EGE spol. s r.o.

MULTIFREQUENCY CURRENT INJECTION

MCI P-01

OPERATING MANUAL

EN
ELA T209.4
Firmware: 1.1.03

Operating instructions of multifrequency current injection MCI P-01
ELA T209.4 en
Version: August 2023

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1 Safety instructions

Multifrequency current injection MCI P-01 is intended for use in power engineering installations and facilities, where all the necessary works are performed by qualified and trained engineers. Qualified engineers are persons, who are familiar with assembly, installation, commissioning and operation of this product type and they have appropriate qualification.

Multifrequency current injection MCI P-01 met all the relevant safety requirements when left the factory. To ensure that it continues to meet all the requirements and function as intended, the user must follow all of the instructions and warnings in the operating instructions.

- Multifrequency current injection MCI P-01 was designed in accordance with IEC EN 61010, safety class I. The device was tested according to this standard before dispatch.
- Before commissioning, read the installation instructions and operating instructions in this document.
- Make sure the device is not operated outside of the ratings.
- Multifrequency current injection MCI P-01 must be permanently grounded with protective conductor (cross-section at least 2.5 mm^2). Both the grounding terminal of power supply connector and grounding terminal of device box must be always connected to the ground.
- The upper limit of the supply voltage must not be exceeded continuously or even briefly.
- Multifrequency current injection MCI P-01 must be completely disconnected from the power supply before changing the fuse. The fuse can be only replaced with a fuse of the same type and rated current.
- Multifrequency current injection MCI P-01 that is visibly damaged or some of its functions is obviously faulty must not be used. It must be secured against unintentional switching on.
- Maintenance and service work on the open multifrequency current injection MCI P-01 can be performed only by qualified engineers.
- Only qualified engineers are allowed to connect and disconnect multifrequency current injection MCI P-01 to the technology.
- If the multifrequency current injection MCI P-01 is used in different way than it is specified by manufacturer, the device function and protection may be impaired.

Multifrequency current injection MCI P-01 may be hot during operation. There is a risk of burns when touched.

Only qualified engineers authorized by the manufacturer are allowed to perform maintenance and service works on multifrequency current injection MCI P-01. Disassembly of the device by other persons is not allowed.

Multifrequency current injection MCI P-01 contains capacitors that are not accessible without disassembly. There is a risk of electric shock during service works. It is necessary to wait 20 minutes for discharging before disassembly

2 Scope of delivery

- 1 piece Multifrequency current injection MCI P-01
- 1 set Connectors (plug components)
- 1 set 4 pieces panel-mounting components and fasteners
- 1 piece Operating manual
- 1 piece Test report
- 1 piece Certificate of quality and completeness (In case of separate delivery of MCI P-01)

3 Purpose

Multifrequency current injection module MCI is designed for automatic tuning of arc suppression coils (ASC) using a new multi-frequency method. The principle is based on injecting of a multi-frequency current signal into the auxiliary power winding of the arc suppression coil and evaluating the voltage response.

Information about network characteristics as detuning of the arc suppression coil comparing to the actual earth capacitance of the network or network damping are always displayed during the injection process.

MCI P-01 is designed for tuning of ASC in cooperation with the controller REG-DP or REG-DPA of the producer A. Eberle GmbH & Co. KG.

4 Function

The main function of the MCI current injection unit is provided by semiconductor converter which is able to generate several current components of different amplitude, frequency and phase shift. The individual generated current components are merged into one multi-frequency signal.

The resulting signal consists of up to 8 frequency components and is injected into the power auxiliary winding (PAW) of the arc suppression coil. MCI measures voltage response of the network and it needs no additional voltage transformer.

Using a mathematical model of arc suppression coil, parameters of a distribution network are calculated. The measured and calculated values provide information about the status of tuning of the resonant circuit that is formed by the arc suppression coil and the network-earth capacitances.

MCI is primarily intended for cooperation with the superior REG-DP(A) controller via the serial interface RS-485 by MODBUS-RTU protocol. In case of communication loss, MCI can operate as an autonomous controller with limitations. Advantages of using REG-DP(A) controller together with MCI is well-arranged visualization of states, measured and calculated parameters of the distribution network and possibility of manual control and parameterization of MCI. REG-DP(A) controller also ensures the communication with dispatching control system.

MCI can be operated in two modes. In the first one, all the binary electrical commands for the adjustment of the arc suppression coil (Up and Down), limit switches and potentiometer states are directly connected to MCI. If the communication with REG-DP(A) is lost, MCI can maintain the arc suppression coil tuned thanks to implemented simple control algorithms. It is not a full replacement of the controller, because there is no direct communication with the control system, no human machine interface and no possibility to modify MCI parameters.

In the second mode, all the ASC commands and states are connected to the REG-DP(A) controller. If the communication of MCI with the controller is lost, MCI cannot operate, but the controller can use the resonance method for ASC tuning, which may not work reliably in all situations.

5 Design

MCI is designed as a single-purpose device controlled by a microprocessor. The main functional parts are power supply circuit with a separating transformer, semiconductor power converter based on frequency converter, converter control system, measuring and protection analogue circuits, microprocessor unit, binary inputs and outputs for ASC control, LEDs, USB communication interface for service and RS-485 interface for communication with the superior controller.

There are two printed circuit boards inside the aluminium housing intended for panel mounting. The design also includes a radiator that is used as supporting structure for all other device components.

The MCI was designed to resist environmental impacts, vibrations and seismic stress. MCI also meets EMC compatibility requirements.

5.1 Block diagram

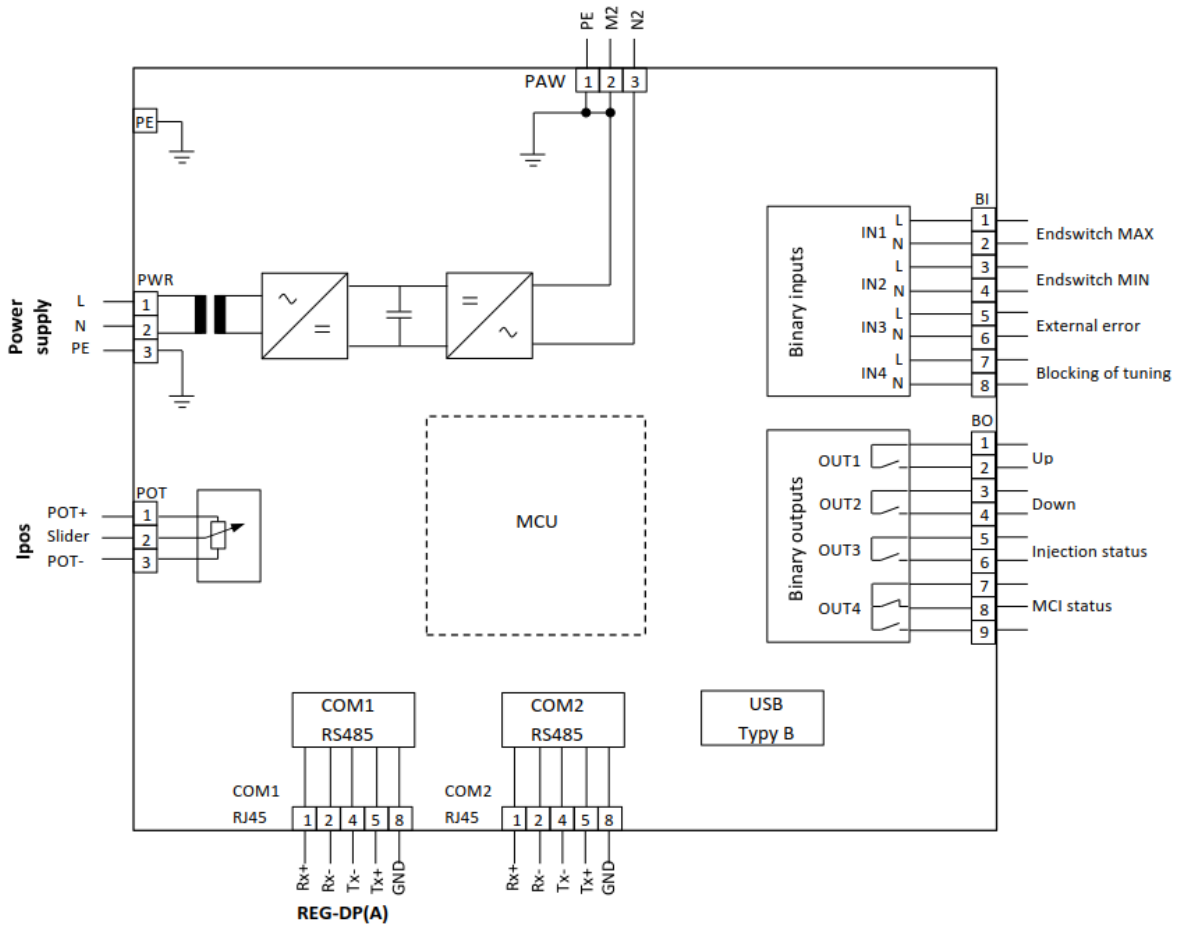

Figure 1: Block diagram of MCI

5.2 Power supply

MCI is powered directly by the network voltage (230 V AC / 50 Hz). The power circuit includes fuse, overvoltage protection, input filter, measuring circuit, transformer for supplying electronics and separating transformer for semiconductor power converter. RCD can be used as power supply protection.

