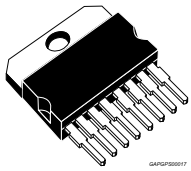
L9915B

C-terminal alternator voltage regulator (CTAVR)

Datasheet - production data



Multiwatt8

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

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).

Table 1. Device summary

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

Contents

List of tables

List of figures

1 Functional description

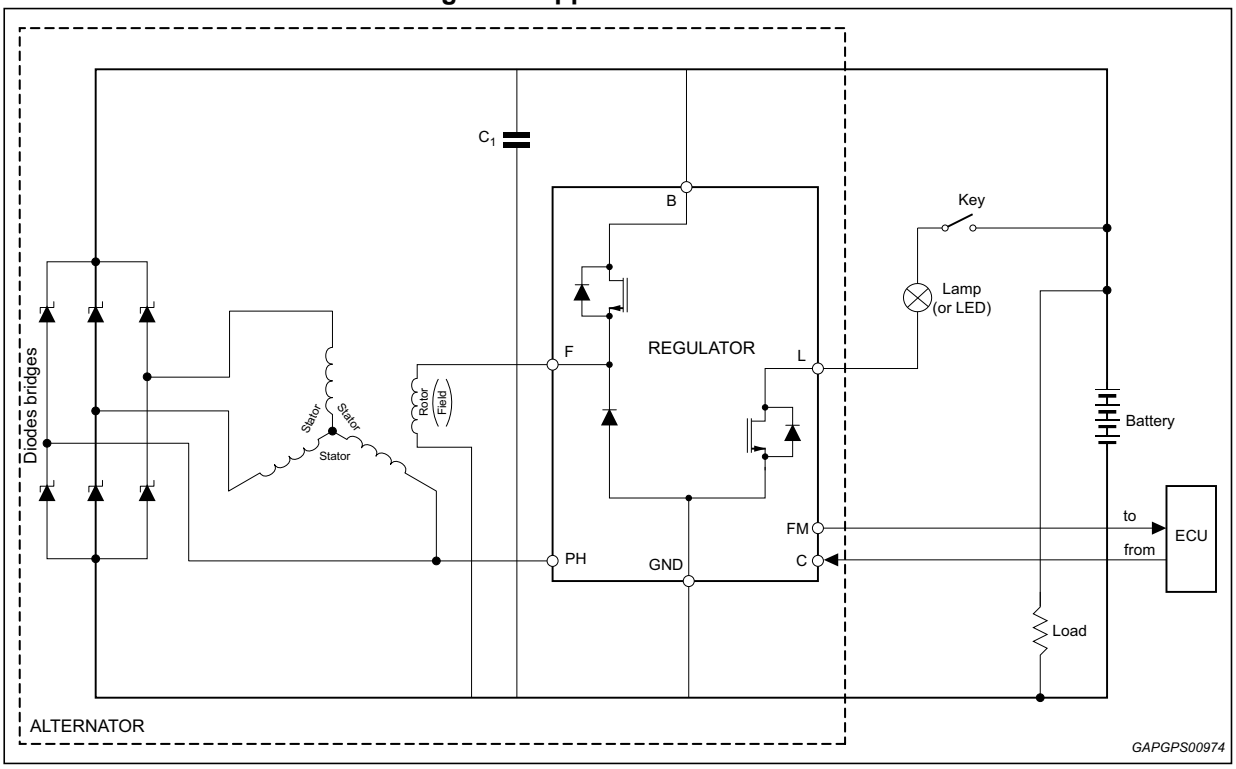
The device, supplied by the battery through B pin, remains in standby condition with low current consumption until there is no activity on the pins L, C or PH. When the switch "Key" is closed (i.e. VL>VL_{HTh}) or the ECU communicates via C-Terminal protocol through C pin (i.e. signal freq. on C pin 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 (fF_{SW}) and duty cycle (DF_{Preex}). The device remains in pre-excitation until the alternator does not run. When an activity is sensed on PH pin (i.e. VPH>VP_{HTh} and fPH>fP_{HPrex}) 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. VPH>VP_{HTh} and fPH>fP_{HPrex}) the device goes in self start characterized by an activity on F pin with fixed frequency (fF_{SW}) and duty cycle (DF_{SS}). When the frequency on PH pin rises above fP_{SS} the device starts to regulate with the internal regulation mode.

