Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of "Quality Parts,Customers Priority,Honest Operation,and Considerate Service",our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

User Guide for
FIS1100 Evaluation Kit

(FEBFIS1100MEMS_IMU6D3X)

6D Inertial Measurement Unit with Motion Co-Processor and Sensor Fusion Library

Featured Fairchild Products:
FIS1100, FAN2558, FXL4TD245, FXMA2102

For technical support, please contact Fairchild Semiconductor
or your local sales team Fairchild Sales Offices

Table of Contents

1. Introduction

This user guide supports the evaluation kit for the FIS1100. The FIS1100 evaluation kit is designed to support your evaluation of the system performance, accuracy and features using the easy to use MT Manager Windows GUI application, as well as to support your hardware integration and embedded software integration efforts using the extensive FIS1100 SDK.

The FIS1100 evaluation kit should be used in conjunction with the FIS1100 datasheets as well as Fairchild's application notes and technical support team. Please visit Fairchild's website at www.fairchildsemi.com.

This document describes the evaluation system for the FIS1100 in combination with the XKF3 sensor fusion library, reference drivers for the FIS1100 (source code) and an example sensor fusion project for ARM Cortex-M microcontrollers. The document contains general information to help the user get started with evaluating the solution, install the FIS1100 SDK and includes an introduction to the MT Manager software, and demonstrates the advantage of the FIS1100 AttitudeEngine^{TM} for building accurate low power 3D motion tracking solutions.

1.1. Description

The FIS1100 is the world's first complete consumer 6D MEMS Inertial Measurement Unit (IMU) with sensor fusion to specify system level orientation accuracy. When using the FIS1100 in combination with the supplied XKF3 9D sensor fusion, the system features an accurate ±3º pitch and roll orientation, and a ±5º yaw/heading typical specification.

The FIS1100 incorporates a 3-axis Gyroscope and a 3-axis Accelerometer and can connect an external 3-axis magnetometer through an I²C master thus forming a complete 9DOF system.

The FIS1100 also incorporates an advanced vector Digital Signal Processor (DSP) motion co-processor called the AttitudeEngine. The AttitudeEngine efficiently encodes high frequency motion at high internal sampling rates, preserving full accuracy across any output data rate.

This enables the application to utilize low Output Data Rates (ODR) or on-demand (host polling) and still acquire accurate 3D motion data. The AttitudeEngine allows reducing the data processing and interrupt load on a host processor with no compromises in 3D motion tracking accuracy. The result is very low total system power in combination with high accuracy, which are essential to many portable and battery powered applications.

The XKF3 sensor fusion library for ARM Cortex-M provides a robust sensor fusion solution based on Xsens' more than 15 years of experience in the industrial and human movement motion tracking fields. The XKF3 sensor fusion algorithm is optimized for use with the FIS1100 AttitudeEngine to provide high accuracy orientation and high-pass 3D velocity outputs at very low processor utilization.

1.2. Features

- FIS1100 6D Inertial Measurement Unit
  - World's First Complete Consumer Inertial Measurement Unit (IMU) with Sensor Fusion Library to Specify Orientation Accuracy: ±3º Pitch and Roll, ±5º Yaw/Heading
  - 3-Axis Gyroscope and 3-Axis Accelerometer in a Small 3.3 x 3.3 x 1 mm LGA Package
  - Integrated AttitudeEngine Motion Co-processor with Vector DSP Performs Sensor Fusion at 1 kHz Sampling Rate, while Outputting Data to Host Processor at a Lower Rate – Improving Accuracy while Reducing Processor MIPS, Power, and Interrupt Requirements
  - Complete System Solution for 3D Motion Tracking, Optimized 9D Sensor Fusion Library (XKF3) Featuring in-use Auto-Calibration Enabling Accurate 3D Orientation (quaternion) and High-Pass 3D Velocity Motion Tracking
  - Large 1536 Byte FIFO can be used to Buffer 9DOF Sensor Data to Lower System Power Dissipation
  - New Motion on Demand Technology for Polling Based Synchronization
  - Large Dynamic Range from ±32 dps to ±2,560 dps and ±2 g to ±8 g
  - Low Latency, High-Resolution OIS Mode
  - Low Noise 50 µg/√Hz Accelerometer and 10 mdps/√Hz Gyroscope
  - Low Power and Warm-Start Modes for Effective Power Management
  - Digitally Programmable Sampling Rate and Filters
  - Host Serial Interface Supporting I^2C or SPI
  - I^2C Master for Interfacing External Magnetometer
  - Embedded Temperature Sensor
  - Wide Extended Operating Temperature Range (-40°C to 85°C)
- XKF3 9D Sensor Fusion Library
  - Continuous Sensor Auto Calibration, No User Interaction Required
  - Real-Time, Low-Latency Optimal estimate of 3D Orientation
  - Best-in-Class Immunity to Magnetic Distortions
  - Best-in-Class Immunity to Transient Accelerations
  - Flexible use Scenarios, North Referenced, Unreferenced
  - Extensive Status Reporting for Smooth Integration in Applications
  - Optimized Library for Popular Microcontrollers

