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This version (06 Jan 2025 16:01) was *approved* by Tom Sharkey [https://ez.analog.com/members/TSharkey520].
The Previously approved version (/resources/eval/user-guides/industrial_wireless_cbm_evaluation_tool_3axis?rev=1620725256) (11 May 2021 09:27) is available.

Voyager 3, Wireless Condition Based Monitoring Platform
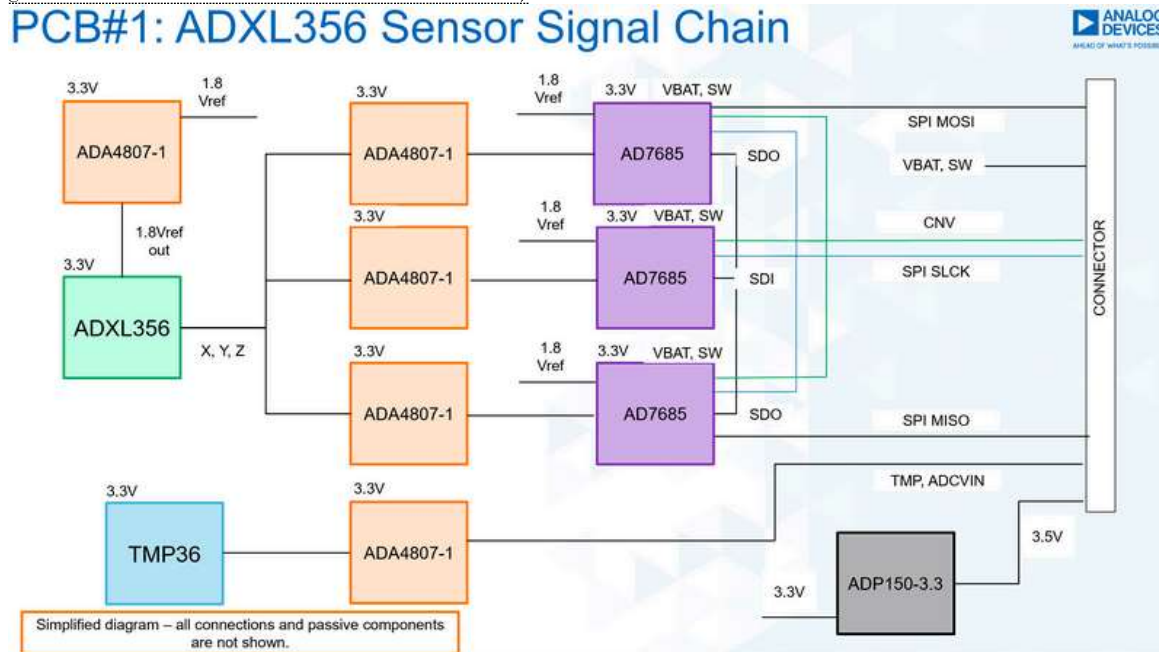
Overview

This document will give a high level explanation of the function and setup of Analog Devices' Condition Based Monitoring (CBM) evaluation software and hardware. This includes a brief introduction to the software and how it is used with the CBM hardware. It also includes a step-by-step guide on the functionality of the CBM Graphical User Interface (GUI (Graphical User Interface)).

