

A central graphic featuring a globe of Earth surrounded by various sensor-related icons: a thermometer, a hand with a red sensor, a compass, a lightbulb, a microphone, a magnet, a gauge, a spring, a clock, a water drop with a percentage sign, and a gyroscope. The background is a view of Earth from space.

World of Sensors

2017 TDK Sensors Developers Conference





SmartMotion® Platform

TDK InvenSense Development Tool for Motion Sensors

Agenda

- SmartMotion Platform
 - 6 Axis, 7-Axis and 9-Axis development kits
 - DK-20602, DK-20648, DK-20789, DK-20948
- SmartMotion Hardware Overview
 - Sensor specifications
 - Board layout and Connectors
 - Bring up the board
 - Purchasing the SmartMotion Platform
- SmartMotion Software
 - MotionLink
 - Embedded Motion Drivers (eMD)
 - External Sensor Connection
 - eMD Porting Guidelines



The SmartMotion Platform

SDC - October 2017

What is a Good development platform ?

- Accelerates development of end products for faster market deployment
- “Out of the box” experience for quick set-up
 - Single board design, simple connection
 - Software included, easy to use collateral
 - No support required to bring up the platform
- Affordable; buy several platforms for parallel development
- Debugging features to assist in code development
- System prototyping and demonstration vehicle
- Ability to develop applications without actual hardware to expedite product delivery

TDK InvenSense SmartMotion® Platform



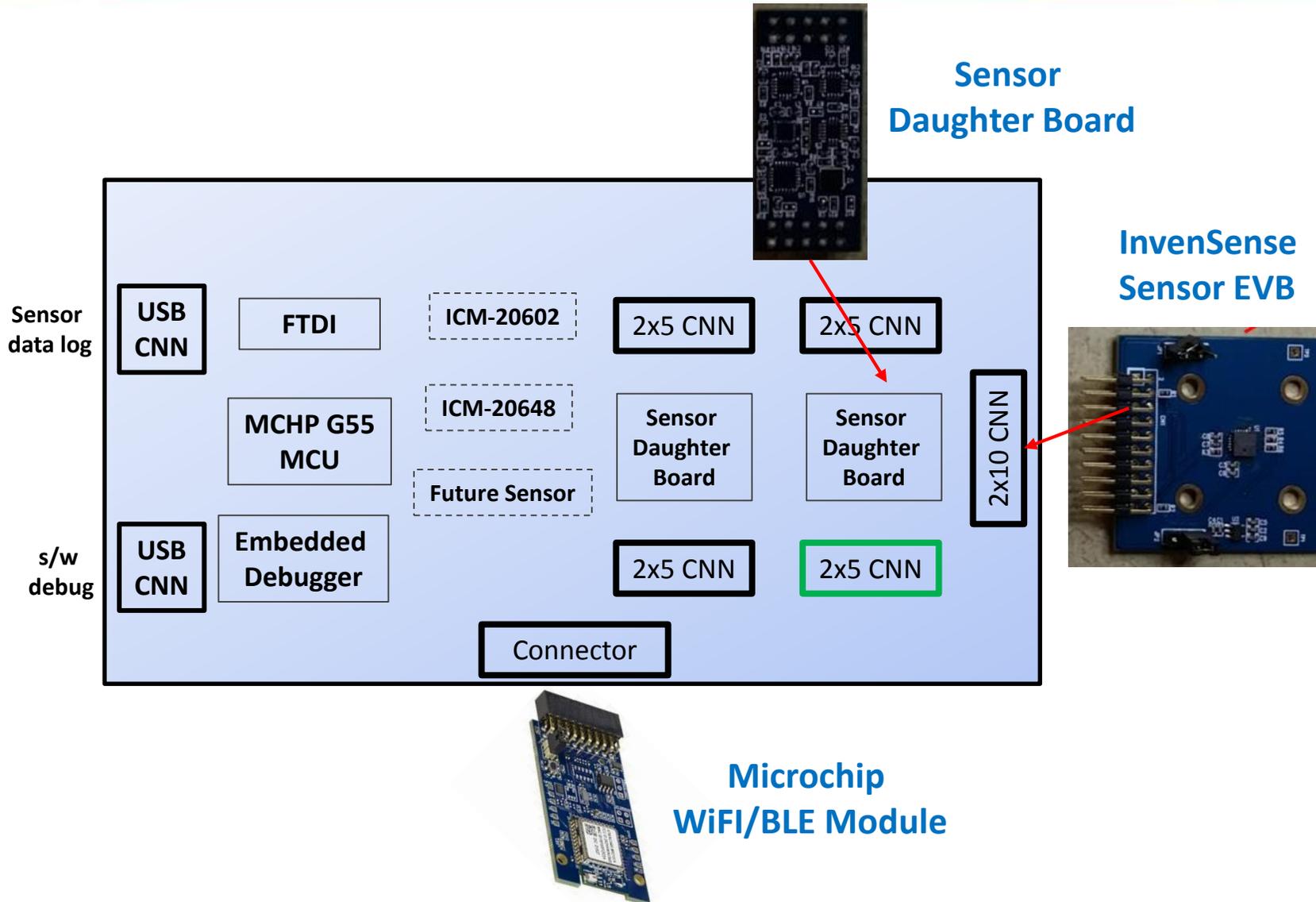
User Friendly Development Platform for InvenSense 6-Axis, 7Axis and 9-Axis Motion Sensors

<https://www.invensense.com/smartmotion-platform/>

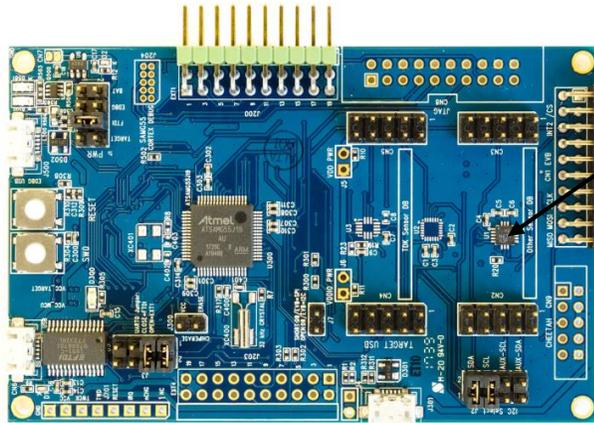
SmartMotion® Platform

- 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
- Affordable - \$99 ASP
- Better than other Sensor Development Kits
- Scalable design
 - Supports legacy and future motion sensors
 - WiFi/BLE support with external modules from Microchip
- Less than 10 minutes to set-up

