Clean Energy for Sustainable Economy and Environment

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Predictive Optimal Switching Vector Controlled Inverters for AC Microgrids- with Overcurrent/ Switching Frequency Constraints

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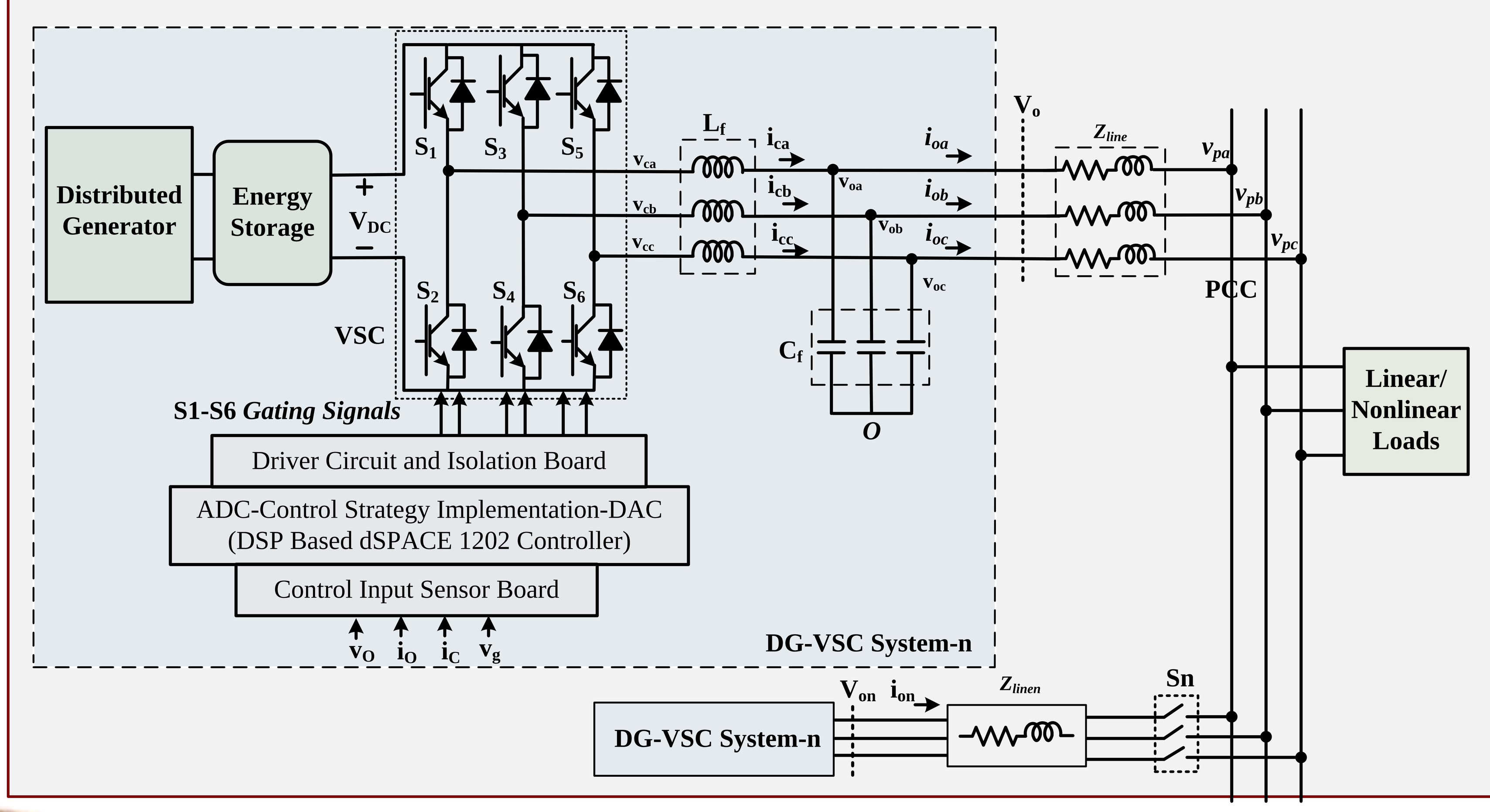
ABSTRACT: The conventional pulse width modulation controllers use output voltage and current with inner and outer current loops, thereby demanding the PI regulators and PWM modulators. They are associated with finite dynamic response transient time by PI controllers and necessitate rigorous tuning for practical implementation purposes. To complement this problem, voltage and current predictive optimal switching vector control is proposed here, which eliminates the PI regulators, PWM modulators and synchronous co-ordinate transformations. It uses the model of the system to predict behavior of output voltages for each sampling instant.

