higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T320(E)(A14)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

COMMUNICATION ELECTRONICS N5

(8080235)

14 April 2015 (Y-Paper)
13:00–16:00

Calculators may be used.

This question paper consists of 5 pages and a formula sheet of 5 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
COMMUNICATION ELECTRONICS N5
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Ensure that your diagrams are clearly labelled.
5. Keep questions and subsections of questions together.
6. Rule off on completion of EACH answer.
7. Consider the following TWO examples regarding the use of units in calculations:

   7.1 INCORRECT: $V = IR = 10 \times 2 = 20$

   7.2 CORRECT: $V = IR = (10\ A) \times (2\ \Omega) = 20\ V$

8. Write neatly and legibly.

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QUESTION 1

1.1 The input power to an amplifier is 0,1 W. The output power is 6 W.

Determine the increase in gain that will result in an output of 12 W. Express the answer in dB. (10)

1.2 Express a power loss of 100 in dB. (3)

[13]

QUESTION 2

Determine the current in each of the parallel branches in FIGURE 1 below.

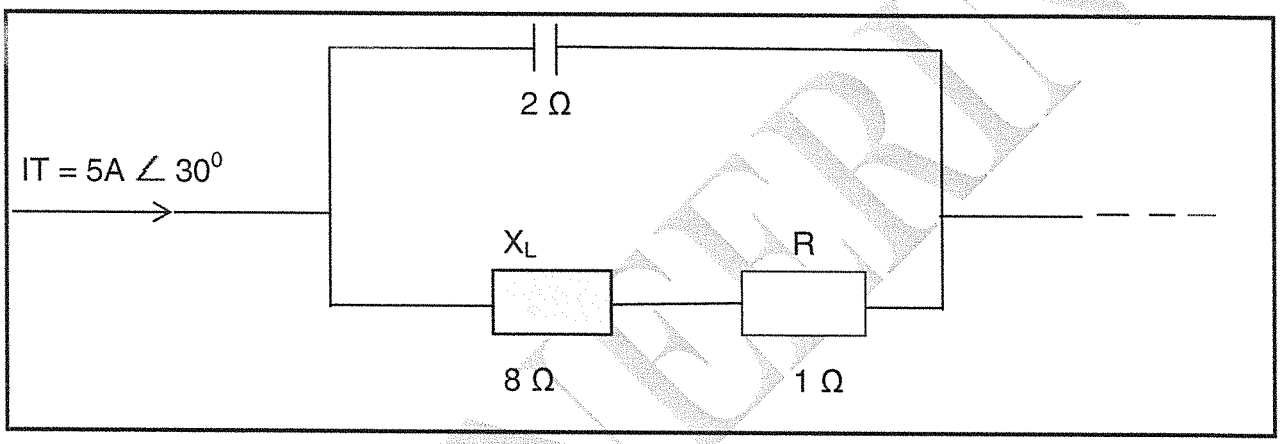

FIGURE 1 **[10]**

QUESTION 3

3.1 When an RLC circuit resonates, it appears purely resistive in that the current is in phase with the supply voltage.

With reference to this statement, derive the equation for the resonance frequency of a series-resonance circuit. (5)

3.2 Given that ZD = L/CR for a parallel resonant circuit, prove that ZD = QXL. (5)

[10]

QUESTION 4

Show how the image impedance Z01 of an L-type network is derived.

HINT: The derivation must be accompanied by TWO sketches. **[10]**

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QUESTION 5

In DSB transmission, two sidebands are generated apart from the carrier wave.

Calculate the spectra of both sidebands for a modulation spectrum of 200 Hz to 15 kHz and a carrier frequency of 750 kHz. Use a labelled sketch to represent the spectrum of the transmitted signal. **[11]**

QUESTION 6

Design a filter circuit with a characteristic impedance of 600 Ω that will suppress all frequencies above 3,4 kHz. Draw the T- and π configurations of the filter and insert the component values. **[12]**

QUESTION 7

7.1 Briefly describe the frequencies present in the output of the mixer of an AM receiver. (4)

7.2 State the functions of the following stages of an FM transmitter:

7.2.1 Oscillator

7.2.2. Reactance modulator

7.2.3 Audio amplifier

(3 x 2) (6)
[10]

