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Solving EMI and grounding problems

Steel conduit is an effective shield for 60 Hz electromagnetic fields

By Richard E. Loyd

Problems with electromagnetic interference and power quality are becoming more common. Typically, people look to electrical professionals as experts to solve their power-quality problems. The number of incidents of electromagnetic interference is increasing because of the growing demand for power and the ever-increasing reliance on digital technology through the use of computerization in the home, office, and industry.

Electromagnetic interference (EMI) is a problem when its presence is made visible by such occurrences as flickering or wavy images on computer monitors. (See Fig. 1.)

Although EMI still pervades our electronic world, awareness of problems it can cause has grown. For example, user manuals for PCs from makers such as IBM and Dell now warn consumers to keep their computers and monitors away from unshielded speaker systems, electric power lines, and other sources of magnetic interference.

Problems with computer monitors are productivity and

industrial health/ergonomic issues. In addition, an issue of equal concern is the potential contamination and corruption of electronic and communications data in all environments, including business centers, manufacturing plants, and beyond. Accurate transmission of data, uncorrupted by EMI, is a major information technology issue.

EMI and grounding research

Electrical professionals are currently dealing with these issues. However, few are aware of some research providing new tools in helping to avoid and overcome these EMI problems (Fig. 2).

Studies conducted over three years by Dr. A.P. Sakis Meliopoulos of the School of Electrical and Computer Engineering at Georgia Institute of Technology (Georgia Tech), Atlanta, Ga., are now complete and will assist electrical contractors, engineers and others in solving problems caused by electromagnetic interference. These studies include some of the first research into the specific impact of EMI on

electronic equipment and are the most definitive research on grounding in more than 40 years. This material provides quantitative data for architects, designers, contractors and electricians to use for guidance whereas before trial-and-error methods were the only option.



Fig. 1 The dramatic effect of EMI on high-tech equipment is shown by the distortion of a typical bar chart (top) and jittery and wavy text on a computer monitor.

Software analysis program

The results of this research have been combined with earlier Georgia Tech studies on grounding and are available as a free software program called GEMI (Grounding and ElectroMagnetic Interference) analysis software. Electrical professionals now have quantitative

data and a means of evaluating actual designs by computer. The Georgia Tech research involving the impedance and permeability of steel conduit was used along with actual measurements of electromagnetic fields (EMF) to validate the all-new GEMI analysis software.

Construction issues

Shielding electromagnetic fields at the design and build stages is the most practical and economical approach to controlling the impact of EMI.



Fig. 2 Opening screen of the Grounding and Electromagnetic Interference (GEMI) analysis software program. One West coast consulting company notes that attention to the selection of conduit type, installation practices and circuit configurations at the time of construction are the best options for managing magnetic fields from commercial building electrical circuits.

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Table 5.6. Reduction of Magnetic Field in Percent Metallic Conduit-Encased Circuit, 60 Hz

Sample No.	Description	Measured (25Amps) (max/min)	Computed (25Amps) (max/min)	Measured (50Amps) (max/min)	Computed (50Amps) (max/min)
1	Steel Conduit, EMT, 1/2 inch, 2-#10	82.20/81.60	79.31/79.30	86.40/85.90	76.32/76.30
2	Steel Conduit, EMT, 1/2 inch, 2-#10	84.00/80.60	79.31/79.30	88.60/84.60	76.32/76.30
3	Steel Conduit, EMT, 3/4 inch, 2-#8	84.20/87.80	82.90/82.80	86.60/85.00	81.20/81.16
4	Steel Conduit, IMC, 3/4 inch, 2-#8	88.20/82.50	89.70/89.50	92.80/86.70	88.70/88.40
5	Steel Conduit, IMC, 3/4 inch, 2-#8	84.10/82.50	89.70/89.50	90.10/86.20	88.70/88.40
6	Steel Conduit, IMC, 3/4 inch, 2-#8	84.20/83.70	89.70/89.50	89.60/89.40	88.70/88.40
7	Steel Conduit, GRC, 3/4 inch, 2-#8	87.20/84.60	91.80/91.70	92.00/87.00	90.90/90.70
8	Aluminum Conduit, ARC, 3/4 inch, 2-#8	8.00/0.00	1.40/1.36	4.60/4.00	1.42/1.28

Fig. 3 Some of the type of information available in the GEMI software.

