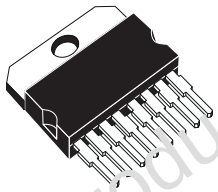
L9407F

Car alternator voltage regulator

Preliminary Data

Features

- 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)



Multiwatt8

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.

Table 1. Device summary

Order code	Package	Packing
L9407F	Multiwatt8	Tube

Contents

1 Functional description

1.1 Circuit operation

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

- voltage regulation
- protection
- control fault diagnosis
- load response control

1.2 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 behavior 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 (2.2µF or 2.7µF) must be inserted between A+ and ground when using the device with very long cables.

1.3 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.

1.4 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 delayed by a fixed time.

1.5 Load response control

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

2 Pin description

Figure 1. Pin connection (top view)

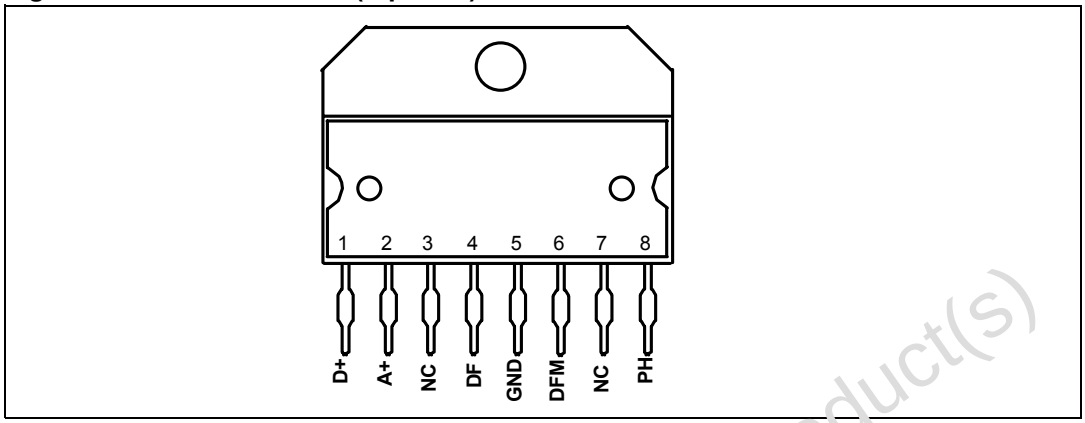


Table 2. Pin description

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

3 Electrical specification

3.1 Absolute maximum ratings

Table 3. 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 *Figure 3: Application diagram* t<500ms	40	V
	Transient supply voltage (low energy spikes) [see *Figure 3: Application diagram*] 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 (@ T_{case} = 150°C, I_{field} = 5A)	8	W
	Reverse voltage (see *Figure 3: 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

3.2 Thermal data

Table 4. Thermal data

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

3.3 Electrical characteristics

Table 5. Electrical characteristics

(T_{case} = -40°C to 150°C; unless otherwise specified)

Symbol	Parameter	Test condition	Min.	Typ.	Max	Unit
V_{bat}	Operating supply voltage		6		18	V
$I_{b\text{-}sinked}$	Supply battery current				50	mA
$I_{b\text{-}stby}$	Standby current	Vbat = A+, DF = 12.5V			500	µA
V_{reg}	Regulated voltage and thermal drift	Ialt=1A-0.9*Inom; T_{case}=20°C; 1200<rpm<RPMMAX; V_{reg} clamped at 14.8V Max. (See *Figure 4*)	13.9 -4.5	14.35 -3.5	14.8 -2.5	V mV/°C
f_{sw}	Switching frequency	pre-excitation	30		400	Hz

Table 5. Electrical characteristics (continued)
(T_{case} = -40°C to 150°C; unless otherwise specified)

