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(54) **APPLICATION APPARATUS, MOTOR ASSEMBLY AND INTEGRATED CIRCUIT FOR DRIVING MOTOR**

(71) Applicant: **Johnson Electric S.A.**, Murten (CH)

(72) Inventors: **Yue LI**, Shenzhen (CN); **Chi Ping SUN**, Shenzhen (CN); **Bao Ting LIU**, Shenzhen (CN); **En Hui WANG**, Shenzhen (CN); **Fei XIN**, Shenzhen (CN); **Shing Hin YEUNG**, Shenzhen (CN); **Xiu Wen YANG**, Shenzhen (CN); **Li Sheng LIU**, Shenzhen (CN); **Yan Yun CUI**, Shenzhen (CN); **Shu Juan HUANG**, Shenzhen (CN)

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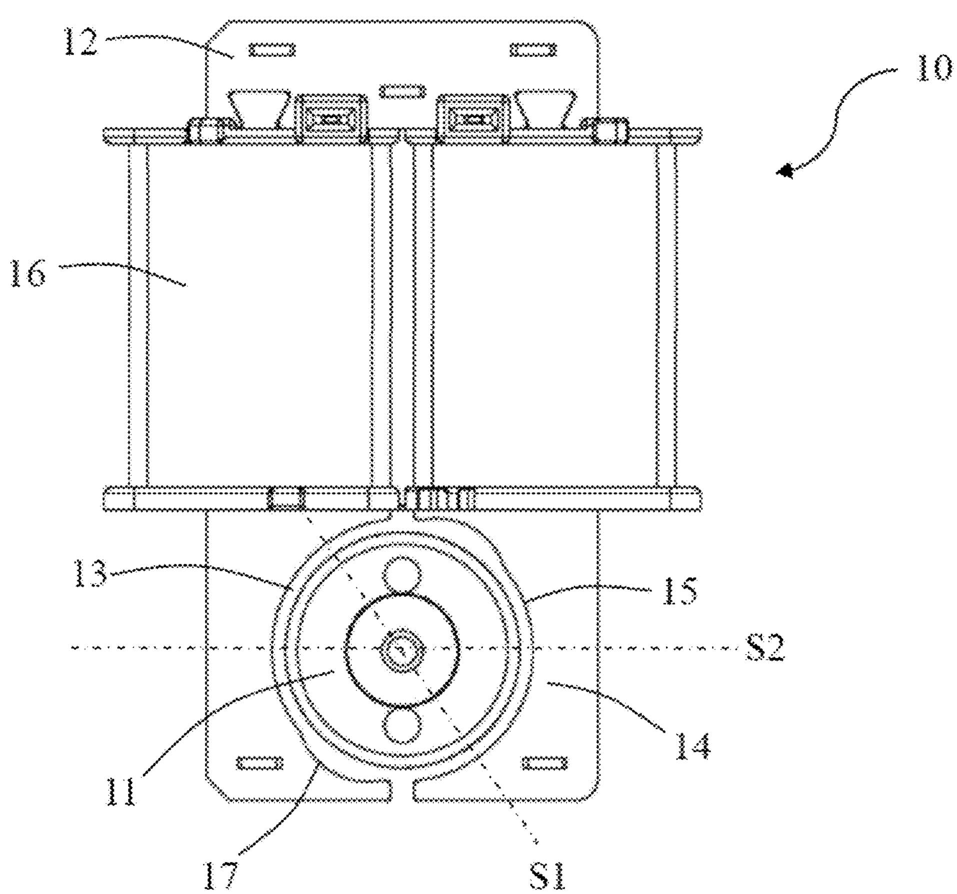
(57) **ABSTRACT**

A motor assembly and an integrated circuit for motor drive. The motor assembly includes a single-phase permanent-magnet synchronous motor capable of being powered by an AC power source and an integrated circuit, wherein the single-phase permanent-magnet synchronous motor comprises a stator and a permanent-magnet rotor capable of rotating relative to the stator, the stator comprises a stator iron core and a stator winding wound on the stator iron core, the integrated circuit comprises: a housing and enabling the single-phase permanent-magnet synchronous motor to be started along a fixed direction when the drive circuit is energized each time.



