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(73) Patenthaver: **Nicholas Møller, Obalah Palic Omladinaca 4, HR-22000 Sibenik, Kroatien**
Milan Mancic, Prvi Ustanak 33, RS-24000 Subotica, Serbien

(72) Opfinder: **Milan Mancic, Prvi Ustanak 33, RS-24000 Subotica, Serbien**
Nicholas Møller, Obalah Palic Omladinaca 4, HR-22000 Sibenik, Kroatien

(74) Fuldmægtig: **LINGPAT V/OLE JAGTBOE, Letlandsgade 3, 2.mf., 1723 København V, Danmark**

(54) Benævnelse: **Charging circuit and use of the circuit**

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(57) Sammendrag:
In a circuit adapted to supply a voltage V to an electronic device having a recharging battery, the voltage V is led to a circuit (ACG) that is able to derive a voltage VACG from V where VACG * V
The circuit consist in a first embodiment of three serial coupled diodes (D1,D2,D3) and two capacitors (C1,C2), and where the capacitor (Cl) is coupled in parallel with two of the diodes (O1,D2) and the capacitor (C2) Fs coupled in parallel with the diodes (D2,D3).
In this way an Asymmetric Current Generator (ACG) is provided, that from a normal periodic source voltage V can derive two voltages both of which are suitable for the electronic device and the rechargeable battery. In this way a cost effective voltage in which the voltage required for the electronic device also is beneficial for recharging the battery, leading to save in current cost and a fast recharging of the rechargeable battery. The invention also covers the use of the Asymmetric Current Generator (ACG).

Fortsættes

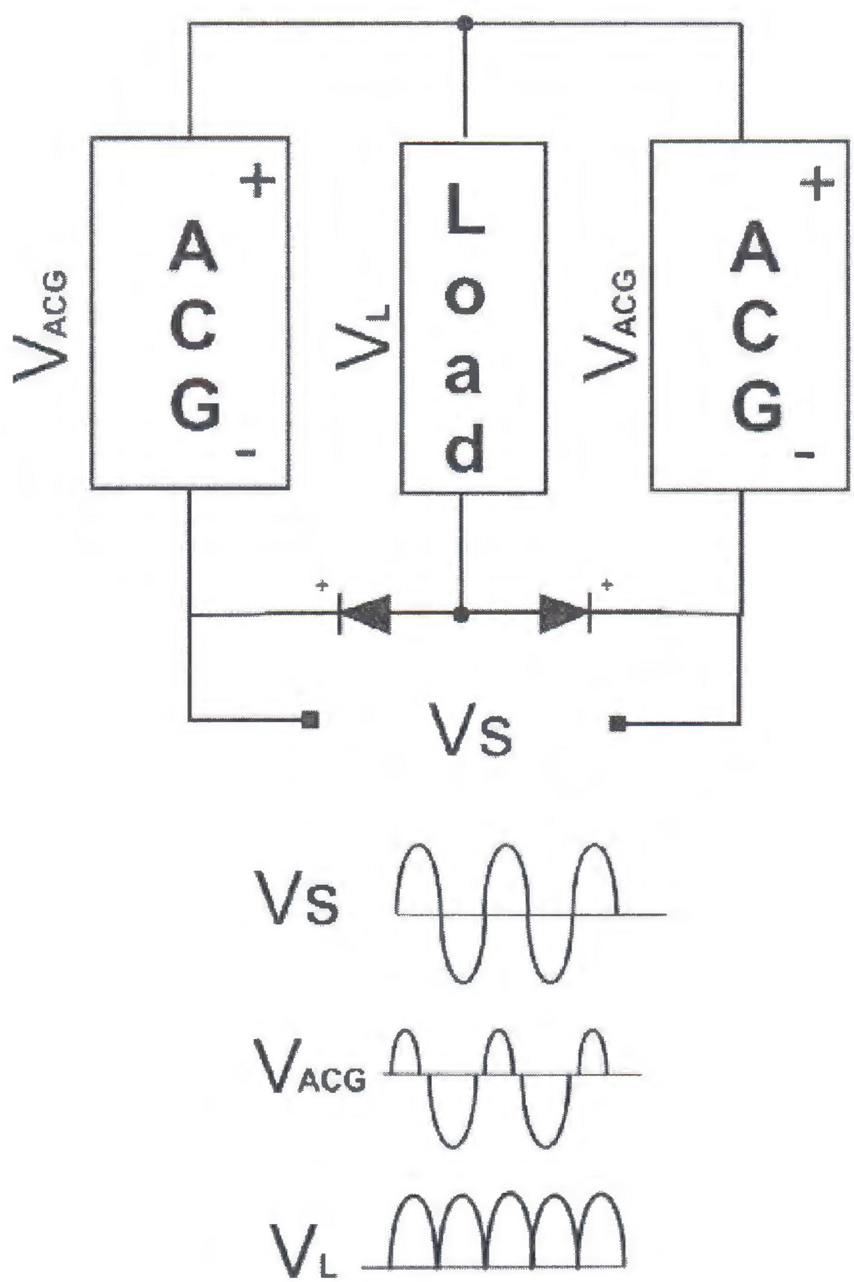

Fig 8

The invention relates to a charging circuit adapted to supply a voltage to an electronic device, such as a load V_L, said voltage is derived from a voltage V_s that has a periodic cycle with a period having a positive part and a negative part, and where the voltage V_s is fed to a series coupling of the load V_L and the input of a circuit (ACG), said circuit consist of three serial coupled diodes and two capacitors, where one of the capacitors is connected in parallel with two of the diodes, and the other capacitor is connected in parallel with two of the other diodes.

In consuming devices, such as mobile phones, it is normal practice to build into the device a rechargeable battery.

Since the rechargeable battery is providing a voltage for the consuming device and a voltage for recharging the battery as well, it is necessary to provide an output voltage from the battery that is higher than the voltage needed for the operating of the consuming device. So the difference between the charging voltage and the voltage for operating the consuming device, gives an idea of how effective the charging process is. However by applying a higher voltage to the consuming device than it is designed for, the effect of the overall system is reduced. By a simple energy calculation, it can be concluded that the efficiency is more or less proportional to the difference between the voltage used for recharging the battery and the voltage for operating the consuming device.

It is therefore the object of the invention to improve the efficiency for a consuming device that uses a rechargeable battery and to improve other capacitive consuming devices.

This object is achieved in a charging circuit of the type defined in the introductory part of claim 1, that is characterized in, at at least a further Asymmetric Current Generator (ACG) is connected in parallel with one or both of two of the diodes.

In this way it is possible to eliminate the difference in voltages between the operating voltage for the consuming device and the voltage for recharging, leading to a higher efficiency of the consuming device, since it is possible from one applied voltage, to generate a nominal voltage for the consuming device and a higher voltage for recharging the battery in the consuming device.

In this way, the result is a multiplication of the applied voltage, given even more efficiency in terms of recharging.

A expedient embodiment of the invention is defined in claims 2.

Practical example using the invention is, as stated in claim 3, that a capacitor is coupled between the voltage V_S and the Asymmetric Current Generator (ACG), and in as stated in claim 4 that a rechargeable battery is coupled between the voltage Vs and the Asymmetric Current Generator.

The embodiment, as stated in claim 5, that the voltage Vs is connected to a series coupling of two diodes and a parallel coupling of the Asymmetric Current Generator and a capacitor, and where one terminal of the load is connected to the parallel coupling whereas the other terminal of the load is connected between the diodes, and claim 6, that the voltage Vs is connected to a series coupling of two diodes and a parallel coupling of two Asymmetric Current Generators, and where one terminal of the load is connected to the parallel coupling, whereas the other terminal is connected between the diodes, gives the possibility to avoid use of conventional rectifiers, when V_s for instance has a sin waveform. Further the earlier mentioned advantages of the circuit according to the invention, of generating a higher voltage from a lower supply voltage, is obtained as explained earlier.

