Design Voltage Regulator for Synchronous Generator

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Abstract

As the loud on an alternator is varied, its terminal voltage is also found to vary. This variation terminal voltage is due to voltage drop in armature (resistance, leakage reactance) and armature reaction, therefore this research aim to design voltage regulator to maintain the terminal voltage of alternator at constant value at load condition. By making the compensation time of voltage drop approach to zero at load condition.

تصميم منظم فولتية لمولدات التيار المتناوب

الخلاصة

في مولدات التيار المتناوب في حالة تغير الحمل من اللاحمل إلى الحمل يحصل هبوط فولتية الحمل ويكون هذا الهبوط على (المقاومة الداخلية والممانعة المغناطيسية عضو الاستنتاج) ورد فعل عضو الاستنتاج ، وهذا التصميم لجهاز يتكون من أشباه الموصلات يعيد فولتية الحمل إلى وضعها الطبيعي في زمن قصير أو يقترب من الصفر.

Introduction

A synchronous machine rotates at constant speed in the steady state. Un like induction machines. The rotating air gap field and the rotor in the synchronous machine rotate at the same speed, called the synchronous speed. Synchronous machine are used primarily as generators or alternator. They are usually large machines generating electrical power at hydro. Nuclear or thermal power stations synchronous generators with power ratings will be used before the end of the twentieth century. Synchronous generators are the primary energy conversion devices of the word's electric power systems today. In spit of continuing research for more direct energy conversion techniques. It is conceded that synchronous generators will continue to be used well into the next century.

Like most rotating machines, asynchronous machine can also operate as both a generator and motor.

Simple regulation

Figure (1) illustrates the idea of voltage regulation, line voltage, normally 120v rms. Drives an unregulated power supply like a full-wave rectifier with capacitor–input filter .The voltage from this unregulated supply varies directly with line voltage .For instance a 10 percent in line voltage results in approximately a 10 percent increase in the un regulated voltage .furthermore any changes in load current produce changes bin unregulated voltage because of supply impedance, filter-capacitor discharge, etc.

This is where the voltage regulation comes in as shown in Fig. (1) the voltage of the unregulated supply drives a voltage regulator, which produces the final output voltage .This output is ideally constant, varying neither with changes in line voltage nor in load current .In a practical regulator, The output voltage is almost constant and the ripple is greatly reduced.

Zener- diode regulator

A zener diode can be used voltage regulator. Figure (2) shown abridge peak rectifier driving a zener diode regulator .as you recall ,the average voltage and ripple across the filter capacitor depend on the source resistance ,the filter capacitance ,and the load resistance ,but as long as V_{in} is greater than V_z, the zener diode regulates in the breakdown region .Ideally ,this means the final output voltage is constant .To a second approximation, however the zener impedance cause the final output to changes in line voltage and load current.

The limitation on the zener diode regulator is this .Changes in load current produce equal and opposite changes in zener current:

$$\Delta I_z = -\Delta I_L \text{.................} (1)$$

The changes in zener current following through the zener impedance produce changes in the final output voltage:

$$\Delta V_L = -Z_z \Delta I_z \text{............} (2)$$

The larger the changes in zener ,the larger the changes in output voltage if the changes in zener current are only a few milliamperes, the changes in load voltage may be accepted ,but when the changes are tens of milliamperes or more ,the changes in load voltage become too large for most applications.

Zener Diode and Emitter Follower

What do we if the changes in zener current are too large ?the simplest approach is to add an emitter followers ,as shown in fig. (3) the load voltage still equal the zener voltage (less than V_{BE} drop of the transistor, but the changes in zener current are reduced by factor of ß.

$$\Delta I_z = \frac{-\Delta I_L}{\beta} \text{...........} (3)$$

When necessary, we can use a Darlington pairs to get a larger *ß* this circuit is an example of a series voltage regulator the collector emitter terminals are in series with the load because of this, the load current must pass through the transistor, and this is the reason the transistor is often called a pass transistor .the voltage across the pass transistor equals

$$V_{ce}=V_{in}-V_{out} \text{............} (4)$$

And its power dissipation is

$$P_D = (V_{in} - V_{out})\, I_L \text{....} (5)$$

Series regulator are the most widely used type.

Sp regulation

In critical application, zener voltages near 6V are used because the temperature coefficient approaches zero. The highly stable zener voltage, sometime called the reference voltage, can be amplified with an SP negative-feedback amplifier to get higher voltages with essentially the some temperature stability as the reference voltage.

A Discrete SP Regulator

Figure (4a) shows a discrete SP regulator. Transistor Q_2 acts like an emitter follower as before. Transistor Q_1 provides voltage gain in a negative-feedback loop. Here is the basic idea behind circuit operation. Suppose the load voltage tries to increase. The feedback voltage V_F will increase. Since the emitter voltage of Q_1 is held constant by the zener diode, more collector current flows throws Q_1; most of it flows through R_3 and causes the base voltage of Q_2 to decrease. In response, the emitter voltage of Q_2 decreases, offsetting almost all the original increase in load voltage.

Figure (4b) shows the circuit redrawn so can recognize the amplifier and feedback section. The output voltage is Fed back to the input side. Because of the SP negative feedback, the dosed-loop gain is

$$A_{SP} = \frac{R_2}{R_1} + 1 \text{ .... (6)}$$

Including the V_{BE} drop of Q_1. The final regulated load voltage equals

$$V_{OUT} = A_{SP}\left(V_E + V_{BE}\right) \ldots (7)$$

This means we can use a low zener voltage where the temperature coefficient approaches zero and still have a higher output voltage with an equally good temperature coefficient.

