DVC-24
Power Factor Controller

User Manual

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1. Before Installation

1.1. About User Manual

This manual is prepared for easy installation, commissioning, and effective use of DVC-24 reactive power control relay.

Before doing the connections and energizing the relay, first read the safety warnings in this manual carefully.

Perform the installation, maintenance and commissioning procedures under the supervision of an authorized person and in accordance with this manual.

1.2. Safety Precautions

The installation, commissioning and maintenance must be done by qualified electrical staff.

Instructions should be followed while connecting the terminals, do not work with live conductors

A dry cloth should be used for cleaning, corrosive or flammable / burning materials such as alcohol should not be used for cleaning.

Before cleaning power of the system should be shut down.

The case of the DVC 24 should not be opened. There are no operator serviceable part inside the case.

Three current transformer should be connected to DVC 24. Make sure that current transformer outputs are short-circuited before removing the transformer terminals. Otherwise, the overvoltages appearing at the end of the current transformer terminals result with hazards.

Attention should be paid for storage and operating temperatures, since the display has a fluid structure.

Do not use the device outside the purpose it has been designed for.

2. Disclosures

In this section the general structure of the relay, input and output connections, the keypad and display structure will be introduced.

2.1. DVC 24 Features

DVC24 is a DSP based power factor controller relay designed for reactive power compensation of unbalanced and rapid changing loads, controlling three phase and single phase capacitor banks and shunt reactor groups.

The characteristics of the system being controlled can be introduced to the relay manually or automatically.

However, the relay is also a power analyzer measuring line currents and voltages, active, reactive and apparent power, power factor, frequency, current and voltage harmonics for each phase and have the capability of displaying voltage and current waveforms.

DVC-24 measures the internal temperature. It has programmable temperature, maximum current, maximum voltage, minimum voltage and harmonics protection. According to internal temperature, DVC-24 can control system fan.

By the help of the digital input, control can be done by differently defined power factor or reference reactive power parameters.

The DVC-24 can be used for contactor switched, thyristor-switched or hybrid applications. For thyristor switching applications relay has an internal 24VDC power supply.

DVC-24 has an easy to use keypad, 160 * 160 graphical LCD operator panel and user friendly menu structure.

DVC-24 has automatic configuration recognition feature with automatic phase connection correction feature.
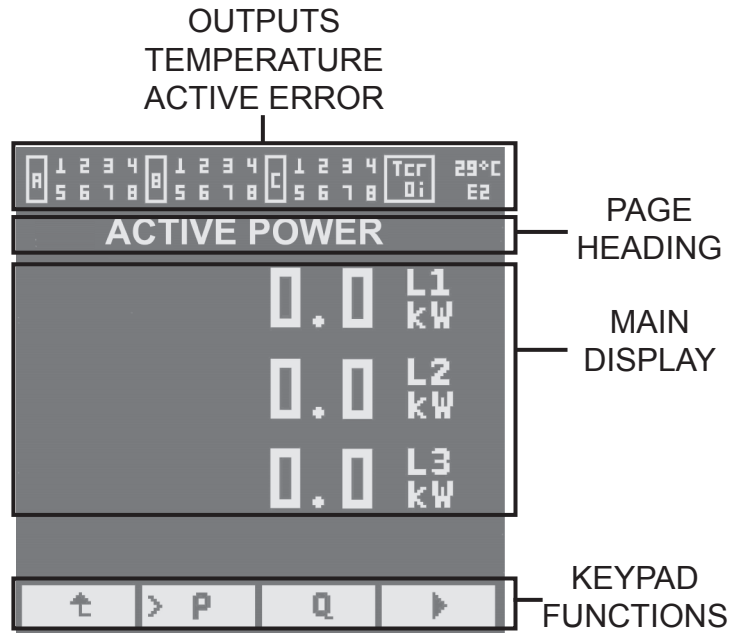
2. Disclosures

