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(54) **A circuit for the piloting of inductive loads, particularly for operating the electro-injectors of a diesel-cycle internal combustion engine.**

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(73) Proprietor : **MARELLI AUTRONICA S.p.A.**
Via Griziotti 4
I-20145 Milano (IT)

(72) Inventor : **Calfus, Marco**
Strada Superga, 298
I-10132 Torino (IT)

(74) Representative : **Quinterno, Giuseppe et al**
c/o Jacobacci-Casetta & Perani S.p.A. Via Alfieri, 17
I-10121 Torino (IT)

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Jouve, 18, rue Saint-Denis, 75001 PARIS

Description

The present invention relates to a circuit for the piloting of inductive loads, and particularly for the control of the electro-injectors of a diesel-cycle internal combustion engine, of the kind defined in the preamble of the amended Claim 1.

FR-A-2533263 discloses a circuit of this type for driving the fuel injectors in the engine of a motor-vehicle. This known circuit is capable of operating the injectors properly also at very high rotational speeds, but this is possible only if the voltage supply is capable of delivering a sufficient current.

When a circuit of the above-defined kind is used for piloting the injectors of an engine, the voltage supply is typically constituted by the battery of the motor vehicle. In some circumstances, this battery is unable to deliver a sufficiently high current for the piloting circuit to be able to energise the electro-injectors in the desired manner. This may occur, for example, when the battery is not sufficiently charged or when, for various reasons, the impedance "felt" by the battery is unusually high. In such a situation, the prior-art circuit described above is unable to pilot the electro-injectors in a satisfactory manner.

It is therefore an object of the present invention to produce a circuit of the type specified above which is able to ensure the correct functioning of the electro-injectors even when the supply is unable to deliver a current of sufficiently high intensity.

This object is achieved according to the invention by means of a circuit of the type specified above, having the features defined in the characterising portion of Claim 1.

Further advantages of the present invention will become clear from the detailed description which follows with reference to the appended drawings, provided by way of non-limiting example, in which :

Figure 1 is an electrical diagram of a circuit according to the invention, and

Figure 2 is a graph which shows the ideal trace of the excitation current of the solenoid for operating an electro-injector for diesel engines as a function of time, and

Figures 3 to 5 are three sets of graphs which illustrate states of the devices of the circuit according to the invention and signals developed in the circuit in three different operating conditions.

With reference to Figure 1, a circuit according to the invention for the piloting of a plurality of inductive loads L_i comprises an input terminal 1 connected in use to a low-tension, direct-voltage supply V_B, such as a battery. In particular, the inductive loads L_i may represent the solenoids for operating the electro-injectors of a diesel engine for a motor vehicle.

In this case, the supply V_B is constituted by the battery of the motor vehicle.

A storage coil, indicated L_1, can be connected to the input terminal 1 through a controlled electronic switch, generally indicated SW_1, which is open at rest. The switch SW_1 has been shown as an interrupter with which a diode D_1 is connected in parallel. This switch may be be constituted, for example, by an integrated MOSFET-type transistor, and in that case the diode D_1 is constituted by its parasitic diode.

A diode whose anode is connected to earth and whose cathode is connected between the storage coil L_1 and the controlled switch SW_1 is indicated R_1.

A further controlled switch SW_2, similar to SW_1 is connected between L_1 and earth in the manner illustrated.

L_1 is connected to a first terminal of a capacitor C whose other terminal is connected to earth. A plurality of branch circuits is connected in parallel with C and each includes an inductive load L_i in series with which a controlled electronic switch SW_i of a similar type to SW_1 and SW_2 is connected. A respective capacitor C_i may be connected in parallel with each load L_i for quenching it, that is, for rapidly cancelling out the current in the corresponding load L_i when the latter is deactivated.

A resistor and a capacitor, indicated R_c and C_c, are connected in parallel with each other between the earth and a junction N to which are connected the cathodes of diodes D_c, each of which has its anode connected between a load L_i and the associated controlled switch SW_i. The diodes D_c together form an OR-type circuit.

A further controlled switch SW_4, similar to the above, is connected between the junction N and the input 1.

An electronic control unit produced in known manner is indicated ECU and comprises, for example, a microprocessor unit and input/output interface circuits. The unit ECU has a series of inputs connected to the earth of the circuit described above, to the positive pole of the supply V_B, and to a sensor S which is adapted to provide electrical signals indicative of the current flowing in the storage coil L_1 during operation. The sensor S may be constituted, for example, by a Hall-effect sensor. As an alternative to this solution, the non-earth terminal of the capacitor C may be connected to the unit ECU for detecting the current flowing in L_1 : the voltage established across the terminals of C at particular stages of operation is related to the intensity of the current flowing in L_1.

A further alternative solution for the detection of the current flowing in L_1 could be constituted, for example, by a shunt resistor connected in series with L_1 and connected to the ECU.

The unit ECU has a plurality of outputs connected in order to the control inputs of the switches SW_1, SW_2, SW_3 and SW_i.

In order to pilot the electro-injectors of a diesel engine, the unit ECU may be provided with further electrical input signals, such as, for example, the rate of revolution of the engine, etc.

Before describing the operation of the circuit shown in Figure 1, some considerations concerning the ideal trace of the current I_{Li} in the solenoid for operating an electro-injector for a diesel engine will be put forward. This ideal behaviour is shown in Figure 2 as a function of time t. The ideal curve illustrated has a rising slope a followed by a stage b of substantially constant high-current intensity I_{max}, followed by a transition c towards a holding current level I_h. This current is maintained for a certain period of time (section d of the curve) and is then followed by the "quenching" of the current (stage e) with possible inversion and definitive cancelling out of the current (stage f).

For optimal and exact control of the injection it is necessary that the actuation time of individual injectors be precisely controllable. For this purpose, therefore, it is necessary that the times during which the current rises and subsequently falls are extremely short, and less than the minimum injection time by at least one order of magnitude.

