JF2 and JN3 MEMS Sensor Application Note

80000NT10074A Rev.2 2012-09-19

Making machines talk.

APPLICABILITY TABLE

PRODUCT
JF2
JN3

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

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Contents

1. Introduction

1.1. Scope

Scope of this document is to give an overview of

- The MEMS sensor related features within the SiRFStarIV based JF2 and JN3
- How these features operate in different environments

1.2. Audience

This document is intended for Designers implementing MEMS into their SiRFStarIV based GPS system.

1.3. Contact Information, Support

For general contact, technical support, to report documentation errors and to order manuals, contact Telit Technical Support Center (TTSC) at:

TS-EMEA@telit.com
TS-NORTHAMERICA@telit.com
TS-LATINAMERICA@telit.com
TS-APAC@telit.com

Alternatively, use:

http://www.telit.com/en/products/technical-support-center/contact.php

For detailed information about where you can buy the Telit modules or for recommendations on accessories and components visit:

http://www.telit.com

To register for product news and announcements or for product questions contact Telit Technical Support Center (TTSC).

Our aim is to make this guide as helpful as possible. Keep us informed of your comments and suggestions for improvements.

Telit appreciates feedback from the users of our information.

1.4. Document Organization

This document contains the following chapters :

"Chapter 1: "Introduction" provides a scope for this document, target audience, contact and support information, and text conventions.

"Chapter 2: "MEMS Overview" gives an overview of the MEMS in Jupiter series.

"Chapter 3: "MEMS System Architecture" describes in details the characteristics of MEMS in Jupiter JF2/JN3 series.

"Chapter 4: "Supported MEMS devices" details the supported/suggested MEMS for Jupiter JF2/JN3 series integration.

"Chapter 5: "MEMS Static Detection vs Static Navigation (position Pinning)" details the difference between Static NAV vs Static Detection..

"Chapter 6: "MEMS Senson OSP Messages" provides details about OSP messages dedicated to MEMS feature..

"Chapter 7: "Reference Design" provides reference design for MEMS integration with JN3/JF2.

1.5. Text Conventions

Danger – This information MUST be followed or catastrophic equipment failure or bodily injury may occur.

Caution or Warning – Alerts the user to important points about integrating the module, if these points are not followed, the module and end user equipment may fail or malfunction.

Tip or Information – Provides advice and suggestions that may be useful when integrating the module.

All dates are in ISO 8601 format, i.e. YYYY-MM-DD.

1.6. Related Documents

- Telit Jupiter JF2 Product Description
- Telit Jupiter JN3 Product Description

2. MEMS Overview

The JF2 and the JN3 modules have fully integrated GPS navigation engines that perform:

- signal acquisition
- tracking
- measurement
- navigation computation

In addition to autonomous GPS functionality, ephemeris assisted GPS, and low-power features, the JF2 and JN3 supports interfaces to other sensors. *Micro-Electro-Mechanical Systems* devices, or MEMS, include accelerometers, gyroscopes, and magnetometers that provide additional capabilities and supplement the GPS data.

3. MEMS System Architecture

The MEMS system architecture for the SiRFStarIV platform uses the concept of a MEMS Gateway. This means that the MEMS sensors are connected to the JF2 or JN3 via a high-speed I2C serial peripheral interface and the sensor data is sampled at a very high rate up to 100Hz. The I2C serial interface can operate at a maximum speed of 400kbps.

The JF2 or JN3 acts as the I2C master and the sensor devices function in Slave mode. This provides a very low latency data pipe for the critical sensor data.

The sensor data can be output to other subsystems in the platform and/or the host processor over the host serial interface and no information is lost.

4. Supported MEMS Devices

The following table lists the MEMS devices currently supported.

Device Type	Manufacturer	Part Number
3-axis accelerometer	Kionix	KXTF9
3-axis accelerometer	Freescale	MMA 8450Q
3-axis magnetometer	Aichi	AMI304
3-axis gyro	ST	L3G4200D

Table 1 Supported MEMS Devices

Note that the MEMS implementation is suitable only for full power applications and does not support the low power modes due to the polling nature of the DR I2C interface.

