high performance needs great design.

Datasheet: AS8222 Enhanced FlexRay Standard Transceiver

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AS8222

Enhanced FlexRay Standard Transceiver

1 General Description

The AS8222 is a high-speed fault tolerant device operating as interface between a generic FlexRay Communication Controller and the copper wiring.

This device is the first FlexRay certified Transceiver for temperature ranges up to 150°C ambient temperature. For bare-die deliveries please contact ams for more information.

The AS8222 is designed to extend the application range for high speed and safety critical time triggered bus systems in an automotive environment. The bus driver is protected against short circuits to the supply and GND. The AS8222 operates at baudrates up to 10 Mbps and is fully conforming to the FlexRay Electrical Physical Layer Specification V2.1 Rev B.

The AS8222 provides a host controller interface consisting of Enable (EN) and Standby (STBN) input pins for mode handling by the microcontroller and the Error (ERRN) output pin, signalling failures and status information.

The device supports the NORMAL mode with activated FlexRay bus transmitter and receiver, the RECEIVE_ONLY mode with activated receiver only to avoid unwanted disturbances while listening to the communication and the low-power modes STANDBY and SLEEP with very low power consumption.

In case of undervoltage at one of the supply voltages (V_{BAT}, V_{CC}, and V_{IO}) the device will change its mode to a low-power mode (either STANDBY or SLEEP mode) and the device will signal an error accordingly. In case of low voltage is detected on both V_{BAT} and V_{CC} the device will enter the POWER-OFF mode.

Ensuring application in safety critical environments a two wire bus-guardian interface is implemented where additional redundant circuitries on the electronic-control-unit can monitor the communication on the receive enable output (RxEN) and can activate and deactivate through the bus guardian enable input (BGE) the transmitter. Additionally in low-power modes the wake conditions at the RxEN pin can be monitored.

A thermal sensor circuit with an integral shutdown mechanism prevents damage to the device in extreme temperature conditions.

2 Key Features

- Data transfer up to 10 Mbps
- Compliant with FlexRay Electrical Physical Layer Specification V2.1 Rev. B
- **Wide operating ambient temperature range -40°C to +150°C**
- Excellent EMC performance
- High common mode range insures excellent EMI immunity
- Interface with optional bus guardian for bus supervision
- Automatic thermal shutdown protection
- Supports 12, 24V systems with low sleep current consumption
- Integrated power management system
- Two INH pins for the external voltage regulators control
- Local wake-up input
- Remote wake-up capability via FlexRay bus in sleep mode
- Supports 2.5, 3, 3.3, 5 V microcontrollers and automatically adapts to interface levels
- Does not disturb the bus line if not powered
- Protected against damage due to short circuit conditions on the bus (positive and negative battery voltage)
- Small Pb-free package: SSOP-20
- Automotive qualified to AEC-Q100, grade 0
- For bare-die deliveries please contact us.

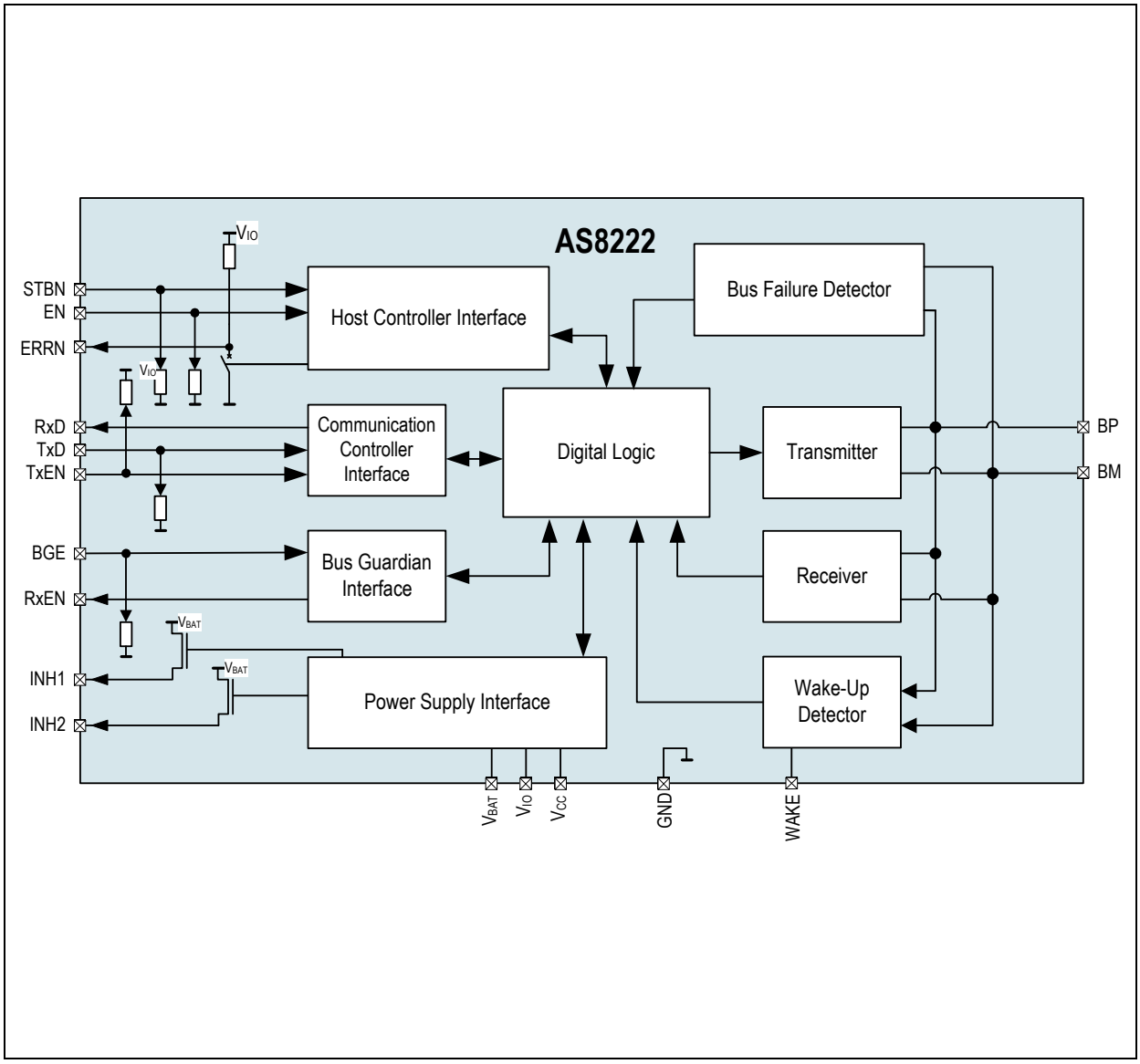
3 Applications

The AS8222 FlexRay Standard Transceiver is best fitting for automotive FlexRay nodes where bus wake-up and voltage regulator control for voltage supplies is needed.

The device addresses all ECUs connected to the permanent battery supply (terminal 30).

The device is best suited for high temperature applications with up to 150°C.

Figure 1. AS8222 Enhanced FlexRay Standard Transceiver Block Diagram

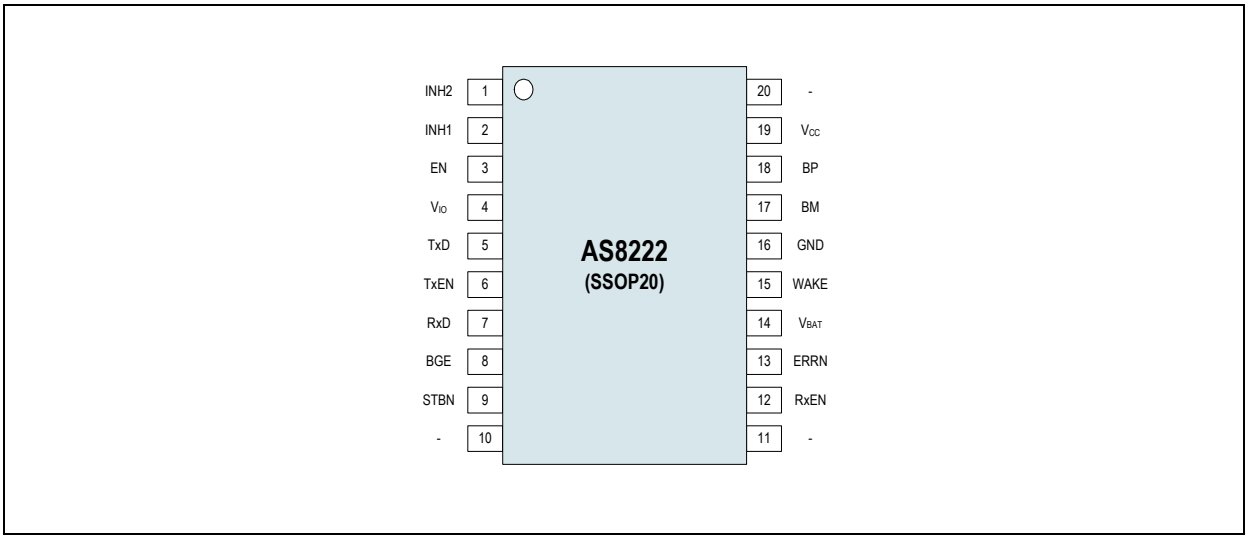


Contents

4 Pin Assignments

The AS8222 is available in SSOP-20 5.3mm.

Figure 2. Pin Assignments (Top View)



4.1 Pin Descriptions

Table 1. SSOP-20 Pin Descriptions

Pin Name	Pin Number	Pin Type	Description
INH2	1	Analog I/O	Analog Output. Inhibit 2 output for switching external voltage regulator
INH1	2		Analog Output. Inhibit 1 output for switching external voltage regulator
EN	3	Digital Input with Pull-down	Digital Input. Enable input
VIO	4	Supply	Supply Voltage. I/O supply voltage
TxD	5	Digital Input with Pull-down	Digital Input. Transmit data input
TxEN	6	Digital Input with Pull-up	Digital Input. Transmitter enable input
RxD	7	Digital Output	Digital Output. Receive data output
BGE	8	Digital Input with Pull-down	Digital Input. Bus guardian enable input
STBN	9		Digital Input. Standby input
Reserved	10	Analog/digital Input/output with Pull-down	To be connected to GND or to be unconnected
Not used	11	-	-
RxEN	12	Digital Output	Digital Output. Receive data enable output
ERRN	13		Digital Output. Error diagnosis output and wake status output
VBAT	14	Supply	Supply Voltage. Battery supply voltage
WAKE	15	Analog I/O	Analog Input. Local wake-up input
GND	16	Supply	Ground
BM	17	Analog I/O	Analog Input/Output. Bus line Minus
BP	18		Analog Input/Output. Bus line Plus
VCC	19	Supply	Supply voltage.
Not used	20	-	-

5 Absolute Maximum Ratings

Stresses beyond those listed in Table 2 may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in Absolute Maximum Ratings is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note: All voltages are referred to pin GND.

Table 2. Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Units	Note
Electrical Parameters					
V_{BAT}	Battery Supply Voltage	-0.3	+50	V	
V_{CC}	Supply Voltage	-0.3	+7.0	V	
V_{IO}		-0.3	+7.0	V	$V_{IO} < V_{CC}$
	DC Voltage at EN, STBN, ERRN, TxD, RxD, TxEN, BGE, RxEN	-0.3	V_{IO} +0.3	V	
	DC Voltage on pin WAKE, INH1, INH2	-0.3	V_{BAT} +0.3		
	DC Voltage at BP and BM	-40	+40	V	
	Input current (latchup immunity)	-100	100	mA	According to JEDEC 78
Electrostatic Discharge					
ESD	Electrostatic Discharge	±2		kV	All pins AEC-Q100-002 (HBM)
	uESDInt	2		kV	ESD on all other pins
	Electrostatic Discharge	±4		kV	For V_{BAT}, GND, WAKE AEC-Q100-002 (HBM)
	$uESD_{Ext}$	4		kV	ESD protection on pins that lead to ECU external terminals
	Electrostatic Discharge	±6		kV	BP, BM AEC-Q100-002 (HBM)
	$uESD_{Ext}$	4		kV	ESD protection on pins that lead to ECU external terminals
	Electrostatic Discharge	±6		kV	BP, BM FlexRay Physical Layer EMC Measurement Specification Version 3.0
	Electrostatic Discharge	±500		V	On all pins AEC-Q100-011 (Charge Device Model)
		±750		V	At the corner pins AEC-Q100-011 (Charge Device Model)
		±100		V	On all pins AEC-Q100-003 (Machine Model)

Table 2. Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Units	Note
Damage Tests					
U_s	Transient voltage on VBAT, Bus and Wake pins (damage tests)	-100		V	ISO7637-2 test pulse 1; class D (see Figure 14)
			+75	V	ISO7637-2 test pulses 2a; class D (see Figure 14)
		-150		V	ISO7637-2 test pulses 3a; class D (see Figure 14)
			+100	V	ISO7637-2 test pulses 3b; class D (see Figure 14)
Power Dissipation					
P_t	Total power dissipation (all supplies and outputs)		150	mW	
Temperature Ranges and Storage Conditions					
T_{strg}	Storage temperature	-55	+150	ºC	
TBODY	Package body temperature [1]		260	ºC	
H	Humidity non-condensing	5	85	%	
MSL	Moisture Sensitivity Level [2]	3			

1. The reflow peak soldering temperature (body temperature) specified is in accordance with IPC/JEDEC J-STD-020 “Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices”. The lead finish for Pb-free leaded packages is matte tin (100% Sn).
2. Represents a maximum floor life time of 168h.

6 Electrical Characteristics

In this specification, all the defined tolerances for external components are assured over the whole operation conditions range as well as over lifetime.

Operation Range:

T_{AMB}=-40ºC to +150ºC, V_{CC}=+4.75V to +5.25V, V_{BAT}=5.5V to +40V, V_{IO}=+2.2 to V_{CC}, R_L=40Ω, C_L= 100pF unless otherwise specified.

