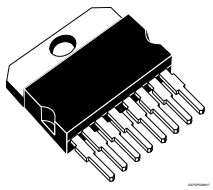
L9409

Alternator voltage regulator with load response control

Features

- IC regulator for 12 V type alternator
- Fixed frequency regulation loop
- 130 mΩ high side field driver
- Fail safe device with double sensing of battery voltage (VB and VS)
- Load response control (LRC) function activates after an initial time delay
- Self start function from phase frequency
- “Z” shaped regulation curve compliant with VW specification.
- Key recognition from L input
- Field driver, lamp driver and relay driver short protection
- Complex diagnostics
- Thermal shutdown at 175 °C



Multiwatt8

Description

The L9409 is a monolithic multifunction alternator voltage regulator intended for use in automotive applications.

The device regulates the output of an automotive generator by controlling the field winding current by means of either an analog fixed frequency PWM signal or digital fixed frequency PWM signal (LRC). The Load Response Control function is activated in order to eliminate IC engine speed fluctuation and vibrations caused by the insertion of sudden electrical loads during alternator low speed operations (f < 310 Hz). Both the analog and digital duty cycle are applied to a high side driver.

The device is able to regulate the voltage either using a feedback signal from B pin or from S pin depending on application needs. S pin is intended to have a clear direct connection with the positive terminal of the car battery. If this connection gets lost the device will regulate voltage using B pin giving a fail safe functionality.

Using L pin is possible to sense key switch and a pre-excitation duty cycle is applied on the field coil in order to start phase voltage sensing. In the case L connection gets lost, device starts to generate using residual magnetism of the generator.

Field, lamp and relay drivers are protected against short circuit.

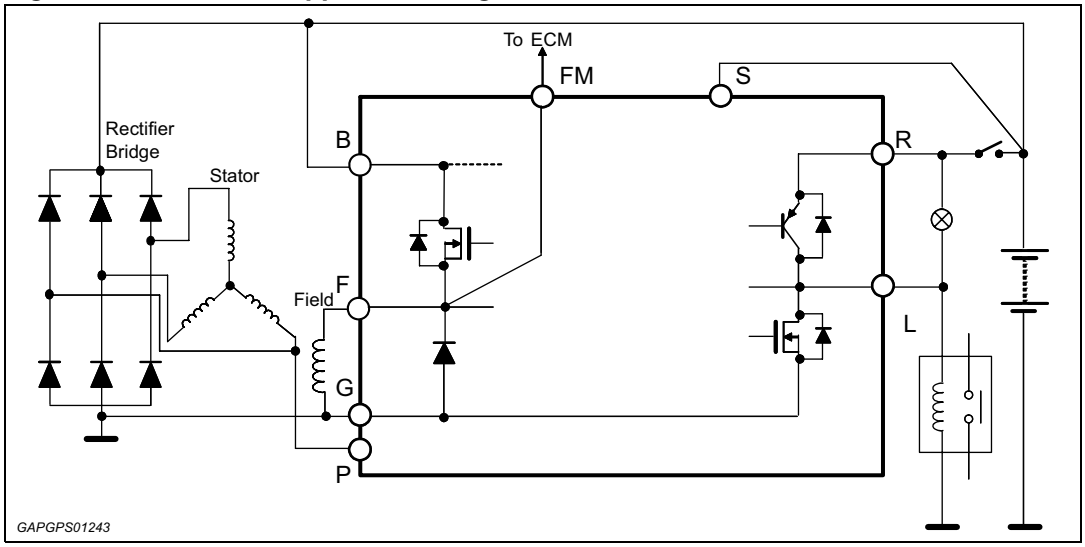
Table 1. Device summary

Order code	Junction temp range, °C	Package	Packing
L9409F	-40 to 150	Multiwatt8	Tube

