



Linko Semiconductor Co., Ltd.

# ***LKS32AT086 Datasheet***

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# 1 Overview

## 1.1 Function

LKS32AT086N8Q9(B) is a 32-bit MCU targeting automobile applications. With the three-phase full-bridge bootstrap gate driver, it can directly drive six N-channel MOSFETs.

### Features

- 96MHz 32-bit Cortex-M0 core
- Customized instruction set DSP for motor control
- Ultra low power sleep mode, 10uA sleep current with MCU low low power consumption
- Three-phase full-bridge bootstrap gate driver
- Automotive temperature range
- High ESD and group pulse reliability
- Pass AEC-Q100 Grade 1 testing certification
- **Memory**
  - 64kB Flash with optional encryption to prevent hex theft
  - 8kB RAM
- **Operating Conditions**
  - Dual power supply. The MCU is powered by 2.2V ~ 5.5V voltage(B-version chip is powered by 3.0V~5.5V),with an integrated internal LDO for the digital circuit. Drive module power supply please refer to Chapter 22.
  - Operating Conditions: -40~125°C
- **Clock**
  - 4MHz built-in high-precision RC oscillator, with an accuracy of  $\pm 1\%$  at -40 ~ 105 °C and  $\pm 1.5\%$  at -40 ~ 125 °C
  - 32KHz built-in low-speed clock for low-power mode
  - Operating on an external 4MHz crystal is available
  - Internal PLL up to 96 MHz
- **Peripheral Modules**
  - Two UARTs
  - One SPI, support master-slave mode
  - One IIC, support master-slave mode
  - One CAN-bus, recommended to use external crystal as reference clock
  - Two 16-bit standard timers (TIM), support capture and edge-aligned PWM function
  - Two 32-bit standard timers (TIM), support capture and edge-aligned PWM function; support orthogonal code input, CW/CCW input, and pulse&symbol input
  - Motor control PWM module, supports 8 channels/4 pairs of PWM waveform output,



independent dead-band control

- Hall signal interface with speed measurement and debouncing function
  - Hardware watchdog
  - 4 Groups of 16bit GPIO at the most. P0.0/P0.1/P1.0/P1.1 could be used as wake-up source。
- P0.15 ~ P0.0 could be used as external IRQ source

#### ● Analog Modules

- 12bit SAR ADC, simultaneous double sampling, 3MSPS sampling and conversion rate, up to 13 analog signal channels
- Four operational amplifiers. Differential PGA mode is available.
- Two comparators. Hysteresis mode is available.
- 12bit digital-to-analog converter (DAC)
- $\pm 3$  °C built-in temperature sensor
- 1.2V 0.8% built-in linear regulator
- Low-power LDO and power monitoring circuit
- RC oscillator with high precision and low temperature drift
- Crystal oscillator circuits

## 1.2 Performance Advantages

- High reliability, high integration level, small package size, saving BOM cost;
- Integrated 4 channels high-speed OPAs and 2 channels comparators, meeting the needs of different system topology like single resistance/double resistance/three resistance current sampling;
- High-speed OPA is integrated with over-voltage protection circuit, which allows high-voltage common-mode signals to be input, which could support direct current sampling of MOSFET resistance with the simplest circuit topology.
- Via a proprietary technique, ADC and high-speed OPA could cooperate well, making them able to handle a wider current dynamic range, while ensuring the sampling precision of high-speed small current and low-speed high current;
- The control circuit is simple and efficient, with strong anti-interference ability, stable and reliable;
- Three-phase full-bridge bootstrap gate driver is integrated;
- Supports IEC/UL60730 functional safety certification;

Applicable to control systems such as inductive BLDC/non-inductive BLDC/inductive FOC/non-inductive FOC and stepper motors, permanent magnet synchronous and asynchronous motors.



