A New Adjustable and Rechargeable Induction Power Supply at High Voltage Side

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Abstract. In respect to the difficulties in power supply for online monitoring equipments at high voltage side, a new design of adjustable and rechargeable induction power supply is presented. A microprocessor is used as the central control unit, which can achieve the intelligent management and control of different modules of the proposed device. The experimental results show that reliable and stable power output can be obtained in the situation of large current variation.

Introduction

The security and stability of the high voltage transmission lines are very important in the development of smart grid. As a result, different kinds of auxiliary devices are installed on high voltage transmission lines to improve the capability of condition monitoring [1]. However, due to the electrical isolation of safety requirements [2], the electronic monitoring equipments installed on the high voltage side can not be directly powered from the low voltage side. Therefore, the power supply has become one of the key technologies which restrict the development of online monitoring systems.

The traditional power supplies, for example, solar energy [3], are unable to provide the monitoring equipments an all-weather, continuous and stable power supply. The induction power supply at high voltage side can work in harsh weather and provide stable and continuous output [4], which makes it an ideal choice for online monitoring equipments to solve their energy supply problem. However, since the current of the transmission lines varies in a wide range, it is crucial how to ensure that the induction power supply device has a stable and reliable output with a wide range of current fluctuation. It is necessary to ensure that the power supply can provide sufficient driving power to the online monitoring equipment when the current of the transmission line is small [5]. It is also needed to ensure that when large current flows in the transmission line, a sustainable and stable power supply still can be obtained. Therefore, a new design of adjustable and rechargeable induction power supply at high voltage side is studied. The proposed induction power supply can produce reliable and stable power supply in the condition of large current variation.

The Structure of the Proposed Power Supply

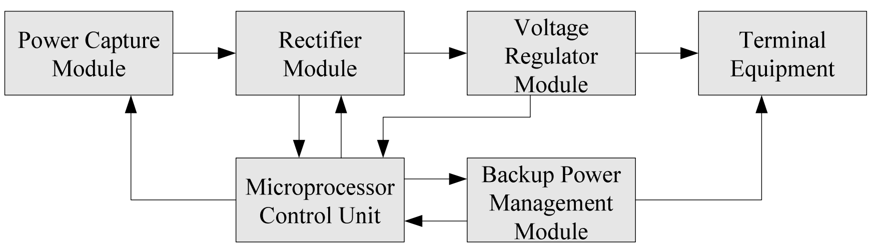

Fig. 1. The overall framework of the proposed induction power supply

The proposed induction power supply consists of the power capture module, the rectifier module, the over-voltage protection module, the voltage regulator module, the backup power management module and the microprocessor control unit (MCU), as shown in Fig. 1. With the MCU, the entire device can be intelligently controlled to produce a stable DC voltage output even with a large current variation in the transmission line [6]. The details of each module of the proposed induction power supply are presented as follows.

Power Capture Module. The structure of the power capture module is shown in Fig. 2. The actual current in the high-voltage transmission lines keeps changing. In order to adapt to the dynamic current changes, there are multiple taps at the CT coil in the secondary side. Different taps correspond to coils with different numbers of turns. With the sampling resistor in the rectifier module, the MCU can achieve a real-time control on the number of coil turns.

When the current in the transmission line is too large, the current at the secondary side also becomes large. The MCU controls the relay 1 and then the coil 1 will be connected to the circuit in order to reduce the current at the secondary side. When the current in the transmission line is in normal variation, the MCU controls the relay 1 and then the coil 2 is connected. Finally, if the current in the transmission line is too small, then the backup battery may be switched on to power the equipment. Such a design makes the proposed device having efficient power capture capability over a wide range of current variations.

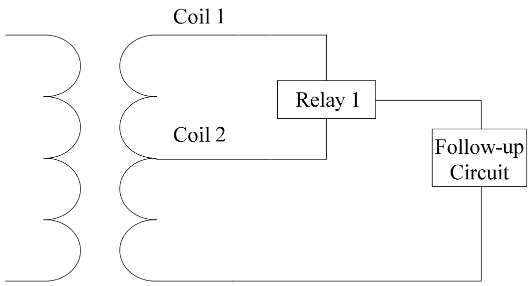

Fig. 2. The structure of the power capture module

Rectifier Module. Rectifier circuit DB107 is used in this design. RC filter and LC filter are connected in parallel. A transient suppression diode TVS, which plays the role of over-current protection, is inserted between the rectifier circuit and the filter. The selected TVS is SMF45A, which has a breakdown voltage of 75 V and a cut-off voltage of 45 V.

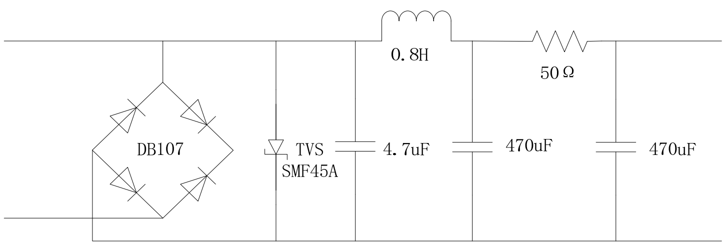

Fig. 3. The structure of the rectifier module

Voltage Regulator Module. The voltage of the DC output of the rectifier module is 7.5 V – 76 V. The role of the DC-DC voltage regulator module is to convert this wide range of input voltage into a stable but adjustable output voltage. In our design, the step-down voltage converter MAX5035BASA is chosen as the core unit of this module. It has high efficiency and wide input voltage range up to 76 V. Its output voltage is fixed to 5 V. Fig. 4 shows the circuit of this module.

