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(54) CIRCUIT FOR AN ELECTROMAGNETIC SWITCHING DEVICE

SCHALTKREIS FÜR EIN ELEKTROMAGNETISCHES SCHALTGERÄT

CIRCUIT POUR UN DISPOSITIF DE COMMUTATION ÉLECTROMAGNÉTIQUE

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Description

[0001] The present invention relates to a circuit for providing a freewheeling current to a coil of an electromagnetic switching device.

[0002] An electromagnetic switching device is typically used for controlling flow of electrical current in an electrical circuit. The electromagnetic switching device is controllable for switching between on and off states for closing and breaking a power supply circuit. The electromagnetic switching device may be manually or electrically controlled. To control the electromagnetic switching device electrically, magnets may be employed to actuate a movable contact element for breaking and closing the power supply circuit.

[0003] Typically, the movable contact element is moved to engagement with a stationary contact element for closing the power supply circuit. The stationary contact element is electrically connected to the power supply. Thus, the power supply circuit is closed when movable contact element is in engagement with the stationary contact element. The magnets employed to actuate the movable contact element are energized by a coil. The coil is energized by a current flowing through the coil. Document US 6061224 discloses a device according to the preamble of claim 1.

[0004] It is an object of the embodiments of the invention to reduce heat dissipation across a freewheeling diode of a circuit for providing a freewheeling current to the coil in an electromagnetic switching device.

[0005] The above object is achieved by a circuit for providing a freewheeling current to a coil of an electromagnetic switching device according to claim 1.

[0006] The freewheeling current is provided to the coil via the switch. The heat dissipation at the switch is lower than the heat that would have been dissipated at the diode if the freewheeling current was provided to the coil via the diode. This enables in deployment of relatively smaller heat sinks for dissipation of the heat produced at the switch, and thus, achieving reduction in cost and size. The switch being controlled responsive to the voltage across the diode enables in preventing short circuit as the switch and the supply switch are not turned at the same time.

[0007] According to an embodiment, the circuit further comprises a controller configured to provide a control signal to the switch responsive to the voltage across the diode. The switch is operable responsive to the control signal provided by the controller. The control signal generated by the controller is responsive to the voltage detected across the diode.

[0008] According to another embodiment, the switch is a solid state static switch. Solid state static switch has a lower voltage drop than the voltage drop across the freewheeling diode. As the voltage drop is less, the heat dissipation is also less with respect to the freewheeling diode.

[0009] According to yet another embodiment, the switch is adapted to be in an on state to conduct the freewheeling current. The switch is turned on responsive to the voltage across the diode to conduct the freewheeling current.

[0010] According to yet another embodiment, the switch is adapted to be in an off state when the dc supply source is electrically connected to the coil. The switch is turned off responsive to the voltage across the diode. This achieves is preventing short circuit when the dc supply source is electrically connected to the coil.

[0011] According to yet another embodiment, the switch comprises a body diode. Certain solid state static switches comprise a diode internally referred to as a body diode.

[0012] According to yet another embodiment, the body diode is adapted as the freewheeling diode. Adapting the body diode as the freewheeling diode eliminates the need of using an external diode.

[0013] According to yet another embodiment, the switch is an MOSFET or an IGBT.

[0014] Another embodiment includes, an apparatus for driving a coil of an electromagnetic switching device, the apparatus comprising the circuit according to any of the claims 1 to 8, a supply switch adapted to electrically connect and disconnect the coil to the dc supply source, and a power supply controller configured to control the supply switch. This enables in controlling the supply switch..

[0015] According to another embodiment, the power supply controller is configured to provide a first control signal and a second control signal to the supply switch. The supply switch is operable responsive to the first control signal and the second control signal.

[0016] According to yet another embodiment, the power supply controller is configured to provide the first control signal and the second control signal to the supply switch responsive to a current flowing through the coil. Thus, the supply switch can be controlled responsive to the current flowing through the coil.

[0017] According to yet another embodiment, the power supply controller is configured to provide the first control signal and the second control signal to the supply switch for respective predefined time periods. The supply switch is operable for respective predefined time periods responsive to the respective control signals.

[0018] According to yet another embodiment, the power supply controller is configured to provide the first control signal to the supply switch for providing a pick-up current the coil and is configured to provide the second control signal to the supply switch for providing a hold-on current to the coil. The pick-up current is the current required for energizing the coil for the circuit closing motion of the contact element. The hold-on current is the current provided to the coil from the dc supply source in order to maintain the contactor in the circuit closing position.

[0019] According to yet another embodiment, the supply switch is adapted to perform a high frequency switching responsive to the second control signal. Performing a high frequency switching enables in reducing the current being provided to the coil and thus, provide the hold-on current to the coil.

[0020] Another embodiment includes, an electromagnetic switching device comprising the apparatus according to any one of the claims 9 to 14.

[0021] Embodiments of the present invention are further described hereinafter with reference to illustrated embodiments shown in the accompanying drawings, in which:

FIG 1a illustrates a carrier of an electromagnetic switching device according to an embodiment herein,

FIG 1b illustrates an assembly of an electromagnet system and the carrier 1 of FIG 1a according to an embodiment herein, and

FIG 2 illustrates a schematic diagram of an apparatus for supplying a pick-up current, a hold-on current and a freewheeling current to a coil according to an embodiment herein, and

FIG 3 illustrates a schematic diagram of an apparatus for supplying a pick-up current, a hold-on current and a freewheeling current to a coil and the change in polarity of the coil when the coil is electrically disconnected from a dc supply source according to an embodiment herein.

