

DATA COLLECTION TOOL FOR PROCESS IDENTIFICATION USING PLC AND KEPWARE TOOLS

UDC ((681.5.015:004.65) + 681.3.06)

**Igor Kocić¹, Saša S. Nikolić¹, Darko Mitić¹,
Petar Đekić², Nikola Danković¹, Nebojša Jotović¹**

¹University of Niš, Faculty of Electronic Engineering, Department of Control Systems,
Republic of Serbia

²The Academy of Applied Technical and Preschool Studies-Niš, Republic of Serbia

Abstract. *In this paper, we are using the Kepware tools as a data collection tool to collecting data for identifying the process and making the mathematical models is described in this paper. The connection to the process was made using a programmable logic controller like a real time DAQ (Data Acquisition Board and System) device, database and a client application developed for these purposes. Special attention is paid to the possibility of collecting a large amount of process data as the same moment time of data sampling.*

Key words: *Kepware, PLC, OPC server, MySQL database, Identification*

1. INTRODUCTION

Kepware solutions enabled the connection of various devices for process monitoring and thus enable the concept of the IoT (Internet of Things) [1]. Kepware have a library with multiple device drivers for connection with devices from various hardware manufacturers, like Allen Bradley, Siemens, ABB, Mitsubishi, Omron, Schneider and others. Within the Kepware tools, it is possible to communicate with various types of devices and various network protocols. Programmable logic controllers (PLCs) have been used in the implementation of control tasks. During the realization of regulation tasks, we need to first identify the process as well as possible. For this reason, it is convenient to use Kepware tools [1], PLC and data base for collection of data and after that make a mathematical model of the process. This PLC controller is used to control the same process.

Received November 18, 2022 / Accepted December 19, 2022

Corresponding author: Saša S. Nikolić

University of Niš, Faculty of Electronic Engineering, Department of Control Systems, Aleksandra Medvedeva 14,
18000 Niš, Republic of Serbia

E-mail: sasa.s.nikolic@elfak.ni.ac.rs

Kepware fastest reliable sampling speed is 10 ms, but the real speed of sampling is lower than that.

This paper describes the possibility of collecting data to identify the process on the example of reading the values of specific tags (arrays) of the PLC controller using Kepware tools, MySQL [3] database, plc program and client program for reading, viewing, graphical display, export and printing data from the database that was written in Delphi programming language.

The connection of the PLC controller and Kepware tools is done using its software component Channels/Devices, within which it is easy to configure communication channels and devices from which data are sampled and collected for process identification and making of models. Channel configuration is done by selecting the appropriate communication driver. Kepware tools are used for connecting to the database using its Data Logger software component by selecting the appropriate driver for the ODBC database. The collected data is read from the field of database tables, using Structure Query Language (SQL) or a client application. Free software tools SQLyog [5] is used to write queries on database.

2. HARDWARE AND SOFTWARE ENVIRONMENT

Kepware product is installed and running on Windows 7 Professional system. OS (Operating systems) Win 7 is general purpose OS system, it does not guarantee the task execution in setting times like a Real time OS [1]. To overcome the problem of real-time operation, a PLC is used that operates and executes instructions in real-time. A MySQL database was installed and setup on the same computer. Client application can be installed and developed on the other Windows OS. The client application is not demanding in terms of the performance of the computer on which it is installed, it can be installed on any computer within the local Ethernet network.

Database for stored of data collection is installed using the multiplatform free open source software XAMPP [3, 4] which is use in the local Ethernet network. XAMPP provides a solution for fast and efficient configuration of the minimum environment that meets all the needs in terms of database application development. In Fig. 1 the basic block diagram of the connection of the Kepware tools with the PLC controller, database and client application with process is shown. Figure 2 shows the layout of the initial screen for setting up the Kepware server communication channel driver and device properties. An example driver was selected to communicate with the Allen Bradley PLC controller using Ethernet [2].

