MOTION SENSORS FOR POWER MANAGEMENT IN CONNECTED IOT DEVICES

JOHNSON SUN
SYSTEM & APPLICATION, Motion Sensors

JULY 2022

Johnson.sun@nxp.com

+86 13918668532

SECURE CONNECTIONS
FOR A SMARTER WORLD

Wireless battery-operated IoT devices continue to expand into all aspects of life.

Power management therefore becomes a critical factor to support the "Green Initiative" by increasing battery lifetime.

Learn how Motion sensors can play a crucial role in power management for wireless battery-operated devices.

Agenda

- Introduction
- NXP Sensors Overview
- Auto S&C, I&M Motion Sensor Products Roadmap
- Auto S&C, I&M Motion Sensor Target Market Segments
- Why customers choose NXP
- Motion Sensors for Power Management
- Summary

Motion Sensors: Overview, Roadmap & Market Segments

SECURE CONNECTIONS
FOR A SMARTER WORLD

NXP MEMS SENSORS OVERVIEW

40+ YEARS OF MEMS PRODUCTION

4 billion devices shipped (motion and pressure)

Focus on Automotive and Industrial / Medical IOT

BROAD PRODUCT PORTFOLIO

Accelerometers for wide range of use cases / market segments

Gyroscopes / 6DOF devices in development / refresh

New generation ultra low power magnetic switch

Absolute and differential pressure sensors

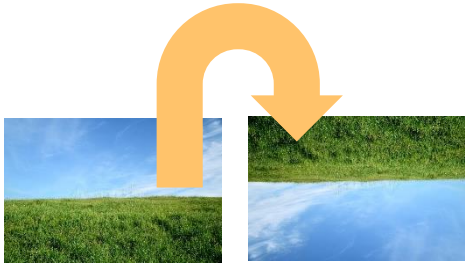Tire Pressure Sensors & Battery pressure sensors

6th GENERATION OF AIRBAG SENSORS
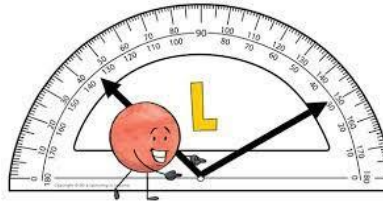
4th GENERATION OF TIRE PRESSURE SENSORS

AUTOMOTIVE

INDUSTRIAL & IOT

• Motion sensors are essential for applications which need to address the following

Orientation:
Which Way is Up?

Inclinometer:
At what angle am I?

Gesture Detection:
What am I doing?
Did I move a certain way? Did I fall?

Power Management / Reduce Waste:
Wake up on motion – am I moving?

Vibration / Shock:
Is my equipment about to fail?
Is my equipment being abused?

Robotics / Navigation:
What direction am I going?

Focus of this presentation

AUTO CONVENIENCE AND SECURITY + INDUSTRIAL / MEDICAL ROADMAP

A = Auto
I = Ind/Med

Products in Production:

- **Accelerometer (Auto)**
  - Newstein (FXLS8962)
  - Newstein SAAF (FXLS8965)

- **Accelerometer (IOT)**
  - Veyron-SPI (FXLS8471)
  - Veyron (MMA845x)
  - Newton (MMA865x)
  - Plutino (MMA8491)
  - Pluto (FXLN83xx)

- **Accel / Mag (IOT)**
  - Gauss (FXOS8700)

Sampling Now
Production 1H'2022

Gemini (FXLS8964AF/67AF)
Timandra (FXLS8974CF)
3-axis Accel, 12bit, I2C/SPI, 2g – 16g
2x2DFN — **A/I**

Solstice
Basic Motion Wakeup — **A/I**

Next gen Motion Sensors

Chiron Lo-g
3-axis Accel (2g – 16g) — **A/I**

Agera
6DOF Gyro (1kdps) + Accel (32g) — **A/I**

Auto non-safety (Navigation, Infotainment)

I / M (Robotics, Gesture Recognition)

	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
		2020				**2021**				**2022**				**2023**				**2024**				**Future**		

Product Idea	Product Study	Approved Concept	In Development	In Production
not yet fully committed. Indicative timing only	Idea only, not yet fully committed, resource estimate. Indicative timing only after PI-gate	Product concept, indicative timing only after PCA-gate	Project, resources, timing committed, after PPA-gate	Product in production, after R-gate

