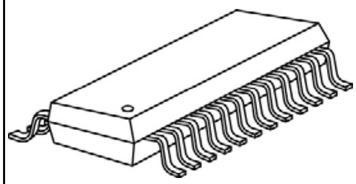
DC-DC Boost Controller with Min. Selector

Thin Shrink SOP



GTS: TSSOP24L-173-0.65

Features

- 10V~30V wide input voltage range
- Adjustable switching frequency: 75KHz to 250KHz
- Peak current mode control
- External soft-start function
- Drive external power MOSFET
- Minimum selector supports up to 4 feedback inputs
- Full protections:
  - Under voltage lockout, UVLO
  - Over temperature protection, OTP
  - Over voltage protection, OVP
  - Over current protection, OCP
  - Input voltage protection, IVP
- TSSOP-24 package

Product Description

MBI6703 is a frequency-adjustable, peak current mode step-up DC/DC controller to drive external constant current LED drivers, ex. MBI1838, with multi-strings. It is designed for large LCD panels that employ an array of LEDs as the light source. MBI6703 accepts wide input voltage range from 10V to 30V.

MBI6703 can receive external pulse width modulation (PWM) dimming control signal to turn on/off the output voltage according to the dimming.

MBI6703 is built with complete protection features to protect the controller from fault situations. The soft-start function eliminates the inrush current while the power is on. The integrated protections, UVLO, OVP, OCP, OTP, and IVP, avoid MBI6703 from being damaged from fault conditions.

MBI6703 supports 4 external feedbacks from the external constant current LED drivers in parallel, and builds in a minimum voltage selector to choose the lowest voltage to make sure all the arrays of LEDs are well controlled.

MBI6703 drives an external MOSFET, which provides good efficiency and maximizes operating voltage. The feature of selectable switching frequency allows optimization of the component size and system efficiency.

MBI6703 is available in a TSSOP-24L-173-0.65 package.

Applications

- LCD TV

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

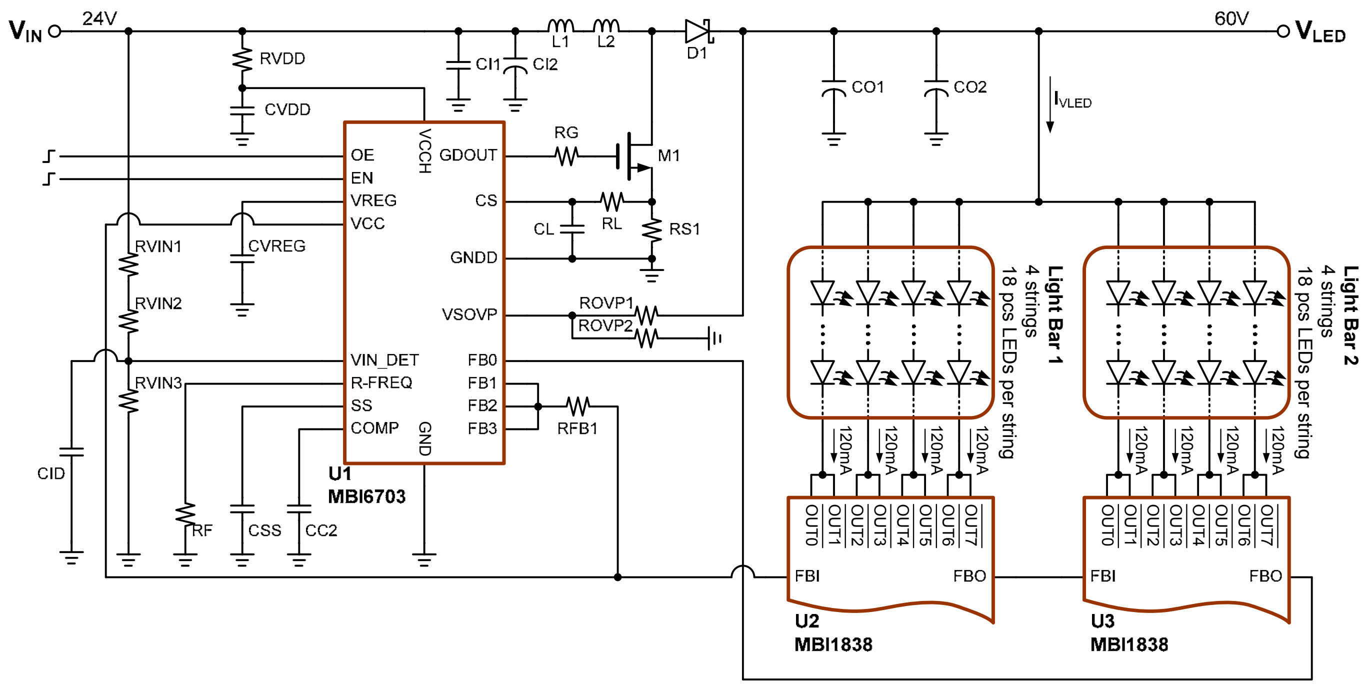


Fig. 1

BOM List of Typical Application Circuit (Fig. 1)

Designator	Qty.	Part Number	Description	Vendor	Contact Information
U1	1	MBI6703	Boost controller, TSSOP24.	MBI	www.mblock.com.tw
M1	1	AP40T10GH	I_D=39A, B_{VDSS}=100V, V_{GS}=±20V, TO-252.	APEC	www.a-power.com.tw
D1	1	MBR16100DC	I_F=16A, V_R=100V, TO-263.	PANJIT	www.panjit.com
L1, L2	2	GSDRK127P-220	22uH, 7A, 40mohm.	GOTREND	www.gotrend.com.tw
CL, CID	2	CC0603KRX7R9BB102	1nF, 50V, 0603.	Yageo	www.yageo.com
CC2	1	CC0603KRX7R9BB104	100nF, 50V, 0603.	Yageo	www.yageo.com
CSS	1	CC0603KRX7R9BB474	470nF, 50V, 0603.	Yageo	www.yageo.com
CVREG	1	CC0603KRX7R7BB105	1uF, 16V, 0603.	Yageo	www.yageo.com
CVDD	1	CC0805KRX7R9BB105	1uF, 50V, 0805.	Yageo	www.yageo.com
CI1	1	GRM32ER72A225K	2.2uF, 100V, 1210.	muRata	www.murata.com/index.html
CO1, CO2	2	EKY-101ELL560MH20D	56uF, 100V, 565mA.	ChemiCon	www.chemi-con.co.jp/e/index.html
CI2	1	EKY-101ETE101MK16S	100uF, 50V, 555mA.	ChemiCon	www.chemi-con.co.jp/e/index.html
RG	1	WR06W1R00 FTL	1Ω/±1%/0603	WALSIN	www.passivecomponent.com
RVDD	1	WR06W10R0 FTL	10Ω/±1%/0603	WALSIN	www.passivecomponent.com
RF	1	WR06X4302 FTL	43KΩ/±1%/0603	WALSIN	www.passivecomponent.com
RL	1	WR06X1001 FTL	1KΩ/±1%/0603	WALSIN	www.passivecomponent.com
RVIN2	1	WR06X2001 FTL	2KΩ/±1%/0603	WALSIN	www.passivecomponent.com
ROVP2, RVIN3	2	WR06X1002 FTL	10KΩ/±1%/0603	WALSIN	www.passivecomponent.com
RVIN1	1	WR06X1803 FTL	180KΩ/±1%/0603	WALSIN	www.passivecomponent.com
RFB1	1	WR06X5103 FTL	510KΩ/±1%/0603	WALSIN	www.passivecomponent.com
ROVP1	1	WR06X6203 FTL	620KΩ/±1%/0603	WALSIN	www.passivecomponent.com
RS1	1	WW12XR330FTL	33mΩ/±1%/1206/0.25W	WALSIN	www.passivecomponent.com

