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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER I
SESSION 2015/2016**

COURSE NAME : ELECTRICAL SYSTEM DESIGN
COURSE CODE : BEF 45303
PROGRAMME : BACHELOR OF ELECTRICAL
ENGINEERING WITH HONOURS
EXAMINATION DATE : DECEMBER 2015/JANUARY 2016
DURATION : 2 HOURS AND 30 MINUTES
INSTRUCTION : ANSWER ALL QUESTIONS

THIS QUESTION PAPER CONSISTS OF **ELEVEN (11)** PAGES

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- Q1** (a) To determine maximum demand, an electrical designer has to be able to estimate diversity factors for each type of load.
- (i) Explain diversity factor. (2 marks)
 - (ii) Give **one (1)** example to show the importance of determining an appropriate diversity factor for a load calculation. (3 marks)
- (b) Generally, earthing can be divided into two parts, namely *system earthing* and *equipment earthing*. Describe the purpose of each earthing. (8 marks)
- (c) According to MS IEC 60038 standards, a TT (Terra-Terra) earthing system is one of the specifications in electricity supply for domestic customers.
- (i) Illustrate and explain TT earthing system. (7 marks)
 - (ii) Give **one (1)** advantage of TT earthing system. (2 marks)
 - (iii) Identify the needs of RCD (Residual Current Device) in TT earthing system (3 marks)
- Q2** (a) In a plot of land with high plot ratio, it is very likely that high rise buildings will be developed by the land owner. Often, with higher structures, engineers are questioned on the *side flashes* risks.
- (i) Show how a side flash can occur upon a lightning strike. (5 marks)
 - (ii) Suggest **two (2)** methods to prevent side flash. (8 marks)
- (b) ELV (Extra Low Voltage) system is one of the scopes to be designed by an M&E consultant. Telephone and internet system is part of this scope. Using appropriate diagrams, show the difference in terms of installation requirement between a building with less than five floors and a building with more than five floors. (4 marks)
- (c) An SMATV (Satellite Master Antenna Television) system represents a mean for sharing the same resources among several users for satellite and terrestrial

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reception. The advanced and latest TV system available in the market is IPTV system. List down **two (2)** advantages and **two (2)** disadvantages of IPTV system.
(8 marks)

Q3 (a) An 18 kW load 400 V, 0.85 pf is located at 90 m from MSB. Determine the appropriate size of the un-armoured multicore PVC cable to be used for the installation. The cables are enclosed in trunking.
(8 marks)

(b) A 4-core PVC/SWA/PVC copper cable is to be installed from SSB to a 3-phase 415V motor with a full load current of 102 A and a p.f. of 0.75 lagging, along with two similar fixed to a perforated cable tray, where sheaths would be touching, as shown in **Figure Q3**. This circuit is to be protected by a BS HRC fuse. The length of cable is 100 m, with ambient temperature of 30 °C, and the voltage drop from MSB to SSB is 9 V.

(i) Recommend the rating of the fuse, which can be chosen either from 80 A, 100 A, 125 A, 160 A or 200 A.
(2 marks)

(ii) Revise the circuit with the appropriate size of cable if total voltage drop from MSB to the load is not to exceed 4%. Use **Table Q3(i)** to **Table Q3(vi)** as references for cable design.
(15 marks)

Q4 **Figure Q4** shows a typical unit for an affordable home. As an M&E consultant, you are required to plan and design for its development.

