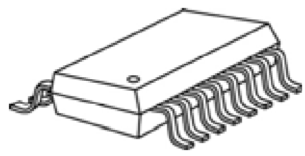
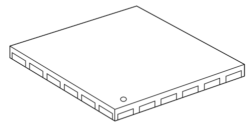
8-Channel All-Ways-On™ Constant Current LED Driver

Thin Shrink SOP



GTS: TSSOP16-173-0.65

Quad Flat No-Lead



GFN: QFN24-4*4-0.5

Features

- Maximum 50V output sustaining voltage
- 8 constant-current output channels
- Adjustable 5 - 60mA output current per channel through an external resistor
- Constant output current invariant to load voltage change
- Excellent output current accuracy:
  between channels: <±3% (max.), and
  between ICs: <±6% (max.)
- Open-circuit detection mode to detect LED errors
- Integrated voltage regulator for 8 - 40V supply voltage
- Voltage feedback for DC/DC controller
- Package Type: “Pb-free & Green” package with thermal pad

Current Accuracy		Conditions
Between Channels	Between ICs	
< ±3%	< ±6%	I_{OUT} = 5 ~ 60mA

Product Description

MBI1828 is an instant On/Off LED driver for lighting applications and exploits PrecisionDrive™ technology to enhance its output characteristics. At MBI1828 output stage, 8 regulated current ports are designed to provide uniform and constant current sinks for driving LEDs within a large range of V_F variations.

MBI1828 provides users 8-channel constant current ports to match LEDs with equal current. Users may adjust the output current from 5mA to 60mA through an external resistor, R_{ext}, which gives users flexibility in controlling the light intensity of LEDs. In addition, users can precisely adjust LED brightness from 0% to 100% via output enable (OE) with Pulse Width Modulation.

Additionally, to ensure the system reliability, MBI1828 is built with thermal pad which enhances the heat dissipation.

Applications

- Automotive lighting
- Channel letter
- Decorative LED lighting
- LCD monitor

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Functional Diagram

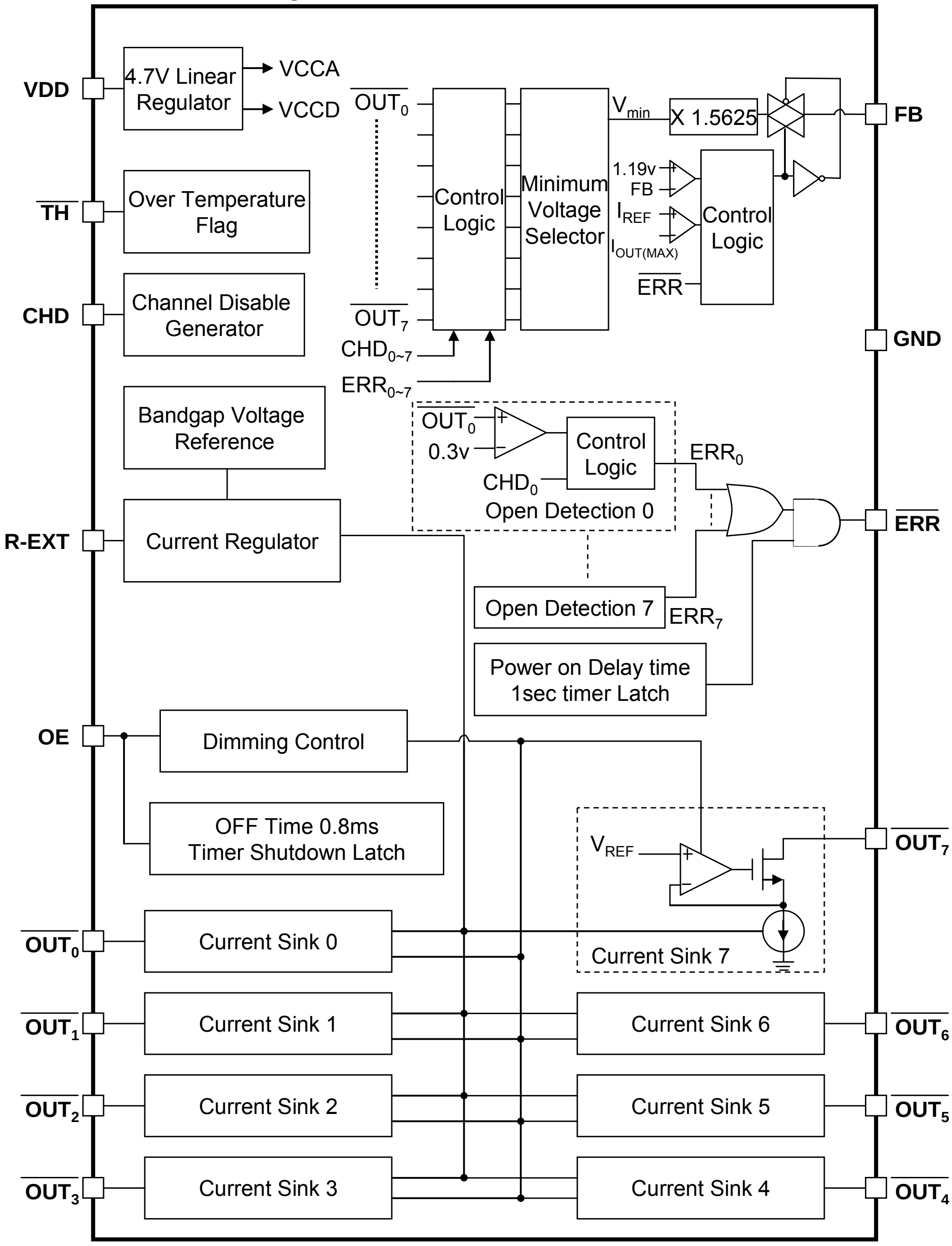
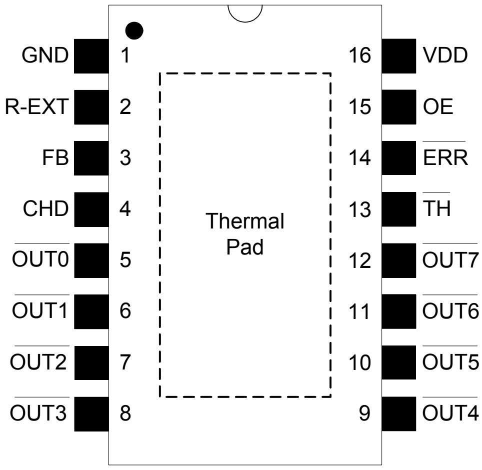
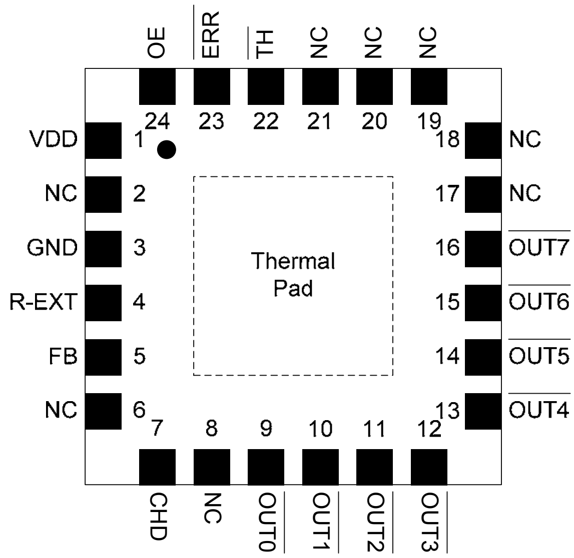


Figure 1

Pin Configuration



MBI1828GTS
Top View



MBI1828GFN
Top View

Pin Description

Pin No.		Pin Name	Function
GTS	GFN		
16	1	VDD	8V~40V Supply voltage terminal
1	3	GND*	Ground terminal for control logic and current sink
5-12	9-16	$\overline{\text{OUT0}}$ ~ $\overline{\text{OUT7}}$	Constant current output terminals
15	24	OE	Output enable terminal When OE is active (high), the output pins are enabled; when OE is inactive (low), all output pins are turned off (blanked).
14	23	$\overline{\text{ERR}}$	Error Flag When any single output channel is open, $\overline{\text{ERR}}$ is going to low.
2	4	R-EXT	The terminal used to connect an external resistor for setting up output current for output channel
13	22	$\overline{\text{TH}}$	Thermal Flag When junction temperature is over 155 ºC, $\overline{\text{TH}}$ is going to low.
4	7	CHD	Channel disable terminal. Non-used channels can be connected to the port for preventing wrong open-circuit detection result.
3	5	FB	Feedback control voltage to DC/DC controller. The relationship between FB and minimum output voltage is V_{FB}=*1.56 x minimum output voltage*($V_{DS,\,min}$)
-	-	Thermal Pad	Power dissipation terminal*
-	2, 6,8, 17-21	NC	No Connection

*The desired thermal conductivity will be improved on condition that a heat-conducting copper foil on PCB is soldered with thermal pad.

