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An ultraviolet measuring and UV index calculating system, with multiple alarm capabilities, using FPGAs and VHDL

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Abstract: A novel ultraviolet measuring system, which uses FPGAs and VHDL, is presented here. The system monitors UV radiation of a light source or sun using GUVA-S12SD sensor connected to DE10-Lite FPGA board and after A/D conversion presents input voltage values in seven-segment displays. Calculated UV index values are also displayed. Five external LEDs, green, blue, white, yellow and red light up depending on UV index values range, with green one corresponding to 0-2 value and red one to values equal or greater than 10.5. The above LEDs unit acts both as indicating and also alarm system presenting UV index ranging and is in parallel operation with 10 board LEDs from which left half lights up for UV index values lower than 5.5 and right half in case that UV index exceeds value of 5.5. Time process starts operating in case that UV index is above zero and switch SW0 is ON. Depending on specific UV index a critical UV exposure time value, different for respective UV index ranges, is set by programmer. The above exposure time value must not be exceeded because there is a danger of skin damage, thus our system incorporates another alarm unit consisting of a buzzer and second red LED. Both of them transition to operating mode, in case that one of different five time set limits is exceeded. Our system is cheap to manufacture, easy to use and due to FPGA incorporation can be combined with IoT and AI systems. It can also be used in healthcare systems, industrial UV systems and various application systems where ultraviolet radiation is needed.

Keywords: UV, UV index, UV sensor, FPGA, VHDL, LEDs, exposure time.

INTRODUCTION

It is well known that FPGAs have attracted attention of a great number of researchers in the recent years, for industrial as well as for a variety of other applications. [1-15] FPGAs have the main advantage of combining software and hardware, thus enabling hardware programming for a series of applications. The most used languages for FPGAs' programming are VHDL and Verilog and VHDL is the one used in our work.

Although a lot of work has been done concerning implementation of FPGAs in a variety of applications as mentioned above, we found only a few works[16,17,19] dealing with UV issues in conjunction with electronic systems and only one work[18] using FPGAs and is related to design of ultraviolet photon detector acquisition system based on FPGA.

There are no works concerning UV measuring systems by using FPGAs. An FPGA-based UV (Ultraviolet) tester uses the high-speed processing and precise timing capabilities of FPGAs to measure, analyze, and log UV radiation or test UV materials. It is highly useful in scientific, industrial, and consumer applications where real-time analysis and high-throughput signal digitization are required.

We present here a system which monitors incident UV radiation and calculates corresponding UV index. Both results are shown in FPGA's seven-segment displays. A set of external different color LEDs is used for indicating UV index value range in conjunction with board LEDs. An additional alarm unit is used in our system incorporating a buzzer and red LED and both of them are ON in case that critical time UV exposure values are exceeded. This informs system user that he must take cover in order to avoid skin burning.

The use of FPGA board in our system provides us all the advantages of these boards, such as real-time signal processing and control, deterministic latency and high-speed parallelism.

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Real time is crucial for dynamic flow profiling and high-frequency analysis, while deterministic latency ensures that measurements are precisely time-stamped and synchronized. The third advantage of parallelism allows simultaneous signal generation, data acquisition, and mathematical modeling without relying on sequential CPU cycles.
Consequently our system can also provide information to a central AI based system or send useful data via 5G system to a health or news center, in order to inform people about UV danger level.

Design overview and operation of the system

Figure1 presents device overview and operational units of our system, using FPGA DE10-Lite board, while Figure 2 presents circuit diagram of the system. Subsequent Figure 3a, b presents the implemented UV measuring and alarm system of this work.

It is obvious from the above figures that our system, except from DE10-Lite FPGA board, contains also some basic circuit parts. It uses GUVA-S12SD sensor unit of 3W light power, providing 240-370nm wavelength sensitivity and acting as main system input. In this work we used this sensor with SV108 UV LED source producing 365nm wavelength UV radiation, which is very close to maximum sensitivity of GUVA-S12SD sensor. Another important unit is UV index range LEDs circuit, responsible for presenting UV index values range using five different color LEDs. Green LED lights up for UV index values of 0-2.49, blue LED for 2.5-5.49 values, white LED for 5.5-7.49 values, yellow LED for 7.5-10.49 values and finally red LED for UV index values over or equal to 10.5.
Needless to mention that all LEDs used in our system are protected with a 330 Ohm series resistance and they are connected to I/O pins of the FPGA board acting as outputs for our system. FPGA's board LEDs and SW0 switch are also used in our system.
Finally our UV measuring and alarm system incorporates an active buzzer and another red LED, both of them being the main alarm unit.
Time is the other input value used here and it is provided by FPGA's clock.

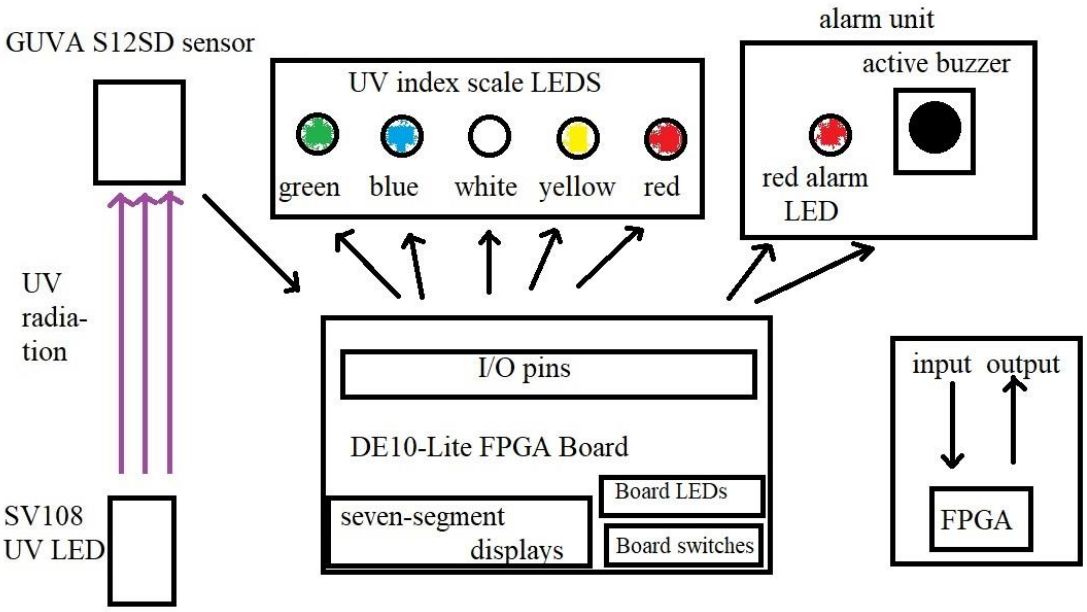

Figure 1: Device overview and operational units of our system.

