

Sensor Toolbox: Complete Ecosystem for Product Development with Sensors

Sahil Choudhary

Technical Marketing and Enablement Manager
IoT Sensors

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SECURE CONNECTIONS
FOR A SMARTER WORLD

Agenda

-Introducing NXP's sensor toolbox

- Showcasing NXP's sensor board repository
- IoT Sensing Software Development Kit (ISSDK) for embedded application development
- Freedom sensor toolbox – Community Edition for sensor data visualization

-Other customer enablement: reference designs, CZ reports, qual reports

-More information/Q&A

Session Goals

After this session the audience will be able to:

- Understand how to use the sensor toolbox for each phase of product development
- Use NXP enablement and boards to simplify customer engagements

NXP Sensor Technology Supports Key Applications

Automotive



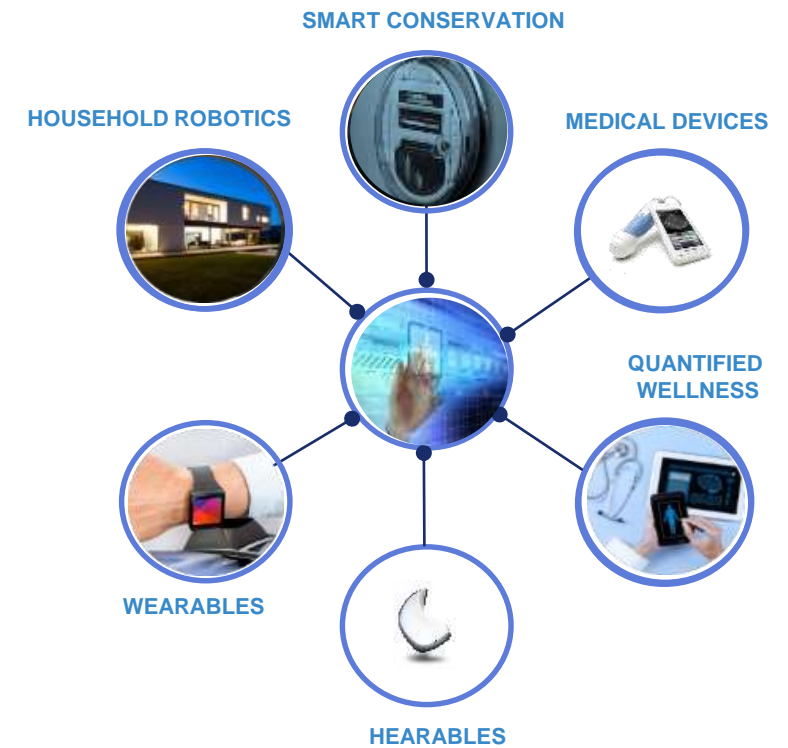
3
billion units
shipped

Magnetic
(MR)

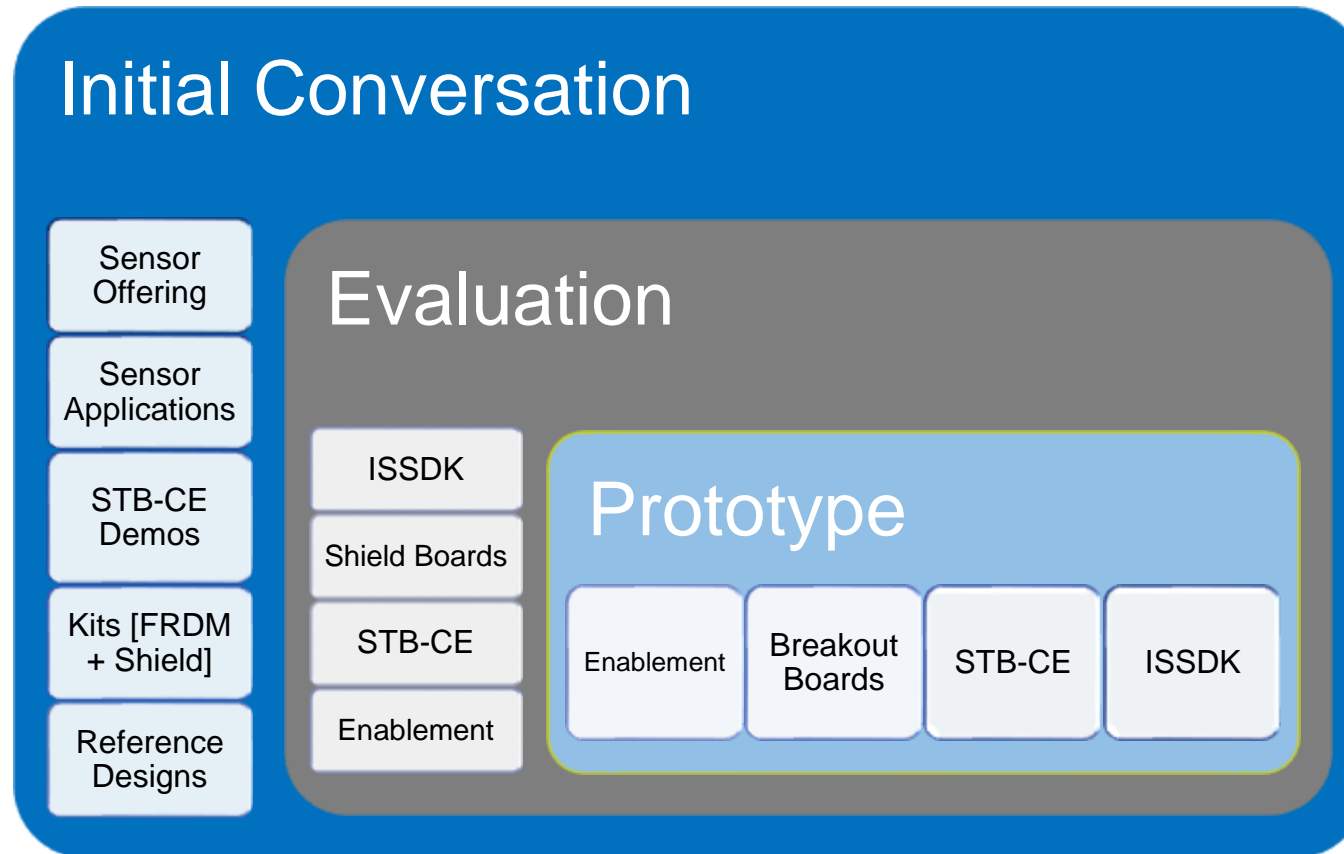
Motion
(MEMS)

Pressure
(MEMS)

Medical & Industrial



Sensor Enablement



Introducing the Sensor Toolbox Ecosystem



Sensor Toolbox Ecosystem



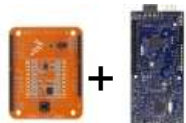
Demo Kit (Shield + MCU)



