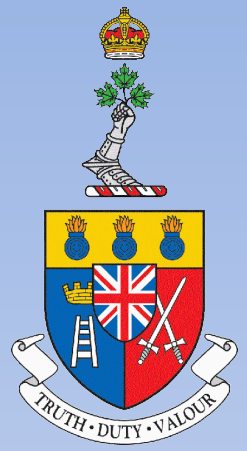
COMSOL CONFERENCE BOSTON 2012



Pulsed Eddy Current Probe Development to Detect Inner Layer Cracks near Ferrous Fasteners Using COMSOL Modeling Software

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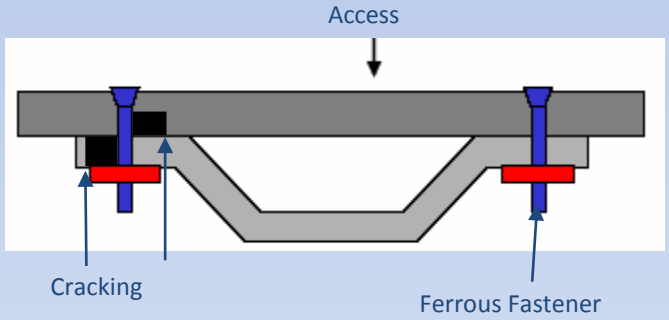
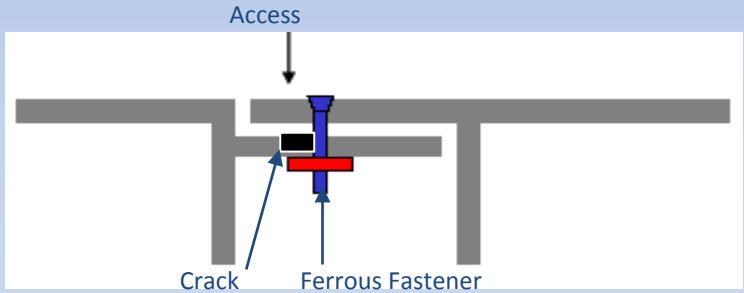
Outline

- Introduction
  - Impetus for Pulsed Eddy Current
  - Why new PEC probes?
- Experimental Work
- Finite Element Models
- Comparison of Modeling and Experimental Results
- Summary

The Motivation



CC-130 Hercules



CP-140 Aurora

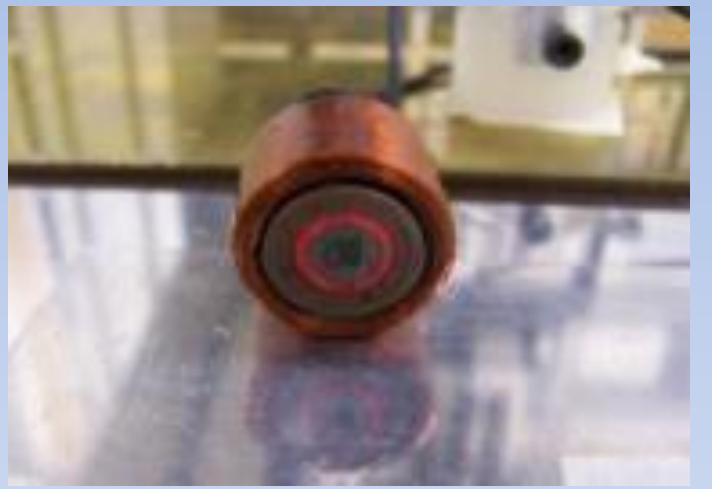
Fatigue induced crack growth at ferrous fasteners is a common mode of failure in aircraft wing structures. Locations of cracks in the second layer are not normally inspectable by conventional techniques (ET or UT).

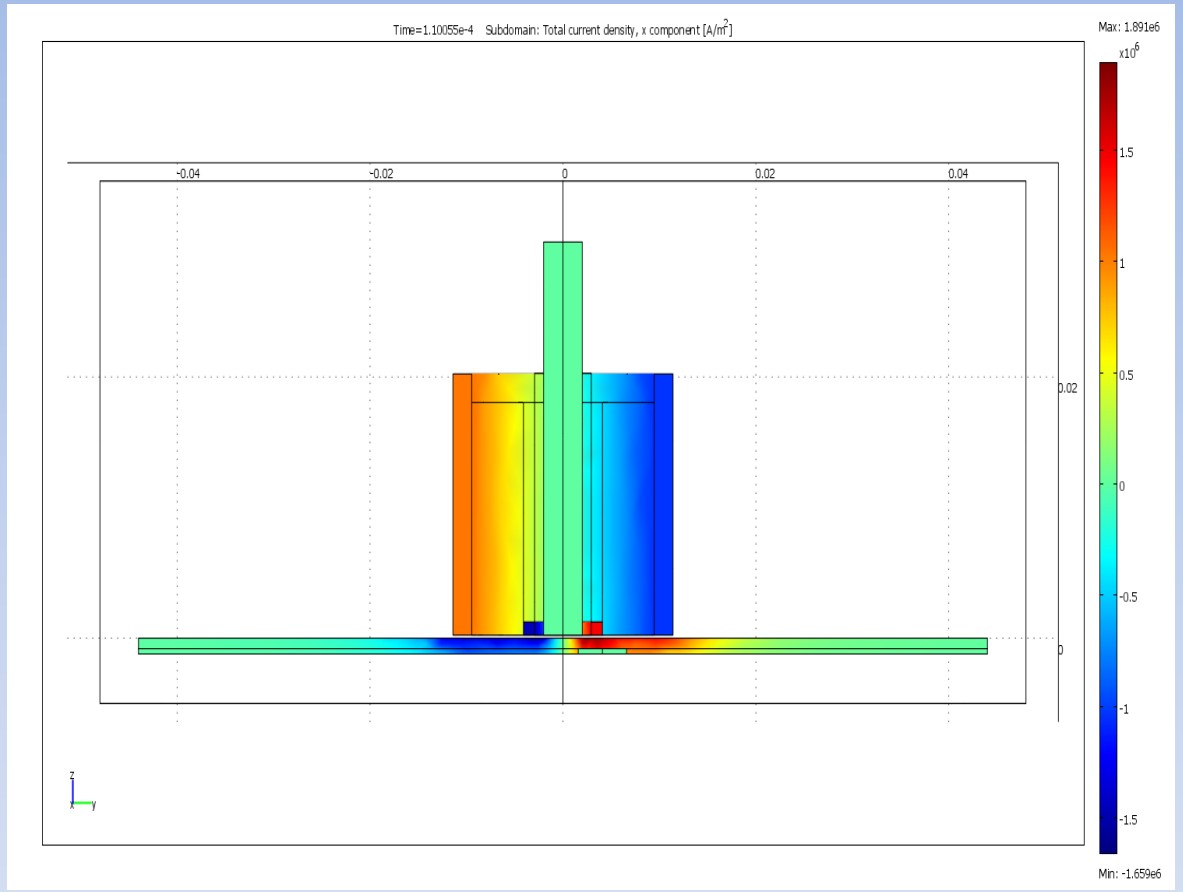
- Typical crack depth ~ 0.10” or less
- Thickness of wing structure ~ 0.25”
- Geometry may be locally varying with only one side access, under installed fasteners.

