RH1051 Product Datasheet

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Revision History

Rev	Date	Description
A	10/23/2024	Initial introduction

1 General Description

The RH1051 is a new generation of high-speed 8Mbps Controller Area Network (CAN) transceiver that is in compliance with ISO 11898-2:2016 and SAE J2284-1 to SAE J3384-5 high-speed CAN specifications. This transceiver provides an interface between a CAN protocol controller and the physical two-wire CAN bus for CAN applications in the automotive and industrial markets.

The RH1051 features two modes of operation: Normal mode and Silent mode, which are selected through S pin. Normal mode allows data rate exceeding 8Mbps, and Silent mode puts the transceiver in low-current mode with the transmitter in shut-off and the receiver remains active. The receiver input has an extended input common-mode range from -40V to +40V, exceeding the ISO 11898 specification of -2V to +7V. The transceiver also features integrated level shifters referenced to the V_{IO} pin, which allows transceiver to interface directly with controller having 2.8V~5.5V logic level.

This transceiver integrates many protections such as thermal shutdown, current-limiting, TXD-dominant timeout, bus fault protection up to ±70V, and fail-safe in supply under-voltage or floating. It also provides robust ±25kV HBM, ±15kV IEC Air Gap and ±8kV IEC Contact protection on bus pins.

The RH1051 is available in 8-pin SO package and operates over -40ºC to +125ºC extended temperature range.

2 Features

- ISO 11898-2:2016 and SAE J2284-1 to ADE J2284-5 compliant
- Support classical CAN and optimized CAN FD at 500kbps, 1Mbps, 5Mbps, and 8Mbps
- Support 12V, 24V and 48V systems
- Low electromagnetic emission, and high electromagnetic immunity
- ±25kV HBM ESD tolerance on CAN bus, ±6kV HBM ESD tolerance on all other pins
- ±15kV IEC Air Gap Discharge and ±8kV IEC Contact Discharge on CAN bus
- All pins pass ±1.5kV CDM, and ±400mA Latch-up test
- Bus fault voltage protection to ±70V
- Bulk Current Injection (BCI) passes ISO 11452-4:2011 400mA
- Perfect signal symmetry greatly improves EMI
- Transmitter TXD-dominant time-out
- Receiver extended common-mode input voltage range from -40V to +40V
- Support controller I/O's logical voltage level from 2.8V to 5.5V with separate V_{IO} pin
- Two operating modes: Normal mode and Silent mode
- Protection features: thermal-shutdown, under-voltage lockout, short-circuit current limit
- Available in industry-standard 8-pin SOIC package

3 Applications

- Power System Communications
- Industrial Control and Networks
- Telecommunication Backplane
- Consumer Applications
- Energy Storage Systems
- Building Automation

4 Typical Operating Circuit

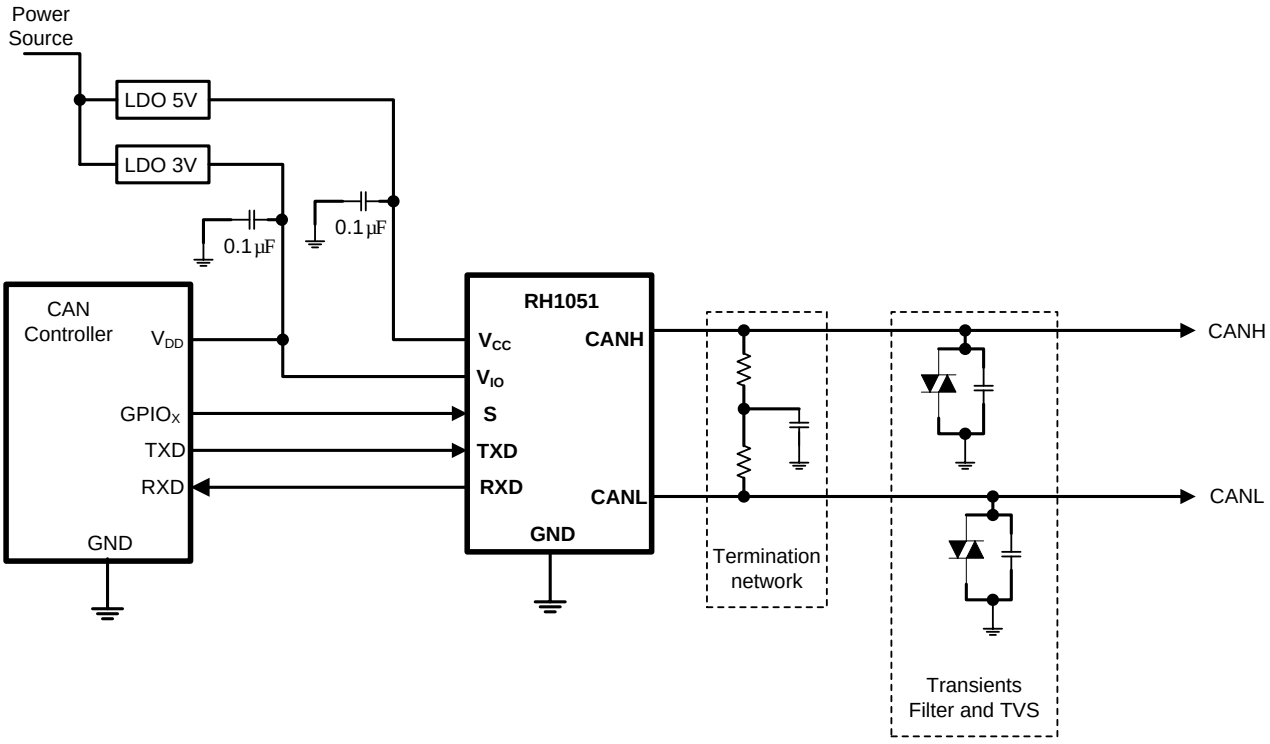


Figure 1 – Typical Operating Circuit

5 Ordering Information

Part Number	Temperature Range	Package-Pin	Description
RH1051ASCE+	-40ºC to +125ºC	SO-8	SO-8, body width 3.9mm in tube
RH1051ASCE+T	-40ºC to +125ºC	SO-8	SO-8, body width 3.9mm in tape and reel

Table 1 – Ordering Information

6 Pin Configuration and Functions

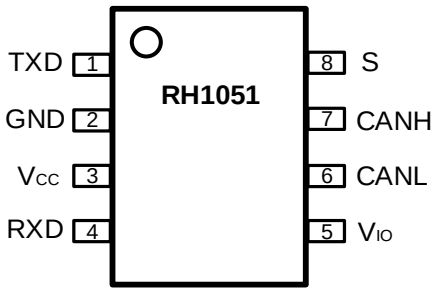


Figure 2 – Device in SO-8 Package

Pin Number	Pin Name	Pin Type	Description
1	TXD	Digital Input	Transmit Data Input, with an internal pull-up.
2	GND	Ground	Ground.
3	V_{CC}	Power	5V Power supply.
4	RXD	Digital Output	Receiver Data Output.
5	V_{IO}	Power	2.8V to 5.5V Power supply for digital input/output.
6	CANL	Analog Bus I/O	CAN Low Bus input/output.
7	CANH	Analog Bus I/O	CAN High Bus input/output.
8	S	Digital Input	Silent mode control, with an internal pull-down.