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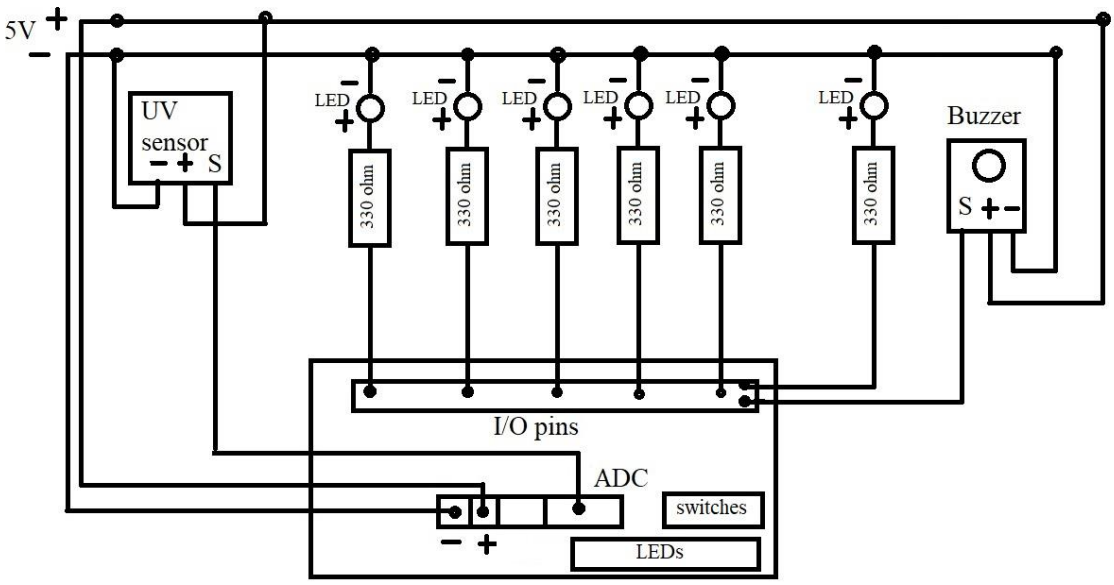
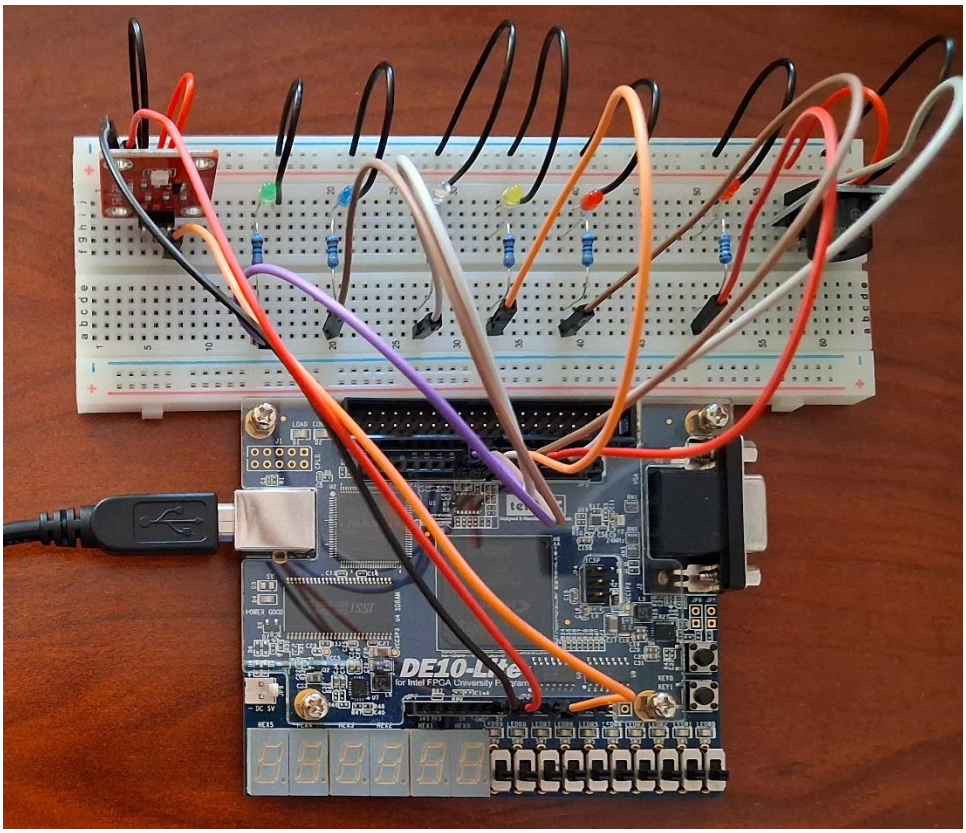


Figure 2: Circuit diagram of our system



a)

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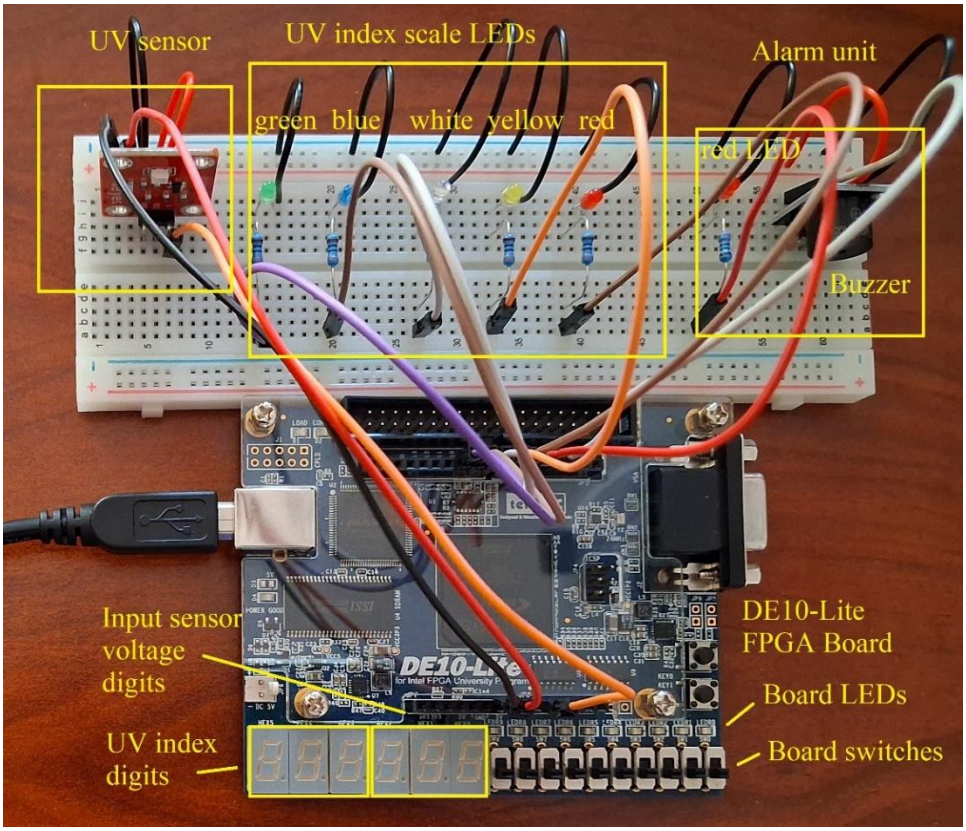

b)

Figure 3a, b: The implemented UV measuring and alarm system of this work a) without notifications and b) with explaining notifications.

Our UV measuring and alarm system starts operating as soon as power supply +5V is applied to the circuits via DE10-Lite appropriate pins and the VHDL program is sent via USB Blaster interface, to FPGA chip. Input values from GUVA-S12SD sensor unit enter our system. FPGA's A/D converter makes the conversion and input voltage values are presented in seven-segment displays of the FPGA board. Corresponding UV index value is also calculated and presented in seven-segment displays of the board. First three left digits of seven-segment displays, present the value of UV index, while next three right digits show input voltage values, both of them corresponding to specific GUVA-S12SD sensor inputs. As mentioned above, UV index range values activate corresponding external LEDs, green, blue, white, yellow or red, providing visual information about the level of the ultraviolet index. In addition 10 board LEDs are used, with left half of them lighting up for UV index values lower than 5.5 and right half being ON, in case that UV index exceeds value of 5.5.

Finally, certain conditions must be met for the alarm unit of our system, to be activated.

SW0 board switch must turn to ON state and simultaneously sensor input values must be non-zero. These conditions activate time measuring process by using FPGA's clock and allow us to measure time interval between starting radiation of UV sensor with specific UV index and reaching the critical time value which is not allowed to exceeded, in order to avoid skin burning or other human tissues damages. If the above time value is exceeded for a specific UV index zone, buzzer starts sounding and simultaneously alarm unit red LED lights up. Needless to mention that if the alarm system is activated human must take cover from incident UV radiation, because he is in danger.

Figure 4 presents the UV measuring and alarm system in operation mode. There is no UV radiation detected by sensor, thus UV index and Vinput values are equal to zero and green LED is ON because the first UV index range is 0 – 2.49, corresponding to green external LED lighting, as mentioned above.

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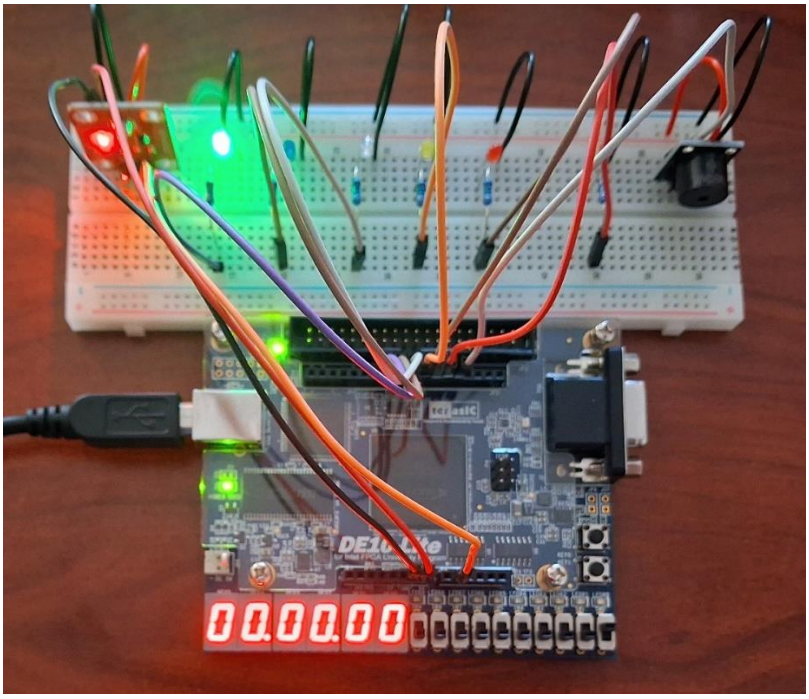

Figure 4: The UV measuring and alarm system in operation mode. No UV radiation is detected by sensor, thus UV index and Vinput values are equal to zero and green LED is ON.

