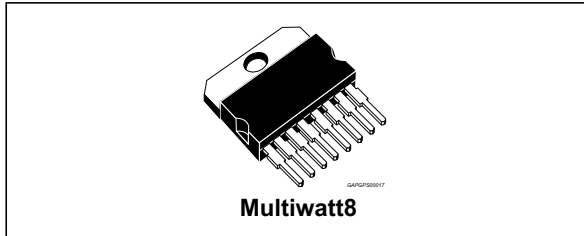


C-terminal alternator voltage regulator (CTAVR)

Datasheet - production data



Description

L9915B is a monolithic 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.

This device regulates in close loop the output of an automotive generator by controlling the field winding current by means of a pulse-width modulation (PWM) high side driver at fixed frequency.

The set-point voltage reference selected by the Engine Control Unit via C-terminal protocol is temperature flat. An internal voltage reference thermally compensated is present in the device and used when the protocol coming from ECU is absent or the wire is broken.

A self-bias circuitry is present on L pin in order to turn-on the warning lamp also when the device is not supplied (battery connection broken).

Features

- Fully monolithic design
- High side field driver
- Field short circuit protection
- Regulated voltage driven by ECU (protocol driven)
- Regulated voltage thermally compensated (without protocol)
- Lamp driver (wake up and warning detection)
- Self start function
- Load response control (LRC)
- Field monitor (FM) output
- Thermal shutdown

Table 1. Device summary

Order code	Internal thermal drift option	High frequency threshold to exit preexcitation option	Temp range, °C	Package	Packing
L9915B	VBITD	fPHPrex	T _j = -40 to +150	Multiwatt8	Tube

Contents

- 1 Functional description 5**
 - 1.1 Application schematic 5
 - 1.2 External component required 6

- 2 Pin description 7**

- 3 Electrical specification 8**
 - 3.1 Absolute maximum ratings 8
 - 3.2 Thermal data 8
 - 3.3 Electrical characteristics 9
 - 3.3.1 Pin "B" 9
 - 3.3.2 Pin "C" 11
 - 3.3.3 Pin 'FM' 13
 - 3.3.4 Pin 'PH' 13
 - 3.3.5 Pin 'F' 14
 - 3.3.6 Pin 'L' 15

- 4 Package information 17**
 - 4.1 Multiwatt 8 (pin 5 GND) package information 17

- 5 Revision history 19**

List of tables

Table 1.	Device summary	1
Table 2.	Pin description	7
Table 3.	Absolute maximum ratings	8
Table 4.	Absolute maximum ratings and operative range by pin	8
Table 5.	Thermal data	8
Table 6.	Electrical characteristics - Pin "B"	9
Table 7.	Electrical characteristics - Pin 'C'	11
Table 8.	Electrical characteristics - Pin 'FM'	13
Table 9.	Electrical characteristics - Pin 'PH'	13
Table 10.	Electrical characteristics - Pin 'F'	14
Table 11.	Electrical characteristics - Pin 'L'	15
Table 12.	TL _{alarm} validation time conditions	16
Table 13.	Multiwatt 8 (pin 5GND) package mechanical drawing	18
Table 14.	Document revision history.	19

List of figures

Figure 1. Application schematic 5
Figure 2. Pin connection (top view) 7
Figure 3. Internal regulation curves versus temperature @ F duty cycle = 15% 10
Figure 4. External regulation curve versus C duty cycle @ $T_J = 30\text{ }^\circ\text{C}$ and F duty cycle = 15%. 10
Figure 5. Cranking security function diagram. 11
Figure 6. Pin 'C' circuit and waveform 12
Figure 7. Pin 'C' terminal signal diagram 12
Figure 8. Pin 'FM' circuit and waveform. 13
Figure 9. Principle of phase regulation. 14
Figure 10. Retry time in case of over-current diagram. 16
Figure 11. Retry time in case of over-current duration > $T_{L_{OC}}$ diagram 16
Figure 12. Multiwatt 8 (pin 5GND) package outline 17

