HUMANIZING THE DIGITAL EXPERIENCE

TDK Developers Conference 2018

TDK InvenSense EPCOS tronics microsystems Chirp MICRONAS

HUMANIZING THE DIGITAL EXPERIENCE

InvenSense – Motion Sensor Applications and Solutions for the Internet of Moving Things

Prakash Madhvapathy

TDK Developers Conference
September 17-18, 2018
Santa Clara Marriott

TDK MEMS Sensors are driving new IOT Applications

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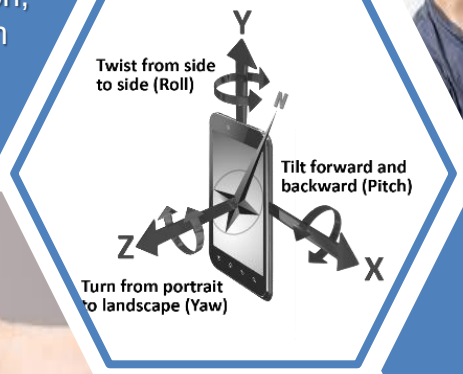
IMU Sensors in Smartphones
Movement, Gestures, Orientation, Image Stabilization



Biometrics
Ultrasonic Fingerprint Authentication for Secure Payment, Medical Access

Microphones
High SNR, high AOP Far-field audibility, Noise cancellation, beamforming

Augmented & Virtual Reality
6 DoF Movement, Orientation Tracking, Object overlay

Pressure
Elevation tracking, Hovering, Autopilot, Navigation Aiding, Image Stabilization in Drones

IMU Sensors in Automotive
In-cabin & safety, GPS Assistance, ADAS, Infotainment

Robotics & Artificial Intell.
Motion, Audio, Touch, Pressure, Proximity, Environmental

TDK Motion Sensors: Leadership for every Application

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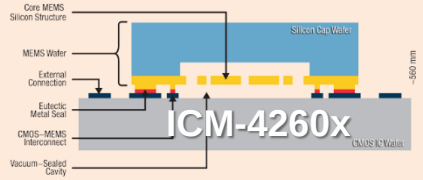
Noise&temp stability for AR/VR/HMD

Noise, sensitivity, offset for Android/ daydream/ARCore

HW engine with hosted algos for features & fusion

Noise, sensitivity, temp stability for Image stabilization

TDK



Precision, stability, range & resolution 6DOF & fast motion

Vibration rejection for HiFi Audio

Predictive Fusion for Hybrid EIS

Lowest noise & Time/temp Stability Robotics & IoT

Consumer Products with TDK Motion Sensors

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Oculus Rift

htc VIVE

magic leap

iRobot

HOBOT

HUAWEI

Microsoft HoloLens

Consumer Motion Sensor Roadmap

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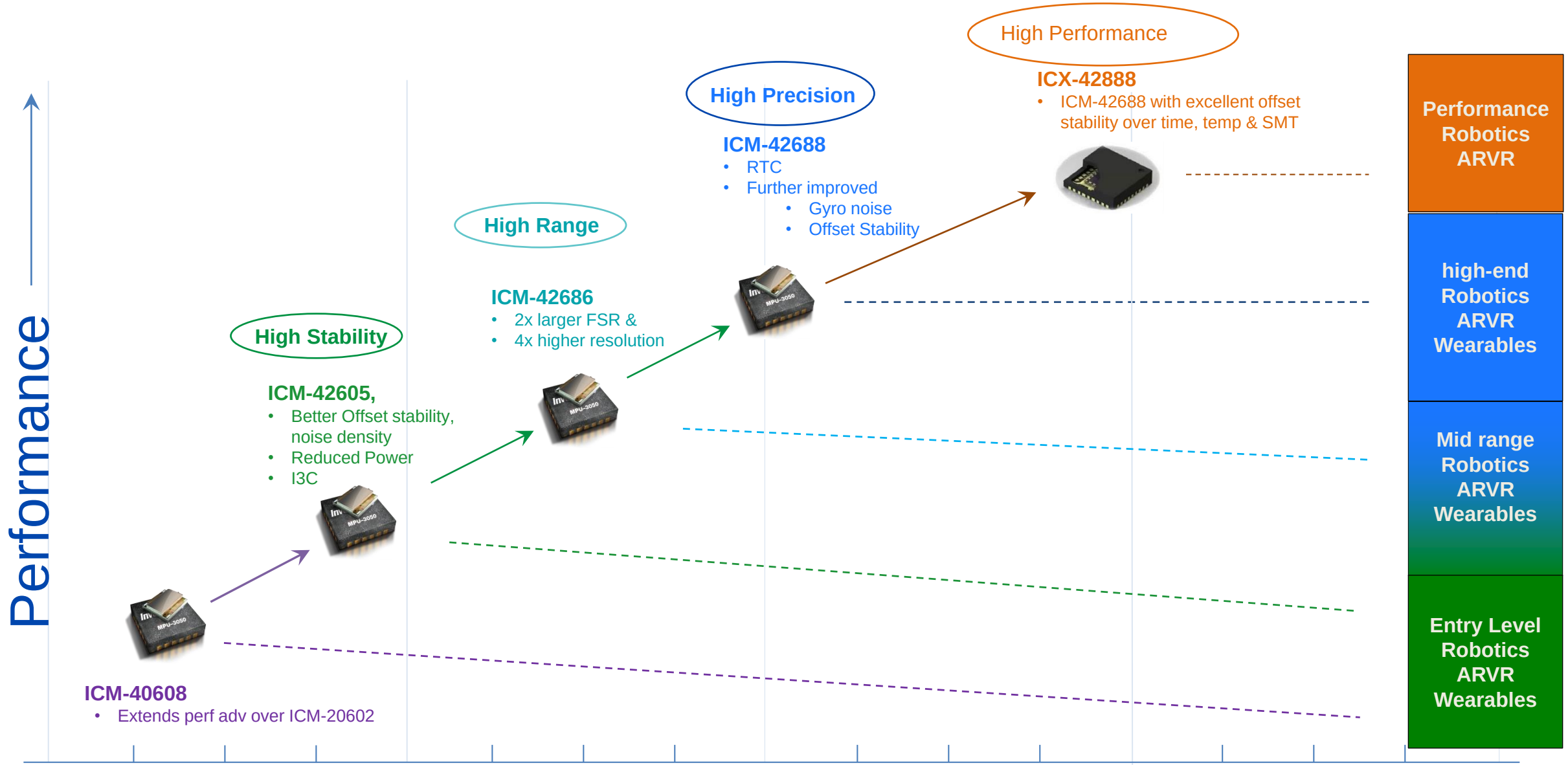

Motion Sensor Use Cases for VR

ICM-42686: the need for speed (… extended FSR)