1.3. Applications

- Sport & Fitness Tracking
- Wearable and Health Monitoring
- Pedestrian Navigation
- Light Industrial, Robotics and Autonomous Machines
- Natural User Interfaces, Gaming, VR/AR
- GNSS Augmentation and Dead Reckoning
- Optical Video and Image Stabilization
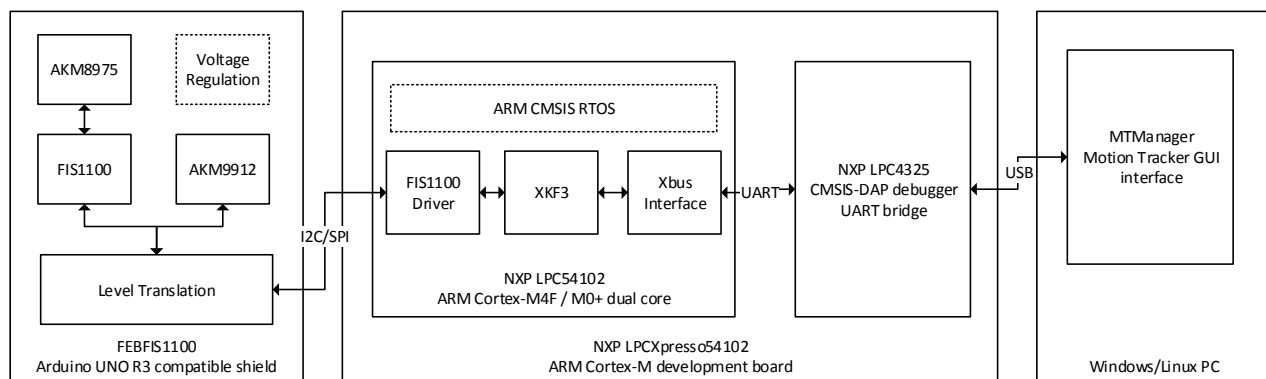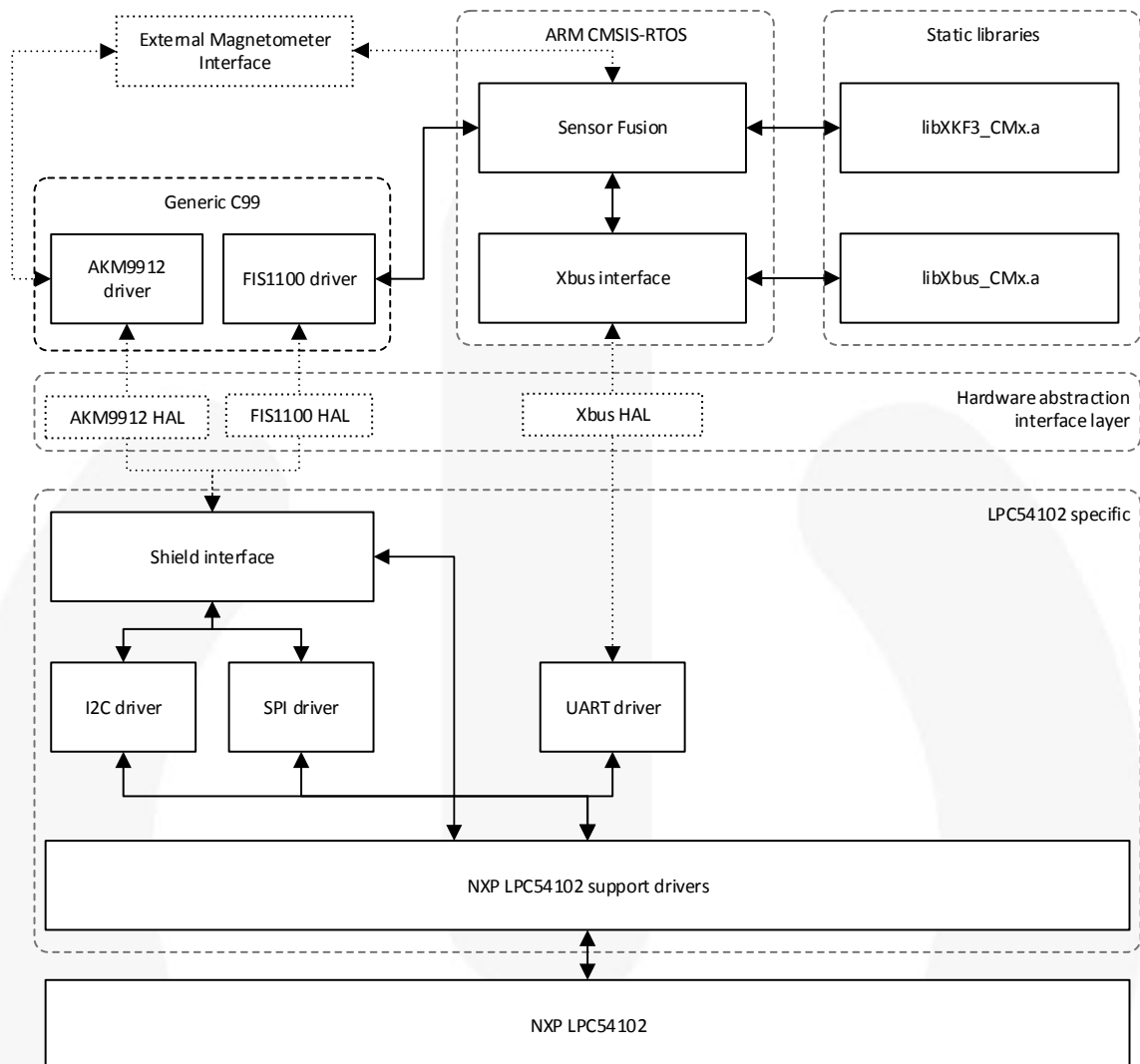
1.4. Evaluation Board Block Diagram

Figure 1. FEBFIS1100MEMS_IMU6D3X Block Diagram

Figure 2. Firmware Component Overview

2.   Evaluation Board Specifications

Table 1. FEBFIS1100MEMS_IMU6D3X Arduino Uno-R3 Shield Electrical Specifications

Description	Symbol	Min	Nominal	Max	Comments
Input Voltage	VIN	3.1 V	3.3 V, 5 V	5.5 V	Choice of voltage input pin controlled by placement of R100 or R101 0-Ohm resistors
IO Reference voltage	IOREF	1.65 V		3.65 V	
Voltage on any other pin		GND		IOREF	

Table 2. FEBFIS1100MEMS_IMU6D3X System Level 3D Orientation Accuracy Specifications

| Subsystem	Parameter	Typical	Unit	Comments
FIS1100+XKF3 quaternion	Roll	±3	deg	Requires use of XKF3 software library on host processor.
	Pitch	±3	deg	Requires use of XKF3 software library on host processor.
	Yaw (Heading) Referenced to North	±5	deg	Requires use of XKF3 software library on host processor, using magnetometer, in a homogenous Earth magnetic field.
	Yaw (Heading) Unreferenced	5-25	deg/h	From Allan Variance bias instability. Does not require a magnetometer. *(See spec above for use with magnetometer.)* Fully immune to magnetic distortions.
FIS1100+XKF3 quaternion	Output Data Rate	8 - 1000	Hz	To benefit from the power saving using the AttitudeEngine, use a max ODR of 64 Hz.

3. Photographs
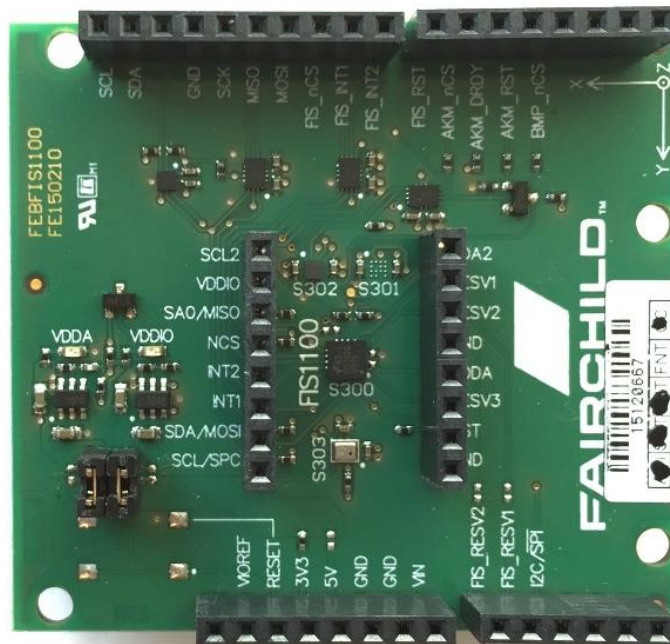
Figure 3.   FEBFIS1100MEMS_IMU6D3X Shield Board (Arduino UNO R3 Compatible)

Figure 4.   FEBFIS1100MEMS_IMU6D3X Shield Board Mounted on NXP LPCXpresso54102 MCU Evaluation Board

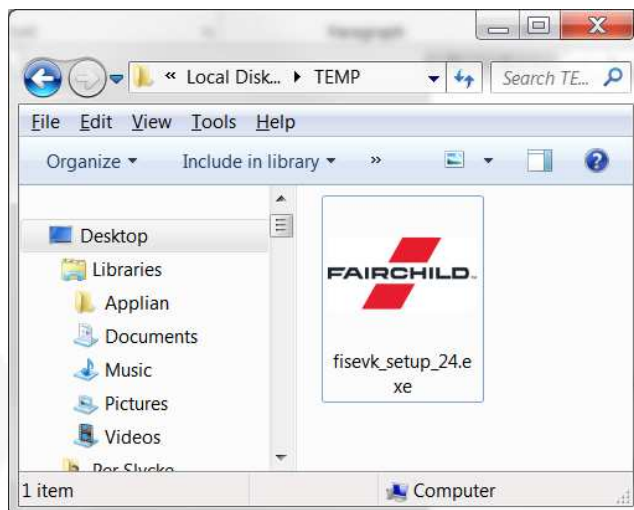# 4. Getting Started with MT Manager

4.1. FIS1100 SDK Installation

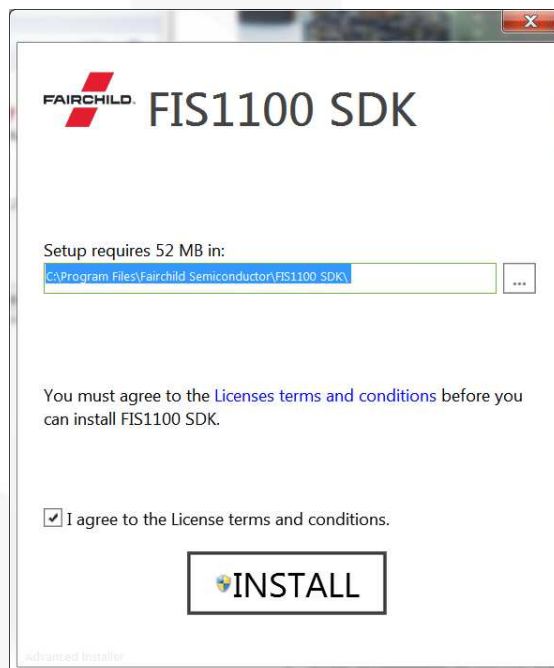**Figure 5.   Execute the FIS1100 SDK Installer**

