AR6000

Alternator regulator with LIN

Rev. 5.2 — 17 June 2019 Product data sheet

1 General description

The AR6000 is an integrated circuit intended to regulate the output voltage of an automotive alternator.

It supplies a current via a high-side MOSFET to the excitation coil of the alternator and provides an internal freewheeling diode. It keeps the battery at its nominal charge and delivers current to electrical devices within the vehicle.

The IC provides a load response control mechanism (LRC), and has an interface for the industry standard LIN protocol (v 1.3 or 2.1) to allow an ECU to control the regulated voltage and the LRC rate among other parameters. The ECU can also read back information about the status of the regulator and the alternator via LIN.

It can be programmed for most functions using OTP (fuses) and fits a large number of alternators and applications.

2 Simplified application diagram

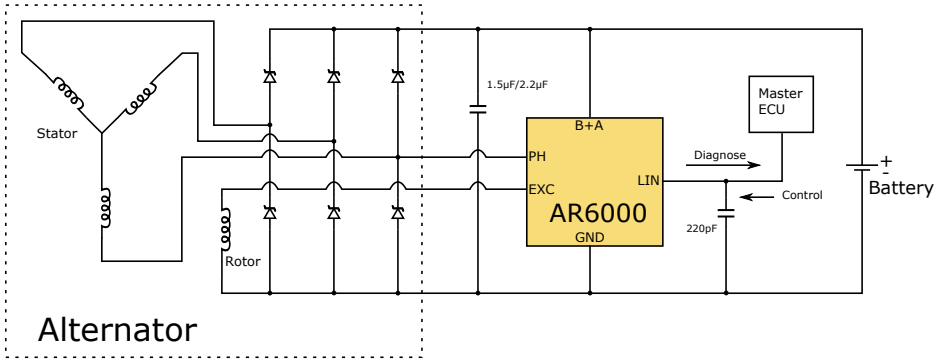


Figure 1. Simplified application diagram (LIN Mode)

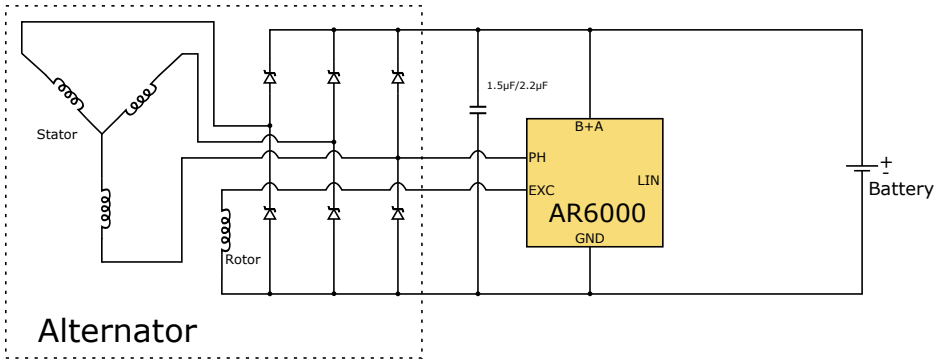


Figure 2. Simplified application diagram (standalone, self-start mode)

3 Features and benefits

- High-side field driver
- Internal freewheeling diode
- Up to 12.0 A rotor current (excitation coil)
- Load response control (LRC) and return LRC
- Current limitation and overcurrent protection
- Thermal protection
- Thermal compensation
- LIN 2.1 physical layer
- Set point voltage selectable from 10.6 V to 16 V
- Accurate rotor current measurement, die temperature, alternator speed, and battery voltage reported by LIN

4 Applications

- Automotive alternators

5 Orderable parts

Table 1. Orderable part variations

Part number	Temperature (T_A)	Package
MC33AR6000BGWS[1]	−40 °C to +150 °C	die
MC33AR6000BGT[1]	−40 °C to +125 °C	TO220

[1] The AR6000 devices are configurable with one time programmable (OTP) options described in Table 58. For easy design-in, contact your local NXP sales representative to receive limited engineering samples in the TO-220 package configured to your system requirements.

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6 Internal block diagram

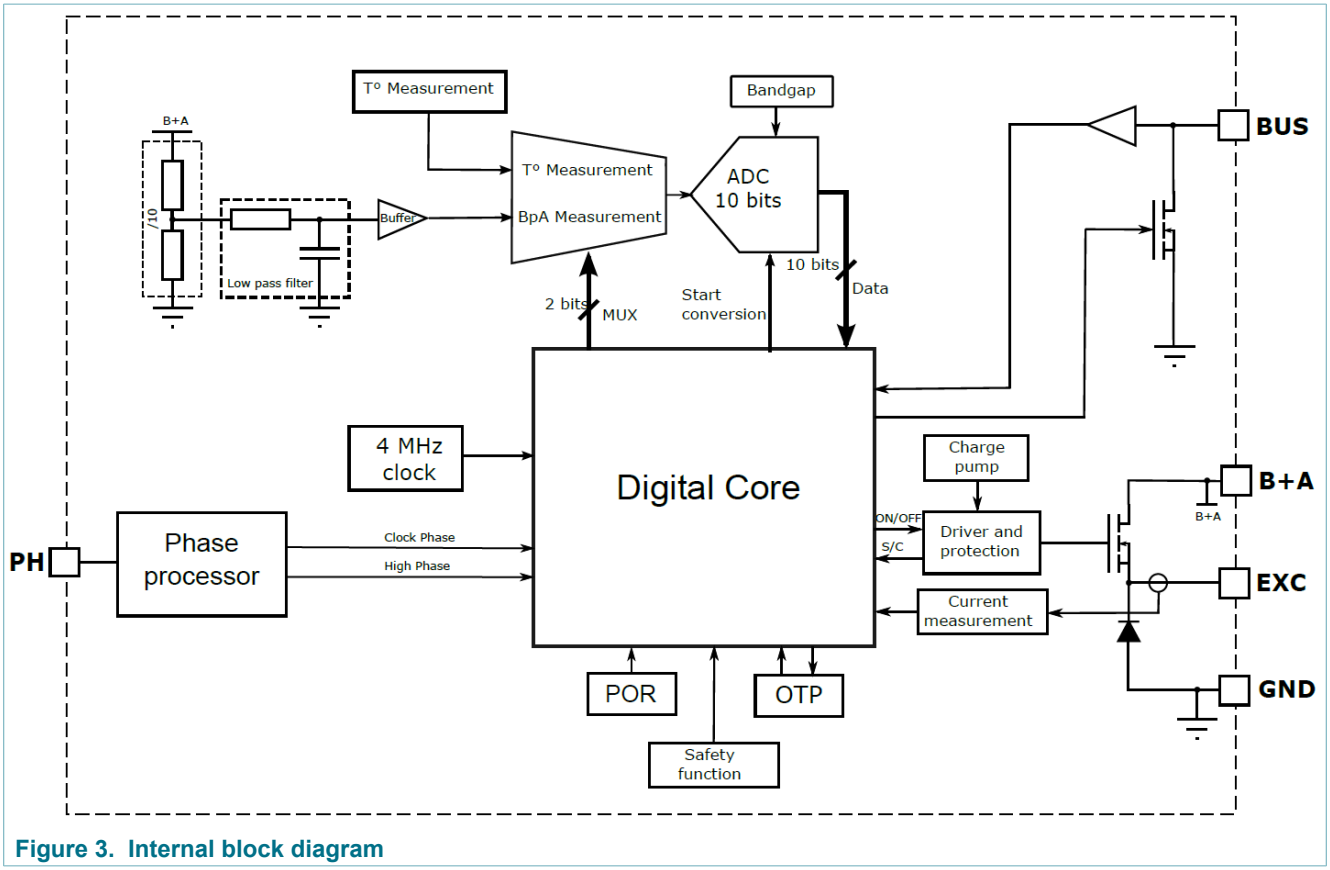


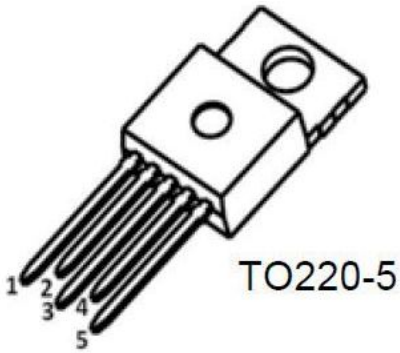
Figure 3. Internal block diagram

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7 Pinning information

7.1 Pinning



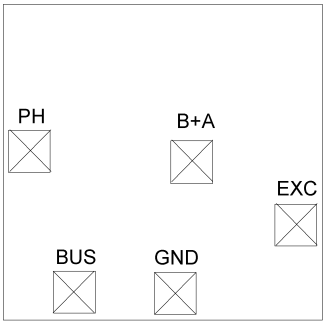


Figure 4. AR6000 pinout diagram

Table 2. Pin coordinates for die version

Pad[1]	Function	Die coordinates (origin at center of die)	
		X/µm	Y/µm
1	EXC	1820	−649
2	B + A	513	181
3	GND	289	−1490
4	BUS	−1010	−1490
5	PH	−1821	337

[1] Pad size is 800 µm × 800 µm.

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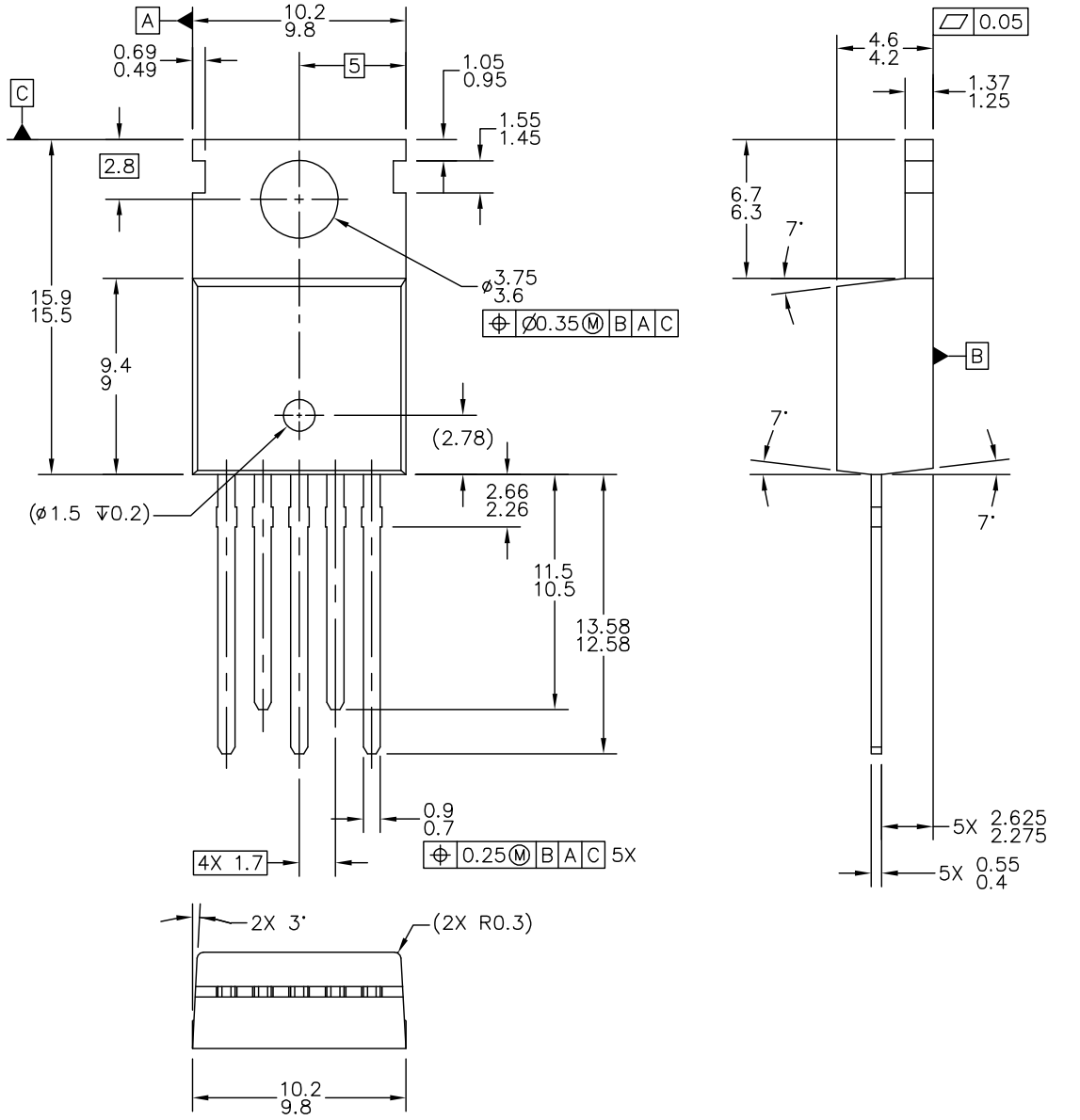
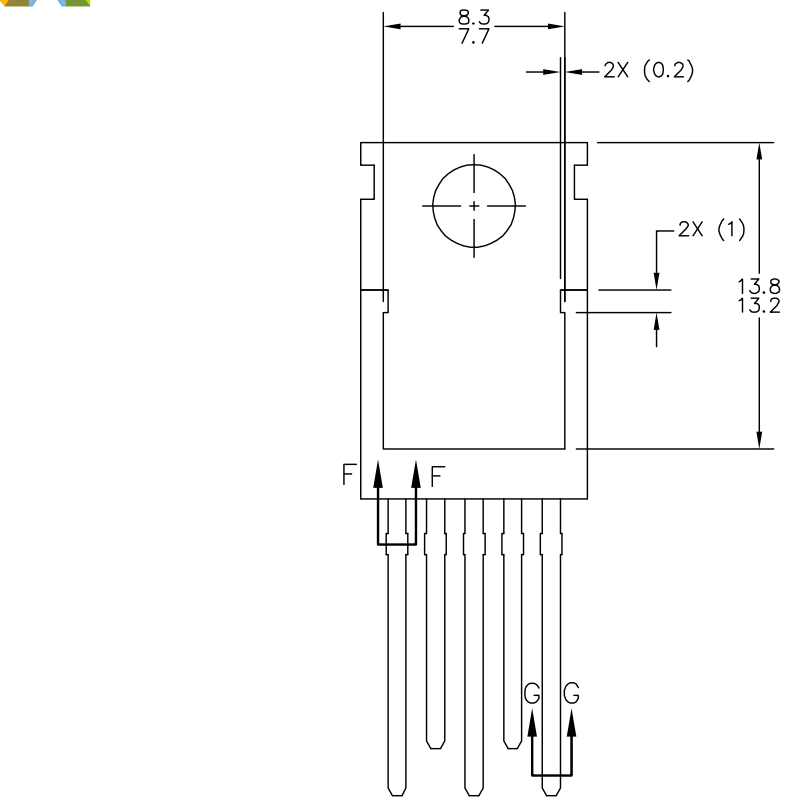
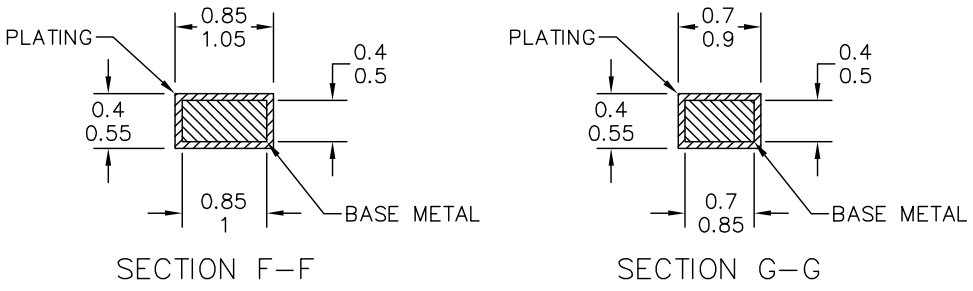


Figure 5. TO220 dimensions

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	STANDARD: NONE	
	SOT1760–1	14 JAN 2016

Figure 6. TO220 dimensions (continued)

7.2 Pin definitions

A functional description of each pin can be found in Section 9.2 "Functional pin description".

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Table 3. Pin description

Pin number	Pin name	Pin function	Formal name	Definition
1	EXC	output	excitation	this pin is connected to the rotor coil of the alternator
2	B+A	power	supply voltage	this pin is connected to the battery of the vehicle
3	GND	power	ground	ground pin
4	BUS	input/output	LIN-bus	LIN-bus connected to master
5	PH	input	phase	signal from alternator phase

Table 4. Mandatory external components

Data	Description	Min.	Typ.	Max.	Unit
B+A capacitor	—	—	1.5	—	µF
LIN-bus capacitor	—	—	220	—	pF

8 General product characteristics

8.1 Maximum ratings

Table 5. Maximum ratings

All voltages are with respect to ground, unless otherwise noted. Exceeding these ratings may cause a malfunction or permanent damage to the device. T_A = 25 °C, unless otherwise stated.

Symbol	Description (Rating)	Min.	Max.	Unit
ELECTRICAL RATINGS				
	B+A supply pin			
$V_{B+A\ MAX}$	DC voltage	—	40	V
	Load dump transient voltage (ISO7637-2)			
$V_{B+A\ MIN}$	DC voltage	—	–0.3	V
$V_{B+A\ REV}$	Maximum reverse B+A voltage [1] (5 seconds)	—	–3.2	V
I_{EXC}	Maximum excitation current [2]	—	12	A
	Recirculation diode peak current	—	12	A
	Recirculation diode reverse voltage	—	+40	V
V_{PHASE}	PHASE input voltage range	–24	+40	V
	BUS pin input range	–2.0	+40	V
	ESD voltage			
V_{ESD1}	Human Body Model - All pins (MIL std 883C) [3]	—	±8000	V
V_{ESD2}	CDM- AECQ100-011B All pins [4]	—	±500	
V_{ESD3}	CDM- AECQ100-011B EXC and Phase pins	—	±750	
V_{ESD4}	Accessible pins (EN61.000-4-2) when mounted on the Alternator (BUS & B+A) by contact discharge [5]	—	±10000	
V_{ESD5}	Air discharge when mounted on the Alternator	—	±15000	

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Symbol	Description (Rating)	Min.	Max.	Unit
Level	Standard Transient Pulses ISO 7637-2 (when mounted on alternator)			
	Pulse 1	—	−100	V
	Pulse 2a	—	+100	
	Pulse 3a	—	−150	
	Pulse 3b	—	+100	

[1] Not tested. Depends on package and bonding.
[2] Time to withstand this current before thermal shutdown depends on thermal characteristics of the package and ambient temperature.
[3] Testing is performed in accordance with the Human Body Model (CZAP = 100 pF, RZAP = 1500 Ω).
[4] Testing is performed in accordance with the Charge Device Model, Robotic (CZAP = 4.0 pF and 30 pF).
[5] Testing is performed in accordance with the EN61000-4-2 specification (CZAP = 150 pF, RZAP = 330 Ω) on unpowered product, (CZAP = 330 pF, RZAP = 330 Ω) on powered product.

8.2 Thermal characteristics

Table 6. Thermal ratings

Exceeding these ratings may cause a malfunction or permanent damage to the device.

Symbol	Description (Rating)	Min.	Max.	Unit
THERMAL RATINGS				
T_{STOR}	Storage temperature	–45	+150	°C
T_J	Operating junction temperature	–40	+150[1]	°C
T_{J-TSD}	Thermal shutdown temperature	170	—	°C
$T_{TSD-HYST}$	Thermal shutdown hysteresis	—	10	°C

[1] Operation is guaranteed by design up to T_{J-TSD}.

8.3 Static electrical characteristics

Table 7. Static electrical characteristics

Electrical parameters are tested at die level at 30 °C and 140 °C. Typical values noted reflect the approximate parameter mean at T_A = 25 °C under nominal conditions, unless otherwise noted. Parametric values guaranteed from T_J = –40 °C to +150 °C, unless otherwise noted. Operation is guaranteed by design up to T_{J-TSD}.

Symbol	Characteristic	Min.	Typ.	Max.	Unit
V_{B+A}	Operating voltage, V_{B+A} [1]	5.0	—	16.5	V
V_{BUS}	Bus operating voltage (LIN)	8.0	—	18	V
I_{SB25}	Standby current at 25 °C, at V_{B+A} = 12.8 V (Phase at 0 V, $V_{LIN} = V_{B+A}$)	—	60	75	µA
I_{SB150}	Standby current at 150 °C, at V_{B+A} = 12.8 V (Phase at 0 V, $V_{LIN} = V_{B+A}$)	—	80	130	µA
I	Standby current In pre wake-up mode at 25 °C	—	—	130	µA
I_{OP}	Operating current no EXC Load at 25 °C and V_{B+A} = 13 V	—	—	18	mA
V_{REG}	Range of regulation voltage (50 % DC)	10.60	—	16	V
ΔV_{REG1}	V_{REG} setting accuracy voltage at 50 % for V_{REG} = 13.8 V at T_J = 25 °C (die version), at T_J = 125 °C (TO220 version), based on test results at 25 °C and 150 °C	−100	—	+100	mV
ΔV_{REG2}	V_{REG} setting accuracy voltage Total variation with respect to real target voltage	−250	—	+250	mV
V_{OS_MAX}	Overvoltage threshold	16.5	—	—	V

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Symbol	Characteristic		Min.	Typ.	Max.	Unit
V_{Low}	Low-voltage threshold	[2]	8.55	—	10.45	V
$R_{DS.ON.EXC}$	R_{DS-ON} FIELD TMOS at T_J = 150 °C (for V_{B+A} > 7.0 V)	[3]	—	—	100	mΩ
V_F	Recirculation diode voltage at 5.0 A (Excitation current)		—	1.2	1.5	V
V_{OV}	Safety function		16.2	16.5	16.8	V
I_{EXC-SC}	EXC short-circuit protection threshold	[2]	8.0	10	13.5	A
LIN INTERFACE (Parameters refer to LIN Physical Layer Spec Revision 2.1)						
I_{BUS_LIM}	Current limitation for driver dominant state, driver on V_{BUS} = 18 V		—	62	150	mA
$I_{BUS_PAS_DOM}$	Input leakage current at the receiver. Dominant state (Driver OFF, V_{BAT} = 12 V, V_{BUS} = 0 V)		−1.0	—	—	mA
$I_{BUS_PAS_REC}$	Input leakage current at the receiver. Recessive state (Driver OFF, 8.0 V < V_{BAT} < 18 V, 8.0 V < V_{BUS} < 18 V, V_{BUS} > V_{BAT})		—	—	20	µA
$I_{BUS_NO_GND}$	Ground disconnection. GND = V_{SUP}, 0 V < V_{BUS} < 18 V, V_{BAT} = 12 V. Loss of local GND does not affect communication in the residual network		−1.0	—	+1.0	mA
$I_{BUS_NO_BAT}$	VBAT disconnection. V_{SUP} = GND, 0 V < V_{BUS} < 18 V. Node sustains the current that can flow under this condition. LIN-bus remains operational		—	—	100	µA
V_{BUS_DOM}	Receiver dominant state		—	—	$0.4V_{SUP}$	V
V_{BUS_REC}	Receiver recessive state		$0.6V_{SUP}$	—	—	V
V_{BUS_CNT}	V_{BUS_CNT} = (V_{TH_REC} + V_{TH_DOM}) / 2		$0.475V_{SUP}$	—	$0.525V_{SUP}$	V
V_{HYST}	V_{HYST} = V_{TH_REC} − V_{TH_DOM}		—	—	$0.175V_{SUP}$	V
R_{SLAVE}	Pull-up resistor		20	—	60	kΩ
C_{LIN}	Internal capacitor		—	—	30	pF

[1] All parameters are tested at V_{BAT} = 16.5 V, except for overvoltage, safety function and LIN tests.
[2] Threshold is selectable by fuse, see Table 58.
[3] The thermal capability of the packaging is critical to the full use of the output drive.