The potentiometer of fig (4a) allows us to adjust the output voltage to the exact value required in a particular application. In this way, we can adjust for the tolerance in zener voltages, V_{BE} drops, and feedback resistors.

Current limiting

The SP cottage regulator of Fig. (3a) is a series regulator. As it now stands, it has no short-circuit protection. If we accidentally place a short across the load terminals, we get an enormous current through a_2. Either a_1 will be destroyed or a diode in the unregulated supply will burn out, or both. To avoid this possibility, regulated supplies often include current limiting.

Figure (5) shows one way to limit load current to safe values even though the output terminals are shorted. For normal load currents, the voltage drop across R_4 is small and a_3 is off; under this condition. The regulator works as previously described. If excessive load current flows, however, the voltage across R_4 becomes large enough to turn on a_3. The collector current of a_3 flows through R_3; this decreases the base voltage of a_2 and reduces the output voltage to prevent damage.

In fig. (5) current limiting starts when the voltage across R_4 is around 0.6 to 0.7 V. At this point, a_3 turns on and decreases the base drive for a_2. Since R_4 is 1Ω, Current limiting begins when load current is the vicinity of 600 to 700 mA. By selecting other values of R_4, we can change the level oh current limiting.

The current limiting of fig (5) is a simple example of how it is done. In more advanced approaches, a_3 may be replaced by an op amp to increase the sharpness of the current limiting.

An op-amp regulator

In fig (5) a_1 provides the open-loop gain. As discussed earlier. The greater the open-loop gain, the more precise the closed-loop gain. Because of this, we can improve performance by using an op amp in the place of a_1.

Figure (6)show an op-amp regulator. Zener voltage V_z drives the noninverting input, and feedback voltage V_F drives the inverting input. Because we have eliminated the V_{BE} drop of Q_1 the regulated output voltage is

$$V_{OUT} = A_{SP} V_z \text{ .... (8)}$$

Where $A_{SP} = \frac{R_2}{R_1} + 1$.

This means the regulated output is as constant ai the zener voltage, with temperature-compensated Zener diodes. Therefore we can build extremely good voltage regulation. As before, we can use a Darlington pair in the place of Q_2 to increase current-handling capability.

A final point, to reduce the changes in zener voltage caused big changes in un regulated voltage, we can use the regulated output to drive the zener series limiting resistor R_s as shown in fig. (6). In this ray, we get an almost rock-solid regulated output.

The main generator

The stator of main generator which used in this design shown in fig (7(a, b))

The rotor of this generator consists of magnetic poles the rate of (pole to pole path) must be (0.707) to give us pure out put sin wave. The fig (8 a) show the rotor.The fig (8b) shows the magnetic char. Of the generator machine

The Excitation generator

The stator of generator excitation consist of two different group of coils, group one produce ¢ Ex1 is inverse the ¢Ex2)

Fig (8) shows the stator and its coils connection.

The rotor of this generator shown in fig (9)

The assistant generator

The generator produce IEx1 which produce ¢Ex1, This current must be constant in no load and in full load and fig (10) show the circuit of assistant generator.

Conclusions

Fig. (12)shown the connected of the three generators with voltage regulator.

Fig. (13) shown the relation between flux density (B) and field intensity (H), this relation for main generator which connected with load this relation on the size of generator.

Fig. (14) shown the relation between e.m.f and the result submersion of(¢ Ex1)and(¢ Ex2) which gave us out put voltage equal to (400V) and value constant between no load and full load.

Fig. (15) shown that the field current (I_f) is proportional to the load current (I_L), and (I_f) equal to the different between (¢ Ex1) and (¢ Ex2).

Fig. (16) shown the relation between load current and flux of main generator.

Fig. (17) shown that the field current is proportional to different between(¢ Ex1) and (¢ Ex1).

Fig. (18) shown the relation between (I_L) and result of the different between (¢ Ex1) and (¢ Ex2).

Fig. (19) shown that (I_L) is proportional to different between (I Ex_1) and (I Ex_2).

Fig. (20) shown the relation between (I_L) and(I Ex_2) , from this figure appear that (I_L) is inverse proportional with (I Ex_2), which mean that (I Ex_2) is inverse to the (I Ex_1).

The values on this relation are practically taken from station generator its output rate is 1 MVA. And the range of d.c current from 0A to8A, in this station generator two exciting winding used and one rotor and assistant generator be using voltage regulator the compensation time is approach to zero to load condition.

References

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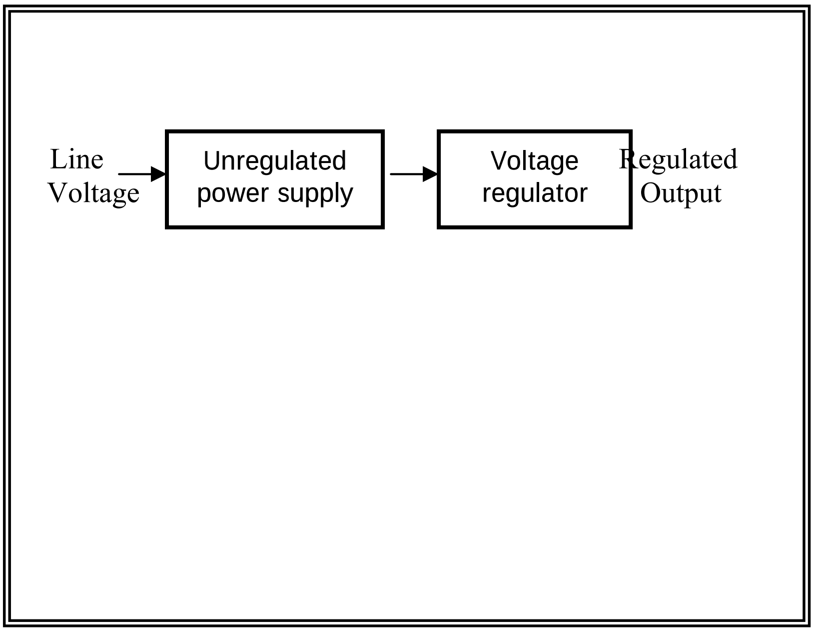

