Future Concerns for Personal Computer EMC Compliance

ROBERT FOSTER
Chomerics, div. of Parker Hannifin Corp., Woburn, MA*

The next generation of desktop personal computers, with high frequency (500 MHz) processors, will not meet radiated emissions requirements if housed in standard chassis.

BACKGROUND

Faster clock speeds and edge rates, as well as increasing circuit board density, pose a great challenge to PC (personal computer) manufacturers in meeting U.S. and international emissions regulations. Clock speeds of 200 MHz are common in today's PCs, and a leading manufacturer has announced it will introduce processors operating at 500 MHz by early 1998. Traditional shielding methods will not be sufficient to assure compliance with radiated emissions on PCs of this speed. New shielding techniques for PC chassis will be needed.

All personal computers must meet U.S. and international radiated electric field emissions requirements. The frequency range covered by international emissions standards is 30 MHz to 1 GHz. The U.S. frequency range is 30 MHz to 5 GHz. The faster the clock speeds, the higher the frequency at which radiated emissions must be contained. PCs with clock speeds from 108 MHz to 500 MHz must be tested to 2 GHz. Those with clock speeds from 500 MHz to 1 GHz must be tested to 5 GHz.

The basic design of the PC chassis has changed little since the mid 1980s. Using very slow microprocessors (by today's standards), PC manufacturers were not concerned about high frequency signals or associated regulations. Two basic chassis styles designed in the 1980s are still used today: the AT (desktop) and the mini tower designs (Figure 1). These chassis are not designed for high frequency shielding (above 1 GHz), which will be essential for PCs in the near future.

This article discusses the high frequency EMI (electromagnetic interference) shielding problems that will be encountered when faster PCs are built using existing chassis styles. Some solutions to these problems will be presented.

SHIELDING EFFECTIVENESS TEST PROCEDURE

Basic AT and mini tower chassis were tested for high frequency (electric field) shielding effectiveness from 30 MHz to 5 GHz. Both chassis were tested without EMI gaskets. No drives (CD-ROM, tapes, etc.) were attached, and the I/O connectors were left in place.

The chassis were tested per a modified MIL-STD-285 test method. The tests were performed inside a shielded room on individual chassis. Each chassis was placed on a wooden table with its cover removed. A custom-made dipole transmitting antenna was placed inside the chassis. A series of receiving antennae were set 1 meter away. A test signal was radiated by the transmitting antenna at discrete frequencies from 30 MHz to 5 GHz. The received power levels were recorded (open reference). The chassis cover was then installed. The test signals were applied to the transmitting antenna at the same power levels as in the open reference measurement. Power levels at the receiving antenna were recorded (closed reference). The difference between the closed reference and the open reference is the shielding effectiveness of the chassis.

The data suggests that both chassis styles offer a moderate degree of shielding (15 dB to 40 dB) in the frequency range of 30 MHz to 1 GHz. However, in the frequency range of 1 GHz to 5 GHz, shielding is minimized (0 to 10 dB), and certainly not sufficient to en-

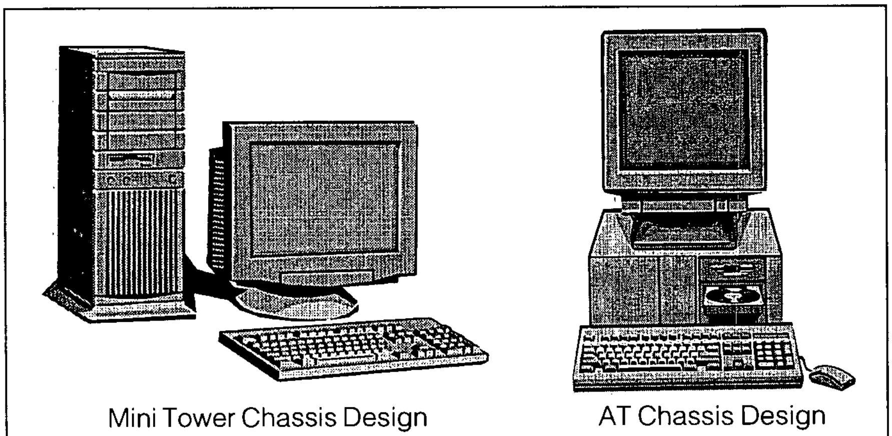

Figure 1. *Mini Tower and AT PC Chassis Designs.*

See advertisement on page 5.

able the PC to meet radiated emissions requirements.

