40 ~ 150	°C
Storage Temperature Range	-65 ~ 150	°C
Lead temperature(soldering, 10sec )	260	°C
Thermal Resistance ( $\theta_{JA}$ )	70	°C/W

**Note 1** : Normal electrical operating is not guaranteed out of the operating junction temperature range.

**Electrical Characteristics**
 $V_{CC}=12V$ ,  $V_{PWMI}=5V$ ,  $C_{GATE}=1nF$ ,  $T_a=25^{\circ}C$ , unless otherwise specified

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
<b>SUPPLY</b>						
$V_{CC,OP}$	Input voltage range	$T_a = -40^{\circ}C \sim 85^{\circ}C$	8.5	-	33	V
$I_{SD}$	Shut down current	$EN = 0V$	40	80	160	$\mu A$
$I_Q$	Operation quiescent current	$PWMI = 0V$ , $EN = 5V$	-	2.5	5.0	mA
$I_{OP}$	Operation Current	$PWMI = 5V$ , $EN = 5V$	-	10	-	mA
$V_{EN}$	$V_{EN,L}$ : Logic Low	-	-	-	0.8	V
	$V_{EN,H}$ : Logic High	-	2.0	-	-	V
$R_{EN}$	Enable pull down resistor	$EN = 5V$	60	120	240	$k\Omega$
$V_{UVLO}$	Under-voltage release threshold	-	7.5	8	8.5	V
	Under-voltage lockout hysteresis	-	-	1	-	V
<b>VLDO &amp; VDD</b>						
$V_{LDO}$	Reference pin voltage	$T_a = -40^{\circ}C \sim 85^{\circ}C$	4.90	5.00	5.10	V
		$T_a = 25^{\circ}C$	4.95	5.00	5.05	V
$V_{LDOL}$	Line regulation	$I_{ref} = 0\mu A$ , $PWMI = 0V$ , $C_{ref} = 0.1\mu F$	-	-	0.02	%/V
$V_{LDOLO}$	Load regulation	$I_{ref} = 0\sim 500\mu A$ , $PWMI = 0V$ , $C_{ref} = 0.1\mu F$	-	-	1	%/mA
$V_{DD}$	Gate Drive voltage	$T_a = 25^{\circ}C$ , $V_{CC} > 12V$ , No load	-	10	-	V
<b>Oscillator</b>						
$F_{OSC}$	Oscillator frequency	-	95	100	105	kHz
$D_{MAX}$	Maximum duty cycle	-	-	90	-	%
<b>GATE</b>						
$I_{SOURCE}$	Gate short circuit current	$V_{GATE} = 0$ , $V_{CC} = 12V$	0.05	0.18	-	A
$I_{SINK}$	Gate sink current	$V_{GATE} = 10V$ , $V_{CC} = 12V$	0.15	0.28	-	A
$T_{RISE}$	GATE output rise time	$C_{GATE} = 1nF$ , $V_{CC} = 12V$	-	50	-	nS
$T_{FALL}$	GATE output fall time	$C_{GATE} = 1nF$ , $V_{CC} = 12V$	-	25	-	nS
$V_{GATE}$	Gate Output Voltage	-	-	10	-	V

**Electrical Characteristics (Continued)**
 $V_{CC}=12V$ ,  $V_{PWMI}=5V$ ,  $C_{GATE}=1nF$ ,  $T_a=25^{\circ}C$ , unless otherwise specified

