MPU-65xx/MPU-92xx/ICM-206xx SFF Board

PURPOSE

This document describes the hardware and circuitry for the MPU-65xx/MPU-92xx/ICM-206xx Small Form Factor (SFF) board. This SFF board is used for evaluating the MPU-65xx/MPU-92xx/ICM-206xx 6-axis and 9-axis Motion Processing Unit (MPU) families in spaced-constraint environments or already finished applications. This document covers applying the SFF board to a larger system such as InvenSense's ARM controller board, and requires a good understanding of key signals, circuit functions, settings, and port/interface connections.

USAGE

This SFF board allows for the following products to be evaluated:

Table 1: Products Supported by this SFF

PART NUMBER	SENSOR TYPE	PACKAGE TYPE	PIN COUNT
MPU-65xx	6-axis	QFN, 3 x 3 x 0.9 mm	24
MPU-68xx	6-axis	QFN, 3 x 3x 0.9 mm	24
MPU-92xx	9-axis	QFN, 3 x 3 x 1 mm	24
ICM-206xx	6-axis	LGA, 3 x 3 x 0.9 mm* QFN, 3 x 3 x 0.75 mm	24
ICM-209xx	9-axis	LGA, 3 x 3 x 1 mm**	24

**Engineering samples only*
***Preliminary package dimensions*

RELATED DOCUMENTS

For a complete set of sensor specification and register map settings, please refer to the individual product specifications. For product specifications that are not readily available on the www.invensense.com website, please contact your local sales office for product/specification availability.

InvenSense reserves the right to change the detail specifications as may be required to permit improvements in the design of its products.

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CONTENTS

PURPOSE 1
USAGE 1
RELATED DOCUMENTS 1
MPU-65XX/MPU-92XX/ICM-206XX SFF BOARD OVERVIEW 3
MPU-65XX/MPU-92XX/ICM-206XX KEY FUNCTIONS AND PINOUT 3
MPU-65XX/MPU-92XX/ICM-206XX I^2C/SPI BUS AND POWER SUPPLY CONNECTIONS 5
BILL OF MATERIAL (BOM) 5
SCHEMATIC 6
POWER SUPPLY CONNECTIONS 6
MPU-65XX/MPU-92XX/ICM-206XX SFF BOARD CONNECTOR SIGNAL DESCRIPTION 7
CONNECTING THE FSYNC LINE 7
SERIAL BUS LEVELS, SPEEDS AND TERMINATIONS 7
DATA GATHERING OPTIONS 7
CONNECTION TO THE ARM CONTROLLER BOARD 7
USE OF MPU-65XX/MPU-92XX/ICM-206XX SFF BOARD WITHOUT THE ARM PCB 8
SPECIAL INSTRUCTIONS 8
ELECTROSTATIC DISCHARGE SENSITIVITY 8
BOARD LAYOUT AND FOOTPRINT DISCUSSION 8
REVISION HISTORY 9

MPU-65XX/MPU-92XX/ICM-206XX SFF BOARD OVERVIEW

The SFF board is populated with components only on its top side, to achieve ease of measurement/probing access. The board's small size (9.6 mm x 9.3 mm x 1.6 mm) is designed to fit into small spaces within a finalized application such as a cell phone, gaming console or other hand-held applications. It's stamp-like, plated half-hole design around the edges of the board allows for easy wiring into tight spaces and for connecting it to the InvenSense ARM controller board (EV_INVARM_D), which is a host microcontroller board useful for connecting the SFF board to a PC/laptop via a USB port.

MPU-65XX/MPU-92XX/ICM-206XX KEY FUNCTIONS AND PINOUT

The MPU-65xx/MPU-92xx/ICM-206xx SFF is fully assembled and functionally tested (Figure 1a, 1b), enabling users to quickly evaluate the sensor's gyroscope and accelerometer (and compass for MPU-92xx). The MPU-65xx/MPU-92xx/ICM-206xx allows communicating via the I^2C or SPI interface.

