HUMANIZING THE DIGITAL EXPERIENCE

TDK Developers Conference 2018

TDK InvenSense EPCOS tronics microsystems Chirp MICRONAS

HUMANIZING THE DIGITAL EXPERIENCE

CORONA Motion Sensor Technology, Products & Applications

Vishal Markandey, Senior Manager Technical Marketing, InvenSense

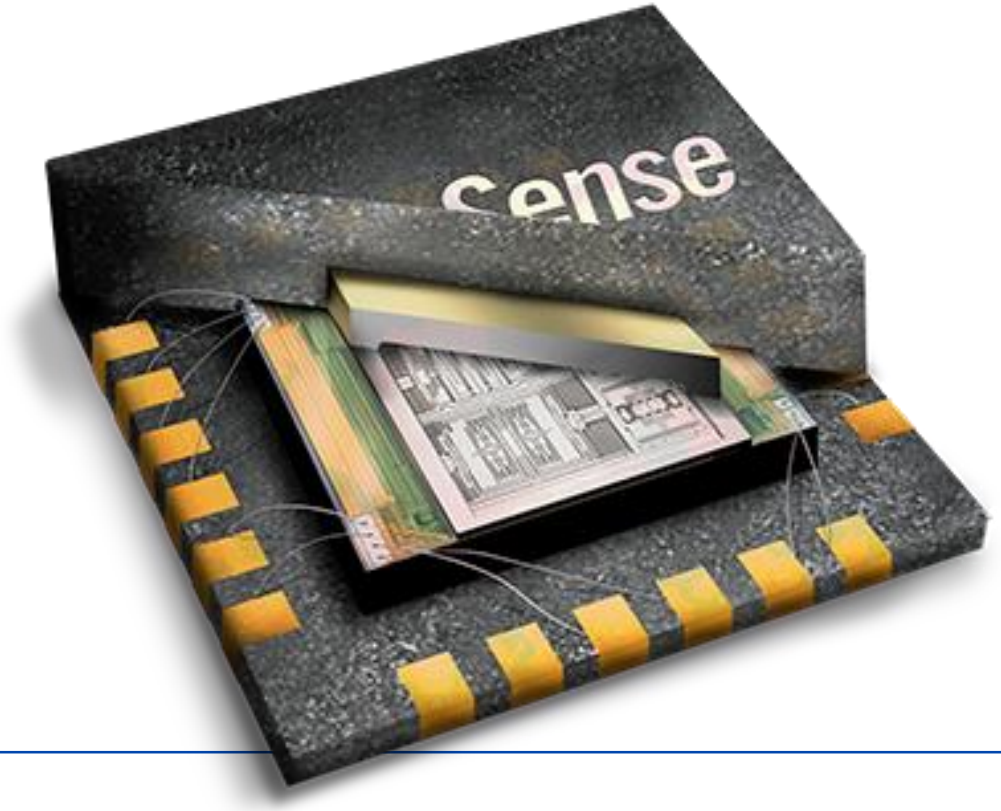
Jim Lin, Senior Software Manager, InvenSense

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

Welcome!!

TDK Developer’s Conference Develop Track

Goal: Introduce customers the Corona product line– TDK InvenSense Next Generation Motion Sensors



ICM-426xx CORONA$_{XLII}$: Premium Motion Sensors

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Performance Leadership
Unparalleled 6-axis Motion Sensor noise/sensitivity/stability

Leading OIS performance
due to low gyro/accel noise & sensitivity error, high temp stability, sample synch

Triple interface supports dual OIS
2 cameras for sharper images or clearer selfies (independent or fully synchronized)

CORONA$_{XLII}$

Low-light video stabilization
Sample synchronization enables higher frame rates and extended shutter times

Concurrent Sensor Usage
due to superior vibration rejection and separate signal path conditioning

High fidelity AR/VR performance
due to extended measurement range & resolution, plus high temp stability

Agenda

- **Introductions to TDK-InvenSense Motion**
  - Basics of Motion Technology
  - Applications of Motion
  - TDK-InvenSense Product Offerings
- **The Corona XLII Motion Sensors**
  - Target Improvements
  - Product Specifications
- **SmartMotion Evaluation Kits**
  - Quick introduction to SmartMotion
  - Evaluating Corona with MotionLink
  - The DK-42605
- **Wrap up**
  - Important Links to Support and further Information
  - Q and A

Presenters –

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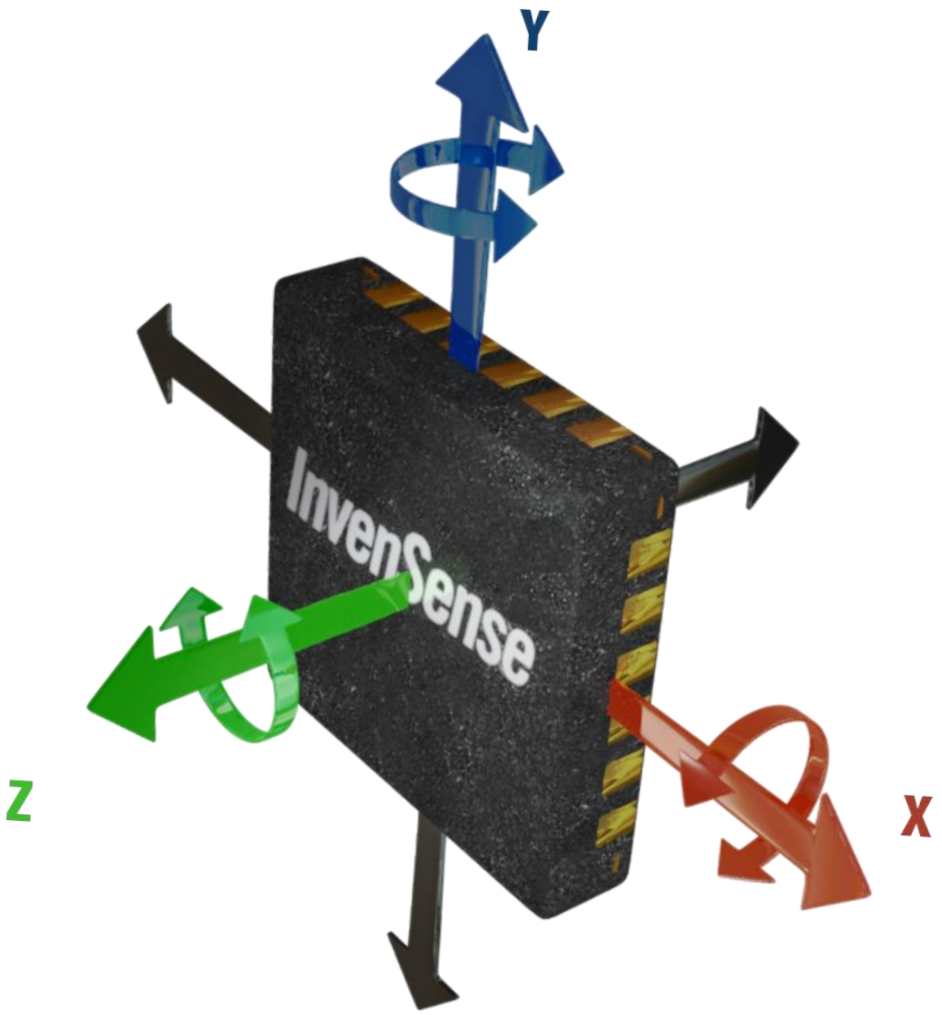
What is Motion?

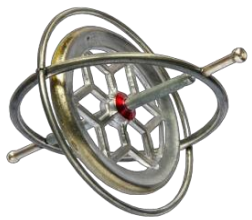
- Motion is full 6 degrees of freedom (DOF) processing that can precisely translate human motion for various applications
- Requires Gyroscopes and Accelerometers



Sensors Summary

Gyroscope

- Measures rate of angular rotation (dps)
- Gyroscope full scale range typically goes up to ±2000dps



Accelerometer

- Measure acceleration or change in linear velocity
- Measured in g or in m/s^2 ($1g = 9.81\ m/s^2$)
- Accelerometer full scale range typically goes up to ±16g

Compass

- Measures magnetic fields
- Prone to magnetic disturbance

Pressure

- Measures atmospheric air pressure
- Prone to air and temperature disturbance

Gyroscopes & Accelerometers – Critical Device Specs

- **Offset**
  - The gyro output for zero rate input rotation (device not moving) and the accel output value for zero-g input acceleration at nominal Vdd and temperature.

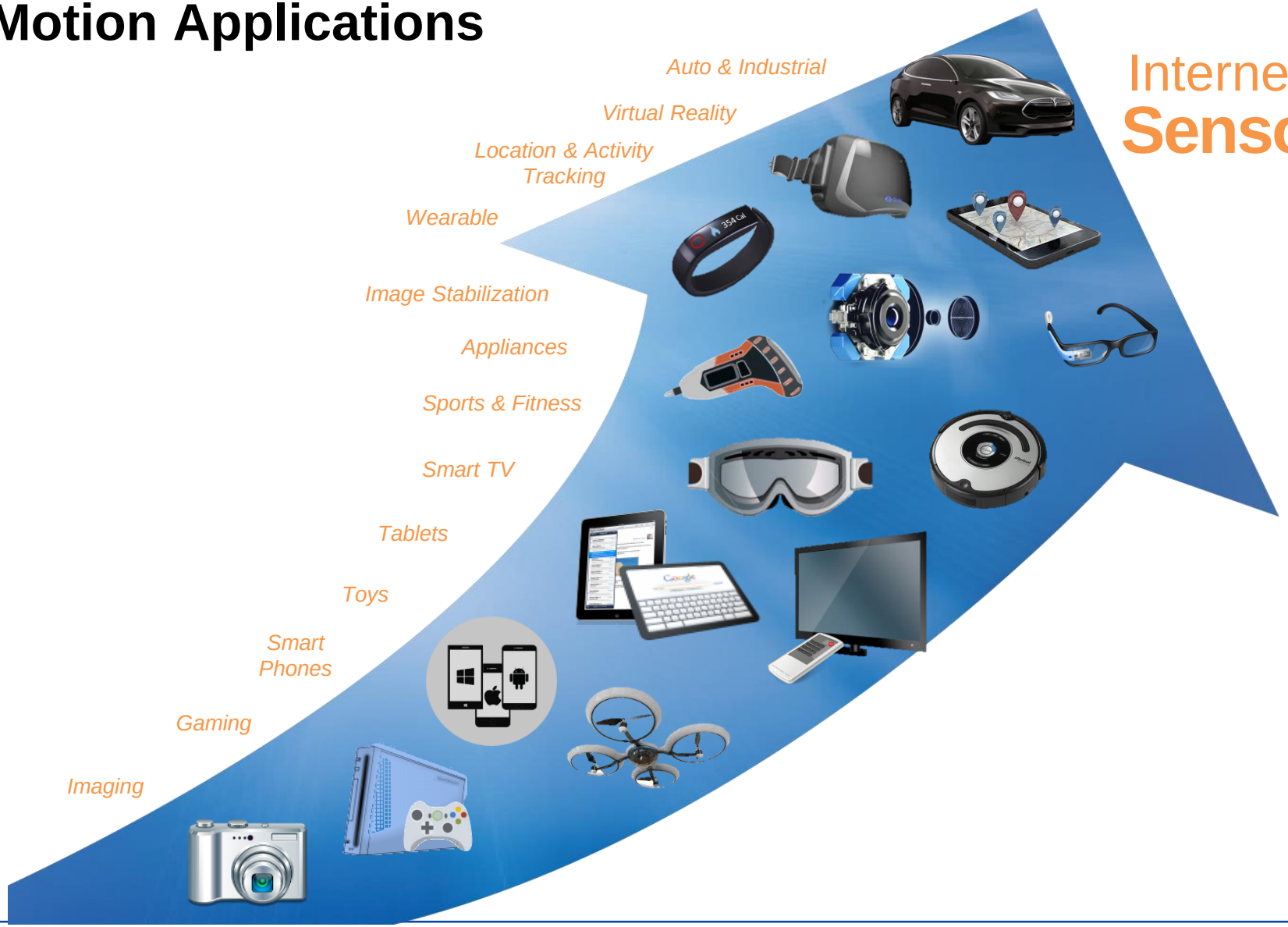
- **Full-Scale Range**
  - This parameter defines the measurement range of the gyroscope in degrees per second (dps) and accelerometer in (g).
  - When the applied angular velocity and the applied linear acceleration is beyond the full-scale range, the gyroscope and accel output signal will be saturated.

- **Offset vs. Temperature**
  - The maximum change in the gyro and accel offset over the full operating temperature range (Typically -40 deg C to +85 deg C).
  - The closer to zero and the more linear, the better.

- **Sensitivity**
  - Gyroscope: The output change per unit of input rotation at nominal Vdd and temperature, measured in LSB/deg/sec.
  - Accelerometer: The output change per unit of input acceleration at nominal Vdd and temperature, measured in LSB/g.

- **Noise Density**
  - When multiplied by the square root of the measurement bandwidth, this value will give the rms noise of the sensor at nominal Vdd and temperature.
  - Rotations and accelerations below this value will not be resolvable.

