LA9938UVD

Product Preview

Igniter Module, 560 V, 12 A, for Gasoline Ignition Systems

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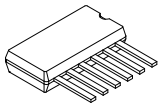


SIP6J 16.8 × 11.8 / SPCM6
CASE 127DM

Overview

The LA9938UVD is an integrated Ignition module with built−in control IC, IGBT and passive devices for Gasoline Ignition Systems. This highly reliable and robust device is designed to operate in under−hood COP−type (coil−on−plug) applications. This device has a wide operating temperature range and is fully integrated to provide a complete ignition solution for coil−on−plug applications.

The LA9938UVD module is automotive qualified and provides a robust and reliable solution of space constraint COP applications. The LA9938UVD also includes a 0.47 μF + 0.1 μF / 50 V input capacitor. This allows the device to withstand the harsh environment commonly found in automotive ignition systems.

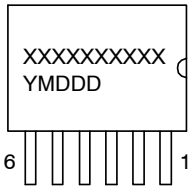
Features

- 12 A, IGBT Collector Current
- 560 V, Clamp Voltage
- 300 mJ, IGBT Collector−Emitter Avalanche Energy
- 4 V to 18 V, Wide Operating Voltage
- −16 V / 1 min, Input Reverse Voltage (Terminal−B)
- 30 ms, Over Dwell Protection
- 0.6 A/ms, Soft Shut Down
- 2.7 A Current Flag ON / 6.0 A Current Flag OFF
- 0.47 μF + 0.1 μF/ 50 V, Battery – GND Capacitor
- 2.3 kΩ, Input Resistance
- Small Size Pb−free Package
- AEC Qualified and PPAP Capable
  - IGBT: AEC-Q101
  - Control IC: AEC-Q100
  - Passive Components: AEC-Q200

Typical Applications

- Automotive Ignition Systems

MARKING DIAGRAM



XXXXX = Assembly Location
Y = Year
M = Month
DDD = Additional Traceability Data

ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

This document contains information on a product under development. ON Semiconductor reserves the right to change or discontinue this product without notice.

Table 1. ORDERING INFORMATION

Part Number	Operating Temperature Range	Package	Packing Method
LA9938UVD−XH	−40°C ~ 150°C	SIP6J	Tube

BLOCK DIAGRAM

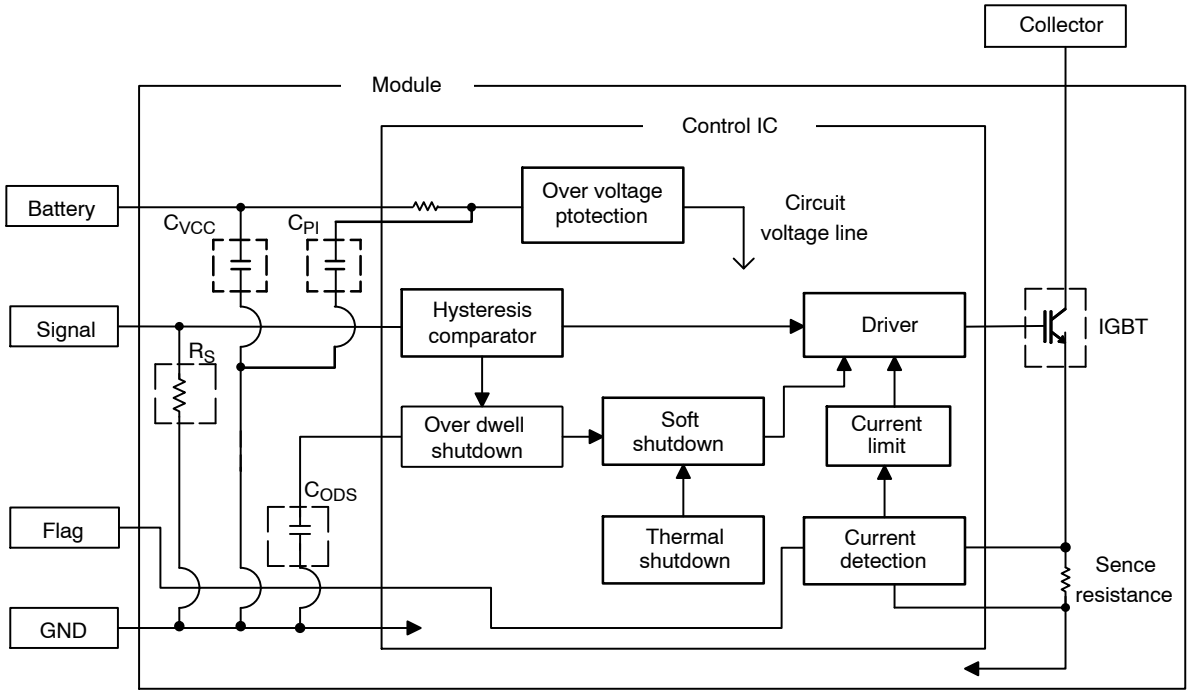


Figure 1. LA9938UVD Block Diagram

Table 2. PASSIVE COMPONETS (Note 1)

Part	Supplier	P/N	Description
C_{Vcc}	TDK CORPORATION	CGA5L2X8R1H474K160AD	Chip capacitor (0.47 μF / 50 V / X8R)
C_{ODS}	TDK CORPORATION	CGA3E3X8R1H104K080AD	Chip capacitor (0.1 μF / 50 V / X8R)
C_{PI}	TDK CORPORATION	CGA3E3X8R1H104K080AD	Chip capacitor (0.1 μF / 50 V / X8R)
R_S	TAIYOSHA ELECTRIC	ZGS05T392J	Chip resistor (3.9 kΩ)

1. Passive components are guaranteed by their own datasheets.

APPLICATION CIRCUIT EXAMPLE

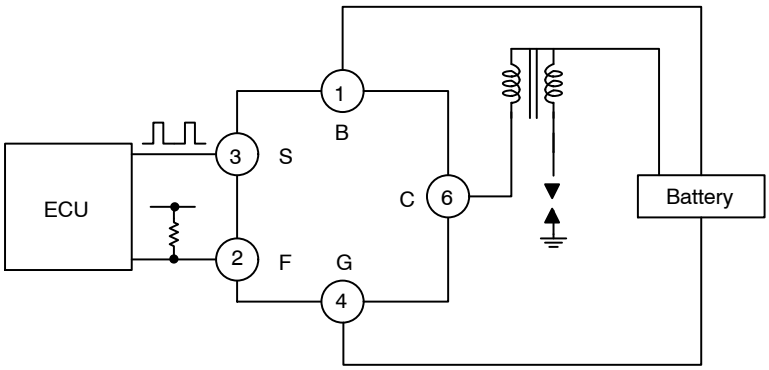


Figure 2. LA9938UVD Application Circuit Example

PIN ASSIGNMENT

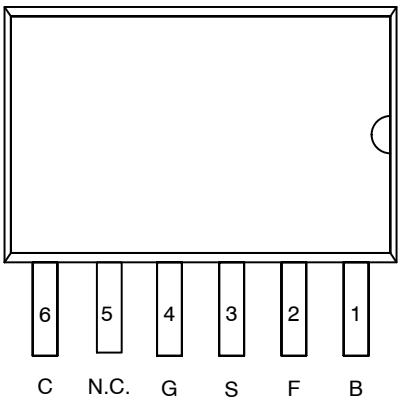


Figure 3. Pin Assignment

Table 3. PIN FUNCTION DESCRIPTION

Pin No.	Pin Name	Description
1	B	Supply Voltage
2	F	Current flag (Open collector)
3	S	Module operation control input Input resistance is 2.3 kΩ (Typ)
4	G	GND
5	N.C.	Non connection terminal with the internal any leadframe
6	C	IGBT Collector (Open collector)

Table 4. MAXIMUM RATINGS

Rating			Symbol	Min	Max	Unit
Storage Temperature	Module (Note 2)		T_{STG}	−40	+150	°C
Junction Temperature	Control IC		$T_{J\ IC}$	−40	+150	°C
	Module (Note 2)		T_J	−40	+150	°C
	IGBT (Note 2)		$T_{J\ IGBT}$	−40	+175	°C
Input Voltage to B			VB max	0	40 (Note 3)	V
Voltage to C			VC max	0	600	V
Current to C (Internally Limited)			IC max	0	Current limit	A
Input Voltage to S (Note 4)			VS max	0.0	16	V
Input Current to S (@ VS = 5 V) (Note 5)			I_S max	0.0	50	mA
Input Voltage to F			V_F max	0	16	V
Output Current to Flag			I_F max	0.0	12	mA
Thermal Resistance			$R_{\theta JA}$	105		°C/W
ESD @IEC61000 4−2		Pin1, Pin2, Pin3	ESD1	5		kV
		Pin 6	ESD2	10		kV

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

2. The maximum rating of the storage temperature is limited by the internal passive components.
3. At surge, do not surpass reliability test condition.
4. This pin−voltage must be equal to or less than Pin1(B) voltage at all times.
5. This pin−voltage must be equal to or less than Pin1(B) voltage at all times. To connect to Pin2 via external resistance for to prevent it from becoming more than 12 mA.

