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Blossoming future

Electro-Magnetic Interference

Relevant Crocus Devices

The concepts and examples in this application note are applicable to all of the following Crocus devices:

CTSR218C-IS4 and CTSR218C-IQ2

Introduction

One of the challenges of smaller spaces, especially in the electromagnetic applications, is the interference from undesirable/parasitic magnetic field. This comes more into picture when measuring current using the induced magnetic field around the conductor, while different conducting wires are close by to the same conductor.

One simple solution for eliminating magnetic field interference is to increase the distance between the conductor and other wires, large enough, so that current from the neighboring wires have minimum impact. This of course means one would need larger distances for wires conducting higher currents.

In the case of measuring the current in multiple wires which are all passing through the same cladding, we need to displace the wires significantly apart on the terminal interface, route the wires over the measuring sensors, and then recombine them all back into the cladding again. This will cause losing significant space in the instruments or devices.

In this application-note we provide a solution to shield crocus sensors from interference of magnetic fields induced by nearby wires. This solution is using ferromagnetic plates to redirect the flux vectors of the nearby magnetic fields in direction to which the sensor is not sensitive.

This document is arranged to first, provide simulation of the existing problem, then a practical implementation of the solution is described and results are compared.

Simulation Tool and Parameters

The main goal of the simulation is to solve for the field vectors of the magnetic field induced by a nearby current-carrying trace. For this purpose, the *QuickFields 6.0 Student Edition* software was used which has the capability of having 2D analysis of induced magnetic fields. This tool allows for defining parameters based on the simulation environment, and then calculates the direction and magnitude of the magnetic field vector.

Magnitude of a magnetic induction **B** generated by the current **I** in a straight and long wire at a distance **r** from the wire is calculated by Ampere's equation below:

$$B = \frac{\mu_0 I}{2\pi r}$$

In this equation, μ_0 is the permeability of the medium. Also, the direction of field **B** vector is defined by the *right hand rule*.

The case described in the application note uses the PCB itself as the insulator between the

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sensor and the current carrying trace. In this case, the magnetic sensor is mounted on the top of the PCB with the current-carrying trace located on the other side of the PCB. The dimensions considered in this simulation are shown in Table 1.

Table 1 – Dimensions defined for simulation.

Feature	Thickness (µm)
Packaged Sensor	700
PCB	1600
Current-Trace	40

The permeability of the different materials is presented in Table 2.

Table 2 - Relative permeability of different materials

Parameter	Value (μ/μ_0)
Relative Permeability of Air	1.00000037
Relative Permeability of PCB	1
Relative Permeability of Chip	1
Relative Permeability of Copper	0.999994

Numeric Simulation of the Problem

The final step is to define the simulation environment. The physical setup is defined as a cross-sectional view of the current-carrying trace on the bottom side of the PCB which is located exactly under a sensor chip package located on the top side of the PCB. This setup is depicted in Figure 1. In this simulation layout, current is considered to be going into the page with the magnitude of 20A DC in the "Current Trace". "Sensor A" is the designated sensor to measure the current in the trace, and "Sensor B" is another sensor placed away to simulate the interference in that location. "Sensor B" is hypothetically placed to measure the current in another current-carrying-trace (not shown in the picture) parallel to the "Current Trace".

The results of this simulation are shown in Figure 3. We can see that although the magnitude of the magnetic field in the x direction at "Sensor B" is very small, there is interference at this point imposed from the current in the "Current Trace". By plotting the