With reference to Figures 1, 3 and 4, we shall now see how the circuit according to the invention is able to make the current rise rapidly in a particular load each time that load is to be activated.

Figure 3 shows the states of SW_1, SW_2 and of the switch SW_i associated with the load L_i to be energised, and the traces of the current I_{L1} in the storage coil, of the voltage V_C across the capacitor C and of the current I_{Li} in the load.

In order to make a current pass into the load L_i, the unit ECU causes the switches SW_1 and SW_2 to close at a time t_O. All the other switches remain open. In this condition, an increasing current flows in the storage coil L_1, as shown in Figure 3.

At a subsequent time t_1, SW_1 and SW_2 are opened, whilst the switch SW_i associated with the load to be energised is closed. In this condition, the storage inductor L_1 is disconnected from the supply but is connected to the capacitor C with which it forms a resonant circuit. This resonant circuit is discharged to the load L_i associated with the switch SW_i which is closed. The current I_{Li} decays in the manner illustrated, whilst the voltage across the capacitor C(i) increases and then decreases until it reaches zero at a time t_2. The current in the selected load therefore increases from the time t_1 until it reaches a maximum value at the time t_2, and then starts to decay, as shown in Figure 3. In order to extend the period for which the current persists at high-intensity levels in the load, the unit ECU may be arranged to cause successive openings and closings of SW_1 after the time t_2, with resultant "chopping" of the current I_{Li}, as shown by the broken line in Figure 3.

The rapid transfer of energy from the supply to the generic load L_i by means of storage in L_1 and the consequent discharge of the resonant circuit $L_{1\text{-}C}$ can be achieved, provided that the supply V_B is able to deliver a current of sufficient intensity.

According to the invention, the control unit ECU may be arranged to detect the intensity of the current which can be delivered by the supply. This may be achieved by the acquisition of the signals provided by the sensor S, or by the reading of the voltage across C when SW_1 and SW_2 are open, or even by the reading of the voltage across a shunt resistor arranged in series with the storage coil L_1. When the current delivered by the supply is less than a predetermined value, the unit ECU can also determine (and possibly signal for diagnostic purposes) whether the inadequacy of the current is due to a low charge level of the supply or to an anomaly in the circuitry connected to the supply, by reading the voltage V_B of the supply.

In any case, when the unit ECU detects that the current which can be delivered by the supply is less than a predetermined threshold, it puts into operation a second procedure for the transfer of current to the load L_i selected from time to time. In this procedure, which will now be described with reference to Figures 1 and 4, the unit ECU causes successive simultaneous closures of SW_1 and SW_2, as indicated at the times t_0, t_2 and t_4 in Figure 4. The switches SW_3 and SW_i, however, are kept open.

Upon each closure of SW_1 and SW_2, the current in the storage coil L_i increases until, as at the times t_1, t_3 and t_5, the switches are opened. Upon each opening of SW_1 and SW_2, the voltage across the capacitor C is increased. The diode R_2 prevents the discharge of C during the stage of storage in L_1. The diode P_2 also serves to protect SW_2 when the capacitor C is subsequently discharged.

The voltage across C therefore rises in steps and can be brought to a level greater than that of the supply, until a level V_S is reached (Figure 4) which is sufficient to cause the rapid passage of a high current to the selected load. This injection of current takes place at the time t_6 in Figure 4 (which, at the limit, may be made to coincide with t_s) when the switch SW_i associated with the selected load is closed while all the other switches are open.

The first operating mode of the circuit of Figure 1, described with reference to Figure 3, is preferable since it is more convenient from an energy point of view. However, this operating mode is only possible if the supply is able to deliver sufficent current. When this does not occur, the circuit according to the invention nevertheless enables a rapid injection of current to the loads to be achieved by the charging and subsequent discharging of the capacitor C, as described with reference to Figure 4. The charging of C obviously takes a certain time, which depends on the intensity of the current which can be delivered by the supply. The unit ECU is correspondingly programmed to start the charging of C correspondingly in advance of the time (t_5 in Figure 4) at which the passage of current to the selected load must be triggered.

In practice, the circuit of Figure 1 requires a single large-capacitance capacitor (the capacitor C) which is used for the injection of the current to the loads L_i in a predetermined sequential order actuated by the unit ECU by means of corresponding sequential piloting of the switches SW_i.

Capacitors C_i of considerably smaller capacitance are consequently sufficient to achieve any final inversion of the current in the loads.

Two ways in which the circuit of Figure 1 can cause a current to pass rapidly into a generic load to achieve the portions a and b of the ideal curve of Figure 2 have been described above. This current can be made to flow at the desired holding level (section d of the ideal curve shown in Figure 2) by the opening of the switch SW_1 or the switch SW_i associated with the load. In order subsequently to cancel out the current I_{Li} (stage 2) SW_i is opened. In this condition, a voltage is developed across the load which rises to high values in a short time. A clamping circuit is provided for limiting the value of this voltage and is constituted by the capacitor C_c to which the resistor R_c can be connected. It should be noted that this is a single circuit connected to all the loads L_i by means of the diodes D_c which are connected so as to form an OR circuit.

Together with the switch SW_3, the "clamping" circuit described above also enables the partial recovery of the reactive energy of the load which is excited from time to time, enabling this energy to be recycled towards the supply V_B. This energy recovery, which will now be described, takes place essentially each time a switch SW_i is opened after the injection of current to the associated load L. This can occur essentially in three circumstances, that is, when the current in the load L_i is changed from the maximum level to the holding level (section c of the ideal curve of Figure 2), when the current in the load is quenched (section e of Figure 2) and, although to a lesser extent, during the stages when the current in the load is being chopped, such as, for example, those described with reference to Figure 3.

