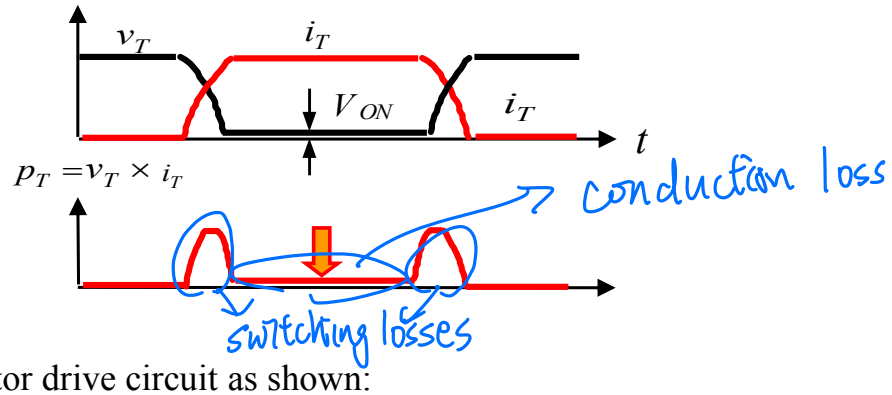
姓名：黃威欽 學號：10806148. Score: Total/2.16 = _____

Electrical Machinery Laboratory: Final Test (2022.06.15, 15:30-18:00)

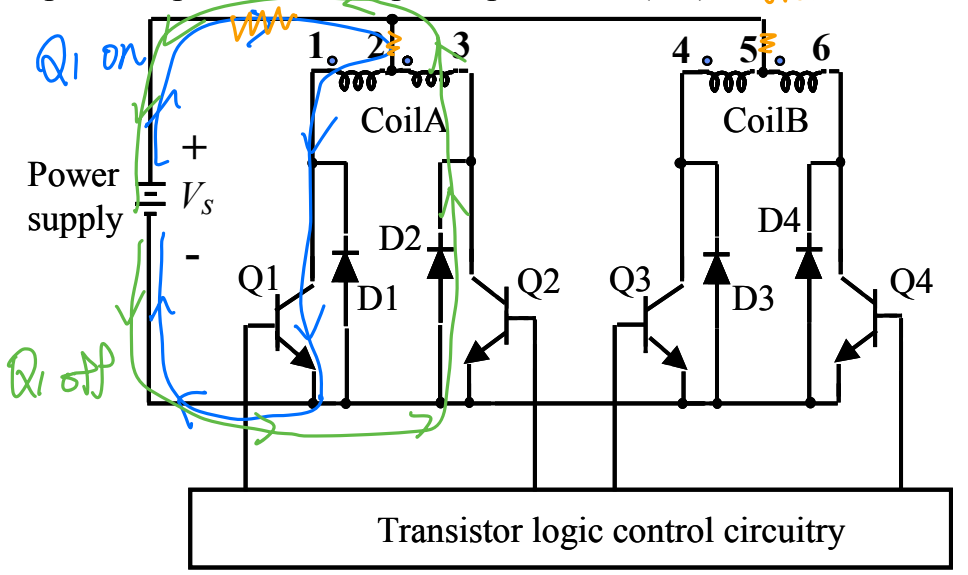
A. Power Electronics

1. The commonly used power devices include **diode**, **SCR**, **MCT**, **BJT**, **MOSFET**, **IGBT**, **TRIAC**, etc.
   (1) Which device is uncontrolled turn-on and turn-off: diode. (2%)
   (2) Give the devices that requires continuous gate signal: MOSFET, BJT, IGBT. (6%)
   (3) Give the devices that requires pulse gate signals: SCR, MCT, TRIAC. (6%)
2. The wide-bandgap devices can be turn-on and turn-off faster than Si-based devices. There are two kinds of wide-bandgap devices: SiC and GaN. (4%)
3. Which device has **negative** temperature coefficient and is **not** suitable for parallel operation? MOSFET or BJT: BJT. (2%)
4. A IGBT is the combination of MOSFET and BJT. (4%)
5. Indicate the conduction loss and switching losses for a power semiconductor switch: (6%)



