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ICM-30630 Product Specification

Revision 1.0

GENERAL DESCRIPTION

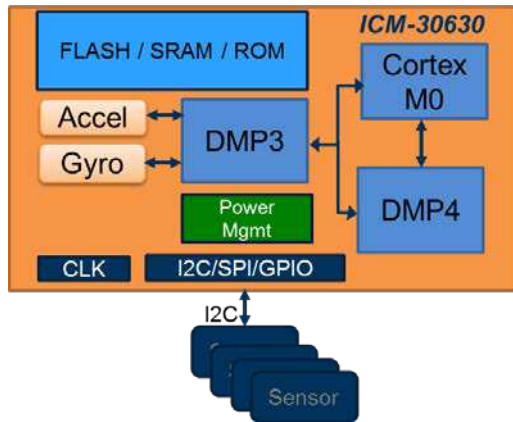
The single-chip ICM-30630 is the world's first tri-core 6-axis motion tracking solution with integrated sensor-hub framework software. It combines industry leading gyroscope and accelerometer sensors with tri-core processors (an ARM Cortex-M0 CPU, a DMP3 and a DMP4 Digital Motion Processor™) in a small 3x3x1mm LGA package.

The ICM-30630 serves as a sensor hub that supports the collection and processing of data from internal and external sensors. The multi-cores are designed to offload processing from the Application Processor, thereby saving system power and improving performance.

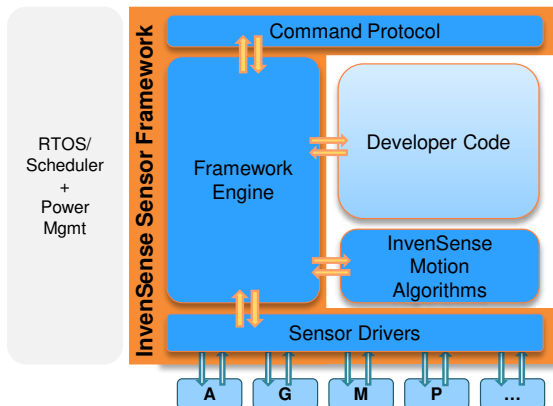
The ARM Cortex-M0 CPU provides a low-power programmable platform for software development. The DMP3 offloads Android L processing from the CPU and provides ready-to-use physical and virtual Android sensors. The DMP4 is optimized for fixed point processing and FFT generation and complements the CPU by offloading math intensive operations.

The integrated InvenSense Sensor Framework provides an open and powerful platform for creating cutting-edge always-on applications for mobile platforms. Developers can use the built-in framework components to rapidly develop and launch new features. The command protocol is designed for seamless porting to new systems, allowing software reuse and thus maximizing returns on software investment.

BLOCK DIAGRAM



SENSOR FRAMEWORK SOFTWARE



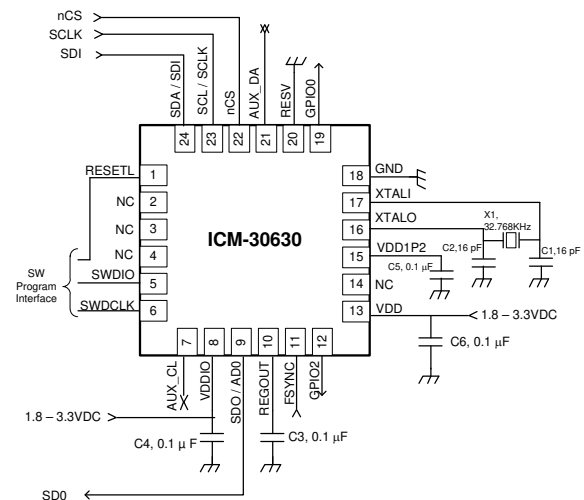
APPLICATIONS

- Smartphones and Tablets
- Wearables

FEATURES

- Tri-core sensor hub with integrated 6-Axis in a 24-Pin LGA: 3mm x 3mm x 1mm package
- Built-in sensor framework for fast time-to-market
- Low Power 6-Axis Device:
 - 2.25mW 6-Axis Power (Gyro+Accel 102.3Hz ODR)
- Android L Support
- On-Chip Runtime Calibration
- Auxiliary I²C interface to support additional sensors, enabling multi-sensor MotionFusion operation
- 3-Axis Gyroscope with Programmable FSR of ± 250 , ± 500 , ± 1000 , and ± 2000 dps
- 3-Axis Accelerometer with Programmable FSR of $\pm 2g$, $\pm 4g$, $\pm 8g$ and $\pm 16g$
- ARM Cortex-M0 CPU & DMP3 and DMP4
- Flash 64Kbytes
- SRAM 64Kbytes (shared by Cortex-M0, DMPs, FIFO)
- DMA Controller
- 4 timers that can be used for timestamp, watchdog, and general purpose timer functions
- Serial Wire Data Port for Cortex-M0 debug/trace
- 3 on-chip oscillators for system clock, accurate time stamping, and periodic wakeup
- 3 GPIO bidirectional pins configurable as general purpose input/output, or interrupt input/output
- I²C up to 2.7MHz; SPI up to 6.4MHz

TYPICAL OPERATING CIRCUIT



ORDERING INFORMATION

PART	TEMP RANGE	PACKAGE
ICM-30630†	-40°C to +85°C	24-Pin LGA

†Denotes RoHS and Green-Compliant Package

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1.1 PURPOSE AND SCOPE

This document is a preliminary product specification, providing a description, specifications, and design related information on the ICM-30630 MotionTracking device.

Specifications are subject to change without notice. Final specifications will be updated based upon characterization of production silicon.

1.2 PRODUCT OVERVIEW

The ICM-30630 is a MotionTracking device that combines a 3-axis gyroscope, 3-axis accelerometer, and tri-core processors (an ARM Cortex-M0 CPU, and a DMP3 and a DMP4 Digital Motion Processor™) all in a small 3x3x1mm LGA package. The device supports the following features:

- ARM Cortex-M0 based open platform optimized for motion applications with dual-DMP based motion accelerators
- Support for Android L and beyond
- Memory (DMP + FIFO): Variable size FIFO based on DMP feature-set
- Runtime Calibration

The ICM-30630 serves as a sensor hub, supporting the collection and processing of data from internal and external sensors. It can offload processing from the Application Processor in a system, thereby helping to save system power and improve performance. The device includes a primary serial interface (I²C and 4-wire SPI) for communication from the host processor.

ICM-30630 devices, with their 6-axis integration, ARM Cortex-M0 CPU, DMPs, and run-time calibration firmware, enable manufacturers to eliminate the costly and complex selection, qualification, and system level integration of discrete devices, guaranteeing optimal motion performance for consumers.