Table 2 – Pin Functions

7 Functional Description

The RH1051 is a high-speed 8Mbps CAN-FD transceiver with pin-selectable Normal mode and Silent mode. It has enhanced EMC and ESD protection for both digital and bus pins, bus fault voltage protection up to ±70V, and an extended receiver input common-mode voltage range to ±40V that provide sample application flexibility.

7.1 Operating modes

The RH1051 supports two operating modes: Normal mode and Silent mode, which can be pin-selectable through S pin.

Operating Mode	Input Pin		Output		
	S	TXD	driver status	receiver status	RXD
Normal	Low	Low	dominant	active	Low
	Low	High	recessive	active	High
Silent	High	Low	disabled	active	Low ($V_{CANH} > V_{CANL}$)
					High ($V_{CANH} \leq V_{CANL}$)
	High	High	disabled	active	Low ($V_{CANH} > V_{CANL}$)
					High ($V_{CANH} \leq V_{CANL}$)

Table 3 – Device Operating Modes

7.1.1 Normal mode

Connect S to logic Low sets RH1051 to normal mode. In this mode, the driver transmits data through TXD and outputs CAN-compliant signals at bus CANH and CANL. When TXD is at logic Low, CAN bus is in dominant state; when TXD is at logic High, CAN bus is in recessive state. In normal mode, the differential receiver converts CAN bus signals into digital output RXD: logic Low (dominant state) when $V_{CANH} > V_{CANL}$, logic High (recessive state) when $V_{CANH} \leq V_{CANL}$. This transceiver can achieve data transmission rate exceeding 8Mbps.

7.1.2 Silent mode

Connect S to logic High sets RH1051 to Silent mode. In this mode, the driver is disabled and its outputs are released. The differential receiver remains in active state, and converts CAN bus signals into digital output RXD: logic Low (dominant state) when $V_{CANH} > V_{CANL}$, logic High (recessive state) when $V_{CANH} \leq V_{CANL}$. The power consumption is reduced in Silent mode as the CAN driver is disabled.

7.2 Driver and Receiver Function

The digital logic inputs (TXD, S) and output (RXD) are CMOS/TTL levels with respect to V_{IO}. The V_{IO} ranges from 2.8V~5.5V, which can align with controllers having 3.3V or 5V I/O's.

Device Mode	Digital Input		Driver Status	Bus Outputs		Bus state
	S	TXD		CANH	CANL	
Normal	Low	Low	enabled	High	Low	dominant
	Low	High	enabled	High impedance	High impedance	recessive, bus biased to ~ V_{CC}/2
Silent	High	X, don't care	disabled	High impedance	High impedance	released

Table 4 – Driver Functions

Device Mode	Digital Input	Receiver Status	CAN Differential Inputs	Digital Output	Bus State
	S		$V_{ID} = V_{CANH} - V_{CANL}$	RXD	
Normal	Low	enabled	$V_{ID} \geq 0.9V$	Low	dominant
	Low	enabled	$0.5V < V_{ID} < 0.9V$	undefined	undefined
	Low	enabled	$V_{ID} \leq 0.5V$	High	recessive
Silent	High	enabled	$V_{ID} \geq 0.9V$	Low	dominant
	High	enabled	$0.5V < V_{ID} < 0.9V$	undefined	undefined
	High	enabled	$V_{ID} \leq 0.5V$	High	recessive

Table 5 – Receiver Functions

7.3 Integrated Protection

7.3.1 Bus Fault Protection

The RH1051 features ±70V of fault protection. CANH or CANL can tolerate an external short fault from -70V to +70V without any damage to the device. Data transmission resumes once the fault voltage is no longer present. In addition to bus fault protection, the RH1051 disengages from the bus when it is not powered up (V_{CC} left floating), and releases itself from the bus.

7.3.2 Driver Output Protection

The RH1051 protects the driver output stage against short-circuit to a positive or negative voltage by limiting the output source or sink current. On-chip thermal shutdown circuit further protects the device and disables the driver if the junction temperature of the RH1051 exceeds the thermal shutdown threshold. The driver returns to normal operation once the junction temperature drops below the thermal shutdown threshold voltage with hysteresis.

7.3.3 Driver TXD Dominant Timeout

The RH1051 features a driver dominant timeout that prevents CAN controllers from dominating the bus more than $t_{to(dom)TXD}$, or limits the minimum possible data rate to ~20kbps. In dominant timeout, the driver is disabled and releases the bus to a recessive state. The driver is enabled and enters into dominant state when TXD transits from High to Low.

7.3.4 Internal Biasing of TXD and S Input Pins

Input pin TXD has an internal pull-up to VIO, such that when it is left floating, the driver stays in recessive and releases the bus. Input pin S has an internal pull-down to Ground, such that when it is left floating, the device is in active normal mode.

7.3.5 Undervoltage Detection on Power V_{CC} and V_{IO} Pins

The RH1051 incorporates separate undervoltage detection for both V_{CC} and V_{IO} pins. The 5V V_{CC} pin supplies power to the device, and if it drops below V_{CC}'s undervoltage threshold, both the driver and receiver will be disabled until V_{CC} has recovered. The V_{IO} pin supplies power to both the digital inputs (TXD and S) and output (RXD), allowing the RH1051 to interface with controllers having GPIO's from 2.8V to 5.5V. If V_{IO} drops below V_{IO}'s undervoltage threshold, the driver will be disabled until V_{IO} has recovered.

7.3.6 Extended Receiver Input Common-mode Range

The RH1051 features a differential receiver that has an extended input common-mode range from -40V to +40V, exceeding the ISO 11898 specification of -2V to +7V. It allows error-free data transmission exceeding 8Mbps through the whole common-mode range.

7.3.7 EMC/ESD Protection

The RH1051 incorporates high ±25kV ESD Human Body Model (HBM) protection at both of the CANH and CANL pins. For all other pins, ±6kV HBM ESD can be tolerated without any damage. In addition, both CANH and CANL pins pass ±8kV IEC Contact Discharge and ±15kV IEC Air Gap Discharge. Furthermore, all pins can tolerate at least ±1.5kV per Charged-device Model (CDM), and pass ±400mA Latch-up (LU) test. For Bulk Current Injection (BCI), RH1051 passes the ISO 11452-4:2011 400mA.

