

AR6000

Alternator regulator with LIN

Rev. 5.1 — 12 October 2017

Data sheet: advance information

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

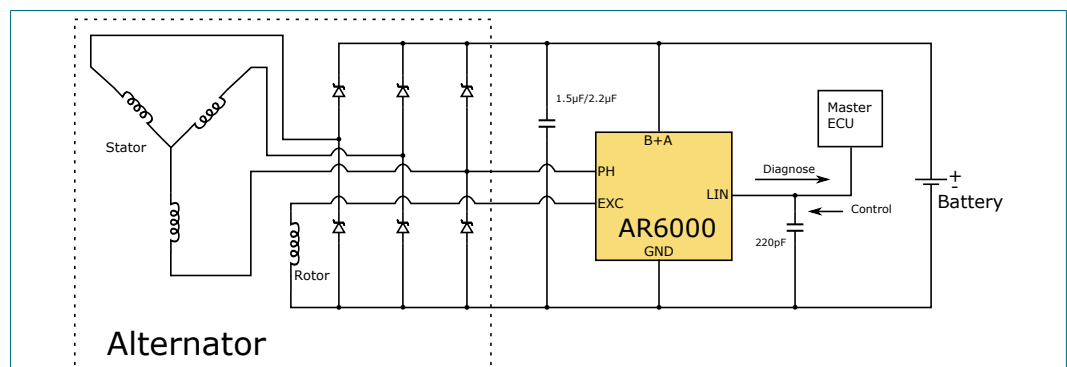


Figure 1. Simplified application diagram (LIN Mode)

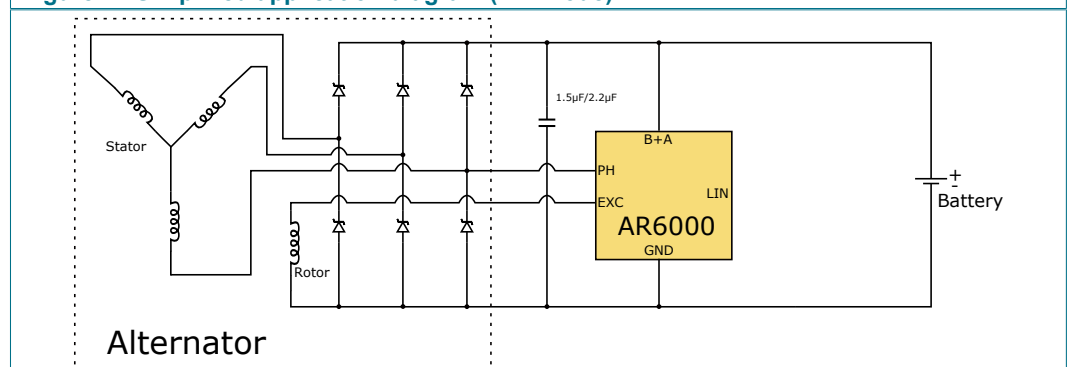


Figure 2. Simplified application diagram (standalone, self-start mode)



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 56](#). 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.

