Compatibility Tests for the DUALEM-1S and Noggin SmartCart* GPR

Electromagnetic induction (EMI) and ground-penetrating radar (GPR) can be complementary techniques for investigating the electrical properties of the near surface. For example, GPR can trace the depth of an interface where there is a change in the electromagnetic properties of materials in the subsurface, and EMI can provide conductivity values for the materials above and below the interface.

To assess the feasibility of simultaneously measuring EMI and GPR, a DUALEM-1S and Noggin GPR system were taken to a test site with low environmental noise and conductivity. While operating, the separation and relative orientation of the instruments was varied to determine the extent to which each instrument affected the measurements of the other.

Four profiles of DUALEM-1S measurements are presented herein, and are summarized in the following table. For all profiles, the location of the DUALEM-1S was fixed, and the Noggin cart was rolled towards the DUALEM.

Profile	Noggin frequency	DUALEM orientation
1	1 GHz	Broadside
2	1 GHz	Aligned
3	250 MHz	Broadside
4	250 MHz	Aligned

Where the DUALEM orientation was broadside, the long axis of the DUALEM-1S was perpendicular to the profile, and the Noggin was rolled toward the midpoint of the DUALEM-1S. The separation distance for the profiles was the distance between the midpoint of the Noggin transmit/receive module and the DUALEM-1S. The DUALEM-1S was supported about 25 cm above the ground.

Where the DUALEM orientation was aligned, the long axis of the DUALEM-1S was parallel to the profile, and the Noggin was rolled toward the transmitter-end of the DUALEM-1S. The separation distance for the profiles was the distance between the midpoint of the Noggin transmit/receive module and transmitter-end of the DUALEM-1S. The DUALEM-1S was laid on the ground so that it could pass under the front of the Noggin cart at small separations.

Figure 1 shows the DUALEM-1S measurements for profile 1. With reference to the legend of the figure, for all profiles HC is apparent conductivity measured with the horizontal co-planar array, PC is apparent conductivity measured with the perpendicular array, HI is secondary in-phase

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measured with the horizontal co-planar array, and PI is secondary in-phase measured with the perpendicular array.

At separations greater than 130 cm, stable measurements indicate that the DUALEM-1S is insensitive to the presence of the Noggin. At closer separations, the measurements show smooth but increasing deviation from stable levels. The smoothness suggests that the DUALEM-1S senses only the metallic components of the Noggin transmit/receive module as an inert conductor, and that there is no dynamic interference from the operation of the GPR.

The greatest changes in measurements are given by the perpendicular array between the separations of 50- and 60-cm. These changes are 3.6 mS/m for apparent conductivity, and 0.54 ppt for secondary in-phase. Thus, if a surveyor were to fix a DUALEM-1S in broadside orientation about 60 cm from the Noggin transmit/receive module, such that the relative motion between the DUALEM-1S and the module was typically less than 1 cm, the surveyor could expect that the noise from this arrangement would be generally insignificant.

The remaining figures show that the separations beyond which the DUALEM-1S is insensitive to the Noggin are 70 cm for profile 2, 140 cm for profile 3 and 120 cm for profile 4. The 250 MHz transmit/receive module is physically larger than the 1 GHz module, and the greater separations required for insensitivity probably arise from its larger metallic components.

Noggin responses were recorded for each profile with the DUALEM-1S operating in place, and repeated with the DUALEM-1S removed. For all profiles, the Noggin sections show no apparent response attributable to the presence of the DUALEM-1S. For example, figure 5 shows a section from 250 MHz data with the DUALEM-1S operating at position 0, and figure 6 shows a virtually identical section with the DUALEM-1S removed.

These compatibility tests indicate that the DUALEM-1S and the Noggin GPR can be operated simultaneously within about 1 m of each other. DUALEM instruments with longer array lengths (e.g. the DUALEM-2S and the DUALEM-4) should be at least as compatible with the Noggin, as the conductor represented by the transmit/receive module would be smaller relative to the array length. As EMI and GPR devices vary greatly in operational characteristics, however, other instrumentation should not be assumed to share the compatibility of DUALEM and Noggin.

Dualem thanks Dave Redman of Sensors & Software Inc. for his assistance with these tests and for figures 5 and 6.

Figure 1: DUALEM-1S Measurements of Profile 1.

