UNIVERSITY OF NAIROBI
DEPARTMENT OF ELECTRICAL & INFORMATION ENGINEERING

INVERTER DRIVE CONTROL OF SYNCHRONOUS MOTORS
PROJECT NO: PRJ 075
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OBJECTIVES

• The theory of operation of synchronous motors
• Design of inverter drive for synchronous motors
• To implement the designed inverter on a synchronous motor
SYNCHRONOUS MOTORS

The motor has the following features:

i. It runs either at synchronous speed or not at all, that is, while running it maintains a constant speed. The only way to change its speed is to vary its supply frequency. This is because the speed of the motor is given by \[ N_s = \frac{120f}{p} \]

ii. It is not inherently self–starting. It has to run up to synchronous speed by some means before synchronization to the supply.

iii. It is capable of being operated under a wide range of power factors both lagging and leading.
PRINCIPLE OF OPERATION

• The three phase alternating current set up a rotating magnetic field
• Speed of rotation is synchronism with supply frequency
• Rotor magnetic field interacts with rotating stator flux to produce rotational force
DRIVE SCHEMATIC

3 phase ac supply

Diode Rectifier → DC Link → PWM Inverter

Control Circuit

AC Motor
The design entailed designing sub-systems of the drive schematic which are:

- SCRs’ Gate Firing Circuits
- Rectifier
- DC Link
- Inverter

Simulations were done in Proteus Professional Ver.7.4
Firing circuits

Were designed using the following
• Two 555 timer ICs
• 1 Johnson counter IC
• TTL Logic OR gates
• Common collector single-stage transistor amplifier
The timers were connected as follows
The Johnson counter and logic circuit
The counter produced 6 pulses that were fed to the logic OR gates.

The OR gates were connected in such a way that at any instance of time, two were high and the other four were low.

OR gate produce a voltage of 5V and 0V when high and low respectively. The output current is 0.4mA and 8mA when high and respectively.

The common collector amplifier was thus used to amplify current to 8.57mA. The output voltage was 857mV from simulation.
The Rectifier and the DC link
The 3-phase rectifier was designed using 6 diodes. The dc output voltage is given by

\[ V_{dc} = \frac{3\sqrt{3}}{\pi} \times V_m \]

Where \( V_m \) is the peak phase voltage.

\( V_m = 110 \text{V}, \) hence \( V_{dc} = 182 \text{V} \)

The dc voltage produced by three phase rectifier had ripples. The ripples were filtered out by the dc link to produce constant dc voltage fed to the pwm inverter.
The designed inverter circuit
The SCRs used were BT-152 with the following specifications

- $P_{iv} = 400\text{V}$
- $I_{gt} = 32\text{ mA}$
- $V_{gt} = 1\text{V}$
FINAL CIRCUIT

[Diagram of the circuit with all components labeled and connected as per the schematic diagram]
Implementation

- The firing circuit was tested in the laboratory. The circuit gave the expected results.
- The inverter circuit was also implemented
Rectifier output

Unrectified dc output

Filtered dc output
Firing signals from simulation
Output waveforms of the inverter
Photograph of gate firing signals
CONCLUSION

- The theory of operation of the 3-phase synchronous motor was covered.
- The firing circuit was implemented and obtained expected results.
- The prototype inverter was tested in the laboratory; the gate firing signals for the SCRs obtained from the built firing circuit.
Recommendations and Further work

- There be provision of a mounting board for thyristors with heat sinks intact.
- It is recommended that the next project uses this design to drive the inverter.
  - commutation circuit of the SCRs to be worked on.
  - Use of the designed firing circuit to implement the designed inverter on the available synchronous motor.
THE END

THANK YOU