1 Functional description

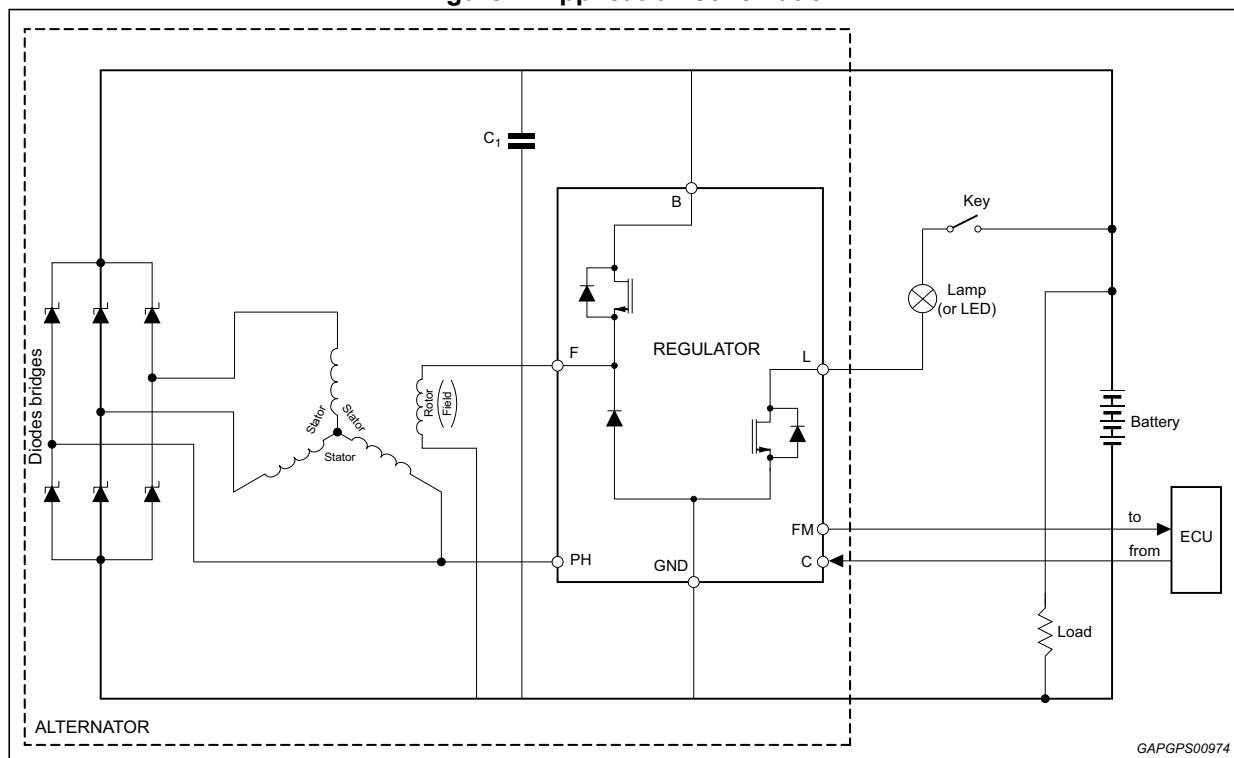
The device, supplied by the battery through B pin, remains in standby condition with low current consumption until there is no activity on the pins L, C or PH. When the switch "Key" is closed (i.e. $V_L > V_{L_{Th}}$) or the ECU communicates via C-Terminal protocol through C pin (i.e. signal freq. on C pin between 100 Hz and 500 Hz) the device exits in standby condition and goes in pre-excitation characterized by an activity on F pin with fixed frequency (f_{FSW}) and duty cycle (DF_{Prex}). The device remains in pre-excitation until the alternator does not run. When an activity is sensed on PH pin (i.e. $V_{PH} > V_{PH_{Th}}$ and $f_{PH} > f_{PH_{Prex}}$) the device starts to regulate; if the communication is present on C pin the regulator goes in external regulation mode, otherwise it goes in internal regulation mode.

Another possibility for the device to start to regulate is the self start. In this way, although there is no activity on pins L or C (for example due to connector open), if an activity is sensed on PH pin (i.e. $V_{PH} > V_{PH_{Th}}$ and $f_{PH} > f_{PH_{Prex}}$) the device goes in self start characterized by an activity on F pin with fixed frequency (f_{FSW}) and duty cycle (DF_{SS}). When the frequency on PH pin rises above $f_{P_{SS}}$ the device starts to regulate with the internal regulation mode.

The regulator stops to regulate when the frequency on PH pin falls below $f_{P_{LPrex}}$. If there is activity on L or C pins the device stays in pre-excitation otherwise comes back in standby.

1.1 Application schematic

Figure 1. Application schematic



1.2 External component required

The only component strictly required is the capacitor C1 (2.2 μ F suggested) to suppress radio frequency injection and has to be connected as near as possible to B and GND pins. Other capacitors can be used to increase the EMI performance.

2 Pin description

Figure 2. Pin connection (top view)

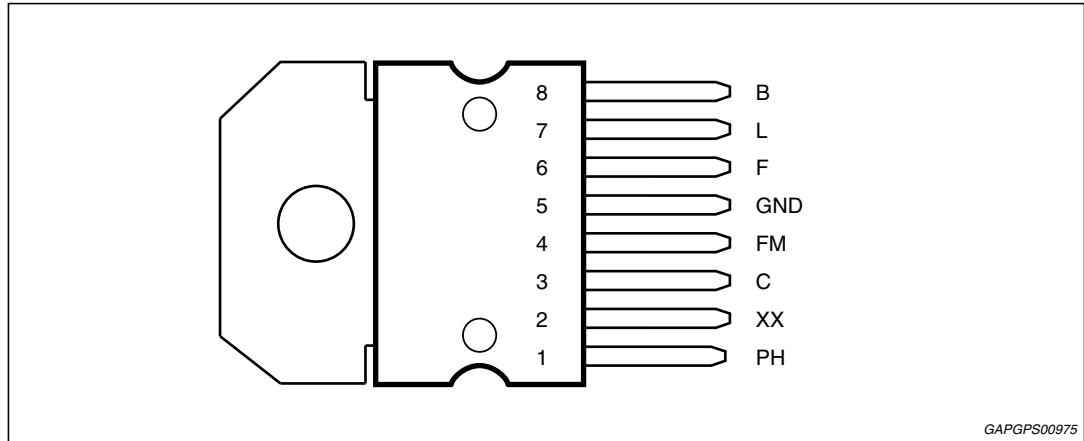


Table 2. Pin description

N°	Pin	Function
1	PH	Phase sense input
2	XX	Reserved pin (to be connected to GND)
3	C	C-Terminal (PWM signal input coming from ECU)
4	FM	Field Monitor (PWM signal going to ECU)
5	GND	Regulator ground
6	F	High side driver output to control the Field current
7	L	Key sensing and Warning Lamp terminal output
8	B	Device power supply and Battery voltage sensing

3 Electrical specification

3.1 Absolute maximum ratings

$T_j = -40$ to 150 °C, unless otherwise specified.

