University of Missouri-Rolla
Electromagnetic Compatibility Laboratory

Title: **The EMIcheck User's Guide (Version 1.0)**

Report Number: TR93-2-010

Author: T. Hubing
J. Drewniak
T. Van Doren

Date: January 4, 1993

An Automated EMC Evaluation Tool for the Boeing CAS Design Process

The EMIcheck User's Guide

version 1.0

1/4/93

Dr. Todd Hubing
Dr. James Drewniak
Dr. Tom Van Doren

Department of Electrical Engineering
University of Missouri-Rolla
Rolla, Missouri 65401

email: thubing@ee.umr.edu
Tel. 314-341-6069
FAX: 314-341-4532

This document provides a brief description of the EMIcheck program and instructions for running EMIcheck on the HP/Apollo platform. EMIcheck looks for potential electromagnetic compatibility problems with printed circuit boards designed using the Mentor Graphics Version 7 tools. A more detailed description of this software can be obtained through the Boeing CAS EMC department.

EMIcheck is an easy-to-use computer program that looks for electromagnetic compatibility (EMC) problems with printed circuit boards that have been designed using the Mentor Graphics Boardstation™ board layout and routing tool. EMIcheck reads board layout and routing information from the Mentor Graphics board description files searching for violations of basic EMC design rules. Currently, EMIcheck will recognize the following potentially troublesome design features,

1. A susceptible net that is routed too close to a noisy net, resulting in a potential crosstalk problem.
2. High-speed or high-frequency nets that are long enough to pose potential radiation problems.
3. Components that are not located over the correct power plane.
4. Large areas of copper with a cross-section that becomes too narrow in one place. The EMIcheck code refers to this as a "thin neck". This can occur if a gap in a plane is too long or poorly positioned.
5. Gaps in a ground plane beneath an input/output connector.
6. Traces in an unbalanced signal line that pass over a gap in the signal return plane.

The Boardstation output files read by the EMIcheck code are the *wires_file*, *comp_file*, and the *neutral_file*. Additional EMC-related information is supplied in a file called *lookuptable*. EMIcheck expects to find the Mentor Graphics files and the file *lookuptable* in the current directory.

To start the program, simply type "EMIcheck" or "EMIcheck *outputfile*" at the command prompt. The optional parameter *outputfile* defines the name of the file where the EMIcheck code will write its output. If no parameter is supplied, EMIcheck will write to a file named *output* in the current directory. The ouptut file is created automatically, whether it has a user-specified name or the default. If a file with this name already exists, it will be overwritten.

The code begins by opening the appropriate Mentor Graphics files to get information relating to the board layout and routing. Using this information and data from the lookup table, EMIcheck assigns values to five classification variables for each net. These five variables are described below:

Radiation = (1,2, or 3)	defines the likelihood that the net will carry a high-frequency or high-speed signal (3 - most likely)
Susceptibility = (1,2, or 3)	defines the likelihood that components connected to the net are highly susceptible to interference (3 - most likely)

Power = (5,15, or 28)	defines the absolute value of the supply voltage associated with this net
Balance = (0 or 1)	a '1' means the net carries a balanced signal
Input/Output = (0 or 1)	a '1' means the net connects to wires that run off the board

Net classification occurs automatically. There is no user input required. After successful completion of the net classification stage, the code will display the following prompt:

```
Net names and Net classifications are stored in the file: output

Do you wish to list the nets ? <y/n>
```

Responding with a "y" will result in another prompt asking for the number of nets to be listed to the display. Responding with a number will cause the appropriate number of net names to be listed. After the net names are listed, or if the user does not respond with a "y" to the above prompt, the following line is displayed,

```
Do you wish to reclassify any net? <y/n>
```

Allowing the user to reclassify nets is an important feature of this code. Very often the person using the EMIcheck code will be aware of information affecting the classification of a net that is unavailable from the Boardstation files or the lookuptable. For example, there may be a net that the board designer wants to protect from unwanted noise, even though it was not automatically classified as a highly susceptible net. By responding to the above prompt with a "y", the user is given an opportunity to reclassify nets.

The sample display text below illustrates how the user would go about reclassifying a net named A(2) from moderately susceptible to highly susceptible. The bold type indicates information entered by the user.

```
Do you wish to reclassify any net? <y/n>  y
Enter the Net Name you want to reclassify ("q" to quit):
A(2)
Net Properties for A(2)
Radiation               :1      (1,2,or 3)
Susceptibility          :2      (1,2,or 3)
Power                   :5      (5,15,or 28)
Balance                 :0      (0=NO, 1=YES)
Input/Output            :1      (0=NO, 1=YES)


Enter the number of the property you wish to modify
Number            Property

______          _______________
  0             Radiation
  1             Susceptibility
  2             Power
  3             Balance
```

```
  4             Input/Output
Any other number to EXIT
1
Susceptibility is 2
Enter new value:
3
Net Properties for A(2)
Radiation               :1      (1,2,or 3)
Susceptibility          :3      (1,2,or 3)
Power                   :5      (5,15,or 28)
Balance                 :0      (0=NO, 1=YES)
Input/Output            :1      (0=NO, 1=YES)


Enter the number of the property you wish to modify
Number            Property

______            ________________
  0               Radiation
  1               Susceptibility
  2               Power
  3               Balance
  4               Input/Output
Any other number to EXIT
5
Reclassification complete...
```

