A Model Predictive Control for Renewable Energy based AC Microgrids Without any PID Regulators

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Abstract

For practical ac micro-grids based on renewable energy, this paper presents a novel model predictive control strategy that does not use any proportional-integral-differential (PID) regulators. A model predictive power control (MPPC) scheme and a model predictive voltage control (MPVC) scheme make up the proposed approach. The MPPC algorithm can be used to control the bidirectional buck-boost converters of battery energy storage systems to smooth the fluctuating output from renewable energy sources while maintaining stable dc-bus voltages as the inverters' inputs. The parallel inverters are then controlled using a combination of the MPVC scheme and the droop method to guarantee proper power sharing and stable ac voltage output. The proposed method is simpler and performs better than the conventional cascade control. This is demonstrated through simulation on the Real-Time Laboratory (RT-LAB) platform and MATLAB/Simulink

1. Introduction

Power electronic control methods have been dominated by cascade linear control for decades. However, this method has significant drawbacks [1]. First, the slow dynamic response is caused by the control structure's complexity, which includes PWM modulation and multiple feedback loops. Second, the controller is difficult to implement due to the time-consuming tuning of the proportional-integral-differential (PID) parameters. Variable output from renewable energy sources can cause oscillations in the dc-bus voltage in a practical ac microgrid, which may further deteriorate the ac side's power quality. As a result, it's possible that conventional cascade control won't be able to deal with this change anymore. Inner current and outer voltage feedback loop control is frequently used in microgrids with multiple energy sources and converters to achieve load sharing between DGs based on droop characteristics [2].

A lot of research has been done over the past few years to figure out how to use traditional PID techniques for ac microgrids and get results that are both good and good enough. Fast transient response in power sharing between inverters can be achieved, for instance, by incorporating power derivative-integral terms and inner voltage/current feedback loops into a conventional droop [3]. Adaptive virtual impedance is proposed to achieve good performance for reactive power sharing nonlinear loads [4-5]. With mismatched feeder impedance, the active and reactive powers can be shared by combining the virtual impedance and secondary control [6]. The incorporation of such cascade linear control, on the other hand, may result in a decrease in the efficiency of the droop function. Another issue is that in most of the research that has been done, the distributed inverter inputs are typically connected to dc power sources in order to simulate a variety of renewable energy sources. Because this assumption can make the design process easier, it is reasonable and sufficient for the development of control techniques for inverters. However, the resource's erratic nature must be taken into account for practical applications. To improve performance, the model predictive control (MPC) scheme has recently been implemented [7]. In this method, a particular cost function is used to determine the power converter's ideal switching state. Even though some system-level algorithms have been proposed to achieve a variety of goals, such as minimizing system operating costs and economic load dispatch [8], MPC is rarely reported in the coordinated control of multiple converters in microgrids. At the system level, these algorithms are created and implemented

