

Attracting Tomorrow



SmartMotion®

Platform Introduction Training

TDK InvenSense Development Tool for Motion Sensors

March 2018

InvenSense

MEMS Sensor Business Group
Sensor System Business Company

[4/22/2019]

- SmartMotion Platform
 - ¬ 6 Axis, 7-Axis, 9-Axis, and 1-Axis development kits
 - DK-20602, DK-20648, DK-20680A, DK-20789, DK-20948, DK-10100, DK-42605
- 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

Attracting Tomorrow



The SmartMotion Platform

March 2018

InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

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 TDK InvenSense 6-Axis, 7-Axis 9-Axis, and 1-Axis Motion Sensor

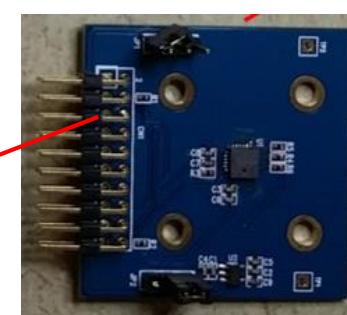
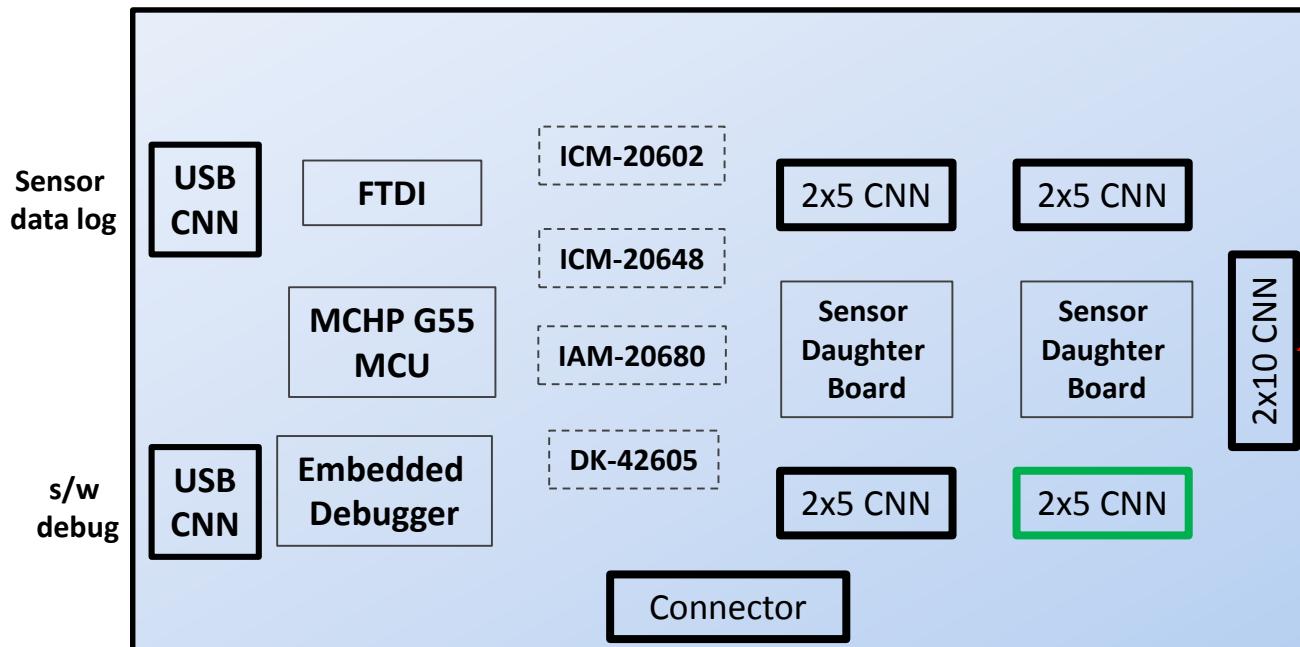
<https://www.invensense.com/smartmotion-platform/>

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 latest MotionLink software tool pre-flashed on the MCU. The board is configured with default jumper settings.
QuickStart Guide	Instructions to for platform bring up with links to software downloads

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
 - 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

