# CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
**SCOTTISH QUALIFICATIONS AUTHORITY**
ON BEHALF OF THE
**MARITIME AND COASTGUARD AGENCY**

**STCW 78 as amended MANAGEMENT ENGINEER REG. III/2 (UNLIMITED)**

**040-33 - ELECTROTECHNOLOGY**

**THURSDAY, 14 DECEMBER 2017**

**0915 - 1215 hrs**

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

**ELECTROTECHNOLOGY**

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. Fig Q1 shows a ring main of total length 1000 m and resistance (go + return) of 0.002 Ω/m. The ring main is supplied with 240 V d.c. and the following loads are connected to the ring at distances measured clockwise from the supply point:

   - 60 A at 200 m
   - 90 A at 500 m
   - 150 A at 700 m

   Calculate EACH of the following:

   (a) the currents fed into the ring main in each direction; (6)

   (b) the lowest voltage across any of the three loads; (5)

   (c) the total power loss in the ring main. (5)

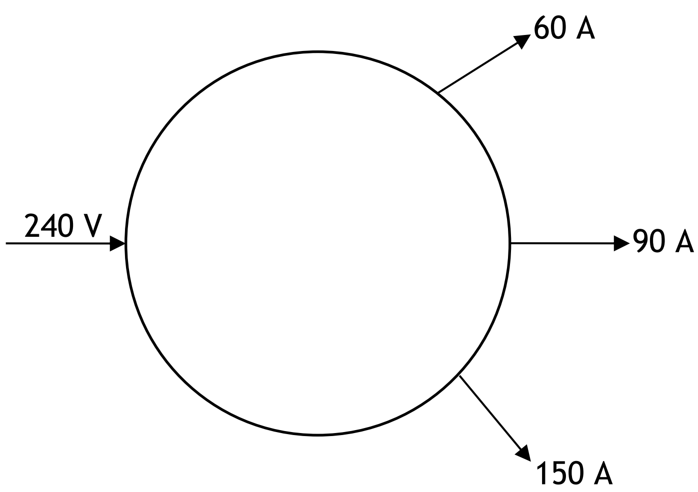


Fig Q1

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2. A 100 μF capacitor is charged from 120 V d.c. supply via a 10 kΩ resistor.

(a) Calculate EACH of the following:

(i) the time taken for the capacitor voltage to reach 80 V; (6)

(ii) the energy stored in the capacitor when its voltage has reached 80 V. (3)

(b) If the supply is now removed and replaced by a second 10 kΩ resistor, calculate EACH of the following:

(i) the time taken for the capacitor voltage to fall to 50 V; (5)

(ii) the circuit current when the capacitor voltage has fallen to 50 V. (2)

3. Three identical coils each of inductance 0.1 H and resistance 30 Ω are connected in delta to a three phase, 440 V, 50 Hz supply. Three identical star connected capacitors are connected in parallel with the delta load to raise the power factor to 0.9 lagging.

Calculate EACH of the following:

(a) the value of each capacitor; (10)

(b the percentage reduction in line current; (3)

(c) the kVAR taken by the three capacitors. (3)

4. A three phase, 440 V, 60 Hz, 8 pole induction motor drives a load of 7 kW and runs at 14.4 rev/sec. The power factor is 0.8 lag. The stator loss is 0.6 kW and the rotational losses (windage + friction) are 0.4 kW.

Calculate EACH of the following:

(a) the slip; (3)

(b) the frequency of rotor e.m.f.; (2)

(c) the input power to the motor; (8)

(d) the line current. (3)

5. Two three phase, 3.3 kV alternators operating in parallel supply the following three loads:

- a lighting load of 600 kW at unity power factor
- motors totalling 2500 kW at p.f. 0.7 lag
- a synchronous motor driving a bow thruster

One alternator supplies 350 A at p.f. 0.9 lag and the other supplies 330 A at p.f. 0.95 lag.

Determine EACH of the following:

(a) the kW supplied to the synchronous motor; (11)

(b) the p.f. of the synchronous motor; (3)

(c) the overall p.f. of the system. (2)

6. A 50 kVA transformer has an efficiency of 98% at full load, 0.8 p.f. and 97% at half load, 0.8 p.f. lag.

Calculate EACH of the following:

(a) the full load copper loss; (8)

(b) load at which maximum efficiency occurs; (4)

(c) the maximum efficiency for 0.8 p.f. load. (4)

7. With reference to shipboard electrical distribution systems:

(a) describe the meaning of the term *earth fault*; (2)

(b) explain why *insulated neutral* is preferred for low voltage systems; (3)

(c) sketch a circuit diagram of one arrangement for detecting phase to earth faults for a star connected alternator with neutral earthing resistor (NER); (6)

(d) calculate the ohmic value of a NER to limit the earth fault current to the full load rating of a 2 MW, 0.8 p.f., 3.3 kV, three-phase neutral earthed a.c. generator. (5)

8. (a) State the main reasons why switchboard instruments are supplied via instrument transformers from the power circuits which they monitor. (3)

(b) Explain why it is hazardous to open circuit a current transformer whilst its primary is still energised. (4)

(c) Sketch a circuit diagram showing an ammeter, a voltmeter and a wattmeter fed from a single phase supply via current and voltage transformers. (5)

(d) An ammeter, a voltmeter and a wattmeter monitoring a single phase supply read 40 A, 240 V and 8 kW respectively.

Calculate the power factor of the circuit. (4)

9. With reference to a full wave bridge rectifier using diodes:

(a) sketch a labelled circuit diagram; (4)

(b) explain the circuit operation; (4)

(c) sketch waveforms to show the relationships between the following:

(i) the bridge input voltage; (2)

(ii) the current through each diode; (4)

(iii) the load current; (2)

# SCOTTISH QUALIFICATIONS AUTHORITY
## MARKERS REPORT FORM

SUBJECT: 040-33 Electrotechnology

DATE: December 2017

*General Comments on Examination Paper*

- Correct standard
- Conformed to Management level syllabus

*General Comments*

- It is expected to specify relevant engineering units at the end of each answer. While failure to show engineering units after the numbers (e.g. 100 **A**) reflects badly, it also causes unnecessary and wasteful loss of marks.
- It is expected that candidates show full working through the solutions as indicated in the "**Notes for the guidance of candidates**" which says: "**All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.**"
- Diagrams without labels make little sense; candidates are expected to not assume that the 'examiner' will know.
- Producing graphs without labels is also poor reflection; hence it is expected that the graph axes be labelled with pertinent information.
- Candidates should also pay attention to the difference between a block diagram and a circuit diagram; one should produce a diagram as required by the questions and not the one that is convenient.

*General Comments of Specific Examination Questions*

**Q1**.

- **93%** of the candidates attempted this question of which **77%** were able to achieve 8 or more marks.
- Most candidates had a good attempt.
- **(a)**: candidates who managed to correctly apply the KVL ($\Sigma V = 0$) had a plain sailing; few struggled with the mathematical manipulation. Some candidates failed to notice the 'go + return' part and still multiplied the segment resistances by 2 – completely wasteful loss of marks.
- **(b)**: those who failed to understand the question struggled with the answer. Number of candidates lost marks because they obtained incorrect values of the currents as required in Part (a); and also did not identify the point of lowest voltage.
- **(c)**: straightforward answers for most, some still calculated the total power!
- General feedback: accurate calculation of segment resistances, correct application of KVL, and step-by-step working through.

**Q2**

- **89%** of the candidates attempted this question of which **95%** were able to achieve 8 or more marks.
- Most candidates had a good attempt.
- **(a)**: well answered by most; few who lost valuable marks struggled with the mathematical manipulation.
- Part (b): caused problems for good number of candidates who failed to notice the change in operating condition; candidates still employed the time constant value calculated in Part (a) and interestingly few candidates either employed the voltage growth equation or 150 V as the $V_{Max}$.

**Q3**.

- **70%** of the candidates attempted this question of which **58%** were able to achieve 8 or more marks.
- Number of candidates lost their way towards the power factor correction part of the question, other than that attempted fairly. Candidates who worked step-by-step and from the first principles had no trouble at all getting to the end unscathed.
- **(a)**: candidates still getting the basic three-phase identities mixed up (such as star $I_{Line} = I_{Phase}$, $V_{Line} = \sqrt{3} \times V_{Phase}$ and so on) and hence arriving at incorrect answers. Power triangle method seemed to be the favoured route as it is straightforward as compared to active/reactive current method.
- **(b)**: few got the line current reduction formula wrong ($Percent\ reduction\ in\ line\ current = \frac{I_L\ Before\ Correction - I_L\ After\ Correction}{I_L\ Before\ Correction}$) and hence arrived at incorrect answers.
- **(c)**: most got this part right, some gave the impression that they did not understand the question and came up with 'creative' ways of calculating the kVAr taken by the capacitors where individual kVAr was calculated. Some candidates applied single phase formula for calculating **Q**.

Q4.

- **95%** of the candidates attempted this question of which **86%** were able to achieve 8 or more marks.
- Successfully answered by most.
- **(a)**: answered well.
- **(b)**: answered well by most however some got the $f_r$ exceeding 10 Hz even 54 Hz, application of wrong formula.
- **(c)**: answered well by most however some candidates lost their way working from shaft power to input power and still subtracting the losses. Few candidates thought P in the formula $P = \sqrt{3} \times V \times I \times pf$ is the shaft output power!
- **(d)**: answered well by most other than those who got the input power figure incorrect.

Q5.

- **87%** of the candidates attempted this question of which **80%** were able to achieve 8 or more marks.
- A straightforward question and most candidates had a good attempt at it; those who got lost in the way did so because they did not follow through the steps. This question is a simple 'accounting exercise'. Candidates who had a good grasp of the power triangle sailed through the question effortlessly. Some students forget to fully specify the 'power factor' and forget to indicate whether the number they have calculated are 'lead' or 'lag'.

Q6.

- **56%** of the candidates attempted this question of which **7%** were able to achieve 8 or more marks.
- A potential practical issue with the question was identified in that due to figures provided in the question the transformer would achieve maximum efficiency at a point well above its rated 50 kVA causing an overload. The designer would obviously try to get the transformer to operate at maximum efficiency within its rated capacity. One of the possibilities, however, is that the transformer may be a standard transformer that has been de-rated to operate in high marine ambient temperatures; in this case the difference between the maximum efficiency and the reduced rating efficiency would be expected to be minimal. As an academic exercise involving the knowledge and understanding of transformer losses and efficiency, provided figures would still allow candidates to work through the steps and arrive at final answers, which may not seem practical. Candidates were not marked down for arriving at such figures, and candidates were given due credit for their academic rigour and application of the principles of transformer losses and efficiency.
- This question requires a bit of imagination and maths proficiency, not attempted well by many candidates. Question is an 'accounting exercise' involving basic understanding of transformer efficiency and losses understanding. The way to go is to obtain two sets of simultaneous equations (of 2 unknowns - $W_{Fe}$ and $(W_{Cu})_{FL}$).
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Q7.

- **41%** of the candidates attempted this question of which **40%** were able to achieve 8 or more marks.
- **(a)**: generally answered well by most.
- **(b)**: generally answered well by most.
- **(c)**: partially answered well by those who attempted, those who lost marks for some reason had no NER incorporated in their circuit or the E/F detection circuit was not provided.
- **(d)**: partially answered well by those who attempted, majority of the candidates lost their way towards the part where NER's Ohmic's values is calculated – it requires the value of phase voltage rather than the line value.

Q8.

- **39%** of the candidates attempted this question of which **63%** were able to achieve 8 or more marks.
- **(a)**: answered well by those who attempted this part; safety, standardisation and economy.
- **(b)**: generally answered well covering the flux, high induced voltages and overheating.
- **(c)**: answered well.
- **(d)**: answered well other than the fact that majority failed to identify the nature of the power factor (lead or lag) in their answers.

Q9.

- **12%** of the candidates attempted this question of which **16%** were able to achieve 8 or more marks.
- **(a)**: a good mix of answers including single and three phase circuits.
- **(b)**: explanation to sketched circuit was where candidates lost marks as the explanation was disjointed from the circuit.
- **(c)**: drawing waveforms without labels especially on the axes means almost nothing.

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**STCW 78 as amended CHIEF ENGINEER REG. III/2 (UNLIMITED)**

**041-33 - ELECTROTECHNOLOGY**

**THURSDAY, 30 MARCH 2017**

**0915 - 1215 hrs**

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate’s examination workbook
Graph paper

**ELECTROTECHNOLOGY**

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. (a) For the circuit shown in Fig Q1, calculate EACH of the following:

   (i) the current through the 12 Ω resistor; (8)

   (ii) the p.d. across EACH resistor. (3)

   (b) Calculate the voltage $V_{AB}$, if the 12 Ω resistor is now removed from the circuit. (5)

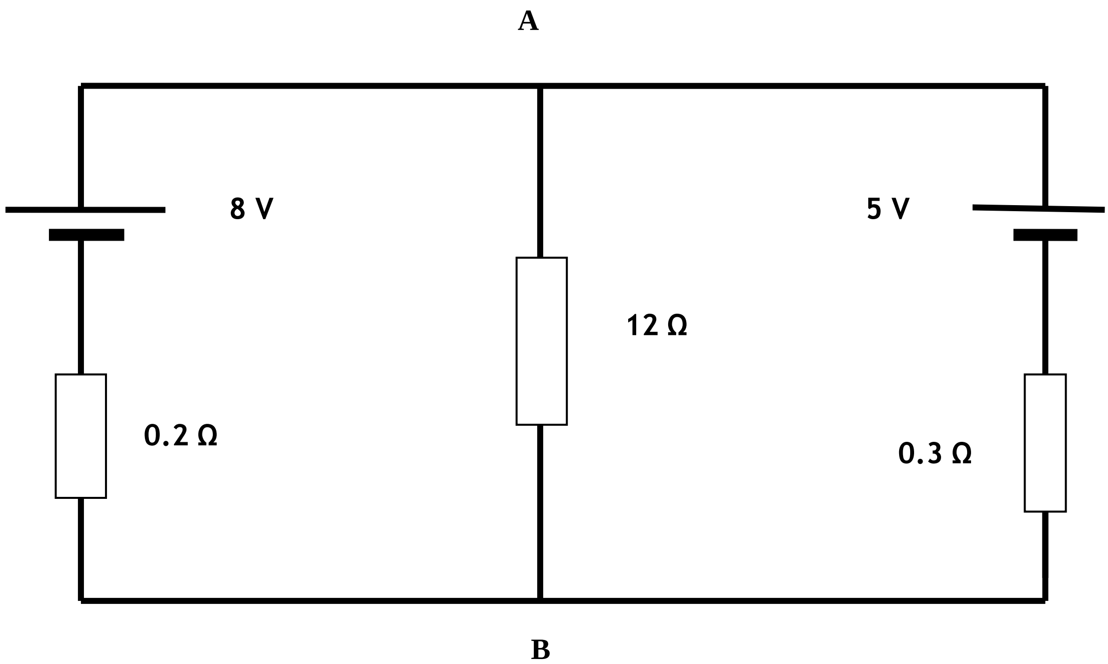


Fig Q1

2. A relay coil has a resistance of 200 Ω and the current required to operate the relay is 150 mA.

When the coil is connected to 50 V d.c. it takes 40 ms for the relay to operate.

(a) Calculate EACH of the following:

(i) the steady state relay current; (2)

(ii) the time constant for the coil; (4)

(iii) the inductance of the coil. (4)

(b) To increase the operating time for the relay, a 50 Ω resistor is connected in series with the coil.

Calculate the new operating time for the relay. (6)

3. The p.d. between base and emitter for the transistor shown in Fig Q3 is 0.3 V and the steady state output voltage $V_c$ is 6 V.

Determine EACH of the following, assuming that the base current is small enough to be ignored:

(a) the voltage at the base with respect to earth; (3)

(b) the p.d. between emitter and collector; (3)

(c) the value of the load resistor $R_L$; (3)

(d) the power dissipated in the 200 Ω resistor; (3)

(e) the power dissipated in the transistor. (4)

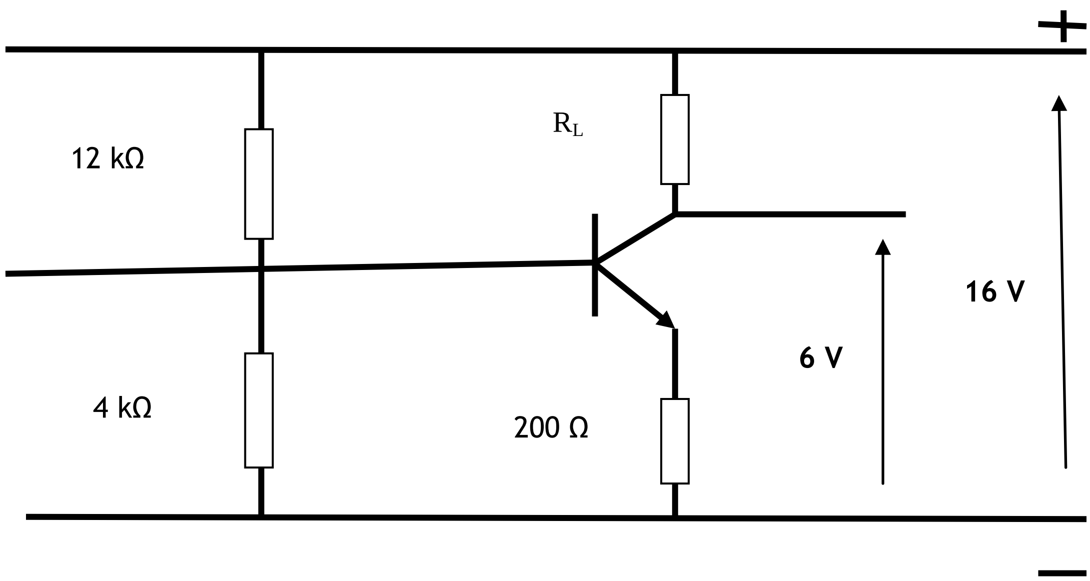


Fig Q3

4. A 200 Ω resistor is connected in series with a coil of resistance R and inductance L across a 240 V 50 Hz a.c. supply.

The p.d. across the 200 Ω is 120 V and the p.d. across the coil is 190 V.

