



Deviceworx Technologies Inc.

xTAG Explorer App

for

xTAG BLE Vibration Sensors

Users Guide



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Revisions

Rev	Author	Notes	Date
1.0	Mark Janke	Original Draft Covering Full Device and App for Vib Diagnostics	Jan 20, 2021
2.0	Mark Janke	Updated for Ver 2.01.002 App Updates	June 9, 2021
3.0	Mark Janke	Updated for Ver 2.02.003 App Updates	Sept 28, 2021

Overview

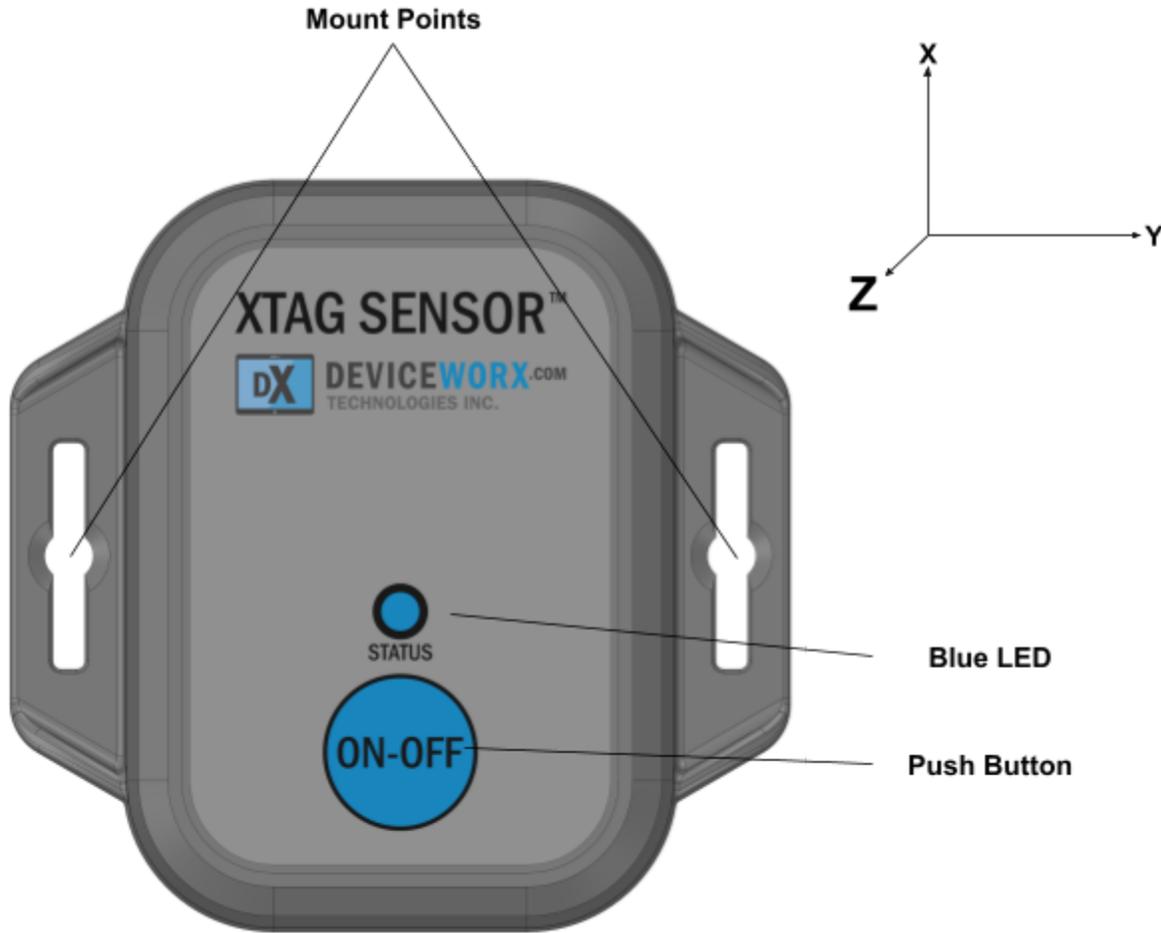
This document is intended to provide users of the Deviceworx xTAG BLE Vibration Sensor (“xTAG” within the remainder of this doc unless stated otherwise) with details on how to use the xTAG along with its supporting xTAG Explorer Android App. The xTAG incorporates a BMI160 Accelerometer that can be used to detect machine on/off status or to read g-force data for machine vibration analysis. The xTAG Explorer App communicates with xTAG devices to configure xTAGs and acquire accelerometer data over BLE 5.0 to a maximum distance of 300 feet (100 m).

xTAG Explorer App Support for All Deviceworx xTAGs

The xTAG Explorer App also supports the management of other xTAG types including xTAG BEACONS with iBeacon, Eddystone UID beacon and NFC tap functionality, listing all xTAG types on its main screen. Selecting a listed xTAG opens a Detail screen that is specific to the type of xTAG selected. This document covers only the screens visible when interacting with xTAG BLE Vibration Sensors. For info on xTAG Explorer screens supporting other xTAG types (e.g. the xTAG BEACON), please consult Deviceworx for appropriate user documentation.

xTAG Controls

The figure below shows an xTAG. Details for each control follows the figure. Note that positive x, y and z directions for G-Force measurements are also shown.



Mount Points

The enclosure includes flanges to support mounting the xTAG on a wood or metal base. Because the internal xTAG antenna is 30 mm+ away from the xTAG base, BLE comms are not adversely affected by RF issues related to mounting XTAGs on metal base structures.

An alternative mounting scheme uses N50 magnets at the 4 corners of the xTAG base (pre-mounted by Deviceworx). N50 magnets have a strength of 11 lbs force (each) and ensure that the xTAG does not slip when magnetic mounts are used on a ferromagnetic metal base. Order part number “xTg-01-B-ACC+M” for xTAGs for magnetic mount support.

Blue LED

The Blue LED will flash on occasion to indicate the status of the xTAG. At present, only the following status indications are provided:

- Flash ON 5 times in approx 3 seconds whenever the xTAG starts or restarts (i.e. new battery inserted or new firmware loaded during manufacturing).

- Flash ON 2 times quickly whenever the xTAG **starts** transmitting beacons to support interaction with the xTAG Explorer App.
- A single longer LED flash occurs when the button is pressed and held for a couple seconds to stop beacon transmission. Beacon transmission on/off control is typically used to support transport of xTAGs: xTAGs can be transported without removal of their battery if they are not transmitting beacons.

