Motion Sensors Technology & Applications from TDK-InvenSense

April 2019
Agenda

- **Introduction to TDK-InvenSense Motion Technology**
  - Basics of Motion Technology
  - Motion Sensor Product Portfolio
  - Applications of Motion Sensing

- **Product Offerings**
  - Specifications, Applications, Solution Benefits
  - Success Stories

- **SmartMotion Evaluation Kits**
  - Quick introduction to SmartMotion
  - Evaluating Corona with MotionLink
  - The DK-42605

- **Wrap up**
  - Important Links to Support and further Information

**Presenter**

Vishal Markandey
Sr. Technical Marketing Manager, Motion Sensors
vmarkandey@invensense.com
Target Applications

- Imaging
- Gaming
- Smart Phones
- Toys
- Tablets
- Smart TV
- Appliances
- Sports & Fitness
- Wearable
- Image Stabilization
- Location & Activity Tracking

Auto & Industrial
Virtual Reality

Internet of Sensors
What is Motion?

• Motion is change in position of an object over time

• Any motion in 3D space is a combination of rotation and translation along X, Y, Z axes

• Gyroscopes and Accelerometers used for Motion Sensing
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/s² (1g = 9.81 m/s²)
- Accelerometer full scale range typically goes up to ±16g

**Compass**
- Measures magnetic fields
- Used to provide “heading” or direction information

**Pressure Sensor**
- Measures atmospheric air pressure
- Used to provide altitude change information
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.

• 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.

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

• 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.
### Motion Sensor Product Portfolio

<table>
<thead>
<tr>
<th>Current Channel Products</th>
<th>Upcoming Corona XLII Offerings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ICM-20690</strong></td>
<td><strong>ICM-42605</strong></td>
</tr>
<tr>
<td>• Dual-Interface: 6-axis UI+OIS</td>
<td>• Next Gen 6-Axis Flagship</td>
</tr>
<tr>
<td>2.5x3x0.9mm</td>
<td>• Further improved Gyro/Accel performance</td>
</tr>
<tr>
<td>in MP</td>
<td>• I3C Support</td>
</tr>
<tr>
<td>• Smartphones, Imaging</td>
<td>• APEX Motion Engine</td>
</tr>
</tbody>
</table>

| **ICM-20948**            | **ICM-42686**                 |
| • 9-axis (w/compass)    | • Highest range Gyro/Accel   |
| 3x3x0.9mm               | • Further improved Gyro/Accel performance |
| in MP                   | • 18-bits(Accel), 19-bits (Gyro) output option |
| • Navigation, IoT       | • I3C Support                 |

| **ICM-20789**            | **ICM-42688**                 |
| • 7-axis (w/pressure sensor) | • Highest precision Gyro/Accel |
| 4x4x1.365mm             | • Further improved Gyro/Accel performance |
| in MP                   | • 18-bits(Accel), 19-bits (Gyro) output option |
| • Wearables, Drones, IoT| • I3C Support                 |

| **ICP-101xy**            | **ICM-42688**                 |
| • 1-Axis pressure       | • Highest precision Gyro/Accel |
| 2x2x0.72mm              | • Further improved Gyro/Accel performance |
| in MP                   | • 18-bits(Accel), 19-bits (Gyro) output option |
| • Smartphones, Drones, IoT| • I3C Support                 |

| **ICM-20648**            | **ICM-42605**                 |
| • 6-axis (w/sensor fusion) | • Next Gen 6-Axis Flagship |
| 3x3x0.9mm               | • Further improved Gyro/Accel performance |
| in MP                   | • I3C Support                 |
| • IoT/Wearables         | • APEX Motion Engine         |

| **ICM-20602**            | **ICM-42686**                 |
| • Single-Interface: 6-axis UI | • Highest range Gyro/Accel   |
| 3x3x0.75mm              | • Further improved Gyro/Accel performance |
| in MP                   | • 18-bits(Accel), 19-bits (Gyro) output option |
| • VR/Game controllers   | • I3C Support                 |

