CHAPTER VI

CONCLUSIONS

In this dissertation, the concepts of virtual switch and virtual switching function are proposed to reduce the complexity of modeling the three-phase switching converters. By means of defining the virtual switching functions, the three-phase switching converters that contains six switches and six diodes can be regarded as an equivalent circuit only with three virtual switches. According to the equivalent circuit, the switching flow-graph can easily be created without complicated mathematics. Under the developed flow-graph, the large-signal, steady-state, and small-signal model of the switching converter can straightforward be derived out just by replacing the switching branches with their corresponding models.

The proposed large-signal SFG model is very suitable for fast time-domain simulation. It can directly be implemented with SIMULINK/MATLAB and connected to other sub-system to complete a system-level simulation. The simulation results of the proposed SFG model closely agree with that generated from PSPICE model. But the simulation run time required by using the proposed SFG model is only 1/10 of that needed by using PSPICE model under the same simulation conditions. In addition, the proposed SFG model can flexibly be modified to consider the ON-resistance effect of the active switch by simply inserting an additional virtual switching function into the SFG model; it is unnecessary to re-derive the whole model. Moreover, the large-signal SFG model of rectifiers can also be used for the application of diode-bridge rectifiers by setting all active switches in OFF-states.

The proposed steady-state SFG model is convenient to find the corresponding steady-state model. Once the working point is obtained from the steady-state model and one can also apply the results to obtain the corresponding small-signal model.

Based on the small-signal SFG model, the closed-form solutions can easily be generated. By using Mason's Rule, the transfer functions of the switching converters can straightforwardly be obtained as well. One can analyze the frequency-domain characteristics of switching converters from the transfer functions. Certainly, that is useful for controller design. The small-signal SFG model supplied more physical insight and cause-effect relations of the circuit.

The proposed SFG modeling technique preserves the merit of the SFG modeling technique of DC-DC converters and overcomes the bottleneck of applying the SFG technique to model a three-phase switching converter. The concept of virtual switch and virtual switching function nimbly solves the modeling problem caused by the AC voltage. The concept also enables one to reduce the complexity of modeling a three-phase switching converter. The coupling effects between the three phases are almost decoupled. Besides, the ON-resistance and blanking-time effect of the active switches can be taken into account flexibly by properly defining extra virtual switching functions.

Furthermore, the proposed SFG modeling technique possesses both advantages of equation form model and non-equation form model. The large-signal SFG model can be utilized to quickly predict the performance of the converter and the controllers. The unified large-signal, small-signal and steady-state models can also easily be created by using the proposed SFG modeling technique. Similar to the equation-form model, the proposed SFG model can be used for frequency analysis and controller design. Nevertheless, unlike the equation-form model needs complex mathematic work, the graphic SFG model only requires easy mathematic derivations, to find the transfer functions.

Actually, the proposed SFG modeling technique can also be applied to other applications. For example, DCM (discontinuous current mode) DC-DC switching converters, parallel VSI systems, wind energy systems, or resonant switching converters. The concept of virtual switching function is very appropriate to be used to reveal the operation of multi-switch systems. Moreover, the proposed SFG model can be implemented as a built-in subsystem in MATLAB/SIMULINK environment. That is convenient for other users to utilize the proposed SFG model to connect with other application and to quickly evaluate the performance of their system. The proposed SFG model can also be extended to help determining parameters of the switching circuit at system-level. Due to limitation of time, the above mentioned topics remain to be for further research.