VOLTAGE SAG INDICES and STATISTICS

by

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Abstract

Voltage sag indices are a way of quantifying the performance of the power supply, as far as voltage sags are concerned. Indices can be defined for individual events, for individual sites, and for a whole system. A standard method for single-event methods is part of IEC standard 61000-4-30.

This thesis emphasizes the importance of voltage sag indices and different methods for calculating three-phase voltage sag characteristics. Three-phase events measured in a medium network voltage over period of one month were analyzed, results examined and statistically evaluated. An algorithm for calculating voltage sag characteristics and indices was created in Matlab.

Algorithm detects if the event is voltage sag, interruption or swell. Two different methods, symmetrical component method and six-phase rms method, for calculating sag type are used in the algorithm. Single-event characteristics as duration, retained voltage, voltage sag energy index, voltage sag severity and sag type are calculated for each event and summarized in synoptic table.

After single-event characteristic results were satisfactory, site and system indices were implemented in MatLab and some statistics were carried out.

Also various implementation issues with a detailed description of symmetrical component method and six-phase rms method were written.

Keywords: power quality, voltage sag, swell, interruption, duration, retained voltage

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Contents

Chapter 1

Introduction

1.1 What is Voltage Sag?

There are two main standards, standard IEC 61000-4-30 [1] and IEEE Std. 1159-1995 [25], that define voltage sag, interruption and swell.
In standard IEC 61000-4-30 [1] the following is defined:

- Voltage sag or voltage dip is temporary reduction of the voltage at a point in the electrical system below a threshold.
- Interruption is reduction of the voltage at a point in the electrical system below a threshold.
- Swell is temporary increase of the voltage at a point in the electrical system above a threshold.

In IEEE Std. 1159-1995 [25] the following is defined:

- Voltage sag or voltage dip is a decrease to between 0.1 and 0.9 pu in rms voltage at the power frequency for durations of 0.5 cycle to 1 min.
- Interruption is a type of short duration variation and is the complete loss of voltage ($<$0.1 pu) on one or more phase conductors for a time period between 0.5 cycles and 3 s.
- Swell is an increase in rms voltage at the power frequency for durations from 0.5 cycles to 1 min. Typical values are 1.1-1.8 pu.

Throughout the text voltage sag, interruption and swell will be understood as following:

- The voltage sag starts when at least one of the rms voltages drops below the threshold and ends when all three rms voltages have recovered above the threshold [7]. Voltage sag threshold is chosen 90% of the reference voltage.
- Interruption starts when all three rms voltages drop below the threshold and ends when at least one of them rises above the threshold [7]. Interruption threshold is chosen 10% of the reference voltage.
- Swell starts when at least one of the rms voltages rises above the threshold and ends when all three rms voltages have recovered below the threshold [7]. Swell threshold is chosen 110% of the reference voltage.

In the Fig. 1.1 example of event that is classified as voltage sag, interruption and swell is shown.

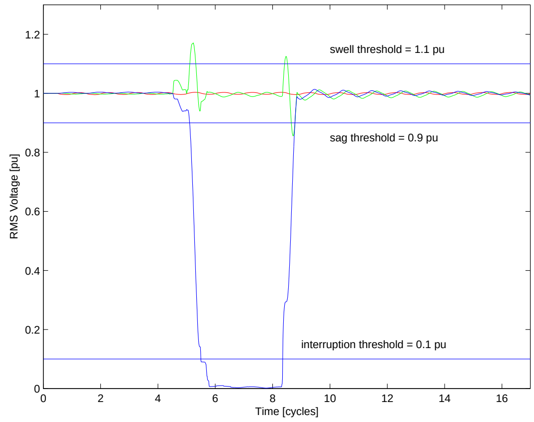


Figure 1.1: Example of voltage sag, interruption and swell in one event

Voltage sags can be mitigated by many different electric devices, depending on the application, but that is not a subject that will be discussed in the following chapters. In the following chapters I will discuss voltage sag indices in more detail along with the analysis of the measured data.

Voltage sags in the electrical system is something we do not like, but we can make improvements in the system to prevent them from happening. Therefore there is a high need for better analysis and understanding of these events.

1.2 Voltage Sag Indices

Nowadays power providers are building databases of power quality events with megabytes to gigabytes of measurements. Therefore there is a need to analyse these data accurately and with a high efficiency. Voltage sag indices are a good tool for analysing these data. Voltage sag indices are a way of quantifying the performance of the power supply, as far as voltage sags are concerned. Indices can be defined for individual events, for individual sites, and for a whole system.

There continues to be a lack of common terminology to assess utility service quality performance, therefore also an overview of the existing knowledge on voltage sag indices together with various statistics will be discussed.

The main document that will be used to obtain voltage sag indices is Voltage sag indices - draft 5, working document for IEEE P1564 [2]. In this document voltage sag indices are explained in a very good manner, so one can understand it.

1.3 Aim and structure of this thesis

The aims of this thesis is firstly to implement the algorithms to calculate site and system indices from sampled voltages according to the listed documents [1] and [2] in Matlab, with written overview of the existing knowledge on voltage sag indices.

Secondly to develop a method for calculating single-event, site and system indices based on three-phase characteristics using document [3] as starting point and to implement this in Matlab as well, with a detailed description of the two methods plus the various implementation issues.

Finally to apply these algorithms to measured data and obtain statistics on the resulting indices.

This thesis is structured in six Chapters.

In Chapters 2, 4 and 6 an overview of the existing knowledge on voltage sag characteristics and indices is given.

In Chapters 3 and 5 results for single event characteristics and site indices are presented. In these two Chapters also various implementation issues are discussed.

In Chapter 7 all the results are summarized.

Chapter 2

Single-Event Characteristics and Indices

In this chapter methods, selected from documents [1] and [2], that have been implemented in Matlab and applied to a large number of events. The starting point is a time-domain waveform of a three-phase voltage sampled with known frequency. Firstly it is important to calculate RMS voltage versus time characteristics, calculate retained voltage and duration of a voltage sag. The second step is to calculate voltage-sag energy index and voltage-sag severity.

2.1 Exact Frequency Estimation

Before calculating some of the single-event characteristics, accurate frequency of the signal is needed. According to [7], this is only possible when at least two cycles of pre-event waveform data are available. The first step is to estimate the length of one cycle of the power system frequency. An integer number of samples with a duration as close as possible to 20 ms (for a 50-Hz system) is used for this. Let the length of this estimation be T. The initial angle α_1 of the fundamental component is determined over the window $[0, T]$ by using a DFT algorithm. The angle over the next "period", $[T, 2T]$ is α_2. The second angle is obtained by increasing the first angle by $2\pi fT$ with f the actual frequency and T the estimated period [7]. The actual frequency can be obtained from the expression:

$$2\pi + \alpha_2 = \alpha_1 + 2\pi fT \tag{2.1}$$

from which the following explicit expression for the actual frequency is obtained:

$$f = \frac{1}{T}\left(1 + \frac{\alpha_2 - \alpha_1}{2\pi}\right) \tag{2.2}$$

Some events start with a voltage sag recovering to nominal post-event voltage. In these cases the pre-event waveform is not available. To get the angles α_1 and α_2, the last two cycles of the post-event voltage are considered instead.

2.2 RMS Calculation

The IEC power-quality measurement standard IEC 61000-4-30 [1] prescribes a very precise method for obtaining the voltage magnitude as a function of time. The first step in this procedure is to obtain the rms voltage over a window with a length exactly equal to one cycle of the power-frequency. The standard does not prescribe a method to obtain the window length, but it does state an accuracy requirement [7].

According to [7], the calculation of this "one-cycle rms voltage" is repeated every half cycle; in other words: the window is shifted one half cycle in time. This results in a discrete function with a time step equal to one half cycle of the power-system frequency. The one-cycle rms voltage calculated every half-cycle is obtained by,

$$U_{rms}(n) = \sqrt{\frac{1}{N} \sum_{k=1+n\frac{N}{2}}^{(\frac{n}{2}+1)N} u(k)^2} \tag{2.3}$$

where N is number of samples per cycle, $u(k)$ is the sampled voltage waveform and $k = 1, 2, 3$, etc. The first value is obtained over the samples (1,N), the next over the samples $(\frac{1}{2}N + 1, 1\frac{1}{2}N)$, etc [1].

The one-cycle rms voltage calculated every sample is obtained by,

$$U_{rms}(n) = \sqrt{\frac{1}{N} \sum_{k=n-N+1}^{n} u(k)^2} \tag{2.4}$$

where N is number of samples per cycle, $u(k)$ is the sampled voltage waveform and $k = 1, 2, 3$, etc.

According to [7], in some cases it may be more appropriate to use a half-cycle window to calculate the rms voltage. The main advantage of using a half-cycle window, compared to a one-cycle window, is a faster transition from the pre-fault voltage to the during-fault voltage and from the during fault voltage to the post-fault voltage.

The half-cycle rms voltage calculated every sample is obtained by,

$$U_{rms\frac{1}{2}}(n) = \sqrt{\frac{1}{N} \sum_{k=n-N+1}^{n} u(k)^2} \tag{2.5}$$

where N is number of samples per half-cycle, $u(k)$ is the sampled voltage waveform and $k = 1, 2, 3$, etc.

2.3 Duration and Retained Voltage

According to [7] voltage sags are described by two main indices: duration and retained voltage.

The duration of a voltage sag is the amount of time during which the voltage magnitude is below the sag threshold. The sag threshold is typically chosen as 90% of the nominal voltage magnitude. In a three phase system, the duration of the voltage sag is the time during which at least one of the rms voltages is below the threshold. The voltage sag starts when at least one of the rms voltages drops below the sag-starting threshold. The sag ends when all three rms voltages have recovered above the sag-ending threshold [7].

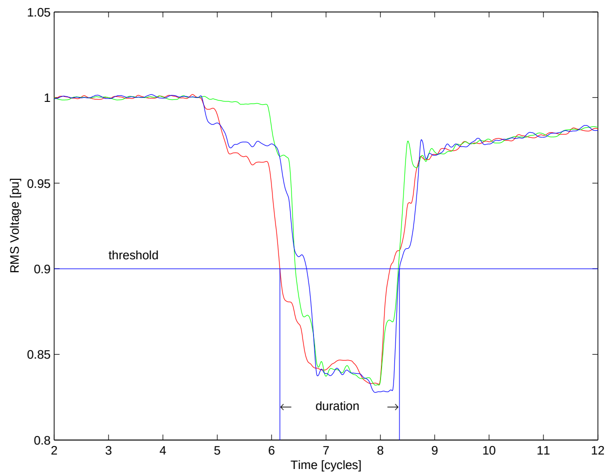


Figure 2.1: Calculation of duration of the voltage sag.

This means that the duration of the voltage sag is the time between the start of the voltage sag and end of the voltage sag. Duration can be then calculated as the difference between the time when all three rms voltages have recovered above the sag-ending threshold and the time when at least one of the rms voltages drops below the sag-starting threshold. Figure 2.1 illustrates how the duration is calculated, where the rms voltage is calculated over one half-cycle and updated every sample.

The retained voltage of the voltage sag is the lowest rms voltage in any of the three phases. To be able to represent retained voltage in per unit, it is important to say that the reference voltage is chosen as the pre-event voltage. The reason why pre-event voltage is chosen, is that the nominal voltage is different for every file that is analysed.

2.3.1 Interruption

According to IEC standard in [1], the interruption starts when all three rms voltages drop below the threshold and ends when at least one of them rises above the threshold. The interruption threshold is typically chosen 10% of the nominal voltage. The duration of the interruption is the time during which all the three rms voltages are below the interruption threshold. If the voltage is zero in all three phases the event is classified as a voltage sag and as an interruption.

2.3.2 Swell

A voltage swell can be characterized in the same way as a voltage sag. The duration of a swell equals the amount of time the rms voltage is above the swell threshold. The swell starts when at least one of the rms voltages rises above the swell-starting threshold. The swell ends when all three rms voltages have recovered below the swell-ending threshold. The retained voltage is the highest value of the rms voltages. The recommended value for the swell threshold is 110% of the declared voltage or of the sliding-reference voltage.

2.4 Voltage-Sag Energy Index

According to [2], the voltage sag energy E_{vs} is defined as:

$$E_{vs} = \int_0^T \left\{ 1 - \left(\frac{U(t)}{U_{nom}} \right)^2 \right\} dt \qquad (2.6)$$

where $U(t)$ is the rms voltage during the event and U_{nom} is the nominal voltage. The integration is taken over the duration of the event, e.g. for all the values of the rms voltage below the threshold. The voltage-sag energy has the unit of time.

Substituting Eq. 2.5 in Eq. 2.6, we obtain an expression with the half-cycle rms voltage that can be implemented in Matlab:

$$E_{vs} = \frac{1}{2f_o} \sum_{n=1}^{N} \left\{ 1 - \left(\frac{U_{rms\frac{1}{2}}(n)}{U_{nom}} \right)^2 \right\} \qquad (2.7)$$

where f_o is the frequency and the sum is taken over the whole duration of the event, e.g. for all values of the rms voltage below the threshold.

In case only retained voltage and duration of an event are available, the rms voltage is assumed constant over the duration of the event. This results in the following expression for the voltage sag energy:

$$E_{vs} = \left\{ 1 - \left(\frac{U}{U_{nom}} \right)^2 \right\} \times T \qquad (2.8)$$

with T the duration and U the retained voltage of the event.

The voltage-sag energy is the duration of an interruption leading to the same loss of energy for an impedance load as the voltage sag [2].

For multi-channel events (e.g. three-phase systems) the voltage-sag energy is defined as the sum of the voltage-sag energy in the individual channels (phases).

$$E_{vs} = E_{vs_a} + E_{vs_b} + E_{vs_c} \qquad (2.9)$$

Voltage swell energy can be defined analogous to voltage-sag energy as follows:

$$E_{vs} = \int_0^T \left\{ \left(\frac{U(t)}{U_{nom}} \right)^2 - 1 \right\} dt \qquad (2.10)$$

where $U(t)$ is the rms voltage during the event and U_{nom} is the nominal voltage. The integration is taken over the duration of the swell, i.e. for all values of the rms voltage that exceed the swell threshold (typically 110%).

Substituting Eq. 2.5 in Eq. 2.10, we obtain an expression with the half-cycle rms voltage

$$E_{vs} = \frac{1}{2f_o} \sum_{n=1}^{N} \left\{ \left(\frac{U_{rms\frac{1}{2}}(n)}{U_{nom}} \right)^2 - 1 \right\} \qquad (2.11)$$

where f_o is the frequency and the sum is taken over the whole duration of the swell, e.g. for all values of the rms voltage above the threshold [2].

2.5 Voltage-Sag Severity

The voltage sag severity is according to [2] calculated from the retained voltage (in pu) and the duration of a voltage sag in combination with a reference curve:

$$S_e = \frac{1 - U}{1 - U_{curve}(d)} \tag{2.12}$$

where U is the retained voltage, d is the duration of the event and $U_{curve}(d)$ is the retained voltage of the reference curve for the same duration. SEMI curve, as shown in Figs. 2.2 and 2.3, is recommended as the reference. SEMI curve can be found in SEMI standard F-47 and in [21]. SEMI is the Semiconductor Equipment and Materials International Group. Construction of CBEMA curve can be found in [17] and [20]. More information can be also found according to [2] in the IEEE Orange book [14].

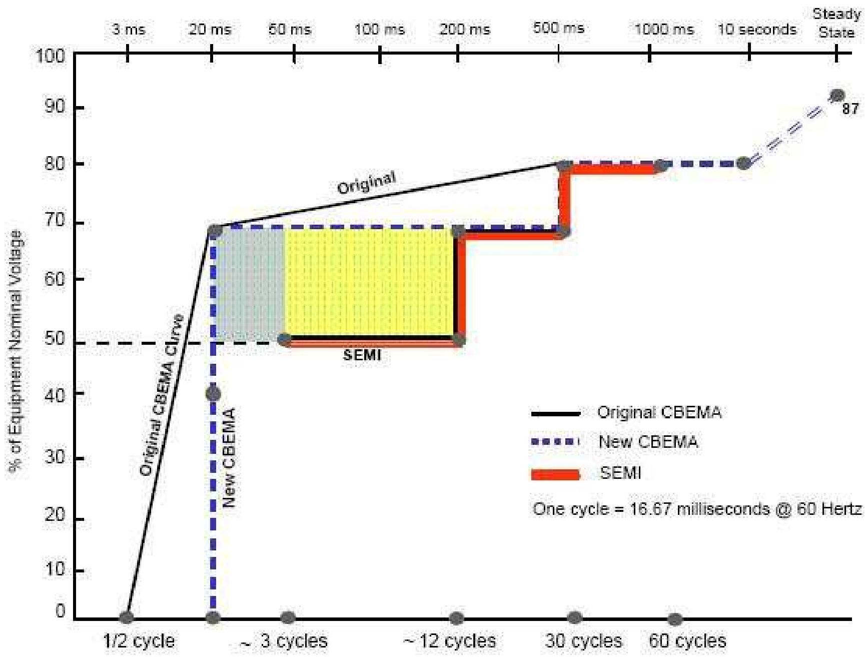


Figure 2.2: Overlay of CBEMA and SEMI curves [21].

From Fig. 2.3 it can be observed, that as the duration of the event gets longer and the retained voltage lower, the voltage-sag severity index increased. For an event

- on the reference curve the voltage-sag severity equals one,
- above the reference curve the voltage-sag severity is less than one,
- below the reference curve the voltage-sag severity is greater than one,
- with retained voltage above the voltage-sag threshold (90%) the voltage-sag severity is equal to zero.

Using the SEMI curve as a reference gives the algorithm for calculating the voltage-sag severity from the retained voltage U and the duration d reported in Table 2.1:

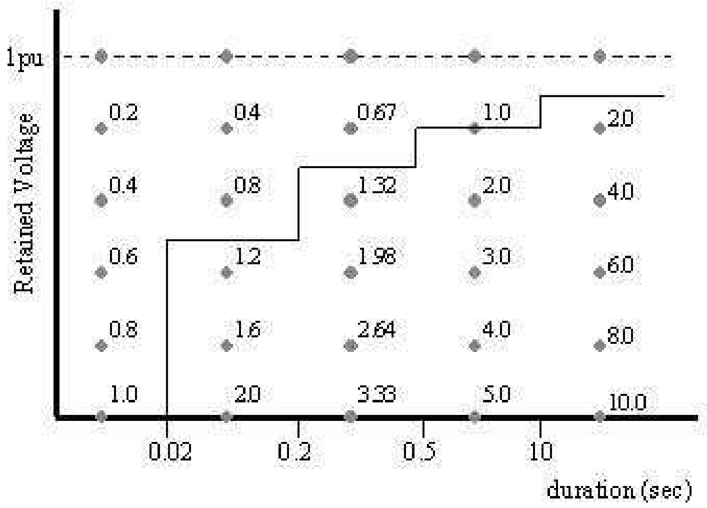


Figure 2.3: Voltage-sag severity with reference to the SEMI curve [2].

U_{curve}	d , duration range	S_e , voltage-sag severity calculation
0.0 pu	d$\leq$ 20ms	$S_e = \frac{(1-U)}{(1-0.0)} = \frac{(1-U)}{1} = 1 - U$
0.5 pu	20ms<d$\leq$ 200ms	$S_e = \frac{(1-U)}{(1-0.5)} = \frac{(1-U)}{0.5} = 2(1 - U)$
0.7 pu	200ms<d$\leq$ 500ms	$S_e = \frac{(1-U)}{(1-0.7)} = \frac{(1-U)}{0.3} = 3.3(1 - U)$
0.8 pu	500ms<d$\leq$ 10s	$S_e = \frac{(1-U)}{(1-0.8)} = \frac{(1-U)}{0.2} = 5(1 - U)$
0.9 pu	10s<d	$S_e = \frac{(1-U)}{(1-0.9)} = \frac{(1-U)}{0.1} = 10(1 - U)$

Table 2.1: Algorithm for calculating the voltage-sag severity.

2.6 Three-phase classification of a voltage sag

Each sag in a three-phase system according to [7] can be characterized by a sag type, retained voltage and duration. Characteristics as retained voltage and duration of a voltage sag were introduced in section 2.3. To obtain sag type two methods can be used:

- symmetrical-component method and
- six-phase RMS method

2.6.1 Voltage sag classification

Before introducing these two methods, it is necessary to classify voltage sags. To classify them ABC classification or Symmetrical component classification can be used. The ABC classification is the oldest classification and the one most commonly used. This is likely due to its simplicity. However the classification is based on incomplete assumptions and cannot be used to obtain the characteristics of measured sags. The symmetrical component classification is more general and gives a direct link with measured voltages. However the method is harder to understand and a translation to the ABC classification may be suitable for many applications [2].

The ABC classification

In [2] the ABC classification distinguishes between seven types of three-phase unbalanced voltage sags. Expressions for the complex voltages for these seven types are given in figure 2.4. The complex pre-fault voltage in phase a is indicated by E_1. The voltage in the faulted phase or between the faulted phases is indicated by V^*. One of the reasons for introducing this classification was to describe the propagation of sags through transformers. Origin and transformation of the seven types are given in Table 2.2 and Fig. 2.5 [2].

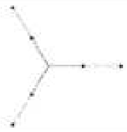
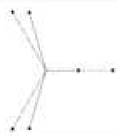
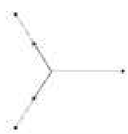
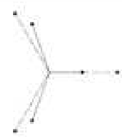
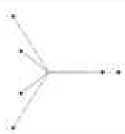
Type	Voltages	Phasors
A	$U_a = V^*$ $U_b = -\frac{1}{2}V^* - \frac{1}{2}jV^*\sqrt{3}$ $U_c = -\frac{1}{2}V^* + \frac{1}{2}jV^*\sqrt{3}$	
B	$U_a = V^*$ $U_b = -\frac{1}{2}E_1 - \frac{1}{2}jE_1\sqrt{3}$ $U_c = -\frac{1}{2}E_1 + \frac{1}{2}jE_1\sqrt{3}$	
C	$U_a = E_1$ $U_b = -\frac{1}{2}E_1 - \frac{1}{2}jV^*\sqrt{3}$ $U_c = -\frac{1}{2}E_1 + \frac{1}{2}jV^*\sqrt{3}$	
D	$U_a = V^*$ $U_b = -\frac{1}{2}V^* - \frac{1}{2}jE_1\sqrt{3}$ $U_c = -\frac{1}{2}V^* + \frac{1}{2}jE_1\sqrt{3}$	
E	$U_a = E_1$ $U_b = -\frac{1}{2}V^* - \frac{1}{2}jV^*\sqrt{3}$ $U_c = -\frac{1}{2}V^* + \frac{1}{2}jV^*\sqrt{3}$	
F	$U_a = V^*$ $U_b = -\frac{1}{2}V^* - \left(\frac{1}{3}E_1 + \frac{1}{6}V^*\right)j\sqrt{3}$ $U_c = -\frac{1}{2}V^* + \left(\frac{1}{3}E_1 + \frac{1}{6}V^*\right)j\sqrt{3}$	
G	$U_a = \frac{2}{3}E_1 + \frac{1}{3}V^*$ $U_b = -\frac{1}{3}E_1 - \frac{1}{6}V^* - \frac{1}{2}jV^*\sqrt{3}$ $U_c = -\frac{1}{3}E_1 - \frac{1}{6}V^* + \frac{1}{2}jV^*\sqrt{3}$	

Figure 2.4: Seven types of three-phase unbalanced voltage sags according to the ABC classification.

This method was originally developed to be part of stochastic prediction of voltage sags. From known statistics on faults it is possible to calculate the frequency of occurrence of the different types of voltage sags. This classification can also be used for testing of equipment against voltage sags. By using this classification it is possible to generate the sags that can be expected at the terminals of three-phase equipment [2]. Generating such sags, referred later as *"synthetic sags"* is very useful to check if the Matlab code created for real measured data gives correct results for sag characteristics.

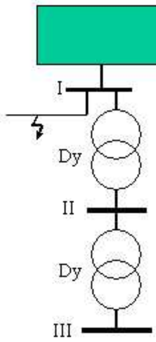


Figure 2.5: Sags at different voltage levels due to different fault types.

Fault type	location		
	I	II	III
Three-phase	A	A	A
Two-phase-to-ground	E	F	G
Two-phase	C	D	C
Single-phase-to-ground	B	C	D

Table 2.2: Sags at different voltage levels due to different fault types.

The weak point of this method is that it is only simulation-based. Extraction of the sag type from measured voltage waveforms was not immediately possible. Recent work however has shown that the sag type may be estimated in the majority of cases from the three rms voltages only [2].

The symmetrical component classification

In [2] the symmetrical component classification does not suffer from the same limitation as the ABC classification. The symmetrical component classification distinguishes between sags with the main voltage drop in one phase and sags with the main voltage drop between two phases. Sags due to three-phase faults, with an equal drop in the three phases, are a limit case for both single-phase and two-phase drops. The zero-sequence voltage is treated as a separate characteristic from the beginning and in many studies not even considered. The two other characteristics are the *"characteristic voltage"* and the *"PN factor"*. The general expression for the *"non-zero-sequence part"* of a voltage sag with the main drop in phase a (referred to as sag type Da) is [2]:

$$\begin{aligned} U_a &= V \\ U_b &= -\frac{1}{2}V - \frac{1}{2}jF\sqrt{3} \\ U_c &= -\frac{1}{2}V + \frac{1}{2}jF\sqrt{3}. \end{aligned} \tag{2.13}$$

The general expression for a voltage sag with the main drop between phases b and c (sag type Ca), is:

$$\begin{aligned} U_a &= F \\ U_b &= -\frac{1}{2}F - \frac{1}{2}jV\sqrt{3} \\ U_c &= -\frac{1}{2}F + \frac{1}{2}jV\sqrt{3}, \end{aligned} \tag{2.14}$$

where $|F| \geq |V|$. Note that a balanced sag, due to a three-phase fault, is obtained for $F = V$. Similar expressions hold for the other four sag types:

- Db (drop in phase b), Dc (main drop in phase c),
- Cb (main drop between phases a and c), Cc (main drop between phase a and b).

The somewhat illogical notation was used to make the classification consistent with the older ABC-classification. For $F = E_1$ and $V = V^*$, Eq. 2.13 and 2.14 are identical to type D and type C, respectively, as defined for the ABC classification in Fig. 2.4. The definition of characteristic voltage and PN-factor as well as the algorithm for obtaining the characteristics from measured voltage wave shapes, are both based on symmetrical components. The underlying mathematics will be described in later Section 2.6.2 [2].

2.6.2 Methods for extracting sag type

The sag type can at most take 19 different values. Seven different types (A through G) have already been introduced in the section 2.6.1. However when extracting voltage-sag characteristics from measurements, the affected phases have to be considered as well. This is shown graphically in Fig. 2.6. Only types C and D are shown for simplicity but similar subdivisions can be defined for other sag types with the exception of type A. Type Ca is a voltage drop between phases b and c (thus with a as *"symmetrical phase"*, type Cb between phases a and c, and type Cc between phases a and b. Type A cannot be further subdivided as it is symmetrical in the three phases.

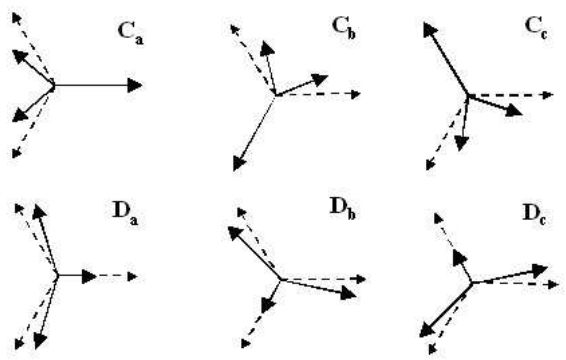


Figure 2.6: Six types of three-phase unbalanced sags.

To obtain sag type two methods can be used:

- symmetrical-component method and
- six-phase RMS method

Symmetrical-component method

The whole method is in a very good manner described in [7]. Symmetrical component method in [7] uses the angle difference of positive and negative-sequence complex voltages to estimate the sag type.

From Eq. 2.13 and 2.14 similar expressions have been derived for sag types Cb, Cc, Db and Dc. The aim of the characterization algorithm is to determine the sag type and to estimate the value of characteristic voltage and PN-factor. A first look at Eq. 2.13 and 2.14 shows that additional information is required. This is given in the form of the requirement that the characteristic voltage in absolute value is less than the PN-factor [7].

The characterization algorithm is based on the expressions for the positive and negative-sequence voltage for the six sag types. The positive-sequence voltage (with reference to a-phase pre-fault voltage) is the same for all sag types [7]:

$$V_1 = \frac{1}{2}(F + V) \tag{2.15}$$

The negative-sequence voltage is the same in magnitude but different in argument [7]:

$$\begin{aligned}
V_2 &= \frac{1}{2}(F - V) && \text{TypeC}_\text{a} \\
V_2 &= \frac{1}{2}a(F - V) && \text{TypeC}_\text{b} \\
V_2 &= \frac{1}{2}a^2(F - V) && \text{TypeC}_\text{c} \\
V_2 &= -\frac{1}{2}(F - V) && \text{TypeD}_\text{a} \\
V_2 &= -\frac{1}{2}a(F - V) && \text{TypeD}_\text{b} \\
V_2 &= -\frac{1}{2}a^2(F - V) && \text{TypeD}_\text{c}
\end{aligned} \tag{2.16}$$

where a constitutes a rotation over 120°. For sags due to single-phase and phase-to-phase faults, the PN-factor is close to unity (in per-unit with the pre-event voltage as a base). If we assume that $F = 1$ the angle between the drop in positive-sequence positive and negative-sequence is an integer multiple of 60 [7].

$$\begin{aligned}
\text{angle}(1 - V_1, V_2) &= 0^\circ && \text{TypeC}_\text{a} \\
\text{angle}(1 - V_1, V_2) &= 120^\circ && \text{TypeC}_\text{b} \\
\text{angle}(1 - V_1, V_2) &= -120^\circ && \text{TypeC}_\text{c} \\
\text{angle}(1 - V_1, V_2) &= 180^\circ && \text{TypeD}_\text{a} \\
\text{angle}(1 - V_1, V_2) &= -60^\circ && \text{TypeD}_\text{b} \\
\text{angle}(1 - V_1, V_2) &= 60^\circ && \text{TypeD}_\text{c}
\end{aligned} \tag{2.17}$$

According to [7], it has been assumed here that the pre-event voltage is 1 per-unit and along the positive real axis. The angles are multiples of 60° and different for the different sag types. The sag type can be estimated by comparing the measured angle with the values in Eq. 2.17. The angle is obtained by calculating the positive and negative-sequence voltage by standard expressions [22]

$$\begin{aligned} \overline{V_1} &= \frac{1}{3}\left(\overline{V_a} + a\overline{V_b} + a^2\overline{V_c}\right) \\ \overline{V_2} &= \frac{1}{3}\left(\overline{V_a} + a^2\overline{V_b} + a\overline{V_c}\right) \\ \overline{V_0} &= \frac{1}{3}\left(\overline{V_a} + \overline{V_b} + \overline{V_c}\right) \end{aligned} \tag{2.18}$$

and next determining the argument of the ratio between the complex positive and negative-sequence voltage [7].

This results in the following algorithm for obtaining the sag type T:

$$T = \frac{1}{60^\circ} \times \arg\left(\frac{V_2}{1 - V_1}\right) \tag{2.19}$$

where T is rounded to an integer. The method of rounding will be closely explained in Chapter 3. Initially let's assume that the rounding takes place to the nearest integer. The value of T is related to the earlier classification in accordance with the following table [7]:

$$\begin{aligned} &T = 0 \quad \mathrm{TypeC_a} \\ &T = 1 \quad \mathrm{TypeD_c} \\ &T = 2 \quad \mathrm{TypeC_b} \\ &T = 3 \quad \mathrm{TypeD_a} \\ &T = 4 \quad \mathrm{TypeC_c} \\ &T = 5 \quad \mathrm{TypeD_b} \end{aligned} \tag{2.20}$$

Knowing the sag type, the other characteristics can be obtained, e.g. from the sum and difference of positive and negative-sequence voltage according to Eq. 2.15 and 2.16. For example, for type C_a we can obtain characteristic voltage and PN-factor from the following expressions [7] :

$$\begin{aligned} V &= V_1 - V_2 \\ F &= V_1 + V_2 \end{aligned} \tag{2.21}$$

and for type D_c:

$$\begin{aligned} V &= V_1 + aV_2 \\ F &= V_1 - aV_2 \end{aligned} \tag{2.22}$$

A general expression can be obtained by using the sag type T as an additional parameter [7]:

$$\begin{aligned} V &= V_1 - b^{6-T}V_2 \\ F &= V_1 + b^{6-T}V_2 \end{aligned} \tag{2.23}$$

with $b = -a^2 = \frac{1}{2} + \frac{1}{2}j\sqrt{3}$ a rotation over 60° [7].

Six-phase RMS method

A simplified algorithm for extracting three phase characteristics is described in [6]. According to [7], the first stage in this so-called "six-phase algorithm" is the subtraction of zero-sequence component voltage. The zero-sequence voltage does not affect the sag type and is therefore treated separately. After subtraction of the zero-sequence voltage,

$$v_0 = \frac{1}{3}\Big(v_a + v_b + v_c\Big) \tag{2.24}$$

the rms voltage is obtained for the three phase voltages and the three phase-to-phase voltages [7]:

$$\begin{aligned} V_A &= \text{rms}\Big\{v_a - \frac{1}{3}(v_a + v_b + v_c)\Big\} \\ V_B &= \text{rms}\Big\{v_b - \frac{1}{3}(v_a + v_b + v_c)\Big\} \\ V_C &= \text{rms}\Big\{v_c - \frac{1}{3}(v_a + v_b + v_c)\Big\} \end{aligned} \tag{2.25}$$

$$\begin{aligned} V_{AB} &= \text{rms}\Big\{\frac{v_a - v_b}{\sqrt{3}}\Big\} \\ V_{BC} &= \text{rms}\Big\{\frac{v_b - v_c}{\sqrt{3}}\Big\} \\ V_{CA} &= \text{rms}\Big\{\frac{v_c - v_a}{\sqrt{3}}\Big\} \end{aligned} \tag{2.26}$$

The sag characteristics are obtained directly from these six rms voltages:

- the characteristic voltage is the lowest of the six rms voltages,
- the PN factor the highest of the six.

The sag type is determined from the voltage according to Eq. 2.25 and 2.26 with the lowest rms value, as in Table 2.3

lowest rms voltage	dip type
V_A	D_a
V_B	D_b
V_C	D_c
V_{AB}	C_c
V_{BC}	C_a
V_{CA}	C_b

Table 2.3: Sag type from the six-phase algorithm.

The six-phase algorithm can also be used to obtain the arguments of the complex voltages V and F. The argument of the characteristic voltage is the phase angle of the voltage that gives the lowest rms value: $v_a - v_0$ for type $D_a, v_b - v_0$ for type C_c, etc. The argument of the PN factor is the phase angle of the voltages that gives the highest rms value [7].

One of the advantages of using six rms method compared to symmetrical component method is that it is easier to understand and implement, especially when large number of events needs to be investigated. Both methods are in a very good manner described in [3] and [7].

Chapter 3

Implementation Issues and Results of Single-Event Characteristics

3.1 Implementation Issues

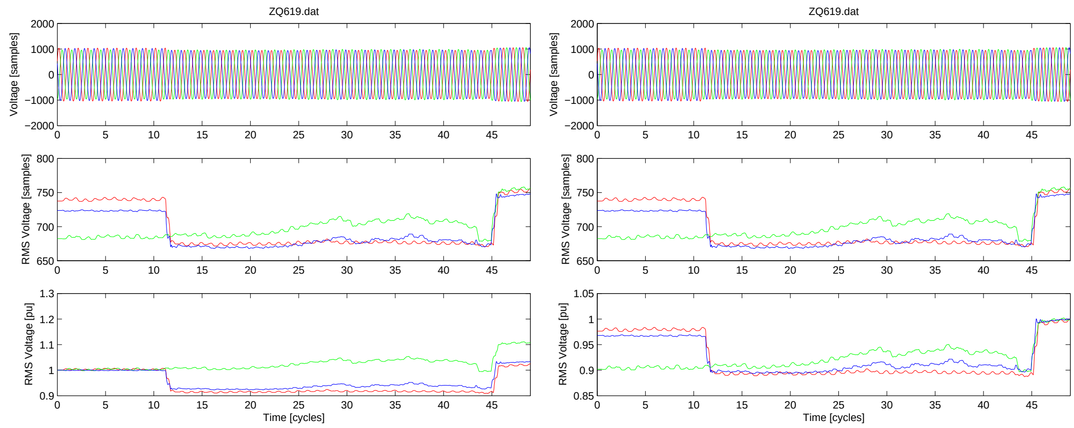
The data analyzed in this thesis consists of 887 files that were recorded on different sites in a medium-voltage network during one month in June 1997. In each .dat file one event is stored, three phase voltages, three phase currents and time are recorded. Although all files contained a current record, the values did not in all cases correspond to actually measured currents. For the work presented here only the voltage records were used.

I decided to analyse these data with help of MatLab. In MatLab environment it is more convenient to work with .mat files. The time to load them is faster and only desired variables are stored in the workspace. Each .dat file was loaded into MatLab and three phase voltages and time were stored into .mat files. This was done automatically by the code attached in Appendix A.

Another code was written to automatically take each .mat file with stored data and calculate single-event characteristics and indices for each event as discussed in Chapter 2. Code was stored in the file SingleEvent.m and is also attached in Appendix A. Firstly the exact frequency for each phase was calculated. Secondly the rms voltage versus time in cycles was calculated and printed in the figure. Then per unit characteristics were obtained and also printed in the same figure.

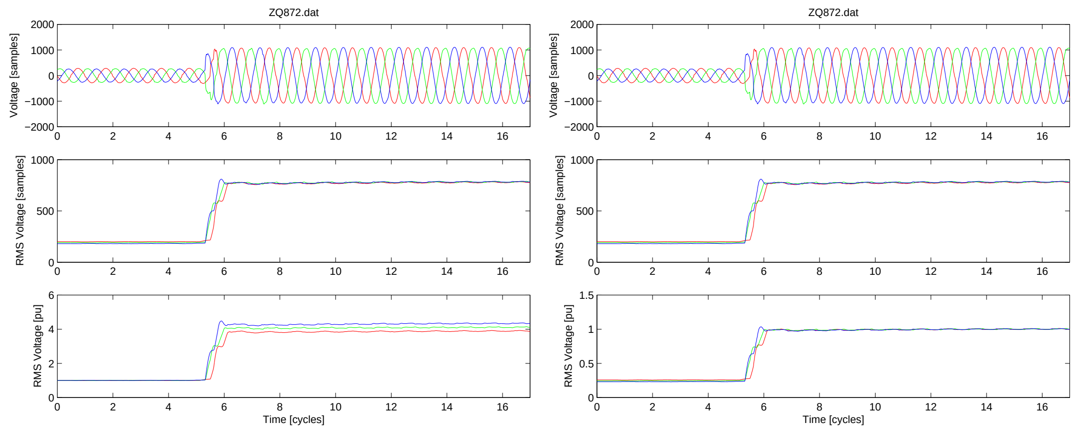
3.1.1 Reference Voltage

To be able to represent rms voltage in per unit, the pre-event voltage instead of the nominal voltage is chosen as the reference. The reason is that a large number of events have been analysed and the nominal voltage is different for each of them. Some events start with a voltage sag, usually also classified as an interruption, and recovering to the post-event voltage close to the nominal voltage. In these cases the pre-event waveform is not available and therefore the post-event voltage was chosen as the reference voltage. Examples of the characteristics before and after corrections of the reference voltage are shown in Figs. 3.1 and 3.2. Note that the difference is only in the per-unit scale in the lower figures. Two upper plots in the figures are kept for better illustration.



(a) Sag before correction. (b) Sag after correction.

Figure 3.1: Sag ZQ619.dat before and after correction of the reference voltage.



(a) Sag before correction. (b) Sag after correction.

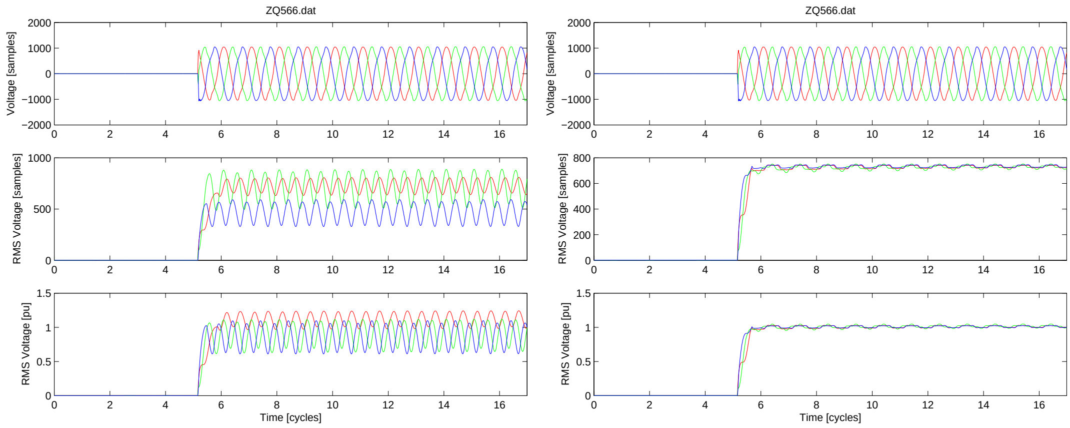
Figure 3.2: Sag ZQ872.dat before and after correction of the reference voltage.

3.1.2 Exact Frequency

Exact frequency was estimated from the pre-event or post-event voltage, depending on the chosen reference. That means, if the pre-event voltage in the file was chosen as the reference, also frequency was estimated from the pre-event voltage or if the post-event voltage was chosen as the reference, also the frequency was estimated from the post-event voltage. To estimate the exact frequency, angles α_1 and α_2 had to be obtained as discussed earlier in the Section 2.1. When the frequency was estimated from the pre-event voltage, corrections were made in those cases when the first cycle was not fully recorded at the beginning of the event. To obtain the angles α_1 and α_2, the DFT algorithm was applied over the window of the next two periods $[T, 2T]$ and $[2T, 3T]$ respectively.

When the length of the recorded event is time t, the frequency of the post-event voltage was estimated over the last two periods $[t-2T, t-T]$ and $[t-T, t]$ to obtain angles α_1 and α_2 respectively. Example of the characteristics before and after corrections of the frequency calculation were made, is shown in Fig. 3.3. In the left-hand plot in Fig. 3.3

the frequency was estimated over the first two periods. Because voltage was almost equal to zero, the frequency was estimated wrongly (about 90 Hz) and big oscillations occurred in the rms voltage. Therefore corrections were made and frequency was estimated over the last two periods as shown in the right-hand plot in Fig. 3.3. In both plots in Fig. 3.3 half-cycle rms voltage updated every sample was used to calculate the rms voltages. Code for the exact frequency estimation named *"FreqEstim-3phase.m"* is included in Appendix A.



(a) Sag before correction.　(b) Sag after correction.

Figure 3.3: Sag ZQ566.dat before and after correction of the frequency calculation.

To be able to correctly calculate the rms value, estimation of the actual frequency is made. Implementing this correctly would however require a resampling of the data. After all, the sampling rate is not synchronized with the actual power-system frequency. The exact frequency estimation plays important role in calculation of the sag type by the symmetrical-component method, but does not necessarily have to be used to calculate rms characteristics. According to [23], the relative error in rms is half the relative error in frequency: thus 0.5% error in frequency (49.75 Hz) gives 0.25% error in rms voltage (0.8975 pu instead of 0.9 pu).

3.1.3 RMS Calculation

RMS calculation can be done by one of the following calculations:

- one-cycle rms voltage calculated every half cycle,
- one-cycle rms voltage calculated every sample,
- half-cycle rms voltage calculated every sample

Equations for every one of them were introduced in Section 2.2. Eq. 2.3 for one-cycle rms voltage calculation every half cycle and Eq. 2.5 for half-cycle rms voltage calculation every sample were implemented in MatLab. The impact of using these two methods on voltage-sag energy index calculation will be reported in Section 3.2. In all the other calculations of single-event indices only half-cycle rms voltage calculated every sample was used. Code for the RMS calculation named *"RMS-3phase.m"* is included in Appendix A.

3.1.4 Implementation of the Two Methods

Symmetrical-component method

Symmetrical-component method explained in Section 2.6.2 was implemented in MatLab according to Eq. 2.15 to 2.23. Code for the symmetrical-component method named *"SymmComp.m"* is included in Appendix A. To estimate the sag type, the angle difference of positive and negative-sequence complex voltages needs to be calculated. To obtain the sequence complex voltages, number of steps need to be carried out.

The first step is the implementation of the exact frequency calculation, as it was done in Section 3.1.2.

The second step is to determine the complex phase voltages in rotating frame [7]. DFT algorithm with calculation over one-cycle pu voltage updated every sample is used to obtain these complex voltages. Code for DFT algorithm named *"comp-samp.m"* is included in Appendix A.
The result of the "sliding-window DFT" gives an estimate of $\widetilde{V_a}$ defined as

$$v_a(t) = \text{Real}\left\{\widetilde{V_a}\right\} \quad \text{thus} \quad \widetilde{V_a} = \overline{V_a} \cdot e^{j\omega t} \tag{3.1}$$

$\overline{V_a}$ can be obtained from Eq. 3.1 as

$$\overline{V_a} = \widetilde{V_a} \cdot e^{-j\omega t} \tag{3.2}$$

where $\overline{V_a}$ is rotating or synchronous-frame voltage and $\widetilde{V_a}$ is non-rotating or stationary-frame voltage. The stationary-frame sequence voltages are obtained as

$$\widetilde{V_1} = \frac{1}{3}\left(\widetilde{V_a} + a\widetilde{V_b} + a^2\widetilde{V_c}\right) = \frac{1}{3}\left(\overline{V_a} + a\overline{V_b} + a^2\overline{V_c}\right) \cdot e^{j\omega t} = \overline{V_1} \cdot e^{j\omega t} \tag{3.3}$$

The synchronous-frame sequence voltages are obtained as $\overline{V_1} = \widetilde{V_1} \cdot e^{-j\omega t}$.
The symmetrical component voltages are calculated according to Eq. 2.20 and the angle between the positive-sequence and negative-sequence complex voltages are obtained from Eq. 2.17. Sag type is finally obtained by the Eq. 2.19 and Eq. 2.20.

The resulting value has to be taken modulus 6 when it is outside of the interval zero through five [7].

After sag type was obtained, characteristic voltage V and PN-factor F were calculated according to Eq. 2.23.

There are only six possible sag types according to this method: C_a, C_b, C_c, D_a, D_b, D_c; against 19 types under the ABC classification [7]. It is possible to define additional sag types in accordance with ABC-classification. In code only relation back to ABC-classification for type A was made.

Sag is classified as sag type A when $F \approx V$. The boundary for V and F was set to ± 0.0065 pu. Boundary has to be selected carefully, because if too wide, some sags that are not type A might fall in that group.

Code could classify sag as three phase sag, if all three phases are below the threshold but the sag is not balanced sag (sag type A).

Six-phase RMS method

Six-phase RMS method was implemented in Matlab according to Eq. 2.24 to Eq. 2.26, as explained in Section 2.6.2.

The sag characteristics are obtained directly from these six rms voltages according to Eq. 2.25 and Eq. 2.26:

- the characteristic voltage is the lowest of the six rms voltages,
- the PN factor the highest of the six rms voltages.

Important is to realize, that the lowest of the six rms voltages for each time instant need to be calculated and then the lowest value is the characteristic voltage V. To calculate the PN factor F, the highest of the six rms voltages for each time instant need to be calculated and then the lowest value is the PN factor. Sag type is obtained according to Table 2.3.

Synthetic sags

Before applying code to a large number of events, code was tested by synthetic sags generated in MatLab. Code for generating synthetic sags named *"SyntheticDips.m "* can be seen in Appendix A and results will be discussed in the next Section 3.2.

Generated synthetic sags were used on code to obtain all the characteristics. The characteristic voltage was chosen from 0.1 to 0.9 pu with step of 0.1 pu. Sag types from type A to G were chosen to represent the unbalanced voltage sags according to ABC classification introduced in 2.6.1. In total 171 (9×19) generated synthetic sags were tested on code. For illustration, synthetic sags for characteristic voltage $V = 0.5$ pu and the pre-fault voltage $E_1 = 1$ pu are included in Appendix B.

After all the corrections in the MatLab code were made, the code was applied to a large number of recorded events. When an event was classified as voltage sag or swell, the duration and retained voltage was calculated. If an event was classified as voltage sag and as interruption, the duration of interruption was also calculated. Indices as voltage sag energy index and voltage sag severity were calculated for all voltage sags or swells according to equations from Sections 2.4 and 2.5. Two different methods, symmetrical component method and six-phase rms method, for calculating sag type, characteristic voltage and PN-factor were used.

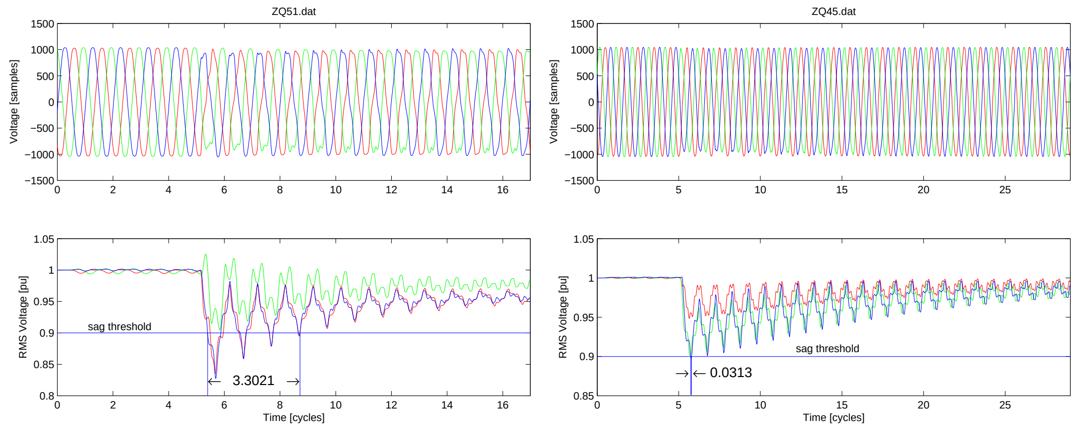
3.2 MatLab Results

3.2.1 Results of Single-Event Characteristics

All the results were stored into table that is shown in Appendix C. In the first column of the table, analysed files are listed. The second column indicates if the event was classified as voltage sag or not.

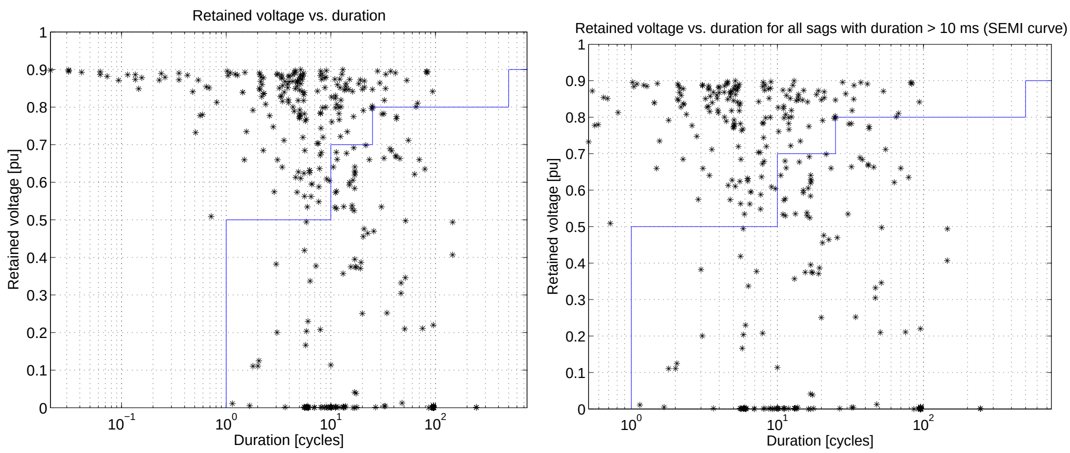
If the event was classified as voltage sag, in the next columns duration and retained voltage are shown respectively. If the event was classified as voltage sag and as interruption, the duration of interruption is also shown.

If the event was not classified as voltage sag, then in the column "Retained voltage", the minimum voltage is shown instead. The seventh column indicates if the event was



(a) Transformer saturation sag ZQ51.dat. (b) Transformer saturation sag ZQ45.dat.

Figure 3.4: Examples of calculation of duration for transformer saturation sags.



(a) All sags. (b) Sags with duration greater than half cycle.

Figure 3.5: Retained voltage vs. duration.

classified as swell or not. If the event was classified as swell, in the next two columns duration and retained voltage for swell are shown respectively.

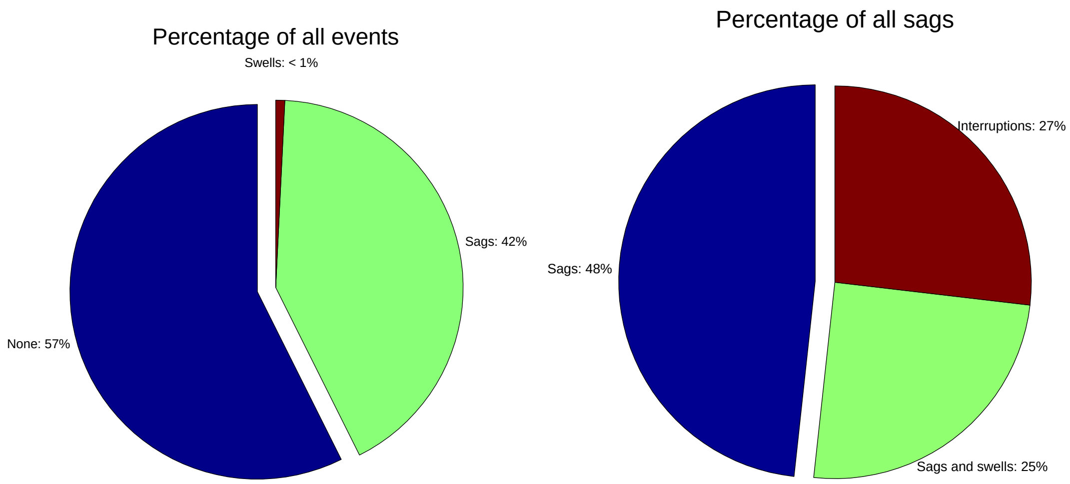
In the next columns voltage sag energy index calculated by two different equations, Eq. 2.7 and Eq.2.8 and also total voltage sag energy index are shown according to Eq. 2.9. If the event was classified as swell, also voltage swell energy index is shown in the next column according to Eq. 2.11.

Voltage sag severity calculated according to Eq. 2.12 is listed in the 16^{th} column.

Finally results for sag type, characteristic voltage V and PN-factor F from both methods, symmetrical-component method and six-phase rms method are listed in last columns.

Another table with only voltage sags listed is shown in Appendix D.

Voltage sags in Fig. 3.4 are typical examples of measurements of transformer saturation sags that take place during energising of transformers. In the left-hand plot in Fig. 3.4 is shown how duration of such a voltage sag is calculated. Because of half-cycle rms voltage calculation, oscillations in rms voltage can be observed. In spite of the fact that rms voltage oscillates, the duration is the amount of time during which the voltage magnitude is below the sag threshold. In the right-hand plot in Fig. 3.4 is shown how some events are classified as sags, but the duration is very small and should not be therefore considered in further calculations. In the right-hand plot in Fig. 3.5 sags with duration greater than half-cycle were plotted. The reason why only sags with duration greater than half-cycle were plotted is the definition of the voltage sag itself, as defined in IEEE Std. 1159-1995 [25]. In the left-hand plot in Fig. 3.5 results of retained voltage versus duration for all the voltage sags with SEMI-curve used as reference were plotted. In both plots in Fig. 3.5 half-cycle rms voltage updated every sample was used to calculate the rms voltages from which retained voltage was obtained.



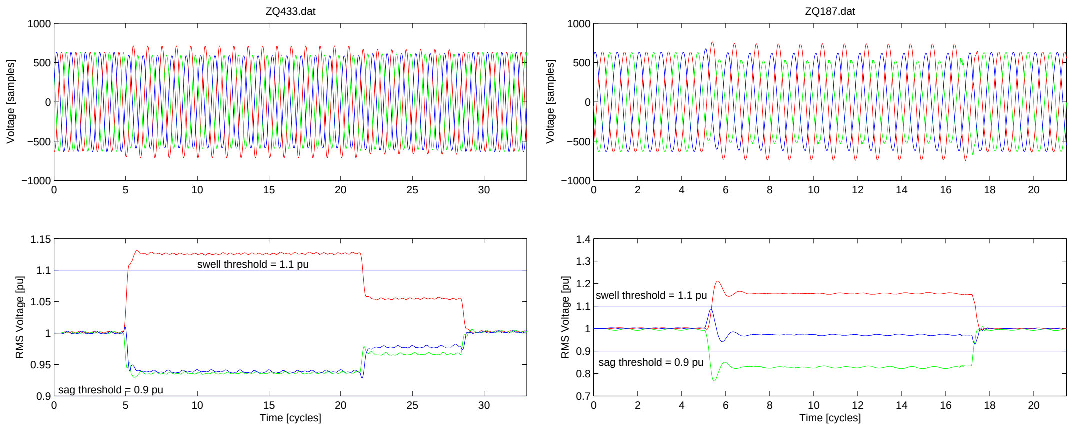
(a) Pie chart for all events. (b) Pie chart for sags.

Figure 3.6: Pie charts for all events and sags.

In the left-hand plot in Fig. 3.6 pie chart diagram for all events is shown and in the right-hand plot in Fig. 3.6 pie chart diagram for only sags is plotted. From the left-hand plot in Fig. 3.6 can be observed that only 1% of all events were classified as swells only. Example of such a swell is shown in the left-hand plot in Fig. 3.7. These were not the only events that were classified as swells. From the right-hand plot in Fig. 3.6 can be observed that 25% of all the events that were classified as sags were classified as swells, too. Example of such event that is classified as swell and sag is shown in the right-hand plot in Fig. 3.7.