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
$V_{B_{MAX}}$	Transient supply voltage with 1 A and $t < 1$ ms	55	V
$V_{B_{MAX}}$	Transient supply voltage (low energy spikes) ISO7637-1 pulse 1,2,3 /ISO7637-3	55	V
T_j	Junction temperature range	-40 to 150	°C
T_{stg} , T_{case}	Storage and case temperature range	-40 to 150	°C
P_{TOT}	Total power dissipation (@ $T_{case} = 150$ °C, $I_{field} = 5$ A)	4	W
V_{BR}	Reverse battery voltage @ 25 °C, $T = 15$ s	-2.5	V
$V_{PH_{min}}$	Normal working condition reverse voltage (PH vs. GND)	-1.5	V
I_{Bond}	DC pin current on F, B, GND (bonding limitation)	15	A
ESD_{HBM}	ESD HBM (All pins vs.GND)	±4	kV

Table 4. Absolute maximum ratings and operative range by pin

Pin #	Pin name	Absolute max. rating		Operative range		Unit
		Min.	Max.	Min.	Max.	
1	PH	-15	50	-1.5	20	V
2	XX	-0.3	7	must be connected to GND		V
3	C	-0.3	50	-0.3	18	V
4	FM	-15	50	-0.3	18	V
5	GND	-	-	-	-	-
6	F	-1.5	B	-1.5	B	V
7	L	-0.3	50	-0.3	18	V
8	B	-2.5	50	6	18	V

3.2 Thermal data

Table 5. Thermal data

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
$R_{th_{j-case}}$	Thermal resistance junction-to-case	Related to MW8	-	-	1.5	°C/W
T_{j-sd}	Thermal shutdown threshold	Temperature to disable F, FM, L drivers.	160	175	190	°C
T_{j-sdhy}	Thermal shut-down hysteresis	L, F, FM from OFF STATE (due to thermal shutdown) to ON STATE	T_{j-sd} -10	-	T_{j-sd} -2	°C

3.3 Electrical characteristics

3.3.1 Pin “B”

Table 6. Electrical characteristics - Pin “B”

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
VB _{OVr}	Operating voltage range	-	6	-	18	V
IB _{stby}	Standby current consumption	VB = 12.5 V; VPH = 0; VL = 0 V; C pin floating; T = -40 °C	250	-	350	μA
IB _{stby}	Standby current consumption		200	-	300	μA
IB _{stby}	Standby current consumption	VB = 12.5 V; VPH = 0; VL = 0 V; C pin floating; T = 130 °C	150	-	250	μA
VB _{ISP}	Internal mode set-point voltage	VPH = 10 Vpp square wave; L pin connected to B pin with 100 Ω; C floating @ T _j = 30 °C F duty cycle = 15%	14.37	14.55	14.73	V
VB _{ITD}	Internal thermal drift	-	-5	-7	-9	mV/°C
VB _{ESP}	External mode set-point voltage	VPH = 10 Vpp square wave; L pin connected to B pin with 100 Ω; C 73% PWM duty cycle @ T _j = 30 °C; F duty cycle = 15%	14.37	14.55	14.73	V
VB _{ESP10}	External mode set-point voltage (duty cycle on C = 10%)	VPH = 10 Vpp square wave; L pin connected to B pin with 100 Ω; C 10 % PWM duty cycle @ T _j = 30 °C; F duty cycle = 15 %	11.5	11.7	11.9	V
VB _{ESP90}	External mode set-point voltage (duty cycle on C = 90%)	VPH=10 Vpp square wave; L pin connected to B pin with 100 Ω; C 90 % PWM duty cycle @ T _j = 30 °C; F duty cycle = 15 %	15.1	15.3	15.5	V
VB _{ETD}	External thermal drift	-	-1	0	1	mV/°C
VB _{DESP}	Default external mode set-point voltage	VPH=10Vpp square wave; L pin connected to B pin with 100 Ω; C <2% or >98% PWM duty cycle @ T _j = 30 °C; F duty cycle = 15 %	14.37	14.55	14.73	V
VB _{DETD}	Default external thermal drift	-	-1	0	1	mV/°C
ΔVB _{load}	Regulated voltage variation with the load (for both int./ext. regulation)	Difference between regulated voltage when F duty cycle is 5% and regulated voltage when F duty cycle is 95%	-	-	300	mV
VB _{wb}	Regulation without battery	N. A.	10	-	16	V
VB _{IntOvp}	Internal mode over-voltage protections threshold	Without ECU communication	15.5	16.2	16.9	V
VB _{ExtOvp}	External mode over-voltage protections threshold	With ECU communication	16.5	17.2	17.9	V

Table 6. Electrical characteristics - Pin "B" (continued)

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
$V_{B_{UV}}$	Under voltage	See note (1)	8.5	9.5	10.5	V
$V_{B_{low}}$	Low Voltage	See note (1)	6	6.5	7	V

1. In order to avoid unpredictable regulation regions during the engine start, the regulator implements a cranking security function.