5.3 Power circuit

The power circuit output is connected to the auxiliary power winding of the arc suppression coil. Individual parts of the power circuit are: frequency converter, overvoltage protection of a DC circuit, output overvoltage protection, drivers, circuit for quick disconnection, measuring and filter circuits.

5.4 Measurement

All measurement circuits are implemented in the device, so MCI is not equipped with any measurement inputs for external measurements (converters, voltage and current transformers). The measured values are voltage and current of the power auxiliary winding (PAW).

5.5 Inputs/Outputs

MCI contains four binary inputs and four binary outputs that are possible to configure. There are also six signal LEDs.

LED	Name	Color	State	Description
1	Device Status	Green	Shining	Device initialization
			Flashing	Status ready
		Red	Shining	Critical error
2	Communication status	Green	Shining	Communication ready
		Red	Shining	Communication error
3	Tuning status	Green	Flashing	ASC tuning process is active
			Shining	ASC tuned
		Red	Flashing	ASC cannot be tuned
			Shining	Tuned, not compensated
		Unlit		ASC tuning process has not been activated yet
4	Injection status	Green	Shining	Current injection is active
		Red	Shining	Error during current injection
5	Earth Fault	Yellow	Shining	Earth fault voltage limit exceeded
6	ASC Limit Switch	Yellow	Shining	End switch MIN or MAX

5.6 Communication and parameterization

MCI is equipped with the RS-485 interface using a MODBUS-RTU protocol for a communication with the superior system. MCI communicates in “SLAVE” mode. This connection is used for a transmission of control commands, states and measured values and parameterization. MCI is fully parameterized by the REG-DP(A) controller connected via the MODBUS interface. The parameters can be entered directly via a user interface of the controller (display, buttons) or via Toolbox parameterization software.

5.7 Technical parameters

Power supply

Power voltage	230 V AC, +25%,-30%
Network frequency	50 Hz
Power consumption:	<160 VA
Internal fuse type:	T1A / 250 V
Insulation level:	4 kV, galvanically isolated circuit

Power circuit

Nominal voltage	500 V AC
Max voltage during injection	165 V rms
Network frequency	50 Hz
Nominal current	5 A rms
Frequency range of generated current components	15–160 Hz (8 frequency components)
Operation time (Duty)	Continuous/short-term

Binary inputs

Number of channels	4
Voltage level	230 V AC, 50 Hz
Overload capacity	120 %
Internal consumption	1.5 mA
Insulation level	4 kV

Binary outputs

Number of channels	4
Relay contact NO (SPNO)	3 x single pole
Relay contact NO/NC (SPDT)	1 x single pole
Max. switching voltage	250 V AC
Switching current	≥ 5 A AC
Insulation level	4 kV

Potentiometer input

Potentiometer resistance range	150 Ω – 3 kΩ
Measuring voltage	5 V DC
Insulation level	4 kV

LEDs

Number of LEDs	6
Type	4x G/R 2x Y

Communication

System communication	2x RS-485 – FULL Duplex, RJ45
Service communication	USB 2.0 type B

Ambient conditions

Ambient temperature (operation)	-25…+65 °C
Ambient temperature (storage)	-45…+85 °C
Relative humidity	< 95 % non-condensing

Design

Case	anodized aluminium
Case dimensions (W x H x D)	210 x 310 x 130 mm
Total dimensions (W x H x D)	260 x 360 x 141 mm
Mounting hole spacing	170 x 330 mm or 230 x 270 mm
Weight	10 kg
Mounting	panel mounting
Connectors	detachable, fixed with screws
Cooling	passive

Electrical safety

Degree of pollution:	2
Safety class:	I
Over-voltage category:	II
IP code	IP2X

5.8 Dimensions

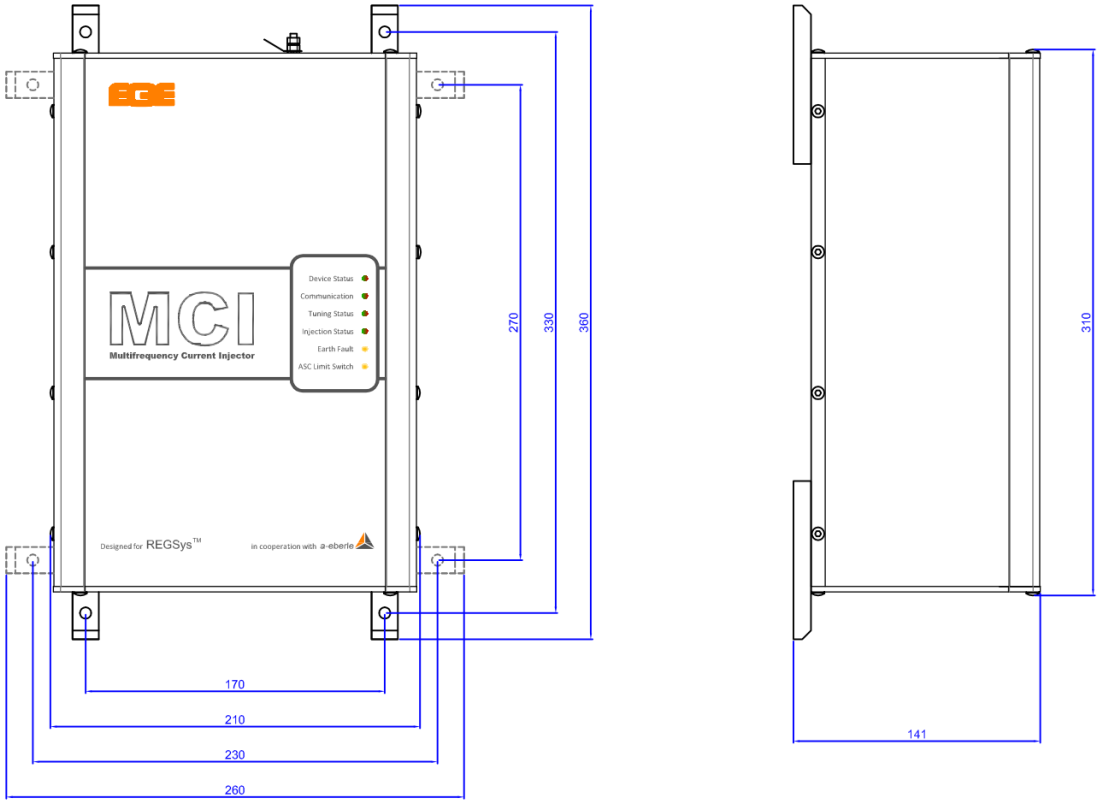

Figure 2: Basic MCI dimensions and layout of mounting holes

5.9 Connectors

Protective earth

The M4 earthing pin (screw) on the top of the case is provided for protective grounding of MCI. FAST ON connector 6.3 mm is also possible to use.

