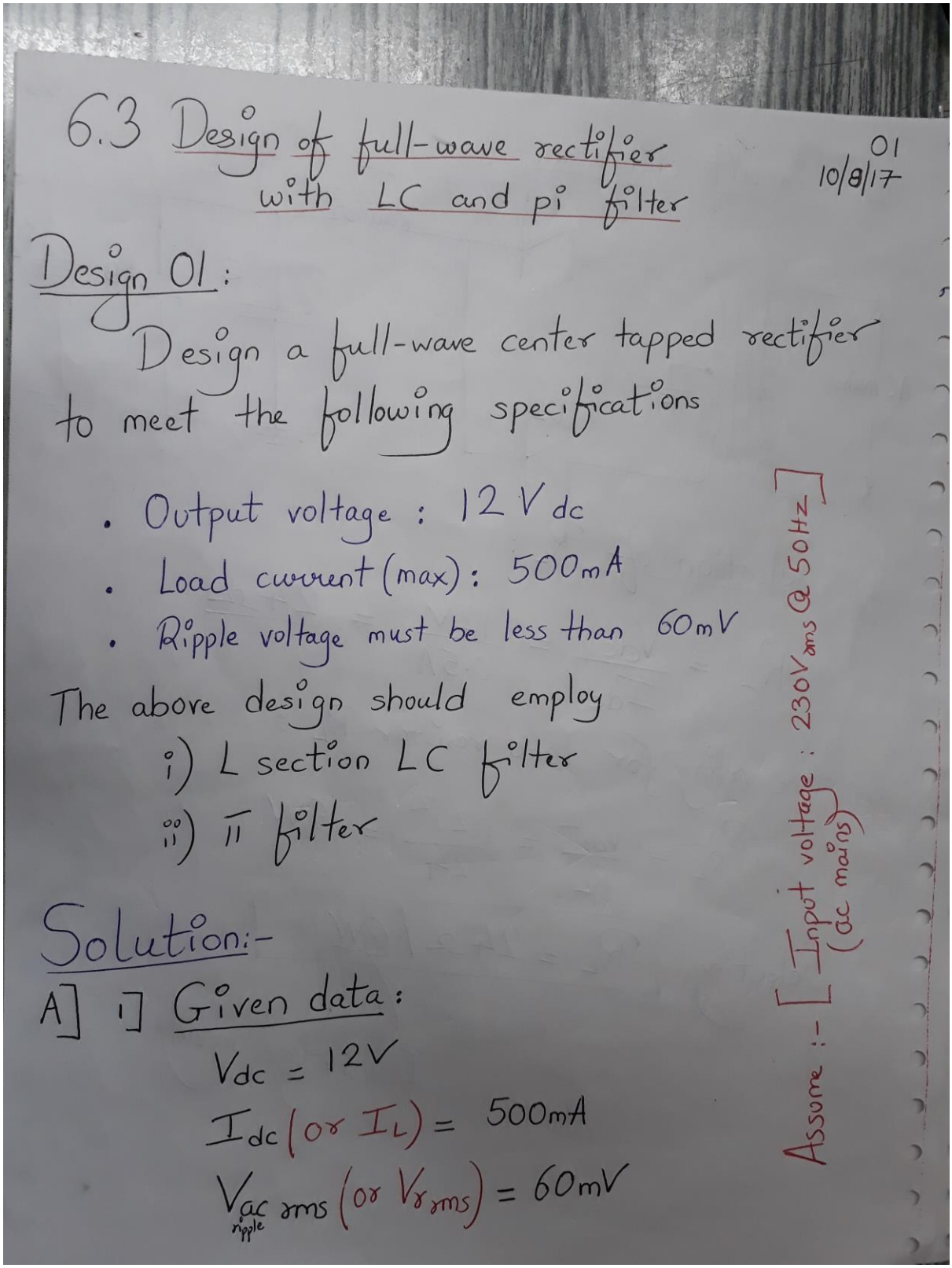
Design of FWR with LC and Pi filter

Reference: Electronics Devices and Circuits 1 by Ravish Singh



6.3 Design of full-wave rectifier with LC and pi filter

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10/8/17

Design 01:

Design a full-wave center tapped rectifier to meet the following specifications

- Output voltage : 12 V dc
- Load current (max): 500mA
- Ripple voltage must be less than 60mV

The above design should employ

i) L section LC filter

ii) π filter

Assume :- [Input voltage : 230 V_{rms} @ 50Hz (ac mains)]

