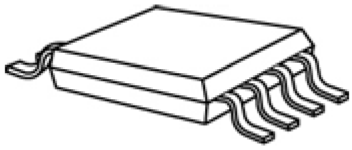
High Power Factor AC/DC LED Driver with Thermal Fold-back

Features

- Constant current LED driver
- Voltage step down converter
- Built-in active power factor correction
- Quasi-resonant switching
- Thermal Fold-back Function
- Full protection: Thermal shutdown
  V_{DD} over voltage protection
  Under voltage lock-out (UVLO)
  LED short- circuit
- Available in MSOP8 package
- Package MSL Level : 3

Mini Small Outline Package



GMS: MSOP-8L-118mil

Product Description

MBI6911 is a 85~135V input AC-DC converter designed to deliver constant current with thermal fold-back Feature. The built-in active power factor correction circuit maintains high power factor over a wide input voltage range. MBI6911 is optimized for interior power applications, and the efficiency is enhanced with quasi-resonant switching technique. MBI6911 is also featured with under voltage lock-out (UVLO), over temperature protection (OTP), over-voltage protection and LED short-circuit protection to protect the converter from being damaged accidentally. A thermal resistor can be used with an external voltage divider circuit to adjust the output current level automatically. If this feature is used to monitor an output current related heat source, a temperature balance condition should be expected.

Applications

- T8 light tube LED alternative solutions
- E26/E27 light bulb LED alternative solutions
- GU10 light LED alternative solutions
- Other Interior LED power module applications

