
enDAQ Documentation

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ENDAQ API REFERENCE

1.1 endaq.ide

The submodule `endaq.ide` contains utility functions for accessing data in *Mide Instrumentation Data Exchange* (.IDE) files, the native format generated by enDAQ data recorders.

1.1.1 endaq.ide.measurement

The module `endaq.ide.measurement` provides an abstract representation of measurement types for easily retrieving specific data from .ide files. Several functions in `endaq.ide` accept combinations of `MeasurementType` constants for filtering datasets by sensor type.

Measurement types are represented by a set of singleton instances of `MeasurementType`.

```
import endaq.ide
from endaq.ide.measurement import *

doc = endaq.ide.get_doc("https://info.endaq.com/hubfs/data/surgical-instrument.ide")
endaq.ide.get_channels(doc, ACCELERATION)
endaq.ide.get_channels(doc, TEMPERATURE+PRESSURE)
```

Strings may also be used, either in combination with or instead of, the `MeasurementType` instances. The strings can be abbreviated, but no shorter than three characters.

```
endaq.ide.get_channels(doc, "acceleration")
endaq.ide.get_channels(doc, "accel")
endaq.ide.get_channels(doc, ACCELERATION+"temp")
```

`endaq.ide.measurement.ACCELERATION = <MeasurementType: Acceleration>`
Marker object for filtering channels with acceleration data

`endaq.ide.measurement.ANY = <MeasurementType: Any/all>`
Marker object for matching any/all measurement types

`endaq.ide.measurement.AUDIO = <MeasurementType: Audio>`
Marker object for filtering channels with sound level data

`endaq.ide.measurement.HUMIDITY = <MeasurementType: Relative Humidity>`
Marker object for filtering channels with (relative) humidity data

`endaq.ide.measurement.LIGHT = <MeasurementType: Light>`
Marker object for filtering channels with light intensity data

`endaq.ide.measurement.LOCATION = <MeasurementType: Location>`
Marker object for filtering channels with location data

`endaq.ide.measurement.ORIENTATION = <MeasurementType: Orientation>`
Marker object for filtering channels with rotation/orientation data

`endaq.ide.measurement.PRESSURE = <MeasurementType: Pressure>`
Marker object for filtering channels with air pressure data

`endaq.ide.measurement.ROTATION = <MeasurementType: Rotation>`
Marker object for filtering channels with angular change rate data

`endaq.ide.measurement.SPEED = <MeasurementType: Speed>`
Marker object for filtering channels with rate-of-speed data

`endaq.ide.measurement.TEMPERATURE = <MeasurementType: Temperature>`
Marker object for filtering channels with temperature data

`endaq.ide.measurement.TIME = <MeasurementType: Time>`
Marker object for filtering channels with time data

1.1.2 endaq.ide Usage Examples

Note: For brevity, the following examples assume everything has been imported from *endaq.ide*:

```
from endaq.ide import *
```

Opening IDE files: `endaq.ide.get_doc()`

endaq.ide includes a convenient shortcut for importing IDE data: `get_doc()`. It can load data from local files, or read data directly from a URL.

```
doc = get_doc("tests/test.ide")
doc1 = get_doc("https://info.endaq.com/hubfs/data/surgical-instrument.ide")
```

IDE files can be retrieved directly from Google Drive using a Drive ‘sharable link’ URL. The file must be set to allow access to “Anyone with the link.”

```
doc2 = get_doc("https://drive.google.com/file/d/1t3JqbZGhuZbIK9agH24YZIdVE26-NOF5/view?
↳usp=sharing")
```

Whether opening a local file or a URL, `get_doc()` can be used to import only a specific interval by way of its `start` and `end` parameters:

```
doc3 = get_doc("tests/test.ide", start="5s", end="10s")
```

Summarizing IDE files: `endaq.ide.get_channel_table()`

Once an IDE file has been loaded, `get_channel_table()` will retrieve basic summary information about its contents.

```
get_channel_table(doc)
```

The results can be filtered by *measurement type*:

```
get_channel_table(doc, ACCELERATION)
```

Measurement types can be combined to retrieve more than one:

```
get_channel_table(doc, ACCELERATION+TEMPERATURE)
```

Information about a specific interval can be retrieved by using the `start` and/or `end` arguments. Note that due to different sampling rates, the start and end times for slower channels may not precisely match the specified `start` or `end`.

```
get_channel_table(doc, ACCELERATION+TEMPERATURE, start="0:05", end="0:10")
```

Extracting intervals: `endaq.ide.extract_time()`

A portion of an IDE file can be saved to another, new IDE. The source can be a local filename or an opened IDE (from a file or URL).

```
extract_time("tests/test.ide", "doc_extracted.ide", start="0:05", end="0:10")
extract_time(doc1, "doc1_extracted.ide", start="0:05", end="0:10")
```

Additional sample IDE recording files

Here are a number of example IDE files, which may be used with `endaq.ide`:

```
file_urls = ['https://info.endaq.com/hubfs/data/surgical-instrument.ide',
             'https://info.endaq.com/hubfs/data/97c3990f-Drive-Home_70-1616632444.ide',
             'https://info.endaq.com/hubfs/data/High-Drop.ide',
             'https://info.endaq.com/hubfs/data/HiTest-Shock.ide',
             'https://info.endaq.com/hubfs/data/Drive-Home_01.ide',
             'https://info.endaq.com/hubfs/data/Tower-of-Terror.ide',
             'https://info.endaq.com/hubfs/data/Punching-Bag.ide',
             'https://info.endaq.com/hubfs/data/Gun-Stock.ide',
             'https://info.endaq.com/hubfs/data/Seat-Base_21.ide',
             'https://info.endaq.com/hubfs/data/Seat-Top_09.ide',
             'https://info.endaq.com/hubfs/data/Bolted.ide',
             'https://info.endaq.com/hubfs/data/Motorcycle-Car-Crash.ide',
             'https://info.endaq.com/hubfs/data/train-passing.ide',
             'https://info.endaq.com/hubfs/data/baseball.ide',
             'https://info.endaq.com/hubfs/data/Clean-Room-VC.ide',
             'https://info.endaq.com/hubfs/data/enDAQ_Cropped.ide',
             'https://info.endaq.com/hubfs/data/Drive-Home_07.ide',
             'https://info.endaq.com/hubfs/data/ford_f150.ide',
             'https://info.endaq.com/hubfs/data/Drive-Home.ide',
```

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```
'https://info.endaq.com/hubfs/data/Mining-Data.ide',
'https://info.endaq.com/hubfs/data/Mide-Airport-Drive-Lexus-Hybrid-Dash-W8.
→ide']
```

These can be directly read from endaq.com using `endaq.ide.get_doc()`, as previously described.

`endaq.ide.extract_time(doc, out, start=0, end=None, channels=None, **kwargs)`

Efficiently extract data within a certain interval from an IDE file, writing it to another file. Note that due to the way data is stored in an IDE, the exported interval will be slightly wider than the specified start and end times; this ensures the data is copied verbatim and without loss.

The *start* and *end* times, if used, may be specified in several ways:

- *int/float* (Microseconds from the recording start)
- *str* (formatted as a time from the recording start, e.g., *MM:SS*, *HH:MM:SS*, *DDd HH:MM:SS*). More examples:
 - *" :01 "* or *" :1 "* or *" 1s "* (1 second)
 - *" 22:11 "* (22 minutes, 11 seconds)
 - *" 3:22:11 "* (3 hours, 22 minutes, 11 seconds)
 - *" 1d 3:22:11 "* (1 day, 3 hours, 22 minutes, 11 seconds)
- *datetime.timedelta* or *pandas.Timedelta* (time from the recording start)
- *datetime.datetime* (an explicit UTC time)

Parameters

- **doc** – A *Dataset* or the name of a local IDE file. *Dataset* objects do not have to be fully imported.
- **out** – A filename or stream to which to save the extracted data.
- **start** – The starting time. Defaults to the start of the recording.
- **end** – The ending time. Defaults to the end of the recording.
- **channels** – A list of channel IDs to specifically export. If *None*, all channels will be exported. Note excluded channels will still appear in the new IDE's *channels* dictionary, but the file will contain no data for them.

Returns The total number of bytes written, and total number of *ChannelDataBlock* elements copied.

`endaq.ide.filter_channels(channels, measurement_type=<MeasurementType: Any/all>)`

Filter a list of *Channel* and/or *SubChannel* instances by their measurement type(s).

Parameters

- **channels** – A list or dictionary of channels/subchannels to filter.
- **measurement_type** – A *MeasurementType*, a measurement type 'key' string, or a string of multiple keys generated by adding and/or subtracting *MeasurementType* objects. Any 'subtracted' types will be excluded.

`endaq.ide.get_channel_table(dataset, measurement_type=<MeasurementType: Any/all>, start=0, end=None, formatting=None, index=True, precision=4, timestamps=False, **kwargs)`

Get summary data for all *SubChannel* objects in a *Dataset* that contain one or more type of sensor data. By using the optional *start* and *end* parameters, information can be retrieved for a specific interval of time.

The *start* and *end* times, if used, may be specified in several ways:

- *int/float* (Microseconds from the recording start)
- *str* (formatted as a time from the recording start, e.g., *MM:SS*, *HH:MM:SS*, *DDd HH:MM:SS*). More examples:
 - *" :01 "* or *" :1 "* or *" 1s "* (1 second)
 - *" 22 : 11 "* (22 minutes, 11 seconds)
 - *" 3 : 22 : 11 "* (3 hours, 22 minutes, 11 seconds)
 - *" 1d 3 : 22 : 11 "* (1 day, 3 hours, 22 minutes, 11 seconds)
- *datetime.timedelta* or *pandas.Timedelta* (time from the recording start)
- *datetime.datetime* (an explicit UTC time)

Parameters

- **dataset** – A *idelib.dataset.Dataset* or a list of channels/subchannels from which to build the table.
- **measurement_type** – A *MeasurementType*, a measurement type ‘key’ string, or a string of multiple keys generated by adding and/or subtracting *MeasurementType* objects to filter the results. Any ‘subtracted’ types will be excluded.
- **start** – The starting time. Defaults to the start of the recording.
- **end** – The ending time. Defaults to the end of the recording.
- **formatting** – A dictionary of additional style/formatting items (see *pandas.DataFrame.style.format()*). If *False*, no additional formatting is applied.
- **index** – If *True*, show the index column on the left.
- **precision** – The default decimal precision to display. Can be changed later.
- **timestamps** – If *True*, show the start and end as raw microsecond timestamps.

Returns A table (*pandas.io.formats.style.Styler*) of summary data.

Return type *pandas.DataFrame*

`endaq.ide.get_channels(dataset, measurement_type=<MeasurementType: Any/all>, subchannels=True)`
Get a list of *Channel* or *SubChannel* instances from a *Dataset* by their measurement type(s).

Parameters

- **dataset** – The *Dataset* from which to retrieve the list.
- **measurement_type** – A *MeasurementType*, a measurement type ‘key’ string, or a string of multiple keys generated by adding and/or subtracting *MeasurementType* objects. Any ‘subtracted’ types will be excluded.
- **subchannels** – If *False*, get only *Channel* objects. If *True*, get only *SubChannel* objects.

Returns A list of matching *SubChannel* instances from the *Dataset*.

`endaq.ide.get_doc(name=None, filename=None, url=None, parsed=True, start=0, end=None, localfile=None, params=None, headers=None, cookies=None, **kwargs)`

Retrieve an IDE file from either a file or URL.

Note: *name*, *filename*, and *url* are mutually exclusive arguments. One and only one must be specified. Attempting to supply more than one will generate an error.

Example usage:

```
get_doc("my_recording.ide")
get_doc("https://example.com/remote_recording.ide")
get_doc(filename="my_recording.ide")
get_doc(url="https://example.com/remote_recording.ide")
get_doc(filename="my_recording.ide", start="1:23")
```

The *start* and *end* times, if used, may be specified in several ways:

- *int/float* (Microseconds from the recording start)
- *str* (formatted as a time from the recording start, e.g., *MM:SS*, *HH:MM:SS*, *DDd HH:MM:SS*). More examples:
 - *" :01 "* or *" :1 "* or *" 1s "* (1 second)
 - *" 22:11 "* (22 minutes, 11 seconds)
 - *" 3:22:11 "* (3 hours, 22 minutes, 11 seconds)
 - *" 1d 3:22:11 "* (1 day, 3 hours, 22 minutes, 11 seconds)
- *datetime.timedelta* or *pandas.Timedelta* (time from the recording start)
- *datetime.datetime* (an explicit UTC time)

Parameters

- **name** – The name or URL of the IDE. The method of fetching it will be automatically chosen based on how it is formatted.
- **filename** – The name of an IDE file. Supplying a name this way will force it to be read from a file, avoiding the possibility of accidentally trying to retrieve it via URL.
- **url** – The URL of an IDE file. Supplying a name this way will force it to be read from a URL, avoiding the possibility of accidentally trying to retrieve it from a local file.
- **parsed** – If *True* (default), the IDE will be fully parsed after it is fetched. If *False*, only the file metadata will be initially loaded, and a call to *idelib.importer.readData()*. This can save time.
- **start** – The starting time. Defaults to the start of the recording. Only applicable if *parsed* is *True*.
- **end** – The ending time. Defaults to the end of the recording. Only applicable if *parsed* is *True*.
- **localfile** – The name of the file to which to write data recieved from a URL. If none is supplied, a temporary file will be used. Only applicable when opening a URL.
- **params** – Additional URL request parameters. Only applicable when opening a URL.
- **headers** – Additional URL request headers. Only applicable when opening a URL.
- **cookies** – Additional browser cookies for use in the URL request. Only applicable when opening a URL.

Returns The fetched IDE data.

Additionally, *get_doc()* will accept the keyword arguments for *idelib.importer.importFile()* or *idelib.importer.openFile()*

`endaq.ide.get_measurement_type(channel)`

Get the appropriate *MeasurementType* object for a given *SubChannel*. Calling with a *Channel* returns a list of *MeasurementType* objects, with one for each child *SubChannel*.

Parameters `channel` – A *Channel* or *SubChannel* instance (e.g., from a *Dataset*).

Returns A *MeasurementType* object (for a *SubChannel*), or a list of *MeasurementType* objects (one for each child) if a *Channel* was supplied.

`endaq.ide.to_pandas(channel, time_mode='datetime')`

Read IDE data into a pandas DataFrame.

Parameters

- **channel** (`Union[idelib.dataset.Channel, idelib.dataset.SubChannel]`) – a *Channel* object, as produced from *Dataset.channels* or *endaq.ide.get_channels*
- **time_mode** (`Literal['seconds', 'timedelta', 'datetime']`) – how to temporally index samples; each mode uses either relative times (with respect to the start of the recording) or absolute times (i.e., date-times):
 - “seconds” - a *pandas.Float64Index* of relative timestamps, in seconds
 - “timedelta” - a *pandas.TimeDeltaIndex* of relative timestamps
 - “datetime” - a *pandas.DateTimeIndex* of absolute timestamps

Returns a *pandas.DataFrame* containing the channel’s data

Return type `pandas.core.frame.DataFrame`

1.2 endaq.calc

`endaq.calc` is a module comprising a collection of common calculations for vibration analysis. It leverages the standard Python scientific stack (NumPy, SciPy, Pandas) in order to enable engineers to perform domain-specific calculations in a few lines of code, without having to first master Python and its scientific stack in their entirety.

1.2.1 endaq.calc Usage Examples

Filters

```
df_accel_highpass = endaq.calc.filters.butterworth(df_accel, low_cutoff=1, high_
↪cutoff=None)
df_accel_lowpass = endaq.calc.filters.butterworth(df_accel, low_cutoff=None, high_
↪cutoff=100)
```

Integration

```
dfs_integrate = endaq.calc.integrate.integrals(df_accel, n=2, highpass_cutoff=1.0, tukey_
↳percent=0.05)
```

PSD

Linearly-spaced

```
df_accel_psd = endaq.calc.psd.welch(df_accel, bin_width=1/11)
```

Octave-spaced

```
df_accel_psd_oct = endaq.calc.psd.to_octave(df_accel_psd, fstart=1, octave_bins=3)
```

Derivatives & Integrals

```
df_vel_psd = endaq.calc.psd.differentiate(df_accel_psd, n=-1)
df_jerk_psd = endaq.calc.psd.differentiate(df_accel_psd, n=1)
```

Vibration Criterion (VC) Curves

```
df_accel_vc = endaq.calc.psd.vc_curves(df_accel_psd, fstart=1, octave_bins=3)
```

Shock Analysis

```
df_accel_pvss = endaq.calc.shock.shock_spectrum(df_accel, freqs=2 ** np.arange(-10, 13,
↳0.25), damp=0.05, mode="pvss")
df_accel_srs = endaq.calc.shock.shock_spectrum(df_accel, freqs=[1, 10, 100, 1000],
↳damp=0.05, mode="srs")
```

Shock Characterization: Half-Sine-Wave Pulse

