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# Industrial High Speed CAN-FD Transceiver

CAN with Flexible Data-Rate

IFX1051LE

**Preliminary Data Sheet**

Rev. 0.92, 2015-07-28

**Standard Power**

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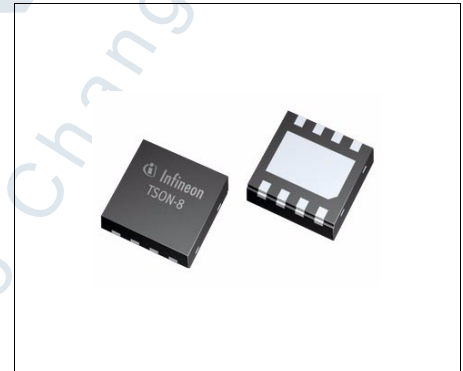
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## 1 Overview

### Features

- Fully compatible to ISO 11898-2
- Wide common mode range for electromagnetic immunity (EMI)
- Very low electromagnetic emission (EME)
- Excellent ESD robustness
- Guaranteed loop delay symmetry to support CAN FD data frames up to 2 MBit/s
- $V_{IO}$  input for voltage adaption to the microcontroller supply
- Extended supply range on  $V_{CC}$  and  $V_{IO}$  supply
- CAN short circuit proof to ground, battery and  $V_{CC}$
- TxD time-out function with very long TxD timeout timing
- Low CAN bus leakage current in power-down state
- Overtemperature protection
- Protected against transients
- Receive-only mode
- Green Product (RoHS compliant)
- Tiny package: PG-TSON-8



PG-TSON-8

### Description

The IFX1051 is a transceiver designed for HS CAN networks in industrial applications. Acting as interface between the physical bus layer and the CAN protocol controller, the IFX1051 drives the signals to the bus and protects the microcontroller against interferences generated within the network. Based on the high symmetry of the CANH and CANL signals, the IFX1051 provides a very low level of electromagnetic emission (EME) within a wide frequency range.

The IFX1051 is available in a small, leadless PG-TSON-8 package. The package is RoHS compliant and halogen free and moreover supports the solder joint requirements for automated optical inspection (AOI). The IFX1051LE is fulfilling or exceeding the requirements of the ISO11898-2.

The IFX1051 provides a digital supply input  $V_{IO}$  and a receive-only mode. It is designed to fulfill the enhanced physical layer requirements for CAN FD and supports data rates up to 2 MBit/s.

On the basis of a very low leakage current on the HS CAN bus interface the IFX1051 provides an excellent passive behavior in power-down state. These and other features make the IFX1051 exceptionally suitable for mixed supply HS CAN networks.

The IFX1051 provides excellent ESD immunity together with a very high electromagnetic immunity (EMI).

Two different operating modes, additional fail-safe features like a TxD time-out and the optimized output slew rates

Type	Package	Marking
IFX1051LE	PG-TSON-8	1051LE

on the CANH and CANL signals make the IFX1051 the ideal choice for large HS CAN networks with high data transmission rates.

The qualification of this product is based on JEDEC JESD47 and may reference existing qualification results of similar products. Such referring is justified by the structural similarity of the products. The product is not qualified and manufactured according to the requirements of Infineon Technologies with regard to automotive and/or transportation applications. Infineon Technologies administrates a comprehensive quality management system according to the latest version of the ISO9001 and ISO/TS 16949

The most updated certificates of the aforesaid ISO9001 and ISOTS 16949 are available on the Infineon Technologies webpage <http://www.infineon.com/cms/en/product/technology/quality/>

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## 2 Block Diagram

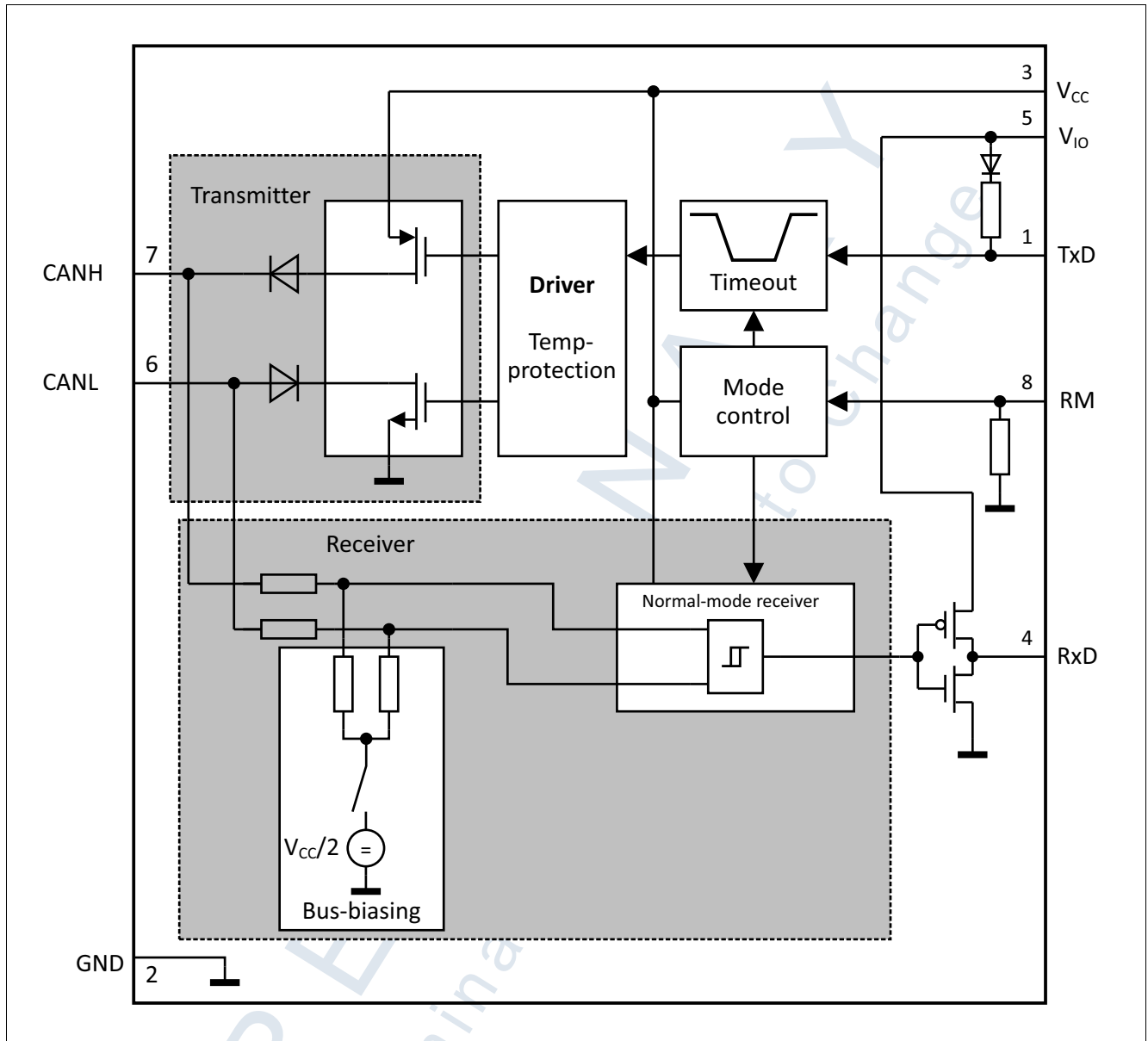


Figure 1 Functional block diagram

### 3 Pin Configuration

#### 3.1 Pin Assignment

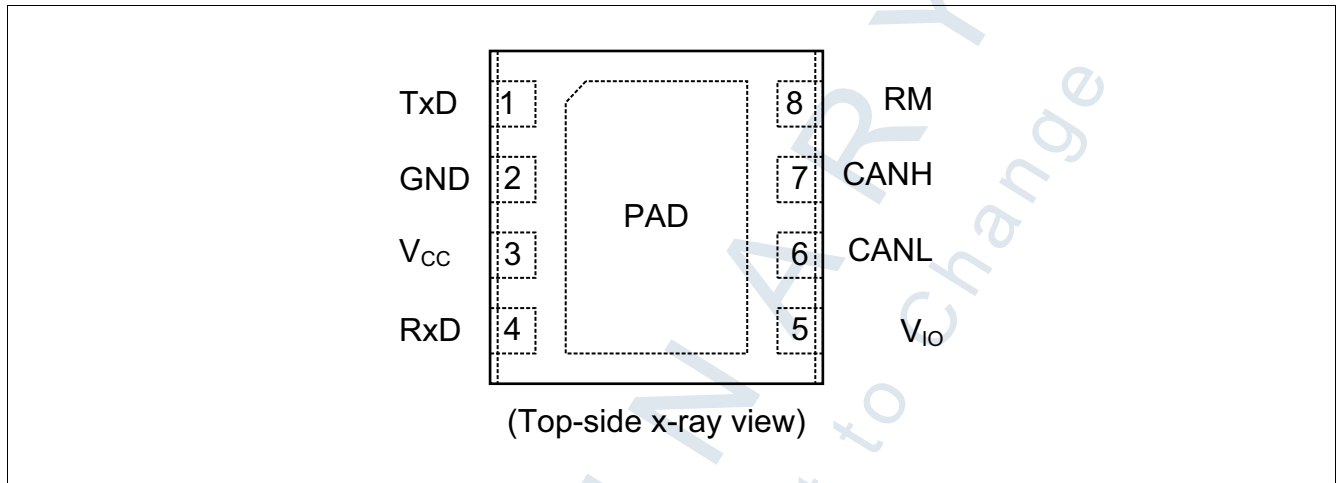


Figure 2 Pin configuration

#### 3.2 Pin Definitions

Table 1 Pin definitions and functions

Pin No.	Symbol	Function
1	TxD	<b>Transmit Data Input;</b> internal pull-up to $V_{IO}$ , “low” for “dominant” state.
2	GND	<b>Ground</b>
3	$V_{CC}$	<b>Transmitter Supply Voltage;</b> 100 nF decoupling capacitor to GND required.
4	RxD	<b>Receive Data Output;</b> “low” in “dominant” state.
5	$V_{IO}$	<b>Digital Supply Voltage;</b> supply voltage input to adapt the logical input and output voltage levels of the transceiver to the microcontroller supply, 100 nF decoupling capacitor to GND required.
6	CANL	<b>CAN Bus Low Level I/O;</b> “low” in “dominant” state.
7	CANH	<b>CAN Bus High Level I/O;</b> “high” in “dominant” state.
8	RM	<b>Receive-only Mode Input;</b> internal pull-down to GND, “low” for normal-operating mode.
PAD	–	Connect to PCB heat sink area. Do not connect to other potential than GND.