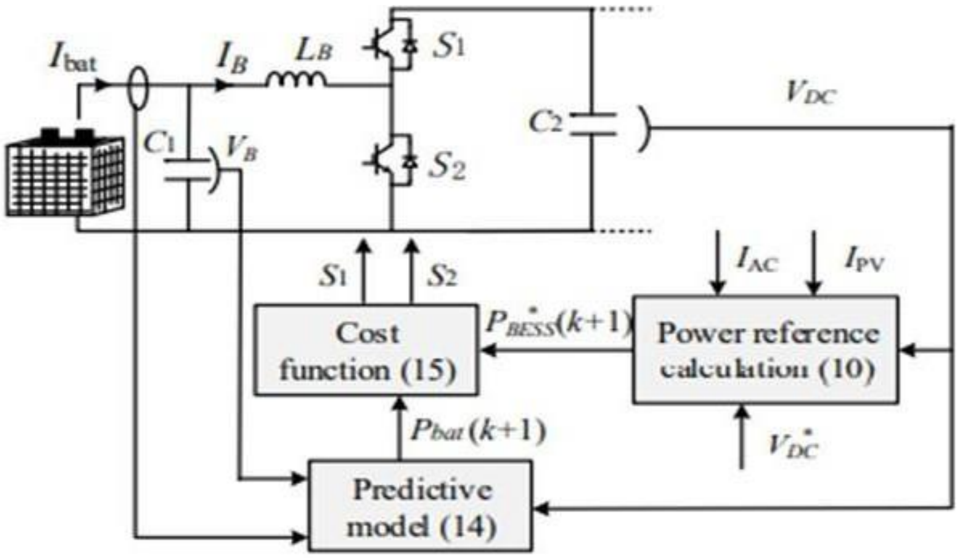

Fig.1 Block diagram of MPPC to control buck boost converters

2. Literature Review

In the DC-DC converter, the input voltage and output can fluctuate due to the need to regulate the average dc output voltage to the desired level. Regulating the switch on and off times in a DC-DC converter with a given input voltage controls the average output voltage. One way to control the output voltage is to switch at a constant frequency and change the o. In this process, called pulse width modulation (PWM), the duty ratio D, which is the ratio of the on-duration to the switching time span, is changed. When switching frequency difference, filtering the ripple components in the Uh's input and output waveforms is difficult. Converter.

In the PWM method, the repetitive waveform that switches at a constant frequency is compared to the signal level control voltage to create the switch control signal, which controls the state of the switch. The switching frequency with a constant peak is established by the frequency of the repeated waveform. This frequency is set to a range of a few hundred kilohertz to a few thousand kilohertz in a PWM power. The comparator has a good performance

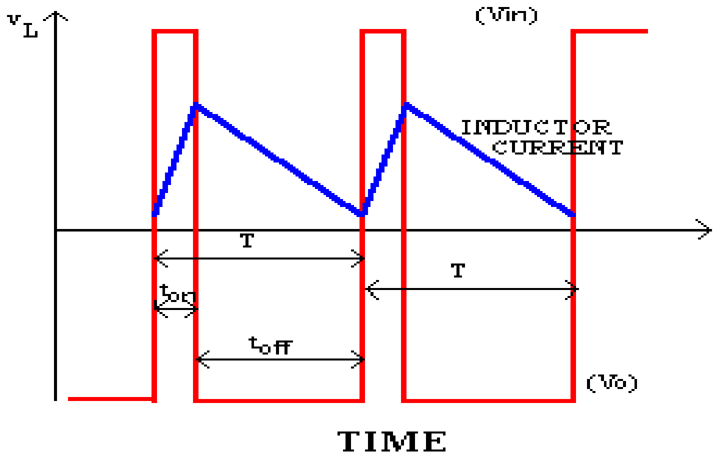

Fig.2 Wave forms

3. Proposed System

Fig. 1 (a) depicts the fundamental circuit diagram of the 3-phase, 4-wire, 4-leg VSC-based AC shunt DSTATCOM. The resistive-inductive (RL) load of three single-phase AC voltage controllers is connected in parallel to the DSTATCOM via a three-phase, four-wire system. The Synchronous Reference Frame (SRF) theory is used to generate the switching signals for the six IGBTs on the three legs of DSTATCOM. The IGBTs on the fourth leg are connected so that the neutral current is zero. As a result, load compensation and neutral current elimination are achieved using this approach. In order to reduce the ripple in the injected current and connect the Voltage source Converter (VSI) to the system, AC inductors are used. To lessen the PCC voltage injection ripple during DSTATCOM switching, RC filters are used in parallel with the load. III. Control Algorithm Fig. 1 (b) depicts the control algorithm's block diagram. The system voltages Va, Vb, and Vc, as well as the load currents ILa, ILb, and ILc, are sensed and utilized for the generation of a reference current. This reference current is then utilized to generate the switching signals for the three legs of DSTATCOM. According to the transformation that follows, three phase load current is transformed through the Park Transformation into two phase revolving vector current with direct axis Id, quadratic axis IQ, and zero sequence I0. Solar power is one of the most important forms of renewable energy. this significantly raises India's global energy consumption rate. The photovoltaic (PV) system is an application of solar cells that is related to research and technology. Solar energy is produced by converting sunlight's light and ultraviolet rays directly into electricity through the use of solar cells. The PV system's power output and efficiency should both improve as a result of this research. It is also necessary to supply the load with a constant voltage regardless of variations in solar temperature and irradiance. Depending on the effects of the environment (such as temperature and solar irradiation), PV arrays are used to generate electricity in parallel or series combinations.