The regulator stops to regulate when the frequency on PH pin falls below fP_{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 µF 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)

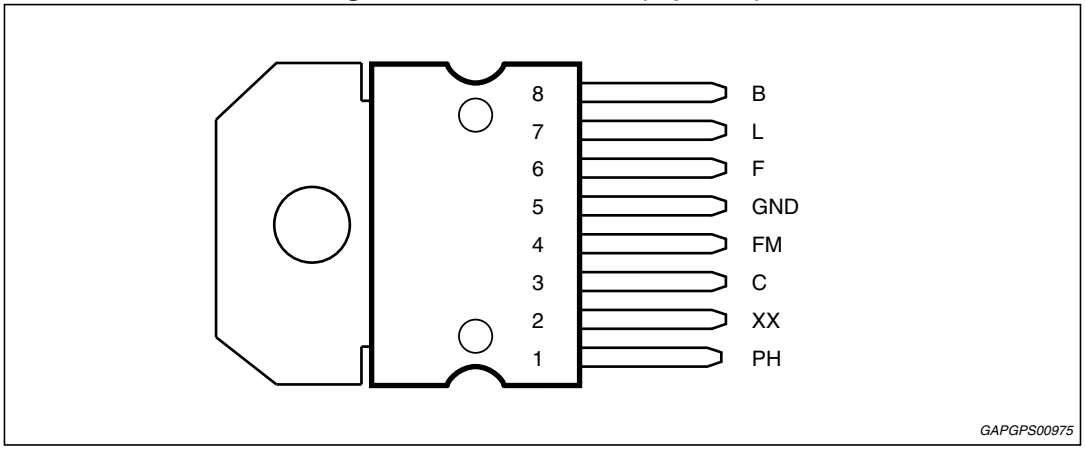


Table 2. Pin description

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
VB_{MAX}	Transient supply voltage with 1 A and t < 1 ms	55	V
VB_{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
VB_R	Reverse battery voltage @ 25 °C, T = 15 s	-2.5	V
VPH_{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
$R_{th\_j\text{-}case}$	Thermal resistance junction-to-case	Related to MW8	-	-	1.5	°C/W
$T_{j\text{-}sd}$	Thermal shutdown threshold	Temperature to disable F, FM, L drivers.	160	175	190	°C
$T_{j\text{-}sdhy}$	Thermal shut-down hysteresis	L, F, FM from OFF STATE (due to thermal shutdown) to ON STATE	Tj-sd -10	-	Tj-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
VB_{UV}	Under voltage	See note (1)	8.5	9.5	10.5	V
VB_{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%