Functional Diagram

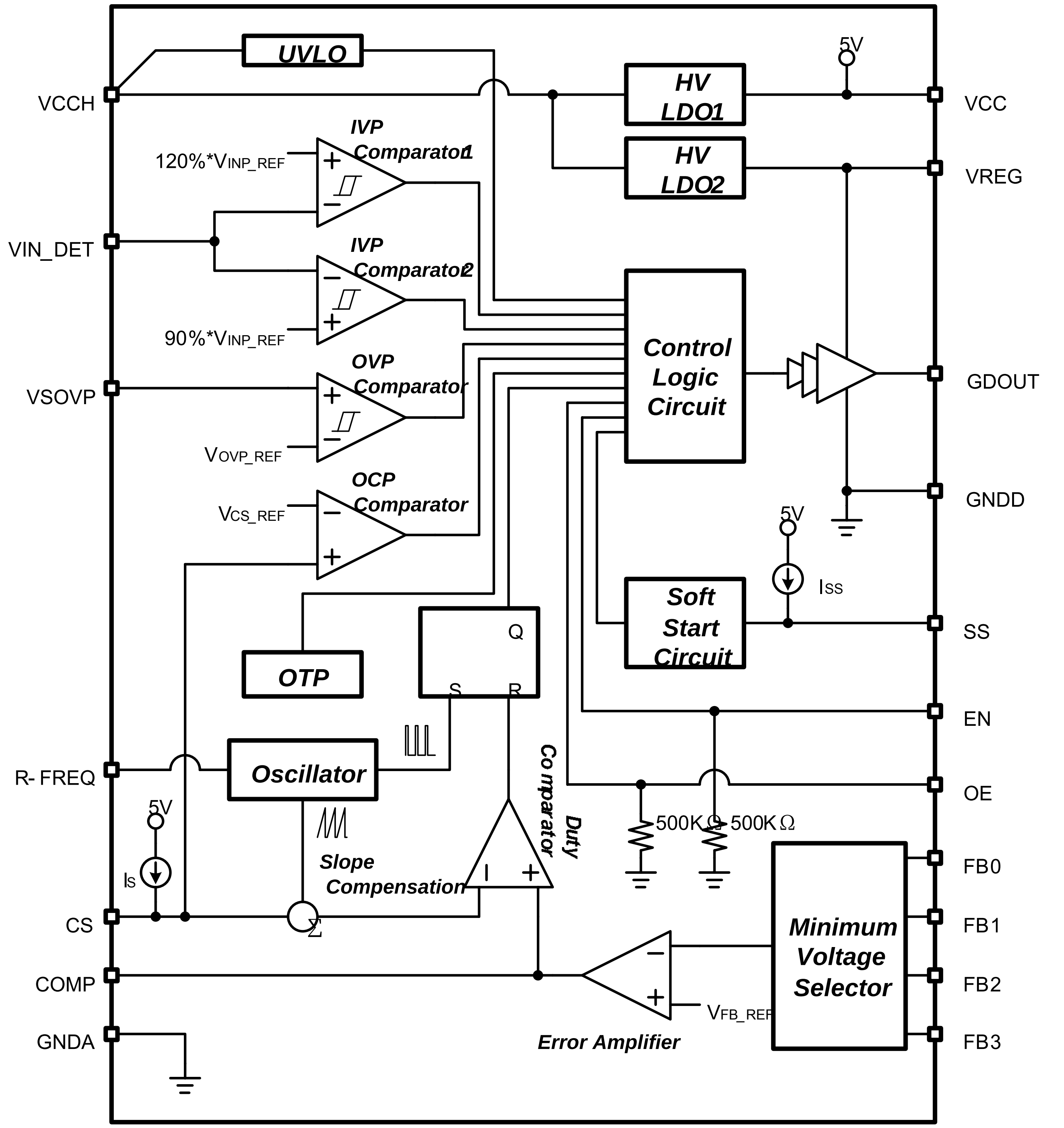
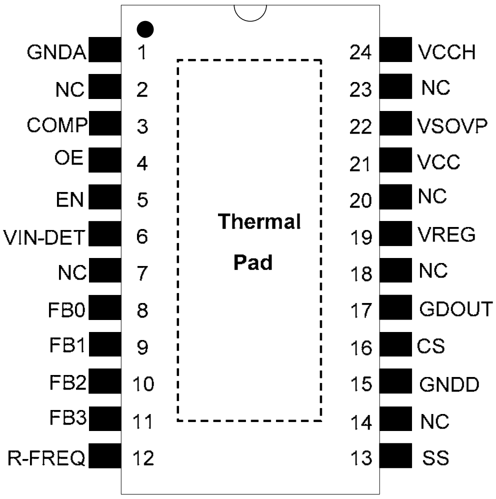


Fig. 2

Pin Configuration



MBI6703GTS (Top View)

Pin Description

Pin No	Pin Name	Function
24	VCCH	Supply voltage terminal.
21	VCC	5V linear regulator output for pulling unused feedback inputs to high.
1	GNDA	Analog ground terminal.
15	GNDD	Digital ground terminal.
3	COMP	Boost converter compensation pin.
4	OE	Output enable terminal When OE is active (high), all output pins are enabled; when OE is inactive (low), all output pins are turned off (blanked).
5	EN	Shut down control input. When EN is high, the chip is enabled. When EN is low, the chip is disabled.
6	VIN_DET	VCCH input range detection. If input voltage >1.2 x expected VCCH or <0.85 x expected VCCH, the converter will shut down. When the input voltage recovers 0.9 x expected VCCH <input voltage<1.1 x expected VCCH, the converter will auto restart.
8	FB0	External constant current LED driver feedback input 1.
9	FB1	External constant current LED driver feedback input 2.
10	FB2	External constant current LED driver feedback input 3.
11	FB3	External constant current LED driver feedback input 4.
12	R-FREQ	Oscillator frequency selection. Users can set the oscillator frequency of boost converter by connecting a resistor to GND. The tuning range is from 75Khz to 250Khz.
13	SS	The soft-start pin is to connect with external capacitor.
16	CS	Current sense input.
17	GDOUT	Gate driver for the external MOSFET.
19	VREG	10V regulator output. Connecting a 1uF ceramic capacitor to GND to enhance the stability of V_{REG}.

22	VSOVP	Over voltage sense input.
2, 7, 14, 18, 20, 23	NC	No connection.
-	Thermal Pad	Power dissipation terminals connect to GND*.

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

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_{CCH}	-0.4~33	V
5V Regulator Output Voltage		V_{CC}	-0.4~6	V
10V Regulator Output Voltage		V_{REG}	-0.4~12	V
Gate Driver Output Voltage (GDOUT)		V_{GDOUT}	-0.4~12	V
Logic Input Voltage of EN, OE, VIN_DET, FB3, VSOVP, CS Pins		V_{LOGIC}	-0.4~6	V
Power Dissipation** (On PCB, Ta = 25°C)	GTS	P_D	3.29	W
Thermal Resistance*** (By simulation)		$R_{th(j-a)}$	38	°C/W
Empirical Thermal Resistance**** (On PCB, Ta = 25°C)			105	
Operating Junction Temperature		$T_{j,max}$	150	°C
Operating Ambient Temperature		T_{opr}	-40~+85	°C
Storage Temperature		T_{stg}	-55~+150	°C

**Users must notice that the power dissipation should be within the Safe Operation Area.

*** 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. 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.

Electrical Characteristics

Test condition: V_{IN} = 24V, GND = 0V, Ta = 25°C, unless otherwise specified.

Characteristic		Symbol	Condition	Min.	Typ.	Max.	Unit
Supply Voltage		V_{CCH}	$V_{IN}=V_{CCH}$	10	-	30	V
Output Voltage of V_{CC}		V_{CC}	$12<V_{CCH}<24V$, $I_{VCC}<500uA$	4.5	5	5.5	V
Output Voltage of V_{REG}		V_{REG}	$V_{IN}=V_{CCH}$, I_{VREG}=10mA	7	9	11	V
UVLO Threshold of V_{CC}		V_{UVLO}	Rising edge, Hysteresis=550mV	7.2	8	8.8	V
Quiescent Current		I_Q	EN=High	400	620	760	μA
Shutdown Current		I_{SHDN}	EN=GND	5	16	30	μA
BOOST CONTROLLER							
GDOUT	“H” level	V_{GDOUTH}	10mA from GDOUT to GND	V_{REG} -0.2	V_{REG}	-	V
	“L” level	V_{GDOUTL}	-10mA from GDOUT to V_{REG}	-	0	0.1	V
GDOUT On-Resistance (sourcing)		$R_{ON(GDOUT)}$	V_{GDOUT}=10V, I_{GDOUT}=10mA	7	10	16	Ω
GDOUT On-Resistance (sinking)		$R_{ON(GDOUT)}$	V_{GDOUT}=0V, I_{GDOUT}=10mA	3	4	8	Ω
Switching Frequency		$F_{osc,75K}$	RF=57.06KΩ/±1%	67.5	75	82.5	KHz
		$F_{osc,250K}$	RF=17.12KΩ/±1%	225	250	275	KHz
Minimum ON Time		Tmin	PWM mode	100	150	200	ns
Maximum Duty Cycle		D_{MAX}	PWM mode	87	90	93	%
FB Voltage		V_{FB_REF}	COMP connecting to FBn	582	600	616	mV
FB Bias Current		I_{FB}	Current flowing out of part	80	100	500	nA
Max. COMP Current		-	Sourcing and sinking	20	40	48	uA
EA Trans Conductance		gm	COMP connecting to FBn; Force±10 uA to COMP	450	620	840	μA /V
Current Sense Bias Current		I_S	Current flowing out of part	3	5	6	μA
Soft-Start Current		I_{SS}	Current flowing out of part	9	12	14	μA
OCP Threshold Voltage		V_{CS_REF}	V_{COMP}=5V, V_{GDOUT} turned off	190	200	230	mV
CONTROL INPUT							
EN/OE Logic	“H” level	V_{BRTH}	V_{OE}=5V, start operation	2.4	-	-	V
	“L” level	V_{BRTL}	V_{OE}=5V, stop operation	-	-	0.6	V
FAULT PROTECTION							
OVP Threshold Voltage		V_{OVP_REF}	Hysteresis = 50mV	1.164	1.2	1.236	V
Thermal Shutdown Threshold		T_{SD}	Hysteresis = 20°C	-	155*	-	°C
IVP Threshold Voltage		V_{IVP_REF}	Hysteresis = 50mV	1.164	1.20	1.236	V
Input Over Voltage Protection		V_{IOP}	Stop operation, Hysteresis=0.1xV_{IVP_REF}	-	1.2xV_{IVP_REF}	-	V
Input Under Voltage Protection		V_{IUP}	Stop operation, Hysteresis=0.05xV_{IVP_REF}	-	0.85xV_{IVP_REF}	-	V

