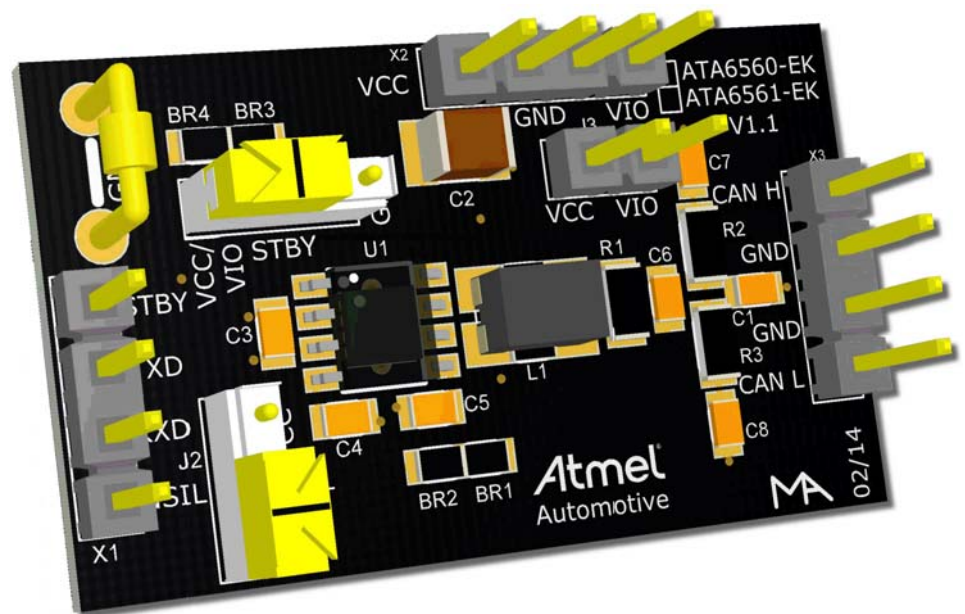# ATA6560-EK, ATA6561-EK

ATAN0103

Introduction

The development board for the Atmel® ATA6560 and ATA6561 enables users to rapidly carry out prototyping and testing of new CAN designs with the Atmel ATA6560 and Atmel ATA6561 high-speed CAN transceivers.

Figure 1.   Atmel ATA6560-EK, ATA6561-EK Development Board

The Atmel ATA6560/ATA6561 is a high-speed CAN transceiver that provides an interface between a controller area network (CAN) protocol controller and the physical two-wire CAN bus. The transceiver is designed for high-speed (up to 5Mbit/s) automotive CAN applications delivering differential transmit and receive capability to (a microcontroller with) a CAN protocol controller. It offers superior electromagnetic compatibility (EMC) and electrostatic discharge (ESD) performance, as well as features such as:

● Ideal passive behavior to the CAN bus when the supply voltage is off
● Direct interfacing to microcontrollers with supply voltages from 3V to 5V (ATA6561)
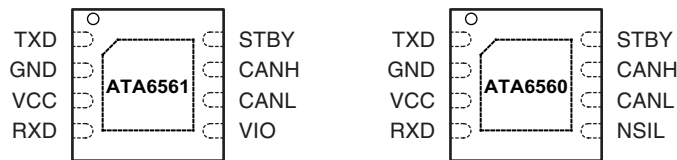
Three operating modes together with dedicated fail-safe features make the Atmel® ATA6560/ATA6561 an excellent choice for all types of high-speed CAN networks, especially in nodes requiring low-power mode with wake-up capability via the CAN bus.

The Atmel ATA6560/ATA6561 is available in a SO8 package as well as in a DFN8 package for space-saving application, as shown in Figure 2 and Figure 3. There are footprints for both package types on the development board.

Figure 2. SO8 Pinning

	ATA6561			ATA6560	
TXD	1	8 STBY	TXD	1	8 STBY
GND	2	7 CANH	GND	2	7 CANH
VCC	3	6 CANL	VCC	3	6 CANL
RXD	4	5 VIO	RXD	4	5 NSIL

Figure 3. DFN8 Pinning

	ATA6561			ATA6560	
TXD		STBY	TXD		STBY
GND		CANH	GND		CANH
VCC		CANL	VCC		CANL
RXD		VIO	RXD		NSIL

The CAN transceiver has the following features:

● Fully compliant with ISO 11898-2,-5 and SAE J2284
● Low electromagnetic emission (EME) and high electromagnetic immunity (EMI)
● Communication speed up to 5Mbit/s
● Differential receiver with wide common-mode range
● Silent Mode (receive only mode, only available at the ATA6560)
● Standby mode
● Remote wake-up capability via CAN bus
● Functional behavior predictable under all supply conditions
● Transceiver disengages from the bus when not powered up
● RXD recessive clamping detection
● High electrostatic discharge (ESD) handling capability on the bus pins
● Bus pins protected against transients in automotive environments
● Transmit data (TXD) dominant time-out function
● Undervoltage detection on VCC and VIO pins
● CANH/CANL short-circuit and overtemperature protected

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1. Development Kit Features

The development board for the Atmel® ATA6560/ATA6561 ICs supports the following features:

- All components necessary to put the ATA6560/ATA6561 into operation are included
- Placeholders for some optional components for extended functions are included (e.g., common-mode choke)
- All pins are easily accessible
- Footprint for DFN8 and SO8 package
- Ground coulter clip for easy probe connection during oscilloscope measurement

2. Quick Start

The development board for the Atmel ATA6560/ATA6561 is shipped including all components allowing immediate CAN node development.

Connecting an external 5V DC power supply between the terminals VCC and GND puts the IC in one of the three operating modes: normal, silent (with the Atmel ATA6560 only) and standby, which can be selected via the STBY and NSIL pins (see Section 3.1.7 "System Control Pins (STBY, NSIL)" on page 6 for more information). See Table 2-1 for a description of the operating modes under normal supply conditions.

