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NEW GENERATION RADIATION METERS DEVELOPED AT TAEA LABORATORIES

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TAEK LABORATUVARLARINDA GELİŞTİRİLEN YENİ NESİL RADYASYON ÖLÇERLER

Abstract:

In past 30 years, research and development (R&D) activities on radiation monitoring and measuring instruments and their production have continuously been conducted in Nuclear Electronics Unit of Technology Development Department of Turkish Atomic Energy Authority. The gained skill and know-how in such activities are applied to develop prototypes, so new models of these radiation instruments are in market order to compete with new technology. In recent times, fully surface mount electronics components are used to minimize the dimensions of radiation measuring instruments. The usage of microcontroller enables reliable, stable measurement and display of low background dose rate fields and makes possible the evaluation of the measurement data through the user friendly menus. It can be stated that these new generation devices developed in TAEA have a broad range of features such as a large graphic LCD screen, wide and accurate measurement range with dynamic dead time correction subroutine, measurement recording feature, audible and visible alarm feature, GPS module, USB port for computer connection, rechargeable lithium battery charged from USB port and comprehensive menu options such as radiation measurement unit and language selection. As another feature, radiation dose rate values can be recorded to internal memory, manually or automatically. The records, can be transferred to the computer by using the Data Management System (VYS-250) computer software which developed by Nuclear Electronics Unit. Radiation levels with the GPS position information can be displayed on the real map when the internet access is provided. All these substantial improvements, enable these devices to compete with their superior features in terms of both software and hardware when compared to similar devices available in the market.

Özet:

Son 30 yılda, Türkiye Atom Enerjisi Kurumu (TAEK), Teknoloji Geliştirme Dairesi Başkanlığı, Nükleer Elektronik Birimi, son 30 yıldır ülkemize hizmet vermek üzere radyasyon izleme ve ölçüm cihazları ile ilgili araştırılması, geliştirilmesi (Ar-Ge) ve üretilmesi konularında çalışmalar yürütmektedir. Bu çalışmalar sırasında edinilen know-how, geliştirilen prototiplere uygulanmakta, böylece yeni teknolojilerle rekabet edebilecek modeller geliştirilmektedir. Son zamanlarda, üretilen radyasyon ölçüm cihazlarının boyutlarını en aza indirmek için tam yüzey montajlı elektronik devre elemanları kullanıldı. Mikro denetleyici kullanımı, düşük radyasyon doz şiddetli alanların güvenilir, kararlı bir şekilde ölçülmesini ve izlenmesini sağlar. Bunun yanı sıra ölçüm verilerinin menüler üzerinden değerlendirilmesini mümkün kılar. Geliştirilen yeni nesil cihazlar; geniş grafik LCD ekran, dinamik ölü zaman düzeltmesi ile geniş ve doğru ölçüm aralığı, ölçüm kayıt özelliği, sesli ve ışıklı alarm özelliği,

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GPS modülü, bilgisayar bağlantısı için USB port, USB port üzerinden şarj edilebilir lityum batarya ve ölçüm birimi veya cihaz dili seçimi gibi çok geniş menü özellik yelpazesine sahiptir. Radyasyon doz hızı değerleri elle veya otomatik olarak kaydedilebilir. Veri Yönetim Sistemi (VYS-250) bilgisayar yazılımı kullanılarak kayıtlar bilgisayara aktarılabilir ve internet erişimi sağlandığında GPS konum bilgisi ile radyasyon seviyeleri gerçek haritada gösterilebilir. Tüm bu yapılan geliştirmeler ile bu cihazlara eklenen üstün özellikler sayesinde, dünyadaki benzer cihazlarla rekabet etme imkânı kazandırılmıştır.

Key Words: Radiation detector, dead time, Geiger Müller, dose rate, alpha, beta, gamma.
Anahtar Kelimeler: Radyasyon tespiti, ölü zaman, Geiger Müller, doz hızı, alfa, beta, gama.

1. Introduction

Turkish Atomic Energy Authority (TAEA), Technology Development Department (TDD), Nuclear Electronics Unit is working on research, development and production of radiation monitoring and measuring instruments in the aims of TAEA to serve in national level since 1989. Between 1988 and 2018, more than 10,000 radiation meters have been produced and entered in service.