6.1 Supply Voltage

Table 3. Supply Voltage

Symbol	Parameter	Conditions	Min	Typ	Max	Units
T_{AMB}	Ambient temperature		-40	+25	+150	ºC
T	Ambient temperature		-40		+125	ºC
V_{CC}-V_{IO}	Difference of supplies		-0.1		3.05	V
I_{BAT}	V_{BAT} current consumption (standard transceiver only)	V_{BAT}=12V; SLEEP mode; T_{AMB}<125ºC [1]	0	30	50	µA
		V_{BAT}=12V; SLEEP mode [1]	0	80	170	µA
		Non-low-power modes	0	0.24	1	mA
I_{CC}	V_{CC} current consumption	Low-power modes; V_{CC} = 0 V to +5.25V [1]	-5	10	20	µA
		Non-low-power mode: NORMAL, driver enabled	15	25	45	mA
		Non-low-power mode: NORMAL, driver enabled; R_{BUS}= ∞Ω	3	7	15	mA
		Non-low-power mode: RECEIVE-ONLY	1	2	10	mA
I_{IO}	V_{IO} current consumption	Low-power Modes; V_{IO} = 0 V to +5.25V [1]	-5	2	20	µA
		Non-low-power Modes	0	0.02	1	mA

1. EN, STBN, ERRN, TxD, RxD, TxEN, BGE, RxEN, WAKE, INH1, INH2: open.

6.2 State Transitions

Table 4. State Transitions

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{STBN_RXD}	Delay STBN high to RxD high with wake flag set		1	10	50	µs
t_{STBN_RXEN}	Delay STBN high to RxEN high with wake flag set		1	10	50	µs
t_{SLEEP_INH1}	Delay STBN high to INH1 high	INH1 high = 80 % V_{BAT}	1	10	50	µs
$t_{STANDBY\_INH2}$	Delay STBN high to INH2 high	INH2 high = 80 % V_{BAT}	1	10	50	µs
t_{SLEEP}	go-to-sleep hold time	INH1 low = 20 % V_{BAT}	10	25	70	µs

6.3 Transmitter

The following parameters are applicable to all the branch transmitters.

Table 5. Transmitter

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$V_{BUS\_DIFF\_D0}$	Differential bus voltage low in NORMAL mode (Data_0)	$V_{BPdata0} - V_{BMdata0}$; 40 Ω < R_L < 55 Ω	-2	-1	-0.6	V
$uBDTx_{active}$	Absolute value of uBus, while sending	Load on BP/BM: 40Ω || 100pF	|2000|		|600|	mV
$V_{BUS\_DIFF\_D1}$	Differential bus voltage high in NORMAL mode (Data_1)	$V_{BPdata1} - V_{BMdata1}$; 40 Ω < R_L < 55 Ω	0.6	1	2	V
$uBDTx_{active}$	Absolute value of uBus, while sending	Load on BP/BM: 40Ω || 100pF	|600|		|2000|	mV
ΔV_{BUS_DIFF}	Matching between Data_0 and Data_1 differential bus voltage in NORMAL mode	$V_{BUS\_DIFF\_D0}$ - $V_{BUS\_DIFF\_D1}$ 40 Ω < R_L < 55 Ω	-200	0	200	mV
$V_{BUS\_COM\_D0}$	Common mode bus voltage in case of Data_0 in non-low-power mode	$V_{BPdata0}/2+V_{BMdata0}/2$ 40 Ω < R_L < 55 Ω	0.4 * Vcc	0.5 * Vcc	0.6 * Vcc	V
$V_{BUS\_COM\_D1}$	Common mode bus voltage in case of Data_1 in non-low-power mode	$V_{BPdata1}/2+V_{BMdata1}/2$ 40 Ω < R_L < 55 Ω	0.4 * Vcc	0.5 * Vcc	0.6 * Vcc	V
ΔV_{BUS_COM}	Matching between Data_0 and Data_1 common mode voltage	$V_{BUS\_COM\_D0}$ - $V_{BUS\_COM\_D1}$ 40 Ω < R_L < 55 Ω	-200	0	200	mV
$V_{BUS\_DIFF\_Idle}$	Absolute differential bus voltage in idle mode	40 Ω < R_L < 55 Ω		0	30	mV
uBDTxidle	Absolute value of uBus, while Idle		0		30	mV
$IBP_{BMShortMax}$ $IBM_{BPShortMax}$	Absolute max current when BP shorted to BM	V_{BP}= V_{BM}		25	+100	mA
$IBP_{BMShortMax}$ $IBM_{BPShortMax}$	Absolute maximum output current when BP shorted to BM				100	mA
$IBP_{GNDShortMax}$	Absolute max current when BP is shorted to GND	V_{BP}=0 V		50	+100	mA
$IBP_{GNDShortMax}$	Absolute maximum output current when shorted to GND				100	mA

Table 5. Transmitter

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$IBM_{GNDShortMax}$	Absolute max current when BM is shorted to GND	V_{BM}=0 V		50	+100	mA
$IBM_{GNDShortMax}$	Absolute maximum output current when shorted to GND				100	mA
$IBP_{-5VShortMax}$	Absolute max current when BP is shorted to -5 V	V_{BP}=-5 V		50	+100	mA
$IBP_{-5VShortMax}$	Absolute maximum output current when shorted to –5V				100	mA
$IBM_{-5VShortMax}$	Absolute max current when BM is shorted to -5 V	V_{BM}=-5 V		50	+100	mA
$IBM_{-5VShortMax}$	Absolute maximum output current when shorted to –5V				100	mA
$IBP_{27VShortMax}$	Absolute max current when BP is shorted to 27 V	V_{BP}=27 V		60	+100	mA
$IBP_{BAT27ShortMax}$	Absolute maximum output current when shorted to 27V				100	mA
$IBM_{27VShortMax}$	Absolute max current when BM is shorted to 27 V	V_{BM}=27 V		60	+100	mA
$IBM_{BAT27ShortMax}$	Absolute maximum output current when shorted to 27V				100	mA
$IBP_{40VShortMax}$	Absolute max current when BP is shorted to 40 V	V_{BP}=40 V		75	+100	mA
$IBM_{40VShortMax}$	Absolute max current when BM is shorted to 40 V	V_{BM}=40 V		75	+100	mA
t_{TXD_BUS01}	Delay time from TxD to BUS positive edge	$t_{riseTxD}$ = 5 ns		25	50	ns
dBDTx01	Transmitter delay, positive edge				100	ns
t_{TXD_BUS10}	Delay time from TxD to BUS negative edge	$t_{fall\ TxD}$ = 5 ns		25	50	ns
dBDTx10	Transmitter delay, negative edge				100	ns
$t_{TXD\_MISMATCH}$	Delay time from TxD to BUS mismatch	$t_{TxD\_BUS10} - t_{TxD\_BUS01}$	-4	0	4	ns
dTxAsym	Transmitter delay mismatch | dBDTx10 - dBDTx01 |				4	ns
t_{BUS_TX10}	Fall time differential bus voltage	80 % - 20 % of V_{BUS}; R_L=45 Ω; C_L= 100 pF	3.75	13	18.75	ns
dBusTx10	Fall time differential bus voltage (80% → 20%)		3.75		18.75	ns
t_{BUS_TX01}	Rise time differential bus voltage	20 % - 80 % of V_{BUS}; R_L=45 Ω; C_L= 100 pF	3.75	13	18.75	ns
dBusTx01	Rise time differential bus voltage (20% → 80%)		3.75		18.75	ns
$t_{TXEN\_BUS\_Idle\_Active}$	Delay time from TxEN to bus active	R_L=45 Ω; C_L= 100 pF		18	50	ns
dBDTxia	Propagation delay idle → active				100	ns

Table 5. Transmitter

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{TXEN\_BUS\_Active\_Idle}$	Delay time from TxEN to bus idle	R_L=45 Ω; C_L= 100 pF		18	50	ns
dBDTxai	Propagation delay active → idle				100	ns
$t_{TXEN\_MISMATCH}$	Delay time from TxEN to BUS mismatch	| $t_{TXEN\_BUS\_Idle\_Active}$ - $t_{TXEN\_BUS\_Active\_Idle}$ |; R_L=45 Ω; C_L= 100 pF		0	50	ns
dBDTxDM	| dBDTxia - dBDTxai |				50	ns
$t_{BGE\_BUS\_IdleActive}$	Delay time from BGE to bus active			18	50	ns
dBDTxia	Propagation delay idle → active				100	ns
$t_{BGE\_BUS\_Active\_Idle}$	Delay time from BGE to bus idle			18	50	ns
dBDTxai	Propagation delay active → idle				100	ns
$t_{BUS\_Idle\_Active}$	Differential bus voltage transition time: idle to active	R_L=45 Ω; C_L= 100 pF		5	30	ns
dBusTxia	Transition time idle → active				30	ns
$t_{BUS\_Active\_Idle}$	Differential bus voltage transition time: active to idle	R_L=45 Ω; C_L= 100 pF		2	30	ns
dBusTxai	Transition time active → idle				30	ns
$t_{TxEN\_timeout}$	TxEN timeout		3	5	10	ms

6.4 Receiver

The following parameters are applicable to all the branch receivers.

Table 6. Receiver

Symbol	Parameter	Conditions	Min	Typ	Max	Units
R_{BP}, R_{BM}	BP, BM input resistance	Idle mode; R_{BUS}= ∞	10	25	40	kΩ
RCM1, RCM2	Receiver common mode input resistance		10		40	kΩ
R_{DIFF}	BP, BM differential input resistance	Idle mode; R_{BUS}= ∞	20	50	80	kΩ
V_{BP}, V_{BM}	Common mode voltage range		-10		+15	V
uCM	Common mode voltage range (with respect to GND) that does not disturb the receive function		-10		+15	V
V_{BPidle}, V_{BMidle}	Idle voltage in non-low-power modes on pin BP, BM	Non-low-power modes; V_{TXEN}=V_{IO} 40 Ω < R_L < 55 Ω	0.4*V_{CC}	0.5*V_{CC}	0.6*V_{CC}	V
uBias	Bus bias voltage during BD_Normal mode		1800		3200	mV

Table 6. Receiver

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{BPidle_low}, V_{BMidle_low}	Idle voltage in low-power modes on pin BP, BM	Low-power modes 40 Ω < R_L < 55 Ω	-0.2	0	+0.2	V
uBias	Bus bias voltage during low-power modes		-200		+200	mV
I_{BPidle}	Absolute idle output current on pin BP	-40 V < V_{BP} < 40 V	0	2	7.5	mA
I_{BMidle}	Absolute idle output current on pin BM	-40 V < V_{BM} < 40 V	0	2	7.5	mA
I_{BPleak_ST}, I_{BMleak_ST}	Absolute leakage current, when not powered	V_{BP}=V_{BM}=5 V, V_{DD}=0 V, V_{BAT}=0 V; V_{IO}=0 V; T_{amb} < 125°C		6	25	µA
iBPLeak, iBMLeak	Absolute leakage current, when not powered				25	µA
I_{BPleak_HT}, I_{BMleak_HT}	Absolute leakage current, when not powered	V_{BP}=V_{BM}=5 V, V_{DD}=0 V, V_{BAT}=0 V; V_{IO}=0 V; 125°C < T_{amb} < 150°C		35	150	µA
$V_{BUSActiveHigh}$	Activity detection differential input voltage high	Normal power modes -10 V < (V_{BP}, V_{BM}) < 15 V	150	260	400	mV
uBusActiveHigh	Upper receiver threshold for detecting activity		150		425	mV
$V_{BUSActiveLow}$	Activity detection differential input voltage low	Normal power modes -10 V < (V_{BP}, V_{BM})< 15 V	-400	-260	-150	mV
uBusActiveLow	Lower receiver threshold for detecting activity		-425		-150	mV
V_{Data1}	Data1 detection differential input voltage	Pre-condition: activity already detected. Normal power mode. -10 V < (V_{BP}, V_{BM})< 15 V	150	225	300	mV
uData1	Receiver threshold for detecting Data_1		150		300	mV
V_{Data0}	Data0 detection differential input voltage	Pre-condition: activity already detected. Normal power mode. -10 V < (V_{BP}, V_{BM})< 15 V	-300	225	-150	mV
uData0	Receiver threshold for detecting Data_0		-300		-150	mV
$V_{DataErr}$	Mismatch between Data0 and Data1 differential input voltage	2 x (| | V_{Data0}| - | V_{Data1}| |) / (| V_{Data0}| +| V_{Data1}|) [1]		0	10	%
ΔuData	Mismatch of receiver thresholds				10	%
t_{BUS_RxD10}	Delay from BUS to RxD negative edge	C_{RXD}=15 pF [2]		34	80	ns
dBDRx10	Receiver delay, negative edge				100	ns
t_{BUS_RxD01}	Delay from BUS to RxD positive edge	C_{RXD}=15 pF [2]		34	80	ns
dBDRx01	Receiver delay, positive edge				100	ns

Table 6. Receiver

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{bit}	Bit time	C_{RXD}=15 pF[2]	60			ns
t_{RxD_ASYM}	Delay time from BUS to RxD mismatch	C_{RXD}=15 pF, $\lvert t_{BUS\_RxD10} - t_{BUS\_RxD01} \rvert$ [2]		0	5	ns
dRxAsym	Receiver delay mismatch | dBDRx10 – dBDRx01 |				5	ns
$t_{RXDfall}$	Fall time RxD voltage	80 % - 20 % of V_{RXDL};C_{RXD}=15 pF[2]		2	5	ns
dRxSlope	Fall and rise time 20%-80%, 15pF load				5	ns
$t_{RXDrise}$	Rise time RxD voltage	20 % - 80 % of V_{RXDL};C_{RXD}=15 pF [2]		2	5	ns
dRxSlope	Fall and rise time 20%-80%, 15pF load				5	ns
$t_{BUSIdleDetection}$	Idle detection time	V_{BUS}: 400mV → 0	50	150	250	ns
dIdleDetection	Filter-time for idle detection		50		250	ns
$t_{BUSActivityDetection}$	Activity detection time	V_{BUS}: 0 V → 400 mV	100	200	300	ns
dActivityDetection	Filter-time for activity detection		100		300	ns
$t_{BUSIdleReaction}$	Idle reaction time	V_{BUS}: 400mV → 0	50	160	300	ns
dBDRxai	Idle reaction time		50		400	ns
$t_{BUSActivityReaction}$	Activity reaction time	V_{BUS}: 0 V → 400 mV	100	210	350	ns
dBDRxia	Activity reaction time		100		450	ns

1. Test condition: (VBP + VBM) / 2 = 2,5V ± 5%
2. For test signal see Figure 13

6.5 Wake-up Detector

The following parameters are applicable to all the branch wake-up detectors.

