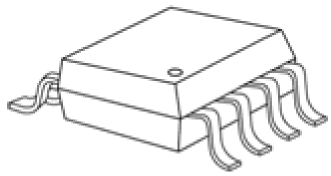
Step-Down, 1A Dimmable LED Driver

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
- Patented fixed frequency analog dimming control
  - PWM-controlled brightness modulation
  - DC voltage-controlled brightness modulation
- 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-Circuit
- Only 4 external components required

Product Description

MBI6653 is a step-down constant-current high-brightness LED driver to provide a cost-effective design solution for interior/exterior illumination applications. It is designed to deliver constant current to light up high power LED with only 4 external components. With hysteretic PFM control scheme, MBI6653 eliminates external compensation design and makes the design simple.

The output current of MBI6653 can be programmed by an external resistor and dimmed via pulse width modulation (PWM) through PWMD pin. In addition, a novel fixed frequency analog dimming method is proposed and offered by the device. Users can achieve higher efficiency linear current modulation from 5% to 100% of preset current by applying either PWM-controlled or DC voltage-controlled brightness modulation.
MBI6653 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 which results from LED open-circuited, short-circuited and other abnormal events.

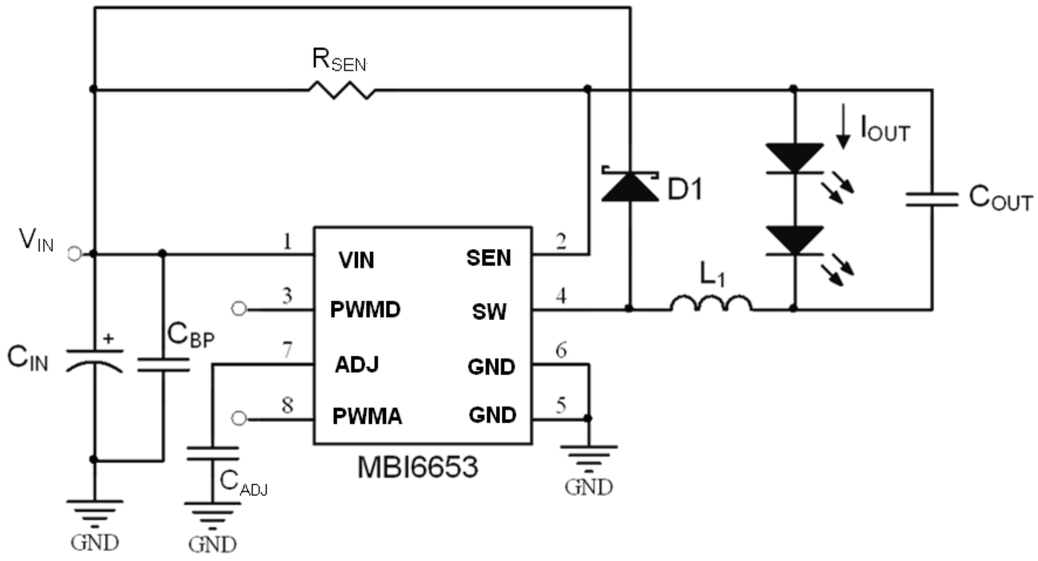
MBI6653 provides thermal-enhanced MSOP-8 and SOP-8 packages as well to handle power dissipation more efficiently.

Applications

- Signage and Decorative LED Lighting
- High Power LED Lighting
- Constant Current Source

Floor 6-4, No.18, Pu-Ting Rd., Hsinchu, Taiwan 30077, ROC.
TEL: +886-3-579-0068, FAX: +886-3-579-7534 E-mail: info@mblock.com.tw

Typical Application Circuit



C_{IN}: 10uF/50V, VISHAY, 293D106X9050D2TE3, D case Tantalum Capacitor.
C_{OUT}: 10uF/50V, VISHAY, 293D106X9050D2TE3, D case Tantalum Capacitor.
C_{BP}: 0.1uF/50V. 0603 / X7R / SMD ceramic capacitor, Gildenconnections.
C_{ADJ}: 0.1uF/50V. 0603 / X7R / SMD ceramic capacitor, Gildenconnections.
R_{SEN}: 0.14Ω ±1% , 1206 SMD Resistor, VIKING
L1: GANG SONG, GSDS106C2-680M.
D1: ZOWIE, SSCD206.

Fig. 1

Functional Diagram

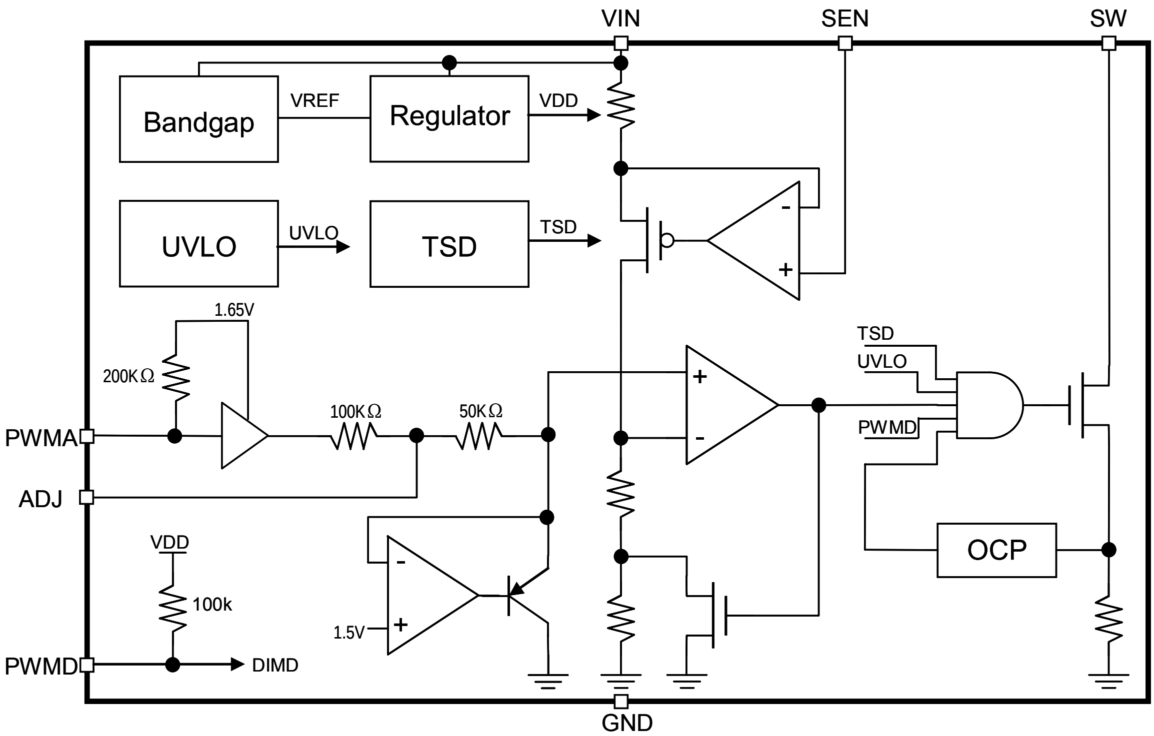
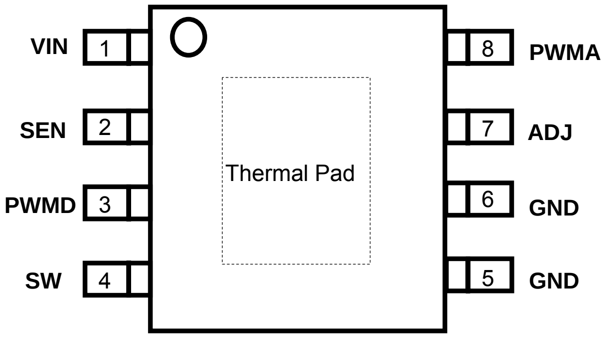
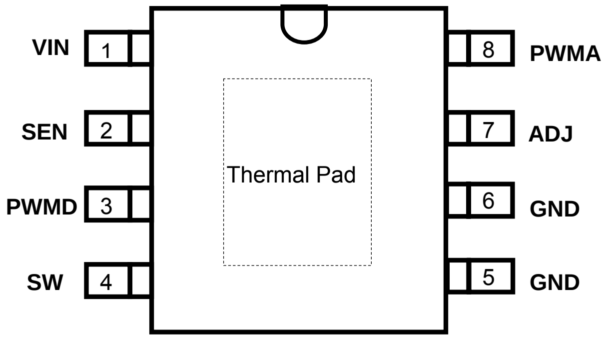


Fig. 2

Pin Configuration



MBI6653GMS (Top View)



MBI6653GD (Top View)

Pin Description

Pin Name	Function
GND	Ground terminal for control logic and current sink
SW	Switch output terminal
PWMD	Digital dimming control terminal. The PWMD can be floating, if the dimming function is not required.
PWMA	PWM dimming control terminal to simulate analog dimming. PWM signal is applied into the terminal for analog brightness control. The PWMA can be floating, if the dimming function is not required.
ADJ	Analog dimming control terminal. DC voltage can be applied into the terminal for analog brightness control. The ADJ can be floating, if the dimming function is not required. Connecting a filter capacitor to this pin when using PWM dimming control through PWMA.
SEN	Output current sense terminal
VIN	Supply voltage terminal
Thermal Pad	Power dissipation terminal connected to GND*

*To improve the noise immunity, 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}	-0.5~40	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
Power Dissipation (On 4-Layer PCB, Ta=25°C)*	GD Type	P_D	3.13	W
Thermal Resistance (By simulation, on 4-Layer PCB)*	GD Type	$R_{th(j-a)}$	40	°C/W
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. Please refer to JEDEC JESD51.