Figure 3. Internal regulation curves versus temperature @ F duty cycle = 15%

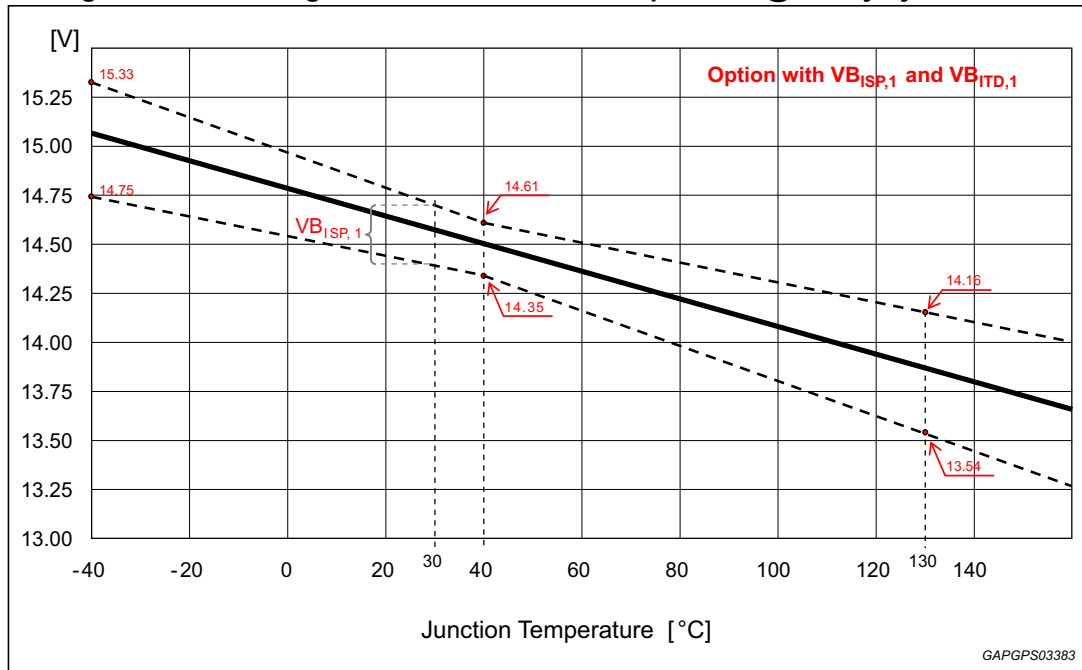
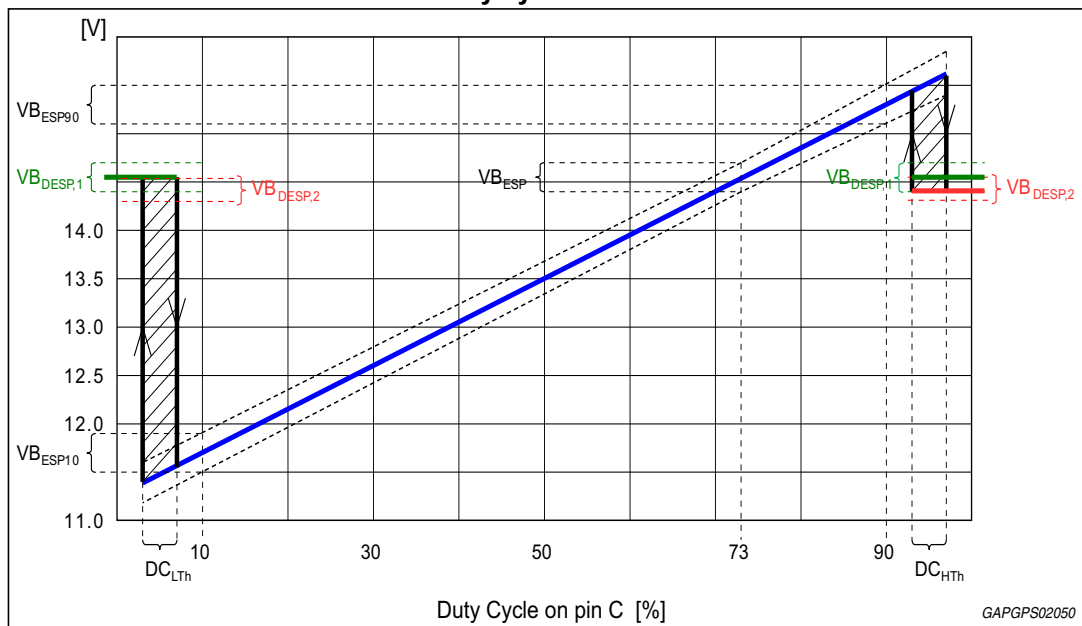
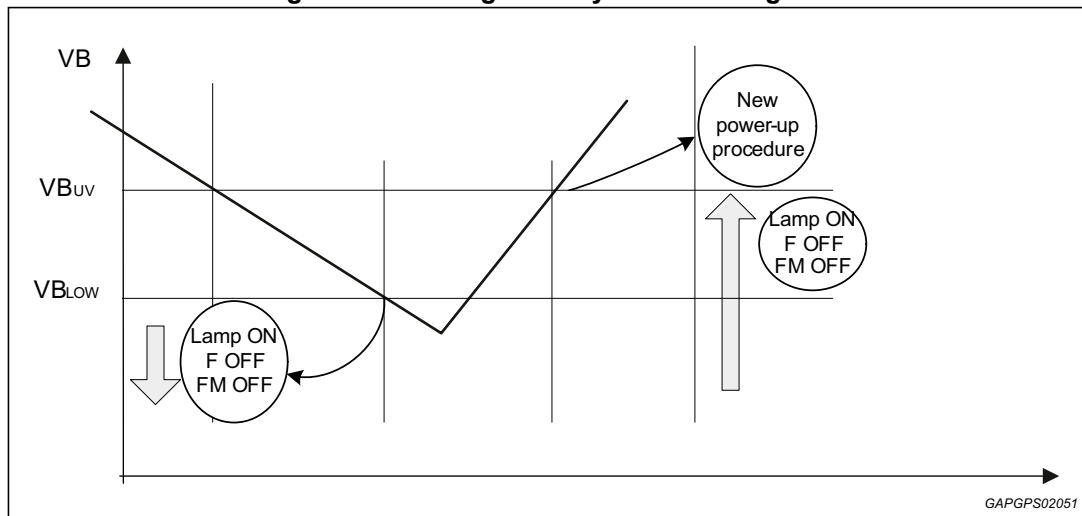


