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Test 2: Electronics 2:

① $V_o = \left(1 + \frac{R_F}{R_i}\right) V_1$

$$V_o = \left(1 + \frac{R_F}{R_i}\right) V_1$$

$$V_o = \left(1 + \frac{750 \times 10^3}{36 \times 10^3}\right) (150 m V_{rms})$$

$$= (21.833)\,(150 \times 10^{-3})\, V_{rms}$$

$$= \boxed{3.275\ V_{rms}}$$

② $V^+ = V^- = 0$

Apply KCL at node V^- in op-Amp ①

$$\frac{0 - 12mV}{33K} + \frac{0 - V_{o1}}{330K} = 0$$

$$\boxed{V_{o1} = -0.12\ V}$$

Apply KCL at node V^- in op-Amp ②

$$\frac{0 + 0.12}{47K} + \frac{0 - 18mV}{47K} + \frac{0 - V_o}{470K} = 0.$$

$$\frac{V_o}{470K} + \frac{0.102}{47K} \Rightarrow \boxed{V_o = 1.02\ V.}$$

③ Lower cut-off

$$f_{oL} = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi \times 10 \times 0.05 \times 10^{-6} \times 10^{3}}$$

$$\boxed{f_{oL} = 318.3098\ Hz}$$

Upper cut-off frequency.

$$f_{oH} = \frac{1}{2\pi R_2 C_2} \Rightarrow f_{oH} = \frac{1}{2\pi \times 20 \times 10^{3} \times 0.02 \times 10^{-6}}$$

$$f_{oH} = \frac{1}{2\pi \times 20 \times 0.02 \times 10^{-3}} \Rightarrow \boxed{f_{oH} = 397.8873\ Hz}$$

④ (a) $I_{DC} = \frac{2}{\pi} I_P$

$$= \frac{2}{\pi} \left(\frac{V_L}{R_L} \right)$$

$$I_{dc} = \frac{2}{\pi} \left(\frac{20}{4} \right) = \frac{40}{12.57} = 3.18 = \boxed{3.18A}$$

$P_i = I_{dc} V_{cc}$

$\Rightarrow P_i = (3.18A)(22V) = 70W$

$$P_o = \frac{V_L^2}{2R_L} \Rightarrow P_o = \frac{(20V)^2}{2(4\Omega)} = \frac{400}{8} = \boxed{50W}$$

$$\% \eta = \frac{P_o}{P_i} \times 100\%$$

$$\% \eta = \frac{50W}{70W} \times 100\% = \boxed{71.43\%}$$

(b) $$I_{dc} = \frac{2}{\pi} I_p = \frac{2}{\pi}\left(\frac{V_L}{R_L}\right) = \frac{2}{\pi}\left(\frac{4V}{4\Omega}\right)$$

$$= \frac{8}{12.57} = \boxed{0.637}$$

$$P_i = I_{dc} V_{cc}$$

$$P_i = (0.637A)(22V) = 16W$$

$$P_o = \frac{V_L^2}{2R_L} \Rightarrow P_o = \frac{(4V)^2}{2(4\Omega)} = \frac{4}{2} = 2W.$$

$$\% \eta = \frac{P_o}{P_i} \times 100\%.$$

$$\% \eta = \frac{2W}{14W} \times 100\% = \boxed{14.3\%}.$$

(5) (a) $$I_{dc} = \frac{2}{\pi} I_{dc}$$

$$= \frac{2}{\pi}\left(\frac{V_o}{R_L}\right) = \frac{2}{\pi}\left(\frac{V_L\sqrt{2}}{R_L}\right)$$

$$I_{dc} = \frac{2}{\pi}\left(\frac{8V\sqrt{2}}{8\Omega}\right) = \frac{2.828}{8\Omega} = 0.9 = \boxed{0.9A}$$

$P_i = I_{dc} V_{cc}$

$P_i = (0.9A)(30V) = \boxed{27W}$

(b) $P_o = \frac{V_L^2}{R_L} \Rightarrow P_o = \frac{(8V)^2}{8\Omega} = \frac{8}{1} = \boxed{8W}$

(6) voltage resolution = $V_{ref}/2^n$ n=12

$\Rightarrow$ V resolution $10/2^{12} = \frac{10}{4096} = \boxed{2.441 \times 10^{-3} V}$

(7) lock range of PLL circuit.

$R = 4.7k\Omega$ and $C_1 = 0.001\mu F$

$f_{lock} = f_o \pm \frac{8f_o}{V}$

from (a) $f_o = 63.82Hz$.

$f_o = \frac{0.3}{R_1 C_1} = \frac{0.3}{(4.7 \times 10^3)(0.001 \times 10^{-6})}$

$= \frac{0.3}{4.7 \times 0.001 \times 10^{-3}} = 6.38 \times 10^4$.

with limitation $2K\Omega < R_1 < 20K\Omega$, the lock range:

$f_L = \pm \frac{8f_o}{V} = \pm \frac{8(6.38 \times 10^4)}{6} = \boxed{85 KHz}$ $\boxed{8.5 \times 10^4 Hz}$