### 1.3 Naming Conventions

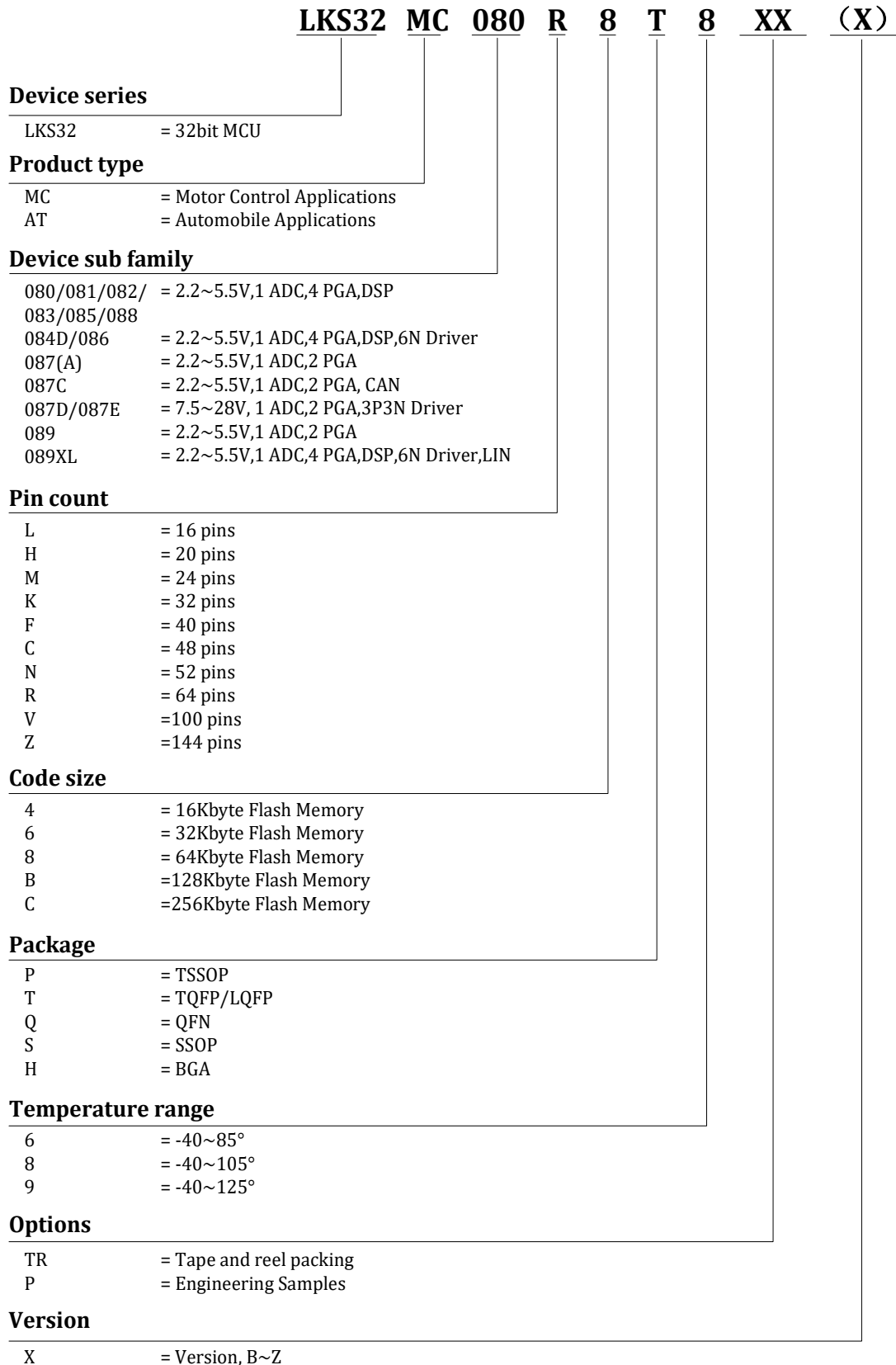


Fig. 1-1 Naming Conventions of Linko Components



### 1.4 Resource Diagram

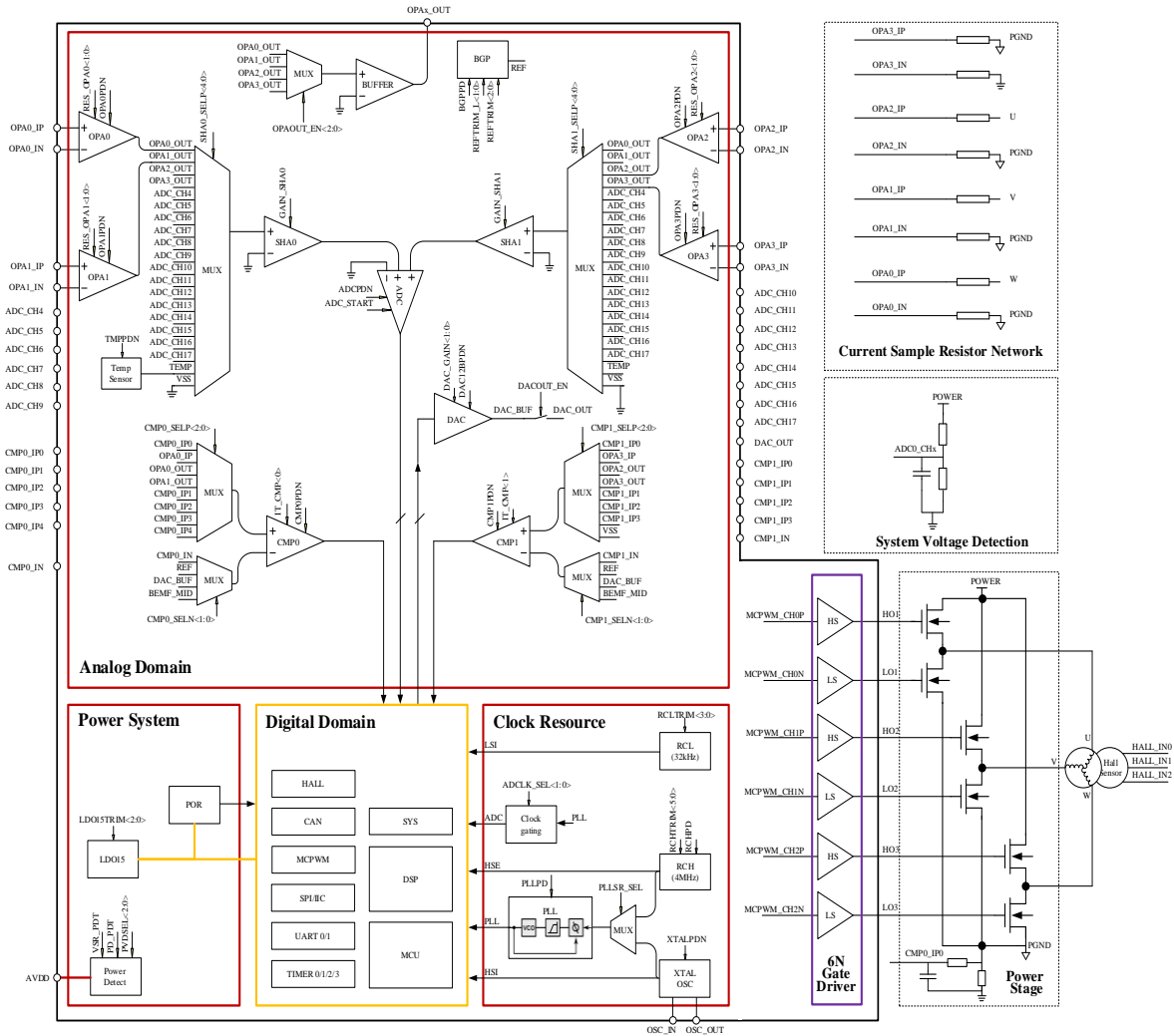


Fig. 1-2 LKS32AT086N8Q9(B) Resource Diagram



### 1.5 FOC System Example

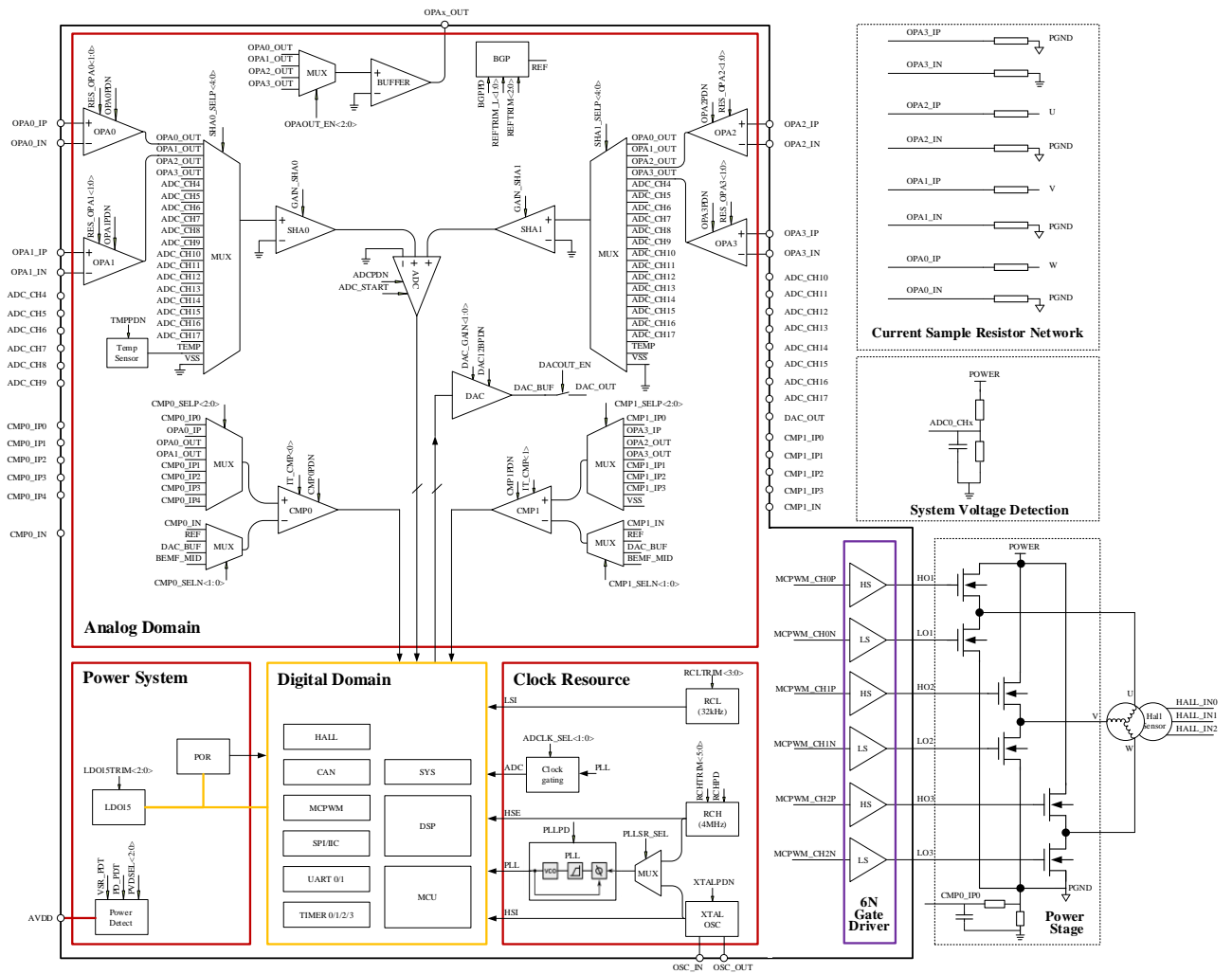


Fig. 1-3 LKS32AT086N8Q9(B) Simplified Schematic of FOC System



## 2 Device Selection Guide

Table 2-1 LKS08x family device selection guide

	Frequency (MHz)	Flash (kB)	RAM (kB)	ADC ch.	DAC	Comparator	Comparator ch.	OPA	HALL	SPI	IIC	UART	CAN	Temp. Sensor	PLL	QEP	Gate driver	Gate Driver current (A)	Pre-drive supply (V)	Gate floating voltage (V)	Others	Package
LKS32MC080R8T8(B)	96	64	8	13	12BITx1	2	9	4	3	1	1	2	Yes	Yes	Yes	Yes						LQFP64
LKS32MC081C8T8(B)	96	64	8	12	12BITx1	2	9	4	3	1	1	2		Yes	Yes							TQFP48
LKS32MC082K8Q8(B)	96	64	8	8	12BITx1	2	6	3	3	1	1	2		Yes	Yes							QFN5*5 32L-0.75
LKS32MC083C8T8(B)	96	64	8	12	12BITx1	2	9	4	3	1	1	2	Yes	Yes	Yes	Yes						TQFP48
LKS32MC084DF6Q8	96	32	8	11	12BITx1	2	7	4	3	1	1	2		Yes	Yes		6N	+1.2/-1.5	4.5~20*1	200		QFN5*5 40L-0.75
LKS32AT085C8Q9	96	64	8	12	12BITx1	2	9	4	3	1	1	2	Yes	Yes	Yes	Yes						QFN6*6 48L-0.55
LKS32AT086N8Q9	96	64	8	11	12BITx1	2	9	4	3	1	1	2	Yes	Yes	Yes	Yes	6N	+1.2/-1.5	4.5~20	200		QFN6*6 52L-0.55
LKS32MC086N8Q8	96	64	8	11	12BITx1	2	9	4	3	1	1	2	Yes	Yes	Yes	Yes	6N	+1.2/-1.5	4.5~20	200		QFN6*6 52L-0.55
LKS32MC087M6S8(B)	96	32	8	5	12BITx1	2	6	2	3			1		Yes	Yes							SSOP24L
LKS32MC087AM6S8(B)	96	32	8	5	12BITx1	2	6	2	3			1		Yes	Yes							SSOP24L
LKS32MC087CM8S8(B)	96	64	8	5	12BITx1	2	6	2	3			1	Yes	Yes	Yes							SSOP24L
LKS32MC087DM6S8	96	32	8	5	12BITx1	2	6	2	3			1		Yes	Yes		3P3N	+0.05/-0.3	7~28		5V LDO*2	SSOP24L
LKS32MC087EM6S8	96	32	8	5	12BITx1	2	7	2	3			1		Yes	Yes		3P3N	+0.05/-0.3	7~28		5V LDO	SSOP24L
LKS32MC088C6T8(B)	96	32	8	12	12BITx1	2	9	4	3	1	1	2		Yes	Yes							TQFP48
LKS32MC088KU8Q8	96	64	8	8	12BITx1	2	7	3	3	1	1	2	Yes	Yes	Yes	Yes	6N	+0.45/-1	4.5~20	600	5V LDO	QFN43L
LKS32AT089XLN8Q9	96	64	8	11	12BITx1	2	9	4	3	1	1	2	Yes	Yes	Yes	Yes	6N	+1.2/-1.5	4.5~20	200	5V LDO	QFN6*6 52L-0.55

\*1: Some devices are divided into different versions due to the integration of multiple pre drives. The power supply voltage range of the pre drive is different. Please refer to the electrical performance parameters for details.

\*2: Some devices are equipped with a 5V LDO, which is powered by 7.5~28V VCC and could supply 5V to MCU or peripheral devices. Please refer to Pin assignment table for more information.



## 3 Pin Assignment

### 3.1 Pin Assignment and Pin Function Description

#### 3.1.1 Special Notes

The red pin in the pin assignment figures below has built-in pull-up resistors:

RSTN has a 100kΩ built-in pull-up resistor, which is enabled automatically after power-up.

SWDIO/SWCLK has a 10kΩ built-in pull-up resistor, which is enabled automatically after power-up.

The remaining red pins have 10kΩ built-in pull-up resistors, which could be software-enabled.

UARTx\_TX(RX): UART TX and RX support interchange. When the second function of GPIO is selected as UART, and GPIO\_PIE is input enabled, it can be used as UART\_RX; when GPIO\_POE is enabled, it can be used as UART\_TX. Generally, the same GPIO does not enable input and output at the same time, otherwise the input PDI will receive the data sent by the PDO.

SPI\_DI(DO): The DI and DO of SPI can also be interchanged. When the second function of GPIO is SPI, and GPIO\_PIE is input enable, it can be used as SPI\_DI; when GPIO\_POE is output enable, it can be used as SPI\_DO. Generally, the same GPIO does not enable input and output at the same time, otherwise the input PDI will receive the data sent by the PDO.



3.1.2 LKS32AT086N8Q9(B)



Fig. 3-1 LKS32AT086N8Q9(B) Pin Assignment

Table 3-1 LKS32AT086N8Q9(B) Pin Function Description

No.	Pin Name	Type	Pin Function Description
0	GND	Ground	Ground Pin. It's strongly recommended to connect all the GND Pin together on PCB
1	HALL_IN1/MCPWM_CH2N/UART1_TX(RX)/TIM1_CH1/ADC_TRIGGER0/CMP1_IP2/P2.5	Input/Output	Hall sensor B-phase input/motor PWM channel 2 low side/UART1 TX(RX)/Timer1 channel 1/ADC trigger signal 0/positive input



No.	Pin Name	Type	Pin Function Description
			2 for comparator 1/P2.5