Power supply – PWR

External fuse: ≥ 2 A, galvanically isolated circuit, RCD can be used.
Connector: GMSTB 2.5 / 3-STF-7.62, conductor cross section min/max: 0.7/2.5 mm2

Pin	Marking	Function/Polarity	Description
1	**L**	Phase conductor	
2	**N**	Neutral conductor	
3	**PE**	Protective conductor	

Power circuit output – PAW

External fuse: ≥ 10 A
Connector: GIC 2.5 / 3-STF-7.62, conductor cross section min/max: 1.5/2.5 mm^2

Pin	Marking	Function/Polarity	Description
1	**PE**	Protective conductor	Internally connected to M2
2	**M2**	Neutral conductor	Internally connected to PE ⚠
3	**N2**	Phase conductor	

Binary inputs – BI

Connector: MSTB 2.5 / 8-STF, conductor cross section min/max: 0.7/2.5 mm^2

Pin	Marking	Function/Polarity	Description (Default)
1	**IN1 - 1**	L	Programmable (End switch – max)
2	**IN1 - 2**	N	
3	**IN2 - 1**	L	Programmable (End switch – min)
4	**IN2 - 2**	N	
5	**IN3 - 1**	L	Programmable (External error)
6	**IN3 - 2**	N	
7	**IN4 - 1**	L	Programmable (Total blocking)
8	**IN4 - 2**	N	

Binary inputs – BO

External fuse: ≤ 6 A AC

Connector: MSTB 2.5 / 9-STF, conductor cross section min/max: 0.7/2.5 mm^2

Pin	Marking	Function/Polarity	Description (Default)
1	**OUT1 - COM**		Programmable (Motor Up)
2	**OUT1 - NO**		
3	**OUT2 - COM**		Programmable (Motor Down)
4	**OUT2 - NO**		
5	**OUT3 - COM**		Programmable (Injection activated)
6	**OUT3 - NO**		
7	**OUT4 - COM**		Programmable (Status)
8	**OUT4 - NC**		
9	**OUT4 – NO**		

Potentiometer input – POT

Connector: MSTB 2.5 / 3-STF, conductor cross section min/max: 0.7/2.5 mm^2

Pin	Marking	Function/Polarity	Default
1	**POT+**	Potentiometer +	
2	**SLIDER**	Potentiometer value	
3	**POT-**	Potentiometer -	

Service communication connector – USB

USB type B.

Pin	Marking	Function	Description
1	**+5V**	Supply	
2	**D-**	Data	
3	**D+**	Data	
4	**GND**	Reference potential	Internally connected to PE ⚠
5	**Shield**	Shield	Internally connected to PE ⚠
6	**Shield**	Shield	Internally connected to PE ⚠

Communication connectors – COM1, COM2
Connector: RJ45

Pin	Marking	Function
1	**Rx+ (A)**	Data IN
2	**Rx- (B)**	Data IN
4	**Tx- (Z)**	Data OUT
5	**Tx+ (Y)**	Data OUT
8	**GND**	Reference potential

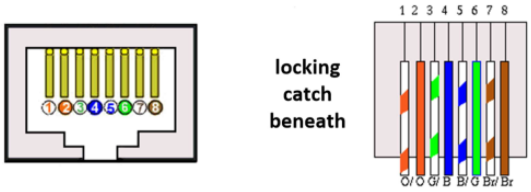

Figure 3: Socket (right) and plug (left) of communication

6 Device installation

Multifrequency current injection MCI P-01 is installed vertically onto the panel either directly into the control box of ASC or into the separate switchboard by the ASC. It can be also installed onto the panel or switchgear in the substation.

MCI P-01 is fixed to the panel with 4 screws and with the wall-mounting components that are part of the delivery. The wall-mounting components are attached to the bottom side of the device housing with M6 screws and spring washers (2 screws for each component). Position of the wall-mounting components on the device housing is optional (see figure 2). The wall-mounting components protrude either on the shorter side of the device or on the longer side of the device. The layout and spacing of the mounting holes are influenced by this option.

Multifrequency current injection MCI P-01 must be permanently grounded with protective conductor (cross-section at least 2.5 mm^2) connected to the protective terminal on the device housing, marked in accordance with IEC EN 61010 – 1 (tab. 1, mark 6), see 5.9. PE conductor must be also connected to the connector PWR, terminal 3. See 5.9. Both the grounding terminal of power supply connector and grounding terminal of device box must be always connected to the ground.

6.1 Arc suppression coil connection

It is recommended to use following cross-section of wires depending on length for connection of PAW connector to power auxiliary winding of ASC:

Wire length	< 10 m	< 20 m	< 50 m	< 100 m	< 200 m
Minimum cross-	1.5 mm^2	2.5 mm^2	4 mm^2	6 mm^2	10 mm^2

It is not recommended to use wires longer than 200 m. Wires 1.5 mm^2 and 2.5 mm^2 are recommended only for installation inside of control box of ASC.

Improperly selected conductor cross-section increases the value of resistance and inductance and can affects the calculation of the network parameters.

If one side of power auxiliary winding is earthed, it is necessary to connect the relevant conductor to the terminal M2 of PAW connector. If the power auxiliary winding is not grounded, it is possible to ground it through the grounding terminal of the PAW connector.

Injector MCI must have information about tuning position (potentiometer) and end switches of ASC. MCI must be able to control tuning of ASC too (Up and Down). These signals must be available for MCI. It can be connected in two modes. These modes determine, if the signals are connected directly to MCI or REG-DP(A). Selecting mode also defines a behavior of how ASC is tuned in case of communication loss.

Mode 1

This mode is suitable for MCI installation inside of the ASC control box or for new installation, if signals of ASC are not connected to REG-DP(A) yet and it is easier to connect them to MCI.

All control signals of ASC drive and ASC core position status are connected directly to the injector MCI P-01 in mode 1. It is not necessary to connect these signals to REG-DP(A). They are communicated via MODBUS between MCI and regulator.

If MCI and ASC are delivered together as part of a single order and ASC signals are already connected to the MCI, it is necessary to operate it in mode 1.

In case of communication loss between MCI and REG-DP(A), MCI is able to tune ASC properly, but status information is not transmitted either to the controller nor master control system.

It is necessary to connect following connectors:

- PWR
- PAW
- BI – End switch MAX, MIN
- BO – Motor Up, Motor Down
- POT
- COM1 – must be connected to COM3 of REG-DP(A)

Connectors must be connected according to the chapter 5.9. Figure 4 shows typical connection of MCI, REG-DP(A) and ASC.

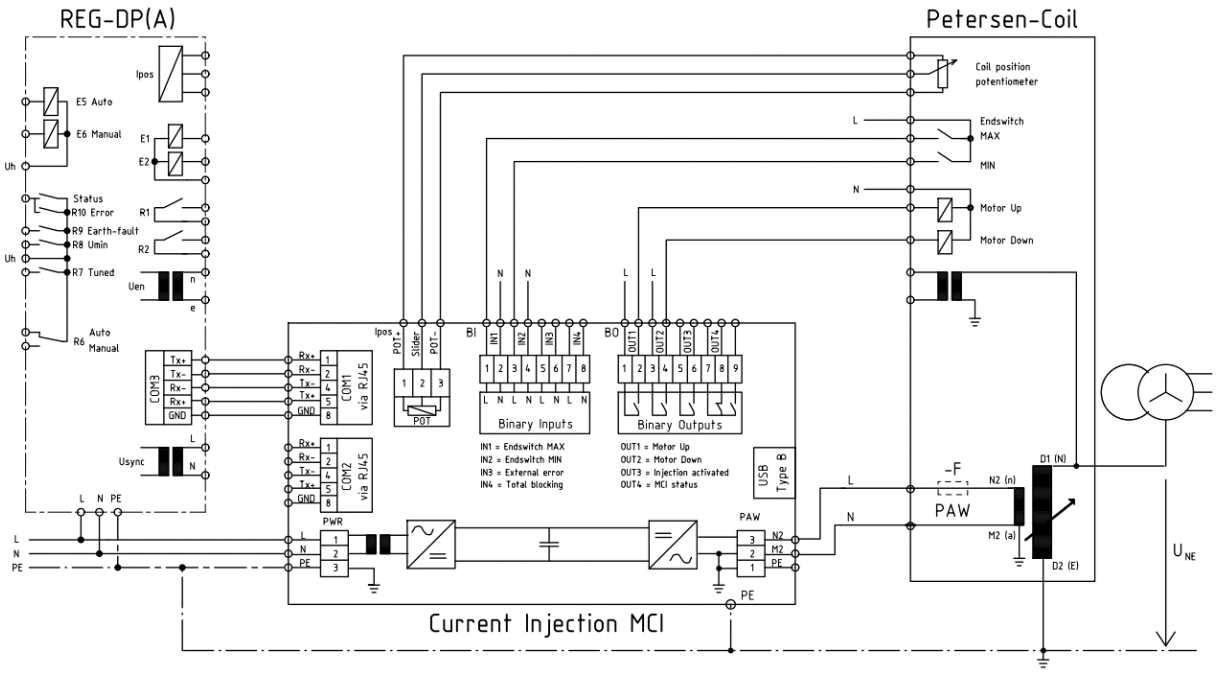

Figure 4: Mode 1 – Connection of REG-DP(A), MCI and arc suppression coil

Mode 2

Mode 2 is suitable if the MCI is added to the existing installation of REG-DP(A) and ASC. In this case, all the signals of ASC are usually already connected to REG-DP(A). It is not necessary then to connect them to MCI. Of course, this mode is available for new installations too, if it is preferred to connect these signals to the controller.

All control signals of ASC drive and ASC core position status are connected to the regulator REG-DP(A) in mode 2 and they are transmitted via MODBUS to MCI.