[0022] Various embodiments are described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purpose of explanation, numerous specific details are set forth in order to provide a thorough understanding of one or more embodiments. It may be evident that such embodiments may be practiced without these specific details.

[0023] Referring to FIG. 1a, a carrier 1 of an electromagnetic switching device is illustrated according to an embodiment herein. A contact element 3 is supported in the carrier to be movable form a circuit breaking position to a circuit closing position, wherein the contact element 3 is moved to be in contact with a stationary contact element to be in the circuit closing position. The stationary contact may be connected to the input power supply.

[0024] FIG 1b illustrates an assembly of an electromagnet system and the carrier 1 of FIG 1a according to an embodiment herein. In the shown example of FIG 1b, the carrier 1 comprises a column 7 extending vertically upwards. The electromagnet system 8 is supported on the column 7 to actuate the carrier. In the present embodiment, the electromagnet system 8 is shown as comprising electromagnetic armatures 9, 13. However, the electromagnet system 8 may be designed in another way comprising fewer or more electromagnetic armatures. Typically, the electromagnetic armatures 9, 13 are adapted to actuate the carrier 1. The electromagnetic armature 9 engages the column 7 via a member 11 for transferring the armature 9 movement to the carrier 1. The carrier 1 in turn moves the contact element 3 into the circuit closing position. In the shown example of FIG 1b, the electromagnetic armature 9 is in engagement with the column mechanically via the member 11. However, the electromagnetic armature 9 may be engaged with the column 7 using other known mechanical means. Another electromagnetic armature 13 comprising coils 17 is also supported on the column 7. In the shown example of FIG 1b two coils 17 have been illustrated. However, in certain implementations the magnetic armature may comprise only a single coil 17. The coils 17 are energized by supplying a current provided by a dc supply source. On the coils 17 being energized, the electromagnetic armature 9 is drawn towards the electromagnetic armature 13. This movement of the armature 9 is transferred to the carrier 1 and to the contact element 3 for the circuit closing motion. However, in other embodiments, the carrier 1 may comprise a column extending vertically downwards and the electromagnetic armature 9 and the electromagnetic armature 13 may be supported on the column.

[0025] In the circuit closing motion, the contact element 3 is moved to be in contact with the stationary contact element. The contact element 3 in contact with the stationary contact element is said to be in the circuit closing position. The current required for energizing the coil 17 for the circuit closing motion of the contact element 3 is hereinafter referred to as a pick-up current. In an aspect, once the contact element 3 is moved to the circuit closing position, the contact element 3 can be maintained in the circuit closing position by providing a hold-on current and a freewheeling current. The hold-on current is the current provided to the coil from the dc supply source in order to maintain the contactor in the circuit closing position. The freewheeling current herein is referred to the current provided to the coil 17 from the energy stored in the coil 17 to maintain the coil 17 in the circuit closing position.

[0026] Typically, the pick-up current is relatively of a very high value than the hold-on current. For example, the pick-up current required for energizing a coil is about five to ten times the hold-on current. Advantageously, the duration for which the contact element 3 is maintained in the circuit closing position by providing the freewheeling current to the coil is substantially greater than the duration for which the hold-on current is provided to the coil 17. By maintaining the contact element 3 in the circuit closing position using the freewheeling current, reduction in the electrical power to be supplied to the coil 17 from an external source is achieved.

[0027] FIG 2 illustrates a schematic diagram of an apparatus 18 for supplying a pick-up current, a hold-on current and a freewheeling current to the coil according to an embodiment herein. In the example of FIG 2, the pick-up current for energizing the coil 17 and the hold-on current for maintaining the coil 17 in a circuit closing position is provided to the coil 17 from the dc supply source 20 using a supply switch 19. The supply switch 19 is operable for providing the pick-up current to the coil 17 during circuit closing motion and is operable for providing the hold-on current to the coil 17 for maintaining the contact element 3 of FIG 1a in a circuit closing position. For example, the switch 19 may be a solid state static switch. In the shown example of FIG 2, one supply switch 19 is illustrated for providing the pick-up current and the hold-on current to the coil 17. However, in an aspect, two supply switches may be deployed for providing the pick-up current and the hold-on current to the coil 17. For example, one of the supply switches can be configured for providing the pick-up current to the coil 17 during circuit closing motion and the other supply switch can be configured for providing the hold-on current to the coil 17 for maintaining the contact element 3 of FIG 1b at the circuit closing position. Use of two supply switches for providing the pick-up current and the hold-on current to the coil 17 respectively reduces electrical losses occurring at the supply switches.

[0028] Referring still to FIG 2, the apparatus 18 further comprises a power supply controller 21 to control the switch 19 for providing the pick-up current and the hold-on current. According to an aspect, the switch 19 can be controlled responsive to the current flowing through the coil 17. In an aspect, the current flowing through the coil 17 can provided to the power supply controller 21 by a conditioning circuit. The controller 21 may be a processor, a microcontroller, and the like. During the circuit closing motion, the switch 19 is turned on to provide the pick-up current to the coil 17. The power supply controller 21 can control the switch 19 by providing a first control signal. Once, the contact element 3 is in contact with the stationary contact element, the current flowing through the coil 17 decreases. This decrease in the current flowing through the coil 17 is detected by the power supply controller 21. The power supply controller 21 in response to the decrease in the current provides a second control signal to the switch 19. The switch 19 is operable for high frequency switching to provide the hold-on current to the coil 17 responsive to the second control signal. The second control signal, in an example, can be a PWM pulse. The high frequency switching performed by the switch 19 reduces the current flowing through the coil 17 and thus provides the hold-on current to the coil 17 to maintain the contact element 3 in the circuit closing position.