Table 5. RECOMMENDED OPERATIONG RANGE: FULL FUNCTIONALITY

Parameter	Symbol	Min	Max	Unit
Normal Operating B Voltage	VB_{OPE}	7	18	V
Operating Frequency	VS_F	0.3	200	Hz

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

Table 6. EXTENDED OPERATING RANGE

Parameter	Symbol	Min	Max	Unit
Cold Crank Start Up B Voltage (Note 6)	VB_{CCS}	4	−	V
Double Battery Operation (Note 7)		−	28	V
GND Shift (VS = 5 V) (Note 8)	GNDs	−1	+1	V

6. Can operate from 4 V at Pin1 (B) voltage (−40 to 25°C, < 200 ms). Note that Pin1 (B) voltage must not be lower than the Pin3 (S) voltage.
7. Can operate above normal battery range for 1 minute subject to thermal consideration.
8. When the IGBT operates at Pin−S = 5V, if GND voltage is shifted till ±1 V, IGBT can keep operation.

Table 7. ELECTRICAL CHARACTERISTICS

(B = 7 V to 16 V, S = 3.5 V, F = 5 V, control IC at Temperature range −40°C ≤ T_J ≤ 150°C, Min/Max values are valid for the temperature range −40°C ≤ T_J ≤ 150°C unless noted otherwise, and are guaranteed by test, design or statistical correlation)

Parameter			Symbol	Conditions	Min	Typ	Max	Unit
ON Delay Time			T_D on	R_Z = 10 kΩ	3	10	30	μs
OFF Delay Time			T_D off	Rz = 10 kΩ	10	20	34	μs
Collector Current Limit			I_{CL}	Rz = 0.5 kΩ	10	12.5	15	A
S Control Voltage	IGBT ON		IN_{ON}	Rz = 10 kΩ	2.5	2.9	3.3	V
	IGBT OFF		IN_{OFF}	Rz = 10 kΩ	1.1	1.4	1.9	V
	Hysteresis		IN_{HYS}	$IN_{ON} - IN_{OFF}$	0.7	–	2.3	V
Over Dwell Shutdown			ODS	Rz = 0.5 Ω	15	30	60	ms
Soft Shutdown			T_{SD}	Rz = 0.5 Ω After ODS operate	–	0.6	2.2	A/ms
Current Flag	Current Level	High	I_{CFON}	Rz = 0.5 Ω	1.8	2.7	3.6	A
		Low	I_{CFOFF}	Rz = 0.5 Ω	3.7	6.0	7.2	A
		High−Low	I_{CFHYS}	$I_{CFON} - I_{CFOFF}$	–	2.8	–	A
	Signal Level	High	V_{CFON}	Rz = 0.5 Ω	3.5	–	–	V
		Low	V_{CFOFF}	Rz = 0.5 Ω	–	–	1.5	V
S−G Clamp Voltage			V_{SL}	I_S = 50 mA	16	20	24	V
F−G Clamp Voltage			V_{FL}	I_F = 50 mA , S = 0 V	18	20	24	V
Over Voltage Protection (Note 9)			V_{BOV}	Rz = 10 kΩ	29	32	35	V
B−G Clamp Voltage			V_{BL}	I_B = 20 mA , S = 0 V	34	37	40	V
B−G Input Current			I_{BG}	VB = 16 V , S = 0 V	–	4.5	9	mA
B−G Capacitor (Note 10)			C_{Vcc}	B = 14 V , S = 0 V , F = 0 V	0.43	0.57	0.73	μF
S−G Resistance			R_S	B = 0 V, S = 3.5 V, F = 0 V	1.8	2.3	2.9	kΩ
C−G Clamp Voltage			BV_{CGS}	I_C = 2.0 mA	530	560	600	V
				I_C = 10 mA				
C−G Saturation Voltage			V_{CG1}	I_C = 6.0 A	–	–	1.8	V
			V_{CG2}	I_C = 10 A	–	–	2.2	
Single Pulse Collector−to−Emitter Avalanche Energy (Note 11)			E_{AS}	T_J = 25°C	–	–	300	mJ

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

9. Protection circuit operate before VB become B−G clamp voltage.
10. This value is referred to the specifications of CGA5L2X8R1H474K160AD and CGA3E3X8R1H104K080AD (TDK Corporation).
11. This value is referred to the specification of IGBT.