Maximum Ratings

Characteristic		Symbol	Rating	Unit
Supply Voltage		V_{DD}	42	V
Sustaining Voltage at OE		V_{IN}	-0.4~V_{DD} + 0.4	V
Sustaining Voltage at $\overline{\text{OUTn}}$		V_{DSn}	-0.5~+50	V
Sustaining Voltage at FB		V_{FB}	5	V
Sustaining Voltage at CHD		V_{CHD}	5	V
Output Current		I_{OUTn}	66*	mA
GND Terminal Current		I_{GND}	520	mA
Power Dissipation* (On PCB, Ta=25°C)	GTS	P_D	1.29	W
	GFN		2.95	
Thermal Resistance** (By simulation)	GTS	$R_{th(j-a)}$	97.15	°C/W
	GFN		42.37	
Empirical Thermal Resistance*** (On PCB, Ta=25°C)	GTS		103.15	
	GFN		99.73	
Operating Junction Temperature		$T_{j,max}$	125	°C
Operating Temperature		T_{opr}	-40~+85	°C
Storage Temperature		T_{stg}	-55~+150	°C

*Users must notice that the power dissipation (almost equaling to I_{OUT} x V_{DS}) should be within the Safe Operation Area shown in Figure 16.

**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.

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

Electrical Characteristics

VDD=12V, GND =0V, Ta=25°C, unless otherwise specified.

Characteristic		Symbol	Condition	Min.	Typ.	Max.	Unit
Supply Voltage		V_{DD}	-	8	-	40	V
Input Voltage of OE	"High" level	$V_{OE,IH}$	T_a= -40~85ºC	2.8	-	V_{DD}	V
	"Low" level	$V_{OE,IL}$	T_a= -40~85ºC	GND	-	0.7	V
Output Voltage of $\overline{ERR}$		$V_{\overline{ERR},OH}$	$I_{\overline{ERR},OH}$ = 1.0mA	4.2	-	5	V
		$V_{\overline{ERR},OL}$	$I_{\overline{ERR},OL}$= 1.0mA	-	-	0.5	V
Output Voltage of $\overline{TH}$		$V_{\overline{TH},OH}$	$I_{\overline{TH},OH}$ =1.0mA	4.2	-	5	V
		$V_{\overline{TH},OL}$	$I_{\overline{TH},OL}$= 1.0mA	-	-	0.5	V
V_{OUT} Feedback Report Voltage		V_{FB}	$V_{OUT(min)}$=0.8V	-	1.25	-	V
Supply Current	OE=Low	I_{DD}(off) 1	R_{ext}= Open, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off	-	0.57	2.5	mA
		I_{DD}(off) 2	R_{ext}= 2.4kΩ, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off	-	0.57	3.5	
		I_{DD}(off) 3	R_{ext}= 1.3kΩ, $\overline{OUT0}$ ~ $\overline{OUT7}$ = Off	-	0.57	4	
	OE=High	I_{DD}(on) 1	R_{ext}= 2.4kΩ, $\overline{OUT0}$ ~ $\overline{OUT7}$ = On	2.5	3.17	5	
		I_{DD}(on) 2	R_{ext}= 1.3kΩ, $\overline{OUT0}$ ~ $\overline{OUT7}$ = On	3.0	3.55	5	
Standby Current		I_{DD}(std)	OE= low, OE waits for 825us	-	0.57	1	mA
Output Current		I_{OUT}	Test Circuit for Electrical Characteristics	5	-	60*	mA
Output Leakage Current		I_{OH}	V_{DS}= 40.0V, OE=Low	-	-	0.5	μA
Output Current 1		I_{OUT1}	V_{DS}= 0.6V, R_{ext}= 2.4kΩ	-	30.75	-	mA
Current Skew 1		dI_{OUT1}	I_{OUT1}= 30.75mA, V_{DS}= 0.6V, R_{ext}= 2.4kΩ	-	±1	±3	%
Output Current 2		I_{OUT2}	V_{DS}= 0.8V, R_{ext}= 1.3kΩ	-	56.7	-	mA
Current Skew 2		dI_{OUT2}	I_{OUT2}= 56.7mA, V_{DS}= 0.8V R_{ext}= 1.3kΩ	-	±1	±3	%
Current Chip Skew			V_{DS} = 0.6V, I_{OL} = 24.6mA, Rext= 3kΩ		-	±6	%
Output Current vs. Output Voltage Regulation		$\%/dV_{DS}$	V_{DS} within 1.0V and 3.0V	-	±0.1	±0.5	% / V
Output Current vs. Supply Voltage Regulation		$\%/dV_{DD}$	V_{DD} within 8.0V and 40V	-	±0.1	±0.5	% / V
Pull-down Resistor of OE		R_{OE-IN}	-	280	400	520	KΩ
Junction Temperature Threshold of Thermal flag		T_x	-	-	155	-	°C
The Hysteresis Temperature of Thermal Flag		T_{hys}	-	-	35	-	°C

*Each output current, I_{OUT}, can be driven up to 60mA.

Test Circuit for Electrical Characteristics

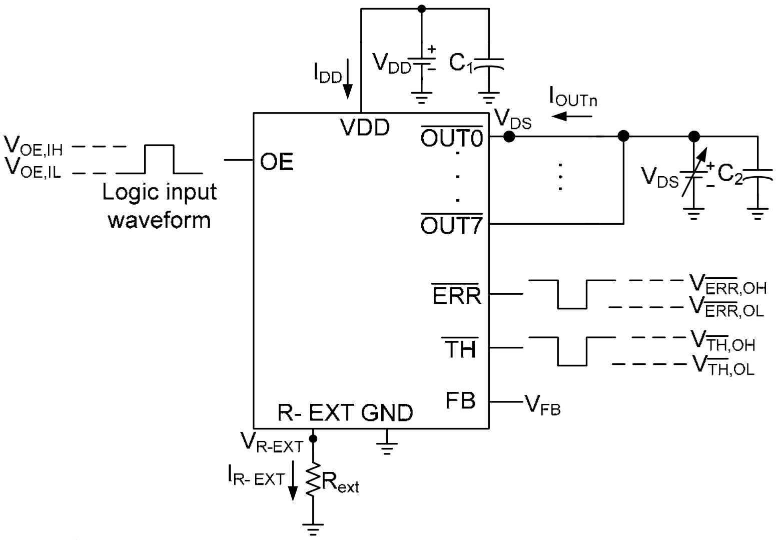


Figure 2

Switching Characteristics

Characteristic		Symbol	Condition	Min.	Typ.	Max.	Unit
Propagation Delay Time ("L" to "H")	OE - $\overline{OUTn}$	t_{pLH}	V_{DD}= 12.0 V V_{DS}= 1.0V V_{IH}= 5V V_{IL}= GND R_{ext}= 1227Ω (I_{OUTn}=60mA) V_{LED}= 4.2 V R_L= 51 Ω C_L= 10 pF Refer to Figure 4	-	1.88	2.5	μs
Propagation Delay Time ("H" to "L")	OE - $\overline{OUTn}$	t_{pHL}		-	1.3	2.5	μs
OE Pulse Width		$t_{w(OE)}$		5	-	-	μs
Output Rise Time of $\overline{OUTn}$ (turn off)		t_{or}		-	1.5	2.5	μs
Output Fall Time of $\overline{OUTn}$ (turn on)		t_{of}		-	1.8	2.5	μs
Standby Time		t_{std}	Refer to Figure 5	491	-	825	us
$\overline{ERR}$ Delay Time		t_{err}	Refer to Figure 6	-	-	1000	ms
FB Delay Time	V_{DS} - FB	t_{FB}	Refer to Figure 7	-	-	200	ns

Note: Where the "n" of $\overline{OUTn}$ refers to 0~7.

