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# LMI Control of Conventional Boost Converter

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## Abstract

This paper analysis about a design of a robust control conventional boost converter using linear matrix inequalities (LMI). LMI is the control technique where we can solve a problem exactly by efficient optimization algorithm LMI (solvers). The small signal model is used to analyze the conventional boost converter The proposed LMI methods guarantee a robust design with uncertainties and non linearity's. Here we use standard optimization algorithm is used for a multi objective robust controller which is computed automatically. The proposed method gives an efficient boost converter in which poles placed are implemented by the operational amplifiers. Here PSIM simulations are used to validate the desired output waveforms.

**Keywords:** Boost Converter, LMI Technique, Pole Placement, State Space Analysis

## 1. Introduction

Most of the control schemes in the power electronics are generally linearized model from the non linear model at a nominal operating point. Large signal transients which are caused due to power surges and over loads are handled in adhoc manner. Generally the analysis of designers of each circuit individually to control designated large signal transients. This paper represents how large signal transients can be avoided. Particularly this paper takes methodology to design the control law fast switching converters, which in turn results in robustness against parametric uncertainties and global stable behavior with satisfactory transient response.

Most of the non linear control design by several authors to have stability over a operating conditions of particular range, in owing switched regulators of non-linear nature. Power electronics circuits which has some non linear control can be found[3–4] who used Lyapunov functions for nonlinear strategies. Recently, Cortes et al.[5], Leyva et al.[6], and He and Luo[7], proposed robust control for power converters using non linear controllers the main disadvantage of the proposed nonlinear controllers are complexity of the implementation and it is difficult to predict the transients analysis. The adoption of some linear robust control techniques by some authors for the power electronic converters with nonlinear control aims to ensure stability for several operating conditions. The adaptability of linear control laws is simple, such as feedback controllers such as PI and PID controllers[8-9]. The parametric uncertainty is not taken in to account in linear control technique if taken so they are not treated correctly since some of the parameters time dependent and storage elements. Some of the non linear methods has robust control of power electronic converters such as μ-synthesis, $H_\infty$, quantitative feedback theory and approaches based on LMI.

LMI technique provides the advantages such as dealing pole placement constraints for transients' requirements and weighting functions are not necessary required for this control technique. Due to these advantages we can easily adapt a dc-dc converter using LMI robust control concepts.

## 2. Uncertainty Model of Boost Converters

DC-DC boost (step-up) converter schematic circuit diagram with relevant control signals is as given below in Figure 1. Line voltage-$v_g$, output voltage-$v_0$ and disturbance current-$i_{load}$ at the output. The output voltage must follow the constant voltage which is given. R is the load of the converter, where L and C represent the values of

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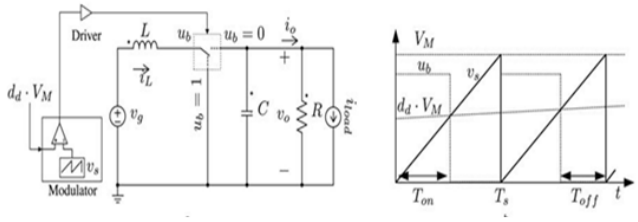


**Figure 1.** Boost converter and its control circuit.

inductor and capacitor respectively. The signal ($u_b$) is the switch control signal by which pulse width modulation (PWM) of a fixed frequency pulse which is controlled by turn on and turn off switches. Where the switching time period is given by $T_s$ which is equal to sum of $T_{off}$ (where $u_b$ = 0) and $T_{on}$ (where $u_b$ = 1), in which duty cycle $d_d$ is given by $\frac{T_{on}}{T_{on}+T_{off}}$. Here $1/T_s$ is the constant switching frequency. A saw tooth signal $v_s$ of amplitude $V_M$ is compared with respect to the duty cycle. We avoid saturation of inductor current by assuming converter operates in continuous conduction mode.

The given expression determines the boost converter model which is linearized. Generally these DC-DC converters which are averaged neglects high frequency dynamics due to switching of device, due to the consideration of switching period is smaller when compared to the time constant of the converter.