```
half_sine_params = endaq.calc.shock.enveloping_half_sine(df_accel_pvss, damp=0.05)
```

1.2.2 endaq.calc.filters

`endaq.calc.filters.butterworth(df, low_cutoff=1.0, high_cutoff=None, half_order=3, tukey_percent=0.0)`
Apply a lowpass and/or a highpass Butterworth filter to an array.

This function uses Butterworth filter designs, and implements the filter(s) as bi-directional digital biquad filters, split into second-order sections.

Parameters

- **df** (*pandas.core.frame.DataFrame*) – the input data; cutoff frequencies are relative to the timestamps in *df.index*
- **low_cutoff** (*Optional[float]*) – the low-frequency cutoff, if any; frequencies below this value are rejected, and frequencies above this value are preserved
- **high_cutoff** (*Optional[float]*) – the high-frequency cutoff, if any; frequencies above this value are rejected, and frequencies below this value are preserved
- **half_order** (*int*) – half of the order of the filter; higher orders provide more aggressive stopband reduction
- **tukey_percent** (*float*) – the alpha parameter of a preconditioning Tukey filter; if 0 (default), no filter is applied

Returns the filtered data

Return type *pandas.core.frame.DataFrame*

See also:

- [SciPy Butterworth filter design](#) Documentation for the butterworth filter design function.
- [SciPy Tukey window](#) Documentation for the Tukey window function used in preprocessing.

1.2.3 endaq.calc.integrate

`endaq.calc.integrate.integrals(df, n=1, zero='start', highpass_cutoff=None, tukey_percent=0.0)`
Calculate *n* integrations of the given data.

Parameters

- **df** (*pandas.core.frame.DataFrame*) – the data to integrate, indexed with timestamps
- **n** (*int*) – the number of integrals to calculate; defaults to 1
- **zero** (*Union[Literal['start', 'mean', 'median'], Callable]*) – the output quantity driven to zero by the integration constant; “start” (default) chooses an integration constant of `-output[0]`, “mean” chooses `-np.mean(output)` & “median” chooses `-np.median(output)`
- **highpass_cutoff** (*Optional[float]*) – the cutoff frequency for the initial highpass filter; this is used to remove artifacts caused by DC trends
- **tukey_percent** (*float*) – the alpha parameter of a preconditioning Tukey filter; if 0 (default), no filter is applied

Returns a length *n+1* list of the kth-order integrals from 0 to *n* (inclusive)

Return type *List[pandas.core.frame.DataFrame]*

See also:

- [SciPy trapezoid integration](#) Documentation for the integration function used internally.
- [SciPy Butterworth filter design](#) Documentation for the butterworth filter design function used in preprocessing.
- [SciPy Tukey window](#) Documentation for the Tukey window function used in preprocessing.

`endaq.calc.integrate.iter_integrals(df, zero='start', highpass_cutoff=None, tukey_percent=0.0)`

Iterate over conditioned integrals of the given original data.

Parameters

- **df** (`pandas.core.frame.DataFrame`) – the input data
- **zero** (`Union[Literal['start', 'mean', 'median'], Callable]`) – the output quantity driven to zero by the integration constant; “start” (default) chooses an integration constant of `-output[0]`, “mean” chooses `-np.mean(output)` & “median” chooses `-np.median(output)`
- **highpass_cutoff** (`Optional[float]`) – the cutoff frequency of a preconditioning high-pass filter; if None, no filter is applied
- **tukey_percent** (`float`) – the alpha parameter of a preconditioning Tukey filter; if 0 (default), no filter is applied

Returns an iterable over the data’s successive integrals; the first item is the preconditioned input data

Return type `Iterable[pandas.core.frame.DataFrame]`

See also:

- [SciPy trapezoid integration](#) Documentation for the integration function used internally.
- [SciPy Butterworth filter design](#) Documentation for the butterworth filter design function used in preprocessing.
- [SciPy Tukey window](#) Documentation for the Tukey window function used in preprocessing.

1.2.4 endaq.calc.psd

`endaq.calc.psd.differentiate(df, n=1.0)`

Perform time-domain differentiation on periodogram data.

Parameters

- **df** (`pandas.core.frame.DataFrame`) – a periodogram
- **n** (`float`) – the time derivative order; negative orders represent integration

Returns a periodogram of the time-derived data

Return type `pandas.core.frame.DataFrame`

`endaq.calc.psd.to_jagged(df, freq_splits, agg='mean')`

Calculate a periodogram over non-uniformly spaced frequency bins.

Parameters

- **df** (`pandas.core.frame.DataFrame`) – the returned values from `endaq.calc.psd.welch`
- **freq_splits** (`numpy.array`) – the boundaries of the frequency bins; must be strictly increasing

- **agg** (*Union[Literal['mean', 'sum'], Callable[[numpy.ndarray, int], float]]*) – the method for aggregating values into bins; ‘mean’ preserves the PSD’s area-under-the-curve, ‘sum’ preserves the PSD’s “energy”

Returns a periodogram with the given frequency spacing

Return type pandas.core.frame.DataFrame

`endaq.calc.psd.to_octave(df, fstart=1.0, octave_bins=12.0, **kwargs)`

Calculate a periodogram over log-spaced frequency bins.

Parameters

- **df** (*pandas.core.frame.DataFrame*) – the returned values from `endaq.calc.psd.welch`
- **fstart** (*float*) – the first frequency bin, in Hz; defaults to 1 Hz
- **octave_bins** (*float*) – the number of frequency bins in each octave; defaults to 12
- **kwargs** – other parameters to pass directly to `to_jagged`

Returns a periodogram with the given logarithmic frequency spacing

Return type pandas.core.frame.DataFrame

`endaq.calc.psd.vc_curves(accel_psd, fstart=1.0, octave_bins=12.0)`

Calculate Vibration Criterion (VC) curves from an acceleration periodogram.

Parameters

- **accel_psd** (*pandas.core.frame.DataFrame*) – a periodogram of the input acceleration
- **fstart** (*float*) – the first frequency bin
- **octave_bins** (*float*) – the number of frequency bins in each octave; defaults to 12

Returns the Vibration Criterion (VC) curve of the input acceleration

Return type pandas.core.frame.DataFrame

`endaq.calc.psd.welch(df, bin_width=1.0, scaling=None, **kwargs)`

Perform *scipy.signal.welch* with a specified frequency spacing.

Parameters

- **df** (*pandas.core.frame.DataFrame*) – the input data
- **bin_width** (*float*) – the desired width of the resulting frequency bins, in Hz; defaults to 1 Hz
- **scaling** (*Optional[Literal[None, 'density', 'spectrum', 'parseval']]*) – the scaling of the output; “density” & “spectrum” correspond to the same options in `scipy.signal.welch`; “parseval” will maintain the “energy” between the input & output, s.t. `welch(df, scaling="parseval").sum(axis="rows")` is roughly equal to `df.abs().pow(2).sum(axis="rows")`
- **kwargs** – other parameters to pass directly to `scipy.signal.welch`

Returns a periodogram

Return type pandas.core.frame.DataFrame

See also:

- [SciPy Welch’s method](#) Documentation for the periodogram function wrapped internally.

- [Parseval's Theorem](#) - the theorem relating the RMS of a time-domain signal to that of its frequency spectrum

1.2.5 endaq.calc.shock

class endaq.calc.shock.HalfSineWavePulse(*amplitude, duration*)

The output data type for `enveloping_half_sine`.

The significant data members are *amplitude* and *duration*, which can simply be unpacked as if from a plain tuple:

```
ampl, T = enveloping_half_sine(df_pvss)
```

However, users can also elect to use the other methods of this class to generate other kinds of outputs.

Note: This class is not intended to be instantiated manually.

to_time_series(*tstart=None, tstop=None, dt=None, tpulse=None*)

Generate a time-series of the half-sine pulse.

Parameters

- **tstart** (*Optional[float]*) – the starting time of the resulting waveform; if *None* (default), the range starts at *tpulse*
- **tstop** (*Optional[float]*) – the ending time of the resulting waveform; if *None* (default), the range ends at *tpulse + duration*
- **dt** (*Optional[float]*) – the sampling period of the resulting waveform; defaults to 1/20th of the pulse duration
- **tpulse** (*Optional[float]*) – the starting time of the pulse within the resulting waveform; if *None* (default), the pulse starts at either:
 - *tstart*, if provided
 - *tstop - self.duration.max()*, if *tstop* is provided
 - `0.0` otherwise

Returns a time-series of the half-sine pulse

Return type `pandas.core.frame.DataFrame`

endaq.calc.shock.abs_accel(*accel, omega, damp=0.0*)

Calculate the absolute acceleration for a SDOF system.

The “absolute acceleration” follows the transfer function: $H(s) = L\{x''(t)\}(s) / L\{y''(t)\}(s) = X(s)/Y(s)$

for the PDE: $x'' + (2)x' + (2^2)x = (2)y' + (2^2)y$

Parameters

- **accel** (*pandas.core.frame.DataFrame*) – the absolute acceleration y''
- **omega** (*float*) – the natural frequency of the SDOF system
- **damp** (*float*) – the damping coefficient of the SDOF system

Returns the absolute acceleration x'' of the SDOF system

Return type `pandas.core.frame.DataFrame`

See also:

- [An Introduction To The Shock Response Spectrum](#), Tom Irvine, 9 July 2012
- [SciPy transfer functions](#) Documentation for the transfer function class used to characterize the relative displacement calculation.
- [SciPy biquad filter](#) Documentation for the biquad function used to implement the transfer function.

`endaq.calc.shock.enveloping_half_sine(pvss, damp=0.0)`

Characterize a half-sine pulse whose PVSS envelopes the input.

Parameters

- **pvss** (`pandas.core.frame.DataFrame`) – the PVSS to envelope
- **damp** (`float`) – the damping factor used to generate the input PVSS

Returns a tuple of amplitudes and periods, each pair of which describes a half-sine pulse

Return type `endaq.calc.shock.HalfSineWavePulse`

See also:

[Pseudo Velocity Shock Spectrum Rules For Analysis Of Mechanical Shock](#), Howard A. Gaberson

`endaq.calc.shock.rel_displ(accel, omega, damp=0.0)`

Calculate the relative displacement for a SDOF system.

The “relative” displacement follows the transfer function: $H(s) = L\{z(t)\}(s) / L\{y''(t)\}(s) = (1/s^2)(Z(s)/Y(s))$
for the PDE: $z'' + (2)z' + (2)z = -y''$

Parameters

- **accel** (`pandas.core.frame.DataFrame`) – the absolute acceleration y''
- **omega** (`float`) – the natural frequency of the SDOF system
- **damp** (`float`) – the damping coefficient of the SDOF system

Returns the relative displacement z of the SDOF system

Return type `pandas.core.frame.DataFrame`

See also:

- [Pseudo Velocity Shock Spectrum Rules For Analysis Of Mechanical Shock](#), Howard A. Gaberson
- [SciPy transfer functions](#) Documentation for the transfer function class used to characterize the relative displacement calculation.
- [SciPy biquad filter](#) Documentation for the biquad function used to implement the transfer function.

`endaq.calc.shock.shock_spectrum(accel, freqs, damp=0.0, mode='srs', two_sided=False, aggregate_axes=False)`

Calculate the shock spectrum of an acceleration signal.

Parameters

- **accel** (`pandas.core.frame.DataFrame`) – the absolute acceleration y''
- **freqs** (`numpy.ndarray`) – the natural frequencies across which to calculate the spectrum

- **damp** (*float*) – the damping coefficient, related to the Q-factor by $= 1/(2Q)$; defaults to 0
- **mode** (*Literal*['srs', 'pvss']) – the type of spectrum to calculate:
 - 'srs' (default) specifies the Shock Response Spectrum (SRS)
 - 'pvss' specifies the Pseudo-Velocity Shock Spectrum (PVSS)
- **two_sided** (*bool*) – whether to return for each frequency: both the maximum negative and positive shocks (*True*), or simply the maximum absolute shock (*False*; default)
- **aggregate_axes** (*bool*) – whether to calculate the column-wise resultant (*True*) or calculate spectra along each column independently (*False*; default)

Returns the shock spectrum

Return type pandas.core.frame.DataFrame

See also:

- [Pseudo Velocity Shock Spectrum Rules For Analysis Of Mechanical Shock](#), Howard A. Gaberson
- [An Introduction To The Shock Response Spectrum](#), Tom Irvine, 9 July 2012
- [SciPy transfer functions](#) Documentation for the transfer function class used to characterize the relative displacement calculation.
- [SciPy biquad filter](#) Documentation for the biquad function used to implement the transfer function.

1.2.6 endaq.calc.stats

`endaq.calc.stats.L2_norm(array, axis=None, keepdims=False)`

Compute the L2 norm (a.k.a. the Euclidean Norm).

Parameters

- **array** (*np.ndarray*) – the input array
- **axis** (*Union[None, typing.SupportsIndex, Sequence[typing.SupportsIndex]]*) – the axis/axes along which to aggregate; if *None* (default), the L2 norm is computed along the flattened array
- **keepdims** (*bool*) – if *True*, the axes which are reduced are left in the result as dimensions of size one; if *False* (default), the reduced axes are removed

Returns an array containing the computed values

Return type np.ndarray

`endaq.calc.stats.max_abs(array, axis=None, keepdims=False)`

Compute the maximum of the absolute value of an array.

This function should be equivalent to, but generally use less memory than `np.amax(np.abs(array))`.

Specifically, it generates the absolute-value maximum from `np.amax(array)` and `-np.amin(array)`. Thus instead of allocating space for the intermediate array `np.abs(array)`, it allocates for the axis-collapsed smaller arrays `np.amax(array)` & `np.amin(array)`.

Note: This method does **not** work on complex-valued arrays.

Parameters

- **array** (*np.ndarray*) – the input data
- **axis** (*Union[None, typing.SupportsIndex, Sequence[typing.SupportsIndex]]*) – the axis/axes along which to aggregate; if *None* (default), the absolute maximum is computed along the flattened array
- **keepdims** (*bool*) – if *True*, the axes which are reduced are left in the result as dimensions with size one; if *False* (default), the reduced axes are removed

Returns an array containing the computed values

Return type *np.ndarray*

`endaq.calc.stats.rms(array, axis=None, keepdims=False)`

Calculate the root-mean-square (RMS) along a given axis.

Parameters

- **array** (*np.ndarray*) – the input array
- **axis** (*Union[None, typing.SupportsIndex, Sequence[typing.SupportsIndex]]*) – the axis/axes along which to aggregate; if *None* (default), the RMS is computed along the flattened array
- **keepdims** (*bool*) – if *True*, the axes which are reduced are left in the result as dimensions with size one; if *False* (default), the reduced axes are removed

Returns an array containing the computed values

Return type *np.ndarray*

`endaq.calc.stats.rolling_rms(df, window_len, *args, **kwargs)`

Calculate a rolling root-mean-square (RMS) over a pandas *DataFrame*.

This function is equivalent to, but computationally faster than the following:

```
df.rolling(window_len).apply(endaq.calc.stats.rms)
```

Parameters

- **df** (*Union[pandas.core.frame.DataFrame, pandas.core.series.Series]*) – the input data
- **window_len** (*int*) – the length of the rolling window
- **args** – the positional arguments to pass into `df.rolling().mean`
- **kwargs** – the keyword arguments to pass into `df.rolling().mean`

Returns the rolling-windowed RMS

Return type *Union[pandas.core.frame.DataFrame, pandas.core.series.Series]*

See also:

- [Pandas Rolling Mean](#) - official documentation for `df.rolling().mean`
- [Pandas Rolling Standard Deviation method](#) - similar to this function, but first removes the windowed mean before squaring

1.2.7 endaq.calc.utils

`endaq.calc.utils.logfreqs(df, init_freq=None, bins_per_octave=12.0)`

Calculate a sequence of log-spaced frequencies for a given dataframe.

Parameters

- **df** (*pandas.core.frame.DataFrame*) – the input data
- **init_freq** (*Optional[float]*) – the initial frequency in the sequence; if *None* (default), use the frequency corresponding to the data’s duration
- **bins_per_octave** (*float*) – the number of frequencies per octave

Returns an array of log-spaced frequencies

Return type *numpy.ndarray*

`endaq.calc.utils.resample(df, sample_rate=None)`

Resample a dataframe to a desired sample rate (in Hz)

Parameters

- **df** (*pandas.core.frame.DataFrame*) – The DataFrame to resample, indexed by time
- **sample_rate** (*Optional[float]*) – The desired sample rate to resample the given data to. If one is not supplied, then it will use the same as it currently does, but make the time stamps uniformly spaced

Returns The resampled data in a DataFrame

Return type *pandas.core.frame.DataFrame*

`endaq.calc.utils.sample_spacing(data, convert='to_seconds')`

Calculate the average spacing between individual samples.

For time indices, this calculates the sampling period *dt*.

Parameters

- **data** (*Union[numpy.ndarray, pandas.core.frame.DataFrame]*) – the input data; either a pandas DataFrame with the samples spaced along its index, or a 1D-array-like of sample times
- **convert** (*Literal[None, 'to_seconds']*) – if “*to_seconds*” (default), convert any time objects into floating-point seconds

`endaq.calc.utils.to_dB(data, reference, squared=False)`

Scale data into units of decibels.

Decibels are a log-scaled ratio of some value against a reference; typically this is expressed as follows:

$$dB = 10 \log_{10} \left(\frac{x}{x_{\text{ref}}} \right)$$

By convention, “decibel” units tend to operate on units of *power*. For units that are proportional to power *when squared* (e.g., volts, amps, pressure, etc.), their “decibel” representation is typically doubled (i.e., $dB = 20 \log_{10}(\dots)$). Users can specify which scaling to use with the *squared* parameter.

Note: Decibels can **NOT** be calculated from negative values.

For example, to calculate dB on arbitrary time-series data, typically data is first aggregated via a total or a rolling RMS or PSD, and the non-negative result is then scaled into decibels.

Parameters

- **data** (*numpy.ndarray*) – the input data
- **reference** (*float*) – the reference value corresponding to 0dB
- **squared** (*bool*) – whether the input data & reference value are pre-squared; defaults to *False*

See also:

- `endaq.calc.stats.rms`
- `endaq.calc.stats.rolling_rms`
- `endaq.calc.psd.welch`

1.3 endaq.cloud

This module houses tools and functions to make both interacting with the enDAQ Cloud API and the [enDAQ Cloud](<https://cloud.endaq.com>) itself easier.

1.3.1 enDAQ Cloud API Wrapper

The API Wrapper provides a simple command-line interface for accessing basic file and device information from the enDAQ Cloud API. Output of all commands except `account` and `attributes` are in csv files in the `output` folder.

To access the cloud, this tool requires an API key associated with a user's enDAQ Cloud account, which can be provided in two ways:

- (recommended) add to the `endaq.cloud` project directory a `.env` file, formatted like so:

```
API_KEY=<Your Key>
```

- pass in an API key through the command line using the `--key` option

Warning: For security reasons, it is generally **discouraged** to make an authentication key visible on-screen or accessible through the clipboard, such as when using the `--key` option; we provide the `key` option solely as a convenience.

Runs on Python 3.6 and higher.

Commands

<code>files</code>	Outputs file information for selected number of files and attributes
<code>file-id</code>	Outputs file information for file with specified ID to output file
<code>devices</code>	Outputs device information for selected number of files
<code>device-id</code>	Output device information for device with specified ID to output file
<code>account</code>	Prints out account information
<code>attributes</code>	Adds an attribute to a specified file
<code>set-env</code>	Creates a <code>.env</code> file with passed-in API key (<i>NOT SECURE</i>)

Parameters

-h	Command Line Help
--id, -i	File or Device ID
--limit, -l	File or Device output limit; Max 100 default 50
--key, -k	API Key
--attributes, -a	Attributes to be outputted; options = all or att1,att2...; default is none
--name, -n	Attribute Name
--type, -t	Attribute Type; options = int, float, string, boolean
--value, -v	Attribute Value
--verbose, -V	Prints out URL API calls

Usages

- `endaq-cloud set-env -k <API_KEY>`
- `endaq-cloud download -i <FILE_ID> -o <OUTPUT_FOLDER>`
- `endaq-cloud files -a <ATTRIBUTES_TO_GET> -l <FILE_OR_DEVICE_OUTPUT_LIMIT>`
- `endaq-cloud file-id -i <FILE_ID>`
- `endaq-cloud devices -l <FILE_OR_DEVICE_OUTPUT_LIMIT>`
- `endaq-cloud device-id -i <DEVICE_ID>`
- `endaq-cloud account`
- `endaq-cloud attribute -n <ATTRIBUTE_NAME> -t <ATTRIBUTE_TYPE> -v <ATTRIBUTE_VALUE> -i <FILE_ID>`

1.3.2 *endaq.cloud.core*

Core enDAQ Cloud communication API

class `endaq.cloud.core.EndaqCloud`(*api_key=None, env=None, test=True*)

A representation of a connection to an enDAQ Cloud account, providing a high-level interface for accessing its contents.

Constructor for an *EndaqCloud* object, which provides access to an enDAQ Cloud account.

Parameters

- **api_key** (*Optional[str]*) – The Endaq Cloud API associated with your cloud.endaq.com account. If you do not have one created yet, they can be created on the following web page: <https://cloud.endaq.com/account/api-keys>
- **env** (*Optional[str]*) – The cloud environment to connect to, which can be production, staging, or development. These can be easily accessed with the variables *ENV_PRODUCTION*, *ENV_STAGING*, and *ENV_DEVELOP*
- **test** (*bool*) – If *True* (default), the connection to enDAQ Cloud will be tested before being returned. A failed test will generate a meaningful error message describing the problem.

property account_email: `Optional[str]`

The email address associated with the enDAQ Cloud account.

property account_id: `Optional[str]`

The enDAQ Cloud account's unique ID.

download_all_ide_files(*output_directory*="", *should_download_file_fn*=None, *force_reload_file_table*=False, *file_limit*=100)

Downloads all IDE files from the enDAQ Cloud (up to a specified file limit).

Parameters

- **output_directory** (*Union[str, pathlib.Path]*) – The directory to download the ide files to
- **should_download_file_fn** (*Optional[Callable]*) – A function which accepts a row of the IDE file table and returns a boolean value which indicates if the IDE file should be downloaded or not. If this function is not given, the default function will always return True.
- **force_reload_file_table** (*bool*) – If the file table to use as reference for what files exist in the cloud should be recomputed even if it is already stored (as *self.file_table*)
- **file_limit** (*int*) – The maximum number of files to download. If the *force_recompute_file_table* parameter is True then this will also be used to limit the number of files put in the file table it creates.

Returns An array of the filenames which were just downloaded

Return type `numpy.ndarray`

TO-DO:

- Would be nice to have a parameter to get only ones with a certain tag
- Maybe Have a blacklist and/or whitelist parameter

get_account_info()

Get information about the connected account. Sets or updates the values of *account_id* and *account_email*.

Returns If successful, a dictionary containing (at minimum) the keys *email* and *id*.

Return type `dict`

get_devices(*limit*=100)

Get dataframe of devices and associated attributes (part_number, description, etc.) attached to the account.

Parameters **limit** (*int*) – The maximum number of files to return.

Returns A *DataFrame* of recorder information.

Return type `pandas.core.frame.DataFrame`

get_file(*file_id*, *local_name*=None)

Download the specified file to *local_name* if provided, use the file name from the cloud if no local name is provided.

Parameters

- **file_id** (*Union[int, str]*) – The file's cloud ID.
- **local_name** (*Optional[str]*) – The downloaded file's destination pathname; defaults to the file's original basename & located in the directory in which the Python interpreter was launched

Returns The imported file, as an *idelib.Dataset*.

Return type *idelib.dataset.Dataset*

get_file_table(*attributes='all', limit=100*)

Get a table of the data that would be similar to that you'd get doing the CSV export on the my recordings page, up to the first *limit* files with attributes matching *attributes*.

Parameters

- **limit** (*int*) – The maximum number of files to return.
- **attributes** (*Union[list, str]*) – A list of attribute strings (or a single comma-delimited string of attributes) to match.

Returns A *DataFrame* of file IDs and relevant information.

Return type *pandas.core.frame.DataFrame*

set_attributes(*file_id, attributes*)

Set the 'attributes' (name/value metadata) of a file.

Parameters

- **file_id** (*Union[int, str]*) – The file's cloud ID.
- **attributes** (*list*) – A list of dictionaries of the following structure:

```
[{
    "name": "attr_31",
    "type" : "float",
    "value" : 3.3,
}]
```

Returns The list of the file's new attributes.

Return type *list*

endaq.cloud.core.count_tags(*df*)

Given the dataframe returned by *EndaqCloud.get_file_table()*, provide some info on the tags of the files in that account.

Parameters *df* (*pandas.core.frame.DataFrame*) – A *DataFrame* of file information, as returned by *EndaqCloud.get_file_table()*.

Returns A *DataFrame* summarizing the tags in *df*.

Return type *pandas.core.frame.DataFrame*

endaq.cloud.core.json_table_to_df(*data*)

Convert JSON parsed from a custom report to a more user-friendly *pandas.DataFrame*.

Parameters *data* (*list*) – A *list* of data from a custom report's JSON.

Returns A formatted *DataFrame*

Return type *pandas.core.frame.DataFrame*

1.4 endaq.plot

1.4.1 endaq.plot Usage Examples

For these examples we assume there is a Pandas DataFrame named `df` which has it's index as time stamps and it's one column being sensor values (e.g. x-axis acceleration, or pressure). It also assumes there is a Pandas DataFrame `attribute_df` which contains all the attribute data about various data files. More information can be found about how to get this data from enDAQ IDE files in the [endaq-cloud readme](#).

```
from endaq.plot import octave_spectrogram, multi_file_plot_attributes, octave_psd_bar_  
    plot  
from endaq.plot.utilities import set_theme
```

Setting The Aesthetic Theme

```
set_theme(theme='endaq')
```

Creating Spectrograms With Octave Spaced Frequencies

```
data_df, fig = octave_spectrogram(df, window=.15)  
fig.show()
```

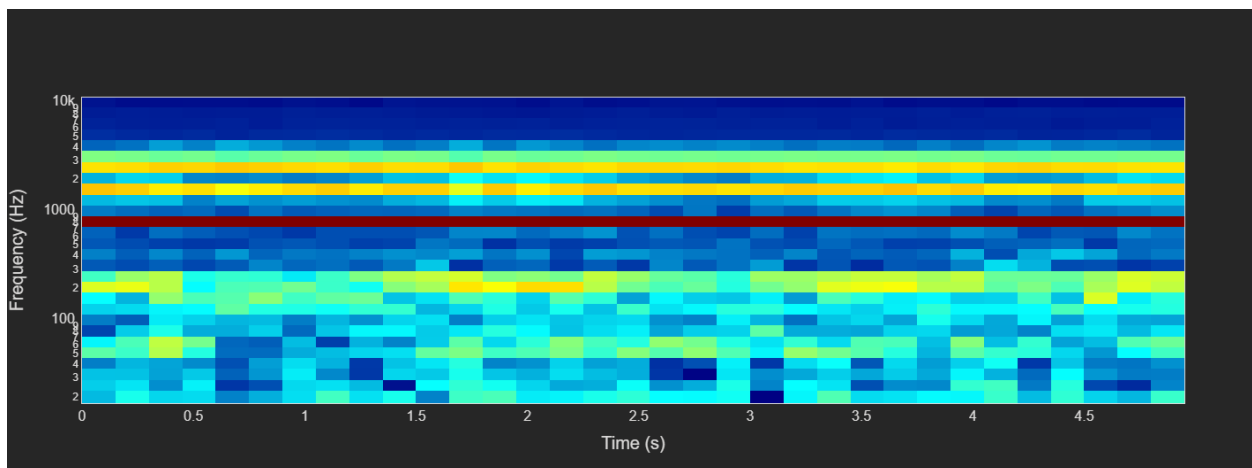


Fig. 1: Spectrogram With Octave Spaced Frequencies

Creating PSD Bar Plots With Octave Spaced Frequencies