8.4 Dynamic electrical characteristics

Table 8. Dynamic electrical characteristics

Electrical parameters are tested at die level at 30 °C and 140 °C. Typical values noted reflect the approximate parameter mean at T_A = 25 °C under nominal conditions, unless otherwise noted. Parametric values guaranteed from T_J = –40 °C to +150 °C, unless otherwise noted. Operation is guaranteed by design up to T_{J-TSD}.

Symbol	Characteristic		Min.	Typ.	Max.	Unit
F_{REG}	Regulation frequency		170	200	230	Hz
T_{DEFECT}	Fault qualification delay/filter	[1]	—	400	—	ms
DC_{MIN}	Minimum duty cycle		—	—	5	%
EX_{PREEXC}	Start-up duty cycle (Pre-excitation)	[2]	5	12.5	25	%
N_{START}	Minimum alternator speed measured to start regulation (if peak to peak value of phase input voltage exceeds 800 mV (typ.))		504	560	616	RPM
N_{HYST}	Hysteresis in speed between start and stop of regulation		50	100	150	RPM
ΔLRC	Delta LRC duty cycle		—	3.125	—	%

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Symbol	Characteristic	Min.	Typ.	Max.	Unit
LIN INTERFACE (Parameters refer to LIN Physical Layer Spec Revision 2.1)					
TOL_{CLK}	Lin controller clock (4 MHz relaxation oscillator) Clock overall tolerance	−10	—	+10	%
F_{TOL_SYNC}	Bit rate tolerance Deviation of slave node bit rate relative to the master node bit rate after synchronization	—	—	2	%
t_{BFS}	Value of accuracy of the byte field detection	—	—	2/16	Tbit
t_{EBS}	Earliest bit sample time, $t_{EBS} \leq t_{LBS}$	7/16	—	—	Tbit
t_{LBS}	Latest bit sample time, $t_{EBS} \geq t_{LBS}$	—	—	10/16Tbit − t_{BFS}	Tbit
D1 Valid for 20 kBaud	Duty cycle D1 $TH_{REC(max)} = 0.744 \times V_{SUP}$, $TH_{DOM(max)} = 0.581 \times V_{SUP}$ V_{SUP} = 7.0 V to 18 V, t_{BIT} = 50 µs $D1 = t_{BUS\ -\ rec(min)} / (2t_{BIT})$	0.396	—	—	%
D2 Valid for 20 kBaud	Duty cycle D2 $TH_{REC(min)} = 0.422 \times V_{SUP}$, $TH_{DOM(min)} = 0.284 \times V_{SUP}$ V_{SUP} = 7.6 V to 18 V, t_{BIT} = 50 µs $D2 = t_{BUS\ -\ rec(max)} / (2t_{BIT})$	—	—	0.581	%
D3 Valid for 10.4 kBaud	Duty cycle D3 $TH_{REC(max)} = 0.778 \times V_{SUP}$, $TH_{DOM(max)} = 0.616 \times V_{SUP}$ V_{SUP} = 7.0 V to 18 V, t_{BIT} = 96 µs $D3 = t_{BUS\ -\ rec(min)} / (2t_{BIT})$	0.417	—	—	%
D4 Valid for 10.4 kBaud	Duty cycle D4 $TH_{REC(min)} = 0.389 \times V_{SUP}$, $TH_{DOM(min)} = 0.251 \times V_{SUP}$ V_{SUP} = 7.6 V to 18 V, t_{BIT} = 96 µs $D4 = t_{BUS\ -\ rec(max)} / (2t_{BIT})$	—	—	0.59	%
t_{RX_PD}	Receiver propagation delay (T_{RX_PD} = MAX (t_{REC_PDR}, t_{REC_PDF})) (internal timing, from physical layer to data layer logic)	—	—	6	µs
T_{RX_SYM}	Symmetry of receiver propagation delay ($T_{RX_SYM} = t_{REC_PDF} - t_{REC_PDR}$)	−2	—	+2	µs

[1] A fault has to be present for the whole of this time before it is considered valid. Four different deglitching times are selectable by fuse, see Table 58.
[2] This parameter is selectable by fuse.

9 Functional description

9.1 Introduction

The AR6000 is an integrated circuit intended to regulate the output voltage of an automotive alternator.

It supplies a current via a high-side MOSFET to the excitation coil of the alternator and provides an internal freewheeling diode. It allows the battery to keep its nominal charge and deliver current to electrical devices within the vehicle.

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The IC provides a load response control mechanism (LRC and return LRC), and has an interface for the industry standard LIN protocol (v1.3 or 2.1, selectable by fuse) to allow an ECU (master) to control the regulated voltage and the LRC rate, among other parameters.

The ECU can also read back information about the status of the regulator and the alternator via LIN.

The programmable parameters through LIN by the ECU:

- Regulation voltage set point
- LRC ramp time
- LRC disable speed
- Excitation current limitation
- Blind zone value and inhibition
- Thermal compensation threshold adjustment

The parameters sent back through LIN to the ECU:

- Excitation duty cycle
- Measured excitation current
- Measured battery voltage
- Measured die temperature
- Measured alternator speed
- Manufacturer and class
- Faults:
  - Electrical, mechanical, temperature
  - LIN timeout
  - LIN communication error on checksum, ID parity, sync break, stop bit or bit sent.

The IC can be programmed as a one time programmable (OTP) device to fit a large number of alternators and applications. These programmable parameters are described in the functional device operation Table 58.

9.2 Functional pin description

9.2.1 Phase (PH)

This pin is connected to one of the stator windings. This signal is used for the rotor speed measurement, stator voltage monitoring as well as the self start detection. The phase oscillation is monitored and phase boost is activated if phase amplitude is not crossing VTH_L and VTH_H successively.

9.2.2 LIN-bus (BUS)

This LIN pin represents the single-wire bus transmitter and receiver. It is suited for automotive bus systems and is based on LIN protocol defined in LIN-bus specification v2.1 and v1.3.

9.2.3 Ground pin (GND)

The AR6000 has one GND pin.

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9.2.4 Supply voltage (B+A)

The AR6000 is supplied by this B+A pin. This voltage is also used as the feedback voltage by the regulation loop.

9.2.5 Excitation (EXC)

This pin is connected to the excitation coil (rotor) of the alternator. The IC supplies a current via a high-side driver to the rotor in order to control the output current of the alternator when load varies so as to maintain battery voltage at defined set point.

10 Functional internal block description

10.1 Supply voltage: filter/divider, band gap, POR

An input filter and divider provides an image of the battery voltage to the internal ADC, which sends the converted value to the digital regulation loop circuit.

The supply block provides the voltages for the internal blocks of the AR6000.

- Main logic
- All analog blocks (in wake-up and in standby modes)
- LIN transceiver
- Charge pump

The purpose of the POR block is to generate a clean reset to the main logic. When a power-on reset occurs, device internal registers are reset and the device goes into standby mode.

The band gap block provides the voltage and current references for the other blocks.

10.2 Power stage: charge pump, drive and protection, current measurement

The power stage of the circuit consists of the gate driver with a charge pump and protection to control the internal N-channel power MOSFET switching a high-side driver. A short-circuit is instantaneously detected and the excitation current is turned off until the next regulation cycle. A freewheeling diode is inserted between the EXC and GND pins, across the excitation coil for the energy recirculation.

The current measurement block provides a value of the excitation current flowing in the high-side switch. The tolerance of the current value is defined according to Figure 7.

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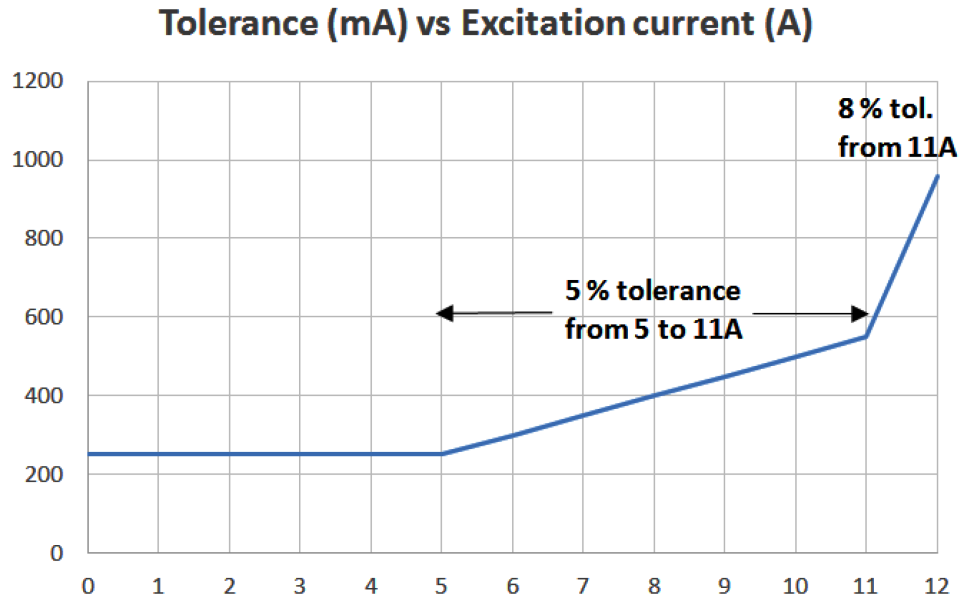


Figure 7. Tolerance (mA) vs. excitation current (A)

10.3 Logic and control

10.3.1 Digital

The digital block gathers all the digital functions of the device. The main functionality is described in Section 11 "Functional device operation".

10.3.2 Clock

This block is the clock reference for all digital blocks. When the regulator has woken, two frequencies are provided: 8 MHz and a derived 4 MHz.

10.3.3 OTP

This block allows easy configuration and adjustment of the circuit. A large number of fuse bits can be programmed either by NXP or by customer at end of line. They are listed in Table 58.

10.3.4 Phase LOW and HIGH

The phase detector monitors the phase input and sends filtered LOW and HIGH levels to the main logic when the phase signal is OK for regulation or for self-start.

10.3.5 ADC

The analog-to-digital converter is used in the voltage regulation loop for voltage and temperature measurements.

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10.3.6 Current measurement

This block provides a measured value of the excitation current flowing in the power LDMOS to the logic.

10.3.7 LIN

This block controls the LIN-bus transmission and reception.

11 Functional device operation

11.1 LIN frames

The configuration of the LIN frames can be selected by fuse to fit the largest number of applications. 11 LIN configurations are available. They are listed in the following tables and their description begins in Section 11.2 "Message frame for configuration version-A".

Table 9. LIN frame configurations

LIN version	Frame type	Identifier (hex)
All	Rx	3C[1]
	Tx	3D[1]
	frames ignored	3E
		3F
LIN1 Version A	Rx	29
	Tx	11
	Tx	12
	Tx	15
LIN2 Version A	Rx	2A
	Tx	13
	Tx	14
	Tx	16
LIN3 Version A	Rx	20
	Tx	15
	Tx	21
	Tx	18
LIN4 Version A	Rx	2A
	Tx	13
	Tx	11
	Tx	16
LIN1 Version B	Rx	29
	Tx	12
	Tx	15

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LIN version	Frame type	Identifier (hex)
LIN2 Version B	Rx	2A
	Tx	14
	Tx	16
LIN3 Version B	Rx	20
	Tx	21
	Tx	18
LIN4 Version B	Rx	2A
	Tx	11
	Tx	16
LIN Version C	Rx	20
	Tx	21
	Tx	18
LIN1 Version D	Rx	29
	Tx	11
	Tx	12
LIN2 Version D	Rx	2A
	Tx	13
	Tx	14
LIN1 Version E	Rx	29
	Tx	21
	Tx	12

[1] ID = 0x3C and ID = 0x3D are accepted only in wake-up and pre-excitation modes.

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Table 10. OTP LIN frame configurations

OTP bits	Corresponding version
0000	LIN1 version A
0001	LIN2 version A
0010	LIN3 version A
0011	LIN4 version A
0100	LIN1 version B
0101	LIN2 version B
0110	LIN3 version B
0111	LIN4 version B
1000	LIN version C
1001	LIN1 version D (with I_{EXC})
1010	LIN2 version D (with I_{EXC})
1011	LIN1 version D (with T°C)
1100	LIN2 version D (with T°C)
1101	LIN version E
1110	LIN version E
1111	LIN version E

Table 11. Node address and read by ID services for LIN2.1 protocol

Address or ID type	Value
NAD	0x46 when device is configured in LIN1 or LIN3, LINC or LINE
	0x47 when device is configured in LIN2 or LIN4
Supplier ID	0x0004
Function ID	0x0000
Variant	0x00

11.2 Message frame for configuration version-A

11.2.1 RxFrame

Table 12. Identifier: 0X29 (LIN1) or 0X2A (LIN2, LIN4) or 0X20 (LIN3)

Byte 1								Byte 2								Byte 3								Byte 4							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A						X	X	B				C				D					X	X	X	E			F	G			H

A: Voltage set value, 6 bits, Table 28

B: Load response ramp time, 4 bits, Table 29

C: Load response cut off speed, 4 bits, Table 30

D: Excitation current limitation, 5 bits, Table 31

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E: Selection of output variable in TxFrame 3 byte 4, 3 bits

Output choice	Code
00000000	000
VB+	001
Umes	010
Tchip	011
Alt Speed	100
00000000	101
00000000	110
00000000	111

F: “Blind zone”, 1 bit, Table 32

G: Voltage limitation for high temperature, 3 bits, Table 33

H: “Blind zone inhibition”, 1 bit (enabled by programming), Table 34

11.2.2 TxFrame 1

Table 13. Identifier: 0X11 (LIN1) or 0X13 (LIN2, LIN4) or 0X15 (LIN3)

Byte 1								Byte 2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A	B	C	D					E						F	G

A: Diagnosis flag for high temperature, 1 bit

B: Diagnosis flag for mechanical failure, 1 bit

C: Diagnosis flag for electrical failure, 1 bit

D: Duty cycle value of the excitation PWM, 5 bits, Table 35

E: Measured excitation current, 6 bits, Table 36

F: Diagnosis flag for LIN error, 1 bit

G: Diagnosis flag LIN communication timeout, 1 bit

11.2.3 TxFrame 2

Table 14. Identifier: 0X12 (LIN1) or 0X14 (LIN2) or 0X21 (LIN3) or 0X11 (LIN4)

Byte 1								Byte 2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A			B					C			D				

A: Alternator supplier identification, 3 bits, Table 37

B: Alternator identification, 5 bits (defined by customer)

C: Chip supplier identification, 3 bits (defined by NXP: 010)

D: Chip identification, 5 bits (defined by NXP)

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11.2.4 TxFrame 3

Table 15. Identifier: 0X15 (LIN1) or 0X16 (LIN2, LIN4) or 0X18 (LIN3)

Byte 1								Byte 2								Byte 3								Byte 4							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A	B	C	D					E								F			G	H	X	I	J	K								

A: Diagnosis flag for high temperature, 1 bit

B: Diagnosis flag for mechanical failure, 1 bit

C: Diagnosis flag for electrical failure, 1 bit

D: Duty cycle value of the excitation PWM, 5 bits, Table 35

E: Measured excitation current, 8 bits, Table 38

F: Confirmation of the selected output variable done in RxFrame byte 4, 3 bits

Selected code	Confirmation code	Output choice
000	000	00000000
001	001	VB+
010	010	Umes
011	011	Tchip
100	100	Alt Speed
101	101	00000000
110	110	00000000
111	111	00000000

G: I_{EXC} flag, 1 bit (enabled by programming)

H: LRC flag, 1 bit (enabled by programming)

I: Diagnosis flag for LIN error, 1 bit

J: Diagnosis flag LIN communication timeout, 1 bit

K: Set voltage, measured voltage, chip temperature or alternator speed, 8 bits, Table 39

11.3 Message frame for configuration version-B

11.3.1 RxFrame

Table 16. Identifier: 0X29 (LIN1) or 0X2A (LIN2, LIN4) or 0X20 (LIN3)

Byte 1								Byte 2								Byte 3								Byte 4							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A								B				C				X	D							E			F		G		H

A: Voltage set value, 8 bits, Table 40

B: Load response ramp time, 4 bits, Table 41

C: Load response cut off speed, 4 bits, Table 30

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D: Excitation current limitation, 7 bits, Table 42

E: Selection of output variable in TxFrame 3 byte 4, 3 bits

Output choice	Code
00000000	000
VB+	001
Umes	010
Tchip	011
Alt Speed	100
00000000	101
00000000	110
00000000	111

F: “Blind zone”, 1 bit, Table 32

G: Voltage limitation for high temperature, 3 bits, Table 33

H: “Blind zone inhibition”, 1 bit (enabled by programming), Table 34

11.3.2 TxFrame 1

Table 17. Identifier: 0X12 (LIN1) or 0X14 (LIN2, LIN4) or 0X21 (LIN3) OX11 (LIN4)

Byte 1								Byte 2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A			B					C			D				

A: Alternator supplier identification, 3 bits, Table 37

B: Alternator identification, 5 bits (defined by customer)

C: Chip supplier identification, 3 bits (defined by NXP: 010)

D: Chip identification, 5 bits (defined by NXP)

11.3.3 TxFrame 2

Table 18. Identifier: 0X15 (LIN1) or 0X16 (LIN2, LIN4) or 0X18 (LIN3)

Byte 1								Byte 2								Byte 3								Byte 4							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A	B	C	D					E								F			G	H	X	I	J	K							

A: Diagnosis flag for high temperature, 1 bit

B: Diagnosis flag for mechanical failure, 1 bit

C: Diagnosis flag for electrical failure, 1 bit

D: Duty cycle value of the excitation PWM, 5 bits, Table 43

E: Measured excitation current, 8 bits, Table 38

F: Confirmation of the selected output variable done in RxFrame byte 4, 3 bits

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Selected code	Confirmation code	Output choice
000	000	00000000
001	001	VB+
010	010	Umes
011	011	Tchip
100	100	Alt Speed
101	101	00000000
110	110	00000000
111	111	00000000

G: I_{EXC} flag, 1 bit (enabled by programming)

H: LRC flag, 1 bit (enabled by programming)

I: Diagnosis flag for LIN error, 1 bit

J: Diagnosis flag LIN communication timeout, 1 bit

K: Set voltage, measured voltage, chip temperature or alternator speed, 8 bits, Table 44

11.4 Message frame for configuration version-C

11.4.1 RxFrame

Table 19. Identifier: 0X20

Byte 1								Byte 2								Byte 3								Byte 4							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A		X						B				C				D								E							

A: LRC blind zone, 2 bits, Table 45

B: Load response ramp time, 4 bits, Table 46

C: Load response cut-off speed, 4 bits, Table 30

D: Regulation voltage set point, 8 bits, Table 40

E: Excitation current limitation, 8 bits, Table 48

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11.4.2 TxFrame 1

Table 20. Identifier: 0X21

Byte 1								Byte 2								Byte 3								Byte 4							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A	B	C	D	E	X	X	X	F								G								H							

A: Diagnosis flag for mechanical failure, 1 bit

B: Diagnosis flag for electrical failure, 1 bit

C: Diagnosis flag for communication error, 1 bit

D: Diagnosis flag for timeout, 1 bit

E: Diagnosis flag for high temperature, 1 bits

F: Measured voltage on pad B+A, 8 bits, Table 51

G: Measured excitation current, 8 bits, Table 50

H: Duty cycle value of the excitation PWM, 8 bits, Table 49

11.4.3 TxFrame 2

Table 21. Identifier: 0X18

Byte 1								Byte 2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A								B			C				

A: Temperature information, 8 bits, Table 52

B: Alternator supplier identification, 3 bits, Table 37

C: Alternator class identification, 5 bits (defined by customer)

11.5 Message frame for configuration version-D

11.5.1 RxFrame

Table 22. Identifier: 0X29 (LIN1) or 0X2A(LIN2)

Byte 1								Byte 2								Byte 3								Byte 4							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A						X	X	B				C				D					X	X	X	X	X	X	X	X	X	X	X

A: Voltage set value, 6 bits, Table 28

B: Load response ramp time, 4 bits, Table 29

C: Load response cut-off speed, 4 bits, Table 30

D: Excitation current limitation, 5 bits, Table 31

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11.5.2 TxFrame 1

Table 23. Identifier: 0X11 (LIN1) or 0X13 (LIN2)

Byte 1								Byte 2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A	B	C	D					E						F	G

A: Diagnosis flag for high temperature, 1 bit

B: Diagnosis flag for mechanical failure, 1 bit

C: Diagnosis flag for electrical failure, 1 bit

D: Duty cycle value of the excitation PWM, 5 bits, Table 35

E: Measured excitation current, 6 bits, Table 36 and temperature measurement, 6 bits, Table 53

F: Diagnosis flag for LIN error, 1 bit

G: Diagnosis flag LIN communication timeout, 1 bit

11.5.3 TxFrame 2

Table 24. Identifier: 0X12 (LIN1) or 0X14 (LIN2)

Byte 1								Byte 2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A			B					C	D	E	F	X	X	X	X

A: Alternator supplier identification, 3 bits, Table 37

B: Alternator identification, 5 bits (defined by customer)

C: Sync break fault, 1 bit

D: ID parity fault, 1 bit

E: Checksum fault, 1 bit

F: Not slave responding fault, 1 bit

11.6 Message frame for configuration version-E

11.6.1 RxFrame

Table 25. Identifier: 0X29

Byte 1								Byte 2								Byte 3								Byte 4							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A						X	X	B				C				D								X	X	X	E	X	X	X	X

A: Voltage set value, 6 bits, Table 28

B: Load response ramp time, 4 bits, Table 47

C: Load response cut-off speed, 4 bits, Table 30

D: Excitation current limitation, 8 bits, Table 56

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E: “Blind zone”, 1 bit, Table 55

11.6.2 TxFrame 1

Table 26. Identifier: 0X21

Byte 1								Byte 2								Byte 3								Byte 4							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A	B	C	D					E								X	X	X	X	X	X	G	H	I							

A: Diagnosis flag for high temperature, 1 bit

B: Diagnosis flag for mechanical failure, 1 bit

C: Diagnosis flag for electrical failure, 1 bit

D: Duty cycle value of the excitation PWM, 5 bits, Table 35

E: Measured excitation current, 8 bits, Table 57

G: Diagnosis flag for LIN error, 1 bit

H: Diagnosis flag LIN communication timeout, 1 bit

I: Chip temperature, 8 bits, Table 52

11.6.3 TxFrame 2

Table 27. Identifier: 0X12 (LIN1)

Byte 1								Byte 2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
A			B					C			D				

A: Alternator supplier identification, 3 bits, Table 37

B: Alternator identification, 5 bits (defined by customer)

C: Chip supplier identification, 3 bits (defined by NXP: 010)

D: Chip identification, 5 bits (defined by NXP)

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12 Lookup tables

Table 28. Voltage set point (6 bits) – versions A, D and E

Code	V (± 100 mV at 25 °C)	Code	V (± 100 mV at 25 °C)
000000	10.6/off	100000	13.8
000001	10.7	100001	13.9
000010	10.8	100010	14
000011	10.9	100011	14.1
000100	11	100100	14.2
000101	11.1	100101	14.3
000110	11.2	100110	14.4
000111	11.3	100111	14.5
001000	11.4	101000	14.6
001001	11.5	101001	14.7
001010	11.6	101010	14.8
001011	11.7	101011	14.9
001100	11.8	101100	15
001101	11.9	101101	15.1
001110	12	101110	15.2
001111	12.1	101111	15.3
010000	12.2	110000	15.4
010001	12.3	110001	15.5
010010	12.4	110010	15.6
010011	12.5	110011	15.7
010100	12.6	110100	15.8
010101	12.7	110101	15.9
010110	12.8	110110	16
010111	12.9	110111	16
011000	13	111000	16
011001	13.1	111001	16
011010	13.2	111010	16
011011	13.3	111011	16
011100	13.4	111100	16
011101	13.5	111101	16
011110	13.6	111110	16
011111	13.7	111111	16[1]

[1] 14.5 V (at 25 °C) with a Tc −4.0 mV/°C for version E.

