

LIN Bus Device Family including Voltage Regulator and LIN SBC⁽¹⁾ with Compatible Footprint

DATASHEET

Features

- Supply voltage up to 40V
- Operating voltage $V_S = 5V$ to 28V
- Supply current
 - Sleep mode: typically 9 μ A
 - Silent mode: typically 47 μ A
 - Very low current consumption at low supply voltages ($2V < V_S < 5.5V$): typically 130 μ A
- Linear low-drop voltage regulator, 85mA current capability:
 - MLC (multi-layer ceramic) capacitor with 0 Ω ESR
 - Normal, fail-safe, and silent mode
 - Atmel 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: $V_{CC} = 5.0V \pm 2\%$
- 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 μ 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
- Package: DFN8 with wettable flanks (Moisture Sensitivity Level 1)

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 ATA663203 (voltage regulator) is a fully integrated low-drop voltage regulator, with 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 5V | 03 |

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

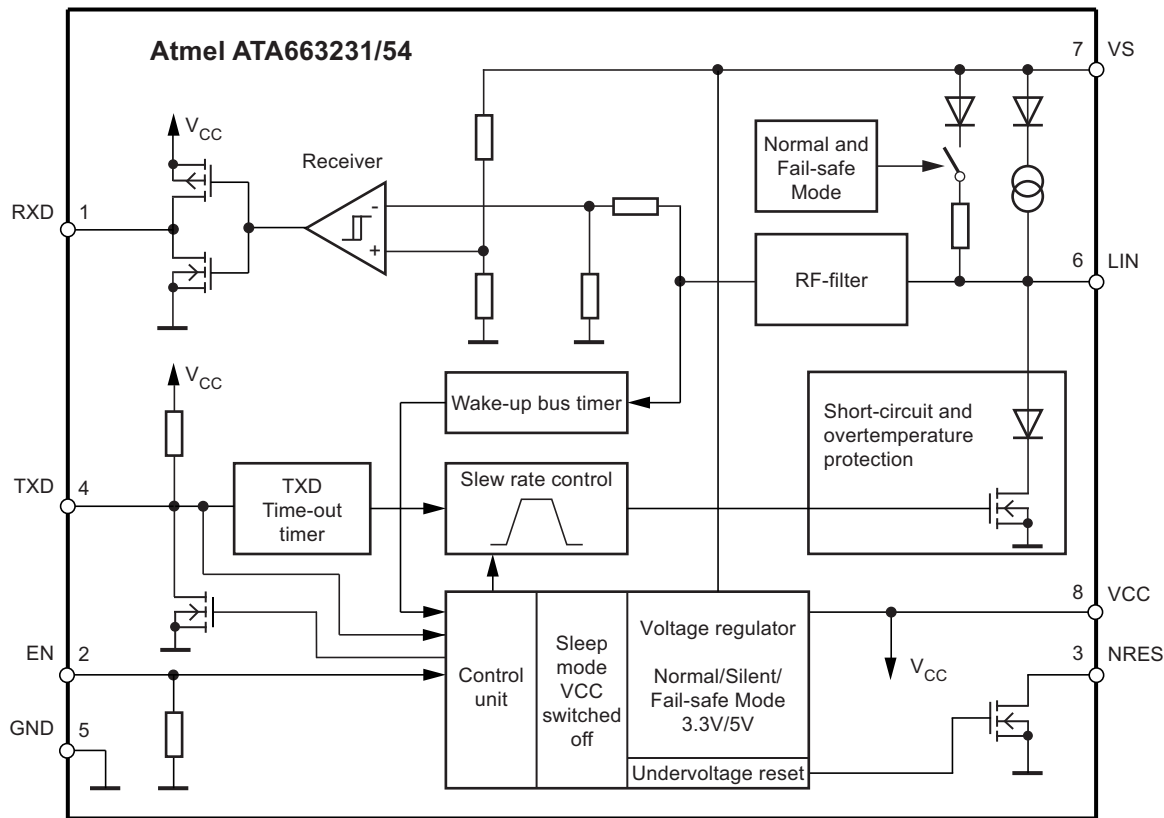
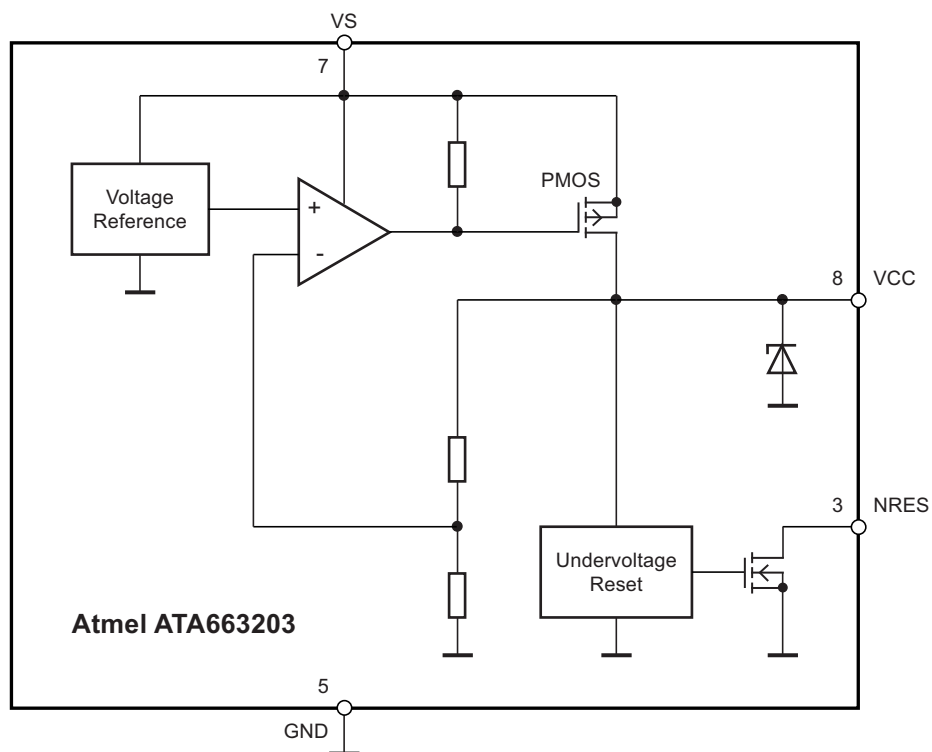


Figure 1-2. Block Diagram Voltage Regulator



2. Pin Configuration

Figure 2-1. Pinning DFN8

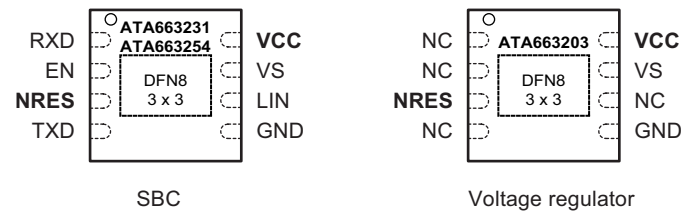


Table 2-1. Pin Description

| 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, heat slug |
| 6 | LIN | LIN bus line input/output |
| 7 | VS | Supply voltage |
| 8 | VCC | Output voltage regulator 3.3V/5V/85mA |
| Backside | | Heat slug, internally connected to the GND pin |

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 μ 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 μ 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