```
fig = octave_psd_bar_plot(df, yaxis_title="Magnitude")
fig.show()
```

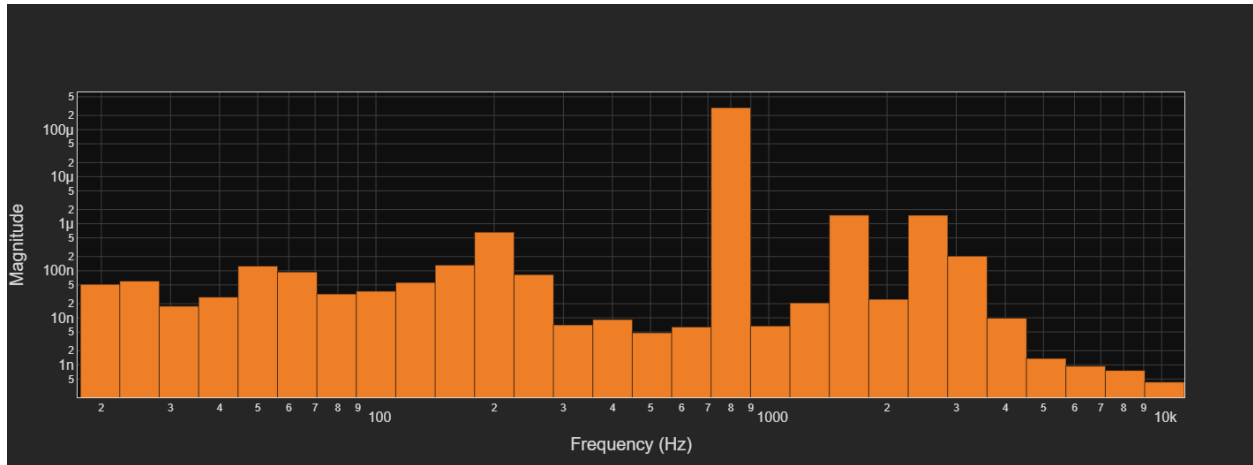


Fig. 2: PSD Bar Plot With Octave Spaced Frequencies

Plot Attributes In Figure With Subplots

```
fig = multi_file_plot_attributes(attribute_df)
fig.show()
```

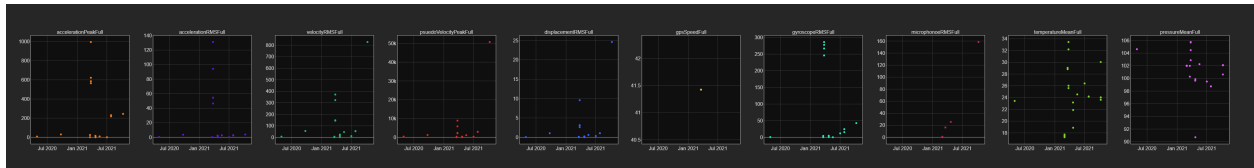


Fig. 3: Attributes Plotted As Subplots

Other Links

- the endaq package - <https://github.com/MideTechnology/endaq-python>
- the enDAQ homepage - <https://endaq.com/>

1.4.2 *endaq.plot*

`endaq.plot.around_peak(df, num=1000, leading_ratio=0.5)`

A function to plot the data surrounding the largest peak (or valley) in the given data. The “peak” is defined by the point in the absolute value of the given data with the largest value.

Parameters

- **df** (*pandas.core.frame.DataFrame*) – A dataframe indexed by time stamps
- **num** (*int*) – The number of points to plot
- **leading_ratio** (*float*) – The ratio of the data to be viewed that will come before the peak

Returns A Plotly figure containing the plot

`endaq.plot.gen_map(df_map, mapbox_access_token, filter_points_by_positive_groud_speed=True, color_by_column='GNSS Speed: Ground Speed')`

Plots GPS data on a map from a single recording, shading the points based some characteristic (defaults to ground speed).

Parameters

- **df_map** (*pandas.core.frame.DataFrame*) – The pandas dataframe containing the recording data.
- **mapbox_access_token** (*str*) – The access token (or API key) needed to be able to plot against a map.
- **filter_points_by_positive_groud_speed** (*bool*) – A boolean variable, which will filter which points are plotted by if they have corresponding positive ground speeds. This helps remove points which didn’t actually have a GPS location found (was created by a bug in the hardware I believe).
- **color_by_column** (*str*) – The dataframe column title to color the plotted points by.

`endaq.plot.general_get_correlation_figure(merged_df, color_col='serial_number_id', color_discrete_map=None, hover_names=None, characteristics_to_show_on_hover=[], starting_cols=None)`

A function to create a plot with two drop-down menus, each populated with a set of options corresponding to the scalar quantities contained in the given dataframe. The data points will then be plotted with the X and Y axis corresponding to the selected attributes from the drop-down menu.

Parameters

- **merged_df** (*pandas.core.frame.DataFrame*) – A Pandas DataFrame of data to use for producing the plot
- **color_col** (*str*) – The column name in the given dataframe (as merged_df) that is used to color data points with. This is used in combination with the color_discrete_map parameter
- **color_discrete_map** (*Optional[dict]*) – A dictionary which maps the values given to color data points based on (see the color_col parameter description) to the colors that these data points should be

- **hover_names** (*Optional[collections.abc.Container]*) – The names of the points to display when they are hovered on
- **characteristics_to_show_on_hover** (*list*) – The set of characteristics of the data to display when hovered over
- **starting_cols** (*Optional[collections.abc.Container]*) – The two starting columns for the dropdown menus (will be the first two available if None is given)

Returns The interactive Plotly figure

Return type `plotly.graph_objs._figure.Figure`

`endaq.plot.get_pure_numpy_2d_pca(df, color_col='serial_number_id', color_discrete_map=None)`

Get a Plotly figure of the 2D PCA for the given DataFrame. This will have dropdown menus to select which components are being used for the X and Y axis.

Parameters

- **df** (`pandas.core.frame.DataFrame`) – The dataframe of points to compute the PCA with
- **color_col** (*str*) – The column name in the given dataframe (as `merged_df`) that is used to color data points with. This is used in combination with the `color_discrete_map` parameter
- **color_discrete_map** (*Optional[dict]*) – A dictionary which maps the values given to color data points based on (see the `color_col` parameter description) to the colors that these data points should be

Returns A plotly figure as described in the main function description

Return type `plotly.graph_objs._figure.Figure`

`endaq.plot.get_tsne_plot(df, perplexity=20, random_seed=0, num_iterations=1000, learning_rate=500, color_col='serial_number_id', color_discrete_map=None, momentum=0)`

Estimates a SNE model, and plots the visualization of the given data.

More information about t-SNE visualizations and how to use them effectively can be found here: <https://distill.pub/2016/misread-tsne/>

(Implementation based around the following: <https://nlml.github.io/in-row-numpy/in-row-numpy-t-sne/>)

Parameters

- **df** (`pandas.core.frame.DataFrame`) – A Pandas Dataframe of the the data to be visualized (e.g. a recording attribute DataFrame)
- **perplexity** (*int*) – A value which can be thought of as determining how many neighbors of a point will be used to update its position in the visualization.
- **random_seed** (*int*) – Integer value to set the seed value for the random
- **num_iterations** (*int*) – The number of iterations to train for
- **learning_rate** (*int*) – The rate at which to update teh values in the model
- **color_col** (*str*) – The column name in the given dataframe (as `merged_df`) that is used to color data points with. This is used in combination with the `color_discrete_map` parameter
- **color_discrete_map** (*Optional[dict]*) – A dictionary which maps the values given to color data points based on (see the `color_col` parameter description) to the colors that these data points should be
- **momentum** (*int*) – The momentum to be used when applying updates to the model

Returns Plotly figure of the, low-dimensional representation of the given data

Return type `plotly.graph_objs._figure.Figure`

```
endaq.plot.multi_file_plot_attributes(multi_file_db, attrs_to_plot=array(['accelerationPeakFull',
    'accelerationRMSFull', 'velocityRMSFull',
    'psuedoVelocityPeakFull', 'displacementRMSFull', 'gpsSpeedFull',
    'gyroscopeRMSFull', 'microphoneRMSFull',
    'temperatureMeanFull', 'pressureMeanFull'], dtype='<U22'),
    recording_colors=None, width_per_subplot=400)
```

Creates a Plotly figure plotting all the desired attributes from the given DataFrame.

Parameters

- **multi_file_db** (`pandas.core.frame.DataFrame`) – The Pandas DataFrame of data to plot attributes from
- **attrs_to_plot** (`numpy.ndarray`) – A numpy ndarray of strings with the names of the attributes to plot
- **recording_colors** (`Optional[collections.abc.Container]`) – The colors to make each of the points (All will be the same color if None is given)
- **width_per_subplot** (`int`) – The width to make every subplot

Returns A Plotly figure of all the subplots desired to be plotted

Return type `plotly.graph_objs._figure.Figure`

```
endaq.plot.octave_psd_bar_plot(df, bins_per_octave=3, f_start=20.0, yaxis_title='', log_scale_y_axis=True)
```

Produces a bar plot of an octave psd.

Parameters

- **df** (`pandas.core.frame.DataFrame`) – The dataframe of sensor data
- **bins_per_octave** (`int`) – The number of frequency bins per octave
- **f_start** (`float`) – The center of the first frequency bin
- **yaxis_title** (`str`) – The text to label the y-axis
- **log_scale_y_axis** (`bool`) – If the y-axis should be log scaled

