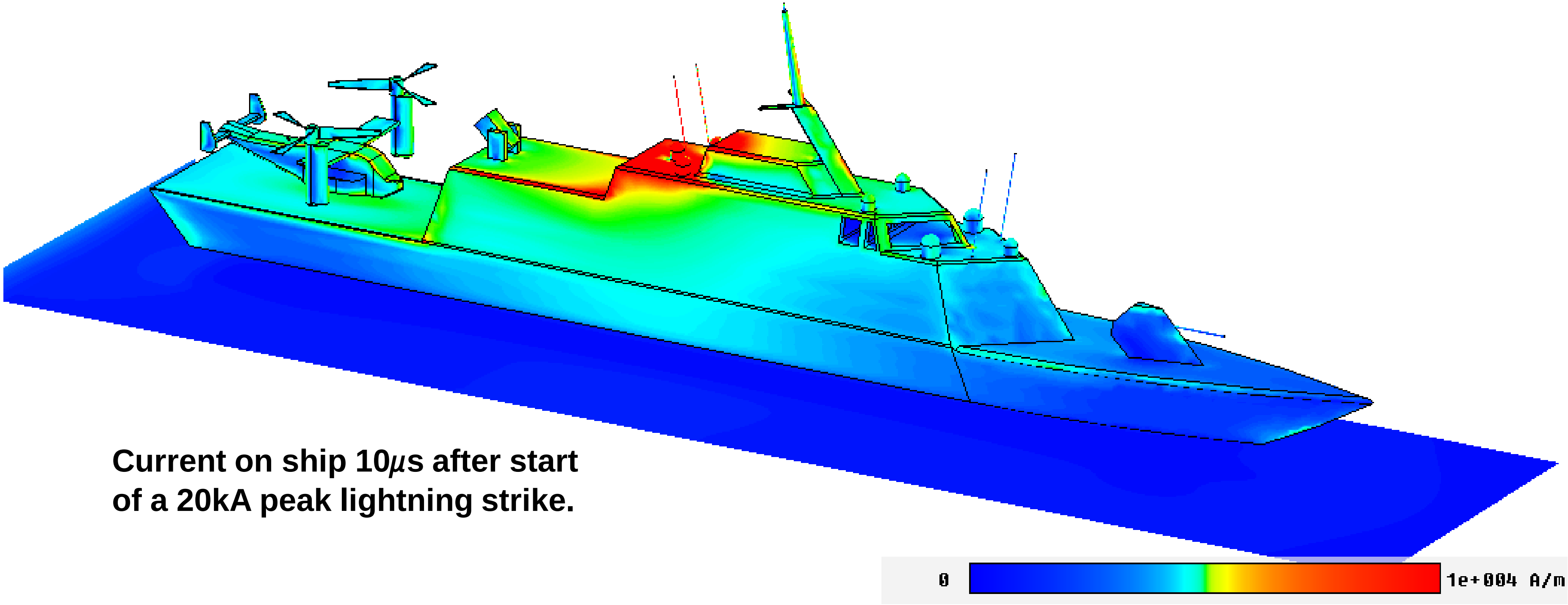
Transient Simulation of a Lightning Strike



Current on ship 10μs after start of a 20kA peak lightning strike.

Simulation Using CST Studio Suite 2009™

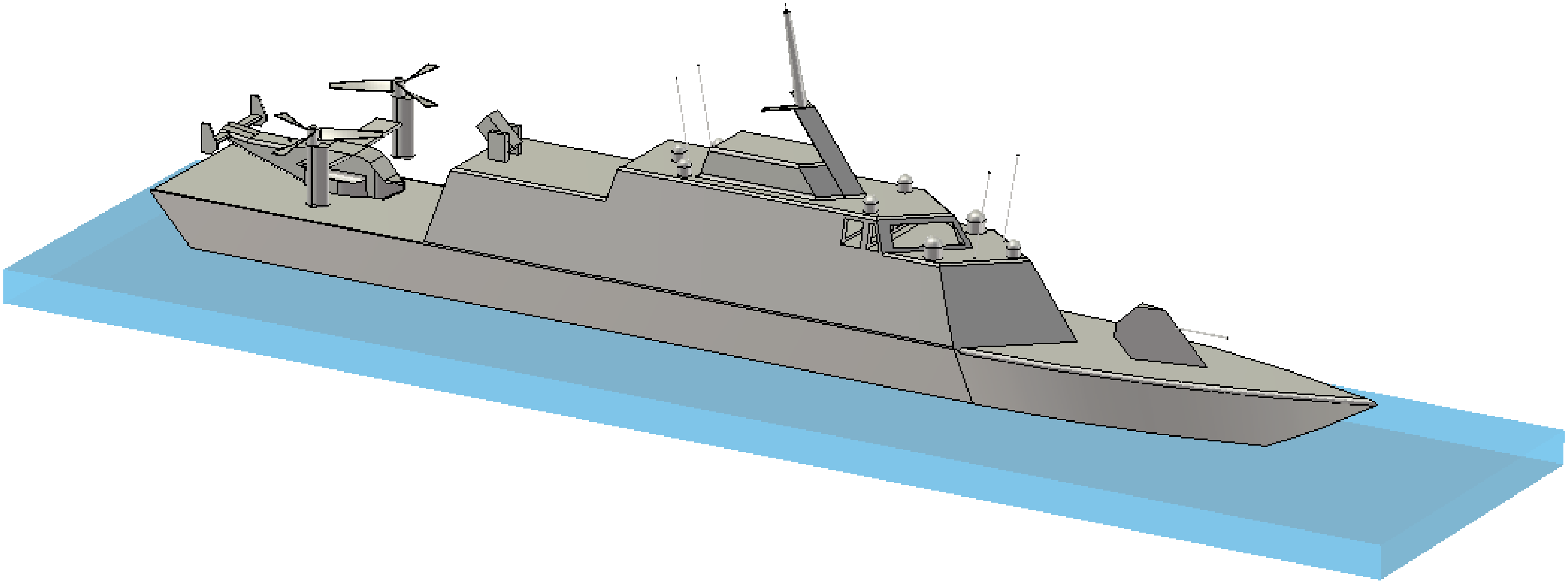
Microwave Studio® at Sonnet Software, Inc.

