Automated System for Visual Control in Microelectronics

Rumen Stoyanov Yordanov, Ivan Petrov Ucherdzhiev and Irena Radkova Yordanova

Abstract – **The following work presents a project developed in order to achieve visual control and support the process of defect detection in microelectronic devices. The possibilities of carrying out practical classes using an automated system for visual control are also described.**
Keywords – **Automated System, Visual Control in Microelectronics**

I. INTRODUCTION

After a thorough analysis of the need for visual control in detecting defects and problems in microelectronic devices, and a research of available practices, a decision was taken to develop and create an automated system for controlling visual inspection equipment in Microelectronics. The idea behind the project is that it provides access to visual inspection equipment and assures a freedom of movement along its X, Y and, Z (focus) axes.

II. METHODS, ALGORITHMS AND REALIZATION OF A VISUAL CONTROL SYSTEM IN MICROELECTRONICS

The realization of the project suggests working in two main directions:

- Development of a Web-based system;
- Development of an automated system for visual control for the needs of Microelectronics.

This article focuses mainly on the second part, having to do with the developed visual control system itself.

The requirements for a system for visual control in Microelectronics are as follows:

- Input and storage of control programs;
- Interpolation;
- High accuracy movement control;
- Logic control;
- Adaptive control;
- Imaging;
- Low power consumption;
- Flexibility;
- Remote control access.

Figure 1 shows a block diagram of an automated system for visual control that meets the aforementioned requirements.

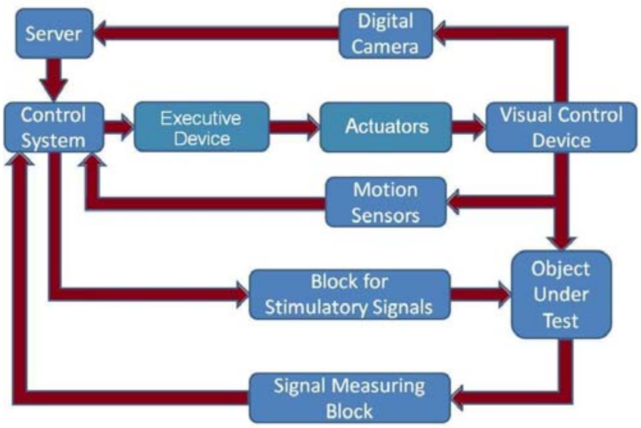

Fig. 1. Block diagram of an automated system for visual control

Server – this block is realized using a computer which communicates with the control system.

Control system – it is based on a low-power consumption MCU. The MCU processes information fed by the server. It generates movement control signals which it then feeds to the actuators, and processes information received from the motion sensors. The control system is realized using the MSP430G2553 microcontroller by Texas Instruments. The main criteria that lead to this choice are [5]:

- Adequate number of I/O ports;
- Adequate peripherals for driving the system for visual control;
- Server communication interface support;
- Clock speed;
- Low power consumption.

MCU work algorithm:

- System startup – at every system startup, the pad is centered in an initial position along the X, Y, and Z axes;
- After centering the pad, a watch cycle for input commands is started;
- When a command is received, it is checked whether it is a one-step move command, or a

R. Yordanov is with the Department of Microelectronics, Faculty of Electronic Engineering and Technologies, Technical University - Sofia, 8 Kliment Ohridski blvd., 1000 Sofia, Bulgaria, e-mail: yordanov@tu-sofia.bg
I. Ucherdzhiev is with the Faculty of Electronic Engineering and Technologies, Technical University - Sofia, 8 Kliment Ohridski blvd., 1000 Sofia, Bulgaria, e-mail: ivan_ucherdjiev@abv.bg
I. Yordanova is with the Department of Microelectronics, Faculty of Electronic Engineering and Technologies, Technical University - Sofia, 8 Kliment Ohridski blvd., 1000 Sofia, Bulgaria, e-mail: riris_ij@yahoo.com

step size change command. One has to keep in mind that the smallest step the system can handle is 10μm;

- If a step size change is required, the new step size is input into the memory and a new watch cycle starts;
- If the received command is a one-step move command, it is checked for axis and direction data;
- Before movement can start, a check is performed to assure the desired move direction is allowed. A reason for movement restriction is the sum of the step and current coordinates being greater than the pad's end position coordinate value. Another reason is the difference between the step and the current coordinates being smaller than the pad's start position coordinate value;
- After receiving permission to move, a sub-program is called, responsible for movement in the designated direction along the designated axis. During the move operation, a constant watch is running, waiting for command termination, or reaching of the pad's maximum or minimum coordinates;
- After the move operation ends, the pad's new coordinates are stored in memory;
- A check is performed for new command input. If a command is present, steps 3 and onward are executed. If there is no new command present, the system reverts to step 2 and waits for input.

