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RADIO II

ROYAL AIR FORCE—AIRCRAFT APPRENTICES

No. 1 Radio School, Locking

FINAL EXAMINATION IN EDUCATIONAL SUBJECTS

SEPTEMBER 1961 (99TH) ENTRY

NOVEMBER 1963

RADIO PRINCIPLES II

Time allowed—Three hours

All questions carry equal marks

FIVE questions to be attempted, but not more than two from Section A.

Section A is common to all trades.

Section B is applicable to wireless trades.

Section C is applicable to radar trades.

Candidates may attempt questions applicable to trades other than their own.

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SECTION A

Common to all Trades

Not more than TWO *questions to be answered from this section*

1. (*a*) Draw the circuit diagram of a tetrode anode and screen modulated radio frequency power amplifier, suitable for use in a wireless transmitter operating in the h.f. band. Include in the circuit diagram a push-pull a.f. modulator stage.

   (*b*) Sketch, on separate time scales, the waveforms of grid voltage, anode voltage and anode current for an amplitude modulated r.f. power amplifier. Show relative phase relationships and reference levels.

   (*c*) State the advantage of using:—

   (i) anode and screen modulation with a tetrode valve, instead of simply anode modulation, and

   (ii) a push-pull stage as modulator instead of a single valve stage.

   (*d*) An anode modulated r.f. power amplifier produces an unmodulated carrier power of 250 watts. Neglecting losses, calculate the modulator power required to achieve 100 per cent. modulation depth.

2. Draw the circuit diagram of an i.f. amplifier followed by a combined detector-delayed a.g.c.-audio frequency amplifier using a double diode-triode valve.

   (*a*) Show the connections between the a.g.c. circuit and the grid of the i.f. valve, and indicate typical values for operation with a 465 Kc/s intermediate frequency in a broadcast h.f. receiver.

   (*b*) Number the components in your diagram and list those associated with the following:—

   (i) filtering the a.f. signal from the a.g.c. line,

   (ii) a.g.c. delay voltage, and

   (iii) a.f. amplifier bias.

   (*c*) Sketch, on the same axes, labelled graphs showing changes of receiver output with change of aerial input voltage for receivers employing:—

   (i) no a.g.c. action,

   (ii) simple a.g.c. action,

   (iii) delayed a.g.c. action, and

   (iv) amplified delayed a.g.c. action.

   (*d*) Explain why it is not possible to achieve absolutely constant output, even for small changes of input signal.

3. (*a*) Explain why the output voltage of a power supply unit will change if the load current drawn from it changes.

(*b*) Describe, with the aid of simple circuit diagrams, how:—

(i) a valve, and

(ii) a magnetic amplifier (saturable reactor)

may be used as an automatically variable "voltage dropper" in a power supply stabilizing circuit.

(*c*) (i) Draw the circuit of a three-phase full-wave rectifier. Show on the circuit the path of the charging current of the reservoir capacitor when one phase of the a.c. supply is at its peak positive value.

(ii) Compare the components used in three-phase and single-phase rectifier filter circuits with reference to physical size and component values.

(iii) Describe with the aid of a diagram the construction of a simple thermal delay switch as used in power supply time delay circuits.

SECTION B

Wireless Trades

4. (*a*) (i) Draw the circuit diagram of a reactance valve modulator.

(ii) Indicate on the diagram the three most important factors affecting the reactance of the circuit.

(*b*) (i) Explain, with the aid of annotated waveform sketches, or otherwise, why frequency modulation is similar to phase modulation.

(ii) Define modulation index for a f.m. signal.

(iii) State the effect of a change in amplitude of the modulating signal on the depth of modulation of an a.m. signal and on the modulation index of a f.m. signal.

(*c*) (i) Describe briefly how amplitude modulation depth can be shown on an oscilloscope (other than by simply displaying the modulated signal on a linear trace). Explain to which electrodes of the oscilloscope the necessary signals must be applied.

(ii) Sketch the patterns which would appear on the oscilloscope for first, 100 per cent. distortionless modulation, second, 40 per cent. distortionless modulation, and third over modulation.