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

***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.

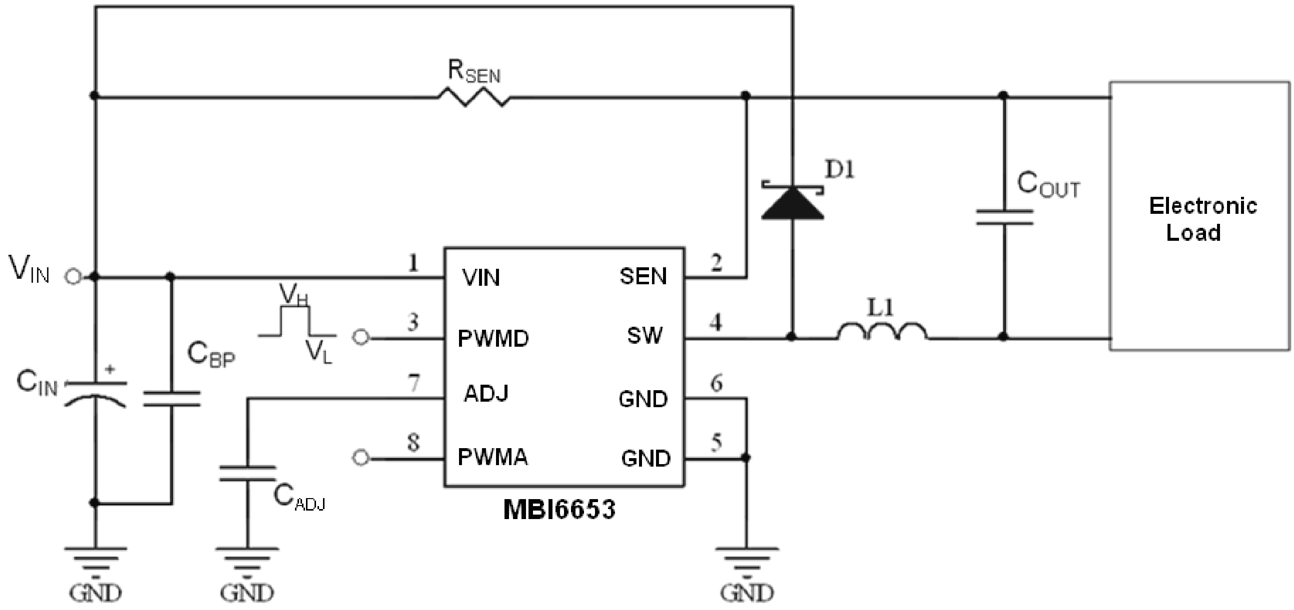
Electrical Characteristics

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

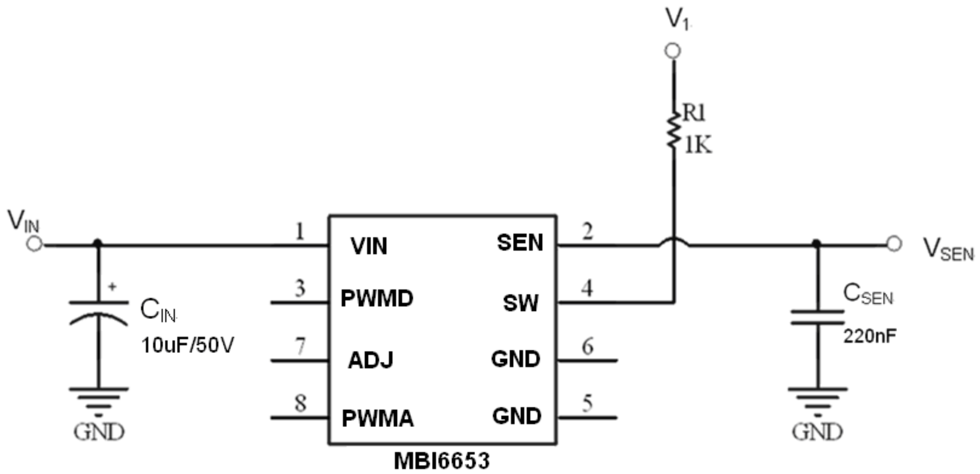
Characteristics		Symbol	Condition	Min.	Typ.	Max.	Unit
INPUT AND OUTPUT							
Supply Voltage		V_{IN}	-	6	-	36	V
Supply Current		I_{IN}	V_{IN}=6V~36V	-	1	2	mA
Start-Up Voltage		V_{SU}		5.5	5.7	5.9	V
Under Voltage Lock Out Voltage		V_{UVLO}		4.3	4.5	4.7	V
HYSTERESIS CONTROL							
Mean Sense Voltage		V_{SENSE}		95	100	105	mV
Sense Voltage threshold hysteresis		$V_{SENSE,HYS}$		-	15	-	%
Internal Propagation Delay Time		Tpd		100	200	320	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		-	200	-	ns
Minimum Switch OFF Time*		T_{OFF},min		-	200	-	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
PWM DIMMING (Control by PWMD)							
Input Voltage of PWMD	"H" level	V_{IH}	-	1.25	-	-	V
	"L" level	V_{IL}	-	-	-	0.4	V
Duty Cycle Range of PWM Signal Applied to PWMD pin		$Duty_{PWMD}$	PWM Frequency: 1kHz	1	-	100	%
Internal Pull Up Resistor		R_{PWMD}			100k		Ω
ANALOG DIMMING (Control by PWMA, ADJ)							
Input Voltage of PWMA	"H" level	V_{IH}	-	3.5	-	-	V
	"L" level	V_{IL}	-	-	-	0.5	V
Duty Cycle Range of PWM Signal Applied to PWMA pin		$Duty_{PWMA}$	PWM Frequency: 1kHz on PWMA	10	-	100	%
Internal Pull Up Resistor		R_{PWMA}		-	100k	-	Ω
Analog Dimming Input Clamp Voltage		$V_{ADJ.CLAMP}$	DC voltage: ADJ	-	1.5	-	V
Analog Dimming Input Voltage turn off SW		$V_{ADJ\ SWOFF}$	DC voltage: ADJ	-	0.2	-	V
OVER CURRENT PROTECTION							
Over Current Threshold*			-	-	1.7	-	A

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

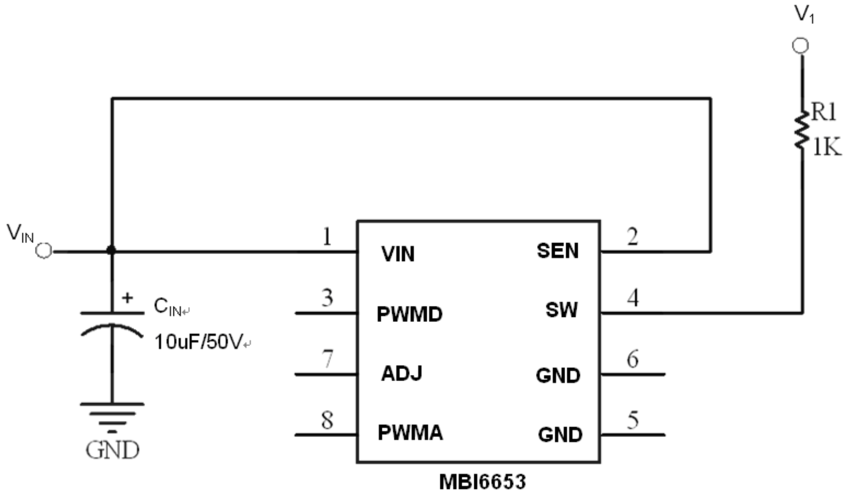
Test Circuit for Electrical Characteristics



(a)



(b)

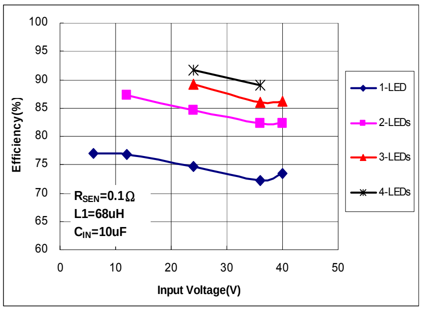


(c)

