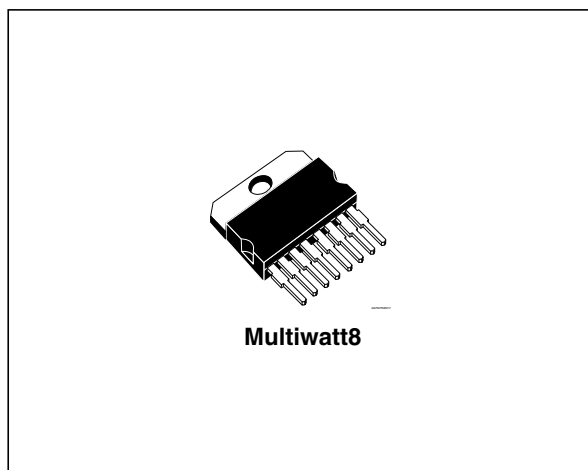


## Car alternator multifunction smart voltage regulator

Datasheet - production data



- Thermal protection
- Field short circuit protection
- Protected diagnostic lamp driver
- Protected high side relay driver
- Complex diagnostics
- Load response control
- DFM output (field monitor)
- Self start function

### Description

The L9911 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

### Features

- Fully monolithic design
- High side field driver

Table 1. Device summary

| Order code | Temp. range, °C       | Package    | Packing |
|------------|-----------------------|------------|---------|
| L9911F     | $T_j = -40$ to $+150$ | Multiwatt8 | Tube    |
| L9911I     |                       |            |         |
| L9911P     |                       |            |         |
| L9911V     |                       |            |         |
| L9911K     |                       |            |         |
| L9911U     |                       |            |         |

# Contents

|          |                                             |           |
|----------|---------------------------------------------|-----------|
| <b>1</b> | <b>Circuit operation</b>                    | <b>5</b>  |
| 1.1      | Voltage regulation                          | 5         |
| 1.2      | Protection                                  | 5         |
| 1.3      | Diagnosis                                   | 5         |
| 1.4      | Load response control                       | 5         |
| 1.5      | Self start function                         | 5         |
| <b>2</b> | <b>Pin description</b>                      | <b>6</b>  |
| <b>3</b> | <b>Electrical specification</b>             | <b>7</b>  |
| 3.1      | Absolute maximum ratings                    | 7         |
| 3.2      | Thermal data                                | 7         |
| 3.3      | Electrical characteristics                  | 7         |
| 3.4      | Principle of phase regulation               | 14        |
| <b>4</b> | <b>Package information</b>                  | <b>17</b> |
| 4.1      | Multiwatt 8 (pin 5 GND) package information | 17        |
| <b>5</b> | <b>Revision history</b>                     | <b>19</b> |

## List of tables

|           |                                                                                           |    |
|-----------|-------------------------------------------------------------------------------------------|----|
| Table 1.  | Device summary . . . . .                                                                  | 1  |
| Table 2.  | Pin description . . . . .                                                                 | 6  |
| Table 3.  | Absolute maximum ratings . . . . .                                                        | 7  |
| Table 4.  | Thermal data . . . . .                                                                    | 7  |
| Table 5.  | Electrical characteristics . . . . .                                                      | 7  |
| Table 6.  | Load response control parameters . . . . .                                                | 10 |
| Table 7.  | Load response control timing options . . . . .                                            | 10 |
| Table 8.  | Correspondence of frequency (typical values) to application features . . . . .            | 11 |
| Table 9.  | Customization of L9911: combination of LRC, regulation, and application options . . . . . | 11 |
| Table 10. | Fault detection . . . . .                                                                 | 16 |
| Table 11. | Multiwatt 8 (pin 5GND) package mechanical drawing . . . . .                               | 18 |
| Table 12. | Document revision history. . . . .                                                        | 19 |

## List of figures

|            |                                                                         |    |
|------------|-------------------------------------------------------------------------|----|
| Figure 1.  | Pin connection (top view) . . . . .                                     | 6  |
| Figure 2.  | $V_{reg-1}$ . . . . .                                                   | 11 |
| Figure 3.  | $V_{reg-2}$ . . . . .                                                   | 12 |
| Figure 4.  | $V_{reg-3}$ . . . . .                                                   | 12 |
| Figure 5.  | $V_{reg-4}$ . . . . .                                                   | 13 |
| Figure 6.  | Output voltage rise/fall time (F+, DFM) . . . . .                       | 13 |
| Figure 7.  | Phase regulation characteristics . . . . .                              | 13 |
| Figure 8.  | Application diagram . . . . .                                           | 14 |
| Figure 9.  | High side/low side driver saturation . . . . .                          | 14 |
| Figure 10. | Test mode to cancel soft-start/attack . . . . .                         | 14 |
| Figure 11. | Soft-start enable frequency range . . . . .                             | 14 |
| Figure 12. | Soft-start characteristics (always activated at engine start) . . . . . | 15 |
| Figure 13. | Soft start/attack characteristics . . . . .                             | 15 |
| Figure 14. | DF monitor electrical configuration . . . . .                           | 16 |
| Figure 15. | Short circuit drivers' protection . . . . .                             | 16 |
| Figure 16. | Multiwatt 8 (pin 5GND) package outline . . . . .                        | 17 |

# 1 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

## 1.1 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 regulator is in fixed-frequency topology, the field switching frequency does not depend on 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 5-6 V. Consequently it doesn't need, in the standard application, any external component. Anyway an external capacitor (2.2  $\mu\text{F}$ ) must be inserted between A+ and ground when using the device with very long cables.

## 1.2 Protection

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

## 1.3 Diagnosis

The circuit detects fault conditions related to the phase and F+ 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.

## 1.4 Load response control

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

## 1.5 Self start function

The device wakes up by the phase signal only. The phase signal must have a voltage amplitude higher than VPHL1 and a frequency higher than EN-x.

## 2 Pin description

Figure 1. Pin connection (top view)

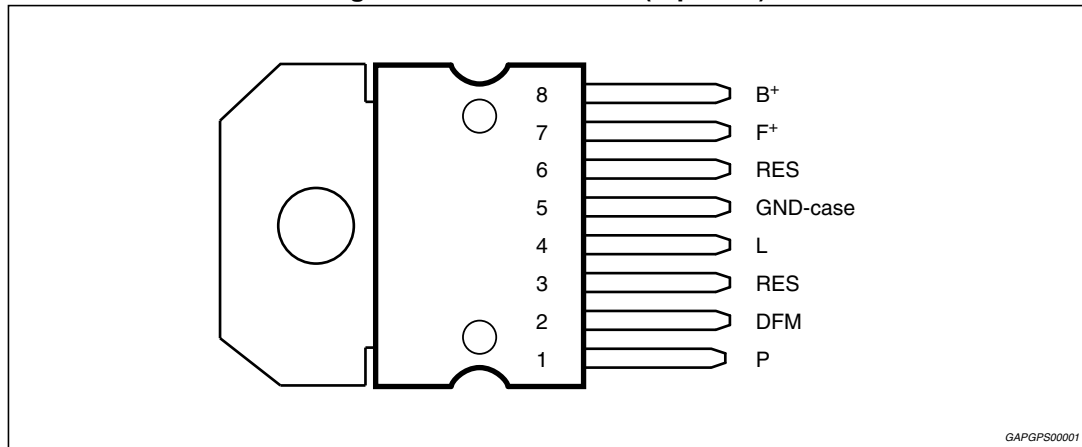


Table 2. Pin description

| N° | Pin            | Function                                                        |
|----|----------------|-----------------------------------------------------------------|
| 1  | P              | Phase sense input.                                              |
| 2  | DFM            | Field monitor output.                                           |
| 3  | RES            | Reserved.                                                       |
| 4  | L              | Lamp terminal low side driver; relay terminal high side driver. |
| 5  | GND-case       | Ground.                                                         |
| 6  | RES            | Reserved.                                                       |
| 7  | F <sup>+</sup> | High side driver output.                                        |
| 8  | B <sup>+</sup> | Sensed power supply.                                            |