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Typical Application Circuit

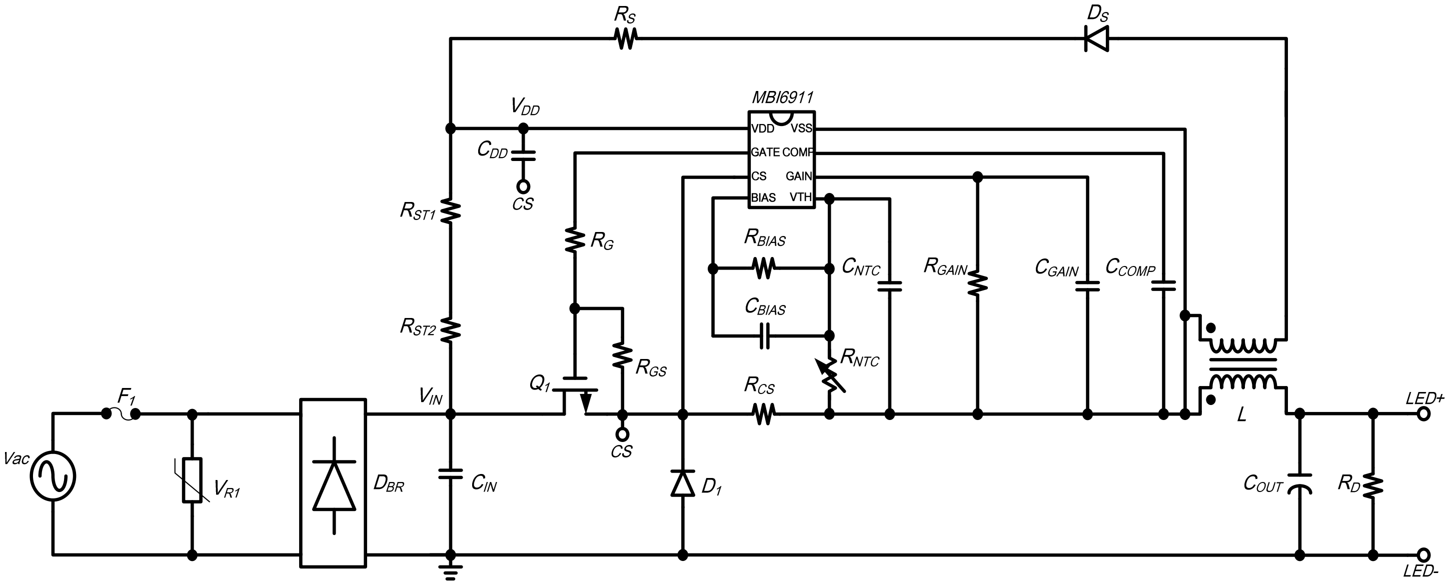


Fig.1 Typical application circuit of MBI6911

Functional Diagram

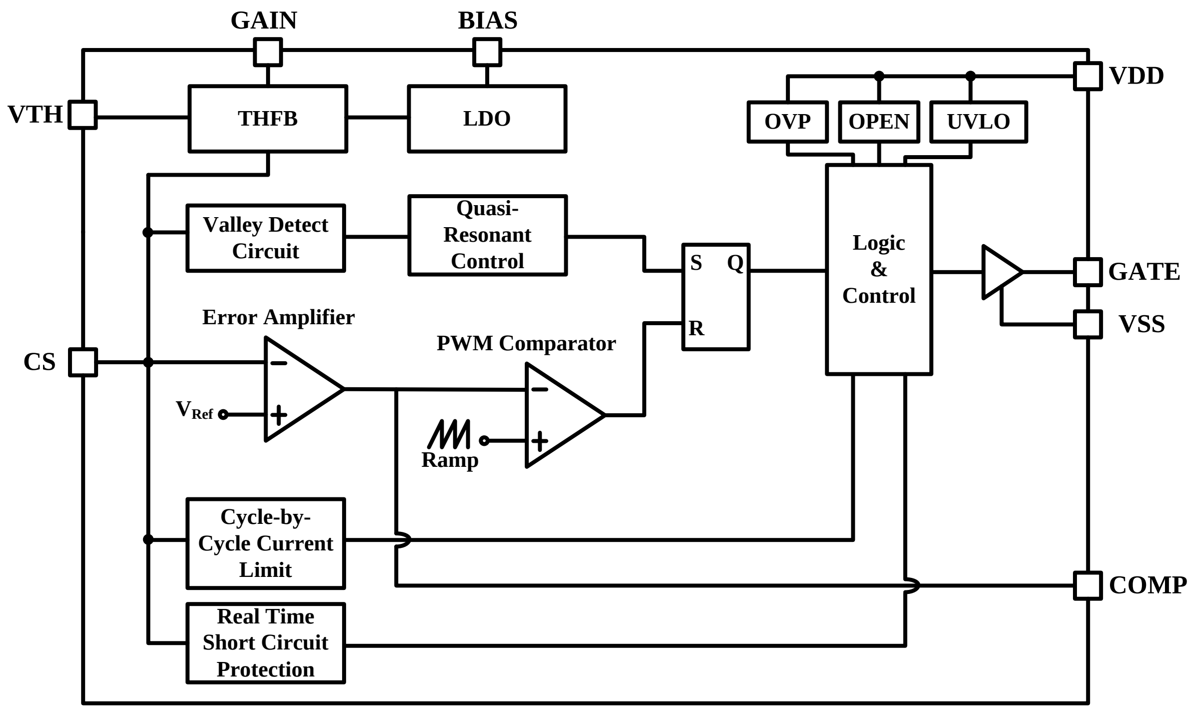


Fig.2 Functional diagram of MBI6911

Pin Configuration

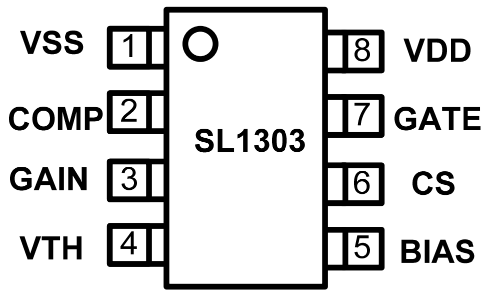


Fig. 3 Pin configuration of MBI6911

Pin Description

No.	Name	Description
1	VSS	Floating ground (IC reference)
2	COMP	Terminal to connect a compensator (EA's output)
3	CS	Sense inductor current and output current.
4	GAIN	Set current decaying slope of thermal fold-back
5	VTH	Set operating point of thermal fold-back
6	BIAS	Voltage reference of thermal fold-back
7	GATE	Drive the gate of the external MOSFET
8	VDD	Supply voltage (With OVP=40V)

Absolute Maximum Ratings

NOTE: Operations above the maximum ratings may cause device failure or reduce device reliability.

Characteristics	Symbol	Min	Max	Unit
Supply voltage	V_{DD}	-0.3	44	V
Output Voltage for COMP pin	V_{COMP}	-0.3	7	V
Output voltage for GATE pin	V_{GATE}	-0.3	16	V
Output voltage for BIAS reference pin	V_{BIAS}	-0.3	7	V
Input voltage for CS pin	V_{CS}	-0.3	7	V
Input voltage for GAIN pin.	V_{GAIN}	-0.3	7	V
Input voltage for VTH pin.	V_{TH}	-0.3	7	V
Storage temperature	T_{STG}	-55	150	°C
Operating ambient temperature	T_{OPA}	-40	85	°C
Junction temperature	T_{JC}	-40	125	°C
Power Dissipation	P_{DISSIP}	-	3.3	W
Thermal resistance	T_{HR}	-	40	°C /W

Electrical Characteristics

Test condition: V_{DD}=24V, C_{IN}=10μF, and T_A=25°C unless otherwise specified.