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
<b>Current Sense</b>						
$T_{BLANK}$	Leading Edge Blanking	-	100	-	375	nS
$T_{DELAY}$	Delay to output of CS comparator(3)	$V_{COMP}=5V$ $V_{CS}=0V$ to 600mV step pulse	-	-	180	nS
$V_{CS,MAX}$	Maximum CS Voltage	$V_{CC}=12V$ , $V_{ADIM}-V_{SOU}=0.2V$	0.44	0.49	0.54	V
<b>Internal Transconductance Opamp</b>						
$A_v$	Open loop DC Gain(3)	-	-	53	-	dB
$V_{CM}$	Input common-mode range	-	0.1	-	3.0	V
$V_o$	Output Voltage Low Limit	$V_{CC}=12V$ , $V_{ADIM}-V_{SOU}=0.2V$	-	0.6	-	V
	Output Voltage High Limit	$V_{CC}=12V$ , $V_{ADIM}-V_{SOU}=0.2V$	-	2.6	-	V
$G_m$	Transconductance(3)	-	400	670	1000	$\mu A/V$
$I_{BIAS}$	Input Bias current	-	-	0.5	1	nA
$V_{OFFSET}$	Input offset voltage	-	-5	-	5	mV
$I_{AMP\_SOURCE}$	AMP Source Current	$V_{ADIM}=2V$ , $V_{SOU}=1V$ , $V_{COMP}=1.5V$	-	-100	-	$\mu A$
$I_{AMP\_SINK}$	AMP Sink Current	$V_{ADIM}=1V$ , $V_{SOU}=2V$ , $V_{COMP}=1.5V$	-	100	-	$\mu A$
<b>PWM Input</b>						
$V_{PWMI(LO)}$	PWMI input Low voltage	-	-	-	0.8	V
$V_{PWMI(HI)}$	PWMI input High voltage	-	2.0	-	-	V
$R_{PWMI}$	PWMI pull-down resistance	$V_{PWMI}=5V$	50	100	200	$k\Omega$
<b>PWM Output</b>						
$T_{RISE,DELAY}$	PWMI_HIGH to DRN On Delay time	-	-	1.0	1.5	$\mu S$
$T_{FALL,DELAY}$	PWMI_LOW to DRN Off Delay time	-	-	0.8	1.2	$\mu S$
<b>Soft-Start</b>						
$T_{SS}$	Time for internal soft-start	-	-	20	-	mS

**Electrical Characteristics (Continued)**
 $V_{CC}=12V$ ,  $V_{PWMI}=5V$ ,  $C_{GATE}=1nF$ ,  $T_a=25^{\circ}C$ , unless otherwise specified

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
<b>Auto Restart Protection ( OVP &amp; LUVP &amp; SCP )</b>						
$T_{AR}$	Auto Restart Time	-	-	2	-	mS
<b>Over Voltage Protection ( OVP )</b>						
$V_{OVP}$	Over voltage protection	-	2.94	3.0	3.06	V
$V_{OVPH}$	Over voltage protection release voltage		-	2.7	-	V
$T_{OVP}$	OVP Filtering time <sup>(3)</sup>		-	200	-	nS
<b>Line Under Voltage Protection ( LUVP )</b>						
$V_{LINE}$	Line under voltage protection	-	1.7	1.8	1.9	V
$V_{LINEH}$	Line under voltage protection release voltage	-	-	2.0	-	V
$T_{LUVP}$	LUVP Filtering time <sup>(3)</sup>	-	-	200	-	nS
<b>Short current protection ( SCP )</b>						
$V_{TH,SCP}$	SCP Comparator threshold voltage	$V_{ADIM} = 0.5V$ $(V_{TH,SCP} = V_{ADIM} * 4)$	1.8	2.0	2.2	V
$V_{SCP}$	SCP Comparator input range	-	1.4	-	4.0	V
$T_{OFF}$	Propagation time for short current detection <sup>(3)</sup>	-	-	-	250	nS
<b>Power Good Indication – Open Drain (Normal : Open, Abnormal : Internal GND)</b>						
$R_{PGOOD}$	Power Good on resistance <sup>(3)</sup>	$V_{PGOOD} = 1V$	-	10	100	ohm
<b>Internal Dimming MOSFET</b>						
$BV_{DSS}$	Drain-Source Breakdown Voltage	$I_D = 250\mu A$ , $V_{CC} = 0V$	250	-	-	V
$I_{DSS}$	Drain Cut-Off Current	$V_{DS} = 250V$ , $V_{PWMI} = 0V$	-	-	1	$\mu A$
$R_{DS(ON)}$	Drain-Source ON Resistance	$V_{GS} = 10V$ , $I_D = 3.1A$	-	-	1	$\Omega$
$T_{SD}$	Thermal Shutdown Temperature	Shutdown Temperature	-	150	-	°C
		Hysteresis, $\Delta T_{SD}$	-	30	-	