### 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 |
|------------------------|------------------------------------------------------------------------------------------------------------------|------------|------|
| $V_S$                  | DC supply voltage (2 min. @ $25$ °C)                                                                             | 24         | V    |
| -                      | Transient supply voltage (load dump) [see <a href="#">Figure 8</a> ]<br>$t < 500$ ms                             | 40         | V    |
| -                      | Transient supply voltage (low energy spikes)<br>(see <a href="#">Figure 8</a> ) ISO7637-1 pulse 1,2,3 /ISO7637-3 | 60         | 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 (@ $T_{case} \leq 150$ °C, $I_{field} \leq 5$ A)                                         | 4          | W    |
| -                      | Reverse battery voltage (see <a href="#">Figure 8</a> ) @ $25$ °C,<br>$T = 15$ sec.                              | -2.5       | V    |
| -                      | Normal working condition reverse voltage (P vs. GND)                                                             | -1.5       | V    |
| -                      | DC pin current on F+, B+, GND (bonding limitation)                                                               | 15         | A    |
| -                      | ESD voltage MILSTD883C (All pins vs.GND)                                                                         | $\pm 4$    | KV   |

#### 3.2 Thermal data

**Table 4. Thermal data**

| Symbol           | Parameter                           | Value      | Unit |
|------------------|-------------------------------------|------------|------|
| $R_{th\ j-case}$ | Thermal resistance junction-to-case | $\leq 1.5$ | °C/W |

#### 3.3 Electrical characteristics

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

**Table 5. Electrical characteristics**

| Symbol         | Parameter                | Test condition        | Min. | Typ. | Max. | Unit |
|----------------|--------------------------|-----------------------|------|------|------|------|
| $V_{bat}$      | Operating supply voltage | -                     | 7    | -    | 18   | V    |
| $I_{b-sinked}$ | Supply battery current   | -                     | -    | -    | 25   | mA   |
| $I_{b-stby}$   | Standby current          | B+ = 12.5 V, F+ = 0 V | -    | -    | 500  | μA   |

Table 5. Electrical characteristics (continued)

| Symbol            | Parameter                                                                                                                         | Test condition                                                                                                                                     | Min.            | Typ.            | Max.            | Unit       |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|-----------------|------------|
| $V_{reg\ 1}$      | Regulated voltage & thermal drift.<br>3 configurations available,<br>selectable by mask option (see<br><a href="#">Table 8</a> ). | $I_{alt} = 1\text{ A} - 0.9 \cdot I_{nom}$ ; $T_{case} = 20\text{ °C}$ ;<br>$1400 < \text{rpm} < \text{RPMMAX}$<br>(see <a href="#">Figure 2</a> ) | 14.0<br>-4.5    | 14.4<br>-3.5    | 14.8<br>-2.5    | V<br>mV/°C |
| $V_{reg\ 2}$      |                                                                                                                                   | $I_{alt} = 10\text{ A}$ ; $T_{case} = 23\text{ °C}$ ;<br>$\text{rpm} = 6000\text{ rpm}$ ; 15 V max.<br>(see <a href="#">Figure 3</a> )             | 14.35<br>-11.8  | 14.5<br>-10     | 14.65<br>-8.2   | V<br>mV/°C |
| $V_{reg\ 3}$      |                                                                                                                                   | $I_{alt} = 10\text{ A}$ ; $T_{case} = 23\text{ °C}$ ;<br>$\text{rpm} = 6000\text{ rpm}$ (see <a href="#">Figure 4</a> )                            | 14.35<br>-6     | 14.5<br>-4      | 14.65<br>-2     | V<br>mV/°C |
| $V_{reg\ 4}$      |                                                                                                                                   | $I_{alt} = 10\text{ A}$ ; $T_{case} = 23\text{ °C}$ ;<br>$\text{rpm} = 6000\text{ rpm}$ (see <a href="#">Figure 5</a> )                            | 13.95<br>-3.5   | 14.2<br>-2.5    | 14.3<br>-1.5    | V<br>mV/°C |
| $\Delta V_{rpm}$  | -                                                                                                                                 | $1400 < \text{rpm} < \text{RPMMAX}$ ; $I_{alt} = 10\text{ A}$                                                                                      | -               | -               | 200             | mV         |
| $\Delta V_{load}$ | -                                                                                                                                 | $5\text{ A} < I_{alt} < I_{nom}$ ; $\text{rpm} = 6000\text{ rpm}$                                                                                  | -               | -               | 250             | mV         |
| $V_{reg-less}$    | Reg. voltage without battery                                                                                                      | $I_{alt} = 3\text{ A}$ resistive; $T_{case} = 25\text{ °C}$ ;<br>$2000 < \text{rpm} < \text{RPMMAX}$                                               | 12              | -               | 16              | V          |
| $V_{ov-p}$        | Overvoltage protection threshold                                                                                                  | Voltage on pin<br>B+ to disable L<br>drivers                                                                                                       | 18              | -               | 22              | V          |
| $V_{ov-d}$        | Overvoltage diagnosis threshold                                                                                                   | VB+ to turn on L low side driver<br>at $V_F + > V_{S1}$                                                                                            | $V_{reg} - 5\%$ | $V_{reg}$       | $V_{reg} + 5\%$ | V          |
| $T_{j-sd}$        | Thermal shutdown threshold                                                                                                        | Temperature to disable F+,<br>DFM, L (high & low side drivers)                                                                                     | 160             | 175             | 190             | °C         |
| $T_{j-sd-dwn}$    | Thermal shut-down hysteresis                                                                                                      | L/F+/DFM from OFF STATE<br>(due to thermal shutdown) to ON<br>STATE                                                                                | $T_{j-sd} - 10$ | -               | $T_{j-sd} - 2$  | °C         |
| $V_{uv-1}$        | Under voltage diagnosis threshold                                                                                                 | VB+ to turn on L low side driver                                                                                                                   | 7.7             | 8.6             | 9.5             | V          |
| $V_{uv-up}$       |                                                                                                                                   | VB+ to turn off L low side driver                                                                                                                  | $V_{uv} + 0.40$ | $V_{uv} + 0.75$ | $V_{uv} + 1.2$  | V          |
| $V_{F+_{sat}}$    | Field driver saturation voltage                                                                                                   | $T_j = 150\text{ °C}$ ; $I = 4.5\text{ A}$                                                                                                         | -               | -               | 0.6             | V          |
|                   |                                                                                                                                   | $T_j = 25\text{ °C}$ ; $I = 7\text{ A}$                                                                                                            | -               | -               | 0.55            | V          |
| $V_f$             | Freewheeling diode F+                                                                                                             | $I = 5\text{ A}$                                                                                                                                   | -               | -               | 2               | V          |
| $I_{f\_SCTH}$     | Field short circuit driver protection<br>threshold current<br>(see <a href="#">Figure 15</a> )                                    | $F+ = 0\text{ V}$ ; $T_j = -40\text{ °C}$                                                                                                          | 11              | -               | 18              | A          |
|                   |                                                                                                                                   | $F+ = 0\text{ V}$ ; $T_j = -25\text{ °C}$                                                                                                          | 9.5             | -               | 18              | A          |
|                   |                                                                                                                                   | $F+ = 0\text{ V}$ ; $T_j = -150\text{ °C}$                                                                                                         | 9               | -               | 18              | A          |
| $V_{s1}$          | Field driver ON-state detection                                                                                                   | -                                                                                                                                                  | 4.5             | -               | 5.5             | V          |
| $f_{pre}$         | Pre-excitation frequency                                                                                                          | -                                                                                                                                                  | 283             | 333             | 383             | Hz         |
| Duty-pre          | Pre-excitation Field driver ON-duty                                                                                               | -                                                                                                                                                  | 15.93           | 18.75           | 21.57           | %          |
| $t_r$             | Output voltage rise time                                                                                                          | $I_{field} = 3\text{ A}$ resistive<br>see <a href="#">Figure 6</a> )                                                                               | 10              | -               | 50              | µs         |
| $t_f$             | Output voltage fall time                                                                                                          |                                                                                                                                                    | 10              | -               | 50              | µs         |
| $F_{sw\_F+}$      | Field switching frequency                                                                                                         | $I_{alt} = 1\text{ A} - 0.9 \cdot I_{nom}$ ;<br>$1400\text{ rpm} < \text{rpm} < \text{RPMMAX}$                                                     | 250             | -               | 400             | Hz         |