Fig. (1)Basic idea of voltage regulation

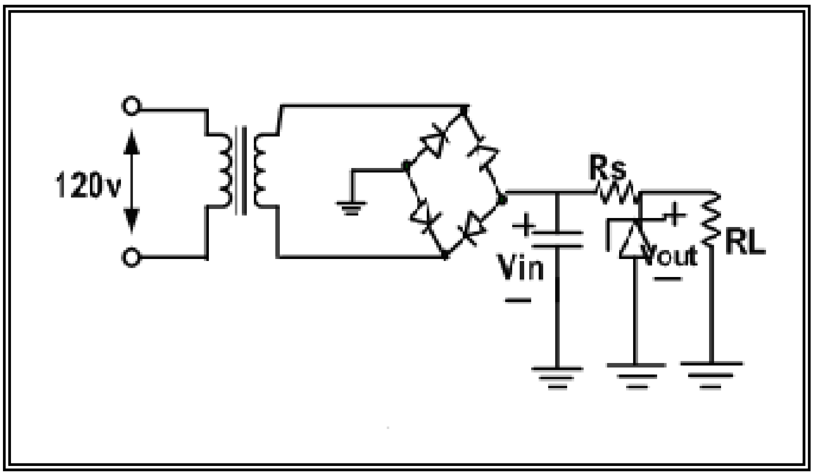

Fig. (2)Zener-Daiode Regulation

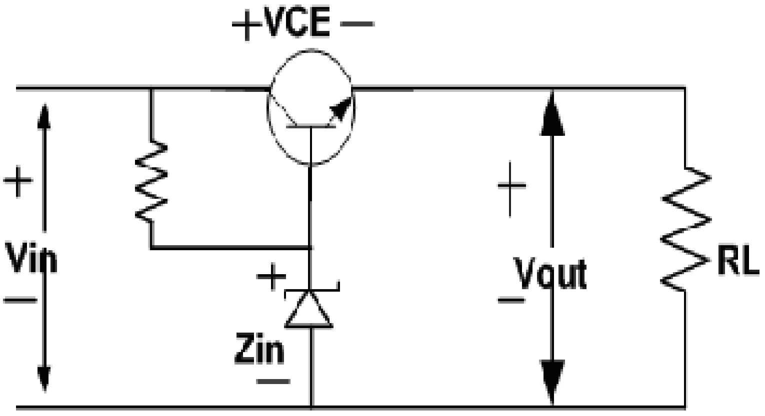

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Fig. (3) Zener Diod and Emitter Follower

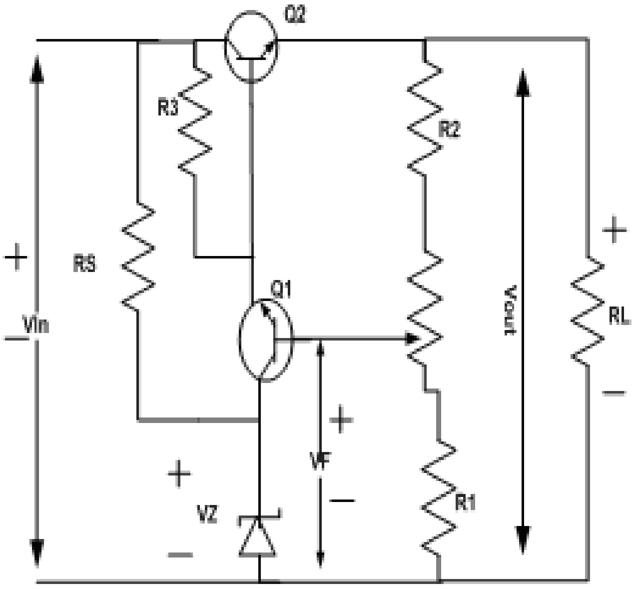
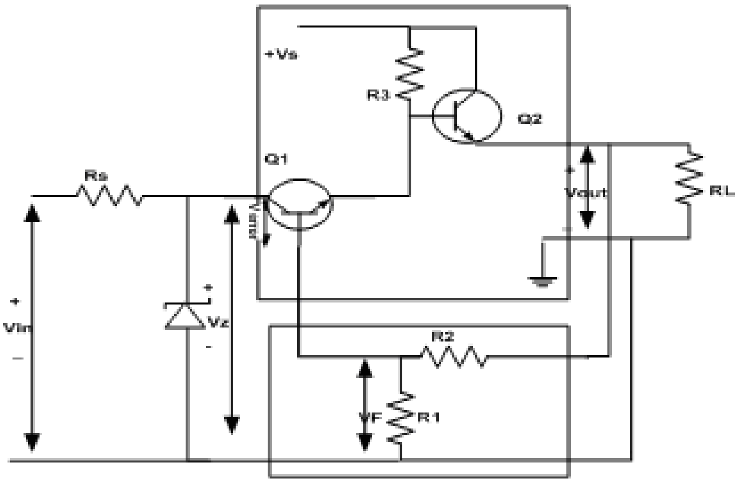


