FCM41

Fast Gas Concentration Meter

User manual

General information

The FCM41 fast gas concentration meter is used to determine the concentration of CO_2 or N_2O. The concentration value is expressed in ppm and determines the ratio of the number of molecules of a specific gas to the number of molecules of a mixture of gases. Assuming that during the measurements there are conditions for which it is possible to apply the ideal gas laws, the concentration value determines the volume fraction of the gas in the mixture. The meter uses the method of non-dispersive absorption of infrared radiation to determine the concentration. A resistance element heated to 650°C was used as the radiation source, and a planar multi-channel pyroelectric detector was used as the detector. Gas samples are introduced into the measuring chamber of the meter continuously through sampling tubes with an internal diameter of about 2mm. Gas flow through the measuring chamber is forced by an additional SMP50 sampling module or by any external suction pump. The small volume of the measuring chamber, the small diameter and length of the sampling tubes, together with the appropriate flow rate of gas samples through the chamber, ensure good dynamic properties of the meter. Gas concentration measurements are performed with a frequency of 4Hz. For a gas sample flow rate of 5 SmL/s (standard flow rate - at temperature 0°C and 1013 hPa absolute pressure) through 2-meter-long, 2-mm-diameter sampling tubes, the meter's frequency response is 0.5 Hz. Using additional software in the "post-process" mode, based on the recorded measurement results, the bandwidth of the measurement system can be extended to 1 Hz. The correction of the concentration value is calculated based on the parameters entered, such as the length and diameter of the sampling tubes, and the sample gas suction flow rate.

Figure 1 Fast gas concentration meter FCM41

Application.

The meter is used to measure the effectiveness of ventilation systems, during which a tracer gas is introduced into the air to simulate real-life pollutants. Good dynamic properties of the meter allow to measure tracer gas concentrations anywhere in the room, especially in the human breathing zone, where there is a complex and dynamic interaction of air streams: human convective stream, exhaled air stream from the lungs and various air streams from the ventilation and air conditioning system. The use of a fast gas concentration meter allows for the measurement of fast changes in the concentration value, thanks to which a reliable analysis of human exposure to pollutants in the air inhaled into the lungs is possible.

Principle of operation

The FCM41 meter uses a method based on the phenomenon of absorption of infrared radiation by gas molecules, the non-dispersive NDIR method, to measure gas concentration. The diagram of the measuring chamber is shown in Figure 2. The radiation source is a resistive element cyclically heated to a temperature of 650°C. The emitter is equipped with a reflector that focuses the radiation beam. A focused beam of radiation propagates along the measuring chamber in which the gas sample is located. On the opposite side of the radiator, there are band-pass radiation filters that allow radiation of a specific wavelength to pass through. To determine the CO2 concentration, radiation with a wavelength of 4.24 µm is used, for N2O it is 4.54 µm. Radiation of the mentioned length is referred to as active radiation, the intensity of which reaching the detector decreases as the concentration of the gas to be determined increases. In order to make the concentration measurement results independent of changes in the properties of the radiation source and changes in radiation attenuation in the measurement chamber, the radiation intensity with a wavelength of 3.94 µm is also measured. Radiation at this wavelength is not absorbed by any gas in the air or other gases usually found in ventilated rooms. This radiation is referred to as reference radiation. Reference and active radiation passing through band-pass filters reach pyroelectric converters, using which the energy of infrared radiation is converted into electrical energy. The concentration value of the determined gas is calculated based on the ratio of the measured values of active and reference radiation intensity.