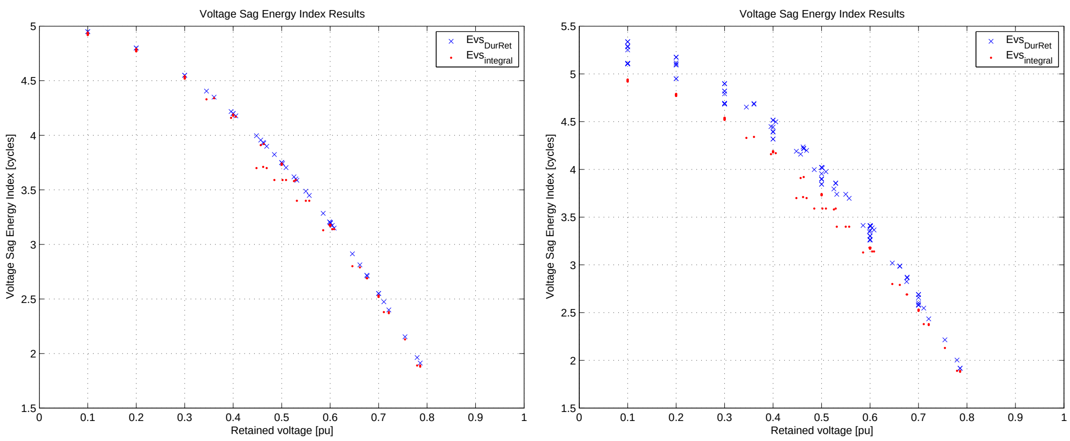
3.2.2 Different calculations of Voltage Sag Energy Index

Two different equations, Eq. 2.7 and Eq. 2.8, were used to calculate voltage sag energy index. Eq 2.7 uses integration over the duration of voltage sag and Eq. 2.8 uses calculated retained voltage and duration of voltage sag as input variables. Therefore voltage sag energy index calculated from Eq. 2.8 is always higher than the one calculated from Eq. 2.7. It was found also that, when duration of voltage sag is calculated from RMS voltage calculated over one-cycle updated every half-cycle, the difference in voltage sag energy index calculated by Eq. 2.7 and Eq. 2.8 is very small. The RMS calculation in code is calculated over one half-cycle updated every sample. One of the reasons is that RMS calculation over one half-cycle updated every sample is easier to implement. The different



(a) Swell only. (b) Swell and voltage sag.

Figure 3.7: Swells.



(a) RMS calculation over one-cycle updated every half-cycle. (b) RMS calculation over one half-cycle updated every sample.

Figure 3.8: Voltage sag energy index vs. retained voltage for synthetic sags.

calculation of RMS voltage was only tested for synthetic sags and table is included in Appendix E. Result of these differences for calculation of voltage sag energy index for synthetic sags was plotted in Fig. 3.8. Only voltage sag energy results for one phase were plotted in Fig. 3.8. The highest value from table in Appendix E in the 10^{th} to the 12^{th} columns was taken and plotted against voltage energy index calculated in the 9^{th} column.

In the Fig. 3.9 voltage sag energy index vs. retained voltage for real measured data using RMS calculation over one half-cycle updated every sample is plotted. There was not any particular relation observed, only the difference of using two different equations for calculation of voltage sag energy index.

In the left-hand plot in Fig. 3.10 voltage sag energy index using two different equations for synthetic sags is plotted. There is a small difference, but nothing significant. In the right-hand plot in Fig. 3.10 the same relation as in the left-hand plot is shown, but this time for real measured data of large number of sags. For real measured data it was observed that for some of the events there was a big difference in calculation of voltage sag energy index using two different equations. The big difference in calculation occurred

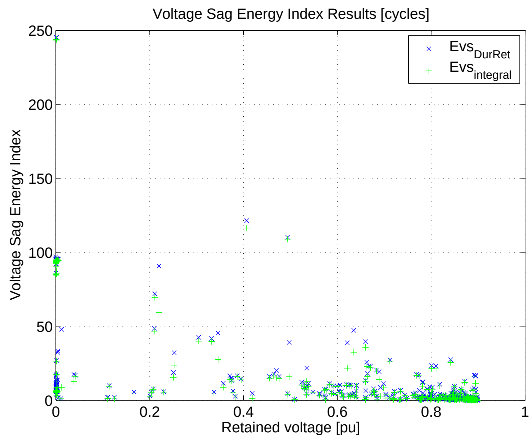
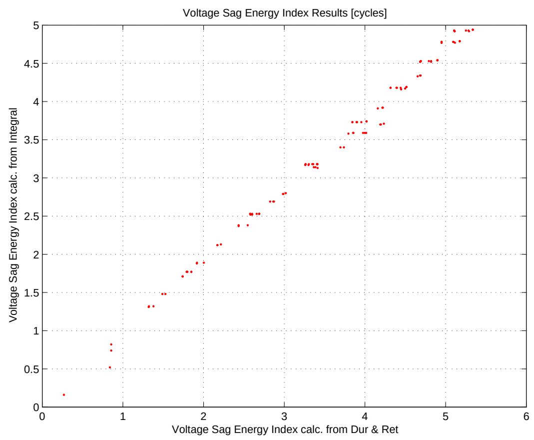
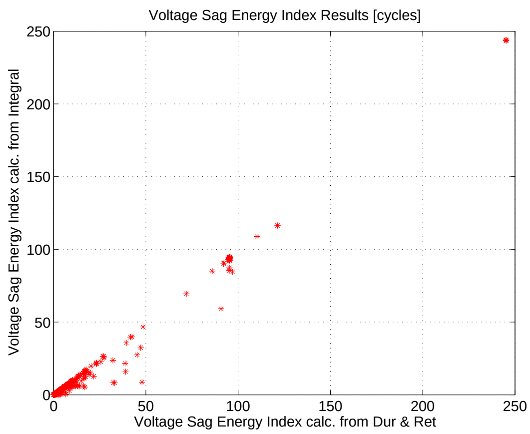


Figure 3.9: Voltage sag energy index vs. retained voltage for real measured data using RMS calculation over one half-cycle updated every sample.



(a) Synthetic sags.



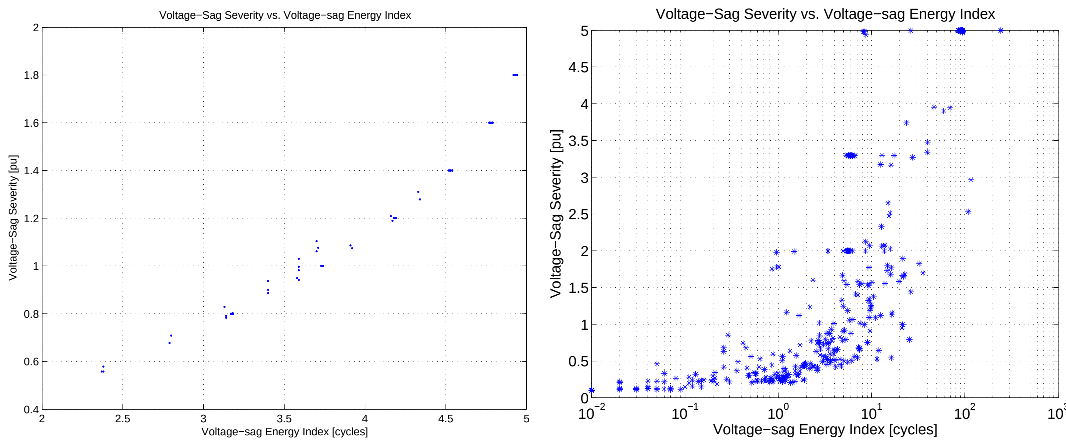
(b) Large number of measured sags.

Figure 3.10: Voltage sag energy index results for synthetic sags and real measurements.

because these sags were all classified as developing faults.

3.2.3 Voltage Sag Severity Results

In Fig. 3.11 voltage sag severity vs. voltage sag energy index for synthetic sags and real measurements is shown. From the left-hand plot in Fig. 3.11 it can be observed that for all synthetic sags there is likely to be a relation, since all the synthetic sags have the same duration. However for measured sags shown in the right-hand plot in Fig. 3.11 there is not any relation expected as they all have different duration. The fact that there is some correlation is understandable as both quantify the severity of the sag.



(a) Synthetic sags. (b) Large number of measured sags.

Figure 3.11: Voltage sag severity vs. voltage sag energy index for synthetic sags and real measurements.

3.2.4 Sag Type Results

Sag type was calculated by symmetrical-component method and six-phase rms method. Matching probability of sag types calculated from two different methods was 70%.

There were several reasons found for probability mismatch of 30%, while looking back on sag characteristics of these mismatched sag types:

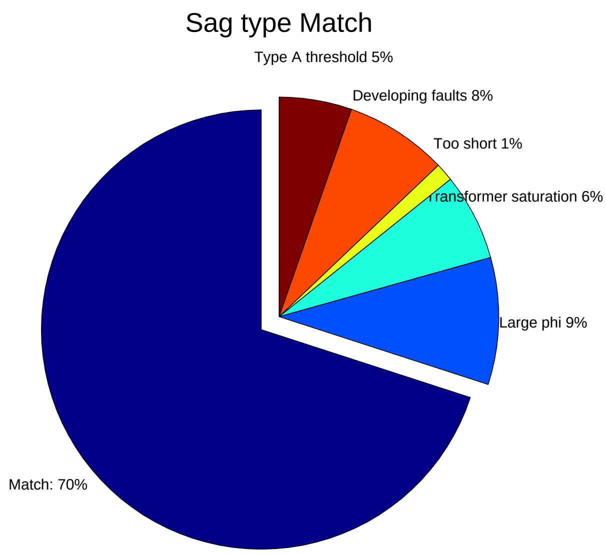
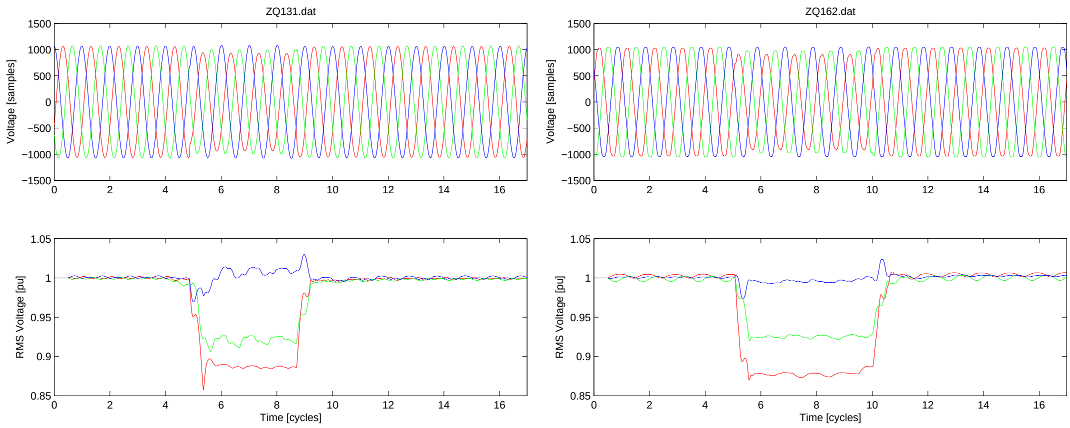


Figure 3.12:

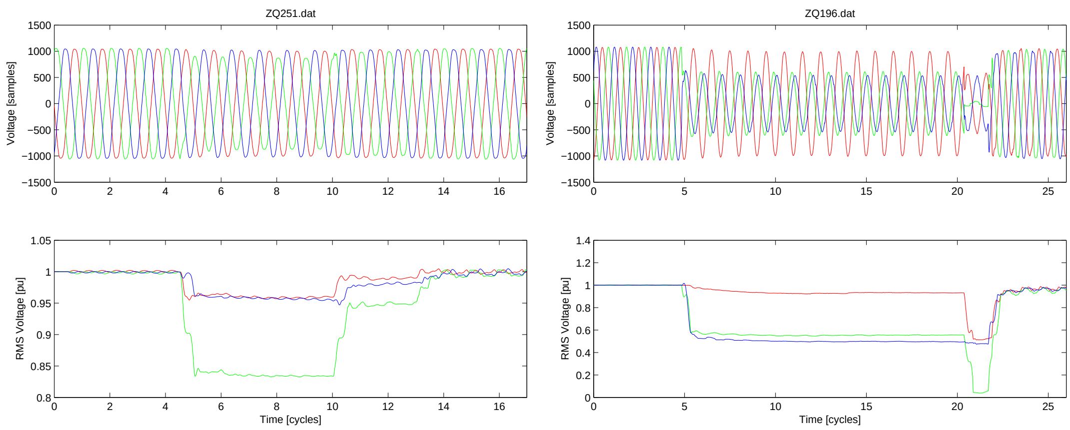
- 9.35% of all voltage sags were possible sags with large phase angle jump. For these sags, phase angle jump was not calculated and therefore it was not proved that phase angle was big enough to obtain wrong sag type for six-phase rms method. Examples of possible voltage sags with large phase angle jump are shown in Fig. 3.13. The differences in sag type for large phase angle jump are in detail explained in [6] and [7].



(a) ZQ131.dat. (b) ZQ162.dat.

Figure 3.13: Examples of possible sags with phase angle jump.

- 6.41% of all voltage sags were classified as measurements of transformer saturation sags that take place during energising of transformers or due to reclosing actions after a fault clearing operation. Different RMS calculation makes the RMS voltage to oscillate and therefore six-phase rms method can obtain different sag type than the symmetrical-component method. Example of such voltage sag is shown in the left-hand plot in Fig. 3.4. How to deal with transformer saturation measurements is in detail explained in [24] and [7].



(a) Developing fault for which sag type matches (sag type Db). (b) Developing fault for which sag type does not match (Db - six RMS, Ca - symm. comp.).

Figure 3.14: Examples of developing fault.

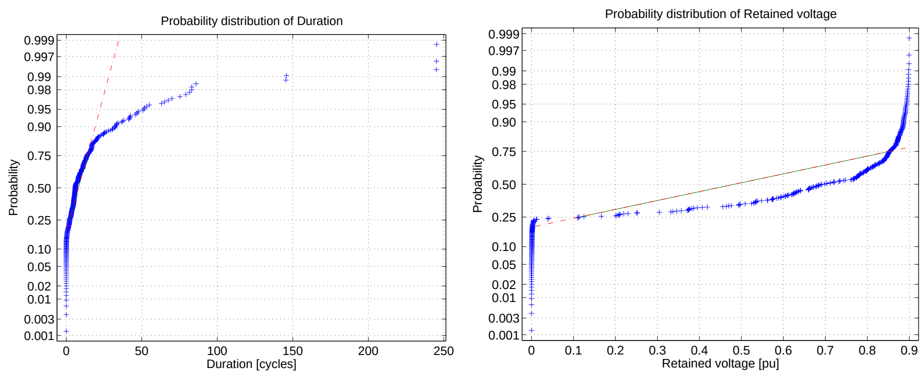
- 1.34% of all voltage sags had too short duration of voltage sag
- 7.55% of all voltage sags were classified as developing faults. Since code calculates sag type of symmetrical component method in the middle of the sag, it can generate different sag type than the six-phase rms method. Six-phase rms method does not calculate sag type in the middle of the sag, but depending on which of the six rms

voltages is the lowest. Sag type of the developing fault changes throughout the sag as it propagates. Examples of such voltage sag are shown in Fig. 3.14. In the left-hand plot in Fig. 3.14 voltage sag for which both methods give the same result is shown. In the right-hand plot in Fig. 3.14 voltage sag for which both methods give different result is shown. In the left-hand plot in Fig. 3.14 in the middle of the sag also rms voltage is the lowest, therefore both methods give the same result. In the right-hand plot in Fig. 3.14 in the middle of the sag the rms voltage is not the lowest, therefore symmetrical component method classifies the sag as type Ca, but the six-phase rms method as type Db. The problem could be solved, if the six-phase rms method calculates the sag type also in the middle of the sag.

- 5.35% of all voltage sags was matter of setting the threshold right for sags type A. In Section 3.1.4 the boundary for sag type A was explained.

In Fig. 3.12 pie chart diagram of matching probability for sag types calculated by two different methods are plotted.

3.2.5 Statistics



(a) Probability distribution of duration.
(b) Probability distribution of retained voltage.

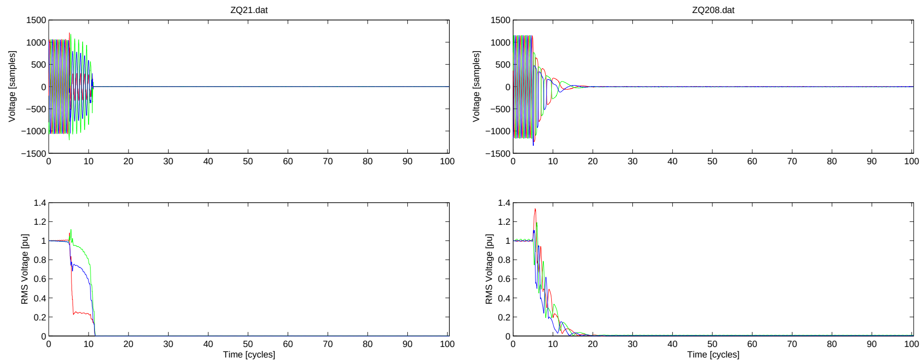
Figure 3.15: Probability distribution of duration and retained voltage for all sags.

In the next Figs. 3.15 to 3.19 some probability plots are shown. In the Fig. 3.15 probability distributions of duration and retained voltage for all sags are plotted. From Figs. 3.15 and 3.5 can be observed that most of the sags have duration less than 50 cycles. Measured data contained recordings that were stopped before the voltage recovered. These events were removed from database and were not plotted in Figs. 3.15 to 3.19. Examples of such events that were not fully recorded are shown in Fig. 3.16. The highest probability of retained voltage is for sags with retained voltage from 0.78 pu to 0.9 pu.

In the Figs. 3.17 to 3.19 probability distributions of duration and retained voltage for each sag type are plotted in the separate plots.

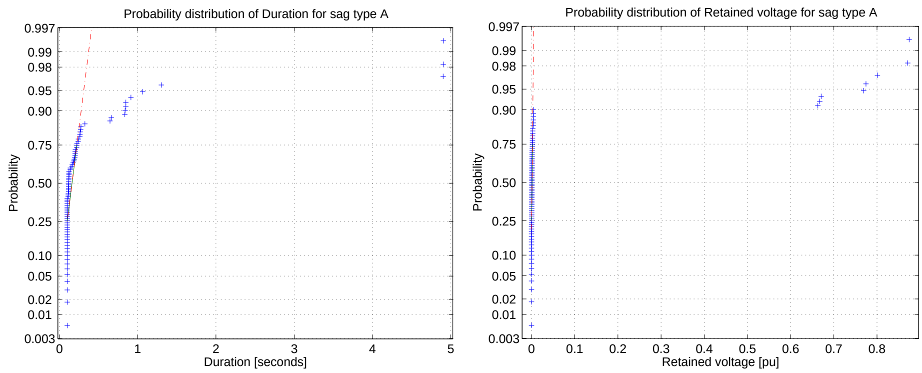
From Fig. 3.17 can be observed that type A sags are usually interruptions with retained voltage 0.0 pu and with duration of around 2s.

From Fig. 3.18 can be observed that the highest probability of retained voltage for sags type C is between 0.8 and 0.9 pu. Most of the sags of this type have duration of between 0.5 cycles and 0.5 s.



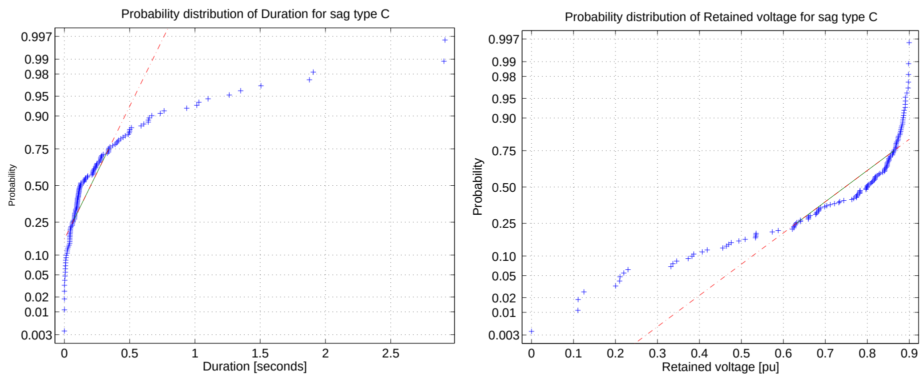
(a) ZQ21.dat. (b) ZQ208.dat.

Figure 3.16: Examples of recordings that stopped before the voltage recovered.



(a) Probability distribution of duration. (b) Probability distribution of retained voltage.

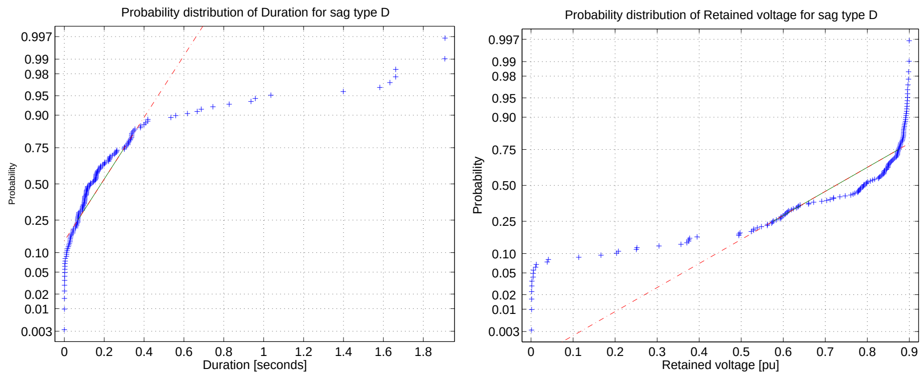
Figure 3.17: Probability distribution of duration and retained voltage for sag type A.



(a) Probability distribution of duration. (b) Probability distribution of retained voltage.

Figure 3.18: Probability distribution of duration and retained voltage for sag type C.

From Fig. 3.19 the similarity with type C can be observed. The highest probability of retained voltage for sags type D is again between 0.8 and 0.9 pu. Most of the sags of this type have duration of between 0.5 cycles and 0.6 s.



(a) Probability distribution of duration.

(b) Probability distribution of retained voltage.

Figure 3.19: Probability distribution of duration and retained voltage for sag type D.

Note that all the plots are plotted with a normal probability distribution curve, but the purpose of it was not to show if the distribution is normal or not. The purpose of it was to see what are the probabilities for duration and retained voltage to occur for certain sag types.

Chapter 4

Site Indices

In this chapter methods to calculate site indices, selected from documents [1] and [2], will be discussed, to be later implemented in Matlab and applied to a large number of events. As input to the site indices, the single-event characteristics are used as obtained from all events recorded at a given site over a given period, typically one month or one year [2].

Firstly it is important to calculate SARFI indices. SARFI is an acronym for *System Average RMS Variation Frequency Index* from which we recognize two types: SARFI-X and SARFI-curve. Secondly is to present the performance of a site by means of a voltage sag table, use the *voltage-sag energy method* of characterization and the *voltage-sag severity method*.

4.1 SARFI-X

SARFI index relates how often the retained voltage of a voltage sag is below a specified threshold. According to [2] SARFI-X corresponds to a count or rate of voltage sags, swell and/or interruptions below or above a voltage threshold:

- SARFI-90 counts voltage sags and interruptions that are below the threshold of 90% of the reference voltage
- SARFI-70 counts voltage sags and interruptions that are below the threshold of 70% of the reference voltage
- SARFI-110 counts voltage swells that are above the threshold of 110% of the reference voltage

$SARFI_X$ is expressed in the equation 4.1 as the number of events per 30 days with a retained voltage below X percent threshold:

$$SARFI_X = \frac{N_E}{D} \cdot 30\,\text{days} \tag{4.1}$$

where N_E is number of events at a single site and D number of days measuring these events at a single site.

The $SARFI_X$ indices are meant to assess short-duration rms variation events only, meaning that only those events with durations less than the minimum duration of a sustained interruption (5 minutes) are included in its computation [2].

4.2 SARFI-Curve

SARFI-curve corresponds to a rate of voltage sags below or above an equipment compatibility curve. We recognize two basic curves: ITIC(CBEMA) curve and SEMI curve. These curves again limit the duration of an rms variation event to the minimum duration of a sustained interruption (5 minutes according to IEEE Std.1366 [18]) [2].

4.2.1 SARFI-ITIC (CBEMA)

The ITIC curve in Fig. 4.1 is being proposed as the new CBEMA curve. The original CBEMA curve is a general curve to describe operational voltage limits for electronic equipment. It was developed a number of years ago based on educated guesswork, and does not apply exactly to all equipment. The new ITIC curve was developed by *Information Technology Industry Council* to better reflect real world performance of electronic equipment [19]. Therefore only the ITIC curve will be used from now on.

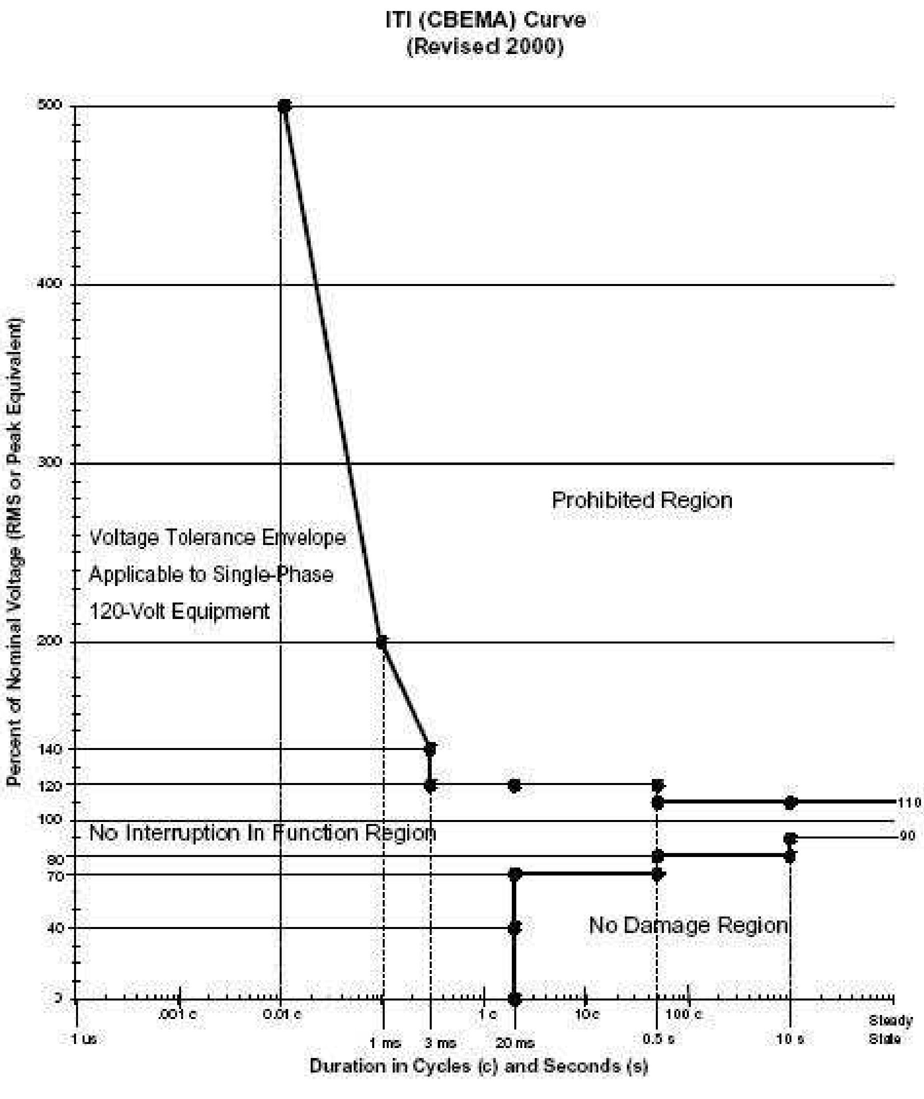


Figure 4.1: ITIC (CBEMA) curve [17].

The ITIC curve describes an ac input that typically can be tolerated (e.g. without an interruption in function) by most information technology equipment. ITIC curve includes two overlay curves that represent upper and lower limits. Events above the upper curve or below the lower curve are presumed to cause misoperation of information technology equipment (e.g., computers, computer network components, and communications networks). The curve is not intended to serve as a design specification for products or ac distribution systems. However, the normal functional state of information technology equipment is not typically expected when rms variations occur that are outside the upper and lower magnitude-duration limits described by the curve [2].

Using the ITIC curve gives the following algorithm for calculating the SARFI-ITIC presented in Table 4.1. The table shows the region of the semiconductor manufacturing equipment, where voltage sags cause damage to the information technology equipment. If a voltage sag is within the boundary, set by the ITIC curve retained voltage U_{ITIC} for a specified duration d, then that event is counted to SARFI-ITIC.

U_{ITIC}	duration d
0.0 pu	1ms<d≤ 20ms
< 0.7 pu	20ms<d≤ 500ms
< 0.8 pu	500ms<d≤ 10s
< 0.9 pu	10s<d

Table 4.1: Algorithm for calculating the SARFI-ITIC.

4.2.2 SARFI-SEMI

The SEMI curve presented in Figs. 2.2 and 2.3 shows the prohibited region for voltage sags below the SEMI curve. Using the SEMI curve gives the algorithm for calculating the SARFI-SEMI presented in Table 4.2. The table shows the region where a voltage sag causes damage to the semiconductor manufacturing equipment. If a voltage sag is within the boundary, set by the SEMI curve retained voltage U_{SEMI} for a specified duration d, then that event is counted to SARFI-SEMI.

U_{SEMI}	duration d
0.0pu	d≤ 20ms
< 0.5pu	20ms<d≤ 200ms
< 0.7pu	200ms<d≤ 500ms
< 0.8pu	500ms<d≤ 10s
< 0.9pu	10s <d

Table 4.2: Algorithm for calculating the SARFI-SEMI.

4.3 Voltage-Sag Table

A commonly used method of presenting the performance of a site is by means of a voltage sag table. Four different tables are presented in [2]:

- *Unipede table*
- *Table based on IEC 61000-4-11*
- *South-African standard NRS 048-2:2003*
- *Table from IEC 61000-2-8*

In each example, a maximum voltage-sag duration has been used equal to the minimum duration of a sustained interruption (5 minutes) as defined in IEEE Std.1366 [18]. A voltage-sag table can be used as a system index as well as a site index. Strictly speaking a voltage-sag table is not an index but a way of presenting a set of indices [2].

retained voltage	duration $d\,[s]$							
$U\,[\%]$	$d < 0.1$	$0.1 \leq d < 0.25$	$0.25 \leq d < 0.5$	$0.5 \leq d < 1$	$1 \leq d < 3$	$3 \leq d < 20$	$20 \leq d < 60$	$1min \leq d < 5min$
$80\% < U \leq 90\%$								
$70\% < U \leq 80\%$								
$60\% < U \leq 70\%$								
$50\% < U \leq 60\%$								
$40\% < U \leq 50\%$								
$30\% < U \leq 40\%$								
$20\% < U \leq 30\%$								
$10\% < U \leq 20\%$								
$U \leq 10\%$								

Table 4.3: Voltage sag table according to IEC 61000-2-8.

Here the *table as proposed in IEC 61000-2-8*, presented in Table 4.3 is chosen. The main difference with the UNIPEDE table is in the higher resolution in the remaining voltage ranges. Also, an additional duration range is added with 250 ms as a limit [2]. The columns of Table 4.3 represent ranges of voltage-sag duration, the rows represent ranges of retained voltage. Each cell in the table gives the number of events with the corresponding range of retained voltage and duration.

4.4 Voltage-sag energy method

The voltage-sag energy method of characterization uses three site indices:

- total lost energy per site represented by *Sag Energy Index (SEI)*
- average lost energy per event represented by *Average Sag Energy Index (ASEI)*
- number of events per site represented by $SARFI_{90}$

4.4.1 Voltage-Sag Energy Index

The *Sag Energy Index (SEI)* is the sum of the voltage sag energies for all qualified events at a given site during a given period

$$SEI = \sum_{i=1}^{n} E_{vs(i)} \tag{4.2}$$

where i is the sag event number and n is the number of qualified events during the given period at a given site. The indices are usually calculated monthly and annually. The *Sag Energy Index*, when expressed in units of time, can be interpreted as the length of the equivalent interruption with the same lost energy as all sags together that occurred during the observation period [2].

4.4.2 Average Sag Energy Index

The *Average Sag Energy Index* or *ASEI* is the average of the voltage sag energies for all qualified events measured at a given site during a given period [2]

$$ASEI = \frac{1}{n}\sum_{i=1}^{n} E_{vs(i)} \tag{4.3}$$

4.4.3 Number of event per site

The $SARFI_{90}$ *index* is used as a third index to quantify the number of events at the site. Note that only two of the three indices are needed as they are related according to [2]

$$SEI = ASEI \cdot SARFI_{90} \tag{4.4}$$

When using voltage-sag energy indices it is recommended to not include momentary interruptions, as one momentary interruption may have a larger contribution to the index than all voltage sags together.

The *Swell Energy Index* is the sum of the voltage-swell energies for all qualified events at a given site during a given period.

The *Average Swell Energy Index* is the average of the voltage-swell energies for all qualified events measured at a given site during a given period.

4.5 Voltage-Sag Severity Method

The calculation of site indices for the *voltage-sag severity method* is very similar to the calculation of site indices based on the *voltage-sag energy method*.

Three site indices are introduced to characterize the site performance:

- total voltage-sag severity

$$S_{site} = \sum_{i=1}^{N} S_{e(i)} \tag{4.5}$$

- average voltage-sag severity

$$S_{average} = \frac{S_{site}}{N} \tag{4.6}$$

- number of events for the site N.

Note that N is equal to $SARFI_{90}$ and that the same relation between the indices holds as for the voltage-sag energy method:

$$S_{site} = S_{average} \cdot SARFI_{90} \tag{4.7}$$

The *Total Voltage Swell Severity* is the sum of the voltage-swell severity for all qualified events at a given site during a given period.

The *Average Voltage Swell Severity* is the average of the voltage-swell severity for all qualified events measured at a given site during a given period.

Chapter 5

Site Indices Results

Because all events measured at different sites were not in any kind of logically saved form, that one could distinguish what event is from what site, all the measured data were considered as one site. Even if one could try to separate data, the amount of data for each site might not be enough to obtain any suitable statistics. Data measured over one month period were not categorized according to different sites.

To calculate site indices new code attached in Appendix A was used and in next sections result will be shown.

5.1 SARFI Indices

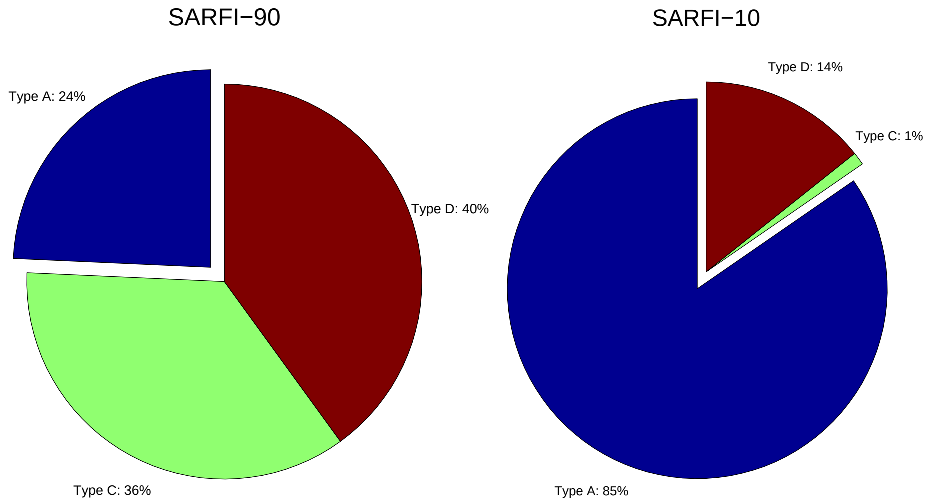
What SARFI indices are and how to calculate them was in detail explained in Chapter 4. The results for calculations of different SARFI indices are shown in Table 5.1.

In the first row in Table 5.1 results of SARFI indices calculations for all sags are shown. In second row all the indices are recalculated in the number of events per 30 days, as in Eq. 4.1. Because analyzed data were measured over one month period, also next row of recalculated indices in number of events per 30 days will be the same. If the measured period of the events would be longer than one month, all indices in the second row will decrease. On the other hand if the measured period of the events would be shorter than one month, all indices in the second row will increase.

	Events	SARFI-110	SARFI-90	SARFI-70	SARFI-50	SARFI-10	SARFI-ITIC	SARFI-SEMI
Count of events	374	94	350	188	128	91	193	167
Events per 30 days	374	94	350	188	128	91	193	167
Six Phase RMS method								
Count of events for type A	374	33 (35.1%)	85 (24.3%)	80 (42.6%)	77 (60.2)	77 (84.6)	82 (42.5%)	82 (49.1%)
Count of events for type C	374	21 (22.3%)	125 (35.7%)	49 (26.1%)	22 (17.2%)	1 (1.1%)	51 (26.4%)	40 (24%)
Count of events for type D	374	33 (35.1%)	140 (40%)	59 (31.4%)	29 (22.7%)	13 (14.3%)	60 (31.1%)	45 (26.9%)
Six Phase RMS method								
Count of events for type A	374	37 (39.4%)	92 (26.3%)	82 (43.6%)	81 (63.3%)	77 (84.6%)	84 (43.5%)	84 (50.3%)
Count of events for type C	374	23 (24.5%)	128 (36.6%)	54 (28.7%)	24 (18.8%)	5 (5.5%)	56 (29%)	42 (25.1%)
Count of events for type D	374	27 (28.7%)	130 (37.1%)	52 (27.7%)	23 (18%)	9 (9.9%)	53 (27.5%)	41 (24.6%)

Table 5.1: SARFI indices table

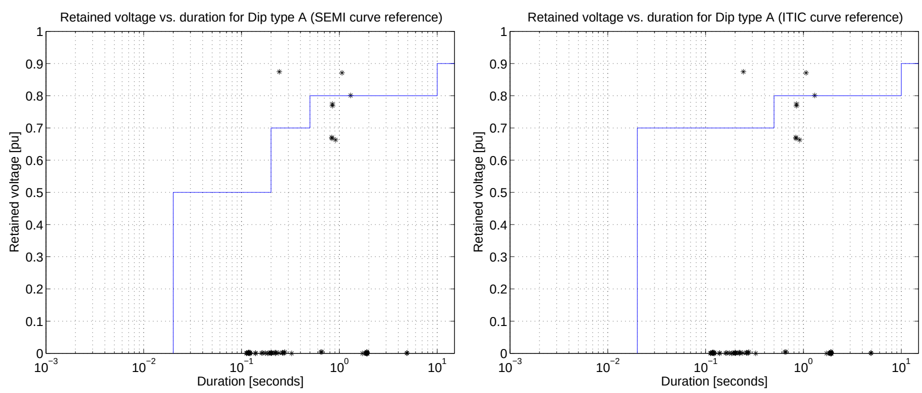
In the next rows of Table 5.1 SARFI indices for different sag types are calculated depending on what method is used to obtain the sag type. Results for some SARFI indices that were the most interesting can be seen also in PIE Diagram in Fig. 5.1. Note that 7 events were classified as swells only and therefore, there is no sag type defined for them. Because of this, SARFI-110 index is always greater than sum of events for each sag type. Note that also only events with duration greater than 0.5 cycles were taken into calculations.



(a) Pie chart for SARFI-90 (b) Pie chart for SARFI-10

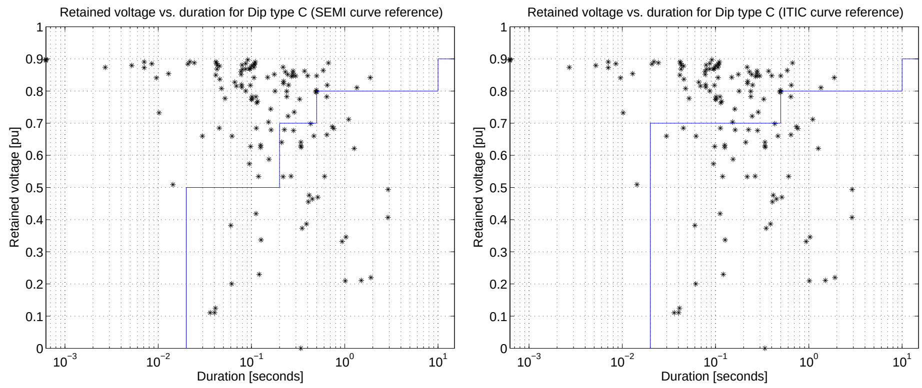
Figure 5.1: Pie chart diagrams for SARFI indices for different sag types.

From Table 5.1, differences in number of SARFI-ITIC and SARFI-SEMI can be observed. But this is not the case for calculation of these two indices for sag type A. Sag type A is usually classified when an event is interruption with retained voltage 0.0 pu. When interruption with 0.0 pu occurs it is usually not restored. Because sags type A occur in duration range where both reference curves have the same characteristics, SARFI-ITIC and SARFI-SEMI will be equal.



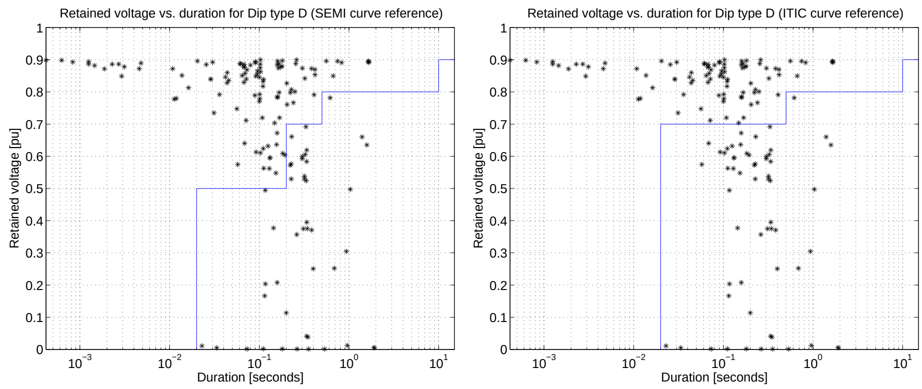
(a) SEMI curve reference. (b) ITIC curve reference.

Figure 5.2: Retained voltage vs. duration for sag type A.



(a) SEMI curve reference. (b) ITIC curve reference.

Figure 5.3: Retained voltage vs. duration for sag type C.



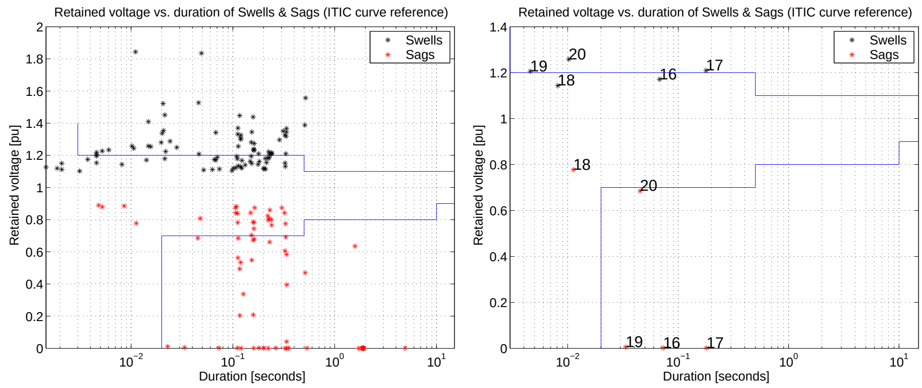
(a) SEMI curve reference. (b) ITIC curve reference.

Figure 5.4: Retained voltage vs. duration for sag type D.

Illustrations of how counting of the events was done for different sag types with different curves used as reference are shown in Figs. 5.2 to 5.4. In Figs. 5.2 to 5.4 retained voltage vs. duration characteristics are shown for different sag types. In the left-hand plot of each figure, for each sag type, SEMI curve is used as reference. In the right-hand plot ITIC curve is used as reference. In Figs. 5.2 and 5.4 large number of sags with retained voltage 0.0 pu can be observed. Most of these sags are recordings that stopped before the voltage recovered, so the duration in these plots is not the real duration of the sag, but the duration until the end of recording.

Results of this counting are shown in the last two columns "SARFI-ITIC and SARFI-SEMI" in Table 5.1.

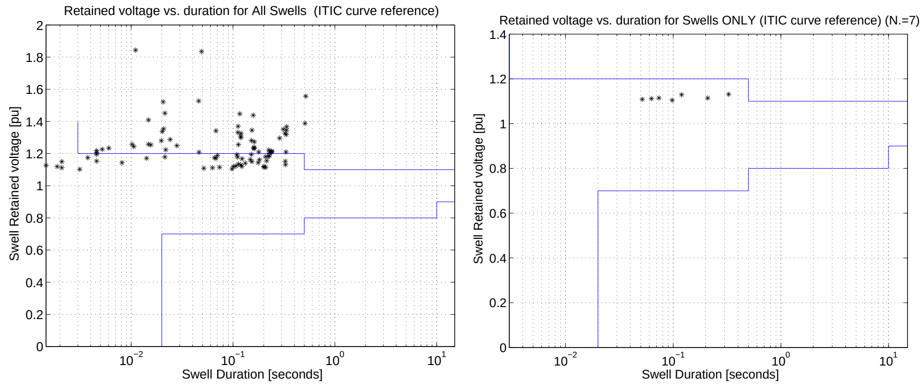
If SARFI-ITIC for upper and lower curve as one index needs to be calculated, following has to be considered:
In Fig. 5.5 all events that were classified as sags and swells are plotted. However, it is difficult to see the same event that is classified as sag and swell in Fig. 5.5. Usually duration of sag is different than duration of swell. For this reason in the right-hand plot of Fig. 5.5 example of five such events is shown. If one would like to calculate SARFI-ITIC above the upper ITIC curve, one has to realize that same event could be counted once in



(a) All events that are swells and sags at the same time.

(b) Example of 5 events.

Figure 5.5: Retained voltage vs. duration for events that are swells and sags.



(a) All events that are swells and sags.

(b) Swells only.

Figure 5.6: Retained voltage vs. duration for events classified as swells.

the SARFI-ITIC for upper curve and in the SARFI-ITIC for lower curve. For example, events number 17, 19 and 20 in the right-hand plot in Fig. 5.5 will be counted once in SARFI-ITIC for upper curve and once in SARFI-ITIC for lower curve. On the other hand event number 16 would be counted only to SARFI-ITIC for lower curve and not in SARFI-ITIC for upper curve. Event number 18 would not be counted to SARFI-ITIC at all. Note that in Table 5.1 SARFI-ITIC is calculated only for the lower ITIC curve.

In the left-hand plot in Fig. 5.6 all swells are plotted, also those that were classified as sags. In the right-hand plot in Fig. 5.6 only events that were classified as swells are plotted. Out of all 887 events only 7 events were classified as swells and 87 were classified as voltage sags and swells.

5.2 IEC Table

In the Table 5.2 all sags with its duration and retained voltage are shown according to Table 4.3. Because the recording time of all the events measured at site were not longer than 250 cycles (5s), there is not more any reason why the last two columns of Table 4.3 should appear in the table.

retained voltage U [%]	duration $d\,[s]$					
	$d < 0.1$	$0.1 \leq d < 0.25$	$0.25 \leq d < 0.5$	$0.5 \leq d < 1$	$1 \leq d < 3$	$3 \leq d < 20$
$80\% < U \leq 90\%$	80	32	17	7	7	0
$70\% < U \leq 80\%$	9	24	4	5	1	0
$60\% < U \leq 70\%$	6	14	9	6	3	0
$50\% < U \leq 60\%$	3	11	7	1	0	0
$40\% < U \leq 50\%$	0	3	3	1	3	0
$30\% < U \leq 40\%$	1	2	7	2	1	0
$20\% < U \leq 30\%$	1	3	1	1	3	0
$10\% < U \leq 20\%$	3	2	0	0	0	0
$U \leq 10\%$	3	34	11	4	36	3

Table 5.2: Voltage sag table according to IEC 61000-2-8.

Some correspondence between Table 5.1 and Table 5.2 was observed. In Table 5.2 sum of the last row is the count of events for SARFI-10 in Table 5.1 and the sum of all rows is the count of SARFI-90. In analogous also SARFI-70 and SARFI-50 similarities can be observed.

If the sum of rows represent SARFI index, one could define also index for sum of all cells in one column in Table 5.2. The new introduced index would count all sags with a certain duration range, regardless of the magnitude. This could play an important role when designing a mitigation device for specific applications.

Chapter 6

System Indices

In this chapter indices for the whole system are introduced. The procedure for obtaining voltage sag system indices is shown in the Fig. 6.1. Firstly it is important to calculate SARFI system indices. Secondly is to present the performance of a system by means of a voltage sag table, calculate the sag energy index for the whole system and the voltage-sag severity system index.

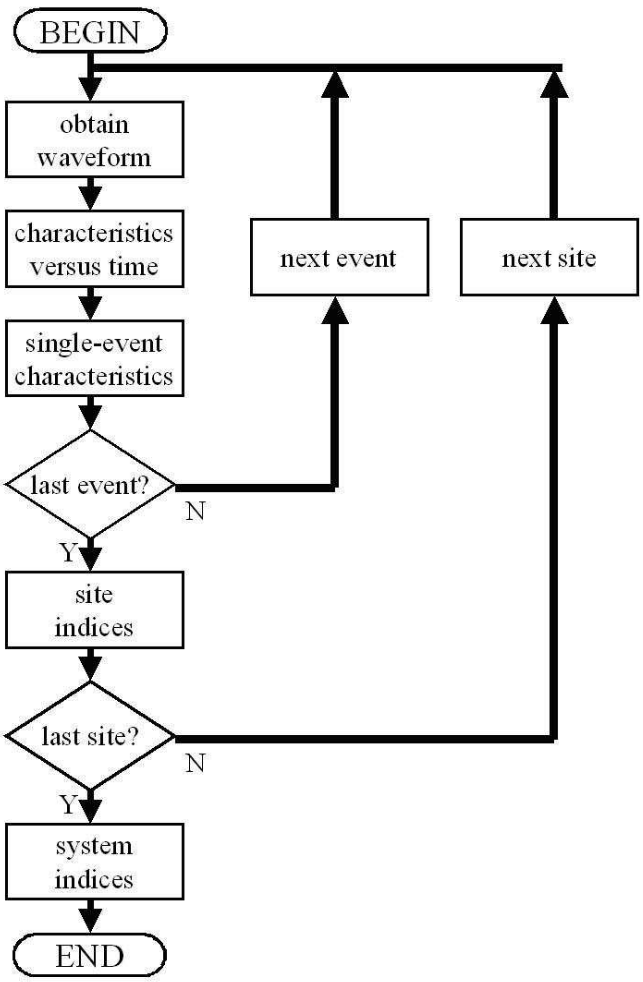


Figure 6.1: Voltage sag system indices procedure

System indices are calculated from the site indices obtained for a number of sites. Two different methods can be distinguished for calculating system indices:

- The system index is defined as a weighted average of the site indices.
- The system index is defined as the value not exceeded for 95% of the sites (the 95 percentile of the site indices).

When calculating voltage sag system indices one ideally has to have access to all sites over a long period of time [2].

6.1 SARFI System Indices

The *SARFI indices for a system* are obtained as the average of the indices for the different sites. The SARFI thus gives the *average voltage quality over the whole system.* As not all sites are monitored and not all monitored sites are equal, a kind of weighing is needed to get an appropriate average [2].

6.2 Voltage-Sag Tables for a system

When voltage-sag tables are used, both average values over all sites and 95 percentile values can be used. When average values are used, weighing of the values may be considered. Weighing is also possible when using the 95 percentile but less useful unless a very large number of sites is being monitored. The voltage-sag table for the whole system may contain a smaller number of cells than for individual sites. For individual sites a certain level of detail is needed to determine the compatibility of sensitive equipment with the supply. For system indices a smaller level of detail may be more appropriate as that makes e.g. the study of year-to-year variations easier. Such a table is presented in Cigre final report on Power Quality Indices and Objectives [15].

6.3 Voltage-Sag Energy Index of a System

When using voltage-sag energy indices, system indices are calculated by taking the average value of the site indices [2]. The *SEI* and *SARFI-90* values for the system are obtained by dividing the sum of the site values with number of sites [2]

$$SEI_{system} = \frac{1}{N}\sum_{s=1}^{N} SEI_s \tag{6.1}$$

where N is the number of sites

$$SARFI_{90(system)} = \frac{1}{N}\sum_{s=1}^{N} SARFI_{90(s)} \tag{6.2}$$

The average sag energy for the whole system is obtained from the SEI and SARFI-90 values for the system [2]

$$ASEI_{system} = \frac{SEI_{system}}{SARFI_{90(system)}} \tag{6.3}$$

6.4 Voltage-Sag Severity System Index

The system index for voltage-sag severity should be obtained from the site indices in the same way as for the other indices: either as a weighted average or as a 95 percentage [2].

Chapter 7

Conclusions

In this thesis algorithms to calculate site and system indices from sampled voltages according to the listed documents [1] and [2] were implemented in Matlab, with written overview of the existing knowledge on voltage sag indices. Method for calculating single-event, site and system indices based on three-phase characteristics using document [3] was developed and implemented in Matlab as well, with a detailed description of the two methods plus the various implementation issues. Finally these algorithms were applied to measured data and statistics on the resulting indices were obtained.

In total 887 recorded events on different sites in a medium-voltage network during one month in June 1997 were analysed in Matlab.

All the results and code for calculation of single-event indices was included in Appendixes. It was found that out of all the events 42% were classified as sags and 1% as swells only. For events classified as sags, it was found that 25% of them were classified as swells, too. There were 27% of sags classified as interruptions.

Two different equations to obtain voltage sag energy index were tested on synthetic sags as well as on the measured large number of events. It was observed that both of these equations could be used when one-cycle rms calculation updated every half-cycle is used to obtain rms voltages. When these two equations were tested on a large number of measured data, some bigger differences in using these equations were observed. This was due to the fact that some of the measured events were developing faults. When applying the equation for using voltage sag energy index equation with retained voltage and duration as input variables, voltage sag energy index was much higher because of the fact that rms voltage throughout the sag changes rapidly.

All the implementation issues for calculation of single-event indices were discussed in detail in Chapter 3.

Two methods, six-phase RMS and symmetrical component methods, to obtain the sag type were implemented in Matlab. It was found that in 70% of cases, these two methods give the same result for the sag type. Various reasons why two methods give 30% of different results for sag type were observed. Some of the differences were due to implementation procedures and some of them because of the different calculations of these two methods themselfs. It was found that 9.35% of all the sags were possible sags with large phase angle jump and therefore in these cases the sag type obtained by these two methods gives different results. For 6.41% of all voltage sags it was observed that the sag type gave different result because these events were caused by transformer saturations. Half-cycle rms calculation updated every sample was used to calculate rms voltages, therefore oscillations in rms voltage characteristics were observed. Another main group in obtaining different results on sag types consists of sags classified as developing faults. Since code calculates sag type of symmetrical component method in the middle of the sag, it can generate different sag type than the six-phase rms method. Sag type of the developing fault changes throughout the sag as it propagates.

In the future the prove of the large phase angle jump mismatch in obtaining sag type could be done. Better calculation of sag type for developing faults sholud be also improved. Interesting to see would be, how different calculation of the rms voltages changes the sag type. Because of the incomplete description of the procedure how to calculate single-event indices, especialy sag type, in Std. IEEE P1564 there was additional literature needed. Therefore there is high need to improve the Std. IEEE P1564 in these points and describe in more detail how to obtain sag type and rms voltages, since there is more than one way to calculate it. General MatLab code included in Std. IEEE P1564 would be a very good way how to solve implementation issues in obtainig such results. However MatLab is copyrighted programme and may not be available for every user. This could be solved by a possibilite to use this programme only for those people willing to use the St. IEEE P1564. It could be done by some additional membership fee to IEEE organisation for use of MatLab, only for those users interested in using MatLab code created to calculate voltage sag indices.

