Real time Capacitance and Absorption Based Voltage Regulation Model for Improved Power Stabilization with Cuk Converter

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Abstract:The problem of voltage regulation in power systems has been well studied. There exist numbers of stabilization model discussed in literature which consider input and output voltage. The methods suffer to achieve higher performance in power stabilization. To handle this issue, an efficient Real-time Capacitance and Absorption based voltage regulation model (RCAVRM) is presented in this paper. The model has been fabricated with different MOFSET and cuk converter connected in serial where the Mofset are designed to maintain the traces of voltage present in different capacitors and inductors. At each duty cycle, the method collects the number of circuits being used and number of other circuits not triggered. Based on these details, the method computes Capacitance Power Stabilization Factor (CPSF) and Voltage Absorption Factor (VAF). Using these two factors, the method computes the value of power stabilization weight (PSW) for different circuits. Based on the value of PSW, a unique circuit is selected to regulate the power supply to the electric system. The proposed model improves the performance of power stabilization with least voltage loss.

Keywords:Power Systems, Voltage Regulation, Cuk Converter, RCAVRM, VAF, CPSF and PSW.

1.Introduction:

The use of electric system is getting increased in recent times. The human society uses the electric power for almost all their works which increases the requirement of generating electric power in huge level. However the electric power required for different electric system varies and we cannot assure that the voltage input available would be equal to the required voltage for the device. Any electric device requires certain level of input voltage for its smooth functioning. But in reality, we cannot assure that the input voltage support the voltage requirement of the electric system.

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To maintain the stage input voltage for the electric system, it is necessary to monitor the incoming voltage and store the excess voltage on the capacitors and inductors. By storing the excess voltage with the capacitor and inductors, the voltage deflection can be avoided. Whenever there is low incoming voltage, which can be adjusted with the residual voltage from inductors and capacitors fabricated with the circuit. The cuk converter is the one which comes with the capacitor and inductor which would support the voltage regulation and stabilization problem. There are number of power stabilization and voltage regulation model designed in literature, which consider only the incoming voltage and uses set of converters to boost the voltage to support power stabilization problem. But there exist higher voltage loss and suffer with poor performance in voltage regulation and power stabilization. This encourages the researcher in designing efficient power stabilization model to maintain steady output voltage.

Towards power stabilization, the power circuits can be assigned in series. By integrating number of circuits in series, the incoming voltage can be stimulated to maintain the required output voltage. Based on this corollary, this article present a Real time Capacitance and Absorption Based Voltage Regulation Model. The model maintains the voltage traces in the MOFSET, and computes Capacitance Power Stabilization Factor (CPSF) and Voltage Absorption Factor (VAF). Using these two factors, the method computes the value of power stabilization weight (PSW) for different circuits. Based on the value of PSW, a unique circuit is selected to regulate the power supply to the electric system.

2.Related Works:

There exist number of power stabilization and voltage regulation model in literature. This section details set of models in detail.

A power-decoupled current-source inverter (PD-CSI) is proposed in [1], which consider the voltage deflection in common coupling and power mismatch problem.

A fuzzy predictive control algorithm is defined in [2], to support DC bus voltage and efficient regulation.

A interactional influence based mathematical model is presented in [3], which performs voltage regulation on DC bus according to the DC-DC converter and ultra capacitor attached. The method uses NTSMC algorithm to handle the voltage fluctuation problem in combined power supply system.

Superconducting Magnetic Energy Storage Integrated Current-source DC/DC Converter is presented in [4], for the support Voltage Stabilization and Power Regulation in DFIG-based DC Power Systems. It handles power variation and multiple disturbances in DC systems.

An automatic voltage regulation is designed to improve power stability in [5], which uses the PID to increase the AVR output to maintain the output voltage.

A Transient-Enhanced Voltage Regulator with Stability and Power-Supply-Rejection Boosting is presented in [6], which uses a voltage regulator in a standard 350 nm BCD technology, whose results indicate the VR can steadily work with 5.5–30 V input voltage. An Voltage Stabilizing Control Strategy is presented in [7], which uses Electric spring control mode being integrated with voltage stabilizing control strategy to maintain the load. Double close loop is used for decoupling.

Droop-based active voltage regulation control is presented in [8], which performs stability analysis of VSC in large-scale RES-integrated power systems to make VSCs continue to operate and regulate the voltage at the point of common coupling (PCC) during a fault without causing overcurrent.

An adaptive PI control is presented in [9], which automatically adjust the controller gain at various disturbances to improve the performance. An ANN controller based voltage regulation model is presented in [10], which uses electric springs to be act according to the result of ANN to perform voltage regulation.