B. Stepping Motors

1. For the stepping motor drive circuit as shown:
   (1) The winding is bifilar or unifilar? bifilar. (2%)
   (2) The drive is bipolar or unipolar? unipolar. (2%)
   (3) Draw or describe the current paths as: (a) Q1 is ON; and (b) Q1 is off. (6%)
   (4) Indicate the possible places for the speed up resistor. (6%) → 橘色部份.

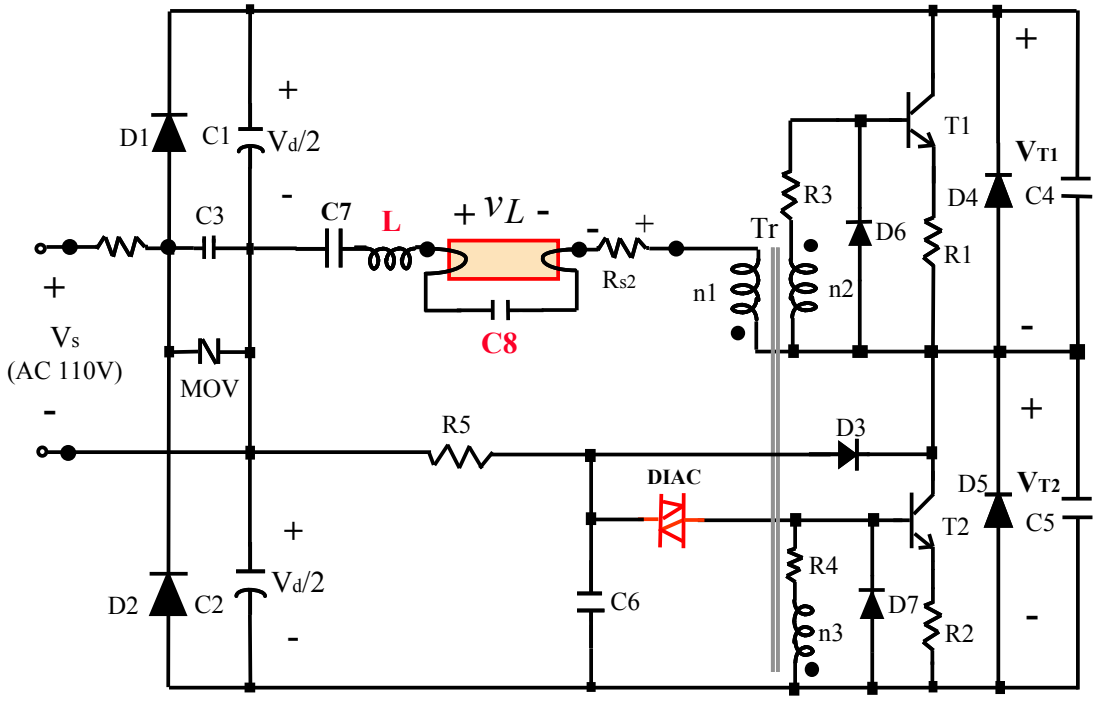


C. Electronic Fluorescent Lamp

1. For the half-bridge electronic fluorescent lamp circuit as shown:

(1) Briefly describe its operation principle. (10%)

首先，C_1、C_2執行半波整流的動作，接著對C_6充電至breakdown voltage，DIAC導通，T_2 ON，電感開始互感耦合，產生諧振。



(2) Refer to given schematic, give the purposes of the following circuit components: (9%)

MOV: 突波電壓抑制元件.

D4,C4,D5,C5: T_1、T_2 的諧振電路，防開關損壞.

