# AR6000

## Alternator Regulator with LIN

Rev. 1.0 — 20 April 2016

Data sheet: Advance information
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## 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 also can 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

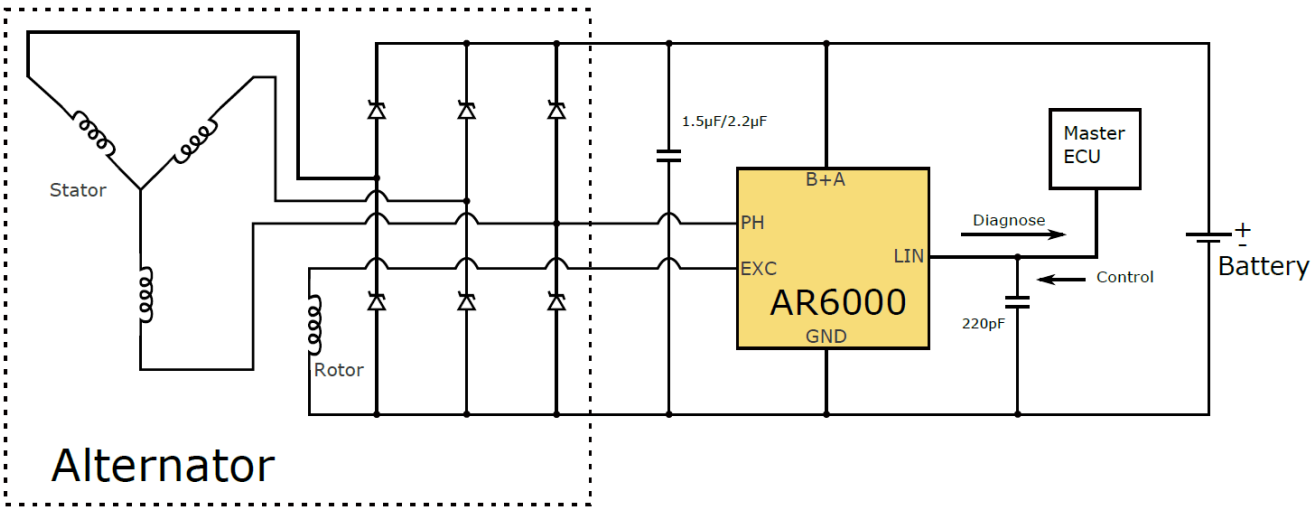


**Figure 1. Simplified application diagram (LIN Mode)**

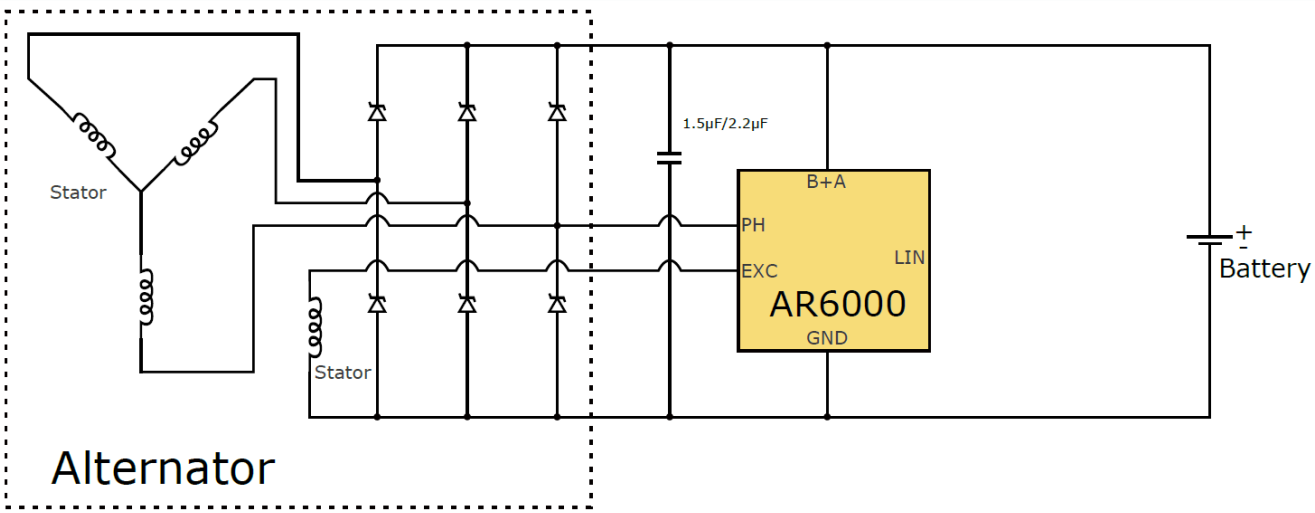


**Figure 2. Simplified application diagram (standalone, self-start mode)**

## 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 |
|---|---|---|
| MC33AR6000AGWS | −40 °C to 150 °C | Die |
| MC33AR6000AxWS[1] | −40 °C to 150 °C | Die |

[1] This IC is One Time Programmable (OTP), during final test. Table 58 describes the programmable functions that are selectable by customer.


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# 6 Internal block diagram

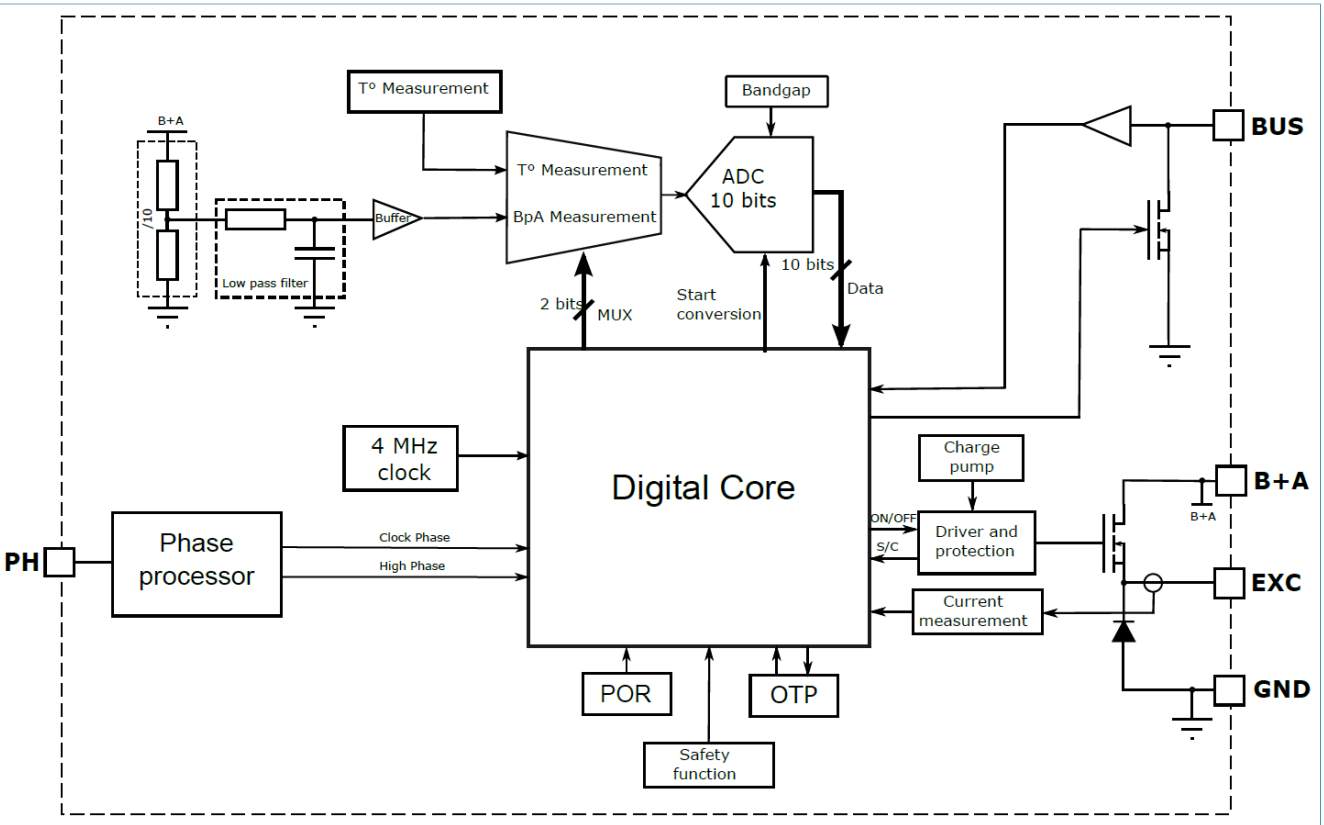


Figure 3. Internal block diagram

# 7 Pinning information

## 7.1 Pinning

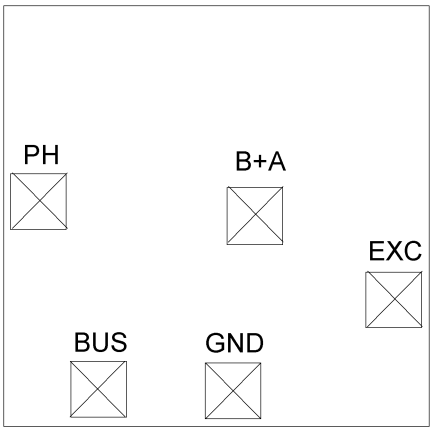


Figure 4. AR6000 pinout diagram

## 7.2 Pin definitions

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


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**Table 2. Pin description**

| Pin number | Pin name | Pin function | Formal name | Definition |
|---|---|---|---|---|
| 1 | EXC | Power | Excitation | This pin is connected to the rotor coil of the alternator |
| 2 | B+A | Output | Supply voltage | This pin is connected to the battery of the vehicle |
| 3 | GND | Input | Ground | Ground pin |
| 4 | BUS | Input/Output | LIN Bus | LIN connected to master |
| 5 | PH | Input | Phase | Signal from alternator phase |

**Table 3. 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 4. 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.*

| Symbol | Description (Rating) | Min. | Max. | Unit |
|---|---|---|---|---|
| **ELECTRICAL RATINGS** | | | | |
| | B+A supply pin | | | |
| $V_{B+A\ MAX}$ | DC voltage | — | 40 | V |
| | Load dump transient voltage (ISO7637-2) | | | |
| $V_{B+A\ MIN}$ | DC voltage | — | –0.3 | V |
| $V_{B+A\ REV}$ | Maximum reverse B+A voltage [1] (5 seconds) | — | –3.2 | V |
| $I_{EXC}$ | Maximum excitation current [2] | — | 12 | A |
| | Recirculation diode peak current | — | 12 | A |
| | Recirculation diode reverse voltage | — | 12 | V |
| $V_{PHASE}$ | PHASE input voltage range | –24 | +40 | V |
| | BUS pin input range | –2.0 | +40 | V |
| | ESD voltage [3] | | | |
| $V_{ESD1}$ | Human Body Model - All pins (MIL std 883C) [4] | — | ±6000 | V |
| $V_{ESD2}$ | CDM- AECQ100-011B All Pins | — | ±750 | |
| $V_{ESD3}$ | Accessible pins (EN61.000-4-2) when mounted on the Alternator (BUS & B+A) by contact discharge | — | ±10000 | |
| $V_{ESD4}$ | Air discharges when mounted on the Alternator | — | ±15000 | |
| Level | Standard Transient Pulses ISO 7637-1 and 7637-3 | | | |
| | 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.


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[3] Testing is performed in accordance with the Human Body Model ($C_{ZAP}$ = 100 pF, $R_{ZAP}$ = 1500 Ω), Charge Device Model, Robotic ($C_{ZAP}$ = 4.0 pF and 30pF), or the EN61000-4-2 specification ($C_{ZAP}$ = 150 pF, $R_{ZAP}$ = 330 Ω).
[4] Product Powered. ESD done on pulley, B+ and metal alternator case ($C_{ZAP}$ = 330 pF, $R_{ZAP}$ = 2.0 kΩ)

## 8.2 Thermal characteristics

### Table 5. Thermal ratings

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

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

## 8.3 Static electrical characteristics

### Table 6. 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 150 °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 |
| $I_{OP}$ | Operating current<br>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 |
| $\Delta V_{REG1}$ | $V_{REG}$ setting accuracy voltage at 50 % for $V_{REG}$ = 13.8 V and $T_J$ = 25 °C | -100 | — | +100 | mV |
| $\Delta V_{REG2}$ | $V_{REG}$ setting accuracy voltage<br>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 TMOS at $T_J$ = 150 °C (for $V_{B+A}$ > 7.0 V) [3] | — | — | 100 | mΩ |
| $V_F$ | Recirculation diode voltage at 5.0 A (Excitation current) | — | 1.2 | 1.5 | V |
| $V_{OV}$ | Safety function | 16.2 | 16.5 | — | V |
| $I_{EXC-SC}$ | EXC short-circuit protection threshold [2] | 8.0 | 10 | 13.5 | A |
| **LIN INTERFACE (Parameters refer to LIN Physical Layer Spec Revision 2.1)** | | | | | |
| $I_{BUS_LIM}$ | Current limitation for driver dominant state, driver on $V_{BUS}$ = 18 V | — | 62 | 150 | mA |
| $I_{BUS_PAS_DOM}$ | Input leakage current at the receiver. Dominant state (Driver OFF, $V_{BAT}$ = 12 V, $V_{BUS}$ = 0 V) | -1.0 | — | — | mA |
| $I_{BUS_PAS_REC}$ | Input leakage current at the receiver. Recessive state (Driver OFF, 8.0 V < $V_{BAT}$ < 18 V, 8.0 V < $V_{BUS}$ < 18 V, $V_{BUS}$ > $V_{BAT}$) | — | — | 20 | µA |


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| Symbol | Characteristic | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $I_{BUS_NO_GND}$ | Ground disconnection. GND = $V_{SUP}$, 0 V < $V_{BUS}$ < 18 V, $V_{BAT}$ = 12 V. Loss of local GND does not affect communication in the residual network | -1.0 | — | 1.0 | mA |
| $I_{BUS_NO_BAT}$ | VBAT disconnection. $V_{SUP}$ = GND, 0 V < $V_{BUS}$ < 18 V. Node sustains the current that can flow under this condition. LIN bus remains operational | — | — | 100 | µA |
| $V_{BUS_DOM}$ | Receiver dominant state | — | — | 0.4 $V_{SUP}$ | 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 | kΩ |
| $C_{LIN}$ | Internal capacitor | — | — | 30 | pF |

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

## 8.4 Dynamic electrical characteristics

### Table 7. Dynamic electrical characteristics

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

| 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 | 504 | 560 | 616 | RPM |
| $N_{HYST}$ | Hysteresis in speed between start and stop of regulation | 50 | 100 | 150 | RPM |
| ΔLRC | Delta LRC duty cycle | — | 3.125 | — | % |
| **LIN INTERFACE (Parameters refer to LIN Physical Layer Spec Revision 2.1)** | | | | | |
| $TOL_{CLK}$ | Lin controller clock (4 MHz relaxation oscillator) Clock overall tolerance | -10 | — | 10 | % |
| $F_{TOL_SYNC}$ | Bit rate tolerance Deviation of slave node bit rate relative to the master node bit rate after synchronization | — | — | 2 | % |
| $t_{BFS}$ | Value of accuracy of the byte field detection | — | — | 2/16 | Tbit |
| $t_{EBS}$ | Earliest bit sample time, $t_{EBS} \leq t_{LBS}$ | 7/16 | — | — | Tbit |
| $t_{LBS}$ | Latest bit sample time, $t_{EBS} \geq t_{LBS}$ | — | — | 10/16Tbit - $t_{BFS}$ | Tbit |
| D1 Valid for 20 kBaud | Duty cycle D1 $TH_{REC(max)}$ = 0.744 x $V_{SUP}$, $TH_{DOM(max)}$ = 0.581 x $V_{SUP}$ $V_{SUP}$ 7.0 V to 18 V, $t_{BIT}$ = 50 µs D1 = $t_{BUS\ -\ rec(min)}$ / ($2t_{BIT}$) | 0.396 | — | — | % |