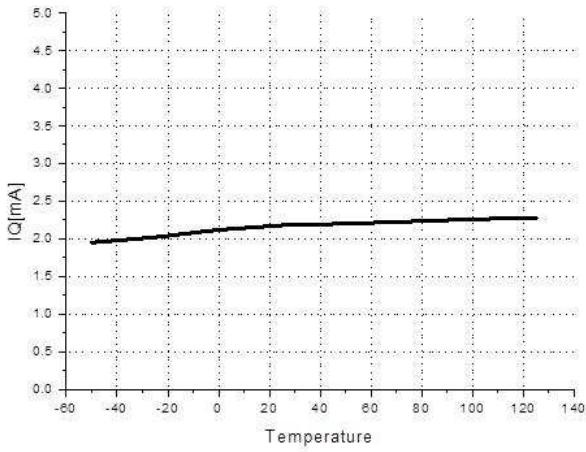
**Note 2** : Stress beyond the maximum ratings listed above may incur permanent damage to the device. Operating above the recommended conditions for extended time may stress the device and affect device reliability. Also the device may not operate normally above the recommended operating conditions. These are stress ratings only.

**Note 3** : These parameters, although guaranteed by design, are not tested in mass production.

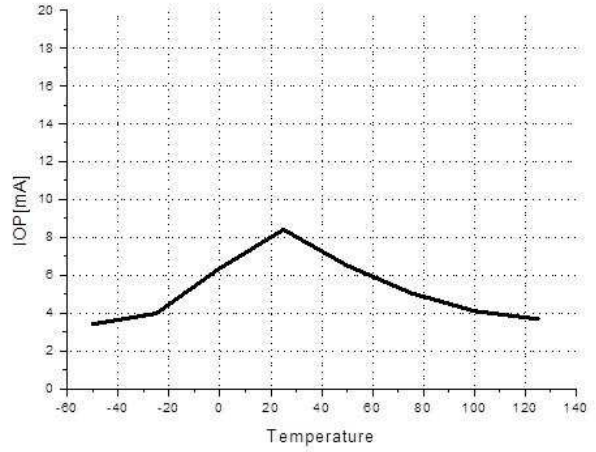
## Typical Operating Characteristics

Unless otherwise noted,  $V_{CC} = 12V$ ,  $V_{PWMI} = 5V$ .