8 Specifications

8.1 Absolute Maximum Ratings

Absolute Maximum Ratings						
Symbol	**Parameter**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
ESD/Voltage ratings						
V_{ESD}	electrostatic discharge voltage	IEC61000-4-2 Air Gap at CANH, CANL		±15		kV
		IEC61000-4-2 Contact Discharge at CANH, CANL		±8		kV
		HBM at CANH, CANL		±25		kV
		HBM at other pins		±6		kV
		CDM field induced charge at all pins		±1.5		kV
LU	latch-up	Latch-up test at all pins		±400		mA
V_{CANH}	voltage on pin CANH		-70		+70	V
V_{CANL}	voltage on pin CANL		-70		+70	V
V_X	voltage on pins other than CANH/CANL		-0.3		+6	V
$V_{(CANH-CANL)}$	voltage between CANH and CANL		-34		+34	V
Temperature						
T_J	junction temperature				150	°C
T_S	storage temperature		-55		150	°C
T_{SD}	Thermal shutdown temperature			160		°C
	Thermal shutdown hysteresis			15		°C

8.2 Electrical Characteristics

Static Characteristics						
T_j=-40°C to +125°C; V_{CC}=4.5V to 5.5V; V_{IO}=2.8V to 5.5V; R_L=60Ω unless specified otherwise.						
Symbol	**Parameter**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Supply - pin V_{CC}						
V_{CC}	supply voltage		4.5		5.5	V
I_{CC}	supply current	Silent mode		1.8	2.5	mA
		Normal mode				
		recessive, $V_{TXD}=V_{IO}$		2.5	5	mA
		dominant, V_{TXD}=0V		40	60	mA
		dominant, V_{TXD}=0V; short circuit on bus lines; -3V < ($V_{CANH}=V_{CANL}$) < +18V		80	110	mA
$V_{UVLO(VCC)}$	undervoltage detection voltage on pin V_{CC}		3	3.5	4.2	V
I/O level adapter Supply - pin V_{IO}						
V_{IO}	supply voltage on V_{IO}		2.8		5.5	V
I_{VIO}	supply current on V_{IO}	Normal/Silent mode				
		recessive, $V_{TXD}=V_{CC}$		30	100	µA
		dominant, V_{TXD}=0V		50	200	µA
$V_{UVLO(VIO)}$	undervoltage detection voltage on V_{IO}		1.3	1.8	2.5	V
Mode control inputs - pin S						
V_{IH}	input high voltage		0.7*V_{IO}		V_{IO}+0.3	V
V_{IL}	input low voltage		-0.3		0.3*V_{IO}	V
I_{IH}	input high current	$V_S=V_{IO}$		30	50	µA
I_{IL}	input low current	V_S=0V	-1		1	µA

Static Characteristics (Continue)						
T_j=-40°C to +125°C; V_{CC}=4.5V to 5.5V; V_{IO}=2.8V to 5.5V; R_L=60Ω unless specified otherwise.						
Symbol	**Parameter**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
CAN transmit data input - pin TXD						
V_{IH}	input high voltage		0.7*V_{IO}		V_{IO}+0.3	V
V_{IL}	input low voltage		-0.3		0.3*V_{IO}	V
I_{IH}	input high current	V_{TXD}=V_{IO}	-1		1	µA
I_{IL}	input low current	V_{TXD}=0V		30	50	µA
C_{in}	input capacitance			5		pF
CAN receive data output - pin RXD						
I_{OH}	output high current	V_{RXD}=V_{IO}-0.4V	8	20		mA
I_{OL}	output low current	V_{RXD}=0.4V, bus dominant	8	30		mA
Bus lines - pins CANH and CANL						
$V_{O(dom)}$	dominant output voltage	V_{TXD}=0V, t < $t_{to(dom)TXD}$				
		CANH - R_L=50Ω to 65Ω	2.75	3.5	4.5	V
		CANL - R_L=50Ω to 65Ω	0.5	1.3	2.25	V
$V_{dom(TX)symm}$	transmitter dominant voltage symmetry	$V_{dom(TX)symm}$=V_{CC}-V_{CANH}-V_{CANL}; Figure 5	-400		400	mV
V_{TXsymm}	transmitter voltage symmetry	V_{TXsymm}=V_{CANH}+V_{CANL}; f_{TXD}=250kHz, 1MHz, and 2.5MHz; V_{CC}=4.75V to 5.25V; C_{SPLIT}=4.7nF; Figure 6	0.9*V_{CC}		1.1*V_{CC}	V
$V_{O(diff)}$	differential output voltage	dominant Normal mode: V_{TXD}=0V, t<$t_{to(dom)/TXD}$; Figure 5				
		R_L=45Ω to 65Ω	1.5		3	V
		R_L=45Ω to 70Ω	1.5		3.3	V
		R_L=2240Ω	1.5		5	V
		recessive mode: no load; Figure 5				
		Normal mode: V_{TXD}=V_{IO}	-50		50	mV
$V_{O(rec)}$	recessive output voltage	Normal/Silent mode: V_{TXD}=V_{IO}, no load	2	0.5*V_{CC}	3	V
$V_{th(RX)diff}$	differential receiver threshold voltage	Normal/Silent mode: -40V≤V_{CANH}≤+40V, -40V≤V_{CANL}≤+40V	0.5	0.7	0.9	V
$V_{rec(RX)}$	receiver recessive voltage	Normal/Silent mode: -40V≤V_{CANH}≤+40V, -40V≤V_{CANL}≤+40V	-4		0.5	V
$V_{dom(RX)}$	receiver dominant voltage	Normal/Silent mode: -40V≤V_{CANH}≤+40V, -40V≤V_{CANL}≤+40V	0.9		9	V
$V_{hys(RX)diff}$	differential receiver hysteresis voltage	Normal/Silent mode: -40V≤V_{CANH}≤+40V, -40V≤V_{CANL}≤+40V		100		mV
$I_{O(sc)dom}$	dominant short-circuit output current	V_{TXD}=0V, t<$t_{to(dom)TXD}$, V_{CC}=5V				
		V_{CANH}= -40V to +40V	-100			mA
		V_{CANL}= -40V to +40V			100	mA
$I_{O(sc)rec}$	recessive short-circuit output current	Normal/Silent mode: V_{TXD}=V_{IO}, V_{CANH}=V_{CANL}= ±40V		2	5	mA
I_L	leakage current	V_{CC}=V_{IO}= 0V; V_{CANH}=V_{CANL}=5V		2.5	5	µA
		V_{CC}=V_{IO}=shorted to ground via 47kΩ; V_{CANH}=V_{CANL}=5V		2.5	5	µA
R_{in}	input resistance	-2V≤V_{CANH}≤+7V, -2V≤V_{CANL}≤+7V	18	30	52	kΩ
ΔR_{in}	input resistance deviation	0V≤V_{CANH}≤+5V, 0V≤V_{CANL}≤+5V	-1		1	%
$R_{in(diff)}$	differential input resistance	-2V≤V_{CANH}≤+7V, -2V≤V_{CANL}≤+7V	36	60	104	kΩ
$C_{in(cm)}$	common-mode input capacitance			15		pF
$C_{in(diff)}$	differential input capacitance			8		pF