| **ICM-20600**            | **ICM-42605**                 |
| • Single-Interface: 6-axis UI | • Next Gen 6-Axis Flagship |
| 2.5x3x0.91mm            | • Further improved Gyro/Accel performance |
| in MP                   | • I3C Support                 |
| • Smartphones           | • APEX Motion Engine         |

| **ICM-42605**            | **ICM-42688**                 |
| • Next Gen 6-Axis Flagship | • Highest precision Gyro/Accel |
| • Further improved Gyro/Accel performance |
| • I3C Support            | • 18-bits(Accel), 19-bits (Gyro) output option |
| • APEX Motion Engine     | • I3C Support                 |
| • Navigation, IoT       | • APEX Motion Engine         |
| • Wearables, Drones, IoT| • RTC Input                   |
| • Smartphones, Drones, IoT| • 2.5x3x0.9mm               |
| • MP: 2Q 2019            | • MP: 2Q 2019                |
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 flight 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
Automotive

- Airbags – Accelerometer used for crash sensing
- Automatic Headlight Leveling – Accelerometer used for tilt sensor
- GPS – Gyro sensor
- Stability Control – Gyro plus accelerometer sensor sense yaw, and compensate for over and under steering on a slick road surface.
- Tire Pressure Monitoring Systems – Pressure, temperature, and accelerometers assure that tires are properly inflated, come standard on all 2008 model year cars sold in the US.
- Manifold Absolute Pressure (MAP) Sensor – Pressure sensor used for engine control
- Seat cushion air bladder – Pressure sensor used for inflating and deflating the bladder.
- Seat belt pre-tensioner system – Pressure sensor used to lock seat belt during a crash
Industrial

- Antenna and Platform Stabilization
- Precision Agriculture
- Precision Robotics
- Land/Aire/Sea Navigation
- Unmanned Systems Control
- Tracking First Responders
HMD & AR/VR
HMD & AR/VR

- HMD & Controller require different capabilities from motion sensors
  - Controller requires fast motion detection (high FSR such as ±4000 dps) for high speed games
  - **User Experience:** If motion sensor in controller cannot handle fast motion, it may result in impact game experience

- HMD requires accurate sensing of subtle head movement
  - **User Experience:** Accurate motion sensing results in HMD presentation being well aligned with user movements

- 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
CORONA ICM-42686: Designed for VR Controllers

ICM-42686 High FSR for VR Controllers: ±4000dps; ±32g

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
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