Table 2-1. Operating Modes

Mode	Inputs			Outputs	
	STBY	NSIL	Pin TXD	CAN Driver	Pin RXD
Normal	LOW	HIGH[2]	LOW	Dominant	LOW
	LOW	HIGH[2]	HIGH	Recessive	HIGH
Standby	HIGH	x[3]	x[3]	Recessive	Active[4]
Silent	LOW	LOW	x[3]	Recessive	Active[1]

Notes: 1. LOW if the CAN bus is dominant, HIGH if the CAN bus is recessive

2. Internally pulled up if not bonded out

3. Irrelevant

4. Reflects the bus only for wake-up

Figure 2-1. Switch Jumpers for Changing the Operating Mode (J2 Available for the Atmel ATA6560 only)
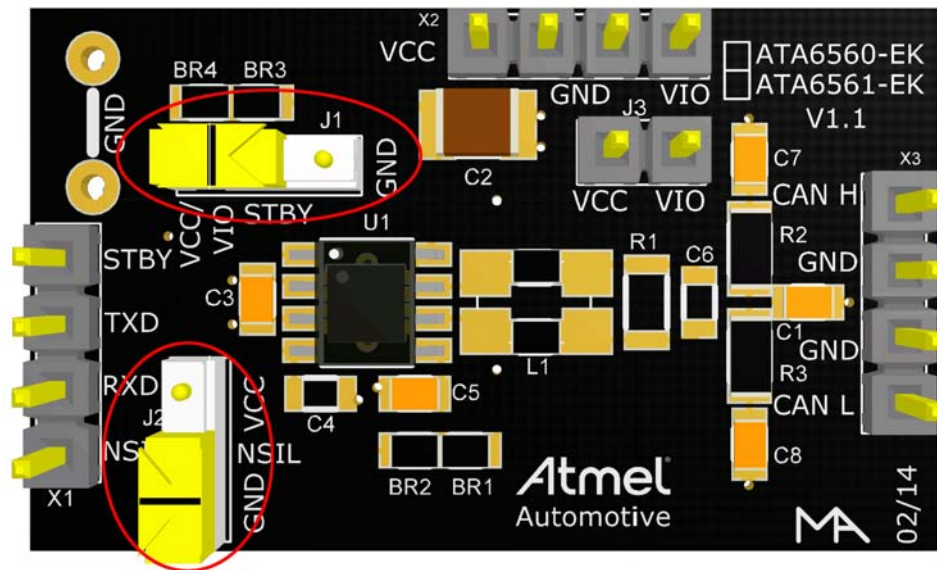
2.1 Normal Mode

A low level on the STBY pin together with a high level on pins TXD and NSIL (if applicable) selects the normal mode. In this mode the transceiver is able to transmit and receive data via the CANH and CANL bus lines. The output driver stage is active and drives data from the TXD input to the CAN bus. The high-speed comparator (HSC) converts the analog data on the bus lines into digital data which is output to the RXD pin. The bus biasing is set to VCC/2 and the undervoltage monitoring of VCC is active.

The slope of the output signals on the bus lines is controlled and optimized in a way that guarantees the lowest possible electromagnetic emission (EME).

To switch the device in normal operating mode, set the STBY pin to low (switch jumper J1 set to the right side) and the NSIL pin (if available) to high (switch jumper J2 set to upper position). For example for test purposes also a signal generator can be connected to the STBY pin and/or to the NSIL pin (at the pin header X1 on the left side of the board). Therefore the switch jumper J1 and/or J2 should be set to the middle position.

Please note that the device cannot enter normal mode as long as TXD is at GND level.

The STBY and the NSIL pins each provide a pull-up resistor to VIO, thus ensuring defined levels if the pins are open.

2.2 Silent Mode (with the Atmel ATA6560 only)

A low level on the NSIL pin and on the STBY pin switches the ATA6560 into silent mode. This receive-only mode can be used to test the connection of the bus medium. In silent mode the Atmel® ATA6560 can still receive data from the bus, but the transmitter is disabled and therefore no data can be sent to the CAN bus. The bus pins are released to recessive state. All other IC functions, including the high-speed comparator (HSC), continue to operate as they do in normal mode. Silent mode can be used to prevent a faulty CAN controller from disrupting all network communications.

2.3 Standby Mode

A high level on the STBY pin selects standby mode. In this mode the transceiver is not able to transmit or correctly receive data via the bus lines. The transmitter and the high-speed comparator (HSC) are switched off to reduce current consumption and only the low-power wake-up comparator (WUC) monitors the bus lines for a valid wake-up signal. A signal change on the bus from "Recessive" to "Dominant" followed by a dominant state longer than t_{wake} switches the RXD pin to low to signal a wake-up request to the microcontroller.

In standby mode the bus lines are biased to ground to reduce current consumption to a minimum. The wake-up comparator (WUC) monitors the bus lines for a valid wake-up signal. When the RXD pin switches to low to signal a wake-up request, a transition to normal mode is not triggered until the STBY pin is forced back to low by the microcontroller. A bus dominant time-out timer prevents the device from generating a permanent wake-up request by switching the RXD pin to high.

For Atmel ATA6560 only: In the event the NSIL input pin is set to low in standby mode, the internal pull-up resistor causes an additional quiescent current from VIO to GND. Atmel therefore recommends setting the NSIL pin to high in standby mode.

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3. Hardware Description

3.1 Pin Description

The following sections show and describe the external elements required for some of the pins. Please see the specific datasheet for more information about this topic.

3.1.1 Power Supply

In order to get the development board running, an external stabilized 5V DC power supply has to be connected to the VCC header. Please keep in mind the maximum rating for the VCC pin is 5.5V and a higher voltage may cause permanent damage to the device.

3.1.2 VIO Supply Pin

There are two versions of the device available, with the function of pin 5 as the only difference.

- On the Atmel® ATA6561 pin 5 is VIO and should be connected to the supply voltage of the connected microcontroller. This adjusts the signal levels of the TXD, RXD, NSIL, and STBY pins to the I/O levels of the microcontroller. A jumper is implemented on the board (J3) connecting the VIO to VCC for test purposes or quick measurements. If the VIO pin has to be supplied with a different voltage, jumper J3 has to be removed and the VIO pin header connected to the second external DC power supply (typically 3.3V)

- On the Atmel ATA6560 without the VIO pin, the VIO input is internally connected to VCC. This sets the signal levels of the TXD, RXD, STBY, and NSIL pins to levels compatible with 5V microcontrollers.