Version 1 - 6 Axis Sensors

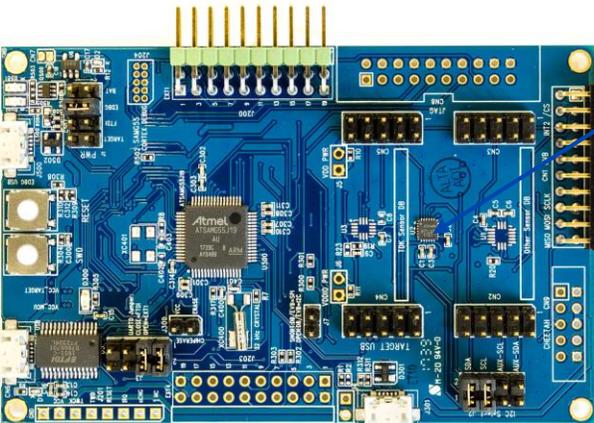


SmartMotion® 6-axis Platforms



ICM-20602

DK-20602

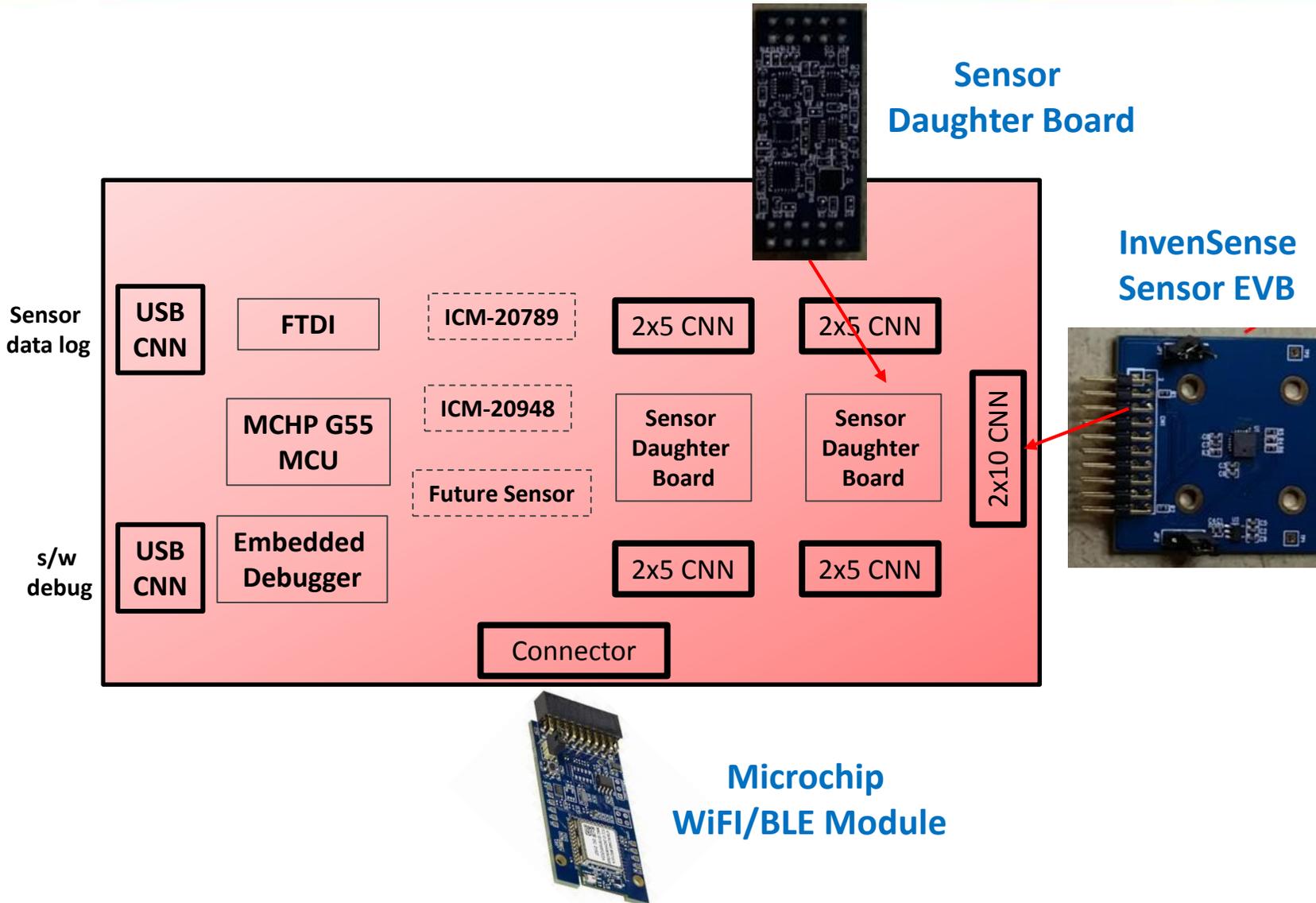


ICM-20648

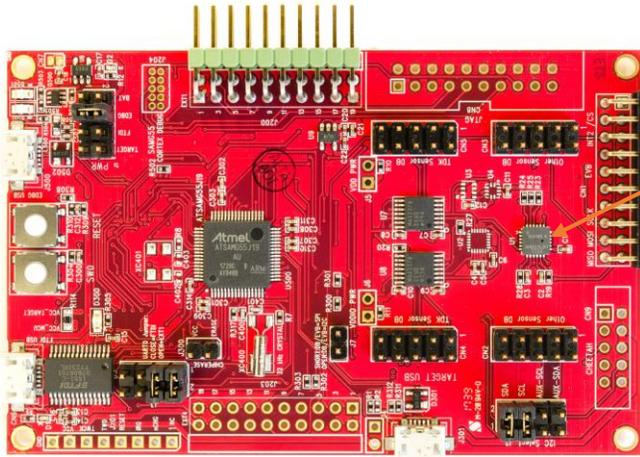
DK-20648



Version 2 – 7 and 9 axis Sensors

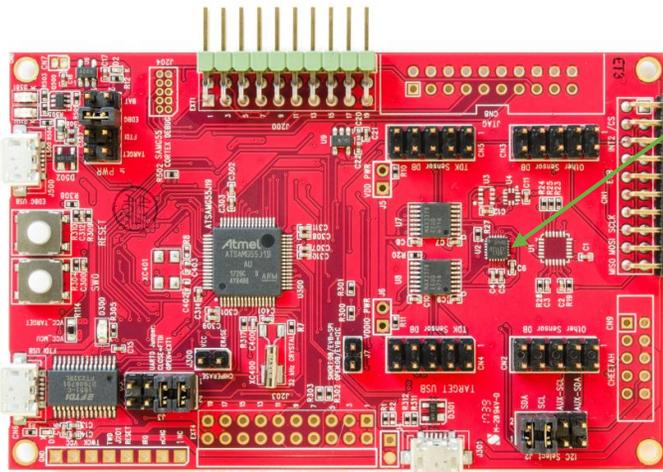


SmartMotion® 7, 9-axis Platforms



ICM-20789

DK-20789



ICM-20948

DK-20948



What is a Good development platform ?

- Accelerates development of end products for faster market deployment
- “Out of the box” experience for quick set-up
 - Single board design, simple connection
 - Required Software, easy to use collateral
 - No support required to fire up the platform
- Affordable; buy several platforms for parallel development
- Debugging features to assist in code development
- System prototyping and demonstration vehicle
- Ability to develop applications without actual hardware to expedite product delivery

TDK InvenSense SmartMotion® Platform



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

<https://www.invensense.com/smartmotion-platform/>

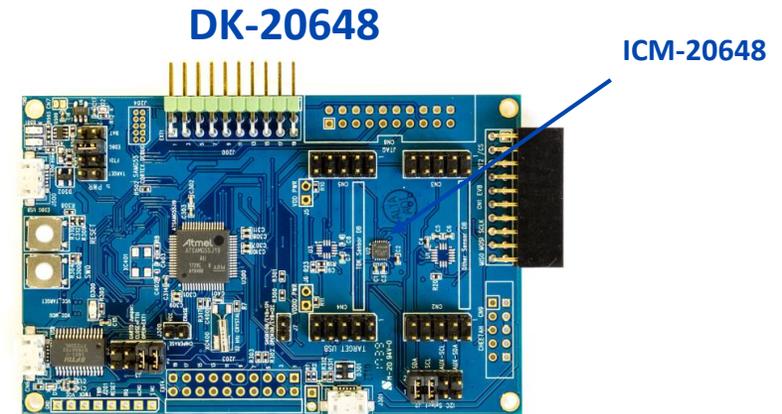
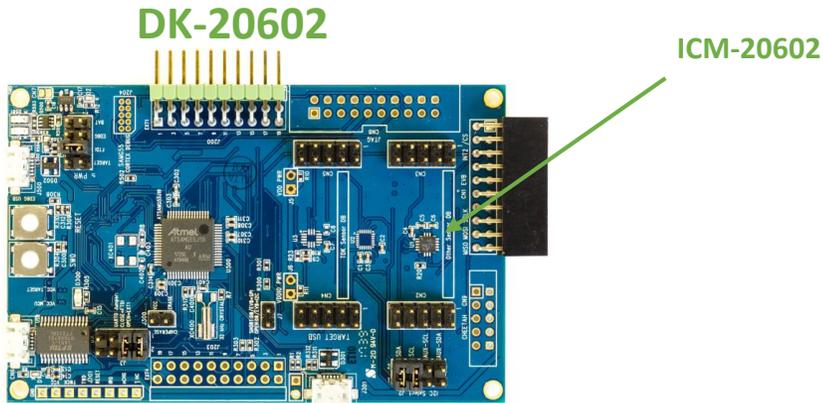


SmartMotion : Hardware and Selection

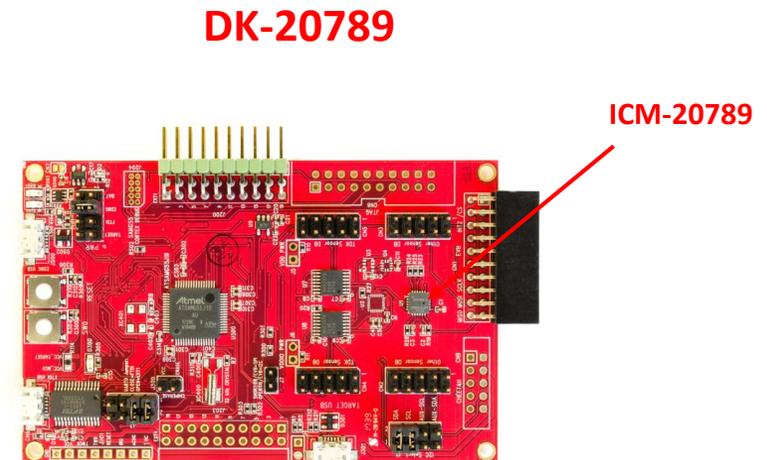
SDC - October 2017

SmartMotion Platforms

SmartMotion™ Platform – 6 Axis



SmartMotion™ Platform – 7 and 9 Axis





SmartMotion : 6 Axis Platforms

SDC - October 2017

DK-20602 Motion Sensor

ICM-20602

World's Best 6-axis Solution



Samples: Now
Production: Now

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: 2.79mA
 - LP Gyro/Accel Mode: 1.33mA
- 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

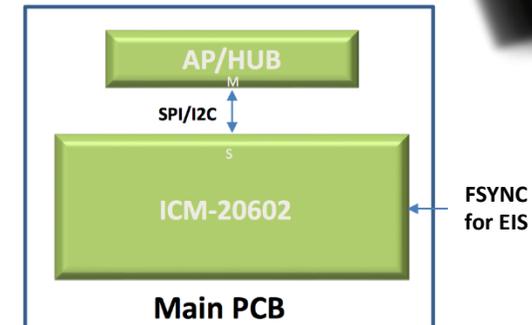
Datasheet: [ICM-20602 DataSheet](#)

Applications

- IoT
- Augmented Reality
- Drone
- Virtual Reality

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.