<table>
<thead>
<tr>
<th>Sensor Spec</th>
<th>Example Spec Value</th>
<th>Velocity Error</th>
<th>Position Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accel Offset</td>
<td>20mg</td>
<td>1.96m/s</td>
<td>9.8m</td>
</tr>
<tr>
<td>Accel Sensitivity</td>
<td>0.5%</td>
<td>0.49m/s</td>
<td>2.45m</td>
</tr>
<tr>
<td>Accel Noise</td>
<td>0.7mg-rms</td>
<td>0.069m/s</td>
<td>0.34m</td>
</tr>
<tr>
<td>Gyro Offset</td>
<td>0.5dps</td>
<td>4.28m/s</td>
<td>14.3m</td>
</tr>
<tr>
<td>Gyro Sensitivity</td>
<td>0.5%</td>
<td>2.6m/s</td>
<td>8.6m</td>
</tr>
<tr>
<td>Gyro Noise</td>
<td>0.038dps-rms</td>
<td>0.32m/s</td>
<td>1.08m</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Current Channel Products</th>
<th>Upcoming Corona XLII Offerings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ICM-20648</strong></td>
<td><strong>ICM-42605</strong></td>
</tr>
<tr>
<td>6-axis (w/sensor fusion)</td>
<td><em>Next Gen 6-Axis Flagship</em></td>
</tr>
<tr>
<td>3x3x0.9mm</td>
<td><em>Further improved Gyro/Accel performance</em></td>
</tr>
<tr>
<td>in MP</td>
<td><em>I3C Support</em></td>
</tr>
<tr>
<td>IoT/Wearables</td>
<td><em>APEX Motion Engine</em></td>
</tr>
<tr>
<td></td>
<td><em>2.5x3x0.9mm</em></td>
</tr>
<tr>
<td></td>
<td><em>MP: 2Q 2019</em></td>
</tr>
<tr>
<td><strong>ICM-20948</strong></td>
<td><strong>ICM-42686</strong></td>
</tr>
<tr>
<td>9-axis (w/compass)</td>
<td><em>Highest range Gyro/Accel</em></td>
</tr>
<tr>
<td>3x3x1mm</td>
<td><em>Further improved Gyro/Accel performance</em></td>
</tr>
<tr>
<td>in MP</td>
<td><em>18-bits(Accel),19-bits (Gyro) output option</em></td>
</tr>
<tr>
<td>Navigation, IoT</td>
<td><em>I3C Support</em></td>
</tr>
<tr>
<td></td>
<td><em>APEX Motion Engine</em></td>
</tr>
<tr>
<td></td>
<td><em>2.5x3x0.9mm</em></td>
</tr>
<tr>
<td></td>
<td><em>MP: 2Q 2019</em></td>
</tr>
<tr>
<td><strong>ICM-20789</strong></td>
<td><strong>ICM-42688</strong></td>
</tr>
<tr>
<td>7-axis (w/pressure sensor)</td>
<td><em>Highest precision Gyro/Accel</em></td>
</tr>
<tr>
<td>4x4x1.365mm</td>
<td><em>Further improved Gyro/Accel performance</em></td>
</tr>
<tr>
<td>in MP</td>
<td><em>18-bits(Accel),19-bits (Gyro) output option</em></td>
</tr>
<tr>
<td>Wearables, Drones, IoT</td>
<td><em>I3C Support</em></td>
</tr>
<tr>
<td></td>
<td><em>APEX Motion Engine</em></td>
</tr>
<tr>
<td></td>
<td><em>RTC Input</em></td>
</tr>
<tr>
<td></td>
<td><em>2.5x3x0.9mm</em></td>
</tr>
<tr>
<td></td>
<td><em>MP: 2Q 2019</em></td>
</tr>
<tr>
<td><strong>ICP-101xy</strong></td>
<td></td>
</tr>
<tr>
<td>1-Axis pressure</td>
<td></td>
</tr>
<tr>
<td>2x2x0.72mm</td>
<td></td>
</tr>
<tr>
<td>in MP</td>
<td></td>
</tr>
<tr>
<td>Smartphones, Drones, IoT</td>
<td></td>
</tr>
</tbody>
</table>

**Motion, Pressure & Combo Sensors**

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

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

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

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

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

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

- **ICM-42605**
  - *Next Gen 6-Axis Flagship*
  - *Further improved Gyro/Accel performance*
  - *I3C Support*
  - *APEX Motion Engine*
  - *2.5x3x0.9mm*
  - *MP: 2Q 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: 2Q 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: 2Q 2019*
ICM-42605
Next Generation 6-axis Solution

Specifications

- **High Performance Gyro**
  - Gyro Sensitivity Error: ±0.5%
  - Gyroscope Noise: ±3.8mdps/√Hz
- **High Performance Accel**
  - Accel Noise: ±70µg/√Hz
  - Accel Sensitivity: ±0.5%
- **Low Power Solution**
  - Full Power: 0.65mA
  - LP Accel Mode: 46µA
- **Gyroscope Full-Scale Range:** ±250/500/1000/2000 deg/sec
- **Accelerometer Full-Scale Range:** ±2/4/8/16g
- **Package Size:** 2.5x3x0.91mm 14-Pin LGA
- **Software Available:** Yes

Solution Benefits

- Device includes 2K-byte FIFO to reduce traffic on serial bus interface
- Reduce power consumption by allowing the system processor to burst read sensor data and then go to LP mode
- Includes on chip, 16-bit ADC’s, programmable digital filters, an embedded temp sensor, and programmable interrupts.