3.1.3 CAN Interface (CANH, CANL, TXD, and RXD)

The CAN transceiver is only active when it is in normal mode. In silent mode the transmitter is switched off and the Atmel ATA6560 is in receive-only mode. In standby mode the transceiver is completely switched off and no communication is possible. Only a low power wake-up comparator (WUC) is active in order to reflect the bus for a wake-up.

3.1.4 CANH and CANL Pins

The CANH and CANL pins are the interface to the bus network. Nodes connected to the bus end must show a differential termination, which is approximately equal to the characteristic impedance of the bus line in order to suppress signal reflection. Instead of a one-resistor termination it is highly recommended to use a so-called split termination. EMC measurements have shown that the split termination is able to significantly improve the signal symmetry between CANH and CANL, thus reducing emission. Basically each of the two termination resistors is split into two resistors of equal value, i.e., two resistors of 60Ω (or 62Ω) (R2 and R3) instead of one resistor of 120Ω. The special characteristic of this approach is that the common-mode signal, available at the center tap of the termination, is terminated to ground via a capacitor. The recommended value for this capacitor is in the range of 4.7nF to 47nF (C7).

As the symmetry of the two signal lines is crucial for the emission performance of the system, the matching tolerance of the two termination resistors should be as low as possible (< 1% is desirable).

In addition, loading the CANH and CANL pin each with a capacitor of about 100pF close to the connector of the ECU (there are placeholders on the PCB for the capacitors C7 and C8) is recommended. The main reason for doing this is to increase the robustness to automotive transients and ESD. The matching tolerance of the two capacitors should be as low as possible.

OEM specifications may require dedicated circuits. Please refer to the corresponding OEM specifications for specific details.

The footprint for an optional common-mode choke, to improve EMC performance, is implemented (L1).

Placeholders (R1, C6, and C4) are implemented on the board for timing measurements.

3.1.5 TXD Input Pin

The signal sent to the TXD input pin controls the state of the CANH/CANL outputs. An internal pull-up resistor to VIO is implemented. The TXD input pin must be pulled to ground in order to drive the CAN bus into dominant state.

An internal timer prevents the bus lines from being driven permanently in the dominant state. If TXD is forced to low longer than $t_{to(DOM)TXD}$ > 3ms, the transceiver internally switches the TXD state to high and the CAN bus driver is switched to the recessive state. This feature is used to prevent a single faulty node (for example with a short to ground at the TXD pin) from paralyzing communication on the entire CAN bus the faulty node is connected to.

3.1.6 RXD Output Pin

This pin reports the state of the CAN bus to the microcontroller. CAN high (recessive state) is reported by a high level at RXD; CAN low (dominant state) is reported by a low level at RXD. The RXD output is a push-pull stage and is short-circuit protected.

3.1.7 System Control Pins (STBY, NSIL)

These input pins are mode pins used for mode control. They are typically directly connected to an output port pin of a microcontroller. The Atmel® ATA6560/ATA6561 supports three operating modes: normal, silent (only with the Atmel ATA6560) and standby, which can be selected via the STBY and NSIL pins. See Table 2-1 on page 3 for a description of the operating modes under normal supply conditions.

The STBY and the NSIL pins each provide a pull-up resistor to VIO, thus ensuring defined levels if the pins are open.

The operating mode can be easily changed via the on-board switch jumpers (switch jumper J1 for STBY pin control and switch jumper J2 for NSIL pin control). If desired this can be done also via an external signal generator, but therefore the switch jumper J1 and/or J2 should be set to the middle position.
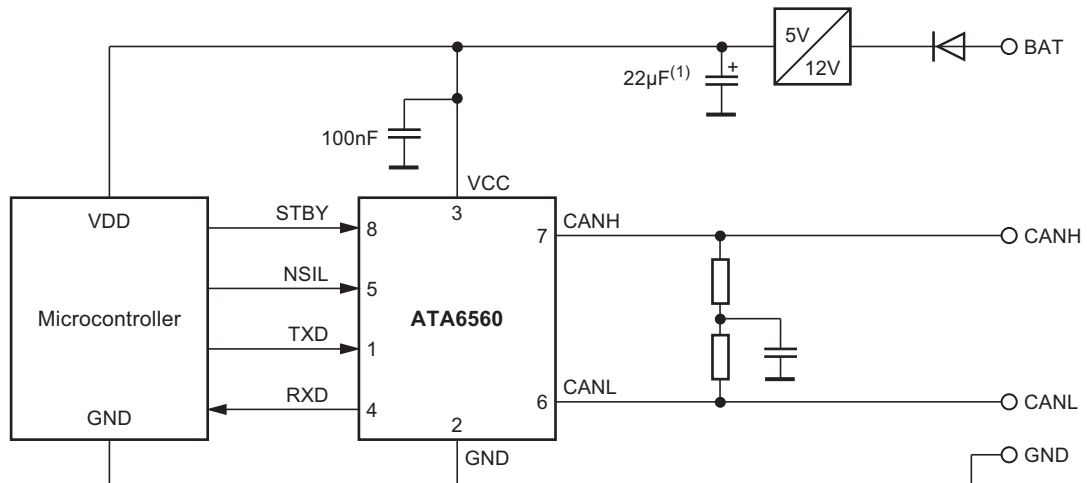
4. Applications

Figure 4-1 and Figure 4-2 illustrate a typical circuit example using the Atmel® ATA6560 and Atmel ATA6561 devices. The Atmel ATA656x-EK board is designed to be used either with the Atmel ATA6560 or Atmel ATA6561 device. The application examples assume either a 5V or a 3V supplied host microcontroller. In each example there is a dedicated 5V regulator supplying the Atmel ATA6560/ATA6561 transceiver on its VCC supply pin (necessary for proper CAN transmit capability). Depending on which device is soldered on the board, all corresponding components required are mounted on the board.