Characteristics	Symbol	Conditions	Min	Typ	Max	Unit
Supply voltage						
Input Voltage	V_{DD}		18		37	V
Mean output current accuracy		Rcs Variation±1%	-	±1	-	%
Line regulation		Vin=85~135Vac, fs=70kHz		-	±1	%
Load regulation		ΔVo=±15% Vo		-	±1	%
Supply voltage						
Continuous operating voltage-AUX VDD	V_{DD-AUX}	Recommended operating voltage, not a testable spec.	-	30	-	V
Turn-on threshold Voltage	V_{DD-ON}	@ Start-up	14.4	16	17.6	V
Turn-off threshold Voltage	V_{DD-OFF}	@ UVLO	6.3	7	7.7	V
V_{DD} over voltage protection	V_{DD-OVP}		37	30	43	V
UVLO Hysteresis	V_{DD-HYS}		8.1	9	9.9	V
Operating current	I_{DD-OP}	V_{DD}=24V, C_L=1nF, No switching (Protection with dummy load)	1.5		2.3	mA
		V_{DD}=24V, C_L=1nF, fsw=30KHz	0.6	-	1.6	mA
Starting current	I_{DD-ST}	@ before start-up	-	20	40	uA
Error amplifier						
COMP upper clamp voltage	V_{COMPH}		2.9	3.2	3.5	V
Current sense reference voltage	V_{REF}		0.19	0.2	0.21	V
Gate driver						
Output high voltage	V_{OH}	V_{DD}=30V	10.8	12	13.2	V
Output low voltage	V_{OL}	V_{DD}=30V	-	-	0.5	V
Rising time	T_R	V_{DD}=30V, C_L=1nF 20%~80%	-	-	100	ns
Falling time	T_F	V_{DD}=30V, C_L=1nF 80%~20%	-	-	100	ns
Maximum frequency	f_{MAX}		170	200	230	kHz
Maximum on time	t_{ON-MAX}		21.6	24	26.4	us
Minimum on time	t_{ON-MIN}		180	200	220	ns
Maximum off time	$t_{OFF-MAX}$		29.97	33.3	36.63	us
Thermal foldback						
BIAS voltage	BIAS		0.95	1	1.05	V
BIAS maximum output current	I_{BIAS_MAX}				2	mA
Thermal foldback operation point	VTH		0.475	0.5	0.525	V
Thermal foldback trans-conductance	GM_{GAIN}		900	1100	1300	uA/V
Over-current protection(OCP)						
Current Limit threshold CS	V_{OC}		1.18	1.2	1.32	V
Short protection threshold CS	V_{SCP}		1.35	1.5	1.65	V
Startup						
Pre-charge COMP Level	V_{PRE}		0.9	1	1.1	V
Over-temperature protection(OTP)						
Thermal shutdown temperature	T_{SD}		140	155	170	°C

Application Information

MBI6911 is an 85~135V ac input constant current LED driver designed for high PF LED applications. In the application circuit, there are distinct grounds, namely VSS and GNDE. VSS is the reference ground for internal circuit while GNDE is the earth ground. Users should be aware that VSS and GND **CAN NOT** be directly connected together to avoid IC damage and system malfunction.

Operation Principle

Buck Converter

The typical application circuit of MBI6911 is shown as Fig.4. In the initial state, the V_{DD} is supplied from V_{IN} through R_{ST1} and R_{ST2}, and then turns on Q_1. In this duration, the energy of V_{IN} stores in inductor and also supplies the output loading. When Q_1 turns off, Q_1 will be turned off, and the output loading is supplied by the energy stored in inductor.

Quasi-Resonant Switching

When power module works in DCM (Discontinuous Conduction Mode), the self-resonance occurs in the duration of MOSFET turns off. The self-resonance will induce the ringing waveform at the Drain terminal of MOSFET, which is the major ingredient of switching loss and EMI. To improve these problems, MBI6911 detects the valley voltage of main switch's V_{DS}. Moreover, Q_1 will be turned on when the MBI6911 detects the valley voltage of V_{DS} after 5us, the minimum switching period. The resonant frequency should be limited less than 500KHz. The illustration of QR is shown as Fig.4.

