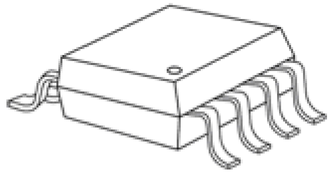
Power Switching Dimming, Step-Down, 1A LED Driver

Mini Small Outline Package

GMS : MSOP-8L-118mil

Small Outline Package



GD: SOP8L-150-1.27

Features

- 6~36V wide input voltage range
- Maximum 1A constant output current
- Support 4-step power switch dimming and PWM dimming
- 97% efficiency @ input voltage 12V, 350mA, 3-LED
- Hysteretic PFM operation eliminates external compensation design
- Integrated power switch with 0.3ohm low Rds(on)
- Full protections: UVLO/Start-Up/OCP/ Thermal/LED Open-/Short-Circuited

Product Description

The MBI6654 is a step-down constant-current high-brightness LED driver provides a cost-effective design solution for interior/exterior illumination applications. It is designed to deliver constant current to light up high power LED. With hysteretic PFM control scheme, MBI6654 eliminates external compensation design and makes the design simple.

The output current of MBI6654 can be programmed by an external resistor and LED dimming can be controlled via pulse width modulation (PWM) through DIMD pin. In addition, a novel power line design is applied in the device. Users can also achieve 4-step analog dimming function by toggling input voltage of the luminaries and enjoy the simplicity without additional dimming signal.

MBI6654 features completed protection design to handle faulty situations. The start-up function limits the inrush current while the power is switched on. Under voltage lock out (UVLO), over temperature protection (OTP), and over current protection (OCP) guard the system to be robust and keep the driver away from being damaged resulting from LED open-circuited, short-circuited and other abnormal events.
MBI6654 provides thermal-enhanced both SOP-8L and MSOP-8L packages as well to handle power dissipation more efficiently.

Applications

- Signage and Decorative LED Lighting
- Simple dimming control desk lamp
- Constant Current Source
- Plant Grow Lighting

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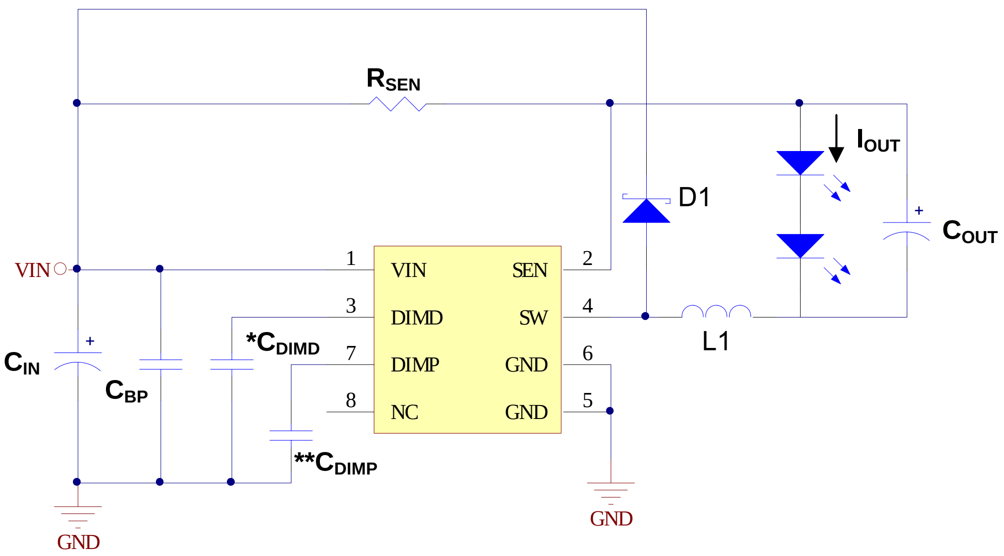
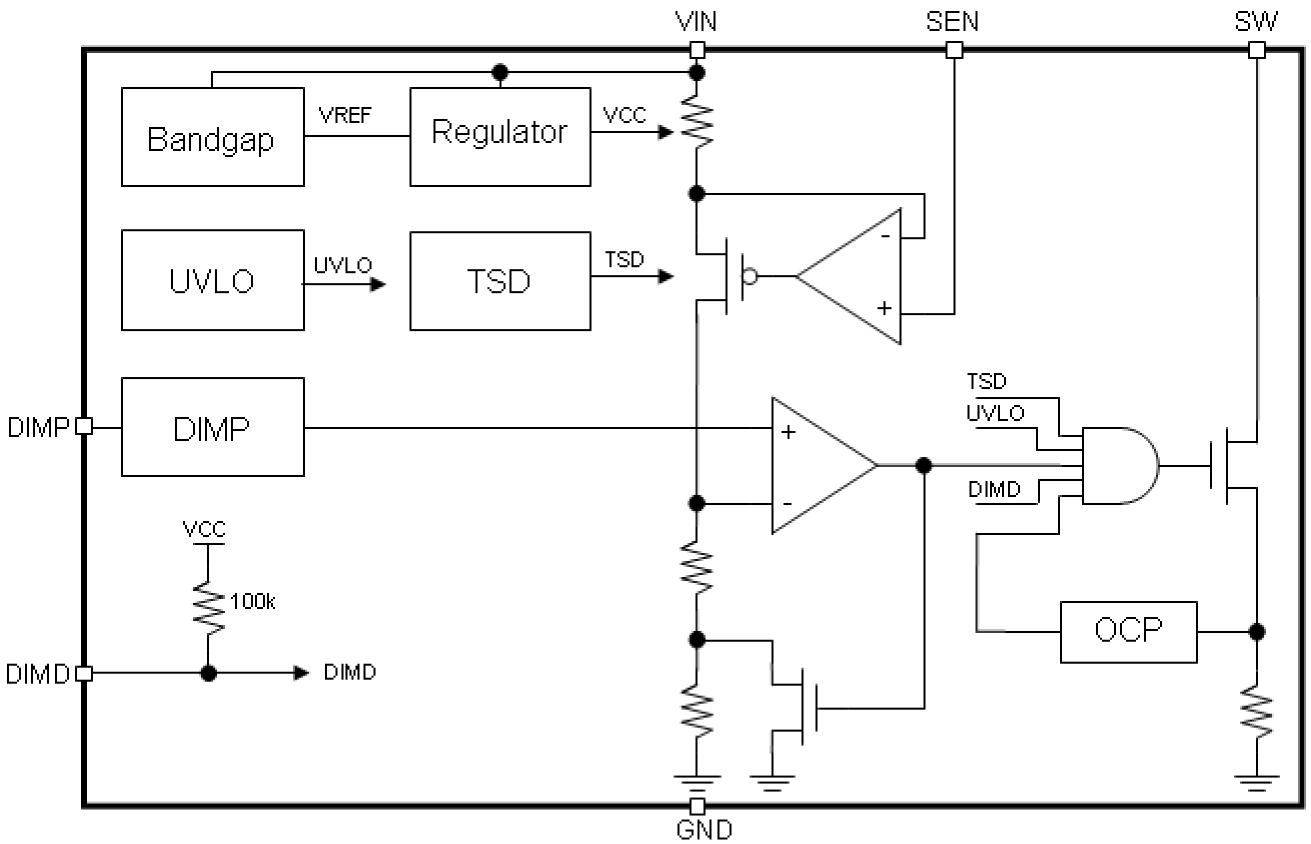
Typical Application Circuit



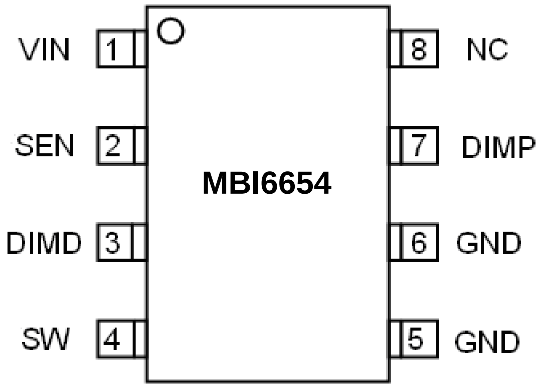
C_{IN}: J.C.TALLY, 10uF/50V, 5*11 electrolytic capacitor
C_{OUT}: J.C.TALLY, 10uF/50V, 5*11 electrolytic capacitor
C_{BP}: GOLDENCONNECTIONS, 0.1uF/50V, X5R 0603 SMD ceramic capacitor
C_{DIMP}: GOLDENCONNECTIONS, 1uF/6.3V, X5R 0603 SMD ceramic capacitor
C_{DIMD}: GOLDENCONNECTIONS, 100pF/6.3V, X5R 0603 SMD ceramic capacitor
R_{SEN}: Viking, 0.1Ω,1206, ±1% SMD Resistor
L1: GANG SONG, GSDS106C2-680M
D1: ZOWIE, 60V /2A, SSCD206

Functional Diagram

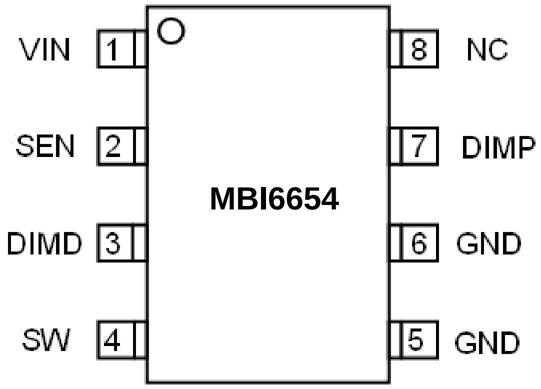


March 2011, V1.01

Pin Configuration



MBI6654GMS



MBI6654GD

Pin Description

Pin Name	Function
GND	Ground terminal for control logic and current sink
SW	Switch output terminal
DIMD	Digital dimming control terminal
DIMP	Control setup terminal for power switch dimming
SEN	Output current sense terminal
VIN	Supply voltage terminal
Thermal Pad	Power dissipation terminal connected to GND*

*To eliminate noise influence, the thermal pad is suggested to connect to GND on PCB. In addition, when a heat-conducting copper foil on PCB is soldered with thermal pad, the desired thermal conductivity will be improved.