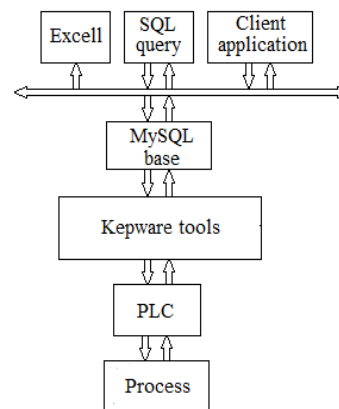


Fig. 1 Block diagram of Kepware tools and PLC connections with process, database and client application

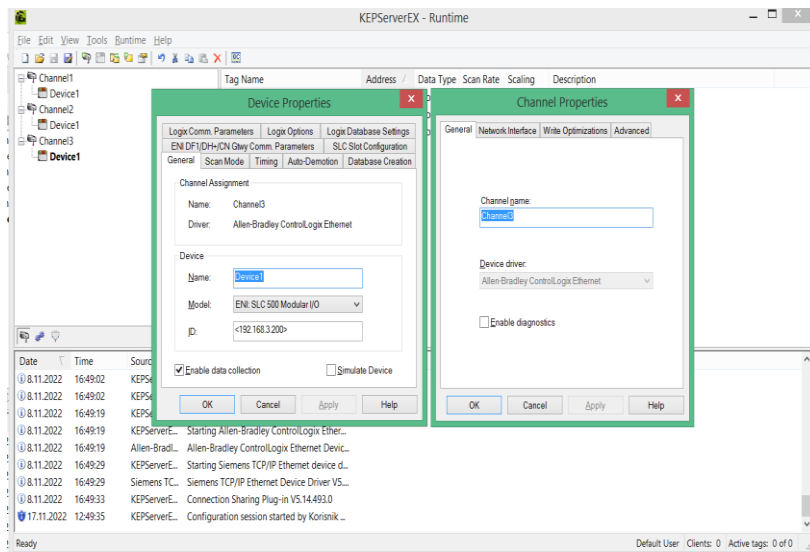


Fig. 2 Selection of communication channel driver and type of PLC device

PLC controller from the SLC 500 series of modular type is connected to the Ethernet network, its IP address, communication port, maximum connection duration, number of connection attempts, and given approval for data collection. Figure 3 shows a window in which the tag from which the data is collected is selected. A tag's array from address N12:160 to N12:163 was entered, which contains the current value of the temperature from zone 1 to zone 4 and others zone of the extruder. The reading (sampling) time is set to 1 s and the access mode is set to read.

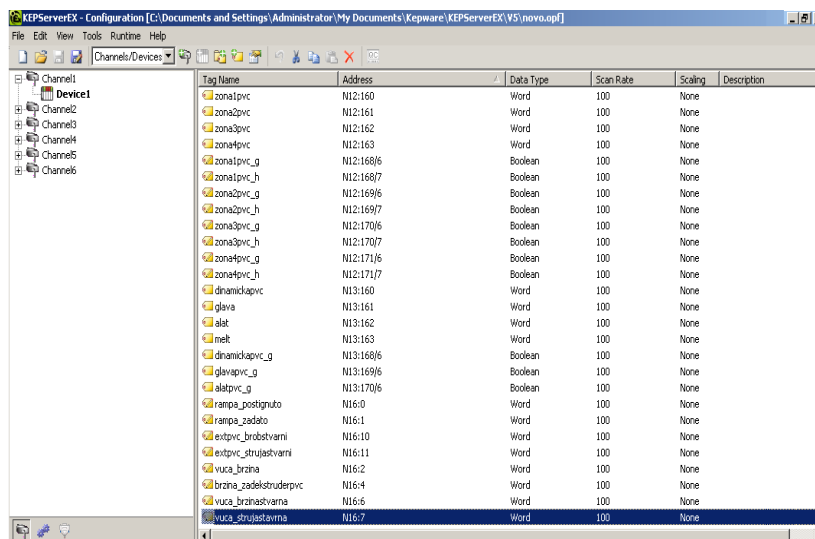


Fig. 3 Defining the parameters of the tag (PLC register)