Figure 5 presents the UV measuring and alarm system in operation mode. The distance between UV light source and UV sensor is 35cm. UV radiation is detected by sensor, thus calculated UV index and Vinput values of 2.3 and 0.23V, respectively, are shown in seven-segment displays. Both green external LED and left half of board's LEDs are ON. Also both right red external LED and buzzer are ON, indicating that critical set time value of skin exposure for this UV index range, has been exceeded.

We must mention here that all critical safe skin exposure time values for UV radiation, are normally ranging in minutes or hour range. Here we set arbitrary those time limits to sec (seconds) time range, in order to obtain faster observation of system's operation. Concerning the first UV range (0 – 2.49), corresponding to green external LED lighting, we set the critical time to 30sec.

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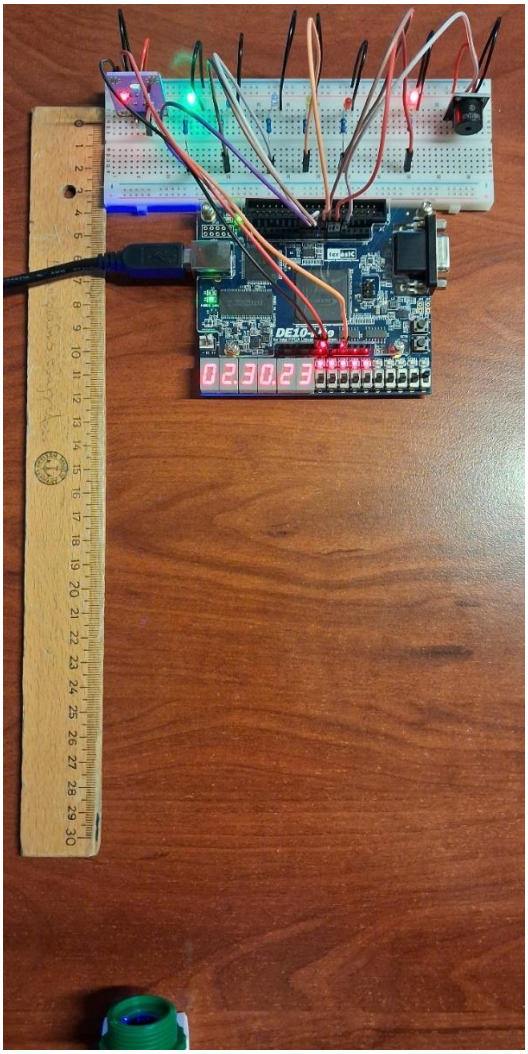

Figure 5: The UV measuring and alarm system in operation mode. UV radiation is detected by sensor, thus UV index and Vinput values of 2.3 and 0.23V, respectively, are shown and both green external LED and left half of board's LEDs are ON. Both right red external LED and buzzer are ON, indicating that critical set time value of skin exposure for this UV index range, has been exceeded.

In Figure 6a, b we present the UV measuring and alarm system in operation mode. UV radiation is detected by sensor, thus UV index and Vinput values of a) 3.4 and 0.34V, respectively and b) 5.0 and 0.50V, respectively, are shown and both blue external LED and left half of board's LEDs are ON. Both right red external LED and buzzer are also ON, indicating that arbitrary critical set time value of 25sec for safe skin exposure of this UV index range, has been exceeded. In 6a) the distance between UV light source and UV sensor was 30cm, while at 6b) it was 23.8cm.

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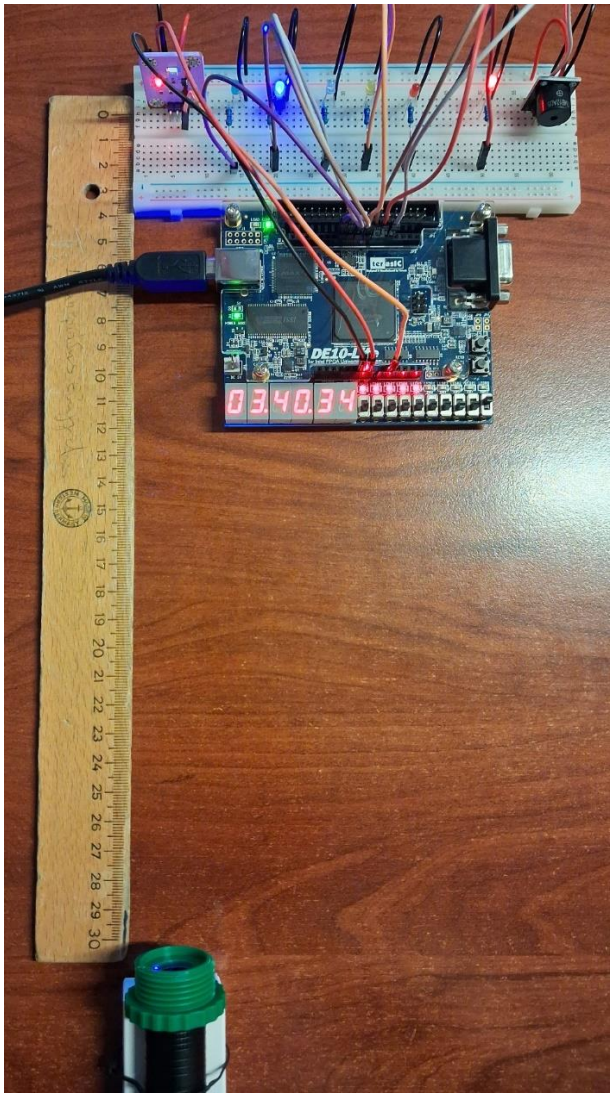

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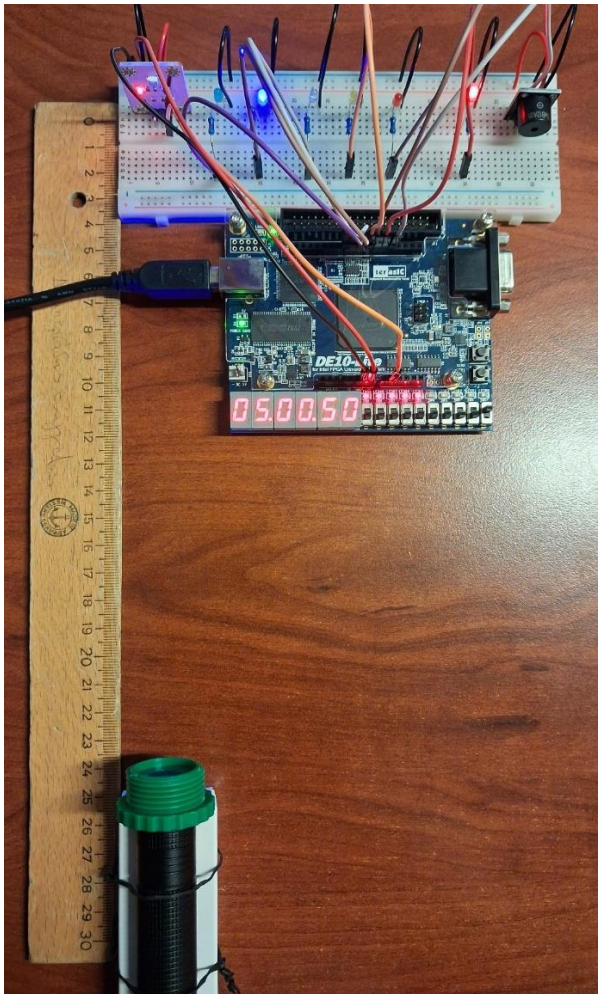

b)

Figure 6a, b: The UV measuring and alarm system in operation mode. UV radiation is detected by sensor, thus UV index and Vinput values a) of 3.4 and 0.34V, respectively and b) 5.0 and 0.50V, are shown and both blue external LED and left half of board's LEDs are ON. Both right red external LED and buzzer are ON, indicating that critical set time value of skin exposure for this UV index range, has been exceeded.

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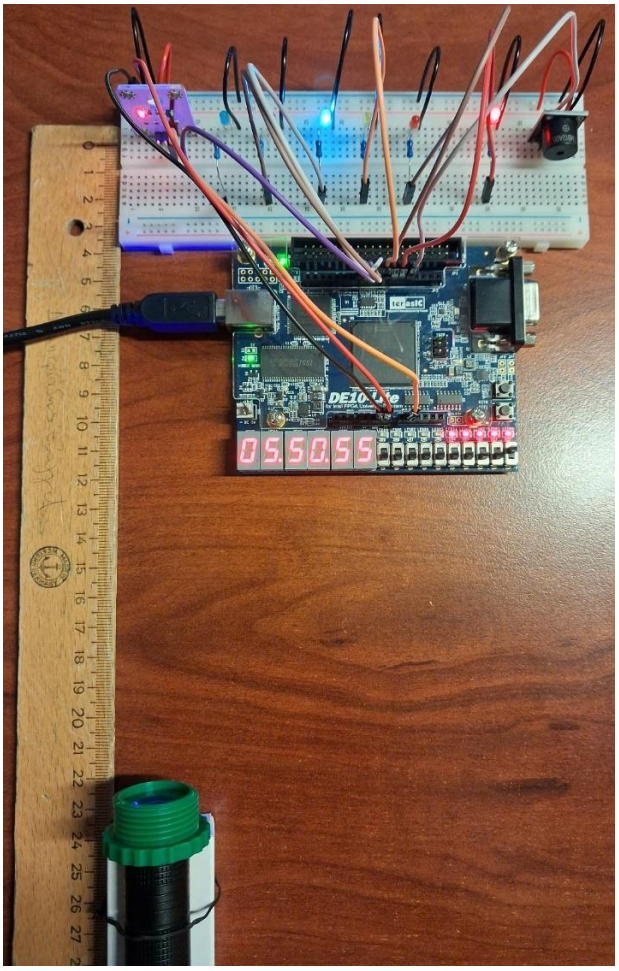

Figure 7: The UV measuring and alarm system in operation mode. UV radiation is detected by sensor, thus UV index and Vinput values of 5.5 and 0.55V, respectively, are shown and both white external LED and right half of board's LEDs are ON. Both right red external LED and buzzer are ON, indicating that critical set time value of skin exposure for this UV index range, has been exceeded.

