International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 2 Issue 12, December-2013, pp: (1-7), Available online at: www.erpublications.com

# Design of impulse generators for different front and Tail Resistors in Impulse voltage testing of power transformers

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**Abstract: The performance of the power system depend on the reliability of its components such as Transformer, transmission lines, circuit breakers etc. National and international standards stipulates a lighting impulse voltage of 1.2/50 when impulse voltage testing electrical equipments. The high voltage Impulse test the with stand capability of power transformer. Then the problems associated in practical wave generation will be stated which solution are to be improved by the proposed method using PC Tools. Then a simulation result will be presented for use in our practical lab test and the range of desired parameter should be compared .The paper show how to simulate the basics impulse voltage testing of power transformer and to practice analyzing the test result. The main objective of the paper is to develop an understanding of impulse voltage generator circuit parameter effect on the standard output wave forms. The simulation circuit can be used to find out the desired front time, tail time and peak voltage for variation of different front and tail resistor. The whole system are studied in the PSpice software.**
**Keywords: Impulse generator impulse test, power transformer, PSpice, spark gap.**

## Introduction

Computer simulation plays an important role in engineering course teaching. Nowadays, a variety of software tools are available to simulate electrical circuits; one such tool is PSpice. Many simulations of different aspects of a power system and engineering application using PSpice have been presented by different researchers . A power transformer, a vital and expensive piece of equipment in a power system, requires critical attention from the standpoint of its insulation design and performance under both steady state and transient stress therefore, observation of the behavior of a transformer winding during an impulse voltage test is highly desirable. The components of high-voltage circuits are bulky and expensive, and power transformers are expensive; therefore, computer simulation can be an efficient tool in teaching when the budget is limited.

## Impulse Testing of Transformers

The purpose of the impulse tests is to determine the ability of the insulation of the transformers to withstand the transient voltages due to lightning, etc. Since the transients are impulses of short rise time, the voltage distribution along the transformer winding will not be uniform. The equivalent circuit of a transformer winding for impulses is shown in Fig. 1 If an impulse wave is applied to such a network (shown in Fig. 1) the voltage distribution along the element will be uneven, and oscillations will be set in producing voltages much higher than the applied voltage. Impulse testing of transformers is done using both the full wave and the chopped wave of the standard impulse, produced by a rod gap with a chopping time of 3 to6 µs to prevent large overvoltage's being induced in the windings not under test, they are short circuited and connected to ground. But the short circuiting reduces the impedance of the transformer and hence poses problems in adjusting the standard wave shape of the impulse generators. It also reduces the sensitivity of detection.

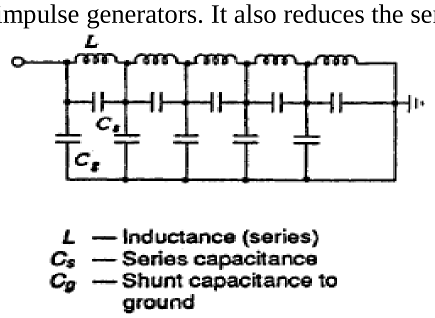


Fig 1:Equivalent circuit of transformer winding for impulses

(**a) Procedure for impulse testing**: The schematic diagram of the transformer connection for impulse testing is shown in Fig 1 and the waveshape of the full and chopped waves are shown in Fig 2.In transformer testing it is essential to record the wave forms of the applied voltage and current through the windings under test. Sometimes, the transferred voltage in the secondary and the neutral current are also recorded. Impulse testing is done in the following sequence:

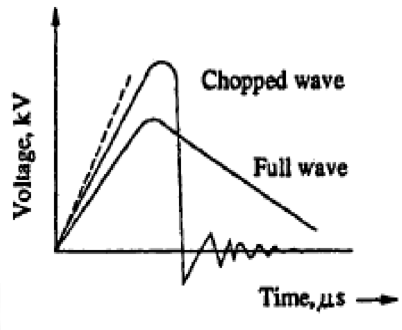


Fig. 2: Full wave and chopped wave

(1) Applying impulse voltage of magnitude 75% of the Basic Impulse Level (BIL) of the transformer under Test,
(2) One full wave voltage of 100% BIL,
(3) Two chopped waves of 100% BIL
(4) One full wave of 100% BIL, and wave
(5) One full wave of 75% BIL.

