TDK-InvenSense Automotive Motion Sensor Universal Evaluation Board (UEVB) User Guide

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1 PURPOSE

This document describes the hardware and circuitry on the Universal Evaluation Board (UEVB). The UEVB is used to evaluate most of TDK-InvenSense's current motion sensing (gyroscope, accelerometer, magnetometer) products. The document explains how to apply the UEVB to a larger system and requires the understanding of key signals and circuit functions, hardware jumper settings, and port connections.

1.1 USAGE

This UEVB provides up to nine axes of motion sensing comprising of:

- Digital-output of 3-axis gyroscope with user-programmable full-scale ranges
- Digital-output of 3-axis accelerometer with user-programmable full-scale ranges
- Digital-output of 3-axis magnetometer
- On-chip temperature sensor
- Data measured using on-chip ADCs and is transmitted over I²C or SPI interfaces

The UEVB may be used by itself utilizing SPI or I²C serial communications interfaces. Alternatively, it may be connected to the TDK-InvenSense ARM Controller Board for connectivity to a host computer via USB interface.

The UEVB was designed to support up to 9-axis MPUs (Motion Processing Units) with a built-in compass (MPU-91xx and MPU-92xx). Connecting an external compass board to the UEVB may require the user to connect their third-party compass to the UEVB via its auxiliary I²C bus. The UEVB is populated with an external compass and can access the main or auxiliary I²C bus lines provided by the sensor (AUX_DA and AUX_CL) via resistor options.

The UEVB is lead-free and RoHS compliant.

1.2 RELATED DOCUMENTS

Please refer to the main motion sensor datasheet for electrical characteristics, pinout, and applications details. Sensor product specifications can be found at tdk.invensense.com. For product specifications for unreleased parts, please contact the TDK-InvenSense sales department at inv.sales.us@tdk.com.

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2 UEVB OVERVIEW

The UEVB hosts most of TDK-InvenSense's motion sensors and MPUs. Resistor options are implemented for easy and flexible circuit configurations to support different products with the UEVB. For example, Table 1 shows the most popular parts that fit on the UEVB. Table 2 lists the resistor options for different configurations.

UEVB IDENTIFIER	PART NUMBER	SENSOR TYPE	FEATURES	PACKAGE TYPE & DIMENSIONS	PIN COUNT
U1C	IAM-20680	6-axis (accel, gyro)		LGA, 3 X 3 X 0.75mm	16
	IAM-20680HP	6-axis (accel, gyro)		LGA, 3 X 3 X 0.75mm	16
	IAM-20680HT	6-axis (accel, gyro)		LGA, 3 X 3 X 0.75mm	16
	IAM-20380	3-axis (gyro)		LGA, 3 X 3 X 0.75mm	16
	IAM-20381	3-axis (accel)		LGA, 3 X 3 X 0.75mm	16

Table 1. Parts for UEVB footprints

There are four different footprints on the UEVB PCB (Figure 1) to fit various motion sensors, but only one can be populated at a time.

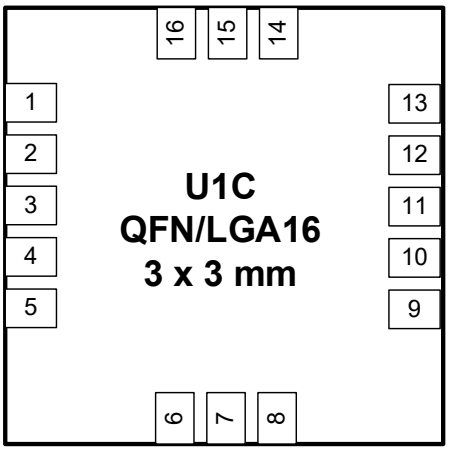

Figure 1. U1C (QFN/LGA16_3x3 mm)

The UEVB is populated with components only on its top side (Figure 2) to achieve ease of measurement access. A 10 x 2 connector (CN1) is designed to interface with the TDK-InvenSense ARM Controller Board, which is a host microcontroller board useful for programming the registers of the sensor on the UEVB and accessing sensor data via a PC or laptop through the USB port.

A 3-pin power selection header (JP1) is provided to choose the voltage level for VDD. Similarly, a 3-pin VDDIO selection header (JP2) allows the user to select the power source for the board's/sensor's digital I/O voltage.

2.1 KEY FUNCTIONS AND PINOUTS

The motion sensing UEVB is a fully assembled and tested evaluation board, allowing for simple and swift evaluation of the device's X-/Y-/Z-axis angular rate gyroscope, X-/Y-/Z-axis accelerometer, and X-/Y-/Z-axis compass. The motion sensing device has a primary interface to talk to the application processor and a secondary interface that allows a user to communicate with an external sensor, such as a pressure sensor or compass.