6 Internal block diagram

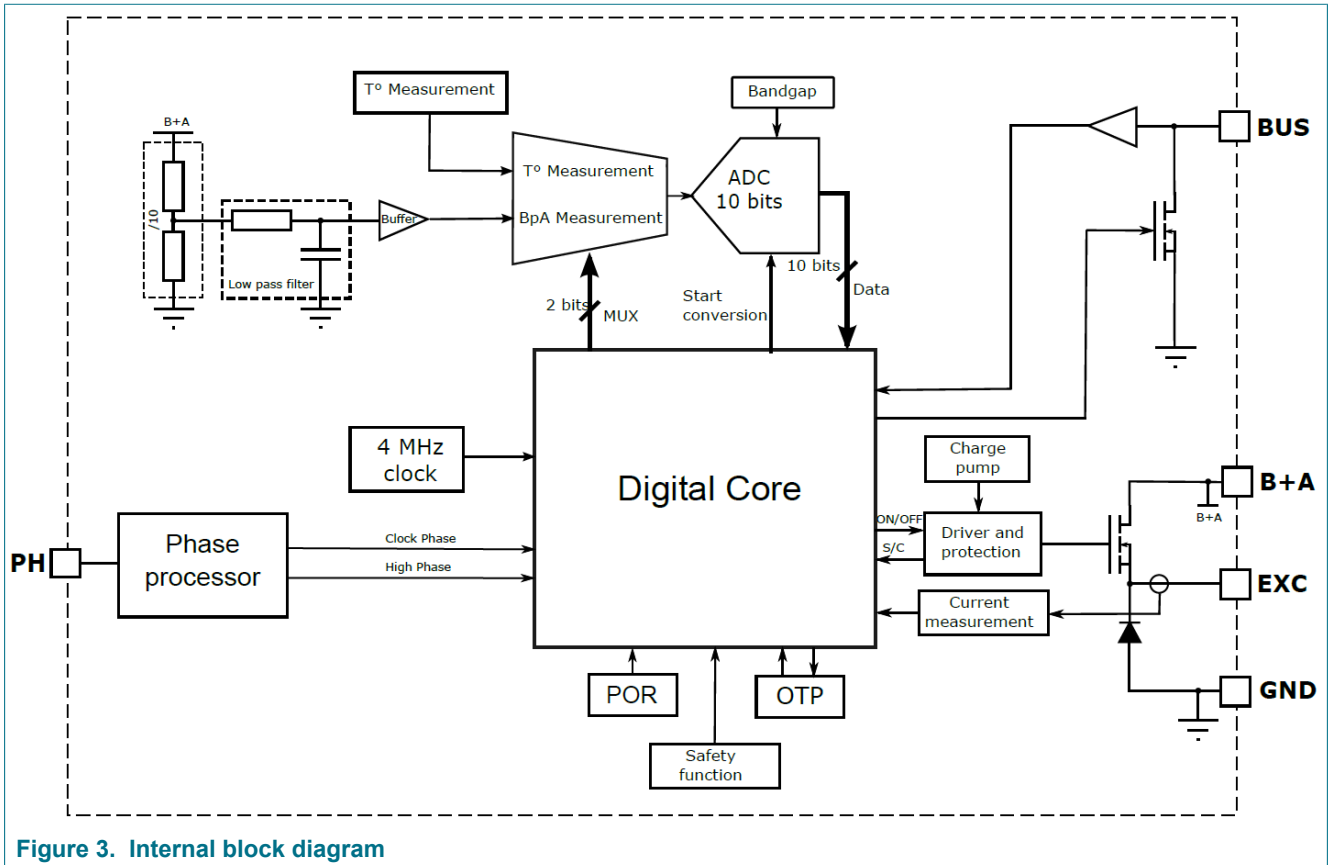


Figure 3. Internal block diagram

7 Pinning information

7.1 Pinning

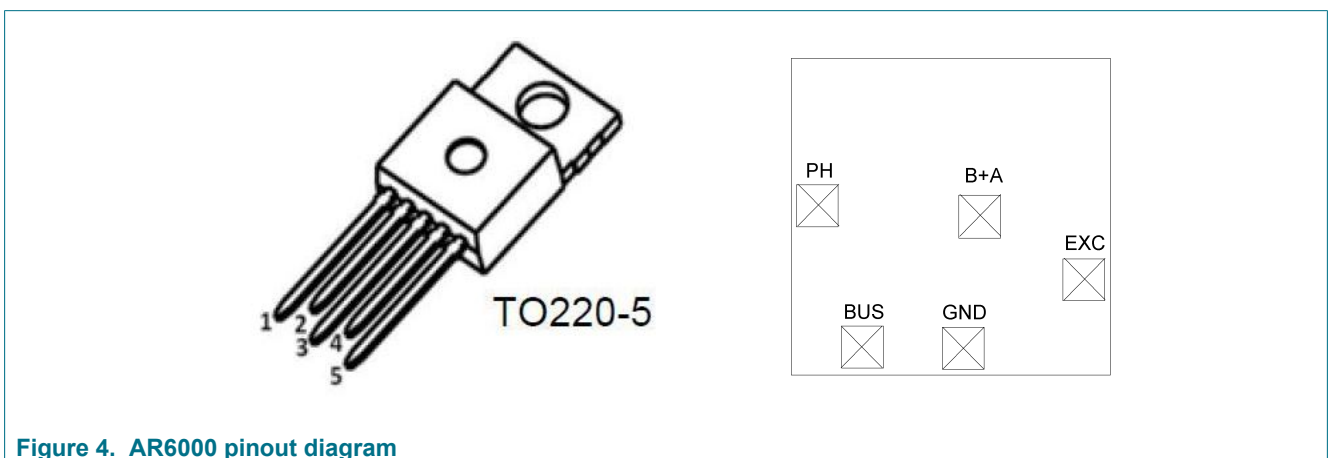
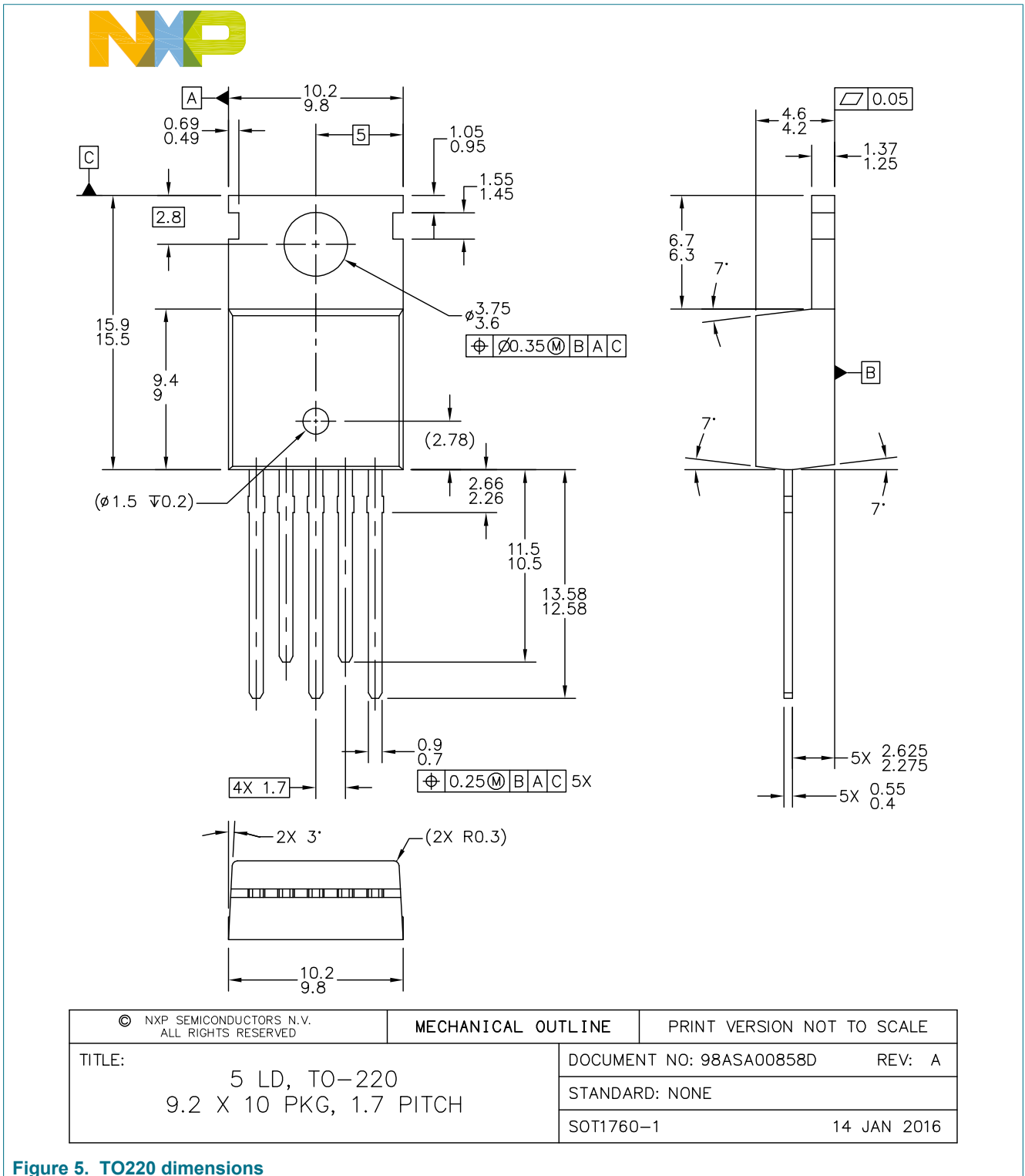


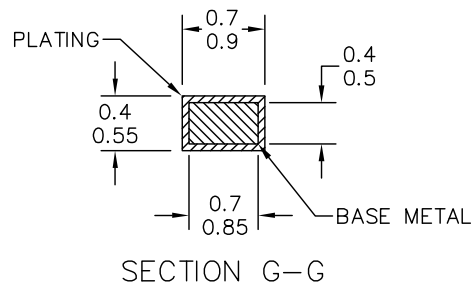
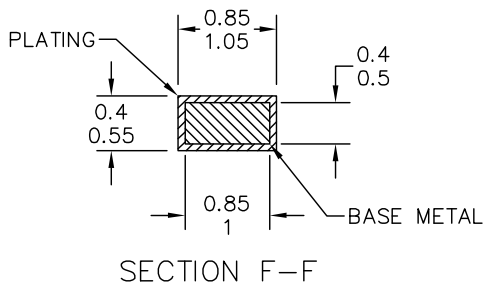
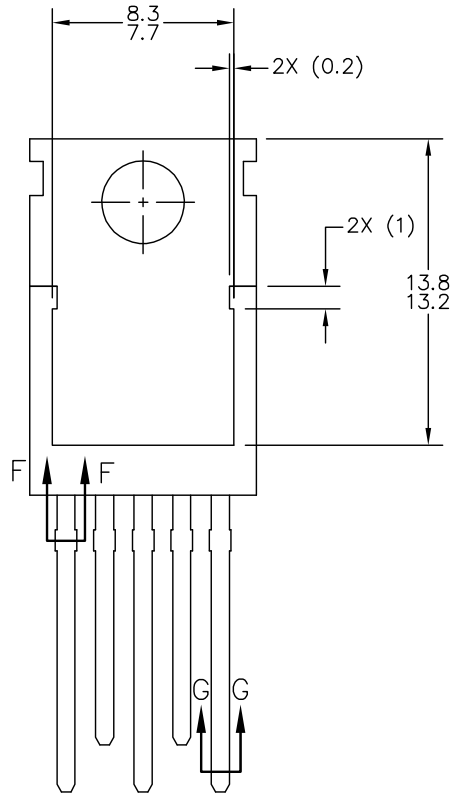
Figure 4. AR6000 pinout diagram

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 x 800 μm .





| | | |
|---|--------------------------|----------------------------|
| © NXP SEMICONDUCTORS N.V. ALL RIGHTS RESERVED | MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE |
| TITLE: 5 LD, TO-220 9.2 X 10 PKG, 1.7 PITCH | DOCUMENT NO: 98ASA00858D | REV: A |
| | 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"](#).

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 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 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. $T_A = 25\text{ °C}$, unless otherwise stated.

| Symbol | Description (Rating) | Min. | Max. | Unit |
|---------------------------|---|------|--------|------|
| ELECTRICAL RATINGS | | | | |
| $V_{B+A\text{ MAX}}$ | B+A supply pin DC voltage | — | 40 | V |
| $V_{B+A\text{ MIN}}$ | Load dump transient voltage (ISO7637-2) DC voltage | — | -0.3 | V |
| $V_{B+A\text{ REV}}$ | Maximum reverse B+A voltage (5 seconds) | [1] | -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 |
| V_{ESD1} | ESD voltage 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 | |

| 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 |

| Symbol | Characteristic | Min. | Typ. | Max. | Unit |
|---|--|-----------------|------|-----------------|---------------|
| 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 |
| V_{Low} | Low-voltage threshold ^[2] | 8.55 | — | 10.45 | V |
| $R_{DS_ON_EXC}$ | R_{DS_ON} FIELD T MOS at $T_J = 150\text{ }^\circ\text{C}$ (for $V_{B+A} > 7.0\text{ V}$) ^[3] | — | — | 100 | m Ω |
| 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 $V_{BUS} = 18\text{ V}$ | — | 62 | 150 | mA |
| $I_{BUS_PAS_DOM}$ | Input leakage current at the receiver. Dominant state (Driver OFF, $V_{BAT} = 12\text{ V}$, $V_{BUS} = 0\text{ V}$) | -1.0 | — | — | mA |
| $I_{BUS_PAS_REC}$ | Input leakage current at the receiver. Recessive state (Driver OFF, $8.0\text{ V} < V_{BAT} < 18\text{ V}$, $8.0\text{ V} < V_{BUS} < 18\text{ V}$, $V_{BUS} > V_{BAT}$) | — | — | 20 | μA |
| $I_{BUS_NO_GND}$ | Ground disconnection. $GND = V_{SUP}$, $0\text{ V} < V_{BUS} < 18\text{ V}$, $V_{BAT} = 12\text{ V}$. Loss of local GND does not affect communication in the residual network | -1.0 | — | 1.0 | mA |
| $I_{BUS_NO_BAT}$ | VBAT disconnection. $V_{SUP} = GND$, $0\text{ V} < V_{BUS} < 18\text{ V}$. Node sustains the current that can flow under this condition. LIN bus remains operational | — | — | 100 | μA |
| V_{BUS_DOM} | Receiver dominant state | — | — | $0.4 V_{SUP}$ | V |
| V_{BUS_REC} | Receiver recessive state | $0.6 V_{SUP}$ | — | — | V |
| V_{BUS_CNT} | $V_{BUS_CNT} = (V_{TH_REC} + V_{TH_DOM})/2$ | $0.475 V_{SUP}$ | — | $0.525 V_{SUP}$ | V |
| V_{HYST} | $V_{HYST} = V_{TH_REC} - V_{TH_DOM}$ | — | — | $0.175 V_{SUP}$ | V |
| R_{SLAVE} | Pull-up resistor | 20 | — | 60 | k Ω |
| C_{LIN} | Internal capacitor | — | — | 30 | pF |

[1] All parameters are tested at $V_{BAT} = 16.5\text{ V}$, except for overvoltage, Safety function and LIN tests.