The gyroscope has a programmable full-scale range of ± 250 , ± 500 , ± 1000 , and ± 2000 degrees/sec. The accelerometer has a user-programmable accelerometer full-scale range of $\pm 2g$, $\pm 4g$, $\pm 8g$, and $\pm 16g$. Factory-calibrated initial sensitivity of both sensors reduces production-line calibration requirements.

Other key features include on-chip 16-bit ADCs, programmable digital filters, an embedded temperature sensor, and programmable interrupts. The device features I²C and SPI serial interfaces, a VDD operating range of 1.71 to 3.6V, and a separate digital IO supply, VDDIO from 1.71V to 3.6V. The device supports the following interface speeds: I²C up to 2.7MHz or SPI up to 6.4MHz.

By leveraging its patented and volume-proven CMOS-MEMS fabrication platform, which integrates MEMS wafers with companion CMOS electronics through wafer-level bonding, InvenSense has driven the package size down to a footprint and thickness of 3x3x1mm (24-pin LGA), to provide a very small yet high performance low cost package. The device provides high robustness by supporting 10,000g shock reliability.

1.3 APPLICATIONS

- Smart Phones and Tablets
- Wearables

2 FEATURES

2.1 GYROSCOPE FEATURES

- Digital-output X-, Y-, and Z-axis angular rate sensors (gyroscopes) with a user-programmable full-scale range of ± 250 , ± 500 , ± 1000 , and $\pm 2000^\circ/\text{sec}$ and integrated 16-bit ADCs
- User-selectable ODR
- User-selectable low pass filters
- Self-test

2.2 ACCELEROMETER FEATURES

- Digital-output X-, Y-, and Z-axis accelerometer with a programmable full scale range of $\pm 2g$, $\pm 4g$, $\pm 8g$ and $\pm 16g$ and integrated 16-bit ADCs
- User-selectable ODR
- User-selectable low pass filters
- Wake-on-motion interrupt for low power operation of applications processor
- Self-test

2.3 ARM CORTEX-M0 FEATURES

- 32-bit microprocessor
- Maximum speed 64MHz
- Serial Wire Data Port for ARM Cortex-M0 user debug
 - Pin 5 (SWDIO) for data signal and pin 6 (SWDCLK) for clock signal

2.4 DMP FEATURES

- DMP3 and DMP4
- Advanced MotionProcessing and low power functions such as gesture recognition using programmable interrupts
- Optimized for Android L support and beyond
- Offloads computation of motion processing algorithms from the host processor. The DMPs can be used to minimize power, simplify timing, simplify the software architecture, and save valuable MIPS on the host processor for use in applications.
- The DMP3 enables ultra-low power run-time and background calibration of the accelerometer, gyroscope, and external sensors, maintaining optimal performance of the sensor data for both physical and virtual sensors generated through sensor fusion. This enables the best user experience for all sensor enabled applications for the lifetime of the device. DMP3 is closely integrated with the MEMS to enable ultra-low power performance.
- The DMP4 is optimized for fixed point processing and FFT generation and complements the CPU by offloading math intensive operations.
- DMP features simplify the software architecture resulting in a more robust overall solution.
- DMP features are OS, Platform, and Architecture independent, supporting virtually any AP, MCU, or other embedded architecture.

2.5 ON-CHIP MEMORY

- 64KB Flash (provides user access for on-chip reprogrammable nonvolatile memory)
- 64KB SRAM (accessible by Cortex-M0, DMPs, FIFO)
- Configurable FIFO with multiple modes of operation and multiple watermark interrupts

2.6 CLOCK GENERATION UNIT

- High frequency RC oscillator for system clock
- Low frequency RC oscillator for periodic wake up
- 32.768kHz crystal oscillator for accurate time stamping
 - This oscillator also requires an external 32.768kHz input (pin 17 XTALI)
 - Oscillator output pin (pin 16 XTALO)

2.7 SERIAL INTERFACES

- One I²C slave controller for communication with application processors, operating at up to 2.7MHz in High-Speed Mode, or up to 0.8MHz in Fast-Mode Plus, or up to 320kHz in Fast-Mode, or up to 80kHz in Standard-Mode
- One I²C master controller for interfacing to external sensors (e.g. compass or barometer), operating at up to 2.7MHz in High-Speed Mode, or up to 0.8MHz in Fast-Mode Plus, or up to 320kHz in Fast-Mode, or up to 80kHz in Standard-Mode
- One 4-wire SPI slave controller operating at speeds of up to 6.4MHz for communication with application processor
- I²C slave controller and SPI slave controller are multiplexed together, only one or the other may be used

2.8 DIGITAL PERIPHERALS

- 3 GPIO bidirectional pins that can be configured as general purpose input, general purpose output, interrupt input, or interrupt output
- Four timers used for watchdog, timestamp, and general purpose timer functions

2.9 POWER MANAGEMENT

- Single 1.8V (1.71V to 3.6V) power supply with on-chip internal voltage regulator for the multiple voltage islands and always on domain
- Single 1.8V (1.71V to 3.6V) IO power supply
- External 1.2 volts supply pin
 - The device can be configured to use external 1.2 volts supply or on-chip regulators
- Power modes for different levels of power savings: Sleep, Deep-Sleep, Power-Down
- Wake up from Sleep, and Deep-Sleep power modes via external interrupts or interrupts generated by always on blocks
- On-chip Power-On Reset and dedicated reset input pin
 - Reset input can be used to wake up the device from sleep

3 ELECTRICAL CHARACTERISTICS

3.1 GYROSCOPE SPECIFICATIONS

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T_A=25°C, unless otherwise noted.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
GYROSCOPE SENSITIVITY						
Full-Scale Range			±250		°/s	1
			±500		°/s	1
			±1000		°/s	1
			±2000		°/s	1
Gyroscope ADC Word Length			16		bits	1
Sensitivity Scale Factor	Full-Scale Range = ±250°/s		131		LSB/(°s)	1
	Full-Scale Range = ±500°/s		65.5		LSB/(°s)	1
	Full-Scale Range = ±1000°/s		32.8		LSB/(°s)	1
	Full-Scale Range = ±2000°/s		16.4		LSB/(°s)	1
Sensitivity Scale Factor Tolerance	25°C		±3		%	2
Sensitivity Scale Factor Variation Over Temperature	-40°C to +85°C		±4		%	2
Nonlinearity	Best fit straight line; 25°C		±0.2		%	2, 3
Cross-Axis Sensitivity			±2		%	2, 3
ZERO-RATE OUTPUT (ZRO)						
Initial ZRO Tolerance	25°C		±20		°/s	2
ZRO Variation Over Temperature	-40°C to +85°C		±0.24		°/s/°C	2
GYROSCOPE NOISE PERFORMANCE (GYRO_FS_SEL=0)						
Total RMS Noise	Noise Bandwidth = 154Hz Calculated from Noise Spectral Density		0.20		°/s-rms	2, 3
Noise Spectral Density	Based on Noise Bandwidth = 10Hz		0.016		°/s/√Hz	2
GYROSCOPE MECHANICAL FREQUENCIES		25	27	29	kHz	2
LOW PASS FILTER RESPONSE	Programmable Range	5.7		197	Hz	1, 3
GYROSCOPE START-UP TIME	From Full-Chip Sleep mode		35		ms	2, 3
OUTPUT DATA RATE	Standard (duty-cycled) Mode	4.4		562.5	Hz	1
	Low-Noise Mode	4.4		1.125k (additional 9kHz option)	Hz	

