MEASURING PHYSICAL DIMENSIONS WITH LASER BEAM AND PROGRAMMABLE LOGIC

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In this report are represented the possibilities of the contemporary electronic elements when building optoelectronic measurement devices. In this type of devices the basic components are: a light beam source, photo receiver, managing system for both the light source and the light receiver (this system also processes the received light information and displays it on an indicator). The universal digital managing and processing unit of the devices is based on FPGA. One of its advantages is the possibility to load different processing algorithms for the received information trough JTAG interface with no changes on the schematic of the devices. In this report are described two practical approaches for measurement of distance based on triangulation and measurement of physical dimensions based on laser parallel scanning beam.

Keywords: Measurement system, Laser, FPGA, VHDL, Real-time applications

1. INTRODUCTION

In the measurement optoelectronic devices with laser light source and programmable logic the main units are: a laser diode, objective with a photo receiver, indication (display) and programmable logic. On fig. 1 is shown the scheme of such type of electronic device.

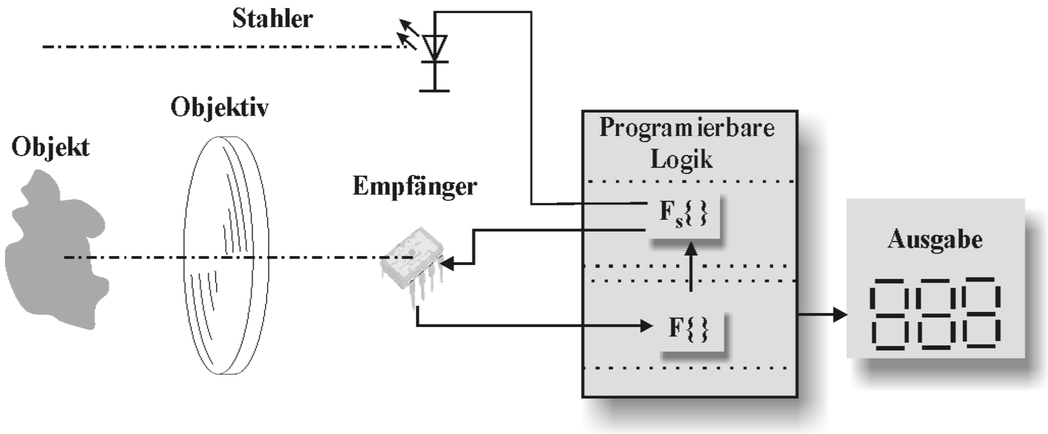

Fig. 1. Block diagram of optoelectronic device with laser diod and programable logic.

The laser source emits electromagnetic flow to the measured object. The objective in front of the photo receiver focuses the reflexed light on the receiver, which transforms the light signal in an electrical one. The programmable logic implements several functions at the same time: generates the driving signal for the laser source, accepts the reflected light, and processes the received information in order to get the value wanted. In the algorithm are inserted constants for the relation between the distance and the projection of the reflected light on the photo receiver. After finishing the measurement procedures the result is processed and after that displayed.

On this common architecture can be build optoelectronic devices for measurement of different values like distance and dimensions. As the processing part can be reprogrammed without changing the hardware configuration, it is reasonable to be build an universal platform like a base for many devices. The main purpose is to create all family of devices only by loading different processing algorithm in the computational part.

2. BUILDING OPTOELECTRONIC MEASURE DEVICES WITH PROGRAMMABLE LOGIC.

2.1 Measuring distance by triangulation

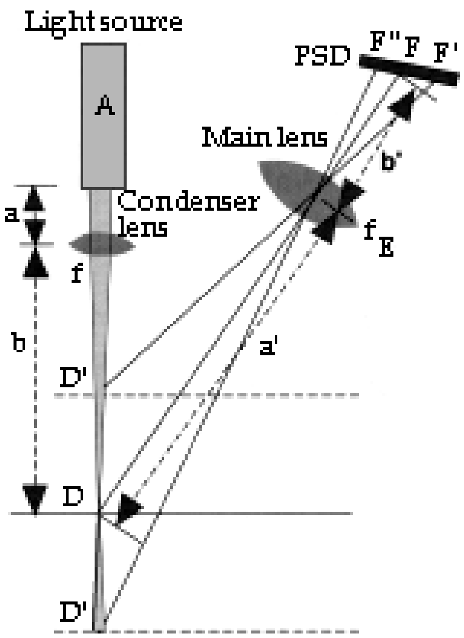

Fig. 2. Optical diagram of measurement the distance.