A control system is designed for automatic voltage stabilizer in [11], which has measuring unit and regulating unit. The model used toroidal type variable autotransformer is for regulating unit and electronic control circuit is used for sensing unit. Fractional Order Controller based automatic voltage regulator is presented in [12], which analyze the stability of voltage in the AVR using fractional order controller.

IGBT and PWM with DSPIC33F Controllers is presented in [13], towards steady voltage regulator to maintain steady voltage in power systems. A fuzzy based coordinated power management strategy is presented in [14], which consider the state-of-charge (SoC) and charging/discharging current of the batteries. The method uses fuzzy logic controller to perform decision making on power flow on any circuit and charging of battery units. Transient power stability and voltage regulation model is presented in [15], to support power systems.

Real time Capacitance and Absorption Based Voltage Regulation Model (RCAVRM):

The proposed model has been fabricated with different MOFSET and cuk converter connected in serial where the Mofset are designed to maintain the traces of voltage present in different capacitors and inductors [16]. At each duty cycle, the method collects the number of circuits being used and number of other circuits not triggered. Based on these details, the method computes Capacitance Power Stabilization Factor (CPSF) and Voltage Absorption Factor (VAF). Using these two factors, the method computes the value of power stabilization weight (PSW) for different circuits. Based on the value of PSW, a unique circuit is selected to regulate the power supply to the electric system [17].

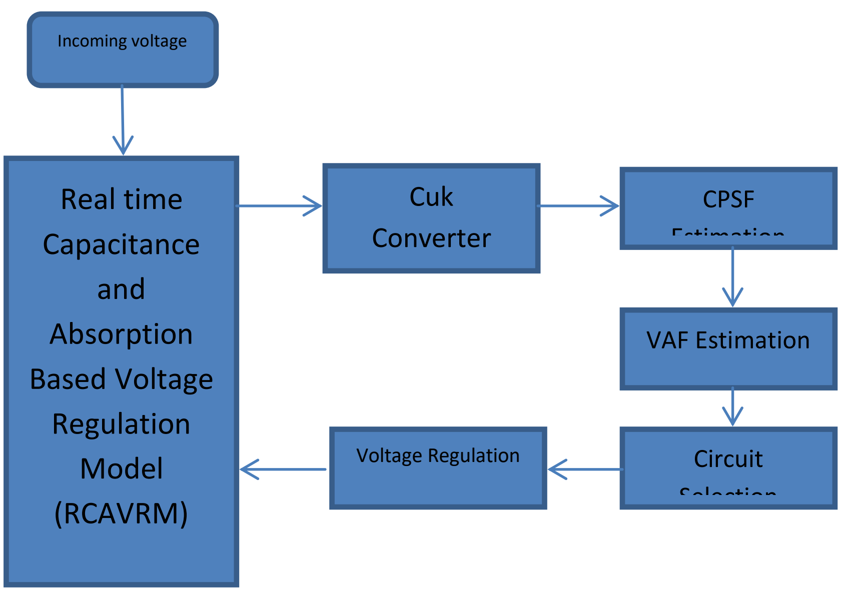

Figure 1: Architecture of Proposed RCAVRM Model

The functional architecture of proposed RCAVRM model is presented in Figure 1, which contains number of functions and explained in detail in this section.

Cuk Converter Collection:

The proposed method identifies the set of circuits which are not triggered at each duty cycle. In each duty cycle, the model triggers only specific circuits in the model to work. The rest of the circuits are changed to charging mode [18]. The selected circuits only support the model to produce output voltage. A circuit which is being triggered on to produce output voltage are triggered to charging mode at the next duty cycle. Accordingly, from the trace, the set of circuits which are being triggered to charging mode are identified in this stage. Such circuits are selected for further analysis in the current duty cycle.

Capacitance Power Stabilization Factor (CPSF) Estimation:

The efficiency of circuit in supporting the power stabilization is measured by computing CPSF value. It is being measured based on the average energy supplied on different duty cycle and residual energy. Also, the method computes the average energy stored on different duty cycle. Using these values, the method computes the value of CPSF to support power stabilization.

Algorithm:
Given: Circuit C, Power Trace PT.
Obtain: CPSF.
Start

Read C and PT.

Compute Residual Energy RE = $Energy \in C.Capacitor$

Identify circuit trace CT = $\sum_{i=1}^{size(PT)} PT(i).Circuit == C$

Compute Average Energy Flow AEF= $\dfrac{\sum_{i=1}^{size(CT)} Sum(CT(i).voltssupplied\ where\ CT(i).state{=}{=}on)}{\sum_{i=1}^{size(CT)} Count(\ CT(i).state{=}{=}on)}$

Compute Average Storage Factor ASF = $\dfrac{\sum_{i=1}^{size(CT)} Sum(CT(i).voltscharged\ where\ CT(i).state{=}{=}off)}{\sum_{i=1}^{size(CT)} Count(\ CT(i).state{=}{=}off)}$

Compute CPSF = AEF$\times\frac{1}{ASF}$

Stop

The above pseudo code represents the method of measuring CPSF value for any circuit given, which represent the efficiency of the circuit in supporting the steady voltage for the system.