Solution:-

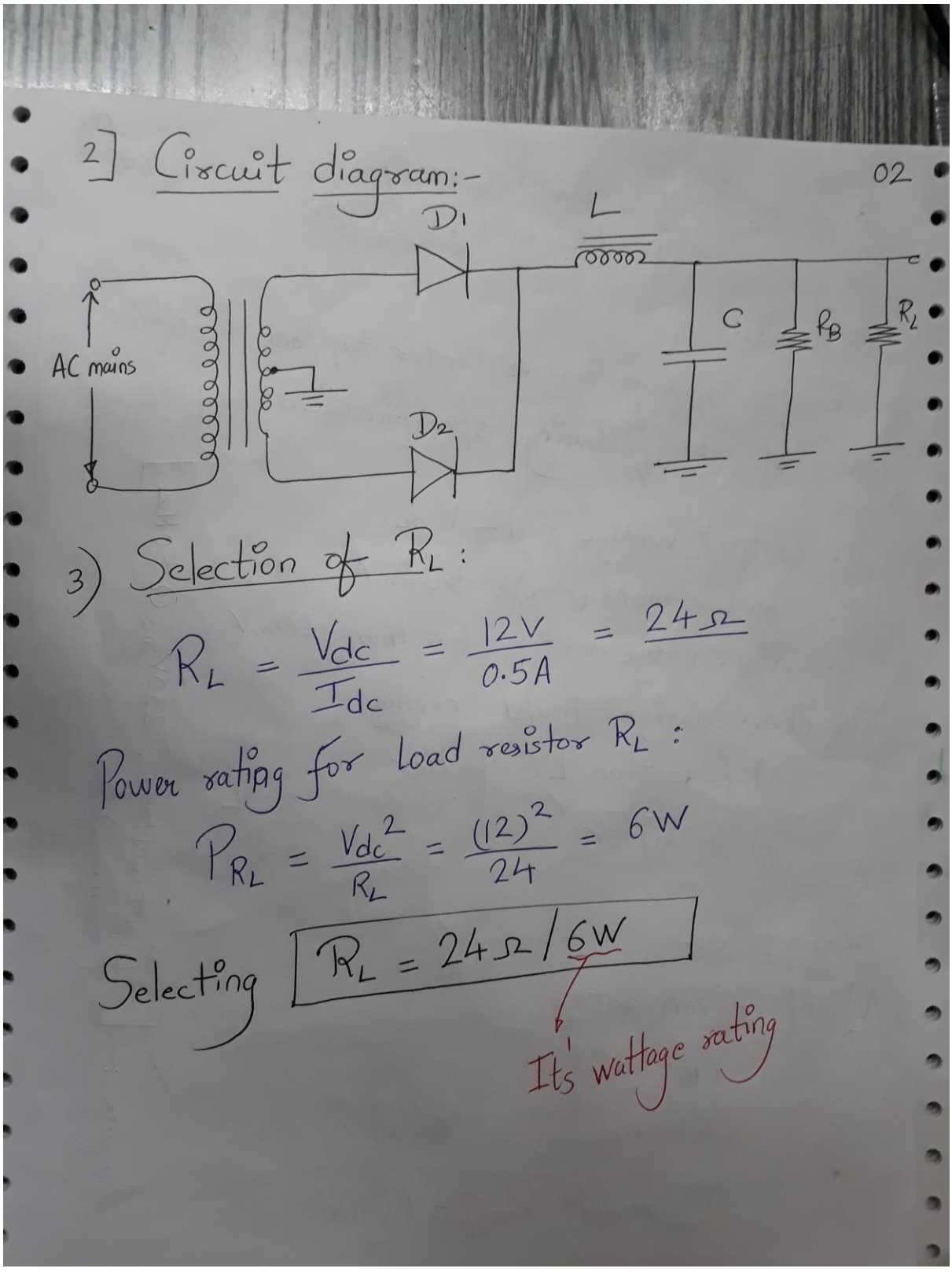
A] i] Given data:

$V_{dc} = 12V$

I_{dc} (or I_L) = 500mA

$V_{ac\ ripple\ rms}$ (or $V_{r\ rms}$) = 60mV

Design of FWR with LC and Pi filter



4) Selection of L and C :-

Ripple factor for an LC filter is given by,

$$\gamma = \frac{1}{6\sqrt{2}\,\omega^2 LC} \quad - (1)$$

(Assume $f = 50Hz$)