5. MEMS Static Detection vs Static Navigation (Position Pinning)

The software incorporates a feature referred to as Static Detection that uses the accelerometer data to constrain position drifts and wander during stationary periods of operation.

Previous modules based on SiRFstarIIITM supported a feature referred to as Static Navigation (or Position Pinning) which served a similar purpose but operated under a different algorithm. The SiRFstarIVTM based modules support both Static Navigation and Static Detection.

In Static Navigation, the position output is artificially clamped at the last known value when the receiver velocity falls below a certain threshold (<1.5m/s) for several consecutive seconds. Likewise, the system does not exit the Static Navigation state unless the velocity exceeded a threshold for several consecutive seconds, or if the instantaneous velocity exceeded a much larger threshold. The Static Navigation state is also exited if the position change exceeds a threshold of 40 meters.

With the Static Navigation method, the accuracy of the velocity (speed and heading) measurement is a function of the actual true velocity of the device. This means the measurements made at low velocity settings are much less accurate than measurements made at higher velocities. The measurement accuracy is also a function of signal level. Speed and heading accuracy degrades as signal level decreases.

The MEMS Static Detection has a different algorithm for constraining the position wander during stationary periods. Static Detection uses the measured data from the 3-axis accelerometer to determine if the receiver is stationary. The software compares the computed velocity to a software-defined threshold, and if the velocity is below the threshold, the Static Detection feature is invoked. This is an improvement over the earlier Static Navigation method because the accuracy of the accelerometer data is not a function of the dynamics of the receiver or the signal level of the GPS satellites. The ability to sense and react to stationary conditions is therefore completely independent and decoupled from the GPS measurements themselves.

6. MEMS Sensor OSP Messages

The table below lists the OSP messages that configure, enable/disable and report the MEMS sensor data.

OSP Message	I/O	Message ID, Sub-ID
Sensor Configuration	Input	234, 1
Sensor Switch	Input	234, 2
Sensor Data Message	Output	72, 1
Receiver State Message	Output	72, 3

Table 2 MEMS Sensor OSP Messages

6.1. Accelerometer

The following example messages are meant for the KXTF9 with the following settings:

- Data Resolution: 12 bits
- Sample Rate (06): 50Hz
- Send Rate (03): 5Hz
- Decimation Method: Raw

6.1.1. Configuration

```
EA 01 01 02 00 0F 01 00 CD 06 03 00 20 01 01 43 06 1B 00 80 02 1B 01 1D 01 02 20
1B C0 1D 4D 01 00 00 04 00
```

Sensors Configuration (ALL VALUES MUST BE IN HEXT FORMAT)	
0x01	Number of sensors: 1
0x02	I2C bus speed: Fast
Configuration for Sensor #2 (KXTF9)	
0x000F	Sensor I2C Address (7 or 10 bit)

0x01	Sensor Type: Accelerometer
0x00	Initialization period after power up for Sensor, unit: 10ms
0xCD	Read Register Description for Sensor 1: Signed 2’s complement data, 6 bytes to read (3 sensor axes), data resolution of 12
0x06	Sample rate: 50Hz
0x03	Send Rate: 5Hz
0x00	Data decimation method (bits 0-2): Raw
0x20	Acquisition time delay, unit: 10µs
0x01	Number of sensor read registers
0x01	Measurement State: Forced (SW controlling)
0x043, 0x06	Read Register #1: (Read Operation, Register Address) Read Operation Bit Definition: Bit7 ~ Bit4: Number of Right Shift before sending to host Bit3 ~ Bit2: Reserved Bit1: Endian, 0 = big, 1 = little Bit0: Read mode, 0 = read only, 1 = write with repeated start read
0x1B	Address of the Register to controls the sensor power states
0x00	Setting for Stand-by (OFF) mode
0x80	Setting for Operating (ON) mode
0x02	Number of Initialization Registers to be read
0x1B, 0x01	Init Read Register #1: (Register Address, Number of Bytes)
0x1D, 0x01	Init Read Register #2: (Register Address, Number of Bytes)
0x02	Number of sensor control registers
0x20	Time delay between two consecutive register writes, unit: ms
0x1B, 0xC0	CTRL_REG1: (Register Address, Value) OpMode, Resolution 12bit
0x1D, 0x4D	CTRL_REG3: (Register Address, Value) Default

