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# DESIGN AND ANALYSIS OF INDUCTION MOTOR START UP METHOD BY MMCI - DSCC

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***Abstract-*** This paper, the sensible without speed-sense start-up approach for an induction motor driven via a modular multilevel cascade inverter based on double-start chopper cells (mmci-dscc) from stand- still to center speed. Utility of this motor power in particular for a big-capability fan-or blower-like load. The load torque is proportional to (motor mechanical velocity)2. The start-up technique is characterised by using combining capacitor-voltage manage with motor-speed manipulate. The motor-speed control with the ordinary stator current performs a important role in doing away with a speed sensor from the power machine and in reducing an ac- voltage fluctuation taking place across every dc capacitor.

***Index Term*** -Medium-voltage induction motor drives, minimal stator current, modular multilevel cascade inverters, speed- sensorless start-up method.

## I.INTRODUCTION

Attention has been paid to medium-voltage motor drives for power financial savings with out regenerative brakes [1]–[4]. A modular multilevel cascade inverter based totally on double- star chopper cells (mmci-dscc) has been expected as one of the next-era medium-voltage multilevel pulsewidth modulation (pwm) inverters for such motor drives [5]–[14]. For the sake of simplicity, the mmci-dscc is called the “dscc” in this paper [5]. Dscc consists of upper and lower arms and a middle-tapped inductor sitting among the two arms. Each arm consists of more than one bidirectional dc/dc choppers called as “chopper cells.” the low- voltage facets of the chopper cells are related in cascade,

The power conversion circuit of the DSCC is so flexible in design that any count of cascaded chopper cells is theoretically possible [6].

Whilst a dscc is carried out to an ac motor power, the dscc might suffer from ac-voltage fluctuations within the dc-capacitor voltages of every chopper cell in a low-speed renge, because the ac-voltage fluctuation gets extra serious as a stator-contemporary frequency receives lower [7]. Therefore, the fluctuation ought to be at- decrease satisfactorily to obtain strong low-velocity and start-up performance. The authors in [10] proposed a easy startup technique without a speed sensor, in which a dscc endured to be operated at the best consistent frequency, e.g. 30 hz, to reduce the ac-voltage fluctuation during the start-up. Right here, the ac output voltage turned into adjusted successfully to produce a required start- up torque. But, an over current may additionally drift not best in the dscc however also within the motor because a slip frequency in a low velocity variety get a great deal better than the rated slip-frequency. This consequences in generating a reduced motor torque.

The intention of this paper is to verify the correctly and nearly of a speed-sensorless start-up technique for a dscc- based totally induction motor drives, in which the motor starts rotating from initial to center speed with a ramp change. This motor drive is appropriate, mainly for an application to a fan- or blower-like load. The load torque is proportional to ( motor mechanical speed)2 [16], and is changing gradual enough to be

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considered as steady-state conditions. The start-up approach mentioned in this paper is characterised through combining capacitor- voltage control with motor-velocity control. The capacitor-voltage control used a component in regulating the imply dc voltage of each of the dc capacitors [7] and in mitigating the ac voltage appearing across every dc capacitor, which fluctuates on the stator-current frequency [4], [14]. The motor-speed control makes it possible to decreased a speed sensor from the energy system and to eliminate of the ac-voltage fluctuation in all of the frequency variety. It's far comparable in basic idea to "v /f " and "slip-frequency" manage strategies, but distinct in terms of mixing the 2 control strategies together. The motor-speed manage is primarily based on "feedback" control of the minimal stator contemporary, which is similar to that within the slip-frequency manipulate, while the instructions for the amplitude and frequency of the stator current are based on "feedforward" manage in attention of a velocity-versus-load-torque. Consequently, no longer motor parameter nor speed sensor is required. Moreover, the motor-pace manage is relevant to any inverter geared up with present day sensors on the ac terminals

## .II.CIRCUIT CONFIGURATION AND CAPACITOR-VOLTAGECONTROL OF THE DSCC

### *A. Circuit Configuration*

Fig. 1(a) shows the circuit configuration of the dscc mentioned on this paper. Every leg consists of 8 cascaded bidirectional chopper cells shown in fig. 1(b) and a middle- tapped inductor per step with phase, as shown in fig. 1(c). The middle tap of each inductor is connected up directly to every of the stator terminals of an induction motor, where in iu is the u-phase stator current. The center-tapped inductor is extra cheap effective than non coupled inductors according to leg, due to the fact the center tab inductor lz.

$$iZu\ \Delta = 1/\ 2(iPu+iNu) \qquad (1)$$

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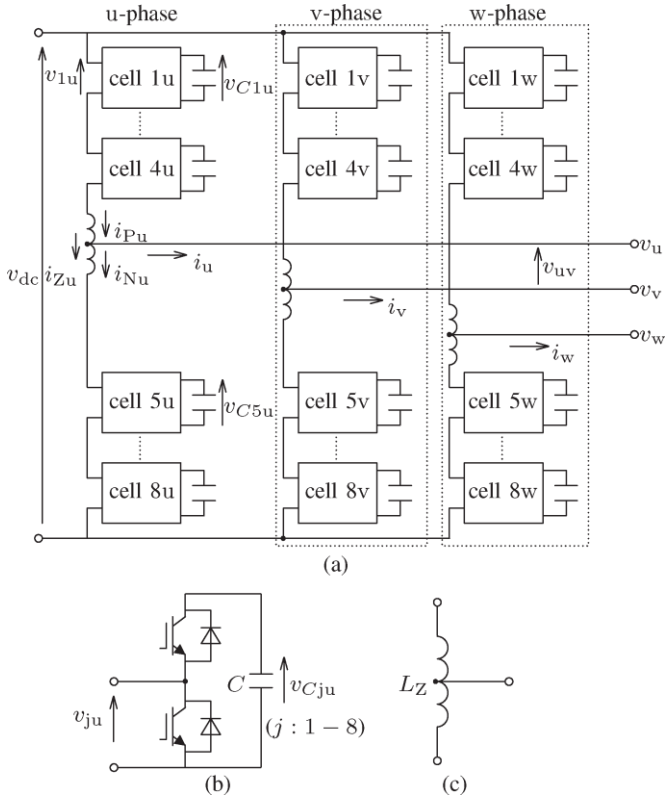



Fig.1.Circuit configuration for an MMCI- DSCC. (a) Power circuit.
(b) Chopper cell. (c) Center-tapped inductor.

