

# SmartMotion Platform Hardware User Guide

## Introduction

The TDK SmartMotion Platform is a comprehensive development system for TDK InvenSense Motion Sensor devices. The platform designed around **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 the SAMG55 MCU. Each InvenSense motion sensor has its own unique development kit. Following SmartMotion development kits are available.

- DK-20602 for ICM-20602 6 Axis Motion Sensor (Ver-B board)
- DK-20648 for ICM-20648 6 Axis Motion Sensor with Digital Media Processor (DMP), (Ver-B board)
- DK-20680A for 6 Axis Automotive Grade Motion Sensor (Ver-B board)
- DK-20789 for ICM-20789 7 Axis Motion Sensor with Integrated Pressure Sensor (Ver-C board)
- DK-20948 for ICM-20948 9 Axis Motion Sensor (Ver-C board)
- DK-101XX for ICP-10111 pressure sensor (Ver-C board)

The SmartMotion platform comes with necessary software including InvenSense Motion Link, a GUI based development tool and embedded Motion Drivers for motion sensor.

Embedded Motion Drivers (eMD) consists 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 (I2C, SPI). All eMDs (except for DK-20680A and DK-101XX) will also provide the following enhanced motion functions that run on the MCU or DMP (if applicable):

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

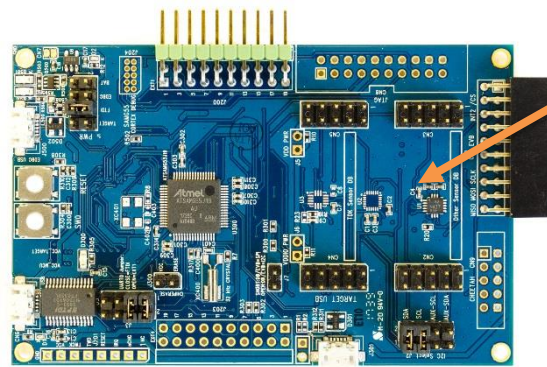
Motion Link is a GUI based development tool included with the platform. It can be used to capture and visualize the sensor data from the motion sensor.

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.

