THE ROLE OF MHDL IN MICROWAVE SYSTEM AND SUBSYSTEM DESIGN

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ABSTRACT

An introduction to MHDL is presented, from the perspective of a microwave system, subsystems and components engineer. Specifically, various pieces of the microwave applications design process are identified where MHDL can make a significant contribution. The constructs available in the language are also described and modeling examples are used to illustrate the descriptive power and ease of use of this language. Finally, the role of MHDL in both the U.S. DoD's MAFET program and in the electronic marketplace are examined.

1.0 MHDL Mission

The mission of MHDL is to provide an open design data repository and thereby provide the means for the clear and unambiguous electronic exchange of design data for microwave and analog hardware, specifically in the following scenarios (see Figure 1):

- between various tools (either tools of a similar functionality from different vendors or between dissimilar tools e.g. synthesis and analysis);
- between members of a design team in the same physical location;
- between different design teams and companies working on the same microwave system project but in different physical locations;
- to archive design data for reuse years later when retrofit purchases are made and when new and improved microwave hardware technology is available;
- capture and make accessible simulation data, measured data and specified data;
- support of hierarchical information (e.g. a radar which consists of a receiver which consists of a mixer); and
- simultaneously capture multiple models of varying levels of approximation for the same piece of hardware, e.g. ideal mixer description with simulated mixer description.

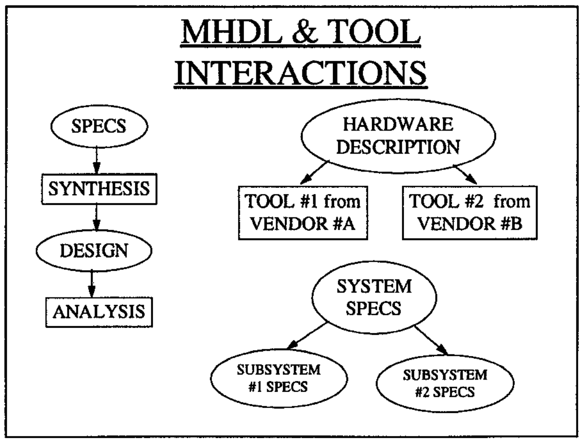

FIGURE 1: The above figure shows 3 common situations: (1) the data flows between synthesis and analysis tools; (2) a common hardware description which may be analyzed by two tools with similar functionality but from different vendors; and (3) the partitioning of system specifications to various subsystem specifications. Each arrow represents an opportunity for the utilization of MHDL.

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2.0 Descriptive Capabilities of the MHDL Language

The descriptive capabilities of the MHDL language are provided by use of the following building blocks, which are discussed in detail below: packages, models, components, structures, attributes, signals, connectors and tables. **Packages** provide the means to collect and to share commonly-used information such as constants, mathematical functions and frequently-used definitions, e.g. special dimensions and units for phase-noise. These packages are then "used" by inclusion in other descriptions. By definition, the language contains a special package, known as **Package Standard**, which is automatically included in all MHDL descriptions. Package Standard defines most mathematical constants and functions which would be assumed by a user to be in the language, examples are PI and trigonometric functions. Models form the basic building blocks of microwave hardware and capture information on logically separate pieces of hardware from resistors to radar systems. **Models** make use of existing models by instantiation of models as components. Models typically capture the performance of black boxes by describing the behavior or relationship between the signals at the external ports of the black box.

Structures are the descriptive mechanism in MHDL which captures different abstractions of a model (i.e. a signal flow abstraction versus the voltage/current abstraction of an op-amp) as well as the different views of a piece of hardware (such as electrical, thermal, mechanical, etc.) A single model may have multiple structures, one for each view and abstraction. **Attributes** enable the sharing of information from one component to another. Attributes can have default values which are defined in their initial definition and which can then be overridden by other values in their instantiation. **Signals** also permit the sharing of information from one component to another. Signals are typically time-dependent or frequency-dependent (but can be dependent on any variable) and are usually shared from component to component via connections. **Connectors** (two or more of which can form a connection) form the external ports to models: connections result when black boxes are connected together. **Tables** (consisting of rows and columns) are familiar to most engineers, particularly in data sheets. The table descriptive mechanism enables data to be organized in this manner.

3.0 MHDL Examples

The following example, namely that of a resistor, provides an example of the utilization of the MHDL structures, models and components. The model, resistor, has an ideal structure, with a default value of 50 ohms, and which is overridden in its usage to become 75 ohms:

```
model resistor
structure ideal
 attribute r : Resistance;
 default  r = 100 'ohms';
end ideal;
end resistor;
--
-- Usage of model resistor
--
model main
structure electrical
 components
   R1 :: resistor.ideal  definitions
        r = 75 'ohms';  end definitions;
  end components;
end electrical;
end main;
```

The following example illustrates the usage of connectors in a signal flow type of description:

```
model FM_mod
structure signal_flow
          includes my_signal_package;
          connectors in, out;
-- Define the model parameters
 attribute cf;                  -- Center frequency
 attribute slope : Freq_per_volt;  -- Hz/V
 attribute ampl : Potential;   -- Volts
 in.ctype = sigflow;  in.dir = in;
 out.ctype = sigflow; out.dir = out;
 out.my_sig(t) = ampl * sin((cf+slope*in.my_sig(t))*t);
end signal_flow;
end FM_mod;
```