The SQLyog is an open-source software by which database and appropriate tables can be created. In Fig. 4 the database table and fields in which the current values of temperatures are entered when identifying the temperature model of the extruder are shown. It is easy to see the possibility of simultaneous collection of current values of a large number of parameters important for process identification. The current values of the temperature of the extruder zones, read from the selected PLC controller, are entered in the fields of the table thus created. Writing simple SQL queries reviews and exports data and, if necessary, import it into Matlab. Table row in id tags that is set to be the primary key, allows data to be viewed with sorting and time selection. MySQL database and DataLogger connected with the appropriate database driver. The DataLogger is linked to the tag values read by the KEPWareEX server and entered in the appropriate fields in the database table. Linking the tag with the corresponding field of the table is done by mapping and linking the name of the PLC tags and the name of the table field (see Fig. 5). The read value of the selected PLC tag is entered in the selected table field.

When started Kepware begins reading values and writing to the corresponding fields in the table of the selected database. Client application was written in the Delphi programming language. This application simplifies the process of collecting, reading, reviewing and exporting data. Ready-made Delphi components for working with databases, such as TADOConnection, TADOQuery, TADOTable and others, were used to write the program.

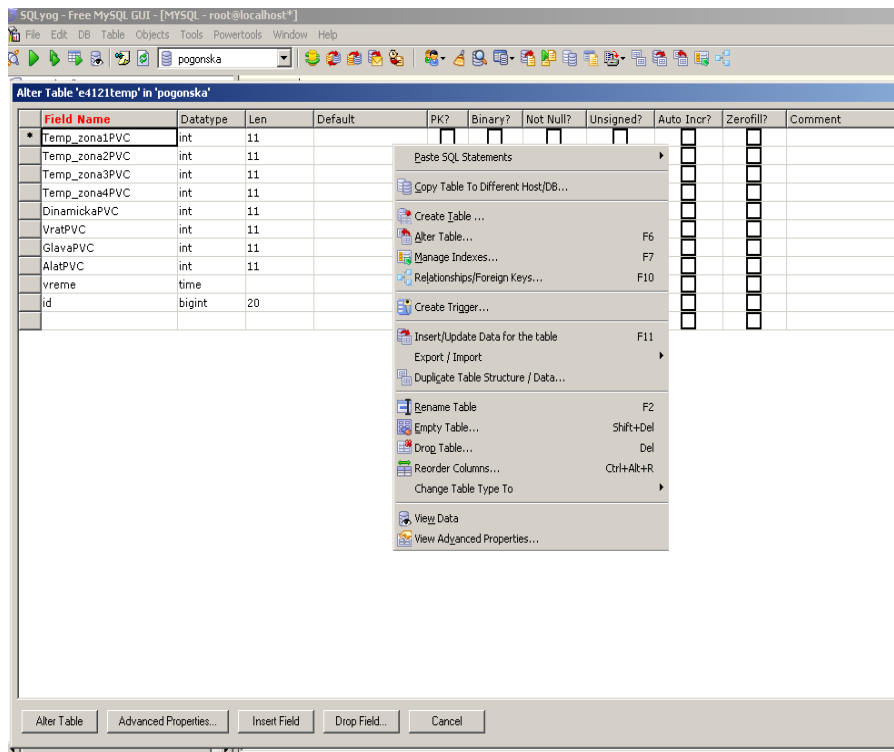


Fig. 4 Defining the database table and field where the values of appropriated PLC tags was stored