Fig. (4a) SP voltage regulators. (a) Actual circuit



(b)

(b) Redrawn to Emphasize A and B blocks

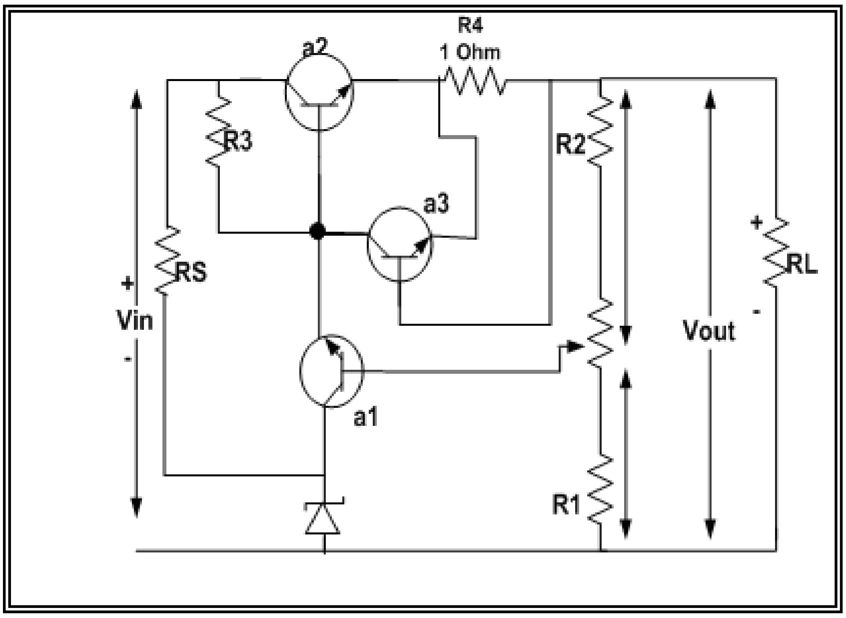


Figure (5) SP regulators including current limiter

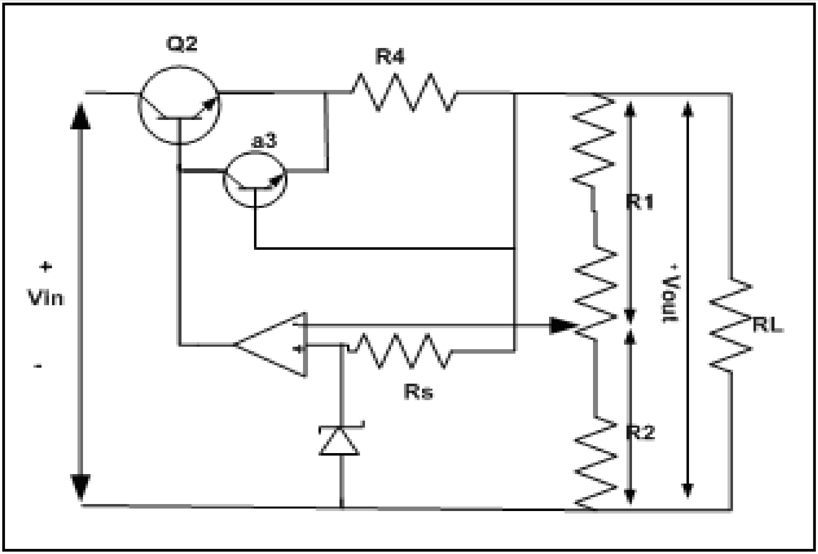
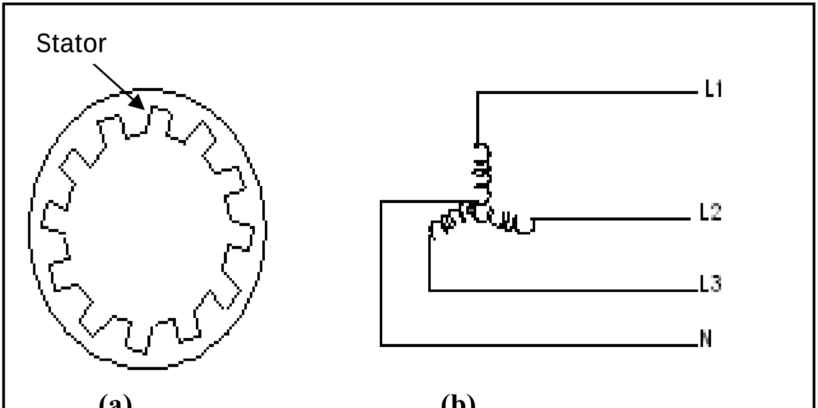
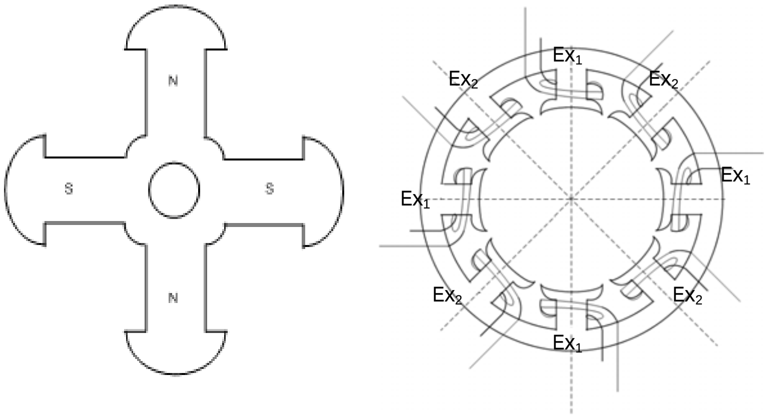