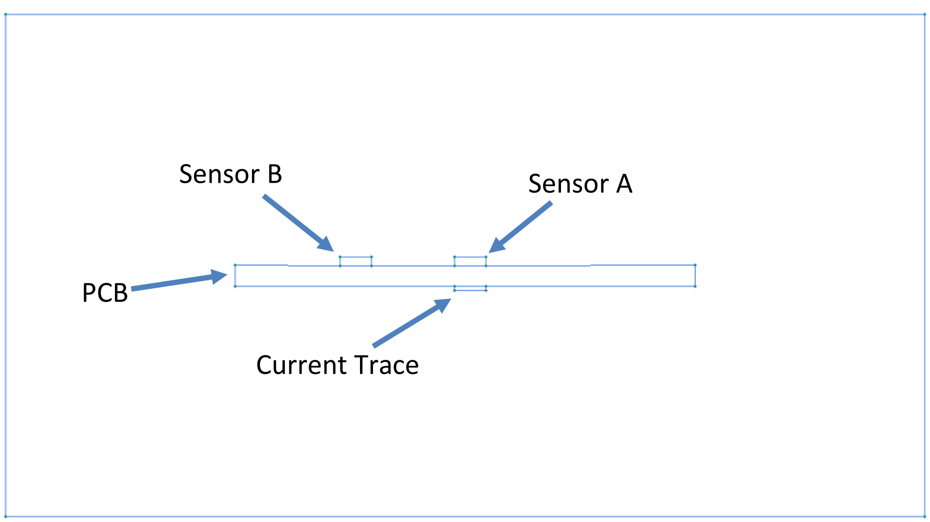

Figure 1 – Cross sectional view of the simulation for the problem.

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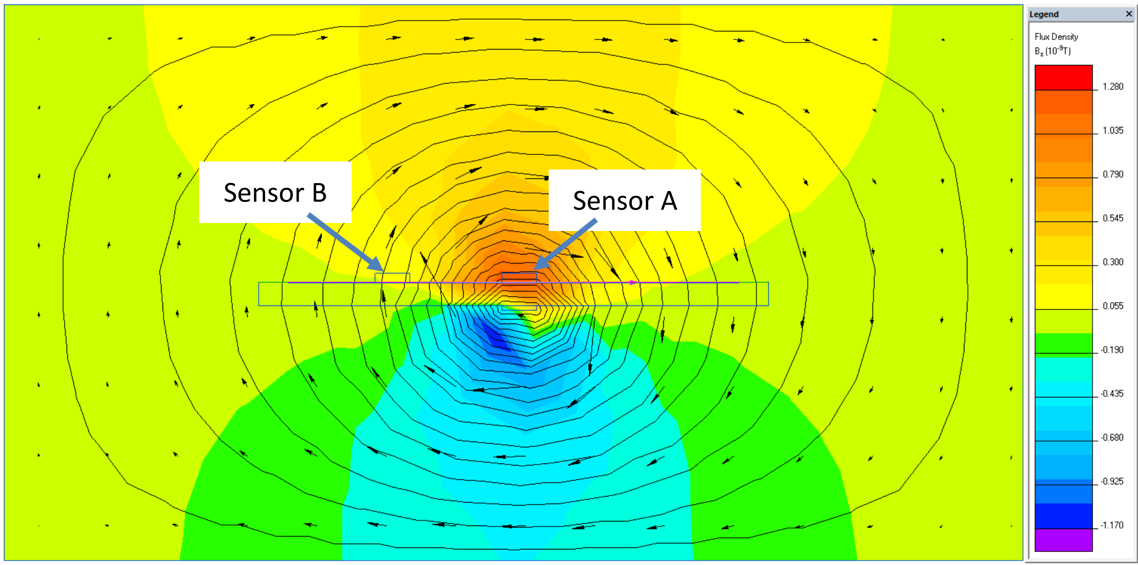

Figure 3 – Result for the simulation of the problem.

magnitude of the magnetic field in the x direction across a contour line (passing directly on top of the PCB), we can confirm that the interference in this direction exists at the position of "Sensor B" (Figure 2). Since we placed "Sensor B" to be 10mm away from "Sensor A", it can be shown on the graph that the magnetic field in the x direction is near $5x10^{-11}$ T at position of "Sensor B".