[2] Threshold is selectable by fuse, see [Table 56](#).

[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 $30\text{ }^\circ\text{C}$ and $140\text{ }^\circ\text{C}$. Typical values noted reflect the approximate parameter mean at $T_A = 25\text{ }^\circ\text{C}$ under nominal conditions, unless otherwise noted. Parametric values guaranteed from $T_J = -40\text{ }^\circ\text{C}$ to $150\text{ }^\circ\text{C}$, 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 |

| Symbol | Characteristic | Min. | Typ. | Max. | Unit |
|---|--|-------|-------|------------------------------|------|
| N _{HYST} | Hysteresis in speed between start and stop of regulation | 50 | 100 | 150 | RPM |
| ΔLRC | Delta LRC duty cycle | — | 3.125 | — | % |
| 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} ≤ t _{LBS} | 7/16 | — | — | Tbit |
| t _{LBS} | Latest bit sample time, t _{EBS} ≥ t _{LBS} | — | — | 10/16Tbit - t _{BFS} | Tbit |
| D1 Valid for 20 kBaud | Duty cycle D1 TH _{REC(max)} = 0.744 × V _{SUP} , TH _{DOM(max)} = 0.581 × 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 × V _{SUP} , TH _{DOM(min)} = 0.284 × 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 × V _{SUP} , TH _{DOM(max)} = 0.616 × 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 × V _{SUP} , TH _{DOM(min)} = 0.251 × 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 56](#).
 [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.

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 time out
 - LIN communication error on check sum, ID parity, sync break, stop bit or bit sent.

The IC can be programmed as an OTP device (One Time Programmable) to fit a large number of alternators and applications. These programmable parameters are described in the functional device operation [Table 56](#).

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.

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, bandgap, 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 stand by mode.

The Bandgap 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](#).

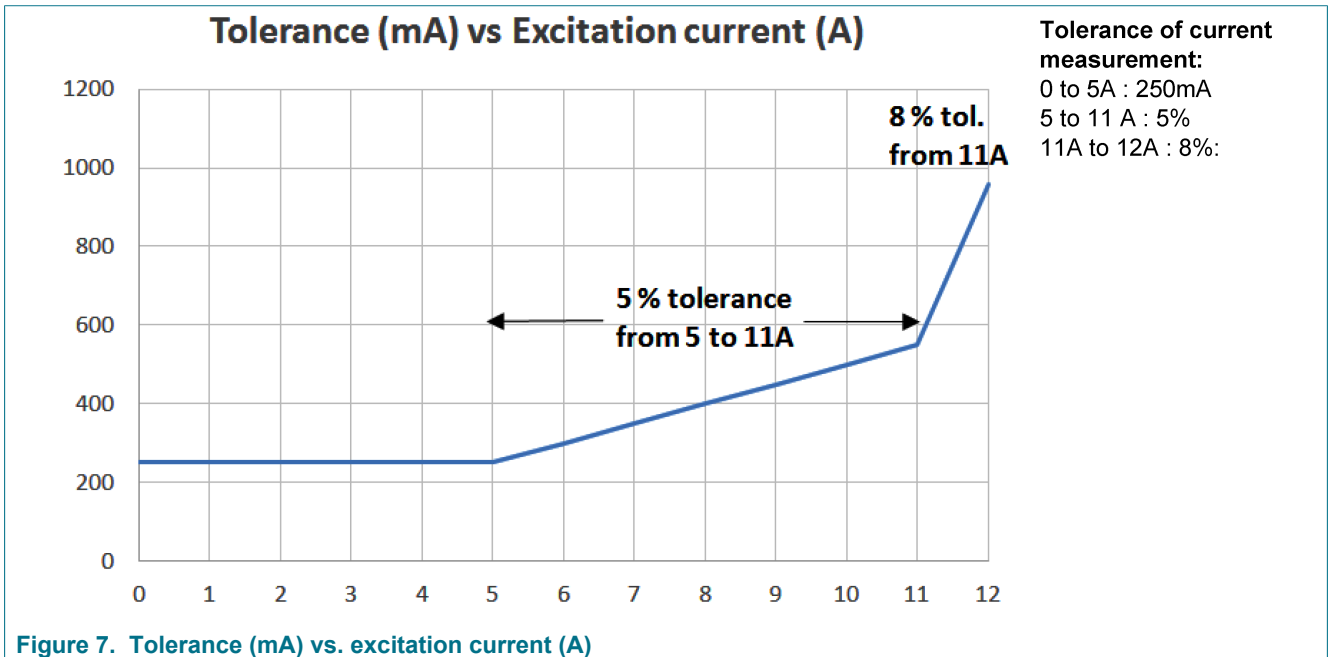


Figure 7. Tolerance (mA) vs. excitation current (A)

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 56](#).

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.

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. Eleven 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 | | 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 |

| LIN Version | | 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.

| | OTP bits | Corresponding version |
|-------------------|----------|---|
| LIN configuration | 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 | |
| 1111 | | |

11.2 Message frame for configuration version-A

11.2.1 RxFrame

Table 10. 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 26](#)

B: Load response ramp time, 4 bits, [Table 27](#)

C: Load response cut off speed, 4 bits, [Table 28](#)

D: Excitation current limitation, 5 bits, [Table 29](#)

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 30](#)

G: Voltage limitation for high temperature, 3 bits, [Table 31](#)

H: “Blind zone inhibition”, 1 bit (enabled by programming), [Table 32](#)

11.2.2 TxFrame 1

Table 11. 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 33](#)

E: Measured excitation current, 6 bits, [Table 34](#)

F: Diagnosis flag for LIN error, 1 bit

G: Diagnosis flag LIN communication timeout, 1 bit

11.2.3 TxFrame 2

Table 12. 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 35](#)

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)

11.2.4 TxFrame 3

Table 13. 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 33](#)
- E: Measured excitation current, 8 bits, [Table 36](#)
- 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 37](#)

11.3 Message frame for configuration version-B

11.3.1 RxFrame

Table 14. 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 38](#)

- B: Load response ramp time, 4 bits, [Table 39](#)
- C: Load response cut off speed, 4 bits, [Table 28](#)
- D: Excitation current limitation, 7 bits, [Table 40](#)
- 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 30](#)
- G: Voltage limitation for high temperature, 3 bits, [Table 31](#)
- H: "Blind zone inhibition", 1 bit (enabled by programming), [Table 32](#)

11.3.2 TxFrame 1

Table 15. Identifier: 0X12 (LIN1) or 0X14 (LIN2, LIN4) or 0X21 (LIN3) 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 35](#)
- 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 16. 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 |
| 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 41](#)

E: Measured excitation current, 8 bits, [Table 36](#)

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 time-out, 1 bit

K: Set voltage, measured voltage, chip temperature or alternator speed, 8 bits, [Table 42](#)

11.4 Message frame for configuration version-C

11.4.1 RxFrame

Table 17. 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 43](#)

B: Load response ramp time, 4 bits, [Table 44](#)

C: Load response cut off speed, 4 bits, [Table 28](#)

D: Regulation voltage set point, 8 bits, [Table 38](#)

E: Excitation current limitation, 8 bits, [Table 46](#)

11.4.2 TxFrame 1

Table 18. 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 49](#)
- G: Measured excitation current, 8 bits, [Table 48](#)
- H: Duty cycle value of the excitation PWM, 8 bits, [Table 47](#)

11.4.3 TxFrame 2

Table 19. 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 50](#)
- B: Alternator supplier identification, 3 bits, [Table 35](#)
- C: Alternator class identification, 5 bits (defined by customer)

11.5 Message frame for configuration version-D

11.5.1 RxFrame

Table 20. 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 | X |

- A: Voltage set value, 6 bits, [Table 26](#)
- B: Load response ramp time, 4 bits, [Table 27](#)
- C: Load response cut off speed, 4 bits, [Table 28](#)
- D: Excitation current limitation, 5 bits, [Table 29](#)

