

Counting Addressing Method – Command Addressable Element and Extinguishing Module

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Abstract: The specific requirements that appear in addressable fire detection and alarm systems and the shortcomings of the existing addressing methods were discussed. A new method of addressing of detectors was proposed. The basic principles of addressing and responding of a called element are stated.

Extinguishing module is specific subsystem in classic fire detection and alarm systems. Appearing of addressable fire detection and alarm systems didn't caused essential change in the concept of extinguishing module because of long calling period of such systems. Addressable fire security system based on counting addressing method reaches high calling rates and enables integrating of the extinguishing module in addressable system. Solutions for command addressable element and integrated extinguishing module are given in this paper. The counting addressing method was developed for specific requirements in fire detection and alarm systems, yet its speed and reliability justifies its use in the acquisition of data on slowly variable parameters under industrial conditions.

Keywords: System architecture, Counting addressing method, Fire detection, Command addressing element.

1 Introduction

Addressability (the ability to recognize an address) is an element of intelligence; by adding this feature to fire detectors, we turn them into intelligent sensors. Addressability is a well-known and widely used feature, especially in computer communications. Addressability in fire detection and alarm systems has its peculiarities, as a result of which the classic and tested solutions have not turned out to be the best for this purpose.

The problem of addressability in fire detection and alarm systems has been solved by various manufacturers on different ways, and there is still no clear method which would be good enough to be accepted as a standard. The selection of addressing method in addressable systems for fire detection is a highly complex and difficult task, due to the peculiarities of these systems and requirements which frequently contradict each other [5].

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Before we proceed discussing possible ways of addressing, we will give a list of peculiarities which make addressability in fire detection and alarm systems a challenging task.

The obligatory request in fire detection and alarm systems is – power supply and communication lines for addressable element (AE) must be realized through the same pair of conductors. Communication in computer systems is realized through special communication lines. This causes an additional problem in AE – extraction of communication signals from a line powered by d.c. voltage, 24 V. At the same time, it is necessary to solve the problem of generating communication signals in the computer which generates counting pulses, polling addressable elements and interprets their responses (usually cold central station, control panel or main console) [2].

Communication requirements in addressable fire detection and alarm systems are quite reduced in comparison with computer communications, and include:

- Addressing (polling AE),
- Command ON/OFF (for Command AE – CAE),
- Response of the called AE.

The response of an addressable element depends on the nature of the device connected to the addressable element; it can be digital (one of the two levels or states), or analog. The response of an addressable element can also include the address of the AE, which confirms the validity of addressing (this is common in computer communications). To increase calling frequency, sending the address can be avoided in the response, while the reliability of calling can be ensured in some other way; this will be discussed in more detail later.

The majority of manufacturers use lines up to 2km [6], which is substantial. For such lengths, computer communications make use of special interfaces (current loop or RS485 – up to 1,2km) with a reduced number of ports on the line (usually up to 30). To connect a larger number of users to the line, and for greater distances, one uses optical cables (highly resistant to electromagnetic disturbances), but their price and the price of the required interfaces are high. Also, optical cables cannot supply the sensors with power.

The required number of addressable element ports on the line in addressable systems ranges from 50 (in Cerberus) to 256 (Apollo, Ziton, Zettler). Such a high number of ports in computer communications is realized through optical cables and special interfaces whose use is impossible in fire detection and alarm systems, due to their price and the need for power supply [1].

This problem can be surmounted by increasing the wire's cross section (which reduces the resistance of the line), by increasing the communication signal amplitude, and by reducing detector's consumption.

As the same line is used for both power supply and communication, the consumption of addressable elements and of the detector represents an important limiting factor for line length and the number of detectors, due to line's resistance. Let the consumption of an addressable element be 0.2mA, 24V. For 256 addressable elements on a line with resistance 100Ω leads to a line voltage drop is:

$$\Delta V = 256 \times 0.2 \times 100 = 5.12 \text{ V.}$$

Reduction of the consumption of addressable elements and detectors enables an increased number of detectors on the line, the use of a longer line, and a smaller cross section of the conductor.

The price of an addressable element certainly affects on the choice of the solution, and eliminates numerous better solutions (otherwise used in computer technology). The price of an addressable element in the global market ranges between 20 and 30 USD; thus, finding a more expensive solution makes no sense, regardless of its quality.

