

## **LIN Bus Device Family including Voltage Regulator and LIN SBC<sup>(1)</sup> with Compatible Footprint**

### **DATASHEET**

### **Features**

- Supply voltage up to 40V
- Operating voltage  $V_S = 5V$  to 28V
- Supply current
  - Sleep mode: typically 9 $\mu$ A
  - Silent mode: typically 47 $\mu$ A
  - Very low current consumption at low supply voltages ( $2V < V_S < 5.5V$ ): typically 130 $\mu$ A
- Linear low-drop voltage regulator, 85mA current capability:
  - MLC (multi-layer ceramic) capacitor with 0 $\Omega$  ESR
  - Normal, fail-safe, and silent mode
    - Atmel<sup>®</sup> ATA663254:  $V_{CC} = 5.0V \pm 2\%$
    - Atmel ATA663231:  $V_{CC} = 3.3V \pm 2\%$
  - Sleep mode: VCC is switched off
  - Active mode
    - Atmel ATA663203:  $V_{CC} = 5.0V \pm 2\%$
    - Atmel ATA663201:  $V_{CC} = 3.3V \pm 2\%$
- VCC undervoltage detection with open drain reset output (NRES, 4ms reset time)
- Voltage regulator is short-circuit and over-temperature protected
- LIN physical layer according to LIN 2.0, 2.1, 2.2, 2.2A and SAEJ2602-2
- Wake-up capability via LIN bus (100 $\mu$ s dominant)
- Wake-up source recognition
- TXD time-out timer
- Bus pin is over-temperature and short-circuit protected versus GND and battery
- Advanced EMC and ESD performance
- Fulfills the OEM "Hardware Requirements for LIN in Automotive Applications Rev.1.3"
- Interference and damage protection according to ISO7637
- Qualified according to AEC-Q100
- Packages:
  - DFN8 (all types) with wettable flanks (Moisture Sensitivity Level 1)
  - SO8 (only Atmel ATA663254)

Note: 1. LIN SBC: LIN system basis chip including LIN transceiver and voltage regulator.

# 1. Description

The Atmel® ATA6632xx device family includes two basic products; a LIN system basis chip (SBC) and a low-drop voltage regulator with compatible footprints.

The Atmel ATA663231/54 (system basis chip) is a fully integrated LIN transceiver, designed according to the LIN specification 2.0, 2.1, 2.2, 2.2A and SAEJ2602-2, with a low-drop voltage regulator (3.3V/5V/85mA). The combination of voltage regulator and bus transceiver makes it possible to develop simple but powerful slave nodes in LIN bus systems. Atmel ATA663231/54 is designed to handle the low-speed data communication in vehicles (for example, in convenience electronics). Improved slope control at the LIN driver ensures secure data communication up to 20Kbaud. The bus output is designed to withstand high voltage. Sleep mode and silent mode guarantee minimized current consumption even in the case of a floating or a short-circuited LIN bus.

The Atmel ATA663201/03 (voltage regulator) is a fully integrated low-drop voltage regulator, with 3.3V/5V output voltage and 85mA current capability. It is especially designed for the automotive environment. A key feature is that the current consumption is always below 170µA (without load), even if the supply voltage is below the regulator's nominal output voltage.

Table 1-1. ATA6632xx Device Family

Description	Atmel ATA6632xx
LIN-SBC with 3.3V regulator	31
LIN-SBC with 5V regulator	54
Voltage regulator 3.3V	01
Voltage regulator 5V	03

Figure 1-1. Block Diagram LIN Transceiver with Integrated Voltage Regulator (SBC)

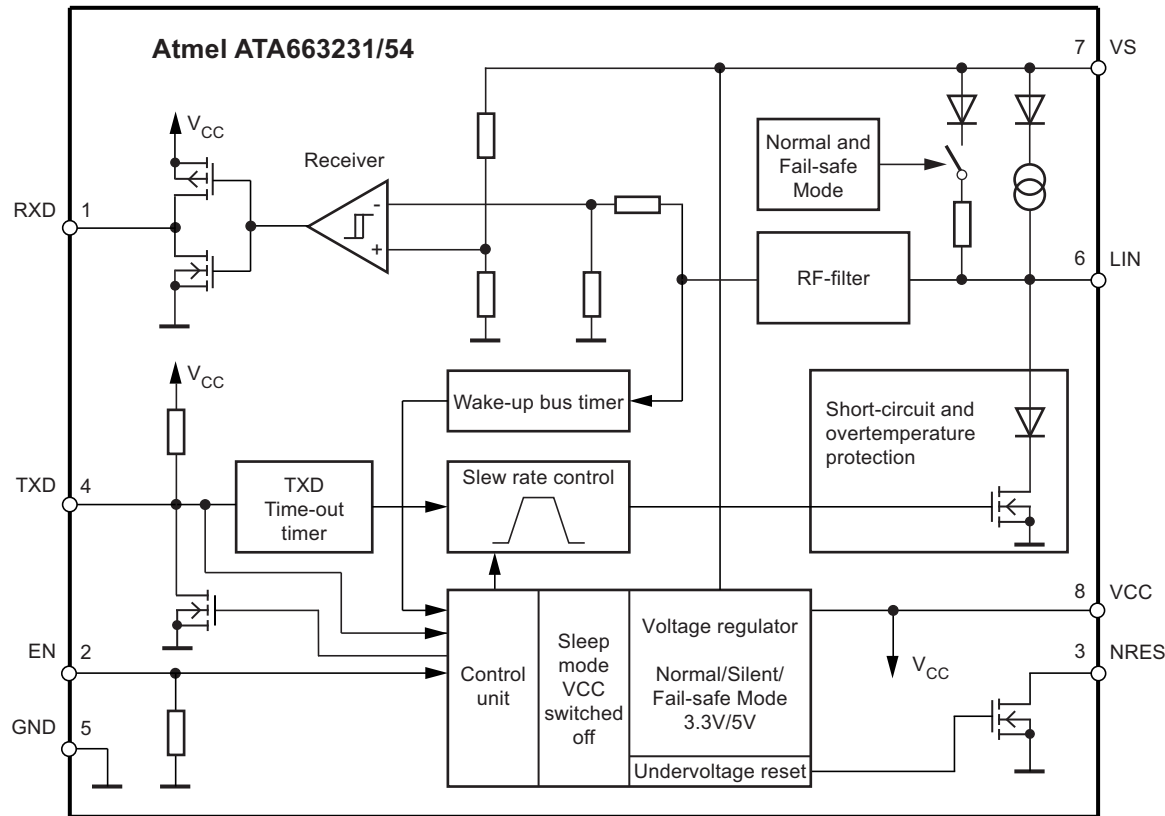
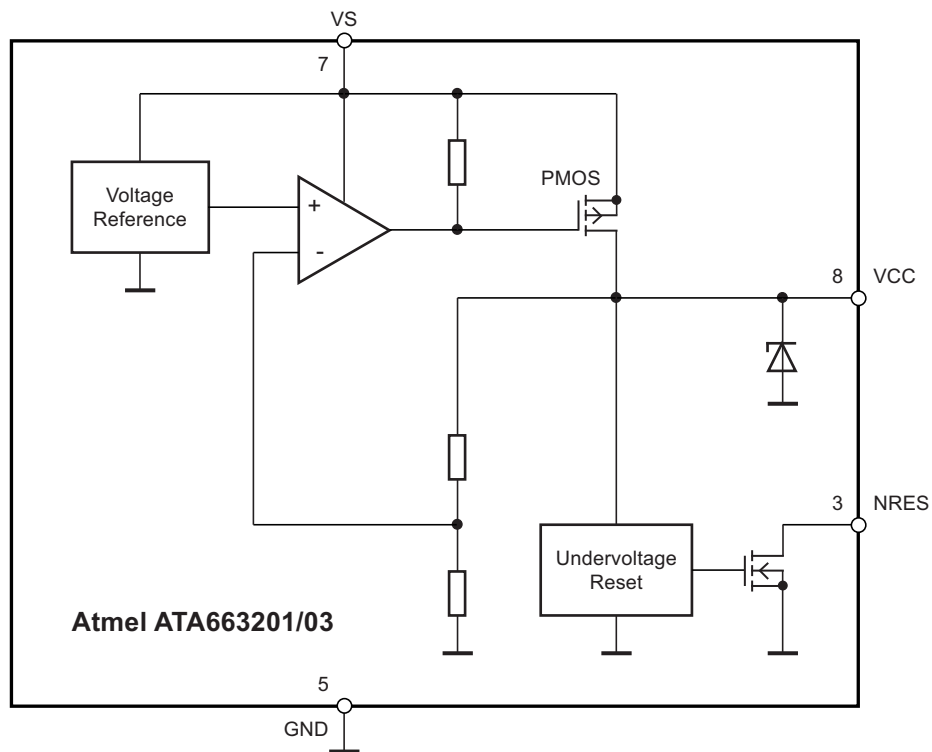


Figure 1-2. Block Diagram Voltage Regulator



## 2. Pin Configuration

Figure 2-1. Pinning DFN8

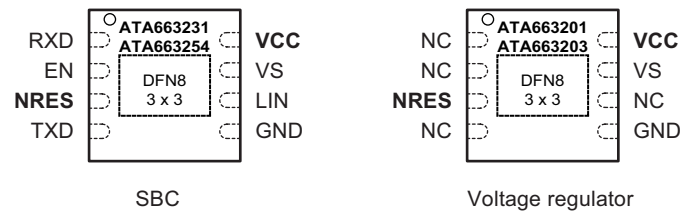


Figure 2-2. Pinning SO8

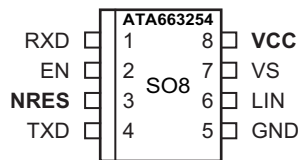


Table 2-1. Pin Description

Pin	Symbol	Function
1	RXD	Receive data output
2	EN	Enables normal mode if the input is high
3	NRES	VCC undervoltage output, open drain, low at reset
4	TXD	Transmit data input
5	GND	Ground
6	LIN	LIN bus line input/output
7	VS	Supply voltage
8	VCC	Output voltage regulator 3.3V/5V/85mA
Backside <sup>(1)</sup>		Heat slug, internally connected to the GND pin

Note: 1. Only for the DFN8 package.

## 3. Pin Description

### 3.1 Supply Pin (VS)

LIN operating voltage is  $V_S = 5V$  to  $28V$ . Undervoltage detection is implemented to disable transmission if  $V_S$  falls below typ.  $4.5V$ , thereby avoiding false bus messages. After switching on  $V_S$ , the IC starts in fail-safe mode and the voltage regulator is switched on.

The supply current in sleep mode is typically  $9\mu A$  and  $47\mu A$  in silent mode.

### 3.2 Ground Pin (GND)

The IC does not affect the LIN bus in the event of GND disconnection. It is able to handle a ground shift of up to 11.5% of  $V_S$ .

### 3.3 Voltage Regulator Output Pin (VCC)

The internal 3.3V/5V voltage regulator is capable of driving loads up to 85mA, supplying the microcontroller and other ICs on the PCB and is protected against overload by means of current limitation and overtemperature shutdown. Furthermore, the output voltage is monitored and causes a reset signal at the NRES output pin if it drops below a defined threshold

$V_{VCC\_th\_uv\_down}$ .