Fig. (6) An op-amp regulator



(a) (b)

Fig. (7) Illustrate (a) Stator core & (b) winding



(a) **(b)**

Fig. (8) (a) the rotor (b) magnetic char. Of the generator machine

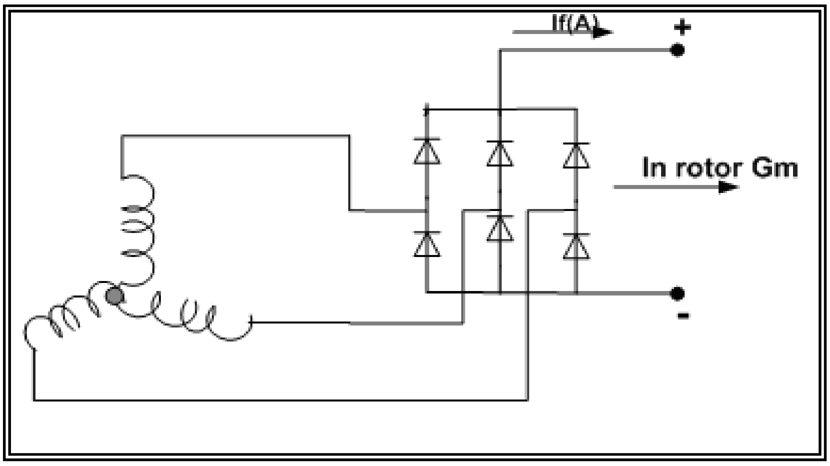


Fig. (9) the rotor of the generator