Impetus for Pulsed Eddy Current

- Rapidly Developing Technology with Potential for:
  - Increased depth of penetration in multi-component conducting and ferromagnetic structures compared with conventional eddy current methods.
  - Able to utilize ferromagnetic components as flux conduits.
  - More versatile electromagnetic field excitation (e.g. variable pulse type, rate and width).
  - Sensitivity at Greater Lift-offs.
- Expanding Number of Applications
- Successful FE modeling using COMSOL has led to new probes with improved performance.

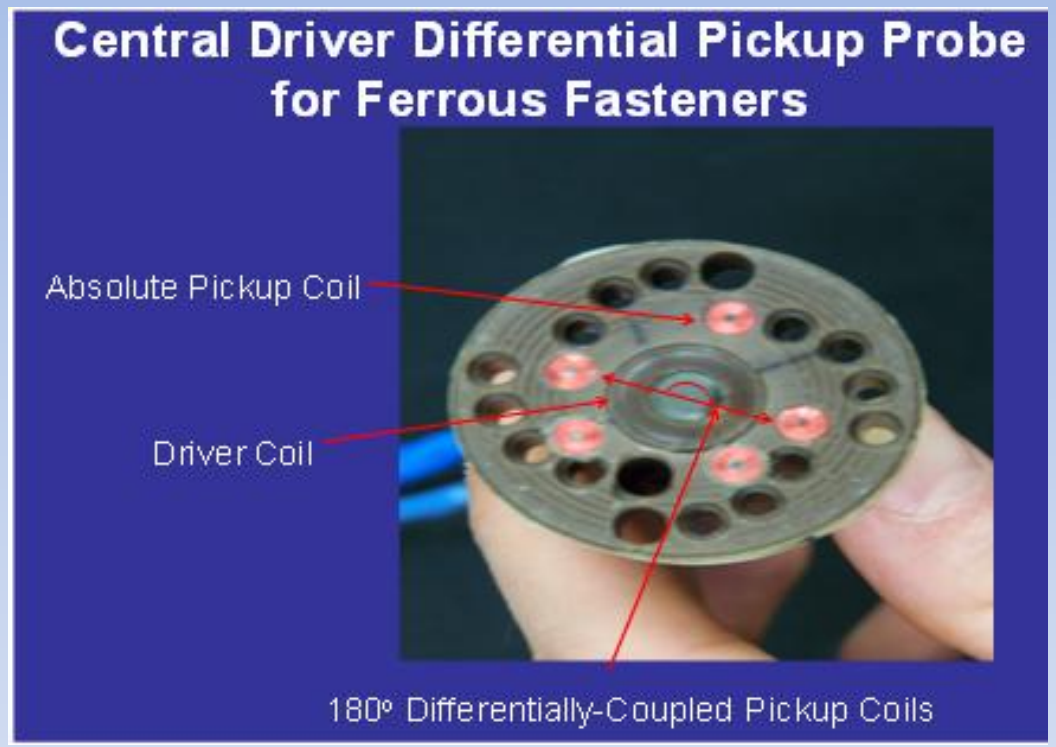
Coaxial Probe from Previous Work

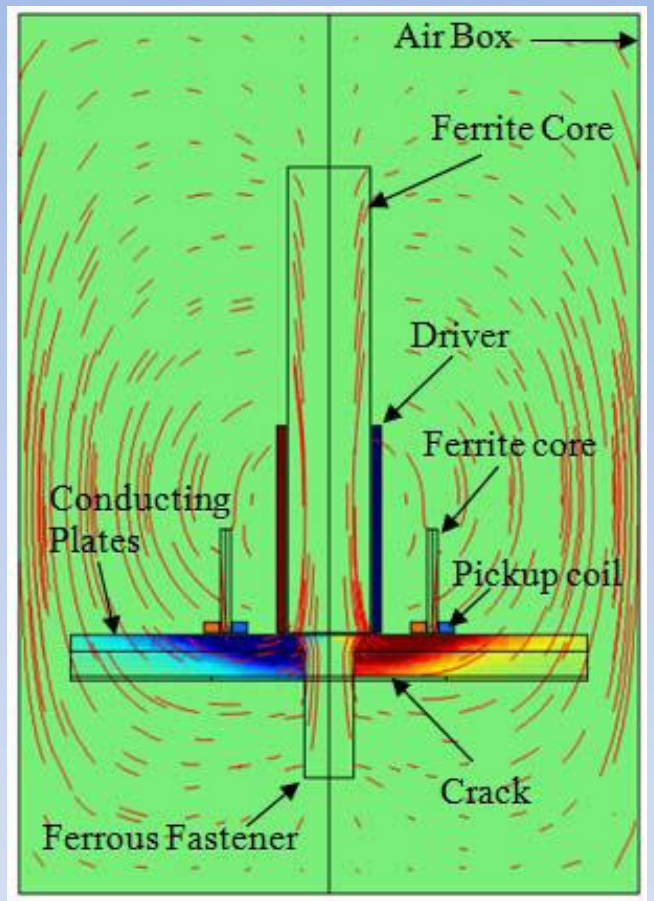




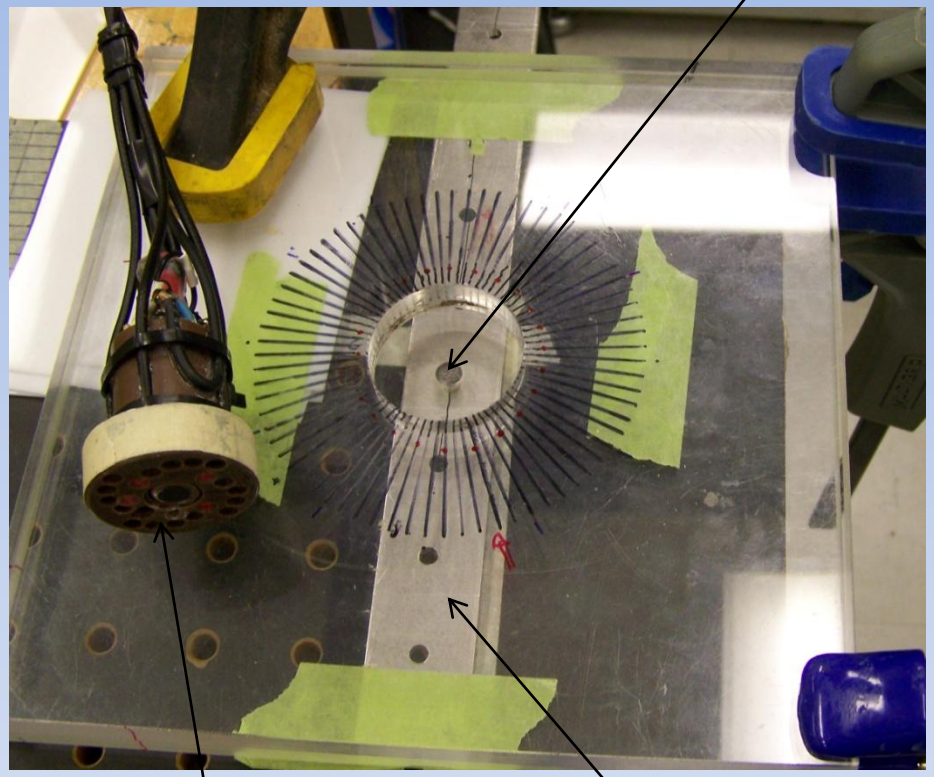
It worked well to detect inner layer cracks in Aluminum structures in the absence of ferrous fasteners, but not when they were present.

