Drive State Analysis Based Electric Drive Control Model for Improved Power Stabilization

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Abstract: The problem of power stabilization in electric drives has been well studied. There exist numbers of approaches around the problem which consider the input power alone and suffer to achieve higher performance in power stabilization. To handle this issue, an efficient Drive State Analysis based Electric Drive Control model (DSA-EDCM) is presented in this article. The model monitors the drive state of electric drive at each duty cycle. According to the drive state and its previous conditions like voltage consumption, voltage leak, rpm and torque required, the method performs drive state analysis. The drive state analysis algorithm computes the power required at different conditions by computing Power Support value (PSV). Based on the PSV value, the method selects specific drive according to the input voltage received. Selected drive has been triggered for the cycle to maintain power stability. The proposed model improves the performance of power stability and maximizes the utilization performance.

Keywords:Drive Control, Electric Drive, Drive State Analysis, DSA-EDCM, PSV.

1. Introduction:

The modern human society utilize the electric devices for variety of purposes. The electric devices comes with different electric drives which requires specific power to perform the required operations. The power distributions systems regulate power for various electric devices and applications. However, each has different power requirement and the performance of the distribution system is greatly depending on the performance of power stabilization.

The power stabilization is the process of regulating the required power required for the electrical system. The electrical system would have number of electrical devices and each have their own drives to control the working of the device. By regulating and supplying the required voltage and by maintaining the power stability, the performance of the electrical system can be improved. In general, the power stability is performed based on

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the power requirement and input voltage produced by the power distribution system. However, the methods suffer to achieve higher performance in power stability.

The electrical drives which are connected in serial would be used to regulate the power as well as to run any electrical device. When the electrical device requires huge power requirement and torque, then the performance of the system is based on the power stability maintained. The torque required by the system can be maintained by regulating the power through the drives. When the drives have different and heterogeneous power requirement and torque required to run the drives, the fluctuating voltage can be used to regulate the power and produce required torque for the system by analyzing the conditions of the drives. In order to analyze the drive condition, it must be monitored at all duty cycle and by maintaining the trace of different electric drives, their average torque produced, average power consumption can be measured. By collecting such details about various drives, the power distributions system would regulate the required power through the drives and allow them to produce the required torque to support the electrical system.

The voltage regulation would maintain various aspects of the electric drives about the voltage or power consumed at various cycles according to the torque to be produced. By doing so, the power stability can be maintained towards effective functioning of the electric drives. As different drives required different voltage and produce various torques, the power stability can be maintained efficiently.

With the consideration to improve the power stability and torque required, an efficient Drive State Analysis based Electric Drive Control model (DSA-EDCM) is presented in this article. The method counts different factors of the electric drives and computes PSV value for various drives and according to the input voltage received, the method would identify different electric drives to perform the required task. The model would perform the power stability by measuring the PSV value for the cycle according to the input voltage and required torque for the drives. The detailed approach is discussed in the next sections.

2.Related Works:

There exists number of power stabilization models described in literature. This section presents the detailed analysis of the previous models.

A natural switching surface (NSS) fast transient boundary control (FTBC) is presented in [1], towards power stabilization for electric vehicles.

Finite-time observers (FTOs) and finite-time controller (FTC) based model is presented in [2], which consider system disturbances towards power stabilization.

A compound stabilizer is presented in [3], to enable floating dual boost converter (FDBC) towards power stabilization.

A systematic method is proposed in [4], which uses a digital filter towards power stabilization and minimizes the deviation.

A high-speed VFD with silicon carbide (SiC)-based MMC feeding scheme is presented in [5].

A sliding mode control (SMC) based energy storage system (ESS) controller is proposed in [6], towards accelerating the power by decoupling SG.

A nonlinear load and a photovoltaic (PV) inverter with adaptive quantum normalized-least mean fourth (q XE-LMF) filter is proposed [7]. A series damped passivity based control (PMC) is presented in [8], which consider dynamic performance of SRG.

A deep learning based model is presented in [9], towards efficient power stability. An inverter voltage compensation (IVC) strategy is presented in [10], which suppress the fluctuation of voltage. An integrated data-driven transient stability monitoring and enhancement (TSMAE) scheme is presented in [11], which uses spatial-temporal synchronous graph convolutional network (STSGCN), wide-area spatial-temporal features according to system stability are sufficiently learned to reliably implement online TSA.

Anonlinear model predictive control (NMPC) is presented in [12], to support torque-vectoring (TV) and front-to-total anti-roll moment distribution control of a four-wheel-drive electric vehicle with in-wheel-motors, a brake-by-wire system, and active suspension actuators.

