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AR6000

Alternator regulator with LIN

Rev. 5.1 — 12 October 2017

Data sheet: advance information

1 General description

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

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

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

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

2 Simplified application diagram

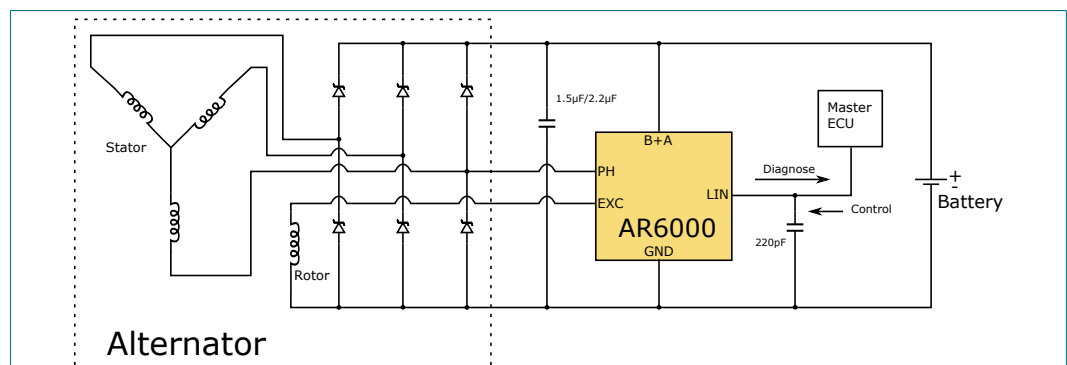


Figure 1. Simplified application diagram (LIN Mode)

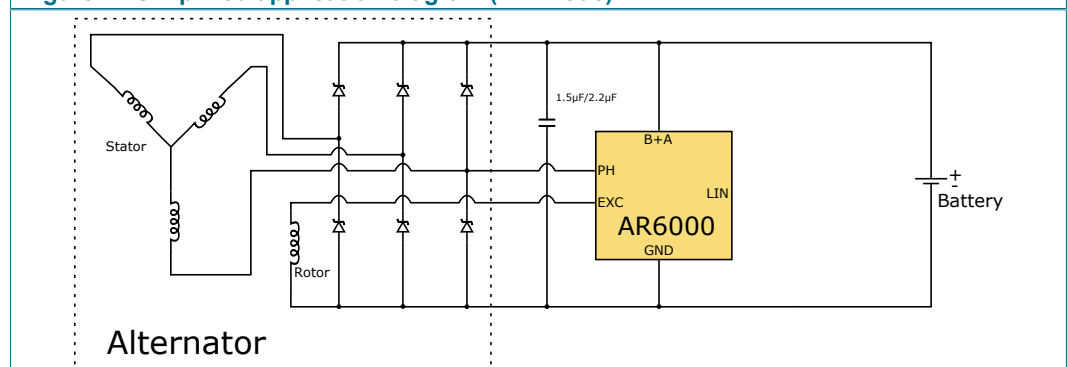


Figure 2. Simplified application diagram (standalone, self-start mode)



3 Features and benefits

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

4 Applications

- Automotive alternators

5 Orderable parts

Table 1. Orderable part variations

Part number	Temperature (T _A)	Package
MC33AR6000BGWS ^[1]	-40 °C to 150 °C	Die
MC33AR6000BGT ^[1]	-40 °C to 125 °C	TO220

- [1] The AR6000 devices are configurable with One Time Programmable (OTP) options described in [Table 56](#). For easy design-in, contact your local NXP sales representative to receive limited engineering samples in the TO-220 package configured to your system requirements.