Table 7. Wake-up Detector

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{BAT_BW}	VBAT voltage supply for bus wake-up	In case a VBAT supply voltage input is implemented, the wake-up detector shall be operable when uVBAT is equal to or greater than 7V even if other supplies are not present.	6.5		40	V
t_{BWU0}	Data_0 detection time in remote wake-up pattern	-10V<(V_{BP}, V_{BM})<15V	1	2	4	µs
dWU0Detect	Acceptance timeout for detection of a Data_0 phase in wake-up pattern		1		4	µs

Table 7. Wake-up Detector

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{BWUIdle}$	Idle or Data_1 detection time in remote wake-up pattern	-10V<(V_{BP}, V_{BM})<15V	1	2	4	µs
dWUIdleDetect	Acceptance timeout for detection of a Idle phase in wake-up pattern		1		4	µs
$t_{BWUDetect}$	Total remote wake-up detection time	-10V<(V_{BP}, V_{BM})<15V	48	75	140	µs
dWUTimeout	Acceptance timeout for wake-up pattern recognition		48		140	µs
V_{BWU0}	Remote wake-up detector threshold	-10V<(V_{BP}, V_{BM})<15V	-300	-250	-150	mV
V_{LWUTH}	Wake-up detection threshold		2	2.8	4	V
I_{LWUL}	Low level input current on WAKE pin	V_{BAT}=12V; V_{LWAKE}=2V for t<$t_{LWUFilter}$	-20	-10	-5	µA
I_{LWUH}	High level input current on WAKE pin	V_{BAT}=12V; V_{LWAKE}=4V for t<$t_{LWUFilter}$	5	10	20	µA
$t_{LWUFilter}$	Local wake filter time		1	20	40	µs
dWakePulseFilter	Wake pulse filter time (spike rejection)		1		500	µs

6.6 Supply Voltage Monitor

Table 8. Supply Voltage Monitor

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$V_{BAT_{THH}}$	V_{BAT} undervoltage recovery threshold		3.5	4	4.5	V
$V_{BAT_{THL}}$	V_{BAT} undervoltage detection threshold		2.5	3	3.5	V
uUV_{BAT}	Undervoltage detection threshold		2		5.5	V
$V_{CC_{THH}}$	V_{CC} undervoltage recovery threshold		3.5	4	4.5	V
$V_{CC_{THL}}$	V_{CC} undervoltage detection threshold		2.5	3	3.5	V
uUV_{CC}	Undervoltage detection threshold		2			V
$V_{IO_{THH}}$	V_{IO} undervoltage recovery threshold		1.25	1.6	2.0	V
$V_{IO_{THL}}$	V_{IO} undervoltage detection threshold		0.75	1.1	1.5	V
uUV_{IO}	Undervoltage detection threshold		0.75			V
t_{UV_DETECT}	Undervoltage detection time		100	300	700	ms
dUV_{BAT}, dUV_{CC}, dUV_{IO}	Undervoltage reaction time				1000	ms
t_{UV_REC}	Undervoltage recovery time		0.7	2	5	ms

6.7 Bus Error Detection

The following parameters are applicable to all the branch error detectors.

Table 9. Bus Error Detection

Symbol	Parameter	Conditions	Min	Typ	Max	Units
I_{THL}	Absolute bus current for low current detection	NORMAL mode, Transmitter enabled not production tested		5	20	mA
I_{THH}	Absolute bus current for high current detection	NORMAL mode, Transmitter enabled not production tested	20	40		mA
V_{SHORT}	Differential voltage on BP and BM for detecting short circuit between bus lines	NORMAL mode, Transmitter enabled	150	260	400	mV
t_{BUS_ERROR}	Bus error detection time	Normal mode, Transmitter enabled (**) detection only required while actively transmitting a data frame, error indication to host latest when transmission stops.			500	ns
t_{BUS_INHIB}	Bus short detection inhibit time	Normal mode, Transmitter enabled	0.5	2	4	µs

6.8 Over Temperature

Table 10. Over Temperature

Symbol	Parameter	Conditions	Min	Typ	Max	Units
OT_{TH}	Over temperature threshold high		175	190	205	°C
OT_{TL}	Over temperature hysteresis low		165	180	195	°C

6.9 Power Supply Interface

Table 11. Power Supply Interface

Symbol	Parameter	Conditions	Min	Typ	Max	Units
ΔV_{OINH}	High level voltage drop on INH1, INH2	I_{INH}=0.2mA; V_{BAT}=5.5V	0	0.2	0.8	V
$\lvert I_{IL} \rvert$	Leakage current	Sleep mode, V_{INH}=0V	-5	0	5	µA

6.10 Communication Controller Interface

Table 12. Communication Controller Interface

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{TxDIH} uVDIG-IN-HIGH	Threshold for detecting TxD as on logical high Threshold for detecting a digital input as on logical high			0.48 * VIO	0.7 * VIO 0.7 × uVDIG	V
V_{TxDIL} uVDIG-IN-LOW	Threshold for detecting TxD as on logical low Threshold for detecting a digital input as on logical low		0.3 * VIO 0.3 × uVDIG			V
I_{TxDIH}	TxD high level input current		20	50	100	µA
I_{TxDIL}	TxD low level input current		-5	0	5	µA
V_{TxENIH} uVDIG-IN-HIGH	Threshold for detecting TxEN as on logical high Threshold for detecting a digital input as on logical high				0.7 * VIO 0.7 × uVDIG	V

Table 12. Communication Controller Interface

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{TxENIL}	Threshold for detecting TxEN as on logical low		0.3 * VIO			V
uVDIG-IN-LOW	Threshold for detecting a digital input as on logical low		0.3 × uVDIG			
I_{TxENIH}	TxEN high level input current		-5	0	5	µA
I_{TxENIL}	TxEN low level input current		-100	-50	-20	µA
V_{RxDOH}	RxD high level output voltage	I_{RxD}=-4mA, VIO=5V	0.8 * VIO	0.9 * VIO	1.0 * VIO	V
uVDIG-OUT-HIGH	Output voltage on a digital output, when in logical high state		0.8 × uVDIG		1.0 × uVDIG	
V_{RxDOL}	RxD low level output voltage	I_{RxD}=4mA, VIO=5V	0	0.1 * VIO	0.2 * VIO	V
uVDIG-OUT-LOW	Output voltage on a digital output, when in logical low state				0.2 × uVDIG	

6.11 Host Interface

Table 13. Host Interface

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{STBNIH} uVDIG-IN-HIGH	Threshold for detecting STBN as on logical high Threshold for detecting a digital input as on logical high			0.48 * VIO	0.7 * VIO 0.7 × uVDIG	V
V_{STBNIL} uVDIG-IN-LOW	Threshold for detecting STBN as on logical low Threshold for detecting a digital input as on logical low		0.3 * VIO 0.3 × uVDIG	0.48 * VIO		V
I_{STBNIH}	STBN high level input current		20	50	100	µA
I_{STBNIL}	STBN low level input current		-5	0	5	µA
$t_{STBN\_DEB\_LP}$	STBN de-bouncing time low-power modes		0.1	1	40	µs
$t_{STBN\_DEB\_NLP}$	STBN de-bouncing time non-low-power modes		0.1	1	2	µs
V_{ENIH} uVDIG-IN-HIGH	Threshold for detecting EN as on logical high Threshold for detecting a digital input as on logical high			0.48 * VIO	0.7 * VIO 0.7 × uVDIG	V
V_{ENIL} uVDIG-IN-LOW	Threshold for detecting EN as on logical low Threshold for detecting a digital input as on logical low		0.3 * VIO 0.3 × uVDIG	0.48 * VIO		V
I_{ENIH}	EN high level input current		20	50	100	µA
I_{ENIL}	EN low level input current		-5	0	5	µA
$t_{EN\_DEB\_LP}$	EN de-bouncing time low-power modes		0.1	1	40	µs
$t_{EN\_DEB\_NLP}$	EN de-bouncing time non-low-power modes		0.1	1	2	µs
V_{ERRNOH} uVDIG-OUT-HIGH	ERRN high level output voltage Output voltage on a digital output, when in logical high state	I_{ERRN} =-4mA, VIO=5V	0.8 * VIO 0.8 × uVDIG	0.9 * VIO	1.0 * VIO 1.0 × uVDIG	V
V_{ERRNOL} uVDIG-OUT-LOW	ERRN low level output voltage Output voltage on a digital output, when in logical low state	I_{ERRN} =4mA, VIO=5V	0	0.1 * VIO	0.2 * VIO 0.2 × uVDIG	V

6.12 Bus Guardian Interface

Table 14. Bus Guardian Interface

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{BGEIH} uVDIG-IN-HIGH	Threshold for detecting BGE as on logical high Threshold for detecting a digital input as on logical high			0.48 * VIO	0.7 * VIO 0.7 × uVDIG	V
V_{BGEIL} uVDIG-IN-LOW	Threshold for detecting BGE as on logical low Threshold for detecting a digital input as on logical low		0.3 * VIO 0.3 × uVDIG	0.48 * VIO		V
I_{BGEIH}	BGE high level input current		20	50	100	µA
I_{BGEIL}	BGE low level input current		-5	0	5	µA
V_{RxENOH} uVDIG-OUT-HIGH	RxEN high level output voltage Output voltage on a digital output, when in logical high state	I_{RxEN}=-4mA, VIO=5V	0.8 * VIO 0.8 × uVDIG	0.9 * VIO	1.0 * VIO 1.0 × uVDIG	V
V_{RxENOL} uVDIG-OUT-LOW	RxEN low level output voltage Output voltage on a digital output, when in logical low state	I_{RxEN}=4mA, VIO=5V	0	0.1 * VIO	0.2 * VIO 0.2 × uVDIG	V

6.13 Read Out Interface

Table 15. Read Out Interface

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{RO\_PROP\_ERRN}$	Propagation delay falling edge EN to ERRN			2	4.5	µs
$t_{RO\_EN\_TIMEOUT}$	Error read out time out		25	50	100	µs

7 Detailed Description

The AS8222 is a FlexRay Transceiver operating as an interface between the Communication Controller and the wired bus lines. The AS8222 is designed to extend the application range for high speed and safety critical time triggered bus systems in an automotive environment. The drivers are short circuit protected against the positive and negative supply voltage to increase the robustness and reliability of automotive systems. The AS8222 operates at baudrates up to 10 Mbps.

7.1 Block Description

The AS8222 consists of 9 functional blocks Figure 1.

Table 16. Functional Blocks

Symbol	Parameter
Host Controller Interface (HCI)	Digital interface between the Transceiver and the host controller (HC) The host interface comprises the read-out handler, which delivers failure and status information via the ERRN pin to the host controller.
Communication Controller Interface (CCI)	Digital interface between the Transceiver and the FlexRay communication controller (CC)
Bus Guarding Interface (BGI)	Digital interface between the Transceiver and the FlexRay bus guardian (BG) or monitoring circuitry.
Power Supply Interface (PSI)	The power supply interface consists of the voltage monitor (VM) with two analog inhibit outputs switching external voltage supplies.
Internal Logic (IL)	The digital signals from the functional blocks of the device are fed into the internal logic where the forwarding of FlexRay messages from analog side to digital interfaces and vice versa is done. The state machine is embedded in the Internal Logic and the handling of error, wake, and power-on flags is executed herein.
Bus Failure Detector (BFD) Temperature Protection (TP)	The bus failure detector is directly connected to the bus pins, in order to detect several external failure conditions which may occur on the bus. The temperature protection turns off the output driver when reaching the specified internal temperature in order to protect the device.
Transmitter	The transmitter provides the differential signaling according the FlexRay standard on the bus pins.
Receiver	The Receiver captures FlexRay valid signals at the bus pins and provides the received data streams to the Internal Logic.
Wake-Up Detector (WUD)	The wake-up detector recognizes valid wake-up frames on the bus, recognizes a wake signal on the local WAKE pin and signals valid wake-up events to the Internal Logic.

7.2 Events

Transitions in order to change between the operation modes are possible only if events are detected. The device supports three types of events:

- Events on the host controller interface (STBN, EN),
- Detection of undervoltage or supply voltage recovery and
- Wake events.

Mode changes are only performed upon detected events.

7.3 Operating Modes

The AS8222 provides the following operating modes:

- NORMAL: Non-low-power mode
- RECEIVE-ONLY: Non-low-power mode
- STANDBY: Low-power mode
- GO-TO-SLEEP: Low-power mode
- SLEEP: Low-power mode

7.3.1 NORMAL Mode

In this mode the transceiver is able to send and receive data signals on the bus. TxEN and BGE control the state of the transmitter. INH1 and INH2 outputs are set high. RxD shows the bus data and RxEN the bus state. The error read out mechanism is enabled. In this mode the transmitter state can be selected as shown in Table 17. In case the over-temperature flag is set the transmitter is disabled. The bus wires are terminated to VCC/2 via receiver input resistances.

Table 17. Transmitter States

BGE	TxEN	TxD	Transmitter State	Bus state
H	L	H	Enabled	Data_1 (BP is driven high, BM is driven low)
H	L	L	Enabled	Data_0 (BP is driven low, BM is driven high)
X	H	X	Disabled	Idle (BP and BM are not driven)
L	X	X	Disabled	Idle (BP and BM are not driven)

- If the differential bus voltage is higher than $V_{BUSActivehigh}$ or lower than $V_{BUSActivelow}$ for a time longer than $t_{BUSActiveDetection}$, then activity is detected on the bus (Bus = active), RxEN is switched to logical “low” and RxD is released.
- If after the activity detection, the differential bus voltage is higher than V_{Data1}, RxD is high.
- If after the activity detection, the differential bus voltage is lower than V_{Data0}, RxD is low.
- If the absolute differential bus voltage is lower than $V_{BUSActivehigh}$ and higher than $V_{BUSActivelow}$ for a time longer than $t_{BUSIdleDetection}$, then idle is detected on the bus (Bus = idle), RxEN and RxD are switched to logical “high”.

