High Efficiency
For LED Backlight, 1ch LED Driver IC

BL0100A

Data Sheet

Description

BL0100A is LED driver IC for LED backlight, and it can do dimming to 0.02% by external PWM signal.

This IC realizes a high efficiency by the boost convertor control that absorbs variability on V_F.

The product easily achieves high cost-performance LED drive system with few external components and enhanced protection functions.

Package

SOIC14

Not to scale

Features

Boost convertor

- Current-Mode type PWM Control
- PWM frequency is 100 kHz to 500kHz
- Maximum On Duty is 90%

LED current control

- PWM Dimming
- Analog Dimming
- High contrast ratio is 1 / 5000

Protections

- Error Signal Output
- Overcurrent Protection for Boost Circuit (OCP) ---Pulse-by-pulse
- Overcurrent Protection for LED Output (LED_OCP) ---Pulse-by-pulse
- Overvoltage Protection (OVP)
- Output Open/Short Protection
- Thermal Shutdown (TSD)

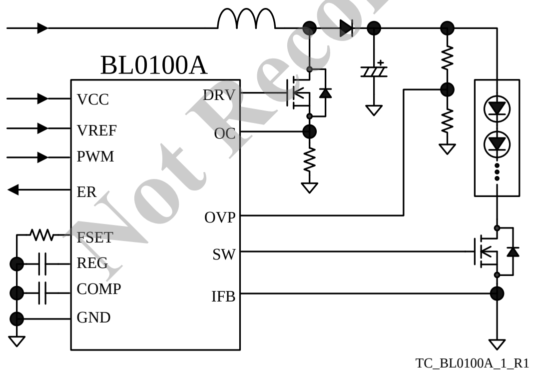
Specifications

- Absolute maximum voltage of VCC pin is 20 V
- Adjustable PWM frequency, 100 kHz to 500 kHz

Applications

- LED Backlights
- LED Lighting etc.

Typical Application



Contents

1. Absolute Maximum Ratings

Current polarities are defined as follows: current going into the IC (sinking) is positive current (+); and current coming out of the IC (sourcing) is negative current (−).
Unless otherwise specified, T_A is 25 °C.

Parameter	Symbol	Test Conditions	Pins	Rating	Unit
REG Pin Source Current	I_{REG}		2−7	−1	mA
OVP Pin Voltage	V_{OVP}		3−7	−0.3 to 5	V
PWM Pin Voltage	V_{PWM}		4−7	−0. to 5	V
IFB Pin Clamp Current	I_{FB}	Single pulse 5 µs	12−7	−10	mA
FSET Pin Source Current	I_{FSET}		6−7	−300	µA
VCC Pin Voltage	V_{CC}		8−7	−0.3 to 20	V
SW Pin Voltage	V_{SW}		9−7	−0.3 to V_{CC} + 0.3	V
DRV Pin Voltage	V_{DRV}		10−7	−0.3 to V_{CC} + 0.3	V
OC Pin Voltage	V_{OC}		11−7	−0.3 to 5	V
ER Pin Voltage	V_{ER}		14−7	−0.3～V_{REG}	V
VREF Pin Voltage	V_{REF}		1−7	−0.3 to 5	V
Operating Ambient Temperature	T_{op}		—	−40 to 85	°C
Storage Temperature	T_{stg}		—	−40 to 125	°C
Junction Temperature	T_j		—	150	°C

2. Electrical characteristics

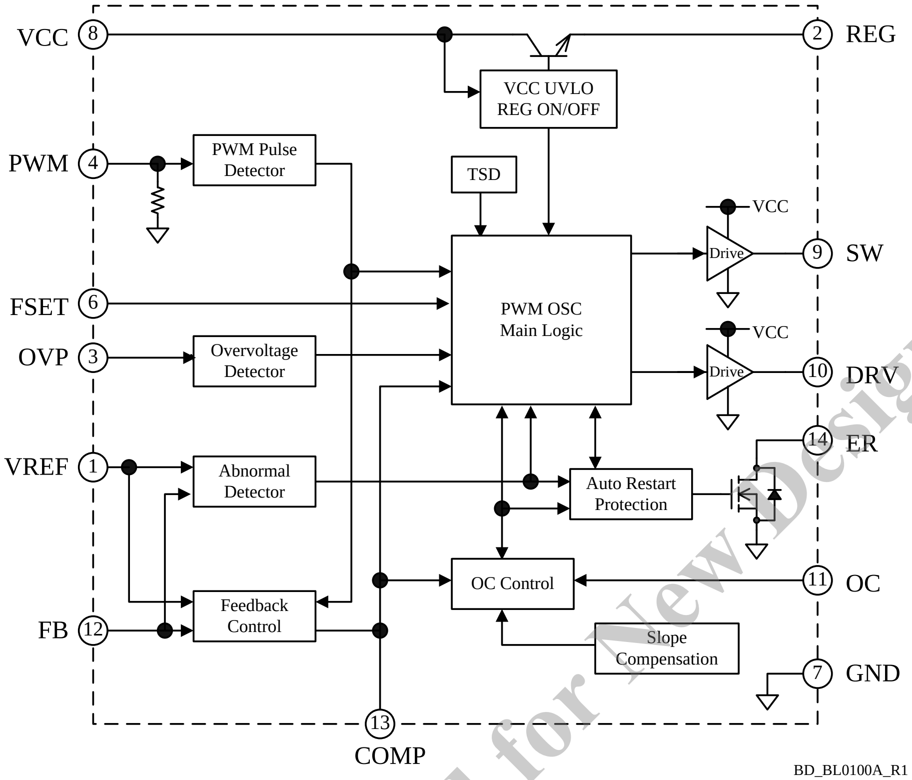
Current polarities are defined as follows: current going into the IC (sinking) is positive current (+); and current coming out of the IC (sourcing) is negative current (−).
Unless otherwise specified, T_A is 25 °C, V_{CC} = 12 V.

Parameter	Symbol	Test Conditions	Pins	Min.	Typ.	Max.	Unit
Start / Stop Operation							
Operation Start Voltage[1]	$V_{CC(ON)}$		8−7	8.5	9.6	10.5	V
Operation Stop Voltage	$V_{CC(OFF)}$		8−7	8.0	9.1	10.0	V
Circuit Current in Operation	$I_{CC(ON)}$		8−7	—	5.3	8.0	mA
Circuit Current in Non-Operation	$I_{CC(OFF)}$	V_{CC} = 8 V	8−7	—	70	200	µA
REG Pin Output Voltage	V_{REG}		2−7	4.9	5.0	5.1	V
Oscillation							
PWM Operation Frequency 1	f_{PWM1}	V_{FSET} = 2 V	10−7	95	100	105	kHz
PWM Operation Frequency 2	f_{PWM2}	R22 = 4.7 kΩ	10−7	440	500	560	kHz
Maximum ON Duty	D_{MAX}		10−7	85	90	95	%
Minimum ON Time	t_{MIN}		10−7	40	140	240	ns
COMP Pin Voltage at Oscillation Start	$V_{COMP(ON)}$		13−7	0.35	0.50	0.65	V
COMP Pin Voltage at Oscillation Stop	$V_{COMP(OFF)}$		13−7	0.10	0.25	0.40	V
VREF / IFB Pin							
VREF Pin Minimum Setting Voltage	$V_{REF(MIN)}$	V_{REF} = 0 V	1−7	0.05	0.25	0.45	V