[0029] However, according to another aspect, the power supply controller 21 can be configured to control the switch 19 for providing the pick-up current and the hold-on current for respective predefined time periods to the coil 17. Thus, in accordance to the present aspect, the conditioning circuit may not be required as the control of the switch 19 is not responsive to the current flowing through the coil 17, but is time based. For example, the power supply controller 21 can be configured to provide the first control signal for a predefined time period so that the switch 19 is operable for providing the pick-up current to the coil 17 for the predefined time period. Similarly, the power supply controller 21 can be configured to provide the second control signal for a predefined time period so that the switch 19 is operable for providing the hold-on current to the coil 17 for the predefined time period. For example, the power supply controller 21 can be configured to operate the switch 19 for providing the pick-up current to the coil 17 for about 100 ms and can be configured to operate the switch 19 for providing the hold-on current through high frequency switching for about 10-15% of the time period of maintaining the contact element in circuit closed position.

[0030] The supply switch 19 may be a solid state static switch selected such that it is suitable for carrying high currents and also Perform high frequency switching with minimum frequency loses. In aspects two supply switches are deployed, one supply switch 19 can be a transistor, such as an IGBT and the other supply switch can be an MOSFET. An IGBT is capable of carrying high currents and an MOSFET is capable of performing high frequency switching with minimum switching loses.

[0031] Referring still to FIG 2, in an aspect, the apparatus 18 further comprises a circuit 25 for providing a freewheeling current to the coil 17. The circuit 25 comprises a freewheeling diode 27 for conducting the freewheeling current when an electrical supply to the coil 17 is disconnected. As illustrated in the example of FIG 2, the freewheeling diode 27 is connected in parallel to the coil 17 in a reverse direction with respect to the polarity of the dc supply source 20, i.e., an anode of the freewheeling diode 27 is connected to the negative terminal of the dc supply source 18 and the cathode of the freewheeling diode 27 is connected to the positive terminal of the dc supply source 18. The circuit 25 further comprises a switch 30 connected in parallel to the freewheeling diode 27. According to an aspect, the switch 30 can be a solid state static switch, such as an IGBT or an MOSFET. In accordance with an embodiment, the switch 30 is used for providing the freewheeling current to the coil 17 instead of the freewheeling diode 27 as the voltage drop across the switch 30 is less than the voltage drop occurring at the freewheeling diode 27 if the freewheeling current is conducted by the freewheeling diode 27. The switch 30 is adapted to be in an on state and an off state responsive to a voltage across the freewheeling diode 27. The circuit 25 comprises a controller 35 configured to detect the voltage across the freewheeling diode 27 and provide a control signal to the switch 30 responsive to the voltage detected across the freewheeling diode 27. The switch is operable to be in the on state and the off state responsive to the control signal. For an example, the switch 30 can be adapted to be in the on state when the control signal is being provided and in the off state when no control signal is being provided. In an aspect, certain solid state static switches comprise a diode internally referred generally as a body diode. Advantageously, if the solid state static switch comprises the body diode, the same can be adapted as the freewheeling diode

27. This eliminates the need of using an external diode as the freewheeling diode 27.

[0032] Referring still to FIG 2, during the circuit closing motion when the pick-up current is being provided to the coil 17, the switch 19 is closed and the current flows from the positive terminal of the dc supply source 18 to the negative terminal though the coil 17 for a predefined time period. Once the contact element 3 is in the circuit closed position, the switch 19 is operable to conduct the hold-on current and the hold-on current flows through the coil 17 for a certain pre-defined time period. Thereafter, the supply switch 19 is turned off so that the energy stored at the coil 17 can be used for maintaining the contact element 3 in the form of the freewheeling current. For example, for a PWN signal of 10 KHz used for providing the hold-on current to the coil 17, the hold-on current to the coil 17 may be provided for 10 to 15 μs. For the remaining 85 to 90 μs, the oil 17 can be energized by the freewheeling current for retaining the contact element 3 in the circuit closed position. When the pick-up current and the hold-on current are being provided to the coil 17, the currents flow though the coil 17 and the freewheeling diode 27 does not conduct the currents as the freewheeling diode 27 is reversed biased. The switch 30 is maintained in the off state when the supply switch 19 is in the on state, thus, allowing the current to flow though the coil 17 and avoiding short circuit. As the freewheeling diode 27 is reversed biased, the voltage drop occurring across the freewheeling diode 27 is negative. The controller 35 on detecting the negative voltage drop across the freewheeling diode 27 is configured to maintain the switch 30 in the off state and the switch 30 being in the off state conducts no current.

[0033] Referring now to FIG 3, when the supply switch 19 is turned off, the current flow from the positive terminal of the dc supply source 18 to the negative terminal is broken. The coil 17 being an inductor will attempt to resist the sudden drop of current by using its stored magnetic field energy to create its own voltage. An extremely large negative potential is created where there was once a positive potential, and a positive potential is created where there was once a negative potential, as designated in FIG 3. Due to this, the freewheeling diode 27 is forward biased relative to the changed polarity of the coil 27 and conducts the freewheeling current, as indicated by the arrow 40 from the positive potential at the bottom of the coil 17 to the negative potential at the top of the coil 17. When the freewheeling current is being conducted by the freewheeling diode 27, the voltage drop occurring across the freewheeling diode 27 is positive. For example, the voltage drop across the diode is about 0.7 to 2 volts. The controller 35 on detecting this positive voltage turns on the switch 30 allowing it to conduct the freewheeling current in a loop as indicated by the arrow 45. When the switch 30 is turned on to conduct the freewheeling current, the freewheeling ceases to flow though the freewheeling diode 27. Using the switch 35 to provide the freewheeling current to the coil 17 enables in reducing the heat dissipation across the freewheeling diode 27 as the freewheeling diode 27 does not conduct the freewheeling current. As the heat dissipation across the freewheeling diode 27 is reduced, smaller heat sinks can be deployed for dissipation of heat, and thus, reduction in cost is achieved.

