Simplis MOSFET Model for Proportional Gate Drive

UCC24624 utilizes the proportional gate drive for improving the turn off speed. The proportional gate drive is essentially a regulation loop that adjusts the MOSFET gate voltage to adjust the MOSFET on state resistor to regulate the voltage drop across SR drain to source.

To use UCC24624 Simplis model, user needs to put special attention on the SR MOSFET mode.

In Simplis, MOSFET can be modeled in three levels, as described in <https://www.simplistechnologies.com/documentation/simplis/sp_semi/topics/mosfet_models.htm>



Figure 1. MOSFET Model in Simplis

For model level 0, the MOSFET is modeled as ideal switch with linear capacitance for only CGS.

For model level 1, the MOSFET is modeled with ideal switch with linear capacitance for both CGS and COSS.

For model level 2, the MOSFET is modeled as a voltage controlled transistor switch with fixed forward transconductance, and nonlinear capacitance for CGS, CDS, and CGD.

Even though the level 2 MOSFET model is quite complicated and includes the nonlinear capacitor effects, it is only good for switching purpose and not suitable for proportional gate drive simulation.

The VI characteristic test circuit of a voltage controlled transistor switch, configured as level 2, is shown in Figure 2 (a). The VI characteristic can be seen in Figure 2 (b). Even though this transistor switch can model the saturation behavior of a MOSFET, the on state resistor is a fixed value regardless of the gate voltage.

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| 1. VI characteristic test circuit | 1. VI characteristic curves |
| Figure 2. VI characteristic of Simplis voltage controlled transistor model | |

Simplis also provides a level 3 MOSFET model that can be done manually, as shown in <https://www.simplistechnologies.com/documentation/simplis/sp_semi/topics/mosfet_models.htm>. This modeling method only addresses the transconductance change caused by different gate voltages, instead of the on state resistor change caused by gate voltage change.

Since the proportional gate drive relies on the on state resistor change, caused by the gate voltage change, to control the SR, the existing Simplis MOSFET model can’t meet the requirement.

VI curves of a desired MOSFET model are shown in Figure 3.

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| Figure 3. Desired VI curve for MOSFET model suitable for proportional gate drive |

To create the MOSFET model that varies its on state resistance based on its gate voltage, multiple Simplis voltage controlled transistor can be used to do the piecewise linear approximation.

After gate voltage across the MOSFET turn on threshold, an extra voltage controlled transistor can be added to achieve the on state resistor change. As shown in Figure 4, a MOSFET model transistor portion used to create such VI curves is demonstrated.



Figure 3. Piecewise linear model for SR MOSFET transistor portion

It can be seen that the transistor is constructed by 15 transistors. Each transistor has its own threshold voltage and resistor values. By choosing the appropriate threshold and resistor value, the resistor value change can be approximated.

For example, when the gate voltage is 4.5V, only switch S1 is turned on, and the resistor is 346mohm. While gate voltage is equal to 4.6V, transistors S1, S2, S3 and S4 are turned on. The resistor value is changes to these 4 resistors in parallel. The same principle can be used to drive resistor in higher gate voltage levels.

By using this method, Simplis MOSFET model that is suitable for proportional gate drive can be developed.