## 4 Functional Description

HS CAN is a serial bus system that connects microcontrollers, sensors and actuators for real-time control applications. The use of the Controller Area Network (abbreviated CAN) is described by the international standard ISO 11898. According to the 7-layer OSI reference model the physical layer of a HS CAN bus system specifies the data transmission from one CAN node to all other available CAN nodes within the network. The physical layer specification of a CAN bus system includes all electrical and mechanical specifications of a CAN network. The CAN transceiver is part of the physical layer specification. Several different physical layer standards of CAN networks have been developed in recent years. The IFX1051 is a High Speed CAN transceiver without a wake-up function and defined by the international standard ISO 11898-2.

### 4.1 High Speed CAN Physical Layer

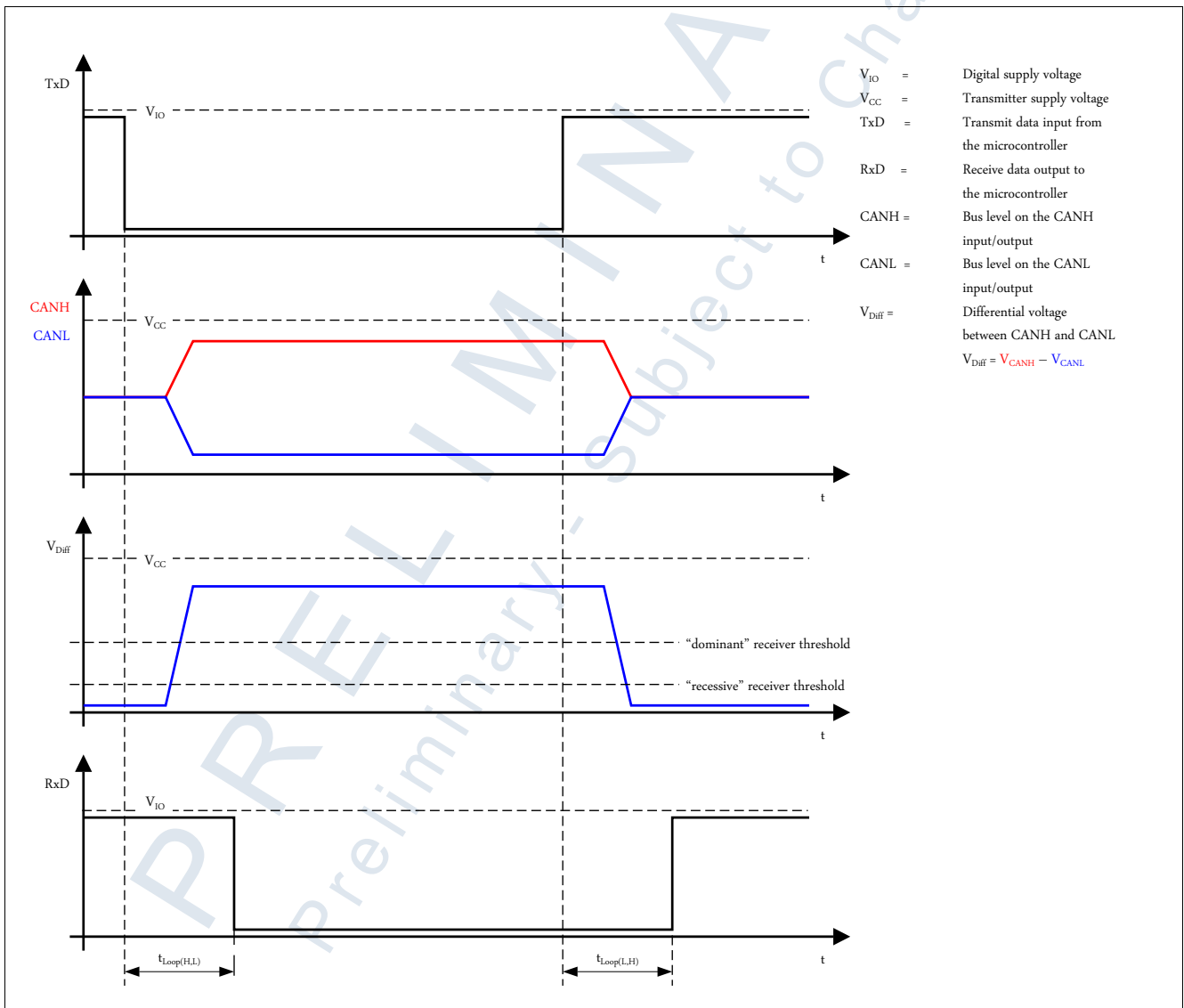


Figure 3 High speed CAN bus signals and logic signals



The IFX1051 is a High-Speed CAN transceiver, operating as an interface between the CAN controller and the physical bus medium. A HS CAN network is a two wire, differential bus network which allows data transmission rates for CAN FD frames up to 2 MBit/s. Main characteristics for HS CAN networks are the two signal states on the HS CAN bus: “dominant” and “recessive” (see [Figure 3](#)).

$V_{CC}$ ,  $V_{IO}$  and GND are the supply pins for the IFX1051. The pins CANH and CANL are the interface to the HS CAN bus and operate in both directions, as an input and as an output. RxD and TxD pins are the interface to the CAN controller, the TxD pin is an input pin and the RxD pin is an output pin. The RM pin is the input pin for the mode selection (see [Figure 4](#)).

By setting the TxD input pin to logical “low” the transmitter of the IFX1051 drives a “dominant” signal to the CANH and CANL pins. Setting TxD input to logical “high” turns off the transmitter and the output voltage on CANH and CANL discharges towards the “recessive” level. The “recessive” output voltage is provided by the bus biasing (see [Figure 1](#)). The output of the transmitter is considered to be “dominant”, when the voltage difference between CANH and CANL is at least higher than 1.5 V ( $V_{Diff} = V_{CANH} - V_{CANL}$ ).

Parallel to the transmitter the normal-mode receiver monitors the signal on the CANH and CANL pins and indicates it on the RxD output pin. A “dominant” signal on the CANH and CANL pins sets the RxD output pin to logical “low”, vice versa a “recessive” signal sets the RxD output to logical “high”. The normal-mode receiver considers a voltage difference ( $V_{Diff}$ ) between CANH and CANL above 0.9 V as “dominant” and below 0.5 V as “recessive”.

To be conform with HS CAN features, like the bit to bit arbitration, the signal on the RxD output has to follow the signal on the TxD input within a defined loop delay  $t_{Loop} \leq 255$  ns.

The thresholds of the digital inputs (TxD and RM) and also the RxD output voltage are adapted to the digital power supply  $V_{IO}$ .

PRELIMINARY - Subject to Change

## 4.2 Modes of Operation

The IFX1051 supports two different modes of operation, receive-only mode and normal-operating mode while the transceiver is supplied according to the specified functional range. The mode of operation is selected by the RM input pin (see [Figure 4](#)).