Voltage Absorption Factor (VAF) Estimation:

The voltage absorption factor represents the efficiency of the circuit in absorbing the excess input voltage pass through the circuit when it is in charging mode. It is being measured by computing the Average Absorption Factor AAF, by considering the excess voltage and voltage stored at each duty cycle. Estimated value of AAF and others are used to compute VAF value to support voltage regulation.

Algorithm:
Given: Circuit C, Power Trace PT.
Obtain: VAF.
Start

Read C and PT.

Compute Residual Energy RE = $Energy \in C.Capacitor + Energy \in C.Inductor$

Identify circuit trace CT = $\sum_{i=1}^{size(PT)} PT(i).Circuit == C$

Compute Average Absorption Factor AAF=

$$\frac{\sum_{i=1}^{size(CT)} Sum(CT(i).voltsreceived\ CT(i).state==off)}{\sum_{i=1}^{size(CT)} Count(\ CT(i).state==off)} \times \frac{\sum_{i=1}^{size(CT)} Sum(CT(i).excess\ volts\ where\ CT(i).state==off)}{\sum_{i=1}^{size(CT)} Count(\ CT(i).state==off)}$$

Compute VAF = $AAF \times \frac{\sum_{i=1}^{size(CT)} Sum(CT(i)..state==on)}{Size(CT)}$

Stop

The above algorithm measure the VAF value according to the average value of voltage being absorbed by any circuit and the frequency of circuit being selected to support power stabilization. Estimated value of VAF is used to perform voltage regulation and power stabilization.

Circuit Selection:

The proposed power stabilization model monitors the incoming voltage and maintains the set of power traces produced according to the circuit conditions at each duty cycle. Accordingly, at each duty cycle, the method receives the incoming voltage and identifies the circuits using cuk converter collection module. For each converter selected, the method computes CPSF value and VAF value to compute Power stabilization weight (PSW). Based on the value of PSW, the method identifies a subset of circuits to support the stabilization process. The rest of the circuits are triggered to get charged to support further duty cycles.

Algorithm:

Given: Power Trace PT, Circuit set Cs

Obtain: Null

Start

```
    Read PT and Cs.
    At each duty cycle
        Circuit set Ics = perform cuk converter selection.
        For each circuit c
            CSPF = Perform CSPF Estimation.
            VAF = Perform VAF Estimation.
            Compute PSW = CSPF×VAF
            If PSW > Th then
                        Trigger c to regulation mode.
            Else
                Trigger c to charging mode.
            End
        End
    End
```

Stop

The above discussed algorithm monitors the incoming voltage and switches the circuits according to the power stabilization weight measured for various circuits.

Results and Discussion:

The proposed RCAVRM model has been implemented and evaluated for its performance with different input voltage. Obtained results are compared with the different existing voltage regulation models.

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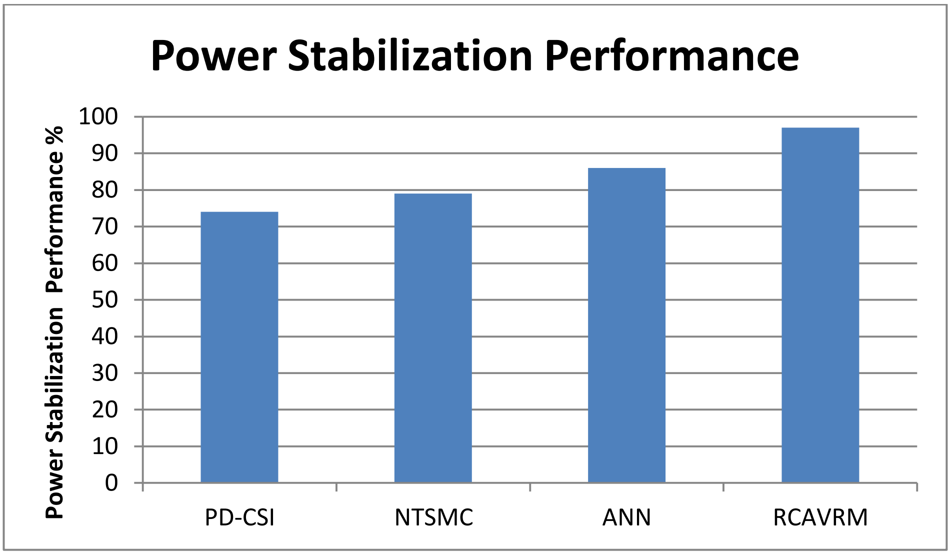

Figure 2: Analysis on Power Stabilization

The performance of models in power stabilization is measured and compared with others. The proposed RCAVRM model introduces higher power stabilization than others.