For distance measuring is used the triangulation as base method (Fig. 2).
The laser source emits electromagnetic flow to the object, which is placed on distance b. By this way on the object is projected light spot with dimensions depending on the distance. The receiver objective projects the reflected spot on the surface of the photo elements line. Depending on the distance the projection of the spot will be on different place of the PSD (a photodiode line). The photodiode line is of linear type with 128 sensitive elements. The programmable logic defines the number of the element, which is most lit. By mathematical calculations with constants, the processing unit calculates the measured distance.

The block-scheme of the device working by this method is shown on Fig. 3.

The main element in it is the programmable logic SPARTAN II of the company XILINX.

The managing program is placed in the PROM memory and it loads the algorithm in the logic on every switch on of the device. The clock generator of the scheme defines the speed of calculation. It is calculated with concordance to the time intervals for normal work of the photo receiver line.

The display indication consists of four seven-segment indicators. The keyboard is represented by two functional buttons and a Reset button. For the programming of the device on the PCB is positioned a JTAG connector.

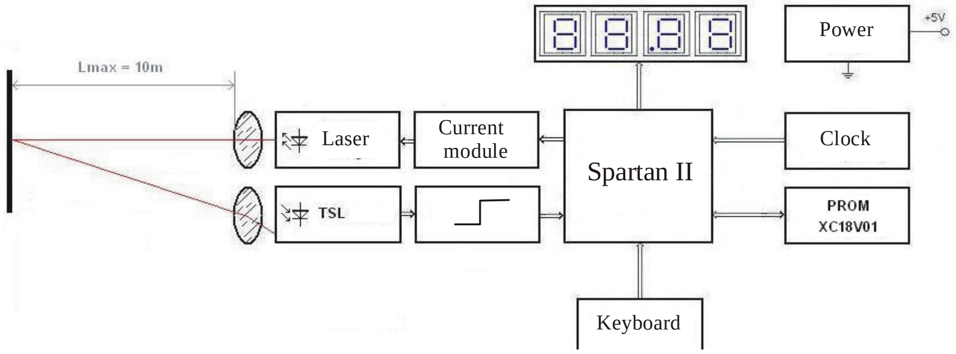

Fig.3 Block diagram of optoelectronic device with laser diod and programable logik.

2.2 Measuring physical dimensions by laser scanning beam.

For the measurement of physical dimensions is used the method of measuring the shade of the measured object on the way of the scanning beam. By this way can be measured dimensions of holes and dimensions of several holes in an object, as the dimensions of the non-transparent parts of the object between the holes. The measurement is fast and accurate (with accuracy of micrometers). On figures 4 and 5 are shown the space configuration of the elements and the realization of the method of scanning. The parts of the optical system are as follows: 1 – Laser Source; 2- DC motor; 3 – a synchronizing optron; 4 – flat mirror; 5 – hyperbolic mirror; 6 – scanning laser beam; 7 – receiving mirror; 8 – receiving photodiode; 9 and 10 – photodiodes which define the active area of scanning.

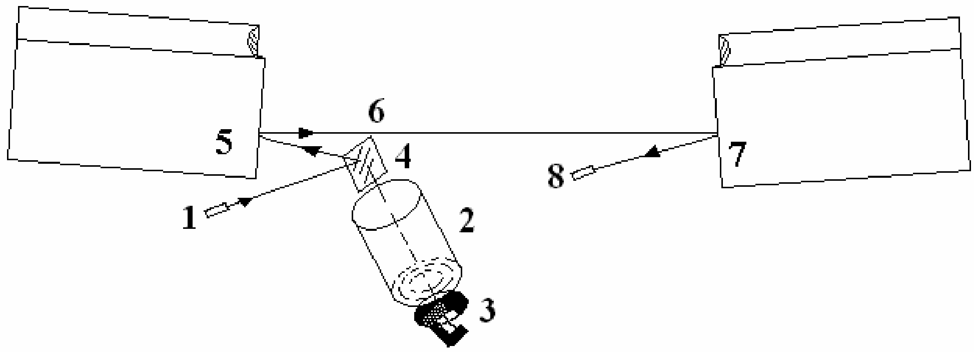

Fig. 4 Space configuration of the optical scanning system (side-view)

The laser beam consecutively scans the space between the mirrors 5 and 7 and projects light pulse signal on the photo receiver 8. If in the active zone of measurement a non-transparent object is placed the laser flow don't reach the photodiode. The calculation of the dimension of the object is based on the measurement of the time of the shade by counting the pulses that are sent and not received.

The algorithm is as follows: on the rotor of the DC motor is placed firmly flat mirror. The position of the rotor is detected by the optron 3. When the reflected beam gets to the mirror 5 the laser diode 1 begins to emit light pulses and by the same time the motor continue rotating. The speed (in rpm – rounds per minute) of the DC motor is precisely controlled. With every period between pulses the position of the rotor is rotated. The flat mirror 4 is in the focus of the mirror 5 and so all reflected rays between 5 and 7 are parallel. In the focus of the mirror 7 is placed the photodiode 8, which forms the signal for the processing unit. By scanning the active area can be shot a section of the object and after processing the result (with programmable logic Spartan II of the company XILINX) the values are shown on the display (four seven segment LED indicators as the previous device). In the programmable logic can be generated several registers for objects with more holes in the section and the system can display both the dimensions of the transparent and non-transparent areas of the section.