Within the scope of the invention, it is an advantage to run the charging circuit in a push/pull configuration as stated in claim 7, i.e. that V_S is a DC voltage V_{DC} that is coupled in series with two switches and the load, and that the Asymmetric Current Generator is connected in parallel with the switch and the load, and as stated in claim 8, that V_s is a DC voltage V_{DC}, that is coupled in parallel with the load and two switches and that the Asymmetric Current Generator is coupled between the switches.

When as stated in claim 9, that Vs is a DC voltage, that is coupled to the load through an inductor in series with a parallel coupling, consisting of a switch and a series coupling of the load and the Asymmetric Current Generator, a useful application in connection with a consuming device that has a lower operating voltage than that needed for the supply of voltage to recharging is obtained.

If the consuming device has an operating voltage that is higher or a similar voltage than the supply voltage, then an alternative preferred embodiment defined in claim 10, states that, V_S is a DC voltage V_{DC} that is coupled to a coil, that is coupled to a parallel coupling consisting of a series coupling of the load and the Asymmetric Current Generator, and a switch.

As mentioned the invention also covers a use of the invention.
This use is defined in claim 11.

The invention will now be explained in details, in which

Fig. 1 shows the basic circuit of the Asymmetric Current Generator according to the invention,

Fig. 2 shows the circuit in Fig. 1, in a multiplication version,

Fig. 3 shows the circuit in Fig. 1, in another multiplication version,

Fig. 4 shows a combination of the circuits in Fig. 2 and Fig. 3,

Fig. 5 shows an embodiment of the circuit in fig 1, in which a capacitor is coupled in parallel with the Asymmetric Current Generator,

Fig. 6 shows the Asymmetric Current Generator in Fig. 1 coupled to a rechargeable battery,

Fig. 7 shows the Asymmetric Current Generator in Fig. 1 coupled to a load,

Fig. 8 shows a preferred embodiment of the invention according to the invention,

Fig. 9 shows the Asymmetric Current Generator used in a three phase net,

Fig. 10 shows the circuit in Fig. 7 in which a DC voltage and a switching arrangement is coupled to the Asymmetric Current Generator,

Fig. 11 shows an embodiment of the circuit in Fig. 10,

Fig. 12 shows a further embodiment where a DC voltage is led to a load and the Asymmetric Current Generator, whereas

Fig. 13 shows another embodiment where a DC voltage is led to a load and the Asymmetric Current Generator.

In Fig. 1 a circuit in the form of an Asymmetric Current Generator consisting of three diodes D1, D2, D3 are coupled in series. Two capacitors C1, C2 are coupled to the diodes, such that the capacitor C1 is coupled in parallel with the diodes D1,D2, whereas the capacitor C2 is coupled in parallel with the diodes D2 and D3.

This circuit is coupled to a voltage V_S through the load V_L said circuit operates as follows:

When the voltage V_s is applied to the load V_L a voltage V_{ACG} is created at the output of the load V_L.

The voltage $V_{s.}$ is on the figure shown as a periodic symmetric sin signal.

The circuit operates as follows:

When the upper terminal of V_s is positive during the first half period, the capacitors C1, C2 will be charged during the first half period of V_s. The current will flow through the load V_L and the serial part of the circuit consisting of the capacitor C1, the diode D2 and the capacitor C2, since diodes D1, D3 will not be open for current.

When the first period is terminated the Voltage V_{ACG} will be the voltage V_s divided by the amount of capacitors, which equals ½ V_S.

In the second period of the voltage V_s, the voltage V_{ACG} will be controlled by the parallel circuit consisting of the capacitors C1, C2 and the diode D1 and the diode D3.

As shown on fig. 1, it is seen that $V_L>V_s$ when V_s is in the second period, because V_L, will be the sum of V_s and V_{ACG}. It is noted that in the beginning of the first half period, the current to the capacitors will be maximum and determined by the resistance of the circuit. When the capacitors are fully charged the current will be minimum.

Below an example is given suggesting that V_S is 9 Volt and the load V_L is a 12v Volt rechargeable battery. Normally it is not possible to recharge a 12 Volt battery with a 9 Volt source.

Due to the use of the circuit in fig 1, cf. also fig. 6, it is possible to recharge the battery since during the charging of the capacitors C1, C2 they will get a voltage of 4,5 volt ($=\frac{1}{2}V_S$), said voltage will be added to the 9 volt source during the discharging of the capacitors C1, C2 and thereby creating 13,5 Volt for charging the battery.

The Fig. 2 circuit differs from that in Fig. 1, that two similar ACG circuits respectively, are coupled between the diodes D1 and D2 and the positive part of V_s and between the diodes D2,D3 and the negative part of $V_{S.}$ The two capacitors in the ACG circuits are denoted C5, C6 and C3, C4 respectively.

In this circuit a faster charging of three capacitors C1, C2, C4 and C2, C5, C6 will be obtained, because they have a lower serial capacitance compared to the using of only two capacitors C1, C2 as shown in Fig. 1.

Similar when discharging the capacitors C3, C4 in parallel, they will ad their voltage to C1 and in the same way capacitors C5, C6 will ad their voltage to C2. In summary a higher output of V_{ACG} compared to the embodiment of Fig. 1 will be the result, or in other words, a multiplication of V_s is achieved.

A variant of the Fig. 1 embodiment is shown in Fig. 3.

This embodiment also provides multiplication. As can be seen from Fig. 3 four ACG circuits are coupled in such a way, that capacitor C2 is coupled between

diodes D21 and D31 to an ACG circuit having diodes D12, D21, D31 and capacitor C21. Another two ACG circuits are coupled in the same manner.
In this circuit multiplication is also provided by the plurality of ACG circuits.
The number of ACG circuits in this arrangement is determined by the value of Vs and the voltage drops in the diodes. The drop is determined by the minimum voltage required for getting the diodes in a conducting state.
If batteries are used in charging, they can receive charge from the series part of the ACG circuit and deliver charge from the parallel part of the ACG circuit
In this way a higher charge is generated, but lower total output voltage is delivered.

Fig. 4 shows a combination of the circuits in Fig. 2 and Fig 3.
This configuration uses the results from Fig. 2 and Fig. 3 i.e. the Fig. 2 circuit provides a higher voltage output and lower charging amount and that the Fig. 3 circuit provides lower voltage output and higher charging amount. The combination results in a higher combined voltage and charging amount output.

In the Fig. 5 embodiment, which is a variant of Fig. 1, V_s is coupled to capacitor C3, which in turn is coupled to the diodes D1, D2 and D3.
This circuit operates as a voltage intensifier gaining V_s.
It order to understand how the circuit in Fig 5 operates, it is assumed that the left terminal is positive and the right terminal is negative.
It is also assumed that no charging is present at capacitors C1 and C2.
In this case the diodes D1, D2, D3 will shorten the capacitors C1 and C2, leading to charging of capacitor C3 in the first positive period of the voltage V_s. When the polarity of V_s in the second half of the period is negative, the capacitor C3 will be coupled in series with V_s, resulting in a doubling of the output voltage leading to charging of the capacitors C1 and C2 to half the voltage output. When the next period of V_s is present, the now charged capacitors C1 and C2 will discharge in parallel to the capacitor C3.
In this way the voltage in C3 will be increased due to the repeating contribution from the voltage from the capacitors and V_s itself.
The ACG circuit produces asymmetry between charging and discharging on capacitor C3.

The amount of voltage multiplication in Fig. 5 is determined by V_S multiplied by the amount of capacitors in the ACG circuit.

In Fig 6, a practical use of the ACG circuit is demonstrated. Compared to the Fig. 5 version, a rechargeable battery is inserted instead of the capacitor C3.
Such a rechargeable battery do not behave as the capacitor C3, but it operates for instance with voltages between 10,8 Volt and 13,5 Volt.
This means that the battery when connected to an ACG circuit, will receive higher amount of charge than it releases.
This again means that it is possible to use a voltage source V_s that is sufficient for a consuming device, and still creating a voltage needed for charging the battery, without increasing the voltage source V_s.

Depending of which and how the ACG circuits are dimensioned or multiplied, it is for instance possible to charge a 36 volt battery with voltage source V_s of 2 volt.