The function of the system is to provide an evaluation tool for a wireless signal chain for MEMS-accelerometer based vibration monitoring. The hardware can be directly attached to a motor or fixture via a stud.
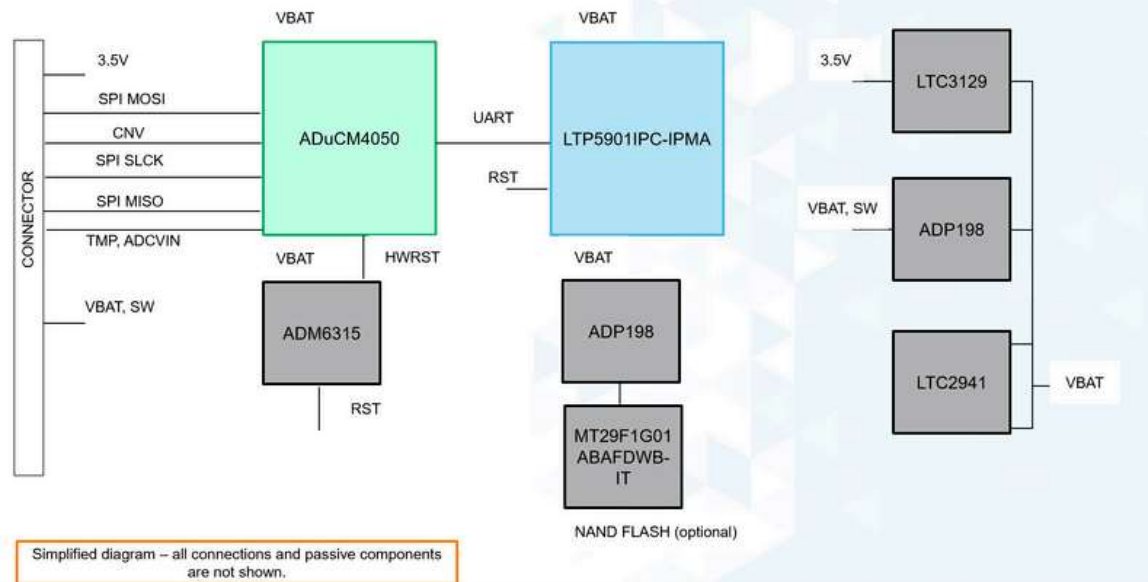
Includes 2 PCBs and mechanical hardware

Wireless CbM Mote

MEMS Accelerometer — Low Power Microcontroller — LTC5800 SmartMesh

PCB#1: ADXL356 Sensor Signal Chain.
PCB#2: MCU and SmartMESH Signal Chain

SmartMesh IP Manager (DC2274A)

SmartMesh IP Manager
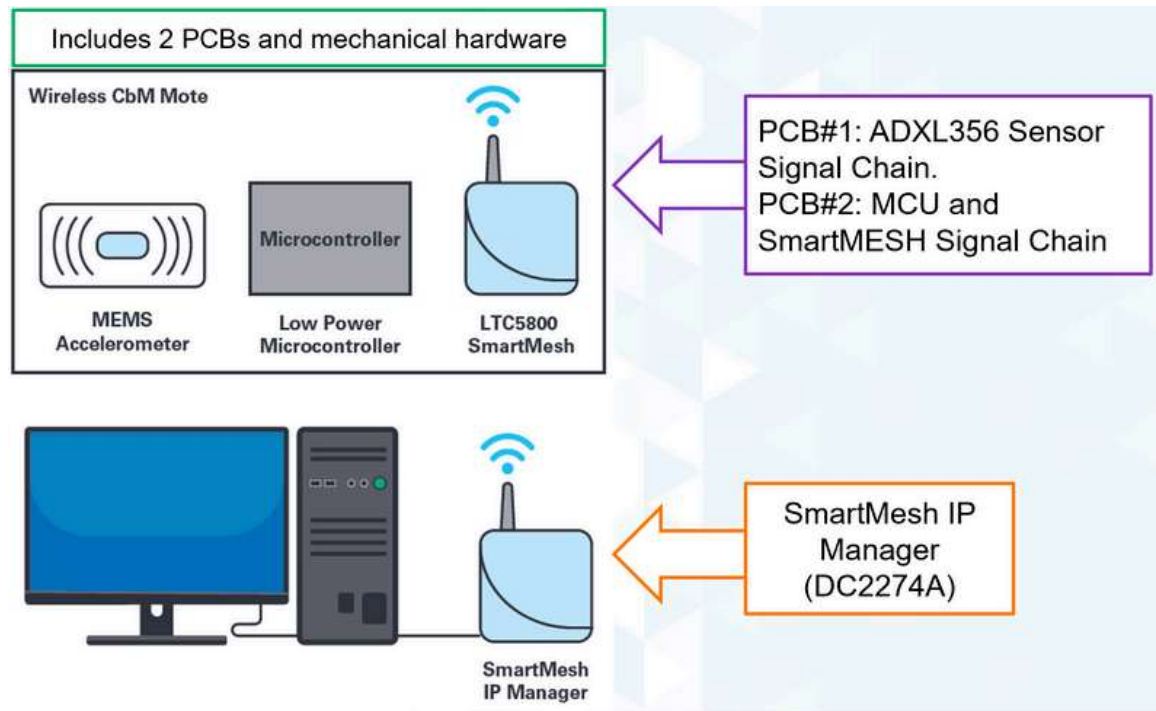
(/_detail/resources/eval/user-guides/fig1.png?id=resources%3Aeval%3Auser-guides%3Aindustrial_wireless_cbm_evaluation_tool_3axis)

