MagnaChip

Datasheet - MAP3301B

Single Channel LED Driver with Internal Dimming MOSFET

General Description

MAP3301B 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.

MAP3301B provides small solution size with internal high voltage & current dimming MOSFET and internal references.

MAP3301B offers the function of accurate and fast LED dimming control using PWM interface.

MAP3301B has the input line under voltage protection, LED Open/Short protection and Power Good indication.

MAP3301B 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 : 200KHz
- 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

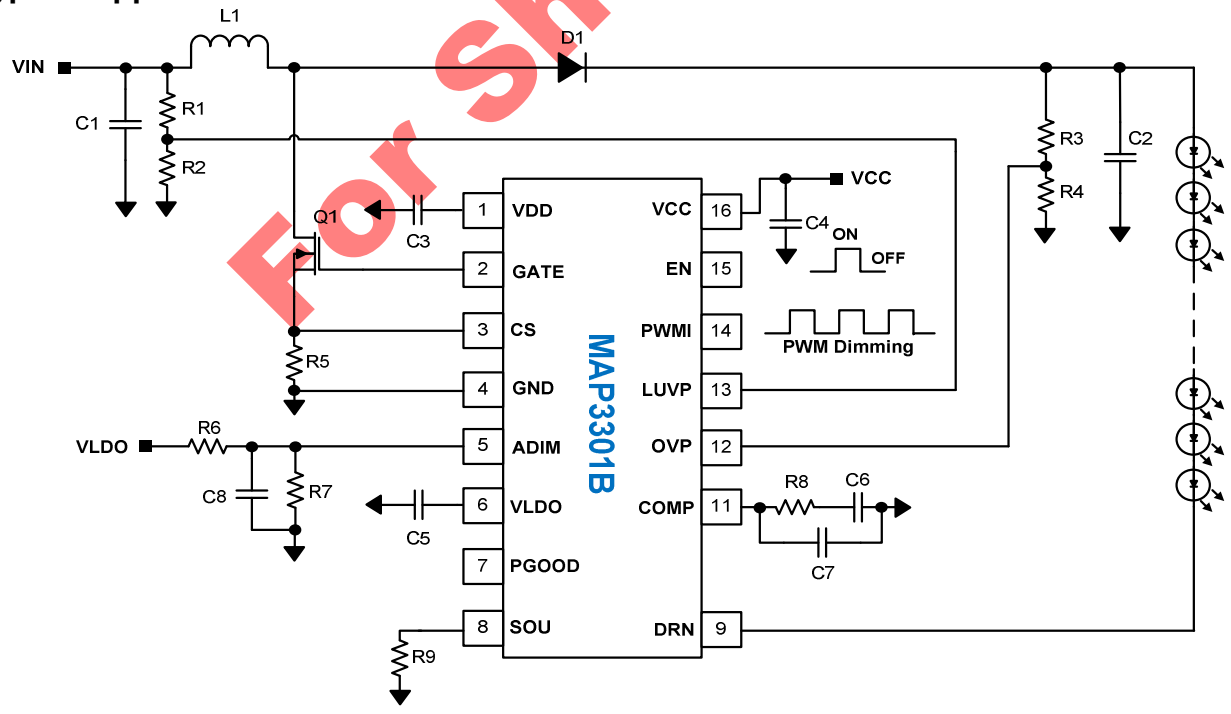
Applications

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

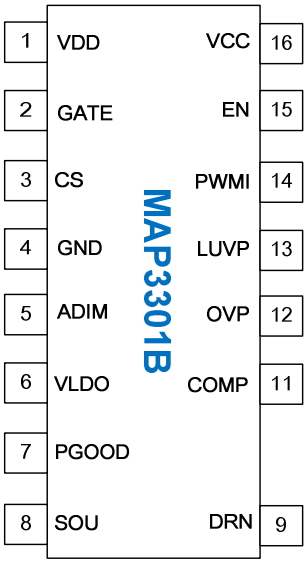
Ordering Information

Part Number	Top Marking	Ambient Temperature Range	Package	RoHS Status
MAP3301BSIRH	MAP3301B	-40℃ to +85℃	SOIC-15 Pin	Halogen Free

