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DAIRY PRODUCTIVITY ACCOUNTING AUTOMATIC DEVICE BASED ON RFID AND LORA TECHNOLOGIES

***S.B.[1]Baiguanysh**, M.Sc.*
***A.B. [1]Mirmanov**, Assoc.Professor*
***O.V. [2]Stukach**, Professor, Dr.Tech.Sc.*
***S.A.[1]Isabekova**, Cand. Agr. Sc.*
[1]S. Seifullin Kazakh Agrotechnical University,
62, Zhenis avenue, Nur-Sultan, 010011, Kazakhstan
[2]National Research University Higher School of Economics
20, Pokrovsky Boulevard, Moscow, Russian Federation
mirmanov.arman@gmail.com

Abstract.

Recent years have been marked by the development of dairy farming in Kazakhstan. The number of small farms is growing, but their equipment with modern milking machines remains at a low level. Due to the lack of total control over livestock, their productivity is decreasing. In addition, poor coverage of communication networks has a negative impact on the introduction of IoT technologies. However, the emergence of energy-efficient long- and short-range networks allows the development of devices for remote digital monitoring of certain livestock production parameters, in this case, associated with milk yield. The developed device is implemented on accessory board for Arduino Mega, and includes milk meter on the reed switch, LF RFID tag reader, RFM95W module for data transfer via LoRa protocol and controller based on Atmega 2560. The device is installed on a mobile milking machine and keeps track of milk productivity of each milking cow individually. The device has been tested in laboratory conditions and on a dairy farm. The test results did not reveal any discrepancies in the milk yield automatically obtained via the LoRa wireless channel and the milk volumes physically measured by the beaker.

Keywords: Agriculture, Internet of Things, Radiofrequency identification, LoRa, intelligent dairy farming, automatic method, milk meter, Arduino, ATmega2560

Introduction

At the moment we observe a rapid development of dairy cattle breeding in Kazakhstan. A large number of imported dairy breeding cattle are imported into the country. For proper management of dairy cattle breeding, it is necessary to keep records of dairy productivity obtained from these animals. At the same time, recording dairy productivity is important for both breeding and non-breeding farms [1].

In Kazakhstan, dairy farms with developed infrastructure, i.e. those with computerized milking parlors, occupy only 15% of the total volume of farms, while the remaining 85% use milking in milk pipelines or mobile barrels, as they use tied maintenance in winter and pasture in summer [2]. Dairy cows' milk productivity is estimated in 305 days of lactation, the recording is possible only when performing control milking [3].

Small farms often do not carry out control milking because this procedure is labor-intensive and the assessment of milk productivity is done conditionally. With the rapid growth of digital technology, the widespread adoption of elements of the Internet of Things (IoT) is taking place [4]. The agricultural sector of Kazakhstan is also being improved, but this is mainly characteristic of large agricultural units, the situation is not the same for small farms. Small-sized farms located in rural remote areas are experiencing great difficulties with the availability of full coverage by communication networks, and as a result of the limited autonomy of radio frequency modules.

The analysis of dairy farming shows certain tendencies for the development of technics for automation and robotization of technological processes [5, 6]. The first is the development of system solutions, which connect all elements of machines complex on the farm in a single whole. It allows to control technological chains in an automatic mode with optimum parameters and taking into account information interrelations of system parts. The second is to improve the design of individual technical means, units and assemblies to improve their functional and technical and technological capabilities. Already today, there are certain achievements in both directions. However, for small farms, expensive solutions such as a robotic "Herringbone parlors" will be illogical [7]. Here, an inexpensive mobile device with automatic data collection system is required.

In this regard, the purpose of our work was to develop an experimental sample (model) of universal equipment for automatic recording of milk productivity.

Materials and research methods

The proposed solution was related to agro-industrial IoT, to provide remote digital monitoring of parameters related to milk yield. Two wireless communication technologies RFID and LoRa were used in the system of the device under development [8, 9].

The developed universal equipment for automatic recording of milk productivity made it possible to measure and record milk yield of individual cows during each milking. This will enable farmers using mobile milking machines to have real-time and strategic data on individual cow productivity [10].