Connection of only three connectors is required for the injector to function properly in mode 2. MCI must be connected to the power auxiliary winding of ASC. There must be communication between MCI and REG-DP(A) and injector must be also supplied with power.

It is therefore necessary to connect the following connectors:

- PAW
- PWR
- COM1 – must be connected to COM3 of REG-DP(A)

Connectors must be connected according to the chapter 5.9. Figure 5 shows typical connection of MCI, REG-DP(A) and ASC in this mode.

In case of communication loss between MCI and REG-DP(A), REG-DP(A) tries to tune ASC, but using only a standard method (resonance method). This function is enabled with controller parameter Emergency mode CoilMoving.

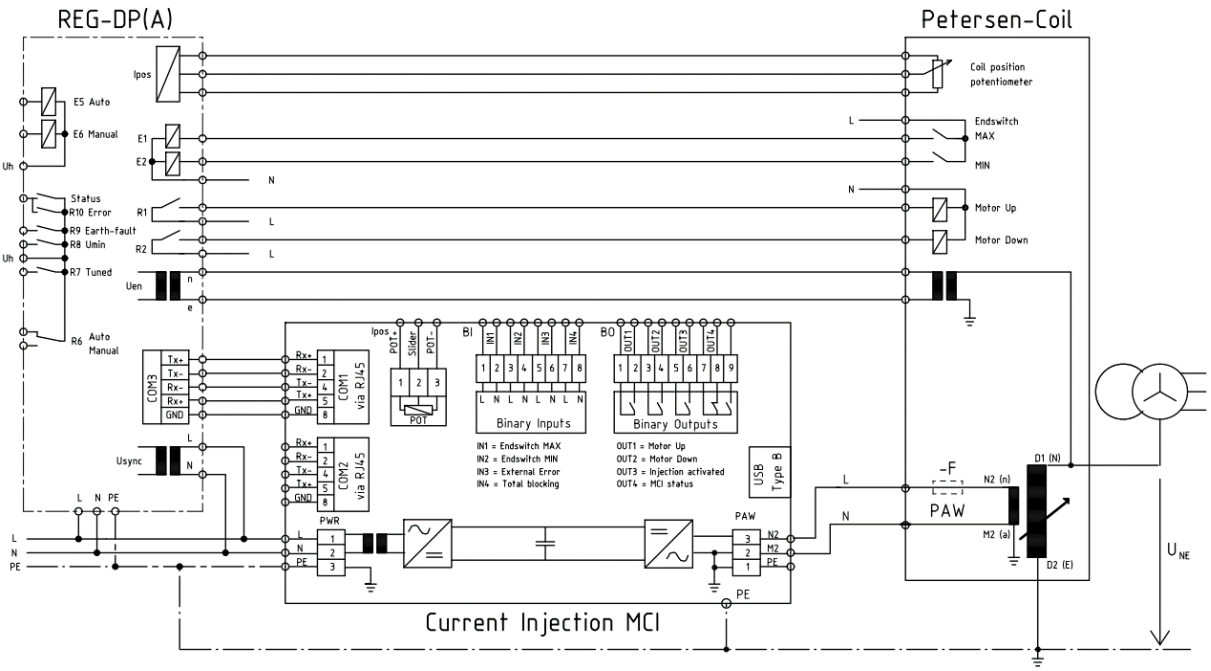

Figure 5: Mode 2 – Connection of REG-DP(A), MCI and arc suppression coil

7 Commissioning

MCI P-01 can be used only with controller REG-DP(A) with firmware version 2.7.46 or higher. A variety of information on the REG-DP/ REG-DPA including firmware version can be queried in the Status menu or in Toolbox. See manual for REG-DP(A).

Required version of Toolbox software is 2.0.1 or higher.

7.1 MCI activation

After MCI P-01 is already connected to REG-DP(A), MCI must be activated in the regulator. This can be done in two ways. Either using the Toolbox software or directly on the controller screen.

In Toolbox, this option is included in the REG-DP(A) tab in *Configuration*. Parameter CI in *Features* section must be change to MCI.

In the user interface of the controller this option is included in *Menu -> Setup -> System -> Feature SE* (Press **<Menu><F3><F5><F1><F1><F3>)**. There must be selected MCI.

After that MCI is activated and it can be used.

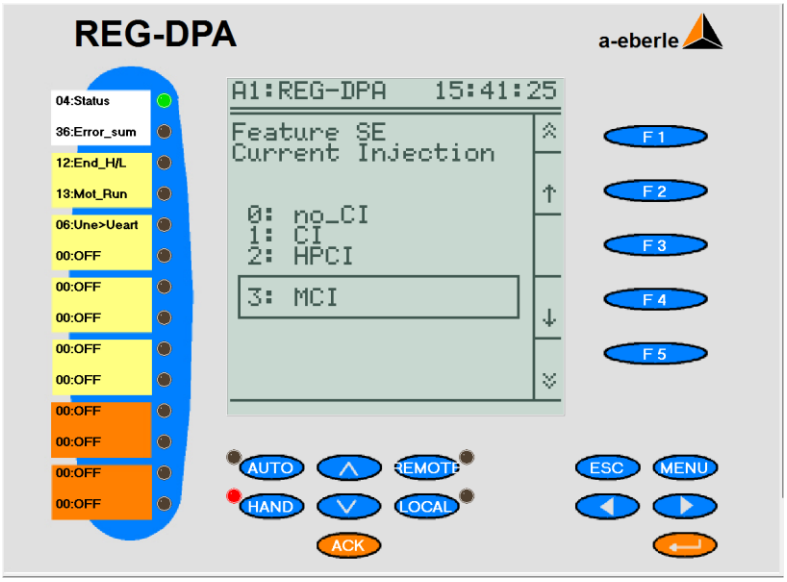

Figure 6: Activation of MCI in REG-DP(A)

For tuning by MCI injection is still necessary to set tuning method in the controller settings. *Menu -> Setup -> Control -> Standard parameters -> Search method* (Press **<Menu><F3><F2><F2><F2>**) Current Injection option must be selected. Or chose this option via Toolbox: In *Control menu*, *General item, Search method* must be changed to *Current injection*. After that MCI will be used to determine the resonance curve.

7.2 Parametrization

All the settings of MCI P-01 can be done vie user interface of REG-DP(A) controller or Toolbox software. MCI must be activated to display the MCI parameters.

Function of MCI is determined by parameters, that are for MCI only. But also other general parameters described in REG-DP(A) manual influence the function.

Special parameters for MCI (set in REG-DP(A)):

- **Nominal voltage of P-coil (default 11 547 V)**
  - *Menu -> Setup -> Initial operation -> P-coils -> Data of P-coil*
  - Parameter necessary for ratio calculation used in mathematical model
- **Nominal voltage of PAW (default 500 V)**
  - *Menu -> Setup -> Initial operation -> P-coils -> Data of P-coil*
  - Parameter necessary for ratio calculation used in mathematical model
- **Coil signal wired to MCI – Yes (Mode 1) / No (Mode 2 – def.)**
  - *Menu -> Setup -> Initial operation -> Current injection*
  - See chapter 6.1.
- **MCI – emergency positioning – Yes/No (def.)**
  - *Menu -> Setup -> Control -> Current injection*
  - See chapter 8.
- **Tuning with continuous CI – Yes (def.) / Ne**
  - *Menu -> Setup -> Control -> Current injection*
  - MCI injects during ASC position adjustment. Estimated resonance curve is updated continuously and it is not necessary to tune ASC in more iteration steps.
- **Periodical start – x minutes / Off (def.)**
  - *Menu -> Setup -> Control -> Current injection*
  - Tuning process is started periodically. Periodical tuning is suitable for networks with very low value of the neutral point voltage. In this case, neutral point voltage change may not be detected. It is periodically verified, that it is tuned.
- **Maximum Une during CI – % of Une (def. 100 %)**
  - *Menu -> Setup -> Initial operation -> Current injection*
  - Power of the injected current signal is reduced in case the neutral point voltage exceeds the limit given by this parameter.

Another parameters of regulator REG-DP(A), that affect the MCI emergency mode (if activated):

- **Delay of forced search**
- **Delay of search**
- **Une-Tolerance**
- **Position tolerance**
- **End position after abort**
- **Home position**
- **Search cycles, maximal**
- **Number of search delays**
- **Follow up of Uref**
- **Type of detuning**
- **Detuning**
- **Une-angle measurement**
- **Umax**
- **Umax_end**
- **Self-extinguishing current limit**
- **Uearth threshold**

Above parameters are standard parameters for REG-DP(A). They are described in REG-DP(A) manual.

