AN APPARATUS FOR RECORDING OF EXTREMES IN ELECTRICAL SIGNALS - FDI-1

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Abstract: *In this work a new device for measuring the parameters of a fog is described. It is developed by our team and is called Fog Detector Indicator 1 (FDI-1). It is a part of a sensor system for control of the parameters of a fog which is used for decontamination of objects polluted by different circumstances. FDI-1 is a custom indication unit used in various systems for evaluation of fog parameters that gives the operator a visual result for the change of the input voltage. The main function of the indicator is to show the measured voltage applied on its coax input. Usually, this measurement can be done with a regular voltmeter, but the nature of the measurement of a fluid (fog) density, droplet diameter or contamination assumes very rapid changes of the measured values and also very short peaks of the maximum and the minimum of the measured variable. FDI-1 is can be used namely in such cases.*

Keywords: FOG PARAMETERS, MEASURING DEVICES, SECURITY, MILITARY APPLICATIONS, DECONTAMINATION

1. Introduction

During the last 20 years terrorist attacks represent a big problem for many countries of the civilized world, including European ones. Security measures should be taken to prevent terrorist attacks and also to deal with consequences of these attacks. Measuring equipment plays an important role in analyzing these consequences. In general, measuring devices used for military applications should be reliable, easy to use, easy to transport and they should work in a large temperature range, during heavy rain, withstand big pressures and be resistive to mechanical hits by different objects.

Chemical weapons are still used, in spite of the fact that their use is prohibited by the international humanitarian law. The international humanitarian law regulates the conduct of war. Its aim is to protect the people that don't participate in hostilities during an armed conflict. Obviously, the international humanitarian law is not respected in some countries. One recent example is the use of chemical weapons in Syria where many people (including civilians) were killed in suffering. Generally, the areas where the chemical weapons are used are not safe for the people for weeks after the attack, so the attacked areas should be chemically cleaned. This cleaning is performed by using a system for spreading a fog in the contaminated area.

2. Prerequisites and means for solving the problem

For the purpose of cleaning the contaminated area it's important to monitor the parameters of the fog. We have created such devices. They convert the parameters of the fog to electrical signals. These signals change very fast and in order to be able control the fog, it's necessary to measure and register these maximums even when there isn't a person near the devices. This was the reason to create the FDI-1 (Fog Detector Indicator 1). FDI-1 can be also used for other purposes where it is needed to measure and register maximums of electrical signals as a result of some ongoing processes. The cleaning properties of fog are known and used in material science [1], applied medicine [2], biology [3], etc.

Another important application of fog is connected to the security of persons in their homes, at work places and during trips. It's the use of fog against fire. The water fog can be used against fire but with caution during winter time because freezing is possible. Also, in some cases water can react with chemicals and as a result of this reaction an explosion can occur [4]. A water fog is used for decontamination of equipment of fire fighters. The decontamination task depends on: the type, quantity and concentration of the pollution material, the type of the decontamination agent and the medium, the available decontamination agents and equipment. Except water, other decontamination materials are used depending on the type of the pollution [5].

The parameters of fog are also important in the meteorology [6, 7] and the FSO (Free Space Optics) [8]. For measuring the parameters of fog are used droplet size spectrometers and systems with fog sensors.

3. Solution of the examined problem

In this work we present a new device for measuring the parameters of a fog. It has the following advantages:

- It has small size (portable to any location);
- It is easy to be supplied with power from an ordinary adaptor or battery;
- It is easy to operate;
- It measures and saves the maximum of the input signal which changes very fast;
- The device has an LCD display and a LED bar graph for visualization of the results;
- It can operate in two modes and is able to measure and save the maximum of the input signal, even without an operator.

The measuring device called FDI-1 (Fog Detector Indicator 1) has overall dimensions of 133 mm x 95 x 30 mm. It is a part of a sensor system for control of the parameters of a fog. When there is a terrorist attack with chemical substances, the attacked area can be checked and cleaned by spreading a fog. Then the parameters of this fog are measured by sensors which are directly connected to FDI-1. The command signal for FDI-1 is an electrical tension delivered by the output of the sensors which are located in the fog. This system can perform 24 hour measurements of the parameters of fog and the results are easy to read on the display of the device. Also, for better visualization of the results, FDI-1 has a LED bar graph. The operator can choose between two different operating modes of the measuring device. The device has a good sensitivity to the fast changing parameters of the fog. The power supply of FDI-1 is ensured by a standard 12V adapter.