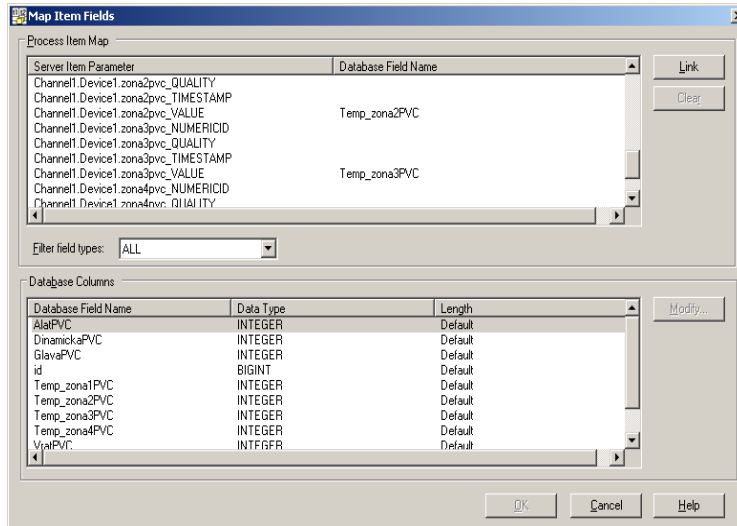


Fig. 5 Associated fields from the PLC tag database using Data Logger

In the PLC controller, a short routine (see Fig. 6) is written that performs the acquisition of the extruder temperatures. A Selectable Timed Interrupt Subroutine (STI) with an execution time of 1s is used. After the execution of the routine, the values of the current temperatures are written in the fields, which are read directly from the registers corresponding to the physical inputs to which the thermocouples are connected (TC type J). The STI program file number must be 8. In this case the enable bit is set to 1. If STI is executing often, the overall scan time may dramatically increase.

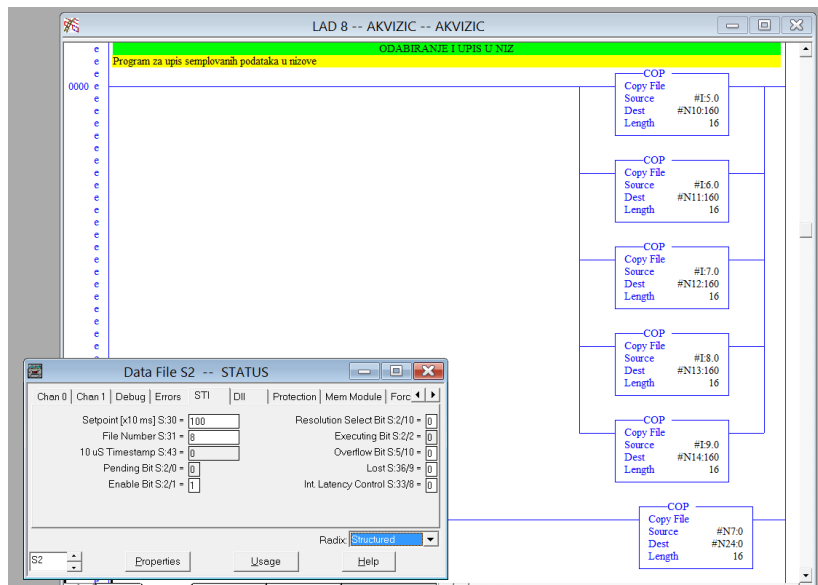


Fig. 6 PLC routine for written current temperatures in arrays

SQL commands are used to create, expand created tables and indexes. The software uses the SQL statements to view data from the database.

Figure 7 shows the layout of the screen of the client application for reading and processing data from the database. Using the client application [6-9], the data from the selected table and column of the table is read, entering the desired time interval in which the review and reading is performed. In a specific example for the identification and development of a mathematical model, the extrusion line is using, and data on the number of turns of the screw extruder that affects the speed and flow of mass are collected, thus the temperature model [6].