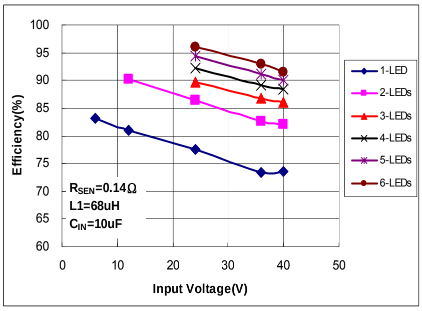
Typical Performance Characteristics

Please refer to the typical application circuit, V_{IN}=6V~40V, L1=68uH, C_{IN}=C_{OUT}, T_A=25°C, 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

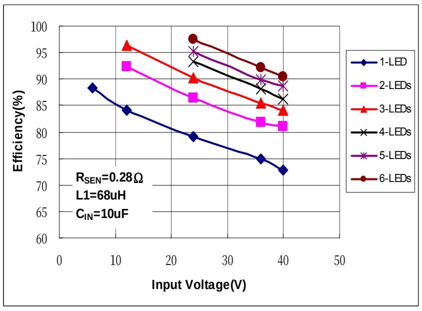
Efficiency vs. Input Voltage at Various LED Cascaded Numbers



I_{OUT}=1A
Fig. 3

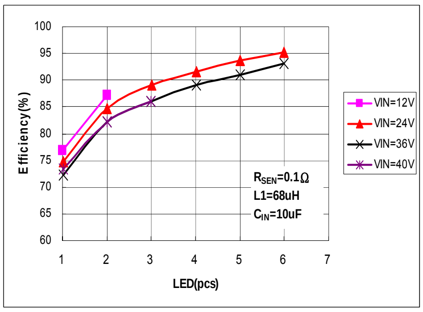


I_{OUT}=700mA
Fig. 4

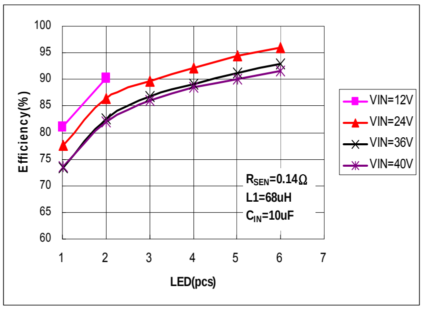


I_{OUT}=350mA
Fig. 5

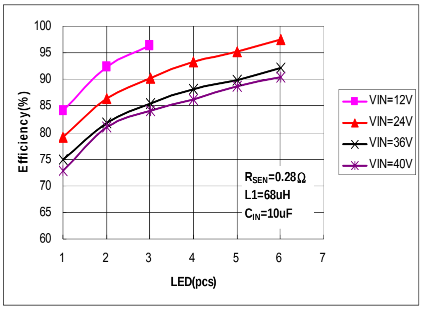
Efficiency vs. LED Cascaded Number at Various Input Voltage



I_{OUT}=1A
Fig. 6

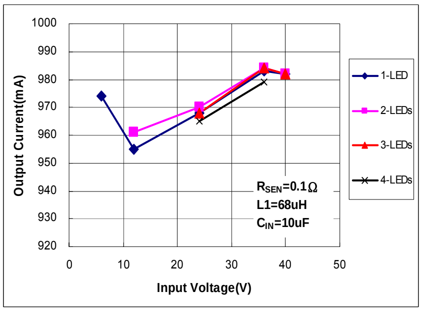


I_{OUT}=700mA
Fig. 7

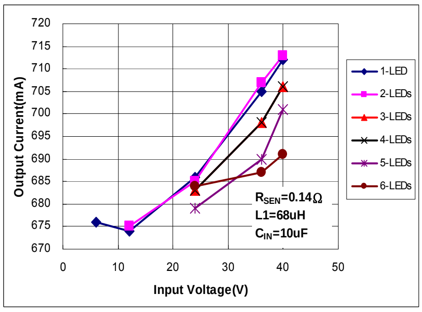


I_{OUT}=350mA
Fig. 8

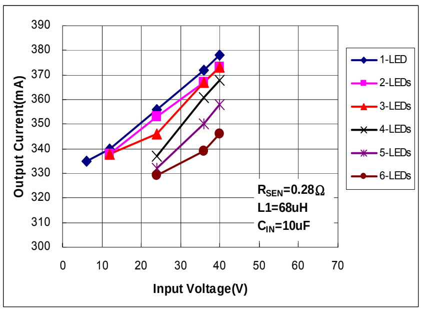
Output Current vs. Input Voltage at Various LED Cascaded Numbers



I_{OUT}=1A
Fig. 9

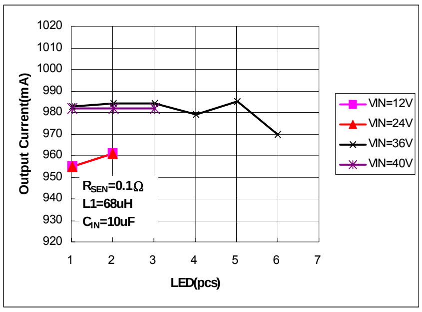


I_{OUT}=700mA
Fig. 10

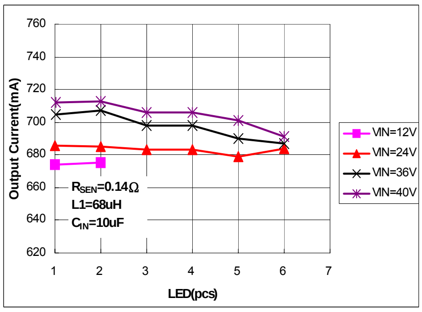


I_{OUT}=350mA
Fig. 11

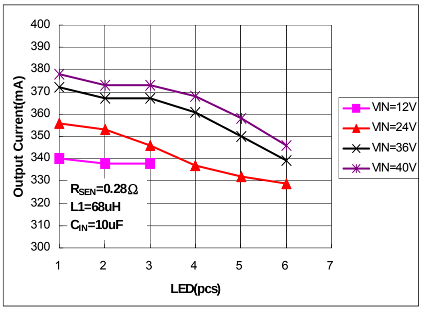
Output Current vs. LED Cascaded Number at Various Input Voltage