11.5.2 TxFrame 1

Table 21. 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 33](#)
- E: Measured excitation current, 6 bits, [Table 34](#) Temperature measurement, 6 bits, [Table 51](#)
- F: Diagnosis flag for LIN error, 1 bit
- G: Diagnosis flag LIN communication time-out, 1 bit

11.5.3 TxFrame 2

Table 22. 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 35](#)
- 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 23. 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 26](#)
- B: Load response ramp time, 4 bits, [Table 45](#)

C: Load response cut off speed, 4 bits, [Table 28](#)

D: Excitation current limitation, 8 bits, [Table 54](#)

E: “Blind zone”, 1 bit, [Table 53](#)

11.6.2 TxFrame 1

Table 24. 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 |
| 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 33](#)
- E: Measured excitation current, 8 bits, [Table 55](#)
- G: Diagnosis flag for LIN error, 1 bit
- H: Diagnosis flag LIN communication time-out, 1 bit
- I: Chip temperature, 8-bits, [Table 50](#)

11.6.3 TxFrame 2

Table 25. 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 35](#)
- 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)

12 Lookup tables

Table 26. 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

Table 27. LRC ramp time – versions A and D

| Ramp time | Seconds ($\pm 10\%$) | Ramp time | Seconds ($\pm 10\%$) |
|-----------|------------------------|-----------|------------------------|
| 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 28. LRC disable speed (4 bits) – versions A, B, C, D and E

| Speed | RPM ($\pm 10\%$) | Speed | RPM ($\pm 10\%$) |
|-------|--------------------|-------|--------------------|
| 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 29. 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 |

| 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 30. Blind zone (1 bit) – versions A and B

| Blind zone ($\pm 1.5\%$) | Value |
|----------------------------|-------|
| 3 % | 0 |
| 12 % | 1 |

Table 31. 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 32. Blind zone inhibition (1 bit) – versions A and B

| BZI | BZ |
|-----|----------|
| 0 | Enabled |
| 1 | Disabled |

Table 33. Duty cycle value (5 bits) – versions A, D and E

| EXC duty cycle | DF ($\pm 3\%$) | EXC duty cycle | DF ($\pm 3\%$) |
|----------------|-----------------------|----------------|-----------------------|
| 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 | $68.75 < DF < 71.875$ |

| 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 34. 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 |

| 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 35. 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 36. 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 |

| 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 |

| 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 |

| 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 |

| 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 37. Battery voltage measurement, temperature measurement or alternator speed (8 bits) – version A

| Tx 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 |

| Tx 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) |
|-------------|-------------------------------|----------------------|----------------------|---|
| 00011101 | 13.5 | 10.9 | 74 °C < T < 78 °C | 637 |
| 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 |

| Tx 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) |
|-------------|-------------------------------|----------------------|----------------------|---|
| 01000000 | — | 14.4 | T > 200 °C | 754 |
| 01000001 | — | 14.5 | T > 200 °C | 758 |
| 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 |

| Tx 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) |
|-------------|-------------------------------|----------------------|----------------------|---|
| 01100011 | — | 17.9 | T > 200 °C | 923 |
| 01100100 | — | 18 | T > 200 °C | 929 |
| 01100101 | — | 18.1 | T > 200 °C | 935 |
| 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 |

| Tx 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) |
|-------------|-------------------------------|----------------------|----------------------|---|
| 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 |
| 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 |

| Tx 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) |
|-------------|-------------------------------|----------------------|----------------------|---|
| 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 |
| 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 |

| Tx 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) |
|-------------|-------------------------------|----------------------|----------------------|---|
| 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 |
| 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 |

| Tx 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) |
|-------------|-------------------------------|----------------------|----------------------|---|
| 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 |
| 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 38. 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 |

| Voltage code | Voltage value (± 100 mV at 25 °C) | Voltage code | Voltage value (± 100 mV at 25 °C) |
|--------------|--|--------------|--|
| 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 |
| 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 |

| Voltage code | Voltage value (± 100 mV at 25 °C) | Voltage code | Voltage value (± 100 mV at 25 °C) |
|--------------|--|--------------|--|
| 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 |
| 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 |

| Voltage code | Voltage value (± 100 mV at 25 °C) | Voltage code | Voltage value (± 100 mV at 25 °C) |
|--------------|--|--------------|--|
| 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 |
| 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 |

| Voltage code | Voltage value (± 100 mV at 25 °C) | Voltage code | Voltage value (± 100 mV at 25 °C) |
|--------------|--|--------------|--|
| 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

Table 39. 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 40. 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 |

| Irot limit code | Irotor limitation value | Irot limit code | Irotor limitation value |
|-----------------|-------------------------|-----------------|-------------------------|
| 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 |
| 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 |

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

Table 41. 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 42. Set point voltage, battery voltage measurement, temperature measurement or alternator speed (8 bits) - version B

| Tx 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 |

| Tx 3 Byte 4 | V _{B+} (± 100 mV at 25 °C) | U _{mes} (± 350 mV) | T _{chip} (± 10 °C) | n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM) |
|-------------|-------------------------------------|-----------------------------|-----------------------------|--|
| 0000011 | 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 |
| 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 |

| Tx 3 Byte 4 | V _{B+} (± 100 mV at 25 °C) | U _{mes} (± 350 mV) | T _{chip} (± 10 °C) | n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM) |
|-------------|-------------------------------------|-----------------------------|-----------------------------|--|
| 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 |
| 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 |

| Tx 3 Byte 4 | V _{B+} (± 100 mV at 25 °C) | U _{mes} (± 350 mV) | T _{chip} (± 10 °C) | n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM) |
|-------------|-------------------------------------|-----------------------------|-----------------------------|--|
| 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 |
| 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 |

| Tx 3 Byte 4 | V _{B+} (± 100 mV at 25 °C) | U _{mes} (± 350 mV) | T _{chip} (± 10 °C) | n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM) |
|-------------|-------------------------------------|-----------------------------|-----------------------------|--|
| 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 |
| 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 |

| Tx 3 Byte 4 | V _{B+} (± 100 mV at 25 °C) | U _{mes} (± 350 mV) | T _{chip} (± 10 °C) | n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM) |
|-------------|-------------------------------------|-----------------------------|-----------------------------|--|
| 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 |
| 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 |

| Tx 3 Byte 4 | V _{B+} (± 100 mV at 25 °C) | U _{mes} (± 350 mV) | T _{chip} (± 10 °C) | n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM) |
|-------------|-------------------------------------|-----------------------------|-----------------------------|--|
| 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 |
| 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 |

| Tx 3 Byte 4 | V _{B+} (± 100 mV at 25 °C) | U _{mes} (± 350 mV) | T _{chip} (± 10 °C) | n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM) |
|-------------|-------------------------------------|-----------------------------|-----------------------------|--|
| 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 |
| 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 | — |

| Tx 3 Byte 4 | V _{B+} (± 100 mV at 25 °C) | U _{mes} (± 350 mV) | T _{chip} (± 10 °C) | n (± 10 % up to 18000 RPM, ± 12 % above 18000 RPM) |
|-------------|-------------------------------------|-----------------------------|-----------------------------|--|
| 11111111 | 16 | — | T > 200 °C | — |

Table 43. Blind zone (2 bits) - version C

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

Table 44. 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 45. 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 46. Excitation current limitation (8 bits) - version C

| Current limitation | Value | Current limitation | Value |
|--------------------|---------------|--------------------|-------|
| 00000000 | Regulator OFF | 10000000 | 5.12 |

| Current limitation | Value | Current limitation | Value |
|--------------------|-------|--------------------|-------|
| 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 |
| 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 |

| Current limitation | Value | Current limitation | Value |
|--------------------|-------|--------------------|-------|
| 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 |
| 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 |

| Current limitation | Value | Current limitation | Value |
|--------------------|-------|--------------------|-------|
| 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 |
| 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 |

| Current limitation | Value | Current limitation | Value |
|--------------------|-------|--------------------|-------|
| 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 |
| 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 47. 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 |

| Measured duty cycle | Value | Measured duty cycle | Value |
|---------------------|-------|---------------------|--------|
| 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 |
| 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 |

| Measured duty cycle | Value | Measured duty cycle | Value |
|---------------------|-------|---------------------|-------|
| 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 |
| 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 |

| Measured duty cycle | Value | Measured duty cycle | Value |
|---------------------|-------|---------------------|-------|
| 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 |
| 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 48. 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 |
| 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 |

| Irotor code | Value | Irotor code | Value |
|-------------|-------|-------------|-------|
| 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 |
| 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 |

| Irotor code | Value | Irotor code | Value |
|-------------|-------|-------------|-------|
| 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 |
| 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 |

| Irotor code | Value | Irotor code | Value |
|-------------|-------|-------------|-------|
| 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 |
| 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. 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 |

| Measured voltage | Value | Measured voltage | Value |
|------------------|-------|------------------|-------|
| 00001111 | 9.75 | 10001111 | 16.15 |
| 00010000 | 9.8 | 10010000 | 16.2 |
| 00010001 | 9.85 | 10010001 | 16.25 |
| 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 |

| Measured voltage | Value | Measured voltage | Value |
|------------------|-------|------------------|-------|
| 00110100 | 11.6 | 10110100 | 18 |
| 00110101 | 11.65 | 10110101 | 18 |
| 00110110 | 11.7 | 10110110 | 18 |
| 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 |

| Measured voltage | Value | Measured voltage | Value |
|------------------|-------|------------------|-------|
| 01011001 | 13.45 | 11011001 | 18 |
| 01011010 | 13.5 | 11011010 | 18 |
| 01011011 | 13.55 | 11011011 | 18 |
| 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 |

| Measured voltage | Value | Measured voltage | Value |
|------------------|-------|------------------|-------|
| 01111110 | 15.3 | 11111110 | 18 |
| 01111111 | 15.35 | 11111111 | 18 |