Determine EACH of the following:

(a) the supply current; (3)

(b) the resistance R and inductance L for the coil; (10)

(c) the power factor of the coil. (3)

5. A balanced star connected three phase load has a coil of inductance 0.2 H and resistance 50 Ω in each phase. It is supplied at 415 V, 50 Hz.

Calculate EACH of the following:

(a) the line current; (4)

(b) the power factor; (3)

(c) the value of EACH of three identical delta connected capacitors to be connected across the same supply to raise the power factor to 0.9 lag; (6)

(d) the new value of the line current. (3)

6. A 6 pole 3 phase squirrel cage induction motor runs on 380 V 60 Hz supply.

It draws a line current of 80 A at a power factor of 0.8 lag.

The shaft speed is 19 rev/sec.

If the iron losses are 2 kW, the stator copper loss is 1 kW and the windage and friction loss is 1.5 kW, calculate EACH of the following:

(a) the slip as a per unit value; (3)

(b) the rotor copper loss; (5)

(c) the shaft output power; (5)

(d) the efficiency. (3)

7. (a) Sketch the reverse voltage/current characteristic for a low power Zener diode with a breakdown voltage of 10 V. (5)

(b) Sketch a simple voltage regulator circuit using a Zener diode. (5)

(c) State which factors determine the value of the series resistor used in the circuit described in Q7(b). (3)

(d) State which factors determine the power rating of the Zener diode in the circuit described in Q7(b). (3)

8. (a) Explain the term *power factor correction.* (3)

(b) State TWO advantages of power factor correction. (4)

(c) Explain, with the aid of a circuit diagram, how power factor correction can be effected in a three-phase circuit using capacitors. (5)

(d) State ONE method, other than the use of capacitors, by which power factor correction can be effected in a 3 ph circuit. (4)

9. (a) Explain how torque is produced in a 3 phase squirrel cage induction motor. (5)

(b) State why the starting current is several times higher than the full load current. (3)

(c) State why the power factor is very low on starting. (3)

(d) Describe ONE method of construction by means of which the starting power factor may be raised, the starting current lowered and the starting torque improved. (5)

# SCOTTISH QUALIFICATIONS AUTHORITY

**MARKERS REPORT FORM**

**PART I**

SUBJECT: Electrotechnology 041-33

DATE: 30th March 2017

*General Comments on Examination Paper*

I am happy that the standard of the paper was correct and it contained a good spread of questions from various sections of the syllabus.

*General Comments of Specific Examination Questions.*

Q.1. This was a simple network which most candidates tackled with confidence and scored full marks. I still worry about candidates who put down answers with p.d.'s in excess of the two battery voltages added together, where are those extra volts coming from?

Q2. This question was also well answered. Most of those who failed to score full marks did so because they did not realise that the time constant had changed in the second part of the question because extra resistance had been added.

Q.3. No problems here. One or two candidates added the base – emitter volt drop rather than subtracting it and got an incorrect value for the emitter voltage.

Q.4. This straightforward series circuit caused few problems, those who did not get all the correct answers generally had made mathematical mistakes.

Q.5. This caused a few problems for those who did not correctly resolve the line current into in phase and quadrature components before finding the reduced quadrature component and hence the phase current for each capacitor.

Q6. A stock induction motor question, but a few candidates are still convinced that the power increases as you move through the motor from input to final shaft power !

Q.7. There were some very 'droopy' reverse characteristics ! The sudden increase in reverse current at the Zener breakdown point is almost right angled.. The question asked for a 'simple voltage regulator circuit', a few candidates offered a full excitation circuit for an alternator. Very few students were able to pinpoint the factors determining the value of the series resistor or the appropriate rating of the Zener diode

Q.8. At least half the candidates explained the term *power factor* not *power factor correction*. The question requires the candidate to mention lagging KVA and the need to add leading KVA to raise the power factor. Full marks will only be obtained for the last part of the question if the candidate states an over excited synchronous motor.

Q.9. There were some very hazy explanations of the production of torque in the induction motor! A fair number of candidates had a ‘pulsating’ magnetic field rather than a ‘rotating’ one and a fair number also thought that the reluctance of the air gap was responsible for the high starting current and poor starting power factor. A method of construction to improve the starting p.f. and reduce the starting current does not include the star-delta starter or the auto transformer starter but does include the wound rotor as well as the Boucherot, trislot and sashbar types of rotor.

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**STCW 78 as amended CHIEF ENGINEER REG. III/2 (UNLIMITED)**

**041-33 - ELECTROTECHNOLOGY**

**THURSDAY, 15 DECEMBER 2016**

**0915 - 1215 hrs**

Examination paper inserts:

Notes for the guidance of candidates:

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**ELECTROTECHNOLOGY**

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. A non-linear element is connected in series with a resistor across 240 V. d.c. supply.

   The non-linear element is governed by the law $I = kV^2$. When the resistor is set to 10 Ω the supply current is 12 A.

   (a) Calculate EACH of the following:

   (i) the resistance value required to reduce the current to 8 A; (8)

   (ii) the resistance of the non-linear element when the current is 8 A. (2)

   (b) The supply voltage is reduced to 159 V. Calculate the power dissipated in the non-linear element if the series resistor is reset to 10 Ω. (6)

2. A 120 uF capacitor is charged through a resistance from a 12 V d.c. supply and the instantaneous charging current at switch-on is 2.55 mA.

   (a) Calculate EACH of the following:

   (i) the value of the charging resistance; (2)

   (ii) the time constant; (2)

   (iii) the voltage across the capacitor after 2 s of charging; (3)

   (iv) the energy stored after 2 s. (2)

   (b) After 2.5 s of charging the supply is switched off and the capacitor is discharged through a 1.2 kΩ resistor.

   Calculate EACH of the following:

   (i) the new time constant; (2)

   (ii) the voltage across the capacitor after 124 ms; (3)

   (iii) the discharge current at 124 ms. (2)

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3. An unstabilised d.c. power supply voltage which varies between 10 V and 60 V is connected across a stabiliser circuit comprising a 520 Ω resistor in series with a 8.2 V zener diode. The zener diode has a slope resistance of 12 Ω and requires a minimum operating current of 1 mA. The arrangement supplies a variable load current of 0-40 mA.

(a) Draw a circuit diagram of the arrangement. (2)

(b) Calculate EACH of the following:

(i) the load voltage when the load current is zero and the supply p.d. is 10 V; (4)

(ii) the load voltage when the load current is 40 mA and the supply p.d. is 50 V; (3)

(iii) the minimum value of the supply p.d. to give a stabilised load voltage for a load current of 40 mA; (3)

(iv) the power dissipated in the zener diode when the supply is 60 V and the load current is 30 mA. (4)

4. A series circuit comprising a pure resistor 'R', a coil having resistance and inductance and a capacitor is connected in series across a 60 V variable frequency supply. When the supply frequency is 400 Hz the current reaches its maximum value of 0.8 A and the voltages across the pure resistor 'R' and the capacitor are 40 V and 200 V respectively.

Calculate EACH of the following:

(a) the value of the pure resistor 'R'; (2)

(b) the value of the capacitor; (2)

(c) the resistance and inductance of the coil; (6)

(d) the p.d. across the coil; (3)

(e) the coil power factor. (3)

5. (a) State two disadvantages of operating electrical circuits at a low power factor. (2)

(b) A 3-ph, 440 V, 80 kVA transformer supplies a unity power-factor load of 15 kW and an inductive load of 55 kW and power-factor of 0.67.

Determine the minimum kVAR rating of a load capacitor bank to ensure that the supply transformer is not overloaded. (10)

Calculate the current supplied by the transformer in EACH of the following:

(i) prior to the power factor correction being applied; (2)

(ii) after the power factor correction is applied. (2)

6. (a) Describe the principle of operation of a 1-ph, a.c. power transformer. (6)

(b) A 500 kVA power transformer has a full load copper loss of 4 kW and iron loss of 2.5 kW.

Calculate EACH of the following:

(i) the kVA load at maximum efficiency; (5)

(ii) the maximum efficiency for a load power factor of 0.75 lagging at this kVA rating in Q6(b)(i). (5)

7. (a) Explain the reasons for using instrument transformers in a ship's electrical distribution system. (4)

(b) Sketch a circuit diagram of a voltmeter, an ammeter and a wattmeter connected to a 1-ph, a.c. circuit utilising appropriate current transformers and voltage transformers on a set of a.c. switchboard instruments. (6)

(c) Explain why the secondary windings of instrument transformers are connected to earth. (4)

(d) A voltmeter, ammeter and wattmeter, connected to a 1-ph, a.c. circuit, recorded the following readings:

440 V, 570 A and 240 kW

Calculate the power factor of the circuit. (2)

8. (a) State two advantages and two disadvantages of the wound rotor method of starting an induction motor. (4)

(b) Sketch a circuit diagram showing the rotor/slip rings and starting resistors connection for a three phase wound rotor induction motor. (6)

(c) A three phase 4 pole wound rotor induction motor has a rotor induced e.m.f. of 230 V, 60 Hz between the slip rings at standstill.

Calculate EACH of the following:

(i) the rotor e.m.f. and rotor frequency at a slip of 0.05 p.u.; (4)

(ii) the synchronous speed. (2)

9. (a) Draw a circuit diagram illustrating how a single thyristor ('silicon controlled rectifier') may be used to provide a variable voltage d.c. output from a single phase a.c. supply. (8)

(b) Explain how the *firing angle* of the thyristor is varied. (4)

(c) Sketch waveforms for the output voltage when the firing angle is:

(i) 60°; (2)

(ii) 120°. (2)

# SCOTTISH QUALIFICATIONS AUTHORITY
## MARKERS REPORT FORM
## PART I

SUBJECT: Electrotechnology 041-33

DATE: 15th Dec. 2016

*General Comments on Examination Paper*

The examination paper was 'fit for purpose': several candidates achieved marks in the upper eighties and nineties and each question earned several candidates full marks. The particularly poor showing of a number of students must be ascribed to a lack of preparedness or inadequate instruction.

*General Comments of Specific Examination Questions.*

Q.1**.** A stock question, used several times before, on which a lot of candidates scored full marks. A few made the mistake of thinking that the p.d. across the nonlinear resistor would remain the same after the supply voltage has been changed; clearly this cannot be so.

Q.2. This too was well tackled and many candidates scored full marks. A handful of scholars assumed that the capacitor discharged through the original charging resistor and the 1200 ohm resistor in series. I have not deducted any marks for this error and awarded full marks if their answers were consistent with this circuit configuration.

Q.3. Also well answered. The only serious mistake made by some students was to forget the currents were in mA. and this produced some amazing Zener diodes rated in KW ! Always put the units in to the working, not just the numbers.

Q.4. This question attracted good response from a fair number of students. Those who failed to score full marks did so because they made the elementary mistake of subtracting and adding voltages arithmetically when they were not in phase.

Q.5.Only about half the candidates attempted this question and of those only a handful scored well. Firstly the answers showed little or no understanding of the effect of a low p.f. on a power supply system and secondly because the numerical part of the question was rather different to the usual p.f. correction question panic set in. Clearly the capacitor bank has to be on the secondary side of the transformer and as the secondary voltage is not known then one cannot work in currents. The KVAr of the load must be found, then the KVAr to bring the burden to 80 KVA and the difference between these two figures is the KVAr of the capacitor bank.. The last part of the question can then be worked out using the voltage on the primary side.

Q.6. This fared much better than the previous question, yet too many students wrote at great length to gain just four marks; mention of 'a common magnetic circuit' and 'mutual inductance' are the vital phrases. A few candidates (too many!) still believe that efficiency can be calculated as the ratio of KVA output to KVA input when ,correctly, it is the ratio of power out to power in.

Q.7.Again there were some long and rambling discourses to score just four points. Mention of safety of personal and the facility to use standard low voltage switchboard instruments is sufficient.. The calculation was correctly carried out by almost all students.

Q.8. There were some good circuit diagrams submitted and a fair number of candidates found the running values of rotor emf and frequency from the standstill values given, together with the synchronous speed.

Q. 9. A lot of correct circuit diagrams and a fair number of correct explanations as to how the firing angle is varied . But a fairly large minority wandered off into how the thyristor (or SCR) works rather than how the circuit components are used to determine the firing angle. Too many candidates appeared to think that the circuit would conduct on positive and negative half cycles, when, of course, a counter parallel connected diode or second thyristor is needed if both half cycles are to be utilised.

**CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY –**
**MARINE ENGINEER OFFICER**

EXAMINATIONS ADMINISTERED BY THE
**SCOTTISH QUALIFICATIONS AUTHORITY**
ON BEHALF OF THE
**MARITIME AND COASTGUARD AGENCY**

STCW 78 as amended **CHIEF ENGINEER REG. III/2 (UNLIMITED)**

**041-33 - ELECTROTECHNOLOGY**

**THURSDAY, 20 OCTOBER 2016**

**0915 - 1215 hrs**

Examination paper inserts:

Worksheet Q3

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook
Graph paper

**ELECTROTECHNOLOGY**

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. For the network shown in Fig Q1 calculate EACH of the following:

   (a) the current drawn from each battery; (8)

   (b) the potential difference across the 40 Ω resistor and the 50 Ω resistor; (4)

   (c) the power dissipated in the 60 Ω resistor. (4)

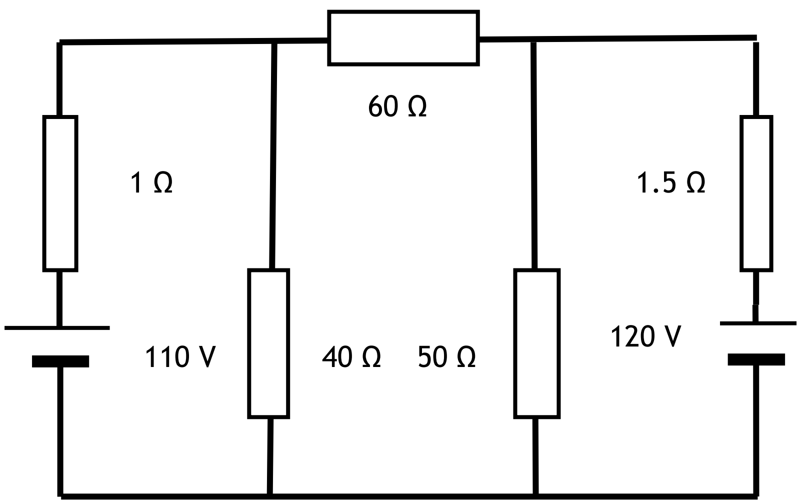



Fig Q1

[OVER

2. The V/I characteristics of a non-linear resistor are given in Table Q2 below.

| V (volts) | 40 | 60 | 80 | 100 | 120 | 140 |
|---|---|---|---|---|---|---|
| I (mA) | 0.65 | 1.05 | 1.55 | 2.20 | 3.20 | 4.70 |

Table Q2

The non-linear resistor is connected in series with a paralleled pair of resistors of 40 KΩ and 60 KΩ and the overall circuit is supplied at 140 V. d.c.

Determine graphically or otherwise:

(a) the current in the non-linear resistor; (8)

(b) the effective resistance of the non-linear resistor; (4)

(c) The current in the 40 KΩ resistor. (4)

3. A power silicon transistor with the characteristics given in Worksheet Q3 is operated from a 16 V d.c. supply. The operating ('quiescent') point is $I_b$ = 40 mA and $I_c$= 3.8 A and the maximum collective current is 6 A.

(a) Draw the load line on the characteristics. (4)

(b) Determine EACH of the following:

(i) the value of the collector load resistance; (4)

(ii) the peak-to-peak variation in collector current if a signal of +/- 40mA is applied to the base; (2)

(iii) the corresponding variation in collector voltage; (2)

(iv) the power dissipated in the transistor due to this signal. (4)

4. An a.c. series circuit consists of four elements as shown in Fig Q4. The power dissipated in the 50 Ω resistor is 200 W and the volt drops across the various parts of the circuit are as shown.

Calculate EACH of the following:

(a) the values of C and L; (8)

(b) the overall power factor of the circuit; (4)

(c) the kVAr for the inductance. (4)

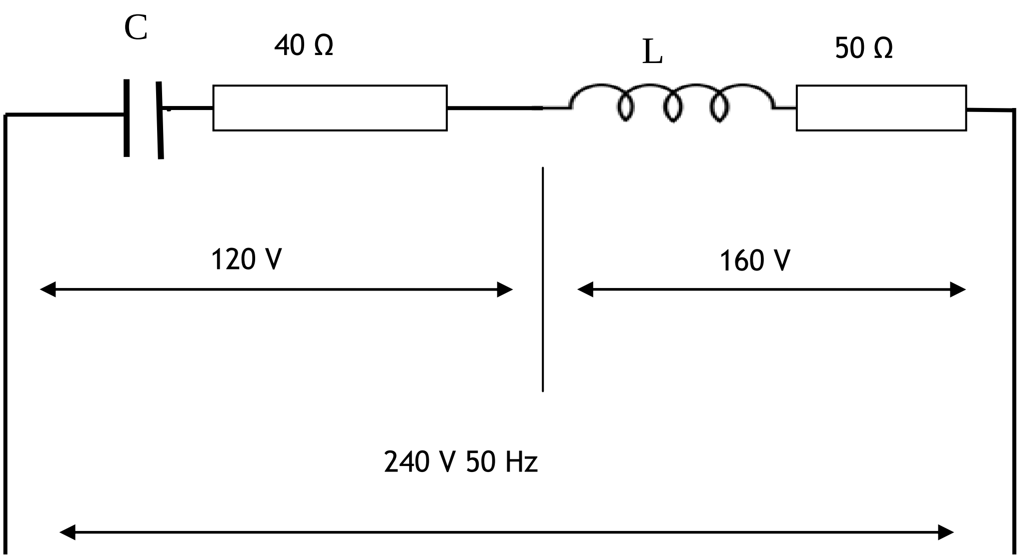



Fig Q4

5. A balanced three phase load is star connected and has a capacitor of 100 μF in series with a resistor of 30 Ω in each phase. It is connected to a three phase supply of 440 V 50 Hz.

Calculate EACH of the following:

(a) the line current; (6)

(b) the power factor of the load; (4)

(c) the value of each of three identical delta connected resistors which, when connected to the same supply, will raise the overall power factor to 0.9. (6)

[OVER

6. A 440 V/110 V single phase transformer takes a no load current of 5 A at power factor 0.25 lag. On load the transformer supplies 7.5 kVA at power factor 0.8 lag.