# PCB#1: ADXL356 Sensor Signal Chain

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Simplified diagram – all connections and passive components are not shown.

(/_detail/resources/eval/user-guides/fig2.png?id=resources%3Aeval%3Auser-

Figure 1. SmartMesh System Overview

The CBM hardware signal chain consists of a tri-axis ADXL356 accelerometer mounted to the base of the module. The output of
the ADXL356 is read into the AD7685 ADC, and then processed by the ADuCM4050 low power microcontroller. Here it is
buffered, transformed to the frequency domain and streamed to the SmartMesh IP mote. From the SmartMesh chip it is wirelessly
streamed to the SmartMesh IP Manager. The manager connects to a PC and visualization and saving of the data can take place.
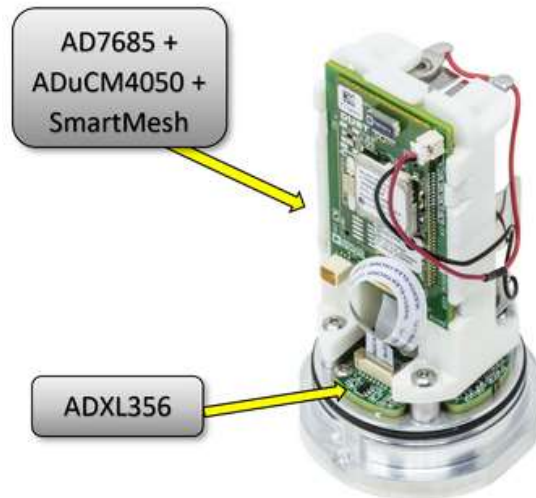
Figure 2. CBM Mote Breakdown

Features

Smartmesh

- 2.4 GHz (Gigahertz) multi-hop wireless mesh networking solution.
- Automatic creation and maintenance of network, with 101 mote limit.
- Scalability for networks to work in different configurations.
- High data capacity with up to 7.2 kbps (kilobits per second) of payload data per node (in a 3 mote setup).

Mote

- Low-power motes (wireless nodes) with >10 year battery life, suitable for tough RF environments.
- Small form factor packages.
- 3-axis acceleration data.

GUI

- Supports real-time plotting of incoming data, tested for up to 3 motes
- Options to update mote parameters on-the-fly.
- Save incoming data to database.
- Customise data plotting.
- Available as both an executable or python file.

Getting Started

Equipment

- SmartMesh IP Manager (DC2274A) [https://www.analog.com//en/design-center/evaluation-hardware-and-software/evaluation-boards-kits/dc2274a-a.html#eb-overview]
- EV-CBM-VOYAGER3-1Z Hardware Module (referred to as "Mote")
- JTAG (Joint Test Action Group - low level interface to cpu) Cable (only needed for firmware upgrade)
- Programming Board (Only needed for firmware upgrade)
- Clamp

Figure 3. Mote, Manager, Programming Board and Clamp

Software Required

The software for this project is available as an executable, or as a python file. The executable only works on windows, but requires no installation of dependencies by the user, these are all packaged into the executable. If running the python file, a number of dependencies must first be installed. Please consult the CBM_setup guide for more detailed instructions on running the python program.

Executable (Windows Only)
- CBM_app.exe

Python
- Python 2.7.15
- Pip for Python (latest version)
- Matplotlib (v2.2.3)
- PySerial (v3.5)
- Scipy (v1.2.2)
- Pandas (v0.23.3)
- openpyxl (v2.6.4)
- CBM_app.py (provided in software package)

- ev-cbm-voyager GitHub [https://github.com/analogdevicesinc/ev-cbm-voyager].

