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Current Reflections and Reflection Coefficients Related to Lightning at Tall Structures

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PRESENTATION OUTLINE

- Introduction
- The Study
- Transmission Line Models
- Excitation Functions
- Response of Models
- Data Analysis
- Discussion and Conclusions

INTRODUCTION

The Presentation will consider lightning current oscillations within Tall Structures and explore whether values of Reflection Coefficients at structure discontinuities are uniquely responsible for observed ratios of incident to reflected waves.

INTRODUCTION CONT'D

Fig.1 – CN Tower

Let us examine this situation for the CN Tower (shown in Fig.1), and indicate complications that exist in the process of determining Reflection Coefficients from measured data.

THE STUDY

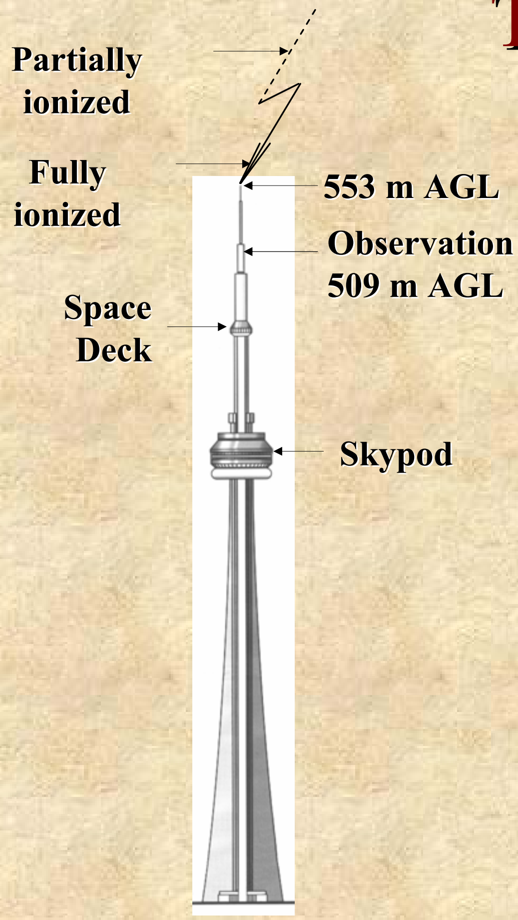


Fig.2 – CNT and Lightning Channel

Two models from the MASc Thesis by Ivan Boev "Development of a Five-Section Model for Computing Lightning Current in the CN Tower" are considered, where individual sections of the tower are represented by transmission lines with constant impedances.

