

Integration of automatic visual solder joint inspection in automotive components assembly system

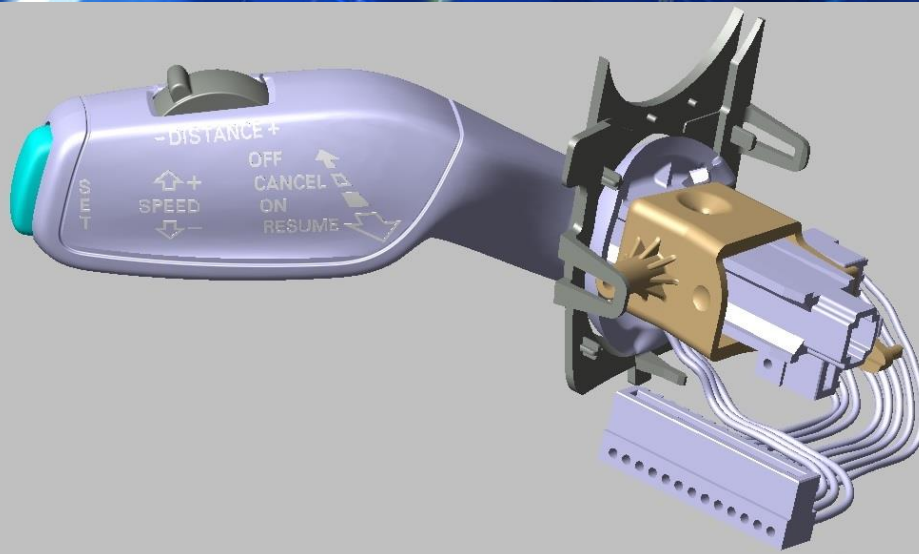
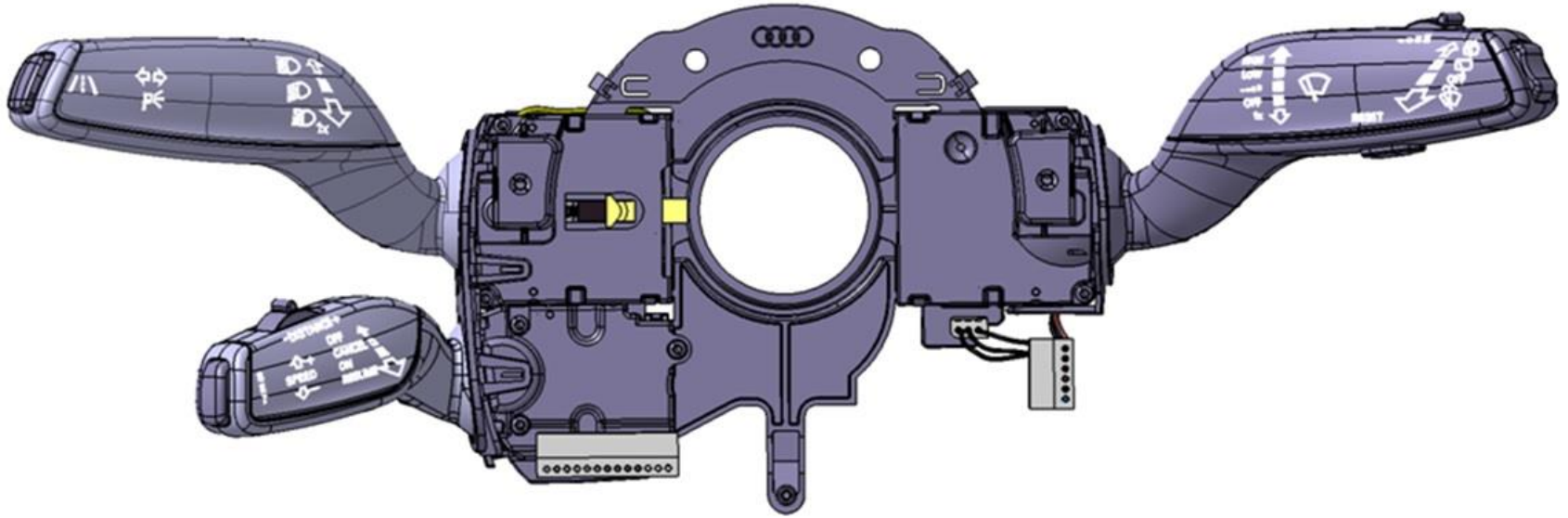
Radoslav Bukov

Product range of the company

Various control panels of electrical equipment in the automobile.



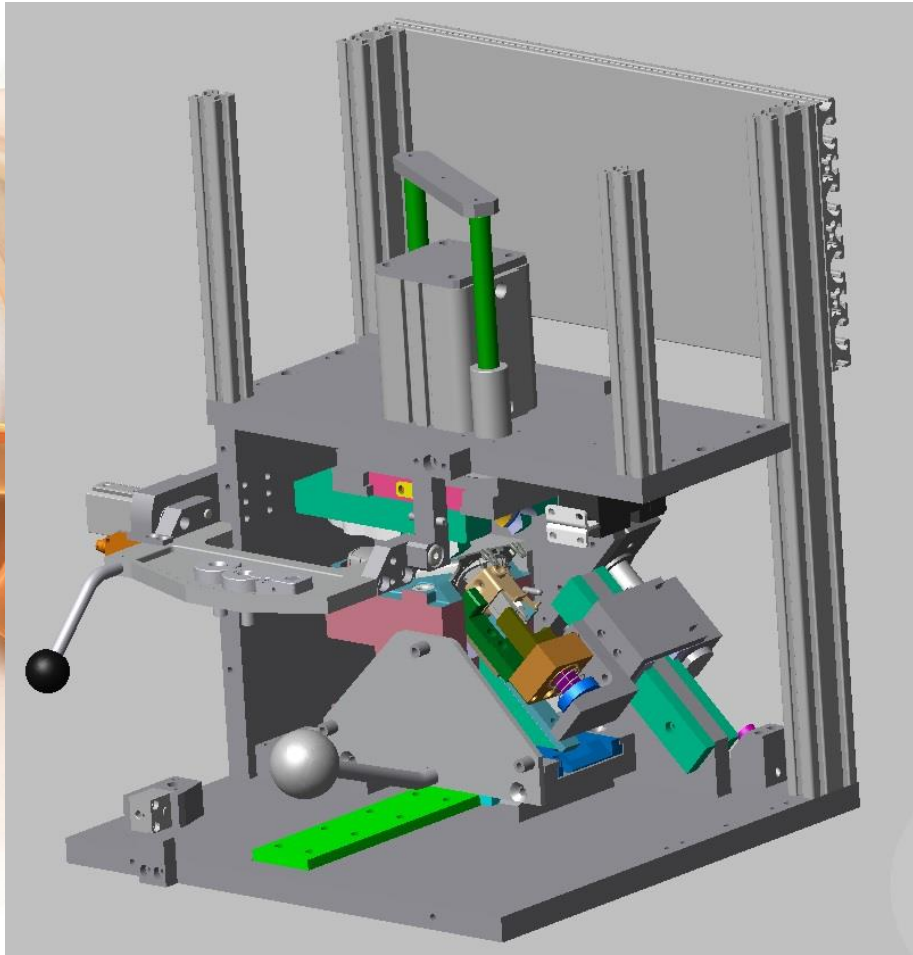
Under steering wheel module - AUDI



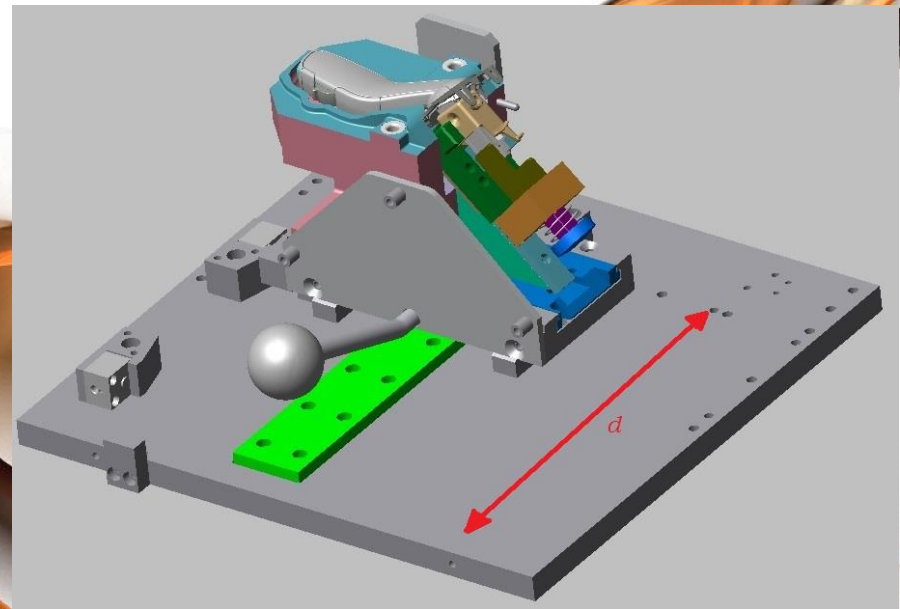
The lever GRA - it is managed automatic speed control and tracking distance of the front car.

