Design of Automatic Cable Path Detection System Using Electronic Marker

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Abstract. Power cable is more and more widely used. But once the cable breaks down, and the direction and location of the cable are not clear, path detection is the first step to eliminate the cable breakdown. After the information of underground cable jacking is detected by detection equipment, positioning and identification are carried out to form management files, and power pipe jacking is managed by information management mode, which can reduce the loss caused by cable jacking accident and the harm to operation and maintenance. In this paper, the cable path detection, cable short-circuit point positioning and electronic marker are integrated. The cable path automatic detection system is designed by using the single-chip fuzzy controller. The self-adjusting fuzzy control scheme is proposed and the hardware and software design of the system is given.

1. Introduction
With the rapid development of the urban economy, a large number of pipelines have been invested and constructed, making the limited space more and more crowded. When the buried cable is phase-to-phase or phase-to-phase short-circuited, the short-circuit point is usually completed by a cable fault detector [1]. Such instruments are expensive, their detection accuracy is greatly affected by environmental factors, and is also related to the operator's experience. With the rapid development of economic construction and urban construction, the use of underground cables is increasing. However, many objective reasons are likely to cause unclear cable paths in field operations [2]. How to strengthen and improve the management level of power pipelines, comprehensively and accurately grasp the distribution and accurate positioning of underground cables and facilities, is not only to meet the needs of urban development and urban modernization management, but also to strengthen and improve the operation and management level of power pipelines [3]. More and more pipelines are replaced by underground pipelines, which makes the environment of underground cables in cities more and more complex. Large-area power outages caused by external force damage of power cables frequently occur [4]. In this paper, the cable short-circuit point automatic positioning system designed by using the cable fault detection principle and the self-adjusting fuzzy control principle can not only detect the direction of the cable path, but also accurately position the cable short-circuit point.

2. Working Principle of Cable Path Automatic Detection System and Electronic Identification

2.1. Cable path automatic detection principle
The 1KHz audio signal generator is used to pass the audio signal current to the cable under test. The cable generates the corresponding electromagnetic wave, receives the signal with the electromagnetic induction coil and amplifies it, and determines the position of the underground cable according to the
change of the strength of the signal. When there is a conductive geological body in the local area, under the action of the alternating electromagnetic field (primary field), eddy current (inductive current) will be generated in the conductor, and the eddy current will generate a secondary magnetic field (secondary field) around it. The appearance of the secondary field distorts the primary field. In the case of unknown frequency input, the signal frequency can be searched, and then the input frequency can be determined and locked. When the axis of the receiving coil (magnet rod) is perpendicular to the ground and the receiving coil is directly above the cable, the magnetic line passing through the coil is the least and the received signal is the weakest. When the coil is offset to both sides of the cable to be measured, the magnetic line passing through the coil increases gradually and the received signal becomes stronger. If the geological body has high magnetic conductivity, the secondary magnetic field is produced by artificial magnetization under the action of a primary field, the anomaly can also be found and the existence of underground magnetic conductivity can be inferred. According to the weakest signal above the cable under test, the laying path of the cable can be determined.

2.2. How the electronic identification system works

The electronic identification system is a receiving/transmitting device, which consists of an identifier detector and an electronic identifier buried underground [5]. The inside of the electronic marker is a passive circuit. The outer shell is moisture-proof, acid and alkali-proof, corrosion-proof and extrusion-resistant, and can fully resist severe changes in the external environment. In this way, the intelligent cable path detector can also be well used under the condition of unknown signal frequency in the cable, so that the operation is more convenient and quick; The detector sends signal pulses with a certain frequency in an intermittent manner; Underground markers with the same resonant frequency absorb and store signal energy; After the detector sends a signal for a short time, it stops sending and enters the signal receiving mode. The relevant information of the underground cable can be written into the spherical electronic information identification ball in advance, and the written information can be established on the computer for management [6]. The signal strength along the non-fault point along the cable path is basically unchanged, and the signal is strongest above the short-circuit point; the signal disappears quickly after the short-circuit point. It combines advanced digital signal processing technology to quickly and efficiently determine the direction and depth of underground cables and provide accurate underground pipeline paths. The operator and the readings are used to inform the operator of the comprehensive information of the underground cable. When the cable is broken in the future and needs to be constructed, the 3M marker locator can be used to understand the accurate information of the underground cable without digging the ground.