The motion sensing device utilizes TDK-InvenSense's proprietary MEMS technology with driven vibrating masses to produce a functionally complete, low-cost motion sensor. The motion processing unit incorporates X-/Y-/Z-axis low-pass filters and an EEPROM for on-chip factory calibration of the sensor. Factory-trimmed scale factors eliminate the need for external active components and end-user calibration. A built-in Proportional-To-Absolute-Temperature (PTAT) sensor provides temperature compensation information. Refer to the datasheet for each sensor to obtain more details on specific sensor features.

2.2 I²C/SPI BUS CONNECTIONS

The UEVB communicates with a system processor (for example, TDK-InvenSense ARM controller board) through the custom header using either the I²C or the SPI serial interface. The device always acts as a slave when communicating with the system processor.

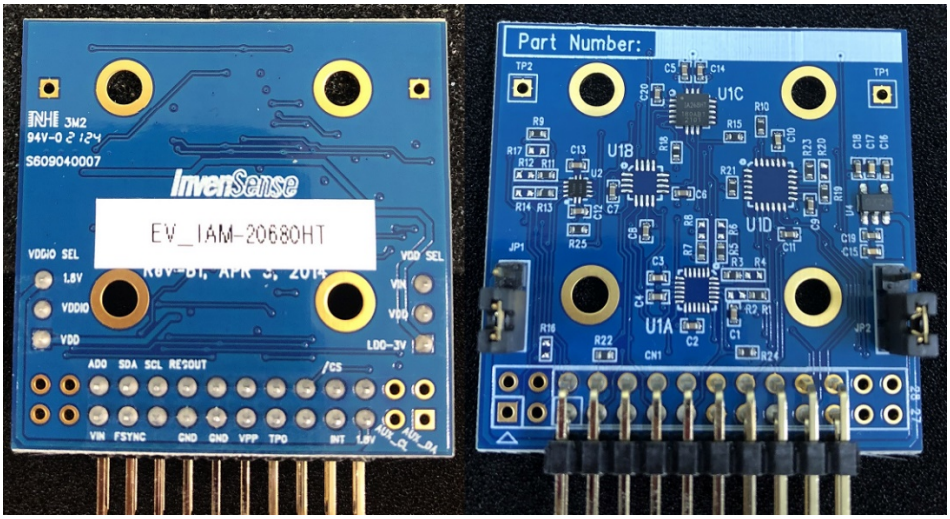

Figure 2. Bottom and Top Side of the UEVB (e.g. EV_IAM_20680HT)

