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# AMIS-30623

## Micro-stepping Motor Driver

### INTRODUCTION

The AMIS-30623 is a single-chip micro-stepping motordriver with position controller and control/diagnostic interface. It is ready to build dedicated mechatronics solutions connected remotely with a LIN master.

The chip receives positioning instructions through the bus and subsequently drives the motor coils to the desired position. The on-chip position controller is configurable (OTP or RAM) for different motor types, positioning ranges and parameters for speed, acceleration and deceleration. The AMIS-30623 acts as a slave on the LIN bus and the master can fetch specific status information like actual position, error flags, etc. from each individual slave node.

An integrated sensor-less step-loss detection prevents the positioner from loosing steps and stops the motor when running into stall. This enables silent, yet accurate position calibrations during a referencing run and allows semi-closed loop operation when approaching the mechanical end-stops.

The chip is implemented in I2T100 technology, enabling both high voltage analog circuitry and digital functionality on the same chip. The AMIS-30623 is fully compatible with the automotive voltage requirements.

### PRODUCT FEATURES

#### Motordriver

- Micro-stepping Technology
- Sensorless Step-loss Detection
- Peak Current up to 800 mA
- Fixed Frequency PWM Current-control
- Automatic Selection of Fast and Slow Decay Mode
- No external Fly-back Diodes Required
- Compliant with 14 V Automotive Systems and Industrial Systems up to 24 V
- Motion Qualification Mode (Note 1)

#### Controller with RAM and OTP Memory

- Position Controller
- Configurable Speeds and Acceleration
- Input to Connect Optional Motion Switch

#### LIN Interface

- Physical Layer Compliant to LIN rev. 2.0. Data-link Layer Compatible with LIN rev. 1.3 (Note 2)
- Field-programmable Node Addresses
- Dynamically Allocated Identifiers
- Diagnostics and Status Information

#### Protection

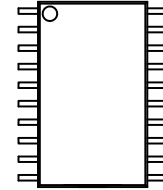
- Overcurrent Protection
- Undervoltage Management

1. Not applicable for "Product Versions AMIS30623C6238(R)G, AMIS30623C623B(R)G"
2. Minor exceptions to the conformance of the data-link layer to LIN rev. 1.3.

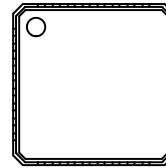


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SOIC-20  
8 or 9 SUFFIX  
CASE 751AQ



NQFP-32  
A or B SUFFIX  
CASE 560AA

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

- Open-circuit Detection
- High Temperature Warning and Management
- Low Temperature Flag
- LIN Bus Short-circuit Protection to Supply and Ground
- Lost LIN Safe Operation

#### Power Saving

- Powerdown Supply Current < 100  $\mu$ A
- 5 V Regulator with Wake-up On LIN Activity

#### EMI Compatibility

- LIN Bus Integrated Slope Control
- HV Outputs with Slope Control

#### Patents

- US 7,271,993
- US 7,288,956
- This is a Pb-Free Device

# AMIS-30623

## APPLICATIONS

The AMIS-30623 is ideally suited for small positioning applications. Target markets include: automotive (headlamp alignment, HVAC, idle control, cruise control), industrial equipment (lighting, fluid control, labeling, process control, XYZ tables, robots...) and building automation (HVAC,

surveillance, satellite dish, renewable energy systems). Suitable applications typically have multiple axes or require mechatronics solutions with the driver chip mounted directly on the motor.

**Table 1. ORDERING INFORMATION**

Part No.	Peak Current	End Market/Version	Package*	Shipping†
AMIS30623C6239G	800 mA	Industrial High Voltage Version	SOIC-20 (Pb-Free)	Tube/Tray
AMIS30623C6239RG	800 mA		SOIC-20 (Pb-Free)	Tape & Reel
AMIS30623C623AG	800 mA		NQFP-32 (7 x 7 mm) (Pb-Free)	Tube/Tray
AMIS30623C623ARG	800 mA		NQFP-32 (7 x 7 mm) (Pb-Free)	Tape & Reel
AMIS30623C6238G	800 mA	Automotive High Temperature Version	SOIC-20 (Pb-Free)	Tube/Tray
AMIS30623C6238RG	800 mA		SOIC-20 (Pb-Free)	Tape & Reel
AMIS30623C623BG	800 mA		NQFP-32 (7 x 7 mm) (Pb-Free)	Tube/Tray
AMIS30623C623BRG	800 mA		NQFP-32 (7 x 7 mm) (Pb-Free)	Tape & Reel

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

## QUICK REFERENCE DATA

**Table 2. ABSOLUTE MAXIMUM RATINGS**

Parameter		Min	Max	Unit
V <sub>BB</sub> , V <sub>HW2</sub> , V <sub>SWI</sub>	Supply voltage, hardwired address and SWI pins	-0.3	+40 (Note 3)	V
V <sub>lin</sub>	Bus input voltage	-40	+40	V
T <sub>J</sub>	Junction temperature range (Note 4)	-50	+175	°C
T <sub>st</sub>	Storage temperature	-55	+160	°C
V <sub>esd</sub> (Note 5)	HBM Electrostatic discharge voltage on LIN pin	-4	+4	kV
	HBM Electrostatic discharge voltage on other pins (Note 6)	-2	+2	kV
	MM Electrostatic discharge voltage on other pins (Note 7)	-200	+200	V

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

**Table 3. OPERATING RANGES**

Parameter		Min	Max	Unit
V <sub>BB</sub>	Supply voltage	+6.5	+29	V
T <sub>J</sub>	Operating temperature range	-40	+165	°C

3. For limited time: V<sub>BB</sub> <0.5 s, SWI and HW2 pins <1.0 s.

4. The circuit functionality is not guaranteed.

5. HBM according to AEC-Q100: EIA-JESD22-A114-B (100 pF via 1.5 kΩ) and MM according to AEC-Q100: EIA-JESD22-A115-A.

6. Tested on AMIS30623C6238(R)G version.

7. Tested on AMIS30623C623B(R)G version.

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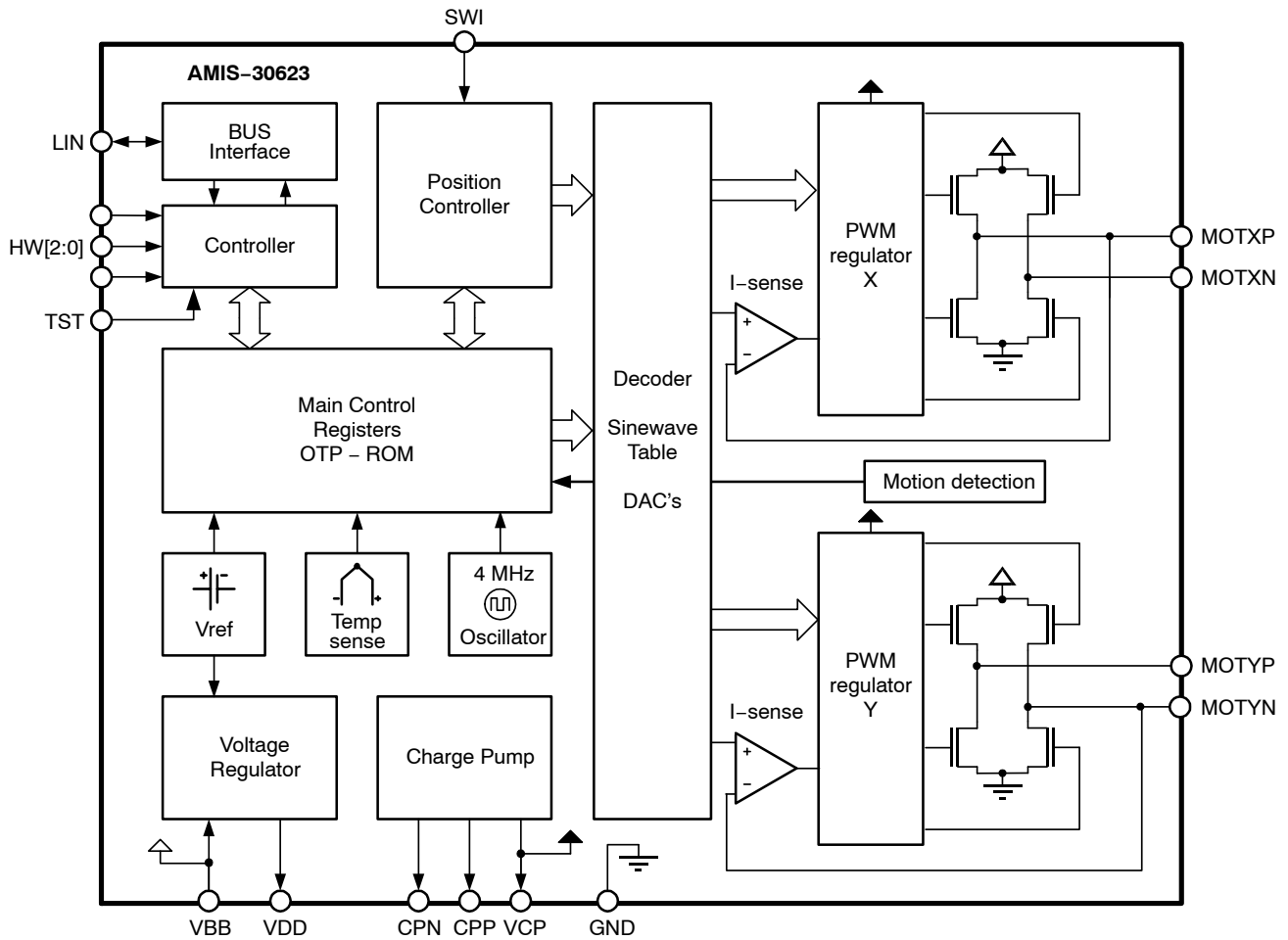
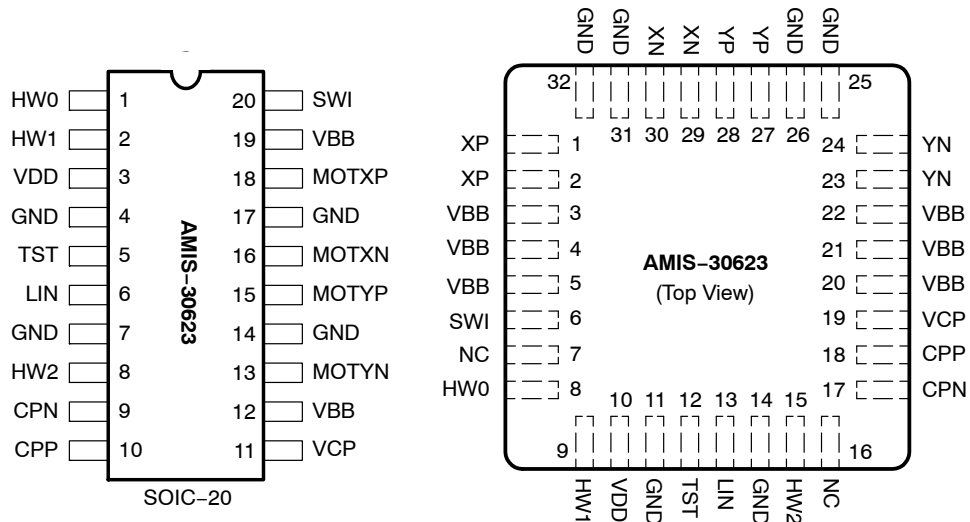