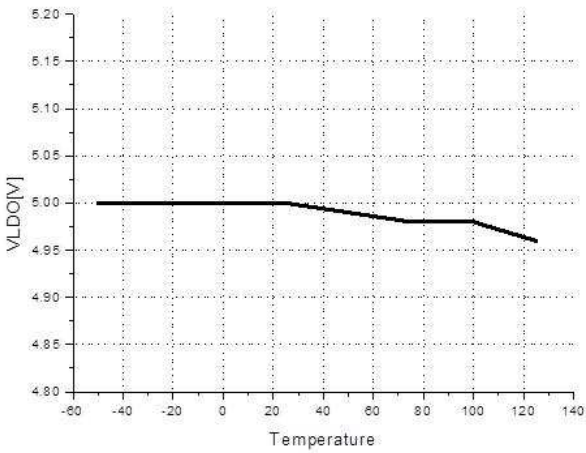
Quiescent Current vs. Temp



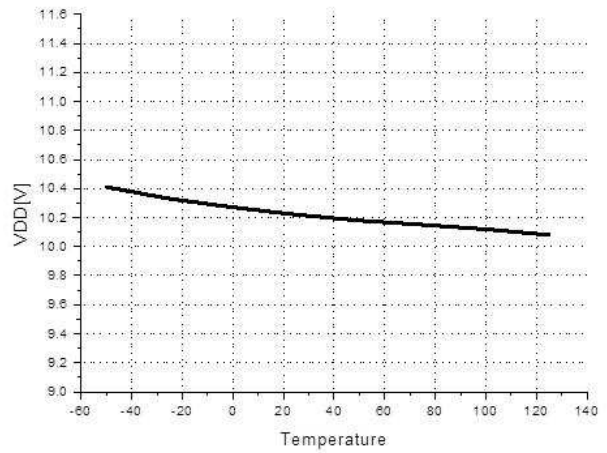
Operation Current vs. Temp



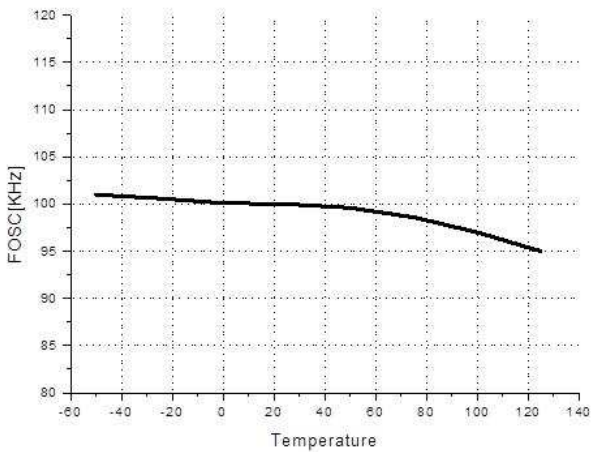
VLDO vs. Temp



VDD vs. Temp



Fosc vs. Temp





## Application Information

### Current Mode Boost switching regulator operation

MAP3301C is being used Current mode control scheme for boost regulation so its response is fast and output voltage is stable.

### Supply voltage and Oscillator

MAP3301C has wide input voltage ranged from 8.5V to 33V. 1uF decoupling capacitor is used to stabilize the internal regulator and minimize noise on VCC pin. This decoupling capacitor should be placed next to VCC pin. Ceramic capacitor is recommended and incorrect placement of this decoupling capacitor may cause the oscillation in the switching waveform

MAP3301C is being operated at fixed 100Khz Switching frequency and max duty is 90%.

### LED Current Input setting (ADIM Input)

MAP3301C's LED current is set by the voltage on ADIM pin and LED sense resistor value as below.

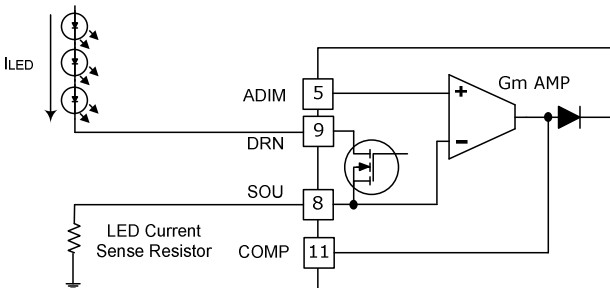


Fig 1. Schematic for LED current set

$$I_{LED} = \frac{V_{ADIM}}{LED\_Current\_Sense\_R}$$

The voltage range on ADIM pin is 0.1V ~ 3.0V. But it is recommended that ADIM Input voltage is higher than 0.4V. The GM Amp Input  $V_{OFFSET}$  is  $\pm 5mV$ . If ADIM voltage use to below 0.4V, LED current tolerance is increases.

### Dimming PWM Input

MAP3301C's PWMI signal is used for both Enable and PWM dimming input. MAP3301C is enabled when PWMI voltage is higher than 2.0V and disabled when PWMI voltage is lower than 0.8V. This pin has internal 100Kohm pull down resistance.

PWM Input	Condition
High (2.0V)	Enable
Low (0.8V)	Disable

### Enable Input

MAP3301C's offers an Enable Function. MAP3301C is enabled when EN voltage is higher than 2.0V and disabled when EN voltage is lower than 0.8V. This pin has internal 120Kohm pull down resistance

EN Input	Condition
High (2.0V)	Enable
Low (0.8V)	Disable

### Protection

MAP3301C has Under Voltage Lock Out (UVLO), Boost switch current limit, Output Over Voltage Protection (OVP), Line Under Voltage Protection(LUVP), LED Short Current Protection(SCP).

