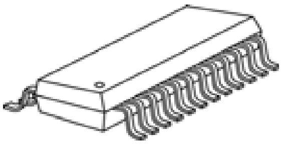
8-Channel All-Ways-On™ Constant Current LED Driver

Features

- Maximum 70V sustaining voltage
- 8 constant current output channels
- Adjustable 15~80mA output current per channel through an external resistor
- Constant output current invariant to load voltage change
- Excellent output current accuracy:
  between channels: <±3% (max.)
  between chips: <±6% (max.)
- Integrated voltage regulator for 8~40V supply voltage
- Dimming control: 1:100@5KHz
- LED open-/short-circuit detection function and error flag ($\overline{\text{ERR}}$)
- Over voltage detection
- Thermal shutdown and thermal flag ($\overline{\text{TH}}$)
- Serial and parallel voltage feedback for DC/DC converter
- RoHS compliant packages with thermal pad

Thin Shrink SOP



GTS: TSSOP24L-173-0.65

Current Accuracy		Conditions
Between Channels	Between ICs	
< ±3%	< ±6%	I_{OUT} = 15 ~ 80mA

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Product Description

MBI1838 is an instant On/Off LED driver for LED backlight applications and exploits PrecisionDrive™ technology to enhance its output characteristics. At MBI1838 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, and in order to eliminate the heat generated by V_F variations, a feedback function is integrated in MBI1838 to control the LED power source.

MBI1838 provides 8-channel constant current ports to match LEDs with equal current. Users may adjust the output current from 15mA to 80mA 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 pin (OE) with pulse width modulation signal.

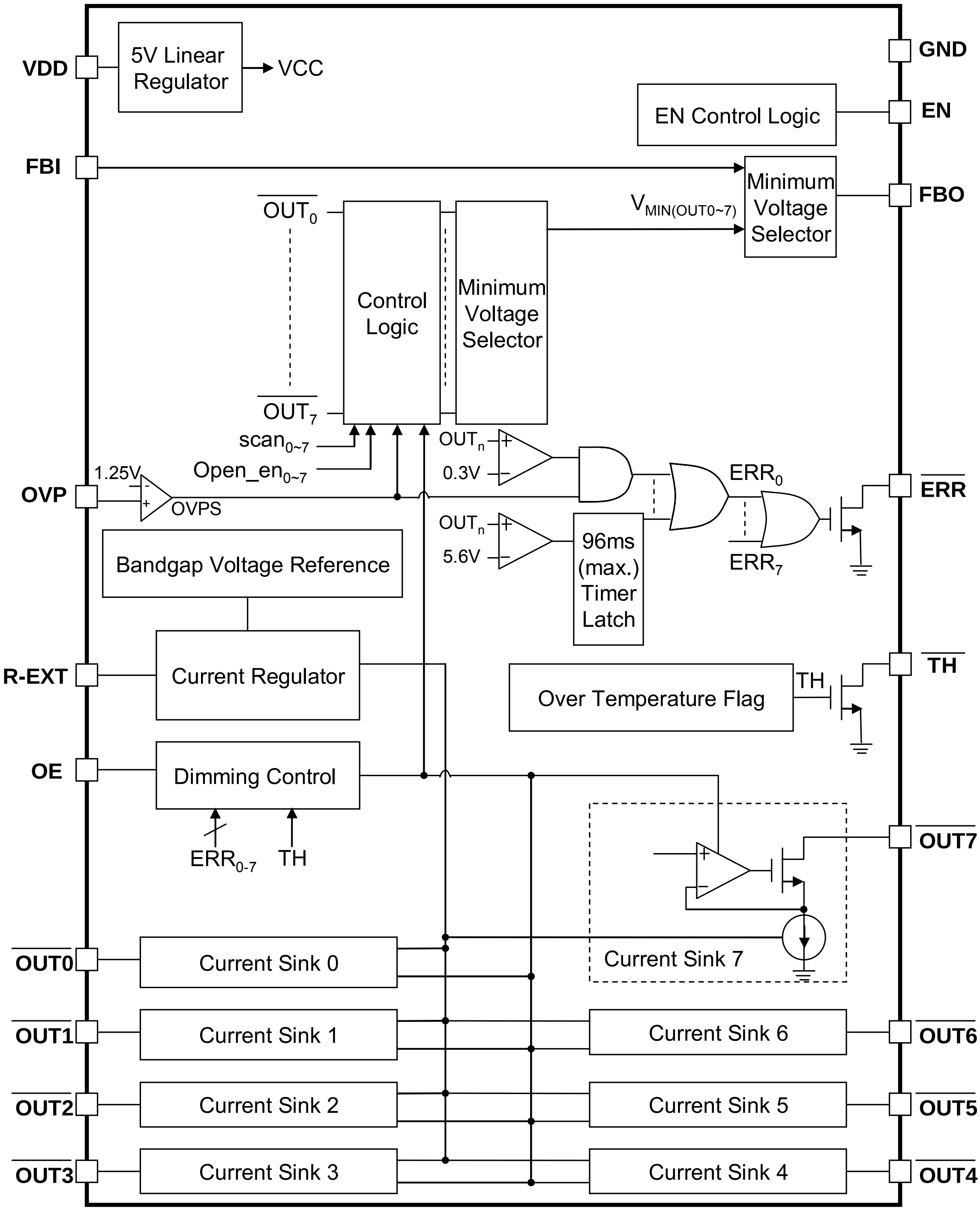
MBI1838 can detect the error status of LED open-circuit, short-circuit, and the over temperature during the operation, and the pins, $\overline{\text{ERR}}$ and $\overline{\text{TH}}$ report these fault conditions. When LED open-circuit or short-circuit faults happen, only the faulted channel will be shut down to avoid affecting other normal channels. MBI1838 will disable all the output channels until the junction temperature is lower than the hysteresis, if the over temperature status occurs.

Additionally, to ensure the system reliability, MBI1838 is built with thermal pad which enhances the heat dissipation.

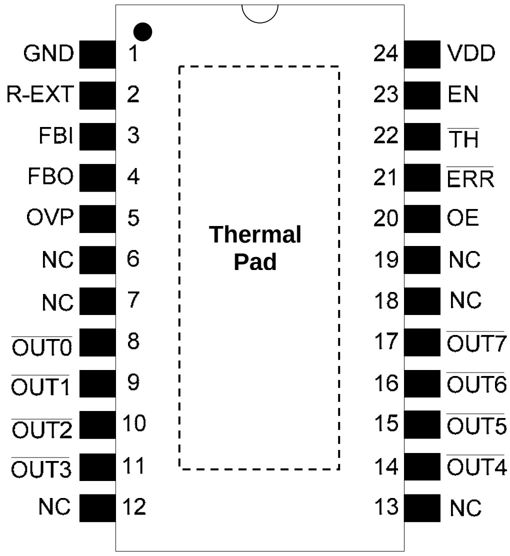
Applications

- LCD TV

Functional Diagram



Pin Configuration



MBI1838GTS
Top View

Pin Description

Pin No. GTS	Pin Name	Function
24	VDD	8V~40V supply voltage terminal
1	GND*	Ground terminal for control logic and current sink
22	$\overline{TH}$	Open drain thermal flag When junction temperature is over 145ºC, $\overline{TH}$ is going to low.
23	EN	Chip enable/disable terminal. When EN is active (high), the chip is enabled; when EN is inactive (low), the chip is turned off (blanked).
2	R-EXT	The terminal used to connect an external resistor for setting up output current for output channel
3	FBI	Feedback control voltage input from another MBI1838. Connected to FBO of the previous MBI1838 in the serial feedback method. If the MBI1838 is the 1st one of the series, connect this pin to R-EXT.
4	FBO	Feedback control voltage to DC/DC converter. The relationship between FBO, FBI, and minimum output voltage is V_{FBO}=*minimum output voltage(FBI,* $V_{DS,\ min}$) Connect this pin to the FBI of the next MBI1838. If the MBI1838 is the last one of the series, connect this pin to the feedback input of DC-DC converter.
5	OVP	Over voltage protection input Connect this pin with appropriate voltage divider resistors to V_{LED} to set OVP detection criterion, V_{OVP}, which compares with the internal voltage, 1.25V. If V_{OVP} exceeds 1.25V, the fault condition, open-circuit will be determined.
8-11 14-17	$\overline{OUT0}$ ~ $\overline{OUT7}$	Constant current output terminals
20	OE	Output enable terminal When OE is active (high), the output pins are enabled; when OE is inactive (low), the output pins are turned off (blanked).
21	$\overline{ERR}$	Open drain error flag When any single output channel is determined as open-circuit or short-circuit, $\overline{ERR}$ is going to low.
-	Thermal Pad	Power dissipation terminal*
6,7,12,13,18,19	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.