Table 5. Electrical characteristics (continued)

| Symbol               | Parameter                                                              | Test condition                                                                                            | Min.  | Typ.  | Max.                | Unit |
|----------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-------|-------|---------------------|------|
| I <sub>f_leak</sub>  | Output field driver leakage current                                    | B+ = 24 V; V <sub>F+</sub> = 0                                                                            | -     | -     | 10                  | μA   |
| DUTY-PR              | Phase regulation max field ON duty                                     | see <a href="#">Figure 7</a>                                                                              | 26.56 | 31.25 | 35.94               | %    |
| V <sub>H_SAT</sub>   | High side driver saturation Voltage (see <a href="#">Figure 9</a> )    | With driver I <sub>source</sub> = 500 mA                                                                  | -     | -     | 1.5                 | V    |
| V <sub>L_SAT</sub>   | Low side driver saturation voltage (see <a href="#">Figure 9</a> )     | With driver I <sub>sink</sub> = 500 mA                                                                    | -     | -     | 1.5                 | V    |
| V <sub>LSB</sub>     | Self bias without supply lamp driver voltage                           | B+ open; L connected to 12 V through a 50 Ohm resistor                                                    | -     | -     | 4                   | V    |
| I <sub>HSC</sub>     | High side driver short circuit current protection                      | B+ = 12.5 V; L = GND                                                                                      | 1.2   | -     | 3                   | A    |
| I <sub>LSC</sub>     | Low side driver short circuit current (see <a href="#">Figure 15</a> ) | B+ = L = 12.5 V                                                                                           | 1     | -     | 2                   | A    |
| V <sub>thL</sub>     | Enable regulator supply voltage threshold                              | -                                                                                                         | 0.8   | -     | 1.15                | V    |
| I <sub>pd_L</sub>    | L terminal pull-down current when the generator is not rotating        | V <sub>L</sub> = 0.6 V                                                                                    | 0.4   | -     | 3.5                 | mA   |
| I <sub>L_sink</sub>  | L sink current when the generator is rotating                          | P frequency 500 Hz; V <sub>B+</sub> = 12 V                                                                | -     | -     | 100                 | μA   |
| t <sub>D</sub>       | Diagnostic alarm delay time                                            | -                                                                                                         | 0.2   | -     | 0.5                 | s    |
| V <sub>can-DFM</sub> | Test mode to cancel soft start/attack (voltage)                        | (see <a href="#">Figure 10</a> )                                                                          | 30    | -     | 50                  | V    |
| t <sub>can-DFM</sub> | Test mode delay time                                                   |                                                                                                           | 25    | -     | -                   | ms   |
| V <sub>PHL1</sub>    | Enable control voltage input high threshold                            | -                                                                                                         | -     | -     | 0.40                | V    |
| V <sub>PHL2</sub>    | Enable control voltage input low threshold                             | -                                                                                                         | -     | -     | 0.25 <sup>(1)</sup> | V    |
| t <sub>PHL1</sub>    | Enable Control Voltage Phase Filtering Time                            | -                                                                                                         | 50    | -     | 115                 | μs   |
| V <sub>PHH1</sub>    | Diagnosis phase loss input high threshold                              | -                                                                                                         | 8     | 9     | 10                  | V    |
| V <sub>PHH2_1</sub>  | Diagnosis phase loss input low threshold                               | -                                                                                                         | 6.4   | 7.4   | 8.4                 | V    |
| t <sub>PHd</sub>     | Diagnostic phase filtering time                                        | -                                                                                                         | 50    | -     | 100                 | μs   |
| I <sub>pd-P1</sub>   | Phase pull-down current                                                | VP = 0.8 V                                                                                                | 1     | -     | 8                   | mA   |
| f <sub>-dfm</sub>    | DFM output open drain switching freq.                                  | I <sub>alt</sub> = 1 A ~ 0.9 · I <sub>nom</sub> ;<br>1400 rpm < rpm < RPMMAX;<br>I <sub>sink</sub> = 4 mA | 125   | -     | 200                 | Hz   |
| V <sub>L-DFM</sub>   | Output low voltage saturation                                          | I <sub>sink</sub> = 14 mA                                                                                 | -     | -     | 1.5                 | V    |
| I <sub>SC-DFM</sub>  | Short circuit current protection                                       | VB+ = VDFM = 12.5 V                                                                                       | 50    | -     | 400                 | mA   |
| I <sub>lk-DFM</sub>  | Output leakage current                                                 | V <sub>DFM</sub> = 16 V at DFM driver OFF                                                                 | -     | -     | 5                   | μA   |

Table 5. Electrical characteristics (continued)

| Symbol   | Parameter                | Test condition                                   | Min. | Typ. | Max. | Unit    |
|----------|--------------------------|--------------------------------------------------|------|------|------|---------|
| $t_{TM}$ | Output voltage rise time | R = 1 k $\Omega$ (see <a href="#">Figure 6</a> ) | 0.5  | -    | 50   | $\mu$ s |
| $t_{TD}$ | Output voltage fall time |                                                  | 0.5  | -    | 50   |         |

1. Guaranteed by design.

Table 6. Load response control parameters

| Symbol            | Parameter                                                                                                                                                                                                                                                                            | Test Condition                                    | Min. | Typ. | Max.  | Unit |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|------|------|-------|------|
| $t_{ST\_1}$       | Soft start delay time (see <a href="#">Figure 12</a> ) 2 steps available, selectable by mask option (see <a href="#">Table 7</a> ).                                                                                                                                                  | Activated always at engine start                  | -    | 0-   | -     | s    |
| $t_{ST\_2}$       |                                                                                                                                                                                                                                                                                      |                                                   | 1.73 | 2    | 2.35  | s    |
| $t_{SL\_1}$       | Soft attack time / soft start time (see <a href="#">Figure 12</a> ). 2 steps available, selectable by mask option (see <a href="#">Table 7</a> ).                                                                                                                                    | From 0 to 100 % field duty cycle                  | 2.13 | 2.5  | 2.87  | s    |
| $t_{SL\_2}$       |                                                                                                                                                                                                                                                                                      |                                                   | 7.65 | 9    | 10.35 |      |
| EN-RES (constant) | Reset frequency range to enable regulation; Frequency judged after 4 periods (see <a href="#">Figure 11</a> )                                                                                                                                                                        | -                                                 | 40   | 50   | 60    | Hz   |
| EN-1              | Soft start enable (EN) and LRC disable (DISAB) frequency ranges.<br>4 configurations available, selectable by mask option (possible combinations in <a href="#">Table 8</a> ). Always activated at engine start. Frequencies judged after 4 periods (see <a href="#">Figure 11</a> ) | $T_j = 25\text{ }^{\circ}\text{C}$                | 108  | 120  | 132   | Hz   |
|                   |                                                                                                                                                                                                                                                                                      | $T_j = -40\text{ to }150\text{ }^{\circ}\text{C}$ | 102  | 120  | 138   | Hz   |
| EN-2              |                                                                                                                                                                                                                                                                                      | $T_j = 25\text{ }^{\circ}\text{C}$                | 131  | 145  | 159   | Hz   |
|                   |                                                                                                                                                                                                                                                                                      | $T_j = -40\text{ to }150\text{ }^{\circ}\text{C}$ | 124  | 145  | 166   | Hz   |
| EN-3              |                                                                                                                                                                                                                                                                                      | $T_j = 25\text{ }^{\circ}\text{C}$                | 144  | 160  | 176   | Hz   |
|                   |                                                                                                                                                                                                                                                                                      | $T_j = -40\text{ to }150\text{ }^{\circ}\text{C}$ | 136  | 160  | 184   | Hz   |
| EN-4              |                                                                                                                                                                                                                                                                                      | $T_j = 25\text{ }^{\circ}\text{C}$                | 174  | 193  | 212   | Hz   |
|                   |                                                                                                                                                                                                                                                                                      | $T_j = -40\text{ to }150\text{ }^{\circ}\text{C}$ | 165  | 193  | 221   | Hz   |
| DISAB-1           |                                                                                                                                                                                                                                                                                      | $T_j = 25\text{ }^{\circ}\text{C}$                | 270  | 300  | 330   | Hz   |
|                   |                                                                                                                                                                                                                                                                                      | $T_j = -40\text{ to }150\text{ }^{\circ}\text{C}$ | 255  | 300  | 345   | Hz   |
| DISAB-2           |                                                                                                                                                                                                                                                                                      | $T_j = 25\text{ }^{\circ}\text{C}$                | 315  | 350  | 385   | Hz   |
|                   |                                                                                                                                                                                                                                                                                      | $T_j = -40\text{ to }150\text{ }^{\circ}\text{C}$ | 298  | 350  | 402   | Hz   |
| DISAB-3           |                                                                                                                                                                                                                                                                                      | $T_j = 25\text{ }^{\circ}\text{C}$                | 367  | 408  | 449   | Hz   |
|                   |                                                                                                                                                                                                                                                                                      | $T_j = -40\text{ to }150\text{ }^{\circ}\text{C}$ | 347  | 408  | 469   | Hz   |
| DISAB-4           |                                                                                                                                                                                                                                                                                      | $T_j = 25\text{ }^{\circ}\text{C}$                | 420  | 466  | 512   | Hz   |
|                   |                                                                                                                                                                                                                                                                                      | $T_j = -40\text{ to }150\text{ }^{\circ}\text{C}$ | 397  | 466  | 535   | Hz   |

