Development of Current Detection Terminal of Wireless 10kV Distribution Line

Du Peidong, Wang Weizhou, Liu Fuchao, Zheng Jingjing

State Grid Gansu Electric Power Research Institute, Lanzhou, 730050, China

peidong9@163.com

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Abstract. This paper developed 10 kV distribution line current terminals with both measurement and communication functions, these terminal hang in the 10 kV power distribution overhead line, and through the open magnetic circuit current transformer current measuring circuit and by using the method of curve correction we realized the accurate calculation of the current value. This kind of terminal designed wireless communication module, and through wireless communication we send the nearby data to the transmission terminal; In order to meet the power supply requirements of MCU and wireless communication module, this device designed module getting charged through the circuit line, this kind of line could realize the charge of the device under the condition that there is a small load of current by pressing the rectifier circuit many times, and it makes the device meet the need of long-term free maintenance work in the open. With ATmega8L single-chip microcomputer as the core, the test terminal could realize wireless data transmission function through NRF24L01.

Introduction

At present, the 10 kV distribution network monitoring current mainly adopt the core with typed current transformer to measure current, the method is not convenient for field installation, and it is commonly installed inside the substation; Line electric current adopt the current transformer with the cables while installing, and the installation is complex with high cost, and difficult to realize long distance transmission of signals. If we can develop a suspended overhead line with small size, convenient installation and simple insulation, and its data transmission needs the current detection of the cable terminal, which will greatly improve the flexibility of our line current monitoring.

Based on the above situation, we designed a kind of current detection terminal with wireless communication function, this current detection terminal hanging on a overhead line can accurately measure the line current, and by means of wireless communication, it could send the line current information to the nearby data receiving terminal, the data terminal could be sent to the monitoring center by light or Ethernet making the staff in the monitoring center can understand the real-time changes of the line current and identify problems, which greatly improves the level of line safe operation.

The Realization Principle of the Distribution Circuit Current Terminal

New distribution network fault indicator can be divided into four main modules from the structural aspect, namely the MCU module, power module, circuit current measurement module and communication module, etc.

The line current terminal with AVR single chip microcomputer Atmega8L as the core, and the single chip microcomputer has low power consumption, whose working current in standby mode is less than 10 μA; The microcontroller itself has 10 block A/D converter and 512 bytes of EEPROM, which can simplify the circuit design of the entire device. Through large capacity battery and power supply circuit, the device could cooperate with the supply of the current. Under normal circumstances, the line current should be measured every 5 minutes (the time

interval can be set), then through wireless communication module, the data could be sent to the nearby data transmission terminal; When line current is too large, according to customer's need, it can also to send out alarm signal; data transmission terminal has Internet communication function, and is able to send the received normal measurement information to the monitoring center, thus making the staff in the monitoring center will be able to understand the working conditions of the distribution network.

The Hardware and Software Realization of Line Current Terminal

The Design of the Line Current Measurement Circuit

Line current measurement circuit is used to measure line load current of 10 kV distribution making users get the real-time understanding of line current value anywhere, which makes it easy for users to find and eliminate the problems in time. the measurement method of line current is to place in the fault indicator's a thoughtful electromagnetic induction coil, the output voltage and line current fall into the approximate proportional relationship, by using 10 bit A/D converter in Atmega8L to convert coil induced voltage into discrete digital quantity, and then through semi-circle integral algorithm to calculate the load current value of the line. The principle diagram of the current detection part of the circuit as shown in figure 1:

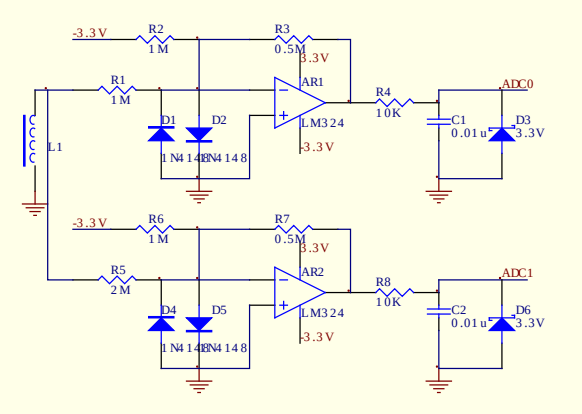

Fig.1 The schematic diagram to detect electric current

Through the test, we got the relations of the line current and output voltage as shown in the following table:

Table1. Relationship between induction coil output voltage and line current

Line current (A)	L1 output voltage (V)	Ratio (voltage/current)
5.00	0.014	0.0028
10.00	0.028	0.0028
15.00	0.048	0.0032
20.00	0.069	0.0035
25.00	0.09	0.0036
30.00	0.116	0.0039
35.00	0.142	0.0041
40.00	0.17	0.0043
50.40	0.26	0.0052
64.00	0.355	0.0055
83.50	0.52	0.0062
107.00	0.8	0.0075
128.00	1.04	0.0081
151.00	1.3	0.0086
175.00	1.56	0.0089
217.00	2.07	0.0095
240.00	2.3	0.0096
285.00	2.7	0.0095
326.00	3	0.0092
366.00	3.3	0.0090
400.00	3.6	0.0090

From the above table, we can know that the relationship between the induction coil output voltage and line current is not in a linear proportional relationship, and when the current is small, the proportion coefficient of the output voltage and input current is small, when the line current is more than 150A, the proportion coefficient tends to be stable.

