L9407F

CAR ALTERNATOR VOLTAGE REGULATOR

■ FULLY MONOLITHIC DESIGN

■ LOW SIDE FIELD DRIVER

■ THERMAL PROTECTION

■ FIELD SHORT CIRCUIT PROTECTION

■ PROTECTED DIAGNOSTIC LAMP DRIVER

■ PROTECTED HIGH SIDE RELAY DRIVER

■ COMPLEX DIAGNOSTICS

■ LOAD RESPONSE CONTROL

■ DFM OUTPUT (FIELD MONITOR)

Multiwatt 8
ORDERING NUMBER: L9407F

DESCRIPTION

The L9407F is a monolithic multifunction alternator voltage regulator intended for use in automotive application. It includes the control section, the field power stage, fault diagnostic circuit which drives a warning lamp, and the protection against short circuits.

CIRCUIT OPERATION

The alternator's voltage regulator performs the following main functions:

– 1) voltage regulation

– 2) protection

– 3) control fault diagnosis

– 4) load response control

VOLTAGE REGULATION

The alternator voltage is compared with a reference voltage in an amplifier, whose output determines the switching frequency of output power MOS whose current excites the coil of the alternator; as the regulators are a self-oscillating type this frequency depends on the whole system parameter set including the alternator characteristics. The regulators have an integrated filter in the voltage sensing path guaranteeing the correct behaviour of the devices also when the rectifier diodes feature very high switching spikes. The internal filtering allows the usage of the
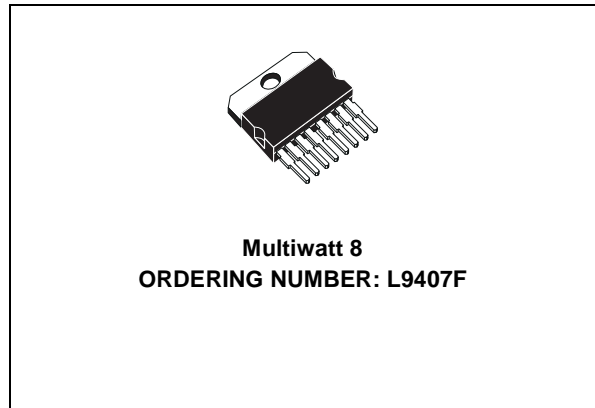
device also with very long cables connecting the alternator to the battery with an impedance so high to cause a superimposed ripple on the alternator voltage higher than 5-6V. Consequently it doesn't need, in the standard application, any external component. Anyway an external application (2.2uF or 2.7uF) must be inserted between A+ and ground when using the device with very long cables.

PROTECTION

It is present a protection against short circuits of the lamp and the relay power drivers (D+) and of the field power driver (DF), a thermal drivers shutdown protection and an overvoltage protection of D+ power drivers.

DIAGNOSIS

The circuit detects fault conditions related to the phase and DF status and receives informations from one of the three alternator phases. In order to prevent spurious indications, fault warnings are not displayed immediately but are dalayed by a fixed time.

LOAD RESPONSE CONTROL

The internal circuit regulates the soft start characteristics (activated always at engine start) and the soft attack characteristics.

PIN CONNECTION
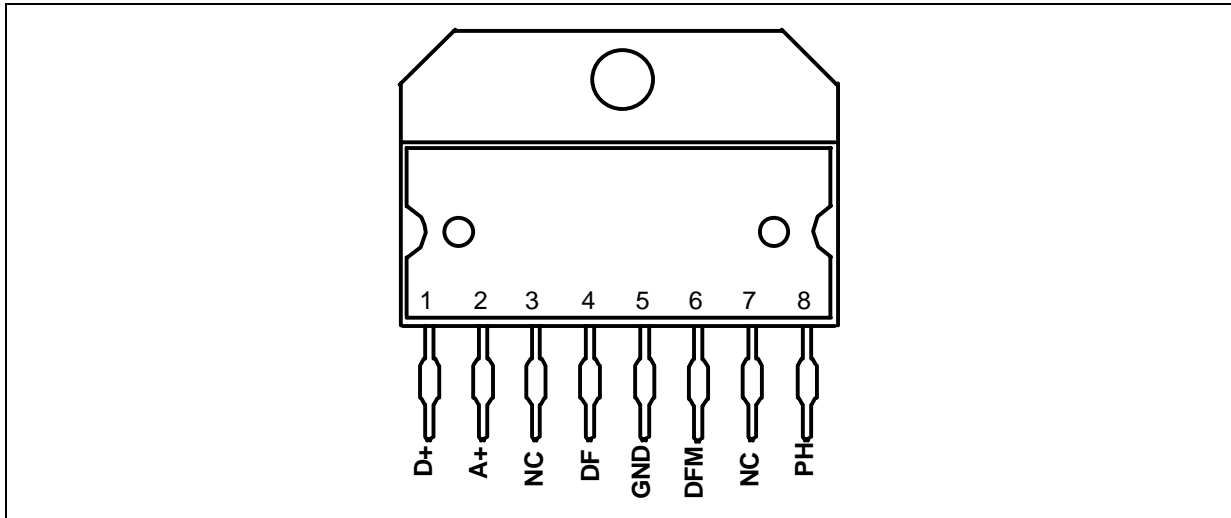
PIN DESCRIPTION

N°	Pin	Function
1	D+	Lamp terminal low side driver; relay terminal high side driver
2	A+	Alternator output voltage supply
3	NC	Not connected
4	DF	Field low side driver output
5	GND	Ground
6	DFM	Field monitor output
7	NC	Not connected
8	PH	Phase sense input