2	HALL_IN0/MCPWM_CH2P/UART1_TX(RX)/TIM1_CH0/ADC_TRIG3/CMP1_IP1/CAN_RX/ P2.4	Input/Output	Hall sensor A-phase input/motor PWM channel 2 high-side output/UART1 TX(RX)/Timer1 channel 0/ADC trigger signal 3/positive input 1 for comparator 1/P2.4, with a 10k software-enabled built-in pull-up resistor
3	CMP1_OUT/MCPWM_BKIN0/SPI_CS/REF/P2.3	Input/Output	Comparator 1 output/motor PWM breaking signal 0/SPI chip select signal/voltage reference signal/P2.3
4	CMP1_IN/P2.2	Input/Output	Comparator 1 negative input/P2.2
5	SPI_CLK/ADC_CH14/CMP1_IP0/P2.1	Input/Output	SPI clock/ADC channel 14/positive input for comparator 1/P2.1, with a 10k software-enabled built-in pull-up resistor
6	OPA3_IP/P3.15	Input/Output	OPA3 positive input/P3.15
7	OPA3_IN/P3.14	Input/Output	OPA3 negative input/P3.14
8	SPI_DI(DO)/SDA/P2.10	Input/Output	SPI data output/IIC data/P2.10, with 10k software-enabled built-in pull-up resistor
9	SPI_DI(DO)/SCL/ADC_CH12/CMP0_IP0/P2.9	Input/Output	SPI data input/IIC clock/ADC channel 12/positive input 0 for comparator 0/P2.9
10	OPA2_IN/P3.11	Input/Output	OPA2 negative input/P3.11
11	OPA2_IP/P3.10	Input/Output	OPA2 positive input/P3.10
12	MCPWM_CH3N/UART0_TX(RX)/SDA/TIM0_CH1/ADC_TRIG3/SIF/P1.11	Input/Output	Motor PWM channel 3 low-side output/UART 0 TX(RX)/IIC data/Timer0 channel 1/ADC trigger signal 3/P1.11, with a 10k software-enabled built-in pull-up resistor
13	ADC_CH13/MCPWM_CH3P/UART0_TX(RX)/SCL/TIM0_CH0/ADC_TRIG2/P1.10	Input/Output	Motor PWM channel 3 high-side output/UART 0 (TX)RX/IIC clock/Timer0 channel 0/ADC trigger signal 2/P1.10, with a 10k software-enabled built-in pull-up resistor
14	VB3	Input/Output	High-side floating input supply voltage 3
15	HO3	Output	The high-side gate drive signal output 3 is controlled by the PWM output function of the MCU P1.8 port, and HO3 output will be in the same phase with P1.8 signal, that is, when input is '1', and HO3 output is '1'.
16	VS3	Input/Output	High-side floating bias voltage 3
17	VB2	Input/Output	High-side floating input supply voltage 2
18	VCC	Power	Full-bridge drive module power supply, 7 ~ 20V
19	HO2	Output	The high-side gate drive signal output 2 is controlled by the PWM output function of the MCU P1.6 port, and HO2 output will be in the



No.	Pin Name	Type	Pin Function Description
			same phase with P1.6 signal, that is, when input is '1', and HO2 output is '1'.
20	VS2	Input/Output	High-side floating bias voltage 2
21	VB1	Input/Output	High-side floating input supply voltage 1
22	HO1	Output	The high-side gate drive signal output 1 is controlled by the PWM output function of the MCU P1.4 port, and HO1 output will be in the same phase with P1.4 signal, that is, when input is '1', and HO1 output is '1'.
23	VS1	Input/Output	High-side floating bias voltage 1
24	LO1	Output	The low-side gate drive signal output 1 is controlled by the PWM output function of the MCU P1.5 port, that is, GPIO1_F7654[7:4] needs to be configured, and P3.13 shall be set to the output state, i.e. GPIO3_POE[13]. LO1 output will be in the same phase with P1.5 signal, that is, when P1.5 output is '1', and LO1 output is '1'.
25	LO2	Output	The low-side gate drive signal output 2 is controlled by the PWM output function of the MCU P1.7 port, that is, GPIO1_F7654[15:12] needs to be configured, and P1.12 shall be set to the output state, i.e. GPIO1_POE[12]. LO2 output will be in the same phase with P1.7 signal, that is, when P1.7 output is '1', and LO2 output is '1'.
26	LO3	Output	The low-side gate drive signal output 3 is controlled by the PWM output function of the MCU P1.9 port, that is, GPIO_FBA98[3:0] needs to be configured, and P1.15 shall be set to the output state, i.e. GPIO1_POE [15]. LO3 output will be in the same phase with P1.9 signal, that is, when P1.9 output is '1', and LO3 output is '1'.
27	OPA0_IN/P3.7	Input/Output	Negative input for OPA 0/P3.7
28	ADC_CH11/OPAx_OUT/LDO15/P2.7	Input/Output	ADC channel 11/OPAx output/LDO15 output/P2.7, with 10k software-enabled built-in pull-up resistor
29	OPA1_IN/P3.1	Input/Output	OPA 1 negative input/P3.1
30	OPA1_IP/P3.0	Input/Output	OPA1 positive input/P3.0
31	OPA0_IP/P3.5	Input/Output	OPA0 positive input/P3.5
32	NC	NC	No connection
33	MCPWM_CH0N/UART0_TX(RX)/SPI_DI	Input/Output	Motor PWM channel 0 low-side output/UART0