Figure 4. External regulation curve versus C duty cycle @ $T_J = 30^\circ\text{C}$ and F duty cycle = 15%



Cranking security function

Figure 5. Cranking security function diagram



At the ignition key on the device (i.e. "key" switch closed in the application schematic) starts in pre-excitation; in this phase the battery voltage is over both VBUV and VLOW and the pin F provides a fixed duty cycle. When the starter is engaged, the battery sources a big current and then the applied voltage on the device decreases, as reported in ISO 7637-1 pulse 4 specification. If the voltage on pin B decreases under VLOW threshold then the device is frozen: the device is in low current consumption with no activity on both F and FM pins, only the L pin is able to turn on the lamp.

The device remains in frozen condition until the voltage on B overcomes the VBUV threshold, after that, the device is able again to evaluate the inputs coming from both PH and C pins.

3.3.2 Pin "C"

Table 7. Electrical characteristics - Pin 'C'

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
VC _{IRPS}	Internal regulated power supply	-	6.2	6.8	7.3	V
RC _{pu}	Pull-up resistor	-	1.75	3.5	5.7	kΩ
VC _{HTh}	High level threshold voltage	-	3.1	3.3	3.5	V
VC _{LTh}	Low level threshold voltage	-	1.3	1.5	1.7	V
fC _{VR}	Valid frequency range	-	100	-	500	Hz
fC _{LNVR}	Low not valid frequency range	-	-	-	74	Hz
fC _{LNVR}	High not valid frequency range	-	676	-	-	Hz
TC _{delay}	Delay time to switch from external to Internal regulation	-	30	50	100	ms
DC _{EDCR}	External duty cycle range	-	7	-	93	%

Table 7. Electrical characteristics - Pin 'C'

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
DC _{LTh}	Low default/external regions transition threshold	-	3	5	7	%
DC _{HTh}	High default/external regions transition threshold	-	93	95	97	%
TC _{MIN}	Communication rejected with T _{ON} or T _{OFF} < TC _{MIN}	-	15	20	40	µs

Figure 6. Pin 'C' circuit and waveform

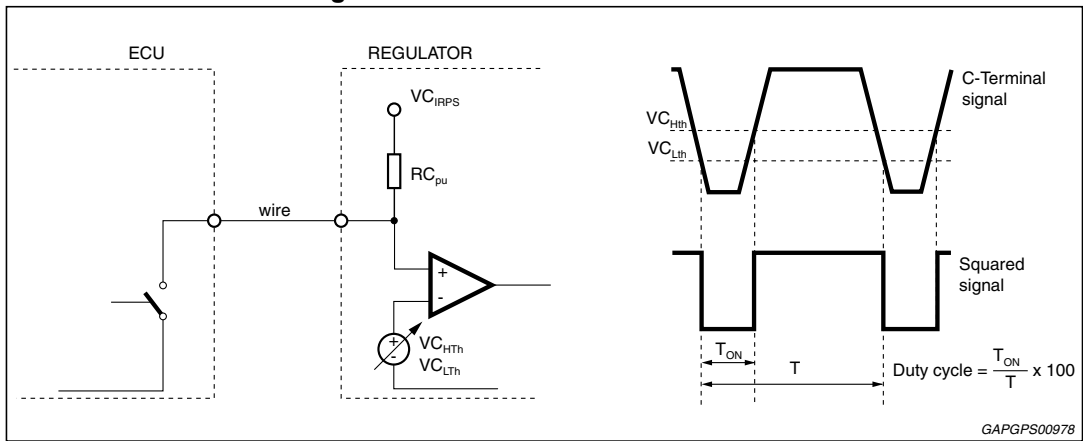
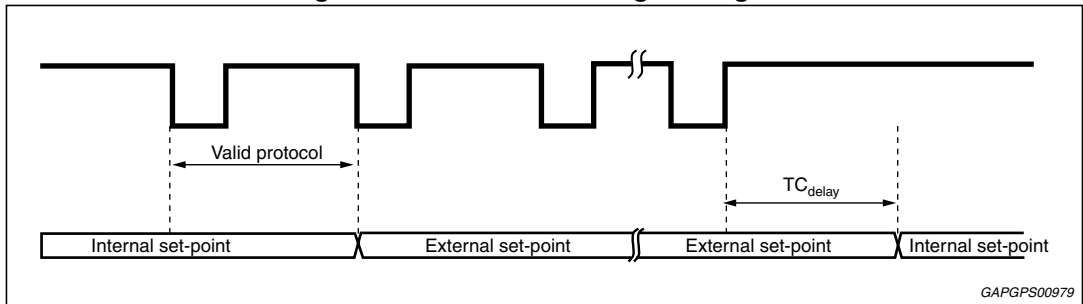