Dr. James R Willhite

(315)453-3096
mwssupport@sonnetsoftware.com

ELECTROMAGNETICS SPECIALISTS

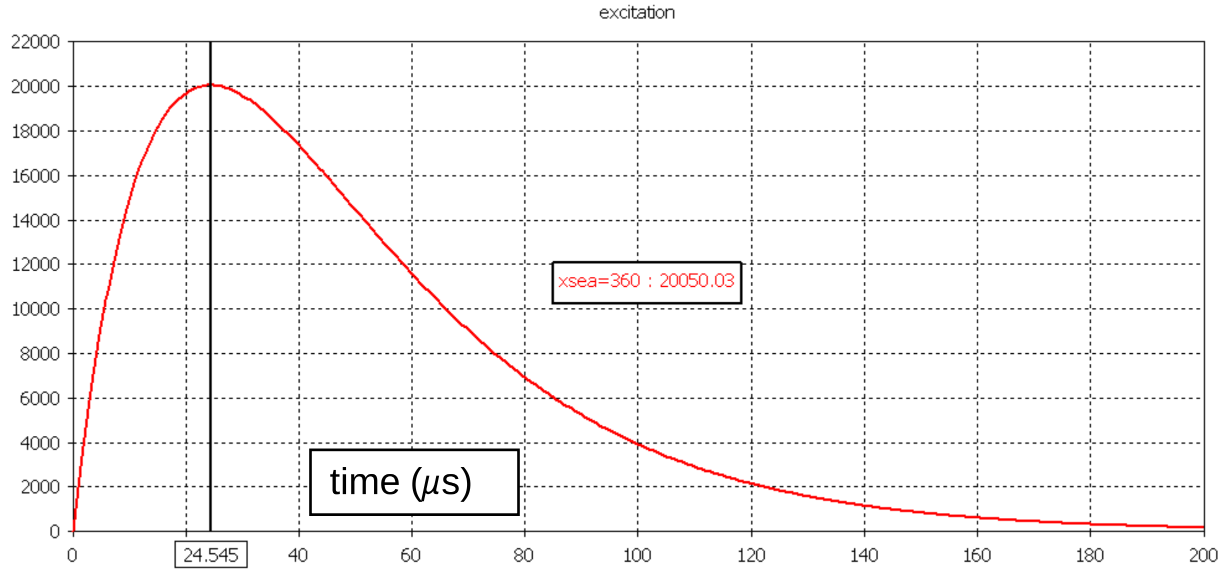
LCS-1 with V-22

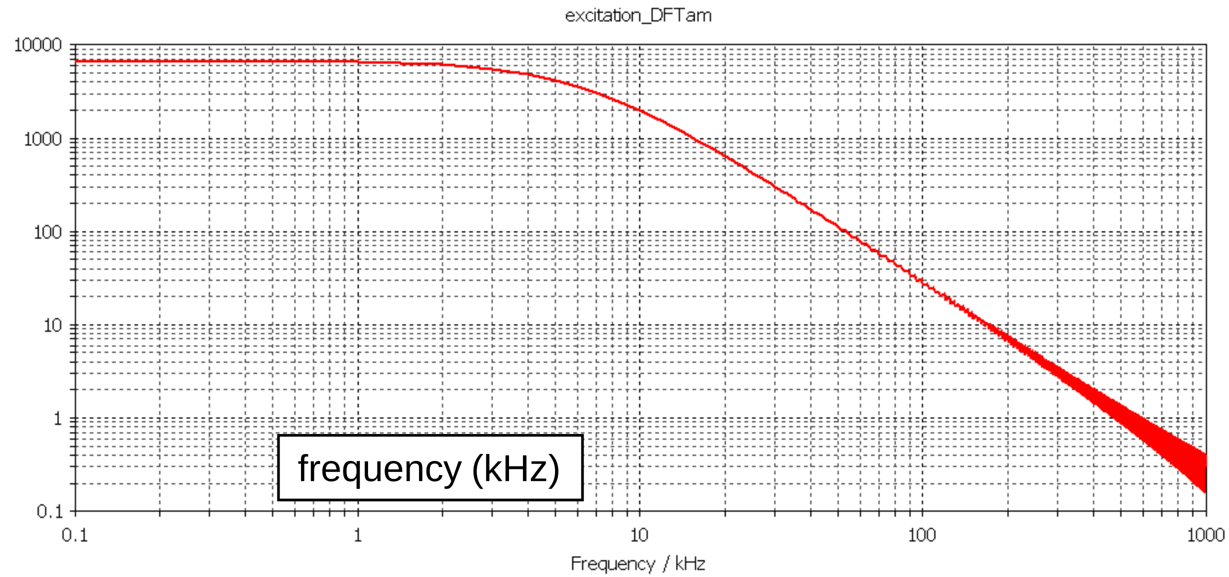


For a training class, a model was built in Microwave Studio of the USS Freedom, LCS-1, using art from web sites. This 379’ long vessel is designed to carry MH60-R/S helicopters. However a model of the larger V-22 had been made previously also for training and some liberty was taken in the mission planning. We imported the V-22 model into the LCS-1 model as a subproject and positioned it above the landing deck as if it were coming in for a short visit. This combined model will be simulated for a lightning strike on one of the booms of the ship.