[1] $V_{CC(ON)} > V_{CC(OFF)}$

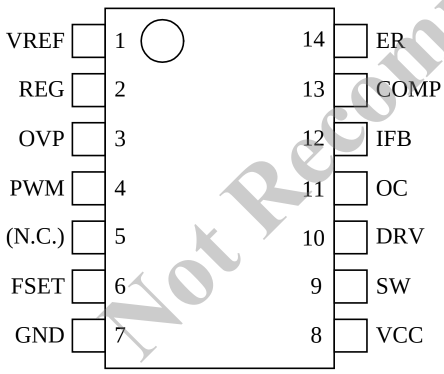
Parameter	Symbol	Test Conditions	Pins	Min.	Typ.	Max.	Unit
VREF Pin Maximum Setting Voltage	$V_{REF(MAX)}$	V_{REF} = 5 V	1−7	1.75	2.00	2.35	V
IFB Pin Voltage at Auto Restart Operation	$V_{IFB(AR)}$	V_{REF} = 1 V	12−7	0.45	0.50	0.55	V
IFB Pin Voltage at COMP Charge Switching	$V_{IFB(COMP)}$	V_{REF} = 1 V	12−7	0.55	0.60	0.65	V
IFB Pin Overcurrent Protection Low Threshold Voltage	$V_{IFB(OCL)}$	V_{REF} = 1 V	12−7	1.9	2.0	2.1	V
IFB Pin Overcurrent Protection Release Threshold Voltage	$V_{IFB(OCL-OFF)}$	V_{REF} = 1 V	12−7	1.5	1.6	1.7	V
IFB Pin Overcurrent Protection High Threshold Voltage	$V_{IFB(OCH)}$		12−7	3.8	4.0	4.2	V
IFB Pin Bias Current	$I_{IFB(B)}$	V_{IFB} = 5 V	12−7	—	—	1	µA
Current Detection Threshold Voltage	V_{IFB}	V_{REF} = 1 V	12−7	0.98	1.00	1.02	V
COMP Pin							
COMP Pin Maximum Output Voltage	$V_{COMP(MAX)}$	V_{IFB} = 0.7 V	13−7	4.8	5.0	—	V
COMP Pin Minimum Output Voltage	$V_{COMP(MIN)}$	V_{IFB} = 2.0 V	13−7	—	0	0.2	V
Transconductance	gm		—	—	640	—	µS
COMP Pin Source Current	$I_{COMP(SRC)}$	V_{IFB} = 0.7 V	13−7	−77	−57	−37	µA
COMP Pin Sink Current	$I_{COMP(SNK)}$	V_{IFB} = 1.5 V	13−7	37	57	77	µA
COMP Pin Charge Current at Startup	$I_{COMP(S)}$	V_{COMP} = 0 V	13−7	−19	−11	−3	µA
COMP Pin Reset Current	$I_{COMP(R)}$		13−7	200	360	520	µA
ER Pin							
ER Pin Sink Current during Non-Alarm	I_{ER}	V_{ER} = 1 V	14−7	2.5	4.4	6.3	mA
Boost Parts Overcurrent Protection (OCP)							
OC Pin Overcurrent Protection Threshold Voltage	V_{OCP}	V_{COMP} = 4.5 V	11−7	0.57	0.60	0.63	V
Overvoltage Protection (OVP)							
OVP Pin Overvoltage Protection Threshold Voltage	V_{OVP}		3−7	2.85	3.00	3.15	V
OVP Pin OVP Release Threshold Voltage	$V_{OVP(OFF)}$		3−7	2.60	2.75	2.90	V
PWM Pin							
PWM Pin ON Threshold Voltage	$V_{PWM(ON)}$		4−7	1.4	1.5	1.6	V
PWM Pin OFF Threshold Voltage	$V_{PWM(OFF)}$		4−7	0.9	1.0	1.1	V
PWM Pin Impedance	R_{PWM}		4−7	100	200	300	kΩ
SW / DRV Pin							
SW Pin Source Current	$I_{SW(SRC)}$		9−7	—	−85	—	mA
SW Pin Sink Current	$I_{SW(SNK)}$		9−7	—	220	—	mA
DRV Pin Source Current	$I_{DRV(SRC)}$		10−7	—	−0.36	—	A
DRV Pin Sink Current	$I_{DRV(SNK)}$		10−7	—	0.85	—	A
Thermal Shutdown Protection (TSD)							
Thermal Shutdown Activating Temperature	$T_{j(TSD)}$		—	125	—	—	°C
Hysteresis Temperature of TSD	$T_{j(TSD)HYS}$		—	—	65	—	°C
Thermal Resistance							
Thermal Resistance from Junction to Ambient	θ_{j-A}		—	—	—	120	°C/W

3. Block Diagram



BD_BL0100A_R1

4. Pin Configuration Definitions



Number	Name	Function
1	VREF	Detection voltage setting
2	REG	Internal regulator output
3	OVP	Overvoltage detection signal input
4	PWM	Dimming MOSFET gate drive output
5	(N.C.)	—
6	FSET	Boost MOSFET drive frequency setting
7	GND	Ground
8	VCC	Power supply voltage input
9	SW	PWM dimming drive output
10	DRV	Boost MOSFET gate drive output
11	OC	Current mode control signal input and overcurrent protection signal input
12	IFB	Feedback signal input of current detection
13	COMP	Phase compensation and soft-start setting
14	ER	Error signal output

5. Typical Application

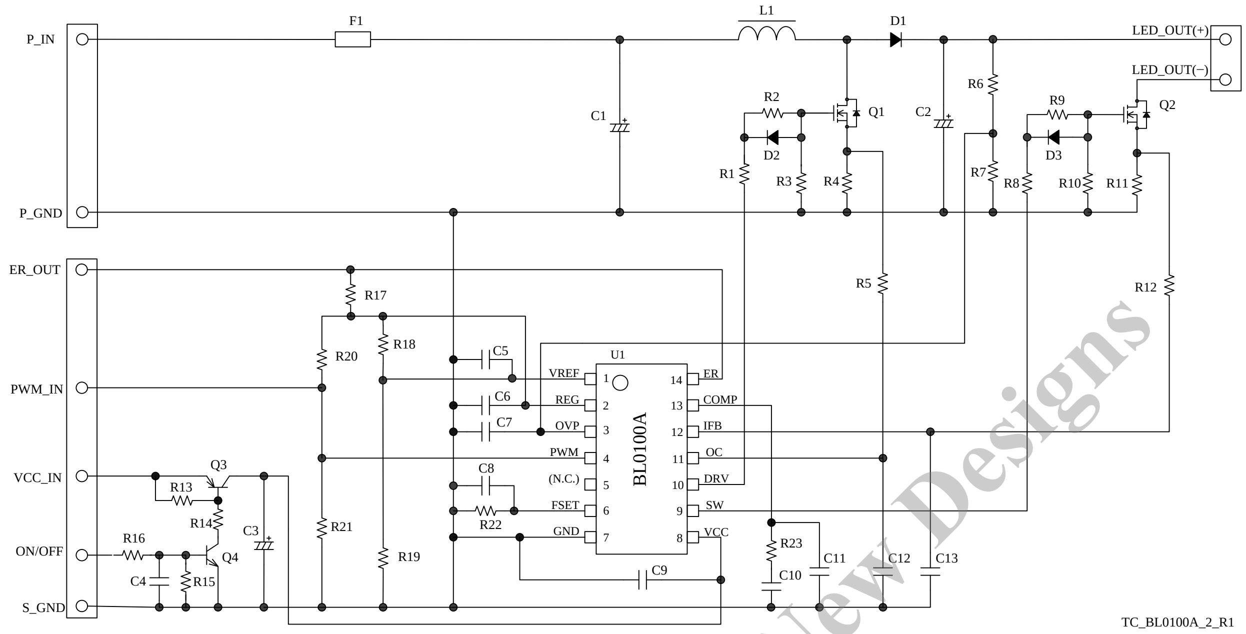
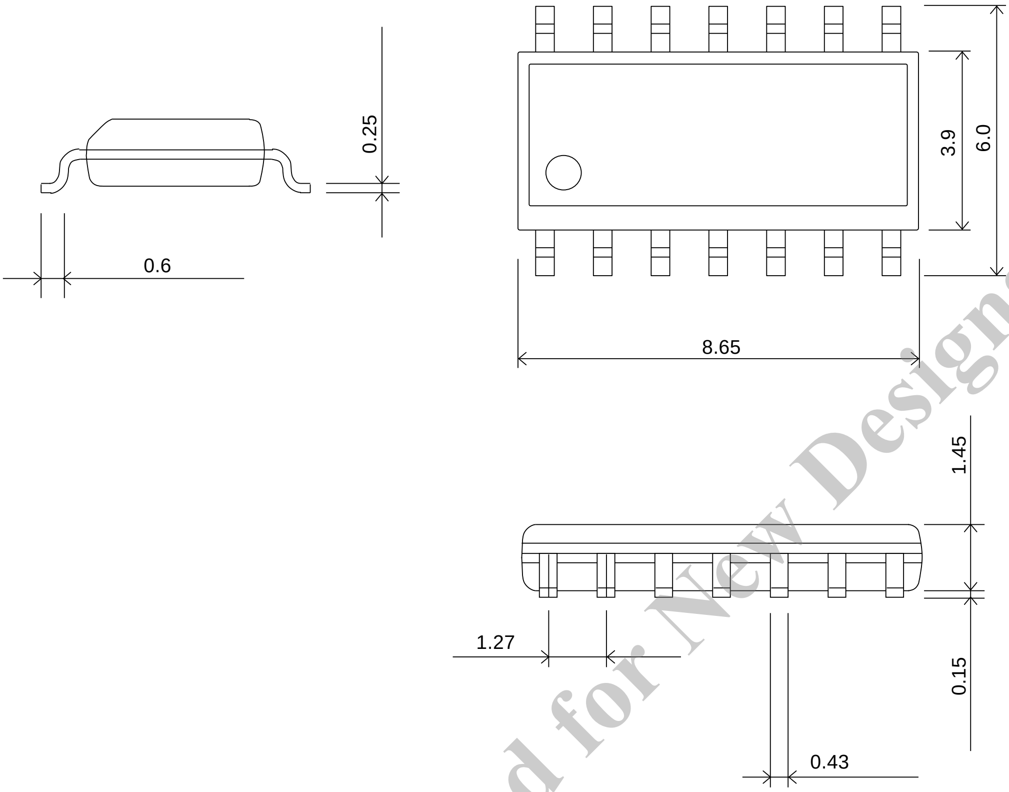