### 3.4 Undervoltage Reset Output (NRES)

If the  $V_{CC}$  voltage falls below the undervoltage detection threshold  $V_{CC\_th\_uv\_down}$ , NRES switches to low after  $t_{res\_f}$ . The NRES stays low even if  $V_{CC} = 0V$  because NRES is internally driven from the  $V_S$  voltage. If  $V_S$  voltage ramps down, NRES stays low until  $V_S < 1.5V$  and then becomes highly impedant.

The implemented undervoltage delay keeps NRES low for  $t_{Reset} = 4ms$  after  $V_{CC}$  reaches its nominal value.

### 3.5 Bus Pin (LIN) (SBC only)

A low-side driver with internal current limitation and thermal shutdown as well as an internal pull-up resistor according to LIN specification 2.x is implemented. The voltage range is from  $-27V$  to  $+40V$ . This pin exhibits no reverse current from the LIN bus to  $V_S$ , even in the event of a GND shift or  $V_{Bat}$  disconnection. The LIN receiver thresholds comply with the LIN protocol specification.

The fall time (from recessive to dominant) and the rise time (from dominant to recessive) are slope-controlled.

During a short circuit at LIN to  $V_{Bat}$ , the output limits the output current to  $I_{BUS\_LIM}$ . Due to the power dissipation, the chip temperature exceeds  $T_{LINoff}$  and the LIN output is switched off. The chip cools down and after a hysteresis of  $T_{hys}$ , switches the output on again. RXD stays on high because LIN is high. The  $V_{CC}$  regulator works independently during LIN overtemperature switch-off.

During a short circuit from LIN to GND the IC can be switched into sleep or silent mode and even in this case the current consumption is lower than  $100\mu A$  in sleep mode and lower than  $120\mu A$  in silent mode. If the short-circuit disappears, the IC starts with a remote wake-up.

The reverse current is  $< 2\mu A$  at pin LIN during loss of  $V_{Bat}$ . This is optimal behavior for bus systems where some slave nodes are supplied from battery or ignition.

### 3.6 Input/Output (TXD) (SBC only)

In normal mode the TXD pin is the microcontroller interface for controlling the state of the LIN output. TXD must be pulled to ground in order to drive the LIN bus low. If TXD is high or unconnected (internal pull-up resistor), the LIN output transistor is turned off and the bus is in the recessive state. If the TXD pin stays at GND level while switching into normal mode, it must be pulled to high level longer than 10 $\mu$ s before the LIN driver can be activated. This feature prevents the bus line from being accidentally driven to dominant state after normal mode has been activated (also in case of a short circuit at TXD to GND). During fail-safe mode, this pin is used as output and signals the fail-safe source.

The TXD input has an internal pull-up resistor.

An internal timer prevents the bus line from being driven permanently in the dominant state. If TXD is forced to low longer than  $t_{dom} > 20\text{ms}$ , the LIN bus driver is switched to the recessive state. Nevertheless, when switching to sleep mode, the actual level at the TXD pin is relevant.

To reactivate the LIN bus driver, switch TXD to high ( $> 10\mu\text{s}$ ).

### 3.7 Output Pin (RXD) (SBC only)

In normal mode this pin reports the state of the LIN bus to the microcontroller. LIN high (recessive state) is indicated by a high level at RXD; LIN low (dominant state) is indicated by a low level at RXD.

The output is a push-pull stage switching between VCC and GND. The AC characteristics are measured by an external load capacitor of 20pF.

In silent mode the RXD output switches to high.

### 3.8 Enable Input Pin (EN) (SBC only)

The enable input pin controls the operating mode of the device. If EN is high, the circuit is in normal mode, with transmission paths from TXD to LIN and from LIN to RXD both active. The VCC voltage regulator operates with 3.3V/5V/85mA output capability.

If EN is switched to low while TXD is still high, the device is forced to silent mode. No data transmission is then possible, and current consumption is reduced to  $I_{VSSilent}$  typ. 47 $\mu$ A. The VCC regulator retains its full functionality.

If EN is switched to low while TXD is low, the device is forced to sleep mode. No data transmission is possible, and the voltage regulator is switched off.

The EN pin provides a pull-down resistor to force the transceiver into recessive mode if EN is disconnected.

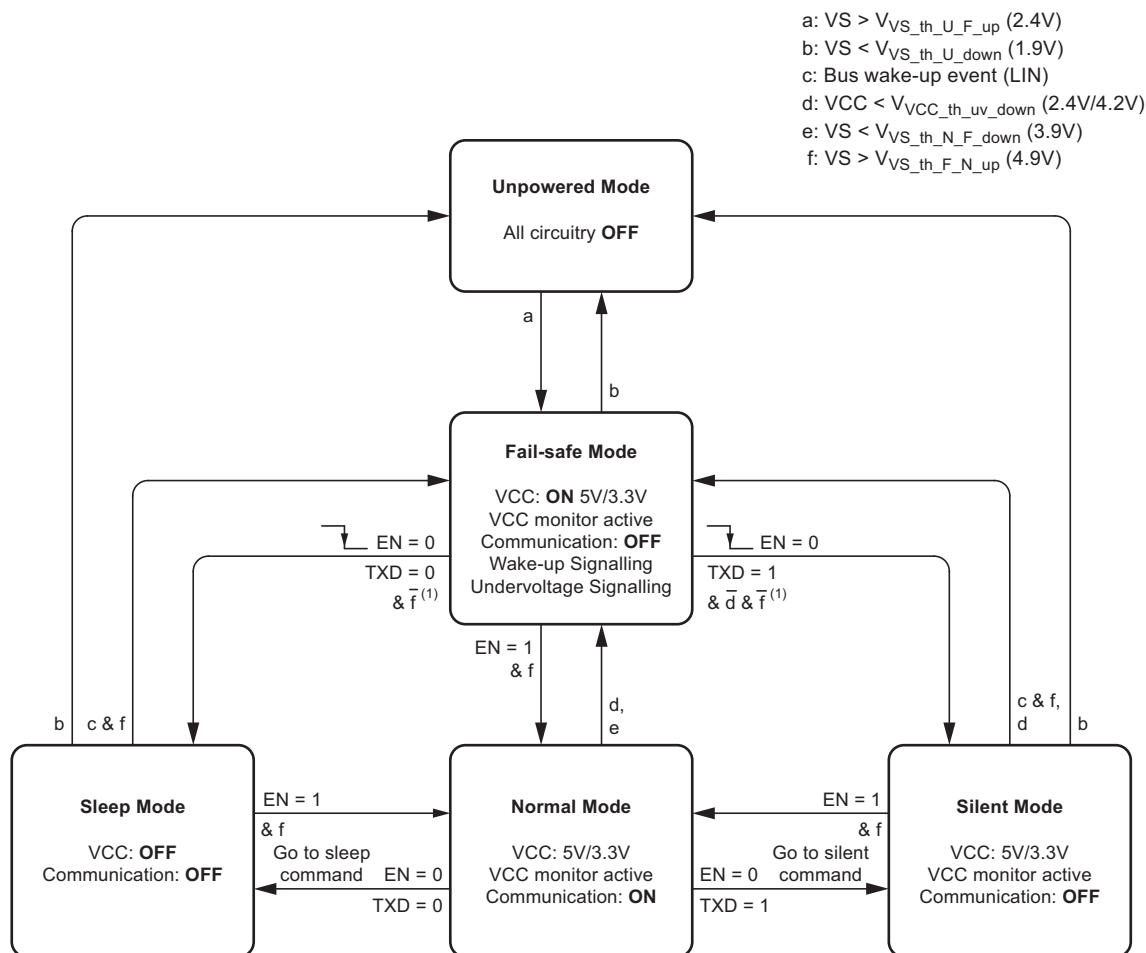
## 4. Functional Description

### 4.1 Physical Layer Compatibility

Because the LIN physical layer is independent of higher LIN layers (e.g., LIN protocol layer), all nodes with a LIN physical layer according to revision 2.x can be mixed with LIN physical layer nodes based on earlier versions (i.e., LIN 1.0, LIN 1.1, LIN 1.2, LIN 1.3) without any restrictions.

### 4.2 Operating Modes

Figure 4-1. SBC Operating Modes

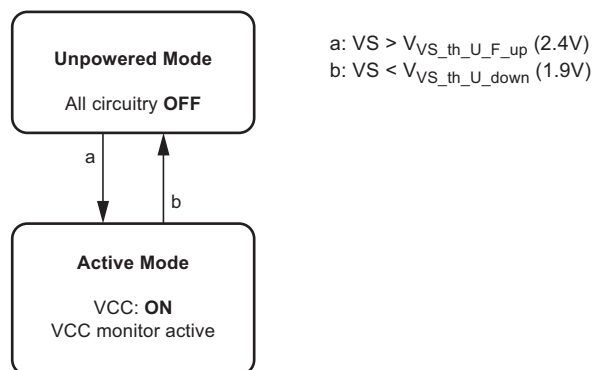


Note: 1. Condition  $\bar{f}$  is valid for VS ramp up; at VS ramp down condition e is valid instead of  $\bar{f}$ .

Table 4-1. SBC (ATA663254, ATA663231) Operating Modes

Operating Mode	Transceiver	V <sub>CC</sub> (SBC only)	LIN	TXD	RXD
Fail-safe	OFF	3.3V/5V	Recessive	Signaling fail-safe sources (see Table 4-2)	
Normal	ON	3.3V/5V	TXD-dependent	Follows data transmission	
Silent (SBC only)	OFF	3.3V/5V	Recessive	High	High
Sleep/Unpowered	OFF	0V	Recessive	Low	Low

**Figure 4-2. Voltage Regulator Operating Modes**



#### 4.2.1 Normal Mode (SBC only)

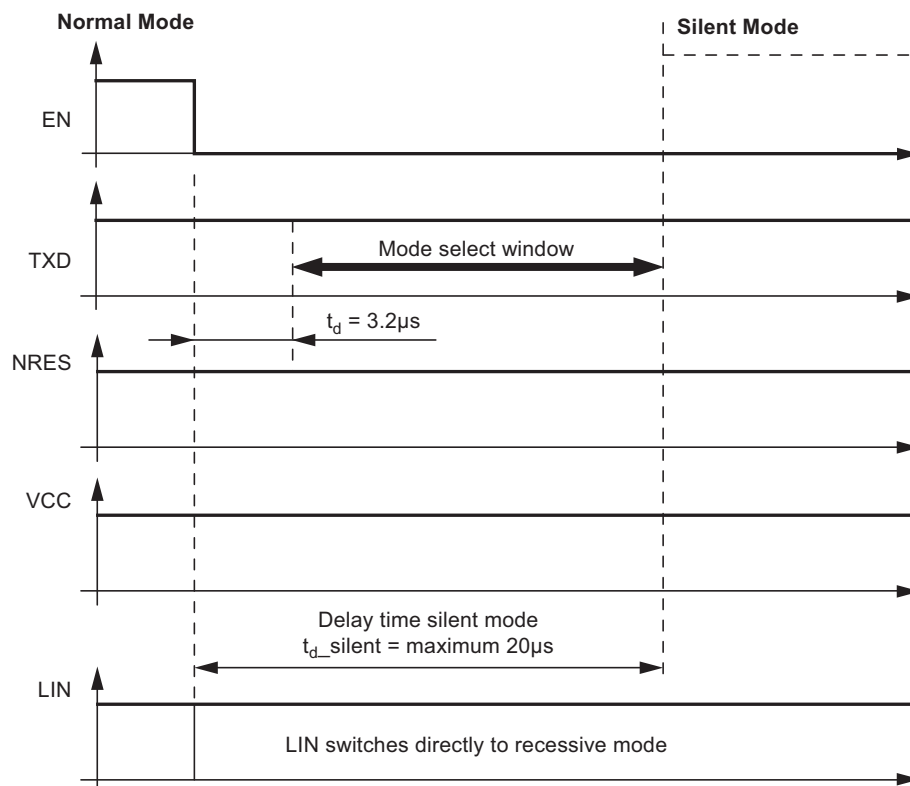
This is the normal transmitting and receiving mode of the LIN Interface, in accordance with LIN specification 2.x.