Figure 7 shows our UV measuring and alarm system in operation mode. UV radiation is detected by sensor, thus UV index and Vinput values of 5.5 and 0.55V, respectively, are shown and both white external LED and right half of board's LEDs are ON. Both right red external LED and buzzer are also ON, indicating that critical set time value of 20sec for skin exposure for this UV index range, has been exceeded. The distance between UV sensor and UV light source is now 22.5cm.

Similarly to previous figures, in Figure 8 the UV measuring and alarm system is also in operation mode. UV radiation is again detected by sensor, thus UV index and Vinput values of 8.0 and 0.80V, respectively, are shown and both yellow external LED and right half of board's LEDs are ON. Both right red external LED and buzzer are ON, indicating that critical set time value of 15sec skin exposure for this UV index range, has been exceeded. The distance between UV sensor and UV light source is now 18cm.

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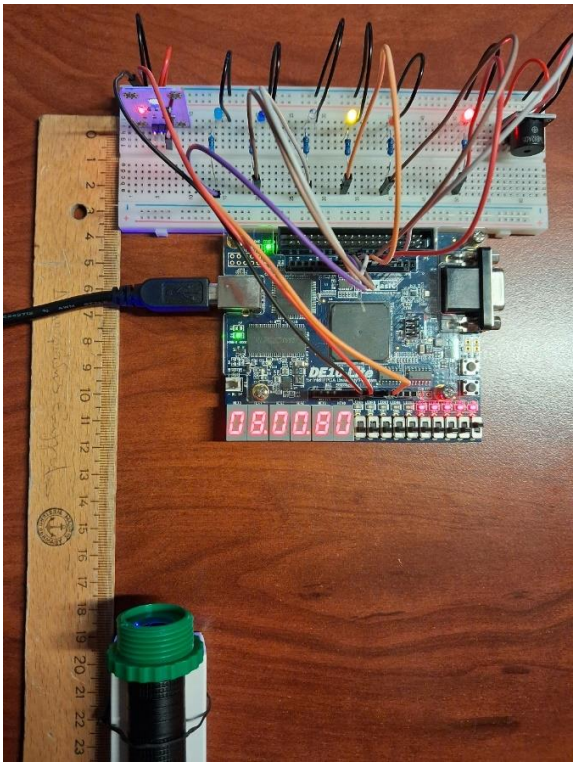

Figure 8: The UV measuring and alarm system in operation mode. UV radiation is detected by sensor, thus UV index and Vinput values of 8.0 and 0.80V, respectively, are shown and both yellow external LED and right half of board's LEDs are ON. Both right red external LED and buzzer are ON, indicating that critical set time value of skin exposure for this UV index range, has been exceeded.

Finally in Figure 9a, b and c, the UV measuring and alarm system is also in operation mode. UV radiation is detected by sensor, thus UV index and Vinput values of a) 10.5 and 1.05V, b) 15.3 and 1.53V and c) 19.7 and 1.97V, respectively, are shown and both red external LED and right half of board's LEDs are ON. Both right red external LED and buzzer are ON, indicating that critical set skin exposure time value of 10sec for this UV index range, has been exceeded. Corresponding distance between UV light source and UV sensor are a) 15cm, b) 11.5cm and c) 9.5cm.

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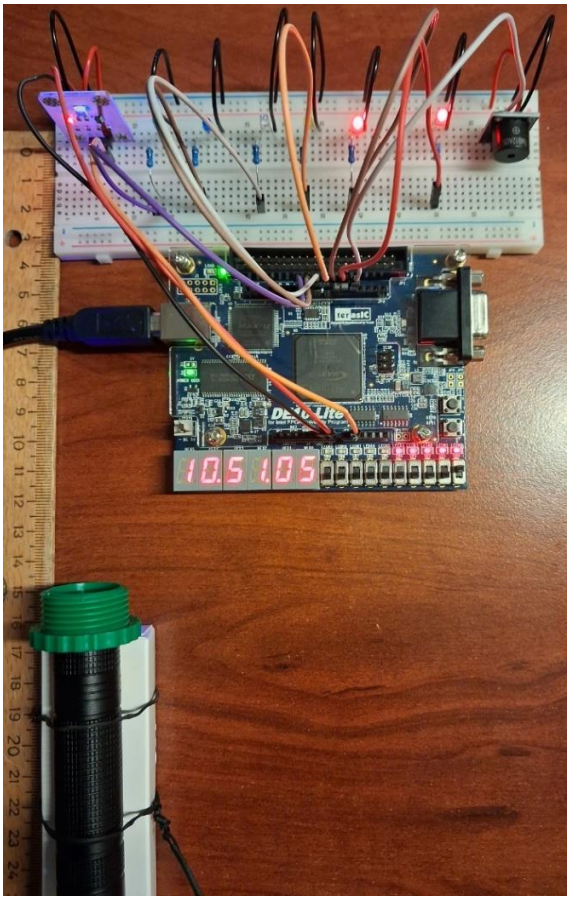

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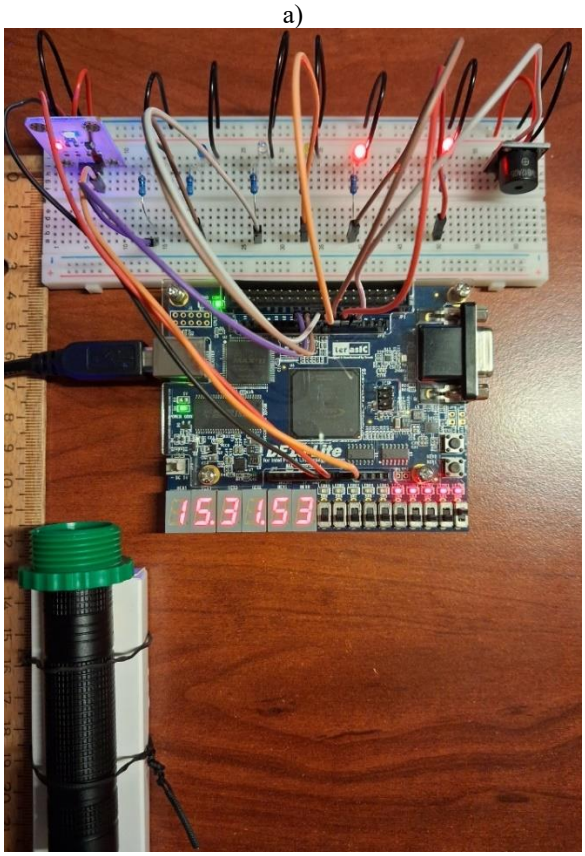

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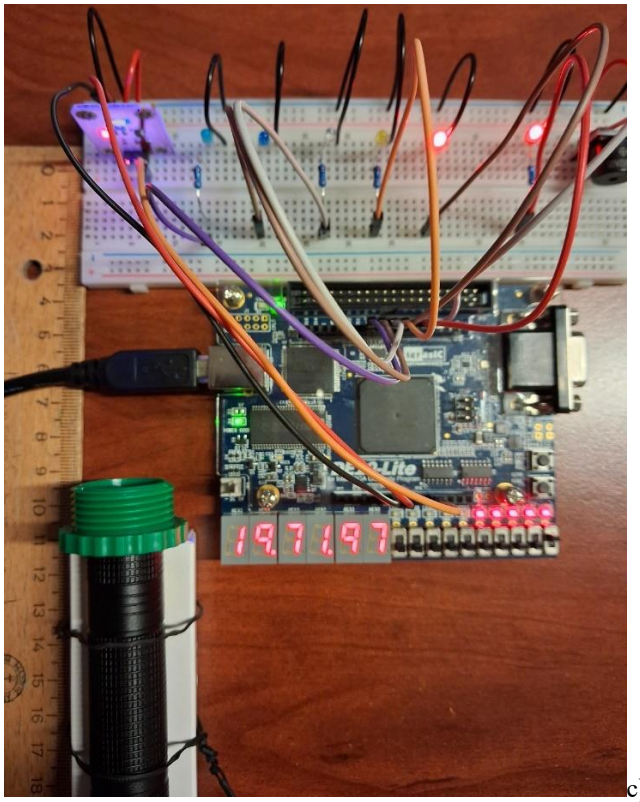

c)

Figure 9a, b and c: The UV measuring and alarm system in operation mode. UV radiation is detected by sensor, thus UV index and Vinput values of a) 10.5 and 1.05V, respectively, b) 15.3 and 1.53V and c) 19.7 and 1.97V, are shown and both red external LED and right half of board's LEDs are ON. Both right red external LED and buzzer are ON, indicating that critical set time value of skin exposure for this UV index range, has been exceeded.

