

## DIGITALLY CONTROLLED CEREAL TRANSPORTER

### BANDĂ RULANTĂ PENTRU CEREALE COMNDATĂ DIGITAL

Flaviu Mihai FRIGURĂ-ILIASA<sup>1</sup>, Sorin BUNGESCU<sup>2</sup>

<sup>1</sup>*POLITEHNICA University of Timișoara, Romania, Faculty of Electrical Engineering,*

<sup>2</sup>*BANAT's University of Agricultural Sciences and Veterinary Medicine Timișoara  
V.Parvan Bvd, 300223 Timișoara, flaviu.frigura@et.upt.ro, tel/fax: +40-256-403413*

**Abstract:** Digital control made by using PLC's (Programmable Logic Controllers) is today the most common technical solution applied to industrial command circuits, due to some obvious advantages like simplicity, flexibility, liability and no maintenance. This paper presents an original technical solution concerning that type of command used for all electrical equipment used on a classic conveyor sequence in agriculture, based on a Möeller PS4 industrial PLC.

**Rezumat:** La ora actuală, cea mai utilizată soluție tehnică pentru realizarea circuitelor de comandă digitale ale aplicațiilor industriale se bazează pe implementarea la scară largă a automatelor programabile-PLC (Programmable Logic Controllers), din cauza unor avantaje evidente, cum ar fi simplitate, flexibilitate, fiabilitate și întreținere redusă. Această lucrare prezintă o soluție tehnică originală pentru comanda unei benzi rulante pentru aplicații în agricultură, bazată pe automate programabile Möeller PS4.

**Key words:** Digital Control, Cereal Transporter;

**Cuvinte cheie:** Control digital, Bandă rulantă pentru cereale;

#### INTRODUCTION

During the last few years we assist to an increased number of command equipments based on PLC's. PLC's (Programmable Logic Controllers) are today the most common technical solution applied to such equipments due to some obvious advantages:

- the electrical scheme of the whole equipment could be easily modified by changing only some program instructions;
- increased flexibility;
- safety in exploitation;
- improved liability;
- reduced volume;
- it not requires special and periodical maintenance;
- it could be easily programmed by any electrical engineer or technician;
- any command sequence could be virtually verified without any costs or risks.

When the price of all classic electrical equipment replaced is higher than PLC's price, this piece of equipment becomes even economically justified, being cheaper than the old parts changed [2].

In fact, a PLC is a small industrial computer specialised in simultaneously treatment of both combinational and sequential logic instructions. It is a equipment which allows connections between a large number of inputs and another large number of outputs.

It simulates the classical wire structure by using logical ports disposed in a flexible and complex structure.

Figure 1 shows us such a PLC type PS4-201 MM1 produced by the German manufacturer Klöckner MOELLER, belonging to the Low Voltage Equipment Laboratory of the POLITEHNICA University of Timisoara.



Figure 1. The PS 4-201 MM1 PLC basic type

This piece of equipment has 6 digital inputs (marked with an A) and 8 digital outputs (marked with a C). All digital inputs and outputs are 24 V DC and maximum current of 100 mA. This current allows enough power to command a semiconductor device, relay or micro-contactor connected to that output [2], [3].

It also disposes of two analogical inputs and one analogical output all offering an array of 0 - 12 V DC at maximum 100 mA.

This PLC disposes of a serial RS 232 communication port which allows program downloading from an external program source (PC or panel). It also has a RS 485 serial communication connector used for PLC connections and an extension module connector for multiplying all the inputs and outputs needed. According to IEC 1131-3, it accepts all languages compatible with:

- **IL** (Instruction list);
- **LD** (Ladder Diagram);
- **FBL** (Function Block Language).

### CONVEYOR BAND PANEL DESCRIPTION

Figure 2 shows the main application panel for this conveyor band sequence.