Dynamic Characteristics						
T_j=-40°C to +125°C; V_{CC}=4.5V to 5.5V; V_{IO}=2.8V to 5.5V; R_L=60Ω unless specified otherwise.						
Transceiver timing: CANH, CANL, TXD and RXD						
$t_{d(TXD-busdom)}$	delay time from TXD to bus dominant	Normal mode, Figure 3		15	40	ns
$t_{d(TXD-busrec)}$	delay time from TXD to bus recessive	Normal mode, Figure 3		35	60	ns
$t_{d(busdom-RXD)}$	delay time from bus dominant to RXD	Normal/Silent mode, Figure 3		115	150	ns
$t_{d(busrec-RXD)}$	delay time from bus recessive to RXD	Normal/Silent mode, Figure 3		110	150	ns
$t_{d(TXDL-RXDL)}$	delay tine from TXD LOW to RXD LOW	Normal mode, Figure 3		125	190	ns
$t_{d(TXDH-RXDH)}$	delay time from TXD HIGH to RXD HIGH	Normal mode, Figure 3		140	190	ns
$t_{bit(bus)}$	transmitted recessive bit width	$t_{bit(TXD)}$=500ns, 2Mbps, Figure 4	435		530	ns
		$t_{bit(TXD)}$=200ns, 5Mbps, Figure 4	155		210	ns
		$t_{bit(TXD)}$=125ns, 8Mbps, Figure 4	100		140	ns
$t_{bit(RXD)}$	bit time on RXD	$t_{bit(TXD)}$=500ns, 2Mbps, Figure 4	400		550	ns
		$t_{bit(TXD)}$=200ns, 5Mbps, Figure 4	120		220	ns
		$t_{bit(TXD)}$=125ns, 8Mbps, Figure 4	85		135	ns
$\Delta t_{symm(rec)}$	receiver timing symmetry	$t_{bit(TXD)}$=500ns, 2Mbps, Figure 4	-65		40	ns
		$t_{bit(TXD)}$=200ns, 5Mbps, Figure 4	-45		15	ns
		$t_{bit(TXD)}$=125ns, 8Mbps, Figure 4	-45		10	ns
$t_{to(dom)TXD}$	TXD dominant time-out time	V_{TXD}=0V, normal mode		3	5	ms