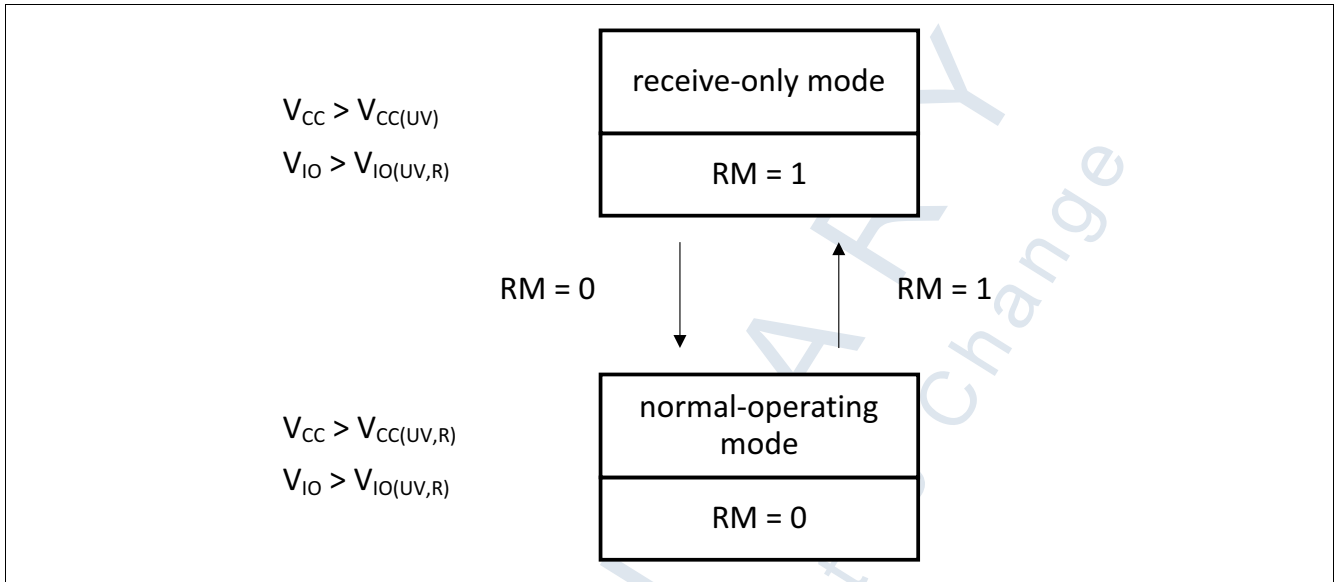


Figure 4 Mode state diagram

### 4.2.1 Normal-operating Mode

In normal-operating mode the transmitter and the receiver of the HS CAN transceiver IFX1051 are active (see [Figure 1](#)). The HS CAN transceiver sends the serial data stream on the TxD input pin to the CAN bus. The data on the CAN bus is displayed at the RxD pin simultaneously. A logical "low" signal on the RM pin selects the normal-operating mode, while the transceiver is supplied by  $V_{CC}$  and  $V_{IO}$  (see [Table 2](#) for details).

### 4.2.2 Receive-only Mode

In receive-only mode the normal-mode receiver is active and the transmitter is turned off. The IFX1051 can receive data from the HS CAN bus, but cannot send any data to the HS CAN bus.

A logical "high" signal on the RM pin selects the receive-only mode, while the transceiver is supplied by  $V_{CC}$  and  $V_{IO}$  (see [Table 2](#) for details).

### 4.3 Power-up and Undervoltage Condition

By detecting an undervoltage event, either on the transmitter supply  $V_{CC}$  or the digital supply  $V_{IO}$ , the transceiver IFX1051 changes the mode of operation. When the digital power supply  $V_{IO}$  is switched off, the transceiver powers down and remains in the power-down state. When switching off the transmitter supply  $V_{CC}$ , the transceiver changes to the forced power-save mode, (details see **Figure 5**).

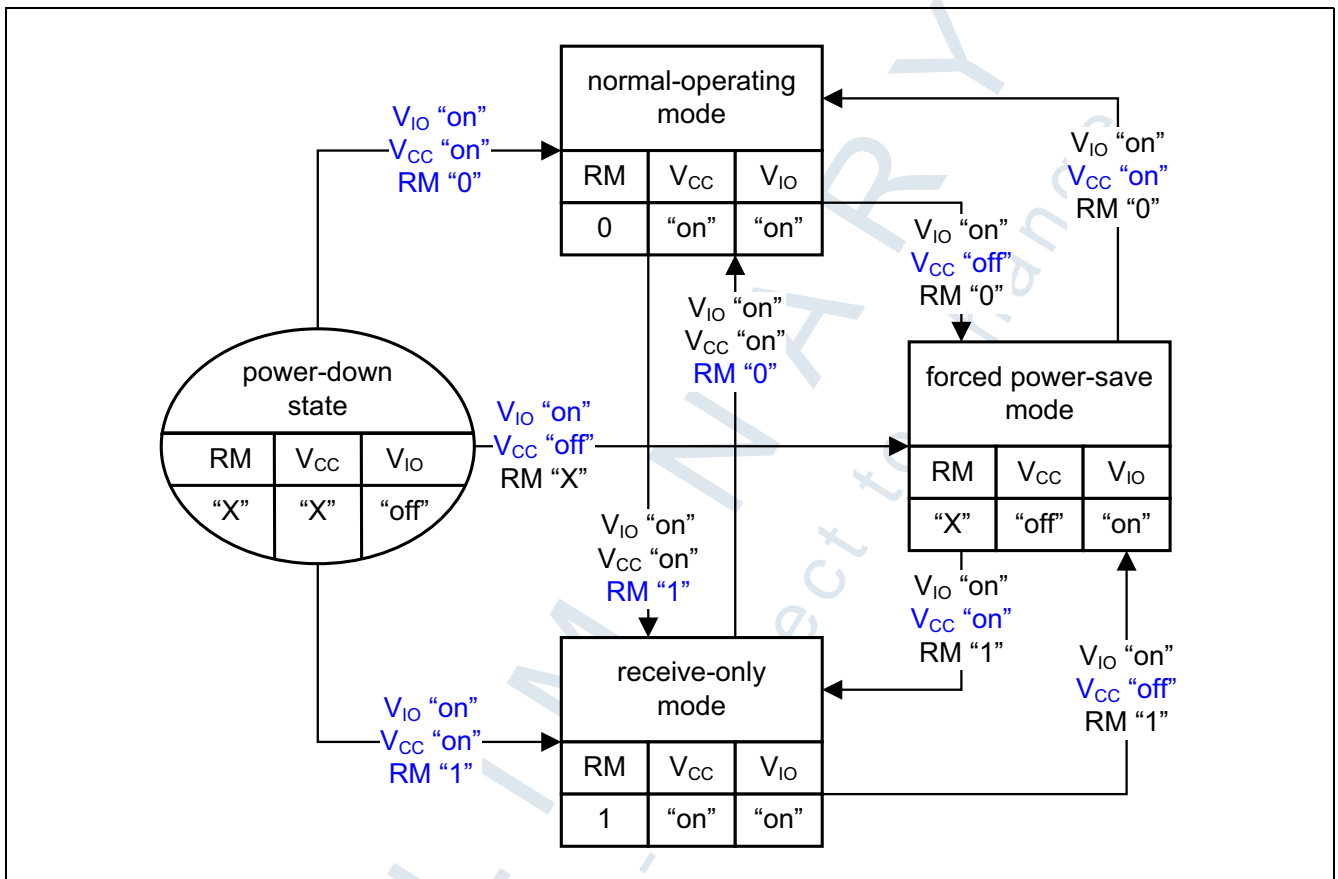


Figure 5 Power-up and undervoltage

Table 2 Modes of operation

Mode	RM	$V_{IO}$	$V_{CC}$	Bus Bias	Transmitter	Normal-mode Receiver	Low-power Receiver
Normal-operating	"low"	"on"	"on"	$V_{CC}/2$	"on"	"on"	not available
Receive-only	"high"	"on"	"on"	$V_{CC}/2$	"off"	"on"	not available
Forced power-save	"X"	"on"	"off"	floating	"off"	"off"	not available
Power-down state	"X"	"off"	"X"	floating	"off"	"off"	not available

### 4.3.1 Power-down State

Independent of the transmitter supply  $V_{CC}$  and of the RM input pin, the IFX1051 is in power-down state when the digital supply voltage  $V_{IO}$  is turned off (see [Figure 5](#)).

In the power-down state the input resistors of the receiver are disconnected from the bus biasing  $V_{CC}/2$ . The CANH and CANL bus interface of the IFX1051 is floating and acts as a high-impedance input with a very small leakage current. The high-ohmic input does not influence the “recessive” level of the CAN network and allows an optimized EME performance of the entire HS CAN network (see also [Table 2](#)).

### 4.3.2 Forced Power-save Mode

The forced power-save mode is a fail-safe mode to avoid any disturbance on the HS CAN bus, while the IFX1051 faces a loss of the transmitter supply  $V_{CC}$ .

In forced power-save mode, the transmitter and the normal-mode receiver are turned off and therefore the transceiver IFX1051 can not disturb the bus media.

The RxD output pin is permanently set to logical “high”. The bus biasing is floating (details see [Table 2](#)).

The forced power-save mode can only be entered when the transmitter supply  $V_{CC}$  is not available, either by powering up the digital supply  $V_{IO}$  only or by turning off the transmitter supply in normal-operating mode or in receive-only mode (see [Figure 5](#)). While the transceiver IFX1051 is in forced power-save mode the RM pin is disabled.

### 4.3.3 Power-up

The HS CAN transceiver IFX1051 powers up if at least the digital supply  $V_{IO}$  is connected to the device. By default the device powers up in normal-operating mode, due to the internal pull-down resistor on the RM pin to GND.

In case the device needs to power-up in receive-only mode, the RM pin needs to be pulled active to logical “high” and the supplies  $V_{IO}$  and  $V_{CC}$  have to be connected.

By supplying only the digital power supply  $V_{IO}$  the IFX1051 powers up in forced power-save mode (see [Figure 5](#)).

### 4.3.4 Undervoltage on the Digital Supply $V_{IO}$

If the voltage on  $V_{IO}$  supply input falls below the threshold  $V_{IO} < V_{IO(U,F)}$ , the transceiver IFX1051 powers down and changes to the power-down state.