QUESTION 8

8.1 Draw a fully labelled diagram of a circuit you would use to eliminate/remove a frequency modulated carrier, leaving the modulating signal. (11)

8.2 Name the circuit in QUESTION 8.1. (1)
[12]

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QUESTION 9

Define or describe in your own words what is understood by the following concepts:

9.1 Isotropic antenna

9.2 Effective aperture

9.3 Directive gain

9.4 Radiation resistance

9.5 Symmetrical network

9.6 Characteristic impedance

(6 x 2) **[12]**

TOTAL: 100

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FORMULA SHEET

COMMUNICATION-ELECTRONICS N5

Any applicable formula may also be used.

Inductive Reactance

$$X_L = 2\pi fL$$

Capacitive Reactance

$$X_c = \frac{1}{2\pi\ fC}$$

Series formulae

$$Z_T = \sqrt{R^2 + (X_L - X_c)^2}$$

$$\tan\theta = \frac{X_L - X_c}{R}$$

$$BW = \frac{f_o}{Q} = \frac{R}{2\pi\ L}$$

$$p.f = Cos\phi$$

$$P = VICos\phi$$

$$Y = \frac{1}{Z} = G \pm jB$$

Parallel formulae

$$I_T = \sqrt{I_R^2 + (I_C - I_L)^2}$$

$$\tan\theta = \frac{I_C - I_L}{I_R}$$

$$I_X = I_C - I_L$$

$$p.f = Cos\phi$$

$$P = VICos\phi$$

$$Y_T = Y_1 + Y_2$$

Series resonance

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$Z = R$$

$$\phi = 0^\circ$$

$$p.f = Cos\phi = 1$$

$$Q = \frac{X_L}{R} = \frac{X_C}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$BW = \frac{f_o}{Q} = \frac{R}{2\pi\ L}$$

Parallel resonance

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

$$Z_D = \frac{L}{RC}$$

$$\phi = 0^\circ$$

$$p.f = Cos\phi = 1$$

$$Q = \frac{X_L}{R} = \frac{X_C}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$BW = \frac{f_o}{Q} = \frac{R}{2\pi\ L}$$

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FILTERS

Low pass

$$R_o = \sqrt{\frac{L}{C}}$$

$$f_c = \frac{1}{\pi\sqrt{LC}}$$

$$C = \frac{1}{\pi\ R_o\ f_c}$$

$$L = \frac{R_o}{\pi\ f_c}$$

$$Z_{OT} = \sqrt{\frac{L}{C}} \times \sqrt{1 - \frac{\omega^2 LC}{4}}$$

$$Z_{O\pi} = \frac{R_o}{\sqrt{1 - \frac{\omega^2 LC}{4}}}$$

High pass

$$R_o = \sqrt{\frac{L}{C}}$$

$$f_c = \frac{1}{4\pi\sqrt{LC}}$$

$$C = \frac{1}{4\pi\ R_o\ f_c}$$

$$L = \frac{R_o}{4\pi\ f_c}$$

$$Z_{OT} = \sqrt{\frac{L}{C}} \times \sqrt{1 - \frac{1}{4\omega^2 LC}}$$

$$Z_{O\pi} = \frac{R_o}{\sqrt{1 - \frac{1}{4\omega^2 LC}}}$$

SYMMETRICAL FOUR-TERMINAL NETWORKS

T- Network

$$Z_{in} = Z_{out\,/\,uit}$$

$$Z_{OT} = \sqrt{Z_{oc} Z_{sc}}$$

$$Z_{OT} = \sqrt{\frac{Z_1^{\,2}}{4} + Z_1 Z_2} = \frac{Z_1 Z_2}{Z_{O\pi}}$$

$$Z_1 = 2\left[Z_{oc} - \sqrt{Z_{oc}(Z_{oc} - Z_{sc})}\right]$$

$$Z_2 = \sqrt{Z_{oc}(Z_{oc} - Z_{sc})}$$

π -Network

$$Z_{in} = Z_{out\,/\,uit}$$

$$Z_{O\pi} = \sqrt{Z_{oc} Z_{sc}}$$

$$Z_{O\pi} = \frac{Z_1 Z_2}{\sqrt{\frac{Z_1^{\,2}}{4} + Z_1 Z_2}} = \frac{Z_1 Z_2}{Z_{OT}}$$