Nowadays, radiation measurement instruments that are produced by large companies usually use microcontrollers and support more than one external probes. In addition, these devices include features such as communication with the computer, data storage, selecting the radiation measurement unit from the menu. Similarly new devices developed in Nuclear Electronics Unit have many new features brought by new generation technology.

Two different software has been developed to work on the device and the computer. With software running on the device, each device can calculate radiation dose rate based on the number of radioactive rays counted by Geiger Müller (GM) tube. On the other side, the embedded software running on the device is responsible for all other functions of the device other than radiation measurement as well. Some of these functions are Scaler/Timer, menu operations, data transfer between device and computer.

18f67k22 model microcontroller unit (MCU) is used in the devices. This MCU enables to present the multi-menu features to the users. In addition, the device, controlled by this MCU, has substantially improved to attain new capabilities such as simultaneously measurement of radiation dose rate and dose, elimination of measurement errors, and storage of measurement data in the device memory (Kucukarslan & Guven, 2001).

When the GPS feature is turned on in the devices (this feature is only available on NEB.250 and NEB.251 models), the device receives GPS information from the satellite via the GPS module. The software running on the device processor stores this information with the recorded data and sent to the computer when the computer connection is established.

As a result of the studies carried out in TDD Nuclear Electronics Unit in recent years, new devices named NEB.250 series have been developed and started production. The NEB.250 series devices consists of NEB.250, NEB.251, NEB.253 and NEB.254.

2. NEB.250 Series Devices

NEB.250 is a hand-held radiacmeter. The NEB.250 device can be used with its internal detector (NEB.250D1 as seen in Figure 1 and Figure 2), with an external detector suitable for low radiation measurement (NEB.250HP2) or with an external detector (NEB.250HP3) suitable for alpha, beta measurement. It has internal memory unit and it can save dose and dose rate

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records, alarms, errors that occurred during operation. It also has GPS module and it can save dose rate records with GPS data. It has lithium batteries charged by USB port easily like smart telephones.

Figure 1. NEB.250D1 Radiacmeter

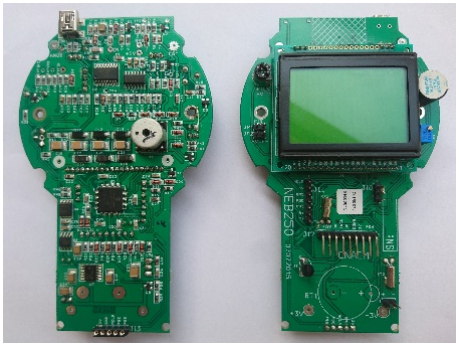

Figure 2. Both sides of NEB.250's PCB

The NEB.251 radiation meter is a stationary type radiation measuring instrument that measures environmental radiation dose and dose rate at the same time. NEB.251 has military type connector and stainless steel body (Figure 3). It is designed for outdoor use and is suitable for installation in vehicles (optional). NEB.251 can measure up to 1000 R/h radiation dose rate from the background radiation level and it is waterproof device.

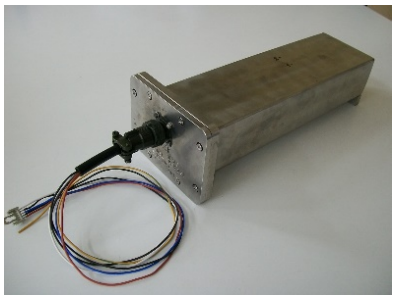

Figure 3. NEB.251 Device

NEB.253 "Precision Radiation Monitor" is a fixed (Figure 4) or portable (Figure 5) radiation measurement system suitable for use in nuclear research centers, all kinds of institution entrances, vehicles and passenger entrances, conveyor systems and similar radiation suspected environment. It has eight high precision GM detectors placed in the device box.

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Figure 4. NEB.253 Precision Radiation Monitor

Figure 5. NEB.253 with a Movable Base

NEB.254 Radiation Area Monitor (Figure 6) is an instrument with its internal detector and external probes measuring radiation dose rate and radiation dose with audible and visible warning. It can be mounted on a wall. It goes on operating with its rechargeable battery during mains voltage shutdowns.

Figure 6. NEB.254 Area Monitor

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3. General Information about NEB.250 Series Devices

The general Information of NEB.250 Series Devices is presented in table 1.