Contents

1 Block and application diagram

Figure 1. Block and application diagram



2 Pin description

Figure 2. Multiwatt8 pin connection diagram

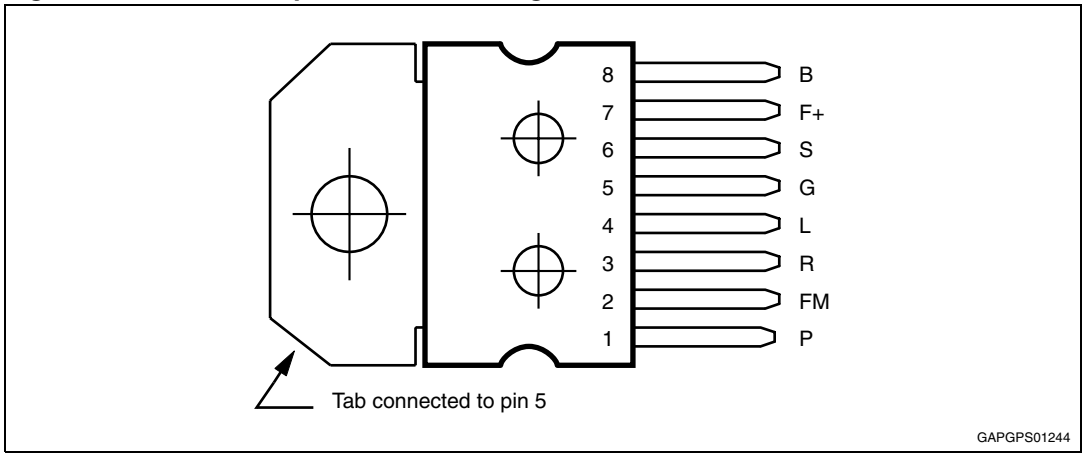


Table 2. Pin description

Pin #	Pin name	Function
1	P	Phase input
2	FM	Field monitor output
3	R	Relay terminal high side driver
4	L	Lamp terminal low side driver
5	G	Power ground
6	S	Battery sense input
7	F+	Field high side driver output
8	B	Voltage supply and generator output sense

3 Maximum ratings

3.1 Voltage maximum ratings

Table 3. Voltage maximum ratings

Pin	Operating range (full spec guaranteed) (V)	Maximum range (functionality guaranteed) (V)	DC Absolute maximum range (no damage guaranteed) (V)
B	8/16	8/28	-0.3/40
L	0/16	0/28	-1/40
F_M	0/16	0/28	-0.3/40
S	8/16	8/28	-0.3/40
P	-1/16	-1/16	-1.5/16
F+	6/16	6/28	6/40
R	8/16	8/28	-0.3/40

Table 4. Transient voltage maximum ratings

Parameter	Conditions	Value	Unit
Transient supply voltage (load dump)	t < 500 ms	40	V
Transient supply voltage (low energy spikes)	ISO7637-1 pulse 1,2,3 ISO7637-3 according to application diagram (*Figure 1*)	60	V
B+ reverse battery voltage	T_j = 25 °C, t = 15 s	-2.5	V
ESD voltage	MILSTD883C, All pins vs. GND	±2	kV

3.2 Thermal data

Table 5. Thermal characteristics

Symbol	Parameter	Value	Unit
T_j	Junction temperature	-40 to 150	°C
T_{stg}	Storage temperature	-50 to 175	°C
T_{sd}	Thermal shut down	175 ±15	°C
$R_{th\ j\text{-}case}$	Thermal resistance junction-to-case	1.5	°C/W

4 Device description

4.1 Voltage regulation

4.1.1 Description

The alternator voltage is compared with a reference voltage in an amplifier. This device senses the battery voltage in two ways: the B+ pin and the S pin. The last could be left unconnected. In this condition the battery voltage is sensed from the V_{GO} pin, otherwise the S pin is used. This second condition assures a better knowledge of the real value of the battery voltage if a direct connection with the positive terminal of the battery is made as shown in *Figure 1*. The field driver works at a fixed frequency. A variable duty cycle is applied on the field winding according with the error between the voltage set-point and the measured battery voltage. The voltage set-point depends on case temperature. A set-point voltage vs. case temperature curve is integrated in the device and is shown in *Figure 3*.