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage (2 min. @ 25°C) [all pins vs. GND]	24	V
	Transient Supply Voltage (load dump) [see application circuit] t<500ms	40	V
	Transient Supply Voltage (low energy spikes) [see application circuit] ISO7637-1 pulse 1,2,3 /ISO7637-3	100 (clamped at 60 by application)	V
T_j	Junction temperature range	-40 to 170	°C
T_{stg}, T_{case}	Storage and case temperature range	-40 to 150	°C
P_{tot}	Total power Dissipation (@ Tcase = 150°C, Ifield = 5A)	8	W
	Reverse Voltage (see application diagram) @ 25°C, T = 15 sec all pins, except for PH (normal working condition)	-2.5	V
	DC Pin Current on DF, A+, GND (bonding limitation)	15	A
	ESD Voltage MILSTD883C (All pins vs.GND)	±4	KV

THERMAL DATA

Symbol	Parameter	Value	Unit
$R_{th\ j\text{-}case}$	Thermal Resistance Junction to Case	0.6	°C/W

ELECTRICAL CHARACTERISTCS

(T_{case} = -40ºC ÷ 150ºC; unless otherwise specified)

Symbol	Parameter	Test Condition	Min.	Typ.	Max	Unit
Vbat	Operating Supply Voltage		6		18	V
Ib-sinked	Supply Battery Current				50	mA
Ib-stby	Stand-by Current	Vbat = A+, DF = 12.5V			500	uA
Vreg	Regulated Volt. & Therm. Drift	Ialt=1A-0.9*Inom; Tcase=20ºC; 1200<rpm<RPMMAX; Vreg clamped at 14.8V Max. (Fig.3)	13.9 -4.5	14.35 -3.5	14.8 -2.5	V mV/°C
fsw	Switching Frequency	preexcitation	30		400	Hz
	Delta Vrpm	1500<rpm<RPMMAX; Ialt=5A; Tcase=23ºC			200	mV
	Delta Vload	5A<Ialt<Inom; rpm=6000rpm; Tcase=23ºC			250	mV
Vreg	Reg. Voltage without Battery	Ialt = 3A resistive; Tcase=25º; 2000<rpm<RPMMAX	12		16	V
Vov	D+ Drivers Disable Threshold	Voltage on pin A+ to have D+ OFF	18		22	V
Tj-sd	Thermal Shut-down	D+/DF = OFF STATE	180	200	220	ºC
Tj-sd-hys	Thermal Shut-down hysteresis	D+/DF from OFF STATE (due to thermal shutdown) to ON STATE	Tj-sd-2		Tj-sd-10	ºC
Vuv	Low voltage detection threshold	D+ low side driver ON after diagnosis delay time	7.7	8.6	9.5	V
Vuv-hys	Low voltage detection threshold hysteresis	D+ low side driver OFF without delay	Vuv + 0.40	Vuv + 0.50	Vuv + 0.60	V
Ron LSD	Low Side Driver Rdson	T = 150ºC; I = 4.5A			189	mΩ
Ron LSD	Low Side Driver Rdson	T = 25ºC; I = 7A			107	mOhm
Vf	Freewheeling diode DF	I=5A			2	V
If_SCTH	Short Circuit Threshold DF	DF = 12V; Tcase = -40ºC	11		18	A
		DF = 12V; Tcase = -25ºC	8.5		18	A
		DF = 12V; Tcase = -150ºC	5.5		18	A
Vs1	Output Short to GROUND DF Threshold		2.1		3.9	V
FS_duty	Pre-excitation F.S.D.F.	f = 333Hz +/- 15%	15.93	18.75	21.57	%

ELECTRICAL CHARACTERISTCS (continued)

(T_{case} = -40ºC ÷ 150ºC; unless otherwise specified)