I_{OUT}=1A
Fig. 12



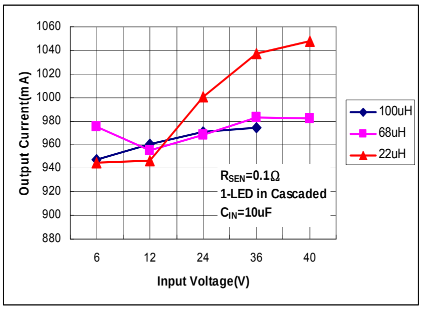
I_{OUT}=700mA
Fig. 13



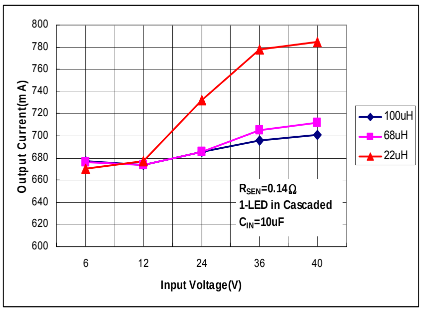
I_{OUT}=350mA
Fig. 14

Output Current vs. Input Voltage at Various Inductors

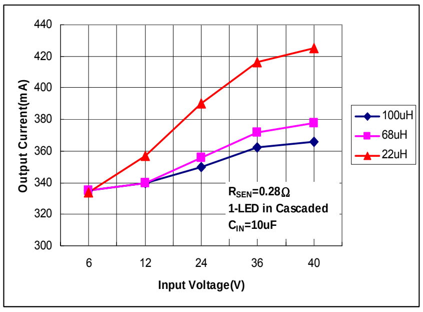
- 1-LED in cascaded



I_{OUT}=1A
Fig. 15

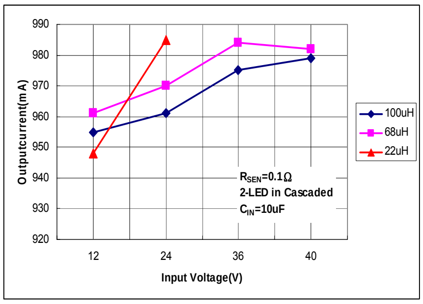


I_{OUT}=700mA
Fig. 16

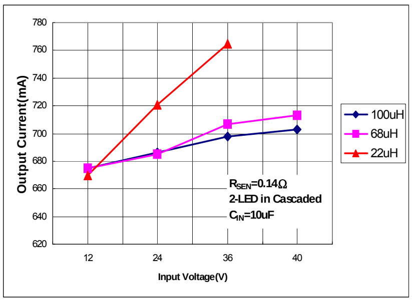


I_{OUT}=350mA
Fig. 17

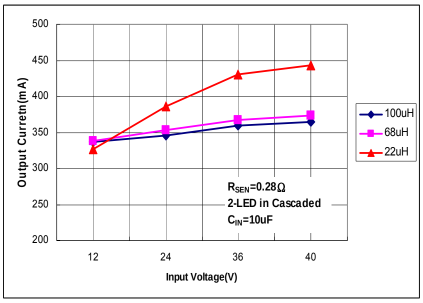
- 2-LED in cascaded



I_{OUT}=1A
Fig. 18

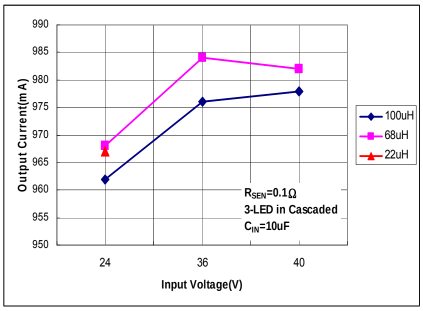


I_{OUT}=700mA
Fig. 19

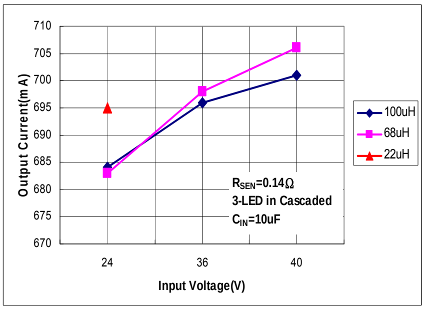


I_{OUT}=350mA
Fig. 20

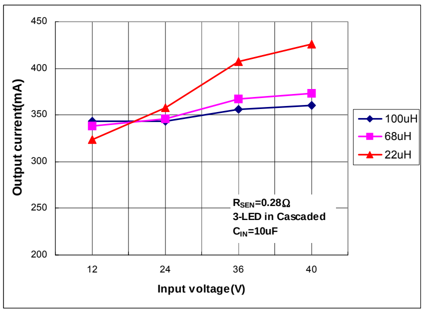
- 3-LED in cascaded



I_{OUT}=1A
Fig. 21



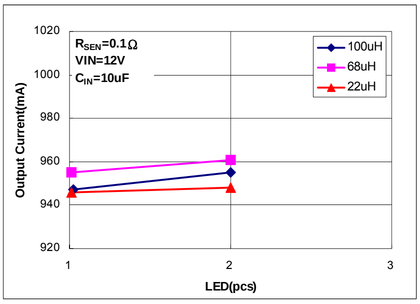
I_{OUT}=700mA
Fig. 22



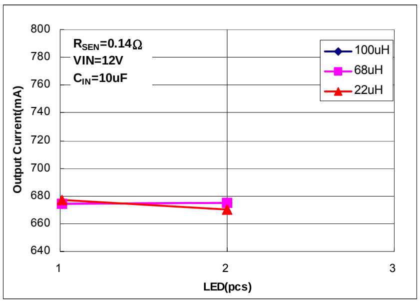
I_{OUT}=350mA
Fig. 23

Output Current vs. LED Cascaded Number at Various Inductor

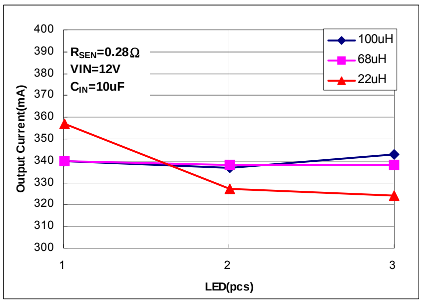
- VIN=12V



I_{OUT}=1A
Fig. 24

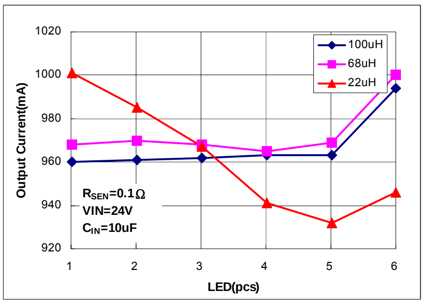


I_{OUT}=700mA
Fig. 25

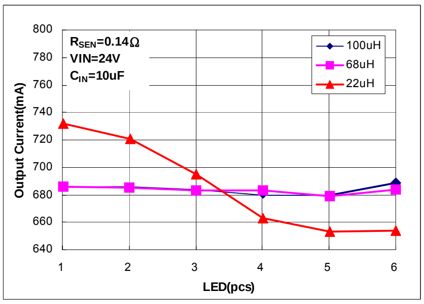


I_{OUT}=350mA
Fig. 26

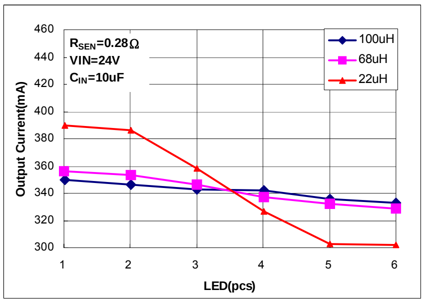
- VIN=24V



I_{OUT}=1A
Fig. 27

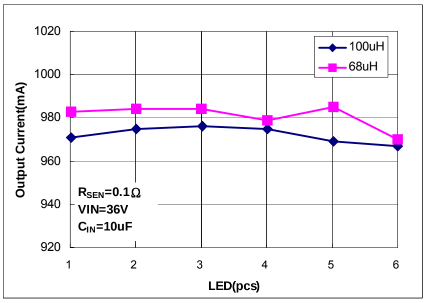


I_{OUT}=700mA
Fig. 28

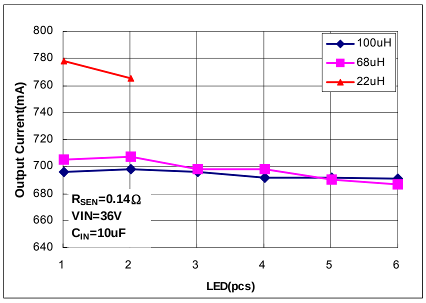


I_{OUT}=350mA
Fig. 29

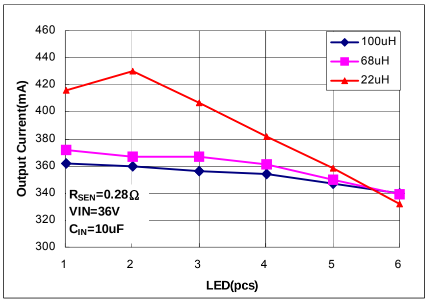
- VIN=36V



I_{OUT}=1A
Fig. 30

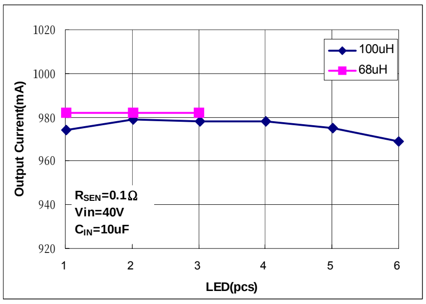


I_{OUT}=700mA
Fig. 31

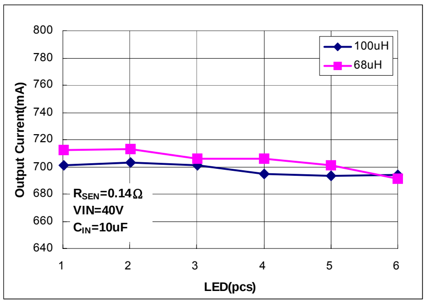


I_{OUT}=350mA
Fig. 32

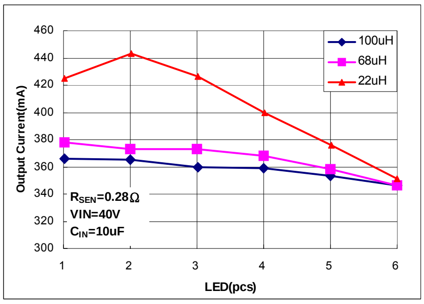
- VIN=40V



I_{OUT}=1A
Fig. 33



I_{OUT}=700mA
Fig. 34



I_{OUT}=350mA
Fig. 35

Application Information

MBI6653 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 ±5% accuracy. Featured by PWM dimming and analog dimming capability, MBI6653 offers flexible ways to meet LED dimming related applications.

Setting Average Output Current

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

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

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

where R_{SEN} is the resistance of the external resistor connecting to SEN pin, 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 drops 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 MBI6653 application circuit is shown in Fig. 36. As the input voltage is smaller than the minimum input voltage such as the 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. 37.

