

Electronic displacement detection for equipment

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The electronic displacement sensor of the invention is an electronic circuit combined with a mechanical position or motion state sensing element, which is capable of protecting enclosed areas, locked buildings or mechanically movable objects against unauthorized intrusion or access with a high degree of security.

Advanced industrial security can be divided into several distinct groups depending on the type of sensors used. Each group of detectors is based on a different physical principle, but they all have one thing in common: they are increasingly moving towards electronic design. To meet the growing demand for central alarms, manufacturers specialising in the protection of property are also trying to make their sensor elements fully electronic, following the trend towards central alarms and installations. The need for greater reliability, the desire to use as little electricity as possible and the fact that there are no major standardisation efforts in the field of security today have led to a number of developments that are almost entirely divergent and incompatible.

The sensor elements developed in this way show an extremely wide variation both in the form of the electronic signal output and in the supply voltage used. The same can be said to a lesser extent for fire detection sensors. In this field, the use of a signal line with a power supply line is gaining ground, where the electronic signal output of the system is manifested by an increase in current. The only problem with this system, which is probably the most modern and reliable system currently available, is the variation in the supply voltage used, although there are already signs of standardisation efforts in this direction. In the field of intrusion detection, this system has also been adopted for piezo-electric glass break detectors, but for other detectors there are no mature solutions yet. A large group of intrusion protection sensors, the area protection sensors, is still at a very early stage of development. Even today, these detectors are still used in almost unchanged mechanical form, possibly with the addition of a resistor.

At industrial level, mechanical sensing elements combined with resistors are commonly used for area protection purposes, and where several sensing elements are used, the design of the sensing loops is usually as shown in Figure 1/a. A loop consisting of mechanical sensor switches $K_1 - K_n$ indicates intrusion into the protected area via the reference resistor R_f in a current-drop manner. On activation of any of the sensing elements - opening, opening of the protected opening structure - switch K opens and the loop current is diverted to the resistor connected in parallel with it. The disadvantage of this procedure is that, in theory, a separate voltage monitoring circuit would have to be built in the central alarm system for each sensor element. In practice, however, the line resistance R_h , the termination resistance R_v and the current drop created by each sensor element after the activation of some switching elements are so large that the recording unit can no longer distinguish between a loop break and an alarm.

In practice, centralised alarm systems currently on the market are no longer capable of registering a further alarm signal after the activation of 3 or 4 sensor elements. This phenomenon is particularly problematic when some of the detectors are not reset in the event of a failure of the

opening mechanism or incorrect closing. In this case, the central alarm system will give a fault signal, which will be interpreted as a loop break, but it will not be able to perform its intended function until the defective opening devices are repaired. Thus, in particular where a large number of detectors are used, a few malfunctioning detectors will prevent the central alarm system from continuing to protect the other opening devices. Another major disadvantage of the loop design shown in Figure 1/a is that any sensor element can be deactivated from the inside by a simple short-circuit at the installation site. In fact, if the loop wire is found, entire groups of sensors can be deactivated by a simple short-circuit without any special aid.

The loop design shown in Figure 1/b tries to overcome this safety disadvantage by adding a series resistor to each sensor element. In the event of a short-circuit of any sensor element, a current increase in the sensor chain is created, similar to a direct loop short circuit, and this current increase, reflected as a voltage increase across resistor R_f , triggers the alarm and fault indication circuits of the central alarm system. However, a major disadvantage of this design is that in practice only a few detector elements can be placed in a loop, since these series resistances increase the loop resistance of the sensor chain to such an extent that the central alarm device is also unable to distinguish between an emergency condition and a loop break beyond a certain limit.

The electronic displacement detector according to the invention is intended to eliminate these safety disadvantages by introducing the state-of-the-art signal line system combined with a power supply line for area protection purposes. The advantage of this method is that, like conventional sensor designs, it does not require more than two wires with more than two orifices. In the loop, the end-signalling is achieved by the individual sensor elements drawing orders of magnitude more current from the central power supply during the alarm period than their quiescent current. After an alarm signal, which can be set for a few seconds, the activated electronic sensor element returns to its resting state and enables itself and the other elements of the sensor chain to continue monitoring. These sensing elements are intrinsically protected against both a trip short circuit and a direct short circuit of the signal line, and a break or wire cut can be protected against by a line end termination resistor connected in parallel.

For area protection, however, the above procedure cannot be implemented with the mechanical coupling elements currently in common use. At present, both industrial and low-cost public intrusion alarms use only opening or closing contact devices. Since these simple switching elements do not allow the creation of a modern electronic version, a changeover switch with both opening and closing contacts was used as a direct mechanical sensing element for the electronic displacement detector of the invention (Figure 2).