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

Efficiency Test Circuit

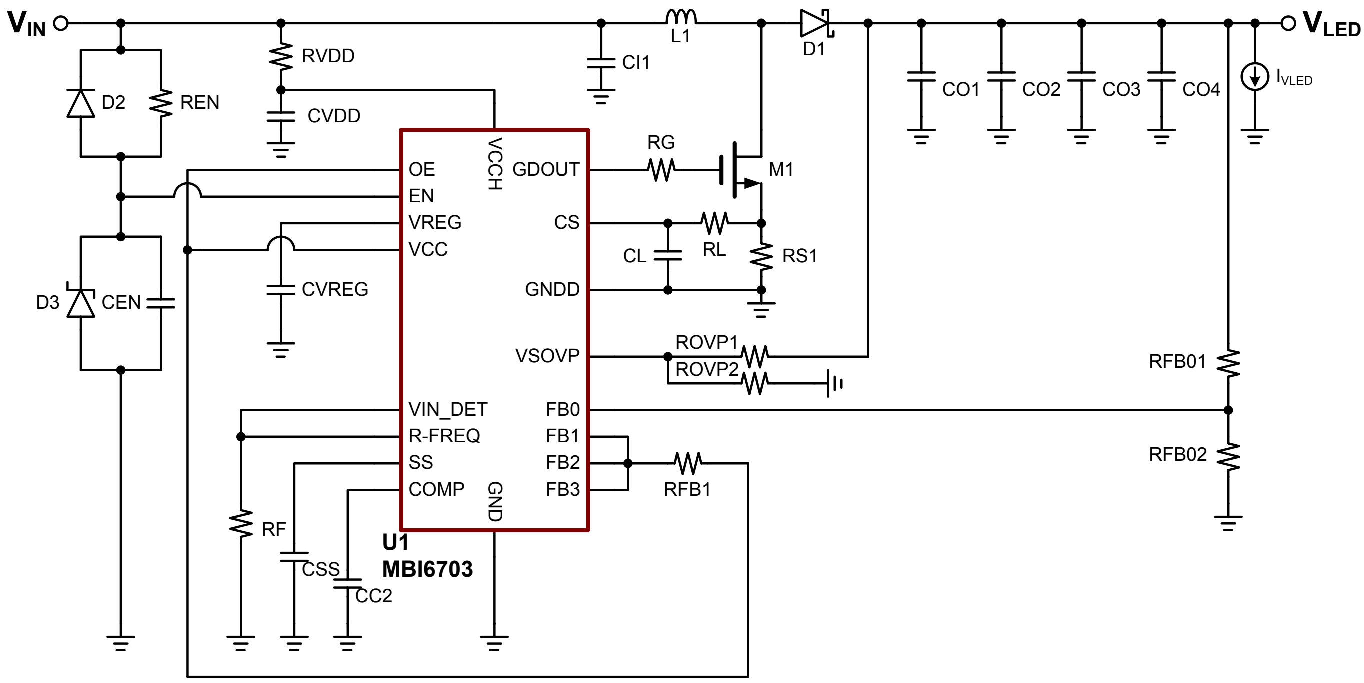


Fig. 3

BOM List of Efficiency Test Circuit (Fig. 3)

Designator	Qty.	Part Number	Description	Vendor	Contact Information
U1	1	MBI6703	Boost controller, TSSOP24.	MBI	www.mblock.com.tw
M1	1	AP40T10GH	I_D=39A, B_{VDSS}=100V, V_{GS}=±20V, TO-252.	APEC	www.a-power.com.tw
D1	1	MBR16100DC	I_F=16A, V_R=100V, TO-263.	PANJIT	www.panjit.com
D2	1	1N4148W	I_F=0.15A, V_R=75V, P_T=0.41W, SOD-123.	PANJIT	www.panjit.com
D3	1	ZMY5V1	I_{ZT}=0.1A, V_Z=5.1V, P_T=1W, MELF-41.	PANJIT	www.panjit.com
L1, L2	2	GSDRK127P-220	22uH, 7A, 40mohm.	GOTREND	www.gotrend.com.tw
CL, CID	2	CC0603KRX7R9BB102	1nF, 50V, 0603.	Yageo	www.yageo.com
CEN	1	CC0603KRX7R9BB103	10nF, 50V, 0603.	Yageo	www.yageo.com
CC2	1	CC0603KRX7R9BB104	100nF, 50V, 0603.	Yageo	www.yageo.com
CSS	1	CC0603KRX7R9BB474	470nF, 50V, 0603.	Yageo	www.yageo.com
CVREG	1	CC0603KRX7R7BB105	1uF, 16V, 0603.	Yageo	www.yageo.com
CVDD	1	CC0805KRX7R9BB105	1uF, 50V, 0805.	Yageo	www.yageo.com
CI1, CO1, CO2, CO3, CO4	5	GRM32ER72A225K	2.2uF, 100V, 1210.	muRata	www.murata.com/index.html
RG	1	WR06W1R00 FTL	1Ω/±1%/0603	WALSIN	www.passivecomponent.com
RVDD	1	WR06W10R0 FTL	10Ω/±1%/0603	WALSIN	www.passivecomponent.com
RF	1	WR06X4302 FTL	43KΩ/±1%/0603	WALSIN	www.passivecomponent.com
RL	1	WR06X1001 FTL	1KΩ/±1%/0603	WALSIN	www.passivecomponent.com
RVIN2	1	WR06X2001 FTL	2KΩ/±1%/0603	WALSIN	www.passivecomponent.com
ROVP2, RVIN3, RFB02	3	WR06X1002 FTL	10KΩ/±1%/0603	WALSIN	www.passivecomponent.com
RVIN1	1	WR06X1803 FTL	180KΩ/±1%/0603	WALSIN	www.passivecomponent.com
REN	1	WR06X4703 FTL	470KΩ/±1%/0603	WALSIN	www.passivecomponent.com
RFB1	1	WR06X5103 FTL	510KΩ/±1%/0603	WALSIN	www.passivecomponent.com
ROVP1	1	WR06X6203 FTL	620KΩ/±1%/0603	WALSIN	www.passivecomponent.com
RFB01	1	WR06X8203 FTL	820KΩ/±1%/0603	WALSIN	www.passivecomponent.com
RS1	1	WW12XR330FTL	33mΩ/±1%/1206/0.25W	WALSIN	www.passivecomponent.com