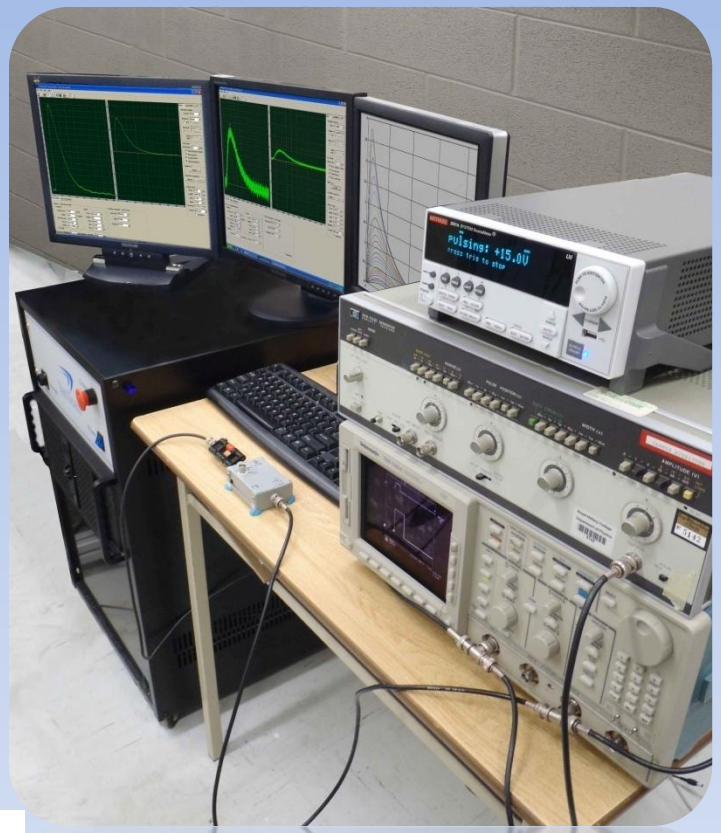
Recent Work - CDDP Probes





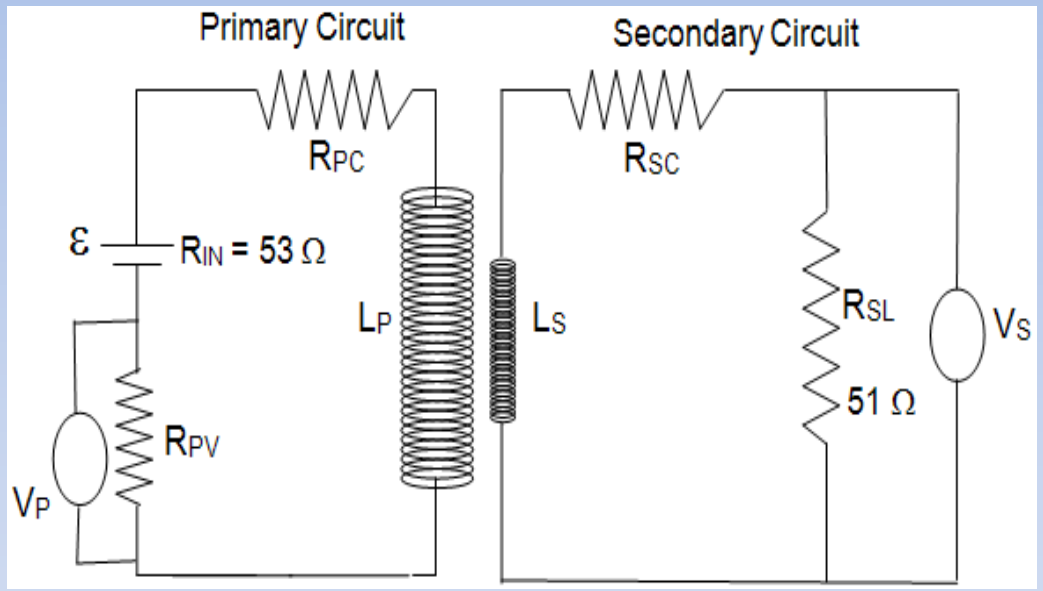
Experimental Set-Up





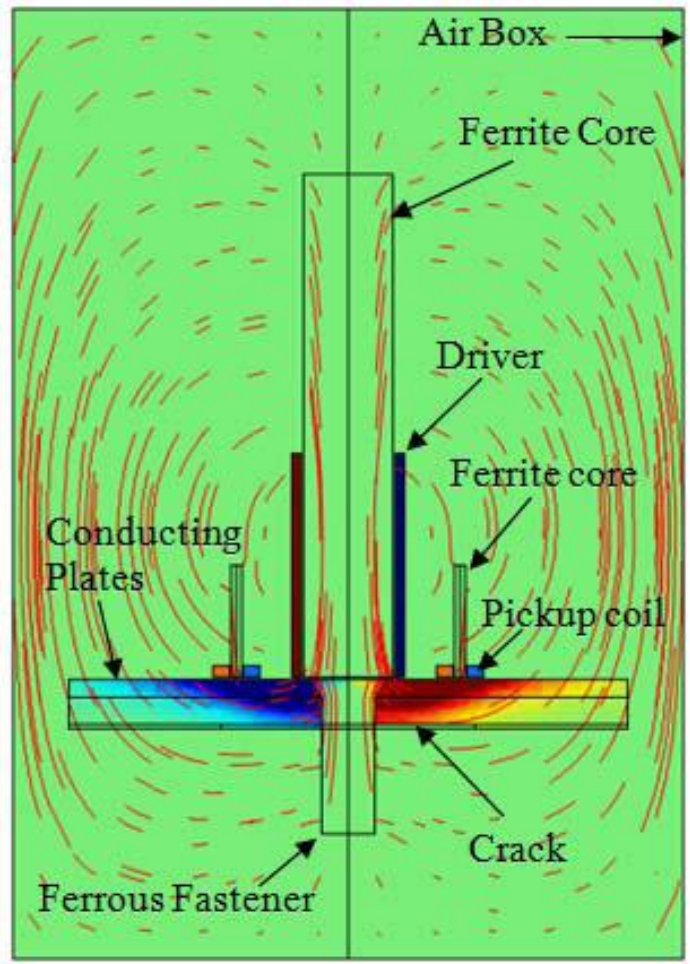
TecScan System

Circuit Diagram and Probe Specifications

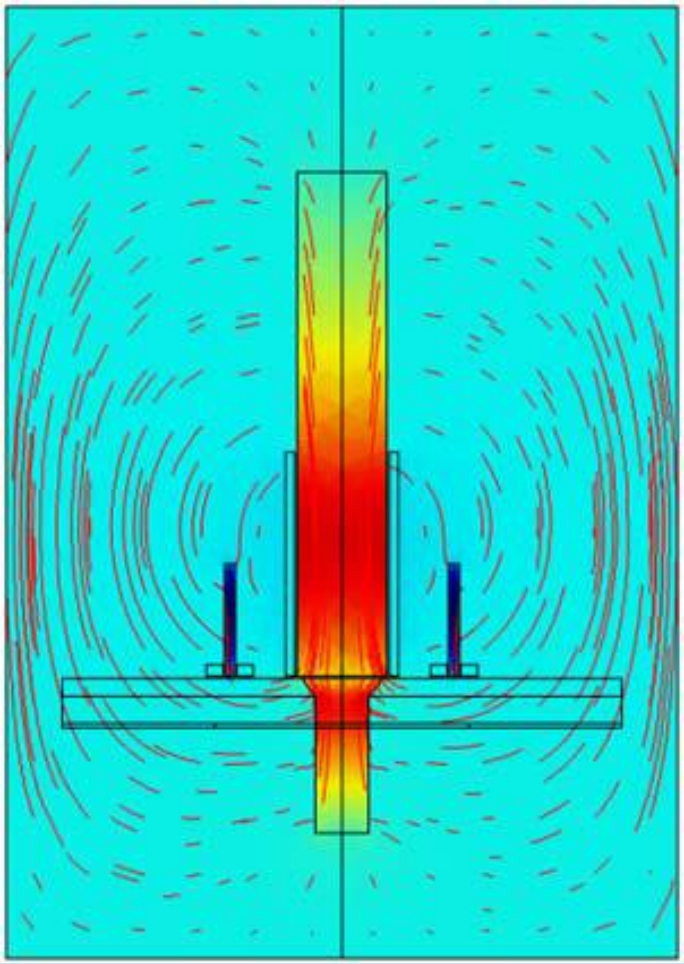


	Driver	Pickup Coil	Driver Ferrite Core	Pickup Ferrite Core
Length, mm	20.0	1.0	40.0	10.0
Outer Dia, mm	10.0	4.0	8.0	1.0
Inner Dia, mm	8.5	1.0	-	-
Turns	1000	400	-	-
Gauge	38	44	-	-
Resistance, Ω	56.6	29.8	-	-
Inductance, mH	29.7	-	-	-
Lift-Off, mm	0.23	0.23	-	-
Permeability,	-	-	2300	48
Conductivity, S/m	-	-	0.5	0.5