Table 1. Gyroscope Specifications

Notes:

1. Guaranteed by design
2. Derived from validation or characterization of parts, not guaranteed in production
3. Low-noise mode specification

3.2 ACCELEROMETER SPECIFICATIONS

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T_A=25°C, unless otherwise noted.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS	NOTES
ACCELEROMETER SENSITIVITY							
Full-Scale Range				±2		g	1
				±4		g	1
				±8		g	1
				±16		g	1
ADC Word Length	Output in two's complement format			16		bits	1
Sensitivity Scale Factor	Full-Scale Range = ±2g			16,384		LSB/g	1
	Full-Scale Range = ±4g			8,192		LSB/g	1
	Full-Scale Range = ±8g			4,096		LSB/g	1
	Full-Scale Range = ±16g			2,048		LSB/g	1
Initial Tolerance	Component-level			±3		%	2
Sensitivity Change vs. Temperature	-40°C to +85°C			±0.026		%/°C	2
Nonlinearity	Best Fit Straight Line			±0.5		%	2, 3
Cross-Axis Sensitivity				±2		%	2, 3
ZERO-G OUTPUT							
Initial Tolerance	Component-level, all axes			±80		mg	2
Zero-G Level Change vs. Temperature	-40°C to +85°C	X and Y axes		±0.64		mg/°C	2
		Z axis		±2		mg/°C	2
ACCELEROMETER NOISE PERFORMANCE							
Total RMS Noise	Noise Bandwidth = 136Hz Calculated from Noise Spectral Density			2.92		mg-rms	2, 3
Noise Spectral Density	Based on Noise Bandwidth = 10Hz			250		µg/√Hz	2
LOW PASS FILTER RESPONSE	Programmable Range		5.7		246	Hz	1, 3
INTELLIGENCE FUNCTION INCREMENT				32		mg/LSB	1
ACCELEROMETER STARTUP TIME	From Sleep mode			20		ms	2, 3
	From Cold Start, 1ms V _{DD} ramp			30		ms	2, 3
OUTPUT DATA RATE	Standard (duty-cycled) Mode		0.27		563	Hz	1
	Low-Noise Mode		4.5		1.125k (additional 4.5kHz option)	Hz	

Table 2. Accelerometer Specifications

Notes:

1. Guaranteed by design
2. Derived from validation or characterization of parts, not guaranteed in production
3. Low-noise mode specification

3.3 ELECTRICAL SPECIFICATIONS

3.3.1 D.C. Electrical Characteristics

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T_A=25°C, unless otherwise noted.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
SUPPLY VOLTAGES						
VDD		1.71	1.8	3.6	V	1
VDDIO		1.71	1.8	3.6	V	1
SUPPLY CURRENTS						
Gyroscope Only (DMP & Accelerometer disabled)	102.3Hz update rate, 1x averaging filter		1.21		mA	2, 3
Accelerometer Only (DMP & Gyroscope disabled)	102.3Hz update rate, 1x averaging filter		66		μA	2, 3
Gyroscope + Accelerometer (DMP disabled)	102.3Hz update rate, 1x averaging filter		1.25		mA	2, 3
Deep Sleep Mode			32		μA	2
Power Down Mode			10		μA	2
TEMPERATURE RANGE						
Specified Temperature Range	Performance parameters are not applicable beyond Specified Temperature Range	-40		+85	°C	1

Table 3. D.C. Electrical Characteristics

Notes:

1. Guaranteed by design
2. Derived from validation or characterization of parts, not guaranteed in production
3. The 102.3Hz ODR value shown here is an example, other ODRs may also be used

3.3.2 A.C. Electrical Characteristics

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T_A=25°C, unless otherwise noted.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
SUPPLIES						
Supply Ramp Time (T _{RAMP})	Monotonic ramp. Ramp rate is 10% to 90% of the final value.	0.4	20	100	ms	1
TEMPERATURE SENSOR						
Operating Range	Ambient	-40		85	°C	1
Sensitivity	Untrimmed		333.87		LSB/°C	
Room Temp Offset	21°C		0		LSB	
Power-On RESET						
Supply Ramp Time (T _{RAMP})	Valid power-on RESET	0.01	20	100	ms	1
Start-up time for register read/write	From power-up		11	100	ms	1
I ² C SLAVE ADDRESS	AD0 = 0 AD0 = 1		1101010 (0x6A) 1101011 (0x6B)			
DIGITAL INPUTS (FSYNC, AD0, SCLK, SDI, CS)						
V _{IH} , High Level Input Voltage		0.7*VDDIO			V	1
V _{IL} , Low Level Input Voltage				0.3*VDDIO	V	
C _i , Input Capacitance			< 10		pF	
DIGITAL OUTPUT (SDO, GPIOs)						
V _{OH} , High Level Output Voltage	R _{LOAD} =1MΩ;	0.9*VDDIO			V	1
V _{OL1} , LOW-Level Output Voltage	R _{LOAD} =1MΩ;			0.1*VDDIO	V	
V _{OLINT1} , INT Low-Level Output Voltage	OPEN=1, 0.3mA sink Current			0.1	V	
Output Leakage Current	OPEN=1		100		nA	
t _{INT} , INT Pulse Width	LATCH_INT_EN=0	1		16	μs	
I2C I/O (SCL, SDA)						
V _{IL} , LOW Level Input Voltage		-0.5V		0.3*VDDIO	V	1
V _{IH} , HIGH-Level Input Voltage		0.7*VDDIO		VDDIO + 0.5V	V	
V _{hys} , Hysteresis			0.1*VDDIO		V	
V _{OL} , LOW-Level Output Voltage	3mA sink current	0		0.4	V	
I _{OL} , LOW-Level Output Current	V _{OL} =0.4V V _{OL} =0.6V		3 6		mA mA	
Output Leakage Current			100		nA	
t _{ofr} , Output Fall Time from V _{IHmax} to V _{ILmax}	C _b bus capacitance in pf	20+0.1C _b		250	ns	
AUXILLIARY I/O (AUX_CL, AUX_DA)						
V _{IL} , LOW-Level Input Voltage		-0.5V		0.3*VDDIO	V	1
V _{IH} , HIGH-Level Input Voltage		0.7* VDDIO		VDDIO + 0.5V	V	
V _{hys} , Hysteresis			0.1* VDDIO		V	
V _{OL1} , LOW-Level Output Voltage	VDDIO > 2V; 1mA sink current	0		0.4	V	
V _{OL3} , LOW-Level Output Voltage	VDDIO < 2V; 1mA sink current	0		0.2* VDDIO	V	
I _{OL} , LOW-Level Output Current	V _{OL} = 0.4V V _{OL} = 0.6V		3 6		mA mA	
Output Leakage Current			100		nA	
t _{ofr} , Output Fall Time from V _{IHmax} to V _{ILmax}	C _b bus capacitance in pF	20+0.1C _b		250	ns	
INTERNAL CLOCK SOURCE						
RC Oscillator	Maximum Frequency			64	MHz	1
	Variation over operating range	-10		+10	%	1
Wakeup Oscillator	Target Frequency		8		kHz	1
	Variation over operating range	-20		+20	%	1