Calculate EACH of the following, for the on load condition:

(a) the transformer secondary current; (2)

(b) the transformer primary current; (8)

(c) the primary power factor; (3)

(d) the efficiency of the transformer at this load. (3)

7. (a) List the various losses which occur in a squirrel cage motor on load. (4)

(b) State, with reasons, which of these losses are:

(i) independent of load current and speed; (4)

(ii) dependent on load current; (4)

(iii) dependent on speed. (4)

8. (a) Sketch the circuit arrangement for a full wave three phase rectifier indicating on your sketch the current directions for both half cycles of one phase. (8)

(b) Sketch the output waveform for the circuit in Q8(a). (3)

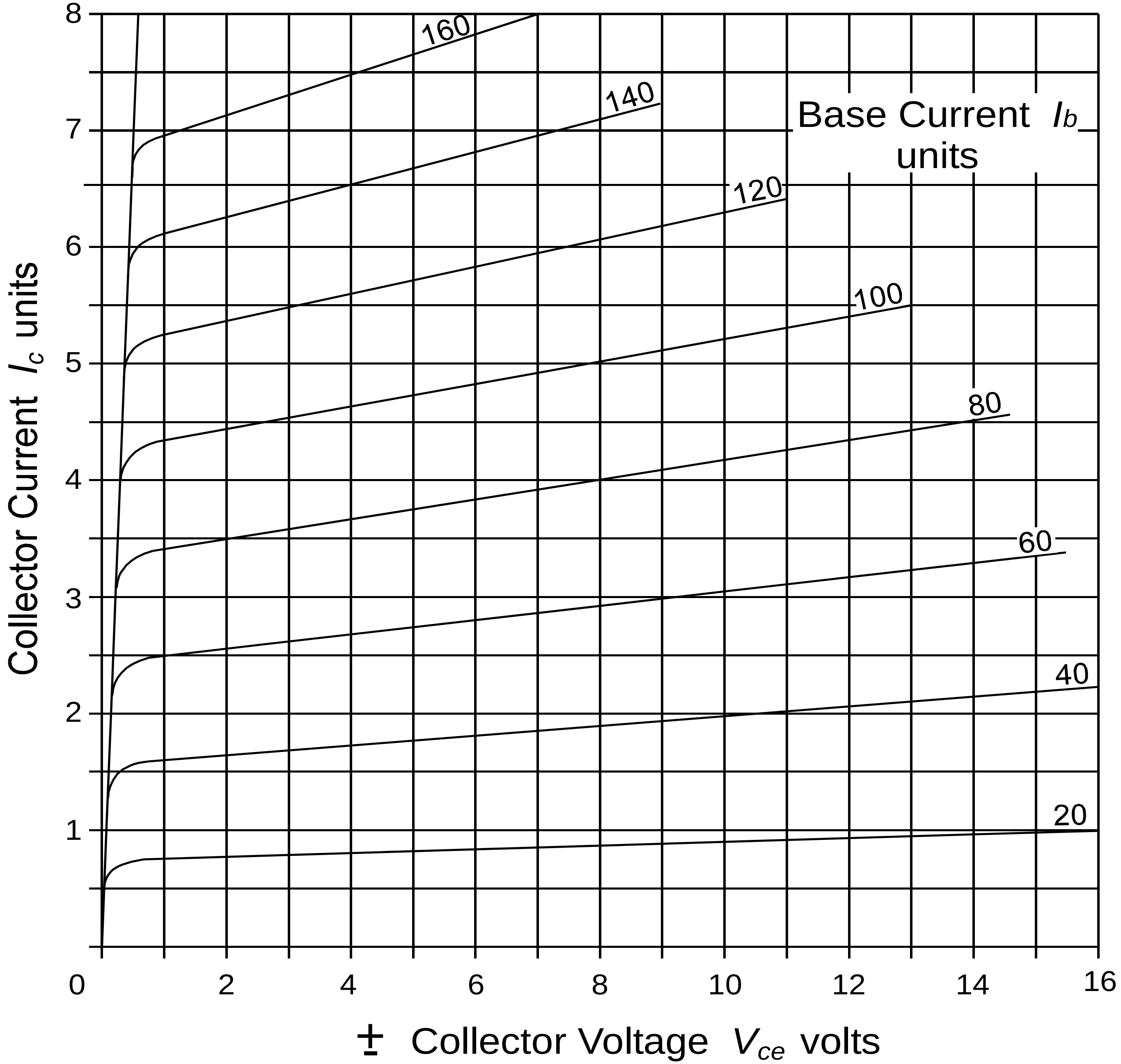
(c) Add a smoothing capacitor to the rectifier circuit and explain why less smoothing capacitance is needed for the three phase rectifier set compared to a single phase rectifier. (5)

9. (a) Explain what is meant by the term *single phasing*. (6)

(b) State the probable effect of single phasing of a three phase induction motor operating on load. (4)

(c) State ONE method by which a motor can be protected against the effects of single phasing. (6)

(This Worksheet must be returned with your answer book)




# COMMON EMITTER TRANSISTOR CHARACTERISTCS

| TYPE | SCALE FACTORS per unit value of | |
|---|---|---|
| | $I_b$ | $I_c$ |
| 1. Small Si<br>2. Power Si | 1 µA<br>1 mA | 1 mA<br>1 A |

Candidate's Name ……………………………………………..…   Examination Centre ……………………………………………….

***refrigerant: $CO_2$***

| saturation values | | | | | | | superheat ($T - T_s$) 50 K | | superheat ($T - T_s$) 100 K | |
|---|---|---|---|---|---|---|---|---|---|---|
| **T** (°C) | $p_s$ (bar) | $v_g$ (m³/kg) | $h_f$ (kJ/kg) | $h_g$ (kJ/kg) | $s_f$ (kJ/(kg K)) | $s_g$ (kJ/(kg K)) | **h** (kJ/kg) | **s** (kJ/(kg K)) | **h** (kJ/kg) | **s** (kJ/(kg K)) |
| -50 | 6.8234 | 0.0558 | -19.96 | 319.77 | -0.0863 | 1.4362 | 365.1 | 1.620 | 409.9 | 1.770 |
| -45 | 8.3184 | 0.0460 | -10.03 | 321.23 | -0.0428 | 1.4091 | 367.81 | 1.594 | 413.26 | 1.744 |
| -40 | 10.0450 | 0.0383 | 0.00 | 322.42 | 0.0000 | 1.3829 | 370.35 | 1.569 | 416.53 | 1.720 |
| -35 | 12.0242 | 0.0320 | 10.15 | 323.33 | 0.0423 | 1.3574 | 372.75 | 1.546 | 419.70 | 1.696 |
| -30 | 14.2776 | 0.0270 | 20.43 | 323.92 | 0.0842 | 1.3323 | 375.00 | 1.524 | 422.77 | 1.674 |
| -28 | 15.2607 | 0.0252 | 24.60 | 324.06 | 0.1009 | 1.3224 | 375.85 | 1.515 | 423.97 | 1.666 |
| -26 | 16.2926 | 0.0236 | 28.78 | 324.14 | 0.1175 | 1.3125 | 376.68 | 1.507 | 425.15 | 1.657 |
| -24 | 17.3749 | 0.0220 | 33.00 | 324.15 | 0.1341 | 1.3026 | 377.48 | 1.498 | 426.31 | 1.649 |
| -22 | 18.5089 | 0.0206 | 37.26 | 324.11 | 0.1506 | 1.2928 | 378.25 | 1.490 | 427.45 | 1.641 |
| -20 | 19.6963 | 0.0193 | 41.55 | 323.99 | 0.1672 | 1.2829 | 378.99 | 1.482 | 428.58 | 1.633 |
| -18 | 20.9384 | 0.0181 | 45.87 | 323.80 | 0.1837 | 1.2730 | 379.70 | 1.474 | 429.68 | 1.626 |
| -16 | 22.2370 | 0.0170 | 50.24 | 323.53 | 0.2003 | 1.2631 | 380.39 | 1.466 | 430.77 | 1.618 |
| -14 | 23.5935 | 0.0159 | 54.65 | 323.19 | 0.2169 | 1.2531 | 381.04 | 1.458 | 431.83 | 1.610 |
| -12 | 25.0095 | 0.0150 | 59.11 | 322.76 | 0.2334 | 1.2430 | 381.66 | 1.450 | 432.88 | 1.603 |
| -10 | 26.4868 | 0.0140 | 63.62 | 322.23 | 0.2501 | 1.2328 | 382.25 | 1.443 | 433.90 | 1.596 |
| -8 | 28.0269 | 0.0132 | 68.18 | 321.61 | 0.2668 | 1.2226 | 382.81 | 1.435 | 434.91 | 1.589 |
| -6 | 29.6316 | 0.0124 | 72.81 | 320.89 | 0.2835 | 1.2121 | 383.34 | 1.428 | 435.89 | 1.582 |
| -4 | 31.3027 | 0.0116 | 77.50 | 320.05 | 0.3003 | 1.2015 | 383.83 | 1.420 | 436.85 | 1.575 |
| -2 | 33.0420 | 0.0109 | 82.26 | 319.09 | 0.3173 | 1.1907 | 384.29 | 1.413 | 437.79 | 1.568 |
| 0 | 34.8514 | 0.0102 | 87.10 | 317.99 | 0.3344 | 1.1797 | 384.71 | 1.405 | 438.71 | 1.561 |
| 2 | 36.7329 | 0.0096 | 92.02 | 316.75 | 0.3516 | 1.1683 | 385.10 | 1.398 | 439.61 | 1.554 |
| 4 | 38.6884 | 0.0090 | 97.05 | 315.35 | 0.3690 | 1.1567 | 385.45 | 1.391 | 440.49 | 1.548 |
| 6 | 40.7202 | 0.0084 | 102.18 | 313.77 | 0.3866 | 1.1446 | 385.77 | 1.384 | 441.34 | 1.541 |
| 8 | 42.8306 | 0.0079 | 107.43 | 311.99 | 0.4045 | 1.1321 | 386.05 | 1.377 | 442.17 | 1.535 |
| 10 | 45.0218 | 0.0074 | 112.83 | 309.98 | 0.4228 | 1.1190 | 386.29 | 1.369 | 442.97 | 1.528 |
| 12 | 47.2966 | 0.0069 | 118.38 | 307.72 | 0.4414 | 1.1053 | 386.49 | 1.362 | 443.76 | 1.522 |
| 14 | 49.6577 | 0.0064 | 124.13 | 305.15 | 0.4605 | 1.0909 | 386.65 | 1.355 | 444.51 | 1.516 |
| 16 | 52.1080 | 0.0060 | 130.11 | 302.22 | 0.4802 | 1.0754 | 386.77 | 1.348 | 445.25 | 1.509 |
| 18 | 54.6511 | 0.0056 | 136.36 | 298.86 | 0.5006 | 1.0588 | 386.85 | 1.341 | 445.95 | 1.503 |
| 20 | 57.2905 | 0.0051 | 142.97 | 294.96 | 0.5221 | 1.0406 | 386.88 | 1.334 | 446.64 | 1.497 |
| 22 | 60.0308 | 0.0047 | 150.02 | 290.36 | 0.5449 | 1.0203 | 386.87 | 1.327 | 447.29 | 1.491 |
| 24 | 62.8773 | 0.0043 | 157.71 | 284.80 | 0.5695 | 0.9972 | 386.81 | 1.320 | 447.91 | 1.485 |
| 26 | 65.8368 | 0.0039 | 166.36 | 277.80 | 0.5971 | 0.9697 | 386.70 | 1.313 | 448.51 | 1.478 |
| 28 | 68.9182 | 0.0035 | 176.72 | 268.30 | 0.6301 | 0.9342 | 386.53 | 1.305 | 449.07 | 1.472 |
| 30 | 72.1369 | 0.0029 | 191.65 | 252.23 | 0.6778 | 0.8776 | 386.30 | 1.298 | 449.58 | 1.466 |
| 30.98 | 73.7730 | 0.0021 | 219.34 | 219.34 | 0.7680 | 0.7680 | 386.15 | 1.294 | 449.82 | 1.463 |

*based on data from NIST:* ***www.nist.gov***

# SCOTTISH QUALIFICATIONS AUTHORITY
## MARKERS REPORT FORM

SUBJECT: Electrotechnology 041-33

DATE: 27th October 2016

*General Comments on Examination Paper*

An examination paper on which one candidate scored a 'full house' and several others scored in the 80's and 90's cannot have been pitched at too demanding a level; I am satisfied the paper was a fair test of the cohort's abilities.

*General Comments of Specific Examination Questions.*

**Q. 1.** A straightforward network which produced some totally correct solutions but which also led to some very tortuous solutions which yielded ridiculous answers. One or two students found p.d.'s across parts of the circuit greater than the combined e.m.f.'s of the two batteries ! Students need to be taught not just how to tackle such network problems but also the shortest and safest method to produce the desired answers.

**Q.2.** There were plenty of correct solutions to this question. The commonest mistake was to 'suppress the zero' i.e. start the voltage scale at 20 V. rather than 0V to get a longer voltage scale. This is fine if you remember that the intercept of the resistance line on the current axis will no longer be at 140V/24Kohms, but at 120V/24 Kohms. This mistake means that slope of the resistance line is incorrect and the answers obtained using this resistance line will be incorrect..

**Q.3.** Most marks were lost because candidates gave the swings in collector voltage and current inr.m.s. values when peak to peak was asked for or perversely used peak to peak values for calculating the power dissipated when r.m.s. values are called for.

**Q.4.** The major problem for most candidates was in calculating the kVAr of the inductance. There were some long solutions involving phasor diagrams and matrices which did not give the correct answer when the simple product of $I^2 X_L$ will give the correct figure in just one line.

**Q. 5.** There were some very good solutions to this question, those who lost marks did so because they did not realise that the three added resistors were connected in delta and used phase voltage rather that line voltage in calculating the values of the resistors

**Q.6.** ,Plenty of candidates scored full marks on this question, those who did not made the mistake of calculating efficacy using KVA values rather the KW values.

**Q.7.** Although the response to the discursive questions was better than usual this question showed a naive approach in too many cases. The question specifically mentions 'a squirrel cage motor on load'. This implies that the listing of the losses must state where they occur e.g. 'stator iron loss', 'rotor copper loss' etc. A bald statement that the losses are, copper losses, iron losses , rotational losses etc is not good enough. A number of students listed the looses as copper losses, iron losses, rotational losses and heat ! Some also included 'slip' amongst the losses ! Many were unsure which losses were load dependent or speed dependent. To score well on this type of question requires a proper understanding of what causes those losses, no amount of 'waffle' will disguise a hazy understanding of how the losses occur.

**Q.8.**This produced some good and bad answers. The question calls for the current directions to be indicated for both half cycles of one phase. This means showing a current path through say the 'red' diode with return paths via both 'yellow' and 'blue' diodes and conversely for the negative half wave. Some waveform diagrams were plainly wrong and the explanations given for the use of a smaller value of capacitor than in the case of the single phase rectifier circuit failed in many cases to mention the greater number of charging pulses per full cycle.

**Q.9.** Too many candidates confused failure of one supply line with an earth fault on one phase of the motor.
The reason for asking for the probable effects of single phasing on a motor running on load was to see if the candidate realised that if the motor was running at less than full load it will almost certainly continue to run without tripping the starting contactors or blowing a fuse, but will draw up to about 180% F/L current in one of the delta connected motor winding with consequent overheating and damage. Many students correctly stated that protection could be afforded by a balanced armature contactor or thermistors in the windings to detect uneven heating of the motor windings..

## CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
**SCOTTISH QUALIFICATIONS AUTHORITY**
ON BEHALF OF THE
**MARITIME AND COASTGUARD AGENCY**

STCW 78 (as amended) **CHIEF ENGINEER REG. III/2 (UNLIMITED)**

**041-33 - ELECTROTECHNOLOGY**

**THURSDAY, 14 JULY 2016**

**0915 - 1215 hrs**

Examination paper inserts:

| |
|---|
| |

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook
Graph paper

**ELECTROTECHNOLOGY**

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. In the network shown in Fig Q1 the meter indicates 2 mA in the direction shown.

   Determine EACH of the following:

   (a) the resistance of the meter; (8)

   (b) the reading on the meter if the 1.5 kΩ and the 2 kΩ resistors are interchanged. (8)

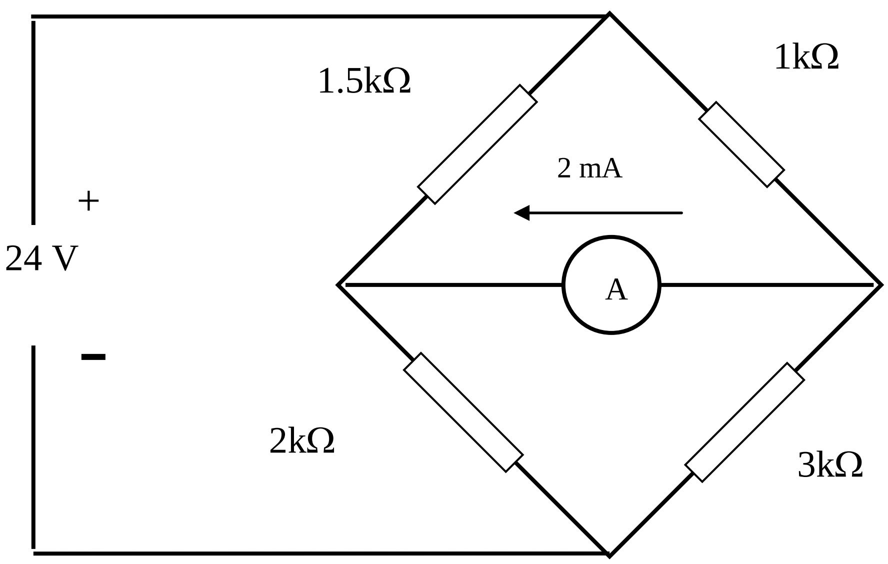



Fig Q1

2. A non-linear resistor whose characteristic is given by:

$I = 0.1\ V^2$ where 'I' is the current in mA and 'V' is the voltage in volts

is connected in series with a 680 Ω resistor to a 16 V d.c. supply.