SCHEMATIC DIAGRAM



CONTROL STRUCTURE

A. System Modeling: $\mathbf{x}(k+1)=\mathbf{A}_z\mathbf{x}(k)+\mathbf{B}_{vz}\bar{\mathbf{v}}_c(k)+\mathbf{B}_{iz}\bar{\mathbf{i}}_o(k)$; $\mathbf{A}_z=e^{\mathbf{A}T_s}$, $\mathbf{B}_{vz}=\int_0^{T_s}e^{\mathbf{A}\tau}\mathbf{B}_v d\tau$, $\mathbf{B}_{iz}=\int_0^{T_s}e^{\mathbf{A}\tau}\mathbf{B}_i d\tau$

B. Predictive Optimal Switching Vector Controller:

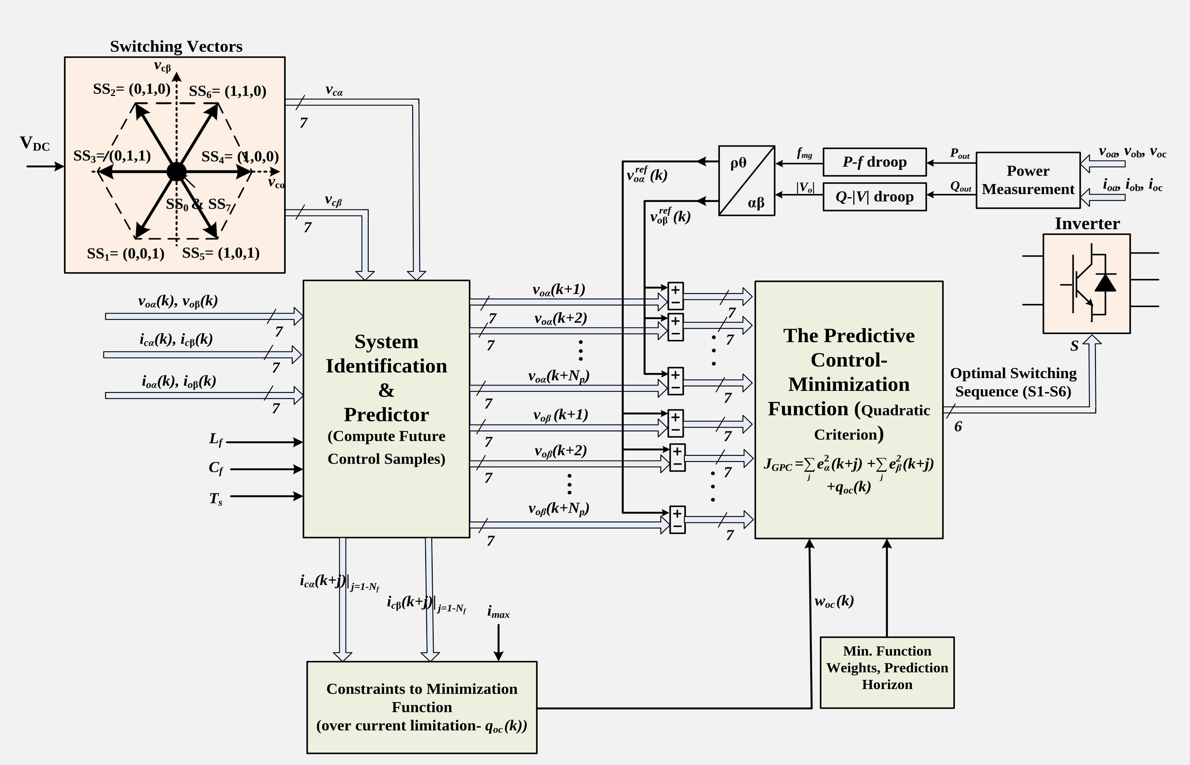
$$\mathbf{v}_o(k+N_p)=A\left(z^{-1}\right)\mathbf{v}_o(k)+N_p.B\left(z^{-1}\right)\mathbf{v}_c(k)+H\left(z^{-1}\right)\left[\sum_{j=1}^{N_p}\mathbf{i}_c(k+j-1)\right]+N_p.G\left(z^{-1}\right)\mathbf{i}_o(k)$$