Test Circuit for Switching Characteristics

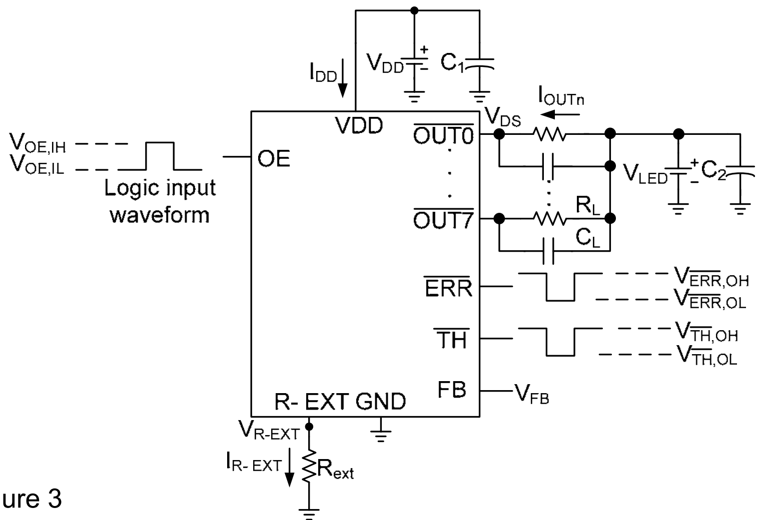


Figure 3

Timing Waveform

A. Propagation Delay Time Timing Waveform

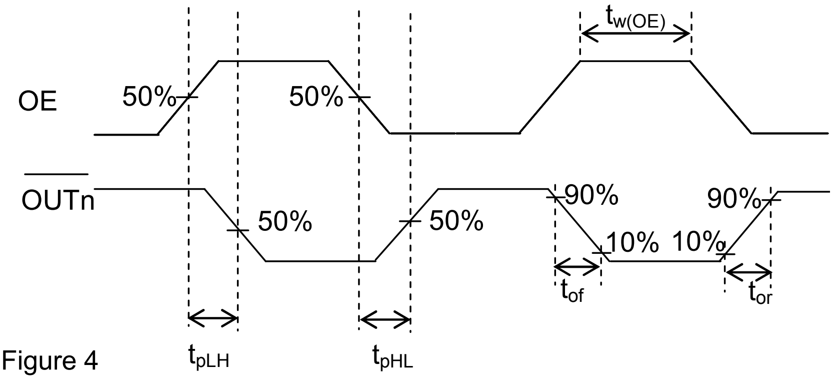


Figure 4

B. Standby Time Timing Waveform

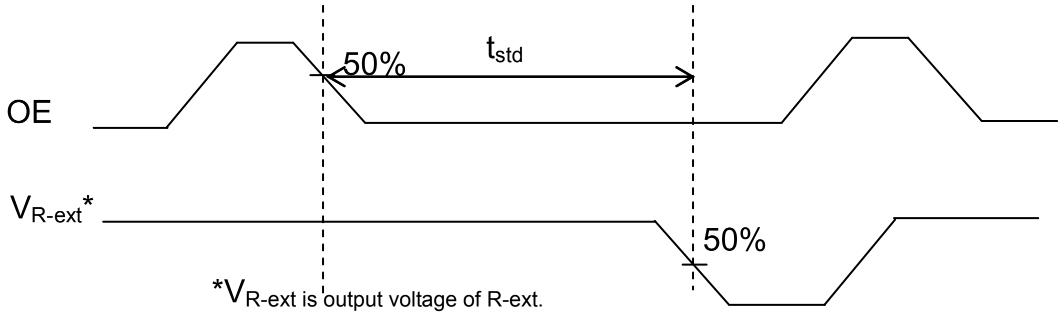


Figure 5

C. $\overline{ERR}$ Delay Time Timing Waveform

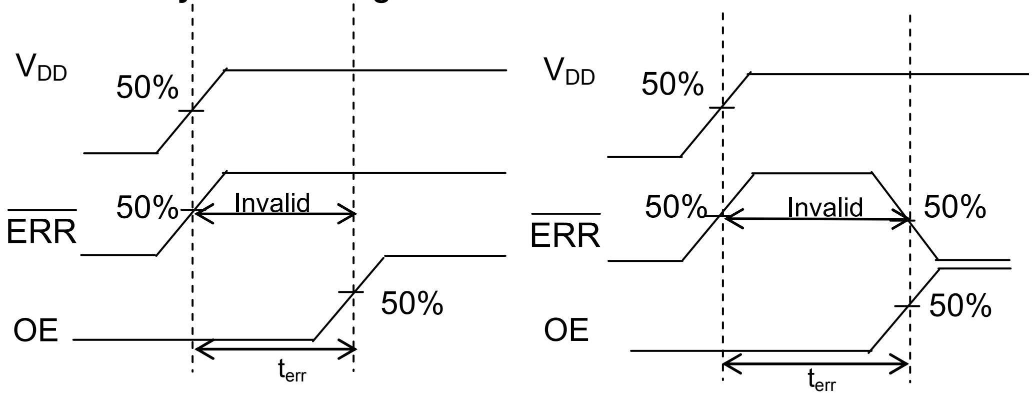


Figure 6

D. FB Delay Time Timing Waveform

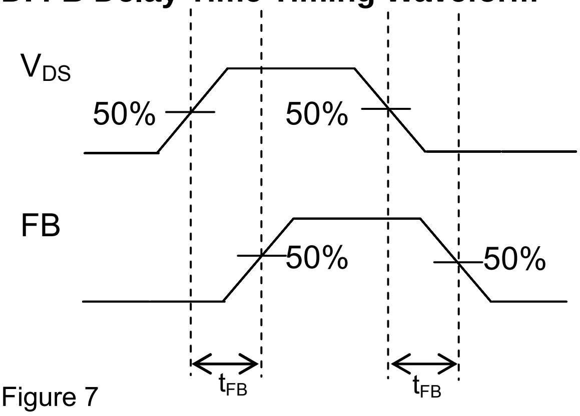


Figure 7

Typical Application Circuits

1. V_{LED} and VDD share a single voltage source

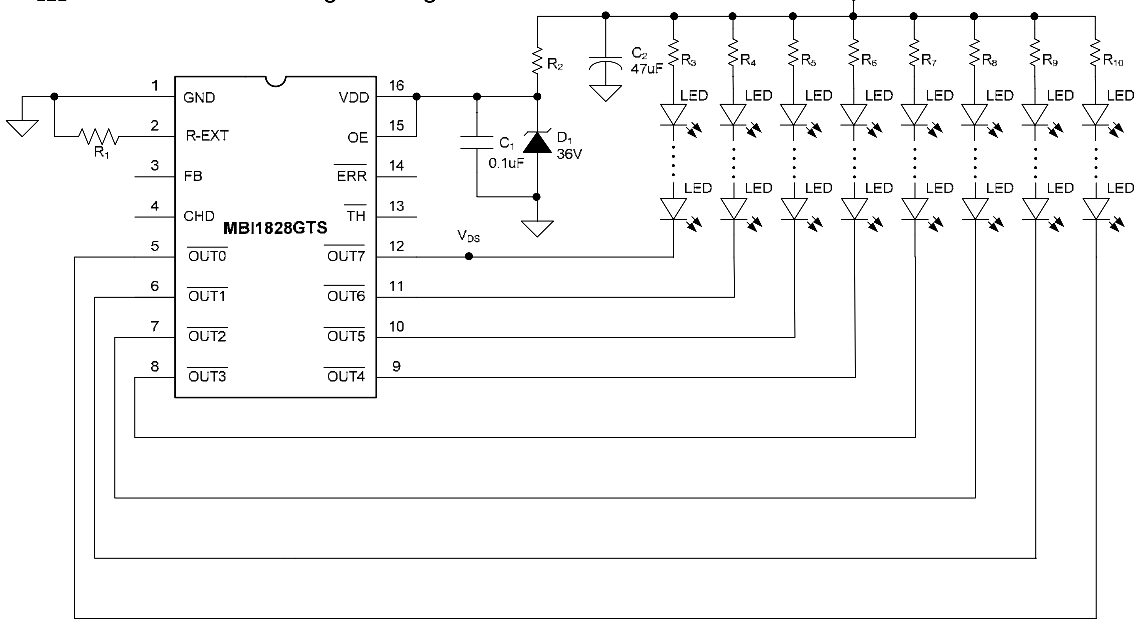


Figure 8

Assume $V_{F,LED}$ x n are the same.