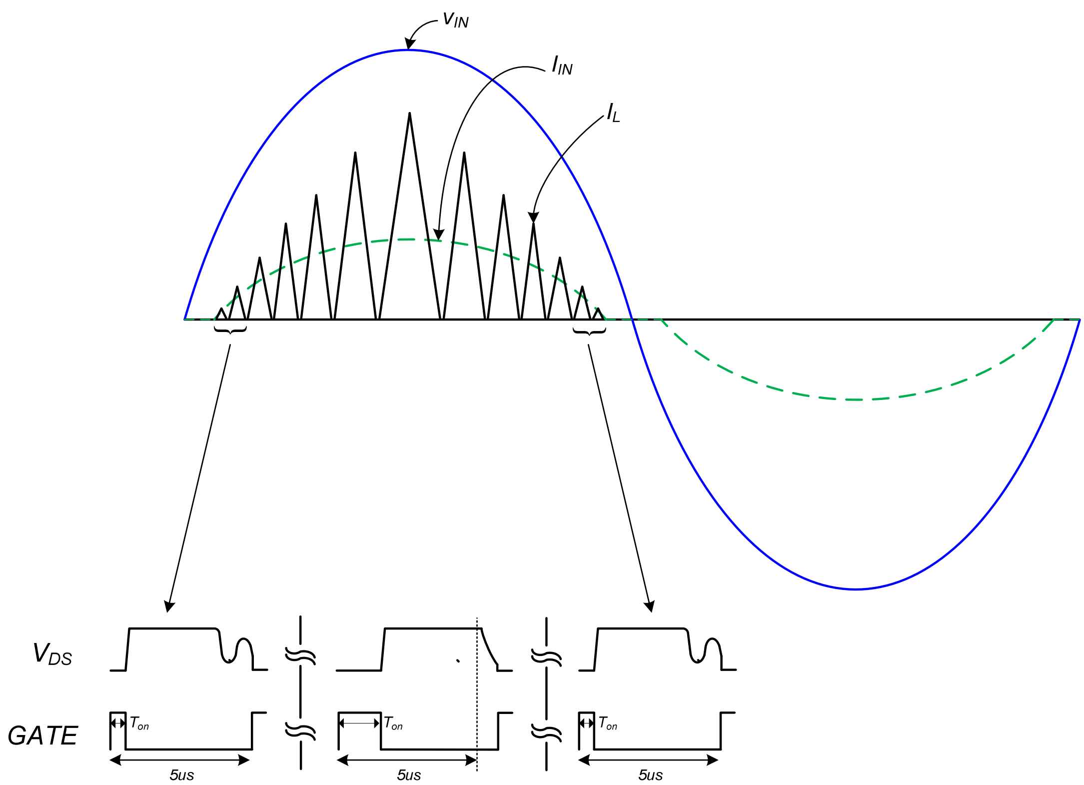
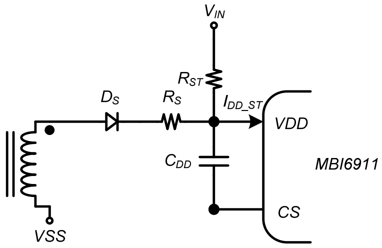


Fig.4 The illustration of Quasi-Resonant switching

Start-Up

In the initial state, the V_{DD} is supplied from the AC source through R_{ST}, once the V_{DD} reaches the start-up voltage, V_{DD_ON}, MBI6911 starts working and consumes the energy stored in C_{DD}. In the meantime, V_{COMP} is charged to 1V and enable the fast start-up function. The fast start-up function, whose duty cycle is 3 times of normal operation, and will be terminated until the V_{DD} reaches 17.3V.

In general the power module with active power factor correction needs large output capacitance to suppress the output ripple current. However, the larger output capacitance results the slower start-up time. To speed up the start-up time, the increasing C_{DD} and decreasing R_{ST} is another method.



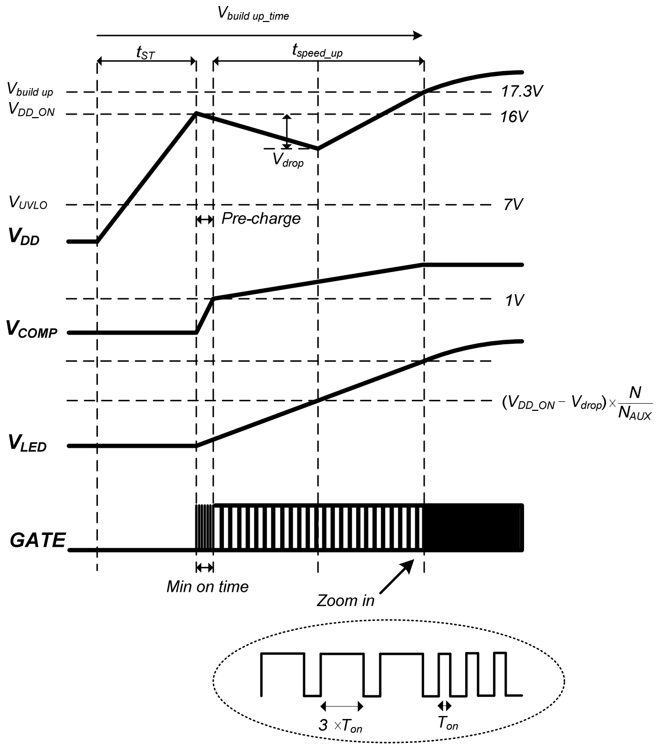


Fig.5 The illustration of fast start-up

Protection

V_{DD} Over Voltage Protection (OVP)

MBI6911 realizes input over voltage protection by sensing the input voltage at pin VDD. Once any abnormal spike occurs and exceeds the V_{DD} OVP threshold V_{DD_OVP}, numerically 40V, GATE signal ceases switching and V_{DD} drops accordingly. The converter is fully turned off when V_{DD} drop below V_{UVLO}.

