IBIS Models for Simulating Crystal Oscillator Output Performance

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Introduction

IBIS models are a compact and secure standard for simulating oscillators within a larger circuit. System-level designers looking to simulate oscillator performance can utilize IBIS models provided by Abracon to simplify and expedite the design process. Figure 1 below shows an example excerpt from an IBIS model, Abracon's ASDDV series CMOS crystal oscillator.

```
[IBIS ver]       3.2
[File name]      asddv33c.ibs
[File Rev]       4.0
[Date]           Monday Oct 18 2021

[Disclaimer]     This information is for modeling purposes only and is not
                 guaranteed.
[Copyright]      Copyright Abracon, LLC
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|
|**************************************************************************
|                           Component ASDDV33C
|**************************************************************************
|
[Component]      ASDDV33C
[Manufacturer]   Abracon, LLC
[Package]
| variable       typ               min                 max
R_pkg            0.1800            NA                  NA
L_pkg            5.0000nH          NA                  NA
C_pkg            1.0000pF          NA                  NA
|
[Pin]  signal_name         model_name          R_pin     L_pin     C_pin
1      NC                  NC                  NA        NA        NA
2      vss                 GND                 0.1200    1.6000nH  0.0F
3      output              ASDDV33C            0.1100    1.4000nH  0.1100pF
4      vdd                 POWER               0.1200    1.6000nH  0.0F
|
```

Figure 1: ASDDV IBIS model header information

IBIS Model Overview

IBIS models represent the inputs and outputs of a represented circuit after a buffer, as seen by the rest of the system. To achieve this, IBIS models save behavioral information, such as current vs voltage and voltage vs time relationships, but do not save any structural information. This method of saving data has advantages in information security when modeling oscillators, as there is very little integrated circuit (IC) data to extract. Another advantage of this method of saving data is that it requires less processing power to determine input/output dynamics, allowing for faster simulation and analysis.

Input/Output Buffer Information Specification

IBIS stands for Input/Output Buffer Information Specification. Thus, IBIS models describe the analog behavior of an oscillator as seen by the rest of the circuit, outside of the input and output buffers. These buffers separate the internal components of the modeled part from the rest of the circuit, as each pad of an oscillator can be presented as an equivalent circuit. Figure 2 shows a simplified design model that isolates the internal oscillator circuitry from the larger system it is incorporated in.

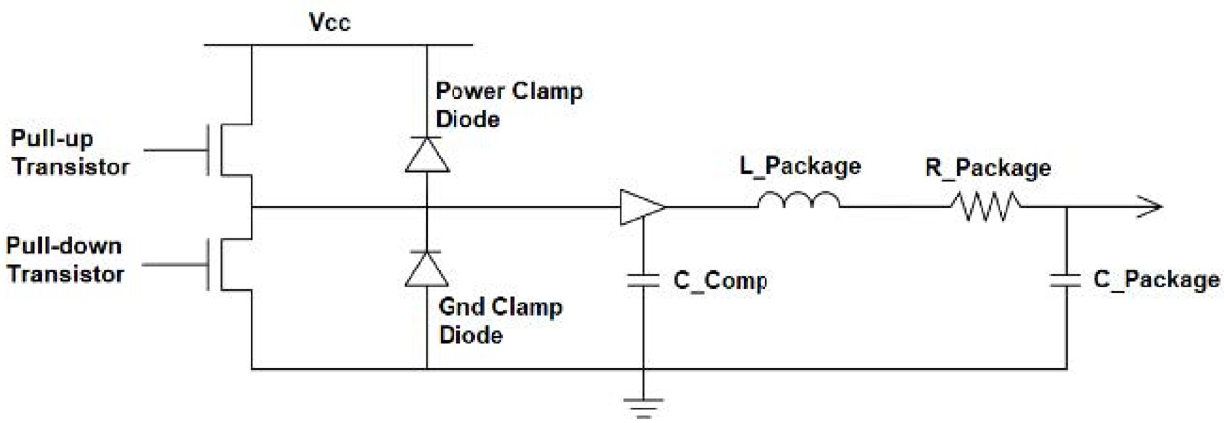

Figure 2: Input/output buffer circuit

This model uses power and ground clamps to ensure that the voltage stays within acceptable regions, relative to the oscillator Vdd and ground. This also means that the equivalent circuit can be represented as a package resistance, inductance, and capacitance. Behavioral information is saved for each pad to determine how it will interact with the rest of the circuit. This includes current vs voltage relationships like pull-up, pull-down, power clamp, and ground clamp information, as well as voltage vs time data like rising and falling waveforms.

Advantage in Privacy

IBIS models can share information about the behavior of an oscillator while revealing very little about the design of the IC. There is a reduced risk of IC components and design being identified compared to other simulation models because IBIS models do not save any structural information about the IC.