Maximum Ratings

Operation above the maximum ratings may cause device failure. Operation at the extended periods of the maximum ratings may reduce the device reliability.

Characteristic		Symbol	Rating	Unit
Supply Voltage		V_{IN}	0~40	V
Output Current		I_{OUT}	1.2	A
Sustaining Voltage at SW pin		V_{SW}	-0.5~45	V
GND Terminal Current		I_{GND}	1.2	A
Power Dissipation (On 4 Layer PCB, Ta=25°C)*	GMS Type	P_D	3.62	W
Thermal Resistance (By simulation, on 4 Layer PCB)*	GMS Type	$R_{th(j-a)}$	34.53	°C/W
Empirical Thermal Resistance**	GMS Type	$R_{th(j-a)}$	117.71	°C/W
Power Dissipation (On 4 Layer PCB, Ta=25°C)*	GD Type	P_D	3.13	°C/W
Thermal Resistance (By simulation, on 4 Layer PCB)*	GD Type	$R_{th(j-a)}$	40	°C/W
Empirical Thermal Resistance**	GD Type	$R_{th(j-a)}$	87.38	°C/W
Operating Junction Temperature		$T_{j,max}$	125***	°C
Operating Temperature		T_{opr}	-40~+85	°C
Storage Temperature		T_{stg}	-55~+150	°C

*The PCB size is 76.2mm*114.3mm in simulation.

** The PCB size is 4 times larger than that of IC and without extra heat sink.

*** Operation at the maximum rating for extended periods may reduce the device reliability; therefore, the suggested operation temperature of the device (T_{opr}) is under 125°C.

Note: The performance of thermal dissipation is strongly related to the size of thermal pad, thickness and layer numbers of the PCB. The empirical thermal resistance may be different from simulative value. Users should plan for expected thermal dissipation performance by selecting package and arranging layout of the PCB to maximize the capability.

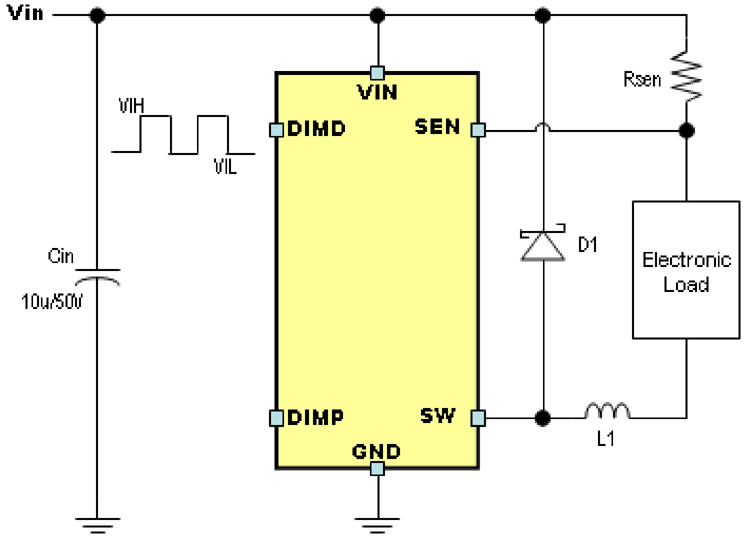
Electrical Characteristics

V_{IN}=12V, V_{OUT}=3.6V, L1=68μH, C_{IN}=C_{OUT}=10μF, T_A=25°C; unless otherwise specified.

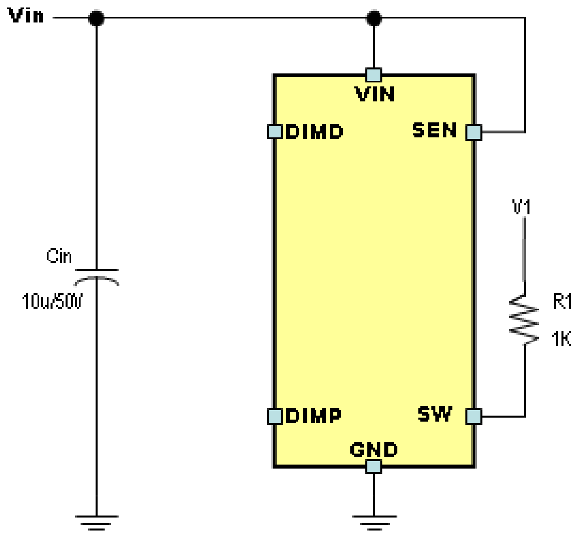
Characteristics		Symbol	Condition	Min.	Typ.	Max.	Unit
INPUT AND OUTPUT							
Supply Voltage		V_{IN}	-	6	-	36	V
Supply Current		I_{IN}	V_{IN}=6V~36V	-	2	4	mA
Start-Up Voltage		V_{SU}	-	-	5.7	-	V
Under Voltage Lock Out Voltage		V_{UVLO}	-	-	4.5	-	V
Output Current Accuracy		dI_{OUT}/I_{OUT}	150mA≤I_{OUT}≤1000mA,	-	±3	±5	%
HYSTERESIS CONTROL							
Mean Sense Voltage		V_{SENSE}	V_{IN}=12V, V1=1V, refer to test circuit (c)	95	100	105	mV
Sense Voltage threshold hysteresis		$V_{SENSE,HYS}$	-	-	15	-	%
Internal Propagation Delay Time		Tpd	-	-	100	200	ns
MOS SWITCH							
Switch ON Resistance		$R_{ds(on)}$	V_{IN}=12V; refer to test circuit (b)	0.2	0.3	0.4	Ω
Minimum Switch ON Time*		T_{ON},min	-	100	350	450	ns
Minimum Switch OFF Time*		T_{OFF},min	-	100	350	450	ns
Recommended Duty Cycle Range of SW*		D_{sw}	-	20	-	80	%
Maximum Operating frequency		$Freq_{Max}$	-	40	-	1000	KHz
THERMAL OVERLOAD							
Thermal Shutdown Threshold*		T_{SD}	-	145	165	175	°C
Thermal Shutdown Hystersis*		T_{SD-HYS}	-	20	30	40	°C
OVER CURRENT PROTECTION							
Over Current Threshold*			-	-	1.8	-	A
DIMD DIMMING							
Duty Cycle Range of PWM Signal Applied to DIMD pin		$Duty_{DIM}$	PWM Frequency: 1KHz, refer to test circuit (a)	1	-	100	%
Input Voltage	“H” level	V_{IH}	-	2.2	-	-	V
	“L” level	V_{IL}	-	-	-	0.5	V
Internal Pull-Up Resistor		P_{DIMD}	-	-	100	-	KΩ
DIMP DIMMING							
Minimum Step of Power Switch Dimming			V_{IN}=12V; refer to test circuit (d)	-	12.5	-	%

*Parameters are not tested at production. Parameters are guaranteed by design.

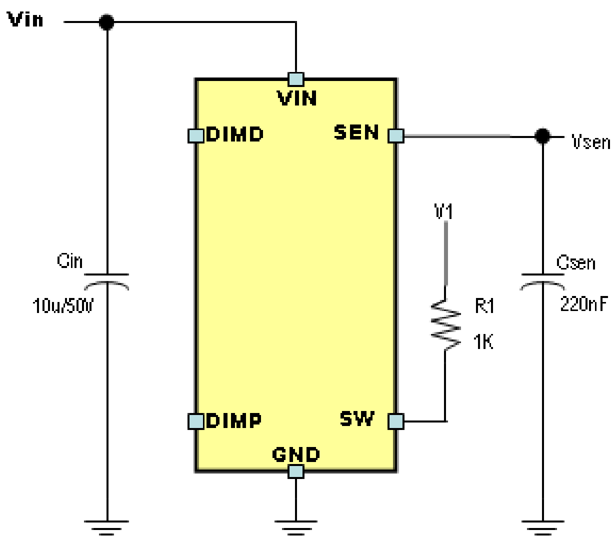
Test Circuit for Electrical Characteristics



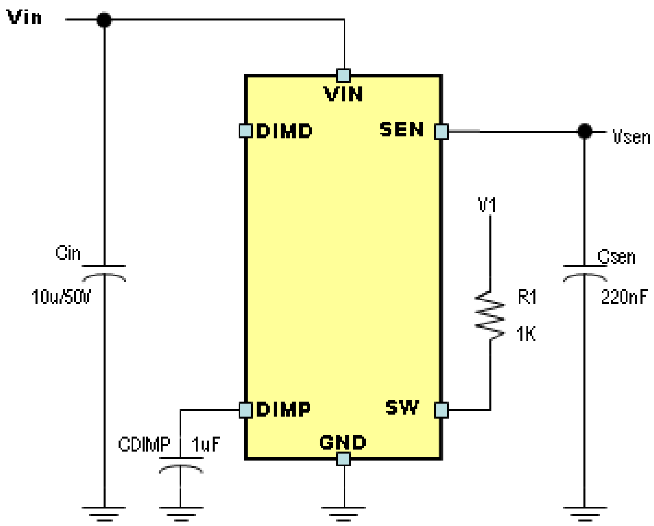
(a)



(b)



(c)



(d)

Application Information

MBI6654 is a simple and high efficient buck converter with capability to drive up to 1A of loading. The device adopts hysteretic PFM control scheme to regulate loading and input voltage variations. The hysteretic PFM control requires no loop compensation bringing very fast load transient response and simplicity of the design.

The device is well suited for applications requiring a wide input voltage range. The high-side current sensing and an integrated current-setting circuitry minimize the number of external components while delivering an average output current with ±3% accuracy. Featured by PWM dimming and power switch dimming capability, MBI6654 offers flexible ways to meet LED dimming related applications.

