논문 2006-43IE-1-5

PACAD/EMTDC을 이용한 유도기 부하를 고려한 DSTATCOM의 보상제어에 관한 연구

(A Study on the Compensation Control of Distribution Static Compensator Considering Induction Motor Load Using PSCAD/EMTDC)

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요 약

유도전동기는 기동 시 전류가 정격전류의 6~8배에 이르기 때문에 경 부하로 운전하는 경우에는 역률을 떨어뜨릴 뿐만 아니라 과다한 기동전류로 인해 계통전원에 순간전압 강하를 유발시켜 선로의 전력품질저하가 심각하게 대두되고 있다. 본 논문에서는 PSCAD/EMTDC 패키지를 이용하여IEEE에서 제시한 배전 계통 13버스 모형 모델 및 유도기 부하를 모델링 하여 사고모의 및 DSTATCOM의 보상효과를 시뮬레이션을 통하여 보였다.

Abstract

When induction motor moves, power quality decline of line is risen seriously because provoking voltage drop the moment to system power supply by excessive moving current as well as power-factor drop in case drive by light-load because current reaches in 6 times ~ 8 times of rated current. In this paper, a modeling did an distribution system 13 bus type model and induction machine load presents in IEEE using a PSCAD/EMTDC package, and it displayed an accident conspiracy and a compensating factor of DSTATCOM through simulation show.

Keywords : direct broadcast system, global positioning system, personal communication services, finite difference time domain, photonics band gap

Ⅰ. Introduction

While cope in demand for power that increase rapidly using minuteness control that use the brilliant development and computer of semi-conductor element technology recently, way to change power transmission mode to active way to be not existent passive way was appeared.

Though next generation power transmission technology that supplement limitation of interchange system introducing control technology that use insulated gate bipolar transistor(IGBT) switching element to usual interchange transmission line using this and improve so that use system as more efficient and accommodating proposed in late 80 year by electric power research institute(EPRI), this is flexible alternate current transmission systems (FACTS).

Attempt for effective and economical power supply and demand calls this as custom power becoming FACTS and division though is held continuously applying power electron technology such as FACTS that is applied to power transmission system to supply of distribution system.

There is some difference in kind etc. of power

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접수일자 : 2005년9월5일, 수정완료일2006년3월15일

electron element technology to concept that is invented by FACTS and custom power each power transmission that increase and purpose that is applied to supply of distribution system thus.

In the case of capacity, in the case of FACTS machine, it is tens to hundreds MWs, but custom power machine are about MW.

Also, while application purpose is FACTS power transmission power increase, power flow control and stability elevation, custom power is believability elevation, power quality sophistication etc.

There are serial, multiple, series parallel 3 method as method to connect various FACTS machine and custom power machine to power system.

Parallel compensation device of them does not deteriorate believability of system and have advantage that catenate is effective component for voltage size control is possible.

STATic COMpensator(STATCOM) that is parallel FACTS machine is expected to achieve important role in power quality sophistication as machine that make Distribution STATic COMpensator(DSTATCOM) that is parallel custom power machine that see to figure 1 as useful machine that can achieve voltage and nullity power control extend STATCOM of power transmission system to supply of power system[1~2]

Improve power-factor using mainly fixing capacitor bank and breakup control capacitor bank etc. for efficient use of private car electrical device for industry and commerce and thyristor reorganization capacitor and thyristor variableness status reactor etc. of load unbalance are used serious arc and electric furnace etc.