6 Internal block diagram

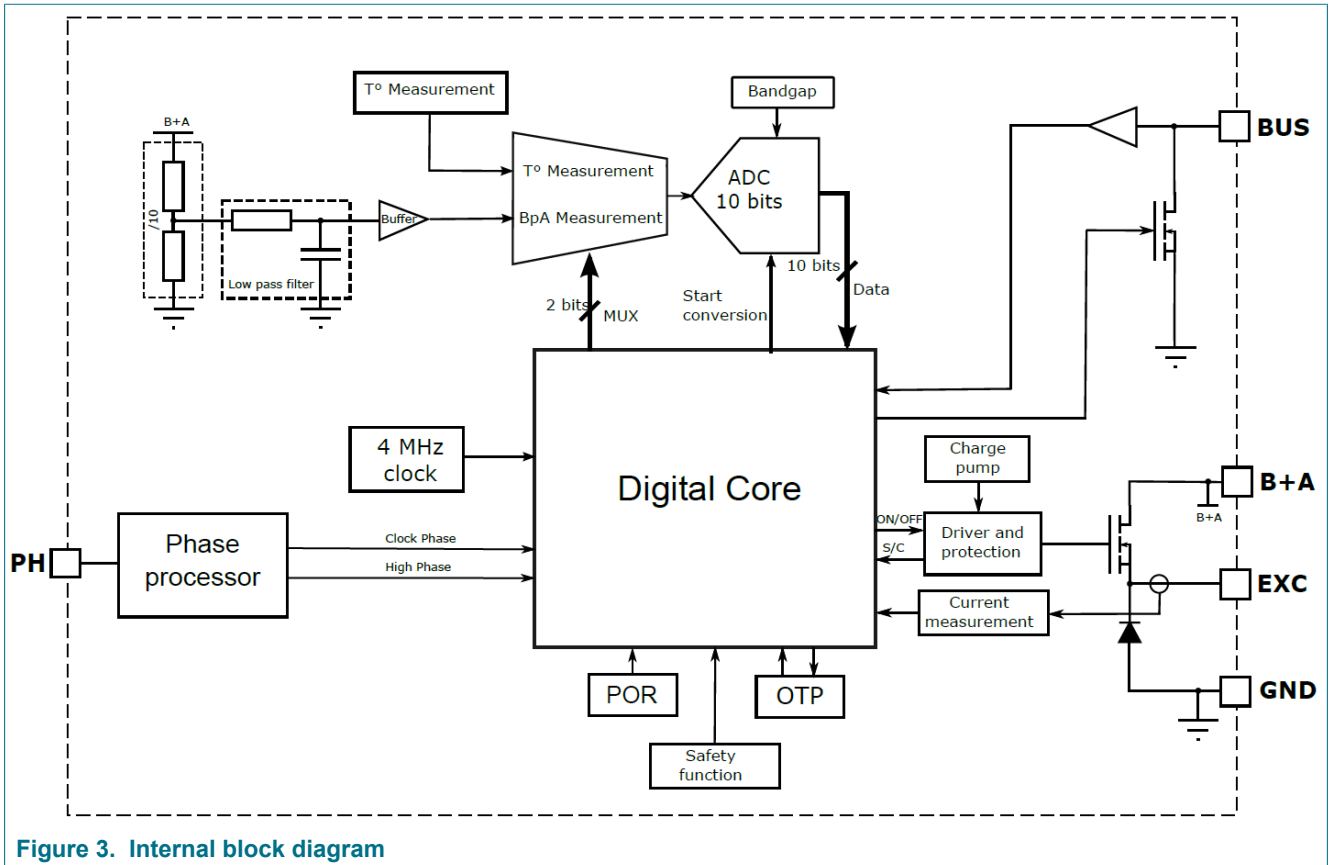


Figure 3. Internal block diagram

