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Designing to Survive a Direct Lightning Strike

Introduction

This paper discusses the commercially available methods, products and materials available to meet the requirements of the direct lightning strike waveforms described in MIL-STD-1757A and MIL-STD 464C.

The existing IEC 62305 and NFPA 780 lightning protection standards do not provide a clear correlation between accepted industry protection waveforms and those seen with the MIL-STD direct strike requirements.

This paper will provide detailed PSpice modeling and numerical analysis to compare the direct strike components in the military 1757A and 464C standards with the relevant IEC 62305 10/350us suggested direct strike waveform.

Introduction

A detailed analysis is performed using PSpice and MathCAD tools to compare the key parameters of peak current, time characteristics, di/dt, charge and energy of the lightning pulse definitions.

PSpice is utilized to model a conventional and isolated lightning circuit with the relevant lightning wave forms injected to simulate lightning conditions. The modeling provides a rough order comparison of the induced voltages at the lightning air terminal and side flash from the down conductor into adjacent metal objects.

The results shown here will allow system designers to select commercially available products to achieve compliance with military standards requirements with a high level of confidence.

Introduction

The paper discusses these topics in detail:

1. Background of Lightning Protection
2. Air Terminal Models and Separation Distance
3. Numerical Comparisons of Waveforms
4. Pspice Simulations of Conventional and Isolated Models
5. Summary

1 Background of Lightning Protection

A lightning protection system functions by intercepting the direct lightning strike energy as it hits near a structure and safely diverting it to the Earth. Much has been published on this topic in great detail by academic experts and industry leading standards bodies.

Lightning phenomena is roughly based on the discharge of huge charge regions (both positive and negative) high in the atmosphere into the Earth. This discharge can initiate in either direction starts a rapid connection “in the general direction” of Earth.

The actual final discharge pathway is only established after the charge region is close enough to the ground to create a high electric field influence to provoke small step leader coronas from all the available sources relative to their impedance.

1 Background of Lightning Protection

Several leaders all "reach out" by virtue of small variation in the electric field and dielectric break down through the air to the rapidly moving charge region and the "winner" establishes the plasma channel, initial stroke and subsequent return strokes.

In other words, the lightning does not have a real plan when it starts to propagate, but only near the end do the step leaders feel enough electric field influence to reach up and connect. This all occurs in 10's to 100's of microseconds.

1 Background of Lightning Protection

The elevated franklin rod allows a preferred step leader jump off point and establishes the discharge path through the rod and down conductors into the Earth, where the charge is dissipated safely. Because the franklin rod is higher, it is closer to the charge source and experiences a stronger electric field to initiate the step leader. This is the best proven means of avoiding lightning damage and is prescribed by the NFPA and IEC peer reviewed lightning standards.

The IEC 62305 and NFPA 780 standards provide guidelines in the specific rod placement locations on structures to optimize the chances of intercepting a lightning strike. These methods include mesh spacing, fall of angle and rolling sphere calculations to guide air terminal placement using basic franklin rod air terminal, down conductor and earth electrode connections.

2 Air Terminal Models and Separation Distance

For this analysis, a single air terminal placed on a 10m tall structure is visualized and the simplified circuit model of a conventional franklin rod is shown in figure 1.

The inductance L4 of 9.6uH is taken from Brocke & Beierl, ICLP 2012 with cable resistance R5 .005ohm derived from standard wire tables.

The simplified circuit of a isolated lightning protection air terminal shown in figure 2.

The High Voltage Isolated jacket is modeled as a parasitic capacitance circuit consisting of C1, C2, L3 and R4 connected to earth through R3.

The lightning current source is pictured as “Implementation=10-350us”.

2 Air Terminal Models and Separation Distance

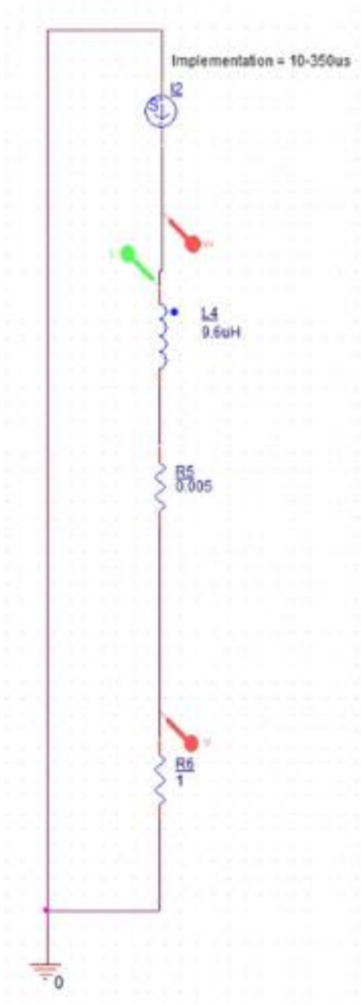


Figure 1

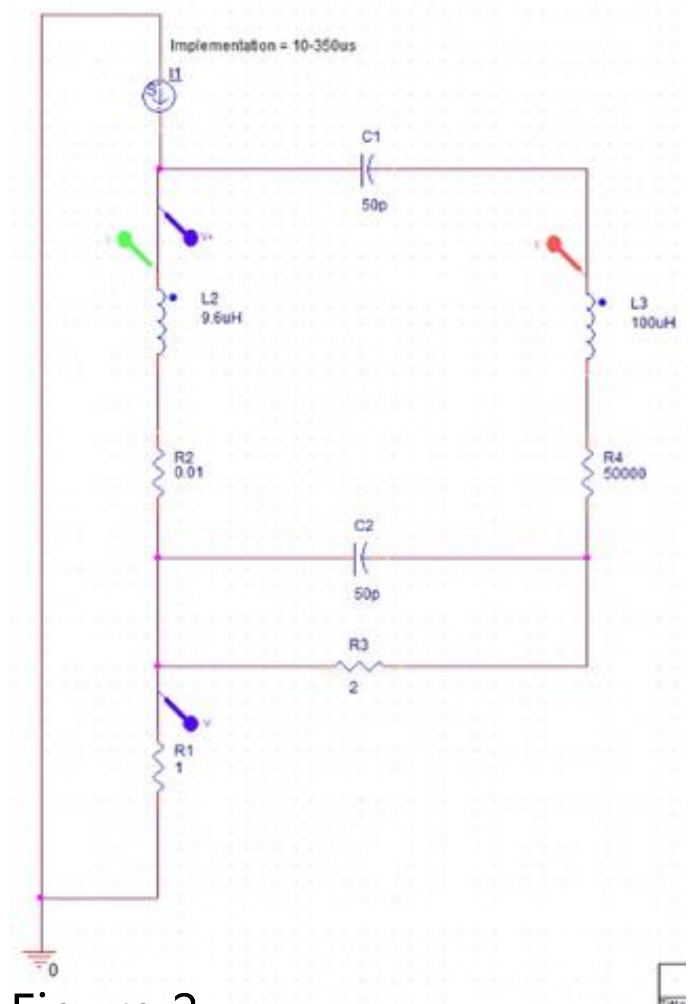


Figure 2

The various 10-350 and MIL STD waveforms are simulated in section 4.

This type of isolated HVI system is investigated because it offers equivalent separation distance to eliminate lightning side flash.

2 Air Terminal Models and Separation Distance

The voltage at the "top" of the lightning rod model just below the current source is used as an important reference to compare the MIL STD and IEC waveforms. The fast di/dt rise time components can be expected to provoke similar high voltage readings as is revealed in the simulations.

Lightning air terminals and down conductors are subject to side flash if there is not enough separation distance to adjacent electrical apparatus. Side flash can manifest like in figure 3.

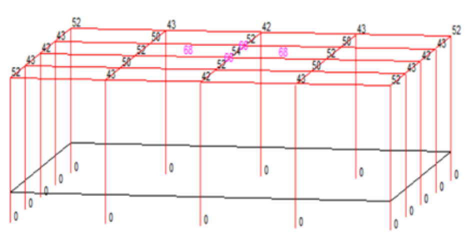
Figure 3 Courtesy DEHN, 2019

2 Air Terminal Models and Separation Distance

The IEC 62305 calculation of separation distance s is shown in figure 4 for a mesh on a structure.

This high voltage induced into the air terminal and down conductor is the source of side flash and is covered in detail through the IEC 62305 standard.

$$s = k_i \cdot \frac{k_c}{k_m} \cdot l \text{ [m]}$$



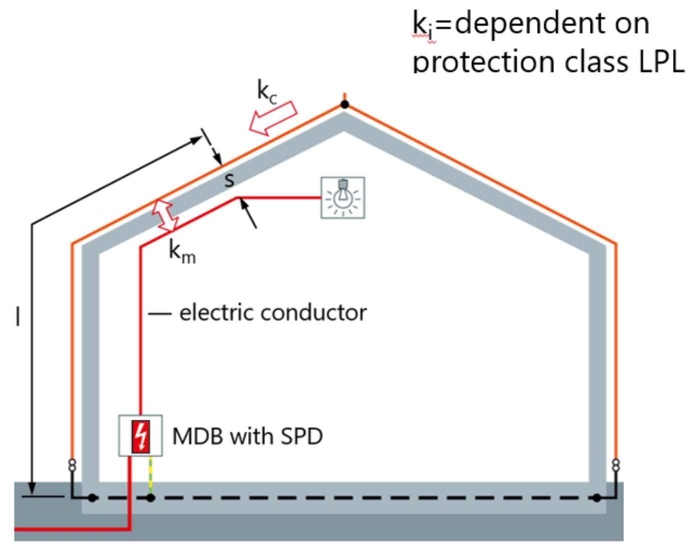


Figure 4 IEC 62305 Separation Distance formula

2 Air Terminal Models and Separation Distance

The IEC calculation for separation distance “s” at 200kA 10/350us for a 10m tall air terminal is illustrated in figure 5. This shows 81cm clearance is required between the 10m high lightning rod to any metal objects per IEC 62305.