We must mention that another important fact of our system's design is that it receives input sensor values periodically, ensuring continuous monitoring.

All the above experimental measurements mentioned in the previous figures are summarized and totally presented below in Figure 10. In 10a) UV index versus UV led light source distance from UV sensor is presented, while in 10b) UV sensor Vinput versus UV led light source distance from UV sensor is shown. Both figures exhibit a clear, significant and important dependence of both UV sensor Vinput and UV index values, on distance between UV light source and UV sensor.

Datasheet concerning GUVA-S12SD sensor mention a relation between analog voltage values sent from sensor to FPGA or Arduino and their corresponding UV index values. The relation is 0.1V of UV sensor input value, corresponds to UV index value 1. This relation was taken into account in our work.

Another interesting experimental observation is that we reached UV index value of 19.7 with corresponding input sensor voltage value Vinput= 1.97V. This was obtained for a source-sensor distance of 9.5cm. It is obvious that our system could work for UV index values reaching 50 and Vinput nearly 5V, since the FPGA supply voltage is 5V.

This fact shows that our system can also be used in very high UV index environments, such as industrial or others.

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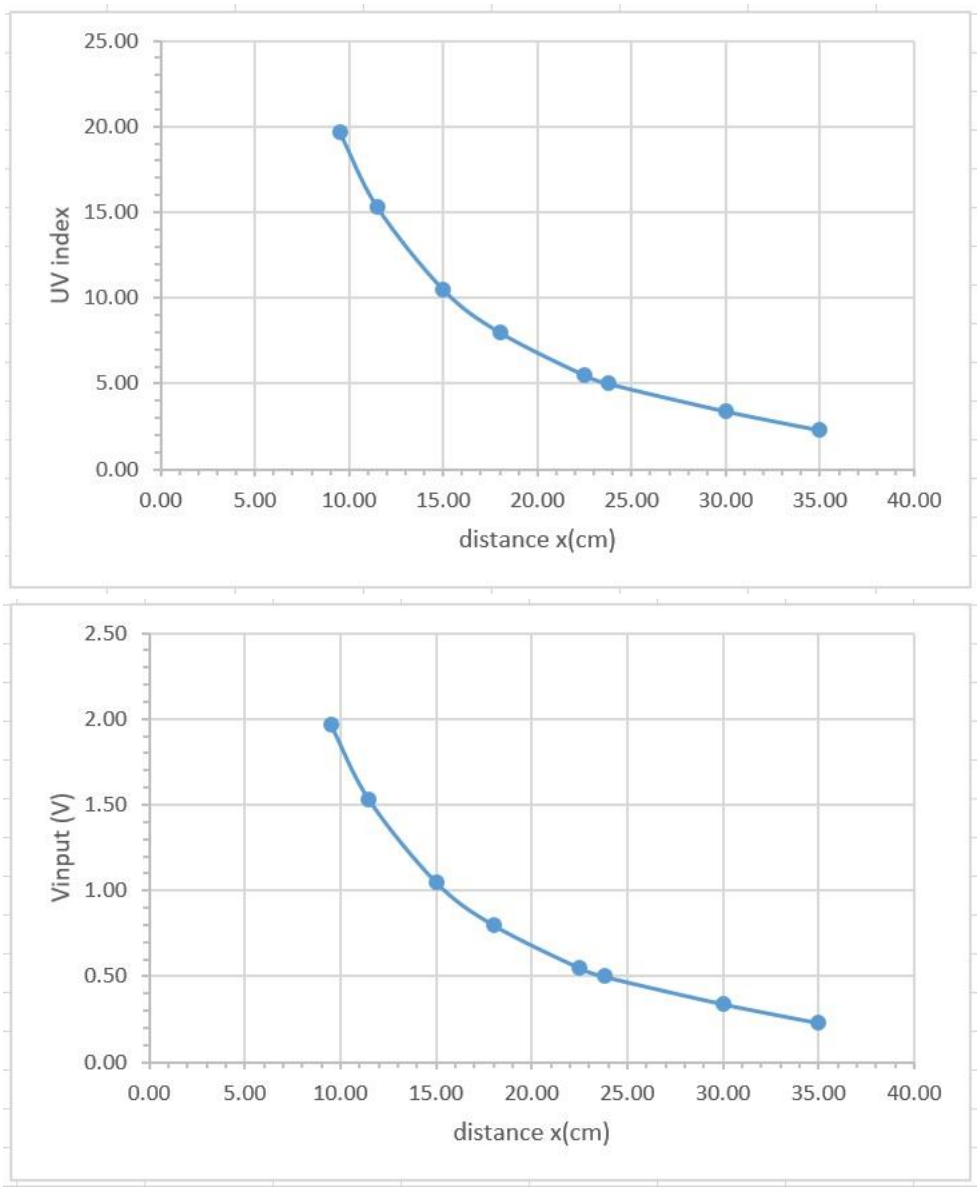

Figure10a and b: a) UV index versus UV led light source distance from UV sensor and b) UV sensor Vinput versus UV led light source distance from UV sensor.

Programing the system

We used Quartus Prime Lite Edition 21.1.1 to create the VHDL programs of our system. It must be mentioned here that before proceeding with the VHDL programming of our system, we had to set a series of parameters controlling the operation of DE10-Lite FPGA's Analog to Digital Converter (ADC). This converter plays a very important role in the whole system operation, since it converts analogue to digital values. The files created by the above ADC parameters setting are imported into the final project of our system.

A flowchart diagram, presenting main functions of our system is presented in Figure 11, while the APPENDIX contains the whole VHDL program.

It is clear that the system operates five basic functions. All of them use processes in VHDL programming language. These processes are running as long as the system is ON. All external and FPGA's LEDs as well as buzzer, are programmed to work as logic outputs, thus they are at the ON state if they receive binary '1' as logic output. UV sensor is programmed to work as analog input of the system, connected to FPGA's A/D converter. SW0 switch acts as logic input.

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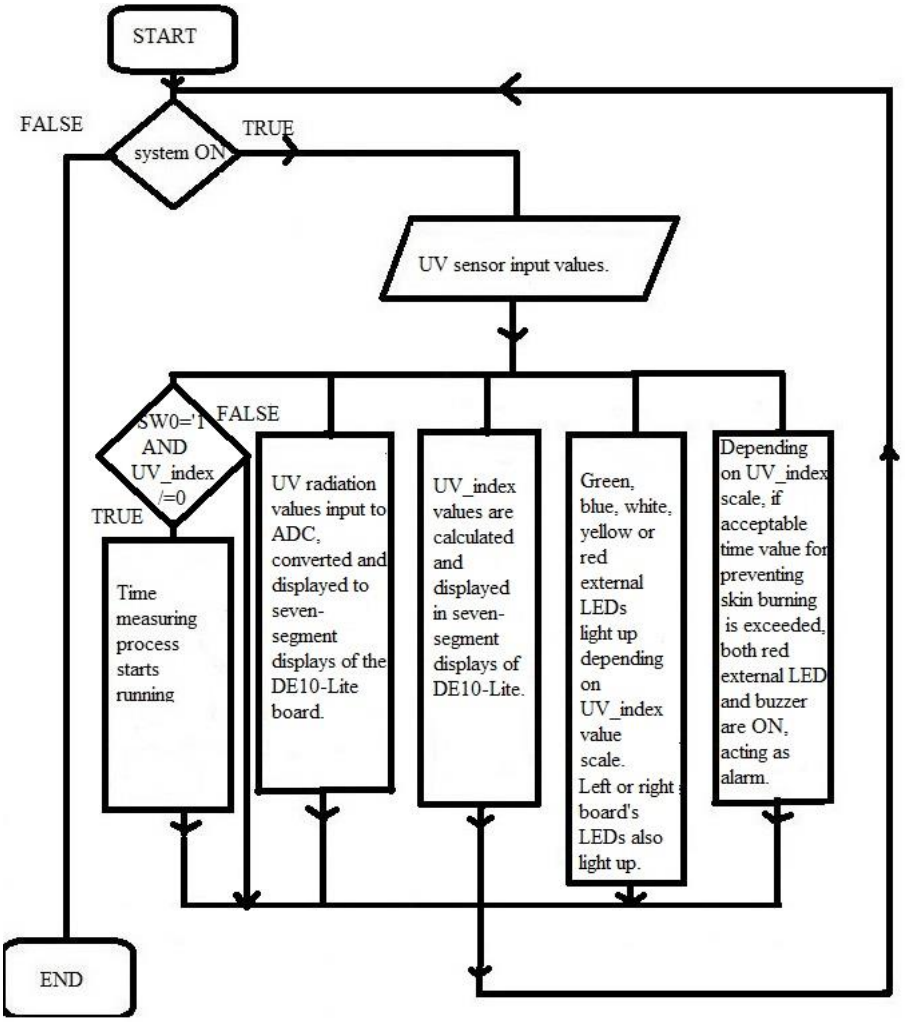

Figure11: Flowchart diagram, presenting main functions-processes of our system.