7 Pinning information

7.1 Pinning

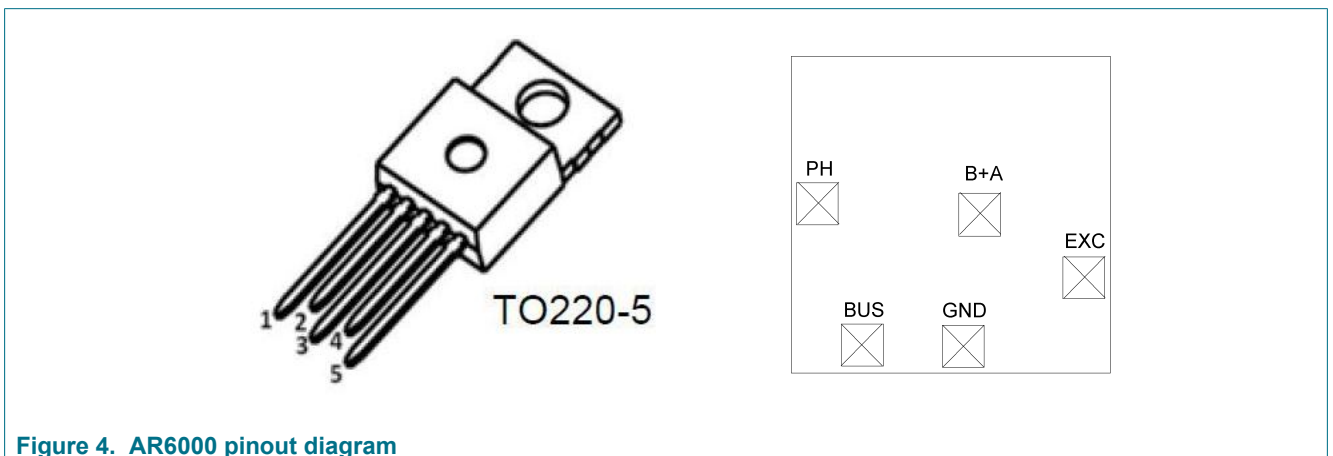
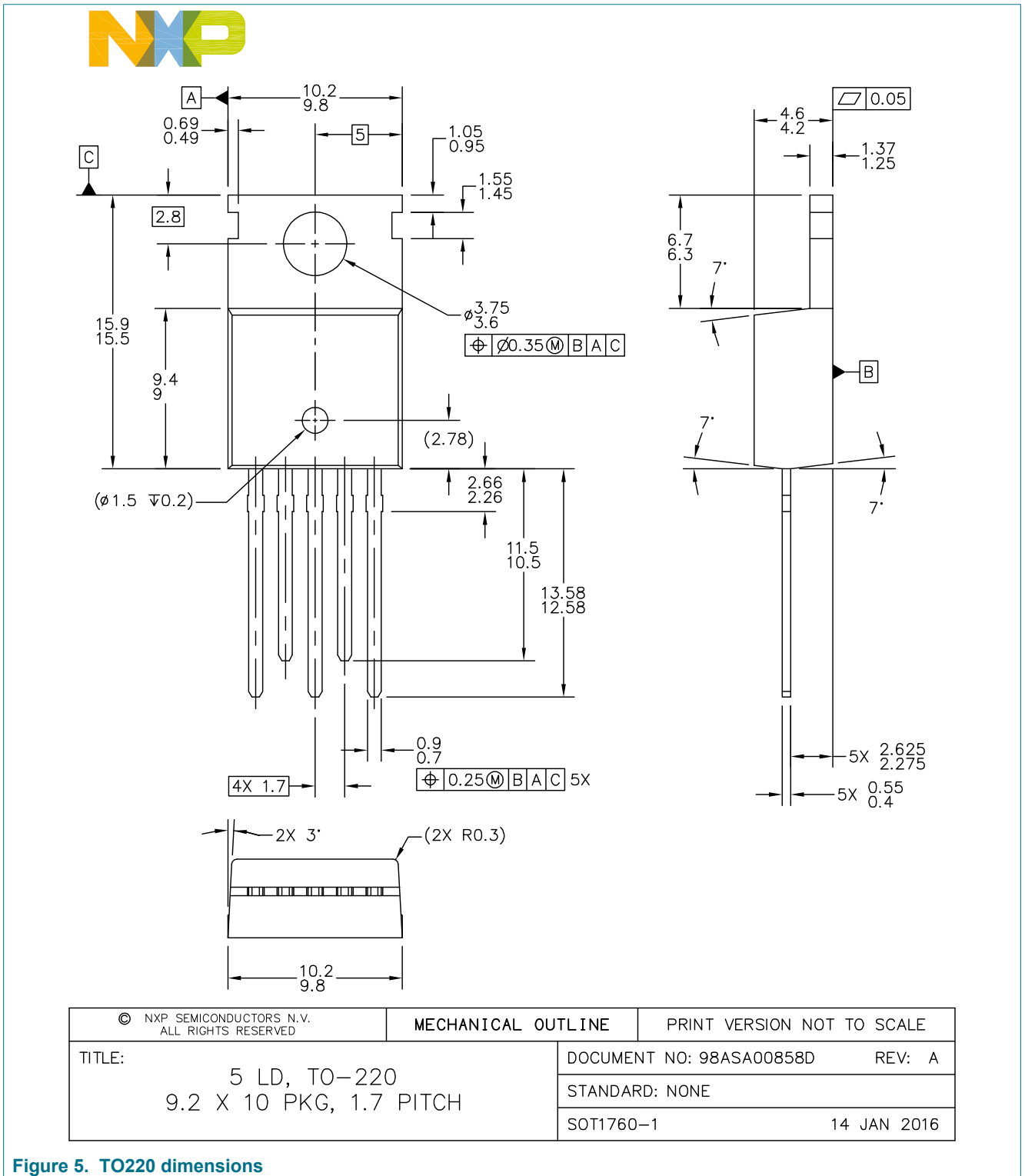