The MIL STD component A simulations in section 4 show high di/dt induced voltage effects that are similar to the IEC 62305 results, and re-enforce the usefulness of the IEC 62305 industry standard methods.

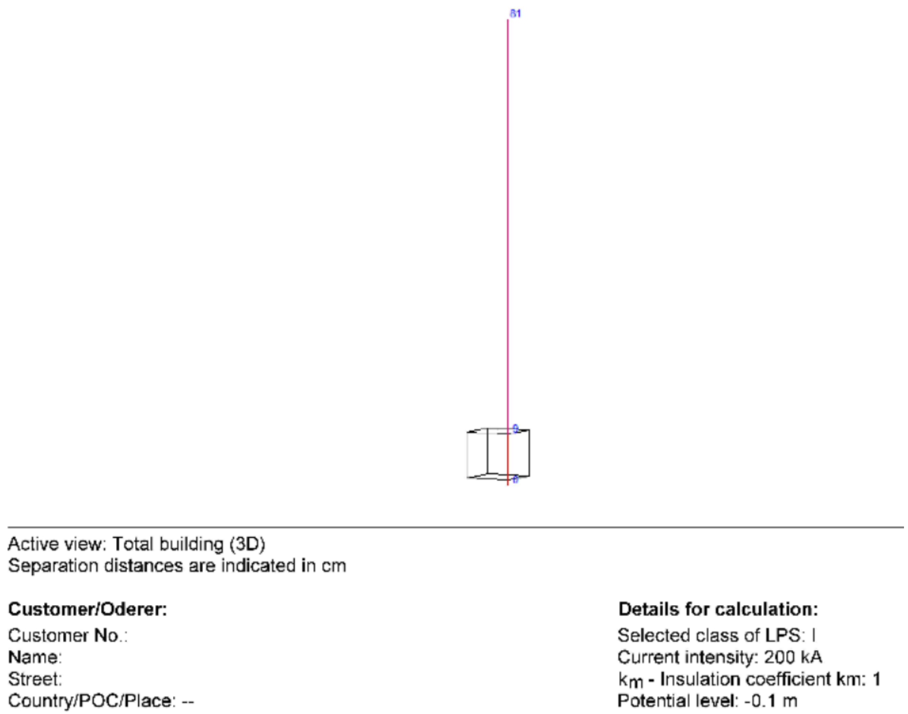
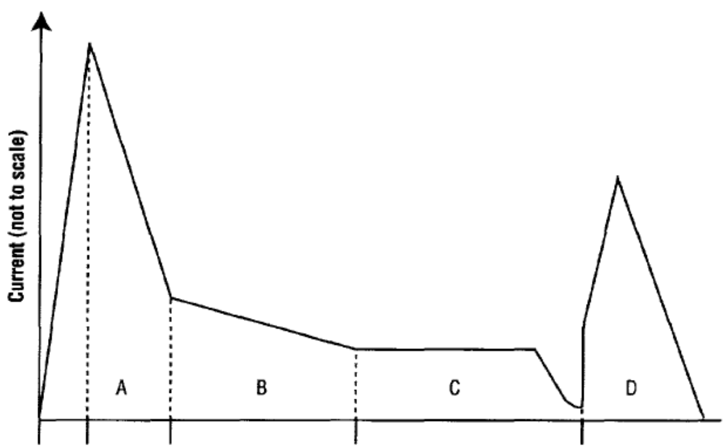


Figure 5 Separation Calculation for 200kA 10/350us 10m height

3 Numerical Comparisons of Waveforms

Here are the MIL-STD-1757A lightning waveforms with the figure 6 references from the standard. Of special note is the rate of rise di/dt which is shown to have profound impact in the simulations.

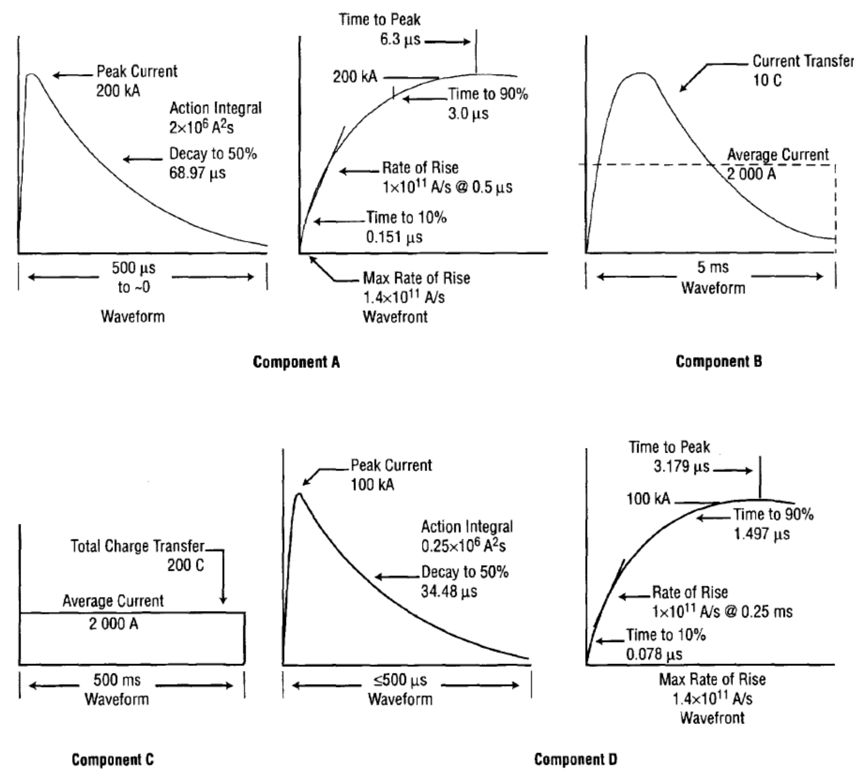


Component A (Initial Stroke)
Peak Amplitude = 200 kA±10%
Action Integral = $2\times10^6\ A^2s\pm20\%$
Time Duration ≤500 µs

Component C (Continuing Current)
Charge Transfer = 200 C±20%
Amplitude = 200 to 800 A
Time Duration 0.25<T≤1 s

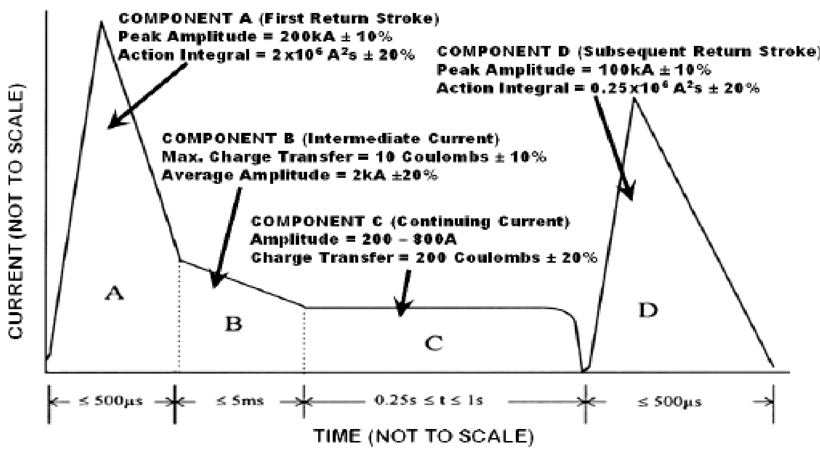
Component B (Intermediate Current)
Maximum Charge Transfer = 10 C
Average Amplitude = 2 kA±10%
Duration ≤5 ms

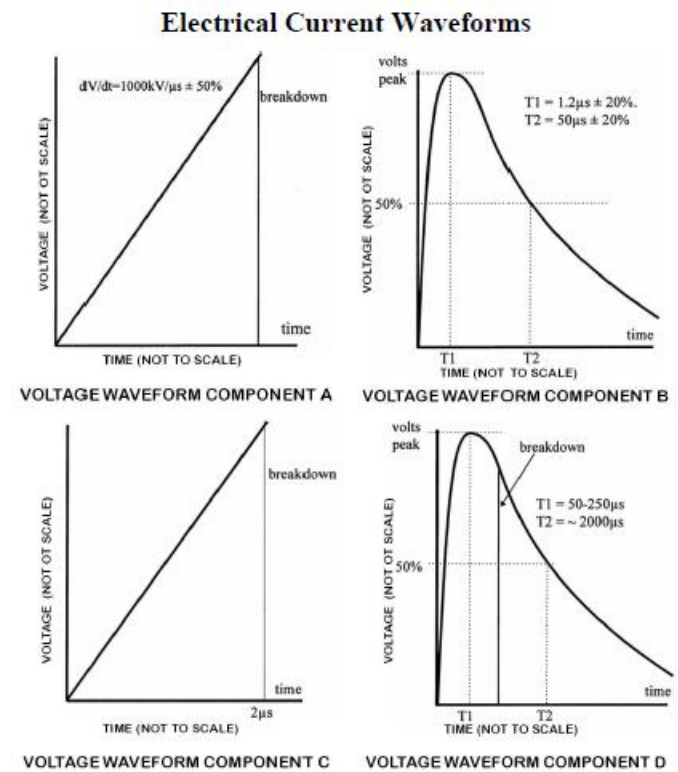
Component D (Restrike)
Peak Amplitude = 100 kA±10%
Action Integral = $0.25\times10^6\ A^2s\pm10\%$
Duration ≤5 µs



3 Numerical Comparisons of Waveforms

Here ar the waveform description excerpts from MIL-STD-464C with the figure and table reference from the standard. These are fundemental identical, with only a minor diference in the component C average current levels.





