Cost Effective PWM Forward Controller

General Description

EM8931 is a high performance, low startup current, low cost, current mode PWM controller. The EM8931 integrates functions of Soft Start(SS), Under Voltage Lockout(UVLO), Leading Edge Blanking(LEB), internal Over Temperature Protection(OTP), internal slope compensation. The EM8931 also features more protection like Over Load Protection(OLP) and Over Voltage Protection(OVP) to prevent circuit damage occurred under abnormal conditions.

The EM8931 provides the users a superior AC/DC power application of high efficiency, excellent EMI performance, low external component counts and lower cost solution.

Features

- Ultra Low Start Up Current (6uA)
- Current Mode Control
- Soft Start Function
- Built-in Slope Compensation
- Internal Leading-edge Blanking
- UVLO
- Over Voltage Protection (OVP) on VDD pin
- Over Load Protection (OLP)
- Cycle-by-cycle Current Limit
- Feedback Open Protection
- Internal Over Temperature Protection (OTP)
- Constant Output Power Limit (Full AC Input Range)
- Excellent EMI performance

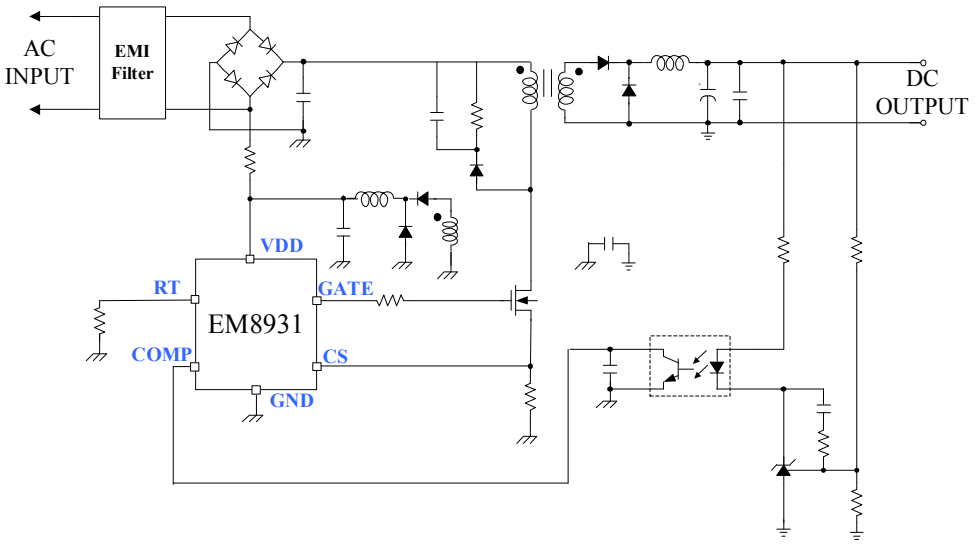
Ordering Information

Part Number	Package	Remark
EM8931J	SOT-23-6	
EM8931S	DIP-8	

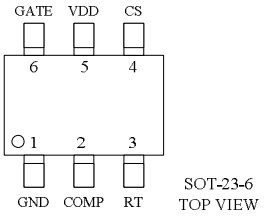
Applications

- Switching AC/DC Adaptor and charger
- Open-Frame SMPS

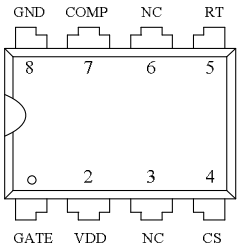
Typical Application Circuit



Pin Configuration



SOT-23-6
TOP VIEW

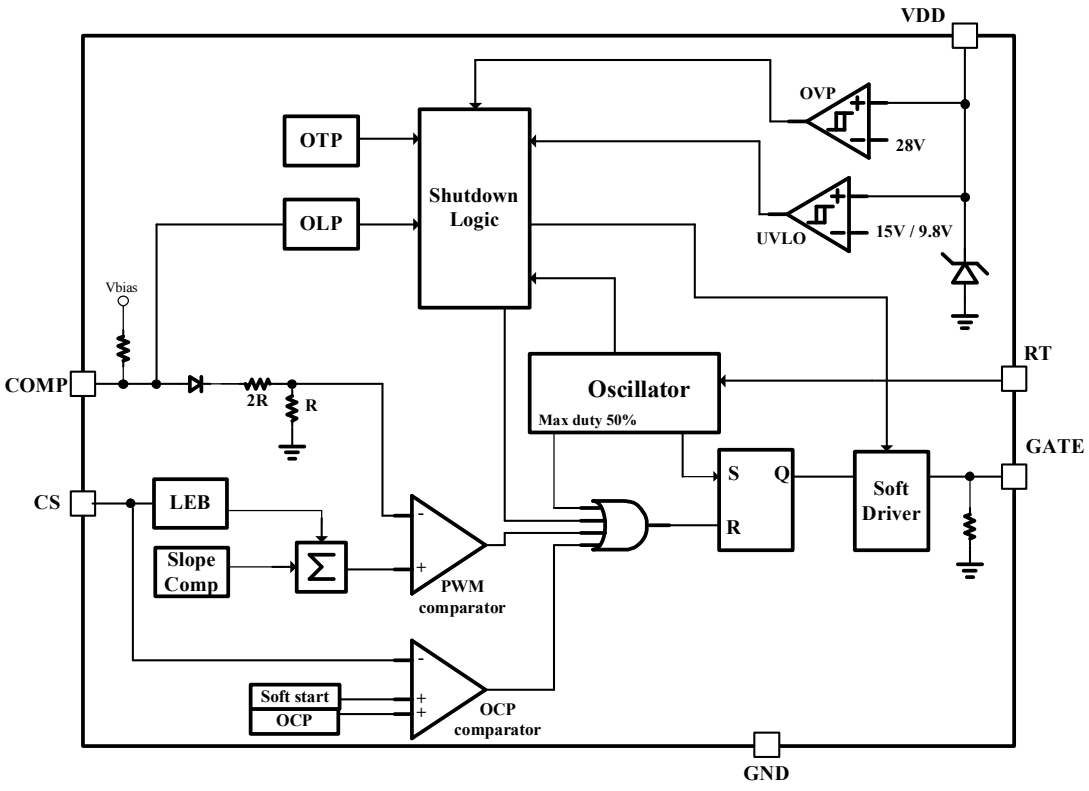


DIP-8
TOP VIEW

Pin Assignment

Pin Name	Pin Number		Pin Function
	SOT236	DIP8	
GND	1	8	Ground.
COMP	2	7	Voltage feedback pin, By connecting a photo-coupler to close the control loop and achieve the regulation.