In Fig. 7 an arrangement of the ACG circuit, where the source V_s is connected to the ACG circuit-V_s is also connected to two diodes D4, D5.
A load is connected between the diodes and the common terminal between the ACG circuit and the capacitor C7. The current passes through the load during each half period of the source V_s such that when the right terminal is positive, the capacitor C7, receives charge from the load and the ACG circuit releases charge. When the right terminal is negative, the capacitor releases charge and the ACG circuit receives charge.
In this way rectifying of current from V_s provides higher voltage and current across the load terminal, compared to using standard method of rectifying current from V_s, cf. the shown waveforms.

The arrangement in Fig. 8 differs from that in Fig. 7 in that the capacitor C7 is replaced by another ACG circuit. The function is basically the same as explained in connection with Fig. 7, but with the differences that both periods of the source V_s provides in a shifting manner charging and discharging in the ACG circuit leading to the output as shown.

In Fig. 9 is shown an arrangement in which a load is connected to a 3 phase network in an "Y" coupling. The operation is similar to the operation of the above mentioned one phase networks.

Now to fig 10.
This embodiment shows an arrangement where a load is coupled in series with a switch S2, said series coupling is connected respectively in parallel with an ACG circuit and a series coupling of a switch S1 and source V_{DC}. As can be seen from the figure the source V_{DC} a DC voltage.
When the switch S1 is open and the switch S2 is closed, then the capacitors in the ACG circuit will be discharged through the load.
When the switch S1 closed and the switch S2 is open, then the capacitors in the ACG circuit will be charged. It's basically the same operation as it was explained in connection with the Fig. 1 – 4.
By driving the switches as explained a push/pull connection is provided.

Fig. 11 differs from Fig. 10 in that the load is connected in parallel with $V_{DC.}$
This configuration is suitable in case that the operating voltage of the load is higher or the same as the voltage V_{DC}.
When the switch S2 is closed and switch S1 is open, the capacitors of the ACG circuit will be charged.
When the switch S1 is closed and the switch S2 is open, then the capacitors in the ACG circuit will discharge in the load, which at the same time provides a value that is higher than V_{DC}.

In the Fig. 12 embodiment a switch S is connected in parallel with a series coupling of a load and an ACG circuit. The switch is further coupled in parallel with a V_{DC} source and a coil.
This arrangement operates as follows.
When switch S is closed, the current passes from V_{DC} source through the coil which creates an electromagnetic field around the coil and stores energy in the coil. In the same time, through the switch S, the capacitors inside the ACG circuit discharges through the load.

When switch S is open, the electromagnetic field around the coil will collapse resulting in producing a high voltage which discharges through the load and the capacitors in the ACG circuit. This will be repeated when the switch is closed, and again when the switch is opened.

In fig 13 it is seen that a load is coupled in series with an ACG circuit. It is also seen that the ACG circuit and the load is in parallel with a coil. A voltage V_{DC} is supplied to the common point of the coil and the load. A switch is coupled to the common point between the coil and the ACG circuit.

When the switch S is closed, the current from the V_{DC} source runs through the load and the ACG circuit in which the capacitors in the ACG circuit are charged. At the same time an electromagnetic field is build up around the coil. When the switch S opens, the electromagnetic field around the coil collapses and produces a higher voltage, which discharges in series with the ACG circuit through the load. The load is supplied with a higher Voltage than V_{DC} in the same way, as it was explained in connection with the foregoing figures.

Even though the invention is explained in connection with passive components, it is clear within the scope of the claims, that the invention could be implemented with active components, such as transistors replacing the diodes or the like.

PATENTKRAV

1. Ladekredsløb der er indrettet til at forsyne en spænding til et elektrisk kredsløb, såsom en belastning V_L, hvor nævnte spænding er udledt fra en spænding V_S, der har en periodisk cyklus med en periode der har en positiv del og en negativ del, og hvor spændingen V_S fødes til en seriekobling af belastningen V_L og indgangen af en asymmetrisk strøm generator (ACG), hvor nævnte kredsløb udgøres af tre seriekoblede dioder (D1, D2, D3) og to kondensatorer (C1, C2) hvor en af kondensatorerne (C1) er forbundet i parallel med to af dioderne (D1, D2) og den anden kondensator (C2) er forbundet i parallel med to af de andre dioder (D2, D3), **kendetegnet ved**, at mindst en yderligere asymmetrisk generator (ACG) er forbundet i parallel med en eller to af dioderne.

2. Ladekredsløb ifølge krav 1, **kendetegnet ved**, at kondensatoren (C2) i den Asymmetriske Strøm Generator (ACG) er forbundet mellem to af dioderne (D21, D31) i den yderligere Asymmetrisk Strøm Generator (ACG).

3. Ladekredsløb ifølge krav 1 – 2, **kendetegnet ved**, at en kondensator (C3) er forbundet mellem spændingen V_S og den Asymmetriske Strøm generator (ACG).

4. Ladekredsløb ifølge kravene, 1 – 2, **kendetegnet ved**, at et genopladeligt batteri er forbundet mellem spændingen V_S og en asymmetriske strøm Generator (ACG).

5. Ladekredsløb ifølge krav 1 – 2, **kendetegnet ved**, at spændingen V_S er forbundet til en seriekobling af to dioder (D4, D5) og en parallelkobling af den asymmetriske strøm generator (ACG) og en kondensator og hvor en terminal på en belastning er forbundet til parallelkoblingen, medens den anden terminal er forbundet mellem dioderne.

6. Ladekredsløb ifølge kravene 1 - 2, **kendetegnet ved**, at spændingen Vs er forbundet til en seriekobling af to dioder (D4, D5) og en parallelkobling af to asymmetriske strømgeneratorer, og hvor en terminal på belastningen er forbundet til parallelkoblingen, medens den anden terminal er forbundet mellem dioderne.

7. Ladekredsløb ifølge krav 1 - 2, **kendetegnet ved**, at V_S er en DC spænding V_{DC} der er forbundet i serie med to omskiftere (S1, S2) og belastningen, og at dem asymmetriske strøm generator (ACG) er forbundet i parallel med omskifteren (S2) og belastningen.

8. Ladekredsløb ifølge krav 1 - 2, **kendetegnet ved**, at V_S er en DC spænding V_{DC} der er forbundet parallelt med belastningen og to omskiftere (S1, S2) og at den asymmetriske strømgenerator (ACG) er forbundet mellem omskifterne (S1, S2).

9. Ladekredsløb ifølge krav 1 - 2, **kendetegnet ved**, at V_S er en DC spænding V_{DC} der er forbundet til belastningen gennem in spole i serie med en parallel kobling bestående af en omskifter (S) og en seriekobling af belastningen og den asymmetriske strøm generator (ACG).

10. Ladekredsløb ifølge krav 1 -2, **kendetegnet ved**, at V_S er en DC spænding V_{DC} der er forbundet til en spole og efterfølgende er forbundet i parallel med en seriekobling af belastningen og den asymmetriske strømgenerator (ACG), hvis udgang er forbundet til en omskifter (S).