Quickstart

- Plug the manager into any available USB (Universal Serial Bus) port on your PC
- Place the 2xAA batteries in the mote.
- Download the available software below in the software installation section.
- Save the CBM_app executable anywhere on your PC and launch the program.
- A window should pop up, prompting you for the COM port of your manager. Search for the manager port number in your computers device manager, under PORTS(COM & LPT). The correct COM port is the last of four consecutive COM ports
- Click connect.
- When the Mote's green LED starts blinking, data is plotted, with the default being time and fft plots.
- While the mote is stationary, double click the remove adc offset checkbox.
- Interact with the mote by shaking it, and observe the changes to the data plotted.
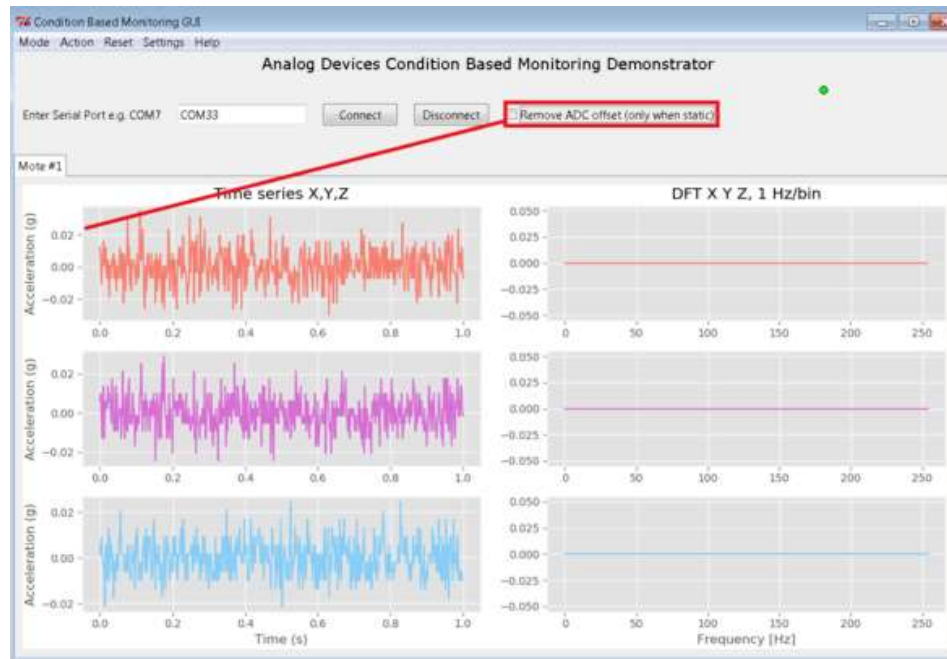
Figure 4. Initial Connection to Single Stationary Mote

Documentation

A setup guide has been created for the Wireless CBM tool which is available on this wiki. This may be used if the quickstart provided here does not result in successful operation of the program, or for more information about this program and its setup.

- CBM Setup Guide (/_media/resources/eval/user-guides/cbm_setup.pdf)
- WCBM-01 Firmware Guide (/_media/resources/eval/user-guides/wcbm-01_firmware_guide.pdf)
- Developers Firmware Guide (/_media/resources/eval/user-guides/developers_firmware_guide.pdf)
- Statistical Functions Guide (/_media/resources/eval/user-guides/condition_based_monitoring_statistical_functions.pdf)

Typical Measurements

If you have the program running, with a mote connected, simply shake the mote in any direction. This should update the plots with some meaningful vibration data.