Symbol	Parameter	Test condition	Min.	Typ.	Max	Unit
	Delta Vrpm	1500<rpm<RPMMAX; Ialt=5A; Tcase=23°C			200	mV
	Delta Vload	5A<Ialt<Inom; rpm=6000rpm; Tcase=23°C			250	mV
V_{reg}	Regulated voltage without battery	Ialt = 3A resistive; Tcase=25°; 2000<rpm<RPMMAX	12		16	V
V_{ov}	D+ drivers disable threshold	Voltage on pin A+ to have D+ OFF	18		22	V
T_{j-sd}	Thermal shut-down	D+/DF = OFF STATE	180	200	220	°C
$T_{j-sd-hys}$	Thermal shut-down hysteresis	D+/DF from OFF STATE (due to thermal shutdown) to ON STATE	Tj-sd-2		Tj-sd-10	°C
V_{uv}	Low voltage detection threshold	D+ low side driver ON after diagnosis delay time	7.7	8.6	9.5	V
V_{uv-hys}	Low voltage detection threshold hysteresis	D+ low side driver OFF without delay	Vuv + 0.40	Vuv + 0.50	Vuv + 0.60	V
$R_{on\ LSD}$	Low side driver R_{dson}	T = 150°C; I = 4.5A			189	mΩ
		T = 25°C; I = 7A			107	mOhm
V_f	Freewheeling diode DF	I=5A			2	V
I_{f_SCTH}	Short circuit threshold DF	DF = 12V; T_{case} = -40°C	11		18	A
		DF = 12V; T_{case} = -25°C	8.5		18	A
		DF = 12V; T_{case} = -150°C	5.5		18	A
V_{s1}	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	%
t_ST	Soft start delay time (See *Figure 6*)	activated always at engine start		0		s
t_SL	Soft attack time / soft start time (See *Figure 6*)	from 0 to 100% field duty cycle	2.45	3	3.45	s
Bl	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 (See *Figure 7*)	4		50	µs
t_fall	Output voltage fall time	Ifield = 3A resistive (See *Figure 7*)	5		50	µs
If_leak	Output field driver leakage current	DF = 24V			1	mA
VH_SAT	High side driver saturation voltage (See *Figure 10*)	I_{source} = 1A			1.2	V

Table 5. Electrical characteristics (continued)
(T_{case} = -40°C to 150°C; unless otherwise specified)

Symbol	Parameter	Test condition	Min.	Typ.	Max	Unit
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 (See *Figure 10*)	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	(See *Figure 8*)			2	ms
Vcan	Test mode to cancel soft start/attack (voltage)	(See *Figure 9*)	36		44	V
VPHL1	Enable control voltage input high threshold	square wave f = 1 kHz	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
EN	Soft start enable frequency range	T_{case} = 25°C T_{case} = -40 to150°C	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	T_{case} = 25°C T_{case} = -40 to150°C	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

Table 5. Electrical characteristics (continued)
(T_{case} = -40°C to 150°C; unless otherwise specified)

Symbol	Parameter	Test condition	Min.	Typ.	Max	Unit
t-TM	Output voltage rise time	R = 2.7 KOhm; C=1nF; Valim =13.5V (See *Figure 7*)	0.05		50	µs
t-TD	Output voltage fall time	R=2.7K Ohm; C=1nF; Valim = 13.5V (See *Figure 7*)	0.05		50	µs
t-D	Diagnostic alarm delay time		0.15		0.5	s