Figure 5 shows examples of the traces of the current I_i in a load and of the voltage V_c across the clamping capacitor, and the corresponding stages of the switch SW_i associated with the load in question and of the switch SW_3. With reference to this Figure, when, at a time t_0, SW_3 is closed as a result of a command provided by the unit ECU and the switch SW_i associated with the energised load is closed, the current I_{Li} decays, whilst the voltage across the clamping capacitor rises. When the current I_H is reached in the load (a condition which can be detected by the unit ECU, for example, by means of a further Hall-effect sensor associated with L_i) at the time t_1, the unit ECU causes the switch SW_i which was previously been opened, to close again and opens SW_3. In these conditions, the clamping capacitor remains charged at the voltage to which it has previously been brought.

When, at the time t_2, the unit ECU subsequently opens SW_i, the current in the load decays rapidly, whilst the voltage V_c across the clamping capacitor rises rapidly, as shown in Figure 5, until the unit ECU closes SW_3 at the time t_3 and the voltage V_C consequently decreases rapidly.

During the stages when the current in the load which is energised from time to time is decaying, the closure of SW_3 enables part of the reactive energy stored in the load to be returned to the supply, by virtue of the concomitant action of the clamping circuit.

This characteristic may be of considerable interest for applications of the circuit according to the invention in the automotive field, particularly in motor cars provided with batteries and/or with relatively low power-recharging systems.

As far as R_c is concerned, this is only necessary (to dissipate the energy stored in C_c) if the circuit according to the invention is not arranged to recover the reactive energy. In this case, resistors, each connected in parallel with a diode D_c, may be provided in place of R_c.

Further possible applications of the circuit according to the invention are, for example, for controlling the relays which scan the punched cards or tapes in Jacquard-type textile machines, for controlling the electro-injectors of an Otto-cycle engine, for controlling the printing heads of matrix printers, etc.

Claims

1. A circuit for the piloting of inductive loads (L_i), particularly for operating the electro-injectors of a diesel-cycle internal combustion engine, comprising :

an input (1) for connection to a low-tension supply (V_B),

a storage coil (L_1) for storing energy delivered by the supply (V_B), and

electronic switching means (SW_1, SW_2, SW_i) for controlling the connection between the input (1), the storage coil (L_1) and each of the loads (L_i) in a predetermined manner to achieve a rapid transfer of current to each of the loads selectively,

a capacitor (C) which is arranged in parallel with the branch circuits containing the loads (L_i), and which is connected to the coil (L_1) and the electronic switching means (SW_1, SW_2, SW_i), and

an electronic control unit (ECU) for piloting the electronic switching means (SW_1, SW_2, SW_i) according to a first operative mode in which, to transfer current into one of the loads (L_i), the switching means cause in succession, after the connection of the storage coil (L_1) to the supply (V_B) :

the connection of the storage coil (L_1) to the capacitor (C) so as to form a resonant circuit, and

then the discharge of the resonant circuit (L_1, C) into the load (L_i) ;
characterised in that it also includes sensor means (S) for providing electrical signals indicative of the current delivered by the supply (V_B), and in that the control unit (ECU) is connected to the sensor means (S) and is arranged to pilot the electronic switching means (SW_1, SW_2, SW_i) in the first operative mode when the current delivered by the supply is greater than a predetermined value and in a second operative mode when the current delivered by the supply is less than a predetermined value ; the unit (ECU) and said switching means (SW_1, SW_2) being adapted to control the connection of the capacitor (C) and of the storage coil (L_1) to the supply (V_B) so as to form a voltage-boosting means (C, L_1, R_2) in the second operative mode, so as to charge the capacitor (C) to a predetermined voltage level greater than the voltage of the supply, and then the discharge of the energy stored in the capacitor (C) into a selected load (L_i).

2. A circuit according to Claim 1, further including a current-inversion capacitor (C_i) in parallel with each load (L_i) for enabling the current in the corresponding load (L_i) to be cancelled out rapidly, characterised in that each of the inversion capacitors (C_i) has a smaller capacitance than that of the said capacitor (C).

3. A circuit according to Claim 1, characterised in that the sensor means comprise a shunt resistor in series with the storage coil (L_1).

4. A circuit according to Claim 1, characterised in that the sensor means comprise a galvanometric-effect sensor (S), particularly a Hall-effect sensor.

5. A circuit according to Claim 1, characterised in that the control unit (ECU) is adapted to detect the voltage across the capacitor (C).

6. A circuit according to any one of the preceding claims, comprising a plurality of branch circuits in parallel with each other, each of which includes a load (L_i), and in which the electronic switching means comprise

a first switch (SW_1) between the supply (V_B) and the storage coil (L_1),
a second switch (SW_2) in parallel with the branch circuits, and
a control switch (SW_i) in each of the branch circuits, between the corresponding load (L_i) and the supply (V_B),
characterised in that it also includes clamping circuit means (R_c, D_c) for limiting and possibly dissipating the voltage generated by each of the loads (L_i) when the associated control switch (SW_i) cuts off the current flowing into the load (L_i).

7. A circuit according to Claim, 6, characterised in that the clamping circuit means comprise a clamping circuit of the parallel-RC type, and in that the loads (L_i) are connected to the clamping circuit by means of an OR circuit (D_c).

8. A circuit according to any one of the preceding claims, characterised in that it also includes energy-recovery circuit means (SW_3, R_c, C_c) controlled by the unit (ECU) and adapted to enable part of the reactive energy stored in the load (R_i) to be recycled towards the supply (V_b) each time a load (L) is deactivated.

9. A circuit according to Claims 7 and 8, characterised in that the recover circuit means include a further electronic switch (SW_3) connected between the clamping circuit (R_c, C_c) and the supply (V_B) and controlled by the electronic unit (ECU).

