

# RFI/EMI Concerns— The Design Advisers

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**E**ffective product design is critical for successful product development. Product development can be regarded as a process which starts with the design of a product and proceeds with its manufacture, test, deployment (use), and scrap. It is generally accepted that poor product design results in significant costs being incurred during the later phases of product development such as manufacturing, test, deployment, and scrap. These phases of product development are often referred to as the product lifecycle. Design For "X" (DFX) is a well-known approach for enabling successful product development (Ref. 1). The DFX approach attempts to incorporate knowledge of the lifecycle of a product into the design of the product. For example, the nature of a particular manufacturing process can have a significant effect on the decisions to be made during the design of a product. Thus, Design For Manufacture focuses on incorporating knowledge about manufacturing into the design process; in this case, the "X" is the manufacturing phase of the product lifecycle.

It is becoming increasingly common for CAD vendors to provide mechanisms through which user-companies can develop their own add-on advice modules to the host CAD system. Indeed, many CAD vendors distribute DFX analysis systems which can be customized to some extent. However, these do not offer user-companies sufficient flexibility to define company-specific design guidelines or full-customized add-on advice generation modules to suit their own unique needs. Thus, what is required is a standard technology for developing such company-specific applications. In this article, a technology for enabling company-specific design advice modules to be developed is presented. This technology is declarative in

nature. Thus, designers simply need to state a requirement that they would like to be true for a design. From this requirement, advice is generated and presented to the designer whenever there is a violation in the design being considered. The technology discussed here represents a novel systematic approach to the development of company-specific design advice modules.

Before the details of the technology are presented, a brief discussion on the utility of design guidelines is required. As part of this discussion various classes of design guideline will be identified.

## THE UTILITY OF DESIGN GUIDELINES

Design guidelines are statements that define the characteristics of "good" designs. What constitutes a good design depends on the metric used to evaluate it. Generally, a design is regarded as good, from the perspective of a life-cycle process, if it fits well with that process. For example, a design is "good" from a manufacturing point of view if it can be easily manufactured using standard tooling, resources, techniques, etc. Alternatively, a design can be regarded as "good" if some relationships between its characteristics are true. For example, that the number of buried vias on a PCB based on a given technology does not exceed a given number. Design guidelines are statements which make explicit those relationships between the characteristics of a design or its lifecycle which the designer would like to ensure are true. The advantages of considering design guidelines during the design process are many. Typically, companies experience a reduction in design time, a reduction in the amount of re-design work, and an increase in product quality as a result of considering design guidelines during the design process.

Two classes of design guidelines can be

identified: generic design guidelines and company-specific design guidelines. Each of these will be discussed in turn below.

## GENERIC DESIGN GUIDELINES

Generic design guidelines attempt to address the most common problems encountered during design in a company-independent way. These guidelines may relate to standard electro-magnetic compatibility (EMC) considerations or standard component placement and routing issues. Some CAD vendors sell advice systems based on these generic guidelines. However, these suffer from many disadvantages. In particular, too many simplifying assumptions are made about their implementation and the representation of objects in the CAD system; they are generally inflexible from the point of view of altering the assumptions upon which they are based; and finally, they are not specific enough for use since they do not take a company's manufacturing infrastructure or business environment into consideration.

## COMPANY-SPECIFIC DESIGN GUIDELINES

Company-specific design guidelines are far more beneficial from a design advice perspective. A company-specific guideline addresses issues which are specific to a particular company and, thus, offer the most relevant source of data upon which to generate design advice which is meaningful to the designer. Consequently, there are significant benefits to be had from a company's point of view since the design advice they are getting can help a designer tailor a design to the lifecycle that exists within the organization.

## DEVELOPING DFX DESIGN ADVISERS

In this section the development of a design advice module for use with a well-known

CAD system will be presented. The development of the module will be done using a technology based upon a constraint programming language called Suntas. This is a declarative language that can be used to encode design guidelines that must be followed during the product development process. The language provides designers with two constructs. These constructs are called frames and constraints. Frames can be used to represent the product being developed, the components and materials from which it is constructed, and the life-cycle environment in which it will be manufactured, sold, and deployed. Constraints can be used to represent the mutual restrictions that these entities, represented as frames, exert on each other.

The design advice module presented in this article was developed using a compilation environment for the Suntas language. Essentially, this compilation environment translates a Suntas specification of a set of design guidelines and a specification of a CAD database representation into a form which is appropriate for a particular CAD system.

In order to develop a CAD-compatible design advice module using the technology presented here a number of files must be created. The details of these files are given below.

