COMMONWEALTH SERVICE

FOURTH DIVISION

Examination No. 5791—29 June 1968 and subsequent dates

TO GAIN PART OF THE QUALIFICATION FOR PROMOTION OR TRANSFER AS SENIOR TECHNICIAN (TELECOMMUNICATIONS), RESEARCH, POSTMASTER-GENERAL'S DEPARTMENT

TELECOMMUNICATION PRACTICE AND MEASUREMENTS

WRITTEN PAPER No. 2

Time allowed: Three hours
Perusal time: Fifteen minutes

Maximum marks 100: Pass mark 60

INSTRUCTIONS TO CANDIDATES

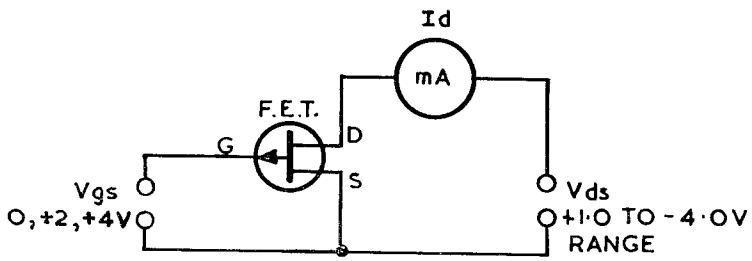
1. The paper comprises twelve questions.
2. Attempt SIX QUESTIONS ONLY.
3. In SECTION I, QUESTION 1 and ONE OTHER QUESTION ONLY to be attempted.
4. SECTION II, attempt ANY FOUR QUESTIONS.
5. Question 1 carries 20 marks: each other question carries 16 marks.
6. Commence the answer to each question on a fresh sheet of paper: use one side only.
7. Where appropriate, illustrate your answer with clear, concise diagrams.
8. Linear 16 cm x 25 cm graph paper and mathematical tables are provided. Slide rules may be used.
9. The output characteristics for an AFY18 transistor are provided on a separate sheet for use with Question 6.

SECTION I

Question 1

A P Channel Field Effect Transistor was tested at low drain to source voltages to determine the drain characteristics below 'pinch-off'.

The drain current, for 3 separate gate bias voltages, was measured over a range of drain-to-source voltages from + 1.0 to − 4.0 volts. The simple measuring circuit is shown below.



The following results were obtained.

Drain Current Id in mA.

Gate Bias Vgs (volts)	Vds (volts)							
	+ 1.0	+ 0.5	0.0	− 0.5	− 1.0	− 2.0	− 3.0	− 4.0
+ 4.0	+ 0.67	+ 0.33	0.0	− 0.33	− 0.66	− 1.3	− 1.75	− 2.0
+ 2.0	+ 2.5	+ 1.25	0.0	− 1.25	− 2.5	− 4.2	− 4.9	− 5.4
0.0	+ 4.6	+ 2.3	0.0	− 2.3	− 4.6	− 8.2	−10.4	−11.9

(*a*) Construct a graph showing the drain voltage-current relationships for each of the three gate bias conditions, for the drain-to-source voltage range of *zero* to − 4 volts.

——[10 marks]

(*b*) What is the voltage-current relationship of the drain for small drain-to-source voltages of either polarity? State the significance of this characteristic.

—[4 marks]

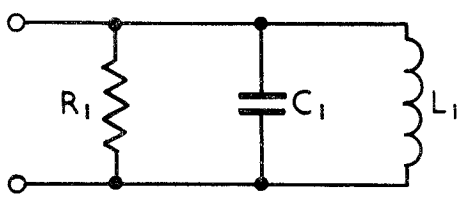
(*c*) From your graph determine the value of the drain-to-source resistance for small alternating voltage signals (of not more than 1 volt peak) applied across the drain and source for each of the three gate bias conditions.

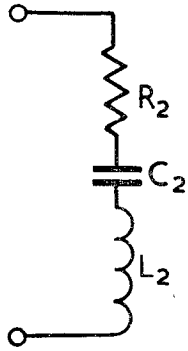
—[6 marks]

Question 2

Answer FOUR of the following five parts.

(*a*) Draw labelled diagrams of the resonance behaviour of the following circuits.





Assume R_1 is much greater than $2\pi fL_1$ and R_2 is much less than $2\pi fL_2$ for the range of frequencies considered.

Give formulae for the Q factor of each circuit.

(*b*) A 25 kHz signal amplitude modulates a 5 MHz signal. Show the relationship between the carrier and the sidebands both in amplitude and frequency for 50 per cent. modulation. What percentage of the total power is carried by each side band.

(*c*) What is meant by:

(i) absorption coefficient?

(ii) reverberation time?

List two factors which control each of these characteristics.