Symbol	Parameter	Test Condition	Min.	Typ.	Max	Unit
t_ST	Soft Start Delay Time (see fig. 5)	activated always at engine start		0		s
t_SL	Soft Attack Time / Soft Start Time (see fig. 5)	from 0 to 100% field duty cycle	2.45	3	3.45	s
BI	Soft Attack Blind Zone	percentage of maximum duty cycle immediate variation at soft attack	0		10	%
t-rise	Output Voltage Rise Time	Ifield = 3A resistive (Fig. 6)	4		50	µs
t_fall	Output Voltage Fall Time	Ifield = 3A resistive (Fig. 6)	5		50	µs
If_leak	Output Field Driver Leakage Current	DF = 24V			1	mA
VH_SAT	High Side Driver Saturation Voltage (Fig. 9)	I source = 1A			1.2	V
VL_SAT1	Low Side Driver Saturation Voltage	I sink = 0.5A			2	V
VL_SAT2	Low Side Driver Saturation Voltage	I sink = 0.3A			1.5	V
VLSB	Selfbias without supply Lamp driver Voltage				4	V
IHSC	High Side Driver short circuit current (Fig. 9)	A+ = 17.5V; D+ = GND	1.2		3	A
ILSC	Low Side Driver short circuit current	A+ = D+ = 17.5V	0.7		2.5	A
VthD+	Enable Regulator Voltage D+		0.5	0.7	0.9	V
IthD+	Enable Regulator pull-down Current D+		0.4		3.5	mA
L-t-D	Lamp on delay at Ign. switch turn on	(Fig. 7)			2	ms
Vcan	Test mode to cancel soft start/ attack (voltage)	(Fig. 8)	36		44	V
VPHL1	Enable control voltage input high threshold	square wave f = 1KHz	0.67	0.795	0.92	V
t_PH	PH Filtering Time		50		200	µs
VPHH1	Diagnosis phase loss input high threshold		9	10.25	11.5	V
VPHH2	Diagnosis phase loss input low threshold	guaranteed by design	4	5	6	V
tPHd	Diagnostic PH Filtering Time	guaranteed by design	50		200	µs
I_Th-PH	Phase Pull-down Current		1		8	mA

ELECTRICAL CHARACTERISTCS (continued)

(T_{case} = -40ºC ÷ 150ºC; unless otherwise specified)

Symbol	Parameter	Test Condition	Min.	Typ.	Max	Unit
EN	Soft start enable frequency range	Tcase = 25ºC Tcase = -40 to150ºC	144 136	160 160	176 184	Hz Hz
f_RESS_SS	Reset frequency range to enable soft start		40	50	60	Hz
DISAB	Soft start enable frequency range	Tcase = 25ºC Tcase = -40 to150ºC	367 347	408 408	449 469	Hz Hz
f-dfm	Output open drain switching freq.	preexc. mode; Isink=14mA	30		400	Hz
VL-DF-MON	Output low voltage saturation	I-sink=14mA			1.5	V
I-DF-MON	Short circuit current protection	V-DF-MON=24V field fully on	15		120	mA
Ilk-DF-MON	Output leakage current	V-DF-MON=24V field off			0.1	mA
t-TM	Output voltage rise time	R=2.7K Ohm; C=1nF; Valim=13.5V (Fig. 6)	0.05		50	us
t-TD	Output voltage fall time	R=2.7K Ohm; C=1nF; Valim=13.5V (Fig. 6)	0.05		50	us
t-D	Diagnostic Alarm Delay Time		0.15		0.5	s

