Proceedings of the 2013 Federated Conference on
Computer Science and Information Systems pp. 667–670

# Creating a Serial Driver Chip for Commanding Robotic Arms

Roland Szabó, Aurel Gontean
Applied Electronics Department
Faculty of Electronics and
Telecommunications,
"Politehnica" Univ. of Timişoara
Timişoara, România
roland.szabo@etc.upt.ro

***Abstract*—In this paper we shall present a serial driver chip creation on FPGA. We created this serial driver chip for the RS-232 interface and we programmed it to 115200 baud rate to be able to communicate with the Lynxmotion AL5 type robotic arms. This serial driver chip was made for bidirectional communication to be able to send and receive SCPI (Standard Commands for Programmable Instruments) commands on the serial interface. If we create the layout of this chip we can create our own ASIC (Application-Specific Integrated Circuit) and this way we shall have a standalone chip which can control a robotic arm.**

## I. Introduction

THIS paper presents the creation of the serial driver chip. Serial driver chip is very useful in controlling many measuring equipments, power supplies, industrial test systems and even robotic arms. No too many types of equipment have USB interface or if they have they have only USB connector, but they still emulate the COM port. This means that the serial interface is still widely used in the industry, even though it's speed it's not the highest. Basically we had to create the UART diver chip ad after it to connect whatever connector to we wish to connect DB9 or DB25, depending on what kind of robotic arm do we wish to control. In our case the Pmod (Peripheral Module) connected to our FPGA board had DB9 connector which was perfect for the Lynxmotion AL5 type robotic arm, but for the Scorbot ER-III robotic arm we needed DB25 connector which we solved with a serial converter from DB9 to DB25.

We can control robotic arms with a PC, but if we have an embedded solution is always better, because it's more portable, and consumes less power. If we find an embedded solution that is implemented in hardware, it's even better, because we shall have no issues regarding to propagation times and we don't' have problems likes bug in software or issues like the system can freeze.

## II. Problem Formulation

We had a Lynxmotion AL5 type robotic arm (Fig. 1) and a Scorbot ER-III robotic arm (Fig. 2).

We had also more FPGA boards one NEXYS 2 board (Fig. 3) with Spartan-3E FPGA and one ATLYS board (Fig. 4) with Spartan-6 FPGA + and Pmod RS232 (Fig 5).

Fig. 1 Lynxmotion AL5A robotic arm

Fig. 2 Scorbot ER-III robotic arm

Fig. 3 NEXYS 2 FPGA board with Spartan-3E FPGA

Fig. 4 ATLYS FPGA board with Spartan-6 FPGA

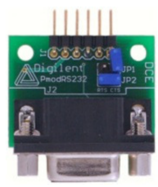

Fig. 5 Pmod RS232 for the ATLYS board

We had all the hardware, but we needed to create the serial driver to make the communication and to control the robotic arms. For the ATLYS FPGA board we needed to use the Pmod RS232, because the board has only micro USB connector to its UART interface and that not the best solution, because it needs software driver to emulate the serial port on USB and the connector is not suitable for us too, because we need not micro USB, but DB9 or DB25. The USB UART is Ok just when the PC is the master and the FPGA board is the slave, because on the PC we can easily install the USB to serial converter driver. In our case the FPGA board is the master and the robotic arm's servo controller is the slave, this way is really hard to impellent a software driver for the serial to USB converter chip. In our case the standard serial port with DB9 connector is the best solution, this way we had to use a Pmod for the ATLYS board.

## III. Problem Solution

### A. Theoretical Background

The SCPI (Standard Commands for Programmable Instruments) for controlling the robotic arm will be presented next, these commands are sent on the serial driver chip and with these commands the robotic arm is moved.

```
// SSC-32 VERSION
\r\rVER\r

// INITALIZE MOTORS
QPL0\rQP0\r
QP1\r
QP2\r
//...
QP31\r

// ALL SERVOS 1500
#0P1500S0\r#1P1500S0\r#2P1500S0\r#3P150
0S0\r#4P1500S0\r#5P1500S0\r

// GRIPPER
#4P1500S1000\r

// WRIST ROTATE
#5P1500S1000\r

// WRITST
#3P1500S1000\r

// ELBOW
#2P1500S1000\r

// SHOULDER
#1P1500S1000\r

// BASE
#0P1500S1000\r
```

Somehow from these commands we managed to create some formulas too, to know the correspondence between the angles and robotic commands.