Figure 6.   Carefully Review the License Terms and if applicable agree to them to install the FIS1100 SDK

4.2. Installed Software

Installed Software Includes:

- **Fairchild MT Manager**
  - GUI to Control FIS1100 Evaluation Board Settings
  - Visualize Real Time Data Streams as Graphs
  - Visualize Real Time 3D Orientation
  - Record Data (ASCII) for Offline Analysis
  - Playback Recorded Data for Offline Analysis

- **FIS1100 Software Development Kit (SDK)**
  - HTML Documentation for FIS1100 SDK, Including XKF3 API
  - High Level C99 Driver for FIS1100
  - XKF3 Libraries for Cortex-M0, M3 and M4F Cores
  - ARM CMSIS-RTOS Reference Implementation for using FIS1100 Driver with XKF3 Library
  - Example Firmware for NXP LPCXpresso5412
  - System Integration Documentation

- **NXP LPCXpresso5412 Board USB Driver**
  - USB UART Emulation
  - ARM CMSIS-DAP Debug Support
  - MCU Power Consumption Measurement[1]

4.3. Hardware Connection

The FEBFIS1100MEMS_IMU6D3X "shield" board should be mounted onto the Arduino compatible MCU board as shown in Figure 4. The MCU board should then be connected to the host PC via a USB cable connected to JP6 as shown in Figure 7

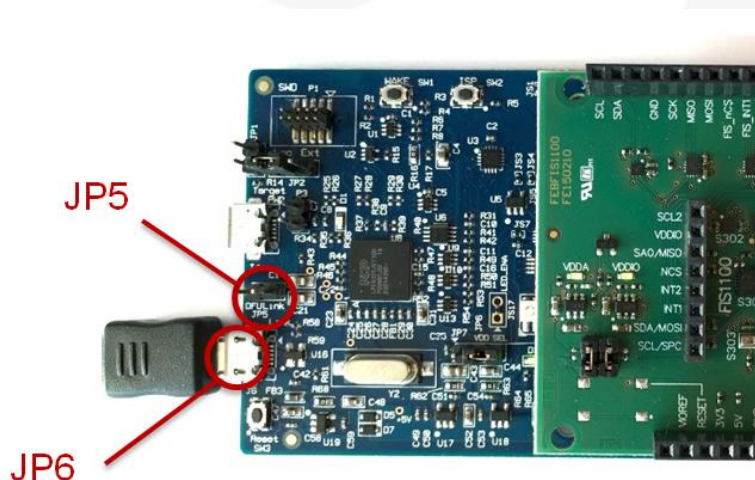For normal use, the DFULink jumper JP5 should be removed before the USB cable is connected to the host PC [2]

Figure 7. Location of USB connection (J6) and DFULink jumper (JP5)

Notes:
1. Requires additional tools from NXP to be installed.
2. JP5 can be used to enable firmware upload to support MCU power measurements.

4.4. Using MT Manager
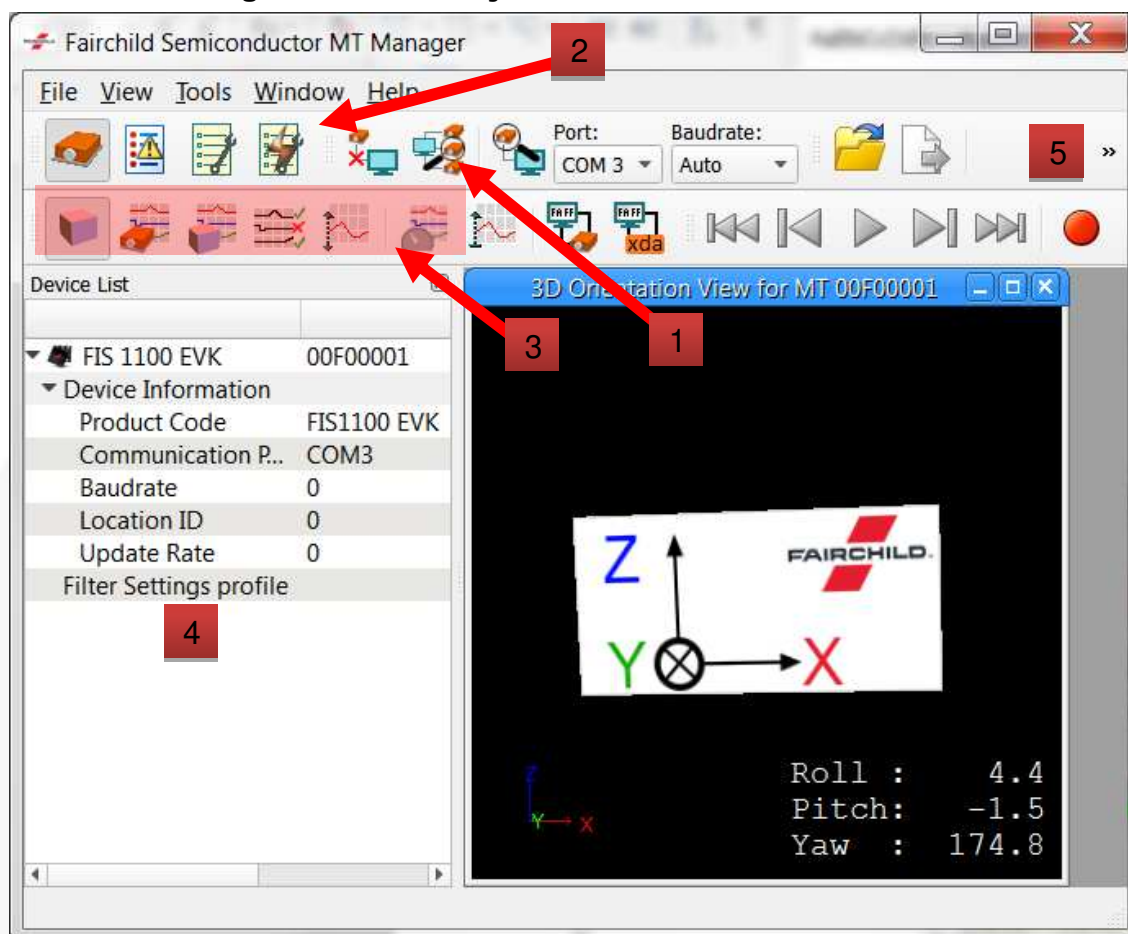
Connecting to Evaluation Systems

Figure 8. MT Manager GUI

With the FEBFIS1100MEMS_IMU6D3X evaluation kit connected to the PC via USB, and drivers installed, start the MT Manager software. The software automatically scans for connected systems and displays these in the device list (4). If the MT Manager software is started before the evaluation board is connected, the scan buttons (1) can be used to rescan for a connected evaluation kit. Alternatively press the *F5* key to rescan for a connected evaluation kit.

With an evaluation kit selected in the device list the system operating parameters can be controlled by opening the output configuration panel (2).

Data from attached evaluation boards can be visualized by selecting one or more the visualization buttons (3).