TYPICAL PERFORMANCE CHARACTERISTICS

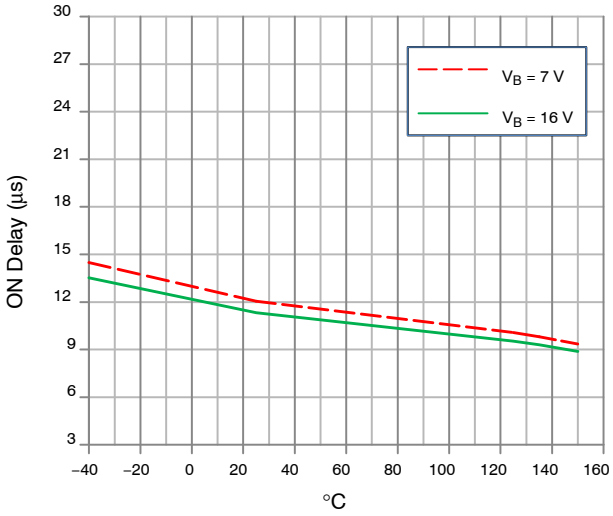


Figure 4. ON Delay Time vs. Temperature

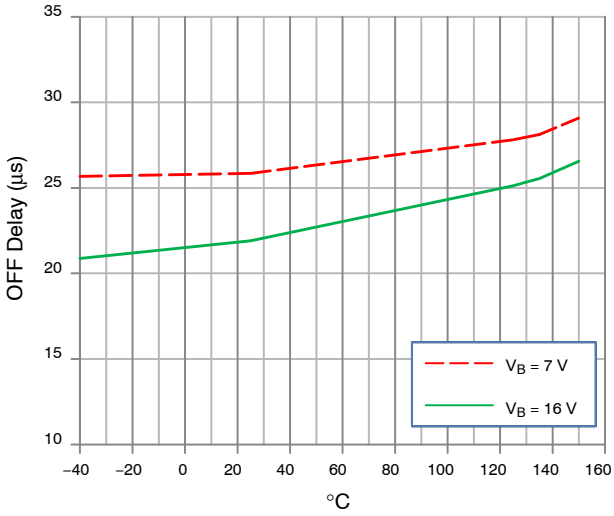


Figure 5. OFF delay time vs. Temperature

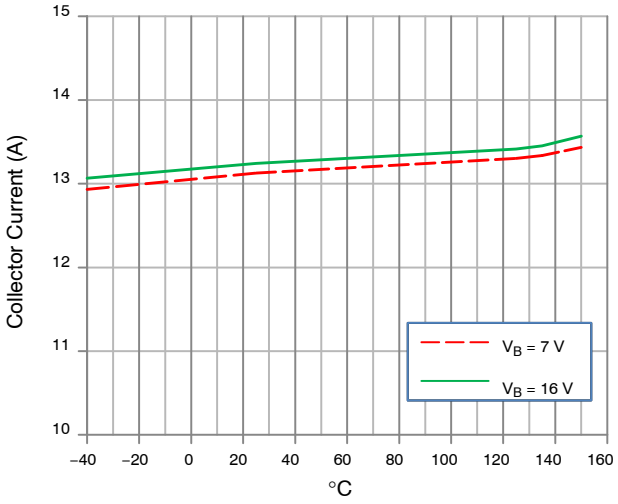


Figure 6. Collector Current Limit vs. Temperature

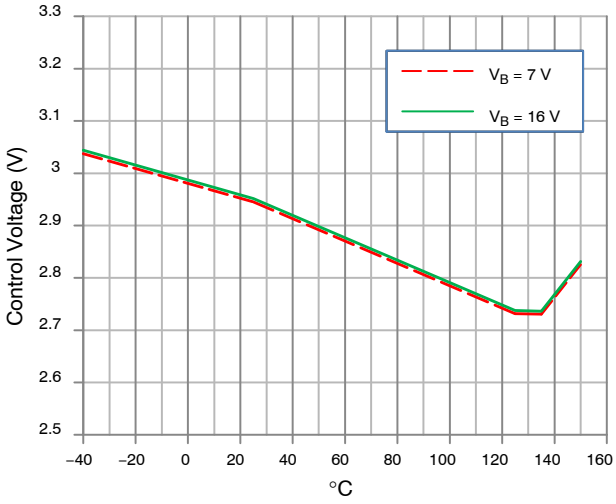


Figure 7. S Control Voltage vs. Temperature IGBT ON

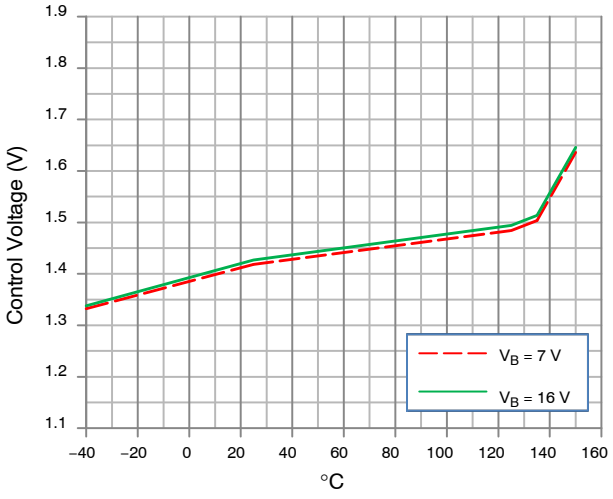


Figure 8. S Control Voltage vs. Temperature IGBT OFF

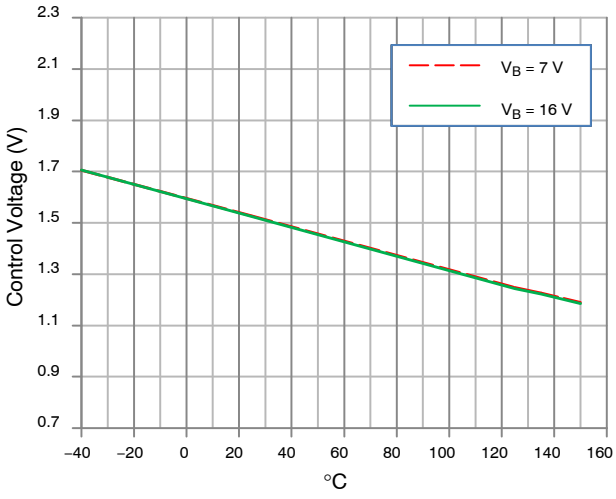


Figure 9. S Control Voltage vs Temperature Hysteresis

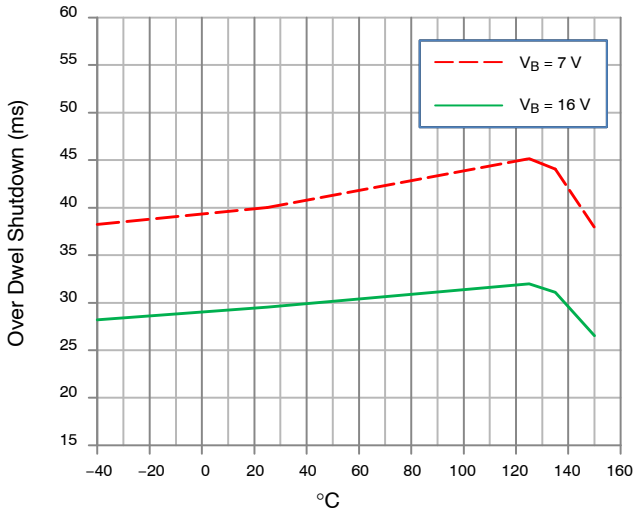


Figure 10. Over Dwell Shutdown vs. Temperature

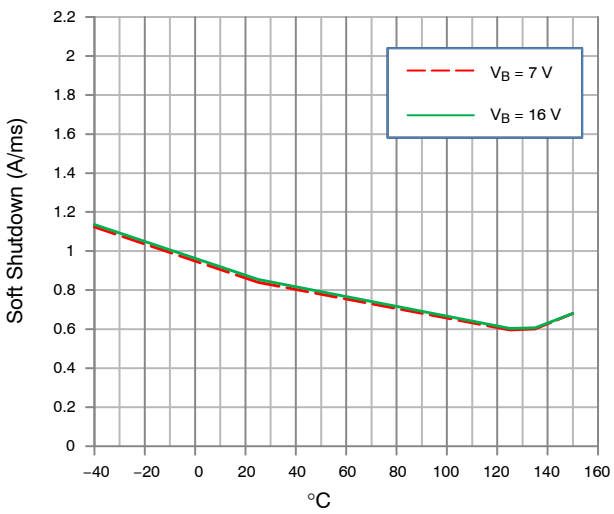


Figure 11. Soft Shutdown vs. Temperature

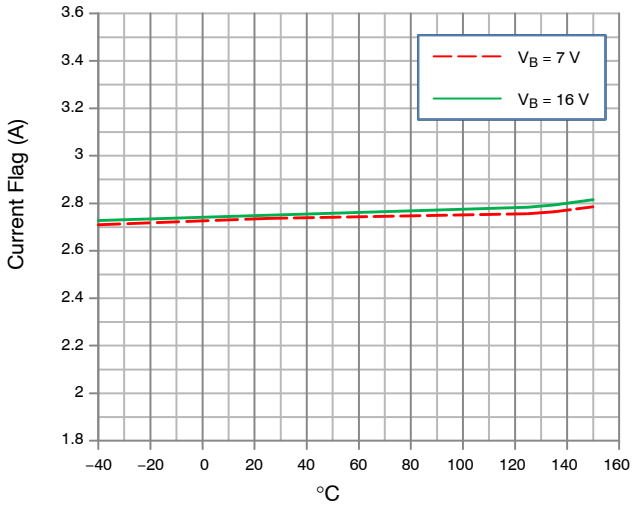


Figure 12. Current Flag vs. Temperature F−pin High to Low Transition Current