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

| Chip temperature | Value ($\pm 10\text{ }^{\circ}\text{C}$) | Chip temperature | Value ($\pm 10\text{ }^{\circ}\text{C}$) |
|------------------|--|------------------|--|
| 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 |

| Chip temperature | Value ($\pm 10\text{ }^{\circ}\text{C}$) | Chip temperature | Value ($\pm 10\text{ }^{\circ}\text{C}$) |
|------------------|--|------------------|--|
| 00011111 | -9 | 10011111 | 119 |
| 00100000 | -8 | 10100000 | 120 |
| 00100001 | -7 | 10100001 | 121 |
| 00100010 | -6 | 10100010 | 122 |
| 00100011 | -5 | 10100011 | 123 |
| 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 |

| Chip temperature | Value ($\pm 10\text{ }^{\circ}\text{C}$) | Chip temperature | Value ($\pm 10\text{ }^{\circ}\text{C}$) |
|------------------|--|------------------|--|
| 01000100 | 28 | 11000100 | 156 |
| 01000101 | 29 | 11000101 | 157 |
| 01000110 | 30 | 11000110 | 158 |
| 01000111 | 31 | 11000111 | 159 |
| 01001000 | 32 | 11001000 | 160 |
| 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 |

| Chip temperature | Value (± 10 °C) | Chip temperature | Value (± 10 °C) |
|------------------|----------------------|------------------|----------------------|
| 01101001 | 65 | 11101001 | 193 |
| 01101010 | 66 | 11101010 | 194 |
| 01101011 | 67 | 11101011 | 195 |
| 01101100 | 68 | 11101100 | 196 |
| 01101101 | 69 | 11101101 | 197 |
| 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 51. 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 |

| T °C code | Temperature (± 10 °C) | T °C code | Temperature (± 10 °C) |
|-----------|----------------------------|-----------|----------------------------|
| 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 |
| 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 52. 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 |

| Exc duty cycle | Df (%) | Exc duty cycle | Df (%) |
|----------------|--------|----------------|--------|
| 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 53. Blind zone (1 bit) - version E

| Blind zone ($\pm 1.5\%$) | Value |
|----------------------------|-------|
| 3 % | 0 |
| 6 % | 1 |

Table 54. 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 |

| Current limitation | Value | Current limitation | Value |
|--------------------|-------|--------------------|-------|
| 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 |
| 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 |

| Current limitation | Value | Current limitation | Value |
|--------------------|-------|--------------------|-------|
| 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 |
| 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 |

| Current limitation | Value | Current limitation | Value |
|--------------------|-------|--------------------|---------------|
| 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 |
| 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 55. Excitation current measurement (8 bits) – version E

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

| Irotor code | Value | Irotor code | Value |
|-------------|-------|-------------|-------|
| 0000010 | 0.08 | 1000010 | 5.2 |
| 0000011 | 0.12 | 1000011 | 5.24 |
| 0000100 | 0.16 | 1000100 | 5.28 |
| 0000101 | 0.2 | 1000101 | 5.32 |
| 0000110 | 0.24 | 1000110 | 5.36 |
| 0000111 | 0.28 | 1000111 | 5.4 |
| 0001000 | 0.32 | 1001000 | 5.44 |
| 0001001 | 0.36 | 1001001 | 5.48 |
| 0001010 | 0.4 | 1001010 | 5.52 |
| 0001011 | 0.44 | 1001011 | 5.56 |
| 0001100 | 0.48 | 1001100 | 5.6 |
| 0001101 | 0.52 | 1001101 | 5.64 |
| 0001110 | 0.56 | 1001110 | 5.68 |
| 0001111 | 0.6 | 1001111 | 5.72 |
| 0010000 | 0.64 | 1001000 | 5.76 |
| 0010001 | 0.68 | 1001001 | 5.8 |
| 0010010 | 0.72 | 1001010 | 5.84 |
| 0010011 | 0.76 | 1001011 | 5.88 |
| 0010100 | 0.8 | 1001010 | 5.92 |
| 0010101 | 0.84 | 10010101 | 5.96 |
| 0010110 | 0.88 | 10010110 | 6 |
| 0010111 | 0.92 | 10010111 | 6.04 |
| 0011000 | 0.96 | 10011000 | 6.08 |
| 0011001 | 1 | 10011001 | 6.12 |
| 0011010 | 1.04 | 10011010 | 6.16 |
| 0011011 | 1.08 | 10011011 | 6.2 |
| 0011100 | 1.12 | 10011100 | 6.24 |
| 0011101 | 1.16 | 10011101 | 6.28 |
| 0011110 | 1.2 | 10011110 | 6.32 |
| 0011111 | 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 |

| 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 | 8.04 |
| 01001010 | 2.96 | 11001010 | 8.08 |
| 01001011 | 3 | 11001011 | 8.12 |

| Irotor code | Value | Irotor code | Value |
|-------------|-------|-------------|-------|
| 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 |
| 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 |

| Irotor code | Value | Irotor code | Value |
|-------------|-------|-------------|-------|
| 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 | 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 56](#)) 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 56. OTP programmable options

| Function | OTP Bits | Comments |
|---|----------|--|
| LIN frame configuration | 4 | See description in Section 11.1 "LIN frames" |
| LIN protocol | 2 | LIN1.3 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, 13.7, 14.0, 14.1, 14.3, 14.5, 14.7 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, 45, 100, 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, 1, 5 or 10 Hz (± 5.0 %) |
| Filter frequency of reported duty cycle report (DF) | 2 | 0, 1, 5 or 10 Hz (± 5.0 %) |
| Filter Frequency of reported excitation current measurement | 2 | 0, 1, 5 or 10 Hz (± 5.0 %) |
| Default LRC disable speed | 2 | 3000, 4000, 4800 and 6000 RPM (± 10 %) |
| Default LRC duration | 3 | 1, 2, 3, 4, 5, 6, 7 or 8 seconds (± 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, 1, 1.5 or 2 seconds (± 10 %) (behavior described in Section 17 "Return LRC") |
| Alternator pole pairs | 2 | 5, 6, 7 or 8 |
| Self-start speed threshold | 2 | 2000, 3000, 4000 or 5000 RPM (± 10 %) |
| Bus Inactivity or data corruption timeout | 1 | 3 or 10 seconds |
| Excitation OFF for $V_{SET} = 10.6$ V | 1 | Enabled or disabled |
| Excitation short-circuit threshold (at 25 °C) | 2 | 9, 10, 11 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 $10.6 \text{ V} < V_{SET} < V_{B+A}$ |

| Function | OTP Bits | Comments |
|---|----------|---|
| Overvoltage fault flag | 1 | Enabled or disabled |
| Low-voltage threshold | 2 | 8.75, 9.25, 9.75 or 10.25 V (± 200 mV) |
| Thermal compensation threshold | 3 | 125, 130, 135, 140, 145, 150, 155 or 160 °C (± 10 °C) |
| Thermal compensation temperature gradient | 3 | -50, -100, -150, -200, -250, -300, -350, -400 mV/°C (± 10 %) |
| Fault deglitching time | 2 | 50, 250, 400 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+5 | Alternator information |

14 State machine

The following figure describes the state machine of the AR6000.