## SmartMotion Development Kits

Rev B

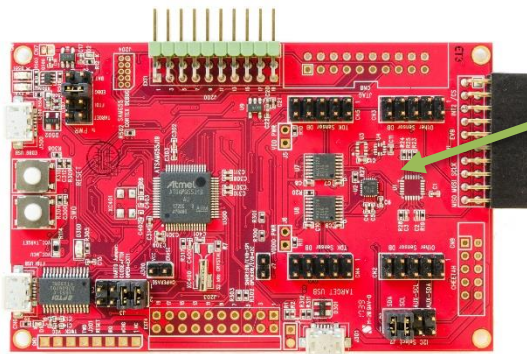
**DK-20602/DK-20648/DK-20680A**



ICM-206XX

Rev C

**DK-20948/DK-20789/DK-101XX**



ICM-20948/20789/ICP-10100

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# 1. Introduction

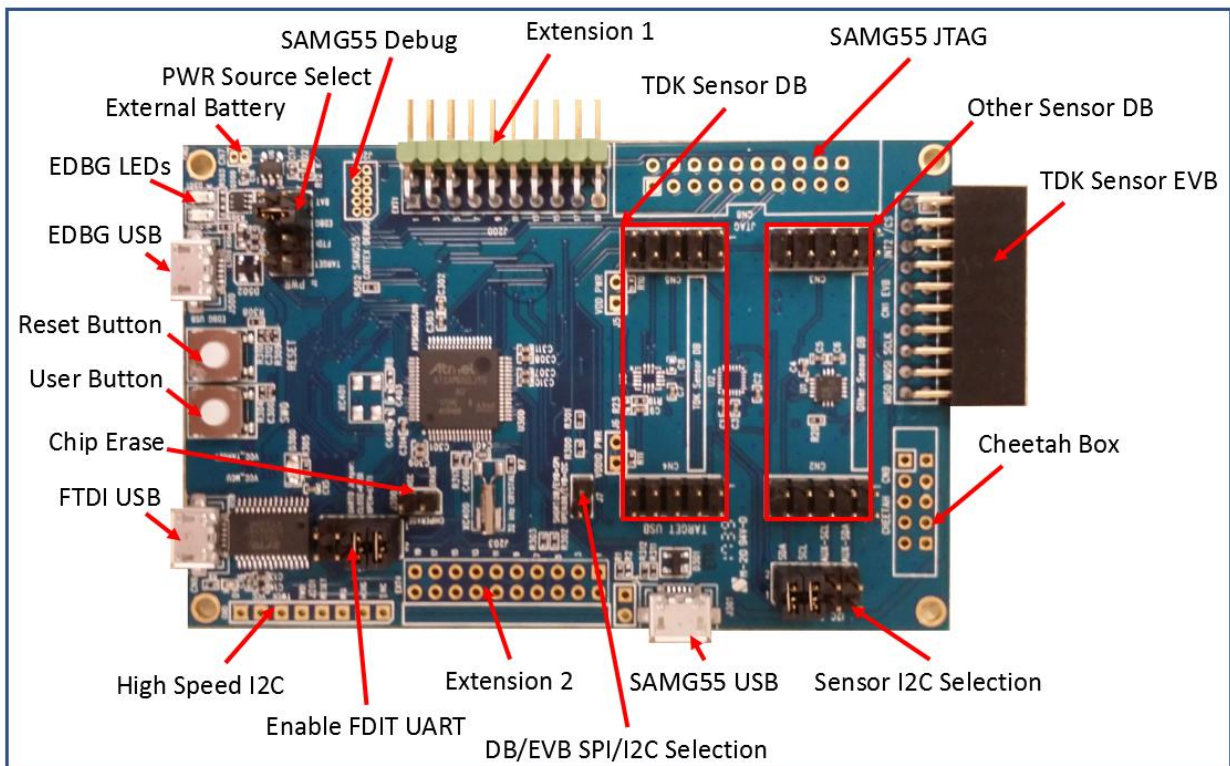
## 1.1. Features

- Integrated TDK InvenSense motion sensor
- Support for other InveSense sensors with plug in daughter boards (DB) and evaluation boards (EVB). DBs and EVBs can be obtained separately for other sensors
- Microchip SAMG55 microcontroller with 512KB 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
- Can be operated by external battery with on board battery charger.

## 1.2 Platform Overview

SmartMotion Platform is a hardware unit for TDK sensor product evaluation and algorithm software development.

With many extensions, the platform offers flexibilities for many different applications developments.



*Figure 1 Platform Overview*

## 2. Hardware User Guide

SmartMotion Platform is compatible with Microchip's SAM G55 Xplained Pro. The link here is the Xplained-Pro user guide.

[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)

### 2.1. System Block Diagram

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

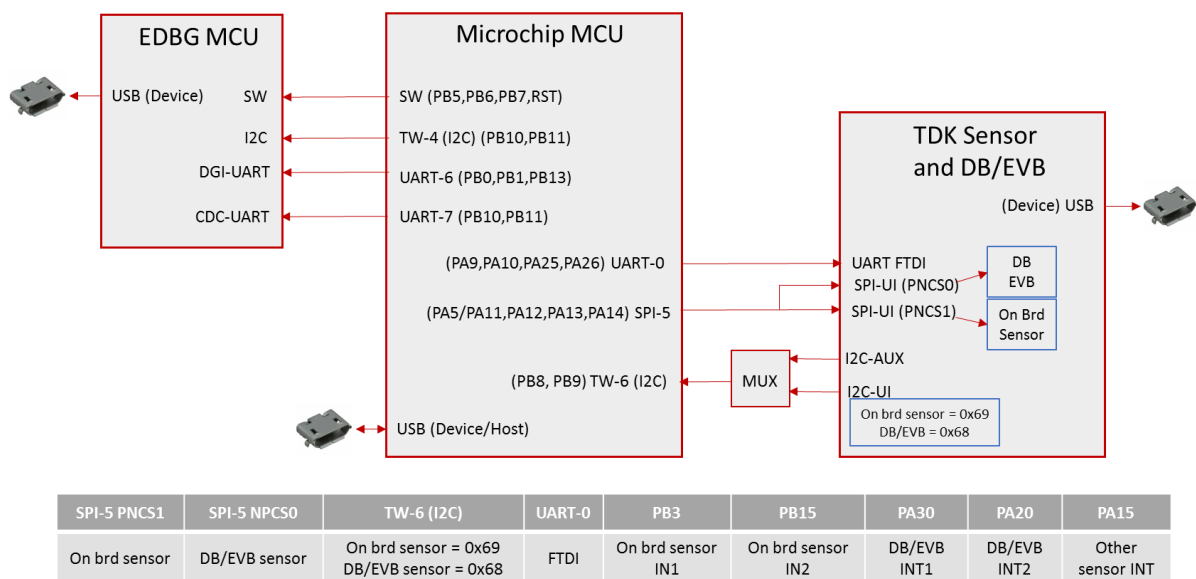


Figure 2 System Block Diagram

### 2.2. Main MCU SAMG55 resource allocation

Table 1 SAMG55 Resource Allocation

| SAMG55 resource                        | Usage                                                                                                                                                        |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| UART 0<br>(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)<br>(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<br>(PA5/11/12/13/14)              | The SPI5 master is connected to TDK sensor. On board sensor /CS = PNCs1, sensor on DB and EVB /CS = NPCs0.                                                   |
| GPIO (INTs)<br>PB3/PB15/PA30/PA20/PA15 | The GPIOs are used for sensor interrupt input. Referring 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.                                                                                                               |

## 2.3. Connectors

Table 2 describes the implementation of the relevant connectors and headers on SmartMotion Platform.