(i) Suggest and show all power outlets and lighting point location (you may tear the sheet and attach it with your answer booklet).
(8 marks)

(ii) Calculate its TCL (Total-Connected Load) and MD (Maximum Demand).
(10 marks)

(iii) Sketch its wiring schematic diagram, clearly showing all related information which includes MCB rating, cable size and RCD rating.
(5 marks)

(iv) If the owner of the house wants to install 1hp aircond in the master bedroom and 1.5hp aircond in the living hall, predict the size of MCB for each aircond unit.
(2 marks)

– END OF QUESTIONS –

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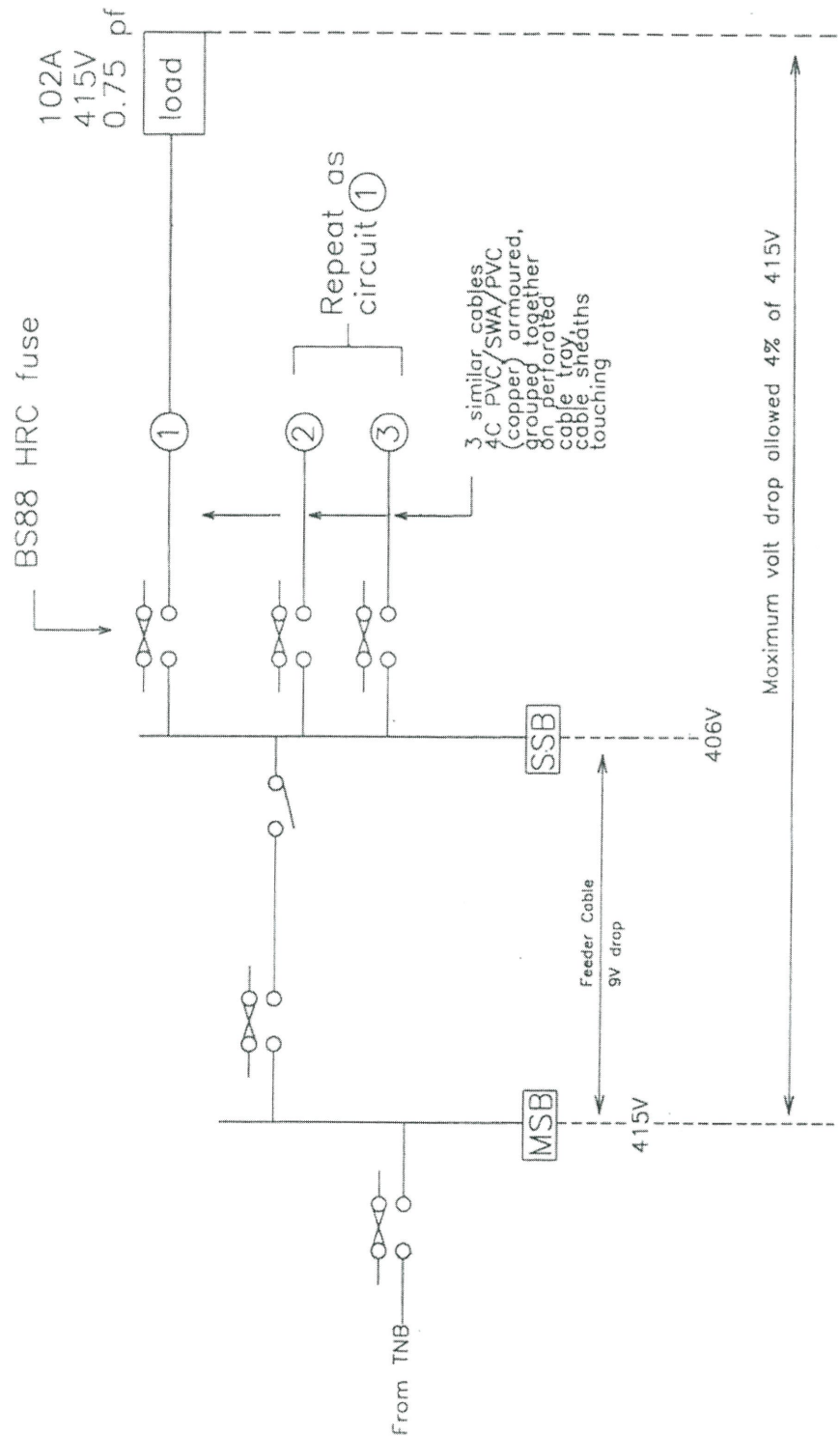


FIGURE Q3

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TABLE Q3(i)