0x01	Sensor Data Processing Rate
0x00	Sensor #2 Zero Point Value
0x400	Sensor #2 Scale Factor (sensitivity)

NOTE: Start Sequence, Payload, Checksum, and End Sequence needs to be added to the message.

6.1.2. Enable Message

To enable the sensors, the sensor enable message:

- EA 02 03

This command turns both the sensor set and the receiver state change notification on.

NOTE: Start Sequence, Payload, Checksum, and End Sequence needs to be added to the message.

7. Reference Design

7.1. Accelerometer

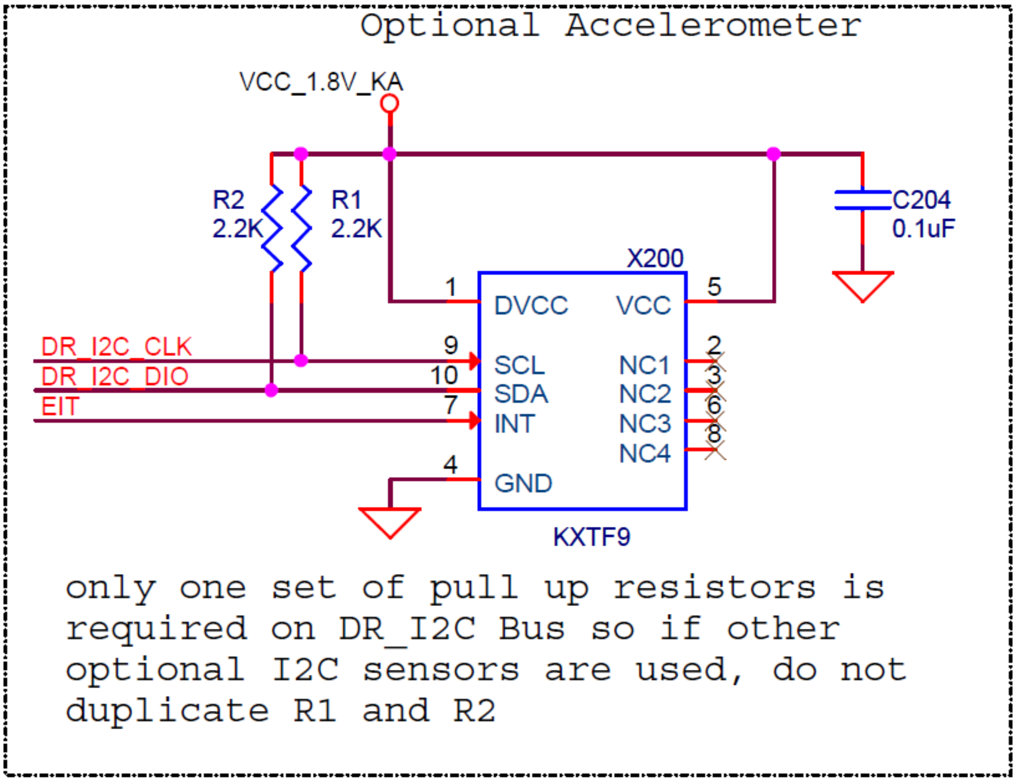

Figure 1 Accelerometer Reference Design

7.1.1. JF2 Connections

DR_I2C_CLK – Pin 29 (GPIO1)
DR_I2C_DIO- Pin 30 (GPIO0)
EIT/GPIO4 – Pin 15 (GPIO4)