Typical Application



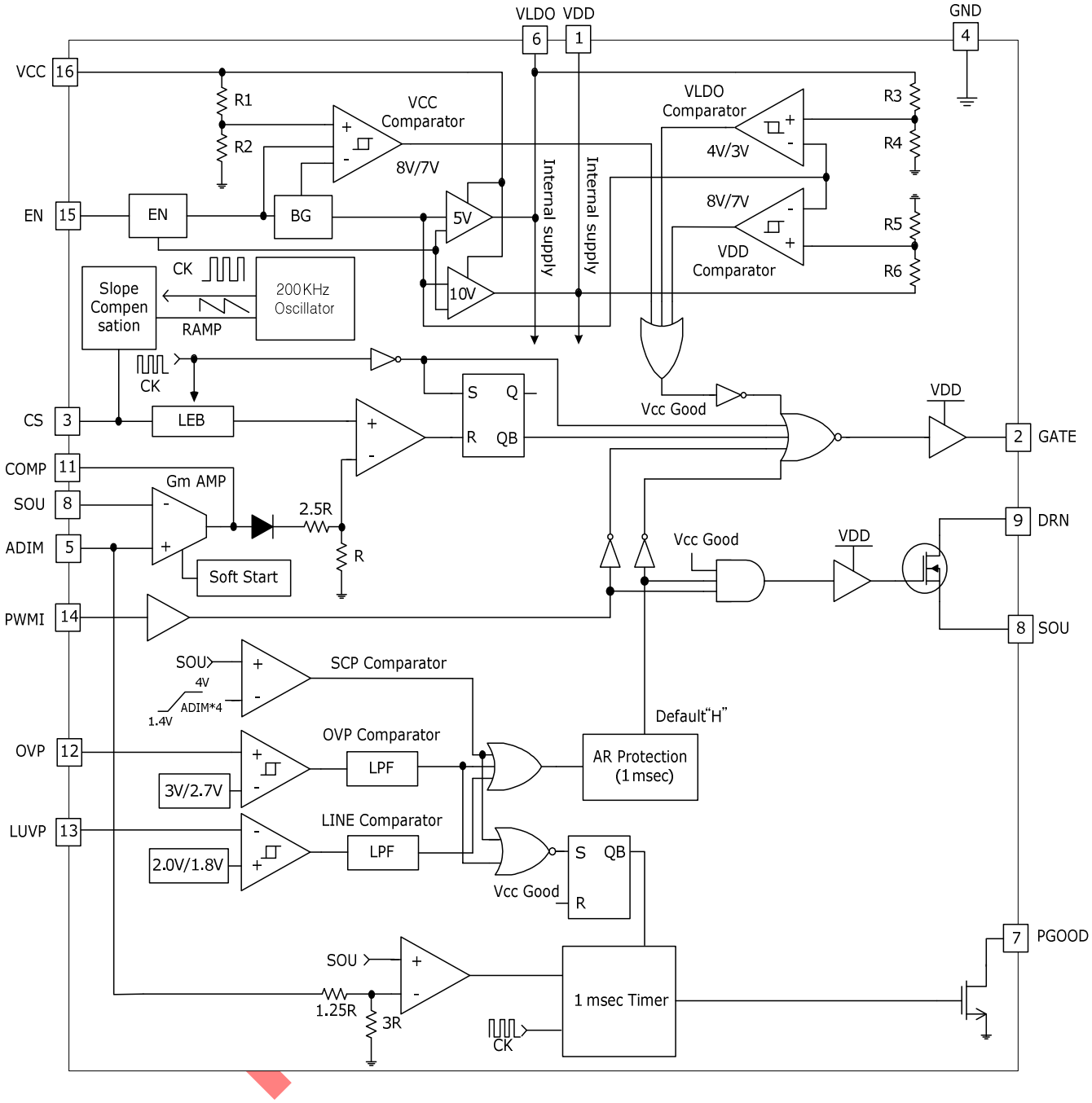
Pin Configuration



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	LUVP	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, LUVP, VDD	-0.3 ~ 20	V
VLDO, CS, COMP, ADIM, PGOOD, SOU, OVP, EN	-0.3 ~ 5	V
DRN Voltage	400	V
DRN Current	3.4	A
Operating Junction Temperature Range	-40 ~ 125	℃
Absolute Temperature Range (1)	-40 ~ 150	℃
Storage Temperature Range	-65 ~ 150	℃
Lead temperature(soldering, 10sec)	260	℃
Thermal Resistance (θJA)	70	℃/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, Ta=25℃, unless otherwise specified

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
SUPPLY						
$V_{CC,OP}$	Input voltage range	Ta = - 40℃ ~ 85℃	8.5	-	33	V
I_{SD}	Shut down current	EN = 0V	40	80	160	uA
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	kΩ
V_{UVLO}	Under-voltage release threshold	-	7.5	8	8.5	V
	Under-voltage lockout hysteresis	-	-	1	-	V
V_{LDO} & V_{DD}						
V_{LDO}	Reference pin voltage	Ta = - 40℃ ~ 85℃	4.875	5.00	5.125	V
		Ta = 25℃	4.925	5.00	5.075	V
V_{LDOLI}	Line regulation	Iref = 0uA, PWMI = 0V, Cref = 0.1uF	-	-	0.02	%/V
V_{LDOLO}	Load regulation	Iref = 0~500uA, PWMI = 0V, Cref = 0.1uF	-	-	1	%/mA
V_{DD}	Gate Drive voltage	Ta = 25℃, Vcc > 12V, No load	-	10	-	V
Oscillator						
F_{OSC}	Oscillator frequency	Ta = 25℃	190	200	210	kHz
D_{MAX}	Maximum duty cycle	-	-	90	-	%
GATE						
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, Ta=25℃, unless otherwise specified

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Current Sense						
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
Internal Transconductance Opamp						