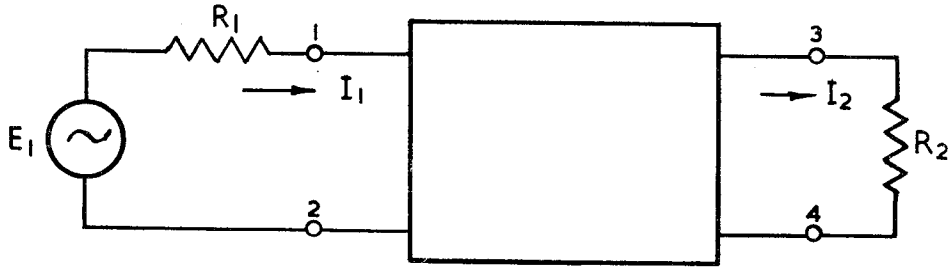
(*d*) With the aid of a diagram show the basic construction of a loudspeaker and briefly explain how it operates.

(*e*) What is diversity reception and why is it used? Mention two types of diversity recepion.

—[16 marks equally divided between four parts]

Question 3

(*a*) What are the gains or losses in dB from the input (terminals 1, 2) to the output (terminals 3, 4) of the following piece of equipment.



(i) if $R_1 = 3000$ ohms, $R_2 = 150$ ohms
$E_1 = 4.5$ volts, $I_2 = 10$mA and
the input impedance is 1500 ohms.

(ii) If $R_1 = R_2$, $I_1 = 100\ I_2$ and
the equipment is matched at both the input and output.

(iii) If $E_1 = 0.5$ volts, $R_1 = 400$ ohms, $I_1 = 1$mA, $I_2 = 10\mu$A, the output impedance is 1000 ohms and R_2 is a matched load.

—[8 marks]

(*b*) Explain what is meant by any FOUR of the following five transmission line terms.

(i) Quad cable.

(ii) Characteristic impedance.

(iii) Inductance loading.

(iv) Reflection.

(v) Wavelength constant.

—[8 marks]

Question 4

(*a*) State the important differences between a free running blocking oscillator and an astable multivibrator, with regard to the type of circuit components, the current drain, and the output signal characteristics. Give one application for each type of oscillator.

—[8 marks]

(*b*) Describe the essential principles of multimetering as applied to the Australian Subscriber Trunk Dialling Network in Australia.

—[4 marks]

(*c*) Explain what is meant by the following telegraphy terms:

(i) Simplex working.

(ii) Double current working.

—[4 marks]

SECTION II

Question 5

Draw basic schematic circuits for FOUR of the following six stages of a superheterodyne receiver. Describe briefly both the function and principle of operation of each stage you have chosen. Each stage may use either transistors or thermionic valves.

(*a*) A radio frequency amplifier stage.

(*b*) An intermediate frequency amplifier stage.

(*c*) A filtered D.C. power supply for a receiver operated from A.C. mains.

(*d*) An audio power output stage.

(*e*) A radio frequency to intermediate frequency converter stage.

(*f*) An audio detector stage.

—[16 marks: equally divided between four sections]

Question 6

(*a*) With the aid of diagrams explain the basic action of a transistor.

—[6 marks]

(*b*) On the characteristic curves provided, for the transistor shown in the circuit below, draw the load line and determine the following:

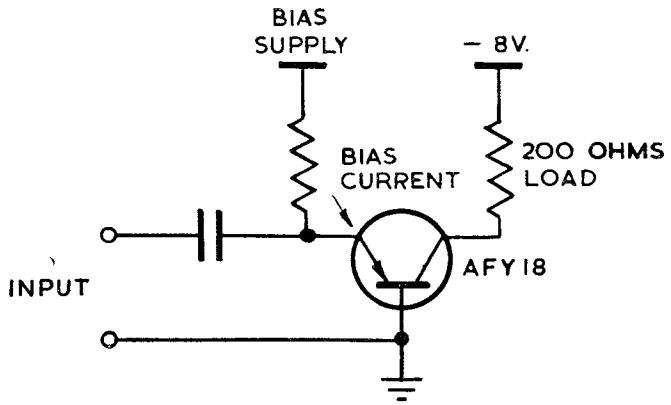
(i) A suitable bias current for linear amplification of a sinusoidal signal.

(ii) The power dissipated at the collector with the bias current you have chosen.

(iii) The voltage gain of the amplifier (given the following formula for the emitter resistance).

$$R_e = \frac{25.6}{I_e} \text{ ohms}$$

Where I_e is emitter bias current in mA.



Note: Hand in the characteristic curve sheet with your answer to this question.

—[10 marks]

Question 7

Answer EITHER part A, OR part B

A. Give a detailed account of wave propagation in ONE of the three following frequency ranges.

(i) Below 100 kHz to 1500 kHz.
Consider separately the Very Low Frequency (VLF), Low Frequency (LF) and Medium Frequency (MF) bands and make comparisons between them.