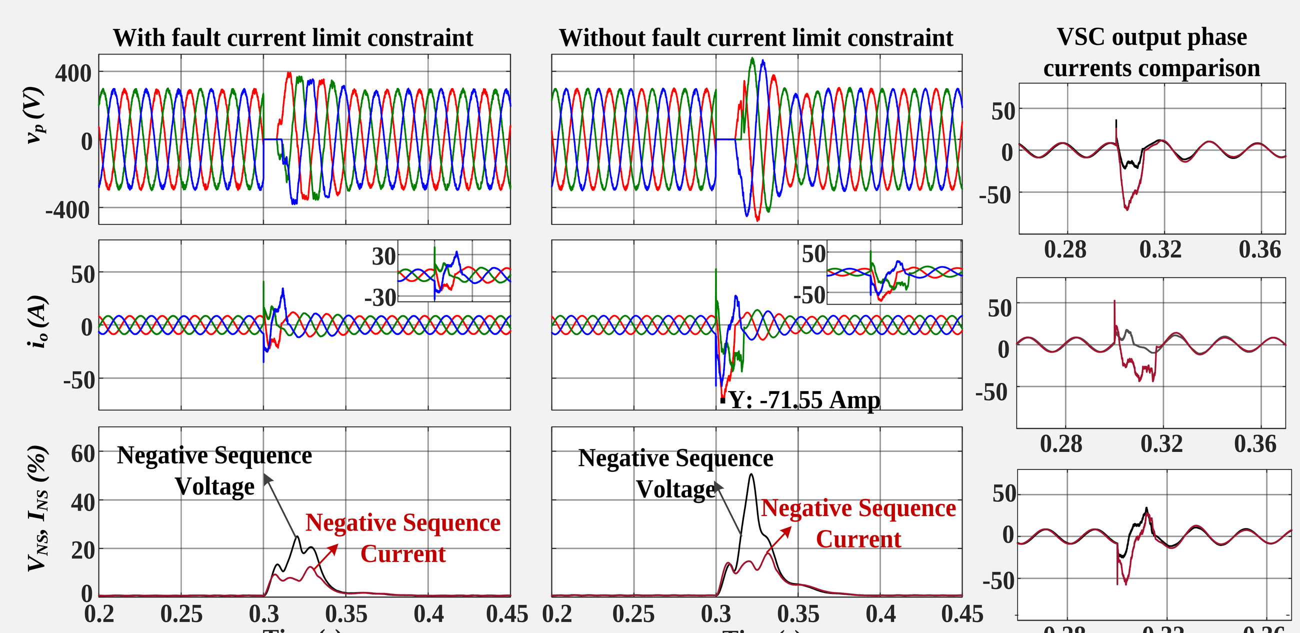
$$M_{GPC}=\sum_{j=1}^{N_p}e_\alpha^2(k+j)+\sum_{j=1}^{N_p}e_\beta^2(k+j)+q_{oc}(k)$$

$$\mathbf{v}_c=\frac{2\mathrm{V_{DC}}}{3}\left(S_a+S_b\boldsymbol{\alpha}+S_c\boldsymbol{\alpha}^2\right)$$

