

# SmartMotion Platform Ver. G Hardware User Guide

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## 1 OVERVIEW

The TDK SmartMotion Platform Ver. G is a comprehensive development system for TDK InvenSense Motion Sensor devices. The platform designed around the Microchip SAMG55 MCU can be used by customers for rapid evaluation and development of InvenSense sensor-based solutions. The platform integrates an on-board Embedded Debugger so external tools are not required to program or debug with the SAMG55 MCU. Each InvenSense motion sensor has its own unique development kit. Their DK numbers are listed in this document.

The SmartMotion platform comes with the necessary software including InvenSense Motion Link, a GUI based development tool and embedded Motion Drivers (eMD) for InvenSense motion sensors.

Embedded Motion Drivers (eMD) consist of a set of APIs to configure various aspects of the platform including motion sensor parameters such as full-scale range (FSR), output data rate (ODR), low-power or low-noise mode, and sensor interface to host (I<sup>2</sup>C, SPI). eMDs will also provide the following enhanced motion functions that run on the MCU:

- Sensor Fusion
- Accelerometer and Gyroscope Calibration
- Android Functions: Game Rotation Vector, Gravity, Linear Acceleration

Motion Link is a GUI based development tool included with the platform. It can be used to capture and visualize the sensor data from the motion sensor.

The platform supports Atmel Studio and is compatible with Microchip Xplained Pro Extension boards. Xplained Pro extension series evaluation kits offer additional peripherals to extend the features of the board and ease the development of customer designs.

## 2 INTRODUCTION

### 2.1. FEATURES OVERVIEW

- Integrated TDK InvenSense motion sensor
- Support for a magnetic sensor with plug in daughter boards (DB)
- Microchip SAMG55 microcontroller with 512 KB Flash
- On-board Embedded debugger (EDBG) for programming and debugging
- Built in FTDI USB to UART interface for fast motion sensor data transfer
- USB Connectors for host interface to software debug and data logging
- Board Power Supply through USB

### 2.2. PLATFORM OVERVIEW

The TDK SmartMotion Platform Ver. G is a hardware unit for TDK sensor product evaluation and algorithm software development. The platform offers support for many different application developments. The board shown below is the DK-20670 board (with TDK sensor in slot U2).

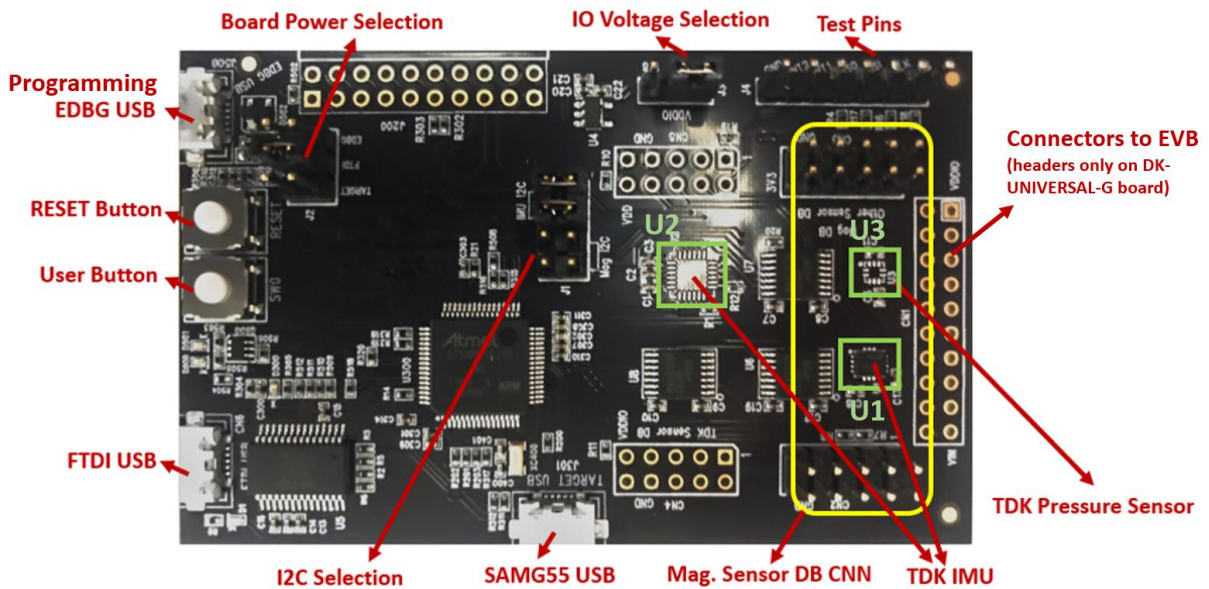


Figure 1. The SmartMotion Platform Overview

### 2.3. HARDWARE USER GUIDE

The TDK SmartMotion Platform Ver. G is compatible with Microchip’s SAM G55 Xplained Pro for updating and flashing the firmware. The link to the Atmel Xplained Pro user guide is here:

[http://www.atmel.com/Images/Atmel-42389-SAM-G55-Xplained-Pro\\_User-Guide.pdf](http://www.atmel.com/Images/Atmel-42389-SAM-G55-Xplained-Pro_User-Guide.pdf) To set up board, click on Device Programming (Ctrl + Shift + P) and select EDBG as the Tool.