To know exactly the angles we can simply calculate with equation (1).

$$\alpha = \frac{\Delta\omega}{180° - 0°} = \frac{2500 - 500}{180° - 0°} = 11,(1)\ robotic\ values \quad (1)$$

This means the following shown in equation (2).

$$1° \sim 11,(1)\ robotic\ values \quad (2)$$

The block diagram of the experimental setup with the ATLYS board and the Pmod RS232 is shown on Fig. 6.

The block diagram of the experimental setup with the NEXYS 2 board is shown on Fig. 7.

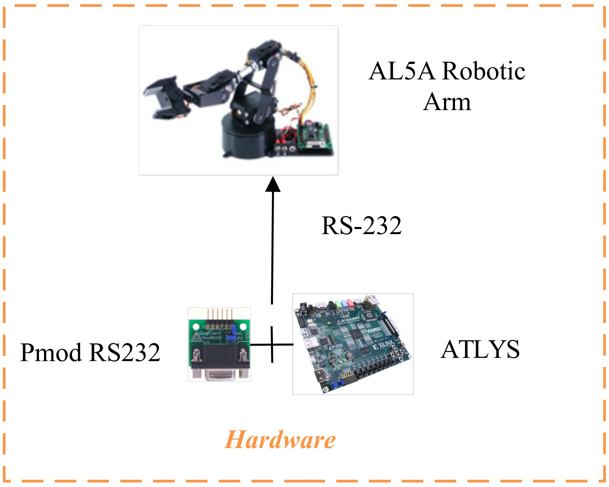


Fig. 6 The block diagram of the experimental setup with the ATLYS board and the Pmod RS232

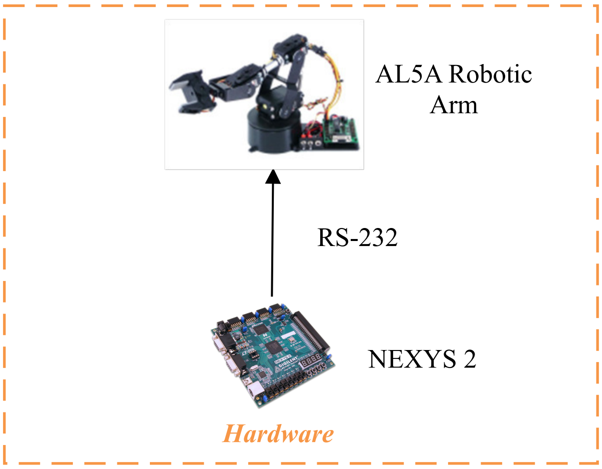


Fig. 7 The block diagram of the experimental setup with the NEXYS 2 board

### *B. Circuit Diagrams*

These circuit diagrams were created from VHDL code in Xilinx ISE. These circuits are what we have inside the serial driver chip.

On Fig. 8 we can see the bidirectional serial driver chip, which has both the transmit (TXD) and receive (RXD) ports.

On Fig. 9 we can see the UART chip which we included in the bidirectional serial driver chip, this chip is actually the serial protocol.

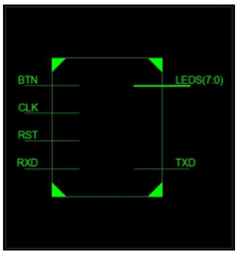


Fig. 8 The bidirectional serial driver chip structure with transmit (TXD) and receive (RXD) functions

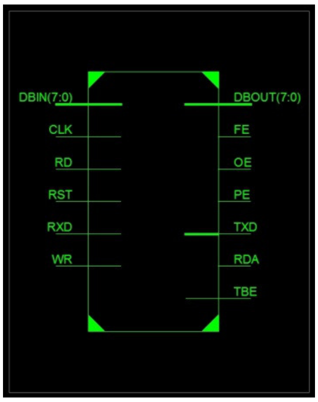


Fig. 9 The UART chip which is included in the bidirectional serial driver chip

On Fig. 10 we can see the circuit structure inside the bidirectional serial drive chip.

On Fig. 11 we can see the circuit structure inside the UART chip.