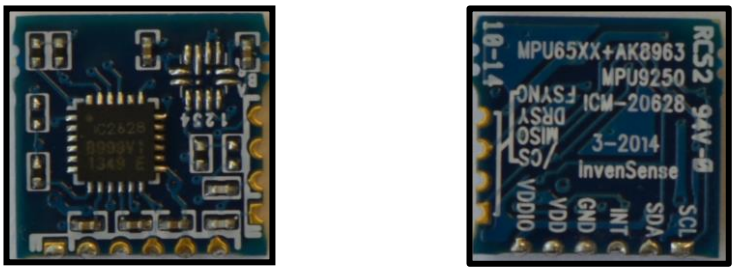

Figure 1a & Figure 1b. Top & Bottom Side of the MPU-65xx/MPU-92xx/ICM-206xx SFF Board

Note that the SFF board also offers a footprint for an external compass from AKM. The AK8963C may be installed and communicated with through the auxiliary I^2C bus. See instructions in the Bill of Material (BOM) for the installation of the proper external passive components to enable the compass via the auxiliary serial interface (Table 2).

The MPU-65xx/ICM-206xx 6-axis MEMS gyroscope and accelerometer and MPU-92xx gyroscope, accelerometer and compass sensors integrate all required conditioning electronics into a single chip measuring 3mm x 3mm x 0.9mm (3 mm x 3 mm x 1 mm for MPU-92XX) and are available in QFN (MPU-65xx, MPU-92xx) or LGA* packages (ICM-206xx). See Figure 1c for pinout and axis orientation of these sensors. For exact outline, pin pad and package dimension, refer to the respective product specification documentation.

The MPU-65xx/MPU-92xx/ICM-206xx SFF is lead-free and RoHS compliant.