Version B - 6 Axis Sensors



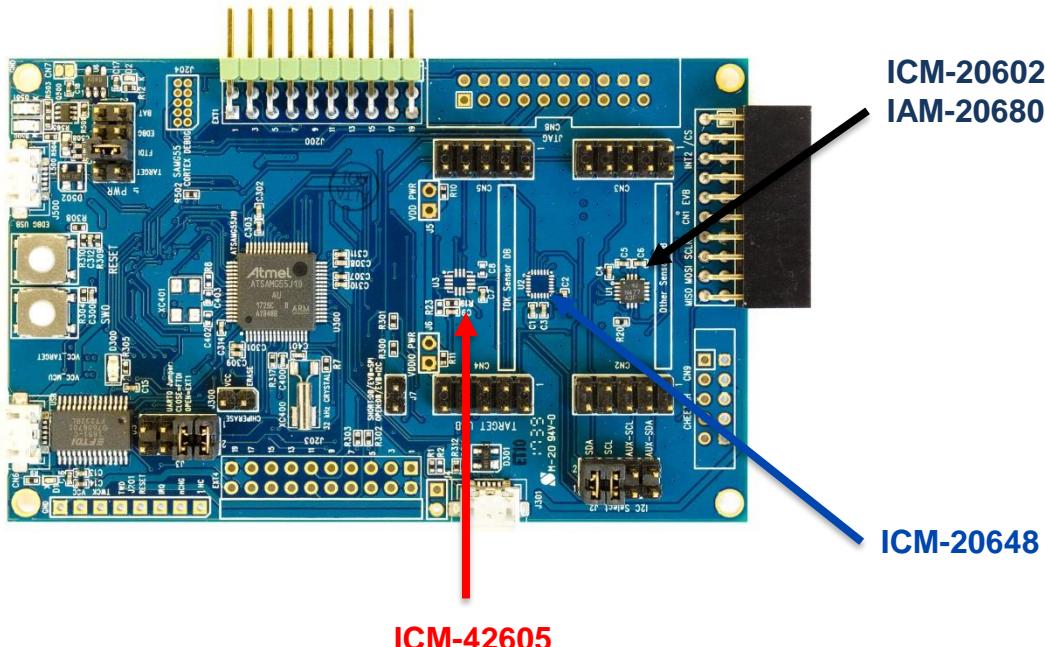
Microchip
WiFi/BLE Module

DK-42605

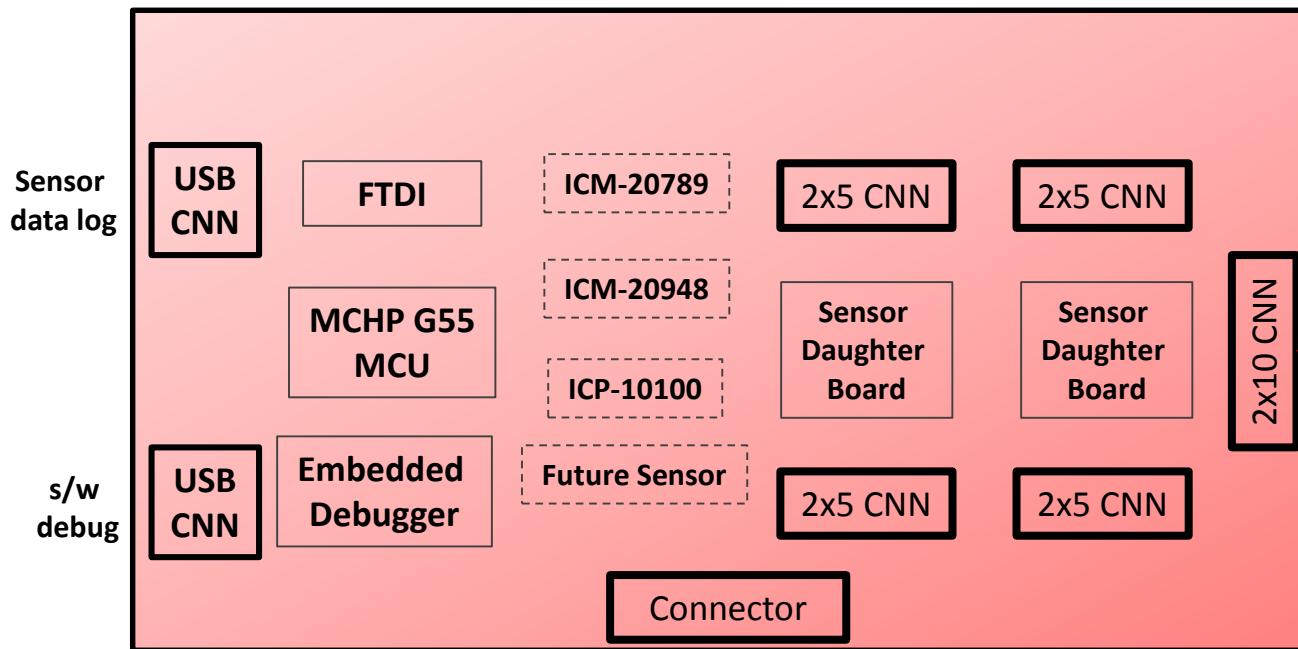
DK-20602

DK-20648

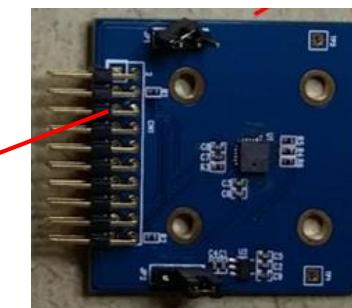
DK-20680A



Version C – 1, 7 and 9 axis Sensors



InvenSense
Sensor EVB



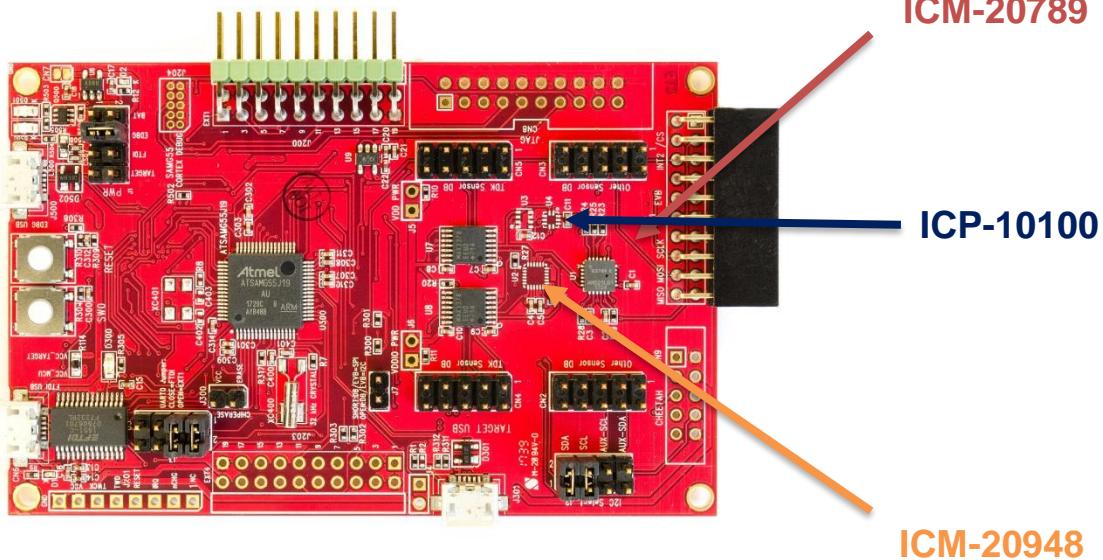
Microchip
WiFi/BLE Module

SmartMotion® 7, 9, 1-axis Platforms

DK-20789

DK-20948

DK-10100



Attracting Tomorrow



SmartMotion : Hardware and Selection

March 2018

InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

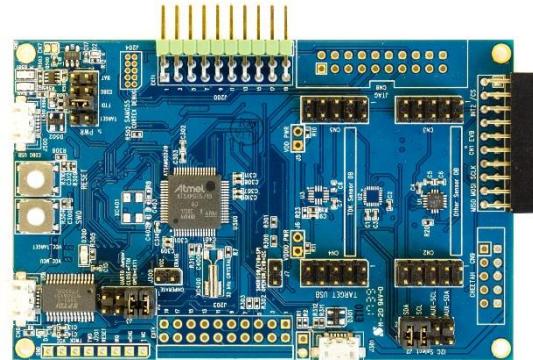
SmartMotion™ Platform – 6 Axis

DK-20602

DK-20648

DK-20680A

DK-42605



SmartMotion™ Platform – 7, 9, and 1 Axis

DK-20789

DK-20948

DK-10100



Attracting Tomorrow



SmartMotion : 6 Axis Platforms

March 2018

InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

ICM-42605

World's Best 6-axis Solution

Specifications

- High Performance Gyro
 - Gyro Sensitivity Error: $\pm .5\%$
 - Gyroscope Noise: $\pm 3.8\text{mdps}/\sqrt{\text{Hz}}$
- High Performance Accel
 - Accel Noise: $70\mu\text{g}/\sqrt{\text{Hz}}$
 - Accel Sensitivity: $\pm .5\%$
- Low Power Solution
 - Full Power: 0.65mA
- Gyroscope Full-Scale Range:
 $\pm 15.625/31.25/62.5/125/250/500/1000/2000 \text{ deg/sec}$
- Accelerometer Full-Scale Range: $\pm 2/4/8/16\text{g}$
- Package Size: 2.5x3x0.91mm 14-Pin LGA
- Software Available: Yes

Datasheet: [ICM-42605 DataSheet](#)

Applications

- Smartphone and Tablets
- Wearable Sensors
- VR/AR
- IoT



Samples: Now
Production: Now

Solution Benefits

- Device includes 2K-byte FIFO to reduce traffic on serial bus interface
- Super low sensor noise with low power
- Includes on chip, 16-bit ADC's, programmable digital filters, an embedded temp sensor, and programmable interrupts.
- Embedded APEX Motion Functions: Pedometer, Tilt Detection, Raise to Wake/Sleep, Tap Detection, Wake on Motion, Significant Motion Detection



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: 2.79mA
 - 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

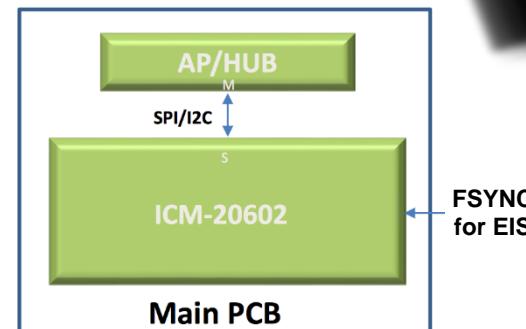
- IoT
- Augmented Reality
- Drone
- Virtual Reality



Samples: Now
Production: Now

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.



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: $\pm 250/500/1000/2000$ deg/sec
- Accelerometer Full-Scale Range: $\pm 2/4/8/16$ g
- 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



Samples: Now
Production: Now

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



IAM-20680

6-Axis Automotive IMU Solution

Specifications

- AEC-Q100 GRADE 3
- High Performance and Accuracy
- Gyroscope Full-Scale Range: $\pm 250/500/1000/2000$ deg/sec
- Accelerometer Full-Scale Range: $\pm 2/4/8/16$ g
- Low Noise
 - Gyro
 - Accel
- Operating Temperature Range: -40°C to 85°C
- Operating Voltage Range:
 - VDD
 - VDDIO:
- Host Interface: SPI 8MHz, I²C up to 400kHz
- Package Size: 3x3x0.75mm 16-Pin LGA

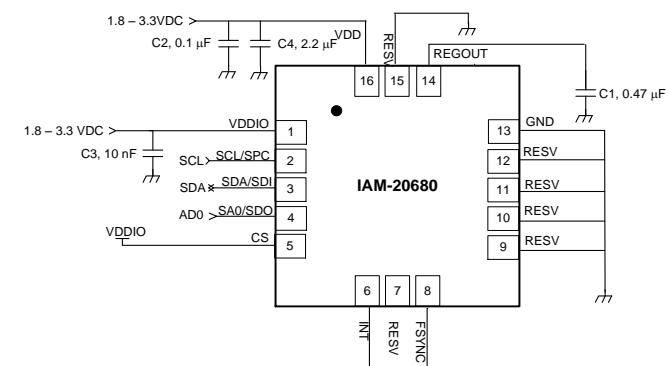
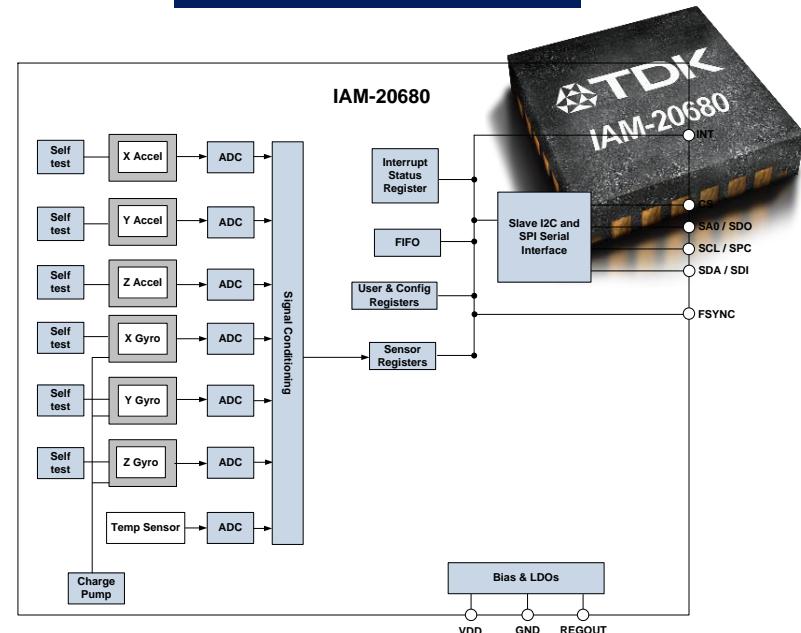
Datasheet: [IAM-20680 DataSheet](#)

