Hyperkit Analysis Solution

User Documentation

Abstract. This document explains the mathematical formulas, which are used to calculate the visualizations provided by the Hyperkit Analysis Solution.

1 Parameters

The software allows to adjust parameters, which apply to all files loaded and all visualizations calculated from the measurements.

Name	Symbol	Value
Steps	$S \in \mathbb{N}$	User-defined in $[100{,}10.000]$

2 Files

The software allows to load files from your file system containing voltage and current measurements associated with timestamps.

Name	Symbol	Value
Measurement length	$L \in \mathbb{N}$	Number of measurements in the file
Timestamp measurement	T_i with $0 \le i < L$	Timestamp of the i^{th} measurement
Voltage measurement	V_i with $0 \le i < L$	Voltage of the i^{th} measurement
Current measurement	C_i with $0 \le i < L$	Current of the i^{th} measurement

3 Properties

The software defines a range of properties per file. One can distinguish between measured, displayed and derived properties.

3.1 Measured Properties

The following properties are extracted from the measurements contained in the files.

Name	Symbol	Value
Minimum timestamp measured	$T_{min}^m \in \mathbb{R}$	$T_{min}^m = min(\{\mathrm{T_i} \mid 0 \le \mathrm{i} < \mathrm{L}\})$
Maximum timestamp measured	$T_{max}^m \in \mathbb{R}$	$T_{max}^m = max(\{\mathrm{T_i} \mid 0 \le \mathrm{i} < \mathrm{L}\})$
Minimum voltage measured	$V_{min}^m \in \mathbb{R}$	$V_{min}^m = min(\{\mathrm{V_i} \mid 0 \le \mathrm{i} < \mathrm{L}\})$
Maximum voltage measured	$V_{max}^m \in \mathbb{R}$	$V_{max}^m = max(\{\mathrm{V_i} \mid 0 \le \mathrm{i} < \mathrm{L}\})$
Minimum current measured	$C_{min}^m \in \mathbb{R}$	$C_{min}^m = min(\{\mathrm{C_i} \mid 0 \le \mathrm{i} < \mathrm{L}\})$
Maximum current measured	$C_{max}^m \in \mathbb{R}$	$C_{max}^m = max(\{\mathrm{C_i} \mid 0 \le \mathrm{i} < \mathrm{L}\})$

3.2 Displayed Properties

The following properties are used to adjust the display settings of the individual parts.

Name	Symbol	Value
Minimum timestamp displayed	$T_{min}^d \in \mathbb{R}$	User-defined in $[T_{min}^m, T_{max}^d]$
Maximum timestamp displayed	$T_{max}^d \in \mathbb{R}$	User-defined in $[T_{min}^d, T_{max}^m]$
Minimum voltage displayed	$V_{min}^d \in \mathbb{R}$	User-defined in $[V_{min}^m, V_{max}^d]$
Maximum voltage displayed	$V_{max}^d \in \mathbb{R}$	User-defined in $[V_{min}^d, V_{max}^m]$
Minimum current displayed	$C_{min}^d \in \mathbb{R}$	User-defined in $[C_{min}^m, C_{max}^d]$
Maximum current displayed	$C_{max}^d \in \mathbb{R}$	User-defined in $[C_{min}^d, C_{max}^m]$

3.3 Derived Properties

The following properties are derived from the measured and user-defined display properties.

Name	Symbol	Value
Timestamp interval measured	$T_*^m \in \mathbb{R}$	$T_*^m = T_{max}^m - T_{min}^m$
Timestamp interval displayed	$T_*^d \in \mathbb{R}$	$T_*^d = T_{max}^d - T_{min}^d$
Voltage interval measured	$V_*^m \in \mathbb{R}$	$V_*^m = V_{max}^m - V_{min}^m$
Voltage interval displayed	$V_*^d \in \mathbb{R}$	$V_*^d = V_{max}^d - V_{min}^d$
Current interval measured	$C_*^m \in \mathbb{R}$	$C_*^m = C_{max}^m - C_{min}^m$
Current interval displayed	$C_*^d \in \mathbb{R}$	$C_*^d = C_{max}^d - C_{min}^d$

4 Voltage timeseries

The software displays a voltage timeseries per file, which can be adjusted according to the parameters and the display properties.

Name	Symbol	Value
Timestamp subset	$T^{vt} \subseteq \{T_i\}$	$T^{vt} = \{T_i \mid T_{min}^d \leq T_i \leq T_{max}^d\}$
Voltage subset	$V^{vt} \subseteq \{V_i\}$	$V^{vt} = \{V_i \mid T_{min}^d \leq T_i \leq T_{max}^d\}$

5 Current timeseries

The software displays a current timeseries per file, which can be adjusted according to the parameters and the display properties.