Current Component	Description	$i(t) = I_o(e^{-\alpha t} - e^{-\beta t})$ t is time in seconds (s)		
		I_o (Amperes)	$\alpha(s^{-1})$	$\beta(s^{-1})$
A	Severe stroke	218,810	11,354	647,265
A_h	Transition zone first return stroke	164,903	16,065	858,888
B	Intermediate current	11,300	700	2,000
C	Continuing current	400 for 0.5 s	Not applicable	Not applicable
D	Subsequent Stroke Current	109,405	22,708	1,294,530
D/2	Multiple stroke	54,703	22,708	1,294,530
H	Multiple burst	10,572	187,191	19,105,100

NOTE: Current Component A_h is applicable in the Transition Zone 1C and represents the estimated shape of the first return stroke (Component A) at higher altitudes.

3 Numerical Comparisons of Waveforms

Here are the IEC 62305-4 10/350us lightning waveform definitions. The lightning protection level LPL I values are the best match for the MIL STD requirements.

62305-1 © IEC:2010(E) – 31 –

Table A.1 – Tabulated values of lightning current parameters taken from CIGRE (Electra No. 41 or No. 69) [3], [4]

Parameter	Fixed values for LPL I	Values			Type of stroke	Line in Figure A.5
		95 %	50 %	5 %		
I (kA)		4[a]	20[a]	90	First negative short[b]	1A+1B
	50	4,9	11,8	28,6	Subsequent negative short[b]	2
	200	4,6	35	250	First positive short (single)	3
Q_{FLASH} (C)		1,3	7,5	40	Negative flash	4
	300	20	80	350	Positive flash	5
Q_{SHORT} (C)		1,1	4,5	20	First negative short	6
		0,22	0,95	4	Subsequent negative short	7
	100	2	16	150	First positive short (single)	8
W/R (kJ/Ω)		6	55	550	First negative short	9
		0,55	6	52	Subsequent negative short	10
	10 000	25	650	15 000	First positive short	11
di/dt_{max} (kA/µs)		9,1	24,3	65	First negative short[b]	12
		9,9	39,9	161,5	Subsequent negative short[b]	13
	20	0,2	2,4	32	First positive short	14
$di/dt_{30\%/90\%}$ (kA/µs)	200	4,1	20,1	98,5	Subsequent negative short[b]	15
Q_{LONG} (C)	200				Long	
T_{LONG} (s)	0,5				Long	
Front duration (µs)		1,8	5,5	18	First negative short	
		0,22	1,1	4,5	Subsequent negative short	
		3,5	22	200	First positive short (single)	
Stroke duration (µs)		30	75	200	First negative short	
		6,5	32	140	Subsequent negative short	
		25	230	2 000	First positive short (single)	
Time interval (ms)		7	33	150	Multiple negative strokes	
Total flash duration (ms)		0,15	13	1 100	Negative flash (all)	
		31	180	900	Negative flash (without single)	
		14	85	500	Positive flash	

[a] The values of I = 4 kA and I = 20 kA correspond to a probability of 98 % and 80 %, respectively.

[b] Parameters and relevant values reported on Electra No. 69.

3 Numerical Comparisons of Waveforms

MathCAD is used to graph the various waveforms.

The mathematical expression for entire set of 10/350us and MIL STD components A, B, C and D has been constructed and the calculus is employed to fill in the gaps in the comparison table.

Then the expressions taken directly from the respective standards are integrated to find the missing values to "fill in" the parameters in Table 1.

These "missing" parameters bridge the gap between the standards to allow comparisons of all four the usual factors that describe lightning.

3 Numerical Comparisons of Waveforms

IEC 62305 Part 1: 2010 - Annex B - Time functions of the lightning current

Parameters for the - - First Positive Impulse

$I\_pos := 200000 \quad k\_pos := 0.93$

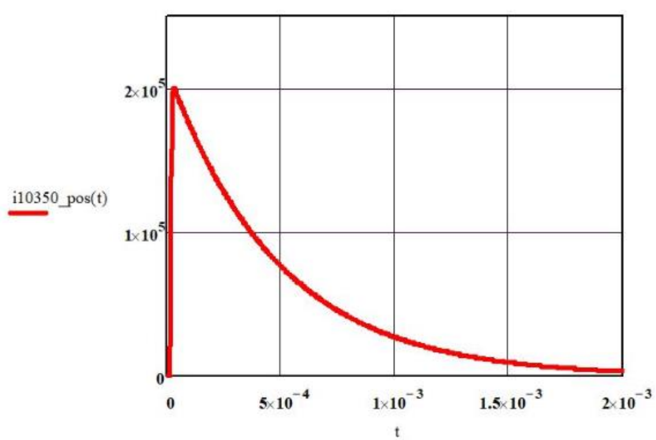
$tmin\_pos := 0$

$tmax\_pos := 2000 \cdot 10^{-6}$

$T1\_pos := 19 \cdot 10^{-6}$

$T2\_pos := 485 \cdot 10^{-6}$

$$i10350\_pos(t) := \frac{I\_pos}{k\_pos} \cdot \frac{\left(\frac{t}{T1\_pos}\right)^{10}}{1 + \left(\frac{t}{T1\_pos}\right)^{10}} \cdot e^{\left(\frac{-t}{T2\_pos}\right)}$$



$$Q\_10350\_pos := \int_{tmin\_pos}^{tmax\_pos} i10350\_pos(t)\, dt = 98.543$$

$$Q\_Long10350 := Q\_C = 200$$

$$Q\_IEC62305 := Q\_10350\_pos + Q\_Long10350 = 298.543$$

Note the charge Q integration result for IEC standard is close to the 300C value listed.

$$Action\_int\_IEC62305 := \int_{tmin\_pos}^{tmax\_pos} (i10350\_pos(t))^2\, dt = 1.027 \times 10^7$$

$I\_pos10\% := (0.1) \cdot I\_pos = 2 \times 10^4 \qquad t\_10\% := 1.518 \cdot 10^{-5}$

$I\_pos90\% := (0.9) \cdot I\_pos = 1.8 \times 10^5 \qquad t\_90\% := 2.314 \cdot 10^{-5}$

$I\_pos50\% := (0.5) \cdot I\_pos = 1 \times 10^5 \qquad t\_50\% := 3.714 \cdot 10^{-4}$

$$didt\_slope\_IEC := \frac{(I\_pos90\% - I\_pos10\%)}{(t\_90\% - t\_10\%)} = 2.01 \times 10^{10} \quad A/s$$

Figure 6a and Equation Set 1 IEC 10/350us Q, A^2s and di/dt calculations

3 Numerical Comparisons of Waveforms

MIL-STD-464C - 1 December 2010 - Table 7
MIL-STD-1575A - Section 2.2

Current component waveforms which represent a severe lightning strike event.

Parameters for the - - Component A - First Return Stroke (Initial Stroke)

$Io\_A := 218810$

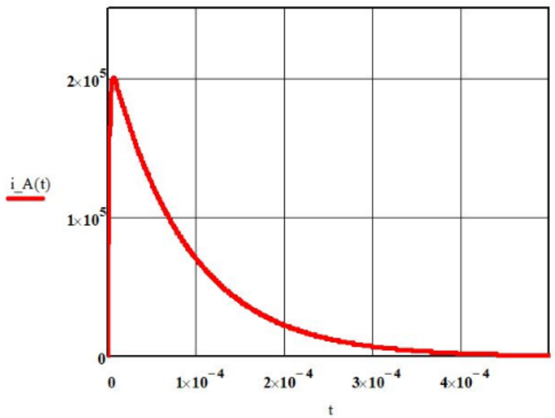
$\alpha\_A := 11354$

$\beta\_A := 647265$

$tminA := 0$

$tmaxA := 500 \cdot 10^{-6}$

$$i\_A(t) := Io\_A \cdot \left(e^{-\alpha\_A \cdot t} - e^{-\beta\_A \cdot t}\right)$$



$$Q\_A := \int_{tminA}^{tmaxA} i\_A(t)\, dt = \mathbf{18.868}$$

$$Action\_int\_A := \int_{tminA}^{tmaxA} (i\_A(t))^2\, dt = \mathbf{2 \times 10^{6}}$$

$$Q\_MIL := Q\_A + Q\_B + Q\_C + Q\_D = \mathbf{233.607}$$

$$Action\_int\_MIL := Action\_int\_A + Action\_int\_B + Action\_int\_C + Action\_int\_D = \mathbf{2.358 \times 10^{6}}$$

Note the action integral A^2s integration result for MIL STD component A as $2x10^6$ in perfect agreement with the standard as specified.

$Io\_A10\% := (0.1) \cdot Io\_A = \mathbf{2.188 \times 10^{4}}$ $\quad t1\_10\% := 1.66 \cdot 10^{-7}$

$Io\_A90\% := (0.9) \cdot Io\_A = \mathbf{1.969 \times 10^{5}}$ $\quad t1\_90\% := 4.685 \cdot 10^{-6}$

$Io\_A50\% := (0.5) \cdot Io\_A = \mathbf{1.094 \times 10^{5}}$ $\quad t1\_50\% := 6.105 \cdot 10^{-5}$

$$didt\_slope\_MIL := \frac{(Io\_A90\% - Io\_A10\%)}{(t1\_90\% - t1\_10\%)} = \mathbf{3.874 \times 10^{10}} \text{ A/s}$$

Figure 6b Equation Set 2 MIL STD component A Q, A^2s and di/dt calculations

3 Numerical Comparisons of Waveforms

MIL-STD-464C - 1 December 2010 - Table 7
MIL-STD-1575A - Section 2.2

Current component waveforms which represent a severe lightning strike event.