3. Design of Self-tuning Fuzzy Controller

In the process of cable path detection, the strength of received signal is related to cable depth, soil properties and the position of electromagnetic induction coil. When the cable depth is constant and the soil is basically unchanged, the signal system is mainly related to the coil position. Using the detection principle of electromagnetic method, a cable or insulated conductor is inserted into the spare pipe of the cable jacking pipe as a trace line, and the alternating low frequency (570 Hz or 35k H) primary field source signal of the transmitter is distributed along the jacking pipe. When the detector stops sending signals, the marker releases the stored energy and reflects it back to the detector; The detector detects the returned signal strength to determine the specific location of the marker [7]. When the location of the cable has been determined and the current geographic location information of the cable needs to be recorded, the GPS positioning function can be selected to record the geographical location information of the current cable, and finally uploaded to the computer for management of the cable data. Two parallel coils with a spacing of 35 cm (adjustable spacing, generally direct buried cable depth less than 80 cm) are used, and the two coils are symmetrical with the cable. It overcomes the detection error caused by traditional underground pipeline detection equipment susceptible to environmental influences such as metal objects and strong electric fields, as well as different signal access conditions, and even large errors [8]. Detect and read the information verification, confirm that the cable buried depth is less than
the maximum detection depth of the marker, otherwise use the relative buried depth mark, that is, the marker is buried at a certain distance above the cable and input the relative distance information in the marker.

Through the marker, the actual record of the special event points such as the position of the cable head, the cable trench and the rainwater pipe, the sewage ditch, the fire water pipe, and the telecommunication pipeline can be effectively realized. The difference in signal between the two coils. And the rate of change of the difference. In order to blur the input amount, the controlled object is a stepping motor, and the number of steps of the stepping motor is the fuzzy output. An alternating electromagnetic field is generated in the space around it, and the detector uses the detector to track the signal on the ground to detect the path and depth of the pipeline. The detector intermittently transmits a signal of a certain frequency; After a short time of signal transmission, the detector stops sending and enters the signal receiving mode; the underground marker with the same resonant frequency absorbs and stores the signal energy; records the ID code of the marker and the field situation, such as the actual burial depth of the ground reference object and the field information of underground target cable facilities. Among them, current and depth display. It can display the current size and burial depth of underground cable in real time. By using the marker detector, any specific marker can be accurately positioned. When the trolley is directly above the cable, the deviation is very small and the deviation change rate is large. When the trolley deviates from directly above, the signal deviation becomes larger, the variation rate of deviation decreases, and the number of steps the stepping motor rotates increases to return it to directly above the cable. This method has the characteristics of strong signal, high positioning and depth determination accuracy, and easy discrimination of adjacent pipelines.

A cable fault detector and a self-adjusting fuzzy control trolley are organically combined to form an automatic cable short-circuit point positioning system. The key point in the working process of the system is to ensure that the system moves directly above the cable, so as to ensure the accurate positioning of the short circuit point. After finding the cable working well, according to the specific conditions in the working well, the transmitter direct method, coupling method or induction method are used to apply signals to the pipe jacking to be detected. For existing cables in distribution network, firstly cable path detection is carried out, then ground markers and underground markers are installed, then data collection and database building are carried out, cable visual display is carried out through the platform, and finally cable file data are submitted. Under this mode, the relative position of the cable and the operator can be judged and the direction of the operator should move can be indicated. Then the buried position of the underground cable can be found. For the cable lines that need to lay the electronic identifier, the laying location, selection type, the letter, content and laying requirements of the corresponding key information points are determined step by step. In the process of control, the system continuously acquires new information, modifies control rules in time depending on self-learning function, adjusts control quantity appropriately, and has better robustness.