4.1.2 Electrical characteristic

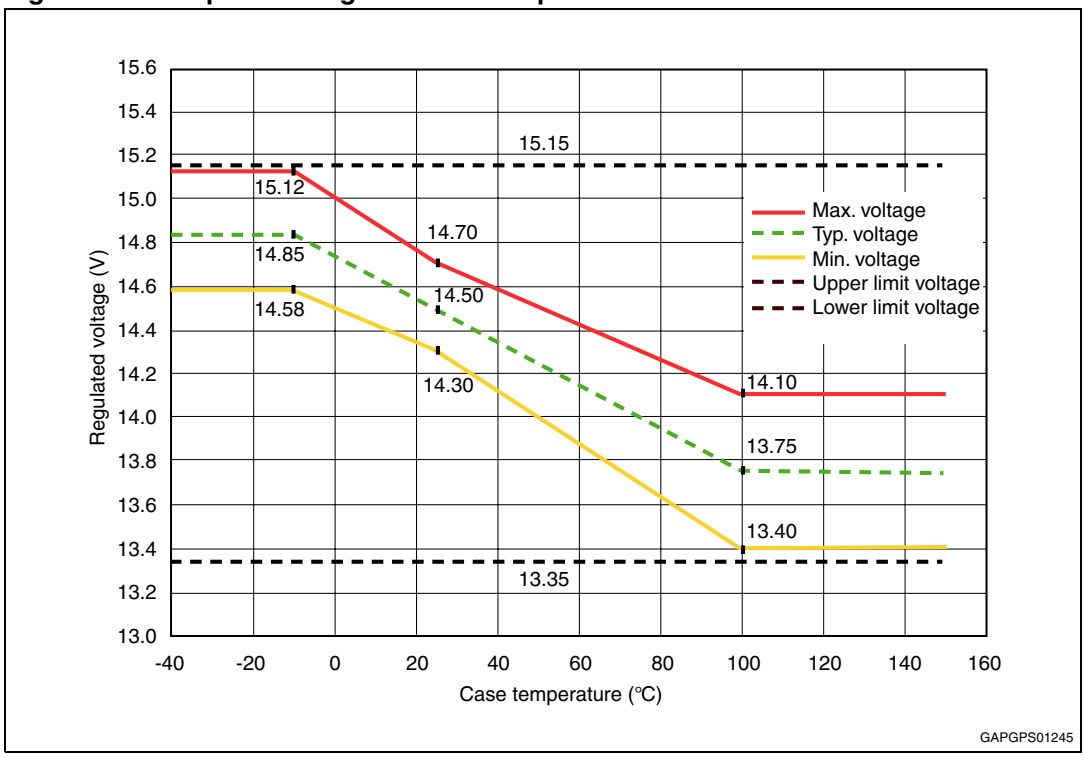
T_j = -40 to 150 °C unless otherwise specified.

Table 6. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
I_{SB}	Standby current	V_B = 13V, -40 °C < T_j <+ 150 °C	-	-	400	µA
V_{SF}	Regulation set-point voltage	@ 25 °C	-	14.5	-	V
V_{P1}	Initiation of regulation detection phase voltage threshold (1)	I_P = 1mA (sinking current)	-	1.5	-	V
D_{PE}	Pre-excitation	-	19	-	25	%
f_{IFR}	Initiation of field regulation frequency	-	360	400	440	Hz
T_C	Thermal compensation	-40 °C ≤ T_{case} ≤ -10 °C	-0.5	0	0.5	mV/°C
		-10 °C ≤ T_{case} ≤ 100 °C	-8	-10	-12	mV/°C
		100 °C ≤ T_{case} ≤ 150 °C	-0.5	0	0.5	mV/°C
V_{LR}	Load regulation	18000 rpm, 10% to 90% load	-	-	200	mV
V_{SR}	Speed regulation	Guarantee by design	-	-	200	mV
R_{ON}	Field driver on resistance	I_F = 5 A, T_{case} = 125 °C	-	-	130	mΩ
I_{FLIM}	Field limit current	F shorted to GND @ -40 °C	8	-	15	A
		F shorted to GND @ 25 °C	8	-	15	A
		F shorted to GND @ 150 °C	7.5	-	14.5	A
V_F	Field discharge rectifier	I_F = 6 A, T_{case}= 25 °C	-	-	1.85	V
I_R	Diode reverse current	-	-	-	20	µA
I_{PD-P}	Pull down current on P terminal	-	0.4	-	1.4	mA

1. This threshold on the phase signal is used to detect the phase frequency, f_{IFR}, for the Initiation of field regulation.