## ENCODED GUIDELINES

This file contains a representation of the design guidelines that a user-company wishes to use during the design process. Guidelines can be organized into rulebooks. For example, a rulebook containing EMC guidelines can be developed along with rulebooks containing manufacturing, fast-circuit design and tracking guidelines. The contents of this file are completely customisable.

## SUNTAS-CAD INTERFACE DESCRIPTION

The interface between Suntas and the CAD system is defined using a pair of files. The first file defines the various object types that are mentioned in the required design guidelines. A user-company may wish to define objects representing components, nets, layers or the PCB itself. Also contained in this first file are definitions for any design parameters which should be customizable at runtime. The second file contains a specification of how the representations of the objects are mapped onto objects in the CAD system.

## LIBRARIES

Any user-company can define libraries of useful utilities which are written in Suntas. In general these utilities will be various functions and predicates that are used frequently in a company's guidelines. A typical library which is of considerable use would contain functions and relations which can handle complex geometric computations on arbitrary objects in the CAD system.

## DEVELOPING A DESIGN ADVICE MODULE

Once the above files have been created, the user can generate a CAD-compatible design advice module by compiling the above files with the Suntas CAD compiler and linking the results with the appropriate CAD system.

## AN ILLUSTRATIVE EXAMPLE

An example design adviser application which has been developed using the technology presented in this article will be discussed in this section. The implementation of a number of typical EMC and design guidelines will be presented. An example interaction with the system will also be presented in order to demonstrate the utility of using design advice modules for CAD.

## NATURAL LANGUAGE GUIDELINES

Three design guidelines are presented in this section. The first two of these guidelines are examples of EMC guidelines which have been implemented using the technology presented in this article. The third guideline is related to a Design For Manufacturing issue for PCBs. All of these guidelines are currently being used in industry. The guidelines are as follow:

- Guideline 1: The length of every signal-carrying net on a PCB cannot be greater than 25% of the wavelength of the signal on the net;
- Guideline 2: For every power-net on a board there must be a ground net within a given dimension;
- Guideline 3: The width of every track on the board cannot be less than a given dimension.

In general, a designer in industry would be faced with the textual representation of a design guideline and would be expected to ensure that her design complied with it. While there are many EDA technologies available to perform particular types of design analysis, the approach that is being advocated here is a single easy-to-use technol-

ogy for specifying and managing a wide variety of both generic and company-specific design guidelines.

## GUIDELINE IMPLEMENTATION IN SUNTAS

In Figure 1, the implementation of the natural language design guidelines given in the previous section is presented. The implementation of these guidelines is beyond the scope of this paper, but has already been presented in the literature (Ref. 2). However, it should be noted from Figure 1 that the implementation of the design guidelines is very concise and high-level. The various concepts that a designer required in order to implement a guideline can be defined in a completely company-specific manner. In this article, the focus is on demonstrating

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module main.
import cad_interface.
import geometry.

rulebook 'EMC':

all net(N): carries_signal(N) implies
lengthOf(N)=< wavelengthOf(N.frequency)/4.0*inch
with name='Maximal Net Length',
suggestion='Maximal_Net_Length_Advice'.

all net(N1): power_net(N1)implies
exists net(N2):
ground_net(N2) and
separationOf(N1,N2)=<reqdNetSeparation" inch
with name='Power Net Separation':
suggestion='Power_Net_Separation_Advice'.

rulebook 'Manufacturing':

all net(N): all R in N.routes:
R.width>=reqdMinTrackWidth *mm
with name='Min Track Width':
suggestion = 'Min_Track_Width_Advice'.

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Figure 1. The natural language guidelines implemented in Suntas.

how a design advice add-on module can be integrated into a CAD system to provide useful feedback to the human designer. A full treatment of the CAD data extraction issues is beyond the scope of this article.

## USING THE DESIGN ADVICE MODULE

Earlier, the process of integrating a set of guidelines into a CAD system was discussed briefly. This section describes how the human designer can use the guidelines that have been implemented in the previous section to critique a design developed using the Zuken CAD system, Visula.