Figure 5-1 Typical Application Circuit

6. Physical Dimensions

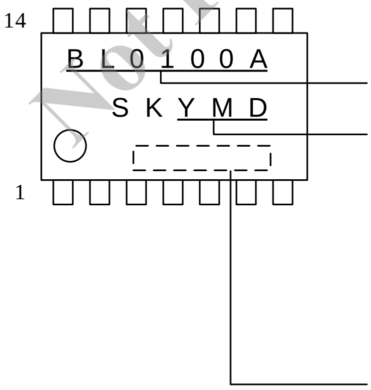
- SOIC14



NOTES:

- Dimension is in millimeters
- Pb-free. Device composition compliant with the RoHS directive

7. Marking Diagram



Part Number

Lot Number:
Y is the last digit of the year of manufacture (0 to 9)
M is the month of the year (1 to 9, O, N, or D)
D is a period of days:
1: the first 10 days of the month (1st to 10th)
2: the second 10 days of the month (11th to 20th)
3: the last 10–11 days of the month (21st to 31st)

Control Number

8. Operational Description

All of the parameter values used in these descriptions are typical values, unless they are specified as minimum or maximum.

Current polarities are defined as follows: current going into the IC (sinking) is positive current (+); and current coming out of the IC (sourcing) is negative current (−).

8.1 Startup Operation

Figure 8-1 shows the VCC pin peripheral circuit. The VCC pin is the power supply input for control circuit from the external power supply.

When the VCC pin voltage increases to the Operation Start Voltage, $V_{CC(ON)}$ = 9.6 V, the control circuit starts operation. After that, when the PWM pin voltage exceeds the PWM Pin ON Threshold Voltage, $V_{PWM(ON)}$ of 1.5 V (less than absolute maximum voltage of 5 V), the COMP Pin Charge Current at Startup, $I_{COMP(S)}$ = −11 µA, flows from the COMP pin. This charge current flows to capacitors at the COMP pin. When the COMP pin voltage increases to the COMP Pin Voltage at Oscillation Start, $V_{COMP(ON)}$ = 0.50 V or more, the control circuit starts switching operation. As shown in Figure 8-2, when the VCC pin voltage decreases to the Operation Stop Voltage, $V_{CC(OFF)}$ = 9.1 V, the control circuit stops operation, by the UVLO (Undervoltage Lockout) circuit, and reverts to the state before startup.

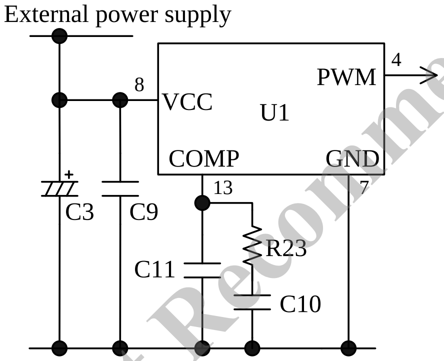


Figure 8-1. VCC Pin Peripheral Circuit

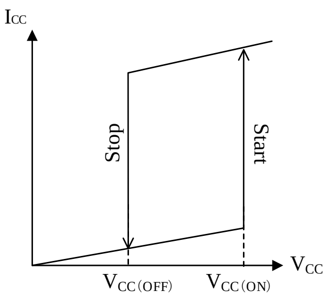


Figure 8-2. V_{CC} Versus I_{CC}

When the on-duty of the PWM dimming signal is small, the charge current at the COMP pin is controlled as follows in order to raise the output current quickly at startup.

Figure 8-3 shows the operation waveform with the PWM dimming signal at startup.

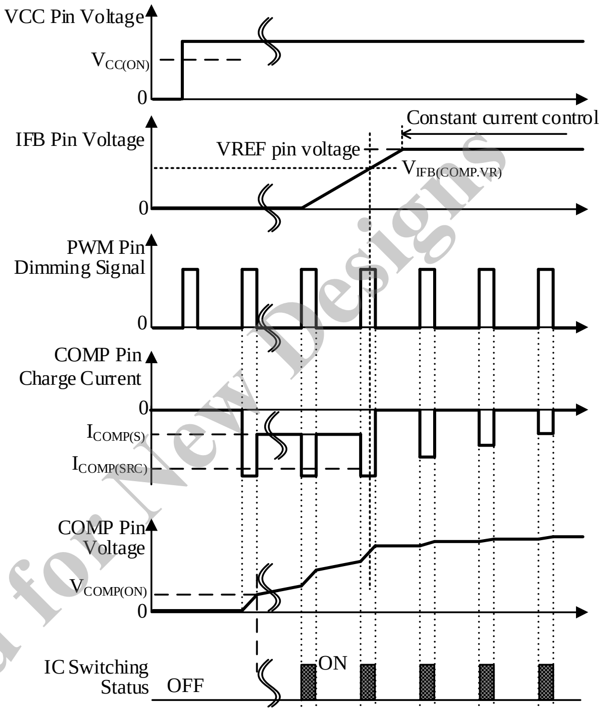


Figure 8-3. Startup Operation during PWM Dimming

While the IFB pin voltage increases to the IFB Pin Voltage at COMP Charge Switching, $V_{IFB(COMP.VR)}$, a capacitors at the COMP pin are charged by $I_{COMP(S)}$ = –11 µA. During this period, they are charged by the COMP Pin Source Current, $I_{COMP(SRC)}$ = –57 µA, when the PWM pin voltage is 1.5 V or more. Thus, the COMP pin voltage increases immediately. When the IFB pin voltage increases to $V_{IFB(CMP1.VR)}$ or more, the COMP pin source current is controlled according to the feedback amount, and the output current is controlled to be constant. The on-duty gradually becomes wide according to the increase of the COMP pin voltage, and the output power increases (Soft start operation). Thus, power stresses on components are reduced.

When the VCC pin voltage decreases to the operation stop voltage or less, or the Auto Restart operation (see the Section 8.5 Protection Function) after protection is achieved, then the control circuit stops switching operation, and capacitors at the COMP pin are discharged by the COMP Pin Reset Current, $I_{COMP(R)}$ = 360 µA, simultaneously. The soft start operation is achieved at restart. The IC is operated by Auto Restart 1 at startup operation. See the Section 8.5 Protection Function about the caution of startup operation. $V_{IFB(COMP.VR)}$ is determined by the VREF pin voltage, as shown in Figure 8-4. When VREF pin voltage is 1V, the value of $V_{IFB(COMP.VR)}$ becomes 0.60 V.

