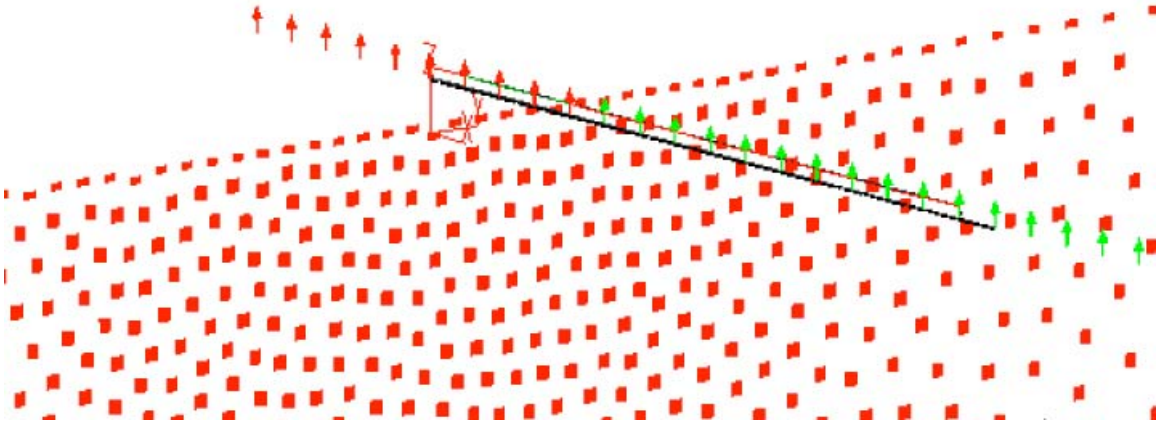
Comparison with P. Weidelt's Quasi-Analytical Solution

Peter Weidelt's[1] quasi-analytical solution employed the Weiner-Hopf technique for solving integral equations. His solution was published with a comparison of his numerical results and scale model data for a Slingram type system, and was considered to be very good. In this comparison, the published data (Weidelt - Figure 7) were digitized and compared with results from MultiLoop III.

The Figure below illustrates the model geometry employed. Red dipoles indicate transmitter locations, while the green dipoles indicate the receivers. Responses were computed for vertical planes at depths of 0.1, 0.3 and 0.5 separations. MultiLoop III files for these models are found in the directory MLPIII Comparison / WeideltHalfPlane.



In the numerical implementation of MultiLoop III, no currents are presently assigned to the edge nodes, and so no current is modeled in the outer half of the mesh elements along the edges. This is normally unimportant unless the conductor is very close to the transmitter. To compensate for this effect here, the actual depths of the meshes used in the computations were displaced from their nominal locations by 0.03 separations.

In the Figure, the axes are plotted at the depth of the conductor. Notice the mesh has been displaced slightly upwards so the top of the currents will be located at the top of the half-sheet.

The response was calculated on a 1000 point expanding mesh generated in Pebble. The expanding mesh is used to represent conductors with infinite extent. A number of mesh dimensions were explored to determine how big the mesh should be to accurately approximate the half-sheet response.