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
Gm	Transconductance(3)	-	400	670	1000	uA/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	-	uA
$I_{\_AMP\_SINK}$	AMP Sink Current	V_{ADIM} = 1V, V_{SOU} = 2V, V_{COMP} = 1.5V	-	100	-	uA
PWM Input						
$V_{PWMI(LO)}$	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	kΩ
PWM Output						
$T_{RISE.DELAY}$	PWMI_HIGH to DRN On Delay time	-	-	1.0	1.5	uS
$T_{FALL.DELAY}$	PWMI_LOW to DRN Off Delay time	-	-	0.8	1.2	uS
Soft-Start						
T_{SS}	Time for internal soft-start	-	-	10	-	mS

Electrical Characteristics (Continued)

V_{CC}=12V, V_{PWMI}=5V, C_{GATE}=1nF, Ta=25℃, unless otherwise specified

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Auto Restart Protection (OVP & LUVP & SCP)						
T_{AR}	Auto Restart Time	-	-	1	-	mS
Over Voltage Protection (OVP)						
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(3)		-	200	-	nS
Line Under Voltage Protection (LUVP)						
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(3)	-	-	200	-	nS
Short current protection (SCP)						
$V_{TH,SCP}$	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 (3)	-	-	-	250	nS
Power Good Indication – Open Drain (Normal : Open, Abnormal : Internal GND)						
R_{PGOOD}	Power Good on resistance(3)	V_{PGOOD} = 1V	-	10	100	ohm
Internal Dimming MOSFET						
BV_{DSS}	Drain-Source Breakdown Voltage	I_D = 250μA, V_{CC} = 0V	400	-	-	V
I_{DSS}	Drain Cut-Off Current	V_{DS} = 410V, VPWMI = 0V	-	-	1	uA
$R_{DS(ON)}$	Drain-Source ON Resistance	V_{GS} = 10V, I_D = 1.7A	-	-	2.5	Ω
T_{SD}	Thermal Shutdown Temperature	Shutdown Temperature	-	150	-	℃
		Hysteresis, ΔT_{SD}	-	30	-	