[0034] At the end of the freewheeling period, i.e., when the coil 17 is to be energized for maintaining the contact element 3 of FIG 1b in the circuit closing position using the hold-on current to be provided by the dc supply source 20, the coil 17 is electrically connected to the dc supply source 20 using the switch 19. However, care is to be taken that when the supply switch 19 is switched on, the switch 30 is turned off to avoid occurrence of a short circuit. The supply switch 19 and the switch 30 can be damaged on the occurrence of a short circuit. In the embodiments herein, the controller 35 is configured to turn the switch 30 off when the supply switch 19 is turned on. Referring now to FIG 2, after the freewheeling period when the supply switch 19 is turned on, the current starts flowing from the positive terminal of the dc supply source 18 to the negative terminal of the dc supply source 18 via the coil 17, and the freewheeling diode 27 is reversed biased. As the freewheeling diode 27 is reversed biased, the voltage drop occurring across the freewheeling diode 27 is negative. The controller 35 on detecting the negative voltage drop across the freewheeling diode 27 being more negative than a threshold is configured to turn off the switch 30 and the switch 30 being in the off state conducts no current. Thus, the switch 30 is turned off when the supply switch 19 is turned on to energize the coil 17, and thus, avoiding short circuit.

Example:

[0035] Assuming the voltage drop across the freewheeling diode 27 to be 1.5 V and the voltage drop across the switch 30 to be 0.5 V. Assuming the freewheeling current to be 3 A. Heat dissipation across the diode and the switch is computed as power dissipation.

[0036] Power dissipation across freewheeling diode is:

$$= V \times I \text{ W} = 1.5 \times 3 = 4.5 \text{ W}$$

[0037] Power dissipation across switch is:

$$= V \times I \text{ W} = 0.5 \times 3 = 1.5 \text{ W}$$

[0038] As the voltage drop across the switch is less than the voltage drop across the diode, the power dissipation across the switch is less than the power dissipation across the freewheeling diode.

[0039] The embodiments described herein enable in providing the freewheeling current to the coil with reduced heat dissipation. This allows for use of smaller heat sinks and, thus, achieves in reduction of cost. Turning off the switch conducting the freewheeling current when the supply switch is turned on enables in preventing short circuit.

Claims

1. A circuit (25) for providing a freewheeling current to a coil (17) of an electromagnetic switching device, the circuit (25) comprising:

   - a freewheeling diode (27) connectable in parallel to the coil (17) in a reverse direction with respect to a polarity of a dc supply source (20) supplying electrical power to the coil (17), **characterised by**
   - a switch (30) connected in parallel to the freewheeling diode (27),

   wherein the switch (30) is controllable responsive to a voltage across the freewheeling diode (27).

2. The circuit (25) according to claim 1, further comprising a controller (35) configured to provide a control signal to the switch (30) responsive to the voltage across the freewheeling diode (27).

3. The circuit (25) according to claims 1 or 2, wherein the switch (30) is a solid state static switch.

4. The circuit (25) according to any one of the claims 1 to 3, wherein the switch (30) is adapted to be in an on state to conduct the freewheeling current.

5. The circuit (25) according to any one of the claims 1 to 4, wherein the switch (30) is adapted to be in an off state when the dc supply source (20) is electrically connected to the coil (17).

6. The circuit (25) according to any one of the claims 1 to 5, wherein the switch (30) comprises a body diode.

7. The circuit (25) according to claim 6, wherein the body diode is adapted as the freewheeling diode (25).

8. The circuit (25) according to claim any one of the claims 1 to 7, wherein the switch (30) is an MOSFET or an IGBT.

9. An apparatus (18) for driving a coil (17) of an electromagnetic switching device, the apparatus (18) comprising:

   - the circuit (25) according to any of the previous claims,
   - a supply switch (19) adapted to electrically connect and disconnect the coil (17) to the dc supply source (20), and
   - a power supply controller (21) configured to control the supply switch (19).

10. The apparatus (18) according to claim 9, wherein the power supply controller (21) is configured to provide a first control signal and a second control signal to the supply switch (19).

11. The apparatus (18) according to claim 9, wherein the power supply controller (21) is configured to provide the first control signal and the second control signal to the supply switch (19) responsive to a current flowing through the coil (17).

12. The apparatus (18) according to claim 9, wherein the power supply controller (21) is configured to provide the first control signal and the second control signal to the supply switch (19) for respective predefined time periods.

13. The apparatus (18) according to claim 9, wherein the power supply controller (21) is configured to provide the first control signal to the supply switch (19) for providing a pick-up current to the coil (17) and is configured to provide the second control signal to the supply switch (19) for providing a hold-on current to the coil (17).

14. The apparatus (18) according to any one of the claims 10 to 13, wherein the supply switch (19) is adapted to perform a high frequency switching responsive to the second control signal.

15. An electromagnetic switching device comprising the apparatus (18) according to any one of the claims 9 to 14.

Patentansprüche

1. Schaltkreis (25) zum Bereitstellen eines Freilaufstroms für eine Spule (17) eines elektromagnetischen Schaltgeräts, wobei der Schaltkreis (25) Folgendes umfasst:

   - eine Freilaufdiode (27), die sich in Bezug auf eine Polarität einer Gleichstromversorgungsquelle (20), die die Spule (17) mit Strom versorgt, in umgekehrter Richtung zur Spule (17) parallelschalten lässt, **gekennzeichnet durch**
   - einen Schalter (30), der zur Freilaufdiode (27) parallelgeschaltet ist,

   wobei sich der Schalter (30) als Reaktion auf eine an der Freilaufdiode (27) anliegende Spannung steuern lässt.