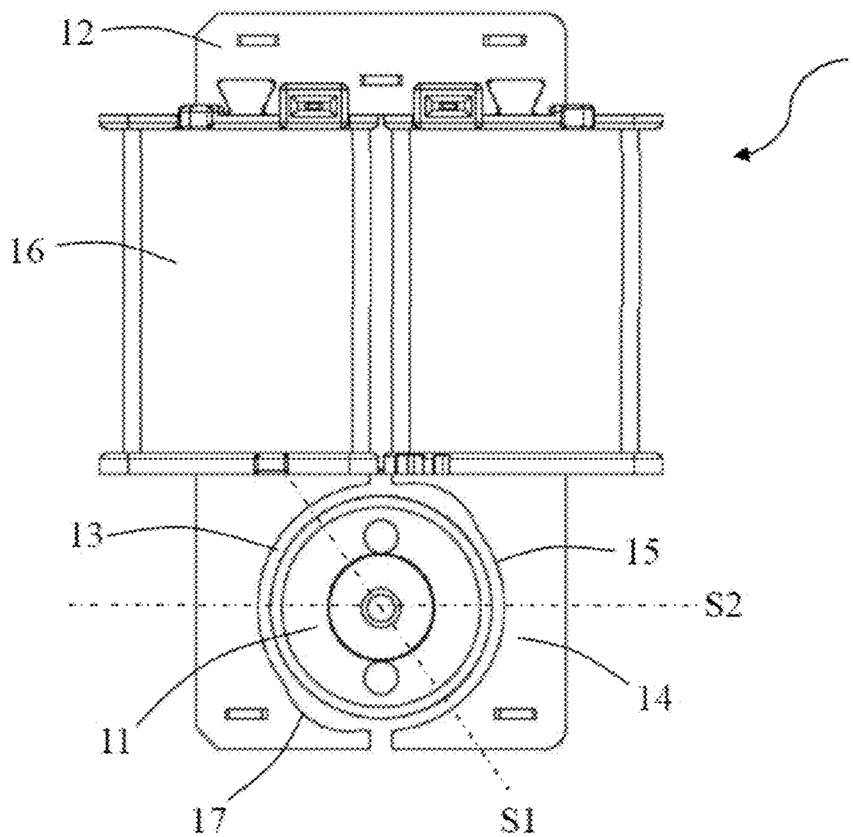


Figure 1

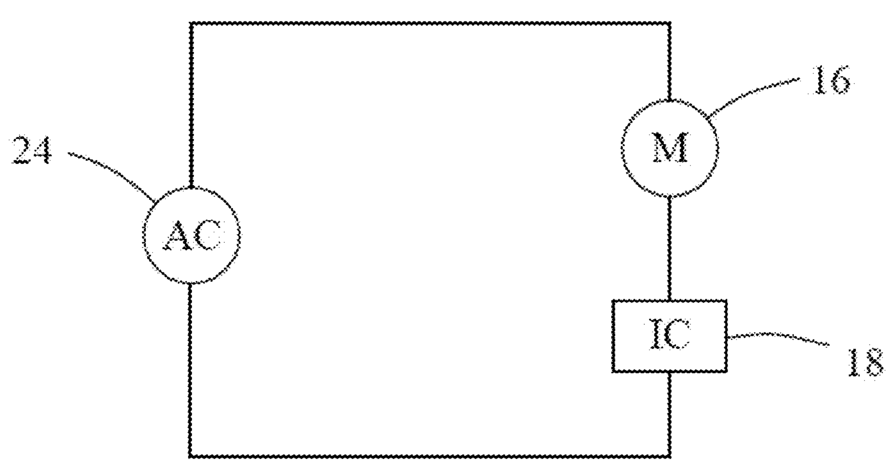


Figure 2

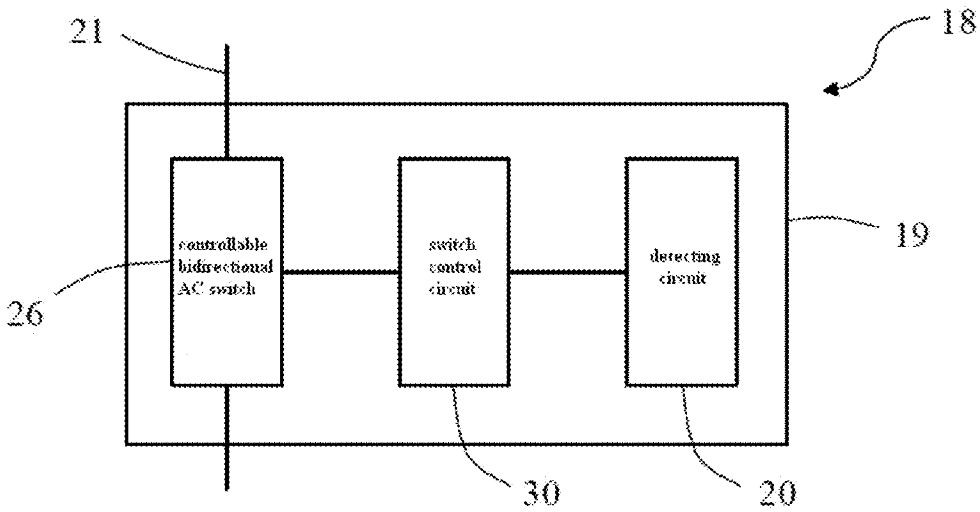
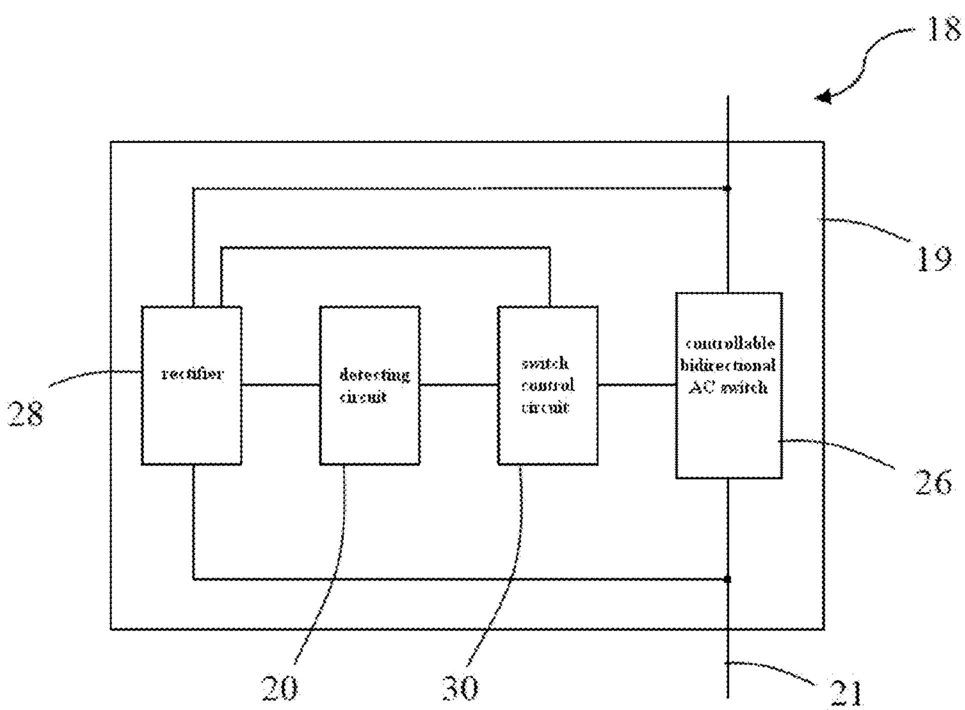


Figure 3



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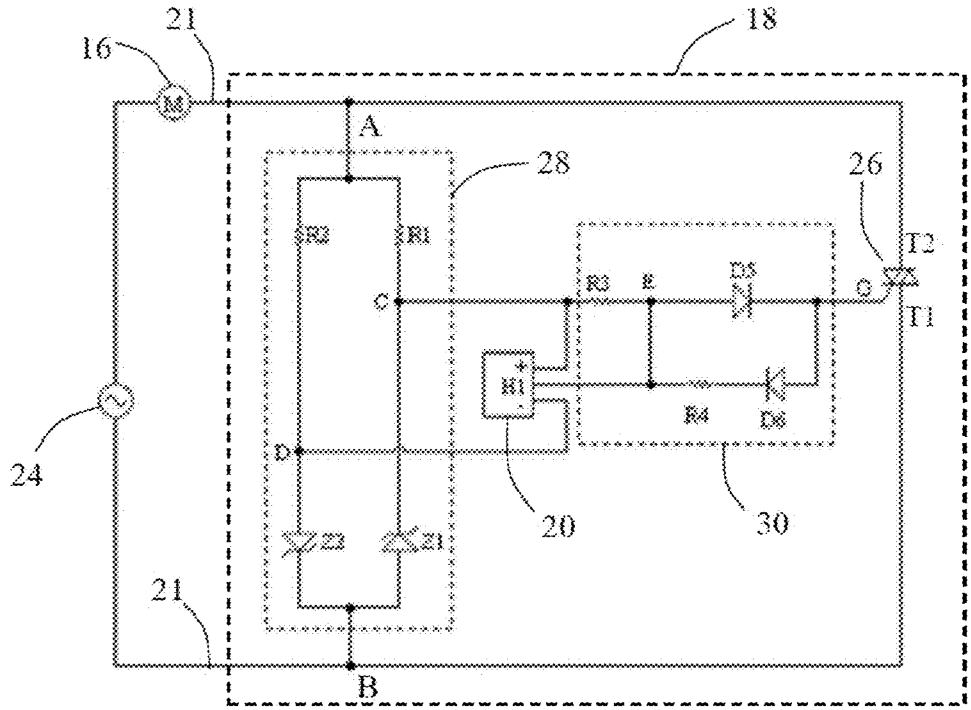
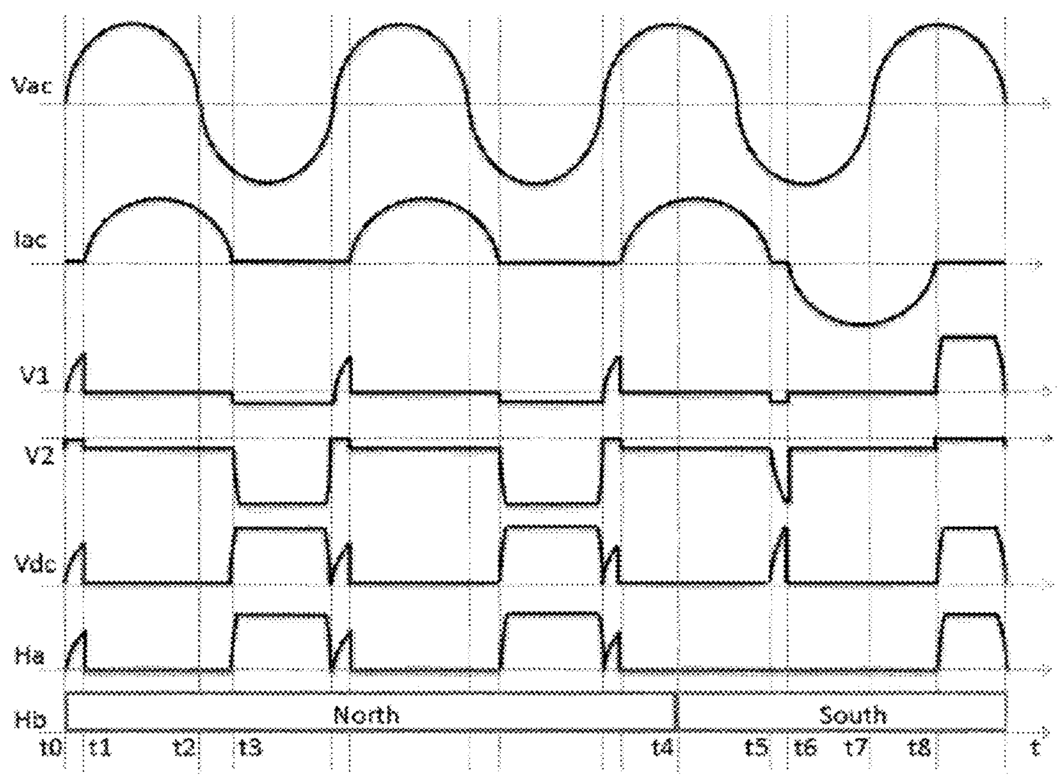