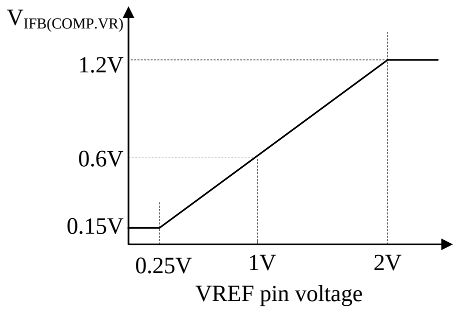


Figure 8-4. VREF Pin Voltage Versus IFB Pin Voltage at COMP Charge Switching

8.2 Constant Current Control Operation

Figure 8-5 shows the IFB pin peripheral circuit.

When Q2 turns on, the LED output current, $I_{OUT(CC)}$, is detected by the current detection resistor, R11. The IC compares the IFB pin voltage with the VREF pin voltage by the internal error amplifier, and controls the IFB pin voltage so that it gets close to the VREF pin voltage.

The reference voltage at the VREF pin is the divided voltage of the REG pin voltage, V_{REG} = 5 V, by R20 and R21, and thus this voltage can be externally adjusted.

The setting current, $I_{OUT(CC)}$, of the LED_OUT can be calculated as follows.

$$I_{OUT(CC)} = \frac{V_{REF}}{R_{SEN}} \qquad (8\text{-}1)$$

where, V_{REF} is the VREF pin voltage (The recommended range is 0.5 V to 2.0 V), and R_{ESN} is the value of R11.

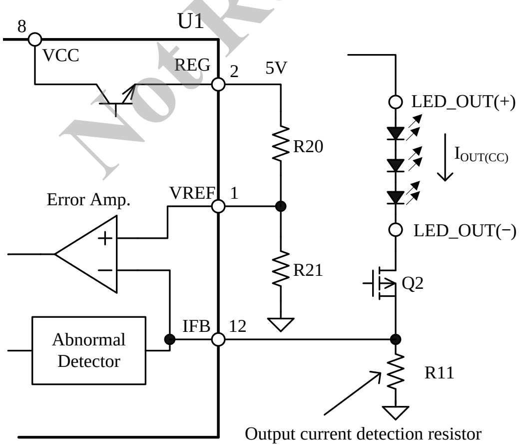


Figure 8-5. IFB Pin Peripheral Circuit

8.3 PWM Dimming Function

Figure 8-6 shows the peripheral circuit of PWM pin and SW pin. The PWM pin is used for the PWM dimming signal input. The SW pin drives the gate of external MOSFET, Q2. The SW pin voltage is turned on / off by PWM signal, and thus the dimming of LED is controlled by PWM signal input.

As shown in Figure 8-7, when the PWM pin voltage becomes the PWM Pin ON Threshold Voltage, $V_{PWM(ON)}$ = 1.5 V or more, the SW pin voltage becomes V_{CC}. When the PWM pin voltage becomes the PWM Pin OFF Threshold Voltage, $V_{PWM(OFF)}$ = 1.0 V or less, the SW pin voltage becomes 0.1 V or less. The PWM pin has the absolute maximum voltage of −0.3 V to 5.0 V, and the input impedance, R_{PWM}, of 200 kΩ. The PWM dimming signal should meet these specifications and threshold voltages of $V_{PWM(ON)}$ and $V_{PWM(OFF)}$.

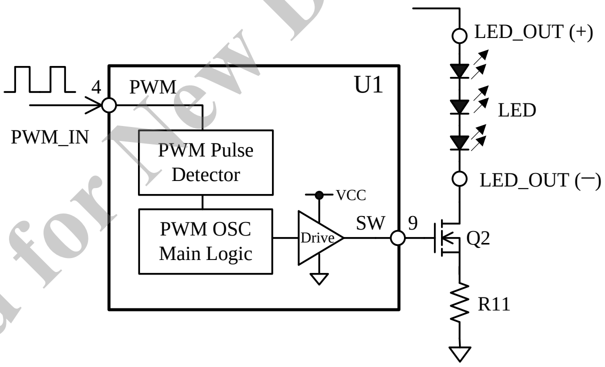


Figure 8-6. The Peripheral Circuit of PWM Pin and SW Pin.

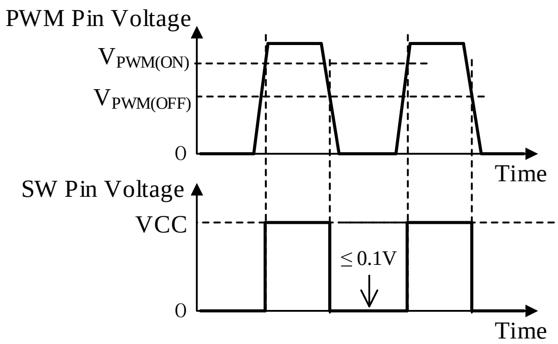


Figure 8-7. The Waveform of PWM Pin and SW Pin

8.4 Gate Drive

Figure 8-8 shows the peripheral circuit of DRV pin and SW pin and FSET pin. The DRV pin is for boost MOSFET, Q1. The SW pin is for dimming MOSFET, Q2. Table 8-1 shows drive voltages and currents of DRV pin and SW pin.

- Q1 and Q2 should be selected so that these $V_{GS(th)}$ threshold voltages are less than V_{CC} enough over entire operating temperature range.
- Peripheral components of Q1 (R1, R2, and D2) and Q2 (R8, R9, and D3) affect losses of power MOSFET, gate waveform (ringing caused by the printed circuit board trace layout), EMI noise, and so forth, these values should be adjusted based on actual operation in the application.
- R3 for Q1 and R10 for Q2 are used to prevent malfunctions due to steep dv/dt at turn-off of the power MOSFET, and these resistors are connected near each the gate of the power MOSFETs and the ground line side of the current detection resistance. The reference value of them is from 10 kΩ to 100 kΩ.

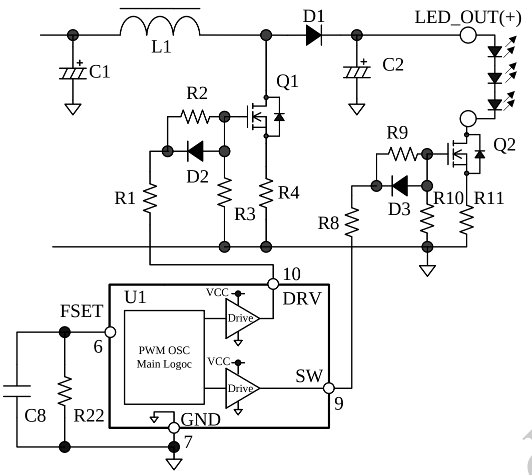


Figure 8-8. The Peripheral Circuit of DRV Pin, SW Pin and FSET Pin

Table 8-1. Drive Voltage and Current

Pins	Drive Voltage, V_{DRV}		Drive Current, I_{DRV}	
	High	Low	Source	Sink
DRV	V_{CC}	0.1V or less	–0.36 A	0.85 A
SW	V_{CC}	0.1V or less	–85 mA	220 mA

As shown in Figure 8-9, the PWM oscillation frequency of DRV pin can be set between 100 kHz and 500 kHz, depending on the value of R22 connected to FSET pin, R_{FSET}.

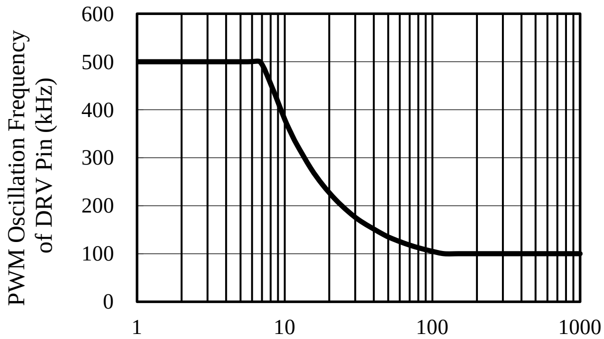


Figure 8-9. Relation between PWM Oscillation Frequency and R_{FSET}

8.5 Protection Function

As shown in Table 8-2, the IC performs protection operations according to kind of abnormal state. In all protection functions, when the fault condition is removed, the IC returns to normal operation automatically. The intermitted oscillation operation reduces stress on the power MOSFET, the secondary rectifier diode, and so forth.