note that izu consists of dc and ac components for use for the capacitor-voltage manage. The dc component flows from the dc link to every leg, whilst the ac issue flows a few of the 3 legs. The character ac additives covered within the three-section circulating currents ˜izu, ˜izv, and ˜izw cancel each other out, so that no ac factor seems in either motor current or dc-link contemporary [14]. The arm currents ipu and inu can be expressed as lin- ear capabilities of unbiased variables iu and izu as follows [7]:

$$iPu = iu/2 + iZu \quad (2)$$

$$iNu = -iu/2 + iZu \quad (3)$$

The dc-capacitor voltage in each chopper cell consists of dc and ac causing an ac-voltage fluctuation. When neither common-mode voltage nor ac circulating current is superimposed, the peak-to-peak ac-voltage fluctuation $\Delta v_{Cju}$ is approximated as follows [10]:

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$\Delta VC\ ju = \sqrt{2}\ i1/\ 4\Pi fc$ (4)

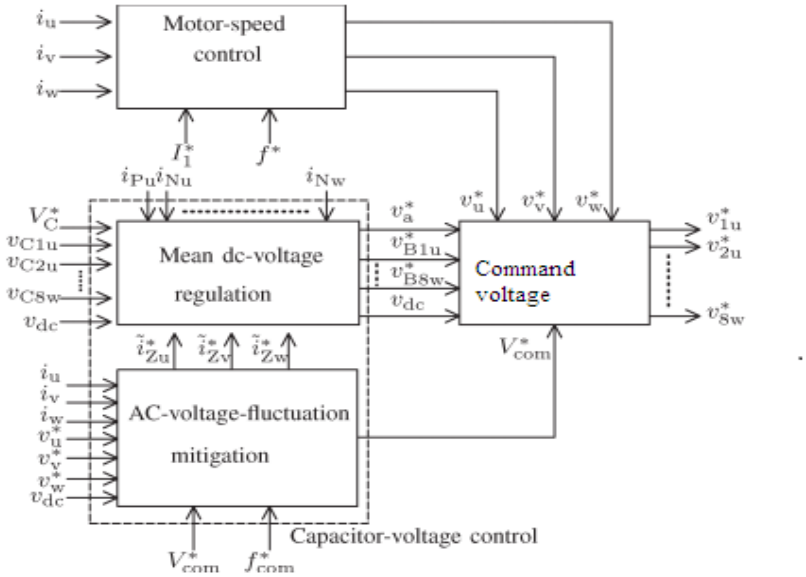



Fig. 2 Overall control block diagram for the start-up method.

the ac-voltage fluctuation is undesirable due to the following reasons [14].

- It impacts the voltage rating of IGBT
- It causes extra modulation to each chopper.
- It makes the system risky due to the ac-voltage flu tuition. Consequently, the ac-voltage fluctuation should be mitigated to a suitable degree.

B. Capacitor-Voltage Control

Fig. 2 shows the overall block diagram of the startup method. The 24 dc-capacitor voltages vcjuvw, the dc-hyperlink voltage vdc, and the six arm currents ipuvw and inuvw are detected, and they're enter indicators for the block diagram. Be aware that the 3 stator currents iuvw are calculated from the detected arm currents. This paper employ of existing capacitor-voltage manage strategies for regulating the mean dc voltage of every dc capacitor and for mitigating the ac-voltage fluctuation on the stator-current frequency.

The mean dc-voltage can be executed by way of the usage of the "arm" balancing control applied to the six arms and the "individual" balancing manipulate carried out to the one arm at the identical time [7]. The ac-voltage fluctuation can be mitigated via the sophisticated manage discussed in [13]. This control interacts the commonplace-mode voltage vcom, which is injected to three middle-faucet terminals of the dscc with the ac additives of the three circulating currents˜ izuvw. This can mitigate the ac voltage fluctuation on the stator-current frequency, for that reason leading to begin up from standstill. As a result, the ultimate ac-voltage fluctuations are unbiased of the time-varying frequencies of the stator contemporary, however dependent on a fixed frequency of the injected common-mode voltage(50hz in this experiment). The circulating-present day feedback control included in the imply dc voltage regulation block yields a command voltage of v∗ a.

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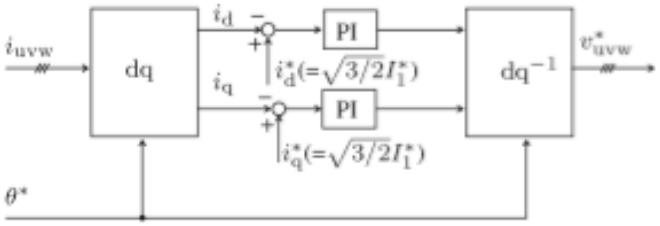



Fig. 3 Block diagram for the motor-speed control based on a feedback control of the stator current.

Finally, command u-phase voltages for each chopper cell, i.e., v∗ ju, are given as follows [14]:

$$v* ju = v* a + v* Bju - v* u + v*com\ 4 + vdc\ 8 (j = 1-4) \quad (5)$$

$$v* ju = v* a + v* Bju + v* u + v*com\ 4 + vdc\ 8 (j = 5-8). \quad (6)$$

Here, v∗ a and v∗ bju are used to alter the dc voltage, v∗ u is the command motor voltage given through fig.3 v∗com is the command commonplace-mode voltage, and vdc is the dc-link voltage used as feedforward control. The command rms value of the common-mode voltage v ∗com must be set as excessive as possible to reduce the amplitude of each ac circulating current, because it's inversely proportional to vcom [14]. Further more, there is no relationship between common-mode voltage and power rating of the motor.

## III.MOTOR-SPEED CONTROL

This section describes a motor-speed control forming a comments loop of three-phase stator currents for accomplishing a strong start-up of an induction motor. First, the motor-speed manage is discussed in terms of a form and function. 2nd, it's far compared with conventional motor-speed control strategies, i. E., “volts-per keeping with-hertz” and “slip-frequency” control techniques.

### A. Control Principles

The motor-speed control forms a feedback loop of three phase stator currents to realize a stable start-up from standstill. This requires the current sensors attached to the ac terminals. The stator current in one phase is calculated by the corresponding arm currents detected. Therefore, no additional current sensor is required

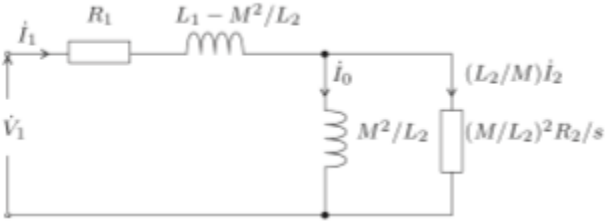



Fig. 4 Per-phase equivalent circuit based on the total linkage flux of the secondary windings [17].

