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AS8223
FlexRay Active Star Device

1 General Description

This document is subject to change without notice.

The AS8223 is a monolithic FlexRay compliant Active Star Device that manages communication traffic among four FlexRay branches of the network, expandable to more branches through an Interstar interface.

The four branches of the AS8223 operate as a FlexRay receiver and transmitter; wherein one of the communication paths operates as a receiver while the rest operate as a transmitter.

Additionally, the AS8223 comes with a Host Controller Interface to achieve active control of the power modes and error diagnosis. An autonomous mode is entered automatically, in which the device operates without the need for a host controller. A Communication Controller interface is also built into the AS8223, to provide the standard transceiver functionality on the ECU using the AS8223.

The product is available in 44-pin MLF (9x9) package.

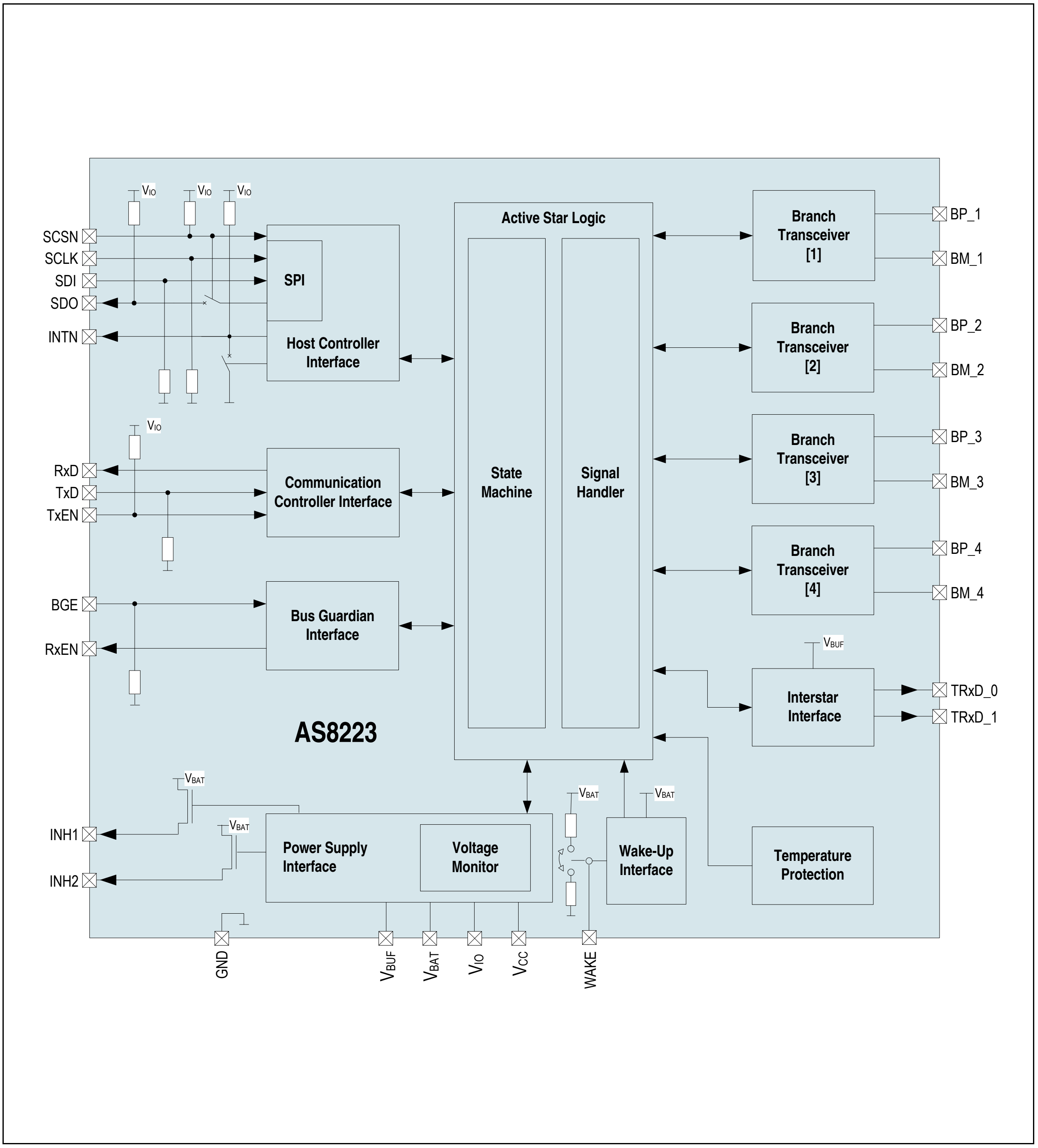
2 Key Features

- Active Star Device with four branches
- Message forwarding on six communication paths (Communication Controller Interface, four FlexRay branches, Interstar Interface)
- Data transfer up to 10Mbps
- Compliant with FlexRay Electrical Physical Layer Specification V2.1 Rev B
- Excellent EMC performance
- Low susceptibility to EMI
- Interface with optional bus guardian for bus supervision
- Automatic thermal shutdown protection
- Supports 12V and 24V systems with low sleep current
- Integrated power management system
- Two INH pins for the external voltage regulators control
- Local wake-up input
- Remote wake-up capability via FlexRay bus
- Supports Autonomous Power Mode and Host Controlled Power Mode management
- Supports 2.5V, 3V, 3.3V and 5V microcontrollers; automatically adapts to interface levels
- VCC supply voltage buffer for fail-safe conditions
- Protection against damage due to short circuit conditions on the FlexRay branches (positive and negative battery voltage)
- Operating ambient temperature range -40ºC to +125ºC
- RoHs compliant
- 44-pin MLF (9x9) package

3 Applications

The AS8223 FlexRay Active Star Device is tailored for automotive gateways with embedded FlexRay Active Star functionality. Several devices can be connected to the chip's Interstar interface, thereby enabling the extension of the FlexRay branches in order to meet specific application requirements.

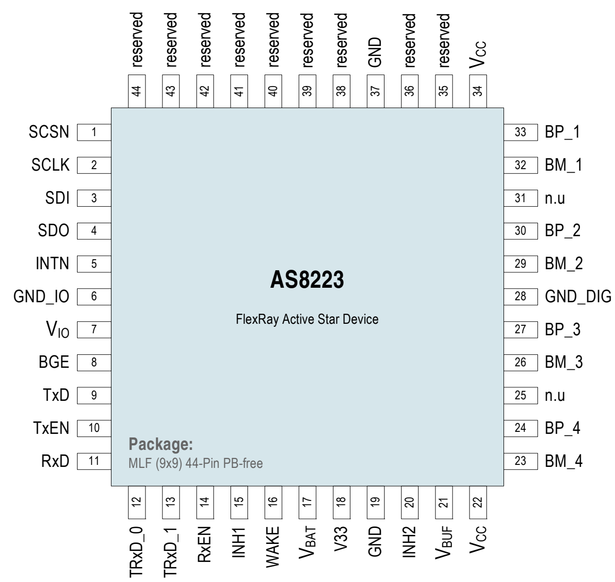
Figure 1. AS8223 FlexRay Active Star Device Block Diagram