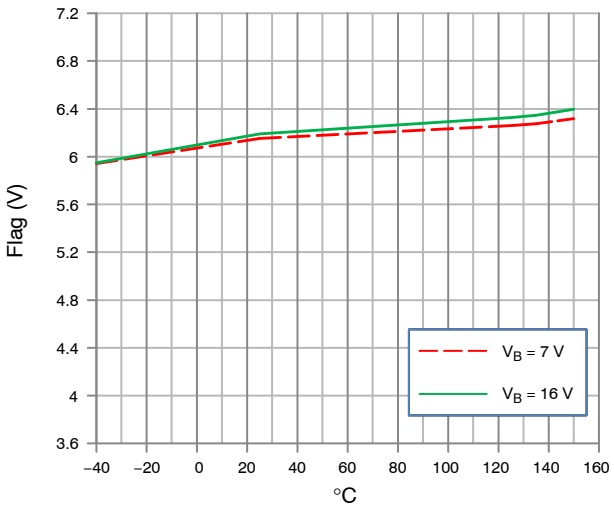


Figure 13. Current Flag vs. Temperature F−pin Low to High Transition Current

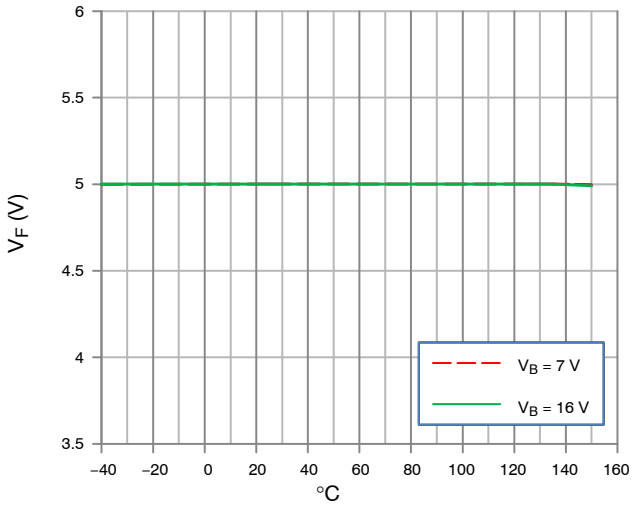


Figure 14. Current Flag vs. Temperature F−pin High Voltage

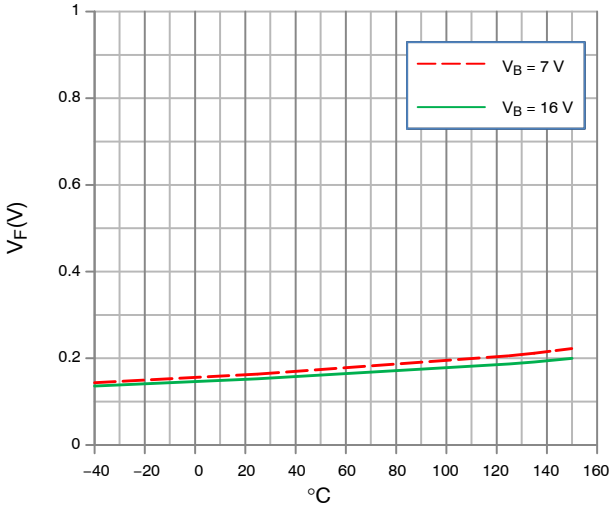


Figure 15. Current Flag vs. Temperature F−pin Low Voltage

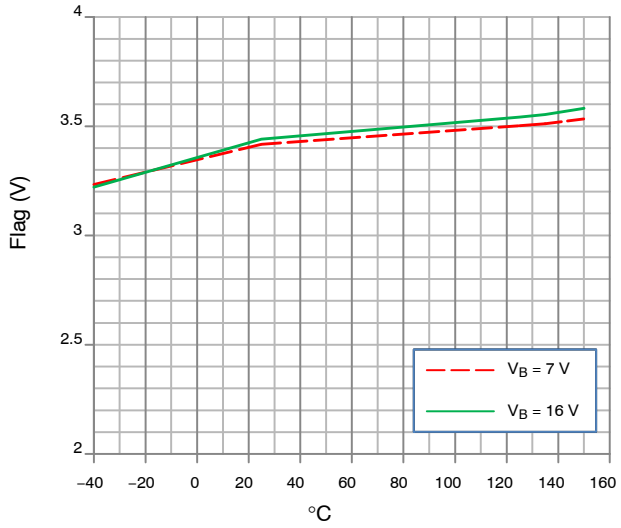


Figure 16. Current Flag vs. Temperature F−pin Low Current Range

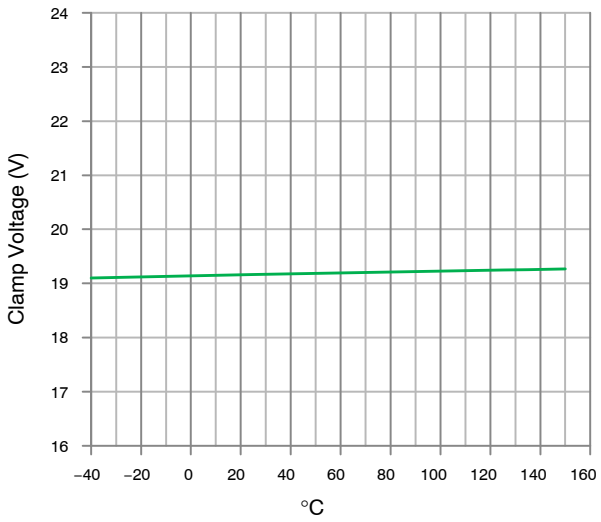


Figure 17. S−G Clamp Voltage vs. Temperature

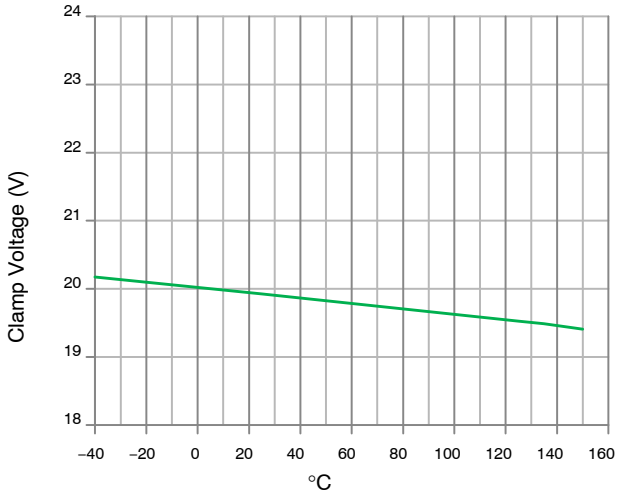


Figure 18. F−G Clamp Voltage vs. Temperature

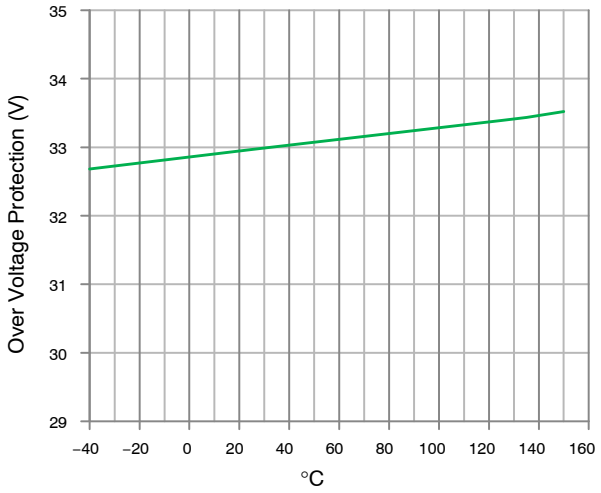


Figure 19. Over Voltage Protection vs. Temperature

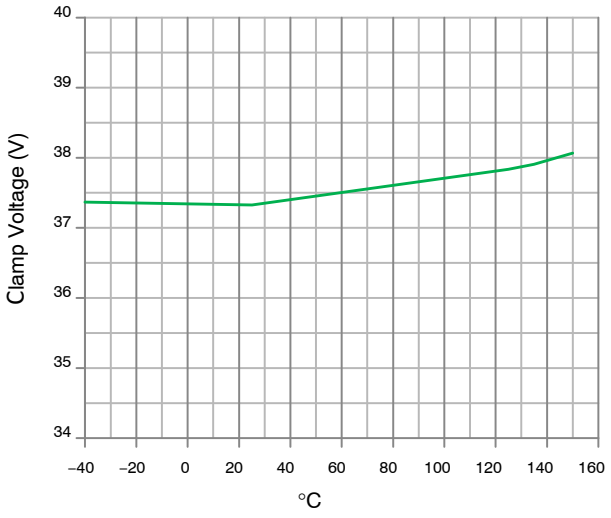


Figure 20. B−G Clamp Voltage vs. Temperature

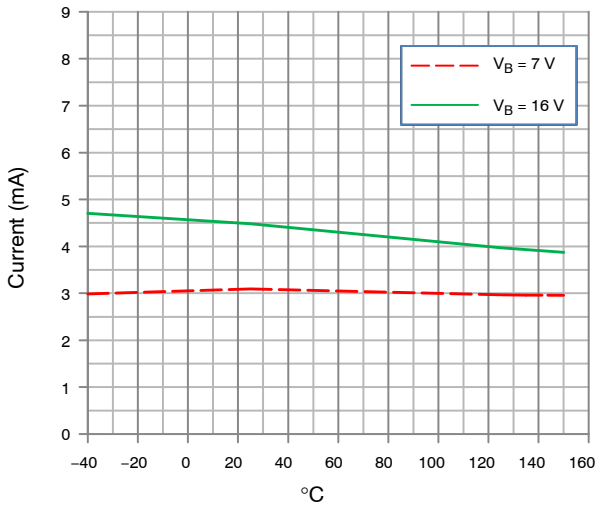


Figure 21. B−G Input Current vs. Temperature