3 SCHEMATIC

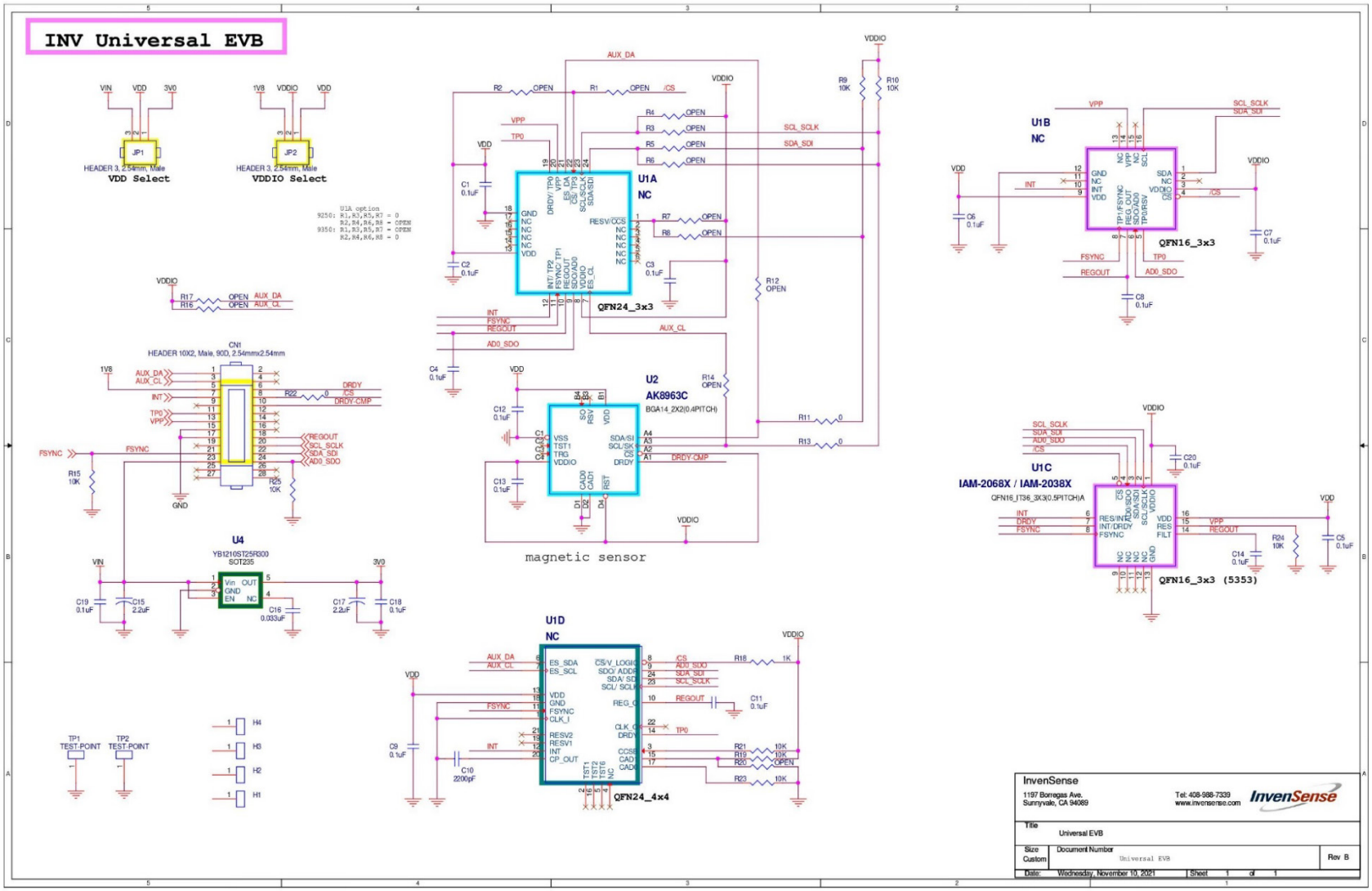

Figure 3. UEVB Circuit Schematic

4 BILL OF MATERIAL (BOM)

The UEVB offers five different BOMs, which cover most of TDK-InvenSense's sensor. There are two BOM versions for U1D, and one each one for U1A, U1B, and U1C.

ITEM	QUANTITY	REFERENCE	PART	PCB FOOTPRINT
1	1	CN1	Header 10x2, M, 90D, 2.54 x 2.54 mm	HDB2X14NRA
2	16	C1,C2,C3,C4,C5,C6,C7,C8,C9,C11, C12,C13,C14,C18,C19,C20	0.1 µF	C0402
3	1	C10	2200 pF	C0402
4	2	C15,C17	2.2 µF	C0402
5	1	C16	0.033 µF	C0402
7	2	JP1,JP2	3-Pin Header, 2.54 x 2.54 mm, Male	SIP-3P
9	8	R9,R10,R15,R19,R21,R23,R24,R25	10 kΩ	R0402
10	3	R11,R13,R22	0 Ω	R0402
11	1	R18	1 kΩ	R0402
15	1	U1C	IAM-20680, HP, HT IAM-20380, IAM-20381	QFN16_IT36_3X3 (0.5PITCH)A
17	1	U2	AK8963C	BGA14_2X2(0.4PITCH)
18	1	U4	YB1210ST25R300	SOT235

Table 2. Bill of Material for U1C (IAM-2068x, 2038x)

5 POWER SUPPLY CONNECTIONS

JP1 and JP2 are 3-pin headers, which allow the user to select between an on-board LDO (Low-Voltage Dropout Regulator, U4) and an external DC supply (VIN) to power the motion sensor. For details, please refer to Table 3.

JP1 PIN NUMBER	SIGNAL DESCRIPTION
1-2 Shorted	VDD = 3V (from LDO, VIN > 3.1V, net name 3V0)
2-3 Shorted	VDD = VIN (from an external source)
JP2 PIN NUMBER	**SIGNAL DESCRIPTION**
1-2 Shorted	VDDIO = VDD
2-3 Shorted	VDDIO = 1.8V (from an external source, net name 1V8)

Table 3. Power Selection Jumpers

The on-board low noise 3V LDO offers an output that is called 3V0 (Figure 3). Using this will ensure that the sensor performance will meet datasheet specifications.

Selecting VIN to power the chip/board is generally done while designing and evaluating an embedded platform, where the host processor and related electronics need full control over the motion processing chipset's power supply.