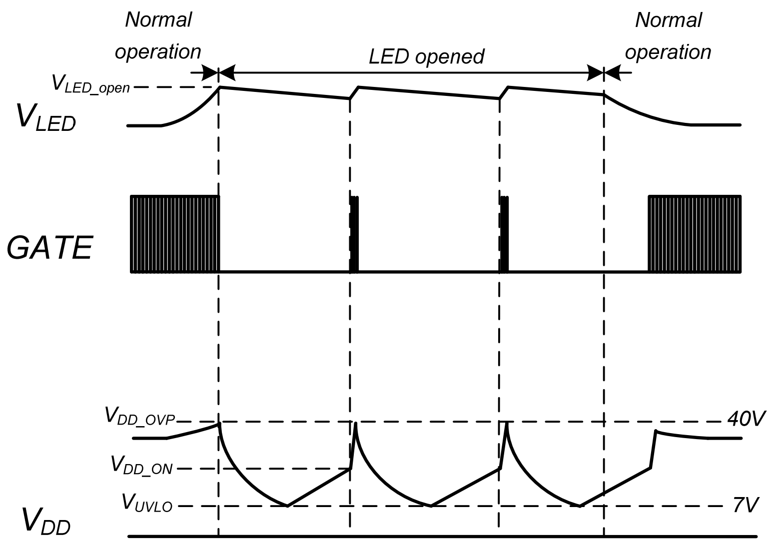


Fig.6 The illustration of V_{DD} over voltage protection

Under Voltage Lock-Out (UVLO)

When V_{IN} drops below 7V, the GATE output will be forced low to turn off the external power MOSFET. When V_{IN} rises above 16.0V, the GATE output resumes normal operation and the external power MOSFET starts switching.

Over Temperature Protection (OTP)

When the junction temperature exceeds 155°C, the built-in over-temperature protection (OTP) is activated to force off the MOSFET. Once the junction temperature drops below 125°C, OTP is deactivated and MBI6911 resumes normal operation.

LED Short-Circuit Protection

When the output terminals of LED string are short, the output voltage will be clamped to zero, and the abnormal current of inductor is detected by CS pin. Once the CS voltage achieves the short- circuit protection threshold level (1.5V), MBI6911 will be shutdown and V_{DD} restart again through start-up resistor. The system operates in hiccup mode until the fault condition is removed; the illustration of short- circuit protection is shown as Fig.7.

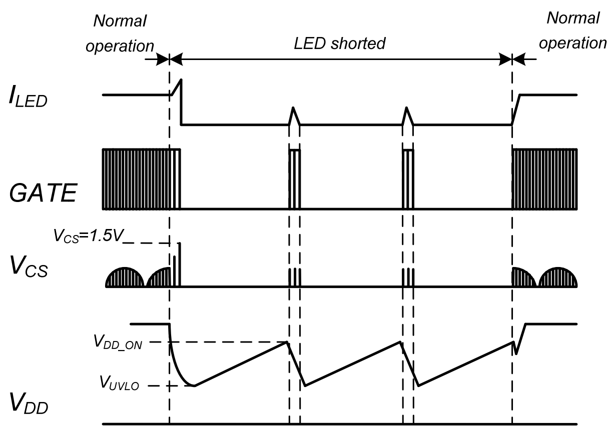


Fig. 7 LED short-circuit protection

Programmable Thermal Fold-back

MBI6911 provides a novel programmable thermal fold-back function to enhance the reliability of lighting system, and the schematic is shown as Fig.8. V_{BIAS} is the reference voltage of thermal fold-back; once the V_{VTH} descends to V_{BIAS} with the rising temperature (T_{FB}), the thermal fold-back will be enabled and descends the LED current (Fig.8). The descending slop of LED current is decided by the NTC and R_{GAIN}, the larger R_{GAIN} results the sharper slope, and vice versa.

When the LED current descends to 20% of normal's, the MBI6911 will into cut-off mode, and then the system will recover to normal operation when the temperature is lower than cut-off point ($T_{cut\text{-}off}$).

If the thermal fold-back is unnecessary, please connect the BIAS and VTH pins together and shorts the GAIN pin to VSS pin.