Fig. 7 Part of the application for selection and tabulation of data from the database

The part of the Delphi [10, 11] client application code that reads the selected table field from the database is listed below.

```

procedure TForm1.Button3Click(Sender: TObject);
var Datum1,Vreme1,Datum2,Vreme2,timeer,timeerdo:String;
begin
  if ComboBox13.Text='IZABERI' then
    ShowMessage('Izbor pregleda nije u redu,ponovi izbor')
  else
    begin
      Datum1:=ComboBox3.Text+ComboBox2.Text+ComboBox1.Text;
      Vreme1:=ComboBox4.Text+ComboBox5.Text+ComboBox6.Text;
      Datum2:=ComboBox9.Text+ComboBox8.Text+ComboBox7.Text;
      Vreme2:=ComboBox10.Text+ComboBox12.Text+ComboBox11.Text;
      timeer:= Datum1+Vreme1;
      timeerdo:= Datum2+Vreme2;
      kolname:=Edit6.Text;
      ime_tabele:=Edit3.Text;
      Edit1.Text:=timeer;
      Edit2.Text:=timeerdo;
      ADOQuery1.SQL.Clear;
    end;
end;
  
```

```

ADOQuery1.SQL.Add('select time,'+ kolname + ' from '+ ime_tabele);
ADOQuery1.SQL.Add('where time >'+timeer);
ADOQuery1.SQL.Add('and time <'+timeerdo);
ADOQuery1.SQL.Add('order by vreme');
ADOQuery1.ExecSQL;
ADOQuery1.Active:=True;
end;
DbGrid3.Visible:=True;
DbChart1.Title.Text.DelimitedText:=ime_tabele+' '+kolname;
Form2.DbChart1.Title.Text.DelimitedText:=ime_tabele+' '+kolname;
Button4.Visible:=True;
end;

```

By entering the time interval and selecting the tabular display, the query is executed and the table with the values of the zone 4 in the selected time interval is displayed when the model characteristic was recorded. As part of the process identification, in the part of recording the process characteristics, the zone 4 of the extruders was identified, the possibility of identifying only one process parameter is presented.

A table IdentTabela was created on the basis of which a field named TZona4 was created. The identification process consists of several steps. The start time of the experiment is noted. Contactor that turn on the heating are switched on manually, thus simulating a Heaviside step function [7, 8]. The sampling time was set at 1s because it is a slow temperature process and the time for query is set at 1 min. The communication channel of the Kepware is activated, which reads the value of the tag in which the current values of the temperature of zone 4 are located. At the end of the experiment, the time is recorded. In the client application, the IdentTable table, the TZona 4 field and the time from the beginning to the end of the experiment are selected and the tabular value of zone 4 temperature is obtained. By pressing the "Graphic display" button, the temperature characteristic of zone 4 is drawn as a dependence of the temperature on the time on the basis of which the process identification is performed Figure 8.

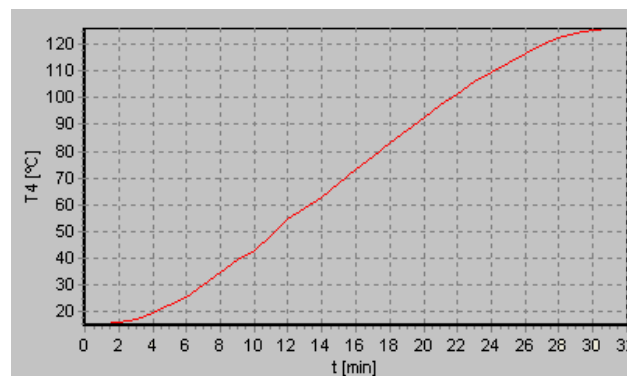


Fig. 8 Temperature characteristic of zone 4

Recorded values using SQL queries or using a client application are transferred to .txt, .csv format or exported to Matlab or Win Excell. As part of the process of identifying the extruder model, the procedure of recording the characteristics of several zones for the purposes of creating a temperature model of the extruder with the mutual influence of the