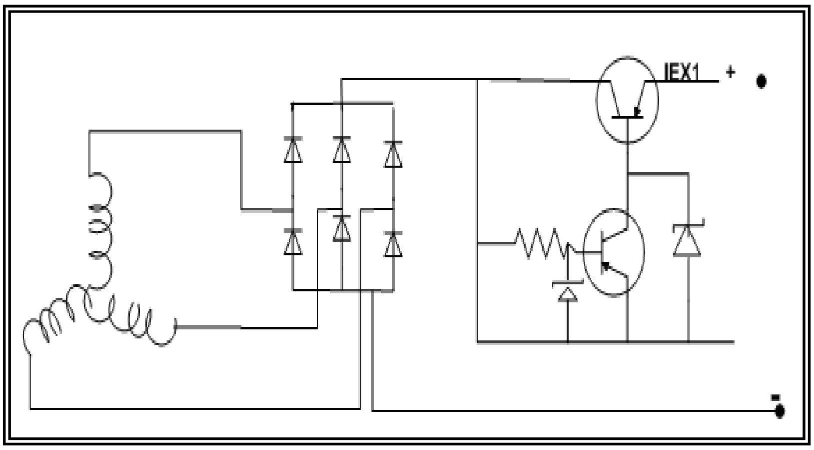


Fig. (10) the circuit of assistant generator

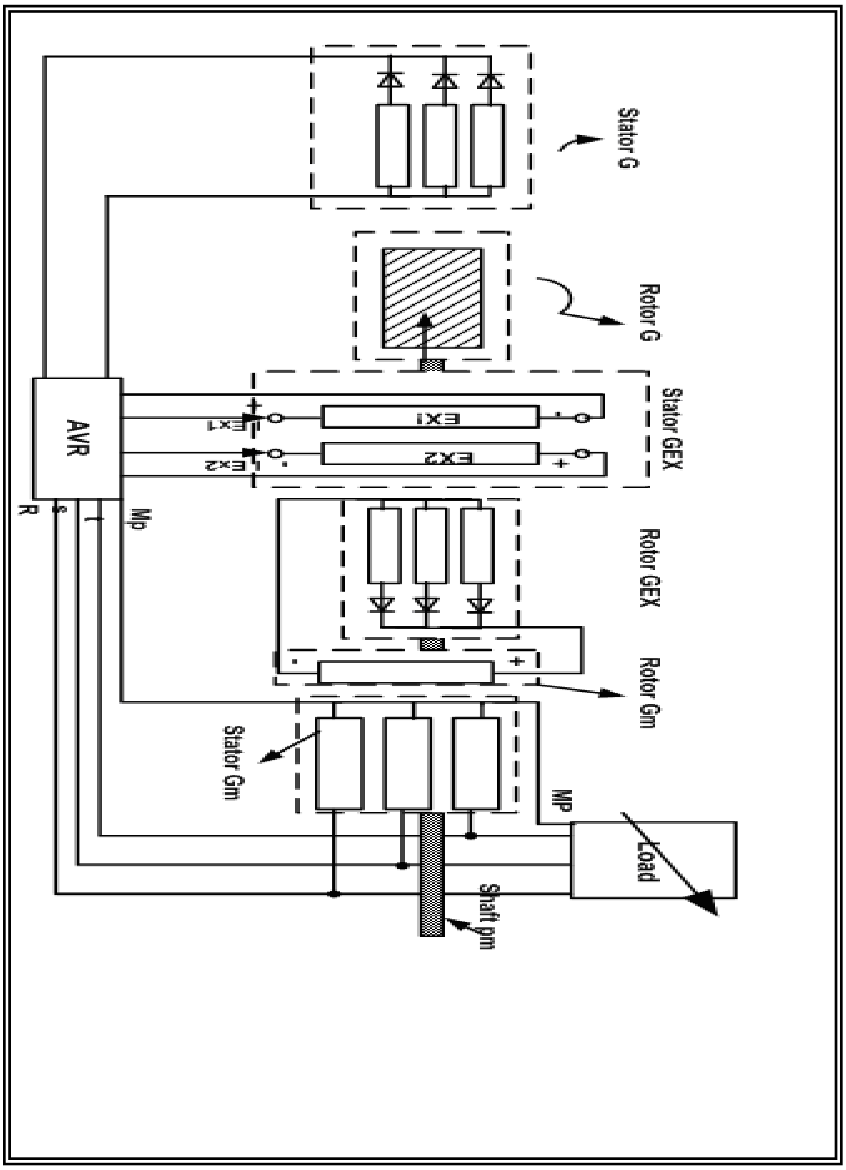


Fig. (11) shows the block diagram of the three generators

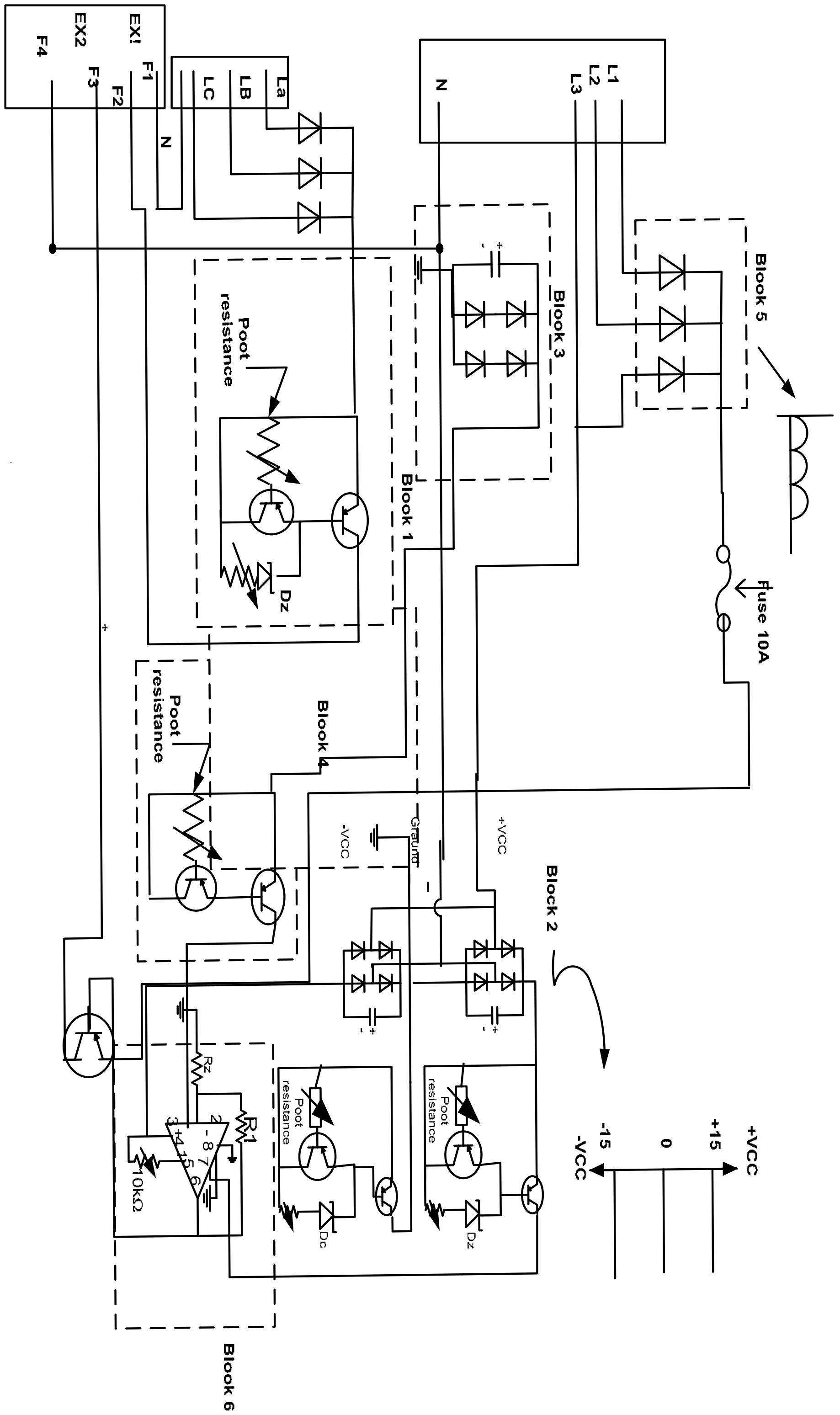


Fig. (12) automatic voltage regulation

