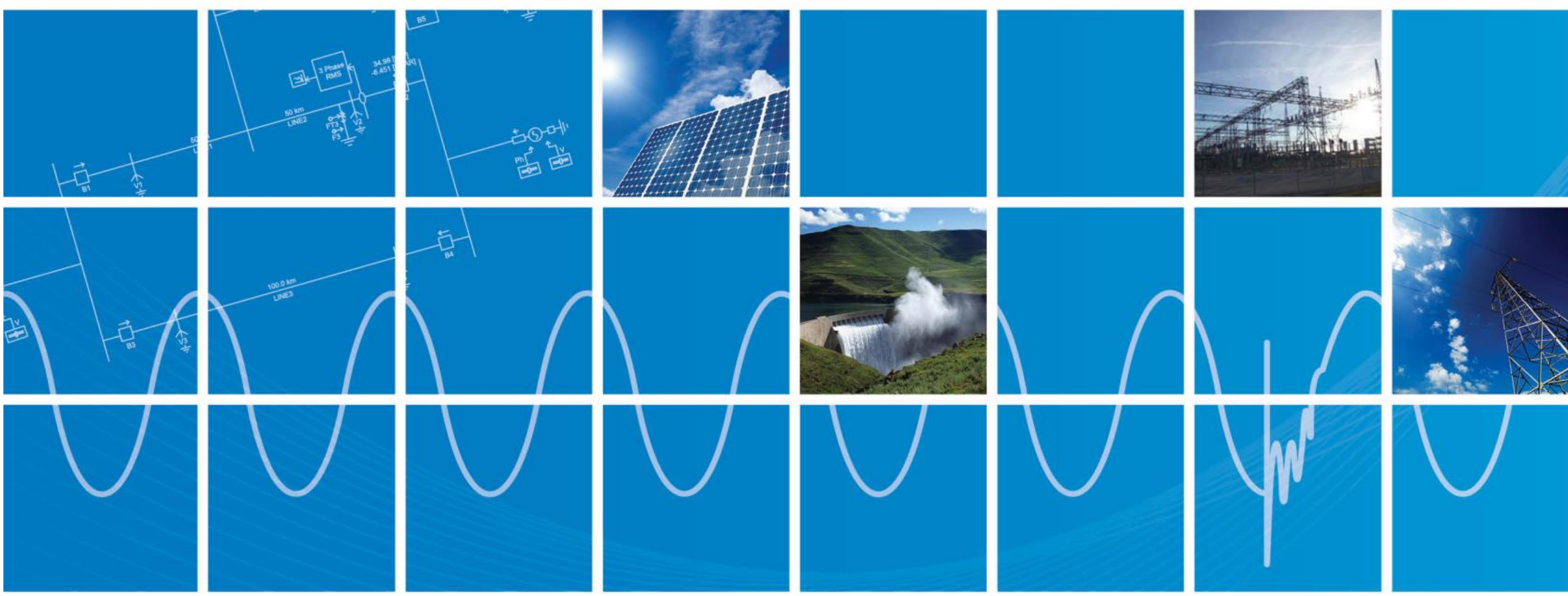
Statistical Breaker Component

For PSCAD Version 5.0

January 30, 2020

Initial



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CONTENTS

1. OVERVIEW

In probability theory, the normal (or Gaussian) distribution is a continuous probability distribution, defined by,

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \tag{1}$$

Where,

μ: The mean of the distribution

σ: The standard deviation

The normal distribution is an important statistical distribution which is often used to describe, at least approximately, any variable that tends to cluster around the mean. Figure 1 demonstrates the normal distribution curve. The Y-axis is the probability, and the X-axis is the samples generated randomly (closing time for the breaker) around the mean.