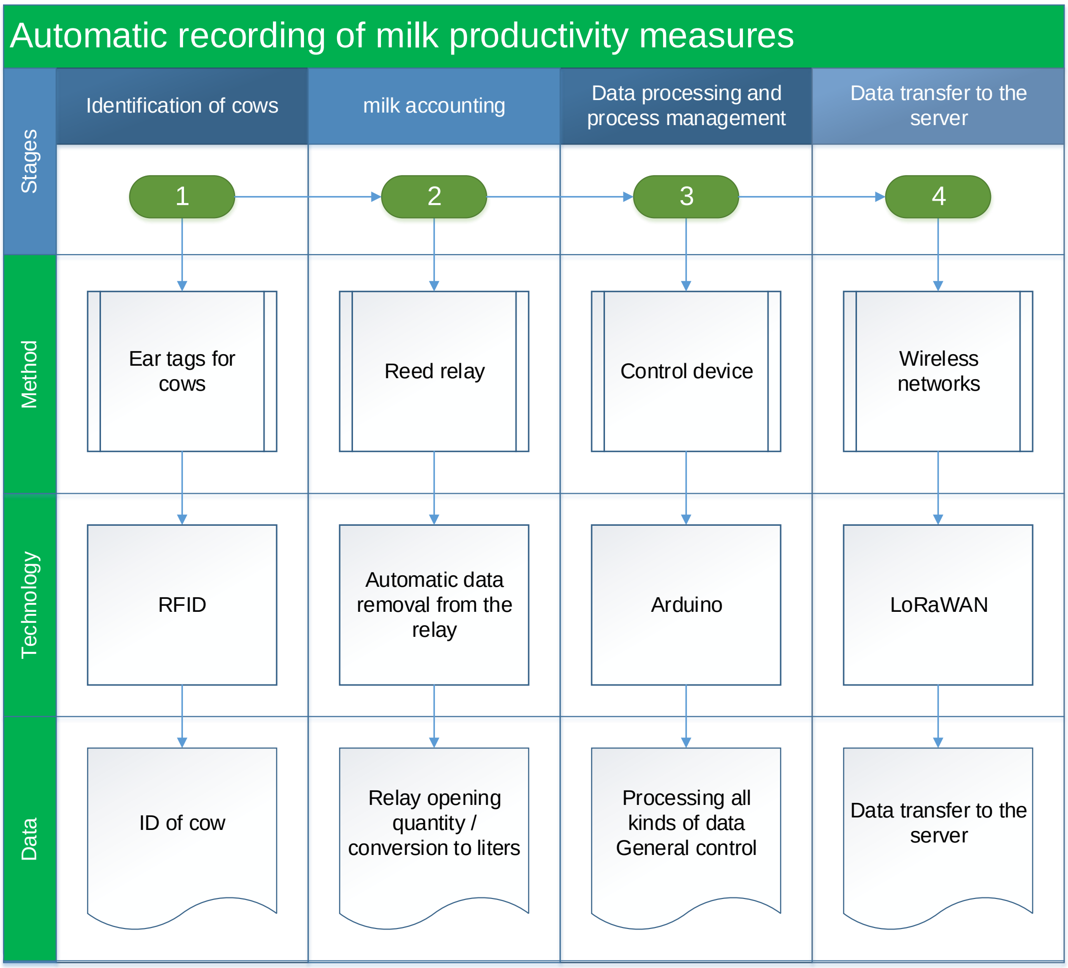

Figure 1 - General structure of the device implementation stages

Figure 1 presents a generalized structure of the device, shown the required stages of work, methods and technologies applied in development. For successful implementation it was necessary to solve four main issues: cow identification, milk yield, data processing and process control, data transmission via wireless channel.

RFID technology has been used to identify cows, including ear tags and an RFID tag reader. For the device under development, as a radio frequency tag reader, LF RFID module supporting ISO11784 with a frequency of 134.2 kHz ± 1.8 kHz used [11].