SINGLE SECTION MODEL

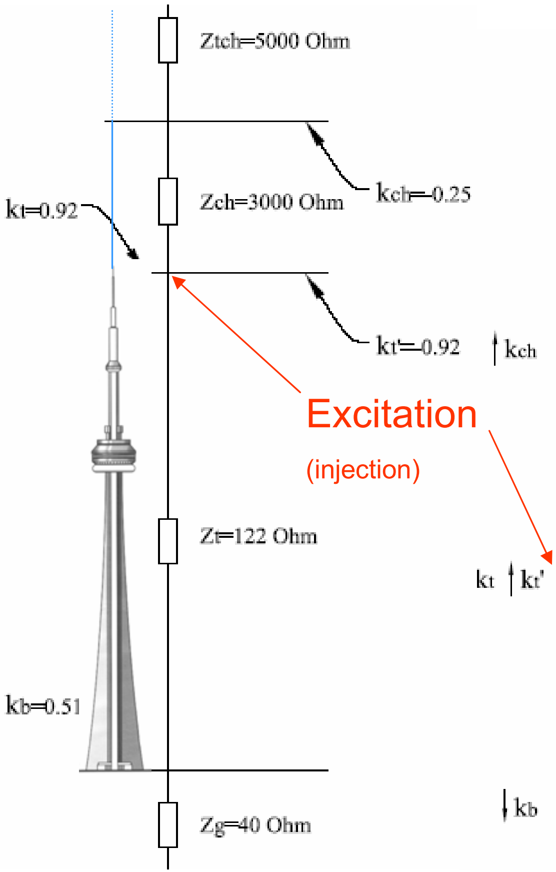


Fig.3 – Model