Users may be able to inspect internal aspects of structural models of oscillator products. IBIS models, however, are behavioral models, meaning that they record relationships between current, voltage, and time to later be repeated within a simulated circuit. This allows for an oscillator's performance to be incorporated into the design of a larger system without revealing any specifics about the composition of the oscillator itself. Table 1 is an IBIS excerpt showing the rising output waveform of Abracon's ASDDV series CMOS oscillator.

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[Rising Waveform]			
R_fixture = 50			
V_fixture = 0.0			
Time	V(typ)	V(min)	V(max)
0.0s	0.0V	0.0V	0.0V
0.20ns	14.680mV	10.330mV	18.450mV
0.40ns	61.800mV	5.427mV	0.175V
0.60ns	0.446V	0.181V	0.798V
0.80ns	0.954V	0.483V	1.469V
1.00ns	1.381V	0.799V	1.935V
1.20ns	1.653V	1.082V	2.129V
...	...	...	...

Table 1: Abracon ASDDV series rising waveform

The information in Table 1 is plotted in Figure 3. Figure 4 plots the corresponding falling waveform.

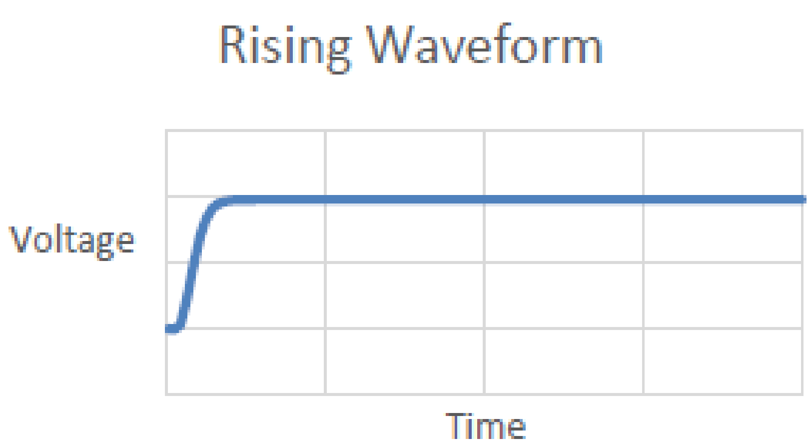

Figure 3: Abracon ASDDV rising waveform

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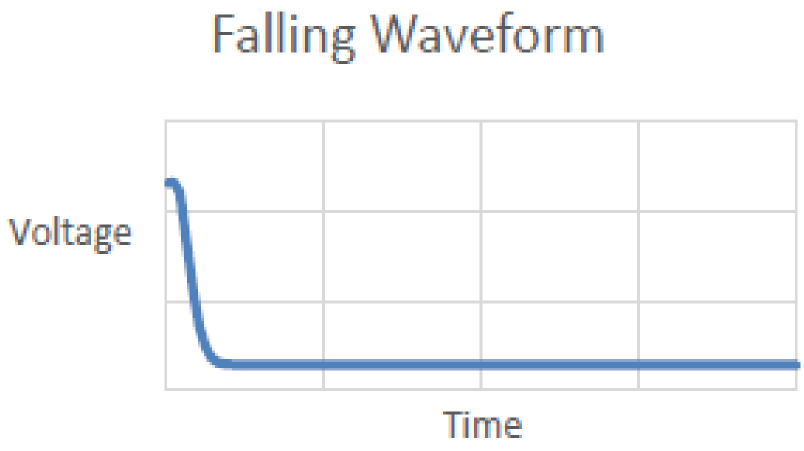

Figure 4: Abracon ASDDV series falling waveform

Faster Simulations

IBIS models allow for faster simulations than their structural model counterparts. Based on empirical measurements, IBIS models save behavioral information as lookup tables, as shown in Table 1. These lookup tables describe how the oscillator reacts to the rest of the circuit, such as input I-V relationships and output waveforms (V-T). This presents the software with pre-measured results instead of requiring it to calculate the interactions between components within a complex IC, serving the same function as a structural model while requiring only a fraction of the processing power.

Conclusion

Using IBIS models to represent crystal oscillators allows for faster and more secure simulations compared to common structural model counterparts. This is valuable because it allows manufacturers to share simulation tools for their products more freely and designers to calculate the effects of oscillators in their designs quickly and easily. System level designers looking to simulate their clock signals efficiently and securely can contact engineering@abracon.com to obtain an IBIS model for any Abracon oscillator. Abracon validates IBIS models to ensure they are compliant with IBIS Open Forum standards, to ensure simulation reliability of our products. The IBIS model used in the previous examples (Abracon's ASDDV series crystal oscillator) can be found on our website.

References

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