RT	3	5	Set the switching frequency by connecting a resistor to GND.
CS	4	4	Senses the primary current.
VDD	5	2	IC Power Supply Pin.
GATE	6	1	Gate drive output to drive the external MOSFET.
NC	--	3 & 6	No Internal Connection.

Function Block Diagram



Absolute Maximum Ratings (Note1)

- Supply Input Voltage, VDD ---------- 30V
- Gate pin---------- 30V
- RT, COMP, CS Pin ---------- - 0.3V to 6.5V
- Power Dissipation, PD @ TA = 25℃
  SOT-23-6 ---------- 0.4W
  DIP-8 ---------- 0.714W
- Package Thermal Resistance (Note2)
  SOT-23-6, ---------- 250℃/W
  DIP-8, ---------- 140℃/W
- Junction Temperature ---------- 150℃
- Lead Temperature (Soldering, 10 sec.) ---------- 260℃
- Storage Temperature Range ---------- - 65℃ to 150℃
- ESD Susceptibility (Note3)
  HBM (Human Body Mode) ---------- 3KV
  MM (Machine Mode) ---------- 300V
- Gate Output Current---------- 300mA

Recommended Operating Conditions (Note4)

- Supply Input Voltage, VDD ---------- 11V to 26V
- Operating Frequency ---------- 50k to 130kHz
- Junction Temperature Range---------- -40℃ to 125℃
- Ambient Temperature Range---------- 0℃ to 85℃

Electrical Characteristics

(V_{DD}=15V, R_{RT}=100K ohm, T_A=25℃, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
VDD Section						
VDD OVP Protect voltage	V_{OVP}		26.5	28	29.6	V
Start up current	I_{START1}	VDD=7V	-	1	2	uA
	I_{START2}	VDD=15V	-	6	12	uA
VDD On Threshold Voltage	V_{TH-ON}		13.5	15	16.5	V
VDD Off Threshold Voltage	V_{TH-OFF}		8.8	9.8	10.8	V
Operating Supply Current 1	I_{DD-OP1}	VDD=15V, V_{COMP}=0V,	-	2	3	mA
Operating Supply Current 2	I_{DD-OP2}	VDD=15V, V_{COMP}=3V, C_{GATE}=1nF	-	2.5	-	mA
Operating Supply Current 3	I_{DD-OP3}	VDD=15V, Protection triggerred	-	0.4	-	mA