Table 8-2. Relationship between a Kind of Abnormal State and Protection Operations

	Abnormal States	Protection Operations
1	Overcurrent of Boost Circuit (OCP)	Auto Restart 1
2	Overcurrent of LED Output (LED_OCP)	
3	Overvoltage of LED_OUT(+) (OVP)	
4	Short Mode between LED_OUT(−) and GND	
5	Short Mode of LED Current Detection Resistor (R_{SEN}_Short)	
6	Short Mode of Both Ends of LED Output	Auto Restart 2
7	Open Mode of LED Current Detection Resistor (R_{SEN}_Open)	
8	Overtemperature of Junction of IC (TSD)	Auto Restart 3

- **Auto Restart 1:**
  As shown in Figure 8-10, the IC repeats an intermitted oscillation operation, after the detection of any one of abnormal states 1 to 5 in Table 8-2. This intermitted oscillation is determined by t_{ARS1} or t_{ARS2}, and t_{AROFF1}. The t_{ARS1} is an oscillation time in the first intermitted oscillation cycle, T_{AR1}. The t_{ARS2} is an oscillation time in the second and subsequent intermitted oscillation cycle, T_{AR2}. The t_{AROFF1} is a non-oscillation time in all intermitted oscillation cycle.
  When PWM dimming frequency is low and the on-duty is small, the startup operation, the restart operation from on-duty = 0% and the restart operation from intermitted oscillation operation need a long time.

Thus the value of t_{ARS1} and t_{ARS2} depend on frequency and on-duty of the PWM dimming signal, as shown in Figure 8-12 and Figure 8-13.
If the on-duty is 100%, the value of t_{ARS1} is 61.4 ms, and t_{ARS2} is 41.0 ms. The value of t_{AROFF1} is about 1.3 s.

- **Auto Restart 2:**
  As shown in Figure 8-11, the IC stops the switching operation immediately after the detection of abnormal states 6 or 7 in Table 8-2, and repeats an intermitted oscillation operation. In the intermitted oscillation cycle, the t_{ARSW} is an oscillation time, the t_{AROFF1} is a non-oscillation time.
  The value of t_{ARSW} is a few microseconds. The value of t_{ARS2} is derived from Figure 8-11, and t_{AROFF2} is calculated as follows:

$$t_{AROFF2} = t_{ARS2} - t_{ARSW} + t_{AROFF1} \qquad (8\text{-}2)$$

If the on-duty is 100%, the value of t_{AROFF2} becomes about 1.341 ms.

- **Auto Restart 3:**
  The IC stops the switching operation immediately after the detection of abnormal states 8 in Table 8-2, and keeps a non-oscillation.

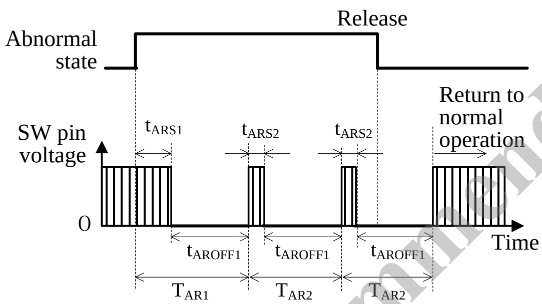


Figure 8-10. Auto Restart 1

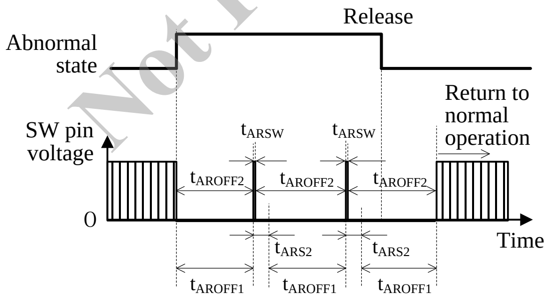


Figure 8-11. Auto Restart 2

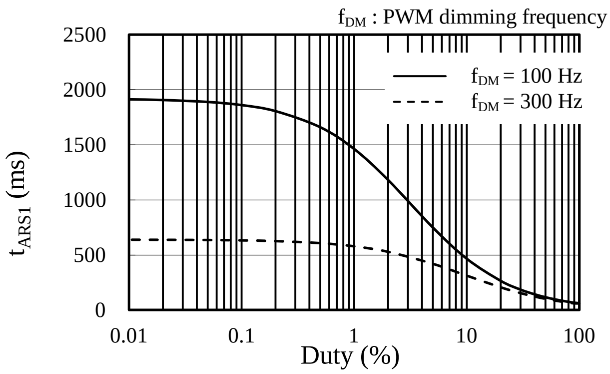


Figure 8-12. PWM Dimming On-duty Versus t_{ARS1}

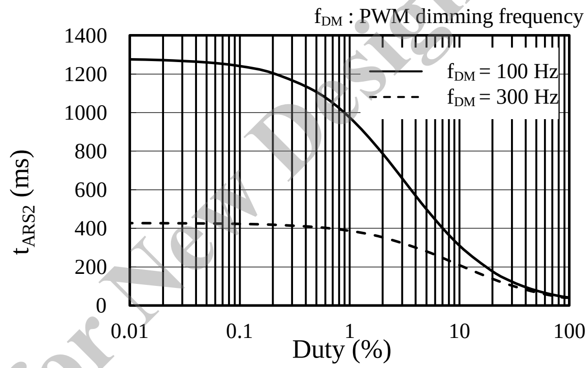


Figure 8-13. PWM Dimming On-duty Versus t_{ARS2}

The operating condition of Auto Restart 1 and 2 is as follows:

< The operating condition of Auto Restart 1 >
The Auto Restart 1 is operated by the detection signals of the OC pin or IFB pin.

- Operation by the detection signal of OC pin:
  When the OC pin voltage increase to the OC Pin Overcurrent Protection Threshold Voltage, V_{OCP} = 0.60 V, or more, the operation of the IC switches to Auto Restart 1. When the fault condition is removed and the OC pin voltage decreases to under V_{OCP}, the IC returns to normal operation automatically.
- Operation by the detection signal of IFB pin:
  As shown in Figure 8-14, IFB pin has two types of threshold voltage. These threshold voltages depend on the VREF pin voltage, as shown in Figure 8-15.

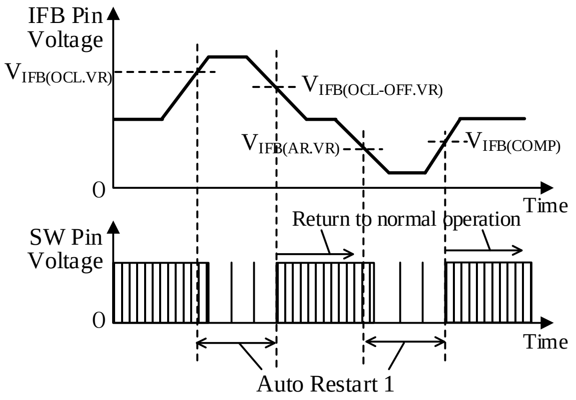


Figure 8-14. IFB Pin Threshold Voltage and Auto Restart 1 Operation

$V_{IFB(OCL.VR)}$: IFB Pin Overcurrent Protection Low Threshold Voltage
$V_{IFB(OCL-OFF.VR)}$:IFB Pin Overcurrent Protection Release Threshold Voltage
$V_{IFB(AR.VR)}$:IFB Pin Auto Restart Operation Threshold Voltage