Table 1. General Information of NEB.250 Series Devices

Feature	NEB.250	NEB.251	NEB.253	NEB.254
Large graphic LCD screen (128x64)	✓	✕	✓	✓
Measurement recording	✓	✓	✓	✓
Audible and visible alarm	✓	✕	✓	✓
GPS module	✓	✓	✕	✕
Rechargeable lithium battery	✓	✕	✕	✕
Computer connection	✓	✓	✓	✓
Military type connector and stainless steel body	✕	✓	✕	✕
Instant dose rate monitoring via computer	✕	✓	✓	✓
Keypad	✓	✕	✓	✓
Turkish/English Language Selection	✓	✓	✓	✓
Measurement units	R and R/h, Sv and Sv/h, CPS			
Scaler/Timer Feature	✓	✕	✓	✓
Measured radiation	Alpha, beta, gamma and X-rays	Gamma and X-rays		
Measurement range (Dose Rate)	D1: 10 µR/h-1,99 R/h HP2: 5 µR/h - 150 mR/h HP3: 10 µR/h-300 mR/h	0-10 Sv/h	5 µR/h - 150 mR/h	10 µR/h-3n R/h
Data management	Data Management System (VYS-250) software can be used for data storage, graphics and map display and reporting.			

In Table 1, some notations are R: Roentgen, µR: microroentgen, mR: milliroentgen, Sv: Sievert, CPS: count per second.

Dead Time Correction

In the NEB.250 series devices, GM detectors were used as radiation detectors. Because the GM tubes have high detection sensitivity, robust construction and simple circuitry. Due to these the well-known features, GM detectors continue to be one of the most widely used radiation detectors in all areas of nuclear applications. Nonlinear response to the radiation intensity at high counting rates is the only drawback of these detectors (Arkani & Khalafi,, 2013).

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Because of the random nature of radioactive decay, there is always some probability that a true event might be lost because it occurs too quickly following a preceding event. These “dead time losses” can become rather severe when high counting rates are encountered (Knoll GF, 1999). The measurement errors caused by this problem are minimized by “Dynamic Dead Time Compensation Software” developed in Nuclear Electronics Unit.

This software recalculates the dead time value used in counts above the second calibration point each measurement. The new dead time uses the "k Constant" calculated by the measurements at the radiation calibration process. “Dynamic Dead Time Compensation Software” provides linear response in the extended measurement range of the detector. In addition, measurement errors due to fatigue (Akyurek, Yousaf, Liu & Usman, 2015) are also reduced.

4. Menu Features

NEB.250 series devices have extensive menu features. Through this menu, users can customize the device for their own use. These features of the device can be changed via the device menu or the data management system software that comes with the device. The following is a menu diagram of the NEB.250 device for an example shown in schema 1.