Setting Output Current

The output current (I_{OUT}) is set by an external resistor, R_{SEN}. The relationship between I_{OUT} and R_{SEN} is as below;

V_{SEN}=0.1V;

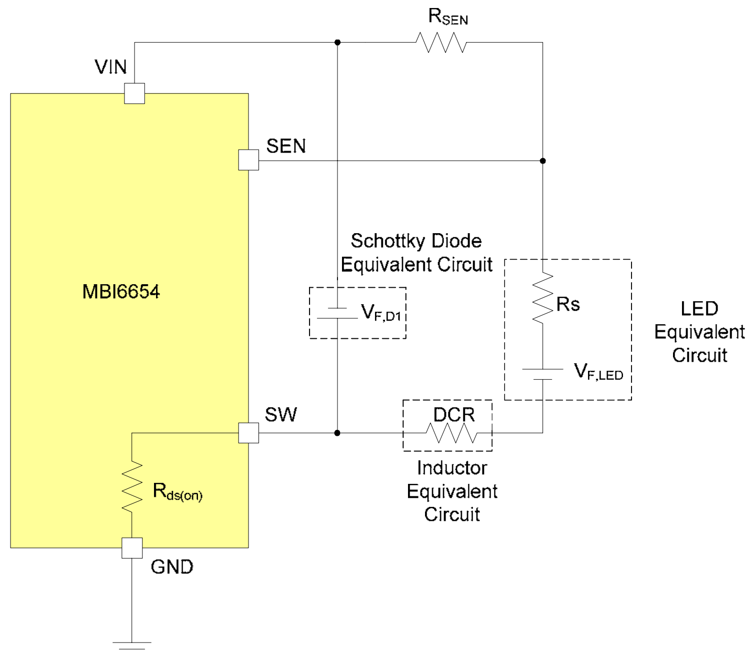
$R_{SEN}=(V_{SEN}/I_{OUT})=(0.1V/I_{OUT})$;

$I_{OUT}=(V_{SEN}/R_{SEN})=(0.1V/R_{SEN})$

where R_{SEN} is the resistance of the external resistor connecting to SEN terminal and V_{SEN} is the voltage of external resistor. The magnitude of current (as a function of R_{SEN}) is around 1000mA at 0.1Ω.

Minimum Input Voltage and Start-up Protection

The minimum input voltage is the sum of the voltage dropped on R_{SEN}, $R_{S,}$ DCR of L1, $R_{ds(on)}$ of internal MOSFET and the total forward voltage of LEDs. The dynamic resistance of LED, R_S, is the inverse of the slope in linear forward voltage model for LED. This electrical characteristic can be provided by LED manufacturers. The equivalent impedance of the MBI6654 application circuit is shown in Fig. 1. As the input voltage is smaller than the minimum input voltage such as start-up condition, the output current will be larger than the preset output current. Thus, under this circumstance, the output current is limited to 1.15 times of preset one as shown in Fig. 2.



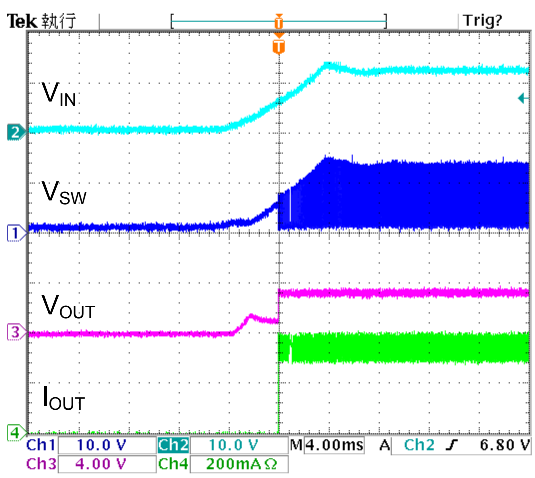


Fig. 2 The start-up waveform @ V_{IN}=12V, V_{OUT}= 3.2V, R_{SEN}=0.28Ω

Fig.1 The equivalent impedance in a MBI6654 application circuit

PWM Dimming

The dimming of LEDs can be performed by applying PWM signals to DIMD pin. A logic low (below 0.5V) at DIMD will disable the internal MOSFET and shut off the current flow to the LED array. An internal pull-up circuit ensures that the MBI6654 is ON when DIMD pin is unconnected, so that no external pull-up resistor is needed. If the input voltage exceeds 30V, please connect DIMD pin with 100pF capacitor in parallel. The following Fig. 3 and 4 show good linearity in dimming application of MBI6654.

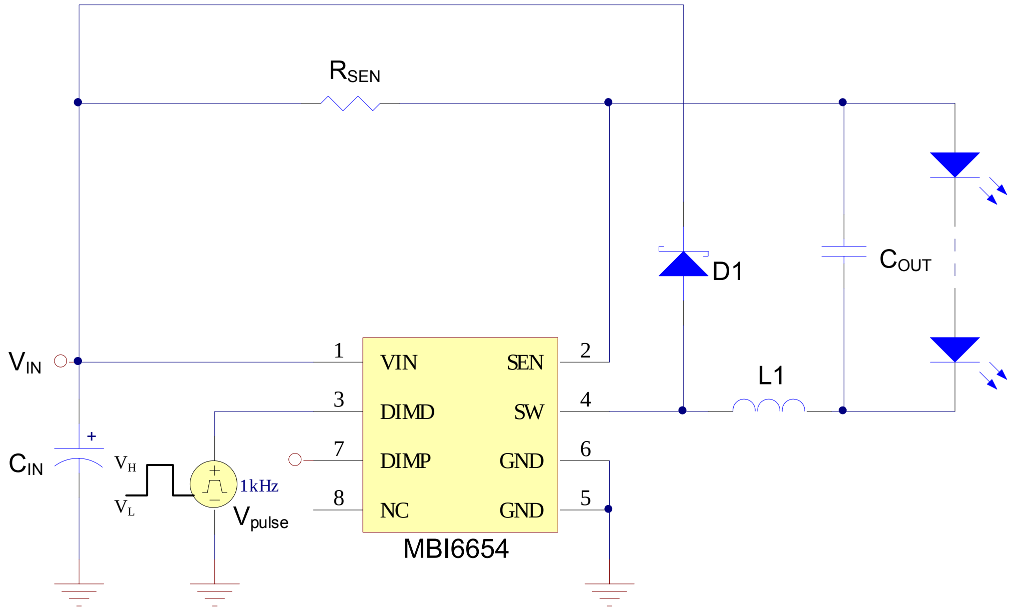
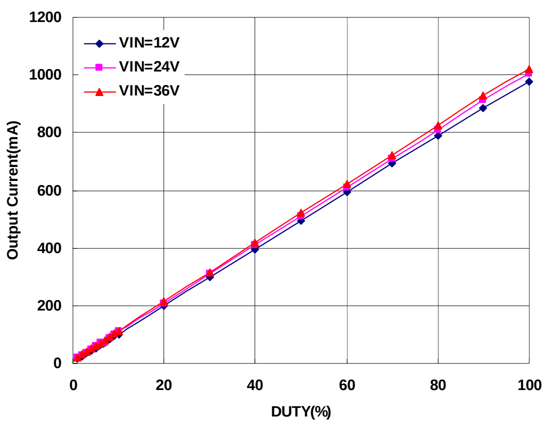
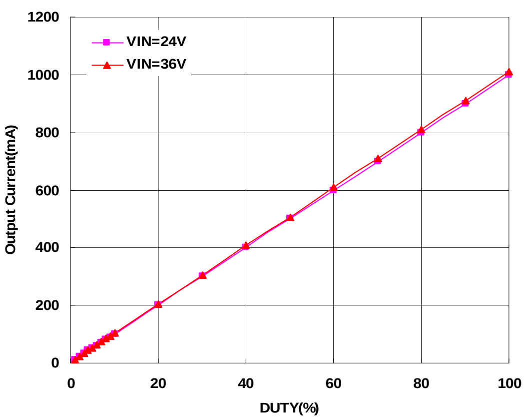


Fig. 3 PWM dimming signal is applied on DIMD



(b)1A @ 1-LED



(c)1A @ 3-LED

Fig. 4 DIMD duty cycle: 0% ~ 100%

Power Switch Dimming

The MBI6654 features power switch dimming, altering the output current by toggling the input voltage within a short period of time.

It utilizes UVLO threshold and voltage level of CPD capacitor (DIMP to GND capacitor) to achieve the function. External components CPD forms a holding and discharging circuitry and connect to DIMP. When input voltage is switched off and fell below UVLO threshold, MBI6654 changes the internal dimming memory state. In this time, voltage on CPD maintains power dimmable circuit active until the voltage which would be discharged by RPD path is incapable to supply the memory circuit normal operation. It is known as a "memory effect" to keep the function active. In the active moment, a step dimming is completed when the driver is powered again and input voltage rise above UVLO threshold. There is a proportion of output current reduction from original current setting when any single step dimming completes. Repeat above operation results in sequential dimming status change in following way 100% → 50%→ 25%→ 12.5%→ 100%.

However, the "memory effect" will lost if voltage on CPD fails to maintain normal operation of power dimmable circuit during low input voltage period. Without the "memory", no step dimming behavior happens when input voltage rise above UVLO threshold again.