11. Anvendelse af et antal N af ACG kredsløb ifølge krav 1 – 10 i et N faset net.

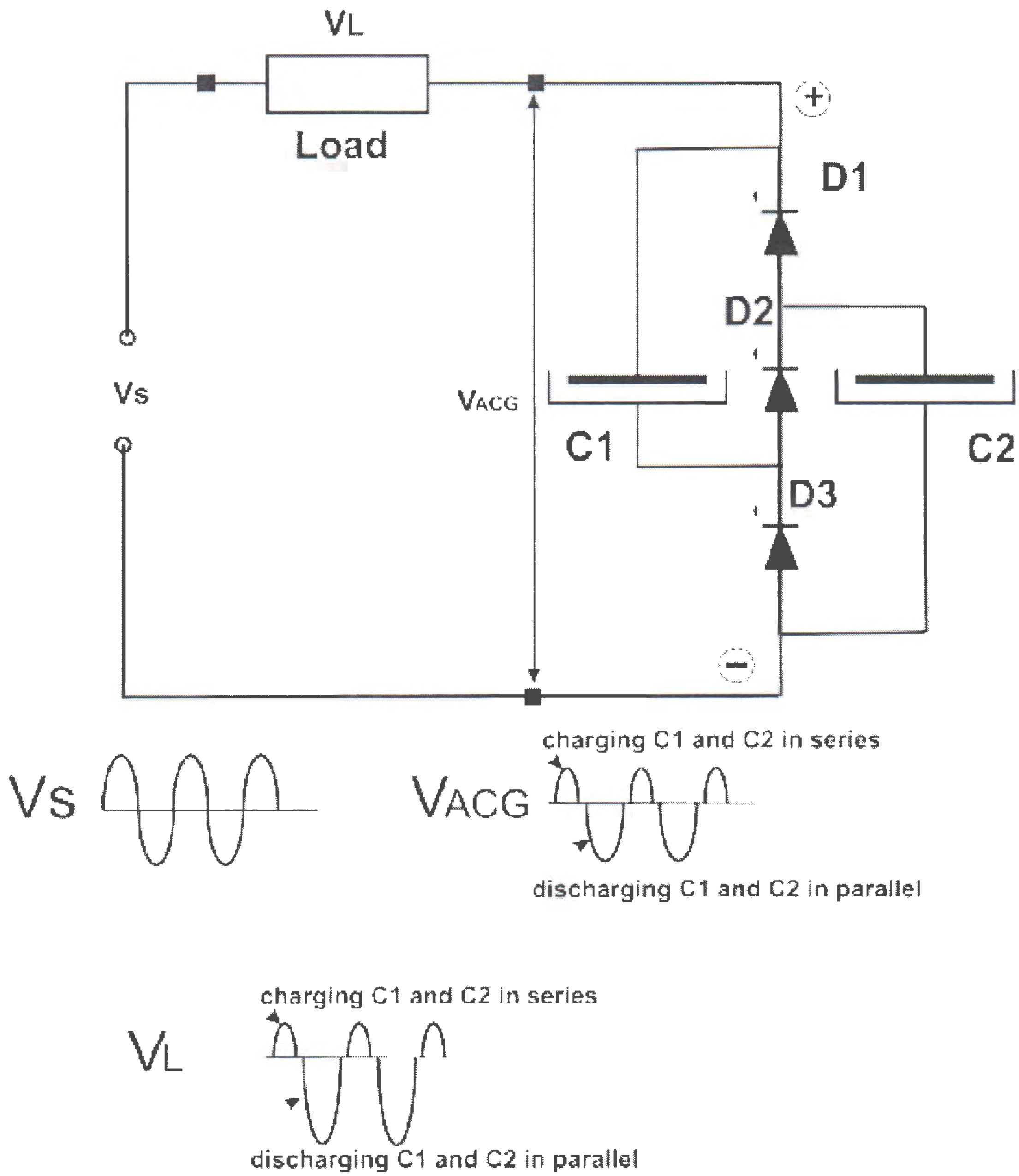
VL
Load
D1
D2
C1
C2
D3
Vs
VACG
+
−
Vs
VACG
charging C1 and C2 in series
discharging C1 and C2 in parallel
VL
charging C1 and C2 in series
discharging C1 and C2 in parallel

