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Power Electronics and Drives

(ACDA6004)

Luke Andersen

Exam 20th May 2022

Question 1/

✓ usually used for electrical machines
Induction motors have 2 main parts, the stator and rotor. The stator is the stationary part and the rotor is the rotating part.

The rotor sits inside the stator. The rotor sits inside the stator. There is a small gap between rotor and stator, known as an air-gap. The radial air gap is between 0.5 to 2 mm.

The speed of the motor depends upon the torque acting on it.

The stator is made by stacking thin-slotted highly permeable steel laminations inside a steel or cast iron frame.

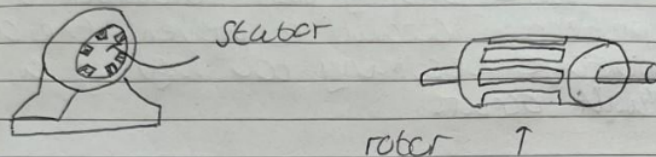
When a 3 phase AC current passes through the stator winding it produces a rotating magnetic field.

The squirrel cage is induced by current and will therefore start to rotate.

3 phase induction motors are self starting

The bars of the squirrel cage are inclined to the axis of rotation, or it has got a skew. This is to prevent torque fluctuation. Voltage is induced in squirrel cage by RMF. Currents in the cage create magnetic field opposing RMF.

The rotor experiences a magnetic force generated between RMF and squirrel cage turn rotor. The induction motor relies on slip and does not run at a fixed speed. The speed is dependant on the load.



The rotor will never be able to catch up with the speed of the magnetic field. It rotates at a specific speed which is slightly less than synchronous speed. The difference between in synchronous and rotor speed is known as slip.

The efficiency of the induction increases when the mechanical load increases because as the motor's load increases, its slip increases and the rotor speed falls.

Question 2/

2/

(MPPT)

Maximum power point tracking is a technique that grid connected inverters, solar battery chargers and similar devices use to get the maximum possible power from one or more photovoltaic devices.

An MPPT system's purpose is to sample the output cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions.

The DC power is converted to AC power by the solar inverters which incorporate MPPT. These inverters sample the output power (I-V curve) from the solar cell. The proper resistance (load) is applied to obtain maximum power.

MPP voltage (V_{mpp}) and MPP current (I_{mpp}) are the products of maximum power points.

The maximum power that a cell can provide with an optimal load is,

$$P = FF \times V_{oc} \times I_{sc}$$

FF = fill factor

V_{oc} = open circuit voltage

I_{sc} = short circuit current

The formula gives information on electrical behaviour of a photovoltaic cell

with

A load resistance $R = V/I$ equal to the reciprocal of this value draws the maximum power from the device. This is called the characteristic resistance of the cell.

Question 3/

Q3/ $I = \frac{P}{V}$

~~Current~~ Current = 250,000 A
Voltage = 6000 V

$P = VI$ $P = 250,000 \times 6000$
 $P = 1,500,000,000 = 1500 \text{ kW}$

24 poles = 12 pairs

$f = \frac{\omega p}{60}$ $f_{\min} = 0$
 $f_{\max} = \frac{1000 \times 12}{60} = 200 \text{ Hz}$

$V = 6000 \text{ V}$ $I = 250,000 \text{ A}$ $f = 200 \text{ Hz}$

$200 \times 20 = 4000 \text{ Hz}$ $200 \times 0 = 0 \text{ Hz}$

~~Assuming~~ The gate switching frequency of the driving transistors would be between 0 Hz - 4000 Hz.