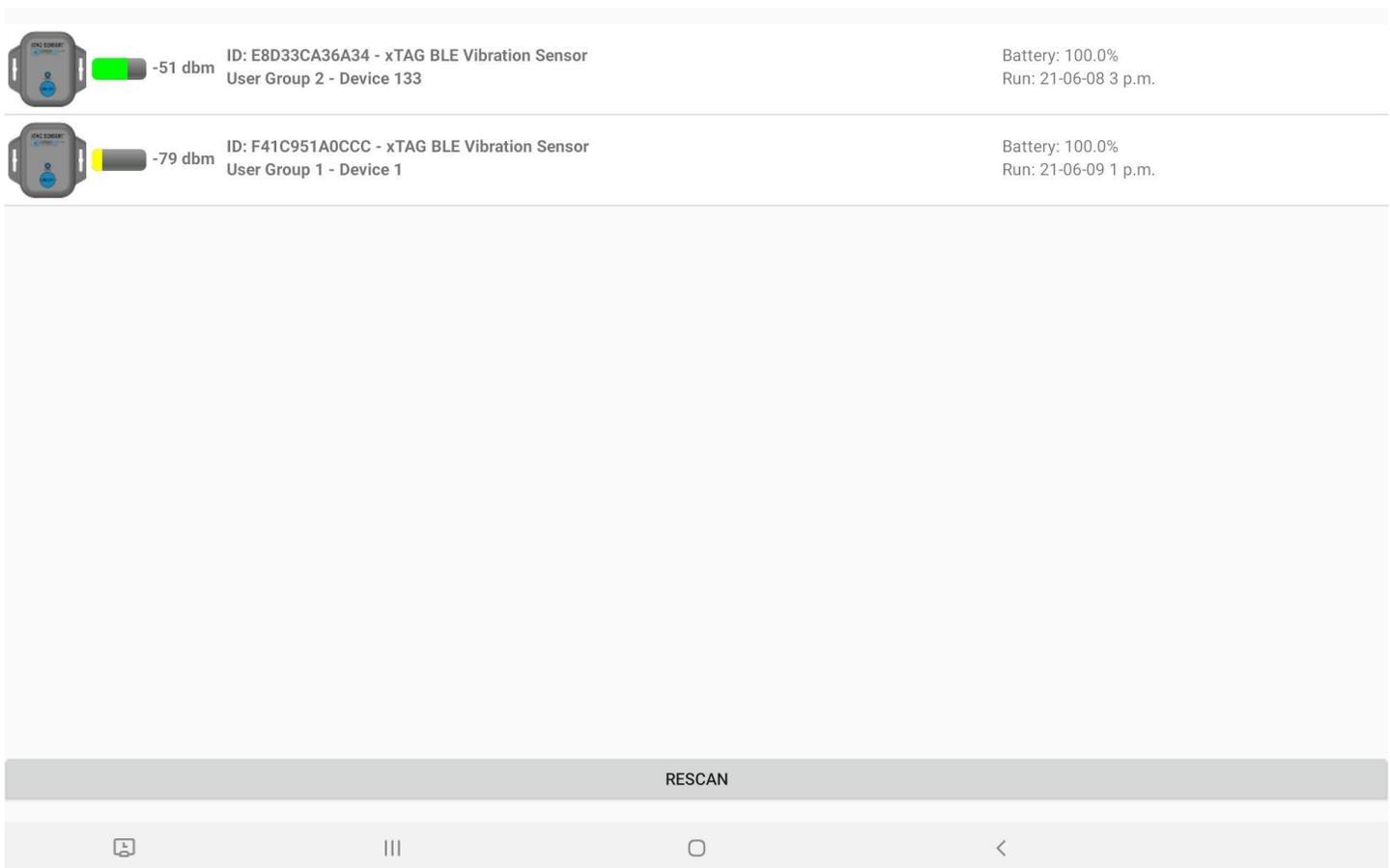
Push Button

This button turns BLE beacon transmissions on and off. See the Blue LED section above for detail on LED indications for beacon transmission status.

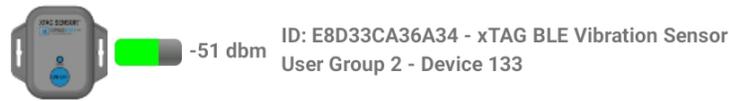
xTAG Explorer App

The xTAG Explorer App (or “App” for brevity) is available for install from the Google Play Store. Note that Apple devices are not supported. Also note that the App works best on the 10” Samsung Galaxy Tab A or Tab A7 running Android 9 or better. Other Android tablets may work, but only the 10” Samsung Galaxy Tab A and Tab A7 have been validated by Deviceworx. This tablet is inexpensive and can be easily purchased worldwide. If another tablet is used, validating that it supports 1080p or better resolution will ensure that App screen layouts are optimized. Deviceworx validation testing indicates that Samsung Galaxy tablets include the most robust BLE support and are recommended.

The figure below shows the Home screen within the App. This screen lists nearby xTAGs (that are currently beaconing) and can be refreshed at any time by pressing the “RESCAN” below the list.



Each listed device will contain (on the left) the device information shown in the figure below.



- ID: Each xTAG has a universally unique ID. This ID is the fixed Bluetooth Address of the xTAG. Note that the type of xTAG is also listed with the ID (“xTAG BLE Vibration Sensor” in the figure above).
- User Group ID: This unique number (“2” in the figure above) can be set within the App (covered in following sections) to group devices. This allows devices to be identified before BLE connections are made.
- User Device ID: This unique number (“133” in the figure above) can also be set within the App to identify the device within a group.
- Signal Strength: A color-coded bar indicates the strength of the BLE signal. No color indicates a very low signal strength, red indicates a low signal strength, yellow denotes an OK signal strength, and green denotes a very strong signal strength. To the right of the bar, the actual signal strength in dbm is shown. To improve signal strength, get closer to the xTAG or increase its transmission (Tx) power level (discussed in a section that follows).

Each listed device will contain (on the right) the device information shown in the figure below.

Battery: 100.0%
Run: 21-06-08 3 p.m.