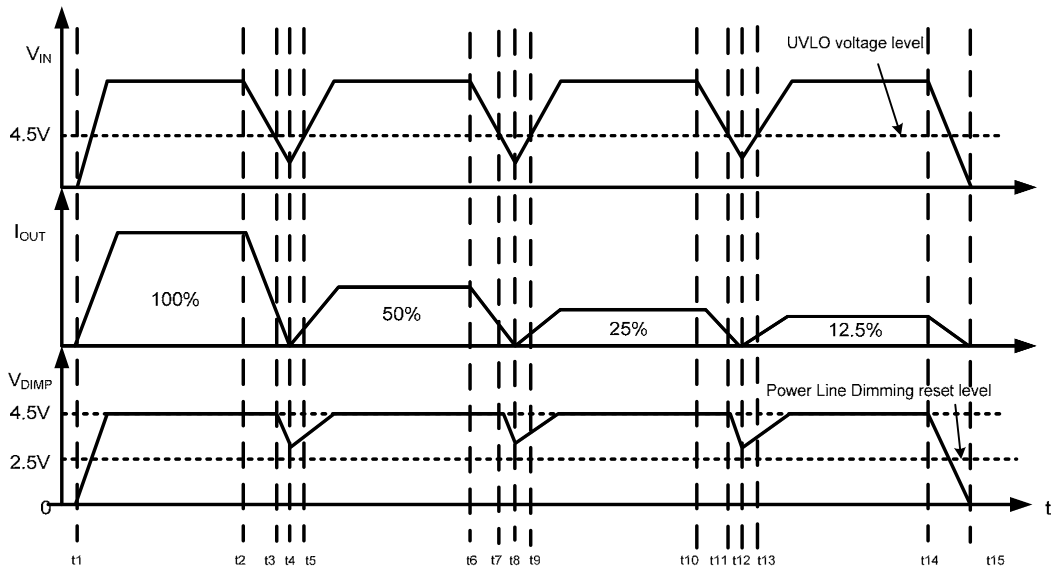


Fig.5 The output current altering due to power switch dimming function

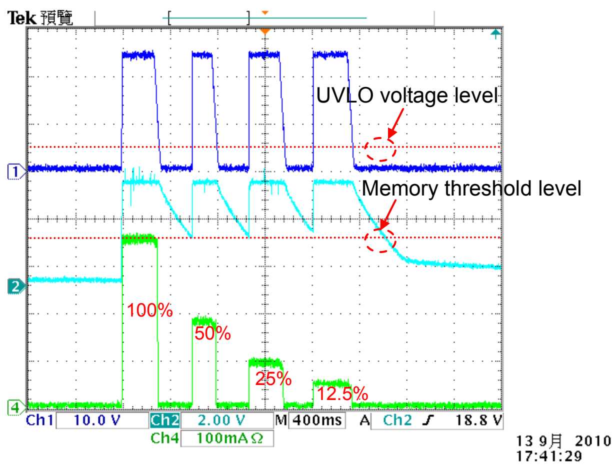


Fig. 6 Timing Waveform of Power Switch Dimming

LED Open-Circuit Protection

When any LED connecting to the MBI6654 is open-circuited, the integrated power switch of MBI6654 will be turned off. The waveform is shown in Fig. 7.

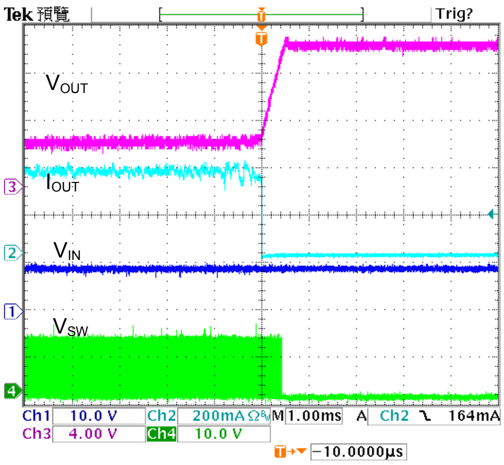


Fig. 7 Open-circuited protection

LED Short-Circuit Protection

When any LED connecting to the MBI6654 is short-circuited, the output current of MBI6654 will still be limited to its preset value as shown in Fig. 8.

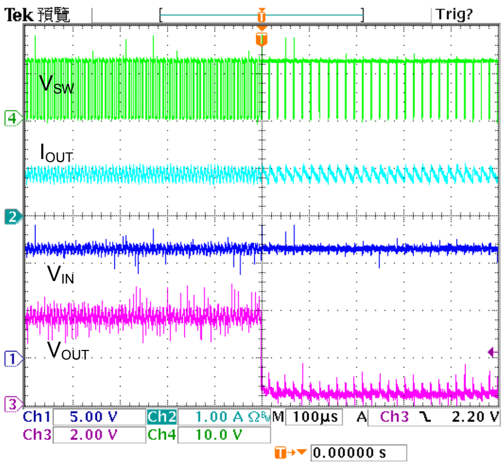


Fig. 8 Short-circuited protection

LED Over Current Protection

MBI6654 offers over current protection to against destructive damage which results from abnormal excessive current flow through. The function is activated when the LED current reaches the threshold which is approximately is 1.8A. Then, the integrated power switch of MBI6654 will be turned off. When the function is activated, it will not be removed until power reset action is taken.

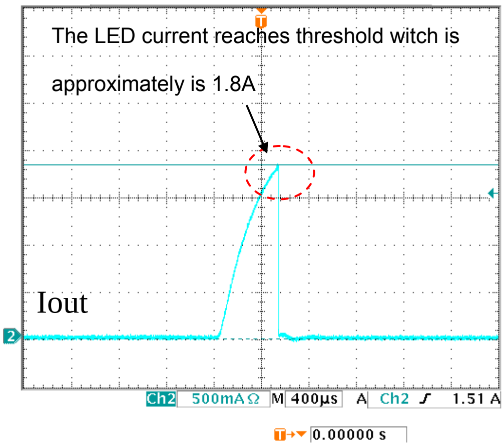


Fig. 9 LED Over Current Protection

TP Function (Thermal Protection)

When the junction temperature exceeds the threshold, T_{SD} (165°C), TP function turns off the output current. The waveform can refer to Fig. 10. The SW stops switching and the output current will be turned off. Thus, the junction temperature starts to decrease. As soon as the temperature is below 135°C, the output current will be turned on again. The switching of on-state and off-state are at a high frequency thus the blinking is imperceptible. The average output current is limited and therefore, the driver is protected from being overheated.

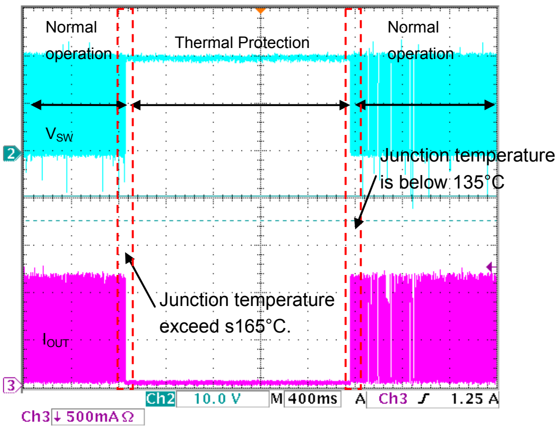


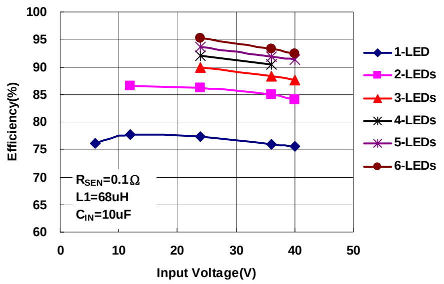
Fig. 10 Thermal protection

Performance

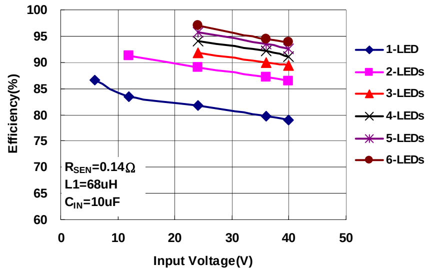
Please refer to Typical Application Circuit, V_{IN}=12V~40V, L1=68uH, C_{IN}=C_{OUT}, T_A=25℃, unless otherwise specified

1-LED V_F=3.6V; 2-LED V_F=7.2V; 3-LED V_F=10.8; 4-LED V_F=14.4V, 5-LED V_F=18V, 6-LED V_F=21.6V

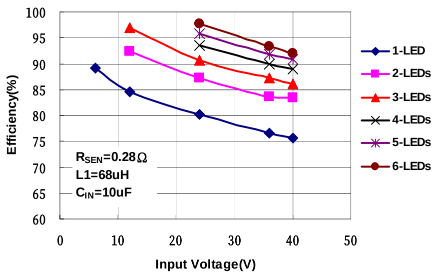
◆ Efficiency vs. Input Voltage at Various LED Cascaded Numbers



I_{OUT}=1A
Fig. 11

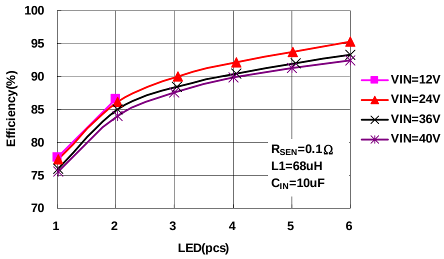


I_{OUT}=700mA
Fig. 12

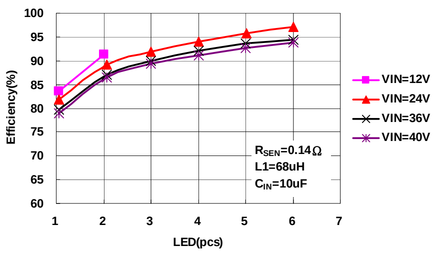


I_{OUT}=350mA
Fig. 13

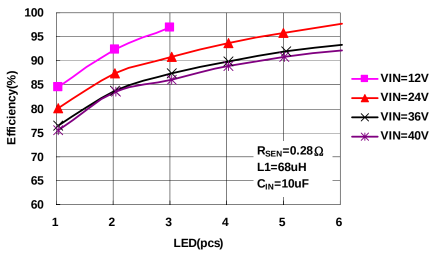
◆ Efficiency vs. LED Cascaded Number at Various Input Voltage



