

Big performance from tiny chips.



General Description

The SENtral™ Motion Coprocessor is a custom integrated circuit that makes it easy to quickly incorporate, optimize and operate multiple motion sensors on mobile consumer electronics devices. In this configuration, SENtral employs and manages an AKM 3-axis magnetometer, and a user-specified 3-axis accelerometer and 3-axis gyroscope to provide reliable motion tracking, and accurate heading and orientation data. SENtral gathers data from the individual sensors, then integrates and fuses this data using PNI's proprietary Kalman filtering and heuristic algorithms.

By offloading the sensor fusion and interface from a dedicated sensor hub MCU or the host CPU to SENtral, overall power requirements are dramatically lowered and processing power is opened up for other uses. These advantages make SENtral the ideal choice for mobile and consumer electronics devices desiring ultra-low power consumption and best-in-class sensor fusion.

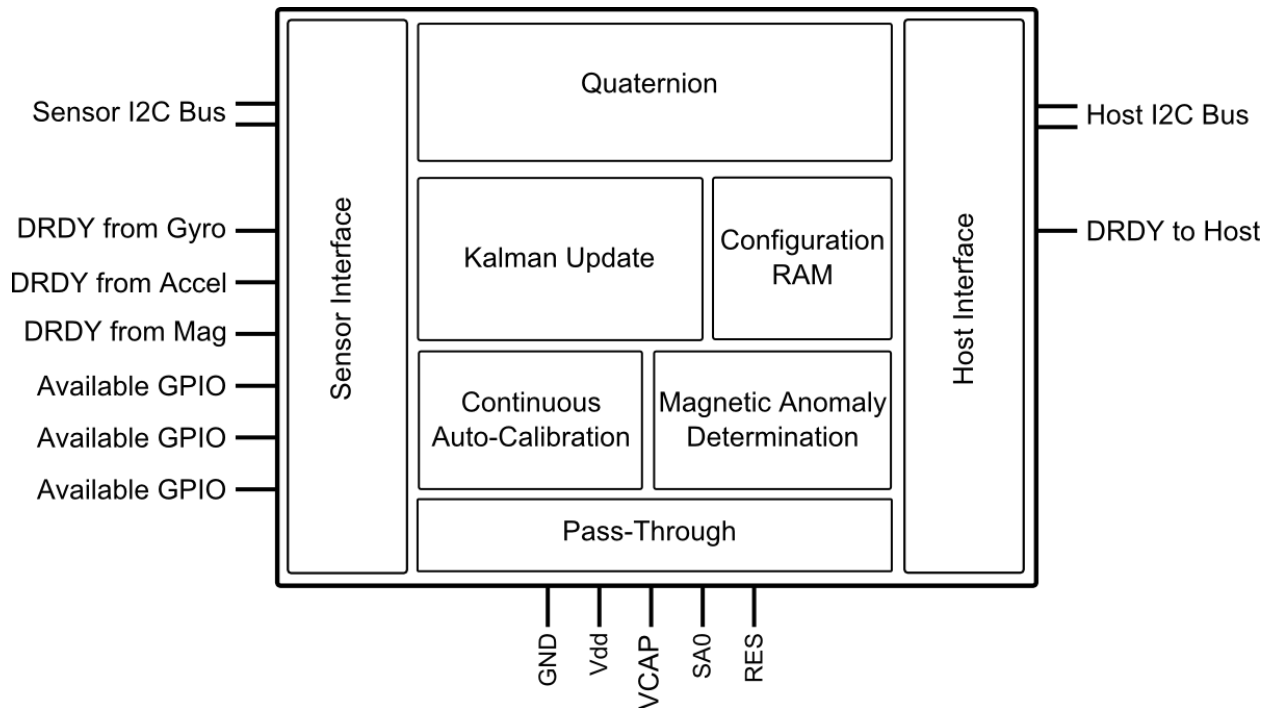
Features and benefits:

- **Low power consumption.** Offloads sensor processing from the less efficient host CPU, consuming <1% of the power of a general purpose processor running a comparable sensor fusion algorithm, enabling “always on” motion sensing applications.
- **Industry-leading heading accuracy.** Unparalleled heading accuracy of up to 2° rms for consumer electronics applications.
- **Continuous hard and soft-iron magnetic auto-calibration.** Provides continual background calibration of the sensors. Leverages PNI's more than 20 years of experience and expertise in magnetic measurement.



