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# INCREASING DATA ADEQUACY IN THE MONITORING SYSTEM WITH MODIFIED ARCHITECTURE

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***Abstract***

*In the article the problem of increasing the data adequacy of remote measurement using monitoring systems on the base of controlled liquid crystal filters is considered. The proposed monitoring system performs joint measurements in the infrared and visible ranges of the spectrum, as well as panchromatic measurements, implements the correction technique of their data, local management of each measuring module, which increases the reliability of the obtained data. Modified architecture provides the ability to set the channels of the alternative measurement system and increases the efficiency of decision-making on the base of monitoring results.*

*The correction of channel error and measurement data, local control of each channel of measuring modules with half-width control, transmission of liquid crystal filters depending on the values of additional parameters and flexible measuring architecture provide correction of internal and external factors of the system.*

*The proposed multifunctional system with a modified architecture allows to obtain the reliable information about the coordinates and areas of oil spots on a sea surface. With the help of limited amount of data obtained from three ranges by different measuring channels, it is possible to reliably estimate the state of the researched object. Multilevel measurements for data validation considering the atmospheric influences and the usage of WEB / GIS communication allow to realize the accounting and evaluation of external factors to correct the measurement data of the system.*

**Keywords**: correction; infrared and visible range; liquid crystal filter; modified architecture; monitoring; reliability

## 1. Introduction

### Problem statement

Among polluting sources of anthropogenic nature, oil and gas industry occupies a major place. The atmosphere, water basins and land surface are contaminated to a variable degree in each stage of oil production, processing, storage and transportation. Controlling the concentration and places of these pollutants spread is an important task of environmental monitoring, which requires special attention at the global level [1].

### Analysis of recent research and publications

There are various multilevel systems designed to solve urgent problems of preventing emergencies and revealing oil spills on the surface of land and water basins. When solving the problem of increasing the accuracy of recorded data via existing on-board multi-channel systems, it becomes necessary to select informative parameters from the set of recorded data, which requires the application of special algorithms for additional processing of data leading to a decrease in the efficiency of decisions made on the monitoring results [2].

The application of individual measurements in the visible and infrared ranges without taking into account additional parameters characterizing external and internal factors leads to decrease the reliability of the obtained data [3].

While measurements are being carried out in the visible and neighboring infrared ranges, the characteristics of the on-board system is partially improved, however, the lack of information on infrared and panchromatic measurements doesn't make it impossible to achieve the required accuracy and reliability of the data in the monitoring system [4].

**Formulating the purpose of the article**

The formulation of the purpose of the article is improving the accuracy and reliability of data in a monitoring system with a modified architecture on the base of controlled liquid crystal filters.

**2. Statement of the main material**

When studying water surfaces, during registration, $L_{MP}$ luminous flux, reflected from the surface of the water, forming a useful $L_M$ signal, creates additional disadvantage - noise. The total intensity of the $L_{PM}$ of reflected light is defined as follows [2]

$$L_{ПМ}(\lambda) = L_M(\lambda) + L_{МП}(\lambda) \quad (1)$$

In order to estimate $L_{MP}$, it is necessary to measure $L_{MP}$ and $L_n$ ($L_{fir}$.) in the near IR range at λ=780nm. These data are obtained either via separate spectrometers and infrared radiometers or from multispectral, hyperspectral and other measuring instruments intended for remote measurements of the radiance of the investigated objects. In this case, $L_M$ equals zero and $L_{MP}$ will consist only of $L_{MP}$ [3].

In contrast to the existing options for multispectral or hyperspectral measurements, (1) a modified system, performing the necessary measurement at selective wavelengths, was proposed. The proposed system is capable of operating in different sub-bands of the electromagnetic spectrum via a minimum number of measuring channels and enables to solve the above-mentioned problem thanks to the structure flexibility and algorithm of operation. The system using blocks on a liquid crystal base has separate measuring channels that implement complex measurements in three sub-bands of the electromagnetic spectrum. The obtained data is simultaneously transmitted to the central microcontroller module as well as to the microcontroller module for co-processing of this data. The structural model of the proposed system is presented in Figure 1.