No.	Pin Name	Type	Pin Function Description
	(DO)/P1.0/OSC_IN/P2.8		TX(RX)/SPI data input/P1.0, with 10k software-enabled built-in pull-up resistor/Crystal oscillator input/P2.5
34	MCPWM_CH0P/UART0_TX(RX)/SPI_DI (DO)/TIM0_CH0/CMP0_IN/P0.15/OSC_OUT/P3.9	Input/Output	Motor PWM channel 0 high-side output/UART0 TX(RX)/SPI data output/Timer0 channel 0/negative input for comparator 0/P0.15/Crystal oscillator output/P3.9
35	CMP0_OUT/MCPWM_BKIN1/SPI_CLK/TIM0_CH1/ADC_TRIG0/SIF/ADC_CH10/CMP0_IP4/P0.14	Input/Output	Comparator 0 output/motor PWM breaking signal 1/SPI clock/Timer0 channel 1/ADC trigger signal 0/SIF/ADC channel 10/ positive input 4 for comparator 0/P0.14
36	HALL_IN2/ADC_CH17/CMP0_IP3/CAN_TX/P0.13	Input/Output	Hall sensor C-phase input/ADC channel 17/ positive input 3 for comparator 0/P0.13
37	HALL_IN1/TIM3_CH1/ADC_CH16/CM P0_IP2/CAN_RX/P0.12	Input/Output	Hall sensor B-phase input/Timer3 channel 1/ADC channel 16/positive input 2 for comparator 0/CAN_RECEIVE/P0.12
38	HALL_IN0/TIM3_CH0/ADC_CH15/CM P0_IP1/P0.11	Input/Output	Hall sensor A-phase input/Timer3 channel 0/ADC channel 15/positive input 1 for comparator 0/P0.11
39	MCPWM_CH1N/TIM2_CH1/ADC_TRIG 2/P2.12	Input/Output	Motor PWM channel 1 low-side output/Timer2 channel 1/ADC trigger signal 2/P2.12
40	MCPWM_CH1P/TIM2_CH0/P2.11	Input/Output	Motor PWM channel 1 high-side output/Timer 2 channel 0/P2.11
41	UART1_TX(RX)/TIM1_CH1/CAN_TX/P 0.7	Input/Output	UART1 TX(RX)/Timer1 channel 1/CAN_SEND/P0.7, with a 10k software-enabled built-in pull-up resistor
42	UART1_TX(RX)/TIM1_CH0/CAN_RX/P 0.6	Input/Output	UART1 TX(RX)/Timer1 channel 0/CAN_RECEIVE/P0.6, with a 10k software-enabled built-in pull-up resistor
43	ADC_CH9/P0.5	Input/Output	ADC channel 9/P0.5
44	SDA/TIM2_CH1/ADC_CH8/P0.4	Input/Output	IIC data/Timer2 channel 1/ADC channel 8/P0.4
45	SCL/TIM2_CH0/ADC_CH7/P0.3	Input/Output	IIC clock/Timer2 channel 0/ADC channel 7/P0.3
46	AVDD	Power	Chip power input, voltage range 3.0 ~ 5.5V. Off-chip decoupling capacitor $\geq 1\mu\text{F}$ is recommended, and should be placed as close as possible to the AVDD pin.
47	RSTN/P0.2	Input/Output	RSTN/P0.2 is usually used as RSTN. Add a 100nF capacitor between RSTN and ground, RSTN has a 100k built-in pull-up resistor.
48	ADC_CH4/DAC_OUT/P0.0	Input/Output	ADC channel 4/DAC output/P0.0, with a 10k

No.	Pin Name	Type	Pin Function Description
			software-enabled built-in pull-up resistor
49	SDA/P2.15	Input/Output	IIC data/P2.15
50	SWDIO/SCL/P2.14	Input/Output	SWD data/IIC clock/P2.14 with 10k built-in pull-up resistor
51	SWCLK	Output	SWD clock with 10k built-in pull-up resistor
52	HALL_IN2/MCPWM_CH3P/TIM3_CH0/ ADC_TRIG1/CMP1_IP3/P2.6	Input/Output	Hall sensor C-phase input/motor PWM channel 3 high-side output/Timer3 channel 0/ADC trigger signal 1/positive input 3 for comparator 1/P2.6, with a 10k software-enabled built-in pull-up resistor

### 3.2 Description of Pin Multiplex Function

Table 3-2 LKS32AT086N8Q9(B) Pin Function Selection

Port	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AFE
P0.0												ADC_CH4, DAC_OUT
P0.1												ADC_CH6
P0.2												
P0.3						SCL		TIM2_CH0				ADC_CH7
P0.4						SDA		TIM2_CH1				ADC_CH8
P0.5												ADC_CH9
P0.6				UART1_TX(RX)			TIM1_CH0			CAN_RX		
P0.7				UART1_TX(RX)			TIM1_CH1			CAN_TX		
P0.8												
P0.9						SCL		TIM2_CH0				
P0.10						SDA		TIM2_CH1				
P0.11		HALL_IN0						TIM3_CH0				ADC_CH15/CMP0_IP1
P0.12		HALL_IN1						TIM3_CH1		CAN_RX		ADC_CH16/CMP0_IP2
P0.13		HALL_IN2								CAN_TX		ADC_CH17/CMP0_IP3
P0.14	CMP0_OUT		MCPWM_BKIN1		SPI_CLK		TIM0_CH1		ADC_TRIG0		SIF	ADC_CH10/CMP0_IP4
P0.15			MCPWM_CHOP	UART0_TX(RX)	SPI_DI(DO)		TIM0_CH0		ADC_TRIG1			CMP0_IN



Port	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AFE
P1.0			MCPWM_CH0N	UART0_TX(RX)	SPI_DI(DO)							
P1.1					SPI_CS							
P1.2								TIM3_CH0				
P1.3								TIM3_CH1				ADC_CH5
P1.4	LRC		MCPWM_CH0P									
P1.5	HRC		MCPWM_CH0N									
P1.6			MCPWM_CH1P									
P1.7			MCPWM_CH1N									
P1.8			MCPWM_CH2P									
P1.9			MCPWM_CH2N									
P1.10			MCPWM_CH3P	UART0_TX(RX)		SCL	TIM0_CH0		ADC_TRIG2			ADC_CH13
P1.11			MCPWM_CH3N	UART0_TX(RX)		SDA	TIM0_CH1		ADC_TRIG3		SIF	
P1.12			MCPWM_CH1N									
P1.13					SPI_CLK		TIM0_CH0					
P1.14					SPI_DI(DO)		TIM0_CH1					
P1.15			MCPWM_CH2N									



Port	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AFE
P2.0					SPI_CS			TIM2_CH1				
P2.1					SPI_CLK							ADC_CH14/ CMP1_IP0
P2.2												CMP1_IN
P2.3	CMP1_OUT		MCPWM_BKIN0		SPI_CS							REF
P2.4		HALL_IN0	MCPWM_CH2P	UART1_TX(RX)			TIM1_CH0		ADC_TRIG3	CAN_RX		CMP1_IP1
P2.5		HALL_IN1	MCPWM_CH2N	UART1_TX(RX)			TIM1_CH1		ADC_TRIG0	CAN_TX		CMP1_IP2
P2.6		HALL_IN2	MCPWM_CH3P					TIM3_CH0	ADC_TRIG1		SIF	CMP1_IP3
P2.7												ADC_CH11/ OPA <sub>x</sub> _OUT/ LDO15
P2.8				UART1_TX(RX)				TIM3_CH0				OSC_IN
P2.9					SPI_DI(DO)	SCL						ADC_CH12/ CMP0_IP0
P2.10					SPI_DI(DO)	SDA						
P2.11			MCPWM_CH1P					TIM2_CH0				
P2.12			MCPWM_CH1N					TIM2_CH1	ADC_TRIG2			
P2.13			MCPWM_CH3N					TIM3_CH1				
P2.14						SCL						
P2.15						SDA						