```
endaq.plot.octave_spectrogram(df, window, bins_per_octave=3, freq_start=20.0, max_freq=inf,
    db_scale=True, log_scale_y_axis=True)
```

Produces an octave spectrogram of the given data.

Parameters

- **df** (`pandas.core.frame.DataFrame`) – The dataframe of sensor data. This must only have 1 column.
- **window** (`float`) – The time window for each of the columns in the spectrogram
- **bins_per_octave** (`int`) – The number of frequency bins per octave
- **freq_start** (`float`) – The center of the first frequency bin
- **max_freq** (`float`) – The maximum frequency to plot
- **db_scale** (`bool`) – If the spectrogram should be log-scaled for visibility (with $10 \cdot \log_{10}(x)$)
- **log_scale_y_axis** (`bool`) – If the y-axis of the plot should be log scaled

Returns

a tuple containing:

- the frequency bins
- the time bins
- the spectrogram data
- the corresponding plotly figure

Return type plotly.graph_objs._figure.Figure

`endaq.plot.rolling_min_max_envelope(df, desired_num_points=250, plot_asBars=False, plot_title="", opacity=1.0, colors_to_use=None)`

A function to create a Plotly Figure to plot the data for each of the available data sub-channels, designed to reduce the number of points/data being plotted without minimizing the insight available from the plots. It will plot either an envelope for rolling windows of the data (plotting the max and the min as line plots), or a bar based plot where the top of the bar (rectangle) is the highest value in the time window that bar spans, and the bottom of the bar is the lowest point in that time window (choosing between them is done with the `plot_asBars` parameter).

Parameters

- **df** (`pandas.core.frame.DataFrame`) – The dataframe of sub-channel data indexed by time stamps
- **desired_num_points** (`int`) – The desired number of points to be plotted for each sub-channel. The number of points will be reduced from it's original sampling rate by applying metrics (e.g. min, max) over sliding windows and then using that information to represent/visualize the data contained within the original data. If less than the desired number of points are present, then a sliding window will NOT be used, and instead the points will be plotted as they were originally recorded (also the subchannel will NOT be plotted as a bar based plot even if `plot_asBars` was set to true).
- **plot_asBars** (`bool`) – A boolean value indicating if the data should be visualized as a set of rectangles, where a shaded rectangle is used to represent the maximum and minimum values of the data during the time window covered by the rectangle. These maximum and minimum values are visualized by the locations of the top and bottom edges of the rectangle respectively, unless the height of the rectangle would be 0, in which case a line segment will be displayed in it's place. If this parameter is `False`, two lines will be plotted for each of the sub-channels in the figure being created, creating an 'envelope' around the data. An 'envelope' around the data consists of a line plotted for the maximum values contained in each of the time windows, and another line plotted for the minimum values. Together these lines create a boundary which contains all the data points recorded in the originally recorded data.
- **plot_title** (`str`) – The title for the plot
- **opacity** (`float`) – The opacity to use for plotting bars/lines
- **colors_to_use** (`Optional[collections.abc.Container]`) – An "array-like" object of strings containing colors to be cycled through for the sub-channels. If `None` is given (which is the default), then the `colorway` variable in Plotly's current theme/template will be used to color the data on each of the sub-channels uniquely, repeating from the start of the `colorway` if all colors have been used.

Returns The Plotly Figure with the data plotted

Return type plotly.graph_objs._figure.Figure

1.4.3 *endaq.plot.dashboards*

```
endaq.plot.dashboards.rolling_enveloped_dashboard(channel_df_dict, desired_num_points=250,
                                                    num_rows=None, num_cols=3,
                                                    width_for_subplot_row=400,
                                                    height_for_subplot_row=400,
                                                    subplot_colors=None, min_points_to_plot=1,
                                                    plot_asBars=False,
                                                    plot_full_single_channel=False, opacity=1.0,
                                                    y_axis_bar_plot_padding=0.06)
```

A function to create a Plotly Figure with sub-plots for each of the available data sub-channels, designed to reduce the number of points/data being plotted without minimizing the insight available from the plots. It will plot either an envelope for rolling windows of the data (plotting the max and the min as line plots), or a bar based plot where the top of the bar (rectangle) is the highest value in the time window that bar spans, and the bottom of the bar is the lowest point in that time window (choosing between them is done with the *plot_asBars* parameter).

Parameters

- **channel_df_dict** (*dict*) – A dictionary mapping channel names to Pandas DataFrames of that channels data
- **desired_num_points** (*int*) – The desired number of points to be plotted in each subplot. The number of points will be reduced from its original sampling rate by applying metrics (e.g. min, max) over sliding windows and then using that information to represent/visualize the data contained within the original data. If less than the desired number of points are present, then a sliding window will NOT be used, and instead the points will be plotted as they were originally recorded (also the subplot will NOT be plotted as a bar based plot even if *plot_asBars* was set to true).
- **num_rows** (*Optional[int]*) – The number of columns of subplots to be created inside the Plotly figure. If *None* is given, (then *num_cols* must not be *None*), then this number will automatically be determined by what's needed. If more rows are specified than are needed, the number of rows will be reduced to the minimum needed to contain all the subplots
- **num_cols** (*Optional[int]*) – The number of columns of subplots to be created inside the Plotly figure. See the description of the *num_rows* parameter for more details on this parameter, and how the two interact. This also follows the same approach to handling *None* when given
- **width_for_subplot_row** (*int*) – The width of the area used for a single subplot (in pixels).
- **height_for_subplot_row** (*int*) – The height of the area used for a single subplot (in pixels).
- **subplot_colors** (*Optional[collections.abc.Container]*) – An “array-like” object of strings containing colors to be cycled through for the subplots. If *None* is given (which is the default), then the *colorway* variable in Plotly's current theme/template will be used to color the data on each of the subplots uniquely, repeating from the start of the *colorway* if all colors have been used.
- **min_points_to_plot** (*int*) – The minimum number of data points required to be present to create a subplot for a channel/subchannel (NOT including *NaN* values).
- **plot_asBars** (*bool*) – A boolean value indicating if the plot should be visualized as a set of rectangles, where a shaded rectangle is used to represent the maximum and minimum values of the data during the time window covered by the rectangle. These maximum and minimum values are visualized by the locations of the top and bottom edges of the rectangle respectively, unless the height of the rectangle would be 0, in which case a line segment will be displayed in its place. If this parameter is *False*, two lines will be plotted for each of the

subplots in the figure being created, creating an “envelope” around the data. An “envelope” around the data consists of a line plotted for the maximum values contained in each of the time windows, and another line plotted for the minimum values. Together these lines create a boundary which contains all the data points recorded in the originally recorded data.

- **plot_full_single_channel** (*bool*) – If instead of a dashboard of subplots a single plot with multiple sub-channels should be created. If this is True, only one (key, value) pair can be given for the *channel_df_dict* parameter
- **opacity** (*float*) – The opacity to use for plotting bars/lines
- **y_axis_bar_plot_padding** (*float*) – Due to some unknown reason the bar subplots aren’t having their y axis ranges automatically scaled so this is the ratio of the total y-axis data range to pad both the top and bottom of the y axis with. The default value is the one it appears Plotly uses as well.

Returns The Plotly Figure containing the subplots of sensor data (the ‘dashboard’)

Return type `plotly.graph_objs._figure.Figure`

```
endaq.plot.dashboards.rolling_metric_dashboard(channel_df_dict, desired_num_points=250,  
                                              num_rows=None, num_cols=3,  
                                              rolling_metrics_to_plot=('mean', 'std'),  
                                              metric_colors=None, width_for_subplot_row=400,  
                                              height_for_subplot_row=400)
```

A function to create a dashboard of subplots of the given data, plotting a set of rolling metrics.

Parameters

- **channel_df_dict** (*dict*) – A dictionary mapping channel names to Pandas DataFrames of that channels data
- **desired_num_points** (*int*) – The desired number of points to be plotted in each subplot. The number of points will be reduced from its original sampling rate by applying metrics (e.g. min, max) over sliding windows and then using that information to represent/visualize the data contained within the original data. If less than the desired number of points are present, then a sliding window will NOT be used, and instead the points will be plotted as they were originally recorded (also the subplot will NOT be plotted as a bar based plot even if *plot_asBars* was set to true).
- **num_rows** (*Optional[int]*) – The number of columns of subplots to be created inside the Plotly figure. If *None* is given, (then *num_cols* must not be *None*), then this number will automatically be determined by what’s needed. If more rows are specified than are needed, the number of rows will be reduced to the minimum needed to contain all the subplots
- **num_cols** (*Optional[int]*) – The number of columns of subplots to be created inside the Plotly figure. See the description of the *num_rows* parameter for more details on this parameter, and how the two interact. This also follows the same approach to handling *None* when given
- **rolling_metrics_to_plot** (*tuple*) – A tuple of strings which indicate what rolling metrics to plot for each subchannel. The options are ['mean', 'std', 'absolute max', 'rms'] which correspond to the mean, standard deviation, maximum of the absolute value, and root-mean-square.
- **metric_colors** (*Optional[collections.abc.Container]*) – An “array-like” object of strings containing colors to be cycled through for the metrics. If *None* is given (which is the default), then the *colorway* variable in Plotly’s current theme/template will be used to color the metric data, repeating from the start of the *colorway* if all colors have been used. The first value corresponds to the color if not enough points of data exist for a rolling metric,

and the others correspond to the metric in *rolling_metrics_to_plot* in the same order they are given

- **width_for_subplot_row** (*int*) – The width of the area used for a single subplot (in pixels).
- **height_for_subplot_row** (*int*) – The height of the area used for a single subplot (in pixels).

Returns The Plotly Figure containing the subplots of sensor data (the ‘dashboard’)

Return type `plotly.graph_objs._figure.Figure`

1.4.4 *endaq.plot.utilities*