Data from the evaluation system can be recorded to file for off-line analysis using the record button (5). Data is recorded in a custom binary file format (.mtb), which can be exported to ASCII data (File/Export) for easy analysis in other tools.
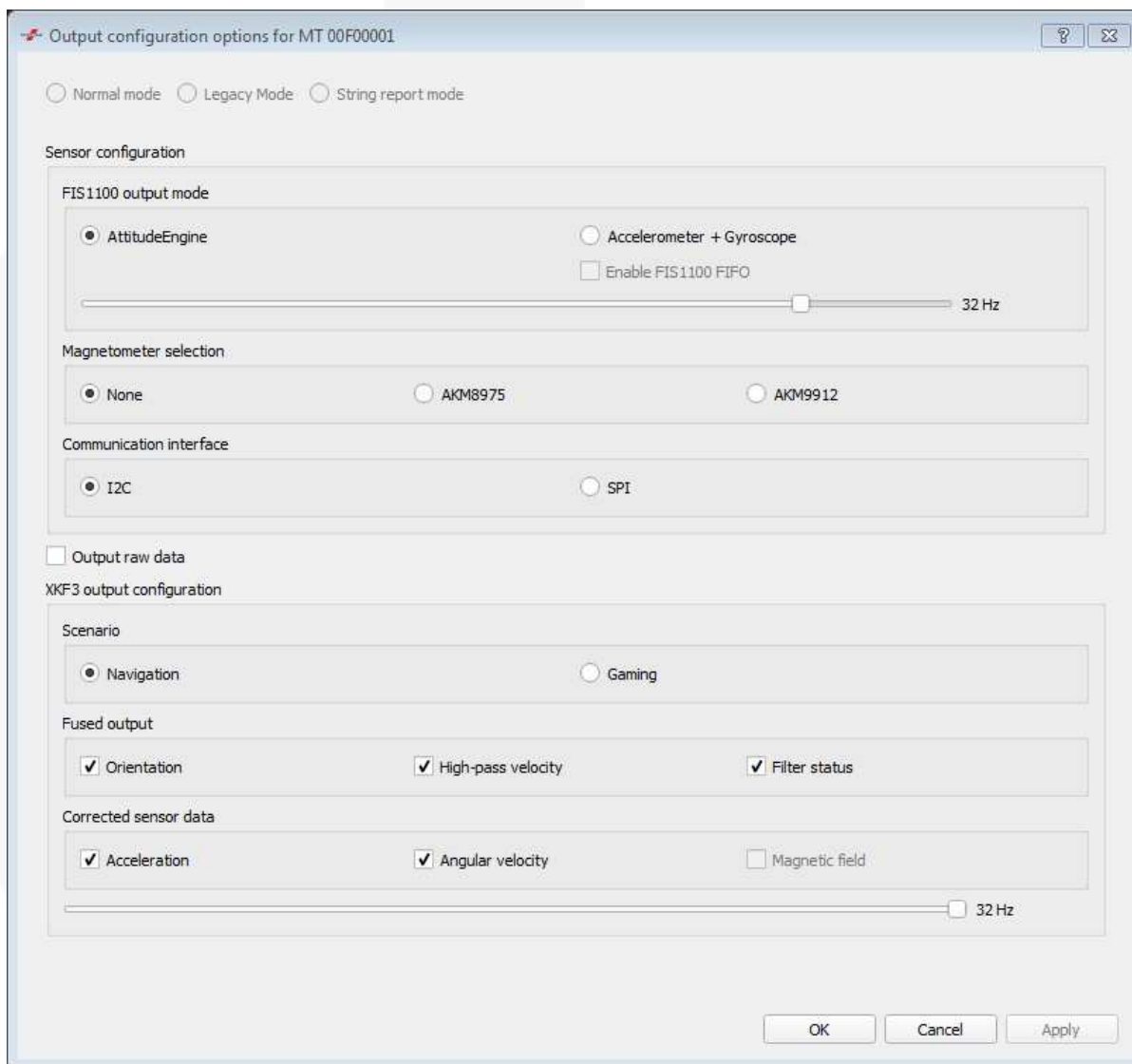
Configuring the FIS1100 Evaluation Kit

Clicking on the output configuration button (2) will open the output configuration dialog for the devices selected in the device list [3]

The output configuration dialog allows the major functions of the FIS1100 and XKF3 fusion library to be configured.

Note:
3. If only a single device is connected it is automatically selected.

Figure 9.   FEBFIS1100MEMS_IMU6D3X Output Configuration Dialog

Table 3. FEBFIS1100MEMS_IMU6D3X Output Configuration Options

Section	Option	Comments
FIS1100 output mode	AttitudeEngine	Uses the FIS1100 Attitude Engine to process data at 1 kHz and output orientation and velocity increments at the selected ODR
	Accelerometer + Gyroscope	Outputs raw accelerometer and gyroscope data at the selected ODR
	Enable FIS1100 FIFO	Enables the FIS1100 FIFO to reduce data interrupt frequency. This option is only available in Accelerometer + Gyroscope mode.
Magnetometer selection	None	Disables magnetometer support.
	AKM8975	Enables the FIS1100 support for a slaved AK8975C magnetometer.
	AKM9912	Enables firmware controlled sampling of the AKM9912 magnetometer
Communication interface	SPI	Uses SPI for communication with sensor components on the FEBFIS1100MEMS_IMU6D3X shield. Note that once SPI communication has been selected the evaluation board must be reset to return to I²C mode.
	I²C	Uses I²C for communication with sensor components on the FEBFIS1100MEMS_IMU6D3X shield
Output Raw Input Data		Enables sending raw sensor data values to MT Manager
Scenario	Navigation	The 3D orientation output from the XKF3 fusion library is referenced to the local magnetic north and will actively track North based on the Earth magnetic field.
	Gaming	Disables north referenced output, use this scenario if you do not need North referenced data and want the smoothest possible 3D orientation output. If magnetometer data is available, yaw drift will be reduced further.
Fused Outputs	Orientation	Enables sending the XKF3 orientation output to MT Manager
	Filter Status	Enables sending XKF3 status flags to MT Manager
	High-pass Velocity	Enables sending XKF3 high-pass velocity output to MT Manager
Corrected Sensor Data	Acceleration	Enables sending XKF3 corrected acceleration data to MT Manager
	Angular Velocity	Enables sending XKF3 corrected angular velocity (gyroscope) data to MT Manager
	Magnetic Field	Enables sending XKF3 corrected magnetometer data to MT Manager

Visualizing Sensor Data

MT Manager provides real time visualization of data sent from the evaluation system.

3D Orientation View

The 3D Orientation View provides a representation of the 3D orientation of the evaluation board. The view is orientated such that the user is looking from North to South at the evaluation board.

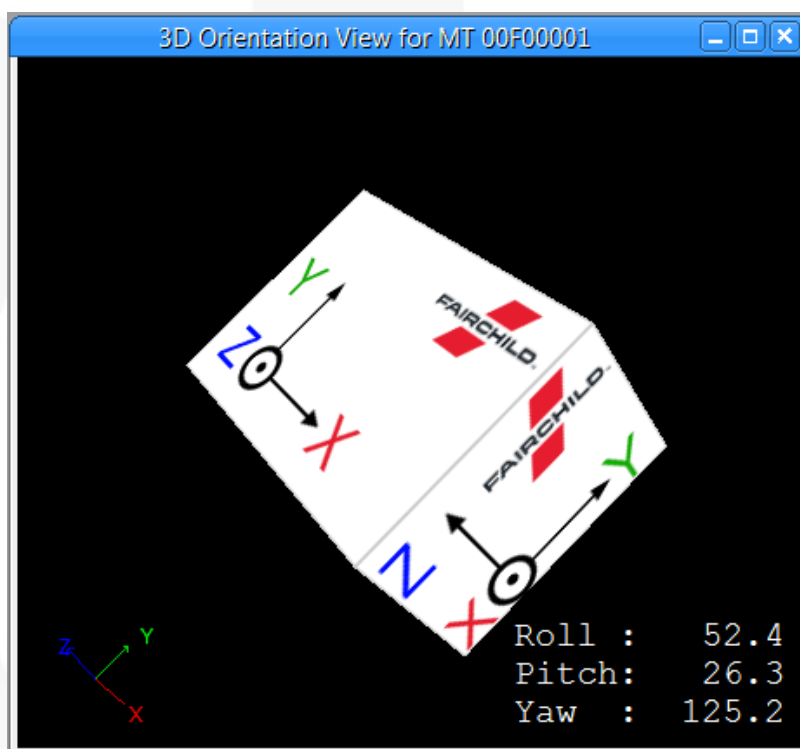The 'Orientation' output must be enabled in the output configuration options dialog to use this view.