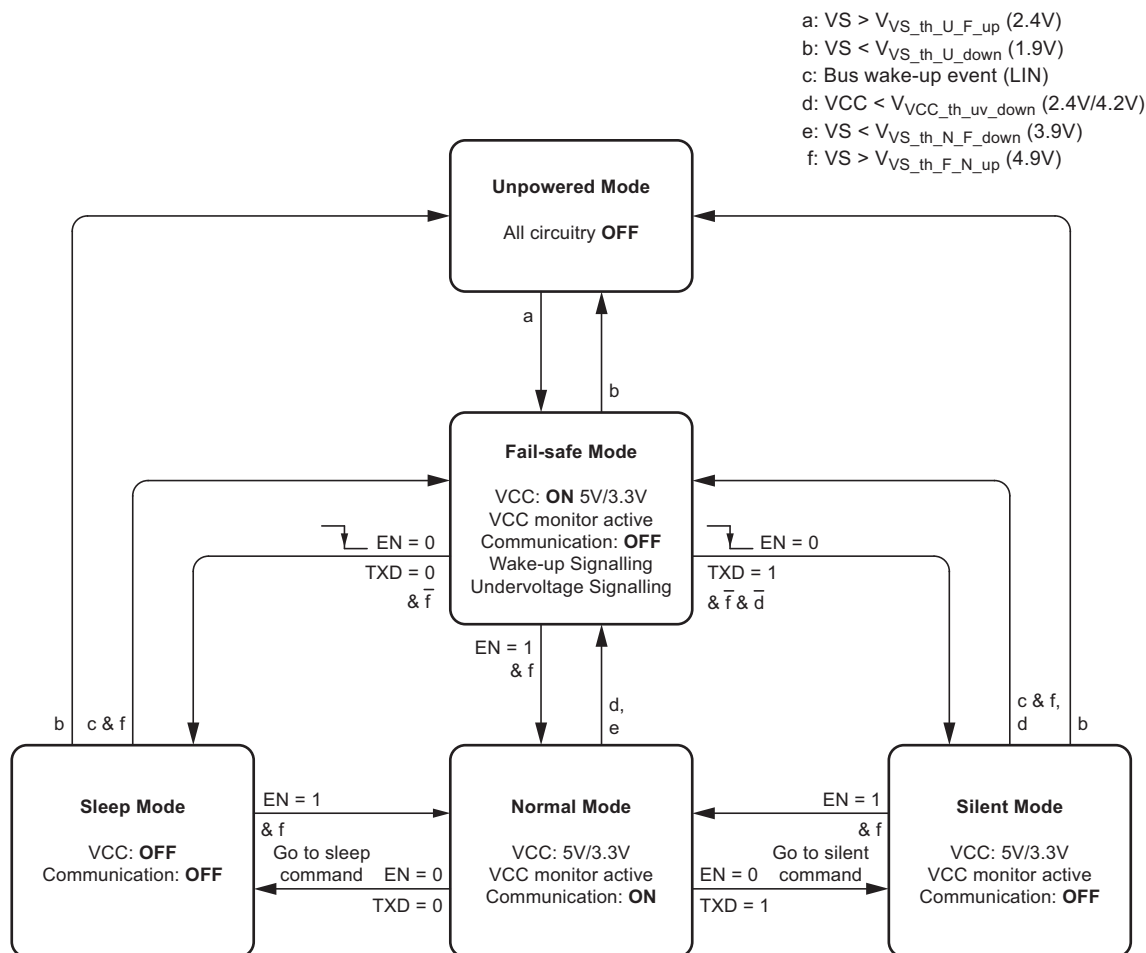
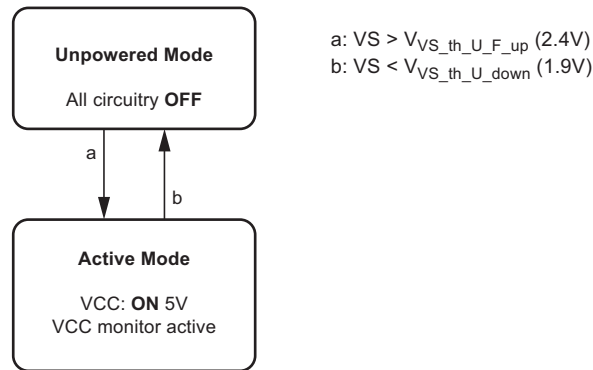


Table 4-1. SBC (ATA663254, ATA663231) Operating Modes

| Operating Mode | Transceiver | V _{CC} (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)

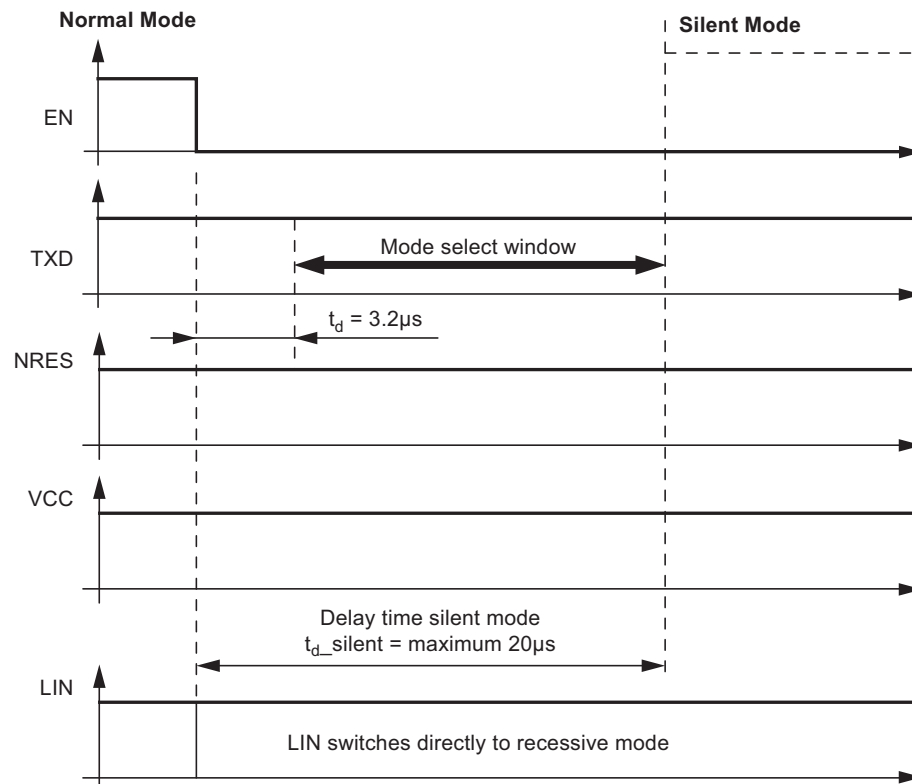
This is the normal transmitting and receiving mode of the LIN Interface, in accordance with LIN specification 2.x.

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



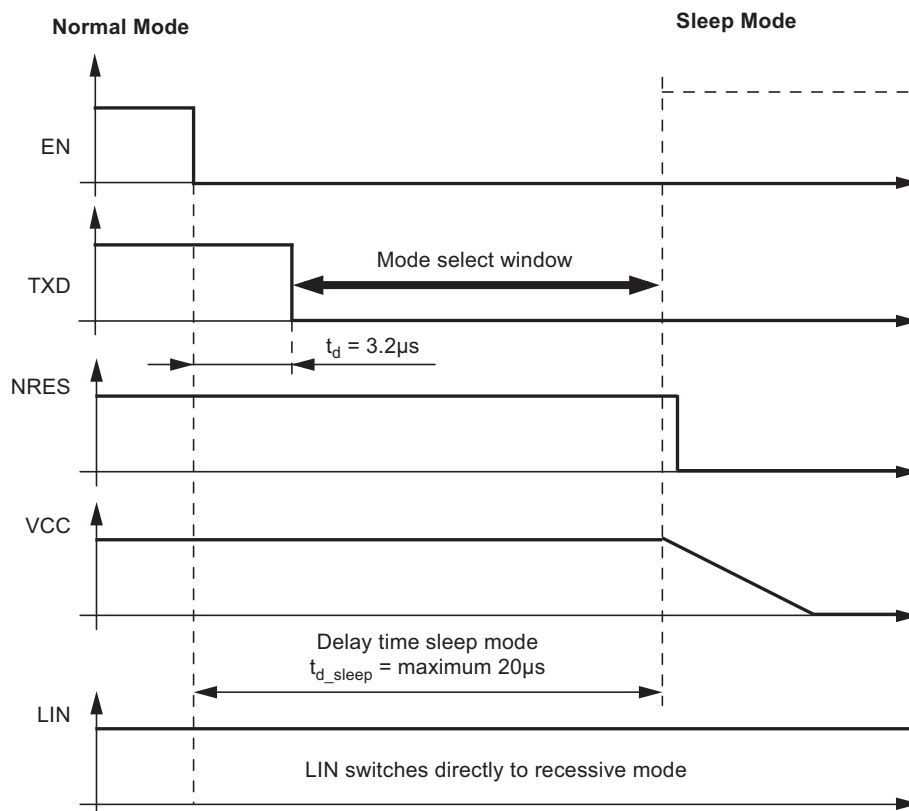
In silent mode the internal slave termination between the LIN pin and VS pin is disabled to minimize the current consumption in case the pin LIN is short-circuited to GND. Only a weak pull-up current (typically 10µA) between the LIN pin and VS pin is present. Silent mode can be activated independently 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 $I_{VSSleep} = 9\mu A$. 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 ($V_S < 3.9\text{V}$) | 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 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.