*Table 2 Connectors*

| Connector Ref Name | Connector Function descriptions                                                  |
|--------------------|----------------------------------------------------------------------------------|
| CN1                | External TDK sensor EVB connector                                                |
| CN2/CN3            | Daughter board connector for non-TDK sensor. I2C interface only.                 |
| CN4/CN5            | Daughter board connector for TDK sensor. I2C and SPI interfaces.                 |
| CN6                | USB connector for FTDI USB to serial UART interface                              |
| CN7 (Not loaded)   | External Battery connector                                                       |
| CN8                | MCU SAMG55 JTAG connector for SAM-ICE and SEGGER boxes.                          |
| CN9 (Not loaded)   | Total-Phase SPI master Cheetah box connector                                     |
| J1                 | Board power source selection.                                                    |
| J2                 | Select sensor I2C slave source from sensor primary I2C or AUX I2C                |
| J3                 | Connect or disconnect MUC SAMG55 UART0 to FTDI.                                  |
| J4 (Not loaded)    | Cheetah box power enable                                                         |
| J5 (Not loaded)    | TDK sensor VDD power consumption measurement point                               |
| J6 (Not loaded)    | TDK sensor VDDIO power consumption measurement point                             |
| J7                 | SPI and I2C selection for DB and EVB.                                            |
| J200               | Extension header 1. Has same function as J200 on Microchip's Xplained-Pro board. |
| J201 (Not loaded)  | High speed I2C interface header                                                  |
| J203 (Not loaded)  | Extension header 4. Has same function as J203 on Microchip's Xplained-Pro board. |
| J204 (Not loaded)  | SAMG55 Cortex Debug Connector for External programmer/debugger                   |
| J300               | MCU SAMG55 chip erase jumper                                                     |
| J301               | MCU SAMG55 USB connector                                                         |
| J500               | EDBG MCU USB connector                                                           |
| SW300              | User button                                                                      |
| SW301              | RESET button.                                                                    |

## 2.4. TDK sensor power consumption measurement

To measure sensor VDD power consumption, remove R10 and inject 3V (or 3.3V) power from J5-pin2.

To measure sensor VDDIO power consumption, remove R11 and inject 3V (or 3.3V) from J6-pin1.

Note, the power consumption measured from J5 and J6 are the total power for on board sensor, DB sensor and EVB sensor.

## 2.5. TDK Sensor to SAMG55 MCU connection

TDK sensor can be connected to SAMG55 MCU I2C or SPI through 3 different hardware connections.

- On board sensor  
On-board sensor I2C slave address is 0x69. Its SPI /CS = NPCS1.
- Sensor from daughter board (DB)  
TDK sensor on DB I2C slave address is 0x68 and SPI /CS = NPCS0. User can plug in their sensor DB on CN4/5 without removing on board sensor.
- Sensor from TDK evaluation board (EVB)  
TDK provides EVB for each of their sensors.  
TDK sensor on EVB I2C slave address is 0x68 and SPI /CS = NPCS0. User can plug in EVB without removing on board sensor.

## 2.6. Other sensors connection

3<sup>rd</sup> party sensors, such like pressure sensor and magnetic sensor, can be connected to the same SAMG55 MCU I2C bus with TDK sensor through DB, assuming they have different slave address. If use plans to use TDK sensor build in DMP function, the 3<sup>rd</sup> party sensor can be connected to TDK sensor auxiliary I2C bus.

CN2/3 are designed for the other sensor DB plug in. It supports I2C only, not SPI.