- The percentage of battery remaining **as it relates to voltage**. This percentage shows the level of the battery between 3.0 VDC (100 percent) and 2.2 VDC (0 percent). Because battery voltages are not linear, this percentage will not be linear. In general, the battery will stay at a level above 75 percent (2.8 Vdc) for a very long time and then it can drop quite quickly to 0 percent. Note that low ambient temperatures can lower a battery’s voltage.
- Run: The date and time that the firmware (software) started on the xTAG. In general, this date should match the date of manufacture, or the date when a battery was last inserted into the xTAG.

xTAG Connection and Use

BLE Pairing

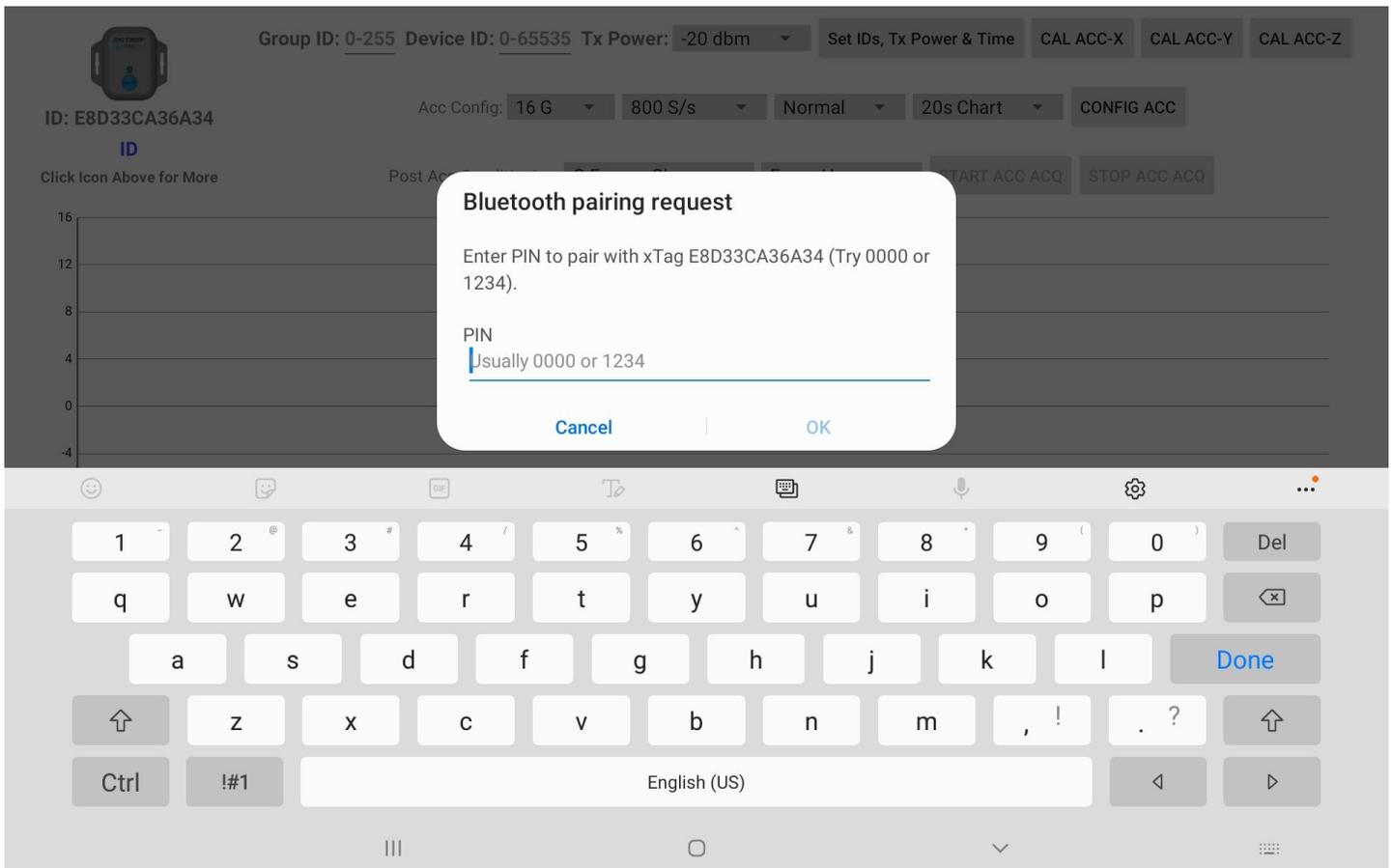
From version 2 forward, xTAG Explorer supports secured access to xTAGs. This is accomplished through the BLE pairing and bonding process. Bonding simply stores pairing data so that pairing only has to occur once. Specifically, xTAGs utilize JustWorks Pairing (requires no user passkey entry to pair and bond) for limited security and Passkey Pairing (user enters 6 digits to pair and bond) for strong security. Both techniques are supported by the more secure Low Energy Secure Connections (LESC) standard. Each xTAG customer is assigned their own unique 6-digit pin. If Passkey Pairing is enabled on their xTAGs they must enter this passkey once when connecting to their xTAGs for the first time. If JustWorks Pairing is enabled on their xTAGs, they simply select a “Pair” option to pair without pin entry.

If another Android device is connected to the same xTAG, that new Android device will also have to be paired and bonded with the xTAG. To disable secure access to any xTAG, simply “unpair” the xTAG from the Android device within the Android Bluetooth settings.

xTAG Connection

Connect to any xTAG by selecting it within the Home screen. BLE connections can take a few seconds and can fail intermittently. Once connected, however, BLE connections are retained very effectively. If a connection to an xTAG fails, the home screen will be re-opened and xTAGs nearby will be re-scanned. Re-select the xTAG to attempt another connection. If no pairing to the xTAG is required (because a bond already exists from a previous pairing), the xTAG Detail screen will be opened with controls populated.