The undervoltage detection on the digital supply  $V_{IO}$  has the highest priority and is independent of the transmitter supply  $V_{CC}$  and also independent of the currently selected operating mode. An undervoltage event on  $V_{IO}$  always powers down the IFX1051.

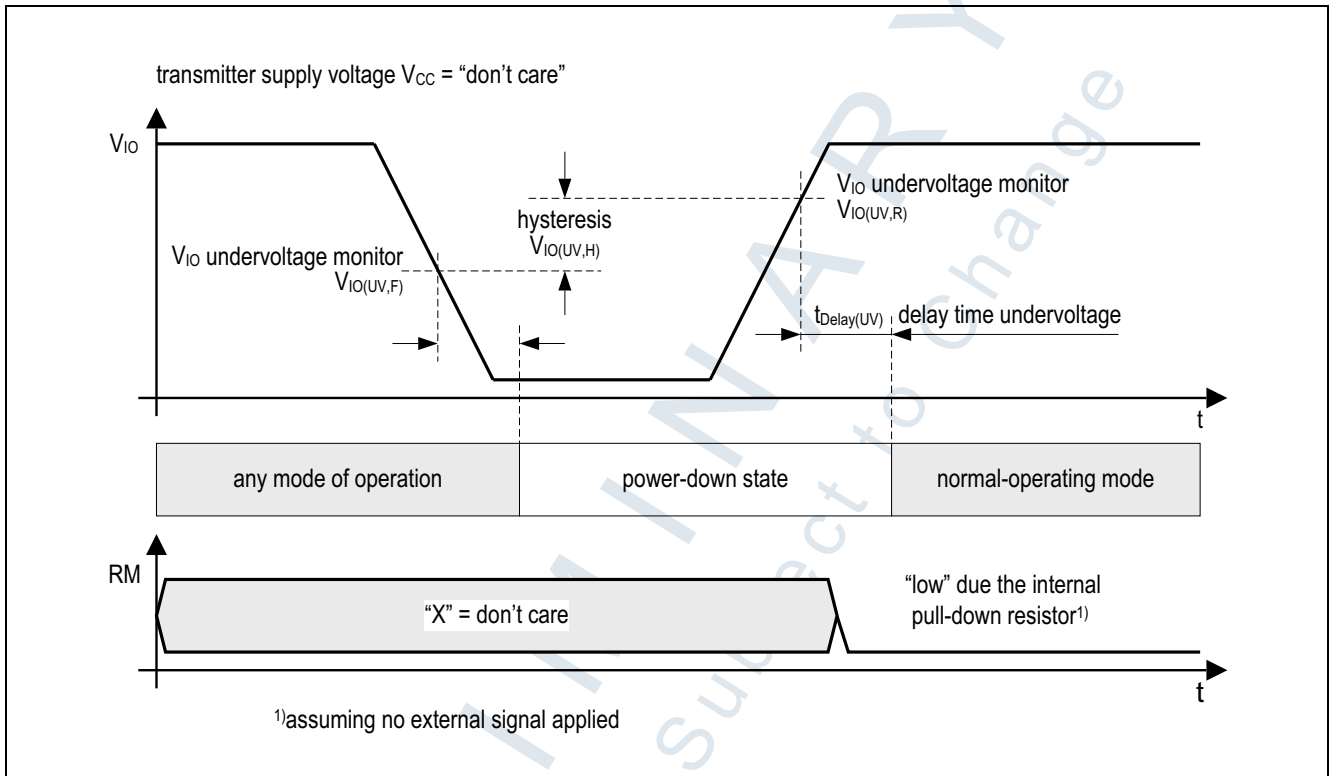


Figure 6 Undervoltage on the digital supply  $V_{IO}$

### 4.3.5 Undervoltage on the Transmitter Supply $V_{CC}$

In case the transmitter supply  $V_{CC}$  falls below the threshold  $V_{CC} < V_{CC(UV,F)}$ , the transceiver IFX1051 changes the mode of operation to forced power-save mode. The transmitter and also the normal-mode receiver of the IFX1051 are powered by the  $V_{CC}$  supply. In case of an insufficient  $V_{CC}$  supply, the IFX1051 can neither transmit the CANH and CANL signals correctly to the bus, nor can it receive them properly. Therefore the IFX1051 blocks the transmitter and the receiver in forced power-save mode (see [Figure 7](#)).

The undervoltage detection on the transmitter supply  $V_{CC}$  is active in normal-operating mode and in receive-only mode (see [Figure 5](#)).

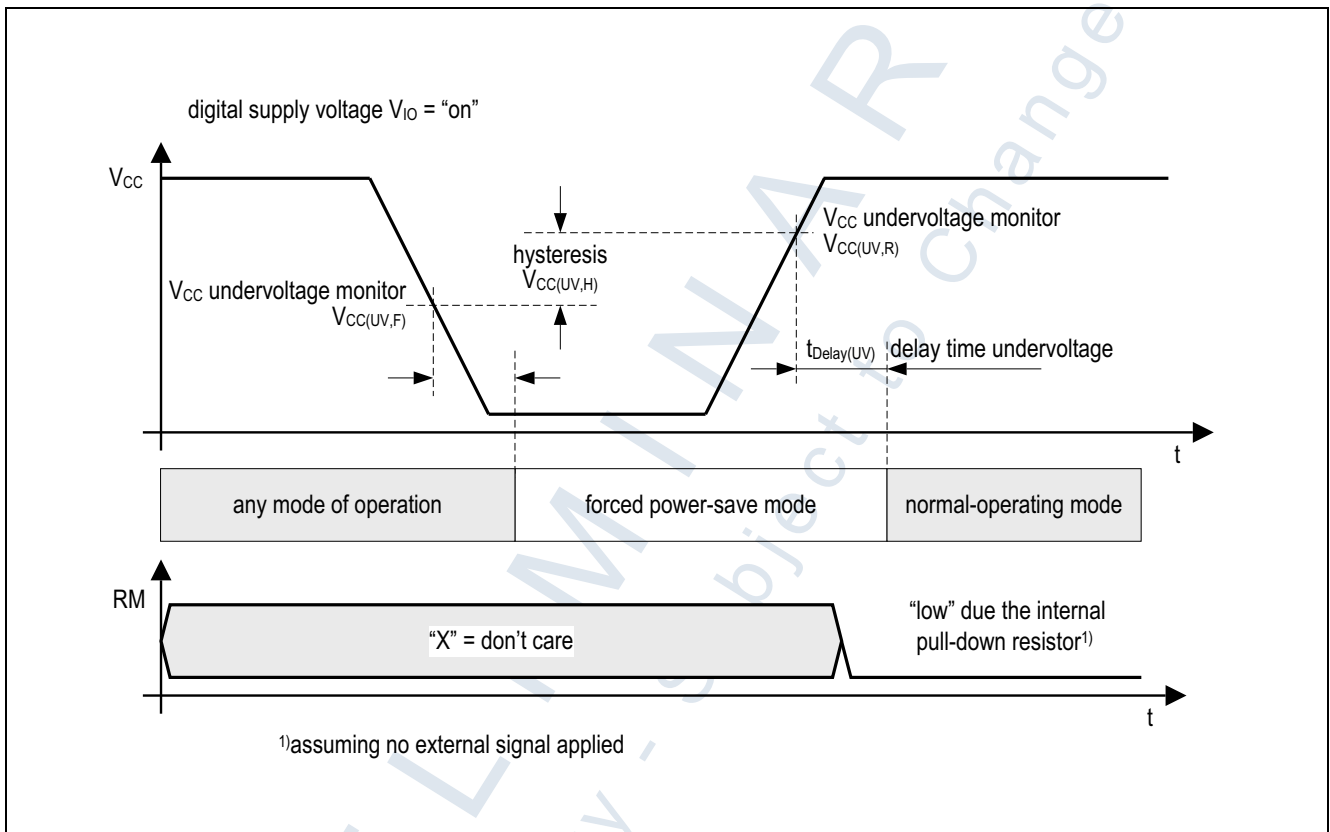


Figure 7 Undervoltage on the transmitter supply  $V_{CC}$

### 4.3.6 Voltage Adaption to the Microcontroller Supply

The HS CAN transceiver IFX1051 has two different power supplies,  $V_{CC}$  and  $V_{IO}$ . The power supply  $V_{CC}$  supplies the transmitter and the normal-mode receiver. The power supply  $V_{IO}$  supplies the digital input and output buffers and it is also the main power domain of the internal logic.

To adjust the digital input and output levels of the IFX1051 to the I/O levels of the external microcontroller, connect the power supply  $V_{IO}$  to the microcontroller I/O supply voltage (see [Figure 13](#)).

*Note: In case the digital supply voltage  $V_{IO}$  is not required in the application, connect the digital supply voltage  $V_{IO}$  to the transmitter supply  $V_{CC}$ .*

## 5 Fail Safe Functions

### 5.1 Short Circuit Protection

The CANH and CANL bus outputs are short circuit proof, either against GND or a positive supply voltage. A current limiting circuit protects the transceiver against damages. If the device is heating up due to a continuous short on the CANH or CANL, the internal overtemperature protection switches off the bus transmitter.