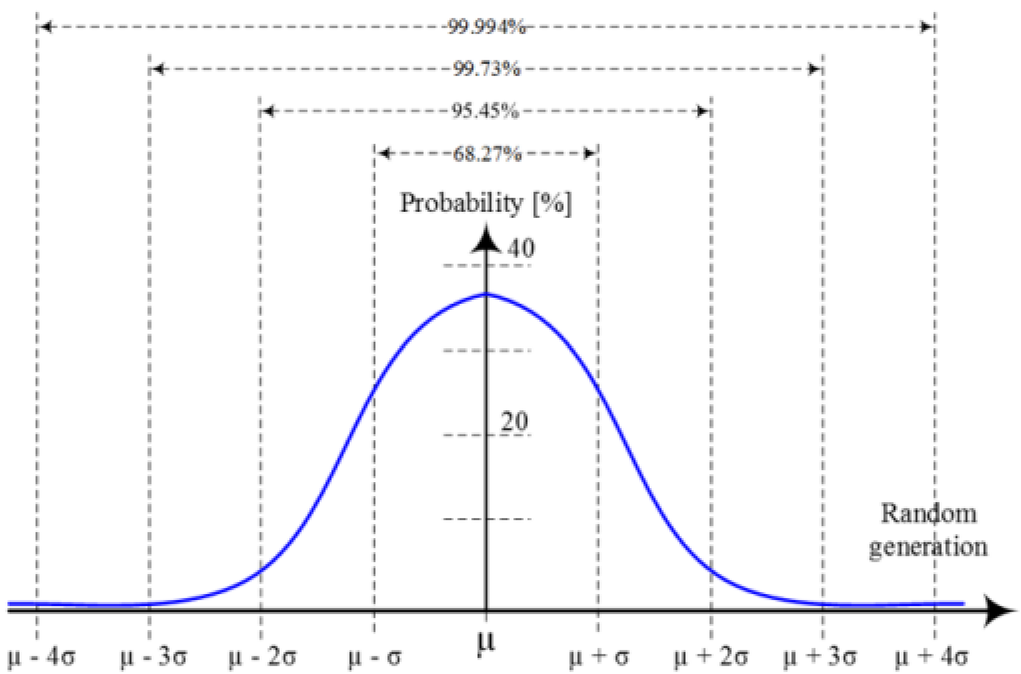

Figure 1: Normal Statistical Generation of Sample Closing Time for Breaker

2. PSCAD/EMTDC EXAMPLE DESCRIPTION

2.1. Example 1: Statistical Breaker Operation

The purpose of this example is to demonstrate how Statistical Breaker component performs. In this example, the highlighted section in Figure 2 is connected to Multiple Run to demonstrate how the close signals of statistical breaker vary at different point of wave.

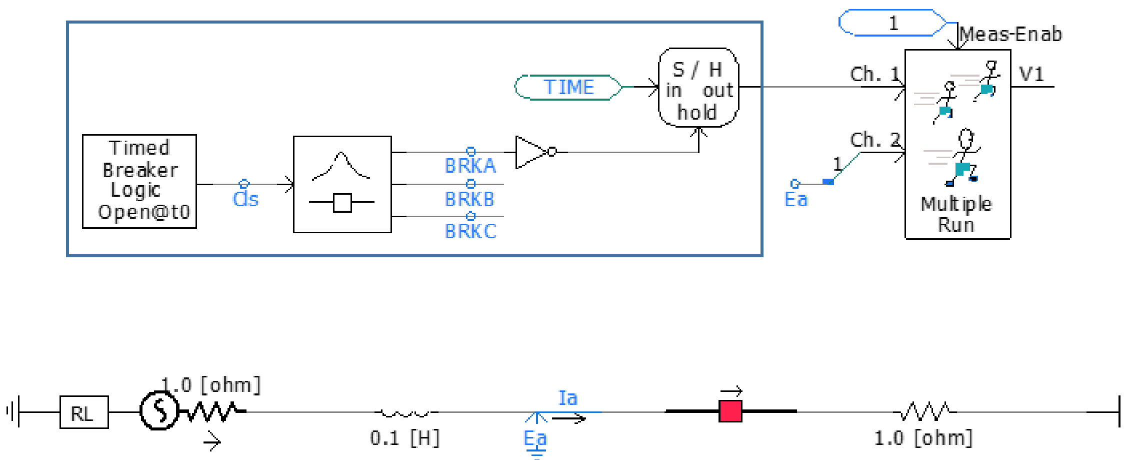

Figure 2: Network Configuration for Example 1

The input “Cls” is breaker closing command signal. The outputs (BRKA, BRKB and BRKC) are signals to control the breaker’s operation (“1” =breaker open, “0”=breaker closed).