SHIELDING DESIGN APPROACH

A realistic design objective for high frequency shielding must be established. If the design objective is too low, the PC may not meet its radiated emission requirements. If the design objective is too high, unnecessary costs will be incurred. Assuming that a reasonable degree of EMI suppression can be designed into the circuit board, 20 to 30 dB of high frequency shielding is a reasonable design goal for these chassis.

It should be noted that this need for 20 to 30 dB of high frequency shielding was determined by a shielding effectiveness test setup using the actual computer housing. The search for adequate shielding solutions will necessarily involve reviews of shielding effectiveness test data provided with such items as EMI gaskets. This data, taken using different test setups, cannot be directly compared with the test described herein.

A variety of tools are available, from simple to sophisticated, for analyzing the EMC characteristics of a PC. They include EMI modeling software, EMI testing, and simple wavelength comparisons. Many EMI software programs can be used to analyze a simple shield, but are not as effective for complex PC shielding systems. EMI testing to detect the emissions from a PC chassis requires expensive equipment and a fair measure of expertise in operation and analysis. A simple method to identify potential problem areas in any shielded enclosure is to compare the wavelength of the radiating signals to the length of any seams, gaps, openings or penetrations in the shield.

By knowing the frequency and wavelength of the radiating EMI source, it is generally possible to identify high frequency shielding flaws in the chassis. The source signal and its harmonics must generally be shielded. Sufficient RF energy exists at the 10th harmonic of an oscillator to warrant concern. The chassis will provide little or no shielding if the wavelength of the source and its 10th harmonic is shorter than any seam, gap, or hole in the shield. Seams or gaps which are precisely ¼ or ½ the wavelength of the source frequency, or its harmonics, will be especially efficient radiators.

Wavelength can be determined by

$$\lambda = c/f$$

where

λ = wavelength

c = the speed of light

f = frequency

PROBLEM AREAS

Using a 500 MHz processor as an example, problem areas on the AT and mini tower chassis can be readily identified. The frequencies of concern are in the 500 MHz to 5 GHz range. Wavelengths are 60 cm to 6 cm, respectively. For the 10th harmonic (5 GHz), a quarter wavelength is 1.5 cm long, and a half wavelength is 3 cm long. Every hole, gap and non-EMI gasketed seam can be measured on the AT and mini tower chassis and compared to these wavelengths.

AT and mini tower chassis were examined in this manner for high frequency shielding design effectiveness. Five problem areas were found:

- Seams between the top cover and the base chassis
- Open slots for the CD-ROM, tape and disk drives
- Expansion I/O card slots and filler panels
- Openings for air ventilation
- I/O connectors

Some of these shielding problems were obvious, while others were surprises. Obvious EMI leakage areas included the chassis seams and the CD-ROM, tape and disk drive slots. The surprises were the I/O card and filler panel slots, air vent apertures, and the I/O connectors. All of the openings except those around the I/O connectors were longer than 6 cm. Gaps around the I/O connectors ranged from 3 cm to 6 cm.

Low-cost solutions to all five problem areas were achievable through minor mechanical redesign or by adding some shielding components to the chassis, as described below.

SEAM BETWEEN THE BASE CHASSIS AND TOP COVER

The most common shielding problem is the electrical bonding between the base chassis and cover. Most Pentium-based PCs contain some kind of EMI gasketing or integral shield in this area. Typical gaskets used are metal spring fingers. In some designs, part of the metal chassis is formed to make contact with the cover. The gasketing or formed metal is typically used only at a few discrete points around the chassis/cover mating flange.