### 5.2 Unconnected Logic Pins

All logic input pins have an internal pull-up resistor to  $V_{IO}$  or a pull-down resistor to GND. In case the  $V_{IO}$  supply is activated and the logical pins are open, the IFX1051 enters into the normal-operating mode by default. The TxD input is pulled to logical “high” due to the internal pull-up resistor to  $V_{IO}$ . The HS CAN transceiver IFX1051 will not influence the data on the CAN bus as long the TxD input pin remains logical “high”.

### 5.3 TxD Time-out Function

The TxD time-out feature protects the CAN bus against being permanently blocked in case the logical signal at the TxD pin is continuously “low”. A continuous “low” signal at the TxD pin might have its root cause in a locked-up microcontroller or in a short circuit on the printed circuit board, for example. In normal-operating mode, a logical “low” signal applied to the TxD pin for the time  $t > t_{TxD}$  triggers the TxD time-out feature and the IFX1051 disables the transmitter (see [Figure 8](#)). The receiver is still active and the data on the bus continues to be monitored by the RxD output pin.

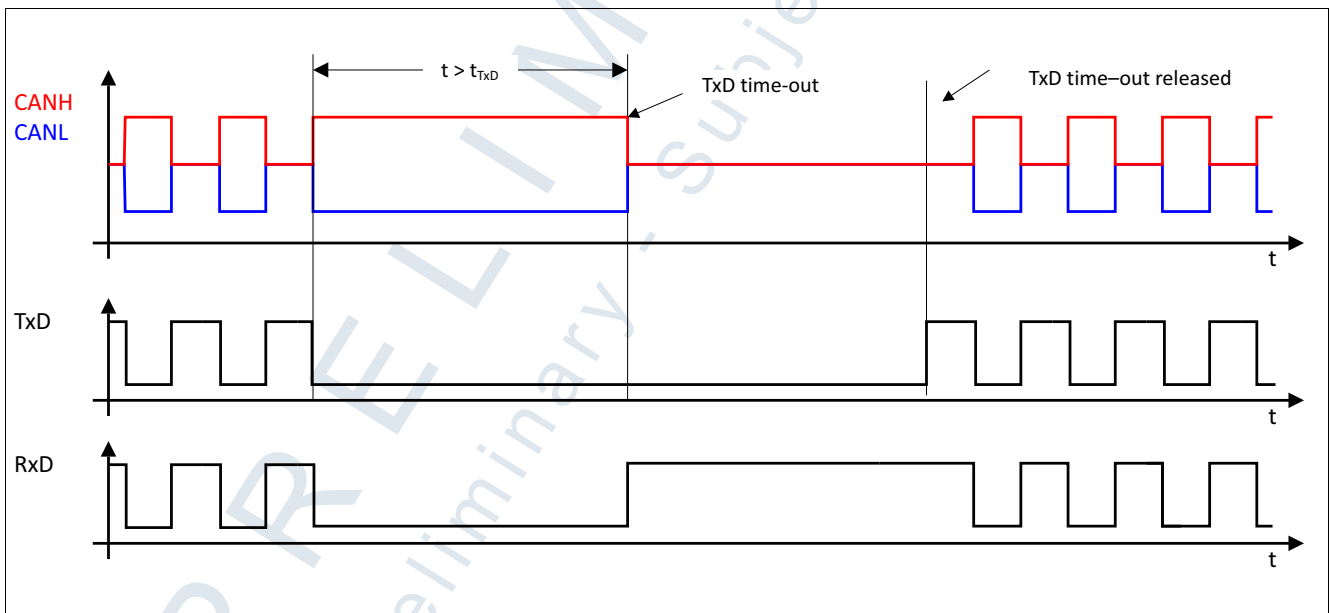


Figure 8 TxD time-out function

**Figure 8** illustrates how the transmitter is deactivated and activated again. A permanent “low” signal on the TxD input pin activates the TxD time-out function and deactivates the transmitter. To release the transmitter after a TxD time-out event the IFX1051 requires a signal change on the TxD input pin from logical “low” to logical “high”.

### 5.4 Overtemperature Protection

The IFX1051 has an integrated overtemperature detection to protect the IFX1051 against thermal overstress of the transmitter. The overtemperature protection is active in normal-operating mode and disabled in receive-only mode. In case of an overtemperature condition, the temperature sensor will disable the transmitter (see [Figure 1](#)) while the transceiver remains in normal-operating mode.

After the device has cooled down the transmitter is activated again (see [Figure 9](#)). A hysteresis is implemented within the temperature sensor circuit.

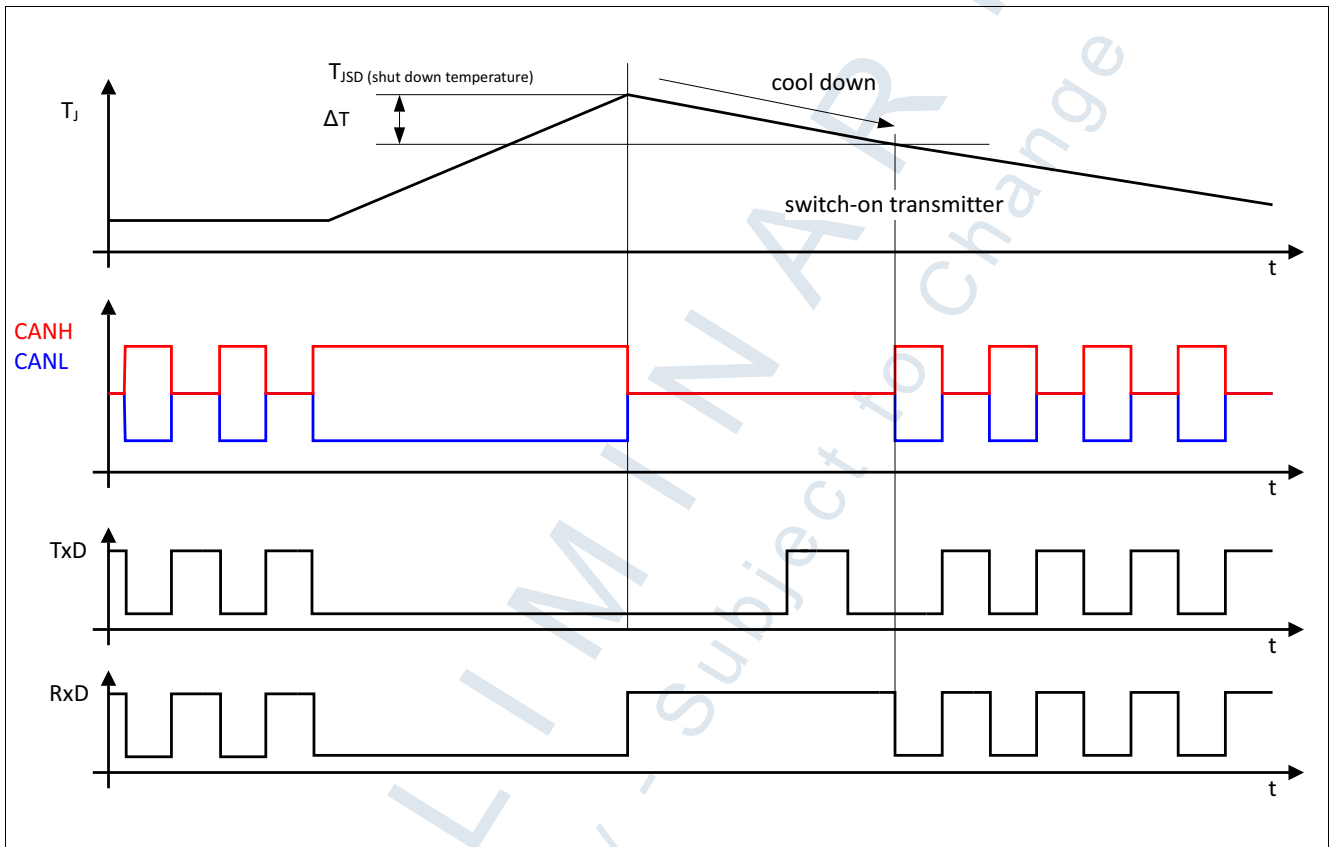


Figure 9 Overtemperature protection

### 5.5 Delay Time for Mode Change

The HS CAN transceiver IFX1051 changes the mode of operation within the time window  $t_{Mode}$ . During the mode change the normal-mode receiver and the RxD output are active and reflect the on the HS CAN input pins (see as an example [Figure 14](#) and [Figure 15](#)).