ELECTROMAGNETICS SPECIALISTS

Lightning Current Excitation





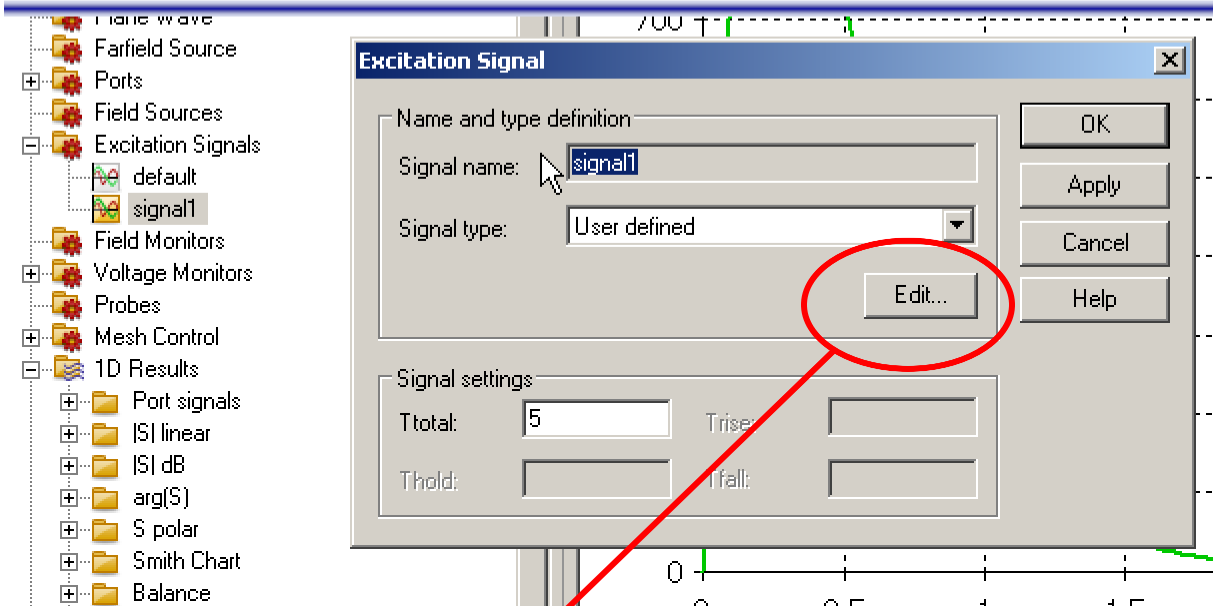
Lightning is a natural phenomena and the waveform varies. We wanted an “average” lightning strike in amplitude and time.

From literature, we chose a peak current flow of 20kA with a shape given by a double exponential function. The rise time was 20μs and the decay time 30μs. This gives the current waveform shown here. The peak current is at 24.5μs.

Notice that the current spectrum has decayed to 1% of peak by 60kHz.

(315)453-3096
mwssupport@sonnetsoftware.com

How to Define a Lightning Waveform




```
Option Explicit

Function ExcitationFunction(dtime As Double) As Double

   'Assign the excitation signal value for the given time to the function name.

   ExcitationFunction = Fmax*N*(Exp(-dtime/t1)-Exp(-dtime/t2))

End Function
```

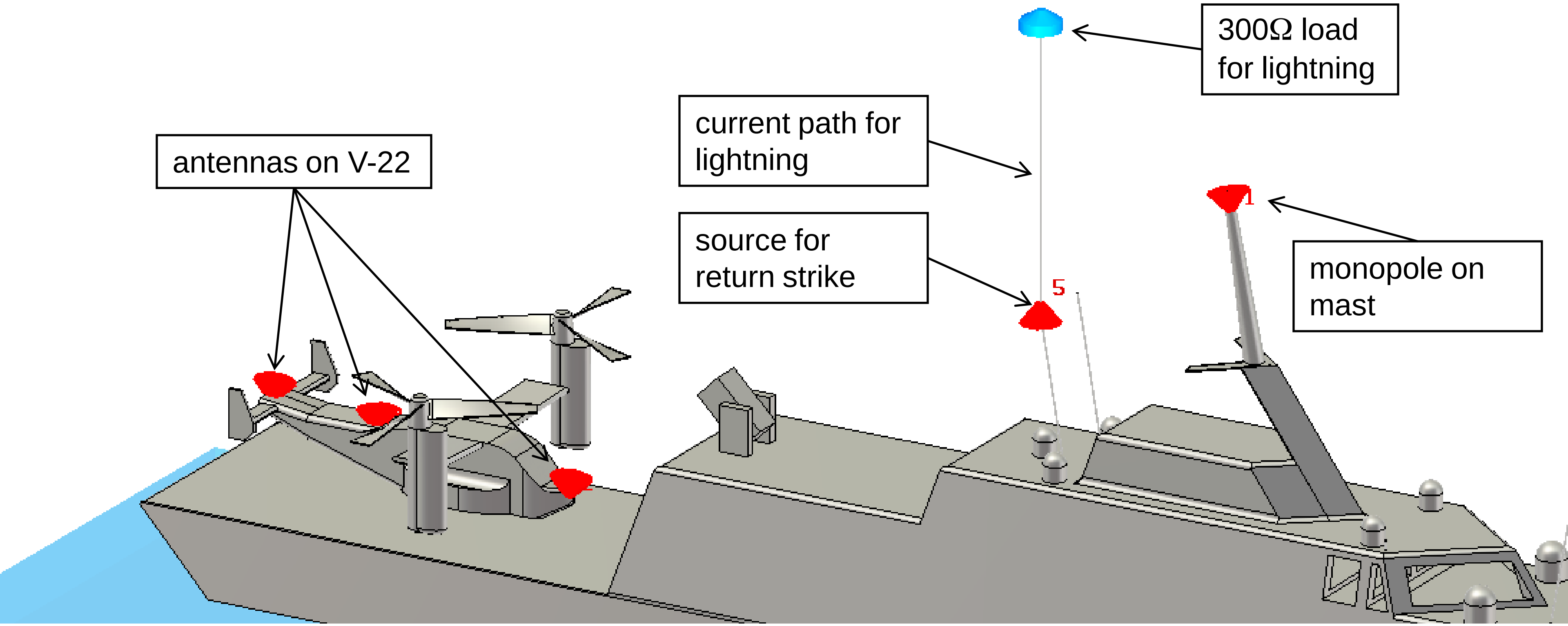
In Microwave Studio the user of the T-solver can do a right click on “Excitation Signals” in the Navigation Tree to add an excitation. The new excitation could be imported, set to one of several standard forms, or to “User defined”. If that, a Visual Basic editor can be opened and the VB function can be defined.