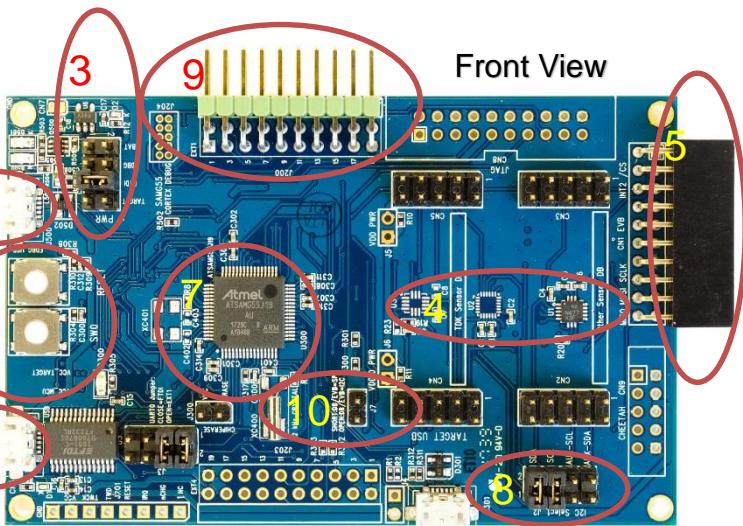
Applications

- Lift Gate Motion Detect
- Navigation
- Image Stabilization
- Vehicle Tracking

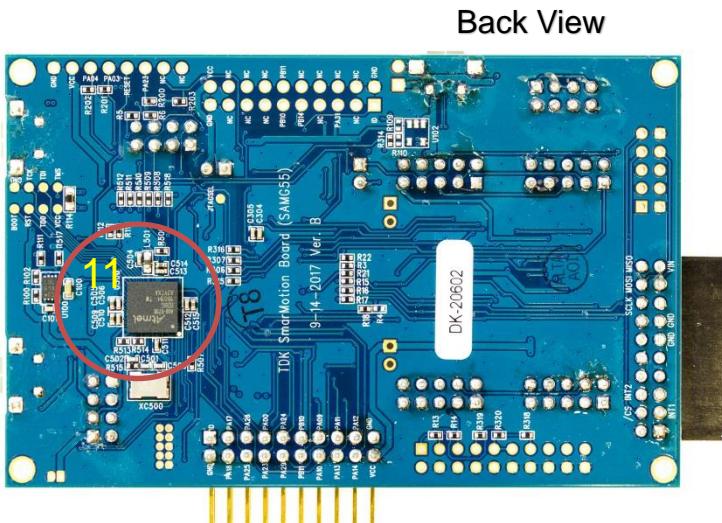


Samples: Now
Production: Now





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 configured 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 and IAM-20680. U2 for ICM-20648, U3 for ICM-42605
5. TDK Sensor EVB Connector – Connector to attach 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. ATMEAL 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!

Attracting Tomorrow



SmartMotion : 9, 7, and 1 Axis Platforms

March 2018

InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

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: $\pm 2/4/8/16$ g
- 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

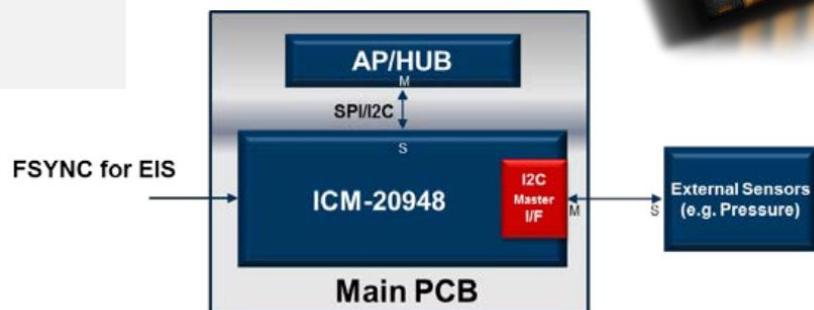
Datasheet: [ICM-20948 DataSheet](#)

Applications

- IoT
- Wearable
- Drone

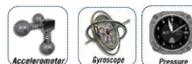
Solution Benefits

- 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



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: $\pm 2/4/8/16$ g
- Pressure Operating Range: 300hPa – 1100hPa
- Relative Pressure Accuracy: $\pm 1\text{Pa}$ (10hPa change, 700-1000hPa)
- Absolute Pressure Accuracy: $\pm 1\text{hPa}$ (300hPa-1100hPa, 0°C-65°C)
- Temperature Sensor Accuracy: $\pm 0.4^\circ\text{C}$
- 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

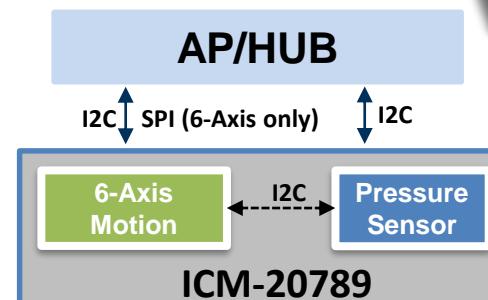
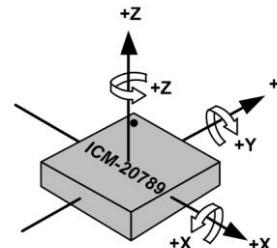
Datasheet: [ICM-20789 DataSheet](#)

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



ICP-101XX

Barometric Pressure and Temperature Sensor



Samples: Now
Production: Now

Specifications

- Pressure Operating Range: 300hPa – 1100hPa
- Relative Pressure Accuracy: **$\pm 1\text{Pa}$** (10hPa change, 700-1000hPa)
- Pressure Noise RMS and Current Consumption:
 - Low-Power Mode: **3.2\text{Pa at }1.3\mu\text{A}**
 - Low-Noise Mode: **0.8\text{Pa at }5.2\mu\text{A}**
 - Ultra Low-Noise Mode: **0.4\text{Pa at }10.4\mu\text{A}**
- Absolute Pressure Accuracy: $\pm 1\text{hPa}$ (300hPa-1100hPa, 0°C-65°C)
- Pressure Sensor Tempco: $\pm 0.5\text{Pa}/^\circ\text{C}$ (25°C-45°C, 100kPa)
- Temp Operate Range: -40°C to 85°C
- Host Interface: I²C, SPI

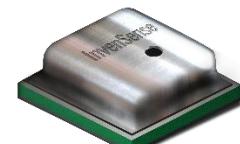
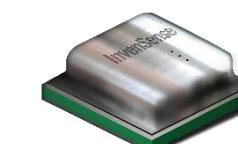
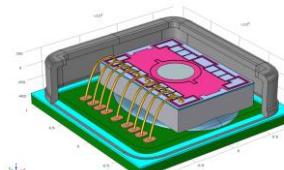
PACKAGE	3-HOLE IPX8: 1.5m WATERPROOF	1-HOLE	5%
2x2x0.72mm 10L LGA	ICP-10100	ICP-10101	
2x2.5x0.92mm 8L LGA	ICP-10110	ICP-10111	

Applications

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

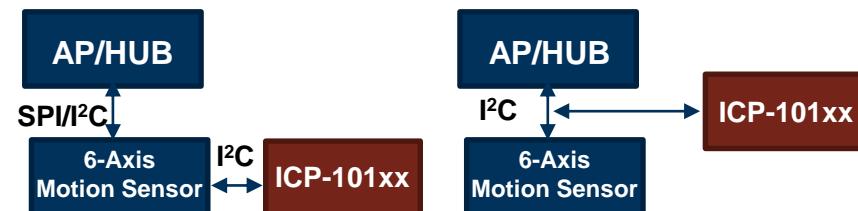
Solution Benefits

- 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

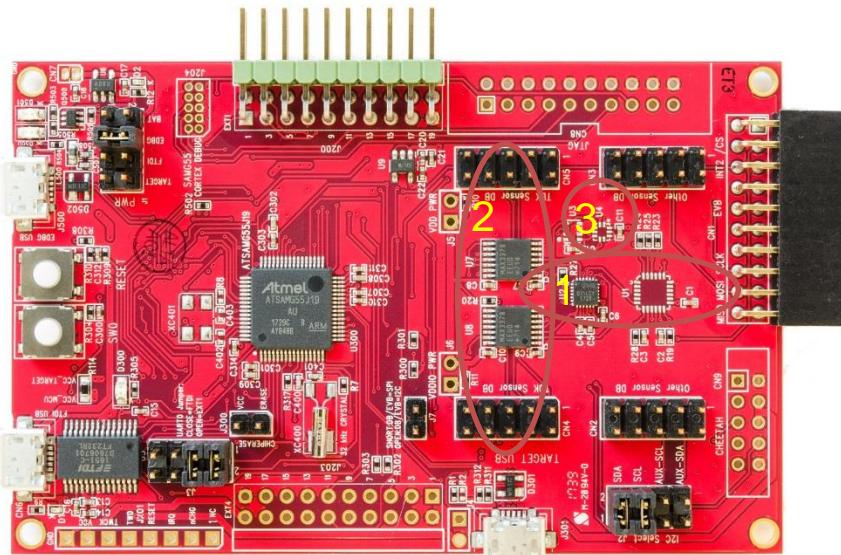


3-Hole: IPX8 Compliant
Waterproof to 1.5m Depth

Single Hole
Package



SmartMotion Platform : 9, 7, and 1 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.
3. On-Board Pressure Sensor – U4 footprint for ICP-101XX

Attracting Tomorrow



Purchasing a SmartMotion Platform

March 2018

InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

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

Distribution	URL
DigiKey	https://www.digikey.com
Mouser	https://www.mouser.com
AVNET	https://www.avnet.com
CDI	https://www.cdiweb.com

Keywords = DK-42605, DK-20602, DK-20648, DK-20789, DK-20948, DK-10100, DK-20680

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

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.

