

# Contributions Regarding the Monitoring in the Command Center of the Anti-Hail Launch Pads

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**Abstract** – This paper describes an Internet-connected radio remote control designed for the positioning system of the launching pad of anti-hail missiles used by the Romanian Anti-Hail System. The remote control works on the ISM band of 433 MHz and was successfully tested on a small size experimental model of the launch pad. The azimuth and elevation position can be locally controlled by the operator, with the possibility of monitoring and even controlling the launch pad from the Command Center, over the Internet. The remote control uses a touch screen display on the operator side and a PLC connected to the launch pad. The commands on the touch screen are grouped into three pages: manual positioning, automatic positioning, and a list of recorded events. Sending the coordinates to the launch pad and firing the missiles are considered events, automatically recorded on an SD card or USB flash drive attached to the remote control. Communication between the touch screen and the PLC is realized by two RF transceivers using LoRa modulation. The touch screen display is connected to the Internet, making it possible to remotely monitor and control the launch pad using an Internet-connected computer. The access to the remote control is password protected and can be disabled by the local operator.

**Cuvinte cheie:** telecomandă, anti-grindină, PLC, ecran tactil, lansator de rachete, sistem de poziționare, ISM, LoRa.

**Keywords:** remote control, anti-hail, PLC, touch screen, missiles launch launch pad, positioning system, ISM, LoRa.

## I. INTRODUCTION

This research is intended to overcome a problem found when the authors visited an anti-hail Zonal Command Center and an anti-hail Local Unit. It has been found that the launching launch pads used by the anti-hail system in Romania are positioned manually, or using temporary cables, with no possibility to monitor the launch pad position from the Command Center [1], [2], [3].

The technical solution described in this paper speeds up the launch pad positioning, eliminates the need for the temporary cables, and makes possible monitoring and controlling the launching launch pad over the Internet.

## II. THE REMOTE CONTROL

The remote control works on a two ways radio communication channel between the touch screen and the PLC, using AS32-DTU-100 RF transceivers. A 178 mm touch screen is used by the operator to send commands to the launch pad, and to display the launch pad position and the presence and type of the missiles on the launch pad (Fig. 1).

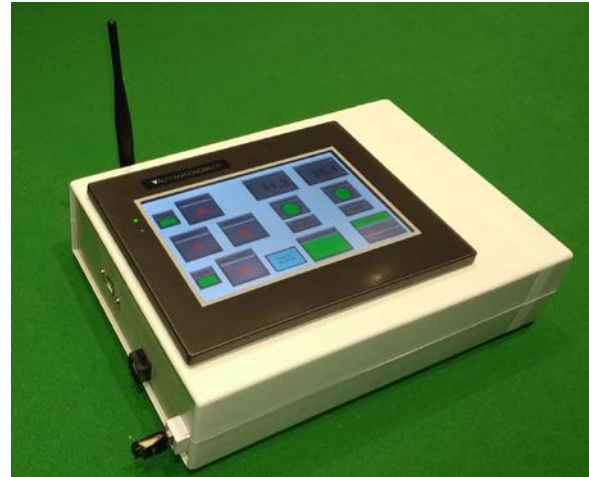


Fig. 1. The remote control

The electrical block schematic of the remote control is shown in Fig. 2.

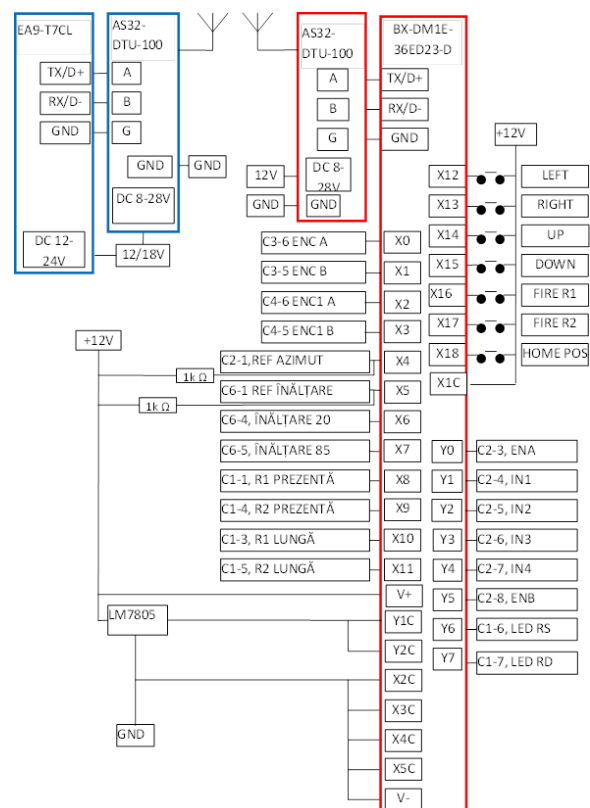


Fig. 2. The remote control block schematic

The commands entered by the operator on the touch screen are grouped into three pages of the screen:

- manual positioning,
- automatic positioning, and
- list of events produced.