If a user intends to use the on-board 3V power source, an external VIN must be provided within the range of 3.1-6.0V to ensure the LDO works properly.

If the user provides a VIN power level of ≥3.6V, JP1 and JP2 must be shorted across pins 1-2, since the motion sensors' VDD and VDDIO operational ranges are ≤3.6V.

6 UEVB CONNECTOR SIGNALS DESCRIPTION

CN1 PIN NUMBER	CN1 SIGNAL NAME	SIGNAL DESCRIPTION
1	AUX_DA	AUX_DA. Auxiliary I^2C serial data signal.
2, 4, 9, 12, 14, 16, 19, 25, 26, 27, 28	N.C.	N.C. Do not connect to these pins.
3	AUX_CL	AUX_CL. Auxiliary I^2C serial clock signal.
5	1V8	1V8 Power. Receive power from TDK-InvenSense ARM controller board or an external source.
6	DRDY	DRDY. Data ready and FIFO interrupt signals.
7	INT	INT. Interrupt output signal to controller.
8	$\overline{CS}$	Test Signal. Not used in I^2C mode; used as chip-select pin in SPI mode.
10	DRDY-CMP	Compass (U2) DRDY. Compass data ready signal.
11	TP0	Test Signal
13	VPP	Test Signal
15, 17	GND	GND. Ground connection.
18	REGOUT	REGOUT. Sensor's on-chip regulator output.
20	SCL_SCLK	SCL/SCLK. I^2C or SPI primary serial clock signal.
21	FSYNC	FSYNC. Frame synchronization input for camera applications.
22	SDA_SDI	SDA/MOSI. I^2C primary data or SPI MOSI signal.
23	VIN	Power. Receive power from TDK-InvenSense ARM controller board or an external source.
24	AD0_SDO	AD0/MISO. Lowest (LSB) address bit in I^2C mode or SPI MISO signal in SPI mode.

Table 4. User Interface Connector Signals (CN1)

6.1 CONNECTING THE FSYNC LINE

The FSYNC line is intended for use in a camera's image-stabilization system. It is an input from the camera platform to the UEVB and is intended to synchronize the motion-sensor serial-bus transfer with the master timing set by the camera system.

6.2 SERIAL BUS LEVELS, SPEEDS, AND TERMINATIONS

Communication with all registers of the device is performed using either I^2C at 400 kHz or SPI at 8 MHz. The I^2C lines are open-drain and pull-up resistors (10 kΩ) are connected to VDDIO.

7 DATA GATHERING OPTIONS

The motion sensor's digital sensor data is available on the UEVB's header CN1. Alternatively, for connectivity with a host PC, a TDK-InvenSense ARM controller board may be used.

7.1 CONNECTION TO THE TDK-INVENSENSE ARM CONTROLLER BOARD

For communications via USB with a host computer, the UEVB can be connected to the TDK-InvenSense ARM controller board. TDK-InvenSense provides a software tool to support the collection of sensor data through the UEVB/ARM controller board combo connected to a PC/laptop via a USB port. Please refer to the *InvenSense Data Logger (IDL) Application Notes* document for additional instructions on how to use the software to obtain sensor data. This information can be provided by your local field team on an as-needed basis.

Figure 4 shows the connection of the UEVB to the TDK-InvenSense ARM controller board. Connections between the two boards are made via header CN1 on the UEVB and connector JP6 on the TDK-InvenSense ARM Controller Board.

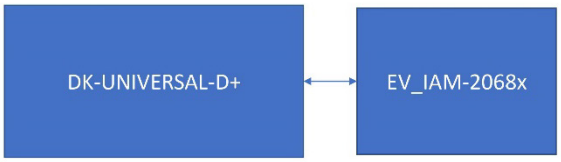

Figure 4. UEVB connected to the TDK-InvenSense ARM Controller Board Block Diagram

7.2 USE OF THE UEVB WITHOUT AN ARM CONTROLLER BOARD

I²C and SPI signals are made available on header CN1. Users may develop their own tools to communicate with the UEVB as there is no bus mode selection setting required.

8 SPECIAL INSTRUCTIONS

8.1 ELECTROSTATIC DISCHARGE SENSITIVITY

The motion sensors can be permanently damaged by electrostatic discharge (ESD). ESD precautions for handling and storage must be taken to avoid damage to the devices.

8.2 BOARD LAYOUT AND FOOTPRINT DISCUSSION

The UEVB is a 4-layer FR-4 PCB design with the dimensions: 38.1 x 38.1 x 1.6 mm (1500 x 1500 x 62 mil). See Figure 5 and Figure 6 for a detailed top and bottom view of the UEVB.