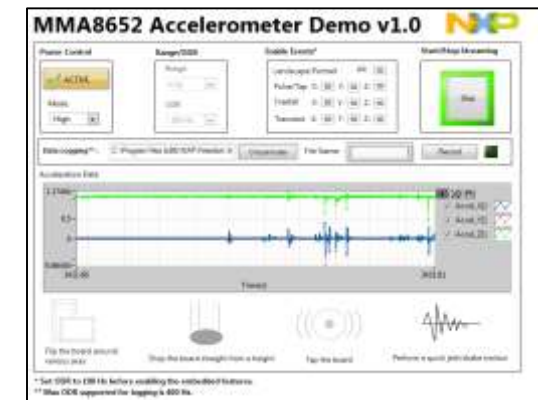
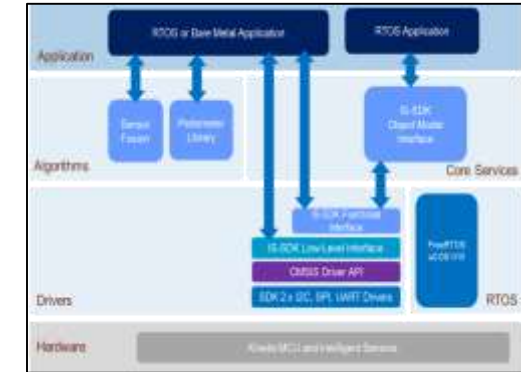
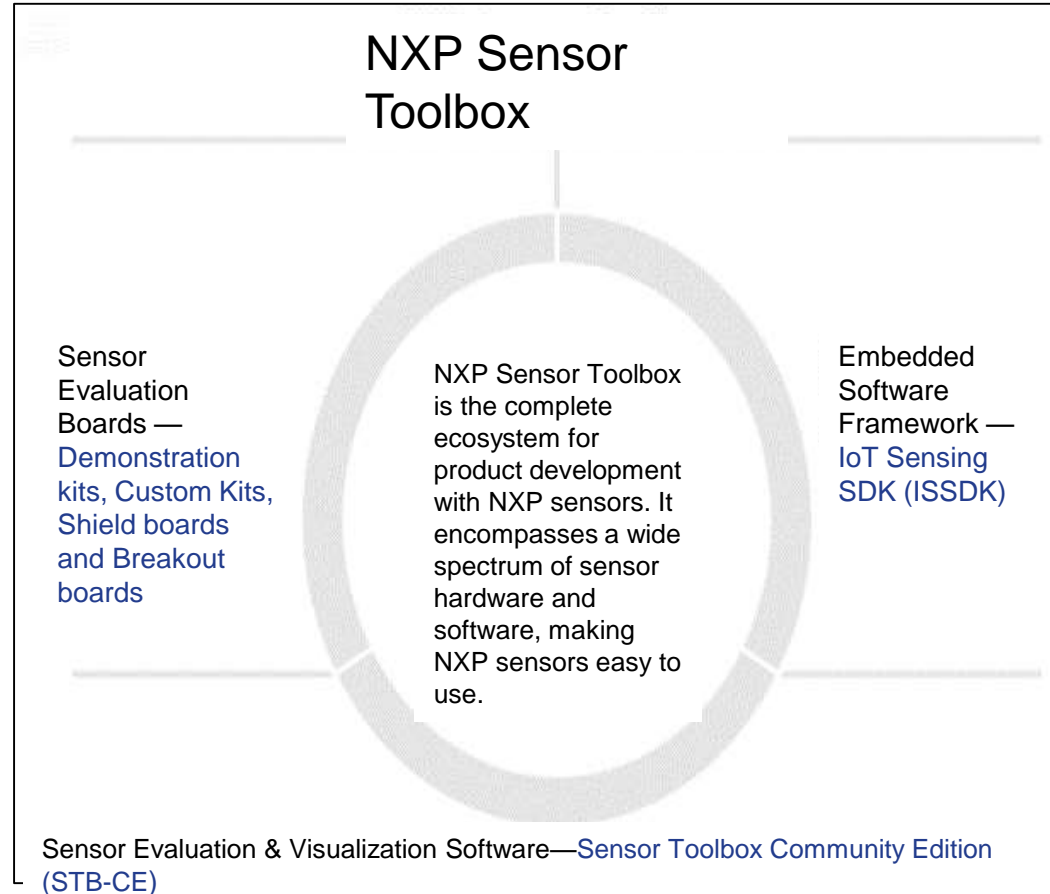
Shield Board



Breakout Board



Custom Kit **NEW**



Sensor Toolbox - Community Edition (STB-CE)

The complete hardware and software ecosystem for NXP sensors



Supported Sensors by Sensor Toolbox Ecosystem

Sensor Part Number	Sensor Type	Interface		
		SPI	I2C	ADC
FXAS21002	Gyroscope	✓	✓	—
FXLC95000	Intelligent accelerometer	✓	✓	—
FXLS8471	Digital accelerometer	✓	✓	
FXOS8700	Digital accelerometer and magnetometer	✓	✓	—
MAG3110	Digital magnetometer	—	✓	—
MMA845X	Digital accelerometer	—	✓	—
MMA8491	Digital accelerometer	—	✓	—
MMA865X	Digital accelerometer	—	✓	—
MMA9553	Intelligent accelerometer	—	✓	—
MPL3115	Digital pressure	—	✓	—
FXLS8962	Accelerometer	✓	✓	—
FXPQ3115	Pressure/bio-compatible	—	✓	—
MPXV5004DP	Differential and gauge, integrated analog pressure sensor	—	—	✓
NPS300xxx	Precise low-pressure Gauge/differential sensor	✓	✓	—

Hardware: Sensor Evaluation Boards

Demo Kit (Shield + MCU)



Complete Solution for 'Out of Box' sensor demonstration, evaluation and development

Shield Board



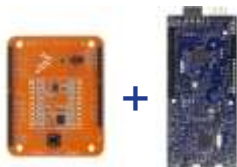
Evaluation Boards, pin compatible with most Arduino and FRDM development boards

Breakout Board



Boards for product prototyping, can be easily wired to host MCU

Custom Kit NEW

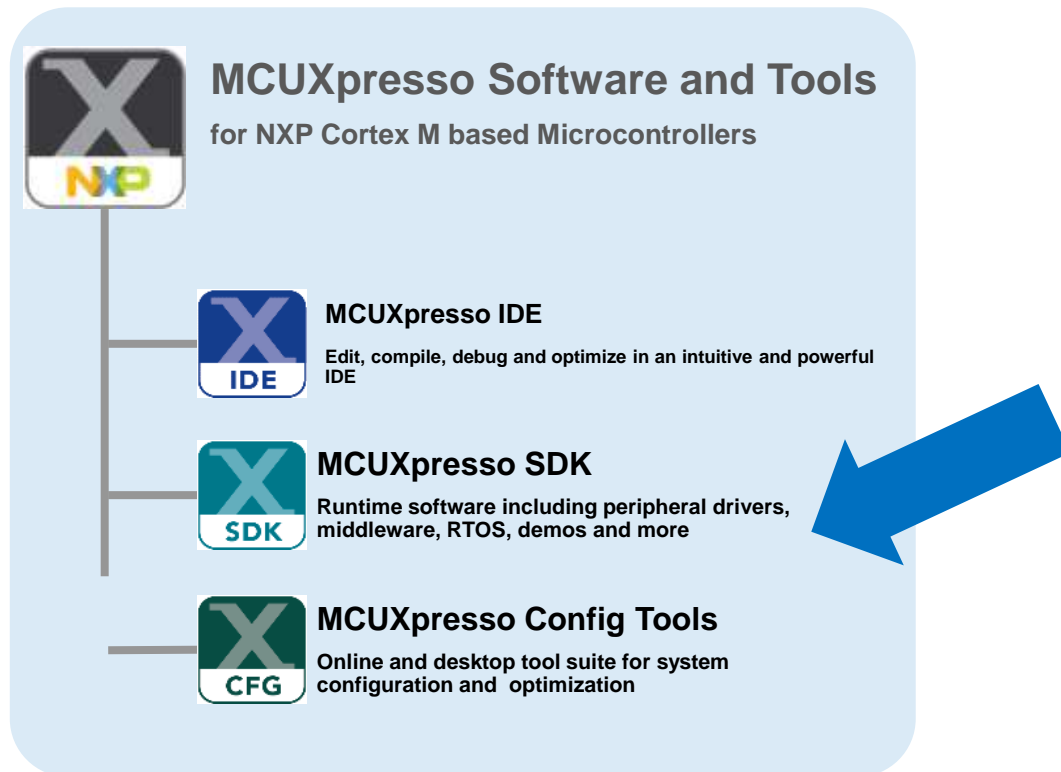


Attach the shield board with the corresponding MCU board for quick demonstration, evaluation and development

Sensor Toolbox Name	Board Type	Board Name
Sensor Toolbox for 9-Axis Solution	Demo kits	FRDM-K22F-AGM01 FRDM-K64F-AGM01
	Custom kit (new)	LPCXpresso54114 with FRDM-STBC-AGM01
	Shield board	FRDM-STBC-AGM01
	Breakout board	BRKT-STBC-AGM01
Sensor Toolbox for FXLC9500CL Intelligent Motion Sensor	Demo kit	FRDM-K22F-SA9500
	Shield board	FRDM-STBC-SA9500
	Breakout board	BRKT-STBC-SA9500
Sensor Toolbox for FXLS8471Q 3-Axis linear Accelerometer	Demo kit	FRDMKL25-A8471
	Shield board	FRDMSTBC-A8471
	Breakout board	BRKTSTBC-A8471
Sensor Toolbox for MMA8491Q 3-Axis Digital Accelerometer	Demo kit	FRDMKL25-A8491
	Shield board	FRDMSTBC-A8491
	Breakout boards	BRKTSTBC-A8491
Sensor Toolbox for MPL3115A2 Pressure Sensor/ Altimeter	Demo kit	FRDMKL25-P3115
	Shield board	FRDMSTBC-P3115
	Breakout boards	BRKTSTBC-P3115
Sensor Expansion board for multiple sensors	Shield board	FRDM-FXS-MULT2-B
	Custom kit (new)	FRDM-K64F with FRDM-FXS-MULT2-B

Find all NXP sensor boards at nxp.com/sensorevaluationboards

MCU Attach: Sensor Enablement SW



Sensor toolbox – CE: visualization / out of box

- Quickly demonstrate & evaluate
- Customizable GUIs
- Integrated with IoT sensing SDK
- Supports all sensor kits (demo kits + custom kits)

