ICM-20948 Transition Guide

TABLE OF CONTENTS

1   INTRODUCTION

The ICM-20948 has been a staple in the TDK InvenSense IMU portfolio for over 6 years. To date it is still one of best performance 9-axis consumer IMU devices in the market and a very popular part with our customers. However due to supply concerns, we recommend that customers do not use ICM-20948 for new developments and investigate alternative IMUs for their application.

This guide will help answer the questions that customers will have in choosing an IMU to replace the ICM-20948.

2   ICM-20948 STATUS FAQ

2.1   WHY IS THE ICM-20948 GOING TO NRND?

The ICM-20948 status has been changed to "Not Recommended for New Designs." The ICM-20948 is a 6+ year old part with a limited amount of magnetometer wafers available. The ICM-20948 is a multi-chip module with a TDK 6-axis (accel and gyro) ICM-20648 and an external third-party mag in same package. AKM no longer manufactures the AK09916C mag. TDK InvenSense has purchased a large quantity of wafers to sustain the current estimated ICM-20948 demand but cannot guarantee supply for new applications.

2.2   WHAT DOES NRND MEAN EXACTLY?

NRND means "Not Recommended for New Designs." The device it is not EOL and is still available from TDK InvenSense authorized distributors. However, because there is a finite supply, we do not recommend the ICM-20948 for any new development that requires an IMU.

2.3   IS THE ICM-20948 GOING TO EOL AND IF SO, WHEN?

Currently, TDK InvenSense does not have a specific plan to EOL the ICM-20948. As part of its EOL process, TDK InvenSense gives 6 months of advance notice before the product is no longer orderable.

2.4   I HAVE ALREADY BEGUN DEVELOPMENT; HOW MUCH SUPPLY IS LEFT OF ICM-20948?

Customers who have already started new designs employing ICM-20948 should contact a local TDK InvenSense sales representative to discuss their forecasts and potential alternative solutions.

2.5   WHO DO I CONTACT FOR MORE INFORMATION?

If you have supply questions you can contact a TDK InvenSense sales representative. A list of TDK InvenSense official sales reps and their regions are found here:

https://invensense.tdk.com/sales-info/

For technical questions you can send in your questions here:

https://invensense.tdk.com/developers/support/

or contact the technical support e-mails for your region listed here:

https://invensense.tdk.com/offices/

3 SELECTING AN ICM-20948 REPLACEMENT FAQ

3.1 WHICH IMUS DOES TDK RECOMMEND TO REPLACE ICM-20948?

Start with the ICM-42670-P or the ICM-42688-P. Both parts are from TDK InvenSense's latest generation of sensors. Both sensors' hardware performance and power are better than the ICM-20948. However, there are differences:

1. ICM-20948 is 9-axis (accel, gyro, mag) while the ICM-42670-P and ICM-42688-P are 6-axis only (accel and gyro)
2. ICM-20948 has a DMP while the ICM-426xx-P has the APEX embedded engine; each has different features. The biggest difference is that APEX does not have on-chip sensor fusion or calibration like the DMP.

If your application is more concerned with power, then we recommend the ICM-42670-P. If your application needs higher performance, then we recommend the ICM-42688-P.

To help you with the selection, please see the spec comparisons in Table 1.

DEVICE	ICM-20948	ICM-42670-P	ICM-42688-P
Key Attribute	Lowest power 9-axis IMU with 3rd GEN embedded motion processor	Cost-Optimal Lowest power IMU with advanced motion features	Highest Performance 6-axis IMU with advanced motion features and events
Target Market & Applications	Drones, Wearables, IoT	Wearables, TWS, Hearables, IoT	Robotics, HMD, High performance IoT, AR, VR
# Axes	9	6	6
Sensors	Accel + Gyro + Mag	Accel + Gyro	Accel + Gyro
Embedded Processor(s)	DMP	Advanced Pedometer and Event Detection (APEX)	Advanced Pedometer and Event Detection (APEX)
Embedded Features	DMP based 6 & 9-axis Cal/Fusion, Android M features: Pedometer, Significant Motion, Bring to See, Basic Activity Classification, Pick Up	Wake on Motion, Freefall Detection, Low-G detection, Pedometer, Tilt Detection, Significant Motion Detection, Independent FIFO ODR	Pedometer, Tilt Detection, Tap Detection, Wake on Motion, Raise to Wake/Sleep, Significant Motion Detection Real Time Clock (RTC) input, 19/18 bit data format in FIFO for Gyro/Accel
Package-Pin	3x3x1mm QFN 24-leads	2.5x3x0.76mm LGA 14-leads	2.5×3×0.91mm LGA 14-leads
Gyroscope Specs			
FSR (dps)	±250/500/1000/2000	±250/500/1000/2000	±15.625/31.25/62.5/125/250/500/1000/2000
GYRO ZRO (dps)	±5	±1	±0.5
GYRO Offset Stability TC (dps/C)	±0.05 (-40C to 85C)	±0.015 (-40C to 85C)	±0.005 (0C to 70C)
GYRO Sensitivity Error (%)	±1.5%	±1%	±0.5%
GYRO Sensitivity/temp (%/C)	±0.024 (-40C to 85C)	±0.007 (-40C to 85C)	±0.005 (0C to 70C)
GYRO Cross-Axis Sensitivity (%)	±2%	±2%	±1.25%
GYRO Nonlinearity (%)	±0.1%	±0.1%	±0.1%
GYRO Noise (dps/√Hz)	0.015	0.007	0.0028
Gyro Output Data Rate (Hz)	4.4Hz to 9KHz	12.5Hz to 1.6kHz	12.5Hz to 32kHz