## 6 General Product Characteristics

### 6.1 Absolute Maximum Ratings

**Table 3 Absolute maximum ratings voltages, currents and temperatures<sup>1)</sup>**

All voltages with respect to ground; positive current flowing into pin;  
(unless otherwise specified)

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
<b>Voltages</b>							
Transmitter supply voltage	$V_{CC}$	-0.3	–	6.0	V	–	P_6.1.1
Digital supply voltage	$V_{IO}$	-0.3	–	6.0	V	–	P_6.1.2
CANH DC voltage versus GND	$V_{CANH}$	-40	–	40	V	–	P_6.1.3
CANL DC voltage versus GND	$V_{CANL}$	-40	–	40	V	–	P_6.1.4
Differential voltage between CANH and CANL	$V_{CAN\_Diff}$	-40	–	40	V	–	P_6.1.5
Voltages at the input pins: RM, TxD	$V_{MAX\_IN}$	-0.3	–	6.0	V	–	P_6.1.6
Voltages at the output pin: RxD	$V_{MAX\_OUT}$	-0.3	–	$V_{IO}$	V	–	P_6.1.7
<b>Currents</b>							
RxD output current	$I_{RxD}$	-20	–	20	mA	–	P_6.1.8
<b>Temperatures</b>							
Junction temperature	$T_j$	-40	–	150	°C	–	P_6.1.9
Storage temperature	$T_S$	-55	–	150	°C	–	P_6.1.10
<b>ESD Resistivity</b>							
ESD immunity at CANH, CANL versus GND	$V_{ESD\_HBM\_CAN}$	-8	–	8	kV	HBM (100 pF via 1.5 kΩ) <sup>2)</sup>	P_6.1.11
ESD immunity at all other pins	$V_{ESD\_HBM\_ALL}$	-2	–	2	kV	HBM (100 pF via 1.5 kΩ) <sup>2)</sup>	P_6.1.12
ESD immunity to GND	$V_{ESD\_CDM}$	-750	–	750	V	CDM <sup>3)</sup>	P_6.1.13

1) Not subject to production test, specified by design

2) ESD susceptibility, Human Body Model "HBM" according to ANSI/ESDA/JEDEC JS-001

3) ESD susceptibility, Charge Device Model "CDM" according to EIA/JESD22-C101 or ESDA STM5.3.1

*Note: Stresses above the ones listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as "outside" normal-operating range. Protection functions are not designed for continuous repetitive operation.*

## 6.2 Functional Range

**Table 4 Functional range**

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
<b>Supply Voltages</b>							
Transmitter supply voltage	$V_{CC}$	4.5	–	5.5	V	–	P_6.2.1
Digital supply voltage	$V_{IO}$	3.0	–	5.5	V	–	P_6.2.2
<b>Thermal Parameters</b>							
Junction temperature	$T_j$	-40	–	125	°C	<sup>1)</sup>	P_6.2.3

1) Not subject to production test, specified by design.

*Note: Within the functional range the IC operates as described in the circuit description. The electrical characteristics are specified within the conditions given in the related electrical characteristics table.*

## 6.3 Thermal Resistance

*Note: This thermal data was generated in accordance with JEDEC JESD51 standards. For more information, please visit [www.jedec.org](http://www.jedec.org).*

**Table 5 Thermal resistance<sup>1)</sup>**

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
<b>Thermal Resistances</b>							
Junction to Ambient PG-TSON-8	$R_{thJA}$	–	55	–	K/W	<sup>2)</sup>	P_6.3.1
<b>Thermal Shutdown (junction temperature)</b>							
Thermal shutdown temperature	$T_{JSD}$	150	175	200	°C	–	P_6.3.2
Thermal shutdown hysteresis	$\Delta T$	–	10	–	K	–	P_6.3.3

1) Not subject to production test, specified by design

2) Specified  $R_{thJA}$  value is according to Jedec JESD51-2,-7 at natural convection on FR4 2s2p board. The product (IFX1051) was simulated on a 76.2 x 114.3 x 1.5 mm board with 2 inner copper layers (2 x 70µm Cu, 2 x 35µm Cu).

## 7 Electrical Characteristics

### 7.1 Functional Device Characteristics

**Table 6 Electrical characteristics**

$4.5\text{ V} < V_{CC} < 5.5\text{ V}$ ;  $3.0\text{ V} < V_{IO} < 5.5\text{ V}$ ;  $R_L = 60\ \Omega$ ;  $-40\text{ }^\circ\text{C} < T_j < 125\text{ }^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
<b>Current Consumption</b>							
Current consumption at $V_{CC}$ normal-operating mode	$I_{CC}$	–	2.6	4	mA	“recessive” state, $V_{TxD} = V_{IO}$ , $V_{RM} = 0\text{ V}$ ;	P_7.1.1
Current consumption at $V_{CC}$ normal-operating mode	$I_{CC}$	–	38	60	mA	“dominant” state, $V_{TxD} = V_{RM} = 0\text{ V}$ ;	P_7.1.2
Current consumption at $V_{IO}$ normal-operating mode	$I_{IO}$	–	–	1	mA	$V_{RM} = 0\text{ V}$ ;	P_7.1.3
Current consumption at $V_{CC}$ receive-only mode	$I_{CC(ROM)}$	–	–	2	mA	$V_{RM} = V_{TxD} = V_{IO}$ ;	P_7.1.4
Current consumption at $V_{IO}$ receive-only mode	$I_{IO(ROM)}$	–	–	1	mA	$V_{RM} = V_{IO}$ ;	P_7.1.5
<b>Supply Resets</b>							
$V_{CC}$ undervoltage monitor rising edge	$V_{CC(UV,R)}$	3.8	4.0	4.3	V	–	P_7.1.6
$V_{CC}$ undervoltage monitor falling edge	$V_{CC(UV,F)}$	3.65	3.85	4.3	V	–	P_7.1.26
$V_{CC}$ undervoltage monitor hysteresis	$V_{CC(UV,H)}$	–	150	–	mV	<sup>1)</sup>	P_7.1.7
$V_{IO}$ undervoltage monitor rising edge	$V_{IO(UV,R)}$	2.0	2.5	3.0	V	–	P_7.1.8
$V_{IO}$ undervoltage monitor falling edge	$V_{IO(UV,F)}$	1.8	2.3	3.0	V	–	P_7.1.27
$V_{IO}$ undervoltage monitor hysteresis	$V_{IO(UV,H)}$	–	200	–	mV	<sup>1)</sup>	P_7.1.9
$V_{CC}$ and $V_{IO}$ undervoltage delay time	$t_{Delay(UV)}$	–	–	100	$\mu\text{s}$	<sup>1)</sup> (see <a href="#">Figure 6</a> and <a href="#">Figure 7</a> );	P_7.1.10
<b>Receiver Output RxD</b>							
“High” level output current	$I_{RD,H}$	–	-4	-2	mA	$V_{RxD} = V_{IO} - 0.4\text{ V}$ , $V_{Diff} < 0.5\text{ V}$ ;	P_7.1.11
“Low” level output current	$I_{RD,L}$	2	4	–	mA	$V_{RxD} = 0.4\text{ V}$ , $V_{Diff} > 0.9\text{ V}$ ;	P_7.1.12

**Table 6 Electrical characteristics (cont'd)**

4.5 V <  $V_{CC}$  < 5.5 V; 3.0 V <  $V_{IO}$  < 5.5 V;  $R_L = 60 \Omega$ ;  $-40 \text{ }^\circ\text{C} < T_j < 125 \text{ }^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
<b>Transmission Input TxD</b>							
“High” level input voltage threshold	$V_{\text{TxD,H}}$	–	0.5 $\times V_{\text{IO}}$	0.7 $\times V_{\text{IO}}$	V	“recessive” state;	P_7.1.13
“Low” level input voltage threshold	$V_{\text{TxD,L}}$	0.3 $\times V_{\text{IO}}$	0.4 $\times V_{\text{IO}}$	–	V	“dominant” state;	P_7.1.14
Pull-up resistance	$R_{\text{TxD}}$	10	25	50	k $\Omega$	–	P_7.1.15
Input hysteresis	$V_{\text{HYS(TxD)}}$	–	450	–	mV	<sup>1)</sup>	P_7.1.16
Input capacitance	$C_{\text{TxD}}$	–	–	10	pF	<sup>1)</sup>	P_7.1.17
TxD permanent “dominant” timeout	$t_{\text{TxD}}$	4.5	–	16	ms	normal-operating mode;	P_7.1.18
<b>Receive-only Input RM</b>							
“High” level input voltage threshold	$V_{\text{RM,H}}$	–	0.5 $\times V_{\text{IO}}$	0.7 $\times V_{\text{IO}}$	V	receive-only mode;	P_7.1.19
“Low” level input voltage threshold	$V_{\text{RM,L}}$	0.3 $\times V_{\text{IO}}$	0.4 $\times V_{\text{IO}}$	–	V	normal-operating mode;	P_7.1.20
Pull-down resistance	$R_{\text{RM}}$	10	25	50	k $\Omega$	–	P_7.1.21
Input capacitance	$C_{\text{RM}}$	–	–	10	pF	<sup>1)</sup>	P_7.1.22
Input hysteresis	$V_{\text{HYS(RM)}}$	–	200	–	mV	<sup>1)</sup>	P_7.1.23
<b>Bus Receiver</b>							
Differential receiver threshold “dominant” normal-operating mode and receive-only mode	$V_{\text{Diff,D}}$	–	0.75	0.9	V	<sup>2)</sup>	P_7.1.24
Differential receiver threshold “recessive” normal-operating mode and receive-only mode	$V_{\text{Diff,R}}$	0.5	0.66	–	V	<sup>2)</sup>	P_7.1.25
Common mode range	CMR	-12	–	12	V	$V_{\text{CC}} = 5 \text{ V}$ ;	P_7.1.28
Differential receiver hysteresis normal-operating mode	$V_{\text{Diff,hys}}$	–	90	–	mV	<sup>1)</sup>	P_7.1.29
CANH, CANL input resistance	$R_i$	10	20	30	k $\Omega$	“recessive” state;	P_7.1.30
Differential input resistance	$R_{\text{Diff}}$	20	40	60	k $\Omega$	“recessive” state;	P_7.1.31
Input resistance deviation between CANH and CANL	$\Delta R_i$	- 1	–	1	%	<sup>1)</sup> “recessive” state;	P_7.1.32
Input capacitance CANH, CANL versus GND	$C_{\text{In}}$	–	20	40	pF	<sup>1)</sup> $V_{\text{TxD}} = V_{\text{IO}}$ ;	P_7.1.33
Differential input capacitance	$C_{\text{In,Diff}}$	–	10	20	pF	<sup>1)</sup> $V_{\text{TxD}} = V_{\text{IO}}$ ;	P_7.1.34