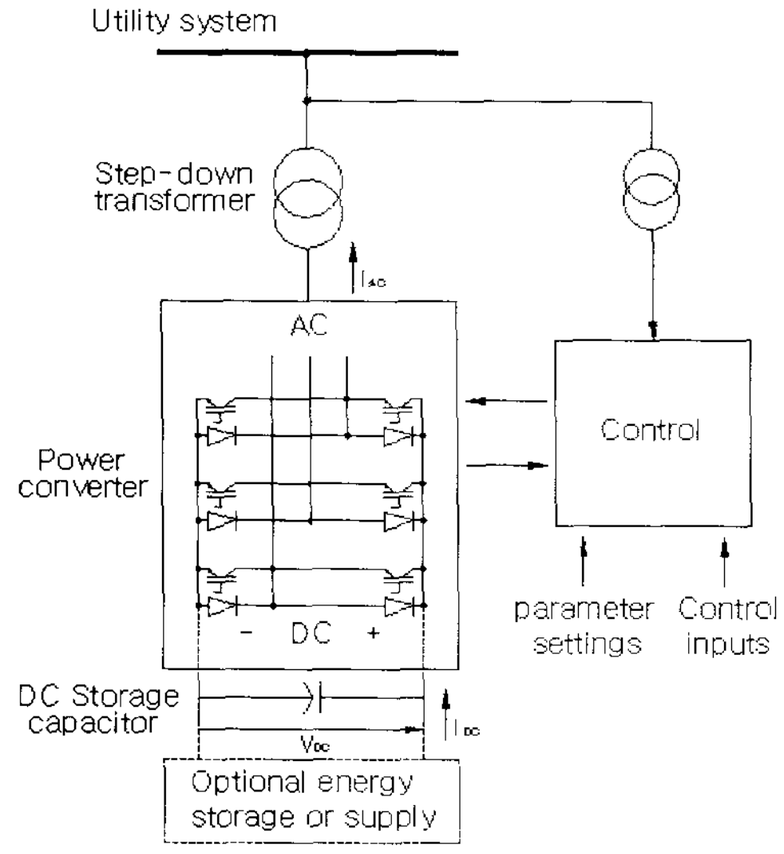

그림 1. DSTATCOM의 구성
Fig. 1. Composition of DSTATCOM.

By the way, discharge problem of current electric charge, distortion of waveform by harmonic, inflow current that exaggerate at capacitor make and break or something wrong voltage etc. of reactive power compensation method by capacitor for power happens and response is very slow and there is shortcoming that authoritativeness drops.

And thyristor valve way is available reactive power compensation of one of condensive or ground and response rain uninterrupted it be and as well as it is noneconomic single pole many switching elements and big capacitor or inductor bank being required, lose power-factor improvement ability because many switching elements and big capacitor or inductor bank should be disadvantageous in private electrical installation in serious load unbalance[3].

Information loss announcement of information communication appliance, exchange information breakdown of system etc. that increase rapidly in the recent info-age because voltage sag occurrence etc. by acumination subordinate rapid increase or single line accident, three phase unbalance etc. can make power quality badly appliance for individual within 1 0%, power quality that keep voltage times same ratio within 5% of large size kinds of machine is required[4].

Also, supply of power of power high quality is required together to equipment that it is stability naturally that medical system that stability and authoritativeness are high excellently than general electric machine designs medical machine itself safety.

Distribution static synchronous compensator can supply ground according to subordinate situation and some side of real situation nullity power suspension style winter season for supply of power that can fulfill power request of such good quality, can

improve power-factor spontaneously to power-factor change that change to do unspecificness controlling nullity power consecutively exactly, is studied so that can prevent malfunction of sensitive machine such as company business courage command or micro processor controller as that remove harmonic current that non-linear load happens[5~6].

Ⅱ. Theoretical ancient temple

1. Instantaneous imaginary power justice

If express their quantity by instantaneous space vector instantaneous voltage and round of instantaneous current mathematically in 3-phases circuit, is same with figure 2.

Instantaneous current (i_a, i_b, i_c) and instantaneous voltage (v_a, v_b, v_c) 3-phase that do not include zero-phase ingredient by α, β next time way by change.

α, β Is same with way (2) with way (1) if define coordinate conversion[7].

$$\begin{bmatrix} v_\alpha \\ v_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \quad (1)$$

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} \quad (2)$$

Usually, round of instantaneous power p of 3-phase circuit is same with way (3).