Closely related to the price and consumption is the complexity of addressable element's electronics. It is clear that the price and consumption of simpler electronics are more acceptable, and that the increase of electronic complexity involves the increase of both price and consumption. Going to a technologically higher level (full custom design) can minimize both the price and the consumption of addressable elements.

Another important element of the price of a fire detection and alarm system is certainly the price for cable needed for distribution of signals and power supply.

The use of optical cables for communication has already been eliminated, because of both their price and the price of the required interface, and the requirement to provide both power supply and communication through a single pair of conductors.

The use of cables with a protective shield, which successfully eliminates the effect of induced electromagnetic disturbances, is not acceptable because of their price, so we are left with the option of using relatively cheap cables without a protective shield. Copper conductors of cross section 0.8mm² are commonly used. The use of conductors of a larger cross section reduces line resistance, causing a line drop, which enables the line to be lengthened or to increase the number of connected addressable elements.

Owing to this requirement, when selecting an addressing method, special attention must be paid to the occurrence of disturbances, their effect on the system, and the methods of overcoming this problem. The methods for overcoming line disturbances used in conventional computer communications cannot be applied in fire detection and alarm systems, due to their peculiarities, as we have already seen.

As a rule, when connecting a larger number of addressable elements to a line, calling is performed cyclically. In such cases, giving priority is achieved through more frequent calling of elements of a higher priority. In systems working in real time, calling rate, defined as the number of calling the same addressable element per unit time, is determined through maximal allowed time between two calls of an AE.

The classic methods of solving this problem are bit speed increase and limitation of the number of addressable elements on the line. Less frequently, the problem is solved by introducing priorities in calling.

For achieving good communication reliability, and bearing in mind line length and quality, bit speed is limited to 2400 bauds. Reduction of the number of addressable elements on the line in systems for fire detection and alarm is not an applicable method, due to the fact that it is required that the largest possible number of addressable elements is connected to the same line. Introducing priorities to addressable elements of the same nature (e.g. fire detectors) is certainly not an acceptable method.

Time between two calls in systems of 256 addressable elements on the line is 4s (Apollo-Pastor), while in systems of 127 AE this time is 2s (Ziton). This clearly tells us that the problems mentioned above have not yet been solved. Some manufacturers have settled to solve this problem by reducing the number of addressable elements on the line; thus, CERBERUS has limited the number of addressable elements to 50. Time of 2s between two successive calls seems plausible, but if we take into account the time required to turn off and relax a detector before the next reading, we come to the result that the alarm will be raised no less than 6 seconds after the moment of the first occurrence of state of the alarm on the sensor. Knowing the dynamics of some fires, this time can be impermissibly long [4].

Calling rate becomes of special importance in addressable analogous systems, a subject which will not be elaborated here.

If we dismiss reduction of the number of detectors on the line as a method for shortening selection time, we are left with reduction of the time required for processing an addressable element as the only way of improving the performance of addressable and, especially, of addressable analogue systems.

2 Addressing of the Counting Type

Let each addressable element on the line has a counter and a comparator. The counter is triggered by voltage clock pulses on the line. The current counter value is compared with the pre-assigned value of the address in the comparator, and the comparator generates EQV signal when the state of the counter is equal to the pre-assigned value of the address. Fig. 1 shows the basic principle of the counting method of addressing.

The host computer generates voltage clock pulses that polls all detectors announce and manages alarms - usually known as main console or control panel. After resetting the counter, all counters on the line are in the initial state. Methods of ensuring RESET and other signals will be discussed later.

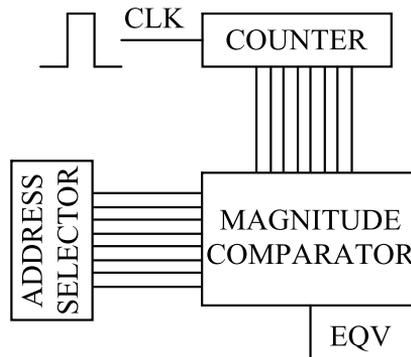


Fig. 1 – Counting addressing method principle.