Typical Application Circuits

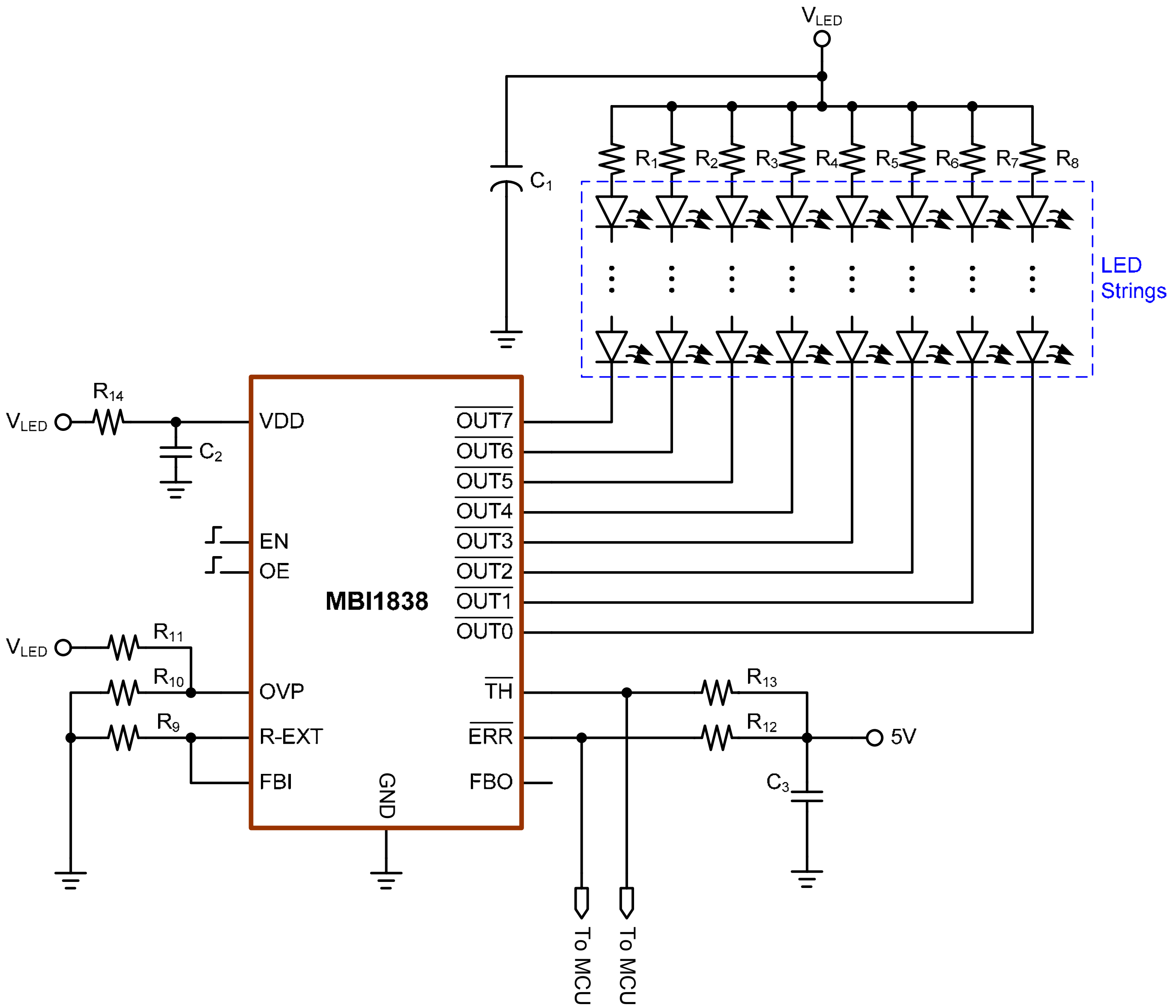


Fig. 1

Assume $V_{F,LED}$ of each LED is the same, where $V_{F,LED}$ is the forward voltage of LED.

V_{LED} and V_{DD} are applied by the same voltage source.

$(V_{DS} + V_{F,LED} \times n) < V_{LED} < (V_{DS} + V_{F,LED} \times n + 5V)$.

$R_1 = R_2 = \dots = R_8 = [V_{LED} - V_{DS} - (V_{F,LED} \times n)] / I_{OUT}$;

n refers to LED count, where V_{DS} denotes the $\overline{OUTn}$ terminal voltage and I_{OUT} denotes the channel current of each $\overline{OUTn}$.

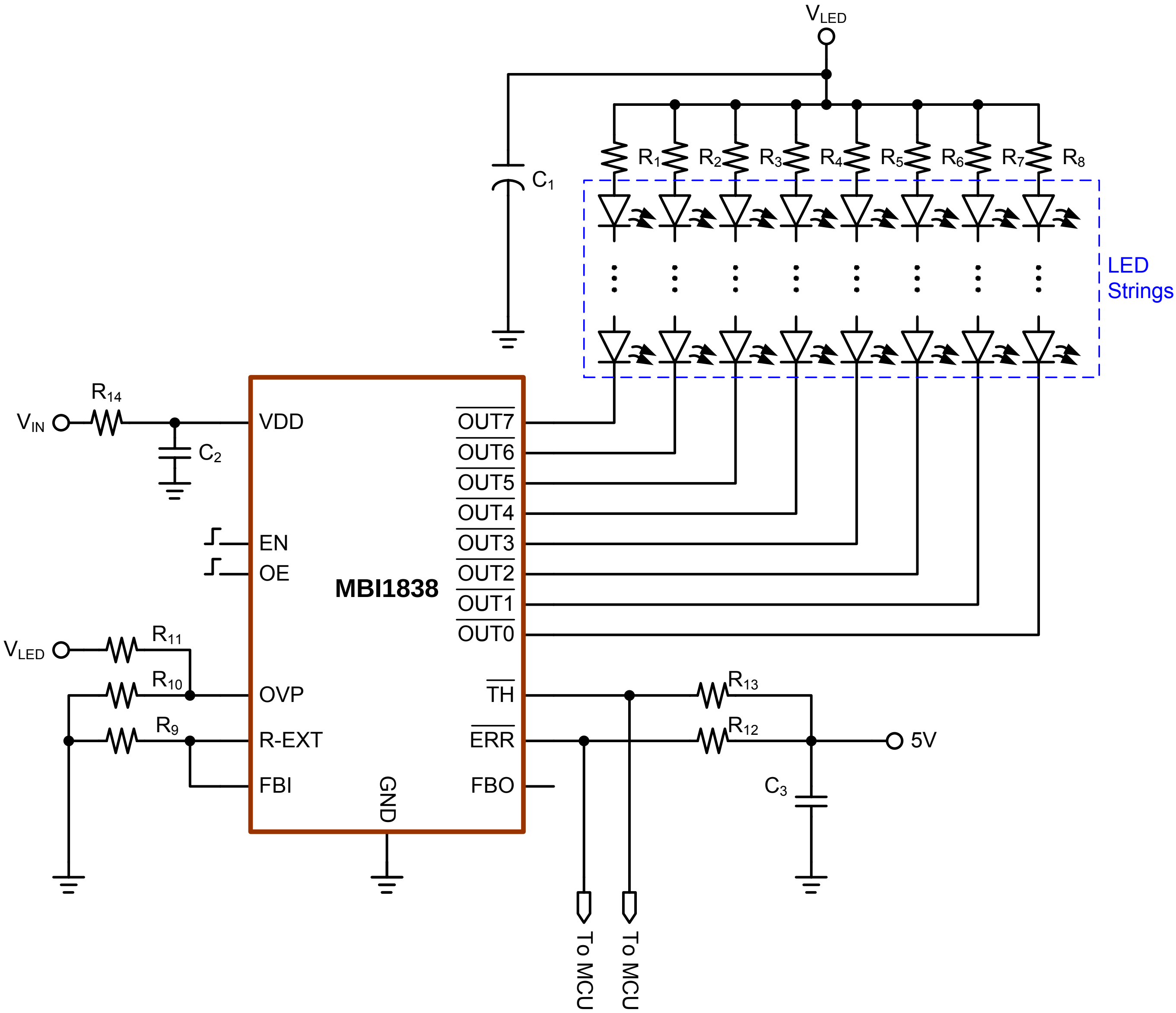


Fig. 2

V_{LED} and V_{DD} are separated. Generally, this scheme is applied with large number of LEDs in series. The V_{DD} is always set lower than V_{LED}, and V_{DD} value just meets the typical VCCH threshold to save the power dissipation on internal device of VCCH pin.