The MPU footprint on the UEVB supports both QFN and LGA packages. Footprints and sensor land patterns were chosen large enough, so they offer ease of use, reliable contact with the sensor, and hand-solder and debugging capabilities for both packages.

Note that to avoid potential shorting/clearance issues at the corner pins for LGA packages, the land pattern shapes for the individual pins in this design are oblong rather than square. The dimensions for the pin pads are 0.225 x 0.7 mm.

Solder mask (also called solder resist is a layer of protective coating for PCB's copper traces, which helps to prevent undesired solder bridges and shorts) dimensions will not be provided as they are dependent upon the manufacturing process and the clearance capabilities of the chosen fabrication house. Contact your PCB vendor to determine the minimum required clearance between pin pads (usually 4 mil to 6 mil or 0.102 mm to 0.152 mm) and traces allowing them enough room to print an adequate solder mask.

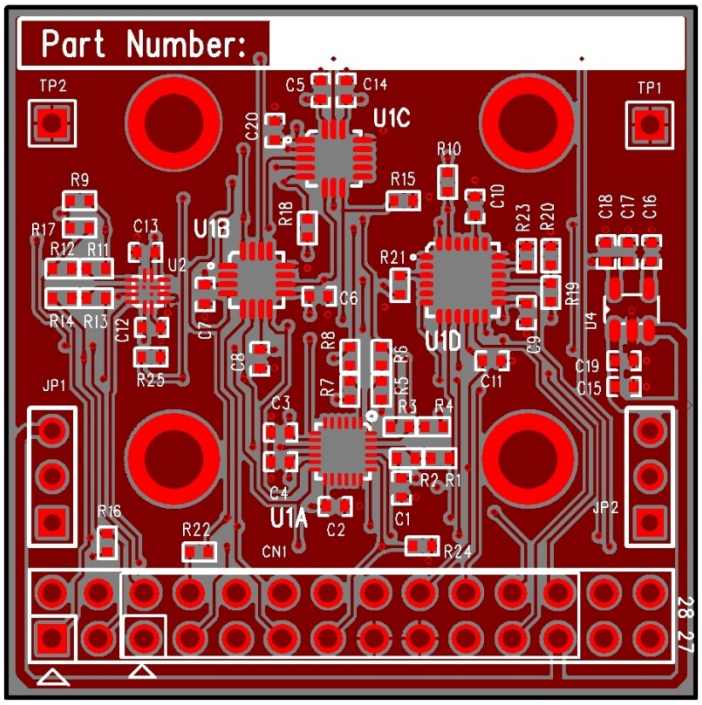

Figure 5. Top View of the UEVB Board Layout

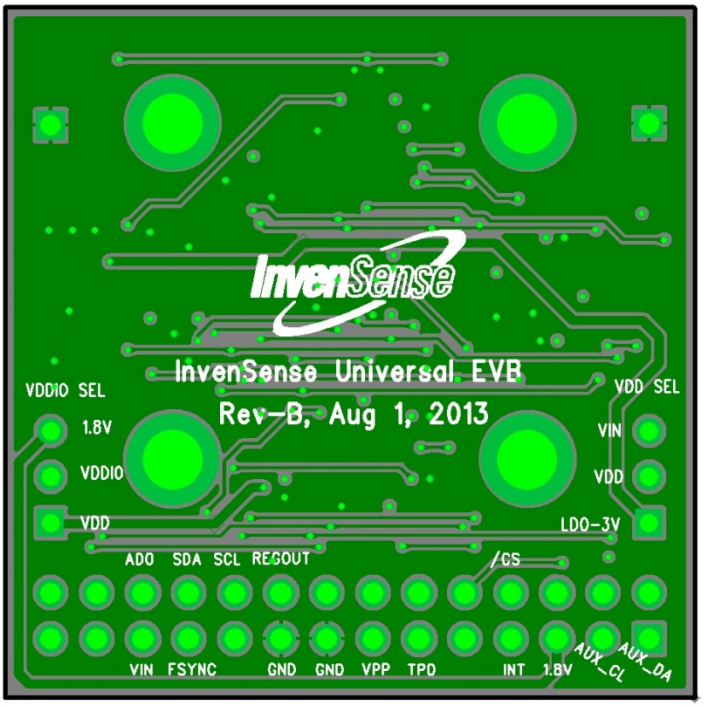

Figure 6. Bottom View of the UEVB Board Layout

9 REVISION HISTORY

DATE	REVISION	DESCRIPTION
11/11/2021	1.0	Initial Release

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