DK-20648 Motion Sensor



ICM-20648

6-Axis DMP Enabled Solution



Samples: Now
Production: Now

Specifications

- Digital Motion Processor (DMP) for autonomous operation
- Programmable interrupts, filters, and 4k-byte FIFO
- Gyroscope Full-Scale Range: $\pm 250/500/1000/2000$ deg/sec
- Accelerometer Full-Scale Range: $\pm 2/4/8/16g$
- 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

Datasheet: [ICM-20648 DataSheet](#)

Applications

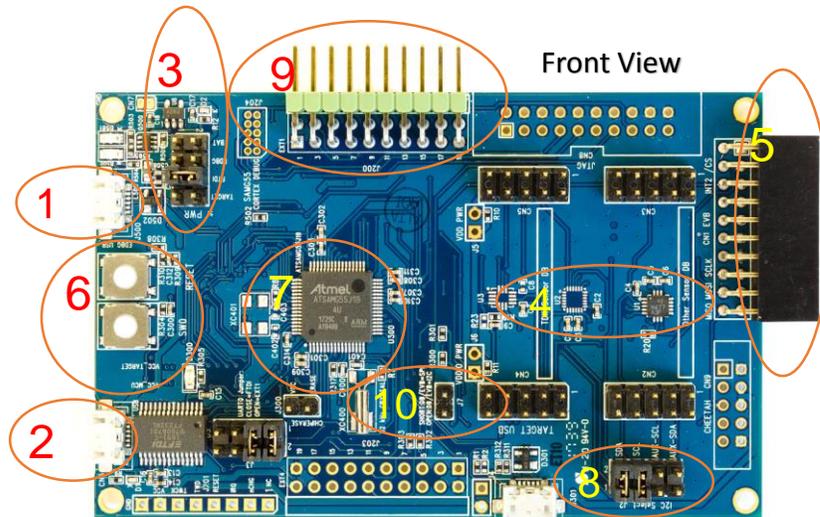
- IoT
- EIS
- Wearables

Solution Benefits

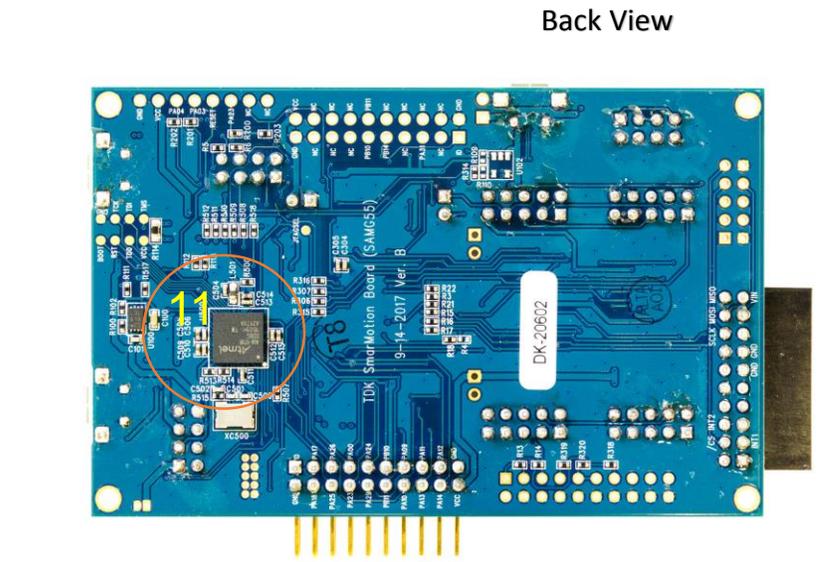
- Provides Step Count, Activity Classifier, and B2S (Bring-to-See) Gestures tuned for wrist worn wearable applications.
- DMP offloads computation of motion processing algorithms from the host processor, improving system power performance
- Enhanced FSYNC functionality to improve timing for applications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



SmartMotion Platform – 6 Axis



Front View



Back View

Main Hardware Features

1. EDBG USB – Embedded Debugger USB output and/or power input
2. FTDI USB – Main UART output for software. Default power input for SmartMotion board
3. PWR Source Select – Can be configure to select power from different sources. By default it is set for FTDI input (5+6)
4. On-Board Motion Sensor – U1 footprint for ICM-20602. U2 for ICM-20648
5. TDK Sensor EVB Connector – Connector to attached other TDK-InvenSense Sensor EVB boards. Can only support 2.5V and above!
6. Reset and User Button – Reset used for SAMG55 MCU, User Button optional for software use
7. ATMEL SAMG55 MCU – ARM Cortex-M4 MCU, <http://www.microchip.com/wwwproducts/en/ATSAMG55>
8. Sensor I2C Selection – selects sensor I2C slave source from primary I2C or AUX I2C. Default is primary (1+2, 3+4)
9. Extension Header – for future support of other components such as BLE. Same header as Microchip's Xplained-Pro Board.
10. External EVB interface – jumper to select I2C (open) or SPI (closed) interface to the external EVB if attached
11. Embedded Debugger – for flashing main MCU and code tracing. No external JTAG needed!



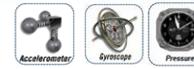
SmartMotion : 7 and 9 Axis Platforms

SDC - October 2017

DK-20789 Motion Sensor

ICM-20789

World's Only 7-axis Integrated Solution



Samples: Now
Production: Now

Specifications

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

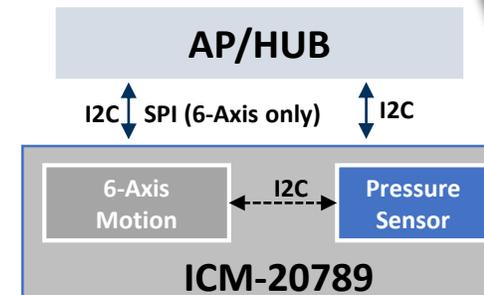
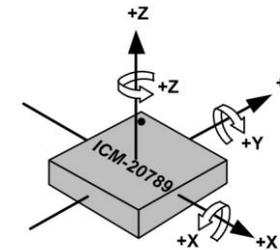
Product Brief:

Applications

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

Solution Benefits

- Integrated & calibrated Accel+Gryo+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



DK-20948 Motion Sensor

ICM-20948

World's Best 9-axis Integrated Solution



Samples: Now
Production: Now

Specifications

- Digital Motion Processor (DMP) for autonomous operation
- Gyroscope Full-Scale Range: $\pm 250/500/1000/2000$ deg/sec
- Accelerometer Full-Scale Range: $\pm 2/4/8/16g$
- 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: $\pm 4900\mu T$
- Package Size: 3x3x.1mm 24-Pin QFN
- Software Available: Yes

Datasheet: [ICM-20948 DataSheet](#)

Applications

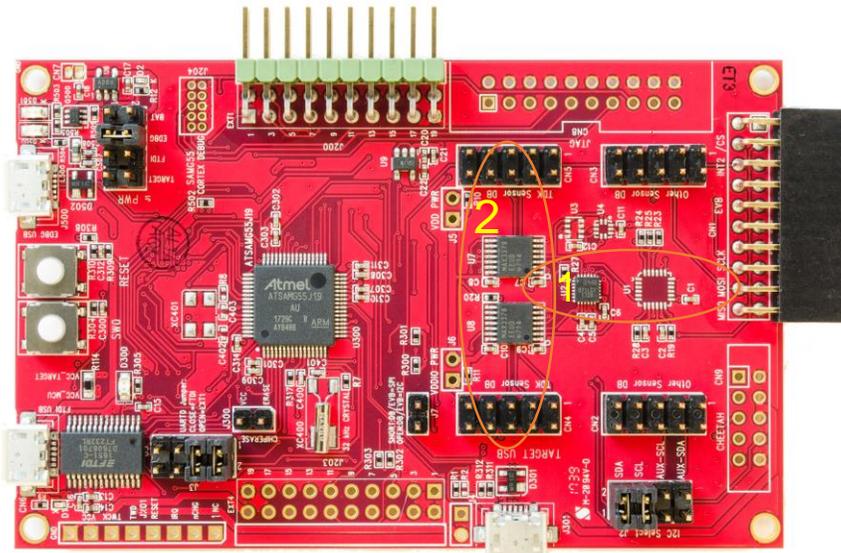
- IoT
- Drone
- Wearable

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



SmartMotion Platform : 7 and 9 Axis



Main Hardware Features

Similar to 6 Axis Board except for the following

1. On-Board Motion Sensor – U2 footprint for ICM-20948, U1 footprint for ICM-20789
2. Level Shifter – change power level to 1.8V for the on-board sensor only. This is primary for ICM-20948 and ICM-20789 which requires this voltage.