Table 7. Load response control timing options

| -                       | $t_{SL} = 2.5\text{ s}$ | $t_{SL} = 9\text{ s}$ |
|-------------------------|-------------------------|-----------------------|
| $t_{ST} = 0\text{ s}$   | LRC-A                   | LRC-D                 |
| $t_{ST} = 0.5\text{ s}$ | LRC-C                   | -                     |
| $t_{ST} = 2\text{ s}$   | LRC-E                   | LRC-B                 |

**Table 8. Correspondence of frequency (typical values) to application features**

| Alternator revolution speed (rpm)  |                     |      | 6 pole pairs | 8 pole pairs |
|------------------------------------|---------------------|------|--------------|--------------|
| Typical configuration A (Config-A) | Initiate regulation | 1200 | EN-1         | EN-3         |
|                                    | LRC Cut             | 3000 | DISAB-1      | DISAB-3      |
| Typical configuration B (Config-B) | Initiate Regulation | 1450 | EN-2         | EN-4         |
|                                    | LRC Cut             | 3000 | DISAB-1      | DISAB-3      |
| Typical configuration C (Config-C) | Initiate Regulation | 1450 | EN-2         | EN-4         |
|                                    | LRC Cut             | 3500 | DISAB-2      | EN-4         |

Considering the overall WW application scenario, there is a direct correspondence between Typical configurations A/B and regulation curve V<sub>reg-1</sub>, and between typical configuration C and regulation curves V<sub>reg-2</sub> and V<sub>reg-3</sub>. This is allowing the summary of all possible customization for L9911 in the table below.

**Table 9. Customization of L9911: combination of LRC, regulation, and application options**

| LRC timing options | Vreg-1/Config-A |              | Vreg-1/Config-B |              | Vreg-2/Config-B |              | Vreg-2/Config-A |              | Vreg-4/Config-A |              |
|--------------------|-----------------|--------------|-----------------|--------------|-----------------|--------------|-----------------|--------------|-----------------|--------------|
|                    | 6 Pole Pairs    | 8 Pole Pairs | 6 Pole Pairs    | 8 Pole Pairs | 6 Pole Pairs    | 8 Pole Pairs | 6 Pole Pairs    | 8 Pole Pairs | 6 Pole Pairs    | 8 Pole Pairs |
| <b>LRC-A</b>       | <b>L9911P</b>   | nya          | nya             | nya          | nya             | nya          | nya             | nya          | <b>L9911K</b>   | nya          |
| <b>LRC-B</b>       | nya             | nya          | <b>L9911F</b>   | nya          | <b>L9911I</b>   | nya          | nya             | nya          | nya             | nya          |
| <b>LRC-C</b>       | nya             | nya          | nya             | nya          | nya             | nya          | <b>L9911V</b>   | nya          | nya             | nya          |
| <b>LRC-D</b>       | nya             | nya          | nya             | nya          | nya             | nya          | nya             | nya          | nya             | nya          |
| <b>LRC-E</b>       | <b>L9911U</b>   | nya          | nya             | nya          | nya             | nya          | nya             | nya          | nya             | nya          |