MEMS Motion Applications



Internet of
Sensors

Motion Sensor Product Portfolio

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Motion, Pressure & Combo Sensors

Current Channel Products

ICM-20648
- **6-axis (w/sensor fusion)**
- 3x3x0.9mm
- in MP
- IoT/Wearables

ICM-20948
- **9-axis (w/compass)**
- 3x3x1mm
- in MP
- Navigation, IoT

ICM-20690
- **Dual-Interface: 6-axis UI+OIS**
- 2.5x3x0.9mm
- in MP
- Smartphones, Imaging

ICM-20602
- **Single-Interface: 6-axis UI**
- 3x3x0.75mm
- in MP
- VR/Game controllers

ICM-20789
- **7-axis (w/pressure sensor)**
- 4x4x1.365mm
- in MP
- Wearables, Drones, IoT

ICM-20600
- **Single-Interface: 6-axis UI**
- 2.5x3x0.91mm
- in MP
- Smartphones

ICP-101xy
- **1-Axis pressure**
- 2x2x0.72mm
- in MP
- Smartphones, Drones, IoT

Upcoming Corona XLII Offerings

ICM-42605
- *Next Gen 6-Axis Flagship*
- Further improved Gyro/Accel performance
- I3C Support
- APEX Motion Engine
- 2.5x3x0.9mm
- MP: 1H 2019

ICM-42686
- *Highest range* Gyro/Accel
- Further improved Gyro/Accel performance
- 18-bits(Accel),19-bits (Gyro) output option
- I3C Support
- APEX Motion Engine
- 2.5x3x0.9mm
- MP: 1H 2019

ICM-42688
- *Highest precision* Gyro/Accel
- Further improved Gyro/Accel performance
- 18-bits(Accel),19-bits (Gyro) output option
- I3C Support
- APEX Motion Engine
- RTC Input
- 2.5x3x0.9mm
- MP: 1H 2019

Note: Color coded chips are from *same product family.* 2.5x3mm packages are pin & register compatible; different packages are register compatible.

Navigation

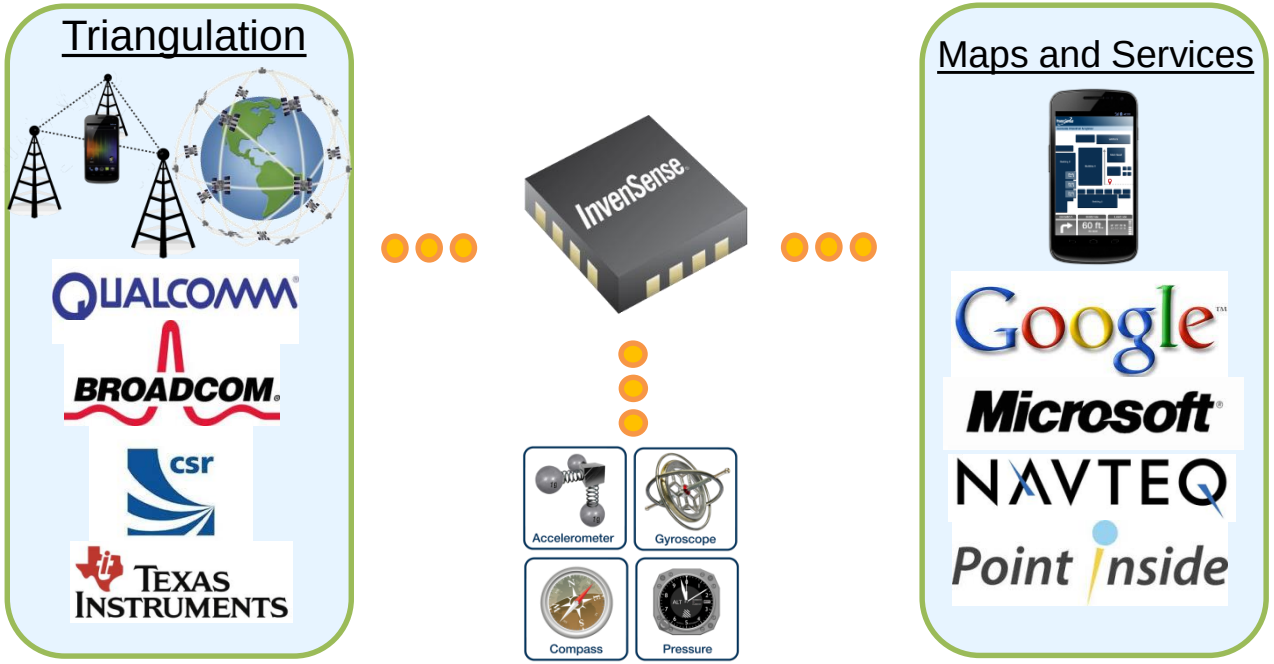
Navigation

Outdoor Navigation:

- GPS + Compass is common (<10m accuracy)
- Motion Sensors help when GPS is lost

Indoor Navigation:

- No GPS, WiFi triangulation for 10-30m accuracy
- Motion Sensors provide 1-10 meter accuracy
- Pressure Sensor: Which floor?



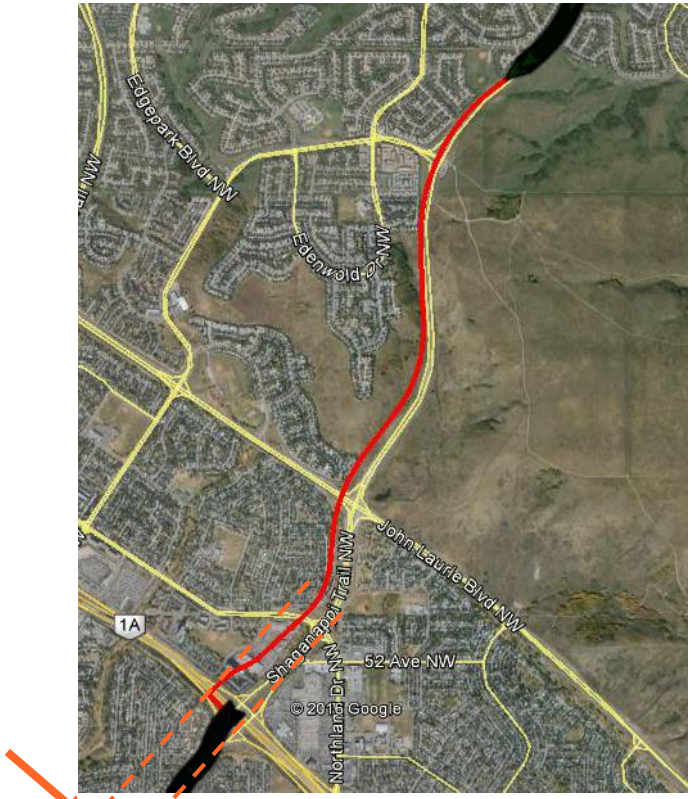
Navigation Errors from Sensor Specs

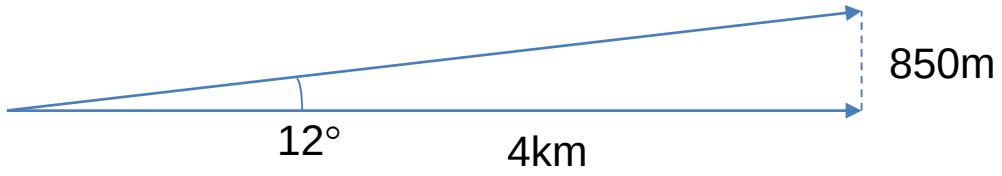
- Relative contributions from various Sensor Specs to Navigation Errors
- Accel and Gyro Offset are biggest error contributors in this example
  - Important to compensate for offset in system

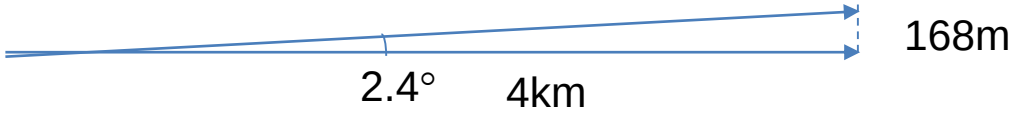
Sensor Spec	Example Spec Value	Velocity Error	Position Error
Accel Offset	40mg	3.92m/s	19.6m
Accel Sensitivity	1%	0.98m/s	4.9m
Accel Noise	0.75mg-rms	0.074m/s	0.37m
Gyro Offset	0.5dps	4.28m/s	14.3m
Gyro Sensitivity	0.5%	2.6m/s	8.6m
Gyro Noise	0.038dps-rms	0.32m	1.08m

Navigation Error Example

- Gyro bias temperature stability: 0.05dps/°C (BMI160)
- Temperature change of 1°C on entering 4km tunnel
- No GPS in tunnel to correct navigation errors
- Driving speed: 60km/hr
- Driving time in tunnel: 240sec
- Max error due to gyro bias temp stability: 0.05*240 = 12°
- Position Error: 4km*tan(12°) = 850m
- If Gyro bias temperature stability: 0.01dps/°C (ICM-426xx)
  - Max angle error: 2.4°
  - Position Error: 4km*tan(2.4°) = 168m







HMD & AR/VR

HMD & AR/VR

HMD & Controller

Mobile AR/VR Gaming

- HMD & Controller may require different capabilities from motion sensors
- Controller may require fast motion detection (high FSR such as ±4000dps) for high speed games

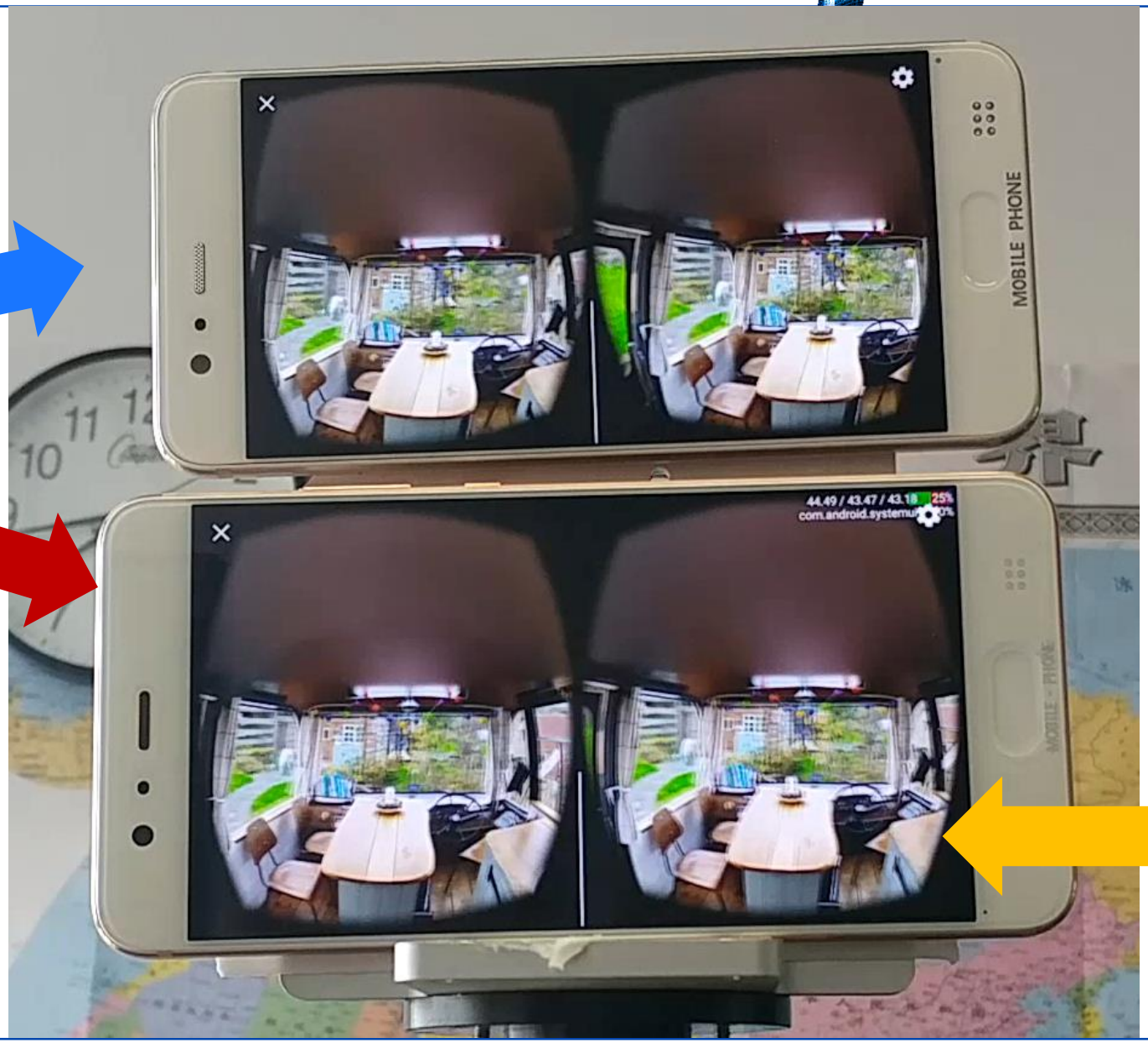
- Mobile gets hot because GPS, AP/Graphics, Display on 100%
- Stable gyroscope performance over temperature is critical
- **User Experience:** Objects won't drift over camera scene as temperature increases

Impact of Gyro Temp Drift

Two Smartphones with identical PCB:

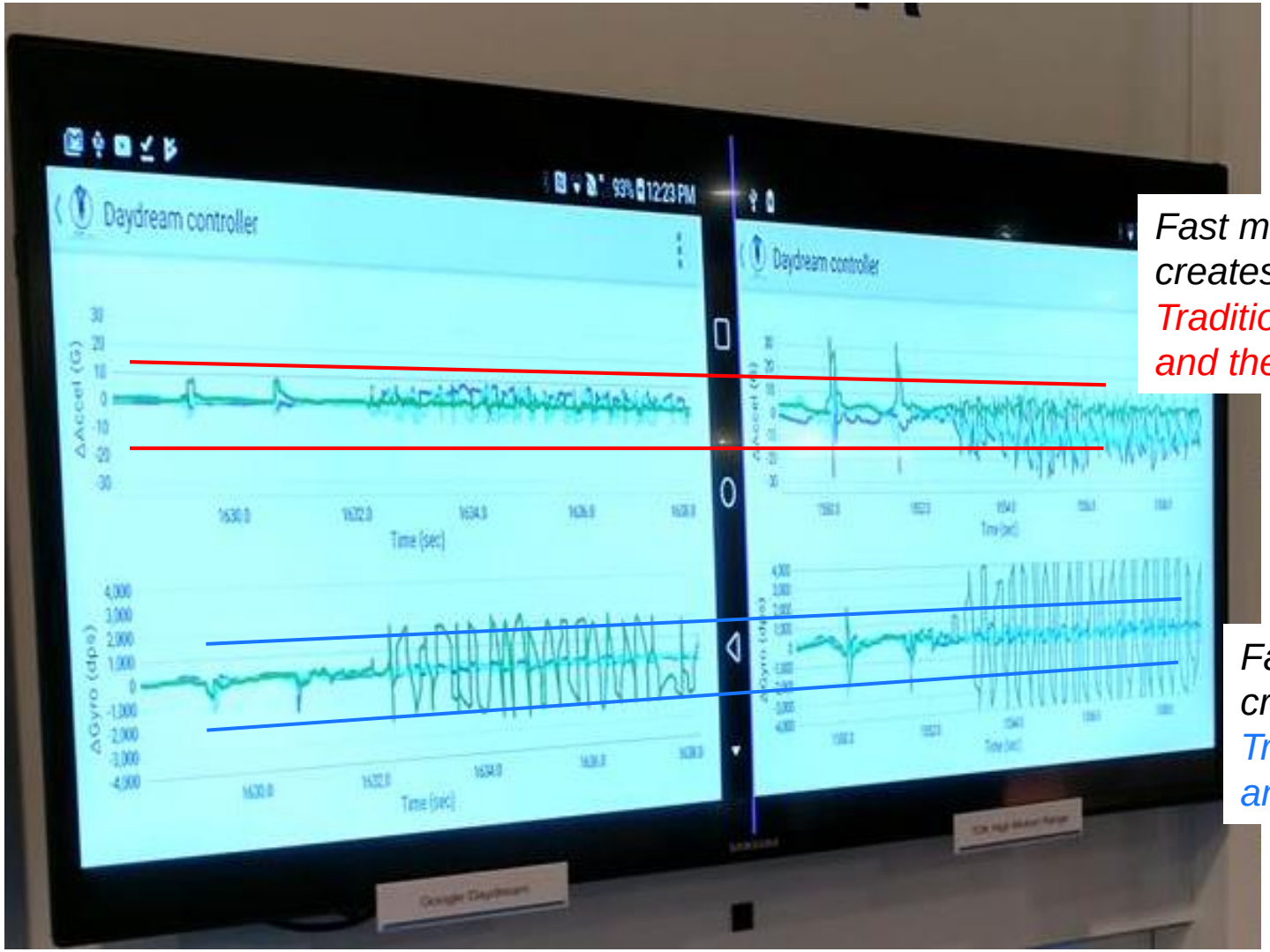
- P10 above with TDK ICM-20690
- P10+ below with ST LSM6DSM

Drift test proves poor temperature offset stability of ST Gyro which shows significant drift of the entire image



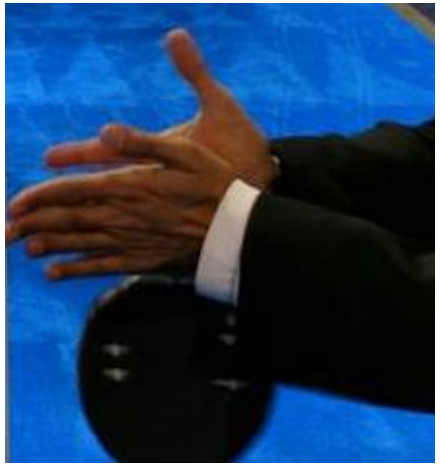
Who knew there is a sink here ?

CORONA ICM-42686: Designed for VR Controllers



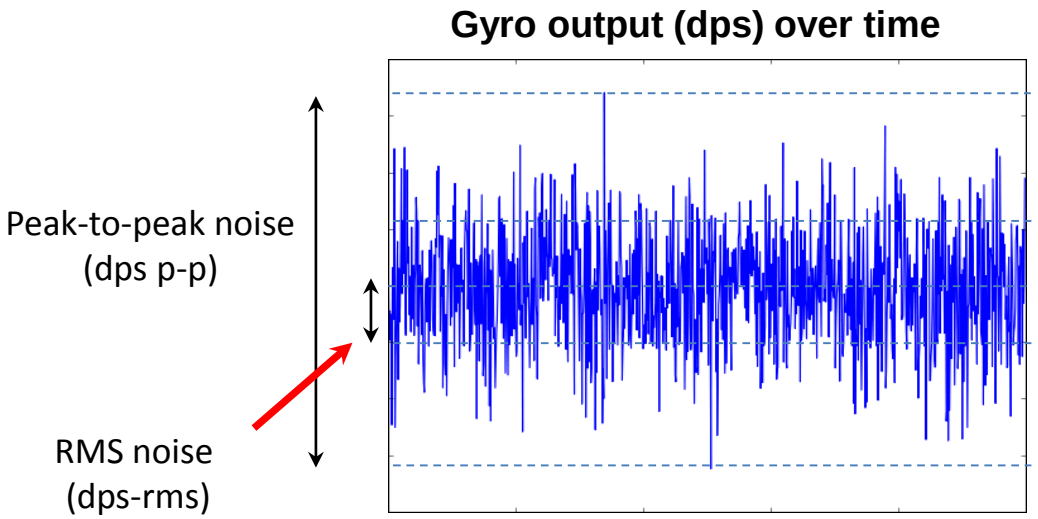
Fast movement easily creates acceleration >16g
Traditional 6-axis saturate and the game is over

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



Gyroscope Noise Error

- Gyroscope Noise is another source of angle error



Theory: Angle error (°) = Time (s) x Noise (dps-rms)

Use Case: Assuming video watching of 2 minutes

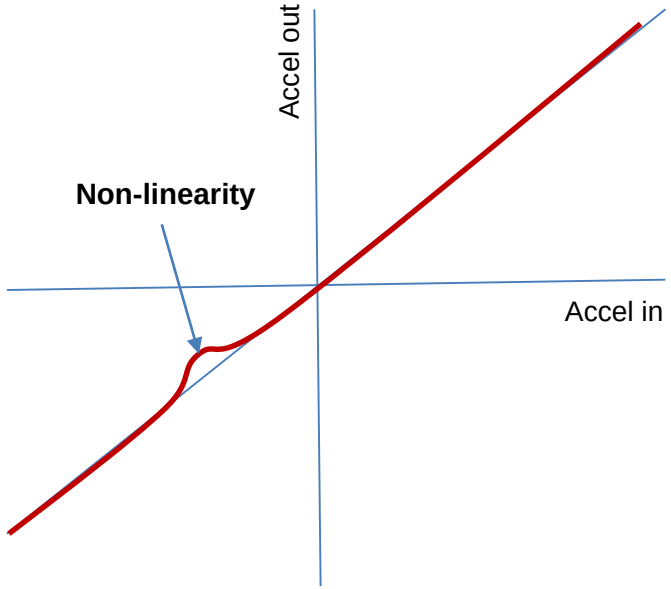
Angle error (°) = 2 * 60 (s) x Noise (dps-rms)

BMI055		ICM-42688	
Spec (dps-rms)	Error (°)	Spec (dps-rms)	Error (°)
0.1	12	0.028	3.4

- **Angle error from Gyroscope Noise is 3.5 times smaller with *TDK ICM-42688***

Accelerometer Nonlinearity Error

- Non-linearity is defined as the maximum deviation of the output response from a best fit line (- range to +range) expressed as a percentage of Full Scale Output (FSO)
- Accel Nonlinearity errors will introduce position estimation errors



Theory: Position error (m) = 1/2 * acceleration (m/s^2) * Nonlinearity * time(s) ^{2}

Use Case: Assuming tracking VR Controller position for 2 sec.

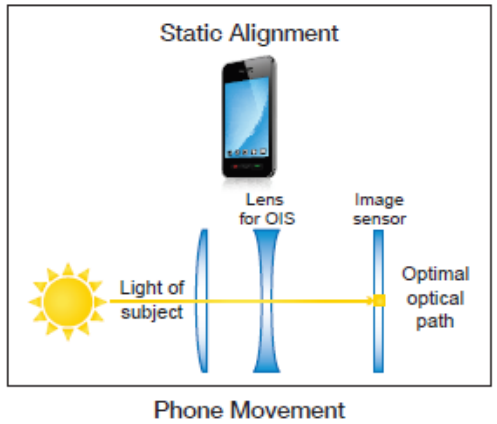
Position error (m) = 1/2 * 9.8(m/s^2) * Nonlinearity * 4

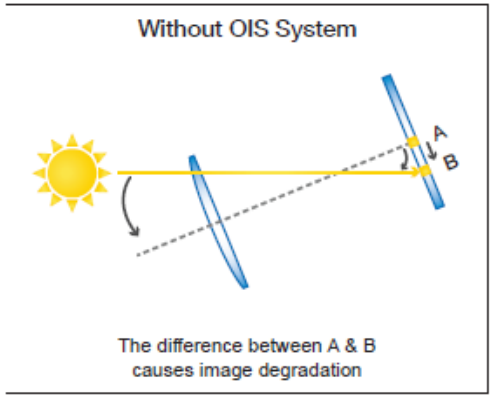
BMI055		ICM-42688	
Spec (%FS)	Error (cm)	Spec (%FS)	Error (cm)
0.5	9.8	0.1	1.96

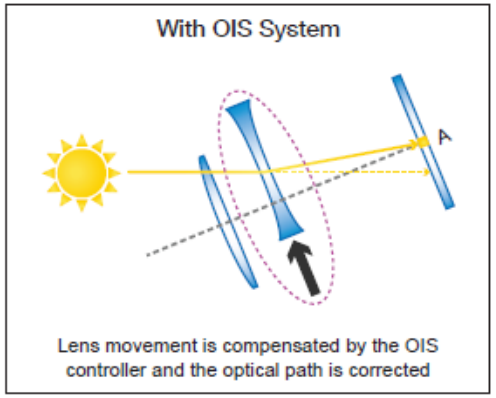
- **Position error from Accel Nonlinearity is 5x lower with TDK ICM-42688**

Optical Image Stabilization (OIS) for Still Images

OIS Basics







OIS action: **sun goes down** **lens shifts up**

- Optical Image Stabilization:
  - ¬ Extended image exposure allows more light to reach every pixel of the image sensor, leading to more vivid pictures
  - ¬ In hand-held (aka Smartphone) photography keeping the shutter open longer risks creating picture blur due to hand jitter
  - ¬ With OIS an OIS controller uses the Gyro measured camera movement to adjust the lens position (shift or tilt) to counteract the physical movement and keep the shutter open longer

Smartphone with and without OIS

Without OIS

With OIS

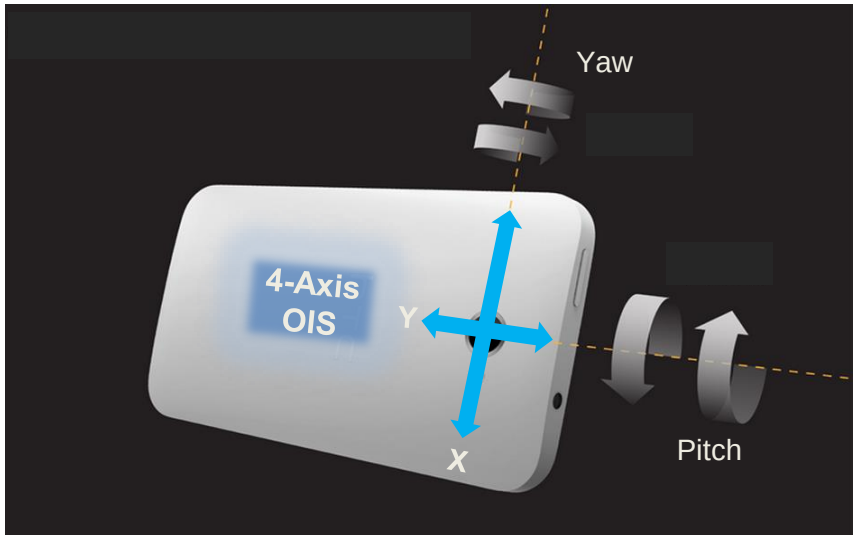
Smartphone with and without OIS (Sh

Without OIS

With OIS

OIS Market Trends

- "Main Board" OIS
  - Single motion sensor for UI and OIS
  - Replacing dedicated OIS motion sensors
  - Dual-interface motion sensors (ICM-20690, ICM-40602)
- Dual OIS support for multi-camera phones
  - iPhone X, Samsung Galaxy S9, Note 8
  - Tripl-interface motion sensors (ICM-42600)
- 4-axis OIS compensates for rotation and linear motion
  - Xiaomi Mi6