Figure 1. DF Monitor Electrical configuration
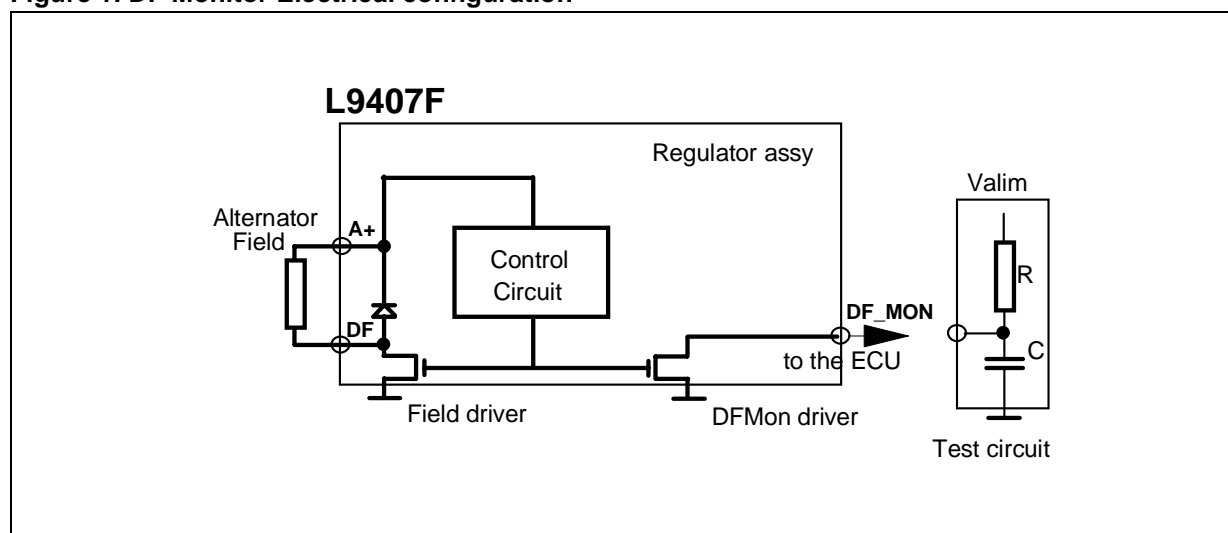
Figure 2. Application Diagram
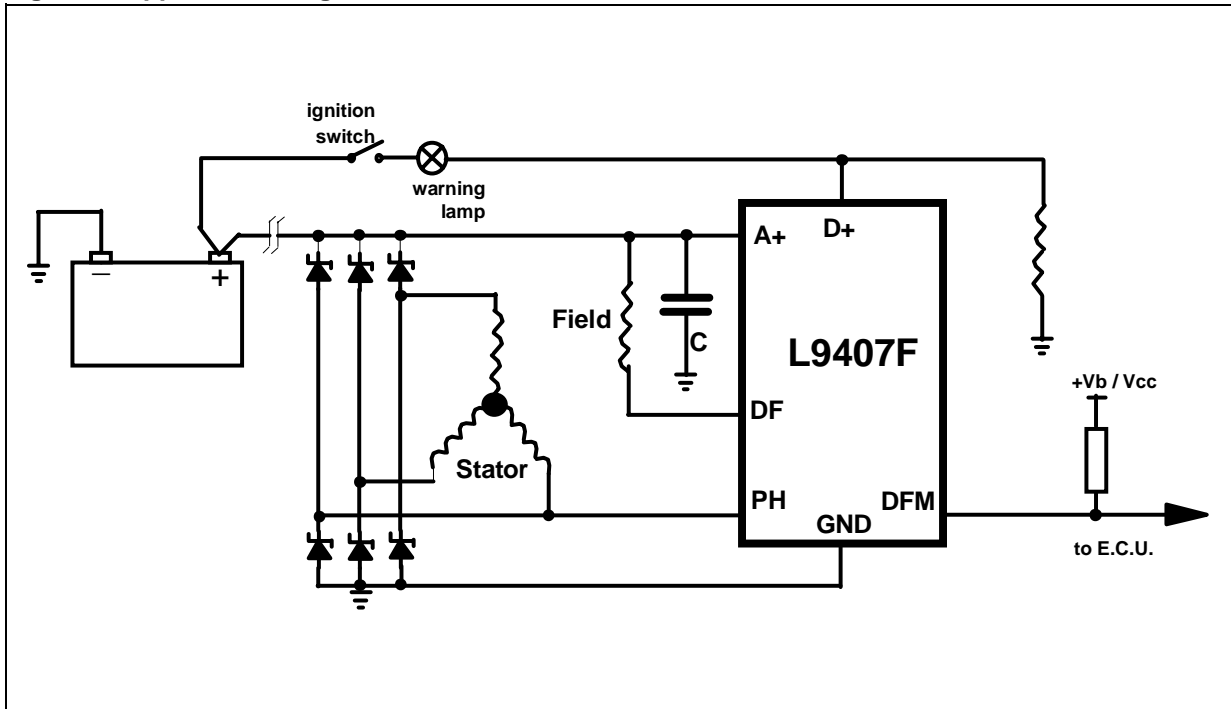