The statistical breaker is meant to be used in the single-pole operation of a 3-phase breaker, in a statistically distributed manner.

Once a breaker closing command signal (Cls) is received on its input, the statistical breaker will generate three individual breaker close status signals within the minimum and maximum delay.

2.1.1. Example 1.1: Impact of Min and Max Time Delay

Table 1 summarizes the statistical breaker's parameter to demonstrate the impact of minimum and maximum time delay.

Table 1: Summary of statistical breaker's parameters

	Case 1	Case 2
Mean Time	0.102s	0.1075s
Min Time Delay	0.1s	0.106s
Max Time Delay	0.104s	0.11s

Figure 3 indicates the probability distribution curves always in between Min and Max time delay.

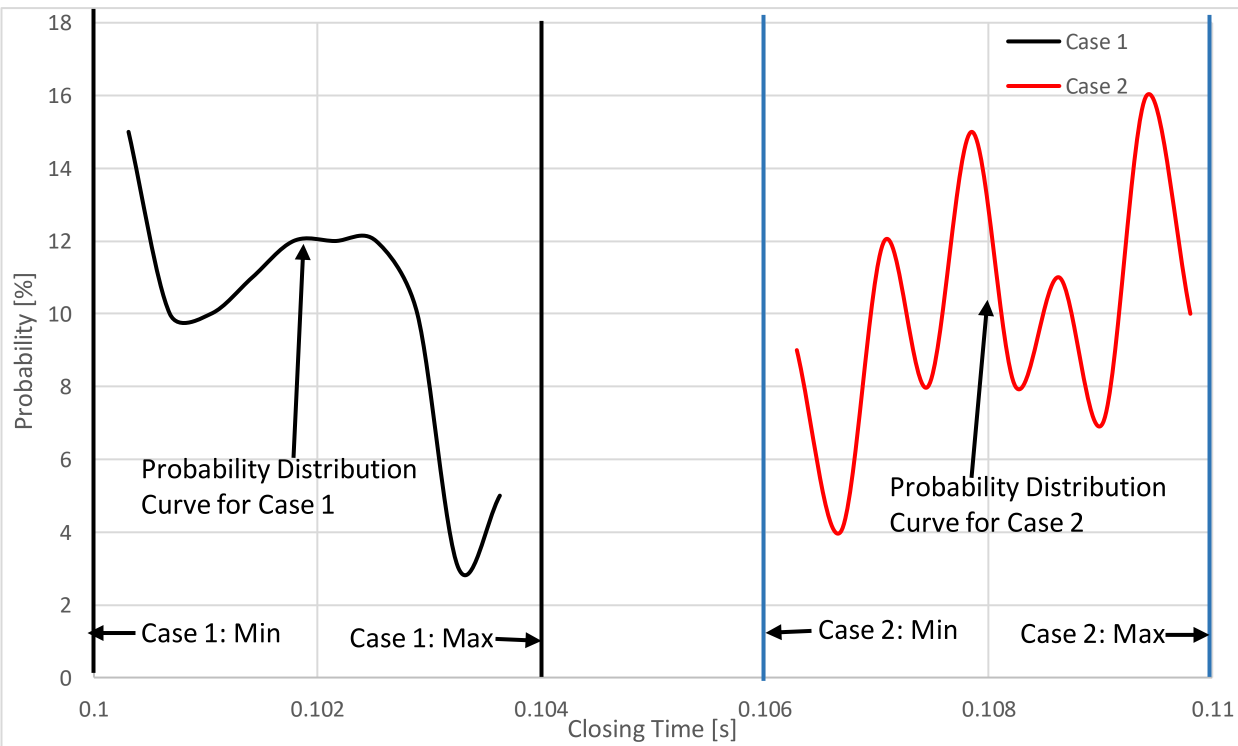

Figure 3: Probability of closing time for 100 runs

2.1.2. Example 1.2: Impact of Number of Standard Deviation

Figure 4 depicts the impact of standard deviation.

