

# ELECTRONIC HMI COMMAND TABLE FOR MEASURING POINT MACHINE FORCES

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**Abstract** – This paper describes *electronic* - computer based HMI equipment for the *measuring and recording of the railway point machine forces* - EPMFM (the retention force and the trailing resistance force) produced by Signalling & Control d.o.o., Belgrade. The equipment is developed, realized, tested and implemented in Serbia and it is accepted for use by the expert commission of the Infrastructure of Serbian Railways a.d. (IZS). EPMFM is meant for measuring point machines' forces after reparations and before reinstallations on sight for IZS. Various types of point machines from different producers: Siemens AG - Germany, AZD - Praha and Sigma - Serbia, are analyzed and their features, in the view of detection and movement for the force measuring purposes, are standardized and implemented in the functionality of the EPMFM. Force measurements are based on the use of the certified and quality approved force sensor. The automatic calibration of the sensor, at the beginning phase of the each measurement process, is implemented in the application software of the EPMFM with the aim to reduce human activity and improve the accuracy of measuring. A modular design with standard industrial components of high quality is applied in the realization of the equipment in order to allow a higher reliability and easier maintenance.

**Keywords** - *Railway point machine, signaling interlocking system, force measurements and recording, test list, retention force, trailing force, reliability and maintainability.*

## 1. INTRODUCTION

EPMFM is developed, realized, tested and implemented by the company "Signalling & Control" d.o.o., Belgrade. The equipment is ordered by the Infrastructure of Serbian Railways a.d. (IZS).

EPMFM is meant for measuring point machines' forces after reparations and before reinstallations on sight for IZS.

It represents an inovated solution for handling measuring and recording of the point machines forces, that is based on modern PLC based HMI system in communication with a standard personal computer - PC and using PC operating system and application software (Microsoft Excel).

The basic requirements from the customer are fully implemented and extended in accordance with the ability of the new technology used. Also, user frendly interface with realtime grafics commands and indications are available to the operators.

Real time grafics and final measuring lists, ready for printing and signing and verifying are available on the PC in the sprervisors room.

## 2. THE PURPOSE AND THE APPROACH

EPMFM is realized for the various types of point machines from different producers: Siemens AG - Germany (two types: S-400 and S-700 [1]), AZD - Praha [2] and Sigma, Subotica, Serbia (option) [3]. The relevant feature of the points machines are analyzed, in the view of detection and movement for the force mesuring purposes, are standardized and implemented in the functionality of the EPMFM.

In accordance with the applied approach, it is possible and easier to include additional point machines from different producers and extend functionality of the realized equipment.

Both hardware and software are realized using modularity and commercially available equipment. For the realization of the modules and their functionality, the knowledge in controlling and detecting points machines inside other railway signalling systems, like interlockings, are used. Hence, the hardware and software modules are simplified and standardized and main logic is placed at the HMI PLC.

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Communication between HMI PLC and PC works over the commercial Ethernet. The same real-time graphics are available to both, the operator at the measuring room and the supervisor at the PC room.

The measuring lists are generated and saved at the PC automatically. The supervisor can at the real-time monitor the measuring process and values and take appropriate actions. The saved lists are in the form that is ready for printing. Correctness of the measuring is also implemented automatically, i.e. the incorrect measuring lists are clearly marked with red and bold label "INCORRECT MEASURING".

### 3. ARCHITECTURE OF THE EPMFM

EPMFM consists of three, functionally independent, main parts:

1. HMI command cabinet,
2. Electro-mechanical measuring equipment and
3. PC with a 27 inch monitor and a laser printer.

First two components are placed in the measuring room (working area) that has enough space in the aim to allow handling of bulky and heavy point machines. Layout of stated equipment at measuring room is presented on Figure 1.

PC, monitor and printer are situated at the other room in the same building - supervisors office (office area).

HMI is connected to the three phase isolated power supply with standard flexible power supply five wires cable. With the PC is connected via standard LAN cable and with Electro-mechanical part is connected with three additional flexible cables (two standard power supply 5 wires cables and one separate cable for force sensor).

#### 3.1. HMI command cabinet

HMI control cabinet represent the main part of the EPMFM equipment. IT contains HMI PLC with all necessary IO and communication module, module for measuring values related to three phase power supply with appropriate LED indications, safety protection switch and all other necessary interface equipment. Layout of the front panel of the cabinet is shown on Figure 2.

Complete controlling and monitoring equipment that is placed at the HMI command cabinet is high quality and commercially available. The cabinet has four wheels and it is connected with other parts with flexible cables in the aim to allow easy movement and positioning as required by the operator.

The HMI cabinet has two doors equipped with key locks, as a protection from the unauthorized access. The layout and arrangement of the equipment inside the HMI cabinet is presented on Figure 3.



*Fig.1. Layout of the EPMFM in the measuring room*



Fig.2. Layout of the front panel of EPMFM



Fig.3. Arrangement of EPMFM equipment

### 3.2. Electro-mechanical measuring equipment

Electromechanical measuring equipment is reused and refurbished the existing equipment that is used for an earlier designed force measuring table. It is designed as a mechanically enforced table, which contains the following:

- holder for placement of the point machine,
- three phase motor with a moving lever and the brake for force simulation purposes (the trailing resistance force and the retention force) and
- moving lever with the holder for the placement of the force measuring sensor.