Figure 1. Block Diagram

# AMIS-30623



**Figure 2. SOIC-20 and NQFP-32 Pin-out**

**Table 4. PIN DESCRIPTION**

Pin Name	Pin Description	SOIC-20	NQFP-32
HW0	Bit 0 of LIN-ADD	1	8
HW1	Bit 1 of LIN-ADD	2	9
VDD	Internal supply (needs external decoupling capacitor)	3	10
GND	Ground, heat sink	4, 7, 14, 17	11, 14, 25, 26, 31, 32
TST	Test pin (to be tied to ground in normal operation)	5	12
LIN	LIN-bus connection	6	13
HW2	Bit 2 LIN-ADD	8	15
CPN	Negative connection of pump-capacitor (charge pump)	9	17
CPP	Positive connection of pump-capacitor (charge pump)	10	18
VCP	Charge-pump filter-capacitor	11	19
V <sub>BB</sub>	Battery voltage supply	12,19	3, 4, 5, 20, 21, 22
MOTYN	Negative end of phase Y coil	13	23, 24
MOTYP	Positive end of phase Y coil	15	27, 28
MOTXN	Negative end of phase X coil	16	29, 30
MOTXP	Positive end of phase X coil	18	1, 2
SWI	Switch input	20	6
NC	Not connected (to be tied to ground)		7, 16

PACKAGE THERMAL RESISTANCE

The AMIS-30623 is available in SOIC-20 and optimized NQFP-32 packages. For cooling optimizations, the NQFP has an exposed thermal pad which has to be soldered to the PCB ground plane. The ground plane needs thermal vias to conduct the heat to the bottom layer. Figures 3 and 4 give examples for good power distribution solutions.

For precise thermal cooling calculations the major thermal resistances of the devices are given. The thermal media to which the power of the devices has to be given are:

- Static environmental air (via the case)
- PCB board copper area (via the device pins and exposed pad)

The thermal resistances are presented in Table 5: DC Parameters.

Package	Rth Junction-to-Leads and Exposed Pad - Rthjp	Rth Junction-to-Leads Rthjp	Rth Junction-to-Ambient Rthja (1SOP)	Rth Junction-to-Ambient Rthja (2S2P)
SOIC-20		19	62	39
NQFP-32	0,95		60	30

The Rthja for 2S2P is simulated conform to JESD-51 as follows:

- A 4-layer printed circuit board with inner power planes and outer (top and bottom) signal layers is used
- Board thickness is 1.46 mm (FR4 PCB material)
- The 2 signal layers: 70 μm thick copper with an area of 5500 mm<sup>2</sup> copper and 20% conductivity

The major thermal resistances of the device are the Rth from the junction to the ambient (Rthja) and the overall Rth from the junction to the leads (Rthjp).

The NQFP device is designed to provide superior thermal performance. Using an exposed die pad on the bottom surface of the package is mainly contributing to this performance. In order to take full advantage of the exposed pad, it is most important that the PCB has features to conduct heat away from the package. A thermal grounded pad with thermal vias can achieve this.

In the table below, one can find the values for the Rthja and Rthjp, simulated according to the JESD-51 norm:

- The 2 power internal planes: 36 μm thick copper with an area of 5500 mm<sup>2</sup> copper and 90% conductivity

The Rthja for 1SOP is simulated conform to JESD-51 as follows:

- A 1-layer printed circuit board with only 1 layer
- Board thickness is 1.46 mm (FR4 PCB material)
- The layer has a thickness of 70 μm copper with an area of 5500 mm<sup>2</sup> copper and 20% conductivity

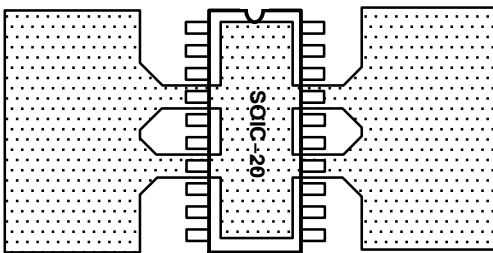


Figure 3. Example of SOIC-20 PCB Ground Plane Layout (preferred layout at top and bottom)

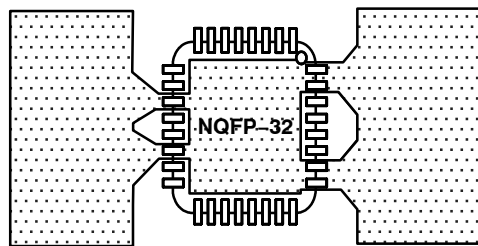


Figure 4. Example of NQFP-32 PCB Ground Plane Layout (preferred layout at top and bottom)

DC PARAMETERS

The DC parameters are guaranteed overtemperature and  $V_{BB}$  in the operating range, unless otherwise specified. Convention: currents flowing into the circuit are defined as positive.

Table 5. DC PARAMETERS

Symbol	Pin(s)	Parameter	Test Conditions	Min	Typ	Max	Unit
<b>MOTORDRIVER</b>							
$I_{MSmax,Peak}$	MOTXP MOTXN MOTYP MOTYN	Max current through motor coil in normal operation	$V_{BB} = 14\text{ V}$		800		mA
$I_{MSmax,RMS}$		Max rms current through coil in normal operation	$V_{BB} = 14\text{ V}$		570		mA
$I_{MSabs}$		Absolute error on coil current (Note 8)	$V_{BB} = 14\text{ V}$	-10		10	%
$I_{MSrel}$		Matching of X & Y coil currents	$V_{BB} = 14\text{ V}$	-7	0	7	%
$R_{DS(on)}$		On resistance for each motor pin at $I_{MSmax}$ (Note 9)	$V_{BB} = 12\text{ V}, T_j = 50^\circ\text{C}$		0.50	1	$\Omega$
			$V_{BB} = 8\text{ V}, T_j = 50^\circ\text{C}$		0.55	1	$\Omega$
	$V_{BB} = 12\text{ V}, T_j = 150^\circ\text{C}$			0.70	1	$\Omega$	
	$V_{BB} = 8\text{ V}, T_j = 150^\circ\text{C}$			0.85	1	$\Omega$	
$I_{MSL}$		Pulldown current	HiZ mode, $V_{BB} = 7.8\text{ V}$		2		mA

LIN TRANSMITTER

$I_{bus\_off}$	LIN	Dominant state, driver off	$V_{bus} = 0\text{ V}, V_{BB} = 8\text{ V} \& 18\text{ V}$	-1			mA
$I_{bus\_off}$		Recessive state, driver off	$V_{bus} = V_{bat}, V_{BB} = 8\text{ V} \& 18\text{ V}$			20	$\mu\text{A}$
$I_{bus\_lim}$		Current limitation	$V_{BB} = 8\text{ V} \& 18\text{ V}$	50	75	130	mA
$R_{slave}$		Pullup resistance	$V_{BB} = 8\text{ V} \& 18\text{ V}$	20	30	47	k $\Omega$

LIN RECEIVER

$V_{bus\_dom}$	LIN	Receiver dominant state	$V_{BB} = 8\text{ V} \& 18\text{ V}$	0		$0.4 * V_{BB}$	V
$V_{bus\_rec}$		Receiver recessive state	$V_{BB} = 8\text{ V} \& 18\text{ V}$	$0.6 * V_{BB}$		$V_{BB}$	V
$V_{bus\_hys}$		Receiver hysteresis	$V_{BB} = 8\text{ V} \& 18\text{ V}$	$0.05 * V_{BB}$		$0.175 * V_{BB}$	V

THERMAL WARNING & SHUTDOWN

$T_{tw}$		Thermal warning (Notes 10 and 11)		138	145	152	$^\circ\text{C}$
$T_{tsd}$		Thermal shutdown (Note 12)			$T_{tw} + 10$		$^\circ\text{C}$
$T_{low}$		Low temperature warning (Note 12)				$T_{tw} - 155$	$^\circ\text{C}$

SUPPLY AND VOLTAGE REGULATOR

$V_{bbOTP}$	$V_{BB}$	Supply voltage for OTP zapping (Note 13)		9.0		10.0	V
$UV_1$		Stop voltage high threshold		7.8	8.4	8.9	V
$UV_2$		Stop voltage low threshold		7.1	7.5	8.0	V
$I_{bat}$		Total current consumption	Unloaded outputs $V_{BB} = 29\text{ V}$		3.50	10.0	mA
$I_{bat\_s}$		Sleep mode current consumption	$V_{BB} = 8\text{ V} \& 18\text{ V}$		50	100	$\mu\text{A}$

8. Tested in production for 800 mA, 400 mA, 200 mA and 100 mA current settings for both X and Y coil.

9. Not measured in production. Guaranteed by design.

10. Parameter guaranteed by trimming relevant OTP's in production test at  $143^\circ\text{C} (\pm 5^\circ\text{C})$  and  $V_{BB} = 14\text{ V}$ .

11. No more than 100 cumulated hours in life time above  $T_w$ .

12. Thermal shutdown and low temperature warning are derived from thermal warning. Guaranteed by design.

13. A buffer capacitor of minimum 100  $\mu\text{F}$  is needed between  $V_{BB}$  and GND. Short connections to the power supply are recommended.