Appendix A

Matlab Code

A.1 Making .mat Files

MakingMATfiles.m

```
%=================================================================
% Creating .mat file from .dat file for large number of files
%
% by FRANTISEK KINCES, CHALMERS University of Technology, Goteborg
%=================================================================

% V A R I A B L E S :
% SignalName: name of the data file
% Ua                : voltage samples in phase A
% Ub                : voltage samples in phase B
% Uc                 : voltage samples in phase C
% t                        : time samples, t stored in seconds
clear
clc

for j=0:887
FileName=([['ZQ' num2str(j)] '.DAT']);
SignalName=Strtok(FileName,'.');
Signal=dlmread(FileName);
if (isempty(Signal)==1)
    NewFile=strcat(Strtok(FileName,'.'),'.mat');
    clear('j','FileName','SignalName','Signal');
    t=[];
    save(NewFile,'t');
    clear('NewFile','t');
else
    t =Signal(:,2)*1e-6;
    Ua=Signal(:,3);
    Ub=Signal(:,4);
    Uc=Signal(:,5);
    NewFile=strcat(Strtok(FileName,'.'),'.mat');
    save(NewFile,'t','Ua','Ub','Uc');
    clear('j','FileName','Signal','t','Ua','Ub','Uc','NewFile');
end
end

```

SingleEvent.m

```
%=========================================================================
%
% S O U R C E   F I L E  for Single Event Characteristics
%
% by FRANTISEK KINCES, CHALMERS University of Technology, Goteborg
%
%=========================================================================
% V A R I A B L E S
```

```
% t = time in seconds, loaded from .mat file
% tC = time in cycles, tC=t/0.02s
% freq = estimated frequency, for each phase separately

clear all
clc

k=0;
m=0;

for j=0:29
    load([['DATonly\ZQ' num2str(j) ] '.mat']);
%for j=1:19 %19
%load([['SyntheticDips\GeneratingSyntheticDips\Sags\' num2str(j)] '_01.mat'])

% load('DATonly\ZQ3.mat');
disp(['ZQ' num2str(j)])
%flag=0;  %  sets flag to 0, when no voltage dip % uncomment only if voltage dips in the table wanted

    if (isempty(t)==1) % and my created empty files are not included in the results

        X(j,1)=j;
        x=nonzeros(X);
        k=length(x);
    %   Status='EMPTY'; %if empty field of created .mat files wanted in the results
    %   Duration=[];
    %   Retained=[];
    else
        tC=t/0.02; % time in cycles

        % frequency estimation for 3-phases, file: FreqEstim_3phase.m

        [freq1,freq2,freq3]=FreqEstim_3phase(Ua,Ub,Uc,t,j);
% disp(['freq1= ' num2str(freq1)])
% disp(['freq2= ' num2str(freq2)])
% disp(['freq3= ' num2str(freq3)])
% freq1=50;
% freq2=50;
% freq3=50;
            %C(j,1)=c; % when corection in frequency calculation was tested, c taken out of FreqEstim_3phase.m
            %c1=nonzeros(C);

        % RMS calculation for 3-phases(in samples & pu calc), in file: RMS_3phase.m

        [Ua_rms,Ua_pu,Ub_rms,Ub_pu,Uc_rms,Uc_pu,Nc1,Nc2,Nc3,pre_event_reference]=RMS_3phase(Ua,Ub,Uc,t,freq1,freq2,freq3,j);

        % [Ua_rms,Ua_pu]=RMS(Ua,t,freq1);
        % [Ub_rms,Ub_pu]=RMS(Ub,t,freq2);
        % [Uc_rms,Uc_pu]=RMS(Uc,t,freq3);

        % ploting phase voltages, RMS voltages (insamples and p.u.) into the figures
%         figure(j+1);
%         set(gcf,'visible', 'on');
%         subplot(3,1,1)
%         plot(tC,Ua,'r',tC,Ub,'g',tC,Uc,'b'), xlim([0 tC(length(tC))]), ylabel('Voltage [samples]'), title([['ZQ' num2str(j
%         subplot(3,1,2)
%         plot(tC,Ua_rms,'r',tC,Ub_rms,'g',tC,Uc_rms,'b'), xlim([0 tC(length(tC))]), ylabel('RMS Voltage [samples]');
%         subplot(3,1,3)
%         plot(tC,Ua_pu,'r',tC,Ub_pu,'g',tC,Uc_pu,'b'), xlim([0 tC(length(tC))]), xlabel('Time [cycles]'), ylabel('RMS Volta


        %clear('Ua_rms','Ub_rms','Uc_rms');

%         % saving figures in .eps format
%         filename=['DATonly\ExmpFigures\ZQ' num2str(j)];
%         print(['-f' num2str(j+1)], '-depsc', filename)
%         clear('filename');

        % detection if there is a voltage dip, calc. of duration & retained voltage, file: VoltageDip.m

        threshold=0.9; %p.u.
        [Status,Duration,Retained,DipTypeA,t_mid]=VoltageDip(Ua_pu,Ub_pu,Uc_pu,tC,threshold,Nc1,Nc2,Nc3);

```

```
        if (isempty(Duration)==0)
             thresholdI=0.1;
             % detection if a voltage dip is also an interruption, file: Interruption.m
             [StatusI,DurationI]=Interruption(Ua_pu,Ub_pu,Uc_pu,tC,thresholdI);
             % calculation of a voltage sag energy index, file: VoltageSagEnergy.m
             [Evs_a,Evs_b,Evs_c,Evs,Evs_Ret]=VoltageSagEnergy(Ua_pu,Ub_pu,Uc_pu,freq1,freq2,freq3,threshold,Duration,Retaine
             % calculation of a voltage sag severity, file: VoltageSagSeverity.m
             [Severity]=VoltageSagSeverity(Duration,Retained);
             % calculation of a voltage dip type, file: SixPhaseRMS.m
             [DipType,V,F]=SixPhaseRMS(Ua,Ub,Uc,t,freq1,freq2,freq3,j,DipTypeA,DurationI);
             %disp(['DipType=' num2str(DipType)])
             [DipTypeS,V_s,F_s,M,angleV_s]=SymmComp(Ua,Ub,Uc,t,freq1,freq2,freq3,j,DipTypeA,t_mid,pre_event_reference);%,XY1

        else StatusI=['NO'];
             DurationI=[];
             Evs=[]; Evs_a=[]; Evs_b=[]; Evs_c=[]; Evs_Ret=[];
             Severity=0;
             DipType=[' '];
             V=[]; F=[];
             V_s=[]; F_s=[];
             %XY1=[' '];
             DipTypeS=[' '];
             M=[];
             angleV_s=[];

         end

        % detection if an event is a voltage swell, calc. of duration, file: Swell.m
        thresholdS=1.1; %p.u.
        [StatusS,DurationS,RetainedS]=Swell(Ua_pu,Ub_pu,Uc_pu,tC,thresholdS);

        if (isempty(DurationS)==0)
             [Evsw]=VoltageSwellEnergy(Ua_pu,Ub_pu,Uc_pu,freq1,freq2,freq3,thresholdS);
        else
             Evsw=[];
        end

        %clear('Ua','Ub','Uc','Ua_pu','Ub_pu','Uc_pu','Nc1','Nc2','Nc3');
%         %==============================
%         if (isempty(Duration)==1) %  uncomment only if voltage dips in the table wanted
%
%             Y(j+1,1)=j;%
%             y=nonzeros(Y);%
%             m=length(y);%
%
%         else %
%             flag=1; %subtracts 1 when voltage dip occurs; in voltage dip cell array
%
%         % ploting phase voltages, RMS voltages (insamples and p.u.) into the figures
%
% %         figure(j+1);
% %         set(gcf,'visible', 'off');
% %         subplot(3,1,1)
% %         plot(tC,Ua,'r',tC,Ub,'g',tC,Uc,'b'), xlim([0 tC(length(tC))]), ylabel('Voltage [samples]'), title([['ZQ' num2str
% %         subplot(3,1,2)
% %         plot(tC,Ua_rms,'r',tC,Ub_rms,'g',tC,Uc_rms,'b'), xlim([0 tC(length(tC))]), ylabel('RMS Voltage [samples]');
% %         subplot(3,1,3)
% %         plot(tC,Ua_pu,'r',tC,Ub_pu,'g',tC,Uc_pu,'b'), xlim([0 tC(length(tC))]), xlabel('Time [cycles]'), ylabel('RMS Vol
% %
% %         % saving figures in .jpg format
% %         filename=['DATonly\SagsONLY\ZQ' num2str(j)];
% %         print(['-f' num2str(j+1)], '-djpeg', filename)
% %         clear('filename');
%
% end
        %==============================

        clear('freq1','freq2','freq3');
        clear('Ua_rms','Ub_rms','Uc_rms');
        clear('Ua','Ub','Uc','Ua_pu','Ub_pu','Uc_pu','Nc1','Nc2','Nc3');
        clear('pre_event_reference');

        % R E S U L T S shown in a cell array variable VoltageDip - table, just copy paste to xls:(cell array:C={'x'...})
```

```

        % VoltageDip = {'Event'    'Voltage Dip or Not ' 'Duration [cycles]  ' 'Retained [pu] ';
        %                num2str(j)       Status          num2str(Duration)    num2str(Retained)};

        VoltageDip{1,1}    ='File n.  ';
        VoltageDip{1,2}    ='Sag';
        VoltageDip{1,3}    ='Duration [cycles] ';
        VoltageDip{1,4}    ='Retained [pu] ';
        VoltageDip{1,5}    ='Interruption';
        VoltageDip{1,6}    ='Int. Dur. [cycles] ';
        VoltageDip{1,7}    ='Swell';
        VoltageDip{1,8}    ='Swell Dur. [cycles] ';
        VoltageDip{1,9}    ='Swell retained voltage [pu] ';
        VoltageDip{1,10}   ='Voltage-Sag Energy calc. from Dur.& Ret [cycles] ';
        VoltageDip{1,11}   ='Evs_a, Voltage-Sag Energy Index [cycles] ';
        VoltageDip{1,12}   ='Evs_b, Voltage-Sag Energy Index [cycles] ';
        VoltageDip{1,13}   ='Evs_c, Voltage-Sag Energy Index [cycles] ';
        VoltageDip{1,14}   ='Evs,  Voltage-Sag Energy Index [cycles] ';
        VoltageDip{1,15}   ='Voltage-Swell Energy Index [cycles] ';
        VoltageDip{1,16}   ='Voltage-Sag Severity [pu] ';
        VoltageDip{1,17}   ='Six Phase RMS - Dip Type ';
        VoltageDip{1,18}   ='V';
        VoltageDip{1,19}   ='F';
        VoltageDip{1,20}   ='Symmetrical comp Method';
        VoltageDip{1,21}   ='V';
        VoltageDip{1,22}   ='F';
        VoltageDip{1,23}   ='m';
        %VoltageDip{1,24}   ='angle(V) [deg]';
        VoltageDip{j+2-k,1} = ['ZQ' num2str(j)];
        VoltageDip{j+2-k,2} = Status;
        VoltageDip{j+2-k,3} = num2str(Duration);
        VoltageDip{j+2-k,4} = num2str(Retained);
        VoltageDip{j+2-k,5} = StatusI;
        VoltageDip{j+2-k,6} = num2str(DurationI);
        VoltageDip{j+2-k,7} = StatusS;
        VoltageDip{j+2-k,8} = num2str(DurationS);
        VoltageDip{j+2-k,9} = num2str(RetainedS);
        VoltageDip{j+2-k,10} = num2str(Evs_Ret);
        VoltageDip{j+2-k,11} = num2str(Evs_a); %[num2str(Evs_a) ' ' num2str(Evs_b) ' ' num2str(Evs_c) ' ' num2str(Evs)]; %Vo
        VoltageDip{j+2-k,12} = num2str(Evs_b);
        VoltageDip{j+2-k,13} = num2str(Evs_c);
        VoltageDip{j+2-k,14} = num2str(Evs);
        VoltageDip{j+2-k,15} = [num2str(Evsw)];
        VoltageDip{j+2-k,16} = num2str(Severity);
        VoltageDip{j+2-k,17} = DipType;
        VoltageDip{j+2-k,18} = num2str(V);
        VoltageDip{j+2-k,19} = num2str(F);
        VoltageDip{j+2-k,20} = DipTypeS;
        VoltageDip{j+2-k,21} = num2str(V_s);
        VoltageDip{j+2-k,22} = num2str(F_s);
        VoltageDip{j+2-k,23} = num2str(M);
        %VoltageDip{j+2-k-m-flag,24} = num2str(angleV_s);

        % flag needs to be subtracted, e.g.: VoltageDip{j+2-k-m-flag,_} when only table with voltage dips wanted

        clear('flag','t','tC','threshold','thresholdI','thresholdS','Status','StatusS','Duration','DurationS','RetainedS');
        clear('Retained','StatusI','DurationI','Evs_a','Evs_b','Evs_c','Evs','Evs_Ret','Evsw','Severity')
        clear('DipType','DipTypeA','V','F','DipTypeS','V_s','F_s','t_mid','M','angleV_s');

end
% saving all the calculations in a table, file Results.mat

save('Results\ResultsSymmCompKonecne.mat', 'VoltageDip');

clear('t');

% phase angle jump calculation, file: AngleJump.m

% dip type calculation, file: DipType.m


end
```

FreqEstim3phase.m

```
% ============================================
% file: FreqEstim.m
% F R E Q U E N C Y estimation of a three phase signal
%
% estimates the true frequency of the three phase signal
% ============================================
% V A R I A B L E S :
% dt     = Time step
% T      = period
% Nc     = Number of samples per one cycle
% alpha1 = initial angle of the fundamental component over the first period
% alpha2 = initial angle of the fundamental component over the first period
% freqX   = estimated frequency (X=1,2,3)

function [freq1,freq2,freq3]=FreqEstim(signal1,signal2,signal3,time,j)

dt=(time(11)-time(1))/10;
T=0.02;
Nc=round(T/dt);
% calculation of the frequency from post-event voltage (correction)

vect1=find(time<0.02);
vect2=find(time<0.02);
vect3=find(time<0.02);
max1=max(signal1(vect1));
max2=max(signal2(vect2));
max3=max(signal3(vect3));

    if ((max1<=300)  || (max2<=300) || (max3<300) ||j==97||j==99||j==104||j==106||j==167||j==324||j==385||j==396||j==417||j=
     % disp('freq = post-event')
     %c=0;
    fftSign1_1=fft(signal1(length(time)-2*Nc:length(time)-Nc))/(Nc/2);
    fftSign2_1=fft(signal2(length(time)-2*Nc:length(time)-Nc))/(Nc/2);
    fftSign3_1=fft(signal3(length(time)-2*Nc:length(time)-Nc))/(Nc/2);

    alphaSign1_1=atan2(imag(fftSign1_1(2)),real(fftSign1_1(2)));
    alphaSign2_1=atan2(imag(fftSign2_1(2)),real(fftSign2_1(2)));
    alphaSign3_1=atan2(imag(fftSign3_1(2)),real(fftSign3_1(2)));

    fftSign1_2=fft(signal1(length(time)-Nc:length(time)))/(Nc/2);
    fftSign2_2=fft(signal2(length(time)-Nc:length(time)))/(Nc/2);
    fftSign3_2=fft(signal3(length(time)-Nc:length(time)))/(Nc/2);

    alphaSign1_2=atan2(imag(fftSign1_2(2)),real(fftSign1_2(2)));
    alphaSign2_2=atan2(imag(fftSign2_2(2)),real(fftSign2_2(2)));
    alphaSign3_2=atan2(imag(fftSign3_2(2)),real(fftSign3_2(2)));

    freq1=1/T*(1+(alphaSign1_2-alphaSign1_1)/(2*pi));
    freq2=1/T*(1+(alphaSign2_2-alphaSign2_1)/(2*pi));
    freq3=1/T*(1+(alphaSign3_2-alphaSign3_1)/(2*pi));

% calculation of the frequency from pre-event voltage
else
    %disp('freq = pre-event')
    %c=0;
    fftSign1_1=fft(signal1(1:Nc))/(Nc/2);
    fftSign2_1=fft(signal2(1:Nc))/(Nc/2);
    fftSign3_1=fft(signal3(1:Nc))/(Nc/2);

    alphaSign1_1=atan2(imag(fftSign1_1(2)),real(fftSign1_1(2)));
    alphaSign2_1=atan2(imag(fftSign2_1(2)),real(fftSign2_1(2)));
    alphaSign3_1=atan2(imag(fftSign3_1(2)),real(fftSign3_1(2)));

    fftSign1_2=fft(signal1(Nc:2*Nc))/(Nc/2);
    fftSign2_2=fft(signal2(Nc:2*Nc))/(Nc/2);
    fftSign3_2=fft(signal3(Nc:2*Nc))/(Nc/2);

    alphaSign1_2=atan2(imag(fftSign1_2(2)),real(fftSign1_2(2)));
    alphaSign2_2=atan2(imag(fftSign2_2(2)),real(fftSign2_2(2)));
```

```
    alphaSign3_2=atan2(imag(fftSign3_2(2)),real(fftSign3_2(2)));

    % correction of the frequency calculation for the pre-event voltage,
    % when the frequency is not calculated from the first and second cycle, but from
    % the second and third cycle, because the first cycle is not complete

          if (alphaSign1_1 <0 && alphaSign1_2 >0 || alphaSign1_1 >0 && alphaSign1_2 <0)
              %disp('correction1')
              %C(j,1)=j;
              %c=nonzeros(C);
              fftSign1_1=fft(signal1(Nc:2*Nc))/(Nc/2);
              alphaSign1_1=atan2(imag(fftSign1_1(2)),real(fftSign1_1(2)));
              fftSign1_2=fft(signal1(2*Nc:3*Nc))/(Nc/2);
              alphaSign1_2=atan2(imag(fftSign1_2(2)),real(fftSign1_2(2)));
            end
          if (alphaSign2_1 <0 && alphaSign2_2 >0 || alphaSign2_1 >0 && alphaSign2_2 <0)
              %disp('correction2')
              %C(j,1)=j;
              %c=nonzeros(C);
              fftSign2_1=fft(signal2(Nc:2*Nc))/(Nc/2);
              alphaSign2_1=atan2(imag(fftSign2_1(2)),real(fftSign2_1(2)));
              fftSign2_2=fft(signal2(2*Nc:3*Nc))/(Nc/2);
              alphaSign2_2=atan2(imag(fftSign2_2(2)),real(fftSign2_2(2)));
            end
          if (alphaSign3_1 <0 && alphaSign3_2 >0 || alphaSign3_1 >0 && alphaSign3_2 <0)
              %disp('correction3')
              %C(j,1)=j;
              %c=nonzeros(C);
              fftSign3_1=fft(signal3(Nc:2*Nc))/(Nc/2);
              alphaSign3_1=atan2(imag(fftSign3_1(2)),real(fftSign3_1(2)));
              fftSign3_2=fft(signal3(2*Nc:3*Nc))/(Nc/2);
              alphaSign3_2=atan2(imag(fftSign3_2(2)),real(fftSign3_2(2)));
            end

    freq1=1/T*(1+(alphaSign1_2-alphaSign1_1)/(2*pi));
    freq2=1/T*(1+(alphaSign2_2-alphaSign2_1)/(2*pi));
    freq3=1/T*(1+(alphaSign3_2-alphaSign3_1)/(2*pi));

end
```

RMS3phase.m

```
% ==========================================================================
% file:  RMS_3phase.m
%
% three phase RMS calculation of a signal
%
% function that calculates all three phase RMS over a signal, over 1/2 period = half cycle RMS
%=========================================================================

% I N P U T S :
% signal     = signal, given in .mat file, now it is voltage
% time       = time given in .mat file
% freq       = frequency of the signal, for now assuming 50 Hz
% O U T P U T S:
% Signal_rms = instantaneous RMS values of a signal
% Signal_pu  = RMS in pu
% V A R I A B L E S :
% dt         = Time step
% Nc         = Number of samples per half cycle

function [Sign1_rms,Sign1_pu,Sign2_rms,Sign2_pu,Sign3_rms,Sign3_pu,Nc1,Nc2,Nc3,pre_event_reference]=RMS_3phase(signal1,signa

% Number of samples per half cycle calculation
T1=1/freq1; T2=1/freq2; T3=1/freq3;
dt=(time(11)-time(1))/10;
Nc1=round((T1/2)/dt);
Nc2=round((T2/2)/dt);
Nc3=round((T3/2)/dt);

for n=Nc1:length(time)
    Sign1_rms(n)=sqrt(1/Nc1*sum(signal1(n-Nc1+1:n).^2));
```

```
end
for n=Nc2:length(time)
    Sign2_rms(n)=sqrt(1/Nc2*sum(signal2(n-Nc2+1:n).^2));
end
for n=Nc3:length(time)
    Sign3_rms(n)=sqrt(1/Nc1*sum(signal3(n-Nc3+1:n).^2));
end

Sign1_rms(1:Nc1)=Sign1_rms(Nc1);
Sign2_rms(1:Nc2)=Sign2_rms(Nc2);
Sign3_rms(1:Nc3)=Sign3_rms(Nc3);

%pu calculation
vect1=find(time<0.02);
vect2=find(time<0.02);
vect3=find(time<0.02);
max1=max(signal1(vect1));
max2=max(signal2(vect2));
max3=max(signal3(vect3));
% post-event voltage chosen as the reference to calculate pu

    if ((max1<=300)||(max2<=300)||(max3<300)||j==97||j==99||j==104||j==106||j==167||j==324||j==385||j==396||j==417||j==437||
     %disp('ref  = post-event')
     Sign1_pu=Sign1_rms./Sign1_rms(length(Sign1_rms));
     Sign2_pu=Sign2_rms./Sign2_rms(length(Sign2_rms));
     Sign3_pu=Sign3_rms./Sign3_rms(length(Sign3_rms));

     pre_event_reference=[];

% pre-event voltage chosen as the reference to calculate pu
 else
    %disp('ref  = pre-event')
    Sign1_pu=Sign1_rms./Sign1_rms(1);
    Sign2_pu=Sign2_rms./Sign2_rms(1);
    Sign3_pu=Sign3_rms./Sign3_rms(1);
    pre_event_reference='pre_event';
end

```

VoltageDip.m

```
% ==========================================================================================
% file:  VoltageDip.m
%
% detection if there is a voltage dip or not, calculation of retained voltage and duration of the dip
%
% function that checks if the RMS voltage is below a certain threshold, if it is a voltage dip,
% and finds a duration of the dip and its retained voltage
%==========================================================================================

% I N P U T S :
% sign1, sign2, sign3  =  signal1, signal2, signal3
% time                 = time in cycles
% threshold            = threshold set for the voltage dip
% O U T P U T S :
% Status               = status of the event: "YES" voltage dip or "NO" voltage dip
% Dur                  = duration of the voltage dip
% Retained             = retained voltage of the dip
% V A R I A B L E S:
% vectX                = vector of signal, below threshold (X=1,2,3)
% t_start              = beginning of the dip
% t_stop               = end of the dip

function [Status,Dur,Retained,DipTypeA,t_mid]=VoltageDip(sign1, sign2, sign3, time, threshold,Nc1,Nc2,Nc3)

vect1=find(sign1<threshold);
vect2=find(sign2<threshold);
vect3=find(sign3<threshold);
    %0&0&0:
if (isempty([vect1 vect2 vect3])==1)
    %disp('No voltage dip')
    Status='NO';
```

```
    DipTypeA='';
    Dur=[];
    t_mid=[];
    Retained=min([sign1 sign2 sign3]);
    Retained=roundn(Retained,-4);
    % disp(['Minimum voltage is ' num2str(Retained) ' pu'])
    %1&1&1:
elseif (isempty(vect1)==0 && isempty(vect2)==0 && isempty(vect3)==0)
    %disp('VOLTAGE DIP')
    Status='YES';
        if (length(vect1)>=(Nc1) && length(vect2)>=(Nc2) && length(vect3)>=(Nc3))
            DipTypeA='3-ph sag';
        else
            DipTypeA='';
        end
    %Duration of the dip calculation
    t_start1=time(vect1(1));
    t_start2=time(vect2(1));
    t_start3=time(vect3(1));

    t_start=min([t_start1 t_start2 t_start3]);

    t_stop1 =time(vect1(length(vect1)));
    t_stop2 =time(vect2(length(vect2)));
    t_stop3 =time(vect3(length(vect3)));

    t_stop=max([t_stop1 t_stop2 t_stop3]);
    t_mid =t_start+(t_stop-t_start)/2;

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])
    %Retained voltage calculation:

    Retained=min([sign1(vect1) sign2(vect2) sign3(vect3)]);
    Retained=roundn(Retained,-4);
    %disp(['Retained voltage = ' num2str(Retained) '  pu'])
    %================================================================
    %0&1&1
elseif (isempty(vect1)==1 && isempty(vect2)==0 && isempty(vect3)==0)
    %disp('VOLTAGE DIP')
    Status='YES';
    DipTypeA='';
    %Duration of the dip calculation
    t_start2=time(vect2(1));
    t_start3=time(vect3(1));

    t_start=min([t_start2 t_start3]);

    t_stop2 =time(vect2(length(vect2)));
    t_stop3 =time(vect3(length(vect3)));

    t_stop=max([t_stop2 t_stop3]);
    t_mid =t_start+(t_stop-t_start)/2;

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])
    %Retained voltage calculation:

    Retained=min([sign2(vect2) sign3(vect3)]);
    Retained=roundn(Retained,-4);
    %disp(['Retained voltage = ' num2str(Retained) '  pu'])
    %========================================================
    %0&0&1
elseif (isempty(vect1)==1 && isempty(vect2)==1 && isempty(vect3)==0)
    %disp('VOLTAGE DIP')
    Status='YES';
    DipTypeA='';
    %Duration of the dip calculation
    t_start=time(vect3(1));

    t_stop =time(vect3(length(vect3)));
```

```
    t_mid =t_start+(t_stop-t_start)/2;

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])
    %Retained voltage calculation:

    Retained=min(sign3(vect3));
    Retained=roundn(Retained,-4);
    %disp(['Retained voltage = ' num2str(Retained) '  pu'])
    %=========================================================
    %1&1&0
elseif (isempty(vect1)==0 && isempty(vect2)==0 && isempty(vect3)==1)
    %disp('VOLTAGE DIP')
    Status='YES';
    DipTypeA='';
    %Duration of the dip calculation
    t_start1=time(vect1(1));
    t_start2=time(vect2(1));

    t_start=min([t_start1 t_start2]);

    t_stop1 =time(vect1(length(vect1)));
    t_stop2 =time(vect2(length(vect2)));

    t_stop=max([t_stop1 t_stop2]);
    t_mid =t_start+(t_stop-t_start)/2;

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])
    %Retained voltage calculation:

    Retained=min([sign1(vect1) sign2(vect2)]);
    Retained=roundn(Retained,-4);
    %disp(['Retained voltage = ' num2str(Retained) '  pu'])

    %=========================================================
    %1&0&0
elseif (isempty(vect1)==0 && isempty(vect2)==1 && isempty(vect3)==1)
    %disp('VOLTAGE DIP')
    Status='YES';
    DipTypeA='';
    %Duration of the dip calculation
    t_start=time(vect1(1));

    t_stop =time(vect1(length(vect1)));
    t_mid =t_start+(t_stop-t_start)/2;

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])
    %Retained voltage calculation:

    Retained=min(sign1(vect1));
    Retained=roundn(Retained,-4);
    %disp(['Retained voltage = ' num2str(Retained) '  pu'])
    %=========================================================
    %0&1&0
elseif (isempty(vect1)==1 && isempty(vect2)==0 && isempty(vect3)==1)
    %disp('VOLTAGE DIP')
    Status='YES';
    DipTypeA='';
    %Duration of the dip calculation
    t_start=time(vect2(1));

    t_stop =time(vect2(length(vect2)));
    t_mid =t_start+(t_stop-t_start)/2;

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])
    %Retained voltage calculation:
```

```
    Retained=min(sign2(vect2));
    Retained=roundn(Retained,-4);
    %disp(['Retained voltage = ' num2str(Retained) '  pu'])
    %======================================================
    %1&0&1
elseif (isempty(vect1)==0 && isempty(vect2)==1 && isempty(vect3)==0)
    %disp('VOLTAGE DIP')
    Status='YES';
    DipTypeA='';
    %Duration of the dip calculation
    t_start1=time(vect1(1));
    t_start3=time(vect3(1));

    t_start=min([t_start1 t_start3]);

    t_stop1 =time(vect1(length(vect1)));
    t_stop3 =time(vect3(length(vect3)));

    t_stop=max([t_stop1 t_stop3]);
    t_mid =t_start+(t_stop-t_start)/2;

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])
    %Retained voltage calculation:

    Retained=min([sign1(vect1) sign3(vect3)]);
    Retained=roundn(Retained,-4);
    %disp(['Retained voltage = ' num2str(Retained) '  pu'])

end
```

Interruption.m

```
% ===========================================================================================
% file:  Interruption.m
%
% detection if there is a interruption or not, calculation of the duration of the interruption
%
% function that checks if the RMS voltage is below a certain threshold, if it is a interruption,
% and finds a duration of the interruption
%============================================================================================

% I N P U T S :
% sign1, sign2, sign3  = signal1, signal2, signal3
% time                 = time in cycles
% threshold2           = threshold set for the interruption
% O U T P U T S :
% Status               = status "Yes" interruption or "No" Interruption
% Dur                  = duration of the interruption
% V A R I A B L E S:
% vectX                = vector of signal, below threshold
% t_start              = beginning of the interruption
% t_stop               = end of the interruption

function [Status,Dur]=Interruption(sign1, sign2, sign3, time, threshold2)

vect1=find(sign1<threshold2);
vect2=find(sign2<threshold2);
vect3=find(sign3<threshold2);


%0&0&0:
if (isempty([vect1 vect2 vect3])==1)
    %disp('NO')
    Status='NO';
    Dur=[];
    %1&1&1:
elseif (isempty(vect1)==0 && isempty(vect2)==0 && isempty(vect3)==0)
    %disp('Interruption')
    Status='YES';
```

```
    %Duration of the dip calculation
    t_start1=time(vect1(1));
    t_start2=time(vect2(1));
    t_start3=time(vect3(1));

    t_start=max([t_start1 t_start2 t_start3]);

    t_stop1 =time(vect1(length(vect1)));
    t_stop2 =time(vect2(length(vect2)));
    t_stop3 =time(vect3(length(vect3)));

    t_stop=min([t_stop1 t_stop2 t_stop3]);

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration        = ' num2str(Dur) '  cycles'])

    %=================================================================
    %0&1&1
elseif (isempty(vect1)==1 && isempty(vect2)==0 && isempty(vect3)==0)
     %disp('Interruption')
    Status='YES';
    %Duration of the dip calculation
    t_start2=time(vect2(1));
    t_start3=time(vect3(1));

    t_start=max([t_start2 t_start3]);

    t_stop2 =time(vect2(length(vect2)));
    t_stop3 =time(vect3(length(vect3)));

    t_stop=min([t_stop2 t_stop3]);

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration        = ' num2str(Dur) '  cycles'])

    %=========================================================
    %0&0&1
elseif (isempty(vect1)==1 && isempty(vect2)==1 && isempty(vect3)==0)
     %disp('Interruption')
    Status='YES';
    %Duration of the dip calculation
    t_start=time(vect3(1));

    t_stop =time(vect3(length(vect3)));

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration        = ' num2str(Dur) '  cycles'])

    %=========================================================
    %1&1&0
elseif (isempty(vect1)==0 && isempty(vect2)==0 && isempty(vect3)==1)
    %disp('Interruption')
    Status='YES';
    %Duration of the dip calculation
    t_start1=time(vect1(1));
    t_start2=time(vect2(1));

    t_start=max([t_start1 t_start2]);

    t_stop1 =time(vect1(length(vect1)));
    t_stop2 =time(vect2(length(vect2)));

    t_stop=min([t_stop1 t_stop2]);

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration        = ' num2str(Dur) '  cycles'])

    %=========================================================
    %1&0&0
```

```
elseif (isempty(vect1)==0 && isempty(vect2)==1 && isempty(vect3)==1)
     %disp('Interruption')
    Status='YES';
    %Duration of the dip calculation
    t_start=time(vect1(1));

    t_stop =time(vect1(length(vect1)));

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])

    %=========================================================
    %0&1&0
elseif (isempty(vect1)==1 && isempty(vect2)==0 && isempty(vect3)==1)
    %disp('Interruption')
    Status='YES';
    %Duration of the dip calculation
    t_start=time(vect2(1));

    t_stop =time(vect2(length(vect2)));

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])

    %=========================================================
    %1&0&1
elseif (isempty(vect1)==0 && isempty(vect2)==1 && isempty(vect3)==0)
    %disp('Interruption')
    Status='YES';
    %Duration of the dip calculation
    t_start1=time(vect1(1));
    t_start3=time(vect3(1));

    t_start=max([t_start1 t_start3]);

    t_stop1 =time(vect1(length(vect1)));
    t_stop3 =time(vect3(length(vect3)));

    t_stop=min([t_stop1 t_stop3]);

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])

end
```

Swell.m

```
% =============================================================================================
% file:  Swell.m
%
% detection if there is a swell or not, calculation of the duration of the swell
%
% function that checks if the RMS voltage is above a certain threshold, if it is a swell,
% and finds a duration of the swell
%=============================================================================================

% I N P U T S :
% sign1, sign2, sign3  = signal1, signal2, signal3
% time                 = time in cycles
% threshold3           = threshold set for the swell
% O U T P U T S :
% Status               = status of the event: "YES" swell or "NO" swell
% Dur                  = duration of the swell
% V A R I A B L E S:
% vectX                = vector of signal, above threshold3 (X=1,2,3)
% t_start              = beginning of the swell
% t_stop               = end of the swell

function [Status,Dur,Ret]=Swell(sign1, sign2, sign3, time, threshold3)
```

```

vect1=find(sign1>threshold3);
vect2=find(sign2>threshold3);
vect3=find(sign3>threshold3);

%0&0&0:
if (isempty([vect1 vect2 vect3])==1)
    %disp('NO')
    Status='NO';
    Dur=[];
    Ret=[];

    %1&1&1:
elseif (isempty(vect1)==0 && isempty(vect2)==0 && isempty(vect3)==0)
    %disp('Swell')
    Status='YES';
    %Duration of the swell calculation
    t_start1=time(vect1(1));
    t_start2=time(vect2(1));
    t_start3=time(vect3(1));

    t_start=min([t_start1 t_start2 t_start3]);

    t_stop1 =time(vect1(length(vect1)));
    t_stop2 =time(vect2(length(vect2)));
    t_stop3 =time(vect3(length(vect3)));

    t_stop=max([t_stop1 t_stop2 t_stop3]);

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])

    Ret=max([sign1(vect1) sign2(vect2) sign3(vect3)]);
    Ret=roundn(Ret,-4);
    %================================================================
    %0&1&1
elseif (isempty(vect1)==1 && isempty(vect2)==0 && isempty(vect3)==0)
     %disp('Swell')
    Status='YES';
    %Duration of the swell calculation
    t_start2=time(vect2(1));
    t_start3=time(vect3(1));

    t_start=min([t_start2 t_start3]);

    t_stop2 =time(vect2(length(vect2)));
    t_stop3 =time(vect3(length(vect3)));

    t_stop=max([t_stop2 t_stop3]);

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])

    Ret=max([sign2(vect2) sign3(vect3)]);
    Ret=roundn(Ret,-4);

    %========================================================
    %0&0&1
elseif (isempty(vect1)==1 && isempty(vect2)==1 && isempty(vect3)==0)
     %disp('Swell')
    Status='YES';
    %Duration of the swell calculation
    t_start=time(vect3(1));

    t_stop =time(vect3(length(vect3)));

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])

    Ret=max(sign3(vect3));
```

```
    Ret=roundn(Ret,-4);

    %=========================================================
    %1&1&0
elseif (isempty(vect1)==0 && isempty(vect2)==0 && isempty(vect3)==1)
    %disp('Swell')
    Status='YES';
    %Duration of the swell calculation
    t_start1=time(vect1(1));
    t_start2=time(vect2(1));

    t_start=min([t_start1 t_start2]);

    t_stop1 =time(vect1(length(vect1)));
    t_stop2 =time(vect2(length(vect2)));

    t_stop=max([t_stop1 t_stop2]);

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])

    Ret=max([sign1(vect1) sign2(vect2)]);
    Ret=roundn(Ret,-4);

    %=========================================================
    %1&0&0
elseif (isempty(vect1)==0 && isempty(vect2)==1 && isempty(vect3)==1)
     %disp('Swell')
    Status='YES';
    %Duration of the swell calculation
    t_start=time(vect1(1));

    t_stop =time(vect1(length(vect1)));

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])

    Ret=max(sign1(vect1));
    Ret=roundn(Ret,-4);

    %=========================================================
    %0&1&0
elseif (isempty(vect1)==1 && isempty(vect2)==0 && isempty(vect3)==1)
    %disp('Swell')
    Status='YES';
    %Duration of the swell calculation
    t_start=time(vect2(1));

    t_stop =time(vect2(length(vect2)));

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration         = ' num2str(Dur) '  cycles'])

    Ret=max(sign2(vect2));
    Ret=roundn(Ret,-4);

    %=========================================================
    %1&0&1
elseif (isempty(vect1)==0 && isempty(vect2)==1 && isempty(vect3)==0)
    %disp('Swell')
    Status='YES';
    %Duration of the swell calculation
    t_start1=time(vect1(1));
    t_start3=time(vect3(1));

    t_start=min([t_start1 t_start3]);

    t_stop1 =time(vect1(length(vect1)));
    t_stop3 =time(vect3(length(vect3)));

```

```
    t_stop=max([t_stop1 t_stop3]);

    Dur= t_stop-t_start;
    Dur=roundn(Dur,-4);
    %disp(['Duration          = ' num2str(Dur) '  cycles'])

    Ret=max([sign1(vect1) sign3(vect3)]);
    Ret=roundn(Ret,-4);

end
```

VoltageSagEnergy.m

```
% ==========================================================================================
% file:  VoltageSagEnergy.m
%
% calculation of the Voltage-Sag Energy Index
%
% function that calculates the Voltage-Sag Energy Index over the duration of the event
%===========================================================================================
% I N P U T S :
% sign1, sign2, sign3  = signal1, signal2, signal3
% freq1,freq2,freq3    = freq of signal1, freq of signal2, freq of signal3
% threshold            = threshold of the voltage dip
% O U T P U T S :
% Evs1,Evs2,Evs3       = Voltage-Sag Energy Index for each signal
% Evs                  = Voltage-Sag Energy Index for three-phase signal
% V A R I A B L E S:
% vectX                = vector of signal, below threshold (X=1,2,3)

function [Evs1,Evs2,Evs3,Evs,Evs_Ret]=VoltageSagEnergy(sign1,sign2,sign3,freq1,freq2,freq3,threshold,Dur,Ret,time)

dt=(time(11)-time(1))/10;

vect1=find(sign1<threshold);
vect2=find(sign2<threshold);
vect3=find(sign3<threshold);

Evs1=(sum(1-(sign1(vect1)).^2))*dt*freq1; %./(2*freq1);
Evs2=(sum(1-(sign2(vect2)).^2))*dt*freq2; %./(2*freq2);
Evs3=(sum(1-(sign3(vect3)).^2))*dt*freq3; %./(2*freq3);

Evs=Evs1+Evs2+Evs3;
Evs=roundn(Evs,-3);

Evs1=roundn(Evs1,-2);
Evs2=roundn(Evs2,-2);
Evs3=roundn(Evs3,-2);

Evs_Ret=(1-Ret^2)*Dur;
Evs_Ret=roundn(Evs_Ret,-3);
```

VoltageSwellEnergy.m

```
% ==========================================================================================
% file:  VoltageSwellEnergy.m
%
% calculation of the Voltage-Swell Energy Index
%
% function that calculates the Voltage-Swell Energy Index over the duration of the swell
%===========================================================================================
% I N P U T S :
% sign1, sign2, sign3  = signal1, signal2, signal3
% freq1,freq2,freq3    = freq of signal1, freq of signal2, freq of signal3
% thresholdS           = threshold of the voltage swell
% O U T P U T S :
% Evs1,Evs2,Evs3       = Voltage-Sag Energy Index for each signal
% Evs                  = Voltage-Sag Energy Index for three-phase signal
% V A R I A B L E S:
% vectX                = vector of signal, below threshold (X=1,2,3)
```

```
function [Evsw]=VoltageSwellEnergy(sign1,sign2,sign3,freq1,freq2,freq3,thresholdS)

vect1=find(sign1>thresholdS);
vect2=find(sign2>thresholdS);
vect3=find(sign3>thresholdS);

Evsw1=(sum(((sign1(vect1)).^2)-1))./(2*freq1);
Evsw2=(sum(((sign2(vect2)).^2)-1))./(2*freq2);
Evsw3=(sum(((sign3(vect3)).^2)-1))./(2*freq3);

Evsw1=roundn(Evsw1,-4);
Evsw2=roundn(Evsw2,-4);
Evsw3=roundn(Evsw3,-4);

Evsw=Evsw1+Evsw2+Evsw3;

Evsw=roundn(Evsw,-4);
```

VoltageSagSeverity.m

```
% ============================================================================================
% file:  VoltageSagSeverity.m
%
% calculation of the Voltage-Sag Severity
%
% function that calculates the Voltage-Sag Severity over the duration of the event
%=============================================================================================
% I N P U T S :
% duration   = duration of the event in cycles
% retained   = retained voltage of the event in pu
% O U T P U T S :
% Severity                  = Voltage-Sag Severity for three-phase signal


function [Severity]=VoltageSagSeverity(duration,retained)

 if        (duration <=   1) %20ms
                          Severity =    (1 - retained);
                          Severity =    roundn(Severity,-4);
    elseif (duration <=  10 && duration >  1)  %200ms
                          Severity =  2*(1 - retained);
                          Severity =    roundn(Severity,-4);
    elseif (duration <=  25 && duration > 10)  %500ms
                          Severity = 3.3*(1 - retained);
                          Severity =    roundn(Severity,-4);
    elseif (duration <= 500 && duration > 25)  % 10s
                          Severity =  5*(1 - retained);
                          Severity =    roundn(Severity,-4);
    elseif (duration >  500)                   %>10s
                          Severity = 10*(1 - retained);
                          Severity =    roundn(Severity,-4);
end
```

SixPhaseRMS.m

```
% ============================================================================================
% file:  SixPhaseRMS.m
%
% Six Phase RMS method is used to calculate the Dip Type of the Voltage Dip
%
% function that claculates six rms voltages and depending on which one of
% them is the lowest, it calculates the dip type
%=============================================================================================

% I N P U T S :
% sign1, sign2, sign3  = signal1, signal2, signal3
% time                 = time in seconds
% freq1, freq2, freq3  = estimated frequency
% O U T P U T S :
```

```
% Dip Type             = Type of the Voltage Dip
% V A R I A B L E S:
%
%

function [DipType,V,F]=SixPhaseRMS(sign1, sign2, sign3, time, freq1,freq2,freq3,j,DipTypeA,DurationI)

% zero sequence component
sign0=(sign1+sign2+sign3)/3;

sign10=sign1-sign0;
sign20=sign2-sign0;
sign30=sign3-sign0;

sign12=(sign10-sign20)/sqrt(3);
sign23=(sign20-sign30)/sqrt(3);
sign31=(sign30-sign10)/sqrt(3);


[Sign10_rms,Sign10_pu,Sign20_rms,Sign20_pu,Sign30_rms,Sign30_pu]=RMS_3phase(sign10,sign20,sign30,time,freq1,freq2,freq3,j);
%clear('Sign10_pu','Sign20_pu','Sign30_pu');

[Sign12_rms,Sign12_pu,Sign23_rms,Sign23_pu,Sign31_rms,Sign31_pu]=RMS_3phase(sign12,sign23,sign31,time,freq1,freq2,freq3,j);
%clear('Sign12_pu','Sign23_pu','Sign31_pu');

% figure(j+13)
% set(gcf,'visible', 'on');
% plot(time, Sign10_pu,time, Sign20_pu,time, Sign30_pu,time, Sign12_pu,time, Sign23_pu,time, Sign31_pu),
% title(num2str(j)),legend('Ua','Ub','Uc','Uab','Ubc','Uca')

%Type of the dip
SIGN10 = min(Sign10_pu);%rms);
SIGN20 = min(Sign20_pu);%rms);
SIGN30 = min(Sign30_pu);%rms);
SIGN12 = min(Sign12_pu);%rms);
SIGN23 = min(Sign23_pu);%rms);
SIGN31 = min(Sign31_pu);%rms);

clear('Sign10_rms','Sign20_rms','Sign30_rms','Sign12_rms','Sign23_rms','Sign31_rms');

Sign_all = [Sign10_pu;Sign20_pu;Sign30_pu;Sign12_pu;Sign23_pu;Sign31_pu];

for n=1:length(Sign10_pu)
    MIN(1,n)=min([Sign_all(1,n),Sign_all(2,n),Sign_all(3,n),Sign_all(4,n),Sign_all(5,n),Sign_all(6,n)]);
    MAX(1,n)=max([Sign_all(1,n),Sign_all(2,n),Sign_all(3,n),Sign_all(4,n),Sign_all(5,n),Sign_all(6,n)]);
end

% figure(j)
% plot(time,MIN,time,MAX)

minimum = min ([SIGN10,SIGN20,SIGN30,SIGN12,SIGN23,SIGN31]);

% minimum = min ([Sign10_pu,Sign20_pu,Sign30_pu,Sign12_pu,Sign23_pu,Sign31_pu])
% maximum = max ([Sign10_pu,Sign20_pu,Sign30_pu,Sign12_pu,Sign23_pu,Sign31_pu]);

if (minimum==SIGN10)% && isempty(DipTypeA)==1)
    DipType='Da';
elseif (minimum==SIGN20)% && isempty(DipTypeA)==1)
    DipType='Db';
elseif (minimum==SIGN30)% && isempty(DipTypeA)==1)
    DipType='Dc';
elseif (minimum==SIGN12)% && isempty(DipTypeA)==1)
    DipType='Cc';
elseif (minimum==SIGN23)% && isempty(DipTypeA)==1)
    DipType='Ca';
elseif (minimum==SIGN31)% && isempty(DipTypeA)==1)
    DipType='Cb';

% elseif (isempty(DipTypeA)==0 && isempty(DurationI)==0)
%     DipType='A';
%     V= roundn(minimum,-3);
%     F= roundn(maximum,-3);
% elseif  isempty(DipTypeA)==0
```

```
%     DipType=DipTypeA;
%     V= roundn(minimum,-3);
%     F= roundn(maximum,-3);
end

% calculation of V & F, - V is the minimum of minimum (in time) from all 6 rms voltages
%                       - F is the minimum of the maximums (in time) of all the 6 rms

    V= roundn(min(MIN),-3);
    F= roundn(min(MAX),-3);

    if (F-V)<=0.005
        DipType='A';
%     elseif F==2/3+1/3*V
%         DipType='E';
    end
```

SymmComp.m

```
% ==========================================================================================
% file:  SymmComp.m
%
% Symmetrical components method is used to calculate the Dip Type of the Voltage Dip
%
% function that claculates
% ==========================================================================================

% I N P U T S :
% sign1, sign2, sign3  = signal1, signal2, signal3
% time                 = time in seconds
% freq1, freq2, freq3  = estimated frequency
% O U T P U T S :
% Dip TypeS            = Type of the Voltage Dip
% V A R I A B L E S:
%
%

function [DipTypeS,V_s,F_s,m,angleV_s]=SymmComp(sign1, sign2, sign3, time, freq1,freq2,freq3,j,DipTypeA,t_mid,pre_event_refe

% Number of samples per half cycle calculation
T1=1/freq1; T2=1/freq2; T3=1/freq3;
dt=(time(11)-time(1))/10;
Nc1=round(T1/(dt));% !!! for practicla appl. use only one cycle window
Nc2=round(T2/(dt));
Nc3=round(T3/(dt));

% calculating pu voltage

if (isempty(pre_event_reference)==0 || j==69 || j==529 || j==530)
    %disp('pre-event')
    vect1=find(time<0.02);
    vect2=find(time<0.02);
    vect3=find(time<0.02);
    max1=max(sign1(vect1));
    max2=max(sign2(vect2));
    max3=max(sign3(vect3));

    Sign1_pu=sign1./max1;
    Sign2_pu=sign2./max2;
    Sign3_pu=sign3./max3;
else
    %disp('post-event')
    vect1=find(time>(time-0.02));
    vect2=find(time>(time-0.02));
    vect3=find(time>(time-0.02));
    max1=max(sign1(vect1));
    max2=max(sign2(vect2));
    max3=max(sign3(vect3));

    Sign1_pu=sign1./max1;
    Sign2_pu=sign2./max2;
    Sign3_pu=sign3./max3;
```

```

end

%     figure(j)
%     plot(time,Sign1_pu,time,Sign2_pu,time,Sign3_pu),legend('Ua','Ub','Uc'),title([['ZQ' num2str(j)] '.dat']),
%     xlim([0 time(length(time))])

%======================================================================

%==== FFT calculation of complex voltages
 a=-0.5+i*sqrt(3)/2;

 [V1,V2,V0]=seqcalc(Sign1_pu,Sign2_pu,Sign3_pu,time,freq1,freq2,freq3,j,pre_event_reference);
 %[V1,V2,V0]=seqcalc(sign1,sign2,sign3,time,freq1,freq2,freq3,j,pre_event_reference);

 clear('Sign1_pu','Sign2_pu','Sign3_pu');


%======================================================================

% to find the position in the time vector, position of the time of the middle of the voltage dip
            r1=find(time>=(t_mid*0.02));
            r=r1(1);
            t_mid1=t_mid; %*0.02


m=angle(V2/(1-V1))*180/pi;

%disp(['m= ' num2str(m)])
if m<0
    m=m+360;
else m=m;
end
%disp(['m= ' num2str(m)]);
%disp(['k_notround =' num2str(m/60)])
k=round(m/60);
%disp(['k =' num2str(k)])
% if (k==-1 || k==-2)
%     k=k+6
% end

if k==6
    k=0;
end

% figure(j+2*46)
% plot(time,k), title('k')

% determine Dip Type from calculated k
b=-a^2;
if  k==0
    DipTypeS='Ca';
elseif k==1
    DipTypeS='Dc';
elseif k==2
    DipTypeS='Cb';
elseif k==3
    DipTypeS='Da';
elseif k==4
    DipTypeS='Cc';
elseif k==5
    DipTypeS='Db';
% elseif k==6
%     DipTypeS='Ca';
end
    %DipTypeS='none';
    %DipTypeS

% V and F as a function of time:
V_s0= (V1-(b^(6-k))*V2);
F_s0= (V1+(b^(6-k))*V2);

%plot of absolute value of V and F as a function of time
```

```
% figure(j)
% plot(time,abs(V_s0),time,abs(F_s0)), legend('abs(V)','abs(F)'), title('Absolute value of V and F as a function of time')

% plot of phase angle of V and F as a function of time
% figure(j+44)
% plot(time,(angle(V_s0)*180/pi),time,(angle(F_s0)*180/pi)),legend('angle(V)','angle(F)'), title('Phase angle of V and F as

% phase angle jump
angleV_s=(angle(min(V_s0)))*180/pi;

 V_s= min(abs(V_s0));
 F_s= min(abs(F_s0));

    V_s= abs(min(V1-(b^(6-k))*V2));
    F_s= abs(min(V1+(b^(6-k))*V2));

    V_s= roundn(V_s,-3);
    F_s= roundn(F_s,-3);

     if (-0.0065<=(F_s-V_s) && (F_s-V_s)<=0.0065)
        DipTypeS='A';
     end

%      figure(j+45)
%      plot(time,V_s,time,F_s),legend('V_s','F_s'),title([['ZQ' num2str(j)] '.dat']),
%      xlim([0 time(length(time))])
```

seqcalc.m

```
function [V1,V2,V0,angleV]=seqcalc(Va,Vb,Vc,time,freq1,freq2,freq3,j,pre_event_reference)

%function [V1,V2,V0]=seqcalc(Va,Vb,Vc)
%Function that calculates the sequence components
%Inputs
%The three phase to ground voltages
%Output
% V1:  positve sequence
% V2:  negative sequence
% V0:  zero sequence

%plot(time,Va,time,Vb,time,Vc)

% Number of samples per cycle calculation
T1=1/freq1; T2=1/freq2; T3=1/freq3;
dt=(time(11)-time(1))/10;
Nc1=round(T1/(dt));% !!! for practicla appl. use only one cycle window
Nc2=round(T2/(dt));
Nc3=round(T3/(dt));

%defining operator a
a=-0.5+i*sqrt(3)/2;

%I need the complex voltages to find the system components
[compVa]=comp_samp(Va,time,freq1);
[compVb]=comp_samp(Vb,time,freq2);
[compVc]=comp_samp(Vc,time,freq3);

%to make the time vector same dimension
for g=1:length(time)
time1(1,g)=time(g,1);
end
compVa_s=compVa.*exp(-i*2*pi*freq1.*time1);
compVb_s=compVb.*exp(-i*2*pi*freq2.*time1);
compVc_s=compVc.*exp(-i*2*pi*freq3.*time1);

%   figure(j)
%   plot(compVa_s),title('complex voltage Ua - FFT')
%   figure(j+45)
%   plot(compVb_s),title('complex voltage Ub - FFT')
%   figure(j+2*45)
%   plot(compVc_s),title('complex voltage Uc - FFT')

```

```
V0=1/3*(compVa_s+compVb_s+compVc_s);
V1=1/3*(compVa_s+(a*compVb_s)+(a.^2*compVc_s));
V2=1/3*(compVa_s+((a.^2)*compVb_s)+(a*compVc_s));
```

comp$_s$amp.m

```
function [CompV]=comp_samp(signal,time,freq)

dt=(time(11)-time(1))/10;
T=1/freq;

N=round(T/dt);

%The complex voltage
for n=N:(length(signal));
  k=n-N+1;
  fftsignal=fft(signal(k:n))/(N/2);
  CompV(n)=fftsignal(2);
end
  CompV(1:N)=CompV(N);

%   for n=N:(length(time));
%       CompV(n)=((CompV(n)./CompV(1))*exp(-i*2*pi*freq*time(n)));
%   end
%       CompV(1:N)=CompV(N);
```