(ii) 3 MHz to 30 MHz.

(iii) 3000 MHz to 10,000 MHz.

Mention any important effects which the ground, the ionosphere, or the troposphere have at the frequencies you have chosen.

—[16 marks]

B. Draw a diagram of any aerial type used by the Australian Post Office. Indicate the application for this type of aerial and describe the principle of its operation. In your answer mention and give examples of any of the following properties which are important in the aerial type you have chosen:

Polar diagram.

Gain

Impedance or V.S.W.R.

Bandwidth.

—[16 marks]

Question 8

Answer EITHER Part A, OR part B

A. (*a*) With the aid of a diagram explain how a hybrid coil may be used to connect a transmission line, impedance Z_1, to the input of one amplifier, impedance Z_2, and the output of another, impedance Z_3, so that signals may pass from Z_1 to Z_2 and from Z_3 to Z_1 but not from Z_3 to Z_2. Assume an unbalanced type of hybrid for simplicity.

—[8 marks]

(*b*) Draw a labelled block diagram to show how hybrid coils enable two way transmission in a two wire V.F. repeater. What is the difference between the gains of the repeater and the appropriate amplifier, for a given direction of transmission? Where do the losses occur?

—[4 marks]

(*c*) Give three possible causes of singing in a two wire repeater. Explain how the signal is passed around each stage of the singing loop in each case.

—[4 marks]

B. Write factual notes about some aspects of a coaxial cable carrier system. Give EITHER general information about the whole system OR more detailed descriptions of some of its components.

—[16 marks]

Question 9

(*a*) A 5-unit binary code is used in machine telegraphy. How many different combinations of signals are possible with this code? Indicate broadly what these combinations represent in terms of signalled information.

—[4 marks]

(*b*) Describe how a transistor can be used as a switch.

Discuss the conditions present during both the 'ON' and 'OFF' states, in the case of a germanium p-n-p transistor used in a common emitter circuit, with a resistive load in the collector circuit.

—[5 marks]

(*c*) Sketch the circuit of a transistor 'INVERTED AND' gate, having two inputs (A and B). Indicate with the aid of a truth table the output conditions for the various combinations of inputs to A and B.

—[7 marks]

Question 10

(*a*) What are the classifications for the switching centres in the Australian trunk line network? With the aid of a sketch show how the different centres can be interconnected. What is the difference between a final choice and a direct route?

—[8 marks]

(*b*) Give the general functions of a relay set repeater in setting up a call between two subscribers connected to adjacent step-by-step exchanges.

—[5 marks]

(*c*) What are the essential characteristics of a high speed relay?

—[3 marks]

Question 11

Answer any TWO parts of the four parts to this question.

(*a*) Describe the main features of a psophometer. What is its application in telephone transmission measurements?

—[8 marks]

(*b*) Describe the construction of a volume unit meter and indicate its chief characteristics. Explain how it is used in measuring speech volumes on a programme line.

—[8 marks]

(*c*) Describe with the aid of a block diagram, the principle and operation of some electronic voltmeter with which you are familiar. Give general details of the measuring range, accuracy, and type of indication which this instrument can provide.

—[8 marks]

(*d*) Describe with the aid of a block diagram, the general principle of operation of a beat frequency oscillator to cover the main audio frequency range. Name one application for such an oscillator.

—[8 marks]

Question 12

A condenser microphone cartridge has a polarizing d.c. voltage fed to it from a nominal 200 volt regulated supply, through a resistor of value 10.0 Megohms ($\pm 1\%$ tolerance). The power supply voltage is not directly accessible for measurement and a potentiometric voltmeter is not available. Using a reliable and sensitive laboratory multi-range meter on its 200 volt range, a d.c. voltage of 170 volts is measured across the microphone cartridge. The meter used has a six inch length scale and a taut-band suspension meter movement with a full scale current sensitivity of 4 microamperes. The maker specifies it to have a measuring error of not more than $\pm 2\%$ of the full scale range deflection at any point of its scale, and a recent calibration check has shown that the meter is within its specified tolerance on all ranges.

(*a*) Draw a simple sketch showing the basic circuit components involved in this measuring set up, and calculate the expected value of voltage indication with this meter. (Assume microphone leakage current is negligible).

—[7 marks]

(*b*) Does the difference between the expected and actual voltage readings mean that the power supply is not providing a precise 200 volt output? Give reasons for your answer.

—[4 marks]

(*c*) Describe briefly what is meant by a taut-band suspension meter movement. Give two advantages of such a suspension over that of the conventional pivoted movement.

—[5 marks]

By Authority: A. J. ARTHUR, Commonwealth Government Printer, Canberra

Candidate's No......

Centre of Examination.....

Question 6