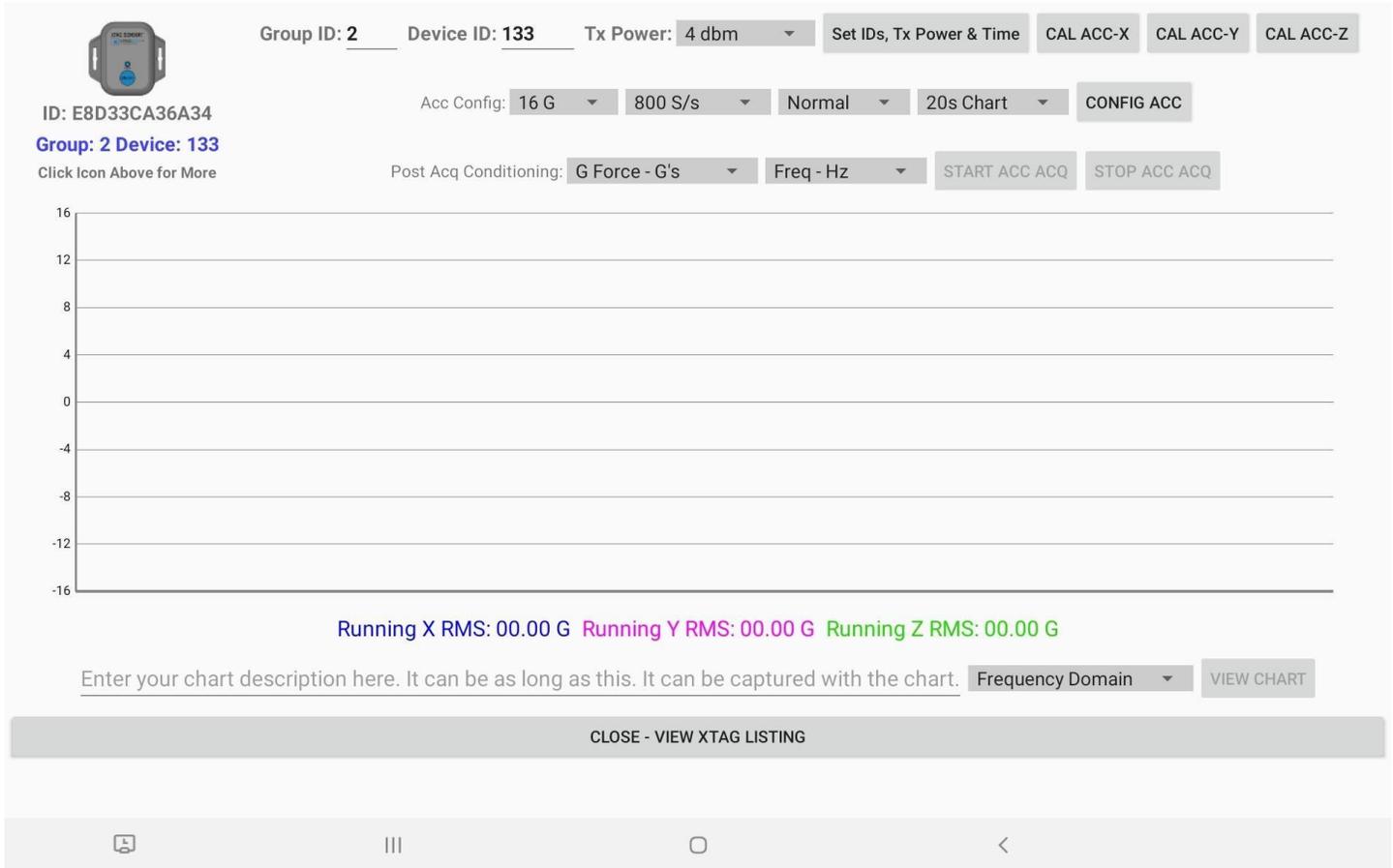
If this is the first connection between the Android device and the xTAG and pairing is required, either a Passkey Entry Dialog will be opened as shown below or a much simpler dialog with “Pair” and “Cancel” options.



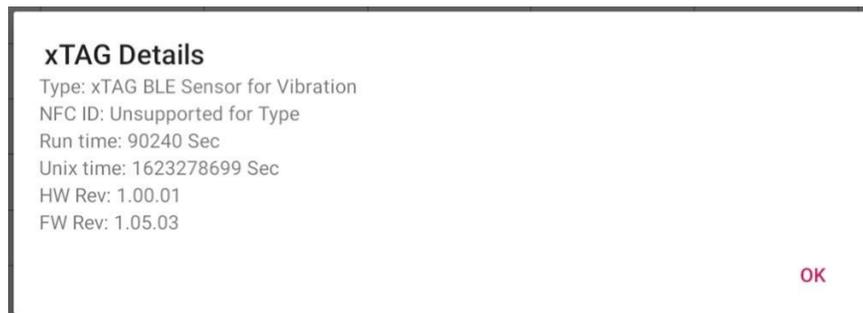
If a Passkey Entry Dialog is opened, the user must enter their 6-digit pin and select OK. Pairing will be completed and the xTAG will be bonded so that no future pairing is required. The Detail screen will close. Re-select the xTAG within the list and it will be opened without the need to enter a passkey to pair as the xTAG will be bonded to the Android device.

If a JustWorks Dialog is opened, just select “Pair” instead of entering a passkey. The xTAG will be bonded to the Android device for subsequent secure connections.

When the Detail screen is opened by selecting a device, data is fetched from the xTAG and information such as the Group and Device IDs are displayed as shown in the figure below.



To see more xTAG device details, click on the icon to open the “xTAG Details” dialog box shown below.



The details include hardware and firmware revisions, how long firmware has been running and the currently stored Unix time within the xTAG.

Additional functions supported within the Details screen are discussed below.

Set xTAG IDs, Tx Power and Time

To identify and group xTAGs for easier identification within the xTAG list shown in the Home screen, enter a group ID (0-255) and device ID (0-65535). Next, select an appropriate transmit power level. For applications with 10-15 meters transmission range, select 0 dbm to conserve xTAG power. Select 4 dbm for up to 100 m transmission range or 8 dbm for up to 300 m. Next, press the “Set IDs, Tx Power & Time” button to store IDs, transmit power and the Android device date and time within the xTAG. A temporary confirmation pop-up message will be displayed when the process is complete.

Calibrate the xTAG

Note that xTAGs are calibrated during assembly by Deviceworx, so users are not required to follow the steps below. The steps are documented to provide users with an understanding of the calibration process and for the sake of completeness.

Before calibration, the xTAG must be positioned correctly. To calibrate the x dimension, position the xTAG (with a level) with its back against a wall as shown below (xTAG positive X direction is pointed away from the center of the earth, or skyward). Adjust the tilt of the xTAG until it is level.



Next, press the CAL ACC-X button to perform the calibration and store calibration data within the xTAG. A confirmation pop-up message will be displayed when the calibration is complete (1 - 2 seconds later).

To calibrate the y dimension, position the xTAG (with a level) with its back against a wall as shown below (xTAG positive Y direction is pointed away from the center of the earth). Adjust the tilt of the xTAG until it is level.



Next, press the CAL ACC-Y button to perform the calibration and store calibration data within the xTAG. A confirmation pop-up message will be displayed when the calibration is complete.

To calibrate the z dimension, position the xTAG on a flat, level surface (use a level to confirm) as shown below (xTAG positive Z direction is pointed away from the center of the earth).



Next, press the CAL ACC-Z button to perform the calibration and store calibration data within the xTAG. A confirmation pop-up message will be displayed when the calibration is complete.