IoT sensing SDK

- Go-To Solution For sensor application development
- Provides sensor drivers, algorithms and examples
- Enables prototyping and production applications
- Supports Kinetis, LPC and i.MX RT+ sensors (all sensor kits)
- Supports sensor based host IO applications

Application algorithms / SW

- 6 & 9 axis sensor fusion
- Pedometer
- Precision inclinometer

Current MCUs supported:

Kinetis: K64F, KL27Z, KL25Z, K22F, KW41Z, KE15Z

I.MX: I.MXRT1050, I.MXRT1020

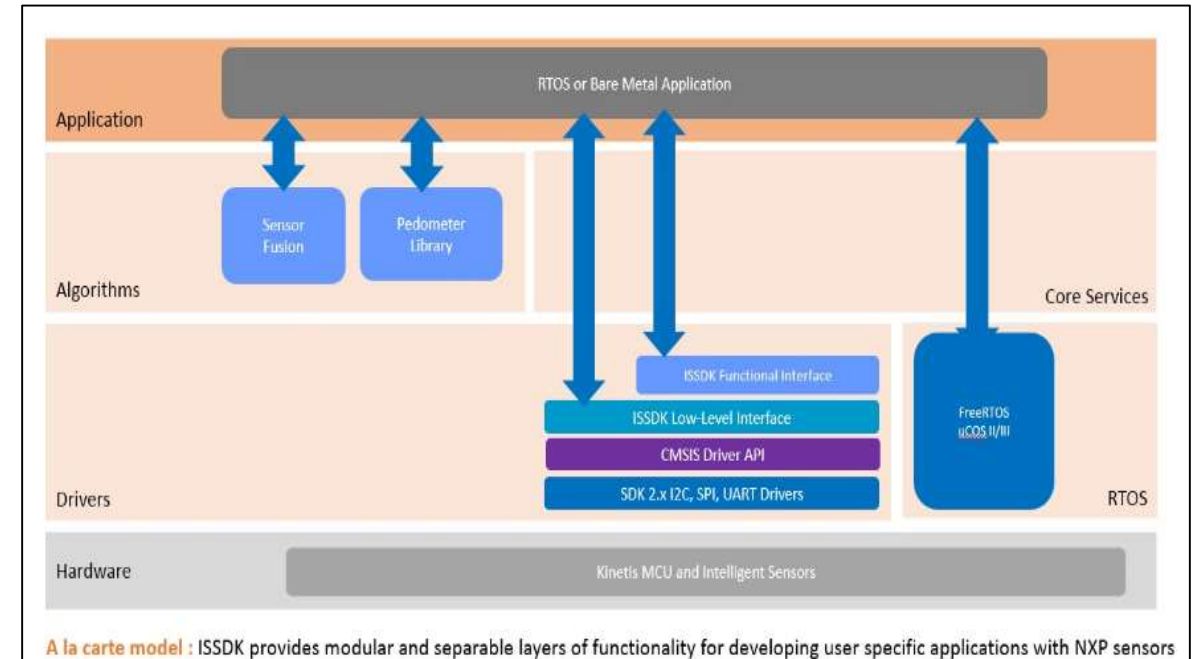
QN: QN9080

LPC: LPCXpresso54114

IoT Sensing SDK (ISSDK)

The embedded software framework for sensor application development with NXP MCUs and sensors

- Leverages MCUXpresso SDK 2.4 drivers and project release infrastructure
- Leverages Open APIs based on CMSIS driver standards (ARM) for portability
- A la carte Model: From register level to Object Oriented APIs
- IDEs supported:
 - MCUXpresso , IAR, Keil, ARM GCC
- Supports bare metal development and FreeRTOS
- Support for LPCXpresso54114 now included
- Host OS supported: Windows, MAC and Linux
- Pedometer and Sensor Fusion algorithms supported



ISSDK 1.7 released on May 17th, 2018

ISSDK Provides

- **Out of box projects for every sensor kit:** visualize sensor output on terminal application
- **Template to create custom embedded applications:** modify the out of box templates for custom use cases with NXP sensor kits
- **Detailed sensor register definition file:** complete bit map of each sensor register. Can be used for development with any MCU platform
- **Generic sensor drivers:** easy to use common set APIs such as sensor Init, configure, read and Deinit for quick application development
- **Arduino IO header pin mapping files:** Arduino board + NXP sensor shield pin mapping definition files for Arduino enthusiasts.
- **Generic host IO template projects:** enables sensor data transmission including STB-CE, cloud or any host GUI.

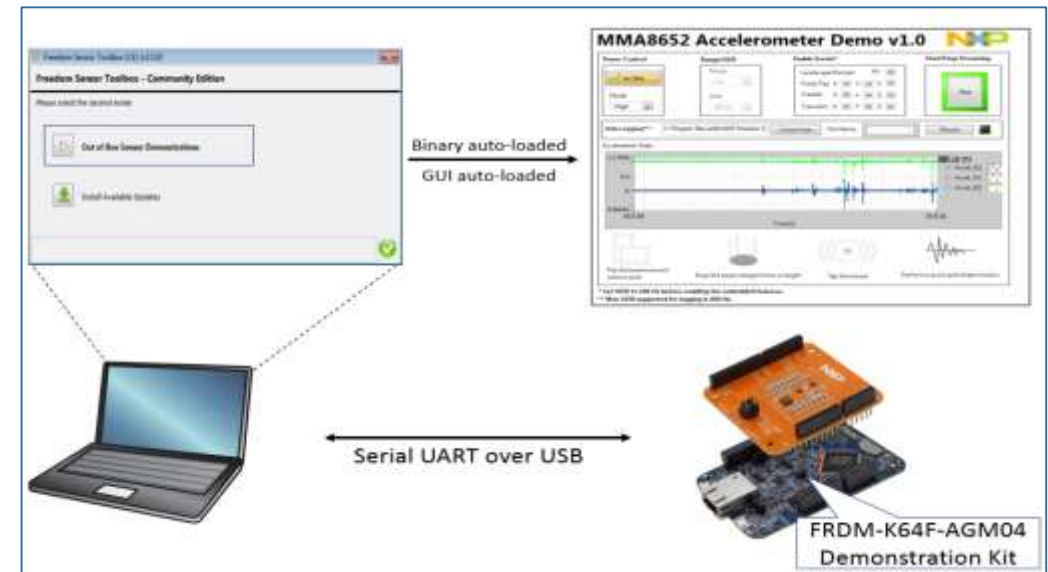
What's New With ISSDK 1.7

- ISSDK v1.7 middleware component integrated and aligned with MCUXpresso SDK 2.4 Rel8 ecosystem.
- Added enablement for NPS300x (Diff-P) sensor
 - Added NPS300xxx sensor driver
 - Added sensors examples for FRDM-KE15Z kit with FRDMSTBIDP300x in MCUXpresso
- Added enablement on EVKB-IMXRT1050 NPI
 - Added sensors examples for EVKB-IMXRT1050 custom kit with AGM01 in MCUXpresso
- Added MCUXpresso IDE support for pedometer examples for multiple sensor kits.
- ISSDK examples enhanced to support Amazon FreeRTOS™ v10.
- ISSDK project generation enhanced to support [MCUXpresso IDE v10.2](#) version upgrade and NPW feature.
- ISSDK demo sources and host i/o enhanced to support STB-CE based out-of-box GUIs.

Sensor Toolbox – Community Edition

The sensor evaluation and visualization SW tool for NXP sensors

- **Quick sensor Demonstration:** Enables quick visualization of sensor data and other sensor outputs based on the pre-configured sensor settings in the firmware
- **Real Time sensor Evaluation:** Enables changing critical sensor settings (ODR, FSR, power modes) and data logging during sensor demonstrations
- **Register interface:** Provides a register map for the sensors and allows quick read and write of different register bits, allowing detailed sensor evaluation