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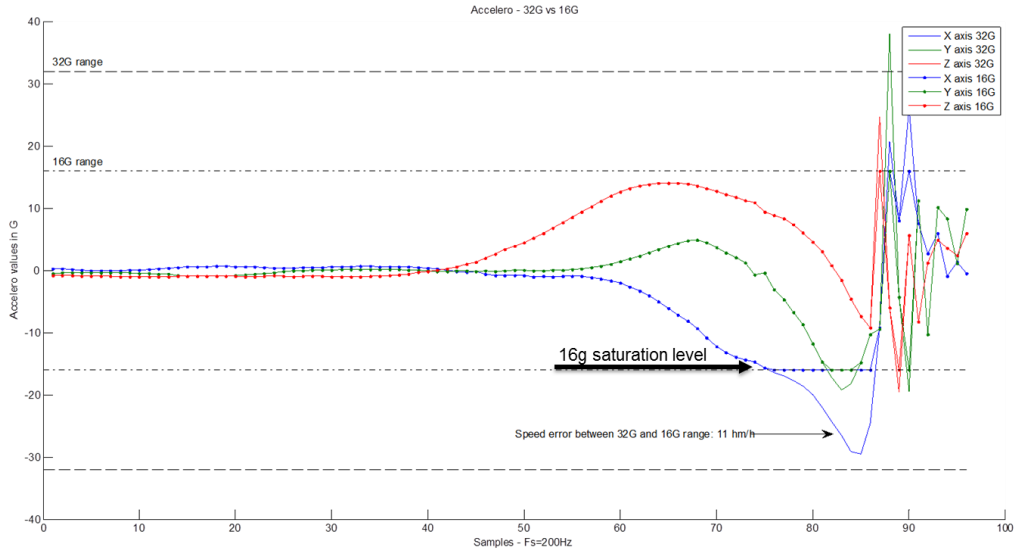
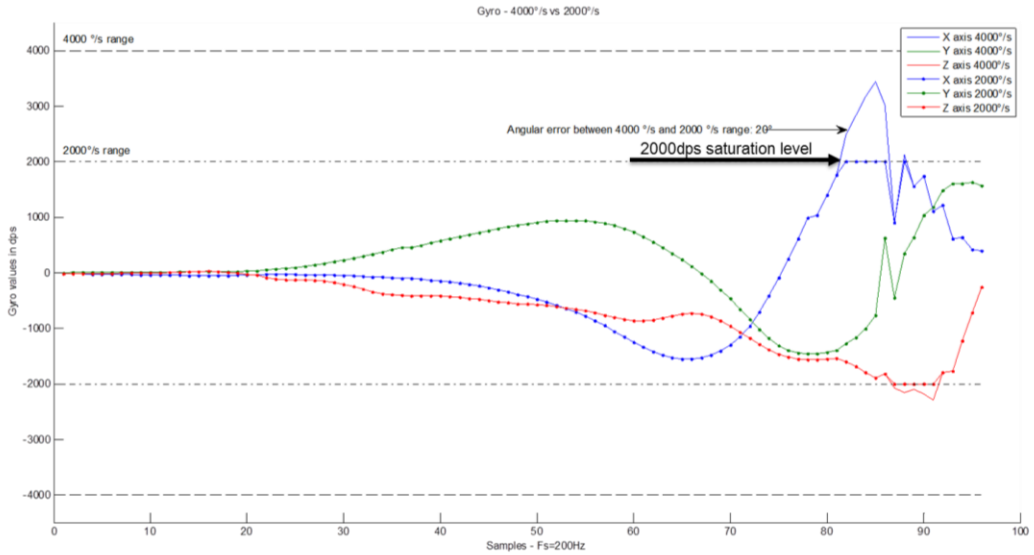
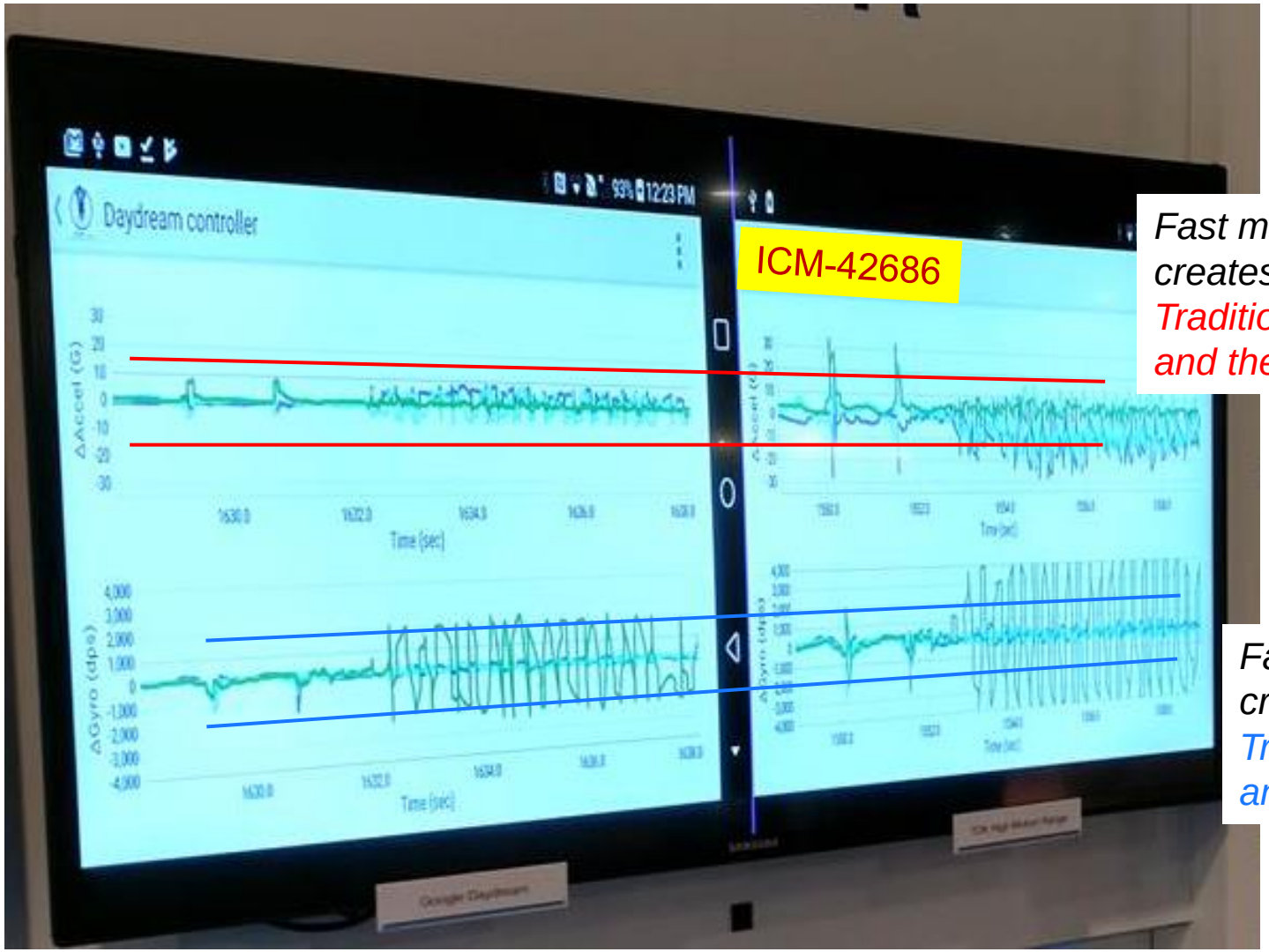
- Problem of Saturation
  - ¬Both accel and gyro sensors saturate during fast linear or rotational acceleration
- Motion Underestimation
  - ¬In saturation, accel/gyro underestimate real acceleration and rotation
- Effect: Virtual to Physical divergence
  - ¬ Virtual and Physical pose and positions diverge, rendering game unplayable

Only ICM-42686 supports any motion:
32g accel and 4000dps gyro FSR





VR/AR use case: keeping track



Fast movement easily creates acceleration >16g
Traditional 6-axis saturate and the game is over

Fast movement easily creates rotation >2000dps
Traditional 6-axis saturate and the game is over

→ Only ICM-42686 can support 32g accel and 4000dps gyro FSR, supporting any motion

AR/VR Tracking Solution: Range, Resolution, Noise

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- 19-bit output for highest resolution gyro motion sensing at any FSR

FSR \ output	Sensitivity @ 16-bit	Sensitivity @ 19-bit	Part #
2000dps	61 mdps/bit	7.6 mdps/bit	ICM-42686, ICM-42688
4000dps	122 mdps/bit	15.2 mdps/bit	ICM-42686 only

→ *42686 resolution @ 4000dps FSR is 4x higher than BMI/ST resolution @ 2000dps*

- 18-bit output for highest resolution linear acceleration sensing

FSR \ output	Sensitivity @ 16-bit	Sensitivity @ 18-bit	Part #
16g	0.488 mg/bit	0.122 mg/bit	ICM-42686, ICM-42688
32g	0.976 mg/bit	0.244 mg/bit	ICM-42686 only

- Drift performance improved significantly with high accuracy bias estimation
  - 8x better resolution in gyro bias estimation, 4x better resolution in accel bias estimation
  - Enhanced in-run calibration and factory calibration

- Low latency enabled by low noise figures (2.8mdps/√Hz, 75ug/√Hz)
  - Less averaging required in software

We saw the racket, now where is the Ball?

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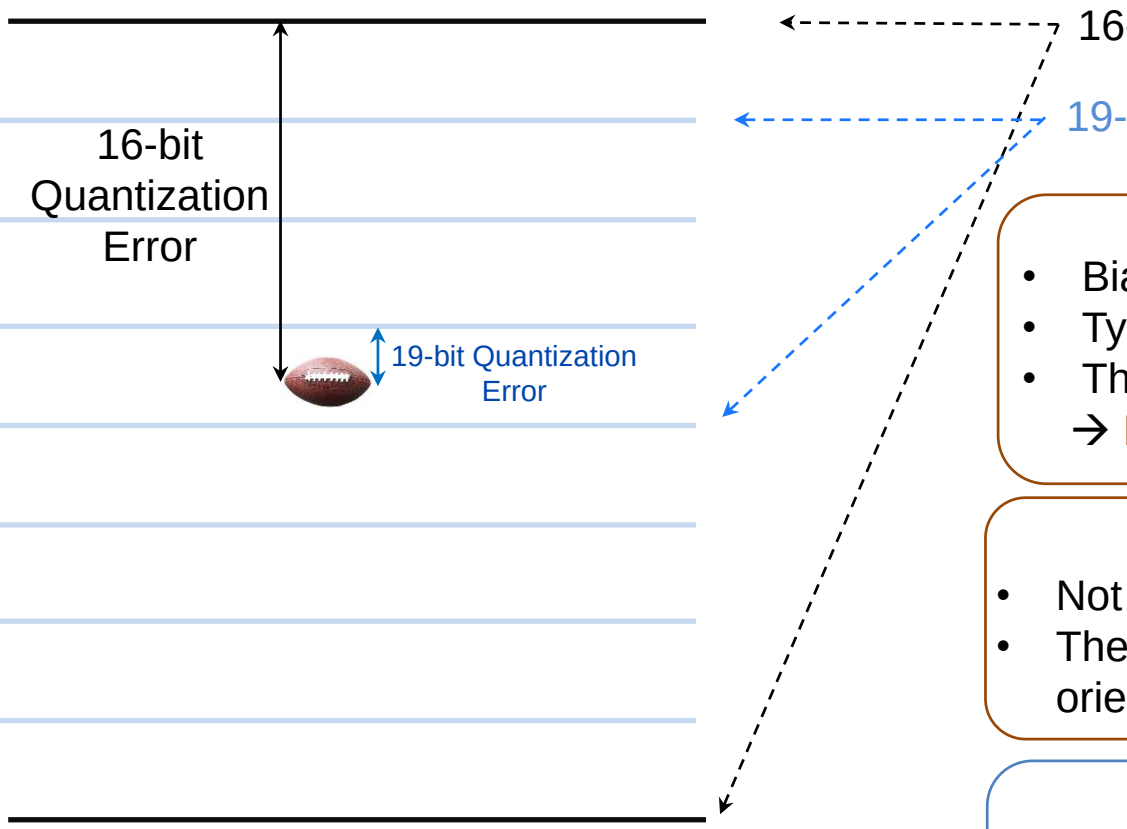
Bias estimation as a function of bit resolution



16-bit quantization levels

19-bit quantization levels

Bias based drift

- Bias leads to drift, hence undesirable
- Typical Algorithms estimate the bias when device is stationary
- This estimated bias is then removed from subsequent measurements

→ Leading to drift-free performance

Did you say, “Drift Free” ?