$$Z_1 = \frac{Z_{sc}\left[Z_{oc} \pm \sqrt{Z_{oc}\,(Z_{oc} - Z_{sc})}\right]}{Z_{oc} + \sqrt{Z_{oc}(Z_{oc} - Z_{sc})} - Z_{sc}}$$

$$Z_2 = \frac{1}{2}\left[Z_{oc} \pm \sqrt{Z_{oc}(Z_{oc} - Z_{sc})}\right]$$

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ASYMMETRICAL FOUR-TERMINAL NETWORKS

ion Image Impedance

$$Z_{O_1} = \sqrt{Z_1^2 + Z_1 Z_2}$$

$$Z_{O_2} = \frac{Z_1 Z_2}{\sqrt{Z_1^2 + Z_1 Z_2}}$$

L-Section Iterative Impedance

$$Z'O_1 = \sqrt{\frac{Z_1^2}{4} + Z_1 Z_2} + \frac{Z_1}{2}$$

$$Z'O_2 = \sqrt{\frac{Z_1^2}{4} + Z_1 Z_2} - \frac{Z_1}{2}$$

NETWORK CONVERSIONS

T → π conversion

$$ZA = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_2}$$

$$ZB = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_3}$$

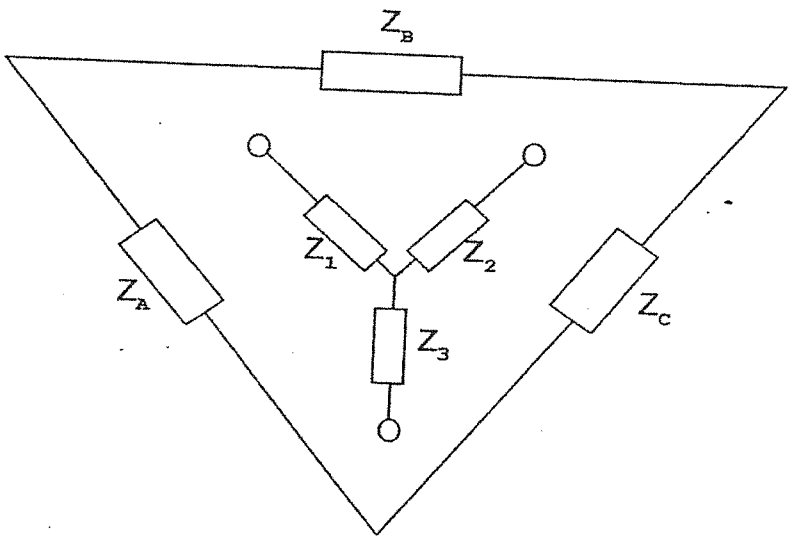
$$ZC = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_1}$$