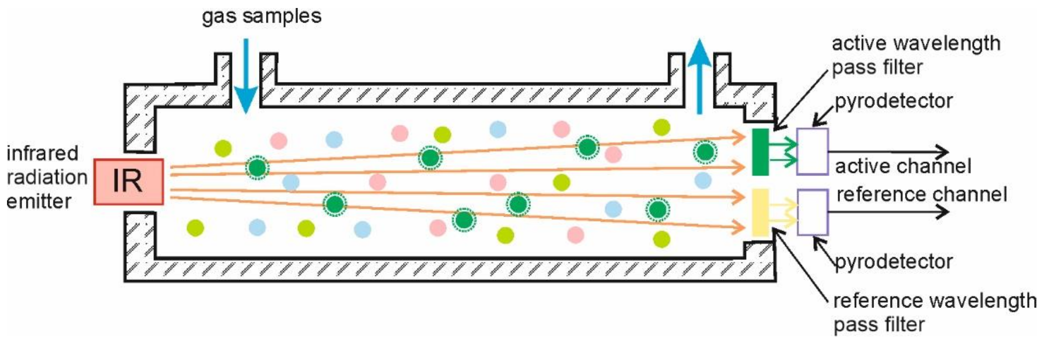

Figure 2 Measurement chamber

In order to optimize the long-term stability of the meter's readings, only that part of the radiation produced by the emitter that directly reaches the detector is used to measure the concentration in the measuring chamber. Indirect radiation, i.e. radiation that reaches the detector after reflection from the internal walls of the measuring chamber, is not used for measurements. Using only direct radiation allows the measurement result to be independent of contamination of the surfaces of the internal walls of the measuring chamber. Dirt enters the chamber along with the sucked gas samples. Contaminants could be removed using filters, but on the other hand, the use of filters would impair the dynamic properties of the high-speed concentration meter.

The concentration value is determined for each flash of the infrared radiator, without averaging taking into account the results of previous measurements. This allows you to obtain 4 independent measurement results every second. The intensity of absorption of radiation of a specific wavelength by the gas being determined depends on the number of molecules of a given gas that are in the optical path of the radiation beam. The number of particles in the constant volume of the measuring chamber is a known function of the temperature and total pressure of the gas. The meter compensates the concentration readings for changes in temperature and absolute pressure in relation to the values of these values during calibration. The meters are calibrated in conditions in which the temperature and gas pressure in the measuring chamber are 298 K and 1013 hPa, respectively.

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System connections.

The FCM41 high-speed concentration meter requires a system that sucks in air samples and delivers them to the measurement chamber. Figure 3 shows a diagram of the connection system of one FCM41 concentration meter with the SPM50 suction pump module and the FCM414 wireless transmission module, which is used to transmit measurement results from the meter to a computer..

The suction pump module ensures a constant gas flow through the measuring chamber. This flow is set using the software supplied with the module. The flow value is expressed in SmL/s, i.e. the flow for standard conditions - temperature 0°C and pressure 1013 hPa. The known flow value allows the calculation of the transport time of gas samples in sampling tubes of known diameter. The flow time value can be taken into account when synchronizing the real time of sample collection at the measurement point with the measurement time in the concentration meter. Instead of the SPM50 module, any constant flow suction pump can be used.

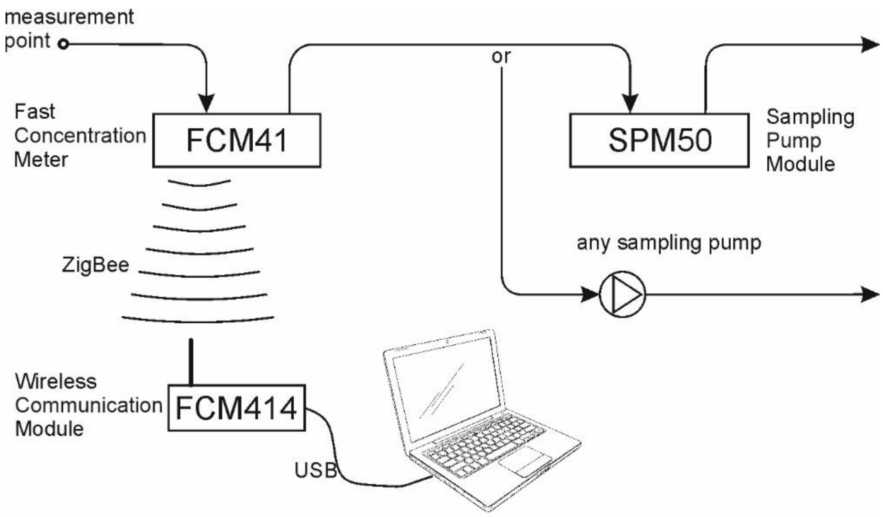

Figure 3 Measuring system connections.