I_{OUT}=1A
Fig. 14

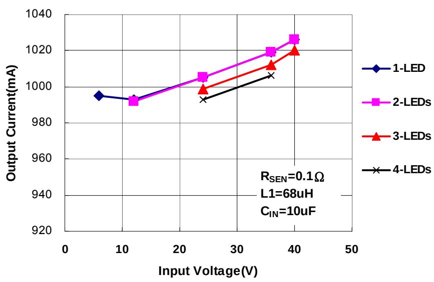


I_{OUT}=700mA
Fig. 15

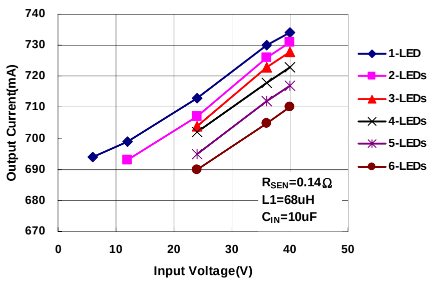


I_{OUT}=350mA
Fig. 16

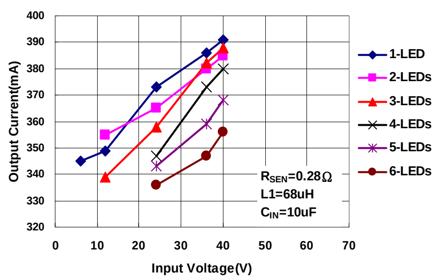
◆ Output Current vs. Input Voltage at Various LED Cascaded Numbers



I_{OUT}=1A
Fig. 17

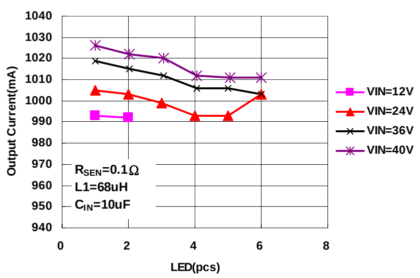


I_{OUT}=700mA
Fig. 18

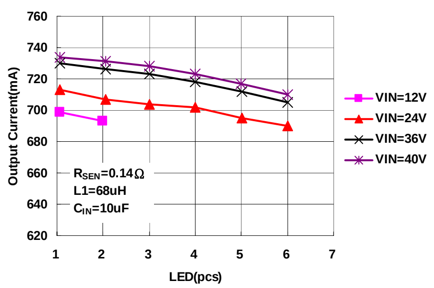


I_{OUT}=350mA
Fig. 19

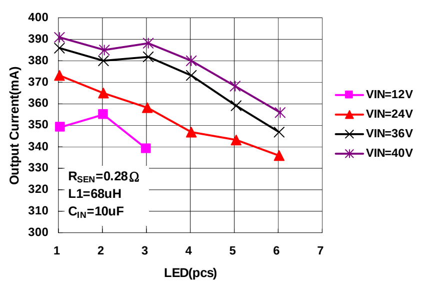
◆ Output Current vs. LED Cascaded Number at Various Input Voltage