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| Symbol | Characteristic | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| D2<br>Valid for 20 kBaud | Duty cycle D2<br>$TH_{REC(min)}$ = 0.422 x $V_{SUP}$,<br>$TH_{DOM(min)}$ = 0.284 x $V_{SUP}$<br>$V_{SUP}$ 7.6 V to 18 V, $t_{BIT}$ = 50 µs<br>D2 = $t_{BUS\ -\ rec(max)}$ / ($2t_{BIT}$) | — | — | 0.581 | % |
| D3<br>Valid for 10.4 kBaud | Duty cycle D3<br>$TH_{REC(max)}$ = 0.778 x $V_{SUP}$,<br>$TH_{DOM(max)}$ = 0.616 x $V_{SUP}$<br>$V_{SUP}$ 7.0 V to 18 V, $t_{BIT}$ = 96 µs<br>D3 = $t_{BUS\ -\ rec(min)}$ / ($2t_{BIT}$) | 0.417 | — | — | % |
| D4<br>Valid for 10.4 kBaud | Duty cycle D4<br>$TH_{REC(min)}$ = 0.389 x $V_{SUP}$,<br>$TH_{DOM(min)}$ = 0.251 x $V_{SUP}$<br>$V_{SUP}$ 7.6 V to 18 V, $t_{BIT}$ = 96 µs<br>D4 = $t_{BUS\ -\ rec(max)}$ / ($2t_{BIT}$) | — | — | 0.59 | % |
| $t_{RX_PD}$ | Receiver propagation delay<br>($T_{RX_PD}$ = MAX ($t_{REC_PDR}$, $t_{REC_PDF}$))<br>(internal timing, from physical layer to data layer logic) | — | — | 6 | µs |
| $T_{RX_SYM}$ | Symmetry of receiver propagation delay<br>($T_{RX_SYM}$ = $t_{REC_PDF}$ - $t_{REC_PDR}$) | -2 | — | 2 | µs |

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

# 9 Functional description

## 9.1 Introduction

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

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

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


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- 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 58.

## 9.2 Functional pin description

### 9.2.1 Phase (PH)

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

### 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
- Analog permanently powered or not
- LIN transceiver
- Charge pump

The purpose of the POR block is to generate a clean reset to the main logic.

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


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## 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 a high-side driver switching the excitation current. 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 5.

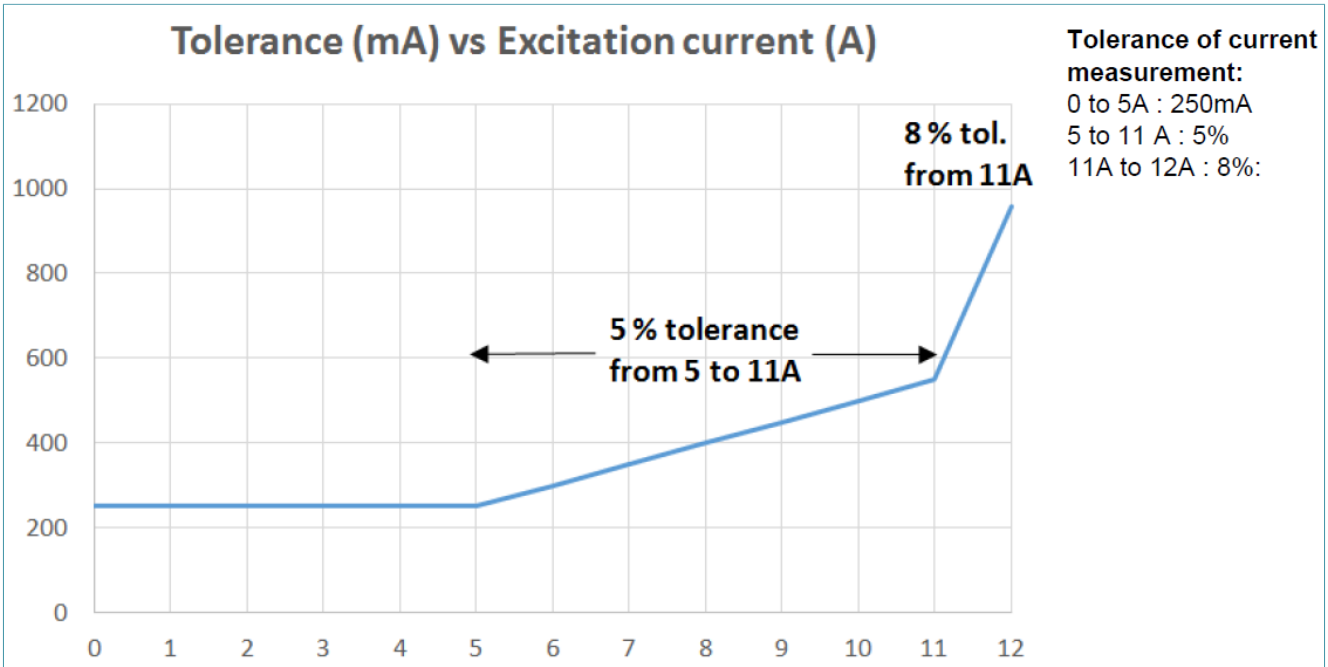


**Figure 5. Tolerance (mA) vs. excitation current (A)**

## 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 the digital block. The oscillator generates a 2.5 V square wave at the frequency of 8.0 MHz in Normal mode operation.

### 10.3.3 OTP

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

### 10.3.4 Phase low and high

The phase detector monitors the phase input and sends filtered low and high levels to the main logic when the phase signal is ok for regulation or for self-start.


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### 10.3.5 ADC

The analog to digital converter is used in the voltage regulation loop for temperature measurement.

### 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.

### 10.3.8 Power on reset (POR)

When a Power On Reset occurs, device internal registers are reset and the device goes into stand by mode.

# 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 8. 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 |


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| LIN Version | | Identifier Hex |
|---|---|---|
| LIN1 Version B | Rx | 29 |
| | Tx | 12 |
| | Tx | 15 |
| 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 | |


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## 11.2 Message frame for configuration version-A

### 11.2.1 RxFrame

**Table 9. 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 | | | BZ | F | | | BZI |

A: Voltage set value, 6 bits, Table 25

B: Load response ramp time, 4 bits, Table 26

C: Load response cut off speed, 4 bits, Table 27

D: Excitation current limitation,5 bits, Table 28

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

| Output choice | Code |
|---|---|
| VB+ | 001 |
| Umes | 010 |
| Tchip | 011 |
| Alt Speed | 100 |

BZ: “Blind zone”, 1 bit, Table 29

F:Voltage limitation for high temperature, 3 bits, Table 30

BZI: “Blind zone inhibition”, 1 bit (enabled by programming), Table 31

### 11.2.2 TxFrame 1

**Table 10. 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 32

E: Measured excitation current, 6 bits, Table 33

F: Diagnosis flag for LIN error, 1 bit

G: Diagnosis flag LIN communication timeout, 1 bit


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### 11.2.3 TxFrame 2

**Table 11. 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 34

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

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

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

### 11.2.4 TxFrame 3

**Table 12. 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 32

E: Measured excitation current, 8 bits, Table 35

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 or measured voltage or chip temperature, 8 bits, Table 36


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## 11.3 Message frame for configuration version-B

### 11.3.1 RxFrame

**Table 13. 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 | | | BZ | F | | | BZI |

A: Voltage set value, 8 bits, Table 37

B: Load response ramp time, 4 bits, Table 38

C: Load response cut off speed, 4 bits, Table 27

D: Excitation current limitation, 7 bits, Table 39

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

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

BZ: “Blind zone”, 1 bit

F: Voltage limitation for high temperature, 3 bits, Table 30

BZI: “Blind zone inhibition”, 1 bit (enabled by programming), Table 31

### 11.3.2 TxFrame 1

**Table 14. Identifier: 0X12 (LIN1) or 0X14 (LIN2, LIN4) or 0X21 (LIN3) OX11 (LIN4)**

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

A: Alternator supplier identification, 3 bits, Table 34

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

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

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


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### 11.3.3 TxFrame 2

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

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

A: Diagnosis flag for high temperature, 1 bit

B: Diagnosis flag for mechanical failure, 1 bit

C: Diagnosis flag for electrical failure, 1 bit

D: Duty cycle value of the excitation PWM, 5 bits, Table 40

E: Measured excitation current, 8 bits, Table 35

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 or measured voltage or chip temperature, 8 bits, Table 41

## 11.4 Message frame for configuration version-C

### 11.4.1 RxFrame

**Table 16. 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 42

B: Load response ramp time, 4 bits, Table 44

C: Load response cut off speed, 4 bits, Table 45

D: Regulation voltage set point, 8 bits, Table 43

E: Excitation current limitation, 8 bits, Table 46


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### 11.4.2 TxFrame 1

**Table 17. 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 temperature, 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 50

G: Measured excitation current, 8 bits, Table 49

H: Duty cycle value of the excitation PWM, 8 bits, Table 48

### 11.4.3 TxFrame 2

**Table 18. 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 51

B: Alternator supplier identification, 3 bits, Table 34

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


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## 11.5 Message frame for configuration version-D

### 11.5.1 RxFrame

**Table 19. 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 |

A: Voltage set value, 6 bits, Table 25

B: Load response ramp time, 4 bits, Table 26

C: Load response cut off speed, 4 bits, Table 27

D: Excitation current limitation, 5 bits, Table 28

### 11.5.2 TxFrame 1

**Table 20. 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 32

E: Measured excitation current, 6 bits, Table 33 Temperature measurement, 6 bits, Table 54

F: Diagnosis flag for LIN error, 1 bit

G: Diagnosis flag LIN communication time-out, 1 bit

### 11.5.3 TxFrame 2

**Table 21. 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 34

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


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## 11.6 Message frame for configuration version-E

### 11.6.1 RxFrame

**Table 22. 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 | BZ | X | X | X | X |

A: Voltage set value, 6 bits, Table 25

B: Load response ramp time, 4 bits, Table 26

C: Load response cut off speed, 4 bits, Table 45

D: Excitation current limitation, 8 bits, Table 56

BZ: “Blind zone”, 1 bit, Table 29

### 11.6.2 TxFrame 1

**Table 23. Identifier: 0X21**

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

A: Diagnosis flag for high temperature, 1 bit

B: Diagnosis flag for mechanical failure, 1 bit

C: Diagnosis flag for electrical failure, 1 bit

D: Duty cycle value of the excitation PWM, 5 bits, Table 53

E: Measured excitation current, 8 bits, Table 56

G: Diagnosis flag for LIN error, 1 bit

H: Diagnosis flag LIN communication time-out, 1 bit

I: Chip temperature, 8-bits, Table 57

### 11.6.3 TxFrame 2

**Table 24. 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 34

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

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

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


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# 12 Lookup tables

**Table 25. Voltage set point (6 bits) – versions A, D and E**

| Code | V | Code | V |
|---|---|---|---|
| 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 |

**Table 26. LRC ramp time – versions A, D and E**

| Ramp time | Seconds | Ramp time | Seconds |
|---|---|---|---|
| 0000 | 0 | 1000 | 8 |
| 0001 | 1 | 1001 | 9 |
| 0010 | 2 | 1010 | 10 |


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| Ramp time | Seconds | Ramp time | Seconds |
|---|---|---|---|
| 0011 | 3 | 1011 | 11 |
| 0100 | 4 | 1100 | 12 |
| 0101 | 5 | 1101 | 13 |
| 0110 | 6 | 1110 | 14 |
| 0111 | 7 | 1111 | 15 |

**Table 27. LRC disable speed (4 bits) – versions A, B and D**

| Ramp time | Seconds | Ramp time | Seconds |
|---|---|---|---|
| 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 28. 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 |
| 01100 | 3 | 11100 | 7 |
| 01101 | 3.25 | 11101 | 7.25 |
| 01110 | 3.5 | 11110 | 7.5 |
| 01111 | 3.75 | 11111 | 7.75 |


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**Table 29. Blind zone (1 bit) – versions A and E**

| Blind zone | Value |
|---|---|
| 3% | 0 |
| 12% | 1 |

**Table 30. 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 31. Blind zone inhibition (1 bit) – versions A and B**

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

**Table 32. Duty cycle value (5 bits) – versions A and D**

| EXC duty cycle | DF (%) | EXC duty cycle | DF (%) |
|---|---|---|---|
| 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 |
| 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 |


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**Table 33. 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 |
| 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 34. Alternator supplier identification (3 bits) – All versions**

| Alternator supplier | Code |
|---|---|
| Bosch | 000 |
| Valeo | 001 |
| Delfphi | 010 |
| Hitachi | 011 |
| Denso | 100 |


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| Alternator supplier | Code |
|---|---|
| Melco | 101 |
| Visteon | 110 |
| Other | 111 |

**Table 35. 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 |
| 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 |


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| Irotor code | Irotor value | Irotor code | Irotor value |
|---|---|---|---|
| 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 |
| 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 |


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| Irotor code | Irotor value | Irotor code | Irotor value |
|---|---|---|---|
| 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 |
| 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 |


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

**Table 36. Battery voltage measurement, temperature measurement or alternator speed (8 bits) – version A**

| Tx 3 Byte 4 | Umes | Tchip | n |
|---|---|---|---|
| 00000000 | > 8 | T < –38 °C | n < 567 |
| 00000001 | 8.1 | –38 °C < T < –34 °C | 567 |
| 00000010 | 8.2 | –34 °C < T < –30 °C | 569 |
| 00000011 | 8.3 | –30 °C < T < –26 °C | 571 |
| 00000100 | 8.4 | –26 °C < T < –22 °C | 574 |
| 00000101 | 8.5 | –22 °C < T < –18 °C | 576 |
| 00000110 | 8.6 | –18 °C < T < –14 °C | 578 |
| 00000111 | 8.7 | –14 °C < T < –10 °C | 581 |
| 00001000 | 8.8 | –10 °C < T < –6.0 °C | 583 |
| 00001001 | 8.9 | –6.0 °C < T < –2.0 °C | 585 |
| 00001010 | 9 | –2.0 °C < T < 2.0 °C | 588 |
| 00001011 | 9.1 | 2.0 °C < T < 6.0 °C | 590 |
| 00001100 | 9.2 | 6.0 °C < T < 10 °C | 593 |
| 00001101 | 9.3 | 10 °C < T < 14 °C | 595 |
| 00001110 | 9.4 | 14 °C < T < 18 °C | 598 |
| 00001111 | 9.5 | 18 °C < T < 22 °C | 600 |
| 00010000 | 9.6 | 22 °C < T < 26 °C | 603 |
| 00010001 | 9.7 | 26 °C < T < 30 °C | 605 |
| 00010010 | 9.8 | 30 °C < T < 34 °C | 608 |
| 00010011 | 9.9 | 34 °C < T < 38 °C | 610 |
| 00010100 | 10 | 38 °C < T < 42 °C | 613 |
| 00010101 | 10.1 | 42 °C < T < 46 °C | 615 |
| 00010110 | 10.2 | 46 °C < T < 50 °C | 618 |
| 00010111 | 10.3 | 50 °C < T < 54 °C | 621 |
| 00011000 | 10.4 | 54 °C < T < 58 °C | 623 |