*Engineering samples only

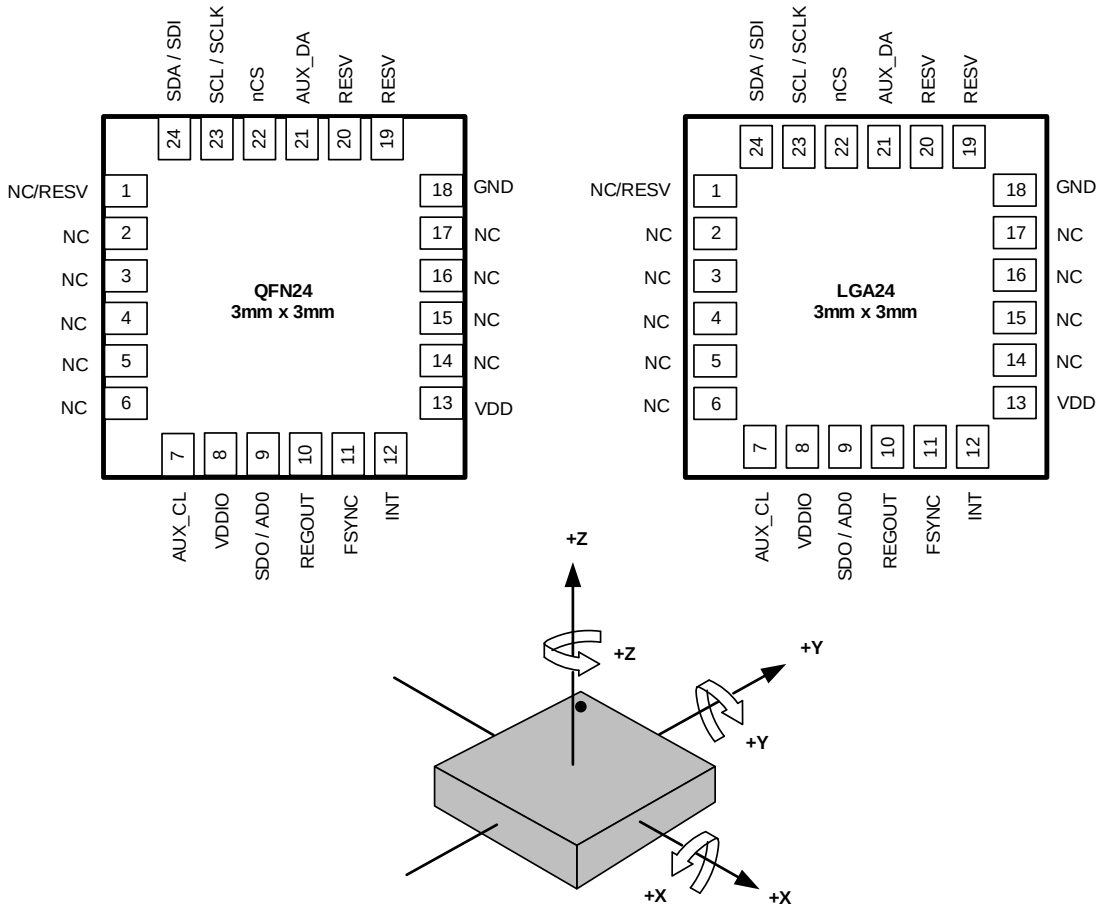

Figure 1c: Pinout & Orientation of the MPU-65xx/MPU-92xx/ICM-206xx Sensors

MPU-65XX/MPU-92XX/ICM-206XX I²C/SPI BUS AND POWER SUPPLY CONNECTIONS

The MPU-65xx/MPU-92xx/ICM-206xx SFF board communicates with a system processor through custom headers in the shape of the outer edges of a stamp. The header holes are plated and cut in half so, a user can easily add wires to the plated half-holes (Figure 2, Figure 4) and connect the SFF board directly into their application via I²C (CN21) or SPI (CN20) serial interface. The device always acts as a slave when communicating with the system processor/controller.

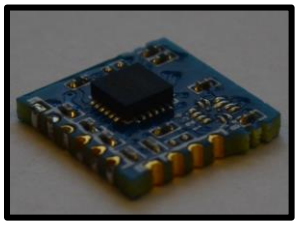

Figure 2. I²C/SPI Plated Half-Hole Wiring Interface for the MPU-65xx/MPU-92xx/ICM-206xx SFF Board

For I²C communications, the SFF must be connected to the application/microcontroller through SCL, SDA and INT (CN21, see Table 3 for signal descriptions/positions). To establish a common power between the SFF/sensor and the user application or microcontroller board in I²C mode, GND, VDD and VDDIO lines must be connected as well.

For SPI communications, the SFF must be connected to SCLK, SDO, SDI and /CS (CN20, see Table 3 for signal description/position). To establish a common power between the SFF/sensor and the user application or microcontroller board in SPI mode, GND, VDD and VDDIO (CN21, see Table 3 for signal descriptions/positions) lines must be connected as well.

BILL OF MATERIAL (BOM)

Table 2. Bill of Material (Component Selection)

Item	Quantity	Reference	Part	PCB Footprint
1	4	BP20, BP21, BP22, BP23, BP24	0.1 µF	C0402
2	1	CN21	6-Pin Header (I²C Connector)	
3	1	CN20	4-Pin Header (SPI Connector)	
4	4	R26, R42, R43, R45	10 kΩ	R0402
5	4	R27, R28, R40, R41	0 Ω (install for external compass communications)	R0402
6	1	U21	MPU-65xx/MPU-92xx/ICM-206xx	QFN-24 LGA-24 (ICM-206xx engineering samples only)
7	1	U20	AK8963C (optional; install in combination with 6-axis sensors)	BGA-14