2.2. Front View
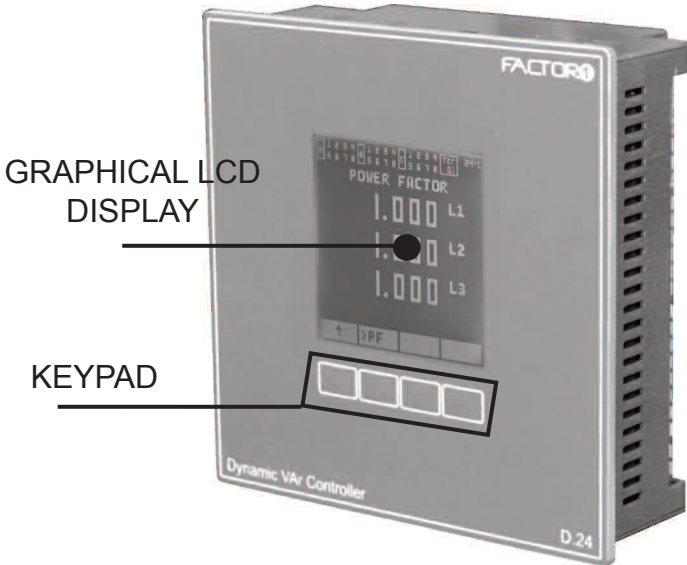
GRAPHICAL LCD
DISPLAY

KEYPAD
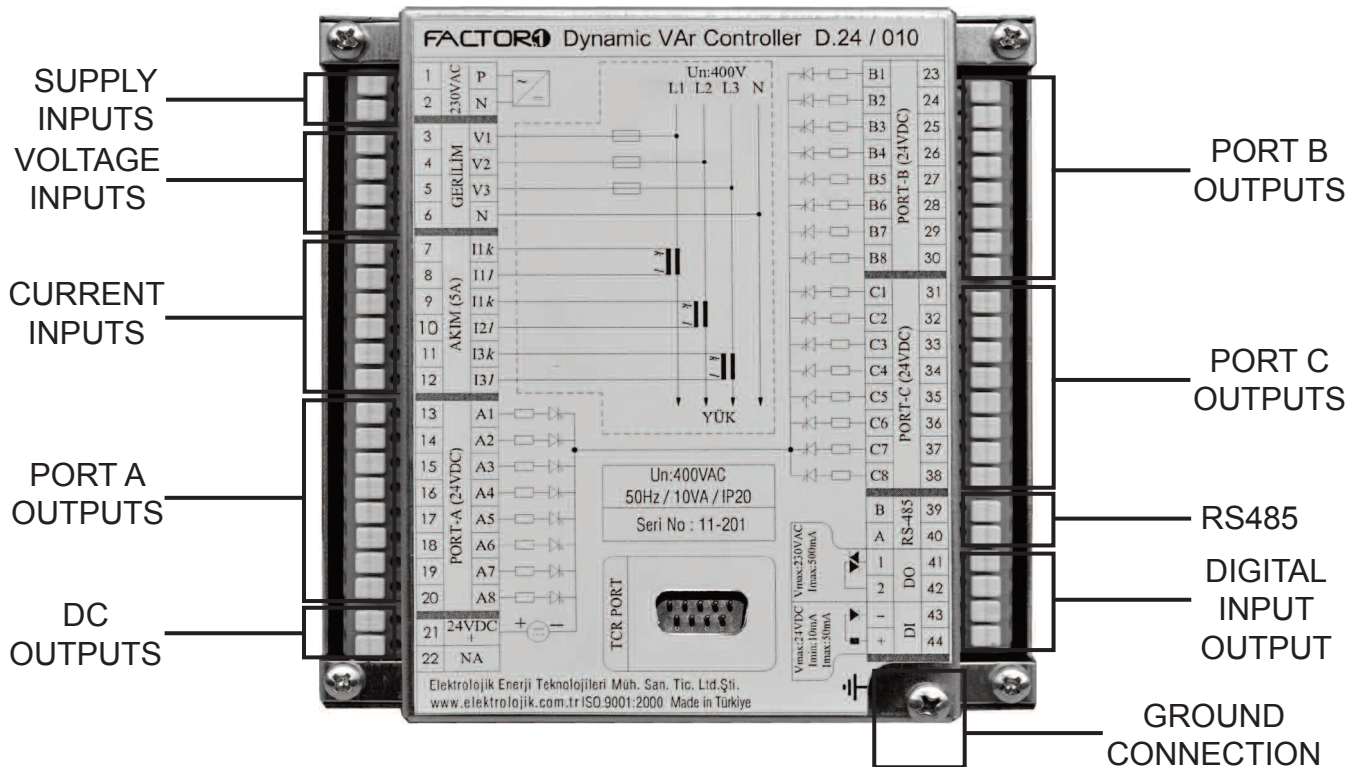
2.4. Display

OUTPUTS
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2.3. Rear View

SUPPLY
INPUTS

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3. Installation

3.1. Mounting

DVC-24 is mounted to a panel by using two fastening apparatus supplied with the relay.