- Not really, the quantization error gets in the way of precise estimation
- The residual bias does contribute to drift based position and orientation errors.

Lowering Bias estimation error

- Therefore, higher bit resolution would lower the quantization (and therefore, bias estimation) error

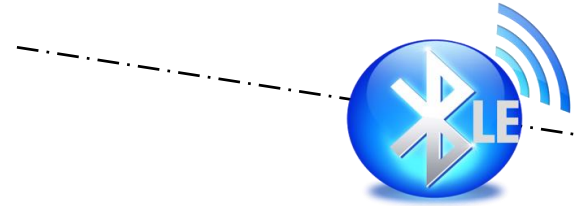
→ 19-bits with 8x lower quantization error, therefore leads to very low drift performance

VR/AR problem: staying aligned

VR Headset & controller alignment is a key requirement for a good VR gaming experience:

- Optical SLAM solutions are limited by line-of-sight requirement, cost and power consumption
- **New InvenSense/Chirp 6DOF reference design provides leading performance at lowest BOM cost**

ICM-4268x 6DOF : maintaining alignment

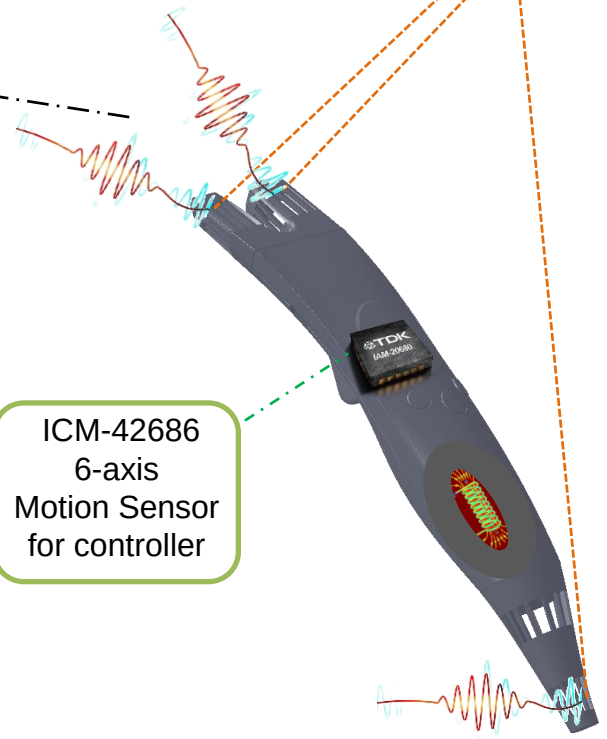


ICM-42688
6-axis
Motion Sensor
for HMD

n

Ultrasound Rx

Ultrasound Tx

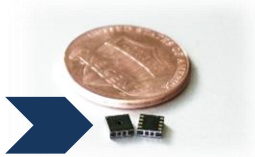


ICM-42686
6-axis
Motion Sensor
for controller

Function	Sensor
6DOF position & orientation tracking	ICM-42686 6-axis
3D spatial position ‘correction’	Chirp Ultrasound
Communication and sync	BLE

Chirp

- Sonar on a chip
- Integrated DSP chip – 100x lower power
- Millimeter-sized sensor – 1000x smaller
- Same great range finding performance



ICM-42686: designed for VR Controllers with superior tracking

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- ICM-42686 6-axis motion sensor for high-performance VR controllers
  - ¬ Leverages the superior accel & gyro performance (noise, thermal stability) of the ICM-4260x series
  - ¬ Provides extended motion measurement range for accel (up to 32g) and gyro (up to 4000 dps)
    - Avoids saturation during performance motion sensing and without loss of precision during minimal motion sensing
    - This enables precise and continuous motion sensing for performance sports and VR/game controller applications
  - ¬ Wake-on-motion enables APEX (motion/gesture/fusion) post-processing
    - 42686 operates in low-power accel only mode until wake-on-motion event is sensed (programmable threshold)
    - Host interrupt spawns programmable accel/gyro measurement settings or returns to low-power accel sensing
  - ¬ Adds unprecedent 19-bit output for highest resolution gyro motion sensing at any FSR
    - 42686 resolution for 4000dps FSR is 4x higher than BMI/ST resolution is for 2000dps

FSR \ output	16-bit – 4268x	19-bit – 4268x
2000dps	61mdps/bit	7.6mdps/bit
4000dps	122mdps/bit	15.2mdps/bit

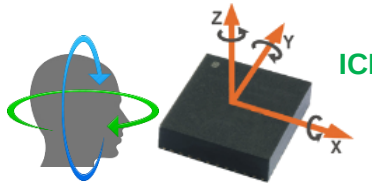
- ICM-42686: availability
  - ¬ ES samples Now and MP in Q4'18

ICM-20603/ICM-426xx Algorithms

- **Developed for Virtual Reality applications**

- **Algorithms:**
  - Sensor Fusion
  - In-Run Calibration

HMD, Controller Processing with ICM-20603, ICM-42688



ICM-20603: Raw Accel, gyro, Mag

400-1000Hz

ICM-20603 SW Stack

In-Run Cal:
Calibrated
Sensors

ICM-20603 SW Stack

Senor Fusion:
3DOF, Cal
Gyro

ICM-20603 SW Stack

Predictive Quat:
Configurable 1ms to 100ms

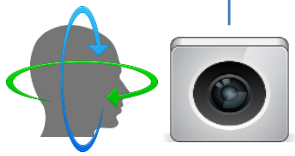
Rendering
Delay

Motion + Vision
Fusion

Rendering

Display

5-120Hz



Predictive Quaternion to compensate rendering time/latency

Predictive Quaternion to compensate sensor latency for TimeWrap

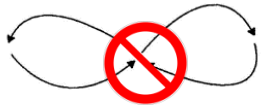
In-Run Offset Calibration for “Head” or VR Remote Use Case

Accelerometer

- Eliminate the need for highly controlled multi-orientation factory calibration
- Eliminate need of calibrating at multiple temperatures

Magnetometer

- Eliminate un-natural head motion for calibration, e.g. figure-8, etc, as required by typical mag calibration algorithms



Gyroscope

- In-use bias tracking reduces residual absolute bias error to <0.2dps
- No need for device to be perfectly stationary, e.g. on table, after power on
- No motion bias calibration also available with <0.01dps accuracy

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ICM-426xx

for Robotic Cleaners

TDK Developers Conference
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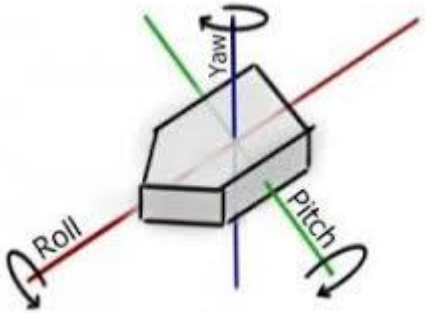
Cleaning Robot Orientation Errors

- **Orientation (Yaw) errors in Cleaning Robots**
  - Cause poor coverage of floor area
  - Require multiple passes over the floor to get full coverage



- **Yaw errors are caused by**

¬ **Gyro Sensitivity**
  - Measured rotation differs from actual rotation by a small percentage

¬ **Gyro Bias**
  - Yaw drift over an hour can be significant
  - This is caused by Gyro Bias
    - Every motion sensor has a non-zero Bias
    - Gyro Bias drifts over time and temperature (Robot can heat up by 20°C))

¬ **Robot tilt**
  - Caused when using gyro only design
  - Change in pitch/roll confuses Yaw in 1-axis and 3-axis devices

→ *Yaw error and drift should be minimized for better Robot Orientation*

ICM-42688: Leadership in Robotics

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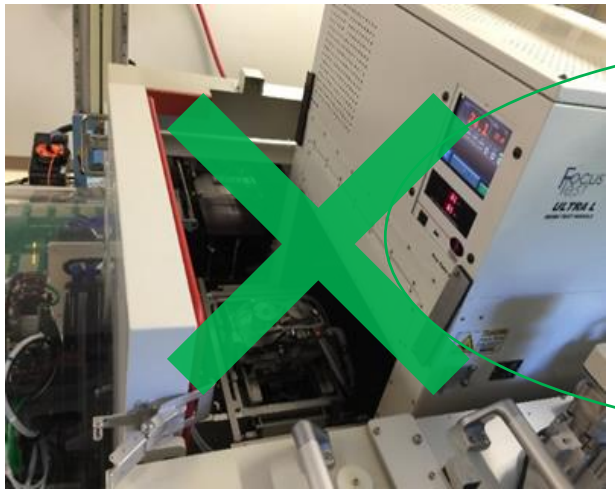
Industry Leading 6-axis IMUs: Corona XLII

Corona XLII is a family of highest performing 6-axis IMUs

- Unparalleled Noise performance: 2.8 mdps/rtHz
- Lowest Sensitivity Error: 0.5%
- Lowest Bias: 0.5dps
- Lowest Bias Temperature Coefficient: 5mdps/°C
- Lowest Accel Bias: 40mg

Minimize Yaw Error



Cost Reduction:
No factory cal required for
Accel or Gyro Sensitivity

→TDK Software Algorithm significantly reduces Bias contribution to Yaw Error
→TDK Corona XLII in combination with TDK Software Algorithm provides best-in-class Robot orientation performance