Figure 10. 3D Orientation View

Inertial Data View

The Inertial Data view provides graphical visualization of the inertial and magnetic field data output by the XKF3 fusion library. The XKF3 fusion library corrects for typical sensor errors such as gyroscope biases and magnetic hard and soft-iron distortions.

The 'Corrected Sensor Data' options in the output configuration options dialog control which sensor data types are available for visualization.
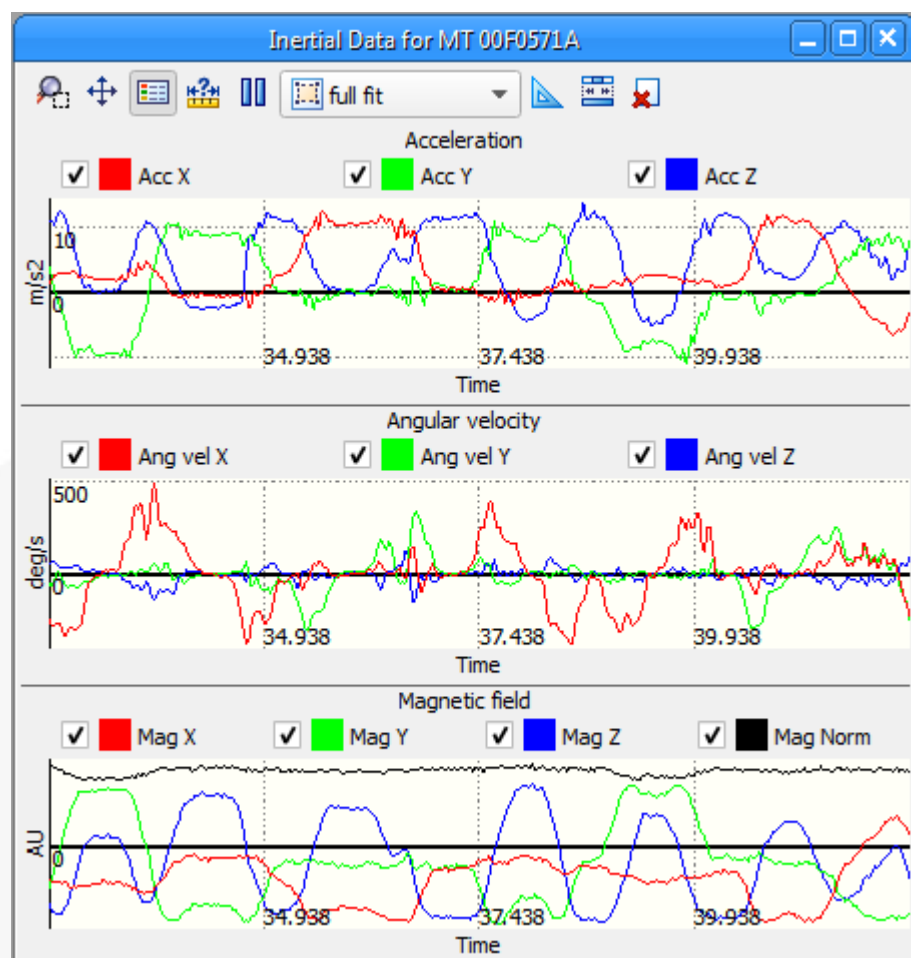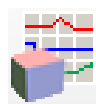
Figure 11. Inertial Data View

Euler/Quaternion Orientation Data View

The Euler/Quaternion Orientation Data views provide graphical visualization of the orientation of the evaluation board. The choice of visualization mode can be made in the Tools → Preferences → MT Manager → Graphs configuration dialog.

The 'Orientation' output must be enabled in the output configuration options dialog to use this view.
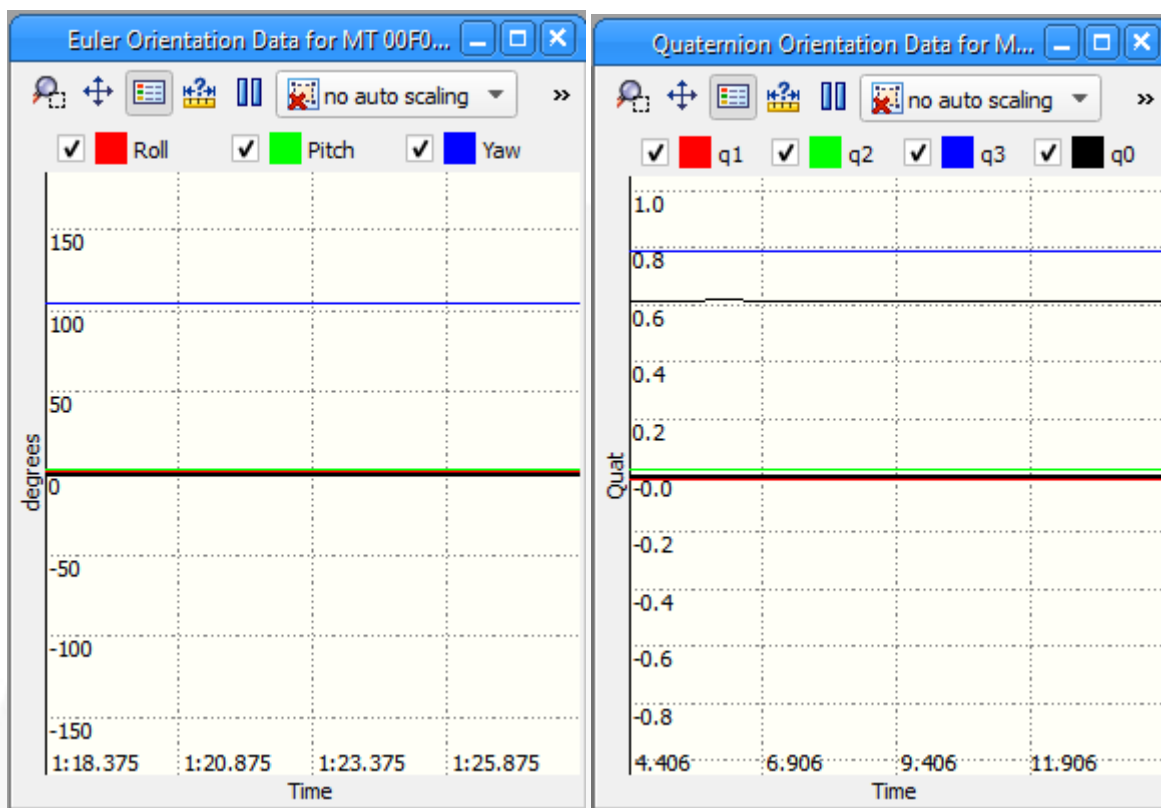
Figure 12. Euler/Quaternion Orientation Data Views

Status Data View

The Status Data view provides a graphical representation of the XKF3 fusion library status flags. These status flags are provided by XKF3 to provide applications feedback on problems with the input sensor data that might affect the quality of the fused output quantities.