First a cross section by 137x137mm should be opened on the panel where the relay rear side can pass.

After the relay has been placed to the cross section, the two fastening apparatus should be properly located to the upper and lower center part of the relay as shown in the figure and tightened with a screwdriver.

3.2. Cabling

Hole diameter of the connection terminals are 2.5mm. For a healthy way for plugging the cable, it is recommended to use cable crimp terminal as shown in the figure.

Press the locking tab of the terminals by a screwdriver, and place the cable to the terminal. Removing the press, the cable will be locked. In order to remove the cable, reverse the operation.

The cabling is done according to the connection diagram shown in the table.

3. Installation

3.3. Connection Table

|	Symbol	Description		Symbol	Description
1	P	Power Input 220VAC Phase	23	B1	Port B Output 1
2	N	Power Input 220VAC Neutral	24	B2	Port B Output 2
3	V1	Voltage Phase 1	25	B3	Port B Output 3
4	V2	Voltage Phase 2	26	B4	Port B Output 4
5	V3	Voltage Phase 3	27	B5	Port B Output 5
6	N	Neutral	28	B6	Port B Output 6
7	I1-k	Line 1 Current In	29	B7	Port B Output 7
8	I1-l	Line 1 Current Return	30	B8	Port B Output 8
9	I2-k	Line 2 Current In	31	C1	Port C Output 1
10	I2-l	Line 2 Current Return	32	C2	Port C Output 2
11	I3-k	Line 3 Current In	33	C3	Port C Output 3
12	I3-l	Line 3 Current Return	34	C4	Port C Output 4
13	A1	Port A Output 1	35	C5	Port C Output 5
14	A2	Port A Output 2	36	C6	Port C Output 6
15	A3	Port A Output 3	37	C7	Port C Output 7
16	A4	Port A Output 4	38	C8	Port C Output 8
17	A5	Port A Output 5	39	B	RS485 B
18	A6	Port A Output 6	40	A	RS485 A
19	A7	Port A Output 7	41	1	Digital Output **
20	A8	Port A Output 8	42	2	Digital Output **
21	24V+	Internal 24VDC + *	43	-	Digital Input ***
22	COM	Common Return *	44	+	Digital Input ***

* 24V+ output is the internal supply output for thyristor switching applications. For contactors do not use the output.
COM output is the common return for contactor switching applications. Do not use the output for thyristor switching applications.
For hybrid applications COM is used for PORT A return for contactor outputs while 24V+ is used as positive supply for thyristor modules controlled by PORT B and C outputs.
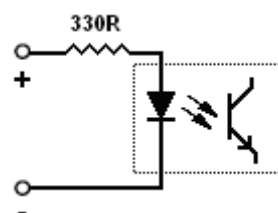
** Isolated triac output. Output current < 1A
Connection diagram:
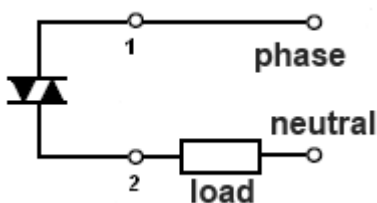
*** Isolated digital input. Directions should be cared in the connection. Current must be in the range of: 5mA < I < 50mA
Internal circuit:

4. Easy Comissioning

Step 1

Make sure that you have properly done the installation and connections of the relay.

Supply the power and three phase grid voltages. Make sure that the short circuit end of the current transformer is removed.

Step 2

Please check if the voltage values are read properly from "U" or " V " screens. Since the current transformer ratio is not entered, the currents will not be read correctly at this step.

Step 3

From the main menu enter the" STP" menu and enter the password . Default password is 0000.

Step 4

Enter "CT" menu to enter the current transformer ratio and save.