$(V_{DS} + V_{F,LED} \times n) < V_{LED} < (V_{DS} + V_{F,LED} \times n + 5V)$.

$R_1 = R_2 = \ldots = R_8 = [V_{LED} - V_{DS} - (V_{F,LED} \times n)] / I_{OUT}$;

n refers to LED count, where V_{DS} denotes the $\overline{\text{OUTn}}$ terminal voltage and I_{OUT} denotes the channel current of each $\overline{\text{OUTn}}$.

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_{DD}	70	V
Sustaining Voltage at OE (in)		V_{IN}	7	V
Sustaining Voltage at $\overline{OUTn}$		V_{DSn}	-0.5~+70	V
Sustaining Voltage at EN (in)		V_{EN}	7	V
Sustaining Voltage at FBI (in)		V_{FBI}	7	V
Sustaining Voltage at FBO (out)		V_{FBO}	7	V
Sustaining Voltage at OVP (in)		V_{OVP}	7	V
Sustaining Voltage at $\overline{TH}$ (out)		V_{TH}	7	V
Sustaining Voltage at $\overline{ERR}$ (out)		V_{ERR}	7	V
Output Current		I_{OUTn}	88*	mA
GND Terminal Current		I_{GND}	720	mA
Power Dissipation* (By simulation)	GTS	P_D	3.44	W
Thermal Resistance** (By simulation)	GTS	$R_{th(j-a)}$	36.29	°C/W
Empirical Thermal Resistance*** (On PCB, Ta=25°C)	GTS		38	
Operating Junction Temperature		$T_{j,max}$	150	°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

**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 for GTS testing is 4-inch square.

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, EN	"High" level	V_H	T_a=-40~85ºC	2.4	-	-	V
	"Low" level	V_{IL}	T_a=-40~85ºC		-	0.8	V
Output Voltage of $\overline{ERR}$		$V_{\overline{ERR},OL}$	$I_{\overline{ERR},OL}$=1.0mA	-	-	0.5	V
Output Voltage of $\overline{TH}$		$V_{\overline{TH},OL}$	$I_{\overline{TH},OL}$=1.0mA	-	-	0.5	V
V_{DS} Feedback Report Voltage		V_{FBO}	EN=High, OE=High, all channels are normal	Min(FBI, V_{DS})		1.23	V
			EN=High, OE=High, channel opened or disabled	Min(FBI, V_{DS})		1.23	V
			EN=High, OE=Low	0.27	0.30	0.35	V
			EN=Low	4.5	5.0	5.5	V
Supply Current	OE=Low	I_{DD}(off) 1	R_{ext}=Open, $\overline{OUT0}$~$\overline{OUT7}$=Off	-	2.8	5	mA
		I_{DD}(off) 2	R_{ext}=4kΩ, $\overline{OUT0}$~$\overline{OUT7}$=Off	-	3.0	6	
		I_{DD}(off) 3	R_{ext}=1.3kΩ, $\overline{OUT0}$~$\overline{OUT7}$=Off	-	4.3	7	
	OE=High	I_{DD}(on) 1	R_{ext}=4kΩ, $\overline{OUT0}$~$\overline{OUT7}$=On	-	3.2	6	
		I_{DD}(on) 2	R_{ext}=1.3kΩ, $\overline{OUT0}$~$\overline{OUT7}$=On	-	4.5	8	
Shutdown Current		I_{SHDN}	V_{EN} = 0	-	300	-	uA
Output Current		I_{OUT}	Test Circuit for Electrical Characteristics	15	-	80*	mA
Output Leakage Current		I_{OH}	V_{DS}=60.0V, OE=Low	-	-	0.5	μA
Output Current 1		I_{OUT1}	V_{DS}=1.0V, R_{ext}=1.6kΩ	-	61.5	-	mA
Current Skew 1		dI_{OUT1}	I_{OUT1}=61.5mA, V_{DS}=1.0V, R_{ext}=1.6kΩ	-	±1	±3	%
Output Current 2		I_{OUT2}	V_{DS}= 1.0V, R_{ext}= 1.3kΩ	-	75.7	-	mA
Current Skew 2		dI_{OUT2}	I_{OUT2}=75.7mA, V_{DS}=1.0V 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, EN		R_{IN}	-	350	500	650	KΩ
Junction Temperature Threshold of Thermal Flag		T_x	-	-	145	-	°C
The Hysteresis Temperature of Thermal Flag		T_{HYS}	-	-	35	-	°C
OVP Detection		V_{OVP}	-	-	1.25	-	V
LED Short Detection Threshold Voltage		$V_{SD,TH}$	Refer to Fig. 7	5.2	5.6	6.0	V
LED Open Detection Threshold Voltage		$V_{OD,TH}$	Refer to Fig. 8	0.27	0.30	0.33	V
The Hysteresis of OVP Detection		$V_{OVP-HYS}$	-	-	40	-	mV

*Each output current, I_{OUT}, can be driven up to 80mA.