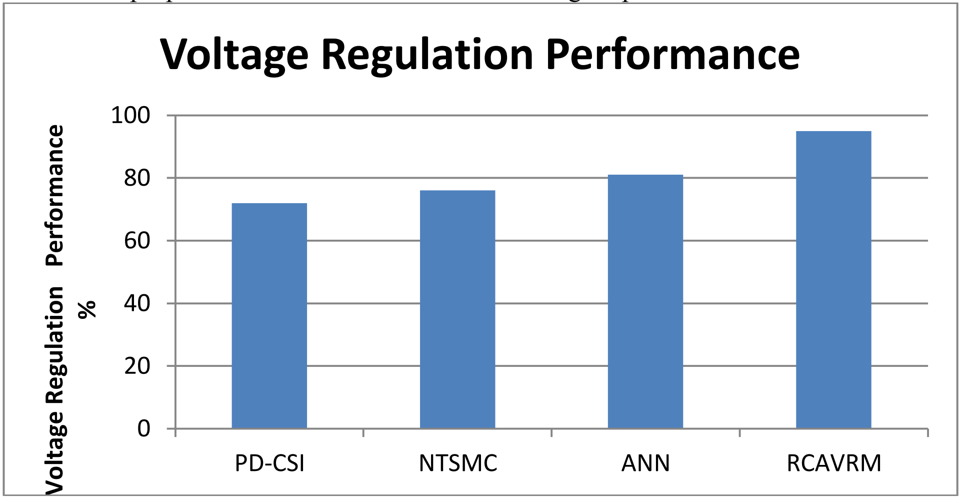

Figure 3: Analysis on Voltage Regulation

The performance of the models in voltage regulation are measured and compared with others. The proposed RCAVRM model introduces higher voltage regulation than others.

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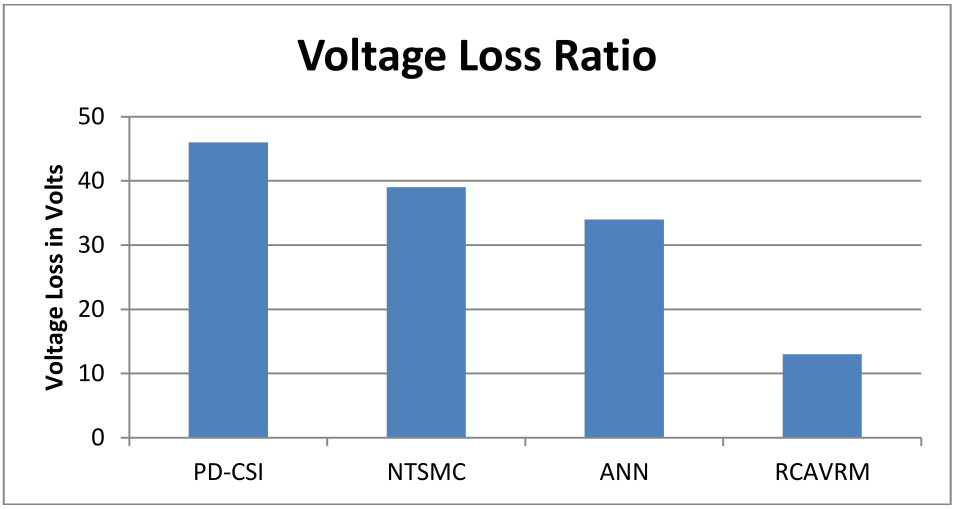

Figure 4: Analysis on voltage loss

The ratio of volts being lost has been measured and presented in Figure 4, where the proposed RCAVRM model produces less voltage loss than others.

3.Conclusion:

This article presents a novel RCAVRM model towards power stabilization. The model has been fabricated with different MOFSET and cuk converter connected in serial where the Mofset are designed to maintain the traces of voltage present in different capacitors and inductors. At each duty cycle, the method collects the number of circuits being used and number of other circuits not triggered. Based on these details, the method computes Capacitance Power Stabilization Factor (CPSF) and Voltage Absorption Factor (VAF). Using these two factors, the method computes the value of power stabilization weight (PSW) for different circuits. Based on the value of PSW, a unique circuit is selected to regulate the power supply to the electric system. The proposed RCAVRM model introduces higher power stabilization performance and voltage regulation with less voltage loss.

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