## 2.7. Jumper settings

*Table 3 Jumper setting*

| Jumper | Description                                                                                                                                                                                                                                                                                                                                                |
|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| J1     | The J1 is for board power source selection. Only one jumper shunt is allowed.<br>Jumper shunt on pin-1/2: board power is from external batter on CN7.<br>Jumper shunt on pin-3/4: board power is from EDBG USB on J500.<br>Jumper shunt on pin-5/6: board power is from FTDI USB on CN6<br>Jumper shunt on pin-7/8: board power is from SAMG55 USB on J301 |
| J2     | J2 is used to select input source for SAMG55 master I2C. Only two jumper shunts are allowed.<br>Jumper shunts on pin-1/2 and 3/4: Sensor primary I2C is connected to SAMG55 I2C master<br>Jumper shunts on pin-5/6 and 7/8: Sensor auxiliary I2C is connected to SAMG55 I2C master                                                                         |
| J3     | J3 is for SAMG55 UART0 target selection.<br>Shunt pin-1/2, 3/4, 5/6 and 7/8: SAMG55 UART0 is connected to FTDI USB/UART<br>Open pin-1/2, 3/4, 5/6 and 7/8: SAMG55 UART0 can be used for extenrtion-1 board on J200.                                                                                                                                        |
| J7     | Short: DB/EVB=SPI<br>Open: DB/DVB=I2C                                                                                                                                                                                                                                                                                                                      |
| J300   | Shunt: AM G55 performs a chip erase after the next power toggle of the board.                                                                                                                                                                                                                                                                              |

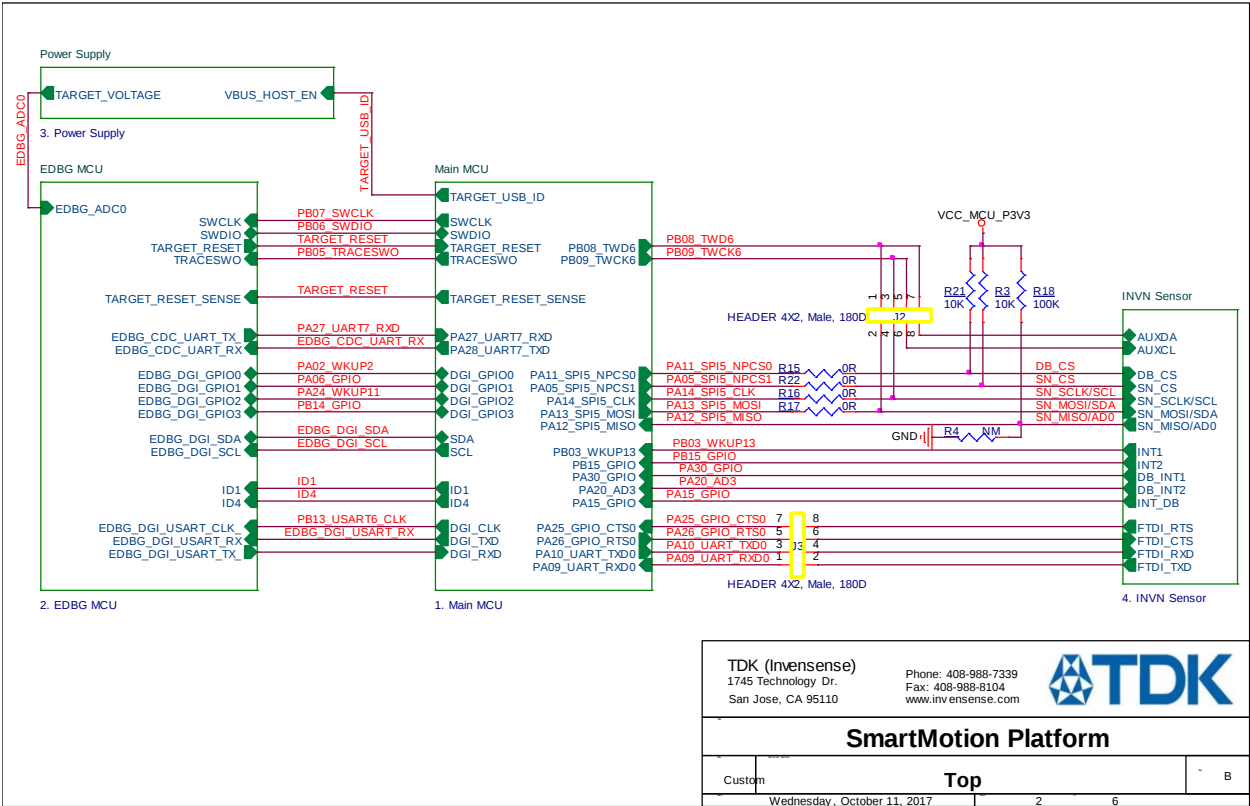
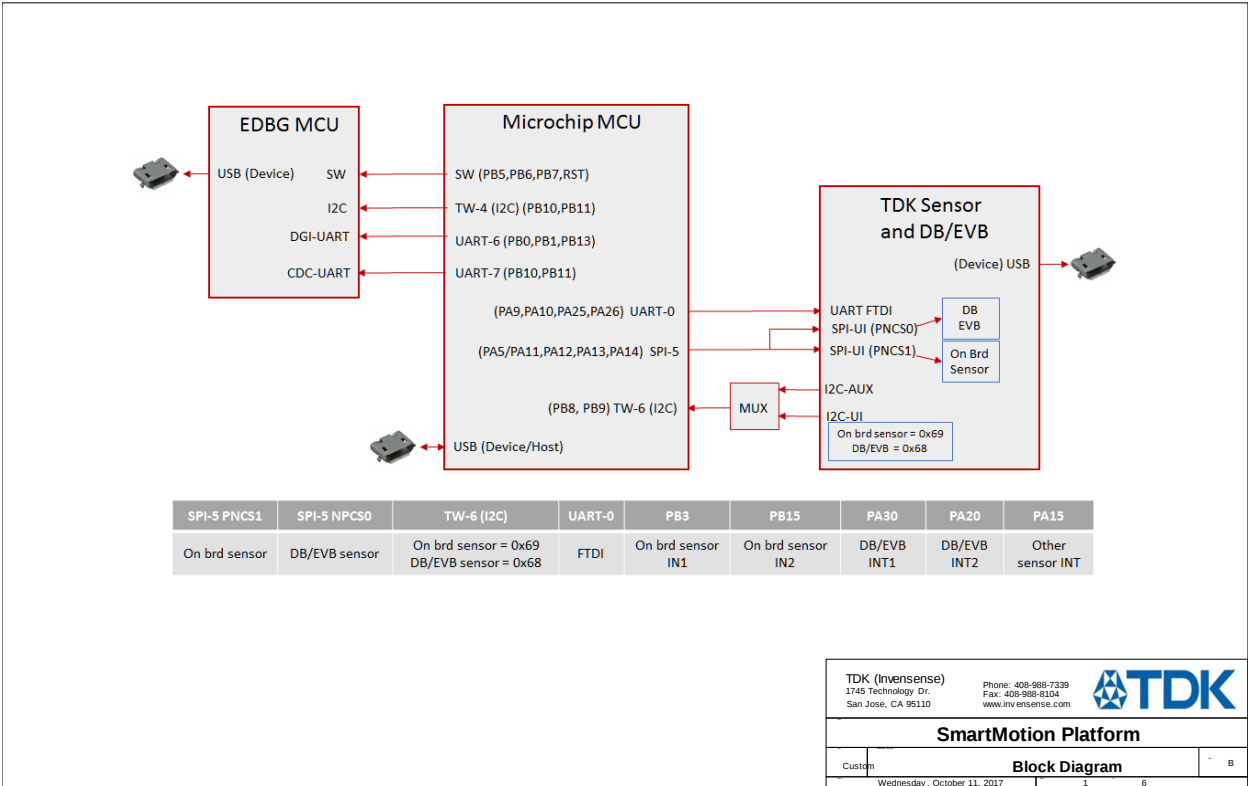
### 3. Schematics