$\therefore$ Also, $\gamma = \frac{V_{ac,rms}}{V_{dc}}$

ie $\gamma = \frac{60 \times 10^{-3}}{12} = 0.005$

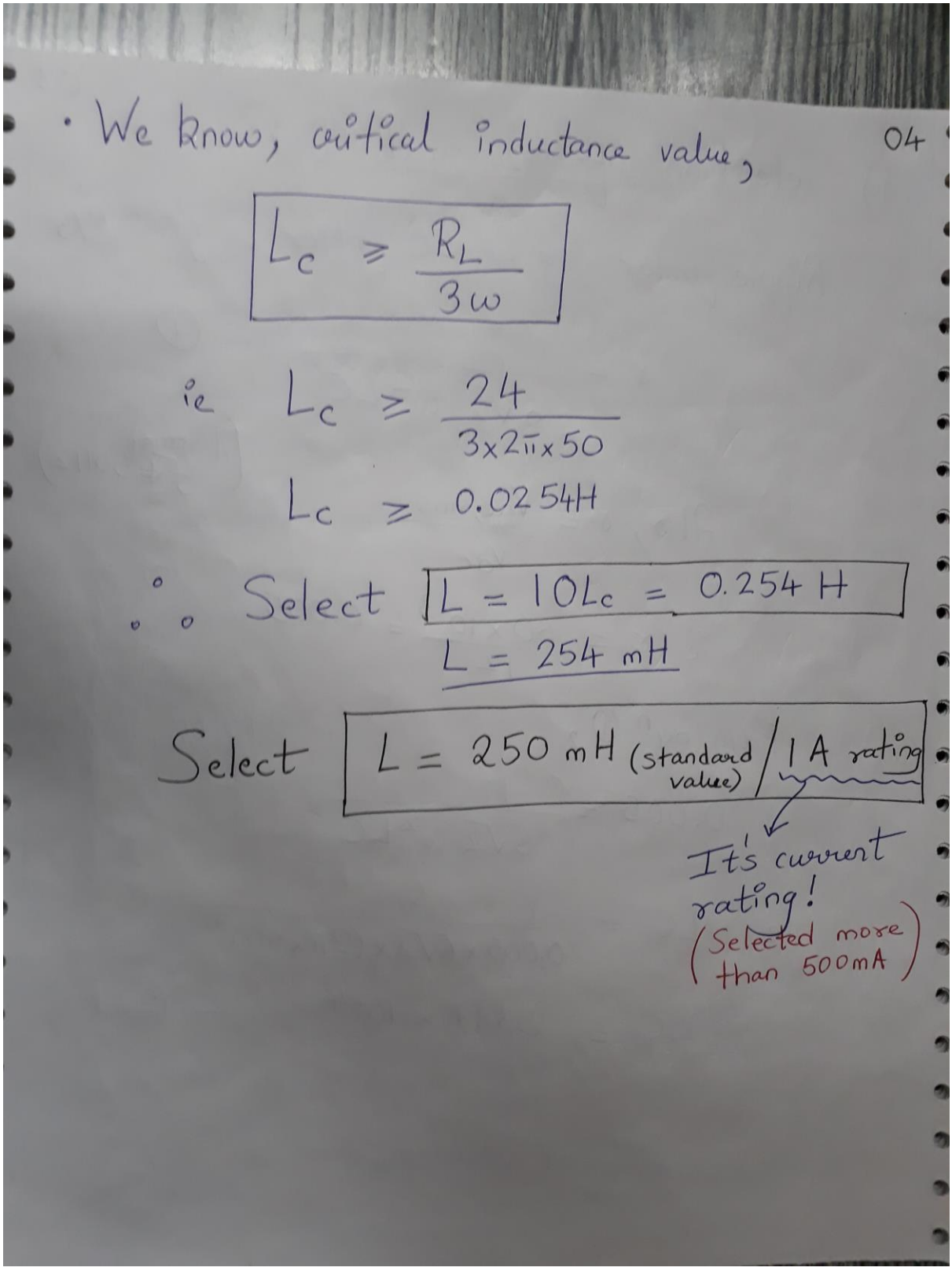
From eqn (1),

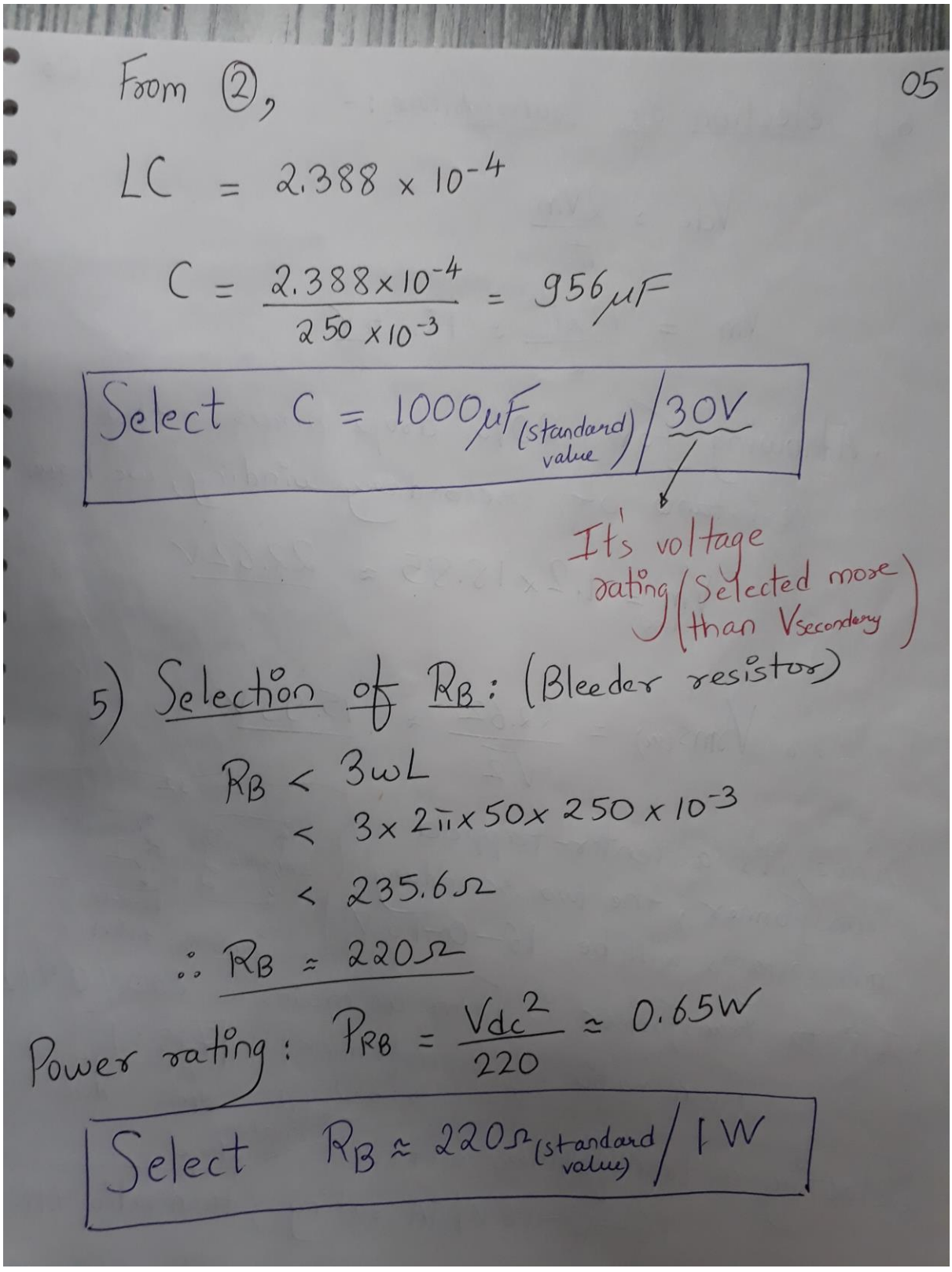
$$0.005 = \frac{1}{6\sqrt{2}\,\omega^2 LC}$$

ie $$LC = \frac{1}{0.005 \times 6\sqrt{2} \times (2\pi \times 50)^2}$$

$$LC = 2.388 \times 10^{-4} \quad - (2)$$

Design of FWR with LC and Pi filter





From ②,

05

$$LC = 2.388 \times 10^{-4}$$

$$C = \frac{2.388 \times 10^{-4}}{250 \times 10^{-3}} = 956\,\mu F$$

Select $C = 1000\,\mu F$ (standard value) / 30V

It's voltage rating (Selected more than $V_{secondary}$)

5) Selection of R_B: (Bleeder resistor)

$$R_B < 3\omega L$$
$$< 3 \times 2\pi \times 50 \times 250 \times 10^{-3}$$
$$< 235.6\,\Omega$$