Finite Element Modeling Results



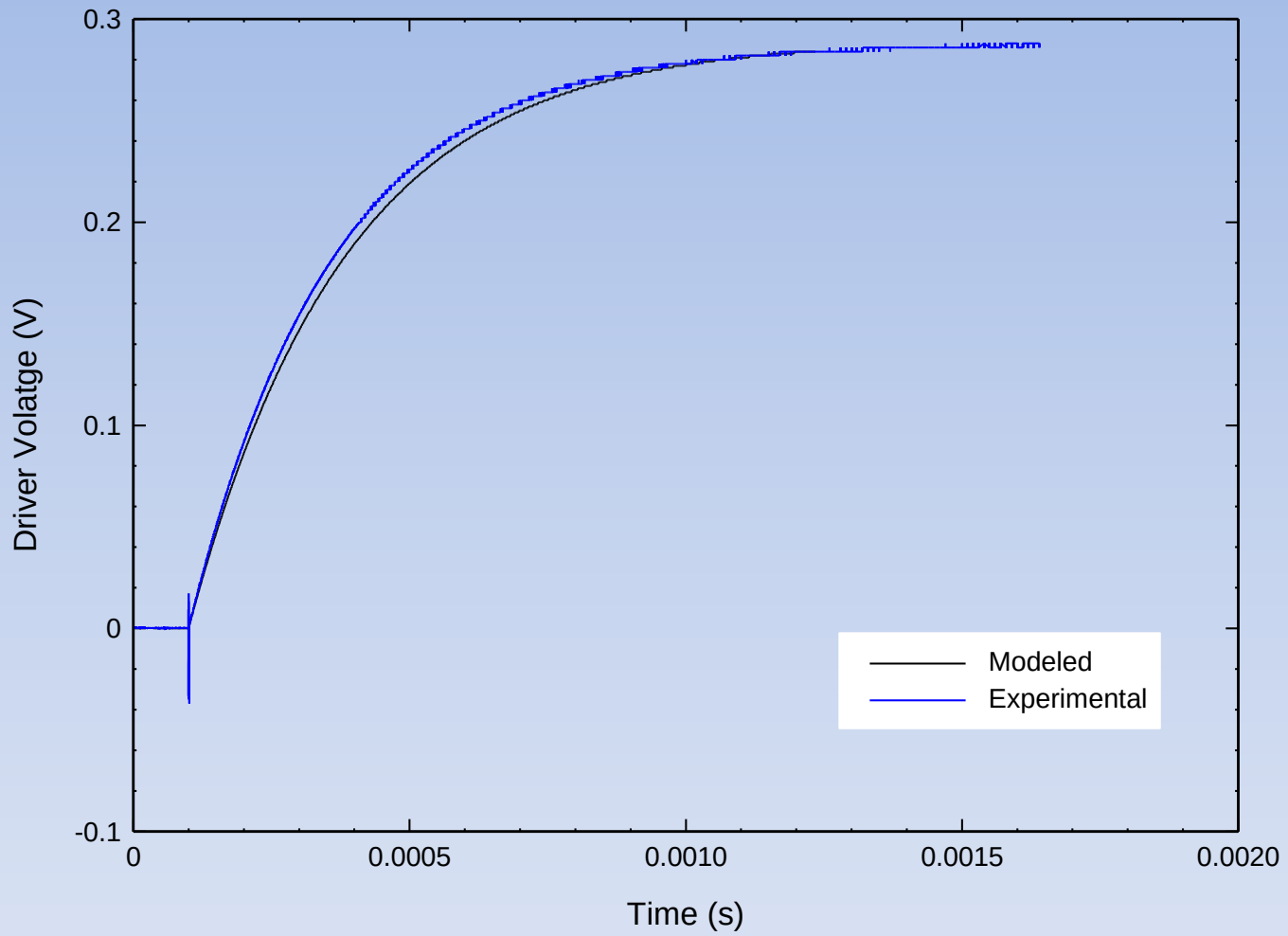
Current density, Jx



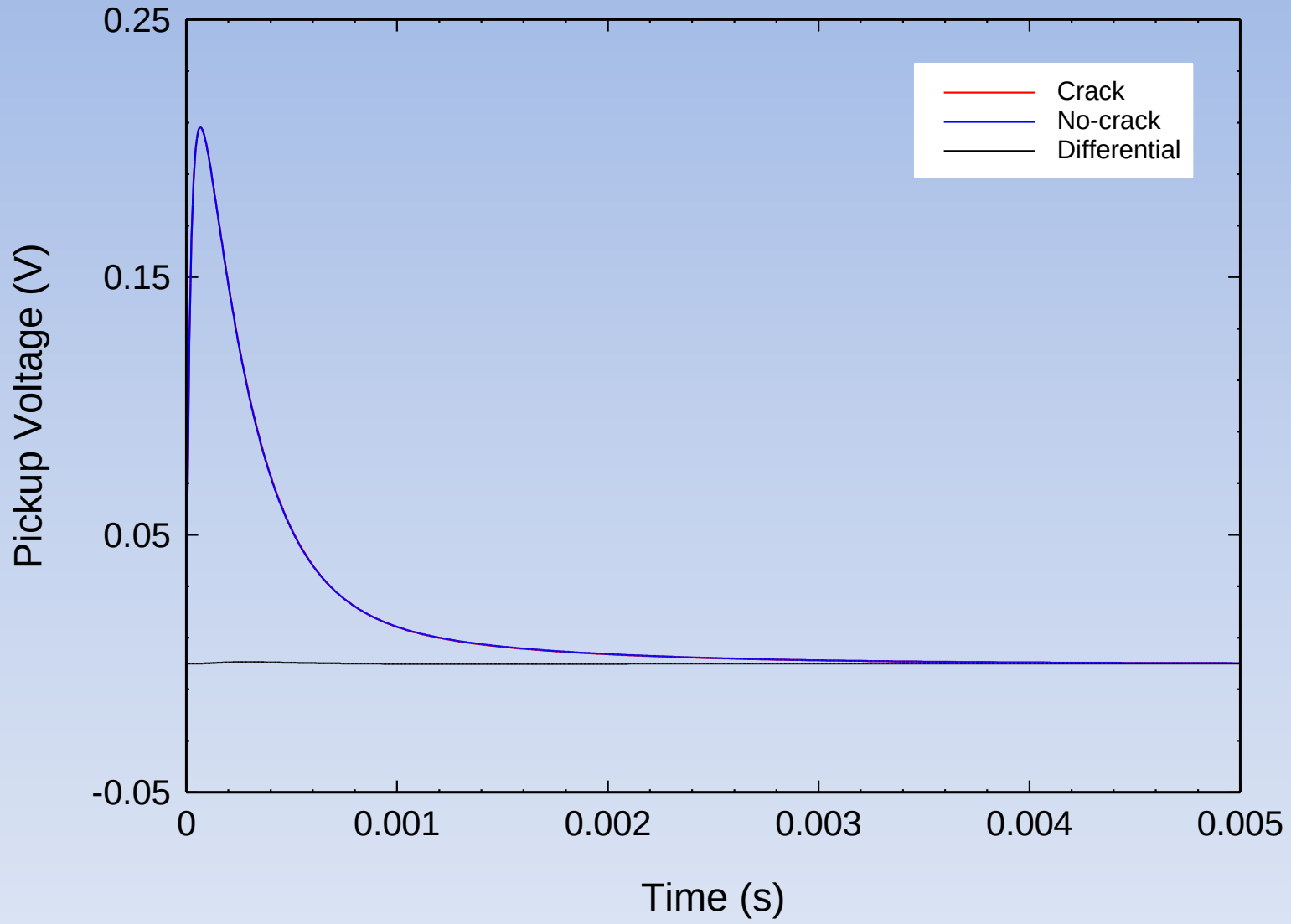
Flux density, Bz

Half model with 2-fold symmetry. Multi turn coil feature.