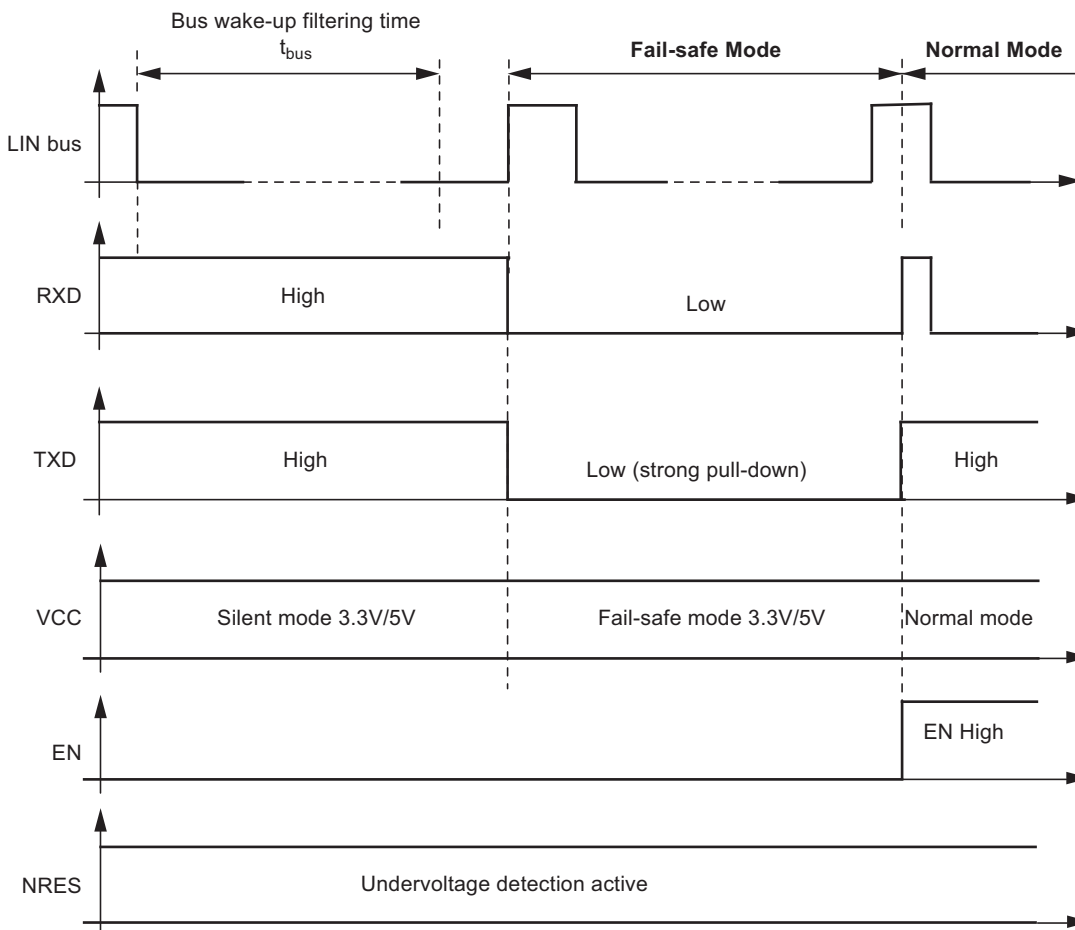
4.3 Wake-up Scenarios from Silent Mode or Sleep Mode

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 V_{LINL} 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



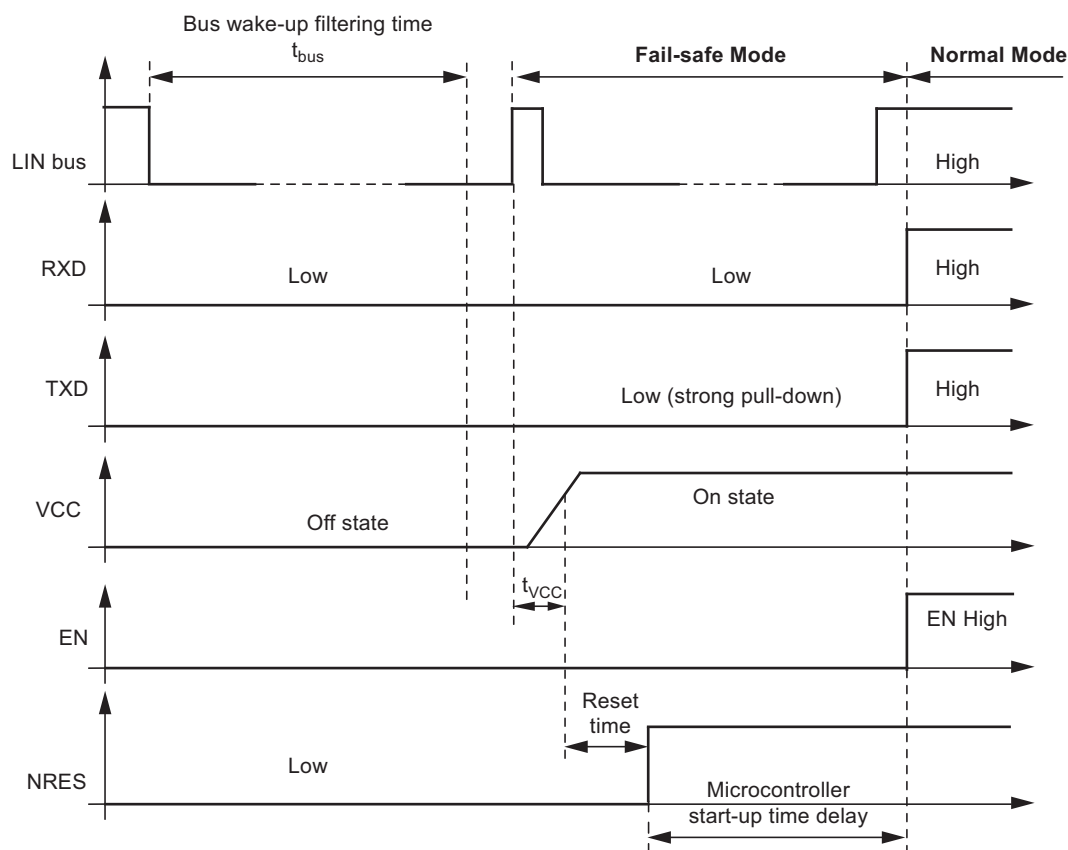
4.3.1.2 Remote Wake-up from Sleep Mode (SBC only)

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 8-1 on page 23](#)). 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 only)