Test Circuit for Electrical Characteristics

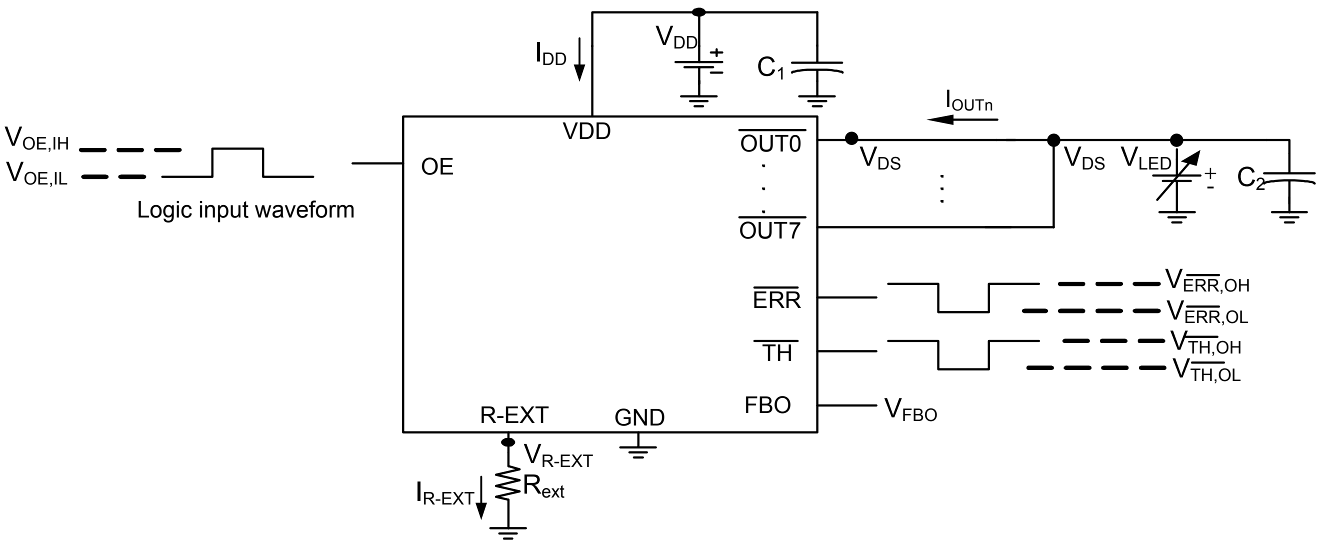


Fig. 3

Switching Characteristics

Characteristic		Symbol	Condition	Min.	Typ.	Max.	Unit
Propagation Delay Time ("L" to "H")	OE - $\overline{OUTn}$	t_{pLH}	V_{DD}= 24.0 V V_{DS}= 0.8V $V_{OE,IH}$= 5V $V_{OE,IL}$= GND R_{ext}= 1230Ω (I_{OUTn}=80mA) V_{LED}= 4.8 V R_L= 50Ω C_L= 10 pF Refer to Fig 4	-	-	1000	ns
Propagation Delay Time ("H" to "L")	OE - $\overline{OUTn}$	t_{pHL}		-	-	1000	ns
OE Pulse Width		$t_{w(OE)}$		2000	-	-	ns
Output Rise Time of $\overline{OUTn}$ (turn off)		t_{or}		-	700	1000	ns
Output Fall Time of $\overline{OUTn}$ (turn on)		t_{of}		-	700	1000	ns
Short-Circuit Detection Delay Time		t_{SLP}	Refer to Fig 7	32	-	96	ms
FBO Delay Time	V_{DS} - FBO	t_{FBO}	Refer to Fig 6	-	200	-	ns

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

Test Circuit for Switching Characteristics

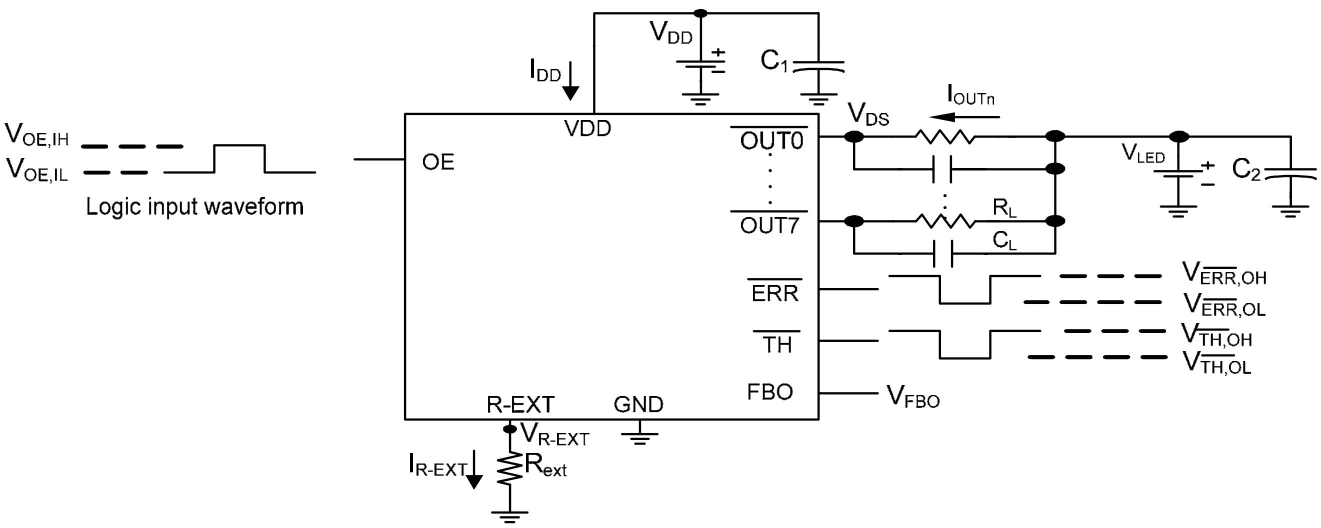


Fig. 4

Timing Waveform

A. Propagation Delay Time

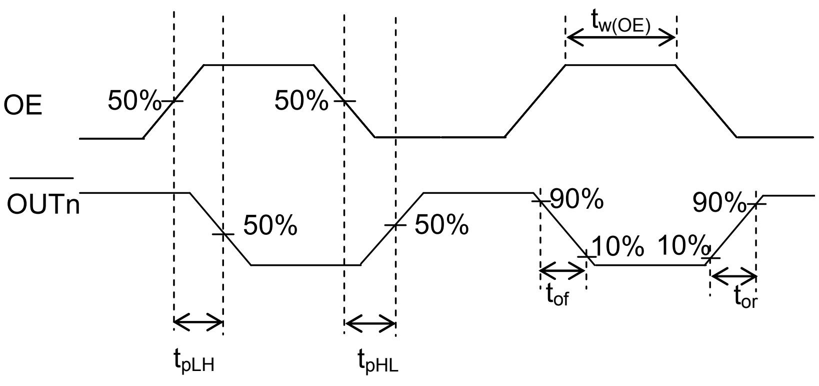


Fig. 5

B. FBO Delay Time

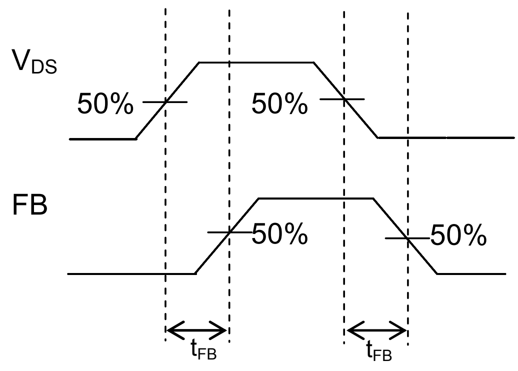


Fig. 6

C. Short-Circuit Detection

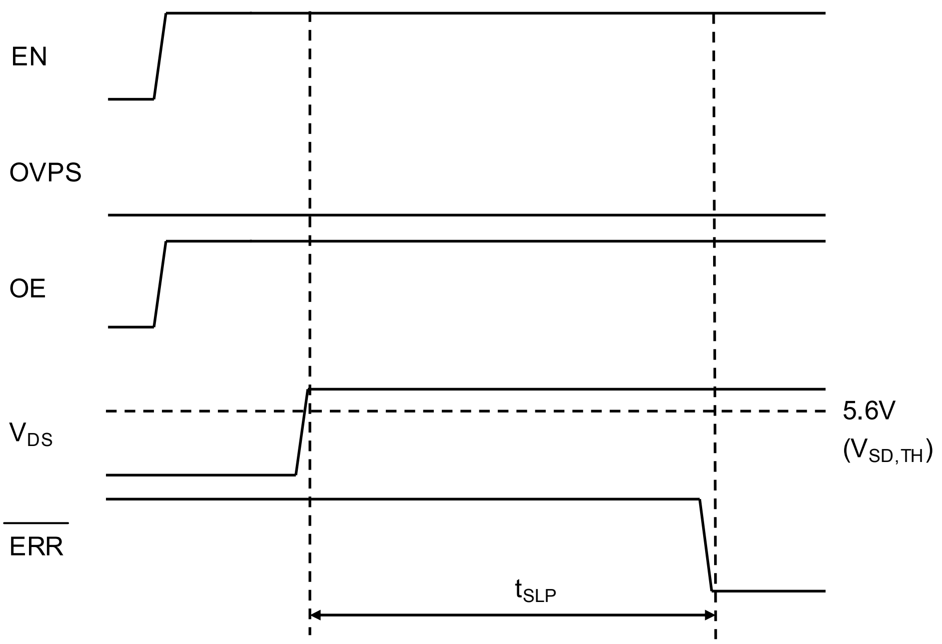
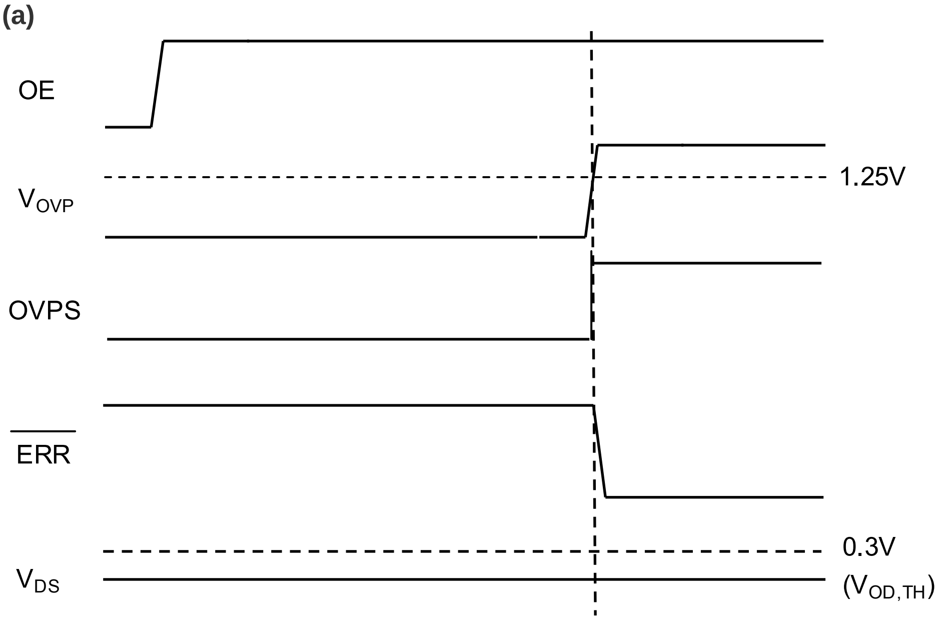