For ease in modifying the excitation, the normalization parameters Fmax & N and the rise (t2) and decay (t1) times were defined in the model’s parameter list before defining the excitation.

After defining a new excitation you can do a right click on it and set it to be the reference signal for the simulations.

(315)453-3096
mwssupport@sonnetsoftware.com
ELECTROMAGNETICS SPECIALISTS

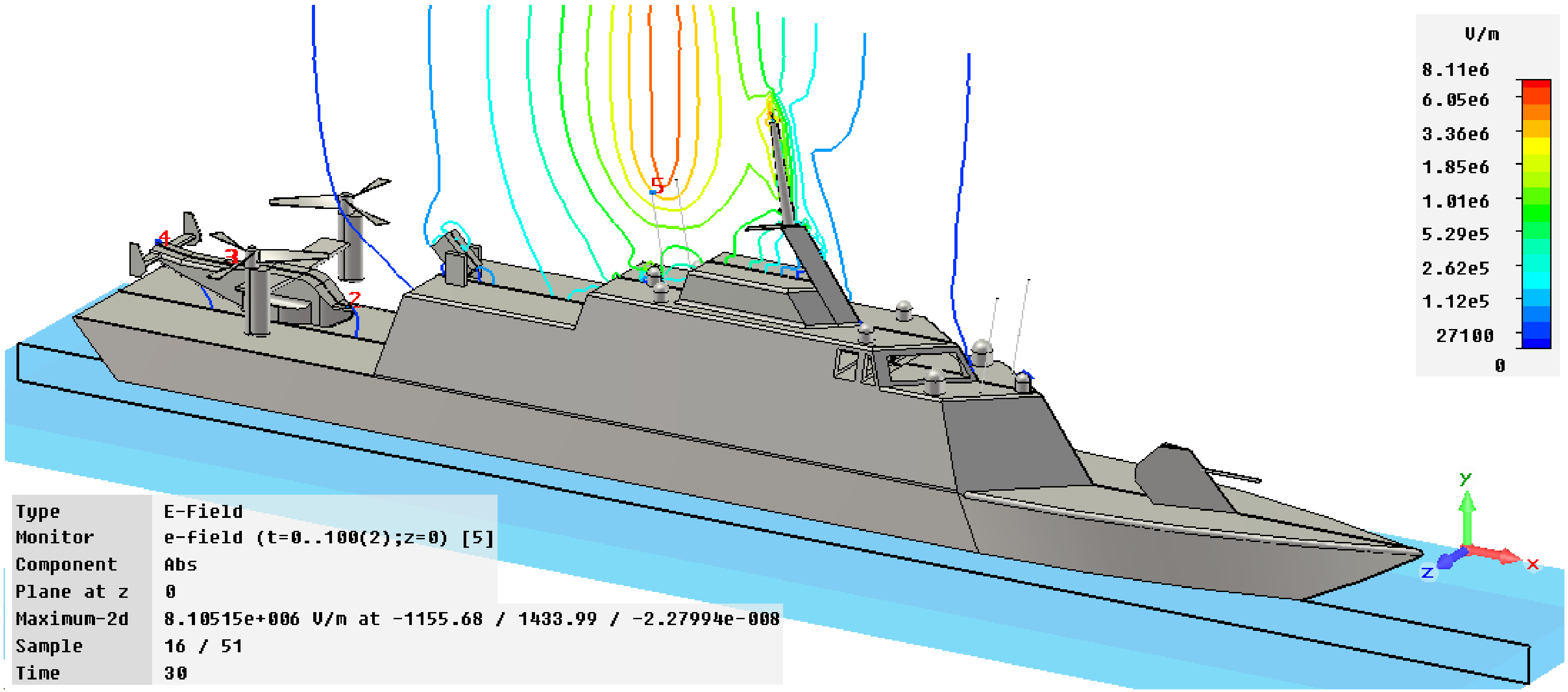
Location of Excitation and Sensing Ports



Cloud to ground lightning often has multiple strikes. Normally the initial strike from the cloud to the ground will be followed by a larger ground to cloud strike tracking the first “stringer”; ionized air. We modeled this ground to cloud strike as starting at the tip of a boom on the LCS-1, traveling upward , and loaded by 300Ω for the return thru the clouds. The LCS-1 and the V-22 have antennas and these will pick up signals from the lightning strike. The return path is through the sea water and electric wall boundaries above (clouds), below (sea), and to the ends of the model.