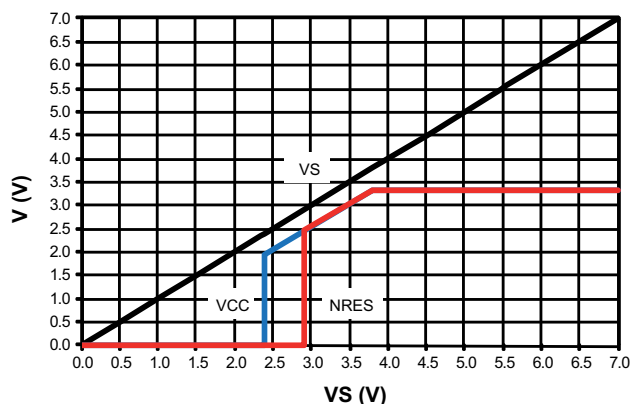


Figure 4-8. VCC and NRES versus VS (Ramp-down) for 3.3V (SBC only)

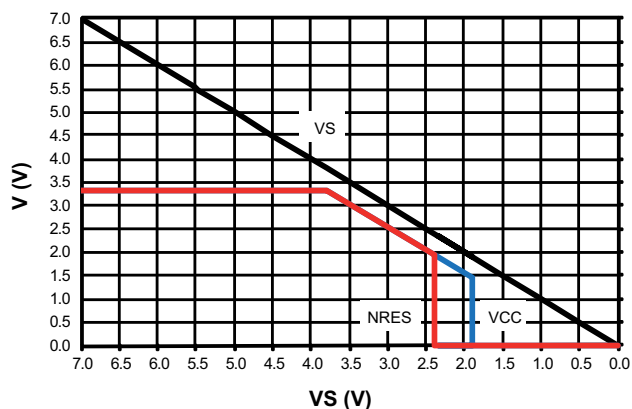


Figure 4-9. VCC and NRES versus VS (Ramp-up) for 5V (SBC and Voltage Regulator)

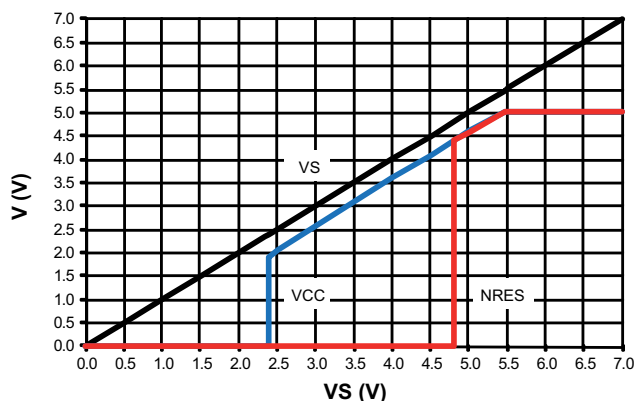
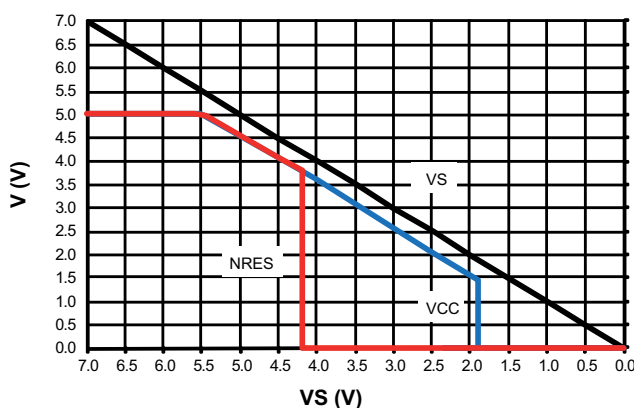


Figure 4-10. VCC and NRES versus VS (Ramp-down) for 5V (SBC and Voltage Regulator)



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.

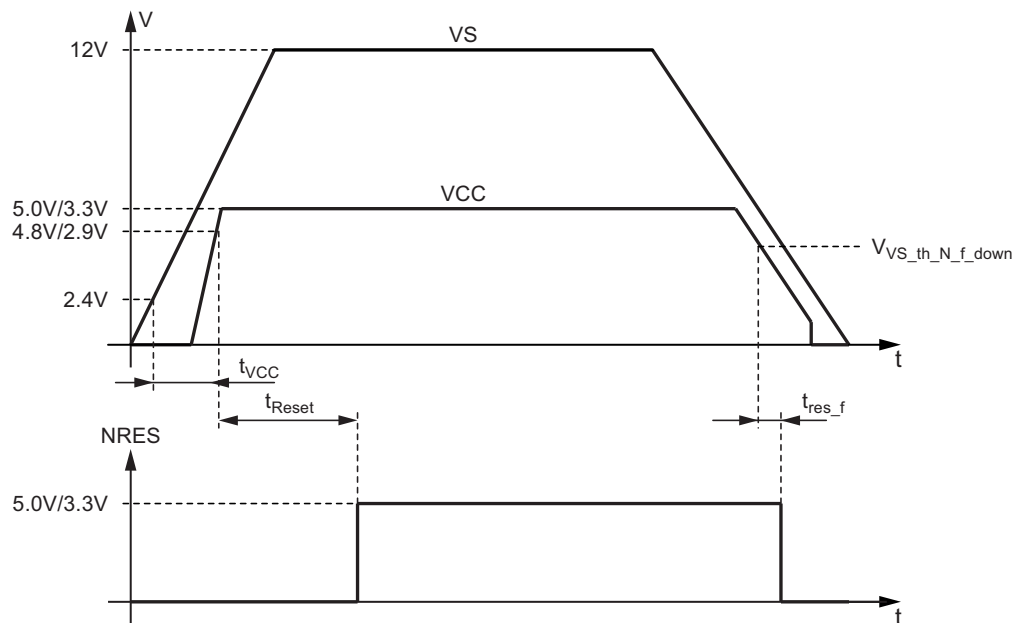
For 5V SBC: Because of the VCC undervoltage condition in this situation, the IC is in fail-safe mode and can be switched into sleep mode only.

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 μ F together with a 100nF ceramic capacitor. Depending on the application, the values of these capacitors can be modified by the customer.

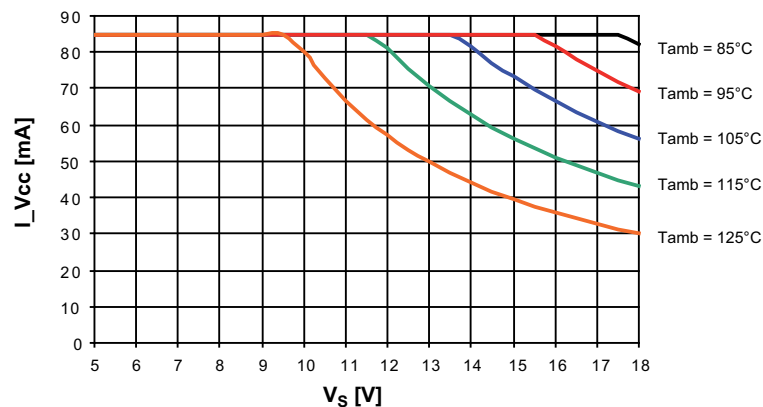
During a short circuit at VCC, the output limits the output current to I_{VCClim} . Because of undervoltage, NRES switches to low and sends a reset to the microcontroller. If the chip temperature exceeds the value T_{VCCoff} , the VCC output switches off. The chip cools down and, after a hysteresis of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

When the Atmel ATA6632xx 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.

"Power Dissipation: Safe Operating Area: Regulator's Output Current I_{VCC} versus Supply Voltage V_S " is shown in [Figure 4-12](#).