Purchasing a SmartMotion Platform

SDC - October 2017

SmartMotion Platform



The various SmartMotions are all easily purchasable on the following TDK authorized distributors for \$99 USD

| Distribution | URL |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DigiKey | https://www.digikey.com/products/en?keywords=DK-20602 https://www.digikey.com/products/en?keywords=DK-20648 https://www.digikey.com/products/en?keywords=DK-20789 https://www.digikey.com/products/en?keywords=DK-20948 |
| Mouser | https://www.mouser.com/ProductDetail/TDK/DK-20602/ https://www.mouser.com/ProductDetail/TDK/DK-20648/ https://www.mouser.com/ProductDetail/TDK/DK-20789/ https://www.mouser.com/ProductDetail/TDK/DK-20948/ |
| AVNET | https://www.avnet.com/wps/portal/us/ |
| CDI | https://www.cdiweb.com/ProductDetail/DK20602-TDK-InvenSense/613431/ https://www.cdiweb.com/ProductDetail/DK20648-TDK-InvenSense/613432/ https://www.cdiweb.com/ProductDetail/DK20789-TDK-InvenSense/613975/ https://www.cdiweb.com/ProductDetail/DK20948-TDK-InvenSense/613433/ |

Individual TDK-InvenSense Motion EVBs are also widely available at same distributors

SmartMotion Platform Contents



Each purchased SmartMotion comes with the following



| Contents | Description |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Protective Packaging | 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. |
| SmartMotion Platform | The SmartMotion board comes with the default jumper settings. It also comes with the latest MotionLink Software Tool pre-flashed into the MCU. |
| QuickStart Guide | Short description on SmartMotion overview and how to quickly get started along with links to downloadable software. |



Connecting the SmartMotion Platform

SDC - October 2017

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 output
 - EDGB USB Connector (J500) to PC – **Optional**, only needed if customers planning to flash or trace code. For eMD can be used for debug message outputs.





SmartMotion : Software Tools

SDC - October 2017

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)

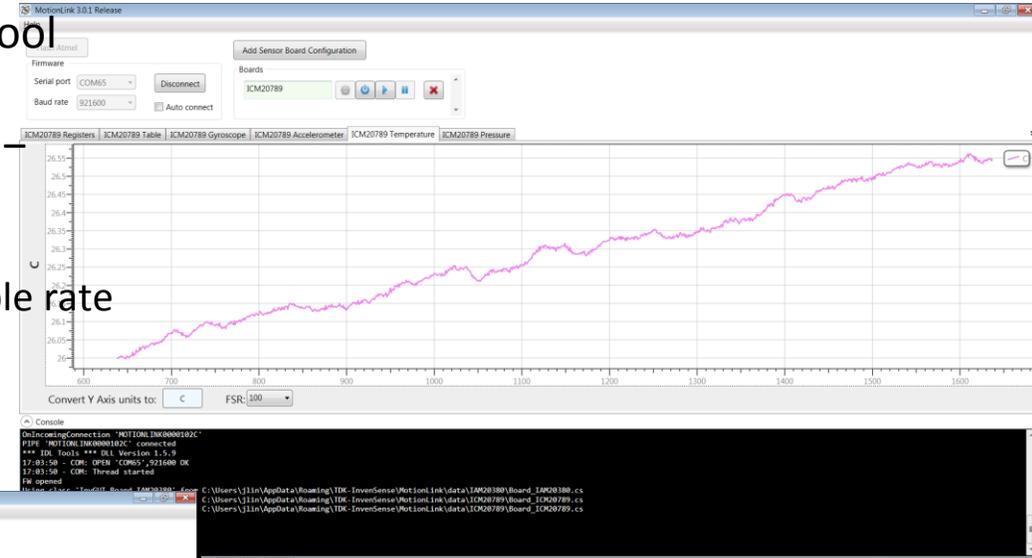
<https://www.invensense.com/developers/software-downloads/>

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



| Timestamp | Accel X (LSB) | Accel Y (LSB) | Accel Z (LSB) | Gyro X (LSB) | Gyro Y (LSB) | Gyro Z (LSB) | Temperature | Pressure (Pa) |
|-----------|---------------|---------------|---------------|--------------|--------------|--------------|-------------|---------------|
| 1622 | -252 | -220 | 16452 | 7 | 0 | 8 | 26.54503 | 100319.9 |
| 1623 | -240 | -168 | 16492 | 9 | 2 | 10 | 26.53969 | 100319 |
| 1624 | -212 | -228 | 16504 | 26 | 1 | 10 | 26.53702 | 100319 |
| 1625 | -212 | -188 | 16580 | 7 | 2 | 8 | 26.53702 | 100319.4 |
| 1626 | -172 | -184 | 16572 | 6 | 1 | 9 | 26.53485 | 100319.9 |
| 1627 | -204 | -84 | 16572 | 5 | 5 | 10 | 26.54236 | 100320.3 |
| 1628 | -300 | -176 | 16540 | -2 | 5 | 10 | 26.54503 | 100319.9 |
| 1629 | -216 | -168 | 16544 | 13 | 4 | 13 | 26.54236 | 100319.6 |
| 1630 | -296 | -140 | 16524 | 11 | 4 | 12 | 26.54503 | 100319.8 |
| 1631 | -272 | -168 | 16560 | 9 | 5 | 9 | 26.54236 | 100319.8 |
| 1632 | -280 | -220 | 16592 | 15 | 2 | 12 | 26.5477 | 100320.1 |
| 1633 | -240 | -156 | 16508 | 6 | 6 | 11 | 26.5477 | 100320 |
| 1634 | -216 | -144 | 16492 | 12 | 2 | 8 | 26.5477 | 100320.6 |
| 1635 | -156 | -156 | 16572 | 2 | 4 | 10 | 26.5477 | 100319.8 |
| 1636 | -252 | -168 | 16488 | 8 | 3 | 13 | 26.54236 | 100321 |
| 1637 | -224 | -80 | 16484 | 4 | 5 | 11 | 26.5477 | 100320.2 |

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

Software Evaluation Tools



MotionLink supports the latest TDK-InvenSense Motion Hardware including

| TDK Part Number | URL |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MPU-6000 | https://www.invensense.com/products/motion-tracking/6-axis/mpu-6050/ |
| ICM-20601 | https://www.invensense.com/products/motion-tracking/6-axis/icm-20601/ |
| ICM-20602 | https://www.invensense.com/products/motion-tracking/6-axis/icm-20602/ |
| ICM-20608-G | https://www.invensense.com/products/motion-tracking/6-axis/icm-20608-2/ |
| ICM-20648 | https://www.invensense.com/products/motion-tracking/6-axis/icm-20648/ |
| ICM-20649 | https://www.invensense.com/products/motion-tracking/6-axis/icm-20649/ |
| ICM-20789 | https://www.invensense.com/products/motion-tracking/7-axis/ |
| ICM-20948 | https://www.invensense.com/products/motion-tracking/9-axis/icm-20948/ |
| IAM-20680 | https://www.invensense.com/products/motion-tracking/6-axis/iam-20680/ |
| ICG-20660L | https://www.invensense.com/products/motion-tracking/6-axis/icm-20660/ |

Software Evaluation Tools



The Embedded Motion Driver (eMD) for SmartMotion Platforms

- Fully Featured Motion Software including
 - Sensor Fusion
 - Gesture Tracking
 - DMP Image (if applicable)
 - Factory Test and Calibration
 - In-Use Calibration
- Currently supported SmartMotion eMDs
 - ICM20602
 - ICM20648
 - ICM20948
 - ICM20789



Software Evaluation Tools



ICM-20948 eMD Features Example -

- Raw Accelerometer
- Raw Gyroscope
- Raw Magnetometer
- Dynamically Calibrated Accelerometer
- Dynamically Calibrated Gyroscope
- Dynamically Calibrated Magnetometer
- Game Rotation Vector – Accel and Gyro based RV
- Rotation Vector – Accel, Gyro, and Mag based RV
- Geomagnetic Rotation Vector – Accel and Mag based RV
- BAC (Basic Activity Classifier) – Android-based activity detection of Walking, Standing, Running, Biking, and Transport
- Step Detector
- Step Counter (Pedometer)
- SMD (Significant Motion Detection)
- Pickup Detection
- Tilt Detection
- Gravity
- Linear acceleration
- Orientation
- B2S (Bring to See) Detection
- Heading
- Euler Angles
- Quaternion generation





MotionLink : Getting Started

SDC - October 2017

Installing the PC Software

3rd Party Software Drivers –

- ATMEL Studios – free Atmel IDE for all Microchip/Atmel MCUs
 - Required to flash and trace code
 - As of release MotionLink and eMD developed using Atmel Studio v. 7.0.1417
 - <http://www.atmel.com/microsite/atmel-studio/>
- FTDI Driver - <http://www.ftdichip.com/Drivers/VCP.htm>