V_{LED} and VDD share a single voltage source.

$V_{LED} > V_{DS} + V_{F,LED}$ x n ; $V_{F,LED}$: Forward voltage of LED.

$R_2 = (V_{LED} - 36V) / I_{DD}$; refer to Electrical Characteristics for $I_{DD.}$

$R_3 = R_4 = \ldots = R_{10} = [V_{LED} - V_{DS} - (V_{F,LED}$ x n)] / I_{OUT}; n refer to LED count.

2. V_{LED} and VDD are separated voltage source

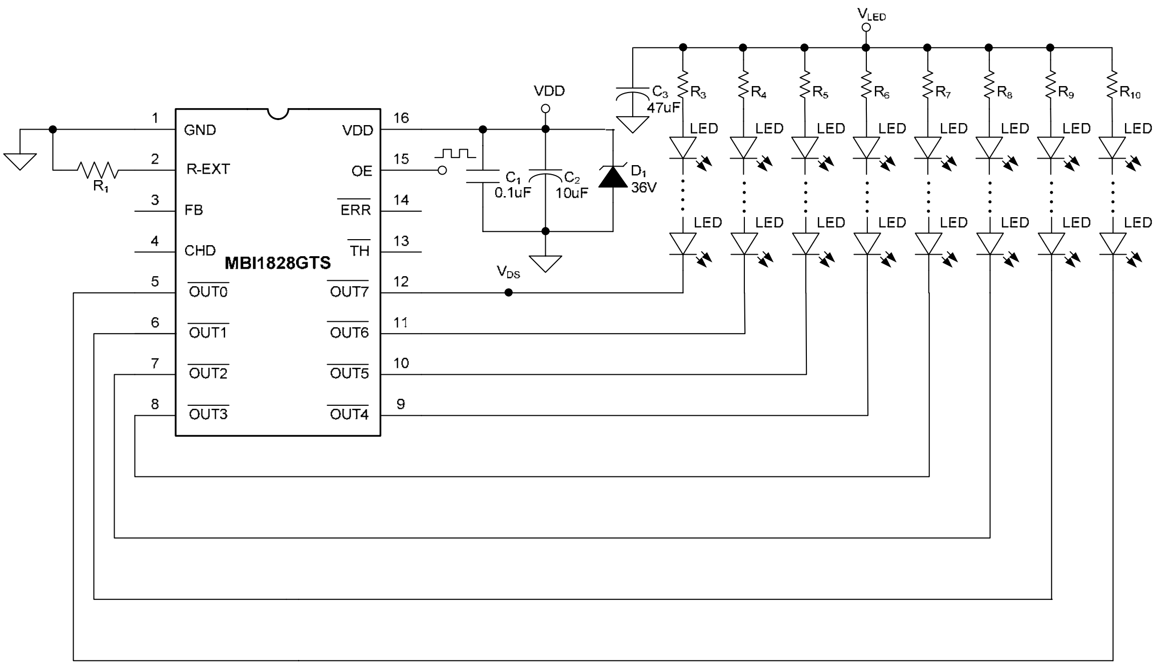


Figure 9

V_{LED} and VDD are separated. The capacitor C_2 is required to get close to MBI1828.

$V_{LED} > V_{DS} + V_{F,LED}$ x n ; $V_{F,LED}$: Forward voltage of LED.

$R_2 = (V_{LED} - 36V) / I_{DD}$; refer to Electrical Characteristics for $I_{DD.}$

$R_3 = R_4 = \ldots = R_{10} = [V_{LED} - V_{DS} - (VF,_{LED}$ x n)] / I_{OUT}; n refer to LED count.

Constant Current

In LED lighting applications, MBI1828 provides nearly no variation in current from channel to channel and from IC to IC. This can be achieved by:

1) The maximum current variation between channels is less than ±3%, and that between ICs is less than ±6%.
2) In addition, the current characteristic of output stage is flat and users can refer to Figure 10. The output current can be kept constant regardless of the variations of LED forward voltages (V_F). This guarantees LED to be performed on the same brightness as user's specification.

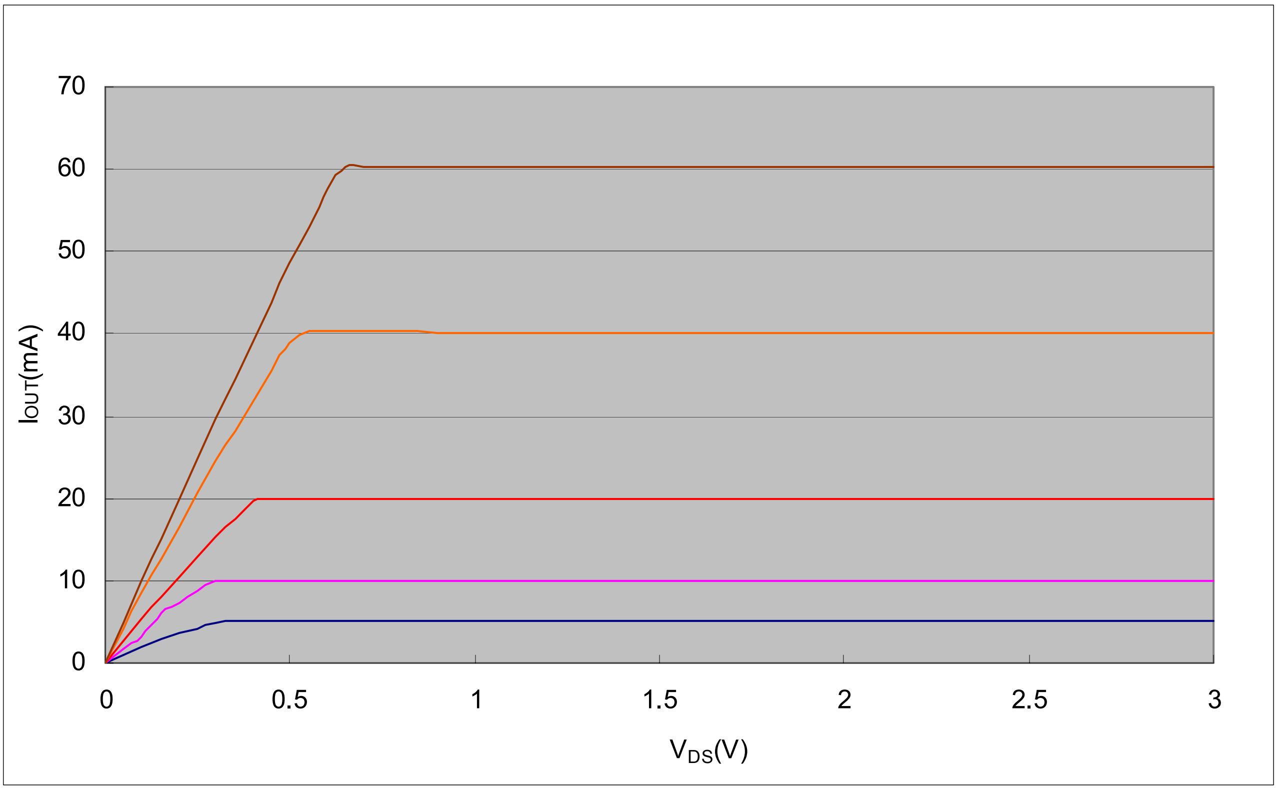


Figure 10

Setting Output Current

The output current of each channel (I_{OUT}) is set by an external resistor, R_{ext}. The relationship between I_{OUT} and R_{ext} is shown in Figure 11.