Step 5

Enter the menu "AUT " for automatic identification of steps. First select the connection of the first steps. A three phase capacitor step must be connected to A1 output, or single phase different steps must be connected to A1, B1, C1 outputs. After selecting your configuration select "START " for automatic identification and wait "OK (For more information, see . " Automatic Comissioning " section)
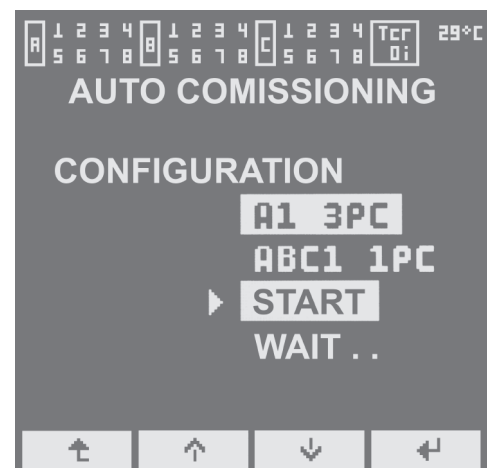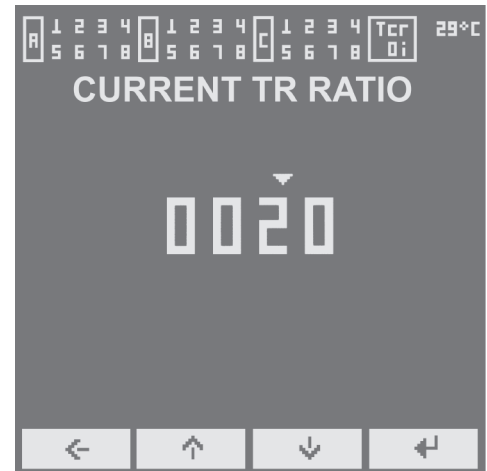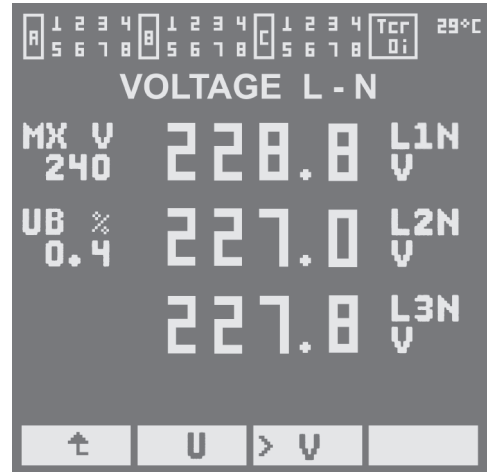
4. Easy Comissioning

Step 6

Enter the "BNK " screen and check the detected values and connection types of the steps detected by the relay. If the are errors fix them manually.
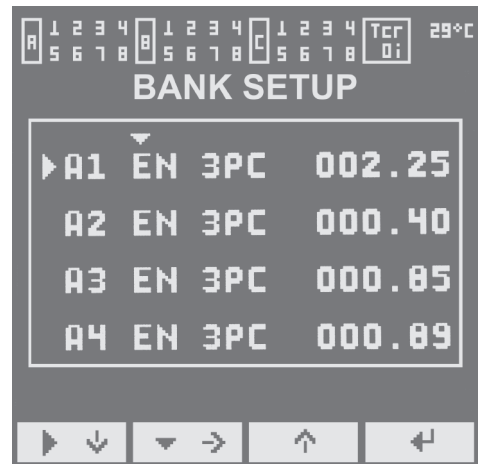
(For more information , see "Bank Setup" section)

BANK SETUP

▶A1	EN	3PC	002.25
A2	EN	3PC	000.40
A3	EN	3PC	000.85
A4	EN	3PC	000.89

Step 7

Enter the "TRG " screen and select the desired relay operation mode.

The factory settings of the operation mode is target-cos (φ) mode and the value is adjusted to 1.00. (For more information, see " Target Setup" section)