Port	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AFE
P3.0												OPA1_IP
P3.1												OPA1_IN
P3.2												
P3.3												
P3.4												
P3.5												OPA0_IP
P3.6												
P3.7												OPA0_IN
P3.8												
P3.9				UART1_TX(RX)				TIM3_CH1				OSC_OUT
P3.10												OPA2_IP
P3.11												OPA2_IN
P3.12												
P3.13	HRC		MCPWM_CH0N									
P3.14												OPA3_IN
P3.15												OPA3_IP

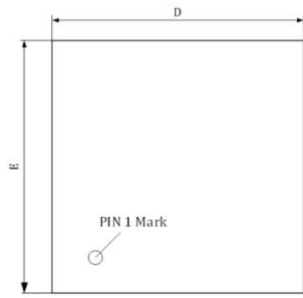


## 4 Package Size

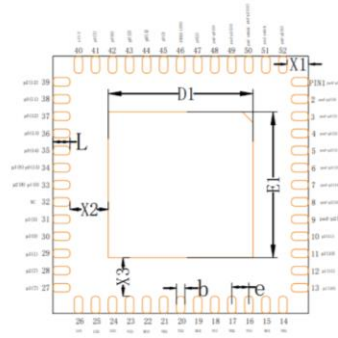
### 4.1 LKS32AT086N8Q9(B)

QFN6\*6 52L-0.55 Profile Quad Flat Package:

Package Top View



Package Bottom View



Package Side View

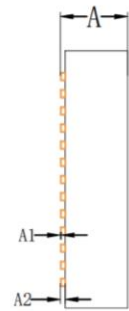


Fig. 4-1 LKS32AT086N8Q9(B) Package Diagram

Table 4-1 LKS32AT086N8Q9(B) Package Dimension

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.500	0.550	0.600
A1	0.007	0.012	0.017
A2	0.040		
D	5.90	6.00	6.10
E	5.90	6.00	6.10
D1	3.350	3.400	3.450
E1	3.350	3.400	3.450
L	0.350	0.400	0.450
b	0.150	0.200	0.250
e	0.350	0.400	0.450
X1	0.450	0.500	0.550
X2	0.850	0.900	0.950
X3	0.850	0.900	0.950

## 5 Electrical Characteristics

Table 5-1 LKS32AT086N8Q9(B) electrical absolute characteristics

Parameter	Min.	Max.	Unit	Description
MCU Power Supply Voltage (AVDD)	-0.3	+6.0	V	
Gate Driver Power Supply Voltage (VCC)	-0.3	+25.0	V	
Operating Temperature	-40	+125	°C	
Storage Temperature	-40	+150	°C	
Junction Temperature	-	150	°C	
Pin Temperature (solder for 10 seconds)	-	260	°C	

Table 5-2 LKS32AT086N8Q9(B) Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit	Description
MCU Power Supply Voltage (AVDD)	3.0	5	5.5	V	The AVDD reset level of version A chip is $2.2V \pm 0.2V$
					The AVDD reset level of version B chip is $2.7V \pm 0.2V$
Analog Power Supply Voltage (AVDD <sub>A</sub> )	3.3	5	5.5	V	ADC use 2.4V internal reference
	2.8	5	5.5	V	ADC use 1.2V internal reference
Gate Driver Power supply voltage (VCC)	7		20	V	

OPA could work under 3.0V, but the output range will be limited.

Table 5-3 LKS32MC086N8Q8 Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit	Description
Power Supply Voltage (AVDD)	3.0	5	5.5	V	
Analog Supply Voltage (AVDD <sub>A</sub> )	2.8	5	5.5	V	

OPA could work under 3.0V, but the output range will be limited.

Table 5-4 LKS32AT086N8Q9(B) ESD parameters

Item	Pin	Min.	Max.	Unit
ESD test (HBM)	Gate Driver Pins (PIN14~26)	-1500	1500	V
	Other Pins	-6000	6000	V

According to "MIL-STD-883J Method 3015.9", under the environment of 25°C and 55% relative humidity, electrostatic discharge is applied to all IO pins of the tested chip for 3 times, with an interval of 1s each time. The test results show that the anti-static discharge level of the chip reaches Class 3A  $\geq 4000V$ ,  $< 8000V$ . If there is a higher requirement for ESD, it is recommended to place TVS diodes on the relevant external pins for protection.

Table 5-5 LKS32AT086N8Q9(B) IO absolute characteristics

Parameter	Description	Min.	Max.	Unit
-----------	-------------	------	------	------



$V_{IN-GPIO}$	GPIO Signal Input Voltage Range	-0.3	6.0	V
$I_{INJ\_PAD}$	Maximum Injection Current of A Single GPIO	-11.2	11.2	mA
$I_{INJ\_SUM}$	Maximum Injection Current of All GPIOs	-50	50	mA

Table 5-6 LKS32AT086N8Q9(B) IO DC Parameters

Parameter	Description	AVDD	Conditions	Min.	Max.	Unit
V <sub>IH</sub>	High input level of digital IO	5V	-	0.7*AVDD		V
		3.3V		2.0		
V <sub>IL</sub>	Low input level of digital IO	5V	-		0.3*AVDD	V
		3.3V		0.8		
V <sub>HYS</sub>	Schmidt hysteresis range	5V	-	0.1*AVDD		V
		3.3V				
I <sub>IH</sub>	Digital IO current consumption when input is high	5V	-		1	uA
		3.3V				
I <sub>IL</sub>	Digital IO current consumption when input is low	5V	-	-1		uA
		3.3V				
V <sub>OH</sub>	High output level of digital IO		Current = 11.2mA	AVDD-0.8		V
V <sub>OL</sub>	Low output level of digital IO		Current = 11.2mA		0.5	V
R <sub>pup</sub>	Pull-up resistor*			8	12	kΩ
R <sub>io-ana</sub>	Connection resistance between IO and internal analog circuit			100	200	Ω
C <sub>IN</sub>	Digital IO Input-capacitance	5V	-		10	pF
		3.3V				

\* Only some IOs have built-in pull-up resistors, see section "Pin Function Description" for details.

Table 5-7 LKS32AT086N8Q9(B) Circuit module current consumption IDD

Module	Min	Typ	Max	Unit
CMP		0.005		mA
OPA		0.450		mA
ADC		3.710		mA
DAC		0.710		mA
Temp Sensor		0.150		mA
BGP		0.154		mA
4MHz RC		0.105		mA
PLL		0.080		mA
CPU+flash+SRAM (96MHz)		8.667		mA
CPU+flash+SRAM (12MHz)		1.600		mA
CRC		0.070		mA
DSP		3.421		mA
UART		0.107		mA
DMA		1.340		mA
MCPWM		0.053		mA



TIMER		0.269		mA
SPI		0.500		mA
IIC		0.500		mA
CAN		2.200		mA

Unless otherwise specified, the above tests are conducted at room temperature of 25 ° AVDD=5V, using a 96MHz clock. Due to device model deviations in the manufacturing process, there may be individual differences in current consumption among different chips.

Table 5-8 LKS32AT086N8Q9(B) Sleep current consumption Iq

Module	Min	Typ	Max	Unit
AVDD	7.5	40	100	uA
VCC	40	43	95	uA

## 6 Analog Characteristics

Table 6-1 LKS32AT086N8Q9(B) analog characteristics

Parameter	Min.	Normal	Max.	Unit	Description
<b>Analog-to-Digital Converter (ADC)</b>					
Power Supply	2.8	5	5.5	V	ADC use 2.4V internal reference
	3.3	5	5.5	V	ADC use 1.2V internal reference
Sampling rate		3		MHz	$f_{adc}/16$
Differential Input Signal Range	-REF		+REF	V	When Gain=1; REF=2.4V
	-3.6		+3.6	V	When Gain=2/3; REF=2.4V
Single-ended Input Signal Range	-0.3		AVDD+0.3	V	Limited by the input voltage of the IO port
DC offset		5	10	mV	Correctable
Effective number of bits (ENOB)	10.5	11		bit	
INL		2	3	LSB	
DNL		1	2	LSB	
SNR	63	66		dB	
Input Resistance	100k			Ohm	
Input Capacitance		10pF		F	
<b>Reference Voltage (REF)</b>					
Power Supply	3.0	5	5.5	V	
Output Deviation	-9		9	mV	
Rejection Ratio of Power Supply		70		dB	
Temperature Coefficient		20		ppm/°C	
Output Voltage		1.2		V	
<b>Digital-to-Analog Converter (DAC)</b>					
Power Supply	3.0	5	5.5	V	
Load Resistance	5k			Ohm	Output BUFFER is on
Load capacitance			50p	F	
Output voltage range	0.05		AVDD-0.1	V	
Conversion speed			1M	Hz	
DNL		1	2	LSB	
INL		2	4	LSB	
OFFSET		5	10	mV	
SNR	57	60	66	dB	
<b>Operational Amplifier (OPA)</b>					
Power Supply	2.8	5	5.5	V	
Bandwidth		10M	20M	Hz	
Load Resistance	20k			Ohm	