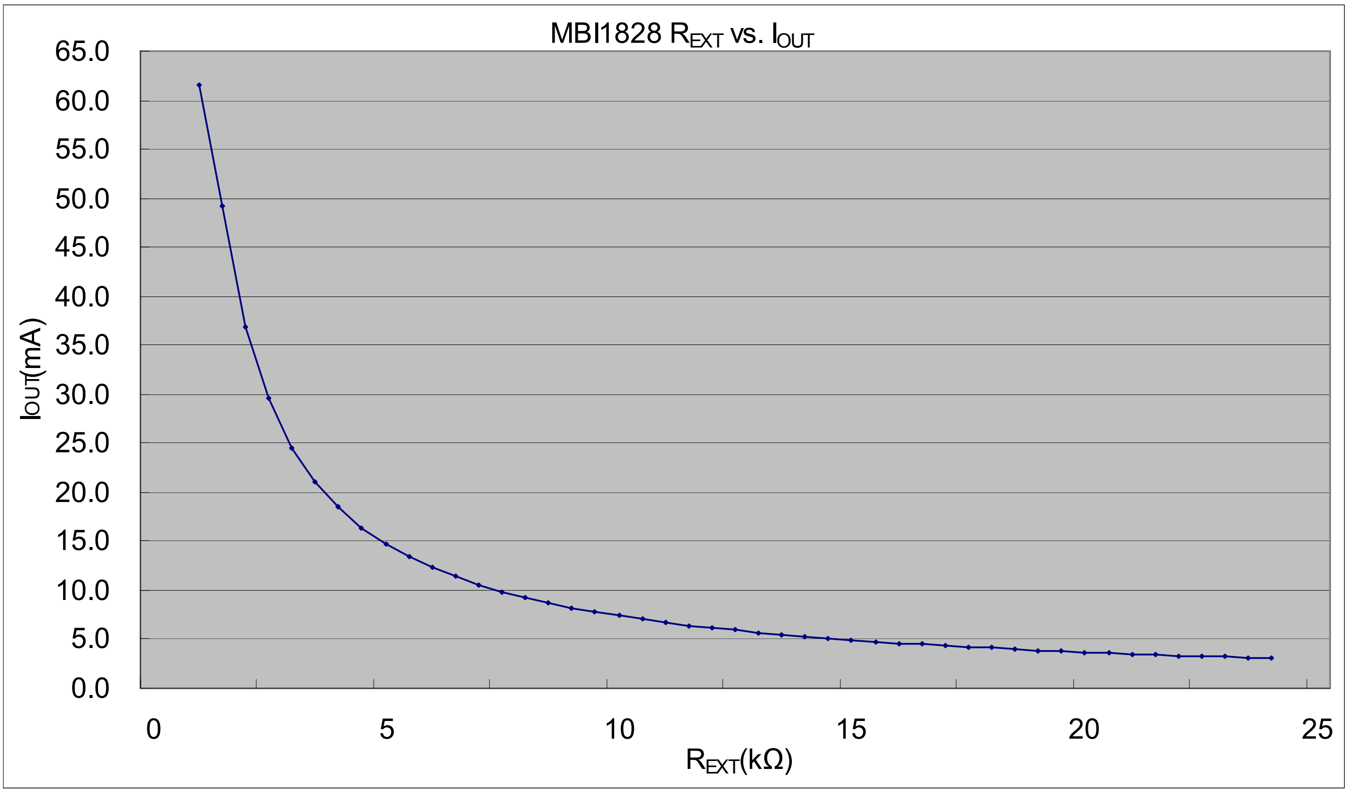


Figure 11

Also, the output current can be calculated from the equation:

$V_{R\text{-}EXT} = 1.23V$;

$R_{ext} = (V_{R\text{-}EXT} / I_{OUT}) \times 60 = (1.23V / I_{OUT}) \times 60$;

$I_{OUT} = (V_{R\text{-}EXT} / R_{ext}) \times 60 = (1.23V / R_{ext}) \times 60$ within $\pm 6\%$ chip skew;

where R_{ext} is the resistance of the external resistor connecting to R-EXT terminal and $V_{R\text{-}EXT}$ is the voltage of R-EXT terminal. The magnitude of current (as a function of R_{ext}) is around 56.7mA at 1.3kΩ and 30.75mA at 2.4kΩ.

Open-Circuit Detection

The principle of LED open-circuit detection is based on the fact that when output voltage (V_{DS}) is lower than 0.3V. The $\overline{\text{ERR}}$ pin will become low. Before activating open-circuit detection, MBI1828 will check CHD pin first. Once it confirms, the open-circuit detection will bypass those non-used pins which are connected to CHD.

Thermal Detection

When the junction temperature exceeds the threshold, T_x (155°C), the thermal flag would be enabled. The $\overline{\text{TH}}$ pin will become low. As soon as the temperature is below 120°C, the $\overline{\text{TH}}$ will go high again.

Standby Operation

When OE goes low for 825us ($t_{std,}$ max.), there will be standby operation. When IC enter in standby, there will be no voltage to generate $V_{R\text{-}ext}$ and the supply current (I_{DD}) will lower to 1mA (max.).

Principle to Cooperate with DC/DC Converter (Boost converter)

MBI1828 can co-work with DC/DC converter through FB terminal. The voltage of FB terminal is V_{FB}=1.56 x ($V_{DS, min}$) to make V_{DS} reaching 0.8V. When the minimum V_{DS} of MBI1828 in any single channel is lower than 0.8V, the V_{FB} will force DC/DC controller to boost V_{LED} as shown in Figure 12.

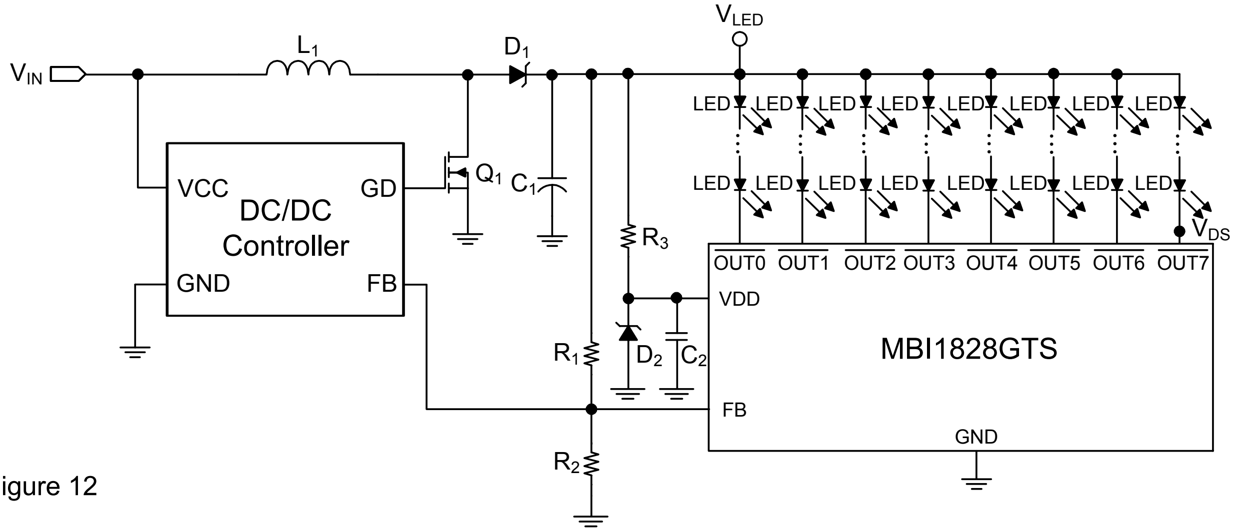


Figure 12

The Scheme of FB Terminal

When OE is disabled, the FB becomes high impedance (also known as floating). When OE is enabled, the minimum voltage selector will ignore to connect CHD and open-circuit output channels. The rest of output channels will select the minimum voltage (V_{min}) through the selector and increase to 1.56 times of V_{min} as the voltage of FB. The maximum voltage of FB terminal is 2.3V as shown in Figure 14. The output status of FB ($V_{FB, MBI1828}$) will be determined by $I_{OUTn, max}$, the FB voltage of DC/DC converter ($V_{FB, DC/DC}$), and $\overline{ERR}$ status shown in Table 1:

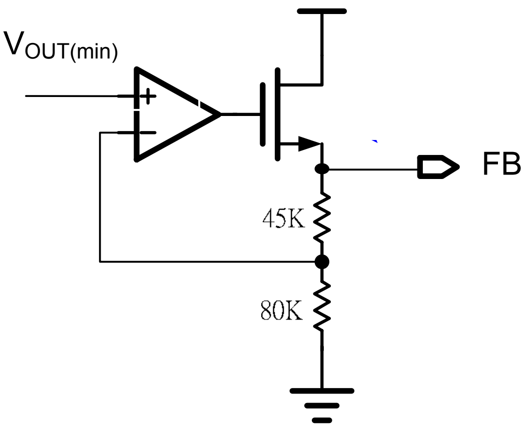


Figure 13. The relationship between V_{FB} and V_{DS} of MBI1828

OE	$I_{OUTn, max}$>0.9I_{REF}	$\overline{ERR}$ is High	$V_{FB, DC/DC}$>1.19V	$V_{FB, MBI1828}$
Disable	Don't care	Don't care	Don't care	**High Impedance**
Enable	FALSE	Don't care	Don't care	**High Impedance**
Enable	TRUE	FALSE	FALSE	**High Impedance**
Enable	TRUE	FALSE	TRUE	**1.56 x V_{min}**
Enable	TRUE	TRUE	TRUE	**1.56 x V_{min}**

Table1. True Table of **$V_{FB, MBI1828}$**

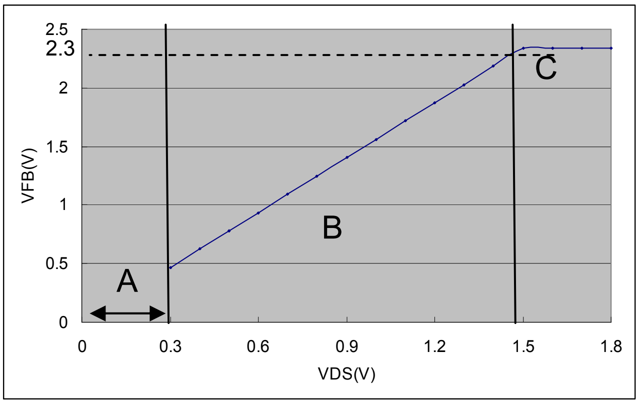


Figure 14. The relationship between V_{FB} and V_{DS} of MBI1828. The area A is High Impedance. The area B is $V_{FB(v)}$=1.56x $V_{DS(min)}$. The area C is Saturation.

As noted previously, MBI1828 reports open-circuit event and results in $\overline{ERR}$ signal change. To avoid false alarm of error report, there should be a 1000ms delay time (t_{err}) after V_{DD} builds up. In Figure 15 (a), the $\overline{ERR}$ is invalid during this delay period and remains high level after the delay time. However, if IC detects the real open-circuit event after the delay time, the $\overline{ERR}$ goes low and the error report shows open-circuit event as shown in Figure 15 (b). However, there are 2 points of power on sequence should be aware when applying DC/DC controller:

1. OE pin cannot directly connect to $\overline{ERR}$, $\overline{TH}$, and VDD pins. OE should be addressed after 1000ms delay time of V_{DD}.
2. The output voltage of DC/DC converter is decided by a voltage divider, $V_{LED}=V_{FB}(1+(R1/R2))$. This output voltage of DC/DC converter should be 1V higher than maximum LED forward voltage.

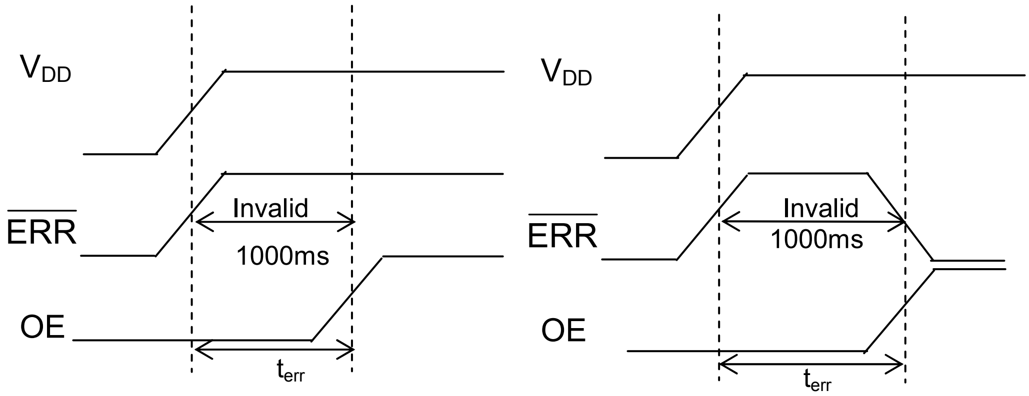


Figure 15 The waveform of power on sequence

(a) If there is no open-circuit event, the $\overline{ERR}$ remains high after the delay time.

(b) If IC detects the real open-circuit event after the delay time, the $\overline{ERR}$ goes low and report open-circuit event.

Package Power Dissipation (P_D)