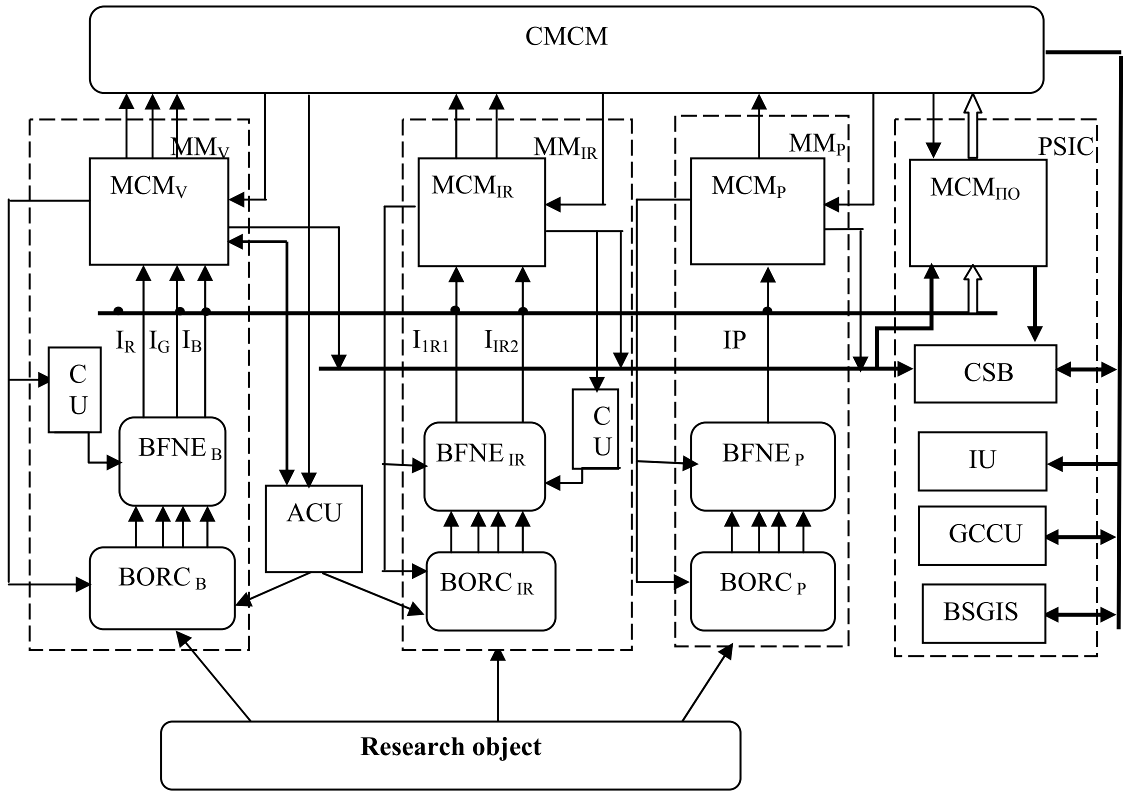


Fig. 1. Structural scheme of the modified instrumentation management system

As it is seen from the figure, the structural model of the monitoring system consists of three measuring modules corresponding to the visible ($MM_V$), infrared ($MM_{IR}$) ranges and panchromatic ($MM_P$) measurements, the preprocessing, storage, indication and communication (PSIC) module, as well as the central microcontroller module (CMCM), the liquid crystal filter control unit (CU), and the atmospheric correction unit (ACU).

The central microcontroller module (CMCM) sets the operation conditions of the system, controls the measuring modules through the corresponding

MCM, organizes the recording and storage of measurement data, provides coordinate communications through the BSGIS, implements the communication via the ground center.

The preprocessing, storage, indication and communication (PSIC) module, in its turn, consists of a constant storage block (CSB), an indication unit (IU), and a ground center communication unit (GCCU).

Each measuring module (MM) consists of the following units operating in the corresponding measuring ranges: a block of optical receivers and converters (BORC); block of filters and normalized elements (BFNE); the control unit of liquid crystal filters (CU) microcontroller modules ($MCM_{VD}$, $McM_{IR}$ and $MCM_{Ph}$).

MMC of each measuring module of the corresponding sub-band enables to perform the correction of the measuring channel, decrease data errors by processing them according to various algorithms, as well as, promptly perform the measurement, control and local control processes of the corresponding units of the module. As a result, the on-board preprocessing capability implemented by the central microcontroller (CMCM) is increased.

The measurement results corresponding to three colors of the visible range (($\dot{I}_R$, $\dot{I}_G$, $\dot{I}_B$) are transmitted to the $MCM_V$ for statistical processing. At the same time, the measurement result of $P_x$ is transmitted to the $MCM_{PO}$ for co- processing with $I_{PX}$.

