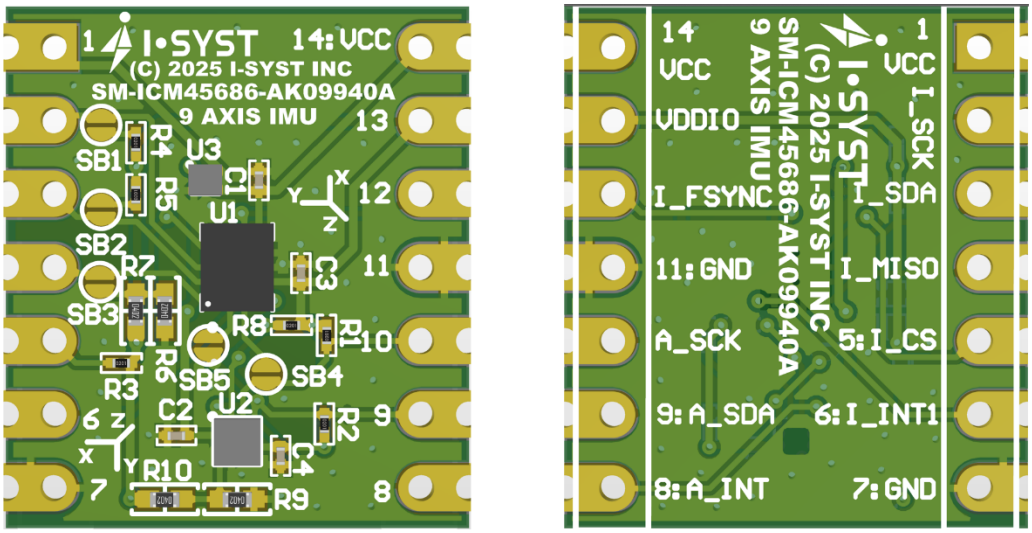
SM-ICM45686-AK09940A

High-Accuracy and Low-Power 9-Axis MEMS Motion Tracking Sensor Module

1. Highlights

The SM-ICM45686-AK09940A is a compact module (16.0mm x 18.0mm) featuring the TDK ICM-45686 6-axis inertial measurement unit (IMU) and the 3-axis Asahi Kasei Microdevices (AKM) AK09940A electronic magnetometer, designed for precise motion tracking and magnetic field sensing in space-constrained applications.

- **TDK ICM-45686** is an IMU delivering 3-axis gyroscope and 3-axis accelerometer with low-noise signal range up to ±4000 degrees/sec (dps) and ±32g, respectively. This IMU can tolerate up to 20,000g of shock.
- **AKM AK09940A** is a geomagnetic sensor delivering precise 3-axis magnetic field measurement with magnetic field range up to ±1200µT and sensitivity of 10 nT/LSB.



(a) Front view (b) Back view

Figure 1. Front and back views of SM-ICM45686-AK09940A sensor module.

2. Applications

- IoT applications
- Wearable devices
- Gaming devices
- Virtual reality (VR)/ augmented reality (AR) controllers

- Tracking applications, e.g., gesture recognition, pedometer, and activity classification
- Robotics applications
- Head mounted display

3. Features

TDK ICM-45686 IMU

- 3-axis gyroscope
  - Gyroscope range: ±15.625 to ±4000 degrees/sec
  - Sensitivity scale factor: 8.2 to 2097.2 LSB
  - Low noise: 3.8 mdps/$\sqrt{Hz}$
  - Shock tolerance: 20,000g
- 3-axis accelerometer
  - Accelerometer range: ±2g to ±32 g
  - Sensitivity scale factor: 1024 to 16,384
  - Low accelerometer noise: 70 µg/$\sqrt{Hz}$
- Configurable serial interface
  - I2C @ 125 KHz, 400 KHz, 1 MHz, or
  - SPI up to 24 MHz
- Low noise and low power modes support
- Output data rate
  - Low noise mode: 12.5 Hz to 6400 Hz
  - Low power mode: 1.5625 Hz to 400 Hz
- 2 programmable interrupt pins with 5 configurable interrupt events
- Wake-on-motion for low power operation of host controller
- Dual interface (UI + AUX)
  - Allowing host controller to communicate with another I2C/SPI device via the ICM-45686's main serial interface
- Digital output temperature sensor
- Self-test