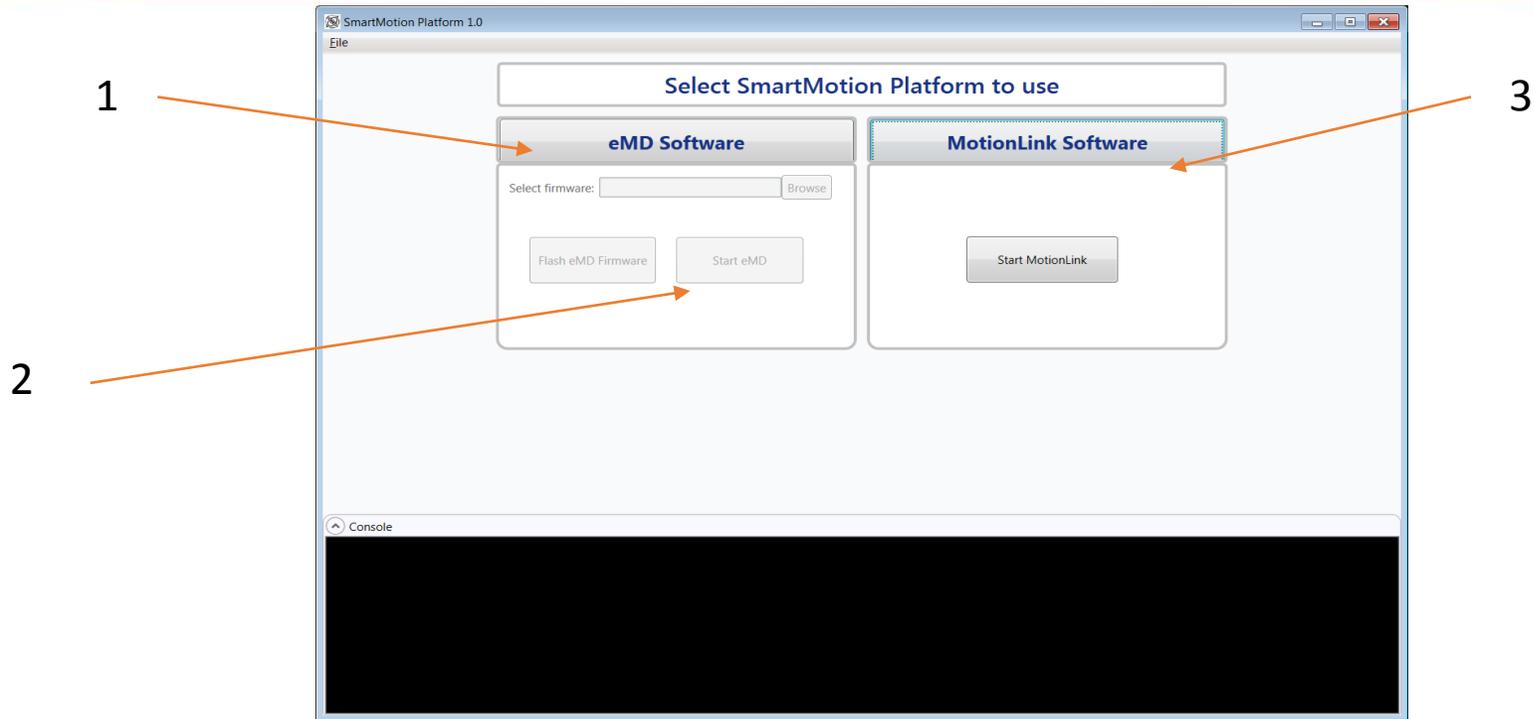
Install SmartMotion Installer with MotionLink–

- Download and Install from InvenSense Developer's Corner –
 - <https://www.invensense.com/developers/software-downloads/>

Connect SmartMotion platform and open MotionLink at Launcher!



SmartMotion Launcher



SmartMotion Hardware is pre-flashed with MotionLink!

SmartMotion Launcher page – select between using eMD or MotionLink

1. eMD Software – flash Atmel G55 MCU with a released version of eMD
 - SmartMotion Installer will have a version of the eMD release
 - Allow customers to browse for MCU images to flash
2. 'Start eMD' - Will open up the 'sensor-cli' command window used for eMD interface
3. MotionLink Software – will start up the MotionLink GUI

MotionLink Features

The screenshot shows the MotionLink 3.0.3 Release software interface. It includes a menu bar (File, Help), a Firmware section with buttons for Flash MCU Firmware (1) and Reset MCU (2), and a Serial port section with a dropdown menu (2) and a Disconnect button. An Add Sensor Board Configuration button (5) is located above a Boards list containing ICM20789 (6). Below this is a Log file section (3) with a dropdown menu and an Enable button (7). The main data display (4) is a table with columns for Timestamp, Accel X (LSB), Accel Y (LSB), Accel Z (LSB), Gyro X (LSB), Gyro Y (LSB), Gyro Z (LSB), Temperature, and Pressure (Pa). The Console section (8) at the bottom shows system messages.

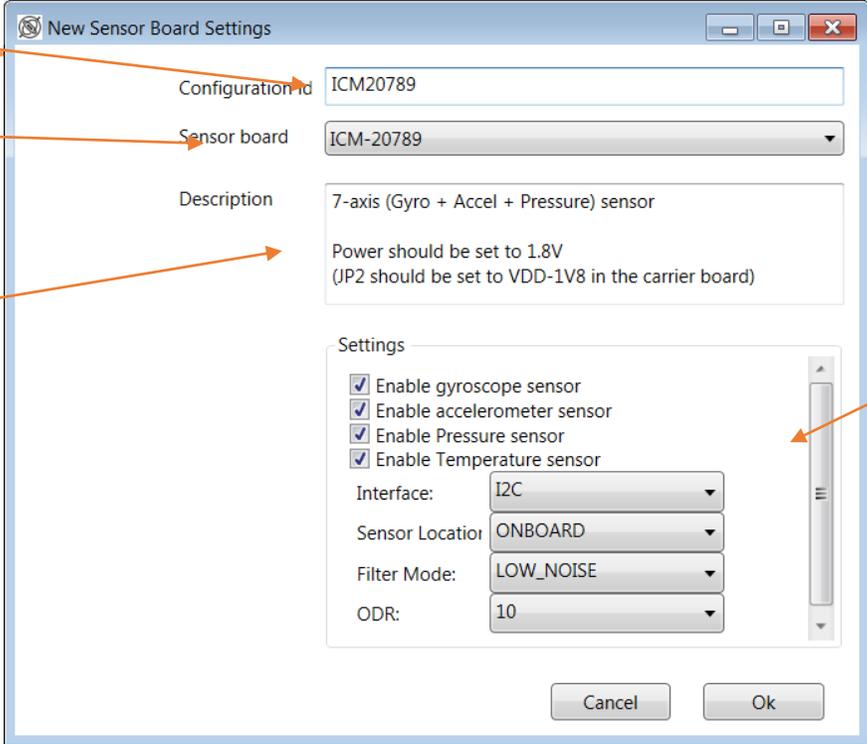
| Timestamp | Accel X (LSB) | Accel Y (LSB) | Accel Z (LSB) | Gyro X (LSB) | Gyro Y (LSB) | Gyro Z (LSB) | Temperature | Pressure (Pa) |
|-----------|---------------|---------------|---------------|--------------|--------------|--------------|-------------|---------------|
| 1 | -3608 | 20 | 16188 | 8 | 44 | -1 | 24.61708 | 101130.6 |
| 2 | -3660 | 32 | 16284 | -2 | 40 | -4 | 24.61708 | 101130.5 |
| 3 | -3656 | -48 | 16264 | 5 | 40 | -12 | 24.61708 | 101129.6 |
| 4 | -3632 | 56 | 16148 | 9 | 42 | -13 | 24.62242 | 101131.5 |
| 5 | -3648 | 60 | 16192 | 3 | 49 | -4 | 24.62509 | 101131.9 |
| 6 | -3708 | -20 | 16200 | 8 | 40 | -2 | 24.62776 | 101131.1 |
| 7 | -3652 | 52 | 16300 | 6 | 39 | -2 | 24.62509 | 101131.5 |
| 8 | -3672 | 12 | 16268 | 10 | 31 | -3 | 24.63043 | 101131 |

```

Console
Using class 'InvGUI_Board_IAM20380' from C:\Users\jlin\AppData\Roaming\TDK-InvenSense\SmartMotion Platform\data\IAM20380\Board_IAM20380.cs
Using class 'InvGUI_Board_ICM20789' from C:\Users\jlin\AppData\Roaming\TDK-InvenSense\SmartMotion Platform\data\ICM20789\Board_ICM20789.cs
Using class 'InvGUI_Board_ICM20789' from C:\Users\jlin\AppData\Roaming\TDK-InvenSense\SmartMotion Platform\data\ICM20789\Board_ICM20789.cs
Sensor #1 'ICM20789' (I2C, 4, 105) opened
Init 20789
Logging 'ICM20789' started
Logging 'ICM20789' stopped
  