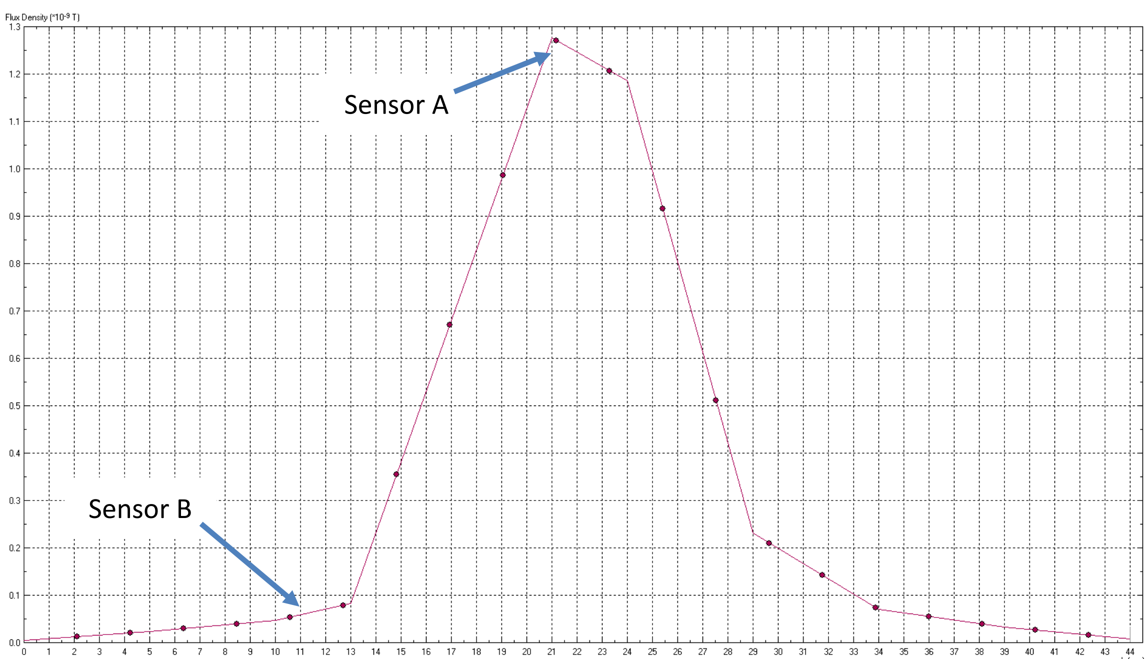

Figure 2 – Flux density over the contour line which passes directly on top of the PCB.

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Numeric Simulation of the Solution

The solution to the interference problem involves ferrite plates. Figure 4 shows the ferrite plate placed on top of the “Sensor B”. The simulation results for this case (Figure 5) shows that the flux lines change direction as they pass through the ferrite plate thus disturbing the magnetic field. As a result, the magnetic field that passes through the package and “Sensor B” is changed and is weaker. Figure 6 shows this transition more clearly by zooming onto the “Ferrite Plate”.

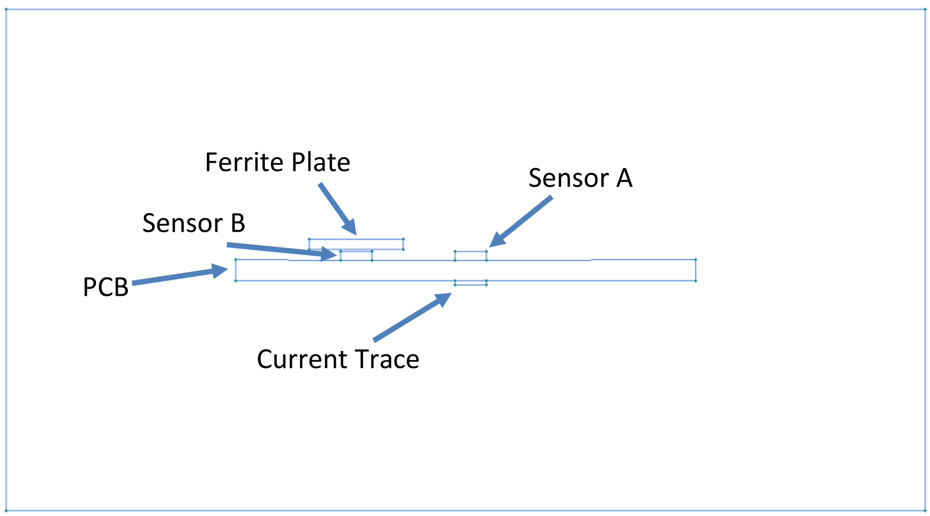

Figure 4 – Cross sectional view of the simulation for the solution.