Fig. 7

D. Open-Circuit Detection

(a)



(b)

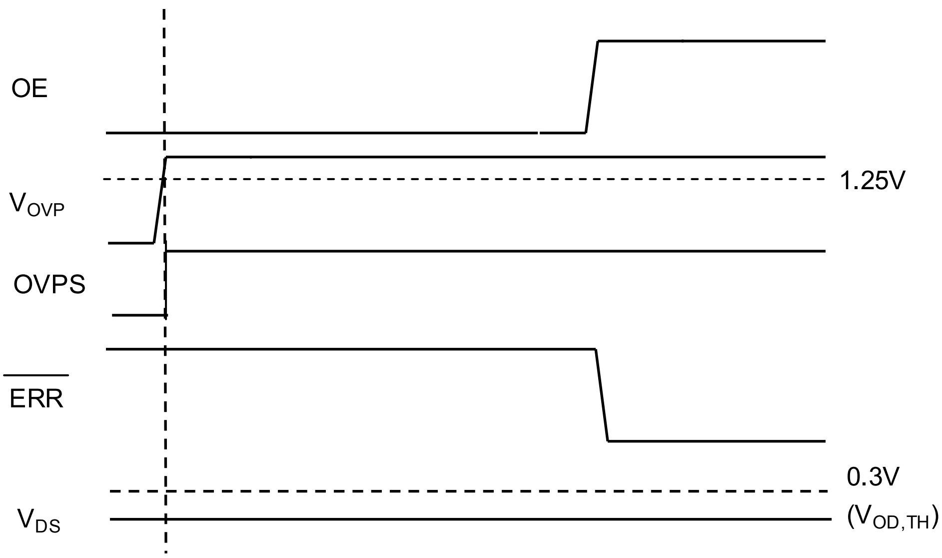
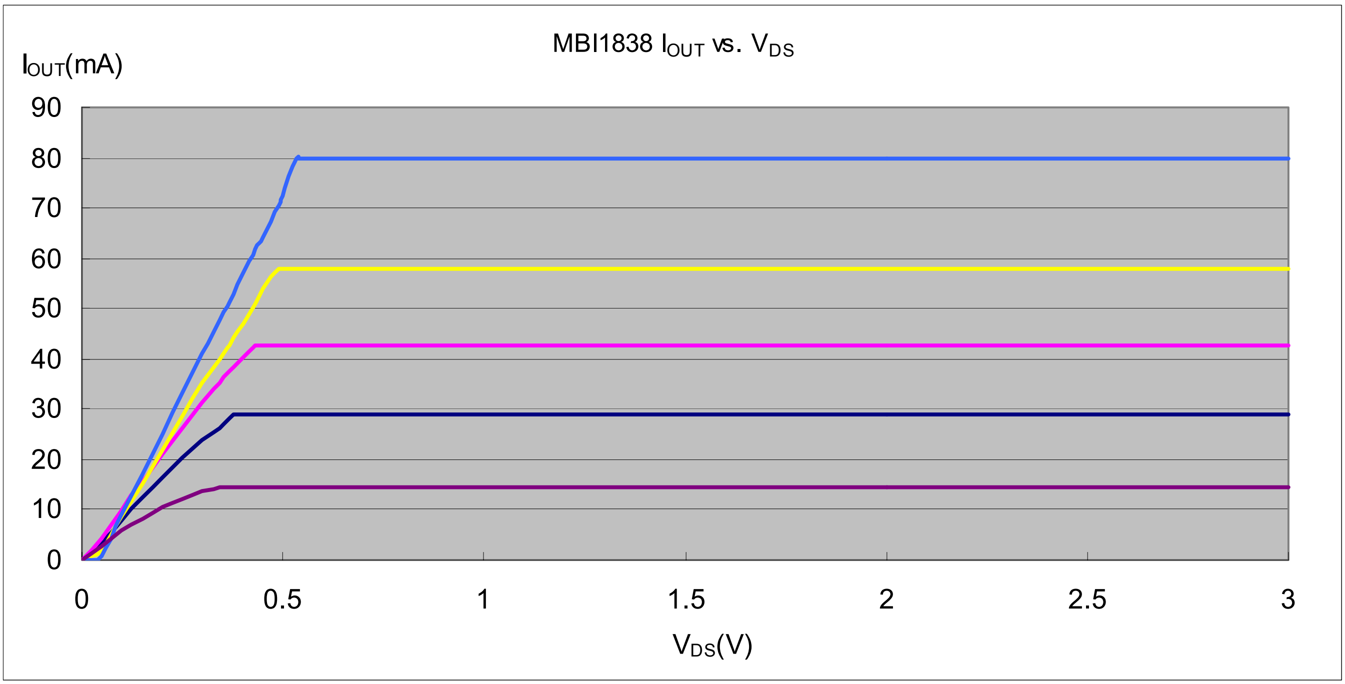