This part originally had the interface group with the interface relays, circuit barkers, transformers, fuses and other interface equipment. The group is removed and replaced with the simple terminals. Its all former functionality is transferred into the HMI command cabinet. Hence, this part is significantly simplified.

### 3.3. PC equipment

PC equipment contains:

- High quality Desk-top PC with windows 10 operating system, standard communication system, Microsoft Excel program and commercial program for communication with HMI command PLC.
- 27 inches FHD monitor with fast response and
- HP A4 laser printer.

This equipment receives real-time data from HMI PLC during the measuring, automatically creates measuring list with graphics and all other necessary information and automatically saves the list with the time stamp after the measuring is finished.

The application software for measuring automatically recognizes correct or incorrect measuring and that data is transmitted to the PC software. Consequently, correct measuring lists are stored without labels and they are ready for the printing and signing and verifying. The lists with the incorrect measuring are clearly marked with a red and bold label "INCORRECT MEASURING". This allows use of these lists for correction of the adjustments of the point machines forces, but, helps in avoiding that an incorrect list get signed and issued. An example of the Measuring list is presented in Figure 4.

## 4. FUNCTIONALITY OF THE EPMFM

EPMFM is realized to cover the detection of the both left and right versions of the point machines, with the detection of the both end positions (normal and reverse) and automatic setup of the power supply phases for the for the direction of throwing.

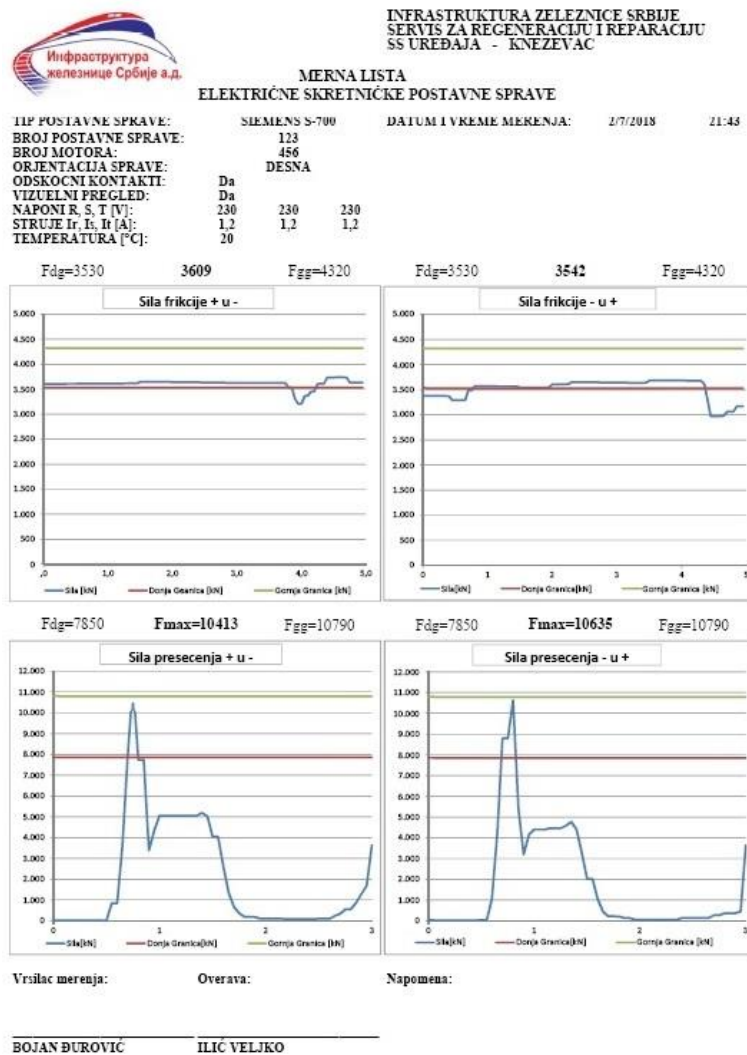


Fig.4. An example of the Measuring list

All general data are already implemented in the software. The data about the particular point machine have to be selected from the first interactive window on the HMI. The rest of the process is automatic.

Three modes of work are implemented: **manual** (separate movement of the point machine and the simulator), **half automatic** (four functions separately: the trailing resistance force for normal and reverse and the retention force from normal and reverse) and **fully automatic** (all four functions in consecutive order with the automatic creation of Measuring list).

For all measuring the equipment uses standard force sensor with the high precision  $< 1\%$  for the range from 0 N to 10.000 N with the short overloading up to 50%. Conversion of the sensor signal to the force value is done by the commercial PLC module specially dedicated for that purpose.

A special feature is implemented to improve accuracy of the measuring and it is practically based on the reset of the measured force from the sensor to 0 immediately before each new measuring phase.

## 5. CONCLUSION

Realized EPMFM is a modern and automatic interactive measuring system with the real-time monitoring of the measuring and the automatic production of the measuring list.

The system is modular and open for the upgrades, so the new types of the points can be easily added.

## ACKNOWLEDGEMENT

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## REFERENCES

- [1] Siemens AG, point machines S-400 and S-700, product documentation, 1969.
- [2] AŽD, Praha, point machinee EP644, product documentation, 2004.
- [3] Sigma Subotica, Skretnička postavna sprava tip 3d.