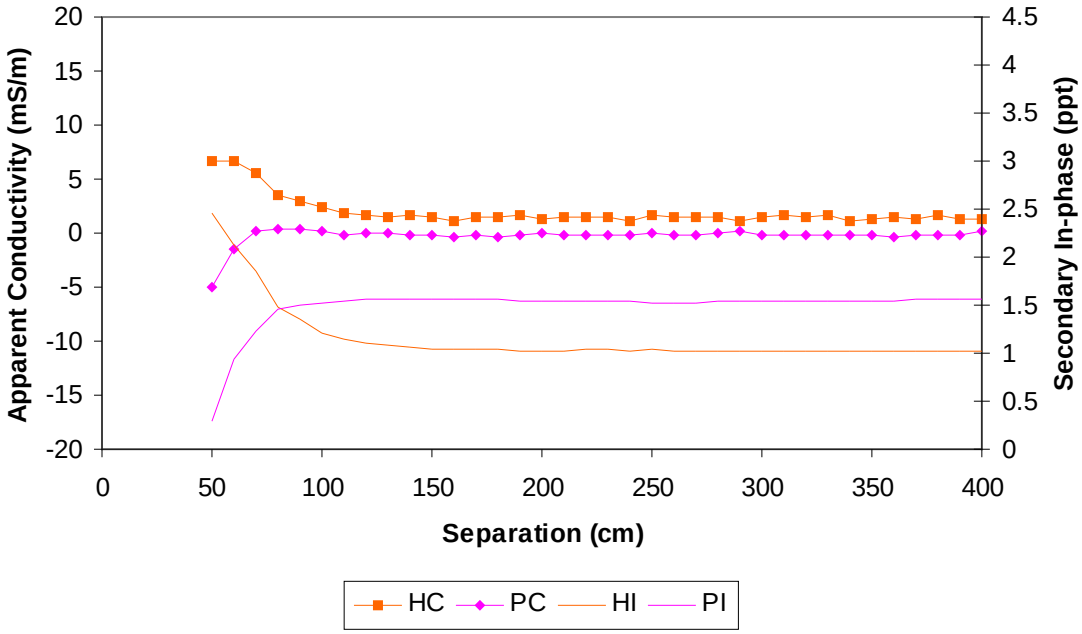


Figure 2: DUALEM-1S Measurements of Profile 2.

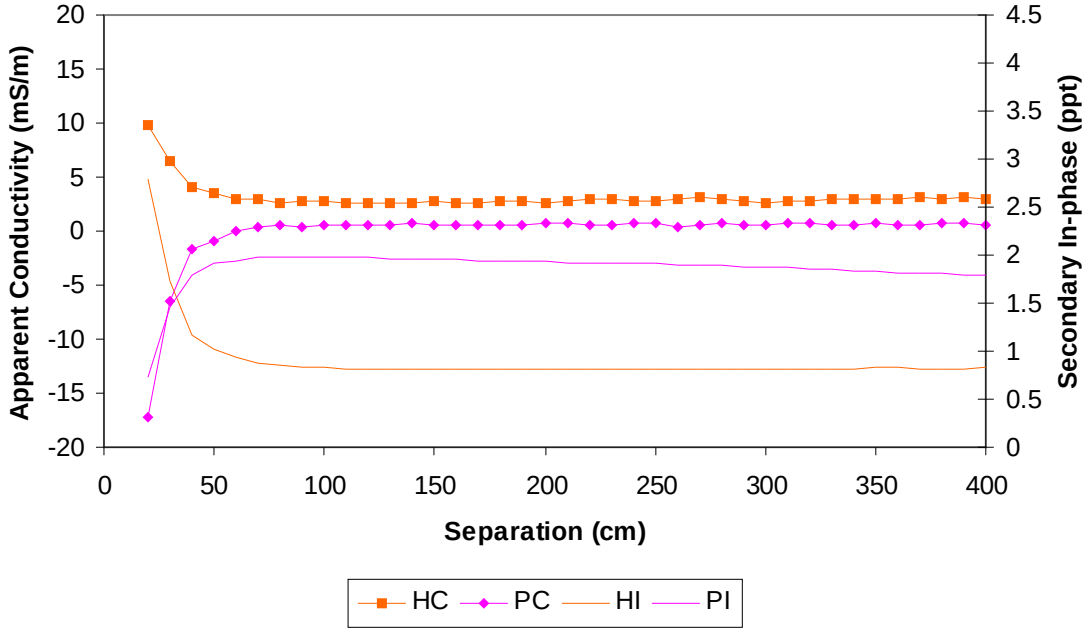


Figure 3: DUALEM-1S Measurements for Profile 3.