The efficiency of solar PV modules is low. In order to provide the load with the maximum amount of power, it is necessary to operate at peak power point. The effects of varying temperature and solar irradiation conditions to improve system efficiency and track a photovoltaic array's maximum power point (MPP). Many MPP tracking (MPPT) methods have been developed and implemented to automatically find the maximum voltage point or maximum current point at which a PV array should obtain the maximum power output under the effects of temperature and irradiance. MPPT is a completely electronic system that can deliver the maximum amount of power to the load by varying the electrical operating point of the module.

Natural resources like sunlight, wind, rain, tides, and geothermal heat constitute renewable energy. These resources can be replenished naturally and are renewable. In contrast to diminishing conventional fossil fuels, these resources are, for all intents and purposes, inexhaustible. The global energy crisis has given the growth and development of Clean and Renewable Energy sources a new boost. Organizations all over the world are adopting Clean Development Mechanisms (CDMs). In addition to the rapidly diminishing global reserves of fossil fuels, the pollution caused by their combustion is another major obstacle to their use. Contrary to their conventional counterparts, renewable energy sources are known to be much cleaner and produce energy without the negative effects of pollutions

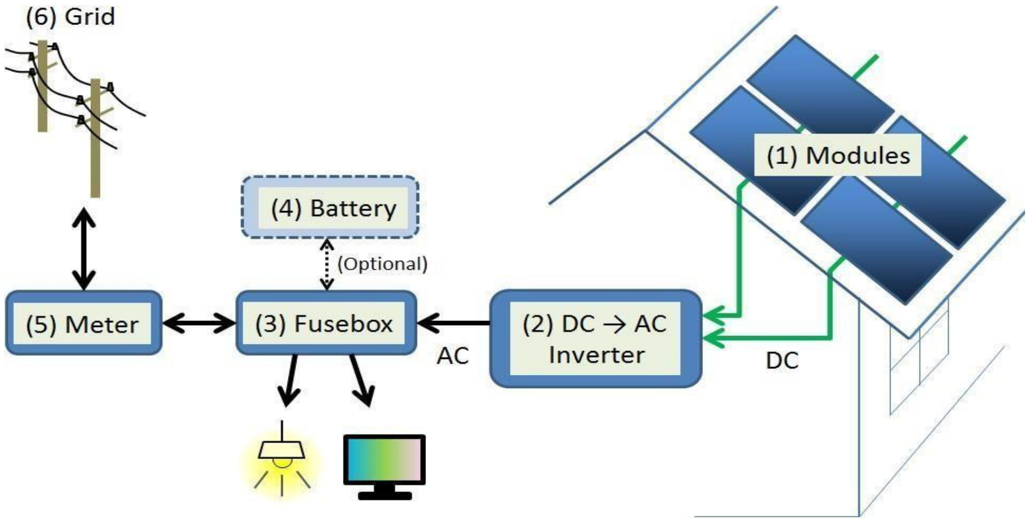

Fig.3 Proposed Structure

A power system that uses photovoltaics to generate usable solar power is known as a photovoltaic system or solar PV system. It is made up of a number of parts, such as solar panels that take in sunlight and convert it directly into electricity, a solar inverter that converts DC to AC electricity, and mounting, cabling, and other electrical accessories. The capacities of PV systems range from a few to several tens of kilowatts for roof-top mounted or building-integrated systems to hundreds of megawatts for utility-scale power stations. The majority of PV systems today are connected to the grid, while stand-alone systems only make up a small portion of the market

4. Conclusion

For ac microgrids incorporating photovoltaics (PVs) and energy storage, a novel model predictive control strategy has been proposed in this paper. Traditional cascade linear control's drawbacks, such as lengthy PID tuning, complicated feedback loops, and sluggish dynamics, are addressed by this approach. As a result, a model predictive power control (MPPC) is created to control the dc voltage and smooth the PV output, and a model predictive voltage control (MPVC) is incorporated with the droop method to control the inverters for load sharing. The proposed control procedure has been approved in both Simulink reenactment and Ongoing Research center stage. The test results showed that the control scheme kept the dc-bus voltage stable with fewer oscillations despite changing power generation and load conditions. In addition, the acvoltage remains stable while the power sharing among inverters is faster and smoother.

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