Electromagnetic radiation monitoring universal device

Panaitescu Mariana [1)], Dumitrescu Marius-Valentin [2)] ,

Panaitescu Fanel-Viorel [1)]

[1)] Engineering Sciences in Mechanics and Environment Department, Maritime University, Constanta, Romania

[2)] Doctoral School of Energy Engineering, POLITEHNICA University, Bucharest, Romania

INTRODUCTION

- The negative consequences of polluting factors has created in the society a culturalization of the population in this direction. Real-time knowledge of indoor and outdoor air quality, water quality, noise pollution level, or electromagnetic radiation level, all these are requirements of today's society. The demand for devices to monitor these polluting factors has increased substantially in recent years. The devices for monitoring electromagnetic radiation are also part of the increasingly requested devices. The current market offers such devices, which have a high cost price, which can usually only indicate the presence of electromagnetic radiation but does not indicate the volume, or area of the radiation origin, nor does it integrate their amount [1, 2].
- Thus the need arose to develop a universal device for the monitoring of electromagnetic radiation called *Electro-Magnetic Radiation-Monitoring Universal Device* (EMR-MUD). It complements the family of universal devices for monitoring *Indoor Air Quality Universal Device* (IAQ-MUD) [3] and *Outdoor Air Quality Monitoring Universal Device* (OAQ-MUD) [4] improving the image of polluting factors.
- Through this paper we present how we designed the electronic scheme of the device, then how we built this device and finally, how we purchased the data through the "Tera Term" programm, which offers the possibility of accessing data both on a serial local communication and accessing it. data via the Internet. This device is able to monitor several areas of interest in the spectrum of electromagnetic radiation, being built for indoor and outdoor spaces [5].

METHODS AND RESEARCHES

2.1. Researches and technologies to built the EMR-MUD

2.1.1. The block diagrams of components

2.1.2. Design of electronic scheme of EMR-MUD

- The device is of real use in all areas where you war careful monitoring of the quality of the environm from: offices, classrooms, industrial spaces, housi etc.
- The structure of the equipment was made around a microprocessor, which is part of a series of low power consumption microcontrollers, with integrated Wi-Fi (ESP8266 series, Figure 3) [8]. This series uses a L106 32-bit RISC microprocessor in the monopolar range and includes built-in antenna switches, RF balloon, power amplifier, low noise reception amplifier, filters and power management modules, using the 40 nm process.
- The storage capacity of the 4MB of ESP8266 microcontroller and its internet connectivity facilities allow the creation of an HTML page and its loading into the processor memory. Thus, the data obtained can be accessed in real time.
- The design of the electronic scheme of the equipment prototype was developed with EAGLE software.
- The prototype wiring was made in its own laboratory, following the final, perfected version, to be made in a factory specialized in wiring (Figure 5).

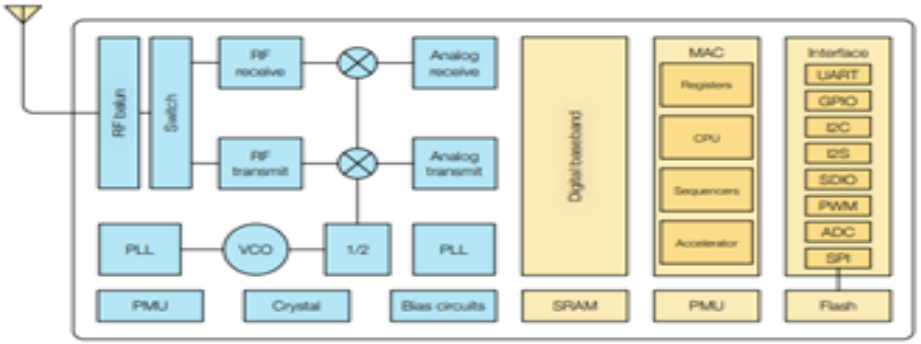

Figure 3. The functional block diagram of ESP8266 series

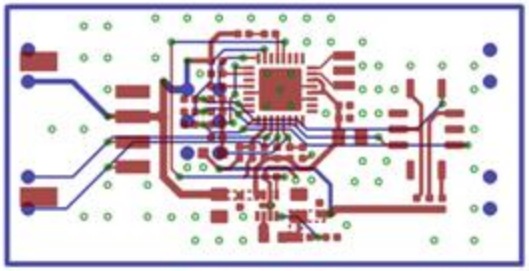

Figure 4. Prototype printed circuit bord of Atmega 328 8-bit microcontroller adapter

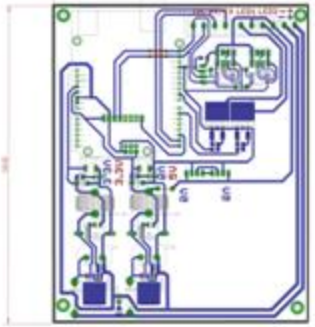

Figure 5. Prototype printed circuit bord of EMR-MUD equipment.

