Scientific Bulletin of the „Petru Maior” University of Tîrgu Mureş
Vol. 14 (XXXI) no. 2, 2017
ISSN-L 1841-9267 (Print), ISSN 2285-438X (Online), ISSN 2286-3184 (CD-ROM)

DATA PROCESSING FOR BRAKE TEST STANDS

Ioan MOCIAN[1], Traian TURC[2]
"Petru Maior" University of Tîrgu-Mureș, Romania
Nicolae Iorga Street, no.1, 540088 Tîrgu-Mureș, Romania
[1]ioan.mocian@ing.upm.ro
[2]traian.turc@ing.upm.ro

Abstract

Processing data generated by a mechanical system (e.g. force, speed, pressure, etc.) requires an interdisciplinary approach that includes mechanics, electronics, and software. The data is collected from a mechanical system that makes use of transmitters. An electronic system performs the first processing step, followed by a software component that turns data into information. This paper discusses the data processing flow for an auto brake check stand. The primary data is transmitted via a serial port to a computer, where it is converted into physical measurements and stored into a database. The data is made available in real time; it can be monitored through dynamic plots, or printed.

Key words: mechanical system, electronic system, VB.NET, data transmission, graphical user interface.

1. Introduction

The demand for monitoring mechanical check stands has been increasing lately. The accuracy of the data collection and processing system is ensured by high-quality transmitters, which send the data from the mechanical side all the way up to the electronic components.

Such applications aim is to bond the gap between mechanics and software, as well as provide an intuitive graphical user interface (GUI) [1], [2], [3] that allows humans to effectively interact with the system being monitored. Developers can define their own GUI objects [5], [6] that can be integrated into the monitoring system.

Our system has two modes of operation: automatic (in which case the entire testing process is controlled by a computer) and manual (allowing a human operator to take remote control). This paper describes the two modes of operation in depth.

2. Operation of brake test stand

The end-to-end system handles both single-axle and double-axle traction vehicles. It consists of three main components:

- A mechanical component;
- An electronic command module;
- A software component.

The mechanical component contains multiple sensors which send data to the electronic component. The command module processes the data and is able to send commands back to the mechanical component (turning the engine off and on, switching rotation direction, etc.), as well as send physical measurements to the computer (weight, friction force, rotations per minute, etc.). This second component is what bridges the actual stand and the computer (fig. 1).

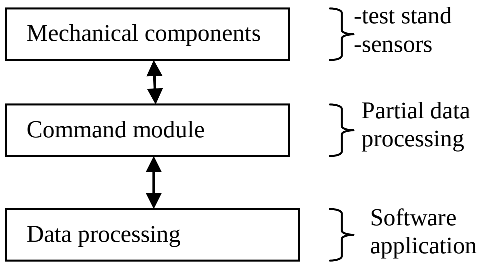


Fig. 1: Operating principle

As shown in fig. 1, communication between the three components of the stand is bidirectional, so that the computer can send commands back to the mechanical component via the electronic component.

3. Software application

The software application incorporates three modules:

- Testing (the actual brake tests);
- Database management (storing data and providing access to it);
- Calibration (calibrating the parameters of the stand, which ensure measurement accuracy).

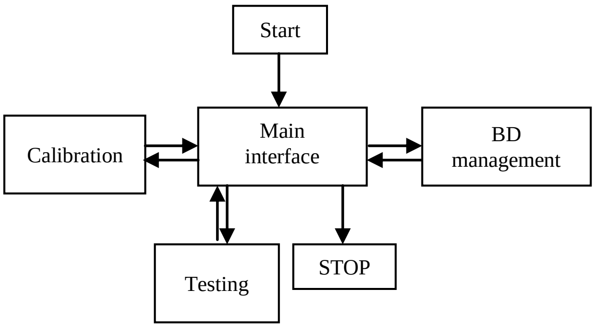


Fig. 2: Software application structure

As shown in fig. 2, the user navigates from the start screen to the main interface, which communicates to the three software modules and provides a way to exit the application. Switching from one mode to another is always intermediated by this main interface.

Next, we will discuss the database management and calibration modules. We leave the testing module for the end, since it is the most complex one.

Calibration is the process of selecting a set of parameters that maximizes accuracy. These parameters control, for instance, the conversion of an electric signal into a concrete physical measurement (e.g. the weight of the vehicle). In order to find the optimal parameters, we start from standard, well-known values (e.g. weights of 10, 50, or 100 kg), then adapt the values according to the signal received back from the sensor.

All such parameters are stored into a database, ready to be used by the testing system. These operations are performed by authorized personnel only and require a password. Each stand has its own set of parameters.

Database management is the module that takes measurements from the testing system, stores them in a relational database. It provides structured access to the stored information and allows printing it. The vehicle and owner information is entered on the first visit and persisted, so that customers can save time during subsequent visits.