In the rest condition, the starting capacitor C_1 is charged to full supply voltage via the opening and closing contacts K_v of the direct displacement sensing switch by means of resistor R_1 . In the event of a switch K_v tipping, i.e. the opening of the shutter, the energy of capacitor C_1 is transferred to the base of T_1 via the opening contact of K_v . This causes transistor T_1 to saturate for a short time, charging the delay element C_2 from near full supply voltage. Since the charging of C_2 takes place in a very short time, it is irrelevant for the electronic displacement sensor of the invention whether or not the opening mechanism is closed immediately after opening.

After C_2 has been charged, transistors T_2 and T_3 remain open until the delay element C_2 is fired through resistor R_4 , which controls the slope of the alarm pulse. The duration of the alarm, which is manifested by a current increase, can therefore be controlled by the value of C_2 . By using a Darlington version of the T_3 transistor, the output current can be converted from a linear current signal to a near-ideal square wave which is easier for the central alarm device to evaluate. Resistor R_6 protects transistor T_3 from over-dissipation and diode D_1 is used to prevent damage caused by a possible reverse polarity. Elements $R_2 - R_3 - R_5$ protect the circuit from thermal runaway and also act as mains noise filters. The supply voltage used can be very wide, ranging from practically a few volts to the maximum UCE termination voltage of the transistors used (4 - 60 V in a standard arrangement).

Based on the output characteristics, it can be concluded that the electronic displacement sensor embodiment of the invention shown in Figure 2 gives an alarm signal of constant duration only above a certain line resistance, with the duration of the alarm signal increasing exponentially as the line resistance decreases. In practice, this means that the duration of the alarm signal is stable above a line resistance of about 1.5-2 kilohms, assuming a delay of the order of a second, and maintains this stable timing for line resistances of the order of megaohms. A very important advantage of the electronic displacement sensor embodiment of the invention, shown in Figure 2, is that the duration of the delay after the steady state is reached is almost completely independent of the applied supply voltage. However, below about 1.5-2 kilohms line resistance, the exponential increase in delay time mentioned above is also greatly influenced by the applied supply voltage.

This particular feature of the embodiment of the electronic displacement sensor of the invention shown in Figure 2 makes it possible not only to use this new type of electronic sensor element as shown in Figure 3/a for complex central alarm systems, but also to create a very simple and inexpensive alarm device. A simple alarm unit as shown in Figure 3/b must be connected to the parallel protective chain formed by the new type of sensor elements according to the invention in such a way that the resistance of the connecting cable between them, i.e. the line resistance, is as low as possible. The lower the line resistance, i.e. the closer the current flowing through the activated electronic sensing element is to the maximum allowed dissipation current for the T3 transistor, the longer the alarm duration will be. Therefore, the electromechanical switching element used as signal receiver J1 must have a winding resistance as close as possible to this minimum permissible line resistance.

Direct alarming within the alarm unit can be achieved in two ways. The first is the direct way, when the new type of electronic sensing element according to the invention is activated or a direct short circuit of the loop line causes the J1 clamp to pull and energise the alarm horn via its working contact. The other way is when a loop break causes the quiescent current provided by resistor Rv to be removed. Then the Darlington transistor pair T4 - T5 opens and now electronically energises the emergency horn. If the loop conductor is intact, the voltage monitoring circuit T6 - R8 prevents T4 - T5 from opening. In the rest condition, the monitoring current generated by resistor Rv causes a voltage drop of a few tenths of a volt on the signal collector J1, which causes transistor T6 to open and keeps transistors T4 - T5 closed via resistor R7.

Another great advantage of this unit with only three transistors is that, as with complex central alarm systems, it protects not only against wire cutting and short-circuiting but also against tampering with the terminating resistor. By changing the value of Rv outside a narrow range, the alarm process is triggered either via the J1 signal clamp or via transistors T4 - T5. The easiest way to set this optimum range is to use a current meter. Connect a current meter between the power supply and the supply voltage connection marked Ut and set Rv so that the system quiescent current consumption is at the minimum point. This quiescent current consumption, which is practically a few milliamperes, can be further reduced by using a transistor with a low base-emitter opening voltage as T6 transistor. To ensure that the alarm unit does not affect the quiescent current consumption, R7 - R8 should be of the order of magnitude above 100 kilohms. Diodes D3 - D4 protect the system against inductive voltage surges and diode D2 protects against manipulation by external, extraneous voltages.

By setting the electronic displacement sensor according to the invention to a constant delay of 1 to 1,5 seconds, the alarm duration of the alarm unit shown in Figure 3/b can reach 40 seconds due to the exponential increase as described above. In the event of a wire cut, wire break or wire blockage, the alarm will be steady. The alarm unit shown in Figure 3/b can be used with the electronic displacement sensors of the invention to provide satisfactory security for the protection of warehouses, shops, small industrial installations or to protect various movable or vibratable objects simply and cheaply.