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| Tx 3 Byte 4 | Umes | Tchip | n |
|---|---|---|---|
| 00011001 | 10.5 | 58 °C < T < 62 °C | 626 |
| 00011010 | 10.6 | 62 °C < T < 66 °C | 629 |
| 00011011 | 10.7 | 66 °C < T < 70 °C | 632 |
| 00011100 | 10.8 | 70 °C < T < 74 °C | 634 |
| 00011101 | 10.9 | 74 °C < T < 78 °C | 637 |
| 00011110 | 11 | 78 °C < T < 82 °C | 640 |
| 00011111 | 11.1 | 82 °C < T < 86 °C | 643 |
| 00100000 | 11.2 | 86 °C < T < 90 °C | 646 |
| 00100001 | 11.3 | 90 °C < T < 94 °C | 649 |
| 00100010 | 11.4 | 94 °C < T < 98 °C | 652 |
| 00100011 | 11.5 | 98 °C < T < 102 °C | 655 |
| 00100100 | 11.6 | 102 °C < T < 106 °C | 658 |
| 00100101 | 11.7 | 106 °C < T < 110 °C | 661 |
| 00100110 | 11.8 | 110 °C < T < 114 °C | 664 |
| 00100111 | 11.9 | 114 °C < T < 118 °C | 667 |
| 00101000 | 12 | 118 °C < T < 122 °C | 670 |
| 00101001 | 12.1 | 122 °C < T < 126 °C | 673 |
| 00101010 | 12.2 | 126 °C < T < 130 °C | 676 |
| 00101011 | 12.3 | 130 °C < T < 134 °C | 679 |
| 00101100 | 12.4 | 134 °C < T < 138 °C | 682 |
| 00101101 | 12.5 | 138 °C < T < 142 °C | 686 |
| 00101110 | 12.6 | 142 °C < T < 146 °C | 689 |
| 00101111 | 12.7 | 146 °C < T < 150 °C | 692 |
| 00110000 | 12.8 | 150 °C < T < 154 °C | 696 |
| 00110001 | 12.9 | 154 °C < T < 158 °C | 699 |
| 00110010 | 13 | 158 °C < T < 162 °C | 702 |
| 00110011 | 13.1 | 162 °C < T < 166 °C | 706 |
| 00110100 | 13.2 | 166 °C < T < 170 °C | 709 |
| 00110101 | 13.3 | 170 °C < T < 174 °C | 713 |
| 00110110 | 13.4 | 174 °C < T < 178 °C | 716 |
| 00110111 | 13.5 | 178 °C < T < 182 °C | 720 |
| 00111000 | 13.6 | 182 °C < T < 186 °C | 724 |
| 00111001 | 13.7 | 186 °C < T < 190 °C | 727 |
| 00111010 | 13.8 | 190 °C < T < 194 °C | 731 |
| 00111011 | 13.9 | 194 °C < T < 198 °C | 735 |
| 00111100 | 14 | 198 °C < T < 200 °C | 738 |
| 00111101 | 14.1 | T > 200 °C | 742 |
| 00111110 | 14.2 | T > 200 °C | 746 |
| 00111111 | 14.3 | T > 200 °C | 750 |
| 01000000 | 14.4 | T > 200 °C | 754 |
| 01000001 | 14.5 | T > 200 °C | 758 |


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


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| Tx 3 Byte 4 | Umes | Tchip | n |
|---|---|---|---|
| 01101011 | 18.7 | T > 200 °C | 973 |
| 01101100 | 18.8 | T > 200 °C | 980 |
| 01101101 | 18.9 | T > 200 °C | 986 |
| 01101110 | 19 | T > 200 °C | 993 |
| 01101111 | 19.1 | T > 200 °C | 1000 |
| 01110000 | 19.2 | T > 200 °C | 1007 |
| 01110001 | 19.3 | T > 200 °C | 1014 |
| 01110010 | 19.4 | T > 200 °C | 1021 |
| 01110011 | 19.5 | T > 200 °C | 1029 |
| 01110100 | 19.6 | T > 200 °C | 1036 |
| 01110101 | 19.7 | T > 200 °C | 1043 |
| 01110110 | 19.8 | T > 200 °C | 1051 |
| 01110111 | 19.9 | T > 200 °C | 1059 |
| 01111000 | 20 | T > 200 °C | 1067 |
| 01111001 | 20.1 | T > 200 °C | 1075 |
| 01111010 | 20.2 | T > 200 °C | 1083 |
| 01111011 | 20.3 | T > 200 °C | 1091 |
| 01111100 | 20.4 | T > 200 °C | 1099 |
| 01111101 | 20.5 | T > 200 °C | 1108 |
| 01111110 | 20.6 | T > 200 °C | 1116 |
| 01111111 | 20.7 | T > 200 °C | 1125 |
| 10000000 | 20.8 | T > 200 °C | 1134 |
| 10000001 | 20.9 | T > 200 °C | 1143 |
| 10000010 | 21 | T > 200 °C | 1152 |
| 10000011 | 21.1 | T > 200 °C | 1161 |
| 10000100 | 21.2 | T > 200 °C | 1171 |
| 10000101 | 21.3 | T > 200 °C | 1180 |
| 10000110 | 21.4 | T > 200 °C | 1190 |
| 10000111 | 21.5 | T > 200 °C | 1200 |
| 10001000 | 21.6 | T > 200 °C | 1210 |
| 10001001 | 21.7 | T > 200 °C | 1220 |
| 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 |


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| Tx 3 Byte 4 | Umes | Tchip | n |
|---|---|---|---|
| 10010100 | 22.8 | T > 200 °C | 1346 |
| 10010101 | 22.9 | T > 200 °C | 1358 |
| 10010110 | 23 | T > 200°C | 1371 |
| 10010111 | 23.1 | T > 200 °C | 1385 |
| 10011000 | 23.2 | T > 200 °C | 1398 |
| 10011001 | 23.3 | T > 200 °C | 1412 |
| 10011010 | 23.4 | T > 200 °C | 1426 |
| 10011011 | 23.5 | T > 200 °C | 1440 |
| 10011100 | 23.6 | T > 200 °C | 1455 |
| 10011101 | 23.7 | T > 200 °C | 1469 |
| 10011110 | 23.8 | T > 200 °C | 1485 |
| 10011111 | 23.9 | T > 200 °C | 1500 |
| 10100000 | > 24 | T > 200 °C | 1516 |
| 10100001 | — | T > 200 °C | 1532 |
| 10100010 | — | T > 200 °C | 1548 |
| 10100011 | — | T > 200 °C | 1565 |
| 10100100 | — | T > 200 °C | 1582 |
| 10100101 | — | T > 200 °C | 1600 |
| 10100110 | — | T > 200 °C | 1618 |
| 10100111 | — | T > 200 °C | 1636 |
| 10101000 | — | T > 200 °C | 1655 |
| 10101001 | — | T > 200 °C | 1674 |
| 10101010 | — | T > 200 °C | 1694 |
| 10101011 | — | T > 200°C | 1714 |
| 10101100 | — | T > 200°C | 1735 |
| 10101101 | — | T > 200°C | 1756 |
| 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 |


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| Tx 3 Byte 4 | Umes | Tchip | n |
|---|---|---|---|
| 10111101 | — | T > 200°C | 2182 |
| 10111110 | — | T > 200°C | 2215 |
| 10111111 | — | T > 200°C | 2250 |
| 11000000 | — | T > 200°C | 2286 |
| 11000001 | — | T > 200°C | 2323 |
| 11000010 | — | T > 200°C | 2361 |
| 11000011 | — | T > 200°C | 2400 |
| 11000100 | — | T > 200°C | 2441 |
| 11000101 | — | T > 200°C | 2483 |
| 11000110 | — | T > 200°C | 2526 |
| 11000111 | — | T > 200°C | 2571 |
| 11001000 | — | T > 200°C | 2618 |
| 11001001 | — | T > 200°C | 2667 |
| 11001010 | — | T > 200°C | 2717 |
| 11001011 | — | T > 200°C | 2769 |
| 11001100 | — | T > 200°C | 2824 |
| 11001101 | — | T > 200°C | 2880 |
| 11001110 | — | T > 200°C | 2939 |
| 11001111 | — | T > 200°C | 3000 |
| 11010000 | — | T > 200°C | 3064 |
| 11010001 | — | T > 200°C | 3130 |
| 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 |


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| Tx 3 Byte 4 | Umes | Tchip | n |
|---|---|---|---|
| 11100110 | — | T > 200 °C | 5760 |
| 11100111 | — | T > 200 °C | 6000 |
| 11101000 | — | T > 200 °C | 6261 |
| 11101001 | — | T > 200 °C | 6545 |
| 11101010 | — | T > 200 °C | 6857 |
| 11101011 | — | T > 200 °C | 7200 |
| 11101100 | — | T > 200 °C | 7579 |
| 11101101 | — | T > 200 °C | 8000 |
| 11101110 | — | T > 200 °C | 8471 |
| 11101111 | — | T > 200 °C | 9000 |
| 11110000 | — | T > 200 °C | 9600 |
| 11110001 | — | T > 200 °C | 10286 |
| 11110010 | — | T > 200 °C | 11077 |
| 11110011 | — | T > 200 °C | 12000 |
| 11110100 | — | T > 200 °C | 13091 |
| 11110101 | — | T > 200 °C | 14400 |
| 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 37. Set point voltage (8 bits) – version B**

| Voltage code | Voltage value | Voltage code | Voltage value |
|---|---|---|---|
| 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 |


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| Voltage code | Voltage value | Voltage code | Voltage value |
|---|---|---|---|
| 00001011 | 10.875 | 10001011 | 14.075 |
| 00001100 | 10.9 | 10001100 | 14.1 |
| 00001101 | 10.925 | 10001101 | 14.125 |
| 00001110 | 10.95 | 10001110 | 14.15 |
| 00001111 | 10.975 | 10001111 | 14.175 |
| 00010000 | 11 | 10010000 | 14.2 |
| 00010001 | 11.025 | 10010001 | 14.225 |
| 00010010 | 11.05 | 10010010 | 14.25 |
| 00010011 | 11.075 | 10010011 | 14.275 |
| 00010100 | 11.1 | 10010100 | 14.3 |
| 00010101 | 11.125 | 10010101 | 14.325 |
| 00010110 | 11.15 | 10010110 | 14.35 |
| 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 |


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| Voltage code | Voltage value | Voltage code | Voltage value |
|---|---|---|---|
| 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 |
| 01011001 | 12.825 | 11011001 | 16 |
| 01011010 | 12.85 | 11011010 | 16 |
| 01011011 | 12.875 | 11011011 | 16 |
| 01011100 | 12.9 | 11011100 | 16 |


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| Voltage code | Voltage value | Voltage code | Voltage value |
|---|---|---|---|
| 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 |
| 01111110 | 13.75 | 11111110 | 16 |
| 01111111 | 13.775 | 11111111 | 16 |

**Table 38. LRC ramp time (4 bits) – version B**

| Ramp time | Seconds | Ramp time | Seconds |
|---|---|---|---|
| 0000 | 0 | 1000 | 5.0 |
| 0001 | 0.25 | 1001 | 6.0 |


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| Ramp time | Seconds | Ramp time | Seconds |
|---|---|---|---|
| 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 39. Excitation current limitation (7 bits) - version B**

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


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| Irot limit code | Irotor limitation value | Irot limit code | Irotor limitation value |
|---|---|---|---|
| 0011111 | 3.1 | 1011111 | 9.5 |
| 0100000 | 3.2 | 1100000 | 9.6 |
| 0100001 | 3.3 | 1100001 | 9.7 |
| 0100010 | 3.4 | 1100010 | 9.8 |
| 0100011 | 3.5 | 1100011 | 9.9 |
| 0100100 | 3.6 | 1100100 | 10 |
| 0100101 | 3.7 | 1100101 | 10.1 |
| 0100110 | 3.8 | 1100110 | 10.2 |
| 0100111 | 3.9 | 1100111 | 10.3 |
| 0101000 | 4 | 1101000 | 10.4 |
| 0101001 | 4.1 | 1101001 | 10.5 |
| 0101010 | 4.2 | 1101010 | 10.6 |
| 0101011 | 4.3 | 1101011 | 10.7 |
| 0101100 | 4.4 | 1101100 | 10.8 |
| 0101101 | 4.5 | 1101101 | 10.9 |
| 0101110 | 4.6 | 1101110 | 11 |
| 0101111 | 4.7 | 1101111 | 11.1 |
| 0110000 | 4.8 | 1110000 | 11.2 |
| 0110001 | 4.9 | 1110001 | 11.3 |
| 0110010 | 5 | 1110010 | 11.4 |
| 0110011 | 5.1 | 1110011 | 11.5 |
| 0110100 | 5.2 | 1110100 | 11.6 |
| 0110101 | 5.3 | 1110101 | 11.7 |
| 0110110 | 5.4 | 1110110 | 11.8 |
| 0110111 | 5.5 | 1110111 | 11.9 |
| 0111000 | 5.6 | 1111000 | 12 |
| 0111001 | 5.7 | 1111001 | 12.1 |
| 0111010 | 5.8 | 1111010 | 12.2 |
| 0111011 | 5.9 | 1111011 | 12.3 |
| 0111100 | 6 | 1111100 | 12.4 |
| 0111101 | 6.1 | 1111101 | 12.5 |
| 0111110 | 6.2 | 1111110 | 12.6 |
| 0111111 | 6.3 | 1111111 | 12.7 |

**Table 40. Duty cycle value (5 bits) - version B**

| 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 |


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| EXC duty cycle | DF (%) | EXC duty cycle | DF (%) |
|---|---|---|---|
| 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 41. Set point voltage, battery voltage measurement, temperature measurement or alternator speed (8 bits) - version B**

| Tx 3 Byte 4 | V_B+ | Umes | Tchip | n |
|---|---|---|---|---|
| 00000000 | 10.6 | > 8 | T < –38 °C | n < 567 |
| 00000001 | 10.625 | 8.1 | –38 °C < T < –34 °C | 567 |
| 00000010 | 10.65 | 8.2 | –34 °C < T < –30 °C | 569 |
| 00000011 | 10.675 | 8.3 | –30 °C < T < –26 °C | 571 |
| 00000100 | 10.7 | 8.4 | –26 °C < T < –22 °C | 574 |
| 00000101 | 10.725 | 8.5 | –22 °C < T < –18 °C | 576 |
| 00000110 | 10.75 | 8.6 | –18 °C < T < –14 °C | 578 |
| 00000111 | 10.775 | 8.7 | –14 °C < T < –10 °C | 581 |
| 00001000 | 10.8 | 8.8 | –10 °C < T < –6.0 °C | 583 |
| 00001001 | 10.825 | 8.9 | –6.0 °C < T < –2.0°C | 585 |
| 00001010 | 10.85 | 9 | –2.0 °C < T < 2.0°C | 588 |
| 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 |