Figure 4-1. Typical Application Circuit Atmel ATA6561 – the VIO Pin allows Direct Interfacing to Microcontrollers with Supply Voltages down to 3V
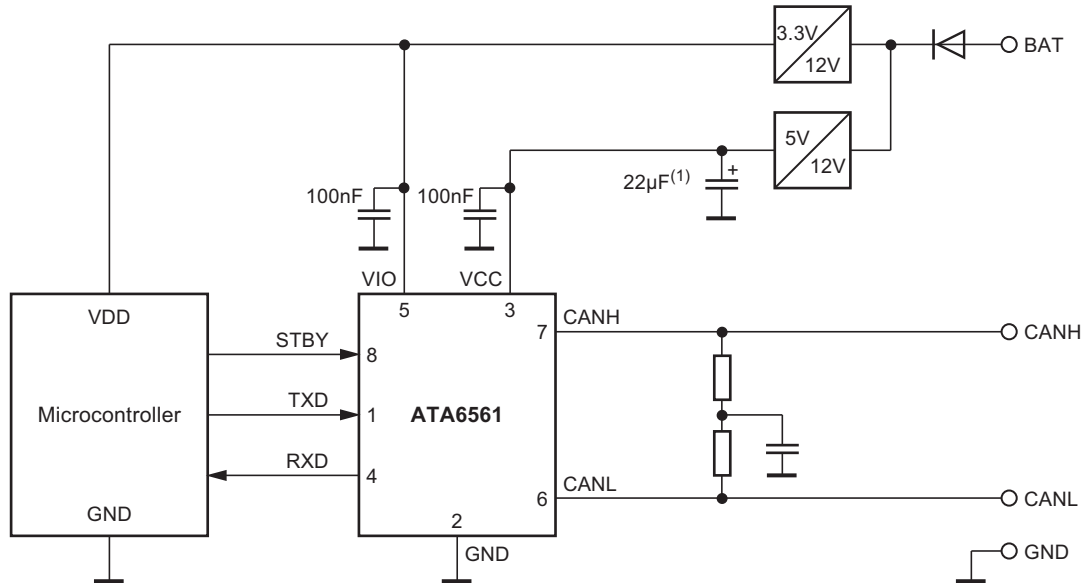
(1) The size of this capacitor depends on the used external voltage regulator.

Figure 4-2. Typical Application Circuit Atmel ATA6560 – the NSIL Pin Allows the Device to be Switched to Receive-Only Mode, Only One LDO is Necessary with a 5V Microcontroller

(1) The size of this capacitor depends on the used external voltage regulator.

5. Test Setups and Measurements

5.1 Timing Measurements

The required components on the basic application board can be found below. A two-channel, or optimally, a four-channel oscilloscope is sufficient to measure the timing characteristics of the Atmel® ATA6560/ATA6561. The transmit data signal TXD can be generated by any signal generator that is capable of delivering a rectangular or pulse signal with 3.3V to 5V amplitude, referred to GND. The characteristics of TXD, RXD and the CANH, CANL signals can be examined.

Figure 5-1. Test Setup for Timing Measurements
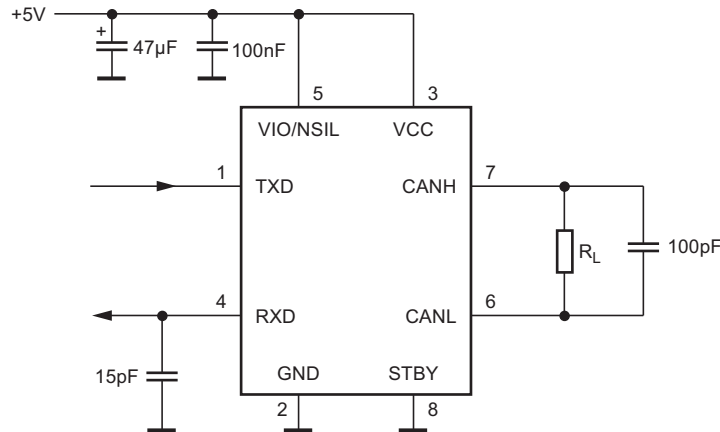
Figure 5-2. Components to be Removed (Red) or Replaced (Green) for the Timing Measurement Setup
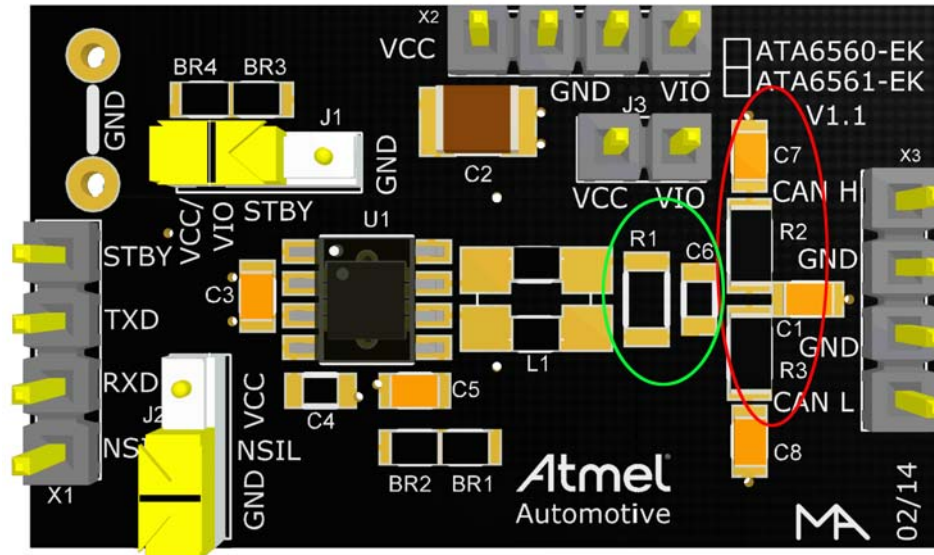
The footprint for an optional common mode choke (L1) is implemented on the development board. This common mode choke (L1) is per default replaced by two 0Ω resistors.