Attracting Tomorrow



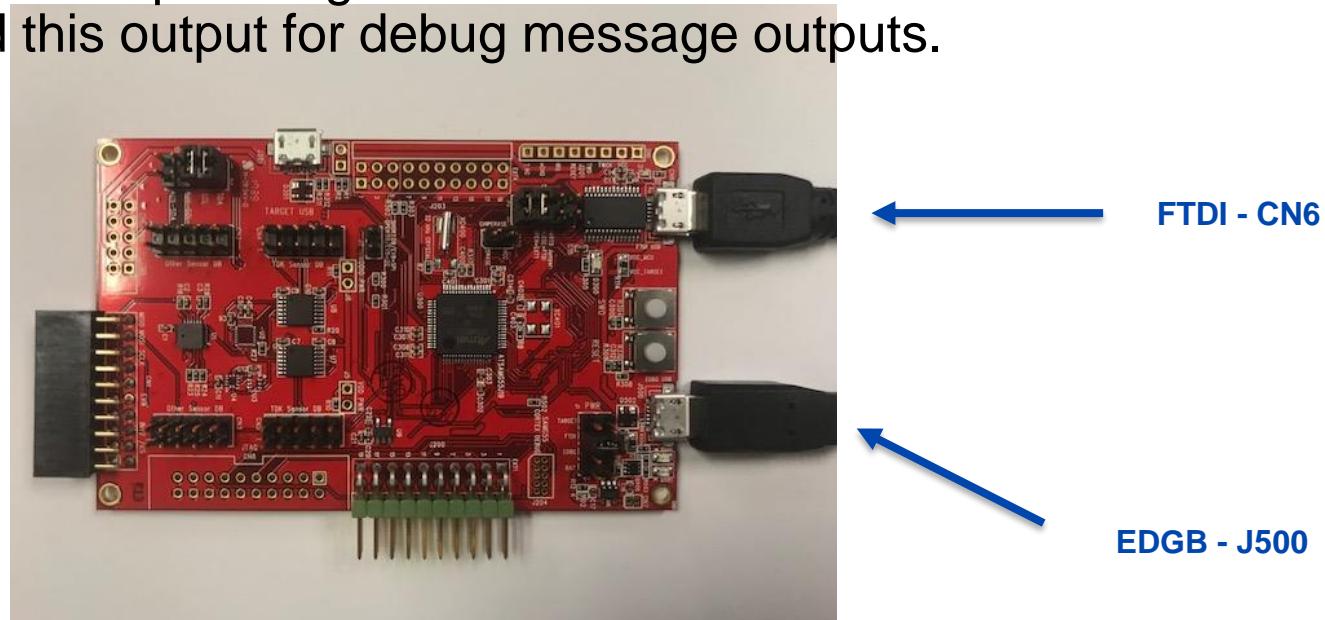
Connecting the SmartMotion Platform

March 2018

InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

- 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.



Attracting Tomorrow



SmartMotion : Software Tools

March 2018

InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

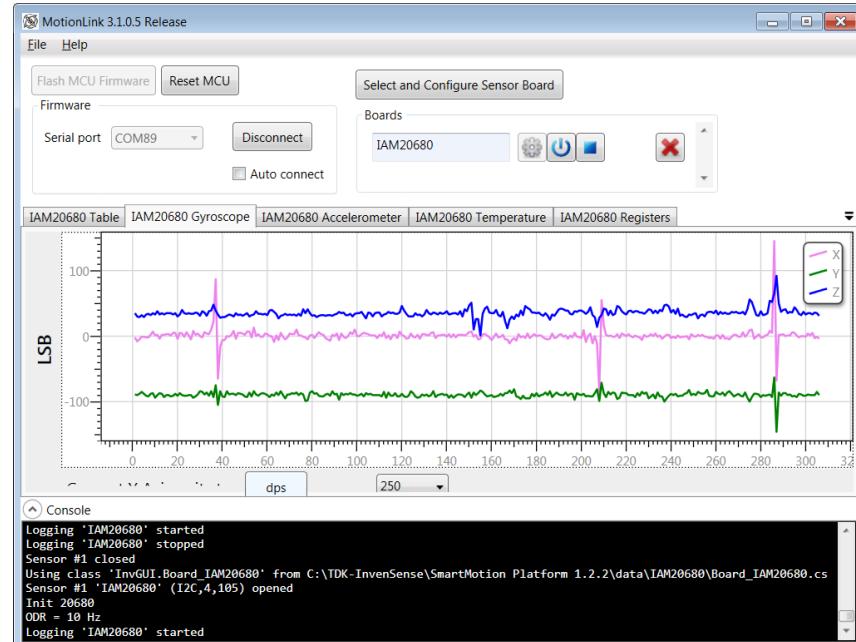
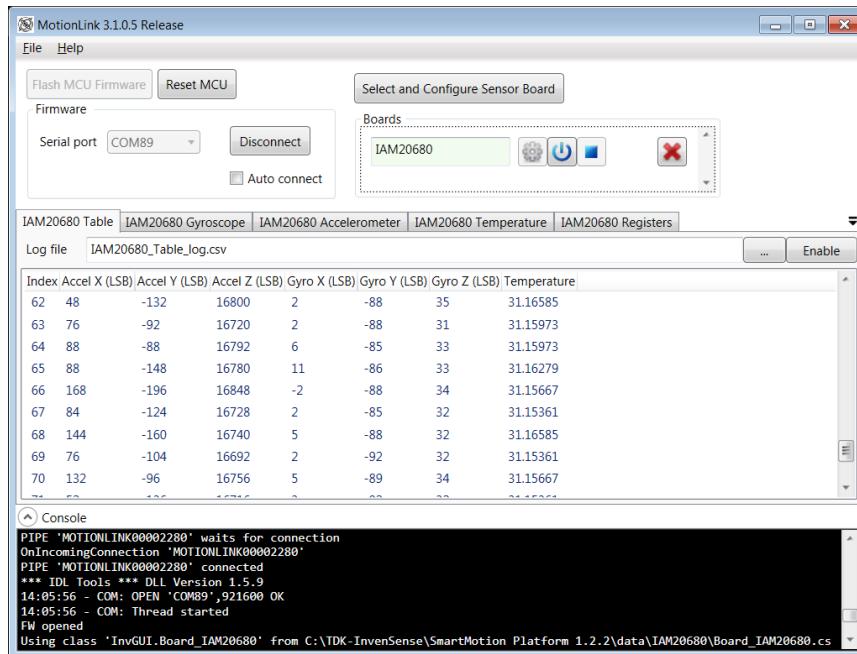
2 Software Packages

- 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/>

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

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/
ICP-10100	https://www.invensense.com/products/icp-10100/
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/

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
 - ¬ ICM-42605



- **ICM-20948 eMD Features Example -**

- Sensor Data -

- Sensor Data -
 - ¬ Raw Accelerometer
 - ¬ Raw Gyroscope
 - ¬ Raw Magnetometer
 - ¬ Dynamically Calibrated Accelerometer
 - ¬ Dynamically Calibrated Gyroscope
 - ¬ Dynamically Calibrated Magnetometer

- Sensor Fusion -

- Sensor Fusion -
 - ¬ Game Rotation Vector – Accel and Gyro based RV
 - ¬ Rotation Vector – Accel, Gyro, and Mag based RV
 - ¬ Geomagnetic Rotation Vector – Accel and Mag based RV
 - ¬ Heading
 - ¬ Euler Angles
 - ¬ Quaternion generation
 - ¬ Gravity
 - ¬ Linear acceleration
 - ¬ Orientation

- Gesture Detection -

- Gesture Detection -
 - ¬ SMD (Significant Motion Detection)
 - ¬ PickUp Detection
 - ¬ Tilt Detection
 - ¬ B2S (Bring to See) Detection
 - ¬ BAC (Basic Activity Classifier) – Android-based activity detection of Walking, Standing, Running, Biking, and Transport
 - ¬ Step Detector
 - ¬ Step Counter (Pedometer)



Attracting Tomorrow



MotionLink : Getting Started

March 2018

InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

3rd Party Software Drivers –

- ATTEL 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
 - ¬ <https://www.microchip.com/avr-support/atmel-studio-7>
- FTDI Driver - <http://www.ftdichip.com/Drivers/VCP.htm>
 - ¬ MotionLink install will include the driver and prompt user for installation

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!