As the main console generates the first clock pulse, the state of all counters on the line is 1. It is only on addressable element 1 (AE1) that the pre-assigned address corresponds to the state of the counter, and it is the only one that generates EQV. Addressable element 1 remains addressed until the next clock pulse [3].

Each clock changes the state of each counter and addresses the next addressable element. This simple way of addressing requires relatively simple electronics, which further means low energy consumption and a competitive price. This method has also turned out to be a very fast addressing method in comparison with other addressing methods [3].

The discussed addressing principle has its shortcomings, such as sensitivity to disturbances. Also, it is not clear how an addressable element will respond or react to a command. These issues will be discussed as we proceed.

3 Extraction of the Clock and Reset Signals

Degradation – the loss of initial shape – of the signal the line is a consequence of line resistance and capacitance (in the case discussed here, inductance of the line is negligible). Fig. 2 shows pulses of different widths at the output end – a), degraded pulses at the input end, – b), and pulses after reconstruction by Schmidt trigger circuit – c).

Too short pulses (first column) resulting from degradation cannot reach the triggering level of the Schmidt trigger, and cannot be reconstructed. This also applies to low-level and short-term disturbances.

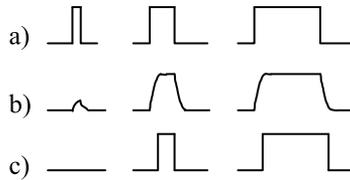


Fig. 2 – Consequences of signal degradation on impulses with different widths
 a) basic pulses; b) degraded pulses; c) reconstructed pulses.

Sufficiently long pulses will be narrowed and delayed due to degradation by the line (second and third columns).

Signal measurement on a line of length 1.5km (conductor cross section 0.5mm^2 , resistance 90Ω) has shown that pulses longer than to $7\mu\text{s}$ can be successfully transmitted.

For achieving greater transmission reliability, we have adopted that the clock pulse is $30\mu\text{s}$. In this way, we have ensured high reliability of triggering counters in the addressable elements on the line.

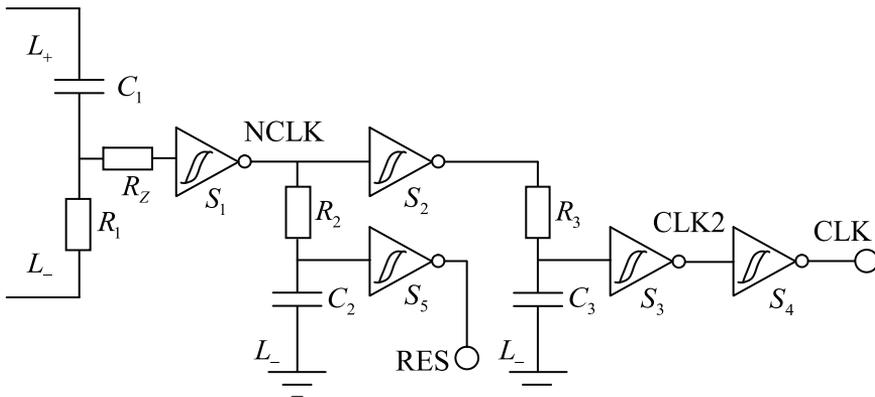


Fig. 3 – Extraction from the line and forming signals CLK and RES.

Fig. 3 shows the clock and RESET pulse extraction block from the distribution and power supply (24V) line, to which clock and RESET pulses (amplitude 5V, different durations) are added.

Integrative element C_1R_1 extracts pulses from the line. Resistor R_2 serves as a protection of Schmidt trigger S_1 that shapes and inverts the input pulse (NCLK in Fig. 3).

The charge of capacitor C_2 through resistor R_2 also serves to shape the RES signal for the counter. Pulses of short duration (clock pulses) are insufficient to fill the capacitor (C_2), and cause no change to RES signal. Resetting of counters in the addressable elements is performed by prolonged pulse on the line (1ms) sufficient to fill capacitor C_2 and generate the signal for resetting of counters - RES.