Parameter	Min.	Normal	Max.	Unit	Description
Load Capacitance			5p	F	
Input Common Mode Voltage Range (VICM)	0		AVDD	V	
Output Signal Range	0.1		AVDD-0.1	V	Under minimum load resistance
OFFSET		10	15	mV	This OFFSET is the equivalent differential input deviation obtained when the OPA differential input is short-circuited and OPA OUT is measured from 0 level. The output deviation of OPA is the OPA magnification xOFFSET
Common Mode Voltage (Vcm)	1.65	1.9	2.2	V	Measurement condition: normal temperature. Operational amplifier swing= $2 \times \min(\text{AVDD}-V_{cm}, V_{cm})$ . It is recommended that the application using OPA single output should be powered on to measure Vcm and make software subtraction correction. For more analysis, please refer to the official website application note "ANN009 - Differences between Operational Amplifier Differential and Single Operating Mode".
Common Mode Rejection Ratio (CMRR)		80		dB	
Power Supply Rejection Ratio (PSRR)		80		dB	
Load Current			500	uA	
Slew Rate		5		V/us	
Phase Margin (PM)		60		Degree	
<b>Comparator (CMP)</b>					
Power Supply	3.0	5	5.5	V	
Input Signal Range	0		AVDD	V	
OFFSET		5	10	mV	
Delay		0.15u		S	Default power consumption
		0.6u		S	Low power consumption
Hysteresis		20		mV	HYS='0'
		0		mV	HYS='1'



**Description of Analog Register Table:**

Address space of 0x40000040 to 0x40000050 are the calibration registers of each analog module. These registers will be set to a unique calibration value in factory. Generally, users are advised not to configure or change these values. If fine-tuning is required, please read the original settings first, and then adjust based on those values.

Addresses space of 0x40000020 to 0x4000003c are registers open to users. The blank registers must be configured to 0 (these registers will be reset to 0 after power on). Other registers could be configured in situations.



## 7 Power Management System

### AVDD Power System

The power management system is composed of LDO15 module, power detection module (PVD), power-on/power-off reset module (POR).

VDD is powered by a 2.2V ~ 5.5V supply(The B-version chip is powered by 3.0V~5.5V), and all internal digital circuits and PLL modules are powered by an internal LDO15.

The LDO15 is automatically turned on after power-on. No software configuration is necessary. And the LDO15 output voltage can be adjusted by software.

The output voltage of LDO15 can be adjusted by setting register LDO15TRIM<2:0>. The corresponding value of the register can be seen in the analog register table. LDO15 has been calibrated before it leaves the factory. Generally, users do not need to configure these registers again. If fine-tuning of the LDO output voltage is required, please read the original configuration value first, and then calculate the new settings accordingly.

The POR module monitors the voltage of the LDO15. When the voltage of the LDO15 is lower than 1.1V, for example, at the beginning of power-on or at the time of power-off, it will provide a reset signal for the digital circuit to avoid any abnormal operation.

The PVD module monitors the 5V input power. If it is below a certain threshold, it will remind the MCU by sending an alarm (interrupt) signal. The interrupt reminder threshold can be set to different voltages through the PVDSEL<1:0> registers. The PVD module can be turned off by setting PD\_PDT = '1'. For the corresponding value of specific register, please refer to the analog register table.

### VCC Power System

The operating power supply voltage range of VCC is 7 ~ 20V, which provides power for the on-chip gate driver module. If this voltage is below 5V it will be considered as undervoltage.



## 8 Clock System

The clock system consists of a 32KHz RC oscillator, a 4MHz RC oscillator, an external 4MHz crystal oscillator, and a PLL.

The 32K RC clock is used in the MCU system as a slow clock for modules such as reset/wakeup source filters or used in the low power mode; The 4MHz RC clock can be used as the main clock of the MCU, and can provide a reference clock to PLL. PLL clock is up to 96MHz; The external 4MHz crystal oscillator is used as a backup clock.

Both 32k and 4M RC clocks will be through factory calibration. In the range of -40 ~ 105 °C, the accuracy of the 32K RC clock is  $\pm 50\%$ , and the accuracy of the 4M RC clock is  $\pm 1\%$ .

The frequency of the 32K RC clock can be set by the register RCLTRIM<3:0>, and the frequency of the 4M RC clock can be set by the register RCHTRIM <5:0>. For the corresponding value of specific register, please refer to the analog register table.

The chip has been calibrated before it leaves the factory. Generally, users do not need to configure these registers again. If fine-tuning of the frequency is required, please read the original configuration value first, and then calculate the new settings accordingly.

The 4M RC clock is turned on by setting RCHPD = '0' (ON by default, turn off when set to "1'). The RC clock needs a reference voltage and current provided by the Bandgap voltage reference module; thus, do remember to turn on the BGP module before turning on the RC clock. When the chip is powered on, the 4M RC clock and BGP module are both turned on automatically. The 32K RC clock is always on and cannot be turned off.

The PLL multiplies the 4M RC clock to provide a higher frequency clock for modules like MCU and ADC. The highest frequency of MCU and PWM module is 96MHz, and the typical working frequency of ADC module is 48MHz. It can be set to different frequency by the register ADCLKSEL <1:0>.

PLL is turned on by setting PLLPDN = '1' (OFF by default, turn on when set to '1'). Before turning on the PLL module, the BGP (Bandgap) module should be turned on first. After the PLL is turned on, it needs a settling time of 6 $\mu$ s to achieve a stable frequency output. When the chip is powered on, the RCH clock and BGP module are both turned on. PLL is OFF by default and could be enabled by software.

The crystal oscillator circuit has a built-in amplifier and an oscillator capacitor. Connect a crystal between IO OSC\_IN/OSC\_OUT and set XTALPDN = '1' to start the oscillation.



## 9 Reference Voltage

Reference voltage and current are provided for ADC, DAC, RC clock, PLL, temperature sensor, operational amplifier, comparator and FLASH. Before using any of the above modules, the BGP voltage reference should be turned on first.

When the chip is powered on, the BGP module is turned on automatically. The voltage reference is turned on by setting BGPPD = '0'. From OFF to ON, BGP needs about 2us to stabilize. BGP output voltage is about 1.2V, and accuracy is  $\pm 0.8\%$

The voltage reference can be measured by setting REF\_AD\_EN = '1' and via IO P2.3.



## 10 Analog Digital Converter

The chip integrated a synchronous double-sampling SAR ADC which is shut down by default when the chip is powered up. Before turning on ADC, the BGP module, 4M RC clock and PLL should be turned on first. In the default configuration, ADC clock is 48MHz, which corresponds to a conversion rate of 3MSPS.

The synchronous double sampling circuit can sample the two input analog signals at the same time. After the sampling is completed, the ADC converts the two signals one by one and writes them into the corresponding data registers.

ADC takes 16 ADC clock cycles to complete one conversion, of which 13 are conversion cycles and 3 are sampling cycles. I.E.  $f_{conv}=f_{adc}/16$ . When the ADC clock is set to 48MHz, the conversion rate is 3MSPS.

When the ADC is working at a lower frequency, the power consumption can be reduced by setting register CURRIT<1:0>.

ADC could work in different modes: One-time single channel trigger mode, continuous single channel sampling mode, One-time 1 to 20 channels scanning mode, continuous 1 to 20 channels scanning mode. It has a set of 20 independent registers for each analog channel.

The ADC trigger can be MCPWM/Timer trigger signals T0, T1, T2 and T3 happened for the preset number of times, or software trigger event.

Among the 20 analog channels, the 19th channel is analog ground and is used to measure the offset of the ADC. The ADC values of other channels will be automatically subtracted by this offset. The offset is calibrated in factory and store in flash. Each time the chip is powered up, this offset will be loaded into ADC\_DC register automatically. If the user needs to improve the offset over the whole temperature, it can be recalculated time by time (for example, each hour) when the ADC is idle.

When GAIN\_REF = 0, the ADC voltage reference is 2.4V. The ADC has two gain modes, which are set by GAIN\_SHAx, corresponding to 1x and 2/3 x gain setting; 1x gain corresponds to an input signal range of ± 2.4V, and 2/3 gain corresponds to an input signal range of ± 3.6V. When measuring the output signal of the OPA, select the specific ADC gain according to the maximum signal that the OPA may output.