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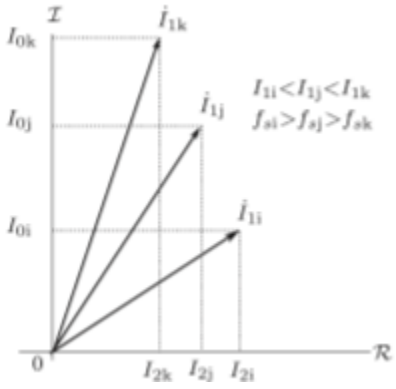


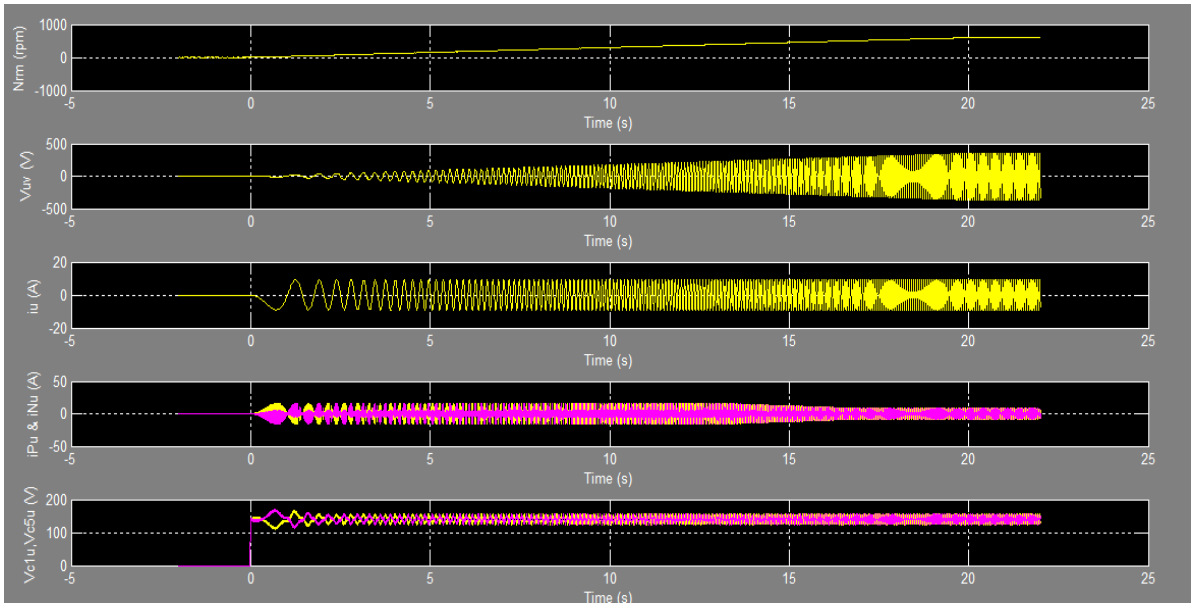

Fig. 5.Phasor diagram for the stator currents with different amplitudes but the same torque.

quantities by using the d−q transformation to enhance current controllability. In Fig. 3, θ∗ is the phase information used for the d−q transformation, whereas i∗ d and i∗ q are the command currents given by

## IV. RESULTS AND DISCUSSION

### A. Comparitive result without & with speed sensor.

The paper aimed to analyse the starting of Induction Motor Without sensor.For that Matlab simulation has been carried out and the results are copmaired with and without sensor.



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**Fig. 6 start-up waveforms when $I_1^*$=6.4 A (20%) and $T_L$ = 0%, where $I_0$ = 6.4 A (35%) (Without speed sensor)**

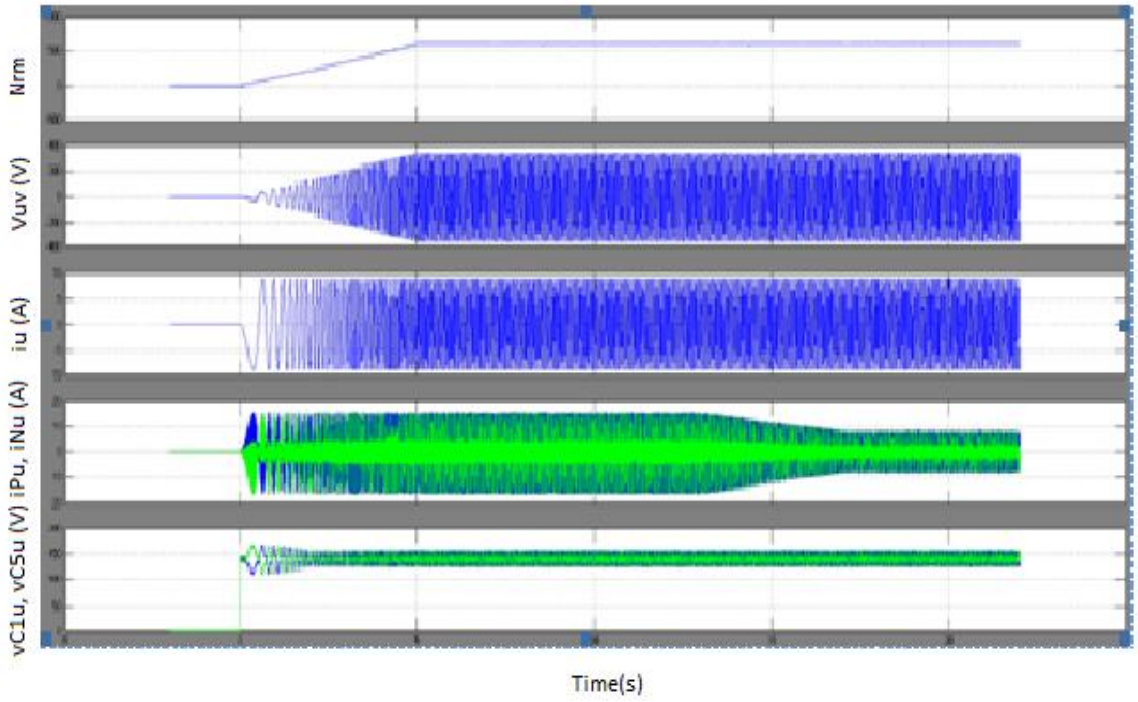



Fig.7 start-up waveforms when $I_1^*$=6.4 A (20%) and TL = 0%, where I0 = 6.4 A (35%) (With speed sensor)

Result proven above is for startup overall performance of induction motor at stator current of 20% at no load torque. But, the maximum value of the arm currents was smaller than the amplitude of the rated stator current of forty five. The height-to-top ac voltage fluctuation of vc1u and vc5u became 29 v, that are 21% of one hundred forty v.

During this performance harmonic voltage in line to line voltage can be eliminated by using low pass filter. A square-wave common-mode voltage with and square-wave circulating currents were superimposed to mitigate the ac-voltage fluctuation of each dc-capacitor voltage.