EXTERNAL CLOCK SOURCE						
Crystal Oscillator	Frequency		32.768		kHz	1
	Crystal Q	4250				1
	Duty Cycle	30		70	%	1
	Crystal Load Capacitance		9		pF	1
	Device Startup Time			200	ms	1

Table 4. A.C. Electrical Characteristics

Notes:

1. Derived from validation or characterization of parts, not guaranteed in production.

3.4 I²C TIMING CHARACTERIZATION

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T_A=25°C, unless otherwise noted.

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
I²C TIMING		I²C HIGH-SPEED MODE				
f _{SCL} , SCL Clock Frequency				2.7	MHz	
t _{HD,STA} , (Repeated) START Condition Hold Time		160			ns	
t _{LOW} , SCL Low Period		320			ns	
t _{HIGH} , SCL High Period		120			ns	
t _{SU,STA} , Repeated START Condition Setup Time		160			ns	
t _{HD,DAT} , SDA Data Hold Time		0		150	ns	
t _{SU,DAT} , SDA Data Setup Time		10			ns	
t _r , SDA and SCL Rise Time		20		160	ns	
t _f , SDA and SCL Fall Time		20		160	ns	
t _{SU,STO} , STOP Condition Setup Time		160			ns	
C _b , Capacitive Load for each Bus Line			< 400		pF	

Table 5. I²C Timing Characteristics

Notes:

1. Timing Characteristics apply to both Primary and Auxiliary I2C Bus

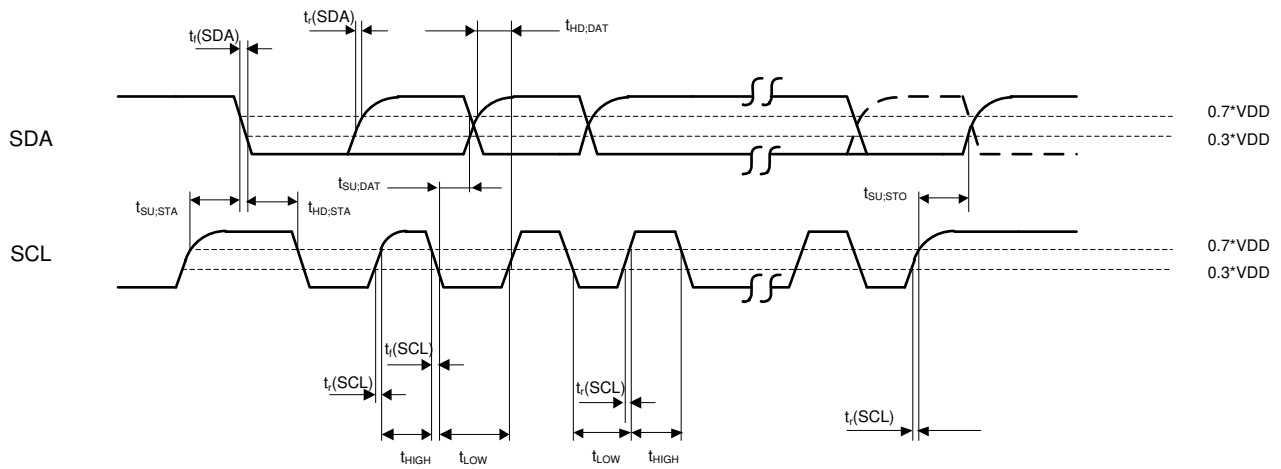


Figure 1.I2C Bus Timing Diagram

3.5 SPI TIMING CHARACTERIZATION

Typical Operating Circuit of section 4.2, VDD = 1.8V, VDDIO = 1.8V, T_A=25°C, unless otherwise noted.

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
SPI TIMING						
f _{SCLK} , SCLK Clock Frequency				6.4	MHz	
t _{LOW} , SCLK Low Period		50			ns	
t _{HIGH} , SCLK High Period		50			ns	
t _{SU,CS} , CS Setup Time		0			ns	
t _{HD,CS} , CS Hold Time		20			ns	
t _{SU,SDI} , SDI Setup Time		0			ns	
t _{HD,SDI} , SDI Hold Time		75			ns	
t _{VD,SDO} , SDO Valid Time				12	ns	
t _{HD,SDO} , SDO Hold Time		15			ns	
t _{DIS,SDO} , SDO Output Disable Time				62	ns	

Table 6. SPI Timing Characteristics

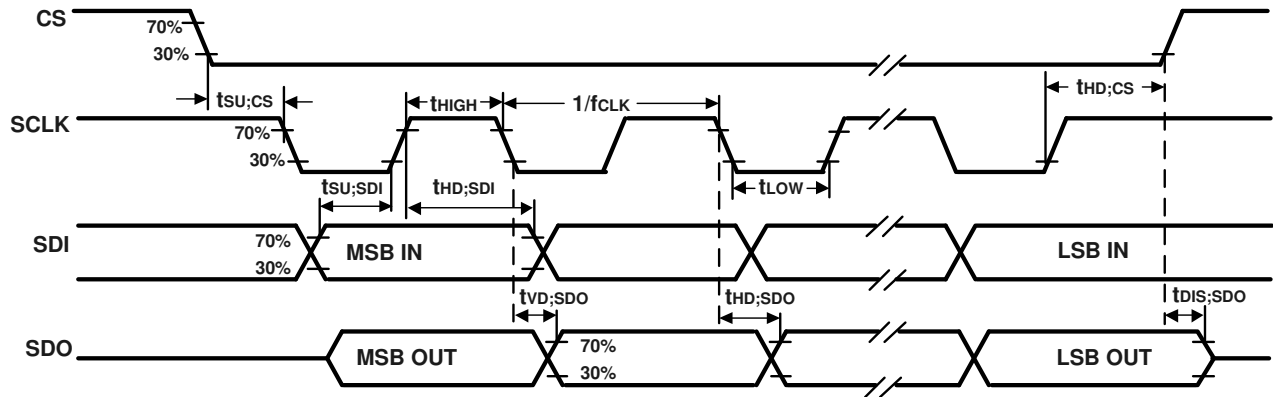


Figure 2. SPI Bus Timing Diagram

3.6 ABSOLUTE MAXIMUM RATINGS

Stress above those listed as “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to the absolute maximum ratings conditions for extended periods may affect device reliability.