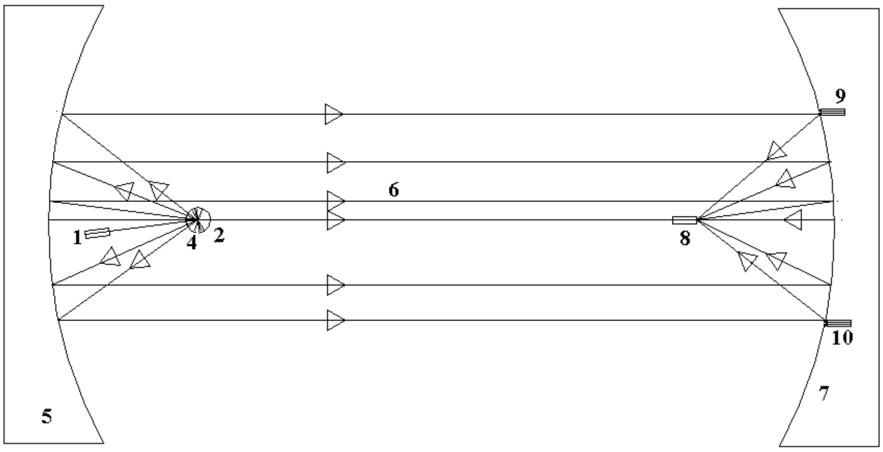

Fig. 5 Space configuration of the optical scanning system (top-view)

The block-scheme of the scanning device is close to the block scheme of the device for distance measurement. The difference is in the type of the photo receiver and the additional driving algorithm and scheme for the DC motor (the optron sends the information about the speed to the programmable logic and the control on the motor is again with the logic). This gives the possibility to use one and the same processing unit for both devices that is just loaded with different program.

3. DESCRIPTION OF THE PROGRAM ALGORITHM.

3.1 Program algorithm for measurement of distance by triangulation.

On figure 6 is shown the block-scheme of the generated logical structure of the processing unit after its programming. The main subunits are:

Management Block – generates pulses for the control of the other subunits; **Seven Bit Counter** – counts the number of the shift pulses sent to the photo receiver line and by this way shows the number of the element which is connected to the output of the photo receiver line. As the line consists of 128 elements when the counter reaches 127 it starts to count again from 0. **Seven Bit Registers A0 и A1 –** in their memory are written the numbers of the elements of the line, which correspond to the edges of the projected on the line light. **Seven Bit Adder –** sums up the values from the registers A0 and A1. The output of the adder is 8 bit is possible to be generated a carry bit. The inputs are also declared as 8 bits because of the specifics of the language.

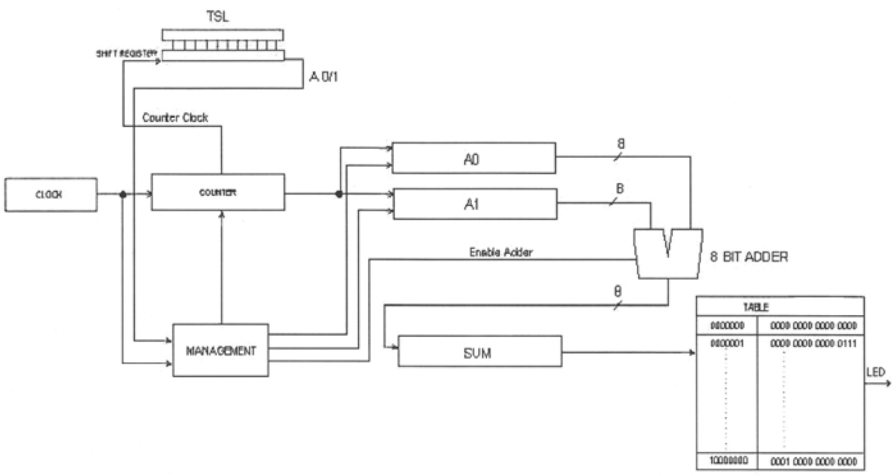

Fig. 6 Block scheme of the program algorithm

Seven Bit Register SUM – in its memory is saved the result of the sum up of the values of the registers A0 and A1. The specific part here is that by skipping the Least Significant Bit, when the value is passed to the Table, it is divided by two. Here is an example – if we divide the number 110100 (binary value) / 52 (decimal value) by two, we just shift right and loose the Least Significant Bit 011010 (binary value)/ 26 (decimal value). **Table with corresponding code for the driving of the seven segment indicators -** in it are saved the driving values for the signals for the indicators for every corresponding distance. When the sum of the first and last bit for the edges of the light spot is divided by two, we receive the number of the most lit element, to which corresponds a value from the table. The first digit of the indication can be only 1, as the maximum distance is 10 meters. This is why some of the pins of this indicator are not used.