In order to ensure an effective RF bond between the chassis and cover at frequencies as high as 5 GHz, an EMI gasket should be installed around the entire periphery of the mating flange seam. Many types of soft, low-cost EMI gaskets are now available for this application. The gasket must function under low compression force and be able to withstand the cycling of cover removal and reattachment.

SLOT APERTURES FOR CD-ROM, TAPE, AND DISK DRIVES

The slots for CD-ROM, tape, and disk

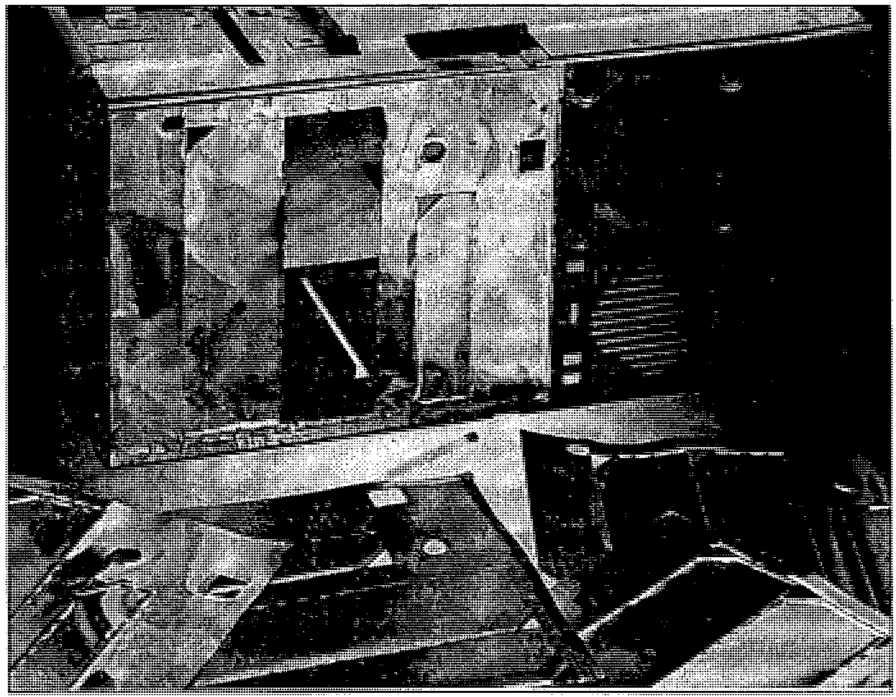

Figure 2. *Foil and film laminate provides shielding of expansion slot areas for add-on disk drives or other devices. Perforated pushouts in the shield allow fast access to expansion slots.*