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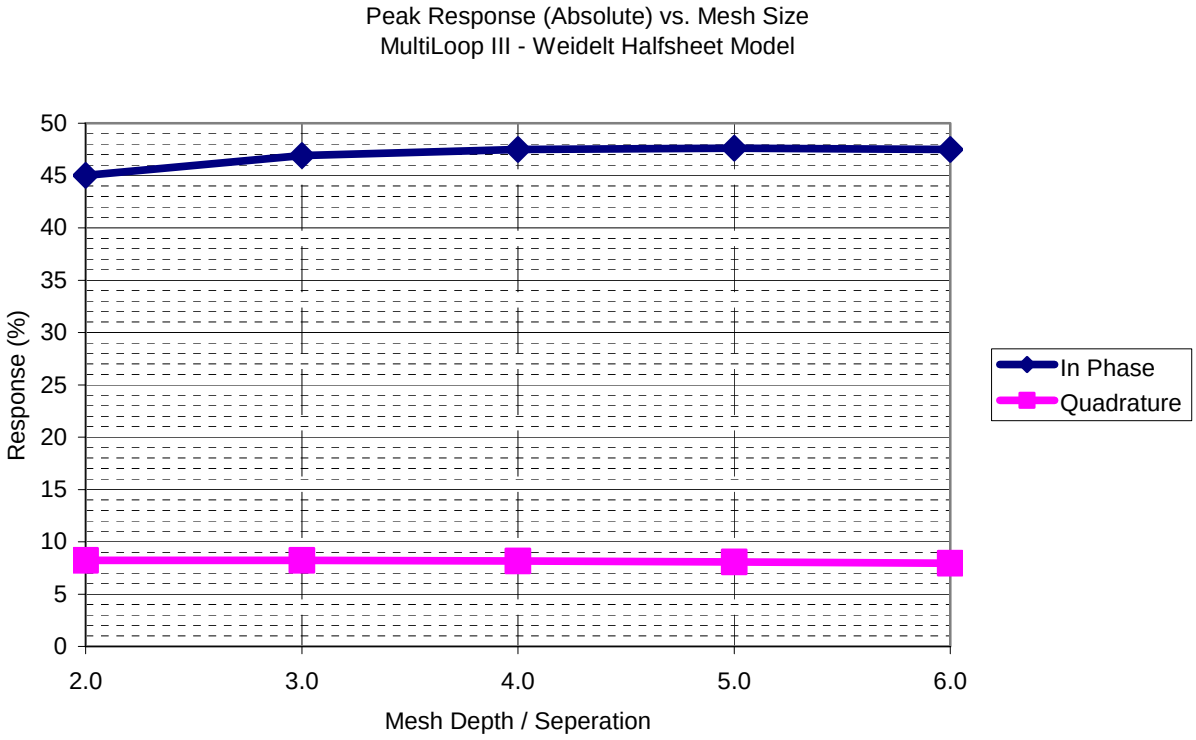
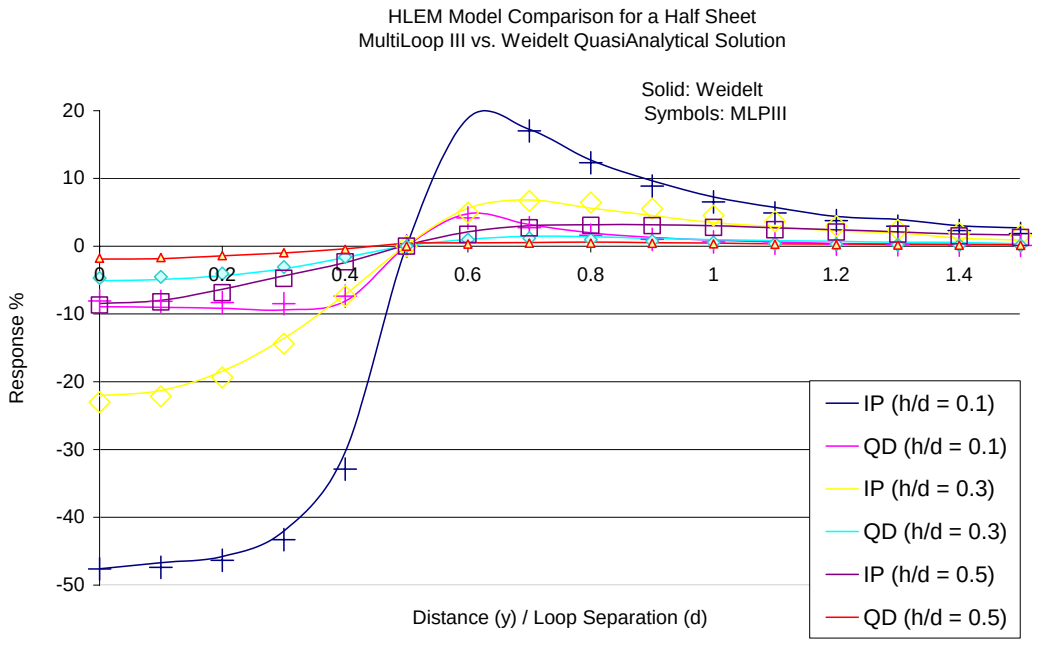
[11]Weidelt, P, 1983, The Harmonic and Transient Response of a Thin Dipping Dyke, Geophysics vol. 48 No .7, p 934-952

The Figure below illustrates the peak in-phase and quadrature responses as a function of mesh size. A dimension of approximately 5 coil separations was found to adequately represent the response.