TABLE 4B1 – Rating factors (C_a) for ambient air temperatures other than 30 °C

Ambient temperature ^a °C	Insulation				
	60 °C thermosetting	70 °C thermoplastic	90 °C thermosetting	Mineral ^a	
				Thermoplastic covered or bare and exposed to touch 70 °C	Bare and not exposed to touch 105 °C
25	1.04	1.03	1.02	1.07	1.04
30	1.00	1.00	1.00	1.00	1.00
35	0.91	0.94	0.96	0.93	0.96
40	0.82	0.87	0.91	0.85	0.92
45	0.71	0.79	0.87	0.78	0.88
50	0.58	0.71	0.82	0.67	0.84
55	0.41	0.61	0.76	0.57	0.80
60		0.50	0.71	0.45	0.75
65		–	0.65	–	0.70
70		–	0.58	–	0.65
75		–	0.50	–	0.60
80		–	0.41	–	0.54
85		–	–	–	0.47
90		–	–	–	0.40
95		–	–	–	0.32

a For higher ambient temperatures, consult manufacturer.

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TABLE Q3(ii)

TABLE 4C1 – Rating factors for one circuit or one multicore cable or for a group of circuits, or a group of multicore cables, to be used with current-carrying capacities of Tables 4D1A to 4J4A

Item	Arrangement (cables touching)	Number of circuits or multicore cables												To be used with current-carrying capacities, Reference Method
		1	2	3	4	5	6	7	8	9	12	16	20	
1.	Bunched in air, on a surface, embedded or enclosed	1.00	0.80	0.70	0.65	0.60	0.57	0.54	0.52	0.50	0.45	0.41	0.38	A to F
2.	Single layer on wall or floor	1.00	0.85	0.79	0.75	0.73	0.72	0.72	0.71	0.70	0.70	0.70	0.70	C
3.	Single layer multicore on a perforated horizontal or vertical cable tray system	1.00	0.88	0.82	0.77	0.75	0.73	0.73	0.72	0.72	0.72	0.72	0.72	E
4.	Single layer multicore on cable ladder system or cleats etc.,	1.00	0.87	0.82	0.80	0.80	0.79	0.79	0.78	0.78	0.78	0.78	0.78	

NOTE 1: These factors are applicable to uniform groups of cables, equally loaded.

NOTE 2: Where horizontal clearances between adjacent cables exceed twice their overall diameter, no rating factor need be applied.

NOTE 3: The same factors are applied to:

- groups of two or three single-core cables;
- multicore cables.

NOTE 4: If a group consists of both two- and three-core cables, the total number of cables is taken as the number of circuits, and the corresponding factor is applied to the tables for two loaded conductors for the two-core cables, and to the Tables for three loaded conductors for the three-core cables.

NOTE 5: If a group consists of *n* single-core cables it may either be considered as *n/2* circuits of two loaded conductors or *n/3* circuits of three loaded conductors.

NOTE 6: The rating factors given have been averaged over the range of conductor sizes and types of installation included in Tables 4D1A to 4J4A and the overall accuracy of tabulated values is within 5%.

NOTE 7: For some installations and for other methods not provided for in the above table, it may be appropriate to use factors calculated for specific cases, see for example Tables 4C4 and 4C5.

NOTE 8: Where cables having differing conductor operating temperature are grouped together, the current rating is to be based upon the lowest operating temperature of any cable in the group.

NOTE 9: If, due to known operating conditions, a cable is expected to carry not more than 30 % of its *grouped* rating, it may be ignored for the purpose of obtaining the rating factor for the rest of the group.

For example, a group of *N* loaded cables would normally require a group rating factor of C_g applied to the tabulated I_t . However, if *M* cables in the group carry loads which are not greater than $0.3 C_g I_t$ amperes the other cables can be sized by using the group rating factor corresponding to (*N-M*) cables.