Figure 4-12. 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)



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_{Logic} | −0.3 | | +5.5 | V |
| Logic pins output DC currents | I_{Logic} | −5 | | +5 | mA |
| LIN - DC voltage | V_{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

| 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. Electrical Characteristics

5V < V_S < 28V, -40°C < T_j < 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_S | 5 | 13.5 | 28 | V | A |
| 1.2 | Supply current in sleep mode | Sleep mode $V_{LIN} > V_S - 0.5V$ $V_S < 14V$, $T = 27^\circ C$ | VS | $I_{VSsleep}$ | 6 | 9 | 12 | μA | B |
| | | Sleep mode $V_{LIN} > V_S - 0.5V$ $V_S < 14V$ | VS | $I_{VSsleep}$ | 3 | 10 | 15 | μA | A |
| | | Sleep mode, $V_{LIN} = 0V$ bus shorted to GND $V_S < 14V$ | VS | $I_{VSsleep_short}$ | 20 | 50 | 100 | μA | A |
| 1.3 | Supply current in silent mode (SBC) / Active mode (voltage regulator) | Bus recessive $5.5V < V_S < 14V$ without load at VCC $T = 27^\circ C$ | VS | $I_{VSSilent}$ | 30 | 47 | 58 | μA | B |
| | | Bus recessive $5.5V < V_S < 14V$ without load at VCC | VS | $I_{VSSilent}$ | 30 | 50 | 64 | μA | A |
| | | Bus recessive $2.0V < V_S < 5.5V$ without load at VCC | VS | $I_{VSSilent}$ | 50 | 130 | 170 | μA | A |
| | | Silent mode $5.5V < V_S < 14V$ bus shorted to GND without load at VCC | VS | $I_{VSSilent_short}$ | 50 | 80 | 120 | μA | A |
| 1.4 | Supply current in normal mode | Bus recessive $V_S < 14V$ without load at VCC | VS | I_{VSrec} | 150 | 230 | 290 | μA | A |
| 1.5 | Supply current in normal mode | Bus dominant (internal LIN pull-up resistor active) $V_S < 14V$ without load at VCC | VS | I_{VSdom} | 200 | 700 | 950 | μA | A |

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

7. Electrical Characteristics (Continued)

5V < V_S < 28V, -40°C < T_j < 150°C; unless otherwise specified all values refer to GND pins.

| No. | Parameters | Test Conditions | Pin | Symbol | Min. | Typ. | Max. | Unit | Type* |
|-----------------------------------|--|--|------|-----------------------------|------------------------|------------------------|------------------------|------|-------|
| 1.6 | Supply current in fail-safe mode | Bus recessive 5.5V < V _S < 14V without load at VCC | VS | I _{VSfail} | 40 | 55 | 80 | μA | A |
| | | Bus recessive 2.0V < V _S < 5.5V without load at VCC | VS | I _{VSfail} | 50 | 130 | 170 | μA | A |
| 1.7 | VS undervoltage threshold (switching from normal to fail-safe mode) | Decreasing supply voltage | VS | V _{VS_th_N_F_down} | 3.9 | 4.3 | 4.7 | V | A |
| | | Increasing supply voltage | VS | V _{VS_th_F_N_up} | 4.1 | 4.6 | 4.9 | V | A |
| 1.8 | VS undervoltage hysteresis | | VS | V _{VS_hys_F_N} | 0.1 | 0.25 | 0.4 | V | A |
| 1.9 | VS operation threshold (switching to unpowered mode) | Switch to unpowered mode | VS | V _{VS_th_U_down} | 1.9 | 2.05 | 2.3 | V | A |
| | | Switch from unpowered to fail-safe mode | VS | V _{VS_th_U_F_up} | 2.0 | 2.25 | 2.4 | V | A |
| 1.10 | VS undervoltage hysteresis | | VS | V _{VS_hys_U} | 0.1 | 0.2 | 0.3 | V | A |
| 2 RXD output pin (only SBC) | | | | | | | | | |
| 2.1 | Low-level output sink capability | Normal mode, V _{LIN} = 0V, I _{RXD} = 2mA | RXD | V _{RXDL} | | 0.2 | 0.4 | V | A |
| 2.2 | High-level output source capability | Normal mode V _{LIN} = V _S , I _{RXD} = -2mA | RXD | V _{RXDH} | V _{CC} - 0.4V | V _{CC} - 0.2V | | V | A |
| 3 TXD input/output pin (only SBC) | | | | | | | | | |
| 3.1 | Low-level voltage input | | TXD | V _{TXDL} | -0.3 | | +0.8 | V | A |
| 3.2 | High-level voltage input | | TXD | V _{TXDH} | 2 | | V _{CC} + 0.3V | V | A |
| 3.3 | Pull-up resistor | V _{TXD} = 0V | TXD | R _{TXD} | 40 | 70 | 100 | kΩ | A |
| 3.4 | High-level leakage current | V _{TXD} = V _{CC} | TXD | I _{TXD} | -3 | | +3 | μA | A |
| 3.7 | Low-level output sink current at LIN wake-up request | Fail-safe Mode V _{LIN} = V _S V _{TXD} = 0.4V | TXD | I _{TXD} | 2 | 2.5 | 8 | mA | A |
| 4 EN input pin (only SBC) | | | | | | | | | |
| 4.1 | Low-level voltage input | | EN | V _{ENL} | -0.3 | | +0.8 | V | A |
| 4.2 | High-level voltage input | | EN | V _{ENH} | 2 | | V _{CC} + 0.3V | V | A |
| 4.3 | Pull-down resistor | V _{EN} = VCC | EN | R _{EN} | 50 | 125 | 200 | kΩ | A |
| 4.4 | Low-level input current | V _{EN} = 0V | EN | I _{EN} | -3 | | +3 | μA | A |
| 5 NRES open drain output pin | | | | | | | | | |
| 5.1 | Low-level output voltage | V _S ≥ 5.5V I _{NRES} = 2mA | NRES | V _{NRESL} | | 0.2 | 0.4 | V | A |
| 5.2 | Undervoltage reset time | V _{VS} ≥ 5.5V C _{NRES} = 20pF | NRES | t _{Reset} | 2 | 4 | 6 | ms | A |
| 5.3 | Reset debounce time for falling edge | V _{VS} ≥ 5.5V C _{NRES} = 20pF | NRES | t _{res_f} | 0.5 | | 10 | μs | A |
| 5.4 | Switch off leakage current | V _{NRES} = 5.5V | NRES | I _{NRES_L} | -3 | | +3 | μA | A |

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

7. Electrical Characteristics (Continued)

5V < V_S < 28V, -40°C < T_j < 150°C; unless otherwise specified all values refer to GND pins.