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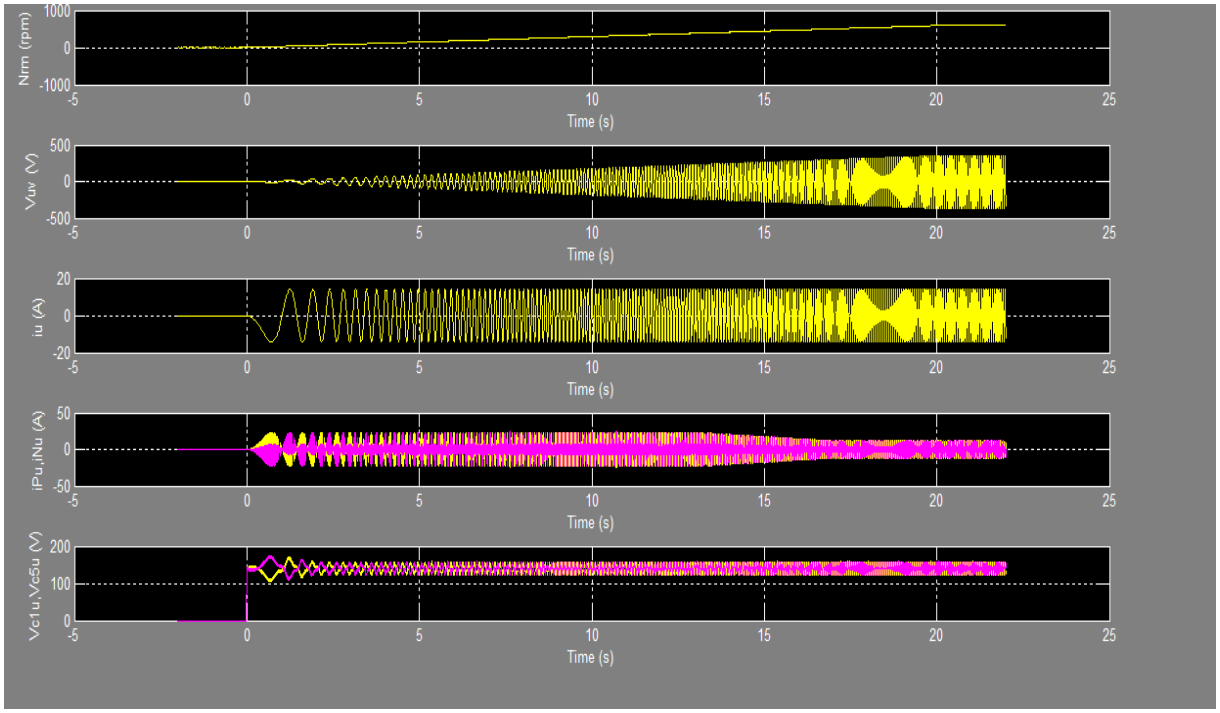



Fig. 8 start-up waveforms when $I_1^*$= 10 A (31%) and
TL = 20%, where $I_0$=7.0 A (37%).(without speed sensor)

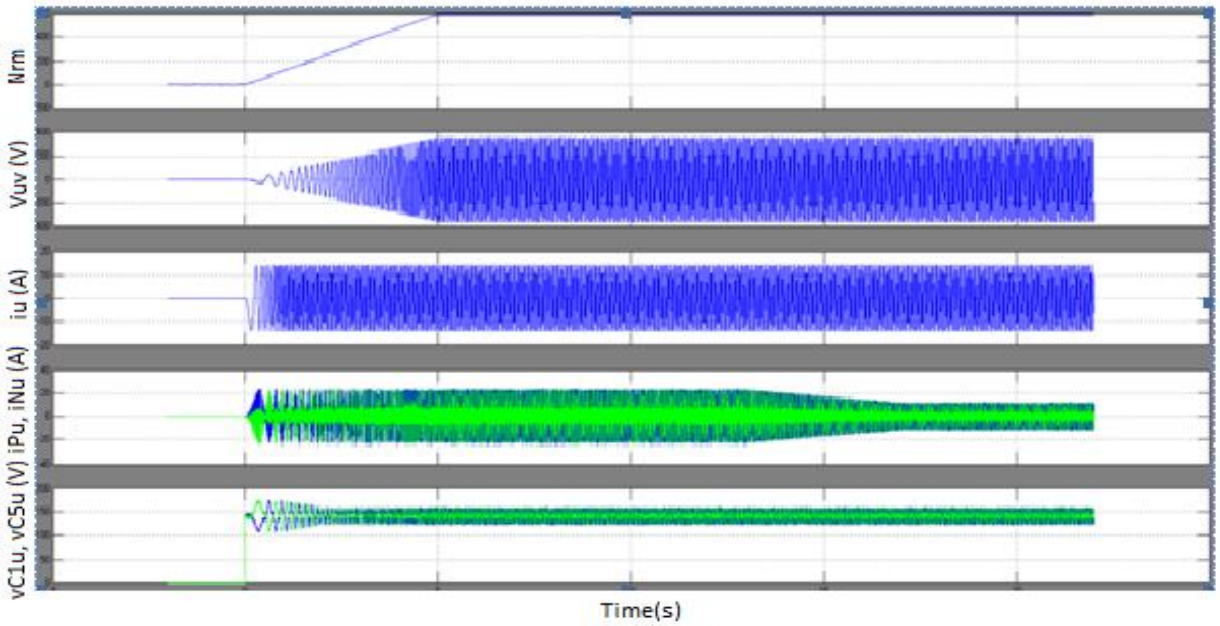



Fig.9 start-up waveforms when I1∗= 10 A (31%) and
TL = 20%, where I0 = 7.0 A (37%).(with speed sensor)

The above figures indicates the experimental start-up overall performance with tl = 20%. Right here, i1* became set to ten a (31%), which is the minimal value to provide a motor torque of 20%. The magnetizing current i0 is 7. Zero a, that is 38% of the rated magnetizing current of 18.4A. The motor mechanical speed became increasing, in which the slip frequency changed into fs = 0. 30 hz. The maximum amplitude of the arm currents became 23 A, which is 41% of 45 a. The height-to-peak ac-voltage fluctuation of vc1u and vc5u become 34 v, that is 24% of 140 v