### 3 SENSORS AND DEVELOPMENT KITS

#### 3.1. TDK SENSOR TO SAMG55 MCU CONNECTION

The TDK SmartMotion Platform Ver. G supports multiple types of TDK IMUs and pressure sensors. Table 1 lists the TDK Sensor Development Kit (DK) ordering information.

SUPPORTED SENSOR	DK PART NUMBER	SENSOR U# SLOT
ICP-20100	DK-20100	U3
IIM-20670	DK-20670	U2
ICM-40627	DK-40627	U1
IIM-42351	DK-42351	U1
IIM-42352	DK-42352	U1
IIM-42652	DK-42652	U1
IIM-42653	DK_IIM-42653	U1
ICM-42670-P	DK-42670-P	U1
ICM-42686-P	DK-42686-P	U1
ICM-42688-P	DK-42688-P	U1
ICM-42688-V	DK-42688-V	U1
No Sensor	DK-UNIVERSAL-G	N/A

**Table 1. Sensors and DKs**

##### 3.1.1.1. DK-20100

The DK-20100 is the development kit for TDK pressure sensor ICM-20100.

The ICP-20100 pressure sensor provides a high-accuracy, low power barometric pressure and temperature sensor solution that integrates a capacitive pressure sensor for monitoring pressure changes in the range of 30 to 110 kPa.

Please refer to the datasheet for the sensor details.

The ICP-20100 is connected to SAMG55 MCU I<sup>2</sup>C or SPI. The software will select the interface type.

The sensor I<sup>2</sup>C slave address is 0x63, and its SPI /CS = NPCS0.

The VDDIO voltage level can be set by J3 to 1.8V or 3.3V.

##### 3.1.1.2. DK-20670

The DK-20670 is the development kit for TDK IMU IIM-20670.

The IIM-20670 is an Industrial grade 6-axis MotionTracking™ device that combines a 3-axis gyroscope and a 3-axis accelerometer in a small 4.5x4.5x1.1 mm (24-pin DQFN). There are two built-in temperature sensors. It uses an SPI digital interface SPI.

Please refer to the datasheet for the sensor details.

The IIM-20670 is connected to SAMG55 MCU SPI with NPCS0.

The digital interface voltage level is 3.3V on the DK-20670. J3 for VDDIO selection must be set to pins 1-2 for 3.3V.

### 3.1.1.3. DK-40627

The DK-40627 is the development kit for TDK IMU ICM-40627.

The ICM-40627 SmartMotion™ sensor is a 6-axis MEMS MotionTracking device that combines a 3-axis gyroscope and a 3-axis accelerometer. This device is targeted at gesture-based handheld devices such as a mouse. It comes bundled with TDK's Air Motion Library, which enables precise mouse pointing, swipe, roll, and other motion gestures. ICM-40627 has a configurable host interface that supports I<sup>2</sup>C and SPI serial communication, features a 2 KB FIFO and 2 programmable interrupts with ultra-low power wake-on-motion support to minimize system power consumption.

Please refer to the datasheet for the sensor details.

The ICM-40627 is connected to SAMG55 MCU I2C and SPI on the DK-40627. The software will select the interface type.

The sensor I<sup>2</sup>C slave address is 0x68, and its SPI /CS = NPCSO.

The VDDIO voltage level can be set by J3 to 1.8V or 3.3V.

### 3.1.1.4. DK-42351

The DK-42351 is the development kit for TDK 3x Accel IIM-42351.

The IIM-42351 is a 3-axis accelerometer packaged in a small 2.5 mm x 3 mm x 0.91 mm (14-pin LGA) package. It has an output data rate up to 8 kHz. The IIM-42351 includes multiple capabilities to enable easy, robust, and accurate inertial and inclination measurements in Industrial applications. It has a 2 KB FIFO that can lower the traffic on the serial bus interface and reduce power consumption by allowing the system processor to burst read sensor data and then go into a low-power mode. Its operation temperature range is -40°C to 105°C.

Please refer to the datasheet for the sensor details.

The IIM-42351 is connected to SAMG55 MCU I2C and SPI on the DK-42351. The software will select the interface type.

The sensor I<sup>2</sup>C slave address is 0x68, and its SPI /CS = NPCSO.

The VDDIO level can be set by J3 to 1.8V or 3.3V.

### 3.1.1.5. DK-42352

The DK-42352 is the development kit for TDK 3x Accel IIM-42352.

The IIM-42352 is a 3-axis accelerometer packaged in a small 2.5 mm x 3 mm x 0.91 mm (14-pin LGA) package. It has a wide and flat frequency response range from dc to 4 kHz ( $\pm 3$  dB point) with an output data rate up to 32 kHz. The IIM-42352 includes multiple capabilities to enable easy, robust, and accurate inertial and vibration measurements in Industrial applications. It has a 2 KB FIFO that can lower the traffic on the serial bus interface and reduce power consumption by allowing the system processor to burst read sensor data and then go into a low-power mode. Its operation temperature range is -40°C to 105°C.

Please refer to the datasheet for the sensor details.

The IIM-42352 is connected to SAMG55 MCU I<sup>2</sup>C and SPI on the DK-42352. The software will select the interface type.

The sensor I<sup>2</sup>C slave address is 0x68, and its SPI /CS = NPCSO.