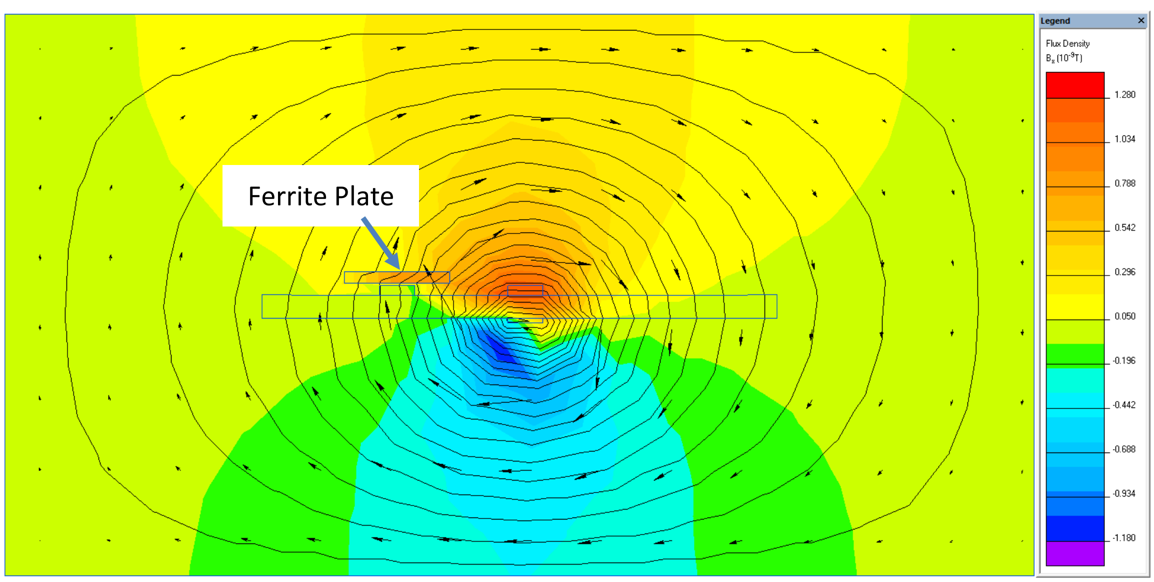

Figure 5 - Result for the simulation of the solution.

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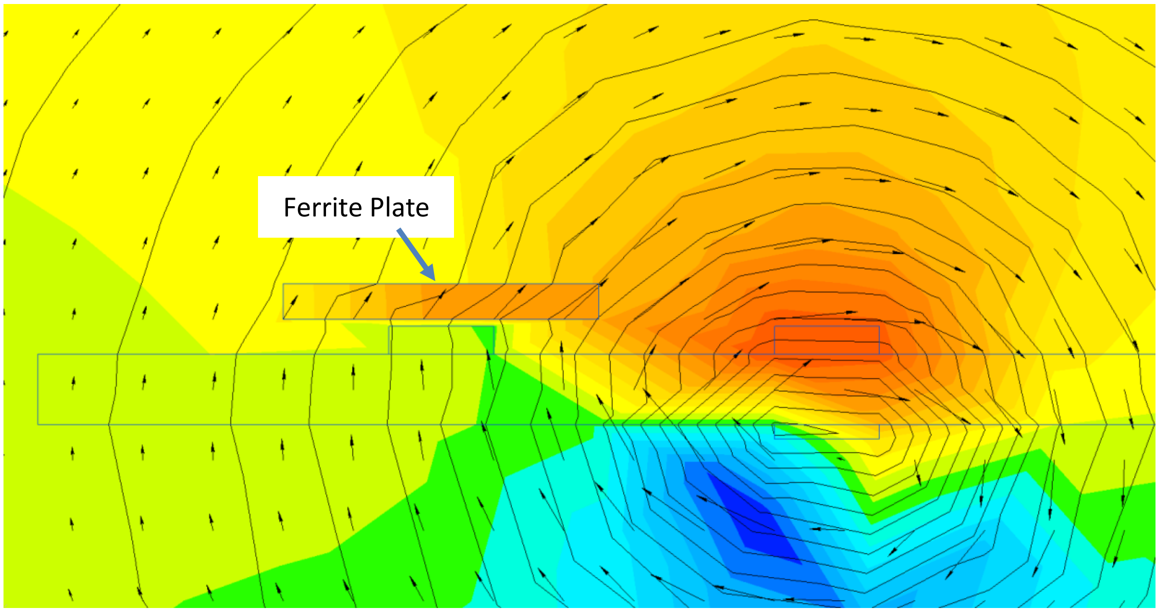

Figure 6 - Result for the simulation of the solution.
Cropped section to better show the flux lines which are passing through the "Ferrite Plate".