π →T conversion

$$Z_1 = \frac{Z_A Z_B}{Z_A + Z_B + Z_C}$$

$$Z_2 = \frac{Z_B Z_C}{Z_A + Z_B + Z_C}$$

$$Z_3 = \frac{Z_A \cdot Z_C}{Z_A + Z_B + Z_C}$$



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ATTENUATORS IN GENERAL

$dB = 8{,}686 \times \text{Neper}$

$$dB = 10 \log \left(\frac{P_{in}}{P_{uit\,/\,out}} \right)$$

$dB = 20 \log N$

$$Insertion\ Loss = 10 \log \frac{P_1}{P_2} = 20 \log \frac{I_1}{I_2}$$

SYMMETRICAL ATTENUATORS

$$N = \frac{I_{in}}{I_{out\,/\,uit}} = \sqrt{\frac{P_{in}}{P_{out\,/\,uit}}}$$

T-Type

$$R_a = \frac{R\,(N-1)}{N+1}$$

$$R_b = \frac{2RN}{N^2-1}$$

π-Type

$$R_a = \frac{R\,(N+1)}{N-1}$$

$$R_b = \frac{R(N^2-1)}{2N}$$

Bridged T

$$R_a = R = Z_o$$

$$R_b = R\,(N-1)$$

$$R_c = \frac{R}{N-1}$$

ASYMMETRICAL ATTENUATORS

$$N = \sqrt{\frac{P_{in}}{P_{out\,/\,uit}}}$$

L-Type

$$R_a = \sqrt{R_1(R_1 - R_2)}$$

$$R_b = \sqrt{\frac{R_1 R_2^2}{R_1 - R_2}}$$

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MUTUAL INDUCTANCE

$$M = \sqrt{L_p \times L_s} \times k$$

$$k = \frac{M}{\sqrt{L_p P_s}}$$

$$k_c = \frac{1}{\sqrt{Q_p Q_s}}$$

$$Z_c = \frac{(\omega M)^2}{Z_s}$$

$$f_1 = \frac{f_o}{\sqrt{1+k}}$$

$$f_2 = \frac{f_o}{\sqrt{1-k}}$$

$$Q_p = \frac{X_{LP}}{R_p}$$

$$Q_s = \frac{X_{LS}}{R_s}$$

Dot rule

$$L_T = L_1 + L_2 + 2M$$

$$L_T = L_1 + L_2 - 2M$$

AM

$$m = \frac{V_m}{V_c}$$

$$P_T = P_c\left(1 + \frac{m^2}{2}\right)$$

$$P_{DSB} = \frac{m^2 Pc}{2}$$

$$m_T = \sqrt{m_1^2 + m_2^2}$$

$$v_c = V_C Sin\omega_C t + \frac{mV_C}{2}\cos(\omega_C - \omega_m)t - \frac{mV_C}{2}\cos(\omega_C + \omega m_m)t$$

FM

$$v_c = V_c \sin(\omega_{\cos} t - m\cos\omega_M t)$$

$$BW = f_{\text{mod}} \times (\text{number of sidebands}) \times 2$$

SHANNON-HARTLEY

$$C = \Delta f \log_2\left(1 + \frac{S}{N}\right)$$

$$dB = 10\log\left(\frac{\text{signal power}}{\text{noise power}}\right)$$

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MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

COMMUNICATION ELECTRONICS N5

14 APRIL 2015

This marking guideline consists of 7 pages.

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QUESTION 1

1.1 $Pi_1 = 0.1$ W; $Po_1 = 6$ W

$dB_1 = 10 \log \frac{Po1}{Pi1} = 10 \log \frac{6\ W}{0.1\ W} = 17.782$ dB

$dB_2 = 10 \log \frac{P_{o2}}{P_{i2}} = 10 \log \frac{12\ W}{0.1\ W} = 20.792$ dB

$dB_2 - dB_1 = 20.792$ dB $- 17.782$ dB $= 3.01$ dB (10)

1.2 $dB = 10 \log \frac{P_i}{P_o}$

$= 10 \log 100$

$= 20$ dB (3)

[13]

QUESTION 2

$I_C = \frac{Z_{RL} I_T}{Z_{RL} + Z_C}$

$= \frac{(1+j8\Omega)(5A \angle 30°}{6.8\ \Omega \angle 80.54°}$

$= \frac{(80.06 \angle 82.87°)(5A \angle 30°)}{6.08 \angle 80.54°}$

$= \frac{40.3\ A \angle 112.87°}{6.083 \angle 80.54°}$

$= 6.625$ A $\angle 32.33°$ (5)

$I_{RL} = \frac{Z_C I_T}{Z_C + I_{RL}}$

$= \frac{(2\Omega \angle -90°)(5A \angle 30°}{-j2\Omega + 1\Omega + j8\Omega}$

$= \frac{10A \angle -60°)}{1+j6}$

$= \frac{10\ A \angle -60°}{6.083 \angle 80.54°}$

$= 1.644$ A $\angle$ -140. 54° (5)

[10]

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QUESTION 3

3.1 $X = 0$

But $X = X_L - X_C$

$X_L - X_C = 0$

$X_L = X_C$

$2\pi f_r L = \frac{1}{2\pi f_r C}$

$f_r^2 = \frac{1}{4\pi^2 LC}$

$f_r = \frac{1}{2\pi\sqrt{LC}}$ (5)