Figure 3. L9407F THERMAL COMPENSATION (Vreg.)
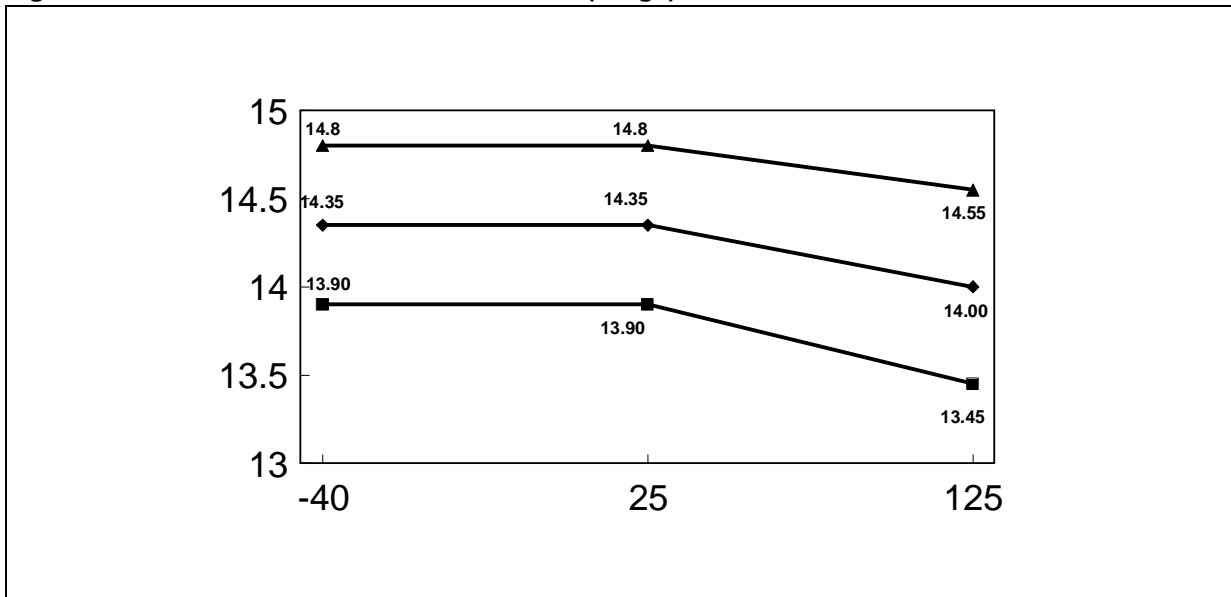
Figure 4. Characteristics (Active always at engine start)