Figure 7. Pin 'C' terminal signal diagram

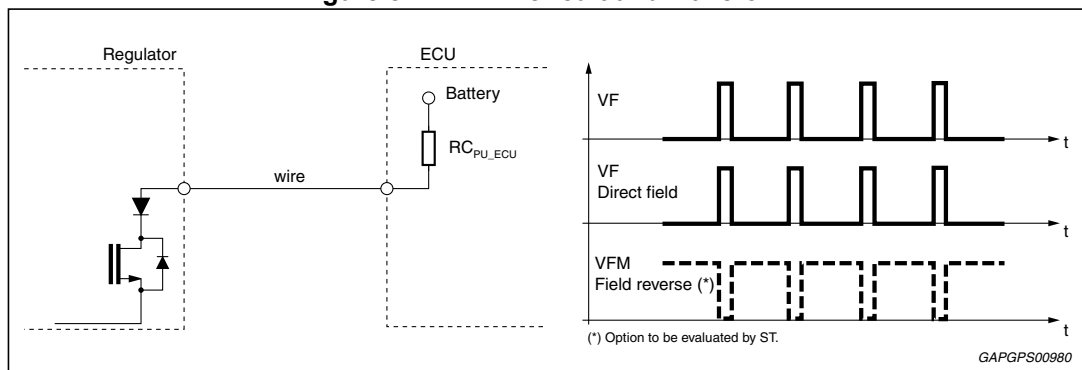


3.3.3 Pin 'FM'

Table 8. Electrical characteristics - Pin 'FM'

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
VM _{LVS}	Low voltage saturation	I-sink = 7 mA	0.9	1.2	1.5	V
fM _{SW}	Field monitor frequency switch option	Direct field	212.5	250	287.5	Hz
DM _{DCR}	Field monitor duty cycle range	-	5	-	95	%
IM _{lim}	Field monitor current limitation	-	25	50	75	mA

Figure 8. Pin 'FM' circuit and waveform



3.3.4 Pin 'PH'

Table 9. Electrical characteristics - Pin 'PH'

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
VP _{HTh}	High voltage threshold of hysteresis input buffer	-	300	375	450	mV
VP _{LTh}	Low voltage threshold of hysteresis input buffer	-	225	275	325	mV
RP _{pd}	Pull-down resistor	-	7	15	22	kΩ
TP _{SR}	Spike rejection time	-	70	125	180	μs
IP _{pull-dw}	Pull-down current	-	1.5	2	3.5	mA
fP _{HPrex}	High frequency threshold to exit pre-excitation	-	102	120	138	Hz
fP _{HYS}	Frequency hysteresis	-	10	20	30	Hz
fP _{LPrex}	Low frequency threshold to enter pre-excitation	-	fP _{HPrex} - fP _{HYS}			Hz

Table 9. Electrical characteristics - Pin 'PH' (continued)

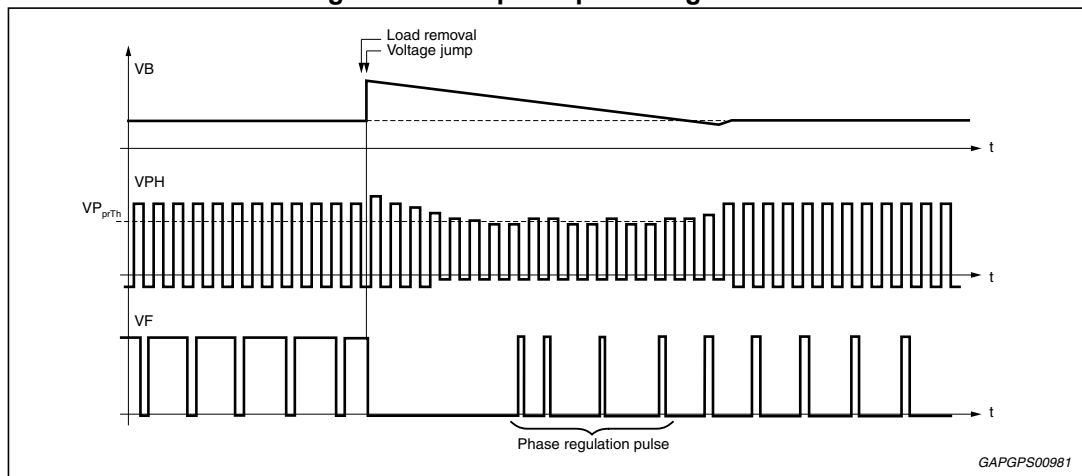
Symbol	Parameter	Test condition	Min	Typ	Max	Unit
f _{SS}	Self start frequency threshold	-	255	300	345	Hz
f _{LRC}	Frequency threshold to exit/enter in LRC		238	280	322	Hz
V _{prTh}	Phase regulation voltage threshold	-	6.7	7.7	8.7	V

To convert phase frequency (Hz) to rotation speed (rpm) according to alternator poles pair number (N), use the following equation: rotation speed (rpm) = phase frequency (Hz) * 60 / N.

Principle of phase regulation

When VB is above the set-point voltage, the field driver is controlled to keep phase peak voltage from falling below V_{prTh}. If phase peak voltage drops below V_{prTh}, phase regulation does not work.