When OVP and LED SCP are happened, MAP3301C monitors if the failure condition is released or not every 2mS at Fs 100Khz.

This is MAP3301C's auto restart function.

#### 1. Under Voltage Lock Out (UVLO)

When VCC is higher than 8.0V, MAP3301C's internal 5V regulator and internal circuitry like oscillator, protections, Gate drivers and PDIMO drivers are enabled, and the MAP3301C starts to operate when PWMI voltage and EN signal are higher than 2.0V.

If VCC is lower than 7.0V, MAP3301C is disable due to its under voltage lock out.

#### 2. Boost current limit and Current Sense (CS)

MAP3301C has the Boost current limit function. If the voltage on CS pin is higher than 0.49V (Typ.), the gate pulse is limited every pulse. MAP3301C has 100nS (Min.) leading edge blank.

#### 3. Output Over Voltage Protection (OVP)

When MAP3301C's output voltage is increased abnormally, MAP3301C stops the switching to protect external components.

MAP3301C has 200nS (Typ.) low pass filter on OVP pin, but using external Capacitor is recommended to minimize noise. The total values of  $R_{OVPH}$  and  $R_{OVPL}$  need to be lower than 1Mohm.

OVP threshold voltage is 3.0V and OVP voltage can be set as below.

- OVP set voltage :

$$V_O = 3.0 \times \frac{R_{OVPH} + R_{OVPL}}{R_{OVPL}}$$

- OVP release voltage :

$$V_O = 2.7 \times \frac{R_{OVPH} + R_{OVPL}}{R_{OVPL}}$$

**4. Line Under Voltage Protection (LUVPL)**

When Line voltage is low voltage input, to prevent the stress of the transition for power component, MAP3301C stops the switching to protect external components.

MAP3301C has 200nS (Typ.) low pass filter on LUVPL pin, but using external Capacitor is recommended to minimize noise. The total values of  $R_{LUVPH}$  and  $R_{LUVPL}$  need to be lower than 1Mohm.

LUVPL threshold voltage is 2.0V and LUVPL voltage can be set as below.

- LUVPL set voltage :

$$V_{IN} = 1.8 \times \frac{R_{LUVPH} + R_{LUVPL}}{R_{LUVPL}}$$

- LUVPL release voltage :

$$V_{IN} = 2.0 \times \frac{R_{LUVPH} + R_{LUVPL}}{R_{LUVPL}}$$

**5. LED Short Current Protection (SCP)**

To protect external components, MAP3301C has the LED short protection. If the LED SCP threshold voltage changes based on ADIM voltage as below, so if SOU voltage is higher than LED SCP threshold voltage, MAP3301C will be in LED SCP mode disabling gate for boost MOSFET and dimming MOSFET.