Figure 5



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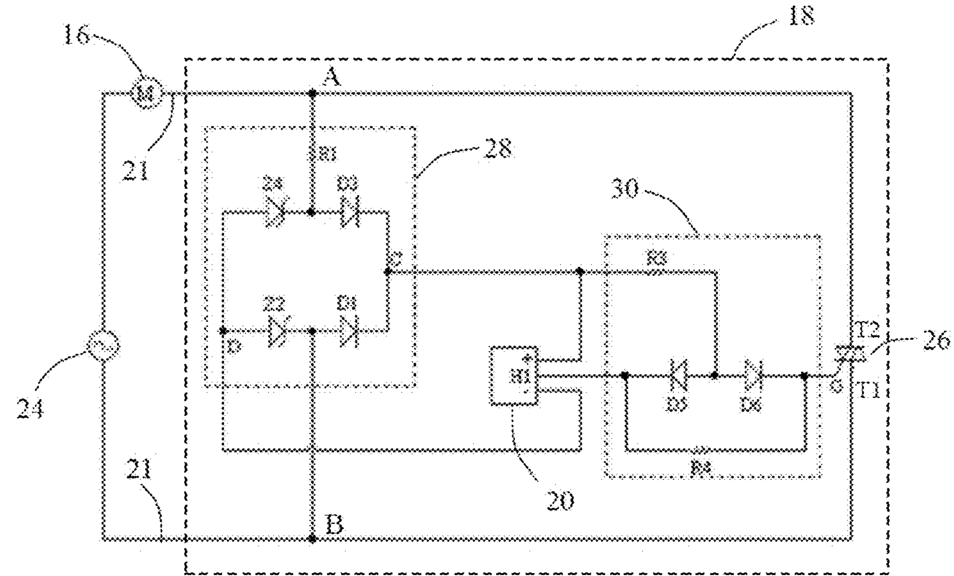

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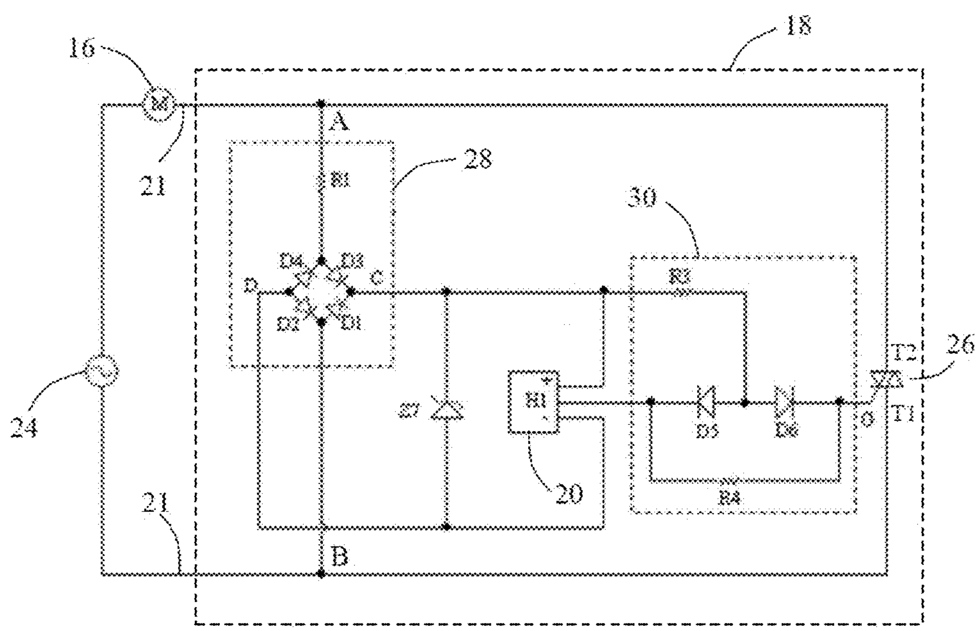

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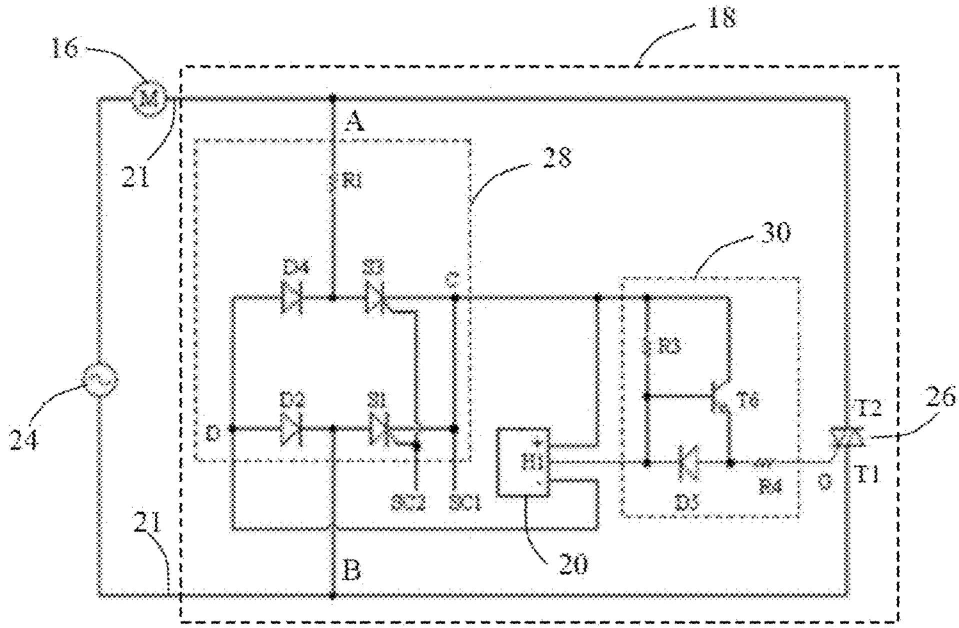

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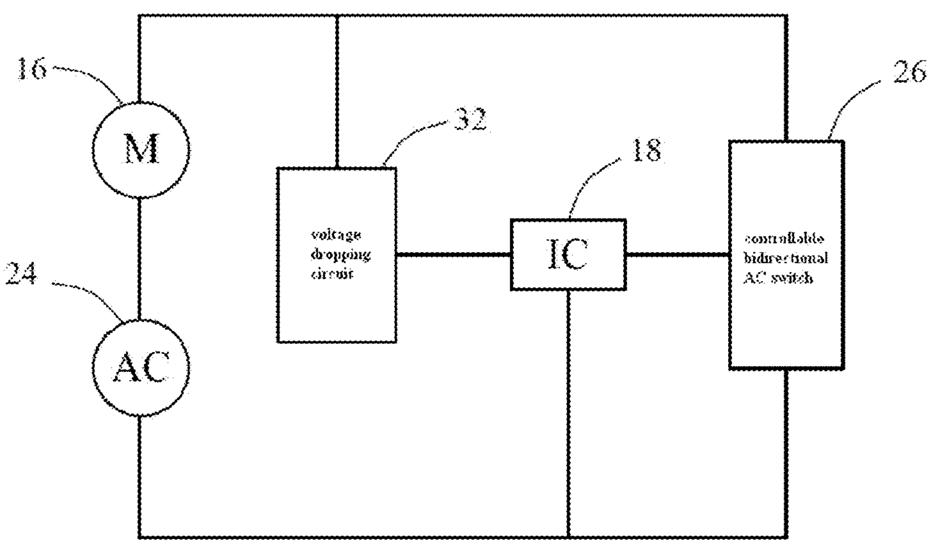