Gate Section						
Rising Time	T_R	C_L = 1nF	-	150	200	nS
Falling Time	T_F	C_L = 1nF	-	30	100	nS
Current-Sense Section						
Maximum Internal Current Setpoint	V_{CSLim}		0.8	0.85	0.9	V
Leading Edge Blanking Time	T_{LEB}		200	300	400	nS
Propagation Delay Time	T_{PD}			100		nS
Soft-Start Period	T_{SS}			2		mS
Internal Oscillator						
Oscillation Frequency	f_{OSC}	R_{RT}=100K ohm	67	72	77	KHz
Maximum Duty	D_{max}	V_{COMP}=3V, V_{CS}=0V	45	50	55	%
Frequency variation vs. VDD		VDD=11V to 25V			3	%
Frequency variation vs. Temperature		-20℃ to 105℃ (Note5)			3	%
COMP Section						
COMP short to GND current	I_{COMP}	V_{COMP}=0V		0.25	0.55	mA
Open loop COMP voltage	V_{COMP}	COMP pin open		5.2		V
Protection Section						
Open loop protection delay time	T_{delay}			56		mS
Open loop protection COMP Trip voltage	V_{OLP}			4.8		V
Internal Temperature Shutdown	T_{SD}			160		℃

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2. θ_{JA} is measured in the natural convection at T_A=25°C on a 4-layers high effective thermal conductivity test board with minimum copper area of JEDEC 51-7 thermal measurement standard. The case point of θ_{JC} is on the expose pad for PSOP-8 package.

Note 3. Devices are ESD sensitive. Handling precaution is recommended.

Note 4. The device is not guaranteed to function outside its operating conditions.

Note 5. Guaranteed by design.

Typical Operating Characteristics

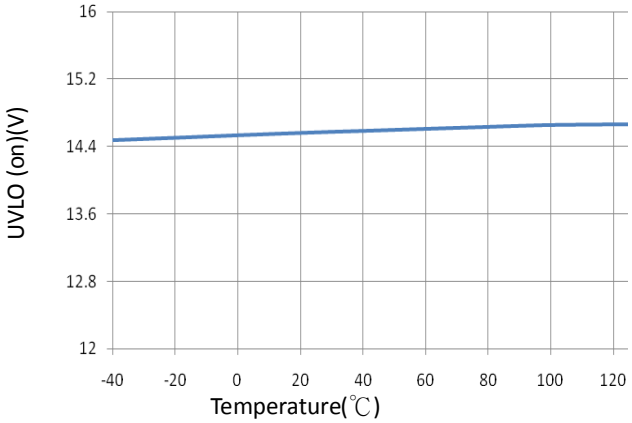


Fig1. UVLO (on) vs. Temperature

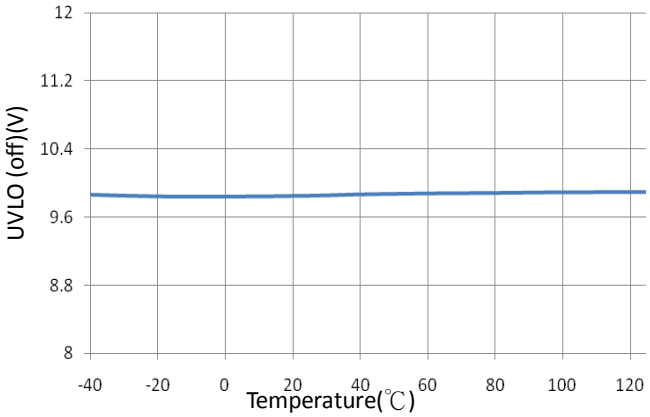


Fig2. UVLO (off) vs. Temperature

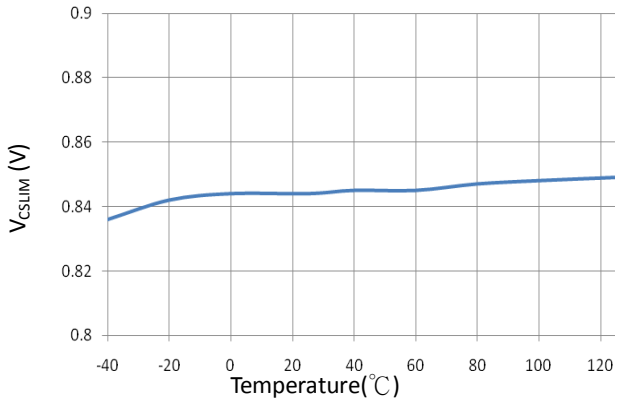


Fig3. V_{CSLIM} vs. Temperature.