△ ES
▲ CES   ★ Production (R-gate)
◆ CQS

Roadmap & milestones are subject to change

PUBLIC   6
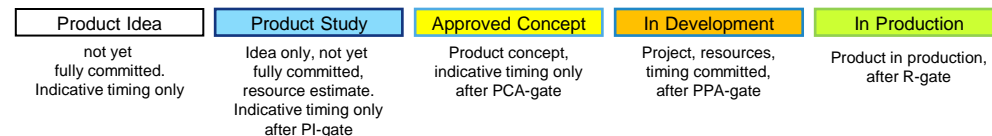
INDUSTRIAL AND MEDICAL (I/M) MOTION SENSOR TARGET MARKET SEGMENTS
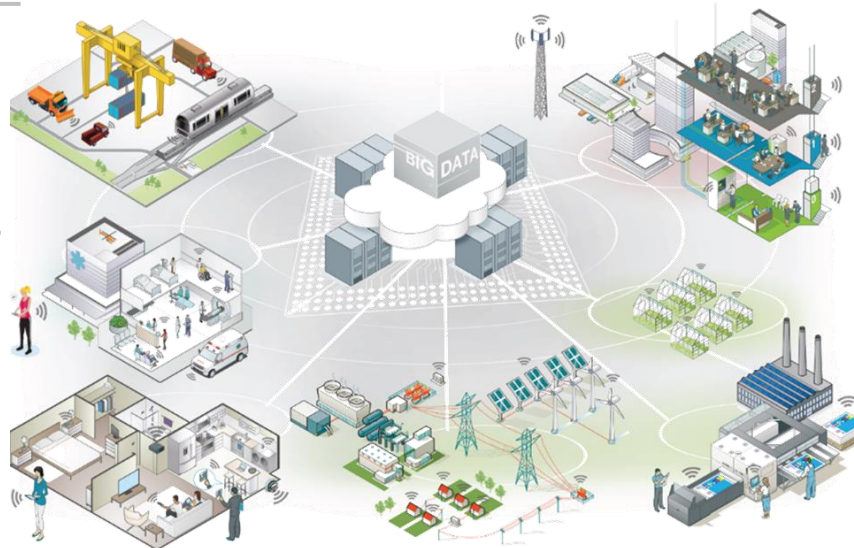

Industrial Transportation
Heavy Machinery
Farm Equipment
Asset Tracking

Patient Care
Medical Wearables
Drug Delivery

Connected Home
Smart Doors/windows
Smart appliances

Building Control
HVAC
Access / Security
Surveillance

Factory Automation
Robotics
Equipment Monitors
Asset Tracking

Conservation
Smart metering (tamper detection)

Sensor Proliferation:

- Human Interaction: Gesture, Orientation, Vibration, Tap

- Machine Learning: Motion and Vibration detection for Preventive Maintenance and Anomaly Detection

- Intelligent Sensors for increasing motion detection at lower power

- Always on applications: Asset Tracking, Security,

AUTOMOTIVE SECURITY & CONVENIENCE APPLICATION EXAMPLES

- **Keyfob / Passive entry**
  - Relay attach prevention
  - Power consumption reduction

- **Car Alarm / Telematics boxes**
  - OEM or aftermarket

- **eCall**
  - Rollover or shock detection when the vehicle is off

- **Smart Doors / Latches**
  - Inclination detection for doors, trunks, and other enclosures

- **Electrical vehicles**
  - Shock during recharging – need safe disconnect of power plug

- **Surround view camera**
  - Capture surrounding scene when the vehicle is "bumped" while parked

Why NXP?

- Lowest Power in Industry
- Developers Ecosystem: Ease of evaluation, development.
- System solution w/ NXP (i.e. Keyfob MCU, Wireless/IoT MCUs)
- Only product that meets the specification & reliability requirements in many automotive applications

What Is Next?