Figure 2. DF monitor electrical configuration

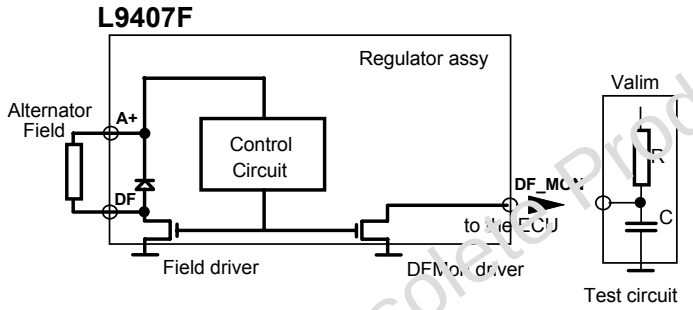


Figure 3. Application diagram

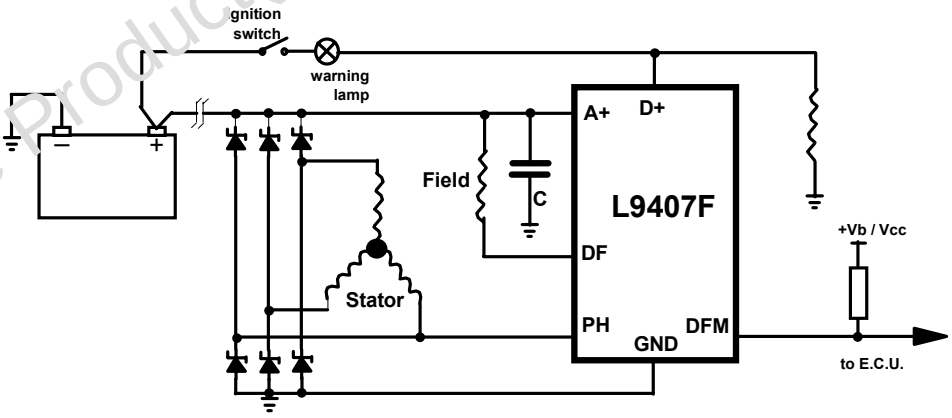


Figure 4. Thermal compensation (Vreg.)

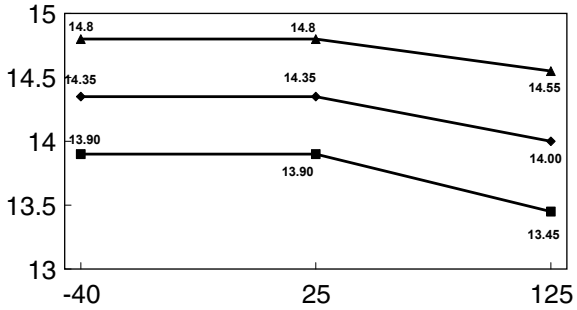


Figure 5. Characteristics (Active always at engine start)

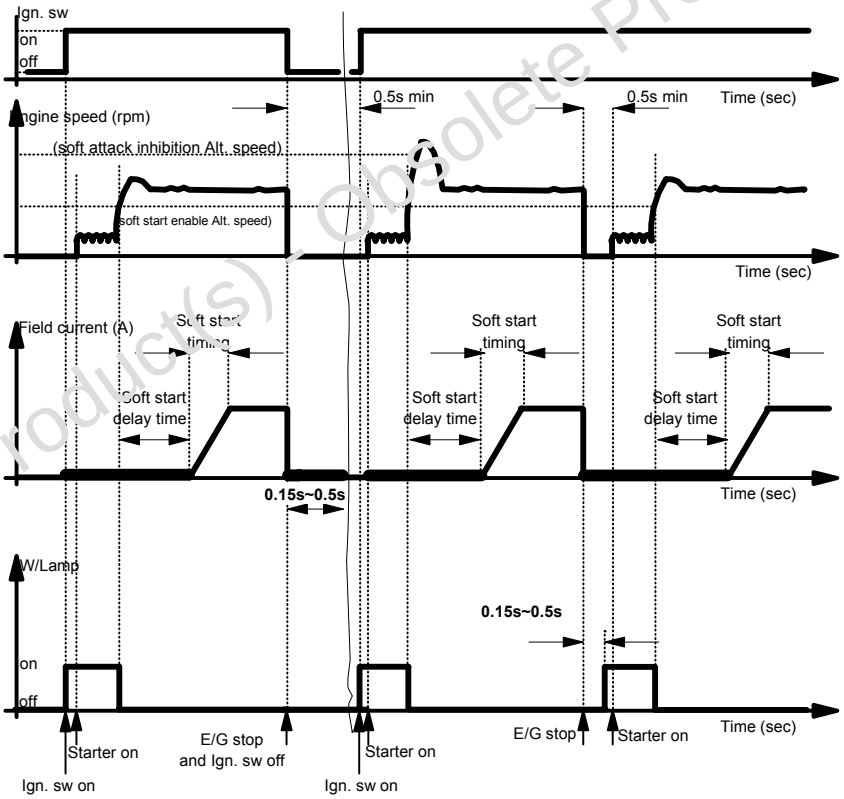


Figure 6. Soft start/attack characteristics

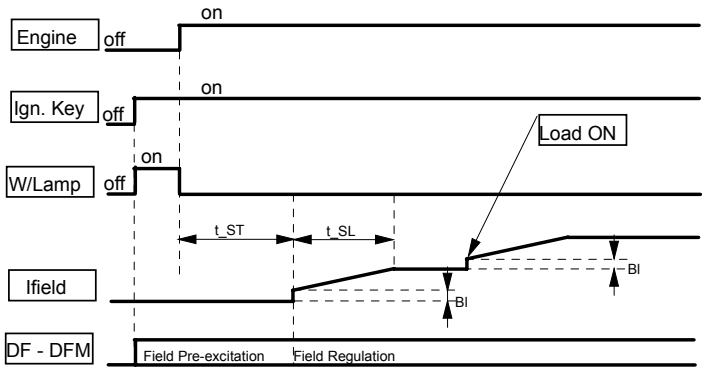


Table 6. Fault detection

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
Not 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 7. Output voltage rise/fall time (DF, DF_MON)