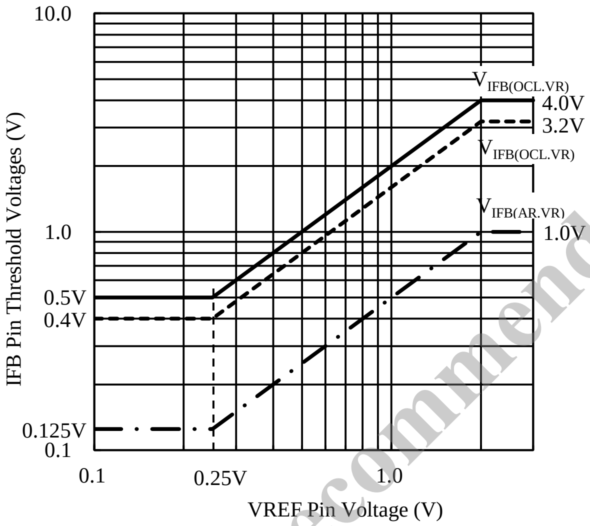


Figure 8-15. VREF Pin Voltage Versus IFB Pin Threshold Voltages

- When IFB Pin Voltage Increases
  When the FB pin voltage increase to $V_{IFB(OCL.VR)}$ in Figure 8-15, or more, the operation of the IC switches to Auto Restart 1. When the fault condition is removed and the IFB pin voltage decreases to $V_{IFB(OCL-OFF.VR)}$ in Figure 8-15, or less, the IC returns to normal operation automatically.
- When IFB Pin Voltage Decreases
  When the FB pin voltage decrease to $V_{IFB(AR.VR)}$ in Figure 8-15, or more, the operation of the IC switches to Auto Restart 1. When the fault condition is removed and the IFB pin voltage increases to above $V_{IFB(COMP)}$, the IC returns to normal operation automatically.

< The Operating Condition of Auto Restart 2 >

The Auto Restart 2 is operated by the detection signal of the IFB pin.

As shown in Figure 8-16, when the FB pin voltage increase to the IFB Pin Overcurrent Protection High Threshold Voltage, $V_{IFB(OCH)}$ = 4.0 V, or more, the operation of the IC switches to Auto Restart 2, and the IC stops switching operation immediately. When the fault condition is removed and the IFB pin voltage decreases to under $V_{IFB(OCH)}$, the operation of the IC switches to Auto Restart 1.

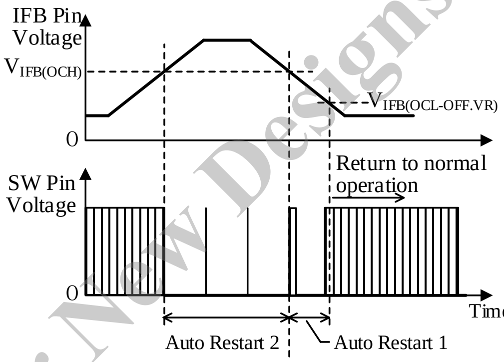


Figure 8-16. IFB Pin Threshold Voltage and Auto Restart 2 Operation

< Note at Startup Operation >

When the LED current is low and the IFB pin voltage is less than $V_{IFB(AR.BR)}$, during startup for example, the IC is operated by Auto Restart 1. If the startup time is too long, the IC operation becomes the intermitted oscillation by the Auto Restart 1. It becomes cause of the fault startup operation, thus the startup time should be set less than t_{ARS1} in Figure 8-10.

The protection operation according to the abnormal states in Table 8-2 is described in detail as follows:

8.5.1 Overcurrent of Boost Converter Part (OCP)

When the OC pin detects the overcurrent of boost circuit, the IC switches to Auto Restart 1.

Figure 8-17 shows the peripheral circuit of OC pin. When Q1 turns on, the current flowing to L1 is detected by R4, and the voltage on R4 is input to the OC pin. When the OC pin voltage increases to the OC Pin Overcurrent Protection Threshold Voltage, V_{OCP} = 0.60 V or more, the on-duty becomes narrow by pulse-by-pulse basis, and the output power is limited.

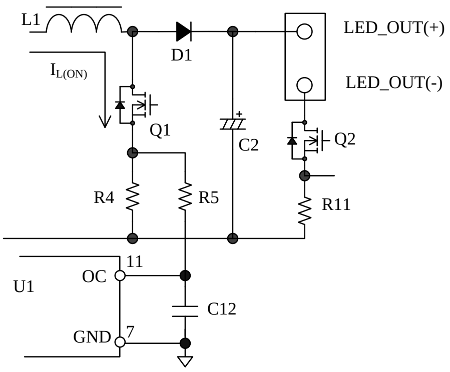


Figure 8-17. OC Pin Peripheral Circuit

8.5.2 Overcurrent of LED Output (LED_OCP)

Figure 8-18 shows the peripheral circuit of IFB pin and COMP pin.

When Q2 turns on, the output current is detected by R11. When the boost operation cannot be done by failure such as short circuits in LED string, the IFB pin voltage is increased by the increase of LED current. There are three types of operation modes in LED_OCP state.

- When the IFB pin voltage is increased by the increase of LED current, COMP pin voltage is decreases. In addition, when the COMP pin voltage decreases to the COMP Pin Voltage at Oscillation Stop, VCOMP(OFF) = 0.25 V or less, the IC stops switching operation, and limits the increase of the output current. When IFB pin voltage is decreased by the decrease of LED current, COMP pin voltage increases. When COMP pin voltage becomes VCOMP(ON) = 0.50 V or more, the IC restarts switching operation.
- When IFB pin voltage becomes VIFB(OCL.VR) or more (see Figure 8-15), the IC switches to Auto Restart 1.
- The LED current increases further and when the IFB pin voltage increases to the IFB Pin Overcurrent Protection High Threshold Voltage, VIFB(OCH) = 4.0 V or more, the IC switches to Auto Restart 2.

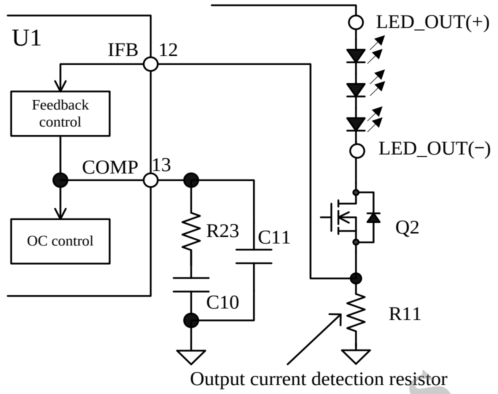


Figure 8-18. The Peripheral Circuit of IFB Pin and COMP Pin

8.5.3 Overvoltage of LED_OUT (+) (OVP)

Figure 8-19 shows OVP pin peripheral circuit.

The OVP pin detects the divided LED output voltage by R6 and R7. When the LED_OUT (+) or the IFB pin is open and the OVP pin voltage increases to the OVP Pin Overvoltage Protection Threshold Voltage, V_{OVP} = 3.00 V, the IC immediately stops switching operation. When the OVP pin voltage decreases to the OVP Pin Overvoltage Protection Release Threshold Voltage, $V_{OVP(OFF)}$ = 2.75 V or the IFB pin voltage decreases to $V_{IFB(AR.VR)}$ in Figure 8-15, then the IC switches to Auto Restart 1.

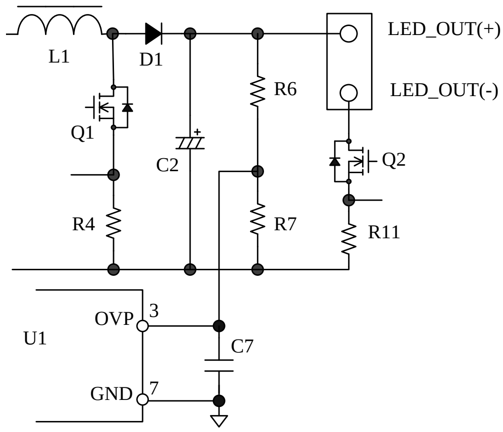


Figure 8-19. OVP Pin Peripheral Circuit

8.5.4 Short Mode between LED_OUT(−) and GND

When the LED_OUT (–) and the GND are shorted, and the IFB pin voltage decreases to $V_{IFB(AR.VR)}$ in Figure 8-15, then the IC switches to Auto Restart 1.

8.5.5 Short Mode of LED Current Detection Resistor (R_{SEN}_Short)

When the output current detection resistor, R11, is shorted, the IFB pin voltage decreases. When the IFB pin voltage decreases to $V_{IFB(AR.VR)}$ in Figure 8-15, then the IC switches to Auto Restart 1.