This demo can be improved by using the mote in conjunction with a small motorized device (e.g. (for example) electric fan). Simply place the mote as close to the vibration source as possible and observe the results in the GUI (Graphical User Interface).
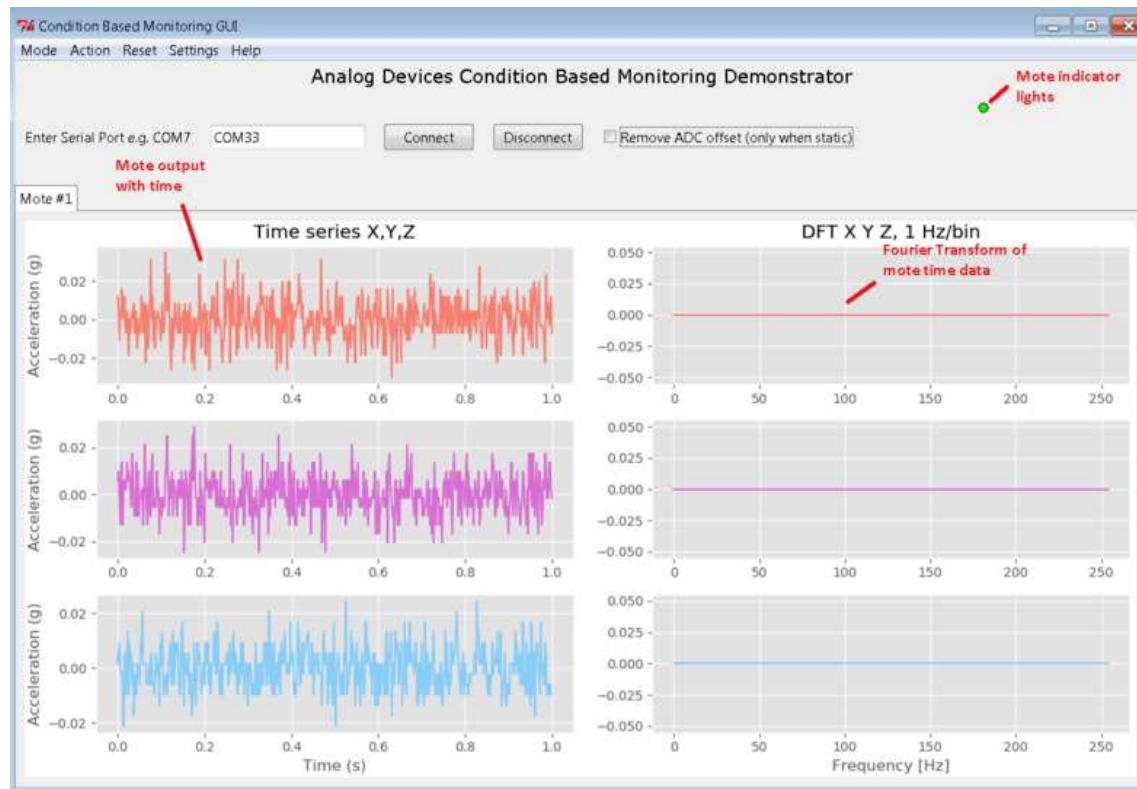
Figure 5. Typical GUI (Graphical User Interface) Output
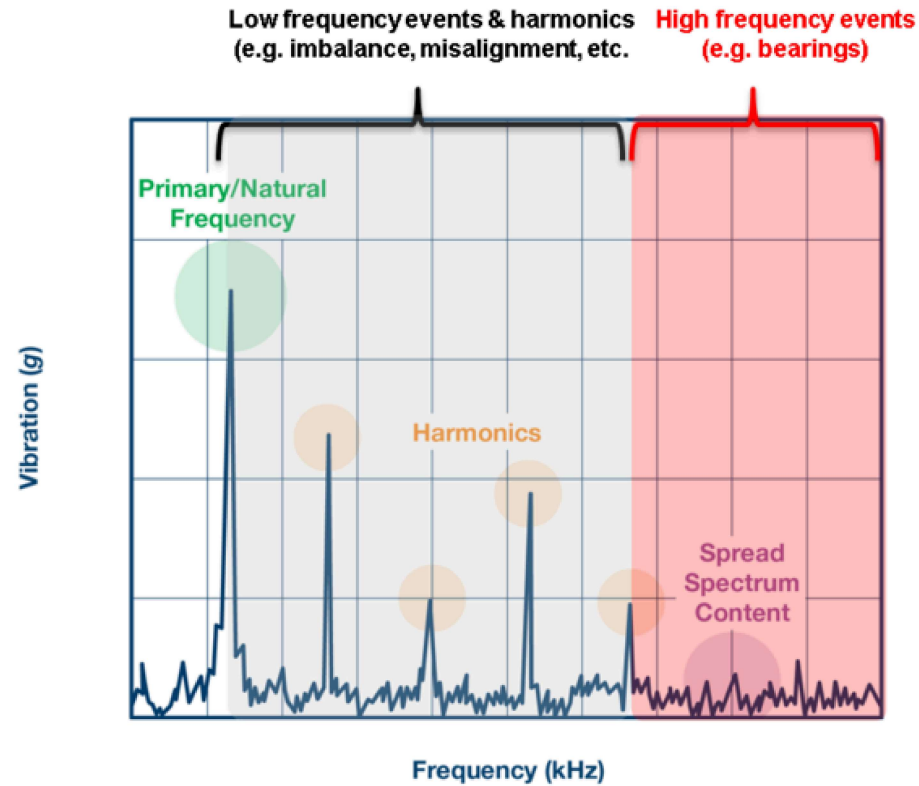
(/_detail/resources/eval/user-guides/fft_markers.png?id=resources%3Aeval%3Auser-guides%3Aindustrial_wireless_cbm_evaluation_tool_3axis) **Figure 6. Fourier Transform graph explained**