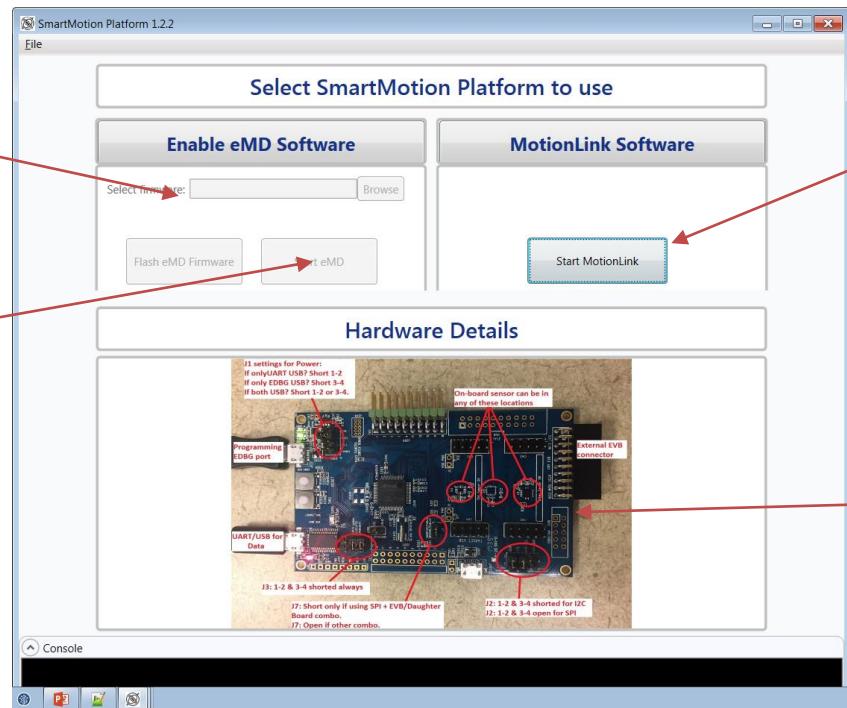


1

2

3

4



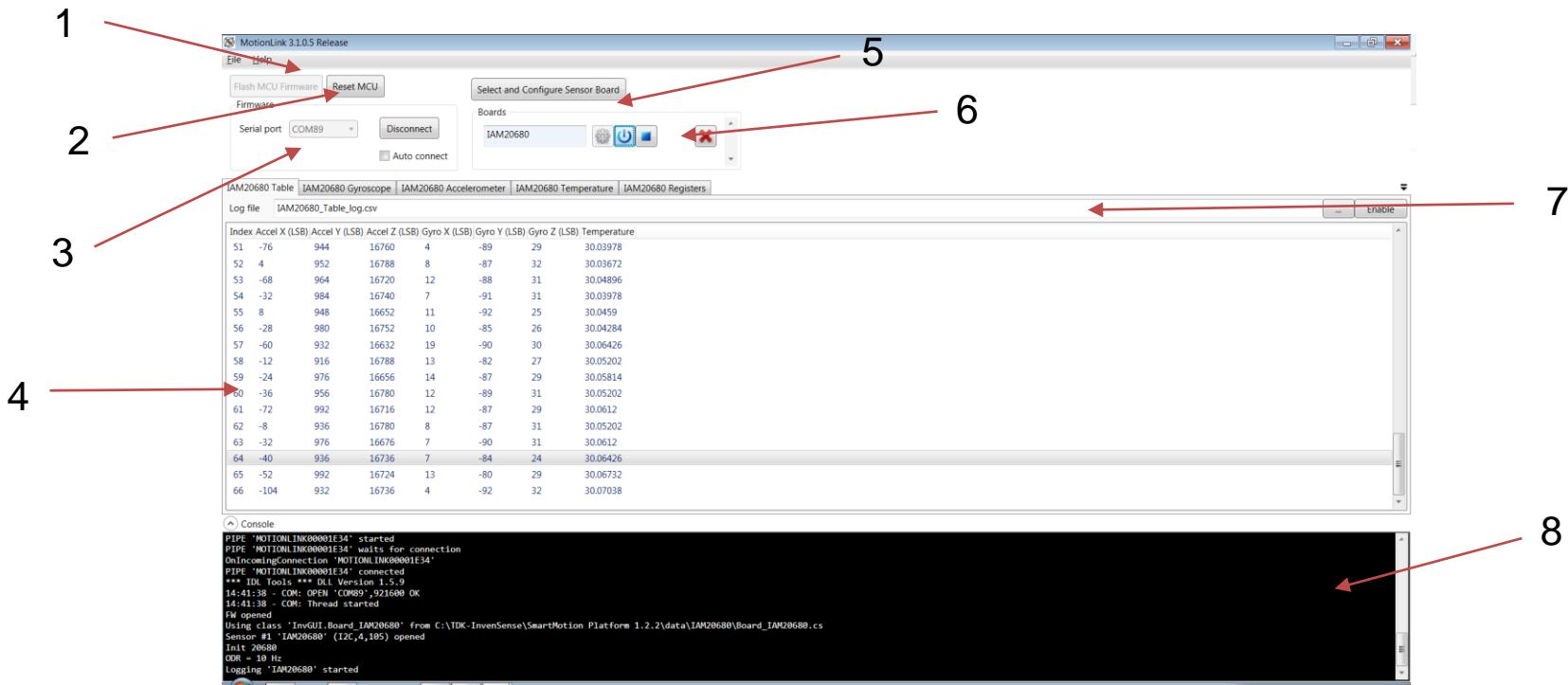
SmartMotion Hardware is pre-flashed with MotionLink!

SmartMotion Launcher page – select between using eMD or MotionLink

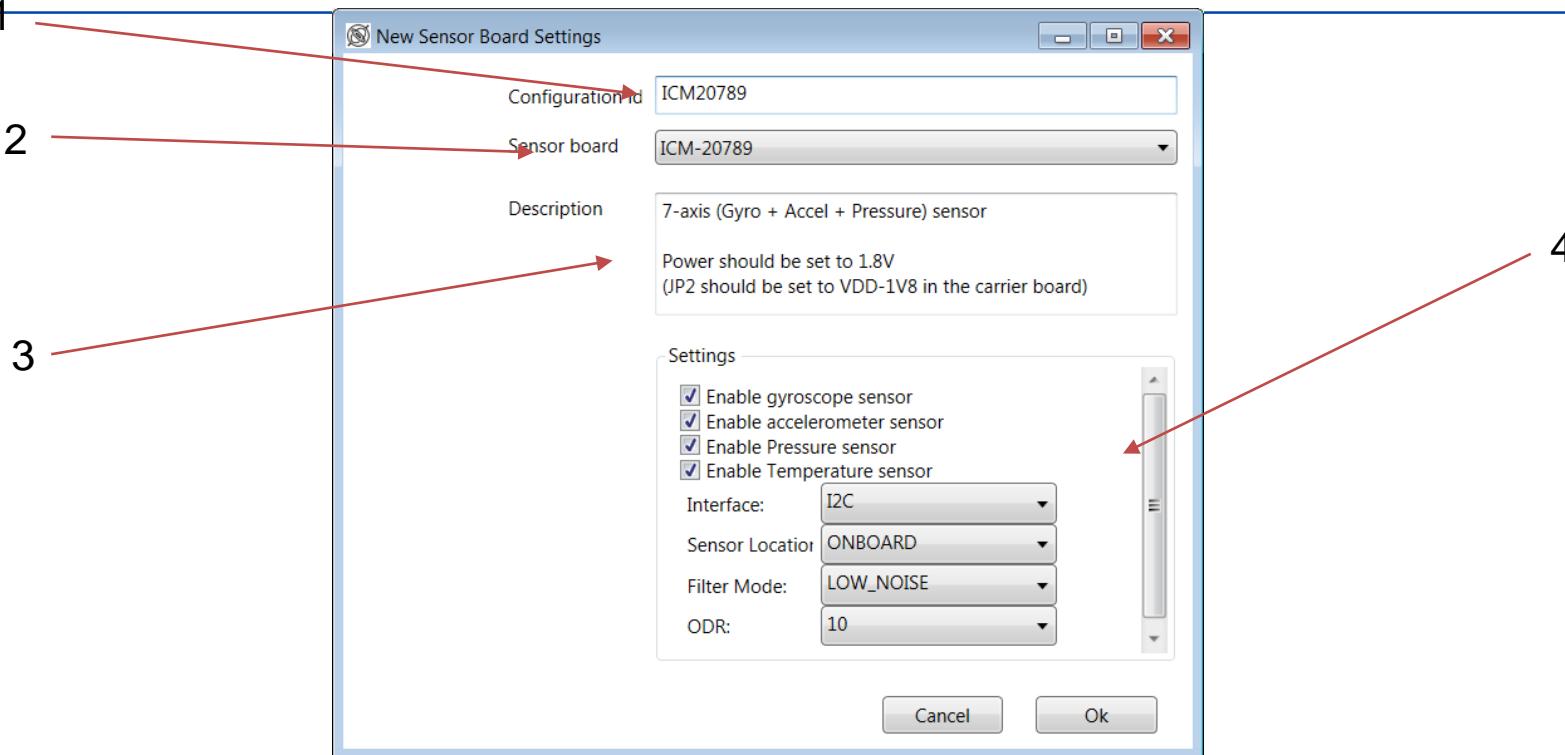
1. eMD Software – flash Atmel G55 MCU with a released version of eMD
 - SmartMotion Installer will have a version of the eMD release
 - Allow customers to browse for MCU images to flash
2. ‘Start eMD’ - Will open up the ‘sensor-cli’ command window usually used for eMD interface
3. MotionLink Software – will start up the MotionLink GUI
4. Hardware Details – Description of DK board jumpers and settings

MotionLink Features

Attracting Tomorrow



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



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

Attracting Tomorrow



Embedded Motion Driver (eMD) : Getting Started

March 2018

InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

3rd Party Software Drivers for Hardware –

- ATTEL 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
 - ¬ <https://www.microchip.com/avr-support/atmel-studio-7>
- FTDI Driver - <http://www.ftdichip.com/Drivers/VCP.htm>
 - ¬ Included with MotionLink install