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| Tx 3 Byte 4 | V_B+ | Umes | Tchip | n |
|---|---|---|---|---|
| 00011001 | 11.225 | 10.5 | 58 °C < T < 62 °C | 626 |
| 00011010 | 11.25 | 10.6 | 62 °C < T < 66 °C | 629 |
| 00011011 | 11.275 | 10.7 | 66 °C < T < 70 °C | 632 |
| 00011100 | 11.3 | 10.8 | 70 °C < T < 74 °C | 634 |
| 00011101 | 11.325 | 10.9 | 74 °C < T < 78 °C | 637 |
| 00011110 | 11.35 | 11 | 78 °C < T < 82 °C | 640 |
| 00011111 | 11.375 | 11.1 | 82 °C < T < 86 °C | 643 |
| 00100000 | 11.4 | 11.2 | 86 °C < T < 90 °C | 646 |
| 00100001 | 11.425 | 11.3 | 90 °C < T < 94 °C | 649 |
| 00100010 | 11.45 | 11.4 | 94 °C < T < 98 °C | 652 |
| 00100011 | 11.475 | 11.5 | 98 °C < T < 102 °C | 655 |
| 00100100 | 11.5 | 11.6 | 102 °C < T < 106 °C | 658 |
| 00100101 | 11.525 | 11.7 | 106 °C < T < 110 °C | 661 |
| 00100110 | 11.55 | 11.8 | 110 °C < T < 114 °C | 664 |
| 00100111 | 11.575 | 11.9 | 114 °C < T < 118 °C | 667 |
| 00101000 | 11.6 | 12 | 118 °C < T < 122 °C | 670 |
| 00101001 | 11.625 | 12.1 | 122 °C < T < 126 °C | 673 |
| 00101010 | 11.65 | 12.2 | 126 °C < T < 130 °C | 676 |
| 00101011 | 11.675 | 12.3 | 130 °C < T < 134 °C | 679 |
| 00101100 | 11.7 | 12.4 | 134 °C < T < 138 °C | 682 |
| 00101101 | 11.725 | 12.5 | 138 °C < T < 142 °C | 686 |
| 00101110 | 11.75 | 12.6 | 142 °C < T < 146 °C | 689 |
| 00101111 | 11.775 | 12.7 | 150 °C < T < 154 °C | 692 |
| 00110000 | 11.8 | 12.8 | 154 °C < T < 158 °C | 696 |
| 00110001 | 11.825 | 12.9 | 158 °C < T < 162 °C | 699 |
| 00110010 | 11.85 | 13 | 162 °C < T < 166 °C | 702 |
| 00110011 | 11.875 | 13.1 | 166 °C < T < 170 °C | 706 |
| 00110100 | 11.9 | 13.2 | 170 °C < T < 174 °C | 709 |
| 00110101 | 11.925 | 13.3 | 174 °C < T < 178 °C | 713 |
| 00110110 | 11.95 | 13.4 | 178 °C < T < 182 °C | 716 |
| 00110111 | 11.975 | 13.5 | 182 °C < T < 186 °C | 720 |
| 00111000 | 12 | 13.6 | 186 °C < T < 190 °C | 724 |
| 00111001 | 12.025 | 13.7 | 190 °C < T < 194 °C | 727 |
| 00111010 | 12.05 | 13.8 | 194 °C < T < 198 °C | 731 |
| 00111011 | 12.075 | 13.9 | 198 °C < T < 200 °C | 735 |
| 00111100 | 12.1 | 14 | 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 |


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| Tx 3 Byte 4 | V_B+ | Umes | Tchip | n |
|---|---|---|---|---|
| 01000010 | 12.25 | 14.6 | T > 200 °C | 762 |
| 01000011 | 12.275 | 14.7 | T > 200 °C | 766 |
| 01000100 | 12.3 | 14.8 | T > 200 °C | 770 |
| 01000101 | 12.325 | 14.9 | T > 200 °C | 774 |
| 01000110 | 12.35 | 15 | T > 200°C | 778 |
| 01000111 | 12.375 | 15.1 | T > 200 °C | 783 |
| 01001000 | 12.4 | 15.2 | T > 200 °C | 787 |
| 01001001 | 12.425 | 15.3 | T > 200 °C | 791 |
| 01001010 | 12.45 | 15.4 | T > 200 °C | 796 |
| 01001011 | 12.475 | 15.5 | T > 200 °C | 800 |
| 01001100 | 12.5 | 15.6 | T > 200 °C | 804 |
| 01001101 | 12.525 | 15.7 | T > 200 °C | 809 |
| 01001110 | 12.55 | 15.8 | T > 200 °C | 814 |
| 01001111 | 12.575 | 15.9 | T > 200 °C | 818 |
| 01010000 | 12.6 | 16 | T > 200 °C | 823 |
| 01010001 | 12.625 | 16.1 | T > 200 °C | 828 |
| 01010010 | 12.65 | 16.2 | T > 200 °C | 832 |
| 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 |


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| Tx 3 Byte 4 | V_B+ | Umes | Tchip | n |
|---|---|---|---|---|
| 01101011 | 13.275 | 18.7 | T > 200 °C | 973 |
| 01101100 | 13.3 | 18.8 | T > 200 °C | 980 |
| 01101101 | 13.325 | 18.9 | T > 200 °C | 986 |
| 01101110 | 13.35 | 19 | T > 200 °C | 993 |
| 01101111 | 13.375 | 19.1 | T > 200 °C | 1000 |
| 01110000 | 13.4 | 19.2 | T > 200 °C | 1007 |
| 01110001 | 13.425 | 19.3 | T > 200 °C | 1014 |
| 01110010 | 13.45 | 19.4 | T > 200 °C | 1021 |
| 01110011 | 13.475 | 19.5 | T > 200 °C | 1029 |
| 01110100 | 13.5 | 19.6 | T > 200 °C | 1036 |
| 01110101 | 13.525 | 19.7 | T > 200 °C | 1043 |
| 01110110 | 13.55 | 19.8 | T > 200 °C | 1051 |
| 01110111 | 13.575 | 19.9 | T > 200 °C | 1059 |
| 01111000 | 13.6 | 20 | T > 200 °C | 1067 |
| 01111001 | 13.625 | 20.1 | T > 200 °C | 1075 |
| 01111010 | 13.65 | 20.2 | T > 200 °C | 1083 |
| 01111011 | 13.675 | 20.3 | T > 200 °C | 1091 |
| 01111100 | 13.7 | 20.4 | T > 200 °C | 1099 |
| 01111101 | 13.725 | 20.5 | T > 200 °C | 1108 |
| 01111110 | 13.75 | 20.6 | T > 200 °C | 1116 |
| 01111111 | 13.775 | 20.7 | T > 200 °C | 1125 |
| 10000000 | 13.8 | 20.8 | T > 200 °C | 1134 |
| 10000001 | 13.825 | 20.9 | T > 200 °C | 1143 |
| 10000010 | 13.85 | 21 | T > 200°C | 1152 |
| 10000011 | 13.875 | 21.1 | T > 200 °C | 1161 |
| 10000100 | 13.9 | 21.2 | T > 200 °C | 1171 |
| 10000101 | 13.925 | 21.3 | T > 200 °C | 1180 |
| 10000110 | 13.95 | 21.4 | T > 200 °C | 1190 |
| 10000111 | 13.975 | 21.5 | T > 200 °C | 1200 |
| 10001000 | 14 | 21.6 | T > 200 °C | 1210 |
| 10001001 | 14.025 | 21.7 | T > 200 °C | 1220 |
| 10001010 | 14.05 | 21.8 | T > 200 °C | 1231 |
| 10001011 | 14.075 | 21.9 | T > 200 °C | 1241 |
| 10001100 | 14.1 | 22 | T > 200 °C | 1252 |
| 10001101 | 14.125 | 22.1 | T > 200 °C | 1263 |
| 10001110 | 14.15 | 22.2 | T > 200 °C | 1274 |
| 10001111 | 14.175 | 22.3 | T > 200 °C | 1286 |
| 10010000 | 14.2 | 22.4 | T > 200 °C | 1297 |
| 10010001 | 14.225 | 22.5 | T > 200 °C | 1309 |
| 10010010 | 14.25 | 22.6 | T > 200 °C | 1321 |
| 10010011 | 14.275 | 22.7 | T > 200 °C | 1333 |


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| Tx 3 Byte 4 | V_B+ | Umes | Tchip | n |
|---|---|---|---|---|
| 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 |
| 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 |


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| Tx 3 Byte 4 | V_B+ | Umes | Tchip | n |
|---|---|---|---|---|
| 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 |
| 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 |


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| Tx 3 Byte 4 | V_B+ | Umes | Tchip | n |
|---|---|---|---|---|
| 11100110 | 16 | — | T > 200 °C | 5760 |
| 11100111 | 16 | — | T > 200 °C | 6000 |
| 11101000 | 16 | — | T > 200 °C | 6261 |
| 11101001 | 16 | — | T > 200 °C | 6545 |
| 11101010 | 16 | — | T > 200 °C | 6857 |
| 11101011 | 16 | — | T > 200 °C | 7200 |
| 11101100 | 16 | — | T > 200 °C | 7579 |
| 11101101 | 16 | — | T > 200 °C | 8000 |
| 11101110 | 16 | — | T > 200 °C | 8471 |
| 11101111 | 16 | — | T > 200 °C | 9000 |
| 11110000 | 16 | — | T > 200 °C | 9600 |
| 11110001 | 16 | — | T > 200 °C | 10286 |
| 11110010 | 16 | — | T > 200 °C | 11077 |
| 11110011 | 16 | — | T > 200 °C | 12000 |
| 11110100 | 16 | — | T > 200 °C | 13091 |
| 11110101 | 16 | — | T > 200 °C | 14400 |
| 11110110 | 16 | — | T > 200 °C | 16000 |
| 11110111 | 16 | — | T > 200 °C | 18000 |
| 11111000 | 16 | — | T > 200 °C | 20571 |
| 11111001 | 16 | — | T > 200 °C | — |
| 11111010 | 16 | — | T > 200 °C | — |
| 11111011 | 16 | — | T > 200 °C | — |
| 11111100 | 16 | — | T > 200 °C | — |
| 11111101 | 16 | — | T > 200 °C | — |
| 11111110 | 16 | — | T > 200 °C | — |
| 11111111 | 16 | — | T > 200 °C | — |

**Table 42. Blind zone (2 bits) - version C**

| Blind zone | Value |
|---|---|
| 00 | 0 |
| 01 | 3.125 |
| 10 | 6.25 |
| 11 | 12.5 |

**Table 43. Set point voltage (8 bits) - version C**

| Voltage code | Voltage value | Voltage code | Voltage value |
|---|---|---|---|
| 00000000 | 10.6 | 10000000 | 13.8 |
| 00000001 | 10.625 | 10000001 | 13.825 |
| 00000010 | 10.65 | 10000010 | 13.85 |
| 00000011 | 10.675 | 10000011 | 13.875 |


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| Voltage code | Voltage value | Voltage code | Voltage value |
|---|---|---|---|
| 00000100 | 10.7 | 10000100 | 13.9 |
| 00000101 | 10.725 | 10000101 | 13.925 |
| 00000110 | 10.75 | 10000110 | 13.95 |
| 00000111 | 10.775 | 10000111 | 13.975 |
| 00001000 | 10.8 | 10001000 | 14 |
| 00001001 | 10.825 | 10001001 | 14.025 |
| 00001010 | 10.85 | 10001010 | 14.05 |
| 00001011 | 10.875 | 10001011 | 14.075 |
| 00001100 | 10.9 | 10001100 | 14.1 |
| 00001101 | 10.925 | 10001101 | 14.125 |
| 00001110 | 10.95 | 10001110 | 14.15 |
| 00001111 | 10.975 | 10001111 | 14.175 |
| 00010000 | 11 | 10010000 | 14.2 |
| 00010001 | 11.025 | 10010001 | 14.225 |
| 00010010 | 11.05 | 10010010 | 14.25 |
| 00010011 | 11.075 | 10010011 | 14.275 |
| 00010100 | 11.1 | 10010100 | 14.3 |
| 00010101 | 11.125 | 10010101 | 14.325 |
| 00010110 | 11.15 | 10010110 | 14.35 |
| 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 |


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| Voltage code | Voltage value | Voltage code | Voltage value |
|---|---|---|---|
| 00101101 | 11.725 | 10101101 | 14.925 |
| 00101110 | 11.75 | 10101110 | 14.95 |
| 00101111 | 11.775 | 10101111 | 14.975 |
| 00110000 | 11.8 | 10110000 | 15 |
| 00110001 | 11.825 | 10110001 | 15.025 |
| 00110010 | 11.85 | 10110010 | 15.05 |
| 00110011 | 11.875 | 10110011 | 15.075 |
| 00110100 | 11.9 | 10110100 | 15.1 |
| 00110101 | 11.925 | 10110101 | 15.125 |
| 00110110 | 11.95 | 10110110 | 15.15 |
| 00110111 | 11.975 | 10110111 | 15.175 |
| 00111000 | 12 | 10111000 | 15.2 |
| 00111001 | 12.025 | 10111001 | 15.225 |
| 00111010 | 12.05 | 10111010 | 15.25 |
| 00111011 | 12.075 | 10111011 | 15.275 |
| 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 |


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| Voltage code | Voltage value | Voltage code | Voltage value |
|---|---|---|---|
| 01010110 | 12.75 | 11010110 | 15.95 |
| 01010111 | 12.775 | 11010111 | 15.975 |
| 01011000 | 12.8 | 11011000 | 16 |
| 01011001 | 12.825 | 11011001 | 16 |
| 01011010 | 12.85 | 11011010 | 16 |
| 01011011 | 12.875 | 11011011 | 16 |
| 01011100 | 12.9 | 11011100 | 16 |
| 01011101 | 12.925 | 11011101 | 16 |
| 01011110 | 12.95 | 11011110 | 16 |
| 01011111 | 12.975 | 11011111 | 16 |
| 01100000 | 13 | 11100000 | 16 |
| 01100001 | 13.025 | 11100001 | 16 |
| 01100010 | 13.05 | 11100010 | 16 |
| 01100011 | 13.075 | 11100011 | 16 |
| 01100100 | 13.1 | 11100100 | 16 |
| 01100101 | 13.125 | 11100101 | 16 |
| 01100110 | 13.15 | 11100110 | 16 |
| 01100111 | 13.175 | 11100111 | 16 |
| 01101000 | 13.2 | 11101000 | 16 |
| 01101001 | 13.225 | 11101001 | 16 |
| 01101010 | 13.25 | 11101010 | 16 |
| 01101011 | 13.275 | 11101011 | 16 |
| 01101100 | 13.3 | 11101100 | 16 |
| 01101101 | 13.325 | 11101101 | 16 |
| 01101110 | 13.35 | 11101110 | 16 |
| 01101111 | 13.375 | 11101111 | 16 |
| 01110000 | 13.4 | 11110000 | 16 |
| 01110001 | 13.425 | 11110001 | 16 |
| 01110010 | 13.45 | 11110010 | 16 |
| 01110011 | 13.475 | 11110011 | 16 |
| 01110100 | 13.5 | 11110100 | 16 |
| 01110101 | 13.525 | 11110101 | 16 |
| 01110110 | 13.55 | 11110110 | 16 |
| 01110111 | 13.575 | 11110111 | 16 |
| 01111000 | 13.6 | 11111000 | 16 |
| 01111001 | 13.625 | 11111001 | 16 |
| 01111010 | 13.65 | 11111010 | 16 |
| 01111011 | 13.675 | 11111011 | 16 |
| 01111100 | 13.7 | 11111100 | 16 |
| 01111101 | 13.725 | 11111101 | 16 |
| 01111110 | 13.75 | 11111110 | 16 |


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| Voltage code | Voltage value | Voltage code | Voltage value |
|---|---|---|---|
| 01111111 | 13.775 | 11111111 | 14.2 V (at 25 °C) with a TC 4.27 mV/°C |

**Table 44. LRC duration (4 bits) - version C**

| Ramp time | Seconds | Ramp time | Seconds |
|---|---|---|---|
| 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 disable speed (4 bits) - version C**

| Ramp time | Seconds | Ramp time | Seconds |
|---|---|---|---|
| 0000 | 1440 | 1000 | 3620 |
| 0001 | 1620 | 1001 | 4060 |
| 0010 | 1810 | 1010 | 4550 |
| 0011 | 2030 | 1011 | 5110 |
| 0100 | 2280 | 1100 | 5730 |
| 0101 | 2560 | 1101 | 6430 |
| 0110 | 2870 | 1110 | 7200 |
| 0111 | 3220 | 1111 | Always active |