**Table 6 Electrical characteristics (cont'd)**

4.5 V <  $V_{CC}$  < 5.5 V; 3.0 V <  $V_{IO}$  < 5.5 V;  $R_L = 60 \Omega$ ;  $-40^\circ\text{C} < T_j < 125^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
<b>Bus Transmitter</b>							
CANL/CANH "recessive" output voltage normal-operating mode	$V_{CANL/H}$	2.0	2.5	3.0	V	$V_{TXD} = V_{IO}$ , no load;	P_7.1.35
CANH, CANL "recessive" output voltage difference normal-operating mode	$V_{Diff\_NM}$	-500	–	50	mV	$V_{TXD} = V_{IO}$ , no load;	P_7.1.36
CANL "dominant" output voltage normal-operating mode	$V_{CANL}$	0.5	–	2.25	V	$V_{TXD} = 0\text{ V}$ ;	P_7.1.38
CANH "dominant" output voltage normal-operating mode	$V_{CANH}$	2.75	–	4.5	V	$V_{TXD} = 0\text{ V}$ ;	P_7.1.39
CANH, CANL "dominant" output voltage difference normal-operating mode according to ISO 11898-2 $V_{Diff} = V_{CANH} - V_{CANL}$	$V_{Diff}$	1.5	–	3.0	V	$V_{TXD} = 0\text{ V}$ , $50 \Omega < R_L < 65 \Omega$ , $4.75 < V_{CC} < 5.25\text{ V}$ ;	P_7.1.40
CANH, CANL "dominant" output voltage difference normal-operating mode $V_{Diff} = V_{CANH} - V_{CANL}$	$V_{Diff\_R45}$	1.4	–	3.0	V	$V_{TXD} = 0\text{ V}$ , $45 \Omega < R_L < 50 \Omega$ , $4.75 < V_{CC} < 5.25\text{ V}$ ;	P_7.1.37
Driver "dominant" symmetry normal-operating mode $V_{SYM} = V_{CANH} + V_{CANL}$	$V_{SYM}$	4.5	5	5.5	V	$V_{CC} = 5.0\text{ V}$ , $V_{TXD} = 0\text{ V}$ ;	P_7.1.41
CANL short circuit current	$I_{CANLsc}$	40	75	100	mA	$V_{CANLshort} = 18\text{ V}$ , $V_{CC} = 5.0\text{ V}$ , $t < t_{TXD}$ , $V_{TXD} = 0\text{ V}$ ;	P_7.1.42
CANH short circuit current	$I_{CANHsc}$	-100	-75	-40	mA	$V_{CANHshort} = 0\text{ V}$ , $V_{CC} = 5.0\text{ V}$ , $t < t_{TXD}$ , $V_{TXD} = 0\text{ V}$ ;	P_7.1.43
Leakage current, CANH	$I_{CANH,ik}$	-5	–	5	$\mu\text{A}$	$V_{CC} = V_{IO} = 0\text{ V}$ , $0\text{ V} < V_{CANH} < 5\text{ V}$ , $V_{CANH} = V_{CANL}$ ;	P_7.1.44
Leakage current, CANL	$I_{CANL,ik}$	-5	–	5	$\mu\text{A}$	$V_{CC} = V_{IO} = 0\text{ V}$ , $0\text{ V} < V_{CANL} < 5\text{ V}$ , $V_{CANH} = V_{CANL}$ ;	P_7.1.45

**Table 6 Electrical characteristics (cont'd)**

4.5 V <  $V_{CC}$  < 5.5 V; 3.0 V <  $V_{IO}$  < 5.5 V;  $R_L = 60 \Omega$ ;  $-40 \text{ }^\circ\text{C} < T_j < 125 \text{ }^\circ\text{C}$ ; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
<b>Dynamic CAN-Transceiver Characteristics</b>							
Propagation delay TxD-to-RxD "low" (“recessive to “dominant”)	$t_{Loop(H,L)}$	–	180	255	ns	$C_L = 100 \text{ pF}$ , $4.75 \text{ V} < V_{CC} < 5.25 \text{ V}$ , $C_{RxD} = 15 \text{ pF}$ ;	P_7.1.46
Propagation delay TxD-to-RxD "high" (“dominant” to “recessive”)	$t_{Loop(L,H)}$	–	180	255	ns	$C_L = 100 \text{ pF}$ , $4.75 \text{ V} < V_{CC} < 5.25 \text{ V}$ , $C_{RxD} = 15 \text{ pF}$ ;	P_7.1.47
Propagation delay extended load TxD-to-RxD "low" (“recessive to “dominant”)	$t_{Loop\_Ext(H,L)}$	–	–	300	ns	<sup>1)</sup> $C_L = 200 \text{ pF}$ , $R_L = 120 \Omega$ , $4.75 \text{ V} < V_{CC} < 5.25 \text{ V}$ , $C_{RxD} = 15 \text{ pF}$ ;	P_7.1.52
Propagation delay extended load TxD-to-RxD "high" (“dominant” to “recessive”)	$t_{Loop\_Ext(L,H)}$	–	–	300	ns	<sup>1)</sup> $C_L = 200 \text{ pF}$ , $R_L = 120 \Omega$ , $4.75 \text{ V} < V_{CC} < 5.25 \text{ V}$ , $C_{RxD} = 15 \text{ pF}$ ;	P_7.1.54
Propagation delay TxD "low" to bus "dominant"	$t_{d(L),T}$	–	90	140	ns	$C_L = 100 \text{ pF}$ , $4.75 \text{ V} < V_{CC} < 5.25 \text{ V}$ , $C_{RxD} = 15 \text{ pF}$ ;	P_7.1.48
Propagation delay TxD "high" to bus "recessive"	$t_{d(H),T}$	–	90	140	ns	$C_L = 100 \text{ pF}$ , $4.75 \text{ V} < V_{CC} < 5.25 \text{ V}$ , $C_{RxD} = 15 \text{ pF}$ ;	P_7.1.49
Propagation delay bus "dominant" to RxD "low"	$t_{d(L),R}$	–	90	140	ns	$C_L = 100 \text{ pF}$ , $4.75 \text{ V} < V_{CC} < 5.25 \text{ V}$ , $C_{RxD} = 15 \text{ pF}$ ;	P_7.1.50
Propagation delay bus "recessive" to RxD "high"	$t_{d(H),R}$	–	90	140	ns	$C_L = 100 \text{ pF}$ , $4.75 \text{ V} < V_{CC} < 5.25 \text{ V}$ , $C_{RxD} = 15 \text{ pF}$ ;	P_7.1.51
<b>Delay Times</b>							
Delay time for mode change	$t_{Mode}$	–	–	20	$\mu\text{s}$	<sup>1)</sup> (see <a href="#">Figure 14</a> and <a href="#">Figure 15</a> );	P_7.1.53

**Table 6 Electrical characteristics (cont'd)**

4.5 V < V<sub>CC</sub> < 5.5 V; 3.0 V < V<sub>IO</sub> < 5.5 V; R<sub>L</sub> = 60 Ω; -40 °C < T<sub>j</sub> < 125 °C; all voltages with respect to ground; positive current flowing into pin; unless otherwise specified.

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
<b>CAN FD Characteristics</b>							
Received recessive bit width at 2 MBit/s	$t_{\text{Bit(RxD)}\_2}$ MB	400	500	550	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF, t <sub>Bit</sub> = 500 ns, (see <a href="#">Figure 12</a> );	P_7.1.55
Transmitted recessive bit width at 2 MBit/s	$t_{\text{Bit(Bus)}\_2}$ MB	435	500	530	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF, t <sub>Bit</sub> = 500 ns, (see <a href="#">Figure 12</a> );	P_7.1.56
Receiver timing symmetry at 2 MBit/s $\Delta t_{\text{Rec}} = t_{\text{Bit(RxD)}} - t_{\text{Bit(Bus)}}$	$\Delta t_{\text{Rec\_2MB}}$	-65	–	40	ns	C <sub>L</sub> = 100 pF, 4.75 V < V <sub>CC</sub> < 5.25 V, C <sub>RxD</sub> = 15 pF, t <sub>Bit</sub> = 500 ns, (see <a href="#">Figure 12</a> );	P_7.1.57

- 1) Not subject to production test, specified by design.
- 2) In respect to common mode range.