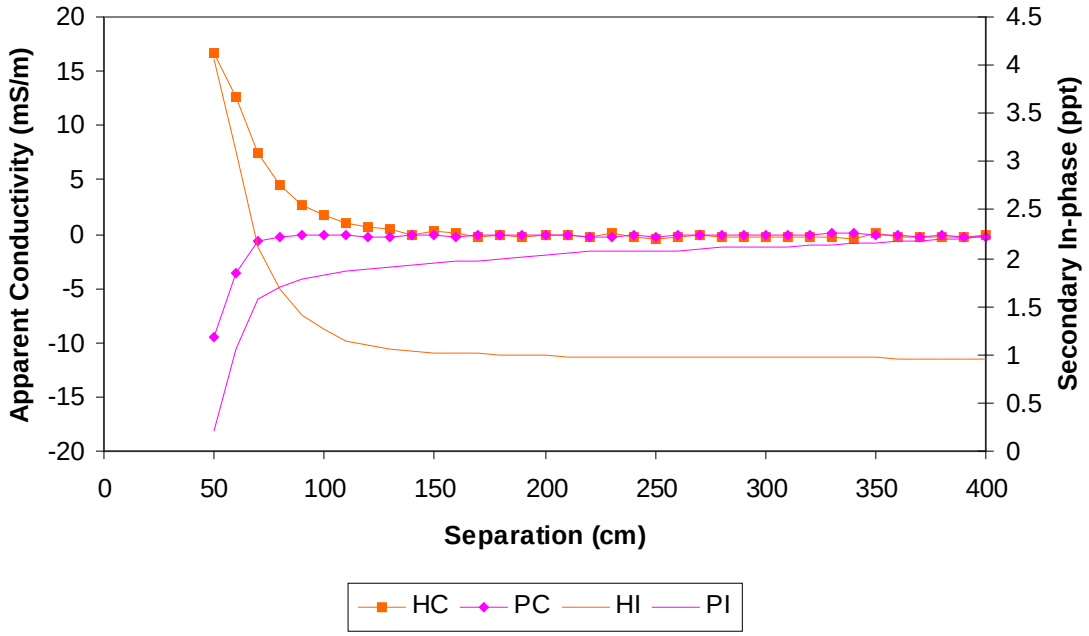


Figure 4: DUALEM-1S Measurements for Profile 4.

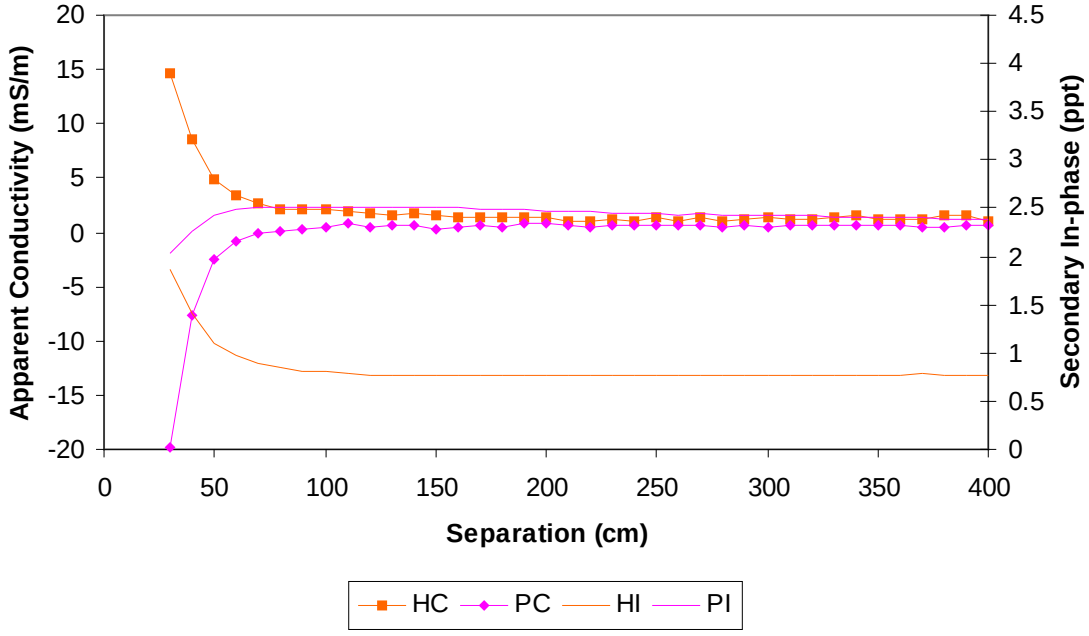


Figure 5: Noggin 250 MHz Section with DUALEM-1S Present.