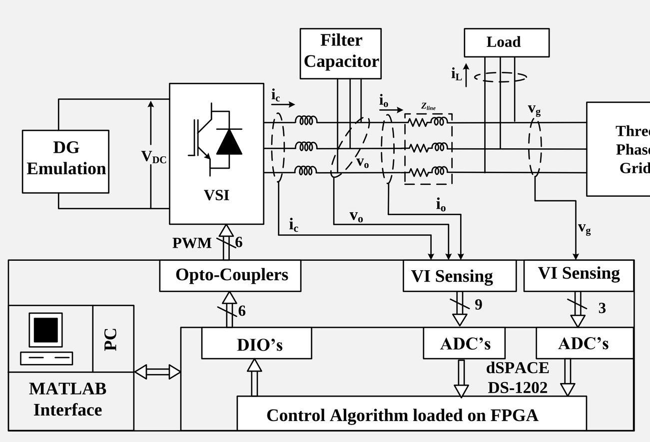
$$\text{Where,}\quad q_{oc}(k)=\begin{cases}0 & \text{if } \left|i_{c\alpha}(k+j)\right|_{for\ \mathrm{j=1\ to\ N_f}}<i_{\max}\ \text{and}\ \left|i_{c\beta}(k+j)\right|_{for\ \mathrm{j=1\ to\ N_f}}<i_{\max}\\ \infty & \text{Otherwise}\end{cases}$$

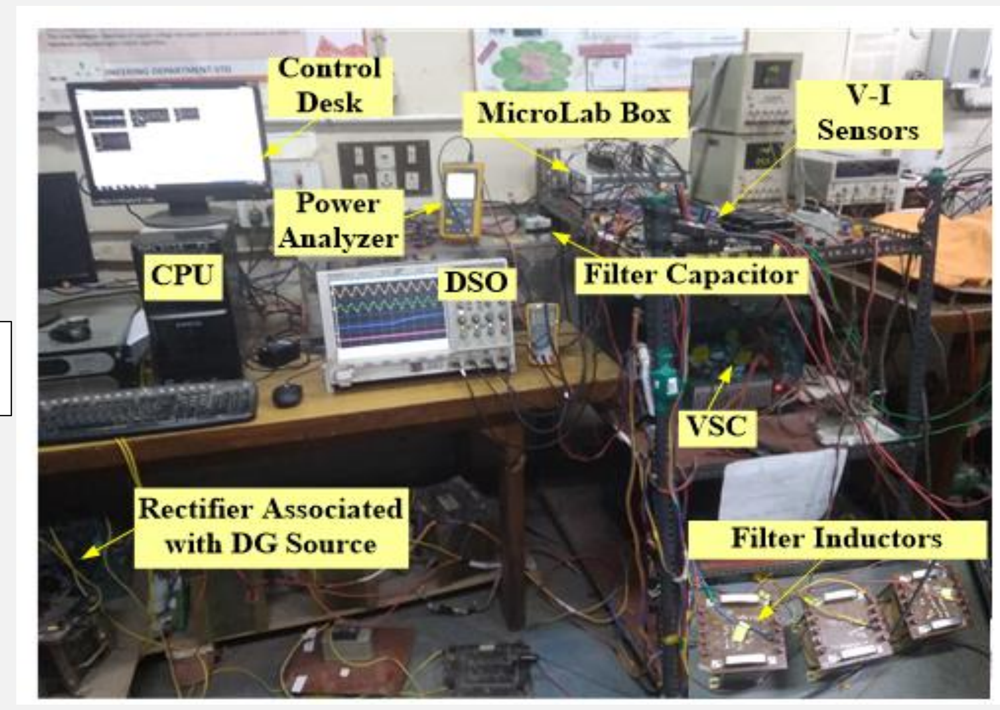
$$M_{GPC}=\sum_{j=1}^{N_p}e_\alpha^2(k+j)+\sum_{j=1}^{N_p}e_\beta^2(k+j)+q_{oc}(k)+\mu\left[\sum_{j=a,b,c}\left|T_j(k+1)-T_j(k)\right|\right]$$