Figure 9. Principle of phase regulation



3.3.5 Pin 'F'

Table 10. Electrical characteristics - Pin 'F'

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
V _{Fsat}	Field driver saturation voltage	T _j = 130 °C; I _{sun} k = 4.5 A	-	-	0.6	V
		T _j = 25 °C; I _{sun} k = 7 A	-	-	0.55	V
V _{Fdiode}	Freewheeling diode	I _{source} d = 5 A	-2	-	-	V
I _{Fleak}	Field leakage current	VB = 24 V; VF = 0	-	-	5	µA
I _{Fovp}	Field driver over-current protection	T _j = -40 °C	9	-	15	A
		T _j = 25 °C	8.5	-	15	A
		T _j = 130 °C	8.5	-	15	A
T _{Fretry}	Retry time in case of over-current		30	40	50	ms

Table 10. Electrical characteristics - Pin 'F' (continued)

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
V _{FONdet}	Voltage threshold on-state detection	<i>Figure 10 on page 16</i>	0.9	1.1	1.3	V
f _{SW}	Field switching frequency	-	212.5	250	287.5	Hz
T _{Frise}	Field voltage rise time	-	5	-	25	μs
T _{Ffall}	Field voltage fall time	-	5	-	25	μs
DF _{Preex}	Field duty cycle in pre-excitation	-	11	12.5	14	%
DF _{SS}	Field duty cycle in self start	-	4	6	8	%
DF _{ef}	Field duty cycle during excitation FIXED	-	3	4	5	%
T _{FLRCUP}	Load response control time (0 % to 100 % DC)	-	-	0	-	s
T _{FSDT}	Start delay time in internal mode only	-	-	0	-	s

3.3.6 Pin 'L'

Table 11. Electrical characteristics - Pin 'L'

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
V _{Lsat}	Lamp driver saturation voltage	V _B = 12.5 V; I _{sun} k = 0.5 A	1	1.2	1.4	V
V _{LsatSB}	Lamp driver saturation voltage in self bias condition	B pin floating; I _{sun} k = 300 mA	1	-	4	V
R _{Lpulldw}	Pull down resistor	-	2	4	8.2	kΩ
V _{LHTH}	High voltage threshold key-ON detector	-	0.8	0.9	1	V
V _{LLTh}	Low voltage threshold key-on detector	-	0.7	0.8	0.9	V
I _{Llim}	Over-current limitation	-	1	1.5	2	A
T _{LOC}	Maximum time duration of linear current limitation	<i>See Figure 11 on page 16</i>	25	30	35	ms
T _{Lretry}	Retry time in case of over-current duration > T _{LOC}		510	600	690	ms
T _{Ldelay}	Turn on delay time	-	-	-	100	μs
T _{Lalarm}	Alarm validation time	-	380	440	500	ms

Figure 10. Retry time in case of over-current diagram

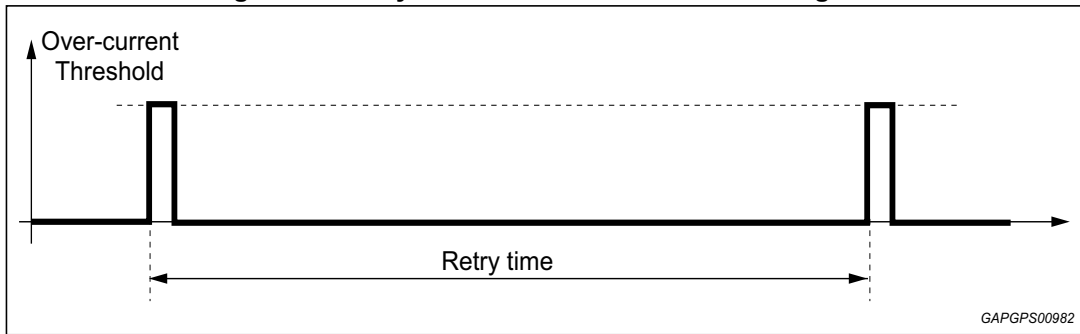
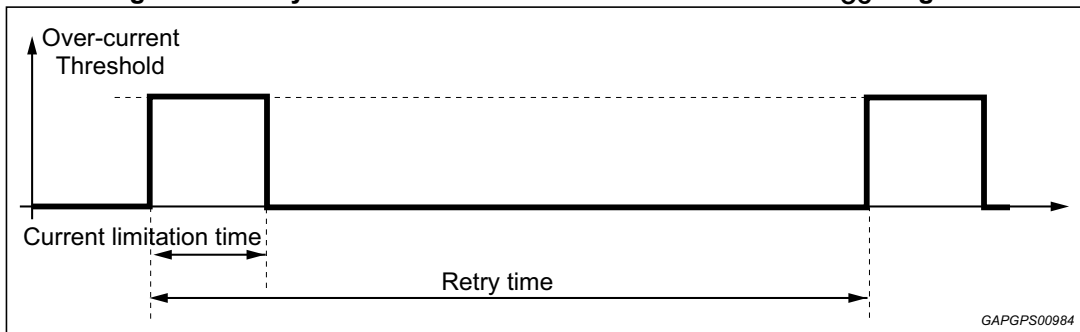


Figure 11. Retry time in case of over-current duration > TL_{OC} diagram



Alarm detection

The device turns ON the lamp after the validation time (TL_{alarm}) if one of the conditions in the below table is verified.

Table 12. TL_{alarm} validation time conditions

Detection condition	Related pin
$V_{PH} < V_{P_{HTh}}$ or PH frequency < $f_{P_{LPrex}}$	No activity on PH pin
$V_{PH} < V_{P_{prTh}}$	F driver or its connection degraded
$I_F > I_{F_{OVP}}$	F shortened to GND (Over-current on F driver)
$V_B > (V_{B_{ISP}}, V_{B_{ESP}})$ and $V_F > V_{F_{ONdet}}$	F shortened to B
$V_B > V_{B_{IntOvp}} \mid V_B > V_{B_{ExtOvp}}$	Battery sensor on B pin or F driver degraded
$V_B < V_{B_{UV}}$	Low B Voltage (Battery under-voltage)

4 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com.

ECOPACK® is an ST trademark.