The Design Line Current Electric Module. Line current electrical module is based on the current transformer principle to transform the current transformer output current into voltage, and through regulator circuit to charge super capacitor meeting the requirements of long running current terminal power supply. The electric circuit adopts the form similar to a current transformer, which means it adopts the closed magnetic circuit, but for the sake of convenient installation, for closed magnetic circuit, we adopt electrical pure iron for the main structure, iron core in the steel sheet coil uses the form of silicon; due to the influence of electrical pure iron part of the eddy current effect and that iron core chip is not tight, when the line current is small, the sensor output voltage is relatively low, so here we adopt multiple rectifying method to get the charge, and the multiple times pressure rectifier circuit principle diagram is as follows:

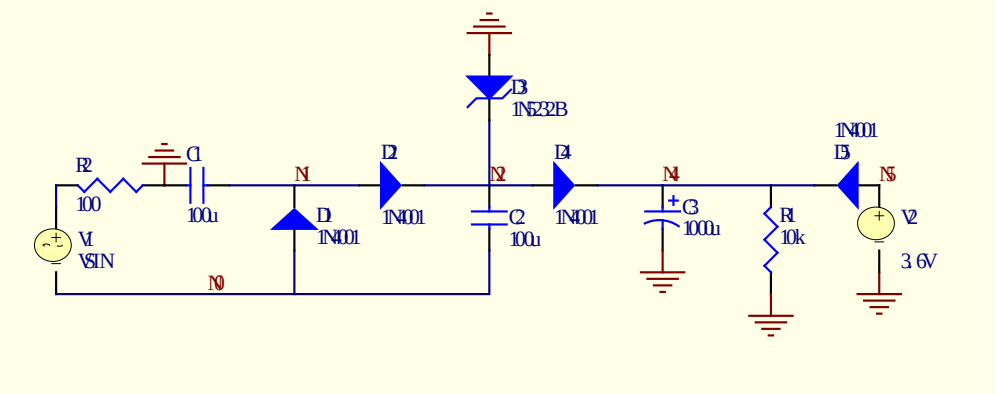

Fig.2. Multiple times pressure rectifier circuit principle diagram

Use simulation function on Protel to simulate the above circuit, the waveform gained based on each point is as follows:

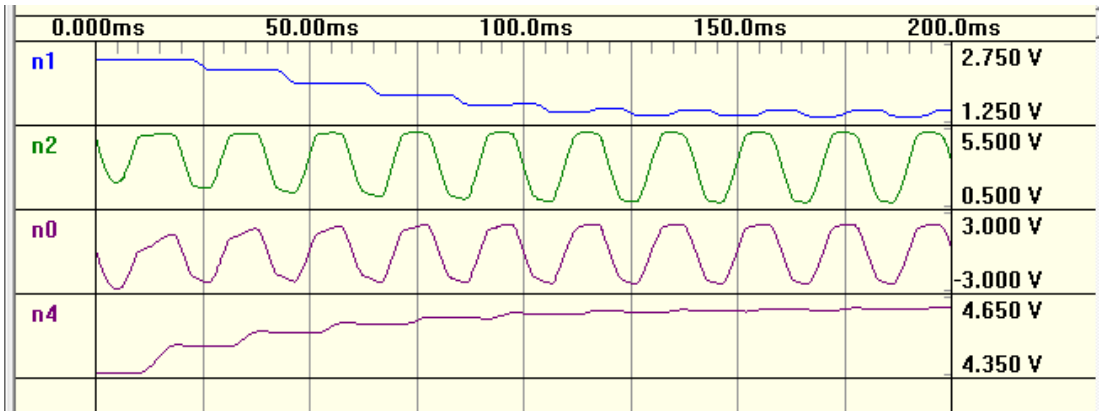

Fig. 3. Operation simulation waveform of multiple times pressure rectifier circuit

In the above diagram, n4 represents the voltage change on the super capacitor, and n0 represents the voltage obtained through the output end of the coil. From the picture, we can know: when the electric coil voltage amplitude is set to be 3 V, the voltage on the super capacitor could get as high as 4.65 V. Due to the fact that the voltage value of the voltage stabilizing diode D3 in the picture is 5.5 V, so the voltage of super capacitor is not too high. If there is no voltage stabilizing diode D3, the super capacitor voltage can reach nearly 9 V, thus, the super capacitor of 5.5 V could be so burned.

Through our experiment to adopt this three times pressure rectifier circuit, then the circuit current is greater than 15A, which would not consume the energy of the battery, and the power obtained from the line will be able to meet the needs of the work.