7.3.2 RECIEVE-ONLY Mode

In this mode the transceiver has the same behavior as in NORMAL mode but the transmitter is disabled.

7.3.3 STANDBY Mode

In this mode the transceiver is not able to send and receive data signals to and from the bus, but the wake up detector is active. The power consumption is significantly reduced with respect to the non-low-power operation modes. RxD, RxEN signals the negation of the wake-up flag. INH1 is set to high. If wake-up flag is set then INH2 is high, otherwise it is floating. The error read out mechanism is not enabled. The bus wires are terminated to GND (bus state: Idle_LP).

7.3.4 GO-TO-SLEEP Mode

In this mode the transceiver has the same behavior as in STANDBY mode but if this mode is selected for a time longer than t_{SLEEP} and the wake flag is cleared the device enters into the SLEEP mode.

7.3.5 SLEEP Mode

In this mode the transceiver has the same behavior as in standby mode but INH1 and INH2 are floating.

7.4 Non-Operating Modes

The AS8222 provides the following non-operating mode:

- POWER-OFF

7.4.1 POWER-OFF Mode

In this mode the transceiver is not able to operate. RxD, RxEN are set to high and ERRN is set to low. INH1 and INH2 are floating. The bus wires are not connected to GND (bus state: Idle_HZ).

7.5 Undervoltage Events

The device monitors the following three voltage supplies:

- **VBAT**:Battery supply voltage
- **VIO**: Supply voltage for I/O digital level adaptation
- **VCC**: Supply voltage (+5V)

7.5.1 Undervoltage / Voltage Recovery V_{BAT}

If V_{BAT} voltage falls below $V_{CC_{THL}}$ for a time longer than t_{UV_DETECT} then an undervoltage V_{BAT} event is detected. Undervoltage recovery is detected if V_{BAT} exceeds the voltage threshold V_{BATTHH} for a time longer than t_{UV_REC}.

7.5.2 Undervoltage / Voltage Recovery V_{IO}

If V_{IO} voltage falls below $V_{IO_{THL}}$ for a time longer than t_{UV_DETECT} then an undervoltage V_{IO} event is detected. Undervoltage recovery is detected if V_{IO} exceeds the voltage threshold $V_{IO_{THH}}$ for a time longer than t_{UV_REC}.

7.5.3 Undervoltage / Voltage Recovery V_{CC}

If V_{CC} voltage falls below $V_{CC_{THL}}$ for a time longer than t_{UV_DETECT} then an undervoltage V_{CC} event is detected. Undervoltage recovery is detected if V_{CC} exceeds the voltage threshold $V_{CC_{THH}}$ for a time longer than t_{UV_REC}.

7.6 Power On/Off Events

- Starting from POWER-OFF mode a power-on event occurs in case V_{BAT} undervoltage recovery is detected.
- Starting from every operation mode a POWER-OFF event occurs in case V_{BAT} and V_{CC} undervoltage flags are set.

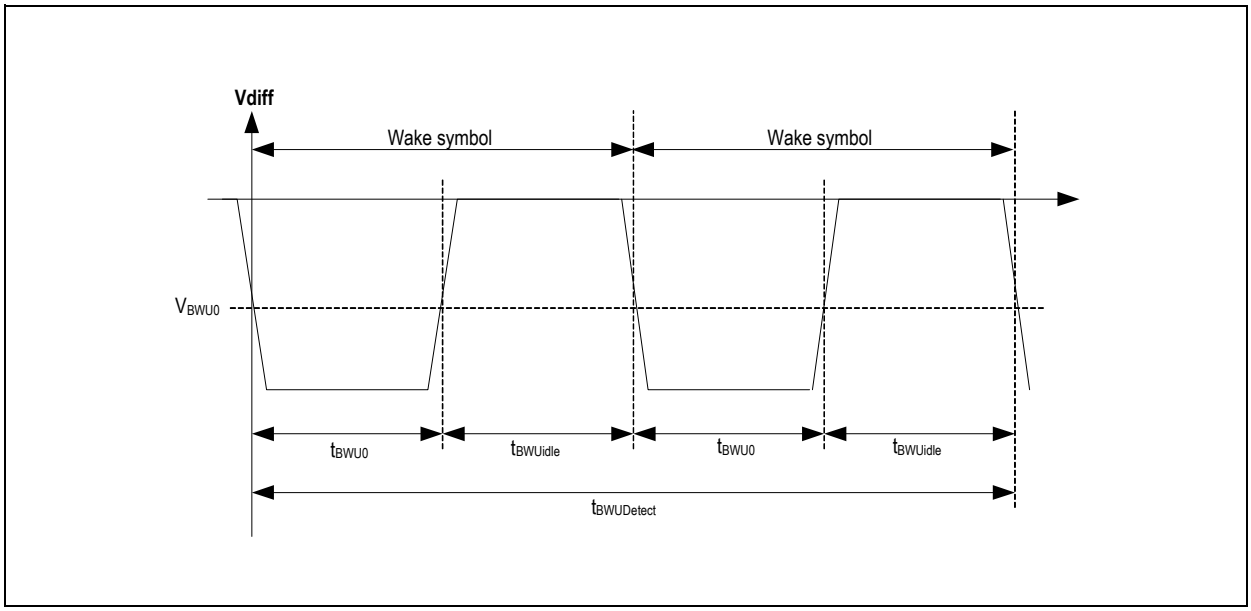
7.7 Wake-Up Events

A wake-up event is only detected in low-power modes.

7.7.1 Remote Wake-Up Event

A remote wake-up event, only possible in low-power modes, is detected if at least two consecutive wake-up symbols via the FlexRay bus within $t_{BWUDetect}$ are received. The wake-up symbol is defined as Data0 longer than t_{BWU0} followed by idle or Data1 longer than $t_{BWUIdle}$ shown in Figure 3.

Figure 3. Signal for Wake-up Pattern Recognition



7.7.2 Remote Wake-up with Frames

A valid wake-up event can be generated out of the standard FlexRay communication in 5 Mbps and 10 Mbps network configurations, while the data bits of the FlexRay Frame are set to “low” for a time longer than t_{BWU0} and set to “high” for time longer than $t_{BWUIdle}$ represent one wake symbol. A valid wake-up pattern consists of two wake symbols as shown in Figure 3.

In a 10Mbps speed configuration of the network, the payload of the frame is configured as follows:

- 1^{st} wake symbol : 0x00 0x00 0x00 0x00 0x00 0xFF 0xFF 0xFF 0xFF 0xFF
- 2^{nd} wake symbol : 0x00 0x00 0x00 0x00 0x00 0xFF 0xFF 0xFF 0xFF 0xFF

Repetitions of wake symbols might be required if network components are shortening valid Wake symbols (e.g. the time until the device is able to re-send wake symbols after wake-up).

7.7.3 Local Wake-Up Event

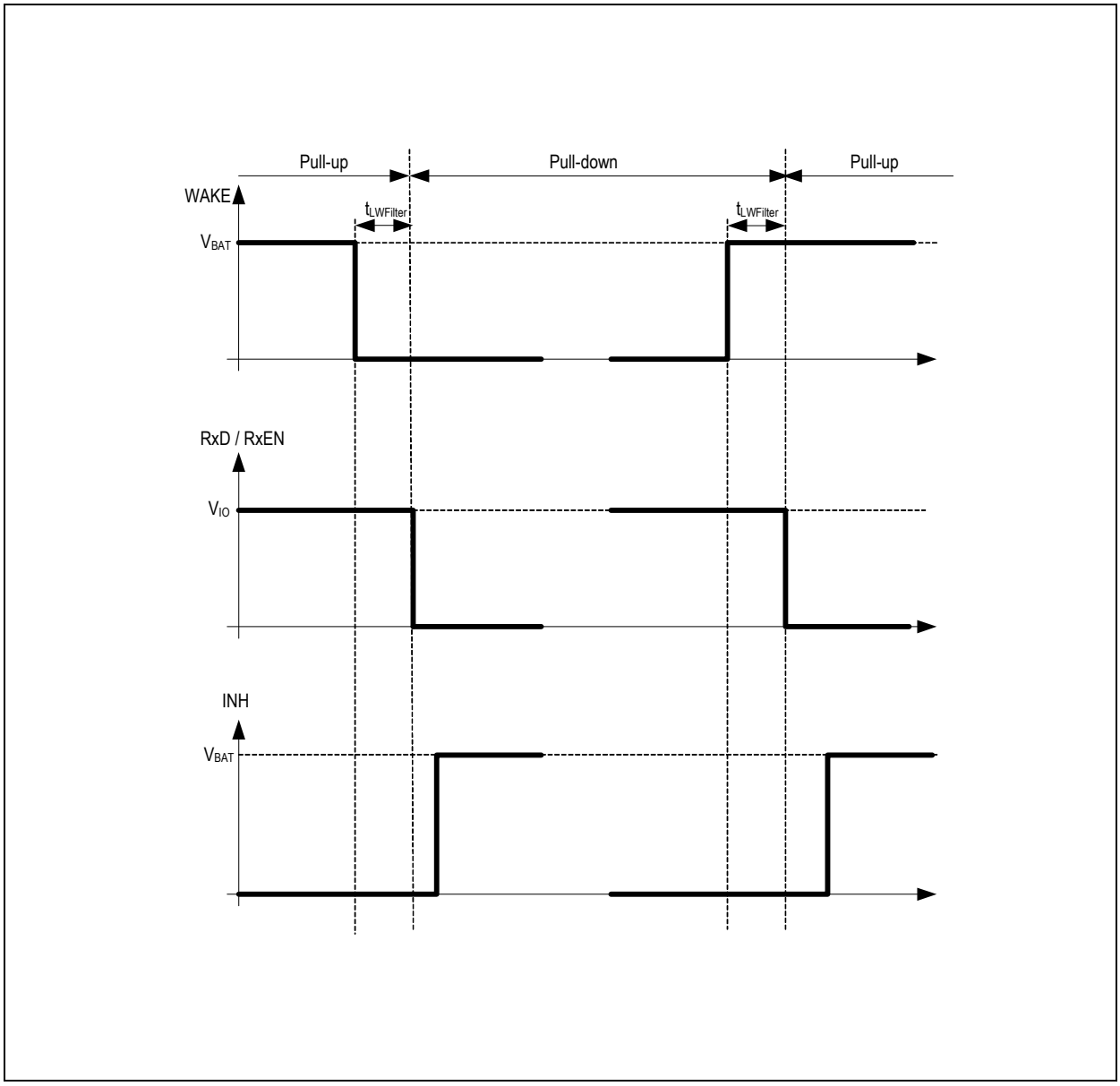
In all low-power modes, if the voltage on the WAKE pin falls below V_{LWUTH} for longer than $t_{LWUFilter}$, a local wake-up event is detected. At the same time the biasing of the pin is switched to pull-down. As well a local wake up event is detected if the voltage on the WAKE pin rises above V_{LWUTH} for longer than $t_{LWUFilter}$, then biasing of the pin is switched to pull-up. The pull-up and -down mechanism is activated in low- and non-low-power modes.

7.8 Over-temperature Events

In NORMAL mode if the temperature exceeds OT_{TH}, the transmitter is deactivated. During this condition the device will remain in NORMAL mode.

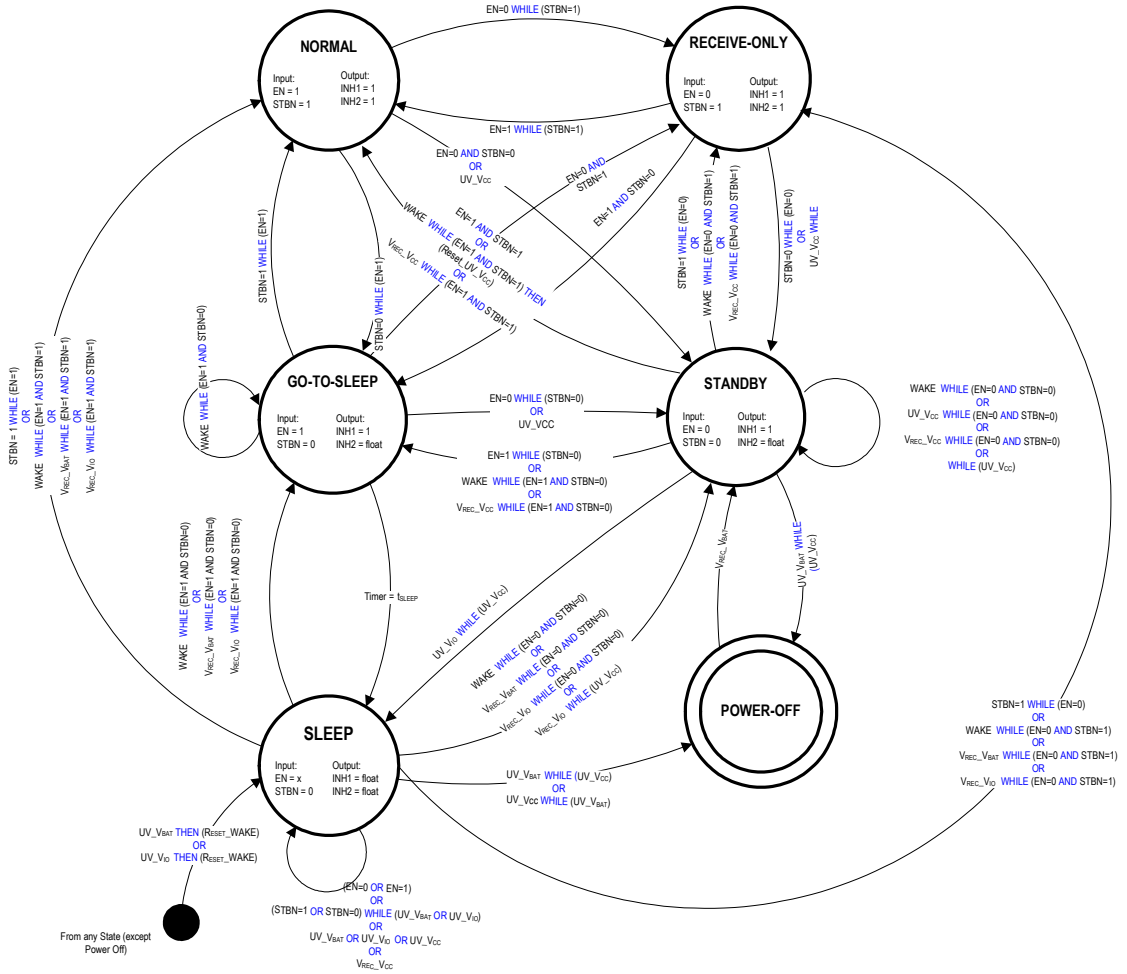
The transmitter is activated again, if the temperature falls below OT_{TL}.