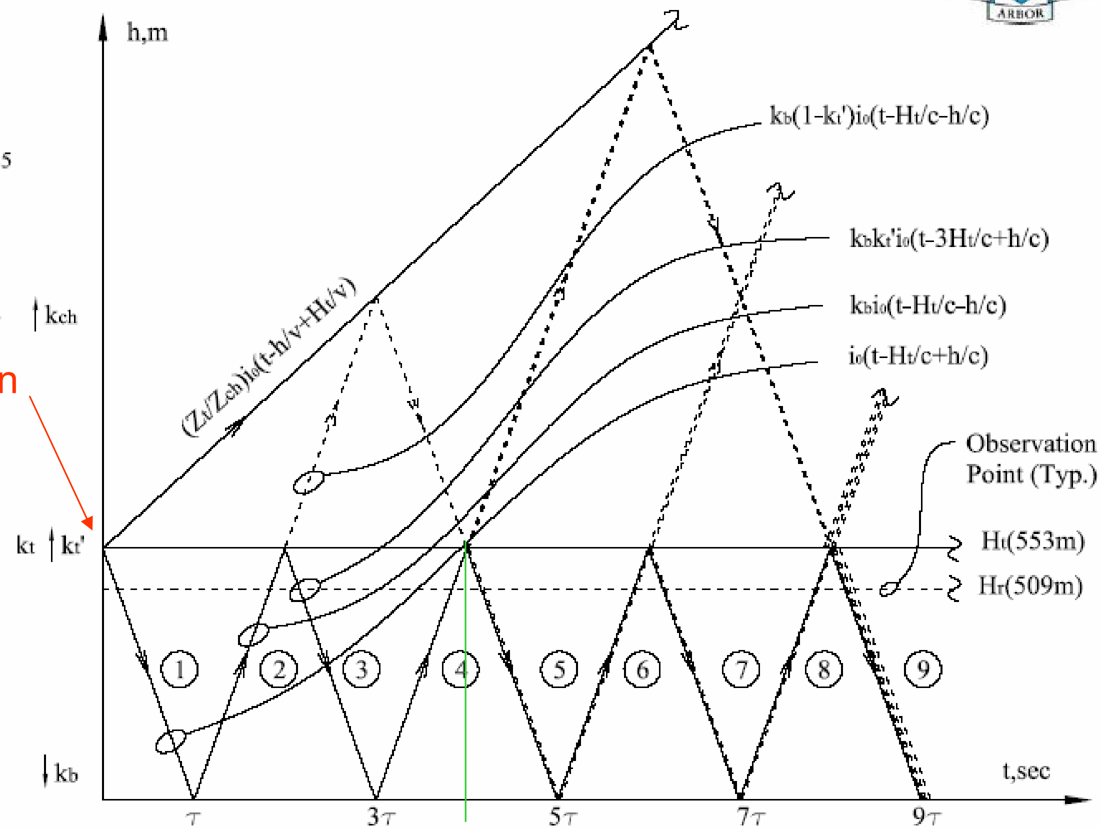
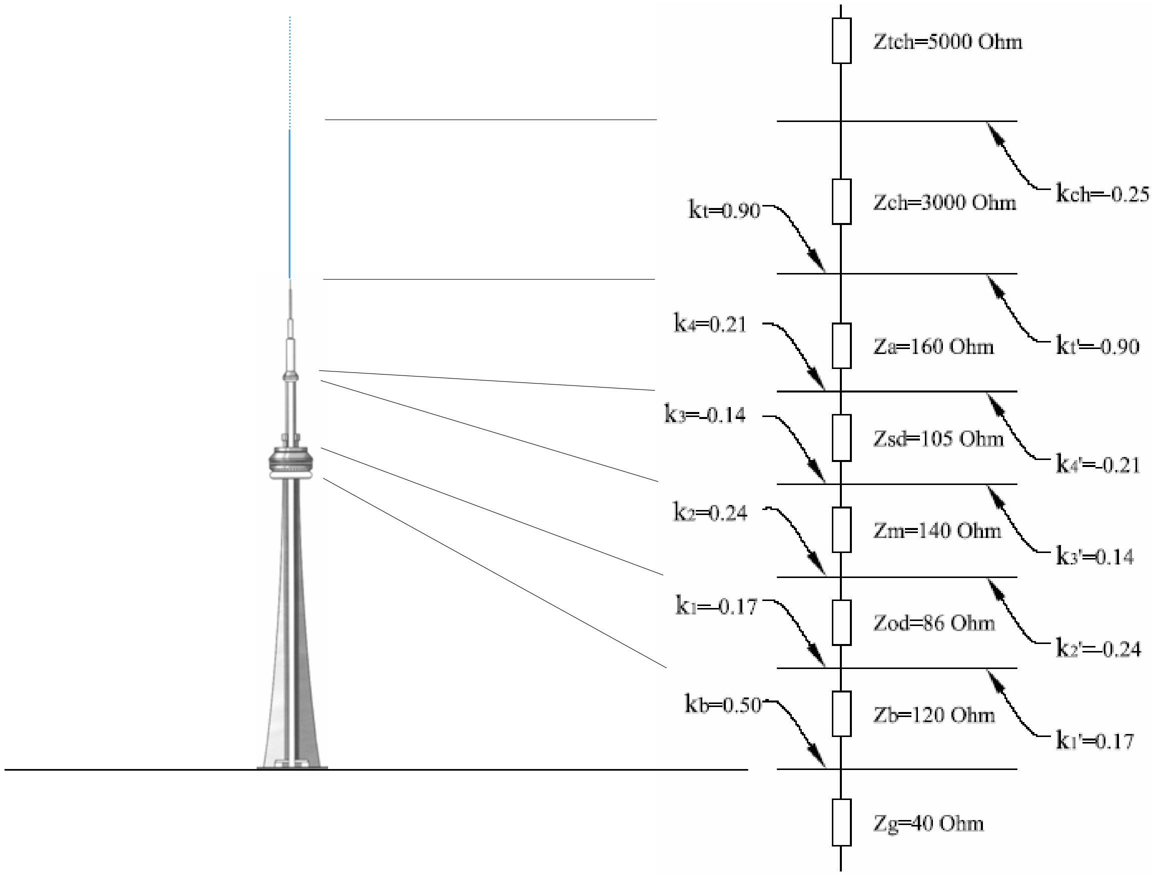