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Table 29. LRC ramp time – versions A and D

Ramp time	Seconds (± 10 %)	Ramp time	Seconds (± 10 %)
0000	0	1000	8
0001	1	1001	9
0010	2	1010	10
0011	3	1011	11
0100	4	1100	12
0101	5	1101	13
0110	6	1110	14
0111	7	1111	15

Table 30. LRC disable speed (4 bits) – versions A, B, C, D and E

Speed	RPM (± 10 %)	Speed	RPM (± 10 %)
0000	2400	1000	4000
0001	2530	1001	4360
0010	2670	1010	4790
0011	2830	1011	5320
0100	3000	1100	5990
0101	3200	1101	6860
0110	3430	1110	8010
0111	3690	1111	always active

Table 31. Excitation current limitation (5 bits) – versions A and D

EXC code	EXC current (A)	EXC code	EXC current (A)
00000	no limitation/ only current protection activated	10000	4
00001	2	10001	4.25
00010	2	10010	4.5
00011	2	10011	4.75
00100	2	10100	5
00101	2	10101	5.25
00110	2	10110	5.5
00111	2	10111	5.75
01000	2	11000	6
01001	2.25	11001	6.25
01010	2.5	11010	6.5
01011	2.75	11011	6.75

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EXC code	EXC current (A)	EXC code	EXC current (A)
01100	3	11100	7
01101	3.25	11101	7.25
01110	3.5	11110	7.5
01111	3.75	11111	7.75

Table 32. Blind zone (1 bit) – versions A and B

Blind zone (± 1.5 %)	Value
3 %	0
12 %	1

Table 33. Reference voltage limitation for high temperatures (3 bits) – versions A and B

Temperature	Code
Default value 0 °C	000
Default value –16 °C	001
Default value –12 °C	010
Default value –8.0 °C	011
Default value –4.0 °C	100
Default value +4.0 °C	101
Default value +8.0 °C	110
Default value +12 °C	111

Table 34. Blind zone inhibition (1 bit) – versions A and B

BZI	BZ
0	enabled
1	disabled

Table 35. Duty cycle value (5 bits) – versions A, D and E

EXC duty cycle	DF (± 3 %)	EXC duty cycle	DF (± 3 %)
00000	0 < DF < 3.125	10000	50 < DF < 53.125
00001	3.125 < DF < 6.25	10001	53.125 < DF < 56.25
00010	6.25 < DF < 9.375	10010	56.25 < DF < 59.375
00011	9.375 < DF < 12.5	10011	59.375 < DF < 62.5
00100	12.5 < DF < 15.625	10100	62.5 < DF < 65.625
00101	15.625 < DF < 18.75	10101	65.625 < DF < 68.75
00110	18.75 < DF < 21.875	10110	68.75 < DF < 71.875

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EXC duty cycle	DF (± 3 %)	EXC duty cycle	DF (± 3 %)
00111	21.875 < DF < 25	10111	71.875 < DF < 75
01000	25 < DF < 28.125	11000	75 < DF < 78.125
01001	28.125 < DF < 31.25	11001	78.125 < DF < 81.25
01010	31.25 < DF < 34.375	11010	81.25 < DF < 84.375
01011	34.375 < DF < 37.5	11011	84.375 < DF < 87.5
01100	37.5 < DF < 40.625	11100	87.5 < DF < 90.625
01101	40.625 < DF < 43.75	11101	90.625 < DF < 93.75
01110	43.75 < DF < 46.875	11110	93.75 < DF < 96.875
01111	46.875 < DF < 50	11111	96.875 < DF < 100

Table 36. Excitation current measurement (6 bits) – versions A and D

EXC code	EXC current (A)	EXC code	EXC current (A)
000000	0	100000	4
000001	0.125	100001	4.125
000010	0.25	100010	4.25
000011	0.375	100011	4.375
000100	0.5	100100	4.5
000101	0.625	100101	4.625
000110	0.75	100110	4.75
000111	0.875	100111	4.875
001000	1	101000	5
001001	1.125	101001	5.125
001010	1.25	101010	5.25
001011	1.375	101011	5.375
001100	1.5	101100	5.5
001101	1.625	101101	5.625
001110	1.75	101110	5.75
001111	1.875	101111	5.875
010000	2	110000	6
010001	2.125	110001	6.125
010010	2.25	110010	6.25
010011	2.375	110011	6.375
010100	2.5	110100	6.5
010101	2.625	110101	6.625
010110	2.75	110110	6.75
010111	2.875	110111	6.875

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EXC code	EXC current (A)	EXC code	EXC current (A)
011000	3	111000	7
011001	3.125	111001	7.125
011010	3.25	111010	7.25
011011	3.375	111011	7.375
011100	3.5	111100	7.5
011101	3.625	111101	7.625
011110	3.75	111110	7.75
011111	3.875	111111	7.875

Table 37. Alternator supplier identification (3 bits) – All versions

Alternator supplier	Code
Bosch	000
Valeo	001
Delphi	010
Hitachi	011
Denso	100
Melco	101
Visteon	110
Other	111

Table 38. Excitation current measurement (8 bits) – versions A and B

Irotor code	Irotor value	Irotor code	Irotor value
00000000	0	10000000	6.4
00000001	0.05	10000001	6.45
00000010	0.1	10000010	6.5
00000011	0.15	10000011	6.55
00000100	0.2	10000100	6.6
00000101	0.25	10000101	6.65
00000110	0.3	10000110	6.7
00000111	0.35	10000111	6.75
00001000	0.4	10001000	6.8
00001001	0.45	10001001	6.85
00001010	0.5	10001010	6.9
00001011	0.55	10001011	6.95
00001100	0.6	10001100	7
00001101	0.65	10001101	7.05

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Irotor code	Irotor value	Irotor code	Irotor value
00001110	0.7	10001110	7.1
00001111	0.75	10001111	7.15
00010000	0.8	10010000	7.2
00010001	0.85	10010001	7.25
00010010	0.9	10010010	7.3
00010011	0.95	10010011	7.35
00010100	1	10010100	7.4
00010101	1.05	10010101	7.45
00010110	1.1	10010110	7.5
00010111	1.15	10010111	7.55
00011000	1.2	10011000	7.6
00011001	1.25	10011001	7.65
00011010	1.3	10011010	7.7
00011011	1.35	10011011	7.75
00011100	1.4	10011100	7.8
00011101	1.45	10011101	7.85
00011110	1.5	10011110	7.9
00011111	1.55	10011111	7.95
00100000	1.6	10100000	8
00100001	1.65	10100001	8.05
00100010	1.7	10100010	8.1
00100011	1.75	10100011	8.15
00100100	1.8	10100100	8.2
00100101	1.85	10100101	8.25
00100110	1.9	10100110	8.3
00100111	1.95	10100111	8.35
00101000	2	10101000	8.4
00101001	2.05	10101001	8.45
00101010	2.1	10101010	8.5
00101011	2.15	10101011	8.55
00101100	2.2	10101100	8.6
00101101	2.25	10101101	8.65
00101110	2.3	10101110	8.7
00101111	2.35	10101111	8.75
00110000	2.4	10110000	8.8
00110001	2.45	10110001	8.85
00110010	2.5	10110010	8.9

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Irotor code	Irotor value	Irotor code	Irotor value
00110011	2.55	10110011	8.95
00110100	2.6	10110100	9
00110101	2.65	10110101	9.05
00110110	2.7	10110110	9.1
00110111	2.75	10110111	9.15
00111000	2.8	10111000	9.2
00111001	2.85	10111001	9.25
00111010	2.9	10111010	9.3
00111011	2.95	10111011	9.35
00111100	3	10111100	9.4
00111101	3.05	10111101	9.45
00111110	3.1	10111110	9.5
00111111	3.15	10111111	9.55
01000000	3.2	11000000	9.6
01000001	3.25	11000001	9.65
01000010	3.3	11000010	9.7
01000011	3.35	11000011	9.75
01000100	3.4	11000100	9.8
01000101	3.45	11000101	9.85
01000110	3.5	11000110	9.9
01000111	3.55	11000111	9.95
01001000	3.6	11001000	10
01001001	3.65	11001001	10.05
01001010	3.7	11001010	10.1
01001011	3.75	11001011	10.15
01001100	3.8	11001100	10.2
01001101	3.85	11001101	10.25
01001110	3.9	11001110	10.3
01001111	3.95	11001111	10.35
01010000	4	11010000	10.4
01010001	4.05	11010001	10.45
01010010	4.1	11010010	10.5
01010011	4.15	11010011	10.55
01010100	4.2	11010100	10.6
01010101	4.25	11010101	10.65
01010110	4.3	11010110	10.7
01010111	4.35	11010111	10.75

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Irotor code	Irotor value	Irotor code	Irotor value
01011000	4.4	11011000	10.8
01011001	4.45	11011001	10.85
01011010	4.5	11011010	10.9
01011011	4.55	11011011	10.95
01011100	4.6	11011100	11
01011101	4.65	11011101	11.05
01011110	4.7	11011110	11.1
01011111	4.75	11011111	11.15
01100000	4.8	11100000	11.2
01100001	4.85	11100001	11.25
01100010	4.9	11100010	11.3
01100011	4.95	11100011	11.35
01100100	5	11100100	11.4
01100101	5.05	11100101	11.45
01100110	5.1	11100110	11.5
01100111	5.15	11100111	11.55
01101000	5.2	11101000	11.6
01101001	5.25	11101001	11.65
01101010	5.3	11101010	11.7
01101011	5.35	11101011	11.75
01101100	5.4	11101100	11.8
01101101	5.45	11101101	11.85
01101110	5.5	11101110	11.9
01101111	5.55	11101111	11.95
01110000	5.6	11110000	12
01110001	5.65	11110001	12.05
01110010	5.7	11110010	12.1
01110011	5.75	11110011	12.15
01110100	5.8	11110100	12.2
01110101	5.85	11110101	12.25
01110110	5.9	11110110	12.3
01110111	5.95	11110111	12.35
01111000	6	11111000	12.4
01111001	6.05	11111001	12.45
01111010	6.1	11111010	12.5
01111011	6.15	11111011	12.55
01111100	6.2	11111100	12.6

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Irotor code	Irotor value	Irotor code	Irotor value
01111101	6.25	11111101	12.65
01111110	6.3	11111110	> 12.65
01111111	6.35	11111111	—

Table 39. Battery voltage measurement, temperature measurement or alternator speed (8 bits) – version A

TxFrame 3 byte 4	Vset (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
00000000	10.6	> 8	T < –38 °C	n < 567
00000001	10.7	8.1	–38 °C < T < –34 °C	567
00000010	10.8	8.2	–34 °C < T < –30 °C	569
00000011	10.9	8.3	–30 °C < T < –26 °C	571
00000100	11	8.4	–26 °C < T < –22 °C	574
00000101	11.1	8.5	–22 °C < T < –18 °C	576
00000110	11.2	8.6	–18 °C < T < –14 °C	578
00000111	11.3	8.7	–14 °C < T < –10 °C	581
00001000	11.4	8.8	–10 °C < T < –6.0 °C	583
00001001	11.5	8.9	–6.0 °C < T < –2.0 °C	585
00001010	11.6	9	–2.0 °C < T < +2.0 °C	588
00001011	11.7	9.1	2.0 °C < T < 6.0 °C	590
00001100	11.8	9.2	6.0 °C < T < 10 °C	593
00001101	11.9	9.3	10 °C < T < 14 °C	595
00001110	12	9.4	14 °C < T < 18 °C	598
00001111	12.1	9.5	18 °C < T < 22 °C	600
00010000	12.2	9.6	22 °C < T < 26 °C	603
00010001	12.3	9.7	26 °C < T < 30 °C	605
00010010	12.4	9.8	30 °C < T < 34 °C	608
00010011	12.5	9.9	34 °C < T < 38 °C	610
00010100	12.6	10	38 °C < T < 42 °C	613
00010101	12.7	10.1	42 °C < T < 46 °C	615
00010110	12.8	10.2	46 °C < T < 50 °C	618
00010111	12.9	10.3	50 °C < T < 54 °C	621
00011000	13	10.4	54 °C < T < 58 °C	623
00011001	13.1	10.5	58 °C < T < 62 °C	626
00011010	13.2	10.6	62 °C < T < 66 °C	629
00011011	13.3	10.7	66 °C < T < 70 °C	632
00011100	13.4	10.8	70 °C < T < 74 °C	634
00011101	13.5	10.9	74 °C < T < 78 °C	637

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TxFrame 3 byte 4	Vset (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
00011110	13.6	11	78 °C < T < 82 °C	640
00011111	13.7	11.1	82 °C < T < 86 °C	643
00100000	13.8	11.2	86 °C < T < 90 °C	646
00100001	13.9	11.3	90 °C < T < 94 °C	649
00100010	14	11.4	94 °C < T < 98 °C	652
00100011	14.1	11.5	98 °C < T < 102 °C	655
00100100	14.2	11.6	102 °C < T < 106 °C	658
00100101	14.3	11.7	106 °C < T < 110 °C	661
00100110	14.4	11.8	110 °C < T < 114 °C	664
00100111	14.5	11.9	114 °C < T < 118 °C	667
00101000	14.6	12	118 °C < T < 122 °C	670
00101001	14.7	12.1	122 °C < T < 126 °C	673
00101010	14.8	12.2	126 °C < T < 130 °C	676
00101011	14.9	12.3	130 °C < T < 134 °C	679
00101100	15	12.4	134 °C < T < 138 °C	682
00101101	15.1	12.5	138 °C < T < 142 °C	686
00101110	15.2	12.6	142 °C < T < 146 °C	689
00101111	15.3	12.7	146 °C < T < 150 °C	692
00110000	15.4	12.8	150 °C < T < 154 °C	696
00110001	15.5	12.9	154 °C < T < 158 °C	699
00110010	15.6	13	158 °C < T < 162 °C	702
00110011	15.7	13.1	162 °C < T < 166 °C	706
00110100	15.8	13.2	166 °C < T < 170 °C	709
00110101	15.9	13.3	170 °C < T < 174 °C	713
00110110	16	13.4	174 °C < T < 178 °C	716
00110111	16	13.5	178 °C < T < 182 °C	720
00111000	16	13.6	182 °C < T < 186 °C	724
00111001	16	13.7	186 °C < T < 190 °C	727
00111010	16	13.8	190 °C < T < 194 °C	731
00111011	16	13.9	194 °C < T < 198 °C	735
00111100	16	14	198 °C < T < 200 °C	738
00111101	16	14.1	T > 200 °C	742
00111110	16	14.2	T > 200 °C	746
00111111	16	14.3	T > 200 °C	750
01000000	—	14.4	T > 200 °C	754
01000001	—	14.5	T > 200 °C	758

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TxFrame 3 byte 4	Vset (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
01000010	—	14.6	T > 200 °C	762
01000011	—	14.7	T > 200 °C	766
01000100	—	14.8	T > 200 °C	770
01000101	—	14.9	T > 200 °C	774
01000110	—	15	T > 200 °C	778
01000111	—	15.1	T > 200 °C	783
01001000	—	15.2	T > 200 °C	787
01001001	—	15.3	T > 200 °C	791
01001010	—	15.4	T > 200 °C	796
01001011	—	15.5	T > 200 °C	800
01001100	—	15.6	T > 200 °C	804
01001101	—	15.7	T > 200 °C	809
01001110	—	15.8	T > 200 °C	814
01001111	—	15.9	T > 200 °C	818
01010000	—	16	T > 200 °C	823
01010001	—	16.1	T > 200 °C	828
01010010	—	16.2	T > 200 °C	832
01010011	—	16.3	T > 200 °C	837
01010100	—	16.4	T > 200 °C	842
01010101	—	16.5	T > 200 °C	847
01010110	—	16.6	T > 200 °C	852
01010111	—	16.7	T > 200 °C	857
01011000	—	16.8	T > 200 °C	862
01011001	—	16.9	T > 200 °C	867
01011010	—	17	T > 200 °C	873
01011011	—	17.1	T > 200 °C	878
01011100	—	17.2	T > 200 °C	883
01011101	—	17.3	T > 200 °C	889
01011110	—	17.4	T > 200 °C	894
01011111	—	17.5	T > 200 °C	900
01100000	—	17.6	T > 200 °C	906
01100001	—	17.7	T > 200 °C	911
01100010	—	17.8	T > 200 °C	917
01100011	—	17.9	T > 200 °C	923
01100100	—	18	T > 200 °C	929
01100101	—	18.1	T > 200 °C	935

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TxFrame 3 byte 4	Vset (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
01100110	—	18.2	T > 200 °C	941
01100111	—	18.3	T > 200 °C	947
01101000	—	18.4	T > 200 °C	954
01101001	—	18.5	T > 200 °C	960
01101010	—	18.6	T > 200 °C	966
01101011	—	18.7	T > 200 °C	973
01101100	—	18.8	T > 200 °C	980
01101101	—	18.9	T > 200 °C	986
01101110	—	19	T > 200 °C	993
01101111	—	19.1	T > 200 °C	1000
01110000	—	19.2	T > 200 °C	1007
01110001	—	19.3	T > 200 °C	1014
01110010	—	19.4	T > 200 °C	1021
01110011	—	19.5	T > 200 °C	1029
01110100	—	19.6	T > 200 °C	1036
01110101	—	19.7	T > 200 °C	1043
01110110	—	19.8	T > 200 °C	1051
01110111	—	19.9	T > 200 °C	1059
01111000	—	20	T > 200 °C	1067
01111001	—	20.1	T > 200 °C	1075
01111010	—	20.2	T > 200 °C	1083
01111011	—	20.3	T > 200 °C	1091
01111100	—	20.4	T > 200 °C	1099
01111101	—	20.5	T > 200 °C	1108
01111110	—	20.6	T > 200 °C	1116
01111111	—	20.7	T > 200 °C	1125
10000000	—	20.8	T > 200 °C	1134
10000001	—	20.9	T > 200 °C	1143
10000010	—	21	T > 200 °C	1152
10000011	—	21.1	T > 200 °C	1161
10000100	—	21.2	T > 200 °C	1171
10000101	—	21.3	T > 200 °C	1180
10000110	—	21.4	T > 200 °C	1190
10000111	—	21.5	T > 200 °C	1200
10001000	—	21.6	T > 200 °C	1210
10001001	—	21.7	T > 200 °C	1220

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TxFrame 3 byte 4	Vset (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
10001010	—	21.8	T > 200 °C	1231
10001011	—	21.9	T > 200 °C	1241
10001100	—	22	T > 200 °C	1252
10001101	—	22.1	T > 200 °C	1263
10001110	—	22.2	T > 200 °C	1274
10001111	—	22.3	T > 200 °C	1286
10010000	—	22.4	T > 200 °C	1297
10010001	—	22.5	T > 200 °C	1309
10010010	—	22.6	T > 200 °C	1321
10010011	—	22.7	T > 200 °C	1333
10010100	—	22.8	T > 200 °C	1346
10010101	—	22.9	T > 200 °C	1358
10010110	—	23	T > 200 °C	1371
10010111	—	23.1	T > 200 °C	1385
10011000	—	23.2	T > 200 °C	1398
10011001	—	23.3	T > 200 °C	1412
10011010	—	23.4	T > 200 °C	1426
10011011	—	23.5	T > 200 °C	1440
10011100	—	23.6	T > 200 °C	1455
10011101	—	23.7	T > 200 °C	1469
10011110	—	23.8	T > 200 °C	1485
10011111	—	23.9	T > 200 °C	1500
10100000	—	> 24	T > 200 °C	1516
10100001	—	—	T > 200 °C	1532
10100010	—	—	T > 200 °C	1548
10100011	—	—	T > 200 °C	1565
10100100	—	—	T > 200 °C	1582
10100101	—	—	T > 200 °C	1600
10100110	—	—	T > 200 °C	1618
10100111	—	—	T > 200 °C	1636
10101000	—	—	T > 200 °C	1655
10101001	—	—	T > 200 °C	1674
10101010	—	—	T > 200 °C	1694
10101011	—	—	T > 200 °C	1714
10101100	—	—	T > 200°C	1735
10101101	—	—	T > 200°C	1756

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TxFrame 3 byte 4	Vset (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
10101110	—	—	T > 200°C	1778
10101111	—	—	T > 200 °C	1800
10110000	—	—	T > 200 °C	1823
10110001	—	—	T > 200 °C	1846
10110010	—	—	T > 200 °C	1870
10110011	—	—	T > 200 °C	1895
10110100	—	—	T > 200 °C	1920
10110101	—	—	T > 200 °C	1946
10110110	—	—	T > 200 °C	1973
10110111	—	—	T > 200 °C	2000
10111000	—	—	T > 200 °C	2028
10111001	—	—	T > 200 °C	2057
10111010	—	—	T > 200 °C	2087
10111011	—	—	T > 200 °C	2118
10111100	—	—	T > 200 °C	2149
10111101	—	—	T > 200 °C	2182
10111110	—	—	T > 200 °C	2215
10111111	—	—	T > 200 °C	2250
11000000	—	—	T > 200 °C	2286
11000001	—	—	T > 200 °C	2323
11000010	—	—	T > 200 °C	2361
11000011	—	—	T > 200 °C	2400
11000100	—	—	T > 200 °C	2441
11000101	—	—	T > 200 °C	2483
11000110	—	—	T > 200 °C	2526
11000111	—	—	T > 200 °C	2571
11001000	—	—	T > 200 °C	2618
11001001	—	—	T > 200 °C	2667
11001010	—	—	T > 200 °C	2717
11001011	—	—	T > 200 °C	2769
11001100	—	—	T > 200 °C	2824
11001101	—	—	T > 200 °C	2880
11001110	—	—	T > 200 °C	2939
11001111	—	—	T > 200 °C	3000
11010000	—	—	T > 200 °C	3064
11010001	—	—	T > 200 °C	3130