The manual controls screen is shown in Fig. 3.

The operator holds the arrow labeled buttons until the desired position of the launch pad is reached. The presence and type of the missiles loaded are displayed on the touch screen, along with the azimuth and elevation coordinates.

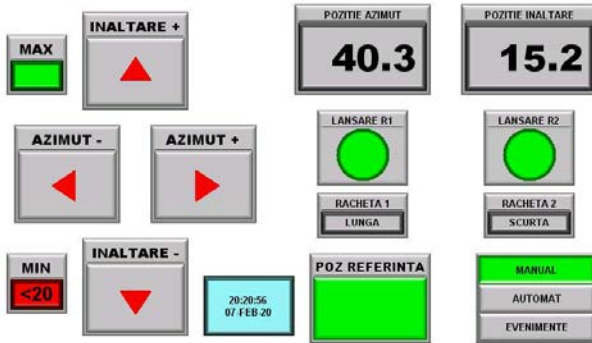


Fig. 3. The manual positioning controls screen

The automatic positioning screen is shown in Fig. 4.



Fig. 4. The automatic positioning screen

From this screen, the operator can prescribe the azimuth and elevation coordinates for the launch pad using a virtual keyboard that pops up on the touch screen when the azimuth or elevation prescribing buttons are depressed. After sending the coordinates, the launch pad moves automatically to the desired position.

The remote control is provided with SD card and USB memory ports. The third screen shows a list of events recorded on the external memory. The positioning of the launch pad using the "SEND COORDINATES" button and the missile launch are recorded as events, with a time stamp.

### III. MONITORING THE LAUNCH PAD OVER THE INTERNET

For the launch pad monitoring in the Control Center, we proposed to connect the remote control to the Internet,

and we used, for this purpose, the Ethernet port of the EA9-T7CL touch screen is provided.

Monitoring the remote control involves, in addition to connecting to the internet, certain settings on the touch screen, as well as on the PLC and the router used by the touch screen to connect to the internet:

- Setting the IP address and DNS server for the touch screen, by accessing the Setup - Panel Network - Ethernet Port menus in the touch screen software.
- Setting the same IP address and DNS server for the PLC, by accessing the PLC menus - System Configuration - Internal Ethernet Port in the PLC software program.
- Activating the Web Server application by accessing the Setup - Panel Network - Web Server menus from the touch screen software.
- Activating the Remote Access application by accessing the Setup - Panel Network - Remote Access menus in the touch screen software program.
- Setting dedicated ports (80 for the Web Server application, respectively port 11102 for the Remote Access application) in the Port Forwarding menu of the router. These ports are suggested by the touch screen software program but are not mandatory.

To connect to the touch screen using a computer, a remote user only needs the public internet address of the touch screen, respectively the public IP of the router to which the touch screen is connected, the account username and the password. No other software is required, an ordinary internet browser is used.

After typing the touch screen public IP address in the browser, the main screen of the "Web Server" app shows up (Fig. 5).

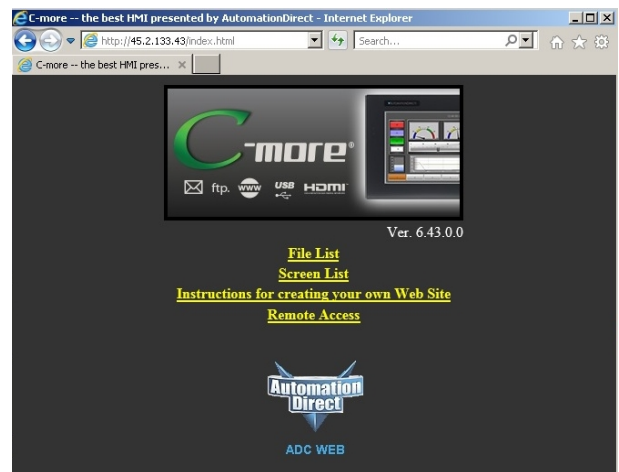


Fig. 5. The main screen of the "Web Server" app

When accessing the "File List" link, a web page opens with the events recorded in the external memory of the remote control (SD card or USB flash, according to the settings used), grouped in text documents created daily.

The "Screen List" link opens a web page from which the remote control screens can be viewed (manual

positioning commands, automatic positioning commands, and recorded events).

The launch pad control is performed using the “Remote Access” application, included in the program loaded in the remote control. Accessing this application is done with the "Remote Access" link from the main screen of the Web Server application.