SCHEMATIC

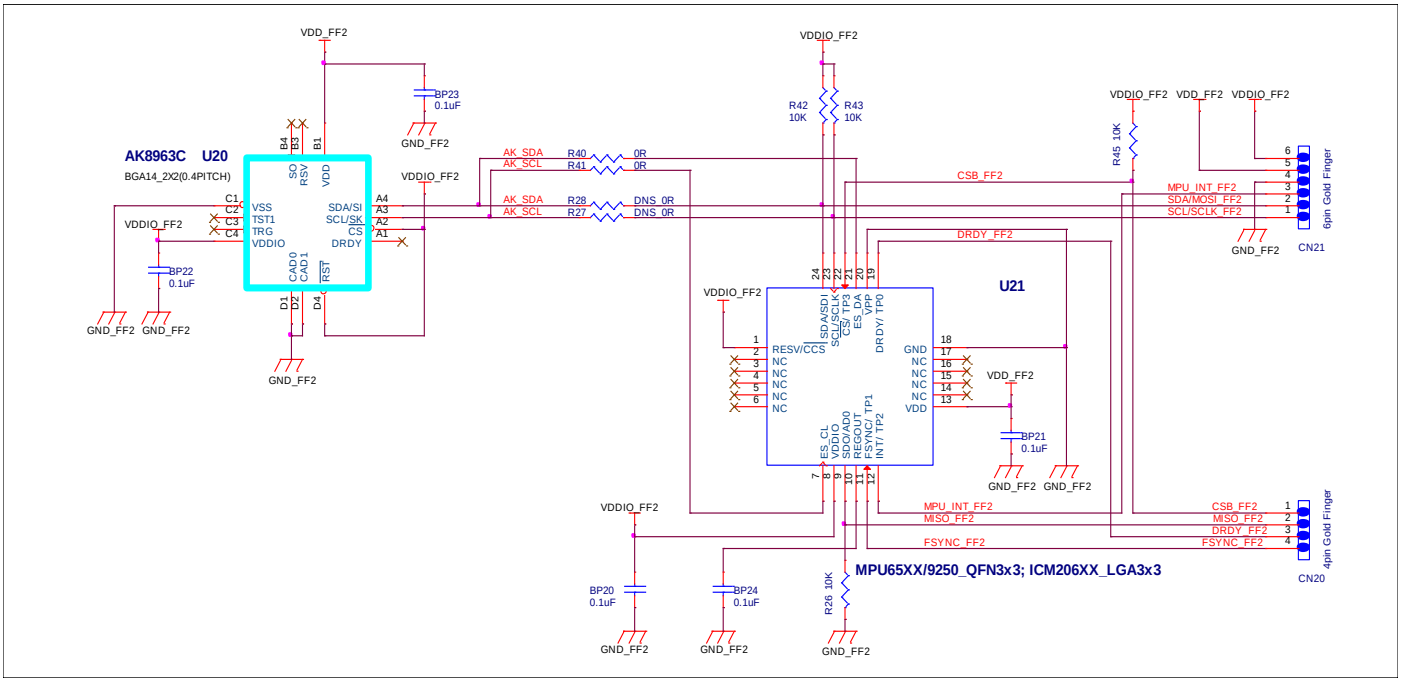

Figure 3. MPU-65xx/MPU-92XX/ICM-206xx SFF Board Schematic

POWER SUPPLY CONNECTIONS

Power connections to the MPU-65xx/MPU-92xx/ICM-206xx and the external compass are established through pins 5 and 6 on connector CN21 (Table 3). This connection supplies the needed core voltages (VDD and VDDIO) for the 6-axis gyroscope/accelerometer MPU-65xx/ICM-206xx (+ external compass AK8963C, which is optional) and for the 9-axis gyroscope/accelerometer/compass MPU-92xx.