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TxFrame 3 byte 4	Vset (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
11010010	—	—	T > 200 °C	3200
11010011	—	—	T > 200 °C	3273
11010100	—	—	T > 200 °C	3349
11010101	—	—	T > 200 °C	3429
11010110	—	—	T > 200 °C	3512
11010111	—	—	T > 200 °C	3600
11011000	—	—	T > 200 °C	3692
11011001	—	—	T > 200 °C	3789
11011010	—	—	T > 200 °C	3892
11011011	—	—	T > 200 °C	4000
11011100	—	—	T > 200 °C	4114
11011101	—	—	T > 200 °C	4235
11011110	—	—	T > 200 °C	4364
11011111	—	—	T > 200 °C	4500
11100000	—	—	T > 200 °C	4645
11100001	—	—	T > 200 °C	4800
11100010	—	—	T > 200 °C	4966
11100011	—	—	T > 200 °C	5143
11100100	—	—	T > 200 °C	5333
11100101	—	—	T > 200 °C	5538
11100110	—	—	T > 200 °C	5760
11100111	—	—	T > 200 °C	6000
11101000	—	—	T > 200 °C	6261
11101001	—	—	T > 200 °C	6545
11101010	—	—	T > 200 °C	6857
11101011	—	—	T > 200 °C	7200
11101100	—	—	T > 200 °C	7579
11101101	—	—	T > 200 °C	8000
11101110	—	—	T > 200 °C	8471
11101111	—	—	T > 200 °C	9000
11110000	—	—	T > 200 °C	9600
11110001	—	—	T > 200 °C	10286
11110010	—	—	T > 200 °C	11077
11110011	—	—	T > 200 °C	12000
11110100	—	—	T > 200 °C	13091
11110101	—	—	T > 200 °C	14400

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TxFrame 3 byte 4	Vset (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
11110110	—	—	T > 200 °C	16000
11110111	—	—	T > 200 °C	18000
11111000	—	—	T > 200 °C	20571
11111001	—	—	T > 200 °C	—
11111010	—	—	T > 200 °C	—
11111011	—	—	T > 200 °C	—
11111100	—	—	T > 200 °C	—
11111101	—	—	T > 200 °C	—
11111110	—	—	T > 200 °C	—
11111111	—	—	T > 200 °C	—

Table 40. Set point voltage (8 bits) – version B and C

Voltage code	Voltage value (± 100 mV at 25 °C)	Voltage code	Voltage value (± 100 mV at 25 °C)
00000000	10.6	10000000	13.8
00000001	10.625	10000001	13.825
00000010	10.65	10000010	13.85
00000011	10.675	10000011	13.875
00000100	10.7	10000100	13.9
00000101	10.725	10000101	13.925
00000110	10.75	10000110	13.95
00000111	10.775	10000111	13.975
00001000	10.8	10001000	14
00001001	10.825	10001001	14.025
00001010	10.85	10001010	14.05
00001011	10.875	10001011	14.075
00001100	10.9	10001100	14.1
00001101	10.925	10001101	14.125
00001110	10.95	10001110	14.15
00001111	10.975	10001111	14.175
00010000	11	10010000	14.2
00010001	11.025	10010001	14.225
00010010	11.05	10010010	14.25
00010011	11.075	10010011	14.275
00010100	11.1	10010100	14.3
00010101	11.125	10010101	14.325
00010110	11.15	10010110	14.35

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Voltage code	Voltage value (± 100 mV at 25 °C)	Voltage code	Voltage value (± 100 mV at 25 °C)
00010111	11.175	10010111	14.375
00011000	11.2	10011000	14.4
00011001	11.225	10011001	14.425
00011010	11.25	10011010	14.45
00011011	11.275	10011011	14.475
00011100	11.3	10011100	14.5
00011101	11.325	10011101	14.525
00011110	11.35	10011110	14.55
00011111	11.375	10011111	14.575
00100000	11.4	10100000	14.6
00100001	11.425	10100001	14.625
00100010	11.45	10100010	14.65
00100011	11.475	10100011	14.675
00100100	11.5	10100100	14.7
00100101	11.525	10100101	14.725
00100110	11.55	10100110	14.75
00100111	11.575	10100111	14.775
00101000	11.6	10101000	14.8
00101001	11.625	10101001	14.825
00101010	11.65	10101010	14.85
00101011	11.675	10101011	14.875
00101100	11.7	10101100	14.9
00101101	11.725	10101101	14.925
00101110	11.75	10101110	14.95
00101111	11.775	10101111	14.975
00110000	11.8	10110000	15
00110001	11.825	10110001	15.025
00110010	11.85	10110010	15.05
00110011	11.875	10110011	15.075
00110100	11.9	10110100	15.1
00110101	11.925	10110101	15.125
00110110	11.95	10110110	15.15
00110111	11.975	10110111	15.175
00111000	12	10111000	15.2
00111001	12.025	10111001	15.225
00111010	12.05	10111010	15.25
00111011	12.075	10111011	15.275

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Voltage code	Voltage value (± 100 mV at 25 °C)	Voltage code	Voltage value (± 100 mV at 25 °C)
00111100	12.1	10111100	15.3
00111101	12.125	10111101	15.325
00111110	12.15	10111110	15.35
00111111	12.175	10111111	15.375
01000000	12.2	11000000	15.4
01000001	12.225	11000001	15.425
01000010	12.25	11000010	15.45
01000011	12.275	11000011	15.475
01000100	12.3	11000100	15.5
01000101	12.325	11000101	15.525
01000110	12.35	11000110	15.55
01000111	12.375	11000111	15.575
01001000	12.4	11001000	15.6
01001001	12.425	11001001	15.625
01001010	12.45	11001010	15.65
01001011	12.475	11001011	15.675
01001100	12.5	11001100	15.7
01001101	12.525	11001101	15.725
01001110	12.55	11001110	15.75
01001111	12.575	11001111	15.775
01010000	12.6	11010000	15.8
01010001	12.625	11010001	15.825
01010010	12.65	11010010	15.85
01010011	12.675	11010011	15.875
01010100	12.7	11010100	15.9
01010101	12.725	11010101	15.925
01010110	12.75	11010110	15.95
01010111	12.775	11010111	15.975
01011000	12.8	11011000	16
01011001	12.825	11011001	16
01011010	12.85	11011010	16
01011011	12.875	11011011	16
01011100	12.9	11011100	16
01011101	12.925	11011101	16
01011110	12.95	11011110	16
01011111	12.975	11011111	16
01100000	13	11100000	16

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Voltage code	Voltage value (± 100 mV at 25 °C)	Voltage code	Voltage value (± 100 mV at 25 °C)
01100001	13.025	11100001	16
01100010	13.05	11100010	16
01100011	13.075	11100011	16
01100100	13.1	11100100	16
01100101	13.125	11100101	16
01100110	13.15	11100110	16
01100111	13.175	11100111	16
01101000	13.2	11101000	16
01101001	13.225	11101001	16
01101010	13.25	11101010	16
01101011	13.275	11101011	16
01101100	13.3	11101100	16
01101101	13.325	11101101	16
01101110	13.35	11101110	16
01101111	13.375	11101111	16
01110000	13.4	11110000	16
01110001	13.425	11110001	16
01110010	13.45	11110010	16
01110011	13.475	11110011	16
01110100	13.5	11110100	16
01110101	13.525	11110101	16
01110110	13.55	11110110	16
01110111	13.575	11110111	16
01111000	13.6	11111000	16
01111001	13.625	11111001	16
01111010	13.65	11111010	16
01111011	13.675	11111011	16
01111100	13.7	11111100	16
01111101	13.725	11111101	16
01111110	13.75	11111110	16
01111111	13.775	11111111	16[1]

[1] 14.2 V (at 25 °C) with a Tc −4.27 mV/°C for version C.

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Table 41. LRC ramp time (4 bits) – version B

Ramp time	Seconds (± 10 %)	Ramp time	Seconds (± 10 %)
0000	0	1000	5.0
0001	0.25	1001	6.0
0010	0.5	1010	7.0
0011	0.75	1011	8.0
0100	1.0	1100	9.0
0101	2.0	1101	10
0110	3.0	1110	12
0111	4.0	1111	15

Table 42. Excitation current limitation (7 bits) - version B

Irot limit code	Irotor limitation value	Irot limit code	Irotor limitation value
0000000	no limitation/only current protection activated	1000000	6.4
0000001	0.1	1000001	6.5
0000010	0.2	1000010	6.6
0000011	0.3	1000011	6.7
0000100	0.4	1000100	6.8
0000101	0.5	1000101	6.9
0000110	0.6	1000110	7
0000111	0.7	1000111	7.1
0001000	0.8	1001000	7.2
0001001	0.9	1001001	7.3
0001010	1	1001010	7.4
0001011	1.1	1001011	7.5
0001100	1.2	1001100	7.6
0001101	1.3	1001101	7.7
0001110	1.4	1001110	7.8
0001111	1.5	1001111	7.9
0010000	1.6	1010000	8
0010001	1.7	1010001	8.1
0010010	1.8	1010010	8.2
0010011	1.9	1010011	8.3
0010100	2	1010100	8.4
0010101	2.1	1010101	8.5
0010110	2.2	1010110	8.6
0010111	2.3	1010111	8.7
0011000	2.4	1011000	8.8

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Irot limit code	Irotor limitation value	Irot limit code	Irotor limitation value
0011001	2.5	1011001	8.9
0011010	2.6	1011010	9
0011011	2.7	1011011	9.1
0011100	2.8	1011100	9.2
0011101	2.9	1011101	9.3
0011110	3	1011110	9.4
0011111	3.1	1011111	9.5
0100000	3.2	1100000	9.6
0100001	3.3	1100001	9.7
0100010	3.4	1100010	9.8
0100011	3.5	1100011	9.9
0100100	3.6	1100100	10
0100101	3.7	1100101	10.1
0100110	3.8	1100110	10.2
0100111	3.9	1100111	10.3
0101000	4	1101000	10.4
0101001	4.1	1101001	10.5
0101010	4.2	1101010	10.6
0101011	4.3	1101011	10.7
0101100	4.4	1101100	10.8
0101101	4.5	1101101	10.9
0101110	4.6	1101110	11
0101111	4.7	1101111	11.1
0110000	4.8	1110000	11.2
0110001	4.9	1110001	11.3
0110010	5	1110010	11.4
0110011	5.1	1110011	11.5
0110100	5.2	1110100	11.6
0110101	5.3	1110101	11.7
0110110	5.4	1110110	11.8
0110111	5.5	1110111	11.9
0111000	5.6	1111000	12
0111001	5.7	1111001	12.1
0111010	5.8	1111010	12.2
0111011	5.9	1111011	12.3
0111100	6	1111100	12.4
0111101	6.1	1111101	12.5

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Irot limit code	Irotor limitation value	Irot limit code	Irotor limitation value
0111110	6.2	1111110	12.6
0111111	6.3	1111111	12.7

Table 43. Duty cycle value (5 bits) - version B

EXC duty cycle	DF (± 3 %)	EXC duty cycle	DF (± 3 %)
00000	0	10000	51.5
00001	3	10001	55
00010	6.5	10010	58
00011	9.5	10011	61.5
00100	13	10100	64.5
00101	16	10101	67.5
00110	19.5	10110	71
00111	22.5	10111	74
01000	26	11000	77.5
01001	29	11001	80.5
01010	32.5	11010	84
01011	35.5	11011	87
01100	38.5	11100	90.5
01101	42	11101	93.5
01110	45	11110	97
01111	48.5	11111	100

Table 44. Set point voltage, battery voltage measurement, temperature measurement or alternator speed (8 bits) - version B

TxFrame 3 byte 4	V_B+ (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
00000000	10.6	> 8	T < –38 °C	n < 567
00000001	10.625	8.1	–38 °C < T < –34 °C	567
00000010	10.65	8.2	–34 °C < T < –30 °C	569
00000011	10.675	8.3	–30 °C < T < –26 °C	571
00000100	10.7	8.4	–26 °C < T < –22 °C	574
00000101	10.725	8.5	–22 °C < T < –18 °C	576
00000110	10.75	8.6	–18 °C < T < –14 °C	578
00000111	10.775	8.7	–14 °C < T < –10 °C	581
00001000	10.8	8.8	–10 °C < T < –6.0 °C	583
00001001	10.825	8.9	–6.0 °C < T < –2.0°C	585
00001010	10.85	9	–2.0 °C < T < +2.0°C	588

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TxFrame 3 byte 4	V_B+ (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
00001011	10.875	9.1	2.0 °C < T < 6.0 °C	590
00001100	10.9	9.2	6.0 °C < T < 10 °C	593
00001101	10.925	9.3	10 °C < T < 14 °C	595
00001110	10.95	9.4	14 °C < T < 18 °C	598
00001111	10.975	9.5	18 °C < T < 22 °C	600
00010000	11	9.6	22 °C < T < 26 °C	603
00010001	11.025	9.7	26 °C < T < 30 °C	605
00010010	11.05	9.8	30 °C < T < 34 °C	608
00010011	11.075	9.9	34 °C < T < 38 °C	610
00010100	11.1	10	38 °C < T < 42 °C	613
00010101	11.125	10.1	42 °C < T < 46 °C	615
00010110	11.15	10.2	46 °C < T < 50 °C	618
00010111	11.175	10.3	50 °C < T < 54 °C	621
00011000	11.2	10.4	54 °C < T < 58 °C	623
00011001	11.225	10.5	58 °C < T < 62 °C	626
00011010	11.25	10.6	62 °C < T < 66 °C	629
00011011	11.275	10.7	66 °C < T < 70 °C	632
00011100	11.3	10.8	70 °C < T < 74 °C	634
00011101	11.325	10.9	74 °C < T < 78 °C	637
00011110	11.35	11	78 °C < T < 82 °C	640
00011111	11.375	11.1	82 °C < T < 86 °C	643
00100000	11.4	11.2	86 °C < T < 90 °C	646
00100001	11.425	11.3	90 °C < T < 94 °C	649
00100010	11.45	11.4	94 °C < T < 98 °C	652
00100011	11.475	11.5	98 °C < T < 102 °C	655
00100100	11.5	11.6	102 °C < T < 106 °C	658
00100101	11.525	11.7	106 °C < T < 110 °C	661
00100110	11.55	11.8	110 °C < T < 114 °C	664
00100111	11.575	11.9	114 °C < T < 118 °C	667
00101000	11.6	12	118 °C < T < 122 °C	670
00101001	11.625	12.1	122 °C < T < 126 °C	673
00101010	11.65	12.2	126 °C < T < 130 °C	676
00101011	11.675	12.3	130 °C < T < 134 °C	679
00101100	11.7	12.4	134 °C < T < 138 °C	682
00101101	11.725	12.5	138 °C < T < 142 °C	686
00101110	11.75	12.6	142 °C < T < 146 °C	689

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TxFrame 3 byte 4	V_B+ (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
00101111	11.775	12.7	146 °C < T < 150 °C	692
00110000	11.8	12.8	150 °C < T < 154 °C	696
00110001	11.825	12.9	154 °C < T < 158 °C	699
00110010	11.85	13	158 °C < T < 162 °C	702
00110011	11.875	13.1	162 °C < T < 166 °C	706
00110100	11.9	13.2	166 °C < T < 170 °C	709
00110101	11.925	13.3	170 °C < T < 174 °C	713
00110110	11.95	13.4	174 °C < T < 178 °C	716
00110111	11.975	13.5	178 °C < T < 182 °C	720
00111000	12	13.6	182 °C < T < 186 °C	724
00111001	12.025	13.7	186 °C < T < 190 °C	727
00111010	12.05	13.8	190 °C < T < 194 °C	731
00111011	12.075	13.9	194 °C < T < 198 °C	735
00111100	12.1	14	198 °C < T < 200 °C	738
00111101	12.125	14.1	T > 200 °C	742
00111110	12.15	14.2	T > 200 °C	746
00111111	12.175	14.3	T > 200 °C	750
01000000	12.2	14.4	T > 200 °C	754
01000001	12.225	14.5	T > 200 °C	758
01000010	12.25	14.6	T > 200 °C	762
01000011	12.275	14.7	T > 200 °C	766
01000100	12.3	14.8	T > 200 °C	770
01000101	12.325	14.9	T > 200 °C	774
01000110	12.35	15	T > 200°C	778
01000111	12.375	15.1	T > 200 °C	783
01001000	12.4	15.2	T > 200 °C	787
01001001	12.425	15.3	T > 200 °C	791
01001010	12.45	15.4	T > 200 °C	796
01001011	12.475	15.5	T > 200 °C	800
01001100	12.5	15.6	T > 200 °C	804
01001101	12.525	15.7	T > 200 °C	809
01001110	12.55	15.8	T > 200 °C	814
01001111	12.575	15.9	T > 200 °C	818
01010000	12.6	16	T > 200 °C	823
01010001	12.625	16.1	T > 200 °C	828
01010010	12.65	16.2	T > 200 °C	832

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TxFrame 3 byte 4	V_B+ (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
01010011	12.675	16.3	T > 200 °C	837
01010100	12.7	16.4	T > 200 °C	842
01010101	12.725	16.5	T > 200 °C	847
01010110	12.75	16.6	T > 200 °C	852
01010111	12.775	16.7	T > 200 °C	857
01011000	12.8	16.8	T > 200 °C	862
01011001	12.825	16.9	T > 200 °C	867
01011010	12.85	17	T > 200 °C	873
01011011	12.875	17.1	T > 200 °C	878
01011100	12.9	17.2	T > 200 °C	883
01011101	12.925	17.3	T > 200 °C	889
01011110	12.95	17.4	T > 200 °C	894
01011111	12.975	17.5	T > 200 °C	900
01100000	13	17.6	T > 200 °C	906
01100001	13.025	17.7	T > 200 °C	911
01100010	13.05	17.8	T > 200 °C	917
01100011	13.075	17.9	T > 200 °C	923
01100100	13.1	18	T > 200 °C	929
01100101	13.125	18.1	T > 200 °C	935
01100110	13.15	18.2	T > 200 °C	941
01100111	13.175	18.3	T > 200 °C	947
01101000	13.2	18.4	T > 200 °C	954
01101001	13.225	18.5	T > 200 °C	960
01101010	13.25	18.6	T > 200 °C	966
01101011	13.275	18.7	T > 200 °C	973
01101100	13.3	18.8	T > 200 °C	980
01101101	13.325	18.9	T > 200 °C	986
01101110	13.35	19	T > 200 °C	993
01101111	13.375	19.1	T > 200 °C	1000
01110000	13.4	19.2	T > 200 °C	1007
01110001	13.425	19.3	T > 200 °C	1014
01110010	13.45	19.4	T > 200 °C	1021
01110011	13.475	19.5	T > 200 °C	1029
01110100	13.5	19.6	T > 200 °C	1036
01110101	13.525	19.7	T > 200 °C	1043
01110110	13.55	19.8	T > 200 °C	1051

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TxFrame 3 byte 4	V_B+ (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
01110111	13.575	19.9	T > 200 °C	1059
01111000	13.6	20	T > 200 °C	1067
01111001	13.625	20.1	T > 200 °C	1075
01111010	13.65	20.2	T > 200 °C	1083
01111011	13.675	20.3	T > 200 °C	1091
01111100	13.7	20.4	T > 200 °C	1099
01111101	13.725	20.5	T > 200 °C	1108
01111110	13.75	20.6	T > 200 °C	1116
01111111	13.775	20.7	T > 200 °C	1125
10000000	13.8	20.8	T > 200 °C	1134
10000001	13.825	20.9	T > 200 °C	1143
10000010	13.85	21	T > 200°C	1152
10000011	13.875	21.1	T > 200 °C	1161
10000100	13.9	21.2	T > 200 °C	1171
10000101	13.925	21.3	T > 200 °C	1180
10000110	13.95	21.4	T > 200 °C	1190
10000111	13.975	21.5	T > 200 °C	1200
10001000	14	21.6	T > 200 °C	1210
10001001	14.025	21.7	T > 200 °C	1220
10001010	14.05	21.8	T > 200 °C	1231
10001011	14.075	21.9	T > 200 °C	1241
10001100	14.1	22	T > 200 °C	1252
10001101	14.125	22.1	T > 200 °C	1263
10001110	14.15	22.2	T > 200 °C	1274
10001111	14.175	22.3	T > 200 °C	1286
10010000	14.2	22.4	T > 200 °C	1297
10010001	14.225	22.5	T > 200 °C	1309
10010010	14.25	22.6	T > 200 °C	1321
10010011	14.275	22.7	T > 200 °C	1333
10010100	14.3	22.8	T > 200 °C	1346
10010101	14.325	22.9	T > 200 °C	1358
10010110	14.35	23	T > 200°C	1371
10010111	14.375	23.1	T > 200 °C	1385
10011000	14.4	23.2	T > 200 °C	1398
10011001	14.425	23.3	T > 200 °C	1412
10011010	14.45	23.4	T > 200 °C	1426

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TxFrame 3 byte 4	V_B+ (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
10011011	14.475	23.5	T > 200 °C	1440
10011100	14.5	23.6	T > 200 °C	1455
10011101	14.525	23.7	T > 200 °C	1469
10011110	14.55	23.8	T > 200 °C	1485
10011111	14.575	23.9	T > 200 °C	1500
10100000	14.6	> 24	T > 200°C	1516
10100001	14.625	—	T > 200 °C	1532
10100010	14.65	—	T > 200 °C	1548
10100011	14.675	—	T > 200 °C	1565
10100100	14.7	—	T > 200 °C	1582
10100101	14.725	—	T > 200 °C	1600
10100110	14.75	—	T > 200 °C	1618
10100111	14.775	—	T > 200 °C	1636
10101000	14.8	—	T > 200 °C	1655
10101001	14.825	—	T > 200 °C	1674
10101010	14.85	—	T > 200 °C	1694
10101011	14.875	—	T > 200 °C	1714
10101100	14.9	—	T > 200 °C	1735
10101101	14.925	—	T > 200 °C	1756
10101110	14.95	—	T > 200 °C	1778
10101111	14.975	—	T > 200 °C	1800
10110000	15	—	T > 200 °C	1823
10110001	15.025	—	T > 200 °C	1846
10110010	15.05	—	T > 200 °C	1870
10110011	15.075	—	T > 200 °C	1895
10110100	15.1	—	T > 200 °C	1920
10110101	15.125	—	T > 200 °C	1946
10110110	15.15	—	T > 200 °C	1973
10110111	15.175	—	T > 200 °C	2000
10111000	15.2	—	T > 200 °C	2028
10111001	15.225	—	T > 200 °C	2057
10111010	15.25	—	T > 200 °C	2087
10111011	15.275	—	T > 200 °C	2118
10111100	15.3	—	T > 200 °C	2149
10111101	15.325	—	T > 200 °C	2182
10111110	15.35	—	T > 200 °C	2215