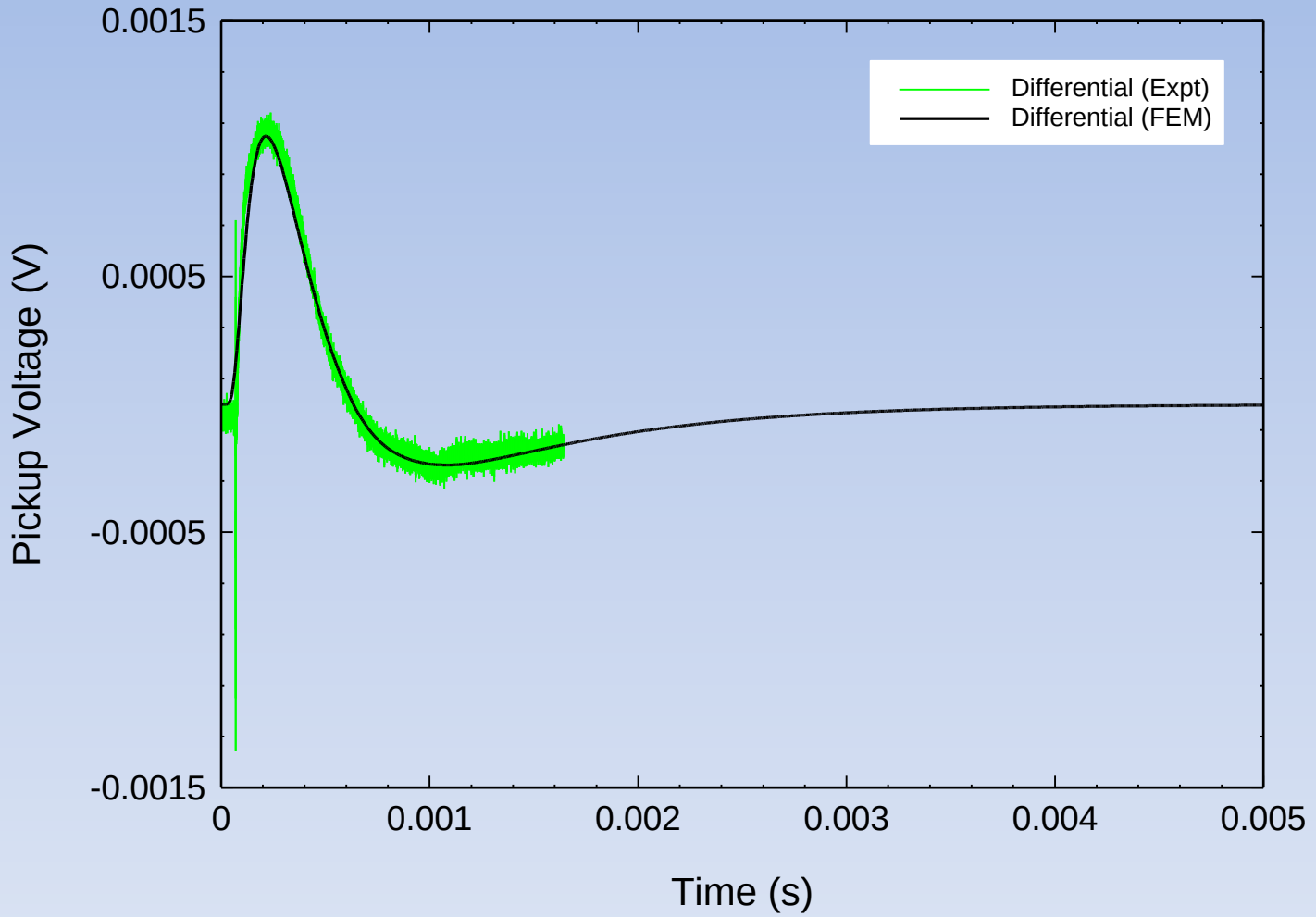
Modeled and Experimental Driver Signal



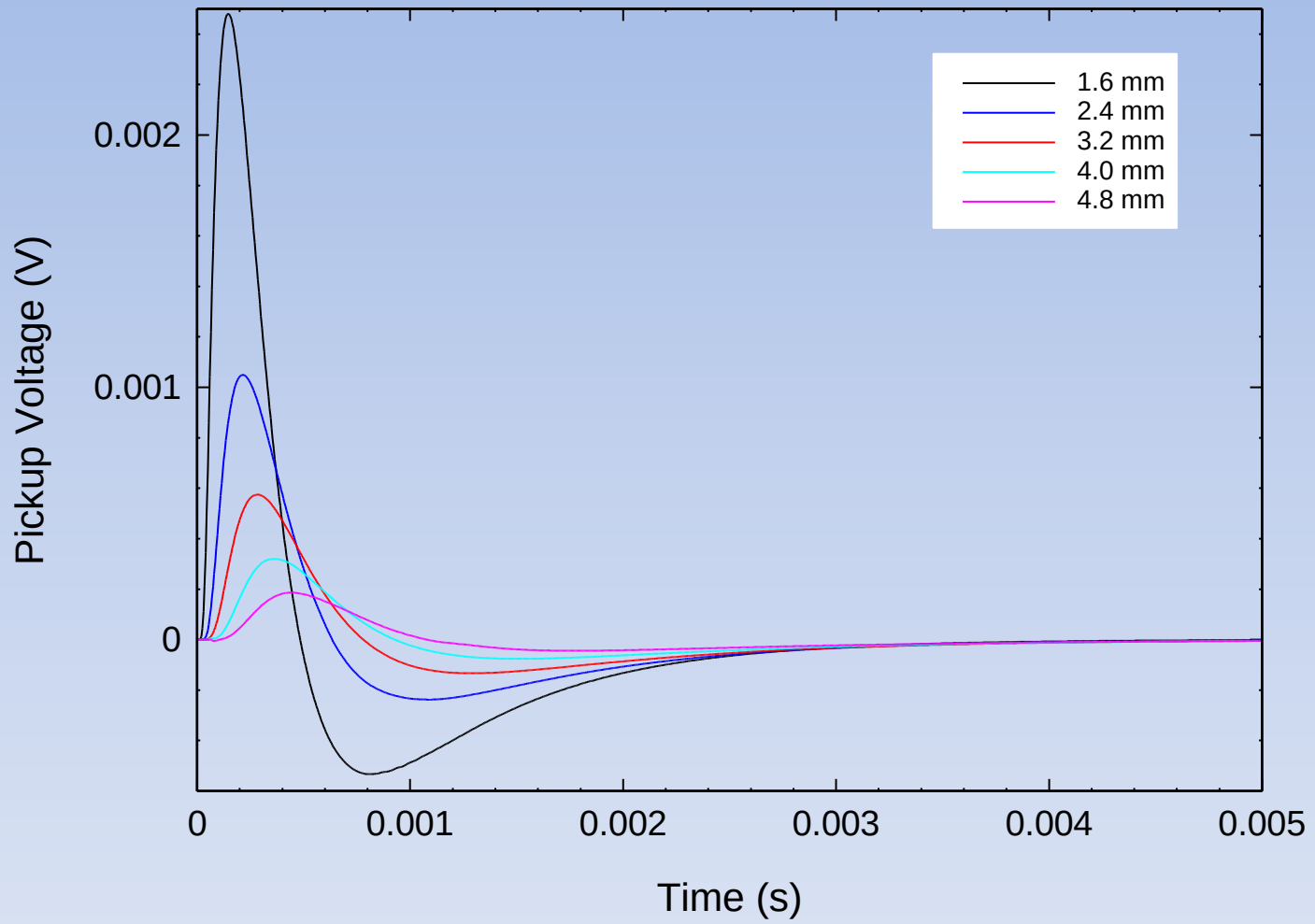
Modeled Pickup Signals



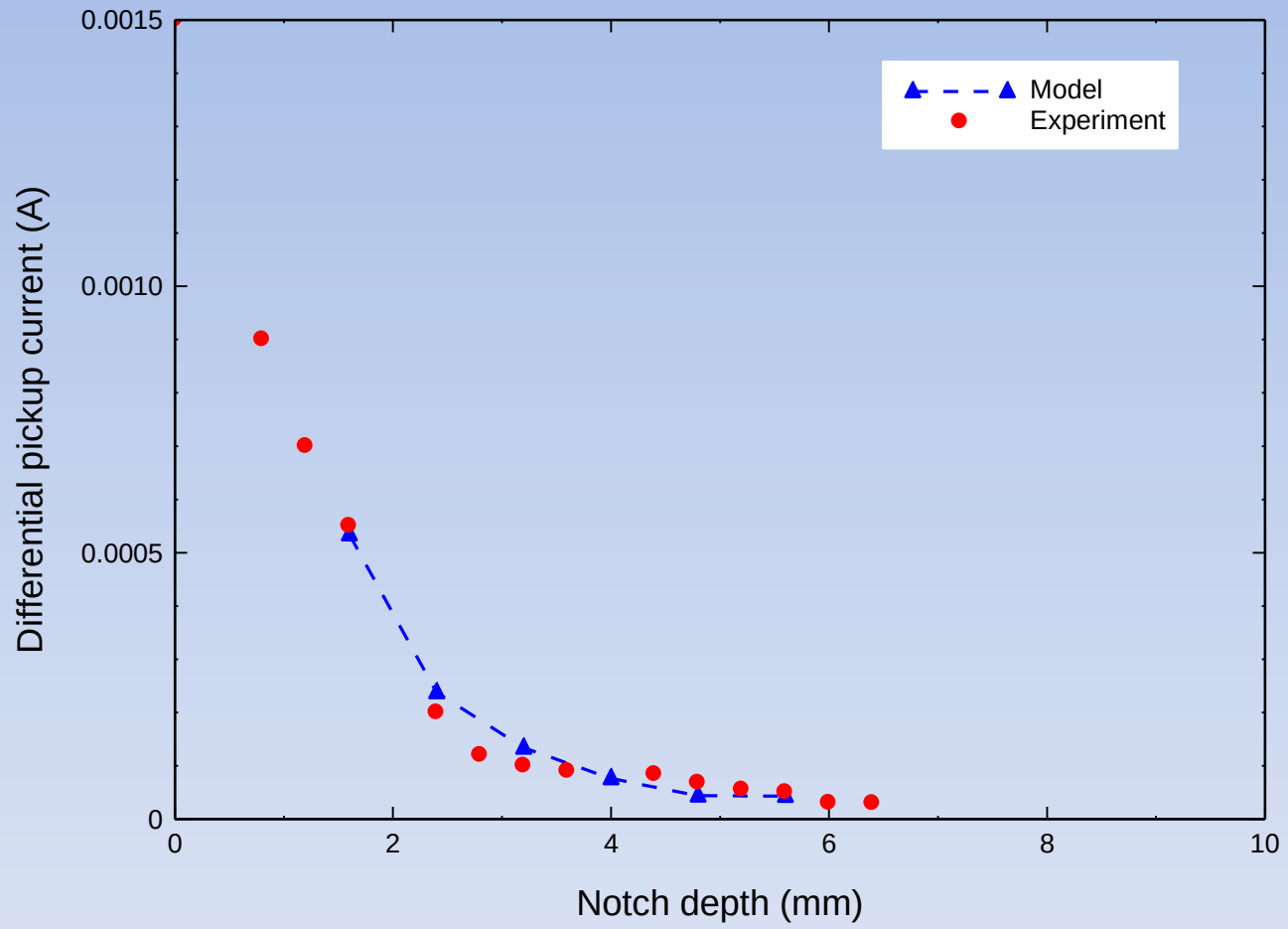
Pickup Signal – Model vs. Experiment



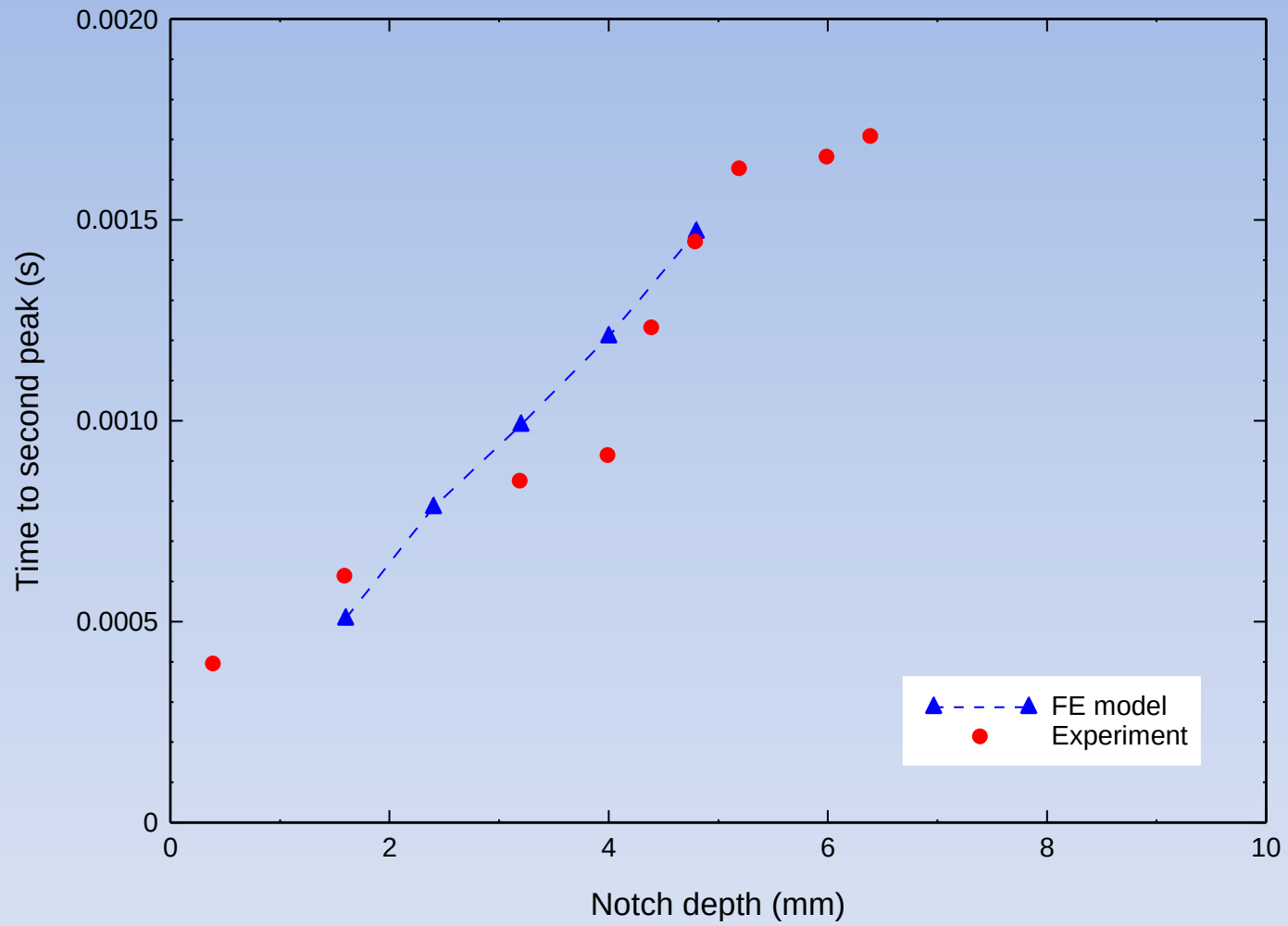
Differential Pickup Signal vs. Crack Depth



Amplitude of Second Peak – Model vs. Experiment



Position of Second Peak – Model vs. Experiment



Speed of second peak is 3.5 m/s, which represents the speed of magnetic flux diffusion through the aluminum structure and back to the pickup coil.

Summary

FE Model results with increasing aluminum thickness are in reasonably good agreement with experiment.

Models indicate that it is possible to detect a notch as deep as 4.8 mm, however noise in the experimental signal currently limits the detection of deep notches.

Analytical and finite element modeling presents flux enhancement in fastener as mechanism for this capability.

Modeled signal peak amplitude decreases and the time-to-peak increases with crack depth.