A.2 Generating Synthetic Sags

SyntheticDips.m

```
clear
clc

% fig8048
% voltage dips of different types, 50% retained characteristic voltage, 10
% cycles duration.
NS=128; % number of samples per cycle
N1=2; % number of cycles pre-event
N2=5; % number of cycles during-event
N3=2; % number of cycles post-event
% t=linspace(0,6*(N1+N2+N3),6*(N1+N2+N3)*NS+1);
% t=t(1:6*(N1+N2+N3)*NS)/50;
t=linspace(0,(N1+N2+N3),(N1+N2+N3)*NS+1);
t=t(1:(N1+N2+N3)*NS)/50;
for g=1:length(t)
t1(g,1)=t(1,g);
end
t=t1;
clear('Va','Vb','Vc');
% calculating pre-event and post-event voltages, with a small unbalance
VA0= 1; %0.995;
VB0=-0.5-0.5*i*sqrt(3); %-0.495-0.50*i*sqrt(3);
VC0=-0.5+0.5*i*sqrt(3);
% calculating voltage dips
a=-0.5+i*sqrt(3)/2;
tC=t/0.02; % time in cycles

for k=1:9
V=(['0.' num2str(k)]);
V=str2num(V);
%V=0.5;Phi=0; % 50% retained voltage, no phase-angle jump


%voltage dip type A
VA=V;
VB=a^2*V;
VC=a*V;
Va1=VoltageDip(N1,N2,N3,VA0,VA,VA0,NS);Vb1=VoltageDip(N1,N2,N3,VB0,VB,VB0,NS);Vc1=VoltageDip(N1,N2,N3,VC0,VC,VC0,NS);
```

```

figure(7*k-6)
plot(tC,Va1,tC,Vb1,'--',tC,Vc1,'-.'),ylim([-1.5 1.5]),title(['Sag type: A for V=' num2str(V)]),xlabel('time[cycles]'),legend

%print -depsc SyntheticFigures/A.eps

print(['-f' num2str(7*k-6)], '-depsc', ['SyntheticFigures/A_0' num2str(k)])

% voltage dip type Ba
VA=V;
VB=-0.5-0.5*i*sqrt(3);
VC=-0.5+0.5*i*sqrt(3);
Va2=VoltageDip(N1,N2,N3,VA0,VA,VA0,NS);
Vb2=VoltageDip(N1,N2,N3,VB0,VB,VB0,NS);
Vc2=VoltageDip(N1,N2,N3,VC0,VC,VC0,NS);
% voltage dip type Bb
VA=1;
VB=-0.5*V-0.5*i*sqrt(3)*V;
VC=-0.5+0.5*i*sqrt(3);
Va3=VoltageDip(N1,N2,N3,VA0,VA,VA0,NS);
Vb3=VoltageDip(N1,N2,N3,VB0,VB,VB0,NS);
Vc3=VoltageDip(N1,N2,N3,VC0,VC,VC0,NS);
% voltage dip type Bc
VA=1;
VB=-0.5-0.5*i*sqrt(3);
VC=-0.5*V+0.5*i*sqrt(3)*V;
Va4=VoltageDip(N1,N2,N3,VA0,VA,VA0,NS);
Vb4=VoltageDip(N1,N2,N3,VB0,VB,VB0,NS);
Vc4=VoltageDip(N1,N2,N3,VC0,VC,VC0,NS);

figure(7*k-5)
subplot(3,1,1)
plot(tC,Va2,tC,Vb2,'--',tC,Vc2,'-.'), ylim([-1.5 1.5]), title(['Sag types: Ba,Bb,Bc for V=' num2str(V)]),legend('Ua','Ub','U
subplot(3,1,2)
plot(tC,Va3,tC,Vb3,'--',tC,Vc3,'-.'), ylim([-1.5 1.5]), ylabel('Bb')
subplot(3,1,3)
plot(tC,Va4,tC,Vb4,'--',tC,Vc4,'-.'), ylim([-1.5 1.5]),ylabel('Bc'),xlabel('time[cycles]')

%print -depsc SyntheticFigures/B.eps

print(['-f' num2str(7*k-5)], '-depsc', ['SyntheticFigures/B_0' num2str(k)])

% voltage dip type Ca
VA5=1;
VB5=-0.5-0.5*i*sqrt(3)*V;
VC5=-0.5+0.5*i*sqrt(3)*V;
Va5=VoltageDip(N1,N2,N3,VA0,VA5,VA0,NS);
Vb5=VoltageDip(N1,N2,N3,VB0,VB5,VB0,NS);
Vc5=VoltageDip(N1,N2,N3,VC0,VC5,VC0,NS);
% voltage dip type Cb
VA6=a^2*VC5;
VB6=a^2*VA5;
VC6=a^2*VB5; %a^2*(-0.5-0.5*i*sqrt(3)*V);
Va6=VoltageDip(N1,N2,N3,VA0,VA6,VA0,NS);
Vb6=VoltageDip(N1,N2,N3,VB0,VB6,VB0,NS);
Vc6=VoltageDip(N1,N2,N3,VC0,VC6,VC0,NS);
% voltage dip type Cc
VA7=a^2*VC6;
VB7=a^2*VA6;%-0.5*V-0.5*i*sqrt(3);
VC7=a^2*VB6;
Va7=VoltageDip(N1,N2,N3,VA0,VA7,VA0,NS);
Vb7=VoltageDip(N1,N2,N3,VB0,VB7,VB0,NS);
Vc7=VoltageDip(N1,N2,N3,VC0,VC7,VC0,NS);

figure(7*k-4)
subplot(3,1,1)
plot(tC,Va5,tC,Vb5,'--',tC,Vc5,'-.'), ylim([-1.5 1.5]),title(['Sag types: Ca,Cb,Cc for V=' num2str(V)]),legend('Ua','Ub','Uc
subplot(3,1,2)
plot(tC,Va6,tC,Vb6,'--',tC,Vc6,'-.'), ylim([-1.5 1.5]),ylabel('Cb')
subplot(3,1,3)
plot(tC,Va7,tC,Vb7,'--',tC,Vc7,'-.'), ylim([-1.5 1.5]),xlabel('time[cycles]'),ylabel('Cc')

%print -depsc SyntheticFigures/C.eps
```

```

print(['-f' num2str(7*k-4)], '-depsc', ['SyntheticFigures/C_0' num2str(k)])

% voltage dip type Da
VA8=V;
VB8=-0.5*V-0.5*i*sqrt(3);
VC8=-0.5*V+0.5*i*sqrt(3);
Va8=VoltageDip(N1,N2,N3,VA0,VA8,VA0,NS);
Vb8=VoltageDip(N1,N2,N3,VB0,VB8,VB0,NS);
Vc8=VoltageDip(N1,N2,N3,VC0,VC8,VC0,NS);
% voltage dip type Db
VA9=a^2*VC8;
VB9=a^2*VA8; %-0.5*V-0.5*i*sqrt(3)*V;
VC9=a^2*VB8; %a^2*(-0.5*V-0.5*i*sqrt(3));
Va9=VoltageDip(N1,N2,N3,VA0,VA9,VA0,NS);
Vb9=VoltageDip(N1,N2,N3,VB0,VB9,VB0,NS);
Vc9=VoltageDip(N1,N2,N3,VC0,VC9,VC0,NS);
% voltage dip type Dc
VA10=a^2*VC9; %a^2*VC;
VB10=a^2*VA9; %a^2*VA;%-0.5*V-0.5*i*sqrt(3);
VC10=a^2*VB9; %a^2*(-0.5*V-0.5*i*sqrt(3)*V); %==a^2*VB in Db
Va10=VoltageDip(N1,N2,N3,VA0,VA10,VA0,NS);
Vb10=VoltageDip(N1,N2,N3,VB0,VB10,VB0,NS);
Vc10=VoltageDip(N1,N2,N3,VC0,VC10,VC0,NS);

figure(7*k-3)
subplot(3,1,1)
plot(tC,Va8,tC,Vb8,'--',tC,Vc8,'-.'), ylim([-1.5 1.5]),title(['Sag types: Da,Db,Dc for V=' num2str(V)]),legend('Ua','Ub','Uc
subplot(3,1,2)
plot(tC,Va9,tC,Vb9,'--',tC,Vc9,'-.'), ylim([-1.5 1.5]),ylabel('Db')
subplot(3,1,3)
plot(tC,Va10,tC,Vb10,'--',tC,Vc10,'-.'), ylim([-1.5 1.5]),ylabel('Dc'),xlabel('time[cycles]')

%print -depsc SyntheticFigures/D.eps

print(['-f' num2str(7*k-3)], '-depsc', ['SyntheticFigures/D_0' num2str(k)])

% voltage dip type Ea
VA=1;
VB=-0.5*V-0.5*i*sqrt(3)*V;
VC=-0.5*V+0.5*i*sqrt(3)*V;
Va11=VoltageDip(N1,N2,N3,VA0,VA,VA0,NS);
Vb11=VoltageDip(N1,N2,N3,VB0,VB,VB0,NS);
Vc11=VoltageDip(N1,N2,N3,VC0,VC,VC0,NS);
% voltage dip type Eb
VA=V;
VB=-0.5-0.5*i*sqrt(3);
VC=-0.5*V+0.5*i*sqrt(3)*V;
Va12=VoltageDip(N1,N2,N3,VA0,VA,VA0,NS);
Vb12=VoltageDip(N1,N2,N3,VB0,VB,VB0,NS);
Vc12=VoltageDip(N1,N2,N3,VC0,VC,VC0,NS);
% voltage dip type Ec
VA=V;
VB=-0.5*V-0.5*i*sqrt(3)*V;
VC=-0.5+0.5*i*sqrt(3);
Va13=VoltageDip(N1,N2,N3,VA0,VA,VA0,NS);
Vb13=VoltageDip(N1,N2,N3,VB0,VB,VB0,NS);
Vc13=VoltageDip(N1,N2,N3,VC0,VC,VC0,NS);

figure(7*k-2)
subplot(3,1,1)
plot(tC,Va11,tC,Vb11,'--',tC,Vc11,'-.'), ylim([-1.5 1.5]),title(['Sag types: Ea,Eb,Ec for V=' num2str(V)]),legend('Ua','Ub',
subplot(3,1,2)
plot(tC,Va12,tC,Vb12,'--',tC,Vc12,'-.'), ylim([-1.5 1.5]),ylabel('Eb')
subplot(3,1,3)
plot(tC,Va13,tC,Vb13,'--',tC,Vc13,'-.'), ylim([-1.5 1.5]),ylabel('Ec'),xlabel('time[cycles]')

%print -depsc SyntheticFigures/E.eps

print(['-f' num2str(7*k-2)], '-depsc', ['SyntheticFigures/E_0' num2str(k)])

% voltage dip type Fa
VA14=V;
```

```
VB14=-0.5*V-(1/3+V/6)*i*sqrt(3);
VC14=-0.5*V+(1/3+V/6)*i*sqrt(3);
Va14=VoltageDip(N1,N2,N3,VA0,VA14,VA0,NS);
Vb14=VoltageDip(N1,N2,N3,VB0,VB14,VB0,NS);
Vc14=VoltageDip(N1,N2,N3,VC0,VC14,VC0,NS);
% voltage dip type Fb
VA15=a^2*VC14;
VB15=a^2*VA14;
VC15=a^2*VB14;
Va15=VoltageDip(N1,N2,N3,VA0,VA15,VA0,NS);
Vb15=VoltageDip(N1,N2,N3,VB0,VB15,VB0,NS);
Vc15=VoltageDip(N1,N2,N3,VC0,VC15,VC0,NS);
% voltage dip type Fc
VA16=a^2*VC15;
VB16=a^2*VA15;
VC16=a^2*VB15;
Va16=VoltageDip(N1,N2,N3,VA0,VA16,VA0,NS);
Vb16=VoltageDip(N1,N2,N3,VB0,VB16,VB0,NS);
Vc16=VoltageDip(N1,N2,N3,VC0,VC16,VC0,NS);

figure(7*k-1)
subplot(3,1,1)
plot(tC,Va14,tC,Vb14,'--',tC,Vc14,'-.'), ylim([-1.5 1.5]),title(['Sag types: Fa,Fb,Fc for V=' num2str(V)]),legend('Ua','Ub',
subplot(3,1,2)
plot(tC,Va15,tC,Vb15,'--',tC,Vc15,'-.'), ylim([-1.5 1.5]),ylabel('Fb')
subplot(3,1,3)
plot(tC,Va16,tC,Vb16,'--',tC,Vc16,'-.'), ylim([-1.5 1.5]),ylabel('Fc'),xlabel('time[cycles]')

%print -depsc SyntheticFigures/F.eps

print(['-f' num2str(7*k-1)], '-depsc', ['SyntheticFigures/F_0' num2str(k)])

% voltage dip type Ga
VA17=2/3+V/3;
VB17=-1/3 -V/6 -0.5*i*sqrt(3)*V;
VC17=-1/3 -V/6 +0.5*i*sqrt(3)*V;
Va17=VoltageDip(N1,N2,N3,VA0,VA17,VA0,NS);
Vb17=VoltageDip(N1,N2,N3,VB0,VB17,VB0,NS);
Vc17=VoltageDip(N1,N2,N3,VC0,VC17,VC0,NS);
% voltage dip type Gb
VA18=a^2*VC17;
VB18=a^2*VA17;
VC18=a^2*VB17;
Va18=VoltageDip(N1,N2,N3,VA0,VA18,VA0,NS);
Vb18=VoltageDip(N1,N2,N3,VB0,VB18,VB0,NS);
Vc18=VoltageDip(N1,N2,N3,VC0,VC18,VC0,NS);
% voltage dip type Gc
VA19=a^2*VC18;
VB19=a^2*VA18;
VC19=a^2*VB18;
Va19=VoltageDip(N1,N2,N3,VA0,VA19,VA0,NS);
Vb19=VoltageDip(N1,N2,N3,VB0,VB19,VB0,NS);
Vc19=VoltageDip(N1,N2,N3,VC0,VC19,VC0,NS);

figure(7*k)
subplot(3,1,1)
plot(tC,Va17,tC,Vb17,'--',tC,Vc17,'-.'), ylim([-1.5 1.5]),title(['Sag types: Ga,Gb,Gc for V=' num2str(V)]),legend('Ua','Ub',
subplot(3,1,2)
plot(tC,Va18,tC,Vb18,'--',tC,Vc18,'-.'), ylim([-1.5 1.5]),ylabel('Gb')
subplot(3,1,3)
plot(tC,Va19,tC,Vb19,'--',tC,Vc19,'-.'), ylim([-1.5 1.5]),ylabel('Gc'),xlabel('time[cycles]')

%print -depsc SyntheticFigures/G.eps

print(['-f' num2str(7*k)], '-depsc', ['SyntheticFigures/G_0' num2str(k)])

%saving sags
%A
Ua=Va1;Ub=Vb1;Uc=Vc1;
save (['Sags/1_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')

%Ba
Ua=Va2;Ub=Vb2;Uc=Vc2;
```

```
save (['Sags/2_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Bb
Ua=Va3;Ub=Vb3;Uc=Vc3;
save (['Sags/3_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Bc
Ua=Va4;Ub=Vb4;Uc=Vc4;
save (['Sags/4_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')

%Ca
Ua=Va5;Ub=Vb5;Uc=Vc5;
save (['Sags/5_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Cb
Ua=Va6;Ub=Vb6;Uc=Vc6;
save (['Sags/6_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Cc
Ua=Va7;Ub=Vb7;Uc=Vc7;
save (['Sags/7_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')

%Da
Ua=Va8;Ub=Vb8;Uc=Vc8;
save (['Sags/8_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Db
Ua=Va9;Ub=Vb9;Uc=Vc9;
save (['Sags/9_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Dc
Ua=Va10;Ub=Vb10;Uc=Vc10;
save (['Sags/10_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')

%Ea
Ua=Va11;Ub=Vb11;Uc=Vc11;
save (['Sags/11_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Eb
Ua=Va12;Ub=Vb12;Uc=Vc12;
save (['Sags/12_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Ec
Ua=Va13;Ub=Vb13;Uc=Vc13;
save (['Sags/13_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')

%Fa
Ua=Va14;Ub=Vb14;Uc=Vc14;
save (['Sags/14_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Fb
Ua=Va15;Ub=Vb15;Uc=Vc15;
save (['Sags/15_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Fc
Ua=Va16;Ub=Vb16;Uc=Vc16;
save (['Sags/16_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')

%Ga
Ua=Va17;Ub=Vb17;Uc=Vc17;
save (['Sags/17_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Gb
Ua=Va18;Ub=Vb18;Uc=Vc18;
save (['Sags/18_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')
%Gc
Ua=Va19;Ub=Vb19;Uc=Vc19;
save (['Sags/19_0' num2str(k) '.mat'],'t','Ua','Ub','Uc')

end
```

VoltageDip.m

```
function [Vt]=VoltageDipTemp(N1,N2,N3,V1,V2,V3,NS);
% [Vt]=VoltageDip(N1,N2,N3,V1,V2,V3,NS);
% generates a time-domain waveform with complex voltage V1 during N1
% cycles, voltage V2 during N2 cycles, voltage V3 during N3 cycles
% sampling rate NS samples per cycle
w1=[1:floor(N1*NS)]; % number of cycles pre-event
w2=[floor(N1*NS+1):floor((N1+N2)*NS)];% number of cycles during-event
w3=[floor((N1+N2)*NS+1):floor((N1+N2+N3)*NS)];% nymber of cycles post-event
t=linspace(0,N1+N2+N3,floor((N1+N2+N3)*NS+1));
t=t(1:(N1+N2+N3)*NS);
```

```
Vt=zeros((N1+N2+N3)*NS,1);
Vt(w1)=real(V1*exp(2*i*pi*t(w1)));
Vt(w2)=real(V2*exp(2*i*pi*t(w2)));
Vt(w3)=real(V3*exp(2*i*pi*t(w3)));
```

A.3 Site Indices and Figures

StatisticsPlots.m

```
clc
clear

load('Results\ResultsSymmCompVDonlyKoncene.mat')

for j=0:373
    File{j+1,1}      = VoltageDip{j+2,1};
    Dur(j+1,1)       = str2num(VoltageDip{j+2,3});
    Ret(j+1,1)       = str2num(VoltageDip{j+2,4});
    Dur_Sec(j+1,1)   = str2num(VoltageDip{j+2,3})*0.02;
    StatusS{j+1,1}   = VoltageDip{j+2,7};
%     Dur_Swell(j+1,1) = str2num(VoltageDip{j+2,8});
%     Ret_Swell{j+1,1} = (VoltageDip{j+2,9});
    Evs_DurRet(j+1,1)= str2num(VoltageDip{j+2,10});
    Evs_a(j+1,1)     = str2num(VoltageDip{j+2,11});
    Evs_b(j+1,1)     = str2num(VoltageDip{j+2,12});
    Evs_c(j+1,1)     = str2num(VoltageDip{j+2,13});
    Se(j+1,1)        = str2num(VoltageDip{j+2,16});
    DipType{j+1,1}   = VoltageDip{j+2,17};
    V(j+1,1)         = str2num(VoltageDip{j+2,18});
    F(j+1,1)         = str2num(VoltageDip{j+2,19});
    DipTypeS{j+1,1}  = VoltageDip{j+2,20};
    V_s(j+1,1)       = str2num(VoltageDip{j+2,21});
    F_s(j+1,1)       = str2num(VoltageDip{j+2,22});
    %calculating max of Evs_a,b,c
    Evs_all = [Evs_a,Evs_b,Evs_c];
    Evs(j+1,1)=max([Evs_all(j+1,1),Evs_all(j+1,2),Evs_all(j+1,3)]);
    %setting up the matrix of dip type
    DipType_all=[DipType,DipTypeS];
    match(j+1,1)=strcmp(DipType_all(j+1,1),DipType_all(j+1,2));
    match_non0=nonzeros(match);

end
for  q=16:20 %q=1:20 q=1:87
   vectStatusS=strmatch('YES',StatusS)+1;
   Dur_Swell(q,1) = str2num(VoltageDip{vectStatusS(q,1),8})*0.02;
   Ret_Swell(q,1) = str2num(VoltageDip{vectStatusS(q,1),9});
   Dur_SwellSags(q,1) = str2num(VoltageDip{vectStatusS(q,1),3})*0.02;
   Ret_SwellSags(q,1) = str2num(VoltageDip{vectStatusS(q,1),4});

end
   clear('match','StatusS');


   load('Results\ResultsSymmCompKonecne.mat') %loading the variables from file with all events
    for c= 0:774
   StatusSAll{c+1,1}   = VoltageDip{c+2,7};
   Status{c+1,1}   = VoltageDip{c+2,2};
   StatusComp=[Status,StatusSAll];


    vectStatusSAll=strmatch('YES',StatusSAll)+1;
              position=strcmp('YES',StatusSAll);
              position2=strcmp('YES',Status);
              positionAll=[position2,position];
                if (position2(c+1,1)==0 & position(c+1,1)==1)
                  positionNEW{c+1,1}='1';
              else positionNEW{c+1,1}='0';
              end
  end
```

```
    vectSwellsONLY=strmatch('1',positionNEW)+1;
        for ONLY=1:7
            Dur_SwellsONLY(ONLY,1) = str2num(VoltageDip{vectSwellsONLY(ONLY,1),8})*0.02;
            Ret_SwellsONLY(ONLY,1) = str2num(VoltageDip{vectSwellsONLY(ONLY,1),9});
        end

  for d=1:94
   Dur_SwellAll(d,1) = str2num(VoltageDip{vectStatusSAll(d,1),8})*0.02;
   Ret_SwellAll(d,1) = str2num(VoltageDip{vectStatusSAll(d,1),9});
   %StatusSags{d,1}   =        (VoltageDip{vectStatusSAll(d,1),2});
   DipTypeSwells{d,1}=        (VoltageDip{vectStatusSAll(d,1),17});
   DipTypeSSwells{d,1}=        (VoltageDip{vectStatusSAll(d,1),20});
%    Dur_SwellSagsAll(d,1) = str2num(VoltageDip{vectStatusSAll(d,1),3})*0.02;
%    Ret_SwellSagsAll(d,1) = str2num(VoltageDip{vectStatusSAll(d,1),4});

end

clear('c','d','vectSwellsONLY','ONLY','position','position2','positionNEW','positionAll');
clear('StatusSAll','Status','StatusComp','vectStatusSAll');

%======% IEC table %================================================================

[IECtable]=IECTable(Dur_Sec,Ret);

    save('Results\StatisticPlots\IECtable.mat', 'IECtable');

%===% Sarfi-X calculation (Six RMS method): ====================================
vectDipTypeA=strmatch('A',DipType);
vectDipTypeC=strmatch('C',DipType);
vectDipTypeD=strmatch('D',DipType);

VectDur1=find(Dur>300/0.02);
VectDur2=find(Dur<0.5);
VectNoHC=find(Dur>0.5);

DurHC=Dur(VectNoHC);
RetHC=Ret(VectNoHC);

HalfCycles=Ret(VectDur2);
Hc=length(find(HalfCycles<0.9));
Ret_length=length(Ret);

% 7 files are only swells, not sags => Sarfi110 is not equal to Sarfi110A+C+D => they do not have dip type defined
[Sarfi110,Sarfi110A,Sarfi110C,Sarfi110D]=SarfiX(Dur_SwellAll,Ret_SwellAll,DipTypeSwells,1.1); % only swells with dur greater
[Sarfi90,Sarfi90A,Sarfi90C,Sarfi90D]=SarfiX(Dur,Ret,DipType,0.9);
[Sarfi70,Sarfi70A,Sarfi70C,Sarfi70D]=SarfiX(Dur,Ret,DipType,0.7);
[Sarfi50,Sarfi50A,Sarfi50C,Sarfi50D]=SarfiX(Dur,Ret,DipType,0.5);
[Sarfi10,Sarfi10A,Sarfi10C,Sarfi10D]=SarfiX(Dur,Ret,DipType,0.1);

[Sarfi_ITIC, Sarfi_SEMI]= SarfiCurve(Dur_Sec,Ret);

[Sarfi_ITIC_ANoPer,Sarfi_ITIC_A, Sarfi_SEMI_ANoPer, Sarfi_SEMI_A]= SarfiCurveType(Dur_Sec,Ret,vectDipTypeA,Sarfi_ITIC, Sarfi
[Sarfi_ITIC_CNoPer,Sarfi_ITIC_C, Sarfi_SEMI_CNoPer, Sarfi_SEMI_C]= SarfiCurveType(Dur_Sec,Ret,vectDipTypeC,Sarfi_ITIC, Sarfi
[Sarfi_ITIC_DNoPer,Sarfi_ITIC_D, Sarfi_SEMI_DNoPer, Sarfi_SEMI_D]= SarfiCurveType(Dur_Sec,Ret,vectDipTypeD,Sarfi_ITIC, Sarfi

Sarfi_ITIC_test=Sarfi_ITIC_ANoPer+Sarfi_ITIC_CNoPer+Sarfi_ITIC_DNoPer;
Sarfi_SEMI_test=Sarfi_SEMI_ANoPer+Sarfi_SEMI_CNoPer+Sarfi_SEMI_DNoPer;

if Sarfi_ITIC_test==Sarfi_ITIC
    disp('correct')
else
    disp('incorrect')
end
if Sarfi_SEMI_test==Sarfi_SEMI
    disp('correct')
else
    disp('incorrect')
end

% %percentage:
% Sarfi_ITIC_Apercent=(Sarfi_ITIC_A/Sarfi_ITIC)*100;
% Sarfi_ITIC_Cpercent=(Sarfi_ITIC_C/Sarfi_ITIC)*100;
% Sarfi_ITIC_Dpercent=(Sarfi_ITIC_D/Sarfi_ITIC)*100;
```

```
%
% Sarfi_ITIC_A=[num2str(Sarfi_ITIC_A) ' (' num2str(roundn(Sarfi_ITIC_Apercent,-1)) '%)'];
% Sarfi_ITIC_C=[num2str(Sarfi_ITIC_C) ' (' num2str(roundn(Sarfi_ITIC_Cpercent,-1)) '%)'];
% Sarfi_ITIC_D=[num2str(Sarfi_ITIC_D) ' (' num2str(roundn(Sarfi_ITIC_Dpercent,-1)) '%)'];


clear('VectDur1','VectDur2','VectNoHC','Sarfi_ITIC_test','Sarfi_SEMI_test');
clear('HalfCycles','Hc','DipTypeSwells');

%===% Sarfi-X calculation (Symm. Comp. method): ====================================

vectDipTypeS_A=strmatch('A',DipTypeS);
vectDipTypeS_C=strmatch('C',DipTypeS);
vectDipTypeS_D=strmatch('D',DipTypeS);

[SarfiS110,SarfiS110A,SarfiS110C,SarfiS110D]=SarfiX(Dur_SwellAll,Ret_SwellAll,DipTypeSSwells,1.1);
[SarfiS90,SarfiS90A,SarfiS90C,SarfiS90D]=SarfiX(Dur,Ret,DipTypeS,0.9);
[SarfiS70,SarfiS70A,SarfiS70C,SarfiS70D]=SarfiX(Dur,Ret,DipTypeS,0.7);
[SarfiS50,SarfiS50A,SarfiS50C,SarfiS50D]=SarfiX(Dur,Ret,DipTypeS,0.5);
[SarfiS10,SarfiS10A,SarfiS10C,SarfiS10D]=SarfiX(Dur,Ret,DipTypeS,0.1);

[SarfiS_ITIC_ANoPer, SarfiS_ITIC_A, SarfiS_SEMI_ANoPer, SarfiS_SEMI_A]= SarfiCurveType(Dur_Sec,Ret,vectDipTypeS_A,Sarfi_ITIC
[SarfiS_ITIC_CNoPer, SarfiS_ITIC_C, SarfiS_SEMI_CNoPer, SarfiS_SEMI_C]= SarfiCurveType(Dur_Sec,Ret,vectDipTypeS_C,Sarfi_ITIC
[SarfiS_ITIC_DNoPer, SarfiS_ITIC_D, SarfiS_SEMI_DNoPer, SarfiS_SEMI_D]= SarfiCurveType(Dur_Sec,Ret,vectDipTypeS_D,Sarfi_ITIC

SarfiS_ITIC_test=SarfiS_ITIC_ANoPer+SarfiS_ITIC_CNoPer+SarfiS_ITIC_DNoPer;
SarfiS_SEMI_test=SarfiS_SEMI_ANoPer+SarfiS_SEMI_CNoPer+SarfiS_SEMI_DNoPer;

if SarfiS_ITIC_test==Sarfi_ITIC
    disp('correct')
else
    disp('incorrect')
end
if SarfiS_SEMI_test==Sarfi_SEMI
    disp('correct')
else
    disp('incorrect')
end

clear('vectDipTypeS_A','vectDipTypeS_C','vectDipTypeS_D','SarfiS_ITIC_test','SarfiS_SEMI_test','DipTypeSSwells');

%=======% sarfi table: %====================================================
Sarfi_row1    ={'' 'Total number of events' 'SARFI_110*' 'SARFI_90**' 'SARFI_70**' 'SARFI_50**' 'SARFI_10**' 'SARFI_ITIC(CBE
Sarfi_row2    ={'Count of events' num2str(Ret_length) num2str(Sarfi110) num2str(Sarfi90) num2str(Sarfi70) num2str(Sarfi50) n
Sarfi_row3    ={'Events per 30 days' num2str(Ret_length) num2str(Sarfi110) num2str(Sarfi90) num2str(Sarfi70) num2str(Sarfi50
Sarfi_row4    ={'Count of events for Type A (Six RMS method)' num2str(Ret_length) num2str(Sarfi110A) num2str(Sarfi90A) num2s
Sarfi_row5    ={'Count of events for Type C (Six RMS method)' num2str(Ret_length) num2str(Sarfi110C) num2str(Sarfi90C) num2s
Sarfi_row6    ={'Count of events for Type D (Six RMS method)' num2str(Ret_length) num2str(Sarfi110D) num2str(Sarfi90D) num2s
Sarfi_row7    ={'','','','','','','','',''};
Sarfi_row8    ={'Count of events for Type A (Symm. Comp. method)' num2str(Ret_length) num2str(SarfiS110A) num2str(SarfiS90A)
Sarfi_row9    ={'Count of events for Type C (Symm. Comp. method)' num2str(Ret_length) num2str(SarfiS110C) num2str(SarfiS90C)
Sarfi_row10   ={'Count of events for Type D (Symm. Comp. method)' num2str(Ret_length) num2str(SarfiS110D) num2str(SarfiS90D)
Sarfi_row11   ={'* in Sarfi_110 7 events are only swells => Dip Type is not defined for them','','','','','','','',''};
Sarfi_row12   ={'** only events with duration between 0.5 cycle and 5 minutes are taken into account','','','','','','','','

SarfiTable = [Sarfi_row1;Sarfi_row2;Sarfi_row3;Sarfi_row4;Sarfi_row5;Sarfi_row6;
              Sarfi_row7;Sarfi_row8;Sarfi_row9;Sarfi_row10;Sarfi_row11;Sarfi_row12];

save('Results\StatisticPlots\SarfiTable.mat', 'SarfiTable');

%==========================================================================

clear('Ret_length','Sarfi110','Sarfi90','Sarfi70','Sarfi50','Sarfi10','Sarfi_ITIC','Sarfi_SEMI');
clear('Sarfi110A','Sarfi90A','Sarfi70A','Sarfi50A','Sarfi10A','Sarfi_ITIC_A', 'Sarfi_SEMI_A');
clear('Sarfi110C','Sarfi90C','Sarfi70C','Sarfi50C','Sarfi10C','Sarfi_ITIC_C', 'Sarfi_SEMI_C');
clear('Sarfi110D','Sarfi90D','Sarfi70D','Sarfi50D','Sarfi10D','Sarfi_ITIC_D', 'Sarfi_SEMI_D');
clear('SarfiS110','SarfiS90','SarfiS70','SarfiS50','SarfiS10','SarfiS_ITIC','SarfiS_SEMI');
clear('SarfiS110A','SarfiS90A','SarfiS70A','SarfiS50A','SarfiS10A','SarfiS_ITIC_A', 'SarfiS_SEMI_A');
clear('SarfiS110C','SarfiS90C','SarfiS70C','SarfiS50C','SarfiS10C','SarfiS_ITIC_C', 'SarfiS_SEMI_C');
clear('SarfiS110D','SarfiS90D','SarfiS70D','SarfiS50D','SarfiS10D','SarfiS_ITIC_D', 'SarfiS_SEMI_D');
clear('Sarfi_ITIC_ANoPer', 'Sarfi_SEMI_ANoPer','Sarfi_ITIC_CNoPer', 'Sarfi_SEMI_CNoPer');
clear('Sarfi_ITIC_DNoPer', 'Sarfi_SEMI_DNoPer');
clear('SarfiS_ITIC_ANoPer', 'SarfiS_SEMI_ANoPer','SarfiS_ITIC_CNoPer', 'SarfiS_SEMI_CNoPer');
```

```
clear('SarfiS_ITIC_DNoPer', 'SarfiS_SEMI_DNoPer');

clear('Sarfi_row1','Sarfi_row2','Sarfi_row3','Sarfi_row4','Sarfi_row5','Sarfi_row6')
clear('Sarfi_row7','Sarfi_row8','Sarfi_row9','Sarfi_row10','Sarfi_row11','Sarfi_row12');

%===============================================================================
%====% Table of most common values of duration and retained voltage for different dip types %======%

DurTypeA=Dur_Sec(vectDipTypeA);
DurTypeC=Dur_Sec(vectDipTypeC);
DurTypeD=Dur_Sec(vectDipTypeD);

RetTypeA=Ret(vectDipTypeA);
RetTypeC=Ret(vectDipTypeC);
RetTypeD=Ret(vectDipTypeD);

clear('vectDipTypeA','vectDipTypeC','vectDipTypeD');

%===========================================================================%
% calculation of probability matching of Dip Type calculated by both methods
matching_probability=(length(match_non0)./(j+1)).*100;
disp([['matching_probability = ' num2str(matching_probability)] ' %'])

clear('matching_probability','match_non0')

% %================ finding if V<F:==============================
%   vect1=find(V>F);
%
%   vect2=find(V_s>F_s);
%   length(vect2);
%
%   vect3=find(F_s-V_s<-0.005);
%   length(vect3);
%
%   N=length(vect2)-length(vect3);
%
%     for n=N+1:length(vect2)
%         Vect3(n)=vect3(n-N);
%     end
%         Vect3(1:N)=1;
%
%    % to make the time vector same dimension%!!!!!!!!!!!!!!!!!!!!!
%     for g=1:length(Vect3)
%         Vector3(g,1)=Vect3(1,g);
%     end
%
% File_of_Vect2=File(vect2);
% File_of_Vect3=File(Vector3);
%
% File_all=[File_of_Vect2,File_of_Vect3];
%=================================================

% plotting figures

figure(1)
%axes('YScale','log'),
semilogx(Dur,Ret,'k*'), grid on, set(gca,'Fontsize',14),  xlabel('Duration [cycles]'), ylabel('Retained voltage [pu]'),ylim(
, xlim([0 750]),
title('Retained voltage vs. duration'),
%set(gca,'YScale','log')
line([1 1],[0 0.5]), line([1 10],[0.5 0.5]),
line([10 10],[0.5 0.7]),line([10 25],[0.7 0.7]),
line([25 25],[0.7 0.8]),line([25 500],[0.8 0.8]),
line([500 500],[0.8 0.9]),line([500 1000],[0.9 0.9]);

%print -depsc Results\StatisticPlots\01_RetDurCyc.eps;

figure(2)
semilogx(Dur_Sec,Ret,'k*'), grid on,set(gca,'Fontsize',14), ylim([0 1]), xlim([0 750*0.02]),
xlabel('Duration [seconds]'), ylabel('Retained voltage [pu]'),
title('Retained voltage vs. duration'),
line([0.02 0.02],[0 0.5]), line([0.02 0.2],[0.5 0.5]),
line([0.2 0.2],[0.5 0.7]), line([0.2 0.5],[0.7 0.7]),
```

```
line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);

%print -depsc Results\StatisticPlots\02_RetDurSec.eps;

Corelation=corrcoef(Dur,Ret);

figure(3)
cdfplot((Dur)),set(gca,'Fontsize',14),title('Probability distribution of Duration'), xlabel('Duration [cycles]');

%print -depsc Results\StatisticPlots\03_DurProb.eps;

figure(4)
normplot((Ret)),set(gca,'Fontsize',14),title('Probability distribution of Retained voltage'), xlabel('Retained voltage [pu]'

%print -depsc Results\StatisticPlots\04_RetProb.eps;

figure(5)
plot(Evs_DurRet,Evs,'r*'),set(gca,'Fontsize',14), title('Voltage Sag Energy Index Results [cycles]'),
xlabel('Voltage Sag Energy Index calc. from Dur & Ret'),
ylabel('Voltage Sag Energy Index calc. from Integral'), grid on

%print -depsc Results\StatisticPlots\05a_Evs.eps

figure(19)
semilogx(Ret,Evs_DurRet,'bX',Ret,Evs,'g+'),set(gca,'Fontsize',14),
xlim([0 1]), title('Voltage Sag Energy Index Results [cycles]'), xlabel('Retained voltage [pu]'),
ylabel('Voltage Sag Energy Index'), legend('Evs_{DurRet}', 'Evs_{integral}'), grid on

%print -depsc Results\StatisticPlots\05b_RetEvs.eps

figure(6)
semilogx(Evs,Se,'*'),set(gca,'Fontsize',14),
title('Voltage-Sag Severity vs. Voltage-sag Energy Index'), xlabel('Voltage-sag Energy Index [cycles]'),
ylabel('Voltage-Sag Severity [pu]'), grid on;

%print -depsc Results\StatisticPlots\06_EvsVS_Se.eps

figure(7)
semilogx(DurHC,RetHC,'k*'), grid on, set(gca,'Fontsize',14), ylim([0 1]), xlim([0 750]),
xlabel('Duration [cycles]'), ylabel('Retained voltage [pu]'),
title('Retained voltage vs. duration for all sags with duration > 10 ms (SEMI curve)'),
line([1 1],[0 0.5]), line([1 10],[0.5 0.5]),
line([10 10],[0.5 0.7]),line([10 25],[0.7 0.7]),
line([25 25],[0.7 0.8]),line([25 500],[0.8 0.8]),
line([500 500],[0.8 0.9]),line([500 1000],[0.9 0.9]);

%print -depsc Results\StatisticPlots\07_RetDurCycNoHC.eps

figure(8)
semilogx(DurTypeA,RetTypeA,'k*'), grid on, set(gca,'Fontsize',14),
ylim([0 1]), xlim([10^-3 750*0.02]), xlabel('Duration [seconds]'), ylabel('Retained voltage [pu]'),
title('Retained voltage vs. duration for Dip type A (SEMI curve reference)'),
line([0.02 0.02],[0 0.5]), line([0.02 0.2],[0.5 0.5]),
line([0.2 0.2],[0.5 0.7]), line([0.2 0.5],[0.7 0.7]),
line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);

%print -depsc Results\StatisticPlots\08_RetDurA_SEMI.eps

figure(9)
semilogx(DurTypeC,RetTypeC,'k*'), grid on, set(gca,'Fontsize',14),
ylim([0 1]), xlim([0 750*0.02]), xlabel('Duration [seconds]'), ylabel('Retained voltage [pu]'),
title('Retained voltage vs. duration for Dip type C (SEMI curve reference)'),
line([0.02 0.02],[0 0.5]), line([0.02 0.2],[0.5 0.5]),
line([0.2 0.2],[0.5 0.7]), line([0.2 0.5],[0.7 0.7]),
line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);

%print -depsc Results\StatisticPlots\09_RetDurC_SEMI.eps


figure(10)
```

```
semilogx(DurTypeD,RetTypeD,'k*'), grid on,set(gca,'Fontsize',14),
ylim([0 1]), xlim([0 750*0.02]), xlabel('Duration [seconds]'), ylabel('Retained voltage [pu]'),
title('Retained voltage vs. duration for Dip type D (SEMI curve reference)'),
line([0.02 0.02],[0 0.5]), line([0.02 0.2],[0.5 0.5]),
line([0.2 0.2],[0.5 0.7]), line([0.2 0.5],[0.7 0.7]),
line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);

%print -depsc Results\StatisticPlots\10_RetDurD_SEMI.eps

figure(11)
semilogx(DurTypeA,RetTypeA,'k*'), grid on,set(gca,'Fontsize',14),
ylim([0 1]), xlim([10^-3 750*0.02]), xlabel('Duration [seconds]'), ylabel('Retained voltage [pu]'),
title('Retained voltage vs. duration for Dip type A (ITIC curve reference)'),
line([0.02 0.02],[0 0.7]), line([0.02 0.5],[0.7 0.7]),
line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);

%print -depsc Results\StatisticPlots\11_RetDurA_ITIC.eps


figure(12)
semilogx(DurTypeC,RetTypeC,'k*'), grid on, set(gca,'Fontsize',14),ylim([0 1]), xlim([0 750*0.02]),
xlabel('Duration [seconds]'), ylabel('Retained voltage [pu]'),
title('Retained voltage vs. duration for Dip type C (ITIC curve reference)'),
line([0.02 0.02],[0 0.7]), line([0.02 0.5],[0.7 0.7]),
line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);

%print -depsc Results\StatisticPlots\12_RetDurC_ITIC.eps

figure(13)
semilogx(DurTypeD,RetTypeD,'k*'), grid on, set(gca,'Fontsize',14),ylim([0 1]),
xlim([0 750*0.02]), xlabel('Duration [seconds]'), ylabel('Retained voltage [pu]'),
title('Retained voltage vs. duration for Dip type D (ITIC curve reference)'),
line([0.02 0.02],[0 0.7]), line([0.02 0.5],[0.7 0.7]),
line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);

%print -depsc Results\StatisticPlots\13_RetDurD_ITIC.eps


figure(14)
semilogx(Dur_Swell,Ret_Swell,'k*',Dur_SwellSags,Ret_SwellSags,'r*'), grid on, set(gca,'Fontsize',14), xlim([0 750*0.02]),
xlabel(' Duration [seconds]'), ylabel(' Retained voltage [pu]'), legend('Swells','Sags')
title('Retained voltage vs. duration of Swells & Sags (ITIC curve reference)'),
%f=gname('cases');
%set(f,'Fontsize',17);

% for q =16:20
% text(Dur_Swell(q)+0.001,Ret_Swell(q),num2str(q-15),'Fontsize',18)
% text(Dur_SwellSags(q)+0.005,Ret_SwellSags(q),num2str(q-15),'Color','r','Fontsize',18)
% end
%sag reference:
line([0.02 0.02],[0  0.7]), line([0.02 0.5],[0.7 0.7]),
line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);
%swell reference:
line([0.003 0.003],[1.4 1.2]), line([0.003 0.5],[1.2 1.2]),
line([0.5 0.5],[1.2 1.1]), line([0.5 20],[1.1 1.1]);

%print -depsc Results\StatisticPlots\14_RetDurSwells.eps

% figure(20)
% semilogx(Dur_SwellAll,Ret_SwellAll,'k*',Dur_SwellSags,Ret_SwellSags,'r*'), grid on, set(gca,'Fontsize',14), xlim([0 750*0.
% xlabel(' Duration [seconds]'), ylabel(' Retained voltage [pu]'), legend('Swells','Sags')
% title('Retained voltage vs. duration of Swells & Sags (ITIC curve reference)'),
% %sag reference:
% line([0.02 0.02],[0  0.7]), line([0.02 0.5],[0.7 0.7]),
% line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
% line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);
% %swell reference:
% line([0.003 0.003],[1.4 1.2]), line([0.003 0.5],[1.2 1.2]),
```

```
% line([0.5 0.5],[1.2 1.1]), line([0.5 20],[1.1 1.1]);
%
% print -depsc Results\StatisticPlots\14_RetDurSwellsAll.eps

figure(15)
plot3(Dur_Swell,vectStatusS(1:20),Ret_Swell,'k*',Dur_SwellSags,vectStatusS(1:20),Ret_SwellSags,'r*'), grid on,
set(gca,'Fontsize',14),xlabel(' Swell Duration [seconds]'), ylabel('Position in the vector'),zlabel(' Swell Retained voltage
title('Retained voltage vs. duration for Swells (ITIC curve reference)'), box on, xlim([0 750*0.02]),
set(gca,'XScale','log')
set(gca,'YMinorGrid','on')
%sag reference: % need to put: vectStatusS(1:20), also need to change q at the begining
for vectStatusS=1:100
line([0.02 0.02],[vectStatusS vectStatusS],[0 0.7]), line([0.02 0.5],[vectStatusS vectStatusS],[0.7 0.7]),
line([0.5 0.5],[vectStatusS vectStatusS],[0.7 0.8]), line([0.5 10],[vectStatusS vectStatusS],[0.8 0.8]),
line([10 10],[vectStatusS vectStatusS],[0.8 0.9]), line([10 20],[vectStatusS vectStatusS],[0.9 0.9]);
%swell reference:
line([0.003 0.003],[vectStatusS vectStatusS],[1.4 1.2]), line([0.003 0.5],[vectStatusS vectStatusS],[1.2 1.2]),
line([0.5 0.5],[vectStatusS vectStatusS],[1.2 1.1]), line([0.5 20],[vectStatusS vectStatusS],[1.1 1.1]);
end
for vectStatusS=98:99
line([0.02 0.02],[vectStatusS vectStatusS],[0 0.7]), line([0.02 0.5],[vectStatusS vectStatusS],[0.7 0.7]),
line([0.5 0.5],[vectStatusS vectStatusS],[0.7 0.8]), line([0.5 10],[vectStatusS vectStatusS],[0.8 0.8]),
line([10 10],[vectStatusS vectStatusS],[0.8 0.9]), line([10 20],[vectStatusS vectStatusS],[0.9 0.9]);
%swell reference:
line([0.003 0.003],[vectStatusS vectStatusS],[1.4 1.2]), line([0.003 0.5],[vectStatusS vectStatusS],[1.2 1.2]),
line([0.5 0.5],[vectStatusS vectStatusS],[1.2 1.1]), line([0.5 20],[vectStatusS vectStatusS],[1.1 1.1]);
end

%print -depsc Results\StatisticPlots\15_RetDurSwells3D.eps

figure(16)
semilogx(Dur_SwellAll,Ret_SwellAll,'k*'), grid on, set(gca,'Fontsize',14), xlim([0 750*0.02]),
xlabel(' Swell Duration [seconds]'), ylabel(' Swell Retained voltage [pu]'),
title('Retained voltage vs. duration for All Swells  (ITIC curve reference)'),
%sag reference:
line([0.02 0.02],[0  0.7]), line([0.02 0.5],[0.7 0.7]),
line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);
%swell reference:
line([0.003 0.003],[1.4 1.2]), line([0.003 0.5],[1.2 1.2]),
line([0.5 0.5],[1.2 1.1]), line([0.5 20],[1.1 1.1]);

%print -depsc Results\StatisticPlots\16_RetDurSwellsAll.eps

figure(17)
semilogx(Dur_SwellsONLY,Ret_SwellsONLY,'k*'), grid on,set(gca,'Fontsize',14),  xlim([0 750*0.02]),
xlabel(' Swell Duration [seconds]'), ylabel(' Swell Retained voltage [pu]'),
title('Retained voltage vs. duration for Swells ONLY (ITIC curve reference) (N.=7)'),
%sag reference:
line([0.02 0.02],[0  0.7]), line([0.02 0.5],[0.7 0.7]),
line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);
%swell reference:
line([0.003 0.003],[1.4 1.2]), line([0.003 0.5],[1.2 1.2]),
line([0.5 0.5],[1.2 1.1]), line([0.5 20],[1.1 1.1]);

%print -depsc Results\StatisticPlots\17_RetDurSwellsONLY.eps

figure(18)

[AX,H1,H2] = plotyy(Dur_Sec,Ret,Dur_Sec,Se,'semilogx'); grid on,set(gca,'Fontsize',14), xlim([0 750*0.02]),
%semilogx(Dur_Sec,Se,'k.'), grid off, xlim([0 750*0.02]),
xlabel('Duration [seconds]'), ylabel('Voltage-sag severity [pu]'),
title('Voltage-sag severity vs. duration'),
set(H1,'LineStyle','.','Visible','on','Color','w'),
set(H2,'LineStyle','.'),
set(AX(1),'visible','on'),
set(get(AX(1),'Ylabel'),'String','Retained voltage [pu]'),
set(get(AX(2),'Ylabel'),'String','Voltage-sag severity [pu]'),

line([0.02 0.02],[0 0.5]), line([0.02 0.2],[0.5 0.5]),
line([0.2 0.2],[0.5 0.7]), line([0.2 0.5],[0.7 0.7]),
line([0.5 0.5],[0.7 0.8]), line([0.5 10],[0.8 0.8]),
```

```
line([10 10],[0.8 0.9]), line([10 20],[0.9 0.9]);
set(gcf,'CurrentAxes',AX(2))
set(gca,'YDir','reverse'),ylim([0 5])

 %print -depsc Results\StatisticPlots\18_DurSecSe.eps;

clear('AX','H1','H2');

figure(21)
normplot(RetTypeA),set(gca,'Fontsize',14),title('Probability distribution of Retained voltage for sag type A'), xlabel('Reta

print -depsc Results\StatisticPlots\19_RetProbA.eps;

figure(22)
normplot(RetTypeC),set(gca,'Fontsize',14),title('Probability distribution of Retained voltage for sag type C'), xlabel('Reta

print -depsc Results\StatisticPlots\20_RetProbC.eps;

figure(23)
normplot(RetTypeD),set(gca,'Fontsize',14),title('Probability distribution of Retained voltage for sag type D'), xlabel('Reta

print -depsc Results\StatisticPlots\21_RetProbD.eps;

figure(24)
normplot(DurTypeA),set(gca,'Fontsize',14),title('Probability distribution of Duration for sag type A'), xlabel('Duration [cy

print -depsc Results\StatisticPlots\22_DurProbA.eps;

figure(25)
normplot(DurTypeC),set(gca,'Fontsize',14),title('Probability distribution of Duration for sag type C'), xlabel('Duration [cy

print -depsc Results\StatisticPlots\23_DurProbC.eps;

figure(26)
normplot(DurTypeD),set(gca,'Fontsize',14),title('Probability distribution of Duration for sag type D'), xlabel('Duration [cy

print -depsc Results\StatisticPlots\24_DurProbD.eps;


clear('Dur_Swell','Ret_Swell','Dur_SwellSags','Ret_SwellSags','Dur_SwellAll','Ret_SwellAll');
clear('Dur_SwellsONLY','Ret_SwellsONLY','vectStatusS');
clear('DurTypeA','DurTypeC','DurTypeD','RetTypeA','RetTypeC','RetTypeD');
clear('File','Dur','Ret','Evs_DurRet','Evs_a','Evs_b','Evs_c','Se','DipType','V','F');
clear('DipTypeS','V_s','F_s','Evs_all','Evs','DipType_all','DurHC','RetHC','j','Corelation');
clear('Dur_Sec','q')

```

SarfiX.m

```
function [Sarfi,Sarfi_A,Sarfi_C,Sarfi_D]=SarfiX(Dur,Ret,DipType,threshold)

%===% Sarfi-X calculation: ====================================

vectDipTypeA=strmatch('A',DipType);
vectDipTypeC=strmatch('C',DipType);
vectDipTypeD=strmatch('D',DipType);

if (threshold == 0.9 )%|| threshold == 1.1)

DurTypeA=Dur(vectDipTypeA);
DurTypeC=Dur(vectDipTypeC);
DurTypeD=Dur(vectDipTypeD);

DurTypeA_NoHC=find(DurTypeA>0.5);
DurTypeC_NoHC=find(DurTypeC>0.5);
DurTypeD_NoHC=find(DurTypeD>0.5);

VectNoHC=find(Dur>0.5);
RetHC=Ret(VectNoHC);
RetHC_TypeA=RetHC(DurTypeA_NoHC);
RetHC_TypeC=RetHC(DurTypeC_NoHC);
RetHC_TypeD=RetHC(DurTypeD_NoHC);
```

```

Sarfi=length(find(RetHC<threshold));
Sarfi_A=length(find(RetHC_TypeA<threshold));
Sarfi_C=length(find(RetHC_TypeC<threshold));
Sarfi_D=length(find(RetHC_TypeD<threshold));
Sarfi_ACD=Sarfi_A+Sarfi_C+Sarfi_D;
    if (Sarfi==Sarfi_ACD)
        disp('correct')
    else
        disp('incorrect')
    end

%percentage:
Sarfi_Apercent=(Sarfi_A/Sarfi)*100;
Sarfi_Cpercent=(Sarfi_C/Sarfi)*100;
Sarfi_Dpercent=(Sarfi_D/Sarfi)*100;

Sarfi_A=[num2str(Sarfi_A) ' (' num2str(roundn(Sarfi_Apercent,-1)) '%)'];
Sarfi_C=[num2str(Sarfi_C) ' (' num2str(roundn(Sarfi_Cpercent,-1)) '%)'];
Sarfi_D=[num2str(Sarfi_D) ' (' num2str(roundn(Sarfi_Dpercent,-1)) '%)'];

elseif (threshold == 1.1)

Ret_TypeA=Ret(vectDipTypeA);
Ret_TypeC=Ret(vectDipTypeC);
Ret_TypeD=Ret(vectDipTypeD);

Sarfi=length(find(Ret>threshold));
Sarfi_A=length(find(Ret_TypeA>threshold));
Sarfi_C=length(find(Ret_TypeC>threshold));
Sarfi_D=length(find(Ret_TypeD>threshold));
Sarfi_ACD=Sarfi_A+Sarfi_C+Sarfi_D;
    if (Sarfi==Sarfi_ACD)
        disp('correct')
    else
        disp('incorrect')
    end

%percentage:
Sarfi_Apercent=(Sarfi_A/Sarfi)*100;
Sarfi_Cpercent=(Sarfi_C/Sarfi)*100;
Sarfi_Dpercent=(Sarfi_D/Sarfi)*100;

Sarfi_A=[num2str(Sarfi_A) ' (' num2str(roundn(Sarfi_Apercent,-1)) '%)'];
Sarfi_C=[num2str(Sarfi_C) ' (' num2str(roundn(Sarfi_Cpercent,-1)) '%)'];
Sarfi_D=[num2str(Sarfi_D) ' (' num2str(roundn(Sarfi_Dpercent,-1)) '%)'];

else

Ret_TypeA=Ret(vectDipTypeA);
Ret_TypeC=Ret(vectDipTypeC);
Ret_TypeD=Ret(vectDipTypeD);

Sarfi=length(find(Ret<threshold));
Sarfi_A=length(find(Ret_TypeA<threshold));
Sarfi_C=length(find(Ret_TypeC<threshold));
Sarfi_D=length(find(Ret_TypeD<threshold));
Sarfi_ACD=Sarfi_A+Sarfi_C+Sarfi_D;
    if (Sarfi==Sarfi_ACD)
        disp('correct')
    else
        disp('incorrect')
    end
%percentage:
Sarfi_Apercent=(Sarfi_A/Sarfi)*100;
Sarfi_Cpercent=(Sarfi_C/Sarfi)*100;
Sarfi_Dpercent=(Sarfi_D/Sarfi)*100;

Sarfi_A=[num2str(Sarfi_A) ' (' num2str(roundn(Sarfi_Apercent,-1)) '%)'];
Sarfi_C=[num2str(Sarfi_C) ' (' num2str(roundn(Sarfi_Cpercent,-1)) '%)'];
Sarfi_D=[num2str(Sarfi_D) ' (' num2str(roundn(Sarfi_Dpercent,-1)) '%)'];

end
```

SarfiCurve.m

```
function [Sarfi_ITIC, Sarfi_SEMI]= SarfiCurve(Dur_Sec,Ret)

%=======% Sarfi-curve calculation: %================
%=% Sarfi-ITIC(CBEMA)==========================
%=% U_itic < 0.7 pu %===% 0.02 < d <= 0.500 %=====
vectDur_ITIC_1=find(0.02<Dur_Sec & Dur_Sec<=0.500);
Ret_ITIC_1=Ret(vectDur_ITIC_1);
vectRet_ITIC_1=find(Ret_ITIC_1<0.7);
Sarfi_ITIC1=length(Ret_ITIC_1(vectRet_ITIC_1));


%=% U_itic < 0.8 pu %===% 0.500 < d <= 10 %=====
vectDur_ITIC_2=find(0.500<Dur_Sec & Dur_Sec<=10);
Ret_ITIC_2=Ret(vectDur_ITIC_2);
vectRet_ITIC_2=find(Ret_ITIC_2<0.8);
Sarfi_ITIC2=length(Ret_ITIC_2(vectRet_ITIC_2));

%=% U_itic < 0.9 pu %===% 10 < d %=====
vectDur_ITIC_3=find(10 < Dur_Sec);
Ret_ITIC_3=Ret(vectDur_ITIC_3);
vectRet_ITIC_3=find(Ret_ITIC_3<0.9);
Sarfi_ITIC3=length(Ret_ITIC_3(vectRet_ITIC_3));

Sarfi_ITIC=Sarfi_ITIC1+Sarfi_ITIC2+Sarfi_ITIC3;

%=% Sarfi-SEMI==========

%=% U_semi < 0.5 pu %===% 0.02 < d <= 0.200 %=====
vectDur_SEMI_1=find(0.02<Dur_Sec & Dur_Sec<=0.200);
Ret_SEMI_1=Ret(vectDur_SEMI_1);
vectRet_SEMI_1=find(Ret_SEMI_1<0.5);
Sarfi_SEMI1=length(Ret_SEMI_1(vectRet_SEMI_1));

%=% U_semi < 0.7 pu %===% 0.200 < d <= 0.500 %=====
vectDur_SEMI_2=find(0.200<Dur_Sec & Dur_Sec<=0.500);
Ret_SEMI_2=Ret(vectDur_SEMI_2);
vectRet_SEMI_2=find(Ret_SEMI_2<0.7);
Sarfi_SEMI2=length(Ret_SEMI_2(vectRet_SEMI_2));

%=% U_semi < 0.8 pu %===% 0.500 < d <= 10 %=====
vectDur_SEMI_3=find(0.500<Dur_Sec & Dur_Sec<=10);
Ret_SEMI_3=Ret(vectDur_SEMI_3);
vectRet_SEMI_3=find(Ret_SEMI_3<0.8);
Sarfi_SEMI3=length(Ret_SEMI_3(vectRet_SEMI_3));

%=% U_semi < 0.9 pu %===% 10 < d %=====
vectDur_SEMI_4=find(10 < Dur_Sec);
Ret_SEMI_4=Ret(vectDur_SEMI_4);
vectRet_SEMI_4=find(Ret_SEMI_4<0.9);
Sarfi_SEMI4=length(Ret_SEMI_4(vectRet_SEMI_4));

Sarfi_SEMI=Sarfi_SEMI1+Sarfi_SEMI2+Sarfi_SEMI3+Sarfi_SEMI4;
```

SarfiCurveType.m

```

function [Sarfi_ITICType,Sarfi_ITICTypePercent, Sarfi_SEMIType, Sarfi_SEMITypePercent]= SarfiCurveType(Dur_Sec,Ret,vectDipTy

%=======% Sarfi-curve calculation: %================
Dur_SecType=Dur_Sec(vectDipType);
Ret_Type=Ret(vectDipType);
lengthtype=length(Dur_SecType);
%=% Sarfi-ITIC(CBEMA)==========================
%=% U_itic < 0.7 pu %===% 0.02 < d <= 0.500 %=====
vectDur_ITIC_1=find(0.02<Dur_SecType & Dur_SecType<=0.500);
Ret_ITIC_1=Ret_Type(vectDur_ITIC_1);
vectRet_ITIC_1=find(Ret_ITIC_1<0.7);
Sarfi_ITIC1=length(Ret_ITIC_1(vectRet_ITIC_1));
```

```
%=% U_itic < 0.8 pu %===% 0.500 < d <= 10 %=====
vectDur_ITIC_2=find(0.500<Dur_SecType & Dur_SecType<=10);
Ret_ITIC_2=Ret_Type(vectDur_ITIC_2);
vectRet_ITIC_2=find(Ret_ITIC_2<0.8);
Sarfi_ITIC2=length(Ret_ITIC_2(vectRet_ITIC_2));

%=% U_itic < 0.9 pu %===% 10 < d %=====
vectDur_ITIC_3=find(10 < Dur_SecType);
Ret_ITIC_3=Ret_Type(vectDur_ITIC_3);
vectRet_ITIC_3=find(Ret_ITIC_3<0.9);
Sarfi_ITIC3=length(Ret_ITIC_3(vectRet_ITIC_3));

Sarfi_ITICType=Sarfi_ITIC1+Sarfi_ITIC2+Sarfi_ITIC3;

% in percentage
Sarfi_ITIC_TypePercent=(Sarfi_ITICType/Sarfi_ITIC)*100;
Sarfi_ITICTypePercent=[num2str(Sarfi_ITICType) ' (' num2str(roundn(Sarfi_ITIC_TypePercent,-1)) '%)'];

%=% Sarfi-SEMI===================================

%=% U_semi < 0.5 pu %===% 0.02 < d <= 0.200 %=====
vectDur_SEMI_1=find(0.02<Dur_SecType & Dur_SecType<=0.200);
Ret_SEMI_1=Ret_Type(vectDur_SEMI_1);
vectRet_SEMI_1=find(Ret_SEMI_1<0.5);
Sarfi_SEMI1=length(Ret_SEMI_1(vectRet_SEMI_1));

%=% U_semi < 0.7 pu %===% 0.200 < d <= 0.500 %=====
vectDur_SEMI_2=find(0.200<Dur_SecType & Dur_SecType<=0.500);
Ret_SEMI_2=Ret_Type(vectDur_SEMI_2);
vectRet_SEMI_2=find(Ret_SEMI_2<0.7);
Sarfi_SEMI2=length(Ret_SEMI_2(vectRet_SEMI_2));

%=% U_semi < 0.8 pu %===% 0.500 < d <= 10 %=====
vectDur_SEMI_3=find(0.500<Dur_SecType & Dur_SecType<=10);
Ret_SEMI_3=Ret_Type(vectDur_SEMI_3);
vectRet_SEMI_3=find(Ret_SEMI_3<0.8);
Sarfi_SEMI3=length(Ret_SEMI_3(vectRet_SEMI_3));

%=% U_semi < 0.9 pu %===% 10 < d %=====
vectDur_SEMI_4=find(10 < Dur_SecType);
Ret_SEMI_4=Ret_Type(vectDur_SEMI_4);
vectRet_SEMI_4=find(Ret_SEMI_4<0.9);
Sarfi_SEMI4=length(Ret_SEMI_4(vectRet_SEMI_4));

Sarfi_SEMIType=Sarfi_SEMI1+Sarfi_SEMI2+Sarfi_SEMI3+Sarfi_SEMI4;

% in percentage
Sarfi_SEMI_TypePercent=(Sarfi_SEMIType/Sarfi_SEMI)*100;
Sarfi_SEMITypePercent=[num2str(Sarfi_SEMIType) ' (' num2str(roundn(Sarfi_SEMI_TypePercent,-1)) '%)'];
```