Table 5. DC PARAMETERS

Symbol	Pin(s)	Parameter	Test Conditions	Min	Typ	Max	Unit
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**SUPPLY AND VOLTAGE REGULATOR**

$V_{DD}$	$V_{DD}$	Regulated internal supply (Note 14)	$8\text{ V} < V_{BB} < 29\text{ V}$	4.75	5	5.50	V
$V_{ddReset}$		Digital supply reset level @ power down (Note 15)				4.5	V
$I_{ddLim}$		Current limitation	Pin shorted to ground $V_{BB} = 14\text{ V}$				45

**SWITCH INPUT AND HARDWIRE ADDRESS INPUT**

$R_{t\_OFF}$	SWI HW2	Switch OPEN resistance (Note 16)		10			k $\Omega$
$R_{t\_ON}$		Switch ON resistance (Note 16)	Switch to GND or $V_{BB}$			2	k $\Omega$
$V_{bb\_sw}$		$V_{BB}$ range for guaranteed operation of SWI and HW2		6		29	V
$I_{lim\_sw}$		Current limitation	Short to GND or $V_{bat}$ $V_{BB} = 29\text{ V}$	20	30	45	mA

**HARDWIRED ADDRESS INPUTS AND TEST PIN**

$V_{ihigh}$	HW0 HW1 TST	Input level high	$V_{BB} = 14\text{ V}$	$0.7 * V_{dd}$			V
$V_{ilow}$		Input level low	$V_{BB} = 14\text{ V}$			$0.3 * V_{dd}$	V
$HW_{hyst}$		Hysteresis	$V_{BB} = 14\text{ V}$	$0.075 * V_{dd}$			

**CHARGE PUMP**

$V_{cp}$	VCP	Output voltage	$6\text{ V} \leq V_{BB} \leq 14\text{ V}$		$2 * V_{BB} - 2.5$		V
			$14\text{ V} \leq V_{BB} \leq 30\text{ V}$	$V_{BB} + 10$		$V_{BB} + 15$	V
$C_{buffer}$		External buffer capacitor		220		470	nF
$C_{pump}$	CPP CPN	External pump capacitor		220		470	nF

**MOTION QUALIFICATION MODE OUTPUT (Note 17)**

$V_{OUT}$	SWI	Output voltage swing	TestBemf LIN command		0 – 4,85		V
$R_{OUT}$		Output impedance	Service mode LIN command		2		k $\Omega$
$A_v$		Gain = $V_{SWI} / V_{BEMF}$	Service mode LIN command		0.50		

**PACKAGE THERMAL RESISTANCE VALUES**

$R_{thja}$	SO	Thermal resistance junction to ambient (2S2P)	Simulated conform JEDEC JESD51		39		K/W
$R_{thjp}$	SO	Thermal resistance junction to leads			19		K/W
$R_{thja}$	NQ	Thermal resistance junction to ambient (2S2P)			30		K/W
$R_{thjp}$	NQ	Thermal resistance junction to leads and exposed pad			0.95		K/W

14. Pin  $V_{DD}$  must not be used for any external supply

15. The RAM content will not be altered above this voltage.

16. External resistance value seen from pin SWI or HW2, including 1 k $\Omega$  series resistor. For the switch OPEN, the maximum allowed leakage current is represented by a minimum resistance seen from the pin.

17. Not applicable for “Product Versions AMIS30623C6238(R)G, AMIS30623C623B(R)G”



# AMIS-30623

## AC PARAMETERS

The AC parameters are guaranteed for temperature and  $V_{BB}$  in the operating range unless otherwise specified. The LIN transmitter and receiver physical layer parameters are compliant to LIN rev. 2.0 & 2.1.

**Table 6. AC PARAMETERS**

Symbol	Pin(s)	Parameter	Test Conditions	Min	Typ	Max	Unit
<b>POWERUP</b>							
$T_{pu}$		Power-up time	Guaranteed by design			10	ms
<b>INTERNAL OSCILLATOR</b>							
$f_{osc}$		Frequency of internal oscillator	$V_{BB} = 14\text{ V}$	3.6	4.0	4.4	MHz
<b>LIN TRANSMITTER CHARACTERISTICS ACCORDING TO LIN v2.0 &amp; v2.1</b>							
D1	LIN	Duty cycle 1 = $t_{Bus\_rec(min)} / (2 \times t_{Bit})$ ; See Figure 5	THRec(max) = $0.744 \times V_{BB}$ THDom(max) = $0.581 \times V_{BB}$ ; $V_{BB} = 7.0\text{ V} \dots 18\text{ V}$ ; $t_{Bit} = 50\ \mu\text{s}$	0.396			
D2		Duty cycle 2 = $t_{Bus\_rec(max)} / (2 \times t_{Bit})$ ; See Figure 5	THRec(min) = $0.284 \times V_{BB}$ THDom(min) = $0.422 \times V_{BB}$ ; $V_{BB} = 7.6\text{ V} \dots 18\text{ V}$ ; $t_{Bit} = 50\ \mu\text{s}$			0.581	
<b>LIN RECEIVER CHARACTERISTICS ACCORDING TO LIN v2.0 &amp; v2.1</b>							
trx_pdr	LIN	Propagation delay bus dominant to RxD = low	$V_{BB} = 7.0\text{ V} \ \& \ 18\text{ V}$ ; See Figure 5			6	$\mu\text{s}$
trx_pdf		Propagation delay bus recessive to RxD = high	$V_{BB} = 7.0\text{ V} \ \& \ 18\text{ V}$ ; See Figure 5			6	$\mu\text{s}$
trx_sym		Symmetry of receiver propagation delay	trx_pdr - trx_pdf	-2		+2	$\mu\text{s}$
<b>SWITCH INPUT AND HARDWARE ADDRESS INPUT</b>							
$T_{sw}$	SW1 HW2	Scan pulse period (Note 18)	$V_{BB} = 14\text{ V}$		1024		$\mu\text{s}$
$T_{sw\_on}$		Scan pulse duration (Note 18)	$V_{BB} = 14\text{ V}$		128		$\mu\text{s}$
<b>MOTORDRIVER</b>							
$F_{pwm}$	MOTxx	PWM frequency (Note 18)	PWMfreq = 0 (Note 19)	20.6	22.8	25.0	kHz
			PWMfreq = 1 (Note 19)	41.2	45.6	50.0	kHz
$F_{jit\_depth}$		PWM jitter modulation depth	PWMJen = 1 (Note 19)		10		%
$T_{brise}$		Turn-on transient time	Between 10% and 90%		140		ns
$T_{bfall}$		Turn-off transient time			130		ns
$T_{stab}$		Run current stabilization time (Note 18)		29	32	35	ms
<b>CHARGE PUMP</b>							
$f_{CP}$	CPN CPP	Charge pump frequency (Note 18)	$V_{BB} = 14\text{ V}$		250		kHz

18. Derived from the internal oscillator

19. See [SetMotorParam](#) and [PWM Regulator](#)

# AMIS-30623

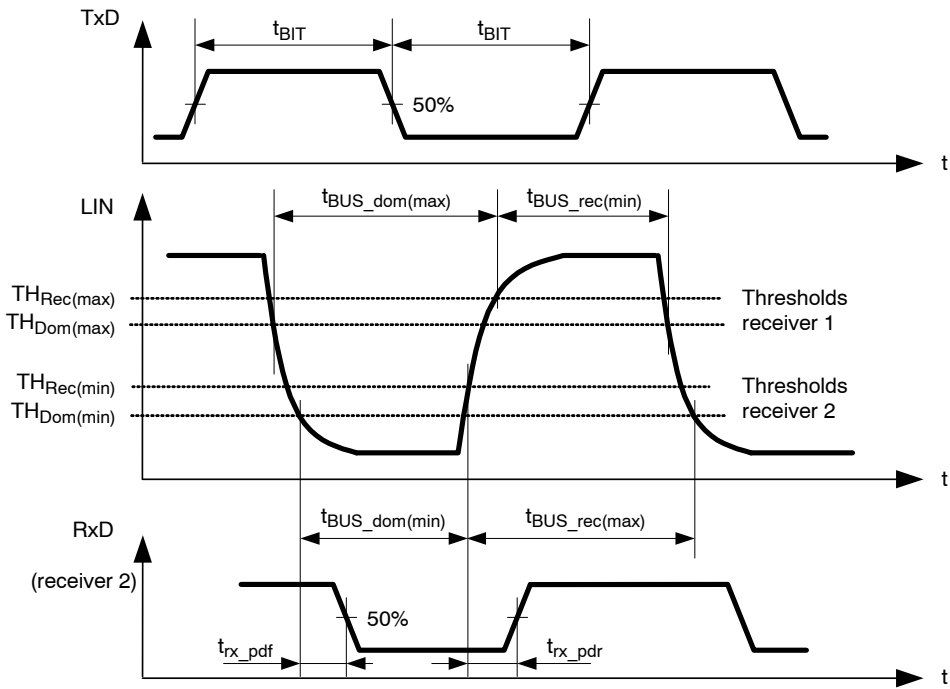


Figure 5. Timing Diagram for AC Characteristics According to LIN 2.0 & 2.1

## Typical Application

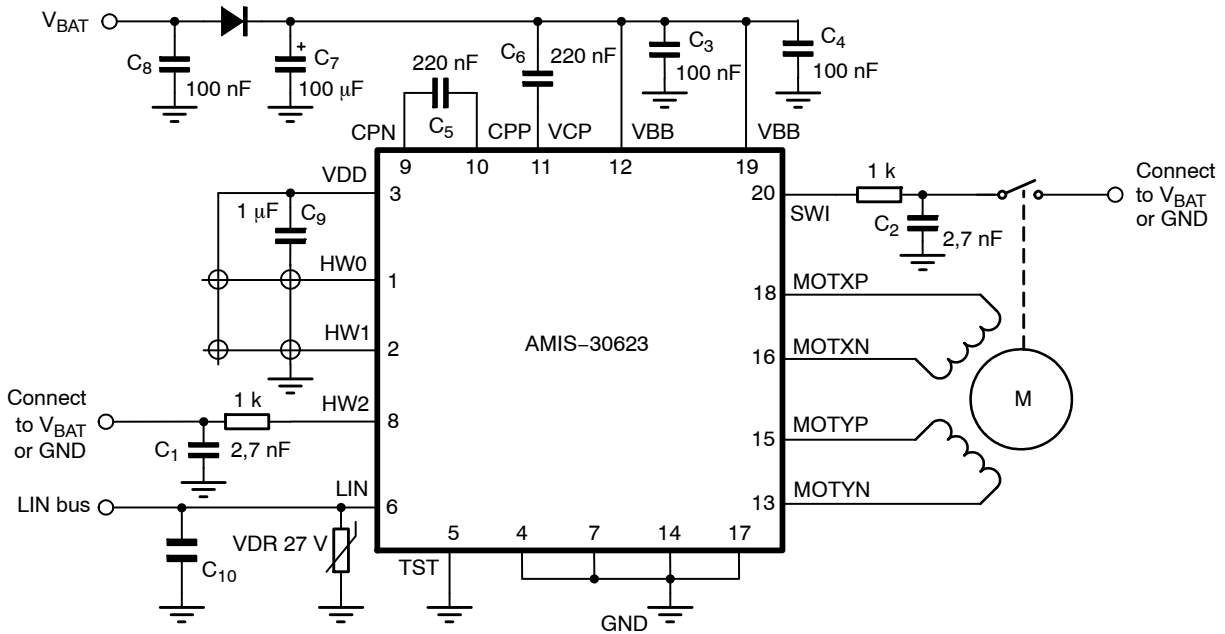


Figure 6. Typical Application Diagram for SO Device

NOTES: All resistors are  $\pm 5\%$ , 1/4 W

C<sub>1</sub>, C<sub>2</sub> minimum value is 2.7 nF, maximum value is 10 nF

Depending on the application, the ESR value and working voltage of C<sub>7</sub> must be carefully chosen

C<sub>3</sub> and C<sub>4</sub> must be close to pins V<sub>BB</sub> and GND

C<sub>5</sub> and C<sub>6</sub> must be as close as possible to pins CPN, CPP, VCP, and V<sub>BB</sub> to reduce EMC radiation

C<sub>9</sub> must be a ceramic capacitor to assure low ESR

C<sub>10</sub> is placed for EMC reasons; value depends on EMC requirements of the application

POSITIONING PARAMETERS

**Stepping Modes**

One of four possible stepping modes can be programmed:

- Half-stepping
- 1/4 micro-stepping
- 1/8 micro-stepping
- 1/16 micro-stepping

**Maximum Velocity**

For each stepping mode, the maximum velocity  $V_{max}$  can be programmed to 16 possible values given in the table below.