Assembly station

Assembly all components of the speed levers.

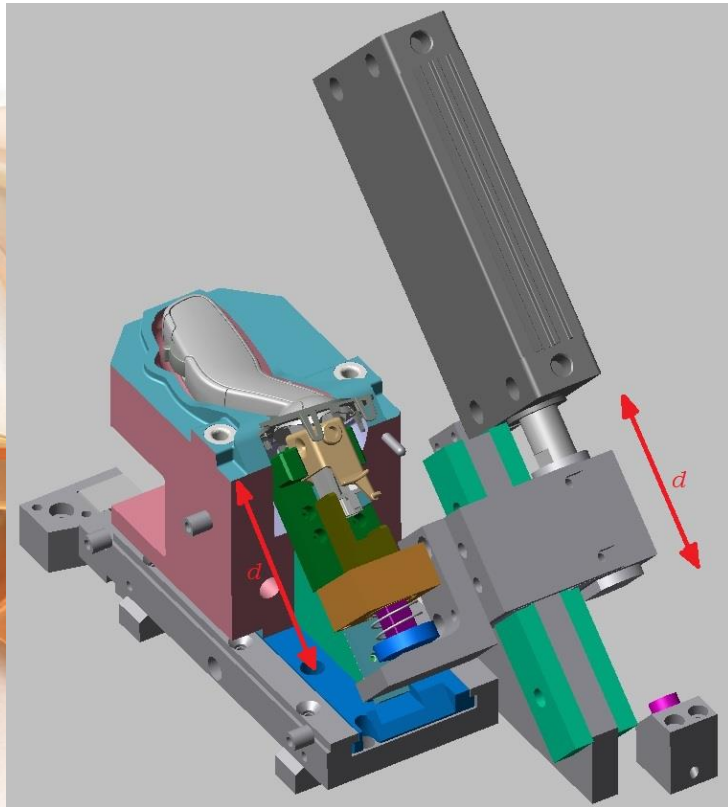


3D model of the system



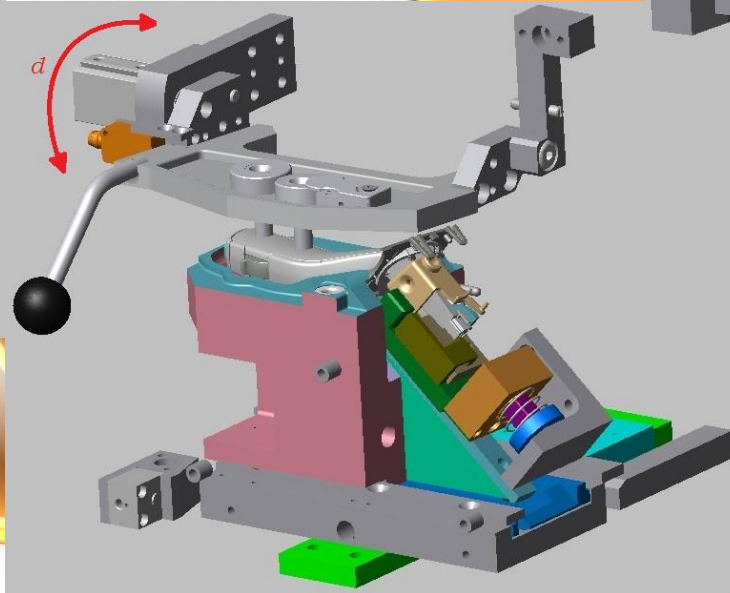
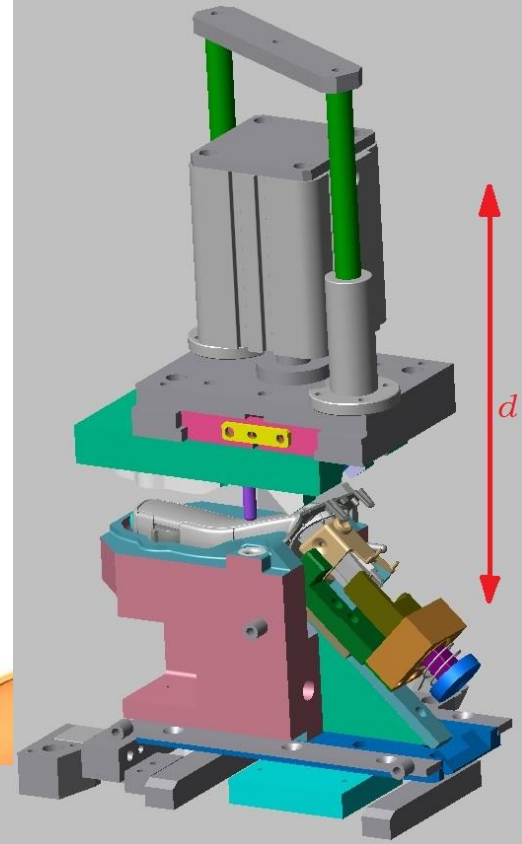
Two basic work condition:

Basic working state:



Assemble position of the handler to the base.