The VCC voltage regulator operates with 3.3V/5V output voltage, with a low tolerance of  $\pm 2\%$  and a maximum output current of 85mA. If an undervoltage condition occurs, NRES is switched to low and the IC changes its state to fail-safe mode.

#### 4.2.2 Silent Mode (SBC only)

A falling edge at EN while TXD is high switches the IC into silent mode. The TXD signal has to be logic high during the mode select window. The transmission path is disabled in silent mode. The voltage regulator is active. The overall supply current from  $V_{Bat}$  is a combination of the  $I_{VSilent} = 47\mu A$  plus the  $V_{CC}$  regulator output current  $I_{VCC}$ .

**Figure 4-3. Switching to Silent Mode**





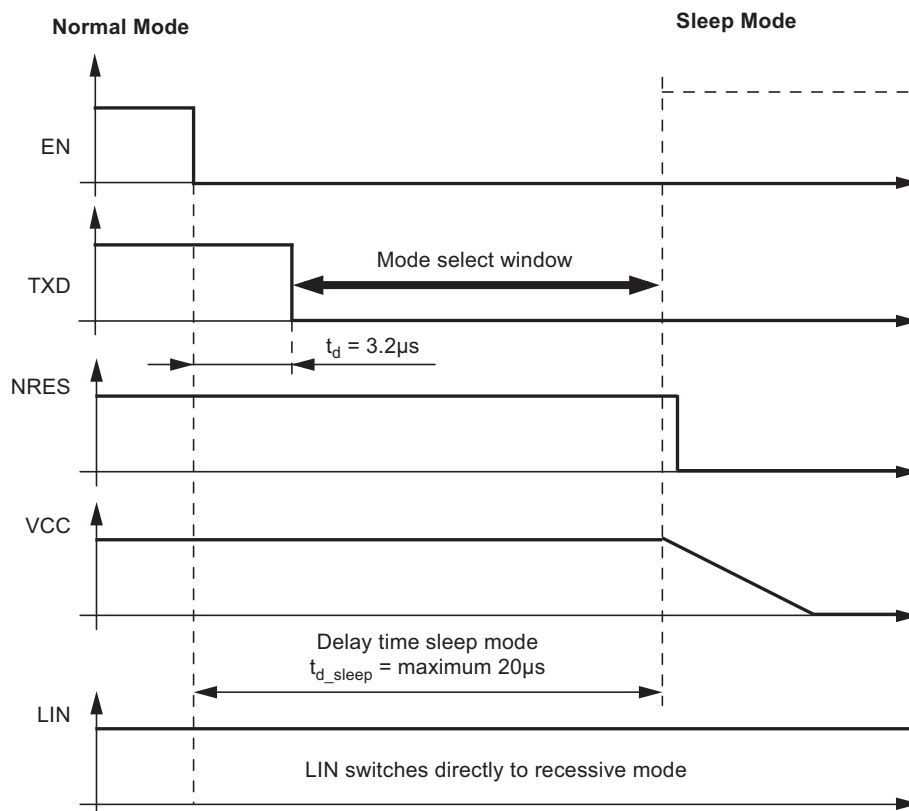
In silent mode the internal slave termination between the LIN pin and VS pin is disabled to minimize the current consumption in case the pin LIN is short-circuited to GND. Only a weak pull-up current (typically 10µA) between the LIN pin and VS pin is present. Silent mode can be activated independently from the current level on pin LIN.

If an undervoltage condition occurs, NRES is switched to low and the Atmel® SBC changes its state to fail-safe mode.

### 4.2.3 Sleep Mode (SBC only)

A falling edge at EN while TXD is low switches the IC into sleep mode. The TXD signal has to be logic low during the mode select window (Figure 4-6).

Figure 4-4. Switching to Sleep Mode



In order to avoid any influence to the LIN pin when switching into sleep mode it is possible to switch the EN up to 3.2µs earlier to low than the TXD. The easiest and best way to do this is by having two falling edges at TXD and EN at the same time.

In sleep mode the transmission path is disabled. Supply current from  $V_{Bat}$  is typically  $I_{V_{SS}sleep} = 9\mu A$ . The  $V_{CC}$  regulator is switched off; NRES and RXD are low. The internal slave termination between the LIN pin and VS pin is disabled to minimize the current consumption in case the LIN pin is short-circuited to GND. Only a weak pull-up current (typically 10µA) between the LIN pin and the VS pin is present. The sleep mode can be activated independently from the current level on the LIN pin. Voltage below the LIN pre-wake detection  $V_{LINL}$  at the LIN pin activates the internal LIN receiver and starts the wake-up detection timer.

If the TXD pin is short-circuited to GND, it is possible to switch to sleep mode via EN after  $t > t_{dom}$ .

#### 4.2.4 Fail-Safe Mode (SBC only)

The device automatically switches to fail-safe mode at system power-up. The voltage regulator is switched on. The NRES output remains low for  $t_{res} = 4\text{ms}$  and causes the microcontroller to be reset. LIN communication is switched off. The IC stays in this mode until EN is switched to high. The IC then changes to normal mode. A low at NRES switches the IC into fail-safe mode directly. During fail-safe mode the TXD pin is an output and, together with the RXD output pin, signals the fail-safe source.

If the device enters fail-safe mode coming from the normal mode ( $EN=1$ ) due to an  $V_S$  undervoltage condition ( $V_S < V_{VS\_th\_N\_F\_down}$ ), it is possible to switch into sleep or silent mode by a falling edge at the EN input. With this feature the current consumption can be further reduced.

A wake-up event from either silent or sleep mode is signalled to the microcontroller using the RXD pin and the TXD pin. A  $V_S$  undervoltage condition is also signalled at these two pins. The coding is shown in the table below.

A wake-up event switches the IC to fail-safe mode.

**Table 4-2. Signaling in Fail-safe Mode**

Fail-Safe Sources	TXD	RXD
LIN wake-up (LIN pin)	Low	Low
$V_{S_{th}}$ (battery) undervoltage detection ( $V_S < 3.9V$ )	High	Low

#### 4.2.5 Active Mode (Voltage Regulator only)

The device automatically switches to active mode at system power-up. The VCC voltage regulator operates with 3.3V/5V output voltage, with a low tolerance of  $\pm 2\%$  and a maximum output current of 85mA. The NRES output remains low for  $t_{res} = 4\text{ms}$  and causes the microcontroller to be reset. The current consumption is typically 47 $\mu\text{A}$ .

If an undervoltage condition occurs, NRES switches to low.

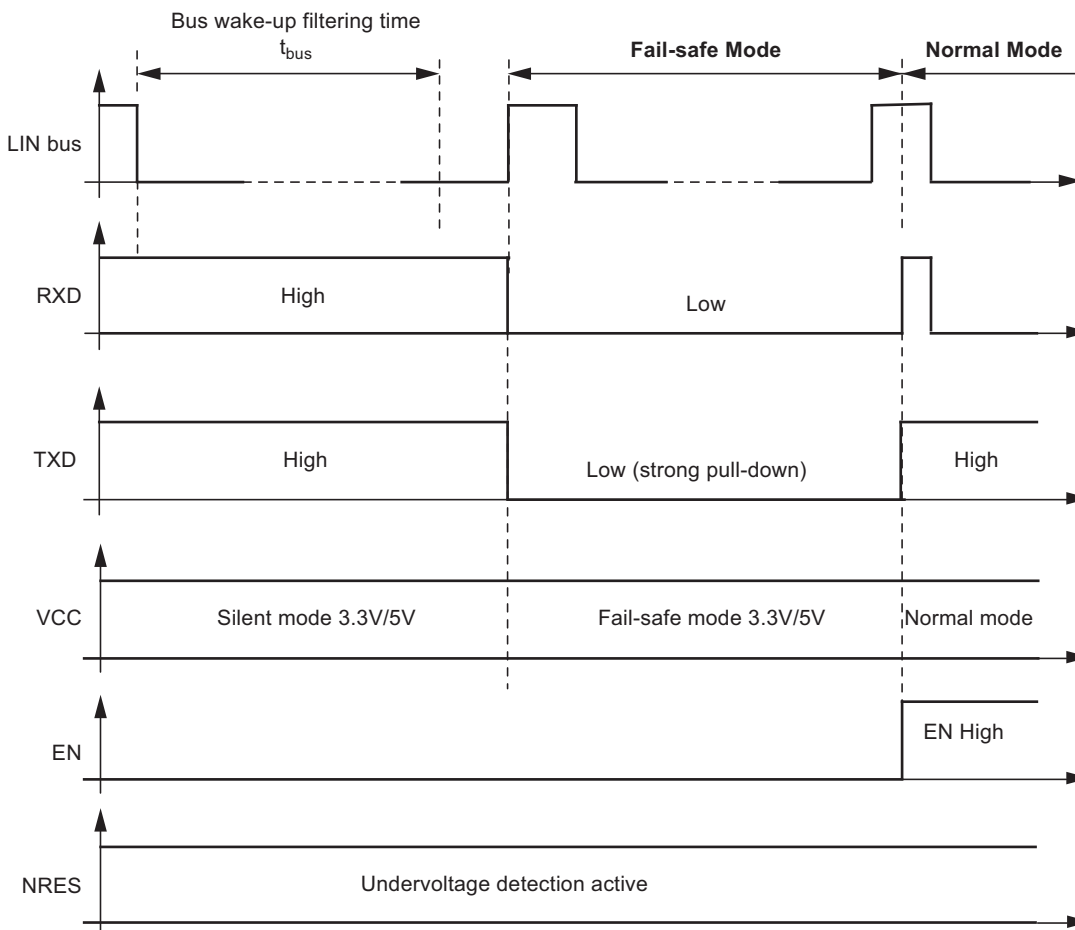
## 4.3 Wake-up Scenarios from Silent Mode or Sleep Mode

### 4.3.1 Remote Wake-up via LIN Bus

#### 4.3.1.1 Remote Wake-up from Silent Mode (SBC only)

A remote wake-up from silent mode is only possible if TXD is high. A voltage less than the LIN pre-wake detection VLINL at the LIN pin activates the internal LIN receiver and starts the wake-up detection timer. A falling edge at the LIN pin followed by a dominant bus level maintained for a certain period of time ( $> t_{bus}$ ) and the following rising edge at pin LIN (see Figure 4-5) result in a remote wake-up request. The device switches from silent mode to fail-safe mode, the VCC voltage regulator remains activated and the internal LIN slave termination resistor is switched on. The remote wake-up request is indicated by a low level at the RXD pin and TXD pin (strong pull-down at TXD). EN high can be used to switch directly to normal mode.