Configure the xTAG Accelerometer

Before acquisition, the xTAG's accelerometer should be configured for use.

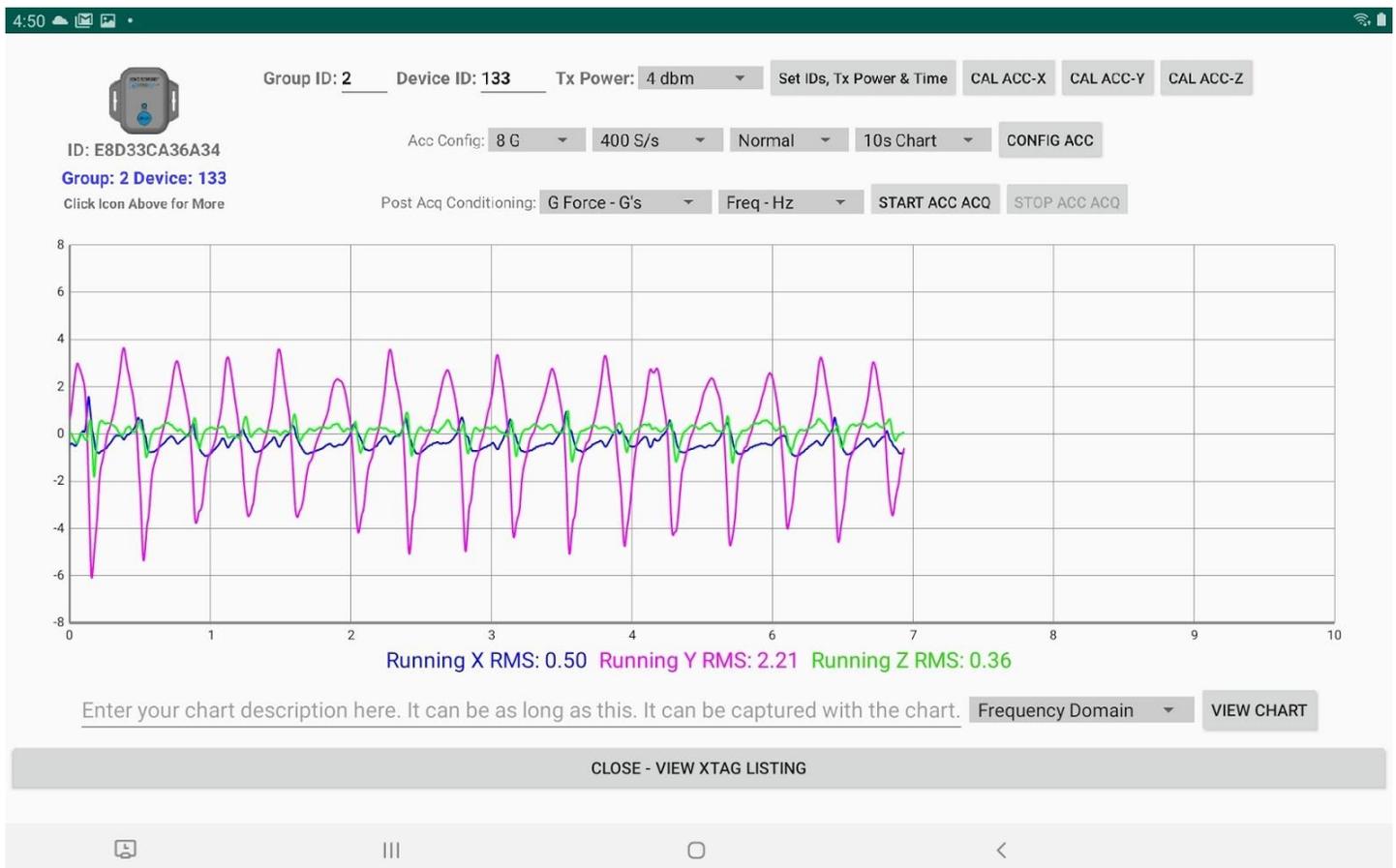
Select the G-Range (+/-2 to +/-16 G), Sample Rate (25 to 1600 Samples/Sec) and chip data filtering (Normal - no oversampling, OSR2 - oversampling with rate of 2, OSR4 - oversampling with rate of 4). The length of the visible stream chart (in seconds) should also be selected. To view the most detail per second, select a 5 second chart. To view the least detail per second, but show more data, select a 20 second chart. A 10 second chart is also available as a compromise. Next, press the CONFIG ACC button to configure the accelerometer within the xTAG and set up the stream chart x axis and y axis values. After the xTAG accelerometer is configured, the START ACC ACQ button will become enabled and sampling with stream chart view is possible.

Acquire a Stream of Accelerometer G-Force Data

To acquire a stream of accelerometer data, ensure that the xTAG is configured as described above.

Next, select conditioning options that will control how data is conditioned after acquisition (to support subsequent charting). G Force can be charted in Standard Gs or inches per second squared and frequency spectrum data can be charted in Hz (cycles per second) or Cycles Per Minute (CPM).

When ready to acquire data, press the START ACC ACQ button. Data acquisition will start and acquired data will be streamed to the chart as shown in the example screen capture below.



Incoming data will be stored within a First In First Out (FIFO) buffer that is **up to** 16k (16 X 1024) samples in size. When more than 16k samples are acquired, older data will be replaced within the FIFO and its stored sample count will remain at 16k. At the fastest sample rate (1600 samples / second) the FIFO will support just over 10 seconds of data.

Streaming chart data will be plotted from left to right. When the chart is full, it will be cleared/wiped and new data will be plotted on the left at the chart origin. This charting approach is taken to ensure that charted data does not move on the screen for easier interpretation.

Note that the stream chart may show more than 16k samples (i.e. when 20 second length is selected with a sample rate of 1600 samples / second) as it uses a separate buffer.

When finished acquiring data, press the STOP ACC ACQ button. All buffered data will remain in the 16k buffer. Further chart views of this 16k data buffer can be selected after acquisition has completed (described below).

Real Time RMS Calculations

Whenever acquisition of a data stream occurs, a real-time Root Mean Square (RMS) calculation on each dimension (X, Y and Z) is performed on incoming stream data. This supports the simplest form of comparison for machine vibration dynamics. Previously recorded RMS values can be compared to current RMS values. All available data within the 16k buffer is used to calculate RMS values. Whenever data samples are replaced within the 16k buffer, their contribution to the RMS value is subtracted; thus the RMS calculations are always on the moving 16k window for streaming data.