Fig 1

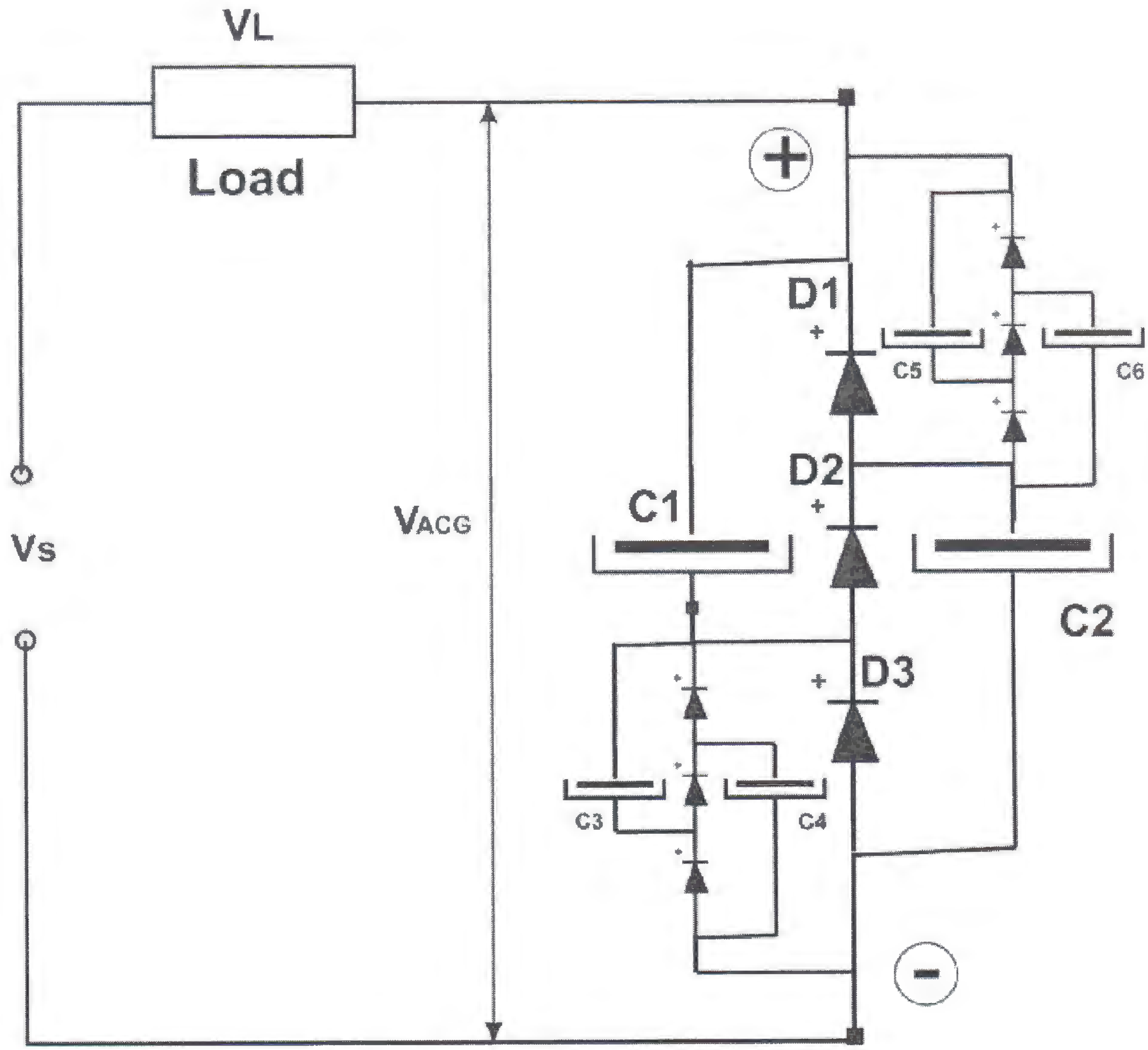

Fig 2

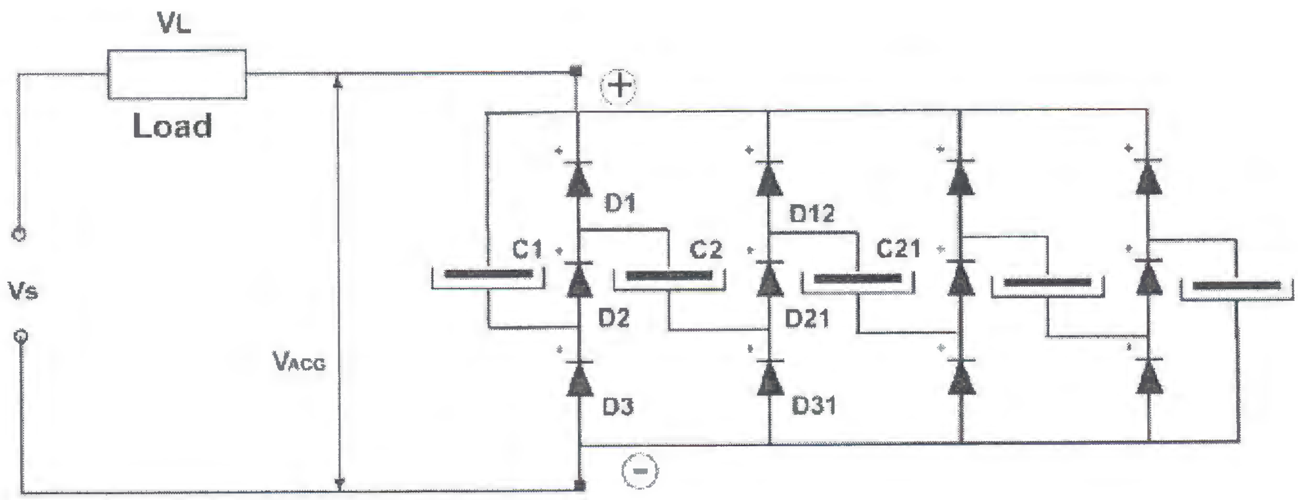
VL
Load
Vs
VACG
D1
C1
C2
D2
D12
C21
D21
D3
D31

Fig 3

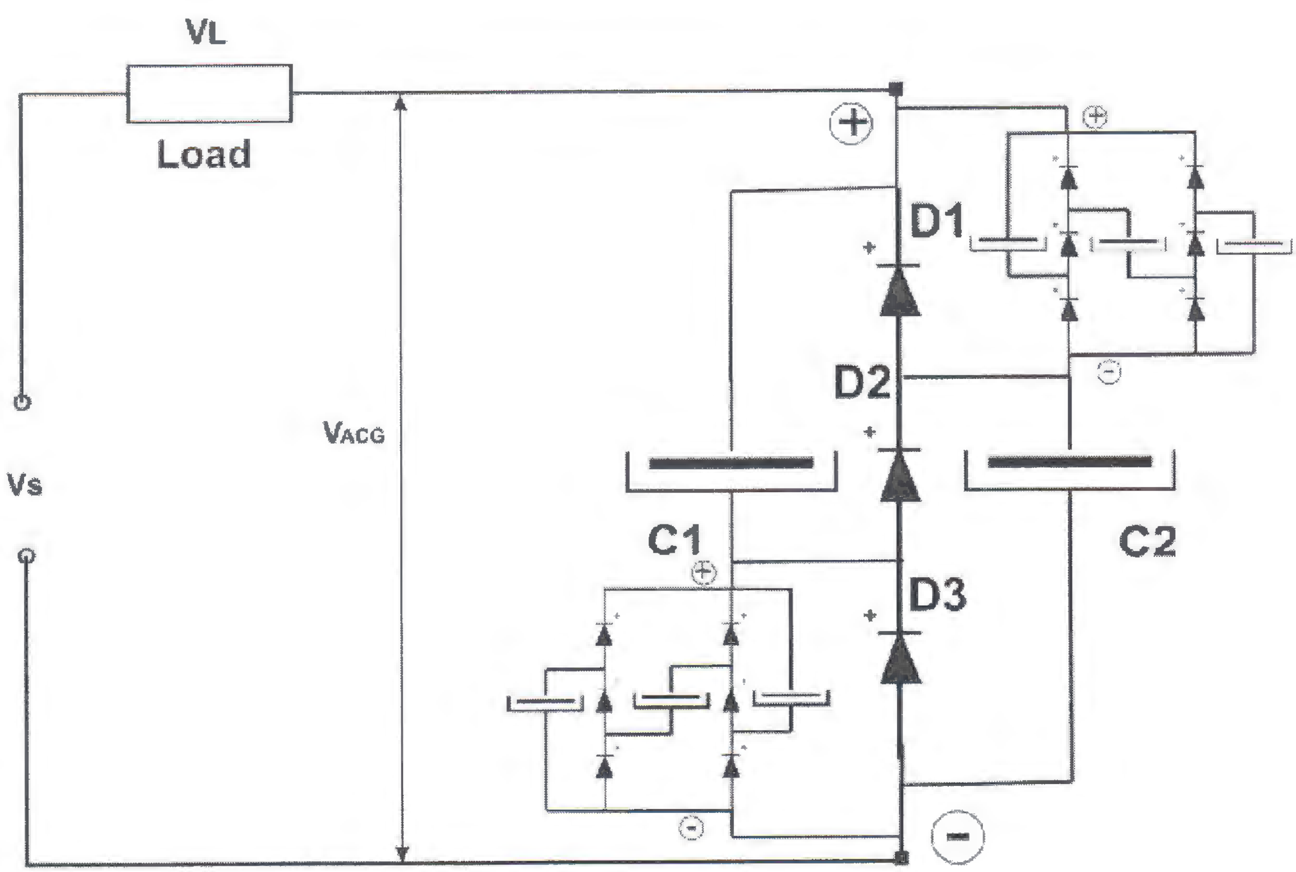
VL
Load
Vs
VACG
D1
D2
C1
C2
D3

Fig 4

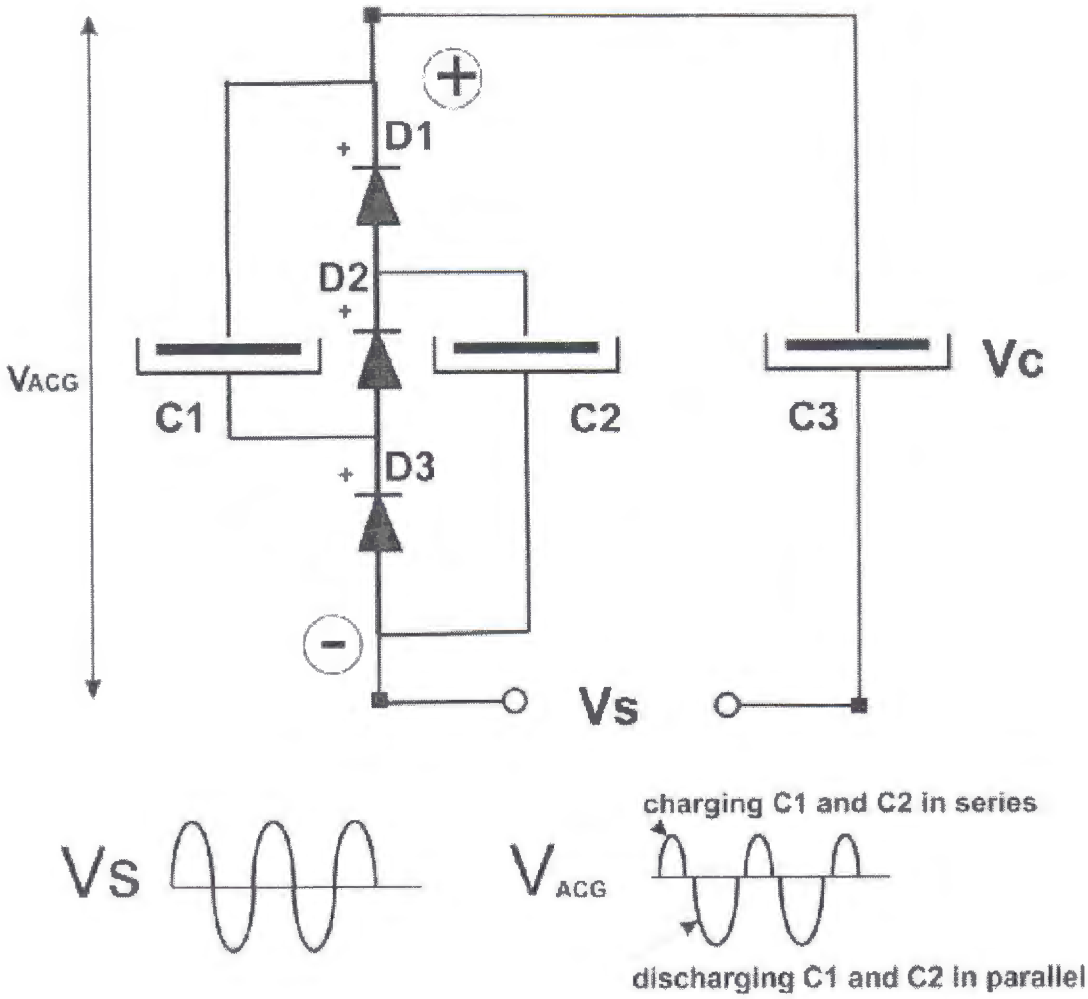
D1
D2
D3
+
+
+
VACG
C1
C2
C3
Vc
Vs
Vs
VACG
charging C1 and C2 in series
discharging C1 and C2 in parallel