MCI contains programable binary inputs and outputs. They are set by default according to the chapter 5.1. Setting is located in v *Menu -> Setup -> Initial operation -> current injection -> Binary Inputs* or *Relays.*

All binary inputs have following parameters:

- **Function DP←→MCI**
  - This parameter determines, if input is used by REG-DP(A) or MCI.
- **MCI function**
  - If MCI device is chosen, then MCI function are available (end-switch low, end-switch high, emergency positioning blocked, CI blocked). Binary inputs are also possible to invert.
- **REG-DP(A) function**
  - If REG-DP(A) device is chosen, then REG-DP(A) function are available. Functions are described in more detail in the REG-DP(A) manual. Binary inputs are also possible to invert.

All binary outputs (relays) have following parameters:

- **Function DP←→MCI**
  - This parameter determines, if output is used by REG-DP(A) or MCI.
- **MCI function**
  - If MCI device is chosen, then MCI function are available (Motor up, motor down, end-switch low, end-switch high, CI on, Search, Earth fault, CI blocked, MCI status, emergency positioning blocked). Binary outputs are also possible to invert.
- **REG-DP(A) function**
  - If REG-DP(A) device is chosen, then REG-DP(A) function are available. Functions are described in more detail in the REG-DP(A) manual. Binary outputs are also possible to invert.
- **Failsafe state**
  - State of binary output (on, off) in case of MCI block or loss of communication between REG-DP(A) and MCI (only for REG-DP(A) functions).

7.3 Calibration

It is recommended to perform all the calibrations to use all the MCI functions and subsequently synchronize MCI with REG-DP(A). Standard parametrization of REG-DP(A) and potentiometer calibration are always necessary to do. These parameters are necessary to synchronize with REG-DP(A) too. The required steps are described below.

Factory calibration

MCI P-01 does not have to be calibrated if it is delivered with ASC and MCI is installed inside the control box of ASC. In this case, MCI calibrations have been fully done by producer. But it is necessary to transfer the calibration results from MCI to REG-DP(A) via calibration wizard. Via *Menu -> Setup -> Initial operation -> P-coils -> Calibration wizard -> Synchronize calibration data* (Press **<Menu><F3><F3><F5><F3><F1><F5>)**. There must be selected option *Copy data MCI -> REG-DP*.

After that, potentiometer calibration must be checked if *Imax* corresponds (The other of two potentiometer installed in ASC might be connected – then it is necessary to reconnect MCI connector POT to the potentiometer, which was used by the factory calibration). *Imin* can be slightly different from the value given on the coil label because of more accurate linearization. After that MCI is ready to use.

Warning! If data are transferred from REG-DP(A) to MCI, original MCI data are lost and cannot be recovered. MCI calibrations must be done again.

On site calibration

If the MCI is delivered separately from ASC or the factory calibration data were lost or the ASC is replaced, next steps must be followed.

Standard parametrization of REG-DP(A) is necessary (*Imin, Imax, Nominal voltage of ASC primary winding and PAW*). See the REG-DP(A) manual. Calibration of the potentiometer in REG-DP(A) is required too. If MCI is added to existing installation, calibration of potentiometer and standard parametrization should be already done and it is not necessary to do it again.

These parameters must be uploaded to MCI. Via *Menu -> Setup -> Initial operation -> P-coils -> Calibration wizard -> Synchronize calibration data* (Press **<Menu><F3><F3><F5><F3><F1><F5>**). There must be selected option *Copy data REG-DP -> MCI*.

Multifrequency current injection can be operated even with default settings of ASC parameters. This default settings and parameters enable to MCI tune ASC sufficiently accurate, because even without the rest of the calibrations the detuning of the network and ASC can be determined accurately enough. But without the further calibration, the measured networks parameters displayed by the controller may differ significantly from real absolute values.

To get all the parameters accurately it is required to do the calibration of MCI with connected ASC.

Injector does not require any external voltage measurement of the neutral point. The voltage value is obtained from the same winding into which the current signal is injected. To get the measured data accurately, it is necessary to calibrate MCI. Values are for each ASC different. Even the same type of ASC can be slightly different due to the production tolerances. Therefore, calibration data cannot be copied and calibration must be done for each ASC separately.

During the calibration MCI evaluates the ASC parameters such as ratio between the main winding and power auxiliary winding and leakage inductances over the whole tuning range. Obtained values are then memorized for the mathematical model, which is used for network parameters calculation.

Calibration wizard

Both ASC calibration and MCI calibration are performed through the *Calibration wizard*. This function can be found in user interface of controller. *Menu -> Setup -> Initial operation -> P-coils -> Calibration wizard* (Press **<Menu><F3><F3><F5><F3>**).

Here it is possible to recognize which calibration step has been already done and which is still required. All the calibrations are divided into two subpages. Calibration can be found in three states:

- No state – calibration has not been done (or no communication REG-DP(A) – MCI)
- Ok – calibration is done and the calibration data are synchronized
- Diff – data in MCI and regulator are different and it is necessary to synchronize them

All the previous calibration steps must be done before next calibration is started. That means previous calibration must be in state *OK* (synchronized).

Data synchronization is possible to perform through the function *Synchronize data* on the second subpage of the *Calibration wizard*. After the function is selected, two options are displayed.

- Upload data from REG-DP(A) to MCI
- Upload data from MCI to REG-DP(A)

If the data are uploaded to the chosen device, original data are irreversibly overwritten. Synchronize data option always copies and overwrites all the calibrations:

- P-coil calibration
- P-coil linearization
- P-coil nominal values
- Zk calibration
- P2 calibration

The injector calibration itself consists of two parts and is located on the second subpage. The parts are:

- Zk calibration
- P2 calibration

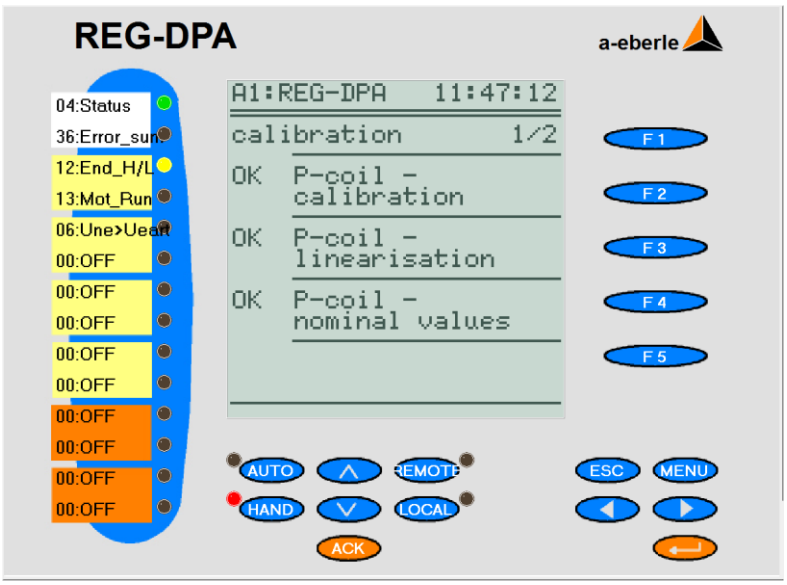

Figure 7: Example of the calibration wizard screen.

ASC calibration (P-coil calibration)

Automatic calibration of potentiometer must be done before the MCI calibration (See REG-DP(A) manual). During this calibration, MIN and MAX positions, run time and other parameters are determined. Before this calibration, all ASC parameters must be already set.

After successful calibration, these data are not automatically synchronized. So the status of this calibration is *Diff*. That means it is not synchronized.

These parameters must be uploaded to MCI. Via *Menu -> Setup -> Initial operation -> P-coils -> Calibration wizard -> Synchronize calibration data* (Press <**Menu><F3><F3><F5><F3><F1><F5>**). There must be selected option *Copy data REG-DP -> MCI*. After that, statuses of *P-coil calibration*, *P-coil linearization* and *P-coil nominal values* are *OK* and it is possible to calibrate MCI.

Zk calibration

Zk calibration determines short circuit impedance (Zk) of the arc suppression coil. Before the calibration procedure can be started, it is necessary to disconnect ASC from the network and short circuit and

ground the primary winding of ASC (usually D1 and D2 bushings for EGE arc suppression coils). See the figure 8.

Before this calibration P-coil calibration, P-coil linearization and P-coil nominal values must be in state OK.

In case of combined arc suppression coils (arc suppression coil and earthing transformer active part placed in a shared housing) it is recommended to short circuit and ground all the phases of grounding transformer. By that the ASC impedance including zero sequence impedance of earthing transformer are calibrated. Zero sequence impedance of earthing transformer is in series with ASC impedance and it influences the zero-sequence impedance of the whole network and therefore actual value of ASC current too.