IECTable.m

```
function [Table]=IECTable(Dur_Sec,Ret)

% putting dur and retained voltage in one matrix
DurRet=[Dur_Sec,Ret];

%========= making Voltage-Sag TABLE  based on IEC 61000-4-11
%== table_?1===== Dur_Sec < 0.1 ===========
%== table_11
vectDur0_01=find(Dur_Sec<0.1);
Ret0_01=Ret(vectDur0_01);
vectRet0_01=find(Ret0_01 >= 0.8);
table_11=length(Ret0_01(vectRet0_01));
%== table_21
vectRet0_01=find(0.7 < Ret0_01  & Ret0_01 <= 0.8 );
table_21=length(Ret0_01(vectRet0_01));
%== table_31
vectRet0_01=find(0.6 < Ret0_01  & Ret0_01 <= 0.7 );
table_31=length(Ret0_01(vectRet0_01));
%== table_41
```

```
vectRet0_01=find(0.5 < Ret0_01  & Ret0_01 <= 0.6 );
table_41=length(Ret0_01(vectRet0_01));
%== table_51
vectRet0_01=find(0.4 < Ret0_01  & Ret0_01 <= 0.5 );
table_51=length(Ret0_01(vectRet0_01));
%== table_61
vectRet0_01=find(0.3 < Ret0_01  & Ret0_01 <= 0.4 );
table_61=length(Ret0_01(vectRet0_01));
%== table_71
vectRet0_01=find(0.2 < Ret0_01  & Ret0_01 <= 0.3 );
table_71=length(Ret0_01(vectRet0_01));
%== table_81
vectRet0_01=find(0.1 < Ret0_01  & Ret0_01 <= 0.2 );
table_81=length(Ret0_01(vectRet0_01));
%== table_91
vectRet0_01=find(Ret0_01 <= 0.1 );
table_91=length(Ret0_01(vectRet0_01));
% true-false test; checking
tableX1=table_11+table_21+table_31+table_41+table_51+table_61+table_71+table_81+table_91;
if (tableX1==length(Ret0_01))
    %disp('true')
    test1='true';
else
    %disp('false')
    test1='false';
end
%===table_?2:====== 0.1 <= Dur_Sec < 0.25 ====================
vectDur01_025=find(0.1 <= Dur_Sec & Dur_Sec<0.25);
Ret01_025=Ret(vectDur01_025);
%== table_12
vectRet01_025=find(Ret01_025 >= 0.8);
table_12=length(Ret01_025(vectRet01_025));
%== table_22
vectRet01_025=find(0.7 < Ret01_025  & Ret01_025 <= 0.8 );
table_22=length(Ret01_025(vectRet01_025));
%== table_32
vectRet01_025=find(0.6 < Ret01_025  & Ret01_025 <= 0.7 );
table_32=length(Ret01_025(vectRet01_025));
%== table_42
vectRet01_025=find(0.5 < Ret01_025  & Ret01_025 <= 0.6 );
table_42=length(Ret01_025(vectRet01_025));
%== table_52
vectRet01_025=find(0.4 < Ret01_025  & Ret01_025 <= 0.5 );
table_52=length(Ret01_025(vectRet01_025));
%== table_62
vectRet01_025=find(0.3 < Ret01_025  & Ret01_025 <= 0.4 );
table_62=length(Ret01_025(vectRet01_025));
%== table_72
vectRet01_025=find(0.2 < Ret01_025  & Ret01_025 <= 0.3 );
table_72=length(Ret01_025(vectRet01_025));
%== table_82
vectRet01_025=find(0.1 < Ret01_025  & Ret01_025 <= 0.2 );
table_82=length(Ret01_025(vectRet01_025));
%== table_92
vectRet01_025=find(Ret01_025 <= 0.1 );
table_92=length(Ret01_025(vectRet01_025));
    % true-false test; checking
tableX2=table_12+table_22+table_32+table_42+table_52+table_62+table_72+table_82+table_92;
if (tableX2==length(Ret01_025))
    %disp('true')
    test2='true';
else
    %disp('false')
    test2='false';
end
%===table_?3:====== 0.25 <= Dur_Sec < 0.50 ==========
vectDur025_050=find(0.25 <= Dur_Sec & Dur_Sec<0.50);
Ret025_050=Ret(vectDur025_050);
%== table_13
vectRet025_050=find(Ret025_050 >= 0.8);
table_13=length(Ret025_050(vectRet025_050));
%== table_23
vectRet025_050=find(0.7 < Ret025_050 & Ret025_050 <= 0.8);
```

```
table_23=length(Ret025_050(vectRet025_050));
%== table_33
vectRet025_050=find(0.6 < Ret025_050 & Ret025_050 <= 0.7);
table_33=length(Ret025_050(vectRet025_050));
%== table_43
vectRet025_050=find(0.5 < Ret025_050 & Ret025_050 <= 0.6);
table_43=length(Ret025_050(vectRet025_050));
%== table_53
vectRet025_050=find(0.4 < Ret025_050 & Ret025_050 <= 0.5);
table_53=length(Ret025_050(vectRet025_050));
%== table_63
vectRet025_050=find(0.3 < Ret025_050 & Ret025_050 <= 0.4);
table_63=length(Ret025_050(vectRet025_050));
%== table_73
vectRet025_050=find(0.2 < Ret025_050 & Ret025_050 <= 0.3);
table_73=length(Ret025_050(vectRet025_050));
%== table_83
vectRet025_050=find(0.1 < Ret025_050 & Ret025_050 <= 0.2);
table_83=length(Ret025_050(vectRet025_050));
%== table_93
vectRet025_050=find(Ret025_050 <= 0.1);
table_93=length(Ret025_050(vectRet025_050));
% true-false test; checking
tableX3=table_13+table_23+table_33+table_43+table_53+table_63+table_73+table_83+table_93;
if (tableX3==length(Ret025_050))
    %disp('true')
    test3='true';
else
    %disp('false')
    test3='false';
end
%===table_?4:====== 0.50 <= Dur_Sec < 1.0 ===========
vectDur050_1=find(0.50 <= Dur_Sec & Dur_Sec<1);
Ret050_1=Ret(vectDur050_1);
%== table_14;
vectRet050_1=find(Ret050_1 >= 0.8);
table_14=length(Ret050_1(vectRet050_1));
%== table_24
vectRet050_1=find(0.7 < Ret050_1 & Ret050_1 <= 0.8);
table_24=length(Ret050_1(vectRet050_1));
%== table_34
vectRet050_1=find(0.6 < Ret050_1 & Ret050_1 <= 0.7);
table_34=length(Ret050_1(vectRet050_1));
%== table_44
vectRet050_1=find(0.5 < Ret050_1 & Ret050_1 <= 0.6);
table_44=length(Ret050_1(vectRet050_1));
%== table_54
vectRet050_1=find(0.4 < Ret050_1 & Ret050_1 <= 0.5);
table_54=length(Ret050_1(vectRet050_1));
%== table_64
vectRet050_1=find(0.3 < Ret050_1 & Ret050_1 <= 0.4);
table_64=length(Ret050_1(vectRet050_1));
%== table_74
vectRet050_1=find(0.2 < Ret050_1 & Ret050_1 <= 0.3);
table_74=length(Ret050_1(vectRet050_1));
%== table_84
vectRet050_1=find(0.1 < Ret050_1 & Ret050_1 <= 0.2);
table_84=length(Ret050_1(vectRet050_1));
%== table_94
vectRet050_1=find(Ret050_1 <= 0.1);
table_94=length(Ret050_1(vectRet050_1));
    % true-false test; checking
tableX4=table_14+table_24+table_34+table_44+table_54+table_64+table_74+table_84+table_94;
if (tableX4==length(Ret050_1))
    %disp('true')
    test4='true';
else
    %disp('false')
    test4='false';
end
%===table_?5:====== 1.0 <= Dur_Sec < 3.0 ===========
vectDur1_3=find(1.0 <= Dur_Sec & Dur_Sec < 3.0);
Ret1_3=Ret(vectDur1_3);
```

```
%== table_15
vectRet1_3=find(Ret1_3 >= 0.8);
table_15=length(Ret1_3(vectRet1_3));
%== table_25
vectRet1_3=find(0.7 < Ret1_3 & Ret1_3 <= 0.8);
table_25=length(Ret1_3(vectRet1_3));
%== table_35
vectRet1_3=find(0.6 < Ret1_3 & Ret1_3 <= 0.7);
table_35=length(Ret1_3(vectRet1_3));
%== table_45
vectRet1_3=find(0.5 < Ret1_3 & Ret1_3 <= 0.6);
table_45=length(Ret1_3(vectRet1_3));
%== table_55
vectRet1_3=find(0.4 < Ret1_3 & Ret1_3 <= 0.5);
table_55=length(Ret1_3(vectRet1_3));
%== table_65
vectRet1_3=find(0.3 < Ret1_3 & Ret1_3 <= 0.4);
table_65=length(Ret1_3(vectRet1_3));
%== table_75
vectRet1_3=find(0.2 < Ret1_3 & Ret1_3 <= 0.3);
table_75=length(Ret1_3(vectRet1_3));
%== table_85
vectRet1_3=find(0.1 < Ret1_3 & Ret1_3 <= 0.2);
table_85=length(Ret1_3(vectRet1_3));
%== table_95
vectRet1_3=find(Ret1_3 <= 0.1);
table_95=length(Ret1_3(vectRet1_3));
          % true-false test; checking
tableX5=table_15+table_25+table_35+table_45+table_55+table_65+table_75+table_85+table_95;
if (tableX5==length(Ret1_3))
    %disp('true')
    test5='true';
else
    %disp('false')
    test5='false';
end
 %===table_?6:====== 3.0 <= Dur_Sec < 20 ===========
vectDur3_20=find(3.0 <= Dur_Sec & Dur_Sec < 20);
Ret3_20=Ret(vectDur3_20);
%== table_16
vectRet3_20=find(Ret3_20 >= 0.8);
table_16=length(Ret3_20(vectRet3_20));
%== table_26
vectRet3_20=find(0.7 < Ret3_20 & Ret3_20 <= 0.8);
table_26=length(Ret3_20(vectRet3_20));
%== table_36
vectRet3_20=find(0.6 < Ret3_20 & Ret3_20 <= 0.7);
table_36=length(Ret3_20(vectRet3_20));
%== table_46
vectRet3_20=find(0.5 < Ret3_20 & Ret3_20 <= 0.6);
table_46=length(Ret3_20(vectRet3_20));
%== table_56
vectRet3_20=find(0.4 < Ret3_20 & Ret3_20 <= 0.5);
table_56=length(Ret3_20(vectRet3_20));
%== table_66
vectRet3_20=find(0.3 < Ret3_20 & Ret3_20 <= 0.4);
table_66=length(Ret3_20(vectRet3_20));
%== table_76
vectRet3_20=find(0.2 < Ret3_20 & Ret3_20 <= 0.3);
table_76=length(Ret3_20(vectRet3_20));
%== table_86
vectRet3_20=find(0.1 < Ret3_20 & Ret3_20 <= 0.2);
table_86=length(Ret3_20(vectRet3_20));
%== table_96
vectRet3_20=find(Ret3_20 <= 0.1);
table_96=length(Ret3_20(vectRet3_20));
              % true-false test; checking
tableX6=table_16+table_26+table_36+table_46+table_56+table_66+table_76+table_86+table_96;
if (tableX6==length(Ret3_20))
    %disp('true')
    test6='true';
else
    %disp('false')
```

```
        test6='false';
    end
     %===table_?7:====== 20 <= Dur_Sec < 60 ===========
    vectDur20_60=find(20 <= Dur_Sec & Dur_Sec < 60);
    Ret20_60=Ret(vectDur20_60);
    %== table_17
    vectRet20_60=find(Ret20_60 >= 0.8);
    table_17=length(Ret20_60(vectRet20_60));
    %== table_27
    vectRet20_60=find(0.7 < Ret20_60 & Ret20_60 <= 0.8);
    table_27=length(Ret20_60(vectRet20_60));
    %== table_37
    vectRet20_60=find(0.6 < Ret20_60 & Ret20_60 <= 0.7);
    table_37=length(Ret20_60(vectRet20_60));
    %== table_47
    vectRet20_60=find(0.5 < Ret20_60 & Ret20_60 <= 0.6);
    table_47=length(Ret20_60(vectRet20_60));
    %== table_57
    vectRet20_60=find(0.4 < Ret20_60 & Ret20_60 <= 0.5);
    table_57=length(Ret20_60(vectRet20_60));
    %== table_67
    vectRet20_60=find(0.3 < Ret20_60 & Ret20_60 <= 0.4);
    table_67=length(Ret20_60(vectRet20_60));
    %== table_77
    vectRet20_60=find(0.2 < Ret20_60 & Ret20_60 <= 0.3);
    table_77=length(Ret20_60(vectRet20_60));
    %== table_87
    vectRet20_60=find(0.1 < Ret20_60 & Ret20_60 <= 0.2);
    table_87=length(Ret20_60(vectRet20_60));
    %== table_97
    vectRet20_60=find(Ret20_60 <= 0.1);
    table_97=length(Ret20_60(vectRet20_60));
                      % true-false test; checking
    tableX7=table_17+table_27+table_37+table_47+table_57+table_67+table_77+table_87+table_97;
    if (tableX7==length(Ret20_60))
        %disp('true')
        test7='true';
    else
        %disp('false')
        test7='false';
    end
     %===table_?8:====== 60 <= Dur_Sec < 300 ===========
    vectDur60_300=find(60 <= Dur_Sec & Dur_Sec < 300);
    Ret60_300=Ret(vectDur60_300);
    %== table_18
    vectRet60_300=find(Ret60_300 >= 0.8);
    table_18=length(Ret60_300(vectRet60_300));
    %== table_28
    vectRet60_300=find(0.7 < Ret60_300 & Ret60_300 <= 0.8);
    table_28=length(Ret60_300(vectRet60_300));
    %== table_38
    vectRet60_300=find(0.6 < Ret60_300 & Ret60_300 <= 0.7);
    table_38=length(Ret60_300(vectRet60_300));
    %== table_48
    vectRet60_300=find(0.5 < Ret60_300 & Ret60_300 <= 0.6);
    table_48=length(Ret60_300(vectRet60_300));
    %== table_58
    vectRet60_300=find(0.4 < Ret60_300 & Ret60_300 <= 0.5);
    table_58=length(Ret60_300(vectRet60_300));
    %== table_68
    vectRet60_300=find(0.3 < Ret60_300 & Ret60_300 <= 0.4);
    table_68=length(Ret60_300(vectRet60_300));
    %== table_78
    vectRet60_300=find(0.2 < Ret60_300 & Ret60_300 <= 0.3);
    table_78=length(Ret60_300(vectRet60_300));
    %== table_88
    vectRet60_300=find(0.1 < Ret60_300 & Ret60_300 <= 0.2);
    table_88=length(Ret60_300(vectRet60_300));
    %== table_98
    vectRet60_300=find(Ret60_300 <= 0.1);
    table_98=length(Ret60_300(vectRet60_300));
    % true-false test; checking
    tableX8=table_18+table_28+table_38+table_48+table_58+table_68+table_78+table_88+table_98;
```

```
    if (tableX8==length(Ret20_60))
        %disp('true')
        test8='true';
    else
        %disp('false')
        test8='false';
    end

    %All Test:
    Test={test1 test2 test3 test4 test5 test6 test7 test8 };
    Table_test=tableX1+tableX2+tableX3+tableX4+tableX5+tableX6+tableX7+tableX8;

    if Table_test==length(Ret)
        disp('correct')
    else
        disp('incorrect')
    end

    % Making the table
    Table_row1    ={ 'Retained voltage [pu]' 'd < 0.1' '0.1 <= d < 0.25' '0.25 <= d < 0.50' '0.50 <= d < 1.0' '1.0 <= d < 3.
    Table_row2    ={ '0.8 < U <= 0.9' num2str(table_11) num2str(table_12) num2str(table_13) num2str(table_14) num2str(table_
    Table_row3    ={ '0.7 < U <= 0.8' num2str(table_21) num2str(table_22) num2str(table_23) num2str(table_24) num2str(table_
    Table_row4    ={ '0.6 < U <= 0.7' num2str(table_31) num2str(table_32) num2str(table_33) num2str(table_34) num2str(table_
    Table_row5    ={ '0.5 < U <= 0.6' num2str(table_41) num2str(table_42) num2str(table_43) num2str(table_44) num2str(table_
    Table_row6    ={ '0.4 < U <= 0.5' num2str(table_51) num2str(table_52) num2str(table_53) num2str(table_54) num2str(table_
    Table_row7    ={ '0.3 < U <= 0.4' num2str(table_61) num2str(table_62) num2str(table_63) num2str(table_64) num2str(table_
    Table_row8    ={ '0.2 < U <= 0.3' num2str(table_71) num2str(table_72) num2str(table_73) num2str(table_74) num2str(table_
    Table_row9    ={ '0.1 < U <= 0.2' num2str(table_81) num2str(table_82) num2str(table_83) num2str(table_84) num2str(table_
    Table_row10   ={ '0.0 < U <= 0.1' num2str(table_91) num2str(table_92) num2str(table_93) num2str(table_94) num2str(table_
    Table_row11   ={ '' '' '' '' '' '' '' '' ''};
    Table_row12   ={ 'Total number of events ' num2str(length(Ret)) '' '' '' '' '' '' ''};

    Table= [Table_row1 ; Table_row2; Table_row3 ; Table_row4; Table_row5; Table_row6; Table_row7; Table_row8; Table_row9; Ta

clear('Table_row1','Table_row2','Table_row3','Table_row4','Table_row5','Table_row6','Table_row7','Table_row8','Table_row9','
```

Appendix B

Synthetic Sags with Characteristic Voltage V=0.5 pu

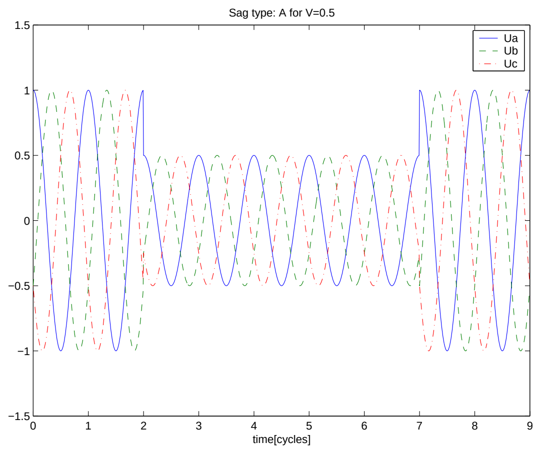
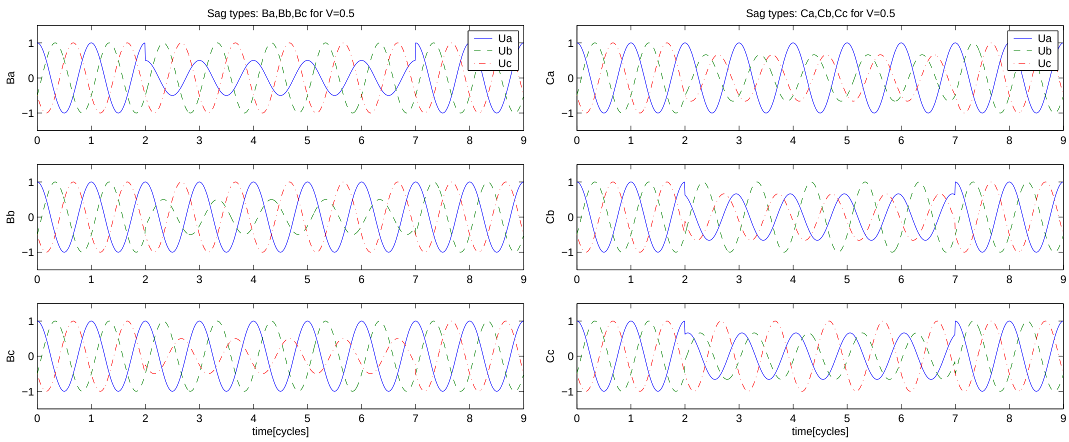


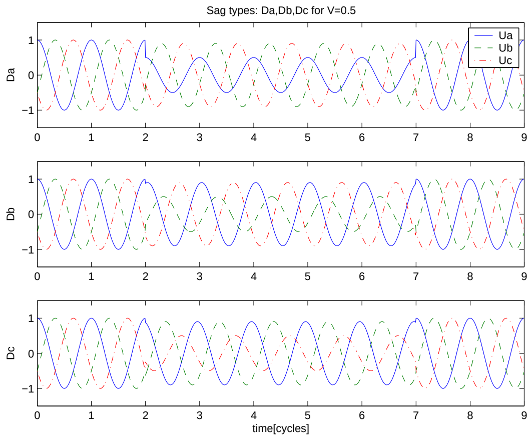
Figure B.1: Sag Type: A



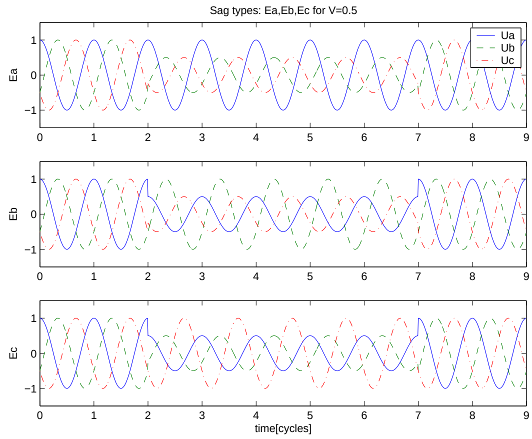
(a) Sag Types: Ba, Bb, Bc

(b) Sag Types: Ca, Cb, Cc

Figure B.2: Sag Types: B and C

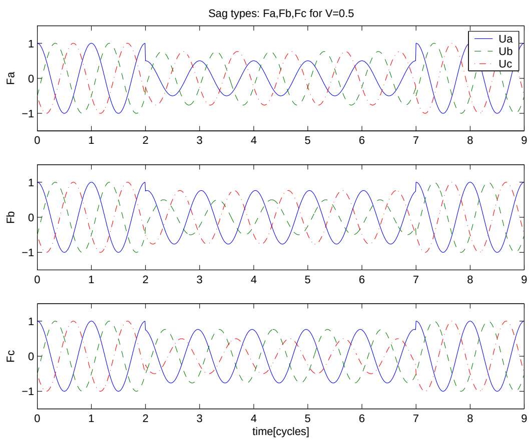


(a) Sag Types: Da, Db, Dc

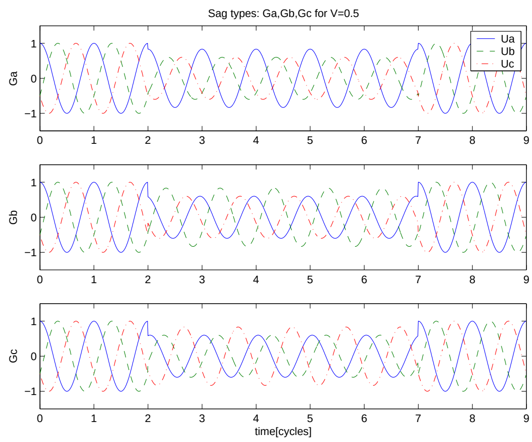


(b) Sag Types: Ea, Eb, Ec

Figure B.3: Sag Types: D and E



(a) Sag Types: Fa, Fb, Fc



(b) Sag Types: Ga, Gb, Gc

Figure B.4: Sag Types: F and G

Appendix C

MatLab Results - all recordings

Synthetic Dip	Sag	Duration of voltage sag [cycles]	Retained voltage * [pu]	Interrup-tion	Interruption Duration [cycles]	Swell	Swell Duration [cycles]	Swell retained voltage [pu]	Sag Energy calc. from Dur.& Ret [cycles]	Evs_a, Voltage-Sag Energy Index [cycles]	Evs_b, Voltage-Sag Energy Index [cycles]	Evs_c, Voltage-Sag Energy Index [cycles]	Evs, Voltage-Sag Energy Index [cycles]	Voltage-Swell Energy Index [cycles]	Voltage-Sagl Severity [pu]	Six Phase RMS - Dip Type	V (from sixRMS)	F (from sixRMS)	Symmetrical Component Method	V (from symm. comp. method)	F (from symm. comp. method)
ZQ0	NO		0.9186	NO		NO									0						
ZQ1	NO		0.9926	NO		NO									0						
ZQ2	NO		0.9926	NO		NO									0						
ZQ3	NO		0.9984	NO		NO									0						
ZQ4	NO		0.9949	NO		NO									0						
ZQ5	NO		0.9186	NO		NO									0						
ZQ6	NO		0.9958	NO		NO									0						
ZQ7	NO		0.9967	NO		NO									0						
ZQ8	NO		0.9966	NO		NO									0						
ZQ9	NO		0.9998	NO		NO									0						
ZQ10	NO		0.9987	NO		NO									0						
ZQ14	NO		0.9961	NO		NO									0						
ZQ15	NO		0.9978	NO		NO									0						
ZQ16	NO		0.9958	NO		NO									0						

ZQ17	NO		0.9981	NO		NO									0						
ZQ18	NO		0.9986	NO		NO									0						
ZQ20	NO		0.9956	NO		NO									0						
ZQ21	YES	95.1563	0	YES	88.9895	YES	0.0938	1.1192	95.156	94.38	90.35	92.4	277.12	0.0239	5	A	0	0	A	0	0
ZQ22	NO		0.9917	NO		NO									0						
ZQ23	YES	1.0938	0.891	NO		NO			0.225	0	0.02	0.02	0.033		0.2	Ca	0.874	0.9	Cb	0.956	0.947
ZQ24	NO		0.9981	NO		NO									0						
ZQ25	NO		0.9318	NO		NO									0						
ZQ27	NO		0.9788	NO		NO									0						
ZQ29	YES	6.1042	0	YES	5.3645	NO			6.104	5.63	5.66	5.57	16.861		2	A	0	0	A	0	0
ZQ30	YES	6.1042	0	YES	5.3645	NO			6.104	5.63	5.66	5.57	16.861		2	A	0	0	A	0	0
ZQ31	YES	65.125	0.801	NO		NO			23.341	21.51	20.97	20.48	62.961		1	A	0.801	0.8	A	0.803	0.809
ZQ32	NO		0.9823	NO		NO									0						
ZQ33	NO		0.929	NO		NO									0						
ZQ37	NO		0.9901	NO		NO									0						
ZQ38	NO		0.9304	NO		NO									0						
ZQ39	NO		0.934	NO		NO									0						
ZQ40	NO		0.9859	NO		NO									0						
ZQ41	NO		0.9959	NO		NO									0						
ZQ45	YES	0.0313	0.8981	NO		NO			0.006	0	0	0.01	0.008		0.1	Ca	0.883	0.9	Ca	0.914	0.985
ZQ46	NO		0.9093	NO		NO									0						
ZQ47	NO		0.997	NO		NO									0						
ZQ48	NO		0.998	NO		NO									0						
ZQ49	NO		0.9976	NO		NO									0						
ZQ50	NO		0.9979	NO		NO									0						
ZQ51	YES	3.3021	0.8275	NO		NO			1.041	0.21	0	0.2	0.407		0.3	Cb	0.794	0.9	Cb	0.899	0.982
ZQ52	YES	18.5208	0.862	NO		NO			4.759	0	4.59	3.02	7.615		0.5	Ca	0.846	1	Ca	0.842	0.953
ZQ53	YES	20.0104	0.8476	NO		NO			5.634	0	5.03	3.87	8.903		0.5	Ca	0.843	1	Ca	0.828	0.959
ZQ54	YES	22.4896	0.4643	NO		NO			17.641	16.31	13.29	10.61	40.202		1.8	Cc	0.456	0.5	A	0.492	0.498
ZQ55	YES	0.2292	0.8719	NO		NO			0.055	0	0	0.05	0.052		0.1	Dc	0.874	1	Cb	0.964	0.989
ZQ56	YES	2.1876	0.8278	NO		NO			0.689	0.55	0.52	0.49	1.569		0.3	Dc	0.827	0.8	A	0.809	0.814
ZQ57	NO		0.961	NO		NO									0						
ZQ58	NO		0.9991	NO		NO									0						
ZQ59	NO		0.9984	NO		NO									0						
ZQ60	NO		0.999	NO		NO									0						
ZQ61	NO		0.9985	NO		NO									0						
ZQ63	YES	13.25	0.0021	YES	5.375	NO			13.25	6.65	6.52	5.56	18.73		3.3	A	0.001	0	A	0.001	0.001
ZQ64	YES	13.6042	0.0007	YES	11.25	NO			13.604	12.75	12.95	12.93	38.636		3.3	A	0	0	A	0	0
ZQ65	YES	8.2188	0.0014	YES	4.4374	NO			8.219	4.64	4.94	4.91	14.493		2	A	0	0	A	0	0
ZQ66	NO		0.9003	NO		NO									0						
ZQ67	NO		0.9105	NO		NO									0						
ZQ68	YES	245.104	0.0009	YES	244.49	NO			245.1	243.92	243.82	243.65	731.383		5	A	0	0	A	0	0

ZQ69	YES	16.4479	0.7746	NO		YES	14.3334	1.2961	6.579	0.08	0.01	0.42	0.507	1.1031	0.7	Cc	0.808	0.9	A	0.002	0.003
ZQ74	YES	16.9062	0	YES	0.0104	YES	16.9479	Inf	16.906	2.12	5.31	0	7.429	Inf	3.3	Cb	0.302	0.9	Cb	0.11	0.558
ZQ75	NO		0.9091	NO		NO									0						
ZQ76	YES	8.7396	0.0009	YES	4.9895	NO			8.74	5.43	5.26	5.55	16.244		2	A	0.001	0	A	0	0
ZQ77	YES	13.2812	0.535	NO		NO			9.48	6.13	9.01	0	15.143		1.5	Cc	0.448	1	Cc	0.464	0.989
ZQ78	NO		0.9315	NO		NO									0						
ZQ79	NO		0.9317	NO		NO									0						
ZQ80	NO		0.9359	NO		NO									0						
ZQ81	NO		0.9487	NO		NO									0						
ZQ82	NO		0.9965	NO		NO									0						
ZQ83	YES	10	0.1136	NO		NO			9.871	9.38	6	4.61	19.986		1.8	Da	0.113	0.7	Da	0.14	0.749
ZQ84	NO		0.9127	NO		NO									0						
ZQ85	NO		0.9992	NO		NO									0						
ZQ86	NO		0.9979	NO		NO									0						
ZQ87	NO		0.9986	NO		NO									0						
ZQ88	NO		0.9868	NO		NO									0						
ZQ89	YES	0.5938	0.7796	NO		NO			0.233	0.14	0.01	0	0.149		0.2	Da	0.78	1	Cc	0.897	0.982
ZQ91	NO		0.9063	NO		NO									0						
ZQ92	NO		0.9995	NO		NO									0						
ZQ93	NO		0.9977	NO		NO									0						
ZQ94	NO		0.9016	NO		NO									0						
ZQ95	YES	13.0937	0.3568	NO		NO			11.427	8.65	8.33	6.5	23.481		2.1	Db	0.357	0.5	Cc	0.385	0.484
ZQ96	YES	0.0209	0.8981	NO		NO			0.004	0	0.01	0	0.006		0.1	Db	0.899	1	Ca	0.914	0.999
ZQ97	NO		0.915	NO		NO									0						
ZQ98	YES	0	0.8997	NO		NO			0	0	0	0	0.002		0.1	Ca	0.899	1	Ca	0.914	0.997
ZQ99	NO		0.9136	NO		NO									0						
ZQ100	YES	16.2708	0	YES	5.4583	YES	5.0521	1.1199	16.271	6.05	6.04	5.72	17.813	0.0685	3.3	A	0	0	A	0	0
ZQ103	YES	0.0313	0.8944	NO		NO			0.006	0	0.01	0	0.008		0.1	Ca	0.894	1	Ca	0.9	1.002
ZQ104	NO		0.9146	NO		NO									0						
ZQ105	YES	0.0416	0.8926	NO		NO			0.008	0	0.01	0	0.01		0.1	Db	0.894	1	Ca	0.903	1.001
ZQ106	NO		0.916	NO		NO									0						
ZQ107	YES	3.8542	0.8608	NO		NO			0.998	0.96	0	0	0.955		0.3	Cc	0.851	1	Da	0.87	0.996
ZQ108	NO		0.9953	NO		NO									0						
ZQ109	YES	6.4792	0.562	NO		NO			4.433	1.46	3.32	2.19	6.962		0.9	Db	0.563	0.8	Db	0.57	0.835
ZQ110	YES	3.0625	0.8883	NO		NO			0.646	0	0.55	0	0.547		0.2	Db	0.888	1	Db	0.896	0.959
ZQ111	YES	3.3854	0.8857	NO		NO			0.73	0	0.66	0	0.664		0.2	Db	0.886	1	Db	0.886	0.954
ZQ115	NO		0.9882	NO		NO									0						
ZQ116	NO		0.9885	NO		NO									0						
ZQ117	NO		0.9878	NO		NO									0						
ZQ118	NO		0.9898	NO		NO									0						
ZQ119	NO		0.9896	NO		NO									0						
ZQ120	NO		0.9891	NO		NO									0						

ZQ121	NO		0.9861	NO		NO									0						
ZQ122	NO		0.9893	NO		NO									0						
ZQ123	NO		0.9881	NO		NO									0						
ZQ124	NO		0.9857	NO		NO									0						
ZQ125	NO		0.9889	NO		NO									0						
ZQ126	NO		0.9871	NO		NO									0						
ZQ127	NO		0.9879	NO		NO									0						
ZQ128	NO		0.9884	NO		NO									0						
ZQ129	NO		0.9621	NO		NO									0						
ZQ130	YES	4.3438	0.8855	NO		NO			0.938	0.86	0	0	0.859		0.2	Cc	0.868	1	Cc	0.87	0.995
ZQ131	YES	3.4688	0.8575	NO		NO			0.918	0.74	0	0	0.736		0.3	Da	0.857	1	Cc	0.866	0.98
ZQ132	YES	13.9479	0.8625	NO		NO			3.572	3.32	0	0	3.323		0.5	Cc	0.85	1	Cc	0.871	1.004
ZQ133	NO		0.9232	NO		NO									0						
ZQ134	NO		0.9885	NO		NO									0						
ZQ135	YES	2.1041	0.8866	NO		NO			0.45	0.03	0.04	0	0.075		0.2	Cc	0.866	0.9	Ca	0.957	0.938
ZQ136	YES	4.5208	0.8909	NO		NO			0.933	0	0.88	0	0.879		0.2	Db	0.89	1	Db	0.888	1.008
ZQ137	YES	63.1354	0.6214	NO		NO			38.756	21.64	8.79	19.95	50.378		1.9	Cb	0.609	0.7	Cb	0.618	0.669
ZQ138	YES	4	0.8673	NO		NO			0.991	0.84	0	0	0.841		0.3	Cc	0.865	1	Cc	0.875	1
ZQ139	YES	1.2187	0.8878	NO		NO			0.258	0	0.05	0.02	0.066		0.2	Ca	0.871	0.9	Ca	0.924	0.965
ZQ140	NO		0.9944	NO		NO									0						
ZQ142	YES	23.3021	0.6602	NO		NO			13.146	12.5	0	7.28	19.785		1.1	Cb	0.624	1	Cb	0.643	0.98
ZQ143	YES	4.8646	0.8178	NO		NO			1.611	0.86	1.52	0	2.379		0.4	Cc	0.802	1	Cc	0.821	0.977
ZQ144	NO		0.9831	NO		NO									0						
ZQ145	YES	51.8021	0.4973	NO		NO			38.991	10.53	15.89	5.15	31.57		2.5	Db	0.497	0.9	Cc	0.574	0.802
ZQ146	NO		0.9085	NO		NO									0						
ZQ147	NO		0.9154	NO		NO									0						
ZQ148	NO		0.9028	NO		NO									0						
ZQ151	YES	8.1771	0.874	NO		YES	10.7083	1.1554	1.931	0	0	0.28	0.283	2.6164	0.3	Dc	0.976	1	A	0.979	0.982
ZQ152	YES	11.0625	0.8302	NO		NO			3.438	0	2.78	3.22	5.997		0.6	Ca	0.778	1	Ca	0.78	0.984
ZQ153	NO		0.9602	NO		NO									0						
ZQ154	YES	0.1562	0.8781	NO		NO			0.036	0	0	0.04	0.036		0.1	Dc	0.892	1	A	0.943	0.938
ZQ155	YES	0.5416	0.8719	NO		NO			0.13	0	0.07	0.07	0.142		0.1	Db	0.86	0.9	Ca	0.913	0.924
ZQ156	YES	0.1146	0.8861	NO		NO			0.025	0.02	0	0.03	0.047		0.1	Dc	0.877	0.9	Cb	0.899	0.959
ZQ157	NO		0.9118	NO		NO									0						
ZQ158	YES	8	0.8958	NO		NO			1.58	0	1.41	0	1.408		0.2	Db	0.895	1	Db	0.909	1.003
ZQ159	NO		0.9798	NO		NO									0						
ZQ160	NO		0.9426	NO		NO									0						
ZQ161	YES	75.3125	0.2108	NO		NO			71.966	69.11	68.6	69.49	207.209		3.9	Cb	0.191	0.2	Cb	0.154	0.238
ZQ162	YES	4.7813	0.8699	NO		NO			1.163	1.08	0	0	1.084		0.3	Cc	0.861	1	Da	0.883	1.018
ZQ163	NO		0.9581	NO		NO									0						
ZQ164	YES	12.2396	0.8515	NO		NO			3.365	2.97	2.87	2.41	8.252		0.5	Cc	0.837	0.9	A	0.895	0.894
ZQ166	YES	50.7396	0.2098	NO		NO			48.506	46.6	46.49	46.61	139.694		4	Cc	0.208	0.2	A	0.24	0.241

ZQ167	YES	1.0417	0.884	NO		NO			0.228	0.15	0.14	0.13	0.42		0.2	Cc	0.883	0.9	Cc	0.867	0.877
ZQ168	YES	19.0938	0.8723	NO		NO			4.565	3.9	4.12	3.92	11.943		0.4	Db	0.877	0.9	Db	0.859	0.881
ZQ170	NO		0.9401	NO		NO									0						
ZQ172	NO		0.9111	NO		YES	4.8959	1.1046						1.0174	0						
ZQ173	NO		0.9456	NO		NO									0						
ZQ174	NO		0.9303	NO		NO									0						
ZQ176	NO		0.9909	NO		NO									0						
ZQ177	NO		0.9506	NO		NO									0						
ZQ178	NO		0.955	NO		NO									0						
ZQ179	NO		0.9968	NO		NO									0						
ZQ181	YES	11.0208	0.8233	NO		YES	11.3854	1.2034	3.551	0	2.8	0	2.801	4.0911	0.6	Ca	0.977	1	Cc	0.973	0.993
ZQ182	YES	11.1041	0.7979	NO		YES	11.3646	1.1866	4.035	0	3.44	0	3.442	3.8237	0.7	Db	0.956	1	Db	0.953	1
ZQ184	YES	5.3125	0.8735	NO		YES	11.1042	1.1816	1.259	0	0.2	0	0.2	3.3619	0.3	Ca	0.979	1	Db	0.959	0.989
ZQ186	YES	11.9479	0.799	NO		YES	11.9688	1.2156	4.32	0	2.84	0	2.842	4.0783	0.7	Ca	0.98	1	Cc	0.977	0.996
ZQ187	YES	12.0104	0.7663	NO		YES	11.9687	1.2116	4.958	0	3.77	0	3.766	3.913	0.8	Db	0.958	1	Db	0.952	0.999
ZQ189	YES	11.4062	0.8074	NO		YES	11.927	1.2083	3.971	0	1.33	0.02	1.351	3.5342	0.6	Db	0.971	1	Db	0.958	0.989
ZQ190	YES	7.9375	0.8839	NO		NO			1.736	0	1.2	0	1.197		0.2	Db	0.885	1	Db	0.873	0.959
ZQ191	YES	8.9792	0.8794	NO		NO			2.035	0	1.84	0	1.837		0.2	Db	0.881	1	Db	0.872	0.958
ZQ193	YES	3.448	0.8156	NO		NO			1.154	0.36	0.29	0	0.647		0.4	Cc	0.786	0.9	Cc	0.879	0.983
ZQ194	YES	20.375	0.4556	NO		NO			16.146	0	13.95	14.81	28.761		1.8	Ca	0.28	0.9	Ca	0.284	0.915
ZQ195	NO		0.9859	NO		NO									0						
ZQ196	YES	17.427	0.0385	YES	0.8438	NO			17.401	1.17	12.12	12.54	25.832		3.2	Db	0.039	0.6	Ca	0.221	0.519
ZQ197	NO		0.9813	NO		NO									0						
ZQ198	NO		0.9983	NO		NO									0						
ZQ200	NO		0.9966	NO		NO									0						
ZQ201	NO		0.9977	NO		NO									0						
ZQ202	NO		0.9981	NO		NO									0						
ZQ203	NO		0.9967	NO		NO									0						
ZQ204	NO		0.9962	NO		NO									0						
ZQ205	NO		0.9971	NO		NO									0						
ZQ206	YES	8.6771	0.8776	NO		NO			1.994	1.91	0	0	1.914		0.2	Da	0.877	1	Da	0.867	0.994
ZQ207	YES	30.4271	0.5346	NO		NO			21.731	12.77	0.83	0.26	13.861		2.3	Cc	0.513	0.9	Da	0.635	0.968
ZQ208	YES	95.3229	0.0006	YES	88.5938	YES	1.0104	1.3373	95.323	92.57	93.06	93.45	279.075	0.5281	5	A	0.001	0	A	0	0
ZQ209	YES	4.3437	0.8003	NO		NO			1.562	1.15	0.67	0	1.816		0.4	Cc	0.798	1	Cc	0.804	0.97
ZQ210	NO		0.9434	NO		NO									0						
ZQ211	YES	11	0.0023	YES	5.2499	NO			11	5.97	5.86	5.45	17.275		3.3	A	0.001	0	A	0.001	0
ZQ212	YES	95.0313	0.0008	YES	88.302	YES	1.0313	1.5221	95.031	92.03	92.62	93.14	277.792	0.8947	5	A	0	0	A	0	0
ZQ213	YES	95.1771	0.0006	YES	87.9895	YES	0.7396	1.4095	95.177	92.74	92.28	93.84	278.859	0.5497	5	A	0	0	A	0	0
ZQ214	YES	6.125	0.0022	YES	5.2499	NO			6.125	5.49	5.51	5.67	16.667		2	A	0.001	0	A	0.001	0.001
ZQ215	YES	95.2396	0.0005	YES	86.6666	YES	1.0729	1.451	95.24	93.04	92.26	93.11	278.409	0.834	5	A	0	0	A	0	0
ZQ216	YES	10.0729	0.0022	YES	5.3333	NO			10.073	5.94	5.58	5.98	17.501		3.3	A	0.001	0	A	0.001	0.001
ZQ217	NO		0.9824	NO		NO									0						

ZQ218	NO		0.9515	NO		NO									0						
ZQ219	NO		0.9943	NO		NO									0						
ZQ220	NO		0.9848	NO		NO									0						
ZQ221	NO		0.9579	NO		NO									0						
ZQ224	NO		0.9999	NO		NO									0						
ZQ225	YES	3.6563	0.0015	YES	2.8438	YES	3.3958	1.171	3.656	0	0.03	3.43	3.463	0.0871	2	Dc	0.004	1	Dc	0.007	0.952
ZQ226	YES	9.0209	0.0019	YES	8.1771	YES	8.9375	1.2094	9.021	0	0	8.63	8.628	0.1276	2	Dc	0.005	1	Dc	0.005	0.98
ZQ227	YES	0.5625	0.7774	NO		YES	0.4063	1.1435	0.223	0	0	0.2	0.2	0.1067	0.2	Dc	0.774	1	Dc	0.781	0.988
ZQ228	YES	1.677	0.005	YES	1.0834	YES	0.2292	1.2057	1.677	0	0.08	1.48	1.554	0.0844	2	Dc	0.008	1	Dc	0.009	0.912
ZQ229	YES	5.5938	0.4186	NO		NO			4.614	1.23	1.16	0	2.395		1.2	Cc	0.042	1	Cc	0.038	0.988
ZQ230	YES	2.2605	0.6847	NO		YES	0.5105	1.258	1.201	0.26	0.01	0	0.261	0.2496	0.6	Cb	0.683	1	Cb	0.774	0.944
ZQ231	YES	11.4896	0.6609	NO		YES	0.0729	1.1262	6.471	1.67	0.21	0	1.88	0.0198	1.1	Da	0.659	1	Da	0.623	0.968
ZQ232	YES	17.7188	0.0012	YES	17.0833	YES	0.2292	1.1956	17.719	0.05	0	17.44	17.484	0.0803	3.3	Dc	0.002	1	Dc	0.004	0.946
ZQ233	YES	13.1979	0.0016	YES	12.5312	YES	11.2083	1.2221	13.198	0.21	0	6.52	6.73	0.2122	3.3	Dc	0.001	1	Dc	0	0.919
ZQ234	YES	26.7292	0.0013	YES	26.0521	YES	0.2604	1.2266	26.729	0.09	0	26.37	26.465	0.1035	5	Dc	0.001	1	Dc	0	0.919
ZQ235	YES	1.1459	0.0109	YES	0.5729	YES	1.4063	1.2492	1.146	0.03	0	0.96	0.983	0.1414	2	Dc	0.018	1	Dc	0.004	0.934
ZQ236	YES	5.5521	0.002	YES	4.6979	YES	3.5208	1.1881	5.552	0.31	0	3.39	3.695	0.0695	2	Dc	0.004	1	Dc	0.003	0.91
ZQ237	YES	0.5104	0.7322	NO		NO			0.237	0.21	0	0.15	0.36		0.3	Cb	0.688	1	Cb	0.758	0.979
ZQ238	YES	95.6354	0.0007	YES	95	YES	0.1875	1.1746	95.635	94.68	94.85	94.81	284.337	0.0832	5	A	0.001	0	A	0	0
ZQ242	YES	7.4062	0.7035	NO		NO			3.741	0.16	0.16	0.88	1.203		0.6	Dc	0.701	0.9	Dc	0.821	0.965
ZQ243	NO		0.9602	NO		NO									0						
ZQ244	YES	5.4062	0.7196	NO		NO			2.607	0.03	0.08	0.51	0.629		0.6	Dc	0.717	0.9	Dc	0.811	0.942
ZQ245	YES	8.3125	0.7981	NO		NO			3.018	0.04	0	0.46	0.5		0.4	Dc	0.798	0.9	Dc	0.867	0.938
ZQ246	NO		0.9936	NO		NO									0						
ZQ247	NO		0.9884	NO		NO									0						
ZQ248	NO		0.9929	NO		NO									0						
ZQ249	YES	11.9687	0.001	YES	5.1354	NO			11.969	5.47	5.47	5.9	16.834		3.3	A	0.001	0	A	0	0
ZQ250	YES	5.125	0.8752	NO		NO			1.199	0	1.16	0	1.16		0.2	Db	0.875	1	Db	0.889	1.008
ZQ251	YES	5.5105	0.8327	NO		NO			1.69	0	1.62	0	1.622		0.3	Db	0.833	1	Db	0.856	1.024
ZQ253	YES	19.9895	0.2506	NO		NO			18.734	14.32	15.41	6.8	36.532		2.5	Da	0.25	0.3	A	0.261	0.262
ZQ254	NO		0.9985	NO		NO									0						
ZQ255	YES	16.6771	0.5241	NO		NO			12.096	7.81	10.12	2.41	20.34		1.6	Da	0.525	0.6	Cc	0.544	0.56
ZQ258	YES	15.948	0.5382	NO		NO			11.329	7.22	9.37	2.62	19.198		1.5	Da	0.538	0.6	Cc	0.564	0.584
ZQ259	NO		0.9975	NO		NO									0						
ZQ260	YES	15.9584	0.5298	NO		NO			11.479	7.35	9.41	2.65	19.412		1.6	Da	0.531	0.6	Cc	0.56	0.578
ZQ269	YES	53.1979	0.8712	NO		NO			12.821	11.96	6.55	6.65	25.154		0.6	A	0.872	0.9	A	0.876	0.882
ZQ270	YES	12.1666	0.8744	NO		NO			2.864	2.61	2.54	2.63	7.786		0.4	A	0.876	0.9	Cb	0.869	0.88
ZQ280	NO		0.9881	NO		NO									0						
ZQ281	YES	0.6458	0.8539	NO		NO			0.175	0.1	0.09	0	0.193		0.1	Cc	0.841	0.9	Cb	0.909	0.921
ZQ282	NO		0.9273	NO		NO									0						
ZQ283	NO		0.9186	NO		NO									0						
ZQ284	NO		0.9311	NO		NO									0						

ZQ285	NO		0.9999	NO		NO									0						
ZQ286	YES	13.0104	0.8995	NO		NO			2.484	0	0.06	0	0.063		0.3	Db	0.899	1	Db	0.905	1.007
ZQ287	YES	5.5001	0.8904	NO		NO			1.14	0	0	1.11	1.109		0.2	Cb	0.982	1	Da	0.989	1.002
ZQ288	NO		0.9902	NO		NO									0						
ZQ290	YES	20.7813	0.4759	NO		NO			16.075	14.7	0	12.45	27.152		1.7	Cb	0.283	0.9	Cb	0.283	0.919
ZQ291	YES	17.0313	0.6253	NO		NO			10.372	9.93	0	6.71	16.636		1.2	Cb	0.572	1	Cb	0.573	0.97
ZQ293	NO		0.9113	NO		NO									0						
ZQ294	NO		0.9952	NO		NO									0						
ZQ295	YES	14.3645	0.7345	NO		NO			6.615	6.02	3.94	0	9.963		0.9	Cc	0.731	0.9	Cc	0.73	0.925
ZQ296	YES	94.7813	0.0009	YES	94.3334	YES	0.5521	1.8438	94.781	93.99	94.12	94.21	282.328	1.3146	5	A	0.001	0	A	0	0
ZQ297	NO		0.977	NO		NO									0						
ZQ298	YES	16.9375	0.6407	NO		NO			9.985	9.6	0	6.27	15.867		1.2	Cb	0.595	1	Cb	0.597	0.969
ZQ299	YES	16.9063	0.6193	NO		NO			10.422	9.89	5.04	0	14.934		1.3	Da	0.619	0.9	Da	0.624	0.952
ZQ300	YES	16.9271	0.6295	NO		NO			10.219	9.73	0	6.37	16.1		1.2	Cb	0.579	1	Cb	0.591	0.976
ZQ301	NO		0.9926	NO		NO									0						
ZQ302	NO		0.9926	NO		NO									0						
ZQ303	YES	95.3229	0.0011	YES	91.1458	NO			95.323	93.9	93.34	93.67	280.915		5	A	0	0	A	0	0
ZQ304	YES	5.3229	0.8415	NO		YES	5.4584	1.1935	1.554	1.29	0	0	1.294	2.0502	0.3	Cc	0.974	1	Cc	0.976	1.001
ZQ305	NO		0.981	NO		NO									0						
ZQ306	YES	5.8334	0.4944	NO		YES	5.6042	1.3693	4.408	3.95	0	0	3.95	5.9752	1	Da	0.931	1	Cc	0.926	0.987
ZQ307	YES	5.8334	0.4944	NO		YES	5.6042	1.3693	4.408	3.95	0	0	3.95	5.9752	1	Da	0.931	1	Cc	0.926	0.987
ZQ308	YES	5.8542	0.2035	NO		YES	5.8229	1.4471	5.612	5.07	0	0	5.075	9.2905	1.6	Da	0.851	1	Da	0.857	0.998
ZQ309	YES	5.6042	0.5628	NO		YES	5.5834	1.3318	3.829	3.53	0	0	3.527	4.8986	0.9	Da	0.935	1	Da	0.944	1.005
ZQ310	YES	0.2604	0.8794	NO		YES	7.3855	1.1622	0.059	0.06	0	0	0.057	1.988	0.1	Cc	0.984	1	Cc	0.985	1.002
ZQ311	YES	0.2396	0.8895	NO		YES	0.1563	1.1022	0.05	0.05	0	0	0.05	0.0343	0.1	Da	0.981	1	Cc	0.983	0.997
ZQ312	NO		0.9799	NO		NO									0						
ZQ313	YES	7.6146	0.7035	NO		YES	7.5833	1.2812	3.846	3.61	0	0	3.607	4.2959	0.6	Cc	0.962	1	Cc	0.958	0.994
ZQ314	NO		0.9886	NO		NO									0						
ZQ315	YES	7.9271	0.2078	NO		YES	7.9063	1.4385	7.585	7.14	0	0	7.139	12.8015	1.6	Da	0.85	1	Da	0.854	0.996
ZQ316	YES	7.6667	0.5481	NO		YES	7.6771	1.3456	5.364	4.97	0	0	4.972	6.2911	0.9	Da	0.934	1	Da	0.942	1.004
ZQ317	YES	7.9063	0.6723	NO		YES	7.5625	1.1945	4.333	4.04	0	0	4.039	2.8866	0.7	Da	0.938	1	Da	0.934	0.991
ZQ318	NO		0.9213	NO		NO									0						
ZQ319	YES	9.8541	0.0011	YES	5.0312	NO			9.854	5.6	5.34	5.38	16.327		2	A	0.001	0	A	0	0
ZQ320	NO		0.9906	NO		NO									0						
ZQ321	NO		0.9906	NO		NO									0						
ZQ322	NO		0.9879	NO		NO									0						
ZQ324	NO		0.9167	NO		NO									0						
ZQ325	YES	5.8542	0.0012	YES	5.0208	NO			5.854	5.21	5.4	5.44	16.04		2	A	0	0	A	0	0
ZQ326	NO		0.9542	NO		NO									0						
ZQ327	NO		0.9007	NO		NO									0						
ZQ328	NO		0.9036	NO		NO									0						
ZQ329	YES	3.5625	0.7116	NO		NO			1.759	0	0.04	1.56	1.593		0.6	Dc	0.724	1	Dc	0.712	0.964

ZQ330	NO		0.9056	NO		NO									0						
ZQ331	YES	10.9271	0.5337	NO		NO			7.815	7.43	0	4.14	11.563		1.5	Cb	0.519	1	Cb	0.507	0.966
ZQ332	NO		0.9052	NO		NO									0						
ZQ333	NO		0.9951	NO		NO									0						
ZQ334	YES	1.5625	0.7348	NO		NO			0.719	0	0.06	0.64	0.696		0.5	Dc	0.743	1	Dc	0.73	0.918
ZQ335	YES	1.4375	0.8396	NO		NO			0.424	0	0.13	0.03	0.164		0.3	Db	0.84	0.9	Cc	0.908	0.917
ZQ336	YES	3.375	0.8298	NO		NO			1.051	0.99	0	0	0.987		0.3	Da	0.826	1	Da	0.81	0.97
ZQ337	YES	0.0625	0.8864	NO		NO			0.013	0	0.02	0	0.015		0.1	Db	0.887	0.9	Cc	0.917	0.959
ZQ338	YES	3.4271	0.6402	NO		NO			2.022	1.18	1.71	1.31	4.206		0.7	Db	0.649	0.8	Db	0.661	0.761
ZQ339	YES	0.4791	0.8409	NO		NO			0.14	0.07	0	0.12	0.187		0.2	Cb	0.821	0.9	Cb	0.874	0.948
ZQ340	YES	0.0938	0.8715	NO		NO			0.023	0	0	0.02	0.023		0.1	Dc	0.887	1	Cb	0.906	0.952
ZQ341	YES	0.0729	0.8819	NO		NO			0.016	0	0	0.02	0.017		0.1	Dc	0.88	0.9	Da	0.945	0.935
ZQ342	YES	24.9895	0.847	NO		NO			7.062	0	5.34	6.13	11.468		0.5	Ca	0.828	1	Ca	0.836	0.989
ZQ343	NO		0.9447	NO		NO									0						
ZQ344	NO		0.9128	NO		NO									0						
ZQ345	NO		0.9909	NO		NO									0						
ZQ346	YES	11.0937	0.5725	NO		NO			7.458	6.74	0	4.34	11.076		1.4	Da	0.576	1	Da	0.567	0.898
ZQ347	NO		0.9497	NO		NO									0						
ZQ348	YES	11.3333	0.5761	NO		NO			7.572	3.34	3.86	7.18	14.376		1.4	Dc	0.576	0.8	Ca	0.593	0.827
ZQ349	NO		0.9252	NO		NO									0						
ZQ354	YES	11.3541	0.5296	NO		NO			8.17	3.27	7.88	0	11.145		1.6	Db	0.524	1	Db	0.52	0.941
ZQ355	YES	1.4375	0.8396	NO		NO			0.424	0	0.13	0.03	0.164		0.3	Db	0.84	0.9	Cc	0.908	0.917
ZQ359	YES	14.125	0.6771	NO		NO			7.649	6.31	5.86	1.08	13.258		1.1	Cc	0.595	0.9	Dc	0.846	0.599
ZQ360	YES	12.3542	0.7217	NO		NO			5.92	5.12	4.94	0.61	10.663		0.9	Cc	0.65	0.9	Cc	0.64	0.887
ZQ361	NO		0.9924	NO		NO									0						
ZQ362	YES	4.4687	0.7892	NO		NO			1.685	1.53	0	0.07	1.6		0.4	Da	0.785	1	Da	0.773	0.972
ZQ363	NO		0.9481	NO		NO									0						
ZQ385	NO		0.9434	NO		NO									0						
ZQ386	NO		0.987	NO		NO									0						
ZQ387	NO		0.9883	NO		NO									0						
ZQ388	NO		0.9449	NO		NO									0						
ZQ389	NO		0.9848	NO		NO									0						
ZQ390	NO		0.9418	NO		NO									0						
ZQ391	NO		0.987	NO		NO									0						
ZQ392	NO		0.978	NO		NO									0						
ZQ393	NO		0.9924	NO		NO									0						
ZQ394	NO		0.9939	NO		NO									0						
ZQ395	NO		0.9304	NO		NO									0						
ZQ396	NO		0.9304	NO		NO									0						
ZQ397	NO		0.9958	NO		NO									0						
ZQ398	NO		0.9128	NO		NO									0						
ZQ399	YES	34.323	0.252	NO		NO			32.143	11.68	23.69	6.1	41.47		3.7	Db	0.252	0.8	Db	0.258	0.829