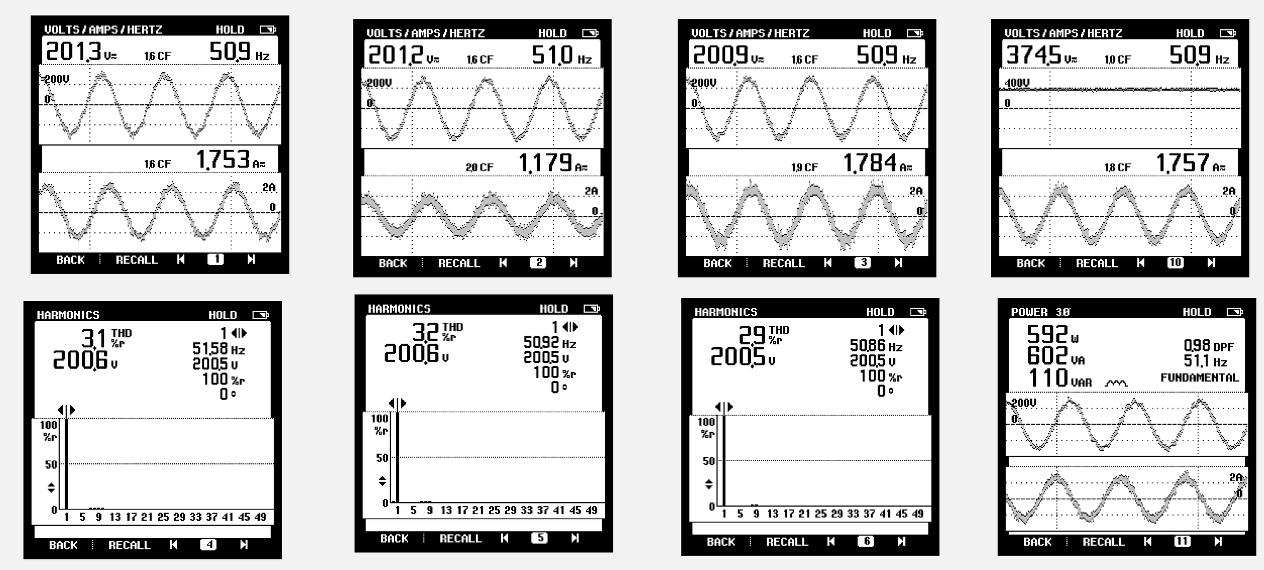


EXPERIMENTAL PROTOTYPE

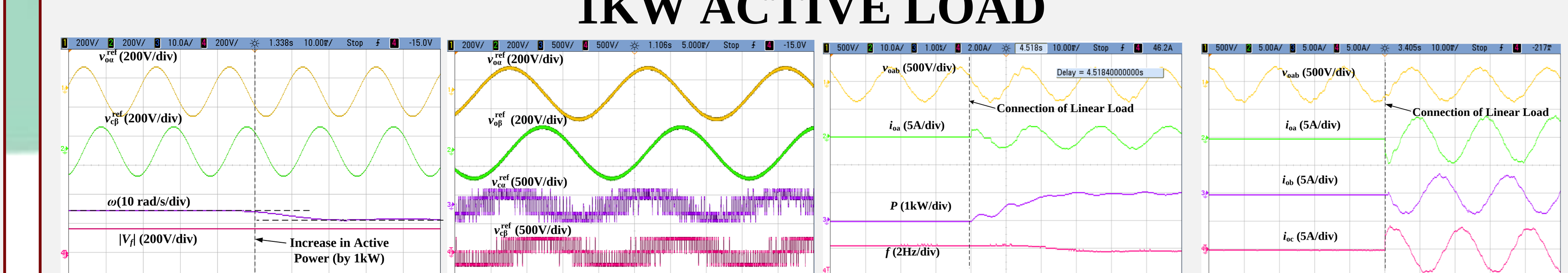




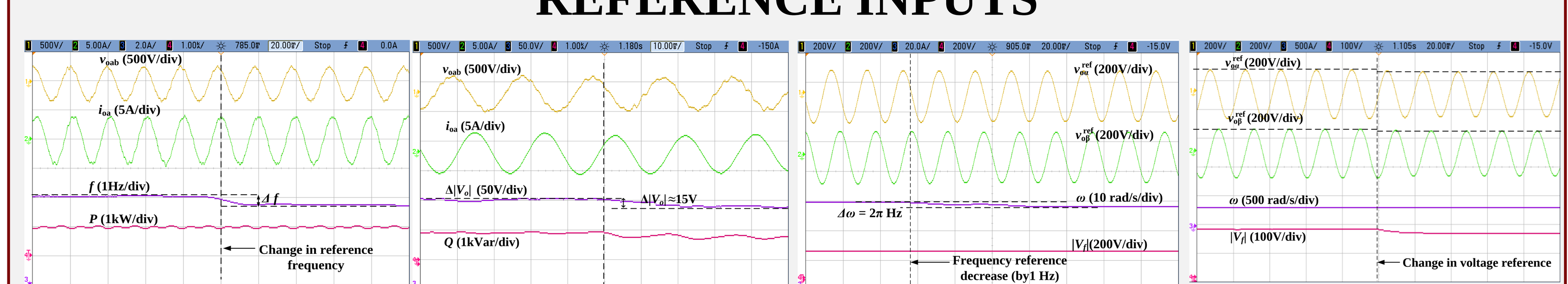
SYSTEM PERFORMANCE UNDER STEADY STATE CONDITION



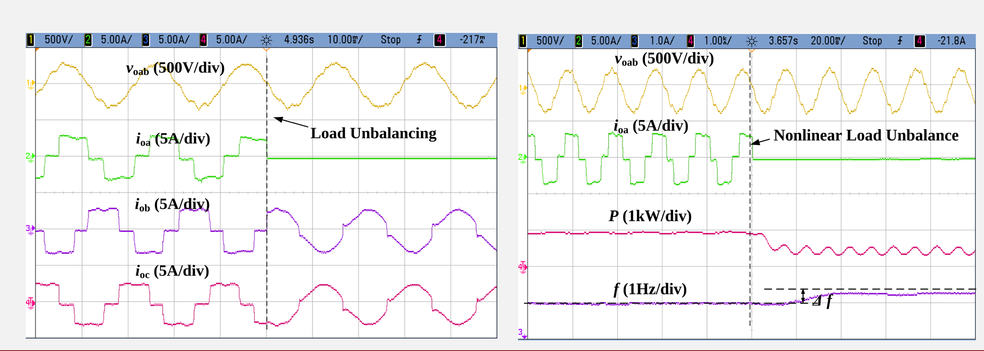
SYSTEM PERFORMANCE UNDER UNDER CONNECTION OF 1KW ACTIVE LOAD



SYSTEM'S RESONSE TO THE CHANGES IN CONTROLLER REFERENCE INPUTS



SYSTEM'S RESONSE TO THE CHANGES IN SYSTEM LOADS



CONCLUSIONS

The controller proves advantageous over the standard PWM controllers as it completely eliminates the PID regulators, PWM modulators and synchronous co-ordinate transformations. Thereby, the controller is easy for practical implementation purposes without any requirement for rigorous tuning.

The controller estimates the future samples of filter output voltages using the system model. The difference between the reference and estimated voltages, is nullified using a minimization criterion. The over-current protection is inherited within the control structure. Additionally, a switching frequency constraint is helps control the switching losses of the inverter. Simulation and experimental results are presented to verify the effectiveness of the proposed controller in tracking the reference voltages produced by the droop controller.

ACKNOWLEDGMENTS

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