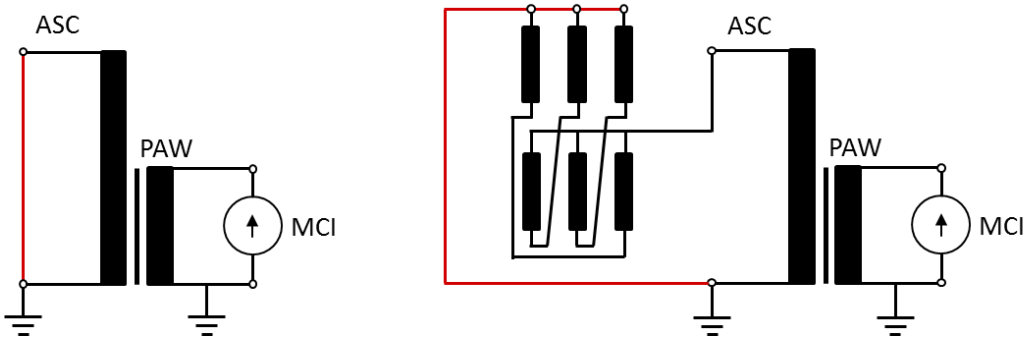

Figure 8: Illustration of shorting of ASC primary winding, that is necessary for Zk calibration. Standard ASC is shown on the left side, combined ASC is shown on the right side.

Option of Zk calibration is included in Calibration wizard menu on the second subpage (Press **<Menu><F3><F3><F5><F3><F1><F2>**). After Zk calibration selecting, a warning of necessity of main winding shorting is displayed. Calibration is started with Start (F2).

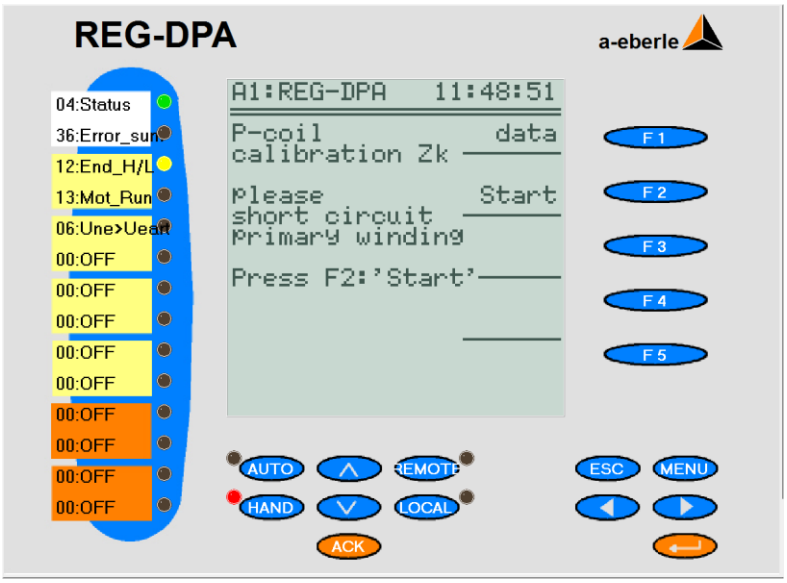

Figure 9: Welcome screen of Zk calibration.

Calibration is performed automatically, no further action is required during the calibration. The measuring is performed at 8 reference points of the whole range of ASC. ASC is adjusted automatically. Depending on the ASC type, Zk calibration usually takes several minutes (each measurement about 30 seconds plus necessary time for ASC adjusting from Imin to Imax). Calibration progress is displayed on the regulator screen.

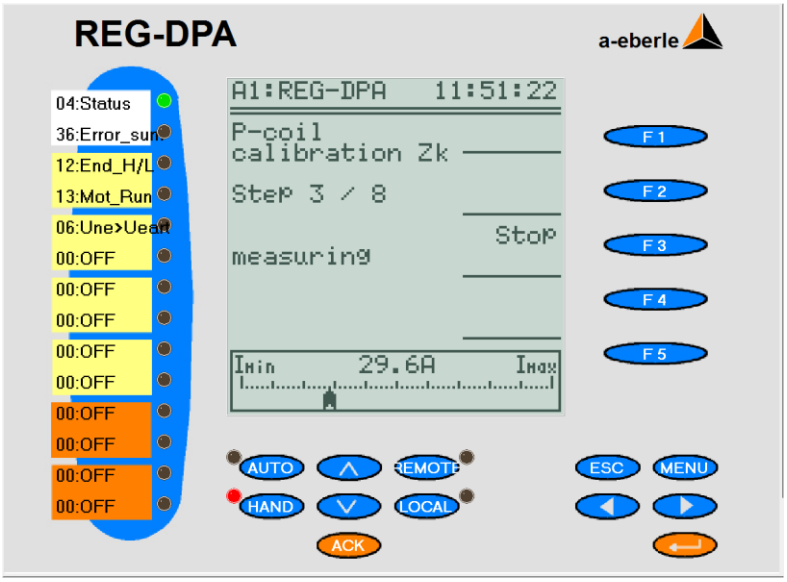

Figure 10: Progress of Zk calibration displayed on the controller REG-DP(A)

After the measuring on the Imax position the final data is possible to be displayed with F1 key. Calibration is completed by accepting the data by pressing F2 key. Data are automatically synchronized to REG-DP(A).

Calibration data is also possible to decline by pressing F3 key. Then the previous data are recovered and the calibration is not completed.

After successful calibration the primary winding short circuit must be removed before the next step of the calibration.

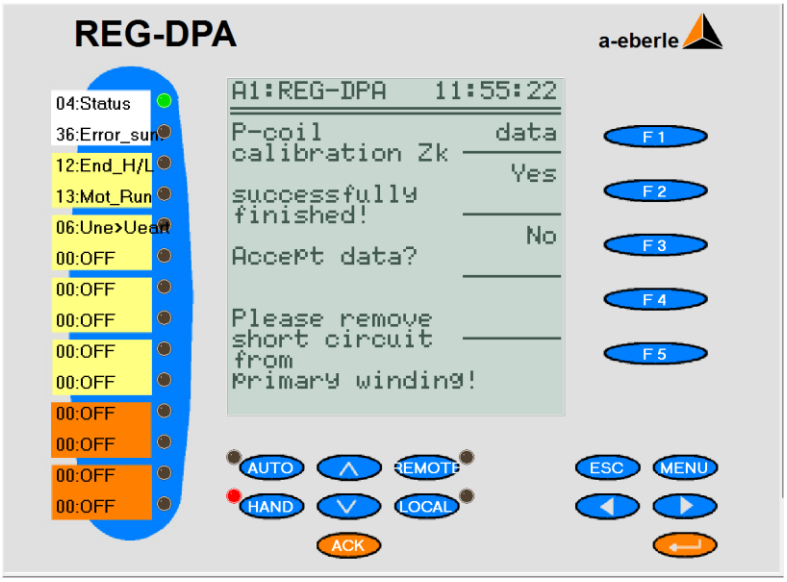

Figure 11: Screen after successful calibration.

If the data is not in typical range for fluently tuned arc suppression coils, warning “values are suspect” is shown (see figure 12). The measured data are not rejected immediately, it is possible to check the data and accept the results anyway.

Reasons of the suspect results of calibration can be:

- The primary winding of the ASC is not short circuited: Usually wide range of Zk between the MIN and MAX position.
- Power auxiliary winding is short circuited instead of main winding: Short circuit impedance of ASC is very low, because short circuit impedance of cables is measured only.

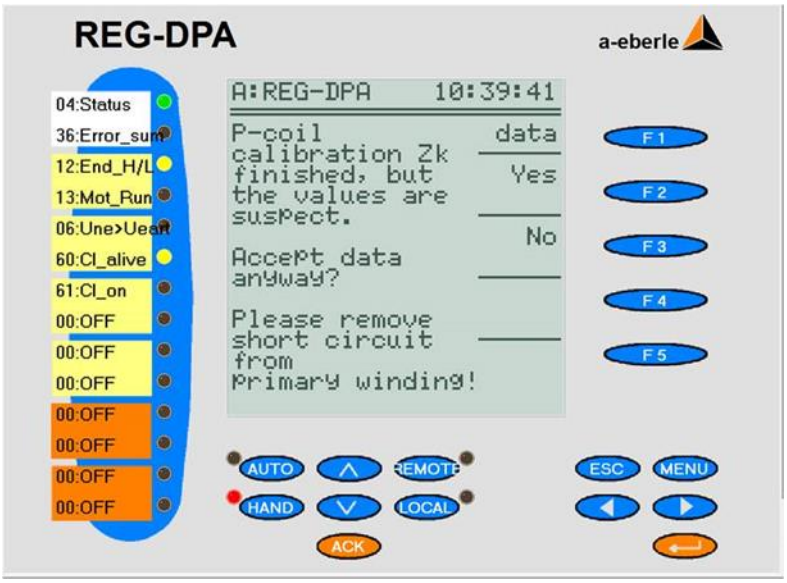

Figure 12: Screen after Zk calibration with suspect results.