Determine EACH of the following:

(a) the voltage across each element; (6)

(b) the circuit current; (4)

(c) the value to which the linear resistance must be changed to give equal voltages across the two elements; (4)

(d) the circuit current for the condition in Q2(c). (2)

3. In the two-stage voltage amplifier shown in Fig Q3 both the npn and pnp transistors have high current gains. Transistor $T_1$ has a base-emitter volt drop of 0.7 V and transistor $T_2$ has a base-emitter volt drop of 0.3 V.

Calculate EACH of the following:

(a) the voltage between collector and emitter for each transistor; (12)

(b) the power dissipated in each transistor. (4)

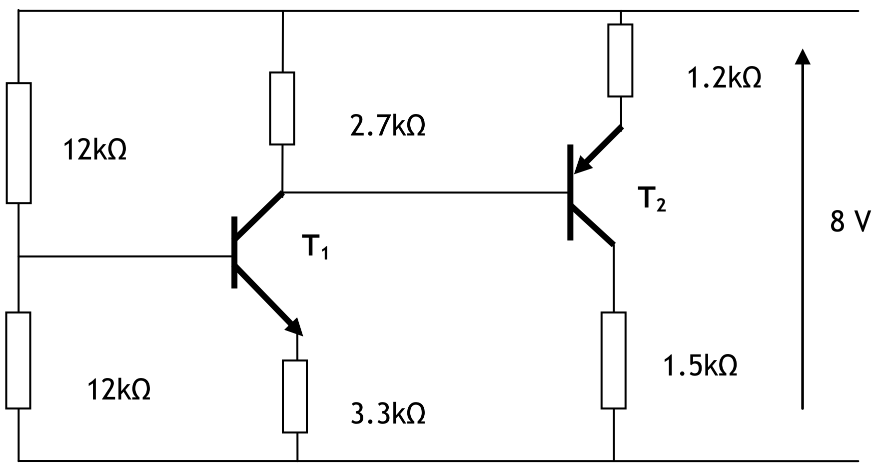



Fig Q3

4. A 220 Ω resistor is connected in series with a coil of resistance *R* and inductance *L* across a 240 V, 50 Hz supply.

The p.d. across the 220 Ω resistance is 110 V and across the coil is 200 V.

Calculate EACH of the following:

(a) the supply current; (2)

(b) the resistance of the coil; (6)

(c) the inductance of the coil; (5)

(d) the power factor of the coil. (3)

5. A 440 V/110 V step down transformer is rated at 60 kVA full load output. The iron loss is 4 kW and the full load copper loss is 6 kW.

Calculate EACH of the following:

(a) the kVA output at which maximum efficiency is achieved; (8)

(b) the efficiency at 50 kW output and 0.85 p.f (8)

6. Three identical coils each of inductance 0.1 H and resistance 30 Ω are connected in delta to a three phase supply of 440 V, 50 Hz.

Three identical capacitors are now connected in star to the same supply to raise the p.f. to 0.9 lag.

Calculate EACH of the following:

(a) the value of each capacitor; (8)

(b) the percentage reduction in line current; (4)

(c) the KVA taken by the capacitors. (4)

7. (a) Explain, with the aid of a circuit diagram, the principle of operation of the wound rotor induction motor. (8)

(b) State TWO advantages of the wound rotor induction motor. (4)

(c) State TWO disadvantages of the wound rotor induction motor. (4)

8. (a) Explain what is meant by the term *single phasing*. (6)

(b) Explain the probable effect of single phasing on a delta connected squirrel cage induction motor on 75% full load. (4)

(c) State ONE method by which a motor can be protected against the effects of single phasing. (6)

9. (a) Sketch the circuit diagram for an uncontrolled three phase bridge rectifier, indicating the current path for one complete cycle for one phase. (8)

(b) Sketch the output waveform for the circuit described in Q9(a). (3)

(c) If a smoothing capacitor is added to the circuit described in Q9(a), explain why less capacitance is required for the three phase rectifier set than for an equivalent single phase rectifier of the same capacity for the same acceptable level of *ripple* voltage at the output. (5)

# SCOTTISH QUALIFICATIONS AUTHORITY
## MARKERS REPORT FORM

SUBJECT: Electrotechnology 041-33

DATE: 14th July 2016

*General Comments on Examination Paper*

The paper was appropriate; variants of all the questions had been used in the recent past and had produced good responses from candidates. The results on this occasion were remarkably poor. Granted there were a few outstanding scripts, but the poorer ones were worse than in recent examinations and the upward trend has most decidedly been reversed.

*General Comments of Specific Examination Questions.*

Q.1. The usual network question should be a safe mark earner for all, but the tortuous working by many candidates turned what should have been eight lines per section into three or four pages of complex algebra. Are students being advised not just how to solve such problems but the best way to tackle them. Make sure the unknown quantity which is asked for is confined to one loop equation and work in units appropriate to the problem, i.e. in this case mA and KΩ.

Q.2. This question cries out for a graphical solution. Find a handful of corresponding values of voltage and current for the nonlinear resistance, plot the characteristic and superimpose the fixed resistance line and the answers can be read off the graph paper. If the candidate chooses a mathematical method it is essential that the quantities involved are of the same order (ohms x mA do not give volts but mV) otherwise chaos rules.

Q.3. This question produced a high percentage of correct solutions. Those who did not score full marks either did not realise that the emitter voltage for $T_2$ is higher than the base voltage or convinced themselves that mA x V gives KW!

Q.4. The most common mistake here was to divide the supply voltage by the 220Ω to give the circuit current when it should, of course, be the 110V which is divided by 220Ω. Once this mistake has been made there is no way the correct answers can be calculated.

Q.5. This produced plenty of correct solutions, the most common mistake was to calculate efficiency as $KVA_{out/}/KVA_{in}$ when KW should be used.

Q.6. All sorts of things went wrong here. Once the line current for the coils has been determined it is time to start working in KW, KVA and KVAR and convert back to current values when the donkey work has been done. The clue lies in part (c) which asks for the KVA taken by the capacitors.
This question yielded only a few totally correct solutions.

Q.7. Not a lot of candidates answered this question and of those that did almost all answered it very poorly. A circuit diagram was called for, not an artist's impression; details of the stator winding should be included, a circle with the word 'stator' will not do. When I ask for TWO advantages or disadvantages I mean TWO not three, four or five, please take your pick. Is this machine not being covered?

Q.8. This did not fare a great deal better than the previous question. A simple statement that one phase lead becomes disconnected whilst a motor is running on three phase supply and the motor will continue to run unless single phasing protection is provided will suffice for part (a) and earn 6 marks. Part (b) specifies a delta connected motor (some candidates chose to make it star connected) operating at 75% full load. The increased current will not trip the normal overcurrent protection gear if this is set to 150% of F/L current. Any of the usual methods of protection such as balanced armature contactor with bi-metal strips to detect current imbalance, three C/T's with fault relay, thermistors in motor windings to detect uneven heating etc. will earn full marks in part (c). A handful of candidates did produce outstanding answers to this question.

Q.9. This was the best of the discursive questions. Quite a few candidates failed to realise that when the ‘red’ positive diode was conducting the return path is via either ‘yellow’ or ‘blue’ negative diodes and similarly during the negative half cycle’ but I only deducted one mark for this. There were some curious waveform diagrams, but most appreciated the faster recharge rate of the smoothing capacitor on 3 phase and overall the response to this question was satisfying.

**CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER**

EXAMINATIONS ADMINISTERED BY THE
**SCOTTISH QUALIFICATIONS AUTHORITY**
ON BEHALF OF THE
**MARITIME AND COASTGUARD AGENCY**

**STCW 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)**

**041-33 - ELECTROTECHNOLOGY**

**THURSDAY, 7 April 2016**

**0915 - 1215 hrs**

Examination paper inserts:

| |
|---|
| Worksheet Q3 |

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

| |
|---|
| Candidate's examination workbook<br>Graph paper |

**ELECTROTECHNOLOGY**

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. For the circuit shown in Fig Q1 determine EACH of the following:

   (a) the current supplied by each battery; (10)

   (b) the voltage across the 8 Ω load resistor; (3)

   (c) the power dissipated in the 8 Ω resistor. (3)

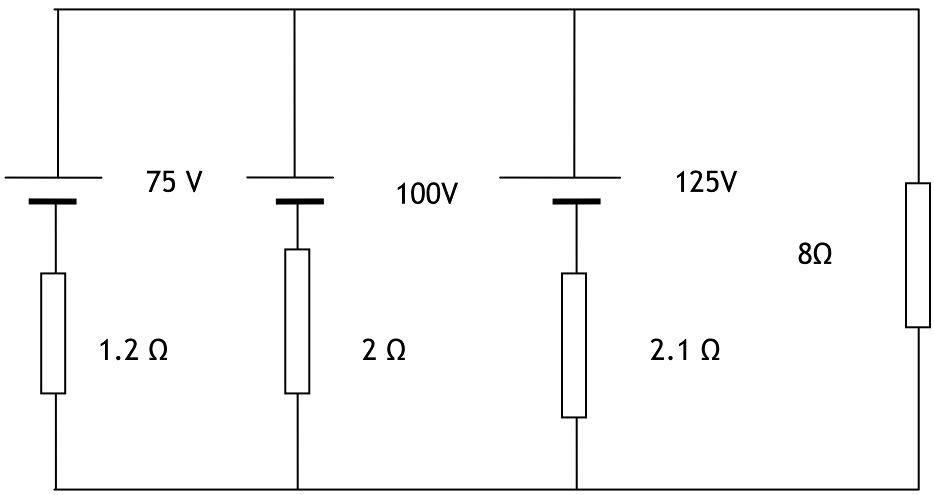



Fig Q1

[OVER

2. The V/I characteristic of a non-linear element is given by the Table Q2.

| V (volts) | 40 | 60 | 80 | 100 | 120 |
|---|---|---|---|---|---|
| I (mA) | 0.65 | 1.1 | 1.5 | 2.2 | 3.3 |

Table Q2

The non-linear element is connected in series with a pair of paralleled resistors of 35 kΩ and 55 kΩ and the overall circuit is connected to a 120 V d.c. supply.

Determine EACH of the following:

(a) the supply current; (8)

(b) the effective resistance of the non-linear element; (6)

(c) the current in each of the two paralleled resistors. (2)

3. A small silicon transistor with the characteristics given in Worksheet Q3 has a maximum safe power dissipation of 18 mW and it is to be operated on a 12 V d.c. supply.

(a) Plot this power dissipation curve on the characteristics. (5)

(b) Determine the minimum value of collector load resistance for the transistor if this dissipation is not to be exceeded. (5)

(c) If the transistor is used in a common emitter configuration and is biased at a base current of 60 μA and an alternating signal of +/- 40 μA is applied to the base, determine the r.m.s. value of:

(i) the voltage variation between collector and emitter; (3)

(ii) the variation in collector current. (3)

4. A series circuit comprising a 50 Ω resistor, a coil having resistance and inductance and a capacitor is connected across a 50 V variable frequency supply.

When the frequency is 400 Hz the current reaches its maximum value of 0.6 A and the voltage across the capacitor is 200 V.

Calculate EACH of the following:

(a) the value of the capacitance; (4)

(b) the resistance and inductance of the coil; (6)

(c) the power taken from the supply; (3)

(d) the circuit power factor. (3)

5. A three phase, 240 V, 4 wire unbalanced system has a current in the red phase of 5A at unity power factor and a current in the yellow phase of 8A lagging by 30°.

If the current in the neutral line is 1.93 A in phase with the red line voltage, calculate EACH of the following:

(a) the magnitude of the current in the blue line; (6)

(b) its angular relationship to the blue line voltage; (6)

(c) the total power drawn by this unbalanced circuit. (4)

6. A 3 ph, 440 V, 60 Hz 8 pole induction motor runs at a power factor of 0.85 lag and drives a load of 8 kW at a speed of 14.4 rev/sec. The stator loss is 1 kW and the rotational losses (windage and friction) amount to 0.8 kW.

Calculate EACH of the following:

(a) the synchronous speed; (3)

(b) the rotor copper loss; (5)

(c) the input power to the motor; (5)

(d) the motor current. (3)

7. Fig Q7 shows a *soft start* circuit for a delta connected induction motor using six thyristors (silicon controlled rectifiers).

(a) Explain how the circuit arrangement reduces the current drawn by the motor during the starting sequence. (7)

(b) Sketch the voltage waveform supplied to any one phase of the motor at the following points in the starting operation:

(i) the commencement of starting; (3)

(ii) part way through the starting operation; (3)

(iii) the completion of starting. (3)

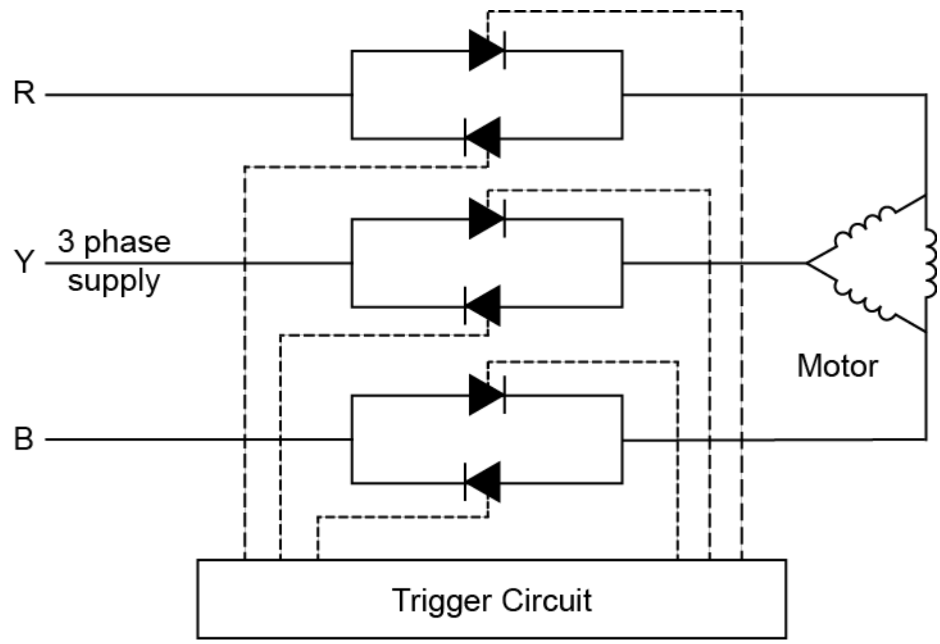



Fig Q7

8. (a) Explain the meaning of the term *power factor correction.* (3)

(b) State TWO advantages of power factor correction. (4)

(c) Explain, with the aid of a circuit diagram, how power factor correction can be effected in a three phase circuit using capacitors. (5)

(d) Explain ONE method other than the use of capacitors by means of which power factor correction may be effected. (4)

9. (a) List the various losses which occur in a squirrel cage induction motor on load. (4)

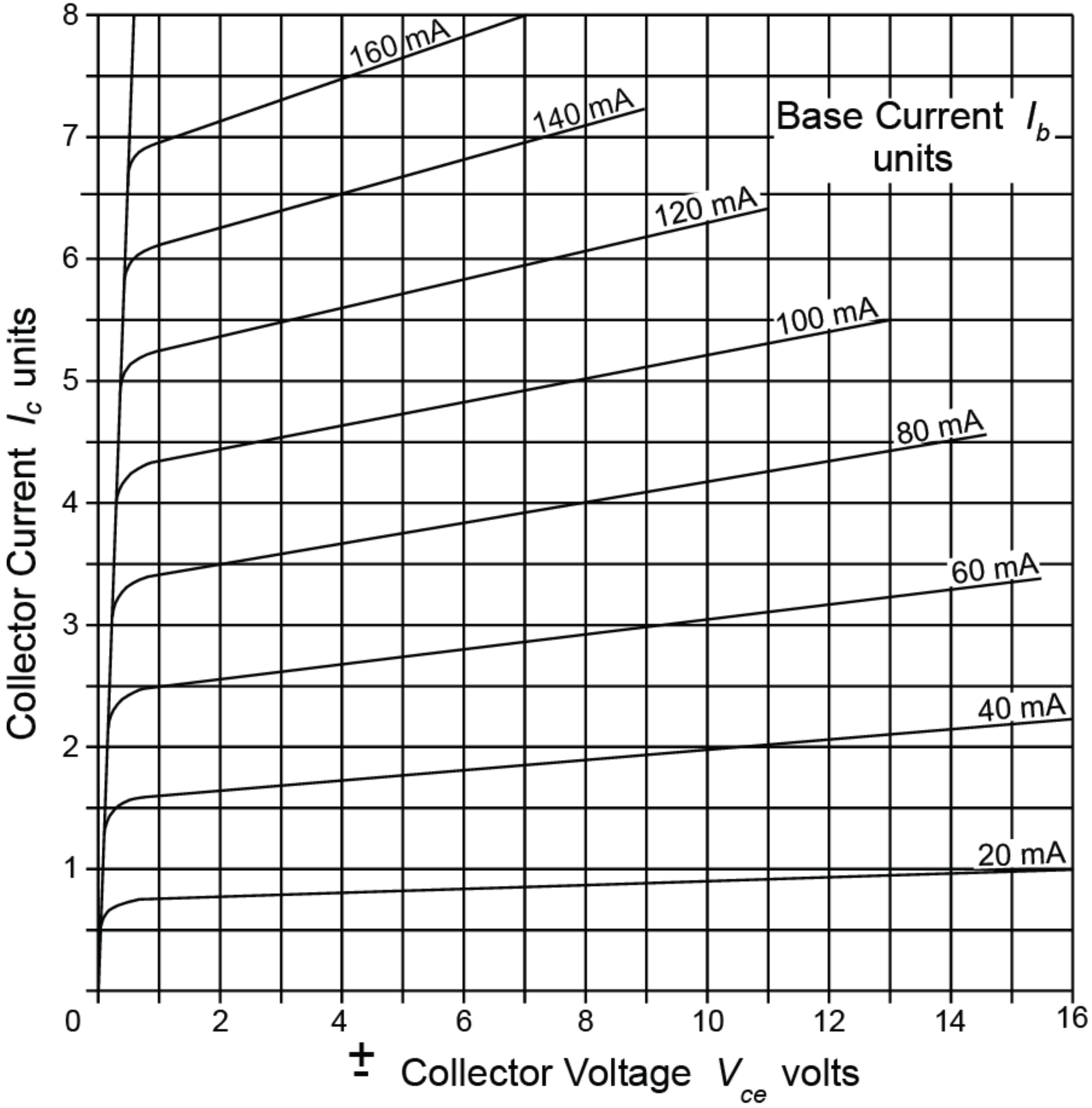
(b) State which of these losses is:

(i) independent of load current and speed; (4)

(ii) dependent on load current; (4)

(iii) dependent on speed. (4)

(This Worksheet must be returned with your answer book)




## COMMON EMITTER TRANSISTOR CHARACTERISTCS

| TYPE | SCALE FACTORS per unit value of $I_b$ | SCALE FACTORS per unit value of $I_c$ |
|---|---|---|
| 1. Small Si | 1 μA | 1 mA |
| 2. Power Si | 1 mA | 1 A |

Candidate's Name …………………………………………….…. Examination Centre ……………………………………………

# SCOTTISH QUALIFICATIONS AUTHORITY
## MARKERS REPORT FORM

SUBJECT: Electrotechnology

DATE: 7th April 2016

*General Comments on Examination Paper*

Firstly it must be stated that despite the wrong (outdated) worksheet being issued for one question the response to that question was particularly good and no students appeared to have been disadvantaged by this minor error. The overall standard of the paper seems to have been appropriate and a number of candidates achieved maximum or near maximum marks.