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

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


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


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| Current limitation | Value | Current limitation | Value |
|---|---|---|---|
| 00110110 | 2.16 | 10110110 | 7.28 |
| 00110111 | 2.2 | 10110111 | 7.32 |
| 00111000 | 2.24 | 10111000 | 7.36 |
| 00111001 | 2.28 | 10111001 | 7.4 |
| 00111010 | 2.32 | 10111010 | 7.44 |
| 00111011 | 2.36 | 10111011 | 7.48 |
| 00111100 | 2.4 | 10111100 | 7.52 |
| 00111101 | 2.44 | 10111101 | 7.56 |
| 00111110 | 2.48 | 10111110 | 7.6 |
| 00111111 | 2.52 | 10111111 | 7.64 |
| 01000000 | 2.56 | 11000000 | 7.68 |
| 01000001 | 2.6 | 11000001 | 7.72 |
| 01000010 | 2.64 | 11000010 | 7.76 |
| 01000011 | 2.68 | 11000011 | 7.8 |
| 01000100 | 2.72 | 11000100 | 7.84 |
| 01000101 | 2.76 | 11000101 | 7.88 |
| 01000110 | 2.8 | 11000110 | 7.92 |
| 01000111 | 2.84 | 11000111 | 7.96 |
| 01001000 | 2.88 | 11001000 | 8 |
| 01001001 | 2.92 | 11001001 | 8 |
| 01001010 | 2.96 | 11001010 | 8 |
| 01001011 | 3 | 11001011 | 8 |
| 01001100 | 3.04 | 11001100 | 8 |
| 01001101 | 3.08 | 11001101 | 8 |
| 01001110 | 3.12 | 11001110 | 8 |
| 01001111 | 3.16 | 11001111 | 8 |
| 01010000 | 3.2 | 11010000 | 8 |
| 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 |


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| Current limitation | Value | Current limitation | Value |
|---|---|---|---|
| 01011111 | 3.8 | 11011111 | 8 |
| 01100000 | 3.84 | 11100000 | 8 |
| 01100001 | 3.88 | 11100001 | 8 |
| 01100010 | 3.92 | 11100010 | 8 |
| 01100011 | 3.96 | 11100011 | 8 |
| 01100100 | 4 | 11100100 | 8 |
| 01100101 | 4.04 | 11100101 | 8 |
| 01100110 | 4.08 | 11100110 | 8 |
| 01100111 | 4.12 | 11100111 | 8 |
| 01101000 | 4.16 | 11101000 | 8 |
| 01101001 | 4.2 | 11101001 | 8 |
| 01101010 | 4.24 | 11101010 | 8 |
| 01101011 | 4.28 | 11101011 | 8 |
| 01101100 | 4.32 | 11101100 | 8 |
| 01101101 | 4.36 | 11101101 | 8 |
| 01101110 | 4.4 | 11101110 | 8 |
| 01101111 | 4.44 | 11101111 | 8 |
| 01110000 | 4.48 | 11110000 | 8 |
| 01110001 | 4.52 | 11110001 | 8 |
| 01110010 | 4.56 | 11110010 | 8 |
| 01110011 | 4.6 | 11110011 | 8 |
| 01110100 | 4.64 | 11110100 | 8 |
| 01110101 | 4.68 | 11110101 | 8 |
| 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 (3 bits) - version C**

| Controller output | Value | Controller output | Value |
|---|---|---|---|
| 000 | 0 % < PWM < 25 % | 100 | 62.5 % < PWM < 75 % |
| 001 | 25 % < PWM < 37.5 % | 101 | 75 % < PWM < 87.5 % |
| 010 | 37.5 % < PWM < 50 % | 110 | 87.5 % < PWM < 100 % |
| 011 | 50 % < PWM < 62.5 % | 111 | 100 % |


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**Table 48. Duty cycle value (8 bits) - version C**

| Measured duty cycle | Value | Measured duty cycle | Value |
|---|---|---|---|
| 00000000 | 0.390625 | 10000000 | 50.390625 |
| 00000001 | 0.78125 | 10000001 | 50.78125 |
| 00000010 | 1.171875 | 10000010 | 51.171875 |
| 00000011 | 1.5625 | 10000011 | 51.5625 |
| 00000100 | 1.953125 | 10000100 | 51.953125 |
| 00000101 | 2.34375 | 10000101 | 52.34375 |
| 00000110 | 2.734375 | 10000110 | 52.734375 |
| 00000111 | 3.125 | 10000111 | 53.125 |
| 00001000 | 3.515625 | 10001000 | 53.515625 |
| 00001001 | 3.90625 | 10001001 | 53.90625 |
| 00001010 | 4.296875 | 10001010 | 54.296875 |
| 00001011 | 4.6875 | 10001011 | 54.6875 |
| 00001100 | 5.078125 | 10001100 | 55.078125 |
| 00001101 | 5.46875 | 10001101 | 55.46875 |
| 00001110 | 5.859375 | 10001110 | 55.859375 |
| 00001111 | 6.25 | 10001111 | 56.25 |
| 00010000 | 6.640625 | 10010000 | 56.640625 |
| 00010001 | 7.03125 | 10010001 | 57.03125 |
| 00010010 | 7.421875 | 10010010 | 57.421875 |
| 00010011 | 7.8125 | 10010011 | 57.8125 |
| 00010100 | 8.203125 | 10010100 | 58.203125 |
| 00010101 | 8.59375 | 10010101 | 58.59375 |
| 00010110 | 8.984375 | 10010110 | 58.984375 |
| 00010111 | 9.375 | 10010111 | 59.375 |
| 00011000 | 9.765625 | 10011000 | 59.765625 |
| 00011001 | 10.15625 | 10011001 | 60.15625 |
| 00011010 | 10.546875 | 10011010 | 60.546875 |
| 00011011 | 10.9375 | 10011011 | 60.9375 |
| 00011100 | 11.328125 | 10011100 | 61.328125 |
| 00011101 | 11.71875 | 10011101 | 61.71875 |
| 00011110 | 12.109375 | 10011110 | 62.109375 |
| 00011111 | 12.5 | 10011111 | 62.5 |
| 00100000 | 12.890625 | 10100000 | 62.890625 |
| 00100001 | 13.28125 | 10100001 | 63.28125 |
| 00100010 | 13.671875 | 10100010 | 63.671875 |
| 00100011 | 14.0625 | 10100011 | 64.0625 |
| 00100100 | 14.453125 | 10100100 | 64.453125 |
| 00100101 | 14.84375 | 10100101 | 64.84375 |
| 00100110 | 15.234375 | 10100110 | 65.234375 |
| 00100111 | 15.625 | 10100111 | 65.625 |


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| Measured duty cycle | Value | Measured duty cycle | Value |
|---|---|---|---|
| 00101000 | 16.015625 | 10101000 | 66.015625 |
| 00101001 | 16.40625 | 10101001 | 66.40625 |
| 00101010 | 16.796875 | 10101010 | 66.796875 |
| 00101011 | 17.1875 | 10101011 | 67.1875 |
| 00101100 | 17.578125 | 10101100 | 67.578125 |
| 00101101 | 17.96875 | 10101101 | 67.96875 |
| 00101110 | 18.359375 | 10101110 | 68.359375 |
| 00101111 | 18.75 | 10101111 | 68.75 |
| 00110000 | 19.140625 | 10110000 | 69.140625 |
| 00110001 | 19.53125 | 10110001 | 69.53125 |
| 00110010 | 19.921875 | 10110010 | 69.921875 |
| 00110011 | 20.3125 | 10110011 | 70.3125 |
| 00110100 | 20.703125 | 10110100 | 70.703125 |
| 00110101 | 21.09375 | 10110101 | 71.09375 |
| 00110110 | 21.484375 | 10110110 | 71.484375 |
| 00110111 | 21.875 | 10110111 | 71.875 |
| 00111000 | 22.265625 | 10111000 | 72.265625 |
| 00111001 | 22.65625 | 10111001 | 72.65625 |
| 00111010 | 23.046875 | 10111010 | 73.046875 |
| 00111011 | 23.4375 | 10111011 | 73.4375 |
| 00111100 | 23.828125 | 10111100 | 73.828125 |
| 00111101 | 24.21875 | 10111101 | 74.21875 |
| 00111110 | 24.609375 | 10111110 | 74.609375 |
| 00111111 | 25 | 10111111 | 75 |
| 01000000 | 25.390625 | 11000000 | 75.390625 |
| 01000001 | 25.78125 | 11000001 | 75.78125 |
| 01000010 | 26.171875 | 11000010 | 76.171875 |
| 01000011 | 26.5625 | 11000011 | 76.5625 |
| 01000100 | 26.953125 | 11000100 | 76.953125 |
| 01000101 | 27.34375 | 11000101 | 77.34375 |
| 01000110 | 27.734375 | 11000110 | 77.734375 |
| 01000111 | 28.125 | 11000111 | 78.125 |
| 01001000 | 28.515625 | 11001000 | 78.515625 |
| 01001001 | 28.90625 | 11001001 | 78.90625 |
| 01001010 | 29.296875 | 11001010 | 79.296875 |
| 01001011 | 29.6875 | 11001011 | 79.6875 |
| 01001100 | 30.078125 | 11001100 | 80.078125 |
| 01001101 | 30.46875 | 11001101 | 80.46875 |
| 01001110 | 30.859375 | 11001110 | 80.859375 |
| 01001111 | 31.25 | 11001111 | 81.25 |
| 01010000 | 31.640625 | 11010000 | 81.640625 |


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| Measured duty cycle | Value | Measured duty cycle | Value |
|---|---|---|---|
| 01010001 | 32.03125 | 11010001 | 82.03125 |
| 01010010 | 32.421875 | 11010010 | 82.421875 |
| 01010011 | 32.8125 | 11010011 | 82.8125 |
| 01010100 | 33.203125 | 11010100 | 83.203125 |
| 01010101 | 33.59375 | 11010101 | 83.59375 |
| 01010110 | 33.984375 | 11010110 | 83.984375 |
| 01010111 | 34.375 | 11010111 | 84.375 |
| 01011000 | 34.765625 | 11011000 | 84.765625 |
| 01011001 | 35.15625 | 11011001 | 85.15625 |
| 01011010 | 35.546875 | 11011010 | 85.546875 |
| 01011011 | 35.9375 | 11011011 | 85.9375 |
| 01011100 | 36.328125 | 11011100 | 86.328125 |
| 01011101 | 36.71875 | 11011101 | 86.71875 |
| 01011110 | 37.109375 | 11011110 | 87.109375 |
| 01011111 | 37.5 | 11011111 | 87.5 |
| 01100000 | 37.890625 | 11100000 | 87.890625 |
| 01100001 | 38.28125 | 11100001 | 88.28125 |
| 01100010 | 38.671875 | 11100010 | 88.671875 |
| 01100011 | 39.0625 | 11100011 | 89.0625 |
| 01100100 | 39.453125 | 11100100 | 89.453125 |
| 01100101 | 39.84375 | 11100101 | 89.84375 |
| 01100110 | 40.234375 | 11100110 | 90.234375 |
| 01100111 | 40.625 | 11100111 | 90.625 |
| 01101000 | 41.015625 | 11101000 | 91.015625 |
| 01101001 | 41.40625 | 11101001 | 91.40625 |
| 01101010 | 41.796875 | 11101010 | 91.796875 |
| 01101011 | 42.1875 | 11101011 | 92.1875 |
| 01101100 | 42.578125 | 11101100 | 92.578125 |
| 01101101 | 42.96875 | 11101101 | 92.96875 |
| 01101110 | 43.359375 | 11101110 | 93.359375 |
| 01101111 | 43.75 | 11101111 | 93.75 |
| 01110000 | 44.140625 | 11110000 | 94.140625 |
| 01110001 | 44.53125 | 11110001 | 94.53125 |
| 01110010 | 44.921875 | 11110010 | 94.921875 |
| 01110011 | 45.3125 | 11110011 | 95.3125 |
| 01110100 | 45.703125 | 11110100 | 95.703125 |
| 01110101 | 46.09375 | 11110101 | 96.09375 |
| 01110110 | 46.484375 | 11110110 | 96.484375 |
| 01110111 | 46.875 | 11110111 | 96.875 |
| 01111000 | 47.265625 | 11111000 | 97.265625 |
| 01111001 | 47.65625 | 11111001 | 97.65625 |


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| Measured duty cycle | Value | Measured duty cycle | Value |
|---|---|---|---|
| 01111010 | 48.046875 | 11111010 | 98.046875 |
| 01111011 | 48.4375 | 11111011 | 98.4375 |
| 01111100 | 48.828125 | 11111100 | 98.828125 |
| 01111101 | 49.21875 | 11111101 | 99.21875 |
| 01111110 | 49.609375 | 11111110 | 99.609375 |
| 01111111 | 50 | 11111111 | 100 |

**Table 49. Excitation current measurement (8 bits) - version C**

| Measured voltage | Value | Current limitation | Value |
|---|---|---|---|
| 00000000 | 0 | 10000000 | 5.12 |
| 00000001 | 0.4 | 10000001 | 5.16 |
| 00000010 | 0.08 | 10000010 | 5.2 |
| 00000011 | 0.12 | 10000011 | 5.24 |
| 00000100 | 0.16 | 10000100 | 5.28 |
| 00000101 | 0.2 | 10000101 | 5.32 |
| 00000110 | 0.24 | 10000110 | 5.36 |
| 00000111 | 0.28 | 10000111 | 5.4 |
| 00001000 | 0.32 | 10001000 | 5.44 |
| 00001001 | 0.36 | 10001001 | 5.48 |
| 00001010 | 0.4 | 10001010 | 5.52 |
| 00001011 | 0.44 | 10001011 | 5.56 |
| 00001100 | 0.48 | 10001100 | 5.6 |
| 00001101 | 0.52 | 10001101 | 5.64 |
| 00001110 | 0.56 | 10001110 | 5.68 |
| 00001111 | 0.6 | 10001111 | 5.72 |
| 00010000 | 0.64 | 10010000 | 5.76 |
| 00010001 | 0.68 | 10010001 | 5.8 |
| 00010010 | 0.72 | 10010010 | 5.84 |
| 00010011 | 0.76 | 10010011 | 5.88 |
| 00010100 | 0.8 | 10010100 | 5.92 |
| 00010101 | 0.84 | 10010101 | 5.96 |
| 00010110 | 0.88 | 10010110 | 6 |
| 00010111 | 0.92 | 10010111 | 6.04 |
| 00011000 | 0.96 | 10011000 | 6.08 |
| 00011001 | 1 | 10011001 | 6.12 |
| 00011010 | 1.04 | 10011010 | 6.16 |
| 00011011 | 1.08 | 10011011 | 6.2 |
| 00011100 | 1.12 | 10011100 | 6.24 |
| 00011101 | 1.16 | 10011101 | 6.28 |
| 00011110 | 1.2 | 10011110 | 6.32 |