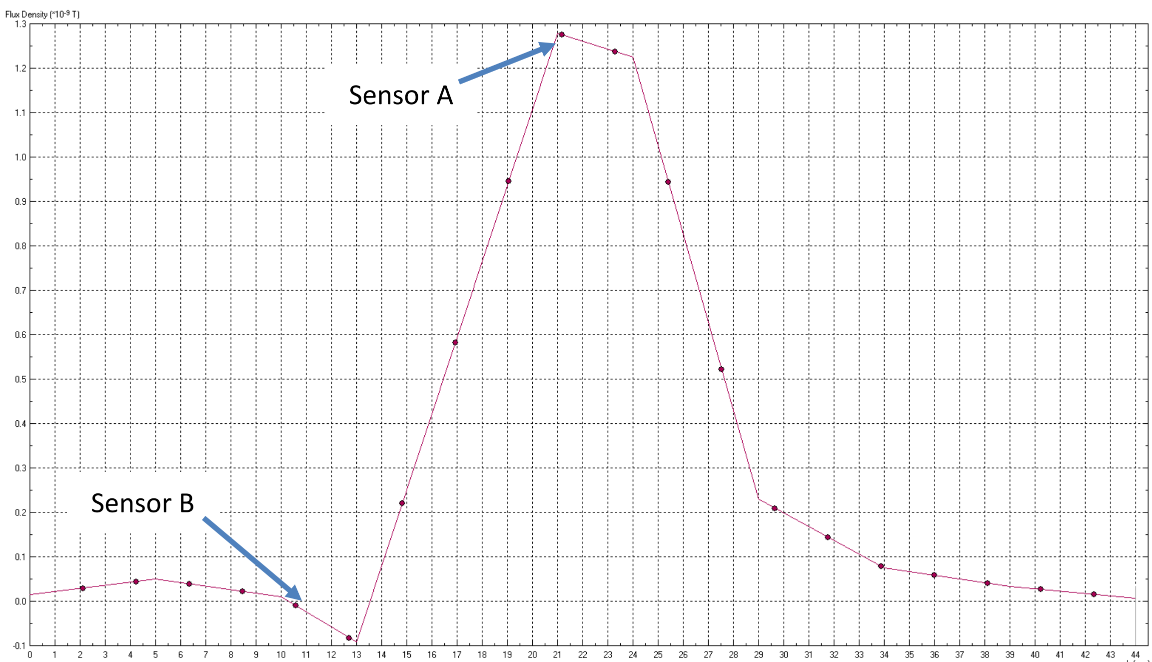

Figure 7 - Flux density over the contour line which passes directly on top of the PCB.

Drawing the magnetic field density graph across x direction while using the "Ferrite Plate", we can see the results in Figure 7. The drop in the magnetic field in the x direction at position of "Sensor B" is easily noticeable. We can see that the magnitude of the magnetic field in the x direction at position of "Sensor B" is significantly reduced to near $5x10^{-13}$ T.

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Practical Implementation of the Solution

Let us consider a 3-phase current measurement circuit according to Figure 8 below:

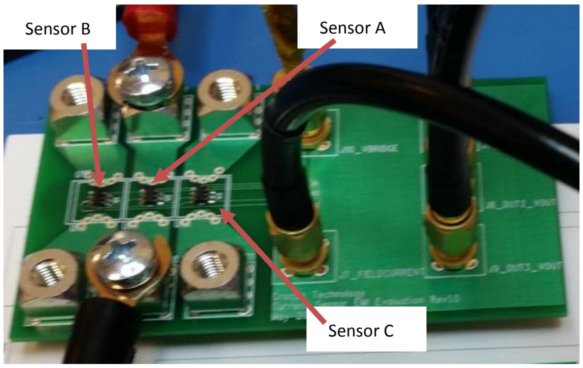

Figure 8 – 3-phase current sensing circuit.

In this setup, as we provide current through the current-trace under the "Sensor A", it is possible to detect the induced magnetic field of the same current (with lower magnitude) via "Sensor B".

The output of each sensor without shielding is shown in Figure 9 using an oscilloscope.

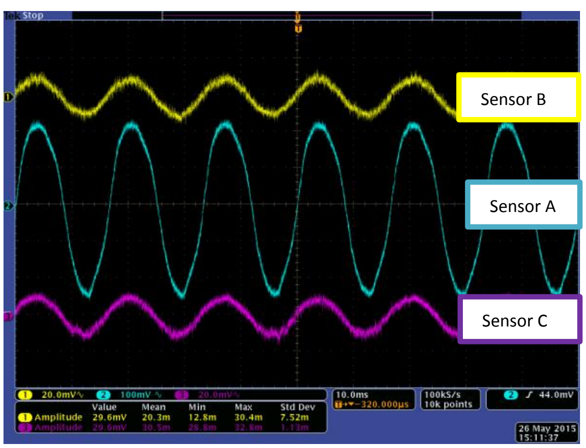

Figure 9 – Output of the oscilloscope. Interference of the magnetic field of the "Current Trace A" is visible on the sensors B and C.