Figure 3. Set-point voltage vs. case temperature

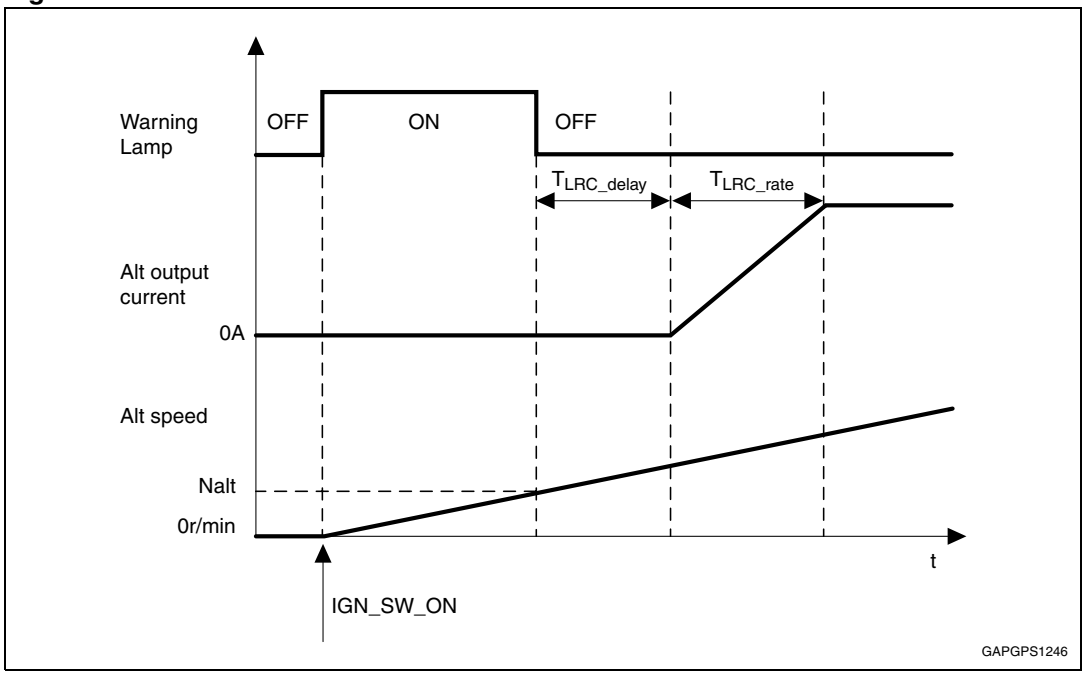


4.2 Load response control (LRC)

4.2.1 Description

This function controls the sudden torque increase on engine when the last is started or electric load is changed within the idling speed. In particular, the alternator output current is increased gradually at a constant rate (LRC_{rate}) when generating is started. The time needed to rump up from 0% to 100% of duty cycle is defined as T_{LRC_rate}. This function is enabled when the alternator achieves a certain speed (f_{LRC_EN}) and after a delay time (T_{LRC_delay}). T_{LRC_delay} is defined as the period from N_{alt} attainment to the start of generating as described in *Figure 4*. The LRC is disabled while the alternator rotor speed is greater than a set value (f_{LRC_DIS}).

Figure 4. LRC function



4.2.2 Electrical characteristics

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

Table 7. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
f_{LRC_EN}	LRC enable frequency	LRC enabled above this frequency	130	145	160	Hz
f_{LRC_DIS}	LRC transition frequency	LRC disabled above this value	270	300	330	Hz
T_{LRC_delay}	Load response control delay	delay of activation of LRC	2.1	-	3.5	s
T_{LRC_rate}	Load response control rate(1)	-	2.1	-	2.9	s

1. This is the time duration that L9460 takes to ramp up from 0% to 100% duty cycle in response to an increased load on the generator.

4.3 Lamp and relay driver

4.3.1 Description

The lamp driver has two functions:

- Switch on the warning lamp in the dash board when any of fault operation occurs.
- Judge if IG-SW is turned on or not.

4.3.2 Electrical characteristic

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

Table 8. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_{LSAT}	Lamp driver saturation voltage	I_L = 1 A @ -40 °C	1.2	-	1.4	
		I_L = 1 A @ 25 °C	1.2	-	1.45	V
		I_L = 1 A @ 150 °C	1.2	-	1.50	V
V_{LON}	Lamp on voltage	I_L = 0.2 A, V_B= open, T_j = -40 °C	4.7	-	6.2	V
		I_L = 0.2 A, V_B= open, T_j = 25 °C	4.5	-	5.5	V
		I_L = 0.2 A, V_B= open, T_j = 150 °C	3.5	-	5	V
I_{LIML}	Limitation lamp current	-	-	-	2.5	A
V_{WU-L}	Wake-up voltage at L terminal	-	0.8	1	1.1	V
I_{PD-L}	Pull down current	V_L = 0.8 V	0.8	-	3	mA

4.3.3 Relay driver description

This terminal is used to provide a current to electric loads such as a Relay coil connected between L terminal and GND. While L terminal is turned off, a current of max. 2.5 A is provided to the relay coil, using a high side driver, between R terminal and L terminal, after a time delay of 300 µs. The R terminal can be connected to the ignition switch, B terminal or it can be left open.