$$p = v_a i_a + v_b i_b + v_c i_c \quad (3)$$

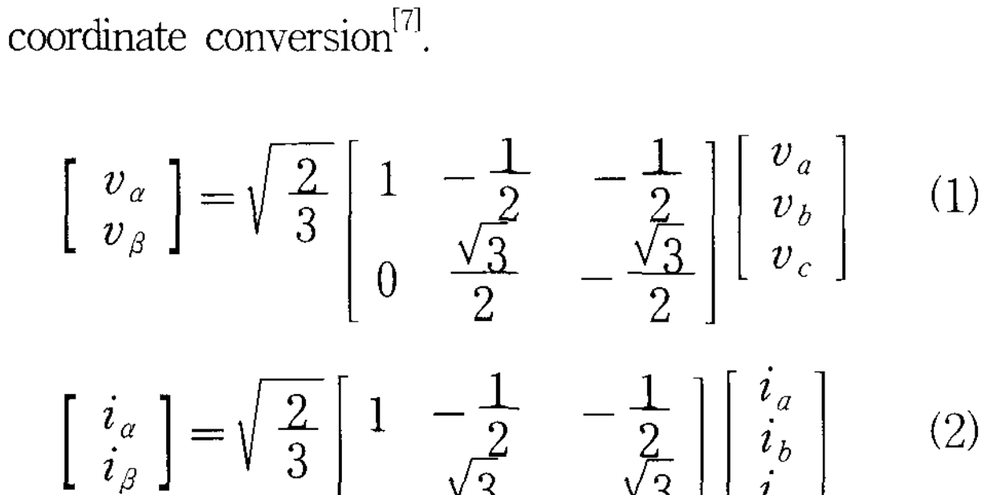

그림 2. α, β 좌표 변환

Fig. 2. α, β coordinate conversion.

This time α, β coordinate upper is expressed by way (4) by way (1) and way (2).

$$p = v_\alpha i_\alpha + v_\beta i_\beta = \begin{bmatrix} v_\alpha & v_\beta \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \quad (4)$$

P is instantaneous active power and by p of way (4) in voltage circle case instantaneous current i_α, i_β as random decide can.

So, define instantaneous imaginary power space vector in way (5) moment.

$$q = v_\alpha \times i_\alpha + v_\beta \times i_\beta \quad (5)$$

If express way (4) and way (5) by matrix

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \quad (6)$$

In way (6)

$$\begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix} = v_\alpha^2 + v_\beta^2 \neq 0 \quad (7)$$

and can know that p and q are independent variable. Therefore, if readjust way (6)

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix}^{-1} \begin{bmatrix} p \\ q \end{bmatrix} \quad (8)$$

only, $\begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix}$1 column and 2 column are linearly independent.

The case of Voltage source, p and q using way (8) instantaneous current i_α, i_β as random decide can.

Also, form at ocean to free voltage (instantaneous value), current (instantaneous value) that do not include zero-phase ingredient by way (1) and way (2).

As clear clearly way (3) and way (4), each clause of p it of instantaneous voltage and instantaneous current of statue because is less instantaneous power be.

q each item is quantity of electricity that it is no substance as energy because is less of instantaneous current other with instantaneous voltage certain about this.

So, in way (8) because instantaneous current

i_α, i_β if separate of p and q

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix}^{-1} \begin{bmatrix} p \\ 0 \end{bmatrix} + \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix}^{-1}$$

$$* \begin{bmatrix} 0 \\ q \end{bmatrix} = \begin{bmatrix} i_{\alpha p} \\ i_{\beta p} \end{bmatrix} + \begin{bmatrix} i_{\alpha q} \\ i_{\beta q} \end{bmatrix} \quad (9)$$

here.

α phase instantaneous active current :

$$i_{\alpha p} = \frac{v_\alpha}{v_\alpha^2 + v_\beta^2} p$$

β phase instantaneous reactive current :

$$i_{\alpha q} = -\frac{v_\beta}{v_\alpha^2 + v_\beta^2} q$$

α phase instantaneous active current :

$$i_{\beta p} = \frac{v_\beta}{v_\alpha^2 + v_\beta^2} p$$

β phase instantaneous reactive current :

$$i_{\beta q} = \frac{v_\alpha}{v_\alpha^2 + v_\beta^2} q$$

is get.

Of each phase instantaneous active current and instantaneous reactive current can decide as random p and q.