Latest version of STB-CE 2.5 released on May 2018

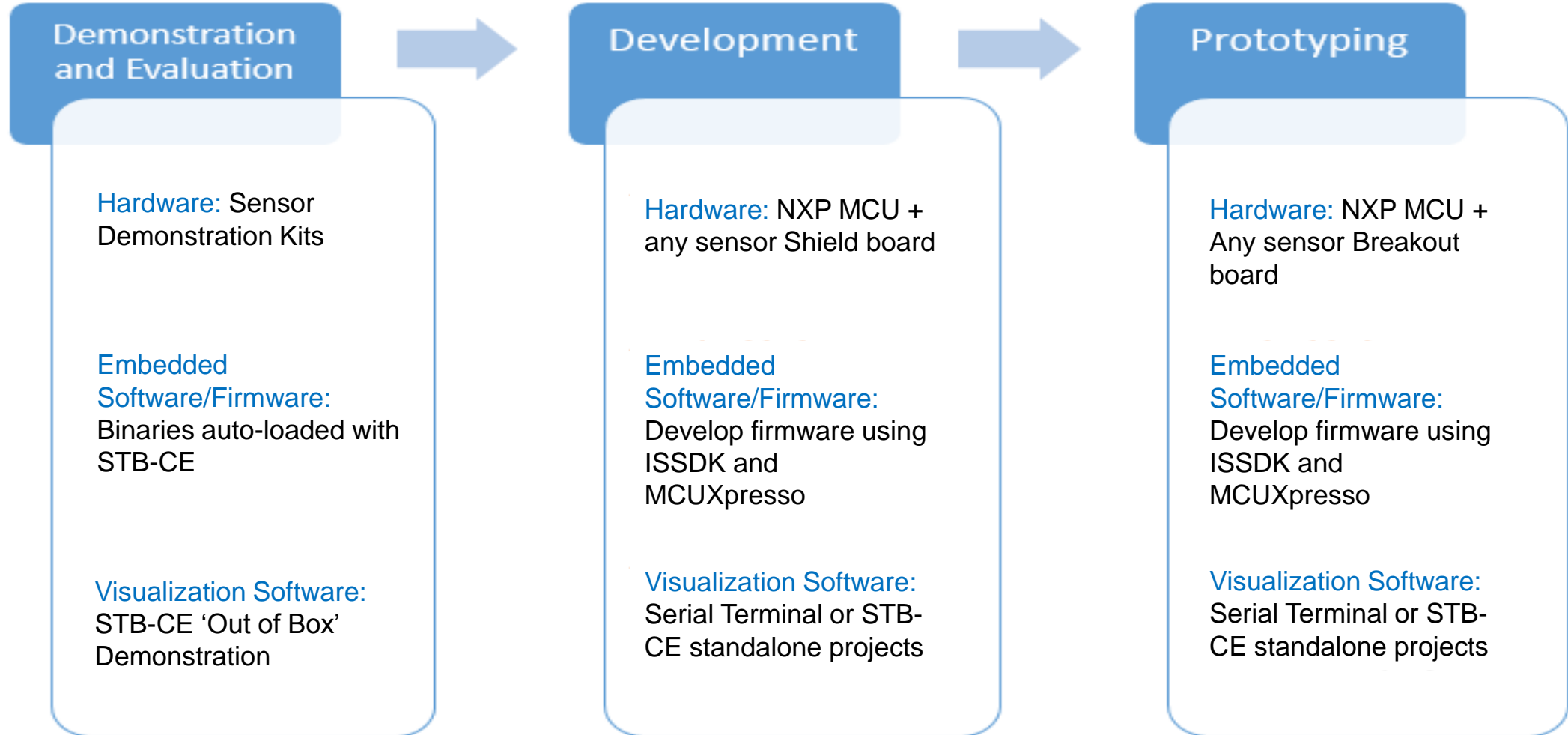
What's New With STB-CE 2.5

- Updated the auto-detection of STB-CE to support every sensor evaluation board for Windows 10
- Upgraded LabView Run-Time engine from 2014 version to 2017 version to enhance the overall performance and error handling.
- Improved the Installation process by improving the real-time installation display and enhancing the error handling during installation.
- Reduced the maximum CPU utilization of STB-CE by ~50% by optimizing each GUI and its corresponding plugins.
- Upgraded the maximum supported sampling rate for data logging in GUIs from 400 Hz to 800 Hz.
- Added support for the NPS300x differential pressure sensor, MMA8452 accelerometer and FXPQ3115BV bio-compatible medical pressure sensor. Added support for QN9080 microcontroller.

Different Phases of Product Development



End to End Tools for Product Development with NXP Sensors

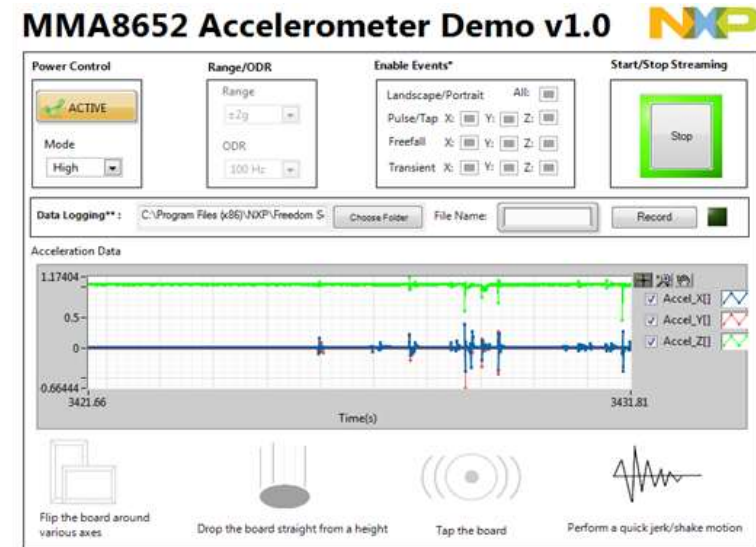


Out of the Box Demonstration and Evaluation

All you need is a sensor demonstration kit and the STB-CE

Get Started:

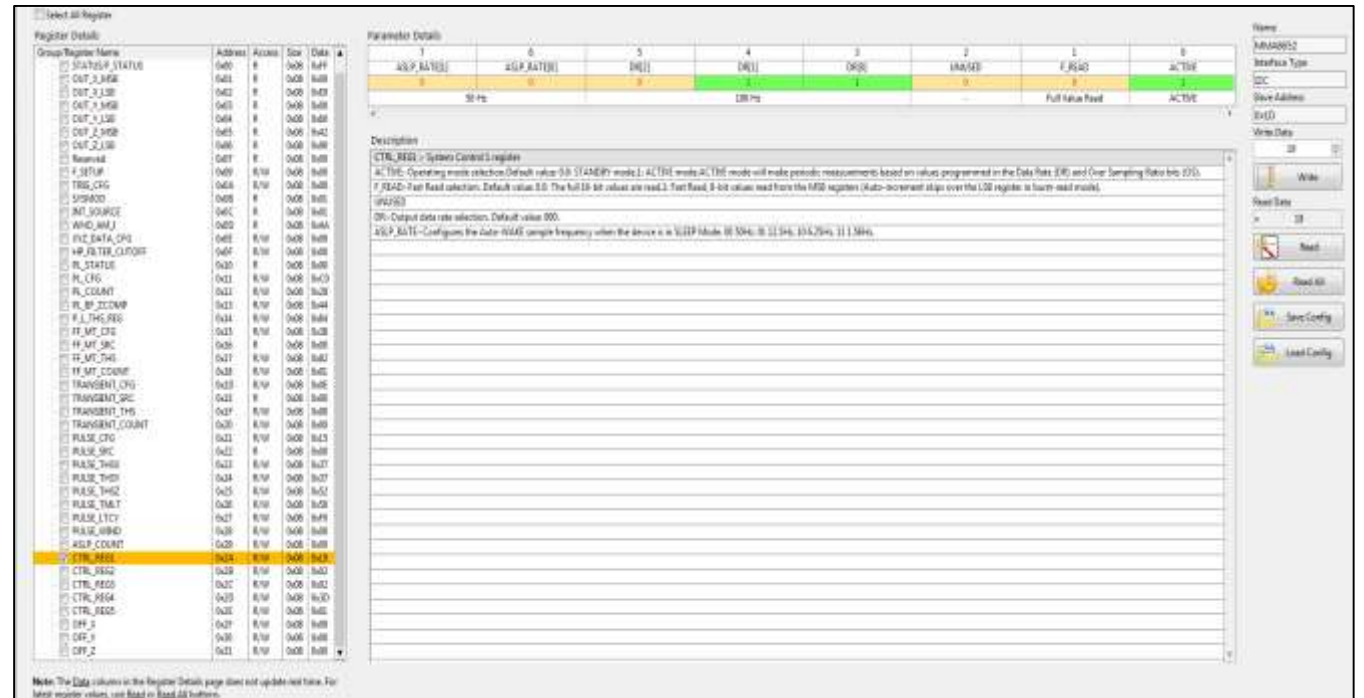
- Download the Freedom Sensor Toolbox – CE software
- Connect any NXP sensor demonstration kit to your PC via USB cable
- Click on the Freedom Sensor Toolbox – CE icon on your desktop, follow the prompts and menus.
- The appropriate FW and GUI will be auto loaded enabling a plug and play experience.
- You are now ALL SET. You can now evaluate the desired NXP sensor
- (Get started at nxp.com/sensortoolboxcommunity edition)