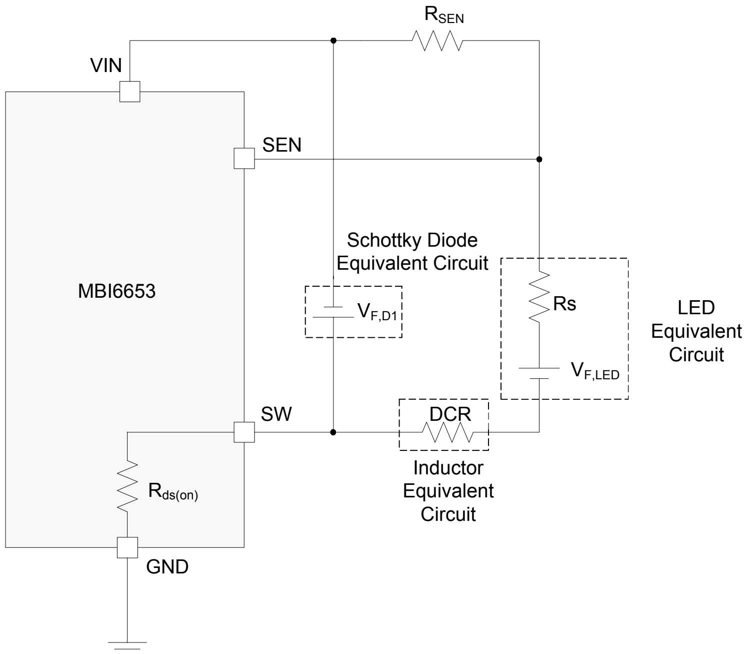


Fig. 36 The equivalent impedance in a MBI6653 application circuit

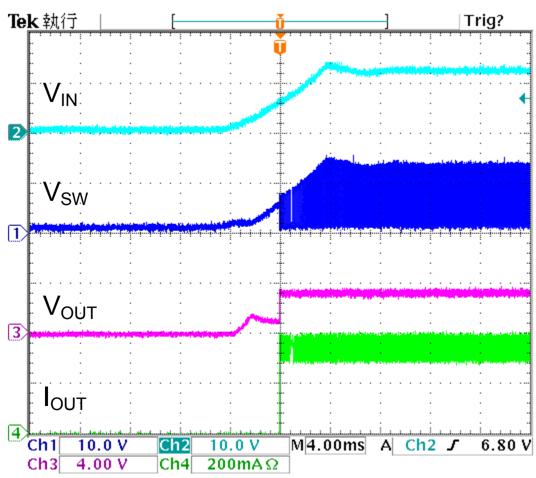
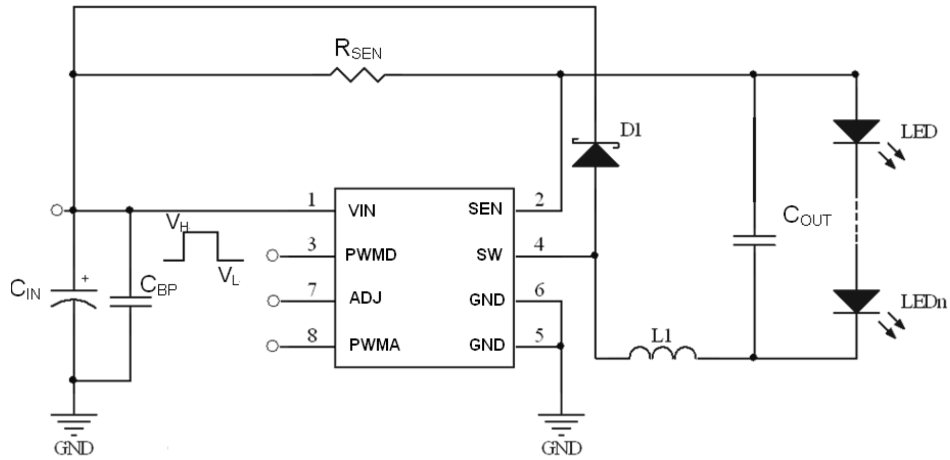


Fig. 37 The start-up waveform @ V_{IN}=12V, V_{OUT}= 3.2V, R_{SEN}=0.28Ω

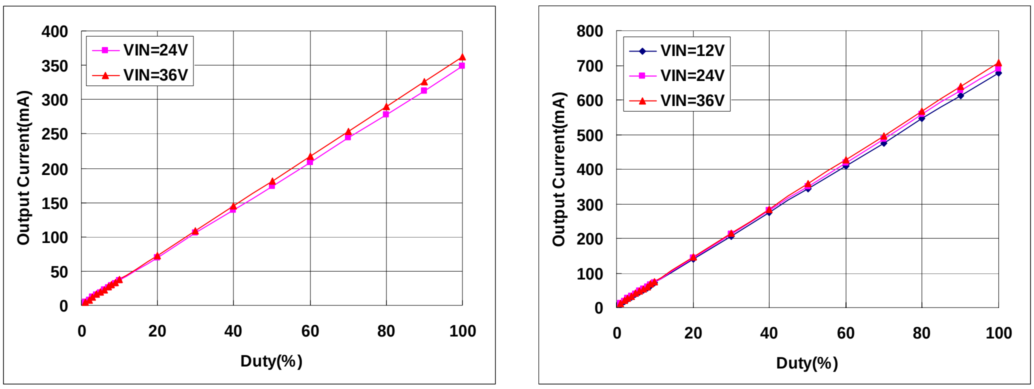
Brightness Control

A. PWM dimming

The dimming of LEDs can be performed by applying PWM signals to PWMD pin. A logic low (below 0.5V) at PWMD disables the internal MOSFET and shuts off the current flow to the LED array. An internal pull-up circuit ensures that the MBI6653 is ON when PWMD pin is unconnected. Therefore, the need for an external pull-up resistor will be eliminated. The following Fig. 38 shows good linearity in dimming control.



(a) PWM dimming signal is applied on PWMD



(a)350mA@3-LED (b)700mA@1-LED

Fig. 38 PWMD duty cycle: 0% ~ 100%

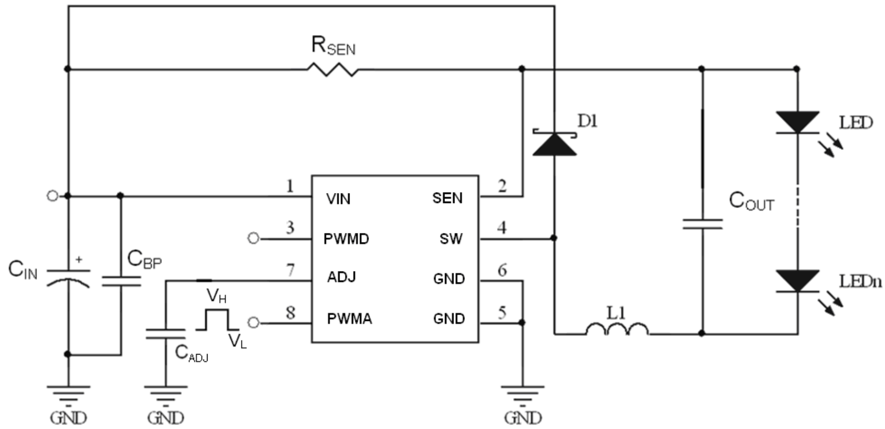
B. Analog Dimming

MBI6653 features patented fixed frequency analog dimming technique, which maintains high efficiency in light loading condition. The technique also benefits users for simple EMI practice and better SNR (Signal-to-Noise Rejection Ratio) when the brightness control is performed. There are two ways to achieve analog dimming control when applying MBI6653 as described in the following paragraphs.

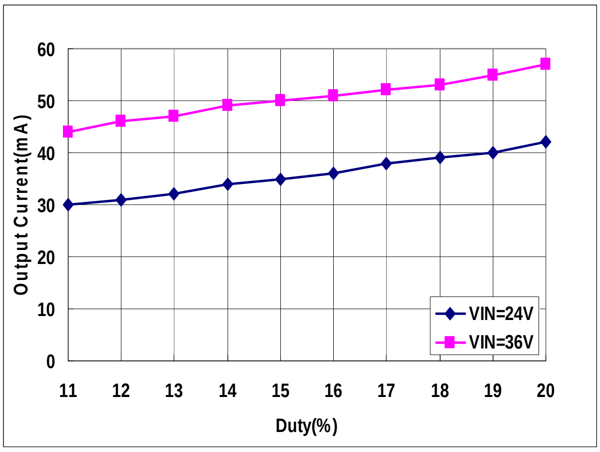
Type 1 – PWM dimming signal is applied on PWMA

The brightness control of LEDs can be performed by applying PWM signals to PWMA pin. It is similar as controlling LED current through PWMD. The difference is the way to change output current. The magnitude of output current is changed when PWM is applied into PWMA.

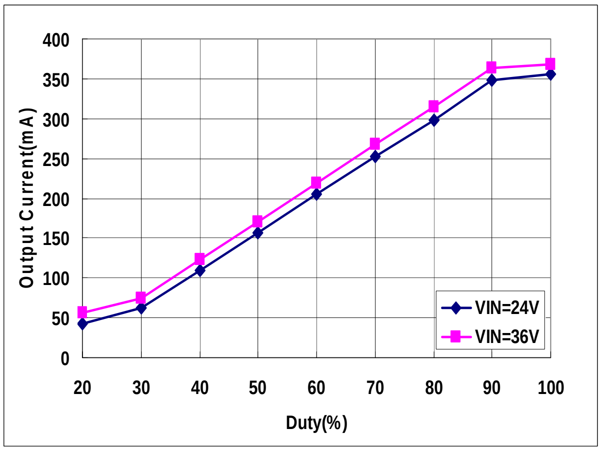
The PWM control signal feeding into PWMA is filtered and averaged into a DC voltage level when C_{ADJ} is provided. Usually, a 1uF, 0805 type with 6.3V rated voltage, tantalum or ceramic capacitor is sufficient. Subsequently, the internal reference voltage is altered and changes V_{SEN} as well, and thus, changes the magnitude of output current. The result is shown in the following figures.