Parameters for the - - Component B - Intermediate Current

$Io\_B := 11300$

$\alpha\_B := 700$

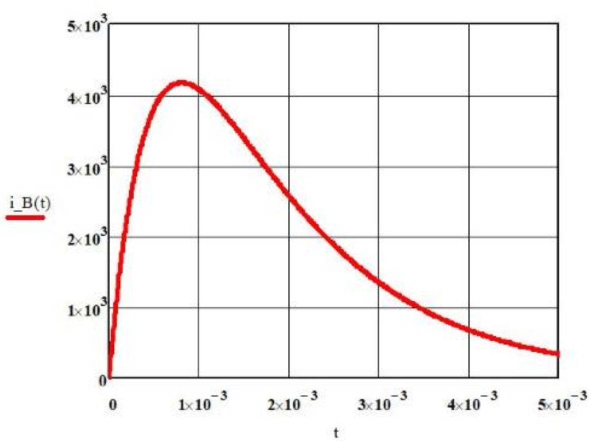
$\beta\_B := 2000$

$tminB := 0$

$tmaxB := 5 \cdot 10^{-3}$

$$i\_B(t) := Io\_B \cdot \left(e^{-\alpha\_B \cdot t} - e^{-\beta\_B \cdot t}\right)$$

Note the charge Q integration result for MIL STD component B as 10.006 As in perfect agreement with the standard as specified.



$$Q\_B := \int_{tminB}^{tmaxB} i\_B(t)\,dt = \mathbf{10.006}$$

$$Action\_int\_B := \int_{tminB}^{tmaxB} (i\_B(t))^2\,dt = \mathbf{2.846 \times 10^4}$$

Figure 6c and Equation Set 3 MIL STD component B Q and A^2s calculations

3 Numerical Comparisons of Waveforms

Note the charge Q integration result for MIL STD component C as 200 As in perfect agreement with the standard as specified.

MIL-STD-464C - 1 December 2010 - Table 7
MIL-STD-1575A - Section 2.2

Current component waveforms which represent a severe lightning strike event.

Parameters for the - - Component C - Continuing Current

$Io\_C := 400$

$tminC := 0$

$tmaxC := 500 \cdot 10^{-3}$

$i\_C(t) := Io\_C$

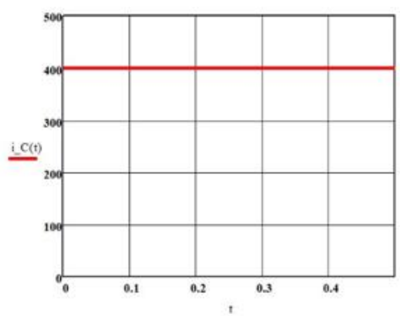


Figure 6d MIL STD component C expression

$$Q\_C := \int_{tminC}^{tmaxC} i\_C(t)\,dt = \mathbf{200}$$

$$Action\_int\_C := \int_{tminC}^{tmaxC} (i\_C(t))^2\,dt = \mathbf{8 \times 10^4}$$

MIL-STD-464C - 1 December 2010 - Table 7
MIL-STD-1575A - Section 2.2

Current component waveforms which represent a severe lightning strike event.

Parameters for the - - Component D - Subsequent Stroke Current (Restrike)

$Io\_D := 109405$

$\alpha\_D := 22708$

$\beta\_D := 1294530$

$tminD := 0$

$tmaxD := 500 \cdot 10^{-6}$

$i\_D(t) := Io\_D \cdot \left(e^{-\alpha\_D \cdot t} - e^{-\beta\_D \cdot t}\right)$

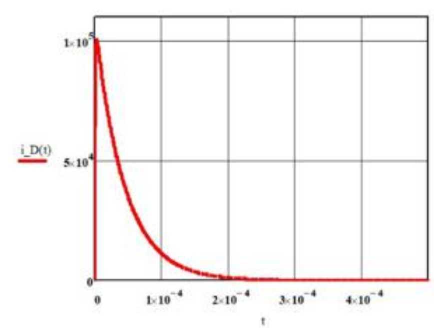


Figure 6e MIL STD component D expression

$$Q\_D := \int_{tminD}^{tmaxD} i\_D(t)\,dt = \mathbf{4.733}$$

$$Action\_int\_D := \int_{tminD}^{tmaxD} (i\_D(t))^2\,dt = \mathbf{2.5 \times 10^5}$$

Figure 6d, 6e and Equation Sets 5 and 6 for the MIL STD C and D components

3 Numerical Comparisons of Waveforms

The numerical values of the relevant peak lightning current Amps, di/dt A/s, action integral A^2s and charge transfer As are tabulated for comparison in table 1.

The values derived through calculus are shown in red italicized font. These are the factors that bridge between IEC and MIL STD requirements.

				amp-second
			Amp-squared-second	coulombs
Waveform	**peak amp**	**di/dt**	**action integral**	**charge transfer**
	A	**A/s**	**A*A*s**	**A*s**
10/350 us LPL I - first stroke	200,000	***2.01.E+10***	16,000,000	300
1757A-464C component A 200kA 500us	200,000	***3.87.E+10***	2,000,000	***18.86***
1757A-464C component B 2kA 5ms	2,000	NA	***28,460***	10
1757A-464C component C 800A	800	NA	***80,000***	200
1757A-464C component D 100kA 500us	100,000	NA	250,000	***4.733***

Table 1 Summary of Numerical Comparison of Waveforms

3 Numerical Comparisons of Waveforms

Table 1 results reveal that the 10/350us waveform has a slightly slower di/dt rate of rise but provides greater or equivalent factors of lightning severity as required by the MIL STDs. The different rate of rise is revealed in the modest differences in the simulation values seen in table 2.

The value of 16,000,000 A^2s action integral calculation of the 10/350us impulse is far more severe than the MIL STD peak of 2,000,000 A^2s. Products designed to withstand the 200kA 10/350us current pulse will meet or exceed the MIL STD requirements.

It serves as a rigorous bench check that several MatrchCAD integration functions were derived from the MIL STD expression for those wave forms and agree with the published value listed the respective MIL STD tables.

4 Pspice Simulations of Concentional and Isolated Models

The circuit models described in figures 1 and 2 were subjected to the stimulus waveforms dervied from the IEC and MIL STD waveforms. The peak values of MIL STD component A were employed as a worst case scenario. The component B waveform of figure 6e was also simulated but produced low magnitude (not very interesting) results as expected.

The entire MIL STD set of components A-B-C-D combined into one simulation is beyond the capabilities of Pspice.

The 10/350us waveform is illustrated in figure 7 along with the specific stimulus double exponential factors.