```
endaq.plot.utilities.define_theme(template_name='endaq_cloud', default_plotly_template='plotly_dark',
                                  text_color='#DAD9D8', font_family='Open Sans',
                                  title_font_family='Open Sans SemiBold', graph_line_color='#DAD9D8',
                                  grid_line_color='#404041', background_color='#262626',
                                  plot_background_color='#0F0F0F')
```

Define a Plotly theme (template), allowing completely custom aesthetics

Parameters

- **template_name** (*str*) – The name for the Plotly template being created
- **default_plotly_template** (*str*) – The default Plotly Template (aspects of this will be used if a characteristic isn’t set elsewhere)
- **text_color** (*str*) – The color of the text
- **font_family** (*str*) – The font family to use for text (not including the title)
- **title_font_family** (*str*) – The font family to use for the title
- **graph_line_color** (*str*) – The line color used when plotting line plots
- **grid_line_color** (*str*) – The color of the grid lines on the plot
- **background_color** (*str*) – The background color of the figure
- **plot_background_color** (*str*) – The background color of the plot

Returns The plotly template which was just created

Return type `go.layout._template.Template`

```
endaq.plot.utilities.determine_plotly_map_zoom(lons=None, lats=None, lonlats=None,
                                                projection='mercator', width_to_height=2.0,
                                                margin=1.2)
```

Finds optimal zoom for a plotly mapbox. Must be passed (lons & lats) or lonlats.

Originally based on the following post: <https://stackoverflow.com/questions/63787612/plotly-automatic-zooming-for-mapbox-maps>

This is a temporary solution awaiting an official implementation: <https://github.com/plotly/plotly.js/issues/3434>

Parameters

- **lons** (*Optional[tuple]*) – tuple, optional, longitude component of each location
- **lats** (*Optional[tuple]*) – tuple, optional, latitude component of each location
- **lonlats** (*Optional[tuple]*) – tuple, optional, gps locations

- **projection** (*str*) – str, only accepting ‘mercator’ at the moment, raises *NotImplementedError* if other is passed
- **width_to_height** (*float*) – float, expected ratio of final graph’s width to height, used to select the constrained axis.
- **margin** (*float*) – The desired margin around the plotted points (where 1 would be no-margin)

Returns The zoom scaling for the Plotly map

Return type float

Note: This implementation could be potentially problematic. By simply averaging min/max coordinates you end up with situations such as the longitude lines -179.99 and 179.99 being almost right next to each other, but their center is calculated at 0, the other side of the earth.

`endaq.plot.utilities.get_center_of_coordinates(lats, lons, as_list=False, as_degrees=True)`

Inputs and outputs are measured in degrees.

Parameters

- **lats** (*numpy.ndarray*) – An ndarray of latitude points
- **lons** (*numpy.ndarray*) – An ndarray of longitude points
- **as_list** (*bool*) – If True, return a length 2 list of the latitude and longitude coordinates. If not return a dictionary of format {“lon”: lon_center, “lat”: lat_center}
- **as_degrees** (*bool*) – A boolean value representing if the ‘lats’ and ‘lons’ parameters are given in degrees (as opposed to radians). These units will be used for the returned values as well.

Returns The latitude and longitude values as either a dictionary or a list, which is determined by the value of the *as_list* parameter (see the *as_list* docstring for details on the formatting of this return value)

Return type Union[list, dict]

`endaq.plot.utilities.set_theme(theme='endaq')`

Set the plot appearances based on a known ‘theme’.

Parameters **theme** (*typing.Literal[('endaq', 'endaq_light', 'endaq_arial', 'endaq_light_arial')]*) – A string denoting which plot appearance color scheme to use. Current options are ‘endaq’, ‘endaq_light’, ‘endaq_arial’ and ‘endaq_light_arial’.

Returns The plotly template which was set

Return type go.layout._template.Template

1.5 endaq.batch

```
class endaq.batch.GetDataBuilder(*, preferred_chs=[], accel_highpass_cutoff, accel_start_time=None,
                                accel_end_time=None, accel_start_margin=None,
                                accel_end_margin=None, accel_integral_tukey_percent=0,
                                accel_integral_zero='start')
```

The main interface for the calculations.

This object has two types of functions:

- *configuration functions* - these determine what calculations will be performed on IDE recordings, and pass in any requisite parameters for said calculations. This includes the following functions:

- `add_psd`
- `add_pvss`
- `add_metrics`
- `add_peaks`
- `add_vc_curves`

- *execution functions* - these functions take recording files as parameters, perform the configured calculations on the data therein, and return the calculated data as a *OutputStruct* object that wraps pandas objects.

This includes the functions `_get_data` & `aggregate_data`, which operates on one & multiple file(s), respectively.

A typical use case will look something like this:

```
filenames = [...]

calc_output = (
    GetDataBuilder(accel_highpass_cutoff=1)
    .add_psd(freq_bin_width=1)
    .add_pvss(init_freq=1, bins_per_octave=12)
    .add_metrics()
    .add_peaks(margin_len=100)
    .add_vc_curves(init_freq=1, bins_per_octave=3)
    .aggregate_data(filenames)
)
file_data = calc_output.dataframes
```

Parameters

- **preferred_chs** – a sequence of channels; each channel listed is prioritized over others of the same type of physical measurement (e.g., acceleration, temperature, pressure, etc.)
- **accel_highpass_cutoff** – the cutoff frequency used when pre-filtering acceleration data
- **accel_start_time** – the relative timestamp before which to reject recording data; cannot be used in conjunction with *accel_start_margin*
- **accel_end_time** – the relative timestamp after which to reject recording data; cannot be used in conjunction with *accel_end_margin*
- **accel_start_margin** – the number of samples before which to reject recording data; cannot be used in conjunction with *accel_start_time*

- **accel_end_margin** – the number of samples after which to reject recording data; cannot be used in conjunction with *accel_end_time*
- **accel_integral_tukey_percent** – the alpha parameter of a tukey window applied to the acceleration before integrating into velocity & displacement; see the *tukey_percent* parameter in `endaq.calc.integrate.integrals` for details
- **accel_integral_zero** – the output quantity driven to zero when integrating the acceleration into velocity & displacement; see the *zero* parameter in `endaq.calc.integrate.integrals` for details

add_metrics()

Add broad channel metrics to the calculation queue.

add_peaks(*, margin_len)

Add windows about the acceleration's peak value to the calculation queue.

Parameters **margin_len** – the number of samples on each side of a peak to include in the windows

add_psd(*, freq_bin_width=None, freq_start_octave=None, bins_per_octave=None, window='hanning')

Add the acceleration PSD to the calculation queue.

Parameters

- **freq_bin_width** – the desired spacing between adjacent PSD samples; a default is provided only if *bins_per_octave* is used, otherwise this parameter is required
- **freq_start_octave** – the first frequency to use in octave-spacing; this is only used if *bins_per_octave* is set
- **bins_per_octave** – the number of frequency bins per octave in a log-spaced PSD; if not set, the PSD will be linearly-spaced as specified by *freq_bin_width*
- **window** – the window type used in the PSD calculation; see the documentation for `scipy.signal.welch` for details

add_pvss(*, init_freq, bins_per_octave)

Add the acceleration PVSS (Pseudo Velocity Shock Spectrum) to the calculation queue.

Parameters

- **init_freq** – the first frequency sample in the spectrum
- **bins_per_octave** – the number of samples per frequency octave

add_vc_curves(*, init_freq, bins_per_octave)

Add Vibration Criteria (VC) Curves to the calculation queue.

Parameters

- **init_freq** – the first frequency
- **bins_per_octave** – the number of samples per frequency octave

aggregate_data(filenamees)

Compile configured data from the given files into a dataframe.

Parameters **filenamees** – a sequence of paths of recording files to process

class endaq.batch.core.OutputStruct(data)

A data wrapper class with methods for common export operations.

Objects of this class are generated by `GetDataBuilder.aggregate_data`. This class is not intended be instantiated manually.

dataframes: `List[pandas.core.frame.DataFrame]`

to_csv_folder(*folder_path*)

Write data to a folder as CSV's.

Parameters **folder_path** – the output directory path for .CSV files

to_html_plots(*folder_path=None, show=False*)

Generate plots in HTML.

Parameters

- **folder_path** – the output directory for saving .HTML plots; if *None* (default), plots are not saved
- **show** – whether to open plots after generation; defaults to *False*

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