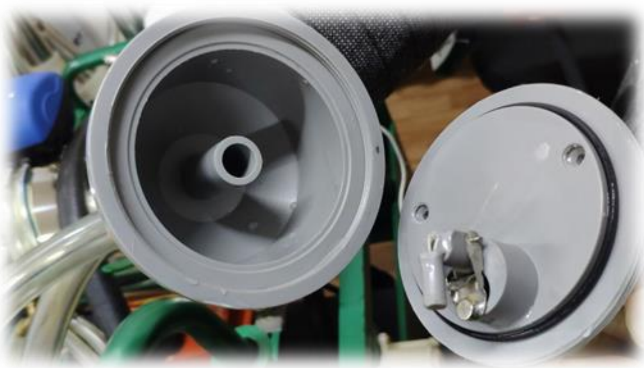

Figure 2 - Milk meter in open condition

A counter with mechanical principle (Fig. 2) used as a device for measuring milk quantity entering during milking. A valve with a cover is installed in the working cavity of the counter base, into which a magnet interacting with the reed switch is formed. The base of the counter covered with a glass with outlet fitting. An O-ring used to seal the meter cavity. Passing milk portions repel the valve cap, which causes the reed relay to open [12].

Arduino Mega based on ATmega2560 was chosen as the controller. It counts the opening time of the reed through the received pulses. To connect the Arduino radio modules is supplemented with a developed expansion board with RFID reader and data transfer chip via LoRaWAN. RFM95W module has been selected as a LoRa standard transceiver [13].

Having determined all the necessary components and intermediate solutions, a device for accounting for milk productivity has been developed. The developed device is a form factor expansion card for the Arduino Mega, and works only in conjunction with this controller. Figure 3 shown the schematic diagram of the device.