Figure 4. Wake Input Pin Behaviour



7.9 System Description

Figure 5. State Machine Diagram



UV_VBAT:Undervoltage event and/or flag for VBAT supply voltage

UV_VIO:Undervoltage event and/or flag for VIO supply voltage

UV_Vcc:Undervoltage event and/or flag for VCC supply voltage

VREC_VBAT:Voltage recovery event and/or flag for VBAT supply voltage

WAKE:Wake event and/or flag

VREC_VIO:Voltage recovery event and/or flag for VIO supply voltage

VREC_Vcc:Voltage recovery event and/or flag for VCC supply voltage

Reset_Wake:Wake flag is set to low

Reset_UV_Vcc:Undervoltage flag VCC is set to low

Notes:

1. This state diagram does not include all transitions, which are shown in Table 19.
2. Prefix of "WHILE" is an event and suffix in brackets checks the flags or in case of EN and STBN the input condition.
   - **For example:** V_{REC_VBAT} WHILE (EN=0 AND STBN=0)
   - After the event VBAT supply voltage recovery is detected, the transition is performed if EN and STBN are "low".

7.10 Fail Silent Behaviour

7.10.1 RxEN / BGE Timeout

In case no edges on RxEN and BGE are detected within $t_{TxEN\_timeout}$, the transmitter will stop transmitting the signals on RxD to the bus pins.

Transmission is only possible in case the BGE (Bus Guardian Enable) pin is set to high and if TxEN (Transmit Enable Not) is set to low (see Table 17).

7.10.2 State Transitions due to Undervoltage Detection

- In case of VBAT or VIO undervoltage is detected, SLEEP mode will be entered regardless the status of EN and STBN.
- In case VCC undervoltage is detected, STANDBY mode will be entered regardless the status of EN and STBN.
- VBAT and VIO undervoltage detection have higher priority than VCC undervoltage detection.
- In case undervoltage at VBAT and VCC is detected, POWER-OFF mode is entered (bus state: Idle_HZ).

7.10.3 State Transitions due to Voltage Recovery Detection

- If the voltage recovers the device will enter the mode selected by the EN and STBN pins, in case no undervoltage is present at the other supply pins.
- Starting from the POWER-OFF, the device enters the state selected by the host input pins (EN, STBN) only if VBAT or VCC recovers ($V_{BAT} \geq V_{BATTHH}$ or $V_{CC} \geq V_{CCTHH}$) while VIO is available (undervoltage flag of VIO flag not set). If the VIO undervoltage flag is set, the STANDBY mode will be entered. In both cases the Power-On flag is set.
- If $V_{BAT} \leq V_{BATTHL}$ and $V_{CC} \leq V_{CCTHL}$ the device will be in POWER-OFF state, thus the bus wires are not terminated (bus state: Idle_HZ).

7.11 Mode Transitions

- Starting from every operation mode the device enters POWER-OFF in case a power-off event occurs regardless the VIO undervoltage flag, the wake-up flag and the host input pins (EN, STBN).
- Starting from the POWER-OFF the device enters STANDBY only in case a power-on event occurs.
- Starting from every operation mode the device enters SLEEP in case VBAT or VIO undervoltage flag is set regardless the VCC undervoltage flag, the wake-up flag and the host input pins (EN, STBN).
- Starting from every operation mode except SLEEP the device enters STANDBY in case VCC undervoltage flag is set and VBAT and VIO undervoltage flags are not set, regardless the wake-up flag indication and the host input pins state.
- Starting from a low-power mode the device enters the operation mode indicated by the host input pins if a wake-up event occurs.
- In case all the undervoltage flags are reset the operation mode is selected by the wake-up flag and the host pins according to Table 18

Table 18. Pin Signalling in Operating Modes

Inputs		Operation Mode	Outputs			
STBN	EN		RxD	RxEN	INH1	INH2
H	H	NORMAL	L Bus = Data_0	L Bus = Active	H	H
			H Bus = Idle or Data_1	H Bus = Idle		
H	L	RECEIVE-ONLY	L Bus = Data_0	L Bus = Active	H	H
			H Bus = Idle or Data_1	H Bus = Idle		
L	H	GO-TO-SLEEP[1]	NOT [Wake-up flag]	NOT [Wake-up flag]	H	Floating[2]
L	L	STANDBY	NOT [Wake-up flag]	NOT [Wake-up flag]	H	Floating[2]
L	X	SLEEP[3]	NOT [Wake-up flag]	NOT [Wake-up flag]	Floating	Floating

1. If GO-TO-SLEEP is selected for more than t_{SLEEP} then the device will enter SLEEP only if the wake-up flag is not set otherwise it will remain in GO-TO-SLEEP.
2. If wake-up flag is set INH2=H otherwise INH2=floating.
3. Starting from SLEEP, if the wake-up flag is set, the device enters STANDBY regardless of the host pins state and undervoltage flags. Starting from SLEEP, if the wake up flag is not set, the only operating mode that can be entered through host pins are the non-low-power modes.

Note: "H" = Digital level high; "L" = Digital level low; "X" = Don't care; "Floating" = the analog output is not driven.

Table 19. Mode Transitions

Initial Mode	Supply Undervoltage Flag / Event			Wake Flag	Host Event		Next Mode
	V_{IO}	V_{BAT}	V_{CC}		STBN	EN	
NORMAL	L	L	L	X	H	H→L	RECEIVE-ONLY
	L	L	L	X	H→L	H→L	STANDBY
	L	L	L→H	X	X	X	
	L	L	L	X	H→L	H	GO-TO-SLEEP
	L→ H	L	X	X	X	X	SLEEP
	X	L→ H	L	X	X	X	
RECEICVE-ONLY	L	L	L	X	H	L→ H	NORMAL
	L	L	L	X	H→ L	L	STANDBY
	L	L	L→ H	X	X	X	
	L→ H	L	X	X	X	X	SLEEP
	X	L→ H	L	X	X	X	

Table 19. Mode Transitions

Initial Mode	Supply Undervoltage Flag / Event			Wake Flag	Host Event		Next Mode
	V_{IO}	V_{BAT}	V_{CC}		STBN	EN	
STANDBY	L	L	H → L	X	H	H	NORMAL
	L	L	L	X	L→ H	L→ H	
	L	L	**(b)** H → L	**(a)** → H	H	H	
	L	L	L	X	L → H	L	RECEIVE-ONLY
	L	L	H → L	X	H	L	
	L	L	**(b)** H → L	**(a)** → H	H	L	
	L	L	L	X	L	L → H	GO-TO-SLEEP
	L	L	H → L	X	L	H	
	L	L	H → L	**(a)** → H	L	H	
	L→H	L	X	X	X	X	SLEEP
	X	L→ H	L	X	X	X	
GO-TO-SLEEP	L	L	L	X	LH	H	NORMAL
	L	L	L→ H	X	X	X	STANDBY
	L	L	L	X	L	H→ L	
	L	L	L	L	L [1]	H [1]	SLEEP
	L → H	L	X	X	X	X	
	X	L → H	L	X	X	X	
SLEEP	L	L	L	L	LH	H	NORMAL
	H → L	L	L	L	H	H	
	L	H → L	L	L	H	H	
	L	L	H → L	L	H	H	
	L	L	L	L	L → H	L	RECEIVE-ONLY
	H → L	L	L	L	H	L	
	L	H → L	L	L	H	L	
	L	L	H → L	L	H	L	
	(b) → L	**(b)** → L	**(b)** → L	**(a)** → H	X	X	STANDBY
POWER-OFF	X	H→ L	X	X	X	X	STANDBY
Any	X	H	L→ H	X	X	X	POWER-OFF
	X	L→ H	H	X	X	X	

1. If GO-TO-SLEEP is selected for more than t_{SLEEP}

Notes:

1. **(a)** indicates the event that causes the transition.
2. **(b)** indicates the consequence of the event **(a)**.
3. “H” = Digital level high; “L” = Digital level low; “X” = Don’t care.

7.11.1 Error Pin Signalling

In Table 20 the signaling at the Error Not (ERRN) pin is shown.

Table 20. Error Not (ERRN) Signalling

Supply undervoltage Flag at VBAT, VIO, VCC	Remote Wake Flag	Local Wake Flag	Host Command		ERRN
			STBN	EN	
L	X	X	H	H	NOT [Error flag]
L	H	X	H	L	L
L	H	X	H	↑ (positive edge)	L → NOT [Error flag]
L	L	X	H	L	H
L	L	X	H	↑ (positive edge)	H → NOT [Error flag]
L	L	L	L	X	H
L	L	↑ (positive edge)	L	X	H → L
L	↑ (positive edge)	L	L	X	H → L
L	H	↑ (positive edge)	L	X	L
L	↑ (positive edge)	H	L	X	L
H	X	X	X	X	L

7.12 Loss of Ground

In case the ground of the device is disconnected and the host pins are open the bus lines are switched to Idle_HZ.

7.13 ERROR Flags Description

All error flags are reset after error readout is completed (see Section 7.15) or in POWER-OFF mode.

7.13.1 Undervoltage Detected VBAT Flag

This flag is set if an undervoltage event at VBAT is detected. This flag signals if undervoltage was detected but will not initiate a mode change.

7.13.2 Undervoltage Detected VIO Flag

This flag is set if an undervoltage event at VIO is detected. This flag signals if undervoltage was detected but will not initiate a mode change.

7.13.3 Undervoltage Detected VCC Flag

This flag is set if an undervoltage event at VCC is detected. This flag signals if undervoltage was detected but will not initiate a mode change.

7.13.4 Bus Error

The bus error flag is set, after a time t_{BUS_INHIB} while the driver is enabled and activated until the end of the frame if

- 2 consecutive rising edges at the TxD pin without any rising edge at the RxD pin are detected, or
- 2 consecutive falling edges at the TxD pin without any falling edge at the RxD pin are detected.

The flag is only set in NORMAL mode.

7.13.5 Bus Open Line

BP open line can only be set in NORMAL mode if the driver is enabled. The flag is set if the absolute current through BP or BM is lower than I_{THL} for a time longer than t_{BUS_ERROR}. The flag is meaningful only if no short circuit flag is set.

7.13.6 BP Short Circuit to VCC

BP short circuit to VCC can only be set in NORMAL mode if the driver is enabled. The flag is set if the absolute current flowing through BP is higher than I_{THH} during transmission of Data0 for a time longer than t_{BUS_ERROR}.

7.13.7 BP Short Circuit to GND

BP short circuit to GND can only be set in NORMAL mode if the driver is enabled. The flag is set if the absolute current flowing through BP is higher than I_{THH} during transmission of Data1 for a time longer than t_{BUS_ERROR}.

7.13.8 BM Short Circuit to Vcc

BM short circuit to VCC can only be set in NORMAL mode if the driver is enabled. The flag is set if the absolute current flowing through BM is higher than I_{THH} during transmission of Data1 for a time longer than t_{BUS_ERROR}.

7.13.9 BM Short Circuit to GND

BM short circuit to GND can only be set in NORMAL mode if the driver is enabled. The flag is set if the absolute current flowing through BM is higher than I_{THH} during transmission of Data0 for a time longer than t_{BUS_ERROR}.

7.13.10 Short Circuit between BP and BM

The flag is set if, after a time t_{BUS_INHIB} while the driver is enabled and active until the end of the current FlexRay frame and the absolute differential bus voltage is lower than V_{SHORT}.

7.13.11 Over-temperature

This flag can only be set and reset in the non-low-power modes. The flag is set if the junction temperature exceeds OT_{TH} and is reset if the junction temperature falls below OT_{TL}.

7.13.12 TxEN_BGE Timeout

This flag can only be set in NORMAL mode if the driver is enabled (TxEN is low and BGE is high) for a time longer than t_{TxEN_max}. It is reset after every status change at TxEN or BGE or if the device exits NORMAL mode. In case the flag is set the driver is disabled.

7.13.13 Error Flag

This flag is set if at least one error flag (as listed below) is set, except undervoltage VBAT, VIO and VCC (refer to sections 7.13.1, 7.13.2 & 7.13.3). The error flag is reset if none of the flags are set.

Table 21. Functional Blocks

Section No.	Flag Name
7.13.4	Bus Error
7.13.5	Bus Open Line
7.13.6	BP Short Circuit to VCC
7.13.7	BP Short Circuit to GND
7.13.8	BM Short Circuit to VCC
7.13.9	BM Short Circuit to GND
7.13.10	Short Circuit between BP and BM
7.13.11	Over-temperature
7.13.12	TxEN_BGE Timeout

Note: The error flag is signalled on ERRN pin according to Table 20.

7.14 STATUS Flags Description

7.14.1 Local and Remote Wake Flag

Local and remote flags and function are described in Section 7.7 Wake-Up Events.

7.14.2 Power on Flag

The power on flag is set leaving the POWER-OFF state and it is reset entering a low-power mode after a non-low-power mode.

