國立中山大學九十學年度博士班招生考試試題

科目：半導體物理與元件【電機所甲組】

1. Show that the density of states in a semiconductor is $\frac{4\pi(2m)^{3/2}}{h^3}\sqrt{E}$, where m is the effective electron mass and h is the plank constant. (25%)

2. The thermionic emission current J for electrons over the Schottky barrier can be derived from $J = e\int_{E_c(0)}^{\infty} v_x\, dn$, where e is the electron charge, v_x is the electron velocity, n is the electron concentration, and $E_c(0)$ is the conduction band edge at the metal-semiconductor junction. Derive the current-voltage relation of the Schottky diode. (note: $\int_0^{\infty} exp(-x^2)dx = \frac{\sqrt{\pi}}{2}$)(25%).

3. The variation of electron current I_n due to the impact ionization in the space charge region can be written as $\frac{dI_n}{dx} = \alpha_n I_n + \alpha_p I_p$, where I_p is the hole current and α_n and α_p are the electron and hole ionization rates. If $\alpha_n = \alpha_p = \alpha$ and the length of the space charge region is L. Show that the avalanche breakdown condition is $\int_0^L \alpha\, dx = 1$.(25%)

4. Consider the MOSFET with the oxide thickness t_{ox}. Show that the shift flat-band voltage ΔV_{FB} due to the fixed charge distribution $\rho(x)$ in the oxide is given by $\Delta V_{FB} = -\frac{1}{C_{ox}}\int_0^{t_{ox}} \frac{x\rho(x)}{t_{ox}}dx$, where $x = 0$ is the gate and $x = t_{ox}$ is the oxide-semiconductor junction.(25%)

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科目：控制系統【電機所乙組】

※※※ There are only two problems.

※※※ Please answer them concisely but with all necessary details.

Problem #1 State all methods that you know for checking stability of a linear time-invariant dynamic system.

Problem #2 State all methods that you know for checking performance of a linear time-invariant dynamic system.

國立中山大學九十學年度博士班招生考試試題

科目：計算機概論【電機所丙組】

1. (15%) Given a binary relation R of 6 elements as { (1,2), (2,3), (1,1), (3,1), (2,4), (5,4), (5,6), (6,2)},
   (a) (5%) represent R in graphical form.
   (b) (5%) represent R in tabular form.
   (c) (5%) derive its transitive closure R^* and represent it in tabular form.

2. (15%) In an undirected complete graph with ***n*** distinct vertices,
   (a) (5%) how many ways can a complete subgraph be constructed in the graph?
   (b) (5%) how many ways can the graph be transformed into a directed complete graph?
   (c) (5%) how many ways can the graph be partitioned into a complete bi-partite graph?

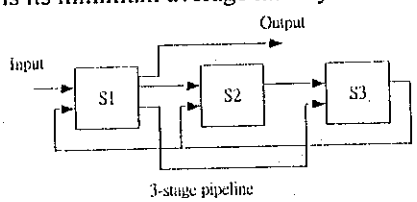
3. (10%)
   (a) (5%) Define a data structure to represent a *binary tree* where each node contains an integer **data** field.
   (b) (5%) Write a preorder traversal function **preorder(B)** given a binary tree B. (When a node is traversed, its **data** field is print out.)

4. (15%)
   (a) (5%) Define a data structure to represent a *sorted linked list* where each element contain an integer **key** field and an integer **data** field.
   (b) (10%) Write a function **insert(L,k,d)** that insert a new element with **key** = **k** and **data** = **d** in *the sorted sequence position* if no element in the linked list **L** has its **key** matching **k**. Otherwise, ignore this operation.

5. (20%) Design a sequential circuit that performs '10101' sequence detection and generate detection bit sequence output B given a bit sequence I. (e.g. An input sequence '110101011010100' will result in the output bit sequence '000001010000100'.)
   (a) (10%) Draw its state transition diagram.
   (b) (10%) Design its sequential circuit implementation with D-type flip-flops.