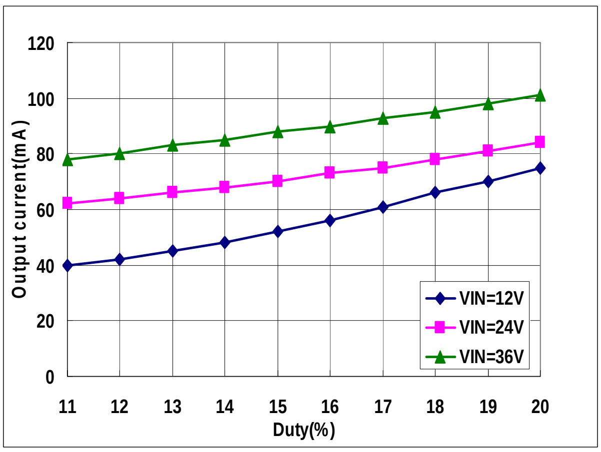
(a) PWM dimming signal is applied on PWMA



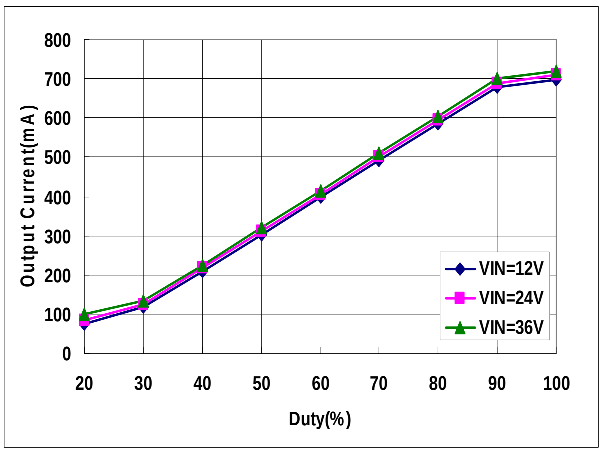
(b)350mA@3-LED, Duty (11%~20%)



(c)350mA@3-LED, Duty (20%~100%)



(d)700 mA@1-LED, Duty(11%~20%)

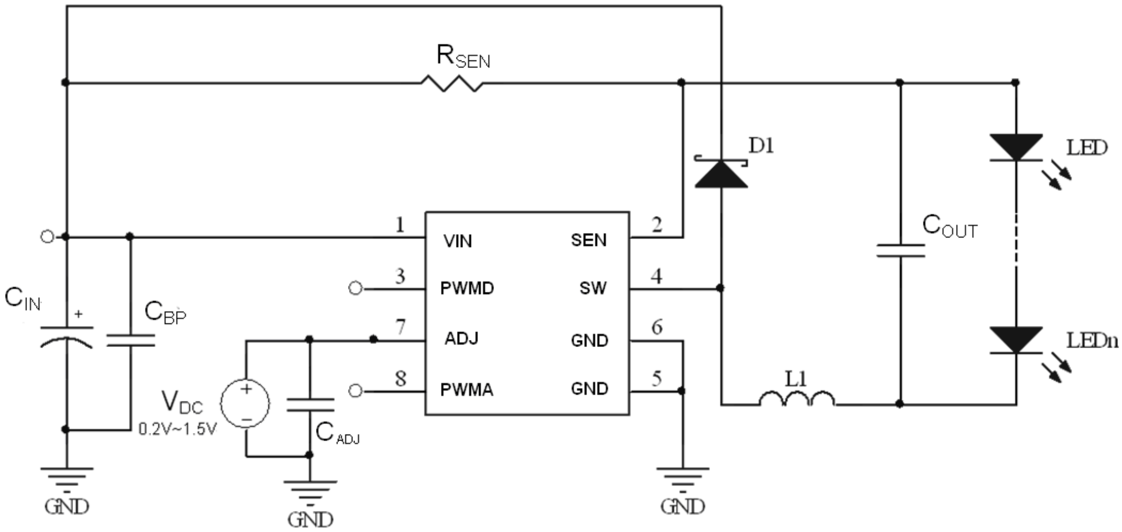


(e)700 mA@1-LED, Duty(20%~100%)

Fig. 39 PWM dimming signal applied on PWMA

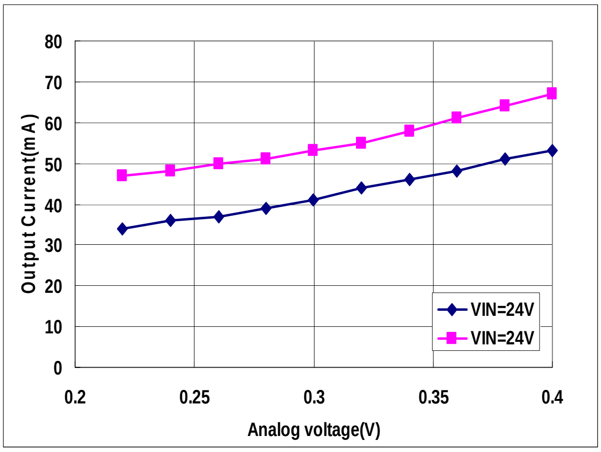
Type 2 – DC voltage is applied on ADJ

Users can also apply DC voltage directly to ADJ for modulating LED current. The result is shown in the following figures.

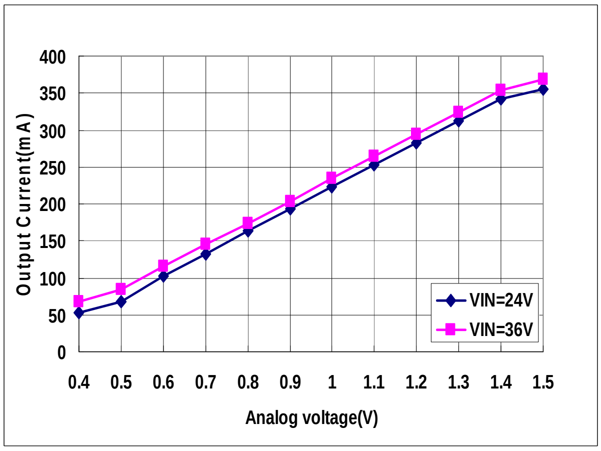


C_{ADJ} (Optional): The capacitor, C_{ADJ}, is to decouple the signal of V_{DC}.

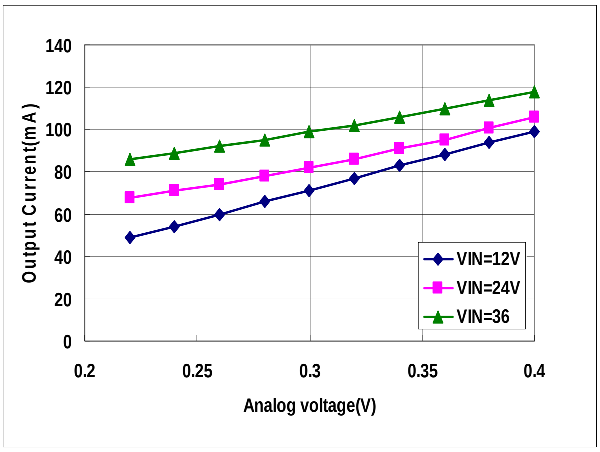
(a) DC voltage is applied on ADJ



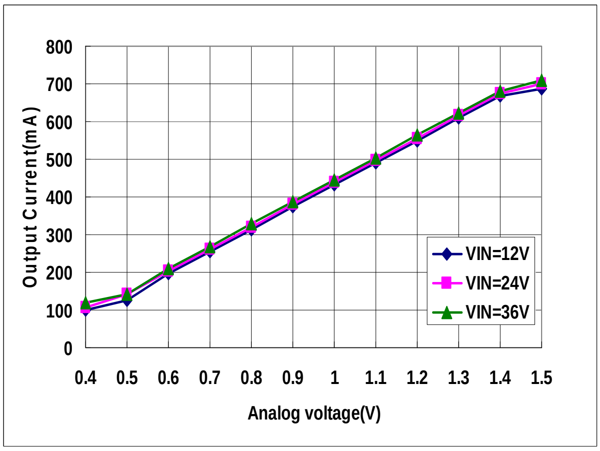
(b)350mA@3-LED, Analog voltage(0.2V~0.4V)



(c)350mA@3-LED ,Analog voltage(0.4V~1.5V)



(d) 700 mA@1-LED , Analog voltage(0.2V~0.4V)



(e)700 mA@1-LED , Analog voltage(0.4V~1.5V)

Fig. 40 DC voltage applied on ADJ

LED Open-Circuit Protection

When any LED connecting to the MBI6653 is open-circuited, the integrated power switch of MBI6653 will be turned off. The waveform is shown in Fig. 41.