It is very important to see that the grounding is proper and the windings not under test are suitably terminated

**(b) Detection and Location of Fault During Impulse Testing**- The fault in a transformer insulation is located in impulse tests by any one of the following methods:

**General observations:** The fault can be located by general observations like noise in the tank or smoke or bubbles in breather.

**Voltage oscillogram method :** Fault or failure appears as a partial or complete collapse of the applied voltage wave. Figure 3 gives the typical waveform. The sensitivity of this method is low and does not detect faults which occur on less than 5% of the winding.

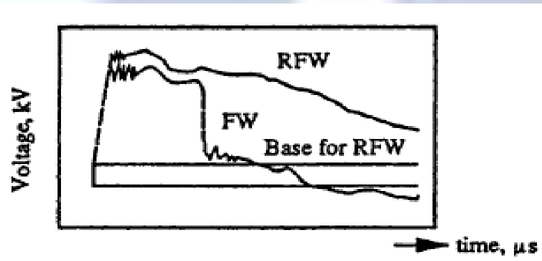


Fig 3(a): Failure from the line lead to ground through oil

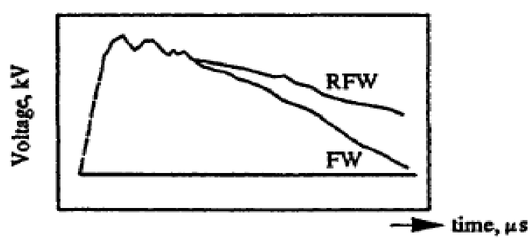


Fig 3 (b): 8.5% of winding fail

**Fig. 3:** Voltage oscillograms of transformer winding with a fault RFW-Reduced full wave FW-Full wave

**Neutral current method**: In the neutral current method, a record of the impulse current flowing through a resistive shunt between the neutral and ground point is used for detecting the fault. The neutral current oscillogram consists of a high frequency oscillation, a low frequency disturbance, and a current rise due to reflections from theground end of the windings. When a fault occurs such as arcing between the turns or from turn to the ground, a turn of high frequency pulses similar to that in the front of the impulse current wave are observed in the oscillogram and the waveshape changes. If the fault is local, like a partial discharge, only high frequency oscillations are observed without a change of wave shape. The sensitivity of the method decreases, if other windings not under test are grounded.

**Transferred surge current method:** In this method, the voltage across a resistive shunt connected between the low voltage winding and the ground is used for fault location. A short high frequency discharge oscillation is capacitively transferred at the event of failure and is recorded. Hence, faults at a further distance from the neutral are also clearly located. The wave shape is distorted depending on the location and type of fault, and hence can be more clearly detected .After the location of the fault, the type of fault can be observed by dismantling the winding and looking for charred insulation or melted parts on the copper winding. This is successful in the case of major faults. Local faults or partial discharges are self healing and escape observation.

**Simulation of impulse voltage test generator for different front and tail resistor**

Impulse voltage testing of transformers, the front time and tail time of the pulse are important; therefore, one must to observe the effect of the wave-shaping control elements on the voltage waveform. The dependence of the shape of the waveform on the resistors Rt (tail resistor) and Rf (front resistor) can be checked by changing the values of these resistors. These resistors can control the front and tail of the output impulse voltage. Figs. 5 and 6 shows the output voltages of the impulse generator for different front and tail resistors.