Instead of a one-resistor termination it is highly recommended to use the commonly used so-called split termination, which is per default assembled. EMC measurements have shown that the split termination is able to significantly improve the signal symmetry between CANH and CANL, thus reducing emissions. Basically the termination is split into two resistors of equal value (R2 = R3 = 62Ω) and a capacitor (C1) to GND at the center tap, which represents one of the two usual bus end terminations. The special characteristic of this approach is that the common-mode signal, available at the center tap of the two resistors, is terminated to ground via the capacitor C1. The recommended value for this capacitor C1 is in the range of 4.7nF to 47nF (4.7nF assembled per default).

As the symmetry of the two signal lines is crucial for the emission performance of the system, the matching tolerance of the two termination resistors R1 and R2 should be as low as possible (< 1% is desirable).

Additionally placeholders are implemented on the board for timing measurements (R1, C6 and C4). If a function generator is connected to the TXD header, it can be adjusted to output a rectangular signal up to a frequency corresponding to the maximum data rate of the final application. Please pay attention that its output signal levels are in the appropriate range particularly that no negative voltage occurs. Of course the function generator can be replaced by a dedicated data generator in order to form a better approach to the desired application. The high-impedance inputs of the oscilloscope can be connected directly - however it's advantageous to use probes, so that the signals are not noticeable affected by the capacitance of the coaxial cable.

Figure 5-3. Timing Diagram for High Speed CAN Bus
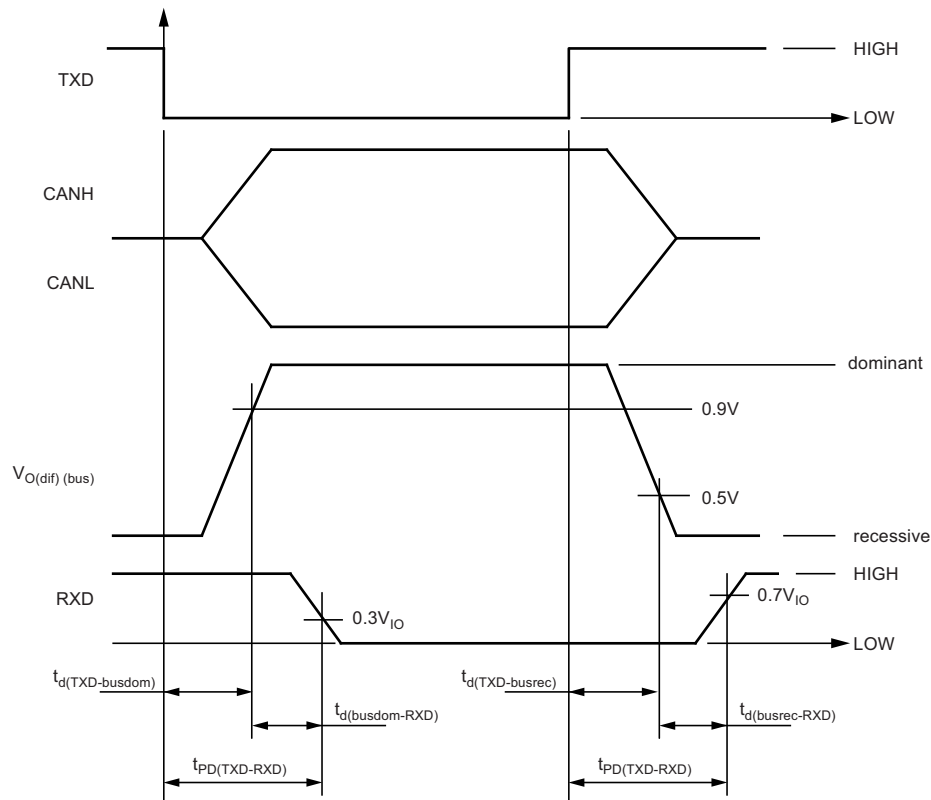
Figure 5-4. Measurement of the TXD, CANH, CANL and RXD Signal at a Data Rate of 1Mbit/s
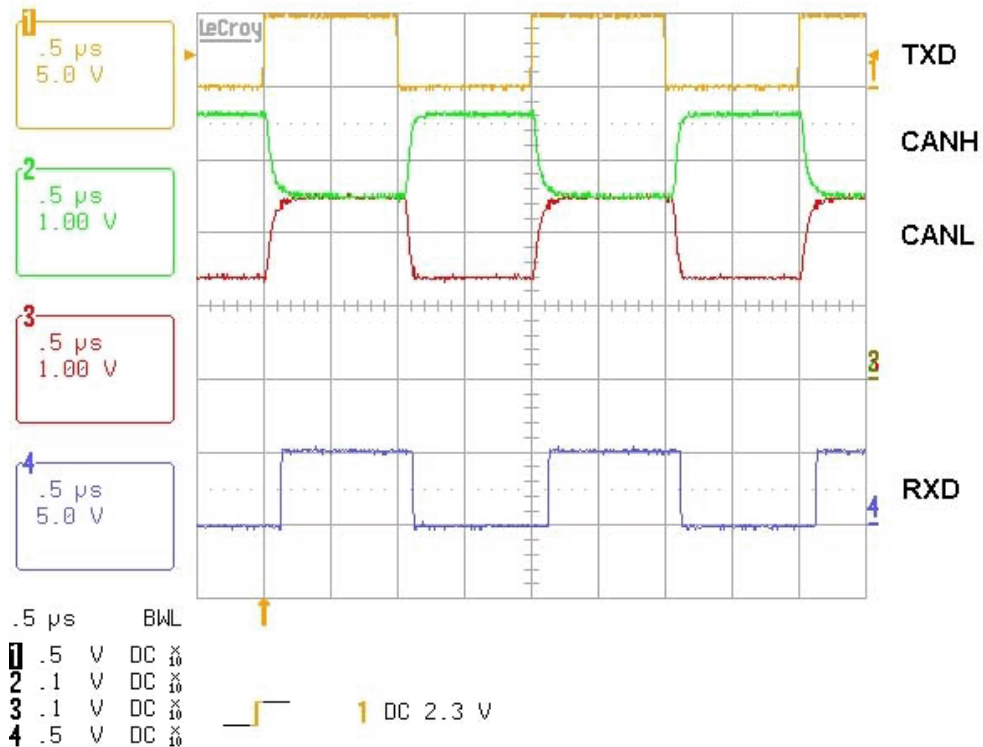
The plot above shows the typical bus line signals for a 0-1 bit sequence at a data rate of 1Mbit/s and VCC = VIO = 5V. The excellent symmetry of the CANH and CANL signals ensures superior EMC performance.