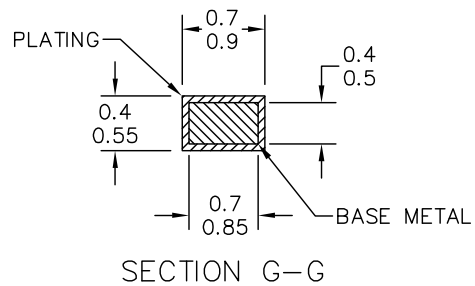
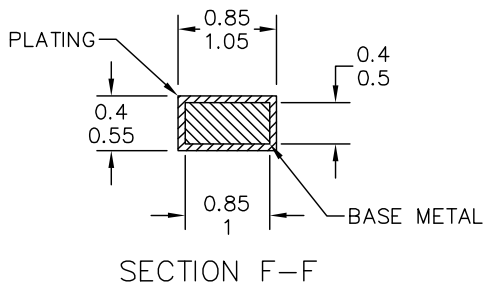
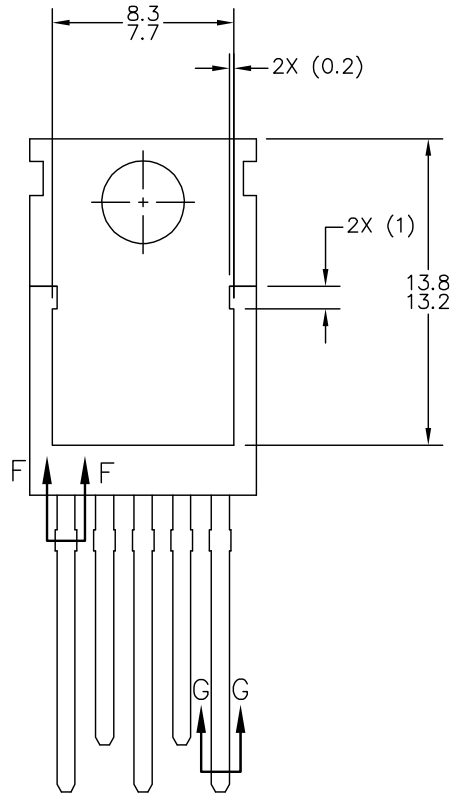
Figure 4. AR6000 pinout diagram

Table 2. Pin coordinates for die version

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

[1] Pad size is 800 μm x 800 μm .





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TITLE: 5 LD, TO-220 9.2 X 10 PKG, 1.7 PITCH	DOCUMENT NO: 98ASA00858D	REV: A
	STANDARD: NONE	
	SOT1760-1	14 JAN 2016

Figure 6. TO220 dimensions (continued)

7.2 Pin definitions

A functional description of each pin can be found in [Section 9.2 "Functional pin description"](#).

Table 3. Pin description

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

Table 4. Mandatory external components

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

8 General product characteristics

8.1 Maximum ratings

Table 5. Maximum ratings

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

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

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

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

8.2 Thermal characteristics

Table 6. Thermal ratings

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

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

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

8.3 Static electrical characteristics

Table 7. Static electrical characteristics

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

Symbol	Characteristic	Min.	Typ.	Max.	Unit
V _{B+A}	Operating voltage, V _{B+A} ^[1]	5.0	—	16.5	V
V _{BUS}	Bus operating voltage (LIN)	8.0	—	18	V
I _{SB25}	Standby current at 25 °C, at V _{B+A} = 12.8 V (Phase at 0 V, V _{LIN} = V _{B+A})	—	60	75	µA
I _{SB150}	Standby current at 150 °C, at V _{B+A} = 12.8 V (Phase at 0 V, V _{LIN} = V _{B+A})	—	80	130	µA
I	Standby current In pre wake-up mode at 25 °C	—	—	130	µA
I _{OP}	Operating current no EXC Load at 25 °C and V _{B+A} = 13 V	—	—	18	mA
V _{REG}	Range of regulation voltage (50 % DC)	10.60	—	16	V
ΔV _{REG1}	V _{REG} setting accuracy voltage at 50 % for V _{REG} = 13.8 V at T _J = 25 °C (die version), at T _J = 125 °C (TO220 version), based on test results at 25 °C and 150 °C	-100	—	+100	mV