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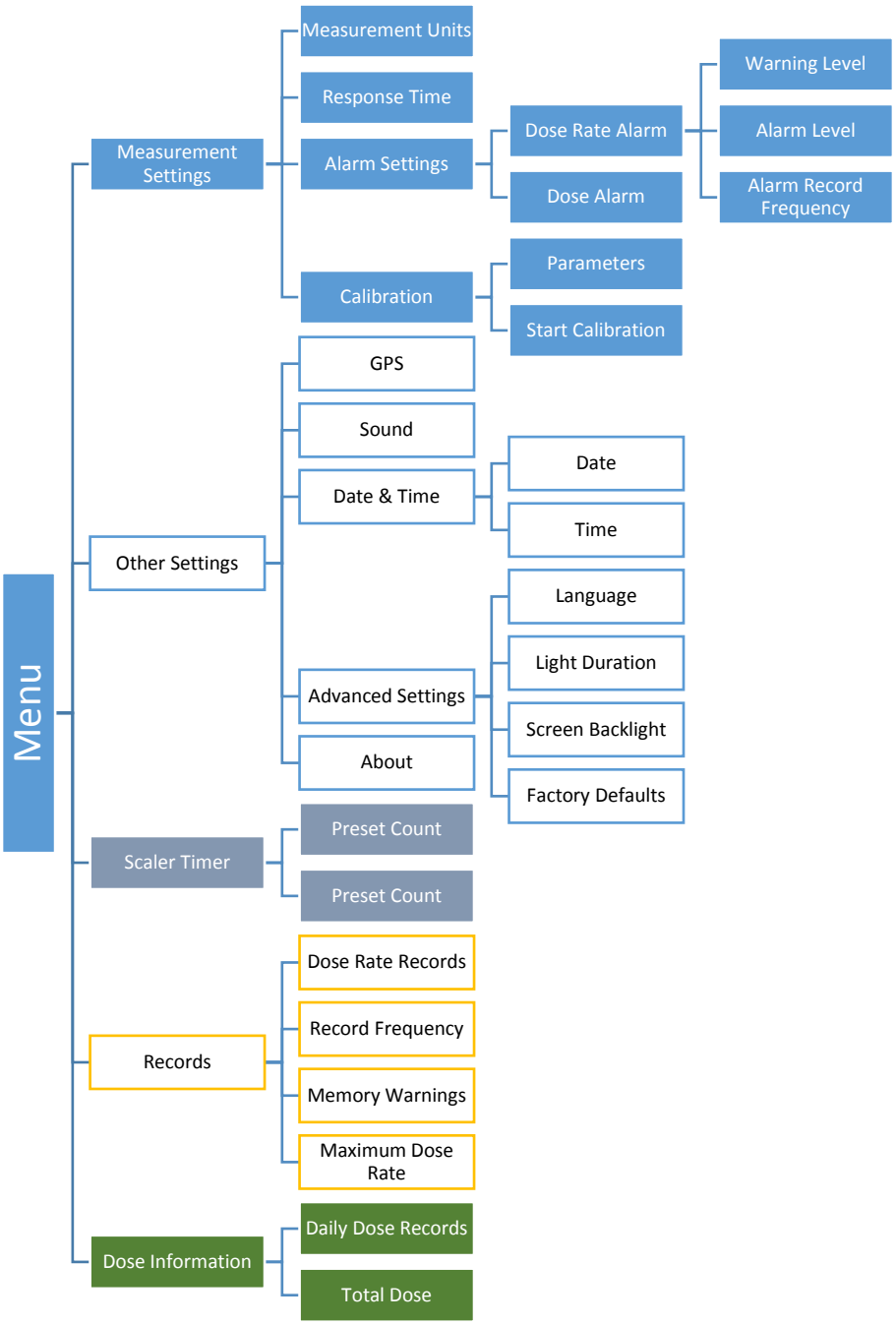

Schema 1. NEB.250 Menu Diagram

5. VYS-250 Data Management System

The second software developed during the production of NEB.250 series devices is Data Management System (VYS-250 Figure 7). The software was developed in TDD-Nuclear Electronics Unit using C # language.VYS-250 is developed by using most recent software development environment ".net Framework 4.7". The software uses SQL Server for database operations.

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VYS-250's main purpose is to transferring records from NEB.250 device series to computer through USB port, saving transferred records, and displaying saved records to users. Transferred records are deleted from devices memory.

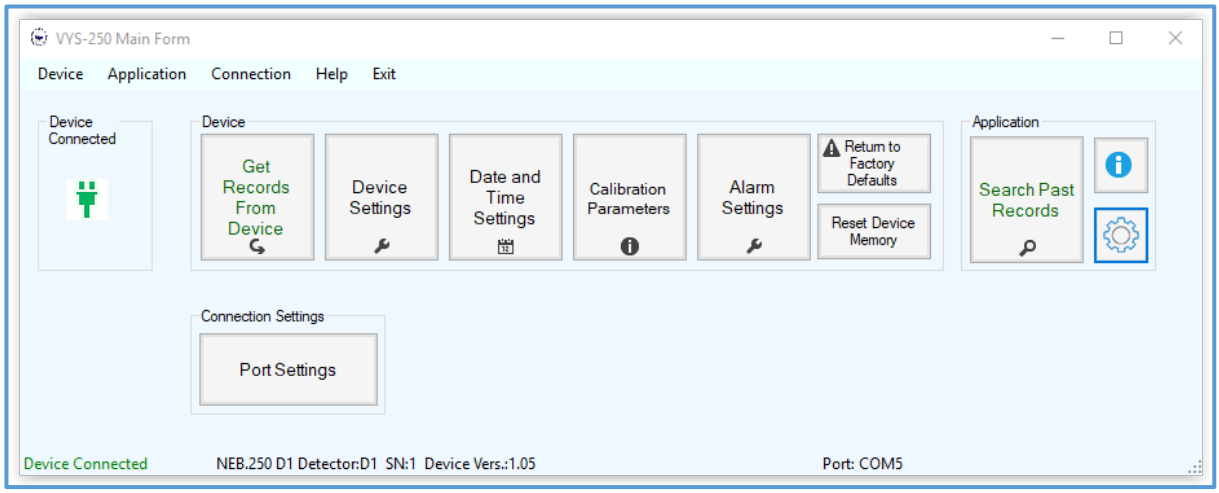

Figure 7. Data Management System Main Screen

In VYS-250;

- Records that kept in database can be searched by specific criteria,
- Records with GPS data can be viewed on map (Figure 8), and they can be reported,
- Connected devices settings can be changed.