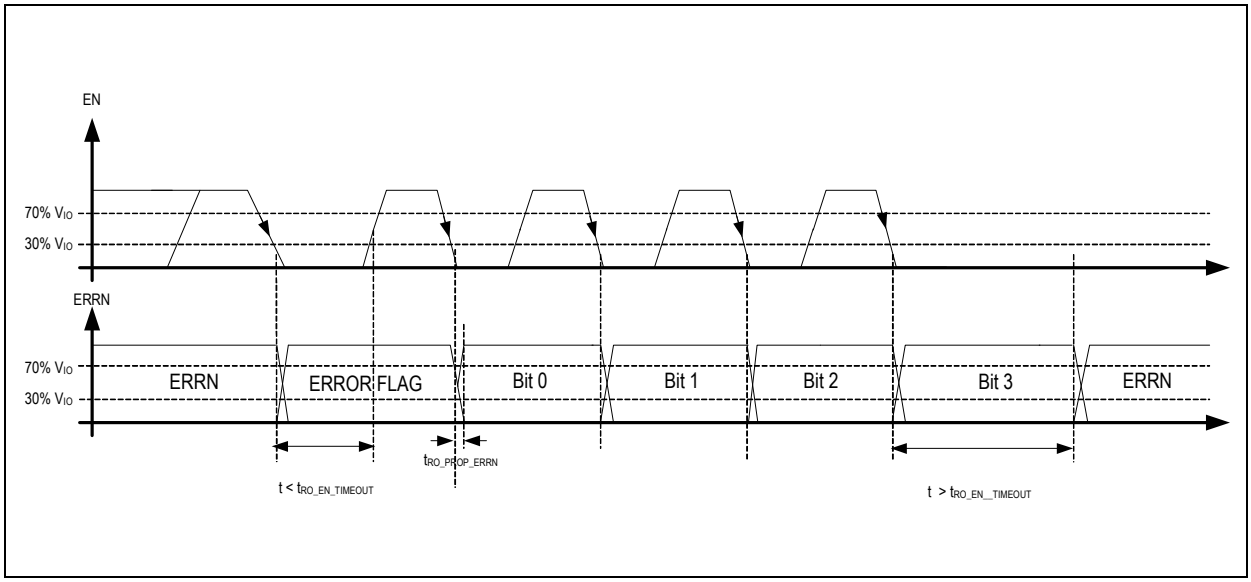
7.14.3 BGE Status

The BGE status flag is set if BGE is high and is reset if BGE is low. The state of the BGE is latched at the beginning of the readout cycle.

7.15 Error and Status Flags Read Out

The error and status flag readout mechanism is a serial transmission which is controlled with the EN pin and the information is submitted on the ERRN pin. The mechanism is only activated in NORMAL and RECEIVE-ONLY mode. In all other operation modes the error and status information cannot be accessed.

Figure 6. Timing of the Readout Mechanism



The error and status flags are read out by applying a clock signal to pin EN. A falling edge on pin EN starts the readout loading the content of the error/status flag into the shift register and signaling the stream of flags on the ERRN pin. On the second falling edge the first flag (Bit 0) will be shifted out. The ERRN data is valid after $t_{RO\_PROP\_ERRN}$. If EN pin keeps on toggling after last flag (Bit 15) the next flag shifted out is Bit 0. The complete list of bits is shown in Table 22. If no transition is detected on pin EN for longer than $t_{RO\_EN\_TIMEOUT}$ the device enters the operation mode indicated by the host pins.

Table 22. Bit Order for the Readout Sequence

BIT	Flag Description
Bit 0	Undervoltage VBAT detected
Bit 1	Undervoltage VIO detected
Bit 2	Undervoltage VCC detected
Bit 3	Bus error
Bit 4	BGE status
Bit 5	BP short circuit to VCC
Bit 6	BP short circuit to GND
Bit 7	Bus open line
Bit 8	BM short circuit to VCC
Bit 9	BM short circuit to GND
Bit 10	Short circuit between BP and BM
Bit 11	Over temperature
Bit 12	TxEN_BGE timeout
Bit 13	Local wake flag
Bit 14	Remote wake flag
Bit 15	Power on flag

8 Bus Driver

8.1 AS8222 Bus States

Activity: Differential bus signals as shown in chapter 10.3 Transmitter and 10.4 Receiver applies.

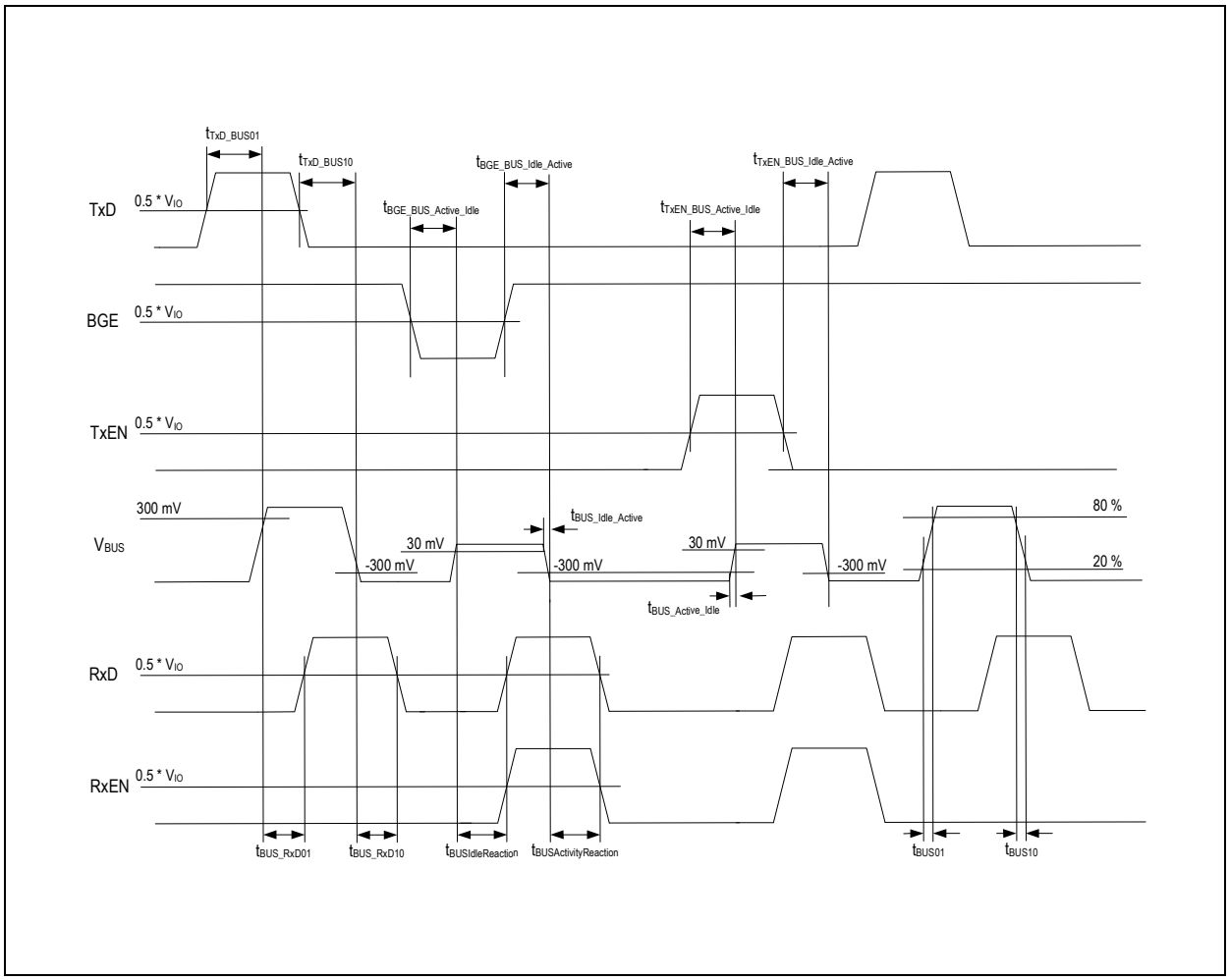
Idle: The bus wires are terminated to VCC / 2 through the receiver input resistances.

Idle_LP: The bus wires are terminated to GND through the receiver input resistances.

Idle_HZ: The bus wires are not terminated. The input resistances are about 1 M Ω.

8.2 Transceiver Timing

Figure 7. Bus Driver Timing Diagram

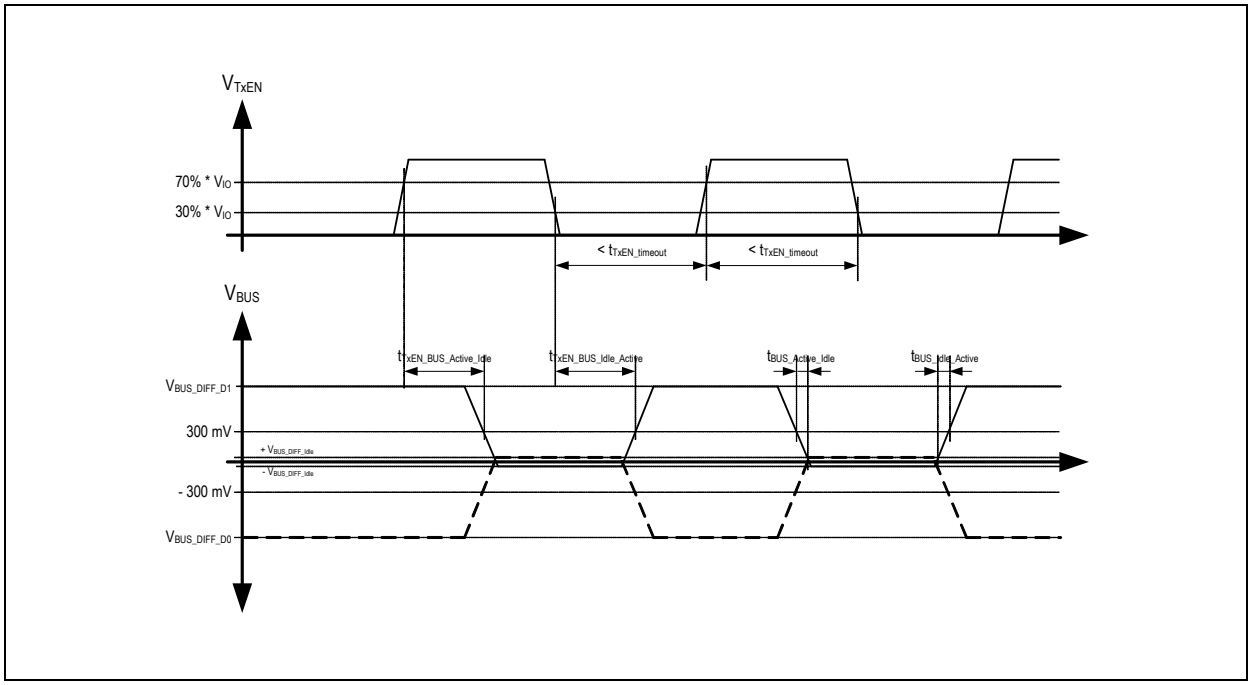


8.3 Transmitter

In NORMAL mode, while BGE is high, the transmitter drives full voltage levels on the bus after $t_{TXEN\_BUS\_Idle\_Active}$ from TxEN falling edge and drives idle after $t_{TXEN\_BUS\_Active\_Idle}$ from TxEN rising edge.

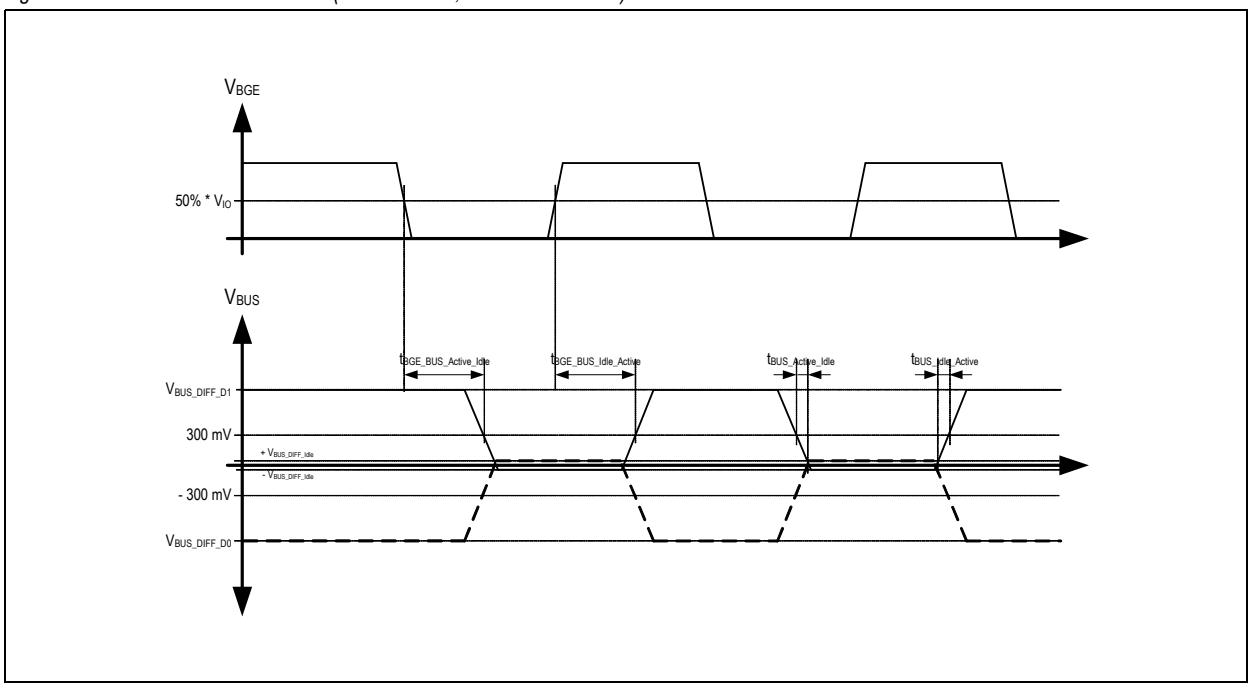
The Transmitter is not permanently enabled. If after the time $t_{TxEN\_timeout}$ no edge is detected at TxEN, the transmission will be stopped to avoid unwanted collisions on the FlexRay bus.