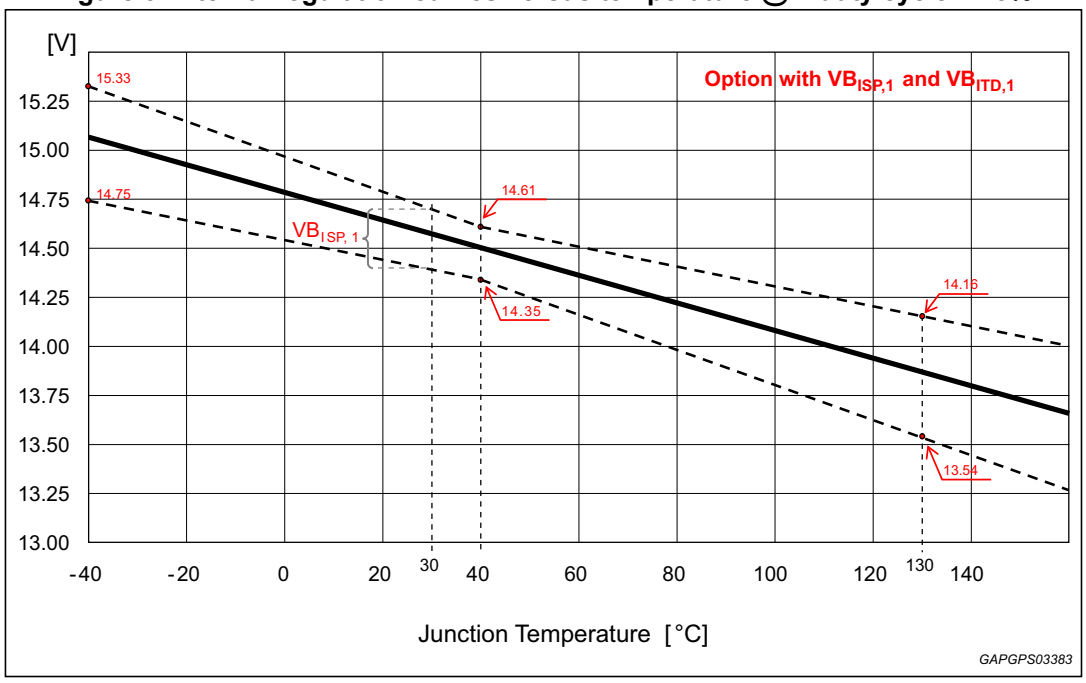
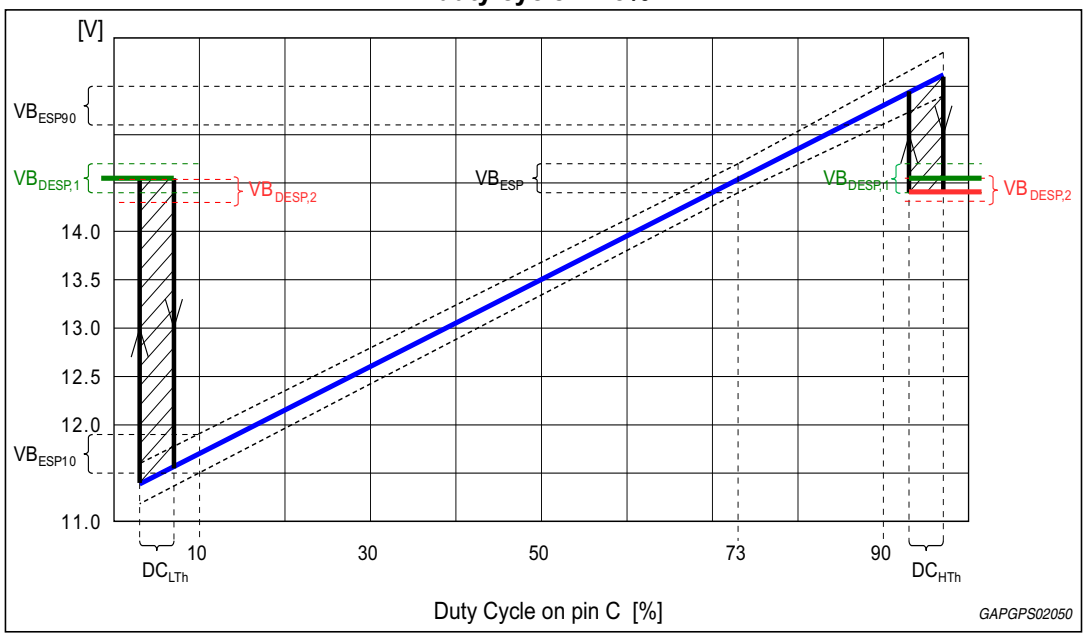
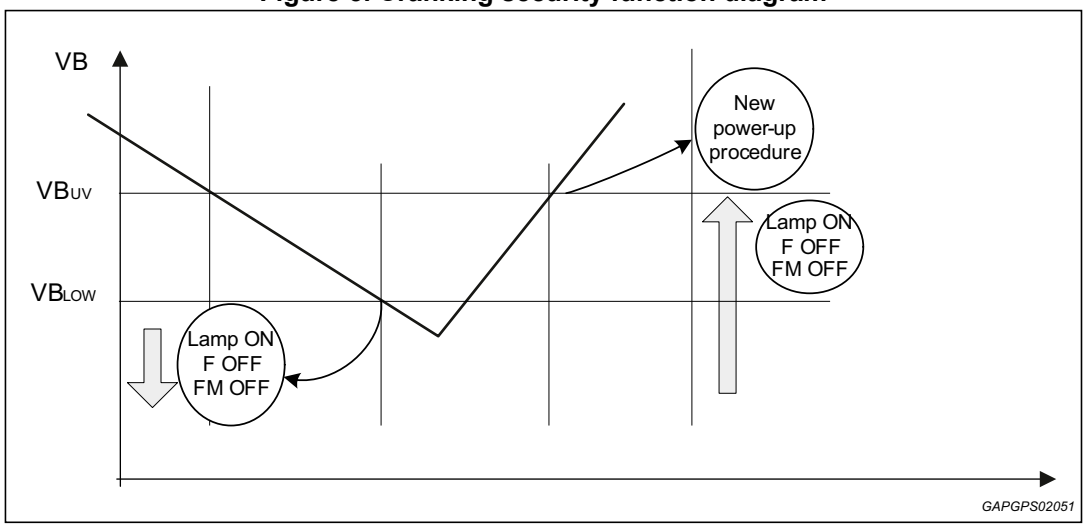