zones was applied, and a similar procedure was applied. The time of the beginning of the identification is noted. The contactor that a turn on the heating is forced on manually, which simulates the bounce function, the sampling time is set to 1 min. First, zone 2 is heated and its characteristics are recorded. The time of completion of identification is recorded. The extruder is then cooled to ambient temperature, the process is repeated with the difference that zones 1, 2, and 3 are now heated simultaneously and their temperature characteristics are recorded at the same time. It is possible to easily examine the mutual influence of zones and create a model of a multivariable system. Figures 9 and 10 shows the characteristics of zone 2 that is heated by it, and shows the characteristics of zones 1, 2 and 3 that are heated at the same time. Both characteristics were obtained using a client application. The extruder is heated to a temperature of 100 °C, which corresponds to a time of about 25 min with ambient temperature of 17 °C.

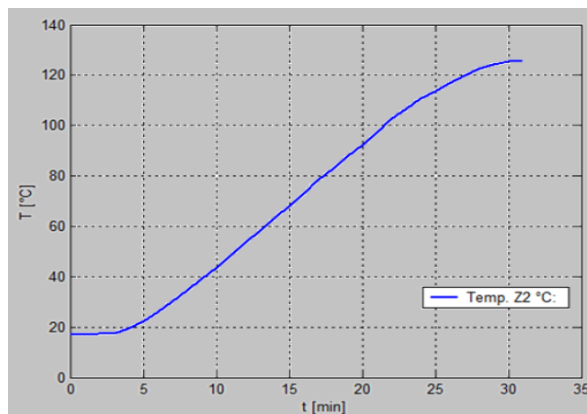


Fig. 9 Characteristic of Zone 2 only, heated only

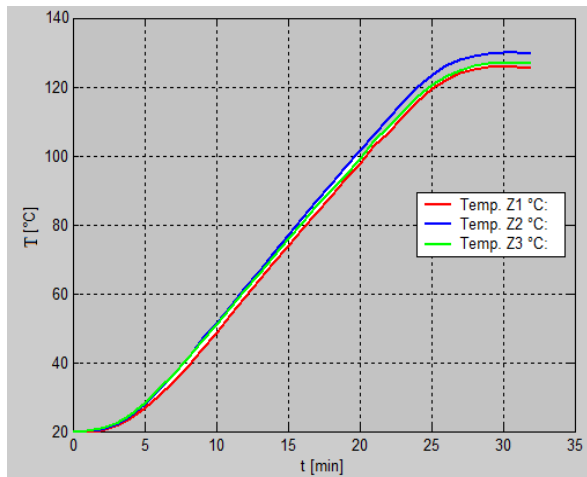


Fig. 10 Temperature characteristic of Zones 1, 2, and 3 obtained using the client application

Using the above identification method, it is easily possible to simultaneously obtain the zone cooling characteristics of an eight -zone extruder (see Fig. 11).

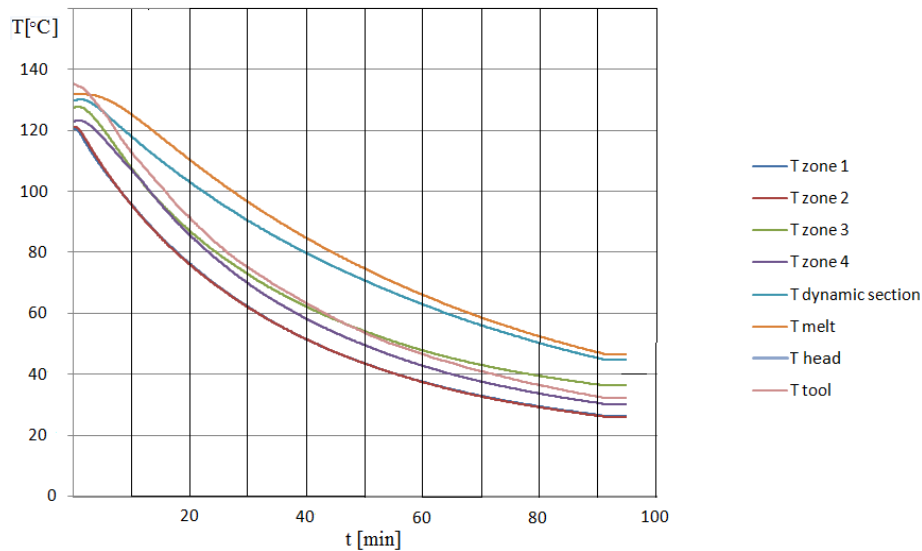


Fig. 11 Temperature characteristic of the extruder zones (cooling)