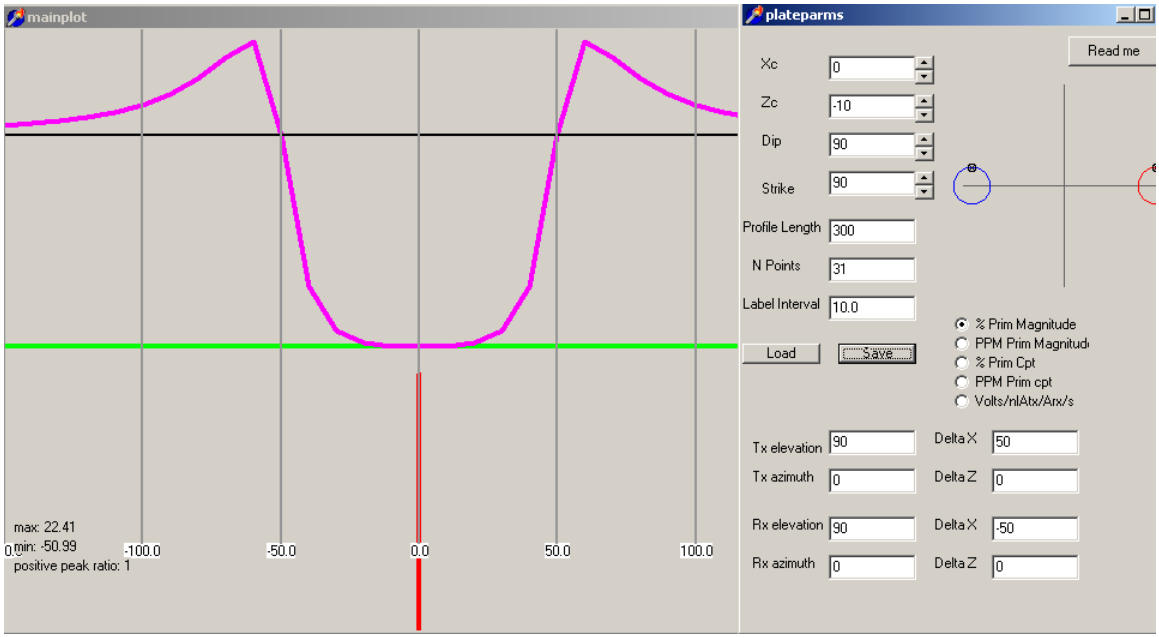
Responses generated by MultiLoop III are compared with Weidelt's results in the Figure below. Some random error is to be expected because Weidelt's results were plotted by hand and then digitized from a .pdf file on a computer screen. Nevertheless, the results compare very well. One minor exception is that there is a slight systematic decrease in the MultiLoop III profiles for the quadrature response for the shallowest half-sheet depth.


HLEM Model Comparison for a Half Sheet
MultiLoop III vs. Weidelt QuasiAnalytical Solution
Solid: Weidelt
Symbols: MLPIII
Response %
20
10
0
-10
-20
-30
-40
-50
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Distance (y) / Loop Separation (d)
IP (h/d = 0.1)
QD (h/d = 0.1)
IP (h/d = 0.3)
QD (h/d = 0.3)
IP (h/d = 0.5)
QD (h/d = 0.5)