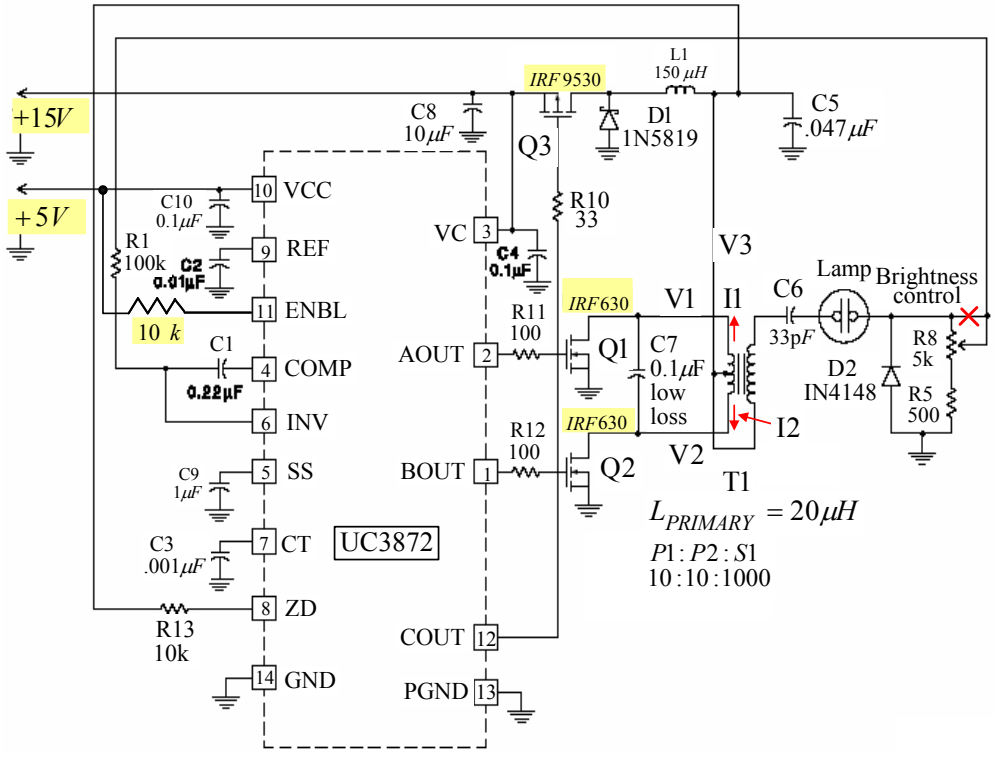
DIAC: 電壓過breakdown voltage時會導通，引發諧振電路開始諧振

D. Cold Cathode Fluorescent Lamp (CCFL)

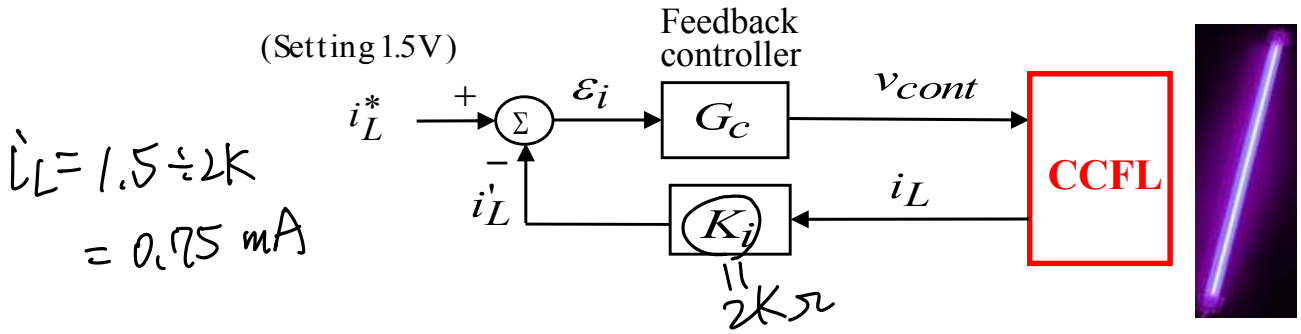
1. Briefly describe operation principle of this experiment circuit (given below). (8%)