6. (10%) In a 32-bit machine, each byte has a distinct address. There is a 32KB 4-way set associative cache where each cache block contains 64 bytes. When the processor perform the cache access given address ADDR<31:0>, what bit fields in ADDR<31:0> are *the set index*, *the compared address tag*, and *the byte offset* utilized to find the corresponding data in the cache?

7. (15%) Given a 3-stage pipeline functional unit with the following reservation table. We want to feed a number of such functional operations into the functional unit. What is its minimum average latency conflict-free scheduling?



3-stage pipeline

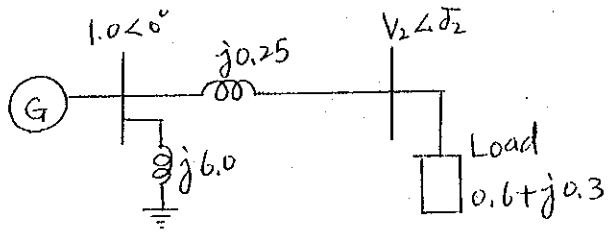
S1	X				X
S2		X		X	
S3			X		X

reservation table

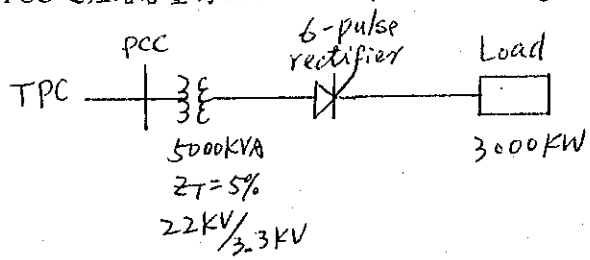
國立中山大學九十學年度博士班招生考試試題

科目：**電力工程【電機所丁組】**

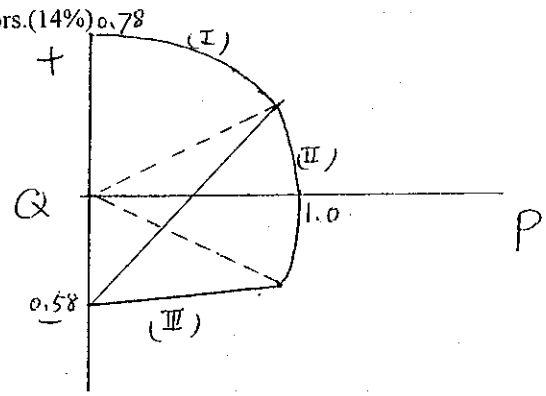
1. Solve the V_2 and δ_2 for one iteration by Newton Raphson Analysis.(20%)



2. PCC 之短路容量為 2500MVA，求 PCC 之 Voltage Harmonic Distortion Factor.(20%)



3. Explain the operation limit for each segment of the loading capability curve for generators.(14%)



4.
   a. 說明感應發電機原理(8%)
   b. 某二個相同元件串聯，其故障率（Failure rate）為 λ（failures／yr），故障修護時間為 r 小時，求系統之可靠度。(8%)

5. 由於一般三相交流電動機的定子與轉子之間相互的磁交鏈會隨著轉子轉動的速度與位置而改變，使得對於交流電動機的驅控上無法似並激或他激式直流電動機般有著近似線性化的輸出入特性。為了改善此種限制，我們必須先將三相交流電動機的相關絡路參數轉至一組彼此正交的參考軸上，以便將時變且耦合的電機磁交鏈表達成固定常數。試說明並定義適用於分析以下兩種交流電動機之正交的參考軸：(a) 三相感應電動機；(b) 三相同步電動機。(15%)

6. 試繪出適當的電路，並藉此說明目前坊間流行之變頻式冷氣機之工作原理（假設為三相電源，且壓縮機為感應馬達）。(15%)