Charts Detailing Buffered Data

To get more detail on acquired data within the 16k buffer, users can view additional charts. To open any chart type, first press the STOP ACC ACQ button to stop streaming. Next, an optional chart description can be provided below the stream chart within the edit box provided. This description is useful if the viewed chart is to be exported for later reference (described within [Chart Screen Capture Exports](#) and [Chart CSV File Exports](#) sections that follow). Next, select a chart type: "Time Domain" - showing the raw data that is visible in the stream chart with additional detail or "Frequency Domain" - showing frequency spectrum components of the data. Lastly, press the VIEW CHART button to open the chart type within a new screen.

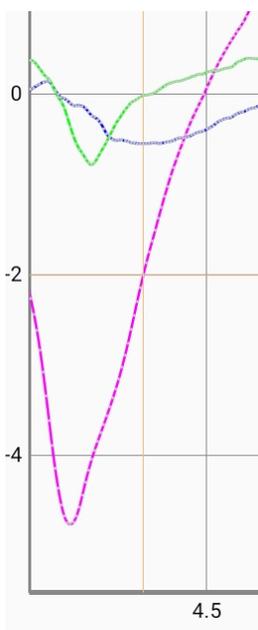
Chart Zoom and Scroll Control

For all chart types, the touchscreen can be used to zoom in and out within the chart view (tighten pinched fingers **horizontally** with sustained touch to zoom out or widen fingers **horizontally** to zoom in). Note that the x-axis scale values will change based on the amount of zoom applied and the y-axis will change automatically as the chart will automatically scale vertically to properly show data within the chart view.

To scroll left or right, simply drag a single finger **horizontally** on the touchscreen. X-axis values will scroll to match movement and y-axis values will change automatically as the chart scales data vertically to best show data within the chart view.

Chart Data Selection

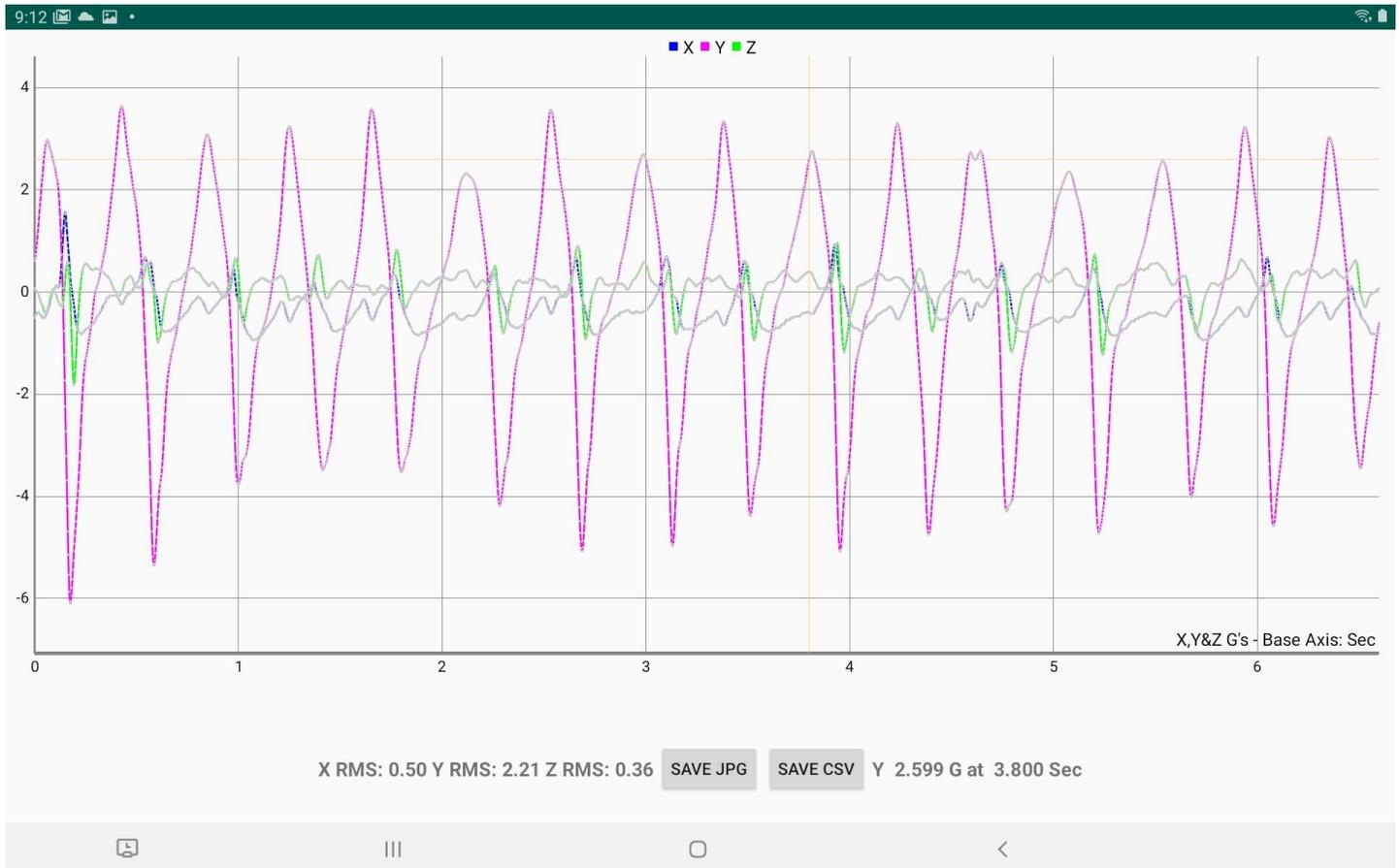
Carefully touch any line within a chart and the closest line data point to the touch will be selected as indicated by a thin orange crosshair. Data values that correspond to the selected point will be shown below the chart. See the figures below for an example crosshair with corresponding values. Note that each data point on chart lines is denoted by a small grey dot and when data points are compressed, lines can look grey in color.



Y -2.003 G at 4.448 Sec

Time Domain Chart

The Time Domain chart data contents will match the last 16k buffer samples displayed within the stream chart. In most cases, it will show all data in the stream chart. Its purpose is to provide more waveform detail to users. An example Time Domain chart is shown below.