Comparison with Ben Polzer's Inductive Limit Widget

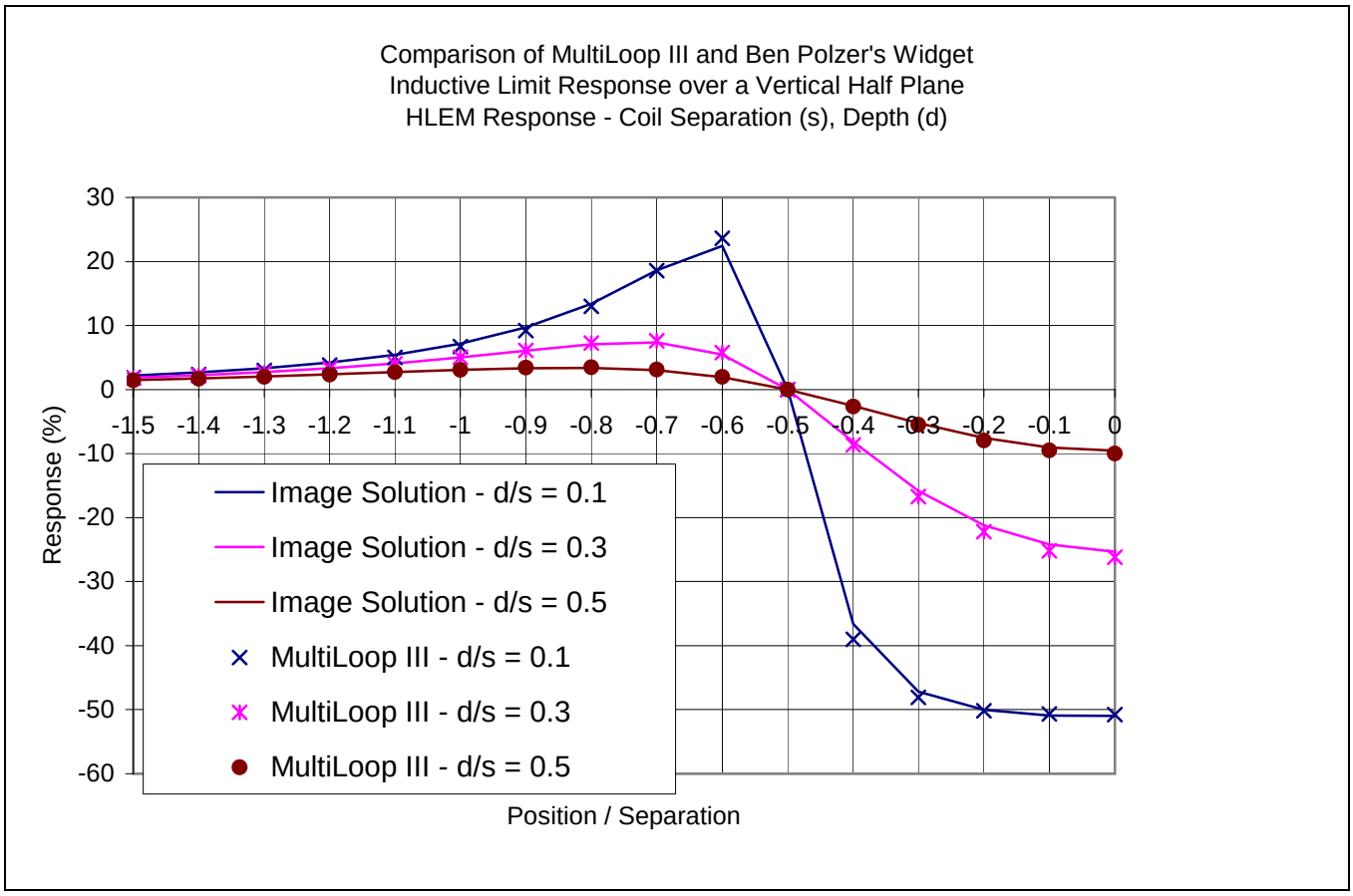
The inductive limit was compared with the image solution for an infinite half-sheet[2] using a computational widget written by Ben Polzer at INCO Ltd. The widget computes the scattering fields from magnetic dipole sources. Ben's contribution to this study is thankfully acknowledged.

The model geometry used is the same as that used in the Weidelt comparisons. A view of the widget is shown below.. To compute the inductive limit response in MultiLoop III, the in-phase response of the sheet was computed at 50 kHz.



The figure below compares MultiLoop III results with the results of the widget. Results are presented below for half-sheets at 1, 3 and 5 separations. The MultiLoop III meshes consisted of 1000 points and were 10 coil separations in extent. The tops of the meshes were placed at a depth of 0.7, 2.7 and 4.7 coil separations respectively. The offset of 0.3 separations corresponded to a half grid cell; the mesh was shifted up so the tops of the currents would be at the required depth.

[2] West,G.F., 1958, Ph.D. Thesis, University of Toronto



As the dipoles become more distant from the mesh, the finite size of the mesh used in MultiLoop III becomes relatively more important. At the extremes of the profile, the error in MultiLoop III was approximately 15% for a 500-meter mesh, 7% for a 750-meter mesh, and 4% for the 1000-meter mesh. While the relative error is large, the absolute error is small, since the response there is only 2.2% of the primary field, so the absolute error would not be noticed in most electromagnetic measurements.