Figure 10

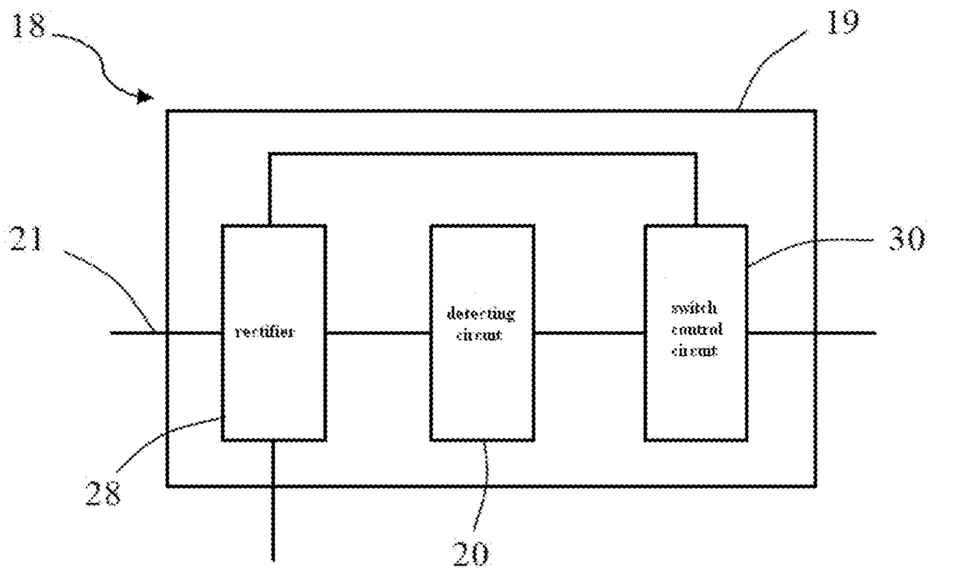
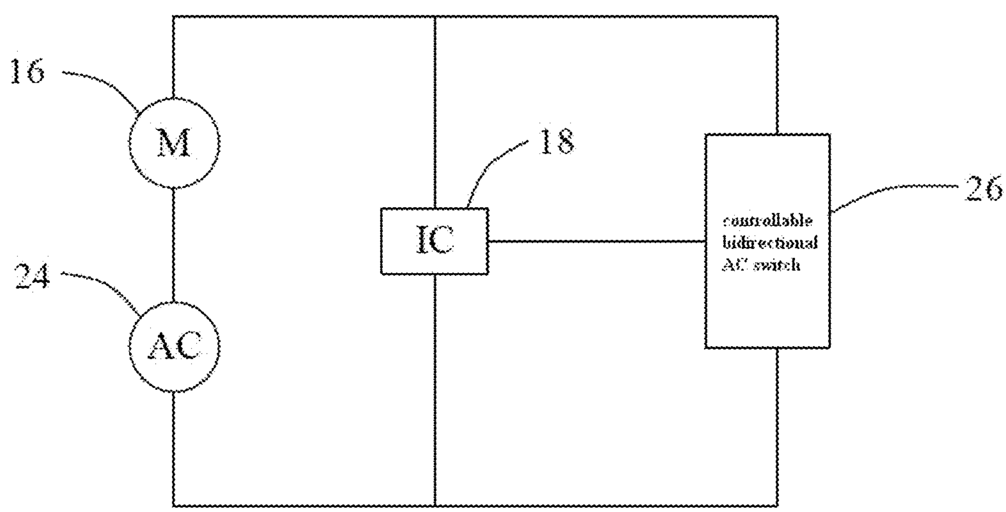


Figure 11



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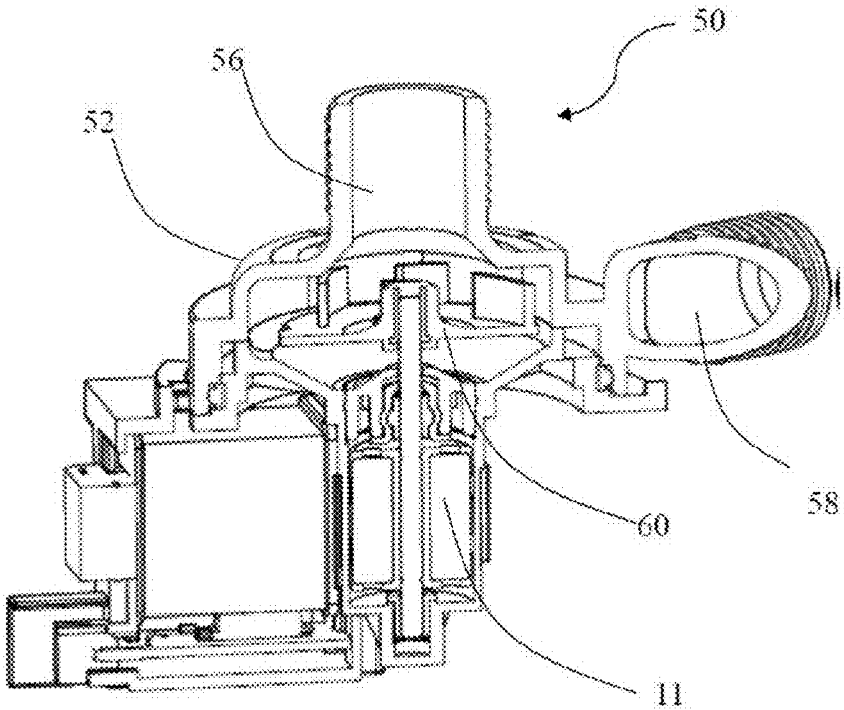

Figure 13

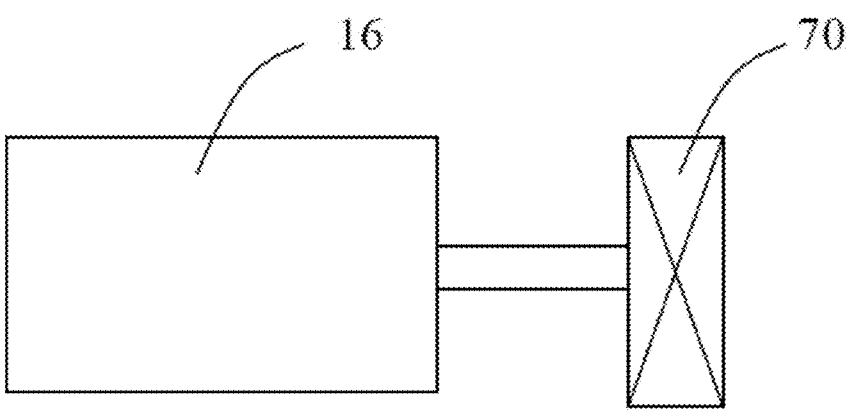

Figure 14

APPLICATION APPARATUS, MOTOR ASSEMBLY AND INTEGRATED CIRCUIT FOR DRIVING MOTOR

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This non-provisional patent application is continuation application of PCT Application No. PCT/CN2015/086423, filed with the Chinese Patent Office on Aug. 7, 2015, which claims priority to Chinese Patent Application No. 201410390592.2, filed on Aug. 8, 2014, and to Chinese Patent Application No. 201410404474.2, filed on Aug. 15, 2014, all of which are incorporated herein by reference in their entirety.

FIELD

[0002] The disclosure relates to a driving circuit for a motor, and in particular to an integrated circuit applied to drive a single-phase permanent magnetic synchronous motor.

BACKGROUND

[0003] In a starting process of a synchronous motor, an electromagnet of a stator generates an alternating magnetic field which is equivalent to a synthetic magnetic field of a forward rotating magnetic field and a backward rotating magnetic field. The alternating magnetic field drags a permanent magnetic rotor to oscillate with a deflection. Finally the rotation of the rotor in a direction is accelerated rapidly to be synchronized with the alternating magnetic field of the stator if oscillation amplitude of the rotor is increasing. To ensure the starting of a conventional synchronous motor, generally a starting torque of the motor is set to be large, and thus the motor operates at a working point with a low efficiency. In addition, the rotor cannot be ensured to the rotor start to rotate in a same direction every time since a stop position of the permanent magnetic rotor and a polarity of an alternating current (AC) in initial energizing are unfixed. Accordingly, in applications such as a blower and a water pump, generally an impeller driven by the rotor has straight radial vanes with a low efficiency, which results in a low operational efficiency of the blower and the water pump.

SUMMARY

[0004] A motor assembly is provided according to embodiments of the present disclosure. The motor assembly includes a single-phase permanent magnetic synchronous motor and an integrated circuit which are powered by an AC power supply, where the single-phase permanent magnetic synchronous motor includes a stator and a permanent magnetic rotor rotatable relative to the stator, the stator includes a stator core and a stator winding wound on the stator core; the integrated circuit includes a housing, a plurality pins extended out from the housing, and a driving circuit, and the driving circuit is packaged in the housing and enables the single-phase permanent magnetic synchronous motor to start and rotate in a fixed direction every time when the single-phase permanent magnetic synchronous motor is energized.