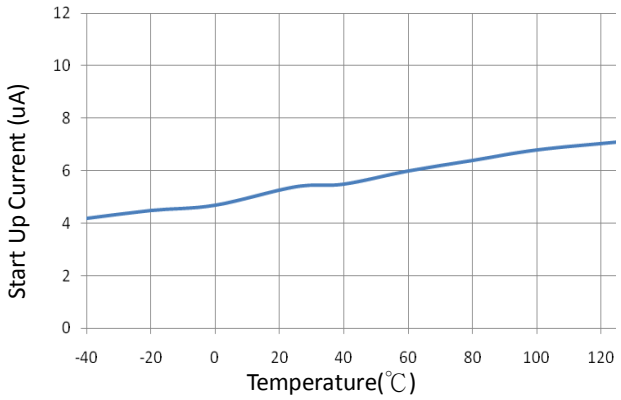


Fig4. Start Up Current vs. Temperature.

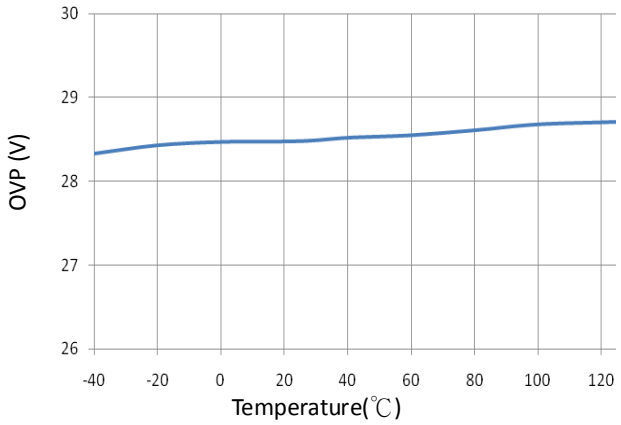


Fig5. OVP vs. Temperature.

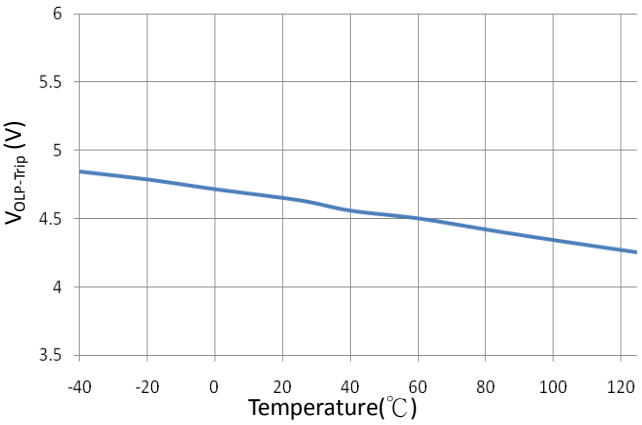


Fig6. $V_{OLP-Trip}$ vs. Temperature.

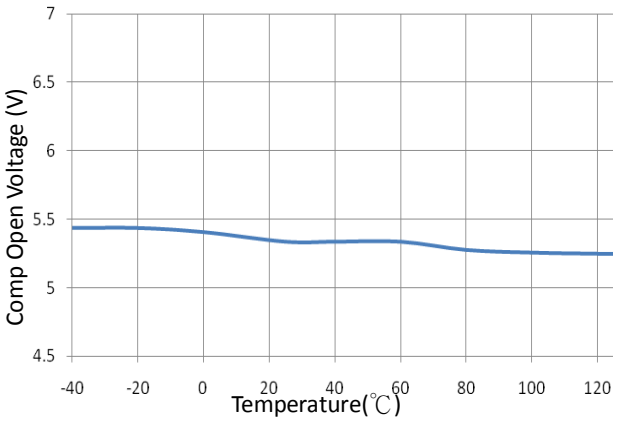


Fig7. Comp Open Voltage vs. Temperature.

