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REACTIVE POWER MITIGATION USING FUZZY CONTROLLER FOR BUCK-TYPE DYNAMIC CAPACITOR

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ABSTRACT*:* The fundamental point of this venture is a half and half fluffy control methodology for receptive power remuneration and sounds concealment for Dynamic capacitor (D-CAP). Dynamic capacitor can give dynamic receptive power and symphonious pay for modern plants. Past papers have presented the standards and control techniques of D-CAP. In any case, there is no paper to concentrate on reverberation states of D-CAP. In this paper, in view of three-stage Buck-type D-CAP, essential structure and guideline are presented. In this task a half and half fluffy controls system for responsive power remuneration and music concealment for Dynamic capacitor (D-CAP). At present, numerous literary works have structured responsive power remuneration control work for single-stage and three-stage D-CAP. So as to make D-CAP have the capacity of consonant remuneration, a few papers planned the symphonious concealment work. Writing proposed an Even Harmonic Modulation (EHM) methodology, which made D-CAP smother the sounds when it was actualizing responsive power remuneration. Besides, in light of single-stage Buck-type D-CAP, writing proposed a procedure that DCAP could create controlled consonant current so as to improve itself comparing yield current waveform quality.

Keywords— Buck-type dynamic capacitor; reactive power compensation; current waveform improvement; even harmonic modulation; selective current tracking control.

1. INTRODUCTION

Because of expanding private and modern power request, different single-or three-stage receptive power loads, for example, cooling, electric-engine and transformer are associated with power framework. These heaps expend a lot of receptive power, prompting poor power factor and incremental framework misfortunes. In the meantime, receptive current move through inductive transmission line would cause a drop of the voltage from the Purpose of Normal Coupling (PCC) to control ground and even make it beneath edge esteem. With the end goal to take care of these issues, responsive power pay is essentially vital to enduring and solid task of entire power framework, which could be mostly executed by static and dynamic remuneration advances. Settled or mechanically exchanged power capacitors are typically introduced in parallel through network framework for power factor adjustment, which couldn't meet quickly changing receptive power request got from the incessant variety of burdens.

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Some progressed compensators dependent on DC/Air conditioning inverter, for example, STATCOM [6]-[8] could understand dynamic receptive power remuneration, however their reliabilities are for the most part impacted on DC-interface electrolytic capacitors, which ought to be supplanted occasionally with vast upkeep costs. Contrasted and above compensators, dynamic capacitor, or, in other words redesigning power capacitor with direct air conditioning/air conditioning converter, is a basic and conservative answer for dynamic receptive remuneration. D-Top could viably repay receptive current dependent on the framework current discovery. Notwithstanding, undesirable symphonious parts from D-Top yield current may be produced under the activity of foundation consonant voltage of lattice voltage or voltage drop of switches, which even causes framework soundness issue because of arrangement or parallel consonant reverberation. This paper exhibits a solitary stage Buck-type dynamic capacitor to create wanted receptive power remuneration current by methods for inductive load current (or given responsive reference current) following control and stifle itself consonant current parts at the same tim

2. LITERATURE SURVEY

2.1 Dynamic Var/harmonic compensation with inverter-less active filters

Industrial plants are faced with stringent requirements enforced by the utility to meet power factor and power quality requirements. These plants, in order to avoid very costly penalties, have traditionally utilized switchable shunt capacitor banks with detuning reactors for power factor correction, along with a separate active harmonic filter in cases where harmonic currents are an issue as well. Alternate solutions such as SVCs and STATCOMs have been considered to be too expensive for use in industrial power conditioning applications. This paper proposes a dynamic capacitor (D-CAP) based on the family of inverter-less active filters (ILAF) that is able to provide a dynamically controllable capacitance with active harmonic compensation integrated onto the same unit. This new device is seen to be compact, and is likely to be cost competitive against simple switched shunt capacitors. It can maintain power factor close to unity, offering dynamic capabilities better than switched capacitors or SVCs, possibly lending itself for arc-furnace type of loads.

2.2Comparison of High Capacity SVC and STATCOM in Real Power Grid

Both SVC (Static Var Compensator) and STATCOM (Static Synchronous Compensator) are important equipment of reactive compensation, which are compared in voltage supporting, improving the transient stability and transmission limit, and damping low frequency oscillation. Simulation results are presented as high capacity static var system for SVC or STATCOM is placed on transmission path of power system. Firstly, single SVC and STATCOM are limited in voltage supporting after fault occurrence, but STATCOM is little better than SVC. Secondly, STATCOM is much better than SVC in improving the transient stability and transmission limit. Thirdly, on the damping low frequency oscillation, STATCOM is much better than SVC as SVC and

STATCOM have the same capacity, and performs similarly with SVC as the two have the same controllable capacity. Lastly, the results also indicate that dynamical response speed effects the control result little though STATCOM responses much faster than SVC.