Measurement results are sent from the FCM meter to the FCM414 wireless transmission module every 1 second, so as not to create unnecessary excessive traffic in the transmission band. Because the meter determines the concentration value 4 times per second, the measurement results are grouped into data packages. In order to avoid the loss of any transmitted data, redundant transmission was used; each packet, in addition to the current measurement results, also contains the results of several previous measurements. Two time tags are transmitted along with the concentration values, one tag contains information about the real time of the measurement (date and time) and the second tag is incremented with each measurement (four times per second), its value changes cyclically modulo 256.

Data transmission is carried out via a wireless transmission link operating in the 2.4 GHz band, with the ZigBee transmission protocol. The network is created by one coordinator and several subordinate modules (nodes). The software of the network elements forms a MESH network, the connections between the elements are configured automatically. The network has the ability to reconfigure itself, the aim of which is to establish a new connection in the event of loss of the current connection. If interference occurs or the signal quality deteriorates, the network tries to find a new connection path (change of intermediary nodes). In the event of a data packet loss, the transmitting node initiates re-transmission of the lost data until it receives confirmation of correct transmission from the coordinator.

The elements that make up the network have unique MAC numbers, assigned at the production stage. Data transmission between the nodes and the coordinator takes place within a specific group of devices, one FCM414 coordinator and several FCM41 meters. The group is identified by a PAN ID number (personal access network identifier), this number is saved to the meters and to the coordinator at the configuration stage when order picking. Each FCM414 communication module can be assigned from one to four FCM41 concentration meters.

In the measurement system, it is possible to synchronize time stamps in several concentration meters. This is an optional operation, required in special cases when, for example, time courses of concentration values from several meters are superimposed. Synchronization involves resetting the timestamp value to zero, which is incremented with each measurement. The synchronization command is sent to the concentration meters from the FCM418 synchronizing signal generator module via the TOSLINK fiber optic link, **Błąd! Nie można odnaleźć źródła odwołania.**. The synchronization moment can be initiated by pressing a button on the front panel, by supplying an external pulse signal from another source, or by pressing a button in a computer program. The FCM418 module is connected to the computer via USB.

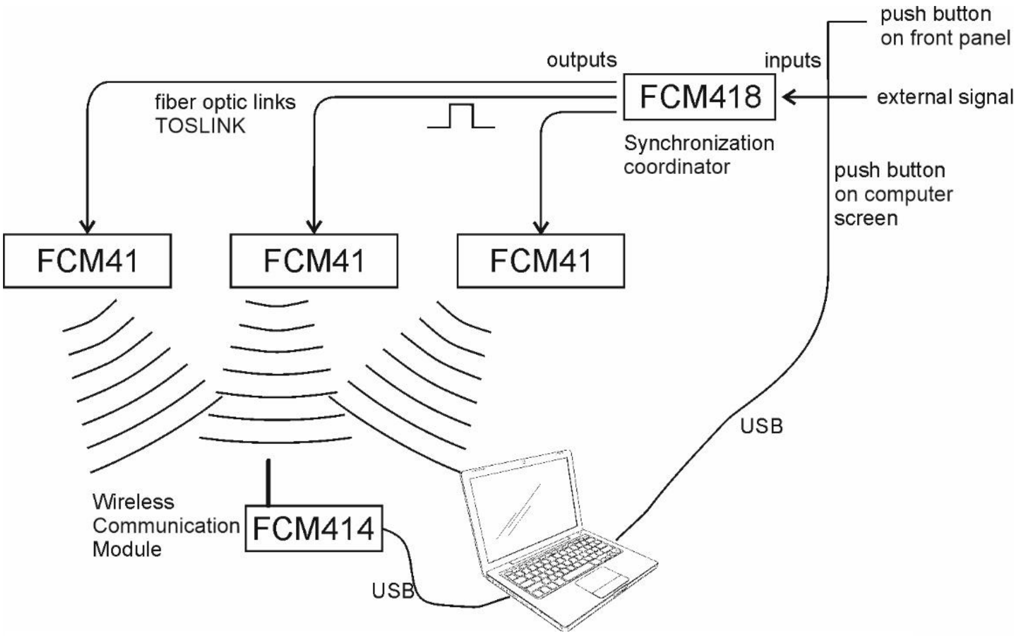

Figure 4 Synchronization diagram

Software.