Mounting Information

The Voyager enclosure includes a ¼-28 threaded hole. To mount the mote, either a mounting stud or a magnetic mount can be used. Magnetic mounts are typically used in situations where the monitored equipment does not include a threaded hole. Several different scenarios for mounting are discussed below, with suggested parts for each scenario.

Mounting Studs

1. If the monitored equipment includes a ¼-28 threaded hole, then a ¼-28 to ¼-28 attach stud can be used. Example Parts:
   - CTC: MH108-1B; [https://www.ctconline.com/mounting_studs.aspx?prd=MH108-1B]
   - PCB Piezotronics 081B20; [https://www.pcb.com/products?m=081B20]
2. If the monitored equipment includes an M6 threaded hole, then a ¼-28 to M6 attach stud can be used. Example Parts:
   - CTC: MH108-5B; [https://www.ctconline.com/mounting_studs.aspx?prd=MH108-5B]
   - https://www.pcb.com/products?m=M081B20PCB Piezotronics: M081B20 Metric mounting stud, ¼-28 to M6 x 0.75, BeCu w/shoulder [https://www.pcb.com/products?m=M081B20PCB Piezotronics: M081B20 Metric mounting stud, ¼-28 to M6 x 0.75, BeCu w/shoulder]
3. If the monitored equipment includes an M8 threaded hole, then a 1/4 -28 to M8 attach stud can be used. Example Parts:
   - MH108-6B; [https://www.ctconline.com/mounting_studs.aspx?prd=MH108-6BCTC]