MPU-65XX/MPU-92XX/ICM-206XX SFF BOARD CONNECTOR SIGNAL DESCRIPTION

Table 3. I²C/SPI Bus Connections

CN21 (6-Pin)	CN20 (4-Pin)	Signal Name	Signal Description
1		SCL_SCLK_FF2	SCL/SCLK – MPU-65xx/MPU-92xx/ICM-206xx I²C or SPI clock
2		SDA/MOSI_FF2	SDA/MOSI – MPU-65xx/MPU-92xx/ICM-206xx I²C SDA or SPI MOSI signal
3		MPU_INT_FF2	INT – MPU-65xx/MPU-92xx/ICM-206xx interrupt output to controller
4		GND_FF2	GND – MPU-65xx/MPU-92xx/ICM-206xx board ground. This connection must be established for both I²C or SPI on CN20.
5		VDD_FF2	Power – MPU-65xx/MPU-92xx/ICM-206xx core supply. Receive power from the ARM controller board or an external source. 3V @ > 200mA current sourcing capabilities recommended. This supply connection must be established for both I²C or SPI on CN20.
6		VDDIO_FF2	Digital/Bus Power - MPU-65xx/MPU-92xx/ICM-206xx digital/bus supply. Receive power from the ARM controller board or an external source. 3V @ > 200mA current sourcing capabilities recommended. This supply connection must be established for both I2C or SPI on CN20.
	1	CSB_FF2	Chip Select – MPU-65xx/MPU-92xx/ICM-206xx SPI chip select (nCS)
	2	MISO_FF2	AD0/MISO – MPU-65xx/MPU-92xx/ICM-206xx I²C lowest address bit or SPI MISO signal
	3	RESV	Reserved Signal – connect to ground
	4	FSYNC_FF2	FSYNC - Frame synchronization digital input (if not used, this pin may be connected to ground.)

CONNECTING THE FSYNC LINE

The FSYNC line is intended for use with image synchronization tasks (e.g. OIS applications). In this case the FSYNC line can be utilized by the host to generate an interrupt to allow precise timing to be achieved with Video Frame Sync at the host level for read out of the frame data. If unused, the FSYNC line should be connected to ground.

SERIAL BUS LEVELS, SPEEDS AND TERMINATIONS

The MPU-65xx/MPU-92xx/ICM-206xx supports I²C communications up to 400 kHz or SPI communications up to 1MHz serial clock rates. Refer to the individual sensor chip's product specifications for details on write/read rates for the serial interface. The I²C bus open-drain pull-up resistors are connected to 3V or an external provided supply voltage (VDD).

DATA GATHERING OPTIONS

The MPU-65xx/MPU-92xx/ICM-206xx's digital sensor data is available on the SFF boards' plated, half-hole (for easy wiring to an external controller/processor board) header CN21 (I²C) or CN20 (SPI). Alternatively, for connectivity with a host PC, an InvenSense ARM controller board may be used.

CONNECTION TO THE ARM CONTROLLER BOARD

For communications via the USB port of a host computer or laptop, the MPU-65xx/MPU-92xx/ICM-206xx SFF board can be connected to the InvenSense ARM controller board (EV_INVARM_D). InvenSense's Universal Data Logger (UDL) software allows users to quickly capture data from an SFF-ARM board combination. This software tool can be downloaded by registered users from the InvenSense website (Developer's Corner). The downloadable file contains software and a user application note guiding the user through the setup and operation of the UDL. Note that due to USB limitations the MPU-65xx/MPU-92xx/ICM-206xx SFF board in combination with the ARM controller board will not allow ODR speeds greater than 1ksps. It is therefore recommended to run an SFF-ARM board combination setup at speeds of ≤1ksps and with the individual sensor's recommended DLPF settings.

Figure 4 shows the connectivity of the MPU-65xx/MPU-92xx/ICM-206xx SFF board to the ARM controller board. Connections between the two boards are made via "blue-wiring" between headers CN21 and/or CN20 (I²C/SPI) on the MPU-65xx/MPU-92xx/ICM-206xx SFF board and connector JP6 on the EV_INVARM_D controller board.

