IMPROVING THE P&O AND INCREMENTAL CONDUCTANCE ALGORITHMS OPERATIONS IN PHOTOVOLTAIC STATION THROUGH A MODEL PREDICTIVE CONTROL

Elzein I. , Petrenko Y. N.
Belarusian National Technical University
Minsk, Belarus
E-mail: Imad.zein@liu.edu.lb, ypetrenko@bntu.by

Introduction

With availability of fast computers and microprocessors, MPC is increasingly Önding application in many other engineering domains such as robotics, automobiles, nuclear and aerospace industries. Major strengths of MPC are abilities to handle multivariable interactions and operating constraints in systematic manner. MPC is formulated as a constrained optimization problem, which is solved on-line repeatedly by carrying out model based forecasting over a moving window of time. More importantly, MPC facilitates optimal control of non-square systems, i.e. systems with unequal number of manipulated inputs and measured outputs. Dynamic models are at the heart of MPC formulations. While initial formulations were based on step response models, a very wide variety of linear / nonlinear black box / mechanistic models are now employed in MPC formulations [1]. This scheme is meant to introduce linear MPC formulation, i.e. one based on linear perturbation models, to a student of advanced control. The linear prediction model for a system can be developed either through linearization of a nonlinear mechanistic model for the system or through identification of a black box linear time series model using input-output data generated by perturbing the system. We assume that the model development exercise is already over and a linear perturbation model for the system under consideration is available with us for controller synthesis.

I. Model predictive controller scheme

The ultimate achievement over the next discussions is to improve the operation of the P&O and INC algorithms and this is can be performed through the usage of predicting the future behavior of the desired control variables until a predefined horizon in time. As we utilize the predicted variables, the switching state will be obtained through minimization of a cost function. Predicted behavior of control variables at the next sampling time k+1 can be described by a discrete-time set of equations in the actions of a switch is “ON” and when a switch is “OFF”.

$$Ipv(k+1) = \frac{Ts}{LV}Vpv(k) + Ipv(k) \tag{1}$$

$$Vc(k+1) = (1 - \frac{Ts}{RC})Vc(k) \tag{2}$$

$$Ipv(k+1) = Ipv(k) - \frac{Ts}{Ln}Vc(k) \tag{3}$$

$$Vc(k+1) = \frac{Ts}{nC}Ipv(k) + (1 - \frac{Ts}{RC})Vc(k) \tag{4}$$

Now after determination of the reference current using the procedure shown in Fig. 1, the cost function can be obtained as following;

$$g_{s=0.1} = |Ipv_{s=0.1}(k+1) - Iref| \tag{5}$$

II. Minimization of cost function

The objective is to minimize the cost function g. The final switching state for MPPT can be determined using procedure illustrated in Fig. 1. Model Predictive Control (MPC) approach is used for controlling the input current of the DC-DC converter [2]. The designed controller should provide the capability of tracking the reference current generated by the suggested MPPT method with satisfactory dynamic and steady-state performances. Based on the MPC concept, the future behavior of the input current should be predicted separately for each of the two different switching states of the converter using appropriate equations. As discussed, the converter has two different switching states: When S is ON; the voltage of inductor L_1 is:

$$V_{L_1} = V_{pv} = L_1\frac{di_{L_1}}{dt} \tag{6}$$

In order to make a discrete formation of the continuous differential equations, the below approximation is applied:

$$\frac{dx}{dt} \approx \frac{x[k+1] - x[k]}{T} \tag{7}$$

Then the discrete formation from (6) and (7) is:

$$\frac{i_{L_1}(k+1) - i_{L_1}(k)}{T_s} = \frac{Vpv(k)}{L_1} \tag{8}$$

In which Ts is the controller sampling time. By rewriting (8), the following equation is obtained for predicting the future behavior of the converter input current in this switching state [3,4]:

$$i_{L_1}(k+1) = \frac{Vpv(k)}{L_1}T_s + i_{L_1}(k) \qquad (9)$$

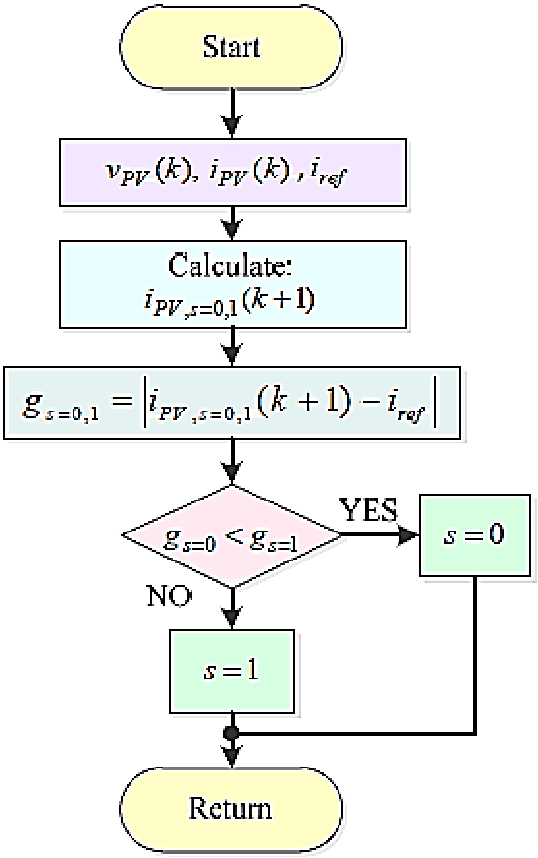

Рис. 1 – Model predictive control process for MPPT

When S is off then for this switching state; the voltage across inductor L_1 is:

$$V_{L_1} = Vpv - V_{c1} = L_1\left(\frac{di_{L_1}}{dt}\right) \qquad (10)$$

Thus the discrete form in (10) is:

$$\frac{i_{L_1}(k+1) - i_{L_1}(k)}{T_s} = \frac{Vpv(k) - V_{c1}(k)}{L_1} \qquad (11)$$

By rearranging formula (11);

$$i_{L_1}(k+1) = \frac{(Vpv(k) - V_{c1}(k))T_s}{L_1} + i_{L_1}(k) \qquad (12)$$

The next step of designing the controller is to select a suitable cost function based on the control objective :

$$g = |i_{Lref}(k+1) - i_{L_1}(k+1)| \qquad (13)$$

The future value of the converter input current is predicted using (9) and (12) in each sampling interval. Then, the switching state that results in minimizing the cost function of (13) is selected to be applied to the converter at next sampling interval. The overall block diagram of the controller is depicted in Fig.2.

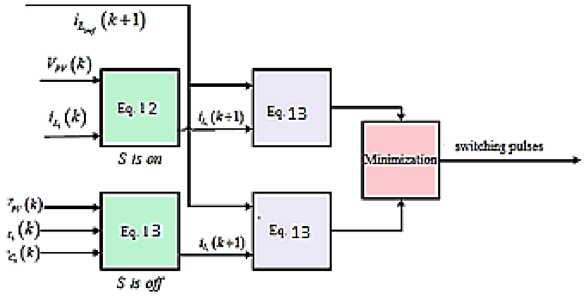

Рис. 2 – Structure model of the model predictive Control

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