5.2 Measurement Hints

5.2.1 Passive Behavior

Partial networking is implemented in the most recent in-vehicle networks. In these applications some transceivers can become unpowered (e.g., clamp-15 nodes) while other transceivers are continuously supplied (e.g., clamp-30 nodes). In such networks the Atmel® ATA6560/ATA6561 is favored for partially unpowered applications because of its excellent passive behavior to the bus when the VCC supply is switched off. In addition, the Atmel ATA6560/ATA6561 is protected against reverse currents via the TXD, RXD, and STB pins. There is no backward current via those pins if the accompanying microcontroller continues to be supplied.

5.2.2 Optional Circuitry at CANH and CANL

The EMC performance of the Atmel ATA6560/ATA6561 has been optimized for use of the CAN termination without a common-mode choke. The excellent output stage symmetry allows use without chokes. If, however, system performance is still not sufficient, there is the option of using additional measures such as common-mode chokes (a footprint for a common-mode choke is implemented at the Atmel ATA656x-EK board), capacitors, and ESD clamping diodes.

Please note that if any critical measurements on EMI (electromagnetic interference) performance, such as electromagnetic immunity or electromagnetic emission, are to be taken, Atmel recommends using a dedicated board with a highly symmetrical layout for the bus lines and ground vias at each connection to the ground plane. For investigations on complete links such as bit error measurements, a test board with at least two transceivers is required in any case.

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5.2.2.1 Common-Mode Choke

A common-mode choke provides high impedance for common-mode signals and low impedance for differential signals. Because of this, common-mode signals produced by RF noise and/or by non-perfect transceiver driver symmetry are effectively reduced while passing the choke. In fact, a common-mode choke helps to reduce emission and to improve immunity against common-mode disturbances. Earlier transceiver devices usually needed a common-mode choke to comply with stringent emission and immunity requirements of the automotive industry when using unshielded twisted-pair cables. The Atmel ATA6560/ATA6561 makes it possible to build in-vehicle bus systems without chokes. Whether a choke is needed or not ultimately depends on the specific system implementation such as the wiring harness and the symmetry of the two bus lines (matching tolerances of resistors and capacitors). Besides the RF noise reduction, the stray inductance (non-coupled portion of inductance) may establish a resonant circuit together with pin capacitance. This can result in unwanted oscillations between the bus pins and the choke both with differential and common-mode signals as well as result in extra emission around the resonant frequency. To avoid oscillations of this kind, it is highly recommended to use only chokes with a stray inductance lower than 500nH. Bifilar wound chokes typically show an even lower stray inductance. The choke should be placed nearest to the transceiver bus pins.

The use of common-mode chokes in CAN systems might cause extremely high transient voltages at the bus pins of the transceiver. These transients are generated by the change in current through the inductance of the common-mode chokes if the CAN bus is shorted to DC voltages. The actual transients that might be generated are highly dependent on the common-mode type and value but also depend on the CAN system architecture, termination, components, and location and the severity of the short circuit.

For systems where common-mode chokes are required, care should be used in the choice of the common-mode choke and the system circuit to avoid the introduction of severe transients during DC short-circuit conditions on the bus.

The best methods to avoid transients generated from common-mode chokes during CAN bus line shorts to DC voltages are:

- Remove common-mode chokes from systems, where applicable
- Move transient suppression circuits between the common-mode choke and the CAN bus pins on the transceiver
- Choose a dedicated common-mode choke and a CAN termination scheme to minimize transients

5.2.2.2 Capacitors

Matched capacitors (in pairs) at CANH and CANL to GND are frequently used to enhance immunity against electromagnetic interferences. Along with the impedance of corresponding noise sources (RF), capacitors at CANH and CANL to GND form an RC low-pass filter. Regarding immunity, the capacitor value should be as large as possible to achieve a low corner frequency. The overall capacitive load and impedance of the output stage establish an RC low-pass filter for the data signals. The associated corner frequency must be well above the data transmission frequency. This results in a limit for the capacitor value depending on the number of nodes and the data transmission frequency. Notice that capacitors increase the signal loop delay due to longer rise and fall times. Due to these time reductions, bit timing requirements, especially at 1Mbit/s, call for a value lower than 100pF (see also SAE J2284 and ISO11898). At a bit rate of 125kBit/s the capacitor value should not exceed 470pF. Typically, the capacitors are placed between the common-mode choke (if applied at all) and the ESD clamping diodes.

5.2.2.3 ESD Protection

The Atmel ATA6560/61 is designed to withstand ESD pulses of up to 8kV according to the human body model at the CANH and CANL bus pins and thus typically does not need any additional external protection methods. Nevertheless, if a higher protection level is required, external clamping devices can be applied to the CANH and CANL lines.