2.3Dynamic capacitor (D-CAP): an integrated approach to reactive and harmonic compensation

Industrial plants are faced with stringent requirements enforced by the utility to meet power factor and power quality requirements. These plants, in order to avoid very costly penalties, have traditionally utilized switchable shunt capacitor banks with detuning reactors for power factor correction, along with a separate active harmonic filter in cases where harmonic currents are an issue as well. Alternate solutions such as SVCs and STATCOMs have been considered to be too expensive for use in industrial power conditioning applications. This paper proposes a dynamic capacitor (D-CAP) based on the family of inverter-less active filters that is able to provide a dynamically controllable capacitance with active harmonic filtering integrated into the same unit. This new device is seen to be compact, and is likely to be cost competitive against simple switched shunt capacitors. It can maintain power factor close to unity, offering dynamic capabilities better than switched capacitors or SVCs, possibly lending itself for arc-furnace type of loads.

2.4Reactive power compensation with improvement of current waveform quality for single-phase buck-type Dynamic Capacitor

Due to relatively low cost and flexible performance, Dynamic Capacitor (D-CAP) is often designed to implement dynamic reactive power compensation, whose output current might distort under the effects of background harmonic voltage from the grid or non-ideal PWM mode caused by non-linear switch characteristics. This paper presents a reactive power compensation control strategy with waveform quality amelioration of output capacitive current for single-phase Buck-type D-CAP. Through establishing basic control equations, reactive power compensation principle and equivalent model of single-phase Buck-type D-CAP are analyzed. In order to suppress output harmonic current, duty ratio of Buck-type D-CAP is generated by means of introducing Even Harmonic Modulation (EHM). Then a selective current control strategy in multiple synchronous reference frames is adopted to track reactive power compensation current reference with nearly zero steady-state error and alleviate output current distortion with demanded harmonic components. Finally, a series of experimental results from single-phase Buck-type D-CAP laboratory prototype are provided to verify the validity of dynamic reactive power compensation and almost sinusoidal output current waveform optimizing method.

3. CIRCUIT PRINCIPLE AND BASIC CONTROL METHOD OF BUCK-TYPE D-CAP

3.1 Principle of Buck-type D-CAP

Basic circuit structure of Buck type D-CAP is shown in Fig. 1(a), which includes mainly power capacitor *C* and Buck type Thin AC

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converter. Power capacitor *C* is in series with a little buffer inductor *L*B so that inrush current of power capacitor could be limited when switches are turned on or off. Front-end filter is used to suppress high-order harmonic components of D-CAP output current, which is composed of filtering inductor *L*F and filtering capacitor *C*F. When D-CAP works normally, the switches S1 and S2 are turned on complementarily. Two basic operating states of switch circuit are shown in Fig. 1(b), where duty ratios of switches S1 and S2 are *D* and 1-*D* respectively. Due to forward and reverse flows of capacitor current, S1 and S2 should be designed as bidirectional switches. As shown in Fig. 1(c), bidirectional switch could be composed of two common-collector or common-emitter IGBTs in reversed series. In this paper, bidirectional switch S1 is composed of two common-collector IGBTs in series while S2 is made up of two common-emitter IGBTs in series.

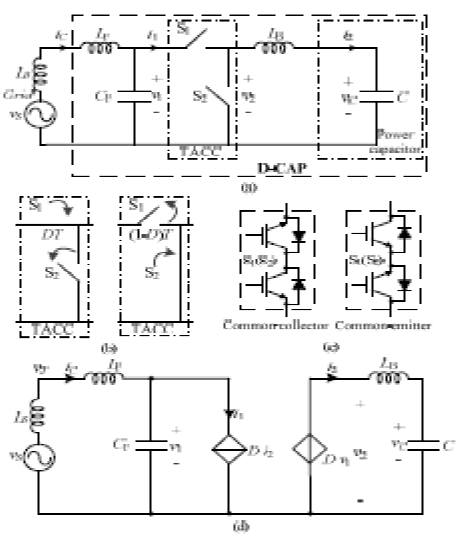

Fig. 1. Single-phase Buck-type D-CAP (a) Main circuit (b) Two operating states of switch circuit (c) Bidirectional switches (d) Equivalent circuit model

In Fig. 1(a), it is defined that iC(t) is D-CAP output current, v1(t) is the voltage of filtering capacitor CF, i1(t) is converter side current flowing through the switch S1, D(t) is duty ratio of S1, v2(t) is port voltage of the branch composed of buffer inductor LB and power capacitor C, and i2(t) is the current of power capacitor C.