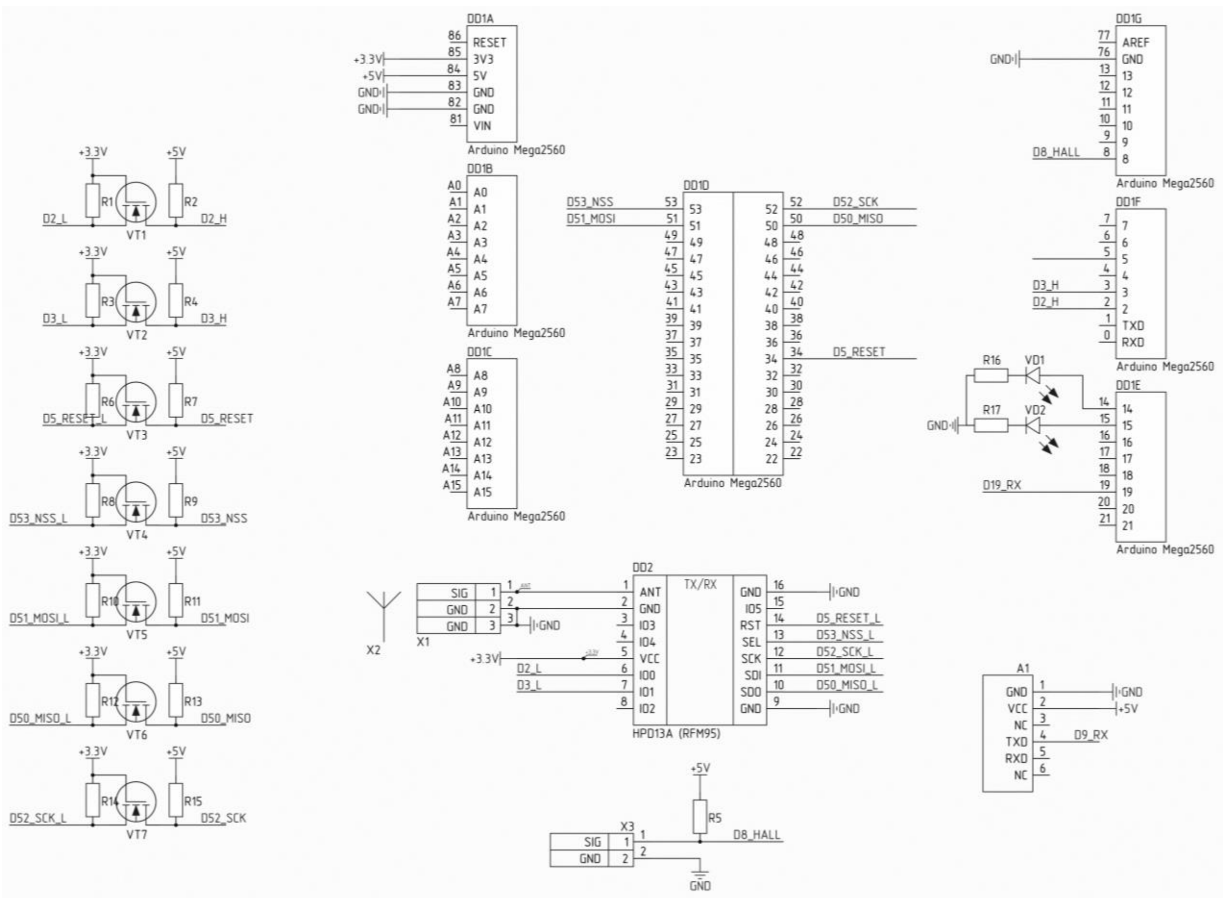

Figure 3 - Schematic diagram of the device

On the basis of VT1 - VT7 transistors the level adapters of 3.3V <-> 5V built. This section of the circuit necessary because Arduino Mega 2560 works with voltage levels 0 - 5V, and RFM95W module with levels 0 - 3.3V. The Arduino Mega 2560 controller terminals shown as DD1A to DD1G components. Diodes VD1, VD2 act as indicators. DD2 was the RFM95W module responsible for data transmission via the LoRaWAN interface. The X2 antenna is connected to connector X1, which operates at a frequency of 868 MHz (LoRa operating frequency for the region of Kazakhstan). Reed switch connected to the X3 connector. One foot of the reed switch is pulled up to the supply voltage through the resistor R5 to provide logical signal levels on the D8 foot of our controller, and the second foot was connected to the ground. A1 is a RFID module. 3 feet used. Two feet were used for module power supply and one for serial port data reading. The data is read on the D9 foot of the Arduino Mega 2560 microcontroller, as it is on this foot inside the controller that the Serial1 serial port was connected.

Figures 4, 5 shown three-dimensional models of the accessory board of the device under development. The LoRa RFM95W module was located on the bottom of the board. Level coordination was implemented on the bottom side of the board.

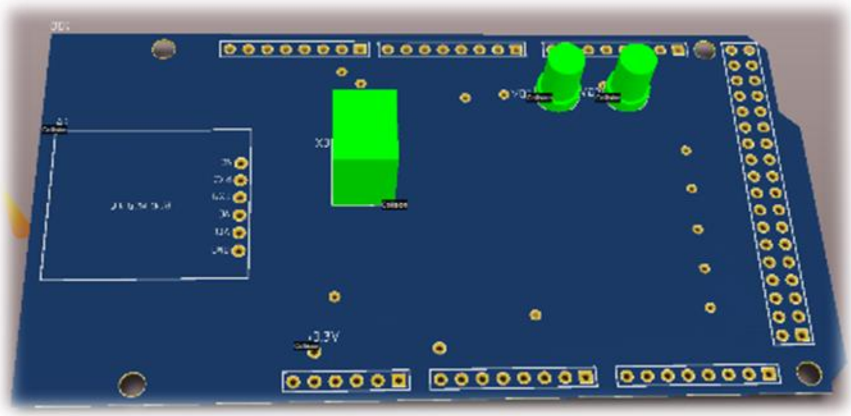

Figure 4 - Three-dimensional device model. View from above.

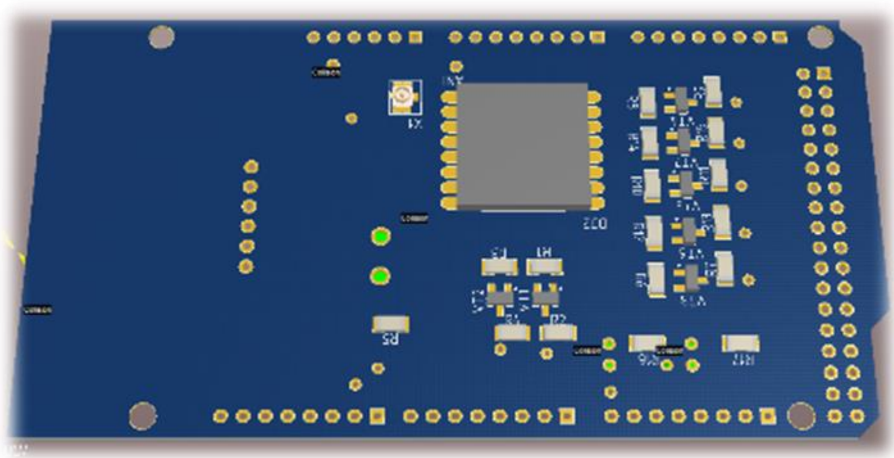

Figure 5 - Three-dimensional device model. Bottom view.