3. CONCLUSION

Kepware consists of different software tool combined with different PLC controllers can make a powerful tool for data acquisitions. In combination with a database can be used as a data collection tool to identify the process. Any program in which it is possible to write SQL queries can be used to read data from the database. In combination with a PLC, we can read and log data in real time frequency and store it in strings or fields readable by Kepware tools. A more advanced solution consists in developing the client application presented in this paper. The advantage of using this method of identification is reflected in the possibility of simultaneous collection of a large number of data from the process, which is especially convenient when creating models of multivariable systems and their experimental verification. The data collected during the recording of the response of the system can be easily used for obtaining the model in the form of a transfer function and amplitude-frequency characteristics (AFFK). In the client application, it is possible to read the selected data, export them and, then print. Kepware tools give an opportunity for experimental verification for different applied methods of control.

Acknowledgement: *This work has been supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia.*

REFERENCES

- [1] Kepserverex manual, <https://www.kepware.com/getattachment/2745a0a9-079a-4630-b15c-8081aba1a91d/kepserverex-manual.pdf>
- [2] Allen-bradley-controllogix-ethernet-manual, <https://www.kepware.com/getattachment/c7cd42b2-e3a8-403e-ac5b-ddff9cb03985/allen-bradley-controllogix-ethernet-manual.pdf>
- [3] XAMPP FOR MYSQL Amey Laxman Gawde, <https://cs.nyu.edu/courses/Fall12/CSCI-GA.2433-001/XAMPP.pdf>
- [4] WebDevelopmentGuide2013Malveaux, <https://viu.eng.rpi.edu/lab/2/WebDevelopmentGuide2013Malveaux.pdf>
- [5] https://static.webyog.com/pdfs/Using_SQLyog_Enterprise_to_Effectively_Synchronize_MySQL_Databases.pdf
- [6] I. Kocić, P. Đekić, A. Milovanović, D. Antić, S. S. Nikolić, N. Danković, "Application of KEPServerEX applications for acquisition and supervision of production processes", *Proceedings of the XV International Conference on Systems, Automatic Control and Measurements, SAUM 2021*, Niš, Serbia, September 09.–10., 2021., pp. 17–20.
- [7] I. Kocić, S. S. Nikolić, A. Milovanović, P. Đekić, and N. Danković, "Sequential control of water level in tanks and pumps from remote location using PROFINET network", *Proceedings of the 9th Small Systems Simulation Symposium, SSSS 2022*, Niš, Serbia, February 28.–March 02., 2022., pp. 90–97.
- [8] I. B. Kocić, D. B. Mitić, N. B. Danković, S. S. Nikolić, P. S. Đekić, "KEPServerEX as a data collection tool for process identification", *Proceedings of the XVI International Conference on Systems, Automatic Control and Measurements, SAUM 2022*, Niš, Serbia, November 17.–18., 2022.
- [9] S. S. Nikolić, I. Kocić, D. Antić, D. Mitić, N. Danković A. Milovanović, P. Đekić, "The winder dancer position control model using different PID control structures and micrologix PLC", *FACTA UNIVERSITATIS Series: Automatic Control and Robotics*, vol. 21, no. 2, 2022, pp. 77–93. <https://doi.org/10.22190/FUACR220409007N>
- [10] M. Cantu, *Delphi 7*, Kompjuter biblioteka Čačak, 2003.
- [11] N. Hodges, *Coding in Delphi*, Nepeta Enterprises, 2014.