4. Testing Module

The testing module performs the following operations:

- Receives data from the check stand via a serial port;
- Turns data into physical measurements;
- Facilitates communication between the human operator and the brake test stand;
- Displays measurements in real time;
- Stores information in the database.

The brake test stand supports the following four configurations (where 2WD stands for two-wheel drive, and 4WD stands for four-wheel drive, also known as 4x4):

- 2WD Automat (first axle, second axle, and parking axle);
- 2WD Remote Control;
- 4WD Automat;
- 4WD Remote Control.

These combinations can be selected from the application interface. Figure 3 depicts the inner workings of the testing module.

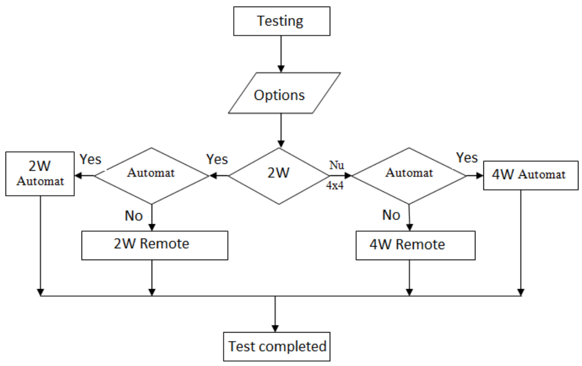


Fig. 3: Logical diagram

Each of the four configurations are approached differently by the operator:

- *2WD Automat*: the software takes initiative and goes through an automatic cycle. The operator needs to complete the instructions displayed on the monitor.
- *2WD Remote Control:* the operator uses the remote control to send commands and enter parameters according to the instructions displayed on the monitor.
- *4WD Automat:* the cycle is defined by the software, and the operator must complete the instructions displayed on the monitor.
- *4WD Remote Control:* the operator uses the remote control to send commands and enter parameters according to the instructions displayed on the monitor.

Each communication scenario has its own communication protocol between the brake test stand and the computer. Table 1 shows the communication protocol required for the 2WD Automatic case.

Table 1: Communication Protocol

Protocol			
Computer	**Event**	**Board**	**Observations**
q	>		Reset.
	<	!,0,0	Reset
k	>		
d	>		Automat.
axe	>		
Start	>		
	Stand, axel 1		

	Scale display, Foot brake symbol.	&	Current values
	Scale display, Foot brake symbol.	&	Foot brake symbol blink
	Scale display, Foot brake symbol	. . .	Foot brake symbol blink
	Scale display	#	Max values
k	>		Confirmation
	Next axis		
	Scale display, Foot brake symbol	&	Current values
	Scale display, Foot brake symbol	&	Foot brake symbol blink
	Scale display, Foot brake symbol.	. . .	Foot brake symbol blink
	Scale display	#	Max values
k	>		Confirmation
	Hand brake symbol	&	Current values
	Scale display, Hand brake symbol	&	Hand brake symbol blink
	Scale display, Hand brake symbol	. . .	Hand brake symbol blink
	Scale display, Hand brake symbol	#	Max values
k	>		Confirmation
	Scale display		
q	>		Reset.
	Test completed		
	Main panel		Main panel 3s

Legend for Table 1:

">" -- The computer sends a message to the electrical equipment.

"<" -- The computer receives a message from the electrical equipment.

"&" -- Prefix used in front of strings received by the computer.

"#" -- Maximum values received by the computer.

"q" -- The computer sends a reset command to the electrical equipment.

"!" -- Prefix used in the string "!,0,0", which is the code that confirms the electrical equipment has been reset.

"k" -- Confirmation code that a certain action has been completed, sent by the computer to the electrical equipment.

"d" -- Code for the 2WD Automatic cycle, sent by the computer to the electrical equipment to signal which testing cycle should be executed.

For the 2WD Automatic cycle, the entire testing process is taken over by the computer. The human operator only needs to execute the instructions displayed on the screen. The computer displays the data in real time on dynamic plots, as shown in fig. 4.

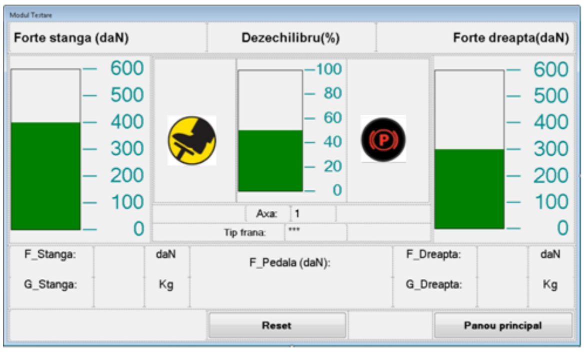
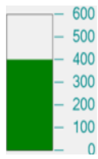


Fig.4: Results display

Legend for fig. 4:

- Foot brake. When this light is turned on, the operator must press the foot brake.