$\therefore R_B \approx 220\,\Omega$

Power rating: $P_{R_B} = \frac{V_{dc}^2}{220} \approx 0.65W$

Select $R_B \approx 220\,\Omega$ (standard value) / 1W

6) Selection of transformer :- 06

$$V_{dc} \approx \frac{2V_m}{\pi}$$

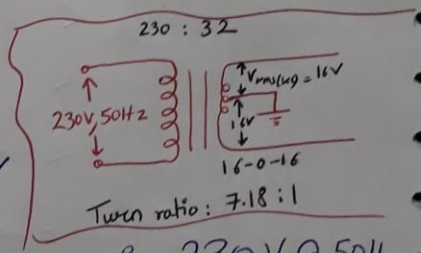
$$V_m = \frac{12 \times \pi}{2} \approx 18.85V$$

. Allowing for 20% drop across the resistance of secondary winding, we have

$$V_{m(sec)} = 1.2 \times 18.85 \approx 22.62V$$

$$\therefore V_{rms(sec)} = \frac{22.62}{\sqrt{2}} \approx 15.99V$$

Since, it's a center-tapped transformer, the two secondary rms voltages will be 16–0–16 V



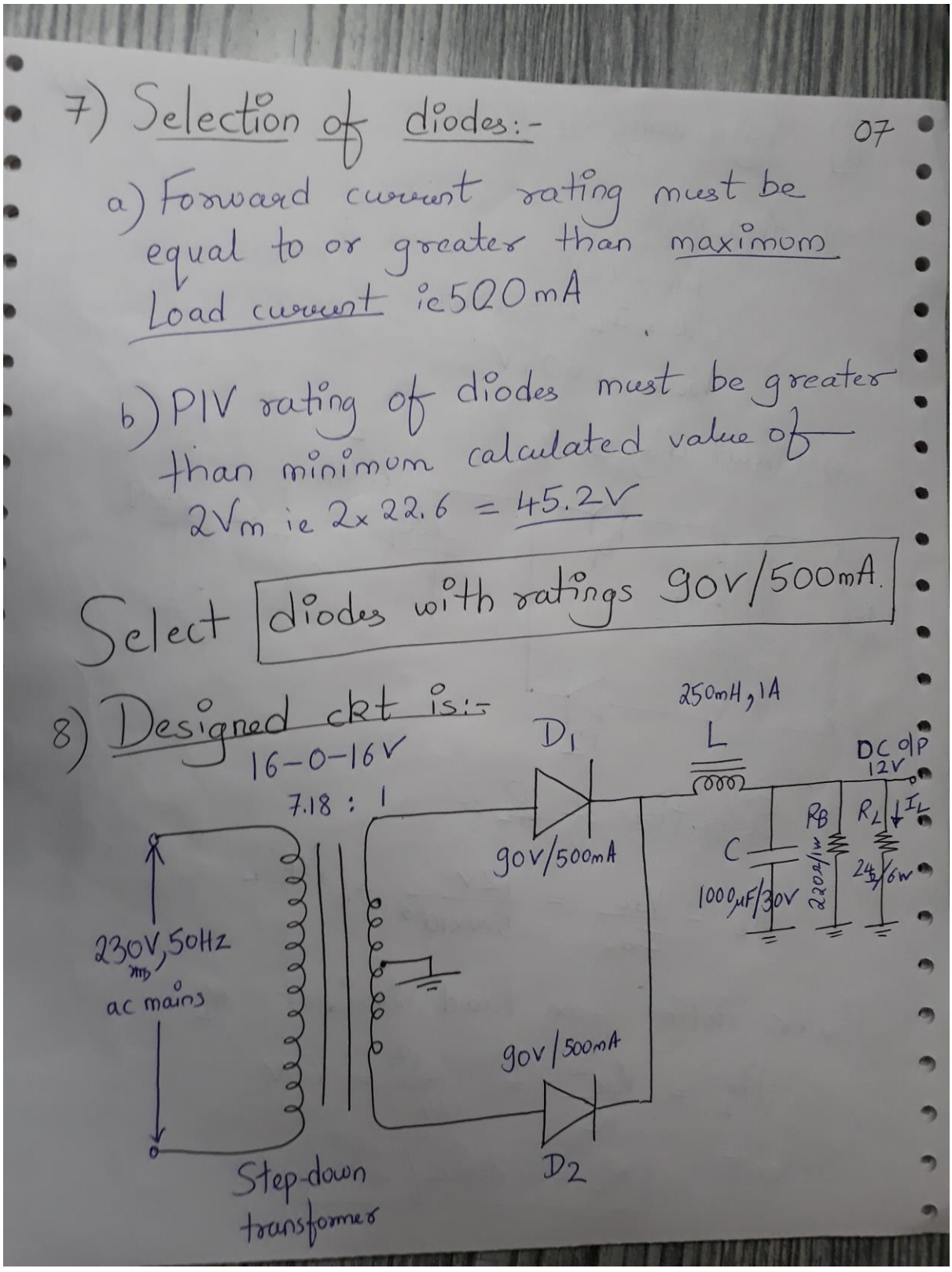
. I/p to transformer is from ac mains ie 230 V_{rms} @ 50Hz