The accuracy of  $V_{max}$  is derived from the internal oscillator. Under special circumstances it is possible to change the  $V_{max}$  parameter while a motion is ongoing. All 16 entries for the  $V_{max}$  parameter are divided into four groups. When changing  $V_{max}$  during a motion the application must take care that the new  $V_{max}$  parameter stays within the same group.

**Table 7. MAXIMUM VELOCITY SELECTION TABLE**

Vmax Index		Vmax (full step/s)	Group	Stepping Mode			
Hex	Dec			Half-stepping (half-step/s)	1/4 <sup>th</sup> Micro-stepping (micro-step/s)	1/8 <sup>th</sup> Micro-stepping (micro-step/s)	1/16 <sup>th</sup> Micro-stepping (micro-step/s)
0	0	99	A	197	395	790	1579
1	1	136	B	273	546	1091	2182
2	2	167		334	668	1335	2670
3	3	197		395	790	1579	3159
4	4	213		425	851	1701	3403
5	5	228		456	912	1823	3647
6	6	243		486	973	1945	3891
7	7	273	C	546	1091	2182	4364
8	8	303		607	1213	2426	4852
9	9	334		668	1335	2670	5341
A	10	364		729	1457	2914	5829
B	11	395		790	1579	3159	6317
C	12	456		912	1823	3647	7294
D	13	546	D	1091	2182	4364	8728
E	14	729		1457	2914	5829	11658
F	15	973		1945	3891	7782	15564

# AMIS-30623

## Minimum Velocity

Once the maximum velocity is chosen, 16 possible values can be programmed for the minimum velocity  $V_{min}$ . The table below provides the obtainable values in full-step/s. The accuracy of  $V_{min}$  is derived from the internal oscillator.

**Table 8. OBTAINABLE VALUES IN FULL-STEP/s FOR THE MINIMUM VELOCITY**

Vmin Index		Vmax Factor	Vmax (Full-step/s)															
			A			B						C					D	
Hex	Dec		99	136	167	197	213	228	243	273	303	334	364	395	456	546	729	973
0	0	1	99	136	167	197	213	228	243	273	303	334	364	395	456	546	729	973
1	1	1/32	3	4	5	6	6	7	7	8	8	10	10	11	13	15	19	27
2	2	2/32	6	8	10	11	12	13	14	15	17	19	21	23	27	31	42	57
3	3	3/32	9	12	15	18	19	21	22	25	27	31	32	36	42	50	65	88
4	4	4/32	12	16	20	24	26	28	30	32	36	40	44	48	55	65	88	118
5	5	5/32	15	21	26	31	32	35	37	42	46	51	55	61	71	84	111	149
6	6	6/32	18	25	31	36	39	42	45	50	55	61	67	72	84	99	134	179
7	7	7/32	21	30	36	43	46	50	52	59	65	72	78	86	99	118	156	210
8	8	8/32	24	33	41	49	52	56	60	67	74	82	90	97	113	134	179	240
9	9	9/32	28	38	47	55	59	64	68	76	84	93	101	111	128	153	202	271
A	10	10/32	31	42	51	61	66	71	75	84	93	103	113	122	141	168	225	301
B	11	11/32	34	47	57	68	72	78	83	93	103	114	124	135	156	187	248	332
C	12	12/32	37	51	62	73	79	85	91	101	113	124	135	147	170	202	271	362
D	13	13/32	40	55	68	80	86	93	98	111	122	135	147	160	185	221	294	393
E	14	14/32	43	59	72	86	93	99	106	118	132	145	158	172	198	237	317	423
F	15	15/32	46	64	78	93	99	107	113	128	141	156	170	185	214	256	340	454

NOTES: The Vmax factor is an approximation.

In case of motion without acceleration (**AccShape** = 1) the length of the steps =  $1/V_{min}$ . In case of accelerated motion (**AccShape** = 0) the length of the first step is shorter than  $1/V_{min}$  depending of **Vmin**, **Vmax** and **Acc**.

**Acceleration and Deceleration**

Sixteen possible values can be programmed for Acc (acceleration and deceleration between Vmin and Vmax). The table below provides the obtainable values in full-step/s<sup>2</sup>. One observes restrictions for some

combinations of acceleration index and maximum speed (gray cells).

The accuracy of Acc is derived from the internal oscillator.

**Table 9. ACCELERATION AND DECELERATION SELECTION TABLE**

Vmax (FS/s) →		99	136	167	197	213	228	243	273	303	334	364	395	456	546	729	973
↓ Acc Index																	
Hex	Dec	Acceleration (Full-step/s <sup>2</sup> )															
0	0	49								106				473			
1	1	218															
2	2	1004															
3	3	3609															
4	4	6228															
5	5	8848															
6	6	11409															
7	7	13970															
8	8	16531															
9	9	19092															
A	10	21886															
B	11	24447															
C	12	27008															
D	13	29570															
E	14	29570								34925							
F	15									40047							

The formula to compute the number of equivalent full-steps during acceleration phase is:

$$Nstep = \frac{Vmax^2 - Vmin^2}{2 \times Acc}$$

**Positioning**

The position programmed in commands SetPosition and SetPositionShort is given as a number of (micro-)steps. According to the chosen stepping mode, the position words must be aligned as described in the table below. When using command SetPositionShort or GotoSecurePosition, data is automatically aligned.

**Table 10. POSITION WORD ALIGNMENT**

Stepping Mode	Position Word: Pos [ 15 : 0 ]																Shift
1/16 <sup>th</sup>	S	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	LSB	No shift
1/8 <sup>th</sup>	S	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	LSB	0	1-bit left ↔ ×2
1/4 <sup>th</sup>	S	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	LSB	0	0	2-bit left ↔ ×4
Half-stepping	S	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	LSB	0	0	0	3-bit left ↔ ×8
PositionShort	S	S	S	B9	B8	B7	B6	B5	B4	B3	B2	B1	LSB	0	0	0	No shift
SecurePosition	S	B9	B8	B7	B6	B5	B4	B3	B2	B1	LSB	0	0	0	0	0	No shift

NOTES: LSB: Least Significant Bit  
S: Sign bit

**Position Ranges**

A position is coded by using the binary two’s complement format. According to the positioning commands used and to the chosen stepping mode, the position range will be as shown in the following table.

**Table 11. POSITION RANGE**

Command	Stepping Mode	Position Range	Full Range Excursion	Number of Bits
SetPosition	Half-stepping	-4096 to +4095	8192 half-steps	13
	1/4 <sup>th</sup> micro-stepping	-8192 to +8191	16384 micro-steps	14
	1/8 <sup>th</sup> micro-stepping	-16384 to +16383	32768 micro-steps	15
	1/16 <sup>th</sup> micro-stepping	-32768 to +32767	65536 micro-steps	16
SetPositionShort	Half-stepping	-1024 to +1023	2048 half-steps	11

When using the command SetPosition, although coded on 16 bits, the position word will have to be shifted to the left by a certain number of bits, according to the stepping mode.

**Secure Position**

A secure position can be programmed. It is coded in 11-bits, thus having a lower resolution than normal positions, as shown in the following table. See also command GotoSecurePosition and LIN lost behavior.

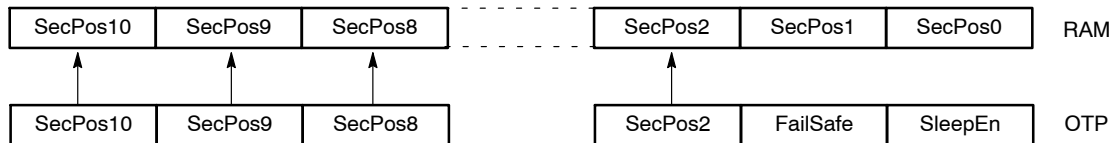
**Table 12. SECURE POSITION**

Stepping Mode	Secure Position Resolution
Half-stepping	4 half-steps
1/4 <sup>th</sup> micro-stepping	8 micro-steps (1/4 <sup>th</sup> )
1/8 <sup>th</sup> micro-stepping	16 micro-steps (1/8 <sup>th</sup> )
1/16 <sup>th</sup> micro-stepping	32 micro-steps (1/16 <sup>th</sup> )

**Important**

NOTES: The secure position is disabled in case the programmed value is the reserved code “1000000000” (0x400 or most negative position).

The resolution of the secure position is limited to 9 bit at start-up. The OTP register is copied in RAM as illustrated below. The RAM bits SecPos1 and SecPos0 are set to 0.



**Shaft**

A shaft bit, which can be programmed in OTP or with command SetMotorParam, defines whether a positive motion is a clockwise (CW) or counter-clockwise rotation (CCW) (an outer or an inner motion for linear actuators):

- Shaft = 0 ⇒ MOTXP is used as positive pin of the X coil, while MOTXN is the negative one.
- Shaft = 1 ⇒ opposite situation

**Exception:** in RunVelocity mode, the shaft bit has no function. In this mode the rotational direction is always CW or CCW, which is only determined by the motor wiring.

**STRUCTURAL DESCRIPTION**

See also the Block Diagram in Figure 1.

**Stepper Motordriver**

The Motordriver receives the control signals from the control logic. The main features are:

- Two H-bridges, designed to drive a stepper motor with two separated coils. Each coil (X and Y) is driven by one H-bridge, and the driver controls the currents flowing through the coils. The rotational position of the

rotor, in unloaded condition, is defined by the ratio of current flowing in X and Y. The torque of the stepper motor when unloaded is controlled by the magnitude of the currents in X and Y.

- The control block for the H-bridges, including the PWM control, the synchronous rectification and the internal current sensing circuitry.

- The charge pump to allow driving of the H-bridges' high side transistors.
- Two pre-scale 4-bit DAC's to set the maximum magnitude of the current through X and Y.
- Two DAC's to set the correct current ratio through X and Y.

Battery voltage monitoring is also performed by this block, which provides the required information to the control logic part. The same applies for detection and reporting of an electrical problem that could occur on the coils or the charge pump.

**Control Logic (Position Controller and Main Control)**

The control logic block stores the information provided by the LIN interface (in a RAM or an OTP memory) and digitally controls the positioning of the stepper motor in terms of speed and acceleration, by feeding the right signals to the motordriver state machine.

It will take into account the successive positioning commands to properly initiate or stop the stepper motor in order to reach the set point in a minimum time.

It also receives feedback from the motordriver part in order to manage possible problems and decide on internal actions and reporting to the LIN interface.

**Motion Detection**

Motion detection is based on the back-emf generated internally in the running motor. When the motor is blocked,

e.g. when it hits the end position, the velocity, and as a result also the generated back-emf, is disturbed. The AMIS-30623 senses the back-emf, calculates a moving average and compares the value with two independent threshold levels. If the back-emf disturbance is bigger than the set threshold, the running motor is stopped.

**LIN Interface**

The LIN interface implements the physical layer and the MAC and LLC layers according to the OSI reference model. It provides and gets information to and from the control logic block, in order to drive the stepper motor, to configure the way this motor must be driven, or to get information such as actual position or diagnosis (temperature, battery voltage, electrical status...) and pass it to the LIN master node.