## 11 Operational Amplifier

4-channel of rail-to-rail OPAs (3 channels for 084D) are integrated, with a built-in feedback resistor R2/R1. A resistor R0 is required to be connected in series to the external pin. The resistance of feedback resistors R2:R1 can be adjusted by register RES\_OPA0<1:0> to achieve different gain. For the corresponding value of specific register, please refer to the analog register table.

The close-loop gain of OPA is  $R2/(R1+R0)$ , where R0 is the resistance of the external resistor.

For the application of MOS resistance direct sampling, it is recommended to connect an external resistance of >20kΩ to reduce the current flowing into the chip pin when the MOS is turned off;

For the application of small resistance sampling, it is recommended to connect an external resistor of 100Ω.

The OPA can select one of the output signals of the 4-channels amplifiers by setting OPAOUT\_EN <2:0>, and send it to the P2.7 IO port through a buffer for measurement (see the corresponding relationship in the datasheet 'Pin Function Description" ). Because of this buffer, the OPA is able to be output to an IO while operating normally.

When the chip is powered on, the OPA module is OFF by default. It can be turned on by setting OPAxPDN = '1', and turn on the BGP module before turning on the amplifier.

For built-in clamp diodes are integrated between the positive and negative OPA inputs, the motor phase line could be directly connected to the OPA input through a matching resistor, thereby simplifying the external circuit for MOSFET current sampling.



## 12 Comparator

Built-in 2-channel rail-to-rail comparators with programmable comparator speed, hysteresis voltage, and signal source.

The comparison delay can be set to 0.15uS/0.6uS by register IT\_CMP. and the hysteresis voltage can be set to 20mV/0mV by CMP\_HYS.

The signal sources of the positive and negative inputs can be programmed by register CMP\_SEL<sub>P</sub><2:0> and CMP\_SEL<sub>N</sub><1:0>. For details, please refer to the analog register description.

When the chip is powered on, the comparator module is OFF by default. The comparator is turned on by setting CMP<sub>x</sub>PDN = '1', and turn on the BGP module before turning on the comparator.



## 13 Temperature Sensor

The chip has a temperature sensor with an accuracy of  $\pm 2^{\circ}\text{C}$ . The temperature sensor will be calibrated in factory, and the calibration value is saved in the flash info area.

When the chip is powered on, the temperature sensor module is OFF by default. Turn on the BGP module before turning on the temperature sensor.

The temperature sensor is turned on by setting  $\text{TMPPDN} = '1'$ , and it takes about  $2\mu\text{s}$  to be stable after turning on. Thus, it should be turned on at least  $2\mu\text{s}$  ahead before the ADC measures the sensor output.





## 14 Digital Analog Converter

The chip has a 1-channel 12bit DAC, the maximum range of the output signal can be set to 1.2V/3V/4.85V through the register DAC\_GAIN <1:0>.

The 12bit DAC can be output via IO port P0.0 by setting register DACOUT\_EN = 1, which can drive a load resistance of over 5k $\Omega$  and a load capacitance of 50pF.

The maximum output data rate of the DAC is 1Msps.

When the chip is powered on, the DAC module is OFF by default. DAC can be turned on by setting DAC12BPDN = 1. Turn on the BGP module before turning on the DAC module.



## 15 Processor

- 32-bit Cortex-M0 + DSP dual-core processor
- Two-wire SWD debug pin
- System frequency is up to 96MHz



## 16 Storage

### 16.1 Flash

- built-in flash including 64kB main area and 1kB NVR
- Endurance: 20,000 Cycles(min)
- Data retention: more than 100 years
- Single byte program: 7.5us(max), Sector erase: 5ms(max)
- Sector size 512bytes, supporting Sector erase/program and in-application program, erase/program one sector while accessing another
- Flash data anti-theft by programming the last word of flash to any words other than 0xFFFFFFFF

### 16.2 SRAM

- built-in 8kB SRAM



## 17 Motor Control PWM

- MCPWM operating frequency is up to 96MHz
- Supports up to 4 channels of complementary PWM output with adjustable phase
- The width of dead-zone in each channel can be configured independently
- Support edge-aligned PWM
- Support software control IO mode
- Support IO polarity control
- Internal short circuit protection to avoid short circuit due to configuration error
- External short circuit protection, enabling fast shutdown by monitoring the external signals
- Internal ADC sampling interrupt
- Preload MCPWM register configuration and update simultaneously
- Programmable load time and period



## 18 Timer

- 4-channel standard timer, 2-channel 16-bit timer, 2-channel 32-bit timer.
- Support capture mode for measuring external signal/pulse width
- Support comparison mode for timed interruption of edge-aligned PWM



## 19 Hall Sensor Interface

- Built-in 1024 cycles filtering
- 3-channel Hall signal input
- 24-bit counter, with overflow and capture interrupt



## 20 DSP

- Customized DSP instruction set for motor control algorithm, , three-stage pipeline architecture
- Operating frequency is up to 96MHz
- 32/16-bit divider, could finish one division calculation in 10 cycles
- 32-bit hardware SQRT, could finish one SQRT calculation in 8 cycles
- Q15 format CORDIC trigonometric function module, could finish sin/cos/atan calculation in 8 cycles
- DSP has independent program memory and data memory, DSP could execute its program independently, and can also be called by MCU to perform a certain calculation as an AHB slave like a coprocessor
- Support DSP IRQ and pause state for data exchange purpose with MCU



## 21 General Peripherals

- Two UART, full-duplex operation, support 7/8 data bit, 1/2 stop bit, odd/even/no parity mode, with 1 byte tx buffer, 1 byte rx buffer, support Multi-drop Slave/Master mode, support 300 to 115200 baud rate
- One SPI, support master-slave mode
- One IIC, support master-slave mode
- One CAN-bus
- Hardware watchdog, driven by 32kHz RC clock and which is independent of system high-speed clock, with write protection and 2/4/8/64 seconds reset interval.





## 22 Gate Driver Module

### 22.1 Module Parameter

#### 22.1.1 LKS32AT086N8Q9(B)(YYWWXC)

Table 22-1 KS32AT086N8Q9(YYWWXC) Module Parameter

Parameter	Min	Typ	Max	Unit	Description
Absolute Maximum Ratings					
Low side and logic fixed supply VCC	-0.3		+25.0	V	To ground
High side floating supply VB	-0.3		+250	V	
High side offset VS	VB-25		VB+0.3	V	
High side output HO <sub>1,2,3</sub>	VS-0.3		VB+0.3	V	
Low side output LO <sub>1,2,3</sub>	-0.3		VCC+0.3	V	
Logic input HIN/LIN <sub>1,2,3</sub>	-0.3		VCC+0.3	V	Lower of +15V or VCC+0.3
Allowable offset voltage slew rate dVs/dt			50	V/ns	
Junction temperature T <sub>J</sub>	-40		150	°C	
Storage temperature T <sub>s</sub>	-55		150	°C	
Lead temperature			300	°C	Soldering for 10s
Recommended Operating Conditions					
Low side and logic fixed supply VCC	+7		+20	V	To ground
High side floating supply VB	VS+8		VS+20	V	
High side offset VS	-5		200	V	
High side output HO <sub>1,2,3</sub>	VS		VB	V	
Low side output LO <sub>1,2,3</sub>	0		VCC	V	
Logic input HIN/LIN <sub>1,2,3</sub>	0		VCC	V	
Ambient temperature T <sub>A</sub>	-40		125	°C	
Gate driver Electrical Characteristic					
Quiescent VCC supply current		50	100	uA	HIN=LIN=0V
Quiescent VBS supply current		20	40	uA	HIN=LIN=0V
Floating supply leakage I <sub>LK</sub>			10	uA	VB=VS=220V
VCC supply under-voltage trigger voltage	3.6	4.9	6.4	V	
VBS supply under-voltage trigger voltage	3.5	4.8	6.2	V	
VCC supply under-voltage hysteresis voltage	0.25	0.5	0.8	V	



VBS supply under-voltage hysteresis voltage	0.25	0.5	0.8	V	
High level input threshold voltage $V_{IH}$	2.8			V	
Low level input threshold voltage $V_{IL}$			0.8	V	
Input bias current $I_{source}$		32	120	$\mu A$	HIN=LIN=5V
Input bias current $I_{sink}$			1	$\mu A$	HIN=LIN=0V
High level output, $V_{BIAS}-V_O$			1	V	$I_O=20mA$
Low level output, $V_O$			1	V	$I_O=20mA$
High level output short current $I_{O+}$	650	1000		mA	$V_{CC}/V_{BS}=15V$
Low level output short current $I_{O-}$	650	1000		mA	$V_{CC}/V_{BS}=15V$
Turn-on propagation delay $T_{on}$		270	500	ns	
Turn-off propagation delay $T_{off}$		80	150	ns	
Turn-on rise time $T_r$		15	30	ns	$C_L=1nF$
Turn-off fall time $T_f$		12	30	ns	
Dead time $D_T$	100	200	400	ns	
Delay matching $M_T$			80	ns	$T_{on}$ & $T_{off}$ for (HS-LS)