ZQ400	NO		0.9965	NO		NO									0						
ZQ401	YES	5.0105	0.8457	NO		NO			1.427	0	0	1.22	1.221		0.3	Dc	0.845	1	Cb	0.858	1.004
ZQ402	YES	4.8021	0.8685	NO		NO			1.18	0	0	1.12	1.122		0.3	Cb	0.865	1	Cb	0.874	1.002
ZQ403	NO		0.9103	NO		NO									0						
ZQ404	NO		0.9966	NO		NO									0						
ZQ405	NO		0.9948	NO		NO									0						
ZQ406	NO		0.9157	NO		NO									0						
ZQ407	NO		0.9928	NO		NO									0						
ZQ408	NO		0.9935	NO		NO									0						
ZQ409	NO		0.9556	NO		NO									0						
ZQ410	NO		0.9967	NO		NO									0						
ZQ411	YES	6.2604	0.6317	NO		NO			3.762	3.42	1.66	0	5.085		0.7	Da	0.632	1	Da	0.641	0.967
ZQ412	YES	6.2708	0.6318	NO		NO			3.768	3.41	0	2.18	5.595		0.7	Cb	0.602	1	Cb	0.602	0.974
ZQ413	YES	6.2709	0.625	NO		NO			3.821	3.47	0	2.21	5.68		0.8	Cb	0.592	1	Cb	0.595	0.981
ZQ414	NO		0.9869	NO		NO									0						
ZQ415	YES	6.0937	0	YES	5.1667	NO			6.094	5.44	5.37	5.53	16.339		2	A	0	0	A	0	0
ZQ416	YES	11.1146	0	YES	5.3437	YES	6.1041	1.1202	11.115	5.59	5.64	6.13	17.354	0.1631	3.3	A	0	0	A	0	0
ZQ417	NO		0.9001	NO		NO									0						
ZQ418	YES	4.7813	0.8653	NO		NO			1.201	0	0	1.14	1.136		0.3	Dc	0.865	1	Dc	0.867	1.004
ZQ419	YES	4.8229	0.8687	NO		NO			1.183	0	0	1.14	1.144		0.3	Cb	0.865	1	Dc	0.87	1.005
ZQ420	NO		0.9719	NO		NO									0						
ZQ421	NO		0.9687	NO		NO									0						
ZQ422	NO		0.9913	NO		NO									0						
ZQ423	NO		0.9901	NO		NO									0						
ZQ424	NO		0.9976	NO		NO									0						
ZQ425	NO		0.9427	NO		NO									0						
ZQ426	NO		0.9339	NO		NO									0						
ZQ427	NO		0.9929	NO		NO									0						
ZQ428	NO		0.9825	NO		NO									0						
ZQ429	NO		0.9961	NO		NO									0						
ZQ430	NO		0.9956	NO		NO									0						
ZQ431	NO		0.9952	NO		NO									0						
ZQ432	NO		0.9974	NO		NO									0						
ZQ433	NO		0.9287	NO		YES	16.3645	1.1311						4.2318	0						
ZQ434	YES	16.9166	0.3951	NO		YES	16.7708	1.3456	14.276	0	13.74	0	13.74	19.374	2	Db	0.883	1	Db	0.887	1.002
ZQ435	NO		0.982	NO		NO									0						
ZQ436	YES	16.875	0.5837	NO		YES	16.6666	1.3186	11.126	0	10.52	0	10.521	11.2787	1.4	Db	0.933	1	Db	0.936	1
ZQ437	YES	0.3541	0.8904	NO		NO			0.073	0.07	0	0	0.074		0.1	Cc	0.858	1	Cc	0.854	0.962
ZQ438	YES	16.1041	0.8418	NO		YES	16.5417	1.2096	4.692	0	4.05	0	4.053	6.8505	0.5	Db	0.985	1	Db	0.973	0.994
ZQ439	NO		0.9976	NO		NO									0						
ZQ440	NO		0.9287	NO		NO									0						
ZQ441	NO		0.9939	NO		NO									0						

ZQ442	NO		0.9939	NO		NO									0						
ZQ443	NO		0.9945	NO		NO									0						
ZQ444	NO		0.9939	NO		NO									0						
ZQ445	NO		0.9949	NO		NO									0						
ZQ446	NO		0.9973	NO		NO									0						
ZQ447	NO		0.9984	NO		NO									0						
ZQ448	NO		0.9857	NO		NO									0						
ZQ449	NO		0.9909	NO		NO									0						
ZQ450	YES	8.7813	0.8517	NO		NO			2.411	1.63	0.8	0	2.422		0.3	Cc	0.87	1	Cc	0.863	0.998
ZQ451	YES	8.9479	0.7998	NO		NO			3.224	2.15	1.19	0	3.335		0.4	Cc	0.804	1	Db	0.815	0.974
ZQ452	NO		0.9441	NO		NO									0						
ZQ453	YES	6.0312	0.0004	YES	5.302	YES	10.0937	1.1157	6.031	5.42	5.62	5.74	16.787	0.3174	2	A	0.001	0	A	0	0.003
ZQ454	NO		0.9774	NO		NO									0						
ZQ455	YES	0.4271	0.8848	NO		YES	6.5938	1.1399	0.093	0.09	0	0	0.09	1.6213	0.1	Cc	0.986	1	Cc	0.987	1.001
ZQ456	YES	7.4584	0.8426	NO		YES	7.6771	1.15	2.163	1.64	0	0	1.644	2.0108	0.3	Cc	0.97	1	Cc	0.978	1.006
ZQ457	NO		0.9856	NO		NO									0						
ZQ458	NO		0.9679	NO		NO									0						
ZQ459	YES	5.3855	0.8819	NO		YES	5.6458	1.1342	1.197	1.06	0	0	1.062	1.3987	0.2	Cc	0.973	1	Cc	0.975	1.001
ZQ460	NO		0.9167	NO		YES	5.9791	1.1294						1.4712	0						
ZQ461	NO		0.9881	NO		NO									0						
ZQ462	YES	38.1979	0.6835	NO		NO			20.353	0	12.11	19.75	31.862		1.6	Ca	0.654	1	Ca	0.663	1.017
ZQ463	YES	11.2917	0.6799	NO		NO			6.072	0	3.53	5.78	9.311		1.1	Ca	0.652	1	Ca	0.647	1.015
ZQ464	NO		0.9929	NO		NO									0						
ZQ465	YES	0.0313	0.8982	NO		NO			0.006	0	0.01	0	0.008		0.1	Db	0.898	1	Db	0.906	1.009
ZQ466	YES	14.875	0.8471	NO		NO			4.201	4.04	3.42	3.33	10.788		0.5	Cc	0.827	0.9	Da	0.876	0.883
ZQ467	YES	13.8958	0.8553	NO		NO			3.73	3.61	0	0	3.612		0.5	Cc	0.852	1	Cc	0.87	1.013
ZQ468	YES	13.948	0.8475	NO		NO			3.93	3.65	0.04	0	3.688		0.5	Cc	0.839	1	Cc	0.884	0.981
ZQ469	YES	13.4479	0.8453	NO		NO			3.839	3.65	0.16	0	3.807		0.5	Cc	0.827	1	Cc	0.854	1
ZQ470	NO		0.9917	NO		NO									0						
ZQ471	NO		0.9937	NO		NO									0						
ZQ472	NO		0.9909	NO		NO									0						
ZQ473	NO		0.9911	NO		NO									0						
ZQ474	NO		0.9928	NO		NO									0						
ZQ475	NO		0.9241	NO		NO									0						
ZQ476	NO		0.9792	NO		NO									0						
ZQ477	NO		0.9426	NO		NO									0						
ZQ478	YES	7.7917	0.6362	NO		NO			4.638	3.06	0	0.71	3.772		0.7	Da	0.641	1	Da	0.622	1.001
ZQ479	YES	4.75	0.5736	NO		NO			3.187	2.77	0	1.37	4.14		0.9	Cb	0.553	0.9	Da	0.573	0.927
ZQ480	YES	7.6979	0.5877	NO		NO			5.039	4.59	0	2.06	6.648		0.8	Cb	0.562	1	Da	0.58	0.944
ZQ481	NO		0.9334	NO		NO									0						
ZQ482	YES	2.3854	0.8078	NO		YES	2.3229	1.2082	0.829	0	0	0.71	0.713	0.9129	0.4	Cb	0.981	1	Cb	0.971	0.984
ZQ483	YES	25.6979	0.4698	NO		YES	25.4687	1.3881	20.026	0	0	15.07	15.067	21.0355	2.7	Cb	0.924	1	Cb	0.922	0.986

ZQ484	YES	16.8542	0.0413	YES	14.9479	YES	25.8959	1.5567	16.825	0	0	16.13	16.134	39.0739	3.2	Dc	0.83	1	Dc	0.825	0.986
ZQ485	NO		0.9782	NO		NO									0						
ZQ486	YES	16.2604	0.6056	NO		YES	16.1979	1.3263	10.297	0	0	9.68	9.676	10.8895	1.3	Dc	0.953	1	Dc	0.942	0.976
ZQ487	YES	4.5417	0.8937	NO		NO			0.914	0	0.81	0	0.811		0.2	Db	0.895	1	Db	0.9	1.014
ZQ488	YES	95.2188	0.0014	YES	71.9896	YES	6.1354	1.1682	95.219	82.02	85.51	80.64	248.17	2.8993	5	A	0.001	0	A	0	0
ZQ489	YES	5.3542	0.8844	NO		NO			1.166	0.27	0.78	0	1.058		0.2	Cc	0.85	1	Cc	0.833	0.97
ZQ490	YES	5.8958	0.0016	YES	5.4583	NO			5.896	5.73	5.66	5.77	17.164		2	A	0.001	0	A	0.001	0
ZQ491	NO		0.9271	NO		NO									0						
ZQ492	NO		0.9816	NO		NO									0						
ZQ493	YES	0.1459	0.8487	NO		NO			0.041	0	0.04	0	0.039		0.2	Db	0.972	1	Db	0.973	0.99
ZQ494	YES	5.8126	0.7676	NO		NO			2.388	1.96	2.2	0	4.153		0.5	Cc	0.68	1	Cc	0.689	0.976
ZQ495	YES	55.0417	0.7117	NO		NO			27.162	26.32	0	10.79	37.111		1.4	Cb	0.683	1	Da	0.715	0.995
ZQ496	YES	2.8125	0.7475	NO		NO			1.241	1.1	0	0.56	1.66		0.5	Da	0.747	1	Da	0.755	0.987
ZQ497	YES	17.4583	0.3733	NO		NO			15.025	8.01	0.09	9.54	17.631		2.1	Cb	0.367	0.9	Cb	0.391	0.874
ZQ498	YES	3	0.3823	NO		NO			2.562	1.41	0.16	2.18	3.758		1.2	Cb	0.361	0.9	Cb	0.38	0.885
ZQ499	YES	19.4271	0.3866	NO		NO			16.524	9.88	0.71	15.92	26.518		2	Cb	0.351	0.9	Dc	0.399	0.894
ZQ500	NO		0.9851	NO		NO									0						
ZQ501	YES	6.5834	0.595	NO		NO			4.253	0	3.86	1.38	5.238		0.8	Db	0.596	1	Db	0.613	0.987
ZQ502	NO		0.988	NO		NO									0						
ZQ503	NO		0.9974	NO		NO									0						
ZQ504	YES	95.2604	0.0005	YES	90.0208	YES	1.0417	1.3538	95.26	92.85	93.49	93.13	279.467	0.5226	5	A	0	0	A	0	0
ZQ505	NO		0.9982	NO		NO									0						
ZQ506	NO		0.9974	NO		NO									0						
ZQ507	NO		0.9919	NO		NO									0						
ZQ508	NO		0.9863	NO		NO									0						
ZQ509	NO		0.993	NO		NO									0						
ZQ510	YES	5.9792	0.0027	YES	5.1979	NO			5.979	5.44	5.43	5.54	16.415		2	A	0	0	A	0	0
ZQ511	YES	5.9792	0.0027	YES	5.1979	NO			5.979	5.44	5.43	5.54	16.415		2	A	0	0	A	0	0
ZQ512	YES	95.125	0.001	YES	89.9791	YES	0.5313	1.2435	95.125	93.6	93.47	93.43	280.504	0.2171	5	A	0	0	A	0	0
ZQ513	YES	5.8749	0.0028	YES	5.0624	NO			5.875	5.24	5.34	5.41	15.984		2	A	0	0	A	0	0
ZQ514	NO		0.9924	NO		NO									0						
ZQ515	YES	5.0105	0.7704	NO		NO			2.037	0.75	0	1.91	2.654		0.5	Dc	0.77	1	Cb	0.78	1.004
ZQ516	YES	5.0521	0.774	NO		NO			2.026	0.92	0	1.94	2.857		0.5	Cb	0.771	1	Cb	0.778	1.012
ZQ517	YES	5.0104	0.7744	NO		NO			2.006	0.84	0	1.91	2.756		0.5	Cb	0.771	1	Dc	0.79	1.009
ZQ518	NO		0.9939	NO		NO									0						
ZQ519	NO		0.9875	NO		NO									0						
ZQ520	YES	5.125	0.8862	NO		NO			1.1	0	1.05	0	1.053		0.2	Db	0.888	1	Ca	0.909	0.989
ZQ521	YES	93.8646	0.8416	NO		NO			27.381	0	0	25.49	25.495		0.8	Ca	0.835	1	Dc	0.849	0.993
ZQ522	YES	79.1354	0.635	NO		YES	3.2917	1.1739	47.226	32.38	14.16	22.63	69.157	1.1151	1.8	Da	0.636	0.8	Cb	0.68	0.756
ZQ523	YES	245.25	0.0008	YES	244.688	NO			245.25	243.95	243.61	243.73	731.295		5	A	0	0	A	0	0
ZQ524	YES	69.9584	0.6602	NO		NO			39.466	35.72	35.6	35.4	106.71		1.7	Da	0.66	0.7	Db	0.686	0.701
ZQ525	NO		0.9144	NO		NO									0						

ZQ526	NO		0.9983	NO		NO									0						
ZQ527	NO		0.9976	NO		NO									0						
ZQ528	NO		0.9996	NO		NO									0						
ZQ529	YES	16.5417	0.6916	NO		YES	15.5833	1.3513	8.63	2.76	0	0.86	3.622	1.1538	1	Da	0.485	1	A	0.005	0.008
ZQ530	YES	11.5417	0.8597	NO		YES	16.8124	1.3673	3.011	0	0.05	0.02	0.076	3.5342	0.5	Cc	0.799	1	A	0.001	0.003
ZQ531	YES	95.3959	0	YES	94.7188	NO			95.396	94.42	94.42	94.58	283.424		5	A	0	0	A	0	0
ZQ532	YES	95.4791	0	YES	94.8959	NO			95.479	94.5	94.74	94.7	283.941		5	A	0	0	A	0	0
ZQ533	YES	5.6354	0	YES	5.1874	NO			5.635	5.42	5.36	5.5	16.276		2	A	0	0	A	0	0
ZQ534	NO		0.9158	NO		NO									0						
ZQ535	YES	42.4479	0.7744	NO		NO			16.992	16.2	16.47	16.28	48.955		1.1	A	0.775	0.8	A	0.78	0.784
ZQ536	YES	42.4376	0.7691	NO		NO			17.335	16.39	16.5	16.68	49.568		1.2	A	0.772	0.8	A	0.774	0.78
ZQ537	YES	9.5	0.0009	YES	5.4479	NO			9.5	5.99	6.26	5.95	18.203		2	A	0.001	0	A	0	0
ZQ538	NO		0.9934	NO		NO									0						
ZQ539	NO		0.9331	NO		NO									0						
ZQ540	NO		0.9929	NO		NO									0						
ZQ541	NO		0.9866	NO		NO									0						
ZQ542	NO		0.99	NO		NO									0						
ZQ543	NO		0.9844	NO		NO									0						
ZQ544	NO		0.9605	NO		NO									0						
ZQ545	YES	95.4688	0	YES	88.2813	YES	0.7396	1.2577	95.469	93.22	93.09	93.46	279.774	0.2281	5	A	0	0	A	0	0
ZQ546	NO		0.994	NO		NO									0						
ZQ547	NO		0.9936	NO		NO									0						
ZQ548	NO		0.9973	NO		NO									0						
ZQ549	NO		0.9397	NO		NO									0						
ZQ550	NO		0.9922	NO		NO									0						
ZQ551	NO		0.9979	NO		NO									0						
ZQ552	NO		0.998	NO		NO									0						
ZQ553	NO		0.9977	NO		NO									0						
ZQ554	NO		0.9946	NO		NO									0						
ZQ555	NO		0.993	NO		NO									0						
ZQ556	NO		0.995	NO		NO									0						
ZQ557	NO		0.9932	NO		NO									0						
ZQ558	NO		0.9847	NO		NO									0						
ZQ559	NO		0.981	NO		NO									0						
ZQ560	NO		0.9897	NO		NO									0						
ZQ561	NO		0.9074	NO		NO									0						
ZQ562	NO		0.9878	NO		NO									0						
ZQ563	YES	20.9584	0.8531	NO		NO			5.705	0	0	5.54	5.541		0.5	Dc	0.853	1	Dc	0.872	1.018
ZQ564	YES	10.2083	0.0008	YES	5.4687	NO			10.208	5.75	5.68	5.85	17.29		3.3	A	0	0	A	0	0
ZQ565	YES	95.0834	0	YES	89.5104	YES	0.7083	1.1706	95.083	93.64	93.57	92.79	280.006	0.1111	5	A	0	0	A	0	0
ZQ566	YES	5.6041	0.0008	YES	5.1667	NO			5.604	5.47	5.41	5.31	16.2		2	A	0	0	A	0	0
ZQ567	NO		0.9832	NO		NO									0						

ZQ568	NO		0.9819	NO		NO									0						
ZQ569	NO		0.9954	NO		NO									0						
ZQ570	NO		0.9544	NO		NO									0						
ZQ571	NO		0.9179	NO		NO									0						
ZQ572	NO		0.9932	NO		NO									0						
ZQ573	NO		0.9304	NO		NO									0						
ZQ574	NO		0.9869	NO		NO									0						
ZQ575	NO		0.9644	NO		NO									0						
ZQ576	NO		0.9657	NO		NO									0						
ZQ577	NO		0.9616	NO		NO									0						
ZQ578	NO		0.9482	NO		NO									0						
ZQ579	YES	20.9167	0.8695	NO		NO			5.103	4.76	0	0	4.761		0.4	Da	0.872	1	Da	0.885	1.005
ZQ580	NO		0.9447	NO		NO									0						
ZQ581	NO		0.9305	NO		NO									0						
ZQ582	YES	95.4166	0	YES	93.6666	NO			95.417	94.27	94.63	94.56	283.453		5	A	0	0	A	0	0
ZQ583	YES	4.75	0.8559	NO		NO			1.27	1.19	0	0	1.19		0.3	Da	0.859	1	Da	0.861	0.96
ZQ584	YES	5.75	0.1664	NO		NO			5.591	4.87	3.12	2.01	10.002		1.7	Da	0.167	0.8	Da	0.173	0.781
ZQ585	NO		0.9989	NO		NO									0						
ZQ586	NO		0.9915	NO		NO									0						
ZQ587	NO		0.9937	NO		NO									0						
ZQ588	YES	5.927	0.0004	YES	5.0937	NO			5.927	5.28	5.32	5.46	16.067		2	A	0	0	A	0	0
ZQ589	NO		0.992	NO		NO									0						
ZQ590	NO		0.992	NO		NO									0						
ZQ591	NO		0.9922	NO		NO									0						
ZQ592	YES	10.125	0.8267	NO		NO			3.205	3.01	0	0	3.008		0.6	Da	0.826	1	Da	0.831	0.974
ZQ593	YES	10.2084	0.7608	NO		NO			4.3	3.22	0.03	0.05	3.303		0.8	Da	0.761	0.9	Da	0.804	0.939
ZQ594	YES	5.073	0.7789	NO		NO			1.995	1.86	0.65	0	2.512		0.4	Da	0.782	1	Da	0.778	0.991
ZQ595	YES	32.4792	0.8182	NO		NO			10.736	9.6	0	0	9.597		0.9	Cc	0.811	1	Da	0.792	1.009
ZQ596	YES	30.8646	0.7815	NO		NO			12.014	9.44	3.03	0	12.47		1.1	Da	0.783	1	Cc	0.786	0.974
ZQ597	YES	3.9687	0.881	NO		NO			0.888	0	0	0.82	0.819		0.2	Cb	0.876	1	Dc	0.889	1.011
ZQ598	NO		0.9767	NO		NO									0						
ZQ599	NO		0.9918	NO		NO									0						
ZQ600	YES	1.4896	0.6596	NO		NO			0.842	0.26	0.45	0	0.714		0.7	Cc	0.559	0.9	Cc	0.696	0.94
ZQ601	YES	92.1041	0.0003	YES	86.9479	YES	3.3959	1.3416	92.104	89.86	89.48	90.11	269.45	0.7217	5	A	0	0	A	0	0
ZQ602	NO		0.9883	NO		NO									0						
ZQ603	NO		0.9812	NO		NO									0						
ZQ604	NO		0.9969	NO		NO									0						
ZQ605	NO		0.9922	NO		NO									0						
ZQ606	NO		0.9905	NO		NO									0						
ZQ607	NO		0.9197	NO		NO									0						
ZQ608	YES	1.0208	0.8958	NO		NO			0.202	0	0	0.02	0.024		0.2	Dc	0.894	1	Ca	0.938	0.982
ZQ609	NO		0.9205	NO		NO									0						

ZQ610	YES	5.8542	0.001	YES	5.4062	NO			5.854	5.7	5.55	5.67	16.917		2	A	0	0	A	0	0
ZQ611	YES	95.3334	0.0003	YES	88.5625	YES	0.1042	1.112	95.333	93.23	92.92	92.87	279.023	0.0254	5	A	0	0	A	0	0
ZQ612	YES	8.0104	0.0009	YES	5.2292	YES	10.4271	1.1807	8.01	5.48	5.57	5.35	16.397	1.6667	2	A	0	0	A	0	0
ZQ613	YES	67.5	0.8105	NO		NO			23.159	13.96	21.21	12.64	47.808		0.9	Cc	0.809	0.8	A	0.816	0.822
ZQ614	YES	41.3333	0.8911	NO		NO			8.512	0	7.07	0	7.071		0.5	Db	0.893	1	Db	0.907	1.001
ZQ615	NO		0.9028	NO		YES	3.6875	1.1148						0.4502	0						
ZQ616	YES	27.9479	0.8958	NO		NO			5.521	0	3.37	0	3.367		0.5	Db	0.896	1	Db	0.895	0.998
ZQ617	NO		0.9048	NO		YES	2.5833	1.1087						0.4699	0						
ZQ618	YES	37.2709	0.8952	NO		NO			7.403	0	4.6	0	4.596		0.5	Db	0.896	1	Db	0.904	0.997
ZQ619	YES	33.4791	0.8873	NO		NO			7.121	6.61	0.21	2.69	9.516		0.6	Cb	0.887	0.9	Dc	0.899	0.908
ZQ620	YES	81.6563	0.8947	NO		NO			16.291	0	11.5	0	11.499		0.5	Db	0.894	1	Db	0.904	0.998
ZQ621	YES	83.1042	0.8914	NO		NO			17.07	0	16.31	0	16.31		0.5	Db	0.893	1	Db	0.904	0.995
ZQ622	YES	83.0834	0.8945	NO		NO			16.606	0	11.39	0	11.394		0.5	Db	0.895	1	Db	0.902	0.992
ZQ623	NO		0.9182	NO		NO									0						
ZQ624	NO		0.9748	NO		NO									0						
ZQ625	NO		0.976	NO		NO									0						
ZQ626	YES	11.9687	0.7827	NO		NO			4.636	1.7	0.71	2.76	5.164		0.7	Cb	0.768	0.9	Cb	0.789	0.845
ZQ627	NO		0.9444	NO		NO									0						
ZQ628	NO		0.9514	NO		NO									0						
ZQ629	YES	12.4896	0.8187	NO		NO			4.118	3	3.93	3.13	10.051		0.6	Ca	0.814	0.9	Ca	0.845	0.891
ZQ630	NO		0.9107	NO		NO									0						
ZQ631	NO		0.9585	NO		NO									0						
ZQ632	YES	12.7708	0.8874	NO		NO			2.714	0	2.62	0	2.616		0.4	Db	0.887	1	Db	0.886	0.994
ZQ633	YES	3.9896	0.8832	NO		NO			0.878	0	0	0.86	0.855		0.2	Dc	0.881	1	Dc	0.909	0.989
ZQ634	NO		0.9479	NO		NO									0						
ZQ635	NO		0.9142	NO		NO									0						
ZQ636	NO		0.9224	NO		NO									0						
ZQ637	NO		0.993	NO		NO									0						
ZQ638	NO		0.997	NO		NO									0						
ZQ639	NO		0.9933	NO		NO									0						
ZQ640	YES	95.5938	0	YES	86.8854	YES	0.2291	1.1533	95.594	92.58	93.11	94.05	279.736	0.0691	5	A	0	0	A	0	0
ZQ641	YES	9.2291	0	YES	5.4687	NO			9.229	5.7	5.92	5.8	17.413		2	A	0	0	A	0	0
ZQ642	YES	3.5833	0.8399	NO		NO			1.056	0.92	0	0	0.925		0.3	Da	0.85	1	Cc	0.887	0.951
ZQ643	NO		0.9082	NO		NO									0						
ZQ644	YES	3.9375	0.812	NO		NO			1.341	1.04	1.2	0	2.237		0.4	Cc	0.771	0.9	Cc	0.776	0.944
ZQ645	YES	3.875	0.8516	NO		NO			1.065	0.92	0.99	0	1.918		0.3	Cc	0.806	1	Cc	0.819	1.004
ZQ646	YES	3.9167	0.8195	NO		NO			1.286	1.12	1.15	0	2.278		0.4	Cc	0.77	0.9	Cc	0.773	0.944
ZQ647	YES	3.3854	0.879	NO		NO			0.77	0	0.73	0	0.73		0.2	Db	0.879	1	Db	0.861	0.955
ZQ648	YES	3.6459	0.8685	NO		NO			0.896	0	0.83	0	0.834		0.3	Db	0.873	1	Db	0.857	0.959
ZQ649	YES	3.3959	0.8764	NO		NO			0.788	0	0.71	0	0.713		0.2	Db	0.876	1	Db	0.856	0.96
ZQ650	NO		0.9058	NO		NO									0						
ZQ651	YES	4.5625	0.8972	NO		NO			0.89	0	0.52	0	0.522		0.2	Cc	0.896	0.9	Cc	0.908	0.936

ZQ652	NO		0.9984	NO		NO									0						
ZQ653	NO		0.9958	NO		NO									0						
ZQ654	YES	8.125	0.6792	NO		YES	8.0937	1.2737	4.377	0	0	4.02	4.015	4.2769	0.6	Cb	0.955	1	Cb	0.967	1.013
ZQ655	YES	7.9687	0.7846	NO		YES	8.0208	1.2394	3.063	0	0	2.36	2.355	3.2612	0.4	Dc	0.972	1	Cb	0.979	1
ZQ656	NO		0.9616	NO		NO									0						
ZQ657	YES	7.9792	0.7828	NO		YES	8.0312	1.2335	3.09	0	0	2.42	2.42	3.205	0.4	Dc	0.958	1	Cb	0.974	1.002
ZQ658	NO		0.9751	NO		NO									0						
ZQ659	YES	8.0417	0.7439	NO		YES	8.0521	1.2308	3.592	0	0	3.06	3.062	3.4203	0.5	Cb	0.959	1	Cb	0.971	1.011
ZQ660	NO		0.9916	NO		NO									0						
ZQ661	NO		0.997	NO		NO									0						
ZQ662	YES	29.375	0.8642	NO		NO			7.437	0	7.26	0	7.262		0.7	Ca	0.856	1	Ca	0.873	1.014
ZQ663	YES	33.3229	0.8494	NO		NO			9.281	0	9.05	0	9.052		0.8	Db	0.849	1	Ca	0.87	1.009
ZQ664	YES	5.1667	0.8623	NO		NO			1.325	0	1.27	0	1.275		0.3	Db	0.863	1	Db	0.866	0.992
ZQ665	YES	5.4896	0.8174	NO		NO			1.822	0	1.72	0	1.722		0.4	Db	0.818	1	Db	0.828	1.002
ZQ666	YES	45.6771	0.6629	NO		NO			25.605	21.06	22.73	20.54	64.328		1.7	A	0.663	0.7	Db	0.653	0.663
ZQ667	NO		0.9882	NO		NO									0						
ZQ668	YES	5.5833	0.7819	NO		YES	5.5417	1.1783	2.17	0	1.91	0	1.907	1.7609	0.4	Ca	0.975	1	Ca	0.987	1.007
ZQ669	YES	5.6355	0.6846	NO		YES	5.6459	1.2558	2.994	0	2.55	0	2.55	2.7518	0.6	Ca	0.967	1	Db	0.95	0.989
ZQ670	NO		0.9795	NO		NO									0						
ZQ671	YES	5.9583	0.5344	NO		YES	5.9792	1.2993	4.257	0	3.7	0	3.7	4.5419	0.9	Ca	0.929	1	Ca	0.924	0.991
ZQ672	YES	6.3333	0.3369	NO		YES	6	1.3253	5.614	0	4.8	0	4.8	6.658	1.3	Ca	0.858	1	Ca	0.859	0.976
ZQ673	YES	41.9479	0.6675	NO		NO			23.258	21.7	21.86	21.88	65.442		1.7	A	0.668	0.7	Dc	0.662	0.67
ZQ674	YES	41.8021	0.6706	NO		NO			23.004	21.74	21.85	21.92	65.512		1.6	A	0.67	0.7	Dc	0.661	0.671
ZQ675	NO		0.9909	NO		NO									0						
ZQ676	NO		0.9808	NO		NO									0						
ZQ677	NO		0.9084	NO		NO									0						
ZQ678	NO		0.9762	NO		NO									0						
ZQ679	YES	21.6042	0.6985	NO		NO			11.063	8.37	7.28	6.42	22.062		1	Cc	0.676	0.8	Da	0.743	0.755
ZQ680	YES	2.1563	0.8801	NO		NO			0.486	0.02	0.12	0	0.138		0.2	Cc	0.865	0.9	Dc	0.958	0.914
ZQ681	YES	94.9688	0.0006	YES	28.3854	YES	0.2291	1.2186	94.969	28.53	28.52	94.06	151.116	0.0908	5	A	0	0	A	0	0
ZQ682	YES	95.3438	0.004	YES	94.3541	NO			95.342	94.25	94.36	94.48	283.095		5	A	0	0	A	0	0
ZQ683	YES	145.406	0.4067	NO		NO			121.36	116.35	99.15	0	215.495		3	Cc	0.069	1	Cc	0.052	1.016
ZQ684	YES	32.3229	0.0041	YES	5.4583	NO			32.322	6.78	8.38	5.64	20.803		5	A	0.001	0	A	0	0
ZQ685	NO		0.9271	NO		NO									0						
ZQ686	NO		0.9939	NO		NO									0						
ZQ687	NO		0.9951	NO		NO									0						
ZQ688	NO		0.9378	NO		NO									0						
ZQ689	YES	94.8959	0	YES	86.802	YES	1.0937	1.2238	94.896	92.12	92.9	92.3	277.317	0.2871	5	A	0	0	A	0	0
ZQ690	YES	95.5	0.0039	YES	94.4896	NO			95.499	94.78	94.89	94.81	284.481		5	A	0	0	A	0	0
ZQ691	YES	1.8021	0.1105	NO		NO			1.78	0.96	0.87	0.57	2.402		1.8	Cc	0.108	0.3	Cc	0.196	0.521
ZQ692	NO		0.9993	NO		NO									0						
ZQ693	YES	2.0834	0.8909	NO		NO			0.43	0.06	0	0.01	0.061		0.2	Cb	0.881	0.9	Da	0.926	0.963

ZQ694	YES	95.3541	0.0004	YES	86.6458	YES	2.3021	1.5272	95.354	91.53	91.4	92.36	275.29	1.3072	5	A	0	0	A	0	0
ZQ695	YES	10.0313	0.0012	YES	5.2187	YES	9.1042	1.1617	10.031	5.52	5.66	5.39	16.57	0.3201	3.3	A	0	0	A	0	0
ZQ696	YES	95.2396	0.0003	YES	85.8958	YES	0.7813	1.2542	95.24	92.87	92.48	92.83	278.186	0.236	5	A	0	0	A	0	0
ZQ697	YES	13.1458	0.0012	YES	5.4375	NO			13.146	5.99	5.99	5.76	17.736		3.3	A	0	0	A	0	0
ZQ698	NO		0.9951	NO		NO									0						
ZQ699	NO		0.9906	NO		NO									0						
ZQ700	YES	51.5209	0.3459	NO		NO			45.357	21.82	27.56	4.15	53.531		3.3	Cc	0.288	0.4	Cc	0.316	0.368
ZQ703	YES	6.9583	0	YES	5.177	NO			6.958	5.52	5.38	5.48	16.389		2	A	0	0	A	0	0
ZQ704	NO		0.9838	NO		NO									0						
ZQ705	NO		0.9909	NO		NO									0						
ZQ706	YES	95.5834	0.0015	YES	88.0416	YES	0.9896	1.2801	95.583	93.11	92.82	93.95	279.876	0.384	5	A	0	0	A	0	0
ZQ707	YES	13.0625	0.0021	YES	5.2187	NO			13.062	5.68	6.32	5.5	17.506		3.3	A	0.001	0	A	0.001	0.001
ZQ708	YES	92.3645	0.0007	YES	85.6875	YES	1.2084	1.2875	92.364	89.84	89.64	90.6	270.08	0.7339	5	A	0	0	A	0	0
ZQ709	YES	11.2083	0.0022	YES	5.375	NO			11.208	6.25	5.81	5.61	17.674		3.3	A	0.001	0	A	0.001	0.001
ZQ710	YES	46.8229	0.3045	NO		NO			42.481	39.21	39.27	39.89	118.364		3.5	Dc	0.304	0.4	Dc	0.343	0.376
ZQ711	YES	3.0938	0.6598	NO		NO			1.747	0.26	0.22	0.14	0.624		0.7	Cc	0.631	0.9	Cc	0.78	0.891
ZQ712	YES	46.8542	0.3321	NO		NO			41.687	39.23	39.23	39.64	118.088		3.3	Ca	0.305	0.4	Dc	0.358	0.378
ZQ713	YES	33.1145	0.0043	YES	5.2917	NO			33.114	7.74	8.18	5.5	21.42		5	A	0.001	0	A	0	0
ZQ714	NO		0.985	NO		NO									0						
ZQ715	YES	15.0625	0.5995	NO		NO			9.649	0	9.2	4.13	13.328		1.3	Db	0.6	1	Db	0.627	1
ZQ716	YES	0.6875	0.8511	NO		NO			0.189	0	0.15	0	0.157		0.1	Db	0.852	0.9	Dc	0.971	0.918
ZQ717	YES	15.052	0.5926	NO		NO			9.766	0	9.44	4.19	13.634		1.3	Db	0.596	1	Db	0.617	1.007
ZQ720	NO		0.9936	NO		NO									0						
ZQ730	YES	0.8125	0.8128	NO		NO			0.276	0	0.22	0	0.216		0.2	Db	0.815	0.9	Cc	0.899	0.962
ZQ731	YES	1.2812	0.8849	NO		NO			0.278	0	0.19	0.16	0.353		0.2	Db	0.89	0.9	Da	0.908	0.923
ZQ732	YES	3.0625	0.2003	NO		NO			2.94	2.14	1.77	2.36	6.271		1.6	Ca	0.198	0.2	Cb	0.214	0.221
ZQ733	YES	2.6042	0.777	NO		NO			1.032	0.79	0.68	0.85	2.329		0.4	Ca	0.777	0.8	Db	0.778	0.792
ZQ734	YES	2.1042	0.8462	NO		NO			0.597	0.45	0.45	0.49	1.391		0.3	Db	0.849	0.9	Dc	0.857	0.885
ZQ735	YES	2.2813	0.8357	NO		NO			0.688	0.5	0.51	0.57	1.579		0.3	Db	0.837	0.8	Ca	0.85	0.867
ZQ736	YES	2.2916	0.8366	NO		NO			0.688	0.58	0.49	0.52	1.594		0.3	Cc	0.839	0.8	Db	0.86	0.87
ZQ737	YES	2.0729	0.8496	NO		NO			0.577	0.42	0.42	0.48	1.322		0.3	Ca	0.849	0.9	Dc	0.866	0.893
ZQ738	YES	12.5	0.8007	NO		NO			4.486	0	4.31	0	4.309		0.7	Db	0.801	1	Ca	0.836	1.005
ZQ739	NO		0.9827	NO		NO									0						
ZQ740	YES	24.875	0.8028	NO		NO			8.843	7.44	0	5.86	13.299		0.7	Cb	0.726	1	Cb	0.753	1.002
ZQ741	YES	2.1355	0.8681	NO		NO			0.526	0	0.08	0.02	0.098		0.3	Ca	0.852	1	Ca	0.939	1.016
ZQ742	YES	3.2188	0.8505	NO		NO			0.89	0.2	0	0.03	0.233		0.3	Da	0.85	0.9	Cb	0.929	0.997
ZQ743	YES	0.0313	0.8984	NO		NO			0.006	0	0.01	0	0.008		0.1	Ca	0.885	0.9	A	0.946	0.947
ZQ744	NO		0.9127	NO		NO									0						
ZQ745	NO		0.9985	NO		NO									0						
ZQ746	NO		0.9983	NO		NO									0						
ZQ747	NO		0.9982	NO		NO									0						
ZQ748	NO		0.9984	NO		NO									0						

ZQ749	NO		0.9985	NO		NO									0						
ZQ750	NO		0.9983	NO		NO									0						
ZQ751	NO		0.9985	NO		NO									0						
ZQ752	NO		0.9984	NO		NO									0						
ZQ753	NO		0.9129	NO		NO									0						
ZQ754	NO		0.998	NO		NO									0						
ZQ755	YES	5.0625	0.7822	NO		NO			1.965	1.87	0.89	0	2.756		0.4	Cc	0.783	1	Da	0.79	0.98
ZQ756	YES	32.1146	0.7823	NO		NO			12.461	11.05	2.67	0	13.721		1.1	Cc	0.782	1	Cc	0.792	0.966
ZQ757	NO		0.9418	NO		NO									0						
ZQ758	YES	5.573	0.8387	NO		YES	5.3542	1.1224	1.653	0	0	1.52	1.519	0.8669	0.3	Dc	0.975	1	Db	0.983	0.974
ZQ759	YES	5.0104	0.8782	NO		NO			1.146	0	0.57	0.59	1.153		0.2	Ca	0.851	1	Ca	0.839	0.96
ZQ760	NO		0.9528	NO		NO									0						
ZQ761	YES	5.6979	0.7632	NO		NO			2.379	0	1.91	1.96	3.876		0.5	Ca	0.688	1	Ca	0.684	0.961
ZQ762	YES	95.2604	0.0012	YES	76.9271	YES	5.9479	1.3079	95.26	83.58	83.95	87.31	254.836	2.4675	5	A	0.001	0	A	0	0
ZQ763	YES	5.9062	0.0014	YES	5.4375	NO			5.906	5.59	5.74	5.73	17.065		2	A	0.001	0	A	0	0
ZQ764	NO		0.9837	NO		NO									0						
ZQ765	NO		0.9919	NO		NO									0						
ZQ766	YES	2.0104	0.1109	NO		NO			1.986	1.02	0.81	0.52	2.357		1.8	Cc	0.085	0.2	Cb	0.497	0.38
ZQ767	YES	95.4271	0.0043	YES	94.5729	NO			95.425	94.49	94.43	94.4	283.32		5	A	0	0	A	0	0
ZQ768	NO		0.9974	NO		NO									0						
ZQ769	YES	8.4167	0.7198	NO		NO			4.056	0.18	0.1	1.11	1.401		0.6	Dc	0.719	0.9	Dc	0.84	0.976
ZQ770	YES	15.1354	0.8735	NO		YES	16.2812	1.1518	3.587	0.26	0	0.2	0.46	2.5725	0.4	Da	0.476	0.8	Da	0.023	0.044
ZQ771	YES	245.156	0.0008	YES	244.5	YES	0.1042	1.15	245.16	243.39	243.34	243.21	729.946	0.0318	5	A	0.001	0	A	0	0
ZQ772	NO		0.9937	NO		NO									0						
ZQ773	YES	6.9374	0.001	YES	5.0937	NO			6.937	5.49	5.27	5.32	16.08		2	A	0.001	0	A	0	0
ZQ774	YES	13.8021	0.0042	YES	5.0312	NO			13.802	5.62	5.3	5.35	16.262		3.3	A	0	0	A	0	0
ZQ775	NO		0.9939	NO		NO									0						
ZQ776	NO		0.908	NO		NO									0						
ZQ777	NO		0.9925	NO		NO									0						
ZQ778	YES	2.2708	0.8777	NO		NO			0.521	0.01	0.16	0.01	0.181		0.2	Cc	0.868	0.9	Ca	0.922	0.945
ZQ779	YES	2.0521	0.1249	NO		NO			2.02	0.86	0.65	0.46	1.966		1.8	Cc	0.116	0.3	Da	0.387	0.595
ZQ780	NO		0.9663	NO		NO									0						
ZQ781	NO		0.9859	NO		NO									0						
ZQ782	NO		0.9042	NO		YES	10.4584	1.1144						2.1431	0						
ZQ783	YES	10.9167	0.8743	NO		NO			2.572	0	0	2.35	2.348		0.4	Cb	0.87	1	Dc	0.87	0.963
ZQ784	YES	8.25	0.8883	NO		NO			1.74	0	0	1.51	1.51		0.2	Dc	0.89	1	Dc	0.874	0.953
ZQ785	YES	2.875	0.5746	NO		NO			1.926	0.02	0.29	0.18	0.487		0.9	Db	0.573	1	Ca	0.755	0.96
ZQ786	YES	4.8958	0.6274	NO		NO			2.969	2.59	1.54	0	4.122		0.7	Cc	0.623	1	Cc	0.639	0.984
ZQ787	NO		0.9732	NO		NO									0						
ZQ788	YES	9.6875	0.6038	NO		NO			6.156	5.3	3.14	0	8.445		0.8	Da	0.604	1	Cc	0.629	0.977
ZQ789	NO		0.9871	NO		NO									0						
ZQ790	NO		0.9982	NO		NO									0						

ZQ791	YES	0.7188	0.509	NO		NO			0.533	0.37	0.25	0	0.626		0.5	Cc	0.426	1	Cc	0.589	1.019
ZQ792	YES	145.792	0.4939	NO		NO			110.23	108.84	0	108.63	217.47		2.5	Cb	0.036	1	Cb	0.039	1.022
ZQ793	NO		0.9803	NO		NO									0						
ZQ794	YES	5.5417	0.6239	NO		NO			3.385	2.78	1.66	0	4.442		0.8	Da	0.624	1	Cc	0.645	0.977
ZQ795	NO		0.9202	NO		NO									0						
ZQ796	YES	4.6042	0.6131	NO		NO			2.874	2.26	1.34	0	3.599		0.8	Da	0.613	1	Cc	0.645	0.975
ZQ797	NO		0.9326	NO		NO									0						
ZQ798	YES	5.1459	0.6104	NO		NO			3.229	2.69	1.54	0	4.234		0.8	Da	0.61	1	Cc	0.642	0.974
ZQ799	YES	9.1146	0.6088	NO		NO			5.736	4.89	3	0	7.891		0.8	Da	0.609	1	Cc	0.636	0.963
ZQ800	NO		0.9769	NO		NO									0						
ZQ801	YES	10.5521	0.6406	NO		NO			6.222	5.54	3.43	0	8.966		1.2	Cc	0.626	1	Cc	0.642	0.978
ZQ802	YES	0.1354	0.8735	NO		NO			0.032	0	0.03	0.01	0.046		0.1	Ca	0.84	1	Cb	0.979	0.959
ZQ803	NO		0.9543	NO		NO									0						
ZQ804	NO		0.9838	NO		NO									0						
ZQ805	YES	0.0313	0.898	NO		NO			0.006	0.01	0	0	0.008		0.1	Cb	0.887	1	Cb	0.937	0.971
ZQ806	NO		0.9728	NO		NO									0						
ZQ807	NO		0.977	NO		NO									0						
ZQ808	NO		0.9917	NO		NO									0						
ZQ809	YES	95.125	0.0003	YES	87.6667	YES	0.302	1.2335	95.125	93.26	93.19	92.82	279.271	0.1132	5	A	0	0	A	0	0
ZQ810	NO		0.9853	NO		NO									0						
ZQ811	NO		0.9773	NO		NO									0						
ZQ812	YES	10.0625	0.0009	YES	5.2708	YES	10.0521	1.1197	10.062	5.41	5.55	5.6	16.549	0.1283	3.3	A	0	0	A	0	0
ZQ813	YES	94.6875	0.0002	YES	88.8958	YES	1.0729	1.1794	94.687	92.98	92.47	93.11	278.554	0.3796	5	A	0	0	A	0	0
ZQ814	YES	5.6874	0.001	YES	5.2499	NO			5.687	5.43	5.45	5.57	16.45		2	A	0.001	0	A	0	0
ZQ815	NO		0.9928	NO		NO									0						
ZQ816	YES	85.9791	0	YES	82.2813	YES	8.8334	1.1434	85.979	85.04	84.42	84.19	253.643	0.2089	5	A	0	0	A	0	0
ZQ817	YES	4.573	0.8489	NO		NO			1.278	0	0	1.12	1.124		0.3	Dc	0.849	1	Cb	0.865	1.002
ZQ818	YES	4.3334	0.8686	NO		NO			1.064	0	0	1.03	1.03		0.3	Cb	0.863	1	Cb	0.858	1.009
ZQ819	NO		0.9707	NO		NO									0						
ZQ820	NO		0.9926	NO		NO									0						
ZQ821	NO		0.9922	NO		NO									0						
ZQ822	NO		0.9803	NO		NO									0						
ZQ823	NO		0.9663	NO		NO									0						
ZQ824	NO		0.9729	NO		NO									0						
ZQ825	NO		0.9547	NO		NO									0						
ZQ826	NO		0.9491	NO		NO									0						
ZQ827	NO		0.9934	NO		NO									0						
ZQ828	NO		0.998	NO		NO									0						
ZQ829	NO		0.9923	NO		NO									0						
ZQ830	YES	9.0416	0.8969	NO		NO			1.768	0	1.35	0	1.348		0.2	Db	0.898	1	Db	0.897	1.011
ZQ831	YES	1.8021	0.7916	NO		NO			0.673	0.62	0	0	0.619		0.4	Da	0.793	1	Da	0.792	0.979
ZQ832	NO		0.9914	NO		NO									0						

ZQ833	YES	7.2084	0.3773	NO		NO			6.182	4.03	4.28	4.98	13.289		1.2	Dc	0.379	0.6	Dc	0.391	0.569
ZQ834	YES	19.1666	0.3708	NO		NO			16.531	10.73	11.87	13.95	36.551		2.1	Dc	0.373	0.6	Dc	0.377	0.582
ZQ835	YES	17.1459	0.3753	NO		NO			14.731	10.51	11.76	13.64	35.92		2.1	Dc	0.376	0.6	Dc	0.382	0.579
ZQ836	YES	15.5208	0.3749	NO		NO			13.339	10.16	11.11	12.85	34.121		2.1	Dc	0.374	0.6	Dc	0.381	0.576
ZQ837	NO		0.9696	NO		NO									0						
ZQ838	NO		0.9981	NO		NO									0						
ZQ839	YES	5.0521	0.7923	NO		NO			1.881	0	0.02	1.75	1.775		0.4	Dc	0.79	1	Dc	0.781	0.97
ZQ840	YES	0.3541	0.8726	NO		NO			0.084	0.04	0	0.03	0.065		0.1	Cb	0.858	1	Da	0.908	0.957
ZQ841	NO		0.9845	NO		NO									0						
ZQ842	NO		0.9911	NO		NO									0						
ZQ843	YES	25.0521	0.7972	NO		NO			9.131	7.55	0	6.21	13.763		1	Cb	0.721	1	Cb	0.731	0.996
ZQ844	YES	97.0104	0	YES	81.4063	YES	2.4583	1.8351	97.01	84.48	84.32	84.24	253.046	4.6028	5	A	0	0	A	0	0
ZQ845	YES	2.1979	0.8598	NO		NO			0.573	0	0	0.11	0.108		0.3	Dc	0.859	0.9	Dc	0.93	0.999
ZQ846	YES	24.4688	0.7969	NO		NO			8.93	7.43	0	6.58	14.01		0.7	Cb	0.721	1	Cb	0.736	1
ZQ847	NO		0.9985	NO		NO									0						
ZQ848	NO		0.998	NO		NO									0						
ZQ849	NO		0.9983	NO		NO									0						
ZQ850	YES	5.1458	0.8996	NO		NO			0.981	0	0.11	0	0.112		0.2	Db	0.898	1	Db	0.896	1.008
ZQ851	NO		0.9046	NO		NO									0						
ZQ852	YES	20.4167	0.7909	NO		NO			7.646	7.22	0	0	7.225		0.7	Da	0.792	1	Da	0.822	1.037
ZQ853	YES	0.1354	0.8864	NO		NO			0.029	0	0	0.03	0.03		0.1	Dc	0.886	1	Cb	0.974	1.012
ZQ854	YES	36.7396	0.6891	NO		NO			19.293	11.7	13.94	9.56	35.193		1.6	Ca	0.648	0.8	Db	0.708	0.745
ZQ855	YES	32.1771	0.6639	NO		NO			17.995	16.03	14.15	11.99	42.172		1.7	Ca	0.619	0.7	Da	0.685	0.659
ZQ856	YES	1.5104	0.8922	NO		NO			0.308	0.3	0	0	0.3		0.2	Da	0.89	1	Cb	0.938	0.98
ZQ857	NO		0.9972	NO		NO									0						
ZQ858	NO		0.9003	NO		NO									0						
ZQ859	YES	3.0833	0.8866	NO		NO			0.66	0	0	0.6	0.599		0.2	Dc	0.886	1	Cb	0.898	0.999
ZQ865	YES	95.5834	0	YES	94.8959	NO			95.583	94.54	94.83	94.75	284.124		5	A	0	0	A	0	0
ZQ867	YES	95.4584	0.0057	YES	89.4791	NO			95.455	93.74	94.25	94.16	282.149		5	Dc	0.006	0	Ca	0.012	0.038
ZQ868	YES	95.4271	0.0052	YES	89.4479	NO			95.425	93.7	94.24	94.15	282.091		5	Dc	0.007	0	Ca	0.012	0.039
ZQ869	YES	47.8958	0.0124	YES	5.2499	NO			47.888	8.68	5.68	8.2	22.56		4.9	Dc	0.014	0.1	Cb	0.007	0.029
ZQ871	YES	95.3541	0.2198	NO		NO			90.747	45.75	59.24	9.01	114.003		3.9	Cc	0.198	0.3	Cc	0.218	0.238
ZQ872	YES	6.052	0.2299	NO		NO			5.732	5.44	5.35	5.32	16.112		1.5	Ca	0.23	0.3	A	0.245	0.248
ZQ873	NO		0.9895	NO		NO									0						
ZQ874	NO		0.9962	NO		NO									0						
ZQ875	NO		0.9102	NO		NO									0						
ZQ876	NO		0.9694	NO		NO									0						
ZQ877	NO		0.9076	NO		NO									0						
ZQ878	NO		0.9848	NO		NO									0						
ZQ879	YES	0.0625	0.894	NO		NO			0.013	0	0.01	0	0.014		0.1	Db	0.894	0.9	Cc	0.934	0.963
ZQ881	NO		0.9978	NO		NO									0						
ZQ882	NO		0.9975	NO		NO									0						

ZQ883	NO		0.9975	NO		NO									0						
ZQ884	NO		0.9955	NO		YES	3.1458	1.1116						1.914	0						
ZQ885	NO		0.9054	NO		NO									0						
ZQ886	NO		0.9976	NO		NO									0						
ZQ887	YES	6.5834	0.595	NO		NO			4.253	0	3.86	1.38	5.238		0.8	Db	0.596	1	Db	0.613	0.987

* when an event is not classified as a voltage dip, in the column retained voltage
minimum voltage is written instead.