The VDDIO level can be set by J3 to 1.8V or 3.3V.

#### 3.1.1.6. DK-42652

The DK-42652 is the development kit for TDK IMU IIM-42652.

The IIM-42652 is a 6-axis SmartIndustrial™ MotionTracking device that supports an extended operating temperature range. The IIM-42652 combines a 3-axis gyroscope and a 3-axis accelerometer in a small 2.5 mm x 3 mm x 0.91 mm (14-pin LGA) package. It also features a 2 KB FIFO that can lower the traffic on the serial bus interface and reduce power consumption by allowing the system processor to burst read sensor data and then go into a low-power mode. Its operation temperature range is -40°C to 105°C.

Please refer to the datasheet for the sensor details.

The IIM-42652 is connected to SAMG55 MCU I2C and SPI on the DK-42652. The software will select the interface type.

The sensor I<sup>2</sup>C slave address is 0x68, and its SPI /CS = NPCSO.

The VDDIO level can be set by J3 to 1.8V or 3.3V.

#### 3.1.1.7. DK\_IIM-42653

The DK\_IIM-42653 is the development kit for TDK IMU IIM-42653.

The IIM-42653 is a 6-axis SmartIndustrial™ MotionTracking device that supports an extended operating temperature range. The IIM-42653 combines a 3-axis gyroscope and a 3-axis accelerometer in a small 2.5 mm x 3 mm x 0.91 mm (14-pin LGA) package. It also features a 2 KB FIFO that can lower the traffic on the serial bus interface and reduce power consumption by allowing the system processor to burst read sensor data and then go into a low-power mode. Its operation temperature range is -40°C to 105°C.

Please refer to the datasheet for the sensor details.

The IIM-42653 is connected to SAMG55 MCU I2C and SPI on the DK\_IIM-42653. The software will select the interface type.

The sensor I<sup>2</sup>C slave address is 0x68, and its SPI /CS = NPCSO.

The VDDIO level can be set by J3 to 1.8V or 3.3V.

#### 3.1.1.8. DK-42670-P

The DK-42670-P is the development kit for TDK IMU ICM-42670-P.

The ICM-42670-P is a high performance 6-axis MEMS MotionTracking device that combines a 3-axis gyroscope and a 3-axis accelerometer. It has a configurable host interface that supports I3C<sup>SM</sup>, I<sup>2</sup>C, and SPI serial communication, features up to 2.25 KB FIFO and 2 programmable interrupts with ultra-lowpower wake-on-motion support to minimize system power consumption.

Please refer to the datasheet for the sensor details.

The ICM-42670-P is connected to SAMG55 MCU I2C and SPI on the DK-42670-P. The software will select the interface type.

The sensor I<sup>2</sup>C slave address is 0x68, and its SPI /CS = NPCSO.

The VDDIO voltage level can be set by J3 to 1.8V or 3.3V.

#### 3.1.1.9. DK-42686-P

The DK-42686-P is the development kit for TDK IMU ICM-42686-P.

The ICM-42686-P is a 6-axis MEMS MotionTracking device that combines a 3-axis gyroscope and a 3-axis accelerometer. It has a configurable host interface that supports I3C<sup>SM</sup>, I<sup>2</sup>C, and SPI serial communication, features a 2 kB FIFO and 2 programmable interrupts with ultra low-power wake-on-motion support to minimize system power consumption.

The ICM-42686-P has an extended full-scale range (FSR) of  $\pm 4000$  dps for gyroscope and  $\pm 32g$  for accelerometer to support precise motion analysis for today's wearable and sports solutions, including game controllers, golf or tennis swing analyzers, intelligent soccer balls, or basketballs that track the player's performance.

Please refer to the datasheet for the sensor details.

The ICM-42686-P is connected to SAMG55 MCU I2C and SPI on the DK-42686-P. The software will select the interface type.

The sensor I<sup>2</sup>C slave address is 0x68, and its SPI /CS = NPCSO.

The VDDIO voltage level can be set by J3 to 1.8V or 3.3V.

#### 3.1.1.10. DK-42688-P

The DK-42688-P is the development kit for TDK IMU ICM-42688-P.

The ICM-42688-P is a 6-axis MEMS MotionTracking device that combines a 3-axis gyroscope and a 3-axis accelerometer. It has a configurable host interface that supports I3C<sup>SM</sup>, I<sup>2</sup>C, and SPI serial communication, features a 2 KB FIFO and 2 programmable interrupts with ultra low-power wake-on-motion support to minimize system power consumption.

Please refer to the datasheet for the sensor details.

The ICM-42688-P is connected to SAMG55 MCU I2C and SPI on the DK-42688-P. The software will select the interface type.

The sensor I<sup>2</sup>C slave address is 0x68, and its SPI /CS = NPCSO.

The VDDIO voltage level can be set by J3 to 1.8V or 3.3V.

#### 3.1.1.11. DK-42688-V

The DK-42688-V is the development kit for TDK IMU ICM-42688-V.

The ICM-42688-V is a 6-axis MEMS MotionTracking device that combines a 3-axis gyroscope and a 3-axis accelerometer. It has a configurable host interface that supports I3C<sup>SM</sup>, I<sup>2</sup>C, and SPI serial communication, features a 2 KB FIFO and 2 programmable interrupts with ultra low-power wake-on-motion support to minimize system power consumption. It is bundled with 3DoF algorithm software.