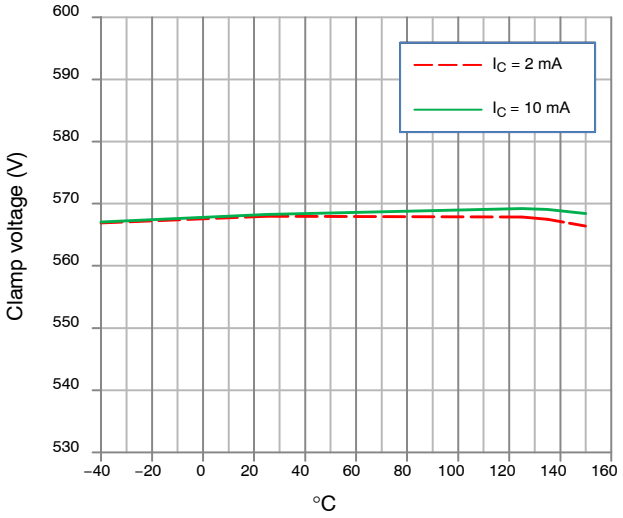


Figure 22. C-G Clamp Voltage vs. Temperature

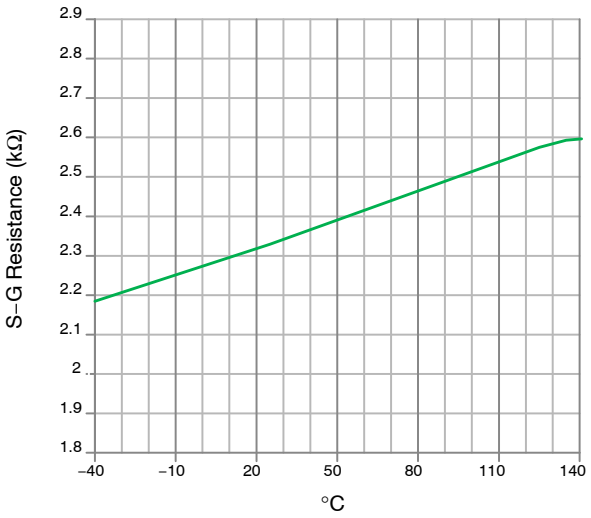


Figure 23. S-G Resistance vs. Temperature

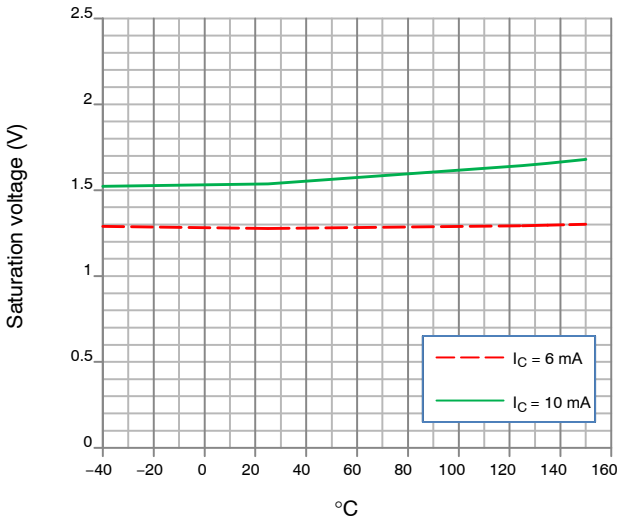


Figure 24. C-G Saturation Voltage vs. Temperature

Evaluation Circuit

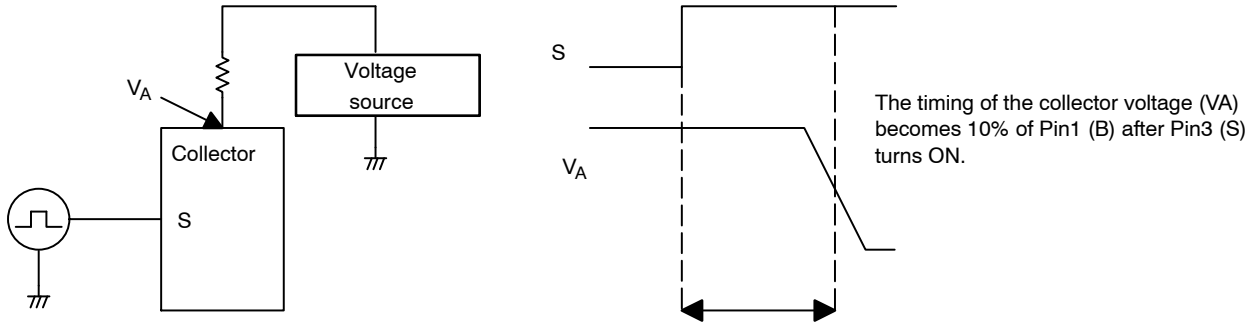


Figure 25. ON Operation

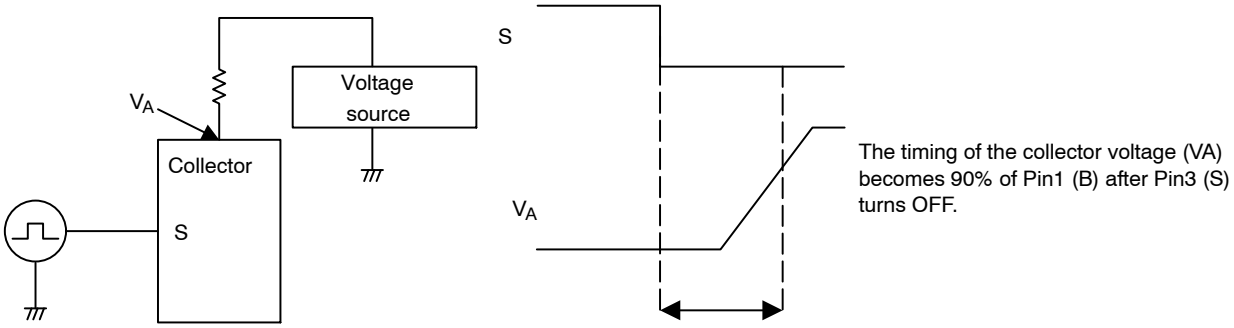


Figure 26. OFF Operation

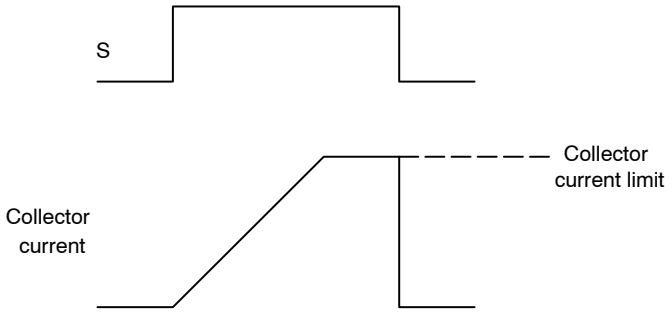


Figure 27. Collector Current Limit Operation

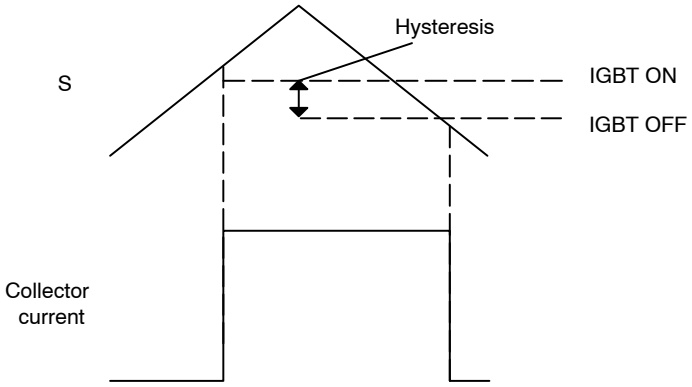
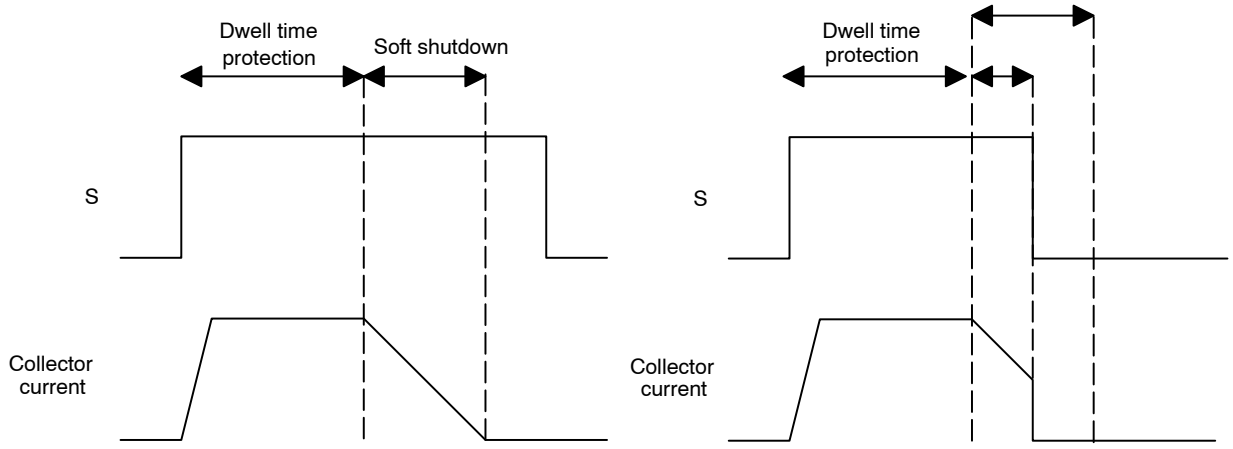


Figure 28. IGBT Control Voltage



Soft shutdown function is activated by Over−dwell shutdown or Thermal shutdown.

Soft shutdown is aborted by high to low transition of Pin3(S) and it may cause spark.

Note: The soft shutdown specification is reference data when thermal shutdown operates.