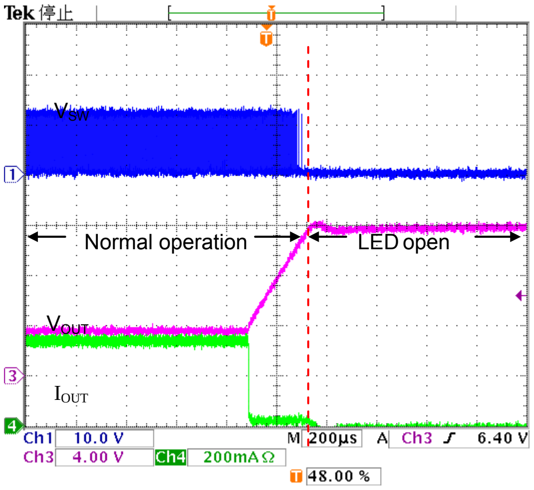


Fig. 41 LED open-circuit protection

LED Short-Circuit Protection

When one or more LEDs are short-circuited, the output voltage will decrease to the corresponding voltage, and the output current will still be the preset value. But if all of the LEDs are short-circuited, the output voltage and output current will drop to zero, as shown in Fig. 42.

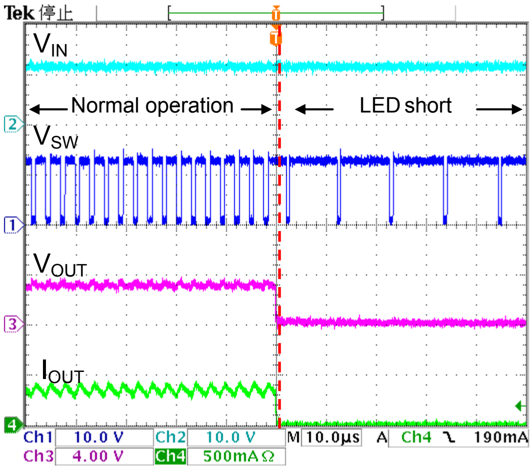


Fig. 42 LED short-circuit protection

LED Over Current Protection

MBI6653 offers over current protection to against destructive damage which results from abnormal excessive current flowing through. The function is activated, when the LED current reaches the threshold which is approximately 1.7A. Then, the integrated power switch of MBI6653 will be turned off. When the function is activated, it will not be removed until the power reset action is taken.

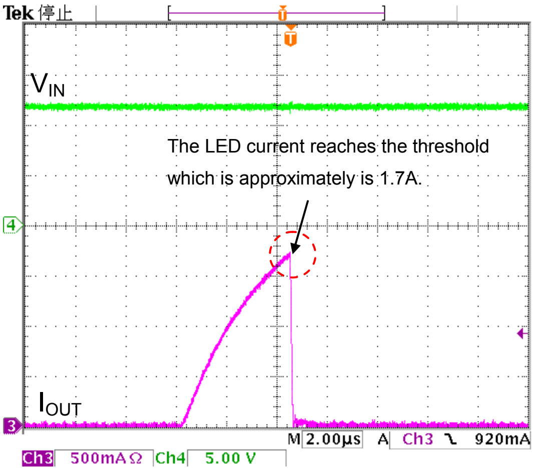


Fig. 43 Over current protection

TP Function (Thermal Protection)

When the junction temperature exceeds the threshold, T_{SD} (165°C), TP function turns off the output current. Please refer to Fig. 44 below for the waveform. 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.

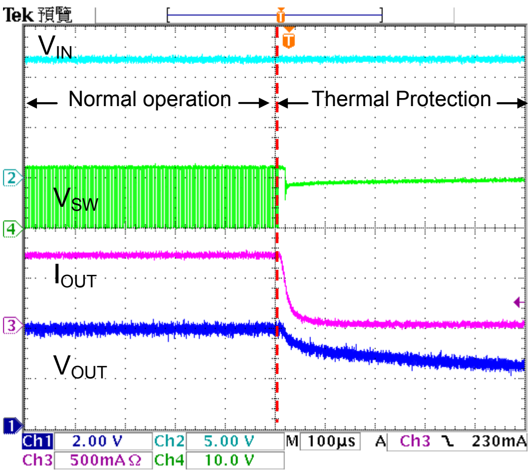


Fig. 44 Thermal protection

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 MBI6653 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 MBI6653 is:

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

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

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 MBI6653. The switching frequency can be ranged from 40kHz to 1.0MHz.

LED Ripple Current

An LED constant current driver, such as MBI6653, 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 to 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 MBI6653. The typical is 0.3Ω at $12V_{IN}$.

D is the duty cycle of the MBI6653, $D=V_{OUT}/V_{IN}$.

f_{SW} is the switching frequency of the MBI6653.

$\triangle I_L$ 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 MBI6653 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 MBI6653 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 MBI6653 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 the input capacitor should be at least 1.5 times of the input voltage.

For system stability, it is recommended to place the C_{IN} to the VIN pin of MBI6653 as close as possible. However, the PCB size might limit this requirement. Therefore, to avoid the noise interference, a bypass capacitor, whose capacitance range is from 0.1uF to 1uF and the material is ceramic, parallels with the VIN and GND pins of MBI6653 is recommended. The rated voltage of the bypass capacitor should be at least 1.5times of the input voltage.

The rated voltage and capacitance are not the only concerns when selecting capacitors, but also the maximum ripple current. If the actual ripple current is larger than the specified maximum ripple current, the capacitor and the IC might be damaged. In general, the ripple current is related to the inductor ripple current. The specification of maximum ripple current of capacitor should be larger than 1.3 times of the inductor ripple current.

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, careful considerations of 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 IC's GND pin and the ground leads of input and output filter capacitors 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 MBI6653 is recommended to connect to ground plane directly.
5. 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 pin 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 parasite element.
11. When SW is ON/OFF, the direction of power loop should keep the same way to enhance the efficiency. The sketch is shown as Figure45.
12. To avoid the unexpected damage 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.

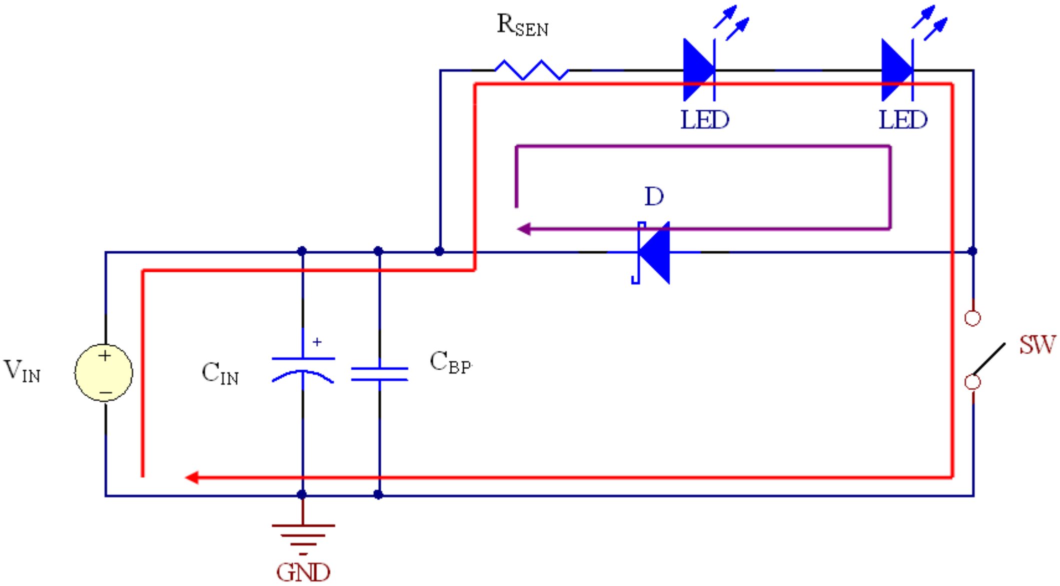
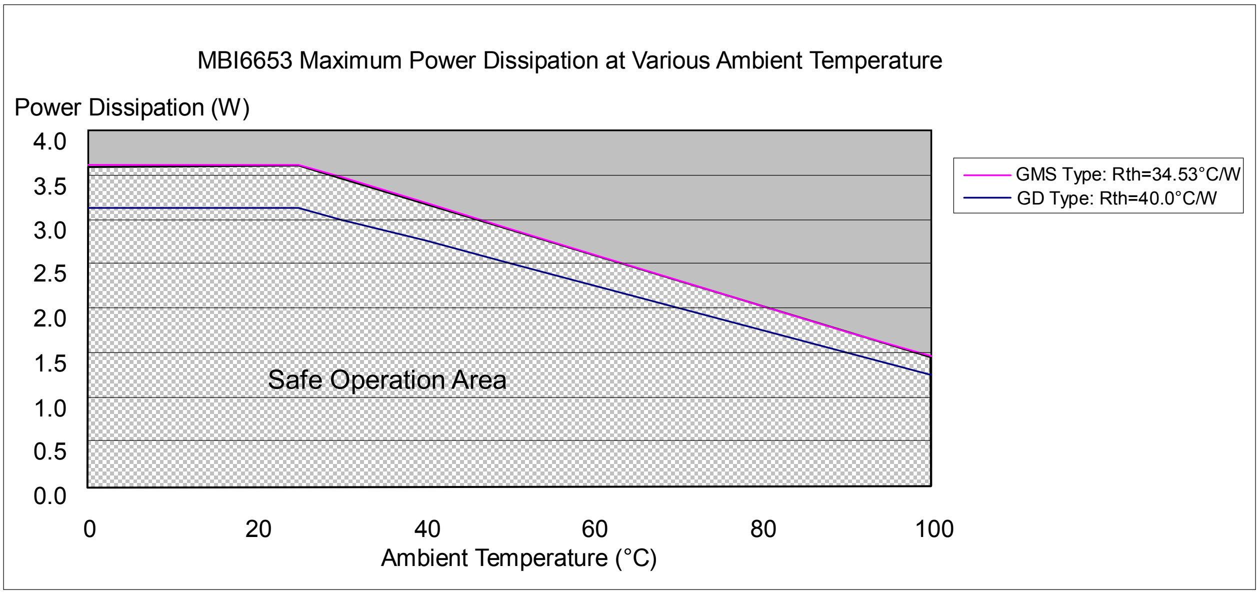