As an equipment grounding conductor, comparably sized GRC, EMT and IMC types of steel conduit allow the flow of higher fault current than copper or aluminum equipment grounding conductors, as detailed in the minimum equipment grounding conductor table in 1999 NEC Table 250-122. In addition, no supplemental grounding conductor is needed with GRC, EMT or IMC runs designed with the model parameters.

The GEMI research shows steel is the most effective shield for 60 Hz electromagnetic fields. Steel conduit was proven to reduce these fields in some cases by more than 90%. Aluminum reduces these fields in some cases by less than 5%, while nonmetallic materials are ineffective as shields against EMI. (See Fig. 3.)

The 1999 NEC Sections 250-2(d) and the note to Table 250-122 clearly require an equipment grounding conductor of sufficient size to be capable of safely carrying the maximum fault current likely to be imposed on it. The path must be permanent and continuous. It must have sufficiently low impedance to facilitate the operation of overcurrent devices under fault conditions.

Example: A typical 200-A 120/208-V feeder installed in electrical metallic tubing (EMT) without an enclosed equipment grounding conductor could be run 390 ft and in the

event of a ground fault the GEMI study shows the overcurrent would operate in a timely fashion. While a similar 200-A circuit not enclosed in steel conduit or tubing but with an equipment grounding conductor run with the circuit conductors, and sized to the 1999 NEC Table 250-122 (1996 NEC Table 250-95), could be safely run only 201 feet. (All calculations based on 400% of the overcurrent device rating and a 40-V arc voltage.)

EMI problems

The sponsorship of the GEMI project occurred due to an EMI problem that Meliopoulos was asked to solve. A row of computer stations was installed in a location and all were experiencing serious interference. After extensive investigation and testing it was determined that EMI from electrical wiring in a rack of aluminum conduit running parallel to the computer stations directly under the floor was causing the distortion on computer monitors. The conduit could not be moved and the office equipment could not be relocated.

Based on these factors, Meliopoulos recommended steel plating be installed above the conduit separating the power conductors from the sensitive equipment. This action solved the company's EMI problem but at a very costly price. Meliopoulos knew from experience that had

the conductors been in steel conduit the problem would not have occurred.

Another example involved an accidental fire in a rack of power cables. Extensive post-mortem analysis in this case concluded the power cables were unevenly loaded because of the interaction of the magnetic field and the current flowing in the cables. It was determined the power conductor initiating the fire was carrying continuously 60% higher current than normal even though the load had not changed and was operating normally. Over time the additional heating in this power cable damaged the insulation and a subsequent fault and fire occurred.

Competitive bidding practices often require engineers and designers to recommend the use of products or construction methods that seem to adequately address the safety issues but perhaps have less than ideal characteristics in support of a healthy electronic equipment operational environment. The GEMI analysis software offers designers a method to support their recommendations to use steel conduit and address grounding system issues and power-quality problems such as the previous examples.

Although steel conduit may not be the least expensive wiring method available, there are three attributes that make it a bargain—its proven effectiveness as a shield against magnetic fields, its superior low impedance path as an equipment grounding conductor, and its life cycle cost benefits.

The GEMI software provides a factual basis to help demonstrate to building owners and developers the higher up-front costs can be justified over the long haul.

Documenting EMI solutions

As a consultant for the Steel Tube Institute of North America, I have received numerous calls from firms specializing in EMI reduction. Representatives from one firm recently wrote they have been recommending the use of steel conduit for many of their shielding solutions, and the GEMI study reinforces their experience.

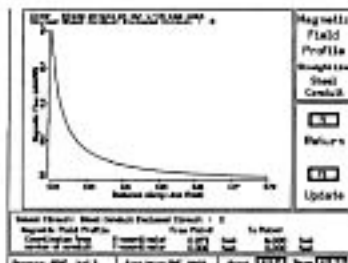


Fig. 4 This GEMI software magnetic field profile shows that steel is the most effective shield against EMI.