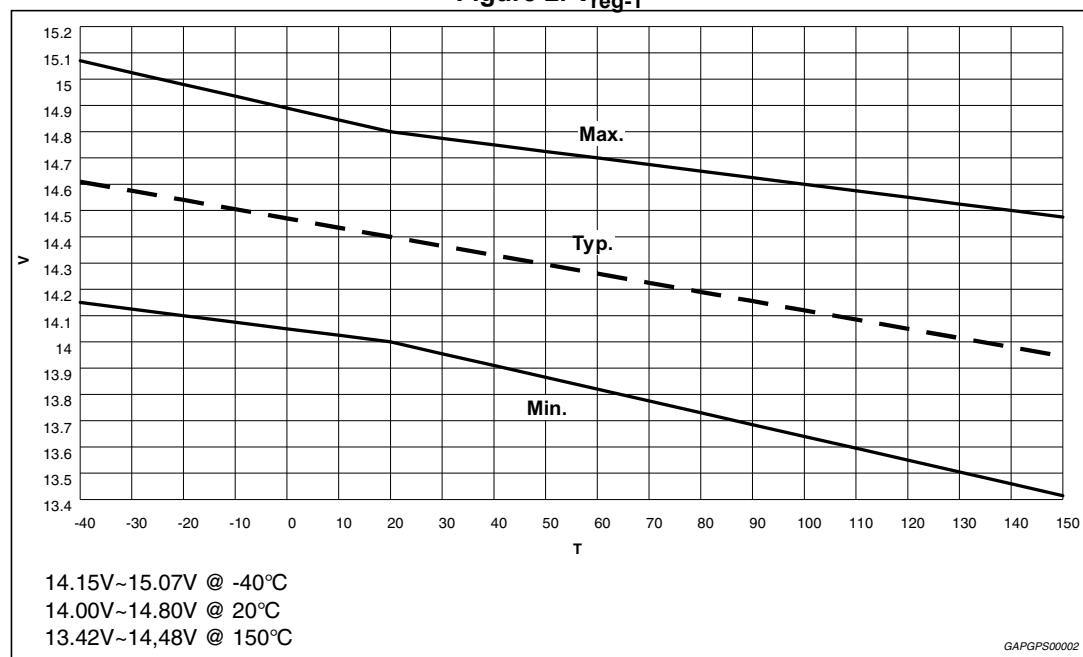
**Figure 2. V<sub>reg-1</sub>**

Figure 3.  $V_{reg-2}$

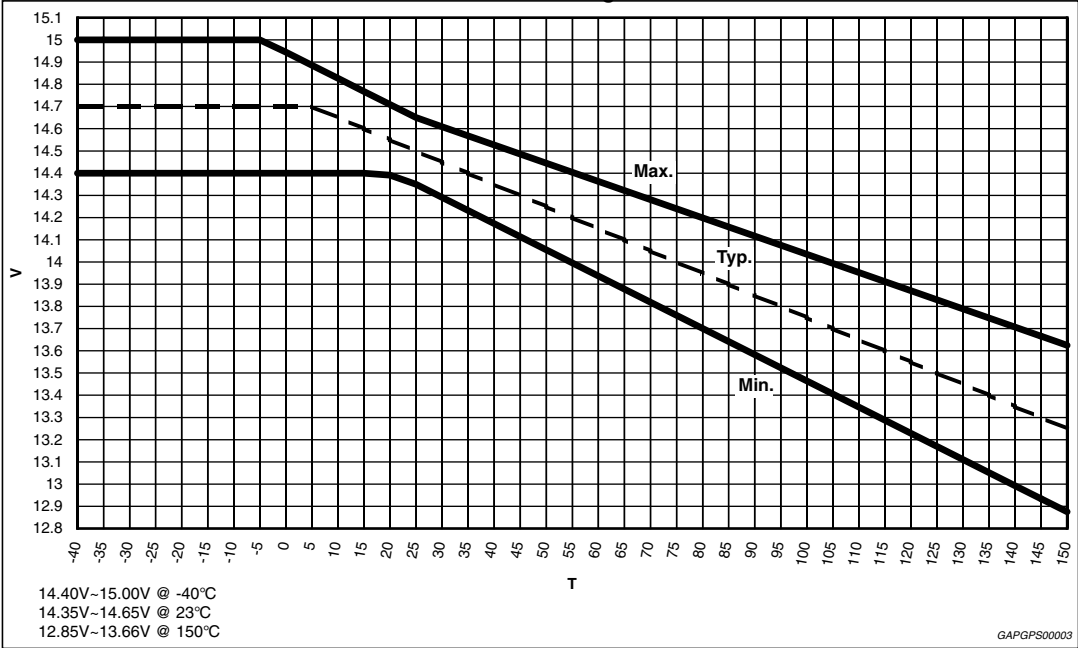


Figure 4.  $V_{reg-3}$

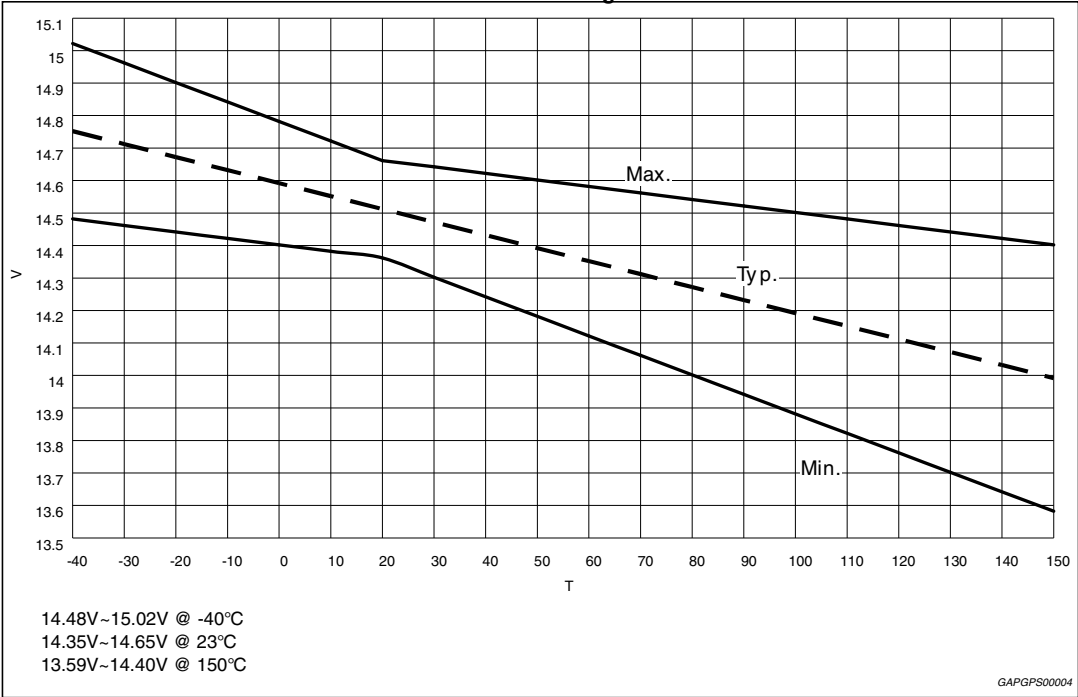


Figure 5.  $V_{reg-4}$

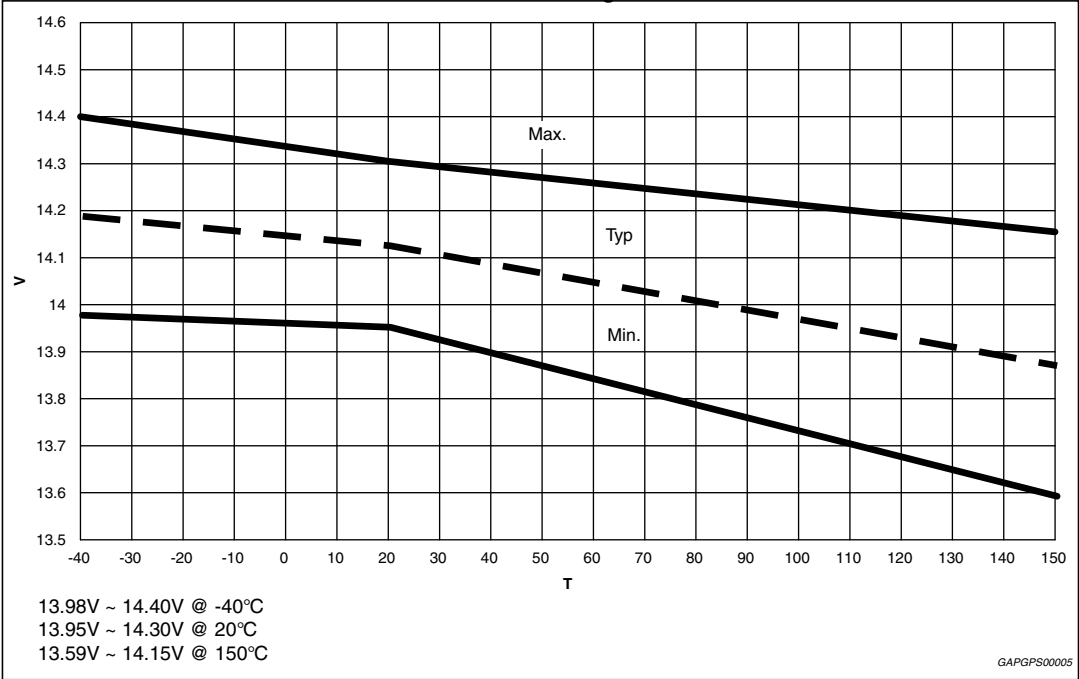


Figure 6. Output voltage rise/fall time (F+, DFM)