Symbol	Characteristic	Min.	Typ.	Max.	Unit
ΔV_{REG2}	V_{REG} setting accuracy voltage Total variation with respect to real target voltage	-250	—	+250	mV
V_{OS_MAX}	Overvoltage threshold	16.5	—	—	V
V_{Low}	Low-voltage threshold ^[2]	8.55	—	10.45	V
$R_{DS_ON_EXC}$	R_{DS_ON} FIELD T MOS at $T_J = 150\text{ }^\circ\text{C}$ (for $V_{B+A} > 7.0\text{ V}$) ^[3]	—	—	100	m Ω
V_F	Recirculation diode voltage at 5.0 A (Excitation current)	—	1.2	1.5	V
V_{OV}	Safety function	16.2	16.5	16.8	V
I_{EXC_SC}	EXC short-circuit protection threshold ^[2]	8.0	10	13.5	A
LIN INTERFACE (Parameters refer to LIN Physical Layer Spec Revision 2.1)					
I_{BUS_LIM}	Current limitation for driver dominant state, driver on $V_{BUS} = 18\text{ V}$	—	62	150	mA
$I_{BUS_PAS_DOM}$	Input leakage current at the receiver. Dominant state (Driver OFF, $V_{BAT} = 12\text{ V}$, $V_{BUS} = 0\text{ V}$)	-1.0	—	—	mA
$I_{BUS_PAS_REC}$	Input leakage current at the receiver. Recessive state (Driver OFF, $8.0\text{ V} < V_{BAT} < 18\text{ V}$, $8.0\text{ V} < V_{BUS} < 18\text{ V}$, $V_{BUS} > V_{BAT}$)	—	—	20	μA
$I_{BUS_NO_GND}$	Ground disconnection. $GND = V_{SUP}$, $0\text{ V} < V_{BUS} < 18\text{ V}$, $V_{BAT} = 12\text{ V}$. Loss of local GND does not affect communication in the residual network	-1.0	—	1.0	mA
$I_{BUS_NO_BAT}$	VBAT disconnection. $V_{SUP} = GND$, $0\text{ V} < V_{BUS} < 18\text{ V}$. Node sustains the current that can flow under this condition. LIN bus remains operational	—	—	100	μA
V_{BUS_DOM}	Receiver dominant state	—	—	$0.4 V_{SUP}$	V
V_{BUS_REC}	Receiver recessive state	$0.6 V_{SUP}$	—	—	V
V_{BUS_CNT}	$V_{BUS_CNT} = (V_{TH_REC} + V_{TH_DOM})/2$	$0.475 V_{SUP}$	—	$0.525 V_{SUP}$	V
V_{HYST}	$V_{HYST} = V_{TH_REC} - V_{TH_DOM}$	—	—	$0.175 V_{SUP}$	V
R_{SLAVE}	Pull-up resistor	20	—	60	k Ω
C_{LIN}	Internal capacitor	—	—	30	pF

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

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

[3] The thermal capability of the packaging is critical to the full use of the output drive.

8.4 Dynamic electrical characteristics

Table 8. Dynamic electrical characteristics

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

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

Symbol	Characteristic	Min.	Typ.	Max.	Unit
N _{HYST}	Hysteresis in speed between start and stop of regulation	50	100	150	RPM
ΔLRC	Delta LRC duty cycle	—	3.125	—	%
LIN INTERFACE (Parameters refer to LIN Physical Layer Spec Revision 2.1)					
TOL _{CLK}	Lin controller clock (4 MHz relaxation oscillator) Clock overall tolerance	-10	—	10	%
F _{TOL_SYNC}	Bit rate tolerance Deviation of slave node bit rate relative to the master node bit rate after synchronization	—	—	2	%
t _{BFS}	Value of accuracy of the byte field detection	—	—	2/16	Tbit
t _{EBS}	Earliest bit sample time, t _{EBS} ≤ t _{LBS}	7/16	—	—	Tbit
t _{LBS}	Latest bit sample time, t _{EBS} ≥ t _{LBS}	—	—	10/16Tbit - t _{BFS}	Tbit
D1 Valid for 20 kBaud	Duty cycle D1 TH _{REC(max)} = 0.744 × V _{SUP} , TH _{DOM(max)} = 0.581 × V _{SUP} V _{SUP} 7.0 V to 18 V, t _{BIT} = 50 μs D1 = t _{BUS-rec(min)} / (2t _{BIT})	0.396	—	—	%
D2 Valid for 20 kBaud	Duty cycle D2 TH _{REC(min)} = 0.422 × V _{SUP} , TH _{DOM(min)} = 0.284 × V _{SUP} V _{SUP} 7.6 V to 18 V, t _{BIT} = 50 μs D2 = t _{BUS-rec(max)} / (2t _{BIT})	—	—	0.581	%
D3 Valid for 10.4 kBaud	Duty cycle D3 TH _{REC(max)} = 0.778 × V _{SUP} , TH _{DOM(max)} = 0.616 × V _{SUP} V _{SUP} 7.0 V to 18 V, t _{BIT} = 96 μs D3 = t _{BUS-rec(min)} / (2t _{BIT})	0.417	—	—	%
D4 Valid for 10.4 kBaud	Duty cycle D4 TH _{REC(min)} = 0.389 × V _{SUP} , TH _{DOM(min)} = 0.251 × V _{SUP} V _{SUP} 7.6 V to 18 V, t _{BIT} = 96 μs D4 = t _{BUS-rec(max)} / (2t _{BIT})	—	—	0.59	%
t _{RX_PD}	Receiver propagation delay (T _{RX_PD} = MAX (t _{REC_PDR} , t _{REC_PDF})) (internal timing, from physical layer to data layer logic)	—	—	6	μs
T _{RX_SYM}	Symmetry of receiver propagation delay (T _{RX_SYM} = t _{REC_PDF} - t _{REC_PDR})	-2	—	2	μs

[1] A fault has to be present for the whole of this time before it is considered valid. Four different deglitching times are selectable by fuse, see [Table 56](#).