Schmidt trigger S_2 has the task to extract time constant R_2C_2 from R_3C_3 . Values R_3 and C_3 have been selected so that the clock pulse is narrowed by additional $15\mu\text{s}$, which brings the duration of the CLK pulse within $10\text{--}15\mu\text{s}$. Thus, pulses of duration up to $15\mu\text{s}$ do not trigger the counter. As pulse disturbances on the line are usually shorter than $15\mu\text{s}$, we have an addressable element protected against undesired counter triggering and misaddressing.

4 Response

Any of the detectors connected ought to recognize its address and give one of the following responses: detector in state of alarm, detector in normal state, detector is not present.

In the previous Section, we discussed the block for extracting the pulse from the line, before the basic principle of addressing was explained.

The block scheme of the addressable element is represented in Fig. 4.

When a detector is not present, SENSE and L'_- are not connected. When a detector is connected, L'_- and L_- become connected, while SENSE contains information on the state of the detector.

Let us now see what happens in the addressed detector.

Output signals from mono-stable multivibrators MMV1 and MMV2 are marked as MV1 and MV2. In the given configuration, transistors T_1 and T_2 behave as d.c. current sources – bringing signals “high” to their bases.

EQV signal remains high until the next counting pulse – 1ms.

The leading edge of the EQV signal triggers mono-stable multivibrator MMV1, whose relaxation time is chosen to be 300 μ s. The trailing edge of MV1 signal triggers mono-stable multivibrator MMV2, whose relaxation time is approximately 400 μ s.

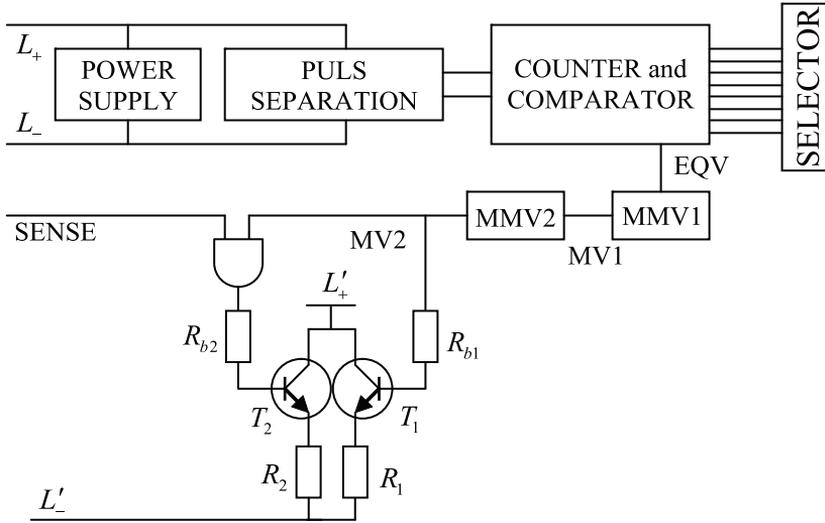


Fig. 4 – Block scheme of the addressable element.

High level of signal MV2 activates d.c. current source T_1 , so that the line current is 5mA. High level of signal MV2 enables SENSE signal through the logical AND circuit, and high level of SENSE signal then activates o.k. current source T_2 (5mA).

To summarize, 5mA current causes the response of the addressable element with the detector in the normal state; if the detector is in the state of alarm, the line current is doubled – 10mA.

Absence of the detector prevents any current flow, since L'_- is connected to the line within the detector itself.

The use of variable d.c. current sources (4–20mA) for transfer of analogue values is often used in industrial equipment and instrumentation, due to their small sensitivity to electromagnetic disturbances.

5 Extinguishing Module

Extinguishing module is microprocessor based system which performs his functions under adequate programm control and by certain number of detection and executable lines.

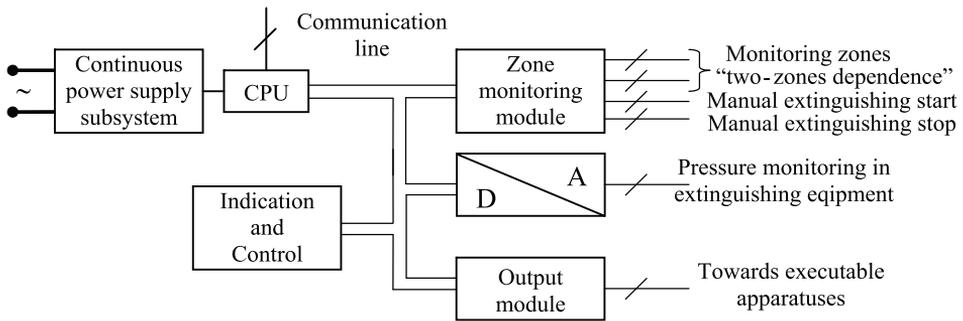


Fig. 5 – Block scheme of the contemporary extinguishing module.

