Characterize I/O Cells Using AccuCell

1. Introduction

AccuCell is used for characterizing cells quickly, accurately and easily. Although AccuCell is primarily designed for the characterization of Standard Cells, it can also be used for characterizing I/O Cells. The characterization method for I/O Cells is different from the Standard Cells method and this application note will explain how to characterize I/O Cells.

2. Characterization differences between Standard Cells and I/O Cells

The characterization differences between Standard Cells and I/O Cells are:

(1) Standard Cells have only one voltage source. I/O Cells may have multiple (usually two) voltage sources. The definitions of voltage sources are different for the two types of cells, and they have to be handled carefully.

(2) For I/O Cells, pad terminal should be specified.

(3) When the I/O Cell has multiple voltage sources, AccuCell cannot recognize the function of the cell automatically. Therefore, the user has to define the function of the cell.

3. How to define voltage sources and a pad for I/O Cells

--Definition of voltage sources

For I/O Cells, the voltage sources are defined by POWERS, GROUNDS and SUPPLIES commands. POWERS and GROUNDS are used for main voltage sources. SUPPLIES are used for specifying the secondary voltage source, typically used for transistors in the output stage. The PIN_RAIL2RAIL command is used for the terminal whose voltage range is not from POWERS to GROUNDS. (For command details, please refer to the command reference manual [1].)

--Definition of I/O pad terminal

I/O pad terminal is specified by PADS command.

Fig.1 is an example of the “Cell cfg file” in which SUPPLIES and PADS commands are used. This cell is a bi-directional buffer with data input (a), control terminal (en), data output (y) and bi-directional pad terminal (pad).

```
#specify the spice netlist for the cell
IN_FILE_NAME            ./pad.spi
CELL_NAME               pad
#TOP_SPICE_SUBCKT        pad

#
#specify the input and output port for the
    cell
#
INPUTS        a en
OUTPUTS      y
INOUTS      pad

PADS        pad
SUPPLIES            3.3     vdd33
PIN_RAIL2RAIL  {3.3 0}   pad

#specify the global power and ground pin
POWERS        vdd
GROUNDS       gnd
#
#specify any EQN or TBL file for the cell
#
TBL_FILE_NAMES  pad_in.tbl pad_out.tbl
```

Figure 1. Example of “Cell cfg file”

4. Cell function specification by user

There are two methods available to the user to specify cell function. One is to use the equation file (Eqn) and the other is to use the table file (Tbl). For simplicity, first try using an equation file if the cell is not bi-directional. If auto vector generation fails or the cell is bi-directional, then use the table file.

Function definition by equations can be described as:

--Equation of input pins when output is 0

--Equation of input pins when output is 1

--Equation of input pins when output is Z (Hi-impedance)

--Equation of input pins when output is X (unknown)

How to describe equations

Descriptions of equations are as follows.

<OutputPin>.0 : =

< Equation of input pins when output is 0> ;

<OutputPin>.1 : =

< Equation of input pins when output is 1> ;

<OutputPin>.z : =

< Equation of input pins when output is z> ;

<OutputPin>.x : =

< Equation of input pins when output is x> ;

Examples of the equations

(a) Input (Output) buffer

An equation of Input (Output) buffer whose input pin is a and output pin is y.

y.0 := ~a ;

y.1 := a ;

(b) Schmitt buffer

Circuit is very complex. But, its function is the same as that of Input (Output) buffer.

y.0 := ~a ;

y.1 := a ;

(c) Tri-state buffer

For this cell, output is Hi-impedance when en=1.

y.0 := ~a & ~en ;

y.1 := a & ~en ;

y.z := en ;

(d) Bi-directional buffer

For bi-directional buffer, the equation file cannot be used to describe its function, therefore, use the table file. For detailed information about table file, please refer to the user manual [2].

5.Conclusion

In this application note, we explained the process of I/O cell characterization using AccuCell. This is a usability enhancement.

Reference

[1] AccuCell Command Reference Manual, 2008.

[2] AccuCell User's Manual, Chapter 3, 2008