3.1. Description of the FDI-1

Fog Detector Indicator 1 (FDI-1) is a custom indication unit used in various systems for evaluation of fog parameters that gives the operator visual results of the change of the input voltage. The main function of the indicator is to show the measured voltage applied to its coax input. This measurement can be done with a regular voltmeter, but the nature of the measurement of the fluid

(fog) density, droplet diameter or contamination assumes very fast change of the measured value and also very short peaks of the maximum and the minimum of the measured variable. Moreover, the indication should be easy to read. FDI-1 has taken into account all the specific requirements, which come from the nature of the measurements. It has a bar-graph indication for fast evaluation of the results, an LCD display for showing the actual values of the measurements with refresh rate, fast enough to meet the requirements. The internal logic allows the implementation of an average function, which is important to exclude the flicking of the input signal, in order to obtain proper measurements. The device allows the operator to choose base level and upper level for the measurement which is important for compatibility with various systems with different sensitivities and output ranges.

3.1.1. Overview of FDI-1

In Fig. 1 an overview of the FDI-1 device is presented. On its right edge there is a power jack for plugging a standard 12V adapter (1), also there is the BNC input (2), where the measured voltage should be applied. On the front panel at the upper left side there is an LCD indication display (3) and LED bar-graph indicator (4) next to the display. At the bottom side of the front panel there is a switch (5) for choosing between positive and negative measurement and also 3 buttons (6) for control. At the upper right corner there is also a special function button, named “Alarm reset” (7).

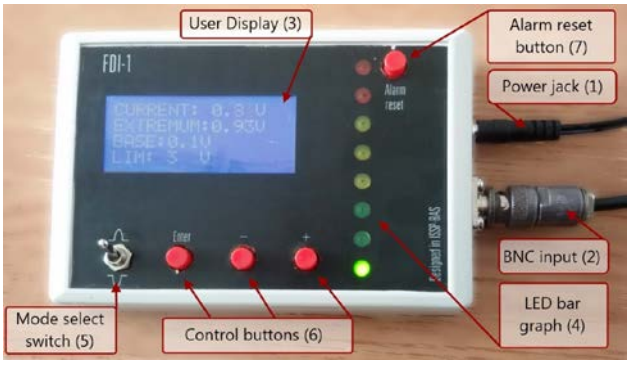

Fig. 1 General view and user interface of FDI-1

3.1.2. Hardware description

The hardware implementation of *FDI-1* is based on Atmel’s Atmega 328P 8Bit microcontroller unit (MCU). A block diagram of FDI-1 is shown in Fig. 2.

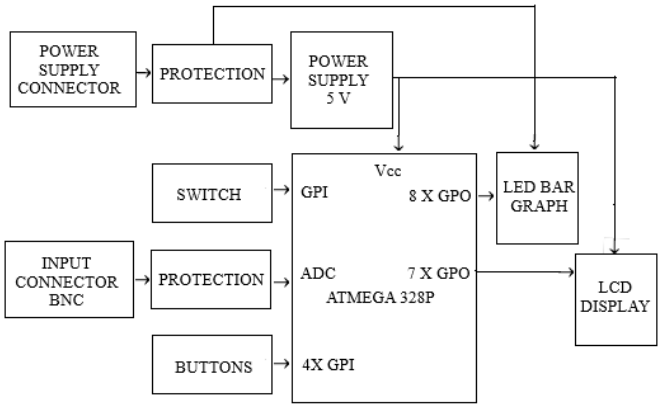

Fig. 2 Block diagram of FDI-1

The main measurement system is implemented through the internal analogue to digital convertor (ADC) of the MCU. For measurement reference is used the main 5V power supply. Additional software calibration of the measured value is done at room temperature (25^{o}C) with a digital multimeter.

The required power supply for FDI-1 is in the range 8V – 16V, which makes possible the use of standard battery pack or any universal power supply adapter for supplying the device. Be aware if you are using any third party power supply that the positive electrode is inside the connector (Fig. 2). FDI-1 includes a reverse polarity protection circuit, but it is not recommended to attach unproved power supplies.