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TABLE Q3(iii)

TABLE 4D1A – Single-core 70 °C thermoplastic insulated cables, non-armoured, with or without sheath (COPPER CONDUCTORS)

Conductor cross-sectional area (mm ²)	CURRENT-CARRYING CAPACITY (amperes):										
	Reference Method A (enclosed in conduit in thermally insulating wall etc.)		Reference Method B (enclosed in conduit on a wall or in trunking etc.)		Reference Method C (clipped direct)		Reference Method F (in free air or on a perforated cable tray horizontal or vertical)			Spaced by one diameter	
	2 cables, single-phase a.c. or d.c.	3 or 4 cables, three-phase a.c.	2 cables, single-phase a.c. or d.c.	3 or 4 cables, three-phase a.c.	2 cables, single-phase flat and touching	3 or 4 cables, three-phase flat and touching or trefoil	2 cables, single-phase a.c. or d.c. flat	3 cables, three-phase a.c. flat	3 cables, three-phase a.c. trefoil		Horizontal
1	2	3	4	5	6	7	8	9	10	11	12
(mm ²)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
1	11	10.5	13.5	12	15.5	14	-	-	-	-	-
1.5	14.5	13.5	17.5	15.5	20	18	-	-	-	-	-
2.5	20	18	24	21	27	25	-	-	-	-	-
4	26	24	32	28	37	33	-	-	-	-	-
6	34	31	41	36	47	43	-	-	-	-	-
10	46	42	57	50	65	59	-	-	-	-	-
16	61	56	76	68	87	79	-	-	-	-	-
25	80	73	101	89	114	104	131	114	110	146	130
35	99	89	125	110	141	129	162	143	137	181	162
50	119	108	151	134	182	167	196	174	167	219	197
70	151	136	192	171	234	214	251	225	216	281	254
95	182	164	232	207	284	261	304	275	264	341	311
120	210	188	269	239	330	303	352	321	308	396	362
150	240	216	300	262	381	349	406	372	356	456	419
185	273	245	341	296	436	400	463	427	409	521	480
240	321	286	400	346	515	472	546	507	485	615	569
300	367	328	458	394	594	545	629	587	561	709	659
400	-	-	546	467	694	634	754	689	656	852	795
500	-	-	626	533	792	723	868	789	749	982	920
630	-	-	720	611	904	826	1005	905	855	1138	1070
800	-	-	-	-	1030	943	1086	1020	971	1265	1188
1000	-	-	-	-	1154	1058	1216	1149	1079	1420	1337

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TABLE Q3(iv)

VOLTAGE DROP (per ampere per metre):

Conductor operating temperature: 70 °C

Conductor cross-sectional area	2 cables, single-phase a.c.						3 or 4 cables, three-phase a.c.					
	Reference Methods A & B (enclosed in conduit or trunking)			Reference Methods C & F (clipped direct, on tray or in free air)			Reference Methods A & B (enclosed in conduit or trunking)			Reference Methods C & F (clipped direct, on tray or in free air)		
	F	X	Z	F	X	Z	F	X	Z	F	X	Z
1	2	3	4	5	6	7	8	9				
(mm ²)	(mV/A/m)	(mV/A/m)	(mV/A/m)	(mV/A/m)	(mV/A/m)	(mV/A/m)	(mV/A/m)	(mV/A/m)				
1	44	44	44	44	38	38	38	38				
1.5	29	29	29	29	25	25	25	25				
2.5	18	18	18	18	15	15	15	15				
4	11	11	11	11	9.5	9.5	9.5	9.5				
6	7.3	7.3	7.3	7.3	6.4	6.4	6.4	6.4				
10	4.4	4.4	4.4	4.4	3.8	3.8	3.8	3.8				
16	2.8	2.8	2.8	2.8	2.4	2.4	2.4	2.4				
25	1.75	1.80	1.80	1.75	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
35	1.25	1.30	1.30	1.25	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
50	0.93	0.95	0.95	0.93	0.82	0.82	0.82	0.82	0.80	0.80	0.80	0.80
70	0.63	0.65	0.65	0.63	0.56	0.56	0.56	0.55	0.55	0.55	0.55	0.55
95	0.46	0.49	0.49	0.47	0.42	0.42	0.42	0.41	0.41	0.41	0.41	0.41
120	0.36	0.39	0.39	0.37	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32
150	0.29	0.31	0.31	0.30	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26
185	0.23	0.25	0.25	0.24	0.23	0.23	0.23	0.21	0.21	0.21	0.21	0.21
240	0.180	0.195	0.195	0.185	0.17	0.17	0.17	0.160	0.160	0.160	0.160	0.160
300	0.145	0.160	0.160	0.150	0.14	0.14	0.14	0.130	0.130	0.130	0.130	0.130
400	0.105	0.130	0.130	0.120	0.115	0.115	0.115	0.105	0.105	0.105	0.105	0.105
500	0.086	0.110	0.110	0.098	0.093	0.093	0.093	0.086	0.086	0.086	0.086	0.086
630	0.068	0.094	0.094	0.081	0.076	0.076	0.076	0.072	0.072	0.072	0.072	0.072
800	0.053	-	-	0.068	0.061	0.061	0.061	0.060	0.060	0.060	0.060	0.060
1000	0.042	-	-	0.059	0.050	0.050	0.050	0.052	0.052	0.052	0.052	0.052