3.2 Given $Z_D = \frac{L}{CR}$

$Z_D = \frac{L}{CR} \cdot \frac{\omega}{\omega}$

$= \frac{\omega L}{R} \cdot \frac{1}{\omega C}$

But $\frac{\omega L}{R} = Q$ and $\frac{1}{\omega C} = X_L$

$Z_D = X_C Q$

But $X_L = X_C$ at f_r

$Z_D = QX_L$ (5)
[10]

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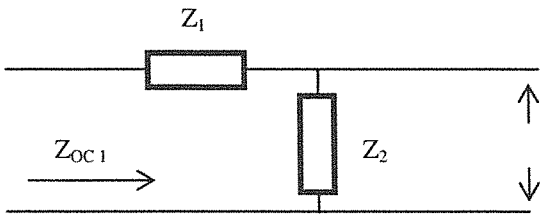
QUESTION 4



$Zoc_1 = Z_1 + Z_2$ $Zsc_1 = Z_1$

$$Zo_1 = \sqrt{Z_{OC}\, Z_{SC}}$$

$$= \sqrt{Z_1 (Z_1 + Z_2)}$$

$$= \sqrt{Z_1^2 + Z_1 Z_2}$$

[10]

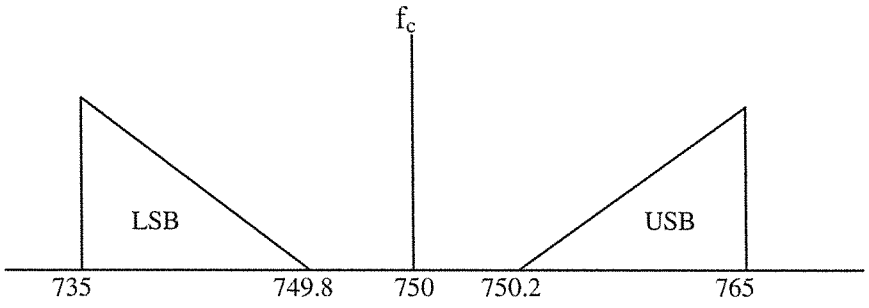
QUESTION 5

USB $= f_c + f_{mhi}$ $= 750\text{ kHz} + 15\text{ kHz} = 765\text{ kHz}$

$f_c + f_{mlo}$ $= 750\text{ kHz} + 0.2\text{ kHz} = 750.2\text{ kHz}$

USB $= f_c - f_{mhi}$ $= 750\text{ kHz} - 15\text{ kHz} = 735\text{ kHz}$

$f_c - f_{mlo}$ $= 750\text{ kHz} - 0.2\text{ kHz} = 74.8\text{ kHz}$



[11]

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QUESTION 6

Low-pass Filter

R_0 = 600 Ω ; f_C = 3.4 kHz

$L = \frac{R_0}{\pi f_C}$

$= \frac{600\ \Omega}{\pi\ (3.4\ X\ 10^3\ Hz}$

= 56.172 mH

$C = \frac{1}{\pi R_0 f_C}$

$= \frac{1}{\pi\ (600\ \Omega)(3.4\ X\ 10^3\ Hz}$

= 156 nF

T-section

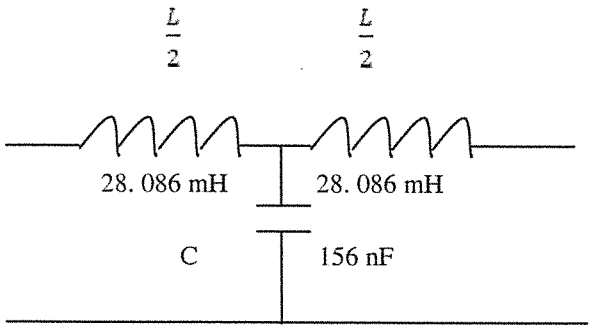
$\frac{L}{2} = \frac{56.172\ mH}{2}$

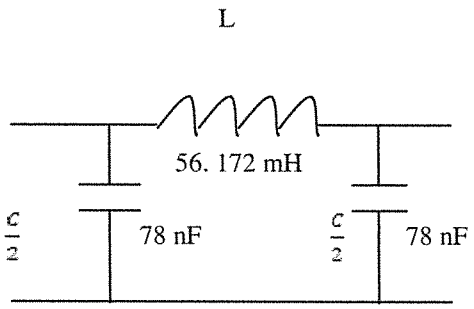
= 28.086 mH

π- section

$\frac{C}{2} = \frac{156\ nF}{2}$

= 78 nF





[12]