Figure 4. External regulation curve versus C duty cycle @ T_J = 30 °C and F duty cycle = 15%



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 VBLOW 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 VBLOW 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

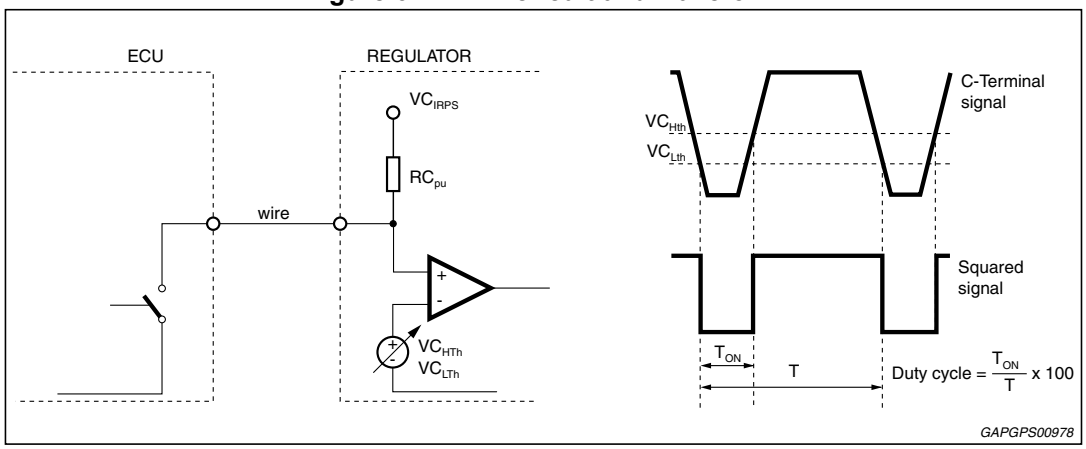
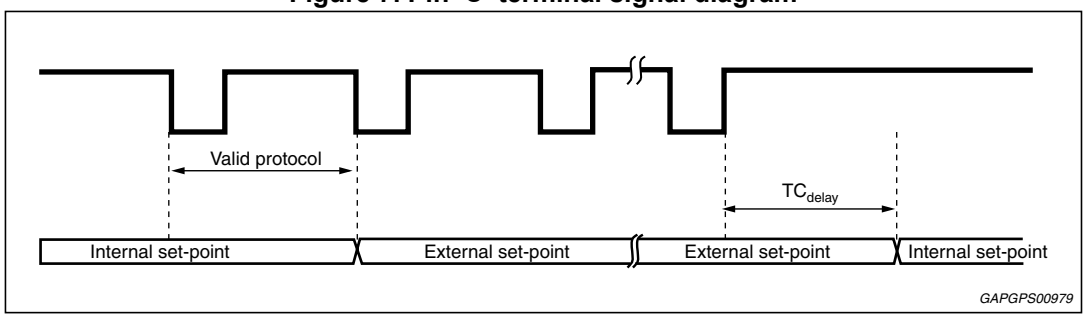