Fig. 8

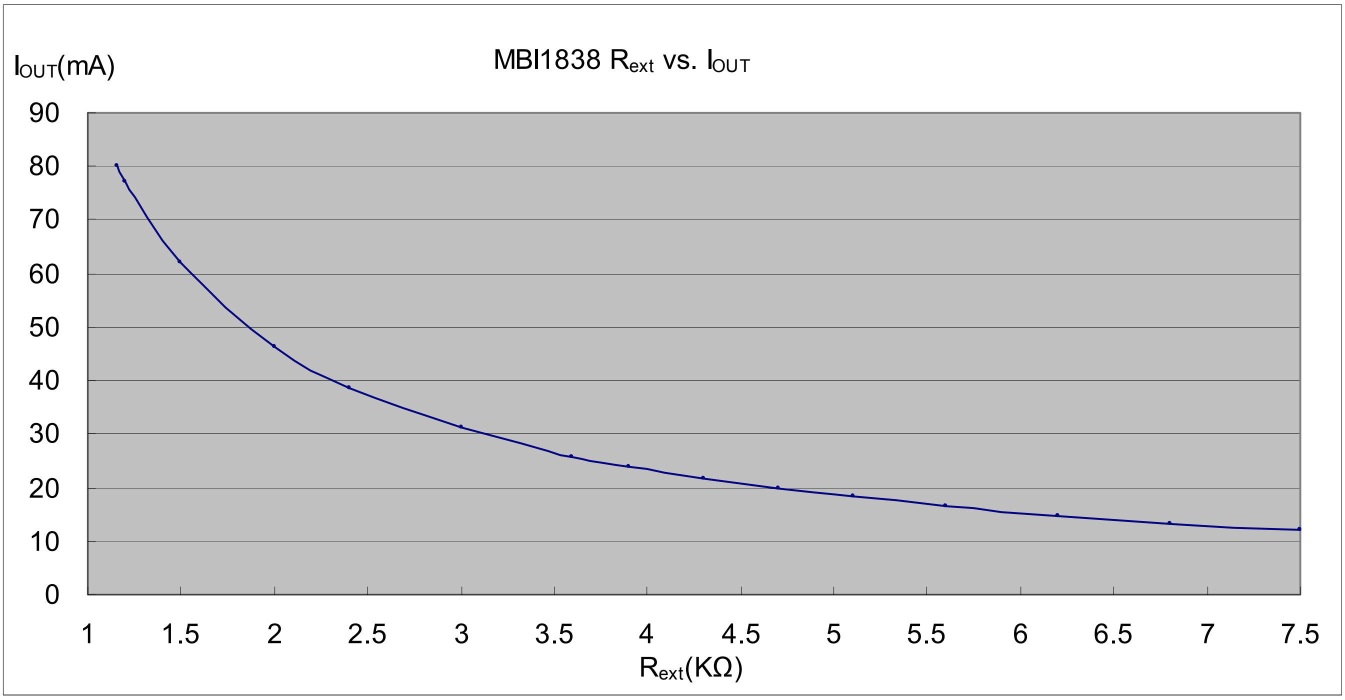
Constant Current

In LED lighting applications, MBI1838 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 the charts as shown below. 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.



Setting Output Current



The output current can be calculated from the equation:

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

$R_{ext} = (V_{R\text{-}EXT} / I_{OUT}) \times 80 = (1.23V / I_{OUT}) \times 80$;

$I_{OUT} = (V_{R\text{-}EXT} / R_{ext}) \times 80 = (1.23V / R_{ext}) \times 80$

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 75.7mA at 1.3kΩ and 41mA at 2.4kΩ.

Short-Circuit Detection

The circuits of short-circuit detection check the voltage, V_{DS}, of every output channel when OE goes high. If the voltage is greater than V_{SHORT} (set by 5.6V), MBI1838 will disable the corresponding channel (after delay time t_{SLP}=96ms, max). The short-circuit detection is inhibited, if OE is low. If the short-circuit is detected, the shorted channel will be disabled and the $\overline{ERR}$ pin will become low.

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 $\overline{ERR}$ pin will become low. Before activating open-circuit detection, the open-circuit detection will bypass those non-used pins which are connected to GND.

Over Voltage Detection

Usually, the fault-over voltage accompanies with the fault-open-circuit. Hence, MBI1838 is designed with over voltage detection function to help determine the fault, open-circuit, when over voltage happens. Connect the pin OVP to V_{LED} with a set of voltage divider resistors, R1 and R2, as shown in Fig. 9. V_{OVP} is used to compare with the internal reference voltage, 1.25V. If V_{OVP} is larger than 1.25V, the flag, OVPS will become high and it means the condition of "over voltage" happens, and MBI1838 will check which channel is open-circuit to cause the "over voltage", and shut down the open-circuit channel. When V_{OVP} is lower than 1.25V, the condition of over voltage will be asserted. The hysteresis of over voltage detection is 40mV. When V_{OVP} is under 1.21V, the fault, OVP, will be de-asserted.

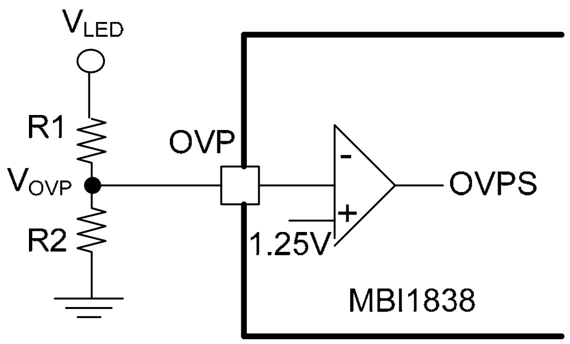


Fig. 9 Illustration of Over Voltage Detection

Thermal Shutdown

When the junction temperature exceeds the threshold, T_x (145°C), the thermal flag would be enabled, and all output channels will be disabled. The $\overline{TH}$ pin will become low. When EN or VDD pin is re-toggled, this fault condition will be released, and all output channels will be enabled again.

Dimming

MBI1838 receives PWM signal from OE to control the ON/OFF of LED strings. The minimum ON pulse width is 2.0μs. When the dimming frequency is below 5KHz, MBI1838 can achieve more than 100-step brightness adjustment from 1% to 100%.

Disable Unused Channel

If the output channel is not used, it has to be tied to ground before powered up. When the channel is defined as an unused channel, MBI1838 will disable the LED open-circuit detection at the unused channel, and the output voltage, V_{DS}, of this channel will not be selected in the minimum voltage selector.

Minimum Voltage Selector

A minimum voltage selector integrated in the MBI1838 monitors the dropped voltages, V_{DS}, of all the output channels when the LED is lit. This function can make the DC/DC converter output an appropriate voltage to light LED to avoid the extra V_{DS} dropped in the chip to generate the unnecessary heat. When plural MBI1838 are cascaded in series, the embedded minimum voltage selector will select the minimum one of the output voltages among the 8 output channels of the first MBI1838 in this series and the output voltage of FBO pin of the previous MBI1838 to FBI of the next MBI1838. The next MBI1838 will choose the lowest V_{DS} among the output channels and

FBI. This algorithm works in the whole series to let the last MBI1838 in this series send the lowest V_{DS} of this series from the pin, FBO. MBI1838 can co-work with DC/DC converter through FBO. When the minimum V_{DS} of MBI1838 in any single channel is lower than 0.6V, the V_{FBO} will force DC/DC converter to boost V_{LED}. The output voltage, V_{DS}, of the disabled channel or open-circuit channel will not be selected in the minimum voltage selector to avoid the DC/DC converter to be clamped in a high voltage or to be shut down caused by OVP.

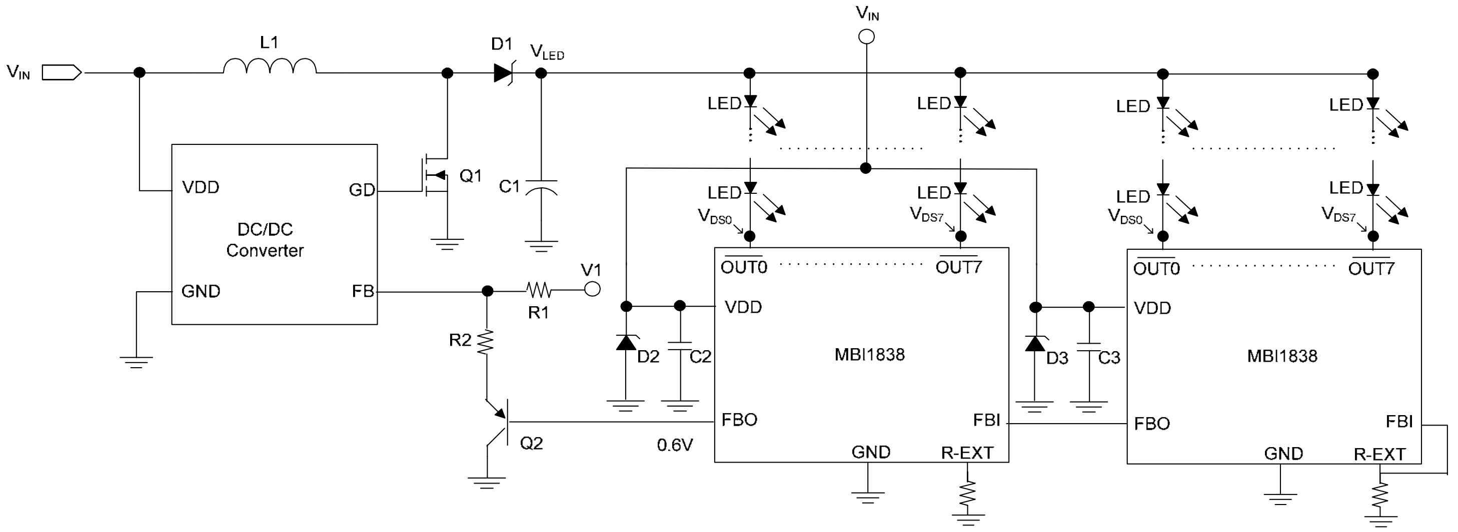
Principle to Cooperate with DC/DC Converter (Boost Converter)

MBI1838 is an 8-channel constant current LED driver which integrates open-circuit, short-circuit and over temperature protection, with a minimum voltage selector to optimize the system efficiency.