- Auto Non-Safety Apps
  - Car Alarm
  - Baby Seat Monitor
  - Under-hood Lamp
  - Two-Wheeler Tilt / Engine Management
- IoT
  - Remote Control Power Management
  - Movement / Vibration Sensor

New Product Introduction: FXLS8964/67 AF & FXLS8974CF

SECURE CONNECTIONS FOR A SMARTER WORLD

FXLS8964 / 67 (GEMINI) – 3-AXIS AUTOMOTIVE QUALIFIED ACCELEROMETER DESIGNED FOR AUTOMOTIVE SECURITY & CONVENIENCE (NON-SAFETY) APPLICATIONS

- ## Features
  - **Fully Pin and SW compatible replacement for FXLS8962**

  - **Ultra Low power: < 1µA** in low power wakeup mode (0.78 Hz to 6.25 Hz ODR)

  - **Sensor Data Change Detection (SDCD) function:** highly configurable digital window comparator for easy / efficient implementation of low-power motion detection

  - **Self-Test Diagnostic:** Can be run in field to assess device health (unaffected by device orientation or motion)

  - **±2 to ±16g** (user selectable) full scale range

  - **12-bit** Sensor Data Output Resolution

  - **I2C / SPI** (pin configurable) digital interfaces

  - **2x2 DFN Package,** 0.4mm pitch with **wettable flanks**

  - **-40 to 105°C** operating temperature, **AECQ-100** auto / industrial qualified

  - **EMC Class III** Compliant

FXLS8964 / 67

10-pin DFN with wettable flanks
2 mm x 2 mm x 1 mm

Top View

Pin		Pin
V$_{DD}$	1	10 GND
BT_MODE	2	9 INTF_SEL
SA0/MISO	3	8 INT1/MOT_DET
MOSI/SDA	4	7 SPI_CS_B
SCL/SCLK	5	6 INT2/BOOT_OUT

Pin Connections

- ## Project Milestones
  - Samples: NOW

  - Automotive PPAPed: Mar. 2022 (8964) / Apr. 2022 (8967)

  - Production Release: NOW

- ## Target Applications
  - **FXLS8964:** Keyfob motion detection

  - **FXLS8967:** Telematics, Car Alarm, Electrified Doors

DATASHEET SPECIFICATION DIFFERENCES (FXLS8964 VS 67AF)

Device	FXLS8964AF	FXLS8967AF
Target Automotive Applications	Keyfob motion detection Direct FXLS8962AF replacement	Angle detection Telematics, Car Alarm, Electrified Doors
Offset	±250mg TYP, ±550mg MAX	XY axis **±50**mg TYP, **±200**mg MAX Z axis **±150**mg TYP, **±550**mg MAX
TCO	1mg/°C	XY axis: **0.55**mg/°C Z axis: **0.8**mg/°C
Noise	280μg/√Hz	XY axis: **217**μg/√Hz Z-axis: **257**μg/√Hz
Idd Hibernate	300 nA MAX (T=-40°C to +85°C)	300 nA MAX (T=-40°C to +85°C) 2 μA MAX (T=-40°C to +105°C)
WHO_AM_I	0x84	0x87

FXLS8974CF (TIMANDRA) – 3-AXIS ACCELEROMETER FOR INDUSTRIAL / MEDICAL

- **Features**

  - **Ultra Low power: < 1µA** in low power wakeup mode (0.78 Hz to 6.25 Hz ODR)

  - **Sensor Data Change Detection (SDCD) function:** highly configurable digital window comparator for easy / efficient implementation of low-power motion detection

  - **Self-Test Diagnostic:** Can be run in field to assess device health (unaffected by device orientation or motion)

  - **±2 to ±16g** (user selectable) full scale range

  - **12-bit** Sensor Data Output Resolution

  - **I2C / SPI** (pin configurable) digital interfaces

  - **2x2 DFN Package,** 0.4mm pitch with **wettable flanks**

  - **-40 to 105°C** operating temperature

  - **EMC Class III** Compliant

- **Target Applications**

  - Medical Wearables, Asset Tracking, Cameras, Smart Meters, Connected Home, Equipment Monitoring, Surveillance / Security

FXLS8974CF

10-pin DFN with wettable flanks
2 mm x 2 mm x 1 mm

Top View

V_DD	1	10 GND
BT_MODE	2	9 INTF_SEL
SA0/MISO	3	8 INT1/MOT_DET
MOSI/SDA	4	7 SPI_CS_B
SCL/SCLK	5	6 INT2/BOOT_OUT

Pin Connections

- **Project Milestones**

  - Samples: NOW

  - Production Release: NOW

ASIC DIFFERENCE (FXLS8964/67AF VS. FXLS8974CF)

- FXLS8974CF are SW compatible to FXLS8964/67AF with exceptions that FXLS8974CF implements a minor in the Sensor Data Change Detection (SDCD) block so it is easier to detect slow motion in IOT application.