2. IRF 9530 is P-channel or N-channel power MOSFET? P-channel. (2%)

AOUT、BOUT產生的訊號驅Q1、Q2 push-pull之後Buck converter電感激入，產生諧振，使燈炮發光。



3. For the brightness control scheme as given, K_i= 2kΩ is set, find the set current i_L= 0.75 m A.(6%)



$I_L = 1.5 \div 2K$
$= 0.75$ mA

4. The devices (Q3, D1, L1) form what type of DC-DC converter? (4%)

DC-DC Buck converter

E. Power Transformers and Power Quality

1. Some test data of the given transformer are measured as follows:

OCT: V_{oc} = 220 (V), I_{oc} = 2.5(A), P_{oc} = 150 (W)

SCT: V_{sc} = 150(V), I_{sc} = 4.545(A), P_{sc} = 250 (W)

(1) For a correct measurement procedure being made, fill in the values of V_{oc} and I_{sc}. (6%)

(2) Find efficiencies at (full load, PF= 0.8 lagging) and at (50% rated load PF = 0.8 lagging): (8%)

$$\eta_{1.0} = \frac{P_{rated}}{P_{rated} + P_{oc} + P_{sc}} = \frac{10k \times 0.8}{10k \times 0.8 + 150 + 250} = 95.24\%$$

$$\eta_{0.5} = \frac{\frac{1}{2}P_{rated}}{\frac{1}{2}P_{rated} + P_{oc} + \frac{1}{4}P_{sc}} = \frac{\frac{1}{2} \times 10k \times 0.8}{\frac{1}{2} \times 10k \times 0.8 + 150 + \frac{1}{4} \times 250} = 94.96\%$$

2. At the a given load, its measured no-load and full-load terminal voltages respectively are: 120V/60Hz and 108V/60Hz. Find the voltage regulation: (4%)

$$VR = \frac{|120 - 108|}{|108|} = 11.11\%.$$

3. The rating of a Delta-Delta connected three-phase transformers is 10kVA. Now a single-phase transformer is removed to form the V-V connection, find its VA rating. (6%)

$\frac{10k}{\sqrt{3}} \div 5.77$ KVA ※

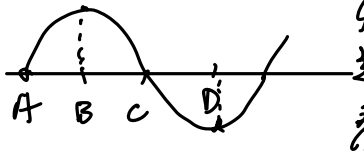
4. (1) Explain the inrush current generation process of a transformer. (6%)

當接下開關時，電壓產生磁通 $(\phi(t) = \frac{1}{N}\int v(t)dt)$，磁通產生激磁電流

$i(t) = \sqrt{2}V\sin\omega t \Rightarrow \phi(t)$ 為 cos func.，且如果是在A、C夾接下開關時

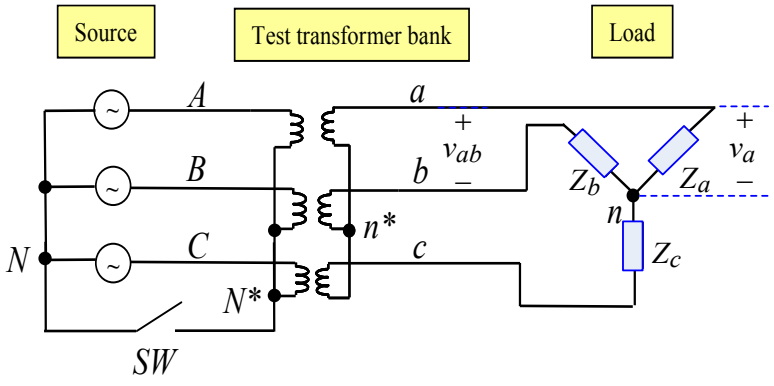
ϕ會很大，此時這很大的磁通產生的激磁電流就是 inrush current ※

(2) In what case the inrush current will be minimum? (4%)