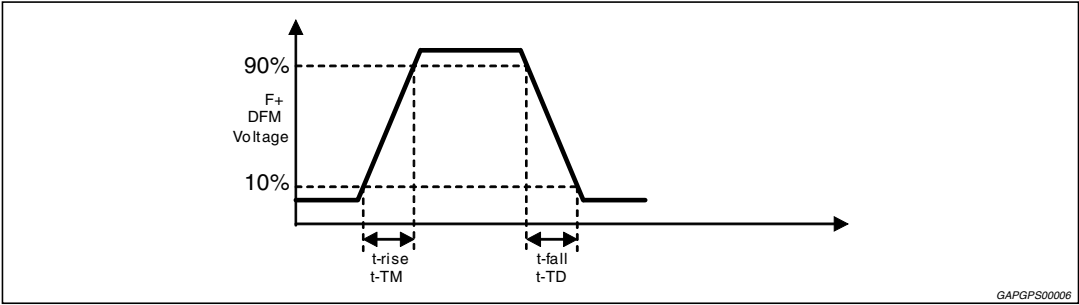
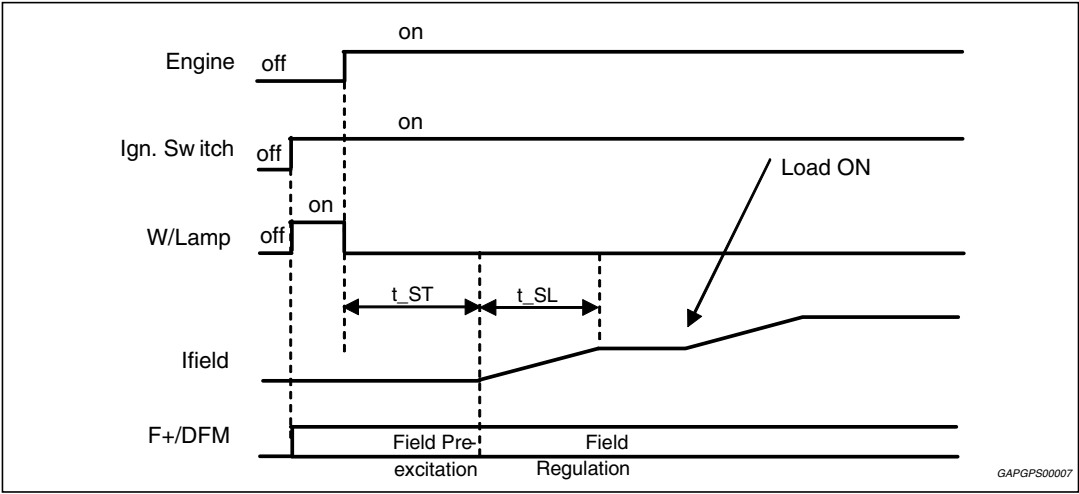


Figure 7. Phase regulation characteristics



### 3.4 Principle of phase regulation

When  $V_{B+}$  is above the regulated voltage, the field driver is controlled to keep phase peak voltage from falling below  $V_{PHH1}$ .

If phase peak voltage drops below  $V_{PHL1}$ , phase regulation does not work.

Figure 8. Application diagram

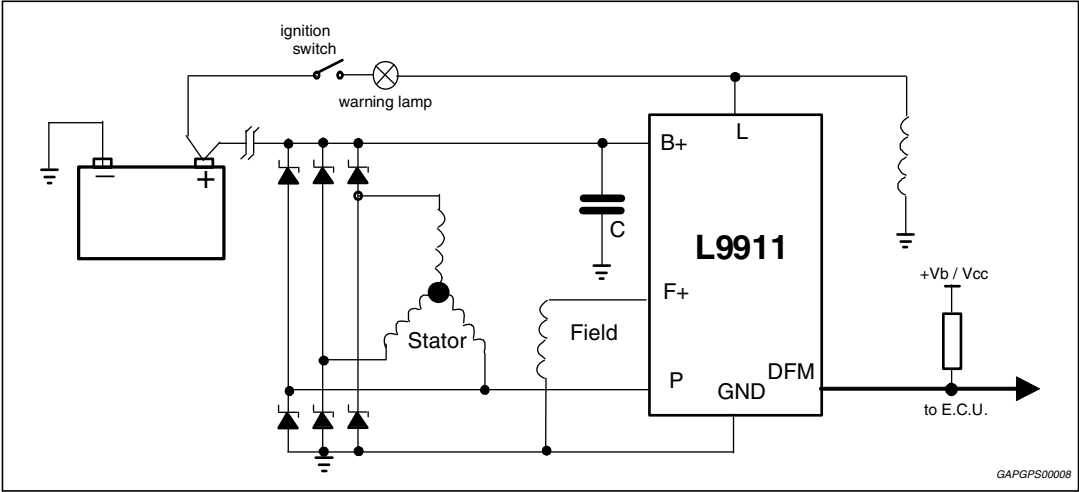


Figure 9. High side/low side driver saturation

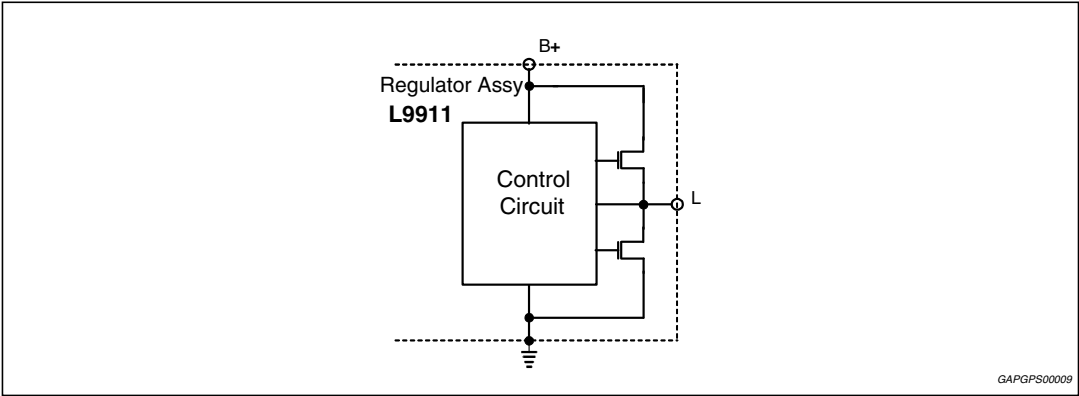


Figure 10. Test mode to cancel soft-start/attack

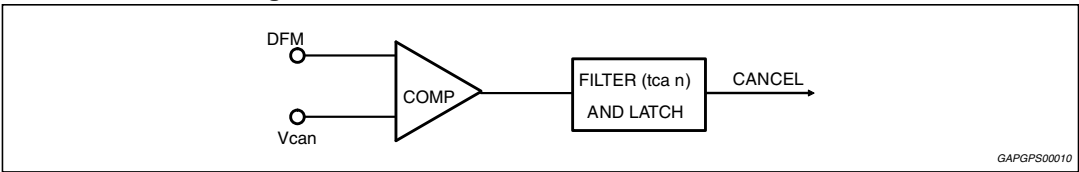


Figure 11. Soft-start enable frequency range

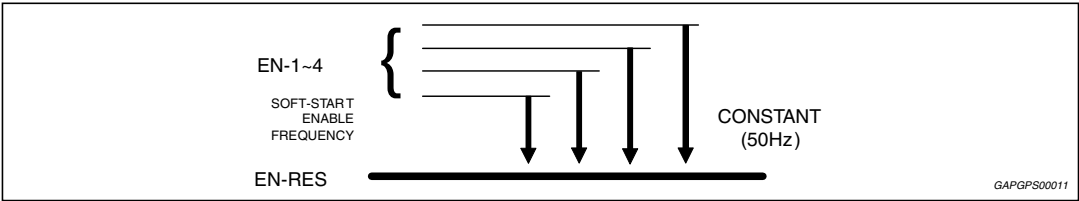


Figure 12. Soft-start characteristics (always activated at engine start)