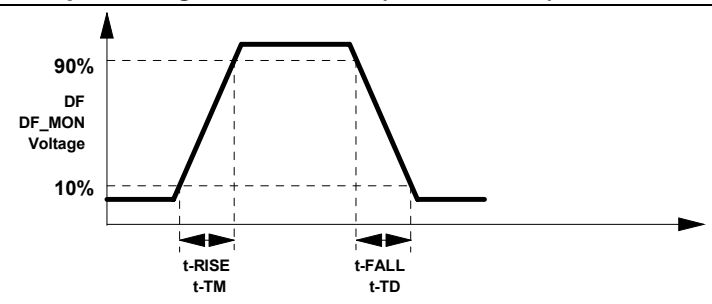


Figure 8. Lamp on delay at Ign. switch turn on

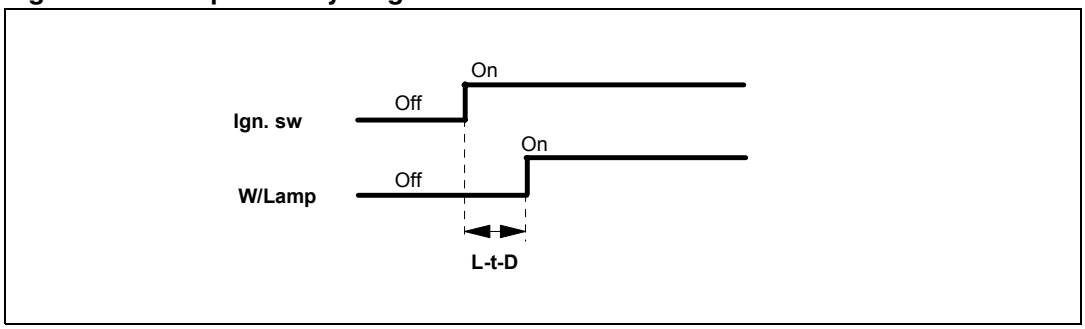


Figure 9. Test mode to cancel soft start/attack

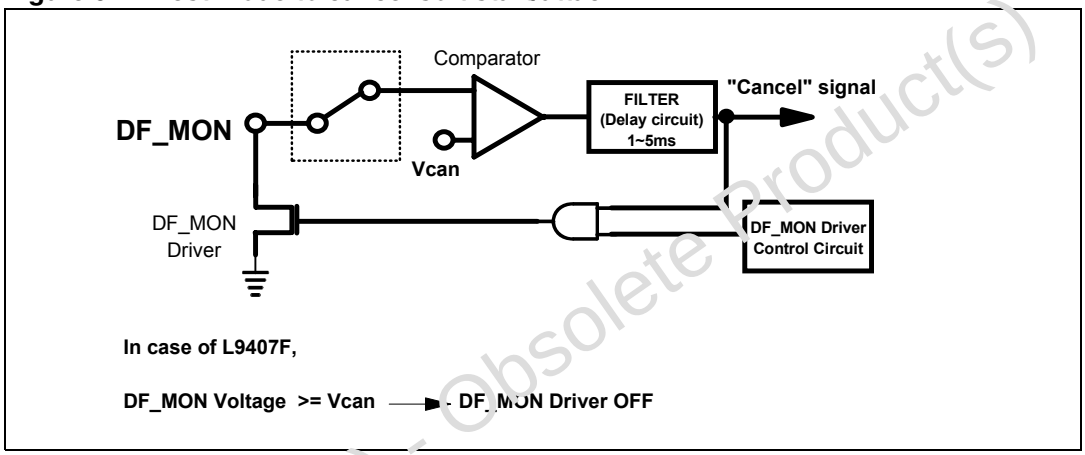
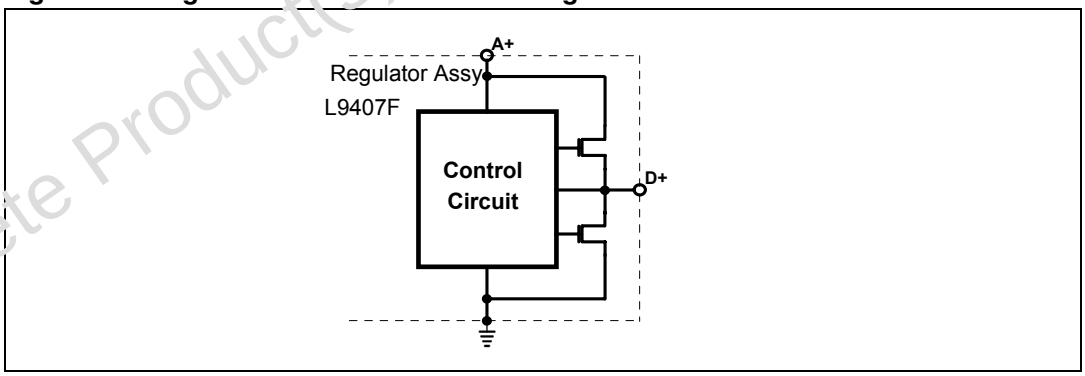