AKM AK09940A Magnetometer

- 3-axis magnetometer
- 18-bit data out for each 3-axis magnetic component
  - Range ±1200 μT (max)
  - Sensitivity 10 nT/LSB (max)
- Serial interface
  - I2C @ 125 KHz (standard mode), 400 KHz (fast mode)
  - SPI up to 24 MHz (not available on SM-ICM45686-AK09940A sensor module)
- 1 programmable interrupt pin for data-ready (DRDY) signaling
- Selectable sensor drive mode
  - low power drive
  - low noise drive
  - ultra-low power drive

Operating voltage

- Supply voltage (VCC) range: 1.8V ~ 3.6V
- Interface voltage (VDDIO) range: 1.8 ~ 3.6V

Temperature range

- -30 ^{0}C ~ +85 ^{0}C

Dimension

- 16.0 x 18.0 [mm]

Block diagram

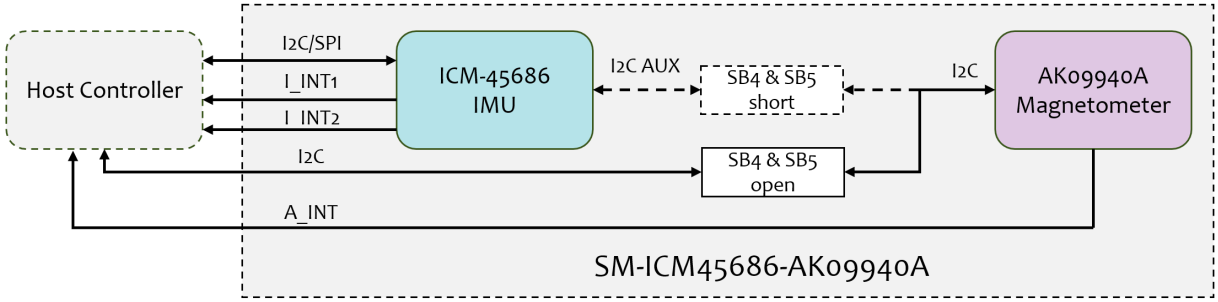


Figure 2. Block diagram of SM-ICM45686-AK09940A

4. Pinout

The SM-ICM45686-AK09940A provides 14 pins equally grouped into two ports P1 and P2. Table 1 lists all the pins and their description.

Table 1. SM-ICM45686-AK09940A pin description

Pin	Name	Function
1	VCC	Supply voltage (1.8V to 3.6V)
2	I_SCL/SCLK	ICM-45686 I2C clock / SPI clock line
3	I_SDA/MOSI	ICM-45686 I2C SDA / SPI MOSI
4	I_MISO	ICM-45686 SPI MISO
5	I_CS	ICM-45686 SPI Chip Select
6	I_INT1	ICM-45686 interrupt 1
7	GND	Ground
8	A_INT	AK09940A interrupt
9	A_SDA	AK09940 I2C SDA
10	A_SCK	AK09940A I2C clock
11	GND	Ground
12	I_INT2/FSYNC	ICM-45686 interrupt 2 / Frame sync output
13	VDDIO	Digital I/O supply voltage
14	VCC	Supply voltage

Table 2 lists the categorizes pins according to their associated sensors.

Table 2. Sensor pinout description

Sensor	Pin Number	Pin Name	I2C	SPI
ICM-45686	2	I_SCK/SCLK	Clock	Clock
	3	I_SDA/MOSI	SDA	MOSI
	4	I_MISO	N/A	MISO
	5	I_CS	N/A	Chip Select
	6	I_INT1	Interrupt 1	
	12	I_INT2/FSYNC	Interrupt 2 / Frame sync output	
AK09940A	8	AK_INT	Interrupt	N/A
	9	AK_SDA	SDA	N/A
	10	AK_SCK	Clock	N/A

Table 3 lists pins for supply voltage, digital I/O supply voltage, and ground.