Contents

4 Pin Assignments

Figure 2. Pin Assignments (Top View)



4.1 Pin Descriptions

Table 1. Pin Descriptions

Pin Name	Pin Number	Pin Type	Description
SCSN	1	Digital input with pull-up	SPI chip select
SCLK	2	Digital input with pull-down	SPI clock
SDI	3		SPI data in
SDO	4	Digital output / tristate	SPI data out
INTN	5	Digital output open drain	Interrupt output
GNDIO	6	Supply	Ground
VIO	7		I/O supply input voltage
BGE	8	Digital input with pull-down	Bus guardian enable input
TxD	9		Transmit data input
TxEN	10	Digital input with pull-up	Transmitter enable input
RxD	11	Digital output	Receive data output
TRxD_0	12	Digital I/O	Interstar Bus line 0
TRxD_1	13		Interstar Bus line 1
RxEN	14	Digital output	Receive data enable output

Table 1. Pin Descriptions

Pin Name	Pin Number	Pin Type	Description
INH1	15	Analog I/O	Inhibit output for switching external voltage regulator
WAKE	16		Local Wake input
V_{BAT}	17	Supply	Battery supply input voltage
V33	18	Analog I/O	Internal voltage stabilizing output
GND	19	Supply	Ground
INH2	20	Analog I/O	Inhibit output for switching external voltage regulator
V_{BUF}	21		TRxD_0, TRxD_1 stabilizing output
V_{CC}	22	Supply	Supply input voltage
BM_4	23	Analog I/O	Bus line minus branch 4
BP_4	24		Bus line plus branch 4
n.u	25	-	Not used
BM_3	26	Analog I/O	Bus line minus branch 3
BP_3	27		Bus line plus branch 3
GNDD	28	Supply	Digital ground
BM_2	29	Analog I/O	Bus line minus branch 2
BP_2	30		Bus line plus branch 2
n.u	31	-	Not used
BM_1	32	Analog I/O	Bus line minus branch 1
BP_1	33		Bus line plus branch 1
V_{CC}	34	Supply	Supply voltage
Reserved	35	-	To be connected to GND
Reserved	36	-	To be connected to GND
GND	37	Supply	Ground
Reserved	38	-	To be left unconnected
Reserved	39	-	To be left unconnected
Reserved	40	-	To be connected to GND or to be left unconnected
Reserved	41	-	To be connected to GND or to be left unconnected
Reserved	42	-	To be connected to GND or to be left unconnected
Reserved	43	-	To be connected to GND or to be left unconnected
Reserved	44	-	To be connected to GND or to be left unconnected

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 Electrical Characteristics on page 9 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	+40	V	
V_{CC}	Supply Voltage	-0.3	+7.0	V	
V_{IO}		-0.3	+7.0	V	$V_{IO} < V_{CC}$
V_{BUF}	Stabilizing voltage output	-0.3	+5.0	V	
V33					
	DC Voltage at INTN, TxD, RxD, TxEN, BGE, RxEN, SCSN, SCLK, SDI, SDO	-0.3	V_{IO} + 0.3	V	
V_{TRxD0}, V_{TRxD1}	DC Voltage at Interstar interface	-0.3	V_{BUF} + 0.3	V	
	DC Voltage on pin WAKE, INH1, INH2	-0.3	V_{BAT} + 0.3	V	
	DC voltage at GNDIO, GNDD	-0.3	+0.3	V	
	DC Voltage at BP_{1-4} and BM_{1-4}	-40	+40	V	
	Input current (latchup immunity)	-100	100	mA	According to AEC-Q100-004
Electrostatic Discharge					
ESD	Electrostatic discharge at bus lines V_{BAT}, WAKE	-4	+4	kV	According to AEC-Q100-002 (HBM)
	Electrostatic discharge at bus lines BP_{1-4}, BM_{1-4}	-6	+6	kV	According to AEC-Q100-002 (HBM)
	Electrostatic discharge at bus lines BP_{1-4}, BM_{1-4}, V_{BAT}, WAKE	-6	+6	kV	According to FlexRay Physical Layer EMC Measurement Specification Version 3.0
	Electrostatic discharge on all pins	-2	+2	kV	According to AEC-Q100-002 (HBM)
		-500	+500	V	According to AEC-Q100-011 (Charge Device Model)
		-100	+100	V	According to AEC-Q100-003 (Machine Model)
Damage Tests					
U_S	Transient voltage on V_{BAT}, BM and BP pins	-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)

Table 2. Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Units	Note
Power Dissipation					
P_t	Total power dissipation (all supplies and outputs)		1	W	
Temperature Ranges and Storage Conditions					
T_{strg}	Storage temperature	-55	+150	ºC	
T_J	Junction temperature	-40	+150	ºC	
T_{BODY}	Package body temperature		+260	ºC	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).
	Humidity non-condensing	5	85	%	
Φja	Package thermal resistance		25	ºC/W	
MSL	Moisture Sensitivity Level	3			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.

T_J=-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=45Ω, C_L= 100pF, C_{RxD}= 15pF, C_{VBUF}=1µF, C_{V33}=1µF unless otherwise specified.

6.1 Supply Voltage

Table 3. Supply Voltage

Symbol	Parameter	Conditions	Min	Typ	Max	Units
T_{AMB}	Ambient temperature		-40		+125	ºC
V_{CC}-V_{IO}	Difference of supplies		-0.1		+3.05	V
I_{BAT}	V_{BAT} current consumption	V_{BAT}=12V; AS_SLEEP and AS_STANDBY mode; T_J<125ºC (see footnote 1)	0		150	µA
		V_{BAT}=12V; AS_SLEEP and AS_STANDBY; T_J<150ºC (see footnote 1)	0		150	µA
		V_{BAT}=12V; AS_SLEEP and AS_ STANDBY mode; T_J<125ºC, one remote wake-up branch active. (see footnote 1)	0		100	µA
		AS_NORMAL mode	0		1	mA
I_{CC}	V_{CC} current consumption	AS_SLEEP and AS_STANDBY mode; V_{CC} = 0V to +5.25V (see footnote 1)	-5		50	µA
		AS_NORMAL, all driver enabled	0		200	mA
		AS_NORMAL, all driver enabled; R_{BUS}=∞ Ω	0		50	mA
I_{IO}	V_{IO} current consumption	AS_SLEEP and AS_STANDBY mode; V_{IO} = 0V to +5.25V (see footnote 1)	-9		+9	µA
		AS_NORMAL mode	0		1	mA
V_{33}	V33 voltage	AS_NORMAL mode; I_{33}=10mA	3		3.6	V
		AS_SLEEP and AS_STANDBY mode; I_{33}=1mA	2.5		3.6	V
V_{BUF}	V_{BUF} voltage		1.2		1.3	V

1. SCSN, SCLK, SDI, SDO, INTN, TxD, RxD, TxEN, BGE, RxEN, WAKE, INH1, INH2, TRxD_0, TRxD_1, Pin 36, Pin 38, Pin 39, Pin 35: Unconnected.