PARAMETER	RATING
Supply Voltage, VDD	-0.5V to +4V
Supply Voltage, VDDIO	-0.5V to +4V
REGOUT	-0.5V to 2V
Input Voltage Level (AUX_DA, AD0, FSYNC, INT, SCL, SDA)	-0.5V to VDDIO + 0.5V
Acceleration (Any Axis, unpowered)	10,000g for 0.2ms
Operating Temperature Range	-40°C to +105°C
Storage Temperature Range	-40°C to +125°C
Electrostatic Discharge (ESD) Protection	2kV (HBM); 200V (MM)
Latch-up	JEDEC Class II (2), 125°C ±100mA

Table 7. Absolute Maximum Ratings

4 APPLICATIONS INFORMATION

4.1 PIN OUT DIAGRAM AND SIGNAL DESCRIPTION

PIN NUMBER	PIN NAME	PIN DESCRIPTION
1	RESETL	External reset input
2	RESV	Reserved
3	RESV	Reserved
4	RESV	Reserved
5	SWDIO	Serial Wire Debug Port – Data Signal
6	SWDCLK	Serial Wire Debug Port – Clock Signal
7	AUX_CL	I ² C master serial clock, for connection to external sensors
8	VDDIO	Digital I/O supply voltage
9	SDO/ADO	SPI slave serial data port output (SPI host interface mode); I ² C slave address LSB (I ² C host interface mode)
10	REGOUT	Regulator filter capacitor connection
11	FSYNC/GPIO1	Frame synchronization digital input, connect to GND if unused; GPIO/Interrupt
12	GPIO2	GPIO/Interrupt
13	VDD	Power supply voltage
14	RESV	Reserved
15	VDD1P2	External 1.2V supply. NC if not used.
16	XTALO	32kHz crystal output
17	XTALI	32kHz crystal input
18	GND	Power supply ground
19	GPIO0	GPIO/Interrupt
20	RESV	Reserved. Do not connect.
21	AUX_DA	I ² C master serial data, for connection to external sensors
22	nCS/RESV	SPI slave chip select (SPI host interface mode); Tie High (I ² C host interface mode)
23	SCLK/SCL	SPI slave serial clock (SPI host interface mode); I ² C slave serial clock (I ² C host interface mode)
24	SDI/SDA	SPI slave serial data input (SPI host interface mode); I ² C slave serial data (I ² C host interface mode)