| No. | Parameters | Test Conditions | Pin | Symbol | Min. | Typ. | Max. | Unit | Type* |
|---------------------------------------|--|---|-----|-----------------------------|----------------------------------|------|-------|------|-------|
| 8 VCC voltage regulator (3.3V) | | | | | | | | | |
| 8.1 | Output voltage VCC | 4V < V _S < 18V (0mA to 50mA) | VCC | VCC _{nor} | 3.234 | | 3.366 | V | A |
| | | 4.5V < V _S < 18V (0mA to 85mA) | VCC | VCC _{nor} | 3.234 | | 3.366 | V | C |
| 8.2 | Output voltage V _{CC} at low V _S | 3V < V _S < 4V | VCC | VCC _{low} | V _{VS} - V _D | | 3.366 | V | A |
| 8.3 | Regulator drop voltage | V _S > 3V, I _{VCC} = -15mA | VCC | V _{D1} | | 100 | 150 | mV | A |
| 8.4 | Regulator drop voltage | V _S > 3V, I _{VCC} = -50mA | VCC | V _{D2} | | 300 | 500 | mV | A |
| 8.5 | Line regulation maximum | 4V < V _S < 18V | VCC | VCC _{line} | | 0.1 | 0.2 | % | A |
| 8.6 | Load regulation maximum | 5mA < I _{VCC} < 50mA | VCC | VCC _{load} | | 0.1 | 0.5 | % | A |
| 8.7 | Output current limitation | V _S > 4V | VCC | I _{VCClim} | | -180 | -120 | mA | A |
| 8.8 | Load capacity | MLC capacitor | VCC | C _{load} | 1.8 | 2.2 | | μF | D |
| 8.9 | VCC undervoltage threshold (NRES ON) | Referred to VCC V _S > 4V | VCC | V _{VCC_th_uv_down} | 2.3 | 2.5 | 2.8 | V | A |
| | VCC undervoltage threshold (NRES OFF) | Referred to VCC V _S > 4V | VCC | V _{VCC_th_uv_up} | 2.5 | 2.6 | 2.9 | V | A |
| 8.10 | Hysteresis of VCC undervoltage threshold | Referred to VCC V _S > 4V | VCC | V _{VCC_hys_uv} | 100 | 200 | 300 | mV | A |
| 8.11 | Ramp-up time V _S > 4V to VCC = 3.3V | C _{VCC} = 2.2μF I _{load} = -5mA at VCC | VCC | t _{VCC} | | 1 | 1.5 | ms | A |
| 9 VCC voltage regulator (5V) | | | | | | | | | |
| 9.1 | Output voltage VCC | 5.5V < V _S < 18V (0mA to 50mA) | VCC | VCC _{nor} | 4.9 | | 5.1 | V | A |
| | | 6V < V _S < 18V (0mA to 85mA) | VCC | VCC _{nor} | 4.9 | | 5.1 | V | C |
| 9.2 | Output voltage V _{CC} at low V _S | 4V < V _S < 5.5V | VCC | VCC _{low} | V _{VS} - V _D | | 5.1 | V | A |
| 9.3 | Regulator drop voltage | V _S > 4V, I _{VCC} = -20mA | VCC | V _{D1} | | 100 | 200 | mV | A |
| 9.4 | Regulator drop voltage | V _S > 4V, I _{VCC} = -50mA | VCC | V _{D2} | | 300 | 500 | mV | A |
| 9.5 | Regulator drop voltage | V _S > 3.3V, I _{VCC} = -15mA | VCC | V _{D3} | | | 150 | mV | A |
| 9.6 | Line regulation maximum | 5.5V < V _S < 18V | VCC | VCC _{line} | | 0.1 | 0.2 | % | A |
| 9.7 | Load regulation maximum | 5mA < I _{VCC} < 50mA | VCC | VCC _{load} | | 0.1 | 0.5 | % | A |
| 9.8 | Output current limitation | V _S > 5.5V | VCC | I _{VCClim} | | -180 | -120 | mA | A |
| 9.9 | Load capacity | MLC capacitor | VCC | C _{load} | 1.8 | 2.2 | | μF | D |
| 9.10 | VCC undervoltage threshold (NRES ON) | Referred to VCC V _S > 4V | VCC | V _{VCC_th_uv_down} | 4.2 | 4.4 | 4.6 | V | A |
| | VCC undervoltage threshold (NRES OFF) | Referred to VCC V _S > 4V | VCC | V _{VCC_hys_uv} | 4.3 | 4.6 | 4.8 | V | A |
| 9.11 | Hysteresis of undervoltage threshold | Referred to VCC V _S > 5.5V | VCC | V _{VCC_hys_uv} | 100 | 200 | 300 | mV | A |
| 9.12 | Ramp-up time V _S > 5.5V to VCC = 5V | C _{VCC} = 2.2μF I _{load} = -5mA at VCC | VCC | t _{VCC} | | 1 | 1.5 | ms | A |

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

7. Electrical Characteristics (Continued)

5V < V_S < 28V, -40°C < T_j < 150°C; unless otherwise specified all values refer to GND pins.

| No. | Parameters | Test Conditions | Pin | Symbol | Min. | Typ. | Max. | Unit | Type* |
|-------|---|---|-----|--------------------------|----------------------|-------|----------------|------|-------|
| 10 | LIN bus driver (only SBC): bus load conditions: Load 1 (small): 1nF, 1kΩ; Load 2 (large): 10nF, 500Ω; C _{RXD} = 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 _{BUSRec} | 0.9 × V _S | | V _S | V | A |
| 10.2 | Driver dominant voltage | V _{VS} = 7V R _{load} = 500Ω | LIN | V _{LoSUP} | | | 1.2 | V | A |
| 10.3 | Driver dominant voltage | V _{VS} = 18V R _{load} = 500Ω | LIN | V _{HiSUP} | | | 2 | V | A |
| 10.4 | Driver dominant voltage | V _{VS} = 7V R _{load} = 1000Ω | LIN | V _{LoSUP_1k} | 0.6 | | | V | A |
| 10.5 | Driver dominant voltage | V _{VS} = 18V R _{load} = 1000Ω | LIN | V _{HiSUP_1k} | 0.8 | | | V | A |
| 10.6 | Pull-up resistor to V _S | The serial diode is mandatory | LIN | R _{LIN} | 20 | 30 | 47 | kΩ | A |
| 10.7 | Voltage drop at the serial diodes | In pull-up path with R _{slave} I _{SerDiode} = 10mA | LIN | V _{SerDiode} | 0.4 | | 1.0 | V | D |
| 10.8 | LIN current limitation V _{BUS} = V _{Bat_max} | | LIN | I _{BUS_LIM} | 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 _{BUS} = 0V V _{Bat} = 12V | LIN | I _{BUS_PAS_dom} | -1 | -0.35 | | mA | A |
| 10.10 | Leakage current LIN recessive | Driver off 8V < V _{Bat} < 18V 8V < V _{BUS} < 18V V _{BUS} ≥ V _{Bat} | LIN | I _{BUS_PAS_rec} | | 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 _{Device} = V _S V _{Bat} = 12V 0V < V _{BUS} < 18V | LIN | I _{BUS_NO_gnd} | -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 _{Bat} disconnected V _{SUP_Device} = GND 0V < V _{BUS} < 18V | LIN | I _{BUS_NO_bat} | | 0.1 | 2 | μA | A |
| 10.13 | Capacitance on pin LIN to GND | | LIN | C _{LIN} | | | 20 | pF | D |

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

7. Electrical Characteristics (Continued)

5V < V_S < 28V, -40°C < T_j < 150°C; unless otherwise specified all values refer to GND pins.

| No. | Parameters | Test Conditions | Pin | Symbol | Min. | Typ. | Max. | Unit | Type* |
|---------------------------------------|---|---|-----|----------------|--------------------|------------------|--------------------|------|-------|
| 11 LIN bus receiver (only SBC) | | | | | | | | | |
| 11.1 | Center of receiver threshold | $V_{BUS_CNT} = (V_{th_dom} + V_{th_rec})/2$ | LIN | V_{BUS_CNT} | $0.475 \times V_S$ | $0.5 \times V_S$ | $0.525 \times V_S$ | V | A |
| 11.2 | Receiver dominant state | $V_{EN} = 5V/3.3V$ | LIN | V_{BUSdom} | -27 | | $0.4 \times V_S$ | V | A |
| 11.3 | Receiver recessive state | $V_{EN} = 5V/3.3V$ | LIN | V_{BUSrec} | $0.6 \times V_S$ | | 40 | V | A |
| 11.4 | Receiver input hysteresis | $V_{hys} = V_{th_rec} - V_{th_dom}$ | LIN | V_{BUShys} | $0.028 \times V_S$ | $0.1 \times V_S$ | $0.175 \times V_S$ | V | A |
| 11.5 | Pre-wake detection LIN high-level input voltage | | LIN | V_{LINH} | $V_S - 2V$ | | $V_S + 0.3V$ | V | A |
| 11.6 | Pre-wake detection LIN low-level input voltage | Activates the LIN receiver | LIN | V_{LINL} | -27 | | $V_S - 3.3V$ | V | A |
| 12 Internal timers (only SBC) | | | | | | | | | |
| 12.1 | Dominant time for wake-up via LIN bus | $V_{LIN} = 0V$ | LIN | t_{bus} | 50 | 100 | 150 | μs | A |
| 12.2 | Time delay for mode change from fail-safe into normal mode via EN pin | $V_{EN} = 5V/3.3V$ | EN | t_{norm} | 5 | 15 | 20 | μs | A |
| 12.3 | Time delay for mode change from normal mode to sleep mode via EN pin | $V_{EN} = 0V$ | EN | t_{sleep} | 5 | 15 | 20 | μs | A |
| 12.5 | TXD dominant time-out time | $V_{TXD} = 0V$ | TXD | t_{dom} | 20 | 40 | 60 | ms | A |
| 12.6 | Time delay for mode change from silent mode into normal mode via EN pin | $V_{EN} = 5V/3.3V$ | EN | t_{s_n} | 5 | 15 | 40 | μs | A |
| 12.7 | Duty cycle 1 | $TH_{Rec(max)} = 0.744 \times V_S$ $TH_{Dom(max)} = 0.581 \times V_S$ $V_S = 7.0V$ to 18V $t_{Bit} = 50\mu s$ $D1 = t_{bus_rec(min)}/(2 \times t_{Bit})$ | LIN | D1 | 0.396 | | | | A |
| 12.8 | Duty cycle 2 | $TH_{Rec(min)} = 0.422 \times V_S$ $TH_{Dom(min)} = 0.284 \times V_S$ $V_S = 7.6V$ to 18V $t_{Bit} = 50\mu s$ $D2 = t_{bus_rec(max)}/(2 \times t_{Bit})$ | LIN | D2 | | | 0.581 | | A |
| 12.9 | Duty cycle 3 | $TH_{Rec(max)} = 0.778 \times V_S$ $TH_{Dom(max)} = 0.616 \times V_S$ $V_S = 7.0V$ to 18V $t_{Bit} = 96\mu s$ $D3 = t_{bus_rec(min)}/(2 \times t_{Bit})$ | LIN | D3 | 0.417 | | | | A |
| 12.10 | Duty cycle 4 | $TH_{Rec(min)} = 0.389 \times V_S$ $TH_{Dom(min)} = 0.251 \times V_S$ $V_S = 7.6V$ to 18V $t_{Bit} = 96\mu s$ $D4 = t_{bus_rec(max)}/(2 \times t_{Bit})$ | LIN | D4 | | | 0.590 | | A |