First function of Figure 11 is practically activated after next three functions shown in this figure and plays definitive role in system operation and alarm behavior. It is the process based on FPGA board's clock for time measuring in seconds and is activated if both SW0 is at logic '1' and UV sensor receives a non-zero incident radiation density. It is a very important process because time parameter is needed in our system for controlling and activating the alarm unit operation as mentioned above. Time values act as input to our system.

Second function of Figure 11 is related to UV sensor input values and is the main function of our system. Analog voltage values from UV sensor are sent to FPGA's ADC and after conversion are displayed in three board's seven-segment displays on the right, using specific program.

Third function of Figure 11 is related to UV index values and also plays very important role in system's operation. We use process that based on UV sensor voltage input values, calculates corresponding UV index values. A supplementary procedure is responsible for converting and presenting these values in FPGA's three seven-segment displays on the left of the board.

Fourth function of Figure 11 is tasked with activating green, blue, white, yellow or red indicating external LEDs, as well as FPGA's embedded LEDs, depending on specific UV index value. Green and blue LEDs correspond to lower UV index values, while white, yellow and especially red LEDs indicate high UV index values, thus providing user with UV index range information. Embedded board's LEDs are programmed to be activated for additional UV index indication, with left half of them being at the ON state if UV index<5.5 and right half activated if UV index>=5.5.

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Finally fifth function of Figure 11 is practically the most useful one for human health or radiated material protection. It is the main alarm unit of our system which depending on the calculated UV index values, activates buzzer in conjunction with the right red external LED, informing user that he must take cover from UV radiation since safe skin exposure time limit has been exceeded and human harmful consequences are following. Time limits corresponding to UV index values are arbitrary set to sec (seconds) range, in order to view system's operation results in short time intervals. Those time limits can be set by programmer to a variety of values which in conjunction with very high values of UV index of nearly 50, that our system can handle, makes it suitable for a variety of health, industrial or environmental applications.

CONCLUSIONS

An FPGA-based, ultraviolet (UV) measuring and alarm system is presented in this work. Our system is able to monitor incident UV radiation using an analog UV sensor.

It also presents simultaneously, in seven-segment displays of DE10-Lite FPGA board, the values of UV sensor input voltage and corresponding calculated UV index. Our system is equipped with a series of external LEDs which light up depending on UV index range, thus providing a useful indication about UV index scaling. Simultaneously 10 embedded board's LEDs light up with half left of them in case that UV index<5.5 and half right if UV index>=5.5. Our system also incorporates an alarm unit consisted of a buzzer and a red external LED. They are both activated if acceptable and non-harmful exposure time intervals at UV radiation, are exceeded for corresponding specific UV index value shown in board's seven-segment displays. The above time intervals are set by programmer and in conjunction with the advantage of our system being able to work with a great range of UV indexes (0-50), gives our system the capability of been applicable in health, industrial, environmental or other projects which use UV radiation.

The system is easy to be manufactured, providing also the benefit of low cost. Additionally, all values of UV index, UV input voltage and safe exposure time intervals, could be sent to an AI system to achieve simultaneous monitor of a large number of systems under UV radiation, especially in the case of an industrial environment.

REFERENCES

[1]. M. Yussup, M.M. Ibrahim, L. Lombigit, N.A.A. Rahman and M.R.M. Zin, "Implementation of data acquisition interface using on-board field-programmable gate array (FPGA) universal serial bus (USB) link", Advanc. in Nuclear Research and Energy Development, AIP Conf. Proc. 1584, 69-72 (2014), doi: 10.1063/1.4866106

[2]. A. Gujar, International Journal of Computer Science and Information Technologies, "Image Encryption using AES Algorithm based on FPGA", vol 5, (5), 2014, 6853-6859

[3]. S. Singh, A.K. Saini, R. Saini, I.J. Image, Graphics and Signal Processing, "Interfacing the Analog Camera with FPGA Board for Real-time Video Acquisition" 2014, 4, 32-38, DOI: 10.5815/ijigsp.2014.04.04

[4]. S. Muthukrishnan and R. Priyadharsini, International Journal of Computer Science and Mobile Computing, "32-Bit RISC and DSP System Design in an FPGA" vol 3, issue 12, Dec. 2014, pg. 361-368

[5]. L. Chen, Y. Chang, L. Yan, IEEE Transactions on Geoscience and Remote Sensing, "On-orbit real-time variational image destriping: FPGA architecture and implementation", 10.1109/tgrs.2022.3140428, 2022, pp. 1-1

[6]. S. Yarlagadda, S. Kaza, A. Tummala, E. Babu, R. Prabhakar, Information Technology in Industry, "The reduction of Crosstalk in VLSI due to parallel bus structure using Data Compression Bus Encoding technique implemented on Artix 7 FPGA Architecture", 10.17762/itii.v9i1.151, 2021, Vol 9 (1), pp. 456-460

[7]. C. Du, Y. Yamaguchi, Electronics, "High-Level Synthesis Design for Stencil Computations on FPGA with High Bandwidth Memory", 2020, 9(8), 1275; https://doi.org/10.3390/electronics9081275

[8]. X. Hao, C. Lin and Q. Wu, Electronics, "A Parallel Timing Synchronization Structure in Real-Time High Transmission Capacity Wireless Communication Systems", 2020, 9(4), 652; https://doi.org/10.3390/electronics9040652

[9]. P. A. Bawiskar, R.K. Agrawal, International Journal of Innovative Research in Science, Engineering and Technology, "FPGA Based Home Security System" vol.4, issue 12, Dec. 2015, p. 12865-12869, DOI: 10.15680/IJIRSET.2015.0412139

[10]. K. Saroch, A. Sharma, IOSR Journal of Electronics and Communication Engineering, "FPGA Based System Login Security Lock Design Using FiniteState Machine" vol 5, issue 3, Mar.-Apr. 2013, pp 70-75

[11]. R.S. Parikh, Int. Journal of Engineering Research and Application, "Alarm System Implementation on Field Programmable Gate Array" vol 8, issue 1, Jan. 2018, pp 01-04.

[12]. E. I. Dimitriadis and L. Dimitriadis, "A Simple, Low Cost and Multiple Input Alarm System, Functioning as Finite State Machine (FSM), Using VHDL and FPGAs", Journal of Active and Passive Electronic Devices, vol. 17, pp. 307–315, 2024.

[13]. E. I. Dimitriadis and L. Dimitriadis, "A g-sensor based alarm system, for multiple tilt sensor applications, using VHDL and FPGAs", Journal of Active and Passive Electronic Devices, vol. 18, pp. 119-129, 2024.

DOI: 10.17148/IJIREEICE.2026.14815

[14]. Evangelos I. Dimitriadis, Leonidas Dimitriadis and Aristeidis Grigoriadis, "A touch-sensing system for precise robotic arm control, using force-sensing resistors (FSR), VHDL and FPGAs", International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, vol. 13, issue 7, pp. 36-50, July 2025.

[15]. Leonidas Dimitriadis and Evangelos I. Dimitriadis, "A Novel System for Monitoring and Controlling Industrial Engine Operation, using Vibration, Magnetic Field, Humidity and Temperature Sensors, Implemented with FPGAs and VHDL", International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, vol. 14, issue 5, pp. 1-18, May 2026.