The 'Filter Status' output must be enabled in the output configuration options dialog to use this view.
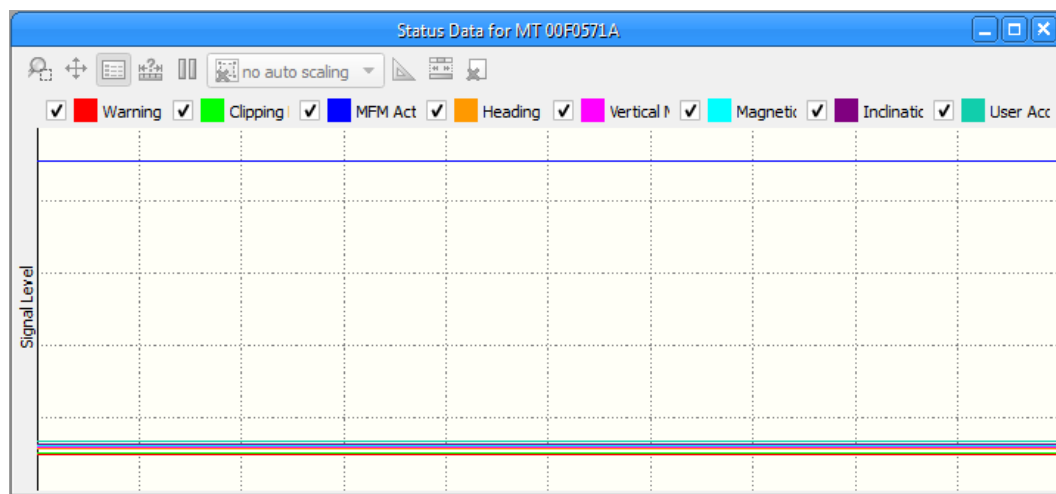
Figure 13. Status Data View

Table 4. XKF3 Status Flag Descriptions

Flag	Description
Warning	High value indicates that the output of XKF3 should not be trusted. Details of possible causes can be found in the subsequent flags.
Clipping Detected	High indicates that one or more sensors have exceeded their dynamic range.
MFM Active	High indicates that automatic magnetometer calibration is active and a new calibration is being determined.
Heading Unreliable	High indicates that the heading of the system cannot be determined accurately. The 'Vertical Mag Field' and 'Magnetic Distortion' flags may provide further details.
Vertical Mag Field	High indicates that the local magnetic field is close to vertical (aligned with gravity).
Magnetic Distortion	High indicates that the local magnetic field is distorted.
Inclination Warning	High indicates that the inclination (roll/pitch) of the system cannot be determined accurately. The 'User Acc Warning' flag may provide further details.
User Acc Warning	High indicates that the acceleration of the system violates the XKF3 model assumption (that the average acceleration is zero within some time period). This can happen when accelerating for long times, such as in a car.

Velocity Data View
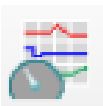
The Velocity Data view provides a graphical representation of the XKF3 fusion library's high pass velocity output. The high pass velocity output is designed for tracking short term motion of the system, such as gestures of the arm with respect to the torso.

The 'High-pass Velocity' option must be enabled in the output configuration options dialog to use this view.
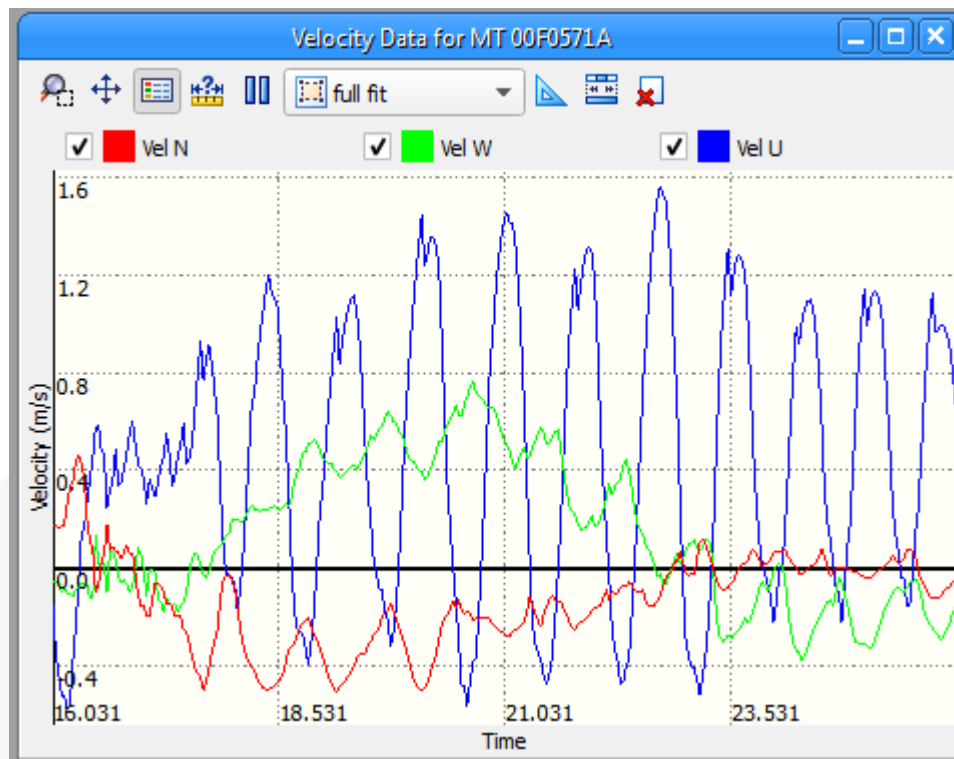
Figure 14. HP Velocity Data View

Device context menu

Right clicking on the FIS1100 SDK device in the Device List provides a context menu with three options:

- Sleep – Wake on Motion: Selecting this menu item places the evaluation kit into wake on motion mode. The FIS1100 will be configured to provide an interrupt on detecting motion that will wake the MCU from sleep.
- Store filter state: Selecting this menu item requests the evaluation kit to save the XKF3 filter state to non-volatile storage. This allows the automatically estimated calibration parameters to be stored over power cycles, resulting in better startup performance.
- Disconnect: Selecting this menu item will disconnect the MTManager GUI from the evaluation kit.
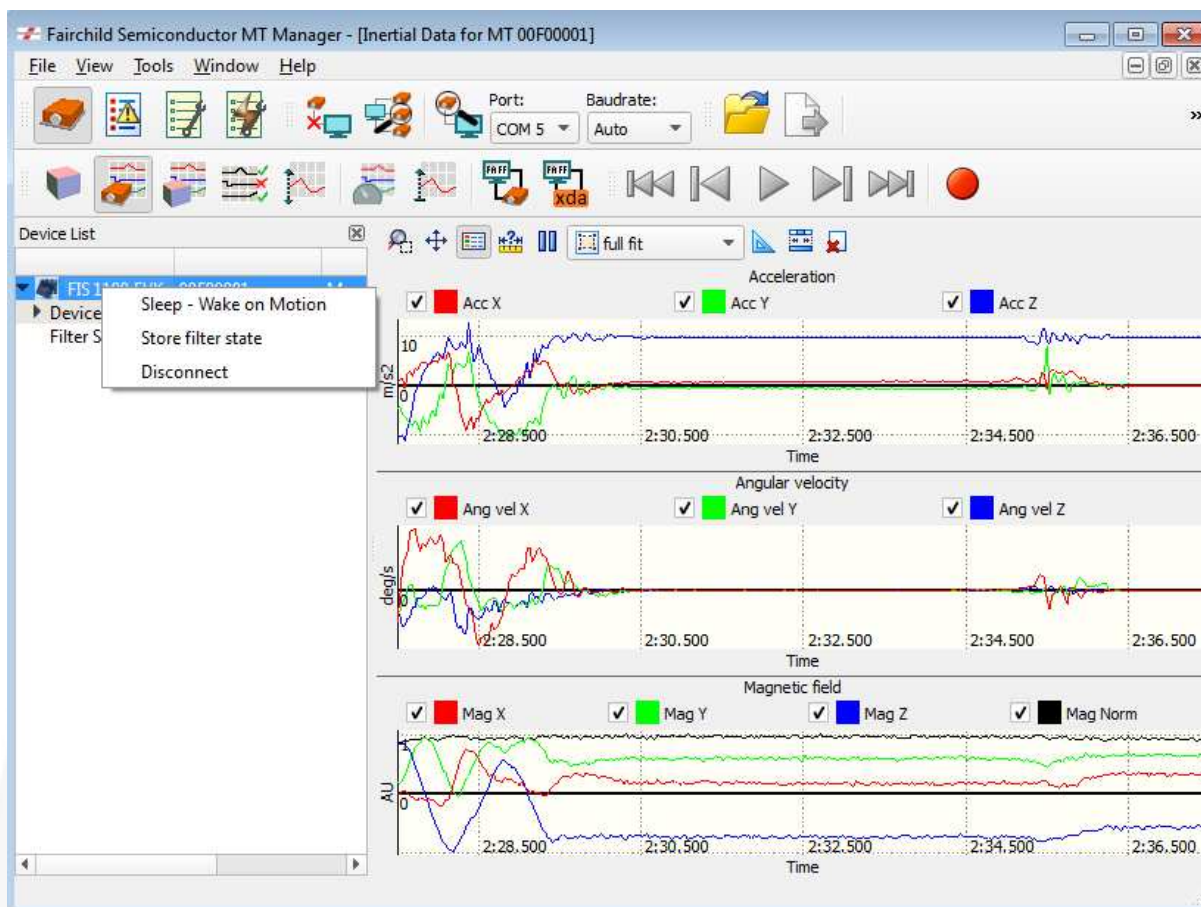
Figure 15. Device Context Menu Available on Right Clicking on FIS1100 SDK Device in Device List