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

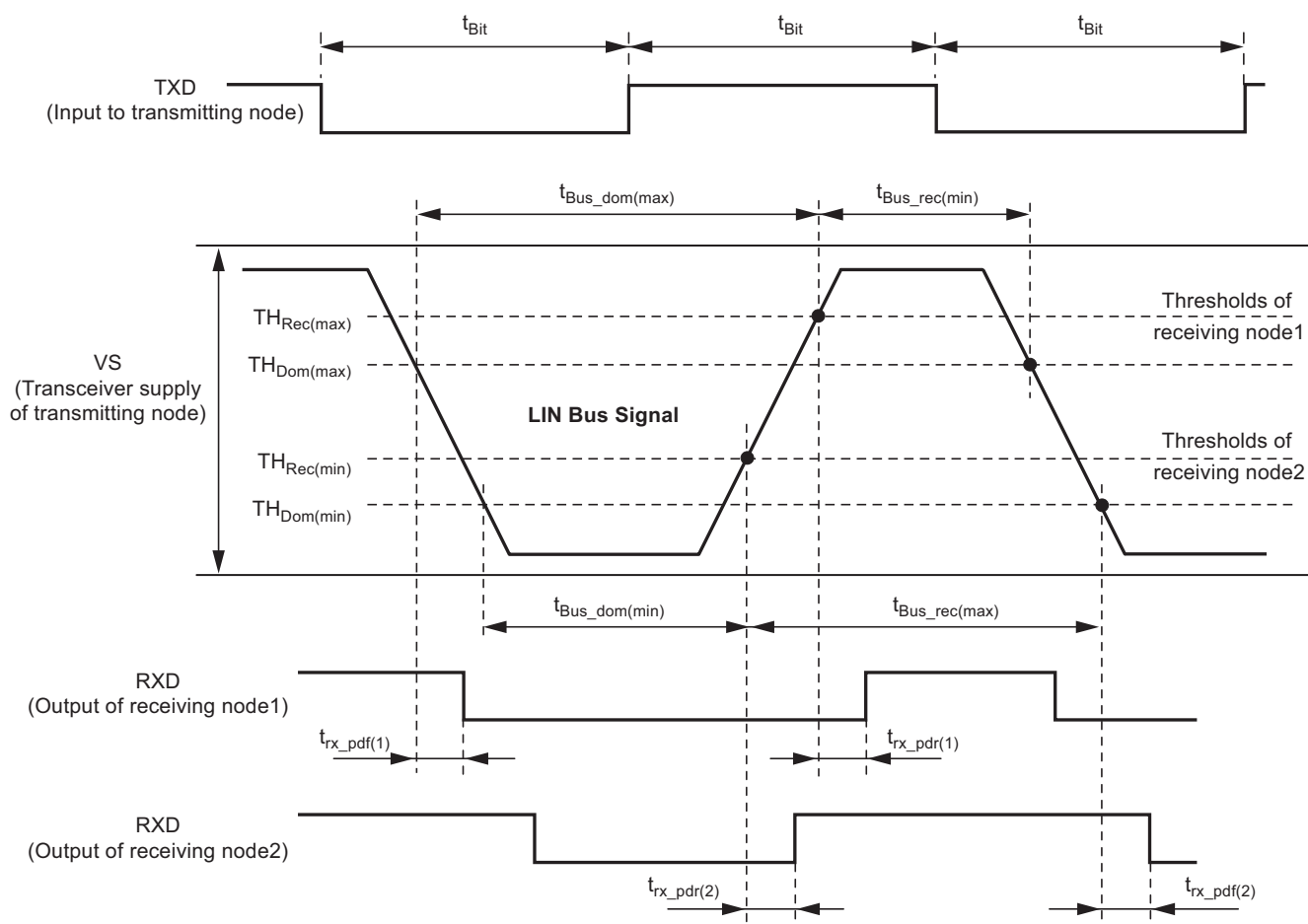
7. Electrical Characteristics (Continued)

5V < V_S < 28V, -40°C < T_j < 150°C; unless otherwise specified all values refer to GND pins.

| No. | Parameters | Test Conditions | Pin | Symbol | Min. | Typ. | Max. | Unit | Type* |
|-------|---|--|-----|--|------|------|------|------|-------|
| 12.11 | Slope time falling and rising edge at LIN | V _S = 7.0V to 18V | LIN | t _{SLOPE_fall} t _{SLOPE_rise} | 3.5 | | 22.5 | μs | A |
| 13 | Receiver electrical AC parameters of the LIN physical layer LIN receiver, RXD load conditions: C _{RXD} = 20pF | | | | | | | | |
| 13.1 | Propagation delay of receiver | V _S = 7.0V to 18V t _{rx_pd} = max(t _{rx_pdr} , t _{rx_pdf}) | RXD | t _{rx_pd} | | | 6 | μs | A |
| 13.2 | Symmetry of receiver propagation delay rising edge minus falling edge | V _S = 7.0V to 18V t _{rx_sym} = t _{rx_pdr} - t _{rx_pdf} | RXD | t _{rx_sym} | -2 | | +2 | μs | A |

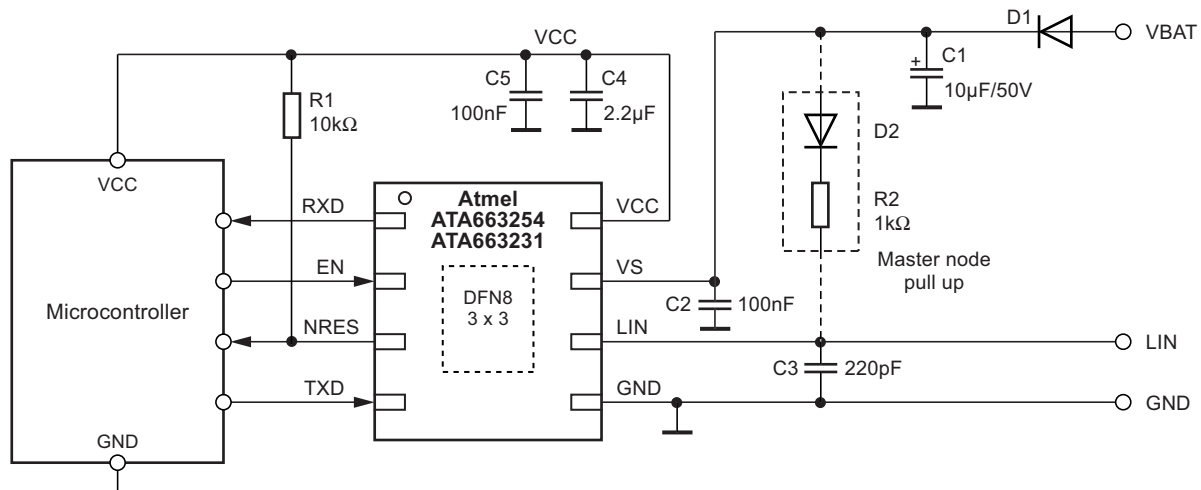
*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