6.2 State Transitions Active Star

Table 4. State Transitions Active Star

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{AS\_LP\_INHx\_H}$	Delay time Host Command to INHx = "high" from AS_SLEEP and AS_STANDBY mode	INHx "high" = 80% VBAT			50	µs
$t_{AS\_Normal\_INHx\_L}$	Delay time Host Command to INHx = "low" from AS_NORMAL mode	INHx "low" = 20% VBAT, 10kΩ external pull-down			10	µs
$t_{AS\_Standby\_INHx\_L}$	Delay time Host Command to INH1 = "low" from AS_STANDBY mode	INH1 "low" = 20% VBAT 10kΩ external pull-down			50	µs
$t_{AS\_LP\_INHx\_H}$	Delay time wake-up event to INHx = "high" from AS_SLEEP and AS_STANDBY mode	INHx "high" = 80% VBAT			50	µs
$t_{AS\_LP\_RxD\_H}$	Delay time wake-up event to RxD = "high" from AS_SLEEP and AS_STANDBY mode	Wake-up flag set			100	µs
$t_{AS\_LP\_RxEN\_H}$	Delay time wake-up event to RxEN = "high" from AS_SLEEP and AS_STANDBY mode	Wake-up flag set			100	µs
$t_{ASSLEEP}$	Go-to-sleep timeout (APM mode)	INH1 low = 20% VBAT 10kΩ external pull-down	640		6400	ms

6.3 Branch to Branch Timing

Table 5. Branch to Branch Timing

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{BUSxy\_TSS\_length\_change}$	Frame TSS length change from BUSx to BUSy				450	ns
$t_{BUSxy\_FES1\_length\_change}$	Prolongation of last bit of a frame from BUSx to BUSy				450	ns
$t_{BUSxy\_symbol\_length\_change}$	Symbol length change		-300		450	ns
$t_{BUSxy01}$	Delay time from BUSx to BUSy positive edge				150	ns
$t_{BUSxy10}$	Delay time from BUSx to BUSy negative edge				150	ns
$t_{BUSxy\_asymmetry}$	Delay time from BUSx to BUSy data asymmetry	$t_{BUSxy01} – t_{BUSxy10}$	-8		8	ns

6.4 Communication Controller to Branch Timing

Table 6. Communication Controller to Branch Timing

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{TxD_BUS01}	Delay time from TxD to BUS positive edge	t_{TxD01} = 5ns			50	ns
t_{TxD_BUS10}	Delay time from TxD to BUS negative edge	t_{TxD10} = 5ns			50	ns
$t_{TxD\_BUS\_asymmetry}$	Delay time from TxD to BUS asymmetry	$t_{TxD\_BUS10} - t_{TxD\_BUS01}$	-4		4	ns
$t_{TxEN\_BUS\_IdleActive}$	Delay time from TxEN to BUS active				250	ns
$t_{TxEN\_BUS\_ActiveIdle}$	Delay time from TxEN to BUS idle				250	ns
$t_{TxEN\_BUS\_asymmetry}$	Delay time from TxEN to BUS active-idle asymmetry	$t_{TxEN\_BUS\_IdleActive} - t_{TxEN\_BUS\_ActiveIdle}$	-50		50	ns
$t_{BGE\_BUS\_IdleActive}$	Delay time from BGE to BUS active				250	ns
$t_{BGE\_BUS\_ActiveIdle}$	Delay time from BGE to BUS idle				250	ns

6.5 Branch to Communication Controller Timing

Table 7. Branch to Communication Controller Timing

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{BUS_RxD10}	Delay from BUS to RxD negative edge				80	ns
t_{BUS_RxD01}	Delay from BUS to RxD positive edge				80	ns
t_{bit}	Bit time		54			ns
$t_{BUS\_RxD\_asymmetry}$	Delay time from BUS to RxD asymmetry	$t_{BUS\_RxD10} - t_{BUS\_RxD01}$	-5		5	ns
t_{BUS_RxEN01}	Delay time from BUS idle to RxEN positive edge		50		400	ns
t_{BUS_RxEN10}	Delay time from BUS active to RxEN negative edge		100		450	ns

6.6 Interstar to Branch Timing

Table 8. Interstar to Branch Timing

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{IS01_BUS01}	Delay time from ISI to BUS positive edge	t_{IS01} = 5ns			70	ns
t_{IS01_BUS10}	Delay time from ISI to BUS negative edge	t_{IS10} = 5ns			70	ns
$t_{IS\_BUS\_asymmetry}$	Delay time from ISI to BUS asymmetry	$t_{IS10\_BUS10} - t_{IS01\_BUS01}$	-5		5	ns
$t_{IS\_BUS\_IdleActive}$	Delay time from ISI to BUS active				200	ns
$t_{IS\_BUS\_ActiveIdle}$	Delay time from ISI to BUS idle				200	ns

6.7 Branch to Interstar Timing

Table 9. Branch to Interstar Timing

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{BUS\_IS\_ActiveIdle}$	Delay time from BUS idle to ISI idle		50		400	ns
$t_{BUS\_IS\_IdleActive}$	Delay time from BUS active to ISI active		100		450	ns
t_{BUS_IS10}	Delay from BUS to ISI negative edge				100	ns
t_{BUS_IS01}	Delay from BUS to ISI positive edge				100	ns
t_{bit}	Bit time		54			ns
$t_{BUS\_IS\_asymmetry}$	Delay time from BUS to ISI asymmetry	$t_{BUS\_IS10} - t_{BUS\_IS01}$	-5		5	ns

6.8 Communication Controller to Interstar Timing

Table 10. Communication Controller to Interstar Timing

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{TxD01_IS01}	Delay time from TxD to ISI positive edge	t_{TxD01} = 5ns			50	ns
t_{TxD10_IS10}	Delay time from TxD to ISI negative edge	t_{TxD01} = 5ns			50	ns
$t_{TxD\_IS\_asymmetry}$	Delay time from TxD to ISI asymmetry	$t_{TxD01\_IS01} - t_{TxD10\_IS10}$	-4		4	ns
$t_{TxEN\_IS\_IdleActive}$	Delay time from TxEN to ISI active				150	ns
$t_{TxEN\_IS\_ActiveIdle}$	Delay time from TxEN to ISI idle				150	ns
$t_{BGE\_IS\_IdleActive}$	Delay time from BGE to ISI active				150	ns
$t_{BGE\_IS\_ActiveIdle}$	Delay time from BGE to ISI idle				150	ns

6.9 Interstar to Communication Controller Timing

Table 11. Interstar to Communication Controller Timing

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{IS01_RxD01}	Delay time from ISI to RxD positive edge	t_{IS01} = 5ns			50	ns
t_{IS01_RxD10}	Delay time from ISI to RxD negative edge	t_{IS10} = 5ns			50	ns
$t_{IS\_RxD\_asymmetry}$	Delay time from ISI to RxD asymmetry	$t_{IS10\_RxD10} - t_{IS01\_RxD01}$	-5		5	ns
$t_{IS\_RxEN\_01}$	Delay time from ISI to RxEN positive edge				150	ns
$t_{IS\_RxEN\_10}$	Delay time from ISI to RxEN negative edge				150	ns

6.10 Active Star General Timing

Table 12. Active Star General Timing

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{STAR_COL}	Active Star collision filter time	Guaranteed by design			50	ns
t_{exit_fail}	Idle detection time to exit branch fail silent	Programmable via SPI command		1.1	10	µs
t_{ears_shut}	Blanking time between two frames	Programmable via SPI command		1		µs
$t_{BranchNoiseTimeout}$	Branch noise timeout	Programmable via SPI command	1.5		10	ms
$t_{CCNoiseTimeout}$	Communication Controller noise timeout	Programmable via SPI command	1.5		10	ms
$t_{EarsShut\_Fault}$	Blanking time between two frames for faulty branches	Programmable via SPI command		5		µs
$t_{TxEN\_RxD\_ActiveIdle}$	Delay time from TxEN rising edge to RxD rising edge; change of bus active to bus idle (loopback)				250	ns

6.11 Transmitter

The following parameters are applicable to all the branch transmitters.