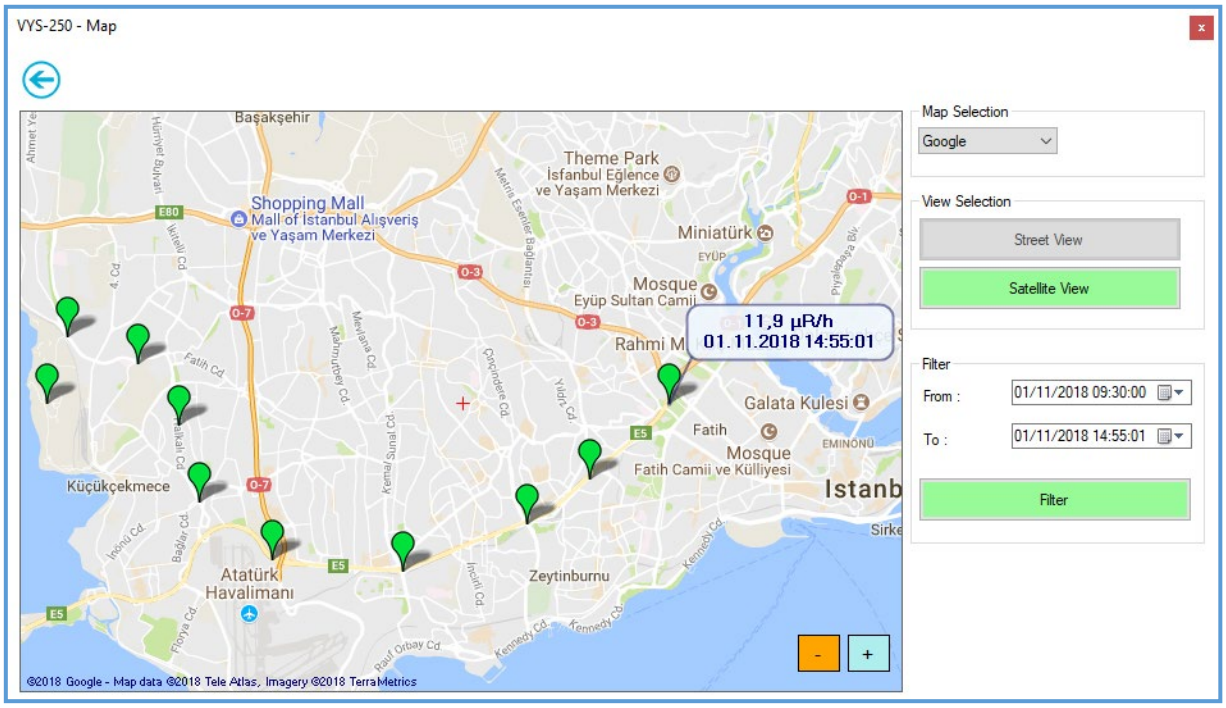

Figure 8. Records Shown On Map

The GPS module is programmed by the software running on the device. By this way, GPS data received from satellite is provided in GPGGA format. GPS data in GPGGA format

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includes many different information such as time, latitude, longitude, and altitude, number of satellites from which data is received. This GPS data is stored in the device memory with the records made. When the recordings are transferred to the computer, it is shown on the map with the dose rate information.

6. Monitoring Feature

One of the most important features that distinguishes NEB.250 series devices from similar is the monitoring feature. In the instant data monitoring screen, dose rate, dose, alarm status, error status and GPS data, if any, are sent to the computer together with the basic information of the device. Instant data is presented to the user via the monitoring screen (Figure 9) shown below. Dose rate information is displayed simultaneously on the graph and dose rate increase can be easily examined. In case of alarm conditions, the user is warned by audible and visible alarm. All data coming here is optionally stored on the computer and can be searched on the stored data. NEB.251 and NEB.253 devices support instant data monitoring via data management system software.