As we notice in Figure 2, this panel refers to an agricultural conveyor band sequence made of 3 different segments called **Band1**, **Band2**, **Band3**, each of them driven by a squirrel-cage induction motor. Those engines are directly connected to the power supply network by using 3 main contactors called **K1**, **K2** și **K3**,

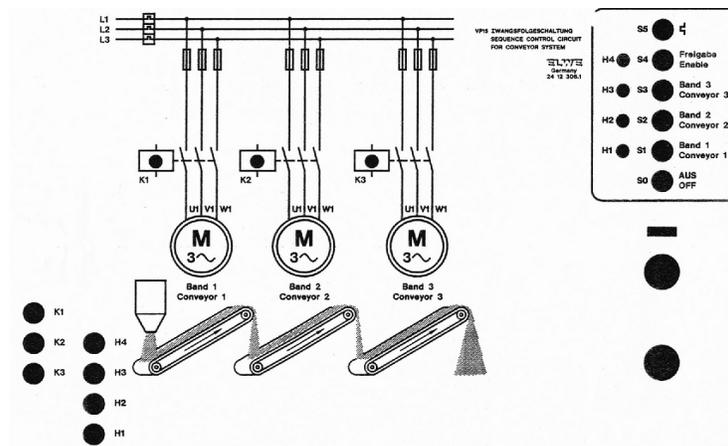


Figure 2. Conveyor band sequence. Command and control panel.

The cereal grains are loaded on the first conveyor segment in order to be transported to the storage area at the end of the third segment. The proper functioning of the 3 contactors is shown by 3 LED's located on the panel. On the up-right corner of the same panel, there is a button set used to activate all PLC inputs (process outputs). They are:

- **S0** is the STOP button;
- **S1** is the button used to start the first segment in manual mode;
- **S2** is the button used to start the second segment in manual mode;
- **S3** is the button used to start the third segment in manual mode.
- **S4** is the start button for the automatic sequence.
- **S5** is the button reserved to simulate a fault caused by an overload.

There are 4 other LED's located in the same area:

- the **H1** LED indicates the appropriate operation of **Band 1**, no matter manual or automatic mode.
- the **H2** LED indicates the appropriate operation of **Band 2**, no matter manual or automatic mode.
- the **H3** LED indicates the appropriate operation of **Band 3**, no matter manual or automatic mode.
- the **H4** LED indicates the appropriate operation of all equipment in automatic mode. When it flickers, a fault is detected.

#### CONVEYOR BAND COMMAND SEQUENCES

The command algorithm is, as follows:

- The conveyor band sequence starts automatically when pressing the **S4** button. Automatically mode selection is confirmed by the **H4** LED.

✓ Then, after 2 seconds (time for feeding the start point with cereal grains), the first segment, **Band 1**, starts by activating the **K1** contactor. This situation is indicated by the **H1** LED showing the operational status of the first engine.

✓ After 5 seconds from **Band 1**'s start through the **K1** contactor, (the necessary time for all cereals to pass through that segment), the second segment will be activated, through the **K2** contactor. The function status of the **K2** contactor is indicated by the **H2** LED.

✓ After another 5 seconds from **Band 2** through **K2**, (the necessary time for all cereals to pass through that segment), the third segment will be activated, through the **K3** contactor. The function status of the **K3** contactor is indicated by the **H3** LED.

✓ During service, for each segment, **K1**, **K2**, **K3** and **H1**, **H2**, **H3**. LED's will rest on. The **H4** LED will indicate automatic mode selection.

- **Band 1**, starts independently from the others (in manual mode) when pressing the **S1** button. The **K1** contactor will be connected as well as the corresponding LED indicator **H1**.

- **Band 2**, starts independently from the others (in manual mode) when pressing the **S2** button. The **K2** contactor will be connected as well as the corresponding LED indicator **H2**.

- **Band 3**, starts independently from the others (in manual mode) when pressing the **S3** button. The **K3** contactor will be connected as well as the corresponding LED indicator **H3**.

- Those operations are not permitted when the automatic mode selected. One, two and even all three conveyor band segments could operate simultaneously during manual mode, depending on the command needs.

- All equipment stops when the **S0** button is pressed, no matter the operational mode.

✓ If the automatically mode is selected, all engines running at that time will be disconnected through the **K1**, **K2**, **K3** contactors. The corresponding LED's **H1**, **H2**, **H3** and, obviously, **H4** will be shut off.

- ✓ If the manual mode is selected, all engines running at that time will be disconnected through their dedicated contactors. The corresponding LED's will be shut off.
- ✓ Overload simulation is made by pressing the **S5** button.
- ✓ That fault could occur no matter automatically or manual mode is active.
- ✓ All segments running will be shut down. The corresponding LED's will be shut off, as well as, of course, all active contactors.
- ✓ The **H4** will blink during 15 seconds, time needed for short engine and relay cooling, indicated fault mode.
- ✓ No re-connections are permitted during this period.
- ✓ After 15 seconds manual or automatically mode selection is permitted.