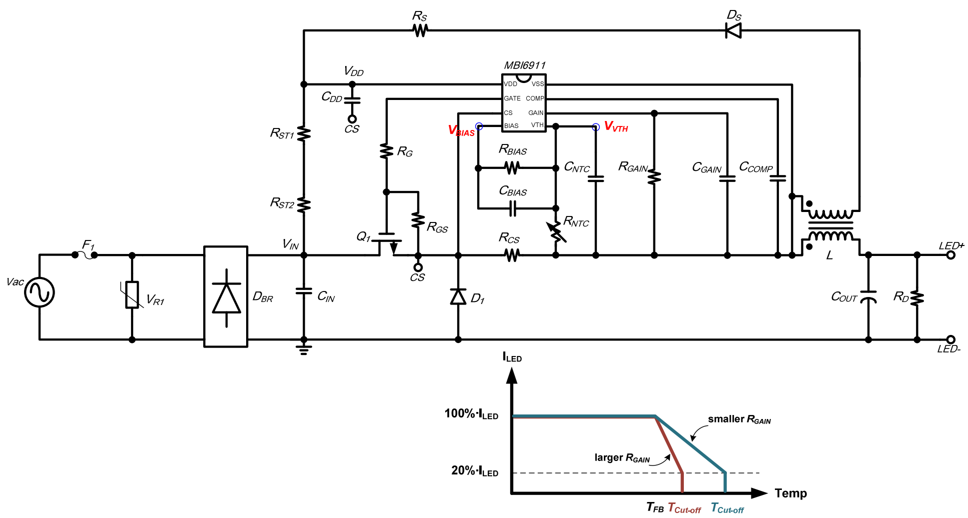
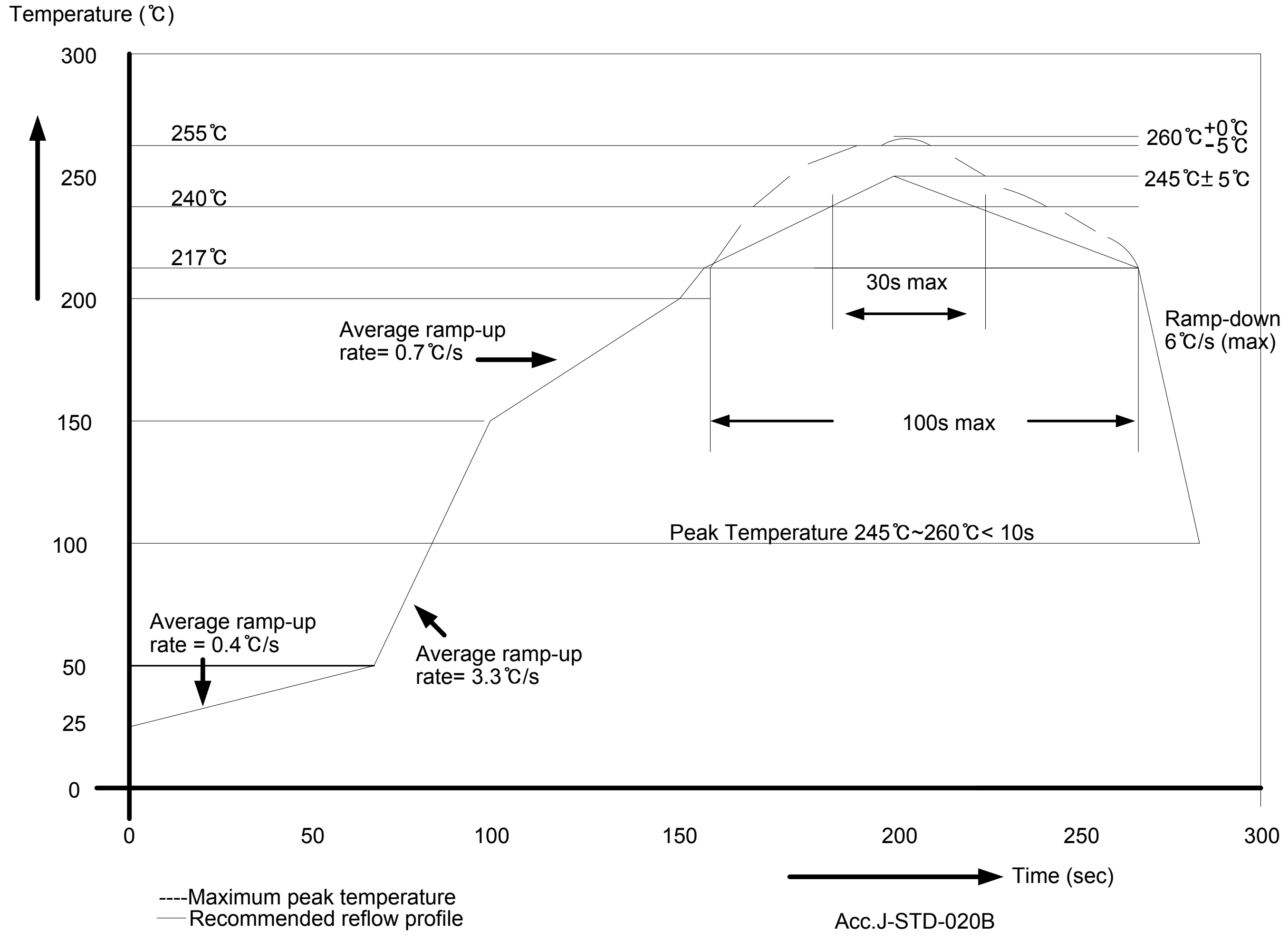