Typical Operating Characteristics

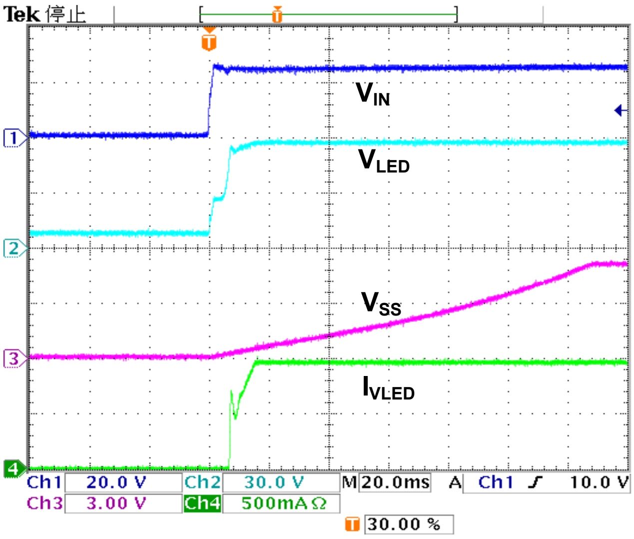


Fig.4 Power On sequence with V_{IN} protection, V_{IN}=24V, I_{VLED}=0.96A

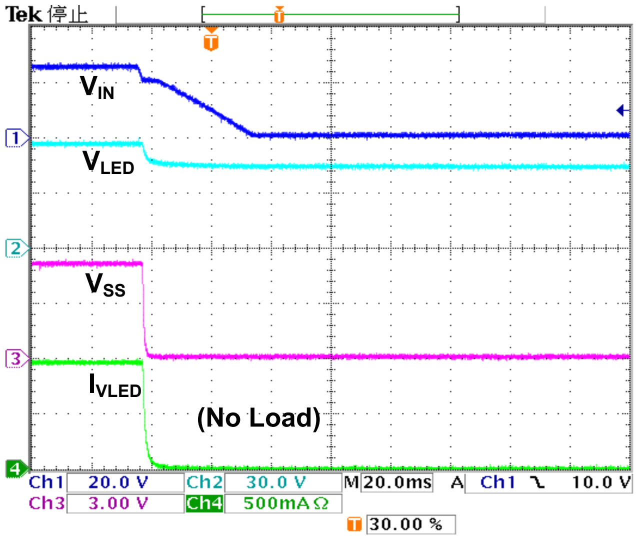


Fig. 5 Power Off sequence with V_{IN} protection, V_{IN}=24V, I_{VLED}=0.96A

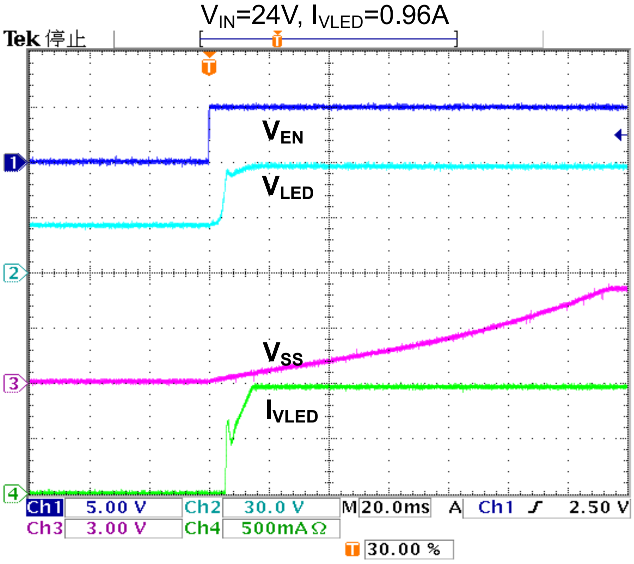


Fig. 6 EN enable, V_{IN}=24V, I_{VLED}=0.96A

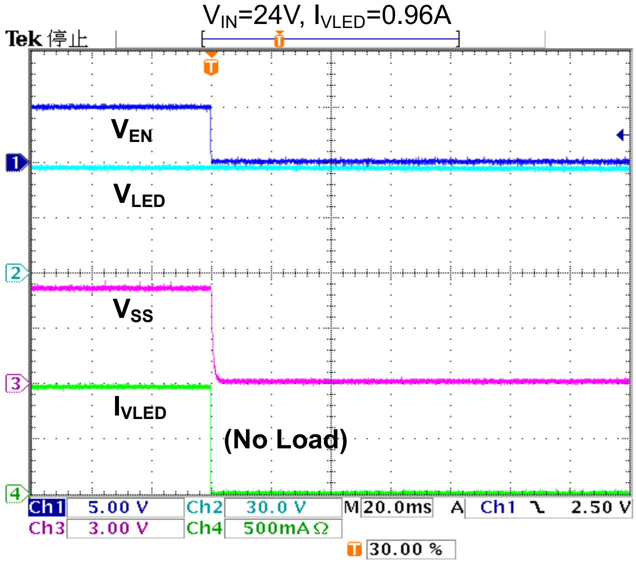


Fig.7 EN disable, V_{IN}=24V, I_{VLED}=0.96A

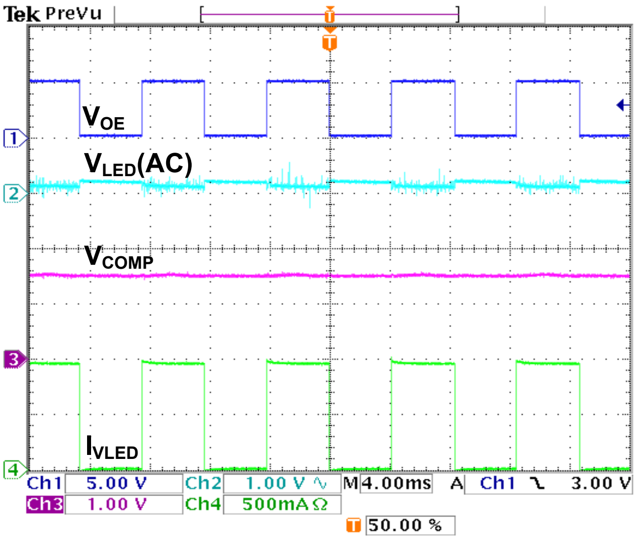


Fig. 8 PWM dimming Freq=120hz, Duty=50%, V_{IN}=24V, I_{VLED}=0.96A

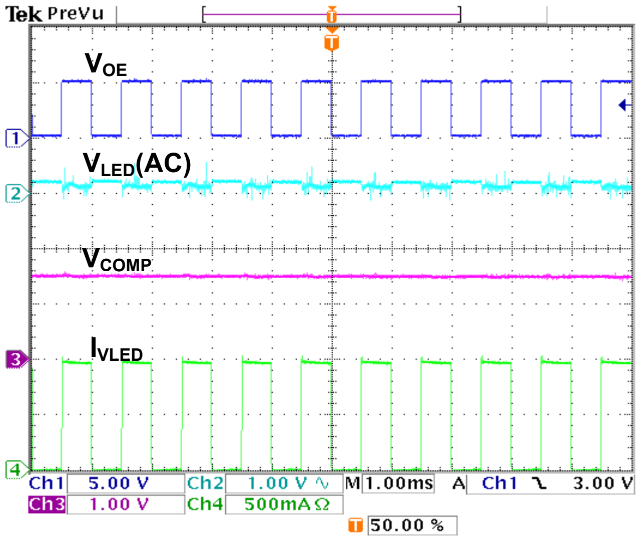


Fig. 9 PWM dimming Freq=1Khz, Duty=50%, V_{IN}=24V, I_{VLED}=0.96A

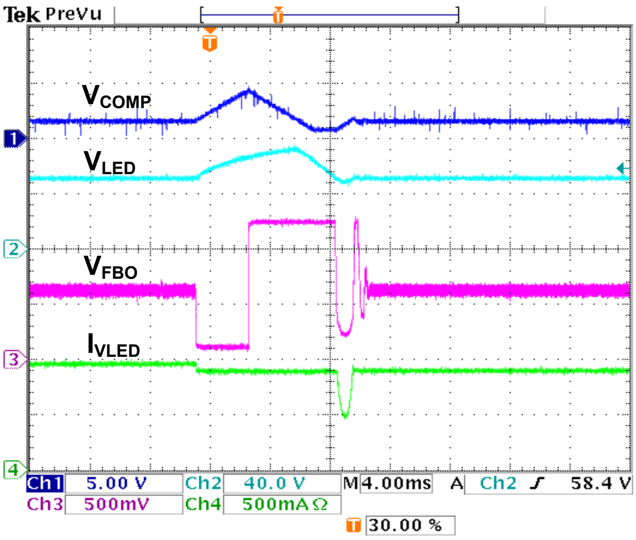


Fig. 10 Over-voltage happened due to LED open string, V_{IN}=24V, I_{LED}=0.96A

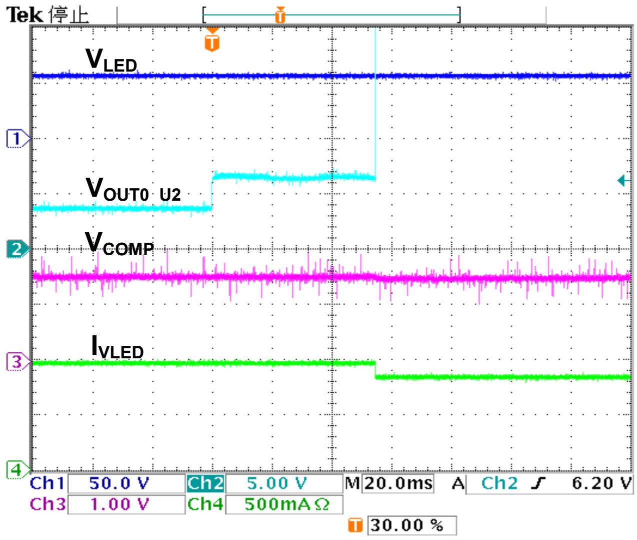


Fig. 11 LED short protection, V_{IN}=24V, I_{VLED}=0.96A

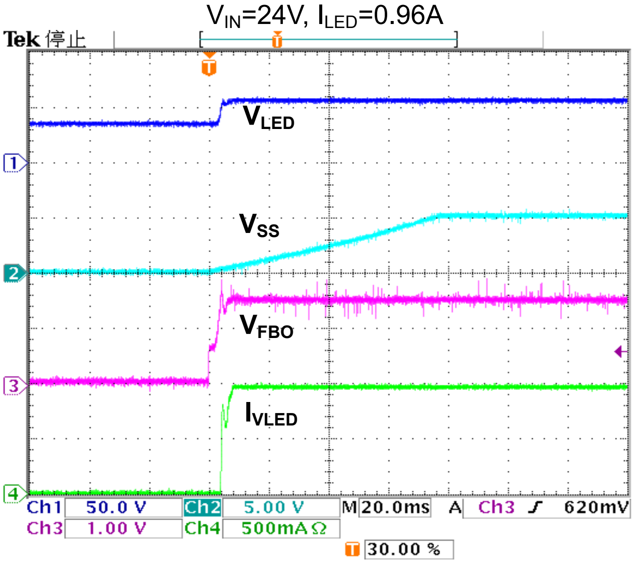


Fig. 12 Thermal shutdown released, V_{IN}=24V, I_{VLED}=0.96A

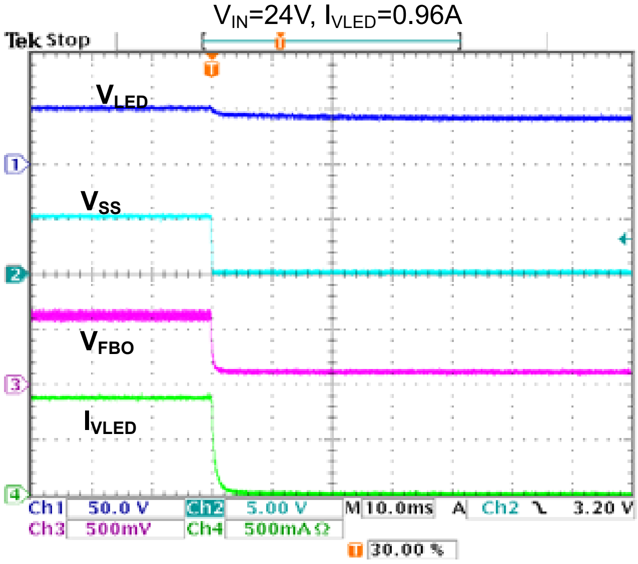