Executive device – this block receives the control signals fed by the control system and generates the needed electrical signals in order to drive the actuators. It is realized using a L293D motor driver by Texas Instruments. The main criteria that lead to this choice are [4]:

- Control by logical signals with a 3,3 V or 5 V amplitude;
- Adequate output current and voltage to drive the actuators;
- Overvoltage protection on the I/O ports.
- Low latency, short output voltage rise and fall time with respect to input;
- Bi-directional drive.

Actuators – this block consists of DC motors used to move the object along the three axes (X, Y, Z). The motors have the following parameters:

- Nominal supply voltage - 24 V;
- Torque - 0,5 Nm;
- Nominal power - 5 W;

Motion sensors – this block is realized using slotted discs with evenly spaced slots. They work by counting out a designated number of pulses per single revolution of the motor. Movement accuracy is highly dependent on the number of pulses generated by this block. The more pulses generated, the higher the accuracy. In this case the sensor generates 100 pulses per revolution. The sensor's accuracy can be easily increased by increasing the number of slots on the disc.

The disc has 100 slots, a diameter of 40 mm and a thickness of 1,2 mm. A single slot is 1 mm in width and 4 mm in length.

Figure 2 shows an image of the motion tracking sensor's disc.

Fig. 2. Disc used in the motion tracking sensor

The photo-coupler has the following parameters:

1. Transmitter parameters:
   - Maximum current - 50mA;
   - Maximum reverse voltage - 5 V;
2. Receiver parameters;
   - Nominal supply voltage - 17 V;
   - Nominal output power - 80 mW;
3. Transient parameters:
   - Delay, low to high - 1,6 μs;
   - Delay, high to low - 2,2 μs;
   - Rise time - 280 ns;
   - Fall time - 120 ns

Figure 3 shows an image of a motion tracking sensor attached to an actuator motor.