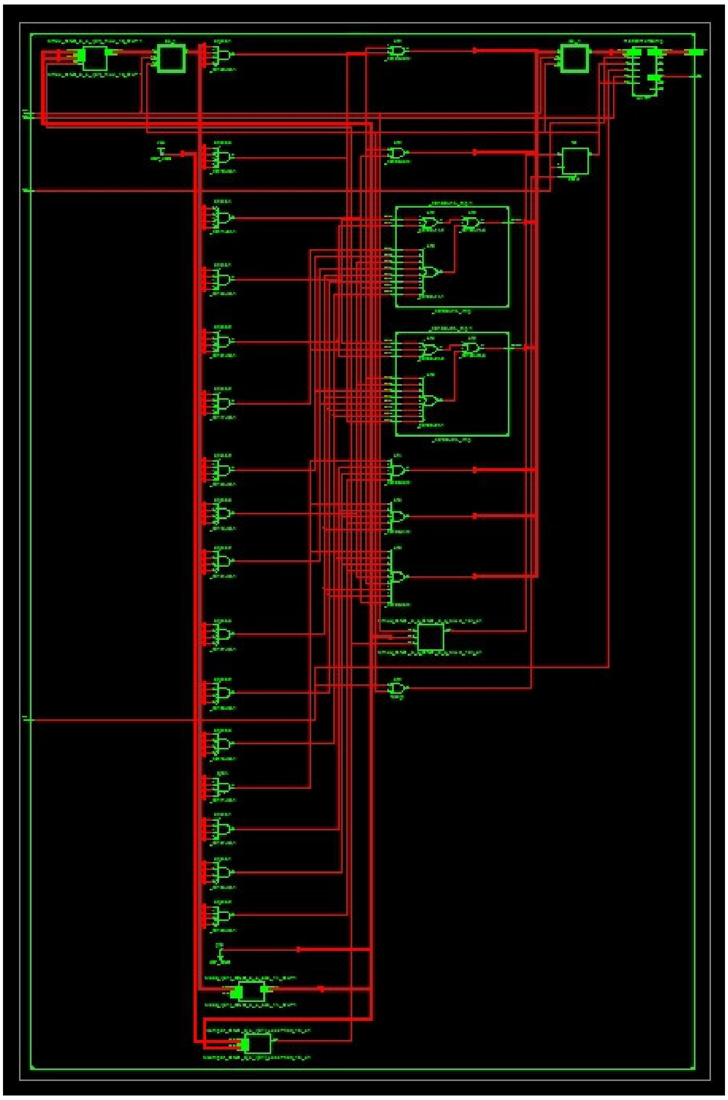

Fig. 10 The bidirectional serial driver chip's circuit (inside the bidirectional serial driver chip)

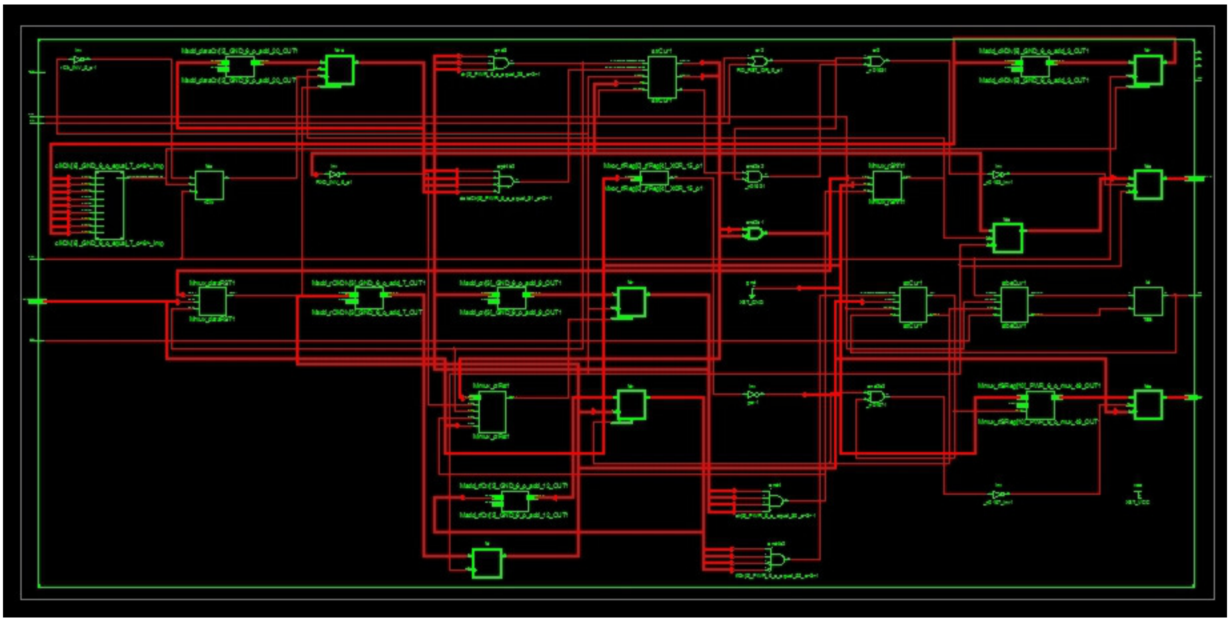

Fig. 11 The UART module's circuit (inside the UART chip)

## IV. Conclusion

As we can see, we have created a serial driver chip which can control measuring equipments, power supplies, industrial equipments and even robotic arms.

