An Architectural Approach to Magnetic Shielding

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INTRODUCTION

In response to complaints about flickering computer displays at the Oregon State Capitol building, the local utility company was contacted for an evaluation of electromagnetic interference levels in the State Treasurer's office. Readings taken at the site by Portland General Electric indicated levels in the range of 30 to 140 milligauss (mG). For comparison purposes, typical CRT video display upset levels range from 10 to 40 mG. Investigation into possible sources of the interference led to an existing, uninsulated 2000-amp busway running below the Treasurer's office.

Two basic options were available to attenuate or remove the interference:

- Replace the existing busway with a new enclosed busway and require the manufacturer to certify a minimum EMI level.
- Design an electromagnetic shield for the existing busway.

Based on the excessive costs and considerable shutdown time required to replace the busway, the capitol staff elected to investigate the possibility of designing an electromagnetic shield for the existing busway.

BACKGROUND

Near-field magnetic shielding has been utilized in military facilities for many years. With the increasing use of 60-Hz power equipment, low frequency magnetic shielding techniques have been researched and developed. The effectiveness of magnetic shielding is highly dependent on the frequency of the field and the type of material used for a shielding medium. The most common low frequency shielding material that is commercially available is steel, which has a depth of penetration rating of approximately 0.0566 cm. (Depth of penetration is defined as a plane in the material where the value of the incoming signal is attenuated to 37% of its value as compared to the strength of the signal at the surface.)

Using field measurements and published information, it is possible to calculate the effectiveness of a fabricated shield constructed from standard materials.

With regard to EMI, the only difference between a new busway and shielding the existing busway with a metal enclosure would be in the spacing of the individual phase buses. The increase in EMI due to the spacing of the individual phase buses could be offset by increasing the thickness of the shielding material. Figure 1 is a schematic diagram of the shielding option. As noted on the diagram, shielding material could be provided to reduce the EMI to approximately 10% of its value at the surface of the shielding.

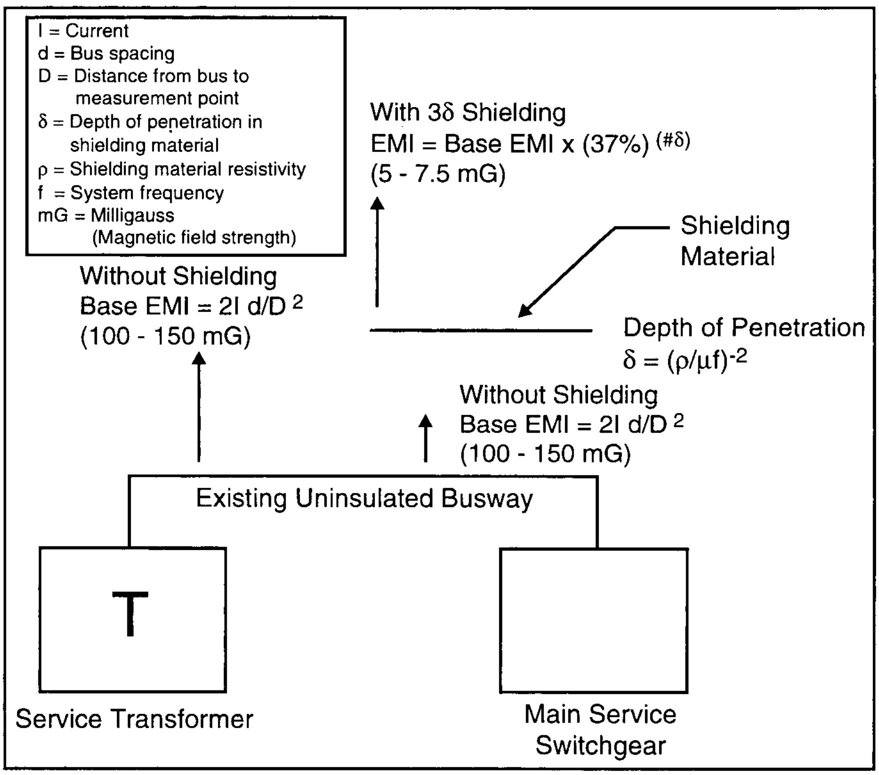

***Figure 1**. EMI Shielding Schematics.*

SHIELDING DESIGN

Based on the equations shown in Figure 1, the expected EMI levels could be calculated; however, variables like the current in the bus and the exact composition of the shielding material cannot be defined with complete accuracy. For example, the current in the bus changes with time and may increase or decrease by a factor of two depending on the electrical activity in the building. The initial shielding design was based on the maximum recorded demand load during the previous year and the relative permeability of commercial iron. Selection of shielding material thickness was based on the following analysis:

Required thickness of commercial iron for 37% attenuation at 100 Hz = 0.0566 cm

Conversion to 60 Hz =

$\sqrt{(100/60\text{ Hz}) \times 0.0566} = 0.0731$ cm

Peak measured (or calculated) flux level approximately = 150 mG

For attenuation of 5 - 10%
Required thickness =
4 x 0.056 cm = 0.2264 cm

Conversion to inches =
0.2264 x 0.3937 = 0.0891" or
3/32" minimum thickness

Based on the variations in current and in the relative permeability of the metal selected, the shield was designed using 3/16" thick sheet metal.

In order to ensure that the final shield design would be within the criteria established, a test portion of the shield was fabricated and installed. Field measurements were taken at two locations on the uninsulated portion of the bus and at the test portion. Results are summarized in Table 1.

The measured attenuation of the flux at the center of the shield was clearly within the range calculated for the project. Since the overall length of the test shield was small in comparison to the overall length of the bus, it was expected that a certain amount of flux would "spill" over the edges. Based on the test measurements, the capitol facilities staff elected to install the complete shield.

The final design included a 3-sided sheet metal enclosure that mounted to the concrete wall around the existing busway. Mounting brackets were fabricated to support the enclosure, provide clearance from the bus bars, and close the seams between each section of the enclosure. In addition, the entire enclosure was positively grounded to insure safety and provide a path to ground for any impressed currents. The ends of the enclosure were left open to provide ventilation for the bus bars. After installation of the completed shield, final measurements were taken and compared to the initial measurements taken in the office space on the floor above the busway. The measurements are given in Table 2.

Clearly, the final measurements indicate that the choice made by the capitol facilities staff to install the busway shield was the correct one.

BUS LOCATION	UNSHIELDED BUS	CENTER OF SHIELD
Measurement Series 1:		
Phase A	10750 mG	1080 mG
Phase B	8360 mG	880 mG
Phase C	8120 mG	944 mG
Floor Level	1600 mG	540 mG
Measurement Series 2:		
Phase A	9040 mG	1360 mG
Phase B	8200 mG	924 mG
Phase C	8600 mG	932 mG
Floor Level	1750 mG	429 mG
Average Value @ Phase	8845 mG	1020 mG

Table 1. *Initial Field Measurements at Test Portion.*

LOCATION	UNSHIELDED BUS	CENTER OF SHIELD
Measurement Series 1:		
Outside Wall	145 mG	19 mG
Desk Location	100 mG	14 mG
Center of Office	120 mG	11 mG

Table 2. *Measurements after Installation of Shield.*

SUMMARY

Based on field measurements and published information, it was possible to calculate the effectiveness of a fabricated shield constructed from standard materials. The selection of a fabricated shield rather than a new busway saved the state a significant amount of money and eliminated several days of downtime throughout the facility. The measured results of the shield design were well within the expected range, given that empirical data on the exact magnetic properties of the materials used were not available at the time that the project was completed.

ACKNOWLEDGMENT

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