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QUESTION 7

7.1 The incoming frequency f_i
The local oscillator frequency f_o
The sum: $f_i + f_o$
The difference: $f_i \sim f_o$ (4)

7.2 7.2.1 To generate an RF wave beating against the incoming frequency

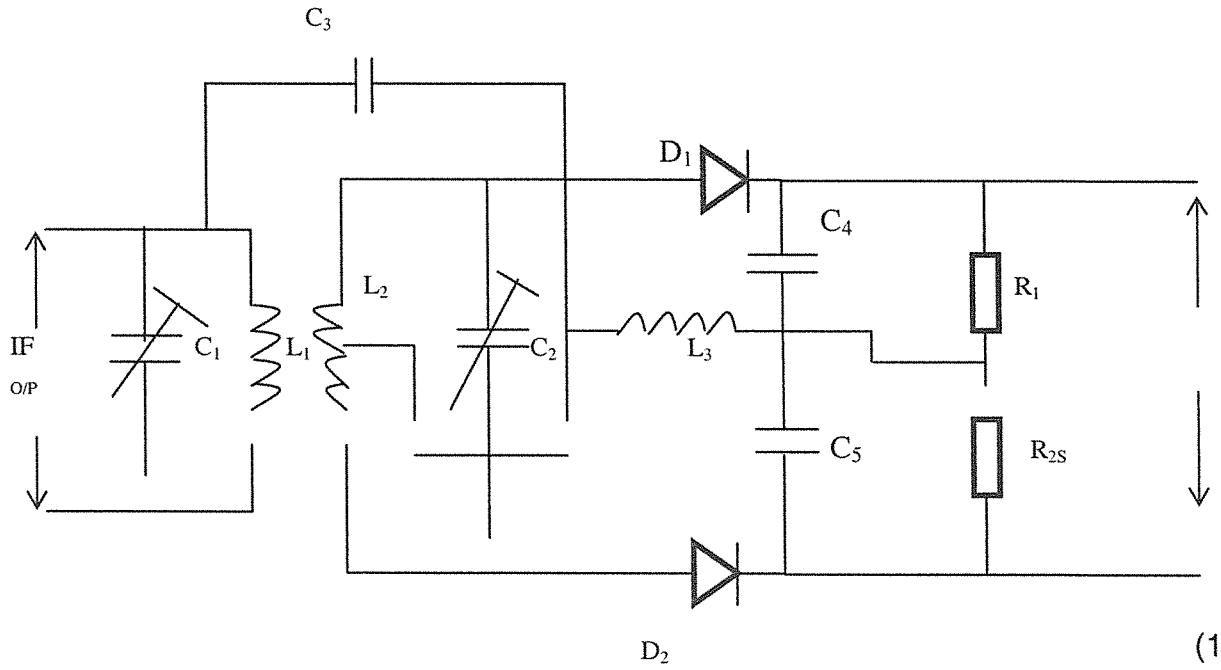
7.2.2. To vary the oscillator frequency in step with the instantaneous value of the modulating signal

7.2.3 To strengthen the AF signal to a level high enough to operate the speaker

(3 x 2) (6)
[10]

QUESTION 8

8.1



(11)

8.2 The discriminator (1)
Alternatives: ratio detector; circuit variations **[12]**

QUESTION 9

9.1 A theoretical antenna that would radiate equally in all directions

9.2 The effective surface area of an antenna

9.3 The ratio of the power density of an antenna to the power density of an isotropic antenna under the same conditions

9.4 The ratio of radiated power to the square of the current at the feed point

9.5 A network whose input and output impedances are equal

9.6 The input impedance of an infinite number of symmetrical networks that are cascaded together, or that of a single network terminated in its characteristic impedance

(6 x 2) **[12]**

TOTAL: 100

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