A finite-time sliding mode surface with a faster convergence rate is presented in [13], which uses adaptive fixed-time reaching law (AFTRL) to perform rapid convergence.

All the above discussed methods suffer to achieve higher power stabilization performance.

2. Drive State Analysis based Electric Drive Control model (DSA-EDCM):

The proposed Drive State Analysis based Electric Drive Control model (DSA-EDCM) model monitors the drive state of electric drive at each duty cycle. According to the drive state and its previous conditions like voltage consumption, voltage leak, rpm and torque required, the method performs drive state analysis. The drive state analysis algorithm computes the power required at different conditions by computing Power Support value (PSV). Based on the PSV value, the method selects specific drive according to the input voltage received. Selected drive has been triggered for the cycle to maintain power stability [14].

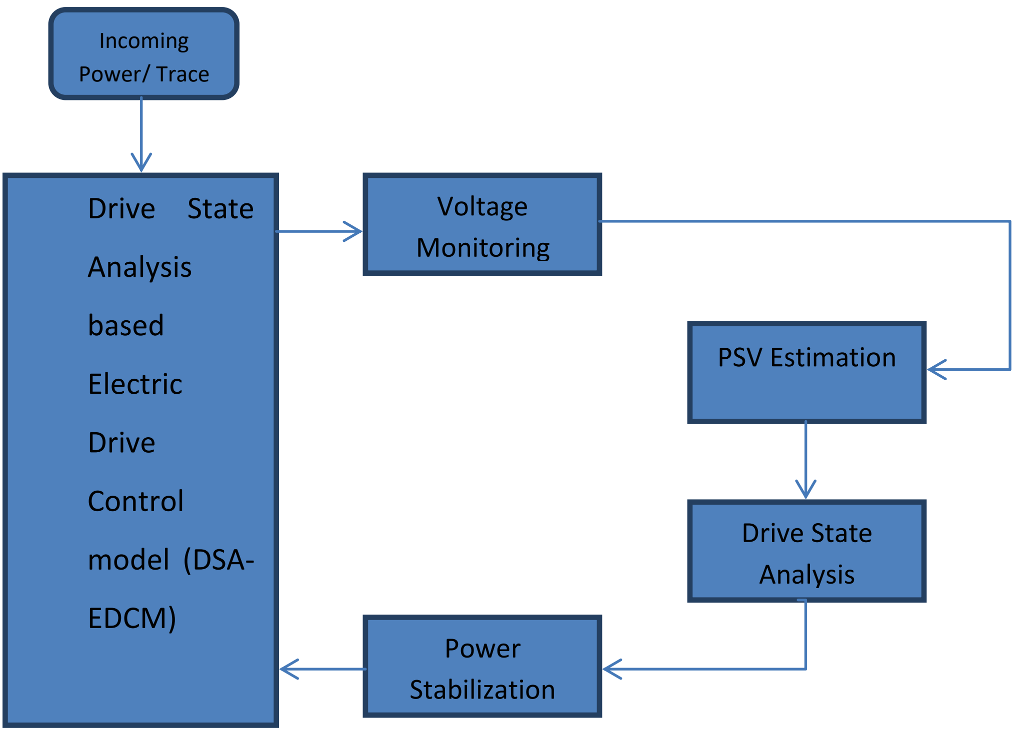

Figure 1: Architecture of Proposed DSA-EDCM model

The working model of proposed DSA-EDCM model is presented in Figure 1, which details the functions in this section

Voltage Monitoring:

The proposed model monitors the incoming voltage at each duty cycle. With the voltage being received, the method identifies set of drives available in the power distribution system. With the drives available, the method perform drive state analysis which estimates Power Support Value (PSV) according to the input voltage and torque support of various drives. According to the set of drives and their PSV value, the method identieis set of drives and performs power stabilization [15].

Algorithm:
Given: Power Trace PT and Input voltage Iv
Obtain: Null
Start
    Read PT and Iv.
    While true
        Receive input voltage Iv.
        Identify set of drives available.
        Drive set Ds = $\left(\sum_{i=1}^{size(PT)} PT(i).Drives \ni Ds\right)$
        For each drive d
            PSV = Perform drive state analysis
        End
        Perform power stabilization.
        Wait for next cycle.
    End
Stop

The voltage monitoring algorithm performs drive state analysis to measure PSV value of various drives and perform power stabilization.