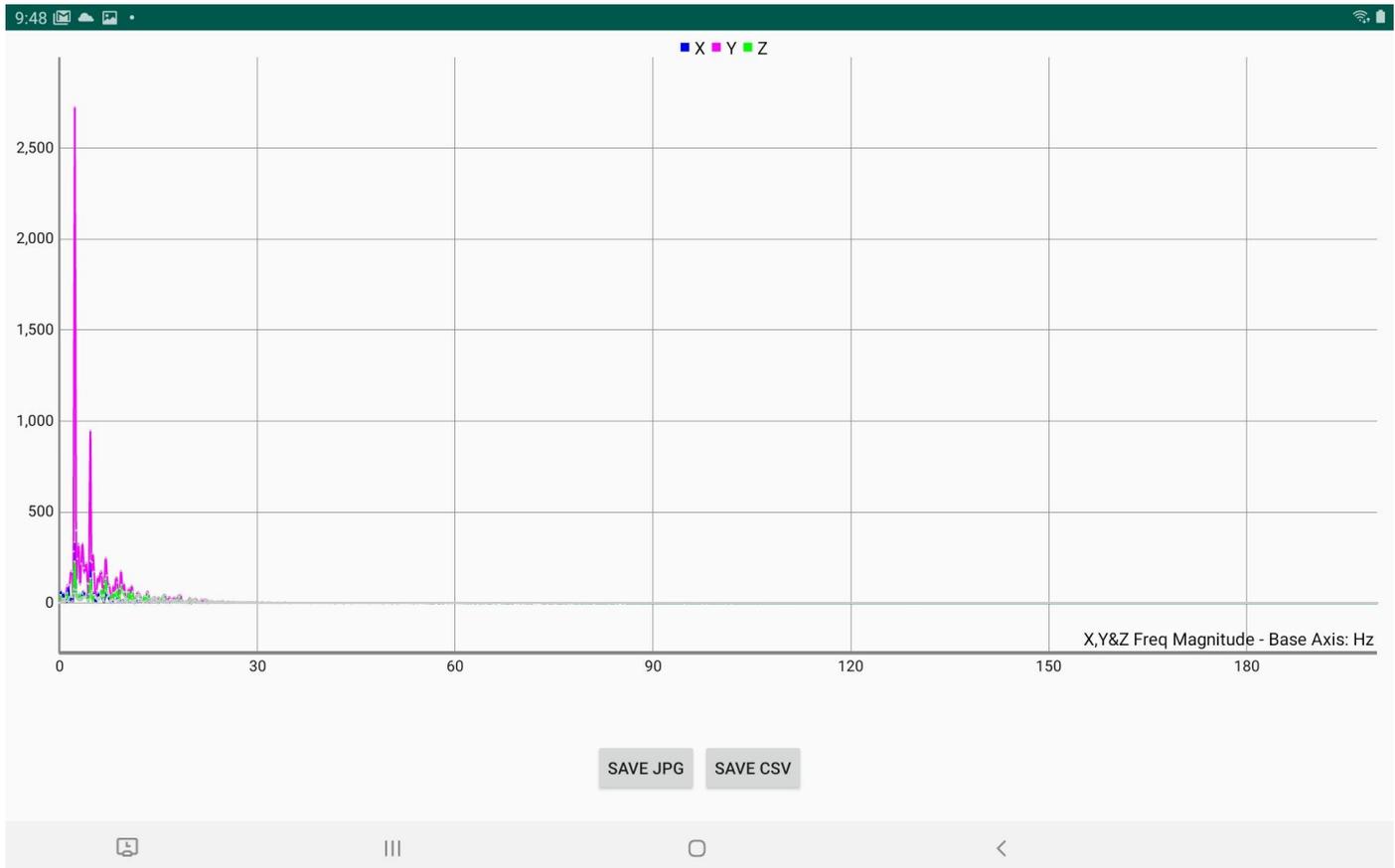
Zoom and scroll the chart to see more data detail (specific steps within [Chart Zoom and Scroll Control](#) above).

Select any data point to retrieve its explicit values (specific steps within [Chart Data Selection](#) above).

Note that X, Y and Z RMS values are shown below the chart. These values are calculated using the same sample data charted. When chart data is exported to a CSV file (as described within [Chart CSV File Exports](#) below), these displayed values are exported along with the raw sample data.

Frequency Spectrum Chart

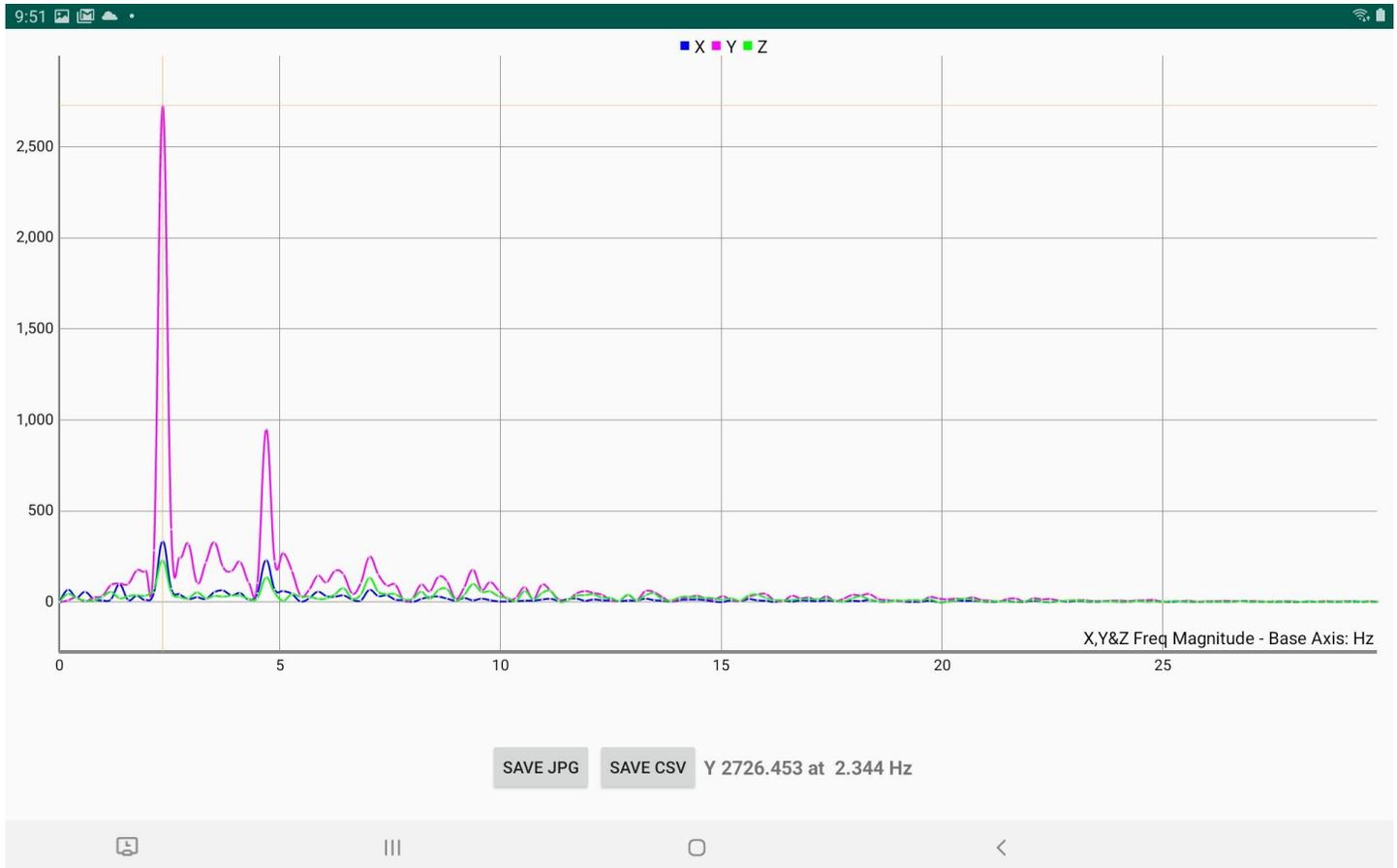
Frequency components of the last 16k buffer samples acquired will be displayed within the Frequency Domain chart. The number of frequencies charted will depend on the number of samples. Often, far more frequencies are displayed than is required and therefore data zoom and scroll to lower frequencies will be common. The figure below shows this.