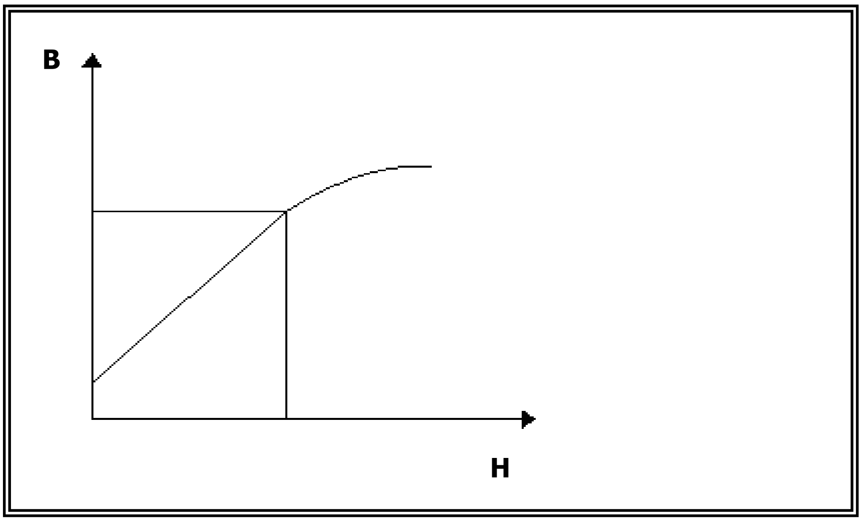


Fig. (13) These References between (B&H)

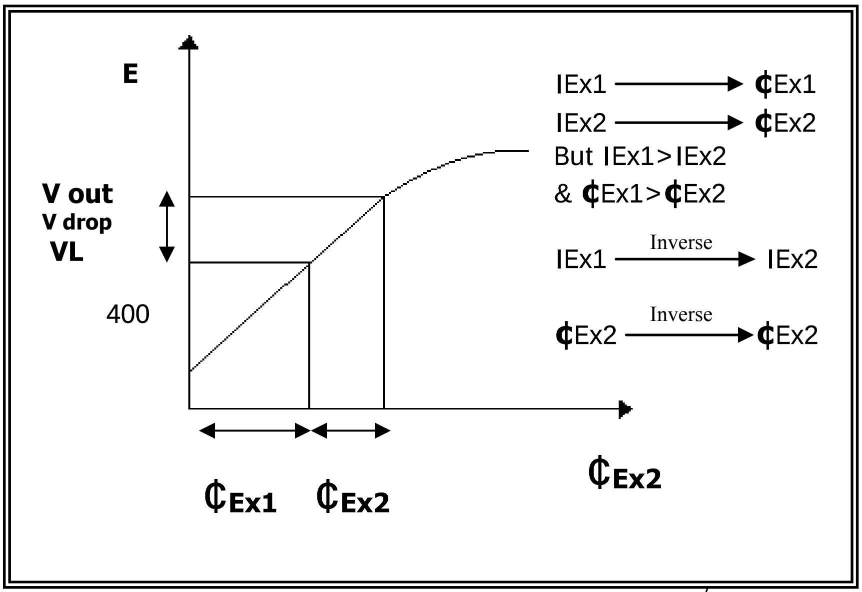


Fig. (14) these references between (E&₵Ex)

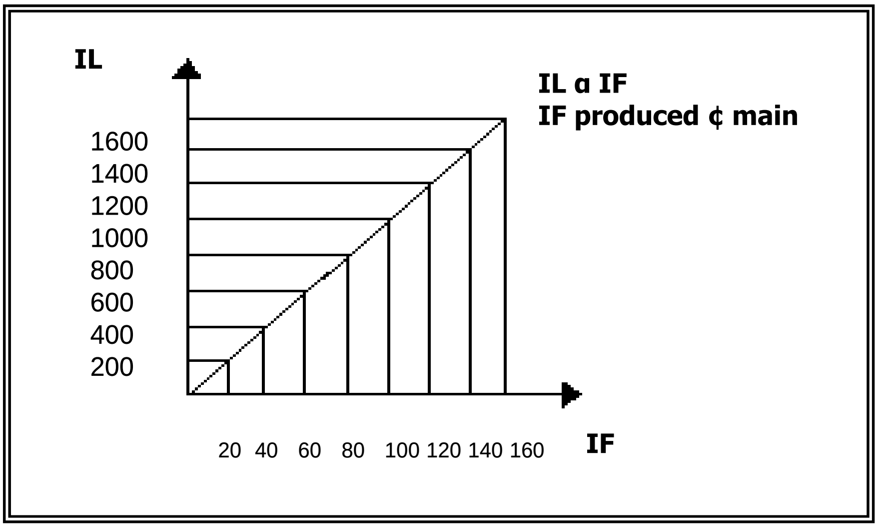


Fig. (15)

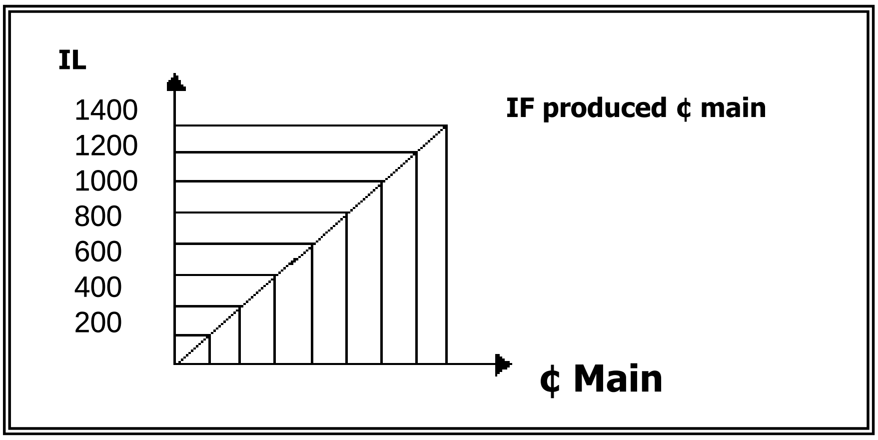


Fig. (16)