3.2 Proposed Reactive Power Compensation Control Strategy

System configuration diagram with single-phase Buck-type D-CAP is shown in Fig. 2(a). D-CAP is designed to generate reactive power compensation current and suppress its own harmonic current simultaneously. Control system of D-CAP is given in Fig. 2(b), in which a selective current tracking control is implemented in multiple synchronous reference frames. In order to obtain reference current components in *αβ* stationary reference frame, inductive load current i_L (or given reactive reference current i_C^*) is directly used to generate *α*-axis reference current components and *β*-axis reference current component is extracted from i_L (or i_C^*) through time-delay of a quarter of fundamental period *T*/4. Meanwhile, D-CAP output current i_C is directly used to generate *α*-axis feedback current component and *β*-axis feedback current component is also extracted from i_C through time-delay of a quarter of fundamental period *T*/4. Then *α*-axis and *β*-axis reference current components from i_L (or i_C^*) are transformed to fundamental reference frame through *C2s/2r* transform in order to extract reactive reference current component i_{Cq1}^*. In addition, *α*-axis and *β*-axis feedback current components from i_C^* are also transformed to

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fundamental reference frame through $C_{2s/2r}$ transform in order to extract reactive feedback current component i_{Cq}^{1}.

Thus fundamental duty ratio D_0 would be generated through the regulation of PI controller. Similarly, α-axis and β-axis feedback current components from i_C is also transformed to h^{th} harmonic reference frame to generate h^{th} harmonic current components i_{Cdh} and i_{Cqh}, which would be adjusted by PIh controller in order to obtain $(h\text{-}1)^{th}$ harmonic duty ratio D_{h-1} through h-1 order reverse $C2s/2r$ transform. Finally, all duty ratio references are added to obtain total duty ratio reference D. Thus D-CAP output current i_C could be regulated to track reactive reference current and alleviate itself distortion simultaneously. Transformation matrix from $\alpha\beta$ stationary reference frame to dq synchronous rotation reference is as bellow.

$$C_{2s/2r} = \begin{bmatrix} (-1)^n \sin(h\omega t) & -\cos(h\omega t) \\ \cos(h\omega t) & (-1)^n \sin(h\omega t) \end{bmatrix}$$

Where n=0 at h=4m-3 while n=1 at h=4m-1 (m is positive integer).

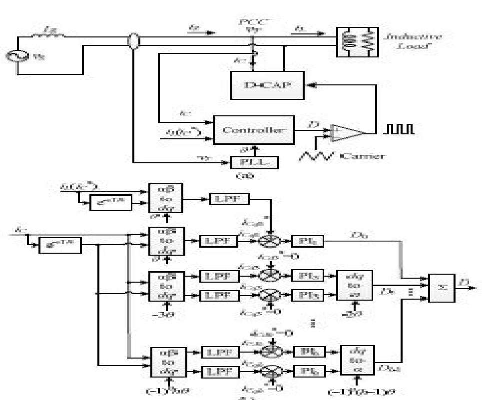

Fig. 2. Single-phase power system configuration with Buck-type D-CAP (a) Total system structure (b) Control system of Buck-type D-CAP