- ✓ Sensor Data Streaming
- ✓ Change ODR, OSR, FSR or Power Modes
- ✓ Embedded Feature Evaluation
- ✓ Real Time Interrupt Source Evaluation
- ✓ Data logging (.csv)
- ✓ Offset and Noise Calculation
- ❖ Offset Calibration
- ❖ Vibration Analysis (FFT)

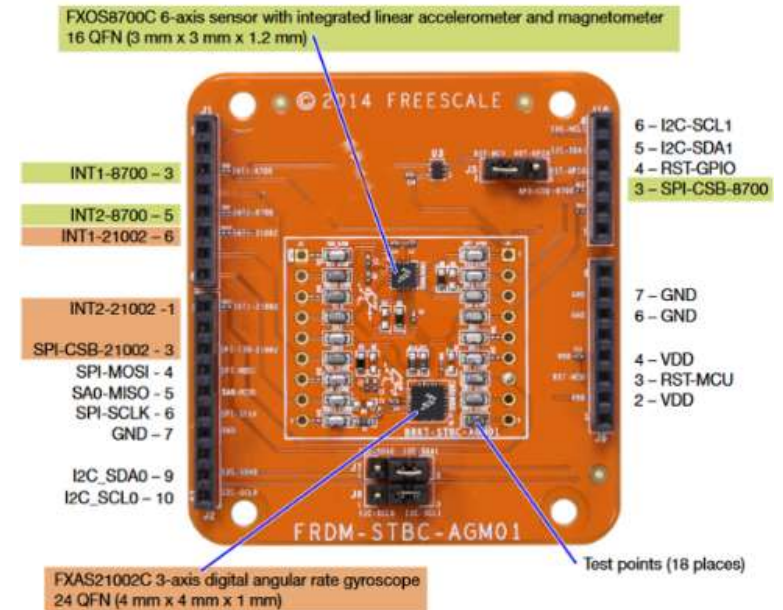
Register Evaluation

- Full access to the Register Map from the datasheet
- Quick Read/Write
- Multiple Read/Write options
- Save/Load Config
- Bidirectional compatibility with the main form



Evaluate Sensor Hardware and Settings

- Current consumption
- Pin voltage levels/characteristics
- Evaluate communication protocols (I2C vs. SPI)
- Change measurement ranges and sample rate
 - Evaluate offset, sensitivity, noise
- Evaluate hardware FIFOs
- Configure and map intelligent sensor features to interrupts
- Modify power mode settings



Development – With ISSDK

SDK Builder
Generate a downloadable SDK archive for use with desktop MCUXpresso Tools.

Current Configuration
FRDM-K64F-AGM01 (1)

MCUXpresso SDK Details [MCUXpresso SDK Documentation](#)
Toolchains and Host OS selections can be edited using the Tools->Configurations Settings menu

Included SDK Contents

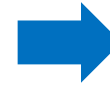
MCU Device(s):	MK64FN1M0xxx12
Development Board(s):	FRDM-K64F
MCUXpresso SDK Version:	KSDK 2.1.0
Toolchain:	Kinetic Design Studio
Host OS:	Windows

Review Optional Middleware
Items here will be included in your SDK download. These selections can be edited using the Tools->Configurations Settings menu.

Selected Middleware:
ISSDK

Click the link below to request this specific MCUXpresso SDK Build
In general, SDK builds should complete within a few minutes. You will be notified via email and notifications in the upper right corner of this webpage.

Request Build Package Name: SDK_2_1_FRDM-K64F-AGM01



After downloading the ISSDK package, you can:

Run/Debug: Out of Box example projects for every NXP sensor demo kit.

Develop: Sensor applications using demo code, sensor drivers and header files

Visualize/Evaluate: Sensor data



- ✓ All sensor demo kits supported
- ✓ All NXP sensors supported
- ✓ Kinetis, LPC and IMX MCUs supported
- ✓ MCUs with examples: FRDM K64F, LPC54114 K22F, KL25Z, KL27Z, KW41Z and KE15Z, QN9800, and EVKB-IMXRT1050

Get Started with ISSDK on:
nxp.com/iotsensingsdk



Deployed ISSDK Project

Example projects added along with other middleware components

Algorithm projects

Sensor specific driver examples

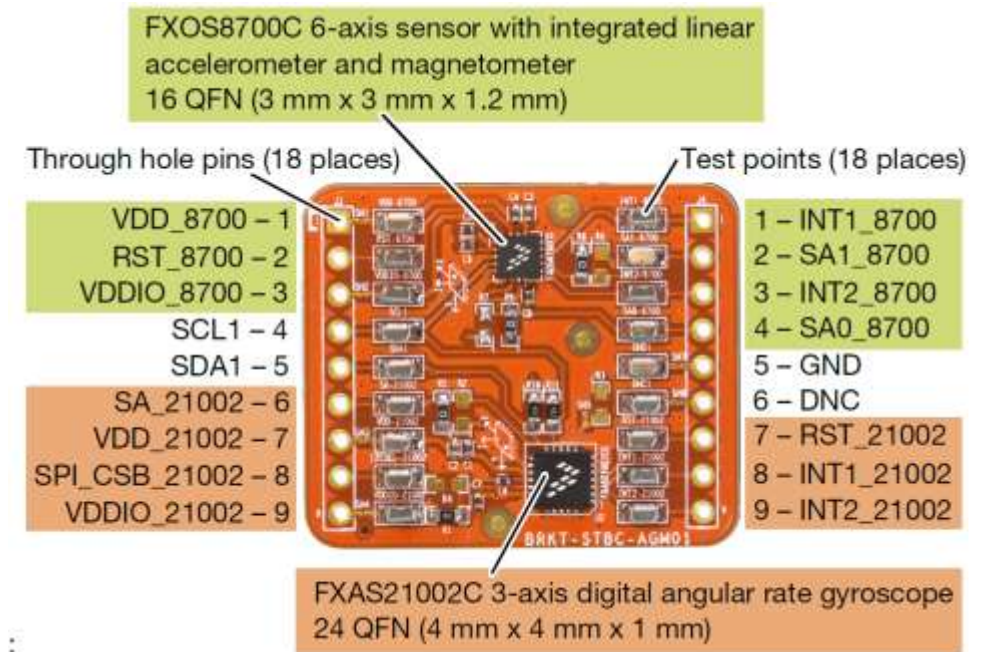
- boards
 - frdmk64f
 - frdmk64f_agm01
 - issdk_examples
 - algorithms
 - pedometer
 - sensorfusion
 - sensors
 - fxas21002
 - fxas21002_fifo
 - fxas21002_interrupt
 - fxas21002_poll
 - fxos8700
 - fxos8700_fifo
 - fxos8700_interrupt
 - fxos8700_poll

Source and header files

Name	Date modified	Type
algorithms	12/14/2016 7:40 PM	File folder
boardkit	12/14/2016 7:40 PM	File folder
driverexamples	12/14/2016 7:40 PM	File folder
drivers	12/14/2016 7:40 PM	File folder
sensors	12/14/2016 7:40 PM	File folder

Prototype Your Application

- Breakout boards: compatible with Freedom and Arduino
- Small form factor
- Same design as the shield board
- Can be wired or clipped into host systems.
- Can be used with Kinetis MCUs, ISSDK and STB-CE.



Other Customer Enablement



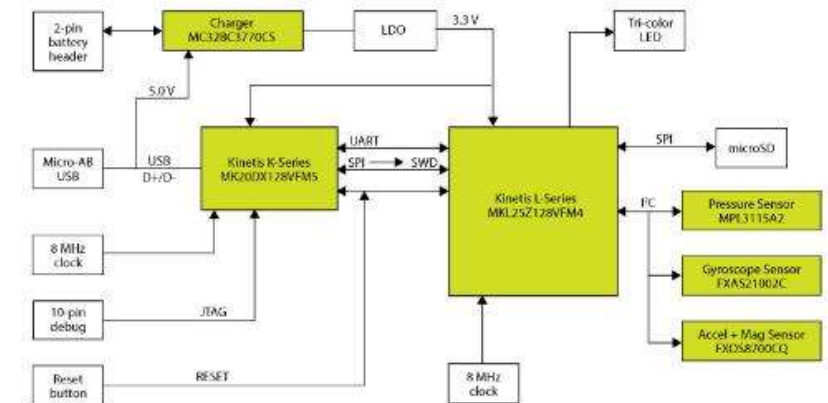
10-axis Data Logger (Reference Design)

The RD-KL25-AGMP01 provides a total system solution for data collection applications. This size of the board is an efficient 1.2 x 1.5 square inches for portability and ease of use

- This board supports the [FXOS8700CQ](#) 6-axis e-compass sensor, the [FXAS21002C](#) 3-axis gyroscope, and the [MPL3115](#) pressure sensor driven by a Kinetis [KL25Z MCU](#)
- A microSD card slot is provided should the user decide to collect the sensor or application data in cases where a host computer might not be available
- Includes NXP's smart Li-ion battery charger and power management
- The board is semi-enclosed, generating a flat surface on one side of the design, to allow easy mounting to different surfaces.