Table 13. Transmitter

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$V_{BUS\_DIFF\_D0}$	Differential bus voltage low in BRANCH_ACTIVE mode (Data_0)	$V_{BPdata0} - V_{BMdata0}$; $40\Omega < R_L < 55\Omega$	-2		-0.6	V
$V_{BUS\_DIFF\_D1}$	Differential bus voltage high in BRANCH_ACTIVE mode (Data_1)	$V_{BPdata1} - V_{BMdata1}$; $40\Omega < R_L < 55\Omega$	0.6		2	V
ΔV_{BUS_DIFF}	Matching between Data_0 and Data_1 differential bus voltage in BRANCH_ACTIVE mode	$V_{BUS\_DIFF\_D0} - V_{BUS\_DIFF\_D1}$ $40\Omega < R_L < 55\Omega$	-200		200	mV
$V_{BUS\_COM\_D0}$	Common mode bus voltage in case of Data_0 in Branch non-low-power mode	$V_{BPdata0}/2+V_{BMdata0}/2$ $40\Omega < R_L < 55\Omega$	0.4 * Vcc		0.6 * Vcc	V
$V_{BUS\_COM\_D1}$	Common mode bus voltage in case of Data_1 in Branch non-low-power mode	$V_{BPdata1}/2+V_{BMdata1}/2$ $40\Omega < R_L < 55\Omega$	0.4 * Vcc		0.6 * Vcc	V
ΔV_{BUS_COM}	Matching between Data_0 and Data_1 common mode voltage	$V_{BUS\_COM\_D0} - V_{BUS\_COM\_D1}$ $40\Omega < R_L < 55\Omega$	-200		200	mV
$V_{BUS\_DIFF\_Idle}$	Absolute differential bus voltage in bus idle mode				30	mV
$IBP_{BMShortMax}$ $IBM_{BPShortMax}$	Absolute maximum current if BP shorted to BM	$V_{BP} = V_{BM}$			+100	mA
$IBP_{GNDShortMax}$	Absolute maximum current if BP is shorted to GND	$V_{BP} = 0V$			+100	mA
$IBM_{GNDShortMax}$	Absolute maximum current if BM is shorted to GND	$V_{BM} = 0V$			+100	mA
$IBP_{-5VShortMax}$	Absolute maximum current if BP is shorted to -5V	$V_{BP} = -5V$			+100	mA
$IBM_{-5VShortMax}$	Absolute maximum current if BM is shorted to -5V	$V_{BM} = -5V$			+100	mA
$IBP_{27VShortMax}$	Absolute maximum current if BP is shorted to 27V	$V_{BP} = 27V$			+100	mA

Table 13. Transmitter

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$IBM_{27VShortMax}$	Absolute maximum current if BM is shorted to 27V	V_{BM} = 27V			+100	mA
$IBP_{40VShortMax}$	Absolute maximum current if BP is shorted to 40V	V_{BP} = 40V			+100	mA
$IBM_{40VShortMax}$	Absolute maximum current if BM is shorted to 40V	V_{BM} = 40V			+100	mA
t_{BUS_TX10}	Fall time differential bus voltage	80% – 20% of V_{BUS}	3.75		18.75	ns
t_{BUS_TX01}	Rise time differential bus voltage	20% – 80% of V_{BUS}	3.75		18.75	ns
$t_{BUS\_IdleActive}$	Differential bus voltage transition time: idle to active				30	ns
$t_{BUS\_ActiveIdle}$	Differential bus voltage transition time: active to idle				30	ns

6.12 Receiver

The following parameters are applicable to all the branch receivers.

Table 14. Receiver

Symbol	Parameter	Conditions	Min	Typ	Max	Units
R_{BP}, R_{BM}	BP, BM input resistance	Idle mode; $R_{BUS}=\infty$	10		40	KΩ
R_{DIFF}	BP, BM differential input resistance	Idle mode; $R_{BUS}=\infty$	20		80	KΩ
V_{CM}	Common mode voltage at receiver	2 x (|| V_{Data0} | - | V_{Data1} ||) / (| V_{Data0} | + | V_{Data1} |) x 100%, Test with (V_{BP} + V_{BM})/2 = V_{CM} = 2.5V	-10		+15	V
V_{BPidle}, V_{BMidle}	Idle voltage in Branch non-low-power modes on pin BP, BM	Branch non-low-power mode; V_{TxEN} = V_{IO} 40Ω || 100pF	0.4 * V_{CC}	0.5 * V_{CC}	0.6 * V_{CC}	V
V_{BPidle_low}, V_{BMidle_low}	Idle voltage in Branch low-power modes on pin BP, BM	Branch low-power modes 40Ω || 100pF	-0.2	0	+0.2	V
I_{BPidle}	Absolute idle output current on pin BP	-40V < V_{BP} < 40V	0		7.5	mA
I_{BMidle}	Absolute idle output current on pin BM	-40 V < V_{BM} < 40V	0		7.5	mA
I_{BPleak}, I_{BMleak}	Absolute leakage current, when not powered	V_{BP}=V_{BM}=5V, V_{CC}=0V, V_{BAT}=0V; V_{IO}=0V	0		20	µA
$V_{BUSActiveHigh}$	Activity detection differential input voltage high	Branch non-low-power modes -10V < (V_{BP}, V_{BM}) < 15V	150	225	400	mV
$V_{BUSActiveLow}$	Activity detection differential input voltage low	Branch non-low-power modes -10V < (V_{BP}, V_{BM}) < 15V	-400	-225	-150	mV
V_{Data1}	Data1 detection differential input voltage	*Pre-condition:* Activity already detected. Branch non-low-power modes. -10V < (V_{BP}, V_{BM}) < 15V	150	225	300	mV
V_{Data0}	Data0 detection differential input voltage	*Pre-condition:* Activity already detected. Branch non-low-power modes. -10V < (V_{BP}, V_{BM}) < 15V	-300	-225	-150	mV
$V_{DataErr}$	Mismatch between Data0 and Data1 differential input voltage	2 x (|| V_{Data0}| - | V_{Data1} ||) / (| V_{Data0} | + | V_{Data1} |) 2)			10	%
t_{bit}	Receiving bit time	C_{RxD}=15pF	54	100		ns