Appendix D

MatLab Results - voltage sags only

Synthetic Dip	Sag	Duration of voltage sag [cycles]	Retained voltage * [pu]	Interrup-tion	Interruption Duration [cycles]	Swell	Swell Duration [cycles]	Swell retained voltage [pu]	Sag Energy calc. from Dur.& Ret [cycles]	Evs_a, Voltage-Sag Energy Index [cycles]	Evs_b, Voltage-Sag Energy Index [cycles]	Evs_c, Voltage-Sag Energy Index [cycles]	Evs, Voltage-Sag Energy Index [cycles]	Voltage-Swell Energy Index [cycles]	Voltage-Sagl Severity [pu]	Six Phase RMS - Dip Type	V (from sixRMS)	F (from sixRMS)	Symmetrical Component Method	V (from symm. comp. method)	F (from symm. comp. method)
ZQ21	YES	95.1563	0	YES	88.9895	YES	0.0938	1.1192	95.156	94.38	90.35	92.4	277.12	0.0239	5	A	0	0	A	0	0
ZQ23	YES	1.0938	0.891	NO		NO			0.225	0	0.02	0.02	0.033		0.2	Ca	0.874	0.9	Cb	0.956	0.947
ZQ29	YES	6.1042	0	YES	5.3645	NO			6.104	5.63	5.66	5.57	16.861		2	A	0	0	A	0	0
ZQ30	YES	6.1042	0	YES	5.3645	NO			6.104	5.63	5.66	5.57	16.861		2	A	0	0	A	0	0
ZQ31	YES	65.125	0.801	NO		NO			23.341	21.51	20.97	20.48	62.961		1	A	0.801	0.8	A	0.803	0.809
ZQ45	YES	0.0313	0.8981	NO		NO			0.006	0	0	0.01	0.008		0.1	Ca	0.883	0.9	Ca	0.914	0.985
ZQ51	YES	3.3021	0.8275	NO		NO			1.041	0.21	0	0.2	0.407		0.3	Cb	0.794	0.9	Cb	0.899	0.982
ZQ52	YES	18.5208	0.862	NO		NO			4.759	0	4.59	3.02	7.615		0.5	Ca	0.846	1	Ca	0.842	0.953
ZQ53	YES	20.0104	0.8476	NO		NO			5.634	0	5.03	3.87	8.903		0.5	Ca	0.843	1	Ca	0.828	0.959
ZQ54	YES	22.4896	0.4643	NO		NO			17.641	16.31	13.29	10.61	40.202		1.8	Cc	0.456	0.5	A	0.492	0.498
ZQ55	YES	0.2292	0.8719	NO		NO			0.055	0	0	0.05	0.052		0.1	Dc	0.874	1	Cb	0.964	0.989
ZQ56	YES	2.1876	0.8278	NO		NO			0.689	0.55	0.52	0.49	1.569		0.3	Dc	0.827	0.8	A	0.809	0.814
ZQ63	YES	13.25	0.0021	YES	5.375	NO			13.25	6.65	6.52	5.56	18.73		3.3	A	0.001	0	A	0.001	0.001
ZQ64	YES	13.6042	0.0007	YES	11.25	NO			13.604	12.75	12.95	12.93	38.636		3.3	A	0	0	A	0	0

ZQ65	YES	8.2188	0.0014	YES	4.4374	NO			8.219	4.64	4.94	4.91	14.493		2	A	0	0	A	0	0
ZQ68	YES	245.104	0.0009	YES	244.49	NO			245.1	243.92	243.82	243.65	731.383		5	A	0	0	A	0	0
ZQ69	YES	16.4479	0.7746	NO		YES	14.3334	1.2961	6.579	0.08	0.01	0.42	0.507	1.1031	0.7	Cc	0.808	0.9	A	0.002	0.003
ZQ74	YES	16.9062	0	YES	0.0104	YES	16.9479	Inf	16.906	2.12	5.31	0	7.429	Inf	3.3	Cb	0.302	0.9	Cb	0.11	0.558
ZQ76	YES	8.7396	0.0009	YES	4.9895	NO			8.74	5.43	5.26	5.55	16.244		2	A	0.001	0	A	0	0
ZQ77	YES	13.2812	0.535	NO		NO			9.48	6.13	9.01	0	15.143		1.5	Cc	0.448	1	Cc	0.464	0.989
ZQ83	YES	10	0.1136	NO		NO			9.871	9.38	6	4.61	19.986		1.8	Da	0.113	0.7	Da	0.14	0.749
ZQ89	YES	0.5938	0.7796	NO		NO			0.233	0.14	0.01	0	0.149		0.2	Da	0.78	1	Cc	0.897	0.982
ZQ95	YES	13.0937	0.3568	NO		NO			11.427	8.65	8.33	6.5	23.481		2.1	Db	0.357	0.5	Cc	0.385	0.484
ZQ96	YES	0.0209	0.8981	NO		NO			0.004	0	0.01	0	0.006		0.1	Db	0.899	1	Ca	0.914	0.999
ZQ98	YES	0	0.8997	NO		NO			0	0	0	0	0.002		0.1	Ca	0.899	1	Ca	0.914	0.997
ZQ100	YES	16.2708	0	YES	5.4583	YES	5.0521	1.1199	16.271	6.05	6.04	5.72	17.813	0.0685	3.3	A	0	0	A	0	0
ZQ103	YES	0.0313	0.8944	NO		NO			0.006	0	0.01	0	0.008		0.1	Ca	0.894	1	Ca	0.9	1.002
ZQ105	YES	0.0416	0.8926	NO		NO			0.008	0	0.01	0	0.01		0.1	Db	0.894	1	Ca	0.903	1.001
ZQ107	YES	3.8542	0.8608	NO		NO			0.998	0.96	0	0	0.955		0.3	Cc	0.851	1	Da	0.87	0.996
ZQ109	YES	6.4792	0.562	NO		NO			4.433	1.46	3.32	2.19	6.962		0.9	Db	0.563	0.8	Db	0.57	0.835
ZQ110	YES	3.0625	0.8883	NO		NO			0.646	0	0.55	0	0.547		0.2	Db	0.888	1	Db	0.896	0.959
ZQ111	YES	3.3854	0.8857	NO		NO			0.73	0	0.66	0	0.664		0.2	Db	0.886	1	Db	0.886	0.954
ZQ130	YES	4.3438	0.8855	NO		NO			0.938	0.86	0	0	0.859		0.2	Cc	0.868	1	Cc	0.87	0.995
ZQ131	YES	3.4688	0.8575	NO		NO			0.918	0.74	0	0	0.736		0.3	Da	0.857	1	Cc	0.866	0.98
ZQ132	YES	13.9479	0.8625	NO		NO			3.572	3.32	0	0	3.323		0.5	Cc	0.85	1	Cc	0.871	1.004
ZQ135	YES	2.1041	0.8866	NO		NO			0.45	0.03	0.04	0	0.075		0.2	Cc	0.866	0.9	Ca	0.957	0.938
ZQ136	YES	4.5208	0.8909	NO		NO			0.933	0	0.88	0	0.879		0.2	Db	0.89	1	Db	0.888	1.008
ZQ137	YES	63.1354	0.6214	NO		NO			38.756	21.64	8.79	19.95	50.378		1.9	Cb	0.609	0.7	Cb	0.618	0.669
ZQ138	YES	4	0.8673	NO		NO			0.991	0.84	0	0	0.841		0.3	Cc	0.865	1	Cc	0.875	1
ZQ139	YES	1.2187	0.8878	NO		NO			0.258	0	0.05	0.02	0.066		0.2	Ca	0.871	0.9	Ca	0.924	0.965
ZQ142	YES	23.3021	0.6602	NO		NO			13.146	12.5	0	7.28	19.785		1.1	Cb	0.624	1	Cb	0.643	0.98
ZQ143	YES	4.8646	0.8178	NO		NO			1.611	0.86	1.52	0	2.379		0.4	Cc	0.802	1	Cc	0.821	0.977
ZQ145	YES	51.8021	0.4973	NO		NO			38.991	10.53	15.89	5.15	31.57		2.5	Db	0.497	0.9	Cc	0.574	0.802
ZQ151	YES	8.1771	0.874	NO		YES	10.7083	1.1554	1.931	0	0	0.28	0.283	2.6164	0.3	Dc	0.976	1	A	0.979	0.982
ZQ152	YES	11.0625	0.8302	NO		NO			3.438	0	2.78	3.22	5.997		0.6	Ca	0.778	1	Ca	0.78	0.984
ZQ154	YES	0.1562	0.8781	NO		NO			0.036	0	0	0.04	0.036		0.1	Dc	0.892	1	A	0.943	0.938
ZQ155	YES	0.5416	0.8719	NO		NO			0.13	0	0.07	0.07	0.142		0.1	Db	0.86	0.9	Ca	0.913	0.924
ZQ156	YES	0.1146	0.8861	NO		NO			0.025	0.02	0	0.03	0.047		0.1	Dc	0.877	0.9	Cb	0.899	0.959
ZQ158	YES	8	0.8958	NO		NO			1.58	0	1.41	0	1.408		0.2	Db	0.895	1	Db	0.909	1.003
ZQ161	YES	75.3125	0.2108	NO		NO			71.966	69.11	68.6	69.49	207.209		3.9	Cb	0.191	0.2	Cb	0.154	0.238
ZQ162	YES	4.7813	0.8699	NO		NO			1.163	1.08	0	0	1.084		0.3	Cc	0.861	1	Da	0.883	1.018
ZQ164	YES	12.2396	0.8515	NO		NO			3.365	2.97	2.87	2.41	8.252		0.5	Cc	0.837	0.9	A	0.895	0.894
ZQ166	YES	50.7396	0.2098	NO		NO			48.506	46.6	46.49	46.61	139.694		4	Cc	0.208	0.2	A	0.24	0.241
ZQ167	YES	1.0417	0.884	NO		NO			0.228	0.15	0.14	0.13	0.42		0.2	Cc	0.883	0.9	Cc	0.867	0.877
ZQ168	YES	19.0938	0.8723	NO		NO			4.565	3.9	4.12	3.92	11.943		0.4	Db	0.877	0.9	Db	0.859	0.881
ZQ181	YES	11.0208	0.8233	NO		YES	11.3854	1.2034	3.551	0	2.8	0	2.801	4.0911	0.6	Ca	0.977	1	Cc	0.973	0.993

ZQ182	YES	11.1041	0.7979	NO		YES	11.3646	1.1866	4.035	0	3.44	0	3.442	3.8237	0.7	Db	0.956	1	Db	0.953	1
ZQ184	YES	5.3125	0.8735	NO		YES	11.1042	1.1816	1.259	0	0.2	0	0.2	3.3619	0.3	Ca	0.979	1	Db	0.959	0.989
ZQ186	YES	11.9479	0.799	NO		YES	11.9688	1.2156	4.32	0	2.84	0	2.842	4.0783	0.7	Ca	0.98	1	Cc	0.977	0.996
ZQ187	YES	12.0104	0.7663	NO		YES	11.9687	1.2116	4.958	0	3.77	0	3.766	3.913	0.8	Db	0.958	1	Db	0.952	0.999
ZQ189	YES	11.4062	0.8074	NO		YES	11.927	1.2083	3.971	0	1.33	0.02	1.351	3.5342	0.6	Db	0.971	1	Db	0.958	0.989
ZQ190	YES	7.9375	0.8839	NO		NO			1.736	0	1.2	0	1.197		0.2	Db	0.885	1	Db	0.873	0.959
ZQ191	YES	8.9792	0.8794	NO		NO			2.035	0	1.84	0	1.837		0.2	Db	0.881	1	Db	0.872	0.958
ZQ193	YES	3.448	0.8156	NO		NO			1.154	0.36	0.29	0	0.647		0.4	Cc	0.786	0.9	Cc	0.879	0.983
ZQ194	YES	20.375	0.4556	NO		NO			16.146	0	13.95	14.81	28.761		1.8	Ca	0.28	0.9	Ca	0.284	0.915
ZQ196	YES	17.427	0.0385	YES	0.8438	NO			17.401	1.17	12.12	12.54	25.832		3.2	Db	0.039	0.6	Ca	0.221	0.519
ZQ206	YES	8.6771	0.8776	NO		NO			1.994	1.91	0	0	1.914		0.2	Da	0.877	1	Da	0.867	0.994
ZQ207	YES	30.4271	0.5346	NO		NO			21.731	12.77	0.83	0.26	13.861		2.3	Cc	0.513	0.9	Da	0.635	0.968
ZQ208	YES	95.3229	0.0006	YES	88.5938	YES	1.0104	1.3373	95.323	92.57	93.06	93.45	279.075	0.5281	5	A	0.001	0	A	0	0
ZQ209	YES	4.3437	0.8003	NO		NO			1.562	1.15	0.67	0	1.816		0.4	Cc	0.798	1	Cc	0.804	0.97
ZQ211	YES	11	0.0023	YES	5.2499	NO			11	5.97	5.86	5.45	17.275		3.3	A	0.001	0	A	0.001	0
ZQ212	YES	95.0313	0.0008	YES	88.302	YES	1.0313	1.5221	95.031	92.03	92.62	93.14	277.792	0.8947	5	A	0	0	A	0	0
ZQ213	YES	95.1771	0.0006	YES	87.9895	YES	0.7396	1.4095	95.177	92.74	92.28	93.84	278.859	0.5497	5	A	0	0	A	0	0
ZQ214	YES	6.125	0.0022	YES	5.2499	NO			6.125	5.49	5.51	5.67	16.667		2	A	0.001	0	A	0.001	0.001
ZQ215	YES	95.2396	0.0005	YES	86.6666	YES	1.0729	1.451	95.24	93.04	92.26	93.11	278.409	0.834	5	A	0	0	A	0	0
ZQ216	YES	10.0729	0.0022	YES	5.3333	NO			10.073	5.94	5.58	5.98	17.501		3.3	A	0.001	0	A	0.001	0.001
ZQ225	YES	3.6563	0.0015	YES	2.8438	YES	3.3958	1.171	3.656	0	0.03	3.43	3.463	0.0871	2	Dc	0.004	1	Dc	0.007	0.952
ZQ226	YES	9.0209	0.0019	YES	8.1771	YES	8.9375	1.2094	9.021	0	0	8.63	8.628	0.1276	2	Dc	0.005	1	Dc	0.005	0.98
ZQ227	YES	0.5625	0.7774	NO		YES	0.4063	1.1435	0.223	0	0	0.2	0.2	0.1067	0.2	Dc	0.774	1	Dc	0.781	0.988
ZQ228	YES	1.677	0.005	YES	1.0834	YES	0.2292	1.2057	1.677	0	0.08	1.48	1.554	0.0844	2	Dc	0.008	1	Dc	0.009	0.912
ZQ229	YES	5.5938	0.4186	NO		NO			4.614	1.23	1.16	0	2.395		1.2	Cc	0.042	1	Cc	0.038	0.988
ZQ230	YES	2.2605	0.6847	NO		YES	0.5105	1.258	1.201	0.26	0.01	0	0.261	0.2496	0.6	Cb	0.683	1	Cb	0.774	0.944
ZQ231	YES	11.4896	0.6609	NO		YES	0.0729	1.1262	6.471	1.67	0.21	0	1.88	0.0198	1.1	Da	0.659	1	Da	0.623	0.968
ZQ232	YES	17.7188	0.0012	YES	17.0833	YES	0.2292	1.1956	17.719	0.05	0	17.44	17.484	0.0803	3.3	Dc	0.002	1	Dc	0.004	0.946
ZQ233	YES	13.1979	0.0016	YES	12.5312	YES	11.2083	1.2221	13.198	0.21	0	6.52	6.73	0.2122	3.3	Dc	0.001	1	Dc	0	0.919
ZQ234	YES	26.7292	0.0013	YES	26.0521	YES	0.2604	1.2266	26.729	0.09	0	26.37	26.465	0.1035	5	Dc	0.001	1	Dc	0	0.919
ZQ235	YES	1.1459	0.0109	YES	0.5729	YES	1.4063	1.2492	1.146	0.03	0	0.96	0.983	0.1414	2	Dc	0.018	1	Dc	0.004	0.934
ZQ236	YES	5.5521	0.002	YES	4.6979	YES	3.5208	1.1881	5.552	0.31	0	3.39	3.695	0.0695	2	Dc	0.004	1	Dc	0.003	0.91
ZQ237	YES	0.5104	0.7322	NO		NO			0.237	0.21	0	0.15	0.36		0.3	Cb	0.688	1	Cb	0.758	0.979
ZQ238	YES	95.6354	0.0007	YES	95	YES	0.1875	1.1746	95.635	94.68	94.85	94.81	284.337	0.0832	5	A	0.001	0	A	0	0
ZQ242	YES	7.4062	0.7035	NO		NO			3.741	0.16	0.16	0.88	1.203		0.6	Dc	0.701	0.9	Dc	0.821	0.965
ZQ244	YES	5.4062	0.7196	NO		NO			2.607	0.03	0.08	0.51	0.629		0.6	Dc	0.717	0.9	Dc	0.811	0.942
ZQ245	YES	8.3125	0.7981	NO		NO			3.018	0.04	0	0.46	0.5		0.4	Dc	0.798	0.9	Dc	0.867	0.938
ZQ249	YES	11.9687	0.001	YES	5.1354	NO			11.969	5.47	5.47	5.9	16.834		3.3	A	0.001	0	A	0	0
ZQ250	YES	5.125	0.8752	NO		NO			1.199	0	1.16	0	1.16		0.2	Db	0.875	1	Db	0.889	1.008
ZQ251	YES	5.5105	0.8327	NO		NO			1.69	0	1.62	0	1.622		0.3	Db	0.833	1	Db	0.856	1.024
ZQ253	YES	19.9895	0.2506	NO		NO			18.734	14.32	15.41	6.8	36.532		2.5	Da	0.25	0.3	A	0.261	0.262
ZQ255	YES	16.6771	0.5241	NO		NO			12.096	7.81	10.12	2.41	20.34		1.6	Da	0.525	0.6	Cc	0.544	0.56

ZQ258	YES	15.948	0.5382	NO		NO			11.329	7.22	9.37	2.62	19.198		1.5	Da	0.538	0.6	Cc	0.564	0.584
ZQ260	YES	15.9584	0.5298	NO		NO			11.479	7.35	9.41	2.65	19.412		1.6	Da	0.531	0.6	Cc	0.56	0.578
ZQ269	YES	53.1979	0.8712	NO		NO			12.821	11.96	6.55	6.65	25.154		0.6	A	0.872	0.9	A	0.876	0.882
ZQ270	YES	12.1666	0.8744	NO		NO			2.864	2.61	2.54	2.63	7.786		0.4	A	0.876	0.9	Cb	0.869	0.88
ZQ281	YES	0.6458	0.8539	NO		NO			0.175	0.1	0.09	0	0.193		0.1	Cc	0.841	0.9	Cb	0.909	0.921
ZQ286	YES	13.0104	0.8995	NO		NO			2.484	0	0.06	0	0.063		0.3	Db	0.899	1	Db	0.905	1.007
ZQ287	YES	5.5001	0.8904	NO		NO			1.14	0	0	1.11	1.109		0.2	Cb	0.982	1	Da	0.989	1.002
ZQ290	YES	20.7813	0.4759	NO		NO			16.075	14.7	0	12.45	27.152		1.7	Cb	0.283	0.9	Cb	0.283	0.919
ZQ291	YES	17.0313	0.6253	NO		NO			10.372	9.93	0	6.71	16.636		1.2	Cb	0.572	1	Cb	0.573	0.97
ZQ295	YES	14.3645	0.7345	NO		NO			6.615	6.02	3.94	0	9.963		0.9	Cc	0.731	0.9	Cc	0.73	0.925
ZQ296	YES	94.7813	0.0009	YES	94.3334	YES	0.5521	1.8438	94.781	93.99	94.12	94.21	282.328	1.3146	5	A	0.001	0	A	0	0
ZQ298	YES	16.9375	0.6407	NO		NO			9.985	9.6	0	6.27	15.867		1.2	Cb	0.595	1	Cb	0.597	0.969
ZQ299	YES	16.9063	0.6193	NO		NO			10.422	9.89	5.04	0	14.934		1.3	Da	0.619	0.9	Da	0.624	0.952
ZQ300	YES	16.9271	0.6295	NO		NO			10.219	9.73	0	6.37	16.1		1.2	Cb	0.579	1	Cb	0.591	0.976
ZQ303	YES	95.3229	0.0011	YES	91.1458	NO			95.323	93.9	93.34	93.67	280.915		5	A	0	0	A	0	0
ZQ304	YES	5.3229	0.8415	NO		YES	5.4584	1.1935	1.554	1.29	0	0	1.294	2.0502	0.3	Cc	0.974	1	Cc	0.976	1.001
ZQ306	YES	5.8334	0.4944	NO		YES	5.6042	1.3693	4.408	3.95	0	0	3.95	5.9752	1	Da	0.931	1	Cc	0.926	0.987
ZQ307	YES	5.8334	0.4944	NO		YES	5.6042	1.3693	4.408	3.95	0	0	3.95	5.9752	1	Da	0.931	1	Cc	0.926	0.987
ZQ308	YES	5.8542	0.2035	NO		YES	5.8229	1.4471	5.612	5.07	0	0	5.075	9.2905	1.6	Da	0.851	1	Da	0.857	0.998
ZQ309	YES	5.6042	0.5628	NO		YES	5.5834	1.3318	3.829	3.53	0	0	3.527	4.8986	0.9	Da	0.935	1	Da	0.944	1.005
ZQ310	YES	0.2604	0.8794	NO		YES	7.3855	1.1622	0.059	0.06	0	0	0.057	1.988	0.1	Cc	0.984	1	Cc	0.985	1.002
ZQ311	YES	0.2396	0.8895	NO		YES	0.1563	1.1022	0.05	0.05	0	0	0.05	0.0343	0.1	Da	0.981	1	Cc	0.983	0.997
ZQ313	YES	7.6146	0.7035	NO		YES	7.5833	1.2812	3.846	3.61	0	0	3.607	4.2959	0.6	Cc	0.962	1	Cc	0.958	0.994
ZQ315	YES	7.9271	0.2078	NO		YES	7.9063	1.4385	7.585	7.14	0	0	7.139	12.8015	1.6	Da	0.85	1	Da	0.854	0.996
ZQ316	YES	7.6667	0.5481	NO		YES	7.6771	1.3456	5.364	4.97	0	0	4.972	6.2911	0.9	Da	0.934	1	Da	0.942	1.004
ZQ317	YES	7.9063	0.6723	NO		YES	7.5625	1.1945	4.333	4.04	0	0	4.039	2.8866	0.7	Da	0.938	1	Da	0.934	0.991
ZQ319	YES	9.8541	0.0011	YES	5.0312	NO			9.854	5.6	5.34	5.38	16.327		2	A	0.001	0	A	0	0
ZQ325	YES	5.8542	0.0012	YES	5.0208	NO			5.854	5.21	5.4	5.44	16.04		2	A	0	0	A	0	0
ZQ329	YES	3.5625	0.7116	NO		NO			1.759	0	0.04	1.56	1.593		0.6	Dc	0.724	1	Dc	0.712	0.964
ZQ331	YES	10.9271	0.5337	NO		NO			7.815	7.43	0	4.14	11.563		1.5	Cb	0.519	1	Cb	0.507	0.966
ZQ334	YES	1.5625	0.7348	NO		NO			0.719	0	0.06	0.64	0.696		0.5	Dc	0.743	1	Dc	0.73	0.918
ZQ335	YES	1.4375	0.8396	NO		NO			0.424	0	0.13	0.03	0.164		0.3	Db	0.84	0.9	Cc	0.908	0.917
ZQ336	YES	3.375	0.8298	NO		NO			1.051	0.99	0	0	0.987		0.3	Da	0.826	1	Da	0.81	0.97
ZQ337	YES	0.0625	0.8864	NO		NO			0.013	0	0.02	0	0.015		0.1	Db	0.887	0.9	Cc	0.917	0.959
ZQ338	YES	3.4271	0.6402	NO		NO			2.022	1.18	1.71	1.31	4.206		0.7	Db	0.649	0.8	Db	0.661	0.761
ZQ339	YES	0.4791	0.8409	NO		NO			0.14	0.07	0	0.12	0.187		0.2	Cb	0.821	0.9	Cb	0.874	0.948
ZQ340	YES	0.0938	0.8715	NO		NO			0.023	0	0	0.02	0.023		0.1	Dc	0.887	1	Cb	0.906	0.952
ZQ341	YES	0.0729	0.8819	NO		NO			0.016	0	0	0.02	0.017		0.1	Dc	0.88	0.9	Da	0.945	0.935
ZQ342	YES	24.9895	0.847	NO		NO			7.062	0	5.34	6.13	11.468		0.5	Ca	0.828	1	Ca	0.836	0.989
ZQ346	YES	11.0937	0.5725	NO		NO			7.458	6.74	0	4.34	11.076		1.4	Da	0.576	1	Da	0.567	0.898
ZQ348	YES	11.3333	0.5761	NO		NO			7.572	3.34	3.86	7.18	14.376		1.4	Dc	0.576	0.8	Ca	0.593	0.827
ZQ354	YES	11.3541	0.5296	NO		NO			8.17	3.27	7.88	0	11.145		1.6	Db	0.524	1	Db	0.52	0.941

ZQ355	YES	1.4375	0.8396	NO		NO			0.424	0	0.13	0.03	0.164		0.3	Db	0.84	0.9	Cc	0.908	0.917
ZQ359	YES	14.125	0.6771	NO		NO			7.649	6.31	5.86	1.08	13.258		1.1	Cc	0.595	0.9	Dc	0.846	0.599
ZQ360	YES	12.3542	0.7217	NO		NO			5.92	5.12	4.94	0.61	10.663		0.9	Cc	0.65	0.9	Cc	0.64	0.887
ZQ362	YES	4.4687	0.7892	NO		NO			1.685	1.53	0	0.07	1.6		0.4	Da	0.785	1	Da	0.773	0.972
ZQ399	YES	34.323	0.252	NO		NO			32.143	11.68	23.69	6.1	41.47		3.7	Db	0.252	0.8	Db	0.258	0.829
ZQ401	YES	5.0105	0.8457	NO		NO			1.427	0	0	1.22	1.221		0.3	Dc	0.845	1	Cb	0.858	1.004
ZQ402	YES	4.8021	0.8685	NO		NO			1.18	0	0	1.12	1.122		0.3	Cb	0.865	1	Cb	0.874	1.002
ZQ411	YES	6.2604	0.6317	NO		NO			3.762	3.42	1.66	0	5.085		0.7	Da	0.632	1	Da	0.641	0.967
ZQ412	YES	6.2708	0.6318	NO		NO			3.768	3.41	0	2.18	5.595		0.7	Cb	0.602	1	Cb	0.602	0.974
ZQ413	YES	6.2709	0.625	NO		NO			3.821	3.47	0	2.21	5.68		0.8	Cb	0.592	1	Cb	0.595	0.981
ZQ415	YES	6.0937	0	YES	5.1667	NO			6.094	5.44	5.37	5.53	16.339		2	A	0	0	A	0	0
ZQ416	YES	11.1146	0	YES	5.3437	YES	6.1041	1.1202	11.115	5.59	5.64	6.13	17.354	0.1631	3.3	A	0	0	A	0	0
ZQ418	YES	4.7813	0.8653	NO		NO			1.201	0	0	1.14	1.136		0.3	Dc	0.865	1	Dc	0.867	1.004
ZQ419	YES	4.8229	0.8687	NO		NO			1.183	0	0	1.14	1.144		0.3	Cb	0.865	1	Dc	0.87	1.005
ZQ434	YES	16.9166	0.3951	NO		YES	16.7708	1.3456	14.276	0	13.74	0	13.74	19.374	2	Db	0.883	1	Db	0.887	1.002
ZQ436	YES	16.875	0.5837	NO		YES	16.6666	1.3186	11.126	0	10.52	0	10.521	11.2787	1.4	Db	0.933	1	Db	0.936	1
ZQ437	YES	0.3541	0.8904	NO		NO			0.073	0.07	0	0	0.074		0.1	Cc	0.858	1	Cc	0.854	0.962
ZQ438	YES	16.1041	0.8418	NO		YES	16.5417	1.2096	4.692	0	4.05	0	4.053	6.8505	0.5	Db	0.985	1	Db	0.973	0.994
ZQ450	YES	8.7813	0.8517	NO		NO			2.411	1.63	0.8	0	2.422		0.3	Cc	0.87	1	Cc	0.863	0.998
ZQ451	YES	8.9479	0.7998	NO		NO			3.224	2.15	1.19	0	3.335		0.4	Cc	0.804	1	Db	0.815	0.974
ZQ453	YES	6.0312	0.0004	YES	5.302	YES	10.0937	1.1157	6.031	5.42	5.62	5.74	16.787	0.3174	2	A	0.001	0	A	0	0.003
ZQ455	YES	0.4271	0.8848	NO		YES	6.5938	1.1399	0.093	0.09	0	0	0.09	1.6213	0.1	Cc	0.986	1	Cc	0.987	1.001
ZQ456	YES	7.4584	0.8426	NO		YES	7.6771	1.15	2.163	1.64	0	0	1.644	2.0108	0.3	Cc	0.97	1	Cc	0.978	1.006
ZQ459	YES	5.3855	0.8819	NO		YES	5.6458	1.1342	1.197	1.06	0	0	1.062	1.3987	0.2	Cc	0.973	1	Cc	0.975	1.001
ZQ462	YES	38.1979	0.6835	NO		NO			20.353	0	12.11	19.75	31.862		1.6	Ca	0.654	1	Ca	0.663	1.017
ZQ463	YES	11.2917	0.6799	NO		NO			6.072	0	3.53	5.78	9.311		1.1	Ca	0.652	1	Ca	0.647	1.015
ZQ465	YES	0.0313	0.8982	NO		NO			0.006	0	0.01	0	0.008		0.1	Db	0.898	1	Db	0.906	1.009
ZQ466	YES	14.875	0.8471	NO		NO			4.201	4.04	3.42	3.33	10.788		0.5	Cc	0.827	0.9	Da	0.876	0.883
ZQ467	YES	13.8958	0.8553	NO		NO			3.73	3.61	0	0	3.612		0.5	Cc	0.852	1	Cc	0.87	1.013
ZQ468	YES	13.948	0.8475	NO		NO			3.93	3.65	0.04	0	3.688		0.5	Cc	0.839	1	Cc	0.884	0.981
ZQ469	YES	13.4479	0.8453	NO		NO			3.839	3.65	0.16	0	3.807		0.5	Cc	0.827	1	Cc	0.854	1
ZQ478	YES	7.7917	0.6362	NO		NO			4.638	3.06	0	0.71	3.772		0.7	Da	0.641	1	Da	0.622	1.001
ZQ479	YES	4.75	0.5736	NO		NO			3.187	2.77	0	1.37	4.14		0.9	Cb	0.553	0.9	Da	0.573	0.927
ZQ480	YES	7.6979	0.5877	NO		NO			5.039	4.59	0	2.06	6.648		0.8	Cb	0.562	1	Da	0.58	0.944
ZQ482	YES	2.3854	0.8078	NO		YES	2.3229	1.2082	0.829	0	0	0.71	0.713	0.9129	0.4	Cb	0.981	1	Cb	0.971	0.984
ZQ483	YES	25.6979	0.4698	NO		YES	25.4687	1.3881	20.026	0	0	15.07	15.067	21.0355	2.7	Cb	0.924	1	Cb	0.922	0.986
ZQ484	YES	16.8542	0.0413	YES	14.9479	YES	25.8959	1.5567	16.825	0	0	16.13	16.134	39.0739	3.2	Dc	0.83	1	Dc	0.825	0.986
ZQ486	YES	16.2604	0.6056	NO		YES	16.1979	1.3263	10.297	0	0	9.68	9.676	10.8895	1.3	Dc	0.953	1	Dc	0.942	0.976
ZQ487	YES	4.5417	0.8937	NO		NO			0.914	0	0.81	0	0.811		0.2	Db	0.895	1	Db	0.9	1.014
ZQ488	YES	95.2188	0.0014	YES	71.9896	YES	6.1354	1.1682	95.219	82.02	85.51	80.64	248.17	2.8993	5	A	0.001	0	A	0	0
ZQ489	YES	5.3542	0.8844	NO		NO			1.166	0.27	0.78	0	1.058		0.2	Cc	0.85	1	Cc	0.833	0.97
ZQ490	YES	5.8958	0.0016	YES	5.4583	NO			5.896	5.73	5.66	5.77	17.164		2	A	0.001	0	A	0.001	0

ZQ493	YES	0.1459	0.8487	NO		NO			0.041	0	0.04	0	0.039		0.2	Db	0.972	1	Db	0.973	0.99
ZQ494	YES	5.8126	0.7676	NO		NO			2.388	1.96	2.2	0	4.153		0.5	Cc	0.68	1	Cc	0.689	0.976
ZQ495	YES	55.0417	0.7117	NO		NO			27.162	26.32	0	10.79	37.111		1.4	Cb	0.683	1	Da	0.715	0.995
ZQ496	YES	2.8125	0.7475	NO		NO			1.241	1.1	0	0.56	1.66		0.5	Da	0.747	1	Da	0.755	0.987
ZQ497	YES	17.4583	0.3733	NO		NO			15.025	8.01	0.09	9.54	17.631		2.1	Cb	0.367	0.9	Cb	0.391	0.874
ZQ498	YES	3	0.3823	NO		NO			2.562	1.41	0.16	2.18	3.758		1.2	Cb	0.361	0.9	Cb	0.38	0.885
ZQ499	YES	19.4271	0.3866	NO		NO			16.524	9.88	0.71	15.92	26.518		2	Cb	0.351	0.9	Dc	0.399	0.894
ZQ501	YES	6.5834	0.595	NO		NO			4.253	0	3.86	1.38	5.238		0.8	Db	0.596	1	Db	0.613	0.987
ZQ504	YES	95.2604	0.0005	YES	90.0208	YES	1.0417	1.3538	95.26	92.85	93.49	93.13	279.467	0.5226	5	A	0	0	A	0	0
ZQ510	YES	5.9792	0.0027	YES	5.1979	NO			5.979	5.44	5.43	5.54	16.415		2	A	0	0	A	0	0
ZQ511	YES	5.9792	0.0027	YES	5.1979	NO			5.979	5.44	5.43	5.54	16.415		2	A	0	0	A	0	0
ZQ512	YES	95.125	0.001	YES	89.9791	YES	0.5313	1.2435	95.125	93.6	93.47	93.43	280.504	0.2171	5	A	0	0	A	0	0
ZQ513	YES	5.8749	0.0028	YES	5.0624	NO			5.875	5.24	5.34	5.41	15.984		2	A	0	0	A	0	0
ZQ515	YES	5.0105	0.7704	NO		NO			2.037	0.75	0	1.91	2.654		0.5	Dc	0.77	1	Cb	0.78	1.004
ZQ516	YES	5.0521	0.774	NO		NO			2.026	0.92	0	1.94	2.857		0.5	Cb	0.771	1	Cb	0.778	1.012
ZQ517	YES	5.0104	0.7744	NO		NO			2.006	0.84	0	1.91	2.756		0.5	Cb	0.771	1	Dc	0.79	1.009
ZQ520	YES	5.125	0.8862	NO		NO			1.1	0	1.05	0	1.053		0.2	Db	0.888	1	Ca	0.909	0.989
ZQ521	YES	93.8646	0.8416	NO		NO			27.381	0	0	25.49	25.495		0.8	Ca	0.835	1	Dc	0.849	0.993
ZQ522	YES	79.1354	0.635	NO		YES	3.2917	1.1739	47.226	32.38	14.16	22.63	69.157	1.1151	1.8	Da	0.636	0.8	Cb	0.68	0.756
ZQ523	YES	245.25	0.0008	YES	244.688	NO			245.25	243.95	243.61	243.73	731.295		5	A	0	0	A	0	0
ZQ524	YES	69.9584	0.6602	NO		NO			39.466	35.72	35.6	35.4	106.71		1.7	Da	0.66	0.7	Db	0.686	0.701
ZQ529	YES	16.5417	0.6916	NO		YES	15.5833	1.3513	8.63	2.76	0	0.86	3.622	1.1538	1	Da	0.485	1	A	0.005	0.008
ZQ530	YES	11.5417	0.8597	NO		YES	16.8124	1.3673	3.011	0	0.05	0.02	0.076	3.5342	0.5	Cc	0.799	1	A	0.001	0.003
ZQ531	YES	95.3959	0	YES	94.7188	NO			95.396	94.42	94.42	94.58	283.424		5	A	0	0	A	0	0
ZQ532	YES	95.4791	0	YES	94.8959	NO			95.479	94.5	94.74	94.7	283.941		5	A	0	0	A	0	0
ZQ533	YES	5.6354	0	YES	5.1874	NO			5.635	5.42	5.36	5.5	16.276		2	A	0	0	A	0	0
ZQ535	YES	42.4479	0.7744	NO		NO			16.992	16.2	16.47	16.28	48.955		1.1	A	0.775	0.8	A	0.78	0.784
ZQ536	YES	42.4376	0.7691	NO		NO			17.335	16.39	16.5	16.68	49.568		1.2	A	0.772	0.8	A	0.774	0.78
ZQ537	YES	9.5	0.0009	YES	5.4479	NO			9.5	5.99	6.26	5.95	18.203		2	A	0.001	0	A	0	0
ZQ545	YES	95.4688	0	YES	88.2813	YES	0.7396	1.2577	95.469	93.22	93.09	93.46	279.774	0.2281	5	A	0	0	A	0	0
ZQ563	YES	20.9584	0.8531	NO		NO			5.705	0	0	5.54	5.541		0.5	Dc	0.853	1	Dc	0.872	1.018
ZQ564	YES	10.2083	0.0008	YES	5.4687	NO			10.208	5.75	5.68	5.85	17.29		3.3	A	0	0	A	0	0
ZQ565	YES	95.0834	0	YES	89.5104	YES	0.7083	1.1706	95.083	93.64	93.57	92.79	280.006	0.1111	5	A	0	0	A	0	0
ZQ566	YES	5.6041	0.0008	YES	5.1667	NO			5.604	5.47	5.41	5.31	16.2		2	A	0	0	A	0	0
ZQ579	YES	20.9167	0.8695	NO		NO			5.103	4.76	0	0	4.761		0.4	Da	0.872	1	Da	0.885	1.005
ZQ582	YES	95.4166	0	YES	93.6666	NO			95.417	94.27	94.63	94.56	283.453		5	A	0	0	A	0	0
ZQ583	YES	4.75	0.8559	NO		NO			1.27	1.19	0	0	1.19		0.3	Da	0.859	1	Da	0.861	0.96
ZQ584	YES	5.75	0.1664	NO		NO			5.591	4.87	3.12	2.01	10.002		1.7	Da	0.167	0.8	Da	0.173	0.781
ZQ588	YES	5.927	0.0004	YES	5.0937	NO			5.927	5.28	5.32	5.46	16.067		2	A	0	0	A	0	0
ZQ592	YES	10.125	0.8267	NO		NO			3.205	3.01	0	0	3.008		0.6	Da	0.826	1	Da	0.831	0.974
ZQ593	YES	10.2084	0.7608	NO		NO			4.3	3.22	0.03	0.05	3.303		0.8	Da	0.761	0.9	Da	0.804	0.939
ZQ594	YES	5.073	0.7789	NO		NO			1.995	1.86	0.65	0	2.512		0.4	Da	0.782	1	Da	0.778	0.991

ZQ595	YES	32.4792	0.8182	NO		NO			10.736	9.6	0	0	9.597		0.9	Cc	0.811	1	Da	0.792	1.009
ZQ596	YES	30.8646	0.7815	NO		NO			12.014	9.44	3.03	0	12.47		1.1	Da	0.783	1	Cc	0.786	0.974
ZQ597	YES	3.9687	0.881	NO		NO			0.888	0	0	0.82	0.819		0.2	Cb	0.876	1	Dc	0.889	1.011
ZQ600	YES	1.4896	0.6596	NO		NO			0.842	0.26	0.45	0	0.714		0.7	Cc	0.559	0.9	Cc	0.696	0.94
ZQ601	YES	92.1041	0.0003	YES	86.9479	YES	3.3959	1.3416	92.104	89.86	89.48	90.11	269.45	0.7217	5	A	0	0	A	0	0
ZQ608	YES	1.0208	0.8958	NO		NO			0.202	0	0	0.02	0.024		0.2	Dc	0.894	1	Ca	0.938	0.982
ZQ610	YES	5.8542	0.001	YES	5.4062	NO			5.854	5.7	5.55	5.67	16.917		2	A	0	0	A	0	0
ZQ611	YES	95.3334	0.0003	YES	88.5625	YES	0.1042	1.112	95.333	93.23	92.92	92.87	279.023	0.0254	5	A	0	0	A	0	0
ZQ612	YES	8.0104	0.0009	YES	5.2292	YES	10.4271	1.1807	8.01	5.48	5.57	5.35	16.397	1.6667	2	A	0	0	A	0	0
ZQ613	YES	67.5	0.8105	NO		NO			23.159	13.96	21.21	12.64	47.808		0.9	Cc	0.809	0.8	A	0.816	0.822
ZQ614	YES	41.3333	0.8911	NO		NO			8.512	0	7.07	0	7.071		0.5	Db	0.893	1	Db	0.907	1.001
ZQ616	YES	27.9479	0.8958	NO		NO			5.521	0	3.37	0	3.367		0.5	Db	0.896	1	Db	0.895	0.998
ZQ618	YES	37.2709	0.8952	NO		NO			7.403	0	4.6	0	4.596		0.5	Db	0.896	1	Db	0.904	0.997
ZQ619	YES	33.4791	0.8873	NO		NO			7.121	6.61	0.21	2.69	9.516		0.6	Cb	0.887	0.9	Dc	0.899	0.908
ZQ620	YES	81.6563	0.8947	NO		NO			16.291	0	11.5	0	11.499		0.5	Db	0.894	1	Db	0.904	0.998
ZQ621	YES	83.1042	0.8914	NO		NO			17.07	0	16.31	0	16.31		0.5	Db	0.893	1	Db	0.904	0.995
ZQ622	YES	83.0834	0.8945	NO		NO			16.606	0	11.39	0	11.394		0.5	Db	0.895	1	Db	0.902	0.992
ZQ626	YES	11.9687	0.7827	NO		NO			4.636	1.7	0.71	2.76	5.164		0.7	Cb	0.768	0.9	Cb	0.789	0.845
ZQ629	YES	12.4896	0.8187	NO		NO			4.118	3	3.93	3.13	10.051		0.6	Ca	0.814	0.9	Ca	0.845	0.891
ZQ632	YES	12.7708	0.8874	NO		NO			2.714	0	2.62	0	2.616		0.4	Db	0.887	1	Db	0.886	0.994
ZQ633	YES	3.9896	0.8832	NO		NO			0.878	0	0	0.86	0.855		0.2	Dc	0.881	1	Dc	0.909	0.989
ZQ640	YES	95.5938	0	YES	86.8854	YES	0.2291	1.1533	95.594	92.58	93.11	94.05	279.736	0.0691	5	A	0	0	A	0	0
ZQ641	YES	9.2291	0	YES	5.4687	NO			9.229	5.7	5.92	5.8	17.413		2	A	0	0	A	0	0
ZQ642	YES	3.5833	0.8399	NO		NO			1.056	0.92	0	0	0.925		0.3	Da	0.85	1	Cc	0.887	0.951
ZQ644	YES	3.9375	0.812	NO		NO			1.341	1.04	1.2	0	2.237		0.4	Cc	0.771	0.9	Cc	0.776	0.944
ZQ645	YES	3.875	0.8516	NO		NO			1.065	0.92	0.99	0	1.918		0.3	Cc	0.806	1	Cc	0.819	1.004
ZQ646	YES	3.9167	0.8195	NO		NO			1.286	1.12	1.15	0	2.278		0.4	Cc	0.77	0.9	Cc	0.773	0.944
ZQ647	YES	3.3854	0.879	NO		NO			0.77	0	0.73	0	0.73		0.2	Db	0.879	1	Db	0.861	0.955
ZQ648	YES	3.6459	0.8685	NO		NO			0.896	0	0.83	0	0.834		0.3	Db	0.873	1	Db	0.857	0.959
ZQ649	YES	3.3959	0.8764	NO		NO			0.788	0	0.71	0	0.713		0.2	Db	0.876	1	Db	0.856	0.96
ZQ651	YES	4.5625	0.8972	NO		NO			0.89	0	0.52	0	0.522		0.2	Cc	0.896	0.9	Cc	0.908	0.936
ZQ654	YES	8.125	0.6792	NO		YES	8.0937	1.2737	4.377	0	0	4.02	4.015	4.2769	0.6	Cb	0.955	1	Cb	0.967	1.013
ZQ655	YES	7.9687	0.7846	NO		YES	8.0208	1.2394	3.063	0	0	2.36	2.355	3.2612	0.4	Dc	0.972	1	Cb	0.979	1
ZQ657	YES	7.9792	0.7828	NO		YES	8.0312	1.2335	3.09	0	0	2.42	2.42	3.205	0.4	Dc	0.958	1	Cb	0.974	1.002
ZQ659	YES	8.0417	0.7439	NO		YES	8.0521	1.2308	3.592	0	0	3.06	3.062	3.4203	0.5	Cb	0.959	1	Cb	0.971	1.011
ZQ662	YES	29.375	0.8642	NO		NO			7.437	0	7.26	0	7.262		0.7	Ca	0.856	1	Ca	0.873	1.014
ZQ663	YES	33.3229	0.8494	NO		NO			9.281	0	9.05	0	9.052		0.8	Db	0.849	1	Ca	0.87	1.009
ZQ664	YES	5.1667	0.8623	NO		NO			1.325	0	1.27	0	1.275		0.3	Db	0.863	1	Db	0.866	0.992
ZQ665	YES	5.4896	0.8174	NO		NO			1.822	0	1.72	0	1.722		0.4	Db	0.818	1	Db	0.828	1.002
ZQ666	YES	45.6771	0.6629	NO		NO			25.605	21.06	22.73	20.54	64.328		1.7	A	0.663	0.7	Db	0.653	0.663
ZQ668	YES	5.5833	0.7819	NO		YES	5.5417	1.1783	2.17	0	1.91	0	1.907	1.7609	0.4	Ca	0.975	1	Ca	0.987	1.007
ZQ669	YES	5.6355	0.6846	NO		YES	5.6459	1.2558	2.994	0	2.55	0	2.55	2.7518	0.6	Ca	0.967	1	Db	0.95	0.989

ZQ671	YES	5.9583	0.5344	NO		YES	5.9792	1.2993	4.257	0	3.7	0	3.7	4.5419	0.9	Ca	0.929	1	Ca	0.924	0.991
ZQ672	YES	6.3333	0.3369	NO		YES	6	1.3253	5.614	0	4.8	0	4.8	6.658	1.3	Ca	0.858	1	Ca	0.859	0.976
ZQ673	YES	41.9479	0.6675	NO		NO			23.258	21.7	21.86	21.88	65.442		1.7	A	0.668	0.7	Dc	0.662	0.67
ZQ674	YES	41.8021	0.6706	NO		NO			23.004	21.74	21.85	21.92	65.512		1.6	A	0.67	0.7	Dc	0.661	0.671
ZQ679	YES	21.6042	0.6985	NO		NO			11.063	8.37	7.28	6.42	22.062		1	Cc	0.676	0.8	Da	0.743	0.755
ZQ680	YES	2.1563	0.8801	NO		NO			0.486	0.02	0.12	0	0.138		0.2	Cc	0.865	0.9	Dc	0.958	0.914
ZQ681	YES	94.9688	0.0006	YES	28.3854	YES	0.2291	1.2186	94.969	28.53	28.52	94.06	151.116	0.0908	5	A	0	0	A	0	0
ZQ682	YES	95.3438	0.004	YES	94.3541	NO			95.342	94.25	94.36	94.48	283.095		5	A	0	0	A	0	0
ZQ683	YES	145.406	0.4067	NO		NO			121.36	116.35	99.15	0	215.495		3	Cc	0.069	1	Cc	0.052	1.016
ZQ684	YES	32.3229	0.0041	YES	5.4583	NO			32.322	6.78	8.38	5.64	20.803		5	A	0.001	0	A	0	0
ZQ689	YES	94.8959	0	YES	86.802	YES	1.0937	1.2238	94.896	92.12	92.9	92.3	277.317	0.2871	5	A	0	0	A	0	0
ZQ690	YES	95.5	0.0039	YES	94.4896	NO			95.499	94.78	94.89	94.81	284.481		5	A	0	0	A	0	0
ZQ691	YES	1.8021	0.1105	NO		NO			1.78	0.96	0.87	0.57	2.402		1.8	Cc	0.108	0.3	Cc	0.196	0.521
ZQ693	YES	2.0834	0.8909	NO		NO			0.43	0.06	0	0.01	0.061		0.2	Cb	0.881	0.9	Da	0.926	0.963
ZQ694	YES	95.3541	0.0004	YES	86.6458	YES	2.3021	1.5272	95.354	91.53	91.4	92.36	275.29	1.3072	5	A	0	0	A	0	0
ZQ695	YES	10.0313	0.0012	YES	5.2187	YES	9.1042	1.1617	10.031	5.52	5.66	5.39	16.57	0.3201	3.3	A	0	0	A	0	0
ZQ696	YES	95.2396	0.0003	YES	85.8958	YES	0.7813	1.2542	95.24	92.87	92.48	92.83	278.186	0.236	5	A	0	0	A	0	0
ZQ697	YES	13.1458	0.0012	YES	5.4375	NO			13.146	5.99	5.99	5.76	17.736		3.3	A	0	0	A	0	0
ZQ700	YES	51.5209	0.3459	NO		NO			45.357	21.82	27.56	4.15	53.531		3.3	Cc	0.288	0.4	Cc	0.316	0.368
ZQ703	YES	6.9583	0	YES	5.177	NO			6.958	5.52	5.38	5.48	16.389		2	A	0	0	A	0	0
ZQ706	YES	95.5834	0.0015	YES	88.0416	YES	0.9896	1.2801	95.583	93.11	92.82	93.95	279.876	0.384	5	A	0	0	A	0	0
ZQ707	YES	13.0625	0.0021	YES	5.2187	NO			13.062	5.68	6.32	5.5	17.506		3.3	A	0.001	0	A	0.001	0.001
ZQ708	YES	92.3645	0.0007	YES	85.6875	YES	1.2084	1.2875	92.364	89.84	89.64	90.6	270.08	0.7339	5	A	0	0	A	0	0
ZQ709	YES	11.2083	0.0022	YES	5.375	NO			11.208	6.25	5.81	5.61	17.674		3.3	A	0.001	0	A	0.001	0.001
ZQ710	YES	46.8229	0.3045	NO		NO			42.481	39.21	39.27	39.89	118.364		3.5	Dc	0.304	0.4	Dc	0.343	0.376
ZQ711	YES	3.0938	0.6598	NO		NO			1.747	0.26	0.22	0.14	0.624		0.7	Cc	0.631	0.9	Cc	0.78	0.891
ZQ712	YES	46.8542	0.3321	NO		NO			41.687	39.23	39.23	39.64	118.088		3.3	Ca	0.305	0.4	Dc	0.358	0.378
ZQ713	YES	33.1145	0.0043	YES	5.2917	NO			33.114	7.74	8.18	5.5	21.42		5	A	0.001	0	A	0	0
ZQ715	YES	15.0625	0.5995	NO		NO			9.649	0	9.2	4.13	13.328		1.3	Db	0.6	1	Db	0.627	1
ZQ716	YES	0.6875	0.8511	NO		NO			0.189	0	0.15	0	0.157		0.1	Db	0.852	0.9	Dc	0.971	0.918
ZQ717	YES	15.052	0.5926	NO		NO			9.766	0	9.44	4.19	13.634		1.3	Db	0.596	1	Db	0.617	1.007
ZQ730	YES	0.8125	0.8128	NO		NO			0.276	0	0.22	0	0.216		0.2	Db	0.815	0.9	Cc	0.899	0.962
ZQ731	YES	1.2812	0.8849	NO		NO			0.278	0	0.19	0.16	0.353		0.2	Db	0.89	0.9	Da	0.908	0.923
ZQ732	YES	3.0625	0.2003	NO		NO			2.94	2.14	1.77	2.36	6.271		1.6	Ca	0.198	0.2	Cb	0.214	0.221
ZQ733	YES	2.6042	0.777	NO		NO			1.032	0.79	0.68	0.85	2.329		0.4	Ca	0.777	0.8	Db	0.778	0.792
ZQ734	YES	2.1042	0.8462	NO		NO			0.597	0.45	0.45	0.49	1.391		0.3	Db	0.849	0.9	Dc	0.857	0.885
ZQ735	YES	2.2813	0.8357	NO		NO			0.688	0.5	0.51	0.57	1.579		0.3	Db	0.837	0.8	Ca	0.85	0.867
ZQ736	YES	2.2916	0.8366	NO		NO			0.688	0.58	0.49	0.52	1.594		0.3	Cc	0.839	0.8	Db	0.86	0.87
ZQ737	YES	2.0729	0.8496	NO		NO			0.577	0.42	0.42	0.48	1.322		0.3	Ca	0.849	0.9	Dc	0.866	0.893
ZQ738	YES	12.5	0.8007	NO		NO			4.486	0	4.31	0	4.309		0.7	Db	0.801	1	Ca	0.836	1.005
ZQ740	YES	24.875	0.8028	NO		NO			8.843	7.44	0	5.86	13.299		0.7	Cb	0.726	1	Cb	0.753	1.002
ZQ741	YES	2.1355	0.8681	NO		NO			0.526	0	0.08	0.02	0.098		0.3	Ca	0.852	1	Ca	0.939	1.016

ZQ742	YES	3.2188	0.8505	NO		NO			0.89	0.2	0	0.03	0.233		0.3	Da	0.85	0.9	Cb	0.929	0.997
ZQ743	YES	0.0313	0.8984	NO		NO			0.006	0	0.01	0	0.008		0.1	Ca	0.885	0.9	A	0.946	0.947
ZQ755	YES	5.0625	0.7822	NO		NO			1.965	1.87	0.89	0	2.756		0.4	Cc	0.783	1	Da	0.79	0.98
ZQ756	YES	32.1146	0.7823	NO		NO			12.461	11.05	2.67	0	13.721		1.1	Cc	0.782	1	Cc	0.792	0.966
ZQ758	YES	5.573	0.8387	NO		YES	5.3542	1.1224	1.653	0	0	1.52	1.519	0.8669	0.3	Dc	0.975	1	Db	0.983	0.974
ZQ759	YES	5.0104	0.8782	NO		NO			1.146	0	0.57	0.59	1.153		0.2	Ca	0.851	1	Ca	0.839	0.96
ZQ761	YES	5.6979	0.7632	NO		NO			2.379	0	1.91	1.96	3.876		0.5	Ca	0.688	1	Ca	0.684	0.961
ZQ762	YES	95.2604	0.0012	YES	76.9271	YES	5.9479	1.3079	95.26	83.58	83.95	87.31	254.836	2.4675	5	A	0.001	0	A	0	0
ZQ763	YES	5.9062	0.0014	YES	5.4375	NO			5.906	5.59	5.74	5.73	17.065		2	A	0.001	0	A	0	0
ZQ766	YES	2.0104	0.1109	NO		NO			1.986	1.02	0.81	0.52	2.357		1.8	Cc	0.085	0.2	Cb	0.497	0.38
ZQ767	YES	95.4271	0.0043	YES	94.5729	NO			95.425	94.49	94.43	94.4	283.32		5	A	0	0	A	0	0
ZQ769	YES	8.4167	0.7198	NO		NO			4.056	0.18	0.1	1.11	1.401		0.6	Dc	0.719	0.9	Dc	0.84	0.976
ZQ770	YES	15.1354	0.8735	NO		YES	16.2812	1.1518	3.587	0.26	0	0.2	0.46	2.5725	0.4	Da	0.476	0.8	Da	0.023	0.044
ZQ771	YES	245.156	0.0008	YES	244.5	YES	0.1042	1.15	245.16	243.39	243.34	243.21	729.946	0.0318	5	A	0.001	0	A	0	0
ZQ773	YES	6.9374	0.001	YES	5.0937	NO			6.937	5.49	5.27	5.32	16.08		2	A	0.001	0	A	0	0
ZQ774	YES	13.8021	0.0042	YES	5.0312	NO			13.802	5.62	5.3	5.35	16.262		3.3	A	0	0	A	0	0
ZQ778	YES	2.2708	0.8777	NO		NO			0.521	0.01	0.16	0.01	0.181		0.2	Cc	0.868	0.9	Ca	0.922	0.945
ZQ779	YES	2.0521	0.1249	NO		NO			2.02	0.86	0.65	0.46	1.966		1.8	Cc	0.116	0.3	Da	0.387	0.595
ZQ783	YES	10.9167	0.8743	NO		NO			2.572	0	0	2.35	2.348		0.4	Cb	0.87	1	Dc	0.87	0.963
ZQ784	YES	8.25	0.8883	NO		NO			1.74	0	0	1.51	1.51		0.2	Dc	0.89	1	Dc	0.874	0.953
ZQ785	YES	2.875	0.5746	NO		NO			1.926	0.02	0.29	0.18	0.487		0.9	Db	0.573	1	Ca	0.755	0.96
ZQ786	YES	4.8958	0.6274	NO		NO			2.969	2.59	1.54	0	4.122		0.7	Cc	0.623	1	Cc	0.639	0.984
ZQ788	YES	9.6875	0.6038	NO		NO			6.156	5.3	3.14	0	8.445		0.8	Da	0.604	1	Cc	0.629	0.977
ZQ791	YES	0.7188	0.509	NO		NO			0.533	0.37	0.25	0	0.626		0.5	Cc	0.426	1	Cc	0.589	1.019
ZQ792	YES	145.792	0.4939	NO		NO			110.23	108.84	0	108.63	217.47		2.5	Cb	0.036	1	Cb	0.039	1.022
ZQ794	YES	5.5417	0.6239	NO		NO			3.385	2.78	1.66	0	4.442		0.8	Da	0.624	1	Cc	0.645	0.977
ZQ796	YES	4.6042	0.6131	NO		NO			2.874	2.26	1.34	0	3.599		0.8	Da	0.613	1	Cc	0.645	0.975
ZQ798	YES	5.1459	0.6104	NO		NO			3.229	2.69	1.54	0	4.234		0.8	Da	0.61	1	Cc	0.642	0.974
ZQ799	YES	9.1146	0.6088	NO		NO			5.736	4.89	3	0	7.891		0.8	Da	0.609	1	Cc	0.636	0.963
ZQ801	YES	10.5521	0.6406	NO		NO			6.222	5.54	3.43	0	8.966		1.2	Cc	0.626	1	Cc	0.642	0.978
ZQ802	YES	0.1354	0.8735	NO		NO			0.032	0	0.03	0.01	0.046		0.1	Ca	0.84	1	Cb	0.979	0.959
ZQ805	YES	0.0313	0.898	NO		NO			0.006	0.01	0	0	0.008		0.1	Cb	0.887	1	Cb	0.937	0.971
ZQ809	YES	95.125	0.0003	YES	87.6667	YES	0.302	1.2335	95.125	93.26	93.19	92.82	279.271	0.1132	5	A	0	0	A	0	0
ZQ812	YES	10.0625	0.0009	YES	5.2708	YES	10.0521	1.1197	10.062	5.41	5.55	5.6	16.549	0.1283	3.3	A	0	0	A	0	0
ZQ813	YES	94.6875	0.0002	YES	88.8958	YES	1.0729	1.1794	94.687	92.98	92.47	93.11	278.554	0.3796	5	A	0	0	A	0	0
ZQ814	YES	5.6874	0.001	YES	5.2499	NO			5.687	5.43	5.45	5.57	16.45		2	A	0.001	0	A	0	0
ZQ816	YES	85.9791	0	YES	82.2813	YES	8.8334	1.1434	85.979	85.04	84.42	84.19	253.643	0.2089	5	A	0	0	A	0	0
ZQ817	YES	4.573	0.8489	NO		NO			1.278	0	0	1.12	1.124		0.3	Dc	0.849	1	Cb	0.865	1.002
ZQ818	YES	4.3334	0.8686	NO		NO			1.064	0	0	1.03	1.03		0.3	Cb	0.863	1	Cb	0.858	1.009
ZQ830	YES	9.0416	0.8969	NO		NO			1.768	0	1.35	0	1.348		0.2	Db	0.898	1	Db	0.897	1.011
ZQ831	YES	1.8021	0.7916	NO		NO			0.673	0.62	0	0	0.619		0.4	Da	0.793	1	Da	0.792	0.979
ZQ833	YES	7.2084	0.3773	NO		NO			6.182	4.03	4.28	4.98	13.289		1.2	Dc	0.379	0.6	Dc	0.391	0.569

ZQ834	YES	19.1666	0.3708	NO		NO			16.531	10.73	11.87	13.95	36.551		2.1	Dc	0.373	0.6	Dc	0.377	0.582
ZQ835	YES	17.1459	0.3753	NO		NO			14.731	10.51	11.76	13.64	35.92		2.1	Dc	0.376	0.6	Dc	0.382	0.579
ZQ836	YES	15.5208	0.3749	NO		NO			13.339	10.16	11.11	12.85	34.121		2.1	Dc	0.374	0.6	Dc	0.381	0.576
ZQ839	YES	5.0521	0.7923	NO		NO			1.881	0	0.02	1.75	1.775		0.4	Dc	0.79	1	Dc	0.781	0.97
ZQ840	YES	0.3541	0.8726	NO		NO			0.084	0.04	0	0.03	0.065		0.1	Cb	0.858	1	Da	0.908	0.957
ZQ843	YES	25.0521	0.7972	NO		NO			9.131	7.55	0	6.21	13.763		1	Cb	0.721	1	Cb	0.731	0.996
ZQ844	YES	97.0104	0	YES	81.4063	YES	2.4583	1.8351	97.01	84.48	84.32	84.24	253.046	4.6028	5	A	0	0	A	0	0
ZQ845	YES	2.1979	0.8598	NO		NO			0.573	0	0	0.11	0.108		0.3	Dc	0.859	0.9	Dc	0.93	0.999
ZQ846	YES	24.4688	0.7969	NO		NO			8.93	7.43	0	6.58	14.01		0.7	Cb	0.721	1	Cb	0.736	1
ZQ850	YES	5.1458	0.8996	NO		NO			0.981	0	0.11	0	0.112		0.2	Db	0.898	1	Db	0.896	1.008
ZQ852	YES	20.4167	0.7909	NO		NO			7.646	7.22	0	0	7.225		0.7	Da	0.792	1	Da	0.822	1.037
ZQ853	YES	0.1354	0.8864	NO		NO			0.029	0	0	0.03	0.03		0.1	Dc	0.886	1	Cb	0.974	1.012
ZQ854	YES	36.7396	0.6891	NO		NO			19.293	11.7	13.94	9.56	35.193		1.6	Ca	0.648	0.8	Db	0.708	0.745
ZQ855	YES	32.1771	0.6639	NO		NO			17.995	16.03	14.15	11.99	42.172		1.7	Ca	0.619	0.7	Da	0.685	0.659
ZQ856	YES	1.5104	0.8922	NO		NO			0.308	0.3	0	0	0.3		0.2	Da	0.89	1	Cb	0.938	0.98
ZQ859	YES	3.0833	0.8866	NO		NO			0.66	0	0	0.6	0.599		0.2	Dc	0.886	1	Cb	0.898	0.999
ZQ865	YES	95.5834	0	YES	94.8959	NO			95.583	94.54	94.83	94.75	284.124		5	A	0	0	A	0	0
ZQ867	YES	95.4584	0.0057	YES	89.4791	NO			95.455	93.74	94.25	94.16	282.149		5	Dc	0.006	0	Ca	0.012	0.038
ZQ868	YES	95.4271	0.0052	YES	89.4479	NO			95.425	93.7	94.24	94.15	282.091		5	Dc	0.007	0	Ca	0.012	0.039
ZQ869	YES	47.8958	0.0124	YES	5.2499	NO			47.888	8.68	5.68	8.2	22.56		4.9	Dc	0.014	0.1	Cb	0.007	0.029
ZQ871	YES	95.3541	0.2198	NO		NO			90.747	45.75	59.24	9.01	114.003		3.9	Cc	0.198	0.3	Cc	0.218	0.238
ZQ872	YES	6.052	0.2299	NO		NO			5.732	5.44	5.35	5.32	16.112		1.5	Ca	0.23	0.3	A	0.245	0.248
ZQ879	YES	0.0625	0.894	NO		NO			0.013	0	0.01	0	0.014		0.1	Db	0.894	0.9	Cc	0.934	0.963
ZQ887	YES	6.5834	0.595	NO		NO			4.253	0	3.86	1.38	5.238		0.8	Db	0.596	1	Db	0.613	0.987

* when an event is not classified as a voltage dip, in the column retained voltage minimum voltage is written instead.