在V的峰值時開啟，如圖B、D矣

5. For the Y-Y connected transformer system as shown:



(1) In which case $v_a(t)$ possesses 3rd-order harmonics: *SW* is closed or opened? opened. (2%)

(2) If *SW* is closed, Z_a=Z_b=Z_c and $i_A(t) = 5\sin 377t + 1.5\sin(3\times 377t)$, find: (4%)

i_{N^*-N} = $3\times 1.5\sin(3\times 377t) = 4.5\sin(3\times 377t)$ (A)

(3) Explain what is roving ground? (6%)

線電壓雖相同，但有著不平衡負載時中點會移動，相電壓會不同，則稱為 roving ground.

6. For the 18-pulse rectifier system applied by multi-phase transformers:

(1) What phase shifts of the output voltage are provided by this system? $-20°$, $0°$, $+20°$. (4%)

(2) If the frequency of input AC voltage is 60Hz. What is the frequency of the DC-link voltage ripple? $60\times 18 = 1080$ Hz. (3%)

7. For an incandescent lamp (白熾燈) load:

(1) Its power factor PF = 1; (2%)

(2) Describe why it possesses inrush current? (4%)

1. 白熾燈泡的電阻會隨時間改變，在一開始啟動時電阻較小，於啟動瞬間有 inrush current. 之後時間久了白熾燈的電阻及電流會趨於穩定。

F. Industrial Control Distribution:

1. How to change the rotational direction of a three-phase induction motor. (3%)

將三條輸入の电源線の其中2條对調.

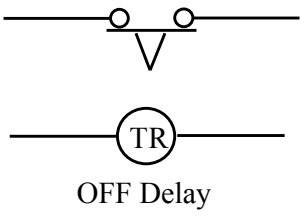
2. For the circuit as shown, as the push button REV is pushed down, describe all the events (including the operations of contacts, lamps, motor, …) to occur. (15%)