The $MCM_{PO}$ implements preprocessing of the measurement data in the MI for the corresponding ranges. In order to visualize $IM_{IR}$ data in $MCM_{PO}$, the comparison of the data $IM_{VD}$ and $IM_{IR}$ is carried out, in order to improve the accuracy of the $IM_{VD}$ data, co-processing of both $IM_{VD}$ and $I_{PX}$ data is implemented, as well as the processed data is transmitted to CMC and BVZU.

The BCU is controlled by the CMCM and the $MCM_V$.

The data are obtained from $IM_{VD}$, $IM_{IR}$, $MCM_{Ph}$, $MCM_{PO}$, as well as from CMCM in the BPOM, where various stages of preprocessing of the measurement data are carried out.

The other blocks of MCM are designed for indication and communication with the ground center and geographic information systems (GIS) using Web/GIS technology.

It is seen from Figure 1 that, the signals obtained from contaminated sites are recorded in the visible range corresponding to the three primary colors; in the infrared range over two wavelengths and in panchromatic measurements using a block of optical receivers and transducers.

The central microcontroller module unit determines the mode of the monitoring and measurement system, controls the MCM range modules ($MCM_{VD}$, $MCM_{IR}$, $MCM_{Px}$ and $MCM_{CC}$), performs initial processing of the obtained data, transmits the data to the external memory devices and the transmission and reception unit for transmission to the ground center. Moreover, the data obtained from the GIS block is used to determine the coordinates of the research area.

## 3. Discussion

In the developed system, BAC controlled from the CMCM or $MCM_B$ carries out the measurement of $L_H$ at various observation angles. Depending on the value of which $MCM_V$ tunes the liquid crystal filters by means of the control unit $BFIN_V$ at other transmission band waves. Since, with an increased $L_{fir}$. indication, in order to obtain informative data about the investigated object, it is necessary to carry out a measurement in the sub-band of 400-500 nm of the visible range.

Taking into account the celestial radiation $L_n$ and the effective reflection coefficient of the sea surface ρ, it is possible to improve the accuracy and informativity of the measurement results obtained through different channels. In this case, the $L_{MP}$ value is considered as a result of the effect of celestial radiation $L_n$.

The multifunctional system simultaneously performs measurement in three modes under the control of one center - BCMCM with small quantities of channels.

Controllable liquid crystal units in the system are used in the processing, modulation, scanning and filtering of optical signals.

Co-processing of the results obtained from the visible range and panchromatic data allows to increase the accuracy of the obtained data. Data merges of these measurements are carried out on the onboard part of the system, as a result of which the amount of data and the processing time at the ground research center are decreased.

Multifunctional monitoring system performs complex measurements carried out on board carrier. On the base of the obtained data corresponding to the three primary colors, it is possible to determine the data of other informative sub-bands.

The characteristics of the multifunctional monitoring system are shown in Fig. 2.

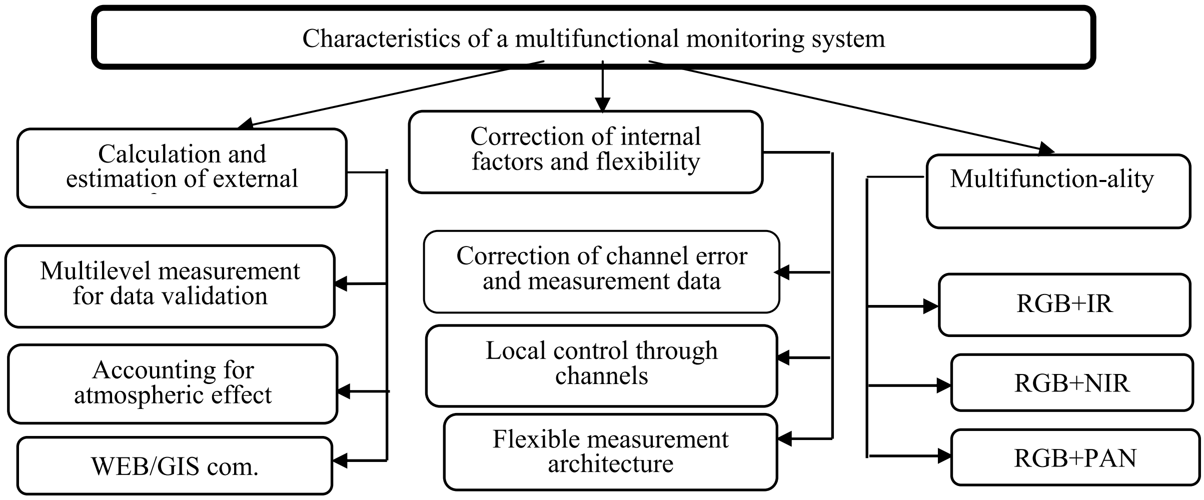


Fig. 2. The main characteristics of a multifunctional monitoring system with extended measurement ranges

**4. Conclusion**

Taking into account atmospheric influences and using WEB/GIS communication, multilevel measurements for data validation allow to carry out the calculation and estimation of external factors, correction of measurement data of the system.