*General Comments of Specific Examination Questions*

**Question 1.**
Surprisingly this question did not attract as many correct solutions as one might expect. Many students seem able to write down correctly three loop equations but then struggle to manipulate the ensuing algebra to reach the right answers. Perhaps more practice is required in this area.

**Question 2.**
Most did well at this question, those who went astray did so because they transformed kΩ into Ω and mA into Amps during the course of the working. Keep the units in at all times.

**Question 3.**
As mentioned above the use of the 'wrong' worksheet did not appear to confuse candidates and this question probably produced the most completely correct solutions out of the nine questions. Once again a few forgot to include the units and finished up with Ω rather than kΩ and amps rather than mA.

**Question 4.**
There was a mixed response to this question. Some candidates did not realise that the circuit was resonant and this led to some complex but totally unnecessary mathematics.

**Question 5.**
Those that did well on this question drew up a simple table of horizontal and vertical components of current and arrived at the components of the blue line current and its position on then phasor diagram. Those who did badly launched themselves into the unfamiliar world of complex (or algebraic) numbers and produced some very unlikely results. Draw a phasor diagram and mark on the components and you cannot go wrong!

**Question 6.**
Together with question 3 this produced the most correct solutions. The few that lost marks did so because they left out the units (kW in this case) and had their induction motor running on a few tens of mA.

**Question 7.**
This was the best answered of the discursive questions and many candidates gave good accounts of how the voltage to the motor was reduced by 'clipping' the waveform and thereby reducing the current demand during starting. A few failed to appreciate that the SCR's are counter parallel connected and that both positive and negative half waves are supplied to the machine. A handful of candidates gave long and detailed explanations of how the SCR or thyristor works (not asked for) but then offered very poor accounts of how it functions in the starter circuit.

**Question 8.**
There was a poor response to this question by too many students. The question did not ask 'what is power factor' but 'what is meant by 'power factor correction'. Many did not have a clear idea what benefits accrue from improving the overall power factor of thee system and one candidate assured me that the principal benefit was 'a reduced tariff from the supplier, for having a higher p.f' !

**Question 9.**

This too did not attract a uniformly high response. Vague statements such as ‘copper losses’ and ‘iron losses’ will not suffice. Every electrical machine’ rotating or otherwise, has both copper and iron losses. A question of this type requires that the student specifies where those losses occur, e.g  stator  iron loss, stator copper loss, rotor iron loss (small), rotor copper loss, windage and friction losses.  A lot of candidates were very unsure of whish losses were independent of load and speed, which varied with load and which varied with speed.

**CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY –**
**MARINE ENGINEER OFFICER**

EXAMINATIONS ADMINISTERED BY THE
**SCOTTISH QUALIFICATIONS AUTHORITY**
ON BEHALF OF THE
**MARITIME AND COASTGUARD AGENCY**

**STCW 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)**

**041-33 - ELECTROTECHNOLOGY**

**THURSDAY, 17 December 2015**

**0915 - 1215 hrs**

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.

2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook

**ELECTROTECHNOLOGY**

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. Fig Q1 shows a circuit designed for measuring temperature.

   (a) Calculate the value of the sensing element 'R' so that the meter will read full scale deflection (F.S.D.) of 1 mA in the direction shown. (8)

   (b) Calculate the value to which the 200 Ω resistor will have to be changed if the meter becomes unserviceable and has to be replaced with one of the same resistance but of 2 mA F.S.D. if the meter is still to read full scale deflection. (8)

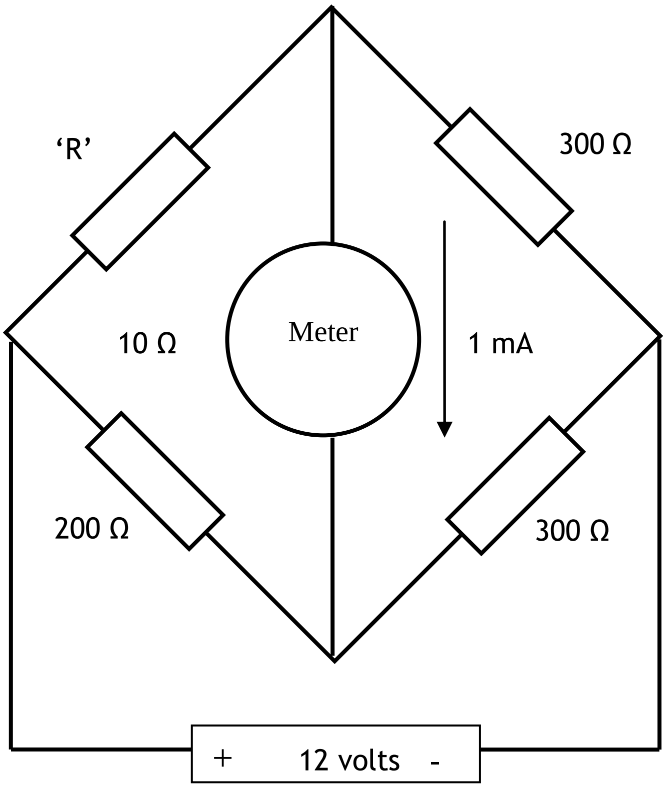



Fig Q1

2. A relay coil has resistance 24 Ω and inductance 2 H. It operates on 12 V d.c.

(a) Calculate the time after switching on the supply for the relay to close if it requires a current of 0.25 A to operate. (6)

(b) Calculate the energy stored in the coil at the time of operation. (4)

(c) Calculate the time delay before operation if a resistor of 6 Ω is connected in series with the relay coil and it is operated from 15 V supply. (6)

3. Fig Q3 shows a basic voltage stabiliser circuit intended to give a regulated output of 8 V d.c. from an unregulated input which can vary between 12 V and 20 V.

The Zener diode has a breakdown voltage of 8 V, a forward resistance after breakdown of 2 Ω and requires a minimum forward current of 2 mA. The Zener diode has a maximum power rating of 1 W.

Calculate EACH of the following:

(a) the minimum value of the series resistance 'R'; (6)

(b) the regulated output voltage when the input is 15 V and the load output current is 40 mA; (4)

(a) the maximum permissible output current for satisfactory regulation if the input voltage is 12 V. (6)

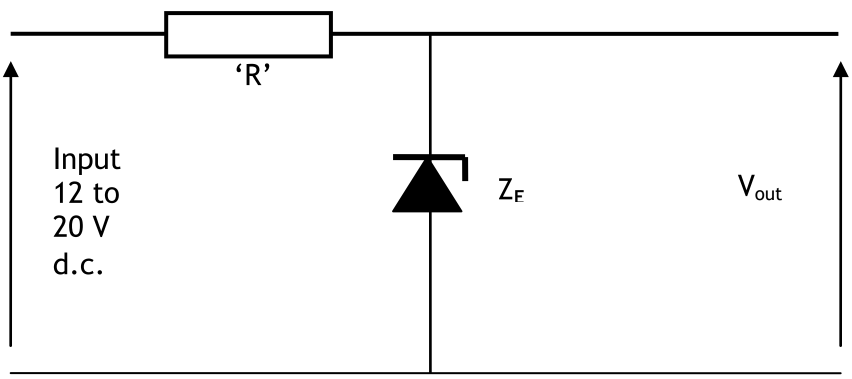



Fig Q3

4. A single phase circuit consists of a capacitor of 50 μF in parallel with a coil of unknown resistance and unknown inductance. When connected to 240 V, 50 Hz the circuit draws 7 A at power factor 0.8 lag.

Calculate EACH of the following:

(a) the resistance of the coil; (5)

(b) the inductance of the coil; (5)

(c) the power factor of the coil. (2)

(d) If the capacitor is now connected in series with the coil to the same supply, calculate the current drawn by this series circuit. (4)

5. A star connected three phase load has a coil of resistance 50 Ω and inductance 0.1 H in each phase. It is connected to a three-phase, three-wire supply of 415 V, 50 Hz.

Calculate EACH of the following:

(a) the line current; (5)

(b) the power factor of the load; (4)

(c) the value of EACH of three identical delta connected capacitors, which if connected in parallel with this load, will raise the overall power factor to unity. (7)

6. The load on a ship's distribution system comprises:

- motors totalling 1200 kW at a p.f. of 0.7 lag;
- lighting totalling 500 kW at u.p.f.;
- an over-excited synchronous motor taking 200 kW at a p.f. 0.5 lead.

This total load is shared by two identical alternators, one of which provides 1000 kVA at a p.f. of 0.85 lag.

Calculate EACH of the following:

(a) the kW provided by the second alternator; (5)

(b) the kVA supplied by this machine; (3)

(c) the power factor of the second alternator; (3)

(d) the power factor of the synchronous motor if the overall p.f. of the system is to be raised to unity. (5)

7. (a) Sketch a basic power circuit diagram for a star/delta starter for a squirrel cage motor. (8)

(b) Explain why the starting voltage and hence the starting current is reduced using a star/delta starter. (4)

(c) State by what factor the initial starting current is reduced using a star/delta starter compared to the direct on line starting current. (4)

8. (a) Explain the term *power factor correction.* (3)

(b) State two advantages of power factor correction. (4)

**(c)** Explain, with the aid of a suitable circuit diagram, how power factor correction can be effected in a three phase circuit using capacitors. (5)

**(d)** State one other method, other than the use of capacitors, of bringing about power factor correction. (4)

9. (a) Explain why it is necessary to monitor and detect faults between the phase windings and earth of a star connected alternator with an earthed neutral point. (4)

(b) Sketch a circuit diagram of one arrangement for detecting phase to earth faults within a star connected alternator with earthed neutral. (7)

(c) Explain how the circuit given in Q9(b) enables earth faults to be detected. (5)

## CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
**SCOTTISH QUALIFICATIONS AUTHORITY**
ON BEHALF OF THE
**MARITIME AND COASTGUARD AGENCY**

**STCW 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)**

**041-33 - ELECTROTECHNOLOGY**

**THURSDAY, 15 OCTOBER 2015**

**0915 - 1215 hrs**

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.

2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook

**ELECTROTECHNOLOGY**

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. A two core feeder cable 1200 m long has a resistance (‘go and return’) of 0.005 Ω /100 m and is fed at each end with 440 V. It supplies the following loads at the distances given, all measured from the same end of the feeder.

   - 200 A at 400 m
   - 150 A at 700 m
   - 250 A at 1000 m

   Calculate EACH of the following:

   (a) the current supplied at each end of the feeder cable; (6)

   (b) the p.d. across the 150A load; (6)

   (c) the power loss in the feeder cable. (4)

2. A capacitor of 200 μF is charged from a 120V d.c. supply via a 100 kΩ resistor for 10 secs. It is now disconnected from the supply and a second capacitor of 150 μF is charged from the same supply via the same resistor for 15 secs. The two charged capacitors are now connected in parallel.

   Calculate EACH of the following:

   (a) the potential to which each of the capacitors has been charged; (6)

   (b) the energy stored in each capacitor at the end of the charging period; (4)

   (c) the final potential across the parallel combination of two capacitors. (6)

3. The NPN transistor shown in Fig Q3 has a volt drop between base and emitter of 0.4 V and the base current is small enough to be ignored. The volt drop across the emitter resistor is 3.6 V.

Calculate EACH of the following:

(a) the value of the resistor $R_b$ in the bias network; (6)

(b) the value of the collector-emitter current; (4)

(c) the value of the load resistor $R_L$ if the steady state voltage at the collector is 12 V as shown. (6)

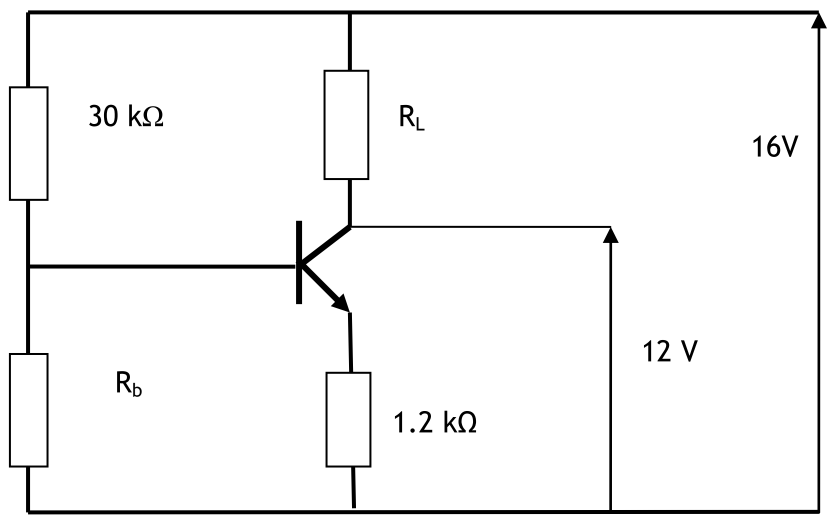



Fig Q3

4. A coil having inductance and resistance is connected to a supply of 120 V 50 Hz and draws a current of 2.5 A at a power factor of 0.75.

Calculate EACH of the following:

(a) the resistance of the coil; (3)

(b) the inductance of the coil. (3)

(c) A capacitor is now connected in series with the coil and the current rises to 3 A and the power factor is still lagging.

Calculate the value of the capacitor. (5)

(d) Calculate the value of capacitor which would have to be connected in series with the coil to raise the current to 3 A with a leading power factor. (5)

5. Fig Q5 shows three identical loads, each consisting of a 100 μF capacitor in series with a 50 Ω resistor, connected in star to a 415 V, 3ph, 50 Hz supply.

Calculate EACH of the following:

(a) the current drawn from the supply; (4)

(b) the power factor; (4)

(c) the power consumed by the three phase load; (4)

(d) the p.d. between points A and B. (4)

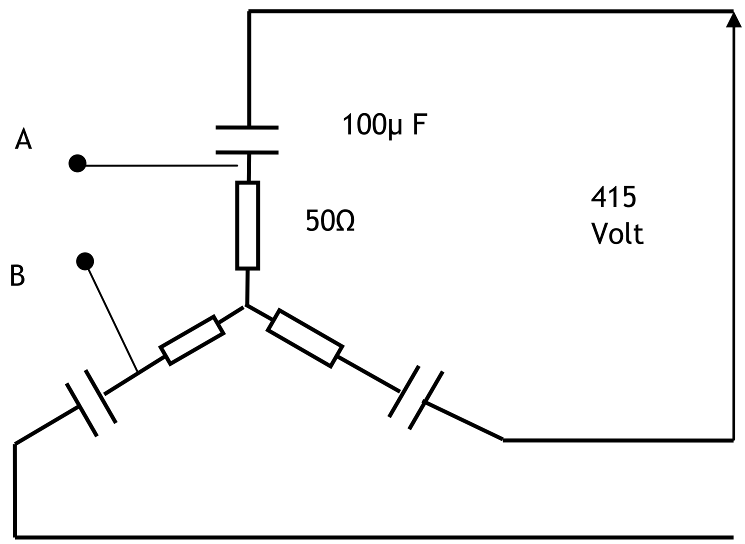



Fig Q5

6. A six pole three phase induction motor operates from a 380 V 60 Hz supply. It draws a current of 40 A at power factor 0.7. The frequency of the e.m.f. in the rotor is 2.4 Hz. If the stator loss is 4 kW and the rotational losses (windage and friction) total 3 kW, calculate EACH of the following:

(a) the power input; (3)

(b) the slip; (3)

(c) the rotor copper loss; (5)

(d) the shaft output power. (5)

[OVER

7. (a) Draw a circuit diagram illustrating how a single thyristor (*silicon controlled rectifier*) may be used to provide a variable d.c. voltage output from a single phase a.c. supply. (8)

(b) Explain how the ‘firing angle ’of the thyristor is varied. (4)

(c) Sketch the output voltage waveform when the firing angles are:

(i) 60° (2)

(ii) 120° (2)

8. (a) Describe, with the aid of a sketch, the construction of a double wound single phase transformer and explain the principle of its operation. (4)

(b) Explain why the transformer is rated in kVA rather than kW. (4)

(c) State why the iron loss in the transformer is not load dependent. (4)

(d) State how the copper losses in the two windings of the transformer vary with the load on the transformer. (4)

9. (a) Explain how torque is produced in a 3 phase squirrel cage induction motor. (5)

(b) State why the starting current is several times higher than the full load current. (3)

(c) State why the power factor is very low on starting. (3)

(d) Describe ONE method of construction by means of which the starting power factor may be raised, the starting current reduced and the starting torque improved. (5)

# SCOTTISH QUALIFICATIONS AUTHORITY
## MARKERS REPORT FORM
## PART I

SUBJECT: Electrotechnology 041-33

DATE: 15th Oct. 2015

*General Comments on Examination Paper*

The paper appeared to be of the appropriate standard, some candidates scored almost full marks within the allotted time.