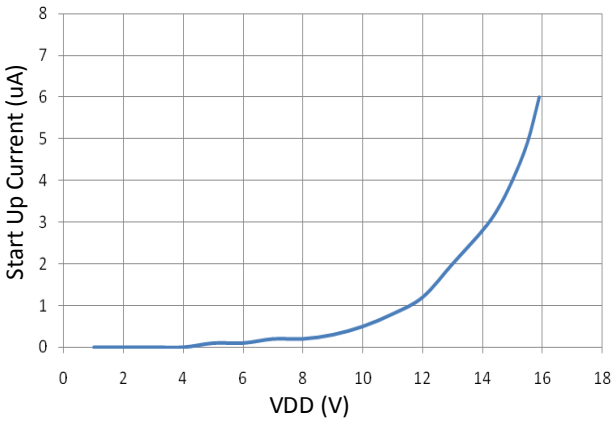


Fig8. Start Up Current vs. VDD

Functional Description

UVLO

An UVLO comparator is implemented in EM8931 to monitor the VDD pin voltage. As shown in Fig. 11, a hysteresis is built in to prevent the shutdown from the voltage drop during startup. The UVLO (on) and UVLO (off) are setting at 15V and 9.8V, respectively.

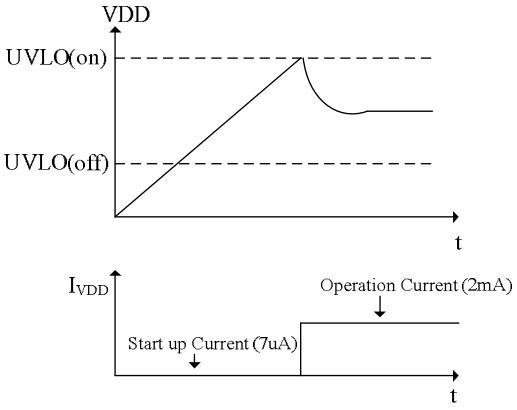


Fig. 11

Switching Frequency

To guarantee accurate frequency, EM8931 is trimmed to 5% tolerance. The internal oscillator also generates slope compensation, 50% maximum duty limit. Connect a resistor form RT pin to GND according to equation below to program the switching frequency:

f_{sw} (KHz)= 7200/RT(KΩ)

Leading Edge Blanking (LEB)

Each time the power MOSFET turn on, the MOSFET C_{OSS}, secondary rectifier reverse recovery current and gate driver sourcing current comprise the current spike. To avoid premature termination of the switching pulse, a leading edge blanking time is built in. During the blanking time (300nS), the PWM comparator is off and cannot switch off the gate driver. It is recommended to adopt a smaller R-C filter (as show ad Fig.13) for high power application to avoid the total spike width over 300nS leading edge blanking time.

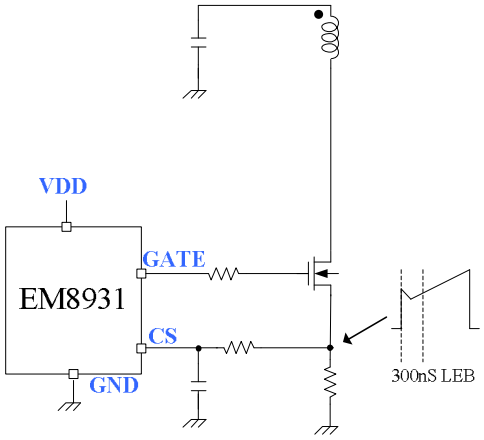


Fig. 13

Soft Start

The EM8931 has an internal soft-start circuit that increases cycle-by-cycle current limit comparator inverting input voltage slowly after it starts. The typical soft-start time is 2mS. The pulse width to the power MOSFET is progressively increased to establish the correct working conditions for transformers, rectifier diodes and capacitors. The voltage on the output capacitors is progressively increased with the intention of smoothly establishing the required output voltage. It also helps prevent transformer saturation and reduces the stress on the secondary diode during startup.

Protection

The EM8931 provides many protection functions that intend to protect system from being damaged. All the protection functions are listed as below:

- **Cycle-by-cycle current limit**
  The EM8931 has over-current protection thresholds (0.85V). It is for cycle-by-cycle current limit, which turns off MOSFET for the remainder of the switching cycle when the sensing voltage of MOSFET current reaches the threshold.

- **Over-load / Open-loop Protection (OLP)**
  When feedback loop is open, as shown in Fig. 14, no current flows through the opto-coupler transistor, the EM8931 pulls up the COMP pin

voltage to 5.2V.