Applications

- IoT
- Augmented Reality
- Drone
- Virtual Reality

Samples: Now
Production: 2Q 2019

ICM-42605
I3C/I2C/SPI
AP/MCU
INT1
INT2
ICM-20602
High Performance 6-axis Solution

### Specifications
- **High Performance Gyro**
  - Gyro Sensitivity Error: \( \pm 1\% \)
  - Gyroscope Noise: \( \pm 4 \text{mdps}/\sqrt{\text{Hz}} \)
- **High Performance Accel**
  - Accel Noise: \( \pm 100 \mu\text{g}/\sqrt{\text{Hz}} \)
  - Accel Sensitivity: \( \pm 1\% \)
- **Low Power Solution**
  - Full Power: 2.79 mA
  - LP Gyro/Accel Mode: 1.33 mA
  - Gyroscope Full-Scale Range: \( \pm 250/500/1000/2000 \text{deg/sec} \)
  - Accelerometer Full-Scale Range: \( \pm 2/4/8/16 \text{g} \)
  - Package Size: 3x3x0.75mm 16-Pin LGA
  - Software Available: Yes

**Datasheet:** [ICM-20602 DataSheet](#)

### Solution Benefits
- Device includes 1K-byte FIFO to reduce traffic on serial bus interface
- Reduce power consumption by allowing the system processor to burst read sensor data and then go to LP mode
- Includes on chip, 16-bit ADC’s, programmable digital filters, an embedded temp sensor, and programmable interrupts.

### Applications
- IoT
- Augmented Reality
- Drone
- Virtual Reality

---

Samples: Now
Production: Now

---

Fsync for EIS
ICM-20648
6-Axis DMP Enabled Solution

Specifications
- Digital Motion Processor (DMP) for autonomous operation
- Programmable interrupts, filters, and 4k-byte FIFO
- Gyroscope Full-Scale Range: ±250/500/1000/2000 deg/sec
- Accelerometer Full-Scale Range: ±2/4/8/16g
- Runtime Calibration
- Operating Temperature Range: -40°C to 85°C
- Operating Voltage Range:
  - VDD: 1.71V – 3.6V
  - VDDIO: 1.71V – 3.6V
- Host Interface: SPI 7MHz, I²C up to 400kHz
- Package Size: 3x3x0.9mm 24-Pin QFN
- Software Available: Yes

Solution Benefits
- Provides Step Count, Activity Classifier, and B2S (Bring-to-See) Gestures tuned for wrist worn wearable applications.
- DMP offloads computation of motion processing algorithms from the host processor, improving system power performance
- Enhanced FSYNC functionality to improve timing for applications like EIS

Datasheet: [ICM-20648 DataSheet](#)

Applications
- IoT
- EIS
- Wearables
ICM-20948
World’s Best 9-Axis Integrated Solution

Specifications
- Digital Motion Processor (DMP) for autonomous operation
- Gyroscope Full-Scale Range: ±250/500/1000/2000 deg/sec
- Accelerometer Full-Scale Range: ±2/4/8/16g
- Operating Voltage Range:
  - VDD: 1.71V – 3.6V
  - VDDIO: 1.71V – 1.95V
- Host Interface: SPI 7MHz, I2C up to 400kHz
- Software Available: Yes
- Low Power Mode: 2.5mW
- Compass FSR: ± 4900µT
- Package Size: 3x3x1mm 24-Pin QFN
- Software Available: Yes

Solution Benefits
- Lowest power 9-axis solution in the world
- P2P compatible with the MPU-9250
  - 1/3 less power than previous solution
- Supports FSYNC for EIS

Datasheet: ICM-20948 DataSheet

Applications
- IoT
- Wearable
- Drone

Samples: Now
Production: Now
ICP-101xx
Barometric Pressure and Temperature Sensor