4 Pspice Simulations of Concentional and Isolated Models

Figure 7 10/350us Pspice Stimulus

4 Pspice Simulations of Concentional and Isolated Models

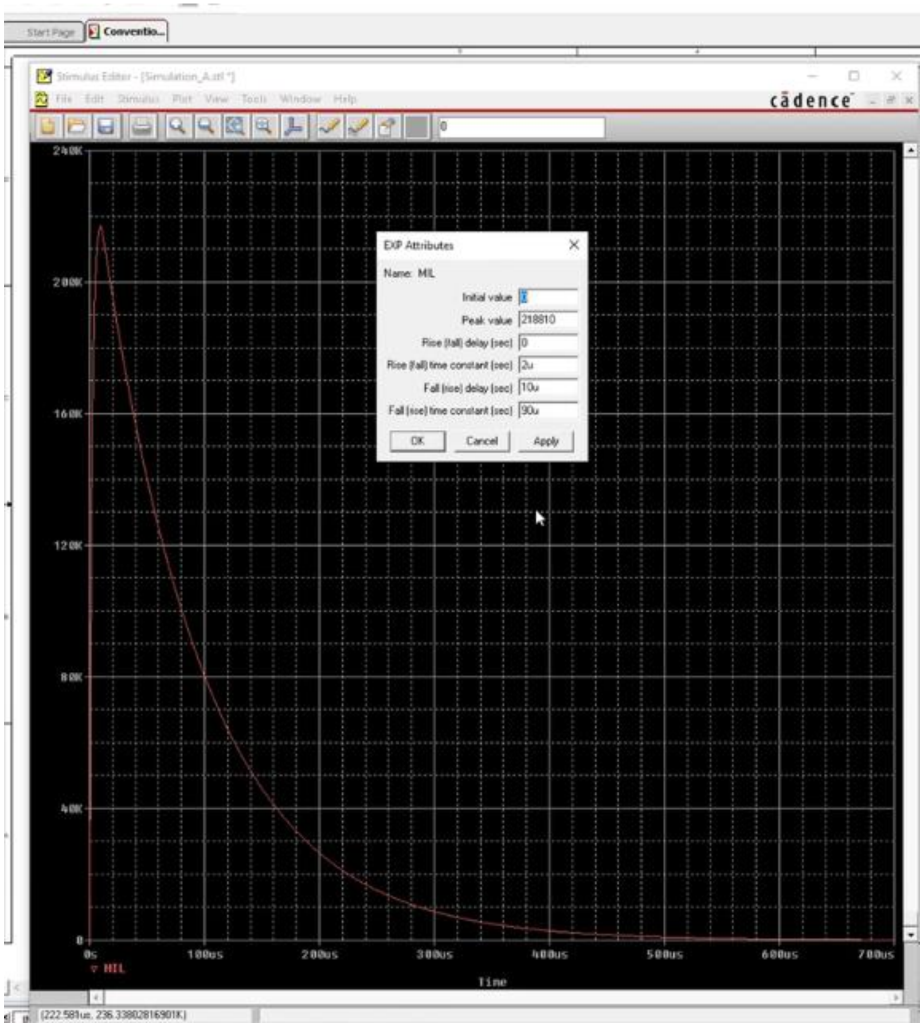


Figure 8 MIL STD component A waveform Pspice Stimulus

4 Pspice Simulations of Concentional and Isolated Models

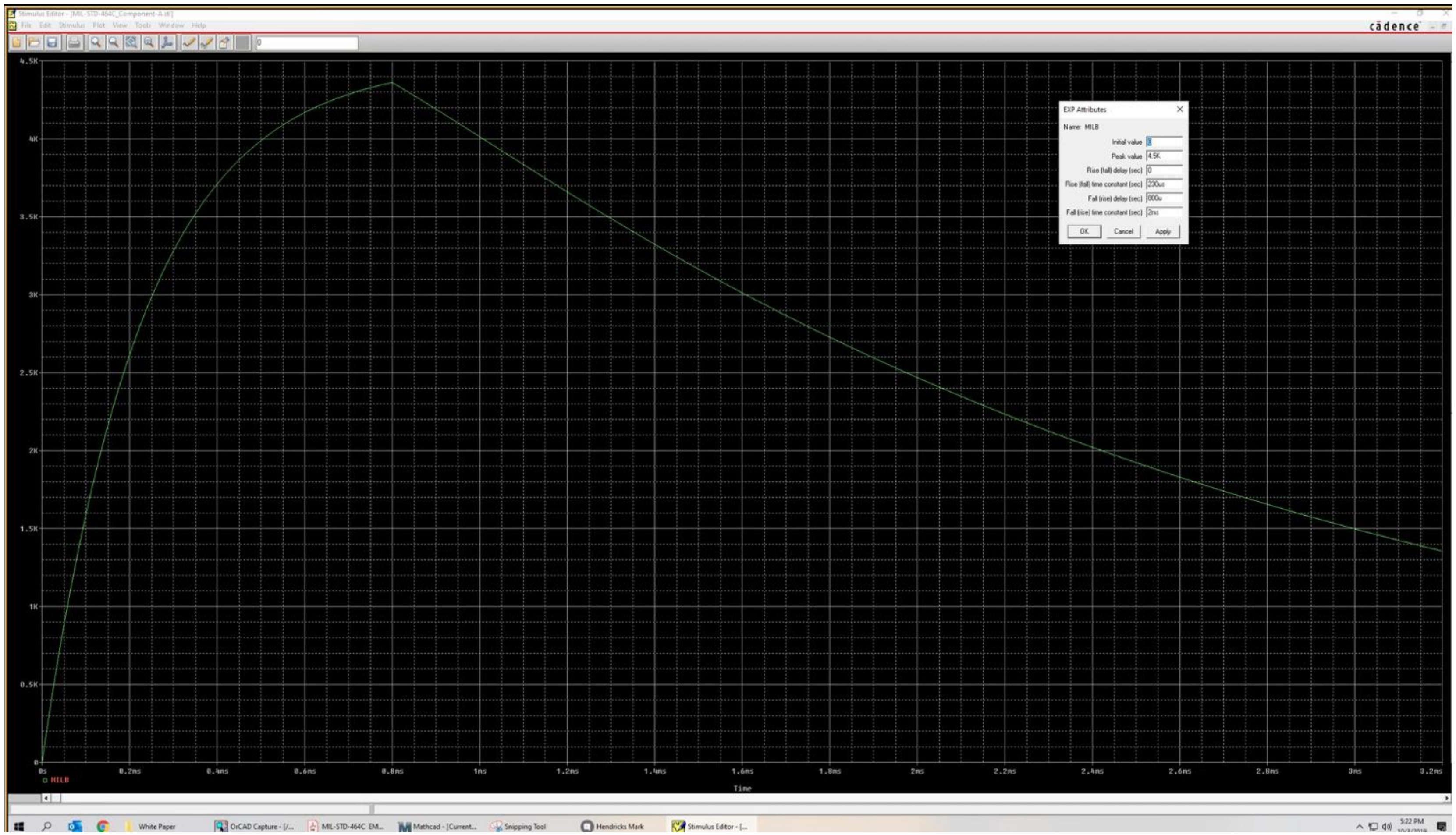


Figure 9 MIL STD component B waveform Pspice Stimulus

4 Pspice Simulations of Concentional and Isolated Models

The stimulus paramters are illustrated in figure 10. Note the limited means to adjustment of the attributes does force some compromises in the Pspice simulations. The di/dt rise for the MIL STD component could force even higher top of rod voltages.

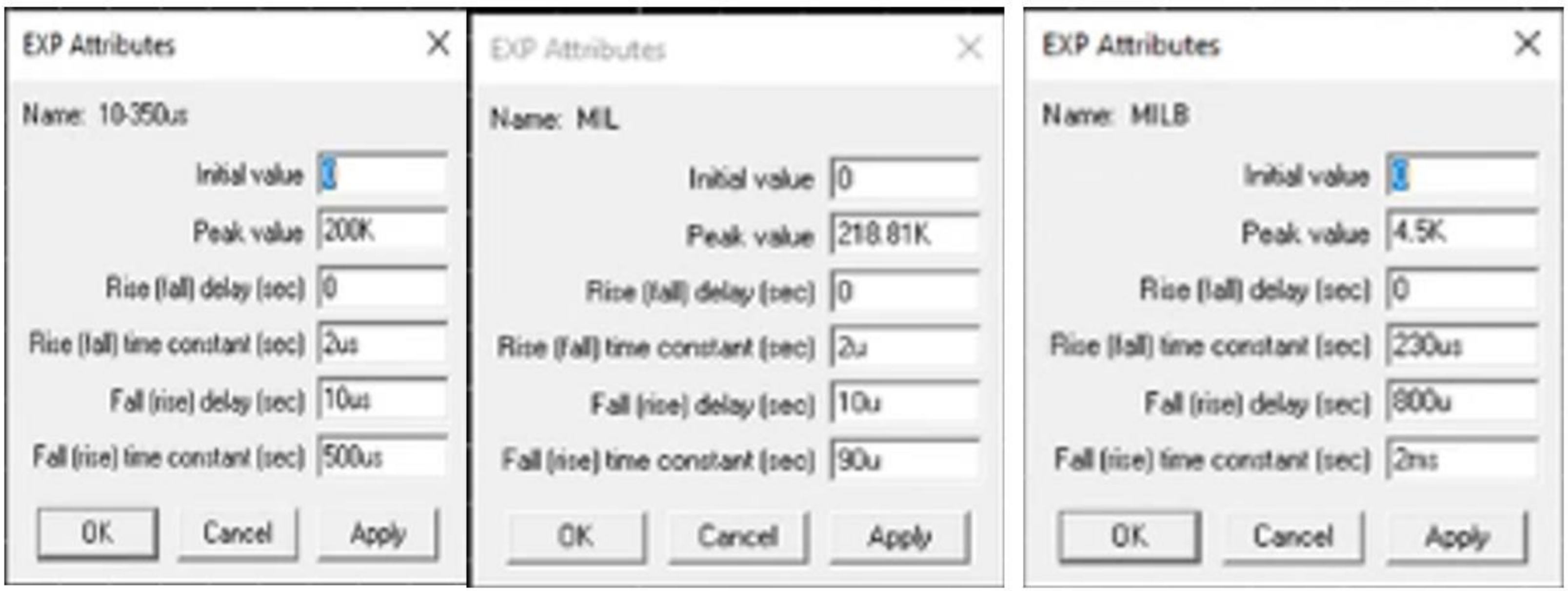


Figure 10 Stimulus Parameters

4 Pspice Simulations of Concentional and Isolated Models

The results of a series of simulations on each rod type and pulse type are listed in table 2. The simulation findings produce very similar ~1000kV side flash source levels and confirm the congruency of IEC to MIL STD references. Of course there is some variation as would be expected from both the numerical MatchCAD equations but also in the limitations in the Pspice stimulus attribute editor.

	Voltage at Air Terminal		
	Rod Type		
Waveform	**Simulation**		**peak amp**
	Conventional	**HVI**	**A**
10/350 us LPL I - first stroke	950kV	920kV	200,000
1757A-464C component A 200kA 500us	1050kV	1030kV	200,000
1757A-464C component B 2kA 5ms	188V		2,000