Fig 5

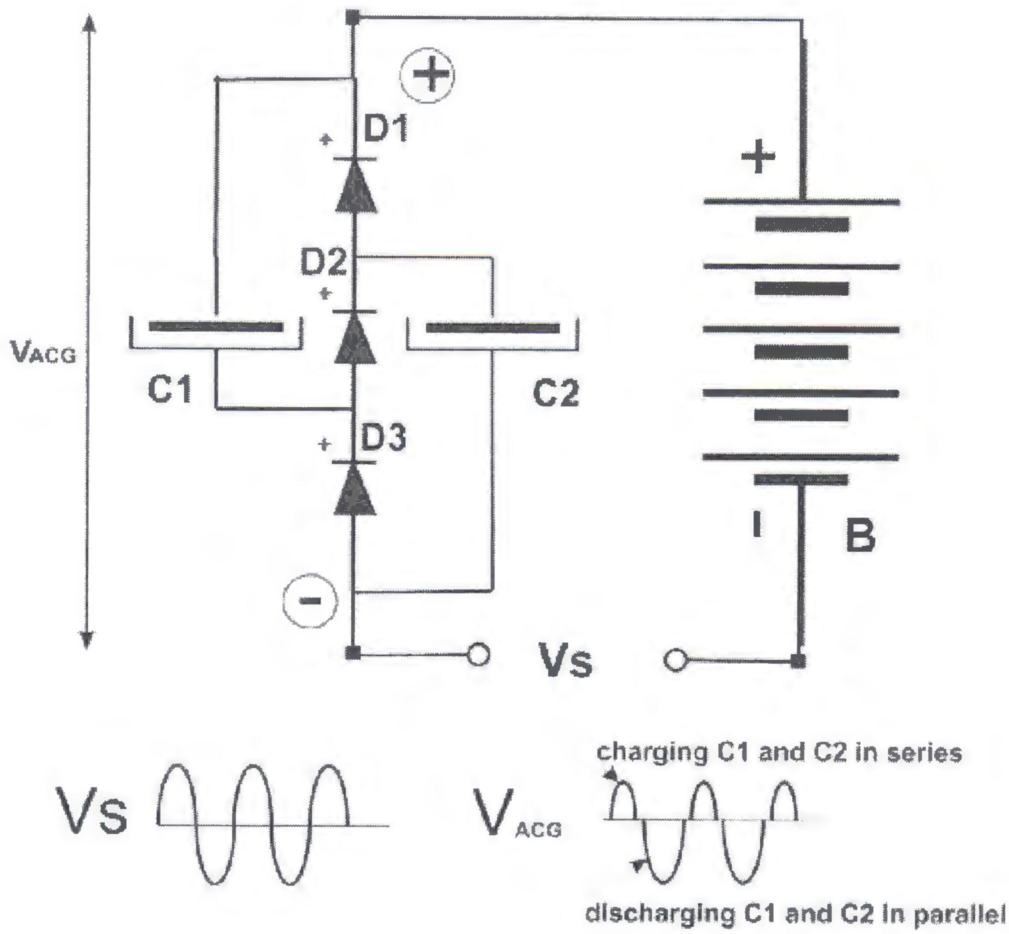
VACG
D1
D2
D3
C1
C2
B
Vs
Vs
VACG
charging C1 and C2 in series
discharging C1 and C2 in parallel