CORONA: Smartphone Imaging Leadership

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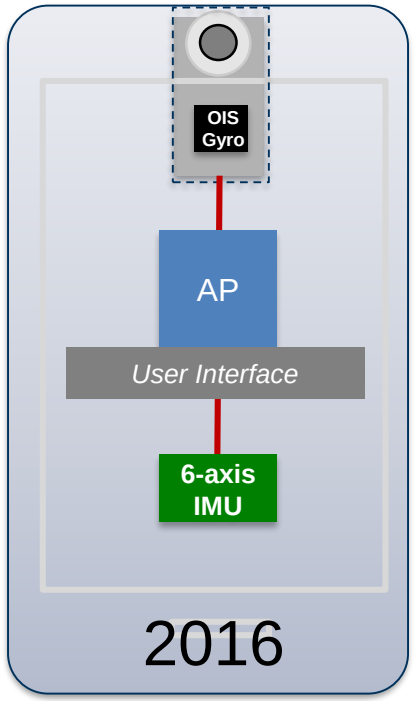
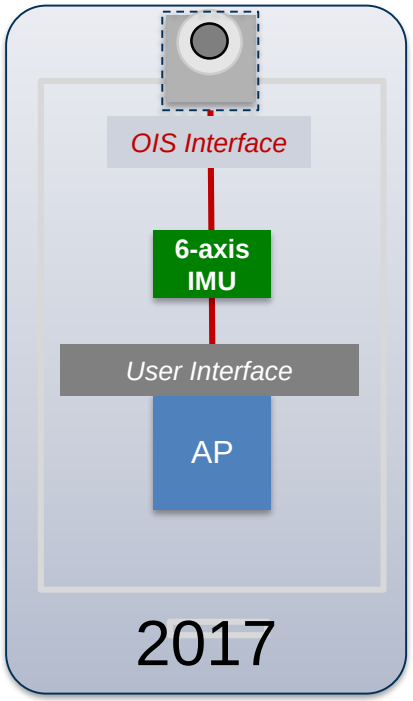
$CORONA_{XX}$
Industry's leading 6-axis Sensor & first dual UI/OIS



Dedicated Gyro for OIS & UI Application

ICM-20602

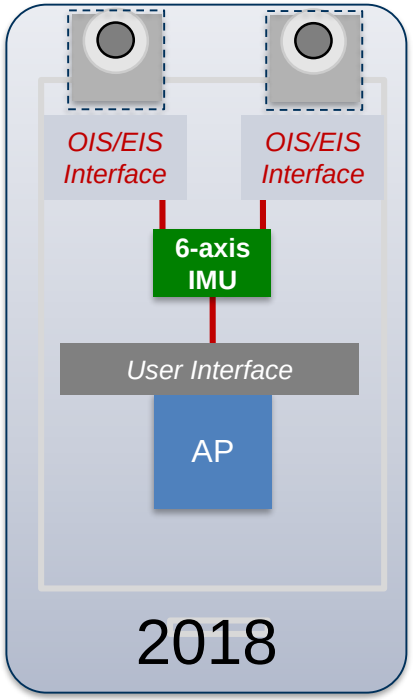
$CORONA_{XL}$
Industry leading 6-axis performance with UI & OIS



Single Gyro for OIS & UI Application

ICM-20690 & 40602

$CORONA_{XLII}$
Industry leading AR/VR performance with UI & dual OIS



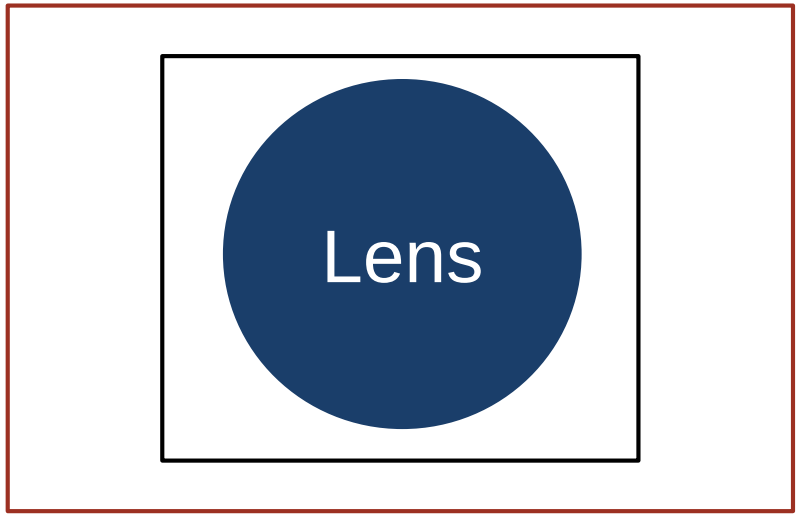
Single Gyro for dual-OIS & UI Application

ICM-426xx

Electronic Image Stabilization (EIS) for Video

EIS Basics

Main-board Gyroscope

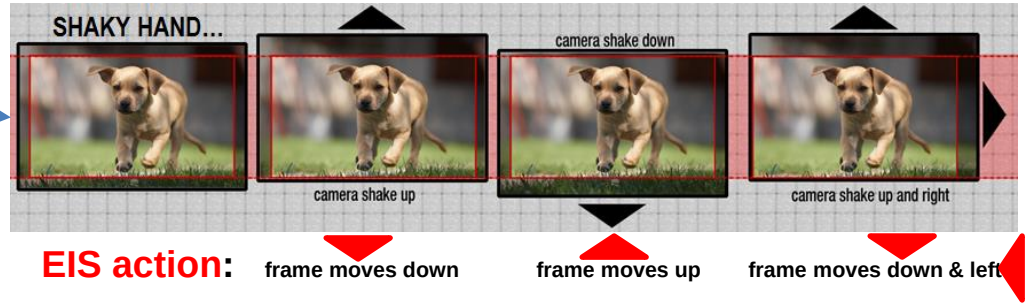


EIS avoids choppy video recordings by moving a target frame inside the full frame

- "fixed frame"

GYRO (up to 8kHz)

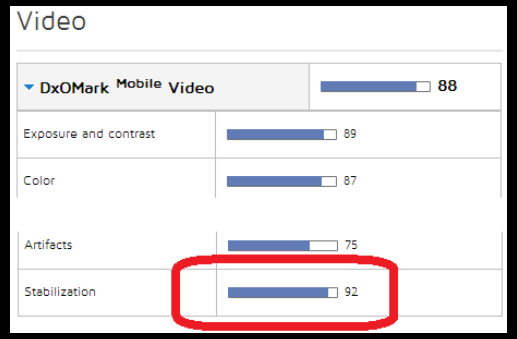
EIS Frame Shift Algos



- EIS processing: frame-to-frame displacement of the object due to camera shake
- Uses gyro output to shift the target frame in the Application Image Signal Processor

TDK EIS Video Image Stabilization

TDK video stabilization gets highest DXO Mark!



No EIS

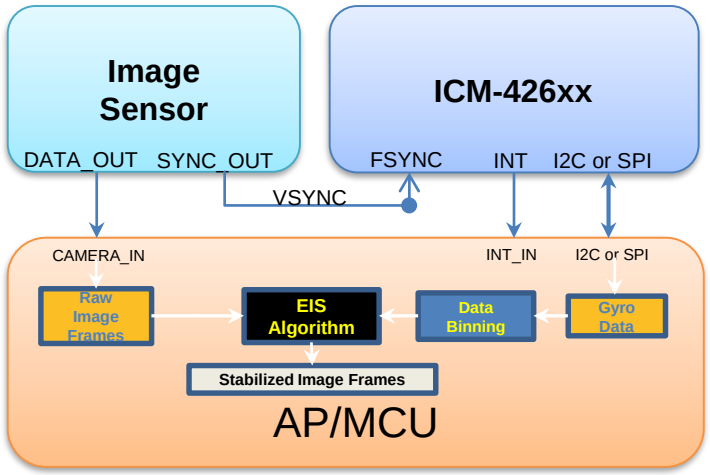
TDK INVN EIS

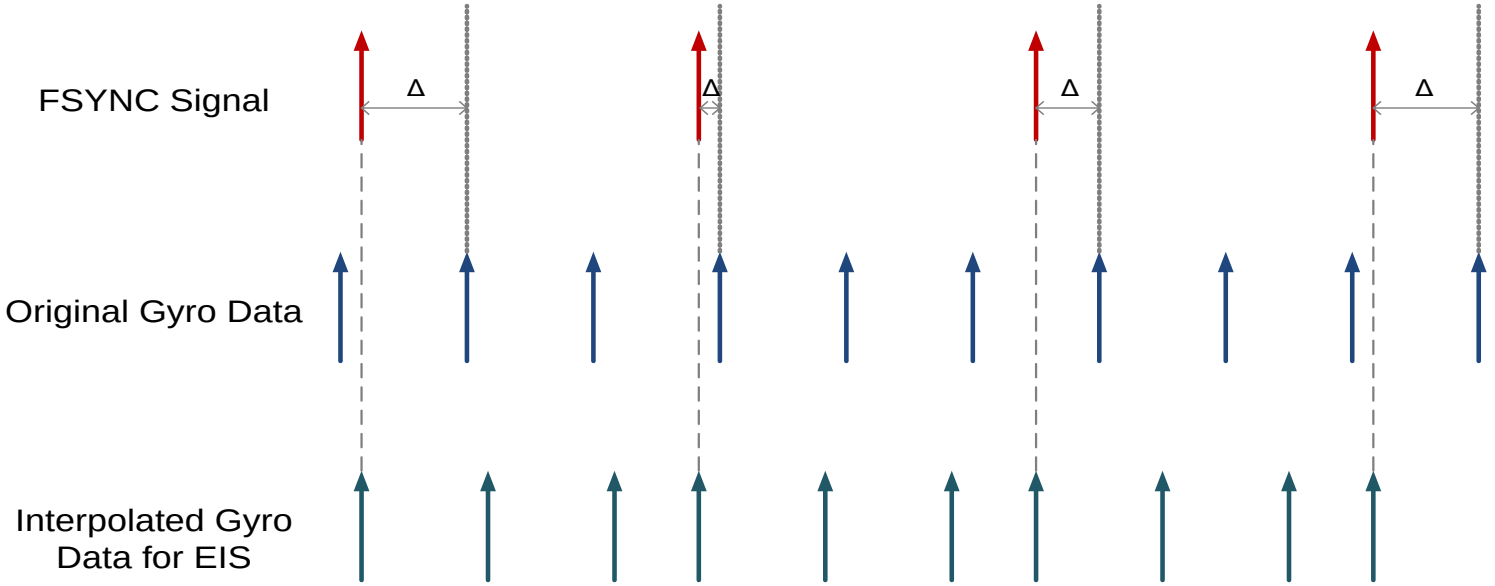
SONY Xperia

TDK has highest Score of Stabilization on DXOMARK THE REFERENCE FOR IMAGE QUALITY Rank

CORONA devices offer unique features for EIS

- **Frame Sync (FSYNC) signal to align motion data with video frames**
- **ODR delay counter to store delay between FSYNC and next gyro sample**
- **Host can read Δ from FSYNC ODR Delay Counter and use it to create interpolated gyro data for EIS**
  - **Interpolated gyro data has better alignment with FSYNC than original gyro data**
  - **Results in more accurate EIS performance**





Other Applications

Sports

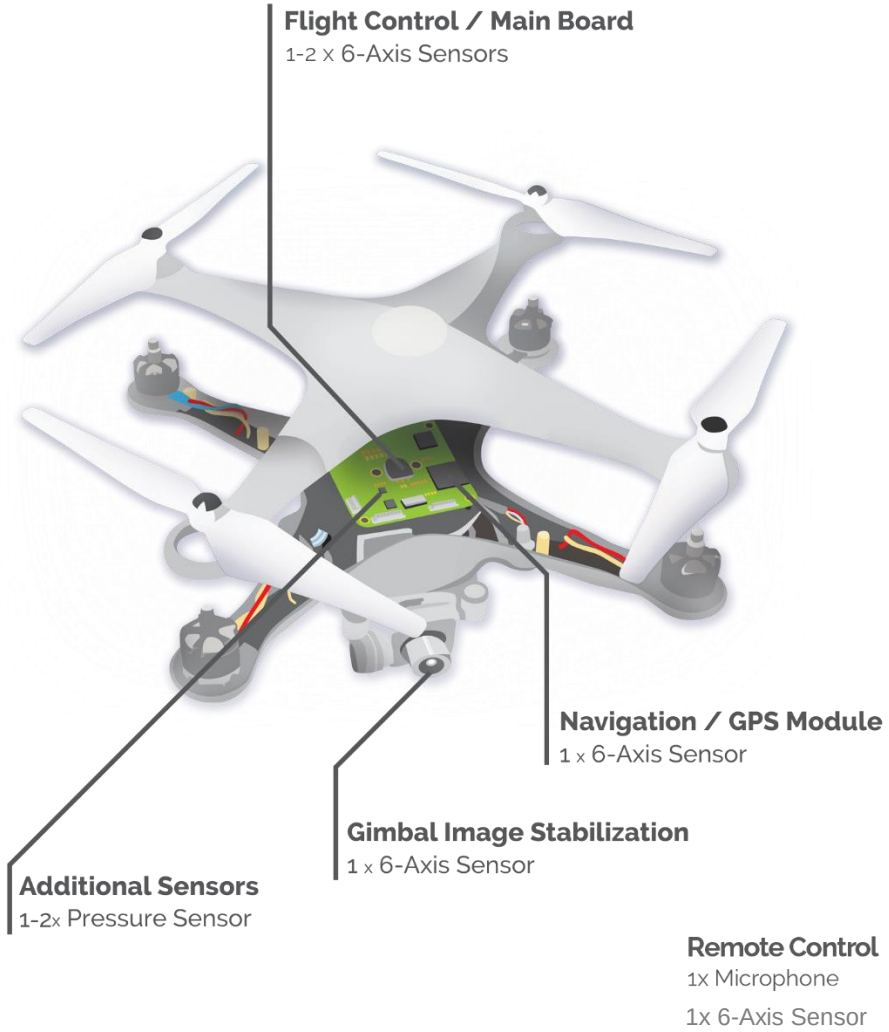
- Swing Analysis:
  - ¬ Golf, baseball, tennis, cricket etc.
  - ¬ 6-axis motion sensor embedded in golf club, bat
  - ¬ Motion sensor tracks player's swing and sends data to computer/smartphone application
  - ¬ Application analyzes player's swing and provides feedback for improvement
- Other sports examples:
  - ¬ Ski motion analysis
  - ¬ Motion sensor in soccer ball to track ball motion during game
  - ¬ Biking: Wheel mounted motion sensor monitors applied forces – used to control suspension system
  - ¬ Archery: Arrow mounted motion sensor measures arrow's flight characteristics and impact ballistics data