[2] This parameter is selectable by fuse.

9 Functional description

9.1 Introduction

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

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

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

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

The programmable parameters through LIN by the ECU:

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

The parameters sent back through LIN to the ECU:

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

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

9.2 Functional pin description

9.2.1 Phase (PH)

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

9.2.2 LIN bus (BUS)

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

9.2.3 Ground pin (GND)

The AR6000 has one GND pin.

9.2.4 Supply voltage (B+A)

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

9.2.5 Excitation (EXC)

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

10 Functional internal block description

10.1 Supply voltage: filter/divider, bandgap, POR

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

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

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

The purpose of the POR block is to generate a clean reset to the main logic. When a Power-On-Reset occurs, device internal registers are reset and the device goes into stand by mode.

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

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

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

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

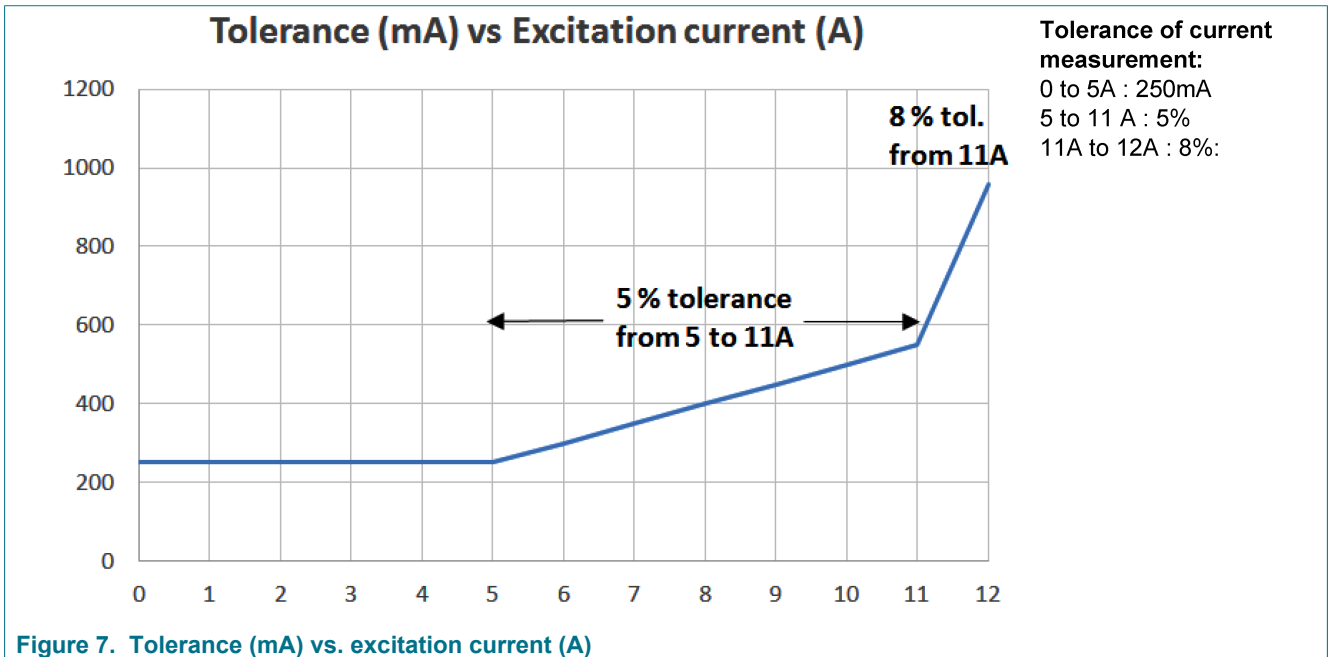


Figure 7. Tolerance (mA) vs. excitation current (A)

10.3 Logic and control

10.3.1 Digital

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

10.3.2 Clock

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

10.3.3 OTP

This block allows easy configuration and adjustment of the circuit. A large number of fuse bits can be programmed either by NXP or by customer at end of line. They are listed in [Table 56](#).

10.3.4 Phase low and high

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

10.3.5 ADC

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

10.3.6 Current measurement

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

10.3.7 LIN

This block controls the LIN bus transmission and reception.