When accessing the "Remote Access" link, the main screen of the application opens (Fig. 6).

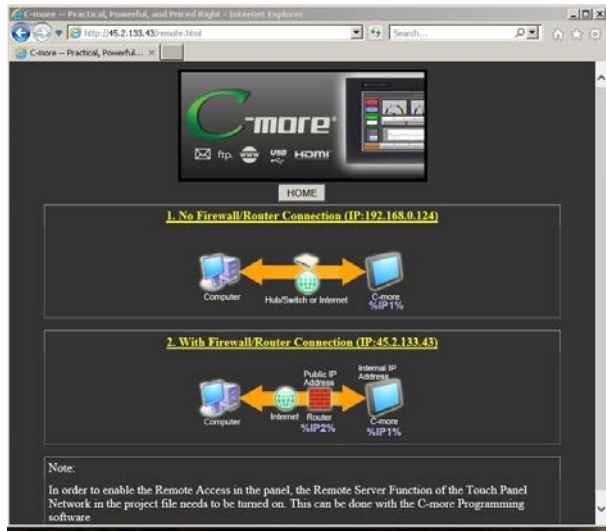


Fig. 6. Remote launch pad control using “Remote Access” app

In order to control the launch pad in the Command Center, the user must choose the connection option no.2, the one that involves the existence of a router. Option 1 can be used in a local network only.

Accessing the link has the effect of downloading the RemoteHMI\_IP executable program, with the possibility of saving or running it on your computer. Saving this program, possibly with a shortcut on the desktop, makes it easier to use the Remote Access application later, in the future it is no longer necessary to go through the Web Server application. When running the application, after entering the account username and password, the image of the remote control touch screen shows in the internet browser. Using a mouse, the launch pad can be controlled as if the commands were performed locally on the touch screen (Fig. 7).

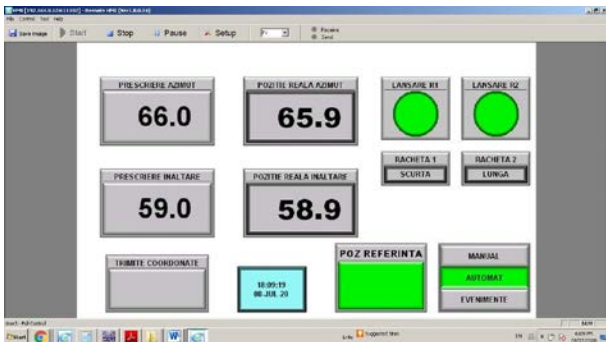


Fig. 7. RemoteHMI\_IP app screen

## V. CONNECTION TO THE LAUNCH PAD

The launch pad azimuth and elevation positioning are achieved by using two permanent magnet synchronous motors, provided with worm gears and incremental encoders, and driven by electrical drives (Fig. 8) [4], [5].



Fig. 8. Elevation motor and drive mounted on the ramp [4]

The PLC connected to the experimental model can be connected to the launch pad drives with minor adjustments:

- all the PLC terminals connected to 0V (GND) on the experimental model will be connected to the 0V control terminal on both drives
- terminals X0-X3 connected to the encoder outputs on the experimental model will be connected to the encoder outputs on the drives, using the buffered encoder output connectors. Ground terminal on the buffered output connectors on both drives will be connected.
- terminal X1C, connected to +12V on the experimental model, will be connected to +V terminal on the buffered encoder output on one drive
- Terminals Y0, Y1 and Y2 connected to ENA, IN1 and IN2 on the experimental model will be connected to control terminals DRIVE ENABLE, RUN FORWARD and RUN REVERSE on the drive used for azimuth positioning
- Terminals Y3, Y4 and Y5 connected to IN3 and IN4 and ENB on the experimental model will be connected to control terminals RUN FORWARD, RUN REVERSE, and DRIVE ENABLE on the drive used for elevation positioning
- an additional digital I/O module will be attached to the PLC, since the experimental model simulates the launch of two missiles, and the launch pad can carry eight missiles
- the PLC program and the local controls panel will be modified for eight missiles
- one constant in the PLC program will be modified, on each axis, to reflect the difference in the number of pulses the encoders provide for one degree of rotation of the launch pad.

## VI. CONCLUSION

The 433 MHz Internet connected remote control is a technical solution that overcomes two challenges of the anti-hail launch pads operation: the use of temporary cables for the launch pad positioning and the lack of monitoring the launch pad from the Command Center. The remote control and its monitoring over the Internet were tested on an experimental model build for this purpose. The implementation of the remote control on the real launch pad can be done with minimal modifications of the equipment used.

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Contribution of authors:

First author – 90%

First coauthor – 10%

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