In case of a problem that can be detected immediately, calibration is canceled during the calibration process. The measured data are rejected and the original data are recovered. Some typical reasons of the unsuccessful calibration are:

- MCI is not connected to the ASC (circuit breaker or fuse switched off).
- Communication is interrupted during the calibration process.
- ASC drive failure – regulator cannot reach required position.

P2 calibration

This calibration determines the real ratio of ASC primary and secondary winding. The ratio is not constant, but it is variable throughout the range of ASC. The voltage response of the current signal is measured through the auxiliary winding and it is therefore necessary to know the value of the ratio.

Zk calibration must be done before P2 calibration and ASC must be connected to the network with a capacitance value that is equal at least to the minimum current of ASC. A network size must not be changed during the calibration! The measured data would be inaccurate.

When P2 calibration is selected (Press **<Menu><F3><F3><F5><F3><F1><F3>**), a warning that the ASC must be connected to the network is displayed. It is also necessary to determine whether there are other fixed coils in the same network. If the coil with MCI is the only one in the network, the calibration can be started with Start button (F2). The calibration will measure the actual range of the coil (may differ slightly from the stated coil parameters) and data is fixed to the upper end position.

With MCI firmware version 1.1.03 or newer and REG-DP(A) 2.8.07 or newer, it is also possible to run the calibration with the external coils in the network. Other coils must not be tuned during the calibration. This calibration is started with the Start++ key (F5). In this case both lower and upper end switches are retained. The range of the coil does not correspond to the actual measured range, but to the specified

range on the label. However, the difference should not be significant, and this calibration is sufficient too.

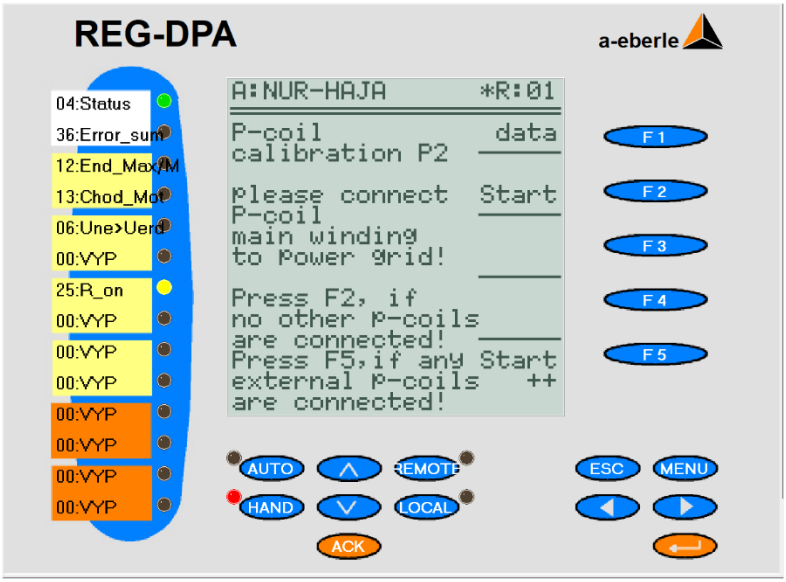

Figure 13: Welcome screen of P2 calibration.

Calibration is performed automatically, no further action is required during the calibration. The measuring is performed at 8 reference points of the whole range of ASC. ASC is adjusted automatically. Depending on the ASC type, P2 calibration usually takes several minutes (each measurement about 30 seconds plus time necessary for ASC adjusting from Imin to Imax). Calibration progress is displayed on the regulator screen.

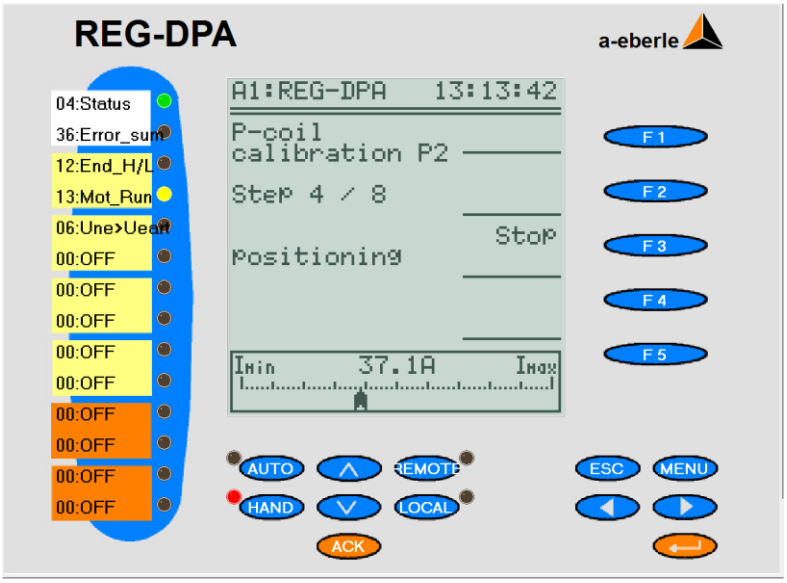

Figure 14: Progress of P2 calibration displayed on the controller REG-DP(A).

After the measuring of the Imax position the final data is possible to be displayed with F1 key. The P2 results should roughly correspond to the nominal voltage ratio between the main winding and PAW. Calibration is completed by accepting the data by pressing F2 key. Data is automatically synchronized to REG-DP(A).

Calibration data is also possible to decline by pressing F3 key. Then the previous data are recovered and the calibration is not completed.

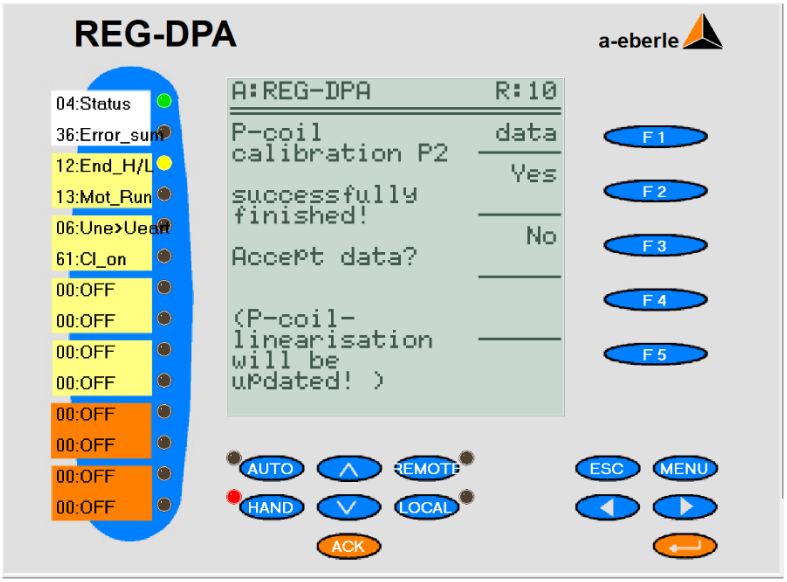

Figure 15: Screen after successful calibration.

After finishing this calibration, linearization table is automatically updated. Two points (Imax and Imin) were already set since the potentiometer calibration was made. Imax value is not changed, but more accurate values are assigned to the other reference points. In case of calibration without external coils in the same network, Imin value is refined too according to tuning range of the coil. The value can be slightly different from the original Imin parameter, but the current ratio between Imax and Imin corresponds to real inductance ratio of ASC after that.

This way of linearization is significantly more accurate than the manual input of this value from the mechanical position indicator. The linearization table is not necessary to complete manually.

After the calibration is complete, the MCI is fully calibrated and ready for operation. All the calibration should be in *OK* state.