Table 8. Signal Descriptions

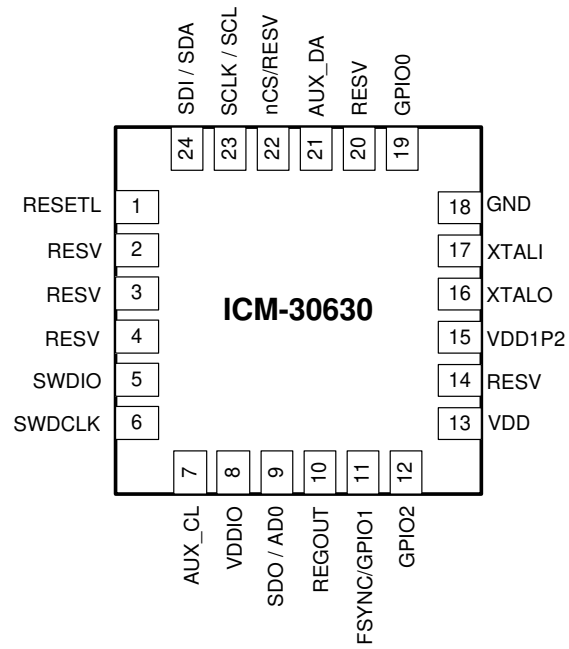


Figure 3. Pin out Diagram for ICM-30630 3x3x1mm LGA

4.2 TYPICAL OPERATING CIRCUIT

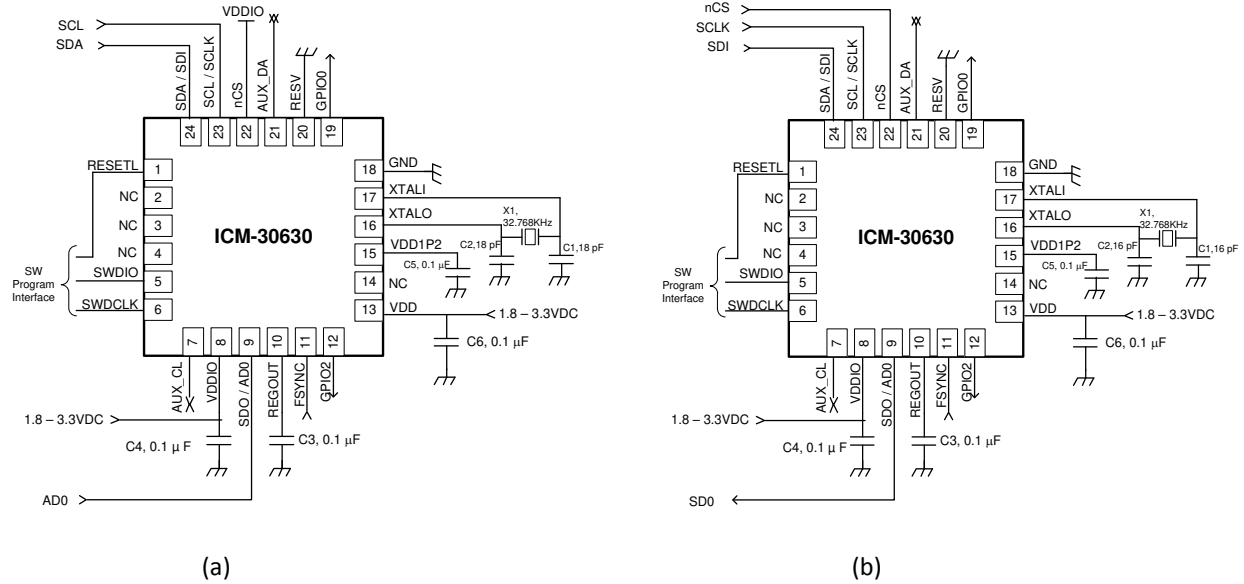


Figure 4. ICM-30630 Application Schematic (a) I2C operation (b) SPI operation

4.3 BILL OF MATERIALS FOR EXTERNAL COMPONENTS

COMPONENT	LABEL	SPECIFICATION	QUANTITY
Decoupling Capacitor	C3, C4, C5, C6	Ceramic, X7R, 0.1μF ±10%, 10V	4
Crystal Resonator Load Capacitor ¹	C1, C2	Ceramic, X7R, 18pF ±5%, 10V	2
Crystal Resonator	X1	Xtal, AH-32.768KDZF-T, or equiv	1

Table 9. Bill of Materials

Note 1:

$$\text{Crystal Resonator Load Capacitor} = 2 \times (C_{\text{crystal}} - 3.15\text{pF} - C_{\text{pcb}})$$

4.4 ICM-30630 BLOCK DIAGRAM

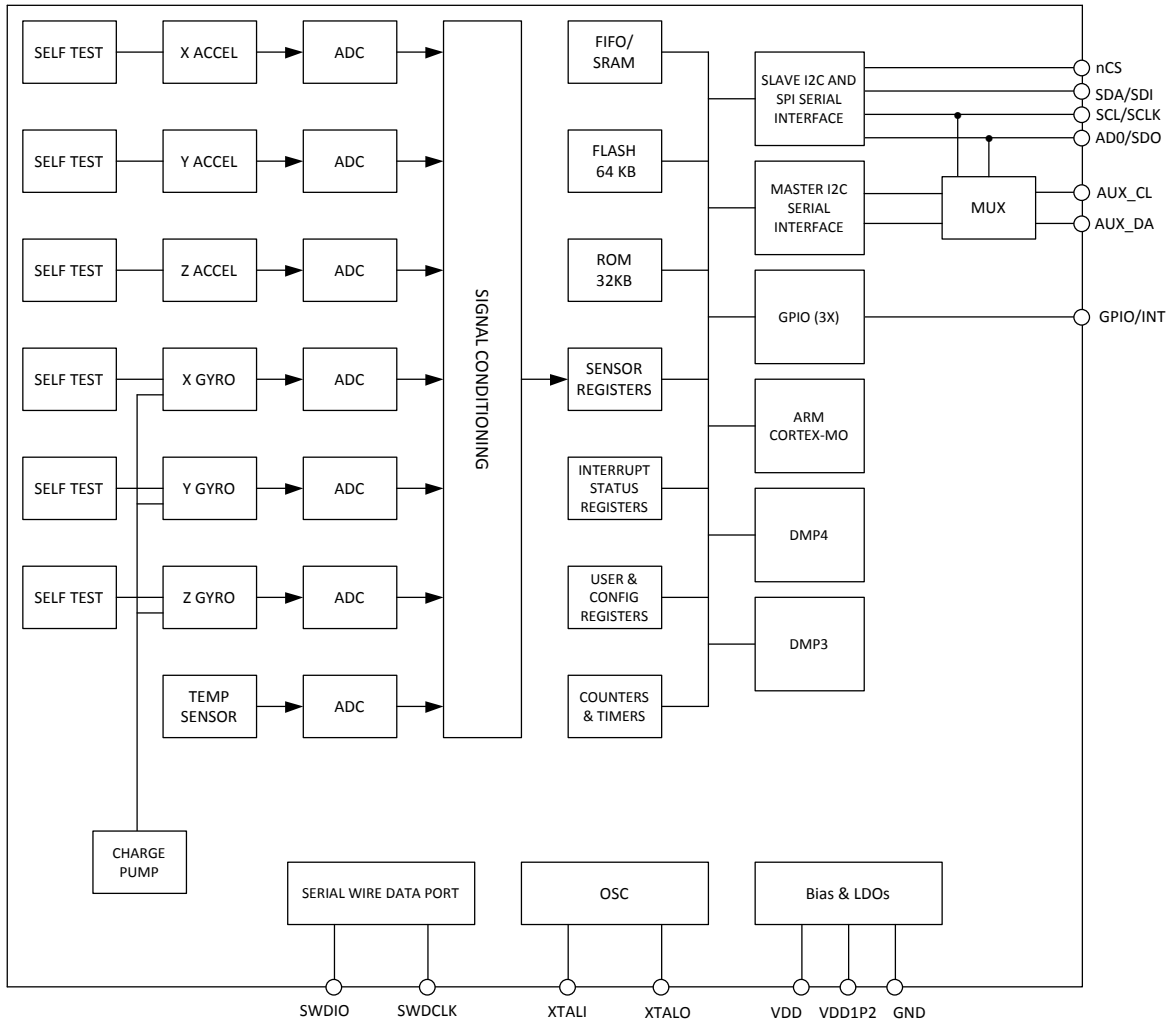


Figure 5. ICM-30630 Block Diagram

4.5 OVERVIEW

The ICM-30630 serves as a hub for collecting sensor data from sensors located on the ICM-30630 as well as external 3rd party sensors. The device consists of the following key blocks and functions:

- Three-axis MEMS rate gyroscope sensor with 16-bit ADCs and signal conditioning
- Three-axis MEMS accelerometer sensor with 16-bit ADCs and signal conditioning
- ARM Cortex-M0 CPU
- Two Digital Motion Processor (DMP) engines
- Flash
- ROM
- SRAM
- FIFO
- 3 GPIOs
- DMA Controller
- Primary slave I²C or slave SPI serial communications interfaces
- Auxiliary I²C serial interface
- 4 Timers
- Serial Wire Data Port
- Self-Test
- Clocking
- Interrupts
- On-Chip Oscillators
- On-Chip Regulators
- Charge Pump
- Power Modes

4.6 THREE-AXIS MEMS GYROSCOPE WITH 16-BIT ADCS AND SIGNAL CONDITIONING

The ICM-30630 consists of three independent vibratory MEMS rate gyroscopes, which detect rotation about the X-, Y-, and Z- Axes. When the gyros are rotated about any of the sense axes, the Coriolis Effect causes a vibration that is detected by a capacitive pickoff. The resulting signal is amplified, demodulated, and filtered to produce a voltage that is proportional to the angular rate. This voltage is digitized using individual on-chip 16-bit Analog-to-Digital Converters (ADCs) to sample each axis. The full-scale range of the gyro sensors may be digitally programmed to ± 250 , ± 500 , ± 1000 , or ± 2000 degrees per second (dps).