<sup>1</sup>YYWW is date code on chip package



## 22.2 Recommended Application Diagram

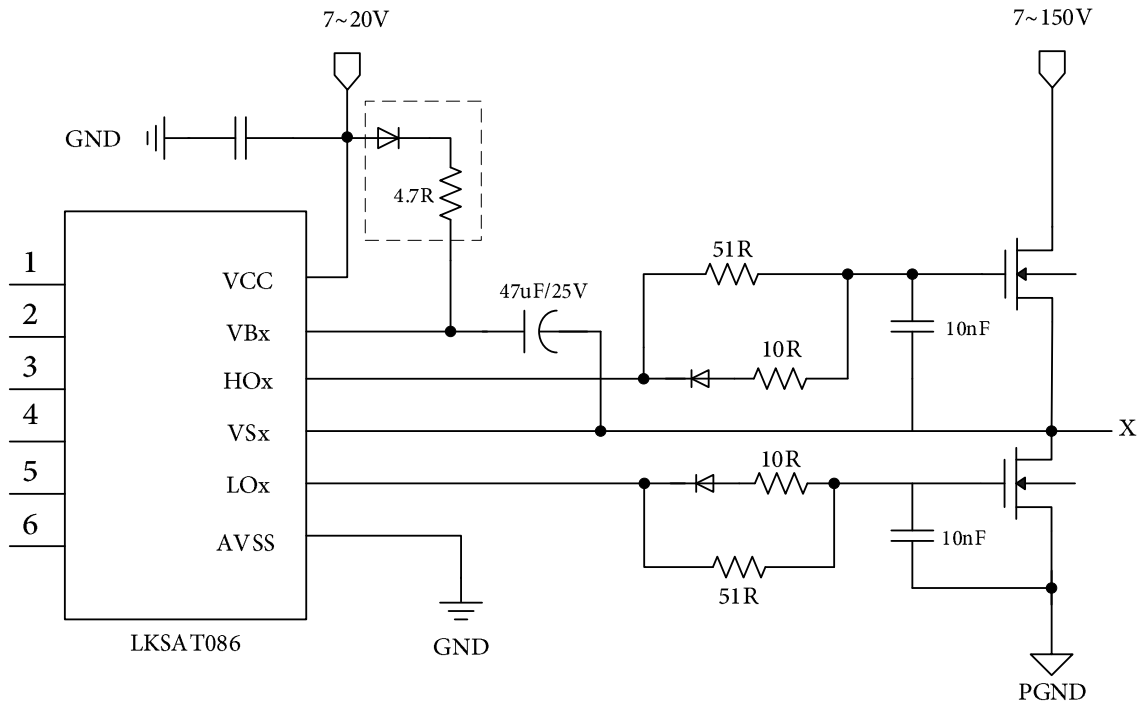


Fig. 22-1 LKS32AT086N8Q9(B) Application Diagram

Only the gate drive module pins are shown in the figure, where x = 1,2,3 corresponding to the three sets of MOS gate drive outputs. The application diagram of each set is shown in Fig. 22-1.

Table 22-2 Gate Driver Module LIN/HIN V.S. MCU Pin

Gate Driver Input	LKS32AT086N8Q9(B)	Note
LIN1	P1.5	P3.13 should be output enabled
HIN1	P1.4	
LIN2	P1.7	P1.12 should be output enabled
HIN2	P1.6	
LIN3	P1.9	P1.15 should be output enabled
HIN3	P1.8	

Gate driver input-output transfer function:

Table 22-3 LKS32AT086N8Q9(B) truth table

{HIN,LIN}	HO	LO	
00	0	0	Low side and high side are all off
01	0	1	Low side on
10	1	0	High side on
11	0	0	Low side and high side are all on, which will trigger short protection

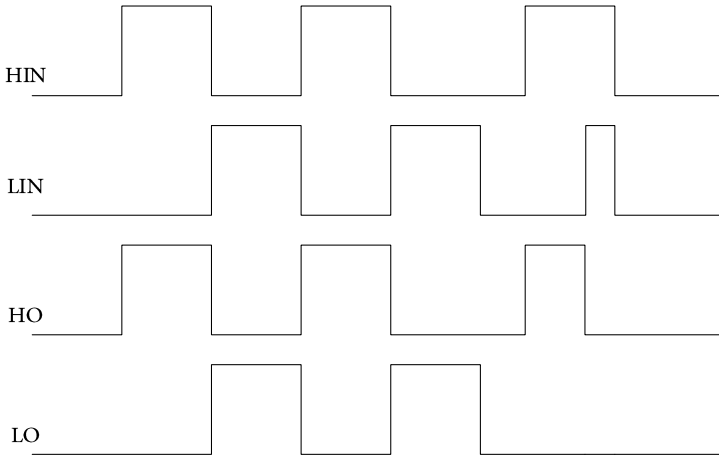


Fig. 22-2 LKS32AT086N8Q9(B) polarity illustration

## 23 Special IO Multiplexing

### Notes for Special IO Multiplexing of LKS08x

The SWD protocol includes two signals: SWCLK and SWDIO. SWCLK is a clock signal. To the chip, it is an input and will always be an input. SWDIO is a data signal. It switches between the input state and the output state during data transmission, and the default is the input state.

Users could use two IOs of SWD as GPIOs P0.0/P2.15. The precautions are as follows:

- The default state of GPIO multiplexing is disabled, IO are used as SWD. After the hard reset of the chip, the initial state of IOs are SWD. Both IOs of SWD are fixed pull-up inside the chip (the internal pull-up resistor of the chip is about 10K). Please pay attention to the initial IO voltage level if application has specific requirements.
- When GPIO multiplexing is enabled, tools such as KEIL cannot directly access the chip, i.e., the Debug and erase download functions cannot access the chip since SWD are now general GPIO. If the program needs to be downloaded again, there are two solutions.
- Firstly, it is recommended to use Linko's dedicated offline downloader to erase. It is recommended to leave a certain margin before switching SWD to GPIO, such as about 100ms, to ensure that the offline downloader can erase the chip and prevent the deadlock. This margin is to ensure a successful offline downloader erasing. A greater margin means a greater probability of the successful one-time erasion.
- Secondly, the application should have a GPIO multiplexing exit mechanism. For example, some other IO invert (usually input), indicates that the SWDIO is required externally, and the software needs to be reconfigured to disable the multiplexing. At this moment, the KEIL function can access the chip via SWD again.

When SWDCLK and SWDIO pins are used as GPIO, they should not act at the same time. That is, when SWDCLK multiplexing is enabled and changes, SWDIO can remain at level 0 (similar to time division multiplexing).

For RSTN signal, the default is for the external reset pin of LKS08x chip.

LKS08x allow users to multiplex RSTN as other IOs, and the multiplexed IO is P0.2. The precautions are as follows:

- The default state of reset IO multiplexing is disabled, and the software needs to write 1 to SYS\_RST\_CFG[5] to multiplex RSTN as GPIO. I.e., the initial state of P0[2] is RSTN. RSTN is provided with a pull-up resistor inside the chip (the internal pull-up resistor of the chip is about 100K). Attention shall be paid when the application has requirements for initial electric level.
- The default state of P0[2] is used as external reset, and the program can only be executed after the RSTN is released. The application needs to ensure that the RSTN has sufficient protection, such as the peripheral circuit with a pull-up resistor. It is better to add a capacitor.
- After RST IO multiplexing is enabled, the external reset is unavailable to the chip. If a hard reset is required, the reset source can only be power-down/watchdog reset.
- The multiplexing of RSTN does not affect the use of KEIL.



## 24 Ordering Information

Device	Package Size	Quantity per disc/tube	Quantity in box	Quantity in case
LKS32AT086N8Q8	QFN6*6 52L-0.55	490/disc	4900PCS	29400PCS



## 25 Version History

Table 25-1 Document's Version History

Date	Version No.	Description
2023.11.09	1.2	OPA OFFSET Adds the description, Renewal storage temperature
2023.04.28	1.1	Add B-version chip with AVDD power supply range of 3.0-5.5V Modify Package Name
2023.04.01	1.0	Initial Version



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