8.5.6 Short Mode of LED Output Both Ends

When the LED_OUT (+) and LED_OUT (–) are shorted, the short current flows through the detection resistor (R11) while Q2 turns on. The IFB pin detects the voltage rise of the detection resistor. When the IFB pin voltage increases to the IFB Pin Overcurrent Protection High Threshold Voltage, $V_{IFB(OCH)}$ = 4.0 V or more, the IC switches to Auto Restart 2.

8.5.7 Open Mode of LED Current Detection Resistor (R_{SEN}_Open)

When the output current detection resistor, R11, is open, the IFB pin voltage increases. When the IFB pin voltage increases to the IFB Pin Overcurrent Protection High Threshold Voltage, $V_{IFB(OCH)}$ = 4.0 V or more, the IC switches to Auto Restart 2.

8.5.8 Overtemperature of junction of IC (TSD)

When the temperature of the IC increases to $T_{j(TSD)}$ = 125 °C (min) or more, the TSD is activated, and the IC stops switching operation. When the junction temperature decreases by $T_{j(TSD)} - T_{j(TSD)HYS}$ after the fault condition is removed, the IC returns to normal operation automatically.

8.6 Error Signal Output Function

When an external circuit such as microcomputer uses the error signal output, configure the peripheral circuit of ER pin using the pull-up resistor, R8, and the protection resistor of ER pin, R_{ER}, as shown in Figure 8-20.

The ER pin is connected to internal switch. When the protection function is active, the internal switch becomes OFF and ER_OUT becomes REG pin voltage from 0 V.

The resistances of R17 and R_{ER} are about 10 kΩ.

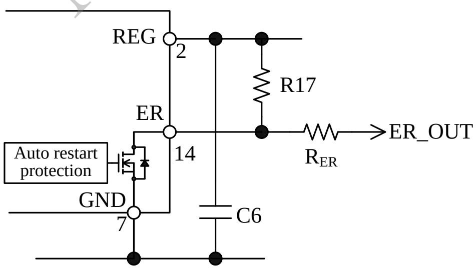


Figure 8-20. ER Pin Peripheral Circuit

9. Design Notes

9.1 Peripheral Components

Take care to use the proper rating and proper type of components.

- Input and output electrolytic capacitors, C1 and C2
  Apply proper design margin to accommodate ripple current, voltage, and temperature rise.
  Use of high ripple current and low impedance types, designed for switch-mode power supplies, is recommended, depending on their purposes.
- Inductor, L1
  Apply proper design margin to temperature rise by core loss and copper loss.
  Apply proper design margin to core saturation
- Current detection resistors, R4 and R11
  Choose a type of low internal inductance because a high frequency switching current flows to the current detection resistor, and of properly allowable dissipation.

9.2 Inductor Design Parameters

The CRM* or DCM* mode of boost converter with PWM dimming can improve the output current rise during PWM dimming.

*CRM is the critical conduction mode,
DCM is the discontinuous conduction mode.

The CRM or DCM inductor design procedure is described as follow:

(1) On-duty Setting

The output voltage of boost converter is more than the input voltage. The on-duty, D_{ON} can be calculated using following equation. The equality of the equation means the condition of CRM mode operation and the inequality means that of DCM mode operation.

$$D_{ON} \leq \frac{V_{OUT} - V_{IN}}{V_{OUT}} \quad (9\text{-}1)$$

where:
V_{IN} is the minimum input voltage,
V_{OUT} is the maximum forward voltage drop of LED string.

D_{ON} is selected by the above equation applied to CRM or DCM mode. If f_{PWM} = 100 kHz, the range of D_{ON} should be 1.4% to 90%. If f_{PWM} = 500 kHz, the range of D_{ON} should be 7% to 90%. (The minimum value results from the condition of t_{MIN} = 140 ns, and f_{PWM}. The maximum value is D_{MAX}).

(2) PWM Oscillation Frequency Selection

The PWM oscillation frequency of DRV pin, f_{PWM}, depends on the value of R22 connected to F_{SET} pin.

The value of f_{PWM} is set by Figure 8-9.

(3) Inductance Value, L

The inductance value, L, for DCM or CRM mode can be calculated as follow:

$$L \le \frac{(V_{IN} \times D_{ON})^2}{2 \times I_{OUT} \times f_{PWM} \times (V_{OUT} - V_{IN})} \qquad (9\text{-}2)$$

where:
I_{OUT} is the maximum output current,
f_{PWM} is the maximum operation frequency of PWM

(4) Peak Inductor Current, I_{LP}

$$I_{LP} = \frac{V_{IN} \times D_{ON}}{L \times f_{PWM}} \qquad (9\text{-}3)$$

(5) Inductor Selection

The inductor should be applied the value of inductance, L, from equation (9-2) and the DC superimposition characteristics being higher than the peak inductor current, I_{LP}, from equation (9-3).

9.3 PCD Trace Layout and Component Placement

Since the PCB circuit trace design and the component layout significantly affects operation, EMI noise, and power dissipation, the high frequency PCB trace as shown in Figure 9-1 should be low impedance with small loop and wide trace.

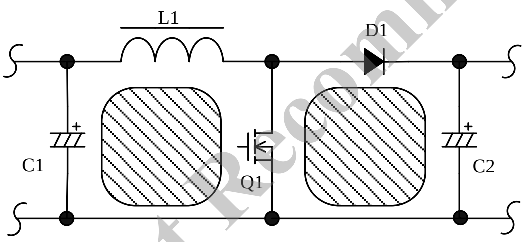


Figure 9-1. High-frequency Current Loops (hatched areas)

In addition, the ground traces affect radiated EMI noise, and wide, short traces should be taken into account.

Figure 9-2 shows the circuit design example.

(1) Main Circuit Trace Layout
This is the main trace containing switching currents, and thus it should be as wide trace and small loop as possible.
C1 should be connected near the inductors, L1, in order to reduce impedance of the high frequency current loop.

(2) Control Ground Trace Layout
Since the operation of IC may be affected from the large current of the main trace that flows in control ground trace, the control ground trace should be connected at a single point grounding of point A with a dedicated trace.

(3) Current Detection Resistor Trace Layout
R4 and R11 are current detection resistors.
The trace from the base of current detection resistor should be connected to the pin of IC with a dedicated trace.

(4) COMP Pin Trace Layout for Compensation Component
R23, C10 and C11 are compensation components.
The trace of the compensation component should be connected as close as possible to the pin of IC, to reduce the influence of noise.

(5) Bypass Capacitor Trace Layout on VCC , REG, and VREF Pins
C9, C6 and C5 of bypass capacitors, connected to VCC, REG, and VREF pins respectively, should be connected as close as possible to the pin of IC

(6) Power MOSFET Gate Trace Layout
R3 for Q1 and R10 for Q2 should be connected near each the gate of the power MOSFETs and the ground line side of the current detection resistance.
Peripheral components of Q1 (R1, R2, and D2) and Q2 (R8, R9, and D3) should be connected as close as possible between each the gate of the power MOSFETs and the pin of IC.