To drive the LEDs with accurate current, the current sinks are implemented by linear regulators. To maintain the current accuracy, the voltage drops ($\overline{OUT0}$~$\overline{OUT07}$) of the current sinks should be kept in a certain value. However, a higher voltage drops ($\overline{OUT0}$~$\overline{OUT07}$) may result in poor efficiency. Hence, MBI1838 takes the minimum voltage from V_{DS0} to V_{DS7} as the feedback voltage to the DC/DC converter, and regulates V_{LED} in an appropriate level.

MBI1838 can co-work with DC/DC converter through the feedback terminal. When the minimum V_{DS} of MBI1838 in any single channel is lower than 0.6V, the V_{FBO} will force DC/DC converter to boost V_{LED} to make the minimum V_{DS} larger than 0.6V as shown in Fig 10.

The MBI1838 provides a cascaded connection to co-work with a DC/DC converter with plural MB1838. When plural MBI1838 are in series, the MBI1838 selects the lowest V_{DS} among the 8 output channels of the MBI1838 and the FBI from the FBO of the previous MBI1838, and then report to the next MBI1838. In this cascade, the final MBI1838 reports the lowest V_{DS} of the whole string through the FBO.

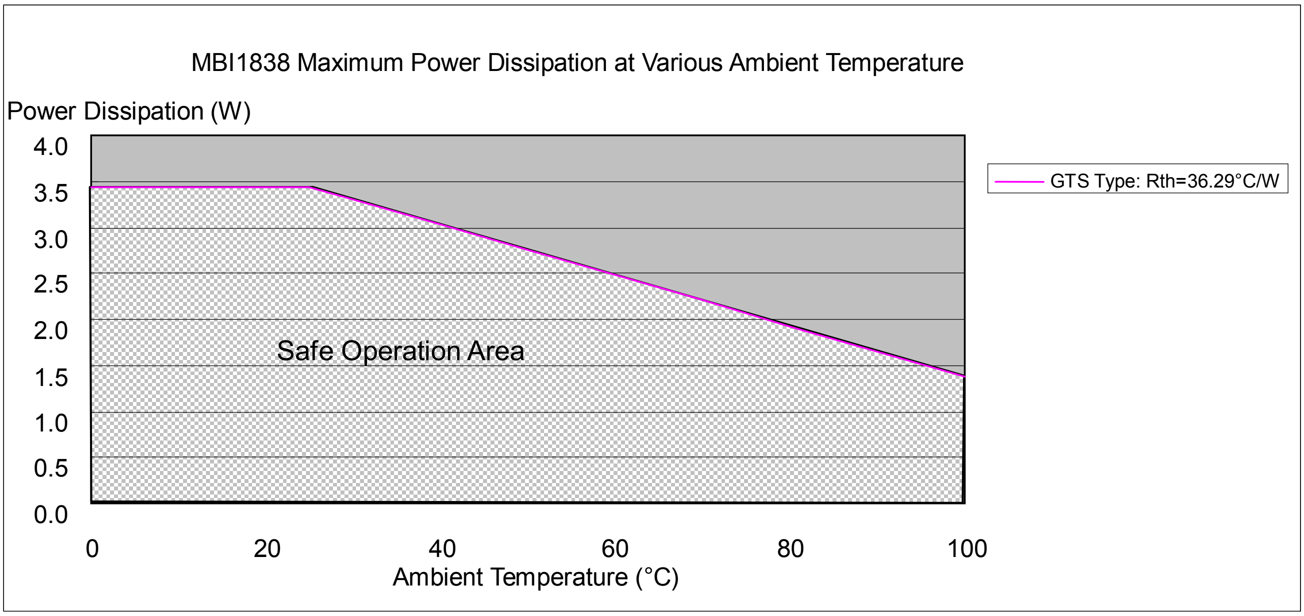


V_{LED}: voltage source of LED strings
V_{IN}: voltage source of DC/DC converter and MBI1838
V1: a level shift voltage source

Fig 10 MBI1838 serial feedback with the DC/DC converter

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.



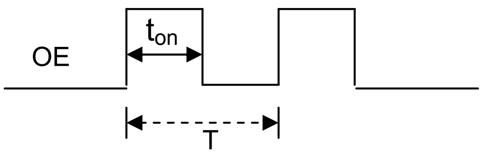
The maximum allowable package power dissipation is determined as $P_D(max) = (T_{j,max} – T_a) / R_{th(j-a)}$. When 8 output channels are turned on simultaneously, the actual package power dissipation is $P_D(act) = (I_{DD} \times V_{DD}) + (I_{OUT} \times Duty \times V_{DS} \times 8)$. Therefore, to keep $P_D(act) \leq P_D(max)$, 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 $T_{j,max} = 150°C$;

Duty= t_{ON} / T;

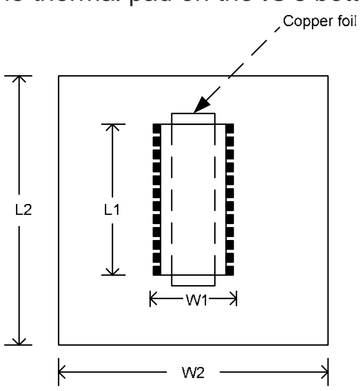
t_{ON}: the time of LEDs turning on; T: OE signal period



*Note: The empirical thermal resistor GTS, $R_{th(j-a)}$ =91.3°C/W; GTS, GFN, $R_{th(j-a)}$ =99.73°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})

MBI1838 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 Fig 11.