**Miscellaneous**

The AMIS-30623 also contains the following:

- An internal oscillator, needed for the LIN protocol handler as well as the control logic and the PWM control of the motordriver.
- An internal trimmed voltage source for precise referencing.
- A protection block featuring a thermal shutdown and a power-on-reset circuit.
- A 5 V regulator (from the battery supply) to supply the internal logic circuitry.

**FUNCTIONS DESCRIPTION**

This chapter describes the following functional blocks in more detail:

- Position controller
- Main control and register, OTP memory + ROM
- Motordriver

The Motion detection and LIN controller are discussed in separate chapters.

**Position Controller**

**Positioning and Motion Control**

A positioning command will produce a motion as illustrated in Figure 7. A motion starts with an acceleration phase from minimum velocity ( $V_{min}$ ) to maximum velocity ( $V_{max}$ ) and ends with a symmetrical deceleration. This is defined by the control logic according to the position required by the application and the parameters programmed by the application during the configuration phase. The current in the coils is also programmable.

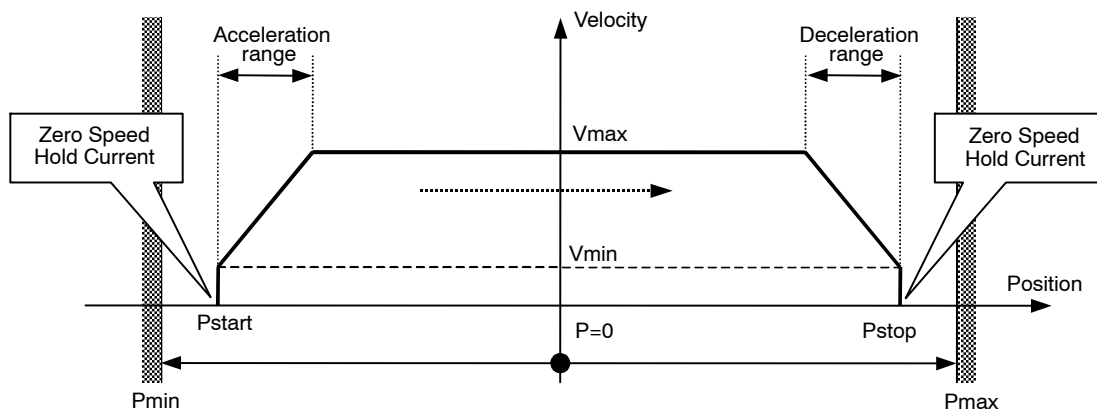


Figure 7. Positioning and Motion Control

**Table 13. POSITION RELATED PARAMETERS**

Parameter	Reference
Pmax – Pmin	See <a href="#">Positioning</a>
Zero Speed Hold Current	See <a href="#">Ihold</a>
Maximum Current	See <a href="#">Irun</a>
Acceleration and Deceleration	See <a href="#">Acceleration and Deceleration</a>
Vmin	See <a href="#">Minimum Velocity</a>
Vmax	See <a href="#">Maximum Velocity</a>

Different positioning examples are shown in the table below.

**Table 14. POSITIONING EXAMPLES**

Short motion.	
New positioning command in same direction, shorter or longer, while a motion is running at maximum velocity.	
New positioning command in same direction while in deceleration phase (Note 20) <b>Note:</b> there is no wait time between the deceleration phase and the new acceleration phase.	
New positioning command in reverse direction while motion is running at maximum velocity.	
New positioning command in reverse direction while in deceleration phase.	
New velocity programming while motion is running.	

20. Reaching the end position is always guaranteed, however velocity rounding errors might occur after consecutive accelerations during a deceleration phase. The velocity rounding error will be removed at Vmin (e.g. at end of acceleration or when AccShape=1).



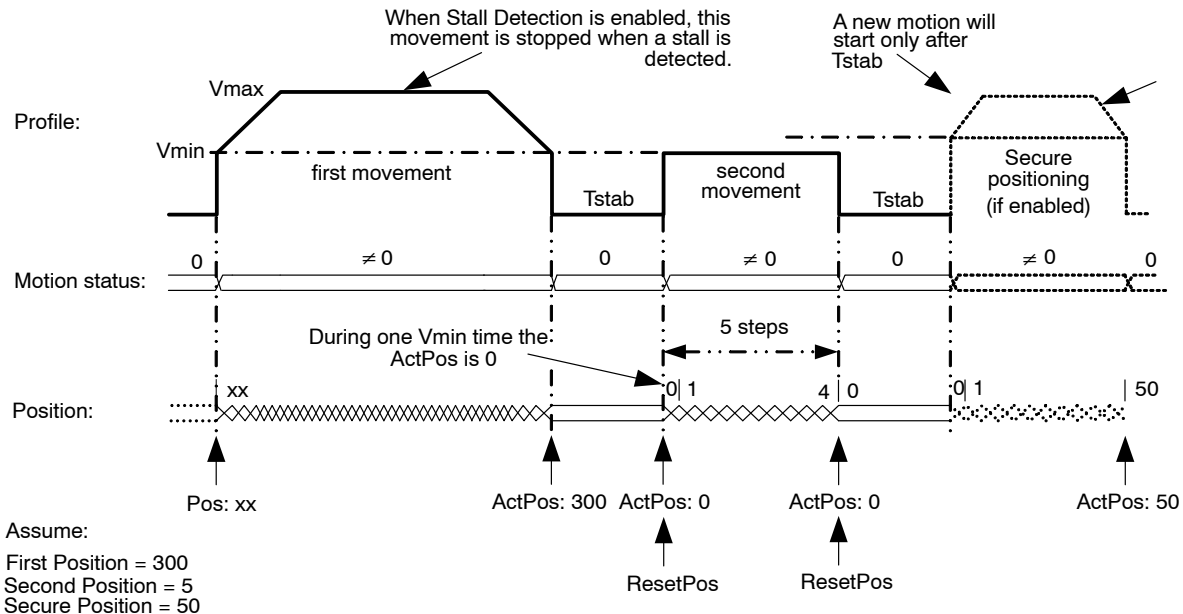
**Dual Positioning**

A SetDualPosition command allows the user to perform a positioning using two different velocities. The first motion is done with the specified  $V_{min}$  and  $V_{max}$  velocities in the SetDualPosition command, with the acceleration (deceleration) parameter already in RAM, to a position  $Pos1[15:0]$  also specified in SetDualPosition.

Then a second relative motion to a physical position  $Pos1[15:0] + Pos2[15:0]$  is done at the specified  $V_{min}$  velocity in the SetDualPosition command (no

acceleration). Once the second motion is achieved, the  $ActPos$  register is reset to zero, whereas  $TagPos$  register is not changed.

When the Secure position is enabled, after the dual positioning, the secure positioning is executed. The figure below gives a detailed overview of the dual positioning function. After the dual positioning is executed an internal flag is set to indicate the AMIS-30623 is referenced.



**Figure 8. Dual Positioning**

**Remark:** This operation cannot be interrupted or influenced by any further command unless the occurrence of the conditions driving to a motor shutdown or by a HardStop command. Sending a SetDualPosition command while a motion is already ongoing is not recommended.

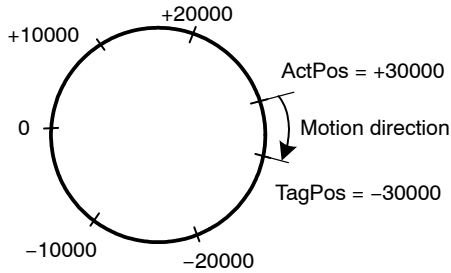
- 21. The priority encoder is describing the management of states and commands.
- 22. A DualPosition sequence starts by setting  $TagPos$  buffer register to  $SecPos$  value, provided secure position is enabled otherwise  $TagPos$  is reset to zero. If a SetPosition(Short) command is issued during a DualPosition sequence, it will be kept in the position buffer memory and executed afterwards. This applies also for the commands Sleep, SetPosParam and GotoSecurePosition.
- 23. Commands such as GetActualPos or GetStatus will be executed while a Dual Positioning is running. This applies also for a dynamic ID assignment LIN frame.
- 24. The  $Pos1$ ,  $Pos2$ ,  $V_{max}$  and  $V_{min}$  values programmed in a SetDualPosition command apply only for this sequence. All other motion parameters are used from the RAM registers (programmed for instance by a former SetMotorParam command). After the DualPosition motion is completed, the former  $V_{min}$  and  $V_{max}$  become active again.
- 25. Commands ResetPosition, SetDualPosition, and SoftStop will be ignored while a DualPosition sequence is ongoing, and will not be executed afterwards.
- 26. Recommendation: a SetMotorParam command should not be sent during a SetDualPosition sequence: all the motion parameters defined in the command, except  $V_{min}$  and  $V_{max}$ , become active immediately.

**Position Periodicity**

Depending on the stepping mode the position can range from  $-4096$  to  $+4095$  in half-step to  $-32768$  to  $+32767$  in 1/16th micro-stepping mode. One can project all these positions lying on a circle. When executing the command SetPosition, the position controller will set the movement direction in such a way that the traveled distance is minimal.

The figure below illustrates that the moving direction going from  $ActPos = +30000$  to  $TagPos = -30000$  is clockwise.

If a counter clockwise motion is required in this example, several consecutive SetPosition commands can be used. One could also use for larger movements the command RunVelocity.