PSV Estimation:

The power support value represents the efficiency of different drives towards power stability. The selection of drives for the cycle is performed using the PSV value measured for any drive. Given with the power trace, the method would compute the PSV value of rht drive for current duty cycle. It has been measured based on voltage consumption, voltage leak, rpm and torque required. Estimated value of PSV has been used to performs drive state analysis [16].

Algorithm:
Given: Power Trace PT, Drive D
Obtain: PSV
Start
    Read PT and D.
    Collect Drive Trace DT = $\sum_{i=1}^{size(PT)} PT(i).Drive == D$
    Compute voltage consumption rate VCR = $\frac{\sum_{i=1}^{Size(DT)} Sum(DT(i).VoltageConsumption)}{size(DT)}$
    Compute Voltage leak rate Vlr = $\frac{\sum_{i=1}^{Size(DT)} Sum(DT(i).VoltageLeak)}{size(DT)}$
    Compute Torque Rate TR = $\frac{\sum_{i=1}^{Size(DT)} Sum(DT(i).Torque)}{size(DT)}$

Compute Rpm rate Rr = $\frac{\sum_{i=1}^{Size(DT)} Sum(DT(i).Rpm)}{size(DT)}$

Compute PSV = $\frac{VCR}{Vlr} \times \frac{Tr}{Rr}$

Stop

The PSV estimation algorithm computes voltage consumption rate, voltage leak rate, rpm rate and torque rate. Using all these values, the method computes the value of PSV to support power stabilization.

Drive State Analysis:

The drive state analysis algorithm finds the set of drives available in the power system. For each drive available, the method computes the PSV value according to the history of traces. Using the PSV value, the method identifies set of drives to meet the requirement. Identified drives are used to perform power stabilization.

Algorithm:
Given: Power Trace PT and Input Voltage Iv
Obtain: Drive set Ds
Start
Read PT and Iv.
Identify drives set Drs = $\sum_{i=1}^{size(PT)} PT(i).Drives \ni Drs)$
Initialize drive set Ds.
For each drive d
PSV = perform PSV estimation.
PSV = PSV×Iv
If PSV>Th then
Add to drive set Ds = DS∪ D
End
End
Perform Power stabilization.
Stop

The drive state analysis algorithm computes PSV value according to various traces available and current input voltage condition.

Power Stabilization:

The power stabilization algorithm reads the drive set provided. Using the drive set, the method engages the selected drives with the power system and regulates the voltage through the drives. The rest of the drives are moved to sleep mode.

3.Results and Discussion:

The proposed drive state analysis based electric drive control model (DSA-EDCM) has been implemented with Simulink. The model has been analyzed for its performance under various simulation conditions. Obtained results are compared with the result of others.

Parameter	Value
Tool used	Simulink
No of Drives	100
Time	10 minutes

Table 1: Simulation Details

The simulation conditions used for the performance evaluation have been presented in Table 1.

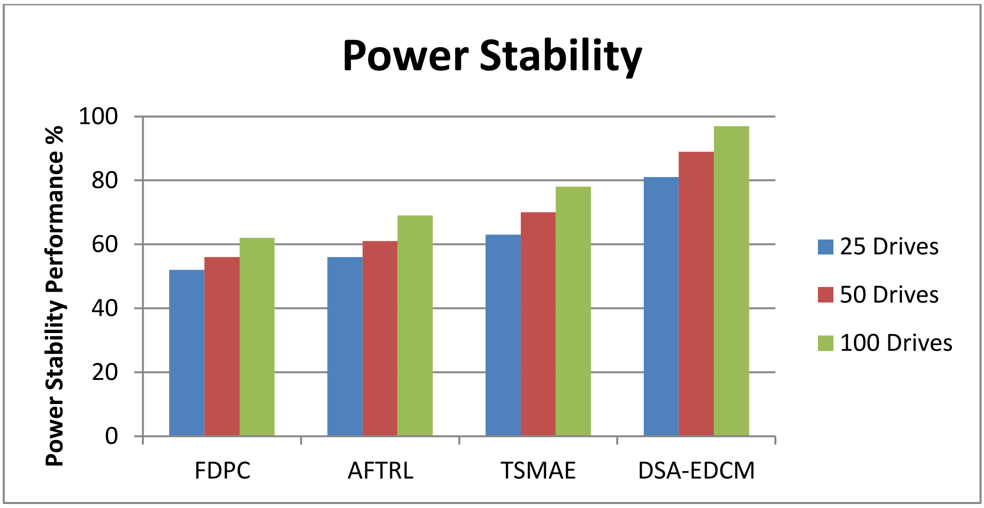

Figure 2: Power Stability Performance

The performance of method in power stability is measured and presented in Figure 2. The DSA-EDCM model introduces higher performance than others.