Classic extinguishing module is connected with fire monitoring zones (automatic and manual) and with executable zones (extinguishing and alarm zones). Information about pressure of extinguishing appliance in bottles is present in extinguishing module, too. Extinguishig zone is activated when fire monitoring zones informs module that fire alarm level was reached. In the case of automatic monitoring zones, extinguishing will be activated when case of “two-zones dependence” is reached. Reaching alarm level on one automatic fire monitoring zone will not cause momentary execution of extinguishing function. Execution is prolonged for some software defined period necessary for verification of alarm stage. During the period of verification is possible to stop extinguishing, or start extinguishin momentary using appropriate buttons. After expiring the period of verification, extinguishing will be activated automatic. All activities of extinguishing modul are represented by signalization on the module.

Contemporary extinguishing modules usualy monitors pressure in extinguishing equipment and indicates fall under appropriate level. The block scheme of the contemporary extinguishing module is represented in Fig. 5.

Integrateing of contemporary extinguishing module in addressable fire detection and alarm system is possible as follows:

- using communication line;
- using addressable elements;
- integrateing extinguishing module in the addressable system.

Connecting by the communication line is classic solution. On command console is present all indications and commands for extinguishing module. It means that all indication and command is doubled and for connection between command console and extinguishing module is used one extra couple of leads.

It is possible to monitor stage of extinguishing module by a few addressable elements and indicate it on the command console. Providing of control function in such designed extinguishing subsystem needs including a few of command addressable elements. Designing of command addressable element enables integrating extinguishing module in the addressable system.

6 Command Addressable Element

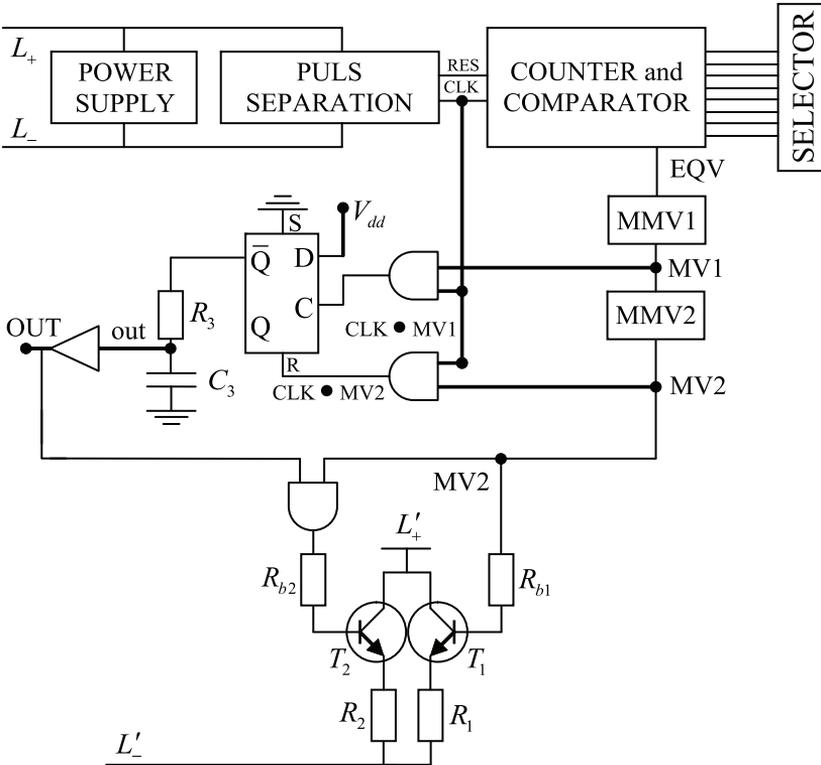


Fig. 6 – Block scheme of the command addressable element.