I_{OUT}=1A
Fig. 20

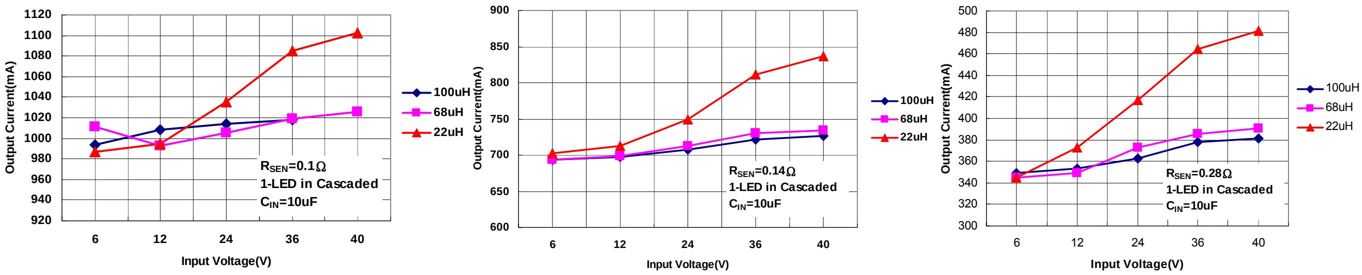


I_{OUT}=700mA
Fig. 21



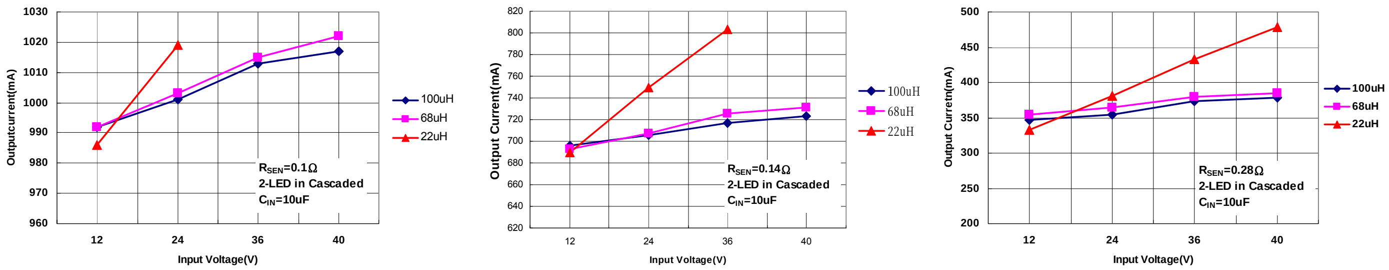
I_{OUT}=350mA
Fig. 22

◆ Output Current vs. Input Voltage at Various Inductors



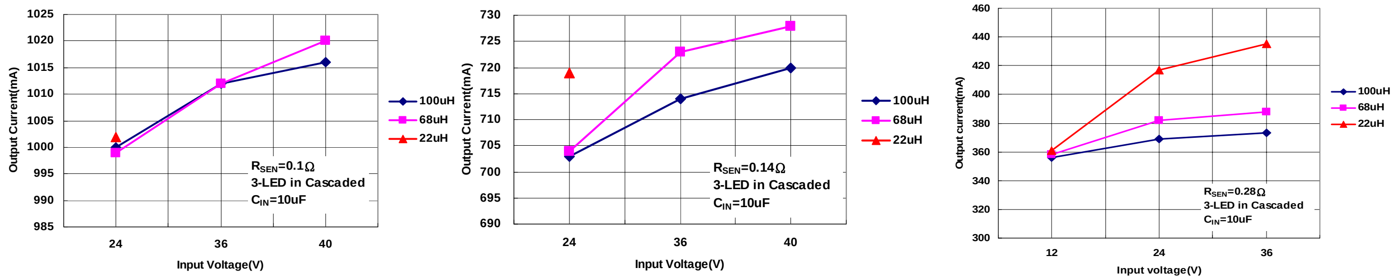
I_{OUT}=1A I_{OUT}=700mA I_{OUT}=350mA

Fig. 23 1-LED in cascaded



I_{OUT}=1A I_{OUT}=700mA I_{OUT}=350mA

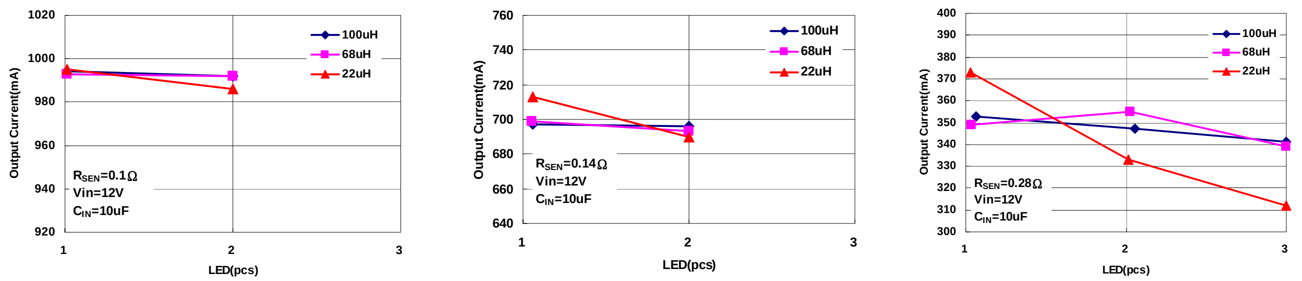
Fig. 24 2-LED in cascaded



I_{OUT}=1A I_{OUT}=700mA I_{OUT}=350mA

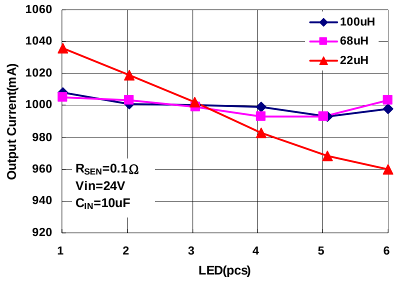
Fig. 25 3-LED in cascaded

◆ Output Current vs. LED Cascaded Number at Various Inductor

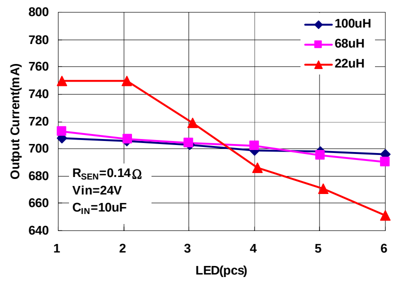


I_{OUT}=1A I_{OUT}=700mA I_{OUT}=350mA

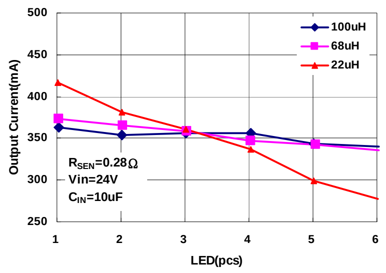
Fig. 26 V_{IN}=12V



I_{OUT}=1A

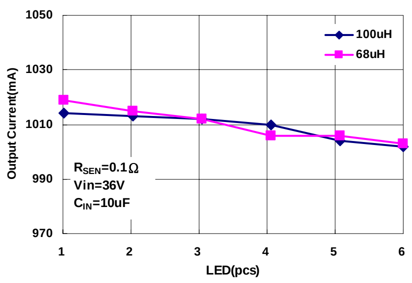


I_{OUT}=700mA

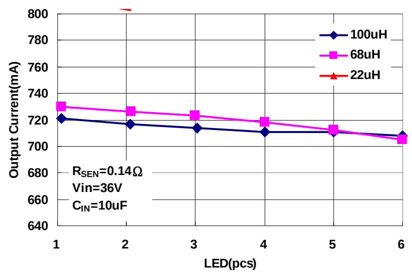


I_{OUT}=350mA

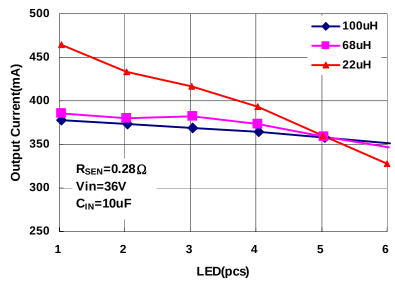
Fig. 27 V_{IN}=24V



I_{OUT}=1A

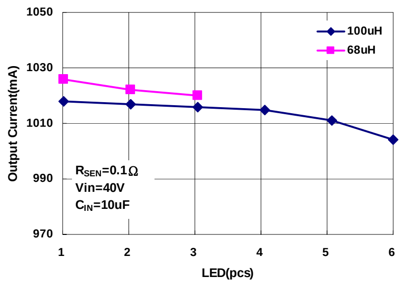


I_{OUT}=700mA

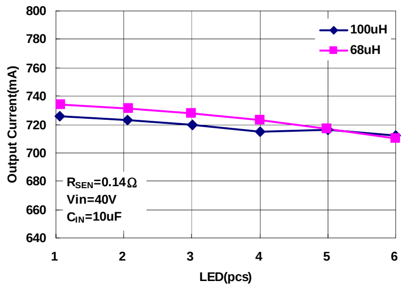


I_{OUT}=350mA

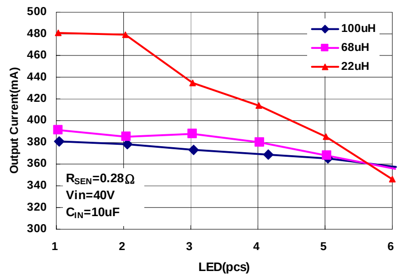
Fig. 28 V_{IN}=36V



I_{OUT}=1A



I_{OUT}=700mA



I_{OUT}=350mA

Fig. 29 V_{IN}=40V

Design Consideration

Switching Frequency

To achieve better output current accuracy, the switching frequency should be determined by minimum on/off time of SW waveform. For example, if the duty cycle of MBI6654 is larger than 0.5, then the switching frequency should be determined by the minimum off time, and vice versa. Thus the switching frequency of MBI6654 is:

$$f_{SW} = \frac{1}{T_S} = \frac{1}{\frac{T_{OFF,min}}{(1-D)}} \text{, when the duty cycle is larger than 0.5} \qquad (1)$$

$$\text{or } f_{SW} = \frac{1}{T_S} = \frac{1}{\frac{T_{ON,min}}{D}} \text{, when the duty cycle is smaller than 0.5.} \qquad (2)$$

The switching frequency is related to efficiency (better at low frequency), the size/cost of components (smaller/ cheaper at high frequency), and the amplitude of output ripple voltage and current (smaller at high frequency). The slower switching frequency comes from the large value of inductor. In many applications, the sensitivity of EMI limits the switching frequency of MBI6654. The switching frequency can be ranged from 40kHz to 1.0MHz.

LED Ripple Current

A LED constant current driver, such as MBI6654, is designed to control the current through the cascaded LED, instead of the voltage across it. Higher LED ripple current allows the use of smaller inductance, smaller output capacitance and even without an output capacitor. The advantages of higher LED ripple current are to minimize PCB size and reduce cost because of no output capacitor. Lower LED ripple current requires larger inductance, and output capacitor. The advantages of lower LED ripple current are to extend LED life time and to reduce heating of LED. The recommended ripple current is from 5% to 20% of normal LED current.

Component Selection

Inductor Selection

The inductance is determined by two factors: the switching frequency and the inductor ripple current. The calculation of the inductance, L1, can be described as

$$L1 > (V_{IN} - V_{OUT} - V_{SEN} - (R_{ds(on)} \times I_{OUT})) \times \frac{D}{f_{SW} \times \Delta I_L}$$

where

$R_{ds(on)}$ is the on-resistance of internal MOSFET of the MBI6654. The typical is 0.3Ω at $12V_{IN}$.

D is the duty cycle of the MBI6654, $D=V_{OUT}/V_{IN}$.

f_{SW} is the switching frequency of the MBI6654.

$\triangle I_L$ is the ripple current of inductor, $\triangle I_L=(1.15xI_{OUT})–(0.85xI_{OUT})=0.3xI_{OUT}$.

When selecting an inductor, not only the inductance but also the saturation current that should be considered as the factors to affect the performance of module. In general, it is recommended to choose an inductor with 1.5 times of LED current as the saturation current. Also, the larger inductance gains the better line/load regulation. However, the inductance and saturation current become a trade-off at the same inductor size. An inductor with shield is recommended to reduce the EMI interference. However, this is another trade-off with heat dissipation.

Schottky Diode Selection

The MBI6654 needs a flywheel diode, D1, to carry the inductor current when the MOSFET is off. The recommended flywheel diode is schottky diode with low forward voltage for better efficiency. Two factors determine the selection of schottky diode. One is the maximum reverse voltage. The recommended rated voltage of the reverse voltage is at least 1.5 times of input voltage. The other is the maximum forward current, which works when the MOSFET is off. And the recommended forward current is 1.5 times of output current. Users should carefully choose an appropriate schottky diode which can perform low leakage current at high temperature.

Input Capacitor Selection

The input capacitor, C_{IN}, can supply pulses of current for the MBI6654 when the MOSFET is ON. And C_{IN} is charged by input voltage when the MOSFET is OFF. As the input voltage is lower than the tolerable input voltage, the internal MOSFET of the MBI6654 remains constantly ON, and the LED current is limited to 1.15 times of normal current. The recommended value of input capacitor is 10uF to stabilize the lighting system.

The rated voltage of input capacitor should be at least 1.5 times of input voltage. A tantalum or ceramic capacitor can be used as an input capacitor. The advantages of tantalum capacitor are high capacitance and low ESR. The advantages of ceramic capacitor are high frequency characteristic, small size and low cost. Due to low ESR characteristic of ceramic capacitor, please do not use hot plugging. Users can choose an appropriate one for their applications.

Output Capacitor Selection (Optional)

A capacitor paralleled with cascaded LED can reduce the LED ripple current and allow smaller inductance.

PCB Layout Consideration

To enhance the efficiency and stabilize the system, PCB layout is important. There are several factors should be considered.

1. A complete ground area is helpful to eliminate the switching noise.
2. Keep the distance between IC's GND pin and the ground leads of input and output filter capacitors to be less than 5mm.
3. To maximize output power efficiency and minimize output ripple voltage, use a ground plane and solder the IC's GND pin directly to the ground plane.
4. To stabilize the system, the heat sink of the MBI6654 is recommended to connect to ground plane directly.
5. To enhance the heat dissipation, the area of ground plane, which IC's heat sink is soldered on, should be as large as possible.
6. The components placement should follow the sequence of the input capacitor, the input filter capacitor, R_{SEN} and VIN pin. The components layout path should not be spread out. In other words, the components should be placed on the same path.
7. The input and bypass capacitors should be placed to IC's VIN and GND pins as close as possible.
8. To avoid the parasitic effect of trace, the R_{SEN} should be placed to IC's VIN and SEN pins as close as possible.
9. The area, which is composed of IC's SW pin, schottky diode and inductor, should be wide and short.
10. The path, which flows large current, should be wide and short to eliminate the parasitic element.
11. When SW is ON/OFF, the direction of current loop should keep the same way to enhance the efficiency. The sketch is shown as Fig. 30.
12. To avoid the unexpected damages of malfunction to the driver board, users should pay attention to the quality of soldering in the PCB by checking if cold welding or cold joint happens between the pins of IC and the PCB.
13. To stabilize the system, do not put the inductor right under the IC.
14. To stabilize the system, when the input voltage is over 30V, please parallel a 100pF ceramic capacitor with DIMD pin.