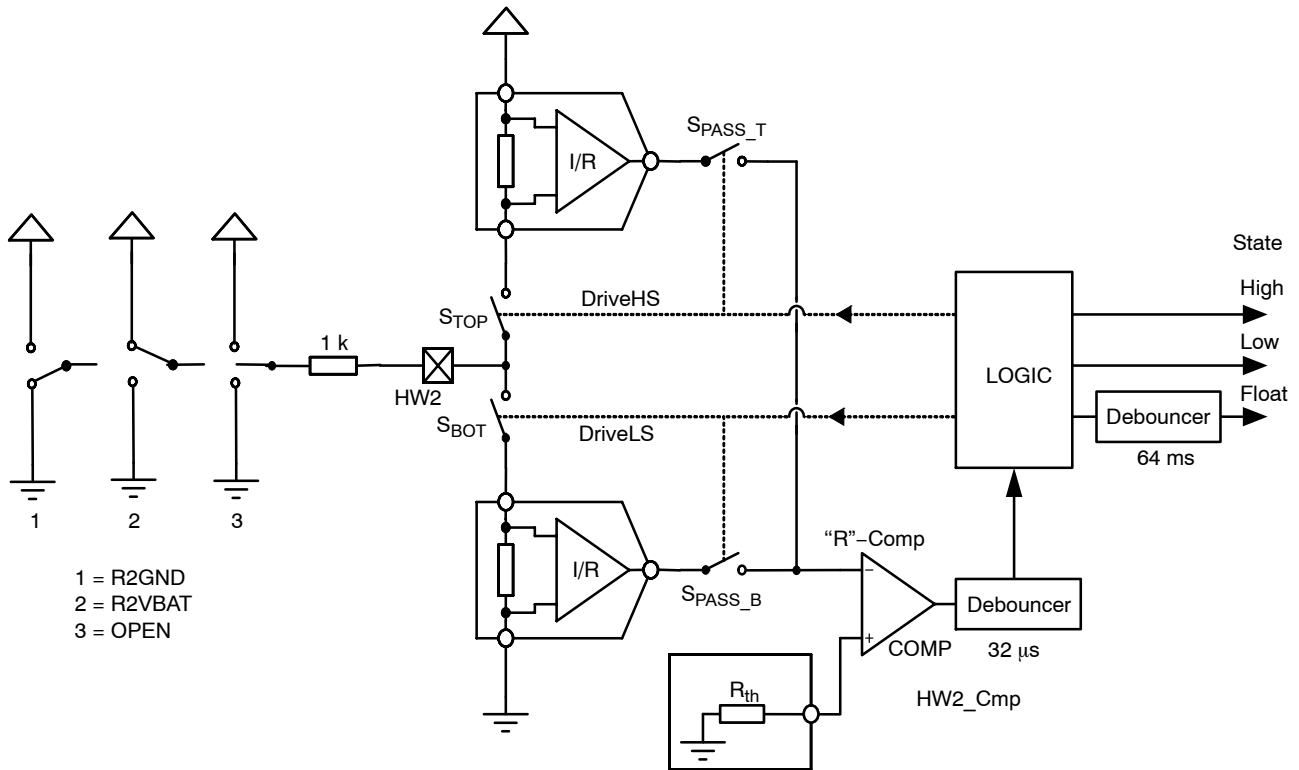


**Figure 9. Motion Direction is Function of Difference between ActPos and TagPos**

**Hardwired Address HW2**

In the drawing below, a simplified schematic diagram is shown of the HW2 comparator circuit.

The HW2 pin is sensed via 2 switches. The DriveHS and DriveLS control lines are alternatively closing the top and bottom switch connecting HW2 pin with a current to resistor converter. Closing  $S_{TOP}$  (DriveHS = 1) will sense a current to GND. In that case the top  $I \rightarrow R$  converter output is low, via the closed passing switch  $S_{PASS\_T}$  this signal is fed to the “R” comparator which output HW2\_Cmp is high. Closing bottom switch  $S_{BOT}$  (DriveLS = 1) will sense a current to  $V_{BAT}$ . The corresponding  $I \rightarrow R$  converter output is low and via  $S_{PASS\_B}$  fed to the comparator. The output HW2\_Cmp will be high.



**Figure 10. Simplified Schematic Diagram of the HW2 Comparator**

3 cases can be distinguished (see also Figure 10 above):

- HW2 is connected to ground: R2GND or drawing 1
- HW2 is connected to VBAT: R2VBAT or drawing 2
- HW2 is floating: OPEN or drawing 3

Table 15. STATE DIAGRAM OF THE HW2 COMPARATOR

Previous State	DriveLS	DriveHS	HW2_Cmp	New State	Condition	Drawing
Float	1	0	0	Float	R2GND or OPEN	1 or 3
Float	1	0	1	High	R2VBAT	2
Float	0	1	0	Float	R2VBAT or OPEN	2 or 3
Float	0	1	1	Low	R2GND	1
Low	1	0	0	Low	R2GND or OPEN	1 or 3
Low	1	0	1	High	R2VBAT	2
Low	0	1	0	Float	R2VBAT or OPEN	2 or 3
Low	0	1	1	Low	R2GND	1
High	1	0	0	Float	R2GND or OPEN	1 or 3
High	1	0	1	High	R2VBAT	2
High	0	1	0	High	R2VBAT or OPEN	2 or 3
High	0	1	1	Low	R2GND	1

The logic is controlling the correct sequence in closing the switches and in interpreting the 32  $\mu$ s debounced HW2\_Cmp output accordingly. The output of this small state-machine is corresponding to:

- High or address = 1
- Low or address = 0
- Floating

As illustrated in the table above (Table 15), the state is depending on the previous state, the condition of the 2 switch controls (DriveLS and DriveHS) and the output of HW2\_Cmp. Figure 11 shows an example of a practical case where a connection to VBAT is interrupted.

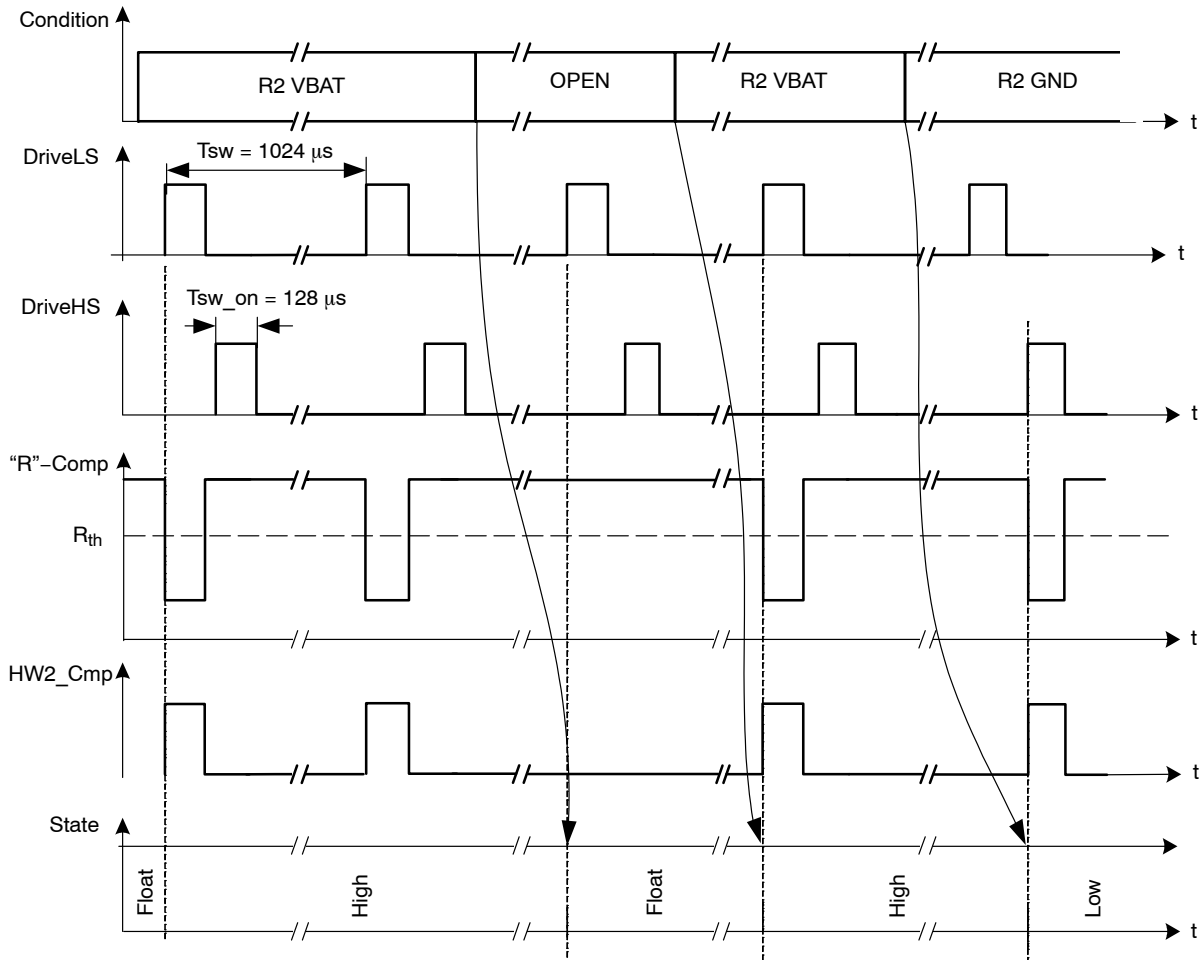


Figure 11. Timing Diagram Showing the Change in States for HW2 Comparator

**R2VBAT**

A resistor is connected between VBAT and HW2. Every 1024  $\mu\text{s}$   $S_{BOT}$  is closed and a current is sensed. The output of the  $I \Rightarrow R$  converter is low and the HW2\_Cmp output is high. Assuming the previous state was floating, the internal logic will interpret this as a change of state and the new state will be high (see also Table 15). The next time  $S_{BOT}$  is closed the same conditions are observed. The previous state was high so based on Table 15 the new state remains unchanged. This high state will be interpreted as HW2 address = 1.

**OPEN**

In case the HW2 connection is lost (broken wire, bad contact in connector) the next time  $S_{BOT}$  is closed, this will be sensed. There will be no current, the output of the corresponding  $I \Rightarrow R$  converter is high and the HW2\_Cmp will be low. The previous state was high. Based in Table 15 one can see that the state changes to float. This will trigger

a motion to secure position after a debounce time of 64 ms, which prevents false triggering in case of micro-interruptions of the power supply.

**R2GND**

If a resistor is connected between HW2 and the GND, a current is sensed every 1024  $\mu\text{s}$  when  $S_{TOP}$  is closed. The output of the top  $I \Rightarrow R$  converter is low and as a result the HW2\_Cmp output switches to high. Again based on the stated diagram in Table 15 one can see that the state will change to Low. This low state will be interpreted as HW2 address = 0.

**External Switch SWI**

As illustrated in Figure 12 the SWI comparator is almost identical to HW2. The major difference is in the limited number of states. Only open or closed is recognised leading to respectively  $ESW = 0$  and  $ESW = 1$ .