Figure 29. Over Dwell Shutdown / Soft Shutdown

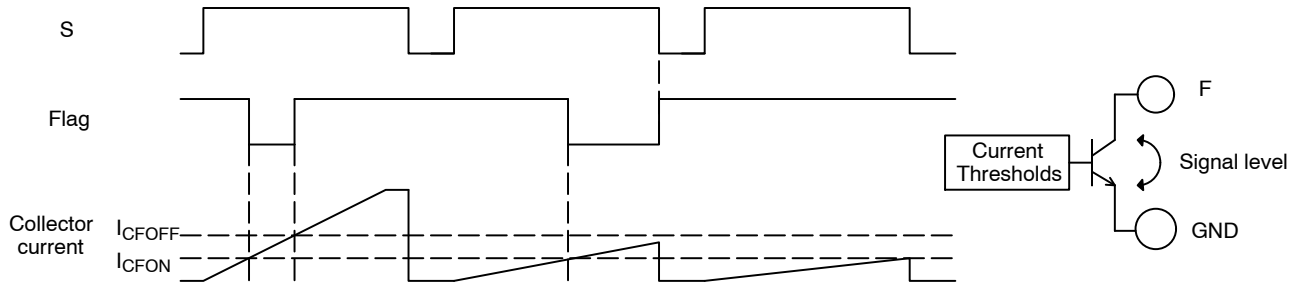


Figure 30. Current Flag

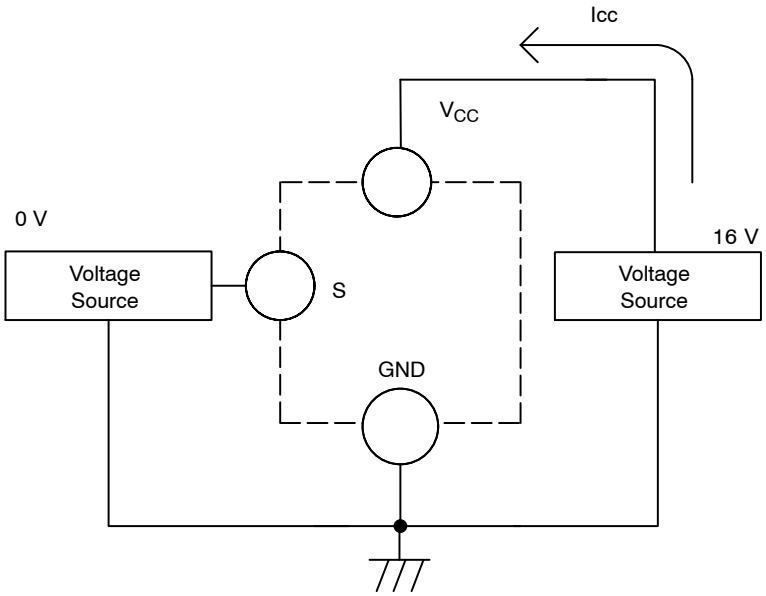


Figure 31. B−G Input Current

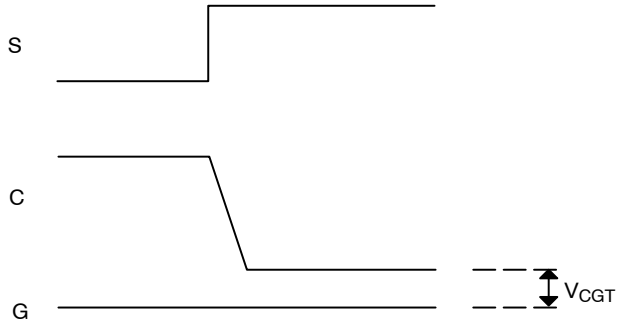


Figure 32. B−G Input Current

Circuit Description

LA9938UVD (clamp voltage: 560 V, current limit: 12 A) is a fully integrated module for ignition coils for gasoline engines. LA9938UVD is a 6−in−1 module with IGBT, control IC, B−G capacitor, S−G resistor and capacitor to implement timer function. B−G capacitor is the battery−to−ground filter capacitor with 0.47 μF + 0.1 μF capacitance and rating voltage of 50 V. S−G resistor sets the signal−to−ground input impedance. And the ODS capacitor provides timer function for the over−dwell timeout and Soft shutdown functions.

Pin3 (S−pin) is a signal input which controls the ignition timing. When S−pin was turned high, IGBT turns on and primary coil current starts to ramp up. Once S−pin was turned low, the IGBT turns off and the energy charged in the primary coil is inducted to the secondary coil. This energy causes very high voltage at the secondary coil which produces a spark at the spark plug.

When the Pin3 (S−pin) is turned high or low, there is a short delay before the IGBT is turned on or off. This delay works as a filter to avoid unintentional turn−on / off due to noises that may exist in the ignition system.

Please see the Figure 33 for additional IC operation.

Current Limit (ICL)

The Current limit (ICL) function protects the IGBT.

The Current detection circuit monitors the IGBT current. When the IGBT current increased and reached a certain level, the Current limit circuit controls the gate voltage of the IGBT to limit the IGBT current to avoid the current exceeding beyond the level.

Please see Figure 33 for the operation.

Current Flag (ICF)

The current flag signal allows the ECU to see if adequate current is flowing the IGBT to cause a spark at the spark plug.

The Pin2 (F−pin) is an open collector port which should be externally pulled−up. At first, the F−pin is high. When the IGBT current started to increase and reached Icfon, the F−pin turns low. After primary current exceeded Icfon and reached Icfoff, the pin will be return to high level again.

Please see Figure 33 for the operation of the function.

Over Dwell Shutdown (ODS)

The ODS function helps to protect the IGBT in case that s−pin signal is tied high for an abnormal length of time. The duration time until timeout is set by the internal ODS capacitor.

Please see Figure 34 and 35 for the operation of this function.

Thermal Shutdown (TSD)

The Thermal shutdown (TSD) function provides protection which turns off the IGBT when die temperature exceeded the thermal shutdown threshold. There is a hysteresis in activating / deactivating temperature, so oscillated TSD operation is avoided.

TSD threshold is designed as 160°C (Min.) / 180°C (Typ.) / 200°C (Max.), but TSD function is not tested in production. TSD is assumed to operate above the rated temperature. Thus, the operating condition where TSD can be activated is in the region of miss−use that we cannot guarantee.

Temperature sensing diode is implemented on the control IC which is apart from IGBT. So, there can be difference between the sensed temperature and actual temperature. This means that TSD function might not protect the IGBT from failure due to overheating.

Please see Figure 36 to 39 for the operation of this function.

Soft Shutdown (SSD)

In case of TSD or ODS condition, the IGBT is shut down in the manner of soft shutdown which will ensure that the IGBT current slowly decreases to zero so that no spark occurs at the spark plug.

Please see Figure 34 to 39 for the operation of this function.

Over Voltage Protection (OVP)

In case that the battery voltage exceeded the normal operating range, the OVP function turns off the IGBT and keeps inoperative until the battery voltage became normal operative voltage.

This function does not have hysteresis.

S−G / F−G / B−G Clamp Voltages

Over voltage protection is a function to protect the LA9938 from overvoltage by clamping Pin3 (S−pin), Pin2 (F−pin) and / or Pin1 (B−pin). This function works when the applied voltage exceeded the rated voltages due to, for example, misconnection, battery line noise, etc.

When the voltage applied to Pin3 (S−pin) exceeded the clamp voltage, the voltage is clamped inside the module. LA9938UVD operates normally even though the clamp circuit is in operation.

When the voltage applied to Pin2 (F−pin) exceeded the clamp voltage, the voltage is clamped inside the module. Pin2 (F−pin) is turned low while clamp circuit is in operation.

When the voltage applied to Pin1 (B−pin) exceeded the clamp voltage, the voltage is clamped inside the module. IGBT will turn off and will not turn on again as far as clamp circuit is in operation.

These three clamp voltages do not have hysteresis.

Please see diagram 40 for the operation of each function.