[0005] Preferably, the driving circuit may include: a controllable bidirectional AC switch connected in series with the stator winding between two terminals of the AC power supply; a detecting circuit configured to detect a magnetic field polarity of the permanent magnetic rotor; and a switch control circuit configured to control the controllable bidirectional AC switch to be switched between a switch-on state and a switch-off state in a preset way, based on a polarity of the AC power supply and the magnetic field polarity of the permanent magnetic rotor detected by the detecting circuit.

[0006] Preferably, the switch control circuit may be configured to switch on the controllable bidirectional AC switch in a case that the AC power supply is in a positive half cycle and the magnetic field polarity of the rotor detected by the detecting circuit is a first polarity, or in a case that the AC power supply is in a negative half cycle and the magnetic field polarity of the rotor detected by the detecting circuit is a second polarity opposite to the first polarity.

[0007] Preferably, the driving circuit may further include a rectifier configured to generate a direct current (DC) to supply at least the detecting circuit.

[0008] Preferably, the rectifier may include a voltage dropping circuit.

[0009] Preferably, the rectifier may be connected in parallel with the controllable bidirectional AC switch.

[0010] Preferably, the controllable bidirectional AC switch may be a TRIAC.

[0011] Preferably, the detecting circuit may include a magnetic sensor, the integrated circuit may be installed near the rotor and the magnetic sensor is capable of sensing the magnetic field polarity of the rotor and variation of the magnetic field polarity.

[0012] Optionally, the detecting circuit may not include a magnetic sensor.

[0013] Preferably, the integrated circuit may not include a microprocessor.

[0014] Preferably, the motor assembly may not include a printed circuit board.

[0015] Preferably, a non-uniformed magnetic circuit may be formed between the stator and the permanent magnetic rotor, and a polar axis of the permanent magnetic rotor has an angular offset relative to a central axis of the stator when the permanent magnetic rotor is at rest.

[0016] Preferably, the rotor may include at least one permanent magnet, the rotor operates at a constant rotational speed of 60 f/p circle/minute during a steady state phase after the stator winding is energized, where f is a frequency of the AC power supply and p is the number of pole pairs of the rotor.

[0017] In another aspect, an integrated circuit for driving a motor is provided according to the present disclosure. The integrated circuit includes a housing, a plurality pins extended out from the housing, and a switch control circuit disposed on a semiconductor substrate, where the semiconductor substrate and the driving circuit are packaged in the housing, the driving circuit includes a controllable bidirectional AC switch connected between two pins, a detecting circuit configured to detect a magnetic field polarity of a rotor of the motor, and a switch control circuit configured to control the controllable bidirectional AC switch to be switched between a switch-on state and a switch-off state in a preset way, based on the magnetic field polarity of the rotor detected by the detecting circuit.

[0018] Preferably, the integrated circuit may have only two pins.

[0019] With the integrated circuit according to the embodiments of the present disclosure, the motor can be ensured to start and rotate in a same direction every time when the motor is energized. In applications such a blower and a water pump, a fan blade and an impeller driven by the rotor may have curved vanes, and thus the efficiency of the blower and the water pump is improved. In addition, all or a part of the driving circuit for the motor are packaged in the integrated circuit, thereby reducing the cost of the circuit and improving the reliability of the circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] In the drawings:

[0021] FIG. **1** shows a single-phase permanent magnetic synchronous motor according to an embodiment of the present disclosure;

[0022] FIG. **2** shows a schematic circuit diagram of a single-phase permanent magnetic synchronous motor according to an embodiment of the present disclosure;

[0023] FIG. **3** shows a circuit block diagram of an implementing way of the integrated circuit shown in FIG. **2**;

[0024] FIG. **4** shows a circuit block diagram of an implementing way of the integrated circuit shown in FIG. **2**;

[0025] FIG. **5** shows a circuit of the motor shown in FIG. **2** according to an embodiment;

[0026] FIG. **6** shows a waveform of the circuit of the motor shown in FIG. **5**;

[0027] FIG. **7** to FIG. **9** show the circuit of the motor shown in FIG. **2** according to other embodiments;

[0028] FIG. **10** shows a schematic circuit diagram of a single-phase permanent magnetic synchronous motor according to an embodiment of the present disclosure;

[0029] FIG. **11** shows a circuit block diagram of an implementing way of the integrated circuit shown in FIG. **10**;

[0030] FIG. **12** shows a schematic circuit diagram of a single-phase permanent magnetic synchronous motor according to an embodiment of the present disclosure;

[0031] FIG. **13** shows a pump using the motor;

[0032] FIG. **14** shows a blower using the motor.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0033] Hereinafter, particular embodiments of the present disclosure are described in detail in conjunction with the drawings, so that technical solutions and other beneficial effects of the present disclosure are apparent. It can be understood that the drawings are provided only for reference and explanation, and are not used to limit the present disclosure. Dimensions shown in the drawings are only for ease of clear description, but are not limited to a proportional relationship.

[0034] FIG. **1** shows a single-phase permanent magnetic synchronous motor according to an embodiment of the present disclosure. The synchronous motor **10** includes a stator and a rotor **11** rotatable relative to the stator. The stator includes a stator core **12** and a stator winding **16** wound on the stator core **12**. The stator core may be made of soft magnetic materials such as pure iron, cast iron, cast steel, electrical steel, silicon steel. The rotor **11** includes a permanent magnet, the rotor **11** operates at a constant rotational speed of 60 f/p circle/minute during a steady state phase when the stator winding **16** is connected with an AC power supply in series, where f is a frequency of the AC power supply and p is the number of pole pairs of the rotor. In the embodiment, the stator core **12** includes two poles **14** opposite to each other. Each pole **14** includes a pole arc **15**, an outside surface of the rotor **11** is opposite to the pole arc **15**, and a substantially uniform air gap **13** is formed between the outside surface of the rotor **11** and the pole arc **15**. The "substantially uniform air gap" according to the present disclosure means that a uniform air gap is formed in most space between the stator and the rotor, and a non-uniformed air gap is formed in a small part of the space between the stator and the rotor. Preferably, a starting groove **17** which is concave may be disposed in the pole arc **15** of the pole of the stator, and a part of the pole arc **15** rather than the starting groove **17** may be concentric with the rotor. With the configuration described above, the non-uniform magnetic field may be formed, a polar axis S1 of the rotor has an angle of inclination relative to a central axis S2 of the pole **14** of the stator in a case that the rotor is at rest (as shown in FIG. **1**), and the rotor may have a starting torque every time the motor is energized under the action of the driving circuit. Specifically, the "pole axis S1 of the rotor" refers to a boundary between two magnetic poles having different polarities, and the "central axis S2 of the pole **14** of the stator" refers to a connection line passing central points of the two poles **14** of the stator. In the embodiment, both the stator and the rotor include two magnetic poles. It can be understood that the number of magnetic poles of the stator may not be equal to the number of magnetic poles of the rotor, and the stator and the rotor may have more magnetic poles, such as 4 or 6 magnetic poles in other embodiments.

[0035] FIG. **2** shows a schematic circuit diagram of a single-phase permanent magnetic synchronous motor **10** according to an embodiment of the present disclosure. The stator winding **16** of the motor and the integrated circuit **18** are connected in series across two terminals of the AC power supply **24**. The driving circuit for the motor is integrated into the integrated circuit **18**, and the driving circuit enables the motor to start in a fixed direction every time the motor is energized.

[0036] FIG. **3** shows an implementing way of the integrated circuit **18**. The integrated circuit includes a housing **19**, two pins **21** extended out from the housing **19**, and a driving circuit packaged in the housing **19**. The driving circuit is disposed on a semiconductor substrate, and the driving circuit includes a detecting circuit **20** configured to detect a magnetic field polarity of a rotor of the motor, a controllable bidirectional AC switch **26** connected between the two pins **21**, and a switch control circuit **30** configured to control the controllable bidirectional AC switch **30** to be switched between a switch-on state and a switch-off state in a preset way, based on the magnetic field polarity of the rotor detected by the detecting circuit **20**.