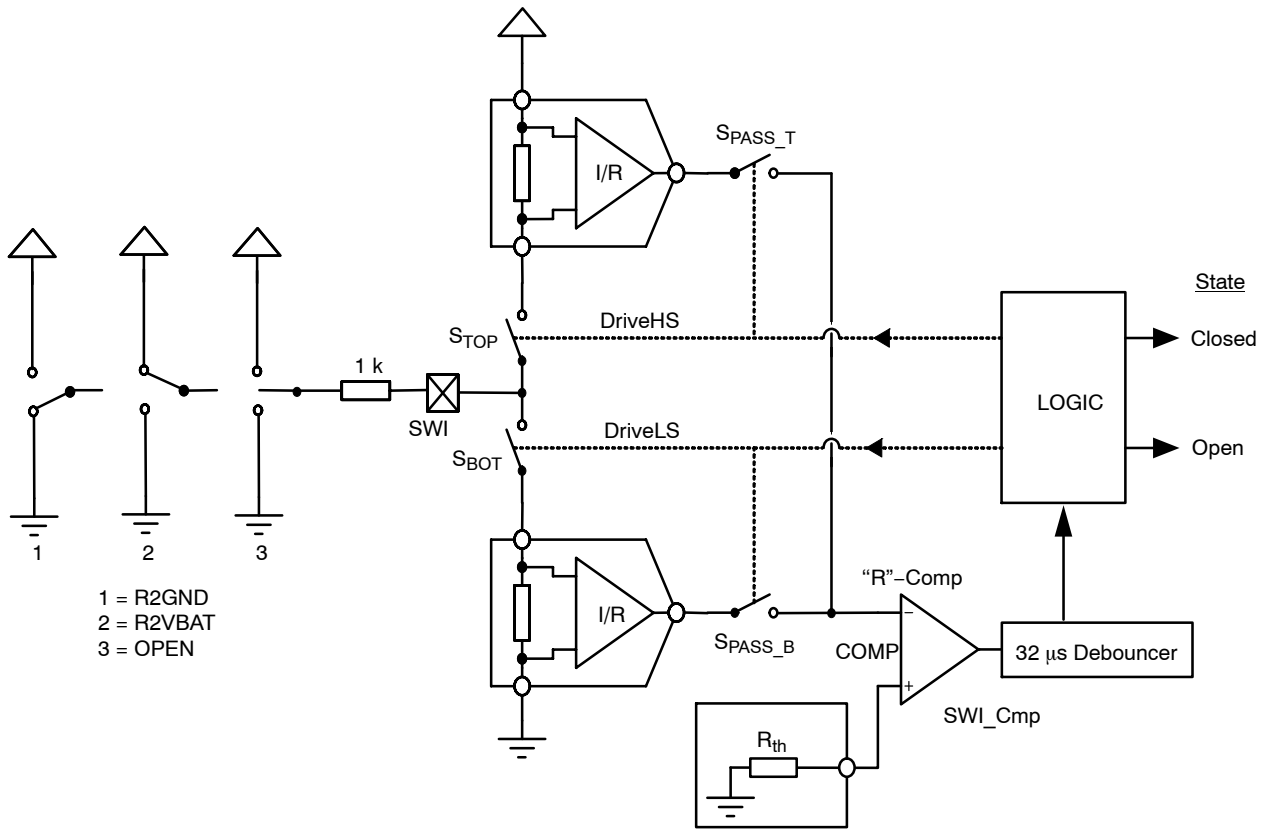


Figure 12. Simplified Schematic Diagram of the SWI Comparator

As illustrated in the drawing above, a change in state is always synchronised with DriveHS or DriveLS. The same synchronisation is valid for updating the internal position register. This means that after every current pulse (or closing of  $S_{TOP}$  or  $S_{BOT}$ ) the state of the position switch together with the corresponding position is memorised.

The `GetActualPos` command reads back the `<ActPos>` register and the status of ESW. In this way the master node may get synchronous information about the state of the switch together with the position of the motor. See Table 16 below.

Table 16. GetActualPos LIN COMMAND

Reading Frame									
Byte	Content	Structure							
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Identifier	*	*	1	0	ID3	ID2	ID1	ID0
1	Data 1	ESW	AD[6:0]						
2	Data 2	ActPos[15:8]							
3	Data 3	ActPos[7:0]							
4	Data 4	VddReset	StepLoss	EIDef	UV2	TSD	TW	Tinfo[1:0]	
5	Checksum	Checksum over data							

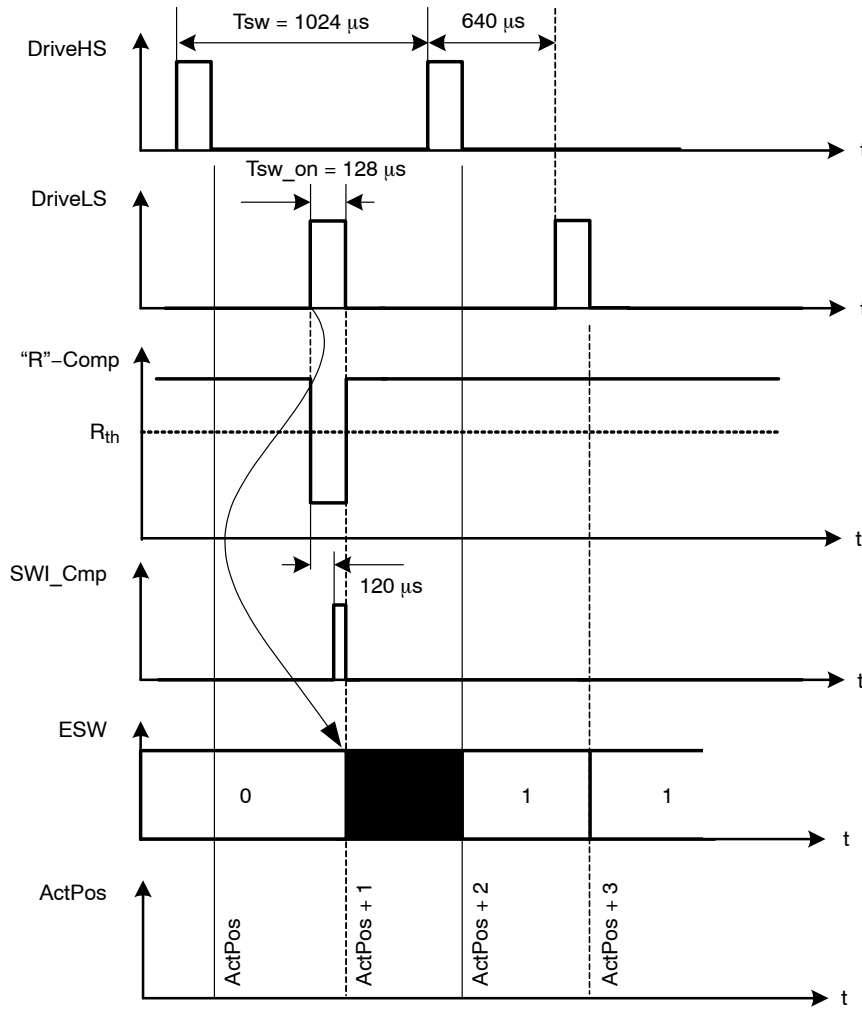


Figure 13. Simplified Timing Diagram Showing the Change in States for SWI Comparator

**Main Control and Register, OTP memory + ROM**

**Power-up Phase**

Power-up phase of the AMIS-30623 will not exceed 10 ms. After this phase, the AMIS-30623 is in standby mode, ready to receive LIN messages and execute the associated commands. After power-up, the registers and flags are in the reset state, while some of them are being loaded with the OTP memory content (see Table 19: RAM Registers).

**Reset**

After power-up, or after a reset occurrence (e.g. a micro-cut on pin V<sub>BB</sub> has made V<sub>DD</sub> to go below V<sub>ddReset</sub> level), the H-bridges will be in high-impedance mode, and the registers and flags will be in a predetermined position. This is documented in Table 19: RAM Registers and Table 20: Flags Table.

**Soft-stop**

A soft-stop is an immediate interruption of a motion, but with a deceleration phase. At the end of this action, the register <TagPos> is loaded with the value contained in

register <ActPos>, see Table 19: Ram Registers). The circuit is then ready to execute a new positioning command, provided thermal and electrical conditions allow for it.

**Sleep Mode**

When entering sleep mode, the stepper-motor can be driven to its secure position. After which, the circuit is completely powered down, apart from the LIN receiver, which remains active to detect a dominant state on the bus. In case sleep mode is entered while a motion is ongoing, a transition will occur towards secure position as described in Positioning and Motion Control provided <SecPos> is enabled. Otherwise, <SoftStop> is performed.

Sleep mode can be entered in the following cases:

- The circuit receives a LIN frame with identifier **0x3C** and first data byte containing **0x00**, as required by LIN specification rev 1.3 and <SleepEn> bit = 1. See also Sleep in the LIN Application Command section.
- In case the >SleepEn> bit = 1 and the LIN bus remains inactive (or is lost) during more than 25000 time slots (1.30 s at 19.2 kbit/s), a time-out signal switches the circuit to sleep mode.

The circuit will return to normal mode if a valid LIN frame is received (this valid frame can be addressed to another slave).

**Thermal Shutdown Mode**

When thermal shutdown occurs, the circuit performs a <SoftStop> command and goes to motor shutdown mode (see Figure 14: State Diagram Temperature Management).

**Temperature Management**

The AMIS-30623 monitors temperature by means of two thresholds and one shutdown level, as illustrated in the state diagram and illustration of Figure 14: State Diagram Temperature Management below. The only condition to reset flags <TW> and <TSD> (respectively thermal warning and thermal shutdown) is to be at a temperature lower than  $T_{tw}$  and to get the occurrence of a GetStatus or a GetFullStatus LIN frame.