The sensors used to make the prototype for the acquisition of data according to the emission area are for:

-household and industrial electrical equipment (type LT5534 with 50 MHz... 3 GHz monolithic, detector capable to measure signals over 60 dB dynamic range)(Figure 6, Figure 7)

-communication equipment (type AD8317- is a demodulating logarithmic amplifier, capable of accurately converting an input signal to a corresponding decibel-scaled output, with accurate log conformance for signals of 1 MHz ... 8 GHz and provides useful operation to 10 GHz, current consumption~ 22 mA)

-UV radiation intensity (UV= ultra violet)-measurements with VEML6070 which is an advanced ultraviolet light sensor with I_2C protocol interface; it has incorporated a photodiode, amplifiers, and analog / digital circuits into a single chip (Figure 10)

-light intensity visible spectrum – measurements with aTSL2591converter which transforms light intensity into a digital signal output capable of direct I_2C interface. The device has two photodiodes on a single integrated circuit (one for visible plus infrared, another for infrared) and two integrating ADCs (to convert the photodiode currents into a digital output = the irradiance measured on each channel (Figure 11).

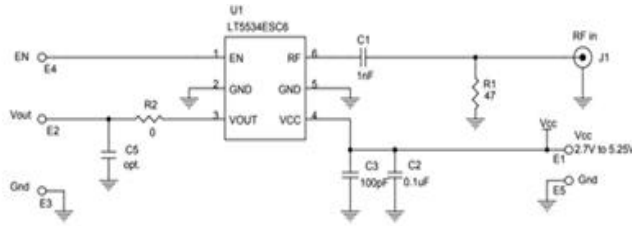

Figure 6. Block diagram of LT5534

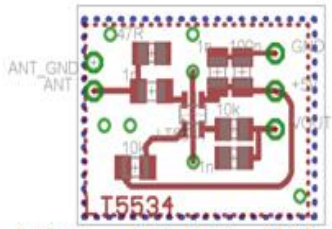

Figure 7. Prototype printed circuit bord of LT5534

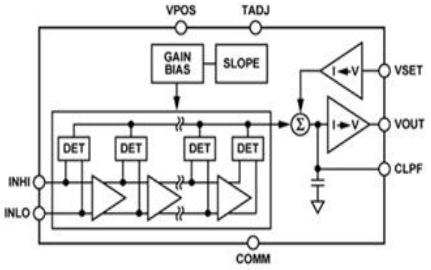

Figure 8. Block diagram of type AD8317

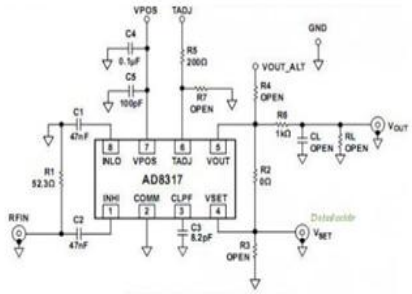

Figure 9. Prototype schematic AD8317

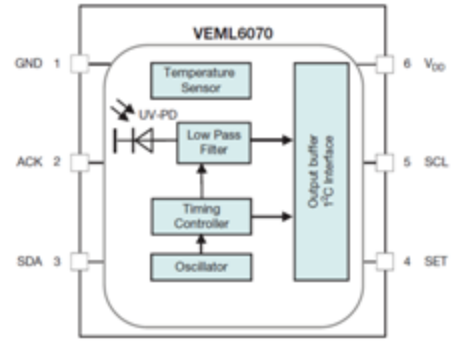

Figure 10. Block diagram of VEML6070 sensor.

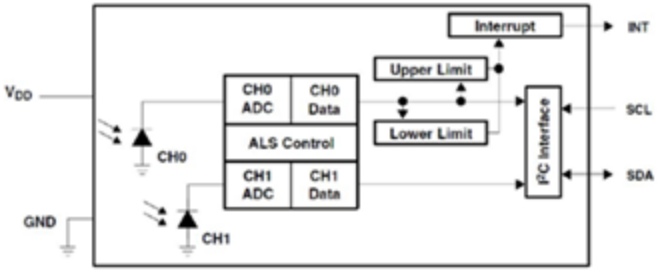

Figure 11. Block diagram of TSL2591converter.