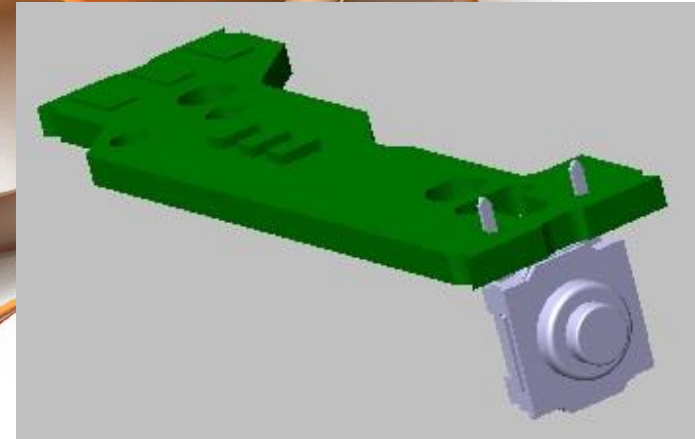
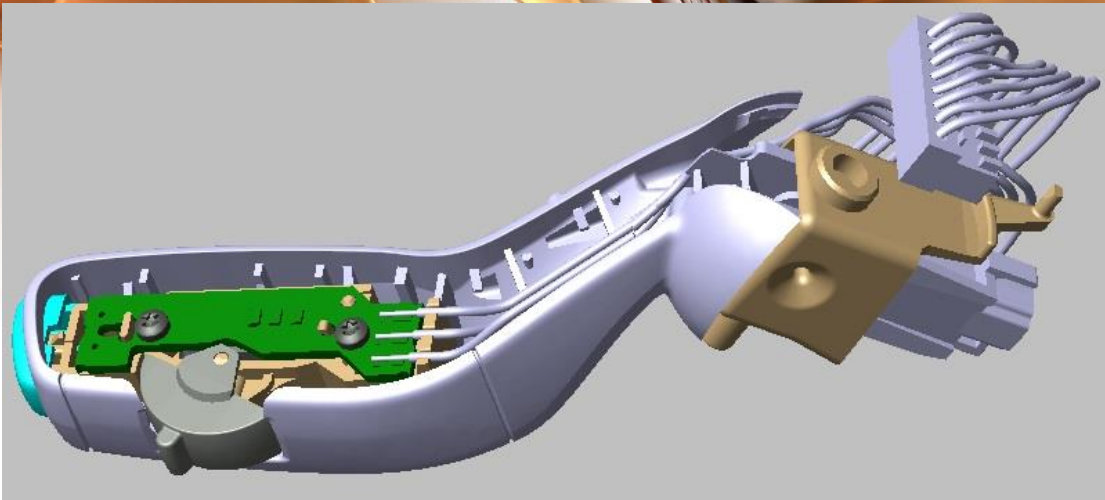
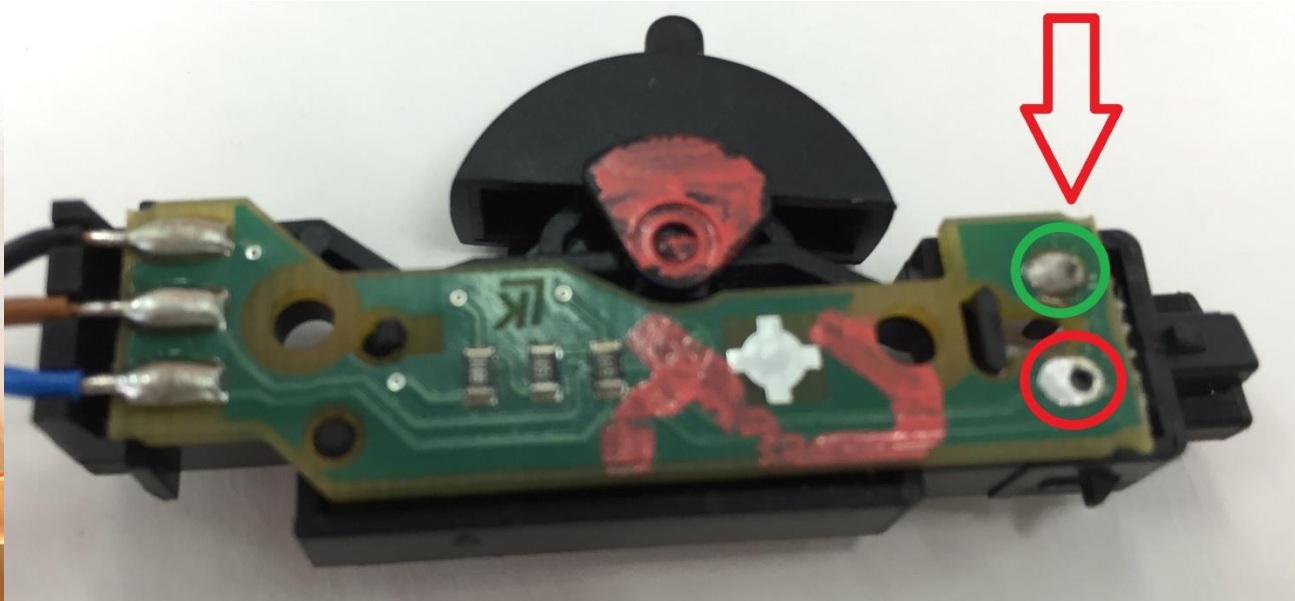
Assemble position of the top cover to the base.



Screwing position of the trager to the main.

Customer Claim – missing soldering

Successfully passed electrical test and send to the customer:



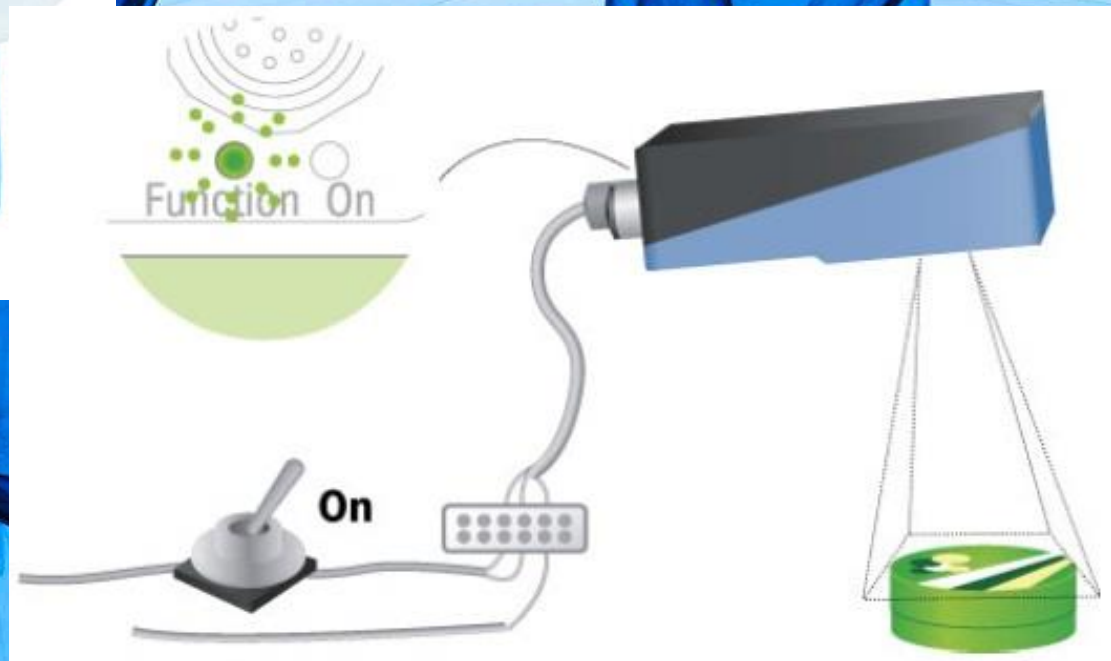
Problem solving

Integrating a visual inspection system is one of the few solutions that can guarantee stability in the production process, due to the specificity of the solder.



The selection of the visual sensor was made after carrying out tests with:

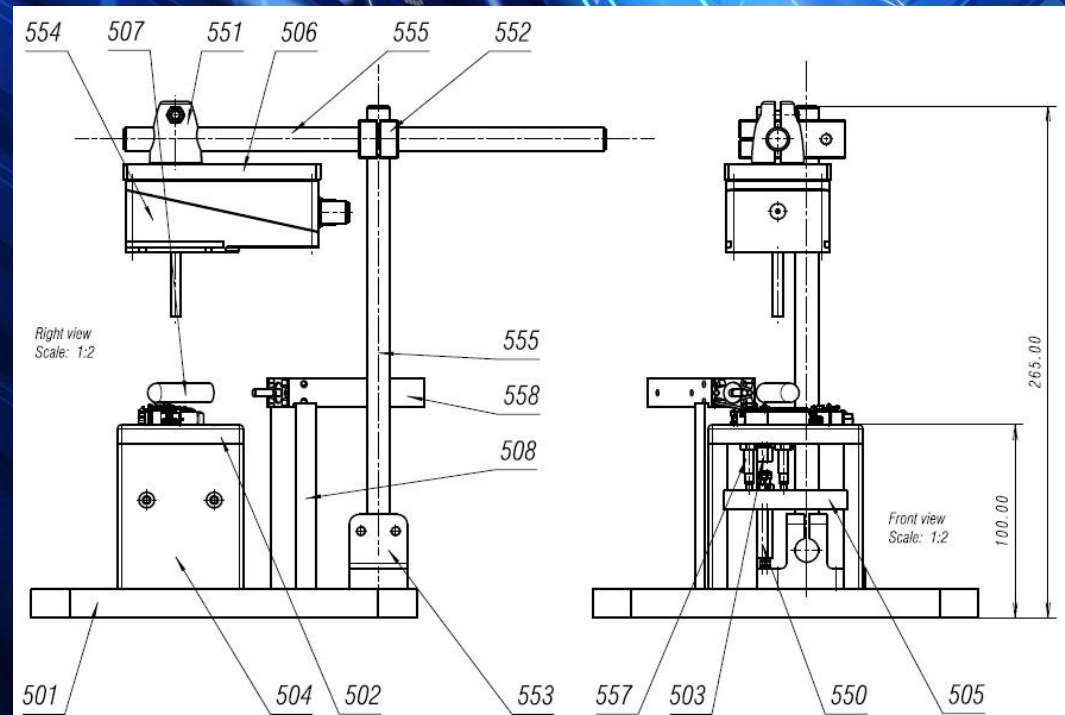
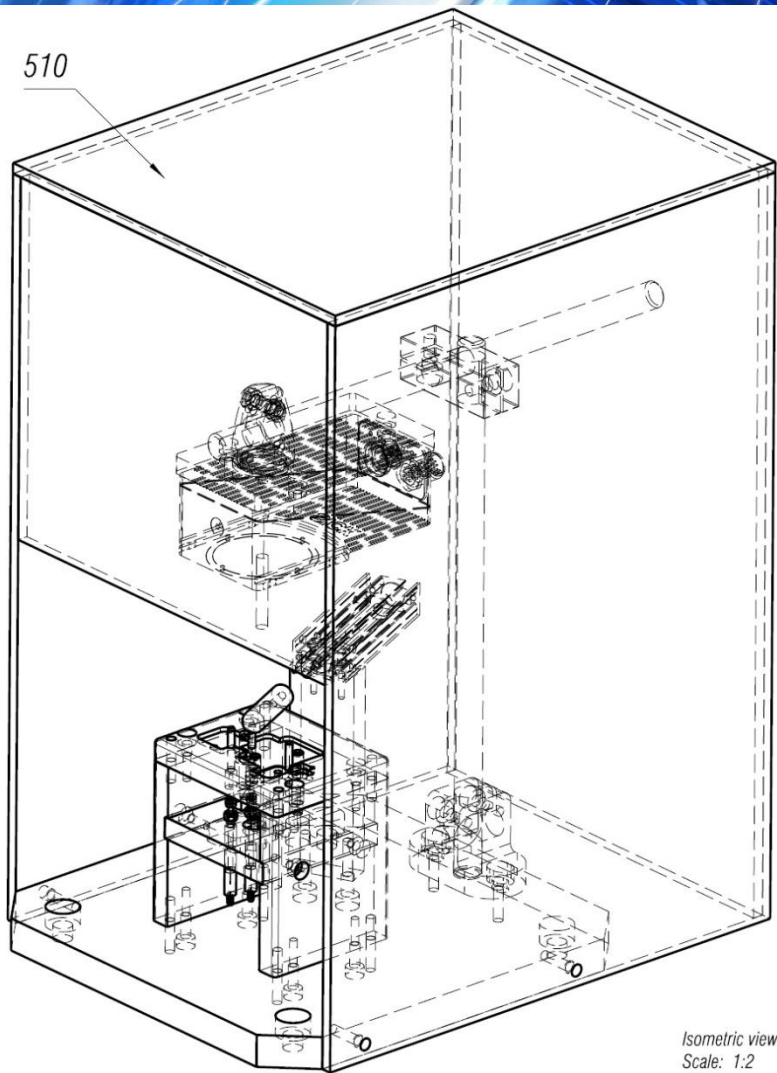
- Sick
- Cognex
- Keyence RGB



New station project:

Due to the impossibility of performing the visual inspection at the existing station.

- Executive mechanisms
 - Pneumatic cylinder
- Sensors
 - Part present
- Red box



Setting of Visual inspector

A pixel counting tool is used to inspect the object in detail. The main consideration of the setup is the impossibility of guaranteeing uniform spillage of the tinol.

The screenshot displays the Visual Inspector software interface. The main view shows a grayscale image of a mechanical part with a blue bounding box and yellow and green pixel counting overlays. The interface includes a top menu bar with 'Main view', 'Run', 'Edit', and 'Reference objects'. The 'Run' button is highlighted. The 'Reference objects' section shows a small image of the object and the label '<Object 1>'. The main image area shows the object with a blue bounding box and yellow and green pixel counting overlays. The 'Image settings' panel on the right shows 'Object locator' and 'Detailed inspections'. The 'Detailed inspections' panel shows two pixel counters: '<Pixel counter 1>' and '<Pixel counter 2>'. The 'Name' field for '<Pixel counter 1>' is set to '<Pixel counter 1>'. The 'Type' is set to 'Pixel counter'. The 'Masks' section shows 'No masks'. The 'Intensity range' is set to '122 - 255'. The 'No. of pixels in range' is set to '844 - 1311'. The 'Output settings' panel shows 'Results' and 'Status & Statistics'. The bottom status bar shows '(NoName)', '169.254.86.25:2112', 'online', 'synchronized', and 'Download Immediately'.

Image settings
Object locator
Detailed inspections

<Pixel counter 1>
<Pixel counter 2>

Name: <Pixel counter 1>
Type: Pixel counter
Masks: No masks
Intensity range: 122 - 255
No. of pixels in range: 844 - 1311

Output settings
Results
Status & Statistics

Frame rate: 19.6 Hz
Minimum delay time: 67.6 ms

(NoName) 169.254.86.25:2112 online synchronized Download Immediately

Settings of output signals

The screenshot shows the 'Output expression editor' dialog box with two instances. The top instance is for 'CheckOK' and the bottom instance is for 'Check NOK'. Both instances show the 'Reference objects' as '<Object 1>' and the 'Expressions' as 'CheckOK' and 'Check NOK'. The 'Edit expression' section shows the 'Name' as 'CheckOK' and 'Check NOK' respectively. The 'True if' section shows the condition '<Pixel counter 1>' AND '<Pixel counter 2>' for 'CheckOK' and '<Pixel counter 1>' OR '<Pixel counter 2>' for 'Check NOK'. The 'pass' and 'fail' buttons are visible for each condition.

Output expression editor

Reference objects: <Object 1>

Expressions: CheckOK, Check NOK

Help: Here you can create your own expressions: Add a new expression to the Expressions list. Edit your expression by selecting the inspection(s) that should be included. Press OK. Expressions are mapped to output signals in the "Output settings" tab.

Edit expression

Name: CheckOK

True if: <Pixel counter 1> AND <Pixel counter 2>

pass fail

Output expression editor

Reference objects: <Object 1>

Expressions: CheckOK, Check NOK

Help: Here you can create your own expressions: Add a new expression to the Expressions list. Edit your expression by selecting the inspection(s) that should be included. Press OK. Expressions are mapped to output signals in the "Output settings" tab.

Edit expression

Name: Check NOK

True if: <Pixel counter 1> OR <Pixel counter 2>

pass fail

OK Cancel Apply

Image settings

Object locator

Detailed inspections

Output settings

Output	Expression
Out 1	CheckOK
Out 2	Check NOK
Out 3	All passed
Ext 1	Detail failed
Ext 2	Not used
Ext 3	Not used
Ext 4	Not used
Ext 5	Not used
Ext 6	Not used
Ext 7	Not used
Ext 8	Not used
Ext 9	Not used

Edit expressions...

Out 1:

Delay: Minimum (67.6 ms)

Fixed: 0.0 ms

Active: Hold until result changes

Fixed: 0.1 ms

Invert output signals

Results

Status & Statistics

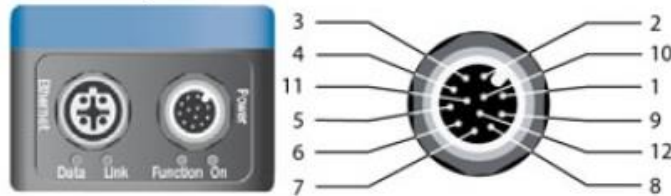
Settings of main 3 signals:

- CheckOK
- Check NOK
- Not located

Electrical connection with PLC

The communication between the visual inspector and the PLC is carried out by means of digital I/O signals:

Power In/Out



Inspector connector pinning - Power In/Out, 12 pin, M12 connector

Pin	Color*	Signal	Signal description
1	Brown	Power	24 V power supply
2	Blue	GND	Ground 0V
3	White	In3	Image trigger + External object selection (24 V)
4	Green	Out1	Output 1 - Object not located (B-type)
5	Pink	In2	External teach + External object selection (24 V)
6	Yellow	Out2	Output 2 - Inspection failed (B-type)
7	Black	Out3	Output 3 - All pass (B-type)
8	Gray	In1	External object selection (24 V)
9	Red	Ext trigger	External trigger, external illumination, (5 V TTL)
10	Violet	In4	Encoder + External object selection (24 V)
11	Gray/pink	TRB	Reserved
12	Red/blue	TRA	Reserved

* Colors are valid for cable type DOL-1212-G02MA/G05MA.