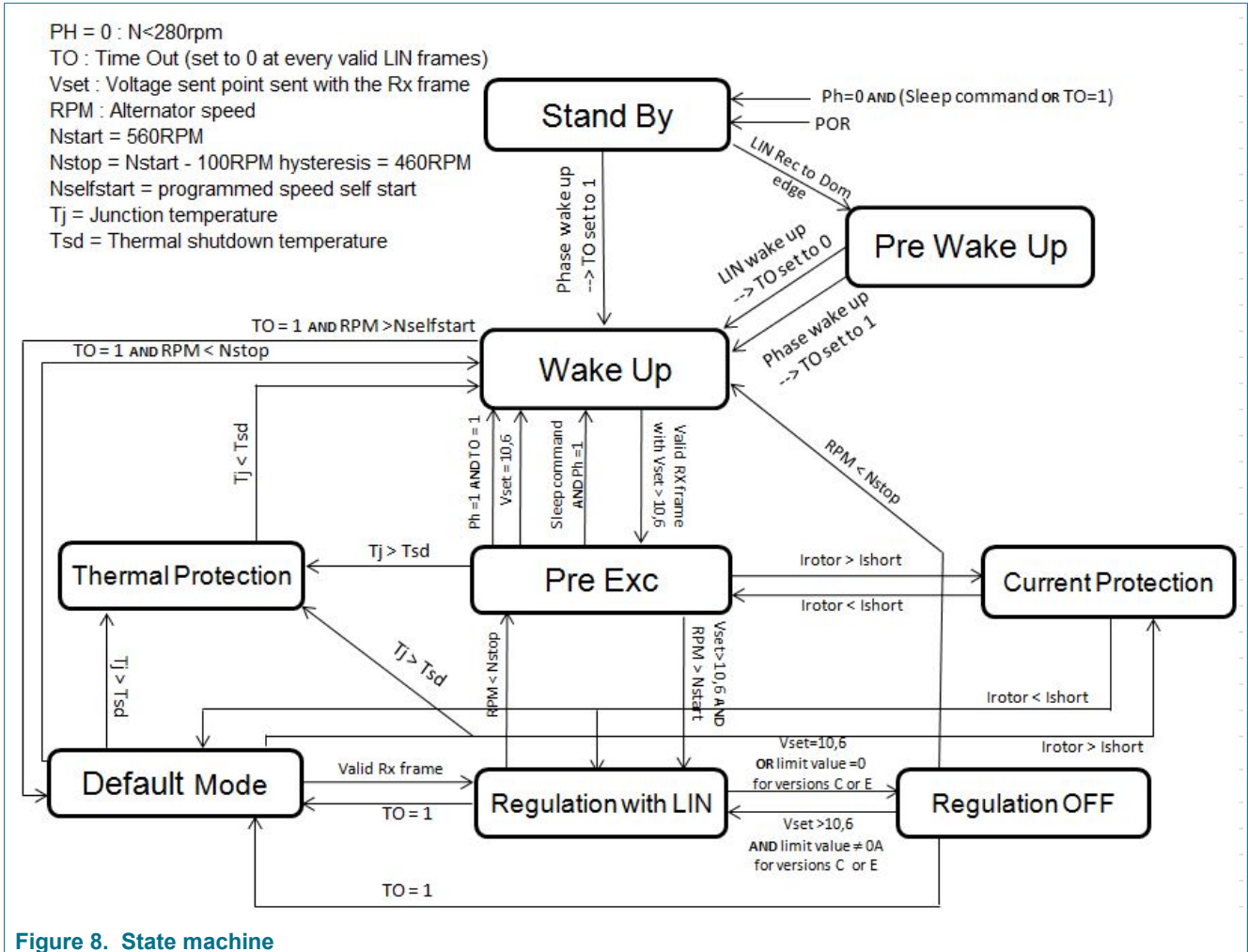


Figure 8. State machine

14.1 Standby

The AR6000 is in stand-by mode, if there is a LIN timeout and when alternator is not in rotation (no phase), or in case of power and 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).

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 800mV 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 then T_{minwu} , 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 (T_{wuto}), wake up event is validated and design goes to Wakeup mode; if wakeup event is not validated, design goes back to STANDBY (unless a wake up by phase input transition is in progress).

Table 57. Pre Wake-up Mode

| Data | Description | Min. | Typ. | Max. | Unit |
|-------------|---|------|------|------|---------|
| T_{minwu} | Minimum dominant pulse timing for LIN wake up | 30 | - | 150 | μs |
| T_{wuto} | 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.
- 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 56](#) (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 time out, 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.

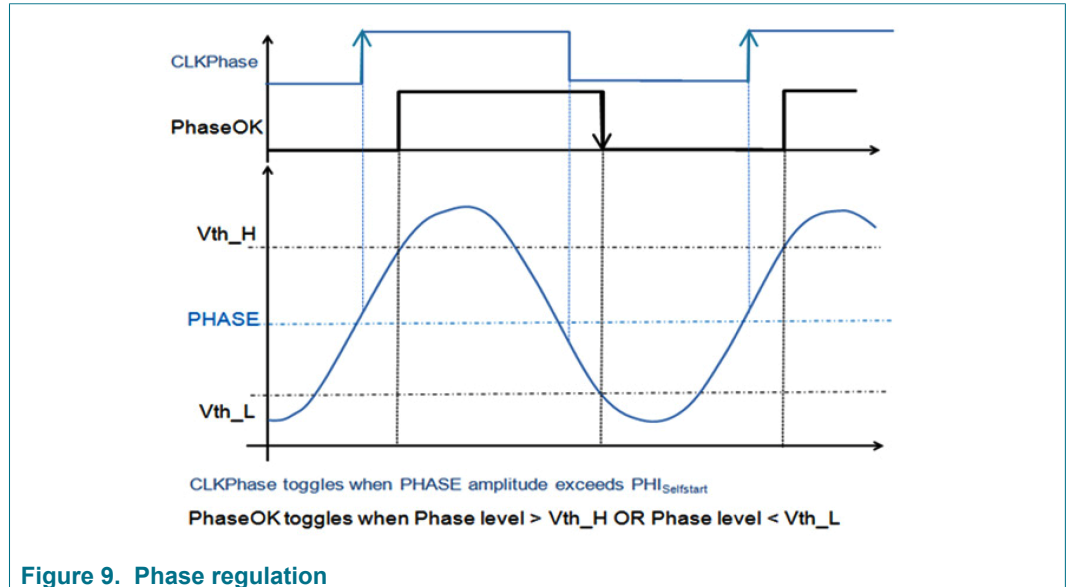


Figure 9. Phase regulation

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

Table 58. CLKPhase detection threshold voltage

| Mode | Description | Min. | Typ. | Max. | Unit |
|-----------------|---|------|------|------|------|
| Φ_{START1} | Minimum peak to peak phase voltage in standby/ wakeup/ 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 59. PHASEOK detection threshold voltage

| Data | Description | Min. | Typ. | Max. | Unit |
|-------------|-------------------------|------|------|------|------|
| V_{th_H} | Positive peak threshold | 3 | 4 | 5 | V |
| V_{th_L} | Negative peak threshold | 0.75 | 1.78 | 2.25 | V |

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

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.