	FXLS8964/67AF	FXLS8974CF
WHO_AM_I Register	0x84 / 0x87	0x86
PROD_REV Register	0x13	0x14
SDCD_CONFIG2 Register	Difference in REF_UPDM as noted	

FXLS8964/67 behavior as noted in original text
FXLS8974 behavior as noted in corrected text

13.31.4 SDCD_CONFIG2 register (address 30h)

Table 101. SDCD_CONFIG2 register (address 30h) bit allocation

Bit	7	6	5	4	3	2	1	0
Name	SDCD_EN	REF_UPDM[1:0]		OT_DBCTM	WT_DBCTM	WT_LOG_SEL	MODE	REF_UPD
Reset (BT_MODE = GND)	0	0	0	0	0	0	0	0
Reset (BT_MODE = V$_{DD}$)	1	1	0	1	1	0	0	0
Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Field	Description
6:5 REF_UPDM	SDCD internal reference values update mode 00b: The function stores the first 12-bit X/Y/Z decimated and trimmed input data (OUT_X/Y/Z[n=0]) as the internal REF_X/Y/Z values after the function is enabled (SDCD_EN is set to 1). The REF_X/Y/Z values are updated with the current 12-bit X/Y/Z decimated input data (OUT_X/Y/Z[n]) at the time the SDCD_OT_EA flag transitions from False to True. is True. whenever 01b: The function stores the first decimated and trimmed X/Y/Z acceleration input data (OUT_X/Y/Z[n=0]) as the internal REF_X/Y/Z values when the SDCD function is enabled; the REF_X/Y/Z values are then held constant and never updated until the SDCD function is disabled and subsequently reenabled, or asynchronously when the REF_UPD bit is set by the host. 10b: The function updates the SDCD_REF_X/Y/Z values with the current decimated and trimmed X/Y/Z acceleration input data after the function evaluation. This allows for acceleration slope detection with Data(n) to Data(n–1) always used as the input to the window comparator. 11b: The function uses a fixed value of 0 for each of the SDCD_REF_X/Y/Z registers, making the function operate in absolute comparison mode.

- MEMS Transducer
  - Two separate transducers: XY and Z
  - Differential topology for increased sensitivity and common mode noise rejection
  - *__Self-Test Diagnostic__*

- Signal Chain
  - Portion of ASIC that converts changes in transducer capacitance to voltage, performs signal conditioning and converts signal to the digital domain.