[16]. J. F. Sánchez-Pérez, D. Vicente-Agullo, M. Barberá, E. Castro-Rodríguez & M. Cánovas, "Relationship between ultraviolet index (UVI) and first-, second- and third-degree sunburn using the Probit methodology", Scientific Reports, (2019), DOI:10.1038/s41598-018-36850

[17]. Ibraam E. Mikhail, Mohamed Hemida, Leo Lebanov, Snezhana Astrakhantseva,Vipul Gupta, Philip Hortin, John S. Parry, Mirek Macka, Brett Paull, "Multi-wavelength deep-ultraviolet absorbance detector based upon program-controlled pulsing light-emitting diodes", Journal of Chromatography A 1709 (2023) 464382, https://doi.org/10.1016/j.chroma.2023.464382

[18]. Yipeng Zheng, Zheng Fu, Xianghui Yang, Yalong Zhang, Yongan Liu, Lizhi Sheng, Zhe Liu, "Design of ultraviolet photon detector acquisition system based on FPGA", Conference Proceedings Volume 13499, 13 Dec 2024, https://doi.org/10.1117/12.3048212

[19]. C.F. Puma, J.L. Yucra1, Y.G. Calla, J.L. Solis, M. Postigo, W.D. Leon-Salas and M.A. Vizcardo, "Development of a UV meter using the sensor AS7331 and a Raspberry Pi 4B", Journal of Physics: Conference Series 3088 (2025) 012006, IOP Publishing, doi:10.1088/1742-6596/3088/1/012006

APPENDIX

```
library ieee;
use ieee.std_logic_1164.all;
use ieee.numeric_std.all;
use ieee.std_logic_signed.ALL;    -- step = step + 1
use ieee.std_logic_unsigned.ALL;
entity DE10_Lite_UV_measure is
generic(ClockFrequencyHz : integer:=50000000);
port
(
rst : in std_logic; --SW8
nRst    : in std_logic; -- Negative reset
Seconds : inout integer;
Ticks : inout integer;
led1: out std_logic;--1-5(0-4) LEDs light up when UV_index >=5.5
led2: out std_logic;
led3: out std_logic;
led4: out std_logic;
led5: out std_logic;
led6: out std_logic;--6-10(5-9) LEDs light up when UV_index <5.5
led7: out std_logic;
```

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```
led8: out std_logic;
led9: out std_logic;
led10: out std_logic;
led_green: buffer std_logic;--UV_index 0-2.49
led_blue: buffer std_logic; --UV_index 2.5-5.49
led_white: buffer std_logic;--UV_index 5.5-7.49
led_yellow: buffer std_logic;--UV_index 7.5-10.49
led_red: buffer std_logic;--UV_index >=10.5
led_red_alarm: buffer std_logic;
led_blue_out: out std_logic;--UV_index 0-2.49
led_green_out: out std_logic;--UV_index 2.5-5.49
led_white_out: out std_logic;--UV_index 5.5-7.49
led_yellow_out: out std_logic;--UV_index 7.5-10.49
led_red_out: out std_logic;--UV_index >=10.5
led_red_alarm_out: out std_logic;
buzzer: out std_logic;
 Vr: buffer integer;
UV_index: buffer integer;
d2bbuf :buffer integer range 0 to 9;
d1bbuf :buffer integer range 0 to 9;
d0bbuf :buffer integer range 0 to 9;

d2cbuf :buffer integer range 0 to 9;
d1cbuf :buffer integer range 0 to 9;
d0cbuf :buffer integer range 0 to 9;
SW0 : in std_logic;
-- Clocks
ADC_CLK_10: in std_logic;
MAX10_CLK1_50: in std_logic;
MAX10_CLK2_50: in std_logic;
-- KEYs
KEY: in std_logic_vector(1 downto 0);
-- HEX
HEX0: out std_logic_vector(7 downto 0);
HEX1: out std_logic_vector(7 downto 0);
```

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```
HEX2: out std_logic_vector(7 downto 0);
HEX3: out std_logic_vector(7 downto 0);
HEX4: out std_logic_vector(7 downto 0);
HEX5: out std_logic_vector(7 downto 0);
ARDUINO_IO: inout std_logic_vector(15 downto 0);
ARDUINO_RESET_N: inout std_logic);
end entity;
architecture DE10_Lite_UV_measure_Arch of DE10_Lite_UV_measure is
-- Analog to Digital Converter IP core
component myADC is
port
(
clk_clk: in std_logic := 'X';
modular_adc_0_command_valid: in std_logic := 'X';
modular_adc_0_command_channel: in std_logic_vector(4 downto 0) := (others => 'X');
modular_adc_0_command_startofpacket: in std_logic := 'X';
modular_adc_0_command_endofpacket: in std_logic := 'X';
modular_adc_0_command_ready: out std_logic;
modular_adc_0_response_valid: out std_logic;
modular_adc_0_response_channel: out std_logic_vector(4 downto 0);
modular_adc_0_response_data: out std_logic_vector(11 downto 0);
modular_adc_0_response_startofpacket: out std_logic;
modular_adc_0_response_endofpacket: out std_logic;
reset_reset_n: in std_logic
);
end component myADC;
signal modular_adc_0_command_valid: std_logic;
signal modular_adc_0_command_channel: std_logic_vector(4 downto 0);
signal modular_adc_0_command_startofpacket: std_logic;
signal modular_adc_0_command_endofpacket: std_logic;
signal modular_adc_0_command_ready: std_logic;
signal modular_adc_0_response_valid: std_logic;
signal modular_adc_0_response_channel: std_logic_vector(4 downto 0);
signal modular_adc_0_response_data: std_logic_vector(11 downto 0);
signal modular_adc_0_response_startofpacket: std_logic;
```

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```
signal modular_adc_0_response_endofpacket: std_logic;
signal clk_clk: std_logic;
signal reset_reset_n: std_logic;
type state_machines is (sm0,sm1, sm2, sm3, sm4);
signal sm: state_machines;
-- signals to store conversion results
signal ADCIN1,ADCIN4, ADCIN3,ADCIN2: std_logic_vector(11 downto 0);
signal AD1,AD4, AD3,AD2: std_logic_vector(11 downto 0);
-- signal for BCD digits
signal digit2b, digit1b, digit0b: std_logic_vector(3 downto 0);
signal digit2, digit1, digit0: std_logic_vector(3 downto 0);
signal digit2c, digit1c, digit0c: std_logic_vector(3 downto 0);
signal digit5, digit4, digit3: std_logic_vector(3 downto 0);
-- signal to determine how fast the
-- 7-seg displays will be updated
signal cnt: integer;
signal state_LED_right: std_logic;
signal state_LED_left: std_logic;
signal state_Vr: integer;
signal state_UV_index: integer;
begin
-- ADC port map
adc1: myADC port map
(
modular_adc_0_command_valid => modular_adc_0_command_valid,
modular_adc_0_command_channel => modular_adc_0_command_channel,
modular_adc_0_command_startofpacket => modular_adc_0_command_startofpacket,
modular_adc_0_command_endofpacket => modular_adc_0_command_endofpacket,
modular_adc_0_command_ready => modular_adc_0_command_ready,
modular_adc_0_response_valid => modular_adc_0_response_valid,
modular_adc_0_response_channel => modular_adc_0_response_channel,
modular_adc_0_response_data => modular_adc_0_response_data,
modular_adc_0_response_startofpacket => modular_adc_0_response_startofpacket,
modular_adc_0_response_endofpacket => modular_adc_0_response_endofpacket,
clk_clk => clk_clk,
```

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```
reset_reset_n => reset_reset_n
);
clk_clk <= MAX10_CLK1_50;
reset_reset_n <= KEY(0);
-- process for reading new samples
p1: process(reset_reset_n, clk_clk)
begin
if reset_reset_n = '0' then
        sm <= sm0;
elsif rising_edge(clk_clk) then
        case sm is
                when sm0 =>
                        sm <= sm1;
                        modular_adc_0_command_valid <= '1';
                        modular_adc_0_command_channel <= "00001";
                when sm1 =>
                        if modular_adc_0_response_valid = '1' then
                                modular_adc_0_command_channel <= "00010";
                         ADCIN4 <= modular_adc_0_response_data;
                                sm <= sm2;
                        end if;
                when sm2 =>
                        if modular_adc_0_response_valid = '1' then
                                modular_adc_0_command_channel <= "00001";
                                modular_adc_0_command_channel <= "00011";
                                ADCIN1 <= modular_adc_0_response_data;
                                sm <= sm1;
                                sm <= sm3;
                        end if;
                when sm3 =>
                        if modular_adc_0_response_valid = '1' then
                                modular_adc_0_command_channel <= "00100";
                                ADCIN2 <= modular_adc_0_response_data;
                                sm <= sm4;
                        end if;
```