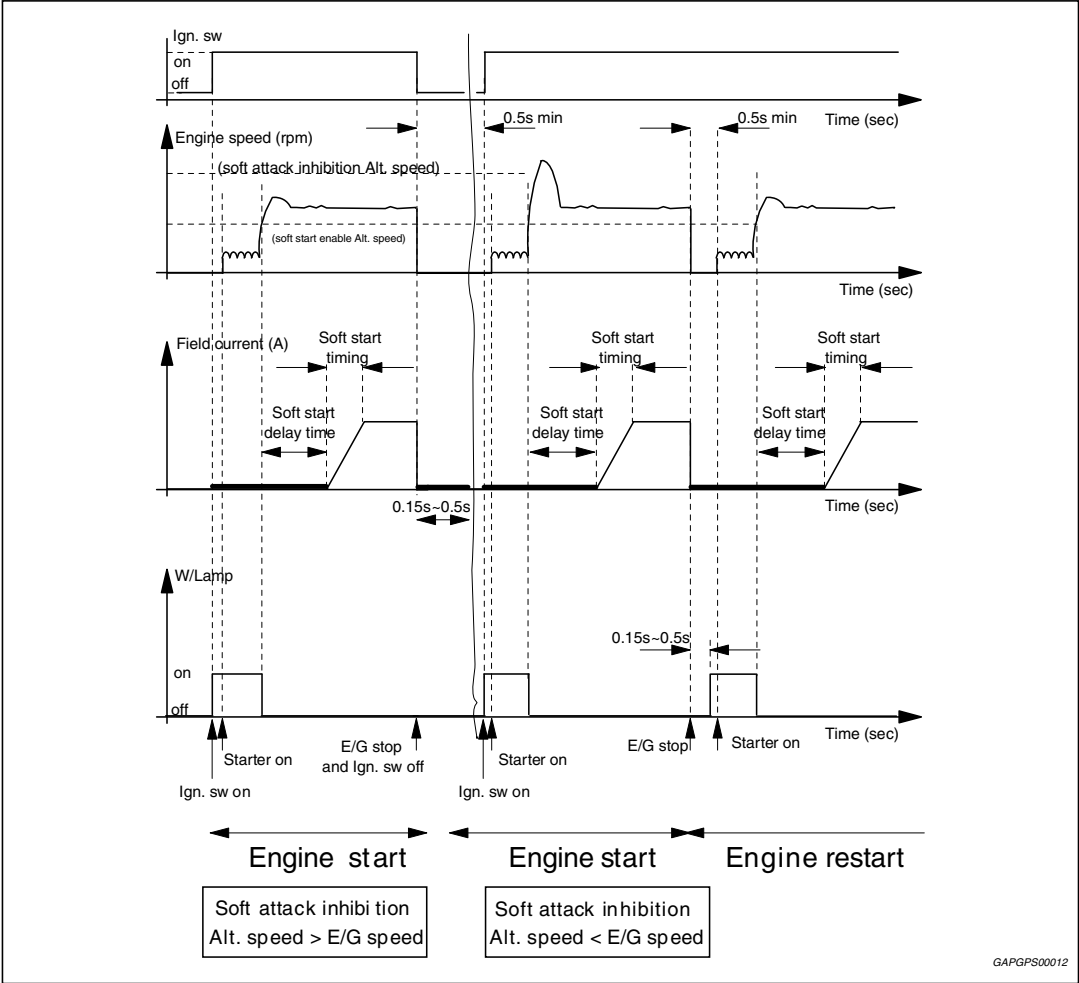


Figure 13. Soft start/attack characteristics

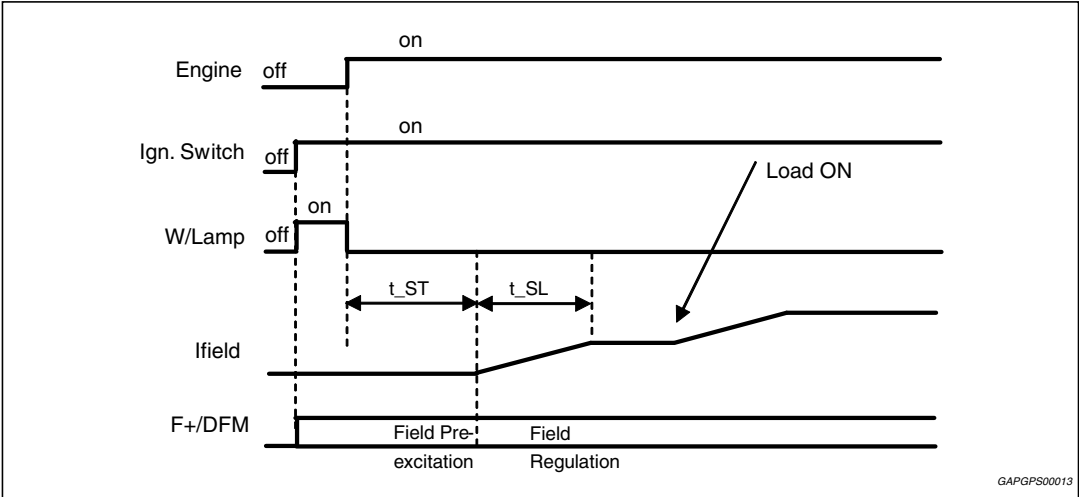


Table 10. Fault detection

| Root cause                         | Signal | Effect                   | Test detect                       |
|------------------------------------|--------|--------------------------|-----------------------------------|
| Alternator belt breaking           | P      | Alternator disexcitation | $VP < V_{PHH1}$ & $VB+ < V_{reg}$ |
| Brushes open                       | P      | Alternator disexcitation | $VP < V_{PHH1}$ & $VB+ < V_{reg}$ |
| Field driver open                  | P      | Alternator disexcitation | $VP < V_{PHH1}$ & $VB+ < V_{reg}$ |
| Field interruption                 | P      | Alternator disexcitation | $VP < V_{PHH1}$ & $VB+ < V_{reg}$ |
| Field short circuit to the battery | F+     | Overvoltage              | $VF+ > VS1$ & $VB+ > V_{ov-d}$    |
| Field short circuit to the ground  | P      | Alternator disexcitation | $VP < V_{PHH1}$ & $VB+ < V_{reg}$ |
| Battery discharge                  | B+     | Undervoltage             | $VB+ < V_{uv}$                    |

Note: The diagnostic result is disabled during the Soft-start delay time  $t_{ST}$  0...3 and the soft-start / soft attack timing  $t_{SL}$  0...3

Figure 14. DF monitor electrical configuration

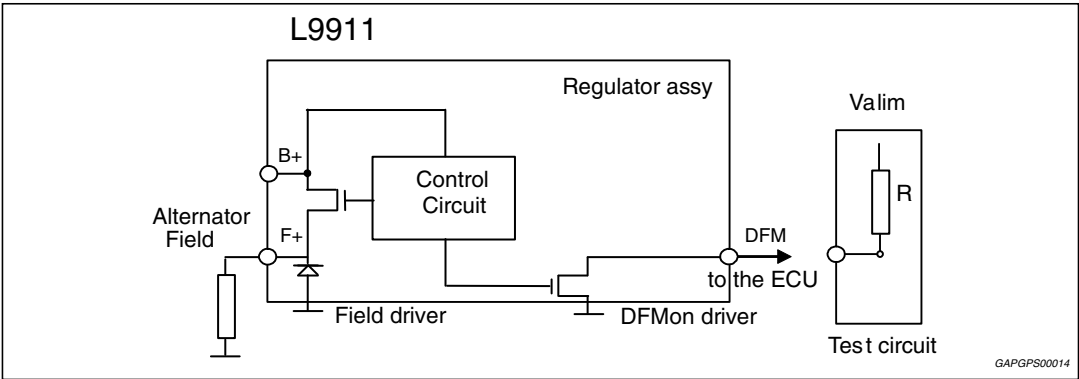
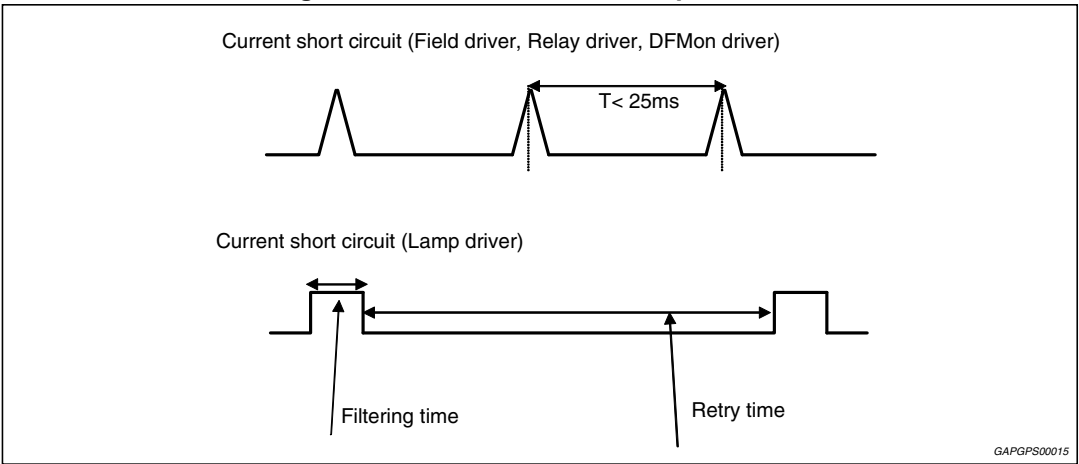


Figure 15. Short circuit drivers' protection



Field driver, DFMon driver and Relay driver are protected in switching mode (not linear), with a retry time less than 25 ms.  
Lamp driver is protected in linear mode, with a retry time of 1 s.