Search for “10-Axis” on NXP.com

Includes: demo code, schematics, reference for vibration and other materials

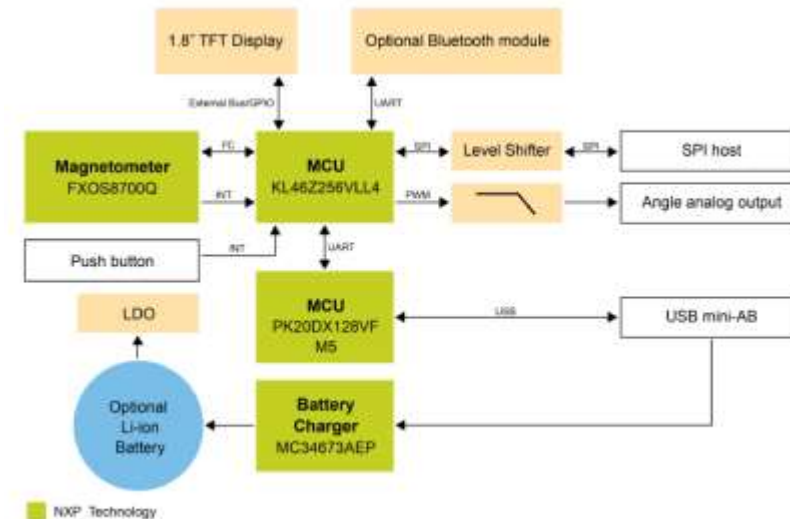


Magnetic Rotary Encoder Reference Design

A reference design showing a contactless knob for angle measurement. Demonstrator for many other smart home and IoT solutions with magnetometer. See the tool first hand and learn how to demonstrate it to your customers.



Find more information here:
<http://www.nxp.com/products/reference-designs/magnetic-rotary-encoder-reference-design:RD-KL46Z-MRE>



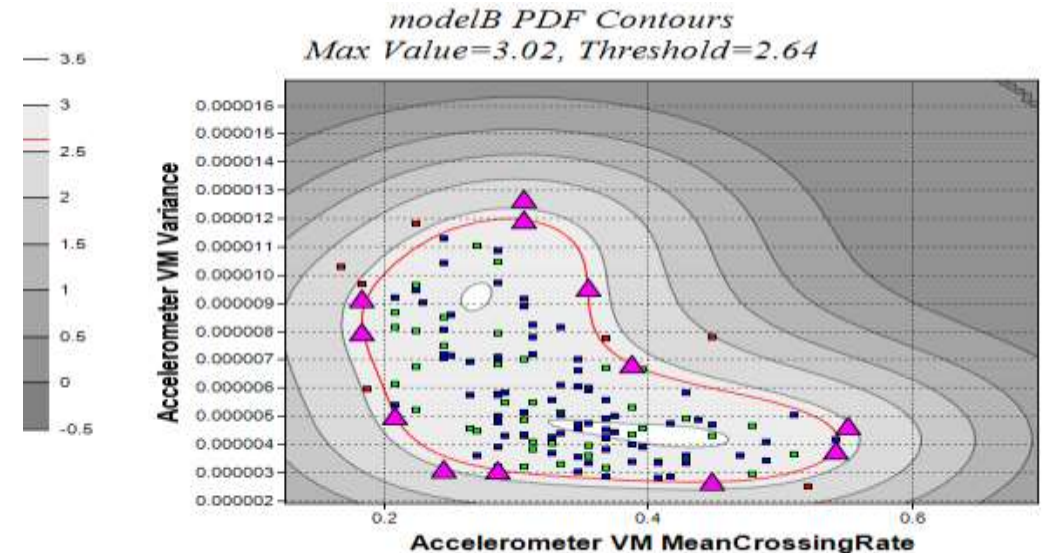
Smart Run Insole Reference Design

- BLE connectivity: QN9080
- 9-axis sensors: FXOS8700 and FXAS21002
- Small Size: 1.5 in.sq
- Battery charging circuitry
- Output on BLE app:
 - Propulsive power
 - Velocity
 - Metabolic efficiency
 - Stride symmetry
 - Peak forces from heel to toe
- Low power consumption
 - 3 mA for BLE transmission
 - 8uA for low power motion wake up
- IoT sensing SDK enabled (www.nxp.com/iotsensingsdk)



Anomaly Detection Toolbox Reference Design

- Machine learning on the edge of the cloud
- Learn normal system behavior and then raise a flag when abnormal behavior occurs
- Supported sensors: accelerometer, gyroscope, magnetometer, and (soon) pressure sensor
- Runs on an ARM Cortex M4F



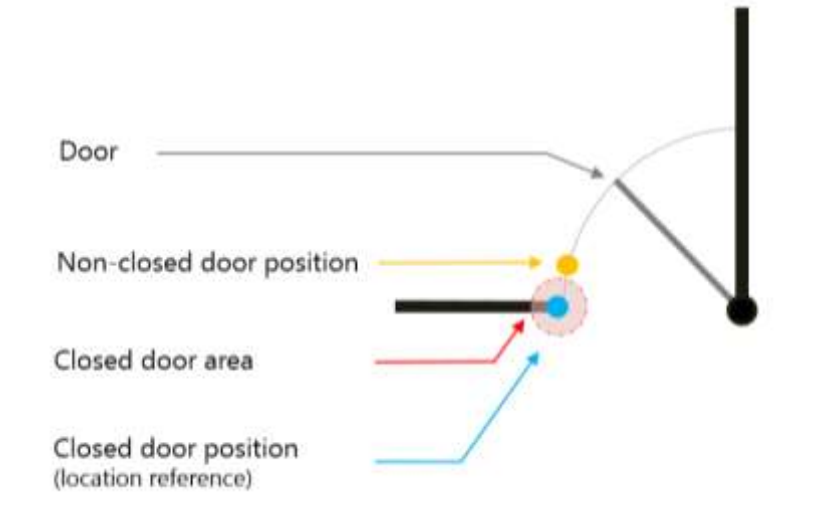
Recommended:
NXP® FXOS8700CQ and
FXAS21002C sensors

Smart Door Lock Demo

The smart low cost sensor solution to ensure home security

Detect door positioning using
FXOS8700CQ 6DOF sensor
(magnetometer plus accelerometer)

Demonstration based on
RD-KL25Z-AGMP01

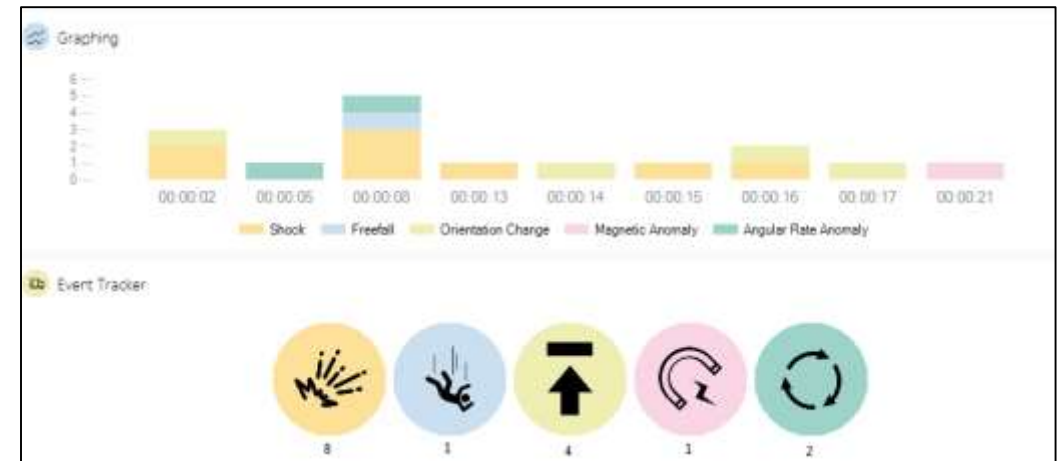


Find more information about the board here: www.nxp.com/products/sensors/gyroscopes/10-axis-sensor-data-logger-reference-design:RD-KL25-AGMP01

Asset Tracking Demo

Track the journey of a package using motion sensors

- Attach the reference design [RD-KL25-AGMP01 10-Axis Sensor Data Logger Reference Design](#) to a transportation package.
- The reference design records 9-axis motion sensor data & critical sensor events on a SD card
 - Components used: FXAS21002 + FXOS8700 9-axis sensors, FRDM-KL25Z MCU & 4GB microSD card
 - Firmware: Enables logging of 9-axis motion sensor data and critical events to a .csv file in the SD card
 - Sensor data logged: accelerometer, magnetometer, gyroscope and timestamp (at a rate of 100Hz)
 - Motion events logged: shock, freefall, angular velocity anomaly, orientation change & magnetic anomaly
- Launch the asset tracking software on a Windows PC to analyze the motion profile of the package.
- The software reads the SD card data, generates the motion profile locally and sends it to the cloud.