Table 3. Voltage supply pins

Pin Number	Pin Name	Description
1, 14	VCC	Supply voltage: 1.8V to 3.6V
13	VDDIO	Digital I/O voltage: 1.8V to 3.6V
7, 11	GND	Ground

5. Solder Bridge Description

The SM-ICM45686-AK09940A provides 5 solder bridges (SB1 to SB5) described in Table 4. All the SBs are opened by default.

The SB1, SB2, and SB3 are used for selecting serial interface of the ICM-45686.

- If the SB1, SB2, and SB3 are shorted, I2C interface is configured for the ICM-45686.
- If the SB1, SB2, and SB3 are opened, SPI is configured for the ICM-45686.

The SB4 and SB5 are used for connecting the AK09940A I2C interface with the ICM-45686 AUX interface.

- If SB4 and SB5 are opened, the AK09940A I2C interface is not connected to the ICM-45686 AUX interface. In this case, the host controller can independently communicate with the two sensors via two different serial interfaces.
- If SB4 and SB5 are shorted, the AK09940A I2C interface (A_SCK and A_SDA pins) is connected to the ICM-45686 AUX interface (MAS_SCK and MAS_SDA pins). In this case, the host controller can communicate with the AK09940A I2C via the ICM-45686 I2C or SPI interface, thereby saving wire connection (and physical serial interface) to the SM-ICM45686-AK09940A sensor module.

Check the SM-ICM45686-AK09940A schematic for more detail about the SBs.

Table 4. SM-ICM45686-AK09940A solder bridges for ICM-45686 interface selection

Solder Bridge	Description
SB1	Short to connect I_SCL/SCLK pin to VDDIO with 100 kΩ pull-up resistor

SB2	Short to connect I_SDA/MOSI to VDDIO with 100 kΩ pull-up resistor
SB3	Short to connect I_MISO to VDDIO or ground via 100 kΩ resistor (check the schematic)
SB4	Short to connect ICM-45686's MAS_SCK pin to AK09940A's A_SCK pin
SB5	Short to connect ICM-45686's MAS_SDA pin to AK09940A's A_SDA pin
* All solder bridges are open by default	

6. Electrical Characteristics

The ICM-45686 and AK09940A share the same power supply voltage (VCC) and digital I/O supply voltage (VDDIO) on the sensor module. Table 5 lists the recommended voltage ranges for VCC and VDDIO.

Table 5. Recommended supply voltage

Supply voltage	Accepted range
VDD	1.8 V ~ 3.6 V
VDDIO	1.8 V ~ 3.6 V
*The AK09940A sensor only accepts VDD up to 2.0V. However, the SM-ICM45686-AK09940A sensor module is equipped with an LDO for accepting the same VDD input range as for the ICM-45686 IMU. The actual supply voltage to the AK09940A is 1.8V.	

7. Serial Interface Configuration

On the SM-ICM45686-AK09940A sensor module, the ICM-45686 IMU provides acceleration and angular rate data, both accessible via I2C or SPI interface. The AK09940A electronic magnetometer measures magnetic fields where the measured data can be accessed via I2C interface. Note that SPI is not available for the AK09940A on the SM-ICM45686-AK09940A sensor module. Figure 2 describes the interface block diagram of the SM-ICM45686-AK09940A sensor module.

SB1, SB2, and SB3 are used for select the I2C/SPI interface for the ICM-45686, as described in Table 6.

Table 6. ICM-45686 interface selection

Interface	SB1, SB2, and SB3
SPI	Open
I2C	Short

Resistors R6 and R7 are used for configuring the I2C address for the ICM-45686, as described in Table 7.

Table 7. I2C address configuration for the ICM-45686

I2C Address	Resistor	Configuration
0x68	R6	Keep
	R7	Remove
0x69	R6	Remove
	R7	Keep

Resistors R9 and R10 are used for configuring the I2C address for the AK09940A, as described in Table 8.