Motion Sensor Use Cases for Wearables

ICM-426xx: Leadership in Wearables

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- Leading 6-axis performance
- Low-power accel with WOM
  - ✓**15uA** Accel LP mode
- **APEX**: the most advanced Motion Engine for Wearables
- Algo library for any motion
- 'Look-at-screen' gesture
- Extended range/resolution for any motion
- Fine-grained accel-gyro sync
- Internal 6-axis sensor-fusion
- External sensor-sensor fusion
- Complete HW/SW solution

Basic Activities/Gestures/Context
Steps, Activity, Sleep

Fast Motion
Big swings

Vital Signs
PPG / HRV

WOM

EIS Videos
"go-pro" style

Barometer Fusion
Floors/Stairs Climbed

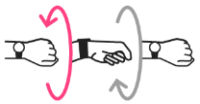
GPS

Sensor Assisted GNSS
Speed/Distance/Route

Compass Fusion
Orientation/Heading

Wearable algorithms

Category	SW Feature/Support
Fitness	Activity Classifier: Walk, Run, Bike, Still
	Walk/Run Step Counter
	Walk/Run Time Accrual
	Stand/Sit Time Detect/Accrual
	Calorie Counter based on Activity (Energy Expenditure)
	Distance (walk/run)
	Floors Climbed
	Stairs Climbed
Gestures	Shake
	DoubleTap preceded by Bring-to-see
	Bring-to-see
	Put Hand Down -> screen off
Wellness	Longtime Sit Alert, Sedentary Alert
	Sleep Analysis (Manual Entry)
	Motion compensated Heart Rate Monitor and Variability

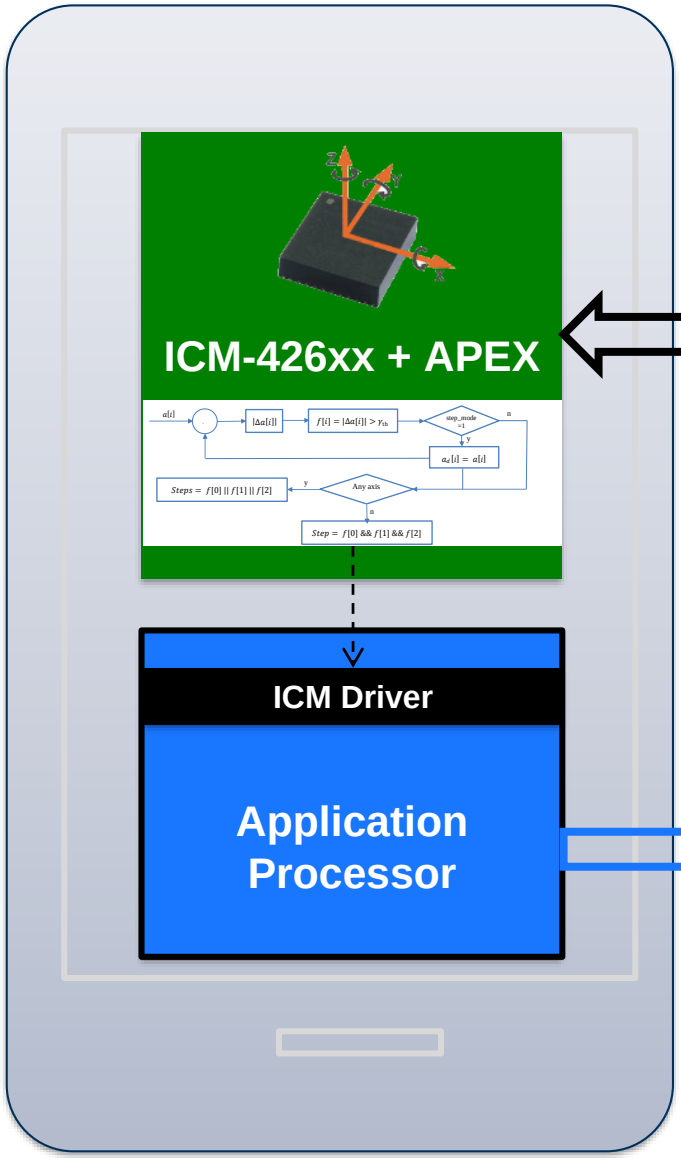


TDK APEX HW Pedometer

- ICM-426xx includes a high-performance, low-power Motion HW engine for pedometer step-counting and major motion gestures/WOM

- The APEX HW Motion Engine offloads the AP from lower-level house-keeping in a very power efficient way

- Hosted Algorithm to enhance performance in special cases, such as slow walk



Validated APEX Sensor Positions

TDK APEX HW Pedometer

- Fully configurable HW Pedometer
- Supports all key **WeChat** requirements
- Lowest in-class false positives for biking and transportation
- Below 5% step count error on an average for typical walk and run
- The only HW Pedo that also reports
  - ¬ Cadency
  - ¬ Walk/run classification

Config Parameter	Units and Default setting	Range
Step_Thres	• Peak threshold value of a valid step	[40, 100] mg
Step_buf_Thres (Pedometer)	• Minimum number of steps that must be detected before step count increments	[5, 15]
Low_Step_buf_thres (Pedometer Low-Latency)	• Minimum number of low latency steps before the pedometer step count begins incrementing	[1, 4]
Step_buf_timer_thres	• Duration of non-walk period to exit the current walk mode.	[1.5, 6] seconds

APEX Slow Walk Performance / 50Hz ODR

Algorithm Enhanced APEX Pedometer and HW-only Pedometer

- Optimized WeChat Configuration

Common WeChat Pedometer DB	Cadency range (step/s)	Step error in %					
		APEX		LSM6DS3 Nexus eval		iPhone iOS 10.3.2	
		Mean	Std	Mean	Std	Mean	Std
Algo-enhanced slow walk	0.8-1.3	44,6%	17,2%	75,7%	12,8%	42,4%	21,7%
HW Pedo based normal/fast	1.5-1.7	2,7%	1,7%	6,7%	3,6%	1,8%	1,5%
HW Pedo based run	2.3-2.6	4,0%	2,5%	8,7%	5,1%	0,9%	1,0%

- APEX HW Pedometer Performance for WeChat walk/run is good, and the pedometer will rely exclusively on the APEX Motion Engine for these use-cases

- **If the APEX Motion Engine detects 'special use-cases' like "slow-walk" then specially tuned APEX algorithms can be made available for integration into the AP to complement the HW pedometer performance, and provide highest accuracy for all use-cases!**

ICM-426xx: designed for Wearables & Handhelds

- ICM-426xx 6-axis motion sensor for high-performance wearable and hand-held devices
  - ¬ Industry leading accel & gyro performance (noise, thermal stability)
  - ¬ Wake-on-motion enables APEX (motion/gesture/fusion) post-processing
    - 426xx operates in low-power accel only mode until wake-on-motion event is sensed (programmable threshold)
    - Host interrupt spawns programmable accel/gyro measurement settings or returns to low-power accel sensing
  - ¬ APEX (motion/gesture/fusion) post-processing algo library for host-based applications
    - The APEX library provides proven performance and easy implementation of key applications
      - Gestures: detection, identification and action
      - Activities: detection, classification and tracking
      - 6-axis sensor-fusion: measures and extrapolates movement and rotation
      - External sensor-fusion for heading (with compass) and elevation change (with pressure sensor)
      - EIS solutions for professional, shake-free video recordings (for watches including cameras)
- ICM-426xx: availability
  - ¬ ES samples Now and MP in Q4’18

Stair Climbing use case for Wearables

Barometer

Barometer
+
Pedometer

Barometer

TDK-InvenSense Barometric Pressure Sensors

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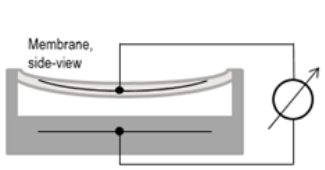
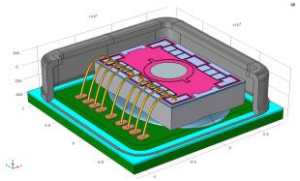
Introduction

Technology

Capacitive MEMS Architecture

Monolithic Barometric Pressure Sensor & ASIC



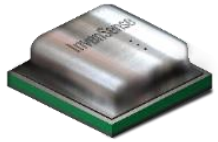


Performance

Industry Leading Accuracy to 8.5cm (±1Pa)

50% Lower Power than Incumbent Technology

Waterproof to 1.5m in 2x2mm Footprint



Integration

Fully Calibrated Digital Pressure + Temp Sensor

Pressure Sensor & 6-Axis IMU (3-Axis Accel, 3-Axis Gyro)

Pressure Sensor + Microphone

ICP-101xx Pressure Sensor based Activity Identification

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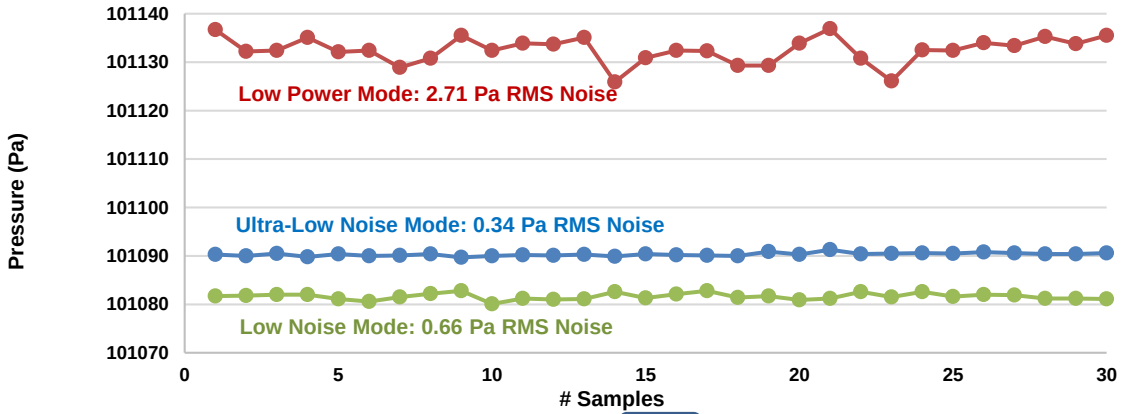
Meeting Every Application Need