Especially in the protection of large industrial installations, where a large number of sensor elements are used in a loop, it can be problematic to know which sensor element has triggered the alarm in the event of an intrusion. This problem is solved by the embodiment of the electronic

displacement detector according to the invention, shown in Figure 4, which is interlocked after the activation of the direct sensing switching element Kv and indicates by means of an LED display unit, which can be placed at a distance from the sensing element, which emergency signal has been triggered by which opening structure. The latching of the emergency alarm is electronically generated. The opening process, initiated by element C1, is maintained by means of the feedback resistor R10 transferred from the collector of transistor T3 and is maintained until the circuit is reset to its initial state by the reset capacitor C3 when the supply voltage is interrupted. By increasing the value of C3, the reset interrupt time can be adjusted depending on the value of C1.

In the embodiment of the electronic displacement sensor of the invention shown in Figure 4, the connection of the latching indicator unit must be carried out with increased care. In the present case, the LED display unit cannot be connected in series with the direct current boosting semiconductor element, as is the case for electronic fire detectors. In the case of intrusion detectors, the possibility of the display unit being forcibly short-circuited or broken must be expected, therefore the LED can only be connected in parallel with the insertion of resistor R9 as shown in Figure 4. Of course, in this case, the applicable emergency current interval is significantly reduced compared to the embodiment shown in Figure 2. Indeed, in the embodiment of the electronic displacement sensor of the invention shown in Figure 4, the minimum value of the emergency current defined by the line resistor and the reference resistor must be such that the voltage across resistor R9 is not less than the opening voltage of the LED due to the emergency current, and its maximum value is limited by the maximum dissipation power of the LED display unit.

The embodiments of the electronic displacement detector of the invention shown in Figures 2 and 4 can be adapted, by means of an additional circuit, to protect high-value installations and objects requiring increased security. In this case, the reverse polarity protection diode D1 of the new type of sensor element according to the invention must be supplemented by an additional circuit consisting of diodes D5 - D6 - D7 and a capacitor C4. This simple additional circuit is in fact a Graetz rectifier circuit with a buffer capacitor. Of course, in this design, the sensor loop is not fed with direct current, but with alternating current at a frequency different from the standard AC network.

If a capacitor or inductance is used as a terminating element instead of a resistor, the sensor loop can be fully protected against overfilling with a high value capacitor, manipulation with various series and parallel resistors, and disabling by external foreign voltage interference. In this loop design, also known as the phase-shift method, it is not possible to determine, at the location where the sensing elements are installed, by any means, the direction and magnitude of the phase shift between the voltage applied by the central alarm device at the start of the loop and the current flowing through any point in the loop. The recording unit of the central alarm system shall continuously monitor the phase shift of the voltage applied to the loop and the current generated in the loop by the line resistance and the termination element as R - C or R - L circuit and shall trigger the alarm in case of any phase shift in either direction. AC shapes of the electronic displacement sensor of the invention, as shown in Figure 4, can be used in DC loops without any modification.

Depending on the purpose for which the electronic displacement sensor according to the invention is intended to be used, micro-switches, magnetically operated reed relays, metallic fluid filled vibration switches or vibration switches which can be mounted in different positions can be used as direct mechanical position or motion state detecting switches. Of course, in order to be used for the electronic displacement sensor according to the invention, these mechanical sensing elements must be of the Morse code type. The monitoring current consumption of the embodiments of the electronic displacement sensor of the invention shown in Figures 2 and 4 is minimal, with a quiescent current below 0.1 microampere when using low leakage current tantalum capacitors.


/ Kun Ákos /

PATENT CLAIMS:

1./ An electronic displacement sensor characterized by having a mechanical position or motion state detecting toggle switch and a signal line combined with a power line.

2./ The electronic displacement sensor according to claim 1, characterized in that it has a DC or AC embodiment as shown in Figure 2, and in that it has a charging actuator in the rest condition.

3./ The electronic displacement sensor according to claim 2, as shown in Figure 4, characterized in that it comprises a safety voltage divider /2/.

E P I T O M E

Electronic displacement detection for equipment

The electronic displacement sensor of the invention is an electronic circuit combined with a mechanical position or motion sensing element which, when actuated, gives an alarm signal for a few seconds in the form of a current increase on its signal line connected to a power supply line and then returns to its resting state.

The electronic displacement detector according to the invention achieves this property by the fact that the mechanical switching element performing the direct detection, after switching over, connects a charging trigger element in the resting state to the input of the circuit, the duration of the alarm signal no longer being influenced by the trigger element.

Simple additional circuitry can be used to make the electronic displacement sensor suitable for use in AC loops and to provide on-site indication of the alarm.