Patentansprüche

1. Schaltung zum Ansteuern von iduktiven Lasten (L_i), insbesonders zum Antreiben von Elektroeinspritzventilen eines Dieselmotors mit :

— einem Eingang (1) für den Anschluß an eine Niederspannungsversorgung (V_B),
— einer Speicherspule (L_1) zum Speichern der von der Versorgung (V_B) gelieferten Energie, und
— elektronischen Schaltern (SW_1, SW_2, SW_i) zur Steuerung der Verbindung zwischen dem Eingang (1), der Speicherspule (L_1) und jeder Last (L_i) in einer vorbestimmten Weise, um eine schnelle Übermittlung von Strom zu jeder der ausgewählten Lasten zu erreichen,
— einem Kondensator (C), der parallel zu den die Lasten (L_i) enthaltenden Zweigschaltungen angeordnet ist und der mit der Spule (L_1) und den elektronischen Schaltern (SW_1, SW_2, SW_i) verbunden ist, und
— einer elektronischen Steuereinheit (ECU) zum Ansteuern der elektronischen Schalter (SW_1, SW_2, SW_i) gemäß einem ersten Betriebsmodus, bei dem die Schalter, um Strom in eine der Lasten (L_i) zu leiten, nach dem Verbinden der Speicherspule (L_1) mit der Versorgung (V_B) in Aufeinanderfolge bewirken :
die Verbindung der Speicherspule (L_1) mit dem Kondensator (C), so daß ein Schwingkreis gebildet wird, und anschließend die Entladung des Schwingkreises (L_1, C) in die Last (L_i) ; dadurch gekennzeichnet, daß sie außerdem Sensoren (S) umfaßt, welche dazu dienen, elektrische Signale zu erzeugen, die den von der Versorgung (V_B) gelieferten Strom anzeigen, und daß die Steuereinheit (ECU) mit den Sensoren (S) verbunden und dazu vorgesehen ist, die elektronischen Schalter (SW_1, SW_2, SW_i) in dem ersten Betriebsmodus anzusteuern, wenn der von der Versorgung gelieferte Strom höher ist als ein vorbestimmter Wert, und in einem zweiten Betriebsmodus, wenn der von der Versorgung gelieferte Strom niedriger ist als ein vorbestimmter Wert ; wobei die Einheit (ECU) und die besag-

ten Schalter (SW_1, SW_2) dazu geeignet sind, die Verbindung des Kondensators (C) und der Speicherspule (L_1) mit der Versorgung (V_B) so zu steuern, daß in dem zweiten Betriebsmodus ein spannungserhöhendes Glied (C, L_1, R_2) gebildet wird, so daß der Kondensator (C) bis auf einen vorbestimmten Spannungspegel, der höher ist als die Versorgungsspannung, aufgeladen wird und anschließend die in dem Kondensator (C) gespeicherte Energie in eine bestimmte Last (L_i) entladen wird.

2. Schaltung nach Anspruch 1, die weiters einen mit jeder Last (L_i) parallelgeschalteten Kondensator (C_i) umfaßt, der der Stromumkehr dient, um zu ermöglichen, daß der Strom in der entsprechenden Last (L_i) schnell gelöscht werden kann, dadurch gekennzeichnet, daß jeder dieser invertierend wirkenden Kondensatoren (C_i) eine geringere Kapazität besitzt als der besagte Kondensator (C).

3. Schaltung nach Anspruch 1, dadurch gekennzeichnet, daß die Sensoren einen mit der Speicherspule (L_1) in Serie geschalteten Parallelwiderstand umfassen.

4. Schaltung nach Anspruch 1, dadurch gekennzeichnet, daß die Sensoren einen auf einem galvanometrischen Effekt beruhenden Sensor (S), insbesonders einen Halleffekt-Sensor umfassen.

5. Schaltung nach Anspruch 1, dadurch gekennzeichnet, daß die Kontrolleinheit (ECU) dazu geeignet ist, die an dem Kondensator (C) anliegende Spannung zu ermitteln.

6. Schaltung nach einem der vorhergehenden Ansprüche, die eine Vielzahl einander parallelgeschalteter Zweigschaltungen umfaßt, von denen jede eine Last (L_i) enthält, und bei der die elektronischen Schalter :

— einen ersten Schalter (SW_1) zwischen der Versorgung (V_B) und der Speicherspule (L_1),

— einen zweiten Schalter (SW_2) parallel mit den Zweigschaltungen, und

— einen Steuerschalter (SW_1) in jeder Zweigschaltung zwischen der entsprechenden Last (L_i) und der Versorgung (V_B)

umfassen, dadurch gekennzeichnet, daß sie außerdem als Klemmschaltung wirkende Mittel (R_c, D_c) umfaßt, die der Begrenzung und möglichen Dissipation der von jeder Last (L_i) erzeugten Spannung dienen, wenn der zugehörige Steuerschalter (SW_1) den Stromfluß in die Last (L_i) unterbricht.

7. Schaltung nach Anspruch 6, dadurch gekennzeichnet, daß die Mittel zur Klemmung aus einer Klemmschaltung vom RC-Parallelschaltungstyp bestehen und daß die Lasten (L_i) über eine ODER-Schaltung (D_c) mit der Klemmschaltung verbunden sind.

8. Schaltung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß sie ebenfalls Mittel zur Energierückgewinnung (SW_3, R_c, C_C) beinhaltet, die von der ECU-Einheit gesteuert werden und ermöglichen, daß ein Teil der in der Last (L_i) gespeicherten reaktiven Energie in die Versorgung (V_b) rückgeführt wird, und zwar jedesmal, wenn eine Last (L_i) ausgeschaltet wird.

9. Schaltung nach Anspruch 7 und 8, dadurch gekennzeichnet, daß die der Rückgewinnung dienende Schaltung einen weiteren elektronischen Schalter (SW_3) umfaßt, der zwischen der Klemmschaltung (R_c, C_c) und der Versorgung (V_B) angeschlossen ist und von der elektronischen Einheit (ECU) gesteuert wird.