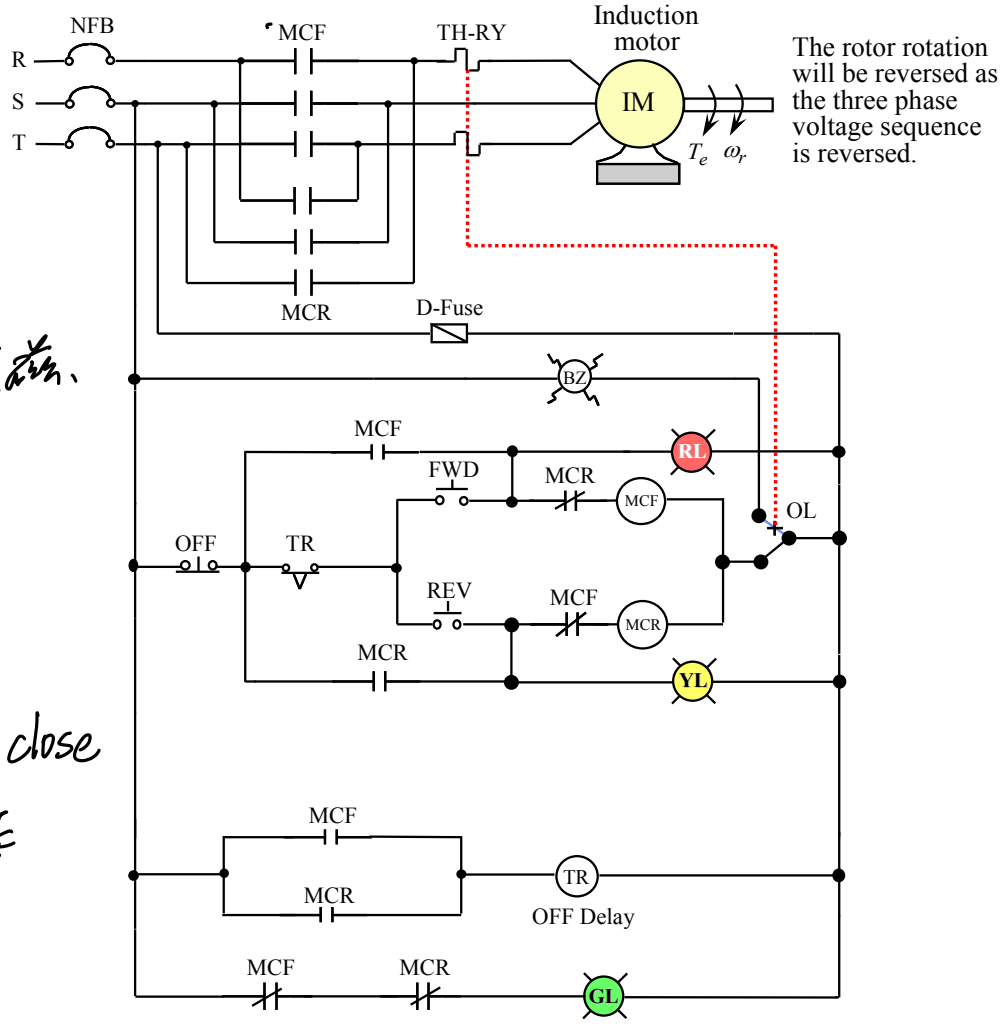
馬達反轉，按FWD無效(∵ MCR 2a open)，亮黃燈，TR激磁

3. What is the component TH-RY? 熱动电驛 (Thermal Relay)(5%) 过載即自动跳掉.

4. MCF ⊣⊢ belongs to a-contact or b-contact? b- contact. (3%)

5. Describe the operation of the off-delay relay TR. (6%)





馬達轉动時，(TR) 激磁.

—o/o— 馬上 open

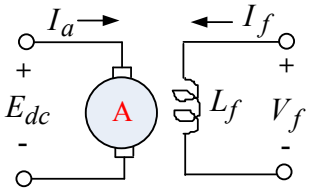
按下off，(TR) 消磁.

等delay時間到，—o/o— close

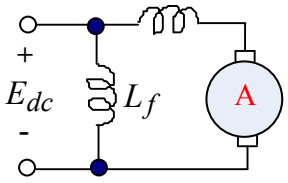
才能執行下一個动作

DC Machines:

1. Give the name of the following DC machines: (4%)



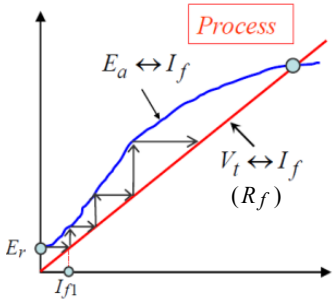
它激式

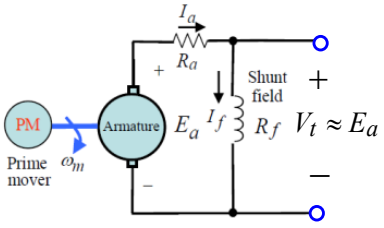


自激-複激式
(長並联)