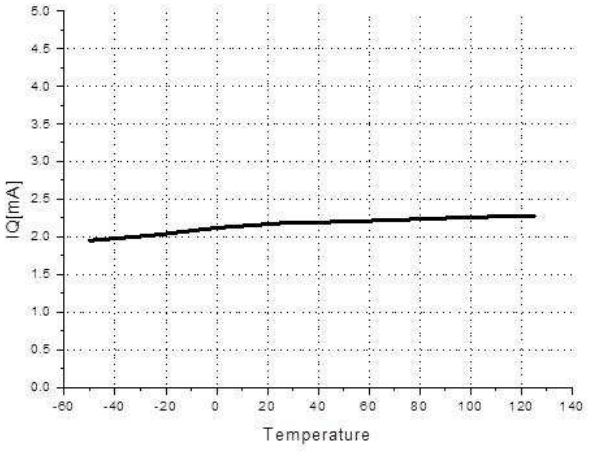
Note 2 : Stress beyond the maximum ratings listed above may incur permanent damage to the device. Operating above the recommended conditions for extended time may stress the device and affect device reliability. Also the device may not operate normally above the recommended operating conditions. These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

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

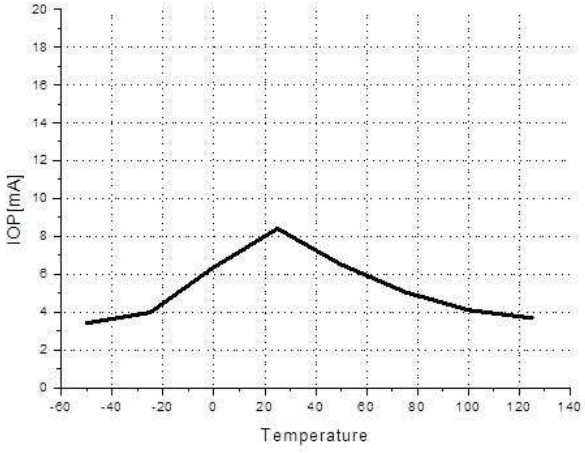
Typical Operating Characteristics

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

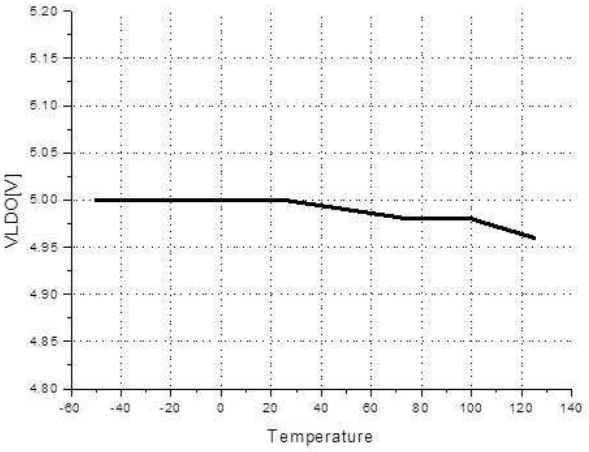
Quiescent Current vs. Temp



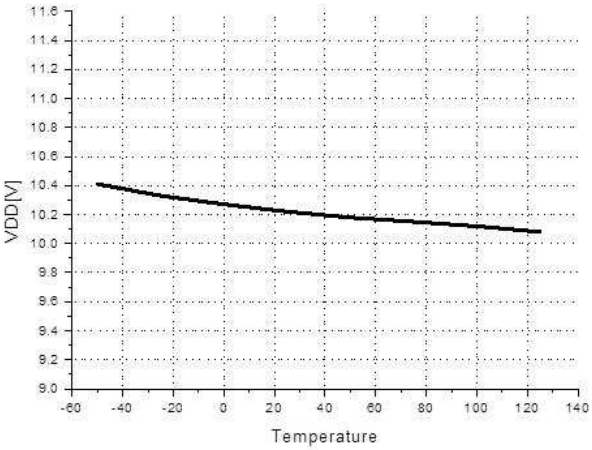
Operation Current vs. Temp



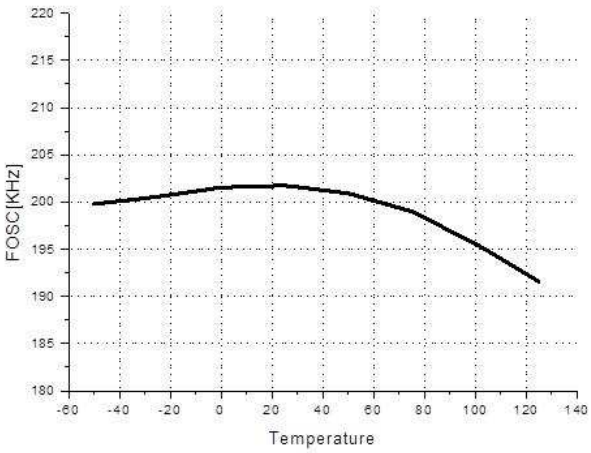
VLDO vs. Temp



VDD vs. Temp



Fosc vs. Temp



Application Information

Current Mode Boost switching regulator operation

MAP3301B is being used Current mode control scheme for boost regulation so its response is fast and output voltage is stable.

Supply voltage and Oscillator

MAP3301B 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
MAP3301B is being operated at fixed 200Khz Switching frequency and max duty is 90%.

LED Current Input setting (ADIM Input)

MAP3301B's LED current is set by the voltage on ADIM pin and LED sense resistor value as below.

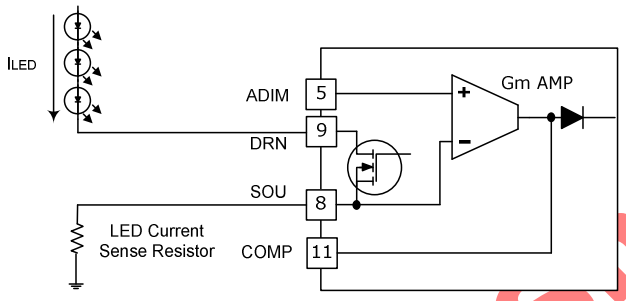


Fig 1. Schematic for LED current set

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

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 ±5mV. If ADIM voltage use to below 0.4V, LED current tolerance is increases.

Dimming PWM Input