(iii) Write down the frequency components in the output of a balanced modulator for an input signal of frequency f_1 and an input signal of frequency f_2.

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5. (*a*) (i) Draw the circuit diagram and explain the action of a pulse width modulator.

(ii) Explain, with the aid of waveform sketches, how a differentiating circuit may be used with this circuit to produce pulse position modulation.

(*b*) (i) Draw the circuit diagram of a free-running anode-coupled multivibrator.

(ii) In the multivibrator circuit the cut-off voltage for each grid is -30 V and when the valves conduct, the anode voltage falls from 200 V to 100 V. Sketch the voltage waveform at one grid indicating voltage levels.

(iii) Draw a block diagram of a simple p.a.m. transmitter, and indicate which stage might be a multivibrator.

6. (*a*) Show, by means of a block diagram, how two teleprinters can be made to modulate simultaneously an a.m., h.f. transmitter. Show on the diagram all necessary stages of the transmitter as well as the drive equipment. If the final radiated carrier frequency is to be 25 Mc/s, indicate typical operating frequencies in the important stages.

(*b*) (i) Sketch the circuit diagram and explain the action of a simple band-pass filter.

(ii) State the conditions which must be fulfilled for a voltage source to be matched to a load via a filter.

(iii) Explain what is meant by the term characteristic impedance of a filter.

(*c*) Explain, with the aid of filter response curves, why two balanced modulators and two sets of filters are sometimes used to produce a single sideband signal.

7. (*a*)

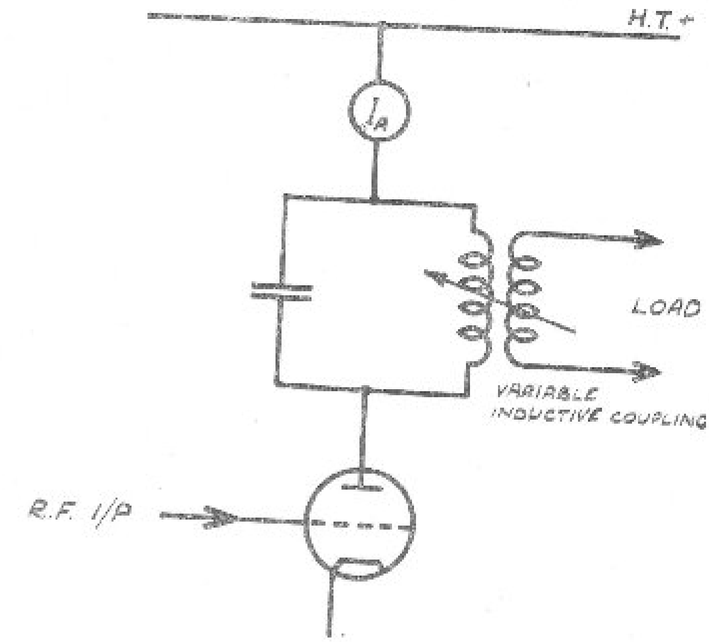

FIG. 1

With reference to the circuit of Fig. 1,

(i) Explain how you would tune to resonance and adjust the loading on a transmitter power amplifier stage. Include in your answer graphs of variation of anode current and movement of tuning control for both lightly loaded and heavily loaded conditions.

(ii) Give two conditions which must be satisfied for the stage to be correctly loaded.

(*b*) Draw circuits to show how the output stage of a high power h.f. transmitter can be connected to:—

(i) a balanced feeder, and

(ii) a coaxial cable.

Arrange each circuit so that harmonics will be suppressed.

(*c*) A 300 ohm transmission line is to be matched to an aerial whose input resistance is 150 ohms and which is to radiate at 20 Mc/s. Calculate the characteristic impedance and the length, in metres, of a quarter-wave transformer which would match the line to the aerial.

8. Two of the limiting factors in long distance communications are selective fading and receiver noise. Selective fading may be overcome by the use of spaced diversity reception, and receiver noise may be reduced by special techniques.

(*a*) Explain how selective fading occurs.

(*b*) Describe how spaced diversity reception overcomes the effects of selective fading.

(*c*) Explain why automatic gain control cannot overcome the effects of selective fading.