Here, instantaneous power p_α of α phase, instantaneous power p_β of β phase that if speak these using instantaneous active current and instantaneous reactive current each phase by way (10) give.

$$\begin{bmatrix} p_\alpha \\ q_\beta \end{bmatrix} = \begin{bmatrix} v_\alpha i_\alpha \\ v_\beta i_\beta \end{bmatrix} = \begin{bmatrix} v_\alpha i_{\alpha p} \\ v_\beta i_{\beta p} \end{bmatrix} + \begin{bmatrix} v_\alpha i_{\alpha q} \\ v_\beta i_{\beta q} \end{bmatrix}$$

$$= \frac{v_\alpha^2}{v_\alpha^2 + v_\beta^2} p + \frac{v_\beta^2}{v_\alpha^2 + v_\beta^2} p \quad (10)$$

If express instantaneous active power using way (9) and way moment (10) in 3-phase circuit.

$$p = p_\alpha + p_\beta$$

$$= \frac{v_\alpha^2}{v_\alpha^2 + v_\beta^2} p + \frac{v_\beta^2}{v_\alpha^2 + v_\beta^2} p - \frac{v_\alpha v_\beta}{v_\alpha^2 + v_\beta^2} q + \frac{v_\alpha v_\beta}{v_\alpha^2 + v_\beta^2} q$$

$$= \frac{v_\alpha^2}{v_\alpha^2 + v_\beta^2} p + \frac{v_\beta^2}{v_\alpha^2 + v_\beta^2} p \quad (11)$$

Is same with that depend way (10) and way (11)

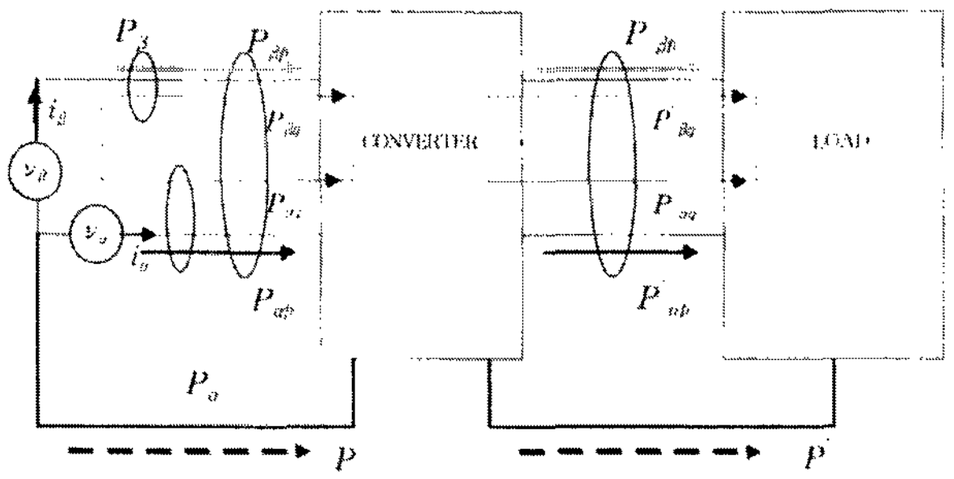

그림 3. 순시 전력 흐름

Fig. 3. Instantaneous power flow.

$$p = v_\alpha i_{\alpha p} + v_\beta i_{\beta p} \quad \triangle p_{\alpha p} \quad p_{\beta p} \quad (12)$$

$$0 = v_\alpha i_{\alpha q} + v_\beta i_{\beta q} \quad \triangle p_{\alpha q} \quad p_{\beta q} \quad (13)$$

only,

α phase instantaneous active power :

$$p_{\alpha p} = \frac{v_\alpha}{v_\alpha^2 + v_\beta^2} p$$

α phase instantaneous reactive power :

$$p_{\alpha q} = -\frac{v_\beta}{v_\alpha^2 + v_\beta^2} q$$

β phase instantaneous active power :

$$p_{\beta p} = \frac{v_\beta}{v_\alpha^2 + v_\beta^2} p$$

β phase instantaneous reactive power :

$$p_{\beta q} = \frac{v_\beta}{v_\alpha^2 + v_\beta^2} q$$

can get following conclusion way (12) and way (13).

1) Sum of instantaneous powers coincides with instantaneous active power in 3-phase circuit moment. Therefore, it is instantaneous active power $p_{\alpha p}$, $p_{\beta p}$.

2) $p_{\alpha p}$, $p_{\beta p}$ do not influence in power from power flow supply to load because is canceled each other.