TDK-InvenSense Solution: ICM-20649/ICM-42686 for industry leading accuracy

Drones

- Vertical stabilization camera takes an image of the ground every 16 milliseconds and compares it to the previous one to determine the speed of the drone
- Ultrasound sensor analyzes the flight altitude up to 16 feet
- Pressure sensor measures air pressure and analyzes fight altitude beyond 16 feet
- 3-axis gyroscope measures the bank angle of the drone
- 3-axis accelerometer measures the positioning of the drone on 3 axes and its linear speed
- 3-axis magnetometer helps define the position of the drone
- Microphone captures audio as part of media recording
- Global Navigation Satellite System (GNSS) chipset (GPS + GLONASS) geo-localize the drone and help measure the speed in order to stabilize the drone in high altitudes
- Drone controller with gyroscope + accelerometer; microphone to record commentary

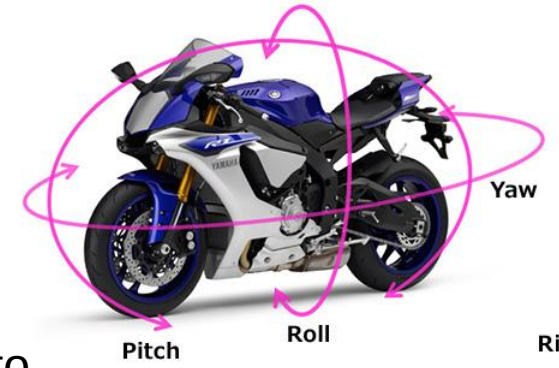
* *Items in blue are sensors provided by TDK-InvenSense*



TDK-InvenSense Solution: ICM-20789 6-axis + pressure sensor

e-Scooters, Bikes, Hoverboards

- 6-axis motion sensor measures
  - Acceleration in the forward-backward, up-down and right-left directions
  - Angular velocity in the vehicle's pitch, roll and yaw directions
  - Calculates and relays position information in real-time to the bike's systems to control the engine and chassis behavior to assist the rider
- Safety: Shuts off engine on fall detection
  - Minimizes rider drag/injury
- Hoverboard: Motion sensor used to control balance and speed



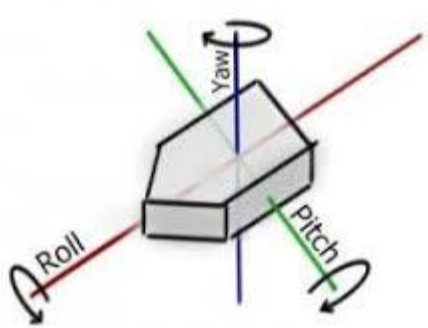
TDK-InvenSense Solution: ICM-20648 6-axis w/DMP for real time motion processing

Tools (Screwdrivers, Drills etc.)

- Motion sensor in tool senses the motion of user wrist
  - Changes direction and speed to help user tackle projects with ease
- Safety: Shuts off if tool jams in a hole
  - Normally, such an occurrence would twist the tool, and user wrists and arms.
  - Motion sensor detects when the drill is suddenly overburdened and turns off the motor

TDK-InvenSense Solution: ICM-42688 for industry leading accuracy

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

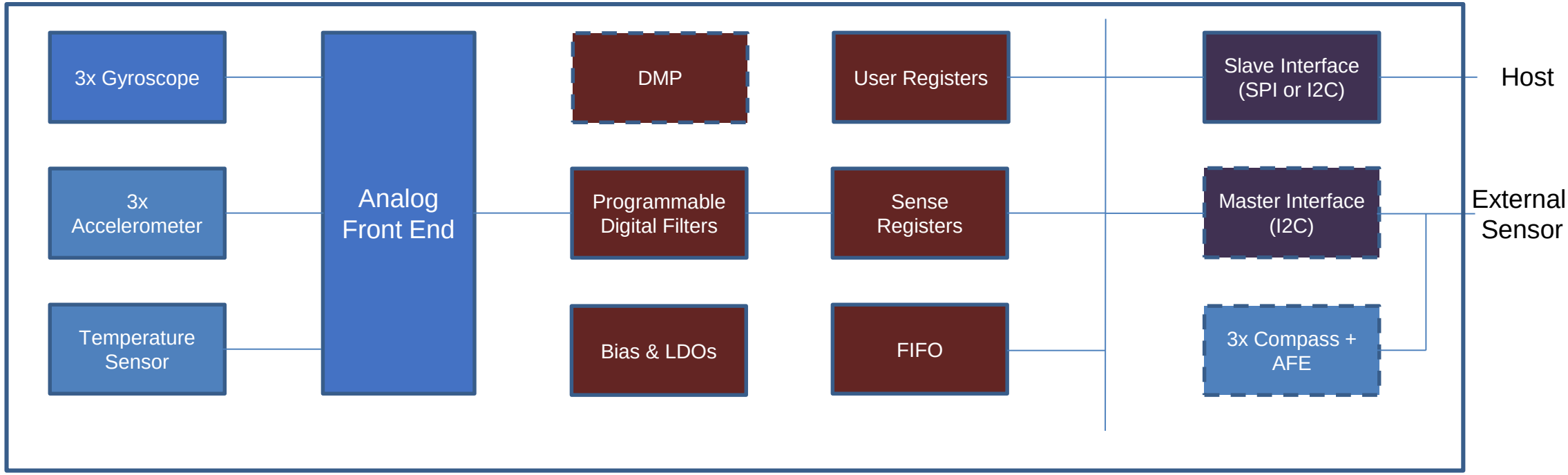
  - ¬ **Gyro Bias**
    - Yaw drift over an hour can be significant
    - This is caused by Gyro Bias
      - Every motion sensor has a non-zero Bias
      - Gyro Bias drifts over time and temperature (Robot can heat up by 20°C))

  - ¬ **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

Product Offerings

Motion Sensor Device



- Digital Filters: Programmable characteristics (bandwidth, noise, latency); Filters for Low Noise and Low Power Modes
- User Registers: User configuration parameters (device modes, FSR, ODR, filter selections); Interrupts status
- FIFO to store data for sending to Host in bursts – helps reduce system power by reducing frequency of host wakeup
- Slave Interface to Host: SPI or I2C
- Master Interface (I2C) for interfacing to external sensors. Bring data from external sensors on chip for fusion with on-chip data
- DMP: On-chip motion processor offloads motion processing from host

Motion Sensor Product Portfolio

HUMANIZING THE DIGITAL EXPERIENCE

Motion, Pressure & Combo Sensors

Current Channel Products

ICM-20648
- **6-axis (w/sensor fusion)**
- 3x3x0.9mm
- in MP
- IoT/Wearables

ICM-20948
- **9-axis (w/compass)**
- 3x3x1mm
- in MP
- Navigation, IoT

ICM-20690
- **Dual-Interface: 6-axis UI+OIS**
- 2.5x3x0.9mm
- in MP
- Smartphones, Imaging

ICM-20602
- **Single-Interface: 6-axis UI**
- 3x3x0.75mm
- in MP
- VR/Game controllers

ICM-20789
- **7-axis (w/pressure sensor)**
- 4x4x1.365mm
- in MP
- Wearables, Drones, IoT

ICM-20600
- **Single-Interface: 6-axis UI**
- 2.5x3x0.91mm
- in MP
- Smartphones

ICP-101xy
- **1-Axis pressure**
- 2x2x0.72mm
- in MP
- Smartphones, Drones, IoT

Upcoming Corona XLII Offerings

ICM-42605
- *Next Gen 6-Axis Flagship*
- Further improved Gyro/Accel performance
- I3C Support
- APEX Motion Engine
- 2.5x3x0.9mm
- MP: 1H 2019

ICM-42686
- *Highest range* Gyro/Accel
- Further improved Gyro/Accel performance
- 18-bits(Accel),19-bits (Gyro) output option
- I3C Support
- APEX Motion Engine
- 2.5x3x0.9mm
- MP: 1H 2019

ICM-42688
- *Highest precision* Gyro/Accel
- Further improved Gyro/Accel performance
- 18-bits(Accel),19-bits (Gyro) output option
- I3C Support
- APEX Motion Engine
- RTC Input
- 2.5x3x0.9mm
- MP: 1H 2019

Note: Color coded chips are from *same product family.* 2.5x3mm packages are pin & register compatible; different packages are register compatible.

