Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Sem-I Regular Examination January / February 2011

Subject code:713101N Subject Name: Medical System Design

Date: 31 /01 /2011 Time: 02.30 pm – 05.00 pm

Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Design a transformer, rectifier and filter for following power supply design specification given below: **07**

Max. Input voltage: 230V+20%
Min. input voltage: 230V-20%
Input current : 5A max.
Output voltage: 15V
Output current : 3A

(b) Design a series pass regulator with fold back protection of 2:1 current ratio. **07**

Q.2 **(a)** Derive the equation of current ripple in forward converter. **07**

(b) Design a transformer for the forward converter configuration with following specifications: **07**

Output voltage, V_o=12V
Output ripple,% = 1% of V_o
Output current, I_o=3A
Switching Freq., f_s = 20KHz
Supply voltage, V_{cc}=24V ± 10%

OR

(b) Design an inductor for a forward converter with following specifications: **07**

Output voltage, V_o=5V
Output current, I_o=5A
Switching Freq., f_s = 40KHz
Supply voltage, V_{cc}=12V ± 10%

Q.3 **(a)** Design a signal conditioning circuit using thermocouple to sense temperature in the range of 0-1000˚C & convert 0-5 V dc. List important points that you will take care of. **07**

(b) Give error budget analysis for the circuit designed above. **07**

OR

Q.3 **(a)** Design a signal conditioning circuit using RTD to sense temperature in the range of 0-200˚ C & convert 0-5 V dc. **07**

(b) Give error budget analysis for the circuit designed above. **07**

Q.4 **(a)** Write a short note on skin effect. **07**

(b) Explain the lock in amplifier and its applications. **07**

OR

Q.4 **(a)** Write a short note on power line filters. **07**

(b) Explain the design and use of auto zero amplifier. **07**

Q.5 **(a)** Explain the sample and hold circuit in detail. **07**

(b) Explain design of voltage controlled current source for grounded loads. **07**

OR

Q.5 **(a)** Explain following terms for S/H circuit: Acquisition time, drop rate, pedestal error, aperture time, maximum allowable input frequency. **07**

(b) Explain instrumentation amplifier circuit and its advantages in detail. **07**

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For Forward converter Transformer Design:

$$V_{2m}D_{max} = V_0 + V_{rl} + V_D$$

$$A_p = \frac{\sqrt{D_{max}}P_{02}\left(1+\frac{1}{\eta}\right)}{K_w J B_m f_s} \qquad N_1 = \frac{V_{comax}D_{min}}{A_c B_m f_s}$$

$$(V_{ccmax}.D_{min} = V_{comin}.D_{max}) \qquad n = \frac{N_2}{N_1} = \frac{V_0'}{V_{comin}D_{max}}$$

$$I_2 = I_0\sqrt{D_{max}}$$

$$I_1 = nI_2 \qquad L_1 = \frac{\mu_0 \mu_r A_c N_1^2}{l_m}$$

$$I_{mag} = \frac{D_{max}V_{comin}}{f_s L_1} \qquad I_3 = I_{mag}\sqrt{\frac{1-D_{max}}{3}}$$

For Inductor design:

$$E = \frac{1}{2}LI_m^2 \qquad I_m = I_0 + \frac{\Delta I}{2} \qquad L = \frac{V_0(1-D_{min})}{\Delta I f_s}$$

$$D_{min} = \frac{V_0}{V_{gmax}} \qquad A_p = A_w A_c = \frac{2E}{K_w K_c J B_m}$$

take $B_m = 0.2T$ for ferrite, $B_m = 1T$ for CRGO, $J = 3$ A/mm^2 and $K_w = 0.6$.