- **Magnetic anomaly compensation.** Heading and motion tracking is unaffected by magnetic anomalies such as rebar in buildings, desks, speakers etc., that can easily throw off the accuracy. SENtral recognizes and compensates for these anomalies.
- **Sensor flexibility.** Works with the most common consumer electronic MEMS gyroscopes and accelerometers, so system designers can choose the sensors most appropriate for their systems.
- **Small form-factor.** 1.6x1.6x0.5 mm chip-scale package on 0.4 mm pitch. Uses little PCB real estate, allowing for painless integration.
- **I²C interface.** Uses the industry-standard I²C protocol in a proprietary low-power implementation to interface to the sensors and the host, so system integration is straightforward. Standard, Fast, Fast Plus, and High Speed are supported on the host bus.
- **Outputs.** SENtral natively outputs quaternions, rotational velocity, linear acceleration, and magnetic field.

SENtral block diagram:



- **Quaternion** provides the orientation output and is updated at a rate limited to the gyro output data rate (ODR), up to a maximum of 400 Hz.
- **Kalman Update** fuses data from the 3-axis gyroscope, 3-axis accelerometer, and the 3-axis AKM magnetometer, plus data from the magnetic anomaly determination and continuous auto-calibration blocks to generate intelligent orientation updates. The Kalman update involves a sophisticated multi-state Kalman algorithm, and this is where most of the heavy calculations are performed.
- **Continuous Hard and Soft-Iron Auto-Calibration.** SENtral auto-calibrates for both hard-iron and soft-iron magnetic distortions. While others may calibrate for hard-iron distortion, soft-iron distortion is more difficult to correct for, and it can be caused by EMI shielding tape and other shielding materials widely used in mobile and consumer electronic devices. It is important to correct for soft-iron distortions since they can contribute up to 90° of error. Additionally, since a host system's magnetic signature can change over time and

temperature, SENtral's continuous auto-calibration ensures accuracy all the time.

- **Magnetic Anomaly Determination** establishes if a transient magnetic distortion is present and accounts for it.
- **Configuration RAM** allows for customizing SENtral to match the specific sensors being used and allows the user to tailor certain parameters for their specific system. The SENtral Configuration Program generates the SENtral Configuration File, and this is subsequently uploaded into SENtral's Configuration RAM.
- **Pass-Through** allows for direct communication with devices on the sensor bus by connecting SENtral's I²C Host Interface to the Sensor Interface.
- **Host Interface** communicates with the host system. Data is transmitted between the host and SENtral via the host I²C bus, in which the host acts as the master and SENtral acts as a slave device. SENtral signals the host that new data is available by sending an interrupt signal on the host DRDY line.
- **Sensor Interface** communicates primarily with the sensors. Sensor data is transmitted from the sensors to SENtral via the sensor I²C bus, in which SENtral acts as the master and the sensors as the slave devices.