4.1 Multiwatt 8 (pin 5 GND) package information

Figure 12. Multiwatt 8 (pin 5 GND) package outline

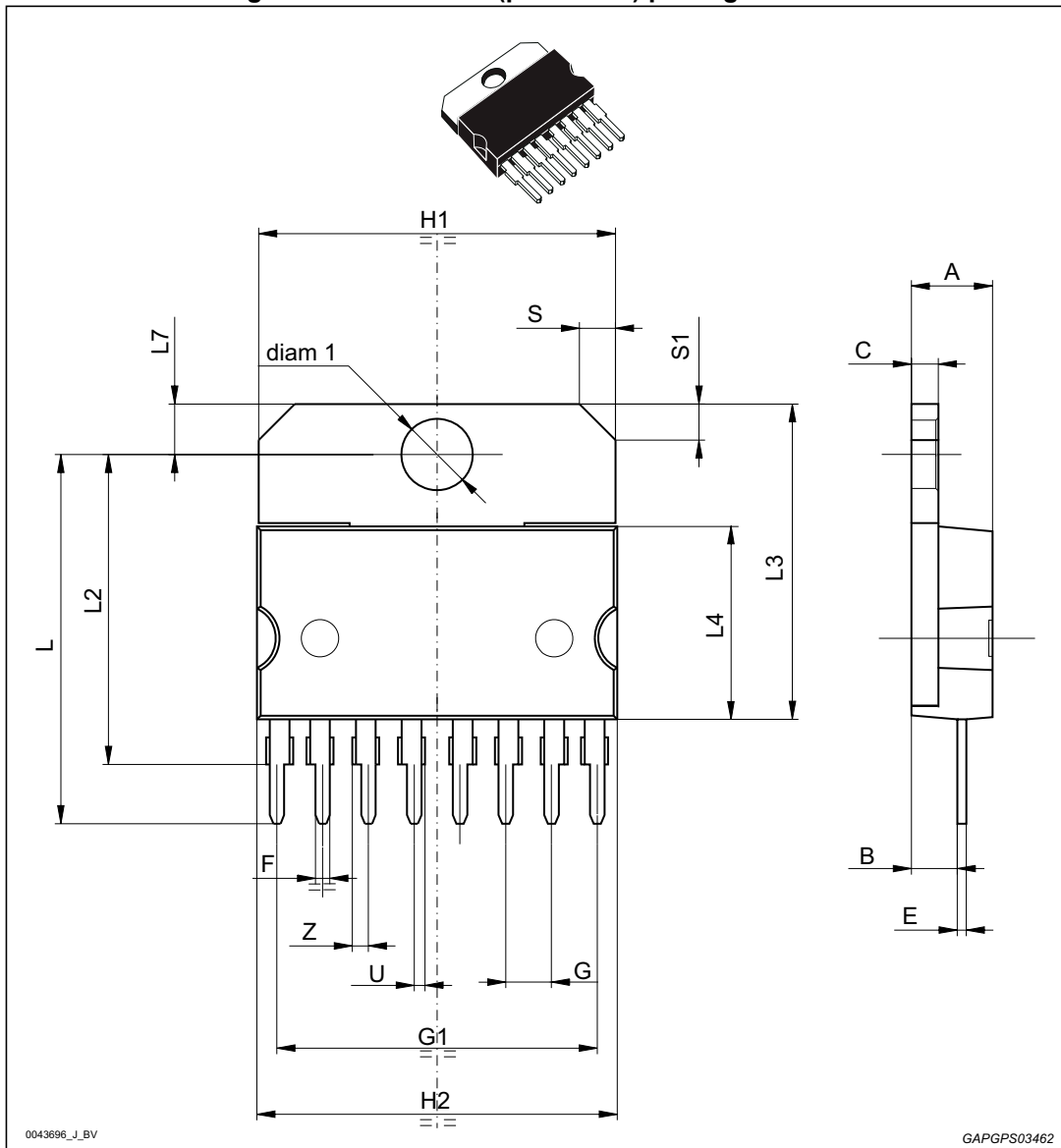


Table 13. Multiwatt 8 (pin 5 GND) package mechanical drawing

Ref	Dimensions					
	Millimeters			Inches ⁽¹⁾		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	-	-	5	-	-	0.1969
B	-	-	2.65	-	-	0.1043
C	-	-	1.6	-	-	0.0630
E	0.49	-	0.55	0.0193	-	0.0217
F	0.78	-	0.85	0.0307	-	0.0335
G	2.40	2.54	2.68	0.0945	0.1000	0.1055
G1	17.64	17.78	17.92	0.6945	0.7000	0.7055
H1	19.6	-	-	0.7717	-	-
H2	-	-	20.2	-	-	0.7953
L	20.35		20.65	0.8012		0.8130
L2	17.05	17.20	17.35	0.6713	0.6772	0.6831
L3	17.25	17.5	17.75	0.6791	0.6890	0.6988
L4	10.3	10.7	10.9	0.4055	0.4213	0.4291
L7	2.65	-	2.9	0.1043	-	0.1142
S	1.9	-	2.6	0.0748	-	0.1024
S1	1.9	-	2.6	0.0748	-	0.1024
U	0.40	-	0.55	0.0157	-	0.0217
Z	0.70	-	0.85	0.0276	-	0.0335
diam1	3.65	-	3.85	0.1437	-	0.1516

1. Values in inches are converted from mm and rounded to 4 decimal digits.

5 Revision history

Table 14. Document revision history

Date	Revision	Changes
23-Feb-2015	1	Initial release.

IMPORTANT NOTICE – PLEASE READ CAREFULLY

STMicroelectronics NV and its subsidiaries (“ST”) reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST’s terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers’ products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2015 STMicroelectronics – All rights reserved