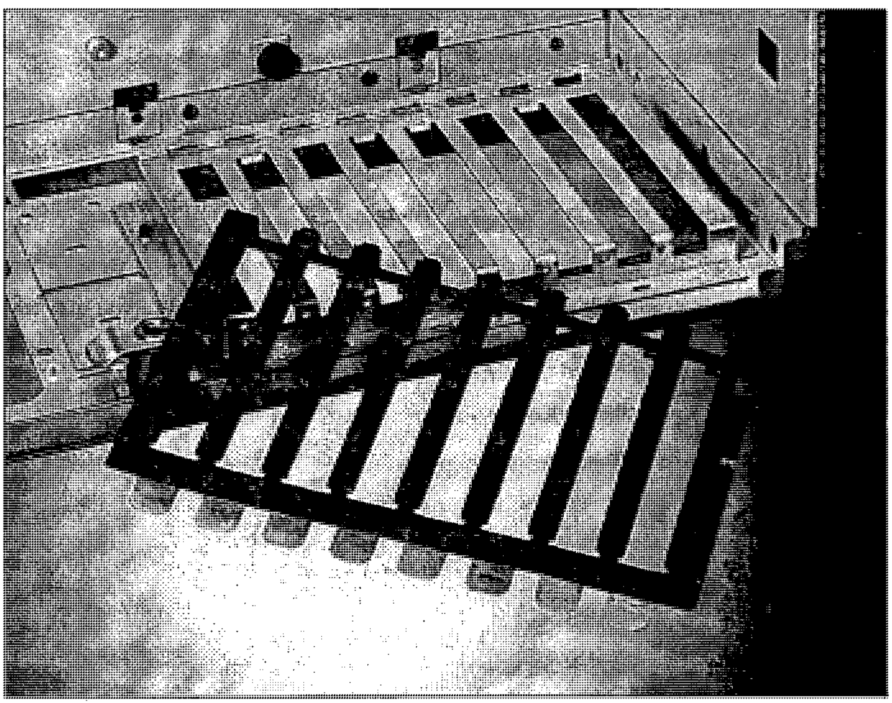

Figure 3. *A stamped and formed metal frame with molded-on conductive elastomer provides snap-in shielding at PC expansion slot areas.*

drives are long when compared to a high frequency wavelength (5 GHz). This is one area where an inexpensive mechanical redesign can be effective. Essentially, the drive opening must not compromise the integrity of the shielded chassis. This can be accomplished by installing a five-sided metal sub-chassis behind the drive opening. The sub-chassis should be electrically bonded to the PC chassis with EMI gasketing. The drive cable and power cable can enter the back of the sub-chassis through a small opening. A bracket can be placed over the opening to reduce leakage opportunities. Foil and film laminates can be used to shield PC slot openings. Attached to the chassis with conductive adhesive, they feature perforated pushouts for quick access to individual slots (Figure 2).

EXPANSION I/O CARD SLOTS AND FILLER PANELS

I/O card slots and filler panels are typically located in the back of a PC, where sound cards, video cards, SCSI cards and similar components are integrated into the chassis. There are typically six or more I/O slots in a desktop PC. The card slots and filler panels are typically bonded to the chassis with a screw at one end and a metal knife-edge at the other. Filler panels are about 10 cm in length, and make only intermittent contact with the chassis. Neither I/O cards nor filler panels provide adequate high frequency shielding.

A reliable and inexpensive mechanical shielding interface can be developed for I/O cards and filler panels. The filler panel needs positive, 360° contact with the chassis. This can be achieved by adding an EMI gasket to the chassis columns between each expansion slot. The gasket must be highly conductive and able to withstand many cycles of I/O card removal and reinstallation in the PC. Best gasket choices typically include bonded-on metal spring fingers or molded conductive elastomers (Figure 3).

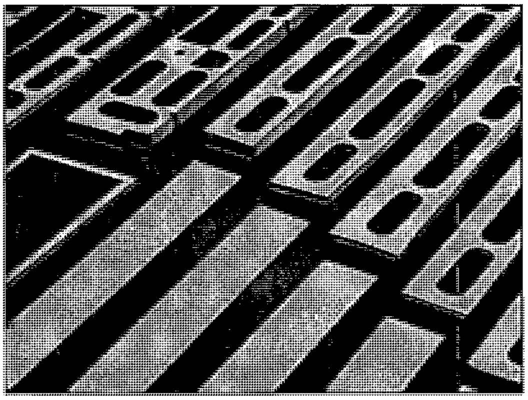

***Figure 4.** Metal foil over foam EMI gaskets can be die-cut to provide flexible, low-closure force shielding of I/O connector sites.*