(315)453-3096
mwssupport@sonnetsoftware.com

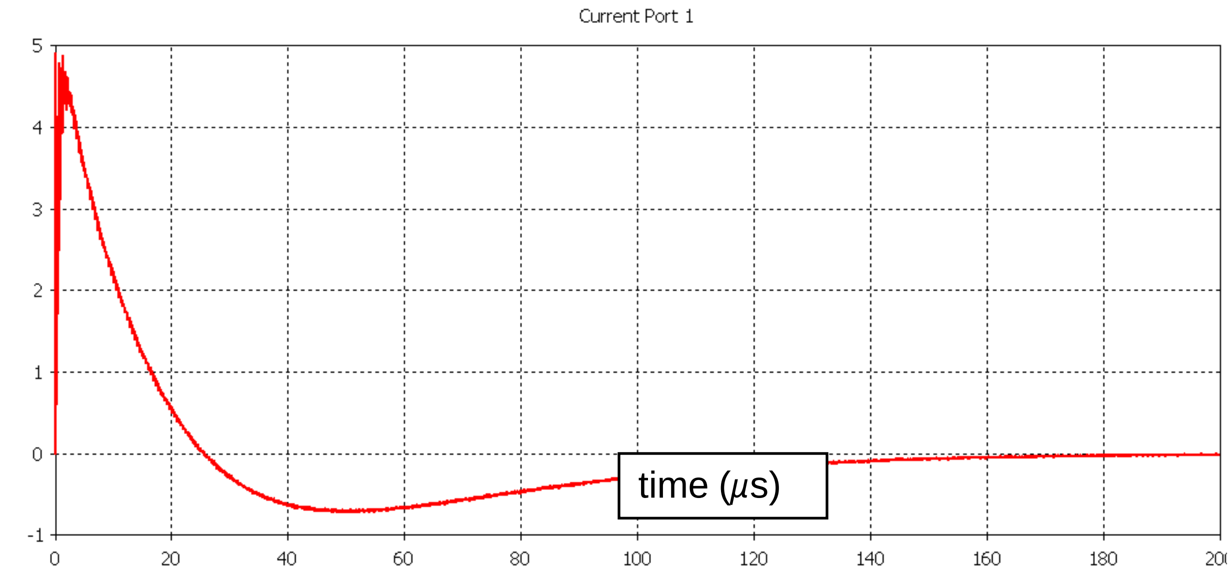
Electric Field Following Lightning Strike

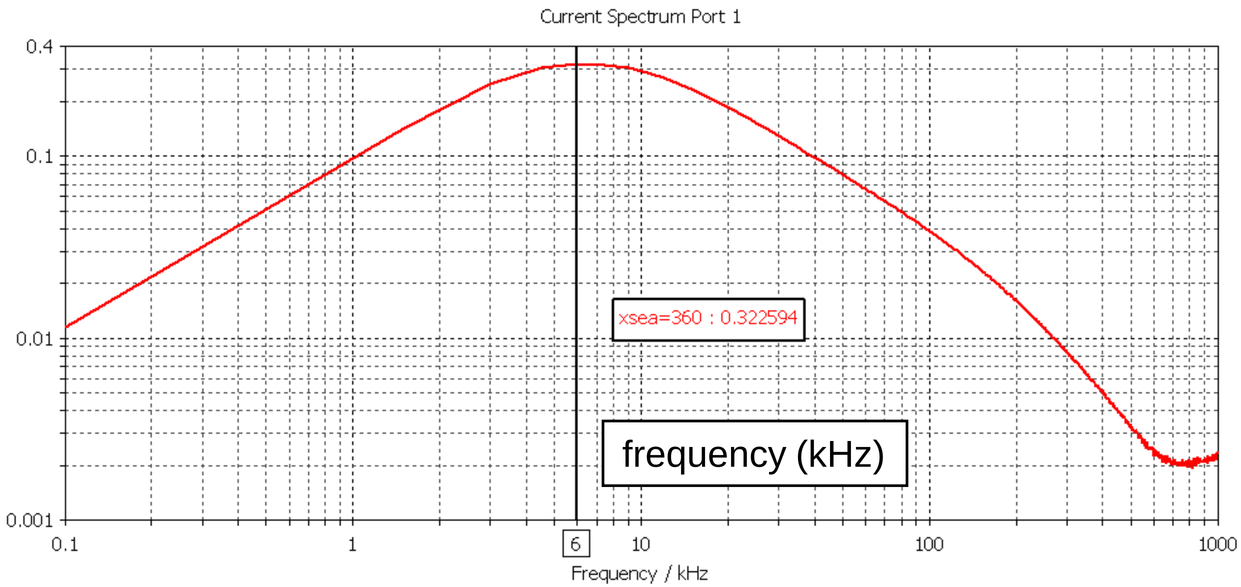


This figure shows the electric field amplitude on a log 1x100 scale on a plane down the center line of the vessel, 6' away from the lightning path. This is a snapshot 30μs after the start of the excitation pulse. The set of snapshots can be animated to see the field progression in time.

(315)453-3096
mwssupport@sonnetsoftware.com

Current on Mast Antenna





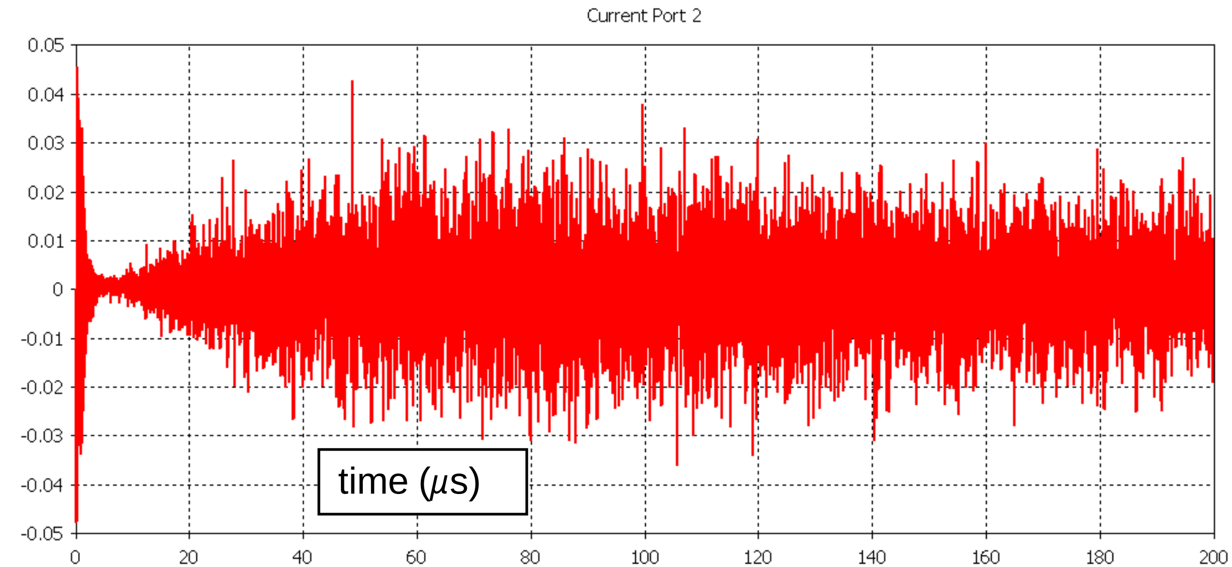
On the mast of the LCS-1, a short monopole had been placed with natural resonance far above the spectrum of the lightning excitation. However a strong current pulse was induced on this monopole, top figure to the left.