Figure 4-5. LIN Wake-up from Silent Mode



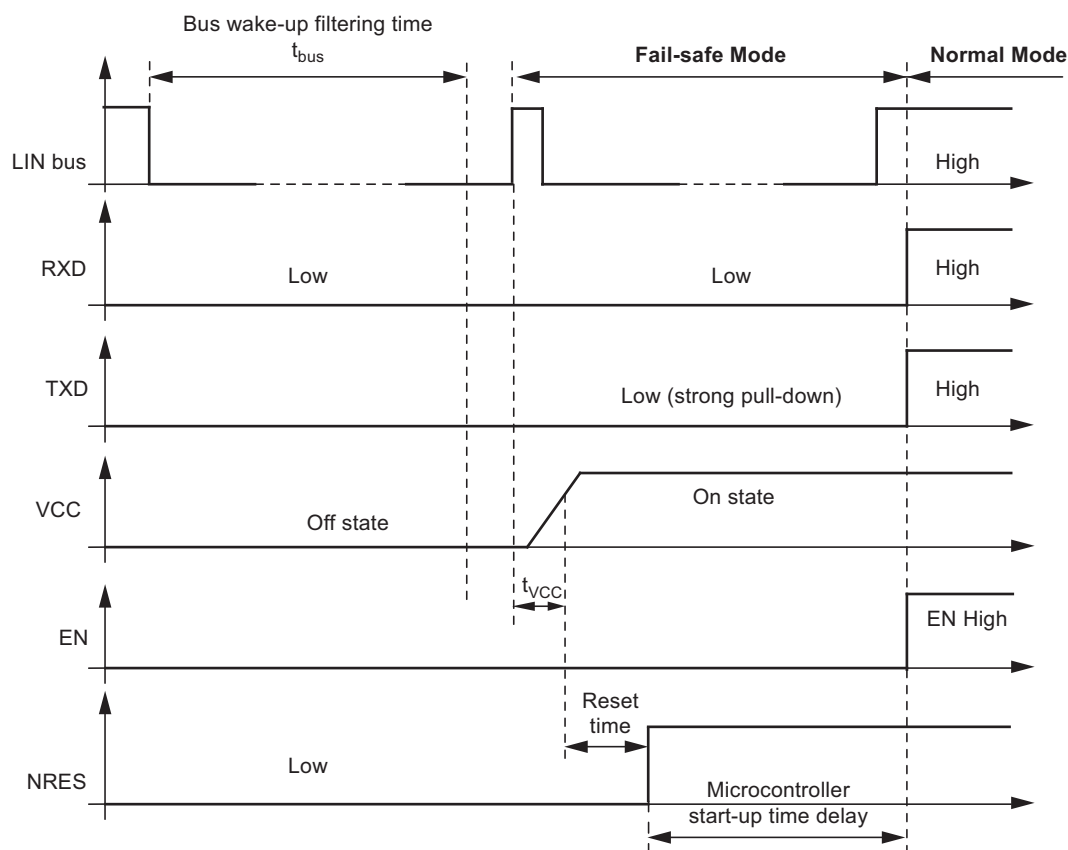
### 4.3.1.2 Remote Wake-up from Sleep Mode (SBC only)

A falling edge at the LIN pin followed by a dominant bus level maintained for a certain period of time ( $> t_{bus}$ ) and a following rising edge at the LIN pin result in a remote wake-up request, causing the device to switch from sleep mode to fail-safe mode.

The  $V_{CC}$  regulator is activated, and the internal LIN slave termination resistor is switched on. The remote wake-up request is indicated by a low level at RXD and TXD (strong pull-down at TXD) (see Figure 4-6).

EN high can be used to switch directly from sleep/silent mode to fail-safe mode. If EN is still high after  $V_{CC}$  ramp-up and undervoltage reset time, the IC switches to normal mode.

**Figure 4-6. LIN Wake-up from Sleep Mode**



### 4.3.2 Wake-up Source Recognition (SBC only)

The device can distinguish between different wake-up sources. The wake-up source can be read on the TXD and RXD pin in fail-safe mode. These flags are immediately reset if the microcontroller sets the EN pin to high and the IC is in normal mode.

**Table 4-3. Signaling in Fail-safe Mode**

Fail-Safe Sources	TXD	RXD
LIN wake-up (LIN pin)	Low	Low
$VS_{th}$ (battery) undervoltage detection ( $VS < 3.9V$ )	High	Low

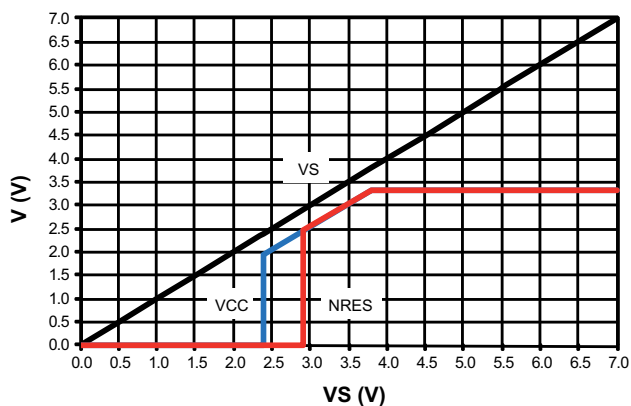
## 4.4 Behavior under Low Supply Voltage Condition

After the battery voltage has been connected to the application circuit, the voltage at the VS pin increases according to the block capacitor used in the application (see [Figure 9-1 on page 25](#)). If  $V_{VS}$  is higher than the minimum VS operation threshold  $V_{VS\_th\_U\_F\_up}$ , the IC mode changes from unpowered mode to fail-safe mode. As soon as  $V_{VS}$  exceeds the undervoltage threshold  $V_{VS\_th\_F\_N\_up}$ , the LIN transceiver can be activated.

The VCC output voltage reaches its nominal value after  $t_{VCC}$ . This parameter depends on the externally applied VCC capacitor and the load. The NRES output is low for the reset time delay  $t_{reset}$ . No mode change is possible during this time  $t_{reset}$ .

The behavior of VCC, NRES and VS is shown in the following diagrams (ramp-up and ramp-down):

**Figure 4-7. VCC and NRES versus VS (Ramp-up) for 3.3V (SBC and Voltage Regulator)**



**Figure 4-8. VCC and NRES versus VS (Ramp-down) for 3.3V (SBC and Voltage Regulator)**

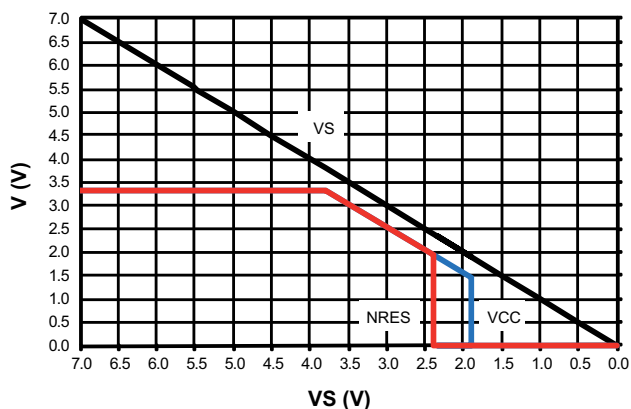


Figure 4-9. VCC and NRES versus VS (Ramp-up) for 5V (SBC and Voltage Regulator)

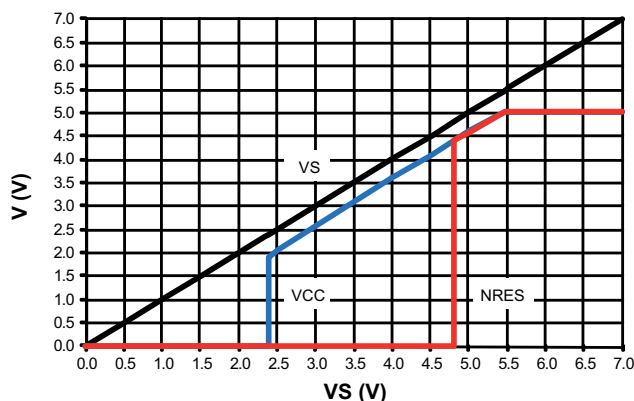
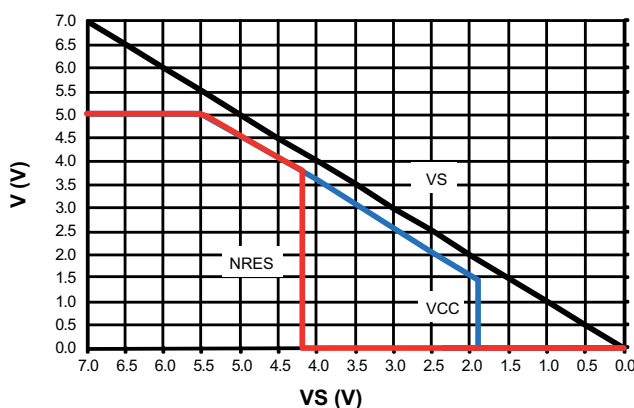


Figure 4-10. VCC and NRES versus VS (Ramp-down) for 5V (SBC and Voltage Regulator)



Please note that the upper graphs are only valid if the VS ramp-up and ramp-down times are much slower than the VCC ramp-up time  $t_{VCC}$  and the NRES delay time  $t_{reset}$ .

If during **sleep mode** the voltage level of  $V_{VS}$  drops below the undervoltage detection threshold  $V_{VS\_th\_N\_F\_down}$  (typ. 4.3V), the operation mode is not changed and no wake-up is possible. Only if the supply voltage on pin VS drops below the VS operation threshold  $V_{VS\_th\_U\_down}$  (typ. 2.05V), does the IC switch to unpowered mode.

If during **silent mode** the VCC voltage drops below the VCC undervoltage threshold  $V_{VCC\_th\_uv\_down}$  the IC switches into fail-safe mode. If the supply voltage on pin VS drops below the VS operation threshold  $V_{VS\_th\_U\_down}$  (typ. 2.05V), does the IC switch to unpowered mode.

If during **normal mode** the voltage level on the VS pin drops below the VS undervoltage detection threshold  $V_{VS\_th\_N\_F\_down}$  (typ. 4.3V), the IC switches to fail-safe mode. This means the LIN transceiver is disabled in order to avoid malfunctions or false bus messages. The voltage regulator remains active.

**For 3.3V SBC:** In this undervoltage situation it is possible to switch the device into sleep mode or silent mode by a falling edge at the EN input. For this feature, switching into these two current saving modes is always guaranteed, allowing current consumption to be reduced even further.

When the VCC voltage drops below the VCC undervoltage threshold  $V_{VCC\_th\_uv\_down}$  (typ. 2.6V) the IC switches into fail-safe mode.

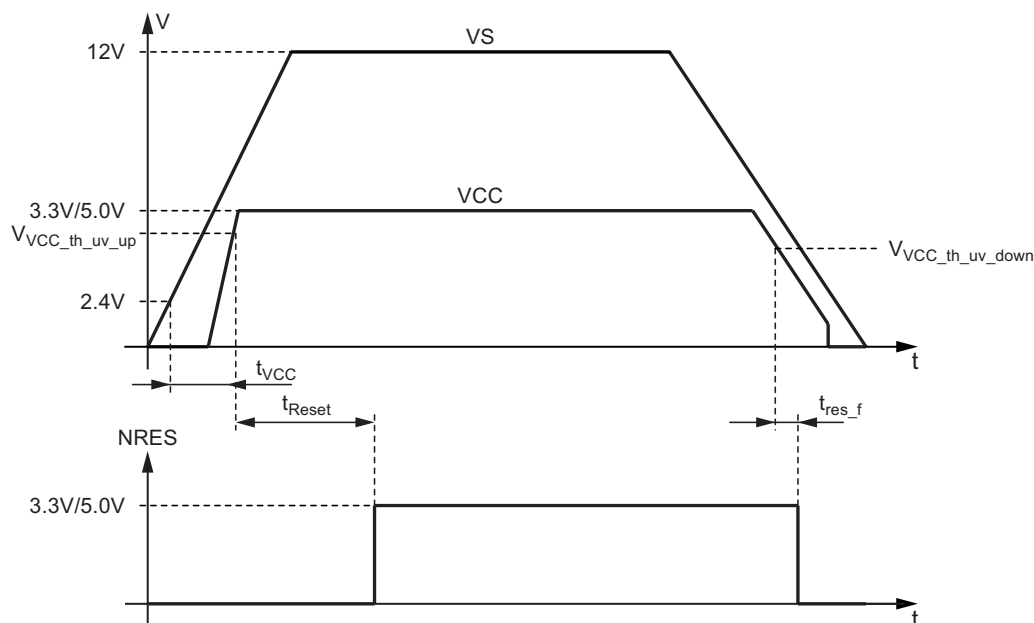
**For 5V SBC:** Because of the VCC undervoltage condition in this situation, the IC is in fail-safe mode and can be switched into sleep mode only.