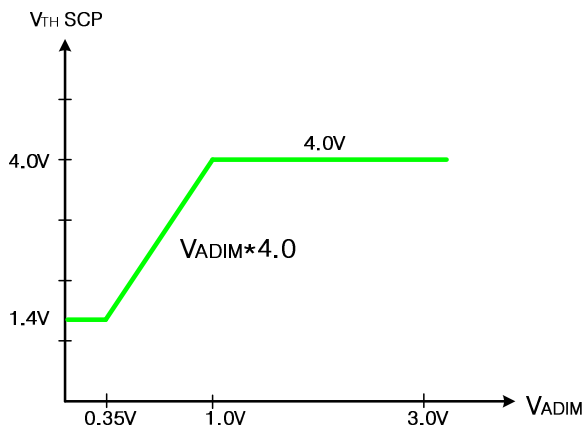


Fig 2. SCP threshold voltage based on ADIM voltage

**6. Auto-Restart Protection**

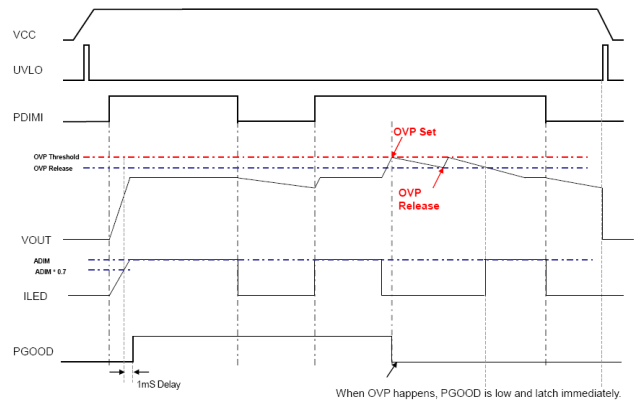
The MAP3301C offers Auto Restart protection function which is recovered into normal operation mode when protection condition is cleared. The auto restart time (TAR) is 2mS at Fs 100Khz.

It is recovered to normal operating mode if SCP or OVP or LUVPL condition is cleared.

**7. Power Good (PGOOD)**

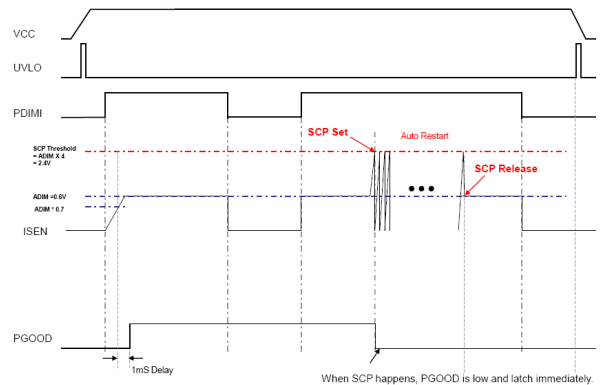
MAP3301C has the PGOOD pin to send out the LED current status. PGOOD will be high when the LED current is higher than 70% of normal LED current.

1) Power Good scheme at OVP Protection.



When OVP happens, PGOOD is low and latch immediately. PGOOD reset should be only shut down of IC Vcc or EN Signal

2) Power Good scheme at SCP Protection.



When SCP happens, PGOOD is low and latch immediately. PGOOD reset should be only shut down of IC Vcc or EN signal.

3) PGOOD Pull up resistance is recommending over than 100Kohm.

## Inductor Selection

Inductor value should be decided before system design. Because the selection of the inductor affects the operating mode of CCM (Continuous current mode) or DCM (Discontinuous current mode), In CCM operation, inductor size should be bigger, even though the ripple current and peak current of inductor can be small. In DCM operation, even ripple current and peak current of inductor should be large while the inductor size can be smaller so that it is more effective in BLU of TV and Notebook application.

The following is the equation to calculate max value of Inductor.

$$L_{(critical)} = \frac{(1-D)^2 \times D \times R_{O(max)} \times T_{S(min)}}{2}$$

Where,

$R_{O(max)}$  = Maximum output impedance  
 $T_{S(min)}$  = Minimum Switching Period

$L_{(Inductance)} > L_{(critical)} \rightarrow$  CCM  
 $L_{(Inductance)} < L_{(critical)} \rightarrow$  DCM