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

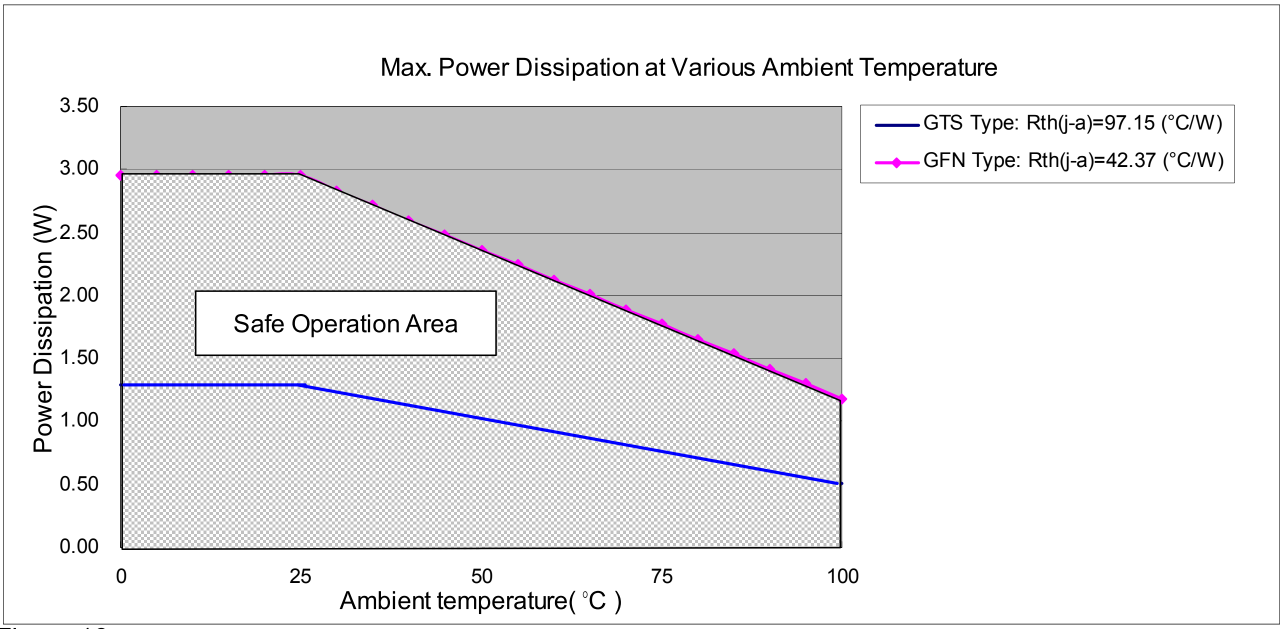


Figure 16

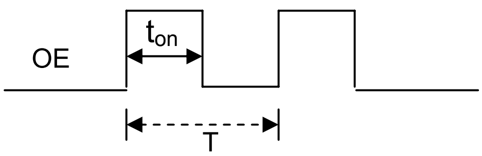
The maximum allowable package power dissipation is determined as $P_D(max) = (T_{j,max} – T_a) / R_{th(j-a)}$. When 8 output channels are turned on simultaneously, the actual package power dissipation is $P_D(act) = (I_{DD} \times V_{DD}) + (I_{OUT} \times Duty \times V_{DS} \times 8)$. Therefore, to keep $P_D(act) \le P_D(max)$, the allowable maximum output current as a function of duty cycle is:

$I_{OUT} = \{ [(T_{j,max} – T_a) / R_{th(j-a)}] – (I_{DD} \times V_{DD}) \} / V_{DS} / Duty / 8$,

where $T_{j,max}$ = 125°C;

Duty= t_{ON} / T;

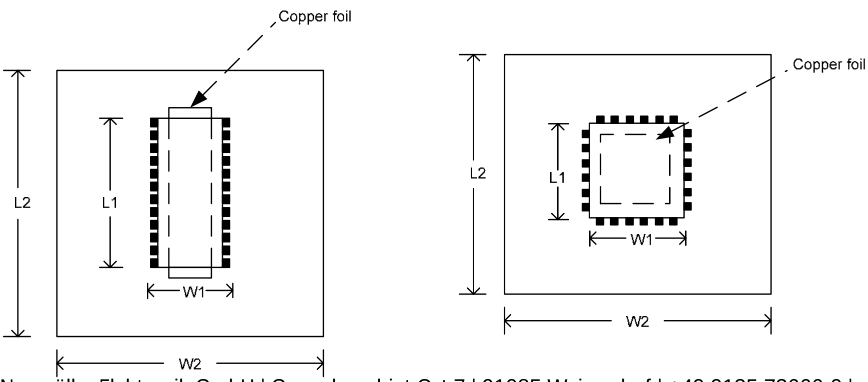
t_{ON}: the time of LEDs turning on; T: OE signal period



*Note: The empirical thermal resistor $R_{th(j-a)}$ =103.15 °C/W; it is based on the following structure.

Usage of Thermal Pad

The PCB area L2xW2 is 4 times (min.) of the IC's area L1xW1.The thickness of the PCB is 1.6mm, copper foil 1 Oz. The thermal pad on the IC's bottom has to be mounted on the copper foil.



Load Supply Voltage (V_{LED})

MBI1828 is designed to operate with adequate V_{DS} to achieve constant current. V_{DS} and I_{OUT} should not exceed the package power dissipation limit, P_D(max).

$V_{DS} = V_{LED} – V_F$, and V_{LED} is the load supply voltage. If V_{DS} drops too much voltage on the driver, P_D(act) will be greater than P_D(max). In this case, it is recommended to use supply voltage as low as possible or to set an external voltage reducer, V_{DROP}.

A voltage reducer allows $V_{DS} = (V_{LED} –V_F) – V_{DROP}$.

Resistors can be used in the applications as shown in Figure17.

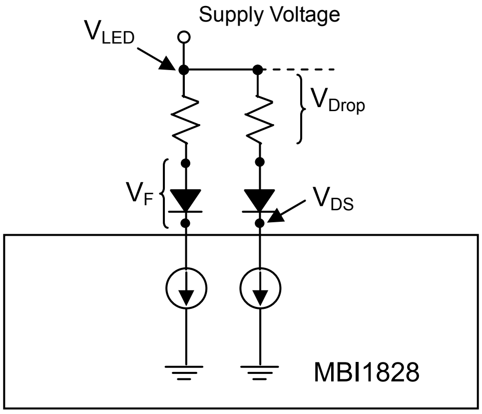
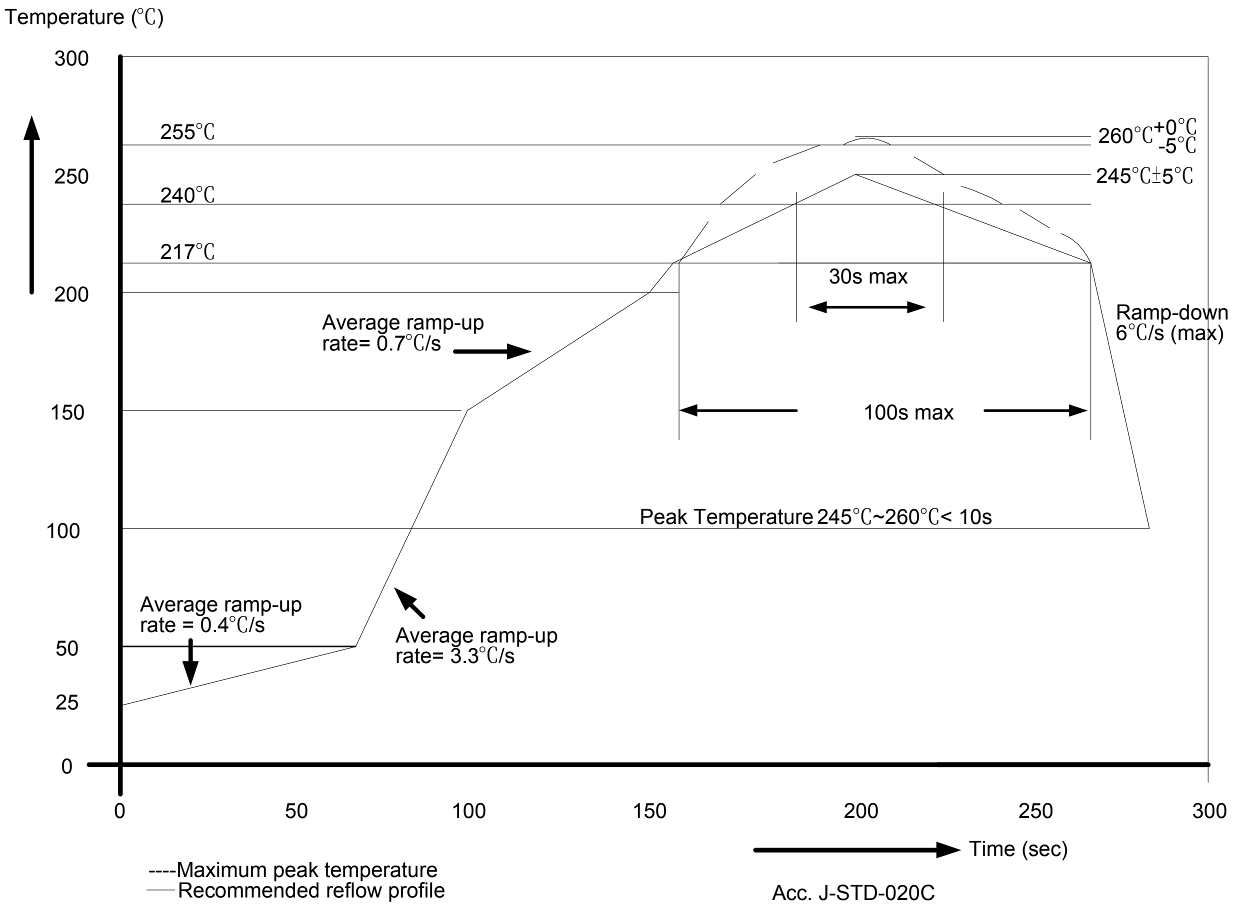