Fig. 13 Thermal shutdown V_{IN}=24V, I_{VLED}=0.96A

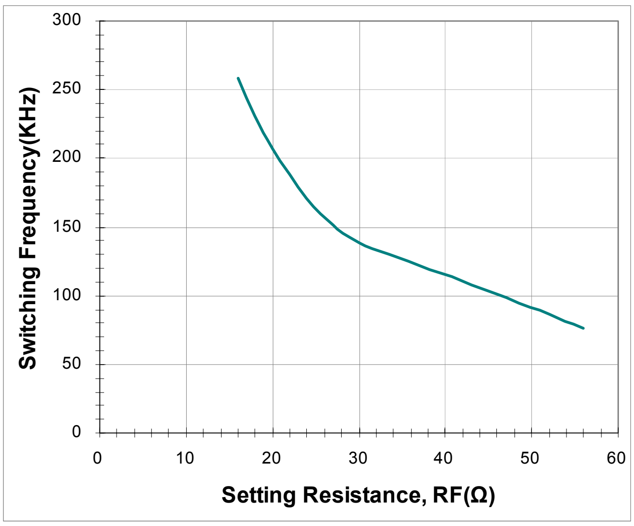


Fig. 14 R-FREQ and switching freq. relationship

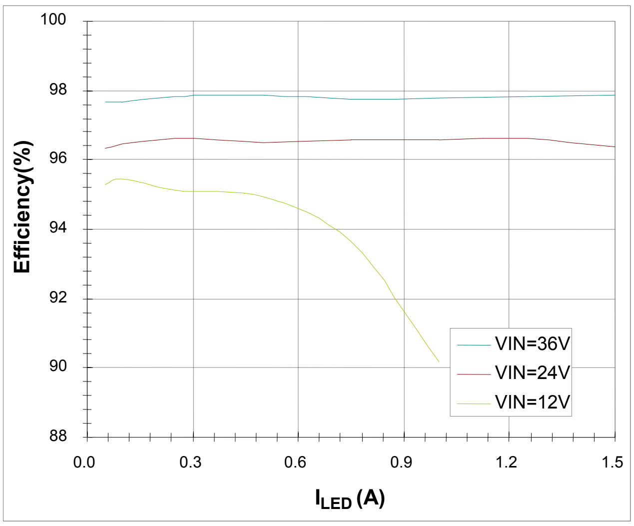


Fig. 15 Efficiency versus I_{LED}, switching frequency is 75KHz

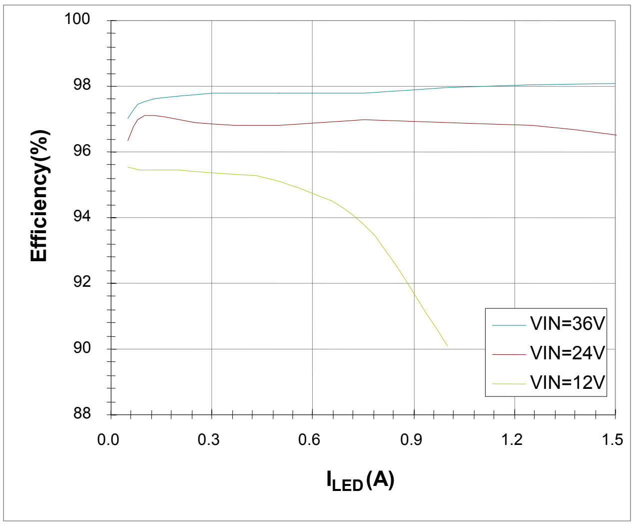


Fig. 16 Efficiency versus I_{LED}, switching frequency is 100KHz

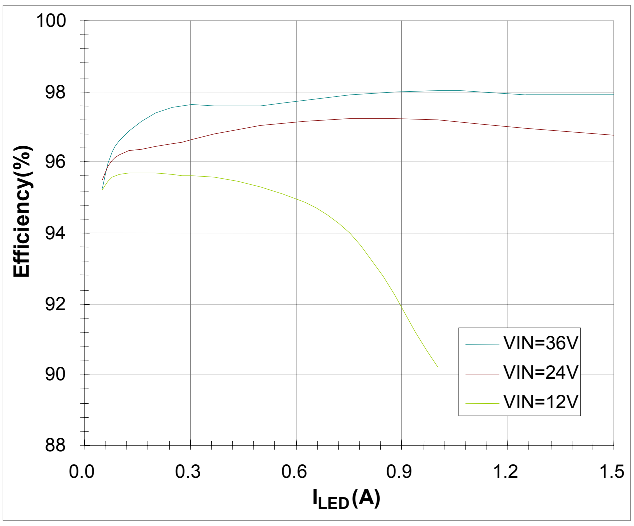


Fig. 17 Efficiency versus I_{LED}, switching frequency is 150KHz

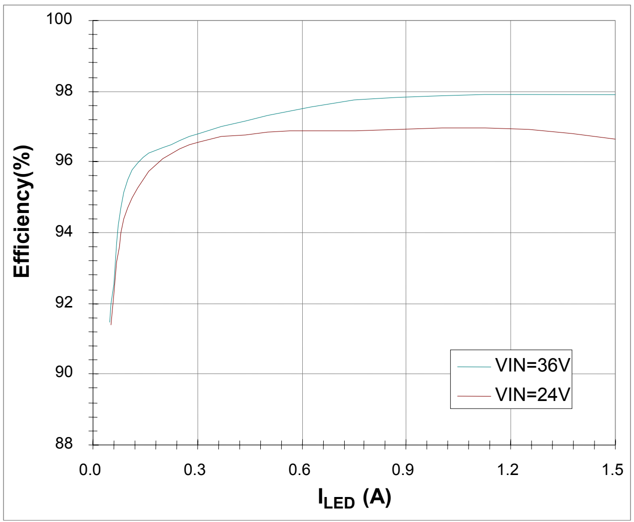


Fig. 18 Efficiency versus I_{LED}, switching frequency is 250KHz

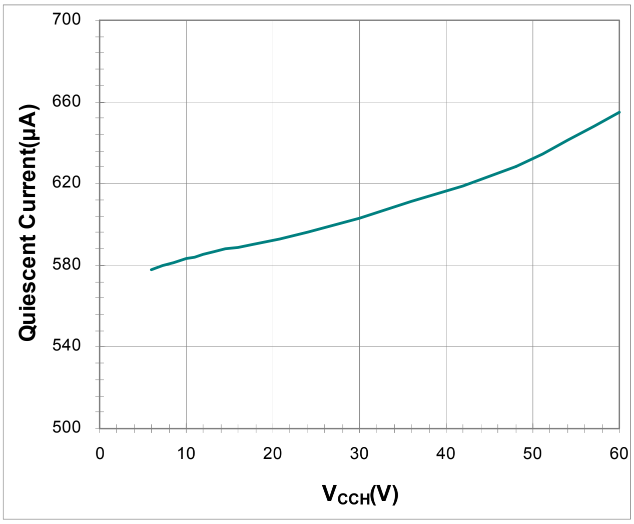


Fig. 19 Quiescent current in normal operation

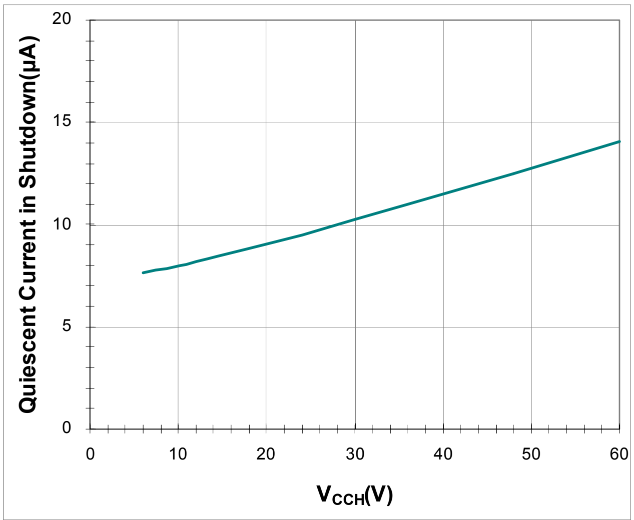


Fig. 20 Quiescent current in shutdown mode

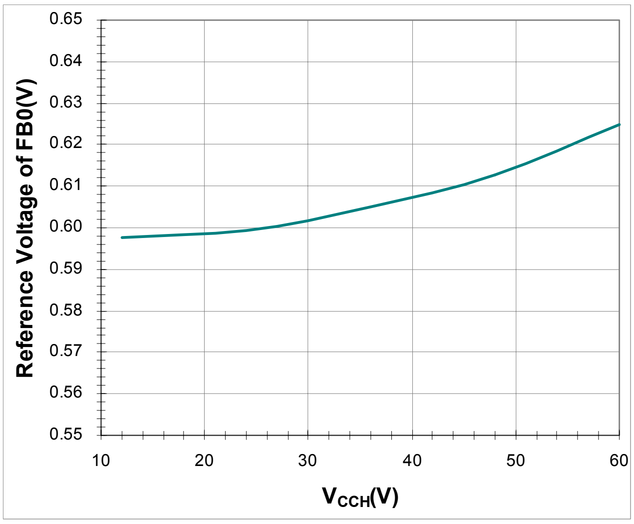


Fig. 21 Internal reference voltage of FB0 versus V_{CCH}

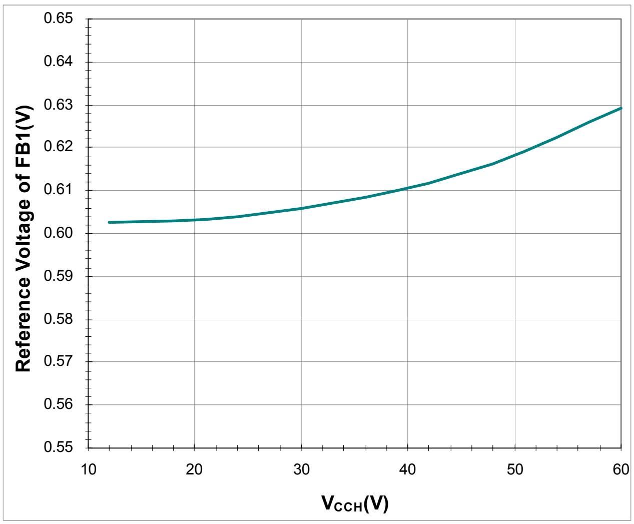


Fig. 22 Internal reference voltage of FB1 versus V_{CCH}

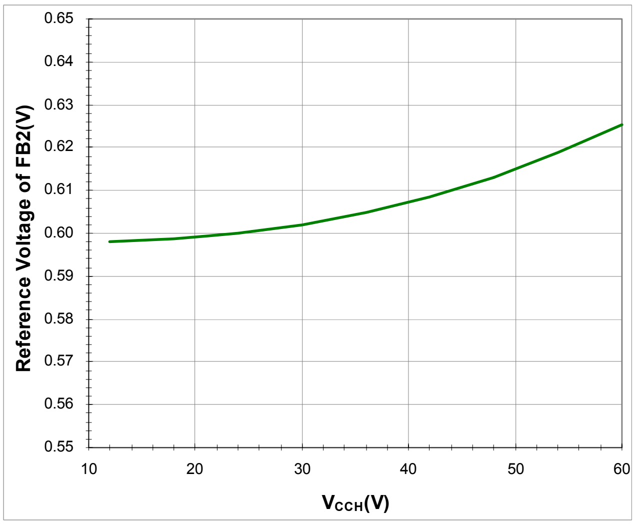


Fig. 23 Internal reference voltage of FB2 versus V_{CCH}