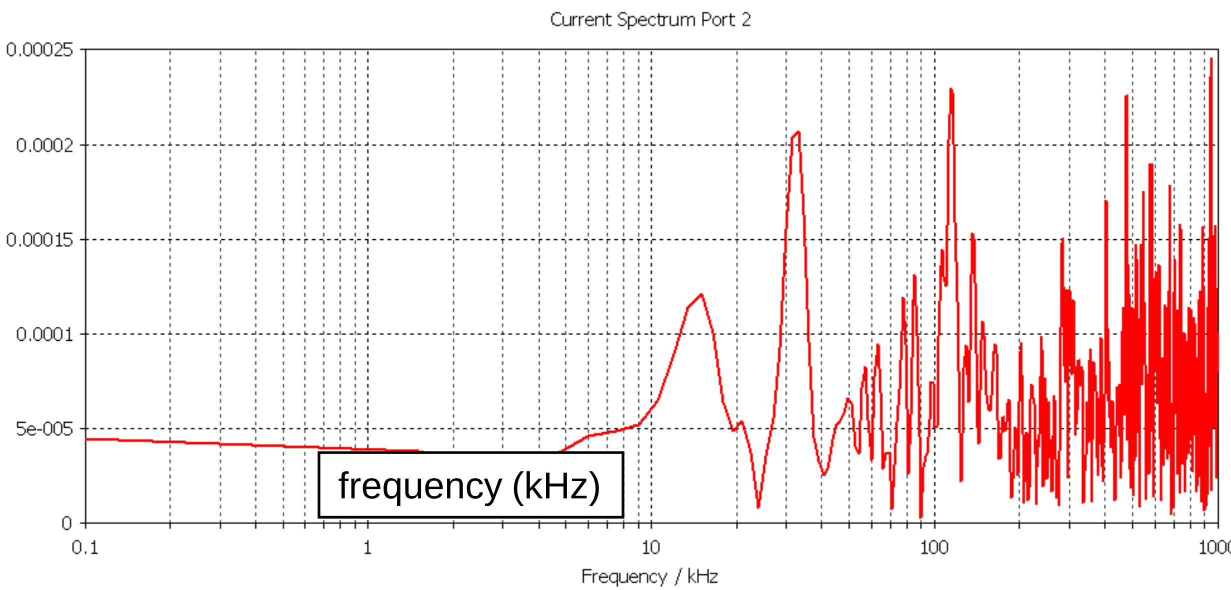
The peak in the spectrum of this induced current was at 6kHz, lower figure to the left.

(315)453-3096
mwssupport@sonnetsoftware.com

ELECTROMAGNETICS SPECIALISTS

Current in Port 2: Antenna on Tilt Rotor





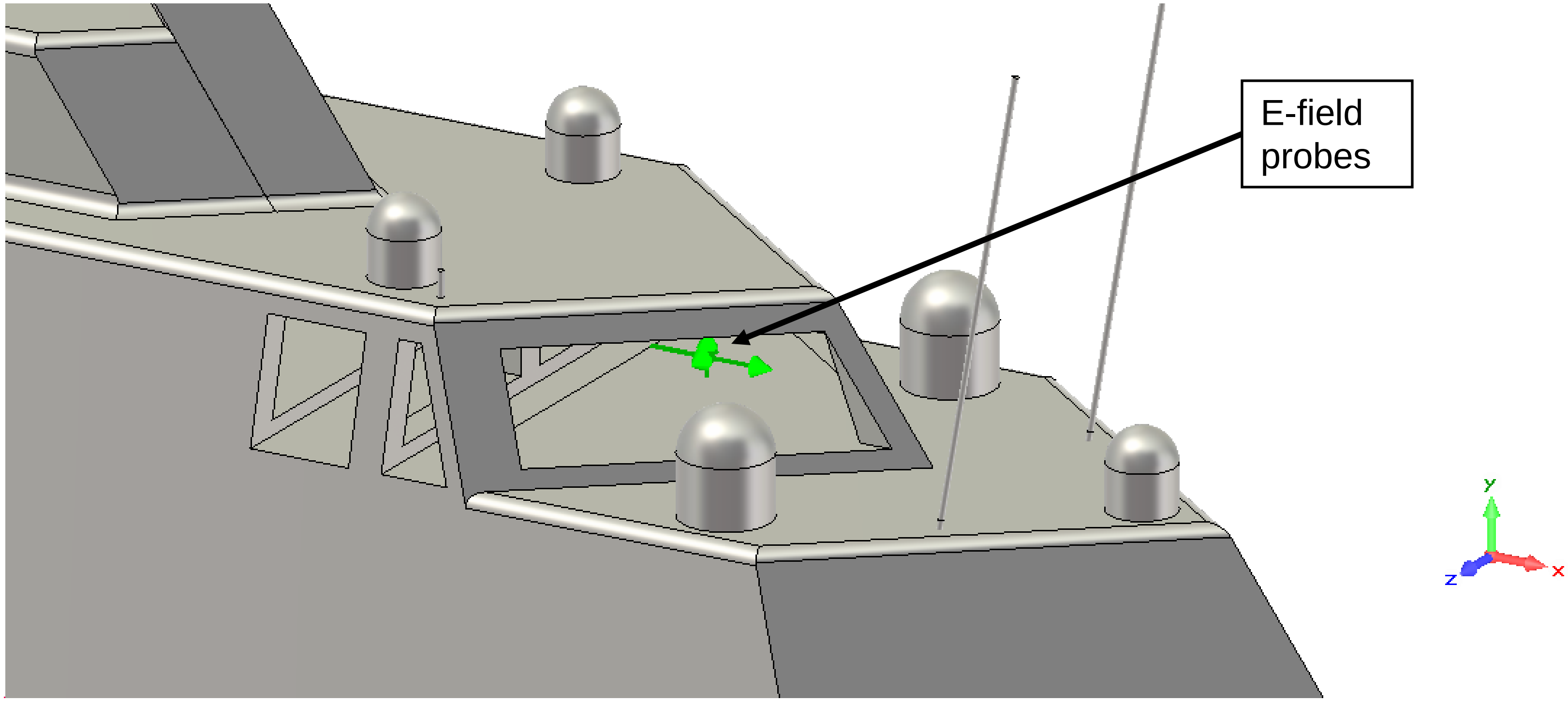
On the V-22 there are 3 blade antennas designed to operate over 300 to 600 MHz; again far above the spectrum of the lightning.