Table 14. Receiver

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{ActivityDetection}$	Activity detection time		100		300	ns
$t_{IdleDetection}$	Idle detection time		50		250	ns

6.13 Bus Wake-up Detector

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

Table 15. Bus Wake-up Detector

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{BAT_WU}	VBAT supply to detect wake-up		7			V
t_{BWU0}	Data_0 detection time in remote wake-up pattern	-10V<(V_{BP}, V_{BM})<15V; VBAT>7V	1		4	µs
$t_{BWUIdle}$	Idle or Data_1 detection time in remote wake-up pattern	-10V<(V_{BP}, V_{BM})<15V; VBAT>7V	1		4	µs
$t_{BWUDetect}$	Total remote wake-up detection time	-10V<(V_{BP}, V_{BM})<15V; VBAT>7V	48		140	us
V_{BWUTH}	Wake-up detector threshold	-10V<(V_{BP}, V_{BM})<15V; VBAT>7V	-300		-150	mV

6.14 Local Wake-up Detector

Table 16. Local Wake-up Detector

Symbol	Parameter	Conditions	Min	Typ	Max	Units
I_{LWUL}	Low level input current on WAKE pin	VBAT=12V; V_{WAKE}=2V for t<$t_{LWUFilter}$; VBAT>7V	-20		-5	µA
I_{LWUH}	High level input current on WAKE pin	VBAT=12V; V_{WAKE}=4V for t<$t_{LWUFilter}$; VBAT>7V	5		20	µA
$t_{LWUFilter}$	Local wake filter time	VBAT>7V	1		40	µs
V_{LWUTH}	Local Wake-up detection threshold voltage		2		4	V

6.15 Supply Voltage Monitor

Table 17. Supply Voltage Monitor

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$VBAT_{THH}$	VBAT undervoltage recovery threshold		3.5		4.5	V
$VBAT_{THL}$	VBAT undervoltage detection threshold		3		4	V
VCC_{THH}	VCC undervoltage recovery threshold		3.5		4.5	V
VCC_{THL}	VCC undervoltage detection threshold		3		4	V
VIO_{THH}	VIO undervoltage recovery threshold		1.25		2.0	V
VIO_{THL}	VIO undervoltage detection threshold		0.75		1.5	V
$t_{UV\_REACTION}$	Undervoltage reaction time for VCC		30		700	µs
$t_{UV\_DETECTION}$	Undervoltage detection time for VBAT, VCC, VIO		100		700	ms
$t_{UV\_RECOVERY}$	Undervoltage recovery detection time for VBAT, VCC, VIO		0.7		5	ms
$t_{UV\_DEBOUNCING}$	Undervoltage debouncing time for VBAT, VCC, VIO		8		64	µs

6.16 Bus Error Detection

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

Table 18. Bus Error Detection

Symbol	Parameter	Conditions	Min	Typ	Max	Units
I_{THL}	Absolute bus current for low current detection	BRANCH_ACTIVE mode, Transmitter enabled		5		mA
I_{THH}	Absolute bus current for high current detection	BRANCH_ACTIVE mode, Transmitter enabled		40		mA
V_{SHORT}	Differential voltage on BP and BM for detecting short circuit between bus lines	BRANCH_ACTIVE mode, Transmitter enabled		225		mV
t_{BUS_ERROR}	Bus error detection time	BRANCH_ACTIVE mode, Transmitter enabled			500	ns

6.17 Over Temperature

Table 19. Over Temperature

Symbol	Parameter	Conditions	Min	Typ	Max	Units
OT_{TH}	Over temperature threshold		150		180	ºC
OT_{TL}	Over temperature hysteresis		10		20	ºC

6.18 Power Supply Interface

Table 20. Power Supply Interface

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

6.19 Communication Controller Interface

Table 21. Communication Controller Interface

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{TxDIH}	Threshold for detecting TxD as on logical high				0.7 * VIO	V
V_{TxDIL}	Threshold for detecting TxD as on logical low		0.3 * VIO			V
I_{TxDIH}	TxD high level input current		30		100	µA
I_{TxDIL}	TxD low level input current		-5		5	µA
V_{TxENIH}	Threshold for detecting TxEN as on logical high				0.7 * VIO	V
V_{TxENIL}	Threshold for detecting TxEN as on logical low		0.3 * VIO			V
I_{TxENIH}	TxEN high level input current		-5		5	µA
I_{TxENIL}	TxEN low level input current		-100		-30	µA
V_{RxDOH}	RxD high level output voltage	I_{RxD}=-4mA, VIO=5V	0.8 * VIO		1.0 * VIO	V
V_{RxDOL}	RxD low level output voltage	I_{RxD}=4mA, VIO=5V	0		0.2 * VIO	V
$t_{RxDfall}$	Fall time RxD voltage	80% – 20% of V_{RxDL}; C_{RxD}=15pF			5	ns
$t_{RxDrise}$	Rise time RxD voltage	20% – 80% of V_{RxDL}; C_{RxD}=15pF			5	ns
$t_{RxD\_mismatch}$	Mismatch of rise and fall time of RxD	$\lvert t_{RxDrise} \rvert - \lvert t_{RxDfall} \rvert$	-2		+2	ns

6.20 Host Controller Interface

Table 22. Host Controller Interface

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{SDI_IH}	Threshold for detecting SDI as on logical high				0.7 * VIO	V
V_{SDI_IL}	Threshold for detecting SDI as on logical low		0.3 * VIO			V
I_{SDI_IH}	SDI high level input current		30		100	µA
I_{SDI_IL}	SDI low level input current		-5		5	µA
V_{SDO_OH}	SDO high level output voltage	I_{SDO}=-4mA, VIO=5V	0.8 * VIO		1.0 * VIO	V
V_{SDO_OL}	SDO low level output voltage	I_{SDO}=4mA, VIO=5V	0		0.2 * VIO	V
V_{SCLK_IH}	Threshold for detecting SCLK as on logical high				0.7 * VIO	V
V_{SCLK_IL}	Threshold for detecting SCLK as on logical low		0.3 * VIO			V
I_{SCLK_IH}	SCLK high level input current		30		100	µA
I_{SCLK_IL}	SCLK low level input current		-5		5	µA
V_{SCSN_IH}	Threshold for detecting SCSN as on logical high				0.7 * VIO	V
V_{SCSN_IL}	Threshold for detecting SCSN as on logical low		0.3 * VIO			V
I_{SCSN_IH}	SCSN high level input current		30		100	µA
I_{SCSN_IL}	SCSN low level input current		-5		5	µA
V_{INTN_OH}	INTN high level output voltage	I_{INTN}=-4mA, VIO=5V	0.8 * VIO		1.0 * VIO	V
V_{INTN_OL}	INTN low level output voltage	I_{INTN}=4mA, VIO=5V	0		0.2 * VIO	V
BR_{SPI}	Bit rate		10 kbps		1 Mbps	
t_{SCLK_High}	Clock high time		500			ns
t_{SCLK_High}	Clock low time		500			ns
t_{DI_Setup}	Data in setup time		20			ns
t_{DI_Setup}	Data in hold time		10			ns
t_{SCSN_Hold}	SCSN in hold time		100			ns
t_{DO_Delay}	Data out delay				150	ns
t_{DOS}	Data out setup time		130			ns
t_{DOH}	Data out hold time		130			ns
t_{DO_HZ}	Data out to high impedance delay	Time for the SPI to release the SDO bus with respect to CS rising edge			150	ns
t_{CP_Setup}	Clock setup time	Setup time of SCLK with respect to CS falling edge	100			ns
t_{CP_Hold}	Clock hold time	Hold time of SCLK with respect to CS falling edge	100			ns
I_{SDO_PU}	SDO pull-up current		30		100	µA
I_{INTN_PU}	INTN pull-up current		30		100	µA