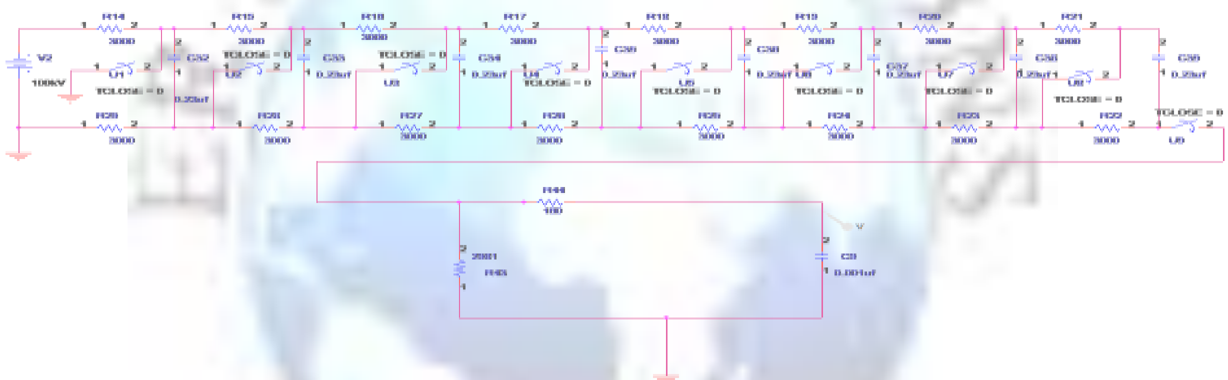

Fig 4: LI Test at a different front and tai l resistor

Graph view: Output of impulse generator for different front Resistor

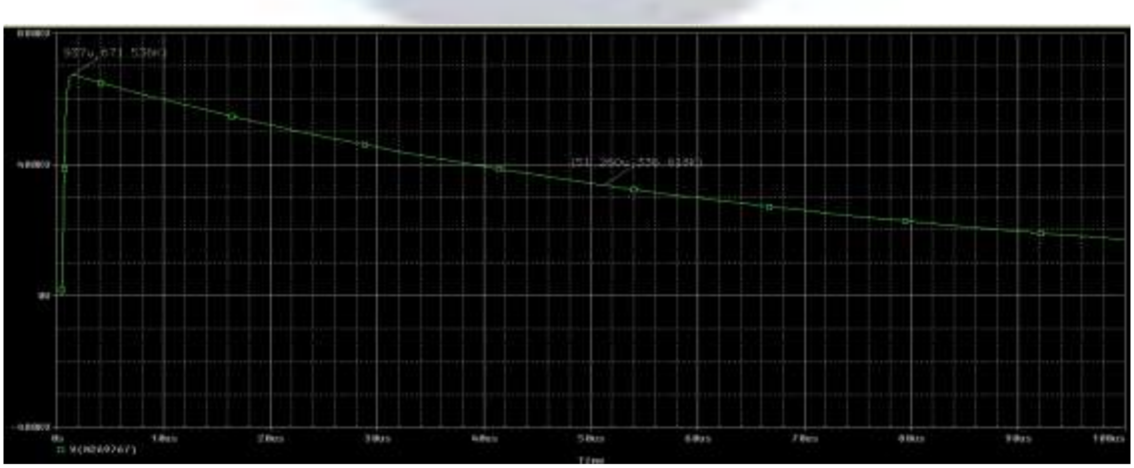

Fig (5a): Pspice output wave with R1(160-ohm)

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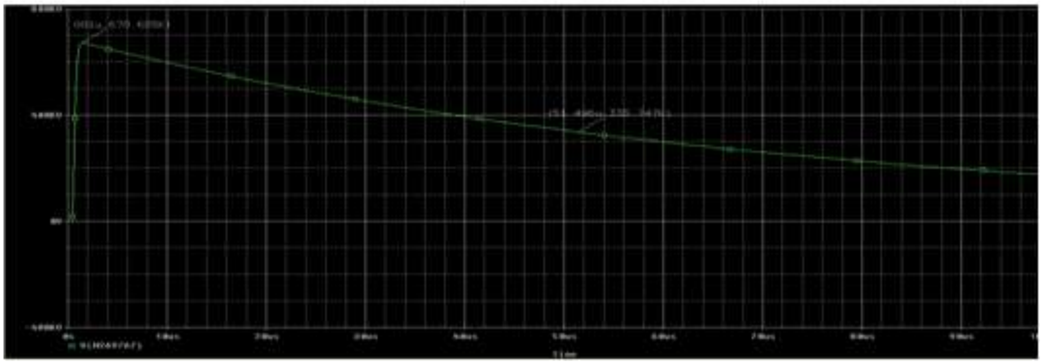

Fig (5b): PSpice output wave with R1(170-ohm)