Fig. 2 Supply polarity connection diagram of FDI-1

3.1.3. Software description

The general software flow diagrams are shown on Fig. 3 and Fig. 4. There are mainly two parts of the software. First is the “menu” part (Fig. 3), where the user sets the limits of the measurements. The second part is the main measuring and calculation system (Fig. 4).

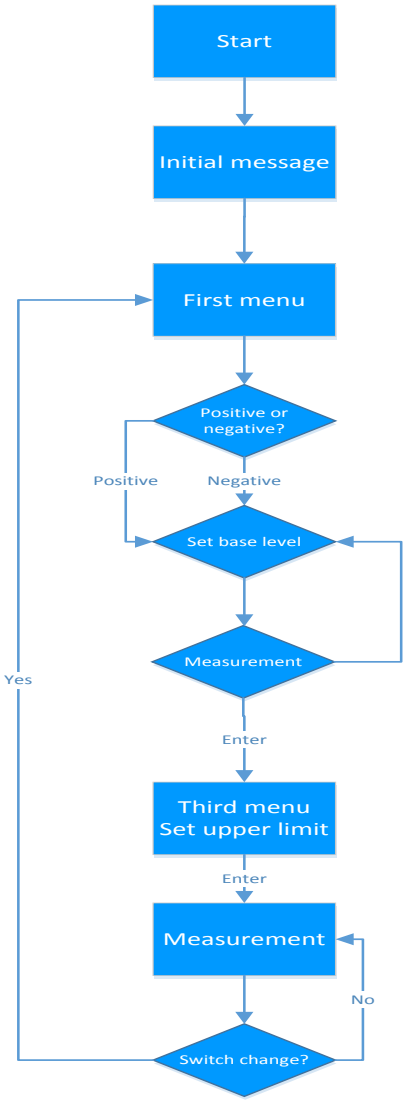

Fig. 3 Menu flow diagram of FDI-1

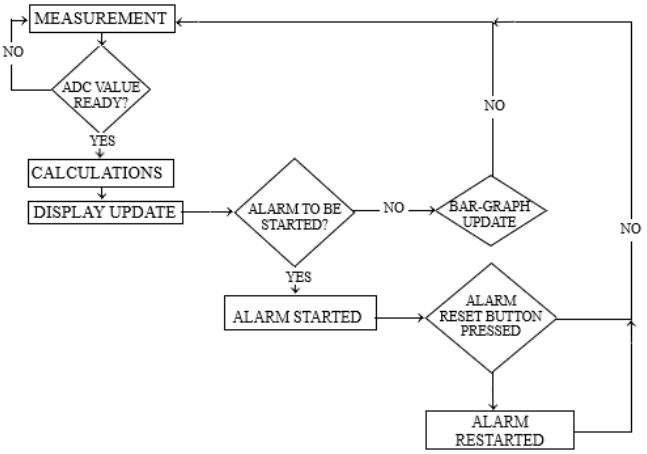

Fig. 4 Measurement flow diagram of FDI-1

3.2. Principle of operation of FDI-1

The signal that should be evaluated must be connected to the dedicated coax connector, which is referenced to ground (the negative pole of the power supply). The maximum measurement range is 0V – 5V DC. However, the input is protected to accept +/- 10V input signal.

The device has four buttons (Enter, Up, Down and Alarm Reset) and one switch for choosing the measurement mode (Positive or Negative). The needed user information is displayed on one four-row dot matrix display. Additional LED bar-graph is presented on the front panel for discrete light indication of the measured value. The user interface of FDI-1 is presented in Fig. 5.

Fig. 5 User Interface of FDI-1

The first menu offers the user to choose between 'Positive mode' and 'Negative mode'. The user can change the mode through the switch. When the mode is chosen the user should press the 'Enter' button to continue.

The second menu gives the user the ability to change the base level of the measurement (from what voltage value to start the measurement). This is normally the steady state signal value of the measurement system without fog. By default the base is equal to the measured level of the coax input at the current moment, but the user can change this level by using buttons 'Up' and 'Down'. When the proper base level is chosen the user should press the 'Enter' button to continue.

