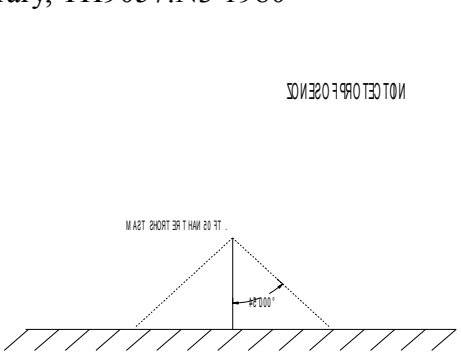
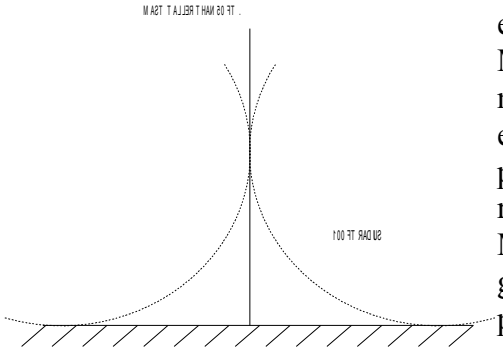
To: File
From: Jon Hagen
Date: 10-21-99
Subject: Lightning protection references

Lightning Protection Code 1980 ANSI/NFPA 78
AO Library, TH9057.N3 1980

p41
height *h*



50 ft
cone of
p42
height
50 ft:



excerpts:
Mast with
not
exceeding
protects
radius *h*.
Mast with
greater than
protection
determined

by volume not accessible to
an imaginary sphere with a 100 ft radius.

p3-15: No bend of a conductor shall form an included angle of less than 90 degrees nor shall have a radius of bend less than 8 inches.

Lightning and Lightning Protection, Wm. C. Hart and Edgar W. Malone, Don White Consultants, Inc. 1979
AO Library TH9061.H325
Includes interesting historical information.
Lightning characteristics: A lightning stroke typically has several current pulses, all of the same polarity. Successive pulses have lower peak currents but last longer and transfer more charge. The median peak current for a first stroke is about 20,000A. A typical first stroke a rise time of 5 to 10 microseconds and a fall time of 10 to 20 microseconds.

First stroke peak current greater than 2 to 8 kA: 90% probability
greater than 10 to 25 kA: 50% probability

greater than 40 to 60 kA: 10% probability
Maximum observed peak current: 230 kA

More than 1 to 2 pulses in a stoke: 90% probability
More than 2 to 4 pulses in a stoke: 50% probability
More than 5 to 11 pulses in a stroke: 10% probability

More than 5 to 10 ms between pulses: 90% probability
More than 30-40 ms between pulses: 50% probability
More than 80 to 130 ms between pulses: 10% probability
Maximum observed time between pulses: 500 ms

On page 3.16, four model strokes are given: low amplitude, typical, high amplitude, and extreme amplitude. The typical stroke has four pulses, separated by 42 ms. This model pulse is shown in three Mathcad plots of current (in Amperes): the leading edges of each pulse, the duration of each pulse, and the complete 4-stroke pulse.

$$a1 := \frac{1}{4.8\ 10^{-5}} \qquad a2 := \frac{1}{4.2\ 10^{-4}} \qquad b1 := \frac{1}{10^{-6}} \qquad b2 := \frac{1}{4.5\ 10^{-6}}$$

$$A1 := 28000 \qquad A2 := 28000 \qquad A3 := \frac{5}{6} A2 \qquad A4 := \frac{2}{3} A2 \qquad B := 115$$

$$I1(t) := A1 \left(e^{-a1\ t} - e^{-b1\ t}\right) + B \left(e^{-a2\ t} - e^{-b2\ t}\right)$$

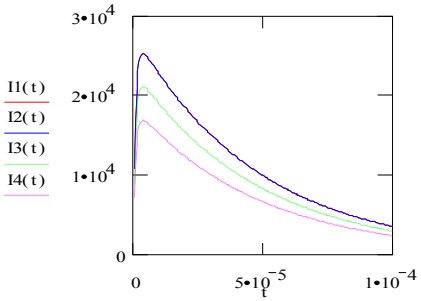
$$I2(t) := A2 \left(e^{-a1\ t} - e^{-b1\ t}\right) + B \left(e^{-a2\ t} - e^{-b2\ t}\right)$$

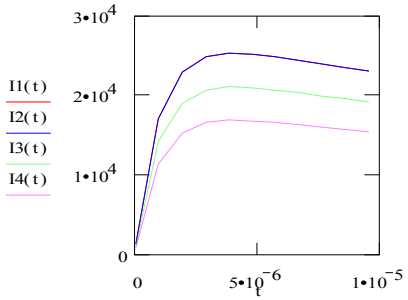
$$I3(t) := A3 \left(e^{-a1\ t} - e^{-b1\ t}\right) + B \left(e^{-a2\ t} - e^{-b2\ t}\right)$$

$$I4(t) := A4 \left(e^{-a1\ t} - e^{-b1\ t}\right) + B \left(e^{-a2\ t} - e^{-b2\ t}\right)$$

$t := .05\ 10^{-6}\ 10^{-6}\ 10\ 10^{-6}$

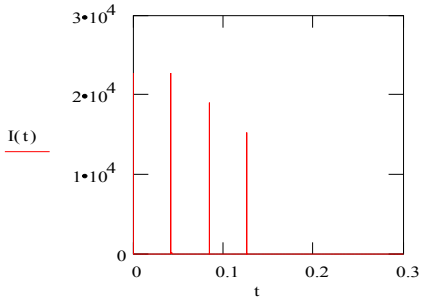
$t := .5\ 10^{-6}\ 10^{-6}\ 100\ 10^{-6}$





$t := .00001\ .00002\ .3$

$$I(t) := I1(t) + (t - .042) \cdot I2(t - .042) + ((t - 2 \cdot .042) \cdot I3(t - 2 \cdot .042) + (t - 3 \cdot .042) \cdot I4(t - 3 \cdot .042))$$



National Association of Broadcasters Engineering Handbook 8th Ed.
Section 2.2, Lightning Protection for Broadcast Facilities
excerpts: Protecting equipment from the effects of lightning involves a combination of grounding, bonding, and surge suppression. Grounding provides a path to introduce lightning currents into the earth. Bonding serves to equalize lightning potential differences between various elements of the equipment to be protected. Surge suppression limits differences in

potential on active circuits which cannot be directly bonded.