4. SIMULATION RESULTS

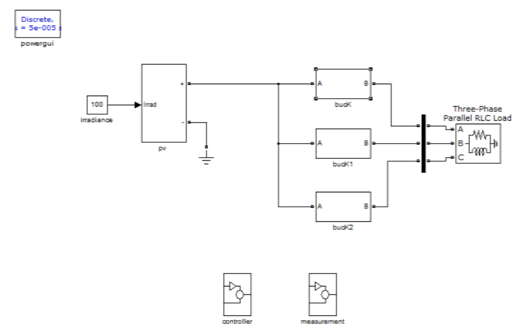

Fig .MATLAB/SIMULINK diagram of proposed buck type D-CAP

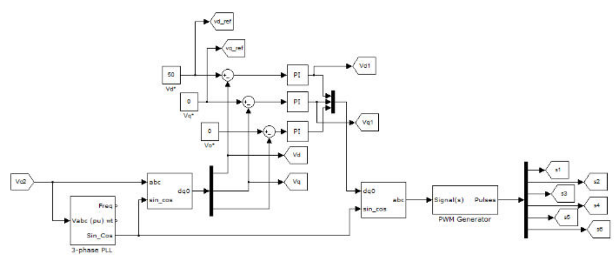

Fig Controller subsystem

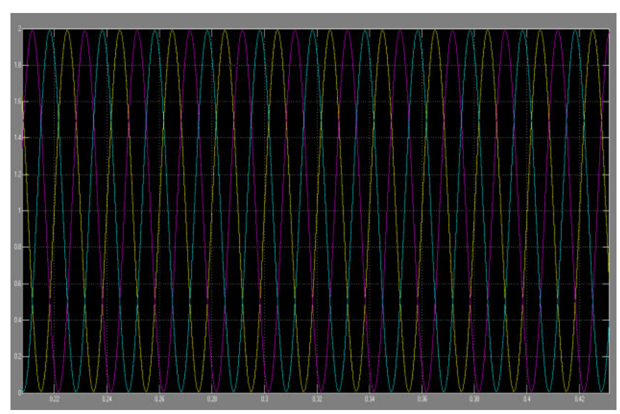

Fig D-CAP realizes reactive power compensation Load voltage

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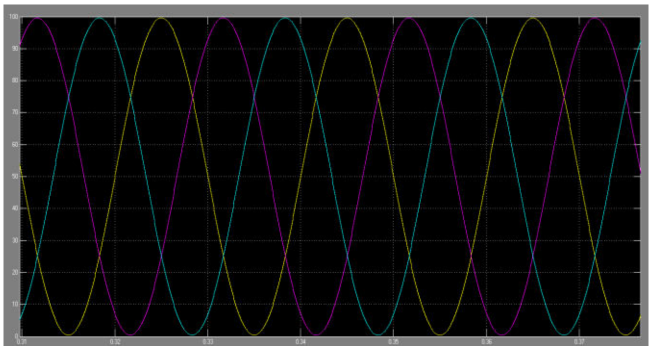

Fig D-CAP realizes reactive power compensation D-CAP voltage

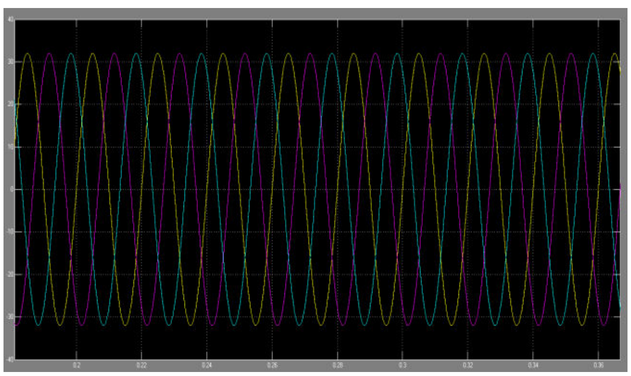

Fig D-CAP realizes reactive power compensation D-CAP current

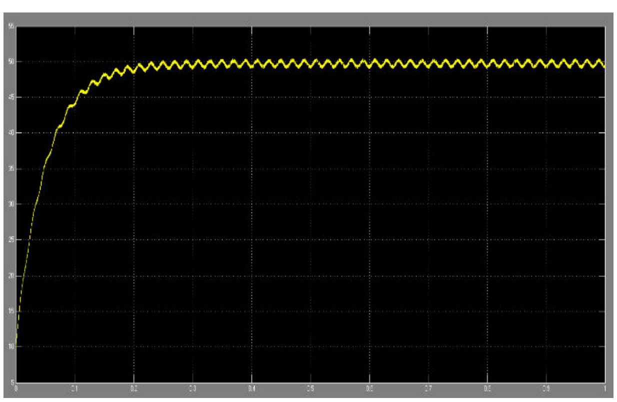

Fig D-CAP input voltage

CONCLUSION

This paper centers around receptive power pay control technique with change of yield current waveform quality for Buck-type D-Top. Essential rule examination gathers that DCAP could be proportionate to constantly customizable capacitor when obligation proportion ranges from 0 to 1. Along these lines dynamic receptive power pay for D-Top could be actualized by methods for modifying obligation proportion. Because of foundation consonant voltage from the framework and non-perfect PWM mode caused by voltage drop of switches, D-Top yield current would incorporate some low-arrange symphonious segments, which couldn't take care of the demand of intensity quality benchmarks. Through receptive power remuneration control with particular change of yield current waveform quality, D-Top yield current twisting could be incredibly moderated. A ton of test results uncover that proposed Buck-type D-Top could create wanted capacitive pay current, whose low-arrange symphonious current segments have been stifled. In the interim, consistent state mistake of yield current could likewise be restricted to around 1%.

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