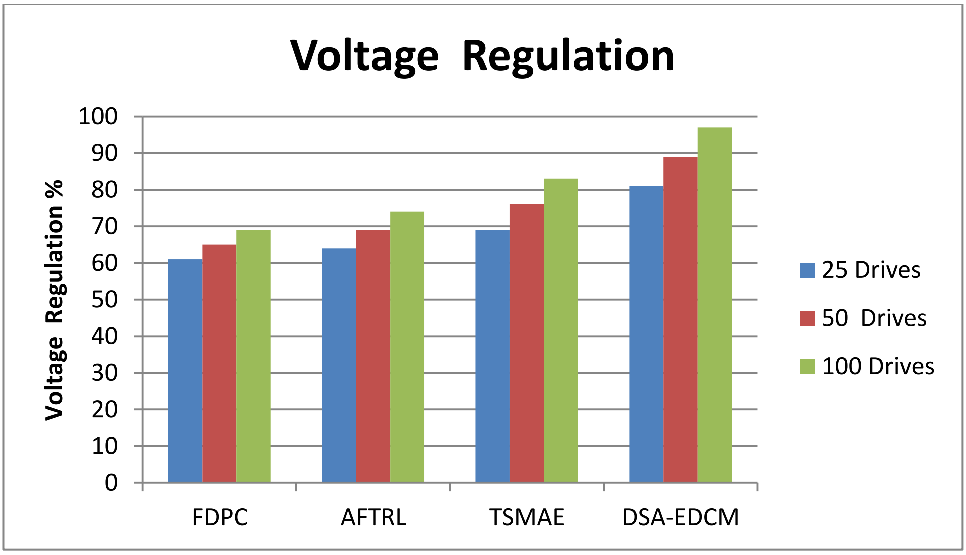

Figure 2: Voltage Regulation Performance

The performance of methods in voltage regulation is measured and presented Figure 3. The proposed DSA-EDCM method produces higher voltage regulation performance than others.

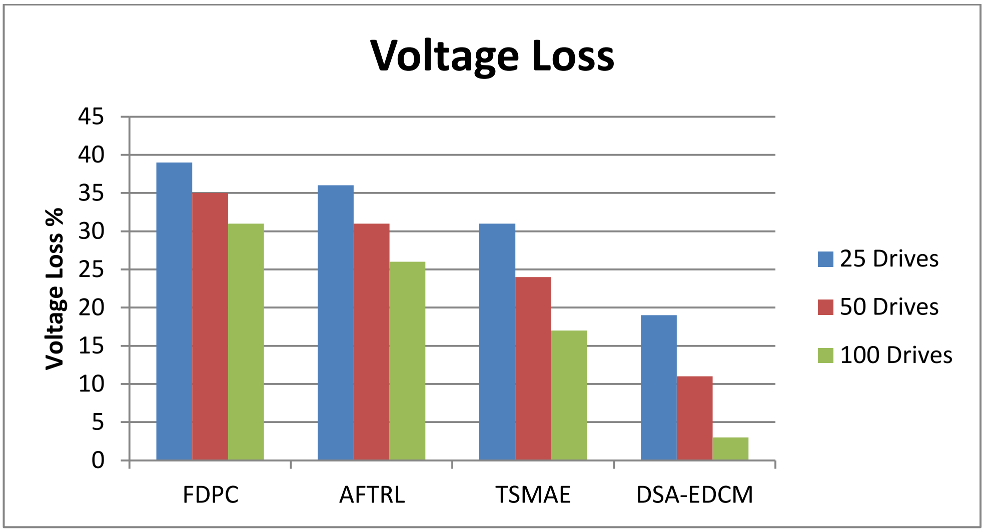

Figure 4: Voltage Loss

The voltage loss introduced by various models is measured and compared in Figure 4. The DSA-EDCM model introduces less voltage loss than other models.

4.Conclusion:

This paper presented a novel Drive state analysis based electric drive control model (DSA-EDCM). The proposed model monitors the incoming voltage at each duty cycle. With the voltage being received, the method identifies set of drives available in the power distribution system. With the drives available, the method perform drive state analysis which estimates Power Support Value (PSV) according to the input voltage and torque support of various drives. According to the set of drives and their PSV value, the method identifies set of drives and performs power stabilization. The proposed method improves the performance of power stability and reduces voltage loss.

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