Care must be taken when selecting the right protection devices. The transient protectors must be fast enough to clamp the transient voltages. In addition, their capacitance must be considered. If the capacitance is too high, it can work together with the choke's inductance and cause ringing on the bus signals. Although this ringing does not corrupt the CAN signals, it might show up as electromagnetic emission at higher frequencies.
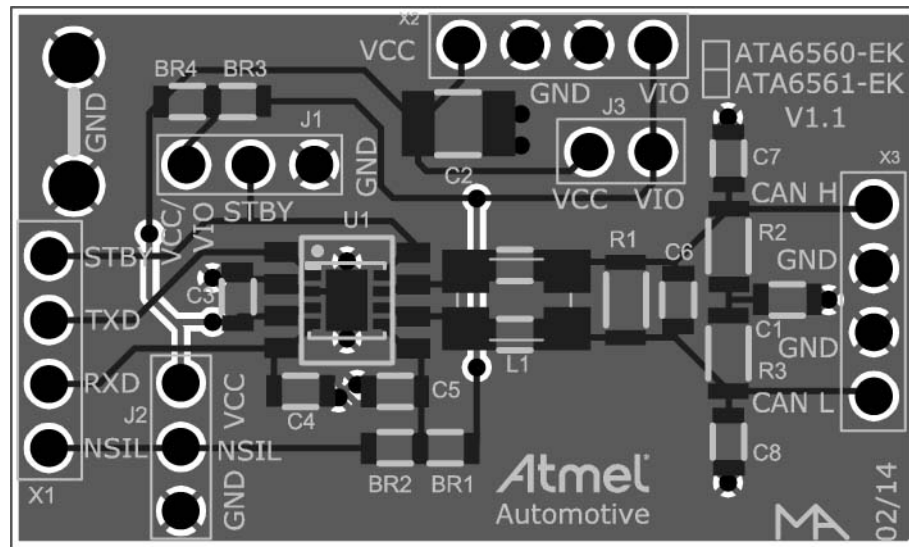
6.   Schematic of the Atmel ATA656x-EK Board

Figure 6-1.   Atmel ATA6560-EK/ATA6561-EK Board Schematic
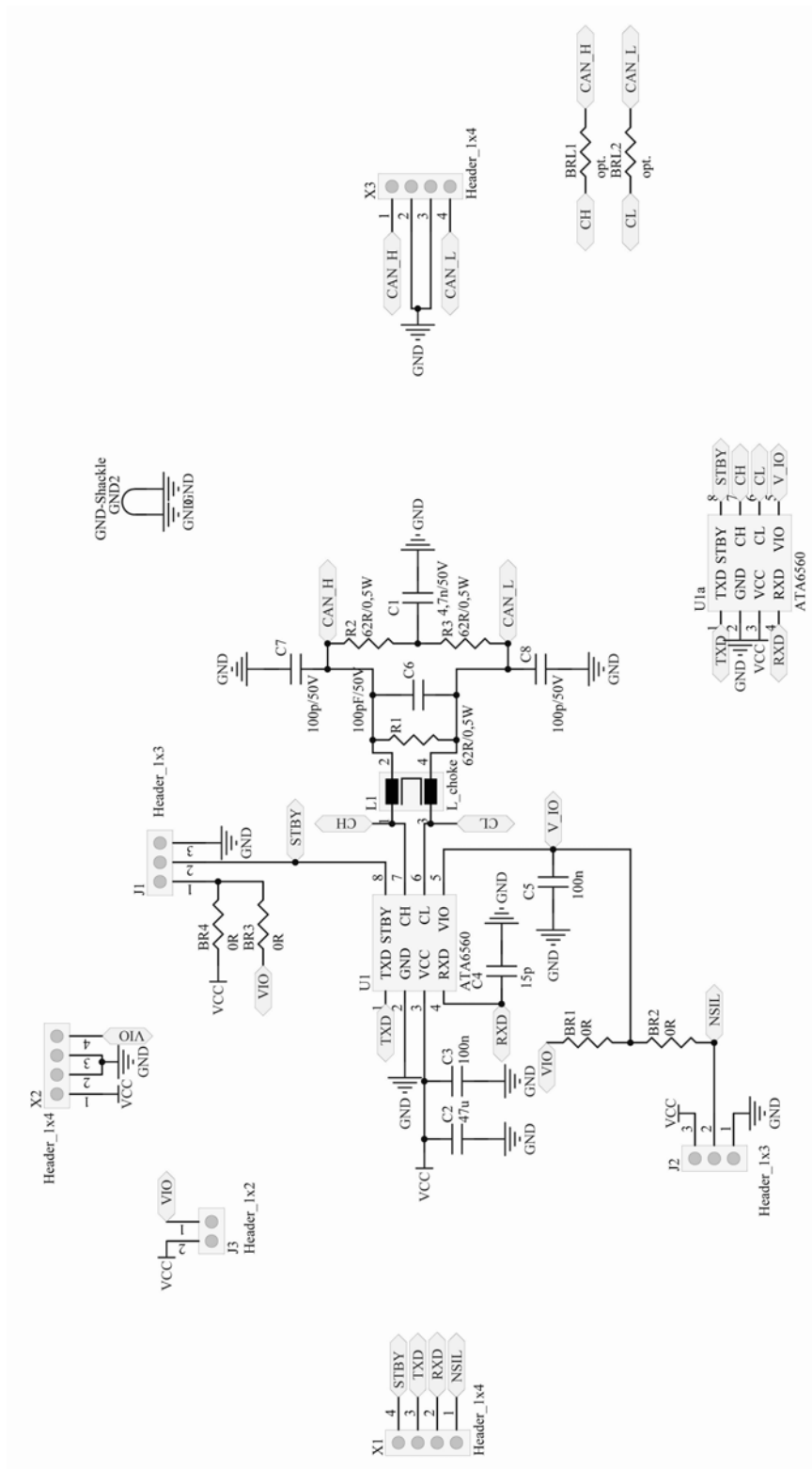
7. Board Layout

Figure 7-1. Atmel ATA6560-EK/ATA6561-EK Board Layout, Top View
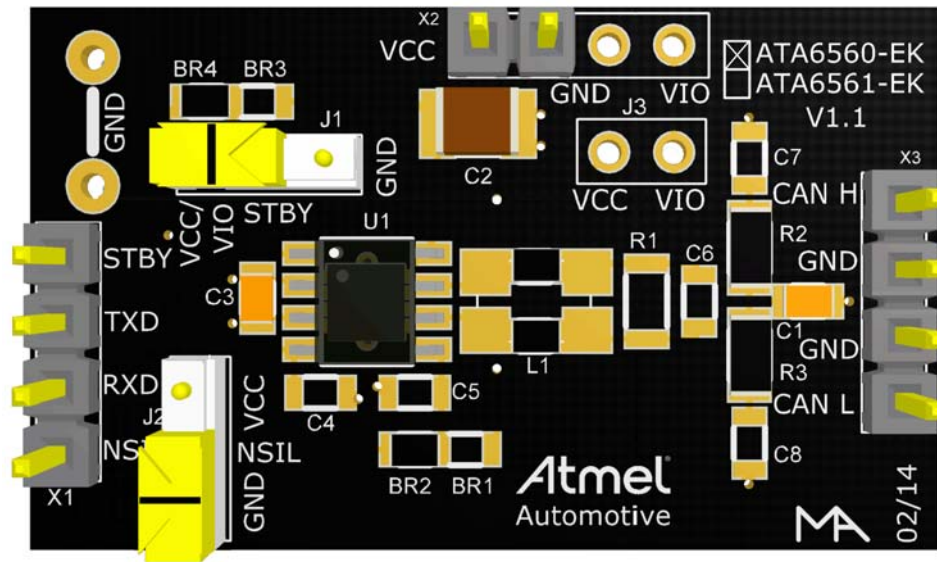
8. Atmel ATA656x-EK Board BOM