Specifications & Performance Characteristics

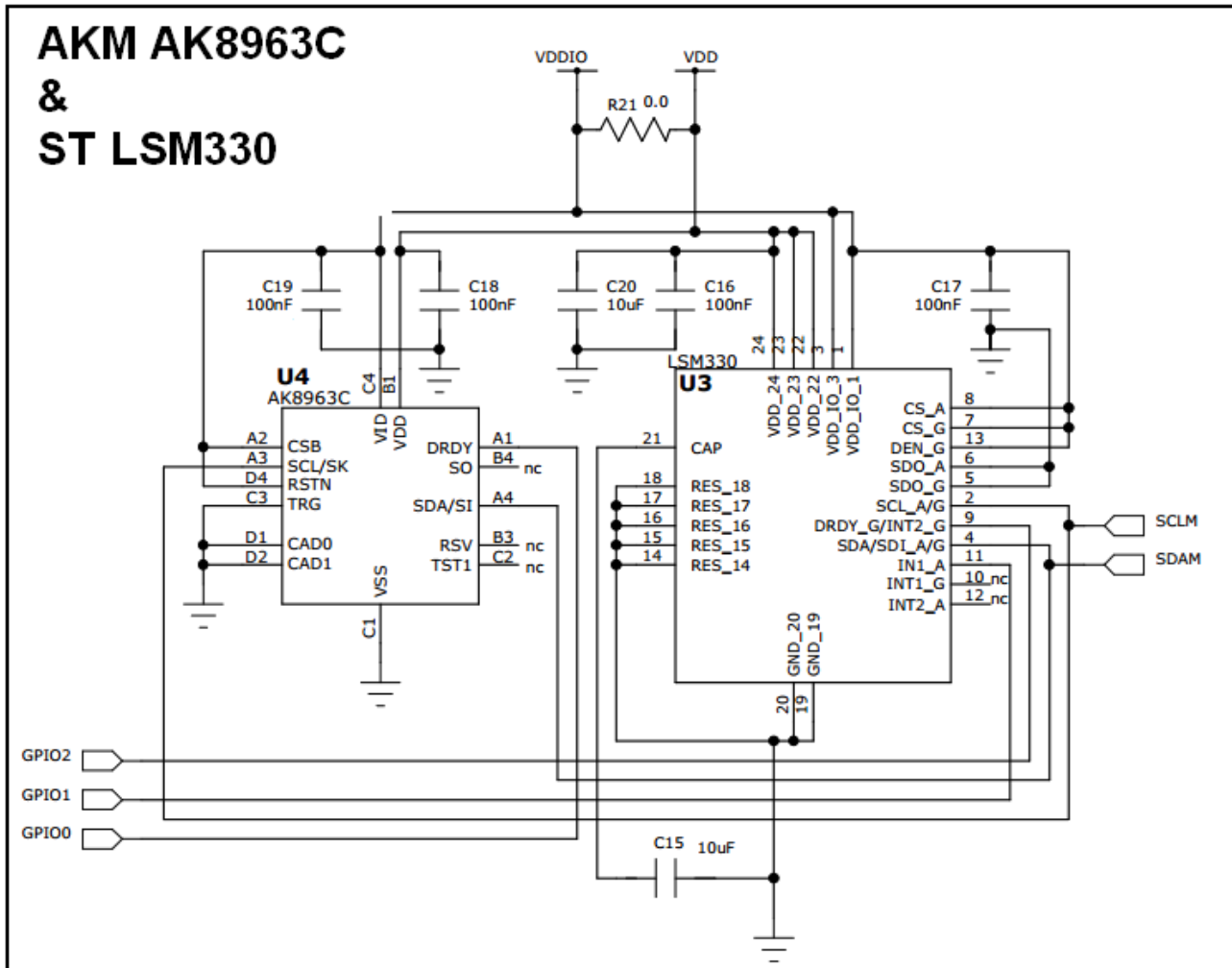
Parameter	Symbol	Minimum	Typical	Maximum	Units
Supply Voltage	V _{DD}	1.6		3.3	VDC
Current Consumption @ 1.8 V _{DD} ¹	Operation @ 30 Hz Kalman update rate		275		μA
	Operation @ 7 Hz Kalman update rate		170		μA
	Pass-Through state		45		μA
	Standby state		7		μA
I ² C Interface Data Rate ²	Host Bus			3400	kbits/sec
	Sensor Bus			1000	kbits/sec
	Pass-Through			400	kbits/sec
Decoupling Capacitor (ESR <2Ω)	C _{reg}	0.33	0.5	1.8	μF
Operating Temperature	T _{OP}	-40	+25	+85	C

Footnotes:

All specifications subject to change.

1. Sensor bus in I²C Fast mode @ 400 kbits/sec, Accel ODR=100 Hz, Gyro ODR=190 Hz, and Mag ODR=Kalman rate. Operation current consumption is the average over 30 sec while the device is in motion. A 30 Hz Kalman update rate provides superior orientation-tracking performance when compared to a 7Hz Kalman rate. Pass-Through current consumption assumes SENtral previously was in Standby state, which is recommended.
2. SENtral's I²C Host Interface supports Standard, Fast, Fast Plus, and High Speed Modes. High Speed Mode (3400 kHz) is supported with a reduced range of V_{DD} and bus capacitance. SENtral's I²C sensor bus interface supports Standard, Fast, and Fast Plus Modes. Pass-Through state, which connects the sensor bus and host bus, supports Standard and Fast Modes.

SENtral Sample System Reference Schematic



About PNI

PNI Sensor Corporation is the leader in the exacting science of producing pinpoint heading and orientation technology and modules for the consumer, military, scientific and oceanography communities. Building on decades of patented sensor development, PNI offers highly accurate magneto-inductive sensor systems and 9-axis sensor fusion technology. Its products are used in consumer electronics, robotics, surveying, navigation and automotive applications across the globe. PNI is based in Santa Rosa, California. Additional information about the Company and its products is available at www.pnicorp.com

About AKM

Asahi Kasei Microdevices (AKM). Asahi Kasei Microdevices (AKM) is a leading manufacturer of 3-axis electronic compass using Hall element technology. They have the leading market share in the global 3-axis electronic compass IC's for consumer applications and play a pivotal role in expanding the use of the electronic compass. They also offer a variety of advanced sensing devices based on compound semiconductor technology and sophisticated IC products featuring analog/digital mixed-signal technology. AKM is based in Tokyo, Japan. Additional company and product information can be found at www.akm.com.