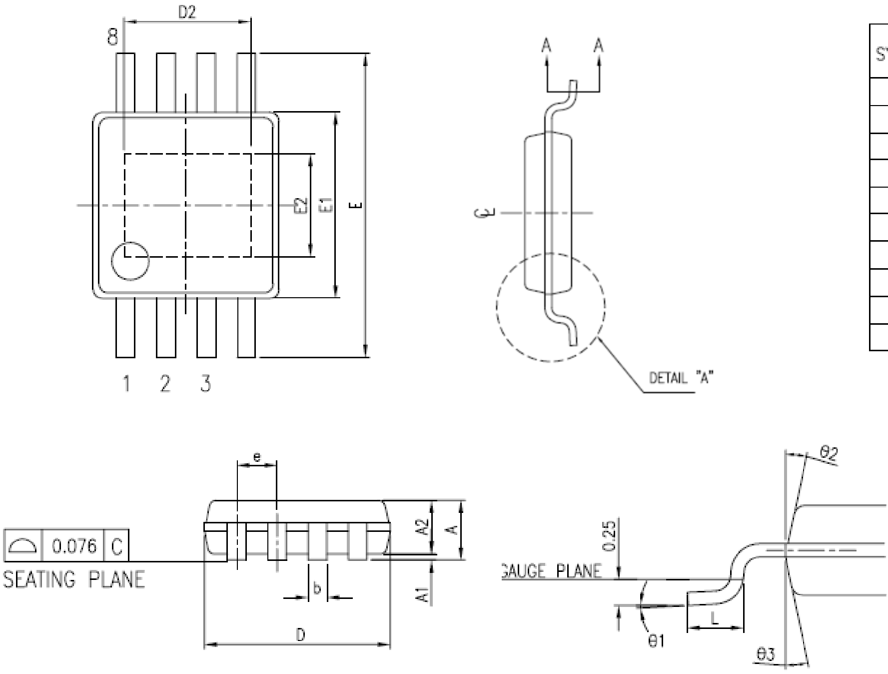
Fig.45 Power loop of MBI6653

Package Power Dissipation (PD)

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



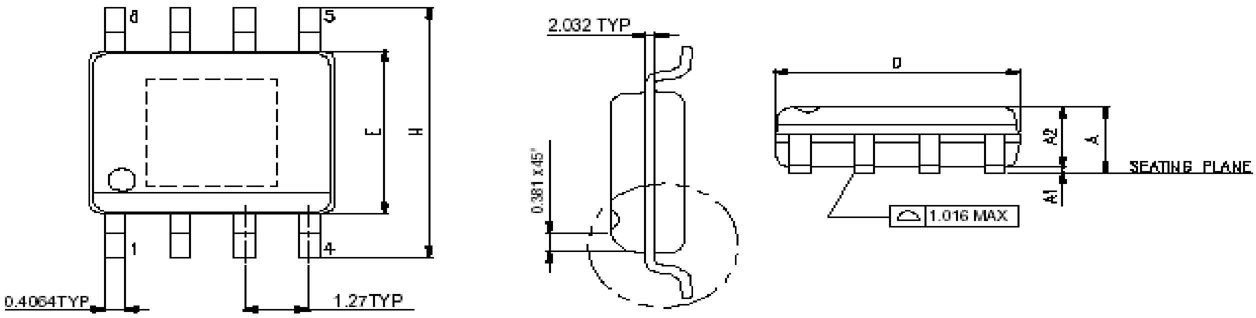
Outline Drawing

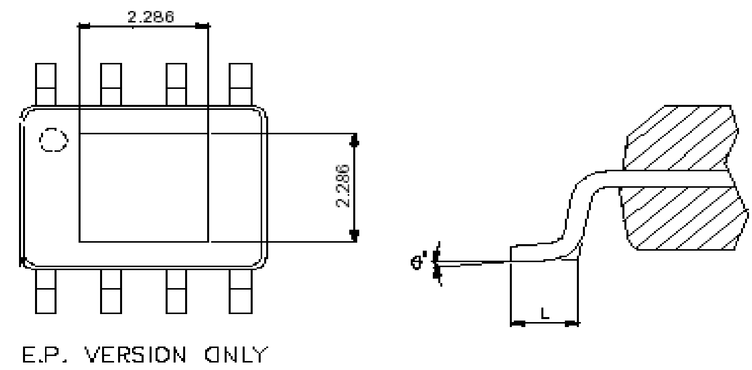


SYMBOL	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
~~A~~	---	---	1.10	---	---	0.043
A1	0.05	---	0.10	0.002	---	0.006
A2	0.81	0.86	0.91	0.032	0.034	0.036
c	0.13	---	0.23	0.005	---	0.009
c1	0.13	0.15	0.18	0.005	0.006	0.007
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.90 BSC			0.193 BSC		
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		

MBI6653GMS 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

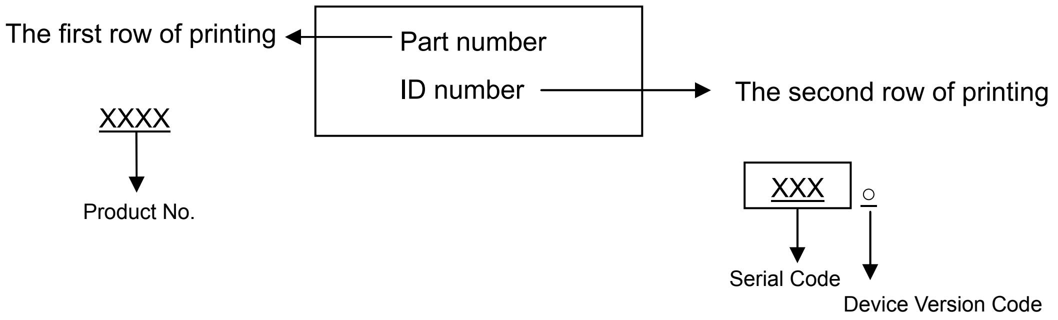
UNIT : mm

MBI6653GD Outline Drawing

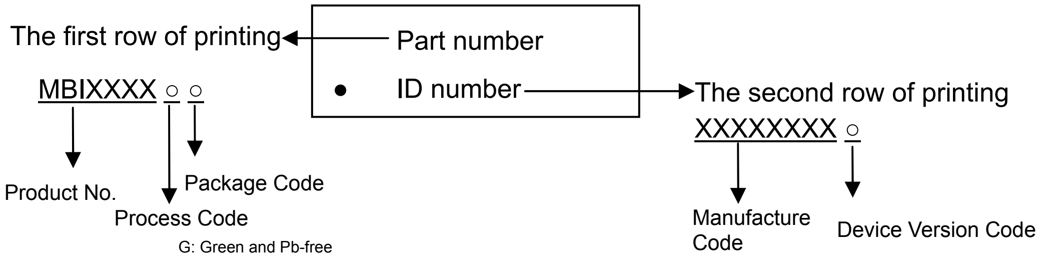
Note: Please use the maximum dimensions for the thermal pad layout. To avoid the short circuit risk, the vias or circuit traces shall not pass through the maximum area of thermal pad.

Product Top Mark Information

GMS(MSOP-8L)



GD(SOP-8L)



Product Revision History

Datasheet version	Device Version Code
V1.00	A

Product Ordering Information

Part Number	"Pb-free" Package Type	Weight (g)
MBI6653GMS	MSOP-8L-118mil	0.0233g
MBI6653GD	SOP8L-150-1.27	0.07g

Disclaimer