The controller work program was written on the basis of the developed algorithm (Figures 6, 7).

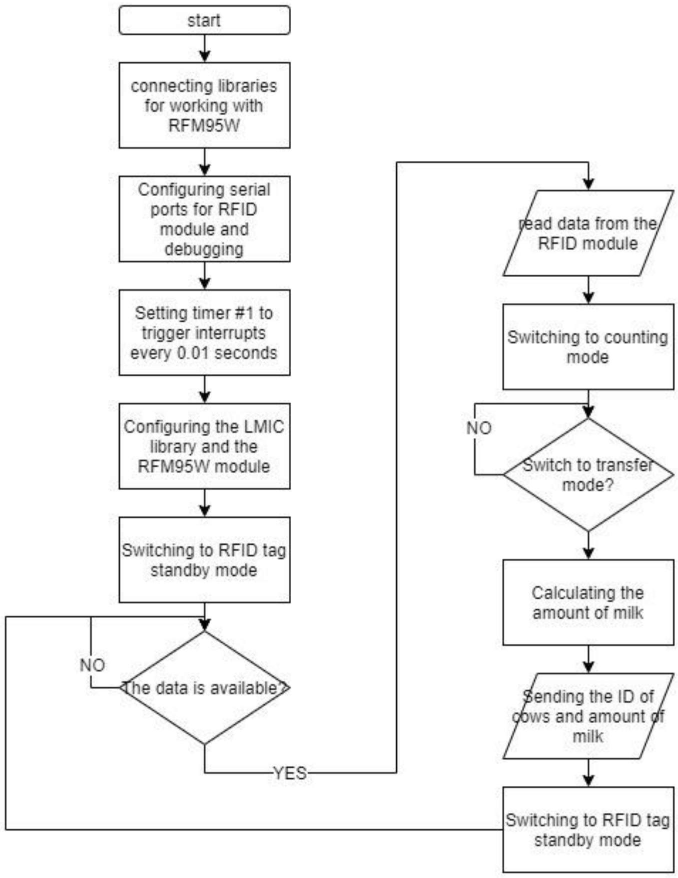

Figure 6 - Structural diagram of the device controller operation algorithm

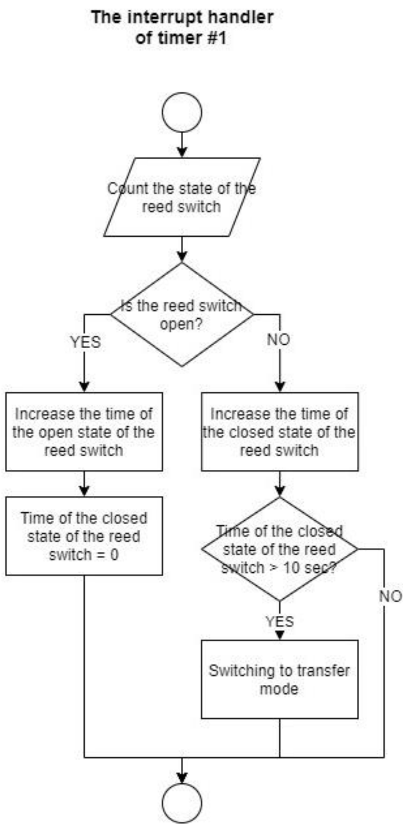

Figure 7 - Structural diagram of the device controller operation algorithm. Clock interrupt handler

When power is supplied to the controller, all device modules were configured. After configuration, the system goes into standby mode for data from the RFID module. As soon as the RFID module returns the tag information, the system enters the counting mode. In fact, the system ran an empty cycle until an interrupt occurs according to timer 1 (Fig. 7). Previously, the timer was set to operate every 0.01 seconds. In the interrupt handler, the controller reads the state of the reed switch, and if it is open, the open time counter increments, the closed state of the reed switch is reset. Otherwise, the time of the closed state of the reed relay were incremented, if it was closed for more than 10 seconds, the program gives a signal to change the state and switch to the processing and data transfer mode. Using this logic, it is possible to eliminate unnecessary operator actions to stop the meter. In data processing and transmission mode, the controller converts the reed open state time to litres and sends the data to the server via the LoRaWAN interface.