MAP3301B's PWMI signal is used for both Enable and PWM dimming input. MAP3301B 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

MAP3301B's offers an Enable Function. MAP3301B is enabled when EN voltage is higher than 2.0V and disabled when EN voltage is lower than 0.8V. This pin has internal 125Kohm pull down resistance

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

Protection

MAP3301B 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, MAP3301B monitors if the failure condition is released or not every 1mS at Fs 200Khz.
This is MAP3301B's Auto restart function.

1. Under Voltage Lock Out (UVLO)

When VCC is higher than 8.0V, MAP3301B's internal 5V regulator and internal circuitry like oscillator, protections, Gate drivers and PDIMO drivers are enabled, and the MAP3301B starts to operate when PWMI voltage and EN signal are higher than 2.0V.
If VCC is lower than 7.0V, MAP3301B is disable due to its under voltage lock out.

2. Boost current limit and Current Sense (CS)

MAP3301B 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. MAP3301B has 100nS (Min.) leading edge blank.

3. Output Over Voltage Protection (OVP)

When MAP3301B's output voltage is increased abnormally, MAP3301B stops the switching to protect external components.
MAP3301B 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 (LUVP)

When Line voltage is low voltage input, to prevent the stress of the transition for power component, MAP3301B stops the switching to protect external components.

MAP3301B has 200nS (Typ.) low pass filter on LUVP 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.
LUVP threshold voltage is 2.0V and LUVP voltage can be set as below.