Therefore,

$p_{\alpha p}$, $p_{\beta p}$ it is instantaneous reactive power moment.

figure 3 generalized round of instantaneous power flow of power converter system.

figure 3 imaginary power q input side instantaneous and imaginary power q' output side instantaneous between relation $q \neq q'$.

Can know that is $p=p'$ if suppose that there is no energy storage and damage of power converter is zero.

2. Consider zero-phase ingredient controller design

Must consider zero-phase ingredient of 3-phase 4-wire system distribution line.

Can extend to instantaneous reactive power theory that zero-phase ingredient is included.

Then, do conversion possibility by with(15) each way (14) with(2) way (1).

$$\begin{bmatrix} v_0 \\ v_\alpha \\ v_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \quad (14)$$

Do conversion possibility by coordinate $0-\alpha-\beta$ is moment similarly instantaneous space vector $i_a,\ i_b,\ i_c$

$$\begin{bmatrix} i_0 \\ i_\alpha \\ i_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} \quad (15)$$

If define on(v_0) and (i_0) instantaneous power p_0 is 0 axis phase, way (16) becomes.

$$p_0 = v_0 \cdot i_0 \quad (16)$$

Then, if way (16) is given by way (17), current to compensate this time is given with way (18).

$$\begin{bmatrix} p_0 \\ p \\ q \end{bmatrix} = \begin{bmatrix} v_0 & 0 & 0 \\ 0 & v_\alpha & v_\beta \\ 0 & -v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} i_0 \\ i_\alpha \\ i_\beta \end{bmatrix} \quad (17)$$

$$\begin{bmatrix} i_{ca}^* \\ i_{cb}^* \\ i_{cc}^* \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & 1 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} -i_0 \\ i_{c\alpha}^* \\ i_{c\beta}^* \end{bmatrix} \quad (18)$$

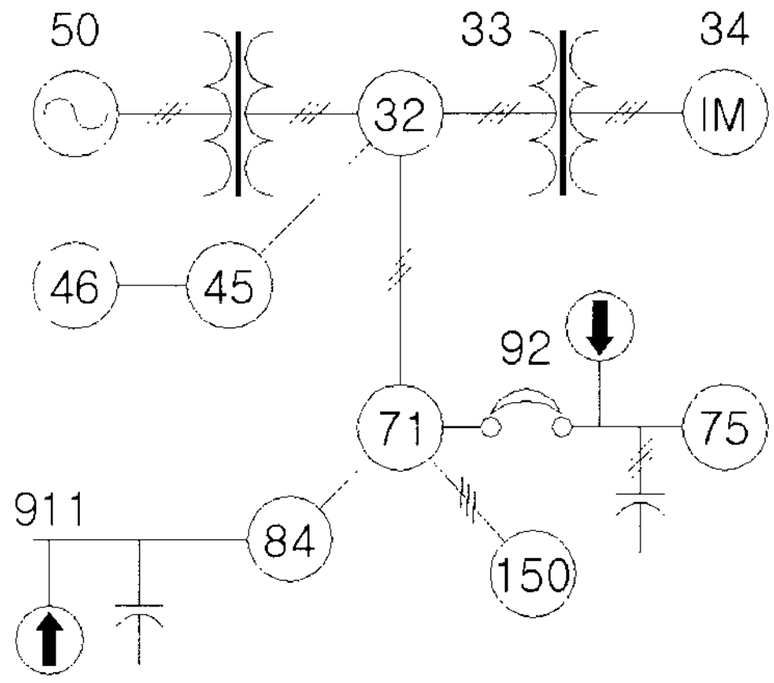

그림 4. IEEE 13 버스 방사 배전 계통
Fig. 4. IEEE 13 bus radial distribution system.

Compensation of zero-phase ingredient zero-phase current i_0 consist.

If voltage change does not happen, $\overline{q_v}$ computational procedure is omitted.

But, to compensate DC voltage fluctuation by DSTATOCM damage $\overline{q}_{loss}$ always arithmetic do.

Therefore, arithmetic of compensation standard current can appear with way (19).

$$\begin{bmatrix} i_{c\alpha} \\ i_{c\beta} \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} -\tilde{p}+\triangle\overline{p} \\ -q+q_v \end{bmatrix} \quad (19)$$

only,

$$\triangle\overline{p} = \overline{p_0} + \overline{p}_{loss}$$

III. Simulations

When induction motor that is representative turning machine of private electrical installation moves, big mobile warfare kind (400~600 % of rated current) can have passed and burn winding because is same with transformer that short-circuit the second.