Figure 8 shown the implemented device in assembled form, with RFID reader, LoRa module and antennas installed.

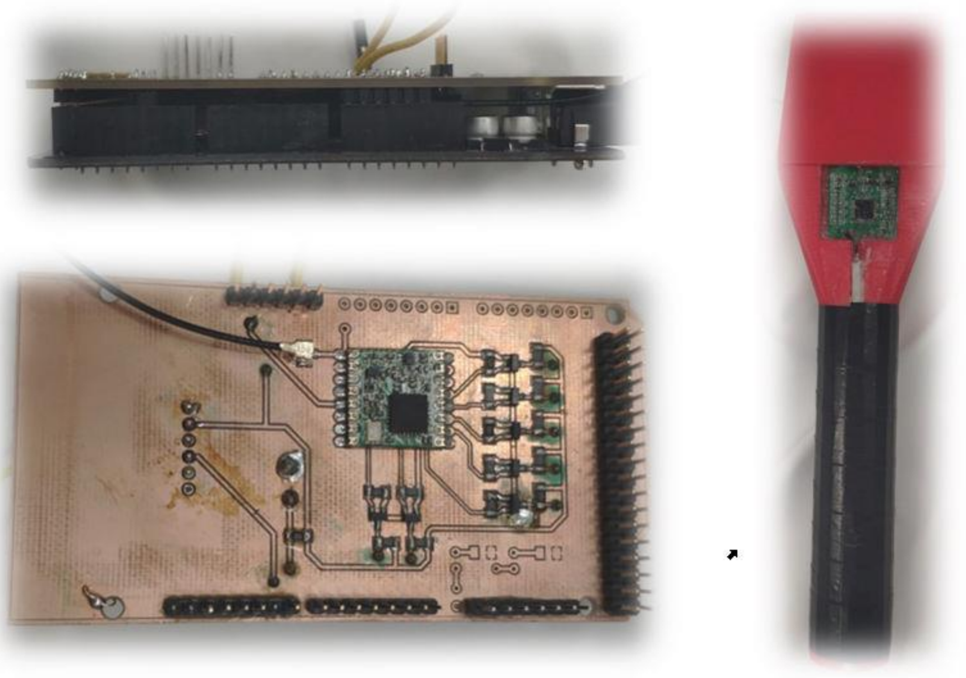

Figure 8 -Components of the implemented device

Research results

The final device encased in a plastic case, which houses a platform with a microcontroller and an expansion module with LoRa transmission chips and an RFID reader. The device captured the individual cow's identification number through an RFID system, compared it with the calculated yield and sends the data to a server via the LoRa wireless interface.

Figure 9 - Mobile milking machine with automatic milk yield recording

Figure 9 shown the connection of the device to the milking machine. The board with the controller was located in a box with a marked frame 1. The reed sensor was located in the grey glass highlighted by the frame.

Several experiments were carried out on the dairy farm KT "Mambetov m Ko", including cows with the first milking after calving (Figure 10). Displacement calculations were calculated on the controller built into the meter, and the result was transmitted via the LoRa channel to a remote server.

Figure 10 - Testing the device

Conclusion

The article was based on the practical implementation of the device related to IoT and using radio interfaces to collect and transmit useful information. The article was based on an understanding of the principles and advantages of RFID and LoRa technology. The developed equipment for accounting milk productivity will allow to receive automatically data on milk yield from a separate cow during milking by mobile devices, which was previously not possible. In conjunction with the RFID system, the device created an opportunity to track their productivity. The use of LoRaWAN network will increase the service life of the module and give independence from cellular network coverage.