RESULTS AND INTERPRETATIONS

The data obtained can be synchronized with local time (LT) or with Coordinated Universal Time (UTC) and can be imported into table programs for further analysis. The data acquisition was made through the "Tera Term" program, which offers the possibility of accessing data both on a serial local communication and accessing the data over the Internet (over ip). Access can be done from any location with internet connection, either on fixed or mobile devices without the need for special applications.

Of these quantities, magnetic induction, contact current, electric field strength, the magnetic field strength and power density can be measured directly. In our paper a daily average of electric field strength E and power density S one-week readings was made in the zones 1, 2, 3, 4 (Table 1, Table 2, Figure 12, Figure 13). The measured values correspond to frequency domains.

Table 1. Daily average of electric field strength during a week

No.crt.	Day	Zone 1	Zone 2	Zone 3	Zone 4
Domain of frecvency		100 kHz - 7 Ghz E (V/m)	925 MHz – 960 MHz E (V/m)	1805 MHz – 1880 MHz E (V/m)	2110 MHz – 2170 MHz E (V/m)
1	Monday	1.83	0.67	1.13	1.08
2	Tuesday	3.51	4.32	0.64	1.9
3	Wednesday	2.23	3.12	1.24	1.07
4	Thursday	1.32	2.43	1.01	0.86
5	Friday	0.95	0.47	0.35	0.25
6	Saturday	0.14	0.51	0.11	0.28
7	Sunday	0.13	0.52	0.12	0.27

Table 2. Daily average of density of power for electromagnetic radiation during a week

No.crt.	Day	Zone 1	Zone 2	Zone 3	Zone 4
Domain of frecvency		100 kHz - 7 Ghz S (W/m^2)	925 MHz – 960 MHz S (W/m^2)m)	1805 MHz – 1880 MHz S (W/m^2)	2110 MHz – 2170 MHz S (W/m^2)
1	Monday	0.053953	0.049502	0.001086	0.009576
2	Tuesday	0.049502	0.058477	0.001376	0.009981
3	Wednesday	0.039802	0.050011	0.001244	0.008213
4	Thursday	0.038491	0.051201	0.001388	0.007214
5	Friday	0.004641	0.048971	0.001032	0.007009
6	Saturday	0.002414	0.000621	0.000351	0.000186
7	Sunday	0.002394	0.000586	0.000325	0.000166

In the testing phase of the equipment, it was installed in the electronics laboratory where it was created and where the radiation emitted by the electrical and electronic equipment in this space was monitored. The identified radiation generating sources are: power supplies for printers and computers, wireless routers, frequency converters for electric motors, mobile phones, microwave oven. The data obtained can be synchronized with local time (LT) or with Coordinated Universal Time (UTC) and can be imported into table programs for further analysis

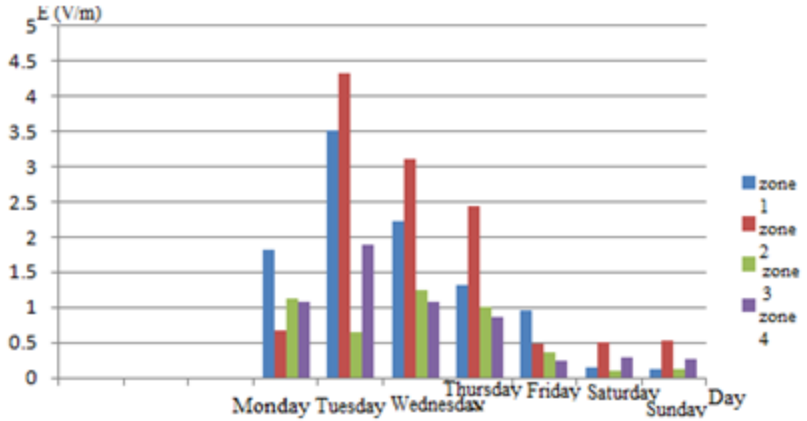

Figure 12. The variation of daily average of electric field strength

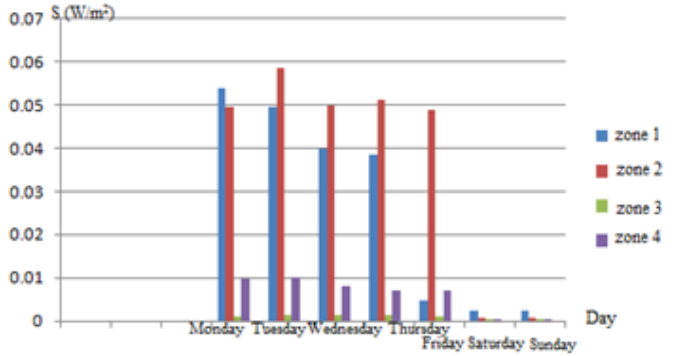

Figure 13. The variation of daily average of density of power for electromagnetic radiation