Recording and Exporting Data

Data from the evaluation system can be recorded to file for off-line analysis using the record button , see Figure 8. The data to record should be configured in the output configuration dialog prior to starting recording.

Data is recorded in a custom binary file format (.mtb). Recorded data in .mtb format can be exported to ASCII format for analysis in external tools. The data fields to export can be selected in the Tools→Preferences dialog as show in Figure 16.
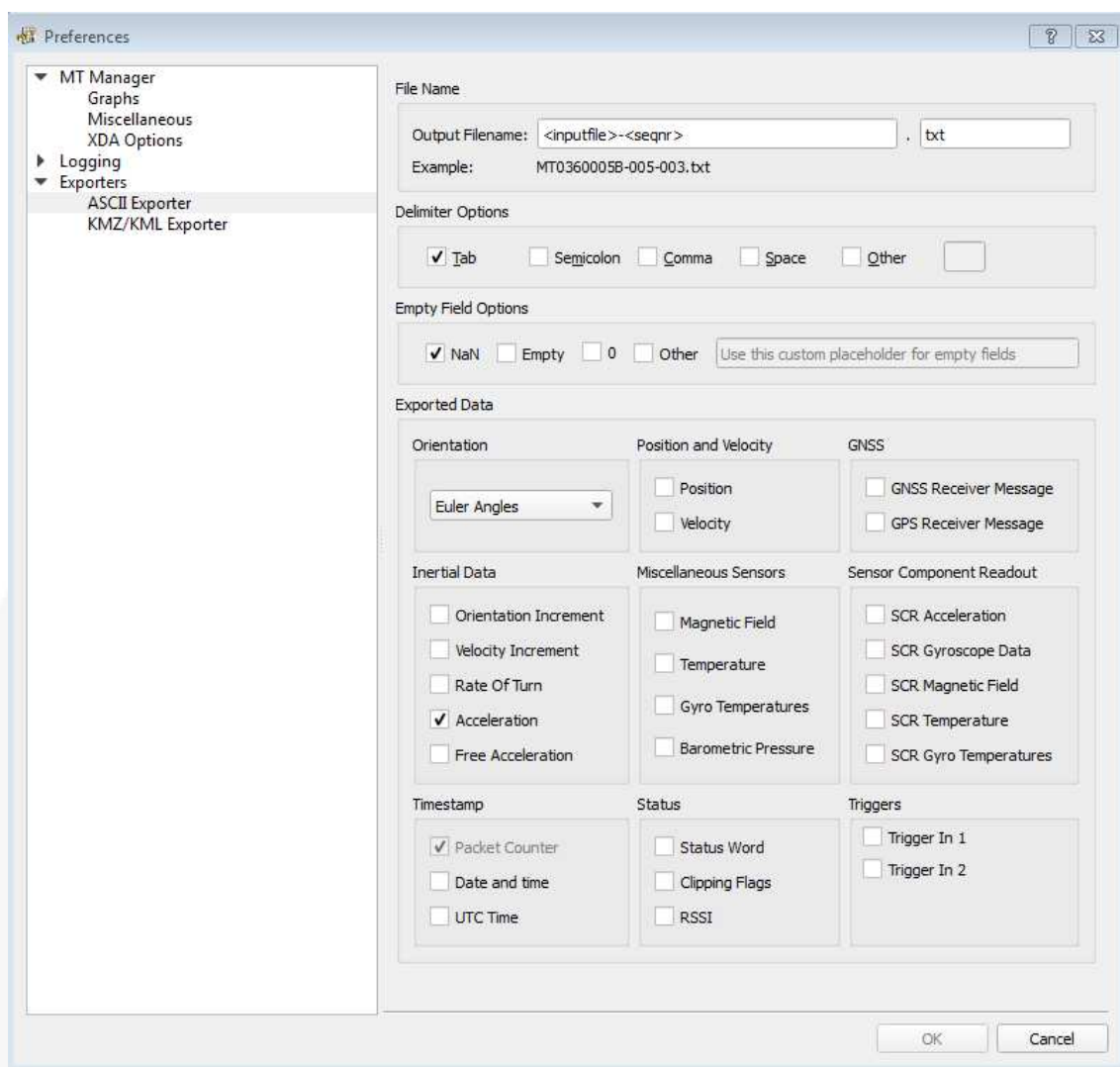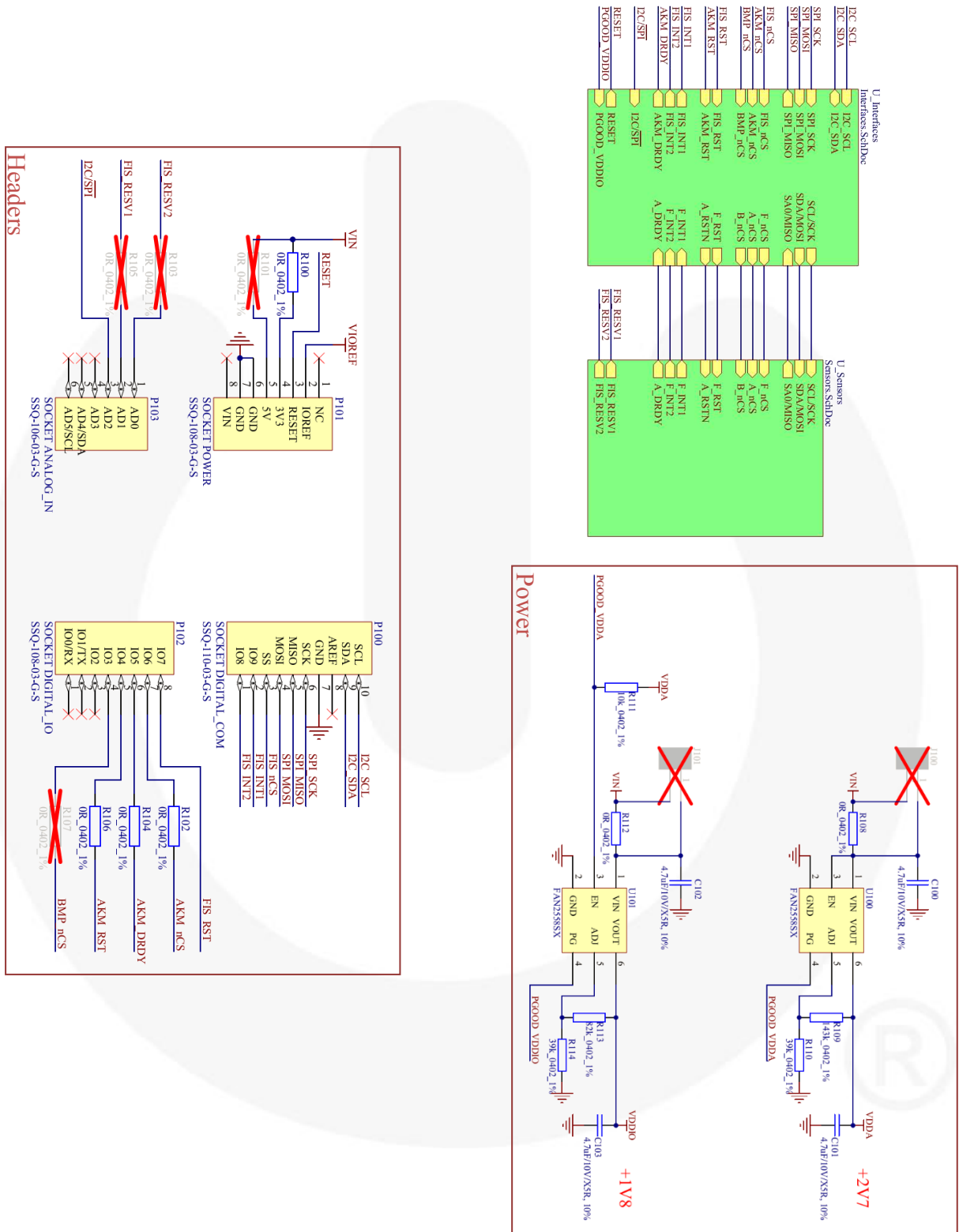
Figure 16.   MT Manager ASCII Export Configuration