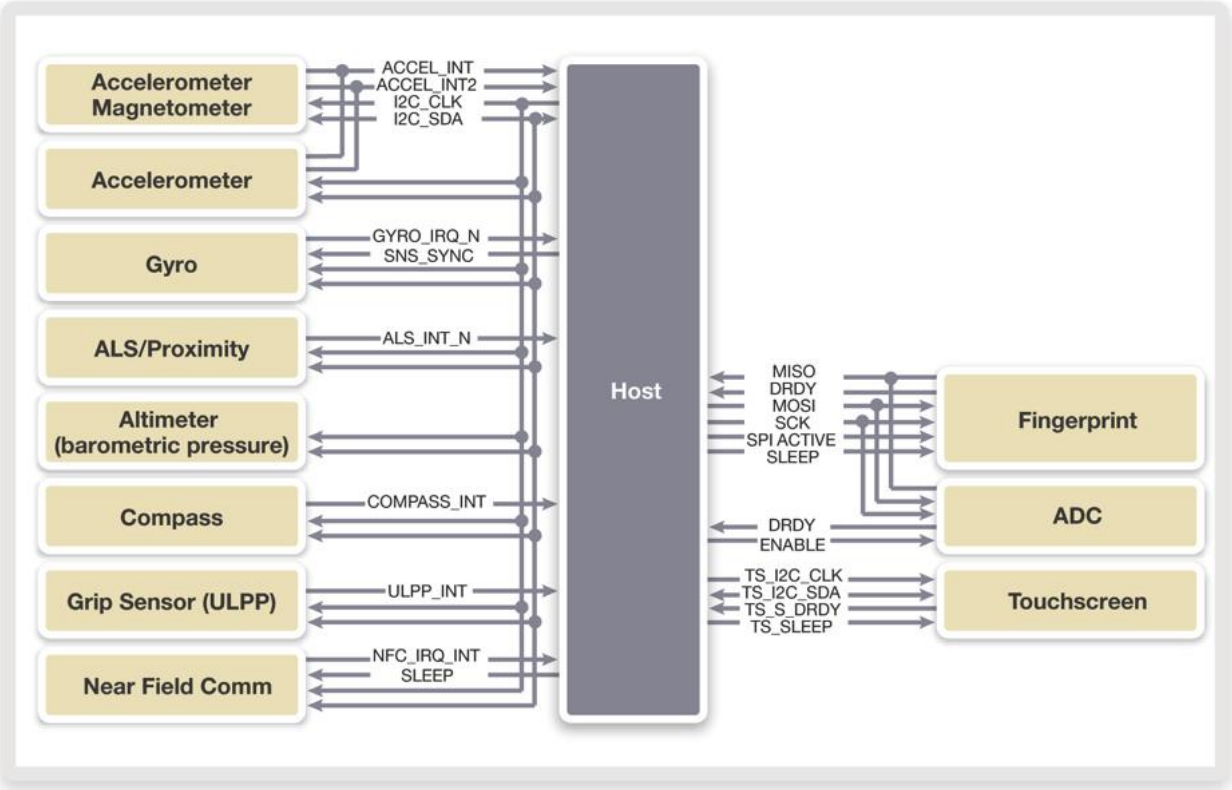
CORONA ICM-426xx Motion Sensors Specs

HUMANIZING THE DIGITAL EXPERIENCE

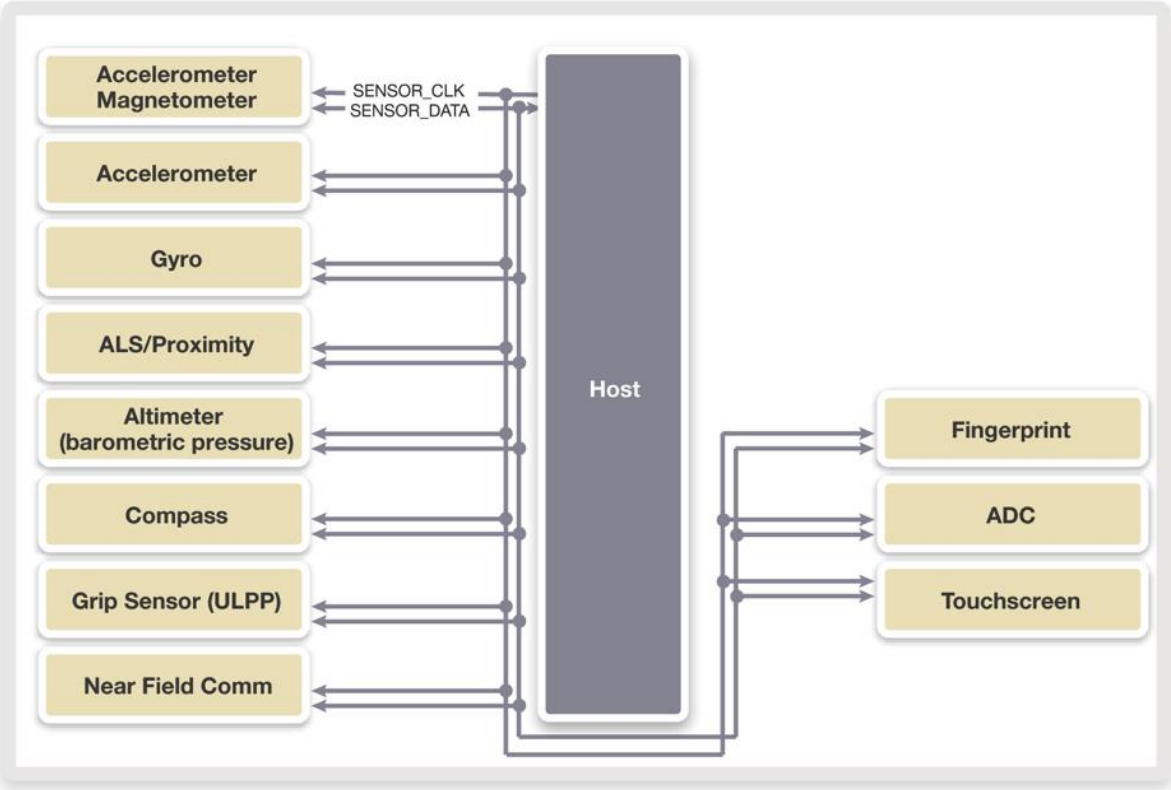
All products 2.5x3mm 14-pin LGA	Units	ICM-42605	ICM-42686	ICM-42688
Gyro FSR	dps	Up to ±2000	Up to ±4000	Up to ±2000
Gyro Offset	dps	±0.5	±0.5	±0.5
Gyro Sensitivity	%	±0.5	±0.5	±0.5
Gyro Noise	mdps/√Hz	3.8	5.8	2.8
Gyro Offset Over Temp	mdps/°C	±10	±10	±5
Gyro Sensitivity Over Temp	%/°C	±0.005	±0.005	±0.005
Gyro Non-Linearity	%	±0.1	±0.1	±0.1
Gyro Cross-Axis Sensitivity	%	±1	±1	±1
Gyro Current (Low Noise)	mA	0.57	0.57	0.77
Accel FSR	g	Up to ±16	Up to ±32	Up to ±16
Accel Offset (Board)	mg	±40	±40	±40
Accel Sensitivity	%	±0.5	±0.5	±0.5
Accel Noise	µg/√Hz	75	75	75
Accel Offset Over Temp	mg/°C	±0.15	±0.15	±0.15
Accel Sensitivity Over Temp	%/°C	±0.007	±0.007	±0.007
Accel Non-Linearity	%	±0.1	±0.1	±0.1
Accel Cross-Axis Sensitivity	%	±1	±1	±1
Accel Current (Low Noise Mode)	mA	0.24	0.24	0.32
6-Axis Current (Low Noise)	mA	0.72	0.72	0.97
Interfaces		SPI/I2C/I3C	SPI/I2C/I3C	SPI/I2C/I3C
Motion Functions		WoM, Pedo, Gestures	WoM, Pedo, Gestures	WoM, Pedo, Gestures
FIFO Size	Kbytes	2	2	2

I3C Overview and Benefits

One Bus to Rule Them All! (all sensor connections at least)



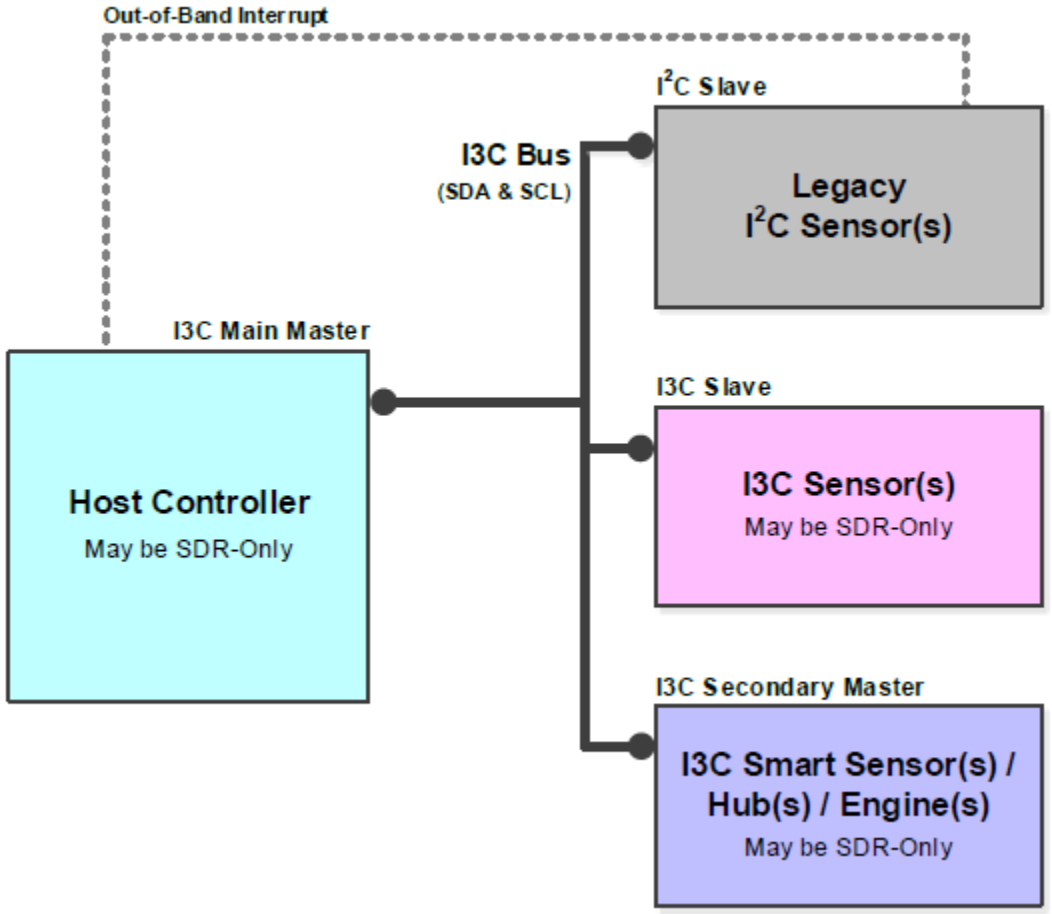
Multi-interface Sensor System (Source: MIPI Alliance)



Single-interface I3C Sensor System (Source: MIPI Alliance)

- I3C provides a simplified interconnect with abundant throughput and in-band-interrupts

Typical System and Sensors Supported



I3C System Diagram (Source: MIPI Alliance)

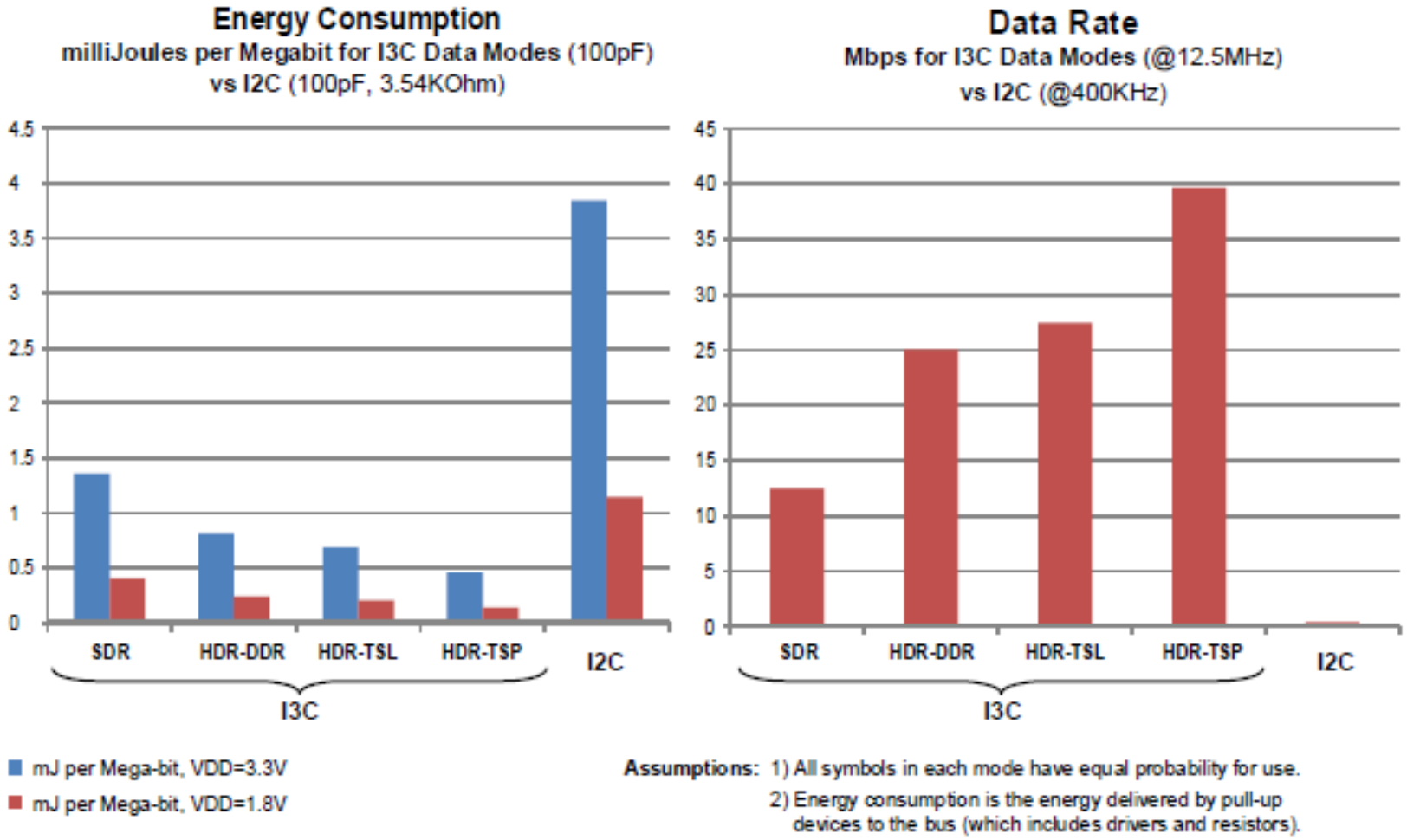
Mechanical / Motion	Biometrics/Health
• Compass/Magnetometer • Gyro • Accelerometer • Proximity • Touch screen • Grip • Time of Flight (gestures) • Audio/Ultrasonic (events)	• Fingerprint • Glucometer • Heart rate • Olfactory (e.g. breathalyzer) • EKG • GSR (galvanic skin response)
Environmental Sensing	**Other**
• Ambient light • Barometric pressure / altimeter • Temperature • Carbon monoxide / pollutants • Humidity	• NFC (Near Field Communication) • Haptic feedback • IR (smart TV remote) • UV/RGB

Sensor Classes Addressed by I3C (Source: MIPI Alliance)

I3C Key Features/Advantages

- Two goals of the I3C interface:
  - Use as little energy as possible in transporting data and control
  - Reducing the number of physical pins used by the interface
- I3C interface features:
  - Two wire serial interface up to 12.5 MHz (legacy I2C supports up to 3.4 MHz)
  - Legacy I2C Device co-existence on the same Bus
  - Dynamic Addressing while supporting Static Addressing for Legacy I2C Devices
  - I2C-like Single Data Rate messaging (SDR)
  - Optional High Data Rate messaging Modes (HDR)
  - Multi-Master capability
  - In-Band Interrupt support

I3C vs. I2C: Power and Data Rate Comparison



I3C vs. I2C Energy and Data Rate Comparison (Source: MIPI Alliance)