7.1.2. JN3 Rev L Connections

DR_I2C_CLK – Pin 19
DR_I2C_DATA – Pin 18
EIT – Pin 4 (EXT_INT)

7.2. Magnetometer

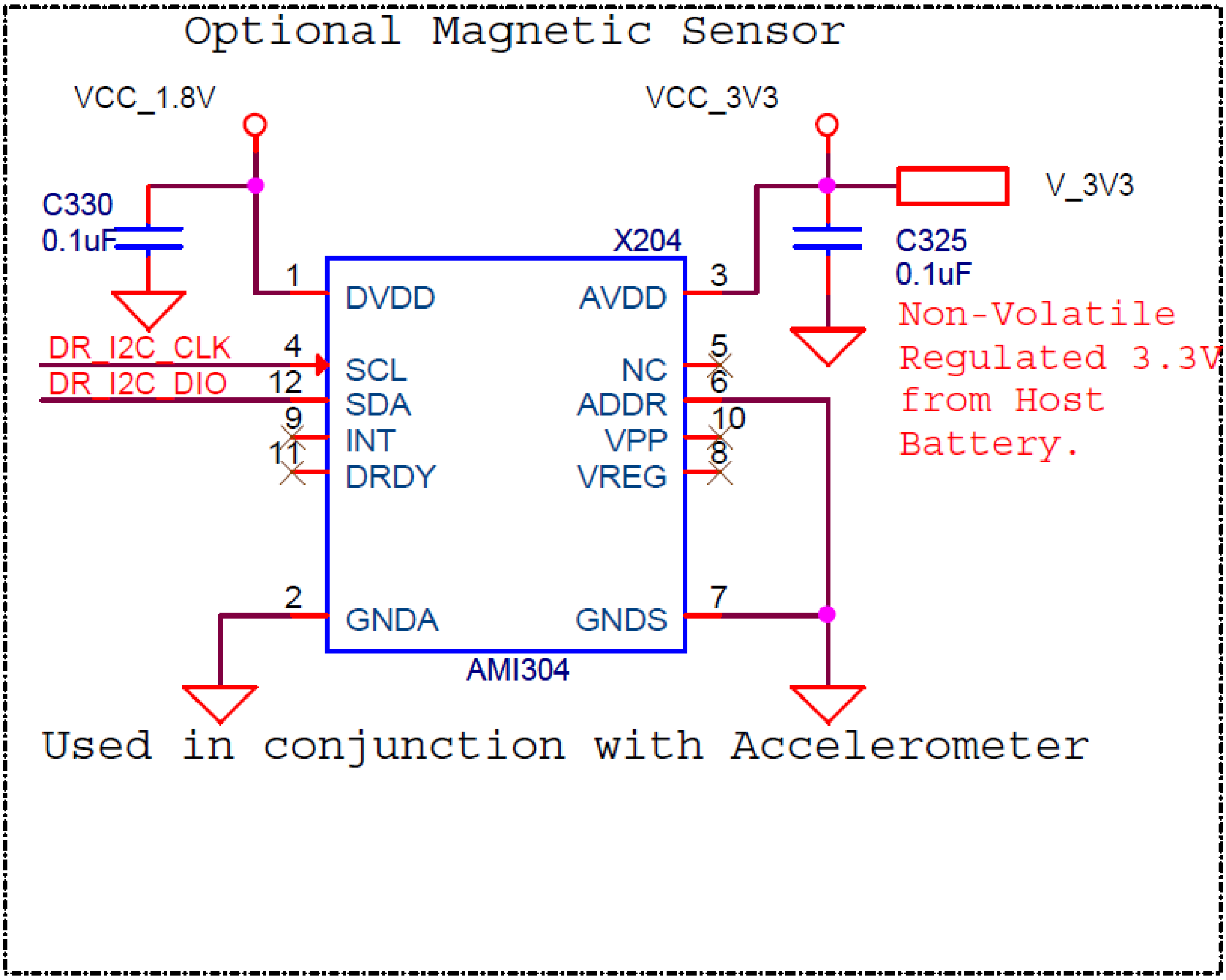

Figure 2 Magnetic Sensor Reference Design

7.2.1. JF2 Connections

DR_I2C_CLK – Pin 29 (GPIO1)
DR_I2C_DIO- Pin 30 (GPIO0)