The correction of channel error and measurement data, local control of each channel of measuring modules and flexible measuring architecture provide the correction of internal factors and flexibility of the system. The application of joint measurement data (RGB + IR, RGB + PAN and RGB + BIC) provides the multifunctionality of the system.

The proposed multifunctional system with a modified architecture enables to obtain reliable data about the coordinates and sites of sea surface oil spills.

It is possible to reliably estimate the state of the investigated object via a limited amount of the data obtained from three ranges along different measuring channels.

In order to monitor the ecological state of the environment, including water resources, in the extraction, processing and transportation of oil, it is advisable to use remote measurement methods, including those related to the IR spectrum range.

In order to increase the efficiency of water resources research using remote sensing systems, rational choice of measuring ranges, as well as hardware and software, is of great importance.

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**Л.Р. Бекірова**
**Підвищення достовірності даних в системі моніторингу з модифікованою архітектурою**
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У статті розглядається проблема підвищення адекватності даних дистанційного вимірювання за допомогою систем моніторингу на основі керованих рідкокристалічних фільтрів. Запропонована система моніторингу виконує спільні вимірювання в інфрачервоному та видимому діапазонах спектру, а також панхроматичні вимірювання, реалізує методику корекції їх даних, локальне управління кожним вимірювальним модулем, що підвищує надійність отриманих даних. Модифікована архітектура забезпечує можливість встановлення каналів альтернативної вимірювальної системи та підвищення ефективності прийняття рішень на основі результатів моніторингу.

Корекція похибок каналів та даних вимірювань, локальний контроль кожного каналу вимірювальних модулів з регулюванням напівширини, передача рідкокристалічних фільтрів залежно від значень додаткових параметрів та гнучкої вимірювальної архітектури забезпечують корекцію внутрішніх та зовнішніх факторів системи.

Запропонована багатофункціональна система з модифікованою архітектурою дозволяє отримувати достовірну інформацію про координати та ділянки нафтових плям на поверхні моря. За допомогою обмеженого обсягу даних, отриманих з трьох діапазонів за допомогою різних вимірювальних каналів, можна надійно оцінити стан досліджуваного об'єкта. Багаторівневі вимірювання для перевірки даних з урахуванням атмосферних впливів та використання WEB / GIS-комунікацій дозволяють здійснити облік та оцінку зовнішніх факторів для виправлення даних вимірювання системи.

**Ключові слова**: достовірність; екологічний моніторинг; інфрачервоний і видимий діапазон; модифікована архітектура; спільні виміри

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Рассмотрена задача повышения достоверности данных дистанционных измерений с помощью систем мониторинга на основе управляемых жидкокристаллических фильтров. Предложенная система мониторинга осуществляет совместные измерения в инфракрасном и видимом диапазонах спектра, а также панхроматические измерения, реализует методику коррекции их данных, локальное управление каждым измерительным модулем, что повышает достоверность полученных данных. Модифицированная архитектура обеспечивает возможность настройки каналов системы альтернативного измерения и повышает оперативность принятия решений на основе результатов мониторинга.

Коррекция погрешности канала и данных измерений в процессе измерение, локальное управления каждым каналом измерительных модулей с управлением полуширину пропускание жидкокристаллических фильтров в зависимости от значений дополнительных параметров и гибкая измерительная архитектура обеспечивают коррекцию внутренних и внешних факторов системы.

Предлагаемая многофункциональная система с модифицированной архитектурой позволяет получать достоверную информацию о координатах и площадях нефтяных пятен морской поверхности. С помощью ограниченного количество данных, полученных из трех диапазонов по различными измерительными каналами, можно достоверно оценить состояние исследуемого объекта. Многоуровневые измерения для валидации данных с учетом атмосферных воздействий и использование WEB/GIS связи позволяет осуществить учет и оценку внешних факторов коррекцию измерительных данных системы.

**Ключевые слова**: достоверность; инфракрасный и видимый диапазон; модифицированная архитектура; совместные измерения; экологический мониторинг

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