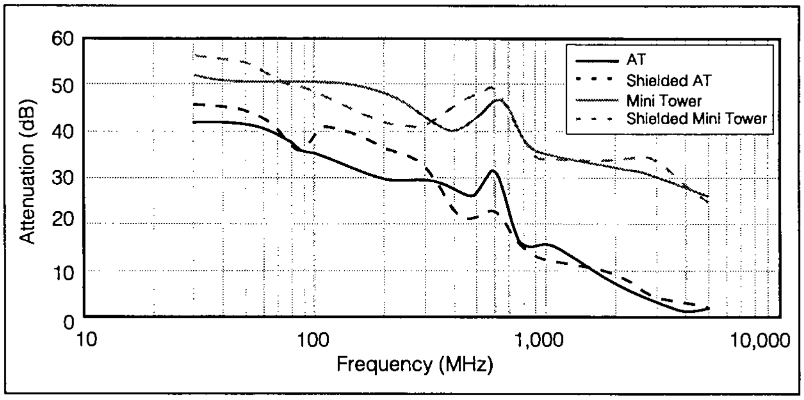

***Figure 5.** Shielding Effectiveness Test Results on Unshielded and Shielded AT and Mini Tower PC Chassis.*

AIR FLOW OPENINGS

Air flow is critical for PC thermal management. Air ventilation openings typically include fan holes and other perforations or louvers in the metal enclosure. Air ventilation openings around the fan in both the AT and mini tower styles feature a pattern of 8-cm long slots punched in the rear of the chassis. The mini tower also includes twelve 10-cm slots in the chassis sides, adjacent to the rear vent slots. These openings are efficient leakage pathways for high frequency signals.

A shielding system must preserve air flow in the PC as well as the chassis' overall shielding integrity. A good approach to providing shielding and sufficient air flow is with shielded EMI vents. Thin, inexpensive shielded vents can be made to fit any PC chassis. They can be designed to fit over fans, or on opposite sides of the chassis for enhanced air flow.

I/O CONNECTORS

The I/O connectors in the back of a PC are typically 9-pin, 15-pin and 25-pin types, with widths ranging from 3 cm to 10 cm. The connectors themselves can act as quarter wavelength and half wavelength antennae. Further, the connector-chassis mating flange area can leak at the quarter and half wavelengths of a high frequency radiated emission.

To prevent an I/O connector from radiating high frequency signals, it must have a low-impedance bond to the chassis. This can be accomplished with an EMI gasket placed between the connector backshell and its mating flange. There are several types of EMI gaskets available for this application, including conductive elastomers, metal foil over foam (Figure 4), and metal-impregnated gaskets. Each type will provide the needed shielding. They should be chosen for the best mechanical fit and available compression force.

APPLICATION OF SHIELDING IMPROVEMENTS

Each of these five problem areas were addressed on an AT and mini tower chassis. Metal spring fingers were installed around the entire cover-base chassis seams. Five-sided aluminum sub-chassis were installed inside the front of the chassis to accommodate the CD-ROM, disk and tape drives. The sub-chassis were bonded to the base chassis with three metal fasteners on each side, or 12 total. Small spring finger gaskets were placed on the columns of the expansion I/O slot assemblies. Thin aluminum EMI vents were placed over the fan openings. The vents were held in place using two fasteners per side, or 8 total. Fabric-reinforced foil over foam EMI gaskets were inserted between the I/O connector backshells and the chassis.

EMI tests made before and after these minor fixes showed improved performance throughout the entire frequency range (Figure 5). Between 20 and 30 dB of shielding effectiveness was achieved at 5 GHz.

CONCLUSION

The next generation of desktop personal computers, with high frequency (500 MHz) processors, will generally not meet radiated emissions requirements if housed in standard AT or mini tower-style chassis. Their covers, I/O slot cards, and I/O connectors must be better bonded, and all openings for air flow and drives must be shielded. These "future" problems with today's AT and mini tower chassis can be overcome with readily available EMI gaskets and shielded vents, along with minor mechanical design changes.

***ROBERT FOSTER** is an EMI engineer at Chomerics, a division of Parker Hannifin Corp. He has over ten years of experience in the analysis, design and development of electrical and electro-mechanical equipment for meeting EMI shielding requirements. Mr. Foster received his electrical engineering degree from Northeastern University. He is currently a certified TEMPEST engineer and a member of the IEEE EMC Society. (617) 935-4850.*