Also, because power-factor is very low, the moving torque is less comparatively and necessary apparent power greatens in moving.

If become so, to supply of distribution system that electric motor is connected hindrance week date that become painfully to order moving smoothly because

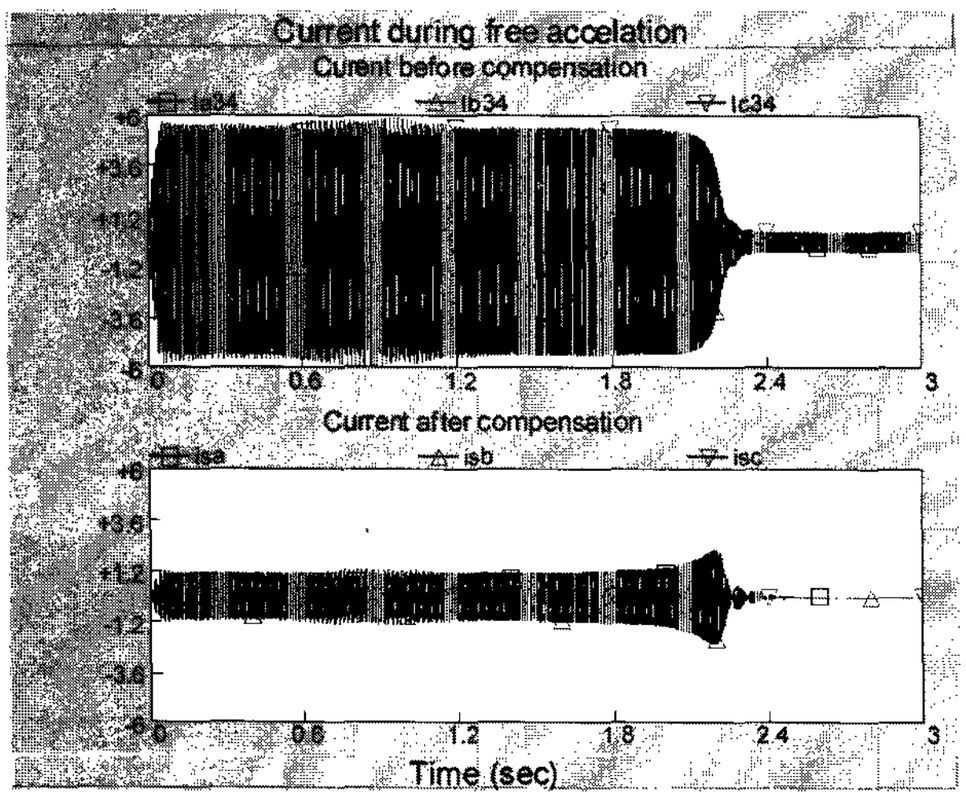

그림 5. 보상전후 기동전류
Fig. 5. After moving current before compensation.

event happens be.

That is, transient current is big and confirmed DSTATCOM transient power-factor improvement special quality because reactive power changes rapidly during moving section.

Apply and tried DSTATCOM in induction machine (600HP, ground power-factor 0.82, moving capacity is home by regular sextuple in ground power-factor 0.41 while drive) front off that is situated to 34 bus of figure 4 IEEE 13 bus supply of distribution systems to verify excessive reactive power compensation effect.

Using controller that instantaneous power concept moment in figure 5 arithmetic at no-load after done DSTATCOM compensation starting current of induction machine that decrease to 120% know can. Therefore, that make use of mainly induction motor since is low establish correct DSTATCOM in capacity of transfer equipment and changes atypically in 2.3 [sec] by do current control properly who consumer's reactive power industry person of moment compensating 25% high moment keep can.

IV. Conclusion

Power quality decline of line is risen seriously provoking voltage drop the moment in system power supply by excessive moving current which occur under induction machine load consideration.

In this paper, supply of distribution system 13 bus models and induction machine load that presents in IEEE using PSCAD/EMTDC package because do modelling accident fur and DSTATCOM compensation effect through simulation show.

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