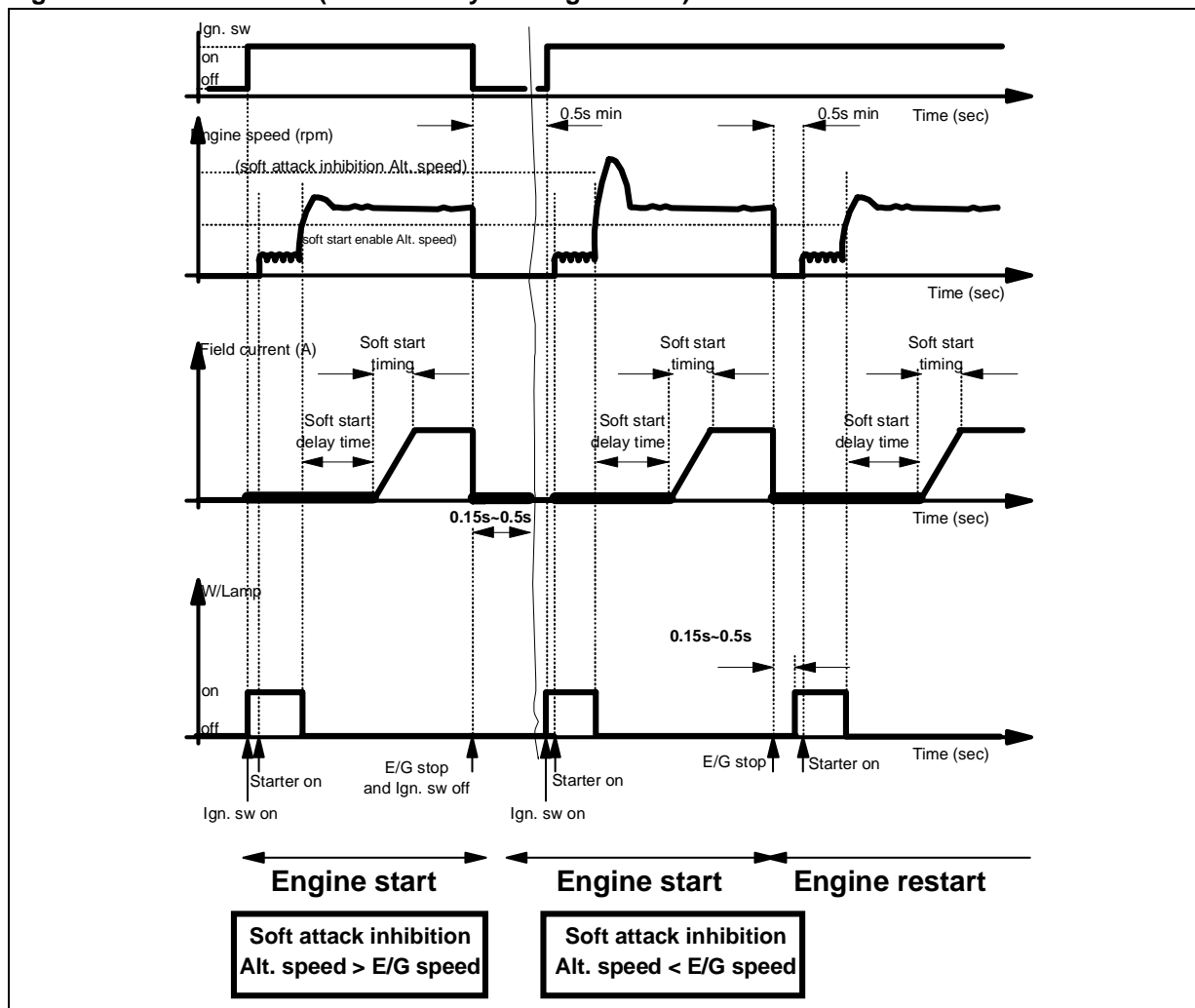
Figure 5. Soft Start/attack Characteristics
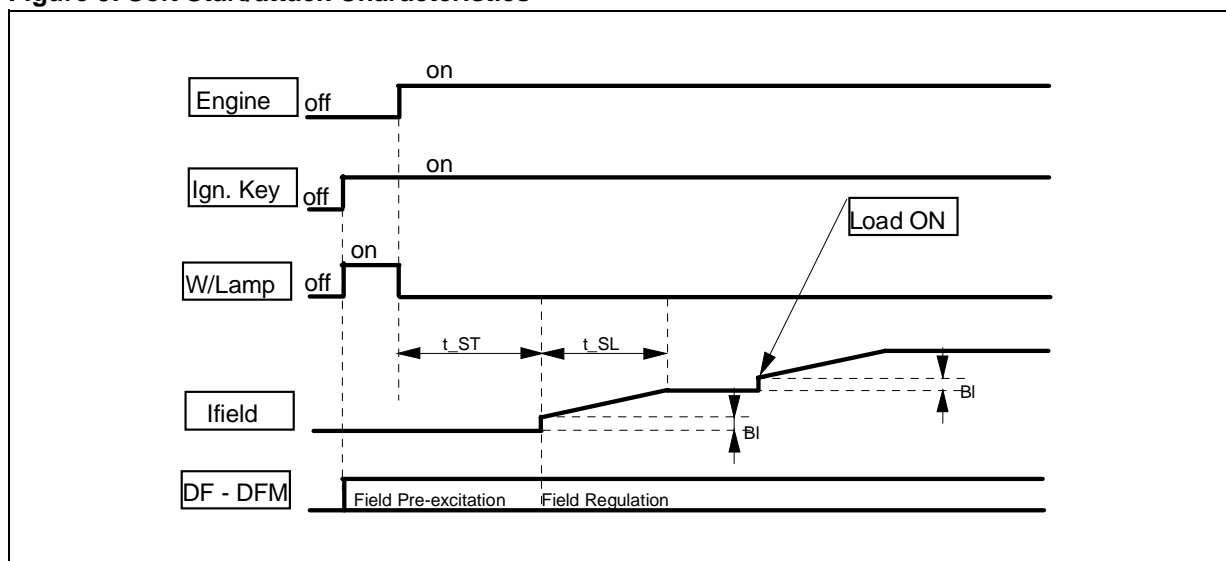
Table 1. FAULT DETECTION TABLE