Only when the supply voltage  $V_{VS}$  drops below the operation threshold  $V_{VS\_th\_U\_down}$  (typ. 2.05V) does the IC switch into unpowered mode.

The current consumption of the SBC in silent mode or in fail-safe mode and the voltage regulator is always below 170μA, even when the supply voltage VS is lower than the regulator's nominal output voltage VCC.

## 4.5 Voltage Regulator

**Figure 4-11. Voltage Regulator: Supply Voltage Ramp-up and Ramp-down**



The voltage regulator needs an external capacitor for compensation and to smooth the disturbances from the microcontroller. It is recommended to use a MLC capacitor with a minimum capacitance of 1.8 $\mu$ F together with a 100nF ceramic capacitor. Depending on the application, the values of these capacitors can be modified by the customer.

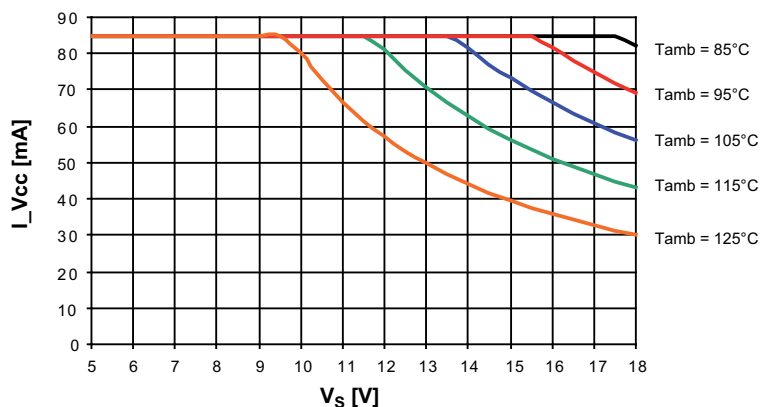
During a short circuit at VCC, the output limits the output current to  $I_{VCClim}$ . Because of undervoltage, NRES switches to low and sends a reset to the microcontroller. If the chip temperature exceeds the value  $T_{VCCoff}$ , the VCC output switches off. The chip cools down and, after a hysteresis of  $T_{hys}$ , switches the output on again.

When the Atmel® ATA6632xx in the DFN8 package is being soldered onto the PCB it is mandatory to connect the heat slug with a wide GND plate on the printed board to get a good heat sink.

The main power dissipation of the IC is created from the VCC output current  $I_{VCC}$ , which is needed for the application.

Figure 4-12 shows the safe operating area of the ATA6632xx in the DFN8 package.

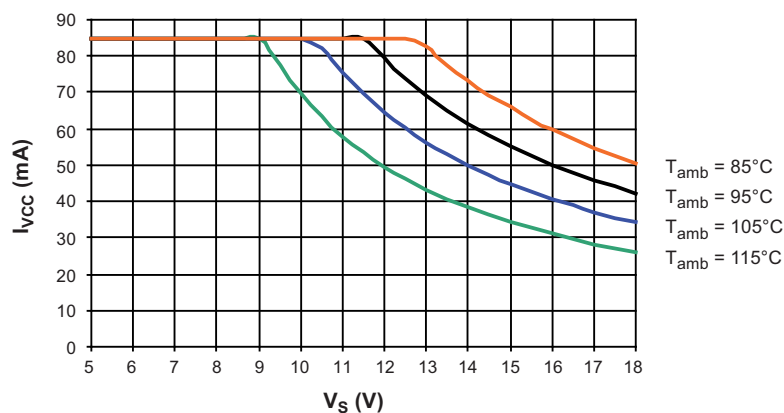
**Figure 4-12. DFN8 Package Power Dissipation: Safe Operating Area: Regulator's Output Current  $I_{VCC}$  versus Supply Voltage  $V_S$  at Different Ambient Temperatures ( $R_{thja} = 50K/W$  assumed)**



When the Atmel® ATA663254 in its special SO8 package (fused lead frame to pin 5) is being soldered on to the PCB, it is mandatory to connect pin 5 with a wide GND plate on the printed board to get a good heat sink.

Figure 4-13 shows the safe operating area of the Atmel ATA663254 in the SO8 package.

**Figure 4-13. SO8 Package Power Dissipation: Safe Operating Area: Regulator's Output Current  $I_{VCC}$  versus Supply Voltage  $V_S$  at Different Ambient Temperatures ( $R_{thja} = 80K/W$  assumed)**





## 5. Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameters	Symbol	Min.	Typ.	Max.	Unit
Supply voltage $V_S$	$V_S$	−0.3		+40	V
Pulse time ≤ 500ms $T_a = 25^\circ\text{C}$ Output current $I_{VCC} \leq 85\text{mA}$	$V_S$			+43.5	V
Pulse time ≤ 2min $T_a = 25^\circ\text{C}$ Output current $I_{VCC} \leq 85\text{mA}$	$V_S$			28	V
Logic pins voltage levels (RxD, TxD, EN, NRES)	$V_{\text{Logic}}$	−0.3		+5.5	V
Logic pins output DC currents	$I_{\text{Logic}}$	−5		+5	mA
LIN					
- DC voltage	$V_{\text{LIN}}$	−27		+40	V
- Pulse time < 500ms				+43.5	V
$V_{CC}$					
- DC voltage	$V_{VCC}$	−0.3		+5.5	V
- DC input current	$I_{VCC}$			+200	mA
ESD according to IBEE LIN EMC Test specification 1.0 following IEC 61000-4-2 - Pin VS, LIN to GND (with external circuitry acc. applications diagram)		±6			kV
ESD HBM following STM5.1 with 1.5kΩ/100pF - Pin VS, LIN to GND		±6			kV
HBM ESD ANSI/ESD-STM5.1 JESD22-A114 AEC-Q100 (002)		±3			kV
CDM ESD STM 5.3.1		±750			V
Machine Model ESD AEC-Q100-RevF(003)		±200			V
Junction temperature	$T_j$	−40		+150	°C
Storage temperature	$T_s$	−55		+150	°C

## 6. Thermal Characteristics DFN8

Parameters	Symbol	Min.	Typ.	Max.	Unit
Thermal resistance junction to heat slug	$R_{thjC}$		10		K/W
Thermal resistance junction to ambient, where heat slug is soldered to PCB according to JEDEC	$R_{thja}$		50		K/W
Thermal shutdown of $V_{CC}$ regulator	$T_{VCCoff}$	150	165	180	°C
Thermal shutdown of LIN output	$T_{LINoff}$	150	165	180	°C
Thermal shutdown hysteresis	$T_{hys}$		10		°C

## 7. Thermal Characteristics SO8

Parameters	Symbol	Min.	Typ.	Max.	Unit
Thermal resistance junction to ambient with a heat sink at GND (pin 5) on PCB (fused lead frame to pin 5)	$R_{thJA}$		80		K/W
Thermal shutdown of $V_{CC}$ regulator	$T_{VCCoff}$	150	165	180	°C
Thermal shutdown of LIN output	$T_{LINoff}$	150	165	180	°C
Thermal shutdown hysteresis	$T_{hys}$		10		°C

## 8. Electrical Characteristics

5V < V<sub>S</sub> < 28V, -40°C < T<sub>j</sub> < 150°C; unless otherwise specified all values refer to GND pins.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
1	VS pin								
1.1	Nominal DC voltage range		VS	V <sub>S</sub>	5	13.5	28	V	A
1.2	Supply current in sleep mode	Sleep mode V <sub>LIN</sub> > V <sub>S</sub> - 0.5V V <sub>S</sub> < 14V, T = 27°C	VS	I <sub>VSsleep</sub>	6	9	12	μA	B
		Sleep mode V <sub>LIN</sub> > V <sub>S</sub> - 0.5V V <sub>S</sub> < 14V	VS	I <sub>VSsleep</sub>	3	10	15	μA	A
		Sleep mode, V <sub>LIN</sub> = 0V bus shorted to GND V <sub>S</sub> < 14V	VS	I <sub>VSsleep_short</sub>	20	50	100	μA	A
1.3	Supply current in silent mode (SBC) / Active mode (voltage regulator)	Bus recessive 5.5V < V <sub>S</sub> < 14V without load at VCC T = 27°C	VS	I <sub>VSsilent</sub>	30	47	58	μA	B
		Bus recessive 5.5V < V <sub>S</sub> < 14V without load at VCC	VS	I <sub>VSsilent</sub>	30	50	64	μA	A
		Bus recessive 2.0V < V <sub>S</sub> < 5.5V without load at VCC	VS	I <sub>VSsilent</sub>	50	130	170	μA	A
		Silent mode 5.5V < V <sub>S</sub> < 14V bus shorted to GND without load at VCC	VS	I <sub>VSsilent_short</sub>	50	80	120	μA	A
1.4	Supply current in normal mode	Bus recessive V <sub>S</sub> < 14V without load at VCC	VS	I <sub>VSrec</sub>	150	230	290	μA	A
1.5	Supply current in normal mode	Bus dominant (internal LIN pull-up resistor active) V <sub>S</sub> < 14V without load at VCC	VS	I <sub>VSdom</sub>	200	700	950	μA	A
1.6	Supply current in fail-safe mode	Bus recessive 5.5V < V <sub>S</sub> < 14V without load at VCC	VS	I <sub>VSfail</sub>	40	55	80	μA	A
		Bus recessive 2.0V < V <sub>S</sub> < 5.5V without load at VCC	VS	I <sub>VSfail</sub>	50	130	170	μA	A
1.7	VS undervoltage threshold (switching from normal to fail-safe mode)	Decreasing supply voltage	VS	V <sub>VS_th_N_F_down</sub>	3.9	4.3	4.7	V	A
		Increasing supply voltage	VS	V <sub>VS_th_F_N_up</sub>	4.1	4.6	4.9	V	A
1.8	VS undervoltage hysteresis		VS	V <sub>VS_hys_F_N</sub>	0.1	0.25	0.4	V	A
1.9	VS operation threshold (switching to unpowered mode)	Switch to unpowered mode	VS	V <sub>VS_th_U_down</sub>	1.9	2.05	2.3	V	A
		Switch from unpowered to fail-safe mode	VS	V <sub>VS_th_U_F_up</sub>	2.0	2.25	2.4	V	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