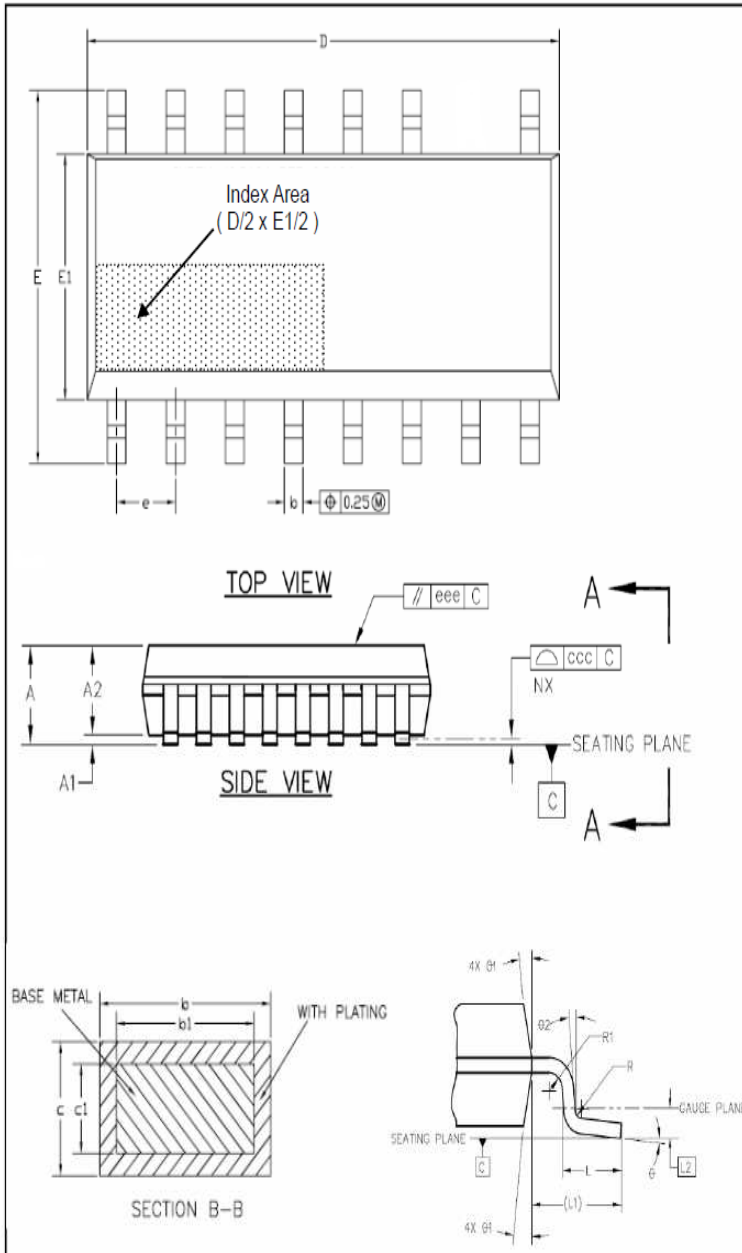
$$D = 1 - \frac{V_{IN}}{V_{OUT}}, \quad R_{O(max)} = \frac{V_{OUT}}{I_{OUT}}, \quad T_{S(min)} = \frac{1}{F_S}$$

## Loop Compensation

The MAP3301C controls in current mode. Current mode easily achieves compensation by consisting simple single Pole from Double Pole that LC filter makes at Voltage mode

In general, crossover frequency is selected from 1/3 ~ 1/6 range of the switching frequency. If  $f_c$  is large, there is possibility of oscillation to occur, although time response gets better. On the other hand, if  $f_c$  is small, time response will be bad, while it has improved stability, which may cause over shoot or under shoot in abnormal condition.

**Physical Dimensions**



Reference JEDEC No. MS-012 (AC)

No	REVISION ITEM	DATE	NAME
Symbol	Min	Nom	Max
A	-	-	1.80
A1	0.05	-	0.25
A2	1.25	-	-
b	0.31	-	0.51
b1	0.28	-	0.48
C	0.10	-	0.30
c1	0.10	-	0.23
D	9.70	-	10.10
E	5.70	-	6.30
E1	3.75	-	4.15
e	1.14	1.27	1.40
L	0.40	-	1.27
L1	1.04 REF		
L2	0.25 BSC		
R	0.07	-	-
R1	0.07	-	-
θ	0°	-	8°
θ1	0°	-	15°

DIV/D	NAME	DATE	TITLE	PACKAGE DRAWING		
DES,BY			DWG,NO			
CH,BY						
APR,BY			REV,NO	0	SHEET	1/1
SCALE	NA	UNIT	mm			

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**Revision History**

Date	Version	Changes
2012-12-07	Version 1.0	Initial Release.
2012-12-18	Version 1.1	Separate part Number. (MAP3301C & MAP3301)