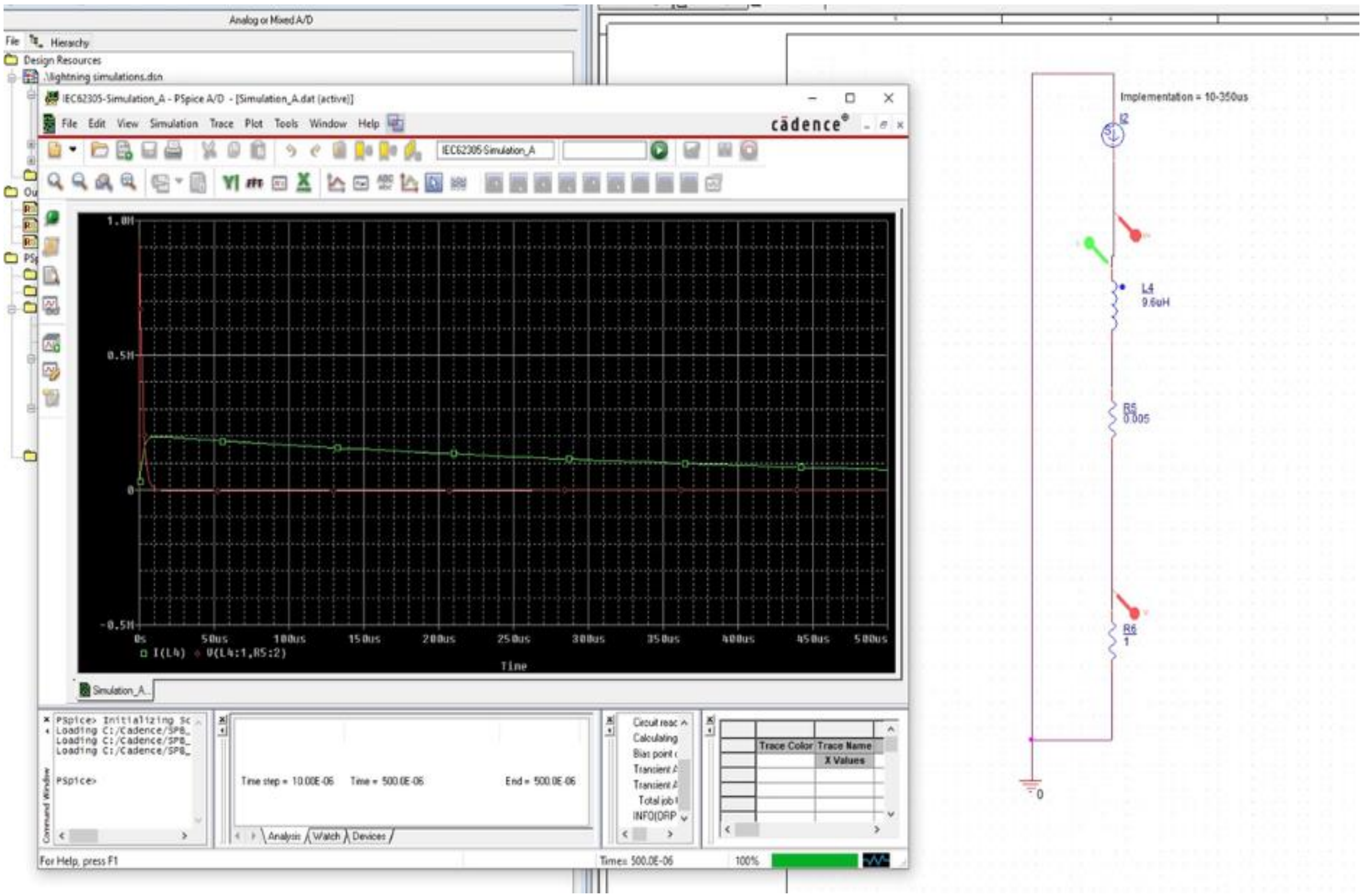
Table 2 – Simulation Results

4 Pspice Simulations of Concentional and Isolated Models

The High Voltage Isolated HVI results show only a small parasitic current on the jacket. The outer sheath serves as a high impedance path to dissipate the parsitic capacitance of the jacket and prevent failure of the insulation. Equivalent separation is acheived for a condcutor mounted directly onto the structure.

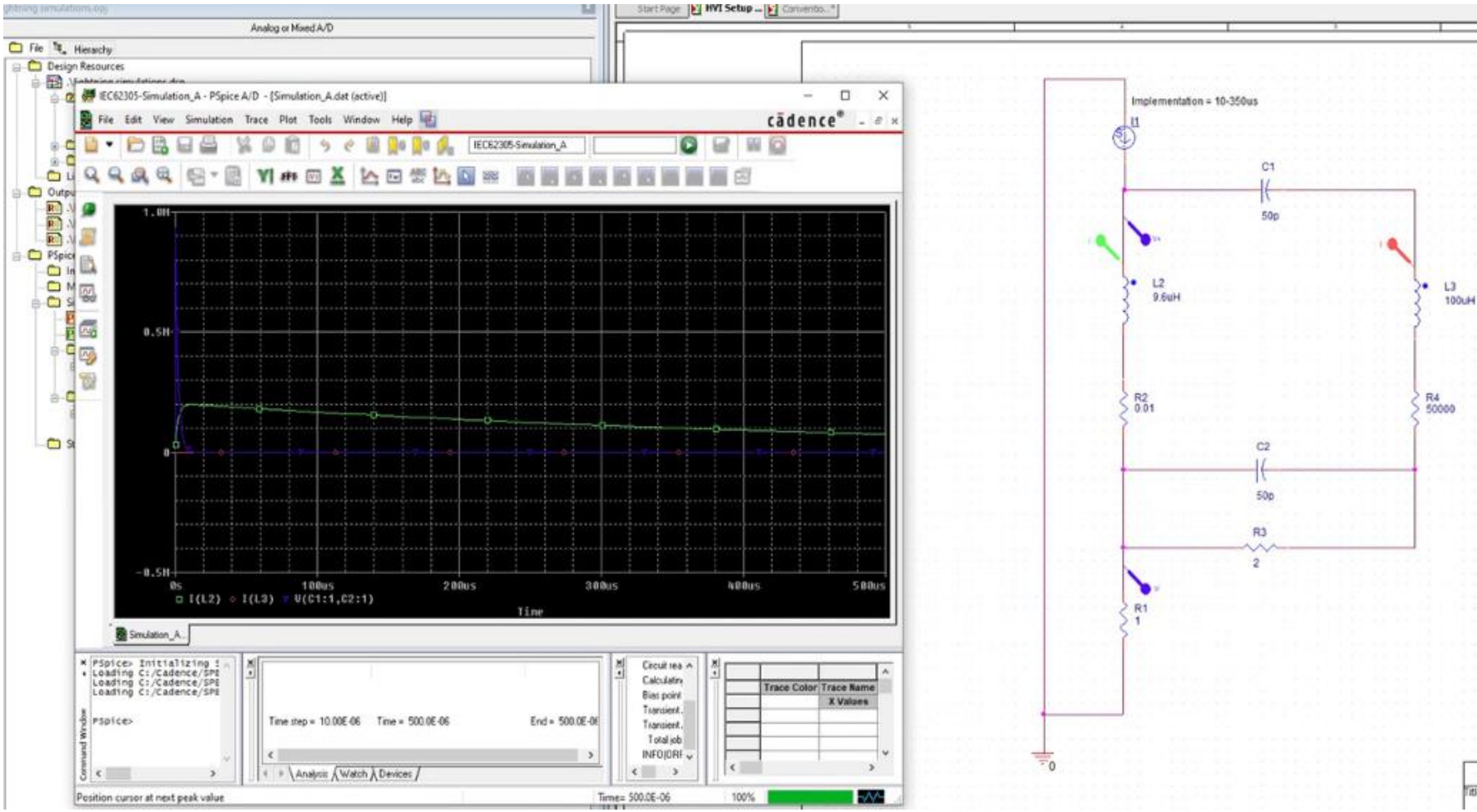
The specific Pspice Simulation Graphs are illustrated. The results from the more modest MIL STD component B showed further modeling was not needed for the scope of this article.