- LUVP set voltage :

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

- LUVP release voltage :

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

5. LED Short Current Protection (SCP)

To protect external components, MAP3301B 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, MAP3301B will be in LED SCP mode disabling gate for boost MOSFET and dimming MOSFET.

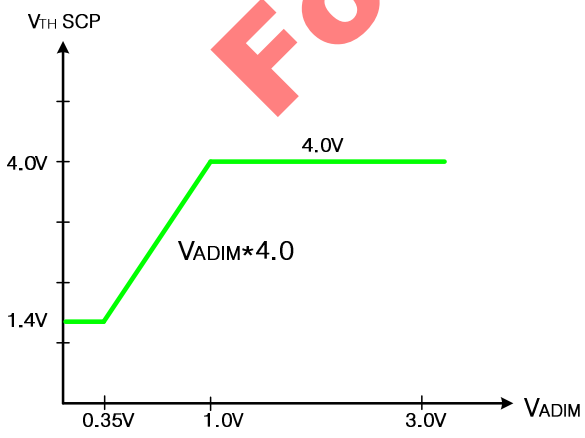


Fig 2. SCP threshold voltage based on ADIM voltage

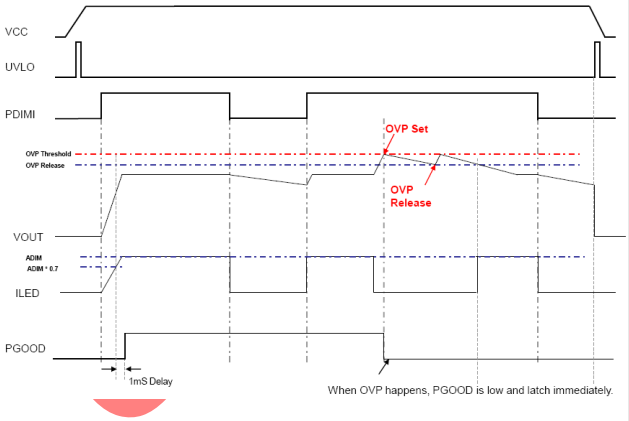
6. Auto-Restart Protection

The MAP3301B offers Auto Restart protection function which is recovered into normal operation mode when protection condition is cleared. The auto restart time (T_{AR}) is 1mS at Fs 200Khz.
It is recovered to normal operating mode if SCP or OVP or LUVP condition is cleared.

7. Power Good (PGOOD)

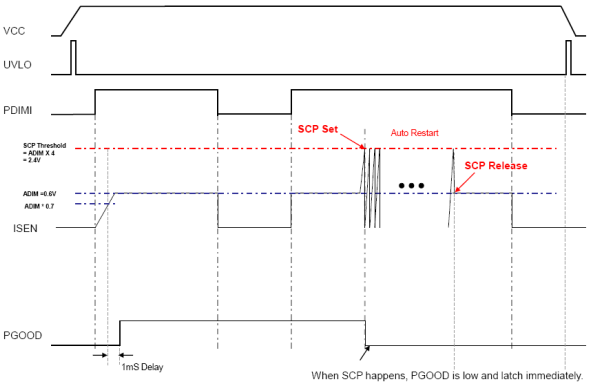
MAP3301B has the PGOOD pin to send out the LED current status. PGOOD will be high when the LED current is higher than 70% of normal LED current.