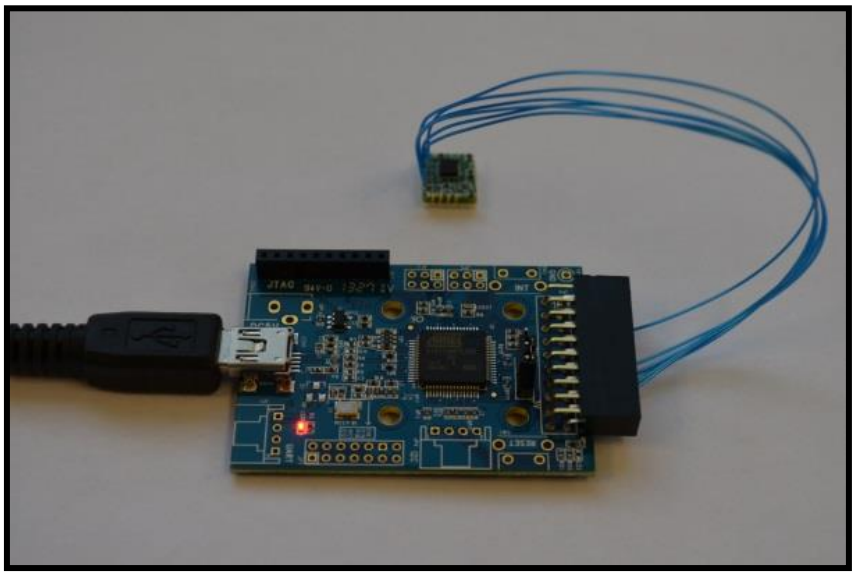

Figure 4. MPU-65xx/MPU-92xx/ICM-206xx SFF Board Connected to the ARM Controller Board

USE OF MPU-65XX/MPU-92XX/ICM-206XX SFF BOARD WITHOUT THE ARM PCB

I²C and SPI signals are easily accessible and made available on plated, half-hole headers CN20 and CN21 (Figure 1a, 1b and 2). Users may develop their own tools to communicate with the MPU-65xx/MPU-92xx/ICM-206xx as there is no bus mode selection setting required.

SPECIAL INSTRUCTIONS

ELECTROSTATIC DISCHARGE SENSITIVITY

The MPU-65xx/MPU-92xx/ICM-206xx sensors can be permanently damaged by electrostatic discharge (ESD). Proper ESD precautions for handling and storage must be taken to avoid damage to the sensors.

BOARD LAYOUT AND FOOTPRINT DISCUSSION

The MPU-65xx/MPU-92xx/ICM-206xx SFF board is a 4-layer FR-4 PCB design measuring 9.6 mm x 9.3 mm x 1.6 mm (366 mil x 379 mil x 64 mil). Figures 5a, 5b and 5c depict the MPU-65xx/MPU-92xx/ICM-206xx SFF's top/bottom silkscreens and the component placement map.

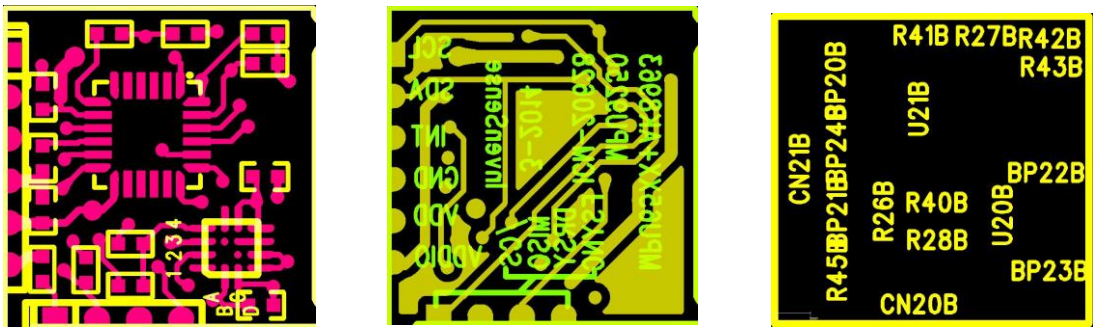

Figure 5a, 5b, 5c: Top Layer/Silkscreen & Bottom Layer/Silkscreen and Component Placement Map of the MPU-65xx/MPU-92xx/ICM-206xx SFF Board