The meter sends the measured concentration values via the ZigBee wireless transmission link to the transmission module FCM414 connected to the computer via the universal USB serial bus. Concentration values are displayed on the computer screen in the form of time courses. At the same time, the data received from the meter can be saved to a file on a computer disk. After the measurements are completed, the saved data can be loaded into the program that enables the dynamic correction of the signal in order to extend the measurement bandwidth of the system to 1 Hz.

Figure 5 Front panel of FCM41

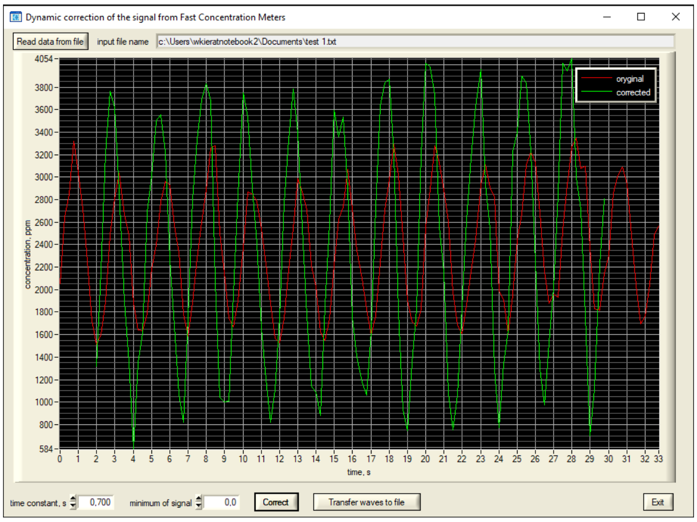

Figure 6 Screen of software used for dynamic correction of recorded measurements.

The transmission module connected to the computer is able to read the measurement results from several meters at the same time. When recording is turned on, the software saves the measurement results to separate files whose name includes the serial number of each meter. In this way, it is possible to create a simple multi-channel measurement system consisting of one transmission module and several meters. In order to synchronize data from different meters, the data sent from the concentration meter contains two markers: real time (hh:min:sec dd.mm.yyyy) and an individual marker for each measurement (integer modulo 256). Thanks to time stamps, it is possible to synchronize measurement results from different meters with an accuracy of 0.25 seconds. Measurement markers, in a system consisting of many meters, are synchronized using one common synchronization signal transmitted to the meters via TOSLINK fiber optic lines. The use of fiber optic lines prevents mutual interference of the meters.

Software installation

The FCM41 concentration meter and the FCM414 communication module are supplied with user software that allows reading data from the meter and writing it to a text file in a format adapted to the EXCELL spreadsheet. The software package contains two installers. First, you need to install the USBL10 program, a program that supervises the operation of the SENSOTRON software. Then, install programs for the FCM414 communication module that reads data from the FCM41 meter. Both programs are available on the SENSOTRON website at https://www.sensotron.pl/produkt_FCM41_ang.html.

Technical parameters

Gases to be determined - N_2O, CO_2
Measuring principle – NDIR
Concentration range – 0 to 5000ppm (optional 50000ppm)
Expanded uncertainty +- 20ppm or 5% of reading (which is higher)
Long-term stability, 1 year - +- 50ppm
Measuring rate – 4Hz
Time constant of response – 0,7s (0,3s with postprocess correction)
Temperature compensation – yes
Barometric pressure compensation – yes
Communication method – wireless ZigBee, USB
Power supply – 220-230 AC / 50 Hz
Gas sampling method – via tube with external sampling unit or suction pump

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