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| Measured voltage | Value | Current limitation | Value |
|---|---|---|---|
| 00011111 | 1.24 | 10011111 | 6.36 |
| 00100000 | 1.28 | 10100000 | 6.4 |
| 00100001 | 1.32 | 10100001 | 6.44 |
| 00100010 | 1.36 | 10100010 | 6.48 |
| 00100011 | 1.4 | 10100011 | 6.52 |
| 00100100 | 1.44 | 10100100 | 6.56 |
| 00100101 | 1.48 | 10100101 | 6.6 |
| 00100110 | 1.52 | 10100110 | 6.64 |
| 00100111 | 1.56 | 10100111 | 6.68 |
| 00101000 | 1.6 | 10101000 | 6.72 |
| 00101001 | 1.64 | 10101001 | 6.76 |
| 00101010 | 1.68 | 10101010 | 6.8 |
| 00101011 | 1.72 | 10101011 | 6.84 |
| 00101100 | 1.76 | 10101100 | 6.88 |
| 00101101 | 1.8 | 10101101 | 6.92 |
| 00101110 | 1.84 | 10101110 | 6.96 |
| 00101111 | 1.88 | 10101111 | 7 |
| 00110000 | 1.92 | 10110000 | 7.04 |
| 00110001 | 1.96 | 10110001 | 7.08 |
| 00110010 | 2 | 10110010 | 7.12 |
| 00110011 | 2.04 | 10110011 | 7.16 |
| 00110100 | 2.08 | 10110100 | 7.2 |
| 00110101 | 2.12 | 10110101 | 7.24 |
| 00110110 | 2.16 | 10110110 | 7.28 |
| 00110111 | 2.2 | 10110111 | 7.32 |
| 00111000 | 2.24 | 10111000 | 7.36 |
| 00111001 | 2.28 | 10111001 | 7.4 |
| 00111010 | 2.32 | 10111010 | 7.44 |
| 00111011 | 2.36 | 10111011 | 7.48 |
| 00111100 | 2.4 | 10111100 | 7.52 |
| 00111101 | 2.44 | 10111101 | 7.56 |
| 00111110 | 2.48 | 10111110 | 7.6 |
| 00111111 | 2.52 | 10111111 | 7.64 |
| 01000000 | 2.56 | 11000000 | 7.68 |
| 01000001 | 2.6 | 11000001 | 7.72 |
| 01000010 | 2.64 | 11000010 | 7.76 |
| 01000011 | 2.68 | 11000011 | 7.8 |
| 01000100 | 2.72 | 11000100 | 7.84 |
| 01000101 | 2.76 | 11000101 | 7.88 |
| 01000110 | 2.8 | 11000110 | 7.92 |
| 01000111 | 2.84 | 11000111 | 7.96 |


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| Measured voltage | Value | Current limitation | Value |
|---|---|---|---|
| 01001000 | 2.88 | 11001000 | 8 |
| 01001001 | 2.92 | 11001001 | 8 |
| 01001010 | 2.96 | 11001010 | 8 |
| 01001011 | 3 | 11001011 | 8 |
| 01001100 | 3.04 | 11001100 | 8 |
| 01001101 | 3.08 | 11001101 | 8 |
| 01001110 | 3.12 | 11001110 | 8 |
| 01001111 | 3.16 | 11001111 | 8 |
| 01010000 | 3.2 | 11010000 | 8 |
| 01010001 | 3.24 | 11010001 | 8 |
| 01010010 | 3.28 | 11010010 | 8 |
| 01010011 | 3.32 | 11010011 | 8 |
| 01010100 | 3.36 | 11010100 | 8 |
| 01010101 | 3.4 | 11010101 | 8 |
| 01010110 | 3.44 | 11010110 | 8 |
| 01010111 | 3.48 | 11010111 | 8 |
| 01011000 | 3.52 | 11011000 | 8 |
| 01011001 | 3.56 | 11011001 | 8 |
| 01011010 | 3.6 | 11011010 | 8 |
| 01011011 | 3.64 | 11011011 | 8 |
| 01011100 | 3.68 | 11011100 | 8 |
| 01011101 | 3.72 | 11011101 | 8 |
| 01011110 | 3.76 | 11011110 | 8 |
| 01011111 | 3.8 | 11011111 | 8 |
| 01100000 | 3.84 | 11100000 | 8 |
| 01100001 | 3.88 | 11100001 | 8 |
| 01100010 | 3.92 | 11100010 | 8 |
| 01100011 | 3.96 | 11100011 | 8 |
| 01100100 | 4 | 11100100 | 8 |
| 01100101 | 4.04 | 11100101 | 8 |
| 01100110 | 4.08 | 11100110 | 8 |
| 01100111 | 4.12 | 11100111 | 8 |
| 01101000 | 4.16 | 11101000 | 8 |
| 01101001 | 4.2 | 11101001 | 8 |
| 01101010 | 4.24 | 11101010 | 8 |
| 01101011 | 4.28 | 11101011 | 8 |
| 01101100 | 4.32 | 11101100 | 8 |
| 01101101 | 4.36 | 11101101 | 8 |
| 01101110 | 4.4 | 11101110 | 8 |
| 01101111 | 4.44 | 11101111 | 8 |
| 01110000 | 4.48 | 11110000 | 8 |


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

**Table 50. Battery voltage measurement (8 bits) - version C**

| Measured voltage | Value | Current limitation | Value |
|---|---|---|---|
| 00000000 | 9 | 10000000 | 15.4 |
| 00000001 | 9.05 | 10000001 | 15.45 |
| 00000010 | 9.1 | 10000010 | 15.5 |
| 00000011 | 9.15 | 10000011 | 15.55 |
| 00000100 | 9.2 | 10000100 | 15.6 |
| 00000101 | 9.25 | 10000101 | 15.65 |
| 00000110 | 9.3 | 10000110 | 15.7 |
| 00000111 | 9.35 | 10000111 | 15.75 |
| 00001000 | 9.4 | 10001000 | 15.8 |
| 00001001 | 9.45 | 10001001 | 15.85 |
| 00001010 | 9.5 | 10001010 | 15.9 |
| 00001011 | 9.55 | 10001011 | 15.95 |
| 00001100 | 9.6 | 10001100 | 16 |
| 00001101 | 9.65 | 10001101 | 16.05 |
| 00001110 | 9.7 | 10001110 | 16.1 |
| 00001111 | 9.75 | 10001111 | 16.15 |
| 00010000 | 9.8 | 10010000 | 16.2 |
| 00010001 | 9.85 | 10010001 | 16.25 |
| 00010010 | 9.9 | 10010010 | 16.3 |
| 00010011 | 9.95 | 10010011 | 16.35 |
| 00010100 | 10 | 10010100 | 16.4 |
| 00010101 | 10.05 | 10010101 | 16.45 |


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


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| Measured voltage | Value | Current limitation | Value |
|---|---|---|---|
| 00111111 | 12.15 | 10111111 | 18 |
| 01000000 | 12.2 | 11000000 | 18 |
| 01000001 | 12.25 | 11000001 | 18 |
| 01000010 | 12.3 | 11000010 | 18 |
| 01000011 | 12.35 | 11000011 | 18 |
| 01000100 | 12.4 | 11000100 | 18 |
| 01000101 | 12.45 | 11000101 | 18 |
| 01000110 | 12.5 | 11000110 | 18 |
| 01000111 | 12.55 | 11000111 | 18 |
| 01001000 | 12.6 | 11001000 | 18 |
| 01001001 | 12.65 | 11001001 | 18 |
| 01001010 | 12.7 | 11001010 | 18 |
| 01001011 | 12.75 | 11001011 | 18 |
| 01001100 | 12.8 | 11001100 | 18 |
| 01001101 | 12.85 | 11001101 | 18 |
| 01001110 | 12.9 | 11001110 | 18 |
| 01001111 | 12.95 | 11001111 | 18 |
| 01010000 | 13 | 11010000 | 18 |
| 01010001 | 13.05 | 11010001 | 18 |
| 01010010 | 13.1 | 11010010 | 18 |
| 01010011 | 13.15 | 11010011 | 18 |
| 01010100 | 13.2 | 11010100 | 18 |
| 01010101 | 13.25 | 11010101 | 18 |
| 01010110 | 13.3 | 11010110 | 18 |
| 01010111 | 13.35 | 11010111 | 18 |
| 01011000 | 13.4 | 11011000 | 18 |
| 01011001 | 13.45 | 11011001 | 18 |
| 01011010 | 13.5 | 11011010 | 18 |
| 01011011 | 13.55 | 11011011 | 18 |
| 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 |


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| Measured voltage | Value | Current limitation | Value |
|---|---|---|---|
| 01101000 | 14.2 | 11101000 | 18 |
| 01101001 | 14.25 | 11101001 | 18 |
| 01101010 | 14.3 | 11101010 | 18 |
| 01101011 | 14.35 | 11101011 | 18 |
| 01101100 | 14.4 | 11101100 | 18 |
| 01101101 | 14.45 | 11101101 | 18 |
| 01101110 | 14.5 | 11101110 | 18 |
| 01101111 | 14.55 | 11101111 | 18 |
| 01110000 | 14.6 | 11110000 | 18 |
| 01110001 | 14.65 | 11110001 | 18 |
| 01110010 | 14.7 | 11110010 | 18 |
| 01110011 | 14.75 | 11110011 | 18 |
| 01110100 | 14.8 | 11110100 | 18 |
| 01110101 | 14.85 | 11110101 | 18 |
| 01110110 | 14.9 | 11110110 | 18 |
| 01110111 | 14.95 | 11110111 | 18 |
| 01111000 | 15 | 11111000 | 18 |
| 01111001 | 15.05 | 11111001 | 18 |
| 01111010 | 15.1 | 11111010 | 18 |
| 01111011 | 15.15 | 11111011 | 18 |
| 01111100 | 15.2 | 11111100 | 18 |
| 01111101 | 15.25 | 11111101 | 18 |
| 01111110 | 15.3 | 11111110 | 18 |
| 01111111 | 15.35 | 11111111 | 18 |

**Table 51. Temperature measurement (8 bits) - version C**

| Measured T °C | Value | Measured T °C | Value |
|---|---|---|---|
| 00000000 | –40 | 10000000 | 87 |
| 00000001 | –39 | 10000001 | 88 |
| 00000010 | –38 | 10000010 | 89 |
| 00000011 | –37 | 10000011 | 90 |
| 00000100 | –36 | 10000100 | 91 |
| 00000101 | –35 | 10000101 | 92 |
| 00000110 | –34 | 10000110 | 93 |
| 00000111 | –33 | 10000111 | 94 |
| 00001000 | –32 | 10001000 | 95 |
| 00001001 | –31 | 10001001 | 96 |
| 00001010 | –30 | 10001010 | 97 |
| 00001011 | –29 | 10001011 | 98 |
| 00001100 | –28 | 10001100 | 99 |


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| Measured T °C | Value | Measured T °C | Value |
|---|---|---|---|
| 00001101 | –27 | 10001101 | 100 |
| 00001110 | –26 | 10001110 | 101 |
| 00001111 | –25 | 10001111 | 102 |
| 00010000 | –24 | 10010000 | 103 |
| 00010001 | –23 | 10010001 | 104 |
| 00010010 | –22 | 10010010 | 105 |
| 00010011 | –21 | 10010011 | 106 |
| 00010100 | –20 | 10010100 | 107 |
| 00010101 | –19 | 10010101 | 108 |
| 00010110 | –18 | 10010110 | 109 |
| 00010111 | –17 | 10010111 | 110 |
| 00011000 | –16 | 10011000 | 111 |
| 00011001 | –15 | 10011001 | 112 |
| 00011010 | –14 | 10011010 | 113 |
| 00011011 | –13 | 10011011 | 114 |
| 00011100 | –12 | 10011100 | 115 |
| 00011101 | –11 | 10011101 | 116 |
| 00011110 | –10 | 10011110 | 117 |
| 00011111 | –9 | 10011111 | 118 |
| 00100000 | –8 | 10100000 | 119 |
| 00100001 | –7 | 10100001 | 120 |
| 00100010 | –6 | 10100010 | 121 |
| 00100011 | –5 | 10100011 | 122 |
| 00100100 | –4 | 10100100 | 123 |
| 00100101 | –3 | 10100101 | 124 |
| 00100110 | –2 | 10100110 | 125 |
| 00100111 | –1 | 10100111 | 126 |
| 00101000 | 0 | 10101000 | 127 |
| 00101001 | 1 | 10101001 | 128 |
| 00101010 | 2 | 10101010 | 129 |
| 00101011 | 3 | 10101011 | 130 |
| 00101100 | 4 | 10101100 | 131 |
| 00101101 | 5 | 10101101 | 132 |
| 00101110 | 6 | 10101110 | 133 |
| 00101111 | 7 | 10101111 | 134 |
| 00110000 | 8 | 10110000 | 135 |
| 00110001 | 9 | 10110001 | 136 |
| 00110010 | 10 | 10110010 | 137 |
| 00110011 | 11 | 10110011 | 138 |
| 00110100 | 12 | 10110100 | 139 |
| 00110101 | 13 | 10110101 | 140 |


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| Measured T °C | Value | Measured T °C | Value |
|---|---|---|---|
| 00110110 | 14 | 10110110 | 141 |
| 00110111 | 15 | 10110111 | 142 |
| 00111000 | 16 | 10111000 | 143 |
| 00111001 | 17 | 10111001 | 144 |
| 00111010 | 18 | 10111010 | 145 |
| 00111011 | 19 | 10111011 | 146 |
| 00111100 | 20 | 10111100 | 147 |
| 00111101 | 21 | 10111101 | 148 |
| 00111110 | 22 | 10111110 | 149 |
| 00111111 | 23 | 10111111 | 150 |
| 01000000 | 24 | 11000000 | 151 |
| 01000001 | 25 | 11000001 | 152 |
| 01000010 | 26 | 11000010 | 153 |
| 01000011 | 27 | 11000011 | 154 |
| 01000100 | 28 | 11000100 | 155 |
| 01000101 | 29 | 11000101 | 156 |
| 01000110 | 30 | 11000110 | 157 |
| 01000111 | 31 | 11000111 | 158 |
| 01001000 | 32 | 11001000 | 159 |
| 01001001 | 33 | 11001001 | 160 |
| 01001010 | 34 | 11001010 | 161 |
| 01001011 | 35 | 11001011 | 162 |
| 01001100 | 36 | 11001100 | 163 |
| 01001101 | 37 | 11001101 | 164 |
| 01001110 | 38 | 11001110 | 165 |
| 01001111 | 39 | 11001111 | 166 |
| 01010000 | 40 | 11010000 | 167 |
| 01010001 | 41 | 11010001 | 168 |
| 01010010 | 42 | 11010010 | 169 |
| 01010011 | 43 | 11010011 | 170 |
| 01010100 | 44 | 11010100 | 171 |
| 01010101 | 45 | 11010101 | 172 |
| 01010110 | 46 | 11010110 | 173 |
| 01010111 | 47 | 11010111 | 174 |
| 01011000 | 48 | 11011000 | 175 |
| 01011001 | 49 | 11011001 | 176 |
| 01011010 | 50 | 11011010 | 177 |
| 01011011 | 51 | 11011011 | 178 |
| 01011100 | 52 | 11011100 | 179 |
| 01011101 | 53 | 11011101 | 180 |
| 01011110 | 54 | 11011110 | 181 |


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| Measured T °C | Value | Measured T °C | Value |
|---|---|---|---|
| 01011111 | 55 | 11011111 | 182 |
| 01100000 | 56 | 11100000 | 183 |
| 01100001 | 57 | 11100001 | 184 |
| 01100010 | 58 | 11100010 | 185 |
| 01100011 | 59 | 11100011 | 186 |
| 01100100 | 60 | 11100100 | 187 |
| 01100101 | 61 | 11100101 | 188 |
| 01100110 | 62 | 11100110 | 189 |
| 01100111 | 63 | 11100111 | 190 |
| 01101000 | 64 | 11101000 | 191 |
| 01101001 | 65 | 11101001 | 192 |
| 01101010 | 66 | 11101010 | 193 |
| 01101011 | 67 | 11101011 | 194 |
| 01101100 | 68 | 11101100 | 195 |
| 01101101 | 69 | 11101101 | 196 |
| 01101110 | 70 | 11101110 | 197 |
| 01101111 | 71 | 11101111 | 198 |
| 01110000 | 72 | 11110000 | 199 |
| 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 52. Duty cycle of controller output (8 bits) - version C**

| Controller output | Value | Controller output | Value |
|---|---|---|---|
| 000 | 0 % < PWM < 25 % | 100 | 62.5 % < PWM < 75 % |
| 001 | 25 % < PWM < 37.5 % | 101 | 75 % < PWM < 87.5 % |
| 010 | 37.5 % < PWM < 50 % | 110 | 87.5 % < PWM < 100 % |
| 011 | 50 % < PWM < 62.5 % | 111 | 100 % |