8.3 Timing Diagrams

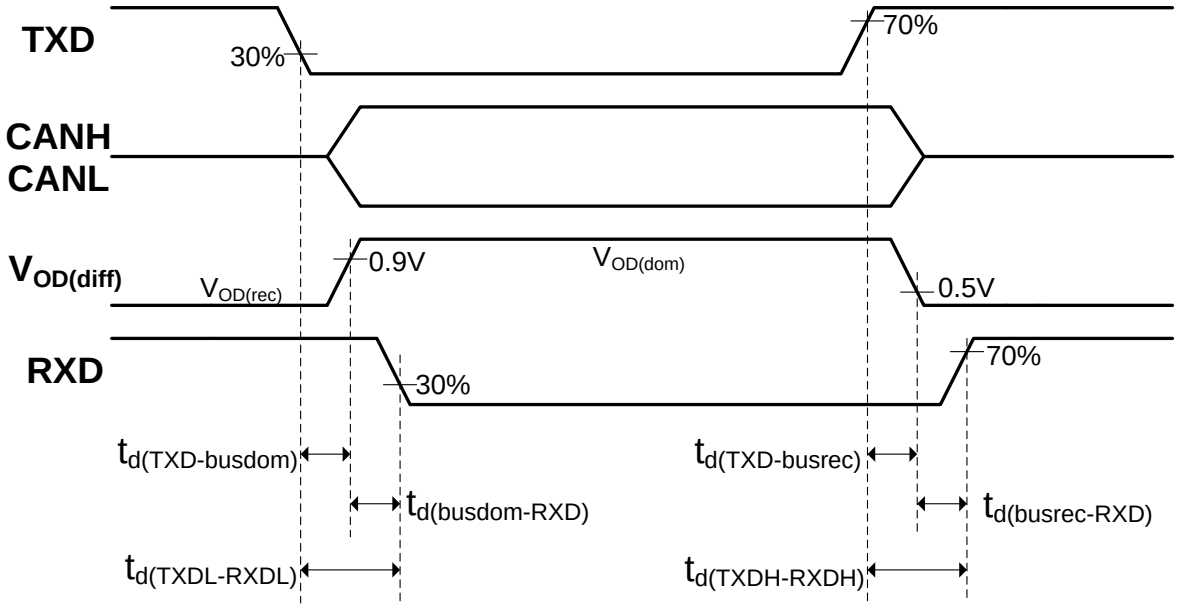


Figure 3 – CAN Transceiver Timing Diagram

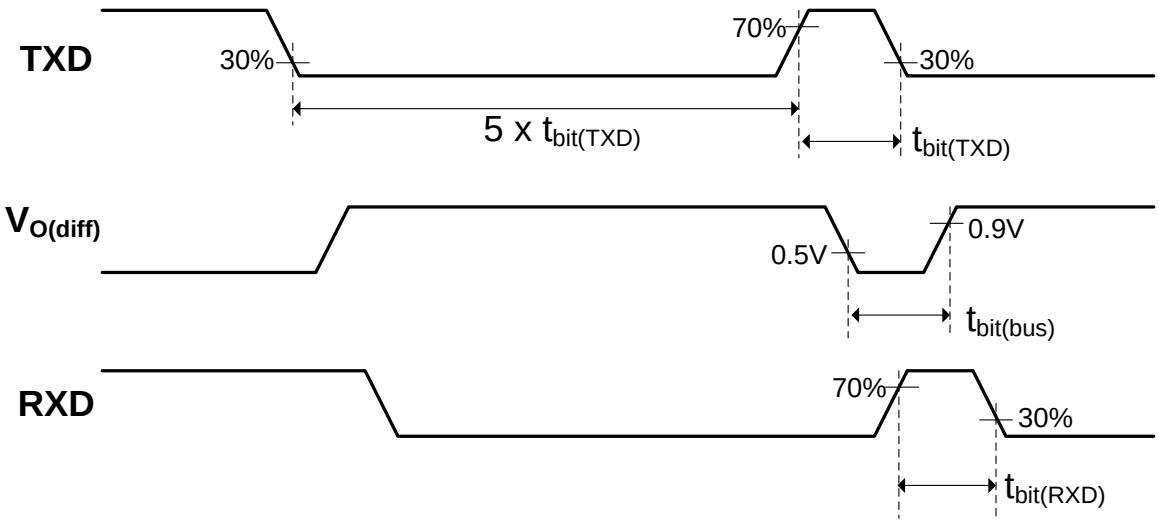


Figure 4 – CAN FD Bitwidth Timing Diagram

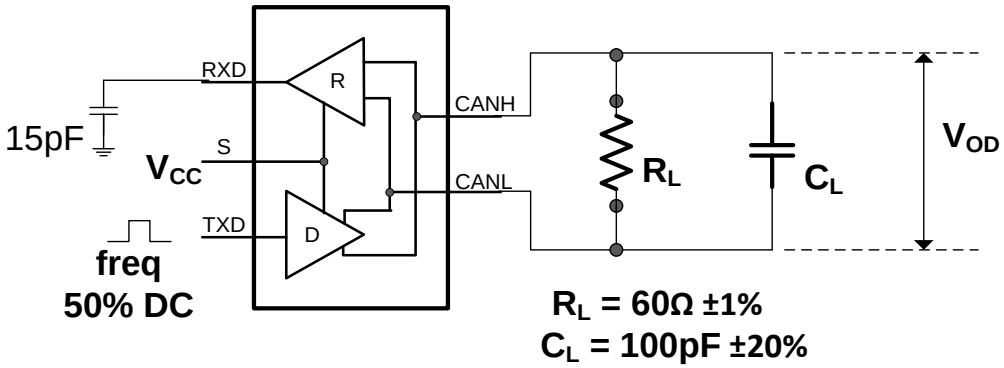


Figure 5 – CAN Transceiver Timing Test Setup Circuit

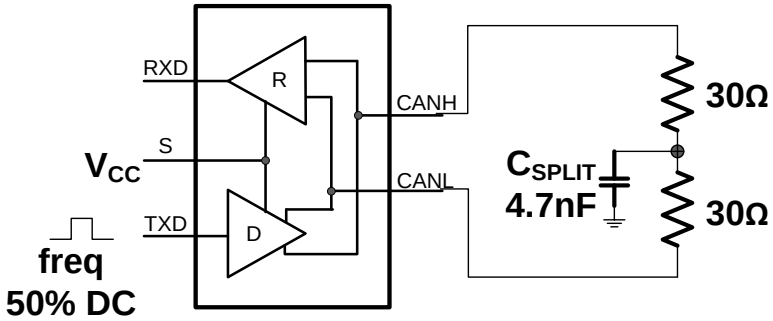
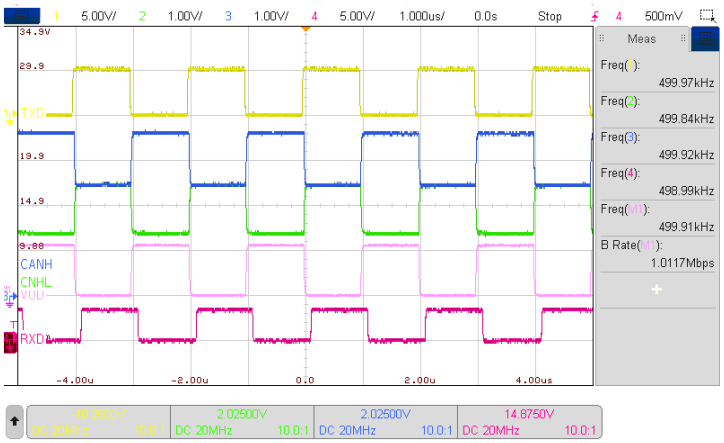


Figure 6 – CAN Transceiver Driver Symmetry Test Setup Circuit

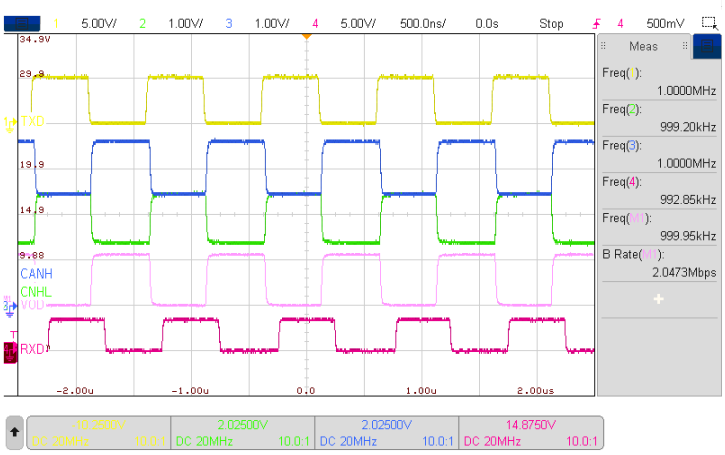
9 Typical Operating Characteristics

V_{CC}=5.0V, V_{IO}=5.0V, R_L=30Ω+30Ω, C_{SPLIT}=4.7nF, T_A=25°C, unless specified otherwise.

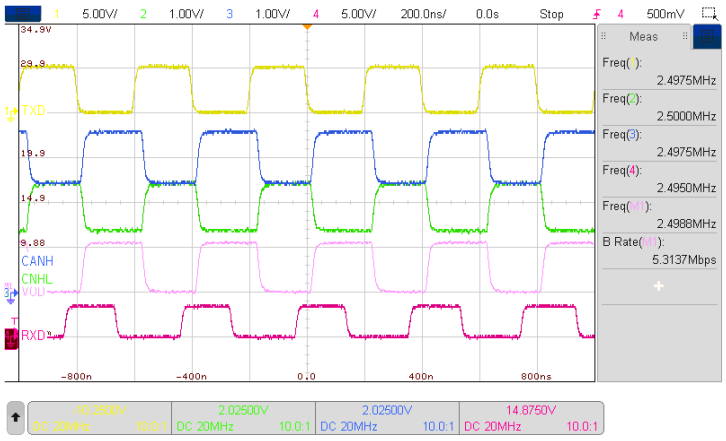
9.1 TXD/CANH/CANL/RXD waveform in different frequencies