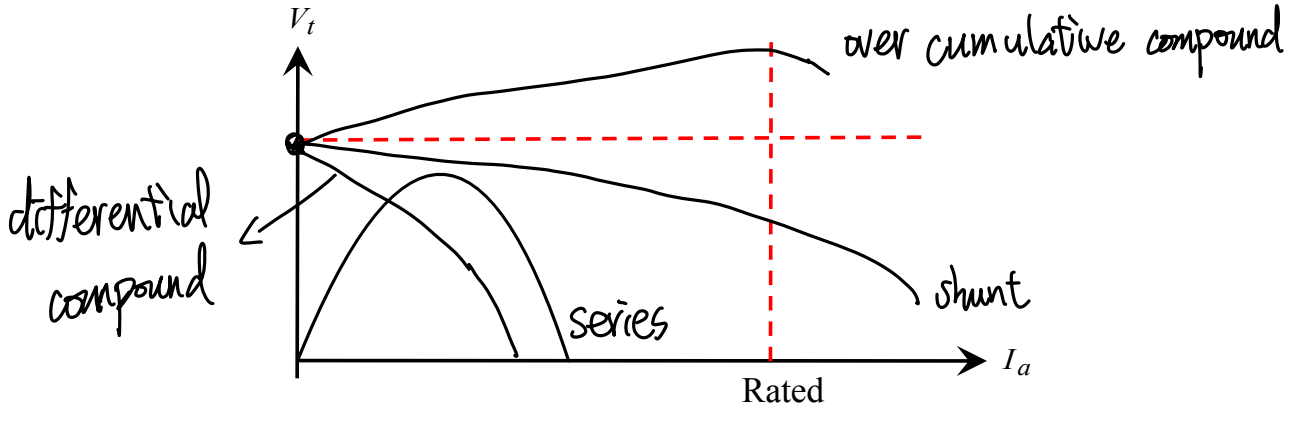
2. (1) Describe the voltage buildup process of a DC shunt generator. (5%)

利用一点剩磁產生小电枢电压 Er。
由Er產生小磁場电流 I_{f1}，進而產生較高之电压，直至磁化曲线与場阻線交矣所获定之电压。

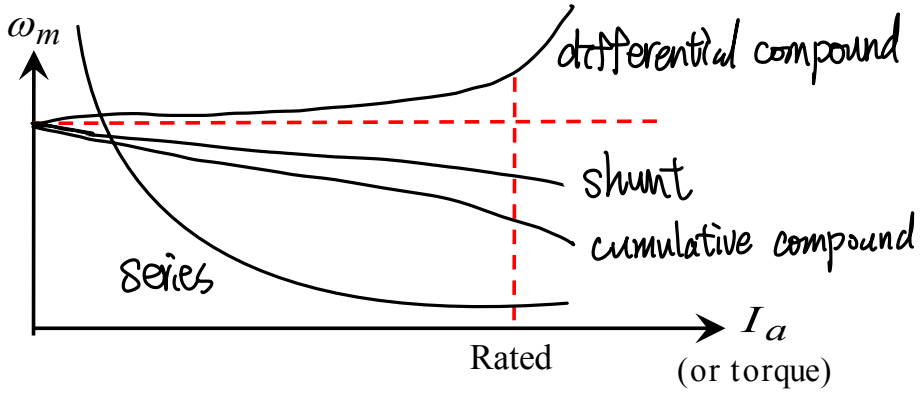




3. (1) Sketch the terminal voltage vs. load (armature current) curves of the following DC generators in the same figure: *Shunt, series, over cumulative compound, differential compound*. (8%)