- Digital Features
  - *__Sensor Data Change Detection:__*
  - Auto Wake/Sleep
  - Programmable interrupts
  - SPI / I2C digital interfaces
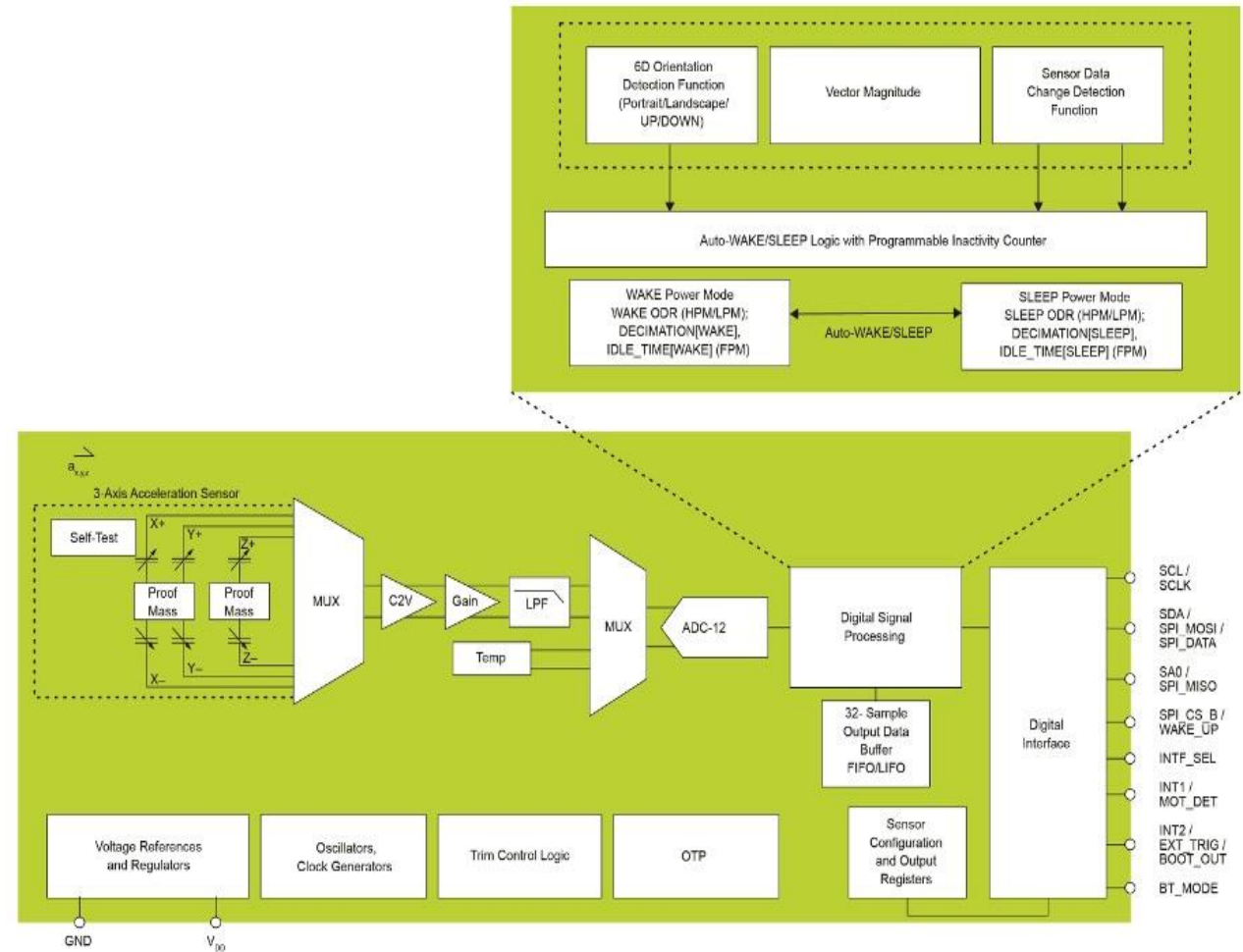
Motion Sensors for Power Management

SECURE CONNECTIONS
FOR A SMARTER WORLD

MOTION SENSORS FOR POWER MANAGEMENT

- Battery operated IoT devices with wireless connectivity (BLE, UWB, SigFox, Wi-Fi etc.) generally have MCUs (ARM Cortex-M0+ or M4 or M33 based) that support low power save modes.

- Depending on end use-case, wireless connectivity can consume between 40-70% of the total power consumption of such devices.

- Motion Sensors can be used to increase battery lifetime by 2x – 4x:
  - Ultra-low power wakeup on motion gestures: wake up MCU from ultra-low power mode.
  - Reduce the wireless RX/TX time for meaningful data transmission ex: motion anomalies.

UWB SmartSensing Tags   BLE SmartSensing Inhaler   SigFox Asset Tracker   UWB/NFC Tag
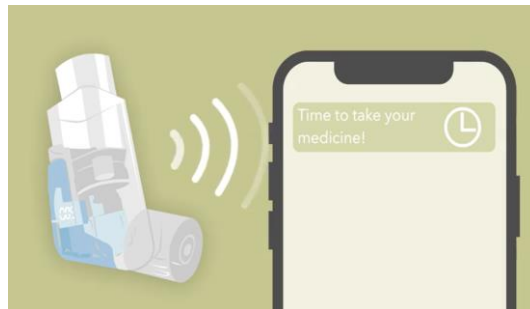
Accelerometer	UWB core	UWB ANT.
PMU & Testing		
Interfaces / UI		
BLE/MCU	BLE ANT.	
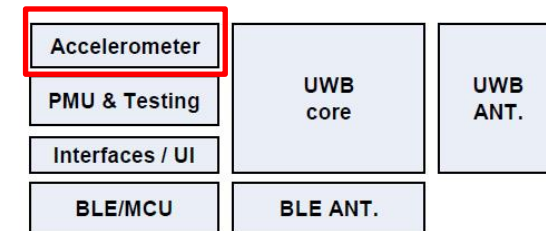
SYSTEM POWER SAVING WITH MOTION DETECTION IN KEYFOB