*General Comments of Specific Examination Questions.*

**Q. 1. A straightforward network problem, most candidates scored well on this, those who failed to do so usually omitted the units involved and finished up with ridiculously low values for the p.d. across one of the loads or very high values for the power lost in the feeder cables. An answer of several KW for the power lost in transmission should ring alarm bells.**

**Q.2. Another good mark gatherer for most, a few went astray in part c) by not realising that charge is conserved not energy.**

**Q.3. Another stock question requiring little maths, the handful who went astray did not put units into their calculations and finished up with 'silly' answers.**

**Q.4. Most candidates tackled this well but some got bogged down in the mathematics. A safe dictum is 'keep bracketed terms intact, if you multiply them out too early you simply add to the algebra to be solved'.**

**Q.5. Well done by most but only one candidate got the correct answer to part d). Clearly the volt drops across the 50 ohm resistors differ in phase by $120^0$ and must be added vectorially, if it had been as easy as adding them arithmetically I would not have asked this part of the question.**

**Q.6. There are still a handful of candidates who add the various losses to the input power and finish up with a shaft output power greater than the power supplied. A few again did not put the units in and finished up with losses almost equal to the power supplied.**

**Q.7. There were a number of good solutions to this question but a handful had not remembered the diagram correctly and connected the trigger mechanism of R and C back to the supply and not to the gate od the SCR. Nether the less, this was the descriptive question which produced the best answers.**

**Q.8. There were many confused attempts at his question (one even offered an auto transformer). It requires a clear understanding and a good grasp of written English to answer parts b) c) and d) as well as writing down a mathematical expression.**

**Q. 9. This too was badly answered by most candidates. Part a) <u>must</u> include mention of the rotating field generated by the stator. Far too many answered part d) by offering alternative starting methods or suggesting p.f. improvement using capacitors. The question asks for 'one method of construction' and this means a description of the Boucherot, Trislot or Sashbar type of rotor. Are these being taught ?**

**CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY –**
**MARINE ENGINEER OFFICER**

EXAMINATIONS ADMINISTERED BY THE
**SCOTTISH QUALIFICATIONS AUTHORITY**
ON BEHALF OF THE
**MARITIME AND COASTGUARD AGENCY**

**STCW 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)**

**041-33 - ELECTROTECHNOLOGY**

**THURSDAY, 26 MARCH 2015**

**0915 - 1215 hrs**

Examination paper inserts:

| |
|---|
| Worksheet Q3 |

Notes for the guidance of candidates:

| |
|---|
| 1. Non-programmable calculators may be used.<br><br>2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer. |

Materials to be supplied by examination centres:

| |
|---|
| Candidate's examination workbook<br>Graph Paper |

**ELECTROTECHNOLOGY**

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. In the network shown in Fig Q1 the 15 Ω resistor dissipates 60 W.

   Calculate EACH of the following:

   (a) the current taken from the supply; (6)

   (b) the value of the applied voltage V; (4)

   (c) the value to which the 60 Ω resistor must be changed to increase the current taken from the supply to 4 A. (6)

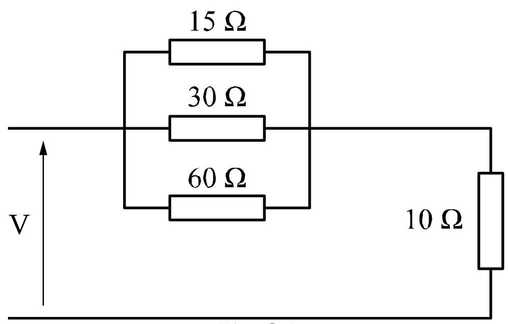



Fig Q1

2. Fig Q2 shows a non-linear resistor connected in series with a linear resistor 'R' to a 12 V d.c. supply. The characteristic of the non-linear element is given by $I(mA) = V^{3/2}$.

Determine EACH of the following:

(a) the value of 'R' to give a current of 12 mA in the circuit; (6)

(b) the value of the non-linear element when the current is 12 mA; (4)

(c) the value to which 'R' must be adjusted to give equal volt drops across the linear and non-linear resistors. (6)

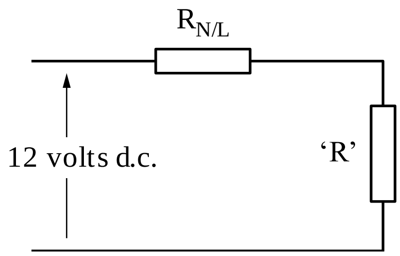



Fig Q2

3. A silicon power transistor with the characteristics given in Worksheet Q3 is operated from a 12 V supply and has a maximum power rating of 18 W.

(a) Plot the 18 W power dissipation curve on the characteristics. (5)

(b) Determine the minimum safe collector load resistor for the transistor. (4)

(c) If the transistor is biased with 80 mA and a sinusoidal signal of +/- 40 mA is applied to the base, determine EACH of the following:

(i) the variation in collector current; (2)

(ii) the corresponding variation in collector voltage; (2)

(iii) the a.c. power output of the transistor. (3)

4. Two impedances $Z_1$ and $Z_2$ are connected in parallel to a 240 V single phase a.c. supply. The total current drawn is 10 A at unity power factor. Impedance $Z_1$ takes a current of 5A at p.f 0.6 lag.

Calculate EACH of the following:

(a) the current in impedance $Z_2$; (6)

(b) the resistance and reactance of each impedance; (6)

(c) the power dissipated by each impedance. (4)

5. A 3ph 440 V a.c. generator supplies the following loads:

- a star connected load of 33 kVA at p.f. 0.9 leading
- a delta connected load of 40 kW at p.f. 0.85 lagging
- miscellaneous loads of 23 kVA at p.f. 0.8 lagging

Calculate EACH of the following:

(a) the kVA supplied by the generator; (10)

(b) the current supplied by the generator; (2)

(c) the phase currents for the star and delta connected loads. (4)

6. An unbalanced star connected three phase load is supplied from a 440 V 50 Hz four wire supply.

The current in the red line is 6 A lagging by 30°, the current in the yellow line is 5A in phase and the current in the blue line is 7A lagging by 15°.

Determine EACH of the following:

(a) the value of the current in the neutral line; (6)

(b) its phase relationship to the voltage between the red line and the neutral; (5)

(c) the total power dissipated in the circuit. (5)

7. (a) Explain the term *single phasing* when applied to a three-phase induction motor. (6)

(b) Describe the effect of single phasing on a three-phase delta connected motor operating at 75% full load and 0.8 power factor. (6)

(c) Describe ONE method of protecting a three-phase motor against the effects of single phasing. (4)

8. (a) List the various losses which occur in the squirrel cage induction motor on load. (4)

(b) State which of these losses is:

(i) independent of load and speed; (4)

(ii) dependent on load; (4)

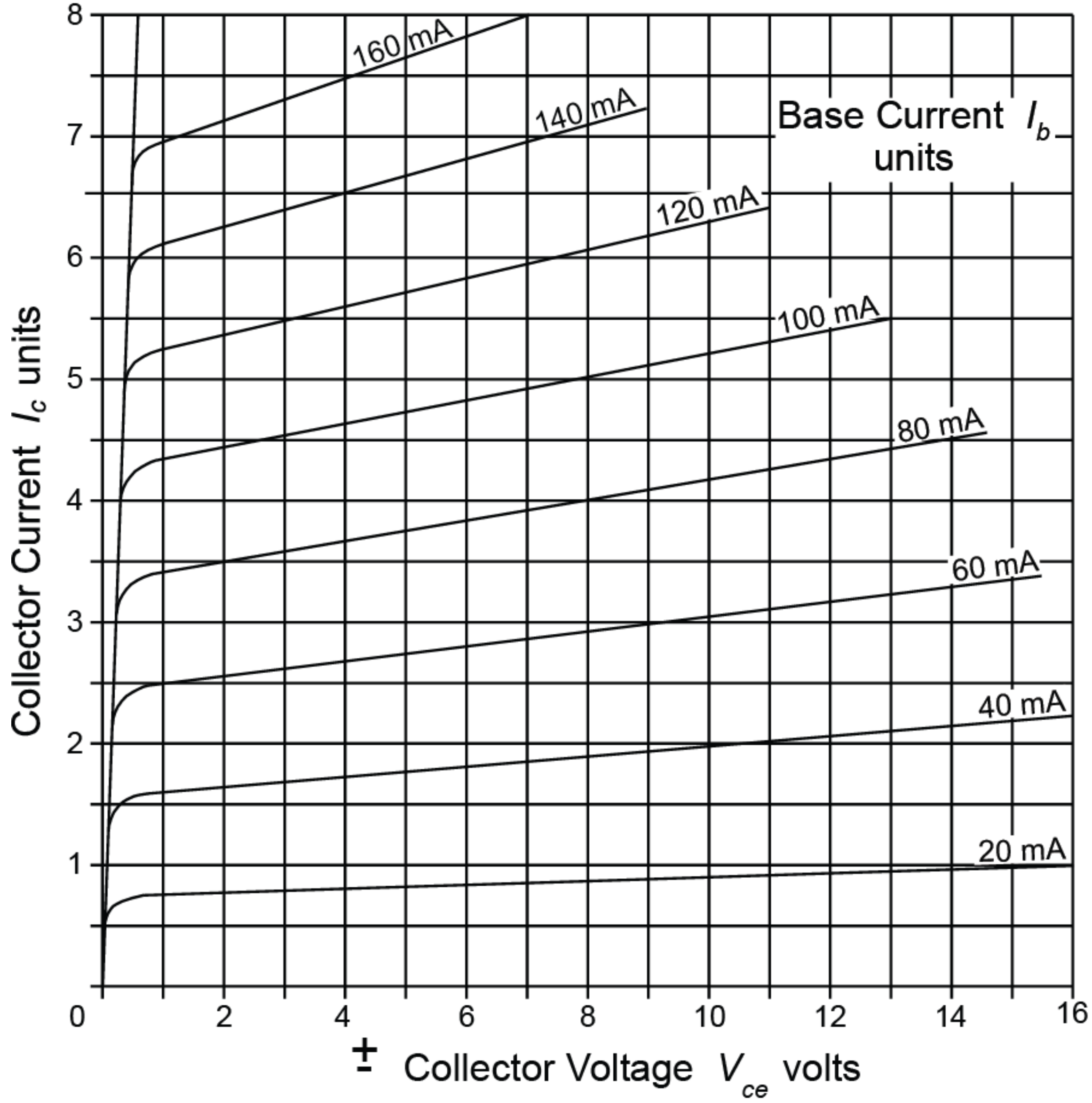
(iii) dependent on speed. (4)

9. (a) Describe the FOUR conditions which have ideally to be met before an alternator can be connected to live busbars. (8)

(b) Explain the process by which load can be taken up by a newly synchronised alternator. (3)

(c) Describe the result of increasing the excitation of an alternator which is sharing load without increasing the shaft power input to the machine. (5)

(This Worksheet must be returned with your answer book)




COMMON EMITTER TRANSISTOR CHARACTERISTCS

| TYPE | SCALE FACTORS per unit value of | |
|---|---|---|
| | $I_b$ | $I_c$ |
| 1. Small Si<br>2. Power Si | 1 μA<br>1 mA | 1 mA<br>1 A |

Candidate's Name …………………………………………….….

Examination Centre …………………………………………….

# SCOTTISH QUALIFICATIONS AUTHORITY
## CONFIDENTIAL MARKERS REPORT FORM

SUBJECT: Electrotechnology

DATE: March 2015

*General Confidential Comments on Examination Paper*

The overall pass rate of 57% and the high marks achieved by a handful of candidates would indicate that the paper was of an appropriate standard. The spread of results is disappointing in the extreme and continues a trend which has been evident for the last half dozen examinations; many candidates are either totally unprepared or perhaps not of sufficient ability to ever hope to pass the examination.

*Specific Confidential Comments Examination Questions*

**Question 1.**

What a disappointment ! A straightforward question requiring the application of Ohm's law only to guarantee 16 marks and all sorts of complicated solutions were offered, mostly leading to incorrect answers . How anybody can believe that if you change the value of one circuit element the current in another remains unchanged defeats me, but a fair number of students were convinced this was the case.

**Question 2.**

This was tackled well by a goodly number of candidates. The only significant mistake was made by those who adopted a graphical solution who drew the load line through 12 V and 12 mA, presupposing the resistance was 1KΩ, which does not give 12mA through the nonlinear resistor.

**Question 3.**

The question stated quite clearly 'a power transistor' which collector currents of Amps. not mA. and therefore a slope resistance of 2Ω not 2 KΩ. Other students gave the correct load resistance of 2Ω but proceeded to give the 'swing' in collector current in mA.

The question did not ask for the R.M.S. value of voltage and current variation, R.M.S. values are only required to calculate the power dissipation

**Question 4.**

This attracted a fair number of correct solutions and was, after all, a straightforward parallel combination of two impedances.

**Question 5.**

The most alarming mistake in this question was the addition of KVA's arithmetically, not by resolving into components of KW and KVAr. I do hope students are not being taught that this is a valid method.

**Question 6.**

There were a handful of totally correct solutions to this question but too many candidates made the mistake of not reversing the resultant of the three phase currents to find the neutral current (if the currents were forces and the equilibrant was asked for I am sure most students would have no hesitation in reversing the resultant). The other mistake, not widespread was to assume all horizontal components were positive, far from the truth.

**Question 7.**

There were more correct answers than this question usually attracts but there were still many candidates who ignored the words 'when applied to a three phase induction motor'. The purpose of the question was to see if candidates realised that the motor continues to run as a single phase motor drawing a greatly increased current but not sufficient to trip the conventional overload devices. More than a few students assured me that the loss of one phase line leaves you with a two phase supply !

**Question 8.**

The question states ‘in a squirrel cage induction motor’ which means that the statement of losses should identify in which part of the machine they occur e.g. stator iron loss, rotor copper loss etc. The bland statement ‘copper losses, iron losses and rotational losses’ could apply to any rotating electrical machine.

All those candidates who think rotational losses are independent of speed should try pedalling an exercise bicycle flat out with the brake screwed hard down to convince themselves that ‘work done per sec (or power) is equal to torque x angular velocity’ !

**Question 9.**

Part a) was tackled well but only about half the candidates had a clear idea of what happens if i) the input power is increased without adjusting the excitation or ii) the excitation is increased without changing the input power. Are students being introduced to the full phasor diagram for an alternator on infinite busbarsd>

**CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER**

EXAMINATIONS ADMINISTERED BY THE
**SCOTTISH QUALIFICATIONS AUTHORITY**
ON BEHALF OF THE
**MARITIME AND COASTGUARD AGENCY**

**STCW 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)**

**041-33 - ELECTROTECHNOLOGY**

**THURSDAY, 16 OCTOBER 2014**

**0915 - 1215 hrs**

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook
Graph Paper

## ELECTROTECHNOLOGY

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. The network shown in Fig Q1 is for sensing temperature.

   (a) Calculate the value of the sensing element 'R' so that the meter will read full scale deflection (FSD) of 1 mA in the direction shown. (8)

   (b) Calculate the value to which the 200 Ω resistor will have to be changed if the meter becomes unserviceable and has to replaced by one of the same resistance but of 2 mA FSD and the meter is still to read full scale deflection. (8)

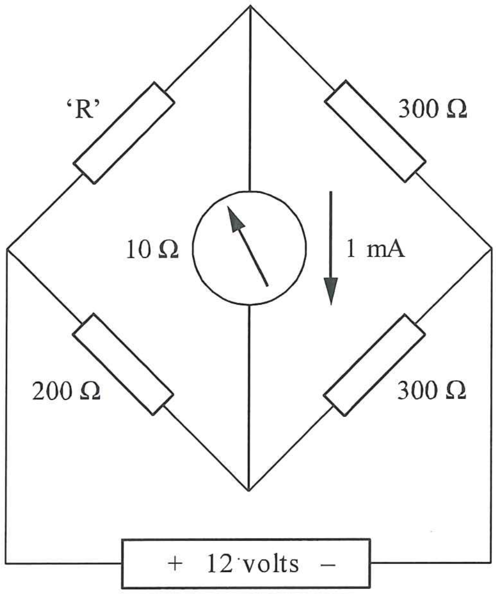



Fig Q1

[OVER

2. A relay coil has a resistance of 200 Ω and the current required to operate the relay is 150 mA.

When the coil is connected to 50 V d.c. it takes 40 ms to operate.

Calculate EACH of the following:

(a) the steady state relay current; (2)

(b) the time constant for the coil; (4)

(c) the inductance of the coil. (4)

(d) To increase the operating time of the relay, a 50 Ω resistor is connected in series with the coil.

Calculate the new operating time for the relay. (6)

3. The p.d. across the base emitter junction of the silicon transistor shown in Fig Q3 is 0.6 V and the output voltage $V_C$ is 4 V.

Assuming that the base current is negligible, calculate EACH of the following:

(a) the p.d. across each of the base bias resistors; (4)

(b) the p.d between collector and emitter; (4)

(c) the value of the load resistor $R_L$; (4)

(d) the power dissipated in the load resistor $R_L$; (2)

(e) the power dissipated by the transistor. (2)

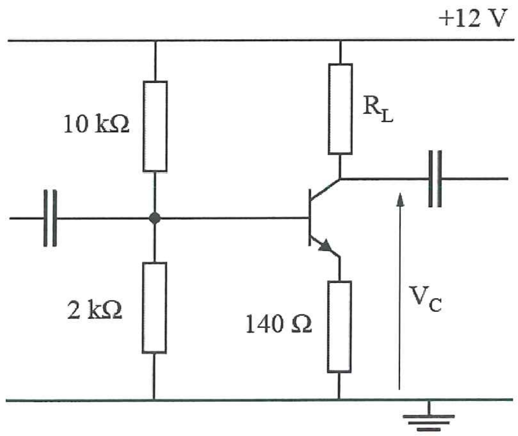



Fig Q3

4. A coil of resistance **R** and inductance **L** is connected to a 50 Hz supply and draws a current at a power factor of 0.8 lag. If a capacitor of 100 μF is now connected in series with the coil the circuit draws the same current but at a power factor of 0.8 lead.

Calculate EACH of the following:

(a) the inductance of the coil; (5)

(b) the resistance of the coil. (5)

If the voltage measured across the capacitor is 36 V, determine EACH of the following:

(c) the current in the circuit; (2)

(d) the supply voltage. (4)

5. A three phase load connected to a 415 V 50 Hz supply takes a current of 40 A at a lagging power factor of 0.7.

(a) Calculate EACH of the following:

(i) the power taken by the load; (3)

(ii) the KVAR taken by the load. (3)

(b) Three capacitors, each of 100 μF, are now connected in delta to the same supply.

(i) Calculate the new power factor of the whole circuit. (3)

(ii) If the capacitors had been connected in star, calculate the new power factor for the whole circuit. (3)

6. A 440/110 volt 10 kVA single phase transformer gives its maximum efficiency at 80% full load. The iron loss is 0.4 kW.