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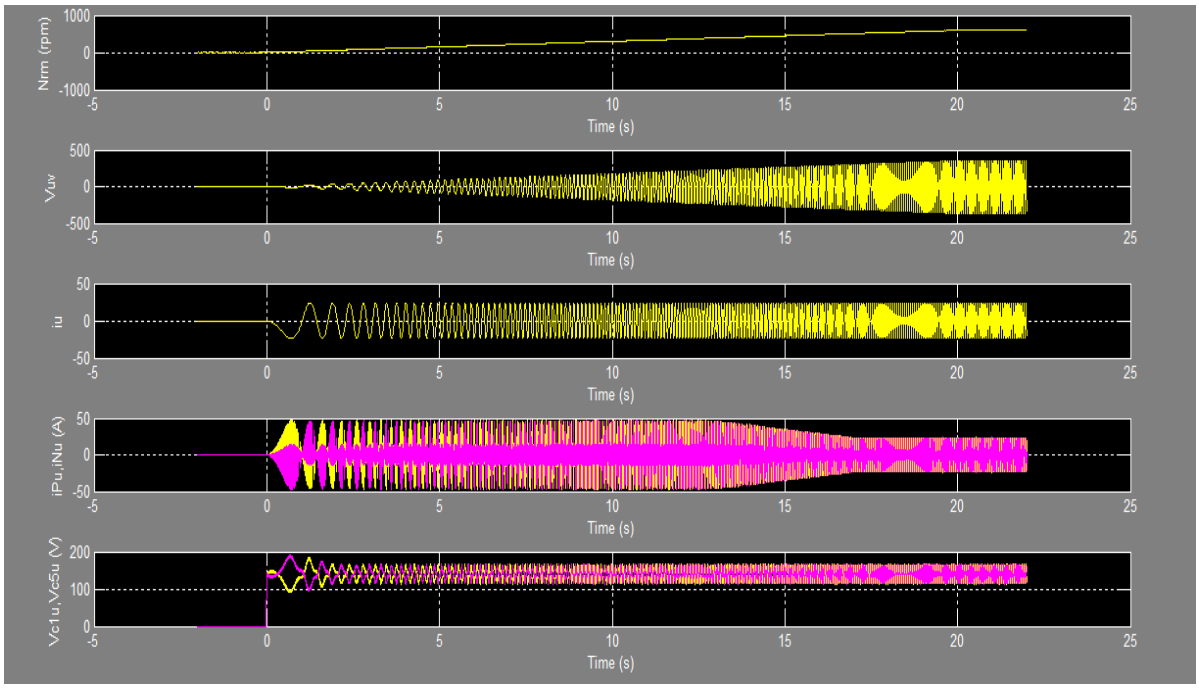



Fig.10 start-up waveforms when $I_1^*$= 17 A (53 %) and
TL = 20%, where I0 = 16.6 A (90%).(without speed sensor)

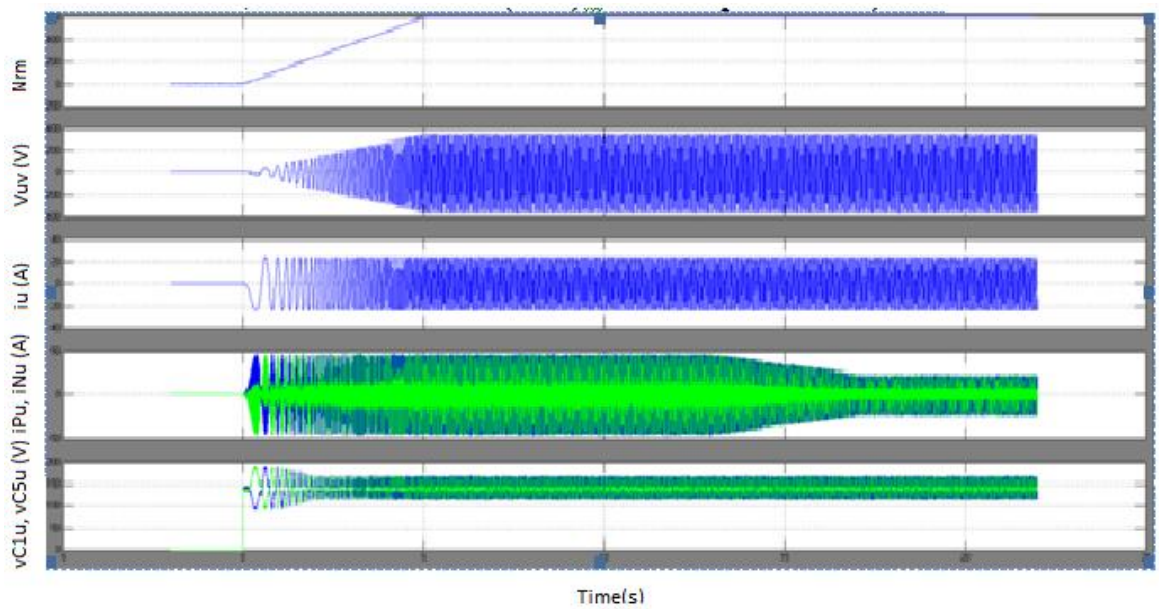



Fig.10 start-up waveforms when $I_1^*$= 17 A (53 %) and
TL = 20%, where I0= 16.6 A (90%).(with speed sensor)

Above determine suggests the experimental start-up performance with tl = 20%. Right here, i1* was set to 17 A (53%), the magnetizing current i0 reached 16. 6 A (90%). The most amplitude of the arm currents changed into 46 A, which is a 101% of 45 A. The peak-to-height ac voltage fluctuation of vc1u

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and vc5u turned in to 51 v, which is 36% of 140 v. The arm-current amplitude and the peak-to-top ac voltage fluctuation elevated via 50% and 12%, respectively,

those experimental consequences proven that the motor-speed control with the minimum stator modern is powerful in reductions of both arm-current amplitude and top to- height ac-voltage fluctuation.

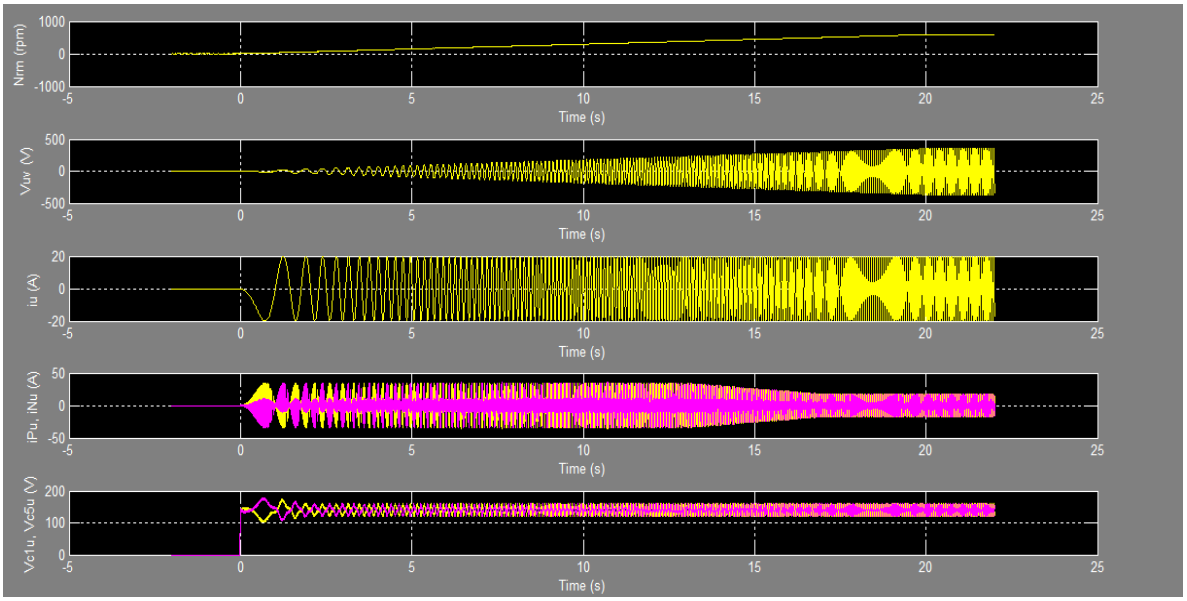



Fig.11 start-up waveforms when $I_1^*$=14 A(44%), TL = 40%,
where I0 = 9.9 A (54%). (without speed sensor)