[0037] Preferably, the switch control circuit **30** is configured to switch on the controllable bidirectional AC switch **26** in a case that the AC power supply **24** is in a positive half cycle and it is detected by the detecting circuit **20** that the magnetic field polarity of the rotor is a first polarity, or in a case that the AC power supply **24** is in a negative half cycle and it is detected by the detecting circuit **20** that the magnetic field polarity of the rotor is a second polarity opposite to the first polarity. The configuration enables the stator winding **16** to drag the rotor only in a fixed direction in a starting phase of the motor.

[0038] FIG. **4** shows an implementing way of the integrated circuit **18**. FIG. **4** differs from FIG. **3** in that, the integrated circuit shown in FIG. **4** further includes a rectifier **28**, which is connected in parallel with the controllable bidirectional AC switch **26** between the two pins **21**, and may generate a DC supplied for the detecting circuit **20**. In the embodiment, preferably, the detecting circuit **20** may be a magnetic sensor (may also be referred as a position sensor), and the integrated circuit is installed near the rotor so that the magnetic sensor can sense a magnetic field variation of the rotor. It can be understood that the detecting circuit **20** may not include a magnetic sensor, and the magnetic field variation of the rotor may be detected in other ways in other embodiments. In the embodiment according to the present disclosure, the driving circuit for the motor is packaged in the integrated circuit, and thus the cost of the circuit can be reduced, and the reliability of the circuit can be improved. In addition, the motor may not include a PCB, and it just needs to fix the integrated circuit in a proper position and connect the integrated circuit to a line group and a power supply of the motor via leading wires.

[0039] In the embodiment according to the present disclosure, the stator winding **16** and the AC power supply **24** are connected in series between two nodes A and B. Preferably, the AC power supply **24** may be a commercial AC power supply with a fixed frequency such as 50 Hz or 60 Hz, and a supply voltage may be, for example, 110V, 220V or 230V. The controllable bidirectional AC switch **26**, and the stator winding **16** and the AC power supply **24** connected in series, are connected in parallel between the two nodes A and B. Preferably, the controllable bidirectional AC switch **26** may be a TRIode AC semiconductor switch (TRIAC) with two anodes are connected to the two pins **21** respectively. It can be understood that the controllable bidirectional AC switch **26** may include two unidirectional thyristors reversely connected in parallel, and the respective control circuit may be disposed to control the two unidirectional thyristors in a preset way. The rectifier **28** and the controllable bidirectional AC switch **26** are connected in parallel between the two pins **21**. An AC between the two pins **21** is converted by the rectifier **28** into a low voltage DC. The detecting circuit **20** may be powered by the low voltage DC output by the rectifier **28**, and be configured to detect the magnetic pole position of the permanent magnetic rotor **11** of the synchronous motor **10** and output a corresponding signal. A switch control circuit **30** is connected to the rectifier **28**, the detecting circuit **20** and the controllable bidirectional AC switch **26**, and is configured to control the controllable bidirectional AC switch **26** to be switched between a switch-on state and a switch-off state in a preset way, based on information on the magnetic pole position of the permanent magnetic rotor detected by the detecting circuit **20** and the polarity of the AC power supply **24** obtained from the rectifier **28**, such that the stator winding **16** drags the rotor **14** to rotate only in the above-mentioned fixed starting direction in the starting phase of the motor. According to the present disclosure, in a case that the controllable bidirectional AC switch **26** is switched on, the two pins **21** are short circuit, and the rectifier **28** does not consume electric energy since there is no current flowing through the rectifier **28**, hence, the utilization efficiency of electric energy can be improved significantly.

[0040] FIG. **5** shows a circuit of the motor shown in FIG. **2** according to an embodiment. The stator winding **16** of the motor is connected in series with the AC power supply **24** between the two pins **21** of the integrated circuit **18**. Two nodes A and B are connected to the two pins **21** respectively. A first anode T**2** of the TRIAC **26** is connected to the node A, and a second anode T**1** of the TRIAC **26** is connected to the node B. The rectifier **28** is connected in parallel with the TRIAC **26** between the two nodes A and B. An AC between the two nodes A and B is converted by the rectifier **28** into a low voltage DC (preferably, the low voltage is in a range from 3V to 18V). The rectifier **28** includes a first zener diode Z**1** and a second zener diode Z**2** which are reversely connected in parallel between the two nodes A and B via a first resistor R**1** and a second resistor R**2**, respectively. A high voltage output terminal C of the rectifier **28** is formed at a connection point of the first resistor R**1** and a cathode of the first zener diode Z**1**, and a low voltage output terminal D of the rectifier **28** is formed at a connection point of the second resistor R**2** and an anode of the second zener diode Z**2**. The voltage output terminal C is connected to a positive power supply terminal of the position sensor **20**, and the voltage output terminal D is connected to a negative power supply terminal of the position sensor **20**. Three terminals of the switch control circuit **30** are connected to the high voltage output terminal C of the rectifier **28**, an output terminal H**1** of the position sensor **20** and a control electrode G of the TRIAC **26** respectively. The switch control circuit **30** includes a third resistor R**3**, a fifth diode D**5**, and a fourth resistor R**4** and a sixth diode D**6** connected in series between the output terminal H**1** of the position sensor **20** and the control electrode G of the controllable bidirectional AC switch **26**. An anode of the sixth diode D**6** is connected to the control electrode G of the controllable bidirectional AC switch **26**. One terminal of the third resistor R**3** is connected to the high voltage output terminal C of the rectifier **28**, and the other terminal of the third resistor R**3** is connected to an anode of the fifth diode D**5**. A cathode of the fifth diode D**5** is connected to the control electrode G of the controllable bidirectional AC switch **26**.

[0041] In conjunction with FIG. **6**, an operational principle of the above-mentioned circuit is described. In FIG. **6**, Vac indicates a waveform of a voltage of the AC power supply **24**, and Iac indicates a waveform of a current flowing through the stator winding **16**. Due to the inductive character of the stator winding **16**, the waveform of the current Iac lags behind the waveform of the voltage Vac. V**1** indicates a waveform of a voltage between two terminals of the zener diode Z**1**, V**2** indicates a waveform of a voltage between two terminals of the zener diode Z**2**, Vcd indicates a waveform of a voltage between two output terminals C and D of the rectifier **28**, Ha indicates a waveform of a signal output from the output terminal H**1** of the position sensor **20**, and Hb indicates a rotor magnetic field detected by the position sensor **20**. In this embodiment, in a case that the position sensor **20** is powered normally, the output terminal H**1** outputs a logic high level in a case that the detected rotor magnetic field is North, or the output terminal H**1** outputs a logic low level in a case that the detected rotor magnetic field is South.

[0042] When the rotor magnetic field Hb detected by the position sensor **20** is North, in a first positive half cycle of the AC power supply, a supply voltage is gradually increased in a period of time from a time instant t**0** to a time instant t**1**, the output terminal H**1** of the position sensor **20** outputs a high level, and a current flows through the resistor R**1**, the resistor R3, the diode D5 and the control electrode G and the second anode T1 of the TRIAC 26 sequentially. The TRIAC 26 is switched on when a drive current flowing through the control electrode G and the second anode T1 is greater than a gate triggering current Ig. Once the TRIAC 26 is switched on, the two nodes A and B are short circuit, a current flowing through the stator winding 16 in the motor is gradually increased until a large forward current flows through the stator winding 16, and the rotor 14 is driven to rotate clockwise as shown in FIG. 3. Since the two nodes A and B are short circuit, there is no current flowing through the rectifier 28 in a period of time from the time instant t1 to a time instant t2. Hence, the resistors R1 and R2 do not consume electric energy, and the output of the position sensor 20 is stopped due to no power supply voltage. Since there is a sufficient large current flowing through two anodes T1 and T2 of the TRIAC 26 (which is greater than a holding current I_{hold}), the TRIAC 26 is kept to be switched on in a case that there is no drive current flowing through the control electrode G and the second anode T1. In a negative half cycle of the AC power supply, after a time instant t3, a current flowing through T1 and T2 is less than the holding current I_{hold}, the TRIAC 26 is switched off, a current begins to flow through the rectifier 28, and the output terminal H1 of the position sensor 20 outputs a high level again. Since a potential at a point C is lower than a potential at a point E, there is no drive current flowing through the control electrode G and the second anode T1 of the TRIAC 26, and the TRIAC 26 is kept to be switched off. Since resistances of the resistors R1 and R2 in the rectifier 28 are much greater than a resistance of the stator winding 16 in the motor, a current currently flowing through the stator winding 16 is much less than the current flowing through the stator winding 16 in a period of time from the time instant t1 to the time instant t2, and there is no driving force for the rotor 14. Hence, the rotor 14 continues to rotate clockwise due to an inertia effect. In a second positive half cycle of the AC power supply, similar to the first positive half cycle, a current flows through the resistor R1, the resistor R3, the diode D5, and the control electrode G and the second anode T1 of the TRIAC 26 sequentially. The TRIAC 26 is switched on again, the current flowing through the stator winding 16 continues to drive the rotor 14 to rotate clockwise. Similarly, the resistors R1 and R2 do not consume electric energy since the two nodes A and B are short circuit; in the negative half cycle of the power supply, the current flowing through the two anodes T1 and T2 of the TRIAC 26 is less than the holding current I_{hold}, the TRIAC 26 is switched off again, and the rotor continues to rotate clockwise due to the inertia effect.