$$\frac{I_{sensorapp}}{I_{conventional}} = \frac{I_{sensor} + (1-p_A) \cdot I_{QQ\_PDMCU} + p_A \cdot I_{LFPUMSIGxx}}{I_{QQ\_LFACT\_Gxx}}$$
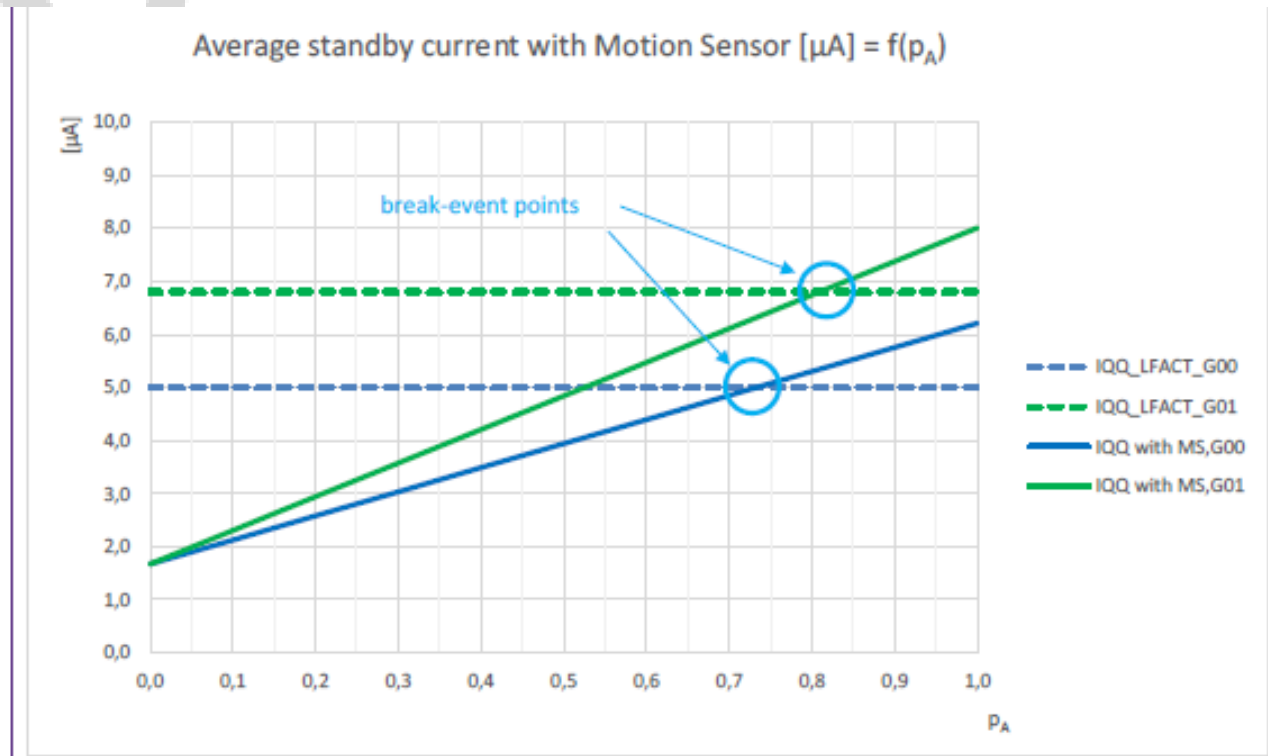
Average standby current with Motion Sensor [µA] = f(p_A)

break-event points

- IQQ_LFACT_G00
- IQQ_LFACT_G01
- IQQ with MS,G00
- IQQ with MS,G01

Fig 4. Average stand-by currents of sensor and conventional application (hardware supported)