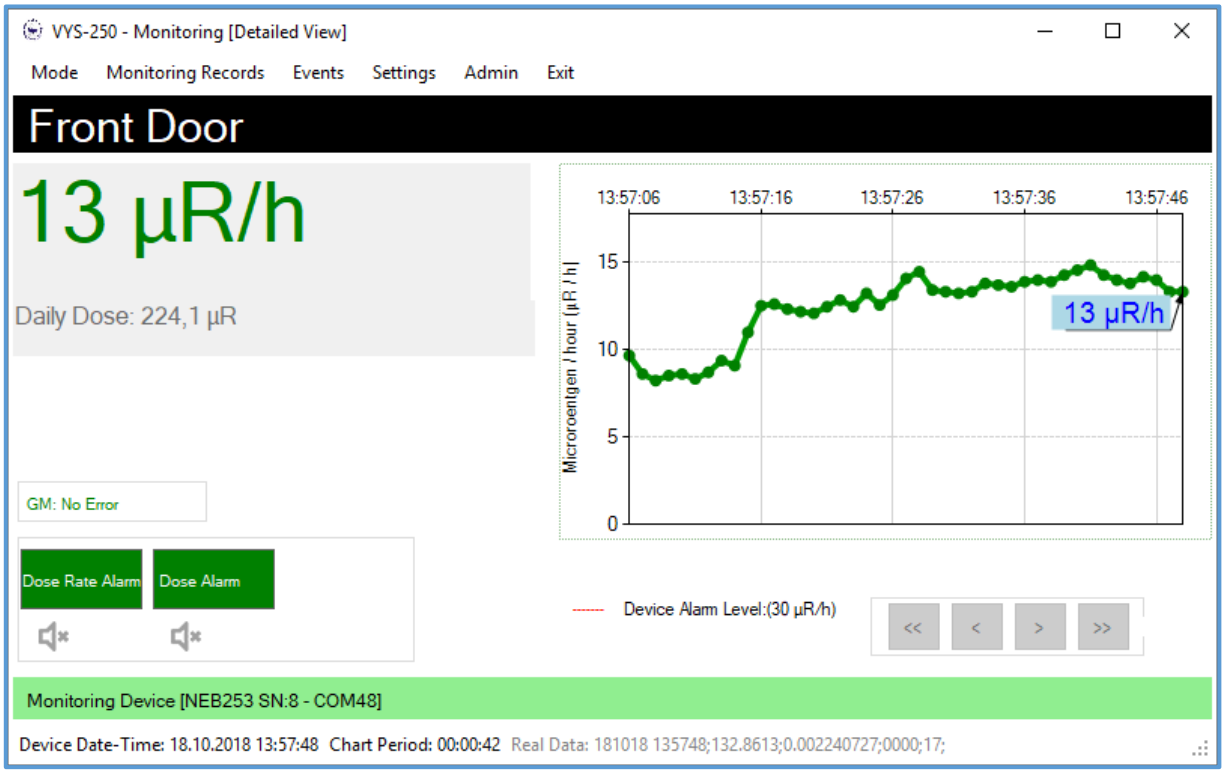

Figure 9. Monitoring Screen

The monitoring feature is designed to operate asynchronously. This allows the user to perform different tasks (such as changing the graphic type, turning the alarm sound on and off) while monitoring is in progress. When monitoring is started, this command is transmitted to the device and the device is able to transfer the measurement data to the computer every second. The thread assigned to retrieve data from the device every second runs independently of other functions in the form and starts to process the data from the USB port. After the data is processed, it is filled in the controls on the form and this data becomes viewable by the user.

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7. Conclusion

When the radiation measurement instruments of companies using today's technology are examined (Berthold Web Site, 2019, Bertin Web Site,2019, Gamatom Web Site, 2019, Thermofisher Web Site, 2019), it will be seen that the devices developed in the TDD Nuclear Electronics Unit can compete with similar devices in the world in terms of both technology and general features. These devices are developed for mass production and produced at the rate of need, in TAEK units, in Turkish Armed Forces, in universities, in hospitals, in Civil Defense, in many institutions and organizations of our country such as Disaster and Emergency Management Authority. Our young engineers working in development and mass production stages have gained experience and have been equipped to take part in new technological projects.

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