```

1. Flash Firmware – flash G55 MCU with MotionLink firmware or base eMD. Requires Atmel Studios!
2. Reset MCU – erases the firmware on the MCU
3. FTDI COM port connection – connect to the FTDI COM output. (not the EDGB COM port)
4. Data Output Console – displays requested data through the tab windows, registers, sensor data, and graphical data
5. Sensor Board Configuration – Adds target sensors to be evaluated
6. Sensor Board Control – Initialize and capture data control
7. Log File Output – can specify text log file for the sensor data if requested
8. Message Console Output – outputs error and status messages

MotionLink Features



The screenshot shows a 'New Sensor Board Settings' dialog box with the following fields and callouts:

- 1** points to the **Configuration ID** field, which contains 'ICM20789'.
- 2** points to the **Sensor board** dropdown menu, which is set to 'ICM-20789'.
- 3** points to the **Description** text area, which contains '7-axis (Gyro + Accel + Pressure) sensor' and 'Power should be set to 1.8V (JP2 should be set to VDD-1V8 in the carrier board)'.
- 4** points to the **Settings** section, which includes:
 - Four checked checkboxes: 'Enable gyroscope sensor', 'Enable accelerometer sensor', 'Enable Pressure sensor', and 'Enable Temperature sensor'.
 - 'Interface' dropdown set to 'I2C'.
 - 'Sensor Location' dropdown set to 'ONBOARD'.
 - 'Filter Mode' dropdown set to 'LOW_NOISE'.
 - 'ODR' dropdown set to '10'.

Adding New Sensor Board Configurations

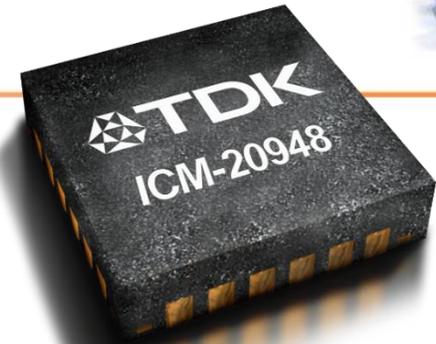
1. Configuration ID – Customer customizable ID for that particular sensor board configuration to be added
2. Sensor Board – drop down list on the full motion parts to be selected
3. Description – short description on the selected parts
4. Sensor Settings –
 - Customer can specify on which hardware sensor to stream
 - Specify I2C or SPI interface
 - Sensor Location if on board or attached external sensor EVB (on-board I2C address is always 0x69 while external I2C address is always 0x68)
 - Filter Mode to either Low_Noise (high power) or Low_Power (higher noise)
 - ODR selectable up to 1Khz



Embedded Motion Driver (eMD) : Getting Started

SDC - October 2017

Installing the PC Software



3rd Party Software Drivers for Hardware –

- ATMEL Studios – free Atmel IDE for all Microchip/Atmel MCUs
 - ↳ Required to flash and trace code
 - ↳ As of release MotionLink and eMD developed using Atmel Studio v. 7.0.1417
 - ↳ <http://www.atmel.com/microsite/atmel-studio/>
- FTDI Driver - <http://www.ftdichip.com/Drivers/VCP.htm>

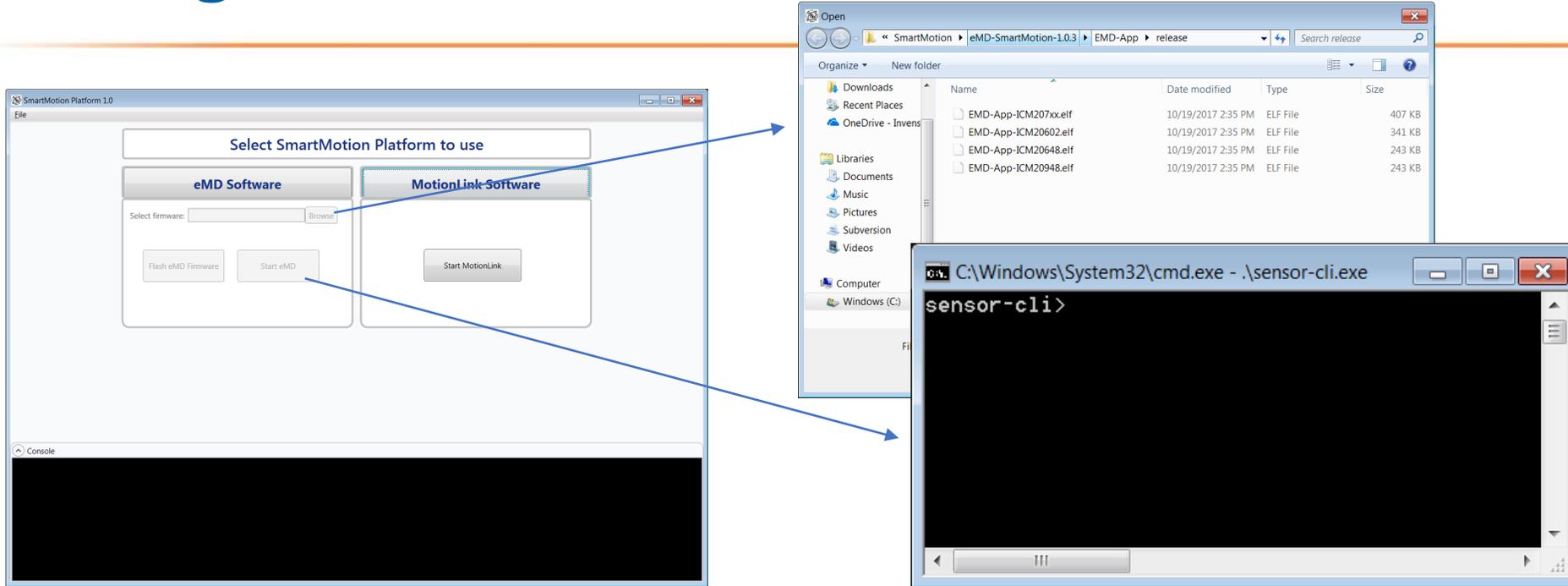
Install TDK-InvenSense eMD – 2 Options

- Option 1 – Download ‘SmartMotion Installer’. SmartMotion Installer will have a base eMD that can be downloaded to the MCU
- Option 2 – Download latest ‘eMD for SmartMotion’ Atmel Studio project to be compiled and download to the MCU

<https://www.invensense.com/developers/software-downloads/>

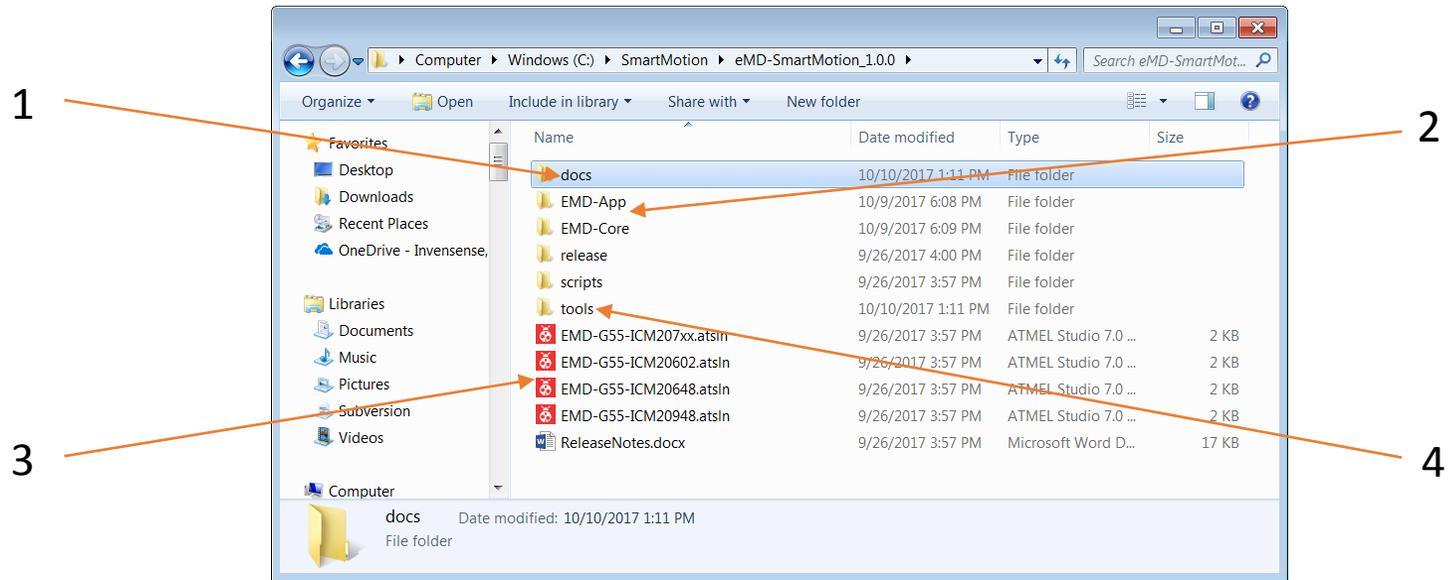
Connect SmartMotion platform and to PC

Using SmartMotion Installer for eMD



- SmartMotion Installer comes with feature to flash and use the eMD firmware
 - Requires Atmel Studio
 - Release eMD image but possibly an earlier version
 - MotionLink feature will not be able to function if using eMD
- In SmartMotion Launcher page click “eMD Software” to start the process
- Selecting “Browse” for will bring up a directory with pre-installed eMD images (.elf files)
- Selecting “Start eMD” will bring up a sensor-cli window