Picture taken from
TR-SCA1601
See section 2.4.3

SENSORS REFERENCE DESIGNS FOR MII SEGMENT

NTAG Sensor Board	NTAG Sensor Button	UWB Finder Tag	Sigfox Asset tracker

NTAG Sensor Board
- Smart Logistics
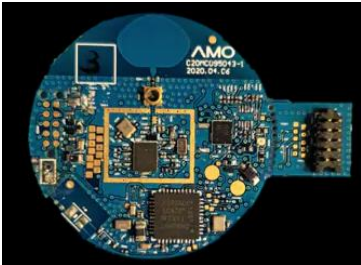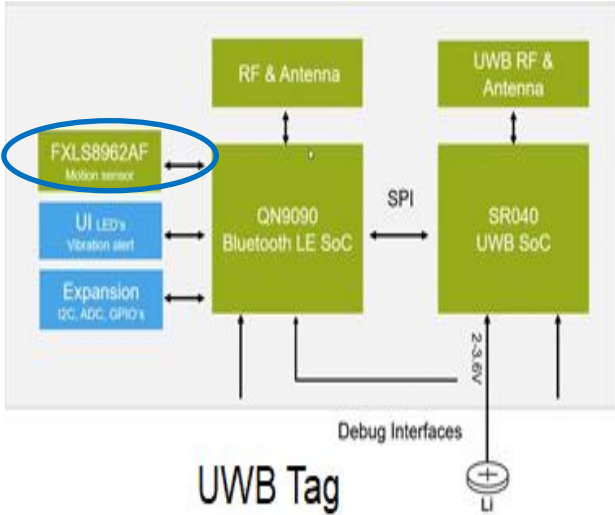- Smart Warehouse
- Factory Automation
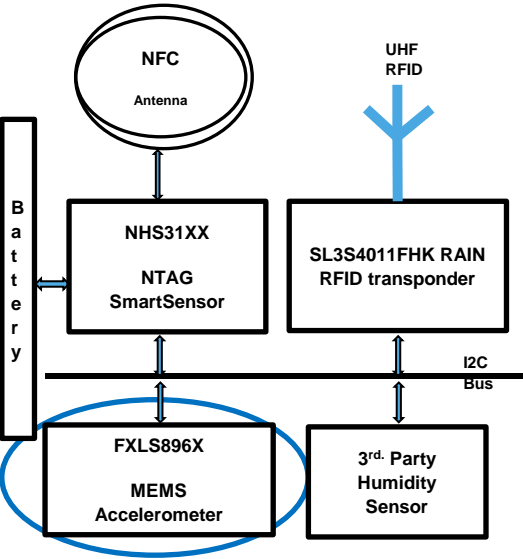
NTAG Sensor Button
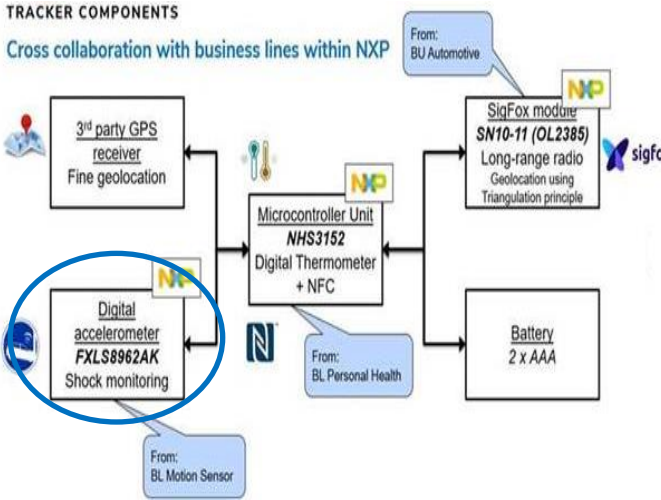- Machine monitoring
- Predictive maintenance
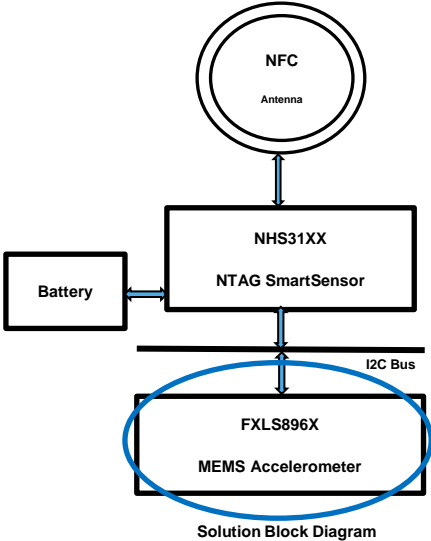
UWB Finder Tag
- Smart Home
- Smart / Safe Workplace
- Tamper /Theft Detection

Sigfox Asset tracker
- Asset tracking
- Smart Warehouse
- Factory Automation

SUMMARY

- NXP has a rich history of supplying motion sensors into automotive, industrial, and medical markets

- NXP has a broad portfolio of sensors covering the needs of various markets and application use cases. In particular, NXP motion sensors are ideal for applications where power management is critical

- Low power motion sensors are a critical component of battery operated systems with wireless connectivity (BLE, UWB, SigFox, Wi-Fi etc.), enabling 2x – 4x power savings in such systems as demonstrated by the use case provided in this presentation.