2. Schaltkreis (25) nach Anspruch 1, der ferner eine Steuerung (35) umfasst, die so konfiguriert ist, dass sie als Reaktion auf die an der Freilaufdiode (27) anliegende Spannung für den Schalter (30) ein Steuersignal bereitstellt.

3. Schaltkreis (25) nach Anspruch 1 oder 2, bei dem es sich bei dem Schalter (30) um einen statischen Halbleiterschalter handelt.

4. Schaltkreis (25) nach einem der Ansprüche 1 bis 3, bei dem der Schalter (30) so ausgelegt ist, dass er sich zum Leiten des Freilaufstroms in einem eingeschalteten Zustand befindet.

5. Schaltkreis (25) nach einem der Ansprüche 1 bis 4, bei dem der Schalter (30) so ausgelegt ist, dass er sich in einem ausgeschalteten Zustand befindet, wenn die Gleichstromversorgungsquelle (20) elektrisch mit der Spule (17) verbunden ist.

6. Schaltkreis (25) nach einem der Ansprüche 1 bis 5, bei dem der Schalter (30) eine Body-Diode umfasst.

7. Schaltkreis (25) nach Anspruch 6, bei dem die Body-Diode als Freilaufdiode (25) ausgelegt ist.

8. Schaltkreis (25) nach einem der Ansprüche 1 bis 7, bei dem es sich bei dem Schalter (30) um einen MOSFET oder IGBT handelt.

9. Vorrichtung (18) zum Ansteuern einer Spule (17) eines elektromagnetischen Schaltgeräts, wobei die Vorrichtung (18) Folgendes umfasst:

- den Schaltkreis (25) nach einem der vorhergehenden Ansprüche,
- einen Versorgungsschalter (19), der so ausgelegt ist, dass er die Spule (17) elektrisch mit der Gleichstromversorgungsquelle (20) verbindet und davon trennt, und
- eine Stromversorgungssteuerung (21), die so konfiguriert ist, dass sie den Versorgungsschalter (19) steuert.

10. Vorrichtung (18) nach Anspruch 9, bei der die Stromversorgungssteuerung (21) so konfiguriert ist, dass sie ein erstes und ein zweites Steuersignal für den Versorgungsschalter (19) bereitstellt.

11. Vorrichtung (18) nach Anspruch 9, bei der die Stromversorgungssteuerung (21) so konfiguriert ist, dass sie als Reaktion auf einen durch die Spule (17) fließenden Strom das erste und das zweite Steuersignal für den Versorgungsschalter (19) bereitstellt.

12. Vorrichtung (18) nach Anspruch 9, bei der die Stromversorgungssteuerung (21) so konfiguriert ist, dass sie das erste und das zweite Steuersignal für jeweils vorgegebene Zeiträume für den Versorgungsschalter (19) bereitstellt.

13. Vorrichtung (18) nach Anspruch 9, bei der die Stromversorgungssteuerung (21) so konfiguriert ist, dass sie zum Bereitstellen eines Anzugsstroms für die Spule (17) das erste Steuersignal und zum Bereitstellen eines Haltestroms für die Spule (17) das zweite Steuersignal für den Versorgungsschalter (19) bereitstellt.

14. Vorrichtung (18) nach einem der Ansprüche 10 bis 13, bei der der Versorgungsschalter (19) so ausgelegt ist, dass er als Reaktion auf das zweite Steuersignal ein hochfrequentes Schalten durchführt.

15. Elektromagnetisches Schaltgerät mit der Vorrichtung (18) nach einem der Ansprüche 9 bis 14.

Revendications

1. Circuit (25) pour délivrer un courant de roue libre à une bobine (17) d'un dispositif de commutation électromagnétique, le circuit (25) comprenant :

- une diode (27) de roue libre pouvant être connectée en parallèle à la bobine (17) dans un sens inverse par rapport à une polarité d'une source (20) d'alimentation CC délivrant une énergie électrique à la bobine (17), **caractérisé par**
- un commutateur (30) connecté en parallèle à la diode (27) de roue libre,

dans lequel le commutateur (30) peut être commandé en réponse à une tension traversant la diode (27) de roue libre.

2. Circuit (25) selon la revendication 1, comprenant en outre un contrôleur (35) configuré pour délivrer un signal de commande au commutateur (30) en réponse à la tension traversant la diode (27) de roue libre.

3. Circuit (25) selon la revendication 1 ou 2, dans lequel le commutateur (30) est un commutateur statique à semiconducteurs.

4. Circuit (25) selon l'une quelconque des revendications 1 à 3, dans lequel le commutateur (30) est adapté à être dans un état activé pour conduire le courant de roue libre.

5. Circuit (25) selon l'une quelconque des revendications 1 à 4, dans lequel le commutateur (30) est adapté à être dans un état inactivé lorsque la source

(20) d'alimentation CC est électriquement connectée à la bobine (17).

6. Circuit (25) selon l'une quelconque des revendications 1 à 5, dans lequel le commutateur (30) comprend une diode de corps.

7. Circuit (25) selon la revendication 6, dans lequel la diode de corps est adaptée comme la diode (27) de roue libre.

8. Circuit (25) selon l'une quelconque des revendications 1 à 7, dans lequel le commutateur (30) est un MOSFET ou un IGBT.