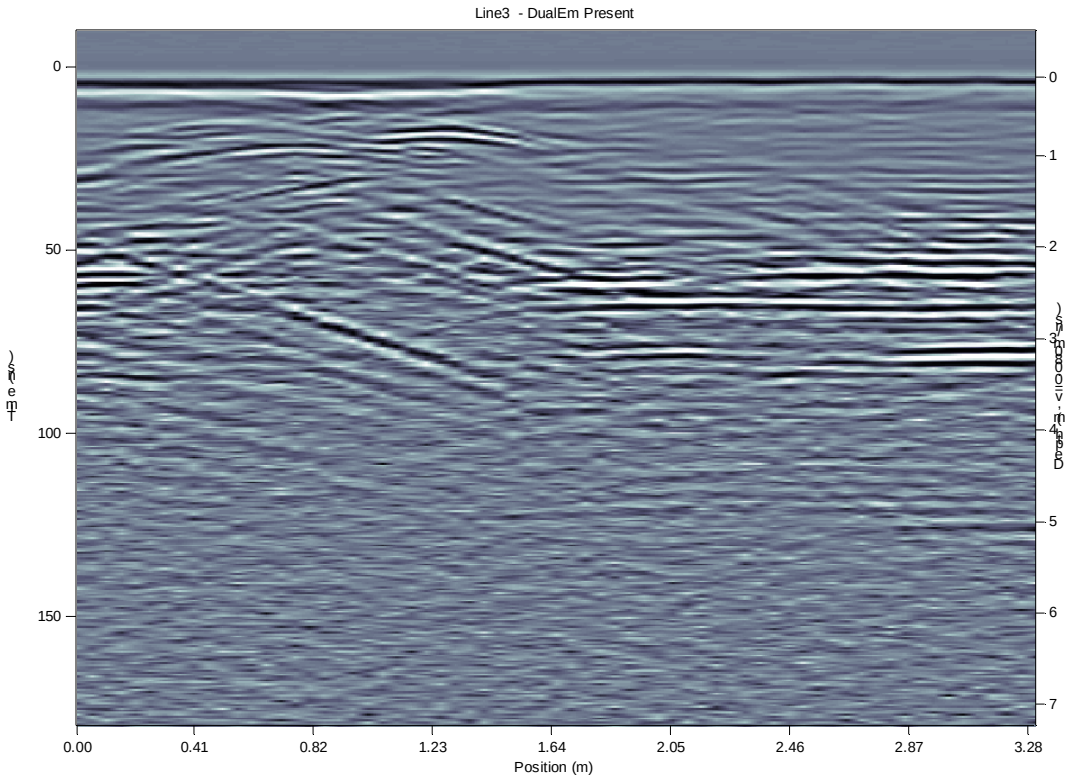
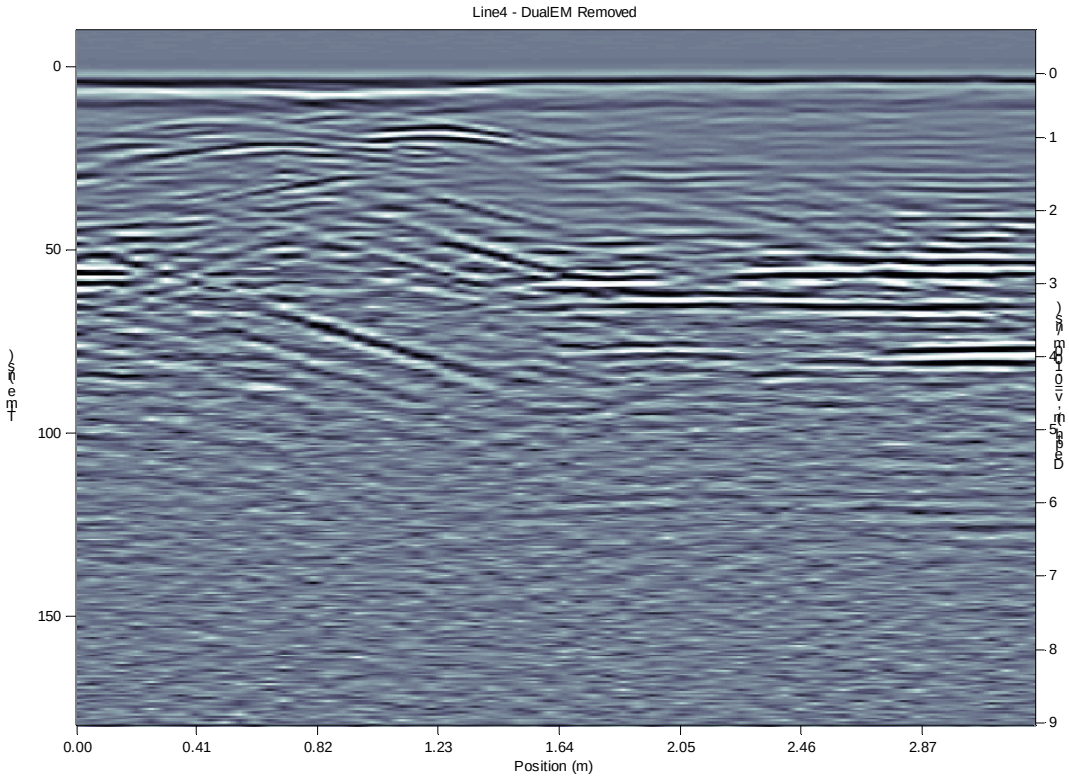


Figure 6: Noggin 250 MHz Section with DUALEM-1S Absent.



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