Zoom and scroll the chart to see more data detail (specific steps within [Chart Zoom and Scroll Control](#) above).

Select any data point to retrieve its explicit values (specific steps within [Chart Data Selection](#) above).

Scrolling to show 0 - 30 Hz in the above figure shows more detail as indicated in the figure below (i.e. this is the same chart with zoom to 30 Hz width for the entire chart and scroll to the left end of the chart).



As depicted in figure above, selecting a frequency data point shows detailed magnitude and frequency values.

A Note About Frequency Domain Chart Amplitude

Due to the nature of the Fast Fourier Transform (FFT) algorithm used to calculate the frequency of acquired data, the magnitude at each frequency is related to the number of samples processed and does not reflect the actual amplitude of accelerometer data at each frequency charted. The charted amplitude is simply a relative indication of frequency components within sampled data.

Chart Screen Capture Exports

To diagnose machine degradation over time, users can store chart images using the SAVE JPG button.

Chart jpg files are stored within the tablet \Download folder.

Chart jpg file names conform to the following format:

xTagChart_[Type]_[Customer ID]_[Device ID]_[YYYYMMDDHHmmSS].jpg

- [Type] denotes “Acc” (Time Domain raw accelerometer data) or “Freq” (Frequency Domain data).
- [Customer ID] denotes the operator controlled customer ID.
- [Device ID] denotes the static device ID.
- [YYYYMMDDHHmmSS] denotes file creation year, month, day, hour, min and second.

An example filename is: xTagChart_Freq_01_F9EACA2541C0_20210121100656.jpg

Chart CSV File Exports

To diagnose machine degradation over time or to create custom reports within Microsoft Excel, users can store chart data with Comma Separated Values (CSV) files using the SAVE CSV button.

Chart csv files are stored within the tablet \Download folder.

Chart csv file names conform to the following format:

xTagChart_[Type]_[Customer ID]_[Device ID]_[YYYYMMDDHHmmSS].csv

- [Type] denotes “Acc” (Time Domain raw accelerometer data) or “Freq” (Frequency Domain data).
- [Customer ID] denotes the operator controlled customer ID.
- [Device ID] denotes the universal static device ID.
- [YYYYMMDDHHmmSS] denotes file creation year, month, day, hour, min and second.

An example filename is: xTagChart_Acc_01_F9EACA2541C0_20210121101724.csv

Time Domain CSV

The first row of each csv file contains information about the data set that follows.

The first row contains (left to right, separated by commas):

“Description:”,

[Description (the user entered description before viewing the chart)],

“GRange:”,

[Selected G Range for the data (e.g. “2” or “4” or “8” “16”)],

“Filter:”,

[0 denoting normal, or 1 denoting 2 times oversampling or 2 denoting 4 times oversampling],

“ODR:”,

[Output data rate (e.g. “25”, “50” ... “1600” denoting samples/second),

“X RMS:”,

[Calculated RMS value for dimension X within the data],

“Y RMS:”,

[Calculated RMS value for dimension Y within the data],

“Z RMS:”,

[Calculated RMS value for dimension Z within the data]

An example first row is:

“Description:,Chart 1,GRange:,8,Filter:,0,ODR:,400,X RMS:,0.5,Y RMS:,2.21,Z RMS:,0.36

Each following row describes a data sample with time (seconds) in the 1st column, x dim data in the 2nd column, y dim data in the 3rd column, z dim data in the 4th column.

Frequency Domain CSV

The first row of each csv file contains information about the data set that follows.

The first row contains (left to right, separated by commas):

“Description:”,

[Description (the user entered description before viewing the chart)],

“GRange:”,

[Selected G Range for the data (e.g. “2” or “4” or “8” “16”)],

“Filter:”,

[0 denoting normal, or 1 denoting 2 times oversampling or 2 denoting 4 times oversampling],

“ODR:”,

[Output data rate (e.g. “25”, “50” ... “1600” denoting samples/second),

“Num Freq Bins:”,

[The number of frequency “bins” used in fast fourier transform calc of frequency data]

An example first row is:

“Description:,Chart 1,GRange:,8,Filter:,0,ODR:,400,Num Freq Bins:,1024

The following rows include frequency (hz or cpm) in the first column, x dim frequency bin data in the 2nd column, y dim frequency bin data in the 3rd column, z dim frequency bin data in the 4th column.

Power Budgeting

Preliminary empirical measurements and calculations support the following use-case power budgets (i.e. how long the xTAG will run from a battery). These budgets are provided as means of planning how long xTAG batteries should last.

Beaconing Only

xTAGs will beacon every 2 sec and are expected to draw approx 150 mAHr per year. A CR-123A battery with 1500 mAHr capacity should last 7-8 years with self-discharge taken into account.

Daily Data Acquisition

If a 5 sec sample is acquired from the xTAG daily, it is expected to draw approximately 160 mAHr per year. Expect a battery life of 6-7 years for this use-case.