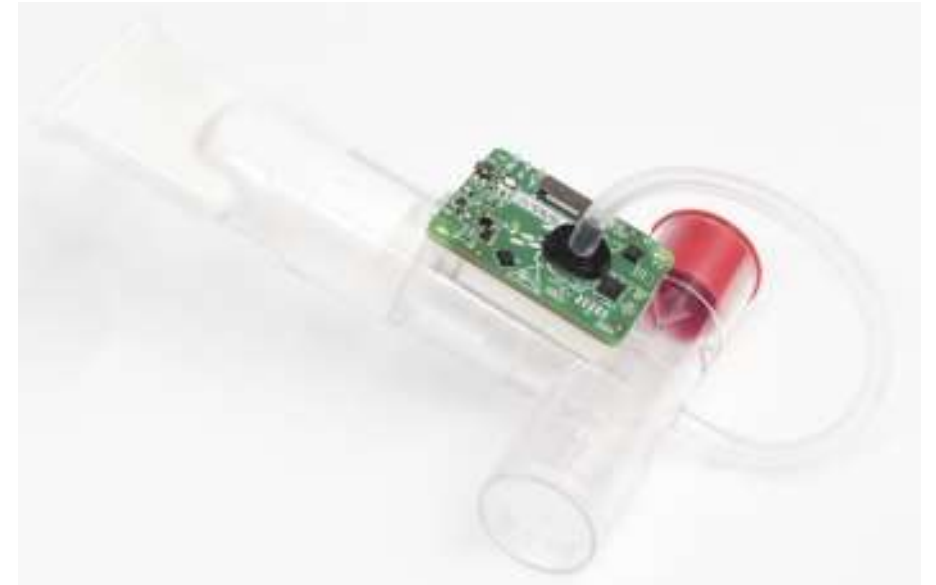


Motion Profile of the package in transit

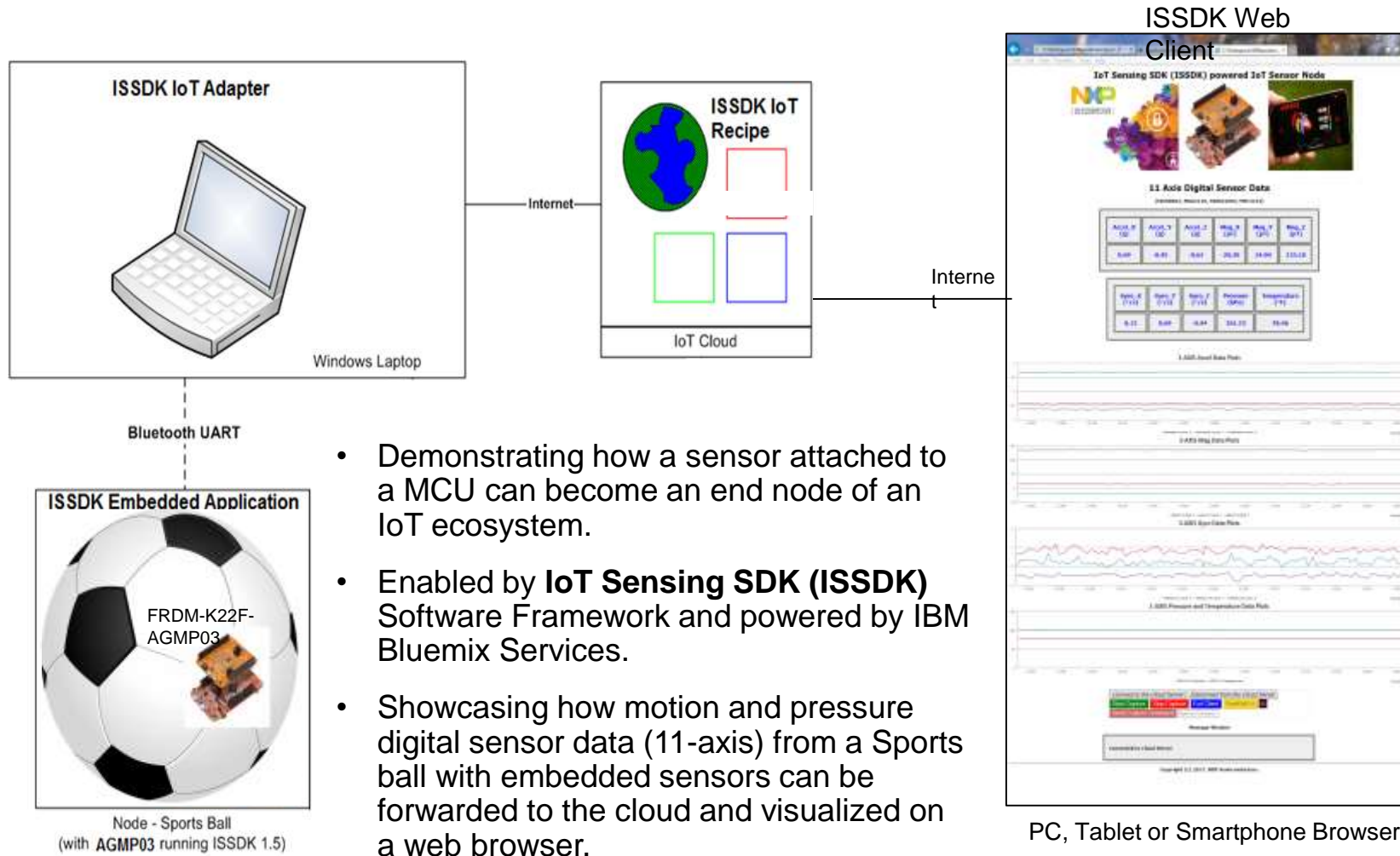
Smart Sensing Inhaler Demo

Uses tidal breathing to trigger medication dispensing, for both adults and infants

- High precision, biocompatible, digital pressure sensor FXPQ3115
- Intelligent trigger function to align dispensation with tidal breathing
- Tilt sensor FXOS8700 assures inhaler posture
- Used with wireless (BLE) connectivity to report on patient adherence and compliance
- Using authentication and encryption to the cloud helping physicians treat more effectively



Smart IoT Ball Demo



- Demonstrating how a sensor attached to a MCU can become an end node of an IoT ecosystem.
- Enabled by **IoT Sensing SDK (ISSDK)** Software Framework and powered by IBM Bluemix Services.
- Showcasing how motion and pressure digital sensor data (11-axis) from a Sports ball with embedded sensors can be forwarded to the cloud and visualized on a web browser.

Find more information about ISSDK here: www.nxp.com/iotsensingsdk

Sensor Fusion Demo on Android Tablet

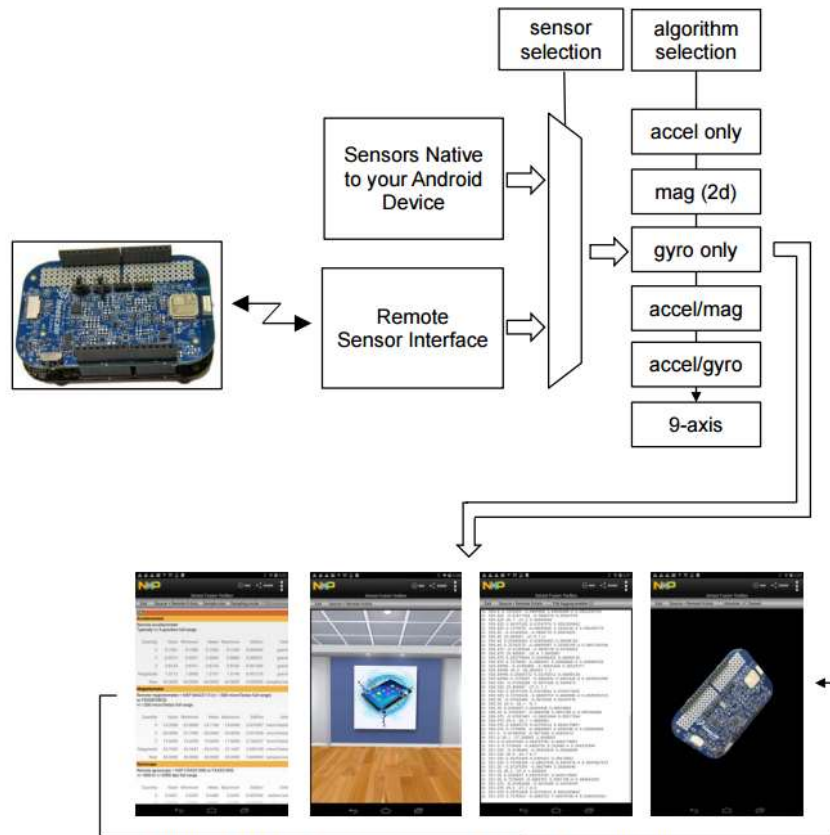


Figure 5. NXP Sensor Fusion Toolbox for Android basic functions

- Demonstrating the latest NXP sensor Fusion demo on an Android device
- 3, 6 and 9-axis sensor fusion options available for accurate orientation detection
- Ideal for applications like drones, wearables, virtual reality etc.
- Based on the open source sensor fusion library included in ISSDK (In MCUXpresso)
- Lowest cost, most complete sensor fusion solution available anywhere