## 3. Analysis

Generally there are two state variables for an boost converter, here we are 3rd state variable as $x_3$ which is integral part of a signal with error which is stated reference voltage minus output voltage .At an equilibrium state the voltage error is zero, so $x_3$ is not change. The DC line voltage is taken as $V_g$. W is defined as the disturbance vector of the output current source which is used to characterized the output impedance, and $V_0$ will give output voltage as a result of variation in load current. The state space representation of the matrices is shown below

$$A = \begin{bmatrix} 0 & -\frac{D'_d}{L} & 0 \\ \frac{D'_d}{C} & -\frac{1}{RC} & 0 \\ 0 & -1 & 0 \end{bmatrix}$$

$$B_w = \begin{bmatrix} 0 \\ -\frac{1}{C} \\ 0 \end{bmatrix}.$$

$$B_u = \begin{bmatrix} \frac{V'_g}{D'_d L} \\ -\frac{V_g}{(D'^2_d R)C} \\ 0 \end{bmatrix}.$$

$$B_{ref} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}.$$

The state space representation with the following representations is written as

$$\begin{cases} \dot{x}(t) = Ax(t) + B_w w(t) + B_u u(t) + B_{ref} V_{ref} \\ z(t) = C_z x(t) + D_{WZ} w(t) + D_{zu} u(t) \end{cases}$$

$$X(\mathrm{t}) = \begin{bmatrix} i_L(t) \\ v_0(t) \\ x_3(t) \end{bmatrix}.$$

$$\mathrm{W(t)} = [i_{load}(t)].$$

$$\mathrm{u(t)} = [d_d(t)].$$

$$\mathrm{z(t)} = [v_0(t)]$$

$$D_{zu} = [0].$$

$$D_{zw} = [0].$$

$$D_z = [0 \quad 1 \quad 0].$$

Figure 2 represents the simulation diagram of a conventional boost converter using LMI technique. Here the desired poles are constructed using op amps. Here state controller feedback K is given by

$$\mathrm{K} = [-2 \quad -2 \quad 725.22]$$

## 4. Simulation Results

Figure 2 represents the simulated boost converter diagram using LMI control technique from tha parameters as shown in Table 1. The obtained results are as shown in the Figure 3 in which top wave form represents the load voltage and the bottom one represents the load current. Figure 3 shows the sudden change in load current at 0.15 sec from 1.5 to 3.5 amps. We observe that the output voltage as disturbances at the sudden change in load current which again become stable.

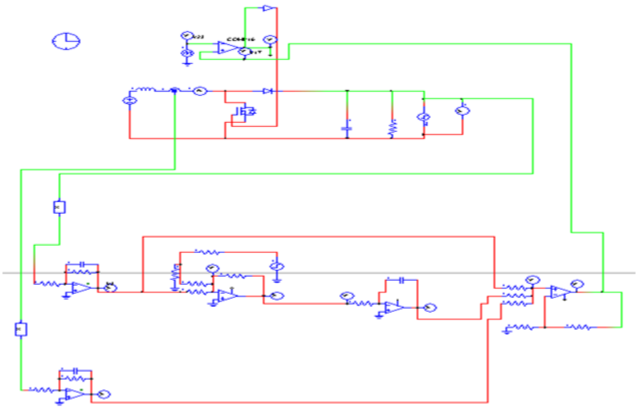

**Figure 2.** Simulation diagram.

**Table1.** Proposed prototype parameters

| PARAMETERS | VALUE |
|---|---|
| R | [10,50] |
| $D_d$ | [0.3,1] |
| $V_0$,$V_{ref}$ | 24 V |
| C | 600 Mf |
| L | 310 mH |
| $T_S$ | 5 ms |

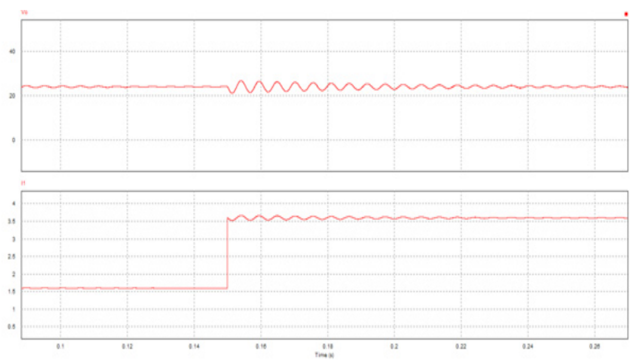

**Figure 3.** Simulated current and voltage waveforms.

## 5. Conclusion

The control diagram which is simulated using linear matrix inequality technique consists of a PWM device, some OP-AMPs and standard current sensor. The non minimum phase converters which are valid for the state feedback control of linear matrix inequality technique. For robust control the state feedback controller is done automatically for which controller should be manually done which is different from other control methods. Since this method is synthesized using MATLAB LMI tool box which can be extensible readily for parasitic resistances capacitor and inductor by editing model state space matrices. This simulation shows perfect designed constraints despite uncertainty.

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