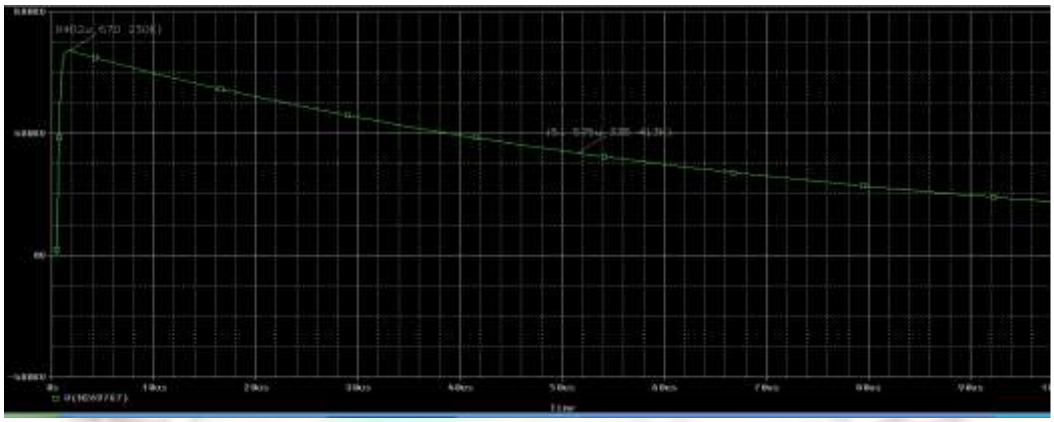

Fig (5c): PSpice output wave with R1(180-ohm)

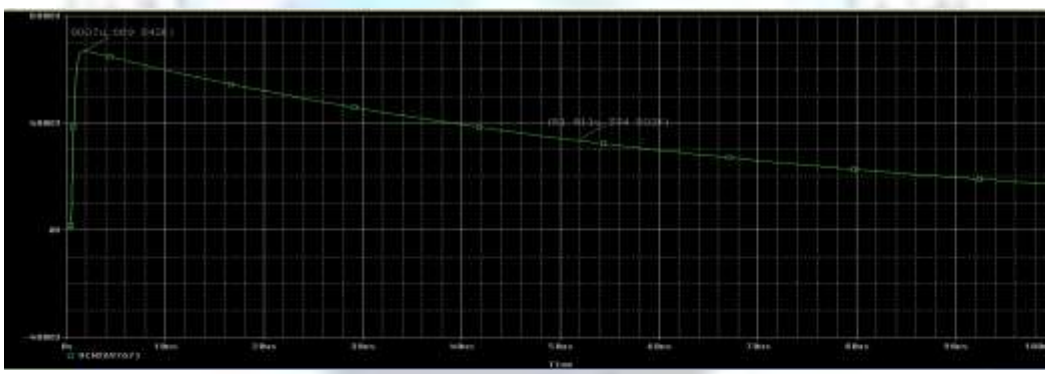

Fig (5d): PSpice output wave with R1(227-ohm)

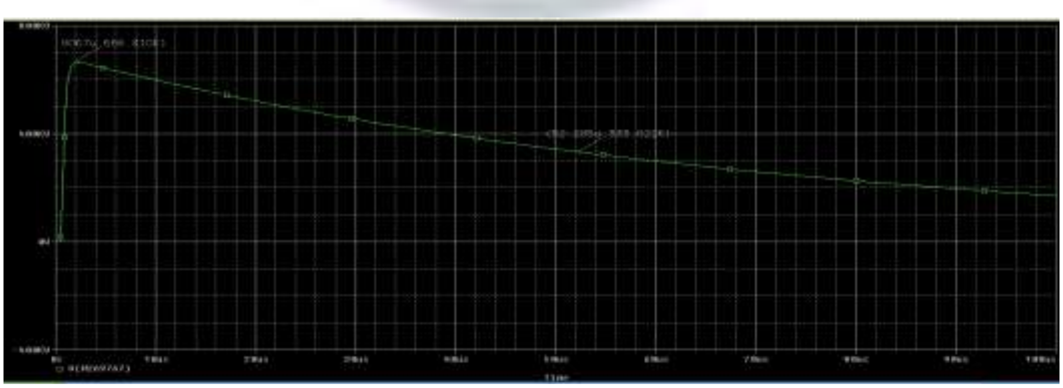

Fig (5e): PSpice output wave with R1(315-ohm)

TABLE - 1

| curve | V(kV) | Cg(uf) | R1(ohm) | R2(ohm) | Cl(uf) | Vp(kv) | T1(us) | T2(us) |
|---|---|---|---|---|---|---|---|---|
| 1 | 100 | 0.23 | 160 | 2981 | 0.001 | 671.536 | 1.3937 | 51.260 |
| 2 | 100 | 0.23 | 170 | 2981 | 0.001 | 670.685 | 1.4001 | 51.496 |
| 3 | 100 | 0.23 | 180 | 2981 | 0.001 | 670.230 | 1.8402 | 51.575 |
| 4 | 100 | 0.23 | 227 | 2981 | 0.001 | 669.842 | 1.9007 | 51.811 |
| 5 | 100 | 0.23 | 315 | 2981 | 0.001 | 666.810 | 2.0067 | 52.205 |