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

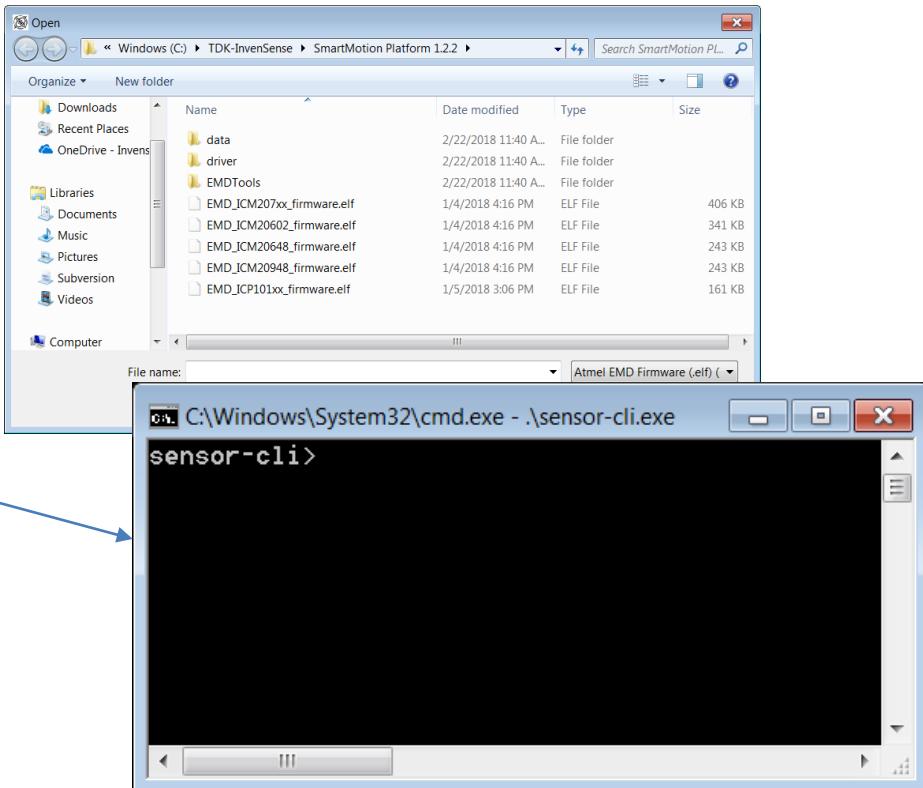
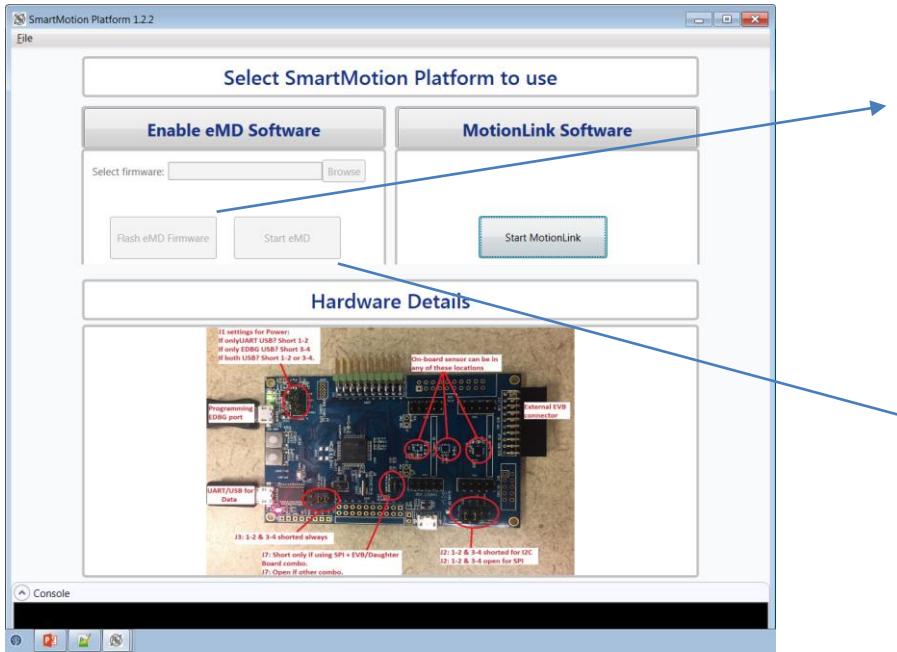
<https://www.invensense.com/developers/software-downloads/>

Connect SmartMotion platform and to PC

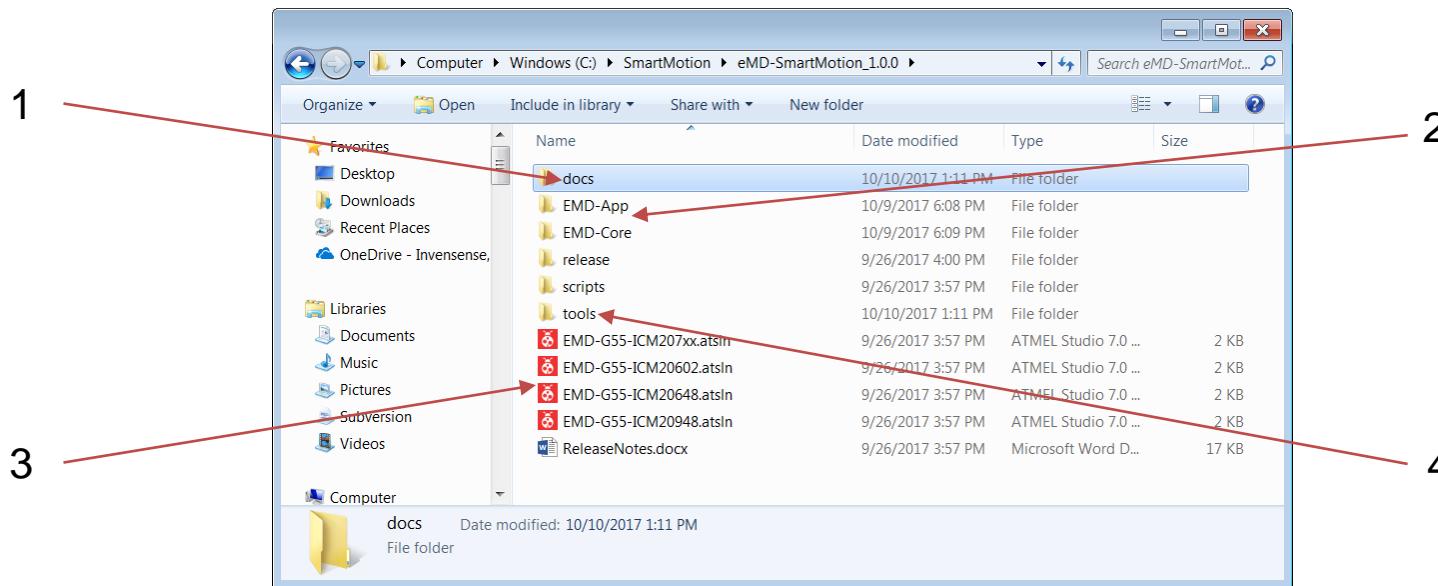


Using SmartMotion Installer for eMD

Attracting Tomorrow

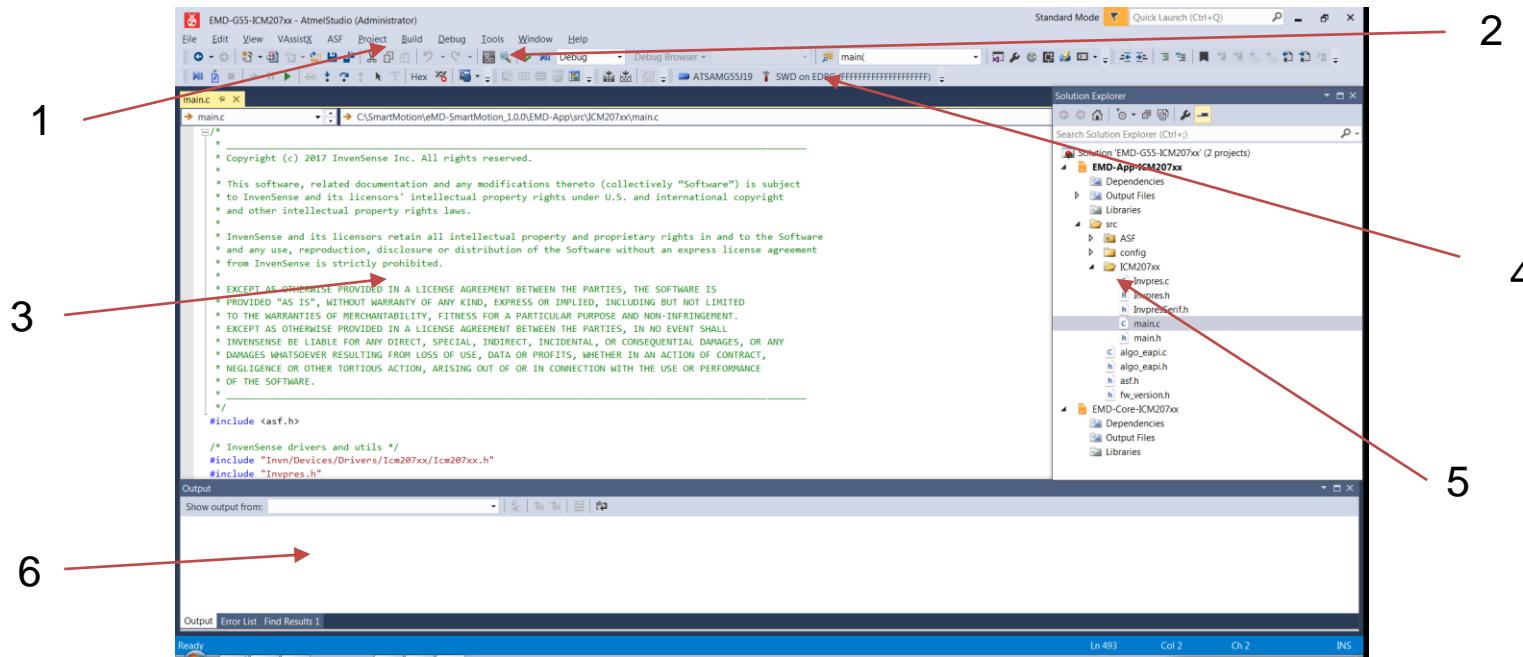


- SmartMotion Installer comes with feature to flash and use the eMD firmware
 - ¬ Requires Atmel Studio
 - ¬ Release eMD image but possibly an earlier version
 - ¬ MotionLink feature will not be able to function if using eMD
- In SmartMotion Launcher page click “eMD Software” to start the process
- Selecting “Browse” for will bring up a directory with pre-installed eMD images (.elf files)
- Selecting “Start eMD” will bring up a sensor-cli window
 - ¬ DK-20680A/DK-42605 does not use the sensor-cli but outputs through the serial port (J500 connector)