(*d*) Define and explain the significance of noise factor of a receiver.

SECTION C

Radar Trades

9. (*a*) A magslip resolver is sometimes used in the production of a P.P.I. display on a fixed-coil cathode ray tube.

(i) Draw a simple circuit diagram showing a magslip resolver used in this way and indicate the input and output connections.

(ii) Explain, with the aid of suitable current waveform sketches, how the magslip resolver produces a rotating radial trace on the c.r.t. screen. The need for switched clamps may be ignored.

(*b*) The output from a ringing oscillator is used to provide range markers on a P.P.I. display.

(i) Draw a labelled block schematic diagram of an arrangement suitable for producing range markers, and sketch the output waveform from each block.

(ii) Calculate the frequency of the ringing oscillator if the markers are to be spaced at intervals representing 20 nautical miles.

(*c*) A P.P.I. display will be confused by the presence of clutter.

(i) Describe a simple circuit which may be employed to reduce the effect of clutter.

(ii) Explain, with the aid of sketches of typical input and output waveforms, the operation of this circuit.

10. (*a*) Describe, with the aid of labelled diagrams, the construction of:—

(i) a trigatron, and

(ii) an artificial transmission line.

(*b*) The modulator circuit of a centimetric radar transmitter includes a delay line, a trigatron and a pulse transformer. The delay line charges to 8 kV from a 4 kV power supply.

(i) Draw a circuit diagram of the modulator.

(ii) State the condition required for a pulse of 4 kV amplitude to be supplied to the load when the line discharges.

(iii) Explain the operation of this circuit.

(*c*) (i) State three functions of the pulse transformer used in the modulator circuit described above.

(ii) Describe two features in which a pulse transformer differs from a normal iron-cored power transformer.

11. (*a*) A voltage generator provides a symmetrical square wave with amplitude limits of +50 V and −50 V. From this waveform it is necessary to derive the following waveforms:—

(i) a square wave between the limits of 0 to +100 volts,

(ii) a square wave between the limits of −10 to −20 volts, and

(iii) a series of negative-going pips of amplitude 100 volts.

Draw the circuits required to produce each of the above outputs.

(*b*) Explain the operation of each of the circuits you have drawn in answer to (*a*) above.

(*c*) (i) Draw the circuit of a phantastron time-base generator.

(ii) Sketch the voltage waveforms at the anode and screen grid of the phantastron. Show in your diagram the time relationship between the waveforms.

(iii) Describe one method by which a diode may be used to vary the rundown time of the anode waveform.

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12. (*a*) (i) State the reason for using additive mixing rather than multiplicative mixing in radar receivers.

(ii) Draw the circuit diagram of an additive mixer which utilises a triode valve, indicating the input and output connections.

(iii) Briefly explain the operation of the circuit which you have drawn, with particular reference to input coupling and bias used.

(*b*) (i) State three reasons why crystal mixers are preferable to valve mixers in microwave receivers.

(ii) Sketch a labelled diagram of a waveguide crystal mixer. Show the positions of the local oscillator coupling device and the crystal with respect to the broad and narrow sides of the waveguide.

(iii) With reference to your diagram state what adjustment would be carried out to change the amplitude of the injected local oscillator signal.

(*c*) With reference to the crystal mixer drawn in answer to part (*b*) state the path taken by:—

(i) the i.f. current, and

(ii) the signal current.

13. (*a*) (i) Draw the circuit diagram of a typical R-C coupled video amplifier which incorporates a low-frequency compensating network.

(ii) Explain why such a compensating network may be needed in a video amplifier.

(iii) Explain how the network achieves low-frequency compensation and indicate, with the aid of waveform sketches, the improvement in the video pulse shape which the network can produce.

(*b*) Directly-coupled amplifiers may be used to amplify low frequency signals.

(i) State and explain two disadvantages of the third-rail type of direct-coupled amplifier.

(ii) Sketch the circuit of a direct-coupled, two-stage amplifier employing a soft valve and explain the circuit operation.

(*c*) State and explain ~~three~~ two factors which influence the choice of the intermediate frequency in a radar receiver.

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