

# ***CAN and LIN transceiver low-power modes***

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## **ABSTRACT**

This application report presents the low-power modes of Texas Instruments's LIN and CAN transceivers, and explains how they work. The need for low-power modes in CAN and LIN applications is explained, how the modes are used in each application, and why they are beneficial to that application. The report ends with a list of LIN and CAN transceivers in TI's portfolio that have low-power modes implemented.

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## **1 Introduction**

As cars become more intelligent, the amount of power consumed from the battery grows due to the increasing number of electronic circuits implemented. Since the car runs on a finite battery supply, system architects need a way to add more functionality without adding significant drain on the battery. Electronics developers are answering this call by developing devices that included low-power modes. These devices allow certain parts of the system to be switched to consume less power, instead of going through a full power cycle, slowing down response times, or leaving every system on in full power mode.

In many cases, this is made possible through the communication channels of the system. The transceivers translating messages from the communication bus in the car indicate when functions are unnecessary by issuing a command to go into a Standby state until they are awakened when needed. The transceivers then can relay the message to their respective controller – typically a microcontroller – instructing it to place the system in a low-power state. With more advanced transceivers and system basis chips, multiple functions of this process (transitioning to a low-power state or waking up) can be handled by one device.

TI's CAN and LIN transceivers are designed with all of this in mind, allowing for normal, standby, silent, and sleep modes depending on the device. All of these modes allow the system to be designed in a way that is fully functioning but power-conservative. Power consumption values are available in the data sheets of all TI LIN and CAN transceivers.

## 2 Normal Mode

The normal mode is the fully-functioning mode of the device. The transceiver is in this state when it is being used for communication in its respective electronic control unit (ECU). The transmit and receive circuits are both enabled, allowing a digital input on TXD to be translated to a bus signal and allowing the bus communication to be translated to a digital output on the RXD pin.

This mode is available on all LIN and CAN transceivers and is the highest current-consuming mode due to all of the functions being available.

## 3 Silent Mode

Silent mode is a slightly less current-consuming mode relative to normal mode on some CAN transceivers. This mode disables the transmit driver to the bus, allowing the bus to stay recessive regardless of what is happening on TXD and keeps the receiver fully active, allowing the bus communication to still be observed by the controller/processor. This mode is typically used for applications that need to listen to the bus but not disturb the bus with any kind of communication in response. Silent mode is implemented on the TCAN1051 CAN transceiver, along with several others.

## 4 Standby Mode

Standby mode is a low-power mode implemented on transceivers to give a state consuming less power, but not quite as low as sleep mode. As it is implemented on the TCAN1042, the overall quiescent current from the device is lowered by disabling the bus communication capabilities, and switching to a low-power bus monitor instead. To transition into standby mode, a logic high-level is applied to the STB pin by the controller/processor. This action disables the normal transmit and receive functions of the device, and a low-power monitoring circuit checks the bus for a valid wake-up pattern (WUP) as it is defined by ISO11898-2. Once a valid WUP is received on the bus, the RXD pin toggles low to indicate the mode transition request to the controller/processor. The controller/processor applies a logic low-level on the STB pin. Though the current consumption drops in the transceiver, there is some quiescent current needed to power the MCU so that it can properly monitor RXD for the wake-up indication.

Standby mode, as it is implemented in all of TI's LIN transceivers, acts as a transitional state that the device goes into from sleep mode. When the LIN transceiver is in sleep mode, only the low-power receiver, and some digital logic is left enabled. The RXD pin is floating and the LIN bus is weakly pulled up internally. Once a valid WUP is detected on the LIN bus, the device transitions into standby mode where it is meant to wait for the microcontroller to complete the transition into normal mode. In standby mode, the RXD pin is held low to indicate to the microcontroller that it is time to transition into normal mode, and the internal LIN pull up is re-enabled.

[Section 5](#) explains the two ways that standby mode is implemented, and standby mode as a transitional state

## 5 Sleep Mode

Sleep mode is the lowest power state of a powered transceiver. All bus driving and controlling interface functions are disabled to lower the power consumption of the device, leaving only some digital logic and a low-power bus receiver enabled. Sleep mode also gives a level of system control that is not available with devices that only feature standby mode.

As it is implemented in the TCAN1043 CAN transceiver, sleep mode is entered from normal mode by keeping EN at a logic high and nSTB at a logic low for longer than  $t_{GO-TO-SLEEP}$ . Once in sleep mode, as stated before, all functions except some digital logic and the low-power bus receiver are disabled. The inhibit pin also changes state when in sleep mode compared to normal, standby, and silent modes. The inhibit output is a high-voltage pin internally tied to the VSUP supply in the TCAN1043 transceiver. This output is meant to be used as an enable for a power supply integrated circuit (IC) that supplies the TCAN1043 and controller in the ECU. Once TCAN1043 goes into sleep mode, inhibit goes into a high-impedance state, no longer enabling the power supply, and thus shutting off power to the microcontroller and rest of the system. In this way, the TCAN1043 is used to put the entire system into a low-power mode when it goes into sleep mode.

There are two ways to wake up from sleep mode: a local wake up on the WAKE pin, or a CAN wake-up on the CAN bus. If either of these methods is used correctly, the TCAN1043 switches into standby mode, where the inhibit output is re-enabled. Once this happens, the power supply is re-enabled through inhibit, and the microcontroller is supplied again. The microcontroller then sets the EN and nSTB pins high again, and the TCAN1043 transitions back into normal mode, allowing for full functionality.

The TLIN1441 also has this function, but instead of inhibit, the integrated LDO is disabled in sleep mode, and then re-enabled in standby and normal mode. The process is similar, where the EN pin is set low for 15  $\mu$ s to go into sleep mode, and all functions on the transceiver are disabled except for some fault-monitoring, digital logic, and a low-power bus receiver to monitor for wake patterns. The integrated LDO also goes low, which is typically used to supply a microcontroller. When a local wake up on the WAKE pin or a LIN wake up happens on the LIN bus, the device transitions into standby mode. The integrated LDO is then re-enabled, thus powering the microcontroller back up, and setting the TLIN1441 back into normal mode through the enable pin from the microcontroller.

In both of these examples, it is shown how the transceiver can be the main control for the system, being the starting point for going into a lower-power state, and also alerting the system when it is needed.

## 6 Conclusion

The low-power modes available on TI's communication transceivers give the system designer options when choosing the correct device. If only lower quiescent current is needed, then standby mode on the TCAN1042, silent mode on the TCAN1051, or even sleep and standby mode on the TLIN1029 is the correct choice. If lower quiescent current and system-level power control is needed, then the sleep mode on TCAN1043 or the TLIN1441 is the better option. Either way, lowering the power consumption without sacrificing time and extra processing steps is made possible through TI's CAN and LIN transceivers. Several transceivers with these modes are listed in this document, but for a full list, visit <http://www.ti.com/interface/can-lin/overview.html>.

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