6.21 Bus Guardian Interface

Table 23. Bus Guardian Interface

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{BGEIH}	Threshold for detecting BGE as on logical high				0.7 * VIO	V
V_{BGEIL}	Threshold for detecting BGE as on logical low		0.3 * VIO			V
I_{BGEIH}	BGE high level input current		30		100	µA
I_{BGEIL}	BGE low level input current		-5		5	µA
V_{RxENOH}	RxEN high level output voltage	I_{RxEN}=-4mA, VIO=5V	0.8 * VIO		1.0 * VIO	V
V_{RxENOL}	RxEN low level output voltage	I_{RxEN}=4mA, VIO=5V	0		0.2 * VIO	V

6.22 Interstar Interface

Table 24. Interstar Interface

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{TRxDOH}	TRxD high level output voltage		1	1.25	1.5	V
V_{TRxDOL}	TRxD low level output voltage		0	0	0.3	V
V_{TRxD_IH}	Threshold for detecting TRxD as logical high				0.7 * V_{BUF}	V
V_{TRxD_IL}	Threshold for detecting TRxD as logical low		0.3 * V_{BUF}			V
R_{TRxD_PU}	TRxD Internal pull-up resistance		60	100	180	KΩ
t_{TRxD01}	TRxD rise time	20% – 80% of V_{BUF}; C_{TRxD}=60pF		5		ns
t_{TRxD10}	TRxD fall time	80% – 20% of V_{BUF}; C_{TRxD}=60pF		5		ns
$t_{ISActiveDetection}$	Activity detection time			10		ns
$t_{ISIdleDetection}$	Idle detection time			10		ns
$t_{ISCollision}$	Collision detection time			10		ns

7 Detailed Description

The AS8223 FlexRay Active Star Device consists of six communication paths. During normal operation one of the communication paths is switched as receiver and the other paths as transmitter. Each of the four Branch Transceivers can be connected to different FlexRay bus lines to provide bi-directional communication of the extended FlexRay network.

Every message stream received at one communication path is converted into a digital signal and then forwarded to the transmitting communication paths.

The device supports different low power states which can be controlled by the host controller. Every Branch Transceiver supports several states for controlling the communication on the respective path.

7.1 Routing Functionality of the Active Star

7.1.1 Branch Transceivers

The basic function of the Branch Transceiver (BT) is to convert the FlexRay bus signal into a digital signal and vice-versa according to the FlexRay Specification. Each BT includes a transmitter, a receiver, a wake-up detector and a failure detector. The receiver of each branch transceiver has got a digital interface to the central logic consisting of an RxD and a RxEN signal. Activity is detected on the FlexRay bus when the differential voltage between the lines BP and BM is lower than $V_{BUSActiveLow}$ or higher than $V_{BUSActiveHigh}$ for a time longer than $t_{ActivityDetection}$. Idle is detected on the bus when the differential signal between BP and BM is higher than $V_{BUSActiveLow}$ or lower than $V_{BUSActiveHigh}$ for a time longer than $t_{IdleDetection}$. The RxEN signal of the corresponding BT is active low and it gets active when activity on the FlexRay bus is detected. The RxEN signal of the corresponding BT is at logic high when Idle is detected on the bus (Idle, Idle_LP, Idle_HZ). The RxD signal is the translated frame from the incoming FlexRay signal to be received by the Active Star. RxD is logical low when the differential signal between BP and BM is lower than V_{Data0}. RxD is logical high when the differential signal is higher than V_{Data1}. The transmitter of the branch transceiver has got a digital interface to the central logic consisting of a TxD and a TxEN signal. The TxEN signal is an active low signal used by the Active Star Device to activate the transmitter. The TxD signal is the frame signal coming from the Active Star Device to be transmitted by the BT into the FlexRay bus. If the TxEN signal is driven low, the transmitter outputs $V_{BUSx\_DIFF\_D0}$ in case TxD is in logical low, and outputs $V_{BUSx\_DIFF\_D1}$ in case TxD signal is in logical high. The transmitter signals $V_{BUS\_DIFF\_Idle}$ in case TxEN is high.

7.1.2 Communication Controller Interface

The AS8223 has a Communication Controller Interface (CC) to connect a FlexRay Communication Controller directly with the central logic of the Active Star Device (ASD). The CC interface includes one receive data signal RxD, one transmit data signal TxD and one transmit enable signal TxEN. When sending a data stream, the central logic outputs the digital frame at the RxD signal of the CC interface. The ASD detects idle at the CC when the voltage level at the TxEN pin is higher than VTxENIH. The ASD detects activity at the CC when the voltage level at the TxEN pin is lower than VTxENIL. The TxD signal is the frame signal coming from the CC to be transmitted to the central logic. When the TxEN signal is driven low, the central logic receives Data0 when TxD voltage is lower than VTxDIL; the central logic receives Data1 when TxD voltage is higher than VTxDIH.

7.1.3 Interstar Interface

The AS8223 has also an Interstar Interface (ISI) to connect two or more of the AS8223 and build a larger FlexRay Active Star (EAS: Extended Active Star). The signal on the ISI bus is a complementary digital signal transmitted and received by the Active Star on two bus lines TRxD_1 and TRxD_0. TRxD_1 and TRxD_0 are interpreted as logic high if the voltage at the pins is higher than V_{TRxD_IH} and are interpreted as logic low if the voltage is lower than V_{TRxD_IL}.

Table 25. Logic Table ISI Receiver

TRxD_0	TRxD_1	State
0	0	ISI Collision
0	1	Data_0
1	0	Data_1
1	1	Idle

Activity is detected if either Data_0 or Data_1 is detected on the ISI after the activity detection time $t_{ISActiveDetection}$ if the previous state was Idle. Idle is detected if TRxD_1 and TRxD_0 are logic high after the idle detection time $t_{ISIdleDetection}$ if the previous state was Activity. In case the ISI is switched to transmit, the logic table is shown in Table 26.

Table 26. Logic Table

TRxD_0	TRxD_1	State
0	1	Data_0
1	0	Data_1
1	1	Idle

The Interstar Interface has a built-in load regulator, therefore it does not require any additional components like resistors or capacitors when connecting several AS8223 devices.