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TxFrame 3 byte 4	V_B+ (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
10111111	15.375	—	T > 200 °C	2250
11000000	15.4	—	T > 200 °C	2286
11000001	15.425	—	T > 200 °C	2323
11000010	15.45	—	T > 200 °C	2361
11000011	15.475	—	T > 200 °C	2400
11000100	15.5	—	T > 200 °C	2441
11000101	15.525	—	T > 200 °C	2483
11000110	15.55	—	T > 200 °C	2526
11000111	15.575	—	T > 200 °C	2571
11001000	15.6	—	T > 200 °C	2618
11001001	15.625	—	T > 200 °C	2667
11001010	15.65	—	T > 200 °C	2717
11001011	15.675	—	T > 200 °C	2769
11001100	15.7	—	T > 200 °C	2824
11001101	15.725	—	T > 200 °C	2880
11001110	15.75	—	T > 200 °C	2939
11001111	15.775	—	T > 200 °C	3000
11010000	15.8	—	T > 200 °C	3064
11010001	15.825	—	T > 200 °C	3130
11010010	15.85	—	T > 200 °C	3200
11010011	15.875	—	T > 200 °C	3273
11010100	15.9	—	T > 200 °C	3349
11010101	15.925	—	T > 200 °C	3429
11010110	15.95	—	T > 200 °C	3512
11010111	15.975	—	T > 200 °C	3600
11011000	16	—	T > 200 °C	3692
11011001	16	—	T > 200 °C	3789
11011010	16	—	T > 200 °C	3892
11011011	16	—	T > 200 °C	4000
11011100	16	—	T > 200 °C	4114
11011101	16	—	T > 200 °C	4235
11011110	16	—	T > 200 °C	4364
11011111	16	—	T > 200 °C	4500
11100000	16	—	T > 200 °C	4645
11100001	16	—	T > 200 °C	4800
11100010	16	—	T > 200 °C	4966

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TxFrame 3 byte 4	V_B+ (± 100 mV at 25 °C)	Umes (± 350 mV)	Tchip (± 10 °C)	n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM)
11100011	16	—	T > 200 °C	5143
11100100	16	—	T > 200 °C	5333
11100101	16	—	T > 200 °C	5538
11100110	16	—	T > 200 °C	5760
11100111	16	—	T > 200 °C	6000
11101000	16	—	T > 200 °C	6261
11101001	16	—	T > 200 °C	6545
11101010	16	—	T > 200 °C	6857
11101011	16	—	T > 200 °C	7200
11101100	16	—	T > 200 °C	7579
11101101	16	—	T > 200 °C	8000
11101110	16	—	T > 200 °C	8471
11101111	16	—	T > 200 °C	9000
11110000	16	—	T > 200 °C	9600
11110001	16	—	T > 200 °C	10286
11110010	16	—	T > 200 °C	11077
11110011	16	—	T > 200 °C	12000
11110100	16	—	T > 200 °C	13091
11110101	16	—	T > 200 °C	14400
11110110	16	—	T > 200 °C	16000
11110111	16	—	T > 200 °C	18000
11111000	16	—	T > 200 °C	20571
11111001	16	—	T > 200 °C	—
11111010	16	—	T > 200 °C	—
11111011	16	—	T > 200 °C	—
11111100	16	—	T > 200 °C	—
11111101	16	—	T > 200 °C	—
11111110	16	—	T > 200 °C	—
11111111	16	—	T > 200 °C	—

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Table 45. Blind zone (2 bits) - version C

Blind zone	Value (± 1.5 %)
00	0
01	3.125
10	6.25
11	12.5

Table 46. LRC duration (4 bits) - version C

Ramp time	Seconds (± 10 %)	Ramp time	Seconds (± 10 %)
0000	0	1000	3.9
0001	0.3	1001	4.8
0010	0.6	1010	5.7
0011	0.9	1011	6.6
0100	1.3	1100	8.4
0101	1.7	1101	10.2
0110	2.1	1110	12.6
0111	3.0	1111	15

Table 47. LRC duration (4 bits) - version E

Speed	Seconds (± 10 %)	Speed	Seconds (± 10 %)
0000	0	1000	7.2
0001	1.3	1001	8.1
0010	2.1	1010	8.9
0011	3.0	1011	9.8
0100	3.8	1100	10.6
0101	4.7	1101	11.5
0110	5.5	1110	12.3
0111	6.4	1111	13.2

Table 48. Excitation current limitation (8 bits) - version C

Current limitation	Value	Current limitation	Value
00000000	regulator off	10000000	5.12
00000001	0.04	10000001	5.16
00000010	0.08	10000010	5.2
00000011	0.12	10000011	5.24
00000100	0.16	10000100	5.28
00000101	0.2	10000101	5.32
00000110	0.24	10000110	5.36

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Current limitation	Value	Current limitation	Value
00000111	0.28	10000111	5.4
00001000	0.32	10001000	5.44
00001001	0.36	10001001	5.48
00001010	0.4	10001010	5.52
00001011	0.44	10001011	5.56
00001100	0.48	10001100	5.6
00001101	0.52	10001101	5.64
00001110	0.56	10001110	5.68
00001111	0.6	10001111	5.72
00010000	0.64	10010000	5.76
00010001	0.68	10010001	5.8
00010010	0.72	10010010	5.84
00010011	0.76	10010011	5.88
00010100	0.8	10010100	5.92
00010101	0.84	10010101	5.96
00010110	0.88	10010110	6
00010111	0.92	10010111	6.04
00011000	0.96	10011000	6.08
00011001	1	10011001	6.12
00011010	1.04	10011010	6.16
00011011	1.08	10011011	6.2
00011100	1.12	10011100	6.24
00011101	1.16	10011101	6.28
00011110	1.2	10011110	6.32
00011111	1.24	10011111	6.36
00100000	1.28	10100000	6.4
00100001	1.32	10100001	6.44
00100010	1.36	10100010	6.48
00100011	1.4	10100011	6.52
00100100	1.44	10100100	6.56
00100101	1.48	10100101	6.6
00100110	1.52	10100110	6.64
00100111	1.56	10100111	6.68
00101000	1.6	10101000	6.72
00101001	1.64	10101001	6.76
00101010	1.68	10101010	6.8
00101011	1.72	10101011	6.84

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Current limitation	Value	Current limitation	Value
00101100	1.76	10101100	6.88
00101101	1.8	10101101	6.92
00101110	1.84	10101110	6.96
00101111	1.88	10101111	7
00110000	1.92	10110000	7.04
00110001	1.96	10110001	7.08
00110010	2	10110010	7.12
00110011	2.04	10110011	7.16
00110100	2.08	10110100	7.2
00110101	2.12	10110101	7.24
00110110	2.16	10110110	7.28
00110111	2.2	10110111	7.32
00111000	2.24	10111000	7.36
00111001	2.28	10111001	7.4
00111010	2.32	10111010	7.44
00111011	2.36	10111011	7.48
00111100	2.4	10111100	7.52
00111101	2.44	10111101	7.56
00111110	2.48	10111110	7.6
00111111	2.52	10111111	7.64
01000000	2.56	11000000	7.68
01000001	2.6	11000001	7.72
01000010	2.64	11000010	7.76
01000011	2.68	11000011	7.8
01000100	2.72	11000100	7.84
01000101	2.76	11000101	7.88
01000110	2.8	11000110	7.92
01000111	2.84	11000111	7.96
01001000	2.88	11001000	8
01001001	2.92	11001001	8
01001010	2.96	11001010	8
01001011	3	11001011	8
01001100	3.04	11001100	8
01001101	3.08	11001101	8
01001110	3.12	11001110	8
01001111	3.16	11001111	8
01010000	3.2	11010000	8

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Current limitation	Value	Current limitation	Value
01010001	3.24	11010001	8
01010010	3.28	11010010	8
01010011	3.32	11010011	8
01010100	3.36	11010100	8
01010101	3.4	11010101	8
01010110	3.44	11010110	8
01010111	3.48	11010111	8
01011000	3.52	11011000	8
01011001	3.56	11011001	8
01011010	3.6	11011010	8
01011011	3.64	11011011	8
01011100	3.68	11011100	8
01011101	3.72	11011101	8
01011110	3.76	11011110	8
01011111	3.8	11011111	8
01100000	3.84	11100000	8
01100001	3.88	11100001	8
01100010	3.92	11100010	8
01100011	3.96	11100011	8
01100100	4	11100100	8
01100101	4.04	11100101	8
01100110	4.08	11100110	8
01100111	4.12	11100111	8
01101000	4.16	11101000	8
01101001	4.2	11101001	8
01101010	4.24	11101010	8
01101011	4.28	11101011	8
01101100	4.32	11101100	8
01101101	4.36	11101101	8
01101110	4.4	11101110	8
01101111	4.44	11101111	8
01110000	4.48	11110000	8
01110001	4.52	11110001	8
01110010	4.56	11110010	8
01110011	4.6	11110011	8
01110100	4.64	11110100	8
01110101	4.68	11110101	8

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Current limitation	Value	Current limitation	Value
01110110	4.72	11110110	8
01110111	4.76	11110111	8
01111000	4.8	11111000	8
01111001	4.84	11111001	8
01111010	4.88	11111010	8
01111011	4.92	11111011	8
01111100	4.96	11111100	8
01111101	5	11111101	8
01111110	5.04	11111110	8
01111111	5.08	11111111	8

Table 49. Duty cycle value (8 bits) - version C

Measured duty cycle	Value	Measured duty cycle	Value
00000000	0.39	10000000	50.40
00000001	0.78	10000001	50.78
00000010	1.17	10000010	51.17
00000011	1.56	10000011	51.56
00000100	1.95	10000100	51.95
00000101	2.34	10000101	52.34
00000110	2.73	10000110	52.73
00000111	3.13	10000111	53.13
00001000	3.52	10001000	53.52
00001001	3.91	10001001	53.91
00001010	4.30	10001010	54.30
00001011	4.69	10001011	54.69
00001100	5.08	10001100	55.08
00001101	5.47	10001101	55.47
00001110	5.86	10001110	55.86
00001111	6.25	10001111	56.25
00010000	6.64	10010000	56.64
00010001	7.03	10010001	57.03
00010010	7.42	10010010	57.42
00010011	7.81	10010011	57.81
00010100	8.20	10010100	58.20
00010101	8.60	10010101	58.60
00010110	8.98	10010110	58.98

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Measured duty cycle	Value	Measured duty cycle	Value
00010111	9.38	10010111	59.38
00011000	9.77	10011000	59.77
00011001	10.16	10011001	60.16
00011010	10.55	10011010	60.55
00011011	10.94	10011011	60.94
00011100	11.33	10011100	61.33
00011101	11.72	10011101	61.72
00011110	12.11	10011110	62.11
00011111	12.50	10011111	62.50
00100000	12.89	10100000	62.89
00100001	13.28	10100001	63.28
00100010	13.67	10100010	63.67
00100011	14.06	10100011	64.06
00100100	14.45	10100100	64.45
00100101	14.84	10100101	64.84
00100110	15.23	10100110	65.23
00100111	15.63	10100111	65.63
00101000	16.02	10101000	66.016
00101001	16.41	10101001	66.41
00101010	16.80	10101010	66.80
00101011	17.19	10101011	67.19
00101100	17.58	10101100	67.58
00101101	17.97	10101101	67.97
00101110	18.36	10101110	68.36
00101111	18.75	10101111	68.75
00110000	19.14	10110000	69.14
00110001	19.53	10110001	69.53
00110010	19.92	10110010	69.92
00110011	20.31	10110011	70.31
00110100	20.70	10110100	70.70
00110101	21.09	10110101	71.09
00110110	21.48	10110110	71.48
00110111	21.88	10110111	71.88
00111000	22.27	10111000	72.27
00111001	22.66	10111001	72.66
00111010	23.05	10111010	73.05
00111011	23.44	10111011	73.44

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Measured duty cycle	Value	Measured duty cycle	Value
00111100	23.83	10111100	73.83
00111101	24.22	10111101	74.22
00111110	24.61	10111110	74.61
00111111	25	10111111	75
01000000	25.40	11000000	75.39
01000001	25.78	11000001	75.78
01000010	26.17	11000010	76.17
01000011	26.56	11000011	76.56
01000100	26.95	11000100	76.95
01000101	27.34	11000101	77.34
01000110	27.73	11000110	77.73
01000111	28.13	11000111	78.13
01001000	28.52	11001000	78.52
01001001	28.91	11001001	78.91
01001010	29.30	11001010	79.30
01001011	29.69	11001011	79.69
01001100	30.08	11001100	80.08
01001101	30.47	11001101	80.47
01001110	30.86	11001110	80.86
01001111	31.25	11001111	81.25
01010000	31.64	11010000	81.64
01010001	32.03	11010001	82.03
01010010	32.42	11010010	82.42
01010011	32.81	11010011	82.81
01010100	33.20	11010100	83.20
01010101	33.59	11010101	83.59
01010110	33.98	11010110	83.98
01010111	34.38	11010111	84.38
01011000	34.77	11011000	84.77
01011001	35.16	11011001	85.16
01011010	35.55	11011010	85.55
01011011	35.94	11011011	85.94
01011100	36.33	11011100	86.33
01011101	36.72	11011101	86.72
01011110	37.11	11011110	87.11
01011111	37.50	11011111	87.50
01100000	37.89	11100000	87.89

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Measured duty cycle	Value	Measured duty cycle	Value
01100001	38.28	11100001	88.28
01100010	38.67	11100010	88.67
01100011	39.06	11100011	89.06
01100100	39.45	11100100	89.45
01100101	39.84	11100101	89.84
01100110	40.23	11100110	90.23
01100111	40.63	11100111	90.63
01101000	41.02	11101000	91.02
01101001	41.41	11101001	91.41
01101010	41.80	11101010	91.80
01101011	42.19	11101011	92.19
01101100	42.58	11101100	92.58
01101101	42.97	11101101	92.97
01101110	43.36	11101110	93.36
01101111	43.75	11101111	93.75
01110000	44.14	11110000	94.14
01110001	44.53	11110001	94.53
01110010	44.92	11110010	94.92
01110011	45.31	11110011	95.31
01110100	45.70	11110100	95.70
01110101	46.09	11110101	96.09
01110110	46.48	11110110	96.48
01110111	46.88	11110111	96.88
01111000	47.27	11111000	97.27
01111001	47.66	11111001	97.66
01111010	48.05	11111010	98.05
01111011	48.44	11111011	98.44
01111100	48.83	11111100	98.83
01111101	49.22	11111101	99.22
01111110	49.61	11111110	99.61
01111111	50	11111111	100

Table 50. Excitation current measurement (8 bits) - version C and E

Irotor code	Value	Irotor code	Value
00000000	0	10000000	5.12
00000001	0.04	10000001	5.16

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Irotor code	Value	Irotor code	Value
00000010	0.08	10000010	5.2
00000011	0.12	10000011	5.24
00000100	0.16	10000100	5.28
00000101	0.2	10000101	5.32
00000110	0.24	10000110	5.36
00000111	0.28	10000111	5.4
00001000	0.32	10001000	5.44
00001001	0.36	10001001	5.48
00001010	0.4	10001010	5.52
00001011	0.44	10001011	5.56
00001100	0.48	10001100	5.6
00001101	0.52	10001101	5.64
00001110	0.56	10001110	5.68
00001111	0.6	10001111	5.72
00010000	0.64	10010000	5.76
00010001	0.68	10010001	5.8
00010010	0.72	10010010	5.84
00010011	0.76	10010011	5.88
00010100	0.8	10010100	5.92
00010101	0.84	10010101	5.96
00010110	0.88	10010110	6
00010111	0.92	10010111	6.04
00011000	0.96	10011000	6.08
00011001	1	10011001	6.12
00011010	1.04	10011010	6.16
00011011	1.08	10011011	6.2
00011100	1.12	10011100	6.24
00011101	1.16	10011101	6.28
00011110	1.2	10011110	6.32
00011111	1.24	10011111	6.36
00100000	1.28	10100000	6.4
00100001	1.32	10100001	6.44
00100010	1.36	10100010	6.48
00100011	1.4	10100011	6.52
00100100	1.44	10100100	6.56
00100101	1.48	10100101	6.6
00100110	1.52	10100110	6.64

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Irotor code	Value	Irotor code	Value
00100111	1.56	10100111	6.68
00101000	1.6	10101000	6.72
00101001	1.64	10101001	6.76
00101010	1.68	10101010	6.8
00101011	1.72	10101011	6.84
00101100	1.76	10101100	6.88
00101101	1.8	10101101	6.92
00101110	1.84	10101110	6.96
00101111	1.88	10101111	7
00110000	1.92	10110000	7.04
00110001	1.96	10110001	7.08
00110010	2	10110010	7.12
00110011	2.04	10110011	7.16
00110100	2.08	10110100	7.2
00110101	2.12	10110101	7.24
00110110	2.16	10110110	7.28
00110111	2.2	10110111	7.32
00111000	2.24	10111000	7.36
00111001	2.28	10111001	7.4
00111010	2.32	10111010	7.44
00111011	2.36	10111011	7.48
00111100	2.4	10111100	7.52
00111101	2.44	10111101	7.56
00111110	2.48	10111110	7.6
00111111	2.52	10111111	7.64
01000000	2.56	11000000	7.68
01000001	2.6	11000001	7.72
01000010	2.64	11000010	7.76
01000011	2.68	11000011	7.8
01000100	2.72	11000100	7.84
01000101	2.76	11000101	7.88
01000110	2.8	11000110	7.92
01000111	2.84	11000111	7.96
01001000	2.88	11001000	8
01001001	2.92	11001001	8
01001010	2.96	11001010	8
01001011	3	11001011	8

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Irotor code	Value	Irotor code	Value
01001100	3.04	11001100	8
01001101	3.08	11001101	8
01001110	3.12	11001110	8
01001111	3.16	11001111	8
01010000	3.2	11010000	8
01010001	3.24	11010001	8
01010010	3.28	11010010	8
01010011	3.32	11010011	8
01010100	3.36	11010100	8
01010101	3.4	11010101	8
01010110	3.44	11010110	8
01010111	3.48	11010111	8
01011000	3.52	11011000	8
01011001	3.56	11011001	8
01011010	3.6	11011010	8
01011011	3.64	11011011	8
01011100	3.68	11011100	8
01011101	3.72	11011101	8
01011110	3.76	11011110	8
01011111	3.8	11011111	8
01100000	3.84	11100000	8
01100001	3.88	11100001	8
01100010	3.92	11100010	8
01100011	3.96	11100011	8
01100100	4	11100100	8
01100101	4.04	11100101	8
01100110	4.08	11100110	8
01100111	4.12	11100111	8
01101000	4.16	11101000	8
01101001	4.2	11101001	8
01101010	4.24	11101010	8
01101011	4.28	11101011	8
01101100	4.32	11101100	8
01101101	4.36	11101101	8
01101110	4.4	11101110	8
01101111	4.44	11101111	8
01110000	4.48	11110000	8

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Irotor code	Value	Irotor code	Value
01110001	4.52	11110001	8
01110010	4.56	11110010	8
01110011	4.6	11110011	8
01110100	4.64	11110100	8
01110101	4.68	11110101	8
01110110	4.72	11110110	8
01110111	4.76	11110111	8
01111000	4.8	11111000	8
01111001	4.84	11111001	8
01111010	4.88	11111010	8
01111011	4.92	11111011	8
01111100	4.96	11111100	8
01111101	5	11111101	8
01111110	5.04	11111110	8
01111111	5.08	11111111	8

Table 51. Battery voltage measurement (8 bits) - version C

Measured voltage	Value	Measured voltage	Value
00000000	9	10000000	15.4
00000001	9.05	10000001	15.45
00000010	9.1	10000010	15.5
00000011	9.15	10000011	15.55
00000100	9.2	10000100	15.6
00000101	9.25	10000101	15.65
00000110	9.3	10000110	15.7
00000111	9.35	10000111	15.75
00001000	9.4	10001000	15.8
00001001	9.45	10001001	15.85
00001010	9.5	10001010	15.9
00001011	9.55	10001011	15.95
00001100	9.6	10001100	16
00001101	9.65	10001101	16.05
00001110	9.7	10001110	16.1
00001111	9.75	10001111	16.15
00010000	9.8	10010000	16.2
00010001	9.85	10010001	16.25

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Measured voltage	Value	Measured voltage	Value
00010010	9.9	10010010	16.3
00010011	9.95	10010011	16.35
00010100	10	10010100	16.4
00010101	10.05	10010101	16.45
00010110	10.1	10010110	16.5
00010111	10.15	10010111	16.55
00011000	10.2	10011000	16.6
00011001	10.25	10011001	16.65
00011010	10.3	10011010	16.7
00011011	10.35	10011011	16.75
00011100	10.4	10011100	16.8
00011101	10.45	10011101	16.85
00011110	10.5	10011110	16.9
00011111	10.55	10011111	16.95
00100000	10.6	10100000	17
00100001	10.65	10100001	17.05
00100010	10.7	10100010	17.1
00100011	10.75	10100011	17.15
00100100	10.8	10100100	17.2
00100101	10.85	10100101	17.25
00100110	10.9	10100110	17.3
00100111	10.95	10100111	17.35
00101000	11	10101000	17.4
00101001	11.05	10101001	17.45
00101010	11.1	10101010	17.5
00101011	11.15	10101011	17.55
00101100	11.2	10101100	17.6
00101101	11.25	10101101	17.65
00101110	11.3	10101110	17.7
00101111	11.35	10101111	17.75
00110000	11.4	10110000	17.8
00110001	11.45	10110001	17.85
00110010	11.5	10110010	17.9
00110011	11.55	10110011	17.95
00110100	11.6	10110100	18
00110101	11.65	10110101	18
00110110	11.7	10110110	18

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Measured voltage	Value	Measured voltage	Value
00110111	11.75	10110111	18
00111000	11.8	10111000	18
00111001	11.85	10111001	18
00111010	11.9	10111010	18
00111011	11.95	10111011	18
00111100	12	10111100	18
00111101	12.05	10111101	18
00111110	12.1	10111110	18
00111111	12.15	10111111	18
01000000	12.2	11000000	18
01000001	12.25	11000001	18
01000010	12.3	11000010	18
01000011	12.35	11000011	18
01000100	12.4	11000100	18
01000101	12.45	11000101	18
01000110	12.5	11000110	18
01000111	12.55	11000111	18
01001000	12.6	11001000	18
01001001	12.65	11001001	18
01001010	12.7	11001010	18
01001011	12.75	11001011	18
01001100	12.8	11001100	18
01001101	12.85	11001101	18
01001110	12.9	11001110	18
01001111	12.95	11001111	18
01010000	13	11010000	18
01010001	13.05	11010001	18
01010010	13.1	11010010	18
01010011	13.15	11010011	18
01010100	13.2	11010100	18
01010101	13.25	11010101	18
01010110	13.3	11010110	18
01010111	13.35	11010111	18
01011000	13.4	11011000	18
01011001	13.45	11011001	18
01011010	13.5	11011010	18
01011011	13.55	11011011	18

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Measured voltage	Value	Measured voltage	Value
01011100	13.6	11011100	18
01011101	13.65	11011101	18
01011110	13.7	11011110	18
01011111	13.75	11011111	18
01100000	13.8	11100000	18
01100001	13.85	11100001	18
01100010	13.9	11100010	18
01100011	13.95	11100011	18
01100100	14	11100100	18
01100101	14.05	11100101	18
01100110	14.1	11100110	18
01100111	14.15	11100111	18
01101000	14.2	11101000	18
01101001	14.25	11101001	18
01101010	14.3	11101010	18
01101011	14.35	11101011	18
01101100	14.4	11101100	18
01101101	14.45	11101101	18
01101110	14.5	11101110	18
01101111	14.55	11101111	18
01110000	14.6	11110000	18
01110001	14.65	11110001	18
01110010	14.7	11110010	18
01110011	14.75	11110011	18
01110100	14.8	11110100	18
01110101	14.85	11110101	18
01110110	14.9	11110110	18
01110111	14.95	11110111	18
01111000	15	11111000	18
01111001	15.05	11111001	18
01111010	15.1	11111010	18
01111011	15.15	11111011	18
01111100	15.2	11111100	18
01111101	15.25	11111101	18
01111110	15.3	11111110	18
01111111	15.35	11111111	18