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TABLE 4D4A – Multicore armoured 70 °C thermoplastic insulated cables
(COPPER CONDUCTORS)

TABLE Q3(v)

Conductor cross-sectional area	Reference Method C (clipped direct)			Reference Method E (in free air or on a perforated cable tray etc. horizontal or vertical)		Reference Method D (direct in ground or in ducting in ground, in or around buildings)	
	1 two-core cable, single-phase a.c. or d.c.	2	3	1 two-core cable, single-phase a.c. or d.c.	4	1 two-core cable, single-phase a.c. or d.c.	6
1							
(mm ²)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
1.5	21	18	18	22	19	22	18
2.5	28	25	25	31	26	29	24
4	38	33	33	41	35	37	30
6	49	42	42	53	45	46	38
10	67	58	58	72	62	60	50
16	89	77	77	97	83	78	64
25	118	102	102	128	110	99	82
35	145	125	125	157	135	119	98
50	175	151	151	190	163	140	116
70	222	192	192	241	207	173	143
95	269	231	231	291	251	204	169
120	310	267	267	336	290	231	192
150	356	306	306	386	332	261	217
185	405	348	348	439	378	292	243
240	476	409	409	516	445	336	280
300	547	469	469	592	510	379	316
400	621	540	540	683	590	-	-

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TABLE 4D4B

VOLTAGE DROP (per ampere per metre): Conductor operating temperature: 70 °C

TABLE Q3(vi)

Conductor cross-sectional area	Two-core cable, d.c.		Two-core cable, single-phase a.c.		Three- or four-core cable, three-phase a.c.	
	1	2	3	4	5	6
(mm ²)	(mV/A/m)		(mV/A/m)		(mV/A/m)	
1.5	29	29	29	25	25	25
2.5	18	18	18	15	15	15
4	11	11	11	9.5	9.5	9.5
6	7.3	7.3	7.3	6.4	6.4	6.4
10	4.4	4.4	4.4	3.8	3.8	3.8
16	2.8	2.8	2.8	2.4	2.4	2.4
25	1.75	1.75	1.70	1.50	1.50	1.50
35	1.25	1.25	1.10	1.10	1.10	1.10
50	0.93	0.93	0.80	0.80	0.80	0.80
70	0.63	0.63	0.55	0.55	0.55	0.55
95	0.46	0.47	0.41	0.41	0.41	0.43
120	0.36	0.38	0.33	0.33	0.33	0.35
150	0.29	0.30	0.26	0.26	0.26	0.29
185	0.23	0.25	0.21	0.21	0.21	0.25
240	0.180	0.190	0.165	0.165	0.165	0.21
300	0.145	0.155	0.135	0.135	0.135	0.185
400	0.105	0.115	0.100	0.100	0.100	0.160