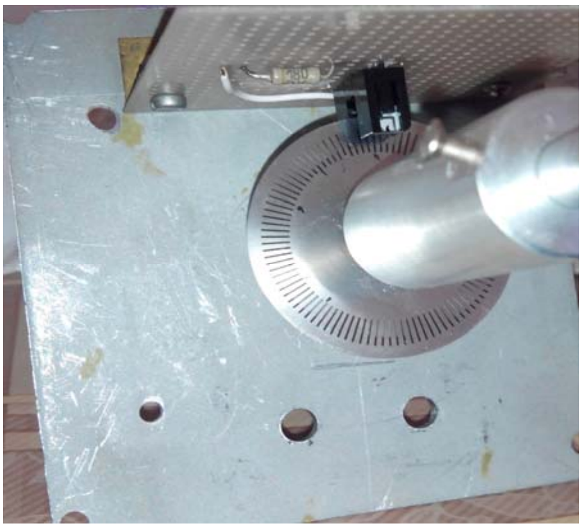

Fig. 3. Motion tracking sensor

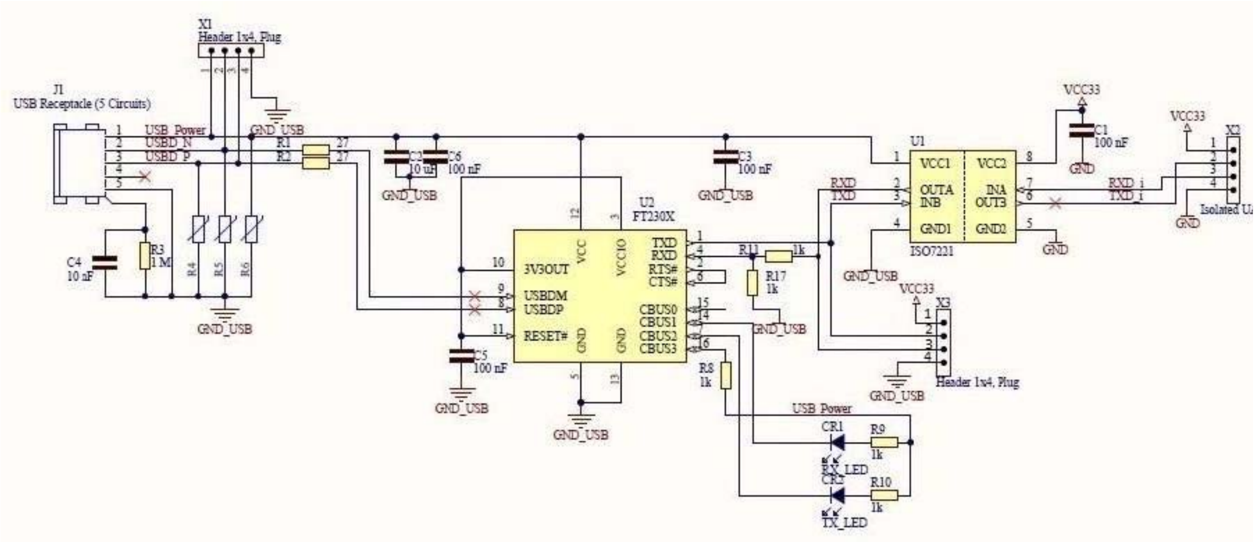

Fig. 4. Schematic of the communication module circuit

Visual control device – this block is realized using a microscope with a mobile pad on which the observed object is placed. The pad is originally moved by hand. In order to achieve automated movement, the mechanisms for manual control are replaced by actuators (DC motors). An image of the object is obtained by replacing one of the microscope's eyepieces with an imaging device.

Imaging – this block is realized using a portable digital camera. The main requirements for the device are:

- Computer connection via USB interface;
- Good image resolution;
- Small size and portability.

The camera used is a MC-A037VU(C) with a resolution of 720x576 pixels and a USB 2.0 interface for computer communication.

The stimulus and measurement blocks are auxiliary blocks for expanding the system's functionality. The purpose of these 2 blocks is performing functional diagnostics on the observed object and generating a pass-fail type evaluation report. The microscope, as a visual control device, has an integrated probing block. The probes are connected to the outputs of the stimulus block and the inputs of the measurement block respectively, which in turn allows for performing functional diagnostics.

Stimulus block – the purpose of this block is generating the needed electrical signals with their respective parameters so functional diagnostics can be run on the object. This block needs to be controlled by logical signals, put out by the MCU, and its inputs must be galvanically isolated from the MCU's outputs.

Measurement block – this block is intended for the measurement of the signals needed to prove the objects functional integrity. The measured values must be calibrated and fed into the MCU, so as to generate a pass-fail type evaluation. Here, as with the previous block, galvanic isolation between the block's inputs and the MCU's outputs is a must.

Communication module – in order to establish communication between the server and the control module, a communication module had to be devised. The solution is based on the FT230 integrated circuit by FTDI, which is a standard USB to UART converter. Figure 4 shows an image of the communication module's schematic.

The control module is made up of the following blocks: the automated system for visual inspection, control system, executive device, actuators and motion tracking sensors.

The control module's schematic is shown in figure. 5.

III. Results

The developed automated system for visual control allows performing visual inspection on microelectronic devices using a computer. Movement control is bi-axial, bi-directional, flexible, and offers step variation for greater work comfort. The minimal step that the system can achieve is 10 µm which allows for a precise inspection of the different sections of the tested object.

The defects and problems that can be detected using the system are [1,2]:

- Cracks and flaws in the object's metal layers;
- Errors in contact pad and device active area alignment;
- Object components' size inspection for evaluation of the used technological operations;
- Wiring and bonding problems – missing wires or bond balls, shorts or broken segments;
- Multi-chip modules can be observed for proper orientation and external component solder quality.