Root Cause	Signal	Effect	Test detect
Alternator belt breaking	PH	Alternator disexcitation	VPH<VPHH & VA+<Vreg
Brushes open	PH	Alternator disexcitation	VPH<VPHH & VA+<Vreg
Driver Open	PH	Alternator disexcitation	VPH<VPHH & VA+<Vreg
Field interruption	PH	Alternator disexcitation	VPH<VPHH & VA+<Vreg
Field short circuit to the battery	PH	Alternator disexcitation	VPH<VPHH & VA+<Vreg
Field short circuit to the ground	DF	Overvoltage	DF<VS1 & VA+>Vreg
Battery discharge (Field Driver open)	A+	Undervoltage	VA+<Vreg
No fully excited	A+	Undervoltage	VA+<Vuv
Battery discharge	A+	Undervoltage	VA+<Vuv

The diagnostic result is disabled during the Soft-start delay time t_ST and the soft-start / soft attack timing t_SL

Figure 6. Output Voltage rise/fall time (DF, DF_MON)
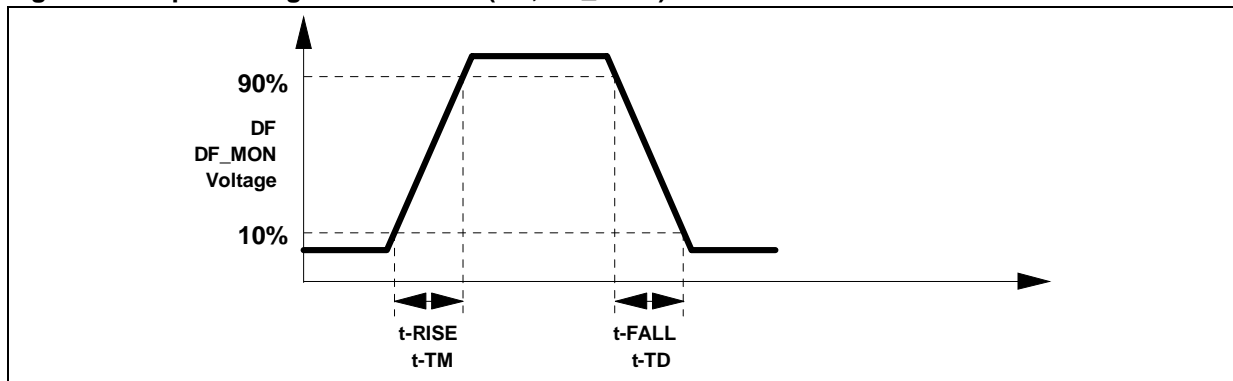
Figure 7. Lamp on delay at Ign. switch turn on
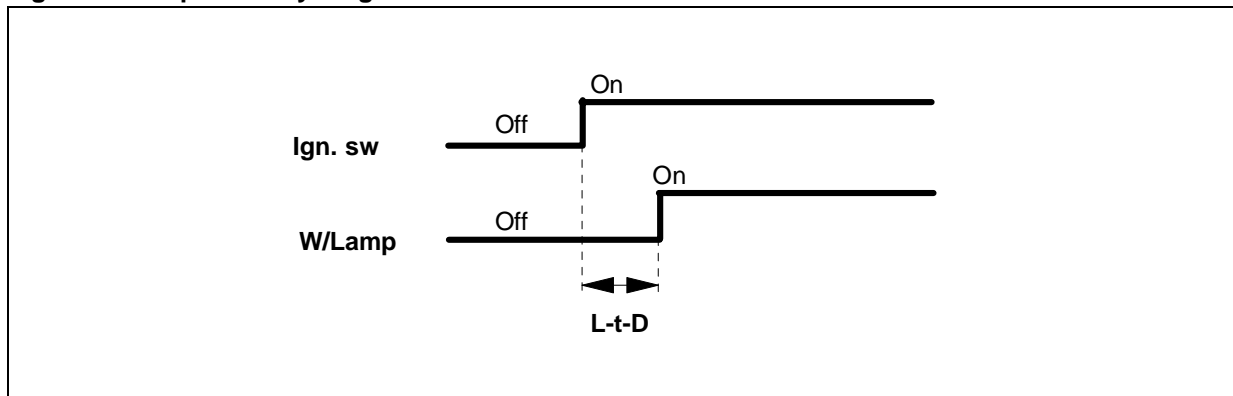