**Solution Features**

- **Pressure Operating Range:** 300hPa – 1100hPa
- **Relative Pressure Accuracy:** ±1Pa (10hPa change, 700-1000hPa)
- **Pressure Noise RMS and Current Consumption:**
  - Low-Power Mode: 3.2Pa at 1.3μA
  - Low-Noise Mode: 0.8Pa at 5.2μA
  - Ultra Low-Noise Mode: 0.4Pa at 10.4μA
- **Absolute Pressure Accuracy:** ±1hPa (300hPa-1100hPa, 0°C-65°C)
- **Pressure Sensor Tempco:** ±0.5Pa/°C (25°C-45°C, 100kPa)
- **Temperature Sensor Accuracy:** ±0.4°C
- **Operating Temp & Voltage:** -40°C-85°C, 1.8V ±5%
- **Host Interface:** I²C up to 400kHz

**Solution Benefits**

- Completely integrated & calibrated pressure and temp sensor IC provides quick time-to-market
- Detect Z-height of 8cm for accurate motion measurements: navigation, dead-reckoning, floor detection, fitness recognition
- Lower power consumption extends battery life or improved accuracy at same power consumption
- Three-0.025mm holes reduce liquid intrusion

**Applications**

- Drones
- Mobile Phones
- Fitness Bands/Trackers
- Virtual Reality Headsets/Controllers
- Elderly Fall Detection
- Security Systems
- Hard Drives & Servers

**Package Options**

<table>
<thead>
<tr>
<th>PACKAGE</th>
<th>3-HOLE</th>
<th>1-HOLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2x2x0.72mm 10L LGA</td>
<td>ICP-10100</td>
<td>ICP-10101</td>
</tr>
<tr>
<td>2x2.5x0.92mm 8L LGA</td>
<td>ICP-10110</td>
<td>ICP-10111</td>
</tr>
</tbody>
</table>

**Features**

- 3-Hole: IPx6 Compliant Waterproof to 1.5m Depth
- Single Hole Package
ICM-20789
7-Axis: 6-Axis Motion Sensor and Barometric Pressure Sensor

Solution Features

- Digital Motion Processor (DMP) for autonomous operation
- Programmable interrupts, filters, and 4k-byte FIFO
- Gyroscope Full-Scale Range: ±250/500/1000/2000 deg/sec
- Accelerometer Full-Scale Range: ±2/4/8/16 g
- Pressure Operating Range: 300hPa – 1100hPa
- Relative Pressure Accuracy: ±1Pa (10hPa change, 700-1000hPa)
- Absolute Pressure Accuracy: ±1hPa (300hPa-1100hPa, 0ºC-65ºC)
- Temperature Sensor Accuracy: ±0.4ºC
- Operating Temperature Range: -40ºC-85ºC
- Operating Voltage Range:
  - VDD: 1.7V – 3.45V
  - VDDIO: 1.8V ±5%
- Host Interface: SPI 8MHz, I2C up to 400kHz
- Packages: 4 x 4 x 1.365mm 24-pin LGA

Solution Benefits

- Integrated & calibrated Accel+Gyro+Pressure+Temp sensor provides quick time-to-market in small footprint
- Allow host to sleep/save power while monitoring motion
- Detect Z-height of 8cm for accurate motion measurements: navigation, dead-reckoning, floor detection, fitness recognition
- Lower power consumption extends battery life
- Easy migration from 6-Axis motion sensor to 6-Axis+Pressure

Applications

- Drones
- Motion-based controllers
- Mobile Phones
- Virtual Reality Headsets/Controllers
- Toys

© TDK 2017
MEMS Sensor Business Group, Sensor System Business Company
[May-17] 28
Success Stories

Wrist Worn Drone: MPU-9250

Drone: MPU-6000

Drone: ICM-20602

Vacuum: MPU-6000

Drone + Controller: MPU-6000 and MPU-6515

Education Robot: MPU-6500

Pro Series Drone: ICM-20789
Success Stories (cont.)