7.2.2. JN3 Rev L Connections

DR_I2C_CLK – Pin 19
DR_I2C_DATA – Pin 18

7.3. Optional Pressure Sensor

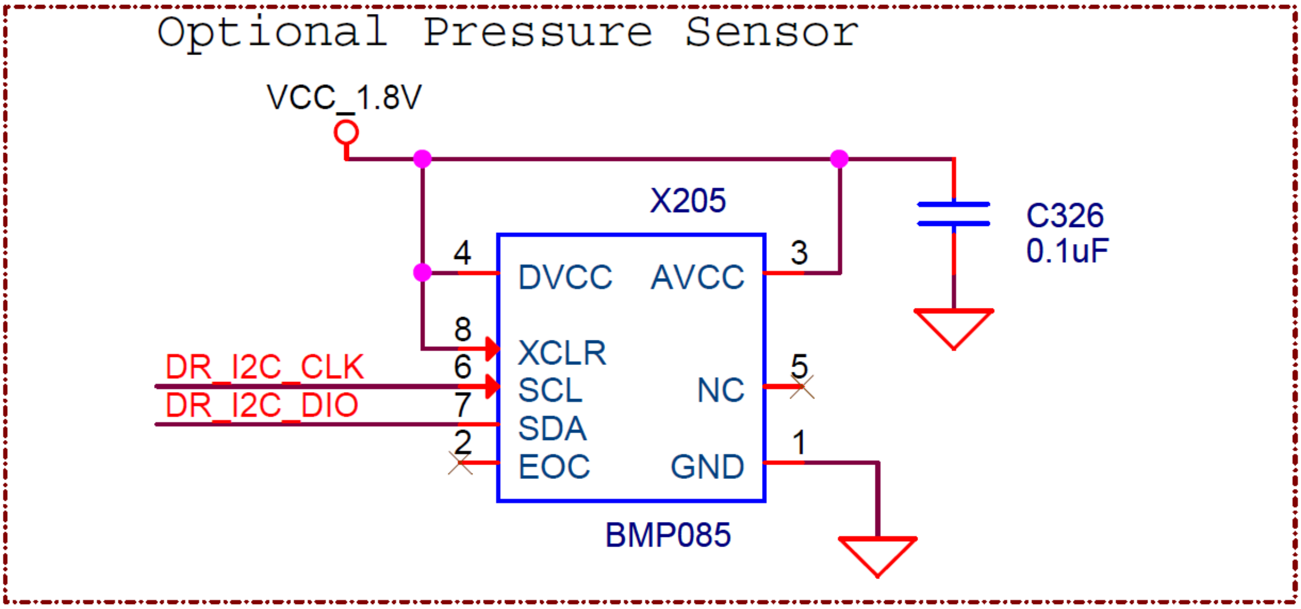

Figure 3 Pressure Sensor Reference Design

7.3.1. JF2 Connections

DR_I2C_CLK – Pin 29 (GPIO1)
DR_I2C_DIO- Pin 30 (GPIO0)