Zuken provides a Design Adviser Frame-

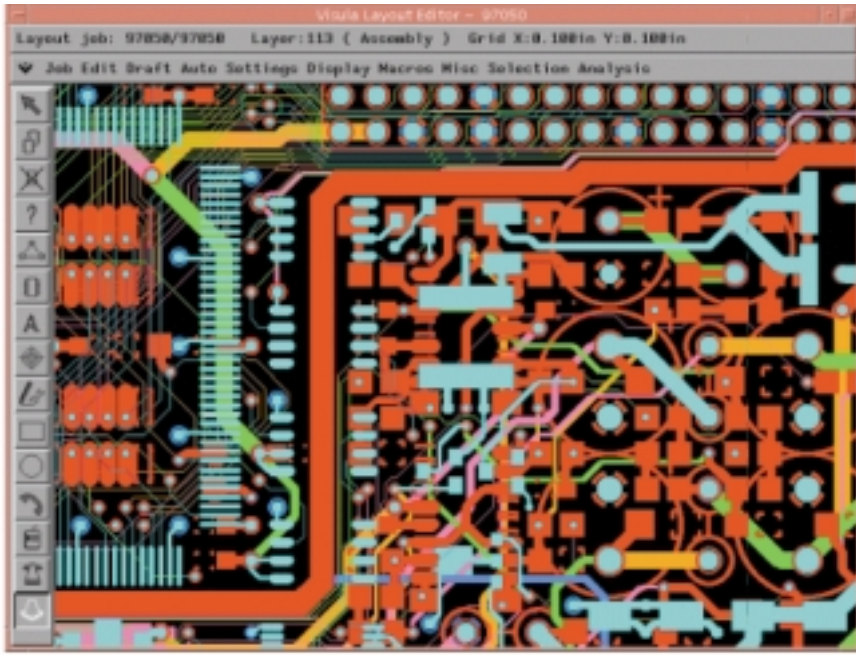


Figure 2. The Visula Layout Tool interface showing a typical view of a design that a layout designer would interact with.

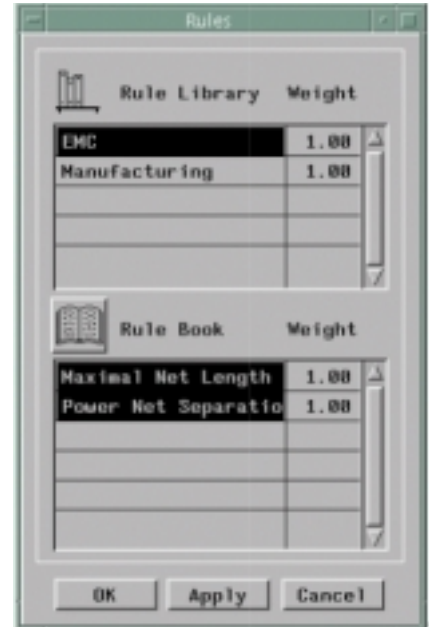


Figure 4. A view of the rulebooks which have been implemented using the technology presented in this article.

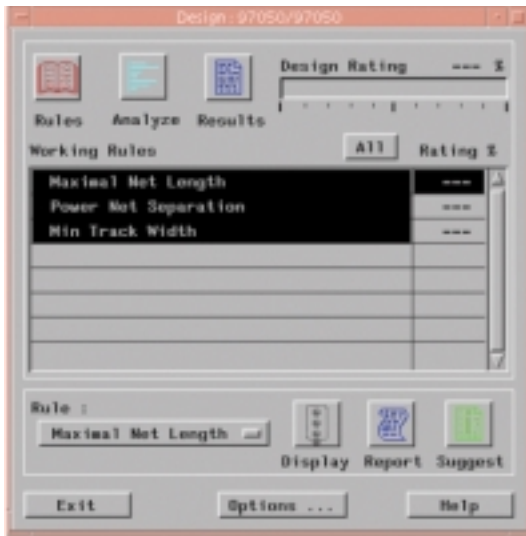


Figure 3. The Visula Design Adviser interface showing the guidelines which have been implemented using the technology presented in this article.

work product which can be used in conjunction with the layout editor interface (Figure 2) to assist the designer in critiquing a design. Figure 3 presents the interface of the Design Adviser Framework when it contains the three design guidelines that were implemented earlier.

A designer can view the available set of rulebooks through the interface presented in Figure 4. The designer can select which rulebooks to apply by interacting with this interface. All of these tasks can be carried out through the interface, shown in Figure 4, which is accessible through the Design Adviser interface by selecting the Rules button shown in Figure 3.

Some guidelines may have parameters which can be specified or modified at runtime. Using the interface presented in Figure 5 a designer can specify a particular value for a particular design parameter. Alternatively, the designer may wish to revert to the default value for a particular design parameter. All of these

tasks can be carried out through the interface shown in Figure 5 which is accessible through the Design Adviser interface by selecting Options button shown in Figure 3.