There are two version schematics, Ver-B and Ver-C. Both them have same function and I2C/SPI assignment for DB (CN4/CN5), EVB (CN1) and other sensor daughter board (CN2/CN3). Jumpers name, function and setting are identical for the Ver-B and C.

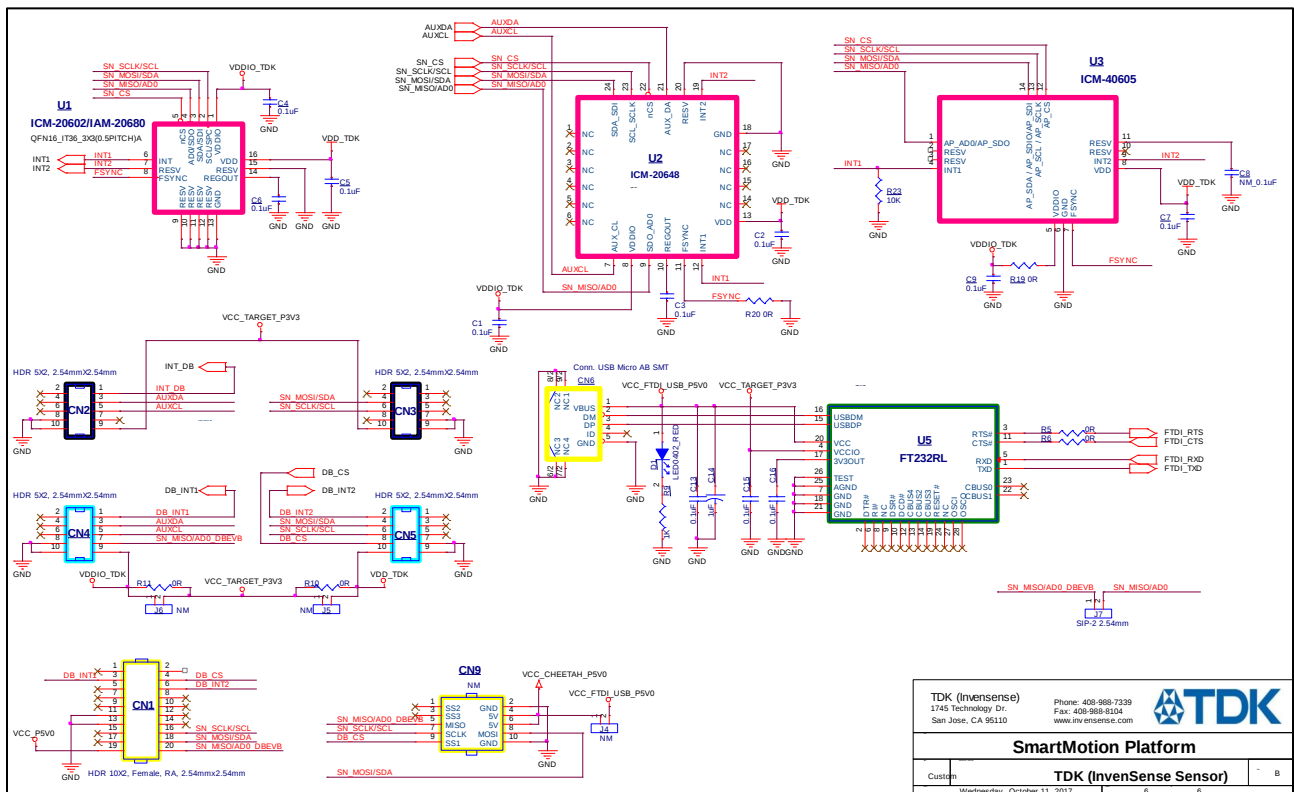
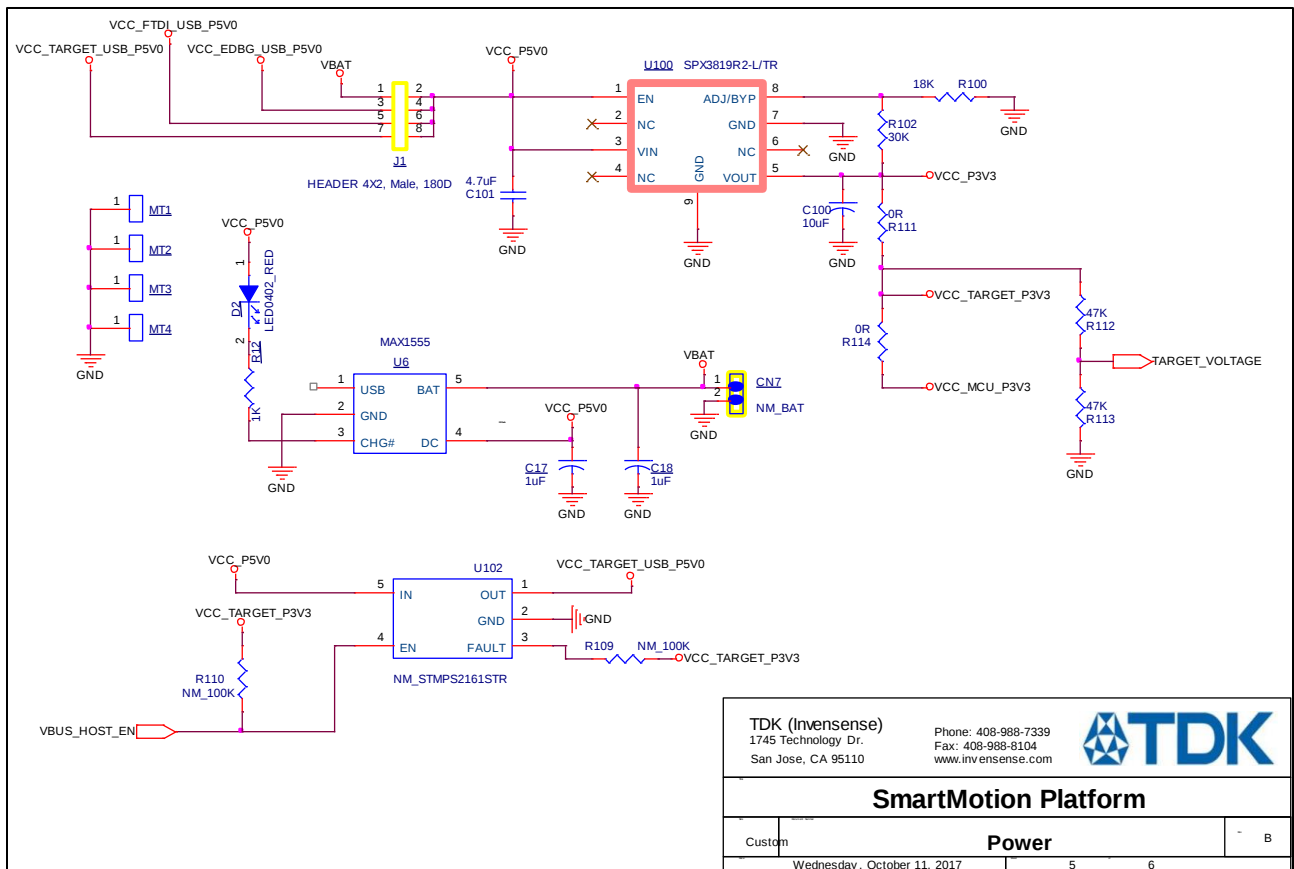
The only difference between the Ver-B and C is on board sensor power supply voltage level. The table below shows the difference between Ver-B and C.