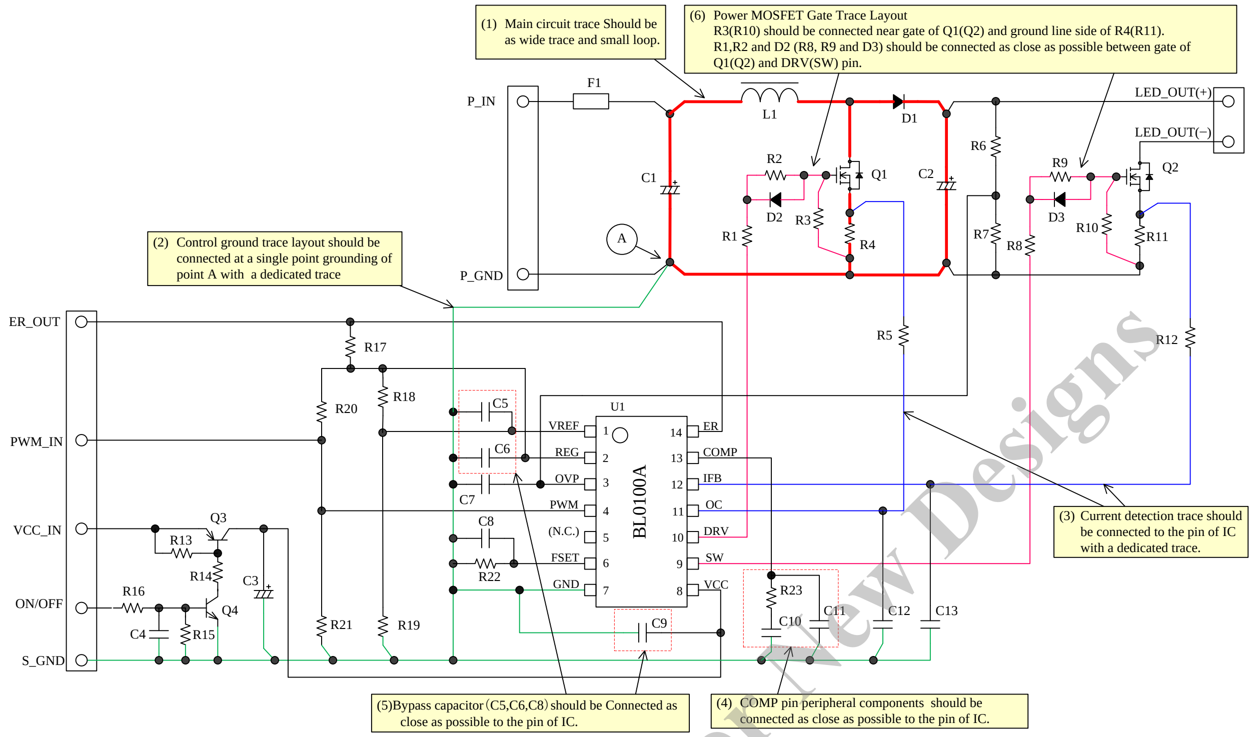


Figure 9-2. Peripheral Circuit Example Around the IC

10. Reference Design of Power Supply

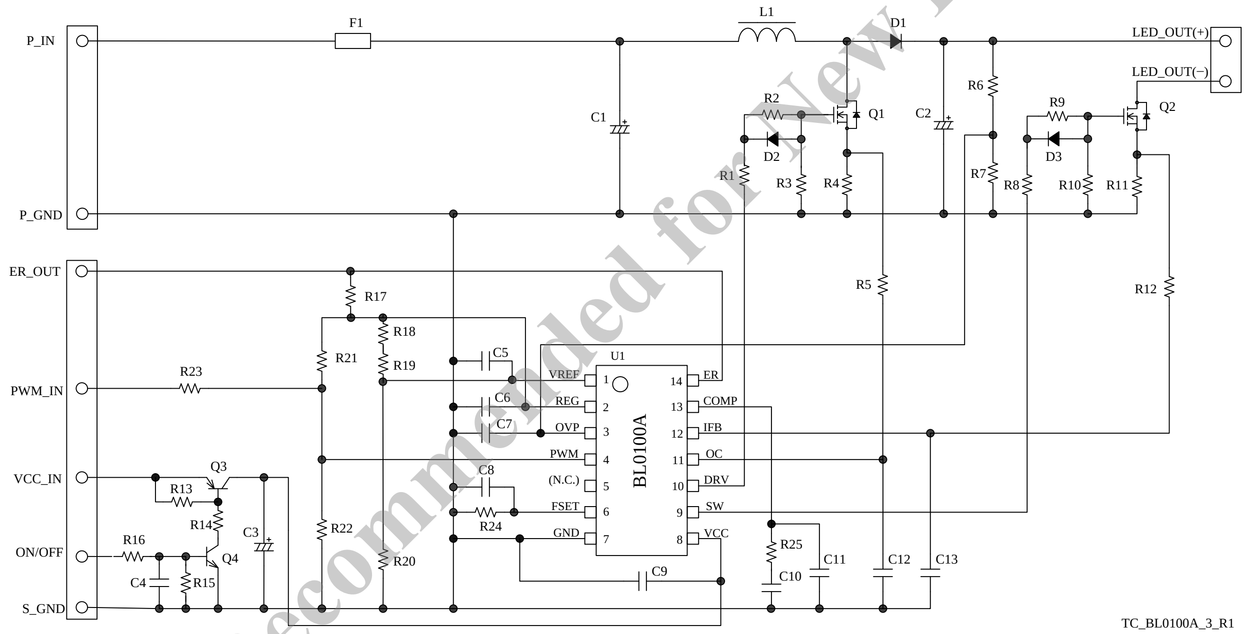
As an example, the following show a power supply specification, circuit schematic, bill of materials, and transformer specification.

This reference design is the example of the value of parts, and should be adjusted based on actual operation in the application.

● Power Supply Specification

IC	BL0100A
Input Voltage	DC 24 V
Maximum Output Power	20 W (max.)
DRV Pin Oscillation Frequency	100 kHz
Output Voltage	50 V
Output Current	400 mA

● Circuit Schematic



● Bill of Materials

Symbol	Part type	Ratings[1]	Recommended Sanken Parts	Symbol	Part type	Ratings[1]	Recommended Sanken Parts
F1	Fuse	3 A		R3	General, chip, 2012	10 kΩ	
L1	Inductor	50 µH, 3 A		R4	General	0.22 Ω, 2 W	
D1	Fast recovery	200 V, 1.5 A	EL 1Z	R5	General, chip, 2012	100 Ω	
D2	Schottky	30 V, 1 A	SJPA-D3	R6 [3]	General, chip, 2012	220 kΩ	
D3	Schottky	30 V, 1 A	SJPA-D3	R7 [2]	General, chip, 2012	11 kΩ	
Q1	Power MOSFET	200 V, 45 mΩ (typ.)	SKP202	R8	General, chip, 2012	470 Ω	
Q2	Power MOSFET	100 V, 1 Ω (typ.)		R9	General, chip, 2012	1.5 kΩ	
Q3	PNP Transistor	−50 V, 0.1 A		R10	General, chip, 2012	10 kΩ	
Q4	NPN Transistor	50 V, 0.1 A		R11	General	1.35 Ω, 1 W	
C1	Electrolytic	50 V, 22 µF		R12	General, chip, 2012	1.5 kΩ	
C2	Electrolytic	100 V, 100 µF		R13	General, chip, 2012	10 kΩ	
C3	Electrolytic	50 V, 47 µF		R14	General, chip, 2012	12 kΩ	
C4	Ceramic, chip, 2012	50 V, 0.1 µF		R15	General, chip, 2012	10 kΩ	
C5	Ceramic, chip, 2012	0.1 µF		R16	General, chip, 2012	15 kΩ	
C6	Ceramic, chip, 2012	10 nF		R17	General, chip, 2012	10 kΩ	
C7	Ceramic, chip, 2012	0.1 µF		R18	General, chip, 2012	82 kΩ	
C8 [2]	Ceramic, chip, 2012	0.1 µF		R19 [2]	General, chip, 2012	560 Ω	
C9	Ceramic, chip, 2012	50 V, 0.1 µF		R20	General, chip, 2012	10 kΩ	
C10	Ceramic, chip, 2012	0.047 µF		R21	General, chip, 2012	10 kΩ	
C11	Ceramic, chip, 2012	2200 pF		R22	General, chip, 2012	33 kΩ	
C12 [2]	Ceramic, chip, 2012	100 pF		R23	General, chip, 2012	1 kΩ	
C13 [2]	Ceramic, chip, 2012	100 pF		R24	General, chip, 2012	Open	
R1	General, chip, 2012	10 Ω		R25	General, chip, 2012	22 kΩ	
R2	General, chip, 2012	100 Ω		U1	IC		BL0100A

[1] Unless otherwise specified, the voltage rating of capacitor is 50V or less, and the power rating of resistor is 1/8W or less.
[2] It is necessary to be adjusted based on actual operation in the application.
[3] Resistors applied high DC voltage and of high resistance are recommended to select resistors designed against electromigration or use combinations of resistors in series for that to reduce each applied voltage, according to the requirement of the application.

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