Calculate EACH of the following:

(a) the efficiency at full load and power factor 0.9; (8)

(b) the efficiency at 60% full load and unity power factor. (8)

[OVER

7. (a) State TWO advantages and TWO disadvantages of the wound rotor induction motor starting method. (4)

(b) Sketch a circuit diagram showing the rotor/slip rings/starting resistor connection for a 3 ph wound rotor induction motor. (6)

(c) A 3 ph 4 pole wound rotor induction motor has a rotor induced e.m.f. of 230 V 60 Hz between the slip rings at standstill.

Calculate EACH of the following:

(i) the rotor phase e.m.f. and frequency at a slip 0.04 p.u.; (4)

(ii) the synchronous speed. (2)

8. (a) State the conditions necessary to *turn on* and *turn off* a thyristor (silicon controlled rectifier). (4)

(b) Describe the operation of the circuit shown in Fig Q8. (8)

(c) Sketch the output waveform across the load for switching delay angles of:

(i) 45°; (2)

(ii) 120°. (2)

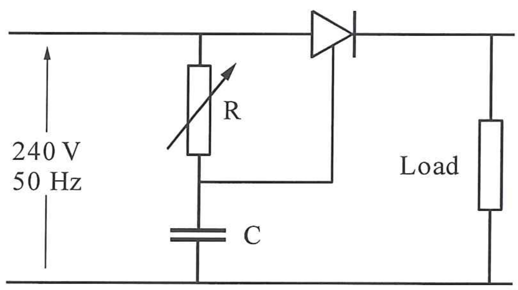



Fig Q8

9. (a) Explain, with the aid of a sketch, the principle of the *auto transformer*. (8)

(b) Explain why the auto transformer is not a suitable choice of transformer for applications where the transformation ratios differs widely from 1:2 or 2:1. (4)

(c) Explain why it is possible, with an auto transformer of ratio 1:2, to use the same gauge of conductor throughout the windings. (4)

***refrigerant: $CO_2$***

| *saturation values* | | | | | | | *superheat ($T - T_s$)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 50 K | | 100 K | |
| T | $p_s$ | $v_g$ | $h_f$ | $h_g$ | $s_f$ | $s_g$ | h | s | h | s |
| (°C) | (bar) | ($m^3$/kg) | (kJ/kg) | | (kJ/(kg K)) | | (kJ/kg) | (kJ/(kg K)) | (kJ/kg) | (kJ/(kg K)) |
| -50 | 6.8234 | 0.0558 | -19.96 | 319.77 | -0.0863 | 1.4362 | 365.1 | 1.620 | 409.9 | 1.770 |
| -45 | 8.3184 | 0.0460 | -10.03 | 321.23 | -0.0428 | 1.4091 | 367.81 | 1.594 | 413.26 | 1.744 |
| -40 | 10.0450 | 0.0383 | 0.00 | 322.42 | 0.0000 | 1.3829 | 370.35 | 1.569 | 416.53 | 1.720 |
| -35 | 12.0242 | 0.0320 | 10.15 | 323.33 | 0.0423 | 1.3574 | 372.75 | 1.546 | 419.70 | 1.696 |
| -30 | 14.2776 | 0.0270 | 20.43 | 323.92 | 0.0842 | 1.3323 | 375.00 | 1.524 | 422.77 | 1.674 |
| -28 | 15.2607 | 0.0252 | 24.60 | 324.06 | 0.1009 | 1.3224 | 375.85 | 1.515 | 423.97 | 1.666 |
| -26 | 16.2926 | 0.0236 | 28.78 | 324.14 | 0.1175 | 1.3125 | 376.68 | 1.507 | 425.15 | 1.657 |
| -24 | 17.3749 | 0.0220 | 33.00 | 324.15 | 0.1341 | 1.3026 | 377.48 | 1.498 | 426.31 | 1.649 |
| -22 | 18.5089 | 0.0206 | 37.26 | 324.11 | 0.1506 | 1.2928 | 378.25 | 1.490 | 427.45 | 1.641 |
| -20 | 19.6963 | 0.0193 | 41.55 | 323.99 | 0.1672 | 1.2829 | 378.99 | 1.482 | 428.58 | 1.633 |
| -18 | 20.9384 | 0.0181 | 45.87 | 323.80 | 0.1837 | 1.2730 | 379.70 | 1.474 | 429.68 | 1.626 |
| -16 | 22.2370 | 0.0170 | 50.24 | 323.53 | 0.2003 | 1.2631 | 380.39 | 1.466 | 430.77 | 1.618 |
| -14 | 23.5935 | 0.0159 | 54.65 | 323.19 | 0.2169 | 1.2531 | 381.04 | 1.458 | 431.83 | 1.610 |
| -12 | 25.0095 | 0.0150 | 59.11 | 322.76 | 0.2334 | 1.2430 | 381.66 | 1.450 | 432.88 | 1.603 |
| -10 | 26.4868 | 0.0140 | 63.62 | 322.23 | 0.2501 | 1.2328 | 382.25 | 1.443 | 433.90 | 1.596 |
| -8 | 28.0269 | 0.0132 | 68.18 | 321.61 | 0.2668 | 1.2226 | 382.81 | 1.435 | 434.91 | 1.589 |
| -6 | 29.6316 | 0.0124 | 72.81 | 320.89 | 0.2835 | 1.2121 | 383.34 | 1.428 | 435.89 | 1.582 |
| -4 | 31.3027 | 0.0116 | 77.50 | 320.05 | 0.3003 | 1.2015 | 383.83 | 1.420 | 436.85 | 1.575 |
| -2 | 33.0420 | 0.0109 | 82.26 | 319.09 | 0.3173 | 1.1907 | 384.29 | 1.413 | 437.79 | 1.568 |
| 0 | 34.8514 | 0.0102 | 87.10 | 317.99 | 0.3344 | 1.1797 | 384.71 | 1.405 | 438.71 | 1.561 |
| 2 | 36.7329 | 0.0096 | 92.02 | 316.75 | 0.3516 | 1.1683 | 385.10 | 1.398 | 439.61 | 1.554 |
| 4 | 38.6884 | 0.0090 | 97.05 | 315.35 | 0.3690 | 1.1567 | 385.45 | 1.391 | 440.49 | 1.548 |
| 6 | 40.7202 | 0.0084 | 102.18 | 313.77 | 0.3866 | 1.1446 | 385.77 | 1.384 | 441.34 | 1.541 |
| 8 | 42.8306 | 0.0079 | 107.43 | 311.99 | 0.4045 | 1.1321 | 386.05 | 1.377 | 442.17 | 1.535 |
| 10 | 45.0218 | 0.0074 | 112.83 | 309.98 | 0.4228 | 1.1190 | 386.29 | 1.369 | 442.97 | 1.528 |
| 12 | 47.2966 | 0.0069 | 118.38 | 307.72 | 0.4414 | 1.1053 | 386.49 | 1.362 | 443.76 | 1.522 |
| 14 | 49.6577 | 0.0064 | 124.13 | 305.15 | 0.4605 | 1.0909 | 386.65 | 1.355 | 444.51 | 1.516 |
| 16 | 52.1080 | 0.0060 | 130.11 | 302.22 | 0.4802 | 1.0754 | 386.77 | 1.348 | 445.25 | 1.509 |
| 18 | 54.6511 | 0.0056 | 136.36 | 298.86 | 0.5006 | 1.0588 | 386.85 | 1.341 | 445.95 | 1.503 |
| 20 | 57.2905 | 0.0051 | 142.97 | 294.96 | 0.5221 | 1.0406 | 386.88 | 1.334 | 446.64 | 1.497 |
| 22 | 60.0308 | 0.0047 | 150.02 | 290.36 | 0.5449 | 1.0203 | 386.87 | 1.327 | 447.29 | 1.491 |
| 24 | 62.8773 | 0.0043 | 157.71 | 284.80 | 0.5695 | 0.9972 | 386.81 | 1.320 | 447.91 | 1.485 |
| 26 | 65.8368 | 0.0039 | 166.36 | 277.80 | 0.5971 | 0.9697 | 386.70 | 1.313 | 448.51 | 1.478 |
| 28 | 68.9182 | 0.0035 | 176.72 | 268.30 | 0.6301 | 0.9342 | 386.53 | 1.305 | 449.07 | 1.472 |
| 30 | 72.1369 | 0.0029 | 191.65 | 252.23 | 0.6778 | 0.8776 | 386.30 | 1.298 | 449.58 | 1.466 |
| 30.98 | 73.7730 | 0.0021 | 219.34 | 219.34 | 0.7680 | 0.7680 | 386.15 | 1.294 | 449.82 | 1.463 |

*based on data from NIST:* ***www.nist.gov***

# SCOTTISH QUALIFICATIONS AUTHORITY
## MARKERS REPORT FORM

SUBJECT: Electrotechnology 041-33

DATE: 16th October 2014

I have no doubts that the paper was a suitable test of the candidates abilities, a pass rate of 63% and marks of 96/96 and 91/96 are testimony to that.
The poor quality of some of the scripts is still a matter of some concern, one would have expected men aiming for a professional qualification to produce neater and more ordered demonstrations of their abilities.

*General Comments of Specific Examination Questions*

**Question 1. Generally well tackled. Those who did go astray started with too many unknowns (there are only ever three) and spent several pages arriving at the wrong answers.**

**Question 2. This too attracted a fair number of correct solutions, but if one knows the correct equations it is simply a matter of using a hand held calculator correctly.**

**Question 3. Plenty of good answers here, but most only scored 14/16 because they failed to notice that the question read 'each of the bias resistors'.**

**Question 4 .About half the candidates performed well on this question. Too many failed to appreciate that the capacitive reactance had to have twice the value of the inductive reactance. This was the key to starting the question.**

**Question 5. Part a) which asked for the KW and KVAr was a strong hint that this was the best approach to part b) . Working in change of KVAr when the capacitors are added is by far the safest approach. Trying to recalculate currents when part of the circuit is star connected and part delta connected is a potential minefield.**

**Question 6. Fine apart from those candidates who failed to notice that part (b) was at the reduced load of 60%**

**Question 7. at least half of those that drew a reasonable circuit diagram had the rotor delta connected ! The external starting resistors would have had no effect whatsoever on the performance of the motor, or the rotor power factor during starting. There were also some very dodgy ideas for calculating synchronous speed, rotor e.m.f. and rotor frequency. It was clear that most candidates had a poor grasp of the theory of the wound rotor induction machine.**

**Question 8. About 50% of those who did this question scored well. Many of the others had such poor powers of description that is what impossible to understand what their explanations were about.**

**Question 9. This was by far the worst answered question of the lot. Nowhere did the question mention the auto transformer starter but at least half the answers submitted started with a sketch and a description of the auto transformer starter. There was only one really good answer to parts b) and c), the rest showed a very poor grasp of the theory behind the auto transformer and the fact that primary and secondary currents flow in opposite directions in the winding.**

# CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
**SCOTTISH QUALIFICATIONS AUTHORITY**
ON BEHALF OF THE
**MARITIME AND COASTGUARD AGENCY**

**STCW 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)**

**041-33 - ELECTROTECHNOLOGY**

**THURSDAY, 24 JULY 2014**

**0915 - 1215 hrs**

Examination paper inserts:

Worksheet Q3

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook
Graph Paper

**ELECTROTECHNOLOGY**

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. In the network shown in Fig Q1, the meter indicates 2mA in the direction shown.

   Determine EACH of the following:

   (a) the resistance of the meter; (8)

   (b) the reading on the meter if the 1.5 kΩ and the 2 kΩ resistors are interchanged. (8)

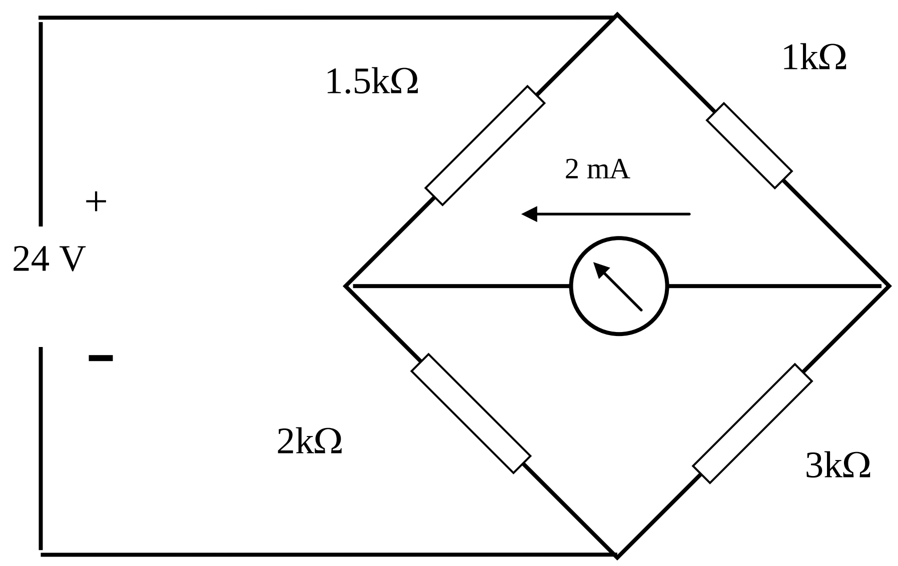



Fig Q1

[OVER

2. The V/I characteristic of a non-linear circuit element is shown in Table Q2.

This non-linear element is connected in series with a paralleled pair of resistors of 40 kΩ and 80 kΩ and the overall circuit is connected to 110V d.c.

Determine EACH of the following:

(a) the current in the non-linear resistor; (8)

(b) the effective resistance of the non-linear resistor; (3)

(c) the current in the 80 kΩ resistor. (5)

| V (volts) | 40 | 60 | 80 | 100 | 120 | 140 |
|---|---|---|---|---|---|---|
| I (mA) | 0.65 | 1.05 | 1.55 | 2.20 | 3.20 | 4.70 |

Table Q2

3. A small silicon transistor with the characteristics given in Worksheet Q3 has a maximum safe power dissipation of 18 mW and it is to be operated on a 12 V d.c. supply.

(a) Plot this power dissipation curve on the characteristics. (5)

(b) Determine the minimum value of collector load resistance for the transistor if this dissipation is not to be exceeded. (5)

(c) If the transistor is used in a common emitter configuration and is biased at a base current of 60 μA and an alternating signal of +/- 40 μA is applied to the base, determine:

(i) the r.m.s. voltage variation between collector and emitter; (3)

(ii) the r.m.s. value of the variation in collector current. (3)

4. (a) A coil having resistance and inductance is connected to a 240 V, 50 Hz supply and draws a current of 4A at power factor 0.8 lag.

Determine EACH of the following:

(i) the resistance of the coil; (4)

(ii) the inductance of the coil. (4)

(b) A capacitor is now joined in series with the coil and the current rises to 5A.

Determine EACH of the following:

(i) the value of the capacitor; (4)

(ii) the new power factor. (4)

5. A three phase star connected load has three identical legs each comprising a 40 Ω resistor in series with a 100 μF capacitor. It is supplied at 415 V, 50 Hz from a three wire supply.

Calculate EACH of the following:

(a) the current in each phase; ( 4)

(b) the current in each phase if due to a fault the red phase lead becomes detached; (6)

(c) the current in each phase if the red phase short circuits to the star point. (6)

6. A 440 V/ 110 V single phase transformer takes a no load current of 5 A at power factor 0.25 lag. On load the transformer supplies 7.5 kVA at power factor 0.8 lag.

Calculate EACH of the following:

(a) the transformer secondary current; (2)

(b) the transformer primary current; (8)

(c) the primary power factor; (3)

(d) the efficiency of the transformer at this load. (3)

7. (a) Describe, with the aid of a sketch, the construction of a double wound, single phase transformer and explain the principle of its operation. (4)

(b) Explain why a transformer is rated in KVA rather than KW. (4)

(c) State why the iron loss in a transformer is not load dependent. (4)

(d) State how the copper losses in the two windings of a transformer vary with the loading of the transformer. (4)

8. (a) State the conditions necessary to *turn on* and *turn off* a thyristor ('SCR'). (4)

(b) Describe the operation of the circuit shown in Fig Q8. (8)

(c) Sketch the voltage waveform across the load for EACH of the following trigger delay angles:

(i) 60°; (2)

(ii) 120°. (2)