Figure 8. Transmitter Characteristics (TxEN → BUS, while BGE is high)



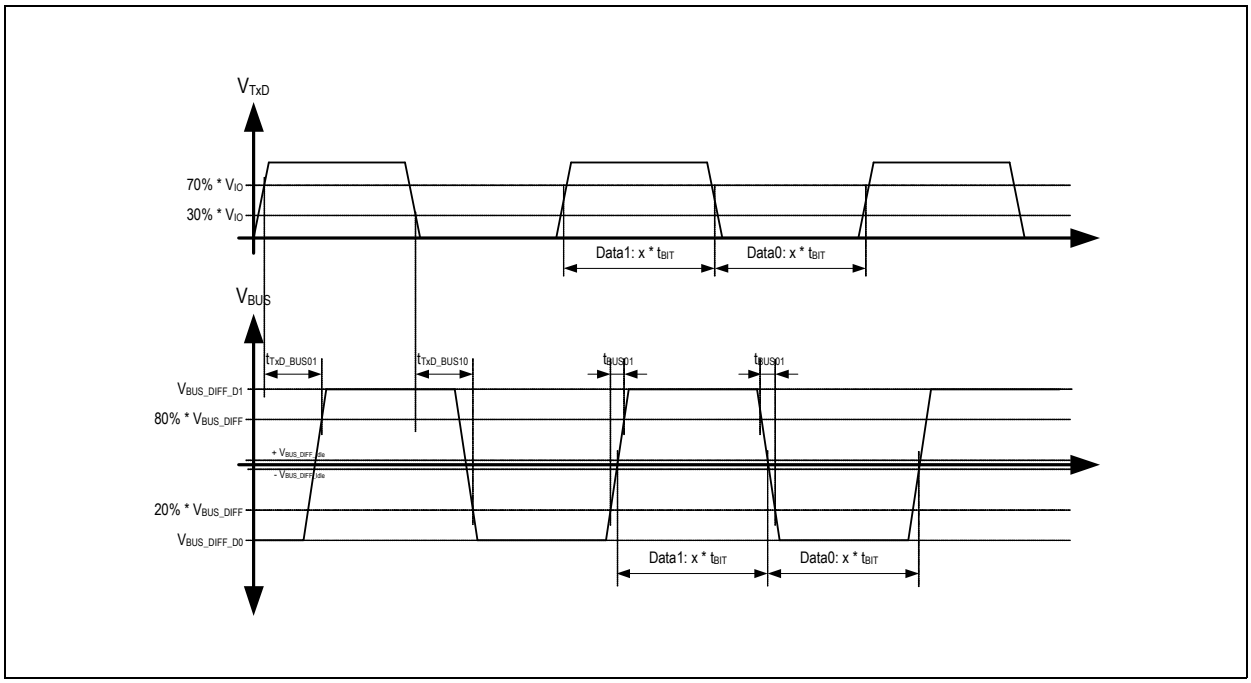
In NORMAL mode, while TxEN is high, the transmitter drives full voltage levels on the bus after $t_{TXEN\_BUS\_Idle\_Active}$ from BGE rising edge and drives idle after $t_{TXEN\_BUS\_Active\_Idle}$ from BGE falling edge.

Figure 9. Transmitter Characteristics (BGE → BUS, while TxEN is low)



The transmitter generates the FlexRay differential bus voltage according to input signal on TxD as shown in Figure 10.

Figure 10. Transmitter Characteristics TxD → BUS

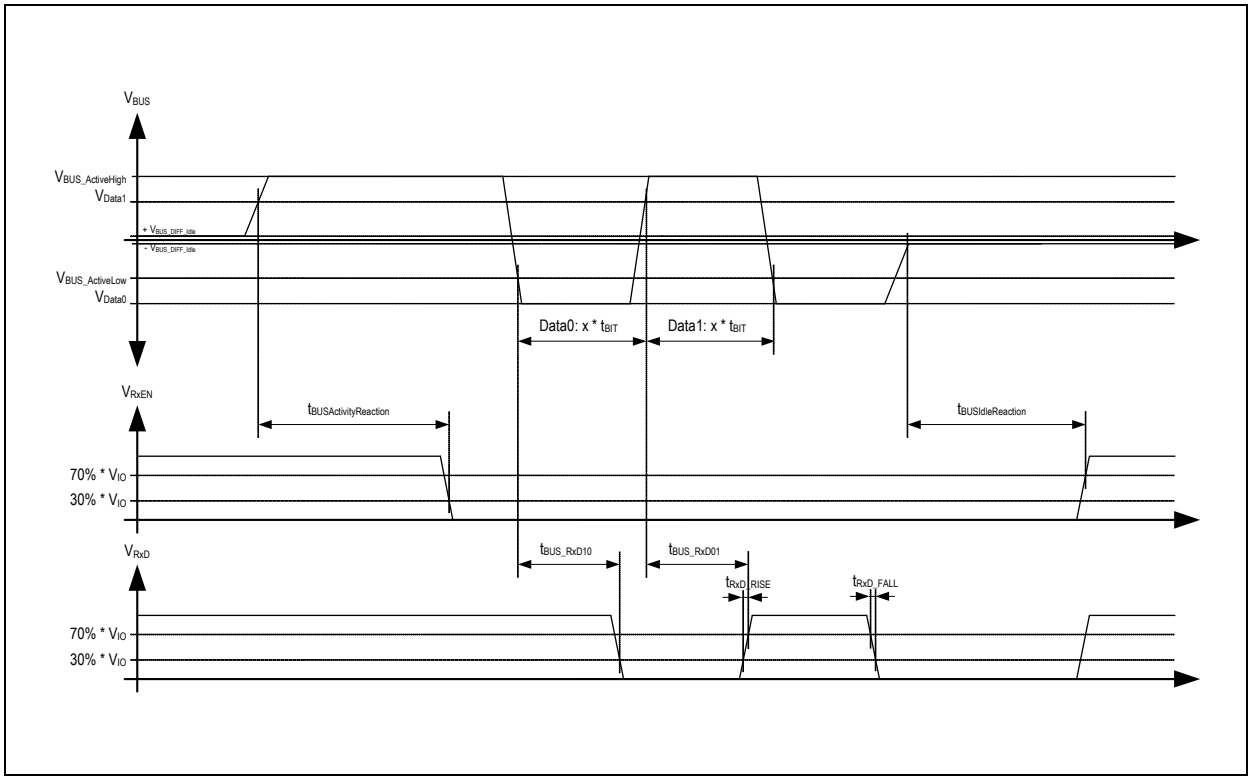


In NORMAL and RECEIVE-ONLY mode the transmitter drives Idle on the bus in case no data are transmitted. In STANDBY, GO-TO-SLEEP and SLEEP mode the transmitter drives Idle_LP (idle low-power) on the bus pins. In POWER_OFF mode the bus pins shows Idle_HZ (idle high impedance).

8.4 Receiver

The receiver generates from the FlexRay differential bus voltage a digital signal on the RxD and RxEN pins. RxD shows the data (Data0 and Data1) and RxEN shows the bus idle and activity status received on the bus pins. The receiver is only active in NORMAL and RECEIVE_ONLY mode.

Figure 11. Timing Characteristics (BUS → RxD and RxEN)



8.4.1 Bus activity and idle detection (only in NORMAL and RECEIVE ONLY mode)

- If the absolute differential bus voltage is higher than $V_{BUSActiveLow}$ and less than $V_{BUSActiveHigh}$ for a time longer than $t_{BUSIdleDetection}$, bus Idle is detected, RxEN and RxD are switched to logical high after with a time $t_{BUSIdleReaction}$.
- If the absolute differential bus voltage is higher than $V_{BUSActiveHigh}$ or lower than $V_{BUSActiveLow}$ for a time loner than $t_{BUSActivitiyDetection}$, bus Activity is detected, RxEN is switched to logical low and RxD is following the detected bus data states as indicated below with a time $t_{BUSActivityReaction}$.

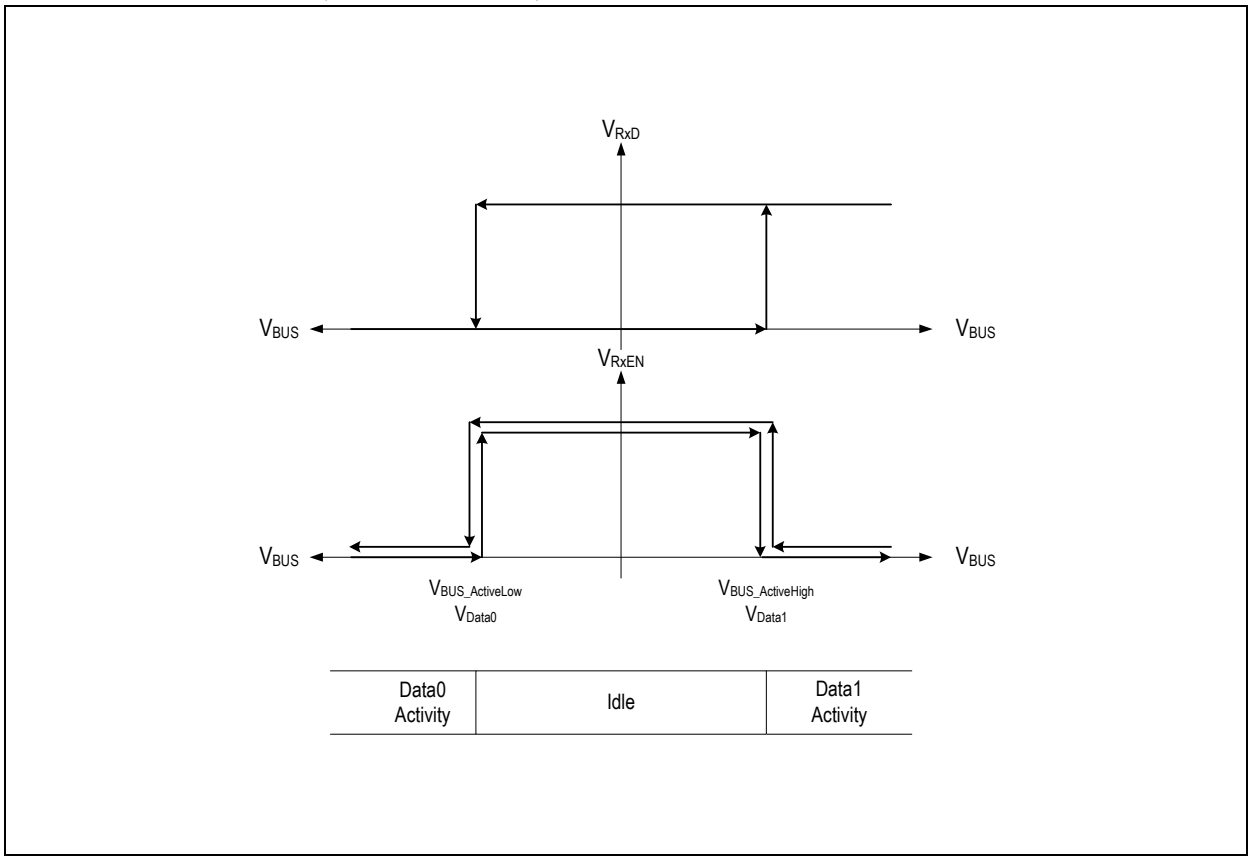
Table 23. Logic Table for Receiver Bus Signal Detection

Receiver Operation Mode	Bus State / Signals	RxEN	RxD
Normal power modes (NORMAL and RECEIVE-ONLY mode)	Idle	H	H
	Data0	L	L
	Data1	L	H

8.4.2 Bus Data Detection (Only in NORMAL and RECEIVE ONLY Mode)

- If, after the activity detection the differential bus voltage is higher than V_{Data1}, RxD will be high after a time t_{BUS_RxD01}.
- If, after the activity detection the differential bus voltage is lower than V_{Data0}, RxD will be low after a time t_{BUS_RxD10}.

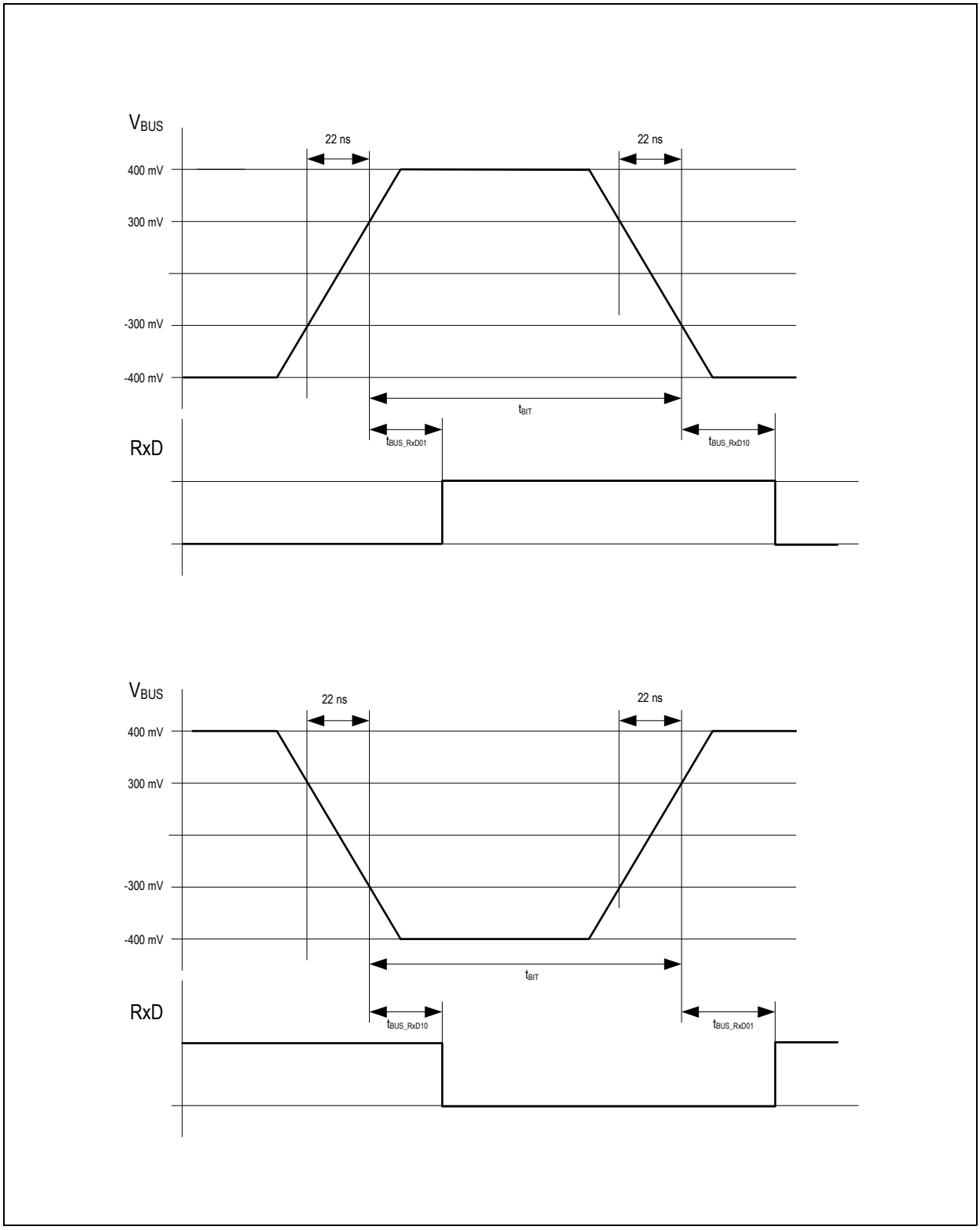
Figure 12. Receiver Characteristics (BUS → RxD and RxEN)



8.4.3 Receiver Test Signal

In Figure 13 the receiver test signal according the FlexRay Electrical Physical Layer specification is shown.