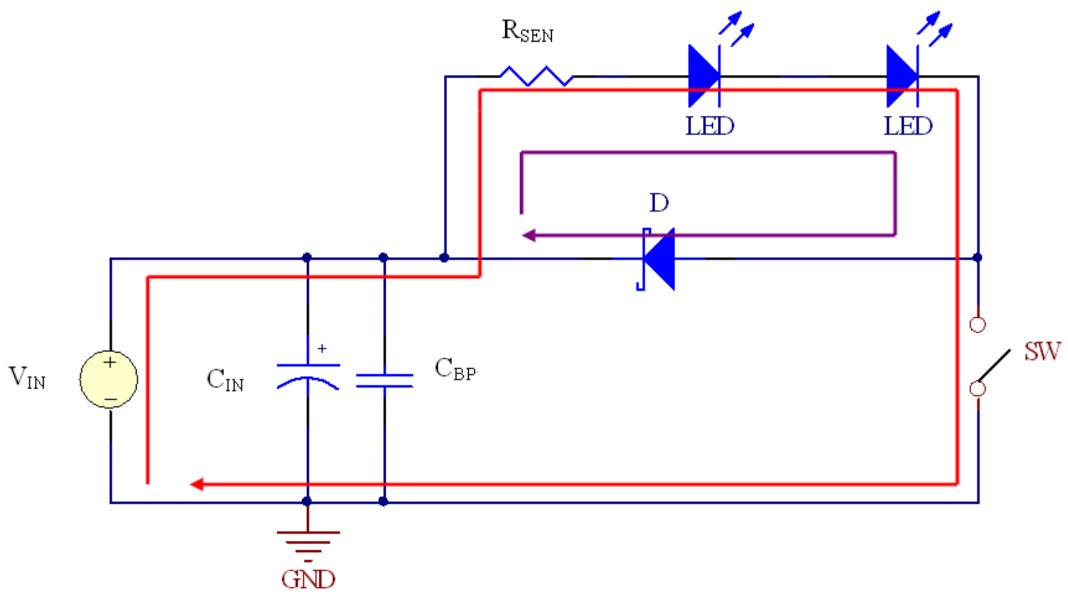
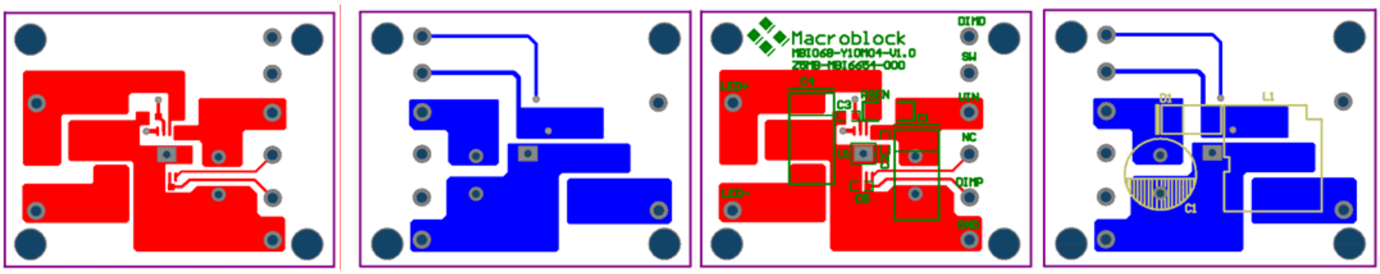


Fig.30 Power loop of MBI6654

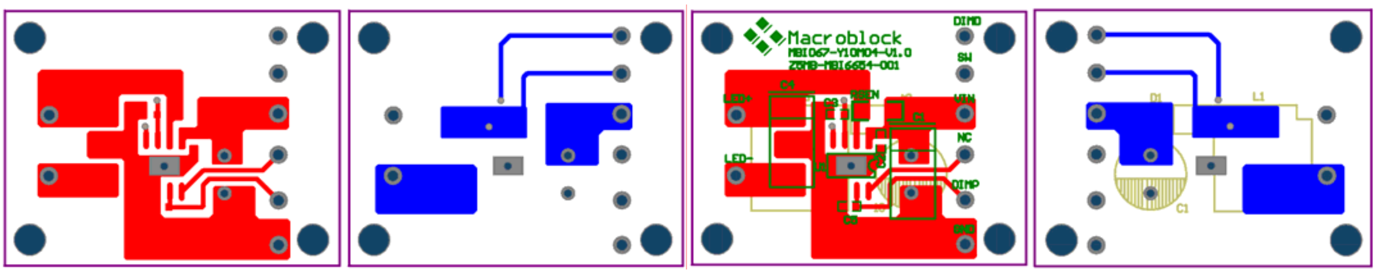
PCB Layout

Fig. 31 and 32 are the recommended layout diagrams of the MBI6654 in different packages.



Top layer | Bottom layer | Top-Over layer | Bottom-Over layer

Fig. 31 The layout diagram of the MBI6654GMS

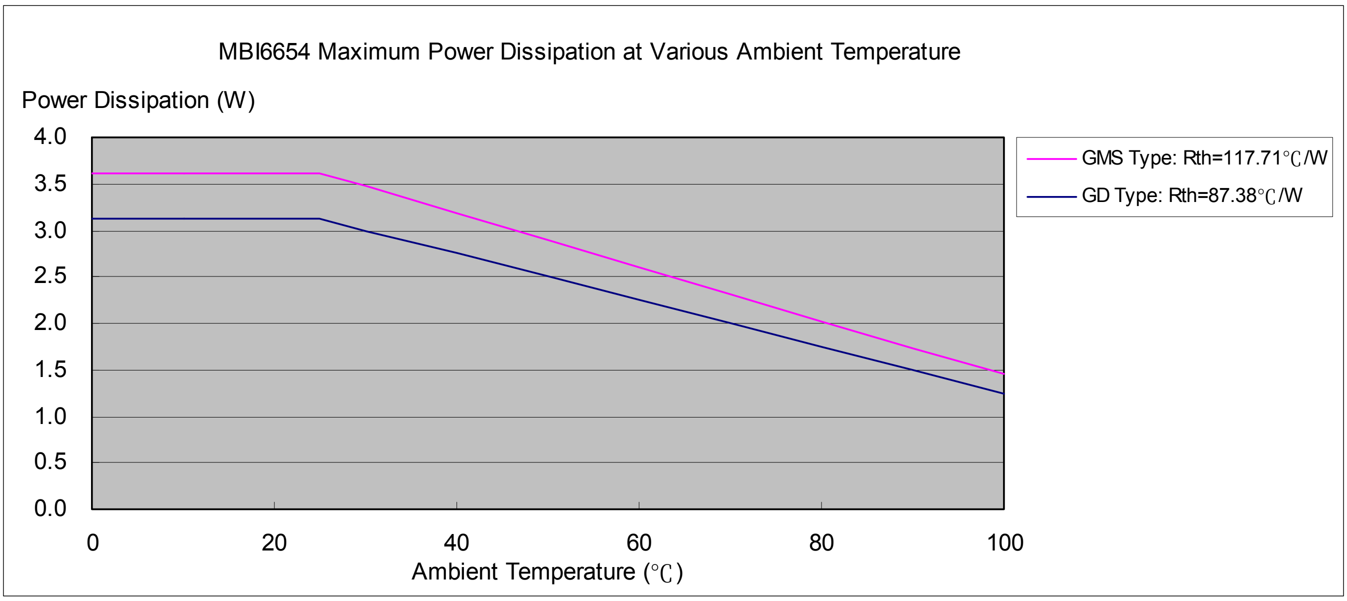


Top layer | Bottom layer | Top-Over layer | Bottom-Over layer

Fig. 32 The layout diagram of the MBI6654GD

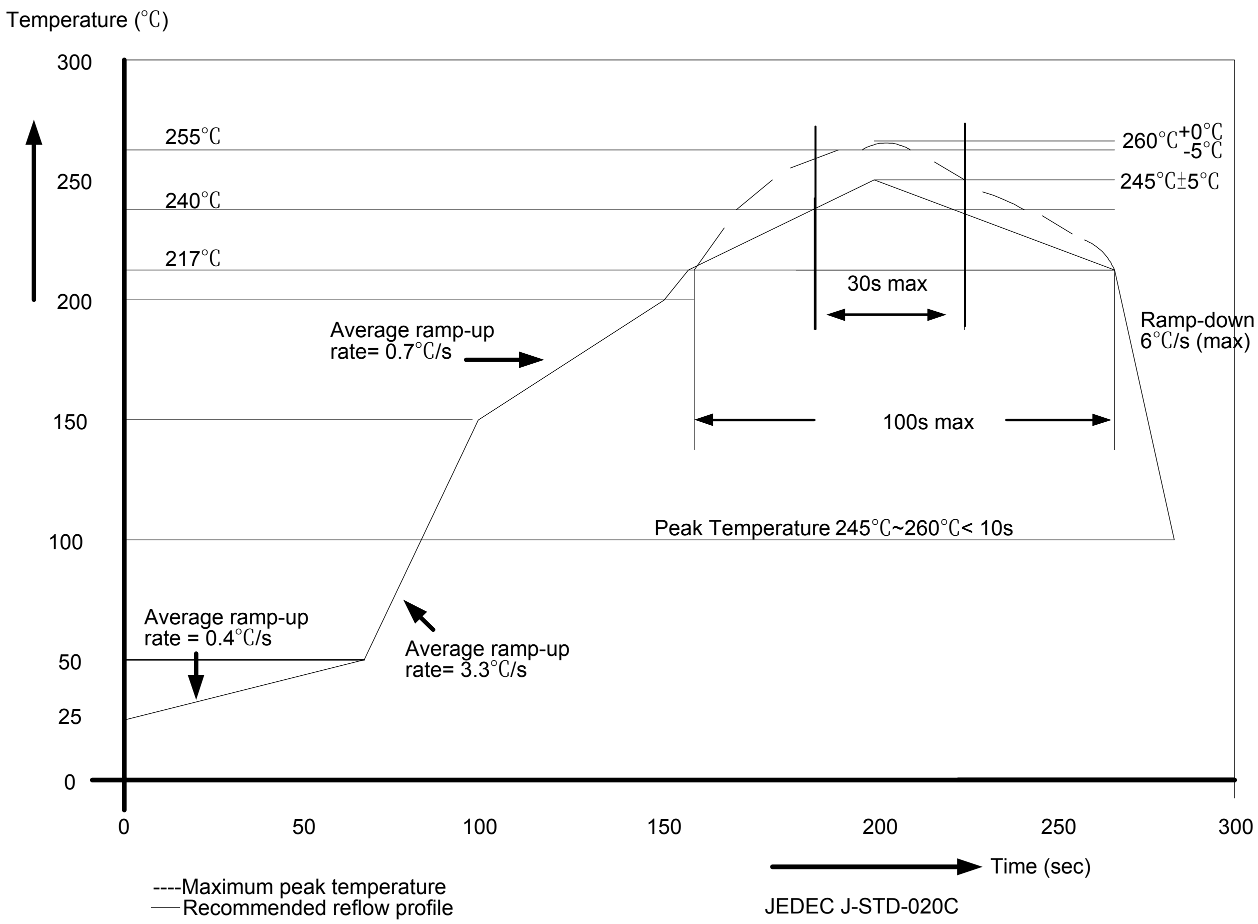
Package Power Dissipation (PD)

The maximum power dissipation, $P_D(max)=(Tj–Ta)/R_{th(j-a)}$, decreases as the ambient temperature increases.