TARGET SETUP
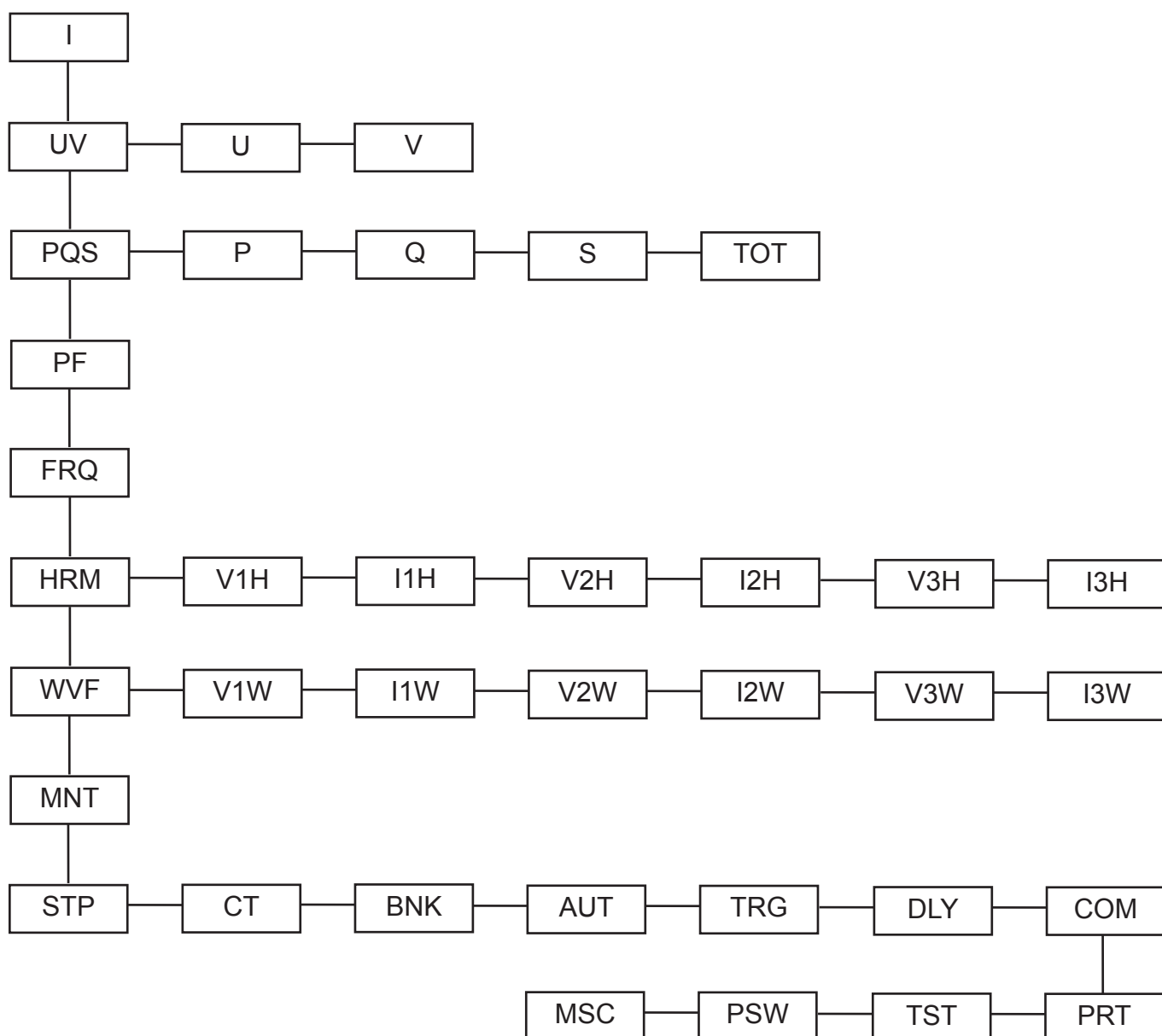
SELECT TARGET
▶ COS PHI
REF VAR
TR COMP
SET

Step 8

Enter the "DLY" screen and set the ON - OFF time of the steps and the reset time . The factory default settings are 60 seconds. After the reset time has expired, the relay will start working .