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Table 52. Temperature measurement (8 bits) - version C and E

Chip temperature	Value (± 10 °C)	Chip temperature	Value (± 10 °C)
00000000	–40	10000000	88
00000001	–39	10000001	89
00000010	–38	10000010	90
00000011	–37	10000011	91
00000100	–36	10000100	92
00000101	–35	10000101	93
00000110	–34	10000110	94
00000111	–33	10000111	95
00001000	–32	10001000	96
00001001	–31	10001001	97
00001010	–30	10001010	98
00001011	–29	10001011	99
00001100	–28	10001100	100
00001101	–27	10001101	101
00001110	–26	10001110	102
00001111	–25	10001111	103
00010000	–24	10010000	104
00010001	–23	10010001	105
00010010	–22	10010010	106
00010011	–21	10010011	107
00010100	–20	10010100	108
00010101	–19	10010101	109
00010110	–18	10010110	110
00010111	–17	10010111	111
00011000	–16	10011000	112
00011001	–15	10011001	113
00011010	–14	10011010	114
00011011	–13	10011011	115
00011100	–12	10011100	116
00011101	–11	10011101	117
00011110	–10	10011110	118
00011111	–9	10011111	119
00100000	–8	10100000	120
00100001	–7	10100001	121
00100010	–6	10100010	122
00100011	–5	10100011	123

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Chip temperature	Value (± 10 °C)	Chip temperature	Value (± 10 °C)
00100100	–4	10100100	124
00100101	–3	10100101	125
00100110	–2	10100110	126
00100111	–1	10100111	127
00101000	0	10101000	128
00101001	1	10101001	129
00101010	2	10101010	130
00101011	3	10101011	131
00101100	4	10101100	132
00101101	5	10101101	133
00101110	6	10101110	134
00101111	7	10101111	135
00110000	8	10110000	136
00110001	9	10110001	137
00110010	10	10110010	138
00110011	11	10110011	139
00110100	12	10110100	140
00110101	13	10110101	141
00110110	14	10110110	142
00110111	15	10110111	143
00111000	16	10111000	144
00111001	17	10111001	145
00111010	18	10111010	146
00111011	19	10111011	147
00111100	20	10111100	148
00111101	21	10111101	149
00111110	22	10111110	150
00111111	23	10111111	151
01000000	24	11000000	152
01000001	25	11000001	153
01000010	26	11000010	154
01000011	27	11000011	155
01000100	28	11000100	156
01000101	29	11000101	157
01000110	30	11000110	158
01000111	31	11000111	159
01001000	32	11001000	160

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Chip temperature	Value (± 10 °C)	Chip temperature	Value (± 10 °C)
01001001	33	11001001	161
01001010	34	11001010	162
01001011	35	11001011	163
01001100	36	11001100	164
01001101	37	11001101	165
01001110	38	11001110	166
01001111	39	11001111	167
01010000	40	11010000	168
01010001	41	11010001	169
01010010	42	11010010	170
01010011	43	11010011	171
01010100	44	11010100	172
01010101	45	11010101	173
01010110	46	11010110	174
01010111	47	11010111	175
01011000	48	11011000	176
01011001	49	11011001	177
01011010	50	11011010	178
01011011	51	11011011	179
01011100	52	11011100	180
01011101	53	11011101	181
01011110	54	11011110	182
01011111	55	11011111	183
01100000	56	11100000	184
01100001	57	11100001	185
01100010	58	11100010	186
01100011	59	11100011	187
01100100	60	11100100	188
01100101	61	11100101	189
01100110	62	11100110	190
01100111	63	11100111	191
01101000	64	11101000	192
01101001	65	11101001	193
01101010	66	11101010	194
01101011	67	11101011	195
01101100	68	11101100	196
01101101	69	11101101	197

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Chip temperature	Value (± 10 °C)	Chip temperature	Value (± 10 °C)
01101110	70	11101110	198
01101111	71	11101111	199
01110000	72	11110000	200
01110001	73	11110001	200
01110010	74	11110010	200
01110011	75	11110011	200
01110100	76	11110100	200
01110101	77	11110101	200
01110110	78	11110110	200
01110111	79	11110111	200
01111000	80	11111000	200
01111001	81	11111001	200
01111010	82	11111010	200
01111011	83	11111011	200
01111100	84	11111100	200
01111101	85	11111101	200
01111110	86	11111110	200
01111111	87	11111111	200

Table 53. Temperature measurement (6 bits) - version D

T °C code	Temperature (± 10 °C)	T °C code	Temperature (± 10 °C)
00000000	–40	10000000	72
00000001	–36.5	10000001	75.5
00000010	–33	10000010	79
00000011	–29.5	10000011	82.5
00000100	–26	10000100	86
00000101	–22.5	10000101	89.5
00000110	–19	10000110	93
00000111	–15.5	10000111	96.5
00001000	–12	10001000	100
00001001	–8.5	10001001	103.5
00001010	–5	10001010	107
00001011	–1.5	10001011	110.5
00001100	2.0	10001100	114
00001101	5.5	10001101	117.5
00001110	9.0	10001110	121

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T °C code	Temperature (± 10 °C)	T °C code	Temperature (± 10 °C)
00001111	12.5	10001111	124.5
00010000	16	10010000	128
00010001	19.5	10010001	131.5
00010010	23	10010010	135
00010011	26.5	10010011	138.5
00010100	30	10010100	142
00010101	33.5	10010101	145.5
00010110	37	10010110	149
00010111	40.5	10010111	152.5
00011000	44	10011000	156
00011001	47.5	10011001	159.5
00011010	51	10011010	163
00011011	54.5	10011011	166.5
00011100	58	10011100	170
00011101	61.5	10011101	173.5
00011110	65	10011110	177
00011111	68.5	10011111	180.5

Table 54. Duty cycle value (5 bits)- version E

Exc duty cycle	DF (%)	Exc duty cycle	Df (%)
00000	0	10000	51.5
00001	3	10001	55
00010	6.5	10010	58
00011	9.5	10011	61.5
00100	13	10100	64.5
00101	16	10101	67.5
00110	19.5	10110	71
00111	22.5	10111	74
01000	26	11000	77.5
01001	29	11001	80.5
01010	32.5	11010	84
01011	35.5	11011	87
01100	38.5	11100	90.5
01101	42	11101	93.5
01110	45	11110	97
01111	48.5	11111	100

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Table 55. Blind zone (1 bit) - version E

Blind zone (± 1.5 %)	Value
3 %	0
6 %	1

Table 56. Excitation current limitation (8 bits) - version E

Current limitation	Value	Current limitation	Value
00000000	Regulator OFF	10000000	5.12
00000001	0.04	10000001	5.16
00000010	0.08	10000010	5.2
00000011	0.12	10000011	5.24
00000100	0.16	10000100	5.28
00000101	0.2	10000101	5.32
00000110	0.24	10000110	5.36
00000111	0.28	10000111	5.4
00001000	0.32	10001000	5.44
00001001	0.36	10001001	5.48
00001010	0.4	10001010	5.52
00001011	0.44	10001011	5.56
00001100	0.48	10001100	5.6
00001101	0.52	10001101	5.64
00001110	0.56	10001110	5.68
00001111	0.6	10001111	5.72
00010000	0.64	10010000	5.76
00010001	0.68	10010001	5.8
00010010	0.72	10010010	5.84
00010011	0.76	10010011	5.88
00010100	0.8	10010100	5.92
00010101	0.84	10010101	5.96
00010110	0.88	10010110	6
00010111	0.92	10010111	6.04
00011000	0.96	10011000	6.08
00011001	1	10011001	6.12
00011010	1.04	10011010	6.16
00011011	1.08	10011011	6.2
00011100	1.12	10011100	6.24
00011101	1.16	10011101	6.28
00011110	1.2	10011110	6.32

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Current limitation	Value	Current limitation	Value
00011111	1.24	10011111	6.36
00100000	1.28	10100000	6.4
00100001	1.32	10100001	6.44
00100010	1.36	10100010	6.48
00100011	1.4	10100011	6.52
00100100	1.44	10100100	6.56
00100101	1.48	10100101	6.6
00100110	1.52	10100110	6.64
00100111	1.56	10100111	6.68
00101000	1.6	10101000	6.72
00101001	1.64	10101001	6.76
00101010	1.68	10101010	6.8
00101011	1.72	10101011	6.84
00101100	1.76	10101100	6.88
00101101	1.8	10101101	6.92
00101110	1.84	10101110	6.96
00101111	1.88	10101111	7
00110000	1.92	10110000	7.04
00110001	1.96	10110001	7.08
00110010	2	10110010	7.12
00110011	2.04	10110011	7.16
00110100	2.08	10110100	7.2
00110101	2.12	10110101	7.24
00110110	2.16	10110110	7.28
00110111	2.2	10110111	7.32
00111000	2.24	10111000	7.36
00111001	2.28	10111001	7.4
00111010	2.32	10111010	7.44
00111011	2.36	10111011	7.48
00111100	2.4	10111100	7.52
00111101	2.44	10111101	7.56
00111110	2.48	10111110	7.6
00111111	2.52	10111111	7.64
01000000	2.56	11000000	7.68
01000001	2.6	11000001	7.72
01000010	2.64	11000010	7.76
01000011	2.68	11000011	7.8

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Current limitation	Value	Current limitation	Value
01000100	2.72	11000100	7.84
01000101	2.76	11000101	7.88
01000110	2.8	11000110	7.92
01000111	2.84	11000111	7.96
01001000	2.88	11001000	8
01001001	2.92	11001001	8.04
01001010	2.96	11001010	8.08
01001011	3	11001011	8.12
01001100	3.04	11001100	8.16
01001101	3.08	11001101	8.2
01001110	3.12	11001110	8.24
01001111	3.16	11001111	8.28
01010000	3.2	11010000	8.32
01010001	3.24	11010001	8.36
01010010	3.28	11010010	8.4
01010011	3.32	11010011	8.44
01010100	3.36	11010100	8.48
01010101	3.4	11010101	8.52
01010110	3.44	11010110	8.56
01010111	3.48	11010111	8.6
01011000	3.52	11011000	8.64
01011001	3.56	11011001	8.68
01011010	3.6	11011010	8.72
01011011	3.64	11011011	8.76
01011100	3.68	11011100	8.8
01011101	3.72	11011101	8.84
01011110	3.76	11011110	8.88
01011111	3.8	11011111	8.92
01100000	3.84	11100000	8.96
01100001	3.88	11100001	9
01100010	3.92	11100010	9.04
01100011	3.96	11100011	9.08
01100100	4	11100100	9.12
01100101	4.04	11100101	9.16
01100110	4.08	11100110	9.2
01100111	4.12	11100111	9.24
01101000	4.16	11101000	9.28

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Current limitation	Value	Current limitation	Value
01101001	4.2	11101001	9.32
01101010	4.24	11101010	9.36
01101011	4.28	11101011	9.4
01101100	4.32	11101100	9.44
01101101	4.36	11101101	9.48
01101110	4.4	11101110	9.52
01101111	4.44	11101111	9.56
01110000	4.48	11110000	9.6
01110001	4.52	11110001	9.64
01110010	4.56	11110010	9.68
01110011	4.6	11110011	9.72
01110100	4.64	11110100	9.76
01110101	4.68	11110101	9.8
01110110	4.72	11110110	9.84
01110111	4.76	11110111	9.88
01111000	4.8	11111000	9.92
01111001	4.84	11111001	9.96
01111010	4.88	11111010	10
01111011	4.92	11111011	10.04
01111100	4.96	11111100	10.08
01111101	5	11111101	10.12
01111110	5.04	11111110	10.16
01111111	5.08	11111111	No limitation

Table 57. Excitation current measurement (8 bits) – version E

Irotor code	Value	Irotor code	Value
00000000	0	10000000	5.12
00000001	0.04	10000001	5.16
00000010	0.08	10000010	5.2
00000011	0.12	10000011	5.24
00000100	0.16	10000100	5.28
00000101	0.2	10000101	5.32
00000110	0.24	10000110	5.36
00000111	0.28	10000111	5.4
00001000	0.32	10001000	5.44
00001001	0.36	10001001	5.48

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Irotor code	Value	Irotor code	Value
00001010	0.4	10001010	5.52
00001011	0.44	10001011	5.56
00001100	0.48	10001100	5.6
00001101	0.52	10001101	5.64
00001110	0.56	10001110	5.68
00001111	0.6	10001111	5.72
00010000	0.64	10010000	5.76
00010001	0.68	10010001	5.8
00010010	0.72	10010010	5.84
00010011	0.76	10010011	5.88
00010100	0.8	10010100	5.92
00010101	0.84	10010101	5.96
00010110	0.88	10010110	6
00010111	0.92	10010111	6.04
00011000	0.96	10011000	6.08
00011001	1	10011001	6.12
00011010	1.04	10011010	6.16
00011011	1.08	10011011	6.2
00011100	1.12	10011100	6.24
00011101	1.16	10011101	6.28
00011110	1.2	10011110	6.32
00011111	1.24	10011111	6.36
00100000	1.28	10100000	6.4
00100001	1.32	10100001	6.44
00100010	1.36	10100010	6.48
00100011	1.4	10100011	6.52
00100100	1.44	10100100	6.56
00100101	1.48	10100101	6.6
00100110	1.52	10100110	6.64
00100111	1.56	10100111	6.68
00101000	1.6	10101000	6.72
00101001	1.64	10101001	6.76
00101010	1.68	10101010	6.8
00101011	1.72	10101011	6.84
00101100	1.76	10101100	6.88
00101101	1.8	10101101	6.92
00101110	1.84	10101110	6.96

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Irotor code	Value	Irotor code	Value
00101111	1.88	10101111	7
00110000	1.92	10110000	7.04
00110001	1.96	10110001	7.08
00110010	2	10110010	7.12
00110011	2.04	10110011	7.16
00110100	2.08	10110100	7.2
00110101	2.12	10110101	7.24
00110110	2.16	10110110	7.28
00110111	2.2	10110111	7.32
00111000	2.24	10111000	7.36
00111001	2.28	10111001	7.4
00111010	2.32	10111010	7.44
00111011	2.36	10111011	7.48
00111100	2.4	10111100	7.52
00111101	2.44	10111101	7.56
00111110	2.48	10111110	7.6
00111111	2.52	10111111	7.64
01000000	2.56	11000000	7.68
01000001	2.6	11000001	7.72
01000010	2.64	11000010	7.76
01000011	2.68	11000011	7.8
01000100	2.72	11000100	7.84
01000101	2.76	11000101	7.88
01000110	2.8	11000110	7.92
01000111	2.84	11000111	7.96
01001000	2.88	11001000	8
01001001	2.92	11001001	8.04
01001010	2.96	11001010	8.08
01001011	3	11001011	8.12
01001100	3.04	11001100	8.16
01001101	3.08	11001101	8.2
01001110	3.12	11001110	8.24
01001111	3.16	11001111	8.28
01010000	3.2	11010000	8.32
01010001	3.24	11010001	8.36
01010010	3.28	11010010	8.4
01010011	3.32	11010011	8.44

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Irotor code	Value	Irotor code	Value
01010100	3.36	11010100	8.48
01010101	3.4	11010101	8.52
01010110	3.44	11010110	8.56
01010111	3.48	11010111	8.6
01011000	3.52	11011000	8.64
01011001	3.56	11011001	8.68
01011010	3.6	11011010	8.72
01011011	3.64	11011011	8.76
01011100	3.68	11011100	8.8
01011101	3.72	11011101	8.84
01011110	3.76	11011110	8.88
01011111	3.8	11011111	8.92
01100000	3.84	11100000	8.96
01100001	3.88	11100001	9
01100010	3.92	11100010	9.04
01100011	3.96	11100011	9.08
01100100	4	11100100	9.12
01100101	4.04	11100101	9.16
01100110	4.08	11100110	9.2
01100111	4.12	11100111	9.24
01101000	4.16	11101000	9.28
01101001	4.2	11101001	9.32
01101010	4.24	11101010	9.36
01101011	4.28	11101011	9.4
01101100	4.32	11101100	9.44
01101101	4.36	11101101	9.48
01101110	4.4	11101110	9.52
01101111	4.44	11101111	9.56
01110000	4.48	11110000	9.6
01110001	4.52	11110001	9.64
01110010	4.56	11110010	9.68
01110011	4.6	11110011	9.72
01110100	4.64	11110100	9.76
01110101	4.68	11110101	9.8
01110110	4.72	11110110	9.84
01110111	4.76	11110111	9.88
01111000	4.8	11111000	9.92

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Irotor code	Value	Irotor code	Value
01111001	4.84	11111001	9.96
01111010	4.88	11111010	10
01111011	4.92	11111011	10.04
01111100	4.96	11111100	10.08
01111101	5	11111101	10.12
01111110	5.04	11111110	10.16
01111111	5.08	11111111	10.2

13 Logic commands and registers

This IC is one time programmable (OTP), during final test at NXP or by the customer on end of line test. The OTP programmable options table (Table 58) describes the programmable functions that are selectable by customer. Programming (fusing) is performed in one time either by the supplier (at probe test) or by the customer (end of line).

Table 58. OTP programmable options

Function	OTP bits	Comments
LIN frame configuration	4	see Table 10
LIN protocol	2	LIN 1.3 or LIN 2.1 with assign frame ID service disabled or LIN 2.1 with assign frame ID service enabled
Specific bit for LIN Version A and B (LRC and I_{EXC} flags)	1	enabled or disabled
Default regulation voltage	3	13.5 V, 13.7 V, 14.0 V, 14.1 V, 14.3 V, 14.5 V, 14.7 V or 14.9 V (± 100 mV at 25 °C)
Excitation duty cycle filter mode in phase regulation	2	regulation duty cycle, pre-excitation duty cycle, 0 % duty cycle or real duty cycle
Maximum on time for phase regulation	2	27 ms, 45 ms, 100 ms, 155 ms (± 5.0 %)
Pre-excitation duty cycle	3	5 %, 7.5 %, 10 %, 12.5 %, 15 %, 17.5 %, 20 %, 25 % (± 1.0 %)
Pre-excitation behavior		two options are selectable (described in Section 14.4 "Pre-exc")
Filter frequency of reported battery voltage measurement	2	0 Hz, 1 Hz, 5 Hz or 10 Hz (± 5.0 %)
Filter frequency of reported duty cycle report (DF)	2	0 Hz, 1 Hz, 5 Hz or 10 Hz (± 5.0 %)
Filter frequency of reported excitation current measurement	2	0 Hz, 1 Hz, 5 Hz or 10 Hz (± 5.0 %)
Default LRC disable speed	2	3000 RPM, 4000 RPM, 4800 RPM and 6000 RPM (± 10 %)
Default LRC duration	3	1 s, 2 s, 3 s, 4 s, 5 s, 6 s, 7 s or 8 s (± 10 %)
LRC after priority charge	1	enabled or disabled (behavior described in Section 18 "Operation voltage - priority charge function")
Default LRC return duration	2	0.5 s, 1 s, 1.5 s or 2 s (± 10 %) (behavior described in Section 17 "Return LRC")
Alternator pole pairs	2	5, 6, 7 or 8

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Function	OTP bits	Comments
Self-start speed threshold	2	2000 RPM, 3000 RPM, 4000 RPM or 5000 RPM (± 10 %)
Bus inactivity or data corruption timeout	1	3 s or 10 s
Excitation off for V_{SET} = 10.6 V	1	enabled or disabled
Excitation short-circuit threshold (at 25 °C)	2	9 A, 10 A, 11 A or 12 A (± 1.0 A)
Electrical flag in case of undervoltage	1	flag = 1 if priority charge function is activated for more than T_{DEFECT} or $V_{SET} > V_{BAT}$ flag = 0 if $V_{SET} > V_{BAT}$
Mechanical flag configuration	1	flag = 1 in PreExc mode or flag = 0 if PreExc mode and 10.6 V < V_{SET} < V_{B+A}
Overvoltage fault flag	1	enabled or disabled
Low-voltage threshold	2	8.75 V, 9.25 V, 9.75 V or 10.25 V (± 200 mV)
Thermal compensation threshold	3	125 °C, 130 °C, 135 °C, 140 °C, 145 °C, 150 °C, 155 °C or 160 °C (± 10 °C)
Thermal compensation temperature gradient	3	−50 mV/°C, −100 mV/°C, −150 mV/°C, −200 mV/°C, −250 mV/°C, −300 mV/°C, −350 mV/°C, −400 mV/°C (± 10 %)
Fault deglitching time	2	50 ms, 250 ms, 400 ms or 1000 ms (± 10 %)
Phase deglitcher duration	2	0.15 ms, 0.75 ms, 1.5 ms or 2.5 ms
Blind zone value in default mode	2	0 %, 3.25 %, 6 % or 12 % (± 1.0 %)
Blind zone inhibition	1	enabled or disabled
Alternator supplier and class	3 and 5	alternator information

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14 State machine

The following figure describes the state machine of the AR6000.