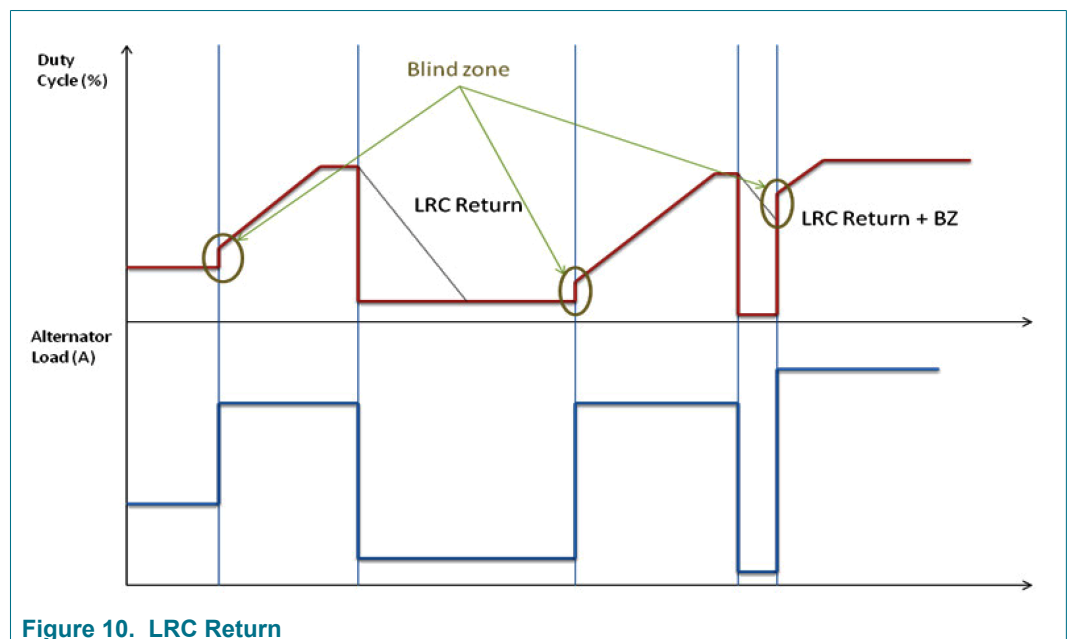


Figure 10. LRC Return

18 Operation voltage - priority charge function

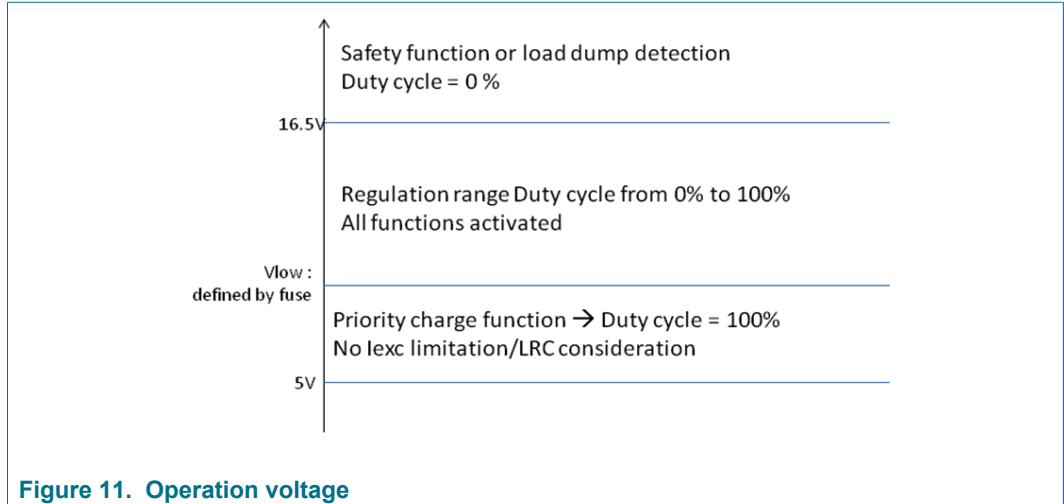


Figure 11. Operation voltage

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.

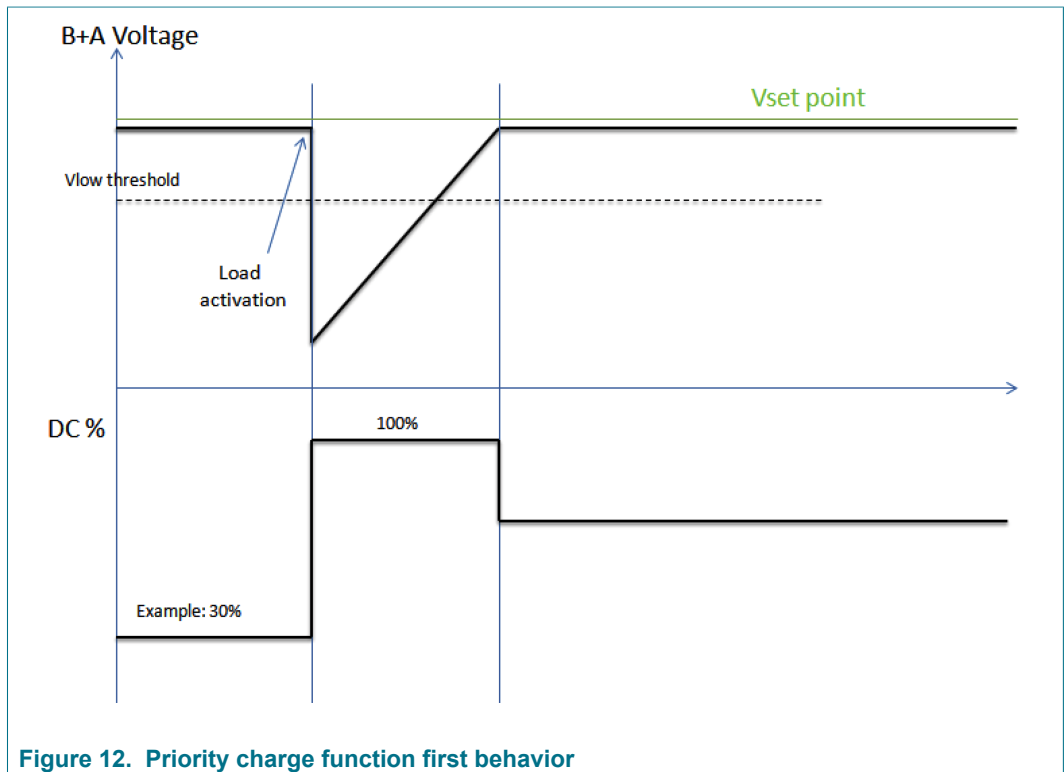


Figure 12. Priority charge function first behavior

- 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 (upwards). When V_{LOW} is reached, LRC is enabled until V_{SET} is reached.

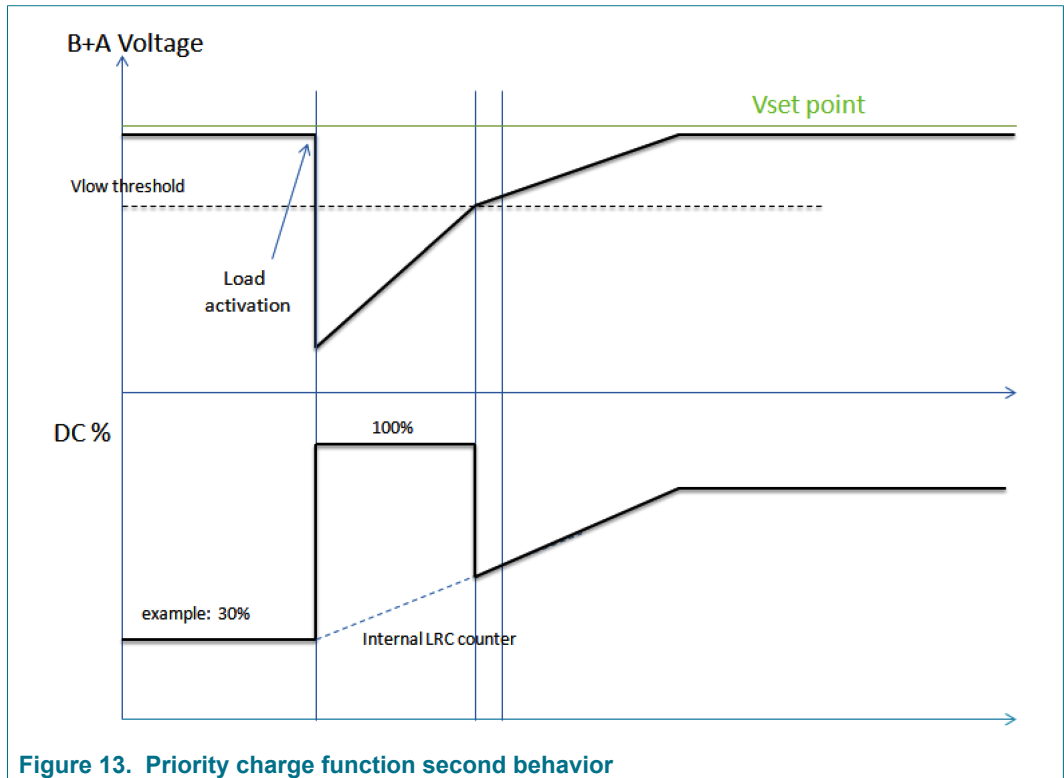


Figure 13. Priority charge function second behavior

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.

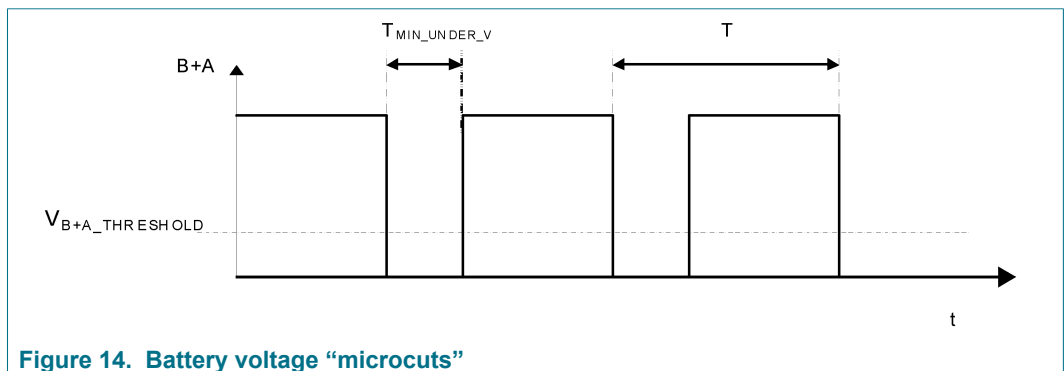


Figure 14. Battery voltage “microcuts”

Table 60. 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 61. 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).