When the COMP pin voltage is above 4.8V longer than 56mS, OLP is triggered. This protection is also triggered when the SMPS output drops below the normal value longer than 56mS due to the overload condition.

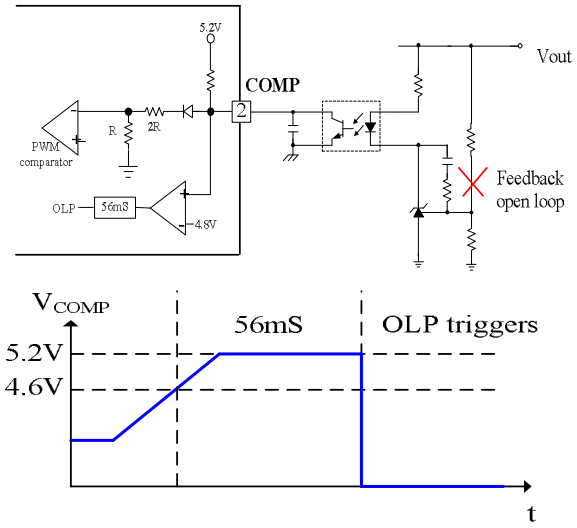


Fig. 14

- **Over Voltage Protection (OVP) on VDD**

  The V_{GS} ratings of the HV power MOSFETs are often limited up to max 30V. To prevent the V_{GS} from the fault condition, the EM8931 are implemented a Over-Voltage-Protection (OVP) on VDD. Whenever the VDD voltage is high than the OVP threshold voltage (28V), the output gate drive will be shutdown to shop the switching of the power MOSFET until the next UVLO (on).

  The Over-Voltage-Protection on VDD function in EM8931 is an auto-restart type protection. If the OVP condition is not released, the VDD will tripped the OVP level again and re-shutdown the gate output. The VDD is working as a hiccup mode as shown in Fig. 15. On the other hand, if the OVP condition is removed, the VDD level will go back to normal level and the output will automatically return to the normal operation.

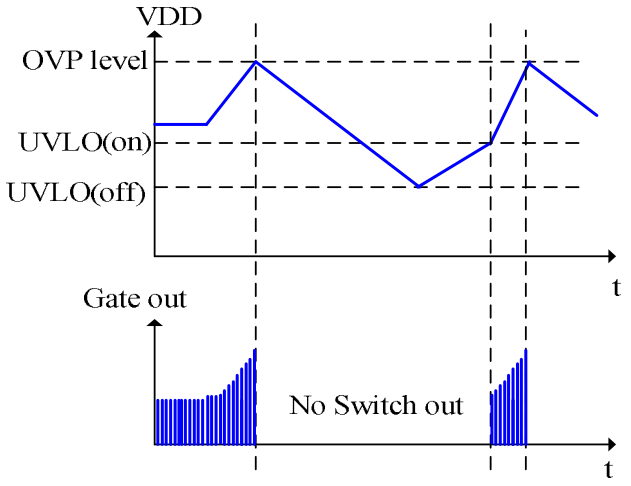


Fig. 15

- **Internal Over-Temperature Protection (OTP)**

  Internal 130℃ / 160℃ hysteresis comparator will provide over temperature protection (OTP). OTP will not shutdown system. It stops the system from switching until the temperature is under 130℃. Meanwhile, if VDD is below the UVLO (off) threshold voltage, the system will hiccup.

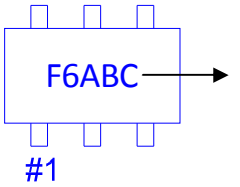
- **Pin open / short Protection**

  There are several open / short protections were integrated in the EM8931 to prevent the power supply or adapter from being damage. Under the conditions list below, the gate output will turn off to protect the system.