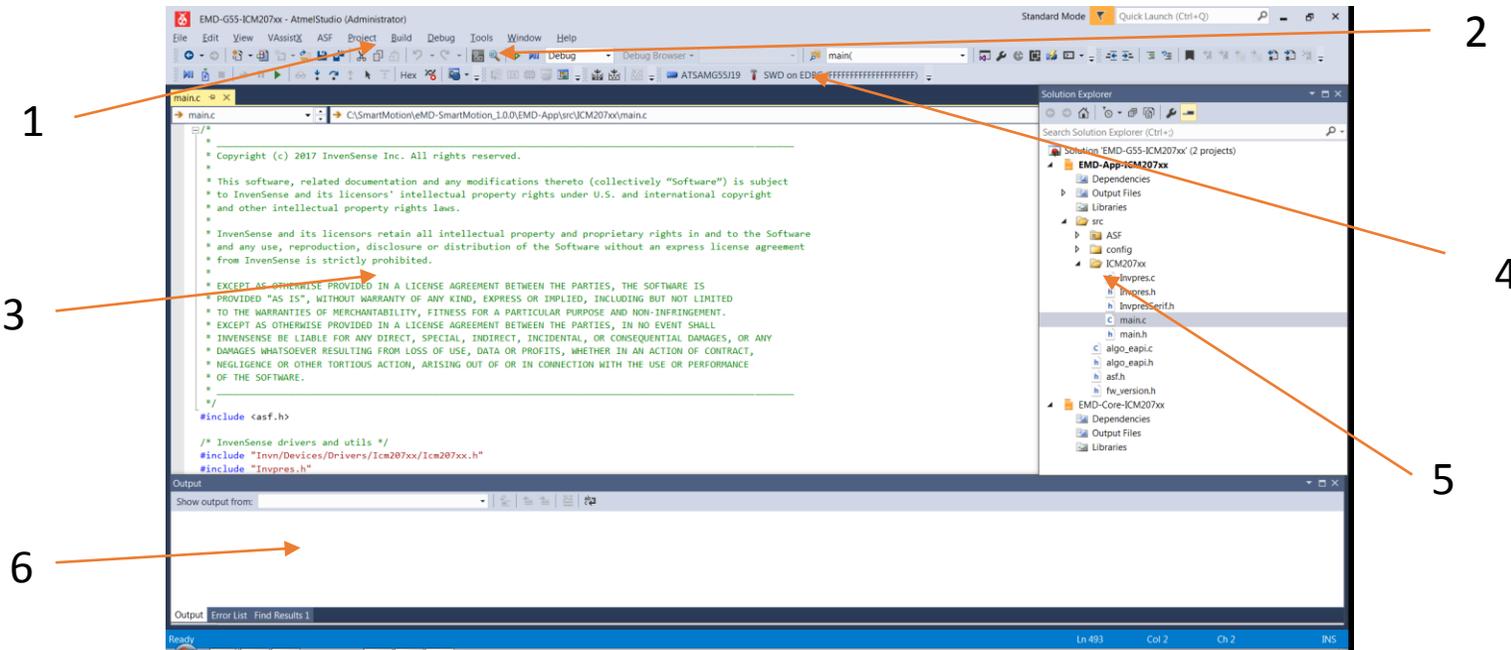
eMD - Atmel Studio Project



eMD Release Package

1. Docs directory : contains detailed SW User Guides and other documentations
2. EMD-App and EMD-Core : contains main driver code. 'App' has the main.c as well as board specific files. 'Core' has the libraries as well as the sensor driver files.
3. Atmel Studio Project Files : A specific main project for each SmartMotion platform to be opened in Atmel Studios
4. Tools directory : Contains 'sensorcli.exe' the command line tool to interface with the eMD

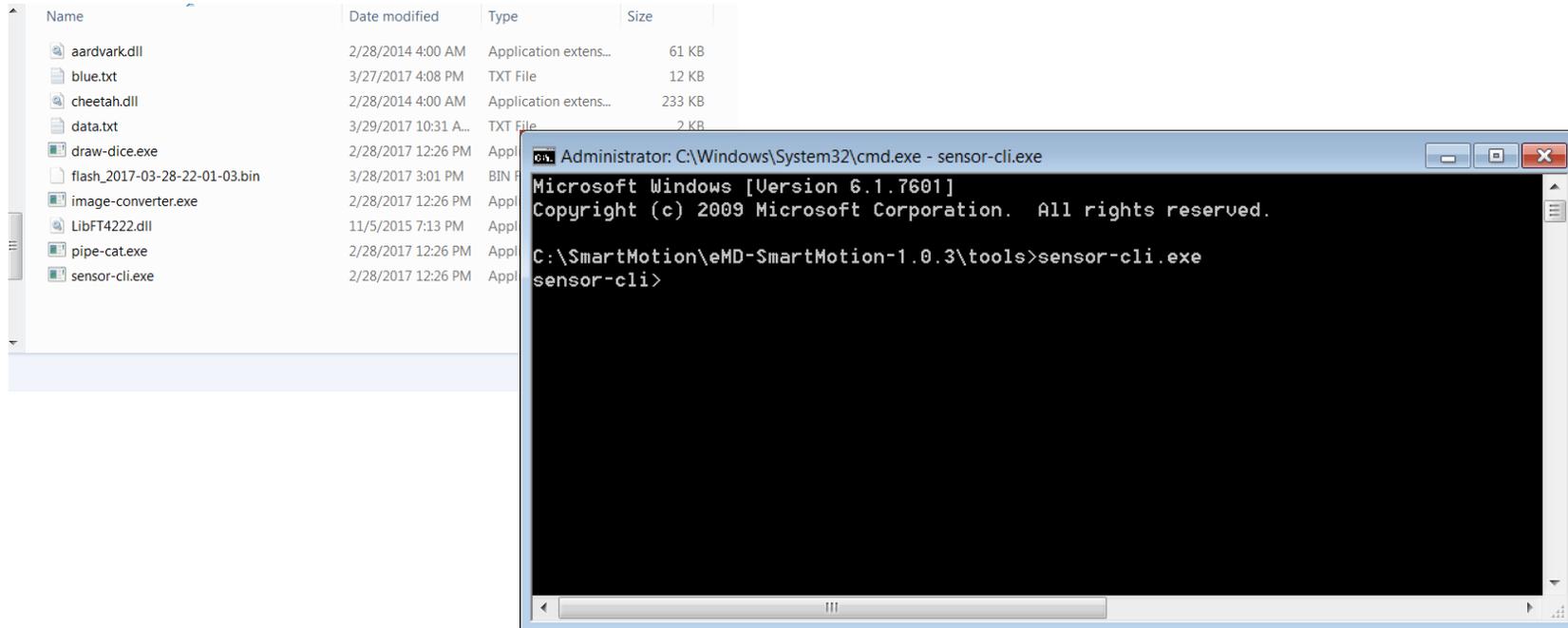
eMD - Atmel Studio Project



Quick Overview - Atmel Studio IDE

1. Control Tabs – Pull down tabs to build and compile project
2. Debug Controls – Used for code tracing
3. Main Code Console – display selected code
4. Target – targeted MCU and also debugger, make sure it is specify to 'ATSAMG55J19' and 'SWD on EDGB'
5. Project Tree – directory of all project files
6. Debugging and Message console – misc messages from IDE

SmartMotion eMD – using sensor-cli.exe



- 'Sensor-cli' is the command line tool which interfaces with the eMD and the SmartMotion board
 - ↳ Open 'tools' directory in release package, you should see the sensor-cli.exe along with other drivers
 - ↳ Open Command Prompt at the directory location and execute the sensor-cli.exe by running command
 - If only 1 SmartMotion hardware is connected to PC
 - 'sensor-cli.exe'
 - Multiple SmartMotion – 'sensor-cli --target=emdwrapicm20x48,port=\\.\COM66 --adapter=dummy'
 - Target argument will be specific to the SmartMotion platform, see SW User Guide for target
 - Port will be the FTDI COM port, can be found in PC Device Manager
 - ↳ If successful you will see a 'sensor-cli>' prompt on the command window