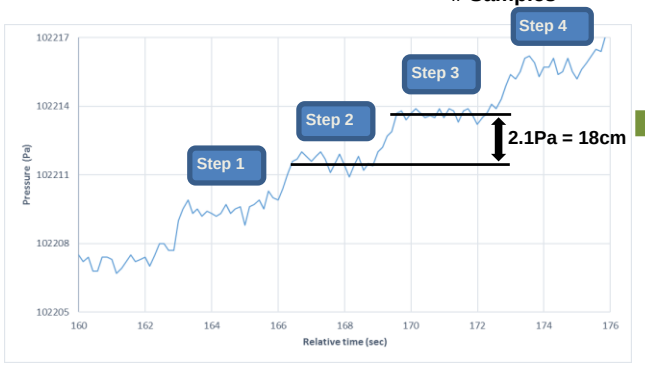
- Monitor Z-height to identify:
  - Path of travel (stairs, escalator, elevator): resolution < 1 stair, ~10cm
  - Type of Fitness Activity: resolution << arm movement radius (~10cm)
  - Fall Detection: resolution < chair seat height (~25cm)
- < 5uA to increase functionality without penalty to battery life
- >20Hz sample rate to effectively monitor high speed motion
- Package height <1mm and small footprint for space constrained applications
- Waterproof to IPx8 (1.5m) OR ~5atm by waterproof industrial design

Solution Benefits

Key Challenges	ICP-101xx Benefits
Measure relative height change <10cm	Pressure Noise RMS: 2 modes of operation: 0.8 Pa RMS & 0.4Pa RMS
Activity identification of small form factor wearables with limited battery capacity	<7cm resolution at 5uA
High sample rate – monitor arm movements, stair running	Sample rate of 48Hz at 0.8Pa RMS
Manufacturing contaminant resistance, water resistance	Three 0.025mm vents eliminate manufacturing contaminants, waterproof to 1.5m depth

Use Case / Application Benefits





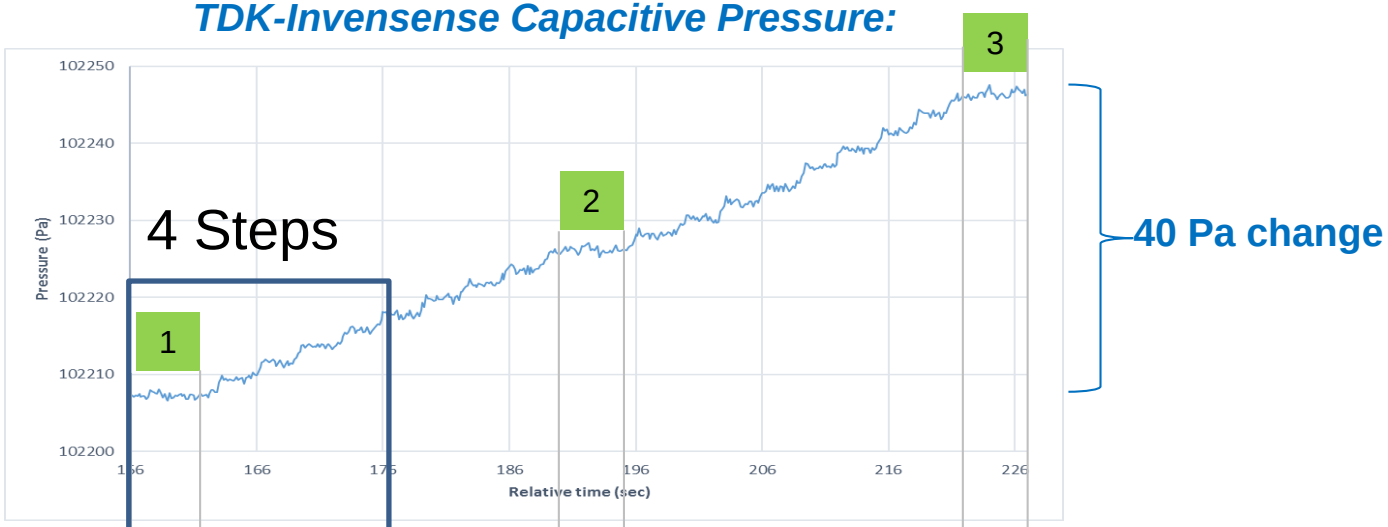
ICP-101xx Benefits in Fitness Tracking:

- Better caloric monitoring by identifying type of activity
- Improved features (path of travel) without battery life penalty
- No additional manufacturing considerations to prevent cavity contamination or water intrusion up to 1.5m

TDK-InvenSense Capacitive Pressure Sensor

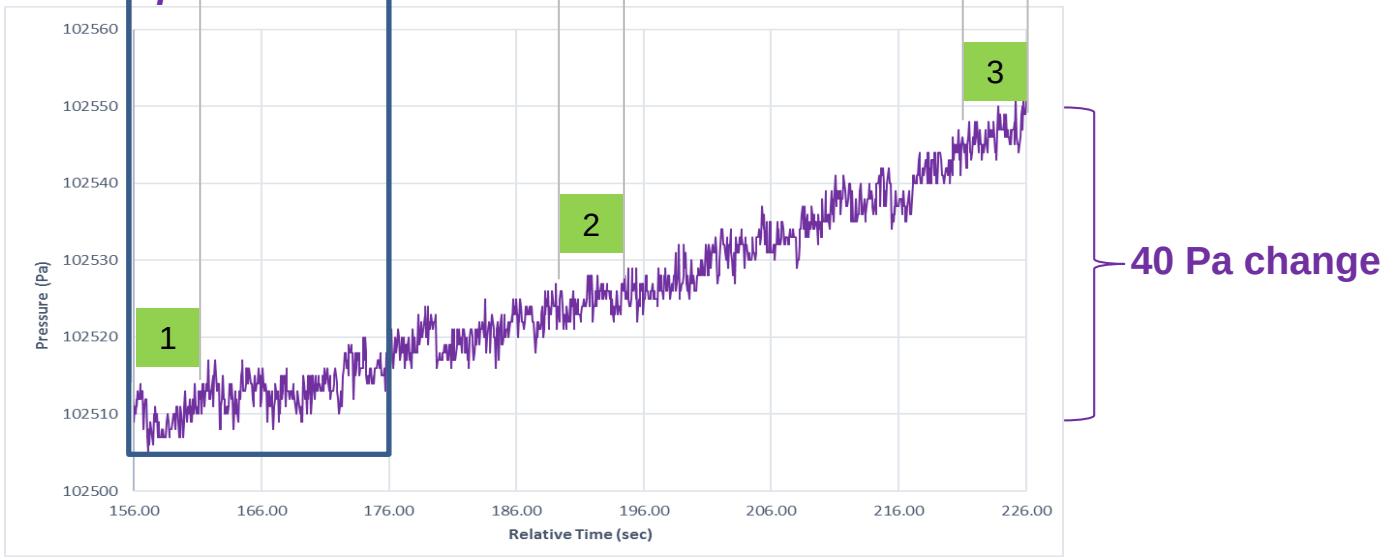
Lowest Pressure Noise & Relative Accuracy

TDK-Invensense Capacitive Pressure:

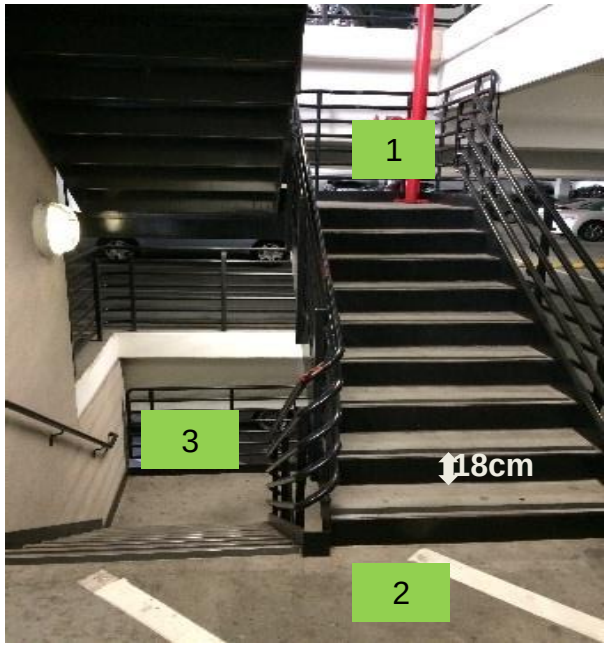


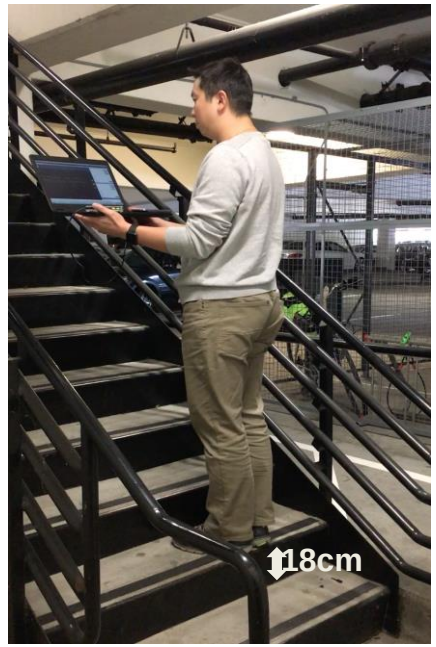
40 Pa change

Competitor B Piezoresisitive Pressure Sensor:



40 Pa change





TDK-InvenSense Pressure Sensor

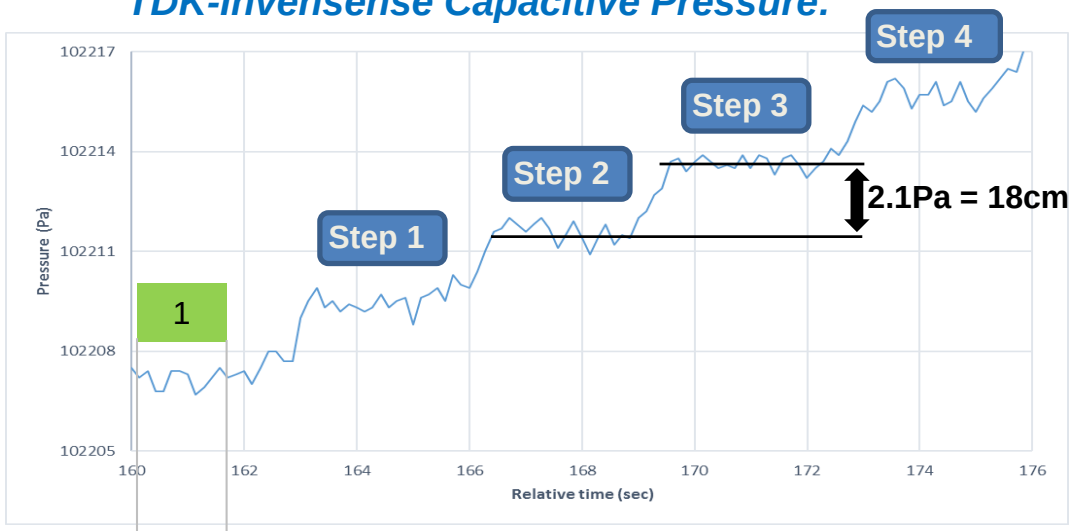
Detects Individual Stair Steps

TDK-InvenSense Capacitive Pressure Sensor

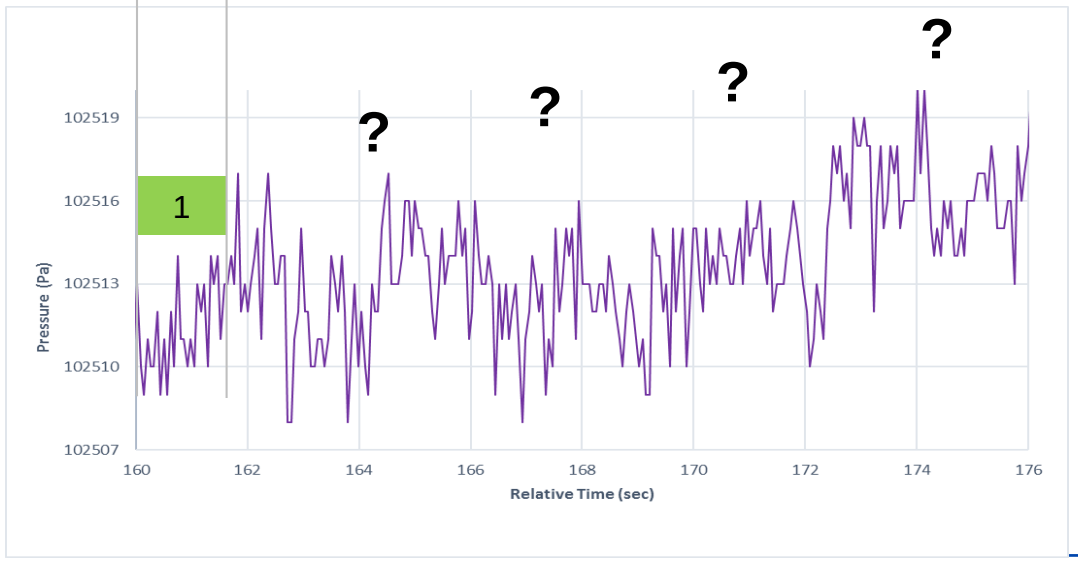
HUMANIZING THE DIGITAL EXPERIENCE

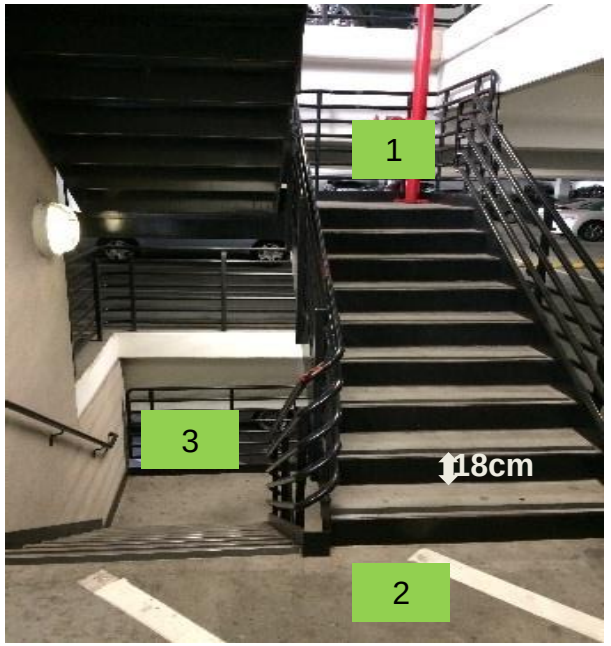
Lowest Pressure Noise & Relative Accuracy

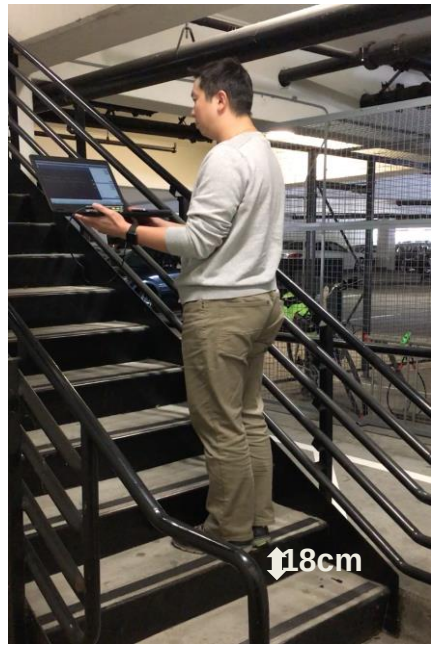
TDK-Invensense Capacitive Pressure:



Competitor B Piezoresisitive Pressure Sensor:





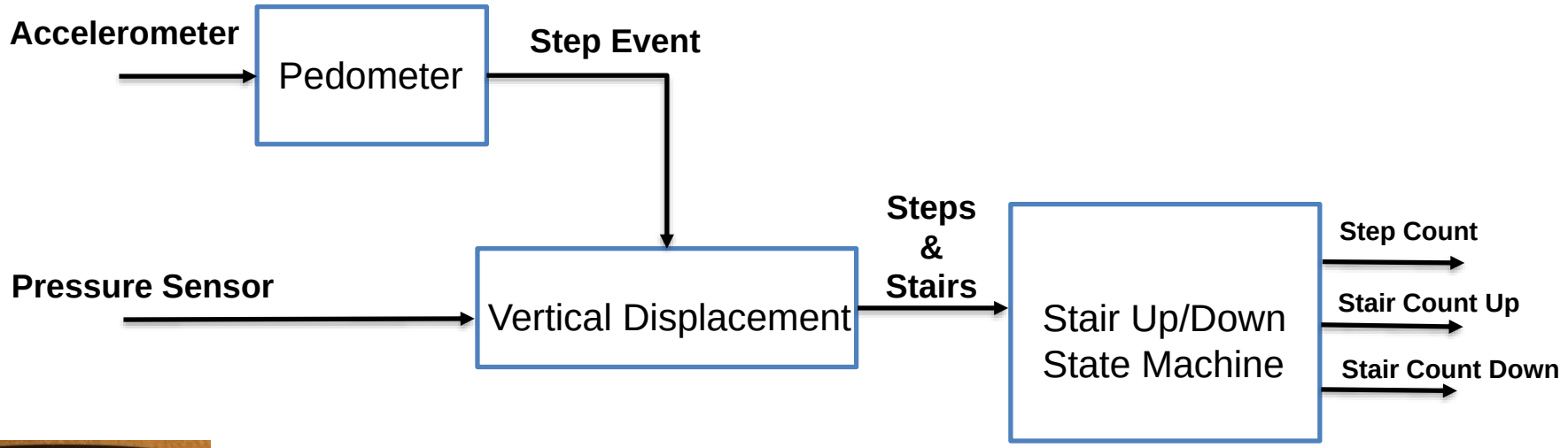


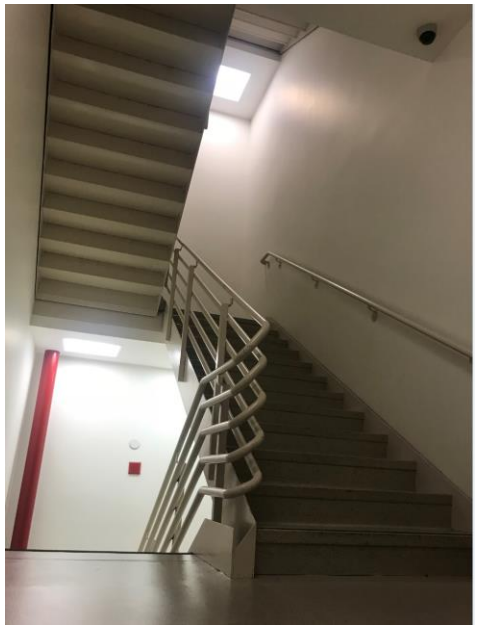
TDK-InvenSense Pressure Sensor

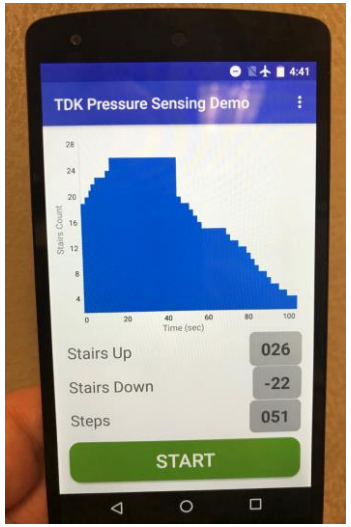
Detects Individual Stair Steps

Stair Counting with Pressure Sensing

Pedometer + Pressure Sensor Algorithm







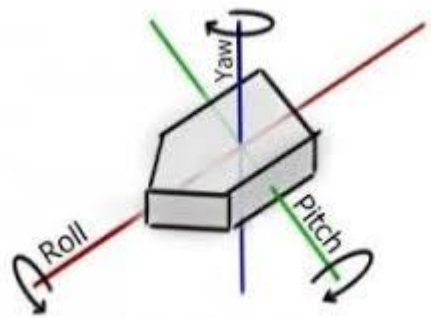
Setup and Data Collection

- Hardware: Google Nexus 5 Smartphone: Populated with ICP-101xx Pressure Sensor
  - Pressure Sensor: Ultra-Low Noise Mode, 10 Hz Output Data Rate
- Data Collection
  - 10 Users Carrying Two Phones: 1 in hand and 1 in pocket
  - Activity
    - 2 Trip walk up and down 8 Floors in Stairwell
    - 2 Trip Flat walk across Building

Motion Sensor Use Cases for Appliances

Leg Leveling Guidance


Leg Adjustment



Problem

- Washer/Dryer leveling is an issue for new installations or relocation
- Without guidance, level adjustment can take time and cost money
- Generally done by experienced installers/repairmen
- Level can also shift over time
  - Resulting in vibrations and inefficient operation
  - Helps in keeping Motor Horizontal/Vertical

Solution

- ✓ 6-axis IMU mounted to Washer/Dryer frame can detect inclination in pitch and roll to help professional or self-install.
- ✓ Detection of inclination is continuous, alerting owner of shifts throughout lifetime of product

→ Benefits from Low noise, high sensitivity 6-axis sensor, ICM-42688

Unbalanced Drum: Early Detection

Problem

- Unbalanced Drum causes:
  - Excessive vibration
  - Inefficient operation
  - Leading to Motor/spindle damage
  - Human detection of such vibration is very late
    - Problem builds up over time

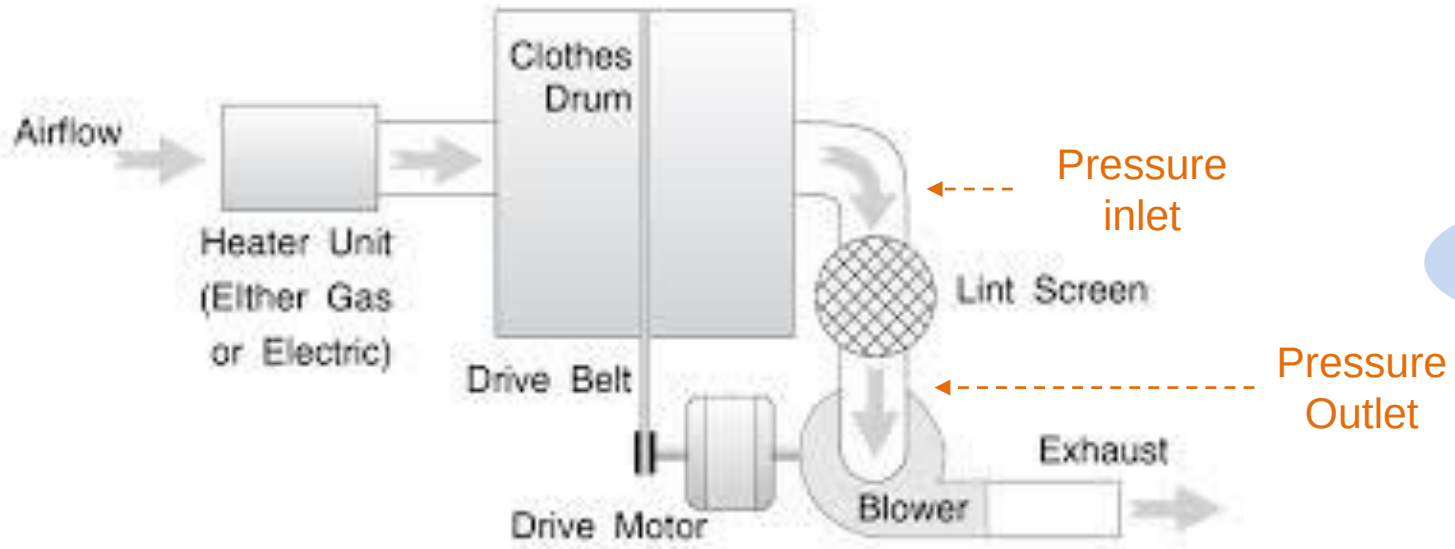
Solution

- ✓ 6-axis IMU mounted to Washer/Dryer frame can efficiently detect small changes in vibration (3D wobble) that builds up over time
- ✓ IMU can therefore provide early warning to owner and provide guidance for timely correction
- ✓ IMU can also flag unbalanced load and warn the user to correct the loading

→ Benefits from Low noise, high sensitivity 6-axis sensor, ICM-42688

Dryer Lint Detection

➢ **Problem:** Detecting Lint build up



Solution

✓ Differential Pressure sensing to detect blockage by lint

✓ Lint Buildup ∝ function of [Pressure inlet – Pressure outlet]

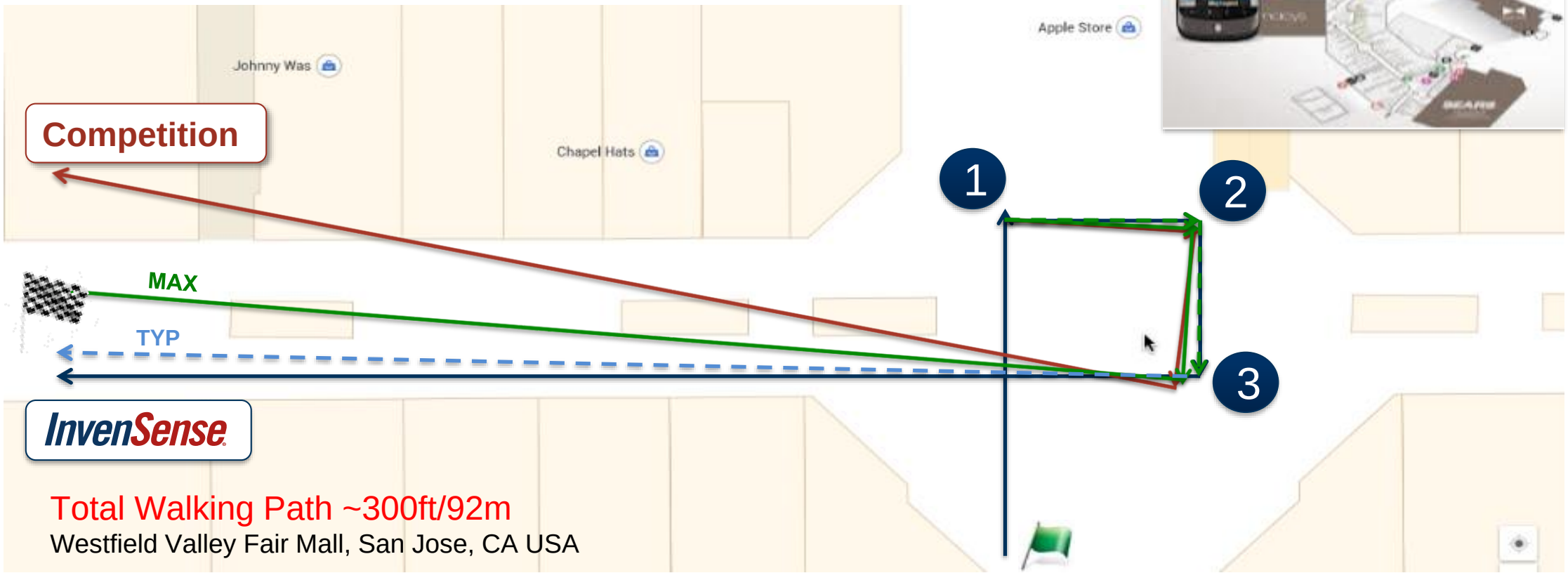
➡ Benefits from Low noise, high sensitivity pressure sensor, ICP-101xx