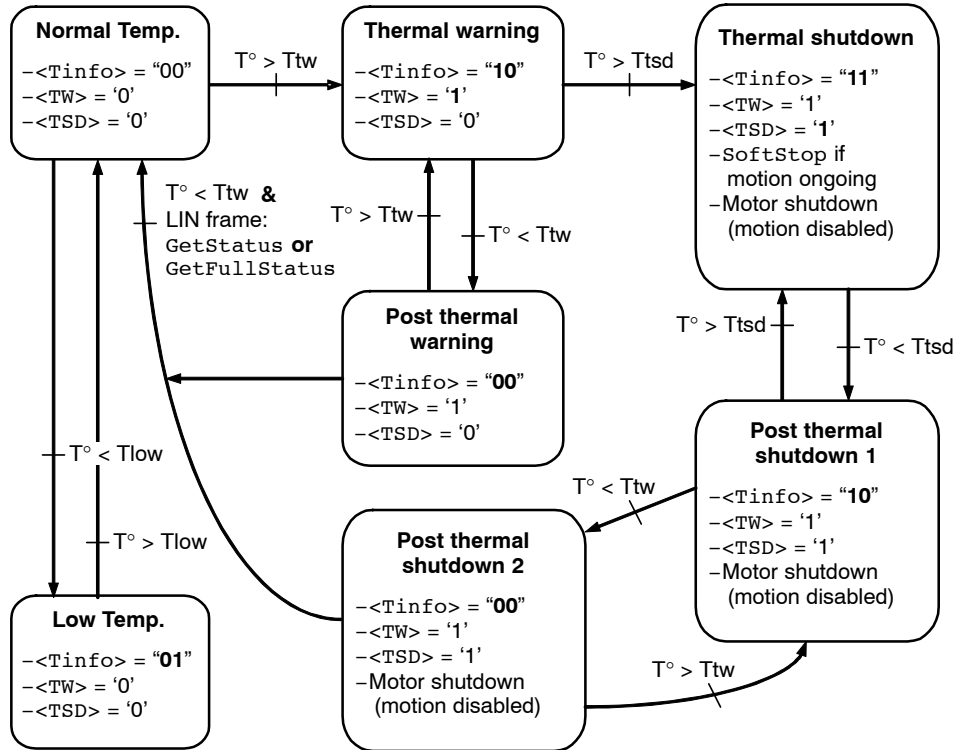


Figure 14. State Diagram Temperature Management

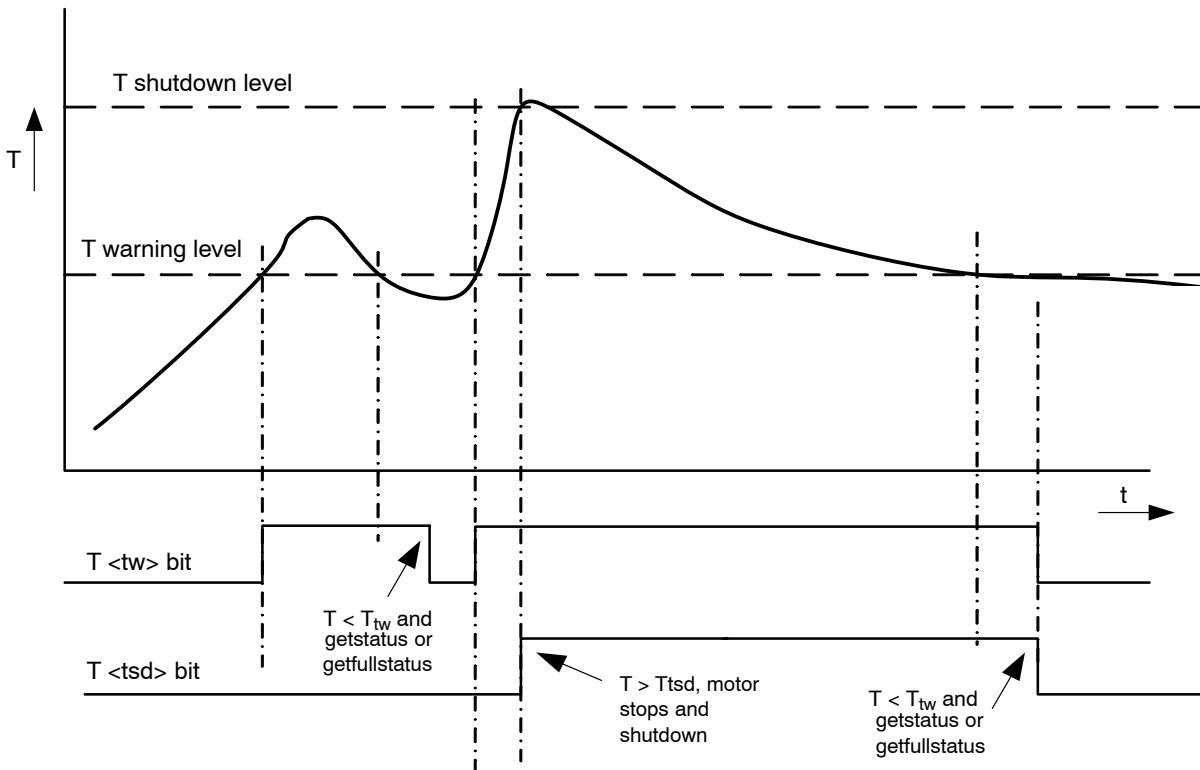


Figure 15. Illustration of Thermal Management Situation

**Autarkic Functionality in Under-Voltage Condition**

**Battery Voltage Management**

The AMIS-30623 monitors the battery voltage by means of one threshold and one shutdown level. The only condition to reset flags <UV2> and <StepLoss> is to recover by a battery voltage higher than UV1 and to receive a GetStatus or a GetFullStatus command.

**Autarkic Function**

The device enters states <HardUnder> (see Figure 16), followed by <ShutUnder> when  $V_{BB}$  is below the UV2 level or <CPFail> = 1. The motion is stopped immediately and Target Position (TagPos) is kept and not overwritten by Actual Position (ActPos). The motor is in HiZ state and the flags <UV2> and <StepLoss> are set to inform the master that the voltage has dropped below UV2 or the charge pump voltage has dropped below the level of the charge pump comparator and loss of steps is possible.

- If in this state  $V_{BB}$  becomes > UV1 within 15 seconds, then AMIS-30623 returns to <Stopped> state. From there, it resumes the interrupted motion and accepts updates of the target position by means of the commands SetPosition, SetPositionShort,

SetPosParam and GotoSecurePosition, even if the <UV2> flag, the <CPFail> flag and <StepLoss> flags are NOT cleared.

- If however the  $V_{BB}$  voltage remains below UV2 level or the charge pump voltage level is below the charge pump comparator for more than 15 seconds, then the device will enter <Shutdown> state and the target position is overwritten by Actual Position. This state can be exited only if  $V_{BB}$  is > UV1, the charge pump voltage is above the charge pump comparator voltage and an incoming command GetStatus or GetFullStatus is received.

**Important Notes:**

1. In the case of Autarkic positioning, care needs to be taken because accumulated steploss can cause a significant deviation between physical and stored actual position.
2. The SetDualPosition command will only be executed after clearing the <UV2>, CPFail and <StepLoss> flags.
3. RAM reset occurs when  $V_{dd} < V_{ddReset}$  (digital Power-On-Reset level).
4. The Autarkic function remains active as long as  $V_{DD} > V_{ddReset}$ .



**OTP Register**

**OTP Memory Structure**

The table below shows how the parameters to be stored in the OTP memory are located.

**Table 17. OTP MEMORY STRUCTURE**

Address	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x00	OSC3	OSC2	OSC1	OSC0	IREF3	IREF2	IREF1	IREF0
0x01	EnableLIN	TSD2	TSD1	TSD0	BG3	BG2	BG1	BG0
0x02	AbsThr3	AbsThr2	AbsThr1	AbsThr0	PA3	PA2	PA1	PA0
0x03	Irun3	Irun2	Irun1	Irun0	Ihold3	Ihold2	Ihold1	Ihold0
0x04	Vmax3	Vmax2	Vmax1	Vmax0	Vmin3	Vmin2	Vmin1	Vmin0
0x05	SecPos10	SecPos9	SecPos8	Shaft	Acc3	Acc2	Acc1	Acc0
0x06	SecPos7	SecPos6	SecPos5	SecPos4	SecPos3	SecPos2	Failsafe	SleepEn
0x07	DelThr3	DelThr2	DelThr1	DelThr0	StepMode1	StepMode0	LOCKBT	LOCKBG

Parameters stored at address 0x00 and 0x01 and bit <LOCKBT> are already programmed in the OTP memory at circuit delivery. They correspond to the calibration of the circuit and are just documented here as an indication.

Each OTP bit is at '0' when not zapped. Zapping a bit will set it to '1'. Thus only bits having to be at '1' must be zapped. Zapping of a bit already at '1' is disabled. Each OTP byte will be programmed separately (see command SetOTPparam). Once OTP programming is completed, bit <LOCKBG> can be zapped to disable future zapping, otherwise any OTP bit at '0' could still be zapped by using a SetOTPparam command.

**Table 18. OTP OVERWRITE PROTECTION**

Lock Bit	Protected Bytes
LOCKBT (factory zapped before delivery)	0x00 to 0x01
LOCKBG	0x00 to 0x07

The command used to load the application parameters via the LIN bus in the RAM prior to an OTP Memory programming is SetMotorParam. This allows for a functional verification before using a SetOTPparam command to program and zap separately one OTP memory byte. A GetOTPparam command issued after each SetOTPparam command allows verifying the correct byte zapping.

**Note:** Zapped bits will become active only after a power cycle. After programming the LIN bits the power cycle has to be performed first to guarantee further communication with the device.

**Application Parameters Stored in OTP Memory**

Except for the physical address <PA[3:0]> these parameters, although programmed in a non-volatile memory can still be overridden in RAM by a LIN writing operation.

**PA[3:0]** In combination with HW[2:0] it forms the physical address AD[6:0] of the stepper-motor. Up to 128 stepper-motors can theoretically be connected to the same LIN bus.

**AbsThr[3:0]** Absolute threshold used for the motion detection

Index	AbsThr				AbsThr level (V) (*)
0	0	0	0	0	Disable
1	0	0	0	1	0.5
2	0	0	1	0	1.0
3	0	0	1	1	1.5
4	0	1	0	0	2.0
5	0	1	0	1	2.5
6	0	1	1	0	3.0
7	0	1	1	1	3.5
8	1	0	0	0	4.0
9	1	0	0	1	4.5
A	1	0	1	0	5.0
B	1	0	1	1	5.5
C	1	1	0	0	6.0
D	1	1	0	1	6.5
E	1	1	1	0	7.0
F	1	1	1	1	7.5

(\*) Not tested in production. Values are approximations.

**DelThr[3:0]** Relative threshold used for the motion detection

Index	DelThr				DelThr Level (V) (*)
0	0	0	0	0	Disable
1	0	0	0	1	0.25
2	0	0	1	0	0.50
3	0	0	1	1	0.75
4	0	1	0	0	1.00
5	0	1	0	1	1.25
6	0	1	1	0	1.50
7	0	1	1	1	1.75
8	1	0	0	0	2.00
9	1	0	0	1	2.25
A	1	0	1	0	2.50
B	1	0	1	1	2.75
C	1	1	0	0	3.00
D	1	1	0	1	3.25
E	1	1	1	0	3.50
F	1	1	1	1	3.75

(\*) Not tested in production. Values are approximations.

**IrUn[3:0]** Current amplitude value to be fed to each coil of the stepper-motor. The table below provides the 16 possible values for <IRUN>.

Index	IrUn				Run Current (mA)
0	0	0	0	0	59
1	0	0	0	1	71
2	0	0	1	0	84
3	0	0	1	1	100
4	0	1	0	0	119
5	0	1	0	1	141
6	0	1	1	0	168
7	0	1	1	1	200
8	1	0	0	0	238
9	1	0	0	1	283
A	1	0	1	0	336
B	1	0	1	1	400
C	1	1	0	0	476
D	1	1	0	1	566
E	1	1	1	0	673
F	1	1	1	1	800

**Ihold[3:0]** Hold current for each coil of the stepper-motor. The table below provides the 16 possible values for <IHOLD>.

Index	Ihold				Hold Current (mA)
0	0	0	0	0	59
1	0	0	0	1	71
2	0	0	1	0	84
3	0	0	1	1	100
4	0	1	0	0	119
5	0	1	0	1	141
6	0	1	1	0	168
7	0	1	1	1	200
8	1	0	0	0	238
9	1	0	0	1	283
A	1	0	1	0	336
B	1	0	1	1	400
C	1	1	0	0	476
D	1	1	0	1	566
E	1	1	1	0	673
F	1	1	1	1	0

**Note:** When the motor is stopped, the current is reduced from <IRUN> to <IHOLD>. In the case of 0 mA hold current (1111 in the hold current table), the following sequence is applied:

1. The current is first reduced to 59 mA (corresponding to 0000 value in the table).
2. The PWM regulator is switched off; the bottom transistors of the bridges are grounded.

**StepMode** Setting of step modes.

StepMode		Step Mode
0	0	1/2 stepping
0	1	1/4 stepping
1	0	1/8 stepping
1	1	1/16 stepping

**Shaft** This bit distinguishes between a clock-wise or counter-clock-wise rotation. The shaft bit is not working in RunVelocity mode.

**SecPos[10:2]** Secure Position of the stepper-motor. This is the position to which the motor is driven in case of a LIN communication loss or when the LIN error-counter overflows. If <SecPos[10:2]> = "100 0000 00xx", secure positioning is disabled; the stepper-motor will be kept in the position occupied at the moment these events occur.