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**Table 53. Duty cycle value (5 bits) - version D**

| Exc duty cycle | Df (%) | Exc duty cycle | Df (%) |
|---|---|---|---|
| 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 |
| 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 54. Temperature measurement (6 bits) - version D**

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


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| T °C code | Temperature | T °C code | Temperature |
|---|---|---|---|
| 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 55. Duty cycle value (5 bits)- version E**

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

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

| Current rotor | Value | Current rotor | Value |
|---|---|---|---|
| 00000000 | Regulator OFF | 10000000 | 5.12 |
| 00000001 | 0.04 | 10000001 | 5.16 |
| 00000010 | 0.08 | 10000010 | 5.2 |
| 00000011 | 0.12 | 10000011 | 5.24 |
| 00000100 | 0.16 | 10000100 | 5.28 |
| 00000101 | 0.2 | 10000101 | 5.32 |
| 00000110 | 0.24 | 10000110 | 5.36 |


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| Current rotor | Value | Current rotor | Value |
|---|---|---|---|
| 00000111 | 0.28 | 10000111 | 5.4 |
| 00001000 | 0.32 | 10001000 | 5.44 |
| 00001001 | 0.36 | 10001001 | 5.48 |
| 00001010 | 0.4 | 10001010 | 5.52 |
| 00001011 | 0.44 | 10001011 | 5.56 |
| 00001100 | 0.48 | 10001100 | 5.6 |
| 00001101 | 0.52 | 10001101 | 5.64 |
| 00001110 | 0.56 | 10001110 | 5.68 |
| 00001111 | 0.6 | 10001111 | 5.72 |
| 00010000 | 0.64 | 10010000 | 5.76 |
| 00010001 | 0.68 | 10010001 | 5.8 |
| 00010010 | 0.72 | 10010010 | 5.84 |
| 00010011 | 0.76 | 10010011 | 5.88 |
| 00010100 | 0.8 | 10010100 | 5.92 |
| 00010101 | 0.84 | 10010101 | 5.96 |
| 00010110 | 0.88 | 10010110 | 6 |
| 00010111 | 0.92 | 10010111 | 6.04 |
| 00011000 | 0.96 | 10011000 | 6.08 |
| 00011001 | 1 | 10011001 | 6.12 |
| 00011010 | 1.04 | 10011010 | 6.16 |
| 00011011 | 1.08 | 10011011 | 6.2 |
| 00011100 | 1.12 | 10011100 | 6.24 |
| 00011101 | 1.16 | 10011101 | 6.28 |
| 00011110 | 1.2 | 10011110 | 6.32 |
| 00011111 | 1.24 | 10011111 | 6.36 |
| 00100000 | 1.28 | 10100000 | 6.4 |
| 00100001 | 1.32 | 10100001 | 6.44 |
| 00100010 | 1.36 | 10100010 | 6.48 |
| 00100011 | 1.4 | 10100011 | 6.52 |
| 00100100 | 1.44 | 10100100 | 6.56 |
| 00100101 | 1.48 | 10100101 | 6.6 |
| 00100110 | 1.52 | 10100110 | 6.64 |
| 00100111 | 1.56 | 10100111 | 6.68 |
| 00101000 | 1.6 | 10101000 | 6.72 |
| 00101001 | 1.64 | 10101001 | 6.76 |
| 00101010 | 1.68 | 10101010 | 6.8 |
| 00101011 | 1.72 | 10101011 | 6.84 |
| 00101100 | 1.76 | 10101100 | 6.88 |
| 00101101 | 1.8 | 10101101 | 6.92 |
| 00101110 | 1.84 | 10101110 | 6.96 |
| 00101111 | 1.88 | 10101111 | 7 |


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


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


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**Table 57. Regulator temperature (8 bits) - version E**

| Chip temperature | Value | Chip temperature | Value |
|---|---|---|---|
| 00000000 | –40 | 10000000 | 88 |
| 00000001 | –39 | 10000001 | 89 |
| 00000010 | –38 | 10000010 | 90 |
| 00000011 | –37 | 10000011 | 91 |
| 00000100 | –36 | 10000100 | 92 |
| 00000101 | –35 | 10000101 | 93 |
| 00000110 | –34 | 10000110 | 94 |
| 00000111 | –33 | 10000111 | 95 |
| 00001000 | –32 | 10001000 | 96 |
| 00001001 | –31 | 10001001 | 97 |
| 00001010 | –30 | 10001010 | 98 |
| 00001011 | –29 | 10001011 | 99 |
| 00001100 | –28 | 10001100 | 100 |
| 00001101 | –27 | 10001101 | 101 |
| 00001110 | –26 | 10001110 | 102 |
| 00001111 | –25 | 10001111 | 103 |
| 00010000 | –24 | 10010000 | 104 |
| 00010001 | –23 | 10010001 | 105 |
| 00010010 | –22 | 10010010 | 106 |
| 00010011 | –21 | 10010011 | 107 |
| 00010100 | –20 | 10010100 | 108 |
| 00010101 | –19 | 10010101 | 109 |
| 00010110 | –18 | 10010110 | 110 |
| 00010111 | –17 | 10010111 | 111 |
| 00011000 | –16 | 10011000 | 112 |
| 00011001 | –15 | 10011001 | 113 |
| 00011010 | –14 | 10011010 | 114 |
| 00011011 | –13 | 10011011 | 115 |
| 00011100 | –12 | 10011100 | 116 |
| 00011101 | –11 | 10011101 | 117 |
| 00011110 | –10 | 10011110 | 118 |
| 00011111 | –9 | 10011111 | 119 |
| 00100000 | –8 | 10100000 | 120 |
| 00100001 | –7 | 10100001 | 121 |
| 00100010 | –6 | 10100010 | 122 |
| 00100011 | –5 | 10100011 | 123 |
| 00100100 | –4 | 10100100 | 124 |
| 00100101 | –3 | 10100101 | 125 |
| 00100110 | –2 | 10100110 | 126 |
| 00100111 | –1 | 10100111 | 127 |


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


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| Chip temperature | Value | Chip temperature | Value |
|---|---|---|---|
| 01010001 | 41 | 11010001 | 169 |
| 01010010 | 42 | 11010010 | 170 |
| 01010011 | 43 | 11010011 | 171 |
| 01010100 | 44 | 11010100 | 172 |
| 01010101 | 45 | 11010101 | 173 |
| 01010110 | 46 | 11010110 | 174 |
| 01010111 | 47 | 11010111 | 175 |
| 01011000 | 48 | 11011000 | 176 |
| 01011001 | 49 | 11011001 | 177 |
| 01011010 | 50 | 11011010 | 178 |
| 01011011 | 51 | 11011011 | 179 |
| 01011100 | 52 | 11011100 | 180 |
| 01011101 | 53 | 11011101 | 181 |
| 01011110 | 54 | 11011110 | 182 |
| 01011111 | 55 | 11011111 | 183 |
| 01100000 | 56 | 11100000 | 184 |
| 01100001 | 57 | 11100001 | 185 |
| 01100010 | 58 | 11100010 | 186 |
| 01100011 | 59 | 11100011 | 187 |
| 01100100 | 60 | 11100100 | 188 |
| 01100101 | 61 | 11100101 | 189 |
| 01100110 | 62 | 11100110 | 190 |
| 01100111 | 63 | 11100111 | 191 |
| 01101000 | 64 | 11101000 | 192 |
| 01101001 | 65 | 11101001 | 193 |
| 01101010 | 66 | 11101010 | 194 |
| 01101011 | 67 | 11101011 | 195 |
| 01101100 | 68 | 11101100 | 196 |
| 01101101 | 69 | 11101101 | 197 |
| 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 |


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| Chip temperature | Value | Chip temperature | Value |
|---|---|---|---|
| 01111010 | 82 | 11111010 | 200 |
| 01111011 | 83 | 11111011 | 200 |
| 01111100 | 84 | 11111100 | 200 |
| 01111101 | 85 | 11111101 | 200 |
| 01111110 | 86 | 11111110 | 200 |
| 01111111 | 87 | 11111111 | 200 |

# 13 Logic commands and registers

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

**Table 58. OTP programmable options**

| Function | OTP Bits | Comments |
|---|---|---|
| LIN frame configuration | 4 | See 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 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 14.3 "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) |


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| Function | OTP Bits | Comments |
|---|---|---|
| Electrical flag in case of undervoltage | 1 | Flag = 1 if priority charge function is activated for more than $T_{DEFECT}$ or $V_{SET} > V_{BAT}$<br>Flag = 0 if $V_{SET} > V_{BAT}$ |
| Mechanical flag configuration | 1 | Flag = 1 in PreEXc mode or<br>Flag = 0 if PreExc mode and 10.6 V < $V_{SET}$ < $V_{B+A}$ |
| Overvoltage fault flag | 1 | Enabled or disabled |
| Low-voltage threshold | 2 | 8.75, 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, −200, −300, −400, −350 or −400 mV/°C (±10 %) |
| Fault deglitching time | 2 | 50, 250, 400 or 1000 ms (±10 %) |
| Blind zone default value | 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.

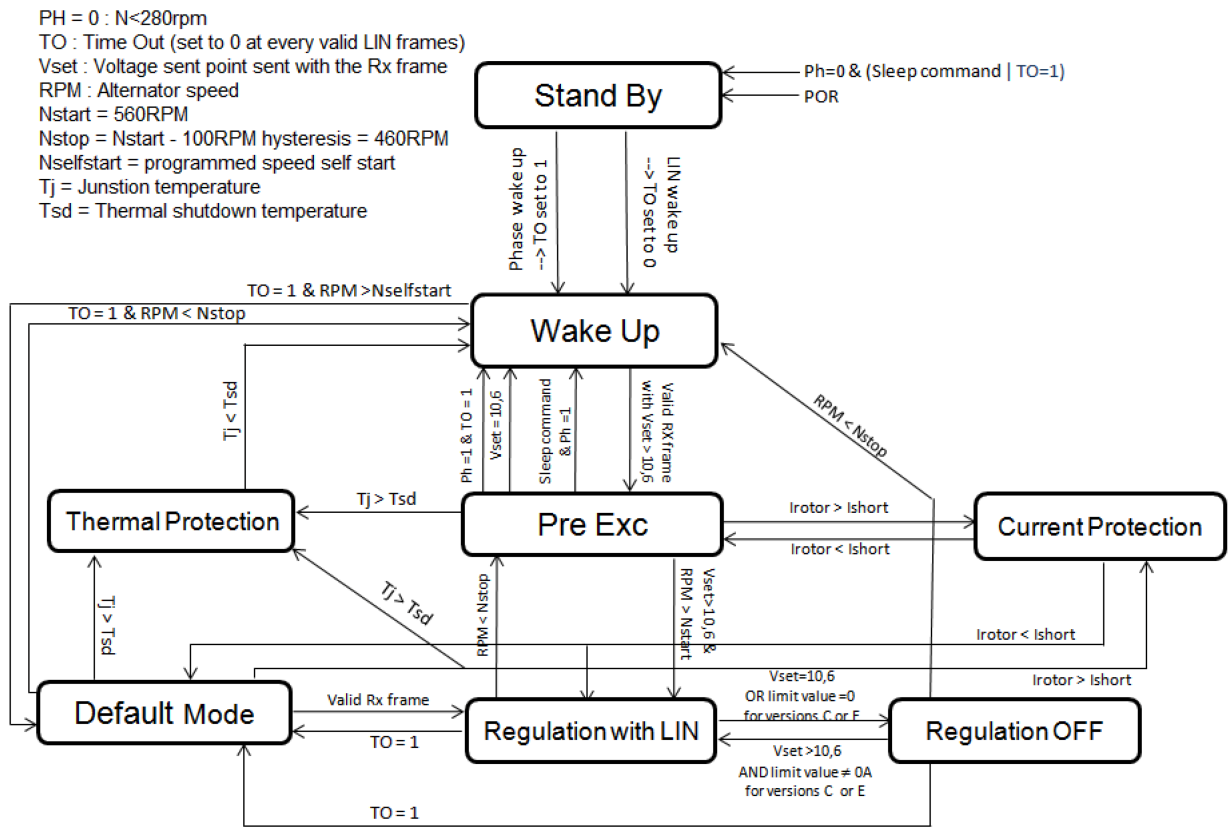


**Figure 6. State machine**

## 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


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- 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 transition is detected on the communication interface or when phase voltage is detected.

- The logic is on and internal clock is available
- All the blocks are on
- There is no regulation. DC = 0%

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

## 14.3 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.

## 14.4 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 ramp time value set by LIN.

## 14.5 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


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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.

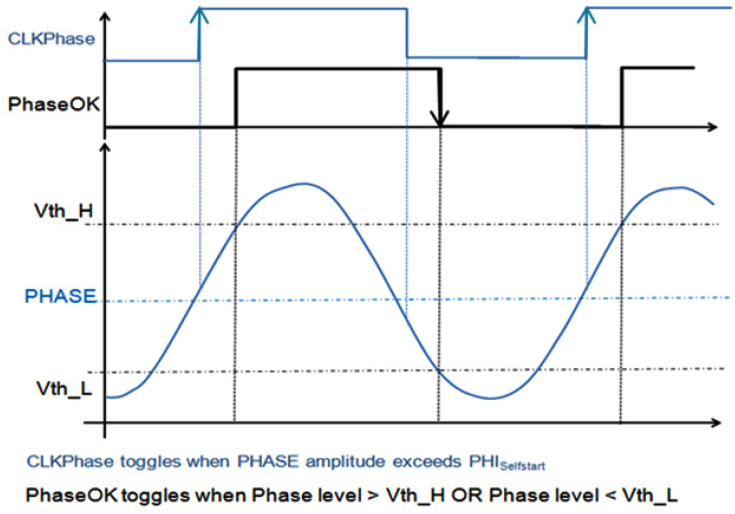


**Figure 7. Phase regulation**

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

**Table 59. CLKPhase detection threshold voltage**

| Mode | Description | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $\Phi_{START1}$ | Minimum peak to peak phase voltage in standby/wake up/default mode | 150 | 200 | 250 | mV |


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| Mode | Description | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $\Phi_{START2}$ | Minimum peak to peak phase processor in pre-excitation/ regulation mode | 700 | 800 | 900 | mV |

Threshold values for PhaseOK signal are as follows:

**Table 60. PHASEOK detection threshold voltage**

| Data | Description | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Vth_H | Positive peak threshold | 3 | 4 | 5 | V |
| Vth_L | Negative peak threshold | 0.75 | 1.78 | 2.25 | V |