Accelerometer Specs			
FSR (g)	±2/4/8/16	±2/4/8/16	±2/4/8/16
Accel ZGO (mg)	±50	±25	±20
Offset Stability TC (mg/C)	±0.8 (0C to 85C)	±0.15 (-40C to 85C)	±0.15 (-40C to 85C)
ACCEL Sensitivity Error (%)	±0.5%	±1%	±0.5%
ACCEL Sensitivity/temp (%/C)	±0.026 (-40C to 85C)	±0.01 (-40C to 85C)	±0.005 (-40C to 85C)
ACCEL Cross-Axis Sensitivity (%)	±2%	±1%	±1%
ACCEL Nonlinearity (%)	±0.5%	±0.1%	±0.1%
ACCEL Noise (µg/√Hz)	230	100	XY: 65, Z: 70
ACCEL Output Data Rate (Hz)	4.5 Hz to 4.5 kHz	1.5625 Hz to 1.6 kHz	1.5625 Hz to 32 kHz
General Specs			
Bus Interface	SPI; I^{2}C	SPI; I^{2}C; I3C^{SM}	SPI; I^{2}C; I3C^{SM}
FSYNC Support	Yes	Yes	Yes
Memory (FIFO)	4Kbytes	2.25 Kbytes	2Kbytes
Accel Current LP Mode	68.9 µA (@102.3 Hz)	9.8 µA (@25Hz)	NA
Gyro Current LN Mode	1.23 mA (Gyro LP Mode @102.3Hz)	0.42 mA	0.73 mA
Accel Current LN Mode	68.9 µA (Accel LP Mode @102.3 Hz)	0.20 mA	0.28 mA
6-Axis Current LN Mode	3.11 mA (9-axis LN Mode)	0.55 mA	0.88 mA
Compass Specs			
Compass FSR (µT)	±4900		
Compass Sensitivity Scale Factor (µT/LSB)	±0.15		
Compass Current (µA)	90µA (@8 Hz)		

Table 1. Spec comparisons

3.2   WHY ARE OTHER PARTS NOT RECOMMENDED?

There are other TDK InvenSense IMUs, such as the ICM-20648, that are closer in package, hardware, and software. Why aren't those parts recommended?

As of 2021 there has been a global chip shortage. While many TDK InvenSense parts are not EOL, availability is an issue, and we have since moved many of those parts to NRND status including parts like the ICM-20648, which is pin-to-pin compatible with the ICM-20948.

3.3   DO I NEED A REALLY NEED A 9-AXIS IMU?

We have seen many 9-axis IMU customers who do not need or use a magnetometer at all. If this applies to you, then you can simplify your design to utilize a 6-axis IMU.

If you do not know if you need a mag, see if your application is for outdoor usage or for navigation and tracking. Customers tend to think that for an indoor application they still need a mag to remove the gyro drift issue. However, a mag's sensitivity to indoor magnetic disturbances tends to cause more inaccuracies to the data.

3.4   WHAT DISCRETE MAGS DOES TDK INVENSENSE RECOMMEND?

If your application requires a magnetometer, you will need to acquire a discrete mag. Our customers have used any of the common discrete magnetometers such as Yamaha, Honeywell, etc. In our eval kits and SW, we tend to utilize the AKM mags. We typically use the AK0991x series such as the AK09915 and AK09918. If you use our example drivers and our sensor fusion algorithms, those mags will already be supported.

We also recommend the AK09919C which is one of the latest mag from AKM. Here is the product information link

AK09919C | Electronic Compass | Products | Asahi Kasei Microdevices (AKM)

3.5   IS THERE ANOTHER SIMILAR IMU WITH DMP?

There is not another TDK InvenSense IMU that is not NRND with the same DMP features as the ICM-20948. Since TDK has moved onto the ICM-426xx series, we have transitioned from the DMP architecture to the APEX architecture. The advantage to APEX is that the firmware is pre-loaded while the DMP requires the driver to load its firmware at every power-on initialization. There are also significant power advantages with the APEX. The features of the embedded engines have also changed.