![NXP logo]

TECHNOLOGY SHOWROOM
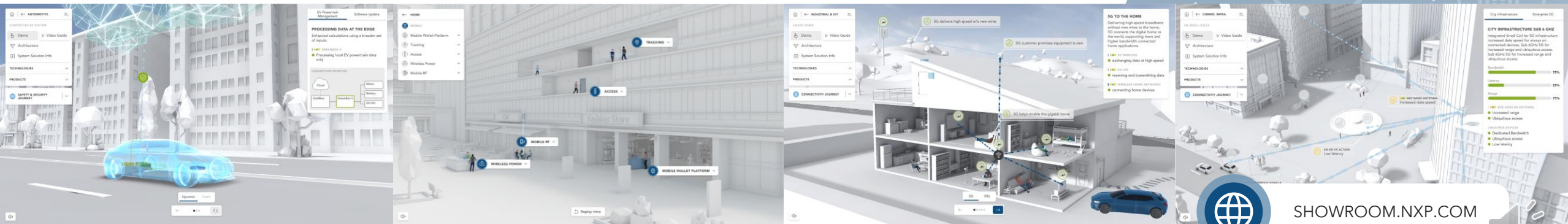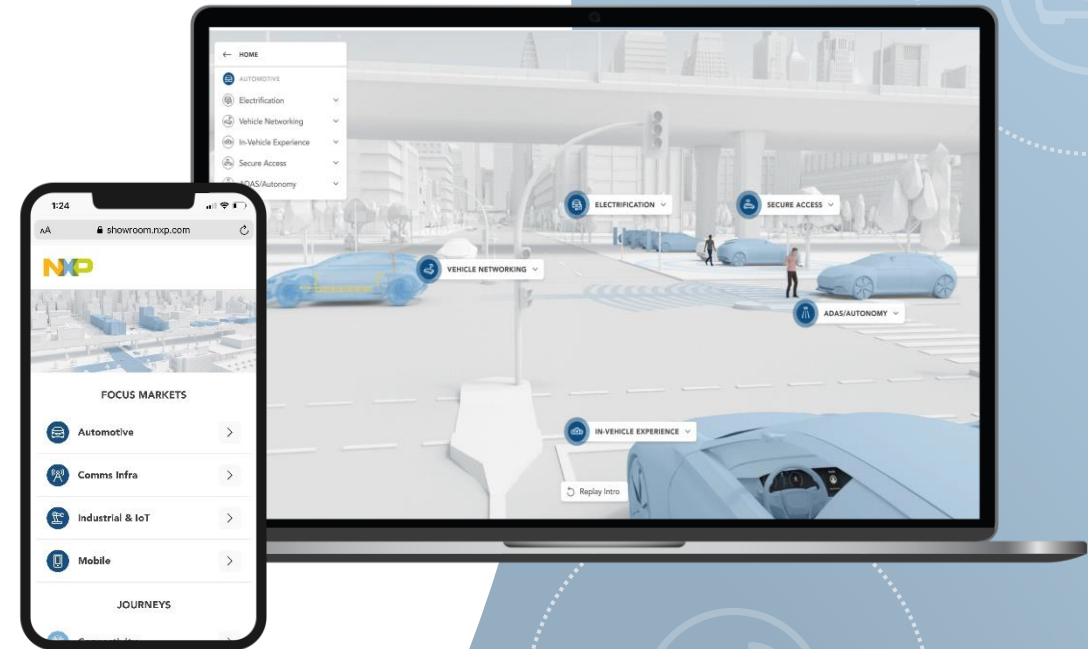
JOURNEYS BY DESIRED ENGAGEMENT

Self-guided tour
Live-streaming at set times
Guided tours

JOURNEYS BY DESIRED FOCUS

Edge & AI/ML
Safety & Security
Connectivity
Analog

40+ VIRTUAL DEMOS

Focus on system solutions
Set up along NXP verticals

SHOWROOM.NXP.COM

SECURE CONNECTIONS FOR A SMARTER WORLD

SHOWROOM.NXP.COM