Once the human designer has set the values of any appropriate design parameters and made a selection from the current col-

lection of design guidelines, an analysis of the design can be performed. This is done by clicking the Analyze button on the Design Adviser interface shown in Figure 3. When the analysis is complete, a rating for each individual guideline and the design as a whole will be presented on the Design Adviser interface. Figure 6 shows an example scenario: it can be seen that the guideline Maximal Net Length was completely satisfied, the guideline called Power Net Separation was satisfied in 92.5% of cases on the board and that the guideline called Min Track Width was completely violated.

The designer can now get feedback on where the problems occur in her design by selecting the appropriate guideline and clicking on either the Display button, Report button or Suggest button on the Design Adviser interface in Figure 6.

If the designer selects the Display button a dialog box appears which contains the name of each object that violated the design guideline. In Figure 7 an example of one such dialog box is presented for the Min Track Width guideline. A designer can use this dialog box to highlight all instances of guideline violation in the layout window (Figure 2) for convenient cross-referencing.

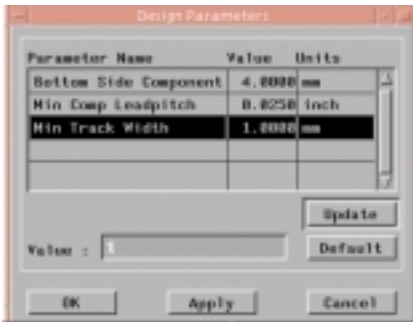


Figure 5. A dialog box showing the various design parameters that a designer can modify at runtime.



Figure 6. The Visula Design Adviser interface showing the results of an analysis of a PCB design using the guidelines implemented earlier.



Figure 7. A dialog box showing the various entities in the design that violated the "Min Track Width" guideline.

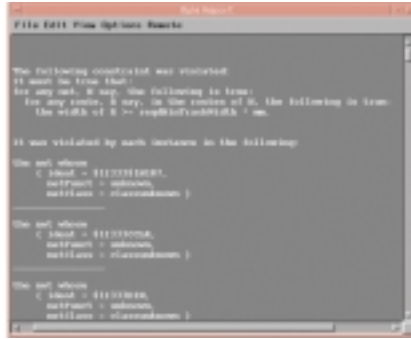


Figure 8. An example violation report for the "Min Track Width" guideline which was automatically generated. (Note the natural language paraphrasing of the Suntas-encoded design guideline).

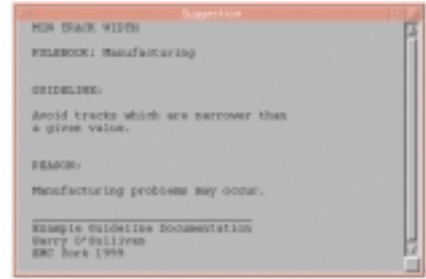


Figure 9. Documentation for a design guideline which is available to a designer.

If the designer selects the Report button in Figure 6, a violation report is displayed which contains a natural language paraphrase of the guideline that was implemented along with a list of the instances of where the guideline was violated in the design. This natural language paraphrase is generated automatically by the system, a feature which can be used to ensure that the guideline which has been implemented in the Design Adviser corresponds with the guideline the designer intended to check. In Figure 8, an example of one such violation report is presented for the Min Track Width guideline. By selecting the name of an object in this violation report a designer can have the object highlighted in the layout window (Figure 2) for convenient cross-referencing.

Finally, if the designer selects the Suggest button a window appears which contains some additional documentation relating to a particular design guideline. An example is illustrated in Figure 9. This documentation can be configured to contain any documentation that is of relevance to a particular design guideline.

#### DESIGN ADVISER MODULES DEVELOPED

At present, quite a large number of design advice modules have been developed for industry. These address not only EMC issues but also other more general design concerns. The guidelines, upon which these advice modules are based, have been grouped into a number of rulebooks. The rulebooks that have been developed to date address such issues as Reliability EMC, ESD, Design For Manufacture, Design For Test, Design For

Assembly, Component Technology, Component Placement, Connectivity, Board Technology, Optical Alignment, and Tracking. A number of user-companies are currently extending these rulebooks in addition to developing new ones.

#### SOME CONCLUDING REMARKS

In this article, the development of design advice add-on modules for electronics CAD was discussed. It was illustrated how a declarative approach to specifying design rule provides a standard approach to the development of fully customised add-on modules. A demonstration of how a design adviser add-on module was given using Zuken's Visula Design Adviser Framework. ■

#### REFERENCES

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