~~Compare table~~

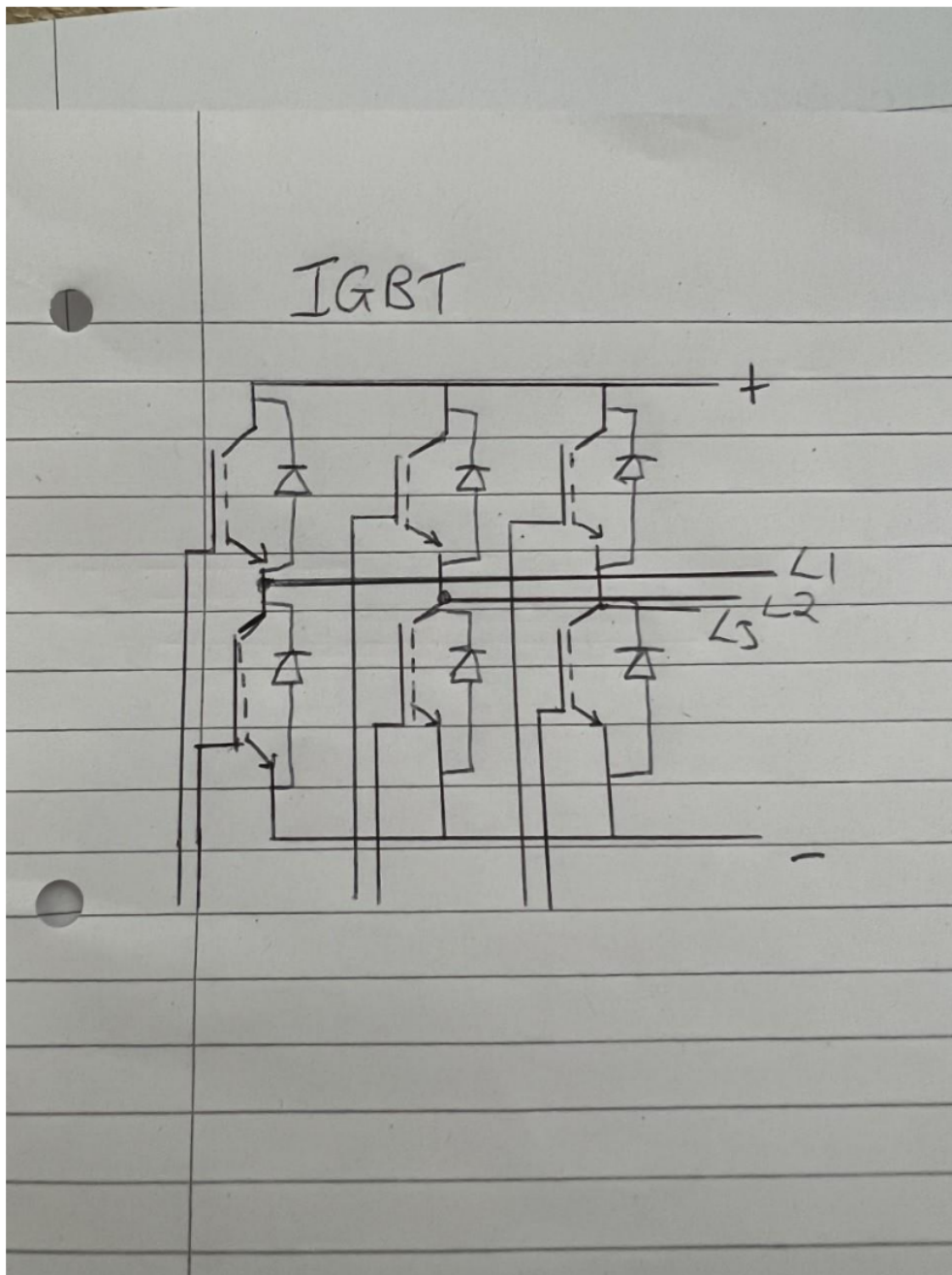
characteristic	Power bipolar	Power mosfet	IGBT
voltage rating	High < 1kV	High < 1kV	Very high > 1kV
Current rating	High < 500A	Very high > 500A	Very high > 500A
input drive	current ratio hFE 20-200	voltage VGS 3-10V	voltage VGE 4-8V
input impedance	Low	High	High
output impedance	Low	Medium	Low
switching speed	Slow (µs)	Fast (ns)	medium
cost.	Low	Medium	High.

By referring to the comparison table above it is clear to see power bipolar transistors would not be suited to this application as the load current is too high for this type of device.

Although the power mosfet transistors have ~~now~~ a current rating ~~capable~~ suited to this application, the ^{load} voltage ~~part~~ of the application exceeds the capabilities of the power mosfet. Therefore the transistor technology best suited to this application is IGBT as they withstand very high voltages, high currents and switch at the required frequency.