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

# 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.


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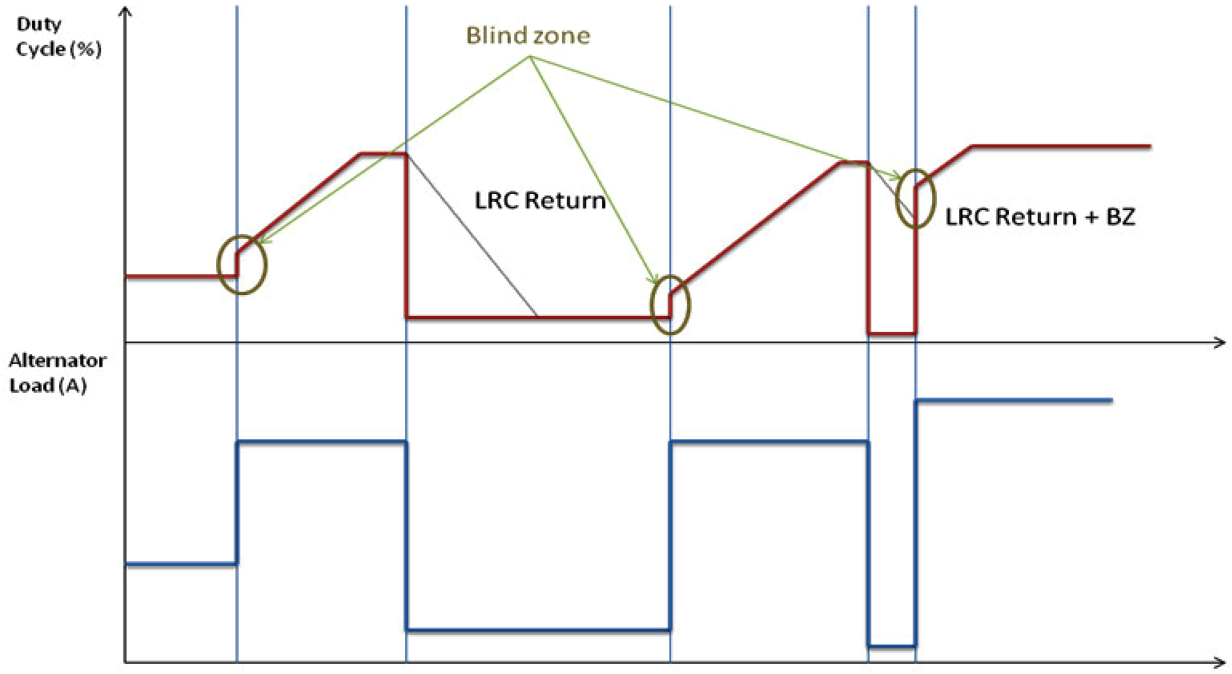


Figure 8. LRC Return

# 18 Operation voltage - priority charge function

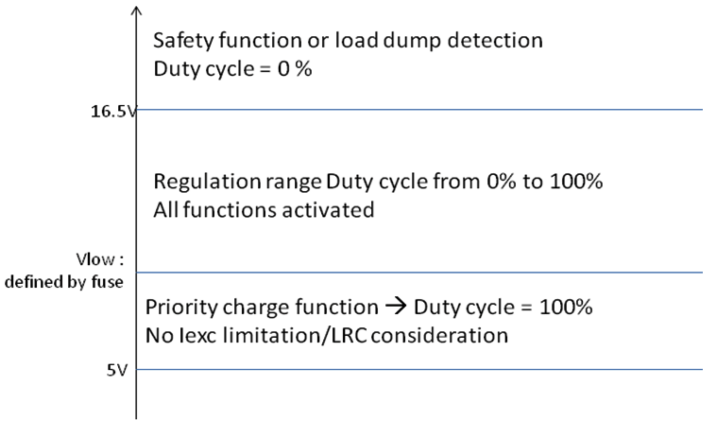


Figure 9. Operation voltage

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.


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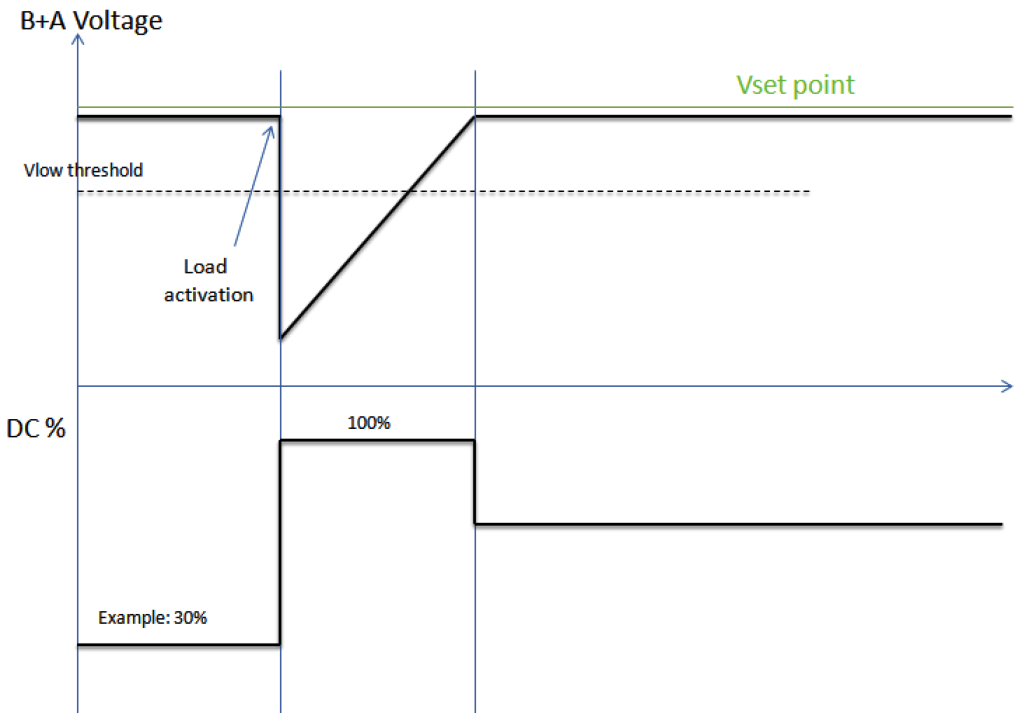


**Figure 10. Priority charge function first behavior**

- 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.

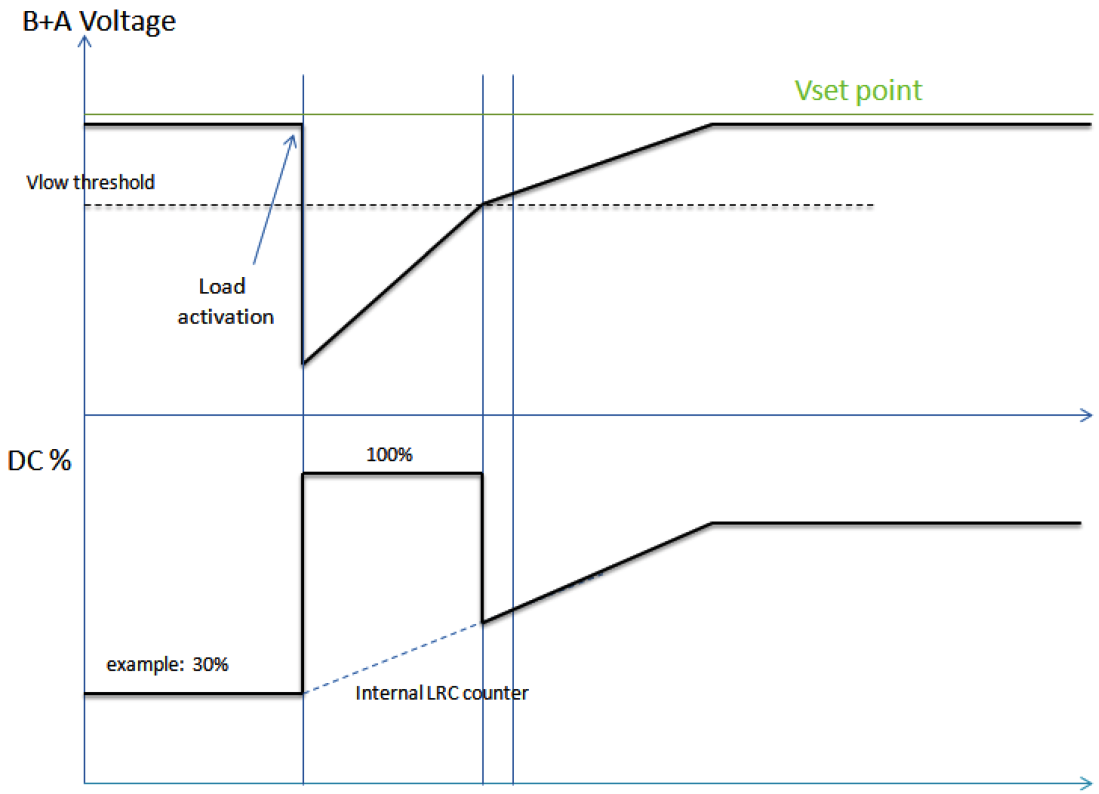


**Figure 11. Priority charge function second behavior**

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


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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.

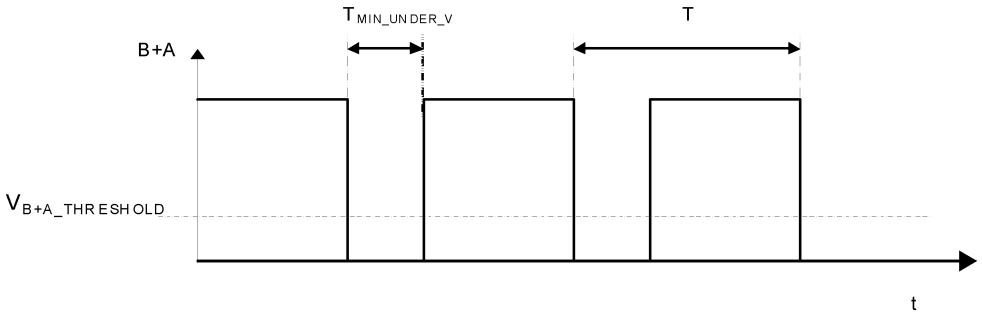


**Figure 12. Battery voltage “microcuts”**

**Table 61. 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 $V_{REAL}$ ±$V_{RIPPLE_WITHOUT_BATTERY}$. The ripple voltage due to the battery disconnection does not exceed $V_{RIPPLE_WITHOUT_BATTERY}$ and regulation continues in these conditions.

**Table 62. 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 to160 °C). In this case, the voltage set point is fixed


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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).

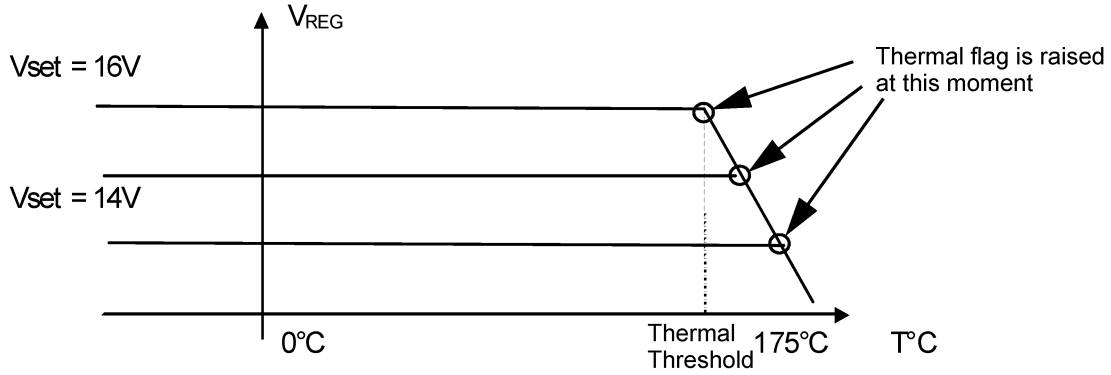


**Figure 13. Thermal compensation**

# 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 regulator is in pre-excitation mode and the alternator speed is $0 < N_{ALT} < N_{STOP}$, the flag must be set to 1.

## 22.3 Electrical fault (F_EL)

If one of these faults appear:

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


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– 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.

## 22.6 Communication error flag

- LIN 2.1 or LIN1.3: “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

## 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 enabled by OTP.

## 22.8 Excitation current limitation flag

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

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

This flag has to be enabled by OTP.

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


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**Table 63. F_MEC, F_EL, and F_HT operation details**

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

[1] Can be disabled by OTP


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# 23 Safety function

To avoid battery overcharge, a safety function is implemented with two redundant methods to measure the battery voltage. The voltage dividers and voltage references shown in Figure 14 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.

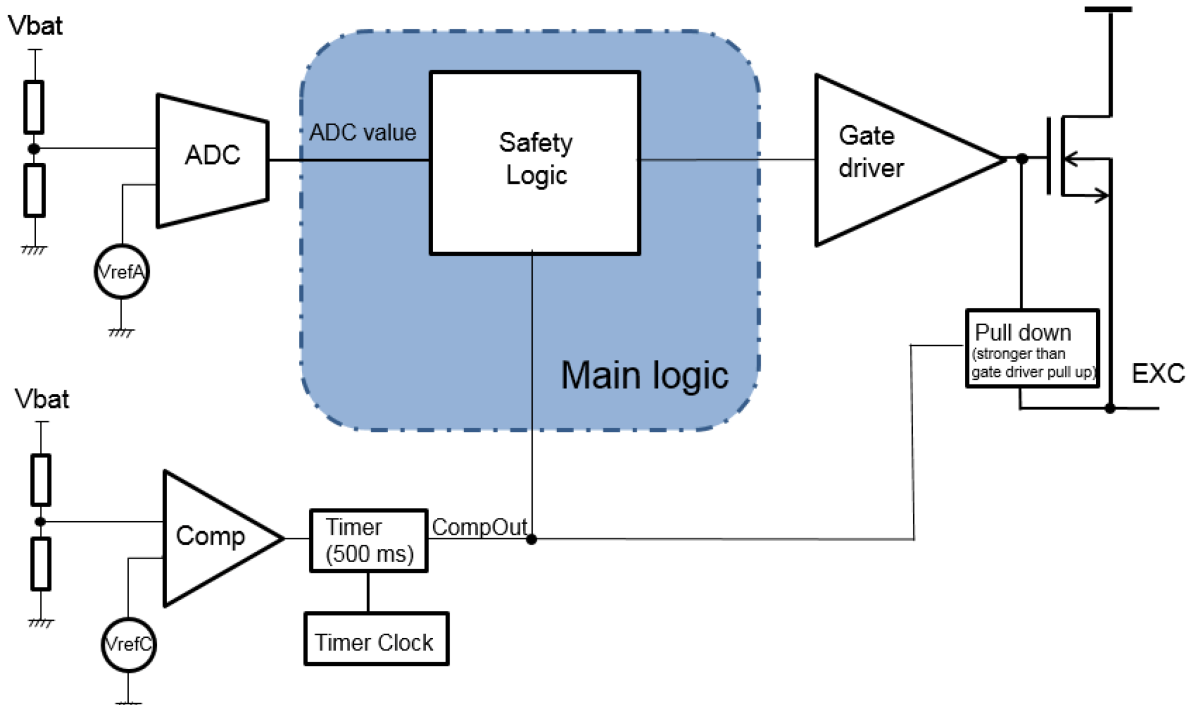


**Figure 14. Safety function**

**Table 64. 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 programmation

## 24.1 Test mode entry

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


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- 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 function are 32 shorter. For example, if an LRC ramp time of 10 s is required by LIN, in this specific mode, the LRC duration is 10 s/32 = 312 ms.

### 24.2.2 ii/ Clocks deactivation

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

### 24.2.3 iii/ Test mode deactivation

This function is used to exit Test mode.

### 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.


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# 25 Revision history

| Revision | Date | Description of changes |
|---|---|---|
| 1.0 | 4/2016 | Initial release |
| | 4/2016 | Updated Table 1 |


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# 27 Contact information

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