Table 2: Summary of statistical breaker's parameters

	Case 1	Case 2
Mean Time	0.102s	0.102s
Number of Standard Deviation	1	4
Min Time Delay	0.1s	0.1s
Max Time Delay	0.104s	0.104s
2% Level	0.1007s	0.1007s
98% Level	0.1034s	0.1034s

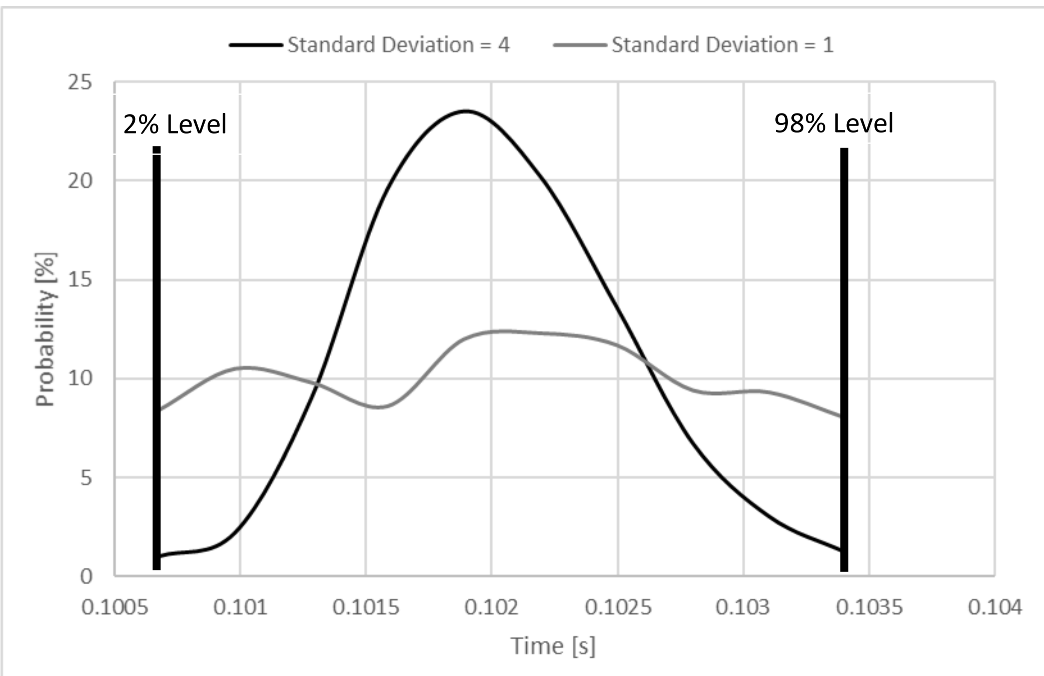

Figure 4: Distribution of Random Closing Time for Different Standard Deviation and 1000 runs

2.1.3. Example 1.3: Interpreting the Output seed value and how to reuse it

The statistical breaker is used to generate the random breaker's closing time with a unique seed value for the associated closing time. The seed value can then be used to re-create the waveforms previously generated by the statistical breaker. The following steps demonstrate how to re-use seed values,