We can see that the magnetic field induced by the "Current Trace A" is being detected via the two other sensors, B and C.

Now by covering the "Sensor B" with a ferrite plate (shielding it), according to Figure 10, the resulting output of the "Sensor B" is shown in Figure 11. The magnetic field at sensor B is reduced by about 5 folds.

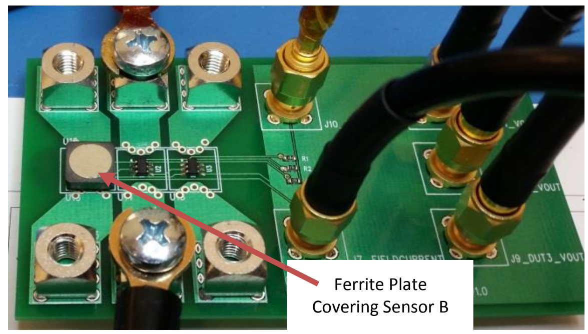

Figure 10 – Covering a sensor with ferrite plate to reduce the magnetic field interference.

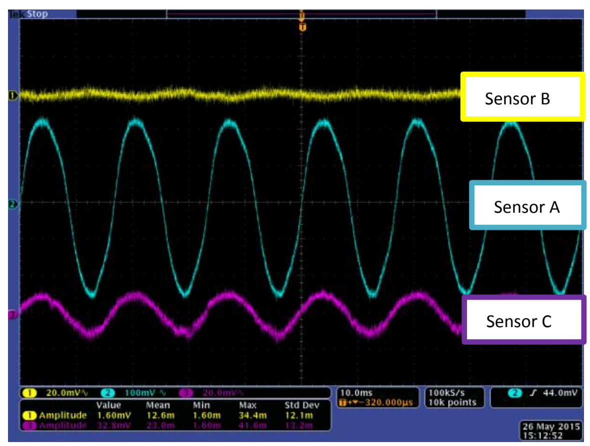

Figure 11 - Output of the oscilloscope after placing the "Ferrite Plate" on "Sensor B". Interference of the magnetic field of the "Current Trace A" is reduced on the "Sensor B".

Covering all the sensors with ferrite plates, according to Figure 12, will result in the output similar to Figure 13. It is noticeable that the interference of the magnetic field from the "Sensor A" is significantly reduced on sensors B and C.

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Figure 12 – Shielding all 3 sensors with the ferrite plates.

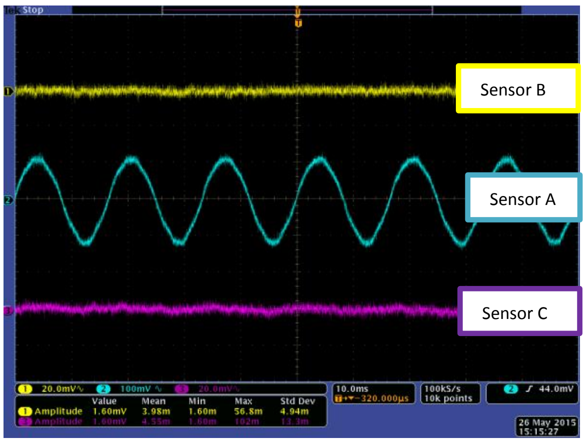

Figure 13 – Output of the oscilloscope after covering all the sensors (shielding) with ferrite plates.

The ferrite plates used in this application are from the Laird Company, which provide a variety of shapes and sizes for ferrite materials in a convenient kit box set to try and find the best fit for a specific application. The specific part used here is DigiKey Part No. 240-2247-ND

Conclusion

In this application-note, the problem of interference having multiple pairs of current-traces and sensors in a close distance is shown. We have demonstrated effective solution to reduce the interference of magnetic field from the nearby current-traces by covering the sensors with a ferrite material, which was shown through simulation and practical application implementation.

Looking at the results in the simulation, we could reduce the interference of the magnetic field at 10 mm away position from near 5×10^{-11}T to 5×10^{-13}T (100 times).

Conclusively, placing ferrite plates on the sensors is a very simple and yet effective approach to solve the magnetic field interference problem in practical applications.

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