9. Appareil (18) pour exciter une bobine (17) d'un dispositif de commutation électromagnétique, l'appareil (18) comprenant :

- le circuit (25) selon l'une quelconque des revendications précédentes,
- un commutateur (19) d'alimentation adapté à connecter et déconnecter électriquement la bobine (17) à/de la source (20) d'alimentation CC, et
- un contrôleur (21) d'alimentation électrique configuré pour commander le commutateur (19) d'alimentation.

10. Appareil (18) selon la revendication 9, dans lequel le contrôleur (21) d'alimentation électrique est configuré pour délivrer un premier signal de commande et un deuxième signal de commande au commutateur (19) d'alimentation.

11. Appareil (18) selon la revendication 9, dans lequel le contrôleur (21) d'alimentation électrique est configuré pour délivrer le premier signal de commande et le deuxième signal de commande au commutateur (19) d'alimentation en réponse à un courant traversant la bobine (17).

12. Appareil (18) selon la revendication 9, dans lequel le contrôleur (21) d'alimentation électrique est configuré pour délivrer le premier signal de commande et le deuxième signal de commande au commutateur (19) d'alimentation sur des périodes de temps respectives prédéfinies.

13. Appareil (18) selon la revendication 9, dans lequel le contrôleur (21) d'alimentation électrique est configuré pour délivrer le premier signal de commande au commutateur (19) d'alimentation pour délivrer un courant minimal d'excitation à la bobine (17) et est configuré pour délivrer le deuxième signal de commande au commutateur (19) d'alimentation pour délivrer un courant de maintien à la bobine (17).

14. Appareil (18) selon l'une quelconque des revendications 10 à 13, dans lequel le commutateur (19) d'alimentation est adapté à exécuter une commutation haute fréquence en réponse au deuxième signal de commande.

15. Dispositif de commutation électromagnétique comprenant l'appareil (18) selon l'une quelconque des revendications 9 à 14.