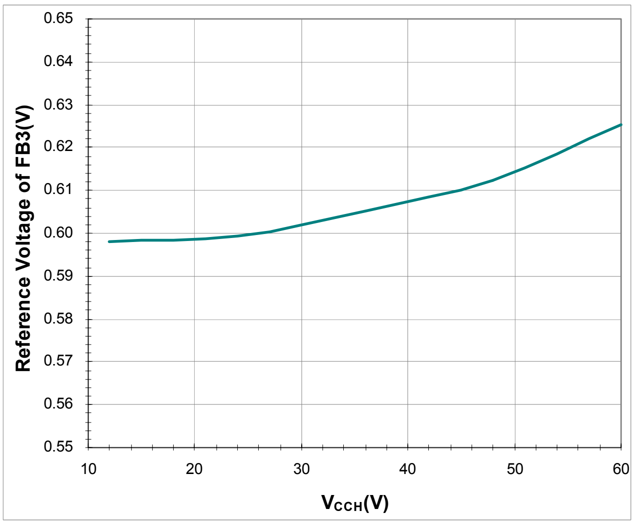


Fig. 24 Internal reference voltage of FB3 versus V_{CCH}

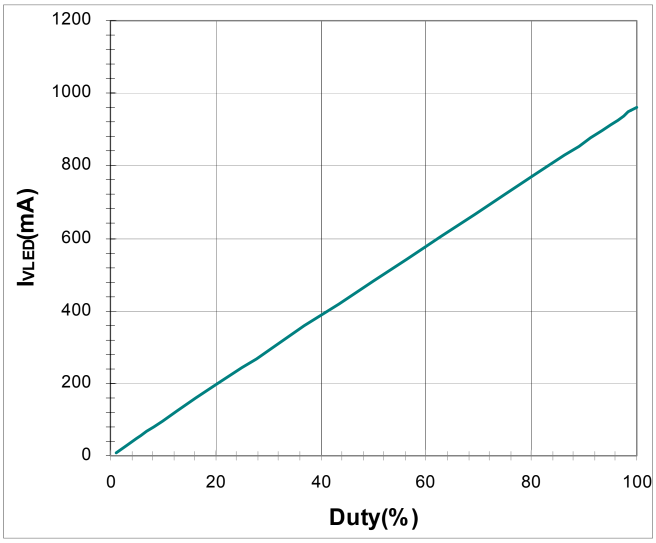


Fig. 25 Dimming linearity by using 120Hz PWM signal

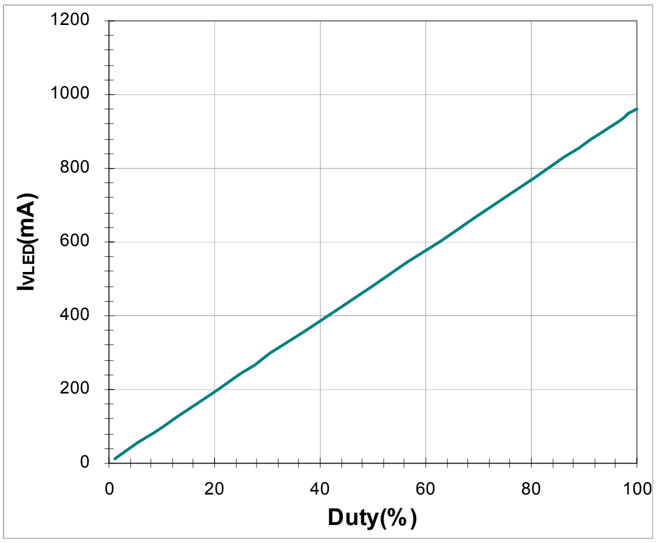


Fig. 26 Dimming linearity by using 1KHz PWM signal

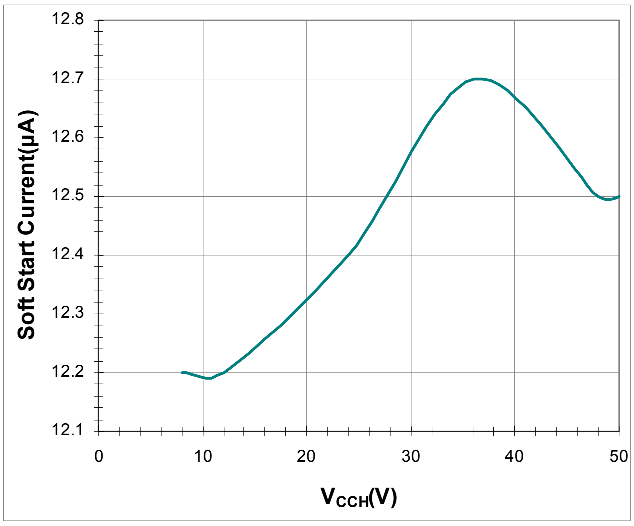


Fig. 27 Internal soft start current versus V_{CCH}

Application Information

MBI6703 is a current mode DC-DC boost controller that integrates PWM dimming control, protection functions and a minimum selector which is used to select the minimum one from the multiple feedback inputs. MBI6703 is designed with selectable switching frequency from 75KHz to 250KHz, which optimizes the component size and operating frequency. MBI6703 determines the switch on-time by controlling 2 loops. One loop is feeding back the error signal which is resulted from the difference of lowest active output voltage and internal level. The other loop is combining switch current slope compensation.