A consultant for the Federal Aviation Administration called to say he had recommended the use of steel conduit to overcome problems occurring when control, communications, and airfield lighting cable cross or run parallel to each other. He wanted to know if any research was available to prove what he instinctively believed—that steel conduit was an effective shield against magnetic forces. Now research is available. The GEMI software provides a way to document and prove solutions to EMI problems. It also eliminates a lot of the time-consuming crunch work.

Two modes of operation

The GEMI analysis software operates in two distinctive modes. In mode 1, the software enables the user to quickly calculate and size equipment grounding conductors using steel rigid conduit, intermediate metal conduit (IMC), electrical metallic tubing (EMT), copper conductors or aluminum conductors to comply with the National Electrical Code.

In mode 2, the software enables the user to calculate the magnetic field intensity in milligauss around power circuits and evaluates criteria to allow the user to select the most effective conduit design. The software can be used to analyze new or existing wiring installations from a single branch circuit to the entire electrical system where linear (60 Hz) and non-linear (harmonic) loads are present. A magnetic field profile analysis shows the intensity from the center of the conduit to any distance in the vicinity. (See Figs. 4 and 5.)

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Impact on communications

EMI also can impact the quality of data transmission over communication cables. Typically, these are shielded with aluminum. Aluminum is an effective shield for high frequencies; however, in a communications EMI shield application at 60 HZ, it is ineffective. Power circuits in close proximity, such as in a cable tray, can and do corrupt these signals. Aluminum does shield equipment in the surrounding environment from any interference that may emanate from the communications cables. But aluminum does virtually nothing to protect the communications circuits from disruptive EMI generated by nearby power cables. It addresses only half the problem. The most effective cure for this situation is to run both communications and power circuits in steel conduit even though it may not be required by the NEC.

Electrical professionals can become key problem solvers and solution providers by using information and materials, such as the

software, to make calculations and provide answers to grounding issues and EMI.

EMI costs

There have been no studies to give an accurate total of dollars companies are spending to correct and protect against EMI. However, based on the facts that some organizations have spent hundreds of thousands of dollars to correct a single EMI situation in only one section of a building,

the total costs are believed to be significantly high.

Based on this information, it becomes more evident the best way to deal with electromagnetic interference is to address it at the engineering/design planning stage when practical and cost-effective shielding can be implemented. The GEMI software provides justification for any additional initial construction costs for specifying steel conduit.

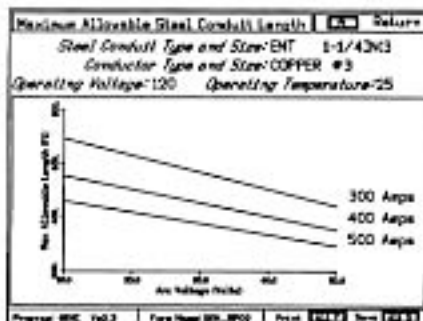


Fig. 5 The GEMI software's analysis of the maximum allowable steel conduit length shows the intensity from the center of the conduit to any distance in the vicinity.

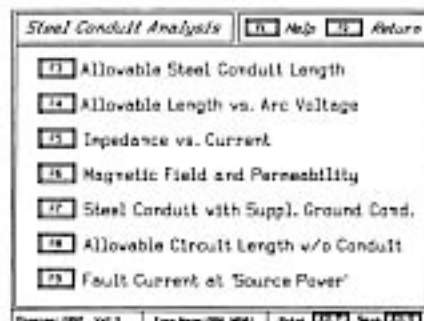


Fig. 6 Another example of the information available on the Georgia Institute of Technology's free GEMI Analysis Software Program.

Free software available

The GEMI analysis program software is available free of charge from the Steel Tube Institute of North America (STINA) to qualified users. To receive the software or a copy of studies used to validate the program software, contact the Steel Tube Institute of North America, 8500 Station Street, Suite 270, Mentor, Ohio, 44060. Phone: (440) 974-6990. Fax: (440) 974-6994. E-mail: sti@apk.net.

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The GEMI analysis program software is available, free of charge, from the Steel Tube Institute, 8500 Station Street, Suite 270, Mentor, Ohio 44060. Phone (440) 970-6990, or fax (440) 974-6994.

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