The third menu offers the user to choose a measurement limit level (to what voltage value the measurement should end). This limit level should correspond to the maximum signal value that can be achieved (sometimes the boundaries of the input range 0-5V cannot be reached). This setting is only needed for the diodes to indicate correctly. By default the value of the limit is set to 5V, but the user can change this level by using buttons 'Up' and 'Down'. When the proper limit level is chosen the user should press the 'Enter' button to continue.

Due to the required logic implementation, it should be noted that:

- For positive measurements, the limit must be higher than the base.
- For negative measurements, the base must be higher than the limit.

After applying the required settings, the measurement can start. On the user display you will have information about the current voltage level applied on the coax input, the extremum of the measurement, the chosen base and limit levels. The extremum value in positive mode is the highest value reached during the measurement. In negative mode the extremum value is the minimum value reached during the measurement.

The LED indication bar-graph will show current value of the voltage applied on the coax input, while the limit value is higher (for positive mode) or lower (for negative mode) than the base level **and** the measured voltage is more than base voltage + 0.3V (for positive mode) or less than base voltage -0.3V (for negative mode).

If those conditions are not satisfied, the device will enter in alarm mode – the LED bar-graph will start blinking with the value of the extremum until the conditions for voltage are fulfilled or the user presses the 'Reset alarm' button.

If the user wants to change the type of the measurement, the base or the limit, it is needed to switch the 'Mode select' switch. This operation will let the user to change all the settings that was previously set.

4. Results and discussion

We have performed investigations of the maximum amplitudes reached during measurements of contaminated fog as a function of the concentration of a pollutant. For the actual measurements we have dissolved 4 grams of the substance monopotassium phosphate (KH_2PO_4) into different quantities of water (200 ml, 300 ml, 400 ml, 500 ml, and 600 ml).

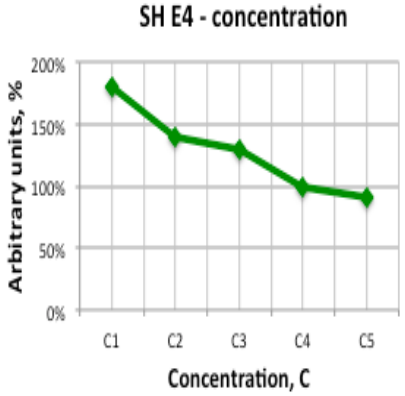

Fig. 6 Change in the signal generated by the sensor head as a function of pollutant concentration in the fog.

FDI-1 is used to measure the maximum deviation of the signal from its initial value in percentage for each concentration. The results are presented graphically in Fig. 6. Table 1 summarizes the values of the deviations.

Table 1: *Change in the signal generated by the sensor head as a function of pollutant concentration in the fog.*

	C1	C2	C3	C4	C5
First	180%	140%	130%	100%	91%

The results clearly show that the amplitude of the generated by the sensor's alternating electrical signal changes with changing the concentration of the pollutant.

This device also can be used in other systems to measure the changing of other non-electrical parameters. The non-electrical parameter should be converted to electrical tension which represents

the input signal for FDI-1. For example, the device can be used in systems for measuring the temperature of ovens for chemical changes, ovens for drying or hardening, diesel engines, the temperature of liquid flow in industrial cooling systems, where the used sensor is a thermocouple. FDI-1 can also be a part of heating systems for measuring the current temperature. The device can measure some other non-electrical parameters, such as pressure, light flow and many others.

4. Conclusion

In this paper a new device – Fog Detector Indicator 1 (FDI-1) - for measuring of fog parameters of is described. It is small in size and therefore portable, it can be supplied with power from an ordinary adaptor or battery, it is easy to work with and operates fast. It has the ability to measure and save the maximum of the input signal which changes very fast. The device has an LCD display and a LED bar graph for visualization of the results. It supports two operating modes and it can measure and save the maximum of the input signal autonomously. In the case of a terrorist attack with chemical or biological substances, the contaminated area can be checked with it and cleaned by releasing a cleaning fog.

The presented results clearly show that the amplitude of the generated by the sensor's alternating electrical signal changes with changing the concentration of the pollutant. This is exactly the function of FDI-1 – continuously measuring and controlling the parameters of fog.

FDI-1 is a solution to the growing need of measuring devices which are easy to use, with clear indications and portable to any location. It is expected that this device has the potential to be very helpful for security applications and military missions for achieving a safer world.

Acknowledgements:

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