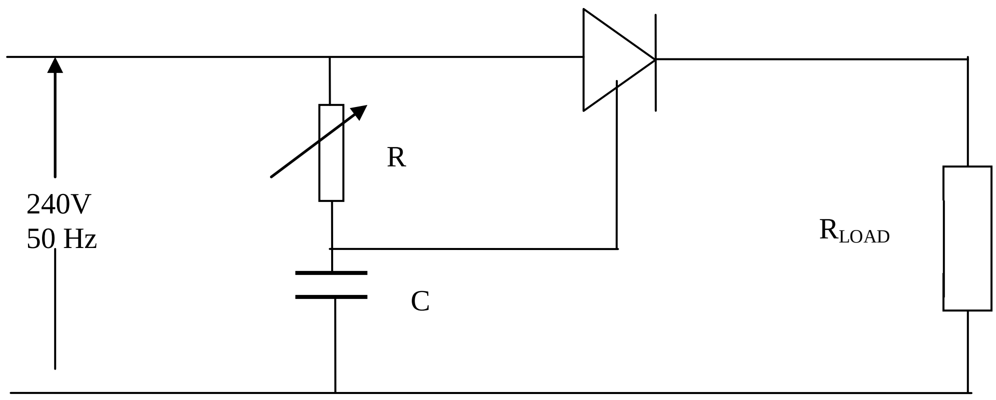


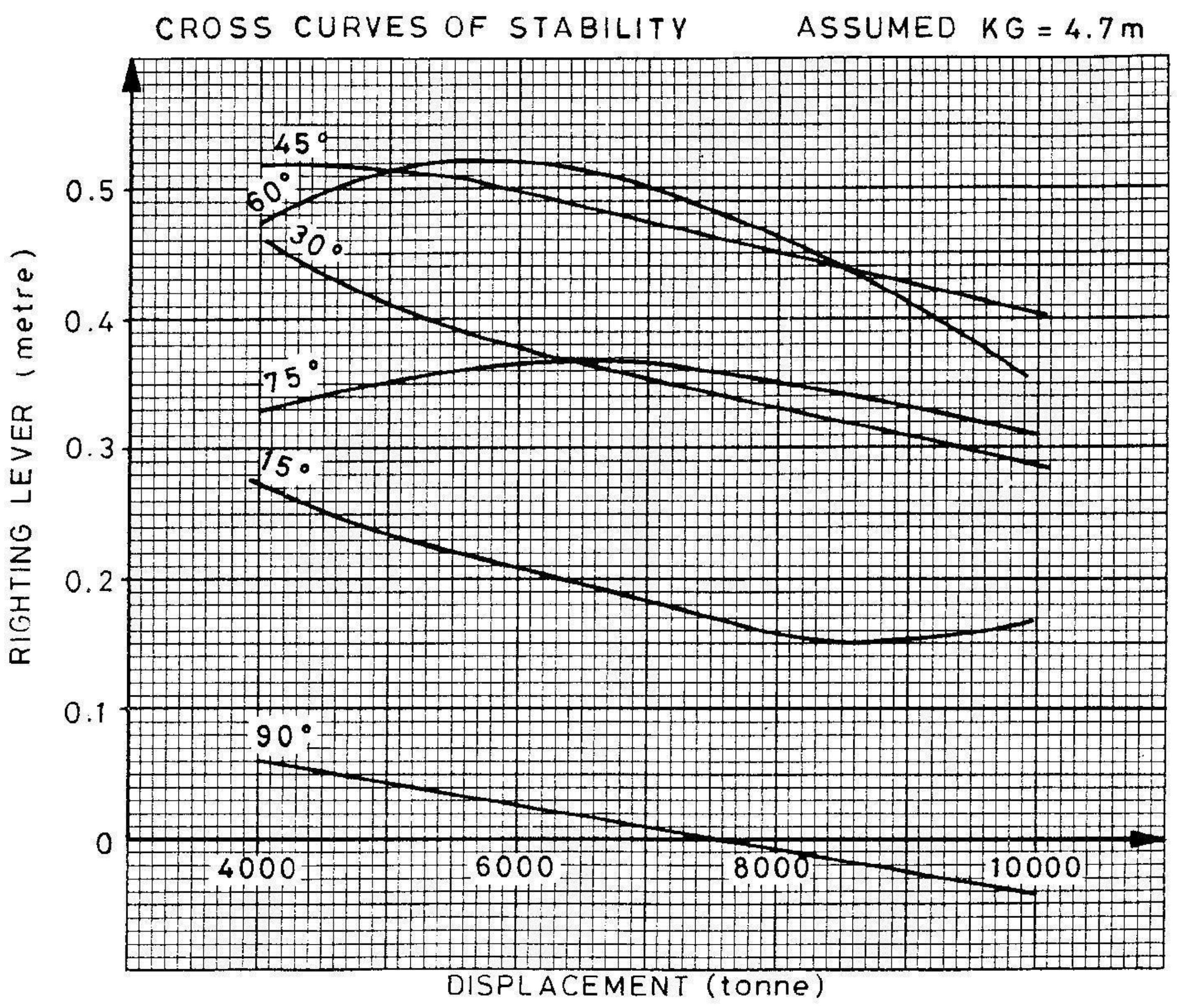

Fig Q8

9. (a) Sketch a circuit diagram showing the essential features of a star/ delta starter for a three phase induction motor, showing the connections to the stator windings. (8)

(b) Explain why the starting current is reduced by the use of such a starter. (4)

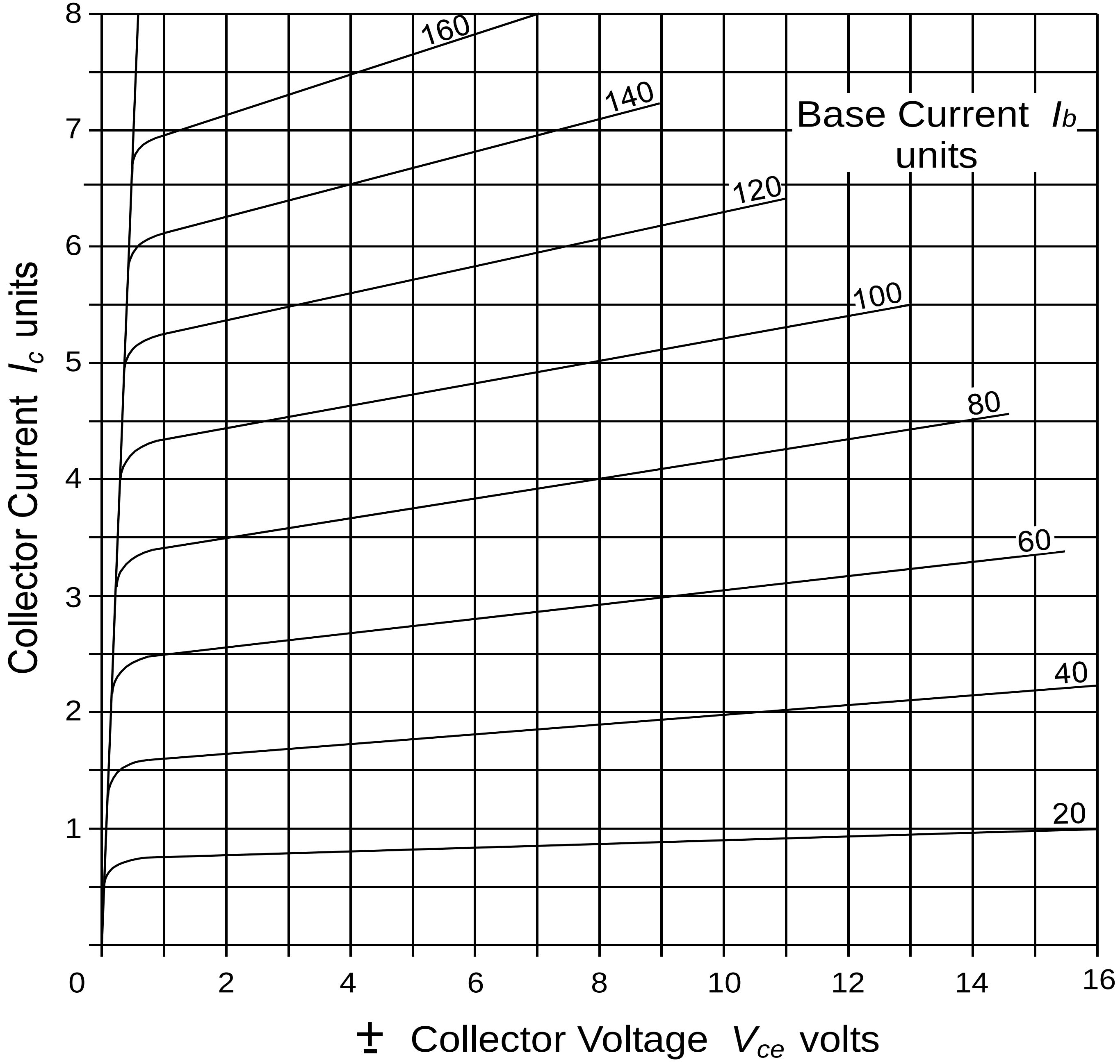
(c) Explain what happens to the current drawn on switching from star to delta. (4)

(This Worksheet must be returned with your answer book)




Candidate's Name ……………………………………… Examination Centre …………………………………………

(This Worksheet must be returned with your answer book)




# COMMON EMITTER TRANSISTOR CHARACTERISTCS

| TYPE | SCALE FACTORS per unit value of | |
|---|---|---|
| | $I_b$ | $I_c$ |
| 1. Small Si | 1 μA | 1 mA |
| 2. Power Si | 1 mA | 1 A |

Candidate's Name ………………………………………….…

Examination Centre ……………………………………………

# CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY –
# MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
**SCOTTISH QUALIFICATIONS AUTHORITY**
ON BEHALF OF THE
**MARITIME AND COASTGUARD AGENCY**

**STCW 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)**

**041-33 - ELECTROTECHNOLOGY**

**THURSDAY, 10 APRIL 2014**

**0915 - 1215 hrs**

Examination paper inserts:

Worksheet Q3

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.

2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook
Graph Paper

**ELECTROTECHNOLOGY**

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. A two core cable is 400 metres long and is fed at each end with 240 V d.c. Three loads are connected to the distributor:

- 120 A at 80 metres
- 80 A at 160 metres
- 100 A at 280 metres

All distances are measured from the same end of the distributor.

The resistance of the twin cable ('go and return') is 0.001 Ω/metre.

Calculate EACH of the following:

(a) the current supplied at each end of the distributor; (6)

(b) the p.d. at each load point; (6)

(c) the total power lost in the distributor cable. (4)

2. A capacitor of 100 μF is charged for 5 secs from a 100 volt d.c. supply via a resistor of 100 kΩ.

Calculate EACH of the following:

(a) the voltage across the capacitor at the end of this period; (4)

(b) the energy stored in the capacitor; (4)

(c) the capacitor is now disconnected and a second capacitor of 100 μF already charged to 70 volts is connected in parallel with it.

Calculate EACH of the following:

(i) the final steady state voltage across the pair; (4)

(ii) the energy stored by the pair of capacitors. (4)

3. A small silicon transistor with the characteristics given in Worksheet Q3 has a maximum safe power dissipation of 18 mW and it is to be operated on a 12 V d.c. supply.

(a) Plot this power dissipation curve on the characteristics. (5)

(b) Determine the minimum value of collector load resistance for the transistor if this dissipation is not to be exceeded. (5)

(c) The transistor is used in a common emitter configuration and is biased at a base current of 60 μA and an alternating signal of +/- 40μA is applied to the base.

Determine:

(i) the r.m.s. voltage variation between collector and emitter; (3)

(ii) the r.m.s. value of the variation in collector current. (3)

4. A capacitor connected in series with a resistor is tested on 240 V 50 Hz and the current is found to be 3.6 A. When the frequency is raised to 100 Hz, the current increases to 4.8 A.

Determine EACH of the following:

(a) the values of the resistor and the capacitor; (6)

(b) the power factor of the circuit at 50 Hz; (4)

(c) the value of an inductor which, when connected in series with the pair, will give the same current of 3.6 A at 50 Hz but with a lagging power factor equal to the value obtained in part (b). (6)

5. A 440 V 400 kVA three- phase transformer is designed to operate at maximum efficiency at ¾ full load and 0.8 power factor. The iron losses total 8 kW.

Determine EACH of the following:

(a) the efficiency at ¾ full load and 0.8 p.f.; (6)

(b) the total losses at full load; (6)

(c) the full load efficiency at 0.7 p.f. (4)

6. An unbalanced three phase load is supplied from a 440 V 50Hz four wire supply. The current in the red line is 6 A lagging by 30°, the current in the yellow line is 5A in phase and the current in the blue line is 7 A leading by 15°.

Determine EACH of the following:

(a) the current in the neutral line; (6)

(b) the phase angle of the neutral current relative to the voltage between the red line and the neutral line; (5)

(c) the total power dissipated by the circuit. (5)

7. (a) Explain, with the aid of a circuit diagram, the *auto transformer* method of starting a squirrel cage induction motor. (8)

(b) State two advantages and two disadvantages of the auto transformer method of starting over the star delta method of starting. (4)

(c) Explain why it is desirable to disconnect the auto transformer when the starting sequence is completed. (4)

8. (a) Sketch the reverse current/voltage characteristic for a low power Zener diode with a breakdown voltage of 10 V. (5)

(b) Sketch a simple voltage regulator circuit using a Zener diode. (5)

(c) State which factors determine the value of the series resistor used in the circuit described in part (b). (3)

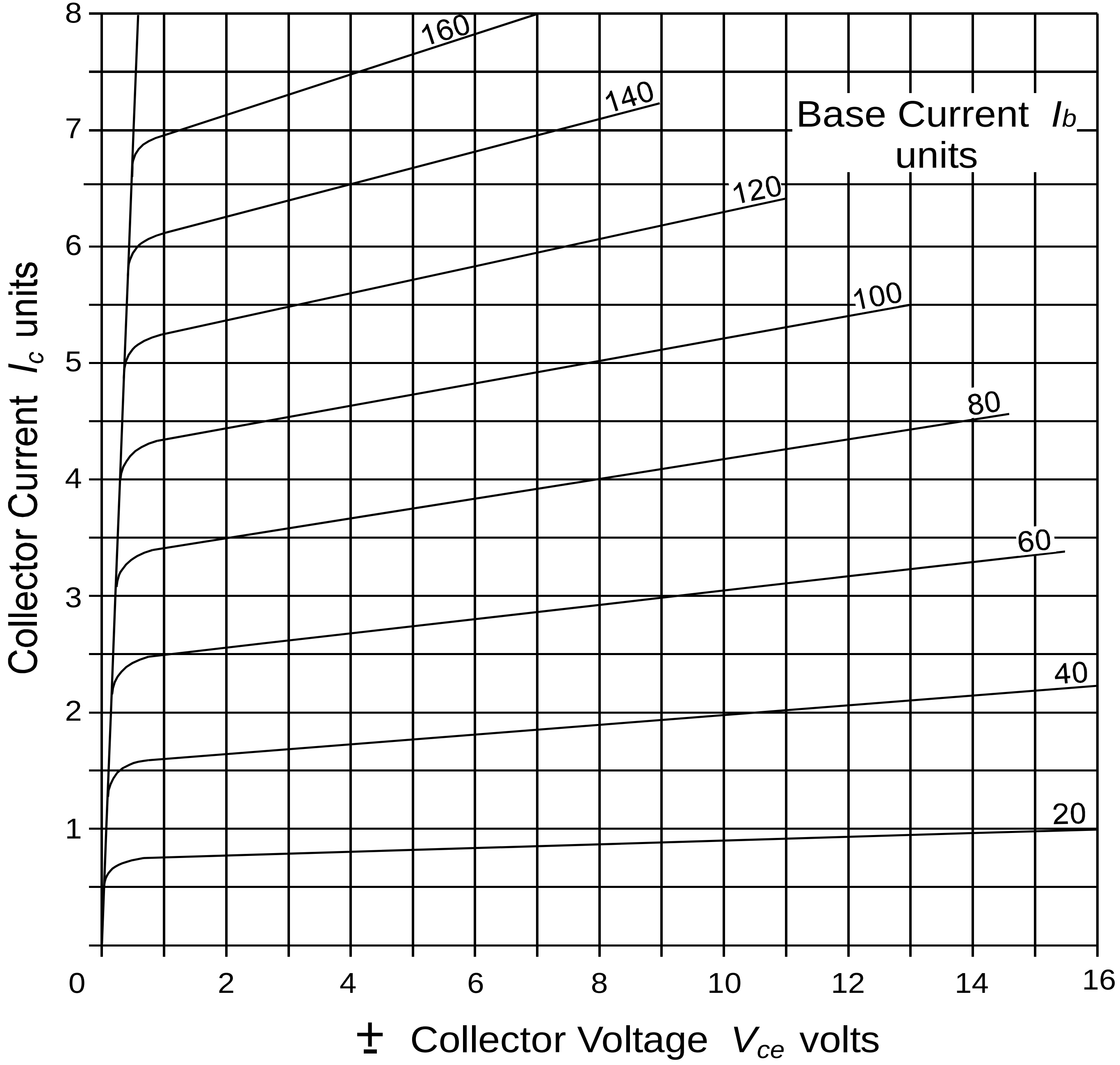
(d) State which factors determine the power rating of the Zener diode in the circuit described in part (b). (3)

9. (a) Explain why it is necessary to monitor and detect faults between the phase windings and earth of a star connected alternator with an earthed neutral point. (4)

(b) Sketch a circuit diagram of one arrangement for detecting phase to earth faults within a star connected alternator with earthed neutral. (7)

(c) Explain how the circuit given in part (b) enables earth faults to be detected. (5)

(This Worksheet must be returned with your answer book)




# COMMON EMITTER TRANSISTOR CHARACTERISTCS

| TYPE | SCALE FACTORS per unit value of | |
|---|---|---|
| | $I_b$ | $I_c$ |
| 1. Small Si | 1 µA | 1 mA |
| 2. Power Si | 1 mA | 1 A |

Candidate's Name ……………………………………………..…

Examination Centre ……………………………………………

# SCOTTISH QUALIFICATIONS AUTHORITY

## MARKERS REPORT FORM

## PART I

SUBJECT: Electrotechnology 041-33

DATE: 10th April 2014

*General Comments on Examination Paper*

The response to this paper was good, several candidates scored in the nineties. The standard of the paper was fair and this was reflected in the overall result.

*General Comments of Specific Examination Questions*

**Question 1.**

A standard type of network question which was completed by most, although there were a number of arithmetic mistakes which should not occur at this level. Candidates should “smell a rat” when the p.d. across one of the loads is higher than then supply voltage.

**Question 2.**

Parts a) and b) caused no problems but in part c) at least half the candidates assumed that the energy would be conserved, whilst it is charge which is conserved. So many made this mistake that I wondered if students had been taught this and as the final answers were only a couple of percent different from the ‘correct’ ones I awarded full marks in these cases. Students should be made aware, if they are not already, that charge is conserved not energy.

**Question 3.**

The response to this question was generally good but a few candidates divided volts by mA and got milliohms and in some cases gave the current ‘swing’ in Amps when it stated quite clearly that the units were mA.

**Question 4.**

This was answered surprisingly well by a large number of candidates who picked their way through the algebra with unerring accuracy !

**Question 5.**

Too many candidates wrote about primary and secondary currents and involved root three when the problem was simply one of finding the changed copper loss and changing the output kW for each section of the question. Keep it simple !

**Question 6.**

A handful of correct solutions here, but far too many candidates resolved the currents along their respective phase voltages rather than finding the horizontal and vertical components. It is still not clear to many that the current in the neutral is equal and opposite to the resultant of the three unbalanced phase current. Root three cropped up again when it should not, the system is not a balanced one.

**Question 7.**

There were some good diagrams and good explanations here together with some good diagrams and hopeless explanations. Remembering a circuit diagram is one thing, explaining how it operates is something altogether different.

**Question 8.**

A few (a very few) good attempts at this question. A surprising number of students confused the Zener diode with the thyristor or SCR and produced a circuit for a variable D.C. output from an A.C. supply.

**Question 9.**

Some very hazy explanations here, this question should only be attempted by those fully conversant with the protection method asked for. But there were a few sound responses to this question.