[0043] At a time instant t4, the rotor magnetic field Hb detected by the position sensor 20 changes to be South from North, the AC power supply is in the positive half cycle and the TRIAC 26 is switched on, the two nodes A and B are short circuit, and there is no current flowing through the rectifier 28. After the AC power supply is in the negative half cycle, the current flowing through the two anodes T1 and T2 of the TRIAC 26 is gradually decreased, and the TRIAC 26 is switched off at a time instant t5. Then the current flows through the second anode T1 and the control electrode G of the TRIAC 26, the diode D6, the resistor R4, the position sensor 20, the resistor R2 and the stator winding 16 sequentially. As the drive current is gradually increased, the TRIAC 26 is switched on again at a time instant t6, the two nodes A and B are short circuit again, the resistors R1 and R2 do not consume electric energy, and the output of the position sensor 20 is stopped due to no power supply voltage. There is a large reverse current flowing through the stator winding 16, and the rotor 14 continues to be driven clockwise since the rotor magnetic field is South. In a period from the time instant t5 to the time instant t6, the first zener diode Z1 and the second zener diode Z2 are switched on, hence, there is a voltage output between the two output terminals C and D of the rectifier 28. At a time instant t7, the AC power supply is in the positive half cycle again, the TRIAC 26 is switched off once the current flowing through the TRIAC 26 crosses zero, and then a voltage of the control circuit is gradually increased. As the voltage is gradually increased, a current begins to flow through the rectifier 28, the output terminal H1 of the position sensor 20 outputs a low level signal, there is no drive current flowing through the control electrode G and the second anode T1 of the TRIAC 26, hence, the TRIAC 26 is switched off. Since the current flowing through the stator winding 16 is small, no driving force is generated for the rotor 14. At a time instant t8, the power supply is in the positive half cycle, the position sensor outputs a low level signal, the TRIAC 26 is kept to be switched off after the current crosses zero, and the rotor continues to rotate clockwise due to the inertia effect. According to the present disclosure, the rotor may be accelerated to be synchronized with the field of the stator by rotating only one circle after the stator winding is energized.

[0044] With the circuit according to the embodiment of the present disclosure, the motor can be ensured to start and rotate in a same direction every time the motor is energized. In applications such a blower and a water pump, a fan blade and an impeller driven by the rotor may have curved vanes, and thus the efficiency of the blower and the water pump is improved. In addition, in the embodiment of the present disclosure, by taking advantage of a characteristic of the TRIAC that the TRIAC is kept to be switched on although there is no drive current flowing though the TRIAC once the TRIAC is switched on, it is avoided that the resistor R1 and the resistor R2 in the rectifier 28 still consumes electric energy after the TRIAC is switched on, hence, the utilization efficiency of electric energy can be improved significantly.

[0045] FIG. 7 shows the circuit of the motor shown in FIG. 2 according to an embodiment. The stator winding 16 of the motor is connected in series with the AC power supply 24 between the two pins 21 of the integrated circuit 18. The two nodes A and B are connected to the two pins 21 respectively. A first anode T2 of the TRIAC 26 is connected to the node A, and a second anode T1 of the TRIAC 26 is connected to the node B. The rectifier 28 is connected in parallel with the TRIAC 26 between the two nodes A and B. An AC between the two nodes A and B is converted by the rectifier 28 into a low voltage DC, preferably, the low voltage is in a range from 3V to 18V. The rectifier 28 includes a first resistor R1 and a full wave bridge rectifier connected in series between the two nodes A and B. The first resistor R1 may be used as a voltage dropper, and the full wave bridge rectifier includes two rectifier branches connected in parallel, one of the two rectifier branches includes a first diode D1 and a third diode D3 reversely connected in series, and the other of the two rectifier branches includes a second zener diode Z2 and a fourth zener diode Z4 reversely connected in series, the high voltage output terminal C of the rectifier 28 is formed at a connection point of a cathode of the first diode D1 and a cathode of the third diode D3, and the low voltage output terminal D of the rectifier **28** is formed at a connection point of an anode of the second zener diode Z**2** and an anode of the fourth zener diode Z**4**. The output terminal C is connected to a positive power supply terminal of the position sensor **20**, and the output terminal D is connected to a negative power supply terminal of the position sensor **20**. The switch control circuit **30** includes a third resistor R**3**, a fourth resistor R**4**, and a fifth diode D**5** and a sixth diode D**6** reversely connected in series between the output terminal H**1** of the position sensor **20** and the control electrode G of the controllable bidirectional AC switch **26**. A cathode of the fifth diode D**5** is connected to the output terminal H**1** of the position sensor, and a cathode of the sixth diode D**6** is connected to the control electrode G of the controllable bidirectional AC switch. One terminal of the third resistor R**3** is connected to the high voltage output terminal C of the rectifier, and the other terminal of the third resistor R**3** is connected to a connection point of an anode of the fifth diode D**5** and an anode of the sixth diode D**6**. Two terminals of the fourth resistor R**4** are connected to a cathode of the fifth diode D**5** and a cathode of the sixth diode D**6** respectively.

[0046] FIG. **8** shows the circuit of the motor shown in FIG. **2** according to an embodiment. The embodiment differs from the previous embodiment in that, the zener diodes Z**2** and Z**4** in FIG. **7** are replaced by general diodes D**2** and D**4** in the rectifier in FIG. **8**. In addition, a zener diode Z**7** is used as a voltage regulator connected between the two output terminals C and D of the rectifier **28** in FIG. **8**.

[0047] FIG. **9** shows the circuit of the motor shown in FIG. **2** according to an embodiment. The stator winding **16** of the synchronous motor is connected in series with the AC power supply **24** between the two pins **21** of the integrated circuit **18**. Two nodes A and B are connected to the two pins **21** respectively. A first anode T**2** of the TRIAC **26** is connected to the node A, and a second anode T**1** of the TRIAC **26** is connected to the node B. The rectifier **28** is connected in parallel with the TRIAC **26** between the two nodes A and B. An AC between the two nodes A and B is converted by the rectifier **28** into a low voltage DC, preferably, the low voltage is in a range from 3V to 18V. The rectifier **28** includes a first resistor R**1** and a full wave bridge rectifier connected in series between the two nodes A and B.

[0048] The first resistor R**1** may be used as a voltage dropper. The full wave bridge rectifier includes two rectifier branches connected in parallel, one of the two rectifier branches includes two silicon controlled rectifiers S**1** and S**3** reversely connected in series, and the other of the two rectifier branches includes a second diode D**2** and a fourth diode D**4** reversely connected in series. The high voltage output terminal C of the rectifier **28** is formed at a connection point of a cathode of the silicon controlled rectifier S**1** and a cathode of the silicon controlled rectifier S**3**, and the low voltage output terminal D of the rectifier **28** is formed at a connection point of an anode of the second diode D**2** and an anode of the fourth diode D**4**. The output terminal C is connected to a positive power supply terminal of the position sensor **20**, and the output terminal D is connected to a negative power supply terminal of the position sensor **20**. The switch control circuit **30** includes a third resistor R**3**, an NPN triode T**6**, and a fourth resistor R**4** and a fifth diode D**5** connected in series between the output terminal H**1** of the position sensor **20** and the control electrode G of the controllable bidirectional AC switch **26**. A cathode of the fifth diode D**5** is connected to the output terminal H**1** of the position sensor. One terminal of the third resistor R**3** is connected to the high voltage output terminal C of the rectifier, and the other terminal of the third resistor R**3** is connected to the output terminal H**1** of the position sensor. A base of the NPN triode T**6** is connected to the output terminal H**1** of the position sensor, an emitter of the NPN triode T**6** is connected to an anode of the fifth diode D**5**, and a collector of the NPN triode T**6** is connected to the high voltage output terminal C of the rectifier.