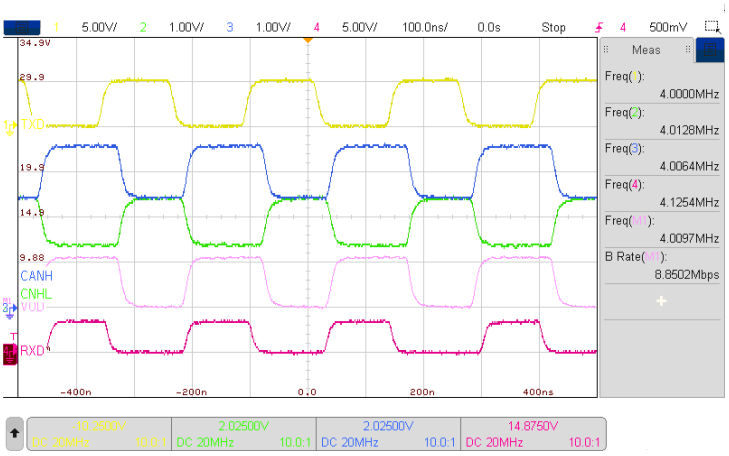
Data Rate = 1Mbps



Data Rate = 2Mbps

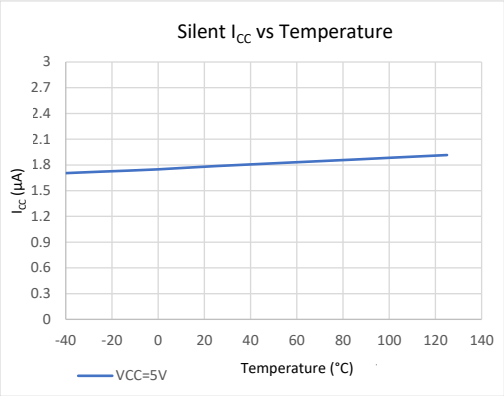


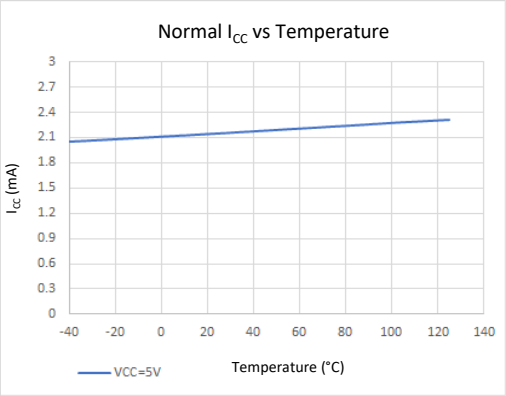
Data Rate = 5Mbps



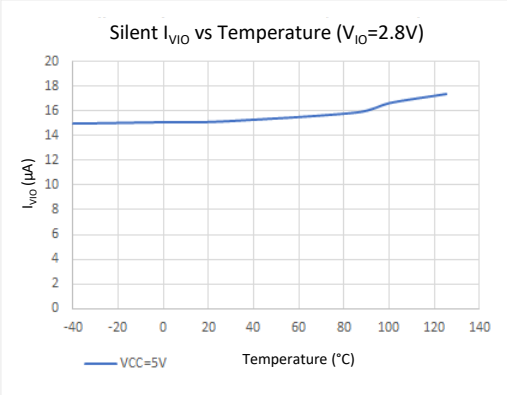
Data Rate = 8Mbps

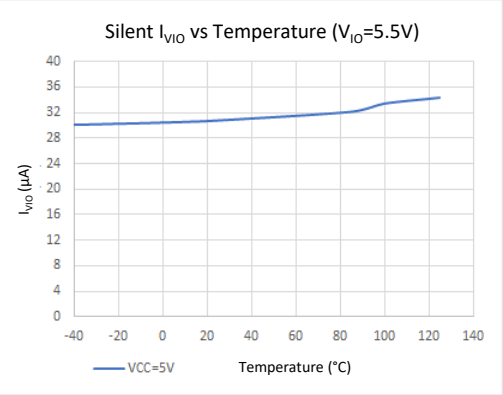
9.2 I_{CC} & I_{VIO} vs Temperature



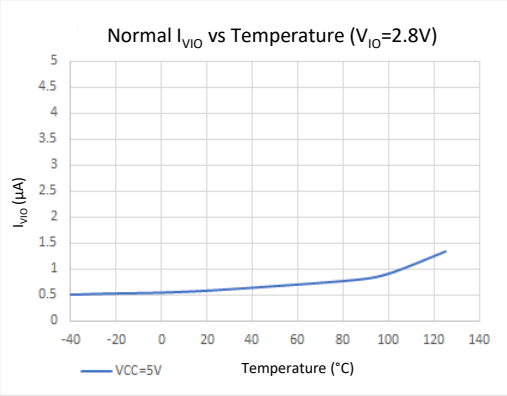


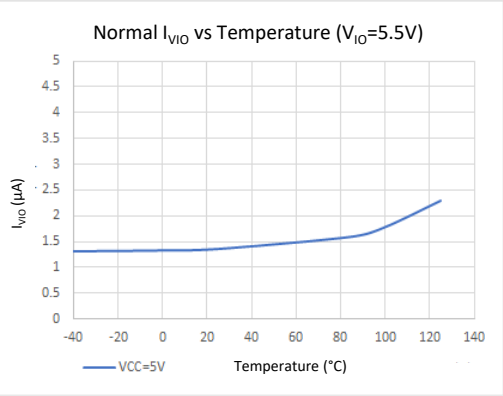
Silent & Normal Quiescent I_{CC} vs Temperature (V_{IO}=2.8V or V_{IO}=5.5V)





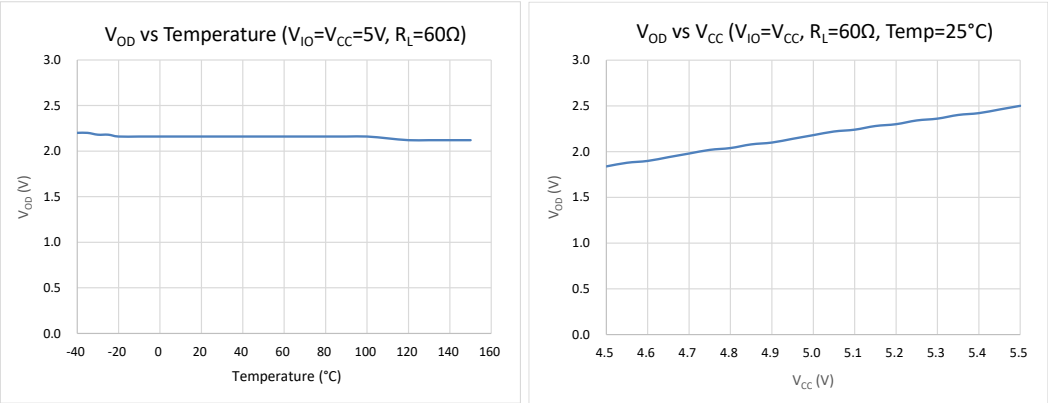
Silent Mode I_{VIO} vs Temperature (V_{CC}=5V)





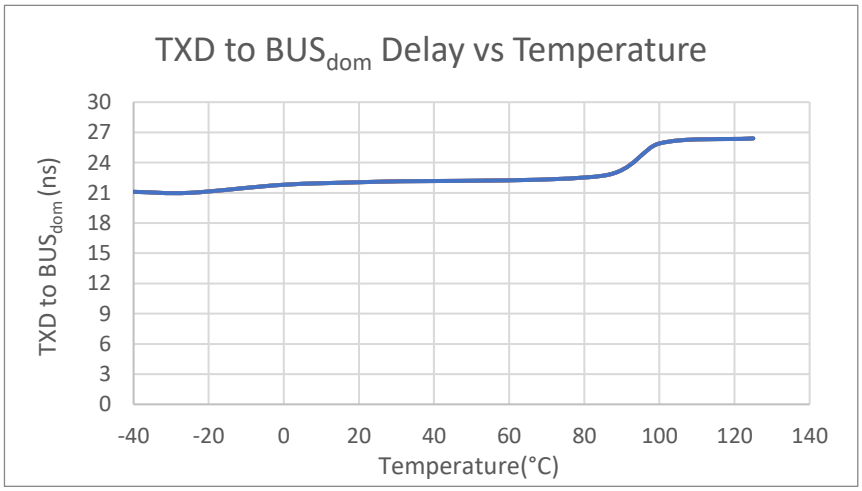
Normal Mode I_{VIO} vs Temperature (V_{CC}=5V)