Helmet Camera: MPU-6500

Smart Jacket: ICM-20648

Senior Wearable: MPU-9250

Gaming Controller: MPU-6500

AR/VR: ICM-20608-B

VR Headset: ICM-20602; Touch Controller: MPU-6500T
Success Stories (cont.)

AR/VR Headset: MPU-9250

Wearable modules: ICM-20601

Personal Theater: ICM-20603

Swing Analyzer: ICM-20649

Smart Lure: ICM-20948

Smart Goggles: ICM-20948
Motion Sensor Development Tools

SmartMotion Platform
TDK InvenSense SmartMotion® Platform

User Friendly Development Platform for TDK InvenSense 6-Axis, 7-Axis, 9-Axis, and 1-Axis Motion Sensor

https://www.avnet.com/wps/portal/abacus/manufacturers/m/tdk-invensense/smartmotion%C2%AE-development-kits/

<table>
<thead>
<tr>
<th>Contents</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protective Packaging</td>
<td>The SmartMotion Platform come in a sturdy easy to carry box with protective foam. Please reference MEMS Handling Guide on how to prevent damage to MEMS sensors.</td>
</tr>
<tr>
<td>SmartMotion Platform</td>
<td>The SmartMotion board comes with the latest MotionLink software tool pre-flashed on the MCU. The board is configured with default jumper settings.</td>
</tr>
<tr>
<td>QuickStart Guide</td>
<td>Instructions to for platform bring up with links to software downloads</td>
</tr>
</tbody>
</table>
SmartMotion® Platform

- Single Board “Out of the Box” experience
  - Microchip G55 MCU + TDK InvenSense Motion Sensor
- On-board embedded debugger
  - Saves ~ €100 for external debugger
  - Simpler set up/no cables for debugger
  - Program and debug the MCU
- Affordable – From €70 through Avnet Abacus
  - Customers can buy multiple platforms to speed up development
- 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™ Platform – 6 Axis**

DK-20602
DK-20648
DK-20680A

**SmartMotion™ Platform – 7, 9, and 1 Axis**

DK-20789
DK-20948
DK-10100
SmartMotion Platform

The various SmartMotion Platforms are easily purchasable at the following website from €70

www.avnet.com/wps/portal/emea

Keywords = DK-20602, DK-20648, DK-20789, DK-20948, DK-10100, DK-20680
It’s so Simple!

- Connecting the Boards
  - PC/Laptop – preferably running Win 7
  - Micro-USB cables –
    - FTDI USB Connector (CN6) to PC – Required for default power and most data output
    - EDGB USB Connector (J500) to PC – Optional, only needed if customers planning to flash or trace code. For eMD can be used this output for debug message outputs.
Software Evaluation Tools

2 Software Packages

- SmartMotion Installer with MotionLink

- Embedded Motion Drivers (eMDs)

- Both tools available for free download at the TDK-InvenSense Developer’s Corner (requires registration)

https://www.avnet.com/wps/portal/abacus/manufacturers/m/tdk-invensense/smartmotion%C2%AE-development-kits/
Software Evaluation Tools

The MotionLink - Hardware Evaluation Tool

- 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

- Why MotionLink? –
  - Evaluate and log raw gyro, accel, and other sensor data
  - Will support all channel motion parts
Software Evaluation Tools

The Embedded Motion Driver (eMD) for SmartMotion Platforms

• Motion Software (dependent on product) can include these features…
  - 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

• Currently supported SmartMotion eMDs
  - ICM20602
  - ICM20648
  - ICM20948
  - ICM20789
  - ICP-10100
  - IAM-20680
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 SmartMotion Support

- Avent SmartMotion Website: https://www.avnet.com/wps/portal/abacus/manufacturers/m/tdk-invensense/smartmotion%C2%AE-development-kits/