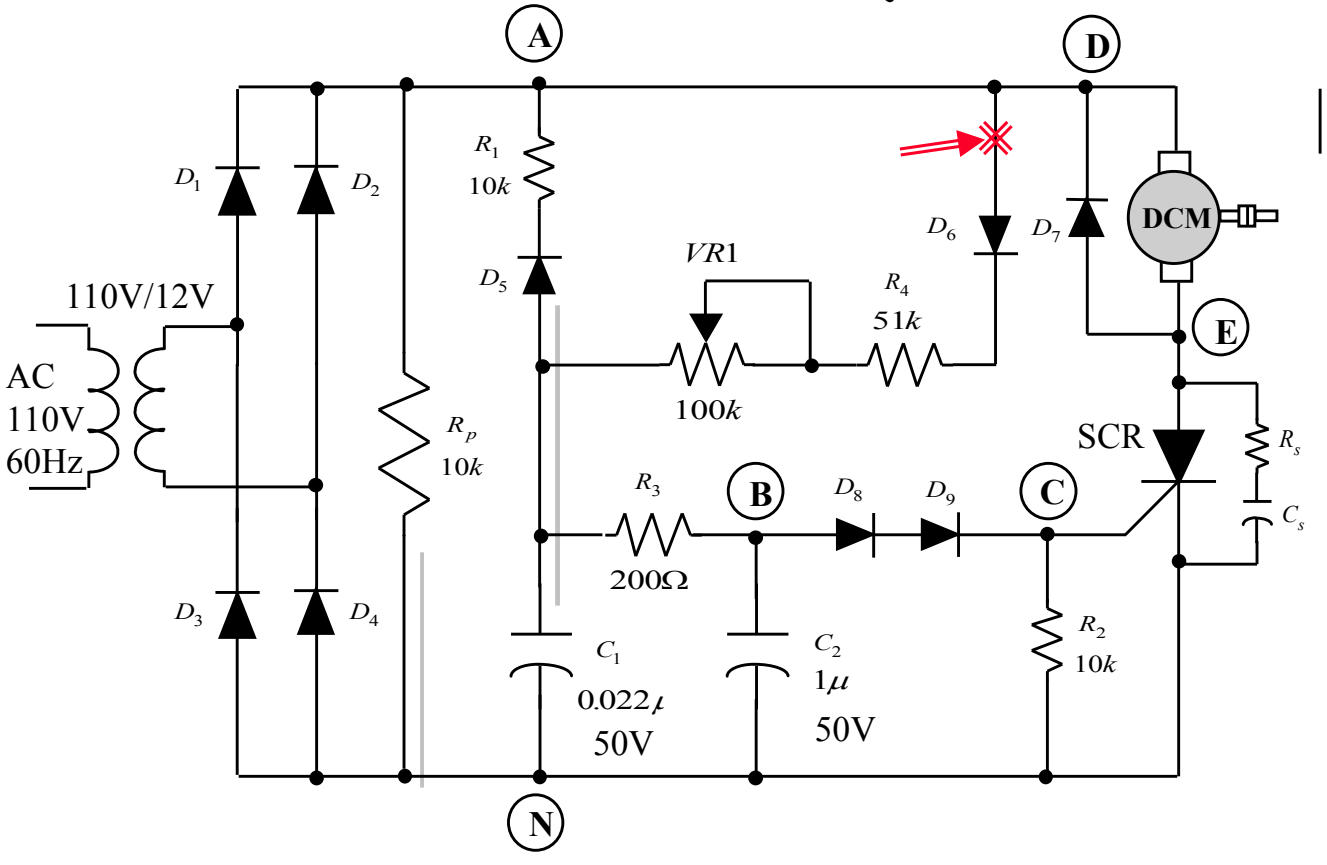
(2) Sketch the speed vs. load (armature current) curves of the following DC motors in the same figure: *Shunt, series, cumulative compound, differential compound*. (8%)



SCR Phase Speed Control of DC Motors:

1. Why we can not add a filtering capacitor between nodes (A) and (N)? (4%)

沒加了之後，會沒有 zero crossing 提供 SCR 之線換相。



3. Describe the purpose of D_7. (3%)

此為飛輪 diode，與電樞反並聯，一般係用以提供電樞電流延續流通路徑，使電樞電流較為連續，D_7 另亦可減小因電樞電流之變化所生電感負載之反電動勢 $(L_a \frac{di_a}{dt})$ 對 SCR 耐壓之危害。

4. Describe the purpose of VR1. (3%)

調整 VR1 可改變 C_2 充電速度，就可改變 SCR 導通角，控制轉速。

5. Describe the difference for the anode D6 being connected to point (D) and (E). (5%)

D6 接 (D) ⇒ 轉速較易受負載改變而影響。

D6 接 (E) ⇒ C_1 之充電電壓由 SCR 之陽極電壓供給，具有較佳調節特性，轉速較不易受其影響。