SmartMotion eMD – common sensor-cli.exe commands



- sensor-cli.exe has full range of commands to interface with the eMD specifies in SW User Guide
- Useful Commands
 - 'help' – displays set of commands and input arguments. You can also 'help <command>'

```
Administrator: C:\Windows\System32\cmd.exe - sensor-cli --target=emdwrapicm20x48,port=\\...
C:\SmartMotion\eMD-SmartMotion_1.0.0\tools>sensor-cli --target=emdwrapicm20x48
sensor-cli> help
alias -- register an alias
batch -- change sensor batch timeout
cube -- display orientation data with a rotating cube
decode -- configure how sensor events data are decoded
dis -- stop a sensor
disp -- enable or disable display of sensor event to stdout or pipe
dumpflash -- dump or compare flash memory
en -- start a sensor
exit -- alias of 'quit'
```

- 'ping' – displays all sensors available and their IDs

```
Administrator: C:\Windows\System32\cmd.exe - sensor-cli --target=emdwrapicm20x48,port=\\...
sensor-cli> ping
Ping OK - SENSOR_ACCELEROMETER (id: 1)
Ping OK - SENSOR_MAGNETOMETER (id: 2)
Ping OK - SENSOR_GYROSCOPE (id: 4)
Ping OK - SENSOR_GRAVITY (id: 9)
Ping OK - SENSOR_LINEAR_ACCELERATION (id: 10)
Ping OK - SENSOR_ROTATION_VECTOR (id: 11)
Ping OK - SENSOR_UNCAL_MAGNETOMETER (id: 14)
Ping OK - SENSOR_GAME_ROTATION_VECTOR (id: 15)
Ping OK - SENSOR_UNCAL_GYROSCOPE (id: 16)
Ping OK - SENSOR_GEOMAG_ROTATION_VECTOR (id: 20)
Ping OK - SENSOR_RAW_ACCELEROMETER (id: 32)
Ping OK - SENSOR_RAW_GYROSCOPE (id: 33)
sensor-cli>
```

SmartMotion eMD – common sensor-cli.exe commands



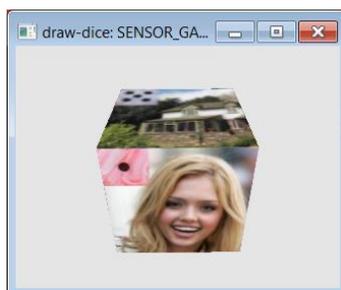
- Useful Commands continued...
 - 'en <sensorid>' – streams the sensor data to console. 'dis all' will stop streaming

```
Administrator: C:\Windows\System32\cmd.exe - sensor-cli --target=emdwrapicm20x48,port=\\\\.\\COM66 --adapter=dummy
sensor-cli> en 4
sensor-cli> EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 573655000 us: 0 data: -0.937500 0.500000 0.437500 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 573853000 us: 0 data: -0.812500 0.187500 0.562500 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 574052000 us: 0 data: -0.375000 0.062500 0.625000 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 574250000 us: 0 data: 0.062500 0.062500 0.625000 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 574448000 us: 0 data: 0.062500 0.187500 0.500000 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 574647000 us: 0 data: 0.062500 0.687500 0.437500 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 574845000 us: 0 data: -0.312500 0.562500 0.750000 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 575044000 us: 0 data: 0.500000 0.875000 0.625000 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 575242000 us: 0 data: 0.625000 0.687500 -0.187500 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 575440000 us: 0 data: 1.562500 0.250000 0.687500 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 575639000 us: 0 data: 0.937500 0.312500 0.562500 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 575837000 us: 0 data: 0.000000 -0.187500 -0.125000 0
EVENT D SENSOR_GYROSCOPE id: 0x00000004 t: 576035000 us: 0 data: 0.125000 0.250000 0.187500 0
```

SmartMotion eMD – common sensor-cli.exe commands



- Useful Commands continued...
 - Displaying the cube
 - 'cube on <sensorid>' – the cube window will appear but will not move until you enable the sensor. Best results are to use fusion sensors like Rotational Vectors ('rv' or 'grv')
 - 'en <sensorid>' – the sensor will start streaming to console, you will see the cube move based on the sensor data.



```
Administrator: C:\Windows\System32\cmd.exe - sensor-cli --target=emdwrapicm20x48,port=\\.\COM66 --adapter=dummy
sensor-cli> cube on grv
sensor-cli> en grv
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1132803000 us: 0 data: 0.996826 0.000244 0
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1133993000 us: 0 data: 0.967163 -0.186096 -0.138733 -0
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1135183000 us: 0 data: 0.990173 -0.109192 -0.086975 -0
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1136373000 us: 0 data: 0.950256 -0.286377 -0.100708 0.
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1137564000 us: 0 data: 0.992859 -0.007568 0.013123 0.1
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1138754000 us: 0 data: 0.958862 0.236450 -0.151611 0.0
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1139944000 us: 0 data: 0.988281 0.150391 0.015137 0.02
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1141134000 us: 0 data: 0.909241 0.414978 -0.020752 -0.
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1142324000 us: 0 data: 0.951782 0.305725 -0.011658 -0.
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1143515000 us: 0 data: 0.948792 0.314819 -0.013123 -0.
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1144705000 us: 0 data: 0.950562 0.309875 -0.012878 -0.
EVENT D SENSOR_GAME_ROTATION_VECTOR id: 0x0000000f t: 1145895000 us: 0 data: 0.954773 0.296814 -0.009460 -0.
```

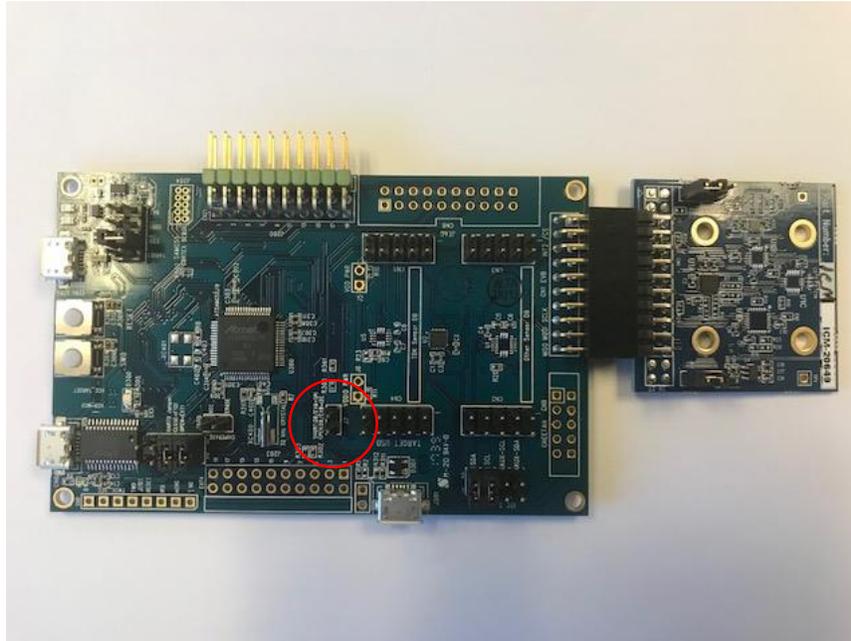
- Other commands –
 - selftest, setting ODRs, bias configurations, logging, etc....



External Sensors

SDC - October 2017

Connecting TDK-InvenSense Motion EVBs



- TDK-InvenSense motion EVBs are sold separately and can be connected to the SmartMotion Platform
- MotionLink and eMDs can interface with the EVB if supported
 - Motion parts which requires 1.8V VDDIO cannot be supported (ICM-20789 and ICM-20948)
 - External EVB requires eMDs to change to I2C address 0x68
 - Jumper J7 – interface to external EVB
 - I2C – Open
 - SPI – Closed
 - ICM-20602, ICM-20648, ICM20948 eMD are default SPI
 - ICM-20789 eMD are default I2C



eMD Porting Guidelines

SDC - October 2017

eMD Porting Guidelines



- MCU requirements
 - Atmel G55
 - Cortex M4 wth FPU
 - 120Mhz CPU Speed
 - 512Kb flash, 176Kb SRAM
 - I2C, SPI, UARTS
 - eMD v 1.0.3 Current Memory
 - 120Kb to 140Kb flash
 - 20Kb SRAM
 - SPI or I2C support
- Sensor Fusion
 - DK-20648 and DK-20948 - on board DMP
 - DK-20789 and DK-20602 – MCU sensor fusion library
- Tool Chains –
 - Atmel Studio - GCC compiler





Take Aways

SDC - October 2017

SmartMotion : Accelerate Product deployment



- **SmartMotion provides everything to evaluate and develop applications with TDK-InvenSense motion sensors**
 - **Simple to set up, easy to use**
 - **Software toolchains are free**
 - **No external debugger required – saves \$\$\$**
- **Affordable : \$99 ASP**
 - **Widely available at TDK Distributors (DigiKey, Mouser, CDI, Avnet) at \$99**
- **MotionLink enables easy evaluation of the sensor hardware**
- **eMD includes sensor fusion and motion algorithms**

TDK-InvenSense SmartMotion Support



- TDK-InvenSense SmartMotion Website -
 - <https://www.invensense.com/smartmotion-platform/>
- General Tech Support - techsupport_NorthAmerica@invensense.com
- General Sales Support – sales.us@invensense.com

Thank you!