4 Pspice Simulations of Concentional and Isolated Models



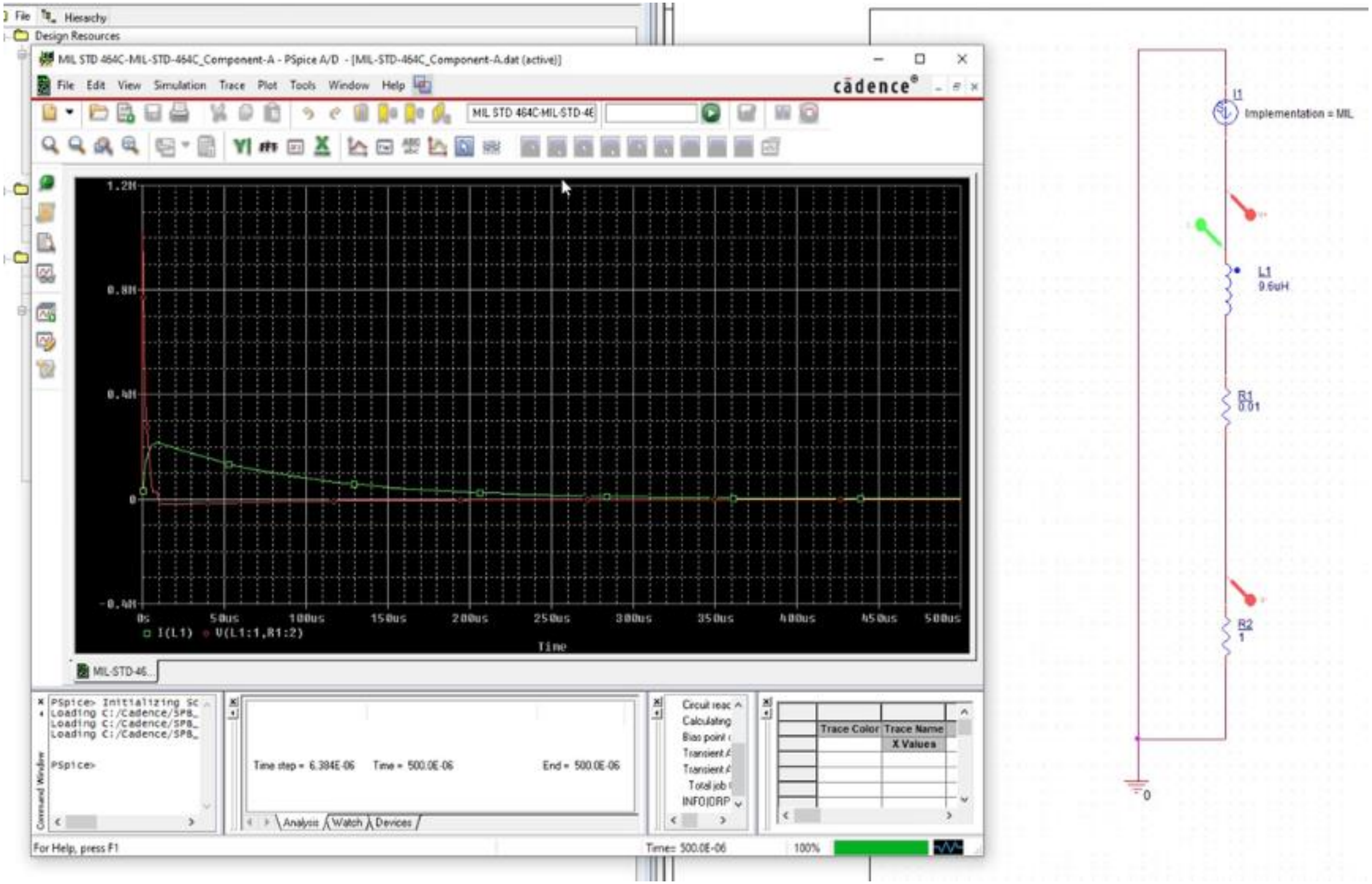
Conventional Rod – 10/350us

4 Pspice Simulations of Concentional and Isolated Models



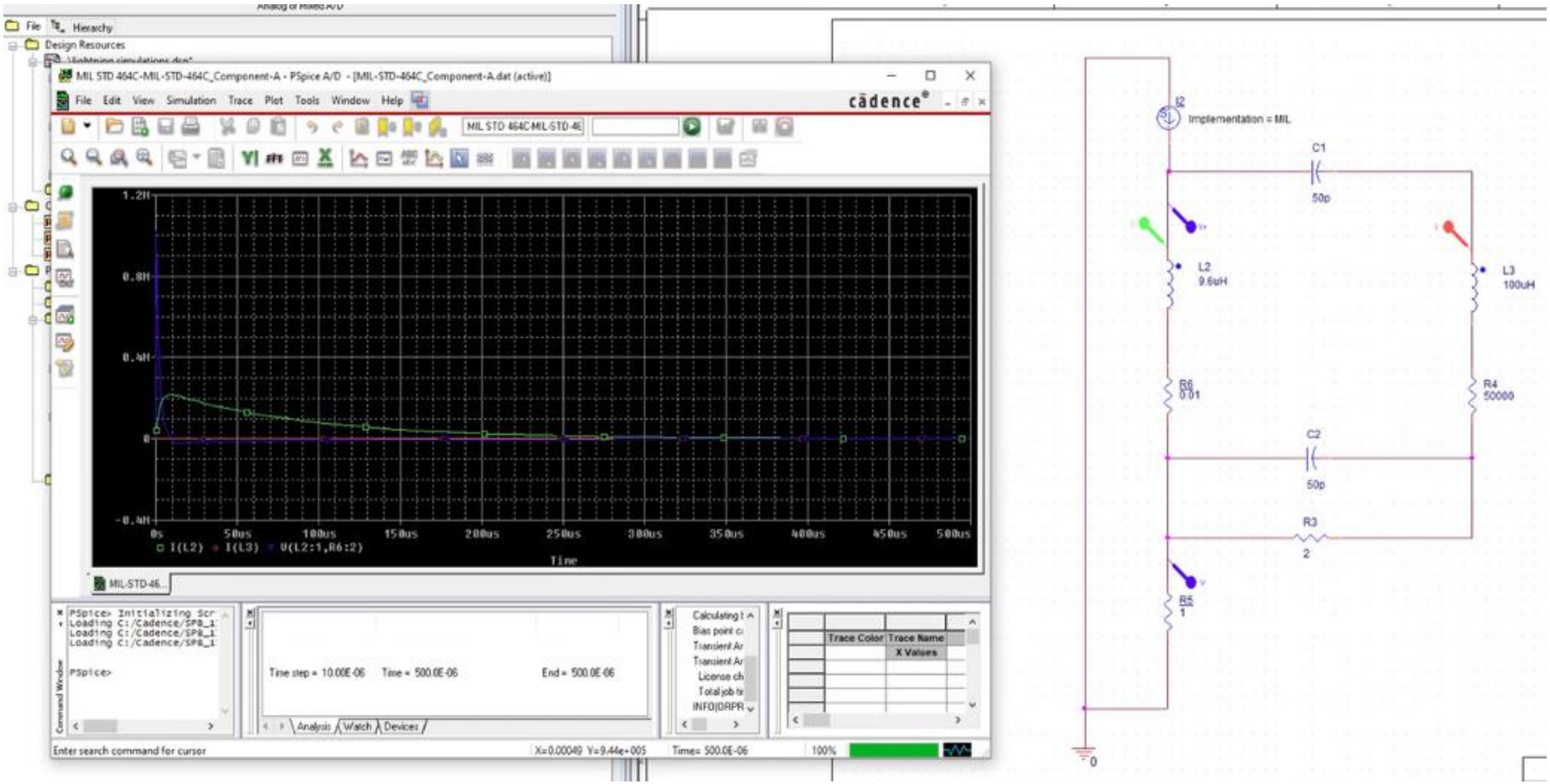
High Voltage Isolated Rod – 10/350us

4 Pspice Simulations of Concentional and Isolated Models



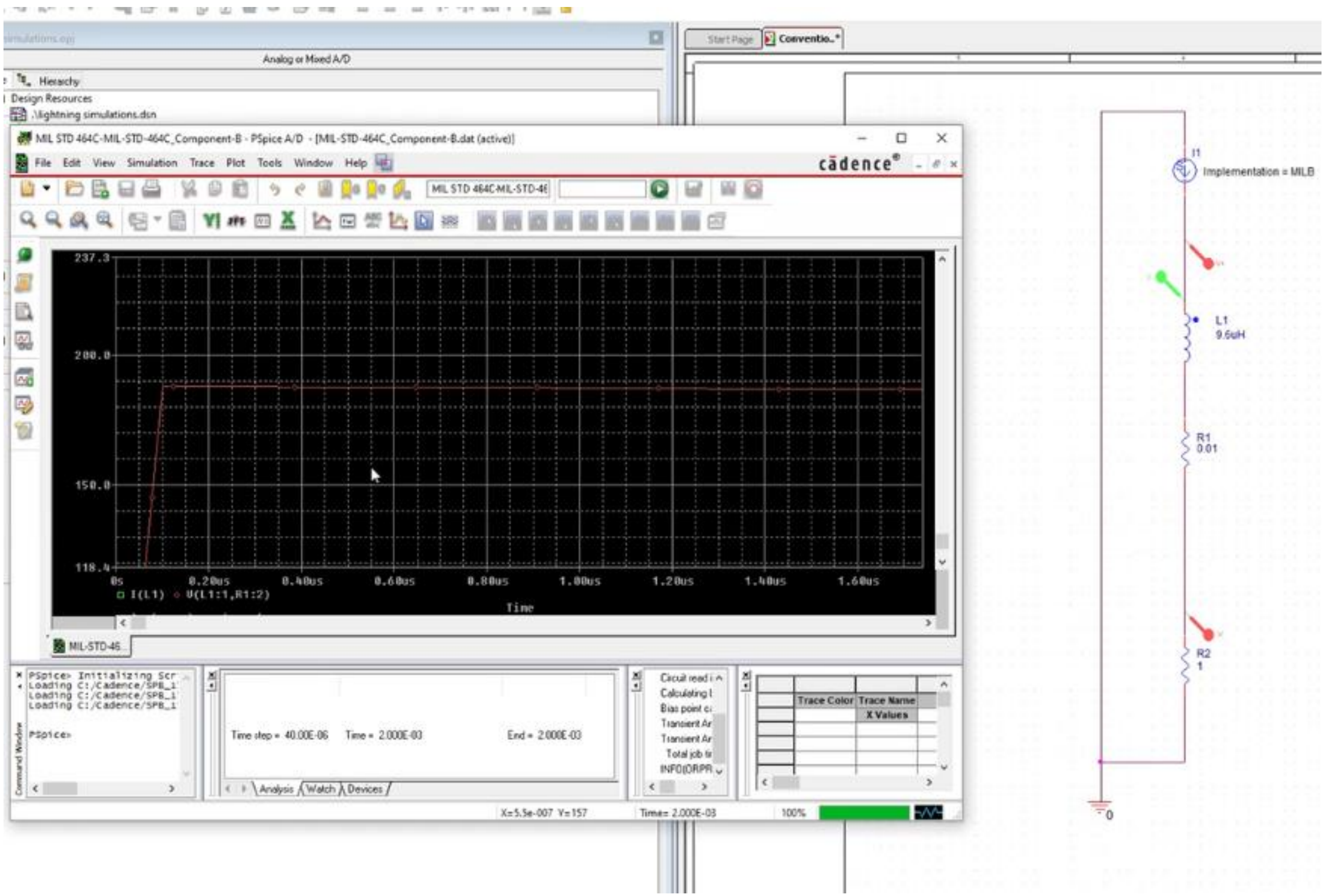
Conventional Rod- MIL STD component A

4 Pspice Simulations of Concentional and Isolated Models



High Voltage Isolated Rod – MIL STD component A

4 Pspice Simulations of Concentional and Isolated Models



Conventional Rod- MIL STD component B

4 Pspice Simulations of Concentional and Isolated Models

A detailed examination of the simulation of MIL STD component A stimulus into a conventional lightning rod in figure 11 shows the high voltage rise of 1050kV at the top of the rod.

This voltage is driven by the fast di/dt and occurs within the first 5us as required by the MIL STD definiton.

This is as would be expected for a fast di/dt pulse into the 10m high rod.

With a dielectric breakdown of air at 3Mv/m, this event would produce side flash into objects at less than 33cm separation distance.

This is in approximate agreement with the IEC separation calculations that requires s>81cm, but shows even more attention should be given to side flash and separation distance for MIL STD concerns.