Table 8. I2C address configuration for the AK09940A

I2C Address	Resistor	Configuration
0x0C	R9	Keep
	R10	Remove
0x0D	R9	Remove
	R10	Keep

7.1 The ICM-45686 AUX interface

This interface allows host controller to communicate with the AK09940A's I2C interface via the ICM-45686's I2C/SPI interface, thereby saving connections wires and the host controller's serial interface.

The SM-ICM45686-AK09940A sensor module provides SB4 and SB5 for controlling the connection between the AK09940A's I2C interface and the ICM-45686 AUX interface, as described in Table 9.

Table 9. ICM-45686 AUX interface configuration

SB4 and SB5	Description
Open (default)	Host controller independently communicates with the ICM-45686 and AK09940A on two different interfaces.
Short	AK09940A's I2C interface are connected to the ICM-45686 AUX interface • A_SCK is connected to MAS_SCK • A_SDA is connected to MAS_SDA Host controller communicates with the AK09940A's I2C interface via the ICM-45686's interface.

8. Orientation of Axes

Figure 3 depicts the orientation of axes with respect to the laser-marking dot on the IC surface of the IMU and the magnetometer. The axis orientation for each device is also printed on the SM-ICM45686-AK09940A sensor module.

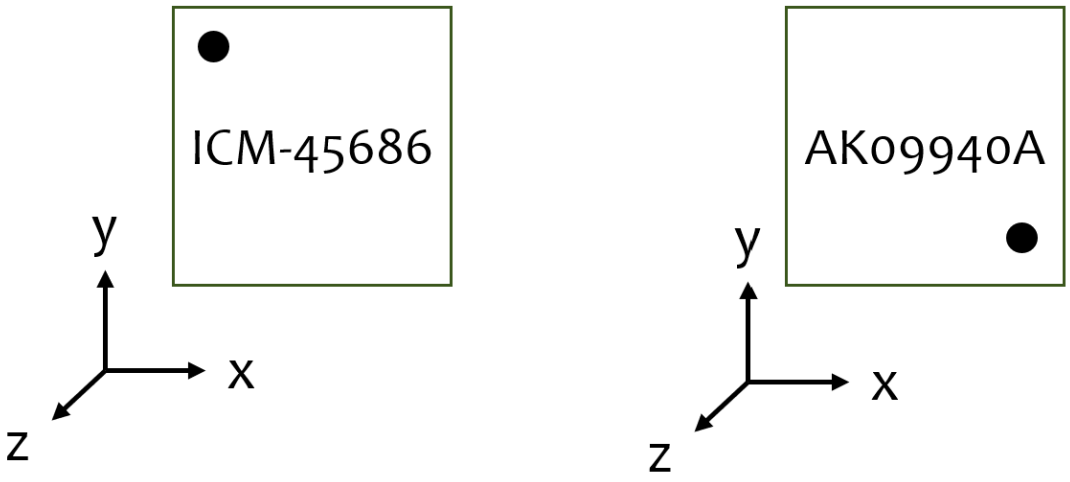


Figure 3. Orientation of axes with respect to the view from laser-marking dot on the IC surface

9. Limited Warranty

The SM-ICM45686-AK09940A board is warranted against defects in materials and workmanship for a period of 30 days from the date of purchase from I-SYST or from an authorized dealer.