Fig.4 – Lattice Diagram

FIVE SECTION MODEL



FIVE SECTION MODEL

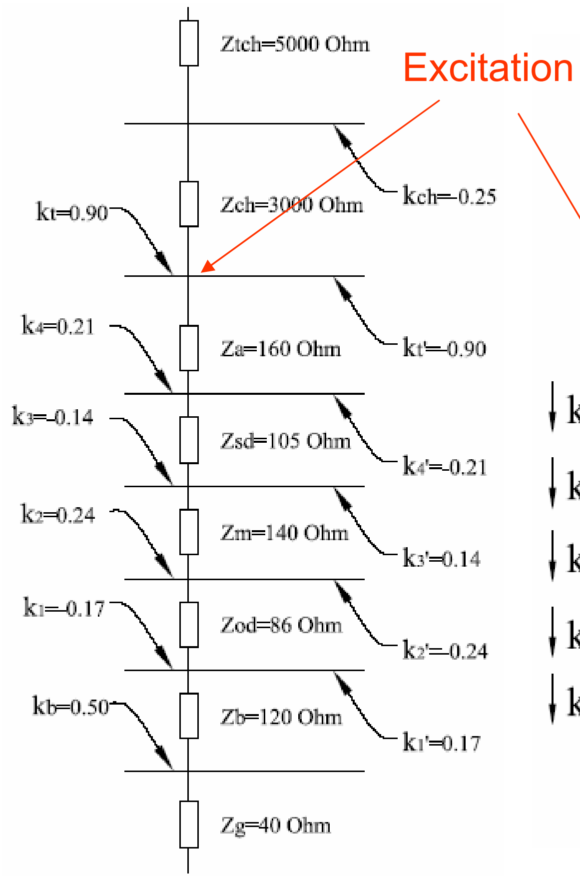


Fig.5 – Model

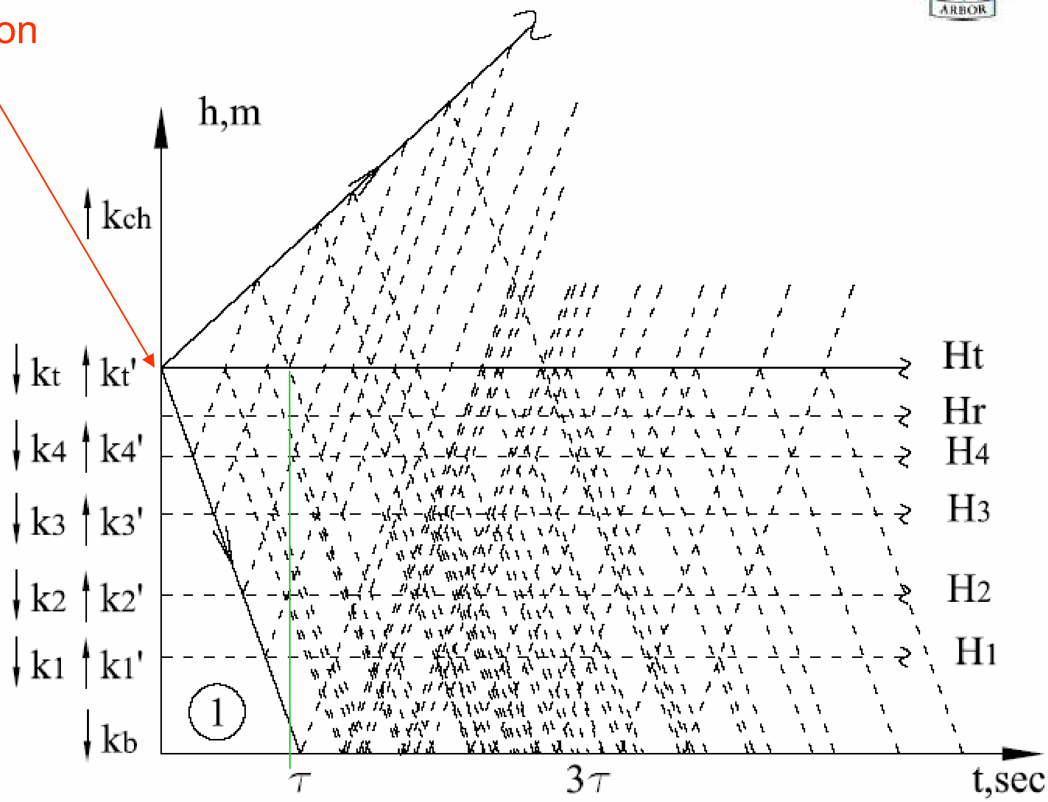


Fig.6 – Lattice Diagram

EXCITATIONS

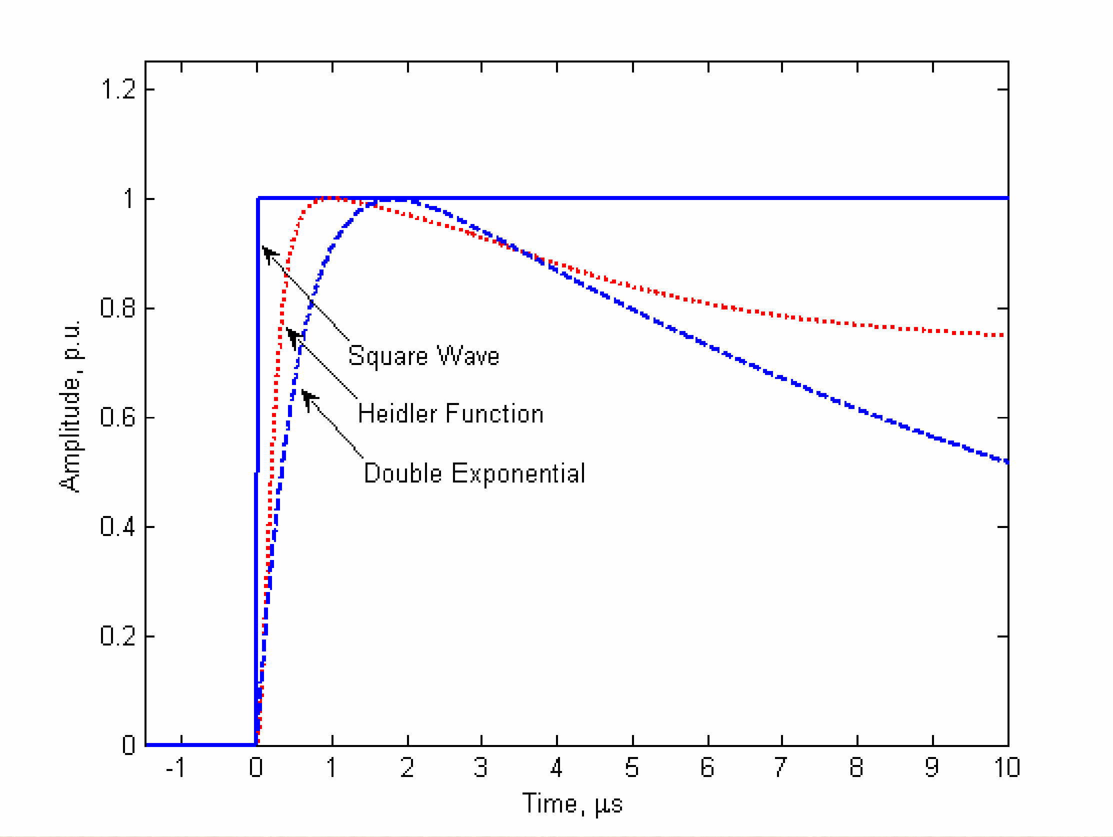


Fig.7 – Three Excitations

PARAMETERS OF INJECTED WAVEFORMS

Heidler Function (actually sum of two Heidler currents):

I_{a1}=0.9 pu t_{11}=0.25e-6 s t_{21} =2.5e-6 s h_1=2

I_{a2} =0.6 pu t_{12} =2.1e-6 s t_{22} =230e-6 s h_1 =2

Double Exponential:

I=1.23 a=-0.866e5 b=-1.732e6

Fig.7 – Three Excitations

RESPONSE OF SINGLE SECTION MODEL

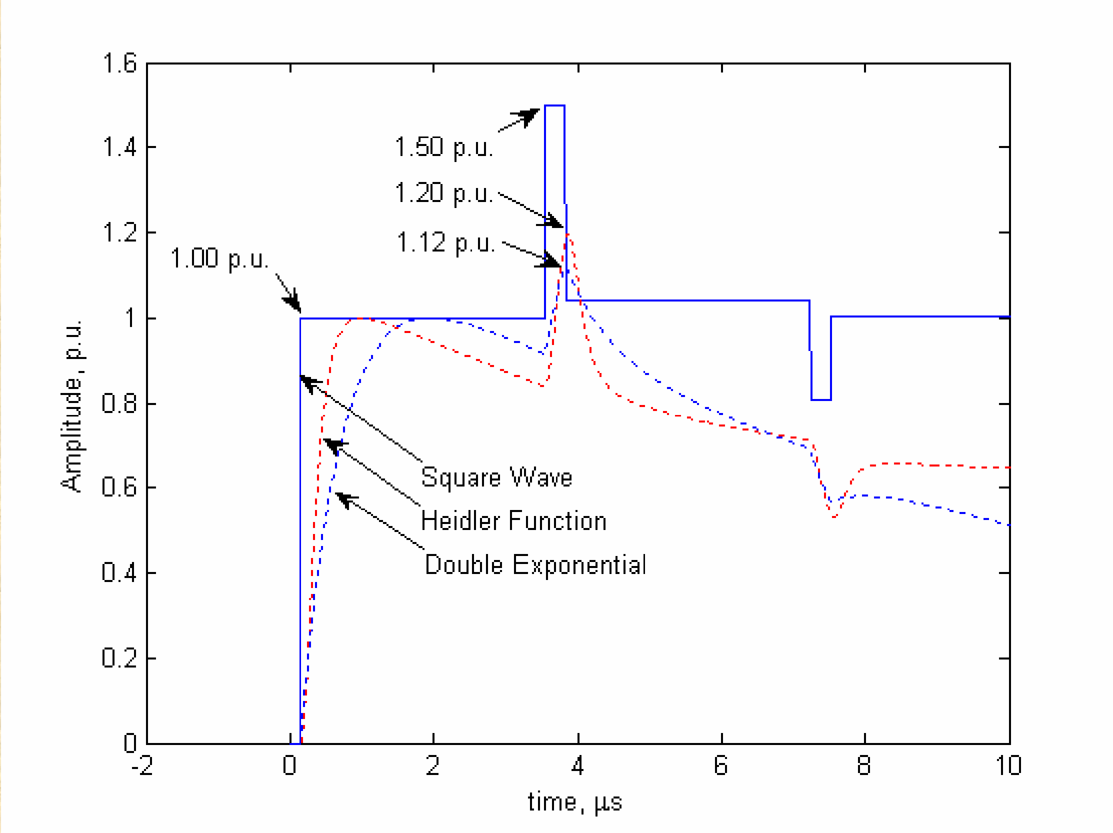


Fig.8 – Response of Single Section Model

RESPONSE OF FIVE SECTION MODEL

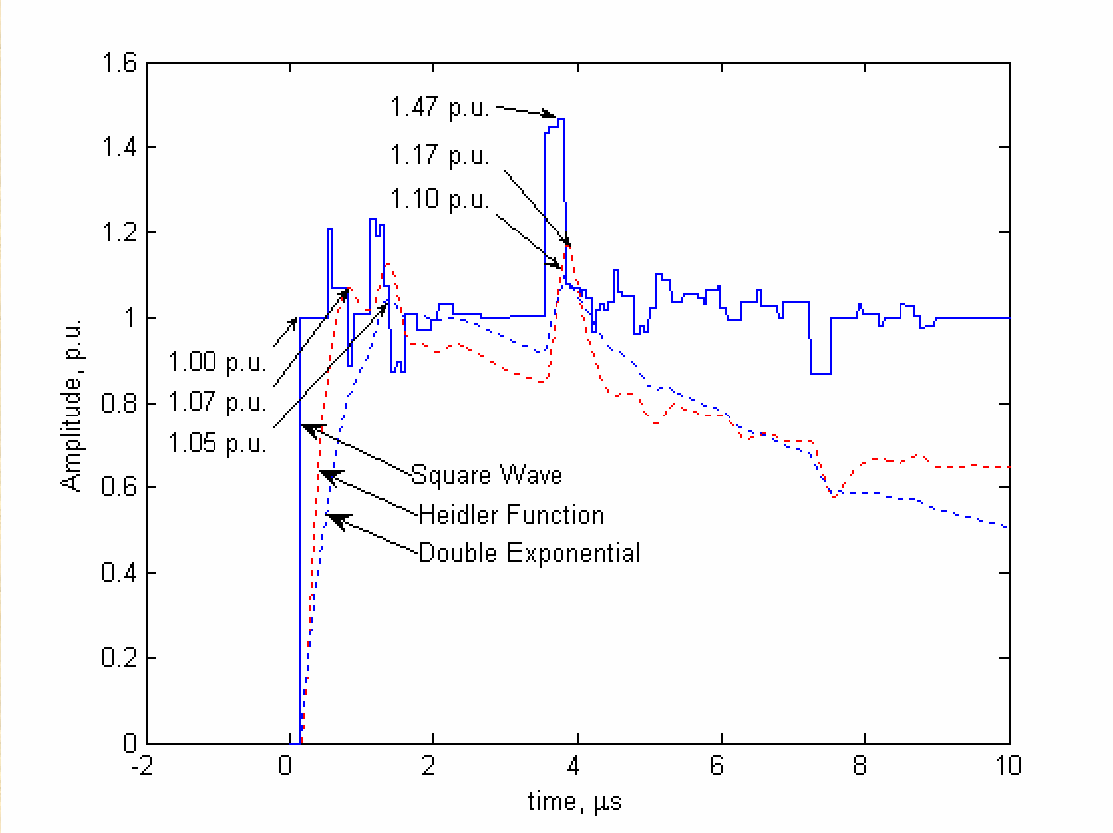


Fig.9 – Response of Five Section Model

ANALYSIS OF RESULTS

Excitation	*First Peak (FP)*	*Absolute Peak (AP)*	*AP/FP*
Square Wave	1.00	1.50	1.50
Heidler Function	1.00	1.20	1.20
Double Exponential	1.00	1.12	1.12

Table 1. – Single Section Response

Excitation	*First Peak (FP)*	*Absolute Peak (AP)*	*AP/FP*
Square Wave	1.00	1.47	1.47
Heidler Function	1.07	1.17	1.09
Double Exponential	1.05	1.10	1.05

Table 2. – Five Section Response

DISCUSSION

- Irrespective of the model used, the observed amplitude of the wave reflected from ground is different for each excitation.

- On closer examination it is recognized that the primary reason for the differences in results computed for each of the three excitations lies in the front rate of rise of each waveform.

- Due to peculiarities of the CN Tower shape and because of the location of the observation point, reflection from tower top "cuts off" the rise of the reflected wave at a different level.

- In addition, the overall shape of the incident wave influences the value of the Absolute Peak.

CONCLUSIONS

- **In cases of lightning wave shapes observed at Tall Structures, one must be very careful when attempting to use the simple ratio of Absolute to First Peak for derivation of Reflection Coefficients.**

- **Additional information about the complete shape of the incident lightning current and its possible distortions due to reflections within the Tall Structure must be fully taken into account.**