Figure 7. Pin 'C' terminal signal diagram

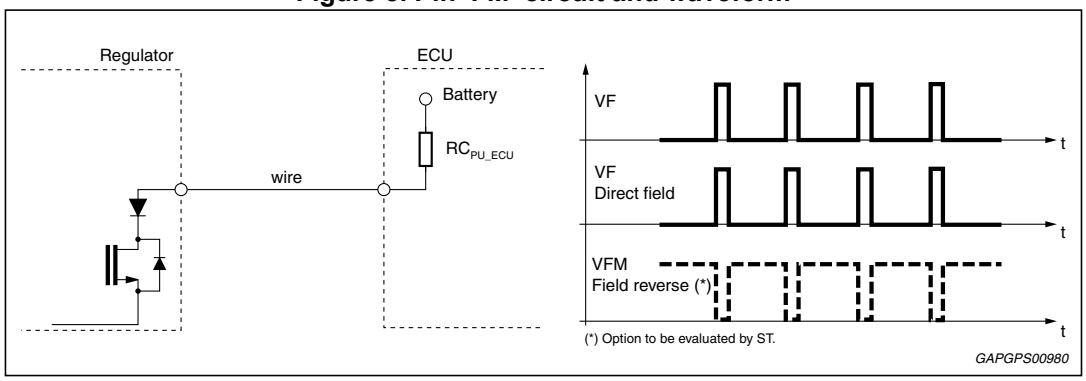


3.3.3 Pin ‘FM’

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)

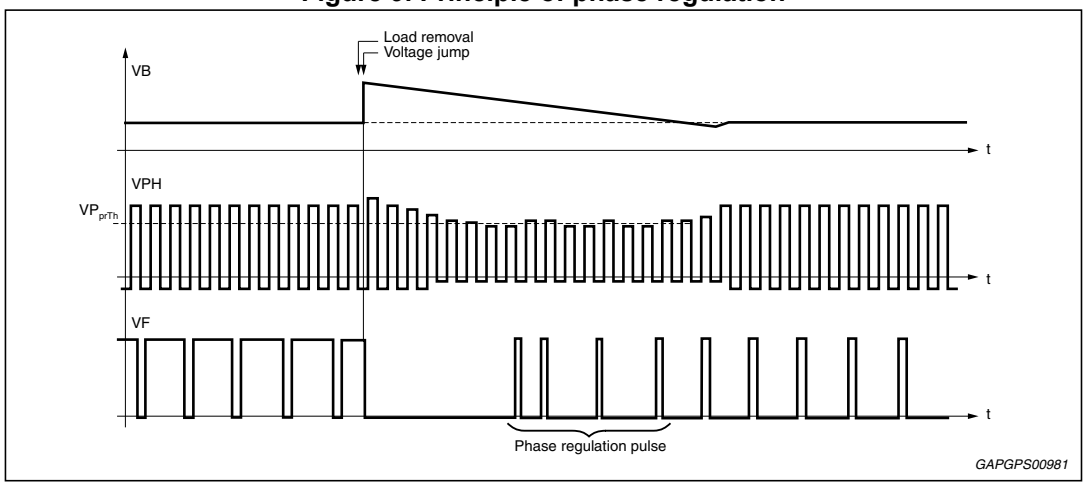
Symbol	Parameter	Test condition	Min	Typ	Max	Unit
fP_{SS}	Self start frequency threshold	-	255	300	345	Hz
fP_{LRC}	Frequency threshold to exit/enter in LRC		238	280	322	Hz
VP_{prTh}	Phase regulation voltage threshold	-	6.7	7.7	8.7	V