## 8. Electrical Characteristics (Continued)

5V < V<sub>S</sub> < 28V, -40°C < T<sub>J</sub> < 150°C; unless otherwise specified all values refer to GND pins.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
1.10	VS undervoltage hysteresis		VS	V <sub>VS_hys_U</sub>	0.1	0.2	0.3	V	A
<b>2 RXD output pin (only SBC)</b>									
2.1	Low-level output sink capability	Normal mode, V <sub>LIN</sub> = 0V, I <sub>RXD</sub> = 2mA	RXD	V <sub>RXDL</sub>		0.2	0.4	V	A
2.2	High-level output source capability	Normal mode V <sub>LIN</sub> = V <sub>S</sub> , I <sub>RXD</sub> = -2mA	RXD	V <sub>RXDH</sub>	V <sub>CC</sub> - 0.4V	V <sub>CC</sub> - 0.2V		V	A
<b>3 TXD input/output pin (only SBC)</b>									
3.1	Low-level voltage input		TXD	V <sub>TXDL</sub>	-0.3		+0.8	V	A
3.2	High-level voltage input		TXD	V <sub>TXDH</sub>	2		V <sub>CC</sub> + 0.3V	V	A
3.3	Pull-up resistor	V <sub>TXD</sub> = 0V	TXD	R <sub>TXD</sub>	40	70	100	kΩ	A
3.4	High-level leakage current	V <sub>TXD</sub> = V <sub>CC</sub>	TXD	I <sub>TXD</sub>	-3		+3	μA	A
3.7	Low-level output sink current at LIN wake-up request	Fail-safe Mode V <sub>LIN</sub> = V <sub>S</sub> V <sub>TXD</sub> = 0.4V	TXD	I <sub>TXD</sub>	2	2.5	8	mA	A
<b>4 EN input pin (only SBC)</b>									
4.1	Low-level voltage input		EN	V <sub>ENL</sub>	-0.3		+0.8	V	A
4.2	High-level voltage input		EN	V <sub>ENH</sub>	2		V <sub>CC</sub> + 0.3V	V	A
4.3	Pull-down resistor	V <sub>EN</sub> = V <sub>CC</sub>	EN	R <sub>EN</sub>	50	125	200	kΩ	A
4.4	Low-level input current	V <sub>EN</sub> = 0V	EN	I <sub>EN</sub>	-3		+3	μA	A
<b>5 NRES open drain output pin</b>									
5.1	Low-level output voltage	V <sub>S</sub> ≥ 5.5V I <sub>NRES</sub> = 2mA	NRES	V <sub>NRESL</sub>		0.2	0.4	V	A
5.2	Undervoltage reset time	V <sub>VS</sub> ≥ 5.5V C <sub>NRES</sub> = 20pF	NRES	t <sub>Reset</sub>	2	4	6	ms	A
5.3	Reset debounce time for falling edge	V <sub>VS</sub> ≥ 5.5V C <sub>NRES</sub> = 20pF	NRES	t <sub>res_f</sub>	0.5		10	μs	A
5.4	Switch off leakage current	V <sub>NRES</sub> = 5.5V	NRES	I <sub>NRES_L</sub>	-3		+3	μA	A
<b>8 VCC voltage regulator (3.3V)</b>									
8.1	Output voltage VCC	4V < V <sub>S</sub> < 18V (0mA to 50mA)	VCC	V <sub>CC_nor</sub>	3.234		3.366	V	A
		4.5V < V <sub>S</sub> < 18V (0mA to 85mA)	VCC	V <sub>CC_nor</sub>	3.234		3.366	V	C
8.2	Output voltage V <sub>CC</sub> at low V <sub>S</sub>	3V < V <sub>S</sub> < 4V	VCC	V <sub>CC_low</sub>	V <sub>VS</sub> - V <sub>D</sub>		3.366	V	A
8.3	Regulator drop voltage	V <sub>S</sub> > 3V, I <sub>VCC</sub> = -15mA	VCC	V <sub>D1</sub>		100	150	mV	A
8.4	Regulator drop voltage	V <sub>S</sub> > 3V, I <sub>VCC</sub> = -50mA	VCC	V <sub>D2</sub>		300	500	mV	A
8.5	Line regulation maximum	4V < V <sub>S</sub> < 18V	VCC	V <sub>CC_line</sub>		0.1	0.2	%	A
8.6	Load regulation maximum	5mA < I <sub>VCC</sub> < 50mA	VCC	V <sub>CC_load</sub>		0.1	0.5	%	A
8.7	Output current limitation	V <sub>S</sub> > 4V	VCC	I <sub>VCClim</sub>		-180	-120	mA	A
8.8	Load capacity	MLC capacitor	VCC	C <sub>load</sub>	1.8	2.2		μF	D

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

## 8. Electrical Characteristics (Continued)

5V < V<sub>S</sub> < 28V, -40°C < T<sub>j</sub> < 150°C; unless otherwise specified all values refer to GND pins.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
8.9	VCC undervoltage threshold (NRES ON)	Referred to VCC VS > 4V	VCC	V <sub>VCC_th_uv_down</sub>	2.3	2.5	2.8	V	A
	VCC undervoltage threshold (NRES OFF)	Referred to VCC VS > 4V	VCC	V <sub>VCC_th_uv_up</sub>	2.5	2.6	2.9	V	A
8.10	Hysteresis of VCC undervoltage threshold	Referred to VCC VS > 4V	VCC	V <sub>VCC_hys_uv</sub>	100	200	300	mV	A
8.11	Ramp-up time VS > 4V to VCC = 3.3V	C <sub>VCC</sub> = 2.2μF I <sub>load</sub> = -5mA at VCC	VCC	t <sub>VCC</sub>		1	1.5	ms	A
9 VCC voltage regulator (5V)									
9.1	Output voltage VCC	5.5V < V <sub>S</sub> < 18V (0mA to 50mA)	VCC	V <sub>VCC_nor</sub>	4.9		5.1	V	A
		6V < V <sub>S</sub> < 18V (0mA to 85mA)	VCC	V <sub>VCC_nor</sub>	4.9		5.1	V	C
9.2	Output voltage V <sub>CC</sub> at low V <sub>S</sub>	4V < VS < 5.5V	VCC	V <sub>VCC_low</sub>	V <sub>VS</sub> - V <sub>D</sub>		5.1	V	A
9.3	Regulator drop voltage	VS > 4V, I <sub>VCC</sub> = -20mA	VCC	V <sub>D1</sub>		100	200	mV	A
9.4	Regulator drop voltage	VS > 4V, I <sub>VCC</sub> = -50mA	VCC	V <sub>D2</sub>		300	500	mV	A
9.5	Regulator drop voltage	VS > 3.3V, I <sub>VCC</sub> = -15mA	VCC	V <sub>D3</sub>			150	mV	A
9.6	Line regulation maximum	5.5V < VS < 18V	VCC	V <sub>VCC_line</sub>		0.1	0.2	%	A
9.7	Load regulation maximum	5mA < I <sub>VCC</sub> < 50mA	VCC	V <sub>VCC_load</sub>		0.1	0.5	%	A
9.8	Output current limitation	VS > 5.5V	VCC	I <sub>VCClim</sub>		-180	-120	mA	A
9.9	Load capacity	MLC capacitor	VCC	C <sub>load</sub>	1.8	2.2		μF	D
9.10	VCC undervoltage threshold (NRES ON)	Referred to VCC VS > 4V	VCC	V <sub>VCC_th_uv_down</sub>	4.2	4.4	4.6	V	A
	VCC undervoltage threshold (NRES OFF)	Referred to VCC VS > 4V	VCC	V <sub>VCC_th_uv_up</sub>	4.3	4.6	4.8	V	A
9.11	Hysteresis of undervoltage threshold	Referred to VCC VS > 5.5V	VCC	V <sub>VCC_hys_uv</sub>	100	200	300	mV	A
9.12	Ramp-up time VS > 5.5V to VCC = 5V	C <sub>VCC</sub> = 2.2μF I <sub>load</sub> = -5mA at VCC	VCC	t <sub>VCC</sub>		1	1.5	ms	A
10 LIN bus driver (only SBC): bus load conditions: Load 1 (small): 1nF, 1kΩ; Load 2 (large): 10nF, 500Ω; C <sub>RXD</sub> = 20pF, Load 3 (medium): 6.8nF, 660Ω characterized on samples 12.7 and 12.8 specifies the timing parameters for proper operation at 20kb/s and 12.9 and 12.10 at 10.4kb/s									
10.1	Driver recessive output voltage	Load1/Load2	LIN	V <sub>BUSrec</sub>	0.9 × V <sub>S</sub>		V <sub>S</sub>	V	A
10.2	Driver dominant voltage	V <sub>VS</sub> = 7V R <sub>load</sub> = 500Ω	LIN	V <sub>_LoSUP</sub>			1.2	V	A
10.3	Driver dominant voltage	V <sub>VS</sub> = 18V R <sub>load</sub> = 500Ω	LIN	V <sub>_HiSUP</sub>			2	V	A
10.4	Driver dominant voltage	V <sub>VS</sub> = 7V R <sub>load</sub> = 1000Ω	LIN	V <sub>_LoSUP_1k</sub>	0.6			V	A
10.5	Driver dominant voltage	V <sub>VS</sub> = 18V R <sub>load</sub> = 1000Ω	LIN	V <sub>_HiSUP_1k</sub>	0.8			V	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

## 8. Electrical Characteristics (Continued)

5V < V<sub>S</sub> < 28V, -40°C < T<sub>j</sub> < 150°C; unless otherwise specified all values refer to GND pins.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
10.6	Pull-up resistor to V <sub>S</sub>	The serial diode is mandatory	LIN	R <sub>LIN</sub>	20	30	47	kΩ	A
10.7	Voltage drop at the serial diodes	In pull-up path with R <sub>slave</sub> I <sub>SerDiode</sub> = 10mA	LIN	V <sub>SerDiode</sub>	0.4		1.0	V	D
10.8	LIN current limitation V <sub>BUS</sub> = V <sub>Bat_max</sub>		LIN	I <sub>BUS_LIM</sub>	40	120	200	mA	A
10.9	Input leakage current at the receiver including pull-up resistor as specified	Input leakage current driver off V <sub>BUS</sub> = 0V V <sub>Bat</sub> = 12V	LIN	I <sub>BUS_PAS_dom</sub>	-1	-0.35		mA	A
10.10	Leakage current LIN recessive	Driver off 8V < V <sub>Bat</sub> < 18V 8V < V <sub>BUS</sub> < 18V V <sub>BUS</sub> ≥ V <sub>Bat</sub>	LIN	I <sub>BUS_PAS_rec</sub>		10	20	μA	A
10.11	Leakage current when control unit disconnected from ground. Loss of local ground must not affect communication in the residual network	GND <sub>Device</sub> = V <sub>S</sub> V <sub>Bat</sub> = 12V 0V < V <sub>BUS</sub> < 18V	LIN	I <sub>BUS_NO_gnd</sub>	-10	+0.5	+10	μA	A
10.12	Leakage current at disconnected battery. Node has to sustain the current that can flow under this condition. Bus must remain operational under this condition.	V <sub>Bat</sub> disconnected V <sub>SUP_Device</sub> = GND 0V < V <sub>BUS</sub> < 18V	LIN	I <sub>BUS_NO_bat</sub>		0.1	2	μA	A
10.13	Capacitance on pin LIN to GND		LIN	C <sub>LIN</sub>			20	pF	D
<b>11 LIN bus receiver (only SBC)</b>									
11.1	Center of receiver threshold	V <sub>BUS_CNT</sub> = (V <sub>th_dom</sub> + V <sub>th_rec</sub> )/2	LIN	V <sub>BUS_CNT</sub>	0.475 × V <sub>S</sub>	0.5 × V <sub>S</sub>	0.525 × V <sub>S</sub>	V	A
11.2	Receiver dominant state	V <sub>EN</sub> = 5V/3.3V	LIN	V <sub>BUSdom</sub>	-27		0.4 × V <sub>S</sub>	V	A
11.3	Receiver recessive state	V <sub>EN</sub> = 5V/3.3V	LIN	V <sub>BUSrec</sub>	0.6 × V <sub>S</sub>		40	V	A
11.4	Receiver input hysteresis	V <sub>hys</sub> = V <sub>th_rec</sub> - V <sub>th_dom</sub>	LIN	V <sub>BUShys</sub>	0.028 × V <sub>S</sub>	0.1 × V <sub>S</sub>	0.175 × V <sub>S</sub>	V	A
11.5	Pre-wake detection LIN high-level input voltage		LIN	V <sub>LINH</sub>	V <sub>S</sub> - 2V		V <sub>S</sub> + 0.3V	V	A
11.6	Pre-wake detection LIN low-level input voltage	Activates the LIN receiver	LIN	V <sub>LINL</sub>	-27		V <sub>S</sub> - 3.3V	V	A
<b>12 Internal timers (only SBC)</b>									
12.1	Dominant time for wake-up via LIN bus	V <sub>LIN</sub> = 0V	LIN	t <sub>bus</sub>	50	100	150	μs	A
12.2	Time delay for mode change from fail-safe into normal mode via EN pin	V <sub>EN</sub> = 5V/3.3V	EN	t <sub>norm</sub>	5	15	20	μs	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