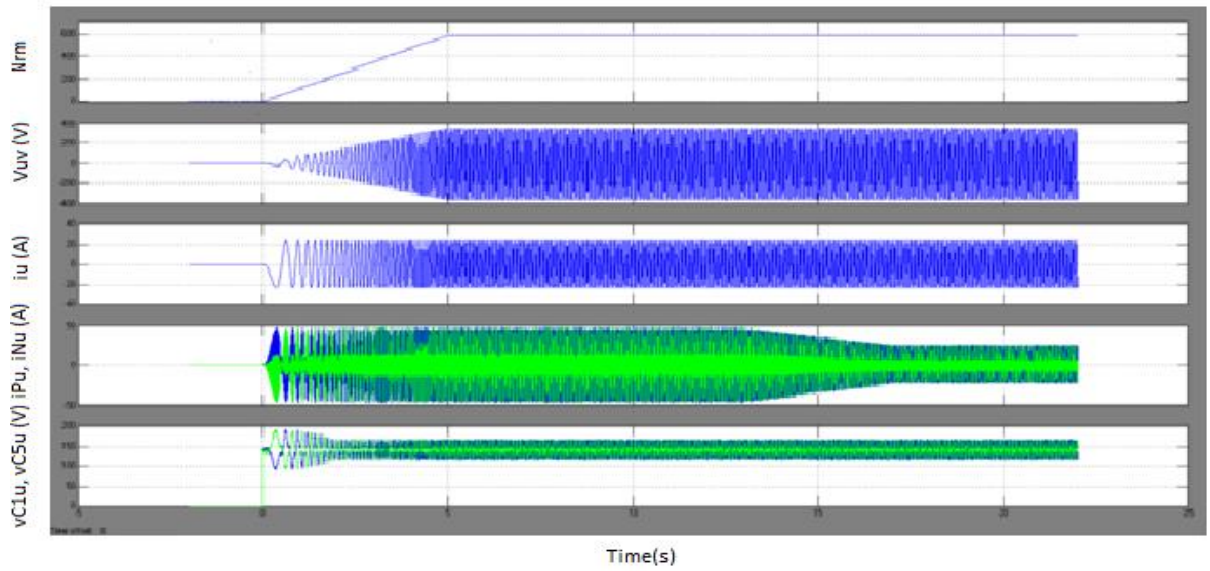



Fig.12 -start-up waveforms when $I_1^*$= 14 A (44%), and
TL = 40%, where I0 = 9.9 A (54%).(with speed sensor)

Above figure shows the experimental start-up performance with $T_L$ = 40%. The motor mechanical speed was increasing up to 590 min−1, where the slip frequency was *fs* = 0.33 Hz. The maximum amplitude of the arm currents was 34 A, which is 76% of 45 A. The peak-to-peak ac-voltage fluctuation of $V_{C1u}$ and $V_{C5u}$ was 38 V, which is 27% of 140 V.

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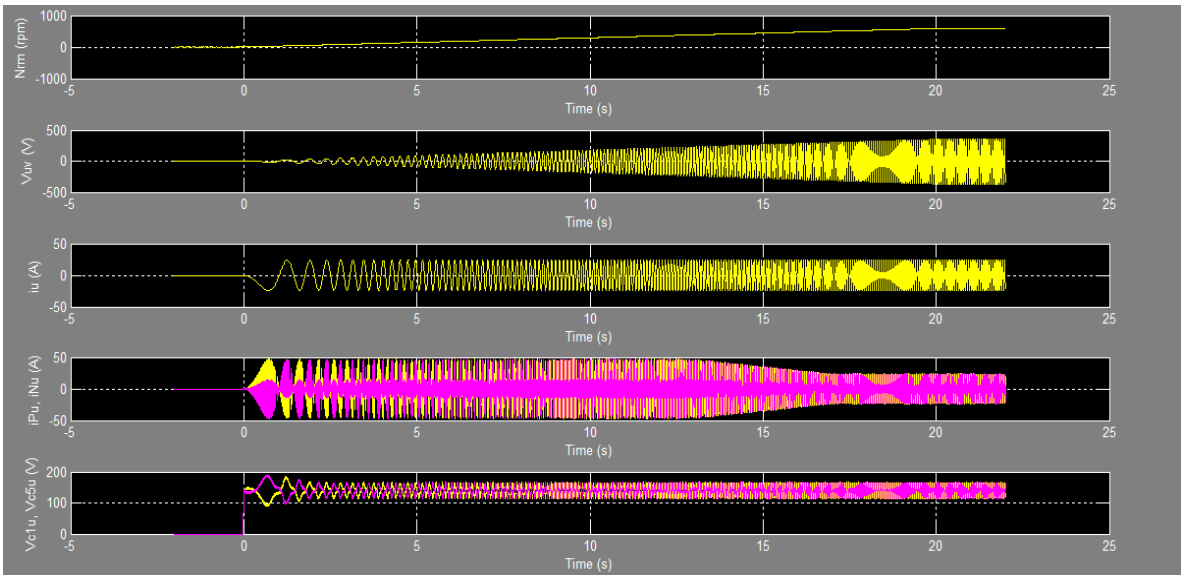



Fig.13 start-up waveforms when $I_1^*$= 17 A (53%), and
TL = 60%, where I0 = 12.0 A (65%).(without speed sensor)