∴ Turn ratio of transformer is 7.18 : 1 (230 : 32)

Npri Nsec

total Secondary rms voltage

Selecting a transformer with 16–0–16 V / 1A rating ; turn ratio 7.18 : 1


7) Selection of diodes:-
07
a) Forward current rating must be equal to or greater than maximum Load current ie 500mA
b) PIV rating of diodes must be greater than minimum calculated value of 2Vm ie 2 x 22.6 = 45.2V
Select diodes with ratings 90V/500mA.
8) Designed ckt is:-
16-0-16V
7.18 : 1
230V, 50Hz ac mains
Step-down transformer
D1
D2
90V/500mA
90V/500mA
250mH, 1A
L
C
1000μF/30V
RB
2200Ω/1W
RL
24Ω/6W
IL
DC O/P 12V

B] Design using π filters :-

08

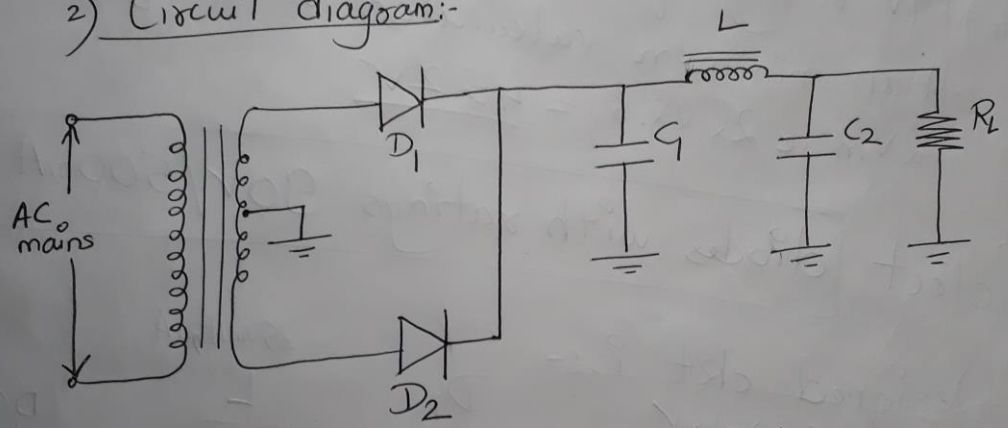
1) Given data:-

$V_{dc} = 12V$

$I_{dc} = I_L = 500mA$

$V_{ac\,rms} = 60mV$

2) Circuit diagram:-



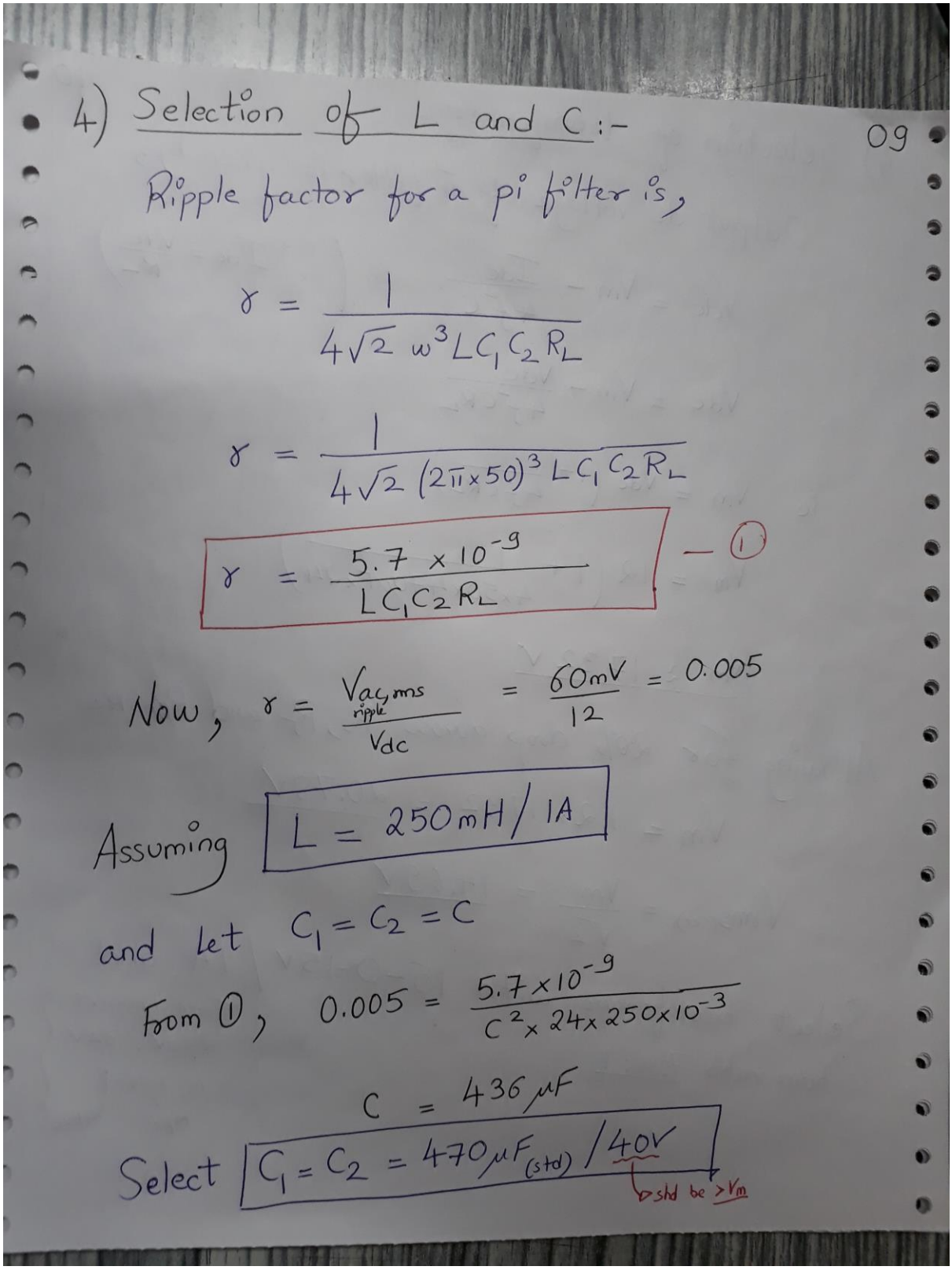
3) Selection of R_L :-

$$R_L = \frac{V_{dc}}{I_{dc}} = \frac{12V}{500 \times 10^{-3}} = 24\Omega$$

Power rating for load resistor R_L :