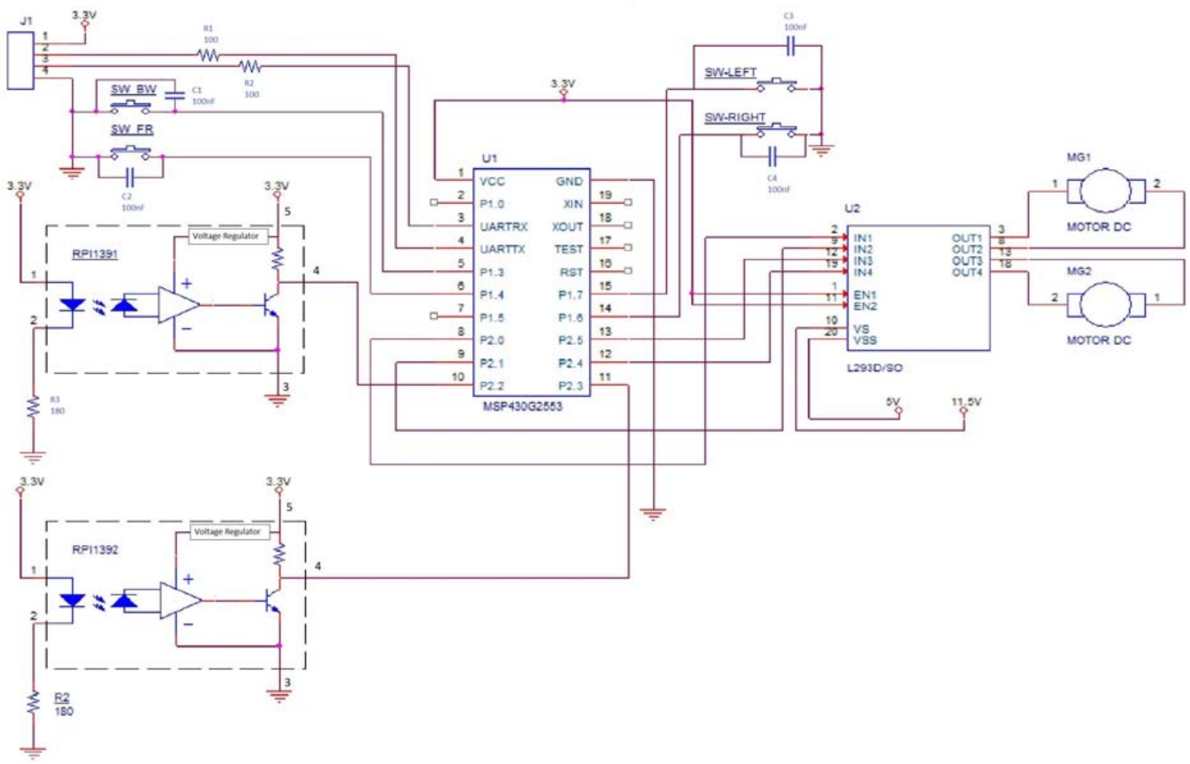

Fig. 5. Control module schematic

The developed automated system for visual control allows the conducting of practical classes during which students can familiarize themselves with the basic methods of carrying out visual inspection on microelectronic devices and the defects that can occur in these devices throughout their life cycle.

Figure 6 shows an image of a working prototype of the visual control system.

.

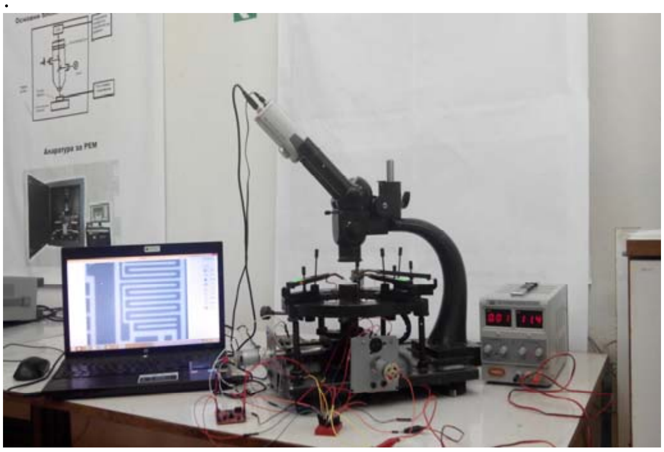

Fig. 6. Visual control system prototype

IV. Conclusion

The automated system for visual inspection of microelectronic devices will allow the implementation of a fundamentally new approach to teaching students in the field of Microelectronics. The system will grant the possibility that any student be able to view, inspect and discover defects in microelectronic devices, no matter what their location is or what time it is. Presently, work is being put into the development of applications for the most widespread mobile operating systems, which will allow controlling the automated visual inspection system using a mobile device.

References

[1] Department of Defence - *Test method standard. Microcircuits.*, MIL – STD883E 1996.

[2] Department of Defence - *Hybrid microcircuits. MIL-PRF-38534H 13 September 2010*

[3] St. Ovcharov – *Automatization of electronics' manufacture* - TU -2008

[4] http://www.ti.com/lit/ds/symlink/l293d.pdf

[5] http://www.ti.com/product/msp430g2553