Revendications

1. Circuit de commande de charges inductives (L_i), en particulier pour faire fonctionner des injecteurs électriques d'un moteur à combustion interne à cycle Diesel, comprenant :

une entrée (1) pour la liaison à une alimentation à basse tension (V_B),

une bobine d'accumulation (L_1) pour accumuler de l'énergie fournie par l'alimentation (V_B), et

des moyens de commutation électronique (SW_1, SW_2, SW_i), pour commander de manière prédéterminée la liaison entre l'entrée (1), la bobine d'accumulation (L_1) et chacune des charges (L_i), afin d'obtenir un passage rapide, de façon sélective, du courant allant à chacune des charges,

un condensateur (C) mis en parallèle avec les circuits de ramification contenant les charges (L_i) et relié à la bobine (L_1) et aux moyens de commutation électronique (SW_1, SW_2, SW_i), et

une unité de commande électronique (ECU) pour commander les moyens de commutation électronique (SW_1, SW_2, SW_i) suivant un premier mode de fonctionnement, dans lequel, pour transférer du courant dans l'une des charges (L_i), les moyens de commutation provoquent successivement, après la liaison de la bobine d'accumulation (L_1) à l'alimentation (V_B) :

la liaison de la bobine d'accumulation (L_1) au condensateur (C), pour former un circuit de résonance, et, ensuite, la décharge du circuit de résonance (L_1, C) dans la charge (L_i) ;

caractérisé en ce qu'il comprend également un moyen de capteur (S) pour produire des signaux électriques représentatifs du courant fourni par l'alimentation (V_B), et l'unité de commande (ECU) étant reliée au moyen de capteur (S) et disposée pour commander les moyens de commutation électronique (SW_1, SW_2, SW_i) suivant le premier mode de fonctionnement lorsque le courant fourni par l'alimentation est supérieur à une vapeur prédéterminée et suivant un second mode de fonctionnement lorsque le courant fourni par l'alimentation est inférieur à une valeur prédéterminée ; l'unité (ECU) et lesdits moyens de commutation (SW_1, SW_2) étant adaptés pour commander la liaison du condensateur (C) et de la bobine d'accumulation (L_1) à l'alimentation (V_B), de façon à former un moyen survolteur (C, L_1, R_2) dans le second mode de fonctionnement, de façon à charger le condensateur (C) à un niveau de tension prédéterminé, supérieur à la tension de l'alimentation, et ensuite à décharger l'énergie stockée dans le condensateur (C) dans une charge (L_i) sélectionnée.

2. Circuit selon la revendication 1, comprenant en outre un condensateur à inversion de courant (C_i), placé en parallèle avec chaque charge (L_i), pour permettre au courant passant dans la charge (L_i) correspondante de tomber rapidement à zéro, caractérisé en ce que chacun des condensateurs à inversion (C_i) présente une capacité inférieure à celle dudit condensateur (C).

3. Circuit selon la revendication 1, caractérisé en ce que le moyen de capteur comprend une résistance de shunt, placée en série avec la bobine d'accumulation (L_1).

4. Circuit selon la revendication 1, caractérisé en ce que le moyen de capteur comprend un capteur à effet galvanométrique (S), en particulier un capteur à effet Hall.

5. Circuit selon la revendication 1, caractérisé en ce que l'unité de commande (ECU) est adaptée pour détecter la tension passant dans le condensateur (C).

6. Circuit selon l'une quelconque des revendications précédentes, comprenant une pluralité de circuits de ramification, placés en parallèle entre eux, chacun comprenant une charge (L_i), et dans lequel les moyens de commutation électronique comprennent

un premier interrupteur (SW_1) mis en circuit entre l'alimentation (V_B) et la bobine d'accumulation (L_1),

un second interrupteur (SW_2) mis en circuit en parallèle avec les circuits de ramification, et

un interrupteur de commande (SW_i) mis en circuit dans chacun des circuits de ramification, entre la charge correspondante (L_i) et l'alimentation (V_B), caractérisé en ce qu'il comprend également des moyens circuit de blocage (R_c, D_c), pour limiter et si possible dissiper la tension produite par chacune des charges (L_i) lorsque l'interrupteur de commande (SW_i) associé coupe le courant passant dans la charge (L_i).

7. Circuit selon la revendication 6, caractérisé en ce que le moyen de circuit de blocage comprend un circuit de blocage du type RC en parallèle, et les charges (L_i) sont reliées au circuit de blocage grâce à un circuit OU (D_c).

8. Circuit selon l'une quelconque des revendications précédentes, caractérisé en ce qu'il comprend également des moyens de circuit de récupération d'énergie (SW_3, R_c, C_c), commandés par l'unité (ECU) et adapté pour permettre de recycler vers l'alimentation (V_B) une partie de l'énergie réactive stockée dans la charge (R_i), chaque fois qu'une charge (L_i) est désactivée.

9. Circuit selon les revendications 7 et 8, caractérisé en ce que les moyens de circuit de récupération comprennent un interrupteur électronique (SW_3) supplémentaire, relié entre le circuit de blocage (R_c, C_c) et l'alimentation (V_B) et commandé par l'unité électronique (ECU).