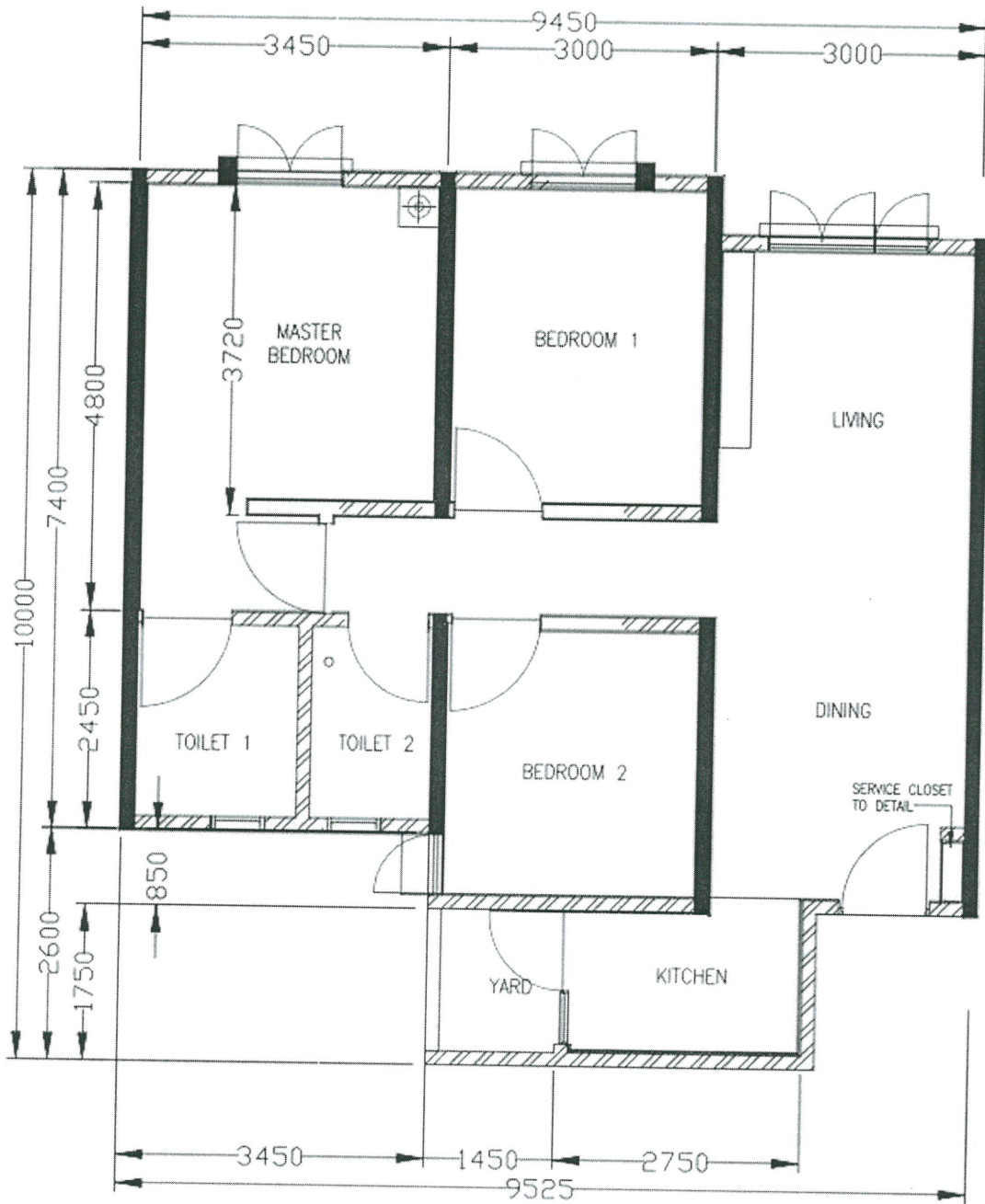
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UNIT FLOOR PLAN
(AREA : 850 sqft, 79.00 sq meter)

FIGURE Q4