Terminal−S vs. Each Terminals

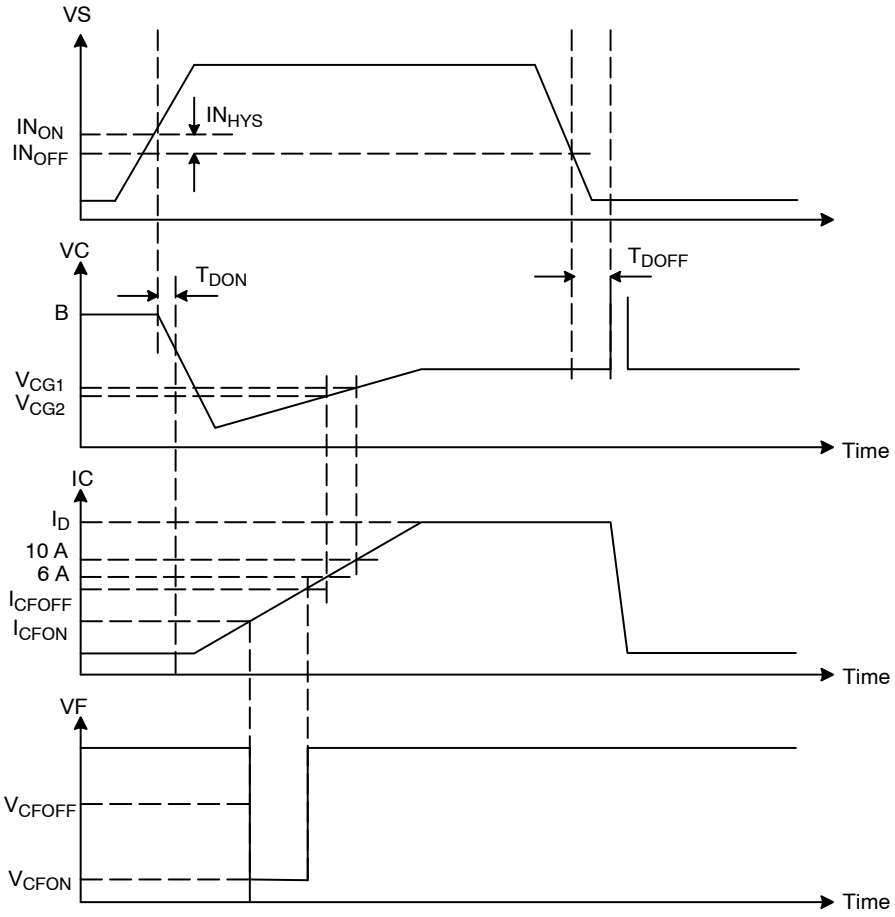


Figure 33. Terminal−S vs. Each Terminals Timing Chart

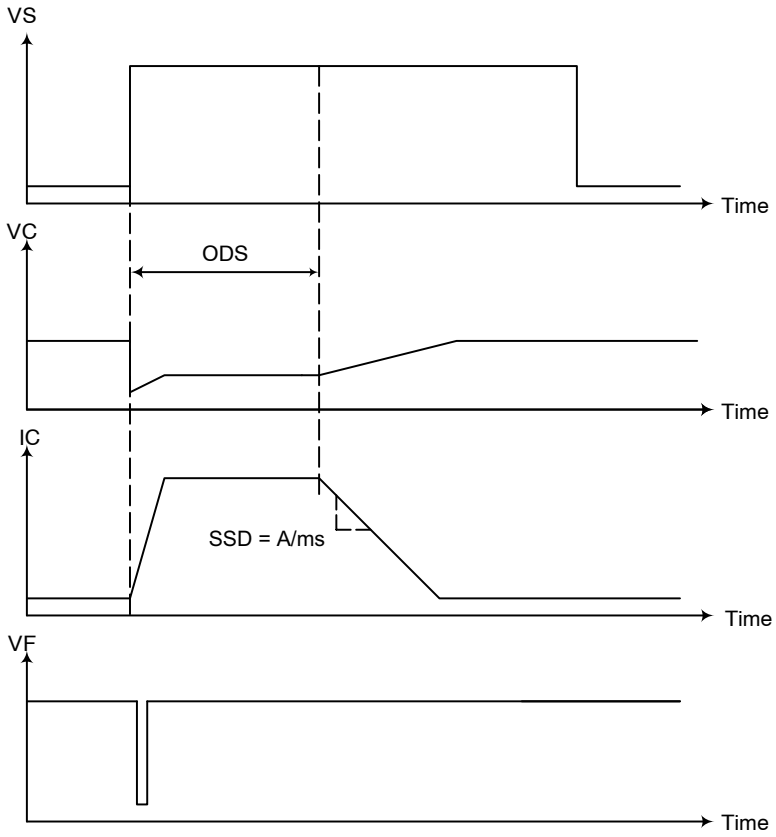


Figure 34. Over Dwell Shutdown and Soft Shutdown Timing Chart

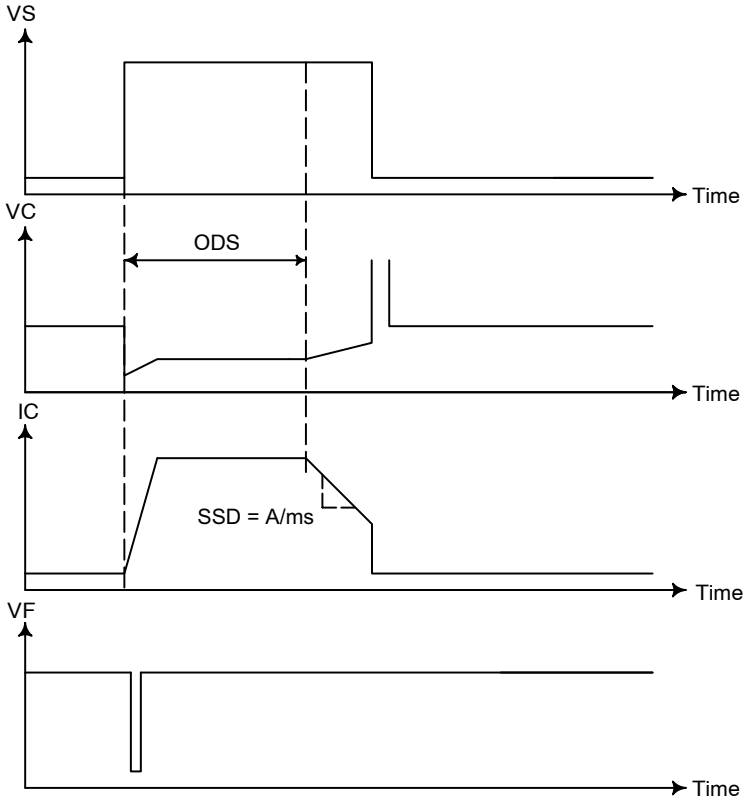


Figure 35. Over Dwell Shutdown and Soft Shutdown Timing Chart

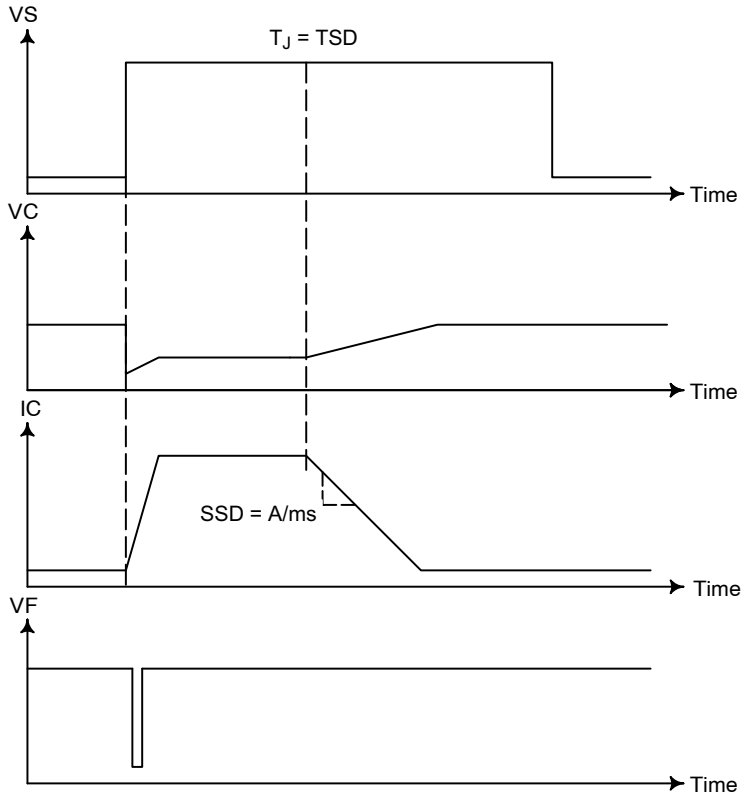


Figure 36. Terminal−S vs. Each Terminals Timing Chart−1

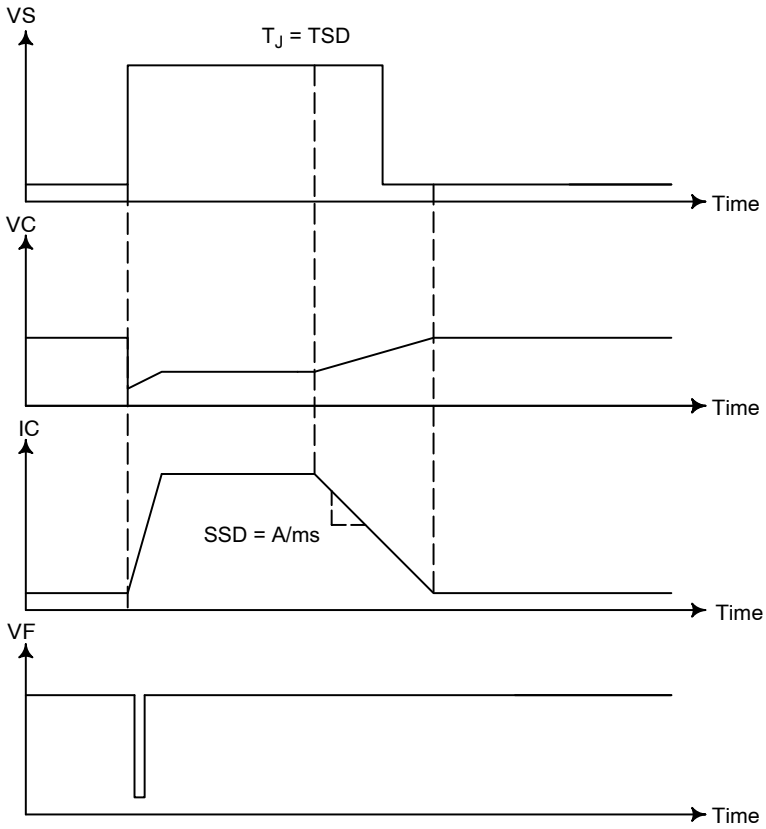


Figure 37. Terminal−S vs. Each Terminals Timing Chart−2

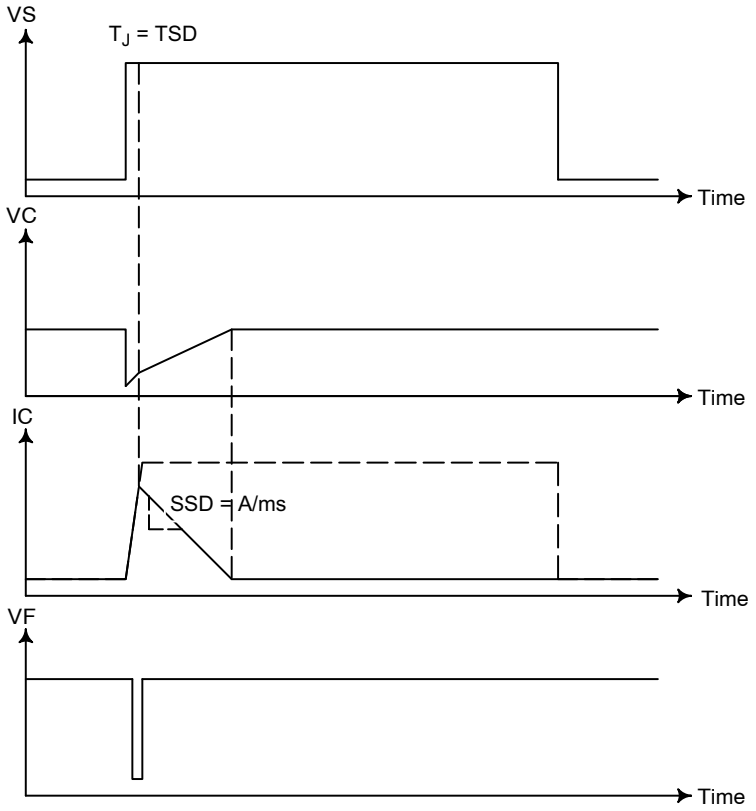


Figure 38. Terminal−S vs. Each Terminals Timing Chart−3

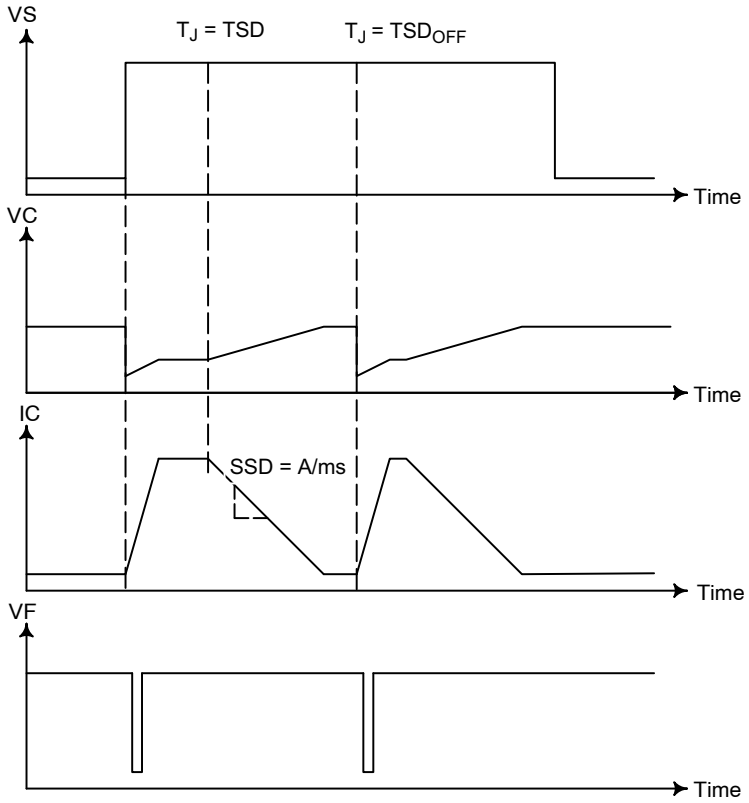


Figure 39. Terminal−S vs. Each Terminals Timing Chart−4

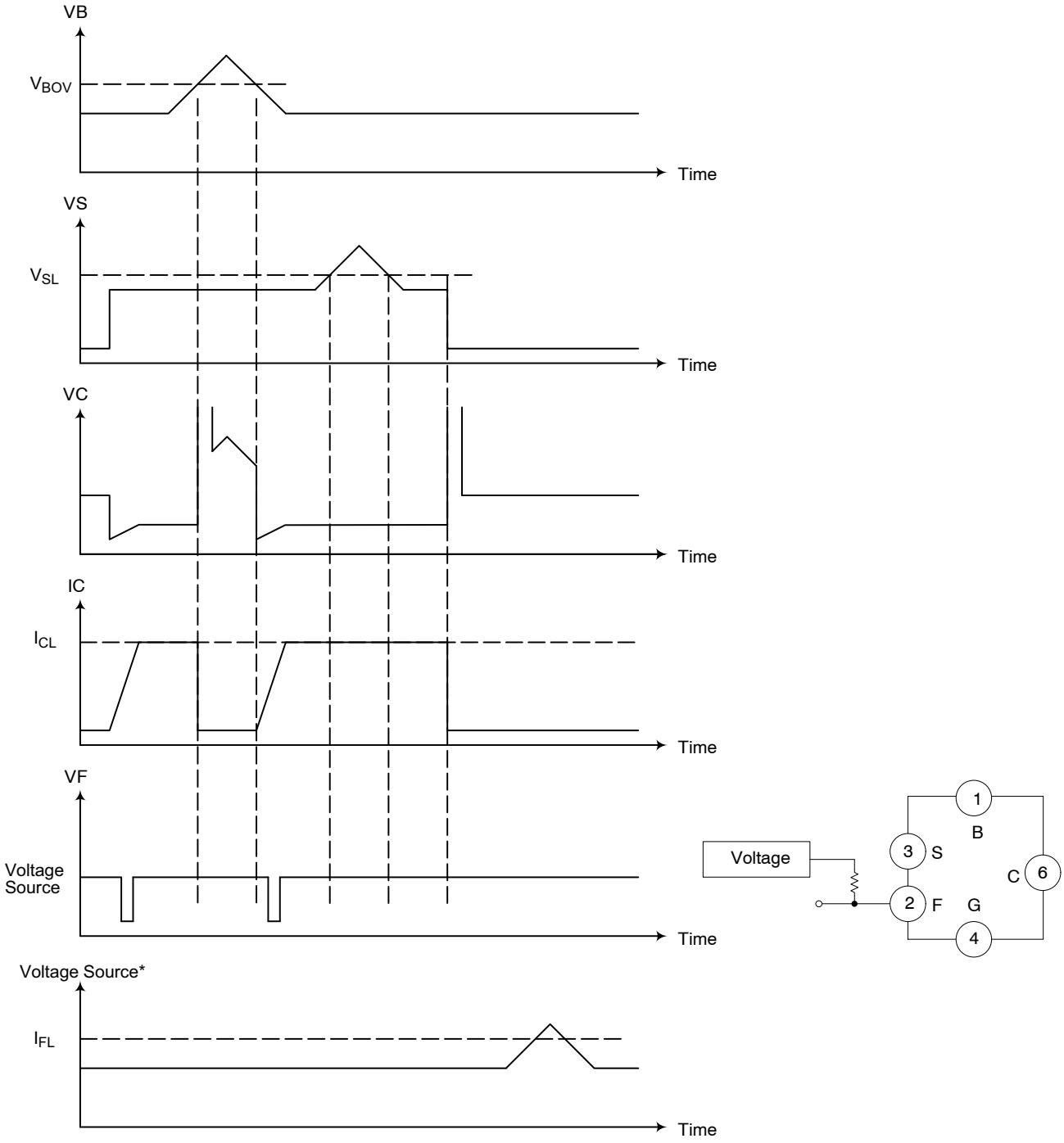
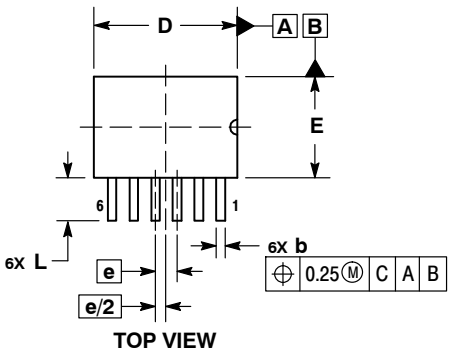


Figure 40. Various Protection Circuit Timing Chart

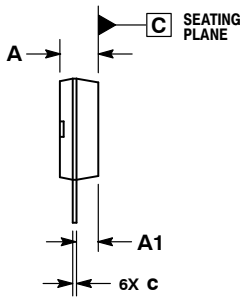
- When the Supply voltage exceeded V_{BOV}, IGBT will be turned off quickly. And IGBT turned on again when the Supply voltage became lower than V_{BOV}
- Even when the Pin3 (S) voltage exceeded V_{SL}, Igniter maintains its operation. Pin(S) voltage is clamped internally
- While Pin2 (F) pull−up voltage (expressed as “Voltage source” in Figure 40) is higher than V_{FL}, Pin2 (F) is clamped

PACKAGE DIMENSIONS

SIP6J 16.8 × 11.8 / SPCM6
CASE 127DM
ISSUE B



TOP VIEW



SIDE VIEW

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b AND c APPLY TO THE PLATED LEAD AND ARE MEASURED BETWEEN 1.00 AND 2.00mm FROM THE TERMINAL TIP.

	MILLIMETERS		
DIM	MIN	NOM	MAX
A	4.40	4.50	4.60
A1	2.20	2.50	2.80
b	0.95	1.00	1.15
c	0.45	0.50	0.65
D	16.70	16.80	17.20
E		11.80 REF	
e		2.54 BSC	
L	4.75	5.00	5.25

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

NOTE: Outer lead frame material Nickel plating.

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