Name	Symbol	Value
Timestamp subset	$T^{vt} \subseteq \{T_i\}$	$T^{vt} = \{T_i \mid T_{min}^d \leq T_i \leq T_{max}^d\}$
Current subset	$C^{vt} \subseteq \{C_i\}$	$C^{vt} = \{C_i \mid T_{min}^d \leq T_i \leq T_{max}^d\}$

6 Voltage probability density function

The software displays a voltage probability density function per file, which can be adjusted according to the parameters and the display properties.

Name	Symbol	Value
Voltage element	V_k^{vp} with $0 \leq k < S$	$V_k^{vp} = V_{min}^d + (j + 0.5)V_*^d$
Probability element	P_k^{vp} with $0 \leq k < S$	$P_k^{vp} = \left\|\{V_i \| V_{min}^d + \mathrm{j}V_*^d \leq V_i < V_{min}^d + (\mathrm{j}+1)V_*^d\}\right\| / Q^{vp}$
Quantity	Q^{vp}	$Q^{vp} = \left\| \bigcup_{0 \leq k < S} P_k^{vp} \right\|$

7 Current probability density function

The software displays a current probability density function per file, which can be adjusted according to the parameters and the display properties.

Name	Symbol	Value
Current element	C_k^{cp} with $0 \leq k < S$	$C_k^{cp} = C_{min}^d + (j + 0.5)C_*^d$
Probability element	P_k^{cp} with $0 \leq k < S$	$P_k^{cp} = \left\|\{C_i \| C_{min}^d + \mathrm{j}C_*^d \leq C_i < C_{min}^d + (\mathrm{j}+1)C_*^d\}\right\| / Q^{cp}$
Quantity	Q^{cp}	$Q^{cp} = \left\| \bigcup_{0 \leq k < S} P_k^{cp} \right\|$

8 POINT CLOUD (ACTUAL)

The software displays the actual point cloud and regression line per file, which can be adjusted according to the parameters and the display properties.

Name	Symbol	Value
Current subset	$C^{pca} \subseteq \{C_i\}$	$C^{pca} = \{C_i \mid T^d_{min} \leq T_i \leq T^d_{max} \wedge C^d_{min} \leq C_i \leq C^d_{max} \wedge V^d_{min} \leq V_i \leq V^d_{max}\}$
Voltage subset	$V^{pca} \subseteq \{V_i\}$	$V^{pca} = \{V_i \mid T^d_{min} \leq T_i \leq T^d_{max} \wedge C^d_{min} \leq C_i \leq C^d_{max} \wedge V^d_{min} \leq V_i \leq V^d_{max}\}$
Regression line	V_*, M	Given the linear equation system $V_i = V_* + M * C_i$ with $V_i \in V^{pca}$ and $C_i \in C^{pca}$ find V_*, M such that $\sum_i (V_i - (V_* + M * C_i))^2$ is minimized

9 POINT CLOUD (STATISTICAL)

The software displays the statistical point cloud (minimum, maximum, average) and regression line per file, which can be adjusted according to the parameters and the display properties.

Name	Symbol	Value
Current subset	$C^{pcs} \subseteq \{C_i\}$	$C^{pcs} = \{C_i \mid T^d_{min} \leq T_i \leq T^d_{max} \wedge C^d_{min} \leq C_i \leq C^d_{max} \wedge V^d_{min} \leq V_i \leq V^d_{max}\}$
Voltage subset	$V^{pcs} \subseteq \{V_i\}$	$V^{pcs} = \{V_i \mid T^d_{min} \leq T_i \leq T^d_{max} \wedge C^d_{min} \leq C_i \leq C^d_{max} \wedge V^d_{min} \leq V_i \leq V^d_{max}\}$
Current element	C^{pc}_k with $0 \leq k < S$	$C^{cp}_k = C^d_{min} + (j + 0.5) C^d_*$
Voltage minimum element	V^{pvmin}_k with $0 \leq k < S$	$V^{pvmin}_k = \min\{V_i \mid C^d_{min} + \mathrm{j} C^d_* \leq C_i < C^d_{min} + (\mathrm{j}+1) C^d_*\}$
Voltage average element	V^{pvavg}_k with $0 \leq k < S$	$V^{pvavg}_k = avg\{V_i \mid C^d_{min} + \mathrm{j} C^d_* \leq C_i < C^d_{min} + (\mathrm{j}+1) C^d_*\}$
Voltage maximum element	V^{pvmax}_k with $0 \leq k < S$	$V^{pvmax}_k = \max\{V_i \mid C^d_{min} + \mathrm{j} C^d_* \leq C_i < C^d_{min} + (\mathrm{j}+1) C^d_*\}$
Regression line	V_*, M	Given the linear equation system $V_i = V_* + M * C_i$ with $V_i \in V^{pcs}$ and $C_i \in C^{pcs}$ find V_*, M such that $\sum_i (V_i - (V_* + M * C_i))^2$ is minimized