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注意：電磁波與光電工程擇一作答

第一部份：電磁波

1. (25pts) Consider time-harmonic fields in free space.
   (a) Write down the Faraday equation and generalized Ampere's equation in differential form. (5pts)
   (b) Derive the non-homogeneous Helmholtz's equation for the electric field. (5pts)
   (c) Show that $\vec{E} = \vec{a}_x e^{-jk_1(y+\sqrt{3}z)}$ satisfies the Helmhltz's equation. (10pts)
   (d) Determine k_1 (5pts)
2. (30pts) A lossless transmission of characteristic impedance Z_0 and phase constant β is terminated with a load Z_L at $z=0$. The incident wave comes from $z<0$.
   (a) Let the voltage wave be $V(z) = V^+ e^{-j\beta z} + V^- e^{+j\beta z}$. Determine $I(z)$. (5pts)
   (b) Define $Z(z) \triangleq V(z)/I(z)$. Impose $Z(0) = Z_L$ to find the reflection coefficient Γ_0 at $z=0$ in terms of Z_0 and Z_L. (5pts)
   (c) Express $\Gamma(z)$ in terms of Γ_0. (5pts)
   (d) Express $Z(z)/Z_0$ in terms of $\Gamma(z)$. (5pts)
   (e) Substitute the result in (c) to prove
   $$\frac{Z(z)}{Z_0} = \frac{Z_L - jZ_0 \tan\beta z}{Z_0 - jZ_L \tan\beta z}$$ (10pts)
3. (20pts) The far field of a short vertical current element $I\Delta z$ located at the origin is
   $$E_\theta = \frac{I\Delta z}{4\pi} j\omega\mu_0 \frac{e^{-jk_0 r}}{r}\sin\theta \quad \text{and} \quad H_\phi = \frac{I\Delta z}{4\pi} jk_0 \frac{e^{-jk_0 r}}{r}\sin\theta$$
   (a) Write the expression for instantaneous Poynting vector. (5pts)
   (b) Find the average power radiated by the current element. (15pts)
4. (15pts) A wave propagates along the $+x$-direction whose x dependence is $\exp(-\gamma x)$. If $E_x = 0$, use Maxwell's equations to derive E_y in terms of H_x.
5. (10pts) Explain why single-conductor hollow waveguides cannot support TEM wave.

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光電工程導論

1. Describe the following technical terms in detail. (60%)
   (a). Acousto-optic effect (b). Nonlinear optics
   (c). Coherence length (d). Photoluminescene
   (E). LED (f). Population inversion
   (g). Mode locking (h). Rayleigh scattering loss
   (i). Mach-Zehnder interferometer (j). Sagnac gyroscope
   (k). Holography (l). Stimulated emission
2. There is a cosine term in two-beam interferometry. Explain why? (20%)
3. What are modal dispersion, waveguide dispersion and material dispersion? (20%)

國立中山大學九十學年度博士班招生考試試題

科目：**訊號與系統【電機所乙組】**　　每題 12.5 分　　

1. 試用數學符號定義非時變（time-invariant）系統。

2. 令 $\phi_n(t) = e^{jn\omega_0 t}$，討論 $\{\phi_n\}$ 為直交（orthogonal）集合的條件並證明之。

3. 令 $f(t)$ 為一複數（complex）信號，其實部與虛部分別為 $f(t)$ 與 $\hat{f}(t)$。即 $f_{複數}(t) = f(t) + j\hat{f}(t)$，試導出 $f(t)$ 的傅氏轉換（Fourier transform）但其結果 $Z(w)$ 即 $f(t)$ 的傅氏轉換本表達，並證明之。

4. 試述取樣定理（Sampling theorem）並證明之。

5. 系統輸出由於初始狀態（initial state）的響應部份與系統的轉換函數（transfer function）有無關係，試說明之。

6. 自相關函數（auto correlation function）在訊號處理上有何意義與應用？

7. 解下問題的 $x(t)$。

$$\begin{bmatrix} \frac{dx_1(t)}{dt} \\ \frac{dx_2(t)}{dt} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} r(t), \quad r(t) = u_0(t)$$

8. 請寫出對本科目的最佳之一心得。