$$P_{R_L} = \frac{V_{dc}^2}{R_L} = \frac{(12)^2}{24} = 6W$$

Select $\boxed{R_L = 24\Omega / 6W}$



4) Selection of L and C :-

09

Ripple factor for a pi filter is,

$$\gamma = \frac{1}{4\sqrt{2}\, w^3 L C_1 C_2 R_L}$$

$$\gamma = \frac{1}{4\sqrt{2}\,(2\pi \times 50)^3 L C_1 C_2 R_L}$$

$$\gamma = \frac{5.7 \times 10^{-9}}{L C_1 C_2 R_L} \quad -(1)$$

Now, $\gamma = \frac{V_{ac_{ripple}\,rms}}{V_{dc}} = \frac{60mV}{12} = 0.005$

Assuming $L = 250mH / 1A$

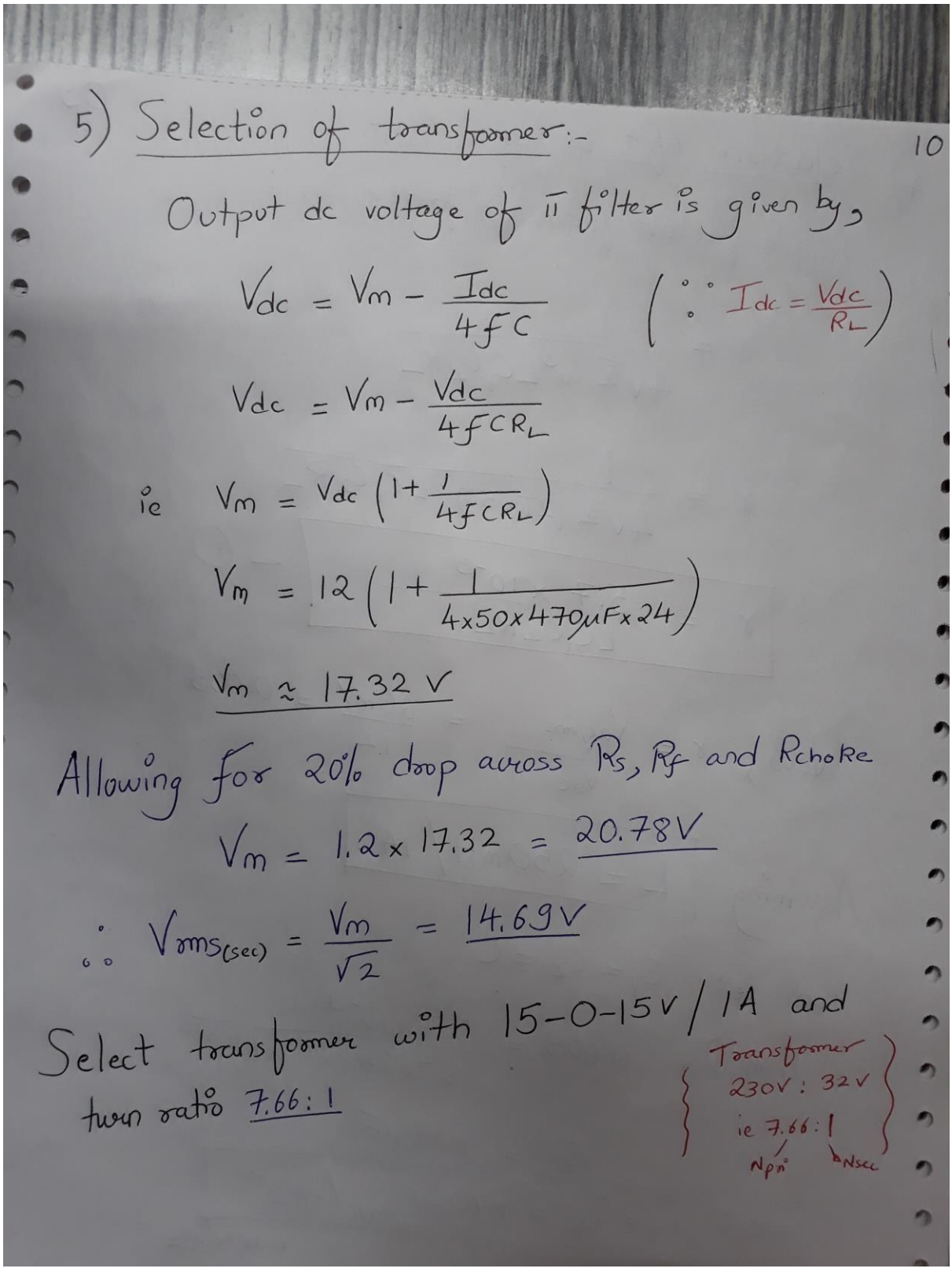
and let $C_1 = C_2 = C$

From (1), $0.005 = \frac{5.7 \times 10^{-9}}{C^2 \times 24 \times 250 \times 10^{-3}}$

$C = 436\,\mu F$

Select $C_1 = C_2 = 470\,\mu F_{(std)} / 40V$

$\triangleright$ std be $> V_m$



5) Selection of transformer:- 10

Output dc voltage of π filter is given by,

$$V_{dc} = V_m - \frac{I_{dc}}{4fC} \qquad \left(\because I_{dc} = \frac{V_{dc}}{R_L}\right)$$

$$V_{dc} = V_m - \frac{V_{dc}}{4fCR_L}$$

ie $$V_m = V_{dc}\left(1 + \frac{1}{4fCR_L}\right)$$

$$V_m = 12\left(1 + \frac{1}{4 \times 50 \times 470\mu F \times 24}\right)$$

$$V_m \approx 17.32\ V$$

Allowing for 20% drop across R_s, R_f and R_{choke}

$$V_m = 1.2 \times 17.32 = 20.78V$$

$$\therefore V_{rms(sec)} = \frac{V_m}{\sqrt{2}} = 14.69V$$

Select transformer with 15-0-15 V / 1A and turn ratio 7.66:1

Transformer
230V : 32V
ie 7.66 : 1
N_{pri} / N_{sec}

6) Selection of diodes:-

11

$PIV \approx 2V_m = 2 \times 20.78V = 41.56V$

Current flowing through both diodes is 500mA in a complete cycle, so current flowing through each diode is $I_D = \frac{I_L}{2} = \frac{500mA}{2} = 250mA$

Select diodes with ratings 80V/500mA

7) Designed circuit is:-