11 Functional device operation

11.1 LIN frames

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

Table 9. LIN frame configurations

LIN Version		Identifier Hex
ALL	Rx	3C ^[1]
	Tx	3D ^[1]
	Frames Ignored	3E
		3F
LIN1 Version A	Rx	29
	Tx	11
	Tx	12
	Tx	15
LIN2 Version A	Rx	2A
	Tx	13
	Tx	14
	Tx	16
LIN3 Version A	Rx	20
	Tx	15
	Tx	21
	Tx	18
LIN4 Version A	Rx	2A
	Tx	13
	Tx	11
	Tx	16
LIN1 Version B	Rx	29
	Tx	12
	Tx	15

LIN Version		Identifier Hex
LIN2 Version B	Rx	2A
	Tx	14
	Tx	16
LIN3 Version B	Rx	20
	Tx	21
	Tx	18
LIN4 Version B	Rx	2A
	Tx	11
	Tx	16
LIN Version C	Rx	20
	Tx	21
	Tx	18
LIN1 Version D	Rx	29
	Tx	11
	Tx	12
LIN2 Version D	Rx	2A
	Tx	13
	Tx	14
LIN1 Version E	Rx	29
	Tx	21
	Tx	12

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

	OTP bits	Corresponding version
LIN configuration	0000	Lin1 version A
	0001	Lin2 version A
	0010	Lin3 version A
	0011	Lin4 version A
	0100	Lin1 version B
	0101	Lin2 version B
	0110	Lin3 version B
	0111	Lin4 version B
	1000	Lin version C
	1001	Lin1 version D (with I _{EXC})
	1010	Lin2 version D (with I _{EXC})
	1011	Lin1 version D (With T°C)
	1100	Lin2 version D (with T°C)
	1101	Lin version E
	1110	
1111		

11.2 Message frame for configuration version-A

11.2.1 RxFrame

Table 10. Identifier: 0X29 (LIN1) or 0X2A (LIN2, LIN4) or 0X20 (LIN3)

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

A: Voltage set value, 6 bits, [Table 26](#)

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

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

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

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

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

F: "Blind zone", 1 bit, [Table 30](#)

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

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

11.2.2 TxFrame 1

Table 11. Identifier: 0X11 (LIN1) or 0X13 (LIN2, LIN4) or 0X15 (LIN3)

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

A: Diagnosis flag for high temperature, 1 bit

B: Diagnosis flag for mechanical failure, 1 bit

C: Diagnosis flag for electrical failure, 1 bit

D: Duty cycle value of the excitation PWM, 5 bits, [Table 33](#)

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

F: Diagnosis flag for LIN error, 1 bit

G: Diagnosis flag LIN communication timeout, 1 bit

11.2.3 TxFrame 2

Table 12. Identifier: 0X12 (LIN1) or 0X14 (LIN2) or 0X21 (LIN3) or 0X11 (LIN4)

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

A: Alternator supplier identification, 3 bits, [Table 35](#)

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

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

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

11.2.4 TxFrame 3

Table 13. Identifier: 0X15 (LIN1) or 0X16 (LIN2, LIN4) or 0X18 (LIN3)

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

- A: Diagnosis flag for high temperature, 1 bit
- B: Diagnosis flag for mechanical failure, 1 bit
- C: Diagnosis flag for electrical failure, 1 bit
- D: Duty cycle value of the excitation PWM, 5 bits, [Table 33](#)
- E: Measured excitation current, 8 bits, [Table 36](#)
- F: Confirmation of the selected output variable done in RxFrame Byte 4, 3 bits

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

- G: I_{EXC} flag, 1 bit (enabled by programming)
- H: LRC flag, 1 bit (enabled by programming)
- I: Diagnosis flag for LIN error, 1 bit
- J: Diagnosis flag LIN communication timeout, 1 bit
- K: Set voltage, measured voltage, chip temperature or alternator speed, 8 bits, [Table 37](#)

11.3 Message frame for configuration version-B

11.3.1 RxFrame

Table 14. Identifier: 0X29 (LIN1) or 0X2A (LIN2, LIN4) or 0X20 (LIN3)

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

- A: Voltage set value, 8 bits, [Table 38](#)

- B: Load response ramp time, 4 bits, [Table 39](#)
- C: Load response cut off speed, 4 bits, [Table 28](#)
- D: Excitation current limitation, 7 bits, [Table 40](#)
- E: Selection of output variable in TxFrame 3/Byte 4, 3 bits

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

- F: "Blind zone", 1 bit, [Table 30](#)
- G: Voltage limitation for high temperature, 3 bits, [Table 31](#)
- H: "Blind zone inhibition", 1 bit (enabled by programming), [Table 32](#)

11.3.2 TxFrame 1

Table 15. Identifier: 0X12 (LIN1) or 0X14 (LIN2, LIN4) or 0X21 (LIN3) 0X11 (LIN4)