Please refer to the datasheet for the sensor details.

The ICM-42688-V is connected to SAMG55 MCU I2C and SPI on the DK-42688-V. The software will select the interface type.

The sensor I<sup>2</sup>C slave address is 0x68, and its SPI /CS = NPCSO.

The VDDIO voltage level can be set by J3 to 1.8V or 3.3V.

#### 3.1.1.12. DK-UNIVERSAL-G

The DK-UNIVERSAL-G is the development kit for DB (sensor daughter board) and EVB (sensor evaluation board). There is no sensor mounted on the DK-UNIVERSAL-G board. CN1 for EVB and CN4/CN5 for DB are mounted on board for people to evaluate sensors which are not listed in this document.



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### **3.2. MAGNETIC SENSORS CONNECTION**

Third party magnetic sensors can be connected to the same SAMG55 MCU I<sup>2</sup>C bus with TDK sensor through DB, assuming it has a different slave address.

CN2/3 are designed for the magnetic sensor DB plug in. It only supports I<sup>2</sup>C.

## 4 THE SMARTMOTION SYSTEM DESIGN

This section is a system design overview and addresses MCU SAMG55 resource allocation.

### 4.1. SYSTEM BLOCK DIAGRAM

On board EDBG MCU AT32UC3A4256HHB-C1UR allows user to do main MCU SAMG55 debug, trace, and programming without using external tools. Figure 2 shows the system block diagram.

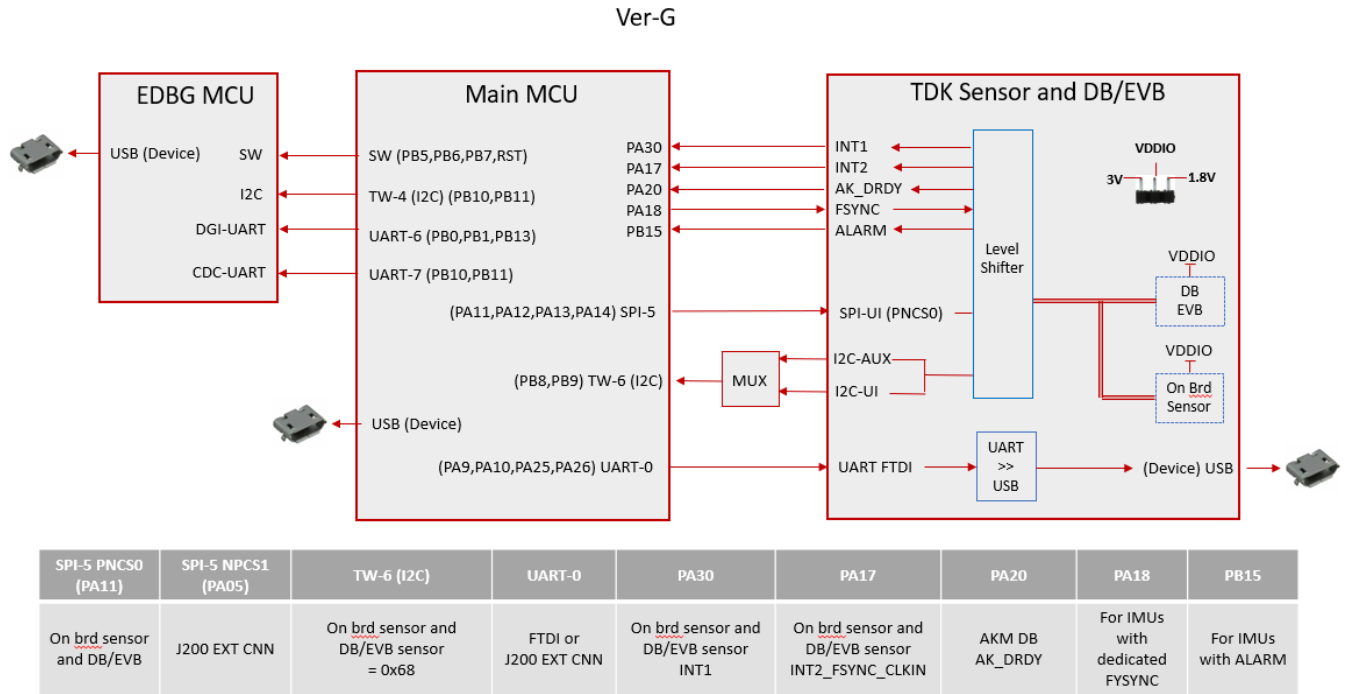


Figure 2. System Block Diagram

### 4.2. MAIN MCU SAMG55 RESOURCE ALLOCATION

SAMG55 RESOURCE	USAGE
UART 0 (PA9/10/25/26)	The UART0 is connected to FTDI input by default. In the use case of Extension-1 on J200, the UART0 to FTDI connection can be disconnected through jumper J3.
TW6 (I2C) (PB8/9)	TDK sensor is connected to this master I2C. On board sensor slave address = 0x69. Sensors on DB and EVB have slave address = 0x68.
SPI5 (PA11/12/13/14)	The SPI5 master is connected to TDK IMU sensor. On board IMU sensor /CS = PNCS0
GPIO (INTs) PA17/18/20/30 and PB15	The GPIOs are used for sensor interrupt inputs and other intelligent functions. Refer to the table in Figure 2.
TW4 (I2C)	The master I2C communicates with EDBG MCU slave I2C.
UART6	The UART6 is used for EDBG DGI-UART interface.
UART7	The UART7 is used for EDBG CDC-UART interface.