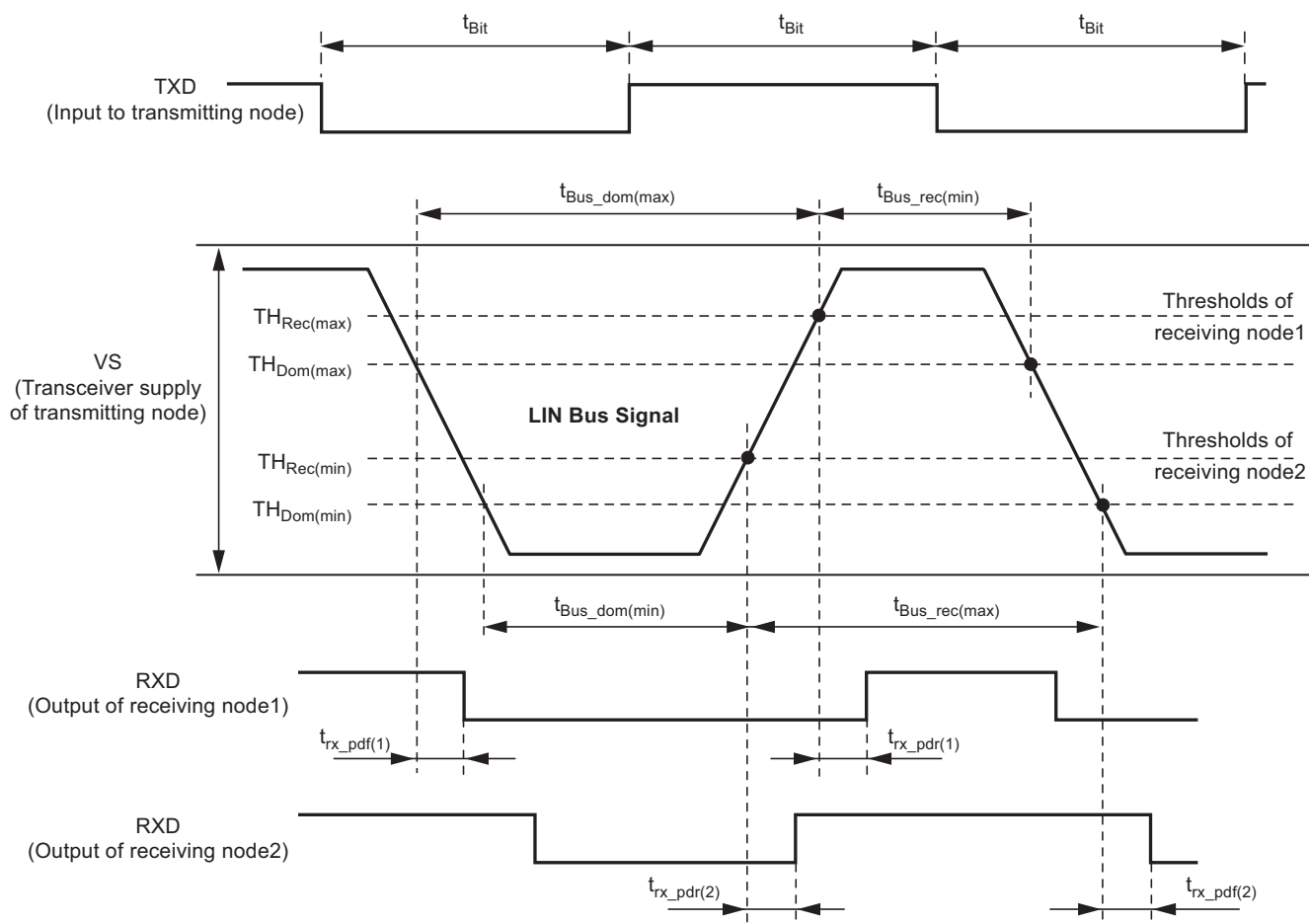
## 8. Electrical Characteristics (Continued)

5V < V<sub>S</sub> < 28V, -40°C < T<sub>j</sub> < 150°C; unless otherwise specified all values refer to GND pins.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
12.3	Time delay for mode change from normal mode to sleep mode via EN pin	V <sub>EN</sub> = 0V	EN	t <sub>sleep</sub>	5	15	20	μs	A
12.5	TXD dominant time-out time	V <sub>TXD</sub> = 0V	TXD	t <sub>dom</sub>	20	40	60	ms	A
12.6	Time delay for mode change from silent mode into normal mode via EN pin	V <sub>EN</sub> = 5V/3.3V	EN	t <sub>s_n</sub>	5	15	40	μs	A
12.7	Duty cycle 1	$TH_{Rec(max)} = 0.744 \times V_S$ $TH_{Dom(max)} = 0.581 \times V_S$ V <sub>S</sub> = 7.0V to 18V t <sub>Bit</sub> = 50μs D1 = t <sub>bus_rec(min) / (2 × t<sub>Bit</sub>) </sub>	LIN	D1	0.396				A
12.8	Duty cycle 2	$TH_{Rec(min)} = 0.422 \times V_S$ $TH_{Dom(min)} = 0.284 \times V_S$ V <sub>S</sub> = 7.6V to 18V t <sub>Bit</sub> = 50μs D2 = t <sub>bus_rec(max) / (2 × t<sub>Bit</sub>) </sub>	LIN	D2			0.581		A
12.9	Duty cycle 3	$TH_{Rec(max)} = 0.778 \times V_S$ $TH_{Dom(max)} = 0.616 \times V_S$ V <sub>S</sub> = 7.0V to 18V t <sub>Bit</sub> = 96μs D3 = t <sub>bus_rec(min) / (2 × t<sub>Bit</sub>) </sub>	LIN	D3	0.417				A
12.10	Duty cycle 4	$TH_{Rec(min)} = 0.389 \times V_S$ $TH_{Dom(min)} = 0.251 \times V_S$ V <sub>S</sub> = 7.6V to 18V t <sub>Bit</sub> = 96μs D4 = t <sub>bus_rec(max) / (2 × t<sub>Bit</sub>) </sub>	LIN	D4			0.590		A
12.11	Slope time falling and rising edge at LIN	V <sub>S</sub> = 7.0V to 18V	LIN	t <sub>SLOPE_fall</sub> t <sub>SLOPE_rise</sub>	3.5		22.5	μs	A
13	Receiver electrical AC parameters of the LIN physical layer (only SBC) LIN receiver, RXD load conditions: C <sub>RXD</sub> = 20pF								
13.1	Propagation delay of receiver	V <sub>S</sub> = 7.0V to 18V t <sub>rx_pd</sub> = max(t <sub>rx_pdr</sub> , t <sub>rx_pdf</sub> )	RXD	t <sub>rx_pd</sub>			6	μs	A
13.2	Symmetry of receiver propagation delay rising edge minus falling edge	V <sub>S</sub> = 7.0V to 18V t <sub>rx_sym</sub> = t <sub>rx_pdr</sub> - t <sub>rx_pdf</sub>	RXD	t <sub>rx_sym</sub>	-2		+2	μs	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

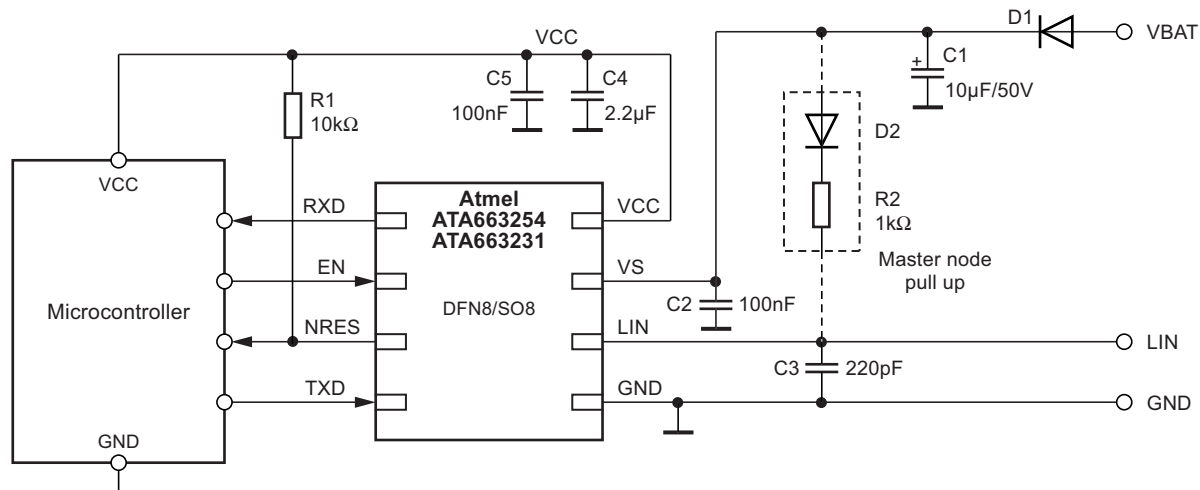
**Figure 8-1. Definition of Bus Timing Characteristics**





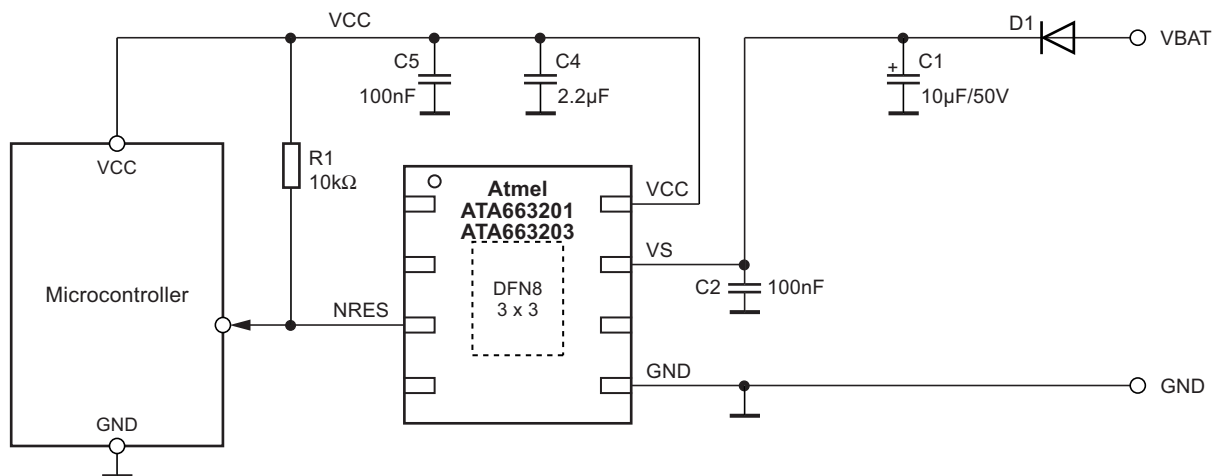
## 9. Application Circuits

Figure 9-1. Typical Application Circuit SBC



Note: Heat slug must always be connected to GND (for DFN8 package).