1. Enter a name for the seed value (i.e. Seedvalue).

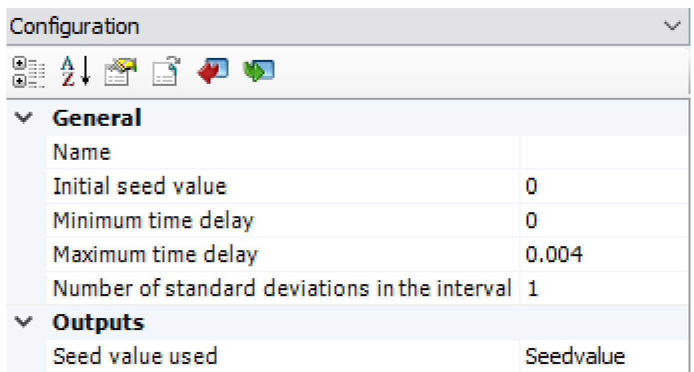

Figure 5: Configuration of Statistical Breaker

2. Connect the Seed value to the input channel of Multiple Run.

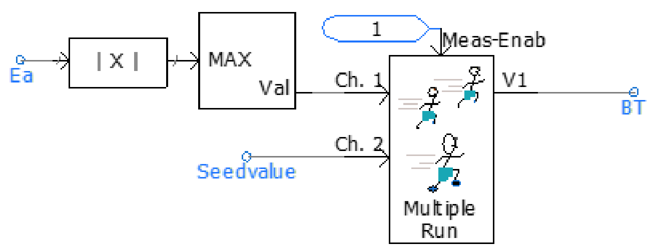

Figure 6: Configuration of multiple run

3. Run the simulation. The Seed value will be recorded in the output file

Multiple Run Output File

Run #	BT	Ea	Seedvalue
1	0.5000000000	291.6380234	539331737.0
2	0.5008000000	398.1539741	574668345.0
3	0.5016000000	344.9883012	610004875.0
4	0.5024000000	403.3505346	645341391.0
5	0.5032000000	241.4127988	716013279.0
6	0.5040000000	390.9386678	751349887.0
7	0.5048000000	390.4651129	786686417.0

Figure 7: Output data

4. For instance, try to re-create Run #4 with seed value of 645341391.
5. Change the "Initial seed value" to the desired value. Disable the multiple run, and change the breaker time to 0.5024 s.

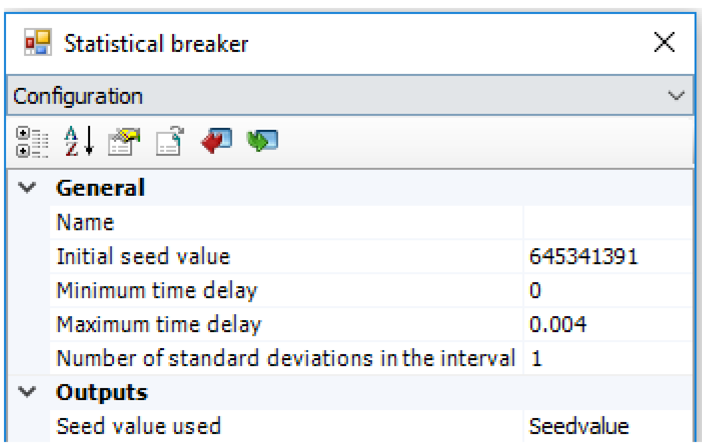

Figure 8: Configuration of Statistical Breaker

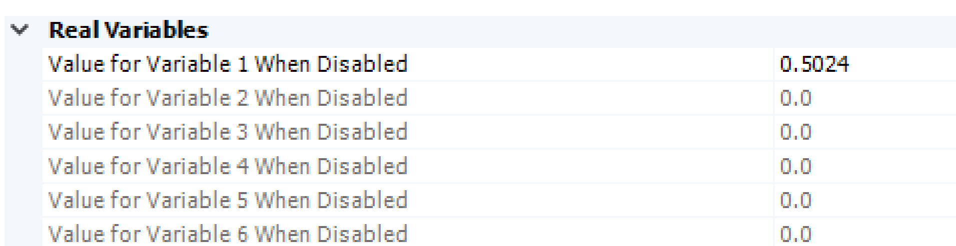

Figure 9: Variable 1 Default Value

[Figure 10](#) compares the original maximum voltage identified by the optimum run with the re-created maximum voltage using seed value.