Frequency Selection

MBI6703 provides design flexibility in selecting internal oscillator frequency from 75KHz to 250KHz. Users are suggested to connect R-FREQ to GND through a resistor for setting the oscillator frequency of step-up converter. Higher frequency operation benefits the smaller component size but at the expense of efficiency due to increasing switching loss. Lower frequency operation offers better efficiency but requires larger components. The formula of setting the switching frequency is:

$$RF = \frac{42.8 \times 10^8}{F_S}.$$

For instance, F_S.=100Khz, RF=42.8KΩ.

Under Voltage Lock Out (UVLO)

MBI6703 is designed with UVLO protection. The controller is disabled until V_{CCH} exceeds the UVLO threshold of 8V. The hysteresis of UVLO is about 550mV.

Soft-Start Function

The soft-start function is implemented by charging an external capacitor CSS. Users can adjust the soft-start time by changing the capacitor. When V_{CCH} exceeds UVLO threshold, there will be the charging action. The output of GDOUT will be restricted by over current limitation until the terminal voltage of soft-start (Vss) exceeds 0.6V. Once Vss exceeds 0.6V, GDOUT will go back to normal and begin switching. This design can effectively limit in-rush current.

Dimming Control

MBI6703 accepts PWM dimming signal from OE pin to control the duty of constant current. The dimming frequency can be adjusted from 100Hz to 1KHz. The minimum ON pulse width is 10μs. To achieve 1% resolution, the dimming frequency should be lower than 1KHz.

Over Voltage Protection (OVP)

When OVP pin exceeds the threshold, 1.2V (Typ.), the output of GDOUT will turn off the external MOSFET to protect the step-up converter. When OVP is below 1.2V, the step-up converter switch will be enabled again. With this scheme, the anode voltage of LED strings (V_{LED}) can be maintained within the expected voltage. The voltage of OVP can be described as below:

$$V_{OVP} = 1.2 \times (1 + \frac{ROVP1}{ROVP2})$$

where ROVP1 and ROVP2 are the voltage dividers to feedback OVP voltage.
OVP integrates a 50mV hysteresis. If output voltage is higher than detecting level, 1.2V (typ.) to stop GDOUT output, GDOUT will start outputting till VSOVP is down to 1.15V (typ.)

Over Temperature Protection (OTP)

When the junction temperature exceeds the threshold, T_{SD} (155°C), OTP function turns off the output channels. As soon as the junction temperature is below 135°C, the output channels will be turned on again. The average output current is controlled by this function. As a result, the driver is protected from being overheated.

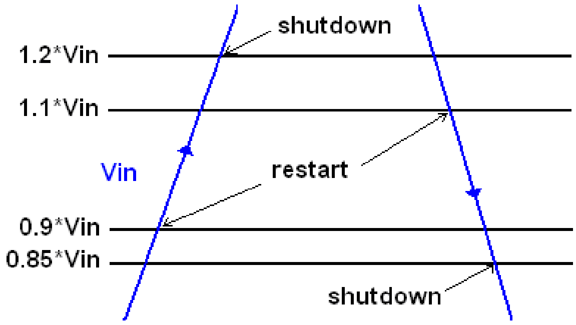
Minimum Selector Function

MBI6703 integrates 4 voltage feedback inputs and a minimum voltage selector to select the lowest feedback voltage. The chosen feedback voltage will be compared with the internal reference voltage, V_{FB}, 0.6V.

Input Voltage Protection (IVP)

In a fixed input voltage, V_{CCH}, application, MBI6703 provides a protection to monitor the variation of V_{CCH}. Connect V_{CCH} to the pin, VIN-DET, with a proper setting of voltage divider resistors to compare the internal reference voltage, 1.2V. If the input of VIN-DET is higher than 120% or lower than 85%, the gate drive output of MBI6703 will be paused. When the input of VIN_DET is under 110% or above 90%, MBI6703 will resume to work. If the MBI6703 works under a variable V_{CCH}, please connect VIN-DET to a fixed voltage input. The voltage of IVP can be described as below:

$$V_{IVP} = 1.2 \times (1 + \frac{RVIN1 + RVIN2}{RVIN3})$$

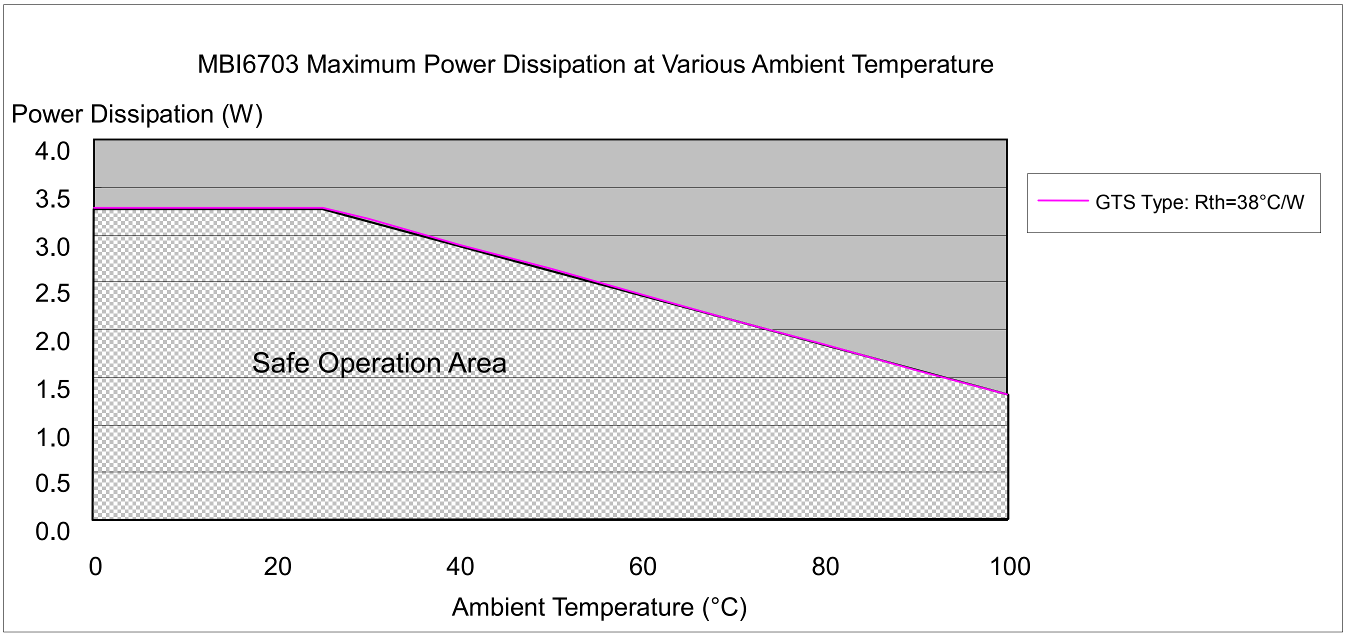


Over Current Protection (OCP)

The OCP is set by an external resistor, R_{SEN}. The OCP detection threshold is 200mV. If I_{SEN} x R_{SEN}>200mV, MBI6703 will trigger the OCP to turn off the GDOUT. The detection is active in every duty cycle. Then internal oscillator sends a synchronous signal to turn on GDOUT periodically. Actually, the average input current is dependent on the conversion ratio and inductance with OCP condition because the OCP is clamping the peak current not average current.