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,

$R_{0(max)}$ = Maximum output impedance
$T_{S(min)}$ = Minimum Switching Period

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

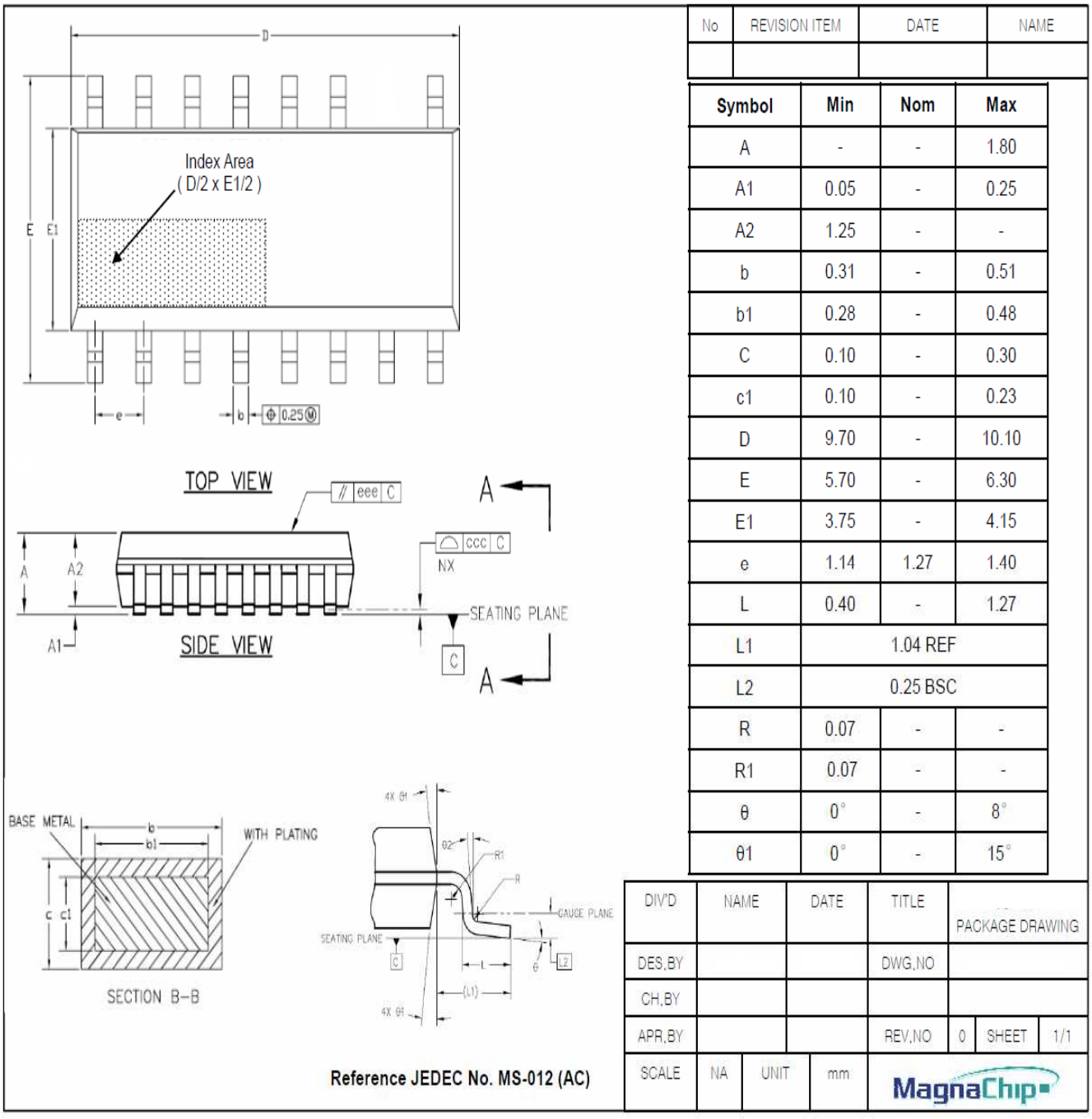
$$D = 1 - \frac{V_{IN}}{V_{OUT}}, \quad R_{O(max)} = \frac{V_{OUT}}{I_{OUT}}, \quad T_{S(min)} = \frac{1}{F_S}$$

Loop Compensation

The MAP3301B controls in current mode. Current mode easily achieves compensation by consisting simple single Pole from Double Pole that LC filer makes at Voltage mode

In general, crossover frequency is selected from 1/3 ~ 1/6 range of the switching frequency. If fc is large, there is possibility of oscillation to occur, although time response gets better.
On the other hand, if fc 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



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	MagnaChip		

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Revision History

Date	Version	Changes
2012-12-18	Version 1.0	Initial Release for Sharp only.