$$N = \frac{LI_m}{A_c B_m} \qquad l_g = \frac{\mu_0 N^2 A_c}{L}$$

APPENDIX - I

Physical, Electrical and Magnetic characteristics of ferrite cores

CORES without air gap	mean length per turn l_t mm	mean magnetic length l_e mm	core cross section area $A_c \times 100$ mm^2	window area $A_w \times 100$ mm^2	area product $A_p \times 10^4$ mm^4	effective relative permeability $\mu_e \pm 25\%$	A_L nH/turns^2 $\pm 25\%$
POTCORES - CEL HP_3C grade, (*Philip 3B7 grade)							
P 18/11	35.6	26	0.43	0.266	0.114	1480	3122
P 26/16	52	37.5	0.94	0.53	0.498	1670	5247
P 30/19	60	45.2	1.36	0.747	1.016	1760	6703
P 36/22	73	53.2	2.01	1.01	2.010	2030*	9500*
P 42/29	86	68.6	2.64	1.81	4.778	2120*	10250*
P 66/56	130	123	7.15	5.18	37.03		
EE - CORES - CEL HP_3C grade							
E 20/10/5	38	42.8	0.31	0.478	0.149	1770	1624
E 25/9/6	51.2	48.8	0.40	0.78	0.312	1840	1895
E 25/13/7	52	57.5	0.55	0.87	0.478	1900	2285
E 30/15/7	56	66.9	0.597	1.19	0.71		
E 36/18/11	70.6	78.0	1.31	1.41	1.847	2000	4200
E 42/21/9	77.6	108.5	1.07	2.56	2.739	2100	2613
E 42/21/15	93	97.2	1.82	2.56	4.659	2030	4778
E 42/21/20	99	98.0	2.35	2.56	6.016	2058	6231
E 65/32/13	150	146.3	2.66	5.37	14.284	2115	4833

CORES without air gap	mean length per turn l_t mm	mean magnetic length l_e mm	core cross section area $A_c \times 100$ mm^2	window area $A_w \times 100$ mm^2	area product $A_p \times 10^4$ mm^4	effective relative permeability $\mu_e \pm 25\%$	A_L nH/turns^2 $\pm 25\%$
UU - CORES							
UU 15	44	48	0.32	0.59	1.190		1100
UU 21	55	68	0.55	1.01	0.555		1425
UU 23	64	74	0.61	1.36	0.823		1425
UU 60	183	184	1.96	11.65	22.83		1900
UU 100	29.3	308	6.45	29.14	187.95		3325
TOROIDS - CEL HP_3C							
T 10	12.8	23.55	0.062	0.196	0.012	2300	765
T 12	19.2	30.40	0.12	0.442	0.053	2300	1180
T 16	24.2	38.70	0.20	0.785	0.157	2300	1482
T 20	25.2	47.30	0.22	0.950	0.213	2300	1130
T 27	34.1	65.94	0.42	1.651	0.698	2300	1851
T 32	39.6	73.00	0.61	1.651	1.010	2300	2427
T 45	54.7	114.50	0.93	6.157	5.756	2300	2367

APPENDIX - II

Wire Size Table

SWG	Dia with enamel mm	Area of bare conductor mm²	R/Km @20°C ohms	Weight Kg/km
45*	0.086	0.003973	4340	0.0369
44	0.097	0.005189	3323	0.0481
43	0.109	0.006567	2626	0.0610
42	0.119	0.008107	2127	0.0750
41	0.132	0.009810	1758	0.0908
40*	0.142	0.011675	1477	0.1079
39	0.152	0.013700	1258	0.1262
38*	0.175	0.018240	945.2	0.1679
37	0.198	0.023430	735.9	0.2202
36	0.218	0.029270	589.1	0.2686
35*	0.241	0.035750	482.2	0.3281
34	0.264	0.04289	402.0	0.3932
33	0.287	0.05067	340.3	0.4650
32*	0.307	0.05910	291.7	0.5408
31	0.330	0.06818	252.9	0.6245
30	0.351	0.07791	221.3	0.7121
29*	0.384	0.09372	184.0	0.8559
28	0.417	0.11100	155.3	1.0140
27	0.462	0.13630	126.5	1.2450
26*	0.505	0.16420	105.0	1.4990
25	0.561	0.20270	85.1	1.8510
24*	0.612	0.24520	70.3	2.2330
23	0.665	0.29190	59.1	2.6550

22*	0.770	0.39730	43.4	3.6070
21	0.874	0.51890	33.2	4.7020
20*	0.978	0.65670	26.3	5.9390
19	1.082	0.81070	21.3	7.3240
18*	1.293	1.16700	14.8	10.5370
17	1.501	1.58900	10.8	14.3130
16	1.709	2.07500	8.3	18.6780
15	1.920	2.62700	6.6	23.6400
14*	2.129	3.24300	5.3	29.1500
13	2.441	4.28900	4.0	38.5600
12	2.756	5.48000	3.1	49.2200
11	3.068	6.81800	2.5	61.0000
10	3.383	8.30200	2.1	74.0000
9	3.800	10.5100	1.6	94.0000
8	4.219	12.9700	1.3	116.0000

*Standardised at CEDT