Figure 9-2. Typical Application Circuit Voltage Regulator



Note: Heat slug must always be connected to GND.

## 10. Ordering Information

Extended Type Number	Package	Remarks
ATA663231-GBQW	DFN8	3.3V LIN system basis chip, Pb-free, 6k, taped and reeled
ATA663254-GBQW	DFN8	5V LIN system basis chip, Pb-free, 6k, taped and reeled
ATA663201-GBQW	DFN8	3.3V voltage regulator, Pb-free, 6k, taped and reeled
ATA663203-GBQW	DFN8	5V voltage regulator, Pb-free, 6k, taped and reeled
ATA663254-GAQW	SO8	5V LIN system basis chip, Pb-free, 4k, taped and reeled

## 11. Package Information

Figure 11-1. DFN8

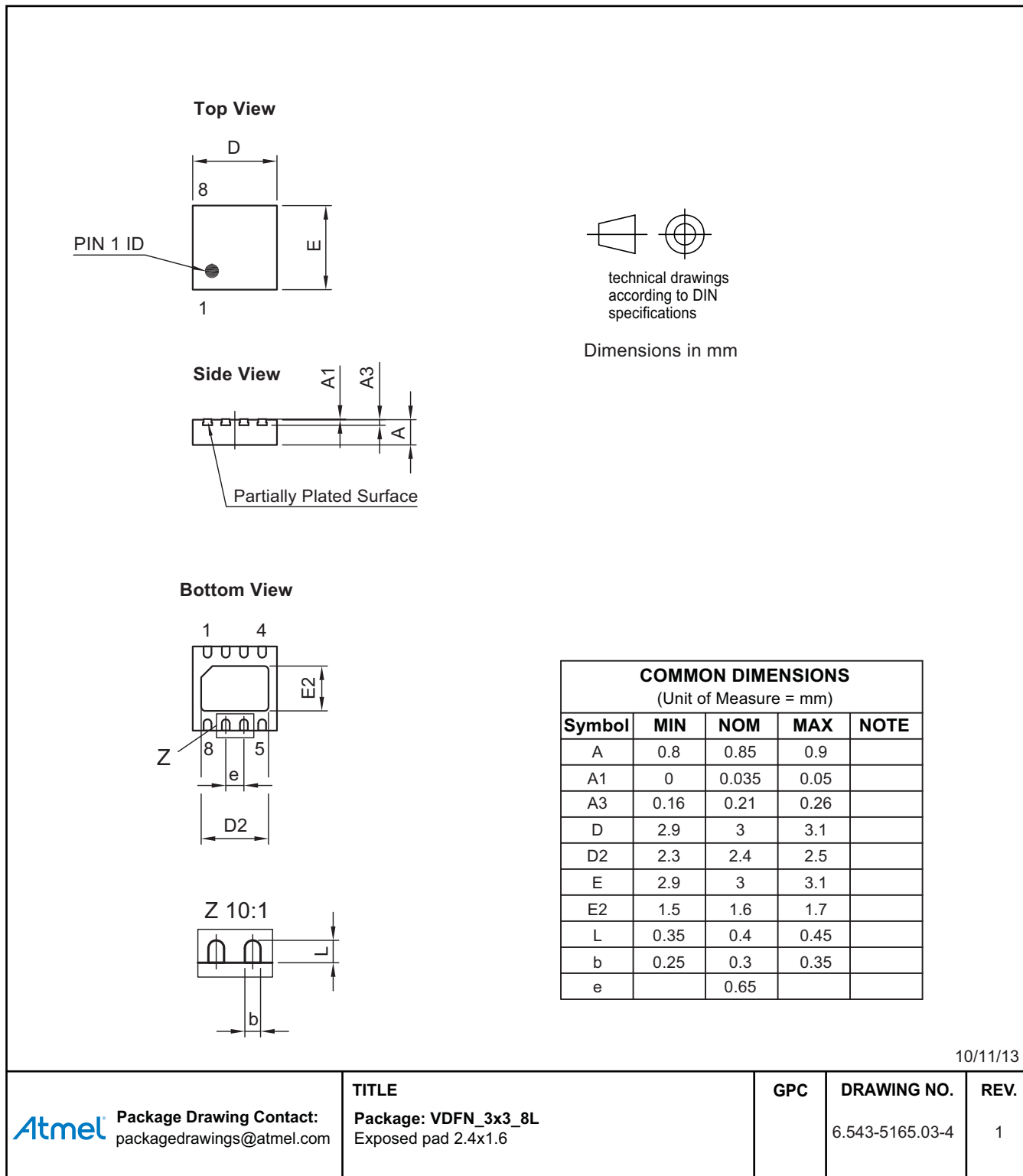
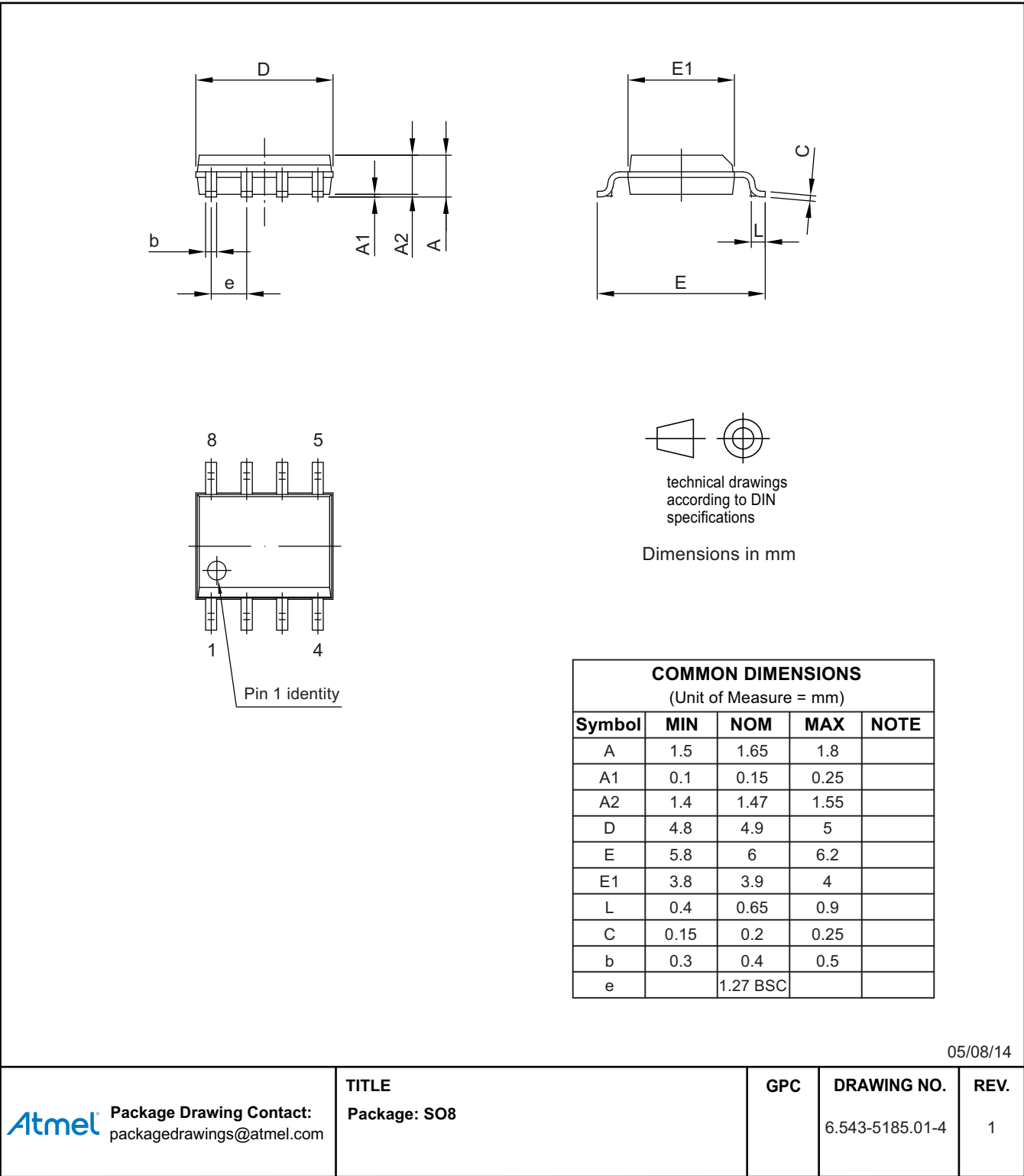


Figure 11-2. SO8



## 12. Revision History

Please note that the following page numbers referred to in this section refer to the specific revision mentioned, not to this document.

Revision No.	History
9337G-AUTO-09/16	<ul style="list-style-type: none"><li>• ATA663201 3.3V voltage regulator added</li></ul>
9337F-AUTO-02/16	<ul style="list-style-type: none"><li>• Features on page 1 updated</li><li>• Section 2 “Pin Configuration” on page 4 updated</li><li>• Section 4.5 “Voltage Regulator” on pages 15 to 16 updated</li><li>• Section 7 “Thermal Characteristics SO8” on page 18 added</li><li>• Section 9 “Application Circuits” on page 25 updated</li><li>• Section 10 “Ordering Information” on page 25 updated</li><li>• Figure 11-2 “SO8” on page 27 added</li></ul>
9337E-AUTO-12/15	<ul style="list-style-type: none"><li>• Section 4.2 “Operating Modes” on page 7: Note 1 added below Figure 4-1</li><li>• Figure 4-11 “Voltage Regulator: Supply Voltage Ramp-up and Ramp-down” on page 15: Parameter names updated</li></ul>
9337D-AUTO-07/14	<ul style="list-style-type: none"><li>• Figure 1- 2 “Block Diagram Voltage Regulator” on page 3 added</li><li>• ATA663203 pin configuration on page 4 added</li><li>• Figure 4-3 “Voltage Regulator Operating Modes” on page 8 added</li><li>• Section 4.2.5 “Active Mode (Voltage Regulator only)” on page 10 added</li><li>• Figure 8-2 “Typical Application Circuit Voltage Regulator” on page 23 added</li><li>• Section 9 “Ordering Information” on page 24 updated</li></ul>



**Atmel Corporation**      1600 Technology Drive, San Jose, CA 95110 USA      T: (+1)(408) 441.0311      F: (+1)(408) 436.4200      |      [www.atmel.com](http://www.atmel.com)

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