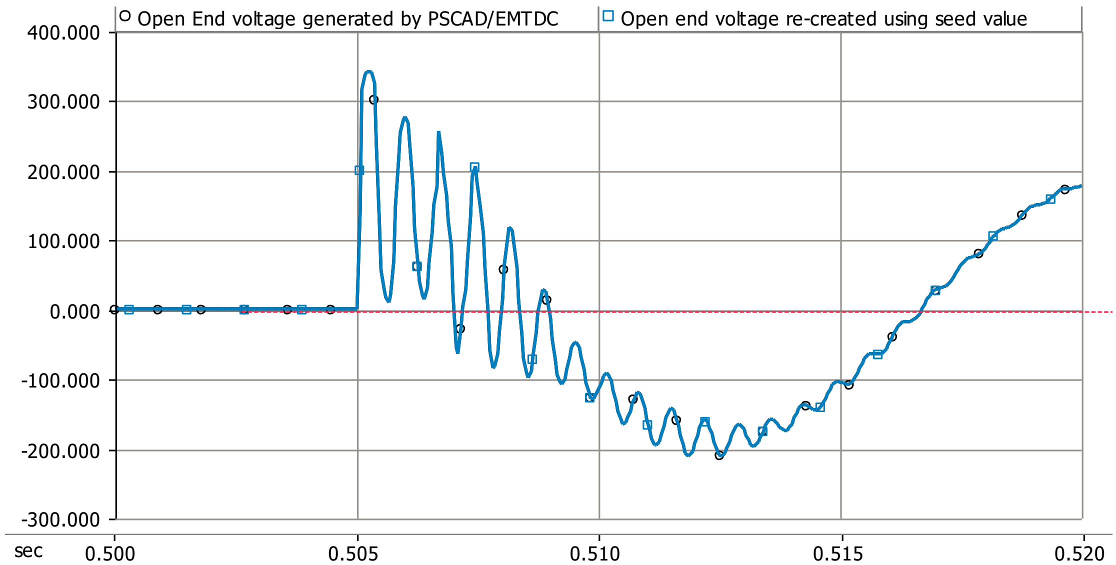

Figure 10: Ea original Waveform and Ea Waveform for Seedvalue is 645341391

2.2. Example 2: Line Re-energizing

The purpose of this example is to demonstrate the impact of breaker closing time when energizing a transmission line with a different length as shown in Figure 11.

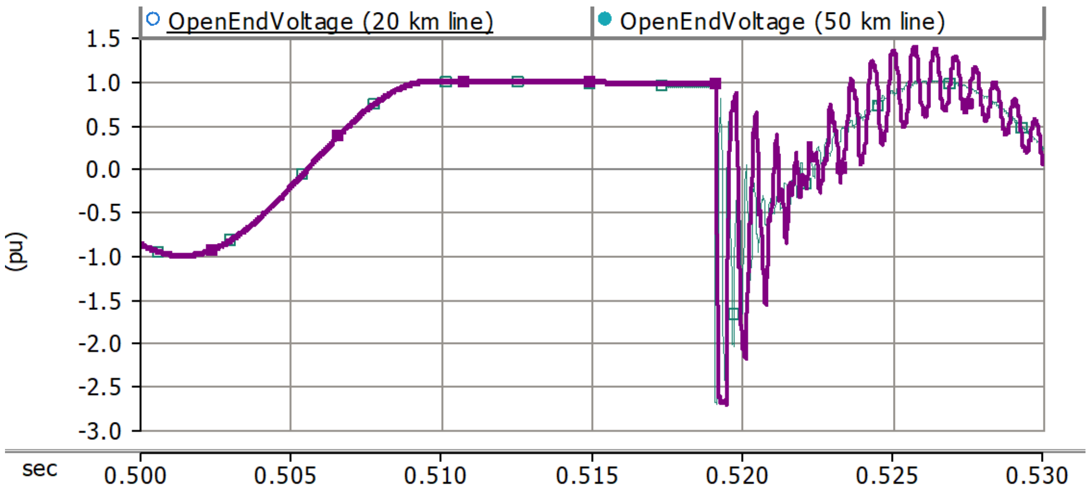

Figure 11: Open end voltage waveform for 20km and 50km transmission line

DOCUMENT TRACKING

Rev.	Description	Date
0	Initial	30/Jan/2020