[0049] In this embodiment, a reference voltage may be input to the cathodes of the two silicon controlled rectifiers S**1** and S**3** via a terminal SC**1**, and a control signal may be input to control terminals of S**1** and S**3** via a terminal SC**2**. S**1** and S**3** are switched on in a case that a control signal input from the terminal SC**2** is a high level, or S**1** and S**3** are switched off in a case that the control signal input from the terminal SC**2** is a low level. Based on the configuration, S**1** and S**3** may be switched between a switch-on state and a switch-off state in a preset way by inputting the high level from the terminal SC**2** in a case that the driver circuit operates normally. S**1** and S**3** are switched off by changing the control signal input from the terminal SC**2** from the high level to the low level in a case that the driver circuit fails. In this case, the TRIAC **26**, the rectifier **28** and the position sensor **20** are switched off to ensure the whole circuit to be in a zero-power state.

[0050] FIG. **10** shows a schematic circuit diagram of a single-phase permanent magnetic synchronous motor **10** according to an embodiment of the present disclosure. The stator winding **16** of the motor is connected in series with the integrated circuit **18** between two terminals of the AC power supply **24**. A driving circuit for the motor is integrated into the integrated circuit **18**, and the driving circuit enables the motor to start in a fixed direction every time the motor is energized. In the present disclosure, the driving circuit for the motor is packaged in the integrated circuit, and thus the cost of the circuit can be reduced and the reliability of the circuit can be improved.

[0051] In the present disclosure, based on actual situations, all or a part of the rectifier, the detecting circuit, the switch control circuit, the controllable bidirectional AC switch may be integrated into the integrated circuit. For example, as shown in FIG. **3**, only the detecting circuit, the switch control circuit and the controllable bidirectional AC switch are integrated into the integrated circuit, and the rectifier is disposed outside the integrated circuit.

[0052] For example, as shown in the embodiments of FIG. **10** and FIG. **11**, the voltage dropping circuit **32** and the controllable bidirectional AC switch **26** are disposed outside the integrated circuit, and the rectifier (which may only include the rectifier bridge but not include a voltage dropping resistor or other voltage dropping components), the detecting circuit and the switch control circuit are integrated into the integrated circuit. In the embodiment, a low power part is integrated into the integrated circuit, and the voltage dropping circuit **32** and the controllable bidirectional AC switch **26** as high power parts are disposed outside the integrated circuit. In an embodiment as shown in FIG. **12**, the voltage dropping circuit **32** may be integrated into the integrated circuit, and the controllable bidirectional AC switch is disposed outside the integrated circuit.

[0053] FIG. **13** shows a water pump **50** using the motor described above. The water pump **50** includes a pump housing **54** having a pump chamber **52**, an entrance **56** and an exit **58** in communication with the pump chamber, an impeller **60** rotatably disposed in the pump chamber, and a motor assembly configured to drive the impeller. FIG. **14** shows a blower using the motor described above. The blower includes a fan blade **70**, and the fan blade **70** is driven directly or indirectly via an output axis of the motor **16**.

[0054] What is described above is only preferred embodiments of the present disclosure and is not intended to define the scope of protection of the present disclosure. Any changes, equivalent substitution, improvements and so on made within the spirit and principles of the present disclosure are all contained in the scope of protection of the present disclosure. For example, the driver circuit according to the present disclosure not only is applied to the single-phase permanent magnetic synchronous motor, but also is applied to other types of permanent magnetic motors such as a single-phase brushless DC motor.

1. A motor assembly, comprising: a single-phase permanent magnetic synchronous motor and an integrated circuit which are powered by an alternating current (AC) power supply, wherein the single-phase permanent magnetic synchronous motor comprises a stator and a permanent magnetic rotor rotatable relative to the stator, the stator comprises a stator core and a stator winding wound on the stator core; the integrated circuit comprises a housing, a plurality pins extended out from the housing, and a driving circuit, wherein the driving circuit is packaged in the housing and enables the single-phase permanent magnetic synchronous motor to start and rotate in a fixed direction every time when the single-phase permanent magnetic synchronous motor is energized.

2. The motor assembly according to claim **1**, wherein the driving circuit comprises:

- a controllable bidirectional AC switch connected in series with the stator winding and configured to be connected between two terminals of the AC power supply;
- a detecting circuit configured to detect a magnetic field polarity of the permanent magnetic rotor; and
- a switch control circuit configured to control the controllable bidirectional AC switch to be switched between a switch-on state and a switch-off state in a preset way, based on a polarity of the AC power supply and the magnetic field polarity of the permanent magnetic rotor detected by the detecting circuit.

3. The motor assembly according to claim **2**, wherein the switch control circuit is configured to switch on the controllable bidirectional AC switch in a case that the AC power supply is in a positive half cycle and the magnetic field polarity of the rotor detected by the detecting circuit is a first polarity, or in a case that the AC power supply is in a negative half cycle and the magnetic field polarity of the rotor detected by the detecting circuit is a second polarity opposite to the first polarity.

4. The motor assembly according to claim **2**, wherein the driving circuit further comprises a rectifier configured to generate a direct current supplied to the detecting circuit at least.

5. The motor assembly according to claim **4**, wherein the rectifier comprises a voltage dropping circuit.

6. The motor assembly according to claim **5**, the rectifier is connected in parallel with the controllable bidirectional AC switch.

7. The motor assembly according to claim **2**, wherein the controllable bidirectional AC switch is a TRIAC.

8. The motor assembly according to claim **2**, wherein the detecting circuit comprises a magnetic sensor, the integrated circuit is installed near the rotor and the magnetic sensor is capable of sensing the magnetic field polarity of the rotor and variation of the magnetic field polarity.

9. The motor assembly according to claim **2**, wherein the detecting circuit does not comprise a magnetic sensor.

10. The motor assembly according to claim **1**, wherein the integrated circuit does not comprise a microprocessor.

11. The motor assembly according to claim **1**, wherein the motor assembly does not comprise a printed circuit board.

12. The motor assembly according to claim **1**, wherein a non-uniformed magnetic circuit is formed between the stator and the permanent magnetic rotor, and a polar axis of the permanent magnetic rotor has an angular offset relative to a central axis of the stator when the permanent magnetic rotor is at rest.

13. The motor assembly according to claim **1**, wherein the rotor comprises at least one permanent magnet, the rotor operates at a constant rotational speed of 60 f/p circle/minute during a steady state phase after the stator winding is energized, where f is a frequency of the AC power supply and p is the number of pole pairs of the rotor.

14. An integrated circuit for driving a motor, comprising: a housing, a plurality pins extended out from the housing, and a switch control circuit disposed on a semiconductor substrate, wherein the semiconductor substrate and the driving circuit are packaged in the housing, the driving circuit comprises a controllable bidirectional AC switch connected across two pins, a detecting circuit configured to detect a magnetic field polarity of a rotor of the motor, and a switch control circuit configured to control the controllable bidirectional AC switch to be switched between a switch-on state and a switch-off state in a preset way, based on the magnetic field polarity of the rotor detected by the detecting circuit.

15. The integrated circuit according to claim **14**, wherein the integrated circuit has only two pins.

16. An application apparatus, comprising: a motor assembly as claim **1**.

17. The application apparatus according to claim **16**, wherein the application apparatus is one of a pump and a blower.

18. The application apparatus according to claim **17**, wherein the pump comprises a pump housing having a pump chamber, an entrance and an exit in communication with the pump chamber, an impeller rotatably disposed in the pump chamber, and the motor assembly configured to drive the impeller.

19. The application apparatus according to claim **17**, wherein the blower comprises a fan blade and a motor assembly configured to drive the fan blade.

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