Interpretations

The EMUD functions are:
- **records individual values for each monitored area (see values**
- **local registration of monitored data and values (see zones in Table 1, 2)**
- **issuing alarms when the limit values are exceeded**
- **online access to data for processing and analysis**
- **IoT compatible.**

- In order to apply the restrictions based on the evaluation of the possible effects of electromagnetic fields on health, a distinction must be made between basic restrictions and reference levels.
- *Restrictions on exposure to time* - varying electric, magnetic and electromagnetic fields are based directly on proven health effects and are defined as biological considerations basic restrictions. Depending on the frequency of the field, the physical quantities used to designate them restrictions are: magnetic induction (B), current density (J), specific absorption rate (SAR) and power density (S). Magnetic induction and power density can be measured directly in the case exposed persons [13].
- *Reference levels* are set for the purpose of practical exposure assessment to determine if they exist the risk of exceeding the basic restrictions. Reference levels refer to perception and to the indirect harmful effects of exposure to electromagnetic fields.
- Derived quantities are electric field strength (E), magnetic field strength (H), magnetic induction (B), power density (S) and current induced in the extremities (I). The sizes that look at perception and the others indirect effects are (contact) currents (I_c) and for pulsed fields, the specific energy absorption (SA). Certain quantities, such as magnetic induction (B) and power density (S), serve both as restrictions as well as as reference levels for certain frequencies. For our measurements the comparative analysis is presented in Table 3.

Comparative analysis

Table 3. Comparative analysis between basic restrictions for power density and recorded values and reference levels for electric field strength and measured values

Domain of frecvencies/zone	E (V/m)		S (W/m^2)	
	Reference level [13]	Recorded average weekly value	Restrictions on exposure to time	Recorded average weekly value
100 kHz-7 GHz	12.825	1.444	-	0.027
925 MHz - 960 MHz	12.825	1.723	-	0.259
1805 MHz - 1880 MHz	12.825	0.657	-	0.001
2110 MHz - 2170 MHz	12.825	0.816	-	0.006

CONCLUSIONS

- As it results from the comparative analysis in the areas where the measurements were performed, the persons are not exposed to the danger of electromagnetic irradiation, the registered values being below the standard values recommended by the European legislation.
- In practice, normal exposure conditions produce lower exposure levels restrictive than those indicated above for reference levels.
- No higher reference levels are expected for exposure to very high electromagnetic fields low frequency for short exposures.
- In many cases, when the measured values exceed the reference levels it does not necessarily appear that they are outdated and basic regulations.
- If the adverse health impact due to the effects indirect exposure (such as micro-shocks) can be avoided, it is admitted that reference levels for the general population may be exceeded provided that the basic current density restriction is not be exceeded.
- The need to monitor electromagnetic emissions on areas of interest has led to the design and implementation of this versatile, adaptable, easy-to-use and maintenance equipment that can be used in different environments to be monitored.
- The energy consumption is low, the supply can be done both from the electricity grid and from batteries.
- The small physical dimensions allow for easy installation and low production costs, making it the ideal device for multiplication. After checking the sensor readings (calibration with certified equipment) we can say that the equipment successfully fulfills the main objectives, ie the readings performed by the sensors fall within the fields specified by their manufacturer.

Acknowledgments

All acknowledgments for technical and financial support and research project PN-III-P1-1.2-PCCDI-2017-0404 / 31PCCDI/2018, " Holistic impact of renewable energy sources on the environment and climate" (*HOLISTICA IMPACTULUI SURSELOR REGENERABILE DE ENERGIE ASUPRA MEDIULUI ŞI CLIMEI)* (acronym **HORESEC**).


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ATOM-N 2020 - 10th EDITION
August 20-23, Constanta, Romania
Advanced Topics in Optoelectronics, Microelectronics and Nanotechnologies

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