4.7 THREE-AXIS MEMS ACCELEROMETER WITH 16-BIT ADCS AND SIGNAL CONDITIONING

The ICM-30630's 3-Axis accelerometer uses separate proof masses for each axis. Acceleration along a particular axis induces displacement on the corresponding proof mass, and capacitive sensors detect the displacement differentially. The ICM-30630's architecture reduces the accelerometers' susceptibility to fabrication variations as well as to thermal drift. When the device is placed on a flat surface, it will measure $0g$ on the X- and Y-axes and $+1g$ on the Z-axis. The accelerometers' scale factor is calibrated at the factory and is nominally independent of supply voltage. Each sensor has a dedicated sigma-delta ADC for providing digital outputs. The full scale range of the digital output can be adjusted to $\pm 2g$, $\pm 4g$, $\pm 8g$, or $\pm 16g$.

4.8 ARM CORTEX-M0 CPU

The ICM-30630 includes an ARM Cortex-M0 CPU. The CPU is a general purpose, 32-bit microprocessor that offers high performance at very low power consumption. It can operate at up to a maximum speed of 64MHz. The CPU uses Thumb-2[®] technology, providing a blend of 16/32-bit instructions that deliver a small code size. Due to its embedded ARM core, the ICM-30630 is compatible with ARM tools and software.

The CPU can be used to collect and process data from sensors that are included in the ICM-30630 as well as external sensors, so that the ICM-30630 can be used as a Sensor Hub. It enables the ICM-30630 to function as a sensor hub which is an open platform where developers can add their differentiated features.

4.9 DIGITAL MOTION PROCESSORS

The ICM-30630 includes 2 Digital Motion Processors (DMPs), a DMP3 and a DMP4. The DMPs together with the ARM Cortex-M0 CPU can offload computation of motion processing algorithms from the host processor. DMP3 is utilized for proven track record and quick deployment, benefiting from the existing code base. DMP4 is a higher functioning processor with specialties in fixed point processing and FFT generation. It is register based for power and flexibility.

4.10 FLASH

Flash Memory is partitioned into two memory blocks:

- A main memory block of 64K bytes that is available for user program.
- A second memory block is reserved for InvenSense use. It is programmed by InvenSense during device production. It contains information for optimizing device performance.

At startup, the ICM-30630 boots from the reserved section that was programmed by InvenSense. At the end of this step, the system boots from the main Flash that contains the user program.

4.11 SRAM

The ICM-30630 includes SRAM whose total size is 64K bytes. This SRAM space is shared among storage for ARM Cortex-M0, DMPs, and FIFO.

4.12 FIFO

The ICM-30630 contains a FIFO that is accessible via the SPI/I2C interfaces. The FIFO is used to keep a history of most recent sensors output, DMP or Cortex M0 results. The FIFO can be configured as a single FIFO or multiple FIFOs. The FIFO uses part of the SRAM, while the remainder of the SRAM is used by the M0, DMP, and as shared SRAM. FIFO size is variable depending on software configuration.

The FIFO can be written to by DMA, DMP, ARM Cortex-M0 and by the user through serial interface. It can be read through serial interface, DMP or ARM Cortex-M0. In multiple FIFO mode, up to 4 FIFOs are available and any number, ranging from 0-3 can be configured. There is no association of a FIFO to a particular sensor type, the DMP or the M0. DMP and M0 can read and write to all 4 FIFOs.

In multiple FIFO mode, each sensor output can be read from a separate FIFO. Separate sensors can control their FIFOs based on individual ODRs. Slower sensors (compass, barometer) do not need to update the FIFO at the same rate as faster sensors. This provides ease of use and more efficient use of FIFO space.

4.13 GPIO

The ICM-30630 supports 3 GPIO bidirectional pins that can be configured as general purpose input, general purpose output, interrupt input, or interrupt output.

4.14 DMA CONTROLLER

The DMA controller allows various types of data transfers without processor intervention.

4.15 PRIMARY SLAVE I2C OR SLAVE SPI SERIAL COMMUNICATIONS INTERFACES

The ICM-30630 communicates to a host application processor through either an I²C or an SPI serial interface. The ICM-30630 always acts as a slave when communicating to the application processor. The I²C and SPI slave interface can be used by the application processor to program the ICM-30630 or to read its on-chip memories. The following interface modes are supported:

- I2C Standard-Mode: Up to 80kHz
- I2C Fast-Mode: Up to 320kHz
- I2C Fast-Mode Plus: Up to 0.8MHz
- I2C High-Speed Mode: Up to 2.7MHz
- SPI Interface: Up to 6.4MHz

4.15.1 ICM-30630 Solution Using I2C Interface

In the figure below, the system processor is an I²C master to the ICM-30630. In addition, the ICM-30630 is an I²C master to the optional external compass sensor.

The ARM Cortex-M0 processor on ICM-30630 can be used to manage the initial configuration of any auxiliary sensors. Alternatively, the system processor can be used for initial configuration of auxiliary sensors. The ICM-30630 has an interface bypass multiplexer, which connects the system processor I²C bus pins 23 and 24 (SDA and SCL) directly to the auxiliary sensor I²C bus pins 6 and 7 (AUX_DA and AUX_CL). Once the auxiliary sensors have been configured by the system processor, the interface bypass multiplexer should be disabled so that the ICM-30630 auxiliary I²C master can take control of the sensor I²C bus and gather data from the auxiliary sensors.

For further information regarding I²C master control, please refer to section 5.