Figure 17

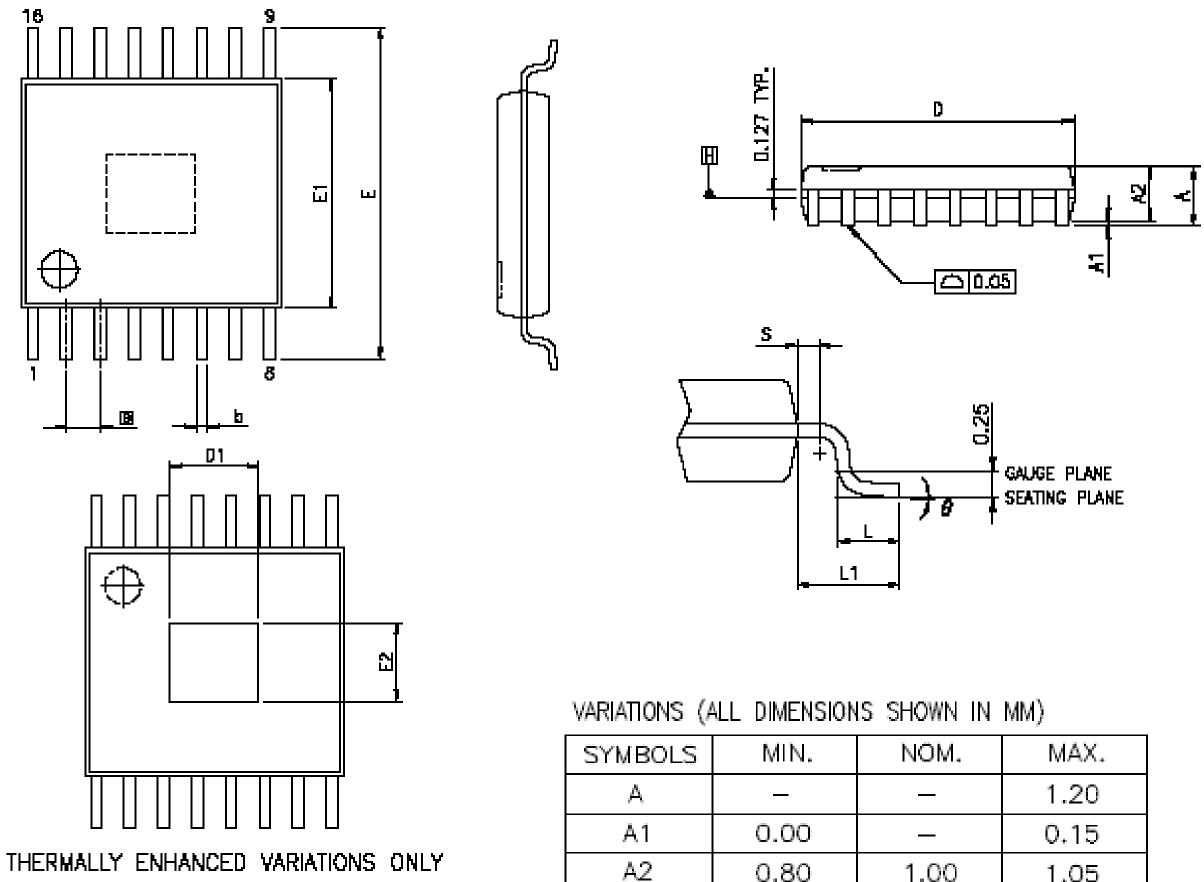
Soldering Process of “Pb-free & Green” Package Plating*

Macroblock has defined "Pb-Free & Green" 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 is backward compatible to standard 215ºC to 240ºC reflow processes which adopt tin/lead (SnPb) solder paste. However, in the whole Pb-free soldering processes and materials, 100% pure tin (Sn) will all require up to 260 ºC for proper soldering on boards. Please refer to J-STD-020C as shown below.



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

Outline Drawing



VARIATIONS (ALL DIMENSIONS SHOWN IN MM)

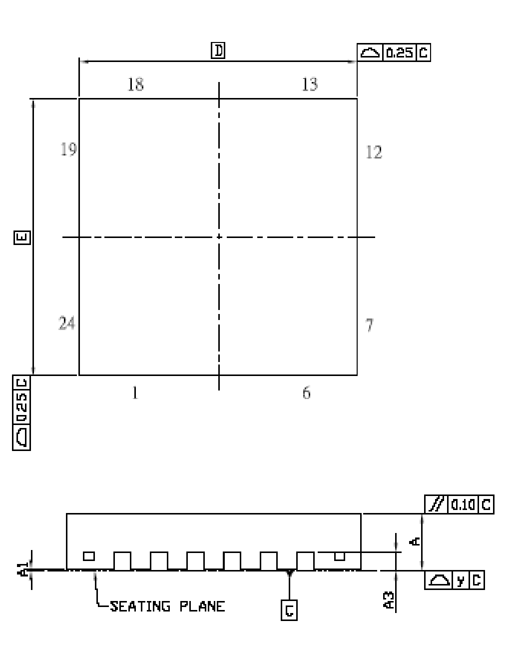
SYMBOLS	MIN.	NOM.	MAX.
A	–	–	1.20
A1	0.00	–	0.15
A2	0.80	1.00	1.05
b	0.19	–	0.30
D	4.90	5.00	5.10
E1	4.30	4.40	4.50
E	6.40 BSC		
e	0.65 BSC		
L1	1.00 REF		
L	0.45	0.60	0.75
S	0.20	–	–
θ	0°	–	8°

4 THERMALLY ENHANCED DIMENSIONS(SHOWN IN MM)

PAD SIZE	E2		D1	
	MIN.	MAX.	MIN.	MAX.
118X11E	2.40	3.00	2.40	3.00

MBI1828 GTS Outline Drawing

Note: The unit for the outline drawing is mm. Please use the maximum dimensions for the thermal pad layout. To avoid the short circuit risk, the via or circuit traces shall not pass through the maximum area of thermal pad.

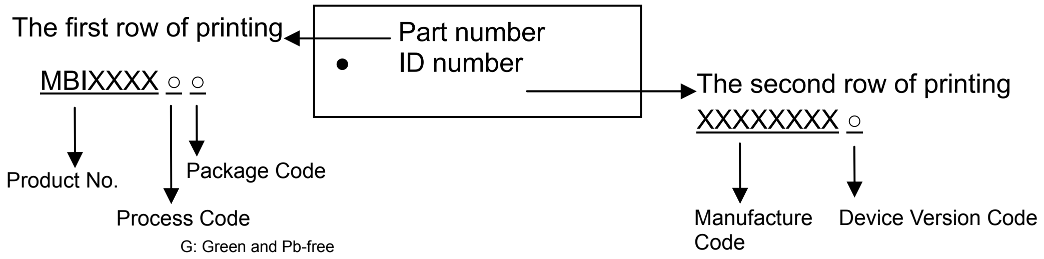


SYMBOL	DIMENSION (MM)			DIMENSION (MIL)		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	27.6	29.5	31.5
A1	0	0.02	0.05	0	0.79	1.97
A3	0.203 REF			8 REF		
b	0.18	0.23	0.28	7.1	9.0	11.0
D	3.90	4.00	4.10	153.5	157.5	161.4
D2	1.90	2.00	2.10	74.8	78.7	82.7
E	3.90	4.00	4.10	153.5	157.5	161.4
E2	1.90	2.00	2.10	74.8	78.7	82.7
e	0.50 BSC			19.69 BSC		
L	0.25	0.35	0.45	9.8	13.7	17.7
y	0.08			3.15		
b1	0.25	0.30	0.35	9.8	11.8	13.7
e1	0.52 REF.			20.5 REF.		

MBI1828 GFN Outline Drawing

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

Product Top-Mark Information



Product Revision History

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

Product Ordering Information

Part Number	**Package Type**	**Weight (g)**
MBI1828GTS	TSSOP16-173-0.65	0.067
MBI1828GFN	QFN24-4*4- 0.5	0.0379

Disclaimer