7.3.2. JN3 Rev L Connections

DR_I2C_CLK – Pin 19
DR_I2C_DATA – Pin 18

7.4. Optional Gyroscope

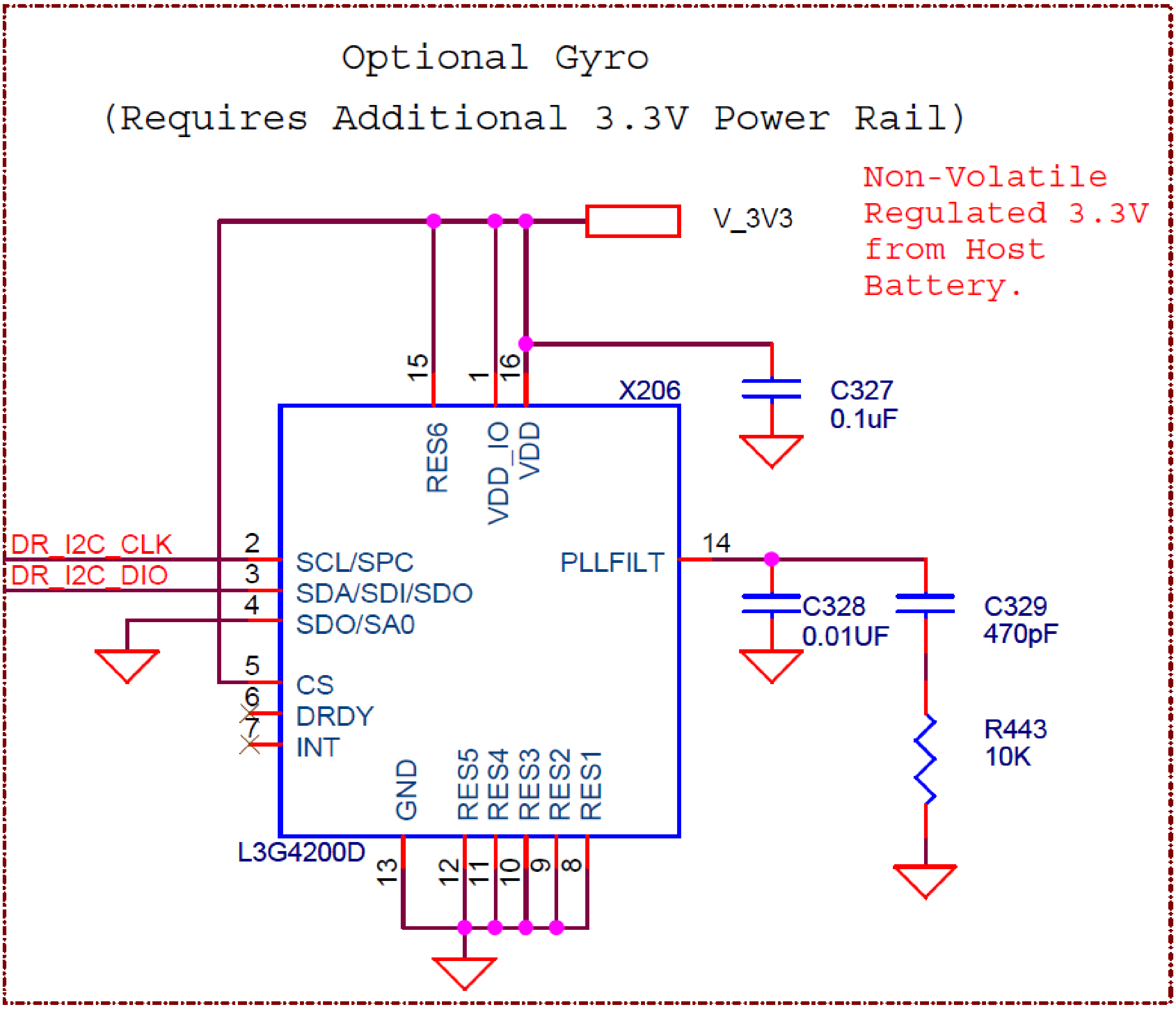

Figure 4 Reference Design Gyroscope

7.4.1. JF2 Connections

DR_I2C_CLK – Pin 29 (GPIO1)
DR_I2C_DIO- Pin 30 (GPIO0)

7.4.2. JN3 Rev L Connections

DR_I2C_CLK – Pin 19
DR_I2C_DATA – Pin 18

8. Document History

Revision	Date	Changes
0	2012-08-08	First issue
1	2012-08-15	Updated 6.1.1 table
2	2012-09-19	Added Pressure Sensor and Gyro reference design