FIG. 1

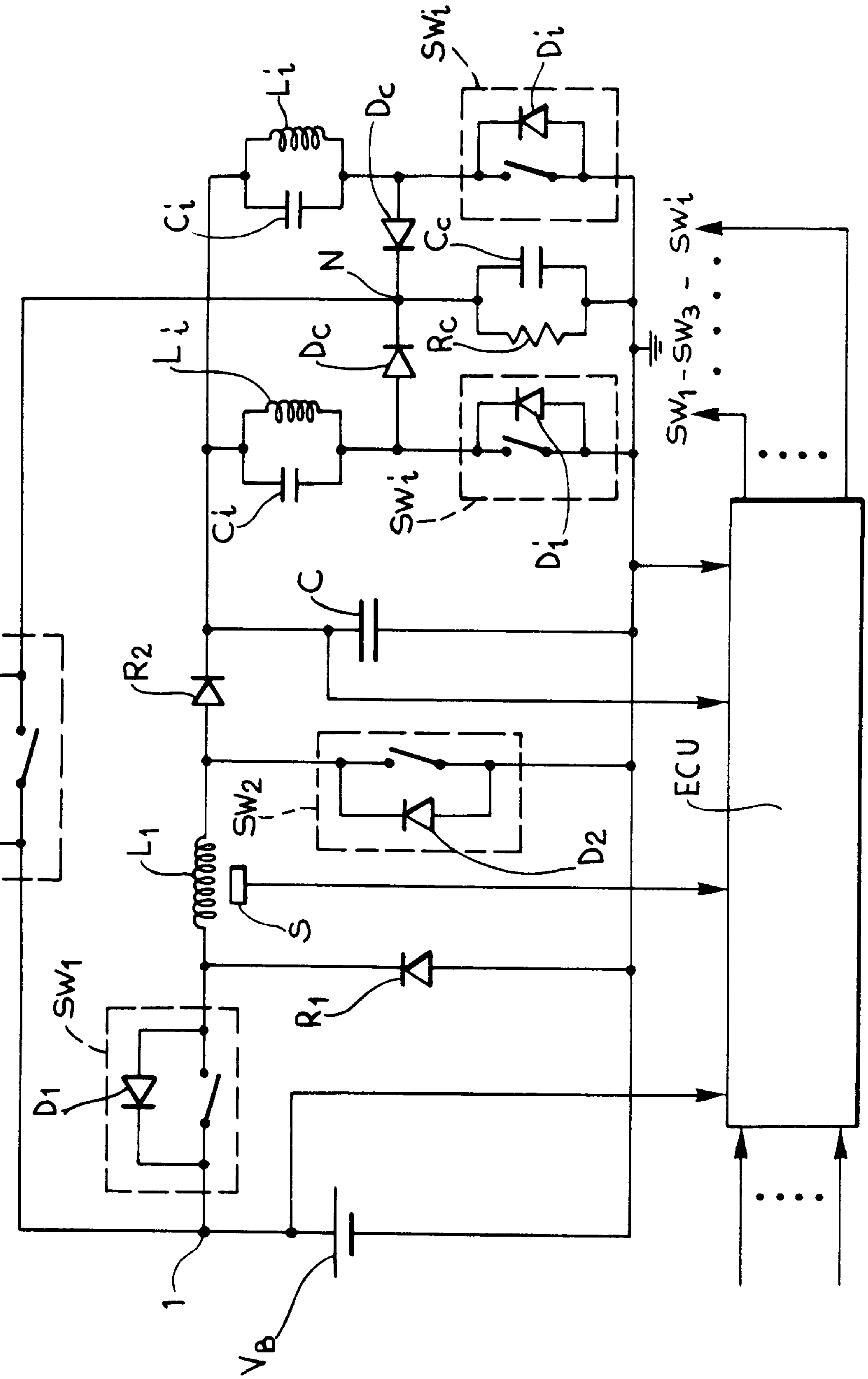

SW3
D3
SW1
D1
L1
S
R1
R2
SW2
D2
C
ECU
Ci
Li
Dc
N
Cc
Rc
SWi
Di
VB
1
SW1 - SW3 - . . . . - SWi

FIG. 2

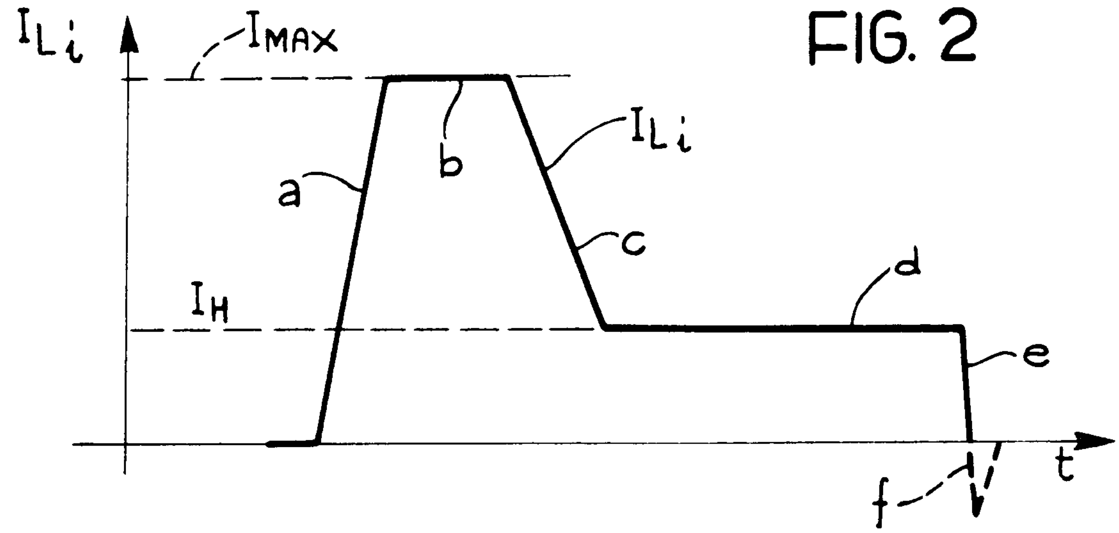

ILi
IMAX
a
b
ILi
c