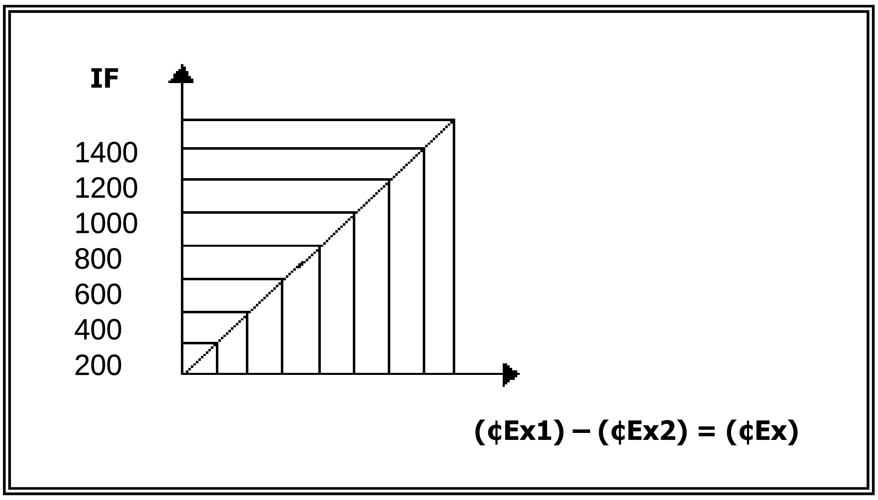


Fig. (17)

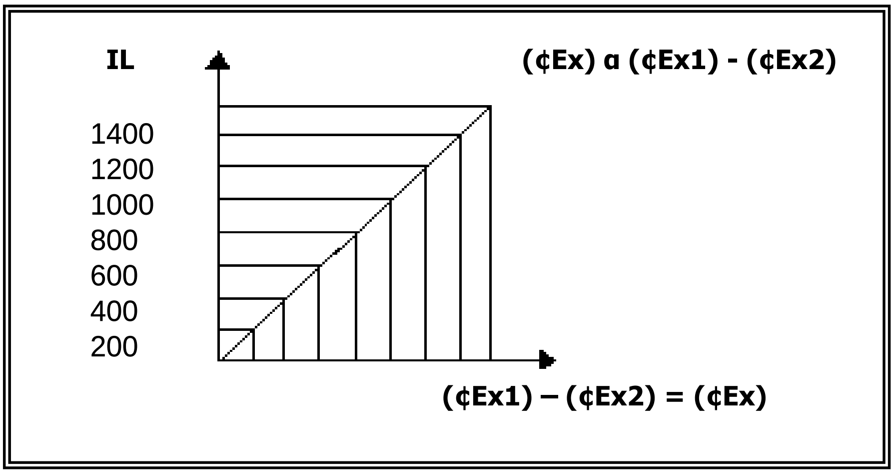


Fig.(18)

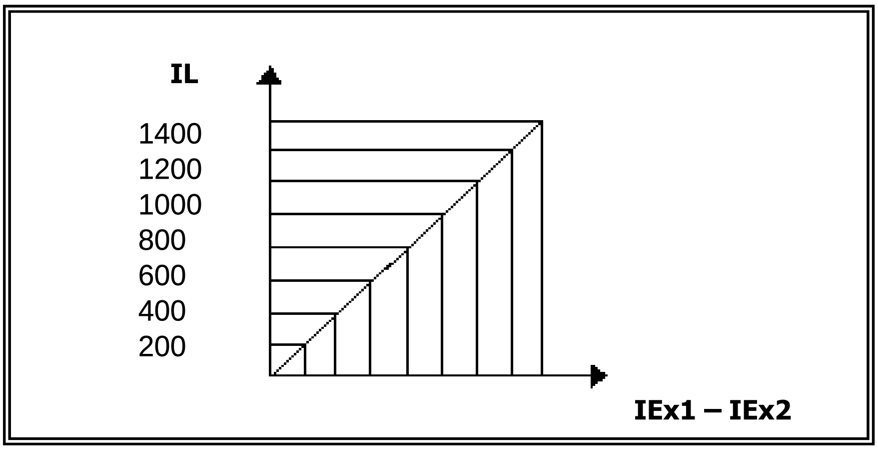


Fig.(19)

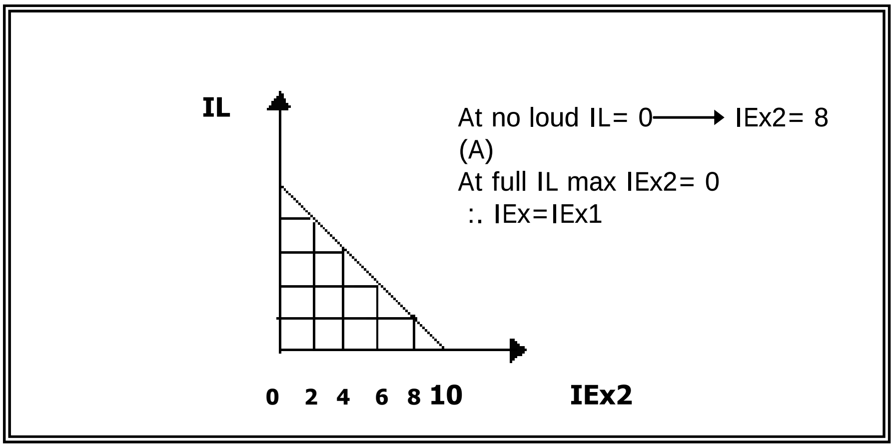


Fig. (20)