- Hand brake. When this light is turned on, the operator must pull the hand brake.



- Graded scale which shows the values of the braking forces and the imbalance between the two wheels.

The graded scale was calibrated in the interval 0-600 daN, determined experimentally such that it covers most cases.

5. Technical Details

The data transmitted to the computer via the serial port must follow a strict protocol in order to prevent corrupted data from flowing through the system. The sender appends an error correction code to the actual data. The receiver uses the same algorithm to compute its own error correction code for the received data, and checks it against the one appended by the sender. In case of a mismatch, the received packet is dropped.

Here are a few examples of data sets that can be sent to the computers

- Current measured values: &, xxx, yyy, zzz, ttt, pc, CR
- Maximum values: #, xxx, yyy, zzz, ttt, pc, CR
- Error message: !, x, x, pc, CR

The strings “xxx”, “yyy”, “x”, etc. are digit strings that, upon receipt, are converted by the computer to physical measurements. The "pc" value is a control number to verify the accuracy of data received from the electronic board. It is obtained by applying modulo 256 to the sum of transferred ascii codes .

The graded scale on the UI shows the moving values currently being measured. Once the maximum values are received, the scale shows these stable values, which are then stored into the database. Finally, a confirmation message informs the operator on successful completion.

The testing cycles for each of the four configurations listed in the Testing Module section are pre-configured. For instance, for the 2WD Automatic configuration, the sequence is: Axle 1 -- foot brake, Axle 2 -- foot brake, Axle 2 -- hand brake

6. Conclusions

This paper described an application developed in VB.NET that gathers, processes and stores data generated by a brake test stand. The main takeaways are:

- A serial port was used to send data to the computer.
- We designed a GUI that enables the human operator to interact with the brake test stand.
- We designed a graded scale object in order to illustrate the variation of the values being recorded in real time (left and right braking forces, imbalance between left and right wheels).
- We used two icons (foot brake and handbrake) to instruct the human operator what actions to take during the testing process.

Acknowledgement

This work was supported by a grant of the Romanian Ministry of Research and Innovation, CCCDI - UEFISCDI, project number PN-III-P2-2.1-CI-2017-0041, within PNCDI III

References

[1] Zhao Zhen, Peng Yinghong. *The theory, technique and practice of engineering design based on KBE*. Mechanical Science and Technology, 2003, 22(1):151–153.

[2] Zietarski, S. (2001), *System integrated product design, CNC programming and post processing for three-axis lathes*, Journal of Materials Processing Technology, vol. 109, issue 3, pp. 294–299.

[3] K. Yamazaki, Y. Hanaki, M. Mori and K. Tezuka, "*Autonomously proficient CNC controller for high-performance machine tools based on an open architecture concept*", Annals CIRP, 46(1), pp. 275–278, 1997.

[4] *VB.NET Documentation website* (2008). [Online].Available:http://msdn.microsoft.com/en-us/library/2x7h1hfk%28v=vs.90%29

[5] Cazacu, R., Mocian, I., *Software for computer aided manufacturing of complex pockets*, The 7th edition of the Interdisciplinarity in Engineering International Conference InterEng2013, Tîrgu Mures, 10-11 octombrie 2013, pp 364-368.

[6] Mocian, I., Cazacu, R., *Study on the possibilities of dedicated CAD applications development for the furniture industry*," Interdisciplinarity in Engineering" Scientific International Conference, Tîrgu Mureş, Romania, 12-13 November 2009, position 83/pp. 418.

[7] Vincenzo, R., Dzmitry, S., Klaus, A. and Valentin, I. (2017), *Estimation of Brake Friction Coefficient for Blending Function of Base Braking Control,* SAE International Journal of Passenger Cars - Mechanical Systems.

[8] Igor, I., Carvajal, S., Michael, H., Peter, E. (2017). *Transient simulation and uncertainty analysis of brake systems using a fuzzy-parameterized multibody system approach*, Mathematics and Mechanics of Solids.

[9] Zhe, W. Xiaojun, Z.,Chenlong, Y.(2017) *An Experimental Study on Hysteresis Characteristics of a Pneumatic Braking System for a Multi-Axle Heavy Vehicle in Emergency Braking Situations*, Aplied Science.

[10] Fauzi, A., Ahmad, K. Hudha, S., Amri, M (2017), *Simulation and experimental investigation of vehicle braking system employing a fixed caliper based electronic wedge brake*, Transactions of The Society for Modeling and Simulation International.

[11] Junnian, W.,Yao, Z., Nannan,Y., Qingnian, V.(2017) *Parameters design and braking efficiency analysis of a hydraulic self-energizing wedge disc brake,* International Journal of Precision Engineering and Manufacturing.

[12] Ömer A., Hakan, Osman, Y., T(2017) *Experimental and computational investigation of disc brake squeal,* INTER-NOISE 2017.