Table 2. SAMG55 Resource Allocation

### 4.3. CONNECTORS

**Error! Reference source not found.** details the TDK SmartMotion Platform Ver. G connector and header reference names and descriptions.

CONNECTOR REF NAME	CONNECTOR FUNCTION DESCRIPTIONS
CN1	Not loaded for: Loaded for: DK-UNIVERSAL G
CN2/CN3	Daughter board connector for Mag. sensor. I <sup>2</sup> C interface only.
CN4/CN5 (Not loaded)	
CN6	USB connector for FTDI USB to serial UART interface
J1	Select host I <sup>2</sup> C connections, for IMU sensor and mag. sensor or mag. sensor only.
J2	Board power source selection.
J3	Select VDDIO voltage level, 3V0 or 1V8.
J4	Digital signal test pins
J200 (Not loaded)	Extension header 1. Has same function as J200 on Microchip's Xplained-Pro board.
J301	MCU SAMG55 USB connector
J500	EDBG MCU USB connector
SW300	User button
SW301	RESET button.

**Table 3. Connectors**

### 4.4. JUMPER SETTINGS

JUMPER	DESCRIPTION
J1	J1 is used to select input source for SAMG55 master I <sup>2</sup> C. Only two jumper shunts are allowed. Jumper shunts on pin-1/2 and 3/4: IMU Sensor primary I <sup>2</sup> C is connected to SAMG55 I <sup>2</sup> C master Jumper shunts on pin-5/6 and 7/8: Magnetic Sensor I <sup>2</sup> C is connected to SAMG55 I <sup>2</sup> C master. In this configuration TDK IMU Sensor is connected to SAMG55 SPI master.
J2	The J2 is for board power source selection. Only one jumper shunt is allowed. Jumper shunt on pin-1/2: board power is from EDBG USB on J500. Jumper shunt on pin-3/4: board power is from FTDI USB on CN6 Jumper shunt on pin-5/6: board power is from SAMG55 USB on J301
J3	J3 is for system VDDIO level selection. Jumper shunts on pin-1/2: VDDIO=3V0 Jumper shunts on pin-3/2: VDDIO=1V8
J4	J4 have digital signals as test points. Pin-1: SPI /CS Pin-2: SPI SCLK, I <sup>2</sup> C SCL Pin-3: SPI MOSI, I <sup>2</sup> C SDA Pin-4: SPI MISO, I <sup>2</sup> C ADO Pin-5: INT1 Pin-6: INT2 Pin-7: GND