After describing all functional requirements for the conveyor band, the necessary command program write into the **Sucosoft S40** dedicated language, which does all those operations through the PLC, is shown below.

```

VAR (variable declaration section)
K2 AT %Q0.0.0.0.2 : BOOL ;
K1 AT %Q0.0.0.0.1 : BOOL ;
K3 AT %Q0.0.0.0.3 : BOOL ;
S1 AT %I0.0.0.0.1 : BOOL ;
avarie : TP ;
stav : BOOL ;
p1 : TP ;
p2 : TP ;
p3 : TP ;
timp1 : TIME := t#2s ;
timpav : TIME := t#15s ;
timpsem : TIME := t#0.5s ;
nosemn : TP ;
S2 AT %I0.0.0.0.2 : BOOL ;
S3 AT %I0.0.0.0.3 : BOOL ;
S0 AT %I0.0.0.0.0 : BOOL ;
S4 AT %I0.0.0.0.4 : BOOL ;
S5 AT %I0.0.0.0.5 : BOOL ;
stpor1 : BOOL ;
stpor2 : BOOL ;
stpor3 : BOOL ;
timp2 : TIME := t#5s ;
timp3 : TIME := t#5s ;
semn : TP ;
stsemn : BOOL ;
stnosemn : BOOL ;
man1 : BOOL ;
avarie : TP ;
stav : BOOL ;
p1 : TP ;
p2 : TP ;
p3 : TP ;
po1 : BOOL ;
auto : BOOL ;
oprire : BOOL ;
H1 AT %Q1.1.0.0.1 : BOOL ;
H2 AT %Q1.1.0.0.2 : BOOL ;
H3 AT %Q1.1.0.0.3 : BOOL ;
H4 AT %Q1.1.0.0.4 : BOOL ;
man2 : BOOL ;
man3 : BOOL ;
END_VAR

Main program section
ld S4 st stav
r oprire cal
ld S4 semn(in:=stsemn,pt:=timpsem)
andn avarie.q ld S1
s H4 r auto
s auto r H4
st stpor1 r oprire
cal p1(in:=stpor1,pt:=timp1) ld S1
ldn p1.q andn avarie.q
and auto andn auto
andn oprire andn oprire
andn avarie.q s k1
s k1 s H1 s man1
st stpor2 ld S2
cal p2(in:=stpor2,pt:=timp2) r auto
ldn p2.q r H4
and auto r oprire
andn oprire ld S2
andn avarie.q andn avarie.q
and k1 andn auto
s k2 andn oprire
s H2 s k2
st stpor3 s H2
cal p3(in:=stpor3,pt:=timp3) s man2
ldn p3.q ld S3
and auto r auto
andn oprire r H4
andn avarie.q r oprire
    
```

and	k1	ld	S3
and	k2	andn	avarie.q
s	k3	andn	auto
s	H3	andn	oprire
ld	S0	s	k3
s	oprire	s	H3
ld	oprire	s	man3
and	auto	ld	S0
r	k1	s	oprire
r	k2	ld	oprire
r	k3	and	man1
r	H1	r	H1
r	H2	r	k1
r	H3	ld	oprire
r	H4	and	man2
ld	S5	r	H2
st	stav	r	k2
st	stsemn	ld	oprire
s	oprire	and	man3
r	k1	r	H3
r	k2	r	k3
r	k3		
r	H1		
r	H2		
r	H3		
r	H4		
cal	avarie(in:=stav,pt:=timpav)		
cal	semn(in:=stsemn,pt:=timpsem)		
ld	avarie.q		
and	semn.q		
s	H4		
ld	avarie.q		
andn	semn.q		
r	H4		
st	stnosemn		
cal	nosemn(in:=stnosemn,pt:=timpsem)		
ld	avarie.q		
andn	nosemn.q		

### CONCLUSIONS

PLC's are fully recommended for command and control of such equipment located in agricultural areas. A small program sequence introduced to a PLC could replace many electrical apparatus involved in a classic scheme, reducing command equipment costs.

It could increase safety and liability of all pieces involved at a lower maintenance cost, with interchanging possibilities. No major changes have to be made in the command scheme in order to apply this technical solution. The program sequence could be easily verified virtually. It is totally suitable for agriculture equipment due to the simplicity of operation process too.

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