Device	ICM-20948	ICM-42670-P	ICM-42688-P
Embedded Features	DMP: 6 & 9-axis Cal/Fusion, Android M features : Pedometer, Significant Motion, Bring to See, Basic Activity Classification, Pick Up	APEX: Wake on Motion, Freefall Detection, Low-G detection, Pedometer, Tilt Detection, Significant Motion Detection	APEX: Pedometer, Tilt Detection, Tap Detection, Wake on Motion, Raise to Wake/Sleep, Significant Motion Detection

3.6   WILL I NEED TO MAKE HARDWARE/LAYOUT CHANGES?

Yes, you will need to make layout changes. The ICM-20948 (24-pin 3x3 QFN) is not pin-to-pin nor package size compatible with either the ICM-42688-P or the ICM-42670-P (14-pin 2.5x3 LGA). Therefore, you will need to make the hardware changes for the accel and gyro sensors. Here are excerpts from the datasheets:
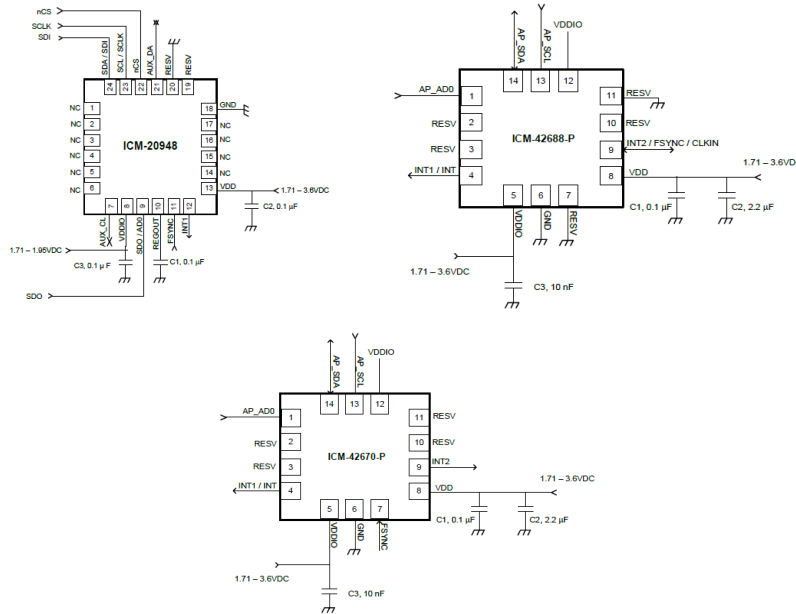
If you need to include a mag for your design, you will need to add it and connect it to the application processor.

3.7   HOW DIFFERENT IS THE SOFTWARE?

The software of the ICM-20948 is very different from the ICM-42670-P and ICM-42688-P software. In the ICM-20948, configuring and interfacing with the DMP brought a significant complexity into the driver. Because there is no DMP, sensor fusion for the ICM-426xx-P parts has been moved to an external library implementation. The ICM-20948 hardware registers are also significantly different compared to the ICM-426xx-P products. For these reasons, there is no simple way to port the ICM-20948 driver to an ICM-426xx-P part.

When transitioning from the ICM-20948 here are some items to watch out for:

1. Integrating the discrete sensor drivers – the ICM-426xx-P example drivers have the AKM recommended parts integrated but if you choose another discrete mag, your engineering teams will need to develop the driver and integrate it.

2. Sensor Fusion Library – The ICM-20948 sensor fusion to get quaternions is implemented in the on-board DMP. For the ICM-426xx-P, the sensor fusion must be done on the external processor. If you need the sensor fusion, you can implement the sensor fusion yourself or you can use the library we provide in our example driver which is compatible with Cortex M4 GCC toolchains. If you need a library compiled with another toolchain, please contact TDK technical support (e-mails above) and it will be taken on a case-by-case basis.

3.8   HOW DO I GET STARTED AFTER SELECTING A REPLACEMENT IMU?

Start with the SmartMotion DK boards and the SmartMotion eMD drivers. The DK boards are TDK InvenSense official evaluation kits and there are DK-42688-P and DK-42670-P kits available in our distribution.

https://invensense.tdk.com/products/dk-42670-p/

https://invensense.tdk.com/products/dk-42688-P/

The SmartMotion eMD drivers are example drivers that run on the DK boards using the ATMEL/Microchip Studio IDE. You can download the drivers here:

https://invensense.tdk.com/developers/software-downloads/#smartmotion

4 REVISION HISTORY

REVISION DATE	REVISION	DESCRIPTION
03/23/2022	1.0	Initial Draft
05/24/2022	1.1	Updated recommended AKM mags