Table 5. FEBFIS1100MEMS_IMU6D3X Export Options

Section	Option	Description	Comments
Orientation	None	Don't output orientation data	
	Quaternion	Output orientation as unit quaternion	Orientation output must be selected in output configuration options dialog for this data to be available for export.
	Euler Angles	Output orientation as Euler angles	
	Matrix	Output orientation as rotation matrix	
Position and Velocity	Position		Not supported by FEBFIS1100MEMS_IMU6D3X
	Velocity	Output high pass velocity data	High pass velocity output must be selected in output configuration dialog for this data to be available for export.
GNSS			
Inertial Data	Orientation Increment		Not supported by FEBFIS1100MEMS_IMU6D3X
	Velocity Increment		
	Rate of Turn	Output XKF3 corrected gyroscope data	Rate of Turn output must be selected in output configuration dialog for this data to be available for export.
	Acceleration	Output XKF3 corrected acceleration data	Accelerometer output must be selected in output configuration dialog for this data to be available for export
	Free Acceleration		Not supported by FEBFIS1100MEMS_IMU6D3X
Miscellaneous Sensors	Magnetic Field	Output XKF3 corrected magnetic field data	Magnetic Field output must be selected in output configuration dialog for this data to be available to export
	Temperature		Not supported by FEBFIS1100MEMS_IMU6D3X
	Gyro Temperatures		
	Barometric Pressure		
Sensor Component Readout	SCR Acceleration	Raw acceleration samples from the FIS1100	Output Raw Input Data must be selected in output configuration dialog for this data to be available to export
	SCR Gyroscope Data	Raw gyroscope samples from the FIS1100	
	SCR Magnetic Field	Raw magnetometer samples	
	SCR Temperature		Not supported by FEBFIS1100MEMS_IMU6D3X
	SCR Gyro Temperature		
Timestamp			
Status	Status Word	Output XKF3 status flags	Filter Status output must be selected in output configuration dialog for this data to be available to export.
	Clipping Flags		Not supported by FEBFIS1100MEMS_IMU6D3X
	RSSI		
Triggers			

5. Printed Circuit Board (PCB)

Figure 17. Top Side

6. Schematics

Figure 18.   FEBFIS1100MEMS_IMU6D3X Evaluation Board Schematic (Main)

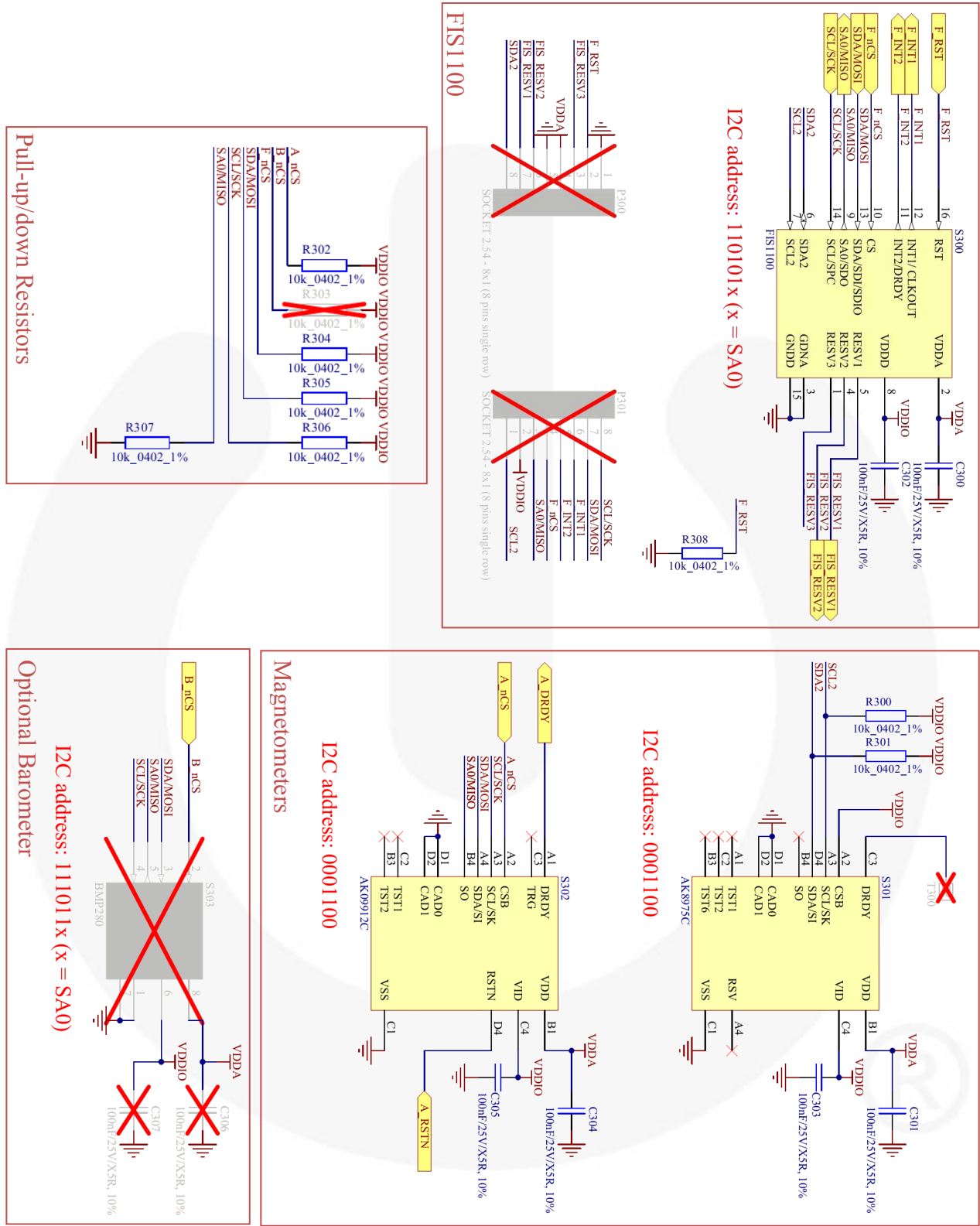**Figure 19.   FEBFIS1100MEMS_IMU6D3X Evaluation Board Schematic (Interfaces)**

Figure 20.   FEBFIS1100MEMS_IMU6D3X Evaluation Board Schematic (Sensors)