7.1.4 Message Forwarding Function of the Active Star

The message forwarding includes all six communication paths (Branch 1 to 4, Communication Controller Interface and Interstar Interface). The message forwarding of FlexRay data streams is only performed in AS_NORMAL mode. On detecting activity on a communication path, the data stream is forwarded to all other communication paths. Activity on other communication paths will only be detected after the t_{ears_shut} time has expired. This is to avoid the unwanted transmission of echoes on the bus lines. As a safety measure a longer $t_{ears\_shut\_f}$ is used for branches that have detected electrical errors during the last transmission (open line, short to VCC and GND, bus short). Collisions among the communication paths are described in Collisions on page 22. The data stream is passed to the central logic based on the specific communication path that is configured as the input data source. From the central logic the data stream is transmitted to all the communication paths, except for the communication path that is configured as the receiver.

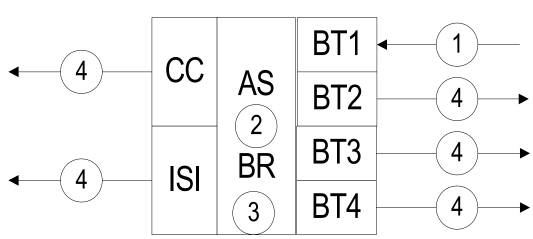
7.2 Routing Paths

There are three main routing configurations of the Active Star in AS_NORMAL mode.

7.2.1 Routing Path 1

- The incoming signal is received from one of the AS8223 bus lines (e.g. BT1).
- BT1 detects activity and indicates this on BT2, BT3, BT4, on the ISI and on the CC.
- The data stream is forwarded to BT2, BT3, BT4, to ISI and to CC.
- If BT1 detects idle on the bus, accordingly idle is indicated to BT2, BT3, BT4, to ISI and to CC.
- Now any other communication path can become the input data source.

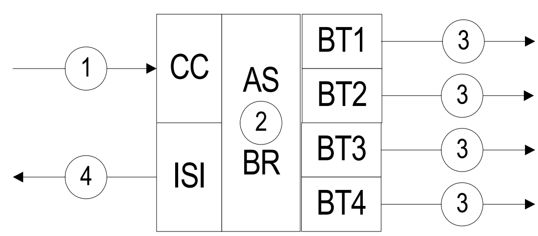
Figure 3. Routing Path 1



7.2.2 Routing Path 2

- The CC connected to the AS8223 is the input data stream source.
- First the Active Star detects activity on the CC and indicates activity on all BT and ISI.
- The data stream is then forwarded to all BT, to ISI and to CC.
- When idle on the CC is detected, accordingly idle is indicated to all BT, to ISI and to CC.
- Now any other communication path can become the input data source.

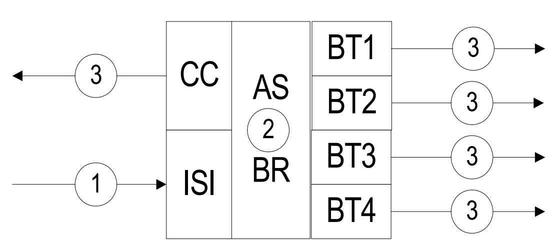
Figure 4. Routing Path 2



7.2.3 Routing Path 3

- A data stream from another AS8223 using the ISI is submitted.
- First the Active Star detects activity on the ISI and indicates activity on all BT and the CC.
- The data stream is forwarded to all BT and to CC.
- When idle on the ISI is detected, accordingly idle is indicated to all BT and to CC.
- Now any other communication path can become the input data source.

Figure 5. Routing Path 3



7.3 Collisions

7.3.1 Extended Active Star (EAS) Collision

Collision is detected on the Interstar Interface if TRxD_0 and TRxD_1 are lower than V_{TRxDIL} for a time longer than $t_{IScollision}$ (ISI collision is possible only if two AS transmit different data on ISI).

7.3.2 Active Star Device Collision

Collision is detected if two or more elements: BT, CC or ISI are receiving an activity within a time t_{STAR_COL} or if one path: BT or CC are receiving an activity and EAS collision is detected or if only EAS collision is detected.

7.3.3 Active Star Collision Sequence

1. AS collision is detected.
2. DATA0 is forced on all communication paths except the colliding communication paths.
3. The colliding communication paths are detecting idle or they are in BT_FAILSILENT mode.
4. The CCI detects idle or timeout during collision.
5. The ISI is released to idle.
6. Idle or timeout is detected at the ISI.
7. Not colliding CCI and BT are released to idle.
8. End of AS collision.

7.4 Operation Mode of the Active Star Device

The AS8223 provides the following operating modes:

- AS_NORMAL: Non low power mode
- AS_STANDBY: Low power mode
- AS_SLEEP: Low power mode

7.4.1 APM (Autonomous Power Mode)

In Autonomous Power mode the AS8223 operates without host controller interaction. The APM flag indicates if the Autonomous Power mode is active or deactivated.

Autonomous Power mode is exited in case of

- A host command forcing the device to change the operation mode
- The APM flag is reset through a host command

The Autonomous Power mode is active

- After Power-on
- After a Wake-up event
- During undervoltage of V_{IO}
- The APM flag is reset via a host command

7.4.2 AS_NORMAL Mode

- The message forwarding is active (see Message Forwarding Function of the Active Star on page 20).
- If no activity is detected on the communication paths, BT is BRANCH_IDLE, ISI is idle and CCI is idle.
- If bus activity is detected at one BT, all BTs enter BRANCH_ACTIVE.
- If an undervoltage V_{CC} is detected, the device enters AS_STANDBY mode.
- If all communication paths stay inactive for longer than $t_{ASSLEEP}$ and the APM mode is set, the device enters AS_SLEEP mode.

7.4.3 AS_STANDBY Mode

- All branches are forced to BRANCH_LOWPOWER mode. The current consumption is significantly reduced compared to AS_NORMAL mode.
- Local and remote wake-up detector is active.
- If a wake-up event is detected, the device enters AS_NORMAL mode.
- If the undervoltage at V_{CC} recovers and the APM mode is set, the device enters AS_NORMAL mode.
- If all communication paths stay inactive for longer than $t_{ASSLEEP}$ and the APM flag is set, the device enters AS_SLEEP mode.
- If the undervoltage condition at V_{CC} persists for longer than $t_{UV\_DETECTION}$, the APM flag is set and power-on flag is set, the device enters AS_SLEEP mode.

7.4.4 AS_SLEEP Mode

- All branches are forced to BRANCH_LOWPOWER mode. The current consumption is reduced compared to AS_NORMAL and AS_STANDBY mode.
- Local and remote wake-up detector is active.
- If a wake-up event is detected, the device enters AS_NORMAL mode.

7.5 Non Operating Modes of the Active Star

The AS8223 provides the following non-operating mode:

7.5.1 AS_POWEROFF

- In this mode the device is not operable.
- INH1 and INH2 are floating.
- Branches are in idle_HZ.
- Local and remote wake-up detector is active.
- RxD and RxEN are set to high.

7.6 Mode Transitions of the Active Star

Starting from every operation mode the device enters AS_POWEROFF in case a power off event occurs regardless of wake-up events and host commands.

Starting from the AS_POWEROFF mode the device enters AS_STANDBY only in case a power on event occurs.

Starting from the AS_STANDBY mode the device enters AS_NORMAL if a wake-up event occurs regardless of any of the undervoltage flags and host commands.