10. Disclaimer

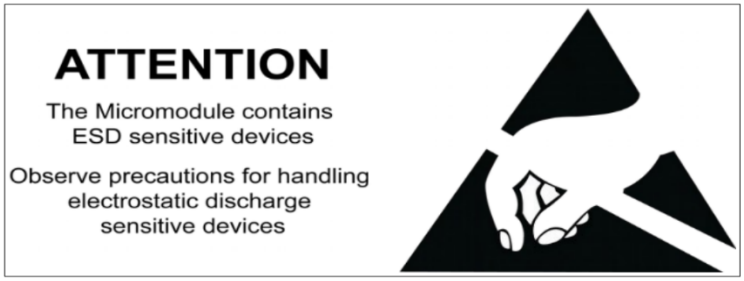
I-SYST reserves the right to change this product without prior notice. Information furnished by I-SYST is believed to be accurate and reliable. However, no responsibility is assumed by I-SYST for its use; nor for any infringement of patents nor other rights of third parties which may result from its use. No license is granted by implication or otherwise under the patent rights of I-SYST. In no event shall I-SYST be liable for any direct, indirect, incidental, special, exemplary, or consequential damages (including, but not limited to, procurement of substitute goods or services; loss of use, data, or profits; or business interruption) however caused and on any theory of liability, whether in contract, strict liability, or tort (including negligence or otherwise) arising in any way out of the use of I-SYST hardware and software, even if advised of the possibility of such damage. I-SYST products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. I-SYST customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify I-SYST for any damages resulting from such improper use or sale.

11. Trademark

TDK is trademark of TDK Group Company.
AKM is a trademark of Asahi Kasei Microdevices Group.

12. Handling and ESD Precautions

This board is ESD-sensitive. Use and anti-static wrist strap when handling.



13. Copyrights

50 Rue de Lauzon, Boucherville, QC, Canada J4B 1E6.

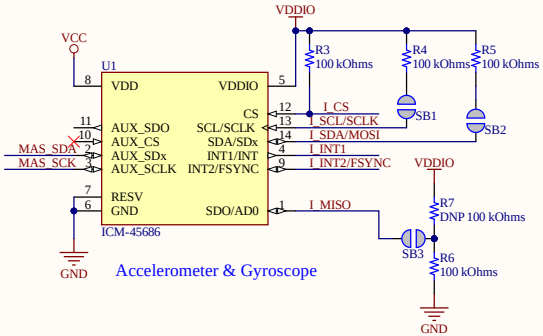
14. Revision History

Version	Date	Description
1.0	2025-04-10	Initial draft

References

[1] TDK ICM-45686 product page: https://invensense.tdk.com/products/motion-tracking/6-axis/icm-45686/

[2] AKM AK09940A product page: https://www.akm.com/us/en/products/tri-axis-magnetic-sensor/lineup-tri-axis-magnetic-sensor/ak09940a/



Accelerometer & Gyroscope

SPI interface mode

SB1, SB2, SB3 Open

I2C interface mode

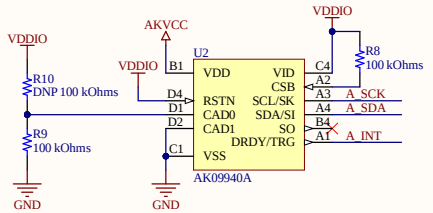
Short SB1, SB2, SB3

I2C Address Select

Addr. 0x68 : R6 Keep, R7 Remove

Addr. 0x69 : R7 Keep, R6 Remove

Magnetometer

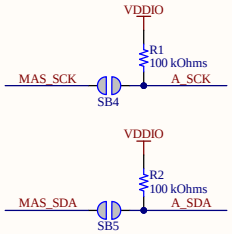


I2C interface mode only. SPI not supported

I2C Address Select

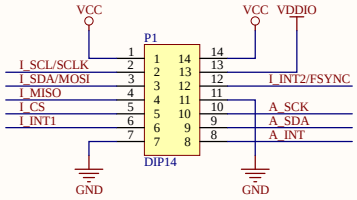
Addr. 0xC : R9 Keep, R10 Remove

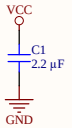
Addr. 0xD : R10 Keep, R9 remove

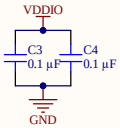


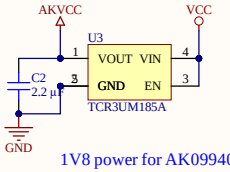
Short SB4, SB5 to connect AK09940A to ICM45686 aux interface