Figure 10. High side driver saturation voltage



4 Package information

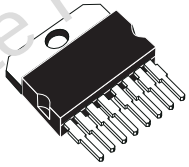
In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, incompliance with JEDEC Standard JESD97. The maximum ratings related to solderingconditions are also marked on the inner box label. ECOPACK is an ST trademark.ECOPACK specifications are available at www.st.com.

Figure 11. Multiwatt8 mechanical data and package dimensions

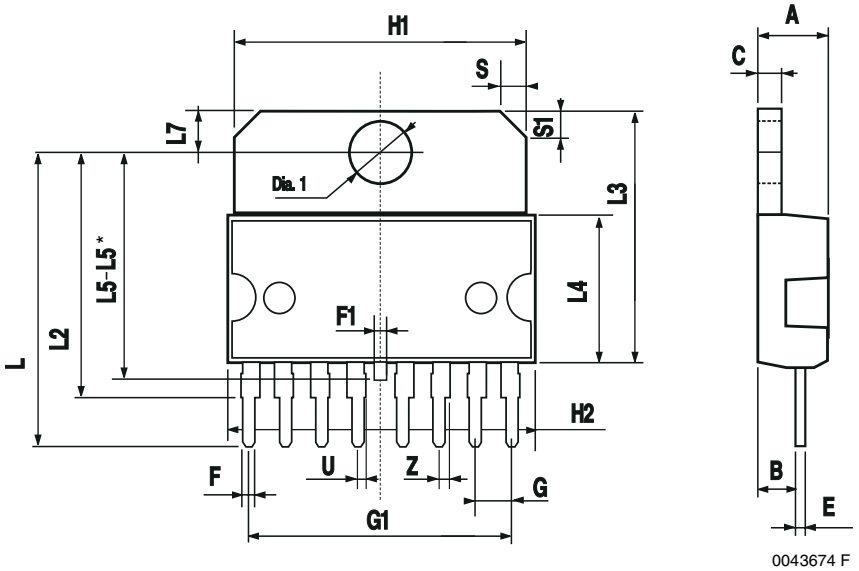
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
E	0.49		0.55	0.019		0.022
F	0.78		0.85	0.030		0.033
F1	0.68		0.75	0.027		0.029
G	2.40	2.54	2.68	0.094	0.10	0.105
G1	17.64	17.78	17.92	0.69	0.70	0.71
H1	19.6			0.772		
H2			20.2			0.795
L	20.35		20.65	0.80		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	15.45		15.75	0.61		0.62
L5*	15.05		15.35	0.59		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	3.85		3.85	0.144		0.152

L5 = with welded frame std.
L5* = with bridged frame anchor holes.

OUTLINE AND MECHANICAL DATA



Multiwatt8 (Floating)



5 Revision history

Table 7. Document revision history

Date	Revision	Changes
09-Sep-2004	4	Initial release.
21-Nov-2008	5	Document reformatted. Document status promoted from “product preview” to “preliminary data“. Added *Table 1: Device summary on page 1*. Updated *Section 4: Package information on page 12*.

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