PLC Programming

PLC - Beckhoff with TwinCAT programming environment and ST programming language.
Registering the required I/O signals:

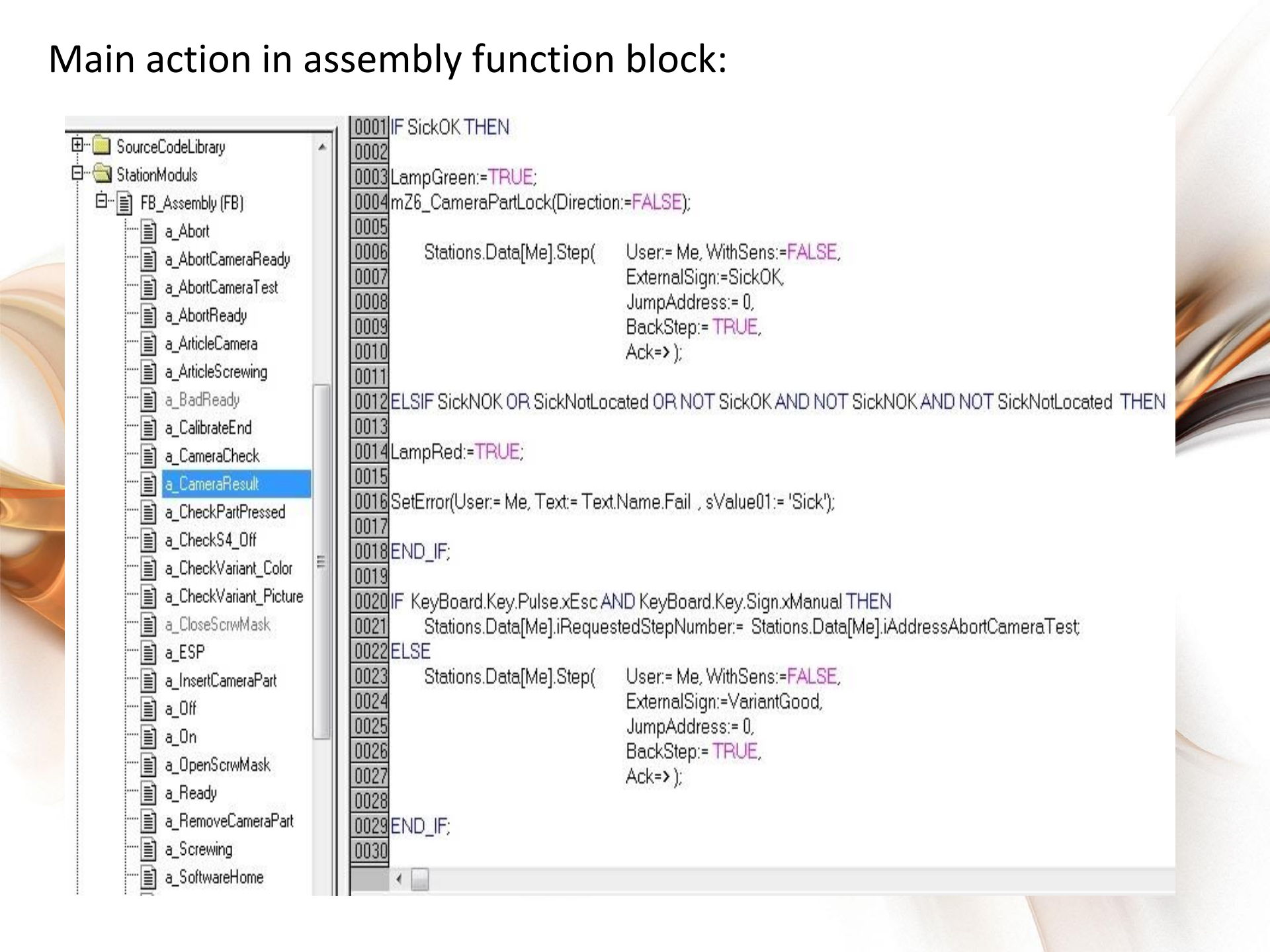
The screenshot displays the TwinCAT programming environment. On the left, the 'Resources' panel shows a tree structure with 'Global Variables' and 'Variables_Konfiguration (VAR_CONFIG)' highlighted. The main area shows a list of I/O signals, with two groups highlighted by red boxes. The first group includes signals from 'Assembly.Sz2b_SliderUp' to 'Assembly.Sz5b_ScrwMaskLock'. The second group includes signals from 'Assembly.Z6B_CameraPartLock' to 'Assembly.SickTrig'. The bottom status bar shows the loading of libraries 'C:\TwinCAT\PLC\LIB\TcComPortBX.lbx' and 'C:\Users\bukov01\Desktop\Дипломна работа 2\System\PLC\Program Built 12_11_2015\Lib\SerialInt'.

Address	Signal Name	Signal Type
0025	.Assembly.Sz2b_SliderUp	AT %IX2.1 : BOOL;
0026	.Assembly.Sz5a_ScrwMaskUnlock	AT %IX2.2 : BOOL;
0027	.Assembly.Sz5b_ScrwMaskLock	AT %IX2.3 : BOOL;
0028	.Assembly.Sz6a_CameraPartUnlock	AT %IX2.4 : BOOL; (*Home position*)
0029	.Assembly.Sz6b_CameraPartLock	AT %IX2.5 : BOOL; (*Work position*)
0030	.Assembly.S7_PartInsert	AT %IX2.6 : BOOL; (*Detect inserting part*)
0031	.Assembly.S8_StartButton	AT %IX2.7 : BOOL; (*Start the Camera station*)
0033	.Assembly.SickOK	AT %IX3.0 : BOOL; (*OK part*)
0034	.Assembly.SickNOK	AT %IX3.1 : BOOL; (*NOK part*)
0035	.Assembly.SickNotLocated	AT %IX3.2 : BOOL; (*Not located object*)
0036	.Assembly.S3_Color	AT %IX3.7 : BOOL;
0038	(*Outputs*)	
0040	.Assembly.ESP.ESP_Release	AT %QX0.0 : BOOL;
0041	.Assembly.ESP.ESP_ResetAll	AT %QX0.1 : BOOL;
0042	.Assembly.H2_GoodPart	AT %QX0.2 : BOOL;
0043	.Assembly.H1_BadPart	AT %QX0.3 : BOOL;
0044	.Assembly.ESP.ESP_ProgramBit_1	AT %QX0.4 : BOOL;
0045	.Assembly.ESP.ESP_ProgramBit_0	AT %QX0.5 : BOOL;
0046	.MainControl.Restart	AT %QX0.6 : BOOL;
0048	.MainControl.K0_MainValve	AT %QX1.0 : BOOL;
0049	.Assembly.Z3_Z4B_CarrierLock	AT %QX1.1 : BOOL;
0050	.Assembly.Z5B_ScrwMaskLock	AT %QX1.2 : BOOL;
0051	.Assembly.Z6B_CameraPartLock	AT %QX1.3 : BOOL; (*Lock the part at the camera station*)
0052	.Assembly.SickTrig	AT %QX1.4 : BOOL; (*Start of the Sick inspection*)
0053	.Assembly.LampGreen	AT %QX1.5 : BOOL;