Fig 6

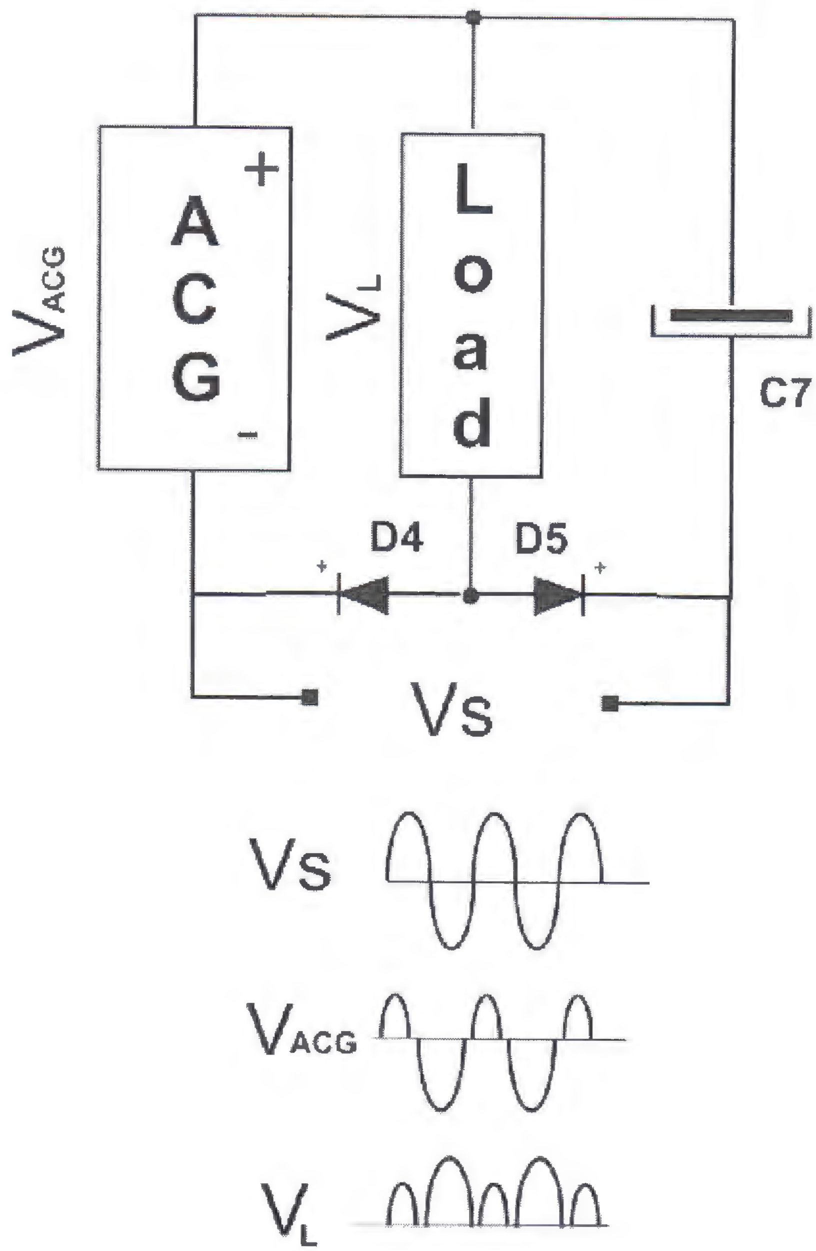

Fig 7

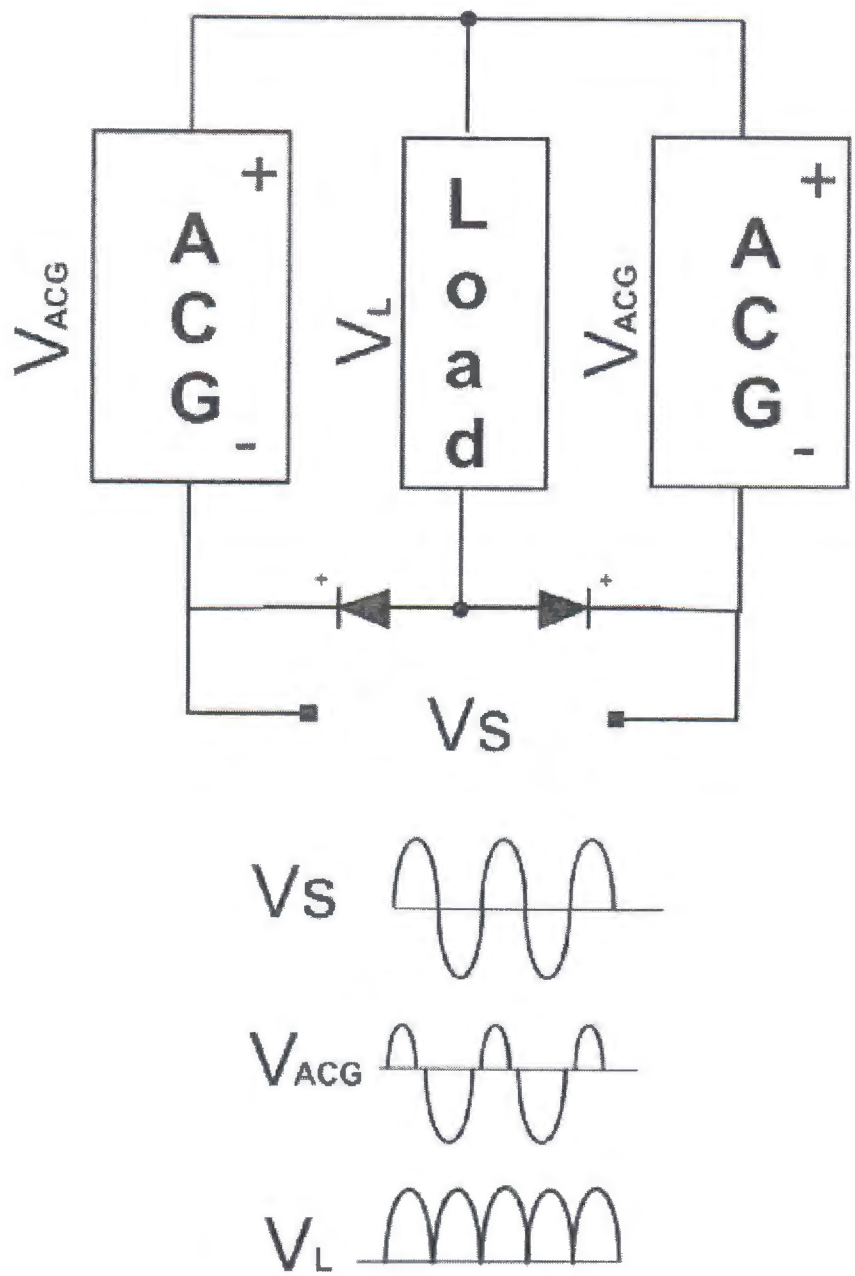

Fig 8

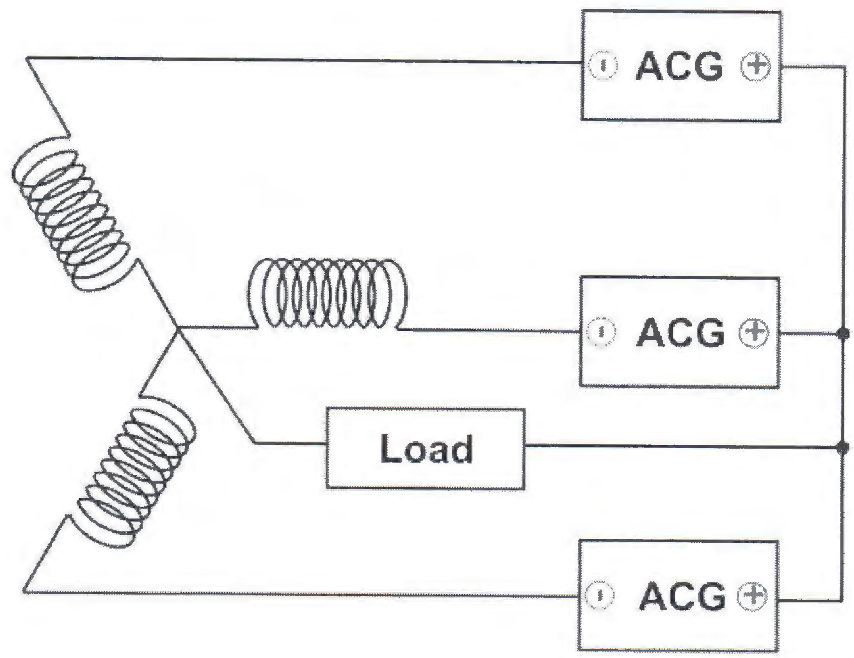

Fig. 9

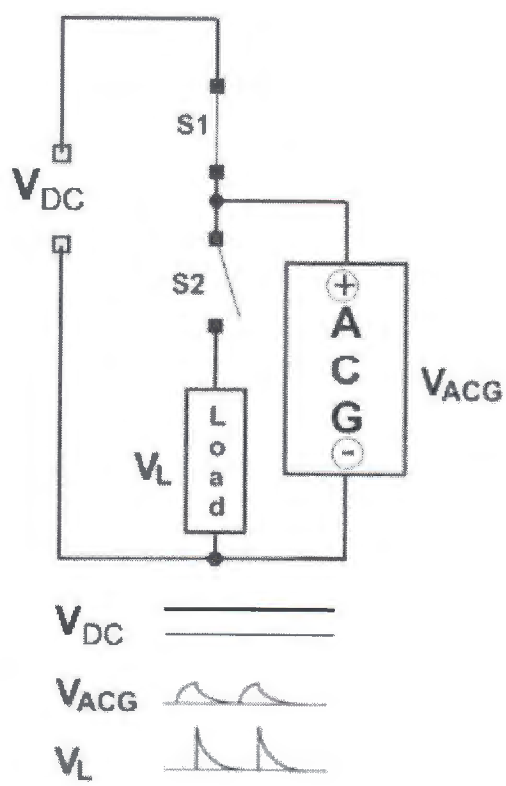