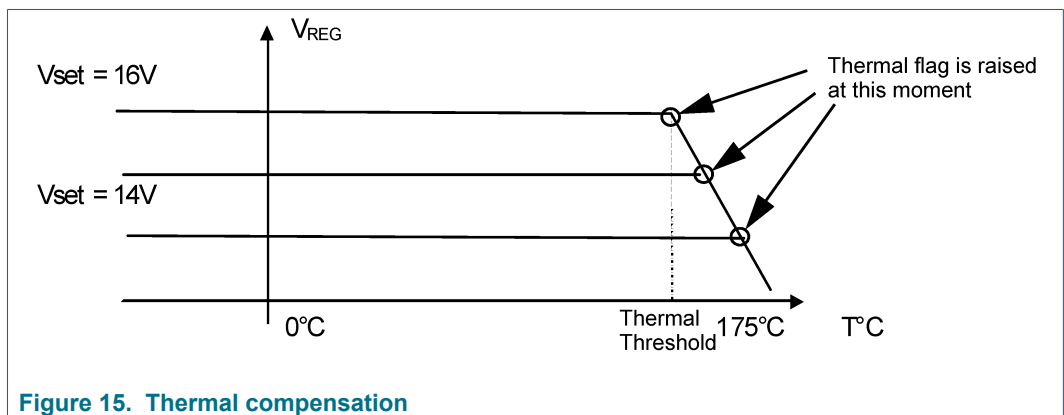


Figure 15. Thermal compensation

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 to 1000 ms.

22.2 Mechanical fault (F_MEC)

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

$N_{STOP} = (N_{START} - N_{S_HYST})$. N_{START} and N_{S_HYST} are defined in [Table 8](#).

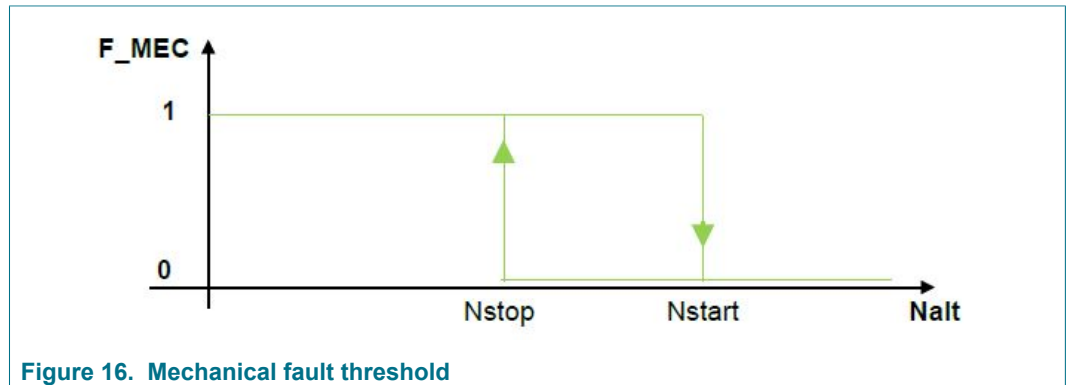


Figure 16. Mechanical fault threshold

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 $V_{EXC} < 1.5 \text{ V}$ 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 $V_{EXC} > 1.5 \text{ V}$ 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"](#)).

22.5 Timeout flag (TO)

Timeout between two consecutive valid messages is 3 or 10 seconds. 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.

Table 62. 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 | |
| | | | | | V _{set} = 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 |
| Overtoltage (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

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 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.

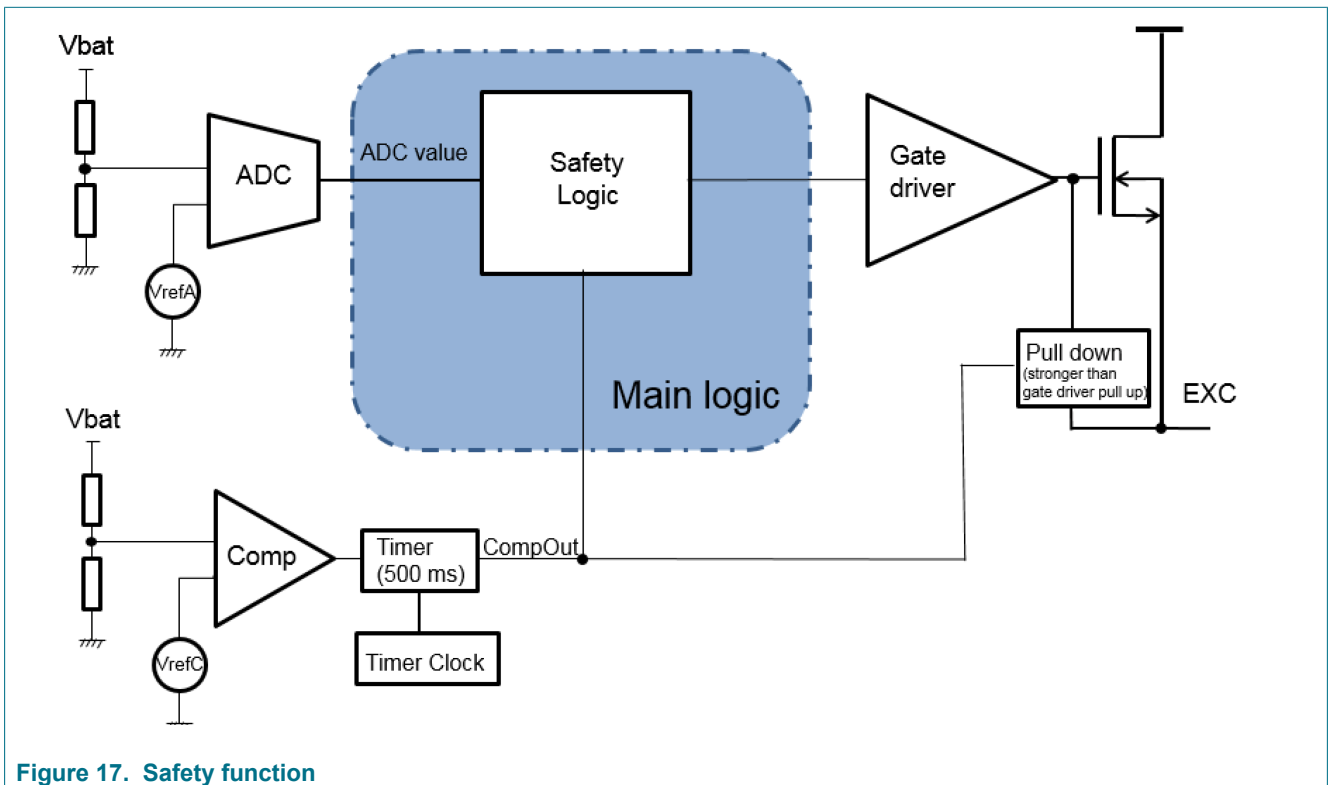


Figure 17. Safety function

Table 63. 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 |

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 $10 \text{ s}/32 = 312 \text{ ms}$.

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.

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 | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> Updated Figure 5 and added Figure 6 |
| | 9/2016 | <ul style="list-style-type: none"> Corrected typo in Table 20 |
| 3.0 | 1/2017 | <ul style="list-style-type: none"> 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 30" to "Table 53" in Table 23. Updated Table 28 column headings Updated title of Table 30 from "Blind zone (1 bit) – versions A and E" to "Blind zone (1 bit) – versions A and B" Updated Table 45 column headings from "Ramp" and "Seconds" to "Speed" and "RPM" Updated Table 48 column headings "Current limitation" to "Irotor code" Updated Table 49 column headings "Current limitation" to "Measured voltage" Added new table, Table 53 |

| Revision | Date | Description of changes |
|----------|-----------|---|
| 3.0 | 1/2017 | <ul style="list-style-type: none"> Updated Function "Specific bit for LIN Version B..." to Specific bit for LIN Version A and B..." in Table 56 Added "-150", "-250", and "-350" to the Comments for "Thermal compensation temperature gradient" Function in Table 56 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 56 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 58 Updated Description for Φ_{START2} to read "Minimum peak to peak phase voltage in pre-excitation/regulation mode" in Table 58 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 |
| 4.0 | 6/2017 | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> Updated chip temperature range in Table 42 Added new footnote to Table 26 and footnote to Table 38 Updated titles for Table 27, Table 28, Table 33, and Table 38 Added Table 54 and Table 55 |
| 5.1 | 10/2017 | <ul style="list-style-type: none"> Corrected formatting issue in Table 46 |

26 Legal information

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| [short] Data sheet: technical data | Production | This document contains the product specification. NXP Semiconductors reserves the right to change the detail specifications as may be required to permit improvements in the design of its products. |

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