Fig.8 The operation principle of programmable thermal fold-back

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 adopts tin/lead (SnPb) solder paste, and please refer to the JEDEC J-STD-020C for the temperature of solder bath. However, in the whole Pb-free soldering processes and materials, 100% pure tin (Sn) will all require from 245 °C to 260°C for proper soldering on boards, referring to JEDEC J-STD-020C as shown below.
For managing MSL3 Package, it should refer to JEDEC J-STD-020C about floor life management & refer to JEDEC J-STD-033C about re-bake condition while IC's floor life exceeds MSL3 limitation.

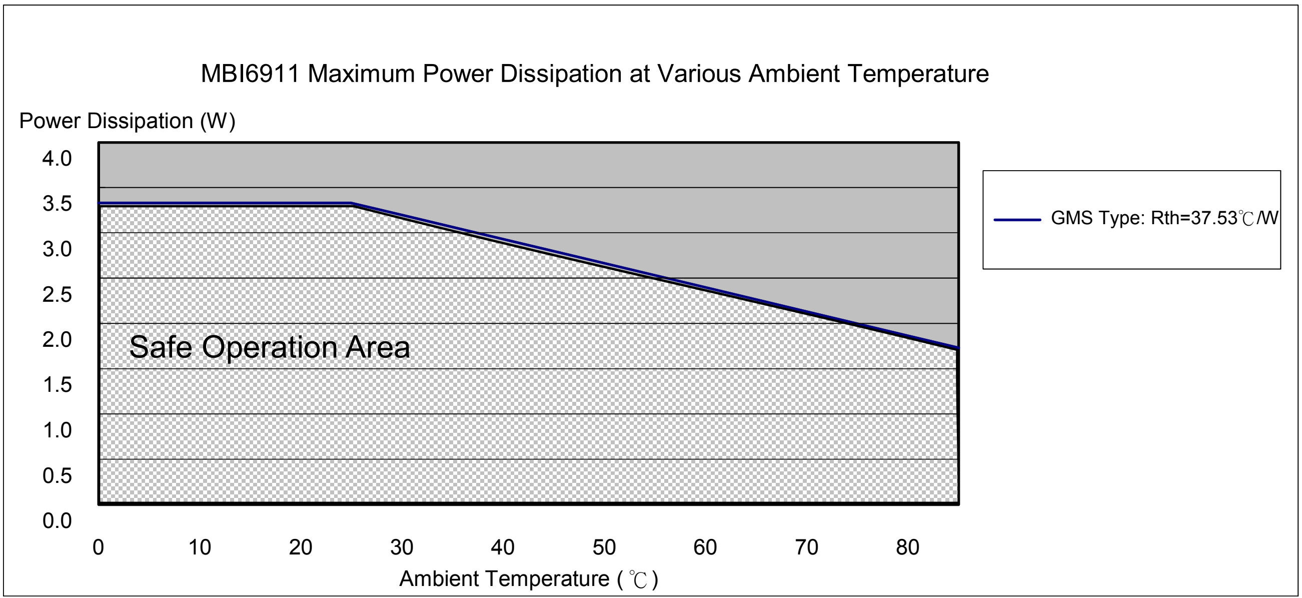


Package Thickness	Volume mm³ <350	Volume mm³ 350-2000	Volume mm³ ≧2000
<1.6mm	260 +0 °C	260 +0 °C	260 +0 °C
1.6mm – 2.5mm	260 +0 °C	250 +0 °C	245 +0 °C
≧2.5mm	250 +0 °C	245 +0 °C	245 +0 °C