A couple of possible solution was considered and all of them uses memory element (D flip-flop). Using of command pulis in the interval between counting pulses requests some extra electronic for separateing counting and command pulses and extra electronic for suppression of command pulses on unaddressed addressable elements. Such solution disables speed counting and speed addressing.

Different pulse width could be a command for addressable element. Pulse width doesn't affects on counting function in addressable element and it needs

not extra electronic for separation counting and command pulses nor for suppression of command pulses on unaddressed addressable elements. Speed counting and speed addressing is now possible.

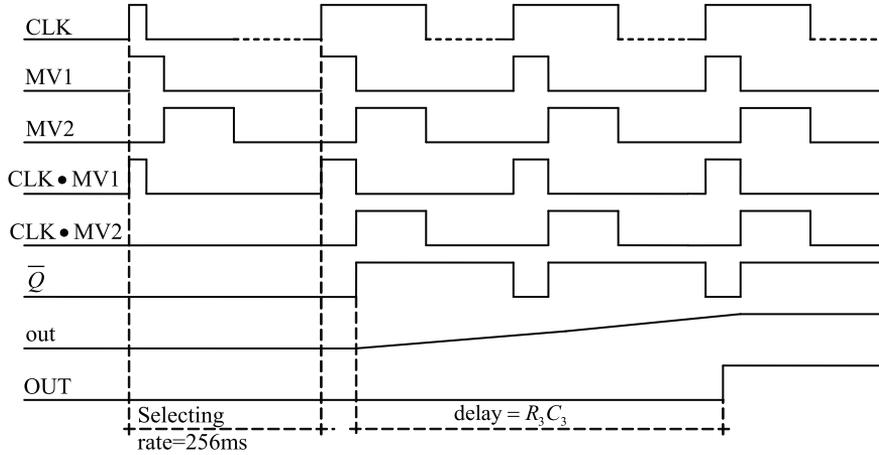


Fig. 7 – Shapes of relevant command addressable element signals.
 Three long selecting pulses set output “high” with delay R_3C_3 .

On the output of the block for pulse separation counting pulse duration is between $10\mu\text{s}$ and $15\mu\text{s}$. Propagation through contemporary electronic circuits is about nanosecond (10^{-9}s) and we can neglect it in our considerations.

The block scheme of the command addressable element and its connection on line is represented in Fig. 6.

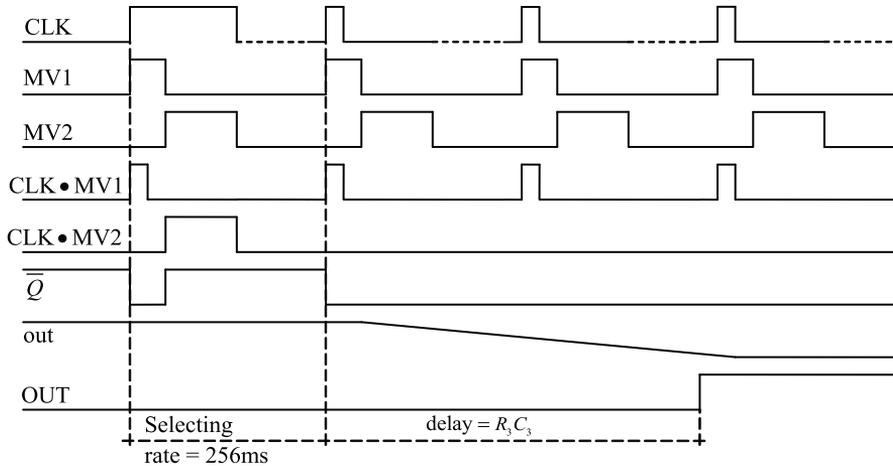


Fig. 8 – Shapes of relevant command addressable element signals.
 Three normal selecting pulses set output “low” with delay R_3C_3 .

Regular counting pulses (duration 10–15 μ s) will set output of memory element on low level. This will happen with any polling of command addressable element.

Period of mono-stable multivibrator MMV1 is easy abbreviated on 40 μ s which is longer than duration of normal counting pulse (10–15 μ s). Duration of signal CLK•MV1 is equal to the duration of addressing pulse (CLK). Leading edge of signal CLK•MV1 will put on “low”.