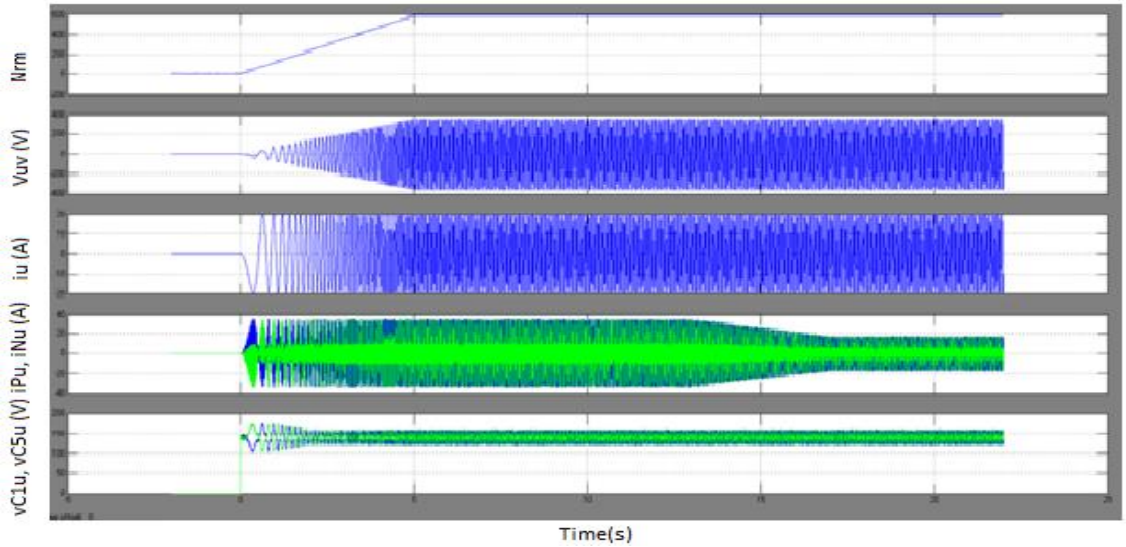



Fig.14 start-up waveforms when $I_1^*$= 17 A (53%), and
TL = 60%, where I0= 12.0 A (65%).(with speed sensor)

The motor mechanical speed was decreasing to 588 min−1, and the slip frequency was increasing to *fs* = 0.4 Hz due to the increase of *TL*. These experimental results show that the motor-speed control with the minimal stator current makes it possible to increase a start-up torque by a factor of three, without additional stress on arm currents and ac-voltage fluctuations

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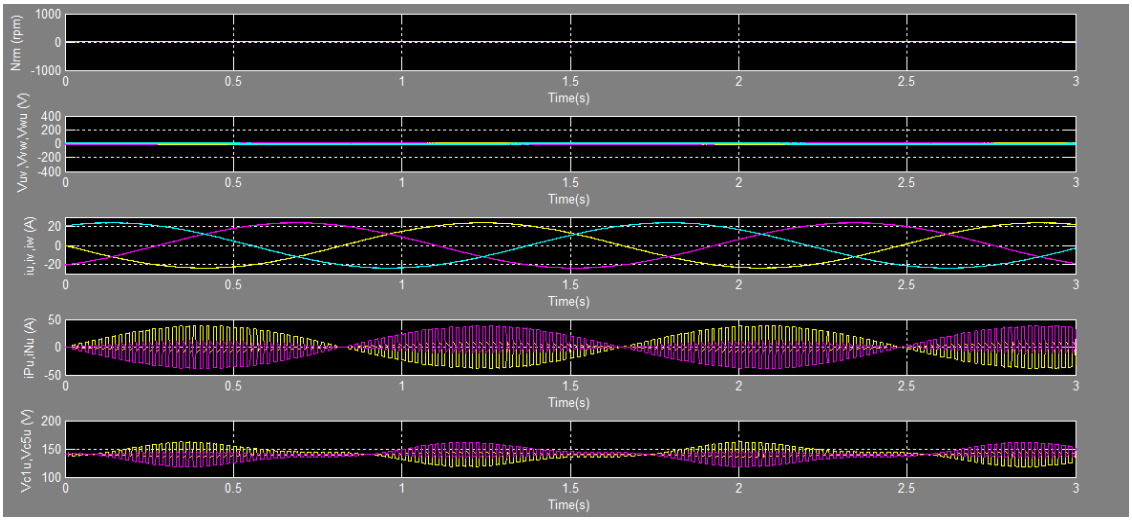



Fig.15 steady-state waveforms when $I_1^*$= 17 A ( 5 3 % ),
f * = 1 Hz, and TL = 60%, where I0 = 12.0 A (65%).(without speed sensor)

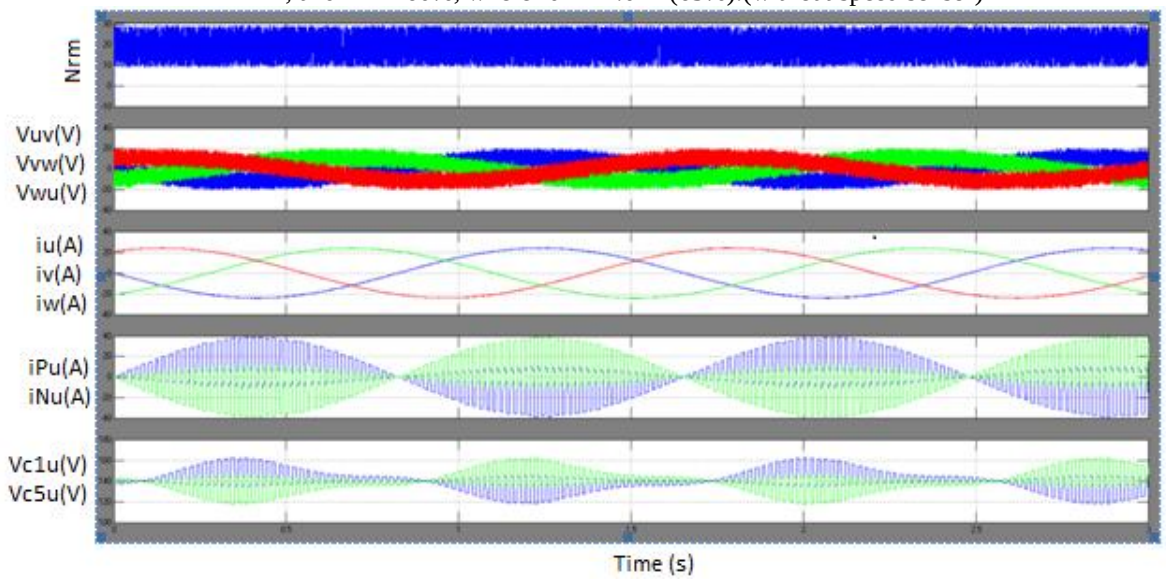



Fig.16 steady-state waveforms when $I_1^*$= 17 A ( 5 3 % ),
f * = 1 Hz, and TL = 60%, where I0 = 12.0 A (65%).(with speed sensor)

Above figure shows those at f* = 1 Hz. Here, the common-mode voltage with $V_{com}$ = 180 V and $f_{com}$ = 50 Hz and the square wave circulating currents were superimposed. The motor mechanical speed and the slip frequency were $N_{rm}$ = 19 min−1 and $f_s$ = 0.38 Hz, respectively. The maximum amplitude of the arm currents was 38 A, which is 84% of 45 A. The peak-to-peak ac-voltage fluctuation of $V_{C1u}$ and $V_{C5u}$ was 34 V, which is 24% of 140 V.