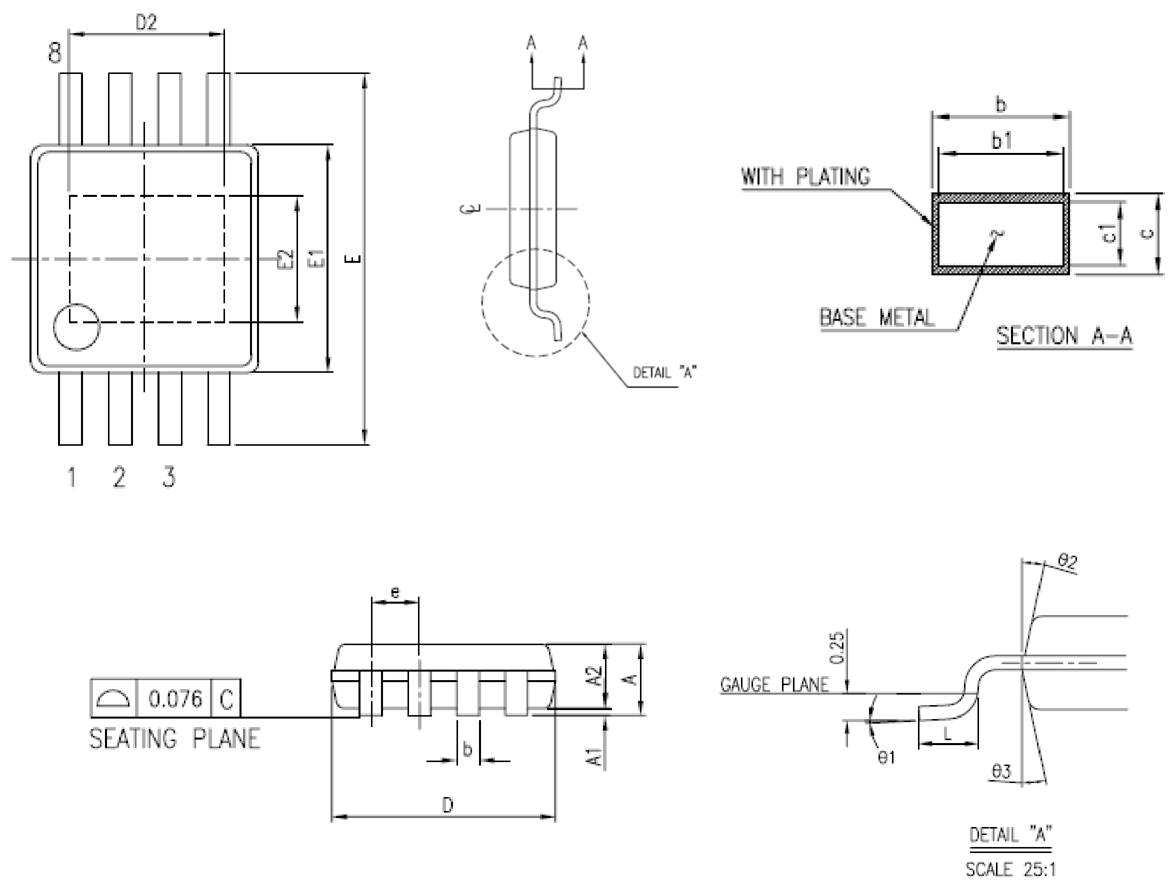
*Note: For details, please refer to Macroblock's "Policy on Pb-free & Green Package".

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



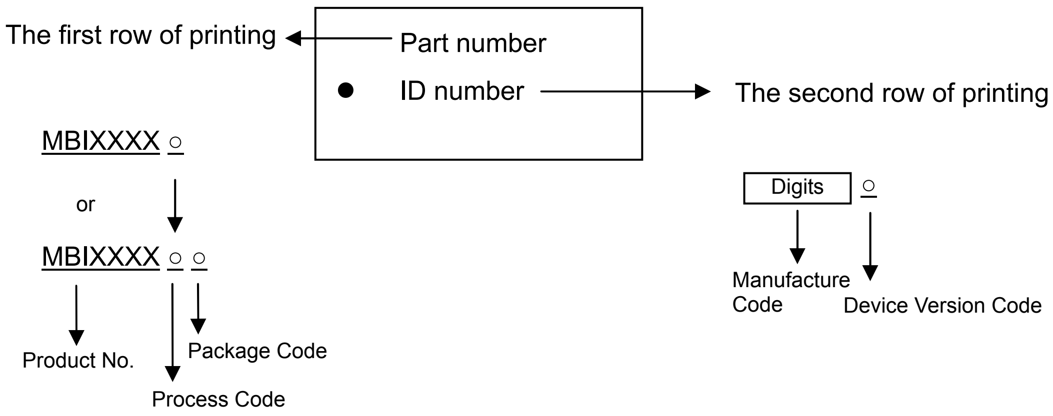
SYMBOL	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	---	---	1.10	---	---	0.043
A1	0.05	---	0.10	0.002	---	0.006
A2	0.81	0.86	0.91	0.032	0.034	0.036
c	0.13	---	0.23	0.005	---	0.009
c1	0.13	0.15	0.18	0.005	0.006	0.007
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.90 BSC			0.193 BSC		
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.
b	0.25	---	0.40
b1	0.25	0.30	0.35
D2	2.00	2.05	2.10
E2	1.60	1.65	1.70
e	0.65 BSC		
JEDEC	MO-187AA		

MBI6911 GMS Outline Drawing

Note: Please use the maximum dimensions for designing the thermal pad layout. To avoid the short- circuit risk, the vias or circuit traces shall not pass across 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	"Pb-free" Package Type	Weight (g)
MBI6911GMS-A	GMS: MSOP-8L-118mil	0.023 g

Disclaimer