Find more information here: www.nxp.com/sensorfusion

Technical Documentation and Collateral

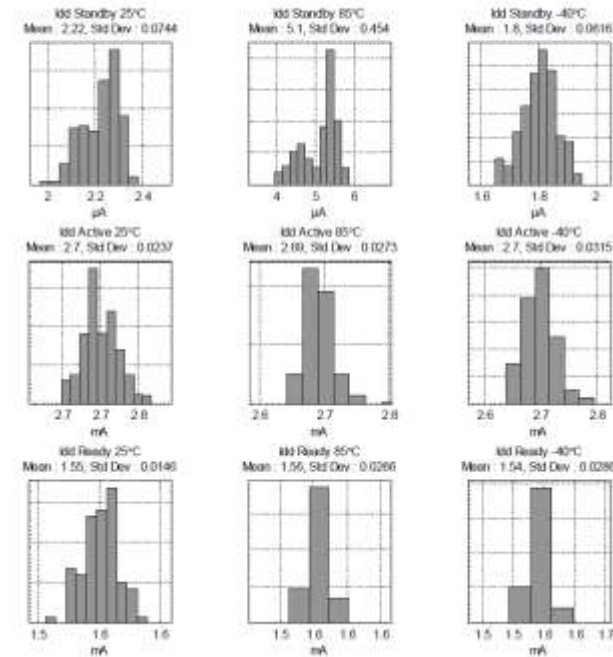
- Datasheets and app notes for design in use available for all products today.
- New standardized characterization and qual reports are planned for all products to provide customers the needed data to plan for production devices variations.

9. Current Consumption

Current consumption denotes the measured current consumption by the device in three different modes: Standby, Active and Ready.

Test Conditions

Device is tested in each mode at three different temperatures (-40/25/85 °C). V_{DD} is varied from 1.95 V to 3.6 V. Number of devices under test = 270 (3 lots).



What Data Goes Into a Sensor Spec?

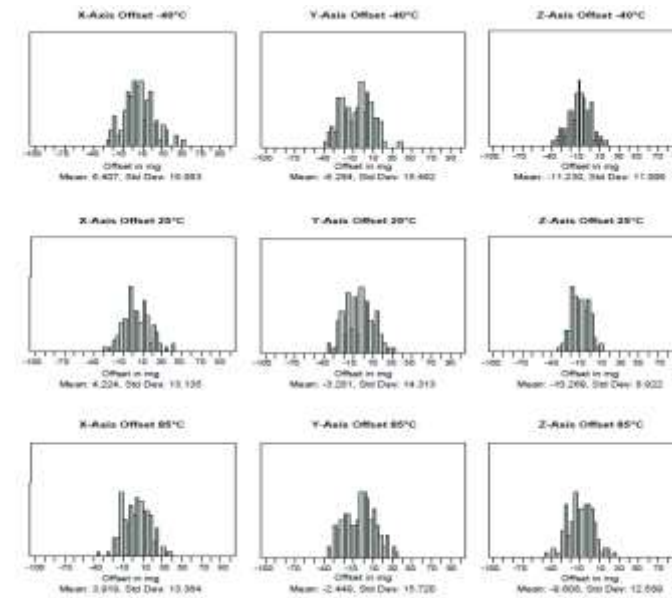
Zero-g level offset accuracy ⁽²⁾	$\pm 2\text{ g}, \pm 4\text{ g}, \pm 8\text{ g}$ modes	OFF _{ACC}	± 20	mg
Zero-g level offset accuracy versus temperature ⁽²⁾	$-40\text{ }^{\circ}\text{C}$ to $85\text{ }^{\circ}\text{C}$ modes	OFF _{ACC-TBM}	± 0.2	mg
Zero-g level change versus temperature	$-40\text{ }^{\circ}\text{C}$ to $85\text{ }^{\circ}\text{C}$ ⁽¹⁾	TCO _{ACC}	± 0.2	mg/ $^{\circ}\text{C}$

For just a single spec line

- 9 data sets
- Over temp (-40, room, +85)
- X, Y and Z axis

One number to represent all data?

- Typical spec means at least 67% of parts will meet
- Worst case represented across all 9 graphs



Characterization Reports

- Generated for most new products including FXAS21002
- Make requests through any convenient SSD channel
 - Marketing
 - PLM
 - Applications
- Report releases are controlled by applications

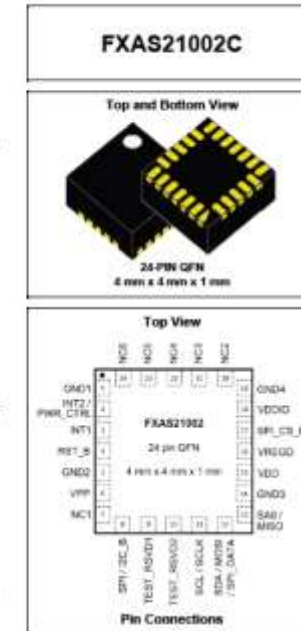
FXAS21002C 3-Axis, Digital Angular Rate Gyroscope Characterization Report

This document describes the characterization data of the FXAS21002C 3-Axis, Digital Angular Rate Gyroscope for:

- Offset (pre- and post-board mount)
- Sensitivity error
- Zero-rate offset temperature coefficient
- Sensitivity temperature coefficient
- Cross-axis sensitivity
- Linearity
- Noise
- Current consumption

The document is supplemental to the product's data sheet (Freescale document number FXAS21002C).

- The FXAS21002C is a 3-axis, low-power, angular rate gyroscope with 16 bits of ADC resolution.
- The full-scale range (FSR) is host software selectable from ± 250 to ± 2000 $^{\circ}/s$.
- The output data rate (ODR) is software selectable from 12.5 to 800 Hz. An integrated low-pass filter allows the host application to limit the output signal bandwidth and noise.
- An embedded 32 XYZ sample FIFO data buffer, rate threshold interrupt function, and external input for power management allow sensor system designers to realize a high performance and power efficient angular rate sensing solution.
- FXAS21002C is available in a 4 mm x 4 mm x 1 mm plastic QFN (Chip on Lead) package with 24 pins. The device is guaranteed to operate over the extended temperature range of -40 to $+85$ $^{\circ}C$.



Ordering Information

Part Number	Temperature Range	Package Description	Shipping
FXAS21002CQR1	-40 $^{\circ}C$ to +85 $^{\circ}C$	QFN-24	Tape and Reel

Enablement and Collateral

All motion IoT products will have support of datasheets, characterization reports, qual reports, and app notes.

Product	Datasheet	Characterization	Qual
FXOS8700	Available now	Q3 '16	Available now
FXAS21002	Available now	Available Now	Available now
MMA8491	Available now	Available Now	Q4 '16
FXLN83xx	Available now	Q3 '16	Available now
MMA955x	Available now	Q4 '16	Q4 '16
FXLC95000	Available now	Q4 '16	Q4 '16
MMA845x	Available now	Available Now	Available now
MMA865x	Available now	Available Now	Q3 '16
MAG3110	Available now	Available Now	Q3 '16

Resources

Distributor extranet:

- <https://nxp1.sharepoint.com/teams/ext96/SitePages/Sensor%20Distribution%20Home%20Page.aspx>

Sensor toolbox ecosystem

- www.nxp.com/sensortoolbox
- www.nxp.com/iotsensingsdk
- www.nxp.com/sensortoolboxcommunityedition
- www.nxp.com/sensorevaluationboards



SECURE CONNECTIONS
FOR A SMARTER WORLD

www.nxp.com