4.3.4 Electrical characteristic

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

Table 9. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_{RSAT}	Relay driver saturation voltage	I_R= 1A @ 25 °C	0.2	-	0.6	V
I_{RTHR}	Relay threshold current	-	1.3	-	2.5	A
T_{RD}	Relay driver activation delay	-	-	300	-	µs

4.4 Protection and diagnosis

Table 10. Fault lamp driver to function

#	Conditions	Delay
1	Phase voltage < V_{PL}. The alternator is not generating, the belt is broken or alternator is not rotating	Yes
2	V_B-V_s > 2 V OR V_s>V_{OH}. Over voltage warning	Yes
3	V_S < V_{SO} AND Phase frequency > f_{LRC_EN}. S terminal is open during generation	Yes
4	V_B< V_{BO} AND Phase frequency > f_{LRC_EN}. B terminal is open during generation	Yes
5	Phase frequency < f_{LRC_EN}	Yes

The table above lists the conditions that cause the fault lamp driver to function. To prevent lamp flicker, specific faults are required to be present for T_{DELAY} seconds before the lamp driver is activated. This delay is indicated in *Figure 11*.

4.4.1 Diagnostic electric parameters

Table 11. Diagnostic electric parameters

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
V_{PL}	Low voltage warning threshold	-	5	6	7	V
V_{OH}	Over voltage protection threshold	-	15.1	16.5	17.5	V
V_{SO}	S-terminal open threshold	-	7	-	12	V
V_{BS}	Open threshold	-	1.6	2.0	2.2	V
f_{LRC_EN}	Low speed threshold	-	130	145	160	V
T_{DELAY}	Fault indication delay time	-	0.8	-	1.2	s

5 Package information

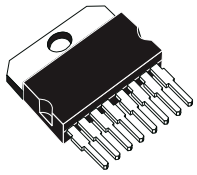
In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*.

ECOPACK® is an ST trademark.

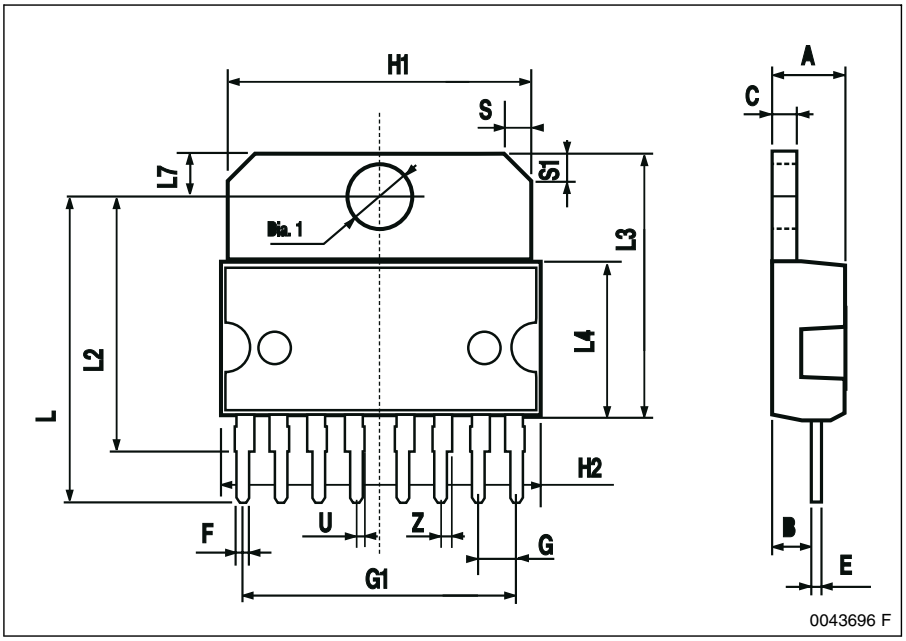
Figure 5. Multiwatt8 mechanical data and package dimensions

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
E	0.49		0.55	0.019		0.022
F	0.78		0.85	0.030		0.033
G	2.40	2.54	2.68	0.094	0.10	0.105
G1	17.64	17.78	17.92	0.69	0.70	0.71
H1	19.6			0.772		
H2			20.2			0.795
L	20.35		20.65	0.80		0.81
L2	17.05	17.20	17.35	0.671	0.677	0.683
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L7	2.65		2.9	0.104		0.114
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
U	0.40		0.55	0.015		0.022
Z	0.70		0.85	0.028		0.034
Dia1	3.65		3.85	0.144		0.152

OUTLINE AND MECHANICAL DATA



Multiwatt8 (Pin 5 GND)



6 Revision history

Table 12. Document revision history

Date	Revision	Changes
12-Jan-2011	1	Initial release.

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries (“ST”) reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST’s terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST’S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY TWO AUTHORIZED ST REPRESENTATIVES, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER’S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com