Radiated fields from the lightning generated currents in these three antennas. There is no good return path for these signals since the V-22 is hanging in air.

Although the induced currents are small they do not decay quickly. The signals at all 3 blade antennas are similar and this shows the results for the antenna in the nose of the aircraft.

(315)453-3096
mwssupport@sonnetsoftware.com

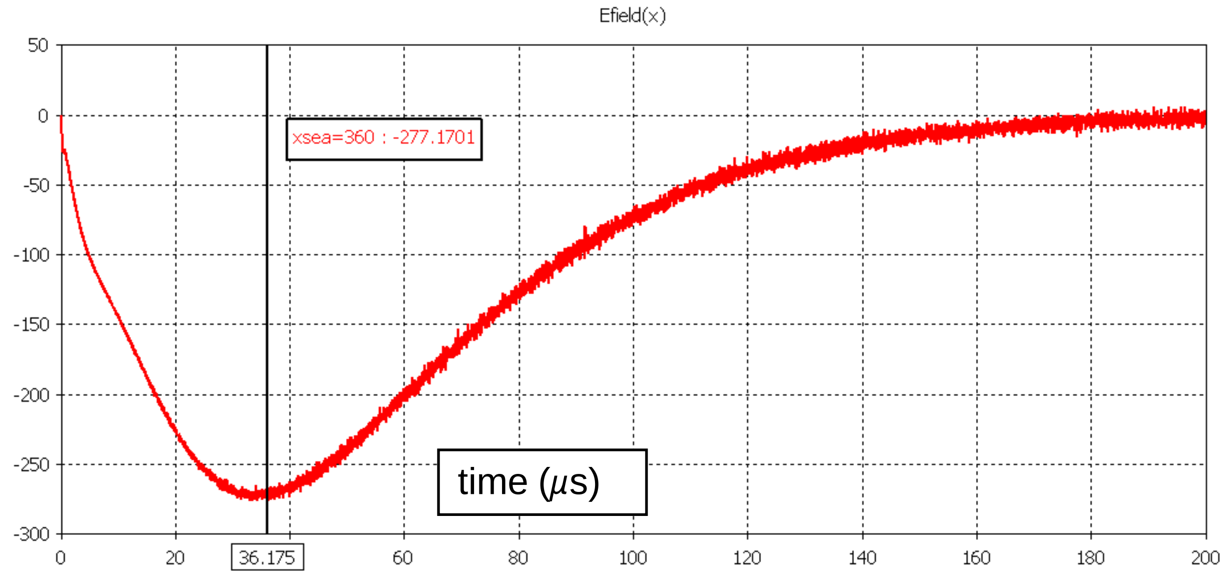
Field Monitor Probes

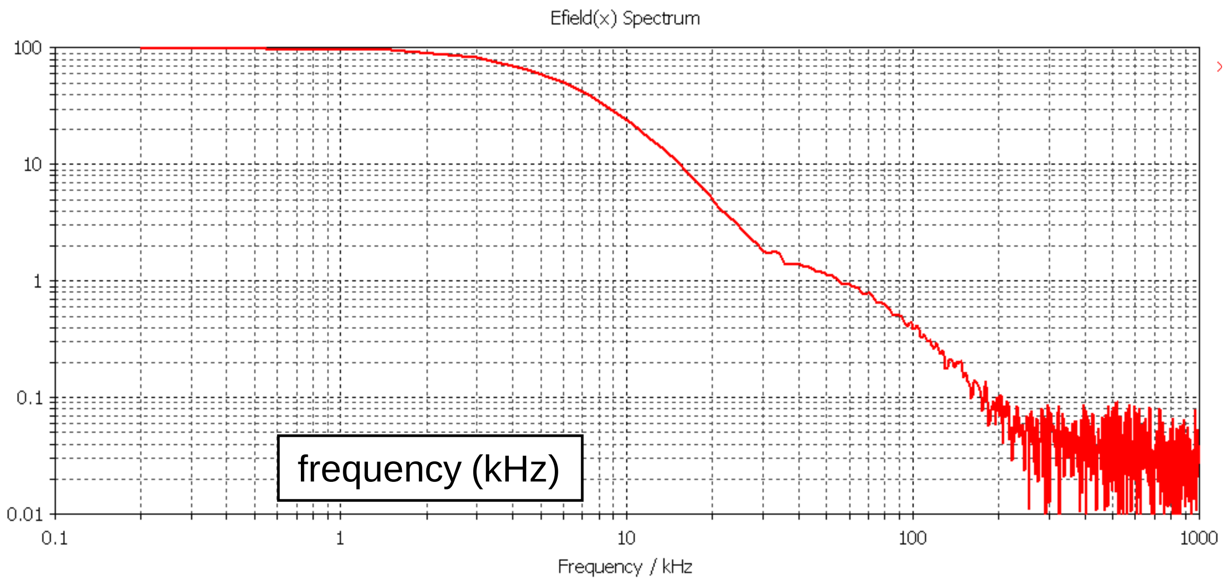


A control area had been made in the LCS-1 model by punching holes in the metal body. Inside this region 3 sensing probes were placed, off any high symmetry plane and monitoring the components of the electric field. For the location selected the electric field was predominantly x-polarized.

(315)453-3096
mwssupport@sonnetsoftware.com

Electric Field in Control Area





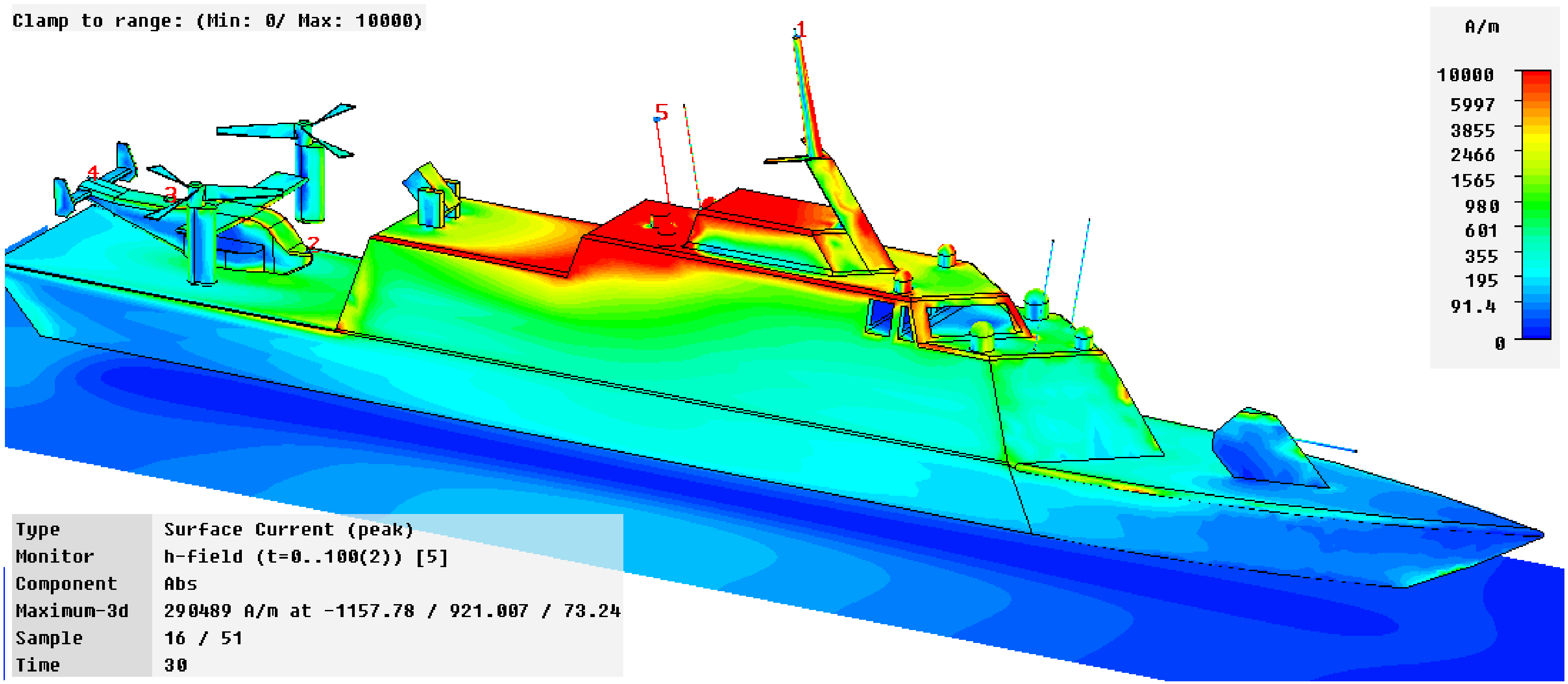
At the sense location in the control area, the electric field from the lighting strike peaked at 36.2μs after the start. At that time the 20kA peak current strike induced a field of 277V/m.

The electric field spectrum decayed to 1% of peak by 60kHz.

(315)453-3096
mwssupport@sonnetsoftware.com

ELECTROMAGNETICS SPECIALISTS

Current Following Lightning Strike



This figure shows the current on the ship 30μs after the start of the strike. A log 1x100 scale is used. The current has spread over the surface and into the sea below.

(315)453-3096
mwssupport@sonnetsoftware.com

ELECTROMAGNETICS SPECIALISTS

Summary

1. The time domain solver in Microwave Studio can be used to follow the effects from non-standard excitations.
2. The time signal used in a simulation can be defined as one of several standard forms, from a text table or as a Visual Basic function as was done in this study.
3. Complex geometries can be built in MWS and models combined into larger assemblies; LCS-1 plus V-22 in this study.
4. The time domain simulation inherently gives broadband results; appropriate for the study of pulse excitations.
5. Fields can be monitored in time as well as at selected frequencies.

(315)453-3096
mwssupport@sonnetsoftware.com