APEX Motion Engine

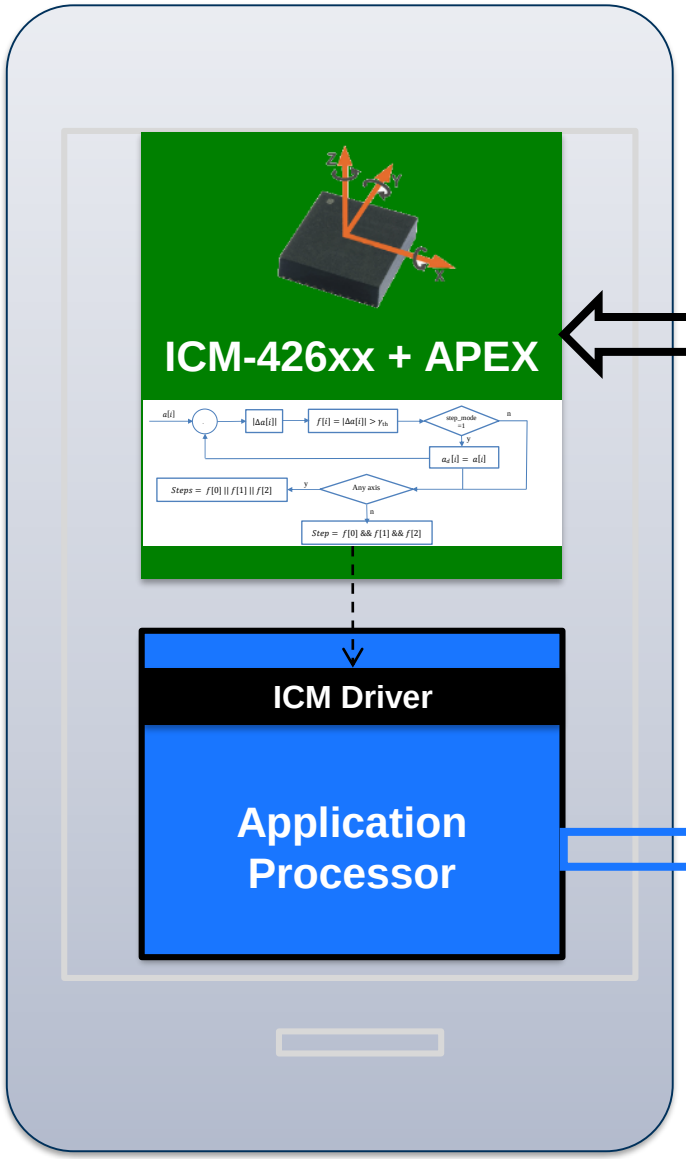
APEX Motion Engine

- Pedometer
  - Step Detect + Step Count
  - Supports all key WeChat requirements
  - Lowest in-class false positives for biking and transportation
  - Below 5% step count error on average for typical walk and run
  - Interrupts for Step Detect and Step Count Overflow
- Tilt Detection
  - Issues an interrupt when the Tilt angle exceeds 35° for more than a programmable time
- Tap Detection
  - Issues an interrupt when Tap is detected
- Wake on Motion
  - Detects motion through accel samples exceeding a programmable threshold
  - Can be used to enable chip operation from sleep mode
- Significant Motion Detection
  - Detects motion if WoM events are detected during a programmable time window (e.g. 2s or 4s)
- Raise to Wake/Sleep
  - Gesture detection for wake and sleep events.
  - Interrupt is issued when either of these two events are detected.

APEX: **A**dvanced **P**edometer and **E**vent detection – ne**X**t gen

Pedometer

- Fully configurable 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 Pedometer that also reports
  - ¬ Cadency (number of samples/step)
  - ¬ Walk/run classification



Validated APEX Sensor Positions

Motion Library: Examples (Offered in Binary)

Activity
Pedometer (SW & HW)
Basic Activity Classifier
Sit & Stand
Tilt
Significant Motion Detect
Energy Spent
High Impact, Shock Detect
Stationary/Motion Detect
Stairs/Floors climbed Count

Gaming
(Game) Rotation Vector
GeoMag Rotation Vector
Rotational Shake
Gravity, Linear Acceleration

Calibration
Gyro Bias Tracker (In motion)
Gyro Bias with No Motion (FNM)
Accel Bias (in motion)
Mag Cal …

Phone
Screen Orientation
Phone on Ear Position Detect
Rotational Shake
Pick up
Double Tap
Look At Screen
High Impact, Shock Detect
Stationary/Motion Detect
Stairs/Floors climbed Count
Pick Up and Put Down

The SmartMotion Evaluation Kits

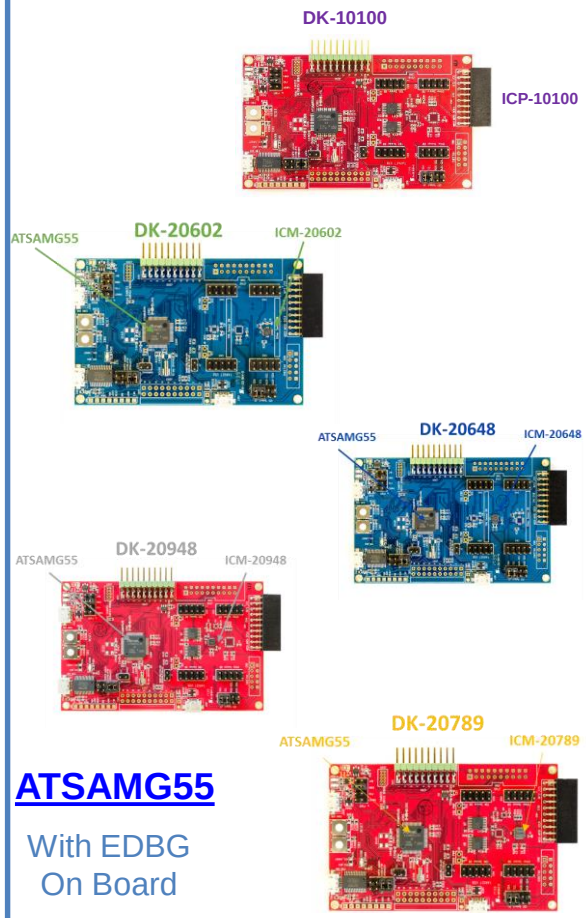
TDK-InvenSense SmartMotion® Platform

User Friendly Development Platform for TDK-InvenSense 6-Axis, 7-Axis and 9-Axis Sensors

- ✓ Single Board "Out of the Box" experience
  - ➢ Microchip G55 MCU + TDK-InvenSense Motion Sensor
- ✓ On-board embedded debugger
  - ➢ Saves $100-$150 for external debugger
  - ➢ Simpler set up/no cables for debugger
  - ➢ Program and debug the MCU
  - ➢ Debugging features to assist in code development
- ✓ Affordable - $99 ASP
  - ➢ Buy several platforms for parallel development
  - ➢ System prototyping and demonstration vehicle
- ✓ Scalable design
  - ➢ Supports legacy and future motion sensors
  - ➢ WiFi/BLE support with external modules from Microchip
- ✓ Less than 15 minutes to set-up

SmartMotion® Platforms

SmartMotion Platforms



ATSAMG55

With EDBG On Board

Motion Sensors

DK-10100 – Development Platform for Invensense ICP-10100

- 1-axis pressure sensor

DK-20602 – Development platform for InvenSense ICM-20602.

- 6-axis motion sensor that combines a 3-axis gyroscope and 3-axis accelerometer.

DK-20648 – Development platform for InvenSense ICM-20648.

- 6-axis motion sensor that combines a 3-axis gyroscope, 3-axis accelerometer, and Digital Motion Processor™ (DMP™).

DK-20789 – Development platform for InvenSense ICM-20789.

- 7-axis motion sensor combining a 3-axis gyroscope, 3-axis accelerometer, and a high accuracy pressure sensor.

DK-20948 – Development platform for InvenSense ICM-20948.

- 9-axis motion sensor that combines a 3-axis gyroscope, 3-axis accelerometer, 3-axis compass, and a Digital Motion Processor™ (DMP™).

Applications

DK-10100

- Drones
- Security systems
- Wearables
- Servers Air Flow Control
- E-cigarettes

DK-20602

- IoT
- Smartphones, Tablets, Smart Watches, Wearables, Activity monitors
- Cleaner Robots
- Sports Equipment
- Drones, Toys

DK-20648

- IoT
- Smart Watches
- Robots
- Wearables, Health Monitoring band

DK-20789

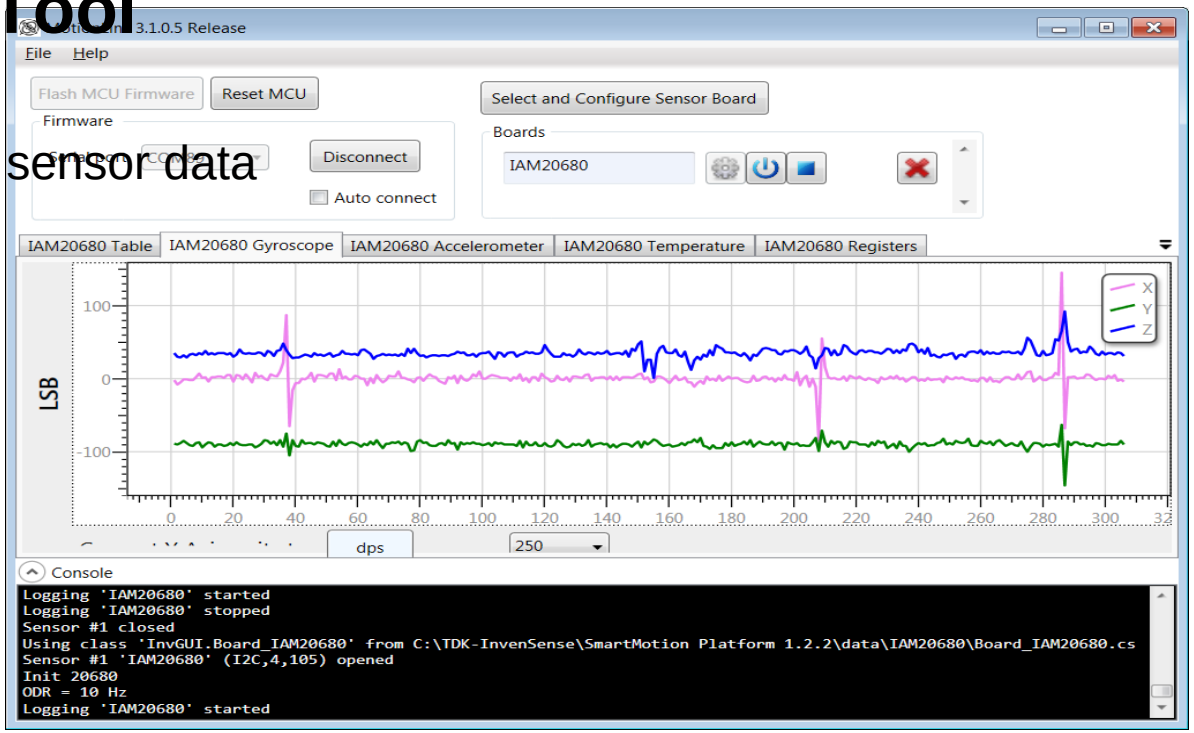
- IoT
- Drones
- Flying Toys
- Wearables, Activity Monitors

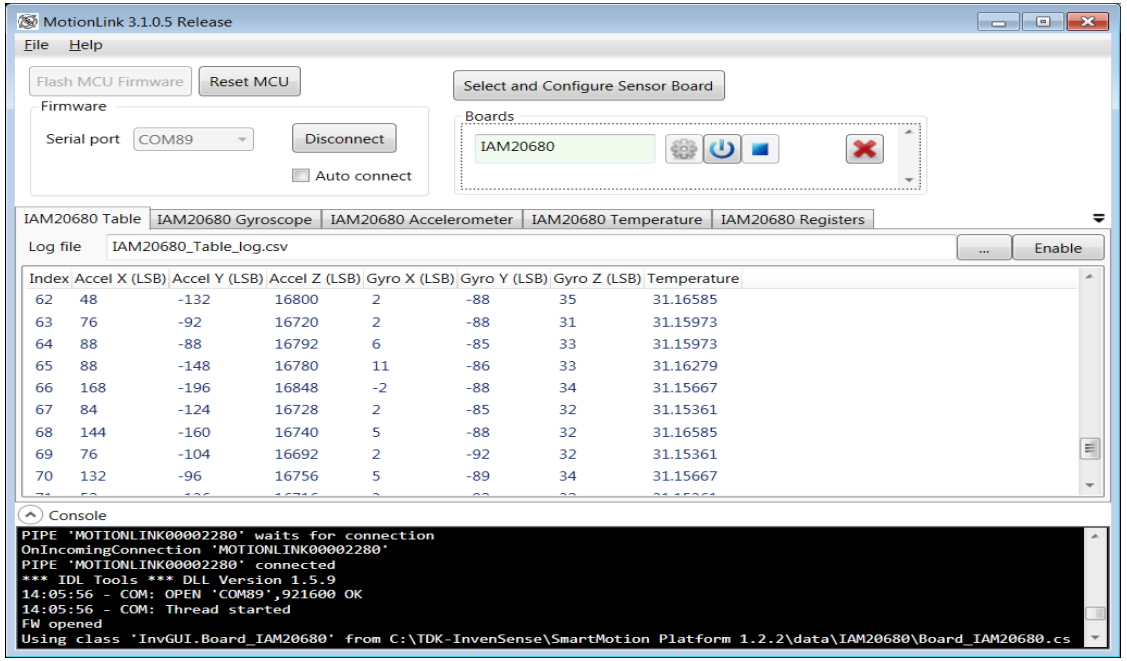
DK-20948

- IoT
- Navigation
- Industrial application
- Wearables, Smartphones, Activity Monitors, Smart Watches
- Drones, Toys and Sports Applications

MotionLink – Hardware Evaluation Tool

- Stream, evaluate, and log raw gyro, accel, and other sensor data
- Supports all TDK-InvenSense Motion Sensors!