## 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](http://www.st.com). ECOPACK® is an ST trademark.

### 4.1 Multiwatt 8 (pin 5 GND) package information

Figure 16. Multiwatt 8 (pin 5GND) package outline

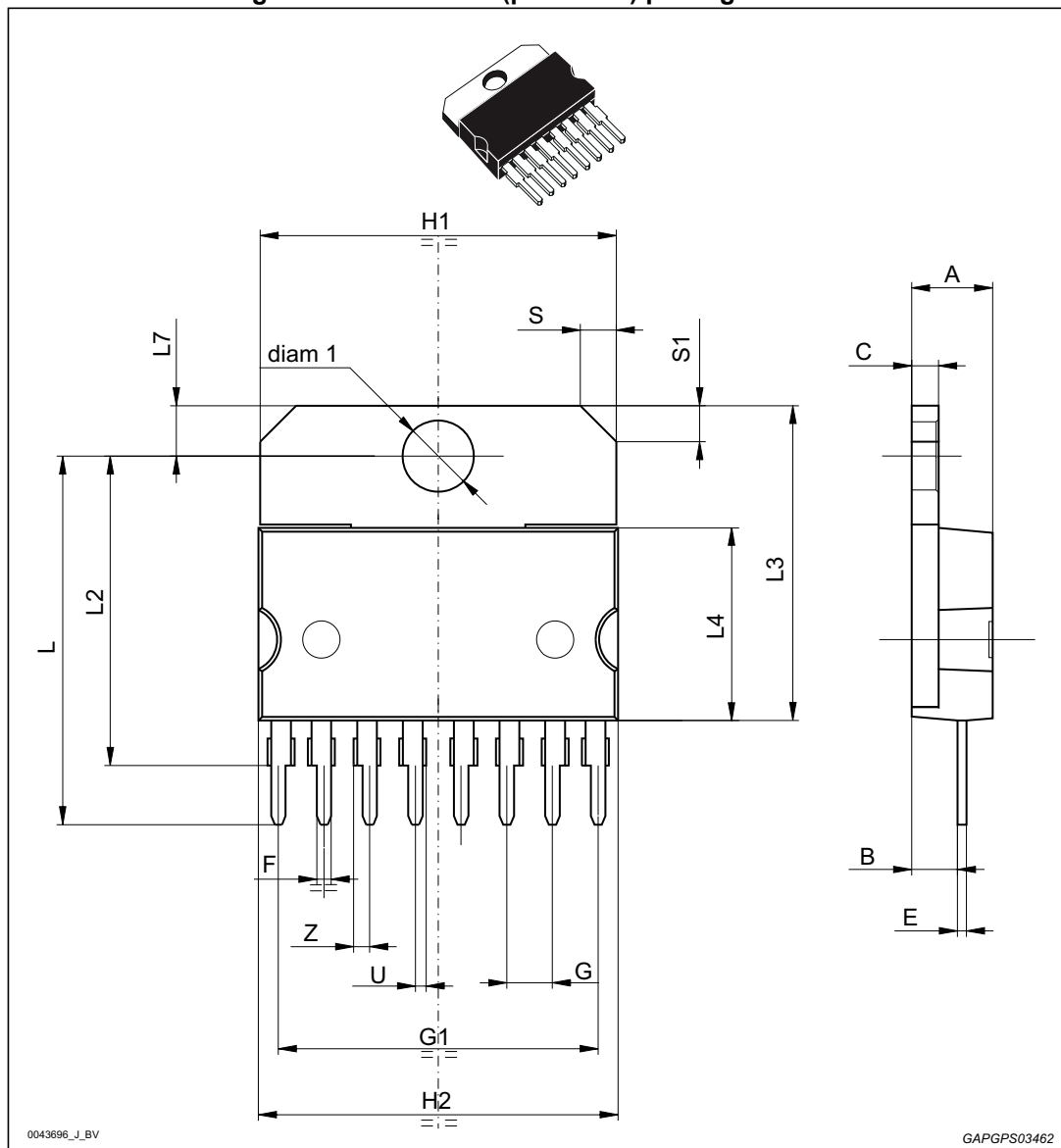


Table 11. Multiwatt 8 (pin 5GND) package mechanical drawing

| Ref   | Dimensions  |       |       |                       |        |        |
|-------|-------------|-------|-------|-----------------------|--------|--------|
|       | Millimeters |       |       | Inches <sup>(1)</sup> |        |        |
|       | 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 12. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                      |
|-------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 22-Jun-2004 | 1        | Initial release.                                                                                                                                                                                                                                                                                                                             |
| 18-May-2005 | 2        | Modified Figure 2, Table 2 and Table 5;<br>Updated Figure 10, 11 and 14; Add Table 7.<br>Add ordering numbers.                                                                                                                                                                                                                               |
| 07-Nov-2005 | 3        | Updated Table 5.<br>Added new tables 6-9.                                                                                                                                                                                                                                                                                                    |
| 28-Nov-2005 | 4        | Added the L9911C part number.<br>Updated the Table 9.                                                                                                                                                                                                                                                                                        |
| 11-Jul-2007 | 5        | Document reformatted.<br>Updated order codes, see <a href="#">Table 1: Device summary</a> .                                                                                                                                                                                                                                                  |
| 09-Nov-2009 | 6        | Updated <a href="#">Table 1: Device summary</a> , <a href="#">Table 7: Load response control timing options</a> and <a href="#">Table 9: Customization of L9911: combination of LRC, regulation, and application options</a> .                                                                                                               |
| 23-Jul-2010 | 7        | Updated <a href="#">Table 1: Device summary</a> , <a href="#">Table 5: Electrical characteristics</a> and <a href="#">Table 9: Customization of L9911: combination of LRC, regulation, and application options</a> .<br>Updated <a href="#">Figure 2</a> , <a href="#">3</a> and <a href="#">4</a> .<br>Added new <a href="#">Figure 5</a> . |
| 25-Jan-2011 | 8        | Updated <a href="#">Table 5: Electrical characteristics</a> .<br>Updated <a href="#">Figure 5</a> .                                                                                                                                                                                                                                          |
| 29-Mar-2011 | 9        | Modified in the <a href="#">Table 5: Electrical characteristics</a> the values of the “V <sub>uv-up</sub> ” parameter.                                                                                                                                                                                                                       |
| 26-Mar-2012 | 10       | Updated:<br><a href="#">Table 1: Device summary on page 1</a> ;<br><a href="#">Table 7: Load response control timing options on page 10</a> ;<br><a href="#">Table 9: Customization of L9911: combination of LRC, regulation, and application options on page 11</a> .                                                                       |
| 28-May-2012 | 11       | Updated <a href="#">Table 9: Customization of L9911: combination of LRC, regulation, and application options on page 11</a> .                                                                                                                                                                                                                |
| 19-Sep-2013 | 12       | Updated disclaimer.                                                                                                                                                                                                                                                                                                                          |
| 30-Sep-2015 | 13       | Added <a href="#">Section 1.5: Self start function on page 5</a> .                                                                                                                                                                                                                                                                           |

**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