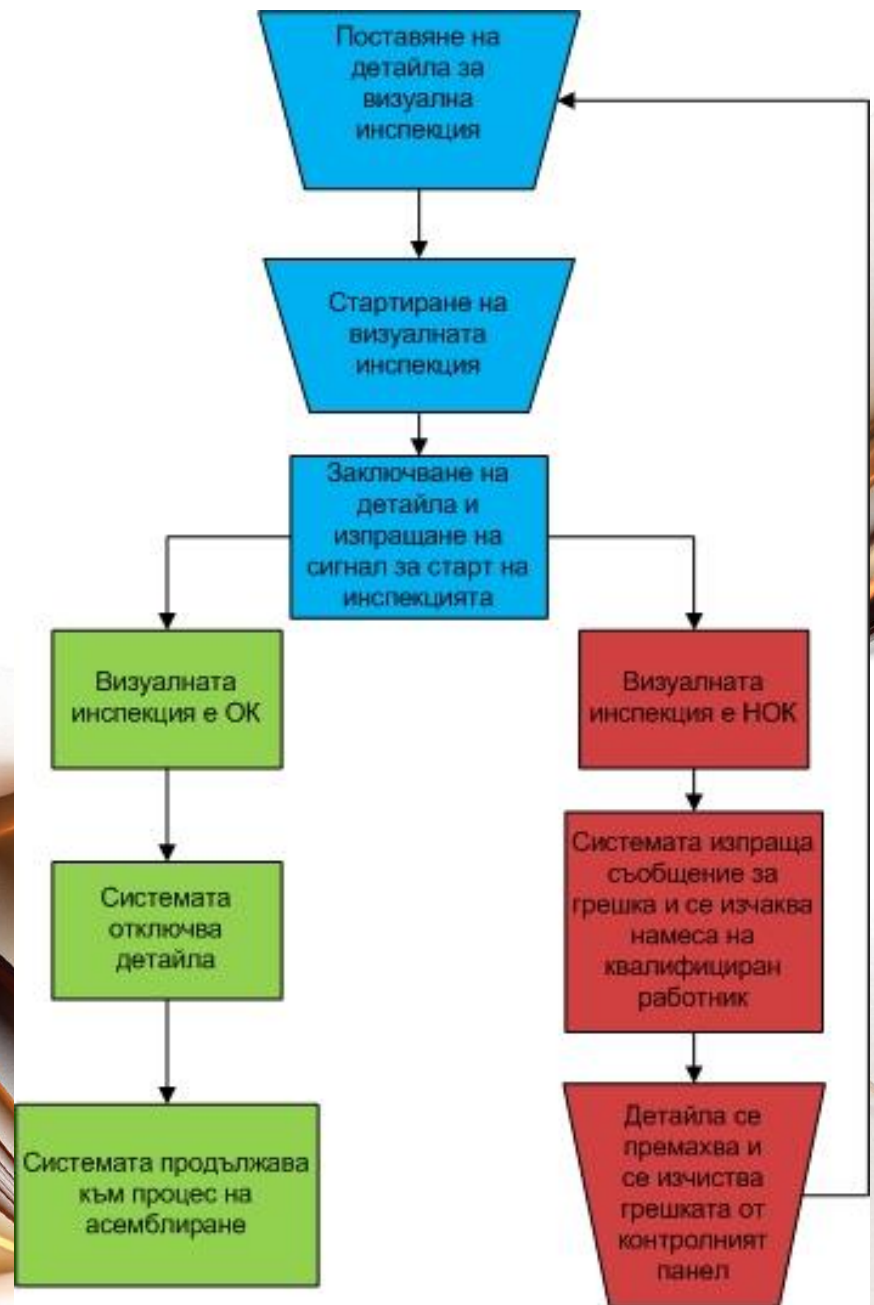
Main action in assembly function block:

The screenshot displays the HW Config interface for a SIMATIC 300 station. On the left, the project tree shows the hierarchy: SourceCodeLibrary > StationModules > FB_Assembly (FB) > a_CameraResult. The main editor area shows the ladder logic for the selected function block. It consists of two parallel normally open contacts labeled 'SickOK' and 'SickNOK'. The output coil is 'LampGreen:=TRUE;'. Below this, there is a call to the function 'mZ6_CameraPartLock' with parameters: Direction:=FALSE, User:=Me, WithSens:=FALSE, ExternalSign:=SickOK, JumpAddress:=0, BackStep:=TRUE, and Ack=>. The entire logic is enclosed in a function block definition box.

```
IF SickOK THEN  
    LampGreen:=TRUE;  
    mZ6_CameraPartLock(Direction:=FALSE;  
        User:= Me, WithSens:=FALSE,  
        ExternalSign:=SickOK,  
        JumpAddress:= 0,  
        BackStep:= TRUE,  
        Ack=> );  
ELSIF SickNOK OR SickNotLocated OR NOT SickOK AND NOT SickNOK AND NOT SickNotLocated THEN  
    LampRed:=TRUE;  
    SetError(User:= Me, Text:= Text.Name.Fail , sValue01:= 'Sick');  
END_IF;  
IF KeyBoard.Key.Pulse.xEsc AND KeyBoard.Key.Sign.xManual THEN  
    Stations.Data[Me].iRequestedStepNumber:= Stations.Data[Me].iAddressAbortCameraTest;  
ELSE  
    Stations.Data[Me].Step( User:= Me, WithSens:=FALSE,  
        ExternalSign:=VariantGood,  
        JumpAddress:= 0,  
        BackStep:= TRUE,  
        Ack=> );  
END_IF;
```

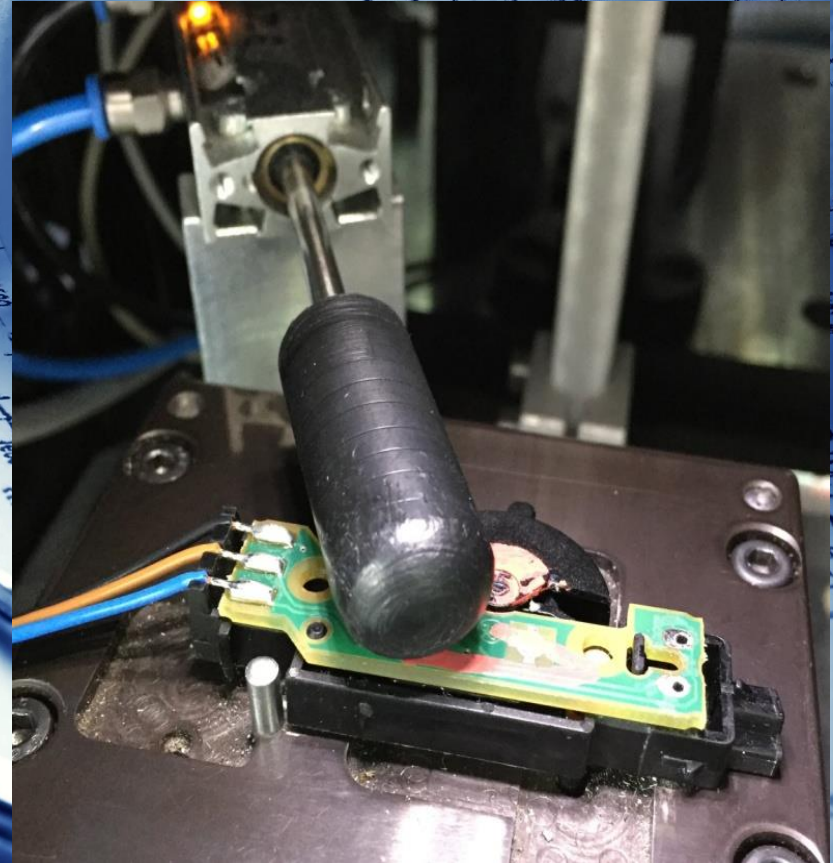
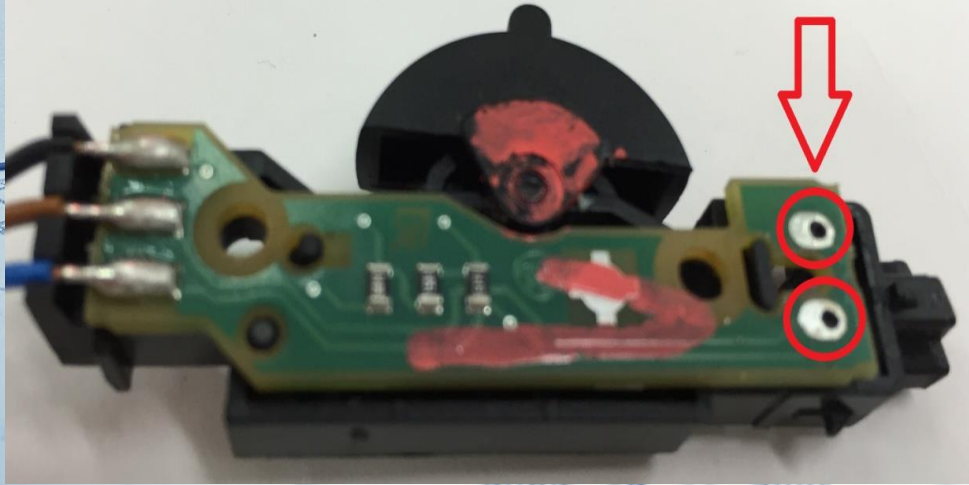