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 VPprTh. If phase peak voltage drops below VPLTh, 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
VF_{sat}	Field driver saturation voltage	T_j = 130 °C; I_{sunk} = 4.5 A	-	-	0.6	V
		T_j = 25 °C; I_{sunk} = 7 A	-	-	0.55	V
VF_{diode}	Freewheeling diode	$I_{sourced}$ = 5 A	-2	-	-	V
IF_{leak}	Field leakage current	VB = 24 V; VF = 0	-	-	5	µA
IF_{OVP}	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
TF_{retry}	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
VF_{ONdet}	Voltage threshold on-state detection	*Figure 10 on page 16*	0.9	1.1	1.3	V
fF_{SW}	Field switching frequency	-	212.5	250	287.5	Hz
TF_{rise}	Field voltage rise time	-	5	-	25	µs
TF_{fall}	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	%
TF_{LRCUP}	Load response control time (0 % to 100 % DC)	-	-	0	-	s
TF_{SDT}	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
VL_{sat}	Lamp driver saturation voltage	VB = 12.5 V; I_{sunk} = 0.5 A	1	1.2	1.4	V
VL_{satSB}	Lamp driver saturation voltage in self bias condition	B pin floating; I_{sunk} = 300 mA	1	-	4	V
RL_{pulldw}	Pull down resistor	-	2	4	8.2	kΩ
VL_{HTh}	High voltage threshold key-ON detector	-	0.8	0.9	1	V
VL_{LTh}	Low voltage threshold key-on detector	-	0.7	0.8	0.9	V
IL_{lim}	Over-current limitation	-	1	1.5	2	A
TL_{OC}	Maximum time duration of linear current limitation	See *Figure 11 on page 16*	25	30	35	ms
TL_{retry}	Retry time in case of over-current duration > TL_{OC}		510	600	690	ms
TL_{delay}	Turn on delay time	-	-	-	100	µs
TL_{alarm}	Alarm validation time	-	380	440	500	ms

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

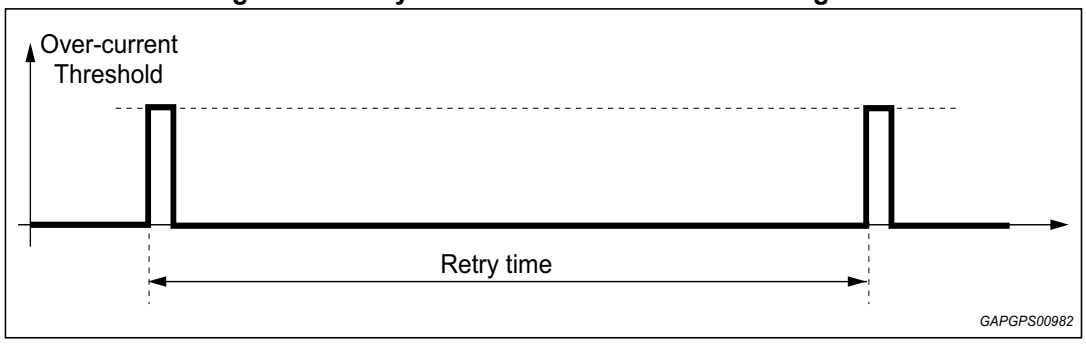
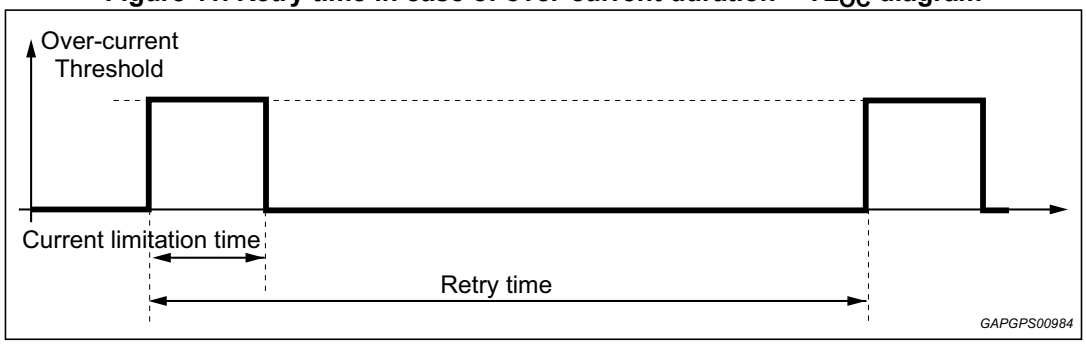


Figure 11. Retry time in case of over-current duration > TL_{OC} diagram



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
VPH<VP_{HTh} or PH frequency < fP_{LPrex}	No activity on PH pin
VPH< VP_{prTh}	F driver or its connection degraded
IF>IF_{OVP}	F shortened to GND (Over-current on F driver)
VB>(VB_{ISP},VB_{ESP}) and VF>VF_{ONdet}	F shortened to B
VB>VB_{IntOvp} | VB>VB_{ExtOvp}	Battery sensor on B pin or F driver degraded
VB<VB_{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