Index	Accel X (LSB)	Accel Y (LSB)	Accel Z (LSB)	Gyro X (LSB)	Gyro Y (LSB)	Gyro Z (LSB)	Temperature
62	48	-132	16800	2	-88	35	31.16585
63	76	-92	16720	2	-88	31	31.15973
64	88	-88	16792	6	-85	33	31.15973
65	88	-148	16780	11	-86	33	31.16279
66	168	-196	16848	-2	-88	34	31.15667
67	84	-124	16728	2	-85	32	31.15361
68	144	-160	16740	5	-88	32	31.16585
69	76	-104	16692	2	-92	32	31.15361
70	132	-96	16756	5	-89	34	31.15667

PC Based Software with following features –

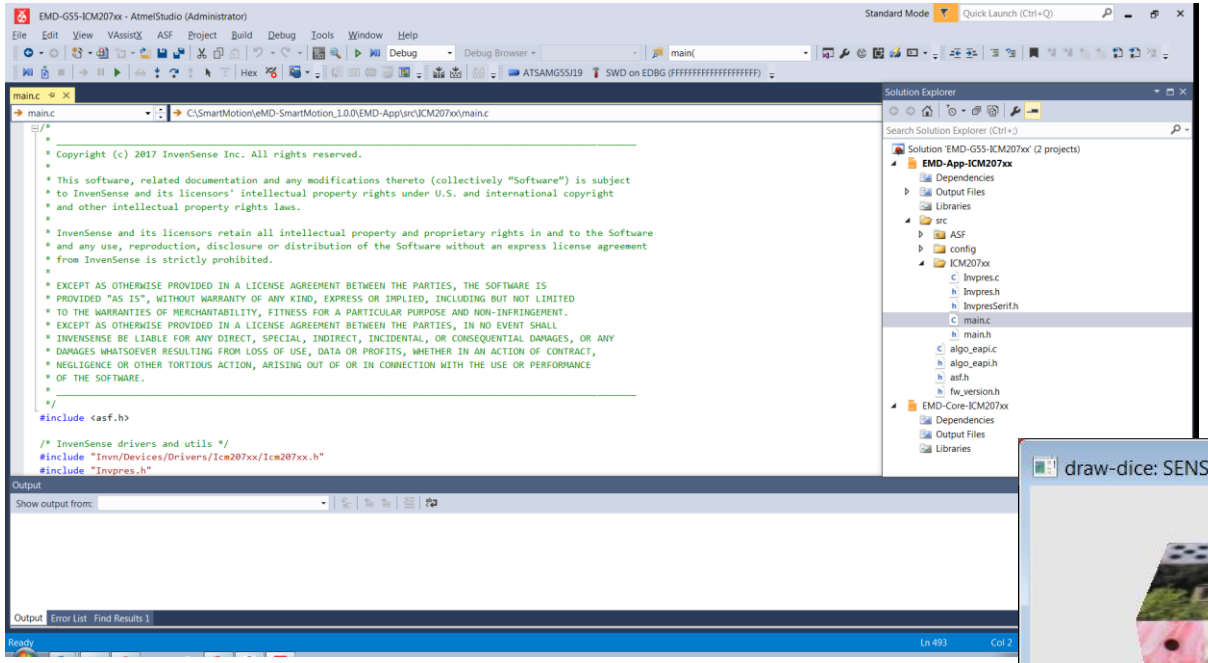
- Read Register Map Values
- Simple I2C read and writes
- Display raw sensor data up to 1Khz sample rate
- Log Data to text file
- Display graphical sensor data

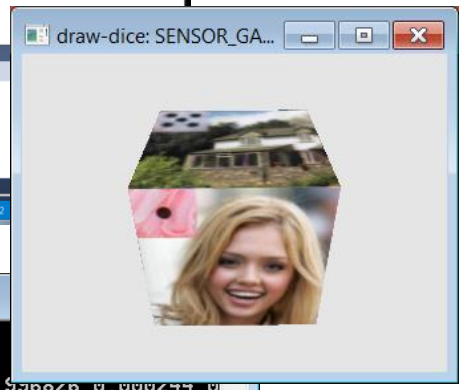
eMD (embedded Motion Driver)

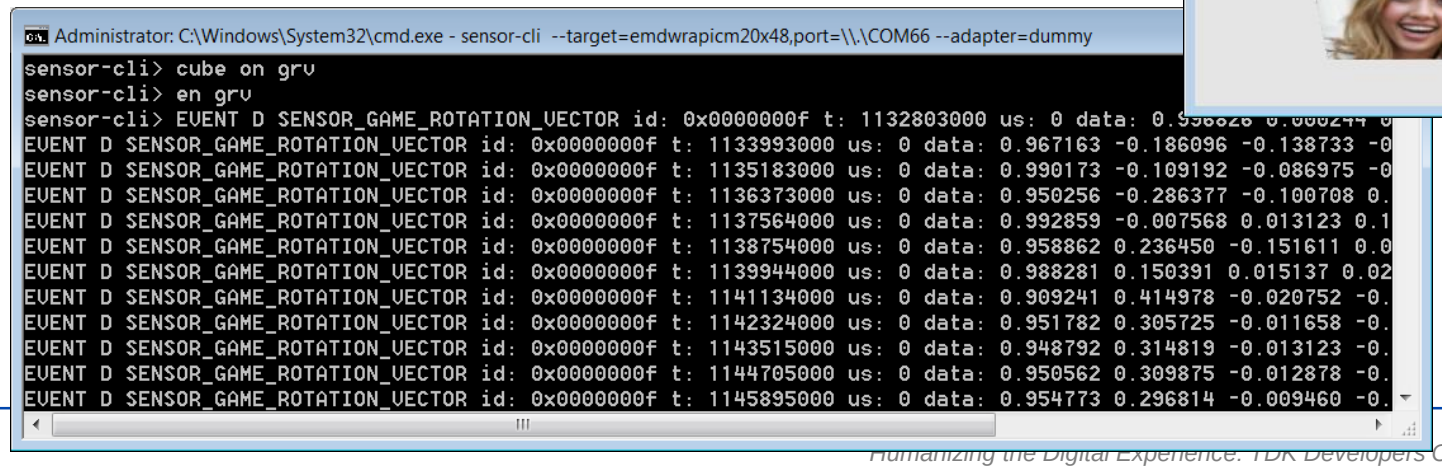
- Motion Software stack includes features like….
  - Initialization and configuration
  - Raw Sensor Data streaming
  - Sensor Fusion output
  - Gesture Tracking
  - DMP Image (if applicable)
  - Factory Test and Calibration
  - In-Use Calibration
  - Wake-On-Motion

- Release Package includes…
  - ATMEL Studio Project
  - sensor-cli : Command line interface to software

- Currently supported eMDs
  - ICP-101XX
  - ICM-20602
  - ICM-20648
  - ICM-20789
  - ICM-20948

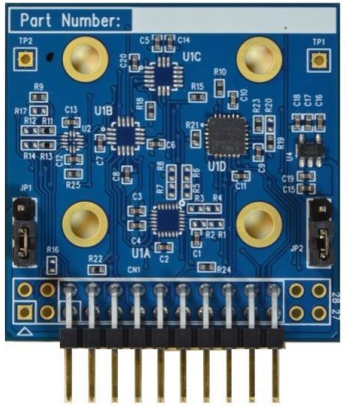




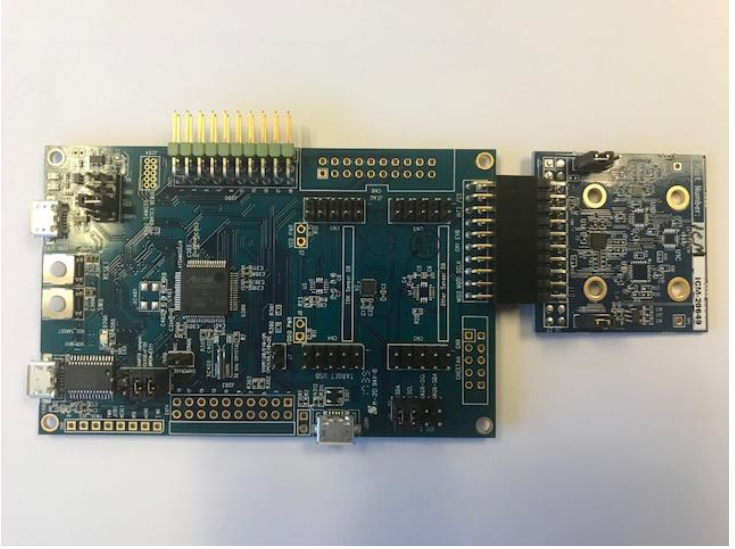


Evaluating Corona…

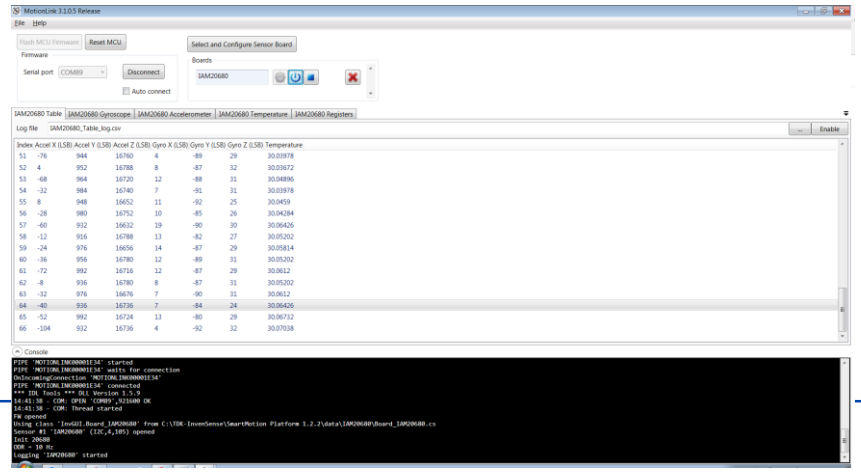
EVBs available at Mass Production at InvenSense Distributors



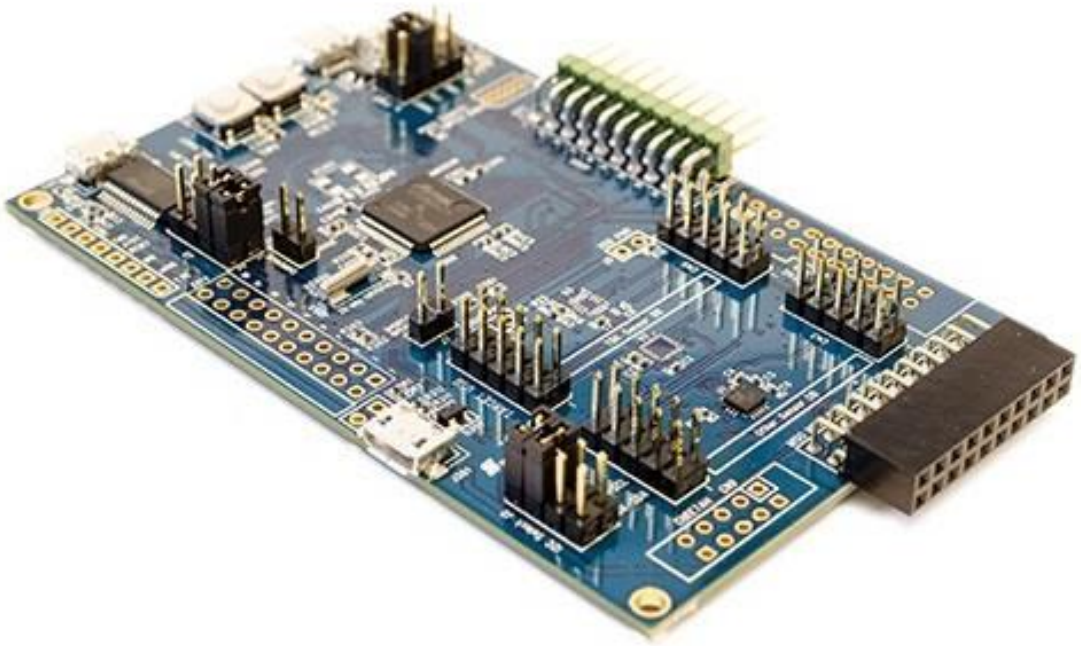
Connect with any SmartMotion DK board



Evaluate with MotionLink!



The DK-42605 available soon after MP!! (…with eMD)



TDK-InvenSense Motion Support

- TDK-InvenSense SmartMotion Website -
  - https://www.invensense.com/smartmotion-platform/

- TDK-InvenSense Developer's Corner (SW, tools, App Notes)
  - https://www.invensense.com/developers/login/

- General Tech Support - techsupport_NorthAmerica@invensense.com

- General Sales Support – sales.us@invensense.com

Thank You!