**Table 4. Jumper Setting**

## 5 SCHEMATICS AND BOARD PCB

### 5.1. SCHEMATICS

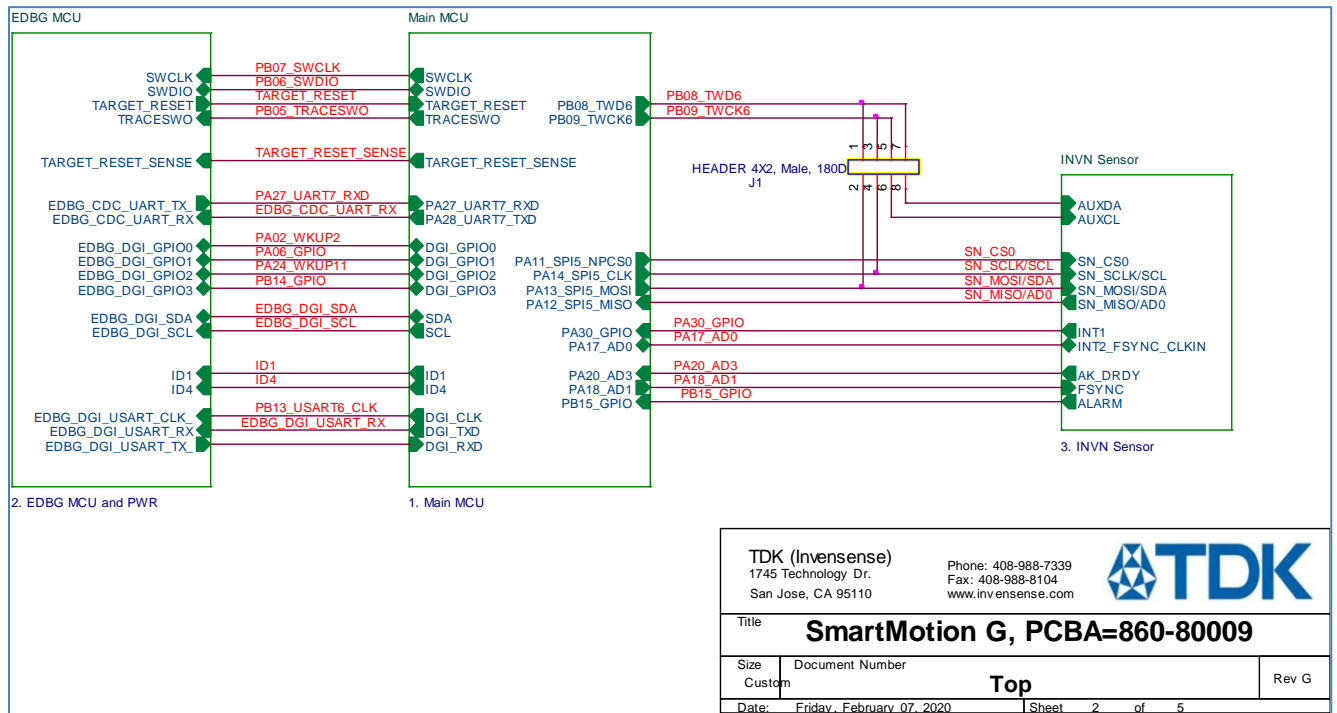


Figure 3. Hierarchy Top

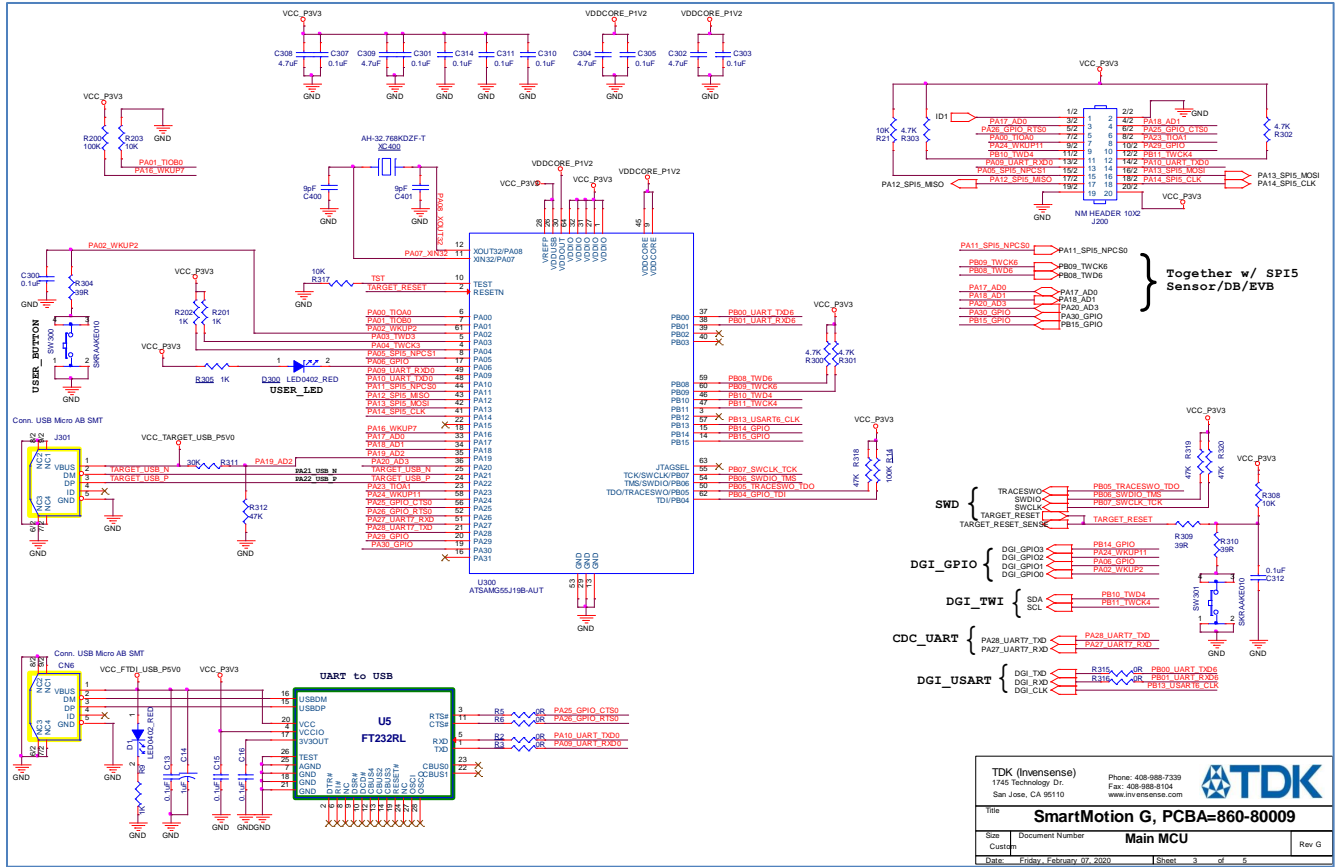


Figure 4. Main MCU

<p>TDK (InvenSense) Phone: 408-998-7339 1745 Technology Dr. Fax: 408-998-8104 San Jose, CA 95110 www.invensense.com</p>		
<p>Title: <b>SmartMotion G, PCBA-860-80009</b></p>		
<p>Doc: Document Number</p>	<p>Case#: <b>Main MCU</b></p>	<p>Rev: G</p>
<p>Date: Friday, February 07, 2020</p>	<p>Sheet: 3 of 5</p>	