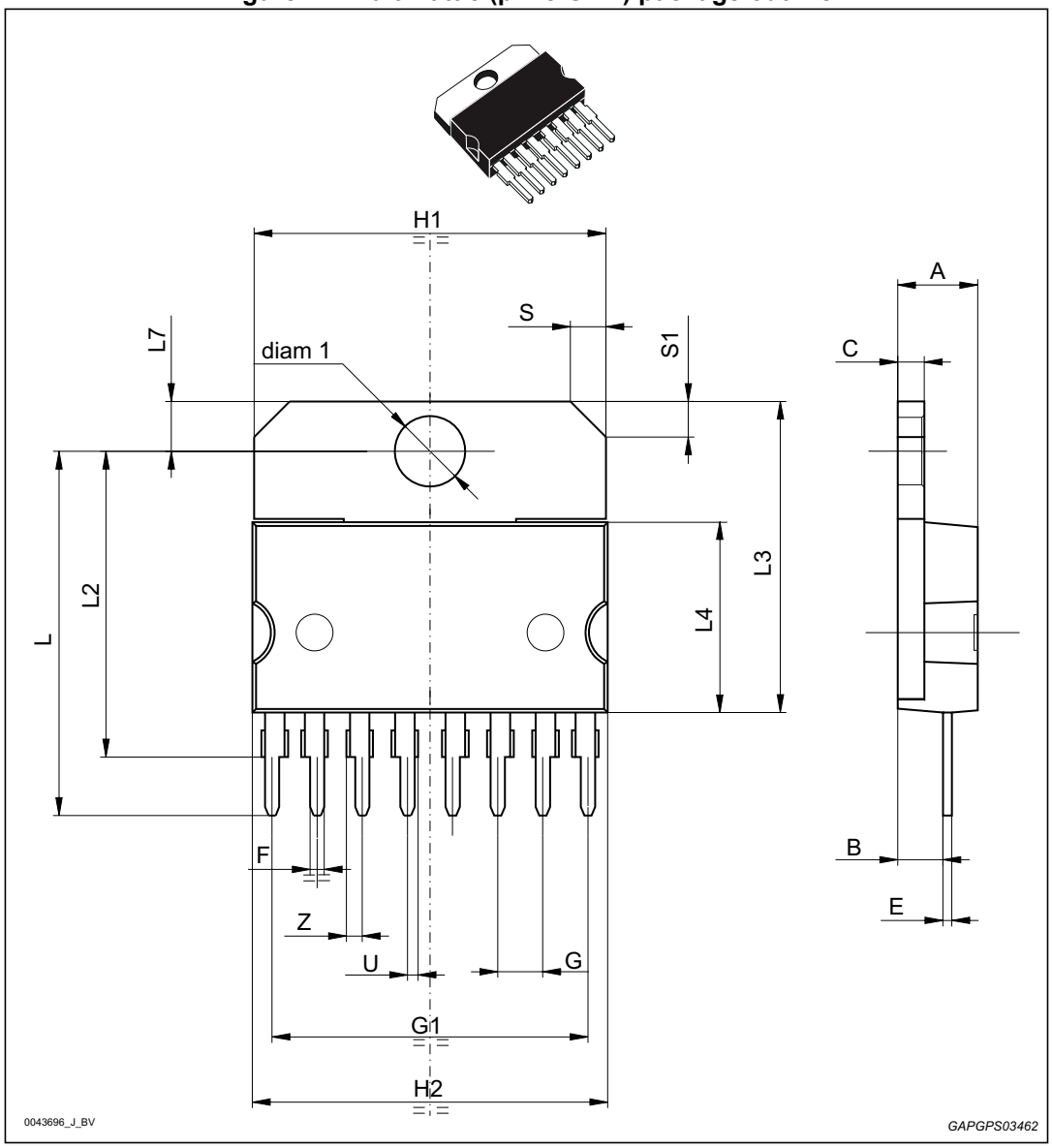


Table 13. Multiwatt 8 (pin 5 GND) package mechanical drawing

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.