Starting from the AS_NORMAL mode the device enters AS_STANDBY in case V_{CC} undervoltage reaction flag is set regardless of wake-up events and host commands.

Starting from the AS_NORMAL mode the device will stay in AS_NORMAL even if V_{BAT} undervoltage flag is set.

Starting from the AS_NORMAL mode the device will stay in AS_NORMAL even if V_{IO} undervoltage flag is set.

Starting from the AS_SLEEP mode the device enters AS_NORMAL if a wake-up event occurs regardless of any of the undervoltage flags and host commands.

Figure 6. State Machine

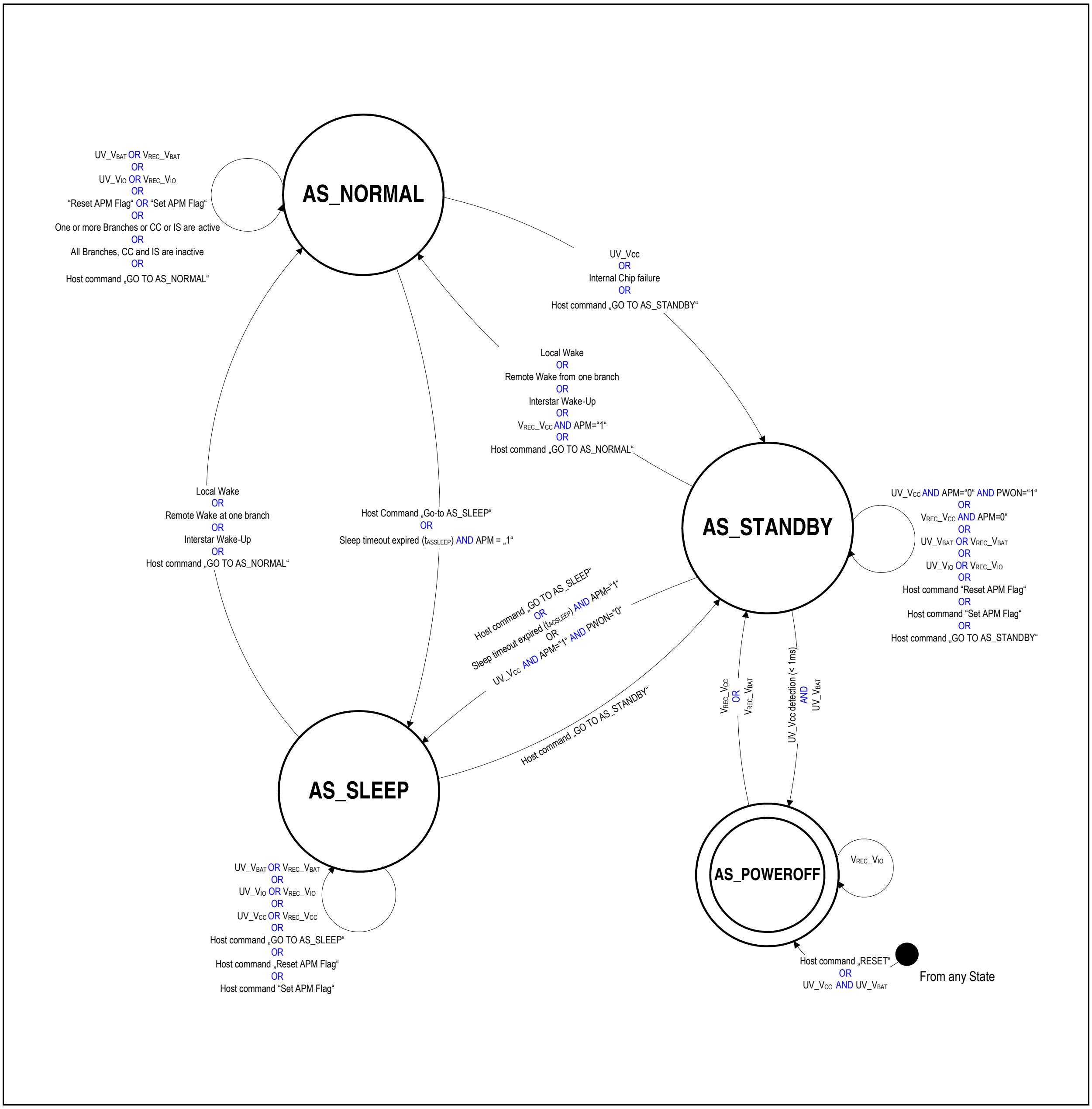


Table 27. Active Star Mode Transition

Initial Mode	Resulting Mode	Condition	Priority
AS_NORMAL	AS_POWEROFF	Undervoltage VCC detection (<1ms) AND undervoltage VBAT event	1
	AS_STANDBY	Undervoltage VCC detection (<1ms)	2
	AS_STANDBY	Internal chip failure	3
	AS_STANDBY	Host command “go to AS_STANDBY mode”	4
	AS_SLEEP	Host command “go to AS_SLEEP mode”	4
	AS_SLEEP	Sleep timeout expired ($t_{ASSLEEP}$) AND APM flag set	5
	AS_NORMAL	Undervoltage VBAT event	6
	AS_NORMAL	Undervoltage recovery VBAT event	6
	AS_NORMAL	Undervoltage VIO event	6
	AS_NORMAL	Undervoltage recovery VIO event	6
	AS_NORMAL	Host command “reset APM flag”	6
	AS_NORMAL	Host command “set APM flag”	6
	AS_NORMAL	All branches, CC and ISI are inactive	6
	AS_NORMAL	One or more branches or CC or ISI are active	6
	AS_NORMAL	Host command “go to AS_NORMAL mode”	6
AS_STANDBY	AS_POWEROFF	Undervoltage VCC reaction (<1ms) AND undervoltage VBAT event	1
	AS_NORMAL	Local Wake event	2
	AS_NORMAL	Remote Wake event from branch_1	2
	AS_NORMAL	Remote Wake event from branch_2	2
	AS_NORMAL	Remote Wake event from branch_3	2
	AS_NORMAL	Remote Wake event from branch_4	2
	AS_NORMAL	Wake on Interstar Interface detected	2
	AS_NORMAL	Undervoltage recovery VCC event AND APM flag is set	3
	AS_NORMAL	Host command “go to AS_NORMAL mode”	4
	AS_SLEEP	Host command “go to AS_SLEEP mode”	4
	AS_SLEEP	Sleep timeout expired ($t_{ASSLEEP}$) AND APM flag set	5
	AS_SLEEP	Undervoltage VCC event and APM flag is set and PWON=0	6
	AS_STANDBY	Undervoltage VCC event and (APM flag is not set or PWON=1)	7
	AS_STANDBY	Undervoltage recovery VCC event AND APM flag is not set	7
	AS_STANDBY	Undervoltage VBAT event	7
	AS_STANDBY	Undervoltage recovery VBAT event	7
	AS_STANDBY	Undervoltage VIO event	7
	AS_STANDBY	Undervoltage recovery VIO event	7
	AS_STANDBY	Host command “reset APM flag”	7
	AS_STANDBY	Host command “set APM flag”	7
	AS_STANDBY	Host command “go to AS_STANDBY mode”	7