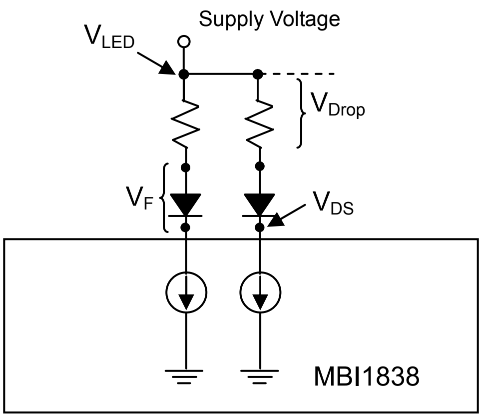
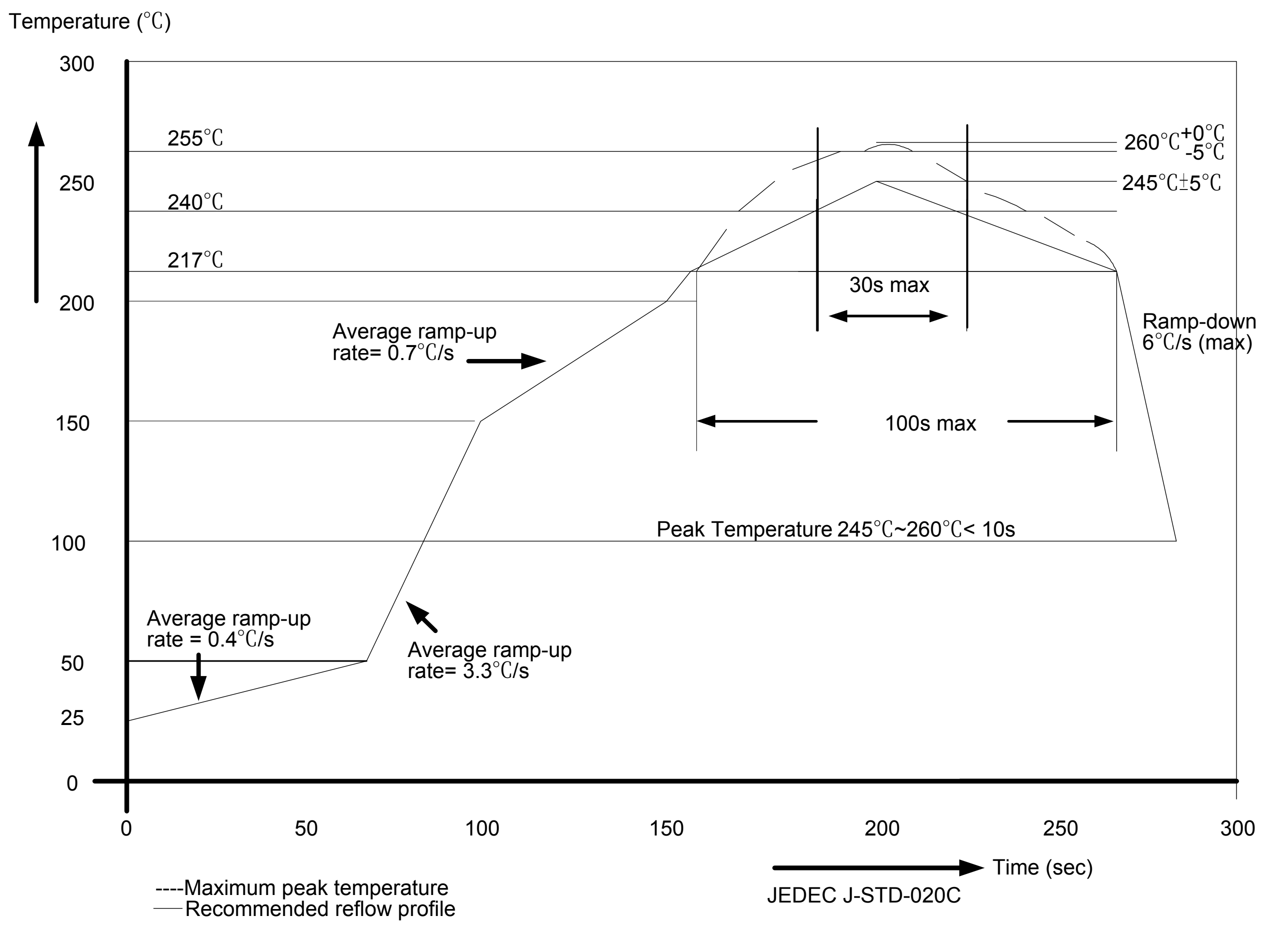


Fig. 11

Soldering Process of “Pb-free” Package Plating*

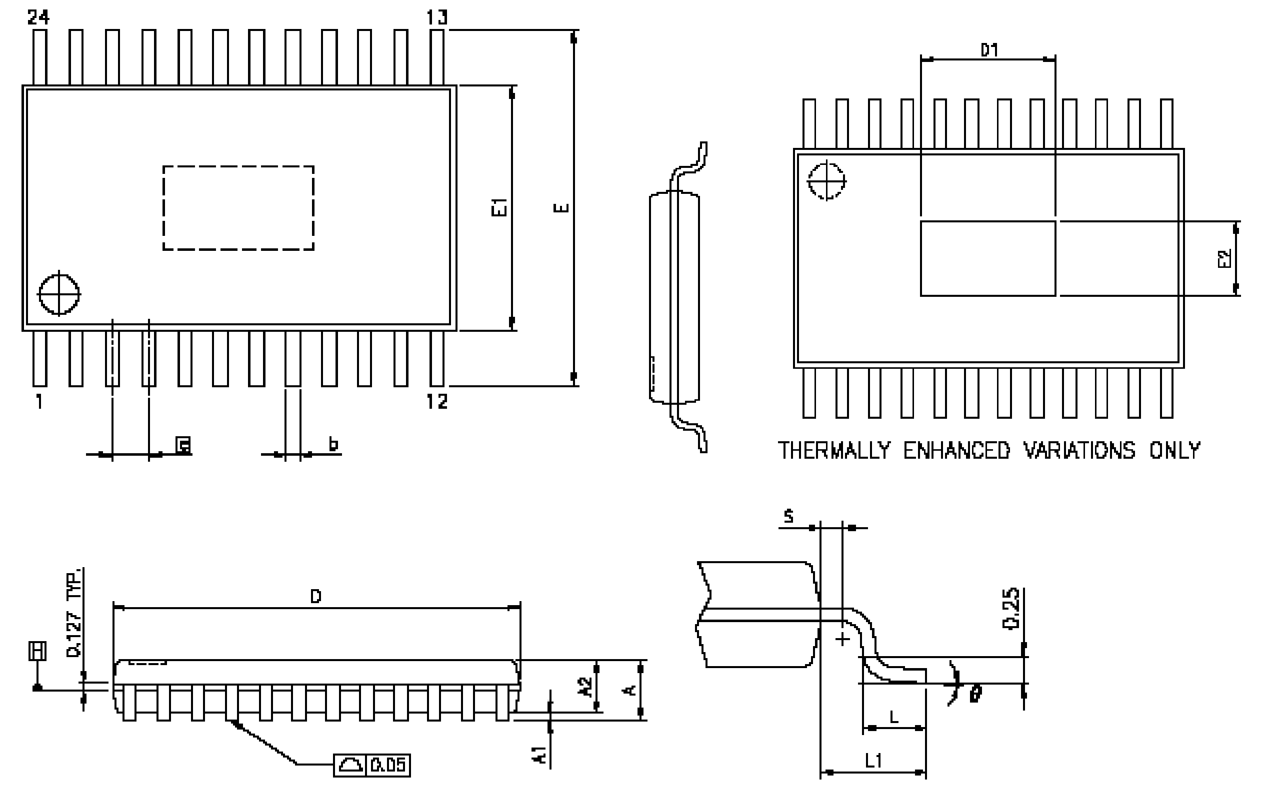
Macroblock has defined "Pb-Free" to mean semiconductor products that are compatible with the current RoHS requirements and selected 100% pure tin (Sn) to provide forward and backward compatibility with both the current industry-standard SnPb-based soldering processes and higher-temperature Pb-free processes. 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 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 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



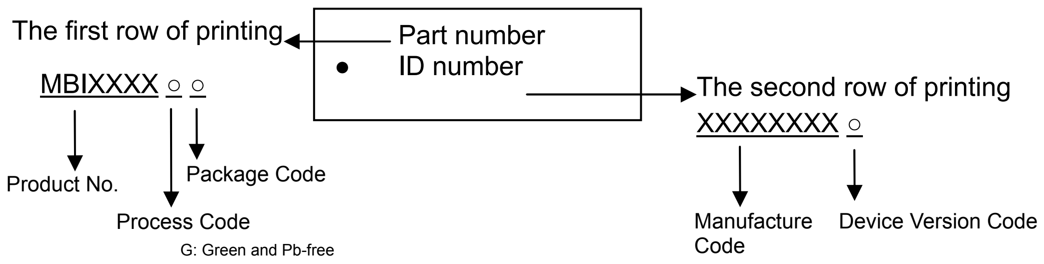
Unit: mm

D			E			E1			A	A1	A2			D1			E2			b		e	θ	
MIN	NOM	MAX	MIN	NOM	MAX	MIN	NOM	MAX	MAX	MAX	MIN	NOM	MAX	MIN	NOM	MAX	MIN	NOM	MAX	MIN	MAX		MIN	MAX
7.7	7.8	7.9	6.2	6.4	6.6	4.3	4.4	4.5	1.2	0.15	0.8	0.9	1.05	3.65	4.63	4.9	2.2	2.946	3.15	0.19	0.3	0.65	0°	8°

MBI1838GTS 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



Product Revision History

Datasheet Version	Device Version Code
V1.00	A

Product Ordering Information

Part Number	Package Type	Weight (g)
MBI1838GTS	TSSOP24L-173 -0.65	0.0967

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