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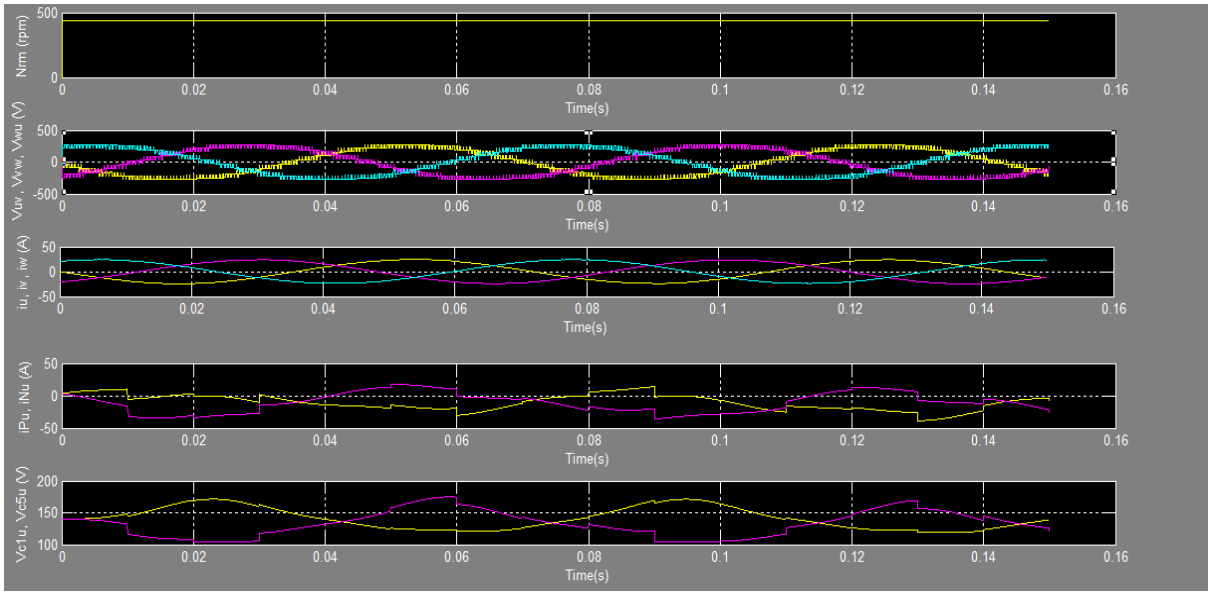



Fig.17 steady-state waveforms when $I_1{}^*$= 17 A (53%),
f * = 15 Hz, and TL = 60%, where $I_0$ = 12.0 A (65%).(without speed sensor)

Above Figure shows those at $f*$ = 15 Hz. Here, $V_{com}$ was reduced to 113 V, and the amplitude of the square-wave circulating currents was reduced simultaneously. The motor mechanical speed and the slip frequency were $N_{rm}$ = 438 min−1 and $f_s$ = 0.4 Hz, respectively. The maximum amplitude of the arm currents was 31 A, which is 69% of 45 A. The peak-to-peak ac voltage fluctuation of $V_{C1u}$ and $V_{C5u}$ was 43 V, which is 31% of 140 V.

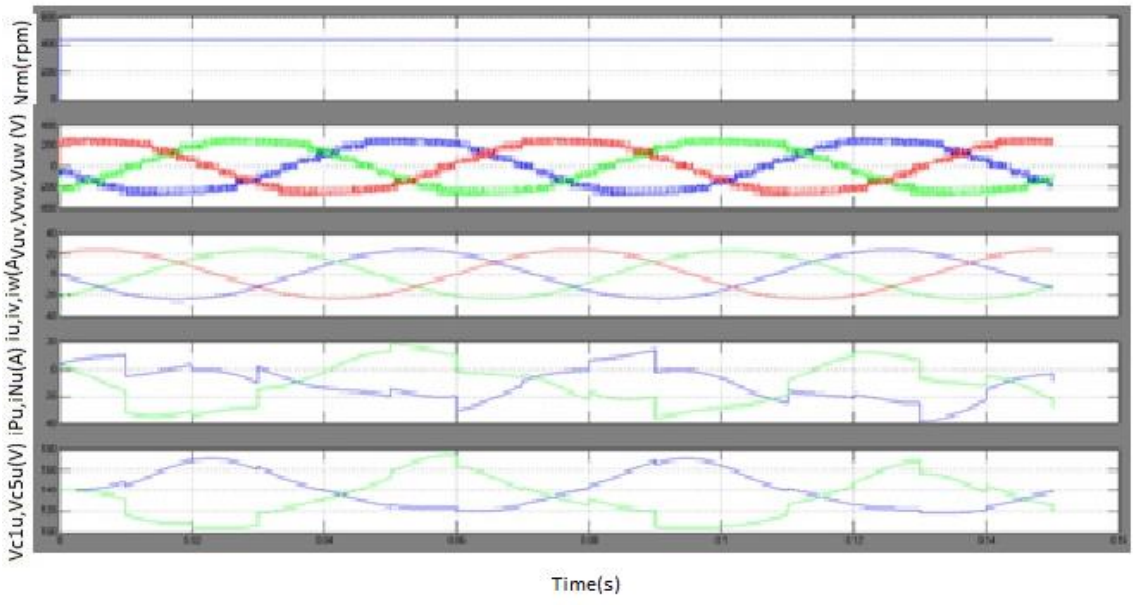



Fig.18 steady-state waveforms when $I_1{}^*$= 17 A (53%),
f * = 15 Hz, and TL = 60%, where I0 = 12.0 A (65%).(with speed sensor)

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# V. CONCLUSION

The proposed start-up approach for dscc-driven induction motor with no speed sensor from standstill to center speed. This start-up method is characterised by way of combining capacitor-voltage manage and motor-speed control. The motor-speed control with the minimal stator cutting-edge below a load torque is primarily based at the aggregate of remarks manage of the three-section stator currents with feed ahead manipulate of their amplitude and frequency. The arm-modern amplitudes and ac-voltage fluctuations across every of the dc capacitors can be reduced to perfect levels. This method is suitable specifically for adjustable-velocity motor drives of applicable for, blowers, and compressors for electricity financial savings. The primary goal of mmci for beginning of i. M is to observe in step with unit rise in the speed from standstill to middle speed inside the without sensor. Then again using the sensor there's an overshoot to the rated speed in the first quarter of the response and it is not always test inside the staring performance.

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