IH
d
e
t
f

FIG. 5

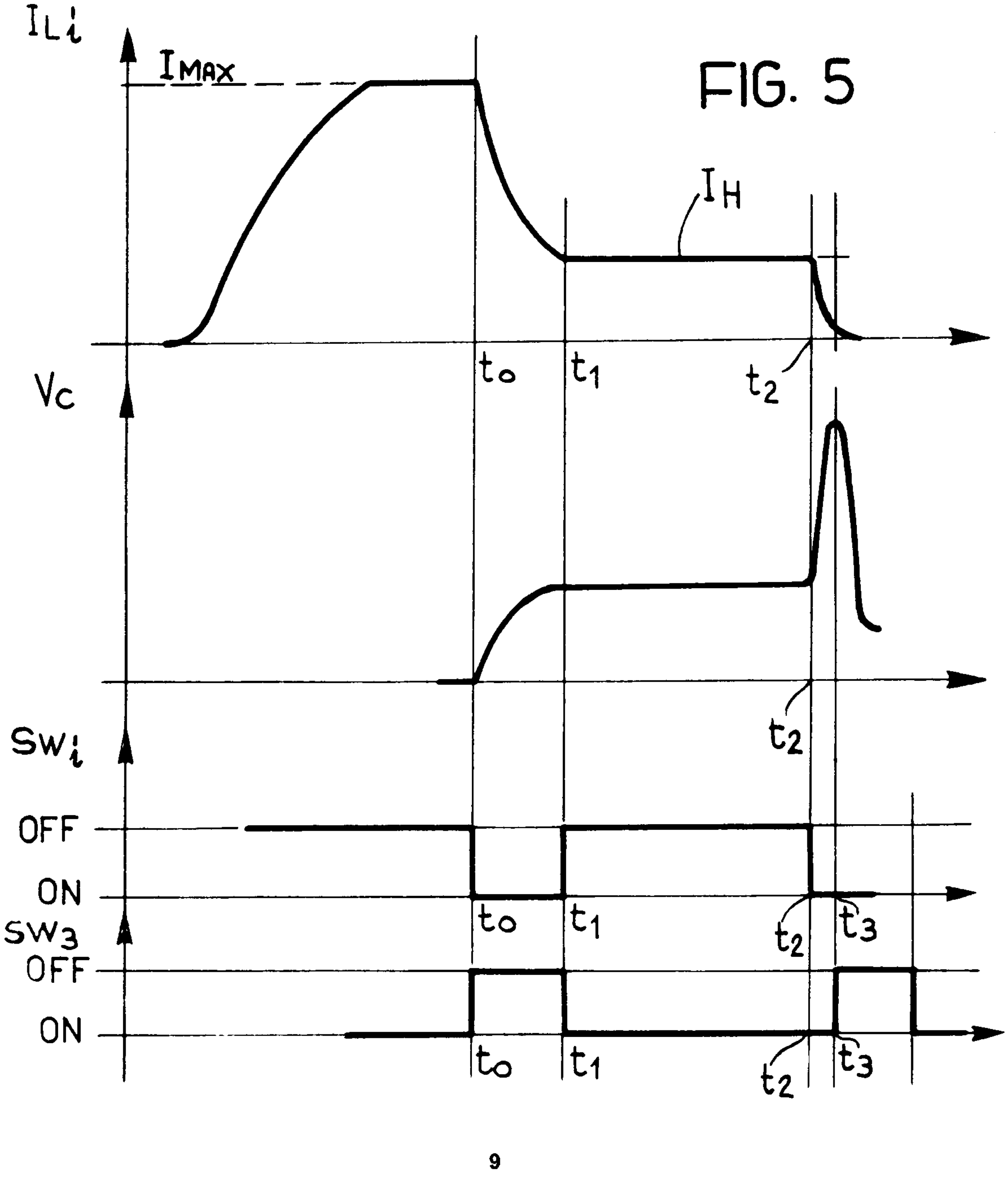

ILi
IMAX
IH
t0
t1
t2
Vc
t2
SWi
OFF
ON
t0
t1
t2
t3
SW3
OFF
ON
t0
t1
t2
t3

FIG. 3

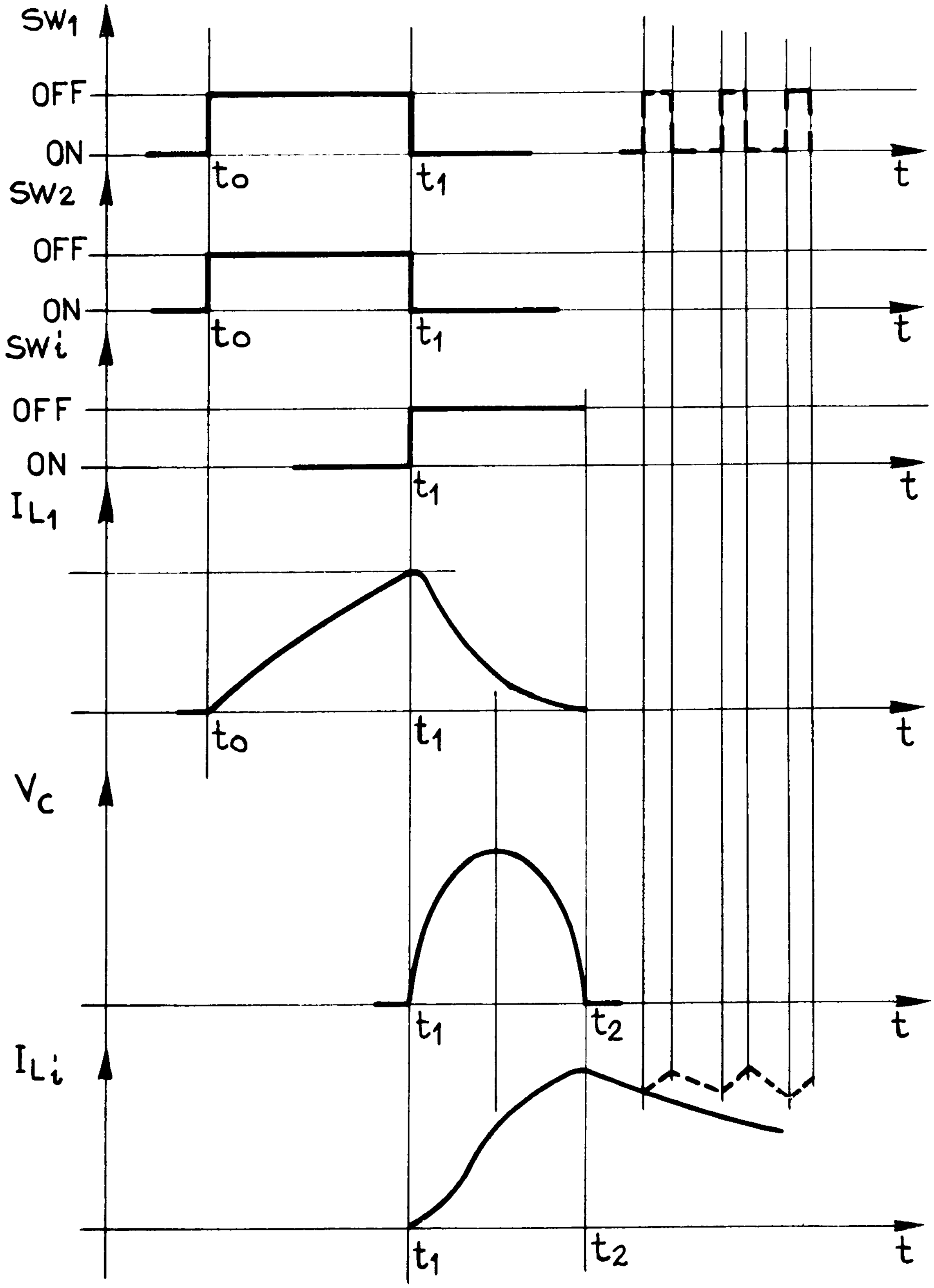
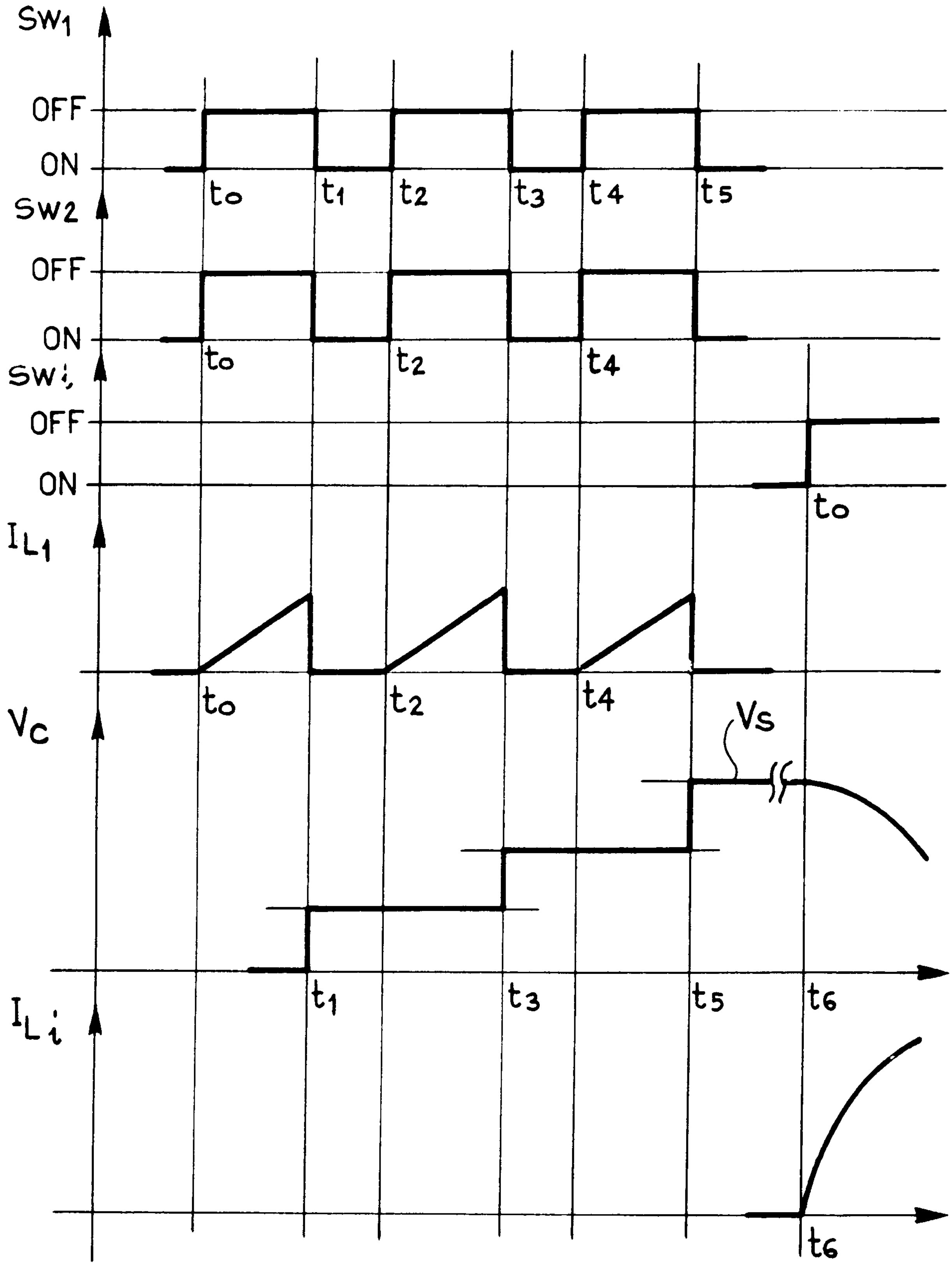

SW1
OFF
ON
t0
t1
t
SW2
OFF
ON
t0
t1
t
SWi
OFF
ON
t1
t
IL1
t0
t1
t
Vc
t1
t2
t
ILi
t1
t2
t

FIG. 4


Sw1
OFF
ON
t0
t1
t2
t3
t4
t5
Sw2
OFF
ON
t0
t2
t4
Swi
OFF
ON
t0
IL1
t0
t2
t4
Vc
Vs
t1
t3
t5
t6
ILi
t6