Magnetic Mounts

1. IFM and PCB Piezotronics provide magnetic mounts with M8 or ¼-28 vibration sensor attach. Example Parts:
   - IFM M8 attachment flat E30448; [https://www.ifm.com/ie/en/product/E30448?tab=details]
   - Note: To use the IFM base then you also need a ¼-28 to M8 adaptor stud for the Voyager enclosure
2. PCB Piezotronics ¼-28. Example Parts:
   - PCB Piezotronics ¼-28, both flat and curved surface attachment [https://www.pcb.com/sensors-for-test-measurement/accelerometers/accessories/magnetic-mounting-bases]
   - Note: The Piezotronics bases 080A54, 080A130/131/132 could be used directly with the Voyager enclosure concept, as they include a ¼-28 treaded hole.
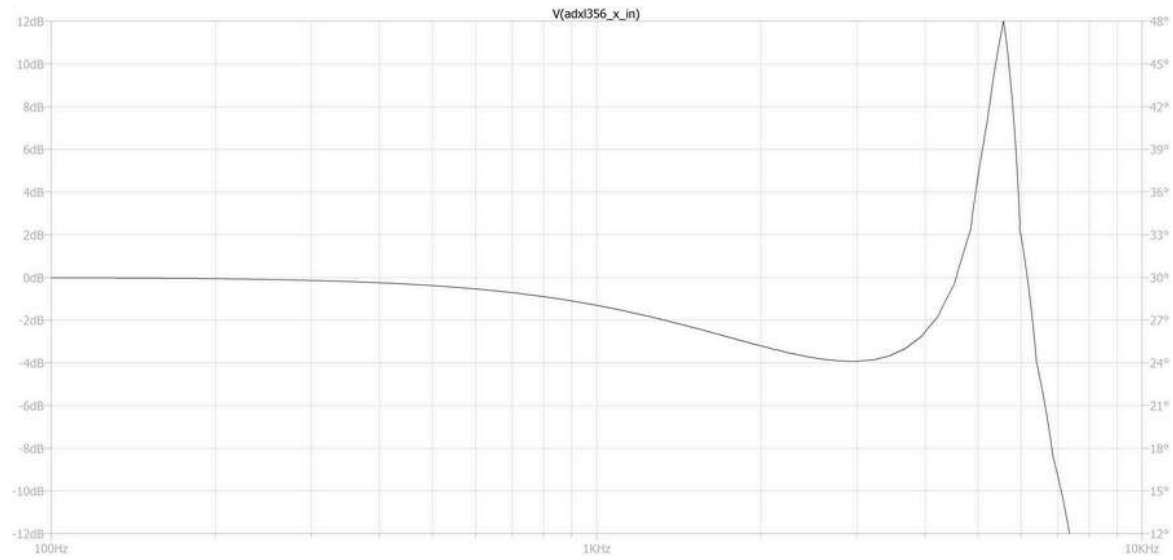
LTspice Simulation

Figure 7 can be used to simulate the frequency response of a MEMS circuit. Figure 7 has two elements - firstly the response of the MEMS mechanical structure estimated using the LAPLACE equation, and secondly the signal chain op-amp filtering. Figure 8 presents the x-axis frequency response of the ADXL356, in good agreement with the ADXL356 data sheet Figure 8. This model assumes a nominal resonant frequency of 5500 Hz, a Q of 17, and the use of a single-pole, low-pass filter that has a cutoff frequency of 1500 Hz. This model does not include consideration of the manner in which the accelerometer is coupled to the platform that it is monitoring.

The simulation model shows good agreement with the data sheet typical performance, with resonant frequency of 5.5kHz. For AC analysis its best to use a LAPLACE circuit in LTspice, but for transient analysis discrete components or a simple voltage waveform input should be used for best simulation performance. This is a good rule of thumb when extending the analysis to the rest of the signal chain beyond the MEMS and op-amp. For example, Figure 9 shows an added ADC on the op-amp output.
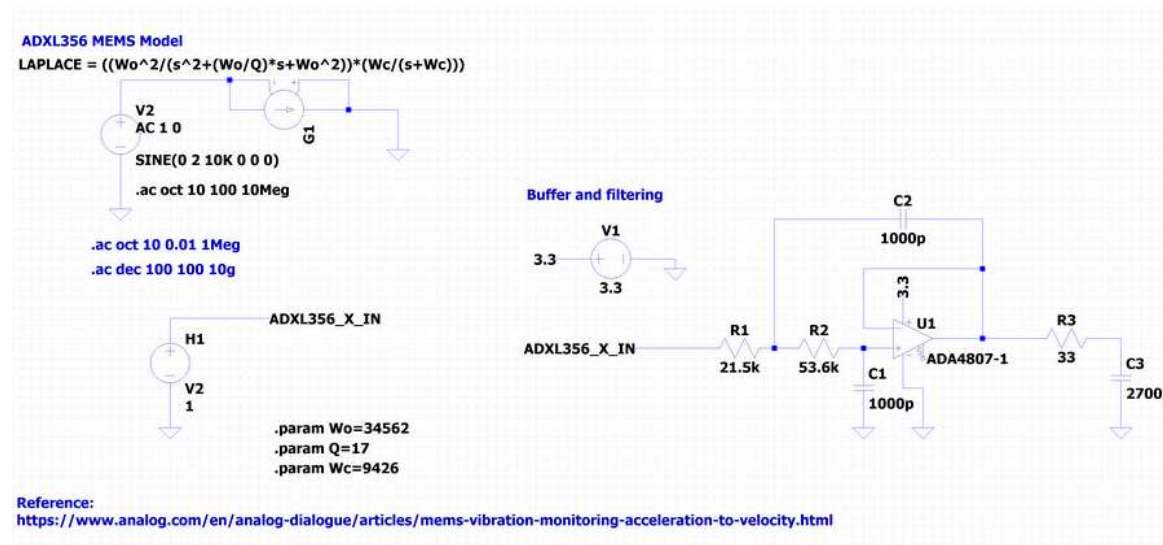
(/_detail/resources/eval/user-guides/voyager_image1.png?id=resources%3Aeval%3Auser-guides%3Aindustrial_wireless_cbm_evaluation_tool_3axis) **Figure 7. LTspice Simulation circuit for ADXL356 MEMS Frequency Response**