The transistors would be connected in a push pull configuration on each phase. This would allow each phase to be ~~more~~ connected to either the positive supply or the ground return path.

~~IRAX IGBT~~
~~gate driver~~



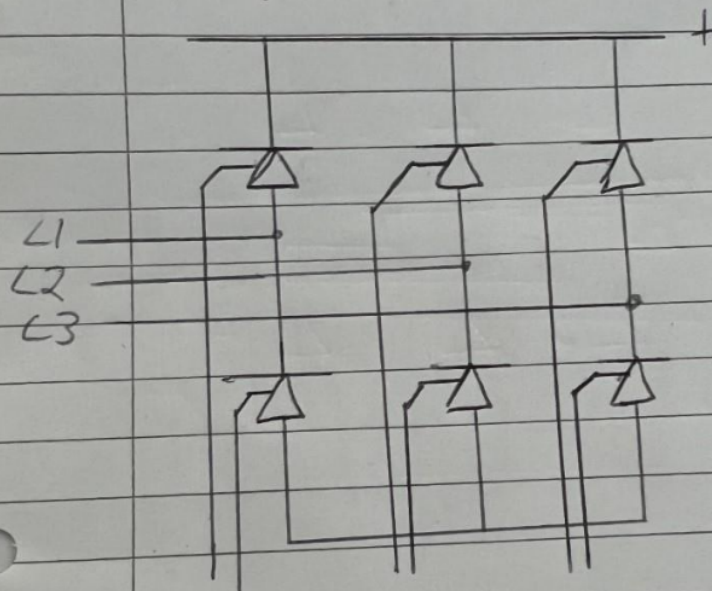
Question 4/

Thyristors

*Rai Aditya
~~2022~~

Thyristors have the capabilities to control the voltage, but will need additional circuitry. They are quite complicated and can only conduct in one direction. They need filtering and smoothing. Thyristors are relatively noisy.

Thyristor (SCR's)

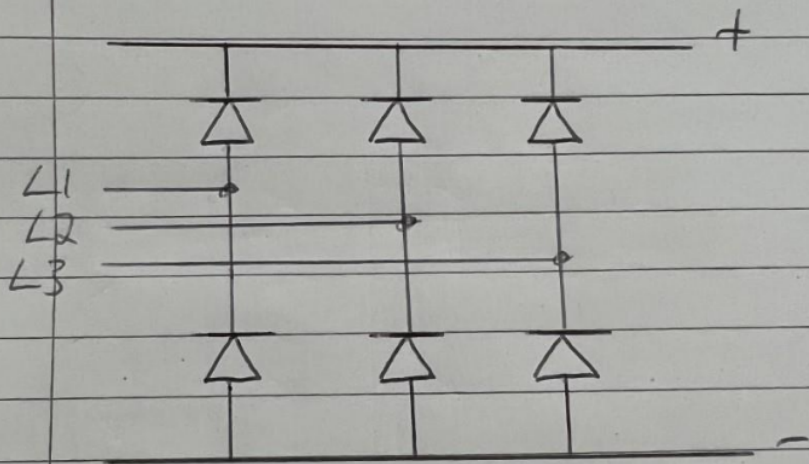


4/ Diodes

~~unpilot~~

diodes are cheap and simple but with restricted control. ~~As~~ There is no switching but there is ripple in DC 3 phase. To get rid of the ripple an addition of a capacitor is needed. A positive of the diodes is that there is very little noise