This development will allow farmers in Kazakhstan to keep accurate records of milk productivity, because milk productivity is influenced by a large number of factors. One of the most important management is feeding, a decrease in milk yield indicates incorrect feeding, which in the future will lead to problems with the health of cows and animal reproduction. An important point is the culling of animals, the farmer will be able to identify low-yielding animals and take timely measures to repair the herd with more productive animals.

The present work was performed within the framework of program-targeted funding of the Ministry of Agriculture of the Republic of Kazakhstan, BR06349515 "Transfer and adaptation of innovative technologies for optimizing the production processes in dairy farms of Northern Kazakhstan".

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S.B.[1]Baiguanysh, M.Sc.
A.B.Mirmanov [1], Assoc.Professor
O.V. [2]Stukach, Professor, Dr.Tech.Sc.
S.A.[1]Isabekova, Cand. Agr. Sc.
[1]S. Seifullin Kazakh Agrotechnical University,
62, Zhenis avenue, Nur-Sultan, 010011, Kazakhstan
[2]National Research University Higher School of Economics
20, Pokrovsky Boulevard, Moscow, Russian Federation
mirmanov.arman@gmail.com

The use of mobile milking machines in dairy farms remains popular. In the near future, a replacement for robotic systems such as " Carrousel", "Herringbone" and others is not foreseen both on small farms and for the first milking after calving. As a result, the presented development is relevant and in demand. The created equipment for automated accounting of milk productivity is a device with a hardware-software module that collects data on milk yield from an identified cow, performed by a mobile milking machine, and sends the data automatically via a wireless communication channel. The technological features of the experimental model of universal equipment for automatic recording of milk production are the use of a reed switch for milk counting, radio frequency identification and data transmission using the LoRa protocol with low energy consumption. A control program was written to execute the developed algorithm. A special Arduino Mega expansion board has been developed for processing RFID signals and reed switch pulses. The algorithm of work assumes obligatory radio-frequency identification of the cow before the start of milking, and automatic transmission of data upon its completion. The data storage server wirelessly sends information about the amount of milk, cow ID, start and end time of milking. Experimental tests were carried out on dairy farms using mobile milking machines. As a result, the viability of the proposed solution and its advantages were proved: efficiency and structured data, no manual logging, flexibility in expanding functionality.

Keywords: Agriculture, Internet of Things, Radiofrequency identification, LoRa, intelligent dairy farming, automatic method, milk meter, Arduino, ATmega2560

УСТРОЙСТВО ДЛЯ АВТОМАТИЧЕСКОГО УЧЕТА МОЛОЧНОЙ ПРОДУКТИВНОСТИ НА БАЗЕ ТЕХНОЛОГИЙ RFID И LORA

С.Б.[1]Байгуаныш, м.т.н.
А.Б.[1]Мирманов, ассоц.профессор
О.В.[2]Стукач, профессор, д.т.н.
С.А.[1]Исабекова, к.с.-х.н.
[1]Казахский агротехнический университет имени С.Сейфуллина, Республика Казахстан, 010011, г.Нур-Султан, пр.Женис, 62
[2] Национальный исследовательский университет Высшая школа экономики Российская Федерация, 109028, г.Москва, ул.Покровский бульвар, 11
mirmanov.arman@gmail.com

Применение мобильных доильных установок на молочных фермах остаётся популярным. В ближайшее время замена на роботизированные системы типа «Карусель», «Ёлочка» и другие не предвидится как на малых фермах, так и для первой дойки после отёла. Это делает представленную разработку актуальной и востребованной. Созданное оборудование автоматизированного учета молочной продуктивности представляет собой устройство с аппаратно-программным модулем, осуществляющее сбор данных об удое с идентифицированной коровы, совершенном мобильным доильным аппаратом, и отправку данных в автоматическом режиме по беспроводному каналу связи. Технологическими особенностями экспериментального образца универсального оборудования по автоматическому учету молочной продуктивности являются применение герконового датчика для подсчёта молока, радиочастотной идентификации и передачи данных по протоколу LoRa с низким энергопотреблением. Для исполнения разработанного алгоритма написана программа управления. Разработана специальная плата расширения на Arduino Mega для обработки сигналов RFID и импульсов геркона. Алгоритм работы предполагает обязательную радиочастотную идентификацию коровы до начала дойки, и автоматическую оправку данных по её завершению. На сервер хранения данных по беспроводному каналу отправляется информация о количество молока, ID коровы, времени начала и окончания дойки. Экспериментальные испытания проводились на молочных фермах с использованием мобильных доильных аппаратов. В результате доказана жизнеспособность предложенного решения и её преимущества: оперативность и структурированность данных, отсутствие ведения журнала в ручном режиме, гибкость в расширении функционала.