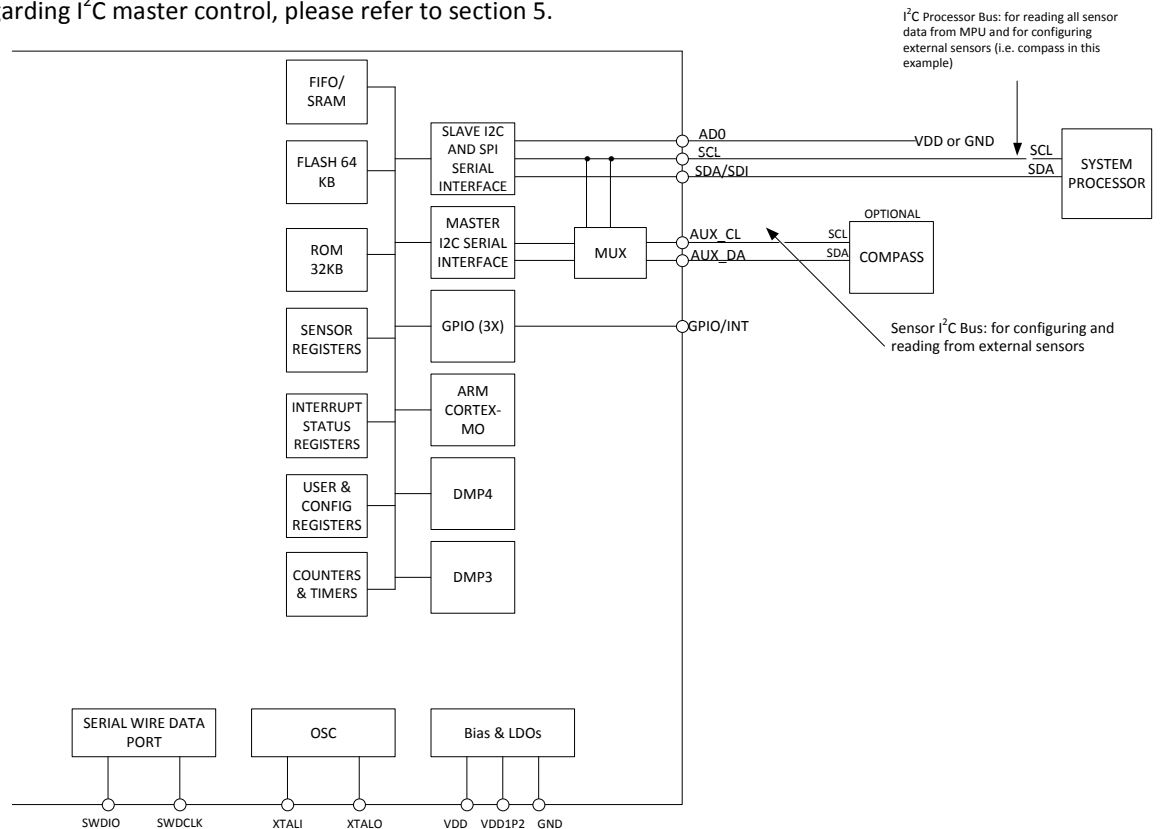


Figure 6 ICM-30630 Solution Using I²C Interface

4.15.2 ICM-30630 Solution Using SPI Interface

In the figure below, the system processor is an SPI master to the ICM-30630. Pins 8, 9, 23, and 24 are used to support the CS, SDO, SCLK, and SDI signals for SPI communications. Because these SPI pins are shared with the I²C slave pins, the system processor cannot access the auxiliary I²C bus through the interface bypass multiplexer, which connects the processor I²C interface pins to the sensor I²C interface pins. The ARM Cortex-M0 can be used to manage the initial configuration of any auxiliary sensors. The alternative approach described in the previous section, of using the system processor to manage initial configuration of auxiliary sensors, cannot be used in this case.

Once the external sensors have been configured, the ICM-30630 can perform single or multi-byte reads using the sensor I²C bus.

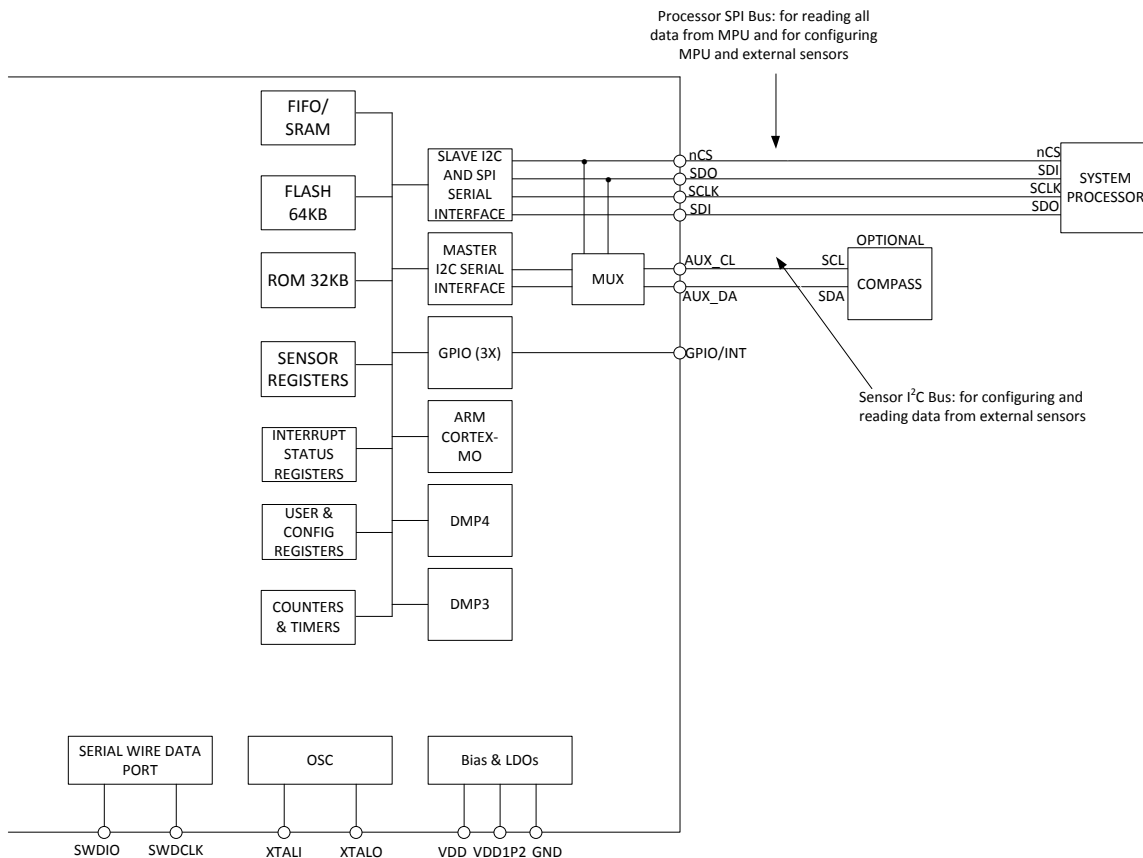


Figure 7. ICM-30630 Solution Using SPI Interface

4.16 AUXILIARY I2C SERIAL INTERFACE

The ICM-30630 has an auxiliary I²C bus for communicating to an off-chip 3-Axis digital output magnetometer or other sensors. This bus has two operating modes:

- **I²C Master Mode:** The ICM-30630 acts as a master to any external sensors connected to the auxiliary I²C bus
- **Pass-Through Mode:** The ICM-30630 directly connects the primary and auxiliary I²C buses together, allowing the system processor to directly communicate with any external sensors.