Figure 7-1. Definition of Bus Timing Characteristics



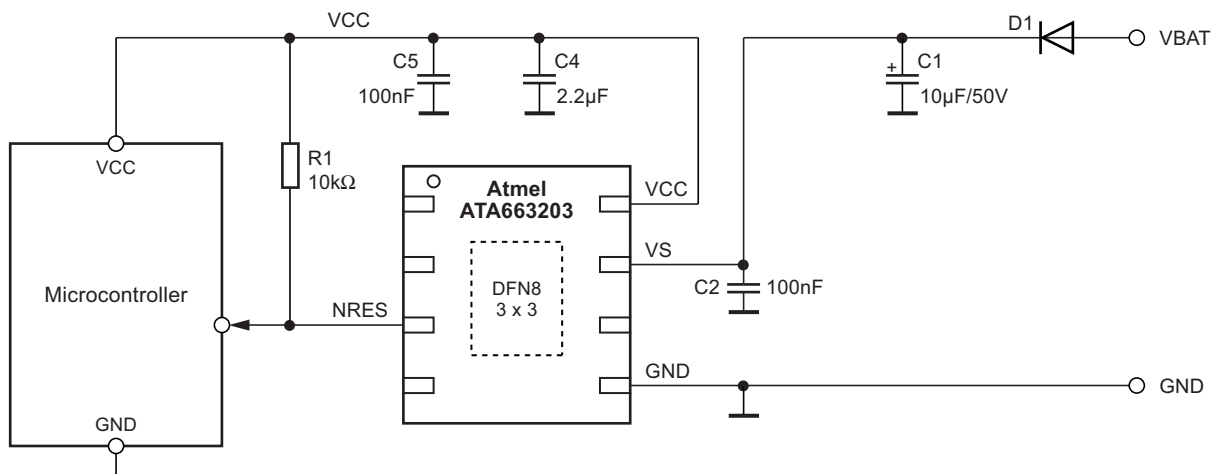
8. Application Circuits

Figure 8-1. Typical Application Circuit SBC



Note: Heat slug must always be connected to GND.

Figure 8-2. Typical Application Circuit Voltage Regulator

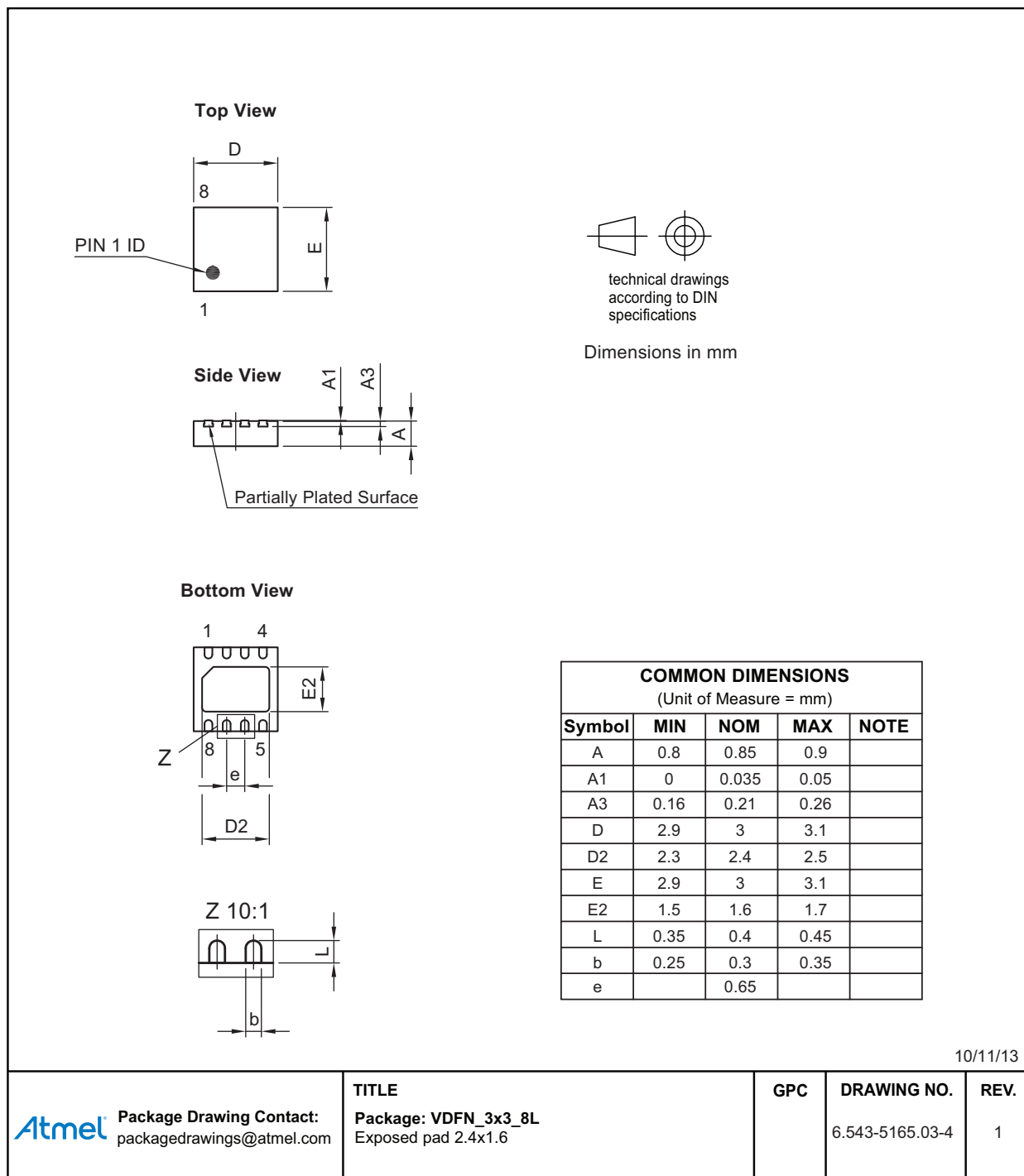


Note: Heat slug must always be connected to GND.

9. Ordering Information

| Extended Type Number | Package | Remarks |
|----------------------|---------|---|
| ATA663231-FAQW | DFN8 | 3.3V LIN system basis chip, Pb-free, 6k, taped and reeled |
| ATA663254-FAQW | DFN8 | 5V LIN system basis chip, Pb-free, 6k, taped and reeled |
| ATA663203-FAQW | DFN8 | 5V voltage regulator, Pb-free, 6k, taped and reeled |

10. Package Information



11. 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 |
|------------------|--|
| 9337D-AUTO-07/14 | <ul style="list-style-type: none">• Figure 1- 2 ATA663203 “Block Diagram Voltage Regulator” on page 3 added• ATA663203 pin configuration on page 4 added• Figure 4-3 ATA663203 “Voltage Regulator Operating Modes” on page 8 added• Section 4.2.5 ATA663203 “Active Mode (Voltage Regulator only)” on page 10 added• Figure 8-2 ATA663203 “Typical Application Circuit Voltage Regulator” on page 23 added• Section 9 ATA663203 “Ordering Information” on page 24 updated |