Logical block diagram of the operation of the additional station:



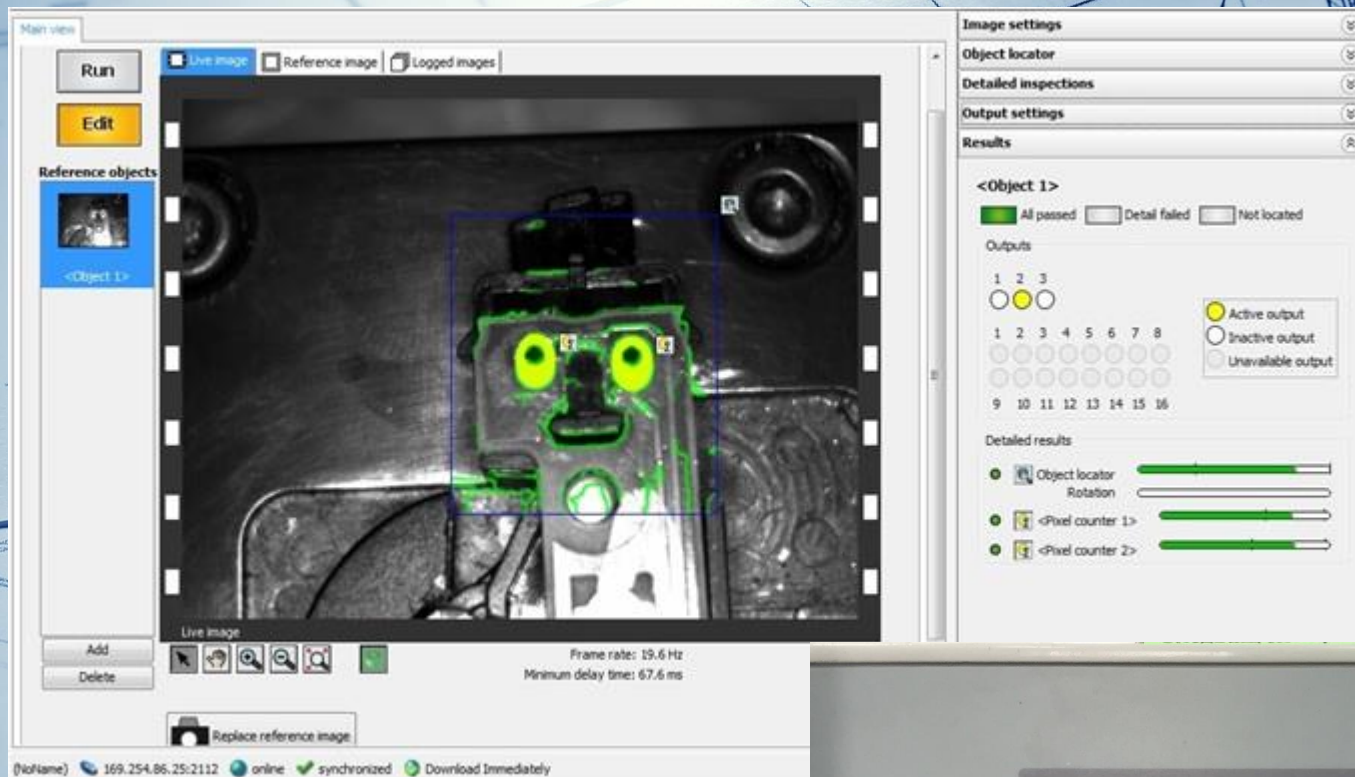
System tests

Experiment 1: Part with two missing solders:



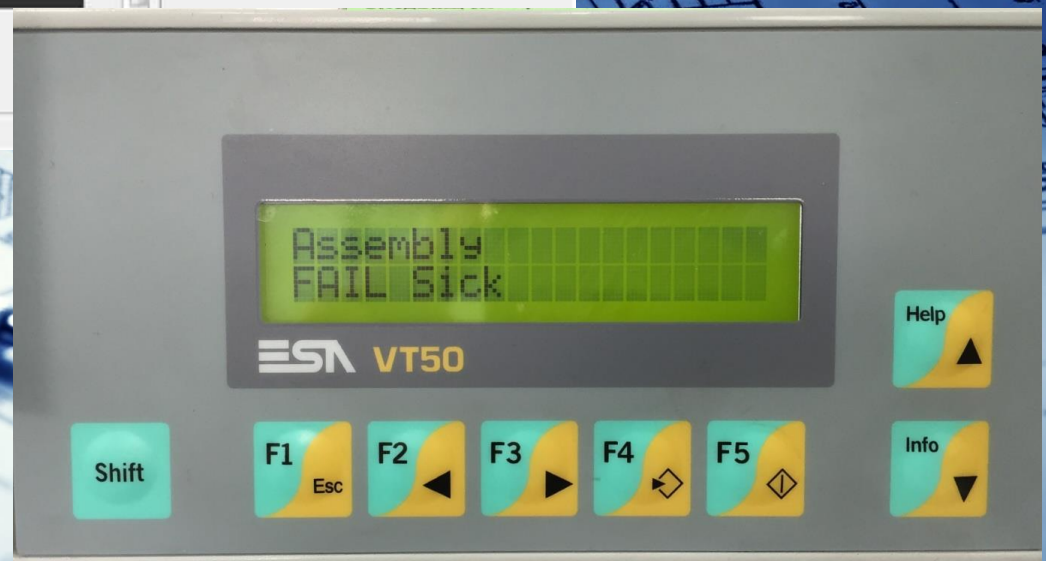
Visual inspection position

Results of simulation experiment 1:



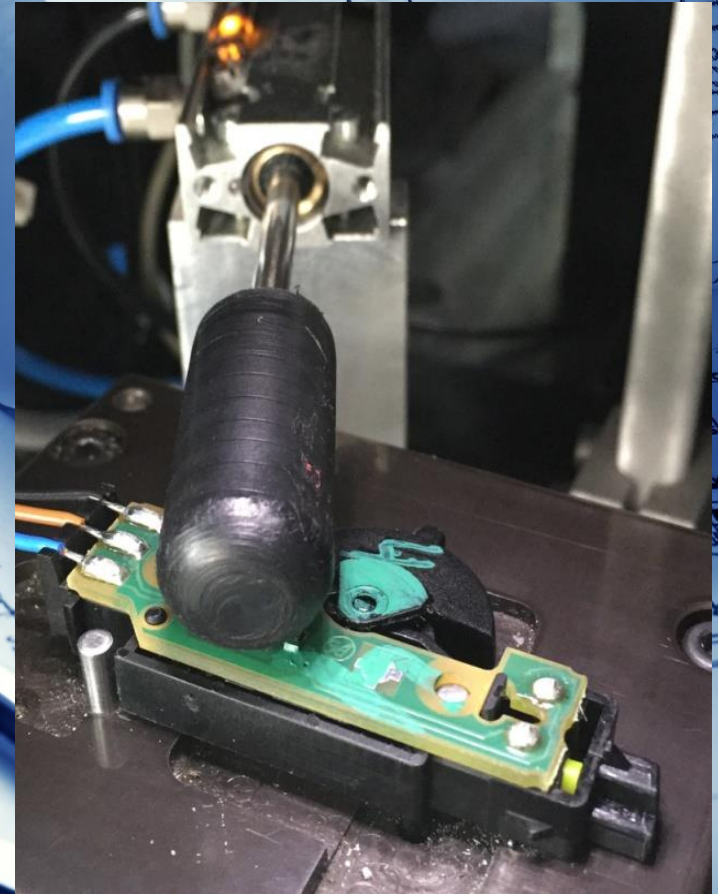
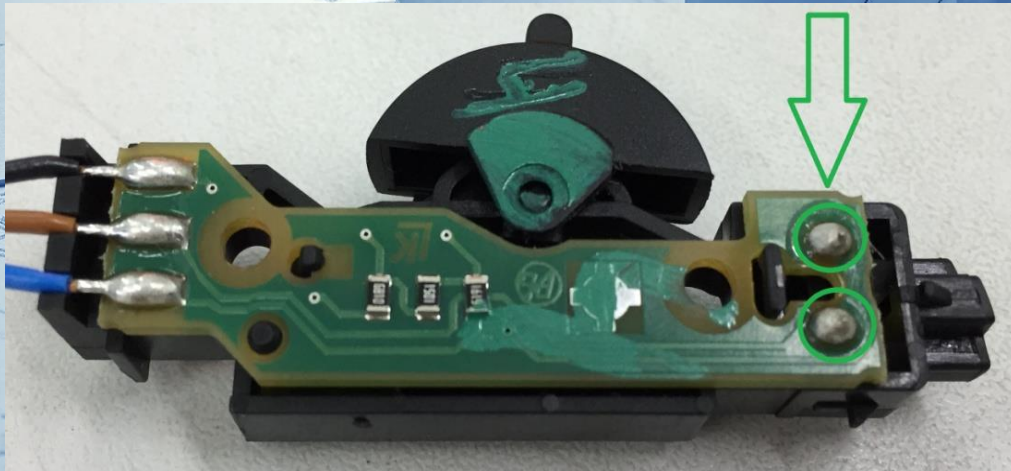
Visual inspector
result:

PLC feedback:



System tests

Experiment 2: Part with two OK solders:



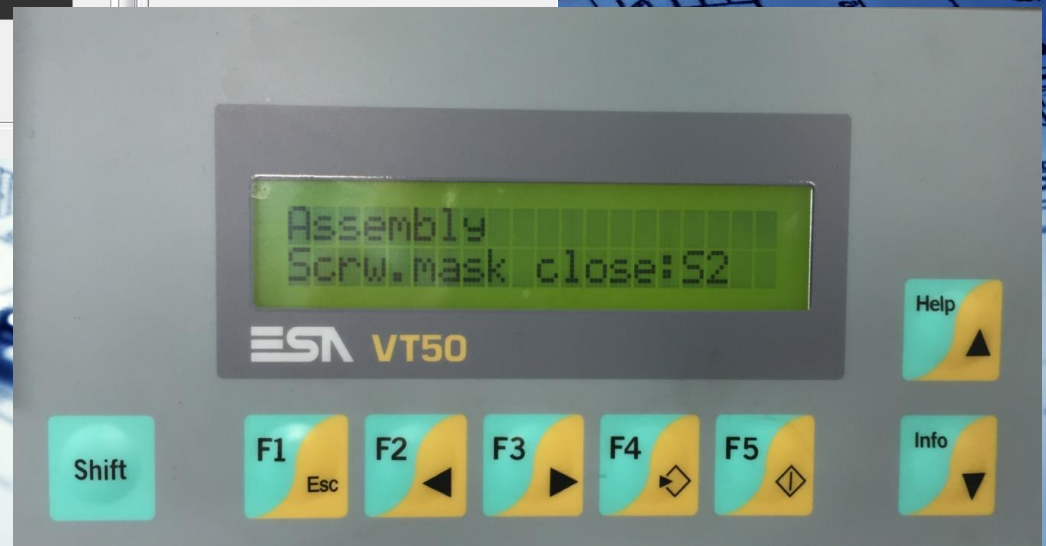
Visual inspection position

Results of simulation experiment 2:




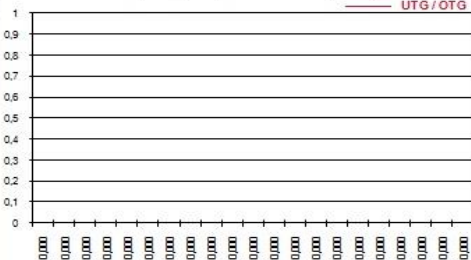
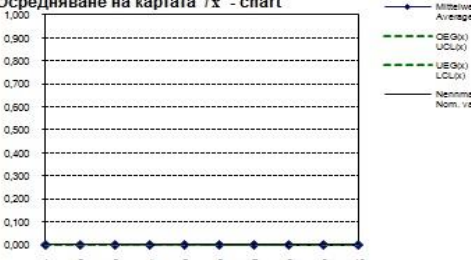
Visual inspector
result:

PLC feedback:



Machine capability test results:

It is performed by the quality department by testing different types of errors with good/bad parts and monitoring the machine performance for 50 parts produced.

Машинна пригодност Machine Capability						KOSTAL						
		Дата: Date:	17.11.2015	Отдел: Department:	AQM- Aliev, Yozlen							
		Част №: Part No.	10051552 1005057	Знак: Sign:	Сензор за следене на качеството на спойките							
		Наименование: Part name:	GRA Audi C7	Мерна единица: Parameter:	-							
		Операция №: Operation No.	table 229	Измерено с: Measured by:	Визуална проверка							
		Номинална стойност: Nominal value:		OTG: UTL:	UTG: LTL:							
1	2	3	4	5	\bar{x}	R	S					
i.O.	i.O.	i.O.	i.O.	i.O.	i.O.	0,00000	#DIV/0!					
i.O.	i.O.	i.O.	i.O.	i.O.	i.O.	0,00000	#DIV/0!					
i.O.	i.O.	i.O.	i.O.	i.O.	i.O.	0,00000	#DIV/0!					
i.O.	i.O.	i.O.	i.O.	i.O.	i.O.	0,00000	#DIV/0!					
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i.O.	i.O.	i.O.	i.O.	i.O.	i.O.	0,00000	#DIV/0!					
i.O.	i.O.	i.O.	i.O.	i.O.	i.O.	0,00000	#DIV/0!					
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i.O.	i.O.	i.O.	i.O.	i.O.	i.O.	0,00000	#DIV/0!					
<p>Честота на разпространение / Frequency distribution</p> 						<table border="1"> <thead> <tr> <th>\bar{x}</th> <th>\bar{R}</th> <th>\bar{S}</th> </tr> </thead> <tbody> <tr> <td>0,00000</td> <td>0,00000</td> <td>#DIV/0!</td> </tr> </tbody> </table>	\bar{x}	\bar{R}	\bar{S}	0,00000	0,00000	#DIV/0!
\bar{x}	\bar{R}	\bar{S}										
0,00000	0,00000	#DIV/0!										
<p>Осредняване на картата / \bar{x} - chart</p> 						<p>Статистика</p> <p>Средно: Average</p> <p>0,000000</p> <p>$\bar{x} + 5s$ #DIV/0!</p> <p>$\bar{x} - 5s$ #DIV/0!</p> <p>Δ #DIV/0!</p> <p>σ #DIV/0!</p> <p>Размах: Range(1-50)</p> <p>0,000000</p> <p>OEG(x): #DIV/0!</p> <p>UCL(x): #DIV/0!</p> <p>UEG(x): #DIV/0!</p> <p>LCL(x):</p>						
<p>Cm:</p>						<p>Cmk:</p>						
<p>Cm:</p>						<p>i.O.</p>						

Öffnen

Speichern

Drucken 1

Drucken 1+2

Drucken 1+2+3

Seitenanp.

Cm:

Cmo:

Cmu:

Cmk:

i.O.

Conclusions

- Based on the obtained results, it can be claimed that the aim of the thesis - integration of a visual inspection system for the presence of solder has been fulfilled, and the obtained results have been confirmed by performing a real-time machine suitability test.

Thank you for your attention!