Soldering Process of “Pb-free” Package Plating*

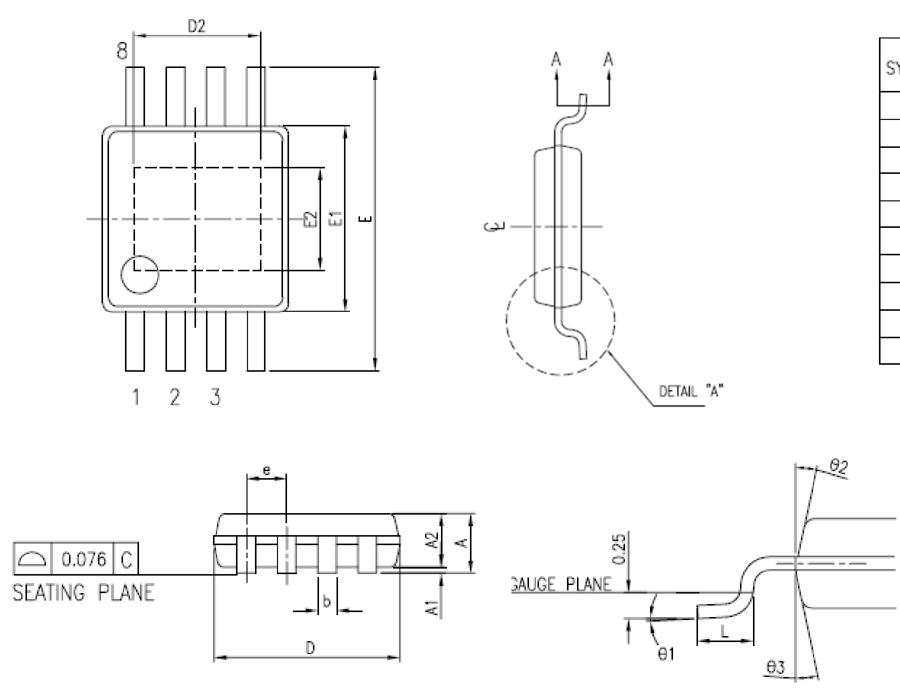
Macroblock has defined "Pb-Free" to mean semiconductor products that are compatible with the current RoHS requirements and selected 100% pure tin (Sn) to provide forward and backward compatibility with both the current industry-standard SnPb-based soldering processes and higher-temperature Pb-free processes. Pure tin is widely accepted by customers and suppliers of electronic devices in Europe, Asia and the US as the lead-free surface finish of choice to replace tin-lead. Also, it adopts tin/lead (SnPb) solder paste, and please refer to the JEDEC J-STD-020C for the temperature of solder bath. However, in the whole Pb-free soldering processes and materials, 100% pure tin (Sn) will all require from 245 °C to 260°C for proper soldering on boards, referring to JEDEC J-STD-020C as shown below.



Package Thickness	Volume mm³ <350	Volume mm³ 350-2000	Volume mm³ ≧2000
<1.6mm	260 +0 °C	260 +0 °C	260 +0 °C
1.6mm – 2.5mm	260 +0 °C	250 +0 °C	245 +0 °C
≧2.5mm	250 +0 °C	245 +0 °C	245 +0 °C

*Note: For details, please refer to Macroblock’s “Policy on Pb-free & Green Package”.

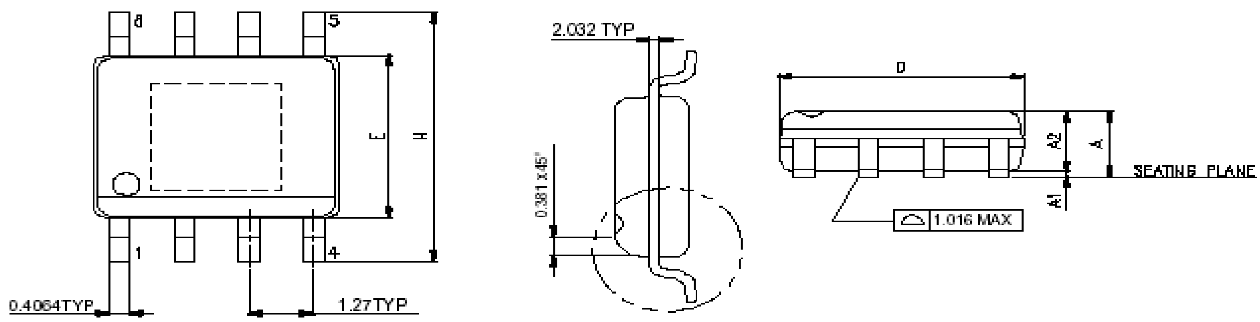
Outline Drawing

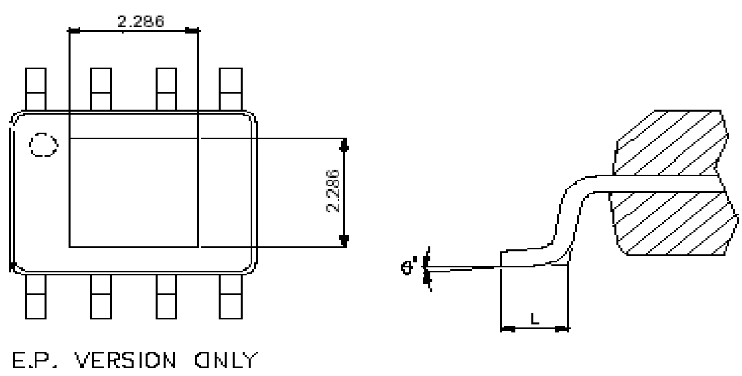


SYMBOL	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	---	---	1.10	---	---	0.043
A1	0.05	---	0.10	0.002	---	0.006
A2	0.81	0.86	0.91	0.032	0.034	0.036
c	0.13	---	0.23	0.005	---	0.009
c1	0.13	0.15	0.18	0.005	0.006	0.007
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.90 BSC			0.193 BSC		
E1	2.90	3.00	3.10	0.114	0.118	0.122
L	0.445	0.55	0.648	0.0175	0.0217	0.0255
θ1	0°		6°	0°		6°

SYMBOL	8L		
	MIN.	NOM.	MAX.
D2	2.00	2.05	2.10
E2	1.60	1.65	1.70
e	0.65 BSC		

MBI6654GMS Outline Drawing





SYMBOLS	MIN.	MAX.
A	1.346	1.752
A1	0.102	0.254
A2	—	1.499
D	4.8	4.978
E	3.81	3.988
H	5.791	6.198
L	0.406	1.27
θ°	0	203.2

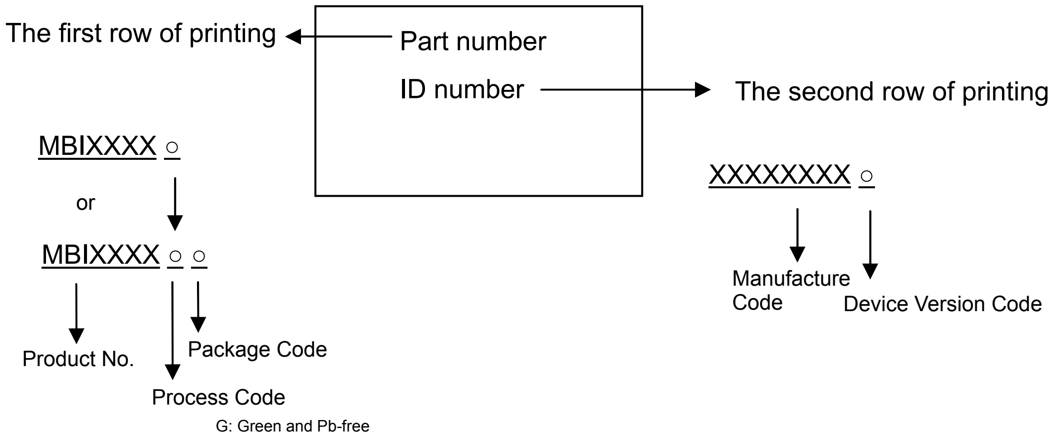
UNIT : mm

MBI6654GD Outline Drawing

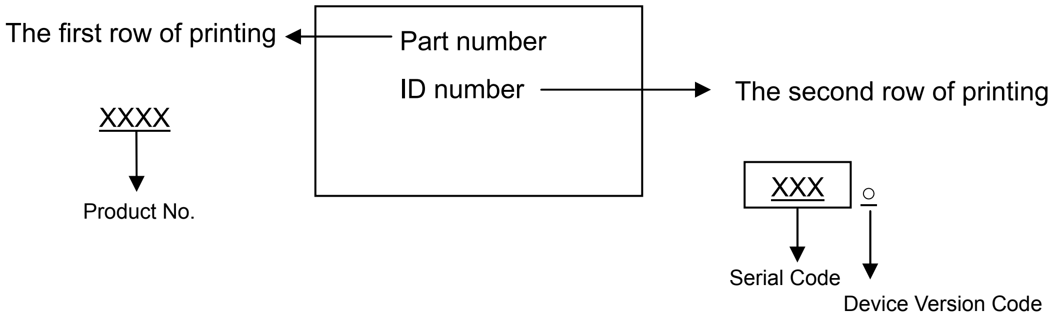
Note: Please use the maximum dimensions for the thermal pad layout. To avoid the short circuit risk, the vias or circuit traces shall not pass through the maximum area of thermal pad.

Product Top Mark Information

GD(SOP-8L)



GMS(MSOP-8L)



Product Revision History

Datasheet version	Device Version Code
V1.00	A
V1.01	A

Product Ordering Information

Part Number	"Pb-free" Package Type	Weight (g)
MBI6654GMS	MSOP-8L-118mil	0.0233g
MBI6654GD	SOP8L-150-1.27	0.07g

Disclaimer