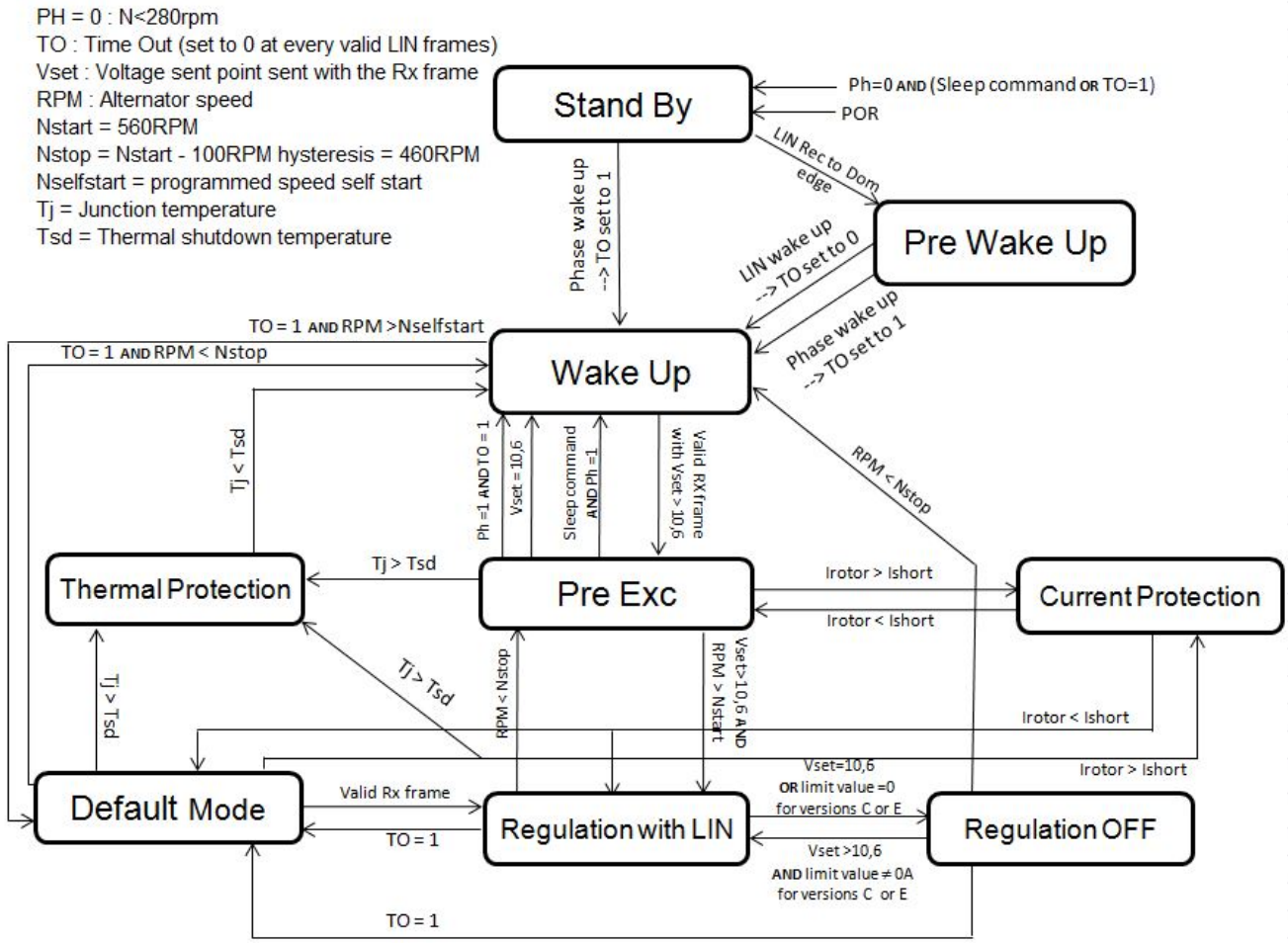


Figure 8. State machine

14.1 Standby

The AR6000 is in standby mode, if there is a LIN timeout and when alternator is not in rotation (no phase), or in case of power-on reset (POR), or with a sleep command without phase activity.

- There is no excitation
- The duty cycle (DC) is equal to zero

The device needs only a small amount of quiescent current to supply logic, phase detector, and LIN receiver.

LIN timeout means no valid LIN frame on the LIN-bus during 3.0 s or 10 s (according to configuration).

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14.2 Wake-up

This state is reached when a LIN wake-up has been validated or when an edge on phase input is detected.

- The logic is on and internal clock is available
- All the blocks are on
- There is no regulation DC = 0 %
- Phase sensitivity is 200 mV typ. for a wake-up by phase and in default mode, otherwise 800 mV typ.

After a LIN timeout, if no valid instruction is decoded, the device goes back into standby mode.

14.3 Pre wake-up mode

When a transition from recessive to dominant is detected on LIN-bus, a timer should be started to check duration of this dominant state. If duration is less than *Tminwu*, design goes back to standby mode. Otherwise design is looking for dominant to recessive LIN transition to validate wake-up event. If dominant to recessive LIN transition takes place before timeout is elapsed (*Twuto*), wake-up event is validated and design goes to wake-up mode; if wake-up event is not validated, design goes back to standby (unless a wake-up by phase input transition is in progress).

Table 59. Pre wake-up mode

Data	Description	Min.	Typ.	Max.	Unit
Tminwu	minimum dominant pulse timing for LIN wake-up	30	-	150	µs
Twuto	LIN wake-up timeout	5	-	-	ms

14.4 Pre-exc

The pre-excitation state is reached as soon as a valid instruction for the regulated value (V_{REG}), different from 10.6 V, is decoded.

The purpose of pre-excitation is to increase the alternator magnetization, to guarantee a minimum phase voltage for rotor speed measurement.

The pre-excitation stays active until the detection of phase starts regulating RPM (N_{START}).

There are two types of pre-excitation (selectable by the OTP fuse):

Pre-exc 1:

- If $V_{SET} < V_{BAT}$ or if $V_{SET} > V_{BAT}$ in the conditions previously described to enter pre-excitation, the regulator has pre-excitation duty cycle until N_{START} is reached.

Pre-exc 2:

- If $V_{SET} < V_{BAT}$ in the conditions previously described to enter pre-excitation, the regulator has pre-excitation duty cycle until N_{START} is reached. Excitation limitation is active and current limitation is set to 1.0 A.

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- If V_{SET} > V_{BAT} in the conditions previously described to enter pre-excitation, the regulator duty cycle goes to 100 % until N_{START} is reached. Excitation limitation and LRC are active if requested by LIN in this pre-excitation type.

In order to avoid disturbance of speed measurement due to parasitics generated by excitation switching, a deglitcher is inserted between phase input and phase processing logic. The duration of this deglitcher is selected by two configuration bits of Table 58 (four values are available: 0.15 ms, 0.75 ms, 1.5 ms and 2.5 ms).

14.5 Regulation with LIN

In this mode, the AR6000 regulates the alternator output to the set reference level. The excitation is controlled by LRC if this LRC mode is active, until speed reaches LRC disable speed.

14.6 Default mode

This mode is equivalent to the “Regulation with LIN” mode except that the default parameters (V_{REG}, LRC rate, LRC_{DISF},...) are used for regulation, as there is no LIN communication. These parameters are programmed at the end of line testing.

When there is no valid frame for more than LIN timeout, regulation voltage target transitions to default V_{REG} with a ramp of 0.2 V/s (± 10 %) and excitation limitation value transitions to “no limitation” (equivalent to a 12.7 A limitation value) with a ramp of 0.375 A/s (± 10 %).

If communication resumes with RX frames, regulation voltage target and current limitation changes with no delay to their respective values set by LIN.

15 Phase regulation

This function avoids losing phase signal amplitude for proper regulation when the voltage in the board harness is higher than the set point value (case of load shedding, or set point below battery voltage).

The regulator monitors the voltage levels of the phase signal and checks if the phase oscillates between V_{TH_L} and V_{TH_H}, ensuring phase amplitude is sufficient for regulation. Phase failure is detected if there is no PhaseOK rising edge for more than 30 ms. In this case the phase regulation is started.

The phase regulation function is performed by applying 100 % duty cycle current to the rotor, so the phase amplitude can build up. This 100 % duty cycle is stopped, either when the rising edge of PhaseOK is present again, or when the maximum duration of phase regulation is reached (this timing is determined by programming the $t_{ONBOOST}$ parameter, max on time for phase boost).

If the PhaseOK signal recovers, then fails again before the end of $t_{ONBOOST}$ timer, another $t_{ONBOOST}$ time is initiated.

If the phase is still not OK after $t_{ONBOOST}$, the device goes back to regulation mode and starts a 300 ms ‘failure’ timer. When this 300 ms timer has elapsed, if there is still no PhaseOK rising edge for the next 30 ms, the phase boost function is active again for a maximum duration of $t_{ONBOOST}$. The number of retries is not limited.

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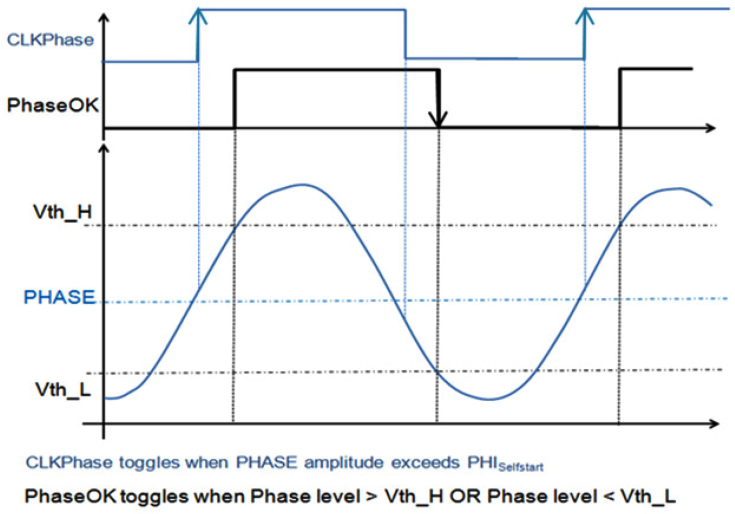


Figure 9. Phase regulation

There are two different values for CLKPhase signal detection, according to regulator mode:

Table 60. CLKPhase detection threshold voltage

Mode	Description	Min.	Typ.	Max.	Unit
Φ_{START1}	minimum peak-to-peak phase voltage in standby/ wake-up/ default mode	150	200	250	mV
Φ_{START2}	minimum peak-to-peak phase voltage in pre-excitation/ regulation mode	700	800	900	mV

Threshold values for PhaseOK signal are as follows:

Table 61. PhaseOK detection threshold voltage

Data	Description	Min.	Typ.	Max.	Unit
Vth_H	positive peak threshold	3	4	5	V
Vth_L	negative peak threshold	0.75	1.78	2.25	V

$t_{ON\ BOOST}$ time is selectable by fuse and four values are available: 27 ms, 45 ms, 100 ms, or 155 ms.

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16 Blind zone

If blind zone function is not inhibited by a LIN command, the duty cycle defined by the fuse configuration is used. For example, if a 3 % blind zone is selected, no LRC ramp is applied for a duty cycle variation less than 3 %.

17 Return LRC

The purpose of return LRC is to control excitation duty cycle in cases of load deactivation.

- This function is always active whatever the alternator speed.
- This function is active in default mode and in regulation mode.
- The LRC return value can be changed by OTP.

Example of operation: duty cycle ramp down is controlled by the return LRC timer when the duty cycle change exceeds blind zone value. In this diagram, LRC is also visible in the ramp up when load is switched on.

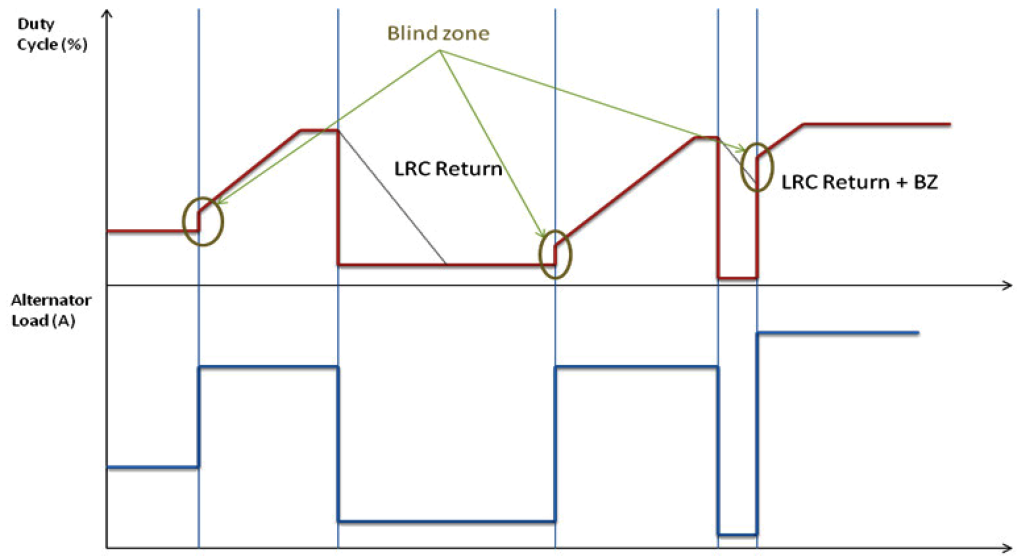


Figure 10. LRC return

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18 Operation voltage - priority charge function

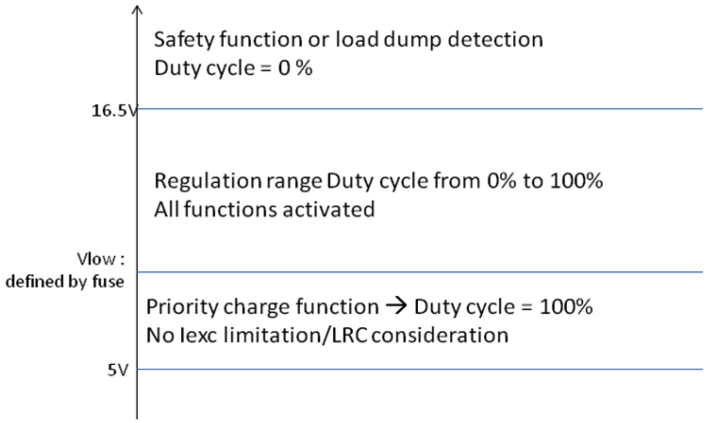


Figure 11. Operation voltage

Nominal operation voltage is from 5.0 V to 16.5 V. When battery voltage drops below V_{LOW} (value selectable by fuse), the priority function is enabled (with two possible behaviors to select by fuse):

- First behavior: When the voltage reaches the V_{LOW} threshold, LRC is disabled and 100 % duty cycle is applied until V_{SET} is reached.

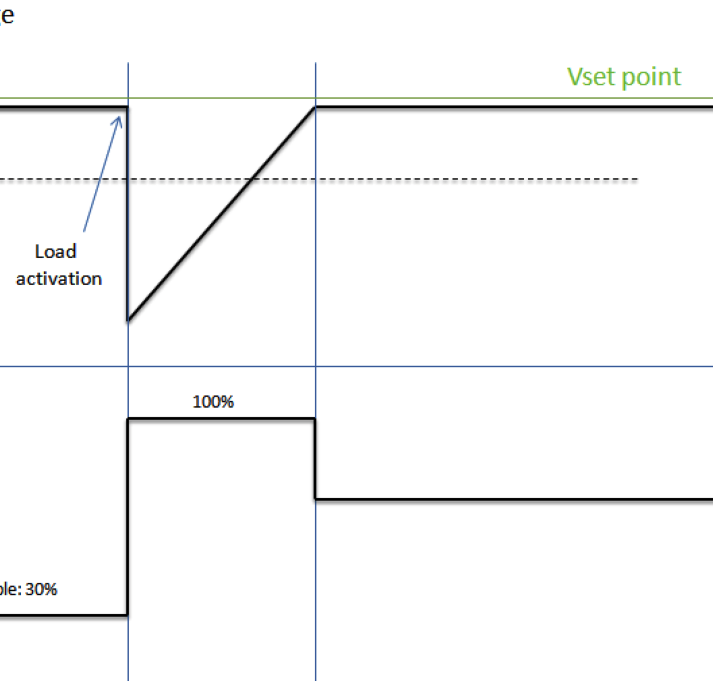


Figure 12. Priority charge function first behavior

- Second behavior: When the voltage reaches the V_{LOW} threshold, the LRC is disabled and 100 % duty cycle is applied until V_{LOW} threshold is reached (upward). When V_{LOW} is reached, LRC is enabled until V_{SET} is reached.

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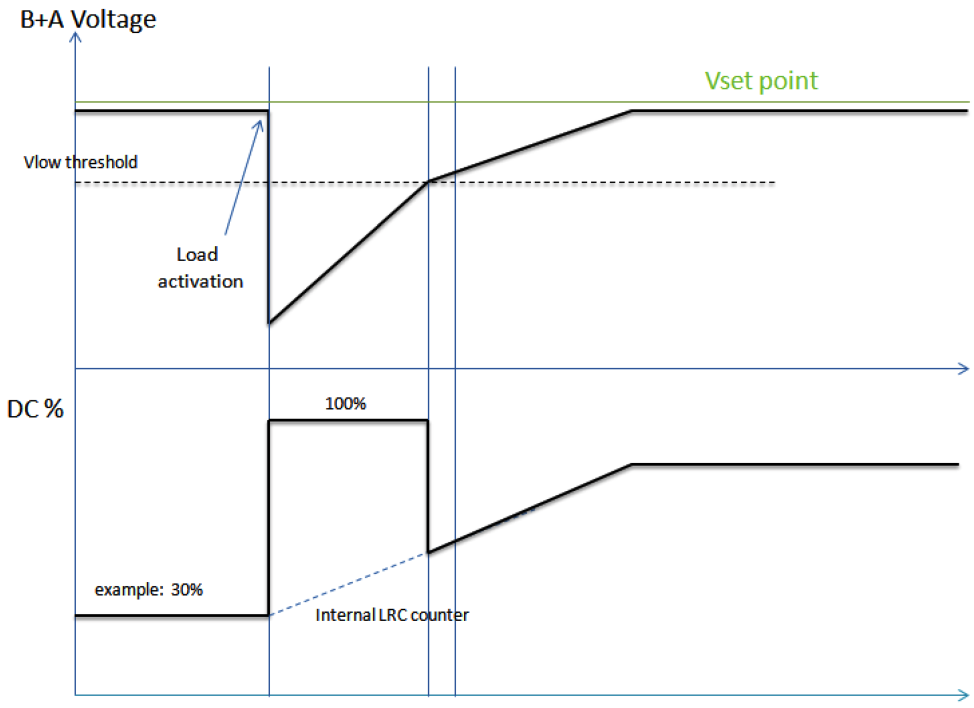


Figure 13. Priority charge function second behavior

When this function is activated, the current limitation is disabled.

If battery voltage drops to 3.0 V, most of the analog blocks are disabled, including the internal clock, but all register contents of the main logic are kept, so that regulation can resume with stored values as soon as possible, when battery voltage is back in the normal operating range. Below 3.0 V, a reset is allowed and therefore all register contents are lost.

19 Power supply rejection

In case of short battery drops (voltage down to zero volt at the lowest), regulation is disturbed only during the low battery pulse and is back to normal regulation after the pulse (all register contents in digital loop are kept). The device is able to withstand such “microcuts” during 40 µs maximum, using an internal tank capacitor.

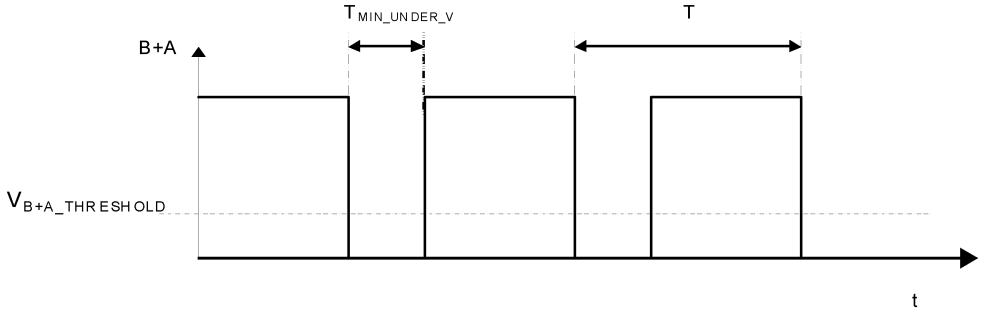


Figure 14. Battery voltage “microcuts”

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Table 62. Battery voltage microcuts

Data	Description	Min.	Typ.	Max.	Unit
T	minimum time between two undervoltage events	250	—	1000	µs
$t_{MIN_UNDER_V}$	minimal undervoltage time the regulator must withstand whatever the T°C	40	—	—	µs
$V_{B+A_THRESHOLD}$	B+A undervoltage threshold	0	—	5.0	V

If timing between two such undervoltage events is shorter than 250 µs, logic registers may reset, resulting in loss of register content.

Below 5.0 V, most analog blocks are disabled (main logic clock, regulation loop, excitation driver, LIN transceiver). Main logic is supplied as long as battery voltage is higher than 3.0 V.

20 Behavior without battery

In case of a battery disconnection from the alternator output, the regulator maintains the alternator voltage within the range of V_{REAL} ± 0.5 V.

Table 63. Behavior without battery

Data	Description	Min.	Typ.	Max.	Unit
$DC_V_{WITHOUT_BATT}$	additional tolerance in case of operation without battery	V_{REAL} – 0.5	V_{REAL}	V_{REAL} + 0.5	V

21 Thermal compensation

This function is activated when the internal temperature is above the thermal threshold (selectable by a fuse, from 125 °C to 160 °C). In this case, the voltage set point is fixed by LIN or by default is decreased to reduce internal temperature. The derating is also selectable by a fuse (from –50 mV/°C to –400 mV/°C).

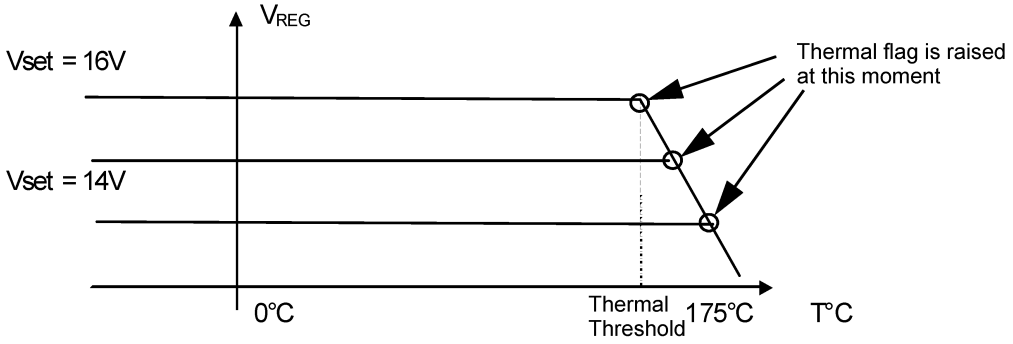


Figure 15. Thermal compensation

22 Protection and diagnosis features

22.1 Fault detection

General Notes

All fault reporting passes through a digital filter to avoid false indication problems, this deglitching time is selectable by fuse from 50 ms to 1000 ms.

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22.2 Mechanical fault (F_MEC)

When the alternator speed is 0 RPM < N_{ALT} < N_{START} the flag must be set to logic 1. When N_{ALT} > N_{START}, regulation starts and F_MEC flag is set to logic 0 as long as N_{ALT} > N_{STOP} (if N_{ALT} < N_{STOP} then F_MEC is set to logic 1).

N_{STOP} = (N_{START} − N_{S_HYST}). N_{START} and N_{S_HYST} are defined in Table 8.

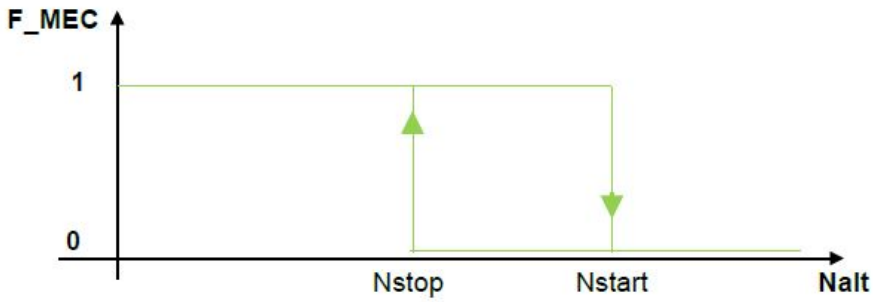


Figure 16. Mechanical fault threshold

22.3 Electrical fault (F_EL)

If one of these faults appear:

- **Excitation short to battery or to ground**:
  Duty cycle of power output driver and excitation voltage are monitored.
  - If V_{EXC} < 1.5 V and duty cycle of excitation driver is 100 % for more than t_{DEFECT}, a short of excitation to ground is detected and F_EL is set to 1.
  - If V_{EXC} > 1.5 V and duty cycle of excitation driver is OFF for more than t_{DEFECT}, a short of excitation to battery is detected and F_EL is set to 1.
- **Alternator rotor open**
  - If excitation current measured is below 1.0 A when excitation duty cycle is 100 % for more than t_{DEFECT}, an open rotor is detected and F_EL is set to 1.
- **Observed phase short**
  - If phase regulation has failed after $t_{ONBOOST}$ for more than t_{DEFECT}, the F_EL is set to 1.
- **B+A voltage too low**
  - If the priority charge function is active during t_{DEFECT} and the target voltage is not reached, F_EL is set to 1 if the “Electrical flag in case of low-voltage” OTP fuse has been set to 1.
- **Overvoltage (safety function activation)**
  - If the OTP fuse “Overvoltage Fault Flag” = 1, F_EL is set to 1, in case of an overvoltage on B+A as shown in Section 23 "Safety function".
- **Double error in configuration OTP fuse**
  - If a double error (error which cannot be corrected with redundant ECC code) in customer configuration OTP fuse bits occurs, F_EL sets to 1 after t_{DEFECT}.