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```
                when sm4 =>
                        if modular_adc_0_response_valid = '1' then
                                modular_adc_0_command_channel <= "00001";
                                ADCIN3 <= modular_adc_0_response_data;
                                sm <= sm1;
                        end if;
                when others =>
        end case;
end if;
end process;
-- process for conversion from binary to BCD (analog input voltage)
p3: process(AD2,d2bbuf,d1bbuf,d0bbuf)
variable vin: integer;
variable d2, d1, d0: integer;
begin
vin := to_integer(unsigned(std_logic_vector(to_unsigned(to_integer(unsigned(AD2)) * 500,
32))(31 downto 12)));
d2 := vin / 100;
d1 := vin mod 100 / 10;
d0 := ((vin mod 100) mod 10);
digit2b <= std_logic_vector(to_unsigned(d2, 4));
digit1b <= std_logic_vector(to_unsigned(d1, 4));
digit0b <= std_logic_vector(to_unsigned(d0, 4));
d2bbuf<= d2;
d1bbuf<= d1;
d0bbuf<= d0;
end process;
state_Vr<= (d2bbuf*100)+(d1bbuf*10)+(d0bbuf);
Vr<= state_Vr; -- Vr 100 corresponds to 1V
-- process for measuring and converting UV_index
p4: process(Vr,seconds,d2cbuf,d1cbuf,d0cbuf)
variable d2, d1, d0: integer;
variable UVindex: integer;
begin
UVindex:= Vr;
```

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```
IF UVindex /=0 THEN
d2 := (UVindex) / 100;
d1 := (UVindex) mod 100 / 10;
d0 := (((UVindex) mod 100) mod 10);
digit2c <= std_logic_vector(to_unsigned(d2, 4));
digit1c <= std_logic_vector(to_unsigned(d1, 4));
digit0c <= std_logic_vector(to_unsigned(d0, 4));
d2cbuf<= d2;
d1cbuf<= d1;
d0cbuf<= d0;
ELSE
d2 := 0 / 100;
d1 := 0 mod 100 / 10;
d0 := ((0 mod 100) mod 10);
digit2c <= std_logic_vector(to_unsigned(d2, 4));
digit1c <= std_logic_vector(to_unsigned(d1, 4));
digit0c <= std_logic_vector(to_unsigned(d0, 4));
d2cbuf<= d2;
d1cbuf<= d1;
d0cbuf<= d0;
END IF;
end process;
state_UV_index<= (d2cbuf*100)+(d1cbuf*10)+(d0cbuf);
UV_index<= state_UV_index; -- UV_index 10 corresponds to 1 physical UV index
process(MAX10_CLK1_50) is
   begin
         IF (SW0='1' AND UV_index /=0) THEN
         if rising_edge(MAX10_CLK1_50) then --ισοδύναμο του IF CLK'EVENT AND CLK='1'
       ------ If the negative reset signal is active
       if nRst = '0' then
          Ticks   <= 0;
          Seconds <= 0;
       else
          -- True once every second
          if Ticks = ClockFrequencyHz - 1 then
```

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```
            Ticks <= 0;
              Seconds <= Seconds + 1;
          else
            Ticks <= Ticks + 1;
          end if;
        end if;
      end if;
                  ELSE
                  Ticks   <= 0;
      Seconds <= 0;
                  END IF;
  end process;
-- determine how fast the 7-seg displays will be updated
p5: process(reset_reset_n, clk_clk)
begin
if reset_reset_n = '0' then
cnt <= 0;
elsif rising_edge(clk_clk) then
if cnt < 20_000_000 then
cnt <= cnt + 1;
else
cnt <= 0;
AD1 <= ADCIN1;
AD2 <= ADCIN2;
AD3 <= ADCIN3;
AD4 <= ADCIN4;
end if;
end if;
end process;
process (UV_index,MAX10_CLK1_50, state_LED_right,led_blue,led_red,
led_green, led_white, led_yellow, state_LED_left )
begin
--50000000 Ticks= 1sec and UV_index 100 corresponds to 1V input voltage and physical UV index 10
IF UV_index >=105 THEN
led_red<='1';
```

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```
else
led_red<='0';
end if;
IF UV_index <105 AND UV_index >=75 THEN
led_yellow<='1';
else
led_yellow<='0';
end if;
IF UV_index >=55 AND UV_index <75 THEN
led_white<='1';
else
led_white<='0';
end if;
IF UV_index >=25 AND UV_index<55 THEN
led_blue<='1';
else
led_blue<='0';
end if;
IF UV_index >=0 AND UV_index <25 THEN
led_green<='1';
else
led_green<='0';
end if;
IF UV_index >0 AND UV_index <55 THEN
state_LED_left<='1';
ELSE
state_LED_left<='0';
END IF;
IF UV_index >=55 THEN
state_LED_right<='1';
ELSE
state_LED_right<='0';
END IF;
end process;
led_green_out<=led_green;
```

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```
led_blue_out<=led_blue;
led_white_out<=led_white;
led_yellow_out<=led_yellow;
led_red_out<=led_red;
led1<=state_LED_right;
led2<=state_LED_right;
led3<=state_LED_right;
led4<=state_LED_right;
led5<=state_LED_right;
led6<=state_LED_left;
led7<=state_LED_left;
led8<=state_LED_left;
led9<=state_LED_left;
led10<=state_LED_left;
Process (UV_index, seconds, led_red_alarm)
BEGIN
IF (UV_index >=0 AND UV_index <25) AND seconds >30 THEN
led_red_alarm <= '1';
elsif (UV_index >=25 AND UV_index<55) AND seconds >25 THEN
led_red_alarm <= '1';
elsif (UV_index >=55 AND UV_index <75) AND seconds >20 THEN
led_red_alarm <= '1';
elsif (UV_index <105 AND UV_index >=75) AND seconds >15 THEN
led_red_alarm <= '1';
elsif (UV_index >=105) AND seconds >10 THEN
led_red_alarm <= '1';
else
led_red_alarm <= '0';
END IF;
end process;
led_red_alarm_out <=led_red_alarm;
--buzzer sounds
Process(MAX10_CLK1_50, led_red_alarm)
variable i : integer := 0;
BEGIN
```

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```
IF led_red_alarm ='1' THEN -- buzzer sounds
if MAX10_CLK1_50'event and MAX10_CLK1_50 = '1' then
if i <= 50000000 then
i := i + 1;
buzzer <= '1';
elsif i > 50000000 and i < 100000000 then
i := i + 1;
buzzer <= '0';
elsif i = 100000000 then
i := 0;
end if;
end if;
else
buzzer <= '0';
end if;
end process;
process(digit2b,digit1b,digit0b,digit2c,digit1c,digit0c)
begin
  IF SW0='1' THEN
  digit2 <= digit2b;--first digit of input voltage
  digit1 <= digit1b;--second digit of input voltage
  digit0 <= digit0b;--third digit of input voltage
  digit5 <= digit2c;--first digit of UV index
  digit4 <= digit1c;--second digit of UV index
  digit3 <= digit0c;--third digit of UV index
  end if;
end process;
WITH digit2 SELECT
HEX2 <= "01000000" WHEN "0000", -- display 0
"01111001" WHEN "0001", -- display 1
"00100100" WHEN "0010", -- display 2
"00110000" WHEN "0011", -- display 3
"00011001" WHEN "0100", -- display 4
"00010010" WHEN "0101", -- display 5
"00000011" WHEN "0110", -- display 6
```

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"01111000" WHEN "0111", -- display 7

"00000000" WHEN "1000", -- display 8

"00011000" WHEN "1001", -- display 9

"11111111" WHEN OTHERS; -- blank display

WITH digit1 SELECT

HEX1 <= "11000000" WHEN "0000", -- display 0

"11111001" WHEN "0001", -- display 1

"10100100" WHEN "0010", -- display 2

"10110000" WHEN "0011", -- display 3

"10011001" WHEN "0100", -- display 4

"10010010" WHEN "0101", -- display 5

"10000011" WHEN "0110", -- display 6

"11111000" WHEN "0111", -- display 7

"10000000" WHEN "1000", -- display 8

"10011000" WHEN "1001", -- display 9

"11111111" WHEN OTHERS; -- blank display

WITH digit0 SELECT

HEX0 <= "11000000" WHEN "0000", -- display 0

"11111001" WHEN "0001", -- display 1

"10100100" WHEN "0010", -- display 2

"10110000" WHEN "0011", -- display 3

"10011001" WHEN "0100", -- display 4

"10010010" WHEN "0101", -- display 5

"10000011" WHEN "0110", -- display 6

"11111000" WHEN "0111", -- display 7

"10000000" WHEN "1000", -- display 8

"10011000" WHEN "1001", -- display 9

"11111111" WHEN OTHERS; -- blank display

WITH digit5 SELECT

HEX5 <= "11000000" WHEN "0000", -- display 0

"11111001" WHEN "0001", -- display 1

"10100100" WHEN "0010", -- display 2

"10110000" WHEN "0011", -- display 3

"10011001" WHEN "0100", -- display 4

"10010010" WHEN "0101", -- display 5

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"10000011" WHEN "0110", -- display 6

"11111000" WHEN "0111", -- display 7

"10000000" WHEN "1000", -- display 8

"10011000" WHEN "1001", -- display 9

"11111111" WHEN OTHERS; -- blank display

WITH digit4 SELECT

HEX4 <= "01000000" WHEN "0000", -- display 0

"01111001" WHEN "0001", -- display 1

"00100100" WHEN "0010", -- display 2

"00110000" WHEN "0011", -- display 3

"00011001" WHEN "0100", -- display 4

"00010010" WHEN "0101", -- display 5

"00000011" WHEN "0110", -- display 6

"01111000" WHEN "0111", -- display 7

"00000000" WHEN "1000", -- display 8

"00011000" WHEN "1001", -- display 9

"11111111" WHEN OTHERS; -- blank display

WITH digit3 SELECT

HEX3 <= "11000000" WHEN "0000", -- display 0

"11111001" WHEN "0001", -- display 1

"10100100" WHEN "0010", -- display 2

"10110000" WHEN "0011", -- display 3

"10011001" WHEN "0100", -- display 4

"10010010" WHEN "0101", -- display 5

"10000011" WHEN "0110", -- display 6

"11111000" WHEN "0111", -- display 7

"10000000" WHEN "1000", -- display 8

"10011000" WHEN "1001", -- display 9

"11111111" WHEN OTHERS; -- blank display

end architecture;