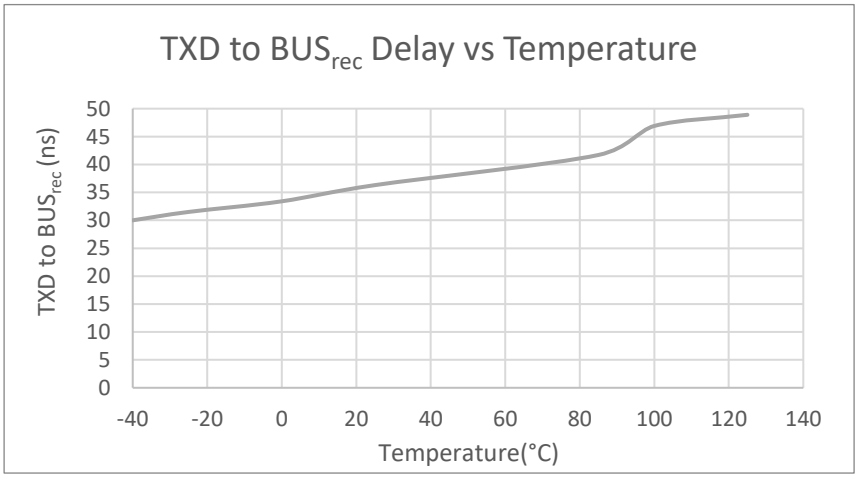
9.3 V_{OD} vs Temperature & V_{CC}



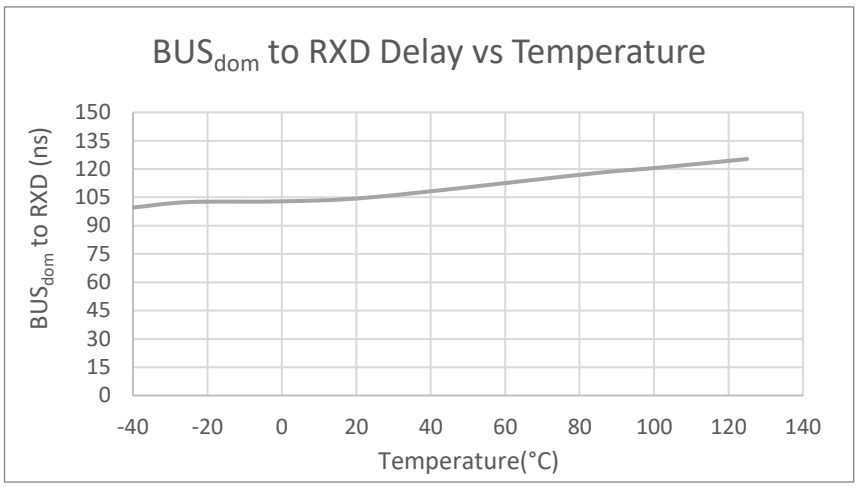
V_{OD} vs Temperature (V_{IO}=V_{CC}=5V, R_L=60 ohm)