4. Software and Hardware Design of the System

4.1. Hardware structure
The system takes the single chip as the core, and the peripheral circuit includes signal acquisition circuit, A/D conversion circuit, stepper motor control and power DC motor control circuit, alarm circuit and so on. A pipeline detector is used to detect the change in the direction and depth of the top tube, and the equipment data obtained during the on-site detection is collected. The signal received by the induction coil is amplified and filtered to obtain a voltage signal, which is converted into a digital signal for processing by the single chip microcomputer. The system is driven by a DC motor and the direction is controlled by a stepper motor. By transferring each electronic identifier and its related data to the GIS system, the specific details of each identified cable can be visually displayed, and the information of different functional departments can be shared through the internal network system. The transmitter is placed on the detected cable along the direction of the cable, and the signal is applied to the cable under test, and the change of the direction and depth of the cable is detected by the detector along the intensity
of the signal. DC motor control: In the system work, as long as the signal received to 1KHz, the DC motor will run. In order to avoid the impact of motor on MCU, photoelectric isolation is used between MCU and DC motor.

![Fig.1. Hardware block diagram](image)

### 4.2. Software design

The system software includes signal acquisition, fuzzy decision-making, output control, keyboard scanning, etc. The signal acquisition module implements the activation of A/D conversion chip, digital filtering of signals, and difference of received signals. And the difference rate of change; When the cable under test is not easy to approach or cannot use direct method to apply signals, the transmitter using coupling access method is a good choice. Each sampling program sets two registers, a threshold value and a counter higher than the threshold value. In each cycle, the singlechip continuously samples, and the real-time value of each sample is compared with the threshold value. When a key is pressed, an external interrupt will occur to the MCU. The MCU responds to the interrupt. In the MCU interrupt program, it will judge which key is pressed according to the code output, and then enter the corresponding key interrupt service program to execute the corresponding program. Then the received digital IF signal is processed by the processing module. Finally, the data are reported to the main control computer through the data interface.

![Fig.2. Main program flow chart](image)

At the beginning of the program, the corresponding port of the MCU is initialized first, and then the interrupt is turned off. If the real-time value of the sampling point is higher than the threshold, the counter above the threshold will be incremented by 1, otherwise the counter above the threshold will remain unchanged. When the counter is higher than the threshold value, it indicates that the higher the load power of the dark cable belt is, the higher the alarm signal frequency is. The fuzzy decision module realizes the fuzzification of the input signals, corrects the fuzzy rules, makes fuzzy decisions and anti-
fuzzifies. In the self-checking process, the equipment legitimacy verification step is carried out, the verification code information of the used equipment is issued in the initialization instruction, the equipment judges whether the verification code information matches the equipment, if so, the equipment legitimacy self-checking is passed, otherwise, the equipment legitimacy self-checking is not passed. After receiving the GPS data, the received data is processed in the single chip microcomputer, and the data processing mainly removes the redundant information and extracts useful positioning information. The system reports the test data of the process to the host, and the host obtains the recommended parameter setting values required for calibration according to the statistics of the test information. Then, according to the calibration result, the operating parameters are set again. The two sampling signals are independent of each other, and the sampling principle is basically the same. It is determined that the cable is detected regardless of the detection of the cable system by a certain path. The system design flow chart is shown in Figure 2.

5. Conclusion
For the detection process of cable short-circuit points with nonlinear and many uncertain factors, the positioning accuracy can be effectively improved by using fuzzy control; the electronic information identification system can effectively and accurately determine the position of the marked pipeline, but if the cable This system is installed on the line, and another line adjacent to it is not installed, and the cable line may be accidentally damaged when the system is not installed. The application of underground cable detection and identification system can solve the difficulties of cable fault maintenance in the past to a certain extent. For accurate geographical distribution data of cables, underground cables are visualized and graphical just like overhead lines. It is believed that with the development of science and technology and the improvement of various components and detection methods, the intelligent cable path detector will surely achieve better performance. The self-adjusting fuzzy control scheme and implementation method make the system have fast response speed and good dynamic performance. The system has the advantages of full hidden installation, accurate location of intrusion position and low false alarm and omission rate, and has a wide application prospect in the field of outdoor alarm.

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