Graph view: Output of impulse generator for different Tail resistor

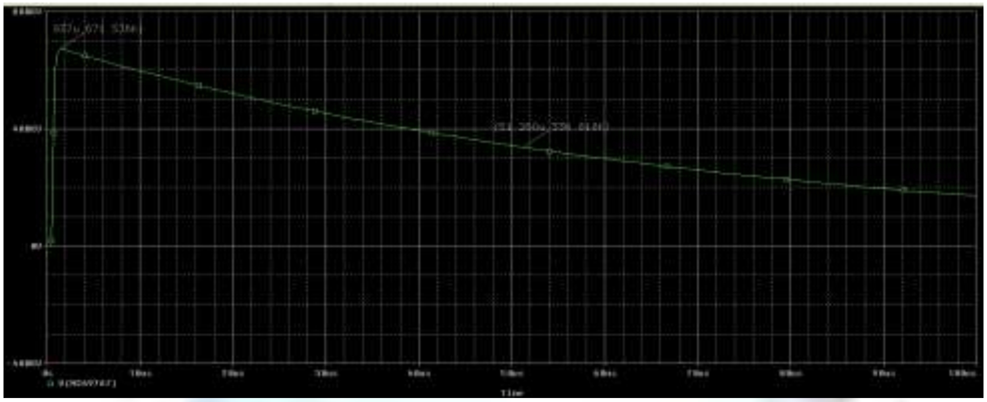

Fig (6a):n  PSpice output wave with (R2-2981)ohm

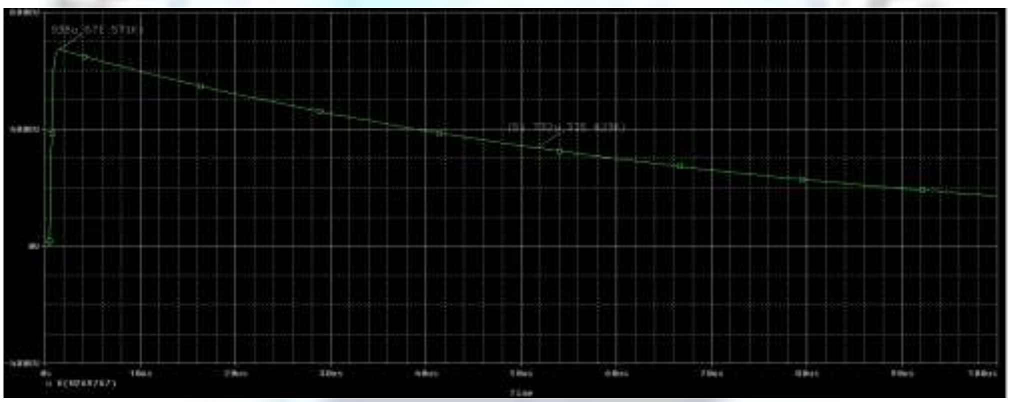

Fig. (6b): PSpice output wave  with (R2-3000)ohm

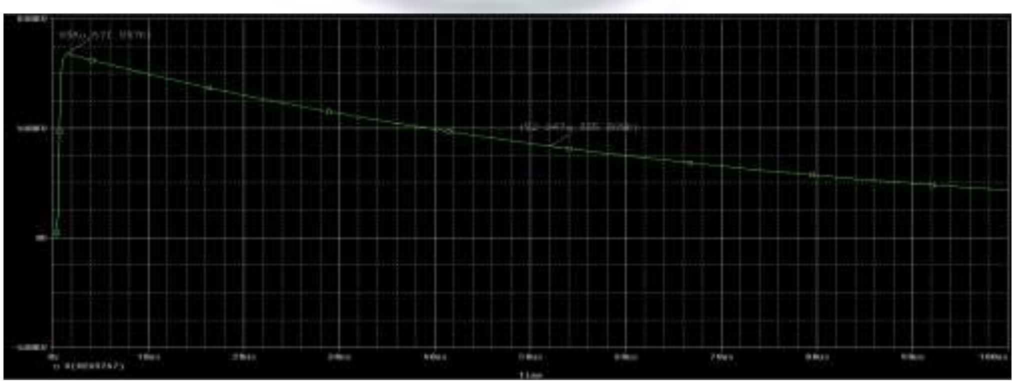

Fig. (6c): PSice output wave with (R2-3015)ohm

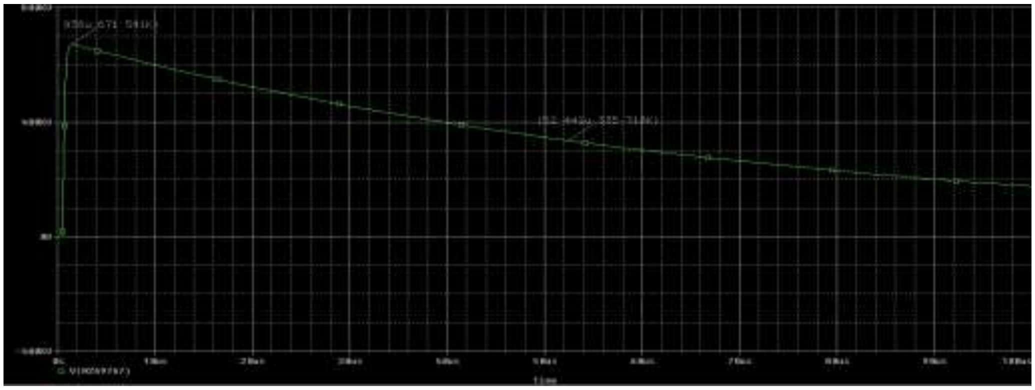

Fig (6d): PSice Output wave with ( R2-3050) ohm

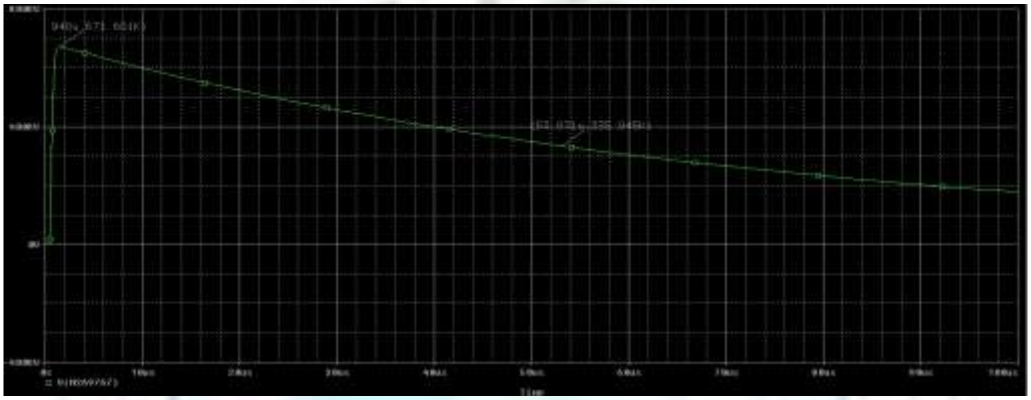

Fig (6E): PSice Output wave with ( R2-3085)ohm

TABLE - 2

| Curve | V(kV) | Cg(uf) | R1(ohm) | R2(ohm) | Cl(uf) | Vp(kv) | T1(us) | T2(us) |
|---|---|---|---|---|---|---|---|---|
| 1 | 100 | 0.23 | 160 | 2981 | 0.001 | 671.536 | 1.3937 | 51.260 |
| 2 | 100 | 0.23 | 160 | 3000 | 0.001 | 671.597 | 1.3938 | 51.732 |
| 3 | 100 | 0.23 | 160 | 3015 | 0.001 | 671.600 | 1.3940 | 52.047 |
| 4 | 100 | 0.23 | 160 | 3050 | 0.001 | 671.571 | 1.3938 | 52.441 |
| 5 | 100 | 0.23 | 160 | 3085 | 0.001 | 671.541 | 1.3939 | 53.071 |
| | | | | | | | | |

## RESULT

The impulse voltage waveforms of Marx circuit for different front resistor and Tail resistor values. Variation of impulse voltage with front resistor small increment in front resistor value leads to negligible increment in tail time but a significant change in peak voltage and front time as summaries Table 1. variation of impulse voltage with tail resistor significant change in tail resistor value only leads to increment in tail time but there is no change in peak voltage and front time as summarized Table 2.

## CONCLUSIONS

This paper has outlined and illustrated a PSpice model to simulate the impulse voltage testing of power transformers. Generate standard output impulse voltage waveforms of 1.2/50 µs which leads to the simulation analyses on impulse voltage testing of power transformer winding. The method considerably reduces the time and cost needed to teach impulse testing of power transformers. Therefore, it is very useful for educational purposes where the budget is limited.

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