PRELIMINARY - Subject to change

7.2 Diagrams

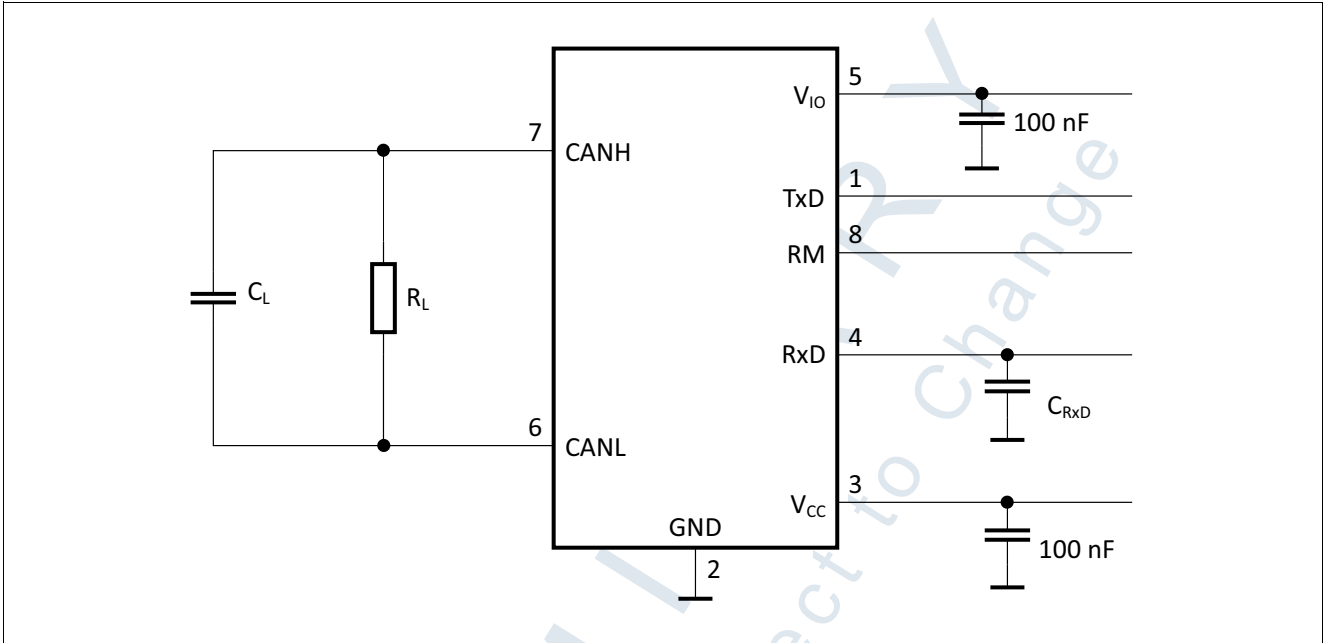


Figure 10 Test circuits for dynamic characteristics

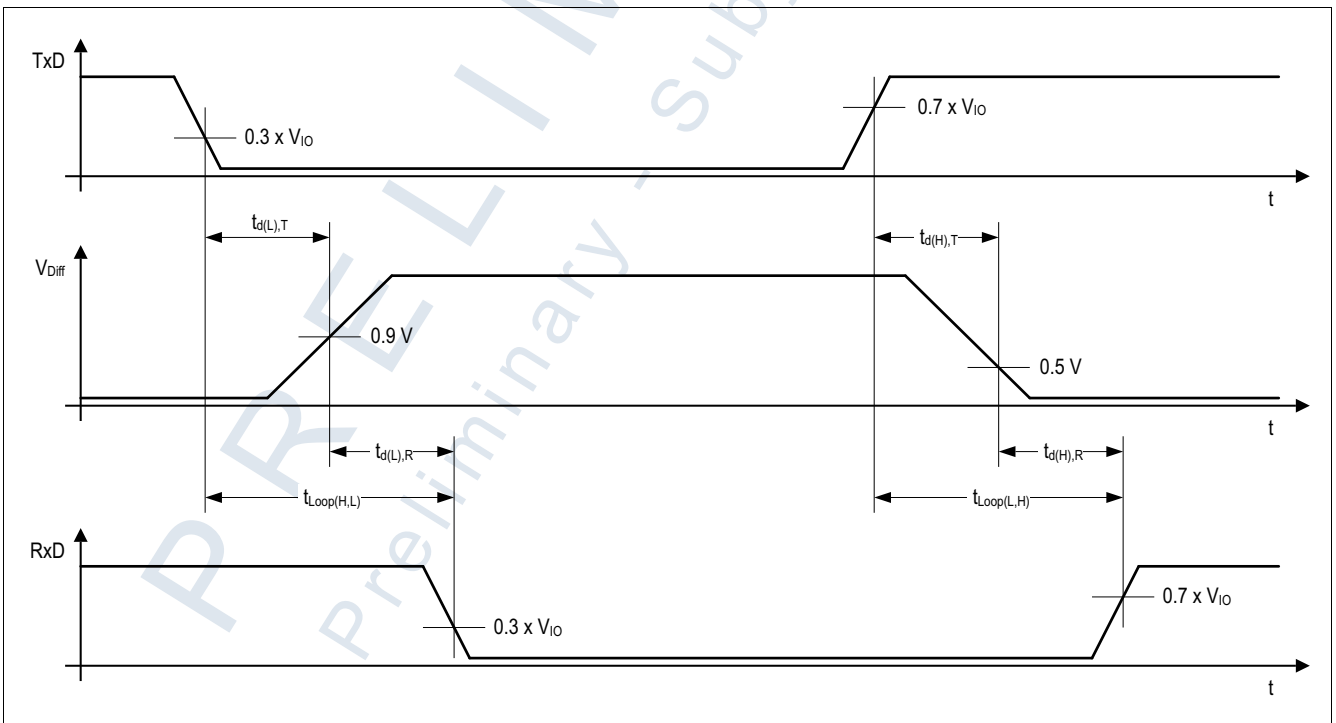


Figure 11 Timing diagrams for dynamic characteristics



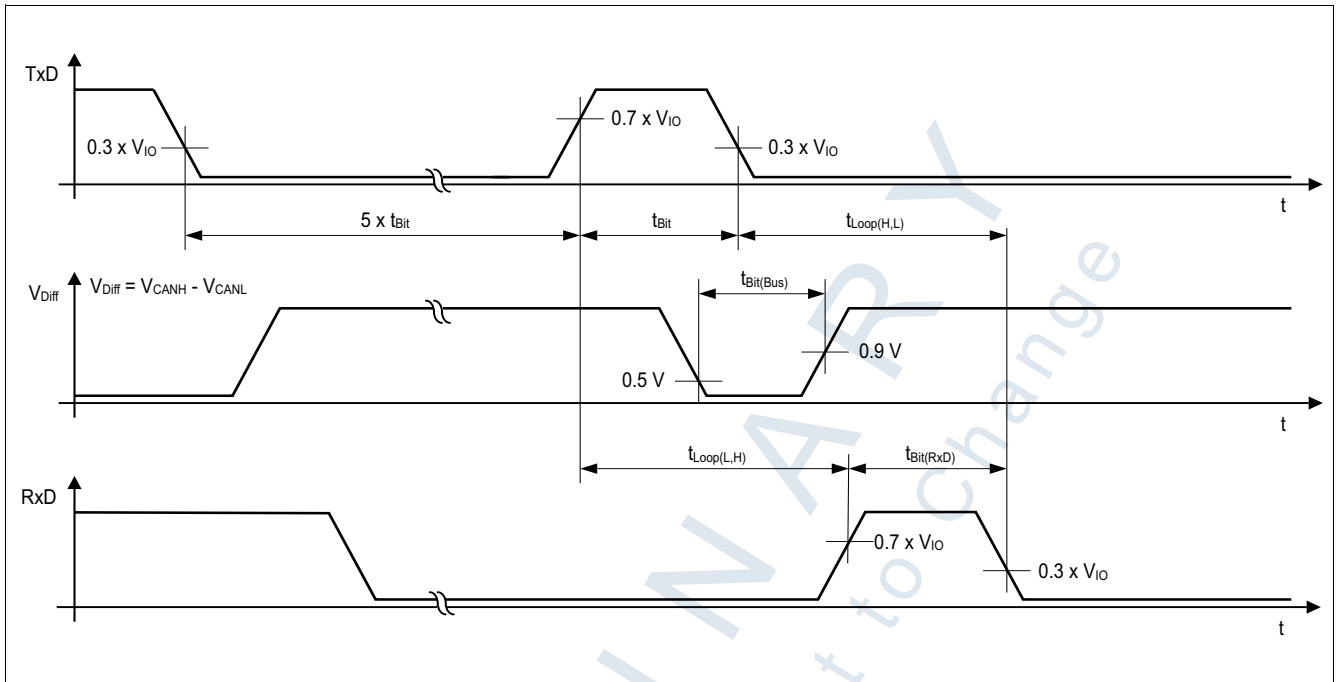


Figure 12 “Recessive” bit time - five “dominant” bits followed by one “recessive” bit

PRELIMINARY - Subject to Change

## 8 Application Information

### 8.1 ESD Robustness according to IEC61000-4-2

Test for ESD robustness according to IEC61000-4-2 "Gun test" (150 pF, 330 Ω) have been performed. The results and test conditions are available in a separate test report.

**Table 7 ESD robustness according to IEC61000-4-2**

Performed Test	Result	Unit	Remarks
Electrostatic discharge voltage at pin CANH and CANL versus GND	≥ +8	kV	<sup>1)</sup> Positive pulse
Electrostatic discharge voltage at pin CANH and CANL versus GND	≤ -8	kV	<sup>1)</sup> Negative pulse

1) ESD susceptibility "ESD GUN" according to GIFT / ICT paper: "EMC Evaluation of CAN Transceivers, version 03/02/IEC TS62228", section 4.3. (DIN EN61000-4-2)  
 Tested by external test facility (IBEE Zwickau).

PRELIMINARY - Subject to Change