Ключевые слова: сельское хозяйство, Интернет вещей, радиочастотная идентификация, LoRa, интеллектуальное молочное животноводство, автоматический метод, счетчик молока, Arduino, ATmega2560

RFID ЖӘНЕ LORA ТЕХНОЛОГИЯЛАРЫ НЕГІЗІНДЕГІ СҮТ ӨНІМДІЛІГІН АВТОМАТТЫ ЕСЕПКЕ АЛУҒА АРНАЛҒАН ҚҰРЫЛҒЫ

С.Б.Байгуаныш[1], т.ғ.м.
А.Б.Мирманов[1], қауымдастырылған профессор
О.В Стукач[2], профессор, т.ғ.д.
С.А.Исабекова[1], а.-ш. ғ. к.
[1]С.Сейфуллин атындағы Қазақ агротехникалық университеті, Қазақстан Республикасы, 010011, Нұр-сұлтан, Жеңіс даңғылы, 62
[2]Ұлттық зерттеу университеті Экономика жоғары мектебі
Ресей Федерациясы, 109028, Мәскеу қ., Покровский бульвары, 11
mirmanov.arman@gmail.com

Сүт фермаларында мобильді сауу қондырғыларын қолдану танымал болып қала береді. Жақын арада ауыстыру уақыты "Әткеншек", "Шырша" типті роботтандырылған жүйелерде және де басқа ауыстыру шағын

фермаларда да, бұзаулағаннан кейін алғашқы сауу үшін де күтілмейді. Осыған байланысты ұсынылған әзірлеме өзекті және сұранысқа ие. Құрылған аппараттық-бағдарламалық модулі бар құрылғы сүт өнімділігін автоматтандырылған есепке алу жабдығын ұсынады, ол мобильді сауу аппараты жасаған сәйкестендірілген сиырдан сауу туралы деректерді жинауды және деректерді автоматты режимде сымсыз байланыс арнасы бойынша жіберуді жүзеге асыратын құрылғы болып табылады. Сүт өнімділігін автоматты есепке алу жөніндегі әмбебап жабдықтың эксперименттік үлгісінің технологиялық ерекшеліктері сүтті есептеу, радиожиілікті сәйкестендіру және энергияны аз тұтынатын LoRa хаттамасы бойынша деректерді беру үшін геркондық датчикті қолдану болып табылады. Әзірленген алгоритмді орындау үшін басқару бағдарламасы жазылған. RFID сигналдары мен геркон импульстарын өңдеу үшін Arduino Mega-да арнайы кеңейту тақтасы жасалды. Жұмыс алгоритмі сиырды сауу басталғанға дейін міндетті түрде радиожиілікті сәйкестендіруді және оның аяқталуы туралы мәліметтерді автоматты түрде түзетуді қамтиды. Сымсыз арна арқылы деректерді сақтау серверіне сүт мөлшері, сиырдың идентификаторы, сауудың басталу және аяқталу уақыты туралы ақпарат жіберіледі. Мобильді сауу қондырғыларын пайдаланатын сүт фермаларында эксперименттік сынақтар жүргізілді. Нәтижесінде ұсынылған шешімнің өміршеңдігі және оның артықшылықтары: деректердің жеделдігі мен құрылымдылығы, журналды қолмен жүргізудің болмауы, функционалды кеңейтудегі икемділігі дәлелденді.

Кілттік сөздер:ауыл шаруашылығы, интернет заттары, радиожиілікті сәйкестендіру, LoRa, ақылды сүтті мал шаруашылығы, а втоматты әдіс, сүт есептегіші, Arduino, ATmega2560

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The present work was performed within the framework of program-targeted funding of the Ministry of Agriculture of the Republic of Kazakhstan, BR06349515 "Transfer and adaptation of innovative technologies for optimizing the production processes in dairy farms of Northern Kazakhstan".