eMD Release Package

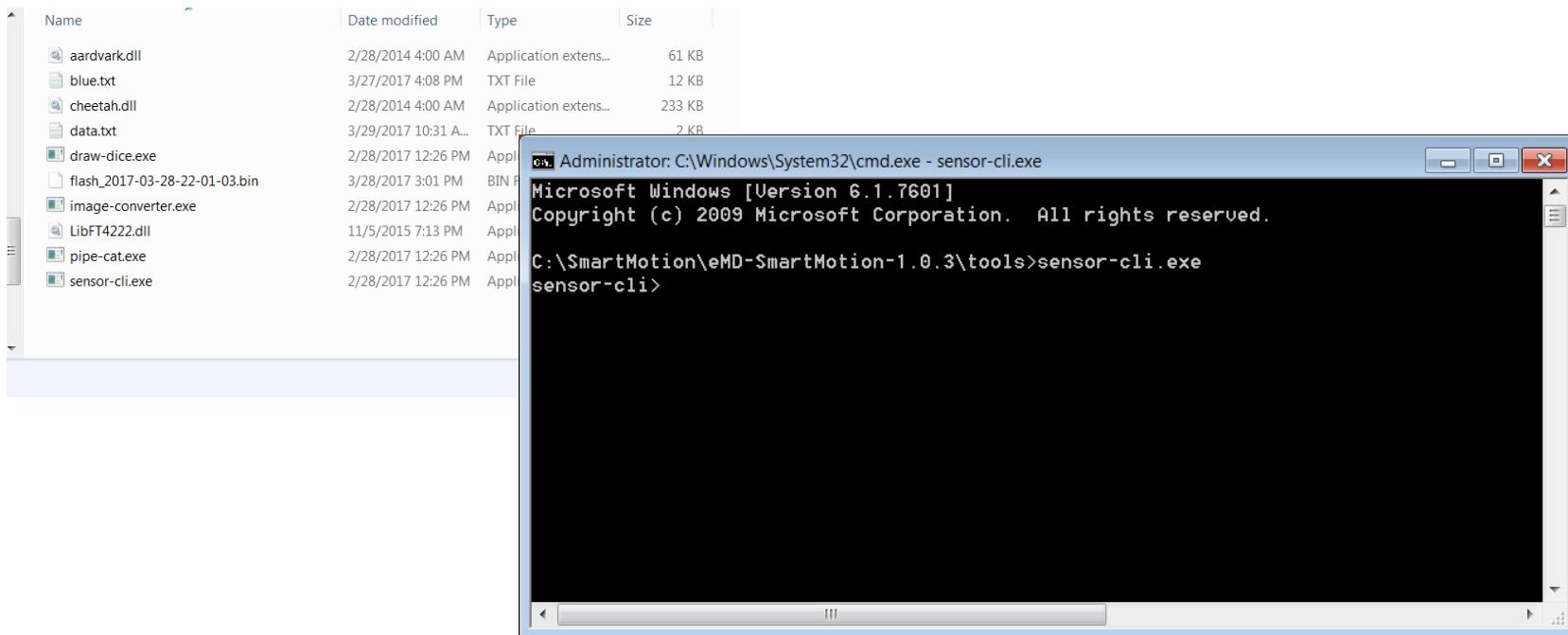
1. Docs directory : contains detailed SW User Guides and other documentations
2. EMD-App and EMD-Core : contains main driver code. 'App' has the main.c as well as board specific files. 'Core' has the libraries as well as the sensor driver files.
3. Atmel Studio Project Files : A specific main project 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



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

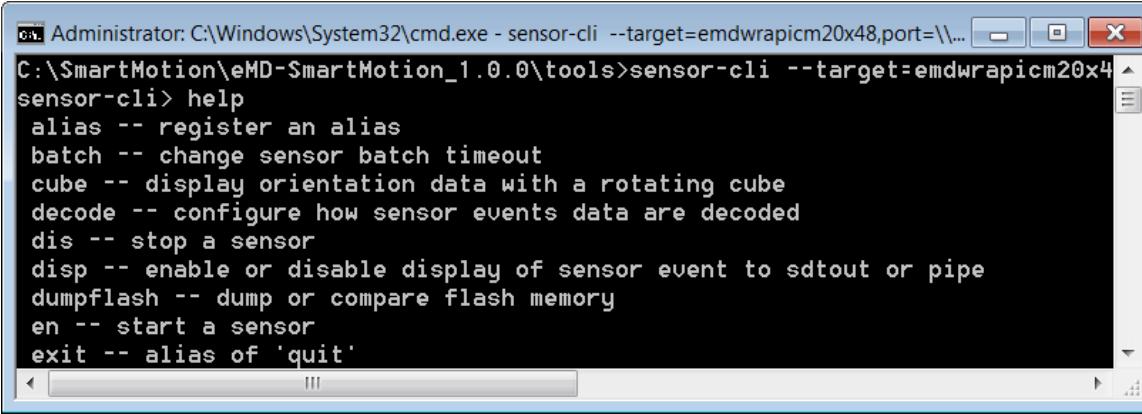
SmartMotion eMD – using sensor-cli.exe



- ‘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

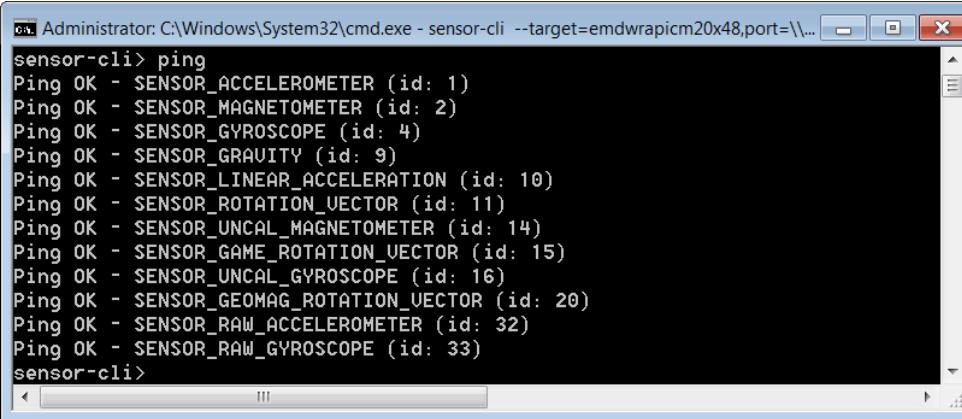
SmartMotion eMD – common sensor-cli.exe commands

- 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:\$martMotion\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 sdtout or pipe  
dumpflash -- dump or compare flash memory  
en -- start a sensor  
exit -- alias of 'quit'
```

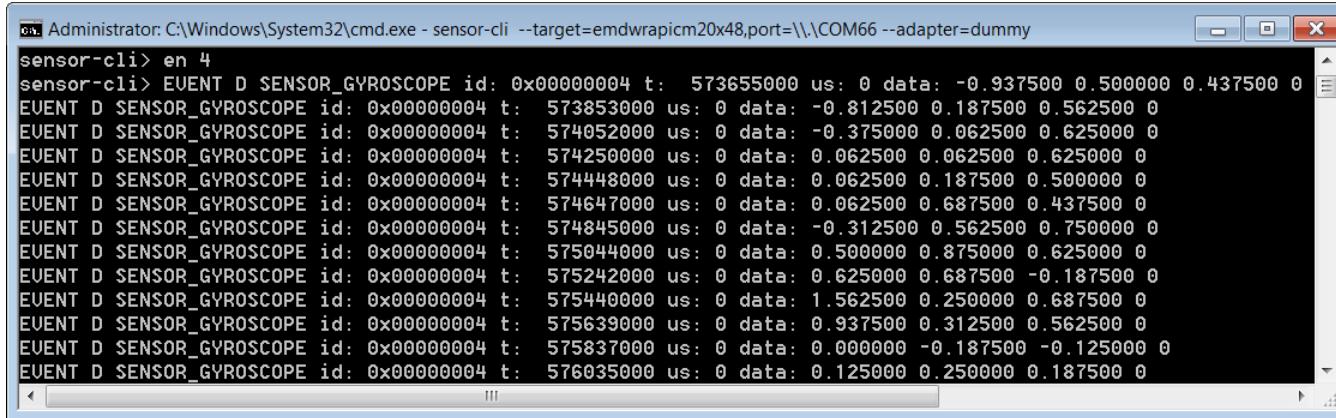
- ¬ ‘ping’ – displays all sensors available and their IDs



```
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.