Immediately following the net classification process, EMIcheck begins checking the board for EMC design guideline violations. As the board design is compared to each guideline, a line of text is displayed indicating what type of violation the code is searching for. If violations are found, the total number of violations is displayed. On some designs this number may be very high, so instead of listing all violations to the screen, the user is prompted for the number of violations to be displayed. Violations are listed in order from most severe to least severe. All rule violations, whether listed to the screen or not, are ranked and stored in the output file. In addition to listing the rule violations, EMIcheck offers a one or two line recommendation for eliminating the problem.

After the code has applied one guideline and any violations have been listed, it continues with the next guideline. This process continues until all of the design guidelines have been applied.

A sample session listing is provided in the Appendix. If at any point the person using EMIcheck is unsure of how to respond to a prompt, hitting return or space-return will assume the default response and normal operation will continue. Any design problems found by EMIcheck will be listed in the output file along with the name and classification of every net on the board.

A more detailed explanation of the operation and structure of the EMIcheck code can be found in [1]. More information on the guidelines used by the EMIcheck software as well as

other basic EMC design guidelines for Boeing CAS printed circuit boards and systems are provided in [2]. Both of these documents are available from the Boeing CAS EMC department.

References

[1]"An Automated EMC Evaluation Tool for the Boeing CAS Design Process: Boeing Project #1 - Final Report," by T. Hubing, T. VanDoren, and J. Drewniak, January 1, 1993.

[2]"EMC Design Guidelines, prepared for Boeing Commercial Avionics Systems," by T. Hubing and T. VanDoren under Purchase Order LL7004, January 15, 1992.

Appendix

```
INITIALIZING ... Please Wait ..
Intermediate files generated...
Classifying Nets...Please Wait
Classification Done
Condensing duplicate nets ...
Nets Condensed ..


Net names and Net classifications are stored in the file: output

Do you wish to list the nets ? <y/n>  y
How many nets do you wish to view ?  12
[1][+5V]
[2][GND]
[3][+15V]
[4][+28V]
[5][-15V]
[6][A(0)]
[7][A(1)]
[8][A(2)]
[9][A(3)]
[10][A(4)]
[11][28RET]
[12][TP_+5]

Do you wish to reclassify any net? <y/n>  y
Enter the Net Name you want to reclassify ("q" to quit):
A(2)
Net Properties for A(2)
Radiation               :1      (1,2,or 3)
Susceptibility          :2      (1,2,or 3)
Power                   :5      (5,15,or 28)
Balance                 :0      (0=NO, 1=YES)
Input/Output            :1      (0=NO, 1=YES)
```

```
Enter the number of the property you wish to modify
Number            Property

______            ________________
  0               Radiation
  1               Susceptibility
  2               Power
  3               Balance
  4               Input/Output
Any other number to EXIT
1
Susceptibility is 2
Enter new value:
3
Net Properties for A(2)
Radiation                :1      (1,2,or 3)
Susceptibility           :3      (1,2,or 3)
Power                    :5      (5,15,or 28)
Balance                  :0      (0=NO, 1=YES)
Input/Output             :1      (0=NO, 1=YES)


Enter the number of the property you wish to modify
Number            Property

______            ________________
  0               Radiation
  1               Susceptibility
  2               Power
  3               Balance
  4               Input/Output
Any other number to EXIT
5
Reclassification complete...
.....................................................................
Calculating Crosstalk factors between R3 and S3 nets

Number of violations:5

How many do you want to view?  5
Excessive crosstalk between DIN(6) and DIN(54).
Excessive crosstalk between DIN(44) and DIN(54).
Excessive crosstalk between DIN(42) and DIN(54).
Excessive crosstalk between DIN(4) and DIN(54).
Excessive crosstalk between DIN(4) and DIN(21).

These nets should be shortened or moved farther apart from each other.

.....................................................................
Checking for Long R3 ( Highest Radiation) nets

Number of violations: 9
How many do you want to view?  6
Net N$1491(1) is too long.
Net I$1066/N$1205 is too long.
```

Net I$1066/N$1205 is too long.
Net DIN(63) is too long.
Net DIN(6) is too long.
Net DIN(44) is too long.

Reroute these nets or reposition components to allow these nets to be shorter.

.....

Checking for components over incorrect power planes

Number of violations : 1

Component using +28V power is not over +28V plane.

.....

Checking for Thin Necks on the board nets

No thin necks in area fills were found.

.....

Checking for connectors located over gaps in the ground plane

No Overlap.

.....

Checking for unbalanced traces crossing gaps in the ground plane

No unbalanced traces crossing gaps in the ground plane were found.

.....

END OF PROGRAM