(/_detail/resources/eval/user-guides/voyager_image2.png?id=resources%3Aeval%3Auser-guides%3Aindustrial_wireless_cbm_evaluation_tool_3axis) **Figure 8. LTspice Frequency Response Simulation Output for ADXL356 (X-Axis)**
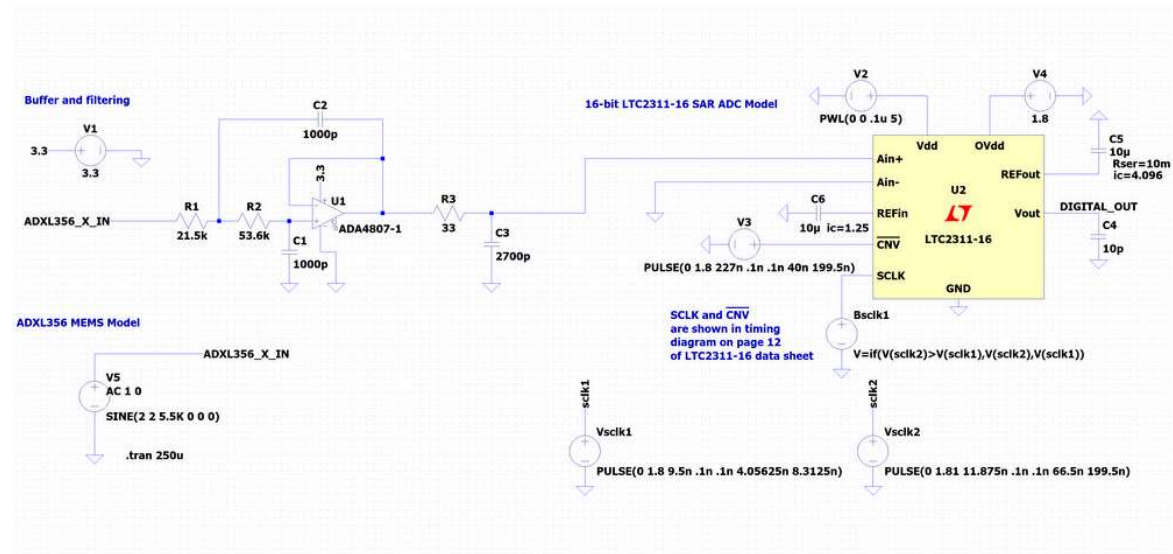
(/_detail/resources/eval/user-guides/voyager_image3.png?id=resources%3Aeval%3Auser-guides%3Aindustrial_wireless_cbm_evaluation_tool_3axis) **Figure 8. Extending the analysis to the ADC)**

LTSpice models are available here: click here to download (/_media/resources/eval/user-guides/voyager.zip)

Further Reading

If you are a developer interested in contributing to this project, or looking at the SmartMesh library in greater detail, more information is available at the SmartMeshSDK space on Dustcloud [https://dustcloud.atlassian.net/wiki/spaces/SMSDK/overview]. This gives links to a number of example programs which show the full capability of the SmartMesh library, and links to the source code for the whole project available on GitHub at SmartMesh GitHub [https://github.com/dustcloud/smartmeshsdk].