# Transfer Function Derivation

We need to derive the control to output transfer function of our topology to be able to design a controller for it. In order to derive the control to output transfer function, we can describe our circuit in terms of state-variable vector x which consists of the capacitor voltage and inductor current. Moreover, in this derivation we analyzed the circuit for switch is opened and closed separately and averaged them. Lastly, capital letters are used for DC values and small letters are used for AC values where every component can be written as a sum of its DC and AC components. We can write the state space equations during d.Ts as follows:

(1)

Where is the input and is the output. We can write the state space equations during (1-d).Ts as follows:

(2)

Averaging the equations (1) and (2) results in:

(3)

In the first part of this equation, the coefficient of x can be called A, the coefficient of can be called B and in the second part the coefficient of x can be called C. Moreover, in this equation every term can be separated to its DC and AC components (etc. x=X+x). The only component that is not separated is the input voltage which is assumed to have no AC component. When every term is separated and the products of two AC components are neglected, we obtain the following equations:

(4)

(5)

At steady state conditions, AC terms can be neglected and results in a transfer function as follows:

(6)

Using Laplace transformation on the AC part of the equation (4) :

(7)

Expressing x(s) in terms of d(s) and combining it with the Laplace of the ac part of the equation (5) results in a control to output transfer function as follows:

(8)

In the figure below forward converter with the state variables is shown. For the switch on case (left hand side of the figure) KVL equations can be written as follows:

(9)

(10)

For the switch off case the only difference is the Vd term in the equation (9) will be zero the rest are the same with the switch on case. From all of these equations and assuming that R is much bigger than gives us the following matrices:

(11)

(12)

(13)

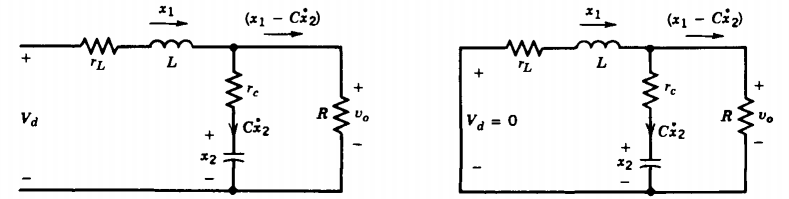


Figure : Forward converter secondary side with state variables.

All of the matrices found in (11), (12), (13) can be implemented into equation (8). This implementation results in the control to output transfer function:

(14)

In order to make this transfer function fit in the standard form, following substitutions can be made:

(15)

(16)

(17)

The transfer function with these implementations can be written as follows:

(18)