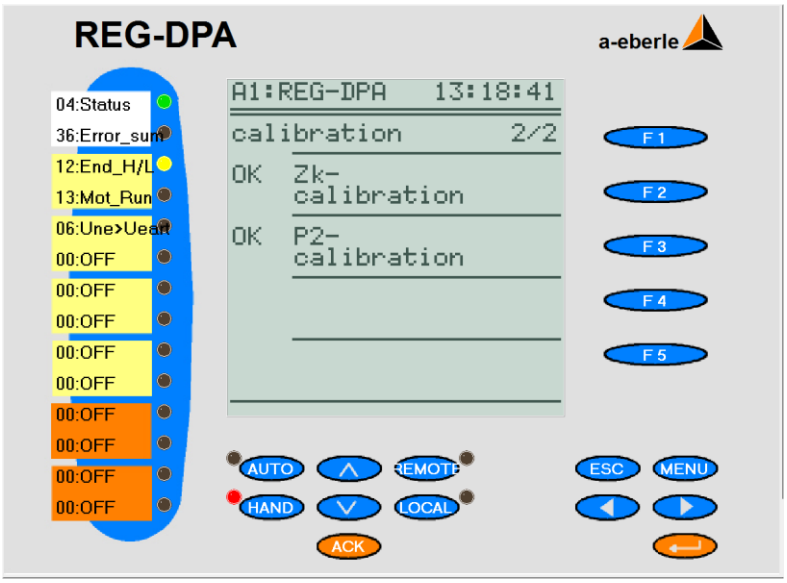

Figure 16: MCI calibration successfully finished.

If the data is not in typical range for fluently tuned arc suppression coils, warning “values are suspect” is shown.

If another ASC is connected in the same network, P2 calibration results will be significantly different from the nominal voltage ratio between the main winding and PAW.

The measured data are not rejected immediately, it is possible to check the data and accept the results anyway.

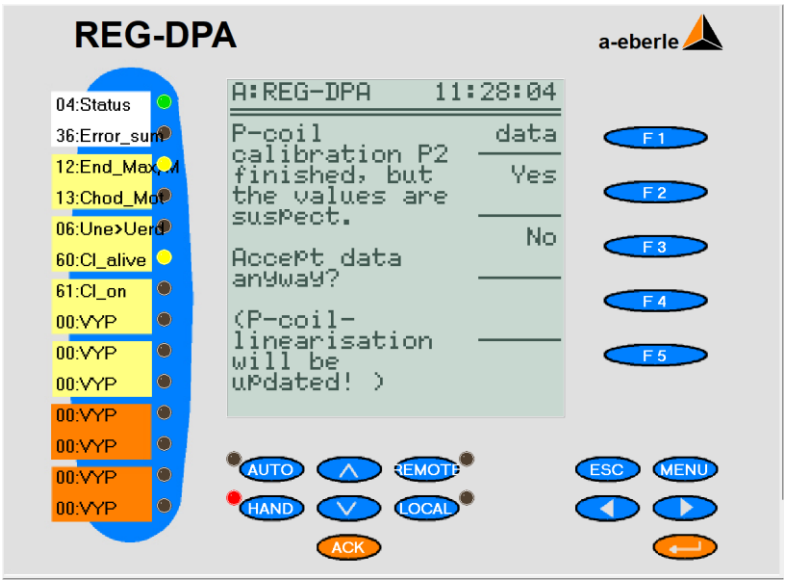

Figure 17: Screen after calibration with suspect results.

Reasons of the suspect results of calibration can be:

- During the P2 calibration network size was changed: Usually irregular changes during calibration process.
- Another coil was connected and tuned in the same network during the P2 calibration.

In case of a problem that can be detected immediately, calibration is canceled during the calibration process. Some typical reasons are:

- MCI is not connected to the ASC (circuit breaker or fuse switched off).
- ASC is short circuited.
- ASC is not connected to the network.
- Communication is interrupted during the calibration process.
- Signal of the same frequencies was detected – Probably another ASC with working MCI is in the network.
- ASC drive failure – regulator cannot reach required position.

8 MCI – emergency positioning

MCI injector is an accessory for REG-DP(A) controllers. It is not intended for stand-alone use. REG-DP(A) controls the whole process of tuning and commands the injector. But MCI is able to emergency tune arc suppression coil in case of loss of internal MODBUS communication between controller and MCI.

It is only emergency tuning and this feature is available only in mode 1 (see 6.1), when all the signals of the arc suppression coils are connected directly to MCI. Injector is able to control a drive of the coil and it can adjust the position thanks to the potentiometer values. Emergency positioning of MCI is necessary to permit via parameter “MCI – emergency positioning” in controller setting. MCI has implemented simple emergency controller without advanced functions that are available for REG-DP(A) controllers. Thanks to the injection, it can evaluate the network parameters and tune arc suppression coil properly.

There is no information about tuning status transmitted to the controller and therefore to the superior system either in emergency mode (without internal communication). Tuning status is indicated only by LED (see chapter 5.5). In this case without communication it is not possible to parametrized injector either. MCI tunes the arc suppression coil according to the parameters set before communication loss.

Tuning process during communication loss is triggered in similar way as for functional communication. Tuning process is started when:

- Voltage change is detected (amplitude and phase)
- Periodical tuning timer expired

These parameters are taken from the basic parameters of REG-DP(A) and it is not necessary to enter them separately. Other parameters, such as detuning, position tolerance etc. are taken from the controller too. Arc suppression coil is kept tuned like in fault-free conditions. Maximal voltage, that is not allowed to be exceeded is respected, as well as maximal detuning, delay of tuning or maximal number of search cycles. See 7.2.

If it is not possible to tune the arc suppression coil, then the position is adjusted to predetermined current value, in case the maximal voltage is not exceeded.

If MCI is restarted, emergency positioning is deactivated from safety reasons. Emergency positioning will be available after communication recovery and following loss.

Emergency positioning by MCI is not available in mode 2, because no signals from the coil are connected to MCI. In communication loss REG-DP(A) can try to tune the coil with standard resonance method. See the REG-DP(A) manual.

9 Maintenance

Before any service works, relevant safety regulations for work on electrical equipment must be met. Only persons with appropriate competence in accordance with regulations of the respective country are allowed to perform service works.

When testing the insulation of wiring circuits, it is required to disconnect the injector, e.g. by pulling out the connectors.

Multifrequency current injection MCI P-01 must be disconnected from power supply and power auxiliary winding of ASC before maintenance.

The device is not maintenance intensive. It is advisable to clean a settled dust from the device e.g. with compressed air. If ambient conditions required so, this cleaning should be performed more often.

10 Disposal

After the end of the service life of the device, it is necessary to ensure dismantling through a professional disposal company, sorting and disposal of individual materials in accordance with waste-disposal regulations in the respective country.

11 Standards and laws

11.1 Ambient conditions

Ambient conditions	Standard	Class	Value
Cold	IEC/EN 60068-2-1		- 40°C / 16h
Dry heat	IEC/EN 60068-2-2		65°C / 16h
Damp heat, cyclic	IEC/EN 60068-2-30		55°C / 6 cycles / 95% rel. humidity non-cond.
Composite cyclic test	IEC/EN 60068-2-38		10 cycles
Altitude			<= 2000m
IP code	IEC/EN 60529		IP20

11.2 Vibration and seismic test

Vibration and seismic test	Standard	Class	Value
Vibration	IEC/EN 60255-21-1	2	
Shock and bump	IEC/EN 60255-21-2	2	
Seismic test	IEC/EN 60255-21-3	2	

11.3 Electromagnetic compatibility

EMC	Standard	Class	Value
1MHz – burst disturbance immunity	IEC/EN 60255-22-1 IEC/EN 61000-4-18		2,5kV asym. 1 kV sym
Electrostatic discharge	IEC/EN 60255-22-2 IEC/EN 61000-4-2	4	8kV contact, 15 kV air
Radio frequency radiated field immunity	IEC/EN 60255-22-3 IEC/EN 61000-4-3		80MHz - 1GHz / 10V/m 1,4GHz - 2,7GHz / 10V/m
Fast transient disturbance immunity	IEC/EN 60255-22-4 IEC/EN 61000-4-4	A	4kV, 5kHz or 100kHz, 2kV (communication)
Surge immunity	IEC/EN 60255-22-5 IEC/EN 61000-4-5		4kV, 4kV L-PE, 2kV L-L
Radio frequency field inducted immunity	IEC/EN 60255-22-6 IEC/EN 61000-4-6		150kHz - 80MHz, 10V
Power frequency immunity	IEC/EN 60255-22-7 IEC/EN 61000-4-16	A	150 V Common mode, 300 V differential mode
Voltage dips	IEC/EN 60255-11 IEC/EN 61000-4-11 IEC/EN 61000-4-29 IEC/EN 61000-4-17		1 cycle/ 20 ms
Power frequency magnetic field immunity	IEC/EN 61000-4-8		30 A/m continuous, 300 A/m 3s
Ring wave immunity	IEC/EN 61000-4-12	4	4kV L-PE, 2kV L - L
Emissions	IEC/EN 60255-25		

11.4 Safety

Safety	Standard	Class	Value
Safety requirements	IEC/EN 60255-27		