Wireless Communications and Other Modules. Wireless communication module is used to complete the wireless sending and receiving, because the distance between the fault indicator and data receiving terminal is less than 10 m, the transmission distance does not require a long distance, but it must have the characteristics of low power consumption and good anti-interference performance. This device choses NRF24L01 as the core of the 2.4 GHz wireless communication module, the antenna of this module is designed on the PCB board, and with small volume, low power consumption, it is particularly suitable for the operation embedded system, the module working voltage is between 1.9 V to 3.6 V, the power charge principle diagram we designed for module NRF24L01 is as follows:

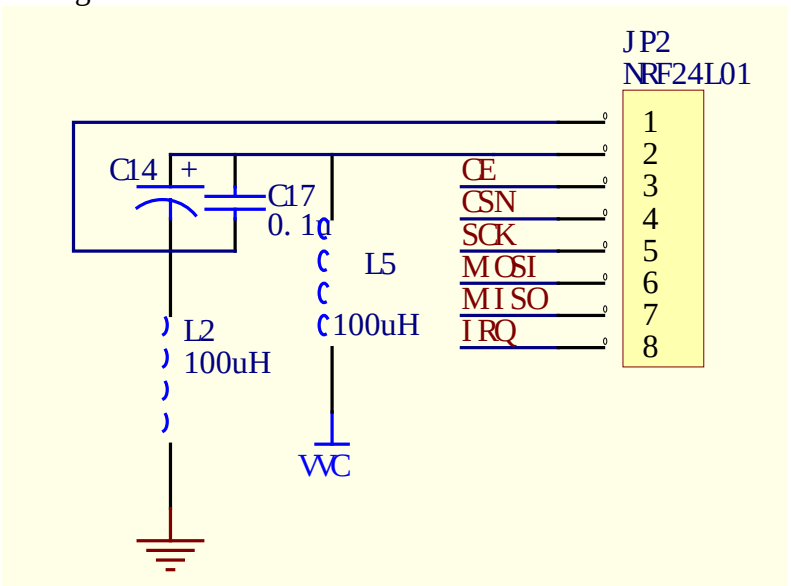

Fig. 4. Operating principle diagram of controlling NRF24L01wireless module

NRF24L01 wireless module has eight interfaces, among them 1 and 2, the two interfaces respectively related to the ground and power supply. In this design, in order to make the wireless module circuit and other parts of the digital circuit does not interfere with each other, it adopts the inductance isolation of political reform, L2 and L5 realizes part isolation of NRF24L01 wireless module power supply, and with C14 and C17 to stabilize NRF24L01 wireless module power supply. In addition, it uses six I/O interfaces to control the work of NRF24L01 wireless module.

In order to guarantee the stability of the wireless communication, we adopt the frequency hopping method. In our design, we used in the design of 2.45, 2.48, and 2.51 GHz, the three jump frequency; before the detection terminal sending the data, detect the location interference signal frequency, if the interference signal frequency is close to the frequency its used load sent, then the terminal should jump to another frequency to send.

Anti-interference Measures

New fault indicator hanging on the way of 10 kV overhead lines, in the running process it will be seriously affected by external environment and the transmission line, in order to make this device work long time and reliably, we must comprehensively use various anti-interference measures in terms of hardware design and software design. To inhibit and remove interferences, we must get rid of the three elements the formation of the interferences: the interference sources, coupling channels and receiving equipment.

Anti-interference Design of Hardware. The main interference of the device is the from power lines, through the coupling inductance loop of the power source to influence the microcontroller work; In the power supply section, we apply high-performance tantalum capacitor to realize wave filtering; In the A/D input pin and high pressure measurement pin, we use the RC filter circuit to realize low-pass filtering; Reset circuit has adopted high anti-interference design. In addition, we also added special STWD100 watchdog chip in circuit design, the chip could work stably with low power consumption.

Apart from the anti-interference measures adopted in power input circuit, we designed anti-interference functions in PCB wiring, the layout of the components etc. For example, we adopt the method of laying copper in large area to weaken the coupling interference among components, which also weakens the external electromagnetic interference to the components.

Anti-interference Design of Software. Anti-jamming function of single chip system can't completely rely on hardware to realize, the design of the software must take the anti-jamming into account, the commonly used anti-interference software techniques are: software trap, instruction redundancy, software "watchdog", digital filtering, etc.

In the design of new detection terminal software, we treated the software trap in our blank software storage space; ATmega8L has 8 KB program storage space, and control the application does not fill the entire program storage, we take the unused program memory space as blank area, we add a software trap in the blank space interval addresses making the program interfered by interferences to jump to no application area, and under this condition to run software trap program, we could get it back to the main program to continue its work.

Conclusion

This paper discusses the development and design of 10 kV distribution line current terminal based on the fact that high performance microcontroller ATmega8L as the core, the above mentioned design can accurately monitor the change of the line current, and is able to send these monitored information through wireless communication. By adopting comprehensive hardware anti-interference circuit and software anti-jamming algorithm, it ensures a long-term stable and reliable running of the equipment under terrible conditions. This device bears the characteristics convenient installation, low cost; and it could be applied to distribution network, which could

greatly improve the management level of power distribution network automation, reduce the labor intensity of workers, and improve the reliability of power grid operation.

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