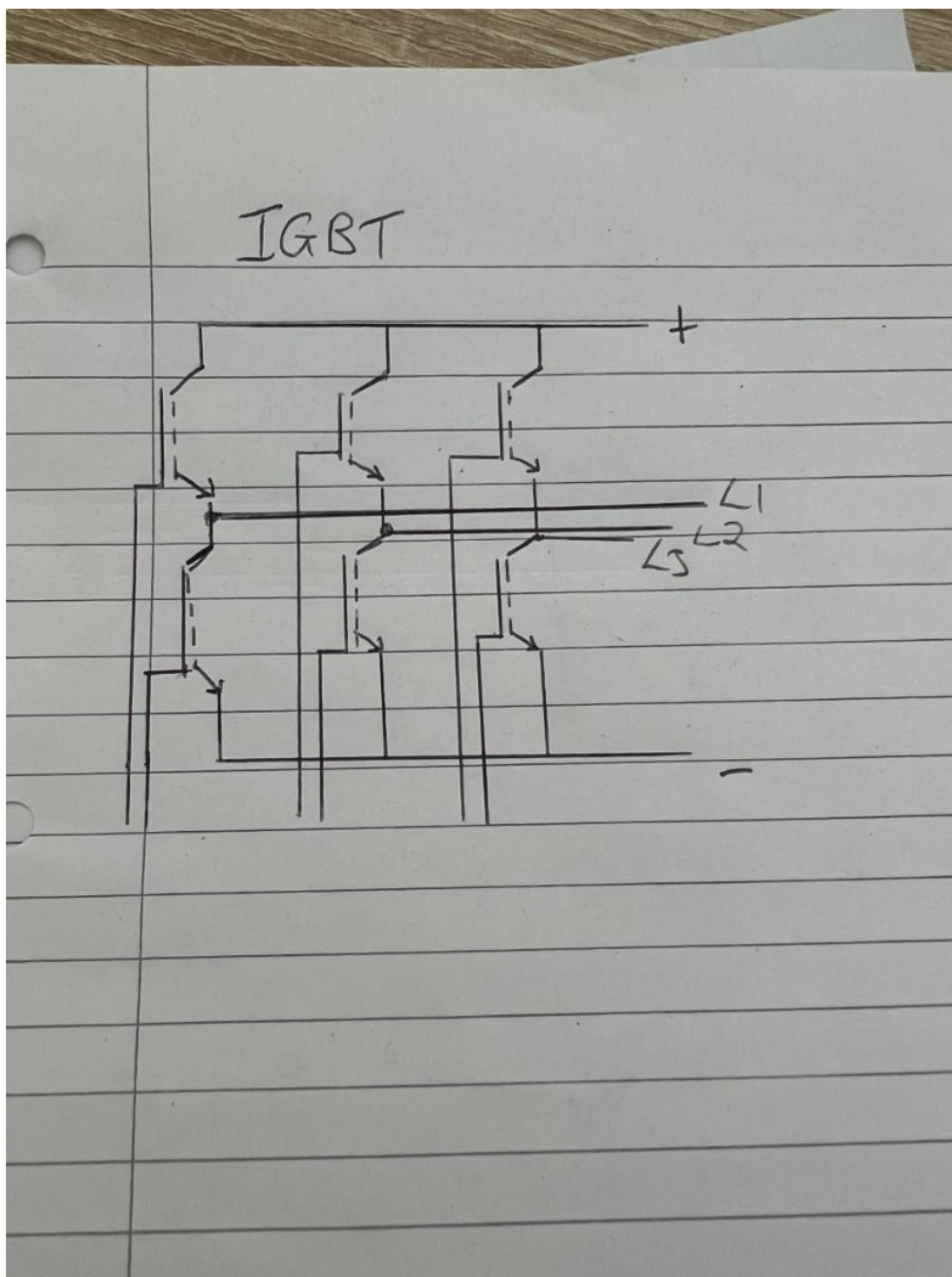
Diode



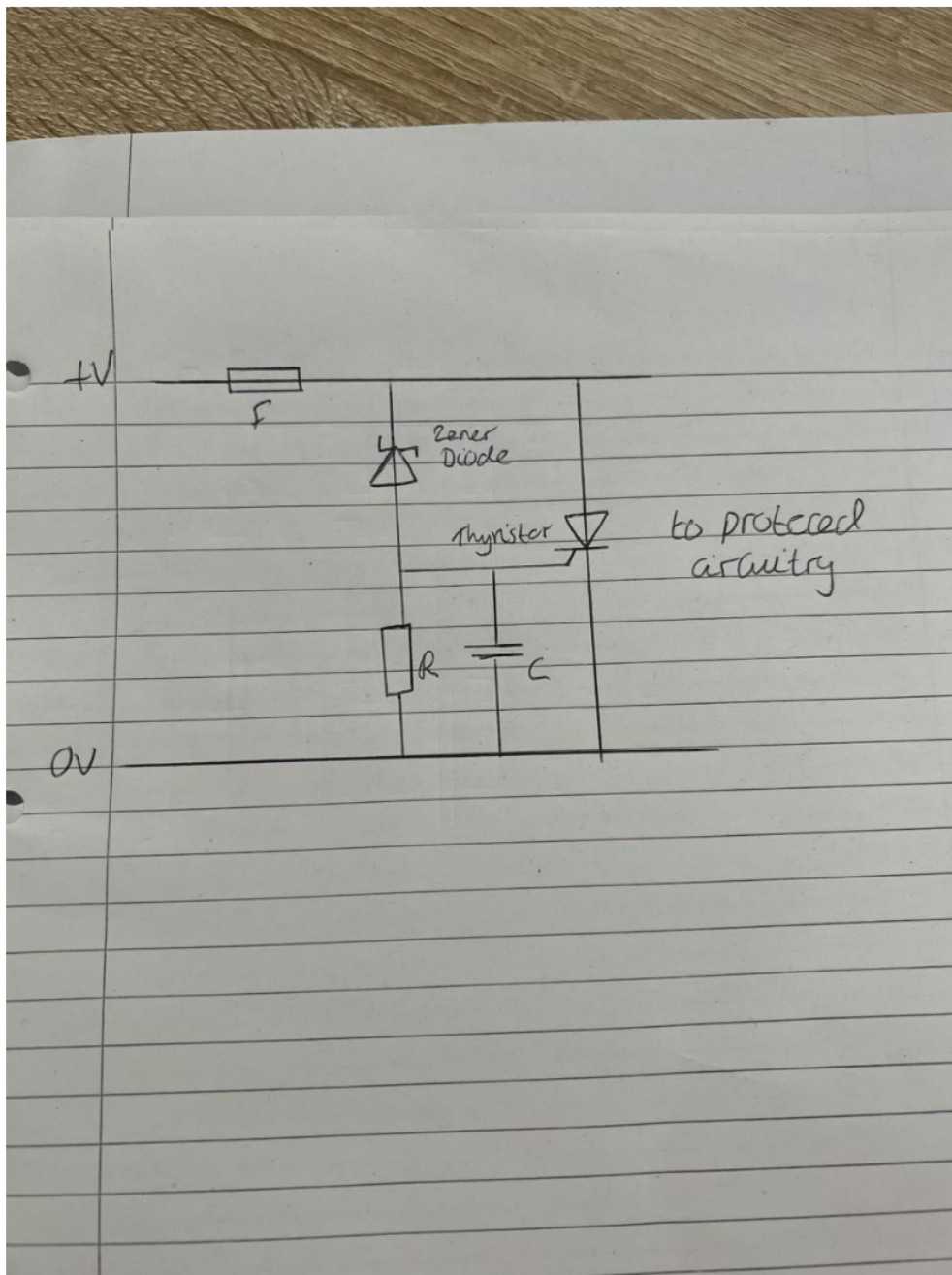
IGBTs

* RDC 100
Doubtless

IGBTs are a new technology that very costly to buy. Although they have bi-directional current flow they are complex to drive. The voltage control needs the gates open whilst the transistors on. A motor can be used to reenergise the main. It will need filtering and smoothing.



Question 5/



5/

~~4/ Drawing~~

A power supply can include a protection circuit to prevent the output voltage becoming too high if a fault occurs.

In the circuit drawn the Zener diode has a Zener voltage greater than the power supply output voltage.

Under normal conditions, the Zener will not conduct. There is an effective open circuit between the anode and cathode of the thyristor.

If the output voltage exceeds its maximum value, the Zener will conduct and turn on the thyristor.

When the thyristor conducts, the current is large enough to blow the fuse. This prevents damage to any device operating from the power supply.

~~When the mechanical load increases, the efficiency of the induction motor decreases as the motor load increases.~~

with

A load resistance $R = V/I$ equal to the reciprocal of this value draws the maximum power from the device. This is called the characteristic resistance of the cell.

FINAL GRADE

GENERAL COMMENTS

85 / 100

Instructor

Q1 - 12 / 15

Q2 - 21 / 25

Q3 - 21 / 25

Q4 - 16 / 20

Q5 - 15 / 15

total 85/100

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Comment 1

incorrect power calculation.

$$I = P/V$$

$$I = 250,000 / 6,000 = 41.67A$$

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