ECE692

Steady-State Analysis of a Time-Invariant SRC

In this problem, consider the same time-invariant SRC from Homework #2, shown in Fig. 1 and Fig. 2. You may re-use your state space description from Homework #2, or use the model posted in the solutions. Note that **A** is non-singular.

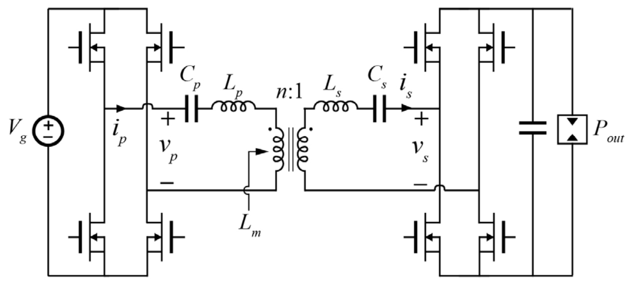

Fig. 1: Series Resonant Converter

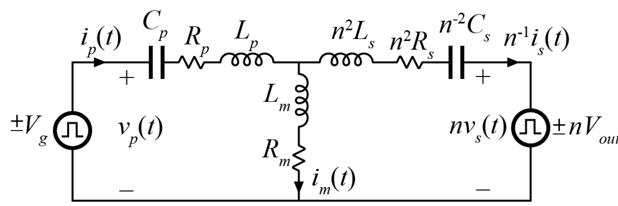

Fig. 2: Time-Invariant Circuit Model of SRC

Given an initial condition vector for the states at the beginning of a switching period $\mathbf{X}_0 = \mathbf{x}(t{=}0)$, the states $\mathbf{X}_\varphi = \mathbf{x}(t{=}t_\varphi)$ are given by

$$\boldsymbol{X}_\varphi = e^{\boldsymbol{A}t_\varphi}\boldsymbol{X}_0 + \boldsymbol{A}^{-1}\left(e^{\boldsymbol{A}t_\varphi} - \boldsymbol{I}\right)\boldsymbol{B}\boldsymbol{u}_1$$

a) Using the same approach, write an expression which uses an initial condition $\mathbf{X}_0 = \mathbf{x}(t{=}0)$ to solve the states at $t = T_s/2$
b) Using results from (a), write a closed expression form expression for $\mathbf{X}_0$ in steady-state for any given t_φ
c) Using the results from (b) and the knowledge that **A** is non-singular, write a closed-form (algebraic) expression for the average input and output dc power as a function of the results (a), (b), and $\boldsymbol{X}_\varphi$

Using the above analysis (and without employing `lsim()` or any other time-stepping integration), examine the following in MATLAB

d) Generate a single plot of the output power and efficiency that the converter exhibits in steady state for $0 < t_\varphi < T_s/2$ for the following converter implementation (from Homework 2).

C_p	R_p	L_p	L_m	R_m	n^2L_s	n^2R_s	$n^{-2}C_s$	V_g	nV_{out}	f_s	t_φ†	n
30 nF	.2 Ω	10 μH	10 μH	.1 Ω	10 μH	.2 Ω	30 nF	20 V	20 V	200 kHz	$T_s/4$	4

† See Fig. 3 for waveform timing definitions

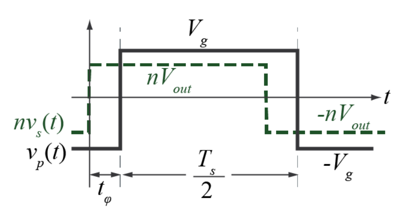

Fig. 3: Input waveform timing definitions