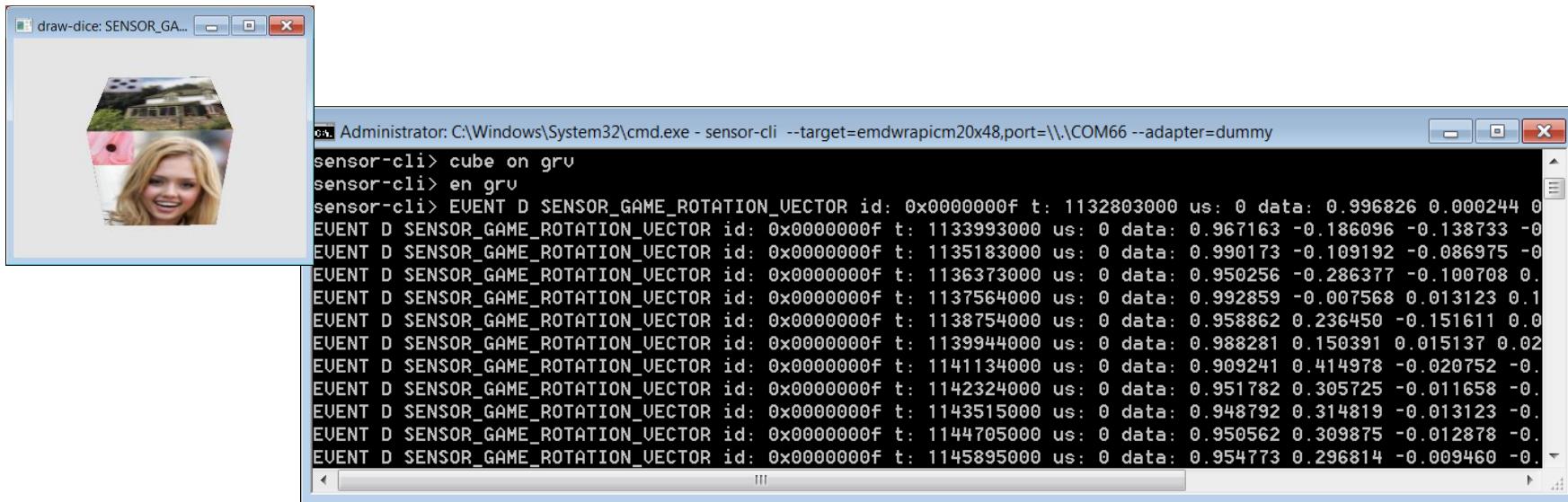
A screenshot of a Windows Command Prompt window titled "Administrator: C:\Windows\System32\cmd.exe - sensor-cli --target=emdwrapicm20x48,port=\.\COM66 --adapter=dummy". The window displays a stream of sensor data for a gyroscope. The output shows multiple "EVENT D SENSOR_GYROSCOPE" entries, each with an ID of 0x00000004, timestamp (t), and data values (us). The data values represent three-axis gyroscope measurements in degrees per second.

```
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
```

- ¬ ‘dis all’ will stop all data streaming

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.



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

Attracting Tomorrow

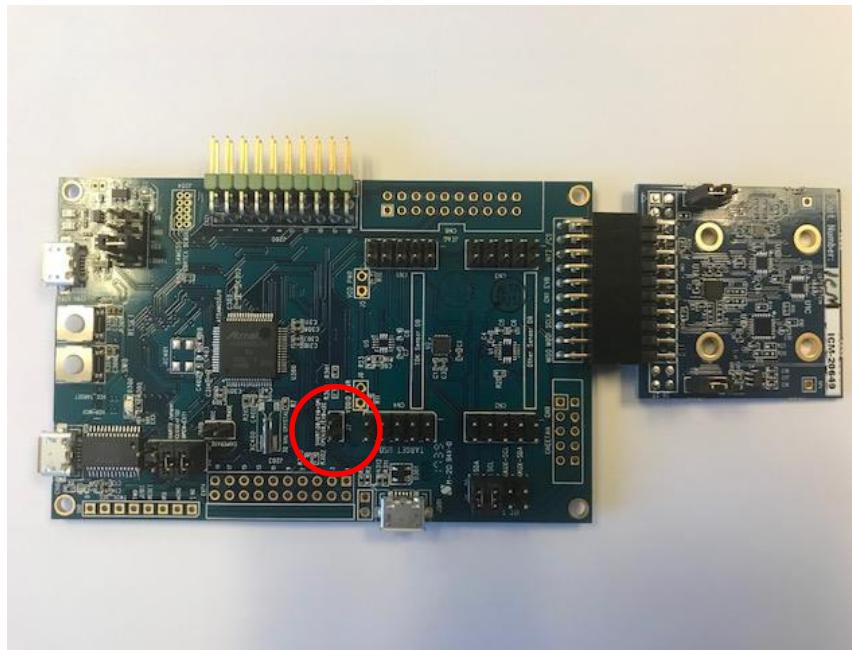


External Sensors

March 2018

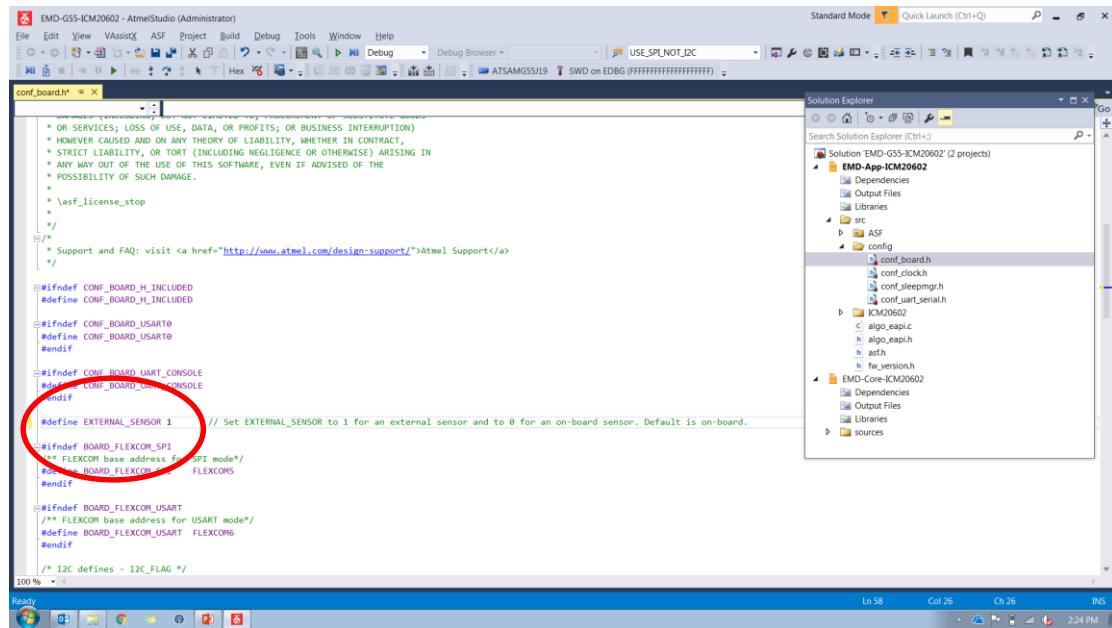
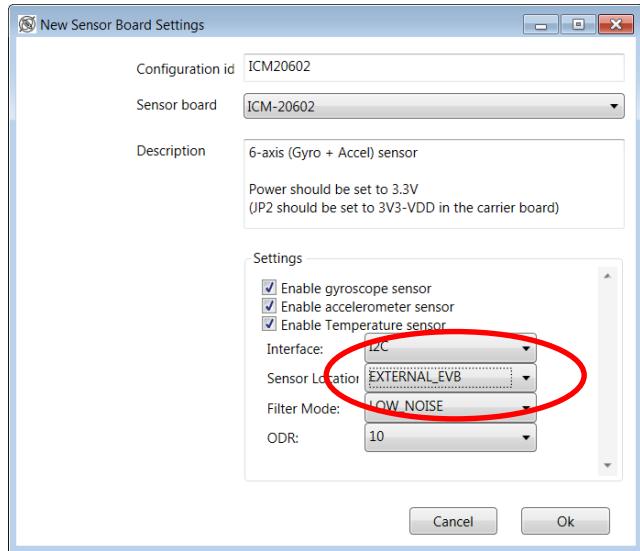
InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

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 require 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, ICM-20948 eMD are default SPI
 - ICM-20789 eMD are default I2C

MotionLink and eMD– External EVB Connection



MotionLink – Select EXTERNAL_EVB as the location when adding new sensors

eMD – conf_board.h , set EXTERNAL_SENSOR flag to '1'

Attracting Tomorrow



eMD Porting Guidelines

March 2018

InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

- MCU requirements
 - ¬ Atmel G55
 - Cortex M4 wth FPU
 - 120Mhz CPU Speed
 - 512Kb flash, 176Kb SRAM
 - I2C, SPI, UARTS
 - ¬ eMD v 1.0.4 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
 - DK-20789 does have DMP fusion version available
 - ¬ DK-20680A and DK-10100 streams raw sensor data only
 - ¬ DK-42605 –
 - Sensor Fusion on MCU
 - Embedded APEX engine : Pedometer, Tap, Significant Motion, Tilt, Wake on Motion
- Tool Chains –
 - ¬ Atmel Studio - GCC compiler



Attracting Tomorrow



Take Aways

March 2018

InvenSense
MEMS Sensors Business Group
Sensor Systems Business Company

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



www.invensense.com