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QUESTION WORKBOOK

Resonant circuits and filters

Electronics · Year 13

AQA 3.13.3.1

17 questions · 51 marks

NAVY SCREEN EDITION

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SECTION A · Warm-up

A1 State how the reactance of an inductor and of a capacitor each change as the frequency rises, and state what happens at resonance in a series LC circuit. [2]

A2 Define the Q factor of a resonant circuit, and state the unit in which it is quoted. [2]

A3 A series LC circuit with resistance is driven by a variable-frequency source. State where the output must be taken to give a band-pass response and where to give a band-stop response. [2]

A4 A resistor and a capacitor are connected in series across a signal source. State which component the output is taken across for a low-pass filter and which for a high-pass filter. [2]

A5 Define the cut-off frequency of an RC filter, and state the output there as a fraction of the full output. [2]

A6 State the effect of adding resistance to a tuned circuit on its resonant frequency, on the height of its resonance peak and on its bandwidth. [2]

SECTION B · Standard

B1 A tuned circuit is built from an inductor of 1.0 mH and a capacitor of 100 nF. Calculate its resonant frequency. [3]

B2 A tuned circuit resonates at 15.9 kHz and has a Q factor of 10. Calculate its bandwidth and give the range of frequencies it passes. [3]

B3 A series circuit of 1.0 mH and 100 nF, resonating at 15.9 kHz, has a total resistance of 25 Ω. Using $Q = 2\pi f_0 L/R$, calculate the Q factor and the bandwidth. [3]

B4 A filter is made from a 1.6 kΩ resistor in series with a 0.10 μF capacitor. Calculate its cut-off frequency. [3]

B5 A low-pass filter is to have a cut-off frequency of 2.5 kHz using a 4.7 kΩ resistor. Calculate the capacitance required, and state which component the output is taken across. [3]

B6 A radio's tuned circuit uses a fixed 1.0 mH inductor with a variable capacitor adjustable from 40 pF to 360 pF. Calculate the resonant frequency at each end of the range, and state the ratio of highest to lowest frequency. [3]

B7 A measured resonance curve peaks at 40.0 kHz, and the current has fallen to $1/\sqrt{2}$ of its peak value at 38.4 kHz and at 41.6 kHz. Calculate the bandwidth and the Q factor. [2]

SECTION C · Stretch

C1 A receiver's tuned circuit is centred on 200 kHz and must pass a signal 8.0 kHz wide, so its bandwidth may not be less than 8.0 kHz. The only inductor available is 250 μH. Calculate the capacitance needed, the largest Q factor the circuit may have, and the smallest total circuit resistance that is acceptable, using $Q = 2\pi f_0 L/R$. Comment on what would go wrong if the resistance were made very much smaller. [7]

C2 Speech occupying 300 Hz upwards shares a line with 50 Hz mains hum. A filter built from a 22 kΩ resistor is to have a cut-off frequency of 120 Hz. State which type of filter is needed, calculate the capacitance, and estimate the fraction of the hum that survives, given that a high-pass filter's output fraction is $(f/f_c)/\sqrt{(1 + (f/f_c)^2)}$. [4]

C3 An audio line is to have 50 Hz mains hum removed by a band-stop filter built from an inductor in series with a 1.0 μF capacitor. Calculate the inductance required, comment on whether the component is practical, and state where the output of the filter must be taken. [4]

C4 Medium-wave stations are spaced 9 kHz apart. A receiver is tuned to a station on 909 kHz and its designer has wound the tuned circuit to a Q factor of 300. Calculate the bandwidth this gives, state the Q the receiver should have instead, and explain what the listener would hear with the Q of 300. [4]