Extended counting pulse (100 μ s) and mono-stable multivibrator MMV2 makes memory element reset signal with duration more than 50 μ s which is enough for reset of memory element. Three successive long counting pulses that selects same command addressable element and shapes of relevant signals are represented on Fig. 7. Any counting pulse which selects command addressable element sets on “low” by his leading edge. Normal counting pulse (10–15 μ s) leaves on “low” and long counting pulse (60–65 μ s) resets on “high”. Low to high transition is delayed by time constant R_3C_3 (500–1000ms) on Fig. 6. This will cause output delay but will increase reliability of command function. Output (OUT on Fig. 6) will stay “high” until long counting pulses selects command addressable element (Fig. 8).

Information about a real stage of output (OUT) is available connecting OUT to a constant current source as on Fig. 6. Line current of 5 mA indicates that OUT is “low” and line current of 10mA indicates that OUT is “high”. Absence of current indicates that command addressable element is not on line.

It is clear that counting pulses, command pulses and responses are under program control.

7 Integrated Extinguishing Module

Main problem with integration of extinguishing module in addressable fire detection system is high response time caused by long polling period. Majority of addressable fire detection and alarm systems uses digital addressing method and reaches selecting rate of 4s for 256 addressable elements on line. That was the reason for changes in the British standard and request for response time for manual fire detectors was moderated from 1s to 8s. That was often used by opposers of addressable systems as their main deficiency.

Counting addressing method overcomes just that deficiency – selecting rate for 256 addressable elements is reduced on 256ms (8 times better).

Extinguishing module integrated in addressable fire detection and alarm system is represented on Fig. 9. It is much easier and cheaper to organize “two-zones dependence” – problem is reduced on logical. Addressable manual

fire detectors are used as buttons for start or stop of extinguishing. Monitoring of extinguishing system pressure is enabled by averidge addressable element and a pressure sensor. On the same couple of leads is connected one or more addressable elements.

For the executable electromechanical apparatus is necessary to provide independent and continuous power supply. Growth of system reliability is reached with extra electronic in executable apparatus for memoring the status of command addressable element (in the case of absence of power supply on the addressable line).

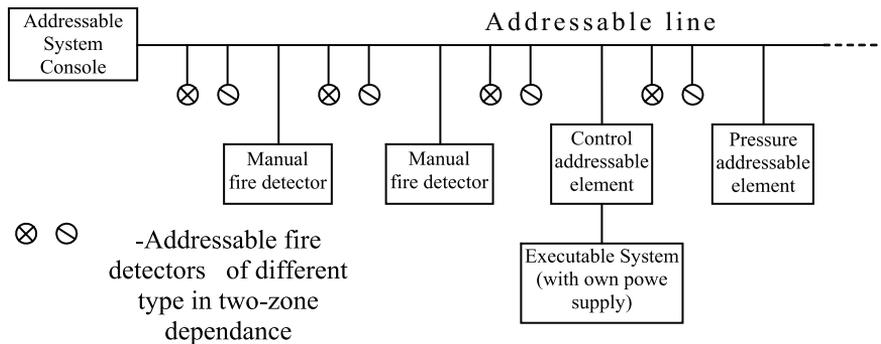


Fig. 9 – Extinguishing module integrated in addressable fire detection and alarm system.

8 Conclusion

Reducing response time, counting addressing method enables complete integration of extinguishing subsystem in addressable fire detection and alarm system.

It is possible by one couple of leads to obtain “two-zones dependances”, monitoring of extinguishing appliances status and command of executable apparatus. Even more, it is possible on one couple of leads to organize a lot of extinguishing modules which is very useful in fire detection and alarm system design in grate hotels, airports and other rooms.

The addressable control panel for fire detection and alarm was made, based on the proposed hardware and software solutions.

Having in mind a significant increase of the calling rate, the proposed addressability concept enables development of addressable analogue systems, where decisions can be made not merely on the basis of the achieved level of detector analogue value, but also on the basis of the rate of change of the analogue value.

The proposed addressability concept can also be applied for acquisition of slowly varying data (temperature, humidity, etc.) when sensors are at considerable distance from each other.

9 References

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