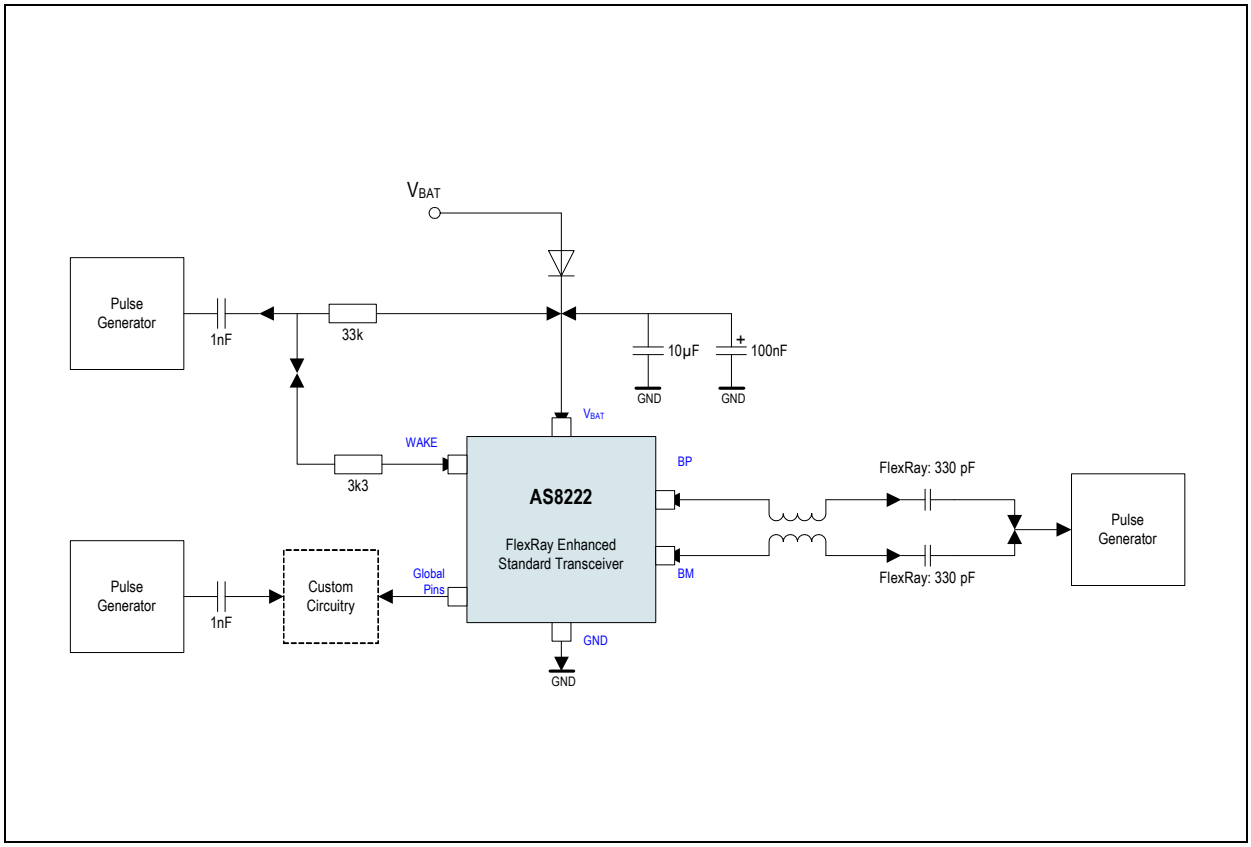
Figure 13. Receiver Test Signal



9 Test circuits

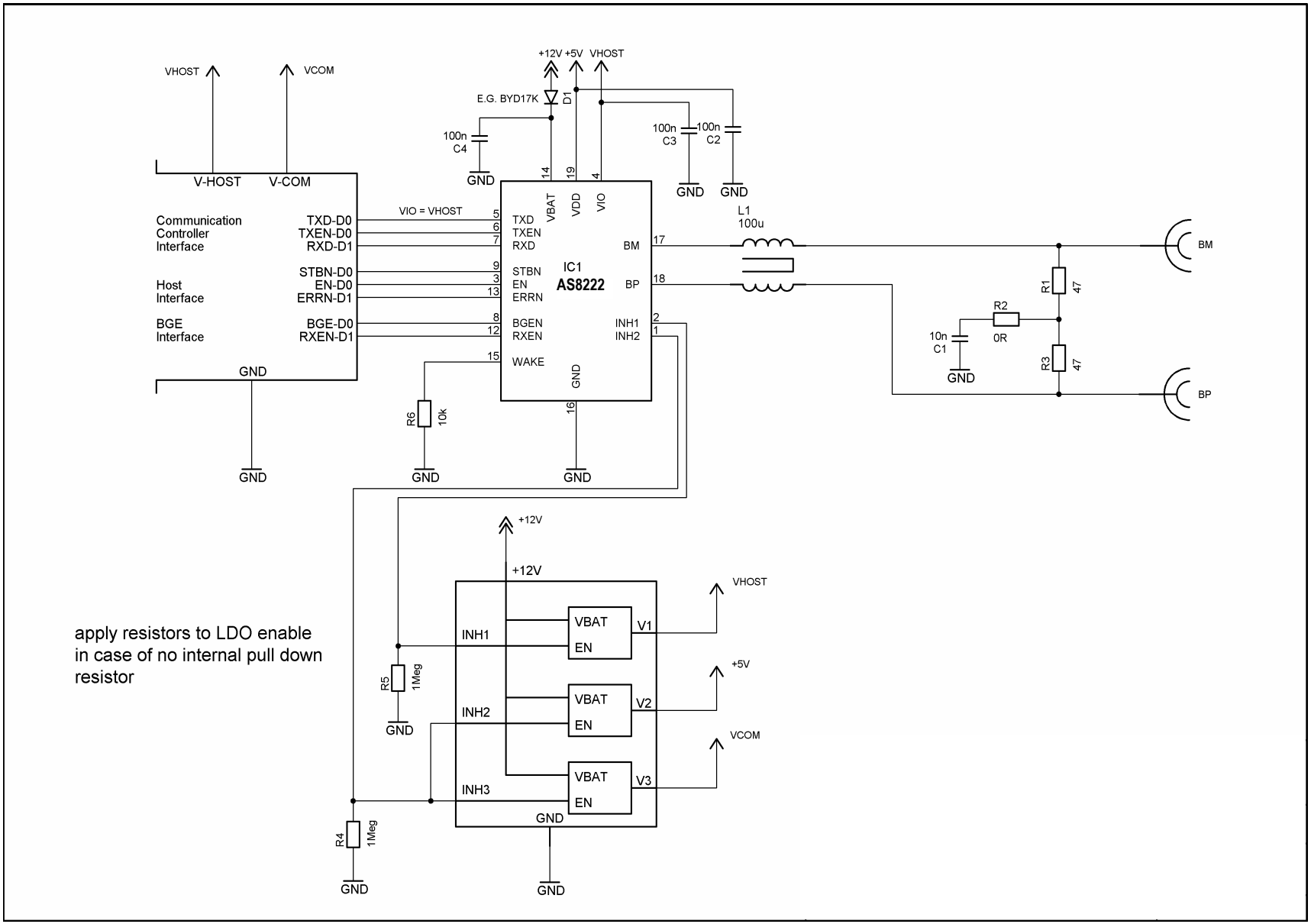
9.1 ISO7637-2 Test Pulses - Class D

Figure 14. Test Circuitry for ISO 7637 - 2 Test Pulses



9.2 Application Circuit

Figure 15. AS8222 Application Schematic



10 Appendix

10.1 FlexRay Functional Classes

The AS8222 FlexRay Enhances Standard Transceiver has the following Bus Driver function classes according the FlexRay Electrical Physical Layer Specification V2.1 Rev B implemented:

- Functional Class: Chapter 8.13.1 “Bus Driver voltage regulator control”
- Functional Class: Chapter 8.13.2 “Bus Driver - Bus Guardian interface”
- Functional Class: Chapter 8.13.4 “Bus Driver logic level adaptation”

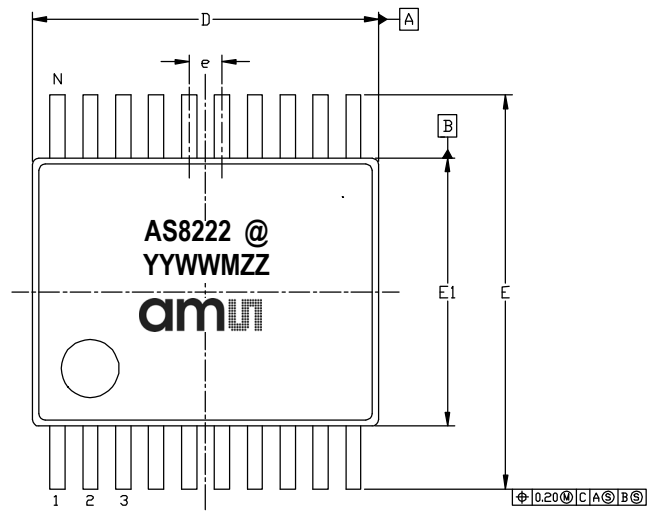
10.2 FlexRay Parameter Comparison

FlexRay Electrical Physical Layer Specification V2.1 Rev. B parameters are shown in color blue in tables (2 to 15).

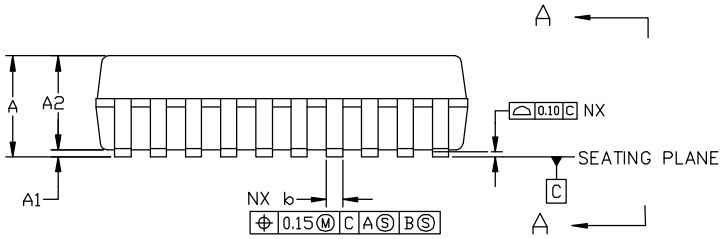
11 Package Drawings and Markings

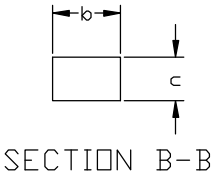
The product is available in 20-Lead Shrink Small Outline Package SSOP-20.

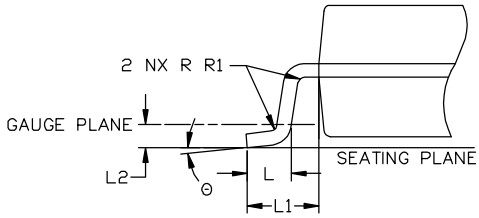
Figure 16. Drawings and Dimensions



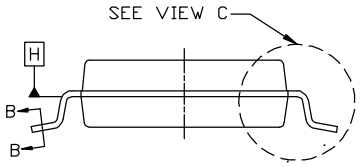
Symbol	Min	Nom	Max
A	1.73	1.86	1.99
A1	0.05	0.13	0.21
A2	1.68	1.73	1.78
b	0.22	0.30	0.38
c	0.09	0.17	0.25
D	6.90	7.20	7.50
E	7.40	7.80	8.20
E1	5.00	5.30	5.60
e	-	0.65 BSC	-
L	0.55	0.75	0.95
L1	-	125 REF	-
L2	-	0.25 BSC	-
R	0.09	-	-
Θ	0°	4°	8°
N		20	







VIEW C



VIEW A-A

Notes:

1. Dimensions & tolerancing conform to *ASME Y14.5M-1994*.
2. All dimensions are in millimeters. Angles are in degrees.
3. N is the total number of terminals.

Marking: YYWWMZZ.

YY	WW	M	ZZ	@
Year	Manufacturing Week	Assembly plant identifier	Assembly traceability code	Sublot identifier

Note: Package marking is not applied to engineering samples!

12 Ordering Information

Table 24. Ordering Information

Ordering Code	Marking	Description	Delivery Form	Package
AS8222-HSSP	AS8222	AS8222 Enhanced FlexRay Standard Transceiver	Tape & Reel in Dry Pack (1 reel = 2000 units)	SSOP-20
AS8222-HSSM	AS8222	AS8222 Enhanced FlexRay Standard Transceiver	Tape & Reel in Dry Pack (1 reel = 500 units)	SSOP-20

For bare die deliveries please contact ams customer service.

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Technical Support is available at www.ams.com/Technical-Support

For further information and requests, email us at sales@ams.com
(or) find your local distributor at www.ams.com/distributor

Revision History

Revision	Date	Owner	Description
1.0	11 Dec, 2012	hgl	Initial version

Note: Typos may not be explicitly mentioned under revision history.

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