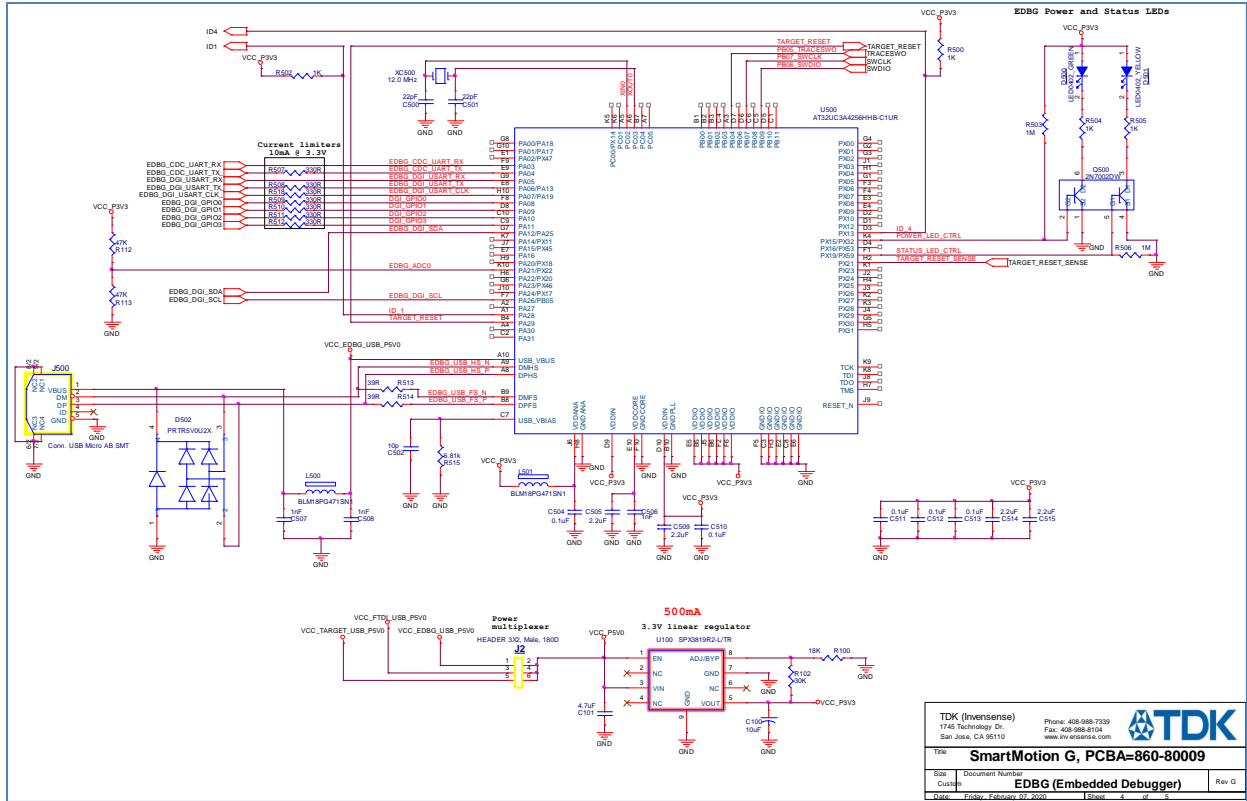


Figure 5. Embedded Debugger

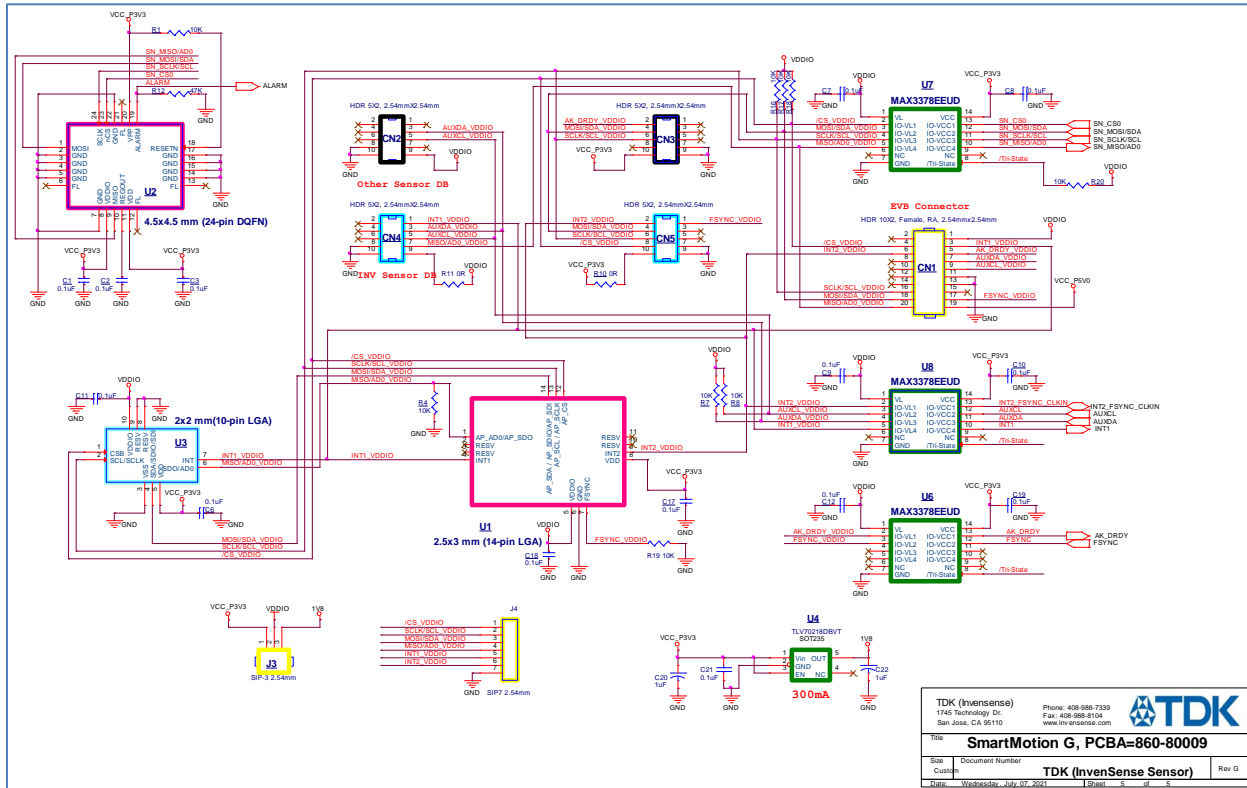
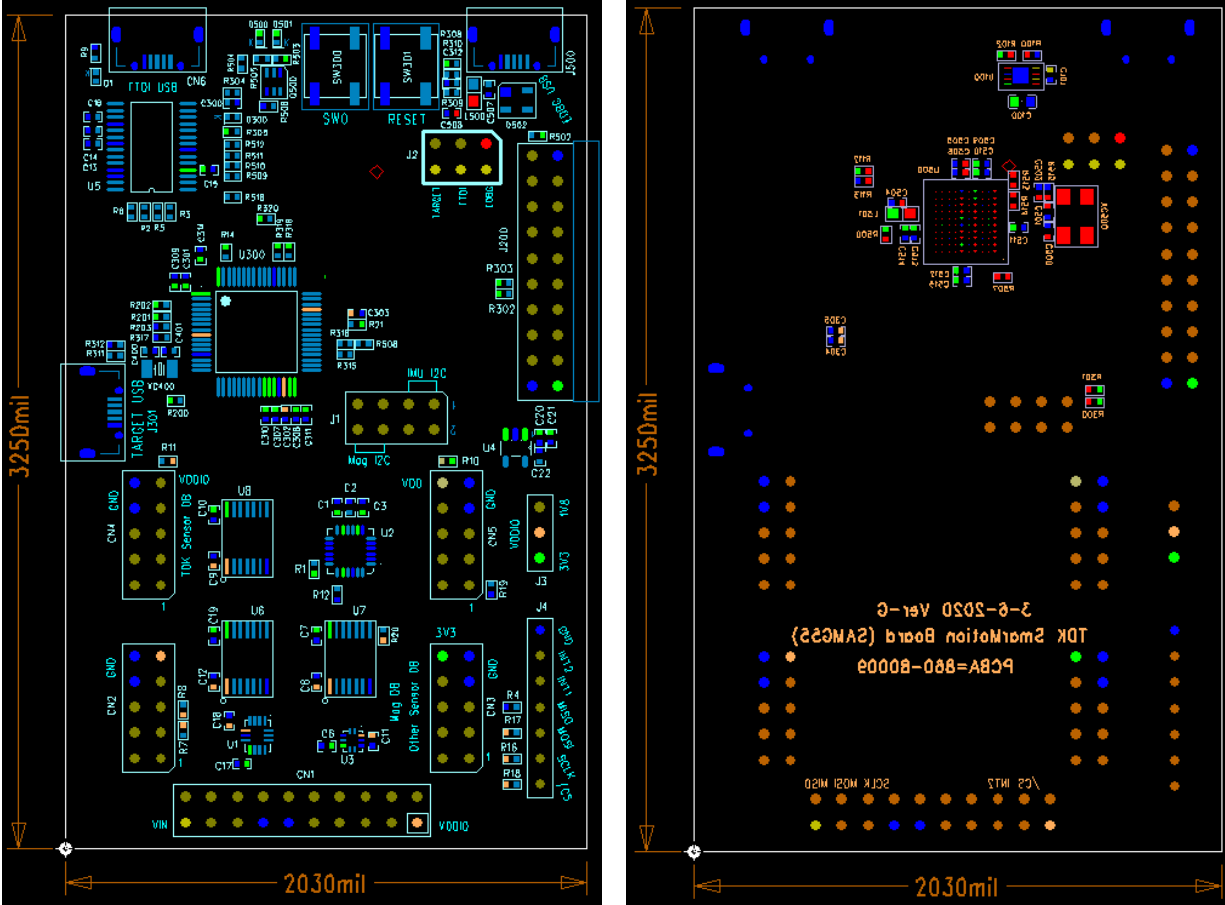


Figure 6. Sensors, DB and EVB connectors

**5.2. BOARD PCB**



**Figure 7. Ver. G PCB Top view (left) and Bottom view (right)**

## 6 REVISION HISTORY

REVISION DATE	REVISION	DESCRIPTION
07/07/2021	1.0	Initial Release
12/12/2022	1.1	Format update, added DK_IIM-42653



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## **7 DECLARATION DISCLAIMER**

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