4 Pspice Simulations of Concentional and Isolated Models

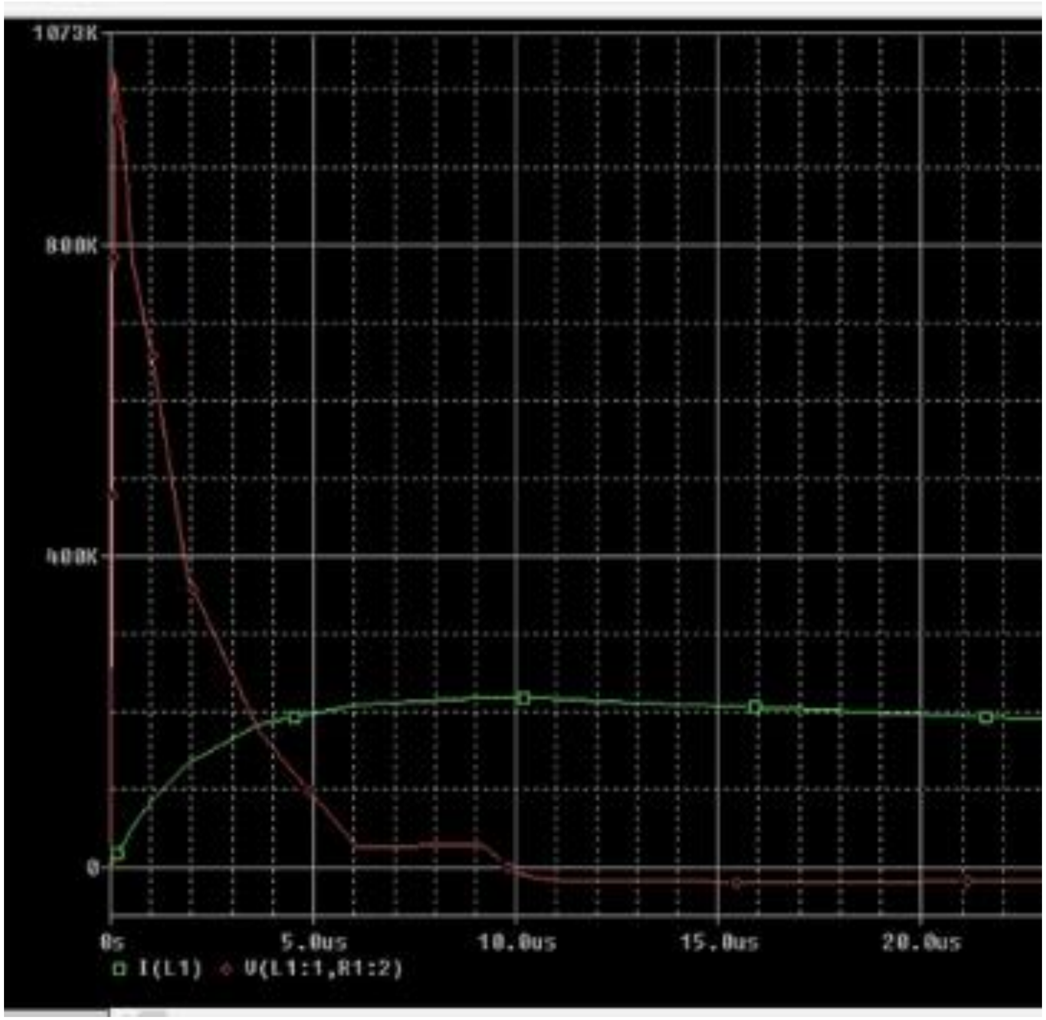


Figure 11 Close up view of the simulation MIL STD component A simulation

4 Pspice Simulations of Concentional and Isolated Models

A close examination of the MathCAD calculation of di/dt figures between IEC and the steeper MIL STD graph in figure 12 offers additional insight how a higher voltage at the top of the rod will be provoked by MIL STD component A.

$$I\_pos10\% := (0.1)\cdot I\_pos = 2 \times 10^{4} \qquad t\_10\% := 1.518\cdot 10^{-5} \qquad Io\_A10\% := (0.1)\cdot Io\_A = 2.188 \times 10^{4} \qquad t1\_10\% := 1.66\cdot 10^{-7}$$

$$I\_pos90\% := (0.9)\cdot I\_pos = 1.8 \times 10^{5} \qquad t\_90\% := 2.314\cdot 10^{-5} \qquad Io\_A90\% := (0.9)\cdot Io\_A = 1.969 \times 10^{5} \qquad t1\_90\% := 4.685\cdot 10^{-6}$$

$$I\_pos50\% := (0.5)\cdot I\_pos = 1 \times 10^{5} \qquad t\_50\% := 3.714\cdot 10^{-4} \qquad Io\_A50\% := (0.5)\cdot Io\_A = 1.094 \times 10^{5} \qquad t1\_50\% := 6.105\cdot 10^{-5}$$

$$didt\_slope\_IEC := \frac{(I\_pos90\% - I\_pos10\%)}{(t\_90\% - t\_10\%)} = 2.01 \times 10^{10} \ \text{A/s} \qquad didt\_slope\_MIL := \frac{(Io\_A90\% - Io\_A10\%)}{(t1\_90\% - t1\_10\%)} = 3.874 \times 10^{10} \ \text{A/s}$$

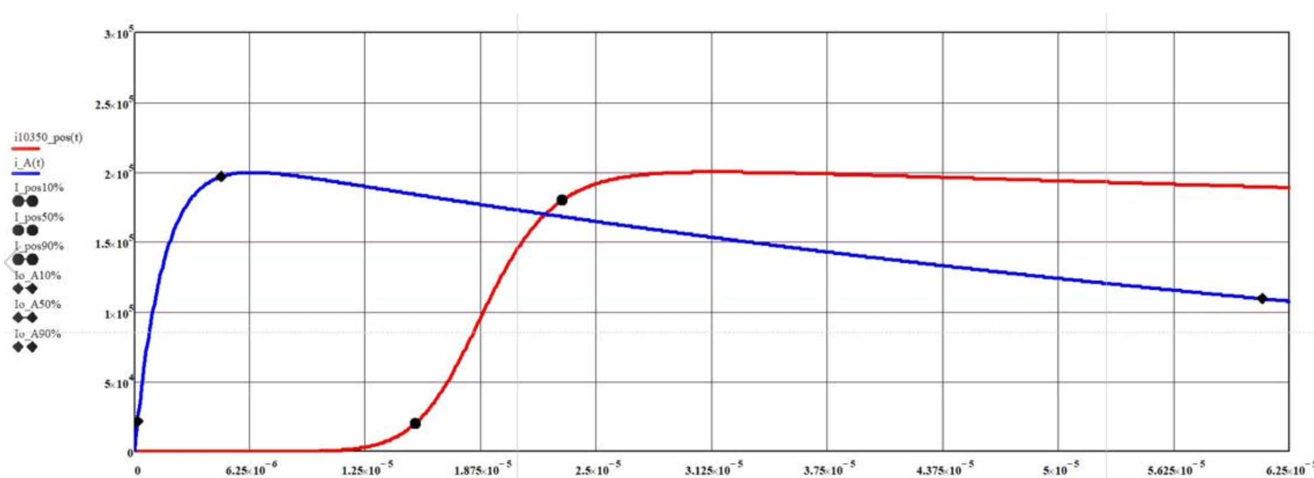


Figure 12 MathCAD di/dt trace comparisons

5 Summary

IEC 62305 and the related IEC 62561 component requirements offer industry standards that come close to providing a reference waveform to approximate the conditions described in MIL-STD-1757A and 464C. The components are tested to the 10/350us impulse so designers can be confident the air terminals, down conductors, earthing rods and clamps can withstand the direct strike event.

In order to describe the overwhelming advantages of using IEC 62305 methods the mathematical models have been compared in detail. There is a strong correlation between IEC and the MIL STDs. Gaps in Table 2 are filled using calculus to find the common factors between the standards. Several of the factors are noted to be in perfect agreement between the MathCAD integration results and the published MIL STD requirements.

5 Summary

The induced effects have been simulated and also show comparable results by virtue of similar side flash potential voltage rise at the top of the rod.

The comparisons and simulations offer a strong argument to show IEC 62305 advantages over alternative NFPA780 and related UL standards that recognize the 8/20us double exponential waveform. This 8/20us waveform offers a slower di/dt with shorter duration and lower magnitude and do not offer comparable factors as need to meet the MIL STDs.

DEHN has over 100 years industry experience providing lightning protection, grounding and surge protections solutions. The company has introduced many innovations through the years, including the first surge protection devices for low voltage distribution and novel high voltage insulated air termination and down conductor systems.

5 Summary

The DEHNsolid surge protection device (SPD) can be employed on the electrical distribution system to control the direct strike lightning induced voltage between the electrical service to ground.

The DEHN HVIpower product line offers exceptional control of the direct strike current induced by lightning.

DEHN protects. For the past 100 years we’ve led the way in lightning and surge protection solutions that guard people, industry and electrical/electronic systems against the effects of lightning and surges.

About the authors

Mark Hendricks – Mark has several publications with ATIS/PEG and IEE, and has contributed to various IEC electromagnetic interference and IEEE protection standards groups with over 25 years of experience in the power quality and lightning protection industry.

Steven Weber – Steven has co-authored South Africa Bureau of Standards adoption of IEC 62305 technical suite of lightning protection standards with over 10 years of experience electrical engineering and lightning protection system design.

Acknowledgements

(1) IEC62305:2010 suite of standards
(2) IEC62561:2012 suite of standards
(3) DEHNsupport Toolbox version 18/26 (3.120)
(4) MIL-STD-1757A
(5) MIL-STD-464C
(6) NFPA 780:2017
(7) Cadence PSpice version 17.2- 2016
(8) MathCad version15.0
(9) Lightning: Physics and Effects, V,A, Rakov, M.A. Martin
(10)American Wire - Wire table impedance chart
(11)Distribution of Real Lightning Strokes and Their Influence on Test Procedures for Isolated LPS, R. Brocke & O. Beierl, 2012 ICLP
(12)Dielectric Strength of Air, HyperTextBook.com