3.2 Program algorithm for the measurement of physical dimensions by scanning laser ray.

The program algorithm for the device for the measurement of physical dimensions generates the internal logical structure shown on Fig. 7. It consists of several subunits. Management is the block that controls, resets and enables all the other blocks, this block also passes information between the blocks. Motor Control is the block that monitors the speed of the motor and if it is out of range it sends corrective signals to the outer driving scheme of the motor. LD PULSE GEN is a block that generates the pulse signal for the laser diode, which is with width 1/10 part of the period of the signal and frequency 8 MHz. It is enabled only when the reflected ray from the first (the flat one) mirror goes in the active area of the hyperbolic mirrors. The block under this one is Measure Counter, which starts the counter for the measurement of the shade. It is enabled only when Block 1 (the logical element sum by module two) is active and shows that the pulses sent with the signal LD are not received by the incoming signal PD. In this case the counter is incremented with 1 on every pulse of the signal LD. On the left of the internal structure are shown the outer signals. The second line from top to down represents the signals PD1 and PD2, which

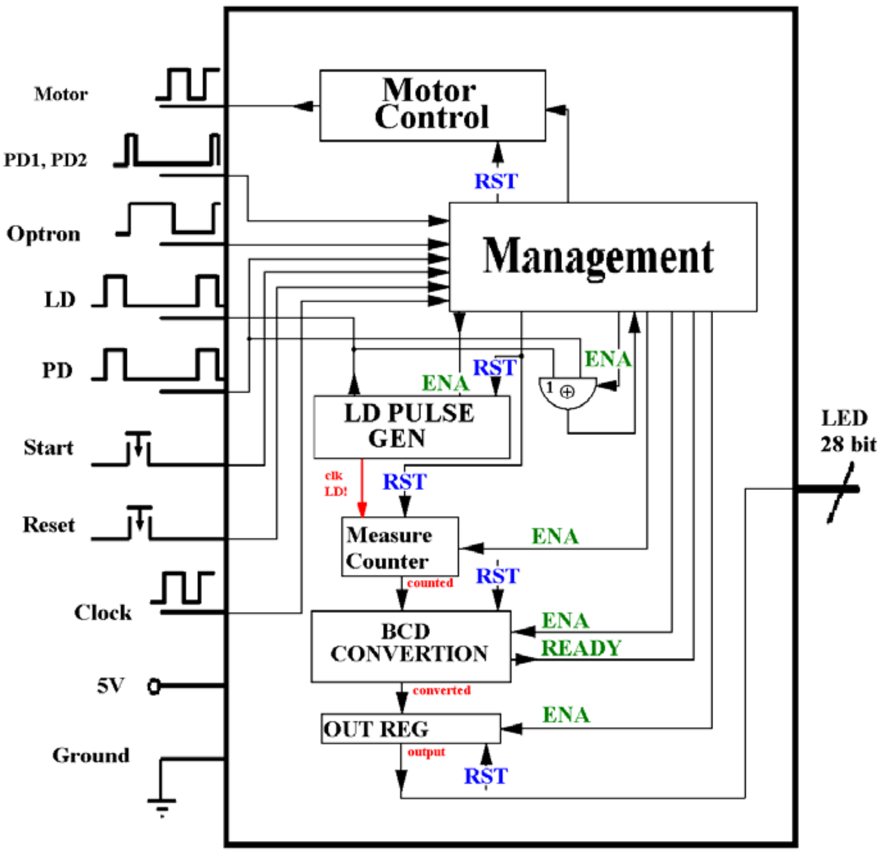

Fig. 7 Block scheme of the generated internal structure of the programmable logic

delimit the active area. When a pulse comes from PD2 this means that the rotation of the rotor of the motor is at the end of the active area. At that moment the block BCD Conversion is enabled. This block generates the BCD signal for the seven segment LED indication, which consists of 28 bits. The OUT REG is for keeping the result until next measurement. All blocks have a RST signal for restart when a decalibration of the motor is detected, or the system is just reset. In this case all internal buffers are erased to prevent any errors .

4. CONCLUSION.

The usage of programmable logic for the driving and controlling of a photo receiver and a light source gives the possibility to use one and the same hardware platform for different devices. The platform can be preconfigured functionally and the realization of calculation and control algorithms can be modified. In this report are shown two devices with laser beam which both use one hardware platform with differences only in the program configuration and partially in the optical system.

5. REFERENCES

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