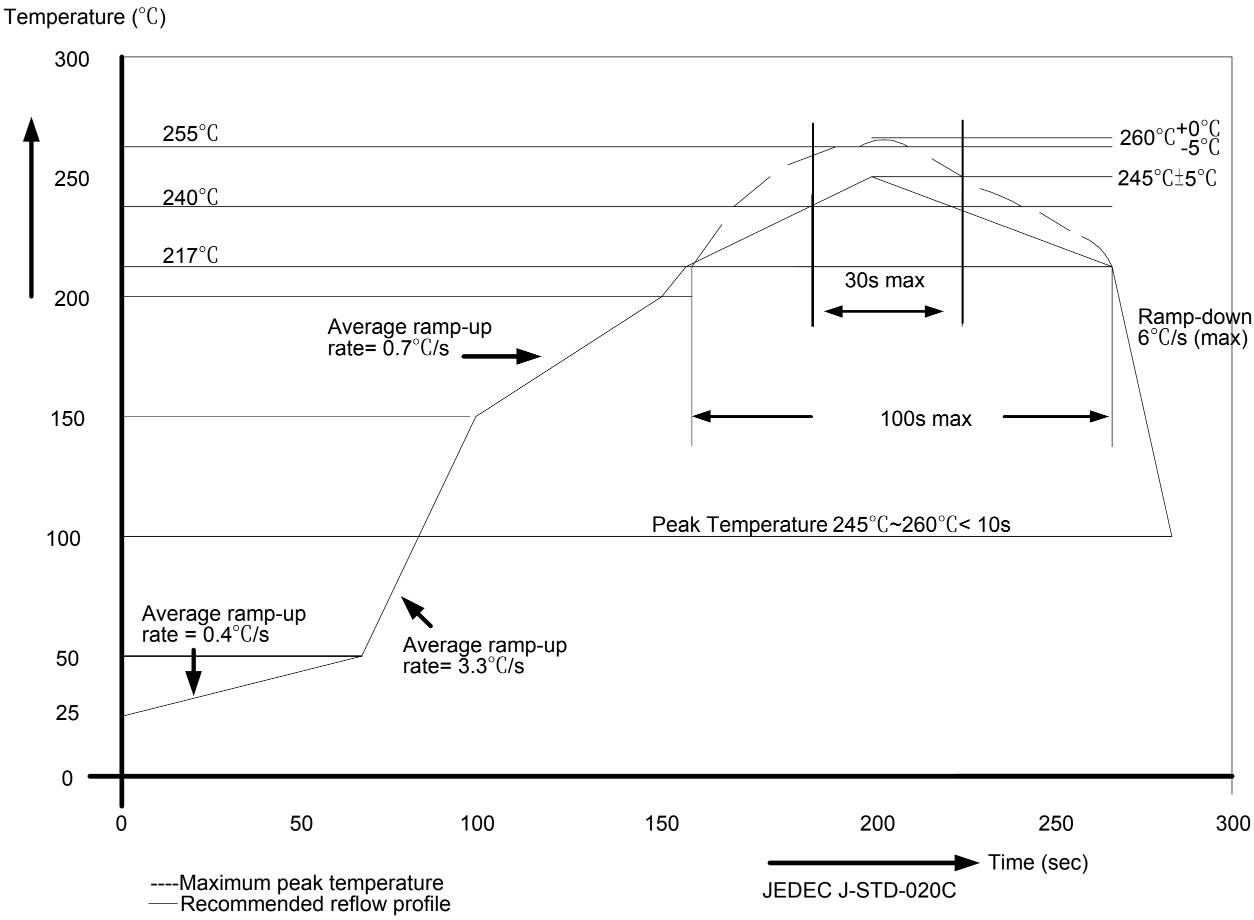
Package Power Dissipation (P_D)

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



Soldering Process of "Pb-free & Green" Package Plating*

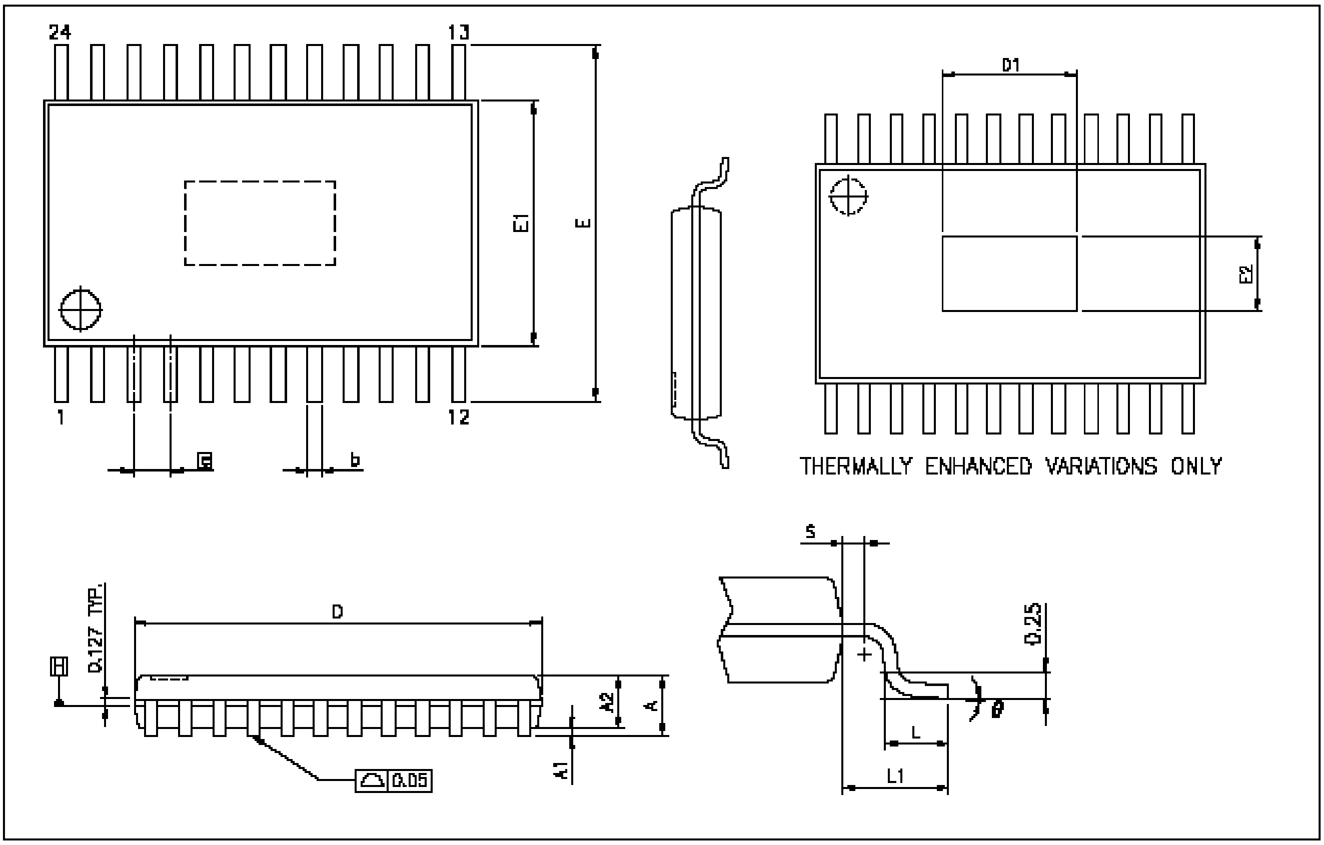
Macroblock has defined "Pb-Free" to mean semiconductor products that are compatible with the current RoHS requirements and selected 100% pure tin (Sn) to provide forward and backward compatibility with both the current industry-standard SnPb-based soldering processes and higher-temperature Pb-free processes. 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 ^{o}C to 260^{o}C for proper soldering on boards, referring to JEDEC J-STD-020C as shown below.



Package Thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 ≧2000
<1.6mm	260 +0 ^{o}C	260 +0 ^{o}C	260 +0 ^{o}C
1.6mm – 2.5mm	260 +0 ^{o}C	250 +0 ^{o}C	245 +0 ^{o}C
≧2.5mm	250 +0 ^{o}C	245 +0 ^{o}C	245 +0 ^{o}C

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

Package Outline



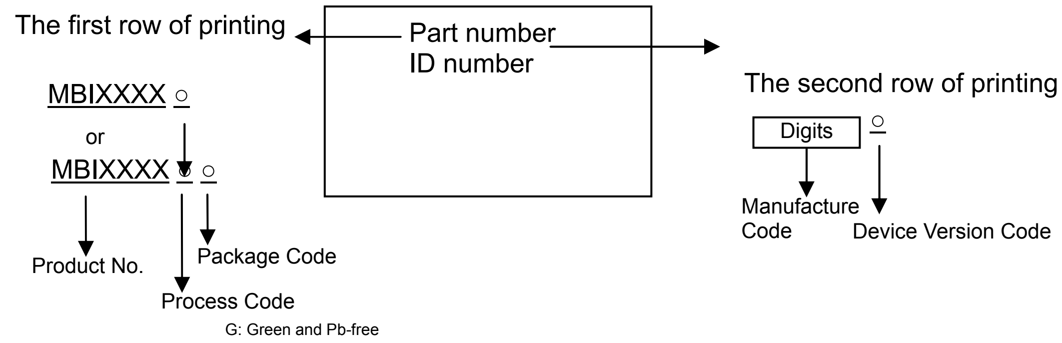
VARIATIONS (ALL DIMENSIONS SHOWN IN MM)

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	7.70	7.80	7.90
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°

MBI6703GTS 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 vias or circuit traces shall not pass through the maximum area of thermal pad.

Product Top Mark Information



Product Revision History

Advance Information	Device version code
V1.00	A

Product Ordering Information

Part Number	RoHS Compliant Package Type	Weight (g)
MBI6703 GTS	TSSOP24L-173-0.65	0.0967

Disclaimer