| Board Version | Support on board sensor             | On board sensor supply voltage |
|---------------|-------------------------------------|--------------------------------|
| B             | ICM-20602<br>ICM-20648              | 3.0V                           |
| C             | ICM-20789<br>ICM-20948<br>ICP-10100 | 1.8V                           |

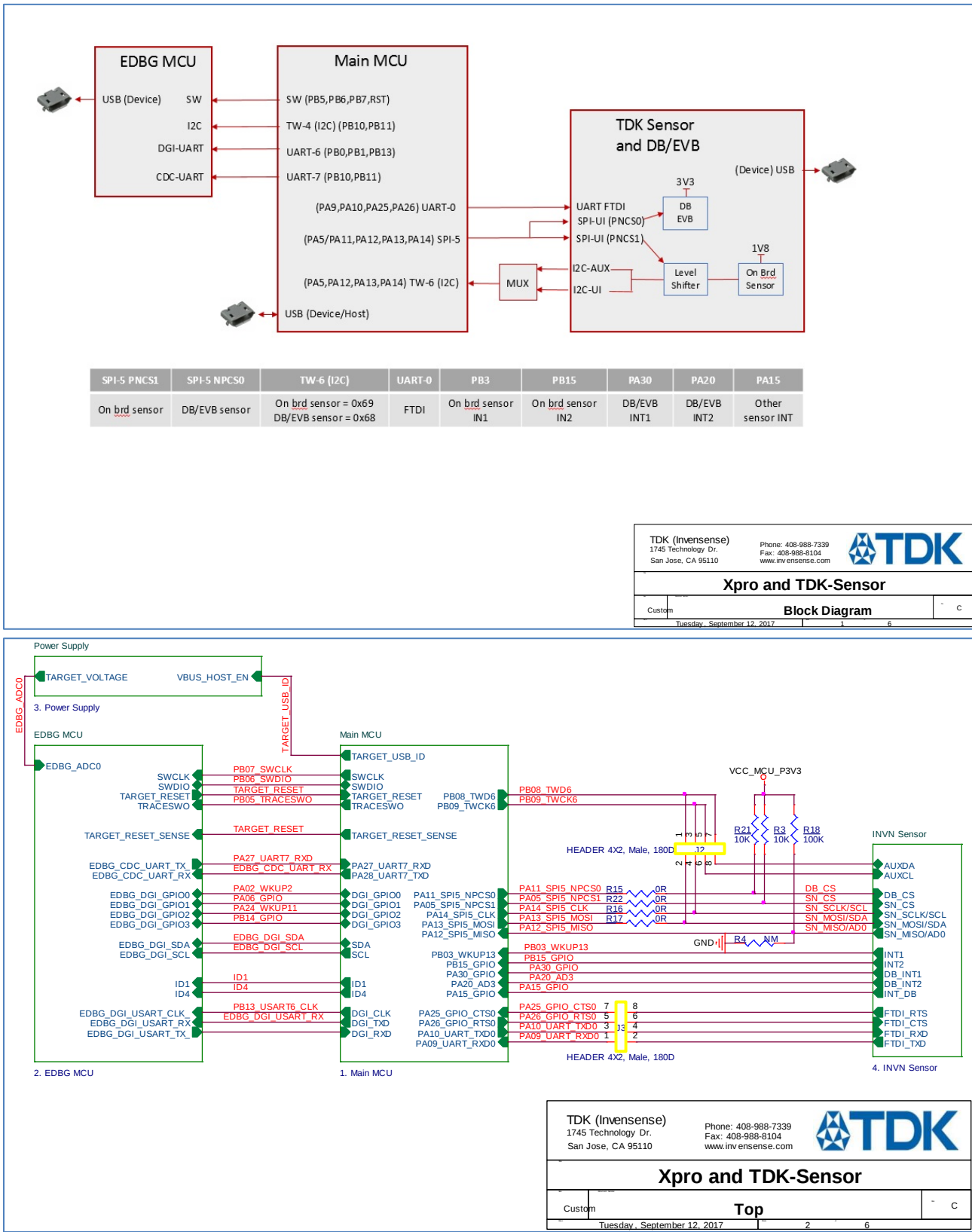
Ver-B schematics:







Ver-C schematics:

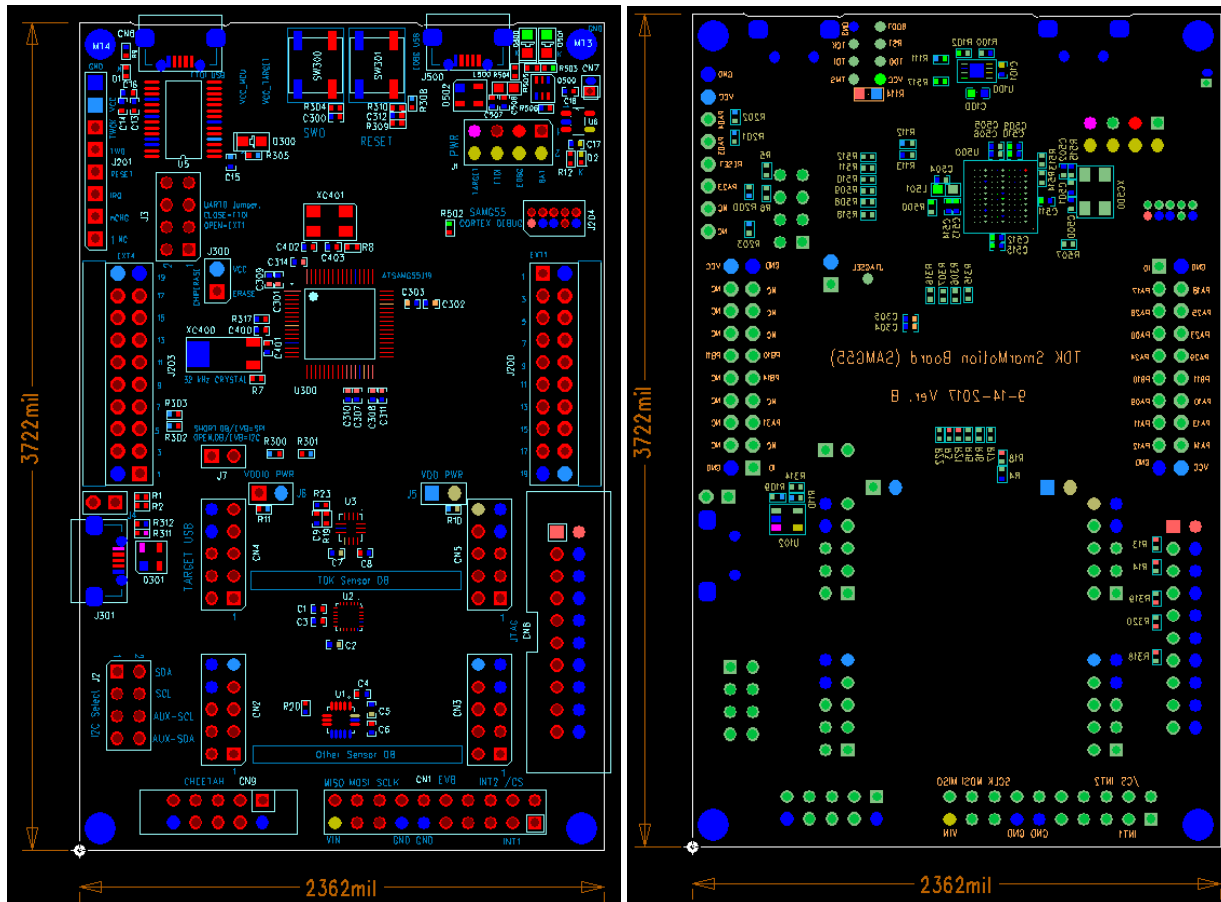






## 4. Board PCB

### Ver-B PCB



## Ver-C PCB