Pedestrian Dead Reckoning Motion Sensor Use Cases

Effect of Gyro Sensitivity Error on in-door navigation

Cumulative error after 3 x 90° turns

- 0.3% (TYP) sensitivity = 0.81° cumulative heading error (0.27° x 3)
- 1% (MAX) sensitivity = 2.7° cumulative heading error (0.9° x 3)
- 3-4% sensitivity = 10.8° cumulative heading error (3.6° x 3)



Other Motion Sensor Use Cases

Pointing TV/STB Remote Gestures

Air Pointing	Basic Gesture	Advanced Gesture	Gaming	Android Touch Emulation
Calibration	Swipe left	Check	3D Orientation	Application Awareness
Flip Detection	Swipe right	Back	Orientation 2 Joystick	Tap Tap & Hold
Basic Pointing	Swipe up	Close	Orientation 2 Keybrd	Drag
Roll Compensated	Swipe down	Shake		Scroll
Absolute pointing 6 axis	Left quick roll	Dynamic Yaw	**Device**	Pinch/Spread
Absolute pointing 9 axis	Right quick roll	Dynamic Pitch	Remote	2x touch Drag
CursorLess Navigation	**AML**	Dynamic Roll	SmartPhone	2x touch rotate

SME

TDK HRM Algo exceeds (Wear OS) requirements

HRM engine bpm performance summary

- Results based on 118 data logs known to have good PPG signal quality

Test Definitions	Mean Absolute Error (MAE) [bpm]	
	Android Specs	TDK
Sedentary Heart Rate	< 5.00	2
Indoor Walking	< 5.00	3.4
Running	< 7.50	4.1
Elliptical	N/A	2.6
Combined	N/A	3.8

HRM Algo	MIPS	Size	
		Code	Data
TDK (Cortex M4 Lib)	1	14KB	15KB

Vital Signs
PPG / HRM

Problem

Motion can affect PPG/HRV sensor's ability to measure accurately.
But people cant be still, adults or kids !

Solution

TDK HRM Algo efficacious in accurately detecting and removing the extraneous effects of motion from PPG signal, allowing continuous monitoring even while wearer is active.

Other IoT use cases for Motion Sensing

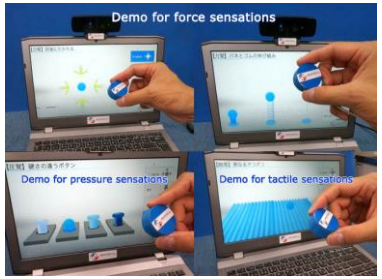
Self Balancing Scooters/Hoverboards

Smart Toothbrush

Smart Screwdriver

Fall Detection

SLAM/Toy Robot



Motion Compensation for Haptic signal

Motion Compensation for PPG sensor

3D pen for AR, AR Glasses

Use cases from your market

Motion Sensor Software

Software: Embedded (eMD) & Android

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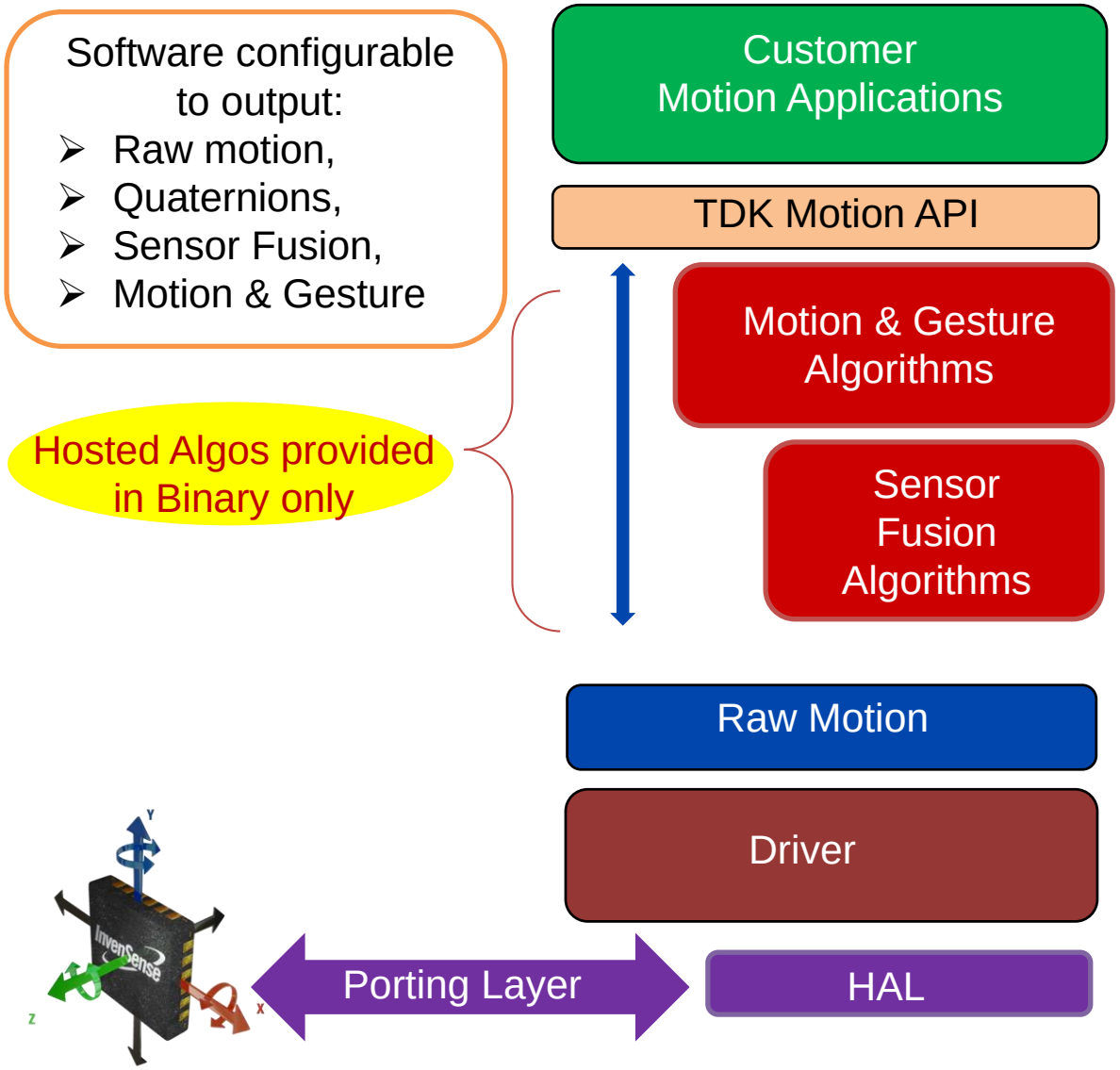
- **Device Drivers in Source code**
  - OS independent for Embedded Systems
  - Android/CHRE compliant for Google ecosystem
- **Algorithms**
  - Binary only
  - Source code negotiable for strategic customers
  - Android compliant for Google ecosystem
- **Security**
  - Software authenticates TDK parts
    - through various security schemes detailed in table
- **Embedded CPUs (Hosts) supported**
  - Cortex M0, M0+..M4, Atmel G55, Nucleo (ST), Ambiq, ARC (EM5)
  - Porting to other CPUs requires Board Support Package (BSP) modifications: I2C, SPI, timers …
- **Toolchain support**
  - GCC, IAR, Keil, CHRE, Android



Conclusion

TDK Motion Sensors Value Proposition

HUMANIZING THE DIGITAL EXPERIENCE

Best in class Performance (ICM-426xx)

- Industry's Lowest noise @ 2.8mdps/√Hz, 75ug/√Hz
- Industry's Highest range @ 4000dps, 32g
- Industry's Highest bit resolution @19bits
- Industry's Lowest temperature coefficient @ 0.15mg/°C, 5mdps/°C
- Very low power @15uA with Wake-on-motion
- Unique Internal fine-grained synchronization of accel/gyro and external sensors (RTC clock based)
- Combo sensors: 7-axis - Pressure+6-axis Motion, 9-axis - Magnetometer+6-axis Motion

Algorithms Expertise

- TDK provides rich set of algorithms finely tuned to TDK motion and pressure sensors
  - Enabling new applications, such as stair climbing, gestures

Software Frameworks and CPU

- Experience with Android, CHRE, Linux frameworks and a wide array of Microcontrollers, CPUs

System Architecture

- Deep system architecture knowledge to enable a wide range of products

ICM-426xx: Algorithms for Wearables & Handhelds

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Class	Algorithm	Example Use Cases	Available
Sensor Fusion	6-Axis fusion, GRV, Quaternion	Describing motion in 3D space	MP Now
	9-axis fusion, RV, Quaternion	Describing motion in 3D space with Heading information	MP Now
	Predictive Quaternion	Latency Reduction	MP Now
	Linear Acceleration, Gravity Vector	Application dependent	MP Now
Gestures	Gestures with IMU	Application dependent	MP Now
	Gestures with Ultrasound	Touchless Gestures	ES Now, MP TBD
	Pointing remote gestures	STB, TV, Appliance pointing remote	MP Now
	Tap, multi-Tap	User interface	MP Now
Motion & Activity	Basic Activity Classification	Activity Monitoring	MP Now
	Stair (and Step) counting with IMU, Pressure	More accurate Caloric expenditure, exercise regimen	MP Now
	Significant Motion detection	Power saving, anomaly detection	MP Now
	Tilt	Pose detection	MP Now
	HRM, HRV sensing with Motion Artifact removal	Health monitoring	MP Now
Calibration	Accel, Gyro (motion & stationary), Mag	In-run calibration	MP Now
	Factory Calibration expertise	Extensive experience to provide guidance	Now
IoT	Vibration detection	Condition Based Monitoring	ES TBD
	Differential Pressure	Building/Home Security	MP Now

Thank You!