Fig. 10

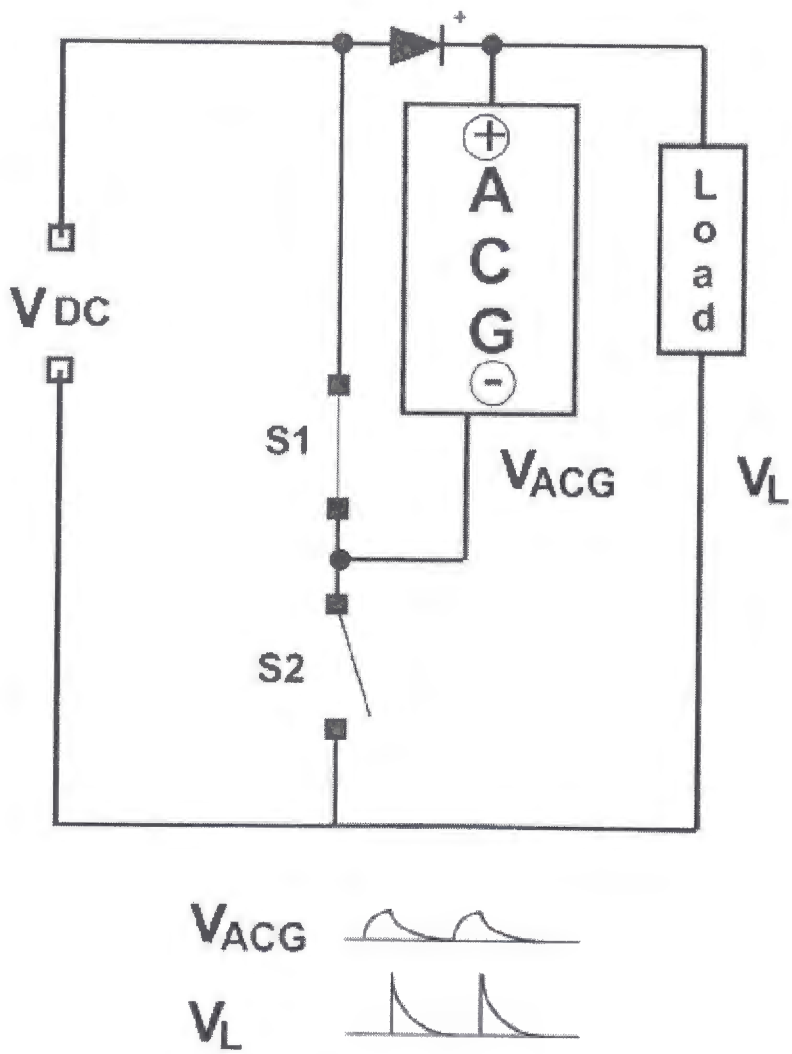

Fig 11

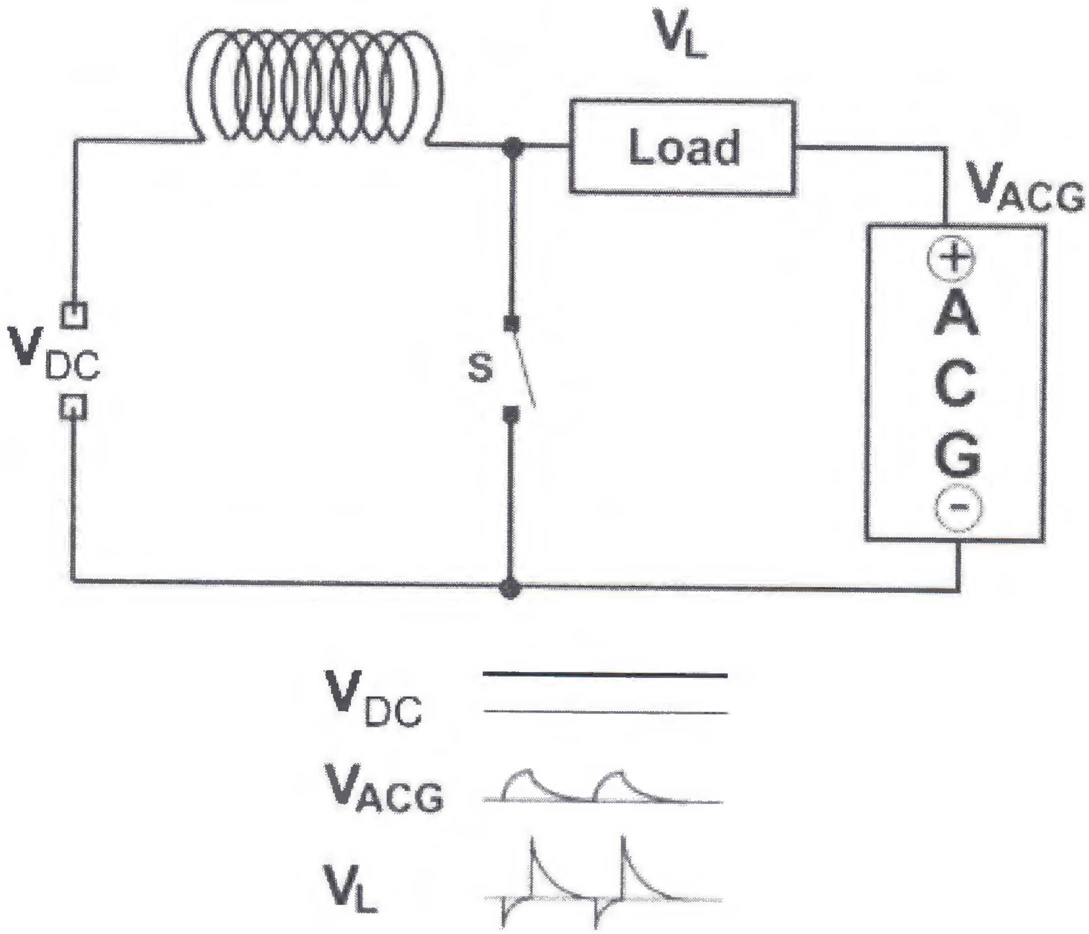

Fig. 12

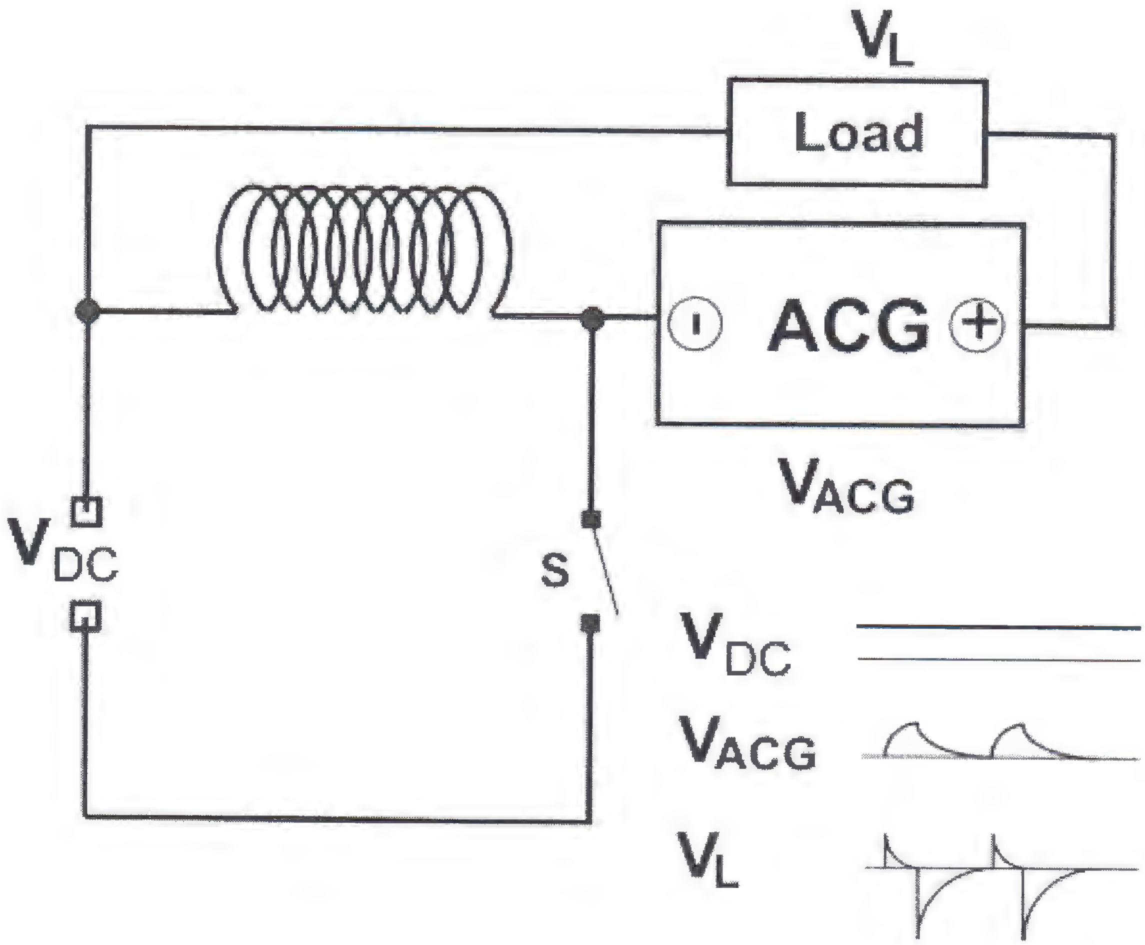

Fig. 13