  - RT pin short to GND
  - RT pin open
  - CS pin open

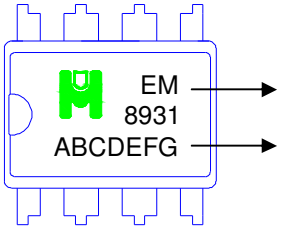
Ordering & Marking Information

Device Name: EM8931J for SOT-23-6



F6: Device Code, F6 for EM8931J
ABC: Date Code

Device Name: EM8931S for DIP-8

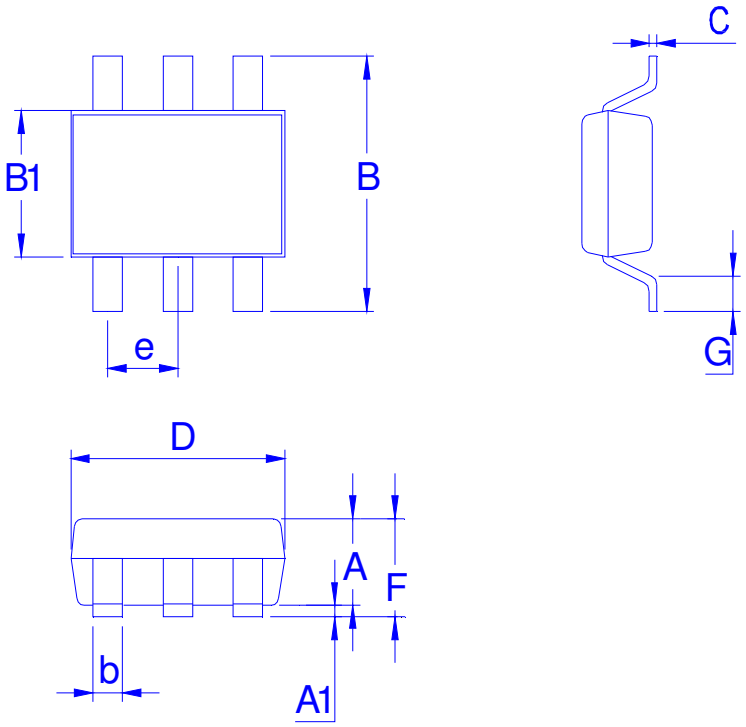


Device : EM8931S

ABCDEFG: Date Code

Outline Drawing

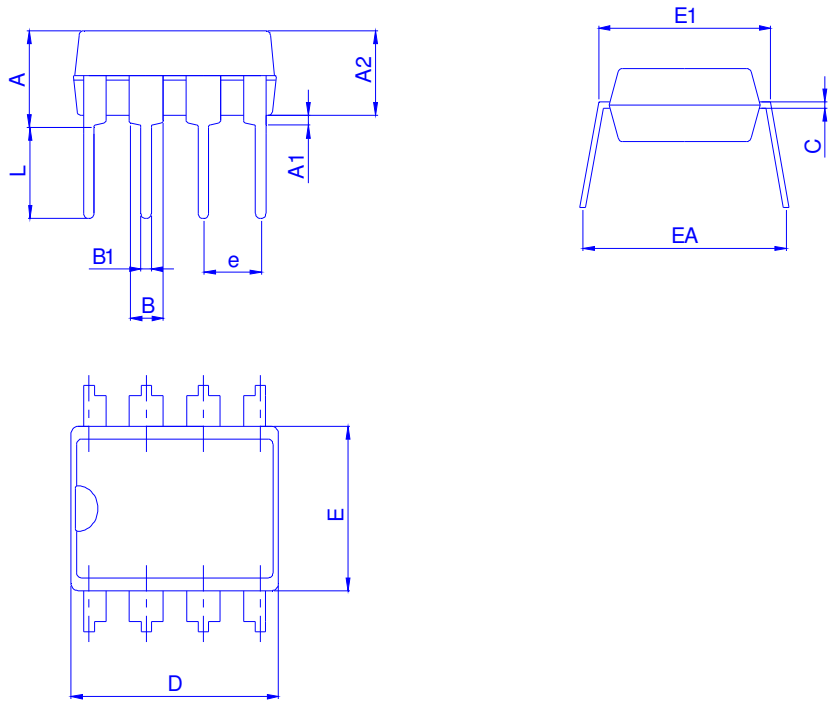
SOT-23-6



Dimension in mm

Dimension	A	A1	B	B1	b	C	D	e	F	G
Min.	0.90	0.00			0.30	0.08				0.30
Typ.	1.15		2.80	1.60			2.90	0.95		0.45
Max.	1.30	0.15			0.50	0.22			1.45	0.60

DIP-8



Dimension in mm

Dimension	A	A1	A2	B	B1	C	D	E	E1	EA	e	L
Min.		0.381	3.17				9.01	6.22	7.36	8.5		2.92
Typ.				1.524	0.457	0.254					2.54	
Max.	5.334		3.429				10.16	6.53	7.87	9.53		3.81