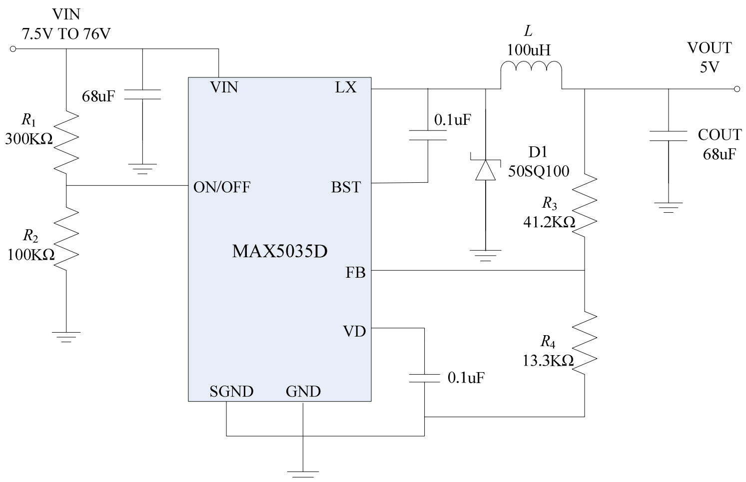

Fig. 4. The circuit of the voltage regulator module

Backup Power Management Module. The backup power management circuit is shown in Fig. 5. The CN3052B chip is chosen as the control chip of lithium battery charging and discharging. Two lithium batteries are used as the backup power source. It can be seen that there is a sensing point for each battery, which will be used by the MCU to manage the backup power.

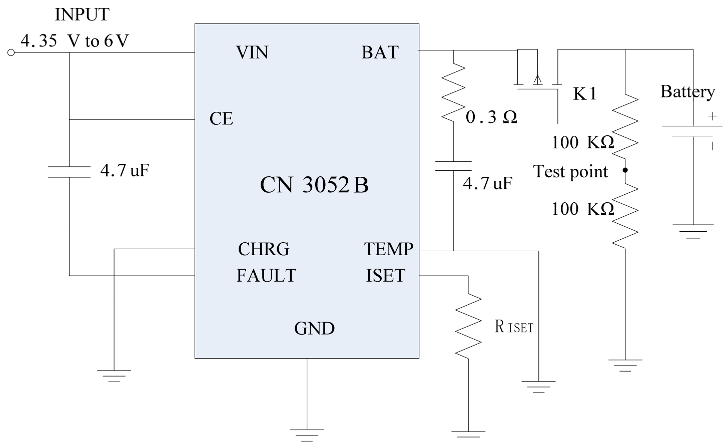

Fig. 5. The circuit of the backup power management module

The charging and discharging operations of the backup battery are as follows. Firstly, when the regulated output voltage reaches the rated value and the sensed battery voltage is below the lowest operating voltage, the power capture device not only provides power to the terminal equipment but also charges the lithium battery. At the same time, the MCU measures the time T used to charge the battery from a certain voltage value to the full power state. If T is smaller than the rated time, then the second backup battery will be switched on. In addition, the system will trigger the alarm program and the battery aging information will be sent to the terminal. Secondly, when the regulated output voltage is lower than the rated value, the power capture device only provides power to the terminal equipment. Thirdly, when the regulated output voltage is too low and lower than the voltage of the backup battery, the lithium battery will discharge and provide power to the terminal equipment.

The above operation makes the terminal equipment obtaining safe and stable power supply without interruption. While at the same time, the charging and discharging of the backup power are intelligently controlled by the MCU, which can extend the battery life and reduce maintenance cost.

Experimental Results

A prototype of the proposed induced power supply was fabricated and tested. As shown in Fig. 6, the transmission line is set to pass through the CT coil. The output voltage of the designed device is tested with different current values in the transmission line. The measured results are shown in Table 1. As can be seen from the table, in the absence of the backup lithium battery, there is no effective output when the current of the transmission line is less than 30 A. While when the backup battery is involved, the proposed device can produce a stable output of 5 V, which can be used to power the terminal equipment.

Fig. 6. The picture of the power capture experiments

Table 1. The measured results of power capture experiments

Current in transmission line [A]	Output voltage without backup battery [V]	Output voltage with backup battery [V]
20	0	4.95
30	5.02	5.02
50	5.02	5.02
100	5.02	5.02
200	5.02	5.02
500	5.02	5.02
1000	5.02	5.02

Conclusion

A new design of adjustable and rechargeable induced power supply at high voltage side has been presented. The microprocessor works as the control center and makes the automatic switching of multi-coils, over-current protection and intelligent management of the backup power possible. The measured results validated that the design power supply is feasible and has the potential to provide stable and reliable power supply for online monitoring devices.

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