The MPU footprint on the SFF supports both QFN and LGA packages. PCB footprints and sensor land patterns were chosen large enough to offer ***ease of use, provide reliable contact with the sensor package pin pads, support hand-solder and debugging capabilities*** for both packages.

The individual PCB land pattern shapes for both QFN and LGA footprints in this design are still rectangular, but corner pins have been adjusted with an approximate 45-degree angle (inside corners of the pin pads have been clipped) to allow for enough clearance (~5mil) between corner pads. This approach will avoid shorting in the corner areas during reflow soldering while at the same time maintaining a maximum connectivity area between package pin pad and LGA/QFN PCB footprint. The dimensions for the PCB footprint pads are 0.82 mm x 0.25 mm (32.3 mil x 9.8 mil). Figures 6a and 6b depict the connectivity area that both QFN and LGA packages will cover once a sensor is soldered onto the board. Package outlines for LGA (Figure 6a) and QFN (Figure 6b) are highlighted in yellow while the PCB footprint outlines are shown in blue.

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 clearances between pin pads (usually 4 mil to 6 mil or 0.102 mm to 0.152 mm), corner pins and traces allowing for sufficient space to print an adequate solder mask.

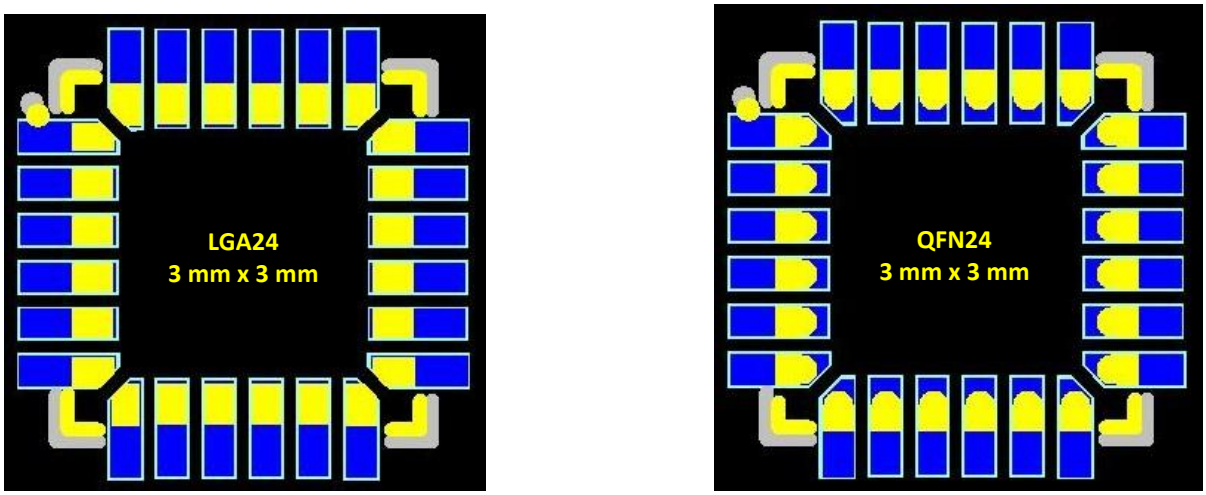

Figure 6a & 6b: LGA vs. QFN Footprint/Package Overlay Details

REVISION HISTORY

REVISION DATE	REVISION	DESCRIPTION
2/14/2014	1.0	Initial Release

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