22.4 Thermal fault (F_HT)

A thermal fault is reported when thermal compensation starts to operate (see Section 21 "Thermal compensation").

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22.5 Timeout flag (TO)

Timeout between two consecutive valid messages is 3 s or 10 s. If this time is exceeded, the TO flag is raised and reset after reading.

22.6 Communication error flag

- LIN 2.1 or LIN 1.3: “checksum” error detected: A checksum error is detected
- LIN 2.1 or LIN 1.3: “identifier parity error” detected: The parity field (P0 and P1) of a known identifier is wrong
- LIN 2.1 or LIN 1.3: “Inconsistent-Synch-Field-Error”: Edges of the SYNCH field are detected outside the given tolerances
- LIN 2.1 or LIN 1.3: “stop bit” detected: LIN-bus line is dominant while stop bit
- LIN 2.1 or LIN 1.3: “bit error” detected: The received bit is different from the bit sent

The communication error flag is reset after reading.

22.7 LRC flag

The LRC flag is set to 1 when LRC is active for more than 15 ms. If LRC is no longer active for more than 15 ms, the LRC Flag is reset. This flag has to be enabled by OTP.

22.8 Excitation current limitation flag

Excitation current limitation flag (IExc flag) is set to 1 when excitation current is limited and has reached the current limitation value set by LIN for more than 15 ms. When excitation current is no longer limited for more than 15 ms, the IExc flag is reset.

Excitation current limitation flag is disabled in Pre-excitation mode 2 when $V_{SET} < V_{BAT}$.

This flag has to be enabled by OTP.

The following table summarizes F_MEC, F_EL, and F_HT operation based on regulator state.

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Table 64. F_MEC, F_EL, and F_HT operation details

Fault Reporting		Wake-up mode	Pre-excitation mode		Regulation mode				
		Nalt < Nstop	N < Nstart		N > Nstart				
		V_{set} = 10.6 V	10.6 < V_{set} < U_{bat}	V_{set} > V_{bat}	Exc OFF state enabled			Exc OFF state disabled	
					Vset = 10.6 V	V_{set} < U_{bat}	V_{set} > V_{bat}	V_{set} < U_{bat}	V_{set} > V_{bat}
Alt speed < Nstart	F_MEC	0	1[1]	1	0	0	0	0	0
Overvoltage (safety function)	F_EL	1[1]	1[1]	0	1[1]	1[1]	0	1[1]	0
Phase regulation failure	F_EL	0	0	0	0	1	1	1	1
Low voltage (Priority charge function)	F_EL	0	0	0	0	0	1[1]	0	1[1]
No power generation (DC = 100 % and I_{exc} < 1 A)	F_EL	0	0	0	0	0	1	0	1
Exc stage short to B+A (V_{exc} > 1.5 V and DC = 0 %)	F_EL	1	0	0	1	1	0	1	0
Exc stage short to GND (V_{exc} < 1.5 V and DC = 100 %)	F_EL	0	0	0	0	0	1	0	1
Double error to OTP fuses	F_EL	1	1	1	1	1	1	1	1
Too high temperature	F_HT	0	0	0	0	1	1	1	1

[1] Can be disabled by OTP

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23 Safety function

To avoid battery overcharge, a safety function is implemented with two redundant methods to measure the battery voltage. The voltage dividers and voltage references shown in Figure 17 are independent. When either of the detectors (ADC or comparator) has reported to safety logic of an overvoltage condition (battery voltage above Alarm_TH), the power LDMOS providing excitation current is turned off and the electrical flag is set to logic 1. A separate pull-down circuitry on the power LDMOS gate ensures that excitation is turned off, even in case of ADC, safety logic, or gate driver failure.

To change to normal regulation mode, both conditions have to be met:

- CompOut = 0
- ADC value < 16.5 V

Once activated, the safety function maintains excitation off until V_{BAT} stays below the safety threshold (typ. 16.5 V) for a minimum of 500 ms.

When the alarm threshold is reached, the electrical flag sets to 1 if the fuse “Overvoltage Error Flag Enable” has been selected.

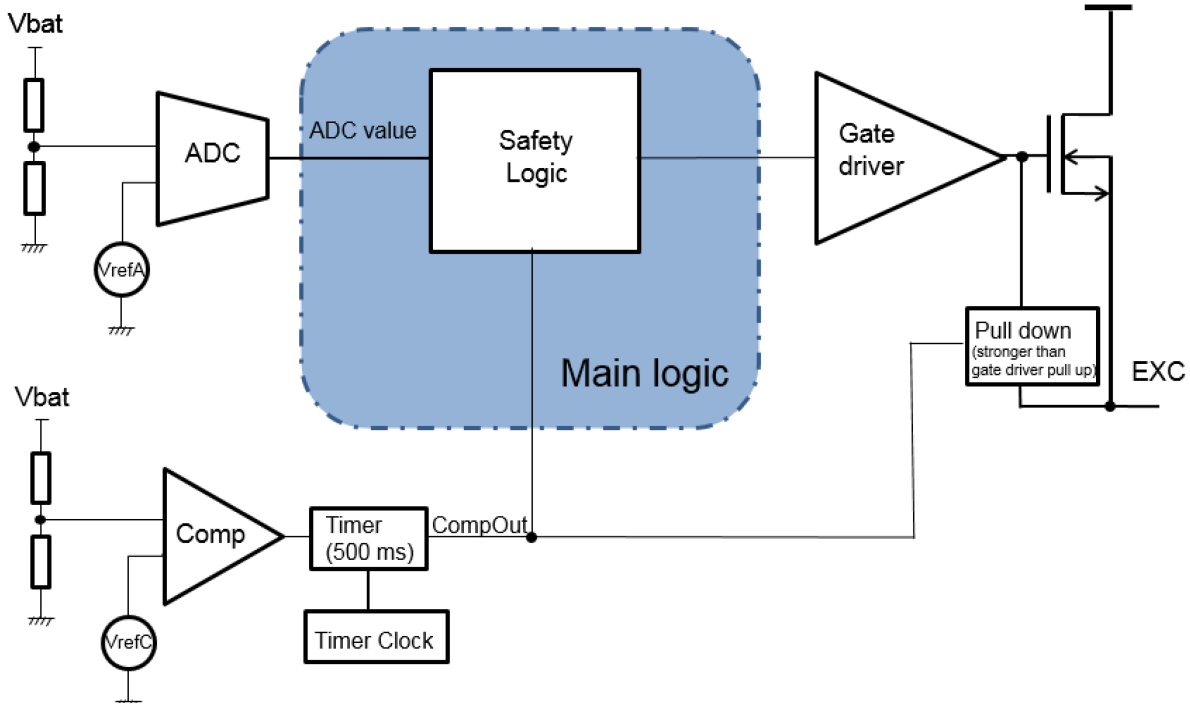


Figure 17. Safety function

Table 65. Safety function threshold and filtering

Symbol	Parameter	Min.	Typ.	Max.	Unit
Alarm_TH	alarm system threshold	16.2	16.5	16.8	V
Filtering	timer	450	500	550	ms

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24 Test mode and programming

24.1 Test mode entry

The entrance in this specific mode is performed through two different steps:

- Key and seed exchange
- Test mode request/activation

24.2 Test mode function

Different functions could be activated according to function ID (**FID**):

- Clocks acceleration
- Clocks deactivation
- Test mode deactivation
- Die information reading
- OTP memory reading (specified in the programming specification)
- OTP memory programming (specified in the programming specification)

24.2.1 i/ Clocks acceleration

This function is used to accelerate all timers during test sequence like:

- Timer fault
- LIN timeout
- Phases timeout
- LRC

The timer test mode increases the timer clock by 32. It means all the previous functions are 32 times shorter. For example, if an LRC ramp time of 10 s is required by LIN, in this specific mode, the LRC duration is 10 s/32 = 312 ms.

24.2.2 ii/ Clocks deactivation

This function deactivates all timers listed previously. This function is used during the alternator end of line test. The aim is to allow the alternator to supply the maximum load in the shortest possible delay. Therefore in this specific mode, the LRC has to be disabled, as well as the default timer.

24.2.3 iii/ Test mode deactivation

This function is used to exit test mode.

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24.2.4 iv/ Die information reading

This function is used to read information like:

- Wafer number
- Wafer lot number
- Die version
- X die position on wafer
- Y die position on wafer

24.2.5 v/ OTP memory bytes reading

This function is used to read some configuration information.

25 Revision history

Revision	Date	Description of changes
1.0	4/2016	Initial release
	4/2016	Updated Table 1
2.0	8/2016	• Updated Figure 4 • Added TO220 dimensions • Updated Table 7 • Updated Figure 8 • Updated Section 14.2 "Wake-up" • Updated Section 22.2 "Mechanical fault (F_MEC)"
	8/2016	• Updated Figure 5 and added Figure 6
	9/2016	• Corrected typo in Table 22

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Revision	Date	Description of changes
3.0	1/2017	• Revised "The ECU also can read..." to "The ECU can also read..." in Section 1 • Updated "MC33AR6000AGWS" to "MC33AR6000BGWS", "MC33AR6000xGT" to "MC33AR6000BGT" and removed entry for MC33AR6000AxWS in Table 1 • Updated Function and X/µm for Pad 3 from "BUS" to "GND" in Table 2 • Updated Function and X/µm for Pad 4 from "GND" to "BUS" in Table 2 • Update the description for "Level" symbol to read "Standard Transient Pulses ISO 7637-2" in Table 5 • Updated Symbol "I" characteristic "Standby current in pre wake-up mode" to include "at 25 °C" in Table 7 • Updated max value for Symbol V_{OV} from "—" to "16.8" in Table 7 • Updated Characteristic for Symbol N_{START} adding "(if peak to peak value of phase input voltage exceeds 800 mV (typ.))" in Table 8 • Updated the table after list item E in Section 11.2.1 • Updated the table after list item E in Section 11.3.1 • Updated Blind zone table reference from "Table 32" to "Table 55" in Table 25. • Updated Table 30 column headings • Updated title of Table 32 from "Blind zone (1 bit) – versions A and E" to "Blind zone (1 bit) – versions A and B" • Updated Table 47 column headings from "Ramp" and "Seconds" to "Speed" and "RPM" • Updated Table 50 column headings "Current limitation" to "Irotor code" • Updated Table 51 column headings "Current limitation" to "Measured voltage" • Added new table, Table 55 • Updated Function "Specific bit for LIN Version B..." to Specific bit for LIN Version A and B..." in Table 58 • Added "−150", "−250", and "−350" to the Comments for "Thermal compensation temperature gradient" Function in Table 58 • Updated "Phase sensitivity" bullet in Section 14.2 • Added new Pre Wake-up mode section in Section 14.3 • Revised Function "Blind zone default value" to read "Blind zone value in default mode" in Table 58 • Updated "Phase sensitivity" bullet adding "for a wake up by phase, otherwise 800mV typ." in Section 14.2 • Moved paragraph "In order to avoid disturbance..." after last bullet in "Pre-exc 2" in Section 14.4 • Updated Description for Φ_{START1} to read "Minimum peak to peak phase voltage in standby/wakeup/ default mode" in Table 60 • Updated Description for Φ_{START2} to read "Minimum peak to peak phase voltage in pre-excitation/regulation mode" in Table 60 • Revised Section 20, updating "+$V_{RIPPLE_WITHOUT_BATTERY}$ to "+ 0.5 V" and removed sentence "The ripple voltage due to the battery disconnection does not exceed $V_{RIPPLE_WITHOUT_BATTERY}$ and regulation continues in these conditions." • Revised "$N_{ALT} > N_{STOP}$..." to "$N_{ALT} < N_{STOP}$..." in Section 22.2 • Updated paragraph, adding "and reset after reading" after "If this time is exceeded, the TO flag is raised" in Section 22.5 • Added sentence "The communication error flag is reset after reading." at end of Section 22.6 • Changed "This flag has to enabled by OTP." to read "This flag has to be enabled by OTP." in Section 22.7

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Revision	Date	Description of changes
4.0	6/2017	• Updated Table 1 • Table 5, Level, changed description from "Standard Transient Pulses ISO 7637-2" to "Standard Transient Pulses ISO 7637-2 (when mounted on alternator)" • Section 10.1, changed "Analog permanently powered or not" to "All analog blocks (in wake up and in standby modes)" • Section 10.1, added "When a Power-On-Reset occurs, device internal registers are reset and the device goes into stand by mode." • Section 10.2, changed "...a high-side driver..." to "...the internal N-channel power MOSFET...." • Section 10.3.2, changed "This block is the clock reference for the digital block. The oscillator generates a 2.5 V square wave at the frequency of 8.0 MHz in Normal mode operation." to "This block is the clock reference for all digital blocks. When regulator is woken up, two frequencies are provided: 8 MHz and a derived 4 MHz." • Section 10.3.5, changed "The analog to digital converter is used in the voltage regulation loop for temperature measurement." to "The analog to digital converter is used in the voltage regulation loop for voltage and temperature measurements." • Removed Section 10.3.8
5.0	9/26/2017	• Updated chip temperature range in Table 44 • Added new footnote to Table 28 and footnote to Table 40 • Updated titles for Table 29, Table 30, Table 35, and Table 40 • Added Table 56 and Table 57
5.1	10/2017	• Corrected formatting issue in Table 48
5.2	20190617	Updated as per CIN 201906004I • Table 9: added header for second column • Table 10: added table title; added corresponding version for OTP bits 1110 and 1111 • Table 11: new table • Table 58: changed reference for LIN frame configuration in comments column

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Tables

Tab. 1. Orderable part variations 2
Tab. 2. Pin coordinates for die version 4
Tab. 3. Pin description 7
Tab. 4. Mandatory external components 7
Tab. 5. Maximum ratings 7
Tab. 6. Thermal ratings 8
Tab. 7. Static electrical characteristics 8
Tab. 8. Dynamic electrical characteristics 9
Tab. 9. LIN frame configurations 14
Tab. 10. OTP LIN frame configurations 16
Tab. 11. Node address and read by ID services for LIN2.1 protocol 16
Tab. 12. Identifier: 0X29 (LIN1) or 0X2A (LIN2, LIN4) or 0X20 (LIN3) 16
Tab. 13. Identifier: 0X11 (LIN1) or 0X13 (LIN2, LIN4) or 0X15 (LIN3) 17
Tab. 14. Identifier: 0X12 (LIN1) or 0X14 (LIN2) or 0X21 (LIN3) or 0X11 (LIN4) 17
Tab. 15. Identifier: 0X15 (LIN1) or 0X16 (LIN2, LIN4) or 0X18 (LIN3) 18
Tab. 16. Identifier: 0X29 (LIN1) or 0X2A (LIN2, LIN4) or 0X20 (LIN3) 18
Tab. 17. Identifier: 0X12 (LIN1) or 0X14 (LIN2, LIN4) or 0X21 (LIN3) OX11 (LIN4) 19
Tab. 18. Identifier: 0X15 (LIN1) or 0X16 (LIN2, LIN4) or 0X18 (LIN3) 19
Tab. 19. Identifier: 0X20 20
Tab. 20. Identifier: 0X21 21
Tab. 21. Identifier: 0X18 21
Tab. 22. Identifier: 0X29 (LIN1) or 0X2A(LIN2) 21
Tab. 23. Identifier: 0X11 (LIN1) or 0X13 (LIN2) 22
Tab. 24. Identifier: 0X12 (LIN1) or 0X14 (LIN2) 22
Tab. 25. Identifier: 0X29 22
Tab. 26. Identifier: 0X21 23
Tab. 27. Identifier: 0X12 (LIN1) 23
Tab. 28. Voltage set point (6 bits) – versions A, D and E 24
Tab. 29. LRC ramp time – versions A and D 25
Tab. 30. LRC disable speed (4 bits) – versions A, B, C, D and E 25
Tab. 31. Excitation current limitation (5 bits) – versions A and D 25
Tab. 32. Blind zone (1 bit) – versions A and B 26
Tab. 33. Reference voltage limitation for high temperatures (3 bits) – versions A and B 26
Tab. 34. Blind zone inhibition (1 bit) – versions A and B 26
Tab. 35. Duty cycle value (5 bits) – versions A, D and E 26
Tab. 36. Excitation current measurement (6 bits) – versions A and D 27
Tab. 37. Alternator supplier identification (3 bits) – All versions 28
Tab. 38. Excitation current measurement (8 bits) – versions A and B 28
Tab. 39. Battery voltage measurement, temperature measurement or alternator speed (8 bits) – version A 32
Tab. 40. Set point voltage (8 bits) – version B and C 39
Tab. 41. LRC ramp time (4 bits) – version B 43
Tab. 42. Excitation current limitation (7 bits) - version B 43
Tab. 43. Duty cycle value (5 bits) - version B 45
Tab. 44. Set point voltage, battery voltage measurement, temperature measurement or alternator speed (8 bits) - version B 45
Tab. 45. Blind zone (2 bits) - version C 53
Tab. 46. LRC duration (4 bits) - version C 53
Tab. 47. LRC duration (4 bits) - version E 53
Tab. 48. Excitation current limitation (8 bits) - version C 53
Tab. 49. Duty cycle value (8 bits) - version C 57
Tab. 50. Excitation current measurement (8 bits) - version C and E 60
Tab. 51. Battery voltage measurement (8 bits) - version C 64
Tab. 52. Temperature measurement (8 bits) - version C and E 68
Tab. 53. Temperature measurement (6 bits) - version D 71
Tab. 54. Duty cycle value (5 bits)- version E 72
Tab. 55. Blind zone (1 bit) - version E 73
Tab. 56. Excitation current limitation (8 bits) - version E 73
Tab. 57. Excitation current measurement (8 bits) – version E 76
Tab. 58. OTP programmable options 80
Tab. 59. Pre wake-up mode 83
Tab. 60. CLKPhase detection threshold voltage 85
Tab. 61. PhaseOK detection threshold voltage 85
Tab. 62. Battery voltage microcuts 89
Tab. 63. Behavior without battery 89
Tab. 64. F_MEC, F_EL, and F_HT operation details 92
Tab. 65. Safety function threshold and filtering 93

Figures

Fig. 1. Simplified application diagram (LIN Mode) 1
Fig. 2. Simplified application diagram (standalone, self-start mode) 1
Fig. 3. Internal block diagram 3
Fig. 4. AR6000 pinout diagram 4
Fig. 5. TO220 dimensions 5
Fig. 6. TO220 dimensions (continued) 6
Fig. 7. Tolerance (mA) vs. excitation current (A) 13
Fig. 8. State machine 82
Fig. 9. Phase regulation 85

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Fig. 10. LRC return 86
Fig. 11. Operation voltage 87
Fig. 12. Priority charge function first behavior 87
Fig. 13. Priority charge function second behavior 88
Fig. 14. Battery voltage “microcuts” 88
Fig. 15. Thermal compensation 89
Fig. 16. Mechanical fault threshold 90
Fig. 17. Safety function 93

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Contents

1 General description 1
2 Simplified application diagram 1
3 Features and benefits 2
4 Applications 2
5 Orderable parts 2
6 Internal block diagram 3
7 Pinning information 4
7.1 Pinning 4
7.2 Pin definitions 6
8 General product characteristics 7
8.1 Maximum ratings 7
8.2 Thermal characteristics 8
8.3 Static electrical characteristics 8
8.4 Dynamic electrical characteristics 9
9 Functional description 10
9.1 Introduction 10
9.2 Functional pin description 11
9.2.1 Phase (PH) 11
9.2.2 LIN-bus (BUS) 11
9.2.3 Ground pin (GND) 11
9.2.4 Supply voltage (B+A) 12
9.2.5 Excitation (EXC) 12
10 Functional internal block description 12
10.1 Supply voltage: filter/divider, band gap, POR ... 12
10.2 Power stage: charge pump, drive and protection, current measurement 12
10.3 Logic and control 13
10.3.1 Digital 13
10.3.2 Clock 13
10.3.3 OTP 13
10.3.4 Phase LOW and HIGH 13
10.3.5 ADC 13
10.3.6 Current measurement 14
10.3.7 LIN 14
11 Functional device operation 14
11.1 LIN frames 14
11.2 Message frame for configuration version-A 16
11.2.1 RxFrame 16
11.2.2 TxFrame 1 17
11.2.3 TxFrame 2 17
11.2.4 TxFrame 3 18
11.3 Message frame for configuration version-B 18
11.3.1 RxFrame 18
11.3.2 TxFrame 1 19
11.3.3 TxFrame 2 19
11.4 Message frame for configuration version-C 20
11.4.1 RxFrame 20
11.4.2 TxFrame 1 21
11.4.3 TxFrame 2 21
11.5 Message frame for configuration version-D 21
11.5.1 RxFrame 21
11.5.2 TxFrame 1 22
11.5.3 TxFrame 2 22
11.6 Message frame for configuration version-E 22
11.6.1 RxFrame 22
11.6.2 TxFrame 1 23
11.6.3 TxFrame 2 23
12 Lookup tables 24
13 Logic commands and registers 80
14 State machine 82
14.1 Standby 82
14.2 Wake-up 83
14.3 Pre wake-up mode 83
14.4 Pre-exc 83
14.5 Regulation with LIN 84
14.6 Default mode 84
15 Phase regulation 84
16 Blind zone 86
17 Return LRC 86
18 Operation voltage - priority charge function ... 87
19 Power supply rejection 88
20 Behavior without battery 89
21 Thermal compensation 89
22 Protection and diagnosis features 89
22.1 Fault detection 89
22.2 Mechanical fault (F_MEC) 90
22.3 Electrical fault (F_EL) 90
22.4 Thermal fault (F_HT) 90
22.5 Timeout flag (TO) 91
22.6 Communication error flag 91
22.7 LRC flag 91
22.8 Excitation current limitation flag 91
23 Safety function 93
24 Test mode and programming 94
24.1 Test mode entry 94
24.2 Test mode function 94
24.2.1 i/ Clocks acceleration 94
24.2.2 ii/ Clocks deactivation 94
24.2.3 iii/ Test mode deactivation 94
24.2.4 iv/ Die information reading 95
24.2.5 v/ OTP memory bytes reading 95
25 Revision history 95
26 Legal information 98

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