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

- A: Alternator supplier identification, 3 bits, [Table 35](#)
- B: Alternator identification, 5 bits (defined by customer)
- C: Chip supplier identification, 3 bits (defined by NXP : 010)
- D: Chip identification, 5 bits (defined by NXP)

11.3.3 TxFrame 2

Table 16. Identifier: 0X15 (LIN1) or 0X16 (LIN2, LIN4) or 0X18 (LIN3)

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

- A: Diagnosis flag for high temperature, 1 bit
- B: Diagnosis flag for mechanical failure, 1 bit
- C: Diagnosis flag for electrical failure, 1 bit

D: Duty cycle value of the excitation PWM, 5 bits, [Table 41](#)

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

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

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

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

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

I: Diagnosis flag for LIN error, 1 bit

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

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

11.4 Message frame for configuration version-C

11.4.1 RxFrame

Table 17. Identifier: 0X20

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

A: LRC blind zone, 2 bits, [Table 43](#)

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

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

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

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

11.4.2 TxFrame 1

Table 18. Identifier: 0X21

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

- A: Diagnosis flag for mechanical failure, 1 bit
- B: Diagnosis flag for electrical failure, 1 bit
- C: Diagnosis flag for communication error, 1 bit
- D: Diagnosis flag for Timeout, 1 bit
- E: Diagnosis flag for High temperature, 1 bits
- F: Measured voltage on pad B+A, 8 bits, [Table 49](#)
- G: Measured excitation current, 8 bits, [Table 48](#)
- H: Duty cycle value of the excitation PWM, 8 bits, [Table 47](#)

11.4.3 TxFrame 2

Table 19. Identifier: 0X18

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

- A: Temperature information, 8 bits, [Table 50](#)
- B: Alternator supplier identification, 3 bits, [Table 35](#)
- C: Alternator class identification, 5 bits (defined by customer)

11.5 Message frame for configuration version-D

11.5.1 RxFrame

Table 20. Identifier: 0X29 (LIN1) or 0X2A(LIN2)

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

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

11.5.2 TxFrame 1

Table 21. Identifier: 0X11 (LIN1) or 0X13 (LIN2)

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

- A: Diagnosis flag for high temperature, 1 bit
- B: Diagnosis flag for mechanical failure, 1 bit
- C: Diagnosis flag for electrical failure, 1 bit
- D: Duty cycle value of the excitation PWM, 5 bits, [Table 33](#)
- E: Measured excitation current, 6 bits, [Table 34](#) Temperature measurement, 6 bits, [Table 51](#)
- F: Diagnosis flag for LIN error, 1 bit
- G: Diagnosis flag LIN communication time-out, 1 bit

11.5.3 TxFrame 2

Table 22. Identifier: 0X12 (LIN1) or 0X14 (LIN2)

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

- A: Alternator supplier identification, 3 bits, [Table 35](#)
- B: Alternator identification, 5 bits (defined by customer)
- C: Sync Break fault, 1 bit
- D: ID parity fault, 1-bit
- E: Checksum fault, 1 bit
- F: Not Slave responding fault, 1 bit

11.6 Message frame for configuration version-E

11.6.1 RxFrame

Table 23. Identifier: 0X29

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

- A: Voltage set value, 6 bits, [Table 26](#)
- B: Load response ramp time, 4 bits, [Table 45](#)

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

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

E: “Blind zone”, 1 bit, [Table 53](#)

11.6.2 TxFrame 1

Table 24. Identifier: 0X21

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

- A: Diagnosis flag for high temperature, 1 bit
- B: Diagnosis flag for mechanical failure, 1 bit
- C: Diagnosis flag for electrical failure, 1 bit
- D: Duty cycle value of the excitation PWM, 5 bits, [Table 33](#)
- E: Measured excitation current, 8 bits, [Table 55](#)
- G: Diagnosis flag for LIN error, 1 bit
- H: Diagnosis flag LIN communication time-out, 1 bit
- I: Chip temperature, 8-bits, [Table 50](#)

11.6.3 TxFrame 2

Table 25. Identifier: 0X12 (LIN1)

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

- A: Alternator supplier identification, 3 bits, [Table 35](#)
- B: Alternator identification, 5 bits (defined by customer)
- C: Chip supplier identification, 3 bits (defined by NXP : 010)
- D: Chip identification, 5 bits (defined by NXP)

12 Lookup tables

Table 26. Voltage set point (6 bits) – versions A, D and E

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

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

Table 27. LRC ramp time – versions A and D

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

Table 28. LRC disable speed (4 bits) – versions A, B, C, D and E

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

Table 29. Excitation current limitation (5 bits) – versions A and D

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