The following example illustrates the usage of tables in a device description:

```
table Device
title "Measured on 1/24/95"
names attrib  | value ;
{{  VDC  |  5 'volts'  ;
   ZOUT | 500 'ohms'  ;
   IDSS  |  100 'mA'  ;  }}
end Device;
```

```
for each row in table Device generate
   attrib = value;
end generate;
```

The following example illustrates a behavioral description of an ideal antenna in MHDL:

```
model antenna
structure ideal
attribute gain : Dimensionless;
attribute diam : Length;
attribute wavelength : Length;
gain = 4.0 * pi * (diam / wavelength)^^2;
end ideal;
end antenna;
```

The following example illustrates a behavioral description of an ideal transmission line in MHDL:

```
model TRL
includes my_definitions;
attribute nports : Int;
attribute freq : Frequency;
attribute l : Length;
attribute z0 : Impedance;
attribute clight : Speed;
default z0 = 50.0 'ohms';
default nports = 2;
default clight = 3*10^8 'm/s';
phase = -2*pi*freq/clight*l;
end TRL;
```

4.0 Scenarios of Usage of MHDL and Their Impact to Design Teams

MHDL will improve the efficiency and quality of various tasks and processes in which microwave subsystem and system engineers are involved. Specifically, MHDL has a role in the following:

a) The partitioning of system specifications by a system designer into subsystem specifications is a significant effort on the part of the systems engineer and is usually accompanied by several iterative cycles as various partitioning options are exercised. Each partitioning of the specifications provides the following opportunities where MHDL will provide significant impact, namely:

- Shorten the time for communication of the subsystem specifications - MHDL will replace the current system of verbal and written communications with electronic communication of the specifications, with the opportunity for design tools to be able to immediately interpret the specifications. An electronic description will also be an enabler to the development of microwave synthesis tools which will further shorten the time for synthesis.

- Verbal and written communications lead to errors both due to misunderstanding as well as incomplete specification descriptions. MHDL will alleviate these problems by providing a complete and unambiguous electronic descriptive capability.

- Fine tuning of subsystem specifications requires that a tracking mechanism be available which can describe the constraint which led to a particular partitioning of the baseline specifications. Fine tuning changes should not violate the original constraints on the partitioning of those specifications. Again, MHDL provides a mechanism for the recording of these partitioning constraints against which all subsequent fine tuning changes can be checked.

- The number of iterations of system architecture designs is dependent on the speed by which each iteration may be evaluated throughout the design hierarchy. MHDL provides for the electronic exchange of information and therefore will facilitate <u>additional</u> cycles of design activity and thereby provide a superior design. It should be noted that most major errors in system design are made at the architecture definition stage.

- The retrofitting of modules with form, fit and functional replacements some many years later requires a review of the specifications and performance which were in place during the original design activity. MHDL provides the means for an electronic archival storage mechanism of previous designs and their associated specifications. Such an archival activity also provides useful starting points for new designs which may be quickly and conveniently electronically searched at the time of a new design activity.

b) System and subsystem engineers rely heavily on product catalogs for the selection of available parts and components. In the age of the electronic marketplace, all such information should be available on the Internet for rapid access by the design engineer and for providing the most up-to-date information by the manufacturer. The standard for the display of documentary information on the Internet is Mosaic. MHDL can provide the database for this Mosaic page as well as be able to provide information which can be electronically operated upon by various synthesis and analysis tools.

5.0 Role of MHDL in the MAFET Program

Thrust 1 of the U.S. DoD MAFET Program is focused on the development of a comprehensive, versatile environment for the low cost, rapid design of the RF portions of systems that incorporate MMICs and related components. As part of this design environment, an information infrastructure will be developed such that designs can be readily exchanged via appropriate standards. MHDL, with its broad descriptive capability, will provide the basis for capturing design descriptions across the hierarchy of component, subsystem and systems designs which regularly interact with one another. With the insertion of MHDL into the design engineering community via the MAFET program, it is anticipated that the language will enable the development of a variety of behavioral synthesis tools. Finally, since MHDL is applicable to analog hardware and has a connection to the digital hardware description language, VHDL, the description of multi-functional hardware will be accomplished by the synergistic combination of MHDL and VHDL.

6.0 Conclusions

It is clear that MHDL provides new opportunities in the future of microwave system and subsystem design. In order that MHDL takes its desired role in the MTT community, it is likely that educational courses will be provided for microwave engineers. Although graphical user interfaces will avoid the need for most design engineers to directly write MHDL, nevertheless there is a requirement that a substantial portion of the microwave engineering community be rapidly educated on this important language and its benefits.

At the time frame of the 1995 MTT Symposium (May 1995), the ARPA/Tri-Service MHDL program will have available the following documentation: an MHDL Language Reference Manual, a draft MHDL User's Guide, and an MHDL Mathematical and Microwave Library. Further documents will continue to be forthcoming from the very active IEEE SCC-30 standards working group.

Finally, the usage of MHDL will play a significant role in the competitive posture of microwave companies in the electronic marketplace of the future and in all commercial transactions involving microwave design and specification data. As microwave design data is a superset of analog data, it is also anticipated that analog companies will make extensive use of this language.

References

The following references are a subset of those publications available on MHDL. In addition to the papers and documents recorded below, there are a number of conferences and workshops at which MHDL has been presented.

1. Intermetrics, "MHDL Reference Manual", Version 2.0, March 21, 1994.
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7. IEEE SCC-30 Study Group Meeting Minutes, for each meeting held.
8. 1991 IEEE MTT-S Symposium, Lunch Panel Session, Boston, MA, June 1991.