With this chip we can control any equipment which has an RS-232 serial interface; the only change is that we have to load the specific SCPI commands for the specific equipment we want to control.

We created only in FPGA in two platforms on NEXYS 2 board with Spartan-3E and on ATLYS board with Spartan-6 + Pmod RS232.

After this we plan to convert the FPGA code in Verilog code and with the Mentor Graphics tools to create the chip's layout. After this we can send it to the production to create the silicon die, we shall do the packaging and with this we shall have our own serial driver ASIC.

This ASIC can be than put on a PCB (Printed Circuit Board) with a DB9 connector and some electronic components and we shall have an embedded control board for almost any equipment which has serial port or even a control board for the robotic arms. The only task is to load in a ROM memory the specific SCPI commands for each equipment which needs to be controlled.

## References


[1] R. Szabó, I. Lie, "Automated Colored Object Sorting Application for Robotic Arms," *Proceedings of International Symposium on Electronics and Telecommunications ISETC 2012*, Tenth Edition, 2012, pp. 95–98.

[2] R. Szabó, A. Gontean, I. Lie, "Smart Commanding of a Robotic Arm with Mouse and a Hexapod with Microcontroller," *Proceedings of 18th International Conference on Soft Computing MENDEL 2012*, 2012, pp. 476–481.

[3] R. Szabó, A. Gontean, I. Lie, M. Băbăiță, "Comparison between Agilent and National Instruments Functional Test Systems," *8th International Symposium on Intelligent Systems and Informatics (SISY)*, 2010, pp. 87–92.

[4] A. Gontean, R. Szabó, I. Lie, "LabVIEW Powered Remote Lab," *15th International Symposium for Design and Technology of Electronics Packages (SIITME)*, 2009, pp 33–340.

[5] Fengdong Sun, Shufan Hou, Hongwei Zhao, Jianguo Liang, "The FPGA verification of USB to RS-232 bridge controller," *International Conference on Automatic Control and Artificial Intelligence (ACAI 2012)*, 2012, pp. 2123–2127.

[6] N. F. Jusoh, M.A. Haron, F. Sulaiman, "An FPGA implementation of shift converter block technique on FIFO for RS232 to universal serial bus converter," *Control and System Graduate Research Colloquium (ICSGRC)*, 2012, pp. 219–224.

[7] V. Vijaya, R. Valupadasu, B.R. Chunduri, C.K. Rekha, B. Sreedevi, "FPGA implementation of RS232 to Universal serial bus converter," *IEEE Symposium on Computers & Informatics (ISCI)*, 2011, pp. 237-242.

[8] Wong Guan Hao, Yap Yee Leck, Lim Chot Hun, "6-DOF PC-Based Robotic Arm (PC-ROBOARM) with efficient trajectory planning and speed control," *4th International Conference on Mechatronics (ICOM)*, 2011, pp. 1–7.

[9] Woosung Yang, Ji-Hun Bae, Yonghwan Oh, Nak Young Chong, Bum-Jae You, Sang-Rok Oh, "CPG based self-adapting multi-DOF robotic arm control," *International Conference on Intelligent Robots and Systems (IROS)*, 2010, pp. 4236–4243.

[10] E. Oyama, T. Maeda, J.Q. Gan, E.M. Rosales, K.F. MacDorman, S. Tachi, A. Agah, "Inverse kinematics learning for robotic arms with fewer degrees of freedom by modular neural network systems," *International Conference on Intelligent Robots and Systems (IROS)*, 2005, pp. 1791–1798.

[11] N. Ahuja, U. S. Banerjee, V. A. Darbhe, T. N. Mapara, A. D. Matkar, R. K. Nirmal, S. Balagopalan, "Computer controlled robotic arm," *16th IEEE Symposium on Computer-Based Medical Systems*, 2003, pp. 361–366.

[12] M. H. Liyanage, N. Krouglicof, R. Gosine, "Design and control of a high performance SCARA type robotic arm with rotary hydraulic actuators," *Canadian Conference on Electrical and Computer Engineering (CCECE)*, 2009, pp. 827–832.

[13] M. C. Mulder, S.R. Malladi, "A minimum effort control algorithm for a cooperating sensor driven intelligent multi-jointed robotic arm," *Proceedings of the 30th IEEE Conference on Decision and Control*, 1991, Vol. 2, pp. 1573–1578.

[14] M. H. Liyanage, N. Krouglicof, R. Gosine, "High speed electro-hydraulic actuator for a scara type robotic arm," *International Conference on Intelligent Robots and Systems (IROS)*, 2010, pp. 470–476.