8.1 Bill of Material of the Atmel ATA656x-EK Board

Table 8-1.   Atmel ATA656x-EK Board BOM

Part	Description	Part Size	Part Value	ATA6561 (Pin 5 = VIO)	ATA6560 (Pin 5 = NSIL)
X1	Header 1×4 or Header 1×3	1×4, 2.54mm or 1×3, 2.54mm	Header 1×4 or Header 1×3	Header 1×3	Header 1×4
X2	Header 1×4 or Header 1×2	1×4, 2.54mm or 1×2, 2.54mm	Header 1×4 or Header 1×2	Header 1×4	Header 1×2
X3	Header 1×4	1×4, 2.54mm	Header 1×4	Header 1×4	Header 1×4
J1	PCB jumper switch	1×3, 2.54mm	PCB jumper switch 1×3, 2.54mm	PCB jumper switch 1×3, 2.54mm	PCB jumper switch 1×3, 2.54mm
J2	PCB jumper switch	1×3, 2.54mm	PCB jumper switch 1×3, 2.54mm	-	PCB jumper switch 1×3, 2.54mm
J3	Header 1×2	1×2, 2.54mm	Header 1×2	Header 1×2	-
C1	Capacitor	SMD 0805	4.7nF/50V	4.7nF/50V	4.7nF/50V
C2	Capacitor	SMD 1210	47μF/10V	47μF/10V	47μF/10V
C3	Capacitor	SMD 0805	100nF	100nF	100nF
C4	Capacitor	SMD 0805	15pF	-	-
C5	Capacitor	SMD 0805	100nF	100nF	-
C6	Capacitor	SMD 0805	100pF	-	-
C7	Capacitor	SMD 0805	100pF/50V	-	-
C8	Capacitor	SMD 0805	100pF/50V	-	-
GND shackle	Measuring bracket	GND shackle	GND2	GND2	GND2
R1	Resistor	SMD 1206	62Ω/0.5W	-	-
R2	Resistor	SMD 1206	62Ω/0.5W	62Ω/0.5W	62Ω/0.5W
R3	Resistor	SMD 1206	62Ω/0.5W	62Ω/0.5W	62Ω/0.5W
L1	Common-mode choke	EPCOS B82799	EPCOS B82799	0Ω resistor 0805 between term. 1 and 2 and between term. 3 and 4	0Ω resistor 0805 between term. 1 and 2 and between term. 3 and 4
BR1	0Ω resistor	SMD 0805	0Ω	0Ω	-
BR2	0Ω resistor	SMD 0805	0Ω	-	0Ω
BR3	0Ω resistor	SMD 0805	0Ω	0Ω	-
BR4	0Ω resistor	SMD 0805	0Ω	-	0Ω
IC - SO8	CAN transceiver	SO8	ATA656x	ATA6561-GAQW	ATA6560-GAQW
IC - DFN8	CAN transceiver	DFN8	ATA656x	ATA6561-GBQW	ATA6560-GBQW

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8.2   Atmel ATA6560-EK Board

Figure 8-1.   Atmel ATA6560-EK Board

8.3   Atmel ATA6561-EK Board

Figure 8-2.   Atmel ATA6561-EK Board
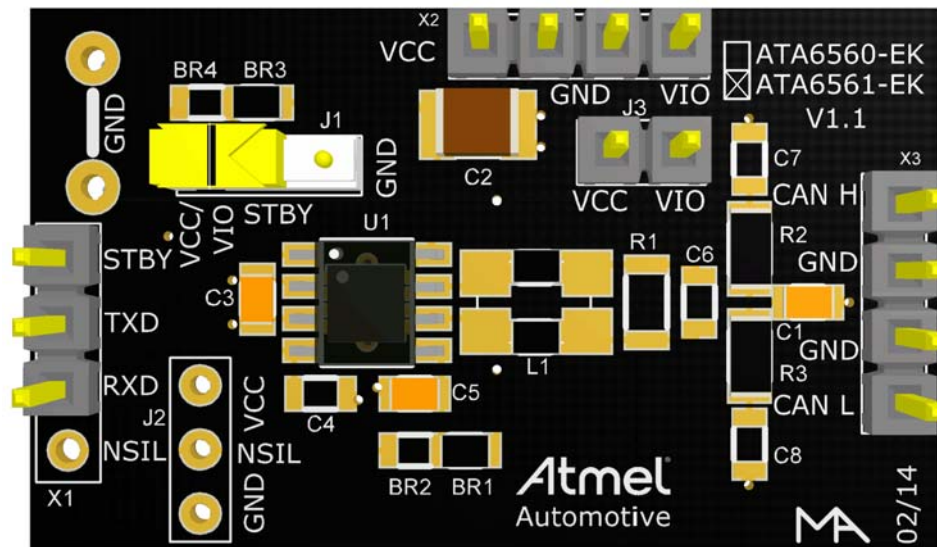
9. Revision History

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
9310E-AUTO-10/16	• Section 5.1 "Timing Measurements" on pages 8 to 9 updated
9310D-AUTO-09/14	• Section "Introduction" on page 2 updated • Section 1 "Development Kit Features" on page 3 updated • Section 4 "Applications" on page 7 updated

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