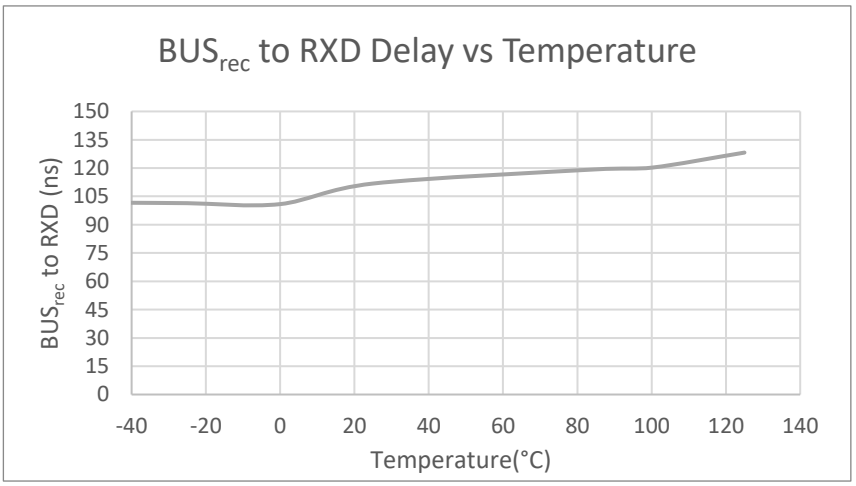
9.4 TXD to BUS Delay vs Temperature



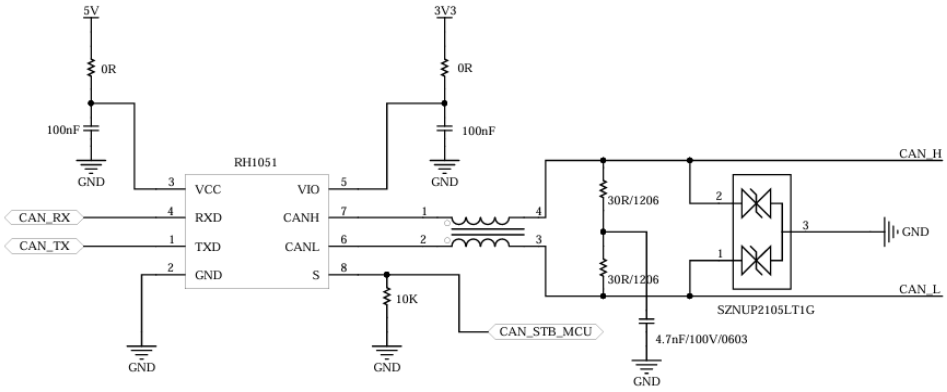


9.5 BUS to RXD Delay vs Temperature

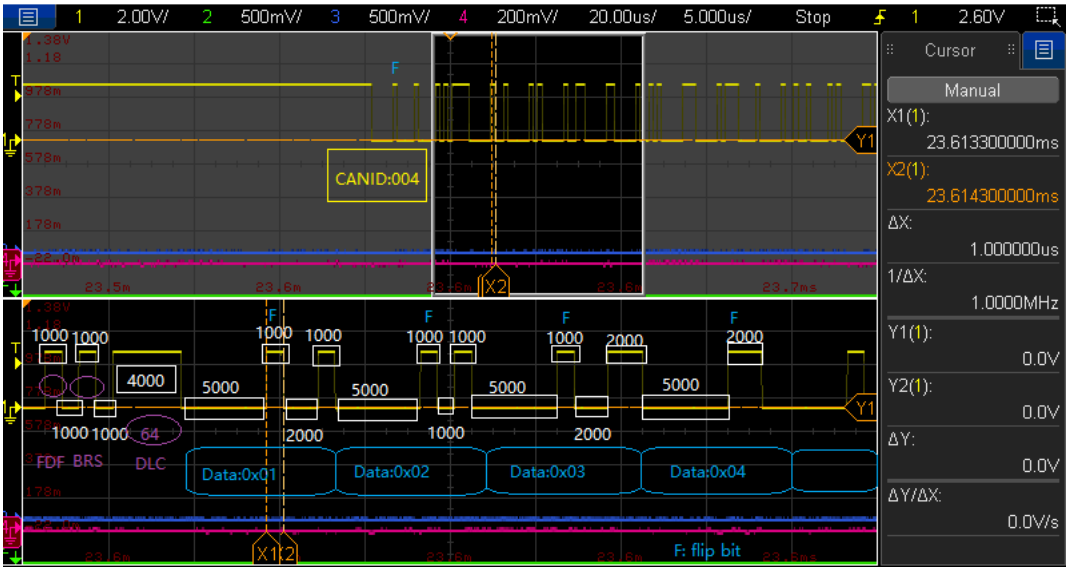




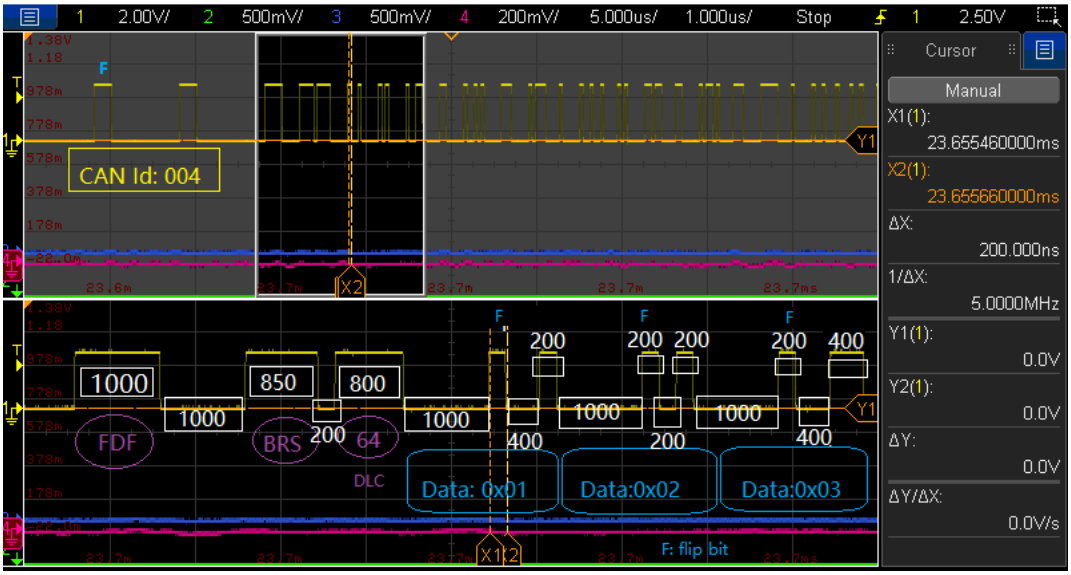
9.6 Typical Application Test Circuit



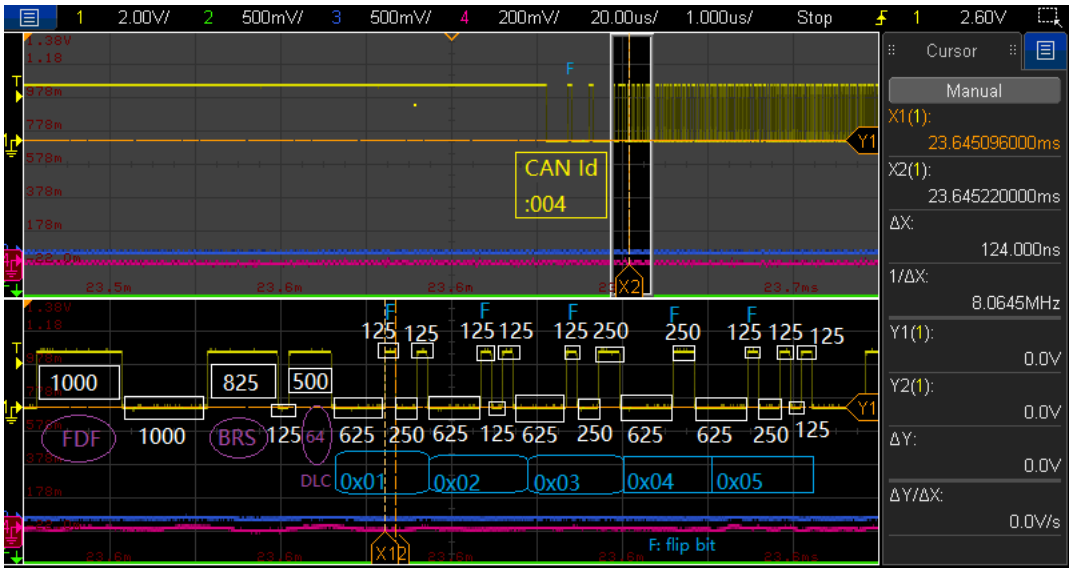
9.7 CAN FD Data Transmissions



1Mbps Data Phase and 1Mbps Arbitration Phase



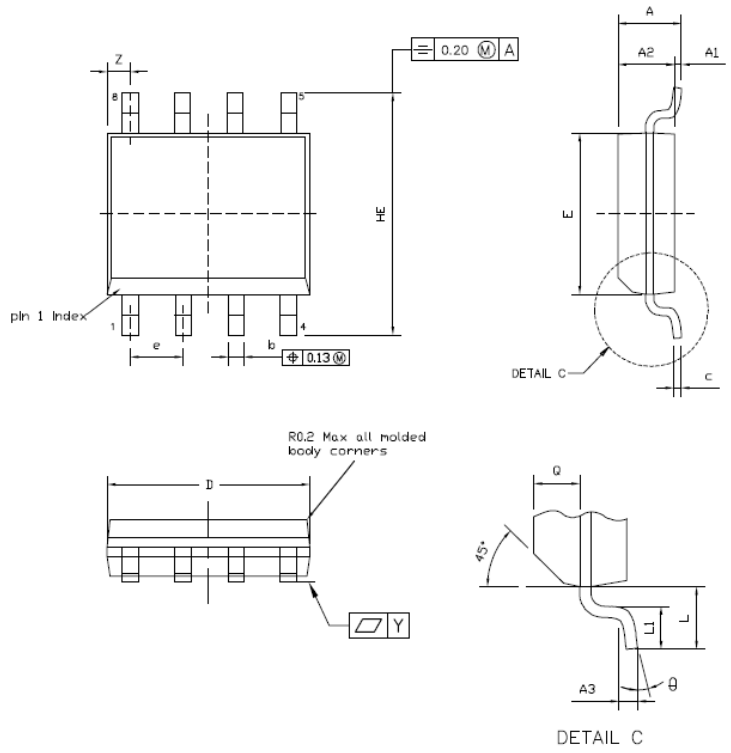
5Mbps Data Phase and 1Mbps Arbitration Phase



8Mbps Data Phase and 1Mbps Arbitration Phase

10 Package Information

Package Outline SO-8 (150 mil)



* CONTROLLING DIMENSION : MM

SYMBOL	MILLIMETER		
	MIN.	NOM.	MAX.
A	---	---	1.75
A1	0.10	---	0.25
A2	1.25	1.35	1.45
b	0.33	0.38	0.49
c	0.19	0.20	0.25
D	4.80	4.90	5.00
E	3.80	3.90	4.00
Q	0.60	0.65	0.70
HE	5.80	6.00	6.20
e	1.27 BSC		
L	1.05 BSC		
L1	0.40	0.64	1.00
Y	---	0.10	---
Z	0.3	0.5	0.7
A3	0.25 BSC		
θ	0°	5°	8°