Appendix E

MatLab Results - Synthetic sags

- half cycle rms voltage calculated every sample

Synthetic Dip	Sag	Duration of voltage sag [cycles]	Retained voltage * [pu]	Interrup-tion	Interruption Duration [cycles]	Swell	Swell Duration [cycles]	Sag Energy calc. from Dur.& Ret [cycles]	Evs_a, Voltage-Sag Energy Index [cycles]	Evs_b, Voltage-Sag Energy Index [cycles]	Evs_c, Voltage-Sag Energy Index [cycles]	Evs, Voltage-Sag Energy Index [cycles]	Voltage-Swell Energy Index [cycles]	Voltage-Sag Severity [pu]	Six Phase RMS - Dip Type	V (from sixRMS)	F (from sixRMS)	Symmetrical Component Method	V (from symm. comp. method)	F (from symm. comp. method)
A_0.1	YES	5.3906	0.1	YES	4.3203	NO		5.337	4.94	4.92	4.93	14.799		1.8	A	0.1	0.1	A	0.1	0.1
Ba_0.1	YES	5.3906	0.1	YES	4.4844	NO		5.337	4.94	0	0	4.94		1.8	Da	0.4	1	Da	0.4	1
Bb_0.1	YES	5.1641	0.1	YES	4.4766	NO		5.112	0	4.92	0	4.925		1.8	Db	0.4	1	Db	0.4	0.999
Bc_0.1	YES	5.1562	0.1	YES	4.3359	NO		5.105	0	0	4.93	4.934		1.8	Dc	0.4	1	Dc	0.4	1
Ca_0.1	YES	5.2422	0.4481	NO		NO		4.19	0	3.7	3.7	7.408		1.1038	Ca	0.1	1	Ca	0.1	1
Cb_0.1	YES	5.3828	0.4618	NO		NO		4.235	3.7	0	3.71	7.41		1.0764	Cb	0.1	1	Cb	0.1	1
Cc_0.1	YES	5.3828	0.4692	NO		NO		4.198	3.7	3.7	0	7.397		1.0616	Cc	0.1	1	Cc	0.101	0.996
Da_0.1	YES	5.3906	0.1	YES	4.4844	NO		5.337	4.94	1.24	1.24	7.416		1.8	Da	0.1	1	Da	0.1	0.996
Db_0.1	YES	5.1641	0.1	YES	4.4844	NO		5.112	1.2	4.92	1.24	7.366		1.8	Db	0.1	1	Db	0.1	0.999
Dc_0.1	YES	5.1562	0.1	YES	4.5	NO		5.105	1.22	1.24	4.93	7.389		1.8	Dc	0.1	1	Dc	0.1	0.999
Ea_0.1	YES	5.3047	0.1	YES	4.3359	NO		5.252	0	4.92	4.93	9.859		1.8	Ca	0.1	0.7	Ca	0.1	0.7
Eb_0.1	YES	5.3906	0.1	YES	4.3203	NO		5.337	4.94	0	4.93	9.874		1.8	Cb	0.1	0.7	Cb	0.1	0.7
Ec_0.1	YES	5.3906	0.1	YES	4.4609	NO		5.337	4.94	4.92	0	9.865		1.8	Cc	0.1	0.7	Cc	0.1	0.7
Fa_0.1	YES	5.3906	0.1	YES	4.4844	NO		5.337	4.94	3.13	3.14	11.202		1.8	Da	0.1	0.7	Da	0.1	0.7
Fb_0.1	YES	5.3438	0.1	YES	4.4844	NO		5.29	3.14	4.92	3.13	11.195		1.8	Db	0.1	0.7	Db	0.1	0.7
Fc_0.1	YES	5.3359	0.1	YES	4.5	NO		5.283	3.13	3.13	4.93	11.203		1.8	Dc	0.1	0.7	Dc	0.1	0.7

Ga_0.1	YES	5.2812	0.345	NO		NO		4.653	2.53	4.33	4.33	11.196		1.31	Ca	0.1	0.7	Ca	0.1	0.7
Gb_0.1	YES	5.3828	0.3606	NO		NO		4.683	4.34	2.52	4.34	11.201		1.2788	Cb	0.1	0.7	Cb	0.1	0.7
Gc_0.1	YES	5.3906	0.3606	NO		NO		4.69	4.34	4.33	2.53	11.192		1.2788	Cc	0.1	0.7	Cc	0.1	0.7
A_0.2	YES	5.3906	0.2	NO		NO		5.175	4.79	4.77	4.78	14.349		1.6	A	0.2	0.2	A	0.2	0.2
Ba_0.2	YES	5.3906	0.2	NO		NO		5.175	4.79	0	0	4.791		1.6	Da	0.467	1	Da	0.467	1
Bb_0.2	YES	5.1563	0.2	NO		NO		4.95	0	4.77	0	4.775		1.6	Db	0.467	1	Db	0.467	0.999
Bc_0.2	YES	5.1562	0.2	NO		NO		4.95	0	0	4.78	4.784		1.6	Dc	0.467	1	Dc	0.467	1
Ca_0.2	YES	5.2266	0.4849	NO		NO		3.998	0	3.59	3.59	7.179		1.0302	Ca	0.2	1	Ca	0.2	1
Cb_0.2	YES	5.3672	0.5017	NO		NO		4.016	3.59	0	3.59	7.179		0.9966	Cb	0.2	1	Cb	0.2	1
Cc_0.2	YES	5.3672	0.5091	NO		NO		3.976	3.59	3.58	0	7.168		0.9818	Cc	0.2	1	Cc	0.2	0.997
Da_0.2	YES	5.3906	0.2	NO		NO		5.175	4.79	1.19	1.2	7.177		1.6	Da	0.2	1	Da	0.2	0.997
Db_0.2	YES	5.1563	0.2	NO		NO		4.95	1.16	4.77	1.2	7.132		1.6	Db	0.2	1	Db	0.2	0.999
Dc_0.2	YES	5.1562	0.2	NO		NO		4.95	1.17	1.2	4.78	7.155		1.6	Dc	0.2	1	Dc	0.2	0.999
Ea_0.2	YES	5.3047	0.2	NO		NO		5.093	0	4.77	4.78	9.558		1.6	Ca	0.2	0.733	Ca	0.2	0.733
Eb_0.2	YES	5.3906	0.2	NO		NO		5.175	4.79	0	4.78	9.574		1.6	Cb	0.2	0.733	Cb	0.2	0.733
Ec_0.2	YES	5.3906	0.2	NO		NO		5.175	4.79	4.77	0	9.565		1.6	Cc	0.2	0.733	Cc	0.2	0.733
Fa_0.2	YES	5.3906	0.2	NO		NO		5.175	4.79	2.91	2.92	10.616		1.6	Da	0.2	0.733	Da	0.2	0.733
Fb_0.2	YES	5.3281	0.2	NO		NO		5.115	2.92	4.77	2.92	10.609		1.6	Db	0.2	0.733	Db	0.2	0.733
Fc_0.2	YES	5.3125	0.2	NO		NO		5.1	2.91	2.92	4.78	10.615		1.6	Dc	0.2	0.733	Dc	0.2	0.733
Ga_0.2	YES	5.2734	0.3956	NO		NO		4.448	2.29	4.16	4.16	10.61		1.2088	Ca	0.2	0.733	Ca	0.2	0.733
Gb_0.2	YES	5.3828	0.4055	NO		NO		4.498	4.17	2.28	4.16	10.614		1.189	Cb	0.2	0.733	Cb	0.2	0.733
Gc_0.2	YES	5.3828	0.4055	NO		NO		4.498	4.17	4.15	2.29	10.606		1.189	Cc	0.2	0.733	Cc	0.2	0.733
A_0.3	YES	5.3828	0.3	NO		NO		4.898	4.54	4.52	4.53	13.599		1.4	A	0.3	0.3	A	0.3	0.3
Ba_0.3	YES	5.3828	0.3	NO		NO		4.898	4.54	0	0	4.54		1.4	Da	0.533	1	Da	0.533	1
Bb_0.3	YES	5.1484	0.3	NO		NO		4.685	0	4.52	0	4.525		1.4	Db	0.533	1	Db	0.533	1
Bc_0.3	YES	5.1562	0.3	NO		NO		4.692	0	0	4.53	4.534		1.4	Dc	0.533	1	Dc	0.533	1
Ca_0.3	YES	5.2109	0.5314	NO		NO		3.739	0	3.4	3.4	6.798		0.9372	Ca	0.3	1	Ca	0.3	1
Cb_0.3	YES	5.3594	0.5499	NO		NO		3.739	3.4	0	3.4	6.799		0.9002	Cb	0.3	1	Cb	0.3	1
Cc_0.3	YES	5.3594	0.5569	NO		NO		3.697	3.4	3.39	0	6.791		0.8862	Cc	0.3	1	Cc	0.3	0.997
Da_0.3	YES	5.3828	0.3	NO		NO		4.898	4.54	1.12	1.13	6.79		1.4	Da	0.3	1	Da	0.3	0.998
Db_0.3	YES	5.1484	0.3	NO		NO		4.685	1.1	4.52	1.13	6.749		1.4	Db	0.3	1	Db	0.3	0.999
Dc_0.3	YES	5.1562	0.3	NO		NO		4.692	1.1	1.13	4.53	6.765		1.4	Dc	0.3	1	Dc	0.3	0.999
Ea_0.3	YES	5.2969	0.3	NO		NO		4.82	0	4.52	4.53	9.059		1.4	Ca	0.3	0.767	Ca	0.3	0.767
Eb_0.3	YES	5.3828	0.3	NO		NO		4.898	4.54	0	4.53	9.074		1.4	Cb	0.3	0.767	Cb	0.3	0.767
Ec_0.3	YES	5.3828	0.3	NO		NO		4.898	4.54	4.52	0	9.064		1.4	Cc	0.3	0.767	Cc	0.3	0.767
Fa_0.3	YES	5.3828	0.3	NO		NO		4.898	4.54	2.66	2.66	9.861		1.4	Da	0.3	0.767	Da	0.3	0.767
Fb_0.3	YES	5.2969	0.3	NO		NO		4.82	2.66	4.52	2.67	9.853		1.4	Db	0.3	0.767	Db	0.3	0.767
Fc_0.3	YES	5.2656	0.3	NO		NO		4.792	2.63	2.67	4.53	9.833		1.4	Dc	0.3	0.767	Dc	0.3	0.767
Ga_0.3	YES	5.2578	0.4569	NO		NO		4.16	2.03	3.91	3.91	9.847		1.0862	Ca	0.3	0.767	Ca	0.3	0.767
Gb_0.3	YES	5.3672	0.4631	NO		NO		4.216	3.92	2.03	3.91	9.86		1.0738	Cb	0.3	0.767	Cb	0.3	0.767
Gc_0.3	YES	5.375	0.4631	NO		NO		4.222	3.92	3.9	2.03	9.853		1.0738	Cc	0.3	0.767	Cc	0.3	0.766
A_0.4	YES	5.375	0.4	NO		NO		4.515	4.19	4.18	4.18	12.547		1.2	A	0.4	0.4	A	0.4	0.4

Ba_0.4	YES	5.375	0.4	NO		NO		4.515	4.19	0	0	4.189		1.2	Da	0.6	1	Da	0.6	1
Bb_0.4	YES	5.1406	0.4	NO		NO		4.318	0	4.18	0	4.176		1.2	Db	0.6	1	Db	0.6	1
Bc_0.4	YES	5.1406	0.4	NO		NO		4.318	0	0	4.18	4.182		1.2	Dc	0.6	1	Dc	0.6	1
Ca_0.4	YES	5.1953	0.5857	NO		NO		3.413	0	3.13	3.13	6.27		0.8286	Ca	0.4	1	Ca	0.4	1
Cb_0.4	YES	5.3359	0.6044	NO		NO		3.387	3.13	0	3.14	6.27		0.7912	Cb	0.4	1	Cb	0.4	1
Cc_0.4	YES	5.3438	0.6083	NO		NO		3.366	3.14	3.13	0	6.262		0.7834	Cc	0.4	1	Cc	0.4	0.998
Da_0.4	YES	5.375	0.4	NO		NO		4.515	4.19	1.01	1.02	6.228		1.2	Da	0.4	1	Da	0.4	0.998
Db_0.4	YES	5.1406	0.4	NO		NO		4.318	1	4.18	1.03	6.207		1.2	Db	0.4	1	Db	0.4	0.999
Dc_0.4	YES	5.1406	0.4	NO		NO		4.318	1	1.04	4.18	6.221		1.2	Dc	0.4	1	Dc	0.4	0.999
Ea_0.4	YES	5.2891	0.4	NO		NO		4.443	0	4.18	4.18	8.358		1.2	Ca	0.4	0.8	Ca	0.4	0.8
Eb_0.4	YES	5.375	0.4	NO		NO		4.515	4.19	0	4.18	8.371		1.2	Cb	0.4	0.8	Cb	0.4	0.8
Ec_0.4	YES	5.375	0.4	NO		NO		4.515	4.19	4.18	0	8.365		1.2	Cc	0.4	0.8	Cc	0.4	0.8
Fa_0.4	YES	5.375	0.4	NO		NO		4.515	4.19	2.37	2.38	8.94		1.2	Da	0.4	0.8	Da	0.4	0.8
Fb_0.4	YES	5.2266	0.4	NO		NO		4.39	2.34	4.18	2.38	8.898		1.2	Db	0.4	0.8	Db	0.4	0.8
Fc_0.4	YES	5.2344	0.4	NO		NO		4.397	2.34	2.38	4.18	8.907		1.2	Dc	0.4	0.8	Dc	0.4	0.8
Ga_0.4	YES	5.2422	0.5255	NO		NO		3.795	1.71	3.58	3.58	8.872		0.949	Ca	0.4	0.8	Ca	0.4	0.8
Gb_0.4	YES	5.3516	0.5292	NO		NO		3.853	3.59	1.77	3.58	8.936		0.9416	Cb	0.4	0.8	Cb	0.4	0.8
Gc_0.4	YES	5.3594	0.5292	NO		NO		3.858	3.59	3.57	1.77	8.931		0.9416	Cc	0.4	0.8	Cc	0.4	0.8
A_0.5	YES	5.3594	0.5	NO		NO		4.02	3.74	3.73	3.73	11.194		1	A	0.5	0.5	A	0.5	0.5
Ba_0.5	YES	5.3594	0.5	NO		NO		4.02	3.74	0	0	3.737		1	Da	0.667	1	Da	0.667	1
Bb_0.5	YES	5.125	0.5	NO		NO		3.844	0	3.73	0	3.726		1	Db	0.667	1	Db	0.667	1
Bc_0.5	YES	5.125	0.5	NO		NO		3.844	0	0	3.73	3.731		1	Dc	0.667	1	Dc	0.667	1
Ca_0.5	YES	5.1797	0.6459	NO		NO		3.019	0	2.8	2.8	5.59		0.7082	Ca	0.5	1	Ca	0.5	1
Cb_0.5	YES	5.3047	0.6614	NO		NO		2.984	2.78	0	2.79	5.575		0.6772	Cb	0.5	1	Cb	0.5	1
Cc_0.5	YES	5.3125	0.6614	NO		NO		2.989	2.79	2.79	0	5.581		0.6772	Cc	0.5	1	Cc	0.5	0.999
Da_0.5	YES	5.3594	0.5	NO		NO		4.02	3.74	0.04	0.04	3.819		1	Da	0.5	1	Da	0.5	0.999
Db_0.5	YES	5.125	0.5	NO		NO		3.844	0.03	3.73	0.07	3.822		1	Db	0.5	1	Db	0.5	1
Dc_0.5	YES	5.125	0.5	NO		NO		3.844	0.03	0.07	3.73	3.833		1	Dc	0.5	1	Dc	0.5	1
Ea_0.5	YES	5.2734	0.5	NO		NO		3.955	0	3.73	3.73	7.457		1	Ca	0.5	0.833	Ca	0.5	0.833
Eb_0.5	YES	5.3594	0.5	NO		NO		4.02	3.74	0	3.73	7.468		1	Cb	0.5	0.833	Cb	0.5	0.833
Ec_0.5	YES	5.3594	0.5	NO		NO		4.02	3.74	3.73	0	7.463		1	Cc	0.5	0.833	Cc	0.5	0.833
Fa_0.5	YES	5.3594	0.5	NO		NO		4.02	3.74	2.06	2.06	7.85		1	Da	0.5	0.833	Da	0.5	0.833
Fb_0.5	YES	5.1953	0.5	NO		NO		3.896	2.02	3.73	2.06	7.812		1	Db	0.5	0.833	Db	0.5	0.833
Fc_0.5	YES	5.2031	0.5	NO		NO		3.902	2.03	2.06	3.73	7.821		1	Dc	0.5	0.833	Dc	0.5	0.833
Ga_0.5	YES	5.2188	0.5988	NO		NO		3.348	1.43	3.17	3.18	7.777		0.8024	Ca	0.5	0.833	Ca	0.5	0.833
Gb_0.5	YES	5.3281	0.6009	NO		NO		3.404	3.18	1.49	3.17	7.844		0.7982	Cb	0.5	0.833	Cb	0.5	0.833
Gc_0.5	YES	5.3359	0.6009	NO		NO		3.409	3.18	3.17	1.49	7.842		0.7982	Cc	0.5	0.833	Cc	0.5	0.833
A_0.6	YES	5.3281	0.6	NO		NO		3.41	3.18	3.17	3.18	9.538		0.8	A	0.6	0.6	A	0.6	0.6
Ba_0.6	YES	5.3281	0.6	NO		NO		3.41	3.18	0	0	3.184		0.8	Da	0.733	1	Da	0.733	1
Bb_0.6	YES	5.0938	0.6	NO		NO		3.26	0	3.17	0	3.174		0.8	Db	0.733	1	Db	0.733	1
Bc_0.6	YES	5.1016	0.6	NO		NO		3.265	0	0	3.18	3.179		0.8	Dc	0.733	1	Dc	0.733	1
Ca_0.6	YES	5.1484	0.7108	NO		NO		2.547	0	2.38	2.38	4.761		0.5784	Ca	0.6	1	Ca	0.6	1

Cb_0.6	YES	5.0703	0.7211	NO		NO		2.434	2.34	0	2.38	4.722		0.5578	Cb	0.6	1	Cb	0.6	1
Cc_0.6	YES	5.0703	0.7211	NO		NO		2.434	2.34	2.37	0	4.715		0.5578	Cc	0.6	1	Cc	0.6	0.999
Da_0.6	YES	5.3281	0.6	NO		NO		3.41	3.18	0	0.01	3.193		0.8	Da	0.6	1	Da	0.6	0.999
Db_0.6	YES	5.0938	0.6	NO		NO		3.26	0	3.17	0	3.174		0.8	Db	0.6	1	Db	0.6	1
Dc_0.6	YES	5.1016	0.6	NO		NO		3.265	0	0.01	3.18	3.187		0.8	Dc	0.6	1	Dc	0.6	1
Ea_0.6	YES	5.25	0.6	NO		NO		3.36	0	3.17	3.18	6.354		0.8	Ca	0.6	0.867	Ca	0.6	0.867
Eb_0.6	YES	5.3281	0.6	NO		NO		3.41	3.18	0	3.18	6.363		0.8	Cb	0.6	0.867	Cb	0.6	0.867
Ec_0.6	YES	5.3281	0.6	NO		NO		3.41	3.18	3.17	0	6.358		0.8	Cc	0.6	0.867	Cc	0.6	0.867
Fa_0.6	YES	5.3281	0.6	NO		NO		3.41	3.18	1.7	1.7	6.59		0.8	Da	0.6	0.867	Da	0.6	0.867
Fb_0.6	YES	5.1563	0.6	NO		NO		3.3	1.67	3.17	1.71	6.555		0.8	Db	0.6	0.867	Db	0.6	0.867
Fc_0.6	YES	5.1641	0.6	NO		NO		3.305	1.68	1.71	3.18	6.564		0.8	Dc	0.6	0.867	Dc	0.6	0.867
Ga_0.6	YES	5.1953	0.6755	NO		NO		2.825	1.15	2.69	2.69	6.528		0.649	Ca	0.6	0.867	Ca	0.6	0.867
Gb_0.6	YES	5.2813	0.6766	NO		NO		2.864	2.69	1.2	2.69	6.579		0.6468	Cb	0.6	0.867	Cb	0.6	0.867
Gc_0.6	YES	5.2969	0.6766	NO		NO		2.872	2.69	2.69	1.2	6.58		0.6468	Cc	0.6	0.867	Cc	0.6	0.867
A_0.7	YES	5.2734	0.7	NO		NO		2.689	2.53	2.52	2.53	7.578		0.6	A	0.7	0.7	A	0.7	0.7
Ba_0.7	YES	5.2734	0.7	NO		NO		2.689	2.53	0	0	2.527		0.6	Da	0.8	1	Da	0.8	1
Bb_0.7	YES	5.0625	0.7	NO		NO		2.582	0	2.52	0	2.525		0.6	Db	0.8	1	Db	0.8	1
Bc_0.7	YES	5.0547	0.7	NO		NO		2.578	0	0	2.53	2.525		0.6	Dc	0.8	1	Dc	0.8	1
Ca_0.7	YES	5.1016	0.7794	NO		NO		2.003	0	1.89	1.89	3.779		0.4412	Ca	0.7	1	Ca	0.7	1
Cb_0.7	YES	5.0156	0.7858	NO		NO		1.919	1.86	0	1.89	3.742		0.4284	Cb	0.7	1	Cb	0.7	1
Cc_0.7	YES	5.0078	0.7858	NO		NO		1.916	1.86	1.88	0	3.738		0.4284	Cc	0.7	1	Cc	0.7	1
Da_0.7	YES	5.2734	0.7	NO		NO		2.689	2.53	0	0	2.527		0.6	Da	0.7	1	Da	0.7	1
Db_0.7	YES	5.0625	0.7	NO		NO		2.582	0	2.52	0	2.525		0.6	Db	0.7	1	Db	0.7	1
Dc_0.7	YES	5.0547	0.7	NO		NO		2.578	0	0	2.53	2.525		0.6	Dc	0.7	1	Dc	0.7	1
Ea_0.7	YES	5.2109	0.7	NO		NO		2.658	0	2.52	2.53	5.05		0.6	Ca	0.7	0.9	Ca	0.7	0.9
Eb_0.7	YES	5.2734	0.7	NO		NO		2.689	2.53	0	2.53	5.053		0.6	Cb	0.7	0.9	Cb	0.7	0.9
Ec_0.7	YES	5.2734	0.7	NO		NO		2.689	2.53	2.52	0	5.052		0.6	Cc	0.7	0.9	Cc	0.7	0.9
Fa_0.7	YES	5.2734	0.7	NO		NO		2.689	2.53	1.31	1.32	5.154		0.6	Da	0.7	0.9	Da	0.7	0.9
Fb_0.7	YES	5.1016	0.7	NO		NO		2.602	1.25	2.52	1.32	5.093		0.6	Db	0.7	0.9	Db	0.7	0.9
Fc_0.7	YES	5.1016	0.7	NO		NO		2.602	1.25	1.32	2.53	5.097		0.6	Dc	0.7	0.9	Dc	0.7	0.9
Ga_0.7	YES	5.1406	0.7544	NO		NO		2.215	0.26	2.12	2.13	4.514		0.4912	Ca	0.7	0.9	Ca	0.7	0.9
Gb_0.7	YES	5.0469	0.755	NO		NO		2.17	2.09	0.86	2.12	5.072		0.49	Cb	0.7	0.9	Cb	0.7	0.9
Gc_0.7	YES	5.0547	0.755	NO		NO		2.173	2.09	2.12	0.86	5.069		0.49	Cc	0.7	0.9	Cc	0.7	0.9
A_0.8	YES	5.1328	0.8	NO		NO		1.848	1.71	1.77	1.77	5.247		0.4	A	0.8	0.8	A	0.8	0.8
Ba_0.8	YES	4.8359	0.8	NO		NO		1.741	1.71	0	0	1.708		0.4	Da	0.867	1	Cc	0.902	0.966
Bb_0.8	YES	4.9766	0.8	NO		NO		1.792	0	1.77	0	1.768		0.4	Db	0.867	1	Ca	0.9	0.968
Bc_0.8	YES	4.9766	0.8	NO		NO		1.792	0	0	1.77	1.77		0.4	Dc	0.867	1	Cb	0.902	0.966
Ca_0.8	YES	4.9922	0.8508	NO		NO		1.379	0	1.32	1.32	2.635		0.2984	Ca	0.8	1	Ca	0.8	1
Cb_0.8	YES	4.8984	0.8544	NO		NO		1.323	1.25	0	1.32	2.569		0.2912	Cb	0.8	1	Cb	0.8	1
Cc_0.8	YES	4.8906	0.8544	NO		NO		1.32	1.25	1.31	0	2.563		0.2912	Cc	0.8	1	Cc	0.8	1
Da_0.8	YES	4.8359	0.8	NO		NO		1.741	1.71	0	0	1.708		0.4	Da	0.8	1	Da	0.8	1
Db_0.8	YES	4.9766	0.8	NO		NO		1.792	0	1.77	0	1.768		0.4	Db	0.8	1	Db	0.8	1

Dc_0.8	YES	4.9766	0.8	NO		NO		1.792	0	0	1.77	1.77		0.4	Dc	0.8	1	Dc	0.8	1
Ea_0.8	YES	5.1328	0.8	NO		NO		1.848	0	1.77	1.77	3.538		0.4	Ca	0.8	0.933	Ca	0.8	0.933
Eb_0.8	YES	4.9766	0.8	NO		NO		1.792	1.71	0	1.77	3.478		0.4	Cb	0.8	0.933	Cb	0.8	0.933
Ec_0.8	YES	5	0.8	NO		NO		1.8	1.71	1.77	0	3.477		0.4	Cc	0.8	0.933	Cc	0.8	0.933
Fa_0.8	YES	4.8359	0.8	NO		NO		1.741	1.71	0	0	1.708		0.4	Da	0.8	0.933	Da	0.8	0.933
Fb_0.8	YES	4.9766	0.8	NO		NO		1.792	0	1.77	0.01	1.776		0.4	Db	0.8	0.933	Db	0.8	0.933
Fc_0.8	YES	4.9766	0.8	NO		NO		1.792	0	0.01	1.77	1.777		0.4	Dc	0.8	0.933	Dc	0.8	0.933
Ga_0.8	YES	5.0469	0.8351	NO		NO		1.527	0	1.48	1.48	2.958		0.3298	Ca	0.8	0.933	Ca	0.8	0.933
Gb_0.8	YES	4.9297	0.8353	NO		NO		1.49	1.42	0	1.48	2.893		0.3294	Cb	0.8	0.933	Cb	0.8	0.933
Gc_0.8	YES	4.9297	0.8353	NO		NO		1.49	1.41	1.48	0	2.889		0.3294	Cc	0.8	0.933	Cc	0.8	0.933
A_0.9	YES	4.5	0.9	NO		NO		0.855	0.16	0.82	0.52	1.504		0.2	A	0.9	0.9	A	0.9	0.9
Ba_0.9	YES	1.4141	0.9	NO		NO		0.269	0.16	0	0	0.157		0.2	Da	0.933	1	Cc	0.95	0.983
Bb_0.9	YES	4.5	0.9	NO		NO		0.855	0	0.74	0	0.741		0.2	Db	0.933	1	Ca	0.95	0.983
Bc_0.9	YES	4.4141	0.9	NO		NO		0.839	0	0	0.52	0.523		0.2	Dc	0.933	1	Cb	0.95	0.983
Ca_0.9	NO		0.9245	NO		NO								0						
Cb_0.9	NO		0.926	NO		NO								0						
Cc_0.9	NO		0.926	NO		NO								0						
Da_0.9	YES	1.4141	0.9	NO		NO		0.269	0.16	0	0	0.157		0.2	Da	0.9	1	Cc	0.926	0.975
Db_0.9	YES	4.5	0.9	NO		NO		0.855	0	0.82	0	0.824		0.2	Db	0.9	1	Ca	0.925	0.975
Dc_0.9	YES	4.4844	0.9	NO		NO		0.852	0	0	0.81	0.806		0.2	Dc	0.9	1	Cb	0.926	0.974
Ea_0.9	YES	4.5	0.9	NO		NO		0.855	0	0.74	0.52	1.263		0.2	Ca	0.9	0.967	Dc	0.917	0.95
Eb_0.9	YES	4.4141	0.9	NO		NO		0.839	0.16	0	0.52	0.68		0.2	Cb	0.9	0.967	Da	0.917	0.95
Ec_0.9	YES	4.5	0.9	NO		NO		0.855	0.16	0.74	0	0.898		0.2	Cc	0.9	0.967	Db	0.917	0.951
Fa_0.9	YES	1.4141	0.9	NO		NO		0.269	0.16	0	0	0.157		0.2	Da	0.9	0.967	Cc	0.917	0.95
Fb_0.9	YES	4.5	0.9	NO		NO		0.855	0	0.82	0	0.824		0.2	Db	0.9	0.967	Ca	0.917	0.951
Fc_0.9	YES	4.4844	0.9	NO		NO		0.852	0	0	0.81	0.806		0.2	Dc	0.9	0.967	Cb	0.917	0.95
Ga_0.9	NO		0.9171	NO		NO								0						
Gb_0.9	NO		0.9171	NO		NO								0						
Gc_0.9	NO		0.9171	NO		NO								0						

Appendix E

MatLab Results - Synthetic Sags

- one cycle rms voltage calculated every sample

Synthetic Dip	Sag	Duration of voltage sag [cycles]	Retained voltage * [pu]	Interrup-tion	Interruption Duration [cycles]	Swell	Swell Duration [cycles]	Sag Energy calc. from Dur.& Ret [cycles]	Evs_a, Voltage-Sag Energy Index [cycles]	Evs_b, Voltage-Sag Energy Index [cycles]	Evs_c, Voltage-Sag Energy Index [cycles]	Evs, Voltage-Sag Energy Index [cycles]	Voltage-Swell Energy Index [cycles]	Voltage-Sag Severity [pu]	Six Phase RMS - Dip Type	V (from sixRMS)	F (from sixRMS)	Symmetrical Component Method	V (from symm. comp. method)	F (from symm. comp. method)
A_0.1	YES	5	0.1	YES	4.3203	NO		4.95	4.94	4.92	4.93	14.799		1.8	A	0.1	0.1	A	0.1	0.1
Ba_0.1	YES	5	0.1	YES	4.4844	NO		4.95	4.94	0	0	4.94		1.8	Da	0.4	1	Da	0.4	1
Bb_0.1	YES	5	0.1	YES	4.4766	NO		4.95	0	4.92	0	4.925		1.8	Db	0.4	1	Db	0.4	0.999
Bc_0.1	YES	5	0.1	YES	4.3359	NO		4.95	0	0	4.93	4.934		1.8	Dc	0.4	1	Dc	0.4	1
Ca_0.1	YES	5	0.4481	NO		NO		3.996	0	3.7	3.7	7.408		1.1038	Ca	0.1	1	Ca	0.1	1
Cb_0.1	YES	5	0.4618	NO		NO		3.934	3.7	0	3.71	7.41		1.0764	Cb	0.1	1	Cb	0.1	1
Cc_0.1	YES	5	0.4692	NO		NO		3.899	3.7	3.7	0	7.397		1.0616	Cc	0.1	1	Cc	0.101	0.996
Da_0.1	YES	5	0.1	YES	4.4844	NO		4.95	4.94	1.24	1.24	7.416		1.8	Da	0.1	1	Da	0.1	0.996
Db_0.1	YES	5	0.1	YES	4.4844	NO		4.95	1.2	4.92	1.24	7.366		1.8	Db	0.1	1	Db	0.1	0.999
Dc_0.1	YES	5	0.1	YES	4.5	NO		4.95	1.22	1.24	4.93	7.389		1.8	Dc	0.1	1	Dc	0.1	0.999
Ea_0.1	YES	5	0.1	YES	4.3359	NO		4.95	0	4.92	4.93	9.859		1.8	Ca	0.1	0.7	Ca	0.1	0.7
Eb_0.1	YES	5	0.1	YES	4.3203	NO		4.95	4.94	0	4.93	9.874		1.8	Cb	0.1	0.7	Cb	0.1	0.7
Ec_0.1	YES	5	0.1	YES	4.4609	NO		4.95	4.94	4.92	0	9.865		1.8	Cc	0.1	0.7	Cc	0.1	0.7
Fa_0.1	YES	5	0.1	YES	4.4844	NO		4.95	4.94	3.13	3.14	11.202		1.8	Da	0.1	0.7	Da	0.1	0.7
Fb_0.1	YES	5	0.1	YES	4.4844	NO		4.95	3.14	4.92	3.13	11.195		1.8	Db	0.1	0.7	Db	0.1	0.7
Fc_0.1	YES	5	0.1	YES	4.5	NO		4.95	3.13	3.13	4.93	11.203		1.8	Dc	0.1	0.7	Dc	0.1	0.7
Ga_0.1	YES	5	0.345	NO		NO		4.405	2.53	4.33	4.33	11.196		1.31	Ca	0.1	0.7	Ca	0.1	0.7

Gb_0.1	YES	5	0.3606	NO		NO		4.35	4.34	2.52	4.34	11.201		1.2788	Cb	0.1	0.7	Cb	0.1	0.7
Gc_0.1	YES	5	0.3606	NO		NO		4.35	4.34	4.33	2.53	11.192		1.2788	Cc	0.1	0.7	Cc	0.1	0.7
A_0.2	YES	5	0.2	NO		NO		4.8	4.79	4.77	4.78	14.349		1.6	A	0.2	0.2	A	0.2	0.2
Ba_0.2	YES	5	0.2	NO		NO		4.8	4.79	0	0	4.791		1.6	Da	0.467	1	Da	0.467	1
Bb_0.2	YES	5	0.2	NO		NO		4.8	0	4.77	0	4.775		1.6	Db	0.467	1	Db	0.467	0.999
Bc_0.2	YES	5	0.2	NO		NO		4.8	0	0	4.78	4.784		1.6	Dc	0.467	1	Dc	0.467	1
Ca_0.2	YES	5	0.4849	NO		NO		3.824	0	3.59	3.59	7.179		1.0302	Ca	0.2	1	Ca	0.2	1
Cb_0.2	YES	5	0.5017	NO		NO		3.741	3.59	0	3.59	7.179		0.9966	Cb	0.2	1	Cb	0.2	1
Cc_0.2	YES	5	0.5091	NO		NO		3.704	3.59	3.58	0	7.168		0.9818	Cc	0.2	1	Cc	0.2	0.997
Da_0.2	YES	5	0.2	NO		NO		4.8	4.79	1.19	1.2	7.177		1.6	Da	0.2	1	Da	0.2	0.997
Db_0.2	YES	5	0.2	NO		NO		4.8	1.16	4.77	1.2	7.132		1.6	Db	0.2	1	Db	0.2	0.999
Dc_0.2	YES	5	0.2	NO		NO		4.8	1.17	1.2	4.78	7.155		1.6	Dc	0.2	1	Dc	0.2	0.999
Ea_0.2	YES	5	0.2	NO		NO		4.8	0	4.77	4.78	9.558		1.6	Ca	0.2	0.733	Ca	0.2	0.733
Eb_0.2	YES	5	0.2	NO		NO		4.8	4.79	0	4.78	9.574		1.6	Cb	0.2	0.733	Cb	0.2	0.733
Ec_0.2	YES	5	0.2	NO		NO		4.8	4.79	4.77	0	9.565		1.6	Cc	0.2	0.733	Cc	0.2	0.733
Fa_0.2	YES	5	0.2	NO		NO		4.8	4.79	2.91	2.92	10.616		1.6	Da	0.2	0.733	Da	0.2	0.733
Fb_0.2	YES	5	0.2	NO		NO		4.8	2.92	4.77	2.92	10.609		1.6	Db	0.2	0.733	Db	0.2	0.733
Fc_0.2	YES	5	0.2	NO		NO		4.8	2.91	2.92	4.78	10.615		1.6	Dc	0.2	0.733	Dc	0.2	0.733
Ga_0.2	YES	5	0.3956	NO		NO		4.218	2.29	4.16	4.16	10.61		1.2088	Ca	0.2	0.733	Ca	0.2	0.733
Gb_0.2	YES	5	0.4055	NO		NO		4.178	4.17	2.28	4.16	10.614		1.189	Cb	0.2	0.733	Cb	0.2	0.733
Gc_0.2	YES	5	0.4055	NO		NO		4.178	4.17	4.15	2.29	10.606		1.189	Cc	0.2	0.733	Cc	0.2	0.733
A_0.3	YES	5	0.3	NO		NO		4.55	4.54	4.52	4.53	13.599		1.4	A	0.3	0.3	A	0.3	0.3
Ba_0.3	YES	5	0.3	NO		NO		4.55	4.54	0	0	4.54		1.4	Da	0.533	1	Da	0.533	1
Bb_0.3	YES	5	0.3	NO		NO		4.55	0	4.52	0	4.525		1.4	Db	0.533	1	Db	0.533	1
Bc_0.3	YES	5	0.3	NO		NO		4.55	0	0	4.53	4.534		1.4	Dc	0.533	1	Dc	0.533	1
Ca_0.3	YES	5	0.5314	NO		NO		3.588	0	3.4	3.4	6.798		0.9372	Ca	0.3	1	Ca	0.3	1
Cb_0.3	YES	5	0.5499	NO		NO		3.488	3.4	0	3.4	6.799		0.9002	Cb	0.3	1	Cb	0.3	1
Cc_0.3	YES	5	0.5569	NO		NO		3.449	3.4	3.39	0	6.791		0.8862	Cc	0.3	1	Cc	0.3	0.997
Da_0.3	YES	5	0.3	NO		NO		4.55	4.54	1.12	1.13	6.79		1.4	Da	0.3	1	Da	0.3	0.998
Db_0.3	YES	5	0.3	NO		NO		4.55	1.1	4.52	1.13	6.749		1.4	Db	0.3	1	Db	0.3	0.999
Dc_0.3	YES	5	0.3	NO		NO		4.55	1.1	1.13	4.53	6.765		1.4	Dc	0.3	1	Dc	0.3	0.999
Ea_0.3	YES	5	0.3	NO		NO		4.55	0	4.52	4.53	9.059		1.4	Ca	0.3	0.767	Ca	0.3	0.767
Eb_0.3	YES	5	0.3	NO		NO		4.55	4.54	0	4.53	9.074		1.4	Cb	0.3	0.767	Cb	0.3	0.767
Ec_0.3	YES	5	0.3	NO		NO		4.55	4.54	4.52	0	9.064		1.4	Cc	0.3	0.767	Cc	0.3	0.767
Fa_0.3	YES	5	0.3	NO		NO		4.55	4.54	2.66	2.66	9.861		1.4	Da	0.3	0.767	Da	0.3	0.767
Fb_0.3	YES	5	0.3	NO		NO		4.55	2.66	4.52	2.67	9.853		1.4	Db	0.3	0.767	Db	0.3	0.767
Fc_0.3	YES	5	0.3	NO		NO		4.55	2.63	2.67	4.53	9.833		1.4	Dc	0.3	0.767	Dc	0.3	0.767
Ga_0.3	YES	5	0.4569	NO		NO		3.956	2.03	3.91	3.91	9.847		1.0862	Ca	0.3	0.767	Ca	0.3	0.767
Gb_0.3	YES	5	0.4631	NO		NO		3.928	3.92	2.03	3.91	9.86		1.0738	Cb	0.3	0.767	Cb	0.3	0.767
Gc_0.3	YES	5	0.4631	NO		NO		3.928	3.92	3.9	2.03	9.853		1.0738	Cc	0.3	0.767	Cc	0.3	0.766
A_0.4	YES	5	0.4	NO		NO		4.2	4.19	4.18	4.18	12.547		1.2	A	0.4	0.4	A	0.4	0.4
Ba_0.4	YES	5	0.4	NO		NO		4.2	4.19	0	0	4.189		1.2	Da	0.6	1	Da	0.6	1

Bb_0.4	YES	5	0.4	NO		NO		4.2	0	4.18	0	4.176		1.2	Db	0.6	1	Db	0.6	1
Bc_0.4	YES	5	0.4	NO		NO		4.2	0	0	4.18	4.182		1.2	Dc	0.6	1	Dc	0.6	1
Ca_0.4	YES	5	0.5857	NO		NO		3.285	0	3.13	3.13	6.27		0.8286	Ca	0.4	1	Ca	0.4	1
Cb_0.4	YES	5	0.6044	NO		NO		3.174	3.13	0	3.14	6.27		0.7912	Cb	0.4	1	Cb	0.4	1
Cc_0.4	YES	5	0.6083	NO		NO		3.15	3.14	3.13	0	6.262		0.7834	Cc	0.4	1	Cc	0.4	0.998
Da_0.4	YES	5	0.4	NO		NO		4.2	4.19	1.01	1.02	6.228		1.2	Da	0.4	1	Da	0.4	0.998
Db_0.4	YES	5	0.4	NO		NO		4.2	1	4.18	1.03	6.207		1.2	Db	0.4	1	Db	0.4	0.999
Dc_0.4	YES	5	0.4	NO		NO		4.2	1	1.04	4.18	6.221		1.2	Dc	0.4	1	Dc	0.4	0.999
Ea_0.4	YES	5	0.4	NO		NO		4.2	0	4.18	4.18	8.358		1.2	Ca	0.4	0.8	Ca	0.4	0.8
Eb_0.4	YES	5	0.4	NO		NO		4.2	4.19	0	4.18	8.371		1.2	Cb	0.4	0.8	Cb	0.4	0.8
Ec_0.4	YES	5	0.4	NO		NO		4.2	4.19	4.18	0	8.365		1.2	Cc	0.4	0.8	Cc	0.4	0.8
Fa_0.4	YES	5	0.4	NO		NO		4.2	4.19	2.37	2.38	8.94		1.2	Da	0.4	0.8	Da	0.4	0.8
Fb_0.4	YES	5	0.4	NO		NO		4.2	2.34	4.18	2.38	8.898		1.2	Db	0.4	0.8	Db	0.4	0.8
Fc_0.4	YES	5	0.4	NO		NO		4.2	2.34	2.38	4.18	8.907		1.2	Dc	0.4	0.8	Dc	0.4	0.8
Ga_0.4	YES	5	0.5255	NO		NO		3.619	1.71	3.58	3.58	8.872		0.949	Ca	0.4	0.8	Ca	0.4	0.8
Gb_0.4	YES	5	0.5292	NO		NO		3.6	3.59	1.77	3.58	8.936		0.9416	Cb	0.4	0.8	Cb	0.4	0.8
Gc_0.4	YES	5	0.5292	NO		NO		3.6	3.59	3.57	1.77	8.931		0.9416	Cc	0.4	0.8	Cc	0.4	0.8
A_0.5	YES	5	0.5	NO		NO		3.75	3.74	3.73	3.73	11.194		1	A	0.5	0.5	A	0.5	0.5
Ba_0.5	YES	5	0.5	NO		NO		3.75	3.74	0	0	3.737		1	Da	0.667	1	Da	0.667	1
Bb_0.5	YES	5	0.5	NO		NO		3.75	0	3.73	0	3.726		1	Db	0.667	1	Db	0.667	1
Bc_0.5	YES	5	0.5	NO		NO		3.75	0	0	3.73	3.731		1	Dc	0.667	1	Dc	0.667	1
Ca_0.5	YES	5	0.6459	NO		NO		2.914	0	2.8	2.8	5.59		0.7082	Ca	0.5	1	Ca	0.5	1
Cb_0.5	YES	5	0.6614	NO		NO		2.813	2.78	0	2.79	5.575		0.6772	Cb	0.5	1	Cb	0.5	1
Cc_0.5	YES	5	0.6614	NO		NO		2.813	2.79	2.79	0	5.581		0.6772	Cc	0.5	1	Cc	0.5	0.999
Da_0.5	YES	5	0.5	NO		NO		3.75	3.74	0.04	0.04	3.819		1	Da	0.5	1	Da	0.5	0.999
Db_0.5	YES	5	0.5	NO		NO		3.75	0.03	3.73	0.07	3.822		1	Db	0.5	1	Db	0.5	1
Dc_0.5	YES	5	0.5	NO		NO		3.75	0.03	0.07	3.73	3.833		1	Dc	0.5	1	Dc	0.5	1
Ea_0.5	YES	5	0.5	NO		NO		3.75	0	3.73	3.73	7.457		1	Ca	0.5	0.833	Ca	0.5	0.833
Eb_0.5	YES	5	0.5	NO		NO		3.75	3.74	0	3.73	7.468		1	Cb	0.5	0.833	Cb	0.5	0.833
Ec_0.5	YES	5	0.5	NO		NO		3.75	3.74	3.73	0	7.463		1	Cc	0.5	0.833	Cc	0.5	0.833
Fa_0.5	YES	5	0.5	NO		NO		3.75	3.74	2.06	2.06	7.85		1	Da	0.5	0.833	Da	0.5	0.833
Fb_0.5	YES	5	0.5	NO		NO		3.75	2.02	3.73	2.06	7.812		1	Db	0.5	0.833	Db	0.5	0.833
Fc_0.5	YES	5	0.5	NO		NO		3.75	2.03	2.06	3.73	7.821		1	Dc	0.5	0.833	Dc	0.5	0.833
Ga_0.5	YES	5	0.5988	NO		NO		3.207	1.43	3.17	3.18	7.777		0.8024	Ca	0.5	0.833	Ca	0.5	0.833
Gb_0.5	YES	5	0.6009	NO		NO		3.195	3.18	1.49	3.17	7.844		0.7982	Cb	0.5	0.833	Cb	0.5	0.833
Gc_0.5	YES	5	0.6009	NO		NO		3.195	3.18	3.17	1.49	7.842		0.7982	Cc	0.5	0.833	Cc	0.5	0.833
A_0.6	YES	5	0.6	NO		NO		3.2	3.18	3.17	3.18	9.538		0.8	A	0.6	0.6	A	0.6	0.6
Ba_0.6	YES	5	0.6	NO		NO		3.2	3.18	0	0	3.184		0.8	Da	0.733	1	Da	0.733	1
Bb_0.6	YES	5	0.6	NO		NO		3.2	0	3.17	0	3.174		0.8	Db	0.733	1	Db	0.733	1
Bc_0.6	YES	5	0.6	NO		NO		3.2	0	0	3.18	3.179		0.8	Dc	0.733	1	Dc	0.733	1
Ca_0.6	YES	5	0.7108	NO		NO		2.474	0	2.38	2.38	4.761		0.5784	Ca	0.6	1	Ca	0.6	1
Cb_0.6	YES	5	0.7211	NO		NO		2.4	2.34	0	2.38	4.722		0.5578	Cb	0.6	1	Cb	0.6	1

Cc_0.6	YES	5	0.7211	NO		NO		2.4	2.34	2.37	0	4.715		0.5578	Cc	0.6	1	Cc	0.6	0.999
Da_0.6	YES	5	0.6	NO		NO		3.2	3.18	0	0.01	3.193		0.8	Da	0.6	1	Da	0.6	0.999
Db_0.6	YES	5	0.6	NO		NO		3.2	0	3.17	0	3.174		0.8	Db	0.6	1	Db	0.6	1
Dc_0.6	YES	5	0.6	NO		NO		3.2	0	0.01	3.18	3.187		0.8	Dc	0.6	1	Dc	0.6	1
Ea_0.6	YES	5	0.6	NO		NO		3.2	0	3.17	3.18	6.354		0.8	Ca	0.6	0.867	Ca	0.6	0.867
Eb_0.6	YES	5	0.6	NO		NO		3.2	3.18	0	3.18	6.363		0.8	Cb	0.6	0.867	Cb	0.6	0.867
Ec_0.6	YES	5	0.6	NO		NO		3.2	3.18	3.17	0	6.358		0.8	Cc	0.6	0.867	Cc	0.6	0.867
Fa_0.6	YES	5	0.6	NO		NO		3.2	3.18	1.7	1.7	6.59		0.8	Da	0.6	0.867	Da	0.6	0.867
Fb_0.6	YES	5	0.6	NO		NO		3.2	1.67	3.17	1.71	6.555		0.8	Db	0.6	0.867	Db	0.6	0.867
Fc_0.6	YES	5	0.6	NO		NO		3.2	1.68	1.71	3.18	6.564		0.8	Dc	0.6	0.867	Dc	0.6	0.867
Ga_0.6	YES	5	0.6755	NO		NO		2.718	1.15	2.69	2.69	6.528		0.649	Ca	0.6	0.867	Ca	0.6	0.867
Gb_0.6	YES	5	0.6766	NO		NO		2.711	2.69	1.2	2.69	6.579		0.6468	Cb	0.6	0.867	Cb	0.6	0.867
Gc_0.6	YES	5	0.6766	NO		NO		2.711	2.69	2.69	1.2	6.58		0.6468	Cc	0.6	0.867	Cc	0.6	0.867
A_0.7	YES	5	0.7	NO		NO		2.55	2.53	2.52	2.53	7.578		0.6	A	0.7	0.7	A	0.7	0.7
Ba_0.7	YES	5	0.7	NO		NO		2.55	2.53	0	0	2.527		0.6	Da	0.8	1	Da	0.8	1
Bb_0.7	YES	5	0.7	NO		NO		2.55	0	2.52	0	2.525		0.6	Db	0.8	1	Db	0.8	1
Bc_0.7	YES	5	0.7	NO		NO		2.55	0	0	2.53	2.525		0.6	Dc	0.8	1	Dc	0.8	1
Ca_0.7	YES	5	0.7794	NO		NO		1.963	0	1.89	1.89	3.779		0.4412	Ca	0.7	1	Ca	0.7	1
Cb_0.7	YES	5	0.7858	NO		NO		1.913	1.86	0	1.89	3.742		0.4284	Cb	0.7	1	Cb	0.7	1
Cc_0.7	YES	5	0.7858	NO		NO		1.913	1.86	1.88	0	3.738		0.4284	Cc	0.7	1	Cc	0.7	1
Da_0.7	YES	5	0.7	NO		NO		2.55	2.53	0	0	2.527		0.6	Da	0.7	1	Da	0.7	1
Db_0.7	YES	5	0.7	NO		NO		2.55	0	2.52	0	2.525		0.6	Db	0.7	1	Db	0.7	1
Dc_0.7	YES	5	0.7	NO		NO		2.55	0	0	2.53	2.525		0.6	Dc	0.7	1	Dc	0.7	1
Ea_0.7	YES	5	0.7	NO		NO		2.55	0	2.52	2.53	5.05		0.6	Ca	0.7	0.9	Ca	0.7	0.9
Eb_0.7	YES	5	0.7	NO		NO		2.55	2.53	0	2.53	5.053		0.6	Cb	0.7	0.9	Cb	0.7	0.9
Ec_0.7	YES	5	0.7	NO		NO		2.55	2.53	2.52	0	5.052		0.6	Cc	0.7	0.9	Cc	0.7	0.9
Fa_0.7	YES	5	0.7	NO		NO		2.55	2.53	1.31	1.32	5.154		0.6	Da	0.7	0.9	Da	0.7	0.9
Fb_0.7	YES	5	0.7	NO		NO		2.55	1.25	2.52	1.32	5.093		0.6	Db	0.7	0.9	Db	0.7	0.9
Fc_0.7	YES	5	0.7	NO		NO		2.55	1.25	1.32	2.53	5.097		0.6	Dc	0.7	0.9	Dc	0.7	0.9
Ga_0.7	YES	5	0.7544	NO		NO		2.154	0.26	2.12	2.13	4.514		0.4912	Ca	0.7	0.9	Ca	0.7	0.9
Gb_0.7	YES	5	0.755	NO		NO		2.15	2.09	0.86	2.12	5.072		0.49	Cb	0.7	0.9	Cb	0.7	0.9
Gc_0.7	YES	5	0.755	NO		NO		2.15	2.09	2.12	0.86	5.069		0.49	Cc	0.7	0.9	Cc	0.7	0.9
A_0.8	YES	5	0.8	NO		NO		1.8	1.71	1.77	1.77	5.247		0.4	A	0.8	0.8	A	0.8	0.8
Ba_0.8	YES	5	0.8	NO		NO		1.8	1.71	0	0	1.708		0.4	Da	0.867	1	Cc	0.902	0.966
Bb_0.8	YES	5	0.8	NO		NO		1.8	0	1.77	0	1.768		0.4	Db	0.867	1	Ca	0.9	0.968
Bc_0.8	YES	5	0.8	NO		NO		1.8	0	0	1.77	1.77		0.4	Dc	0.867	1	Cb	0.902	0.966
Ca_0.8	YES	5	0.8508	NO		NO		1.381	0	1.32	1.32	2.635		0.2984	Ca	0.8	1	Ca	0.8	1
Cb_0.8	YES	5	0.8544	NO		NO		1.35	1.25	0	1.32	2.569		0.2912	Cb	0.8	1	Cb	0.8	1
Cc_0.8	YES	5	0.8544	NO		NO		1.35	1.25	1.31	0	2.563		0.2912	Cc	0.8	1	Cc	0.8	1
Da_0.8	YES	5	0.8	NO		NO		1.8	1.71	0	0	1.708		0.4	Da	0.8	1	Da	0.8	1
Db_0.8	YES	5	0.8	NO		NO		1.8	0	1.77	0	1.768		0.4	Db	0.8	1	Db	0.8	1
Dc_0.8	YES	5	0.8	NO		NO		1.8	0	0	1.77	1.77		0.4	Dc	0.8	1	Dc	0.8	1

Ea_0.8	YES	5	0.8	NO		NO		1.8	0	1.77	1.77	3.538		0.4	Ca	0.8	0.933	Ca	0.8	0.933
Eb_0.8	YES	5	0.8	NO		NO		1.8	1.71	0	1.77	3.478		0.4	Cb	0.8	0.933	Cb	0.8	0.933
Ec_0.8	YES	5	0.8	NO		NO		1.8	1.71	1.77	0	3.477		0.4	Cc	0.8	0.933	Cc	0.8	0.933
Fa_0.8	YES	5	0.8	NO		NO		1.8	1.71	0	0	1.708		0.4	Da	0.8	0.933	Da	0.8	0.933
Fb_0.8	YES	5	0.8	NO		NO		1.8	0	1.77	0.01	1.776		0.4	Db	0.8	0.933	Db	0.8	0.933
Fc_0.8	YES	5	0.8	NO		NO		1.8	0	0.01	1.77	1.777		0.4	Dc	0.8	0.933	Dc	0.8	0.933
Ga_0.8	YES	5	0.8351	NO		NO		1.513	0	1.48	1.48	2.958		0.3298	Ca	0.8	0.933	Ca	0.8	0.933
Gb_0.8	YES	5	0.8353	NO		NO		1.511	1.42	0	1.48	2.893		0.3294	Cb	0.8	0.933	Cb	0.8	0.933
Gc_0.8	YES	5	0.8353	NO		NO		1.511	1.41	1.48	0	2.889		0.3294	Cc	0.8	0.933	Cc	0.8	0.933
A_0.9	YES	5	0.9	NO		NO		0.95	0.16	0.82	0.52	1.504		0.2	A	0.9	0.9	A	0.9	0.9
Ba_0.9	YES	5	0.9	NO		NO		0.95	0.16	0	0	0.157		0.2	Da	0.933	1	Cc	0.95	0.983
Bb_0.9	YES	5	0.9	NO		NO		0.95	0	0.74	0	0.741		0.2	Db	0.933	1	Ca	0.95	0.983
Bc_0.9	YES	5	0.9	NO		NO		0.95	0	0	0.52	0.523		0.2	Dc	0.933	1	Cb	0.95	0.983
Ca_0.9	NO	5	0.9245	NO		NO		0.726	0	0	0	0		0.151	Ca	0.9	1	Dc	0.925	0.973
Cb_0.9	NO	5	0.926	NO		NO		0.713	0	0	0	0		0.148	Cb	0.9	1	Da	0.926	0.973
Cc_0.9	NO	5	0.926	NO		NO		0.713	0	0	0	0		0.148	Cc	0.9	1	Db	0.926	0.976
Da_0.9	YES	5	0.9	NO		NO		0.95	0.16	0	0	0.157		0.2	Da	0.9	1	Cc	0.926	0.975
Db_0.9	YES	5	0.9	NO		NO		0.95	0	0.82	0	0.824		0.2	Db	0.9	1	Ca	0.925	0.975
Dc_0.9	YES	5	0.9	NO		NO		0.95	0	0	0.81	0.806		0.2	Dc	0.9	1	Cb	0.926	0.974
Ea_0.9	YES	5	0.9	NO		NO		0.95	0	0.74	0.52	1.263		0.2	Ca	0.9	0.967	Dc	0.917	0.95
Eb_0.9	YES	5	0.9	NO		NO		0.95	0.16	0	0.52	0.68		0.2	Cb	0.9	0.967	Da	0.917	0.95
Ec_0.9	YES	5	0.9	NO		NO		0.95	0.16	0.74	0	0.898		0.2	Cc	0.9	0.967	Db	0.917	0.951
Fa_0.9	YES	5	0.9	NO		NO		0.95	0.16	0	0	0.157		0.2	Da	0.9	0.967	Cc	0.917	0.95
Fb_0.9	YES	5	0.9	NO		NO		0.95	0	0.82	0	0.824		0.2	Db	0.9	0.967	Ca	0.917	0.951
Fc_0.9	YES	5	0.9	NO		NO		0.95	0	0	0.81	0.806		0.2	Dc	0.9	0.967	Cb	0.917	0.95
Ga_0.9	NO	5	0.9171	NO		NO		0.795	0	0	0	0		0.1658	Ca	0.9	0.967	Dc	0.917	0.95
Gb_0.9	NO	5	0.9171	NO		NO		0.795	0	0	0	0		0.1658	Cb	0.9	0.967	Da	0.917	0.95
Gc_0.9	NO	5	0.9171	NO		NO		0.795	0	0	0	0		0.1658	Cc	0.9	0.967	Db	0.917	0.951

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