Figure 8. Test mode to cancel soft start/attack
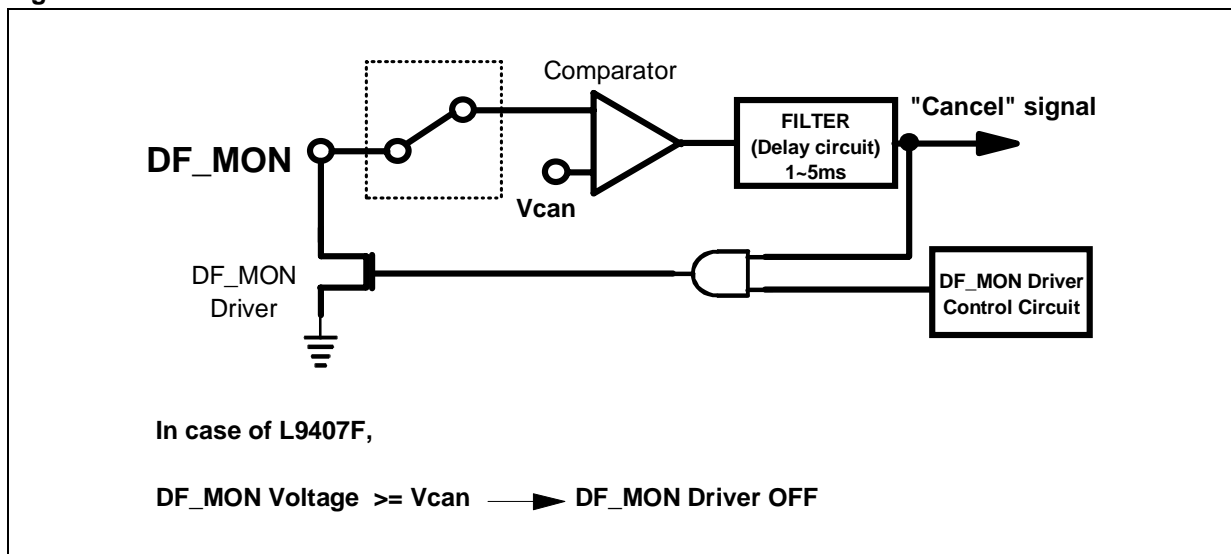
Figure 9. High Side driver saturation voltage
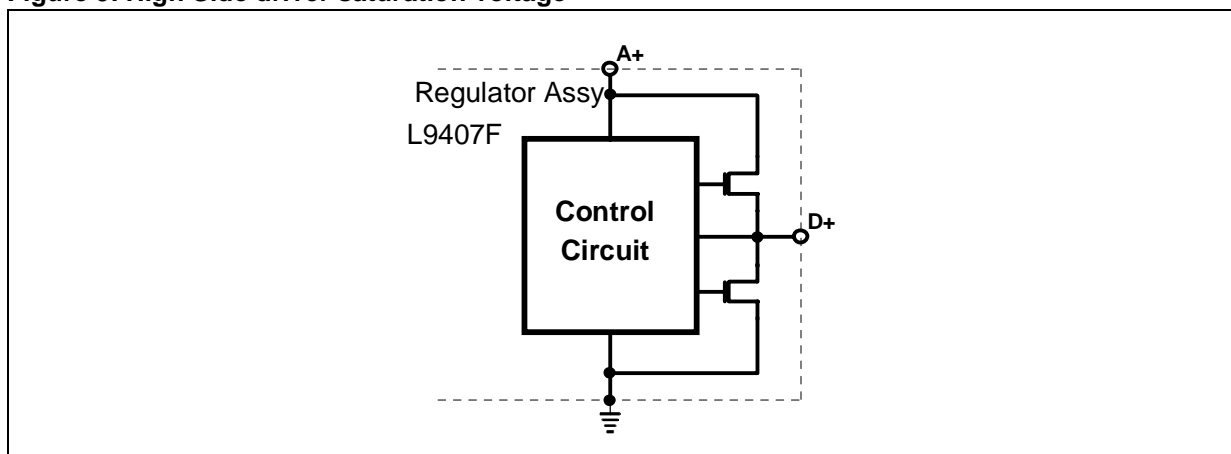
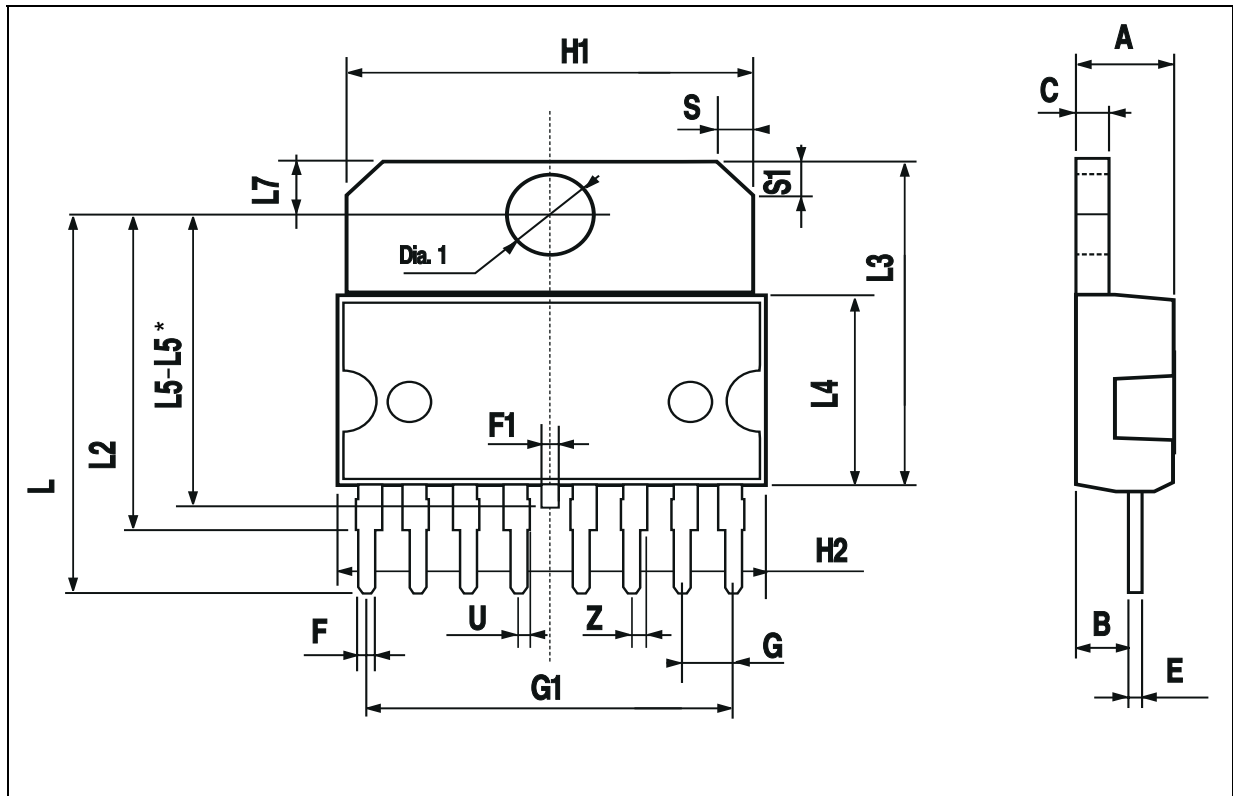| DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
E	0.49		0.55	0.019		0.022
F	0.78		0.85	0.030		0.033
F1	0.68		0.75	0.027		0.029
G	2.40	2.54	2.68	0.094	0.10	0.105
G1	17.64	17.78	17.92	0.69	0.70	0.71
H1	19.6			0.772		
H2			20.2			0.795
L	20.35		20.65	0.80		0.81
L2	17.05	17.20	17.35	0.67	0.68	0.68
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L5 L5*	15.45 15.05		15.75 15.35	0.61 0.59		0.62 0.60
L7	2.65		2.9	0.104		0.114
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
U	0.40		0.55	0.015		0.022
Z	0.70		0.85	0.028		0.034
Dia1	3.65		3.85	0.144		0.152

L5 = with wedged frame std.
L5* = with wedged frame anchor holes.

**OUTLINE AND
MECHANICAL DATA**

Multiwatt8 (Floating)