Edge header pins









1V8 power for AK09940A

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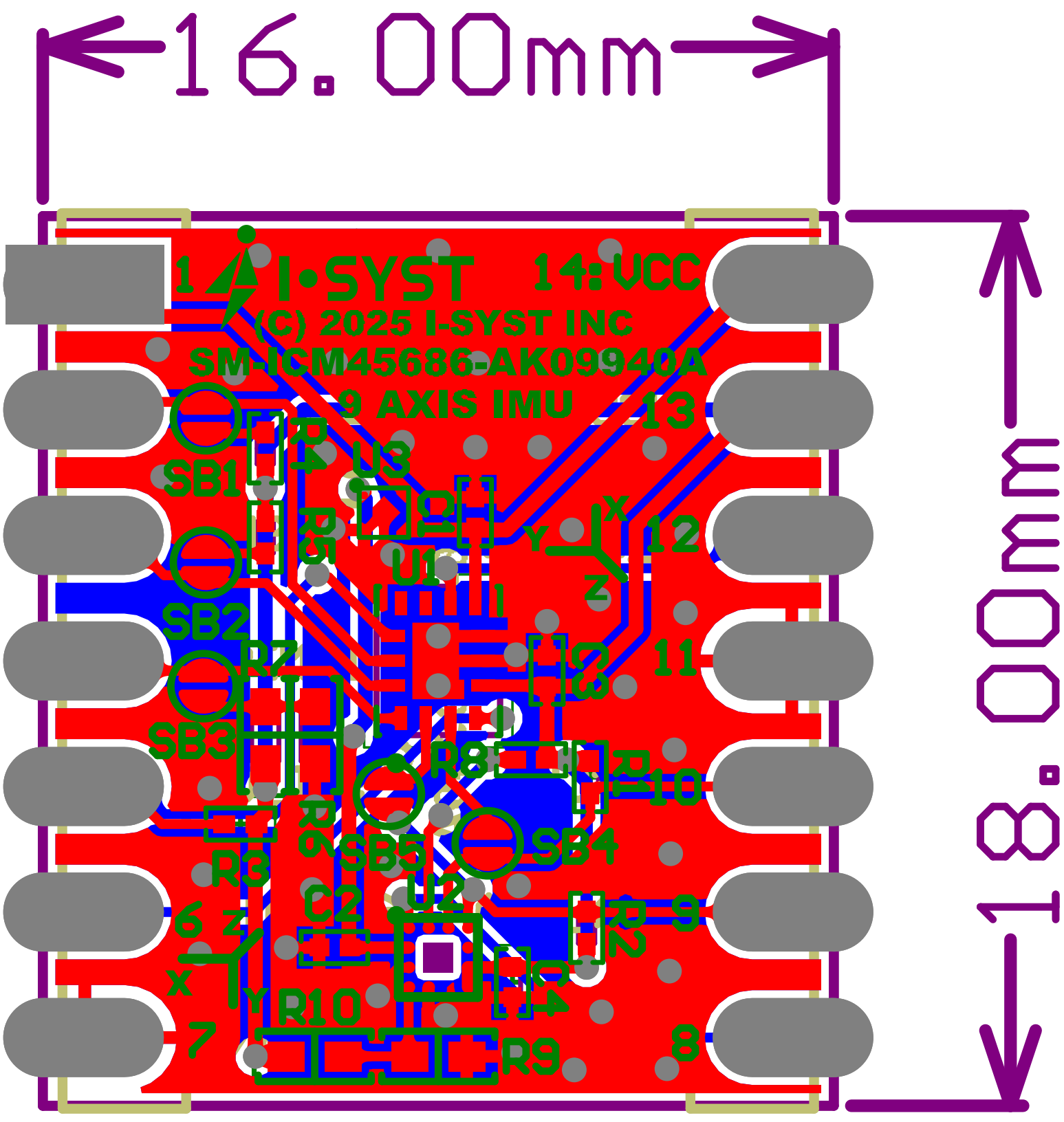
16.00mm
18.00mm
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12
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SB1
SB2
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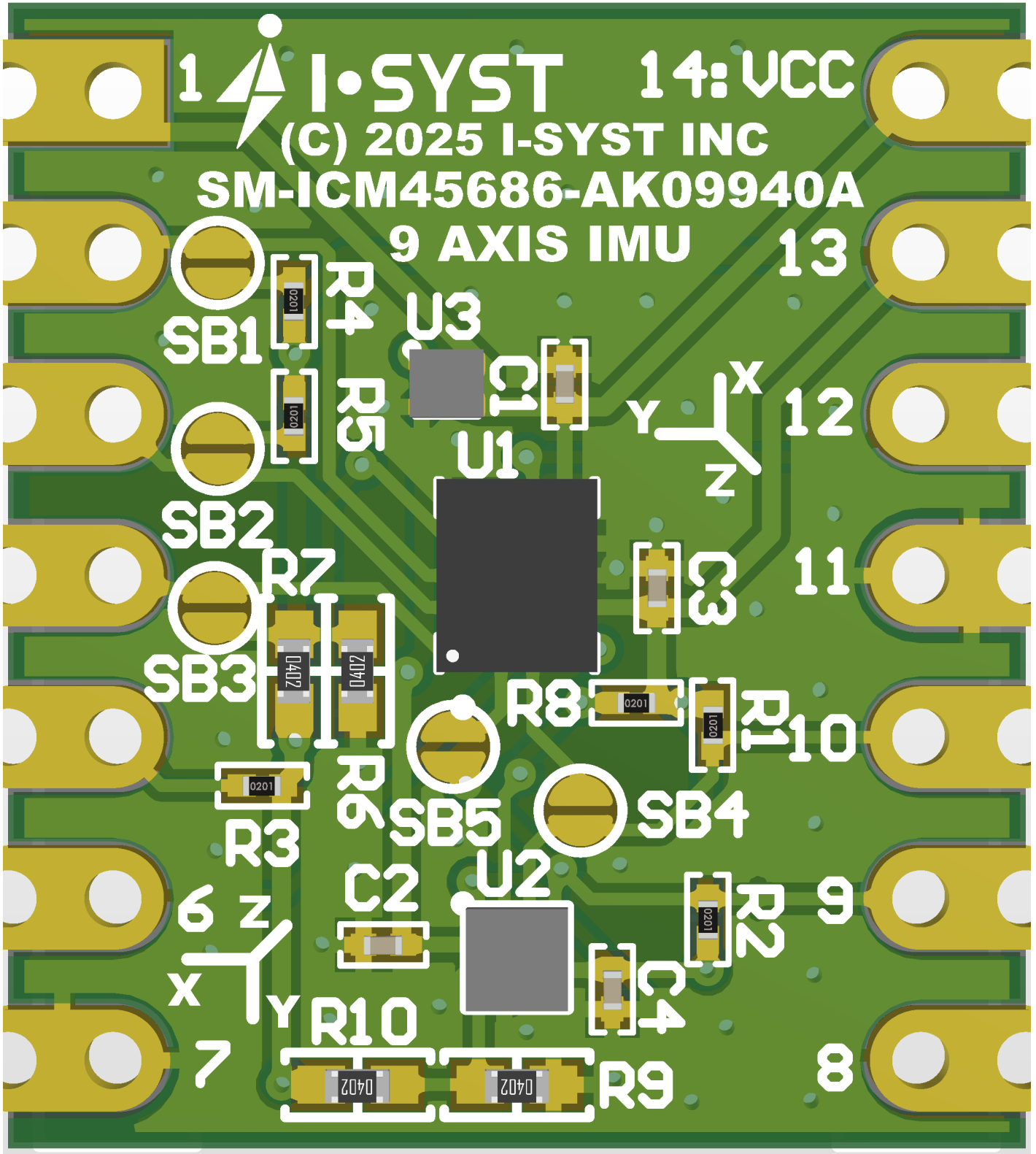
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14:VCC
(C) 2025 I-SYST INC
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14
VCC
VDDIO
I_FSYNC
11: GND
A_SCK
9: A_SDA
8: A_INT
SM-ICM45686-AK09940A
9 AXIS IMU
(C) 2025 I-SYST INC
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I_SDA
I_MISO
5: I_CS
6: I_INT1
7: GND