FIG 1a

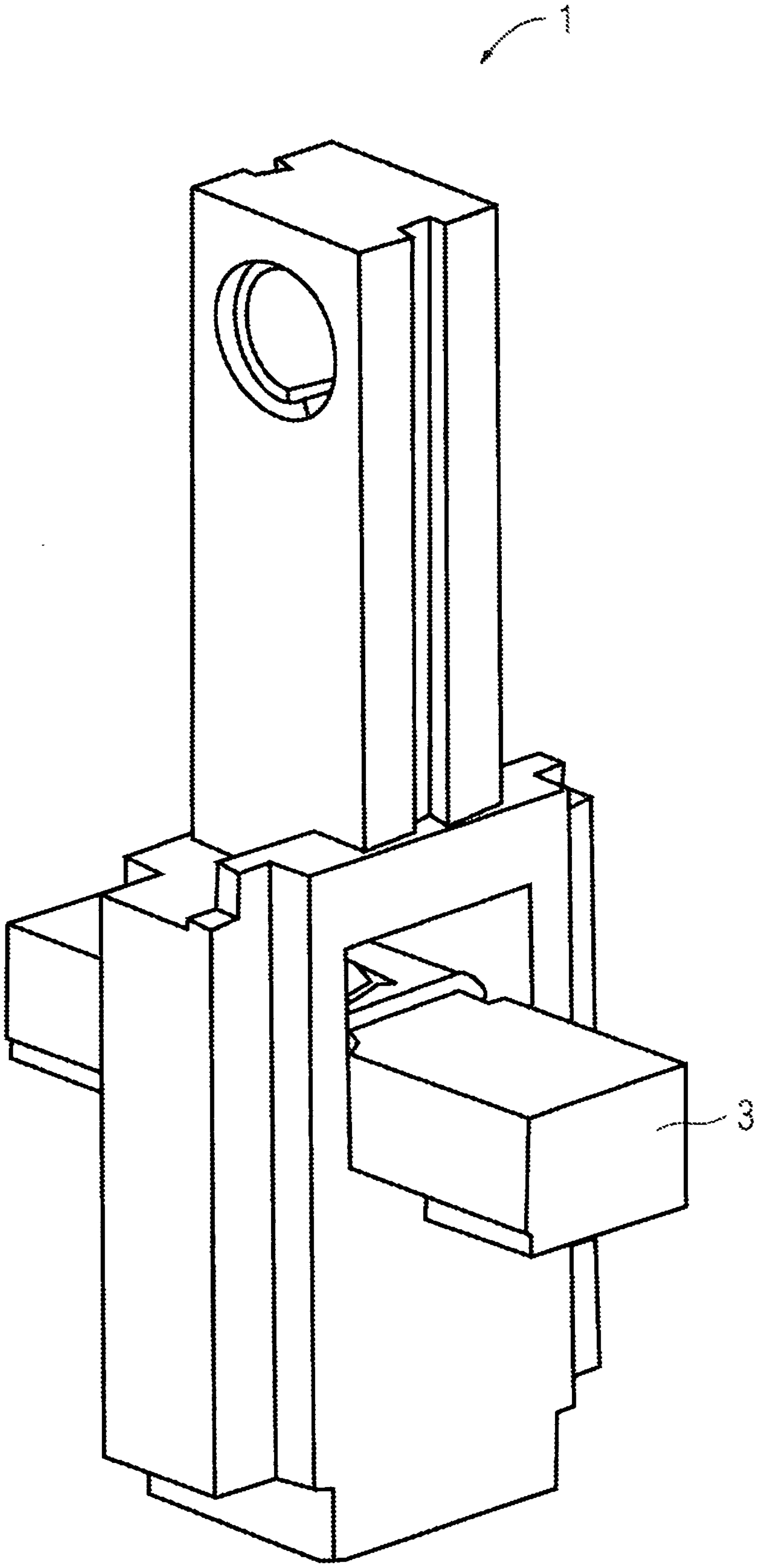


FIG 1b

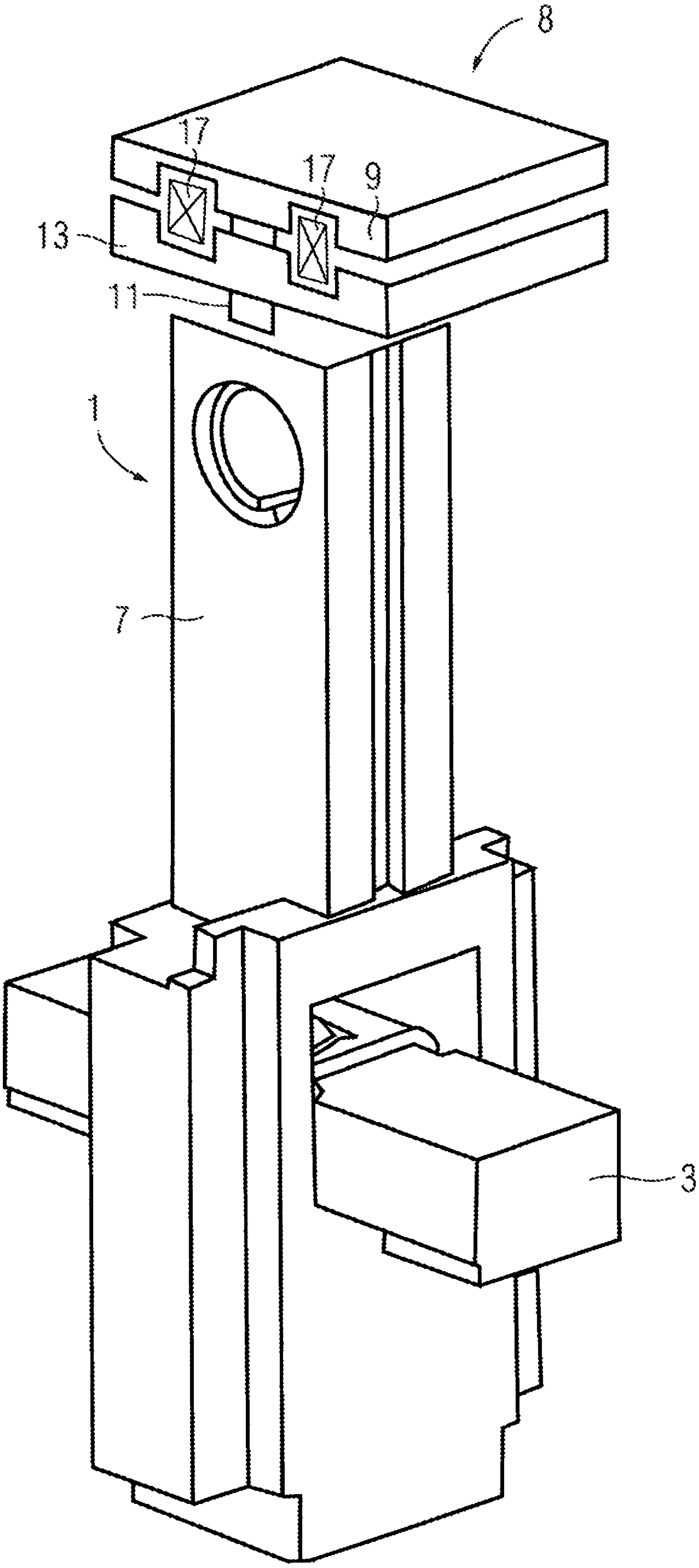


FIG 2

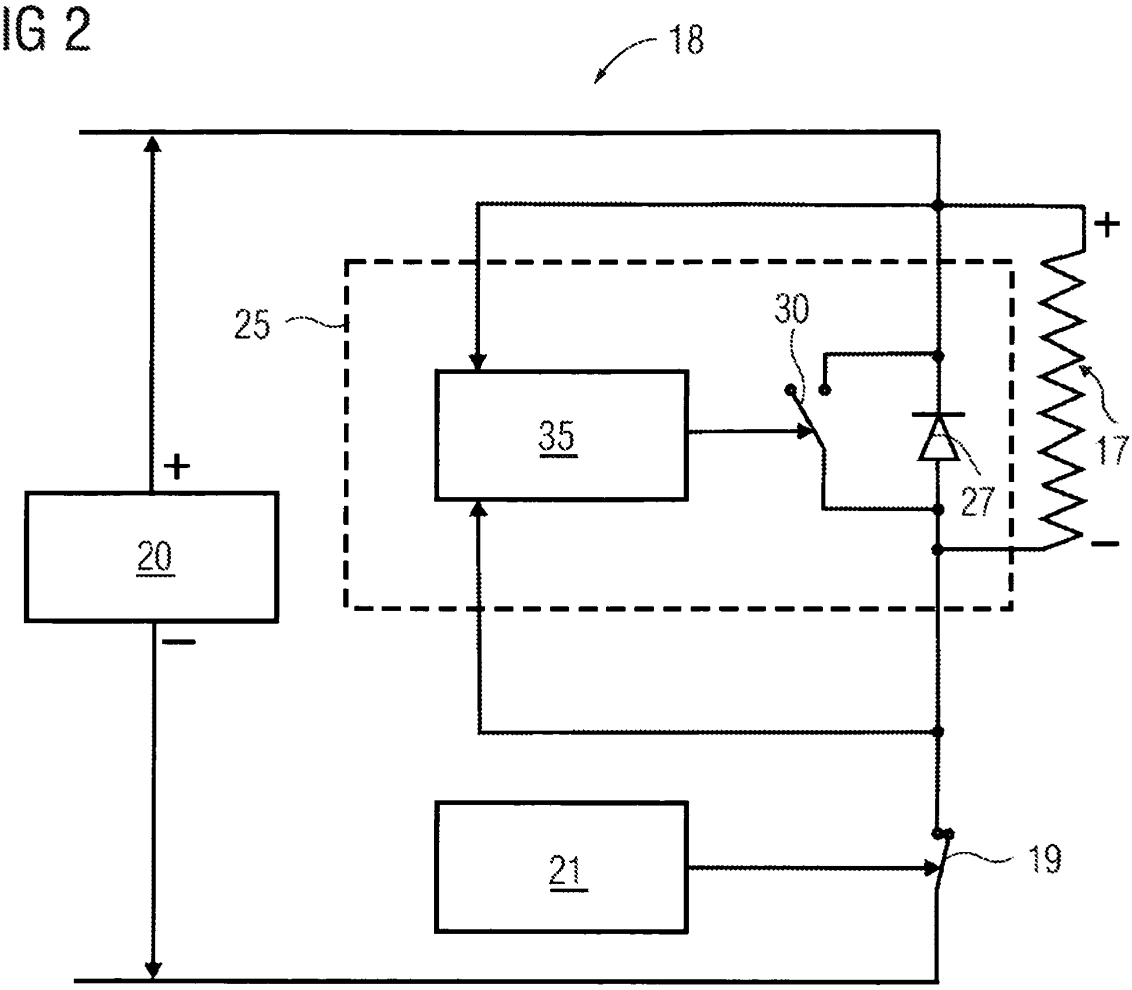
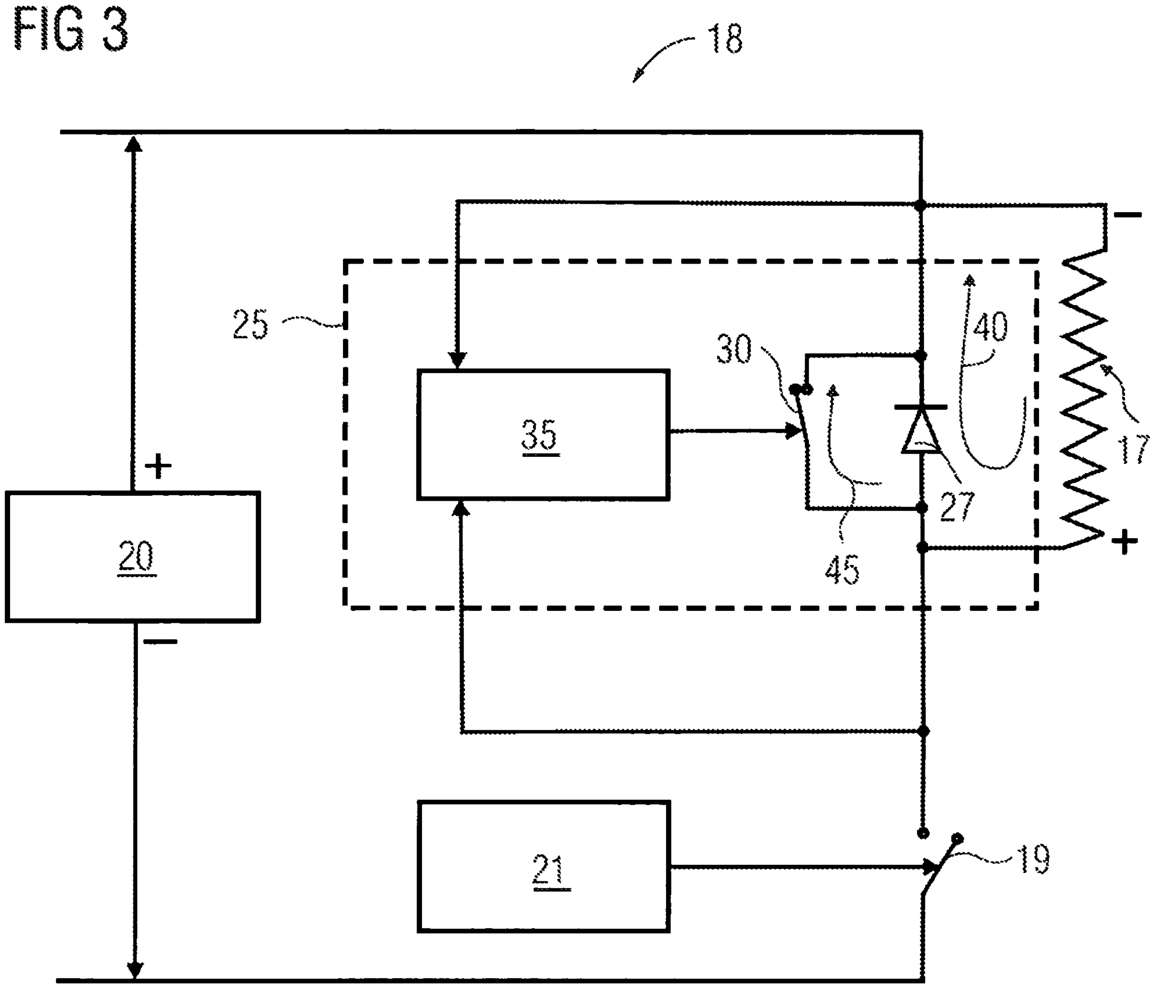


FIG 3



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Patent documents cited in the description

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