DELAY SET

	ON	OFF
P.A	001.0	001.0
P.BC	001.0	001.0
▶RST	010.0	

5. Menu Map

DVC-24 has a simple menu structure, easy to understand. The main menu consists of nine sub-sections. Navigating between pages, entering to the page and exiting from the pages, doing the settings is done with the help of four buttons. The functions of the buttons will appear on the screen above the buttons, indicated by symbols. DVC-24 menu structure is shown in the chart.

```
[ I ]

[ UV ]──[ U ]──[ V ]

[ PQS ]──[ P ]──[ Q ]──[ S ]──[ TOT ]

[ PF ]

[ FRQ ]

[ HRM ]──[ V1H ]──[ I1H ]──[ V2H ]──[ I2H ]──[ V3H ]──[ I3H ]

[ WVF ]──[ V1W ]──[ I1W ]──[ V2W ]──[ I2W ]──[ V3W ]──[ I3W ]

[ MNT ]

[ STP ]──[ CT ]──[ BNK ]──[ AUT ]──[ TRG ]──[ DLY ]──[ COM ]
                                                        │
         [ MSC ]──[ PSW ]──[ TST ]──[ PRT ]
```
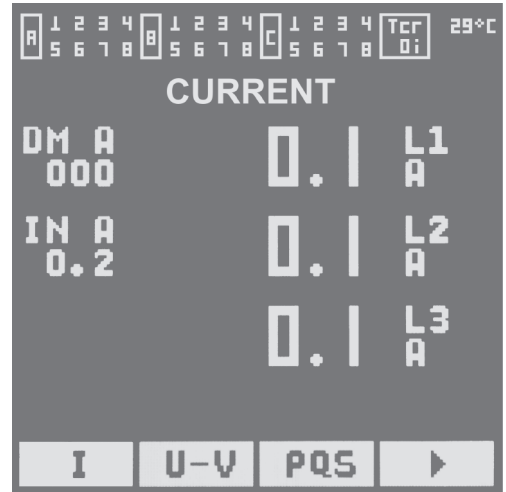
5.1 Measurement Menu

5.1.1 I (Current) Page

The effective (rms) values of three phase currents are displayed in the middle right side of the screen, whereas on the left side, the demand current and the neutral current values are displayed. Neutral current is calculated from the sum of the instantaneous values of three phase currents:

$$In = Ia + Ib + Ic \qquad (1)$$

Demand is the maximum value of the averages of current in 15 minute periods. Demand current value is reset when RESET DSP is activated in MSC page.

5.1.2 U (L-L Voltage) Page

The effective (rms) values of the phase-phase voltages (L1-L2, L2-L3 and L3-L1) are displayed in the middle right side of the screen, whereas on the left side, the maximum measured phase to phase voltage and the percent of voltage unbalance values are displayed. Voltage unbalance is calculated as:

$$V_{UB} = 100 \times (V_{MAX} - V_{AVE}) / V_{AVE} \qquad (2)$$
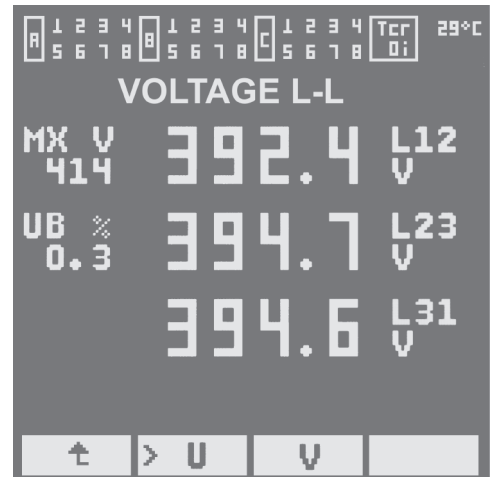
5.1.3 V (L-N Voltage) Page

The effective (rms) values of the phase-neutral voltages (L1-N, L2-N and L3-N) are displayed in the middle right side of the screen, whereas on the left side, the maximum measured phase to neutral voltage and the percent of voltage unbalance values are displayed. Voltage unbalance is calculated as also in eq (2).
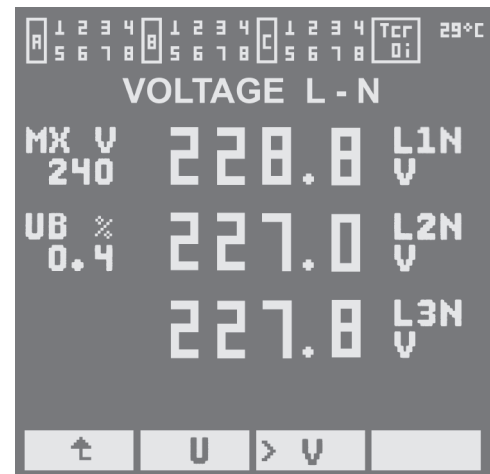
5.1 Measurement Menu

5.1.4 P (Active Power) Page

Active power values for each phase in kW are displayed on the page. If the active power is positive it means that power is drawn from the mains. If the active power is negative, and the system does not transmit energy outward, it means that a connection problem is likely to occur. If automatic phase sequence and bank determination process is carried out from AUT page or from MSC page the current orders and directions are corrected according to connection, the right values of the active power can be seen.

ACTIVE POWER

0.0 L1 kW

0.0 L2 kW

0.0 L3 kW

↑ > P Q ▶
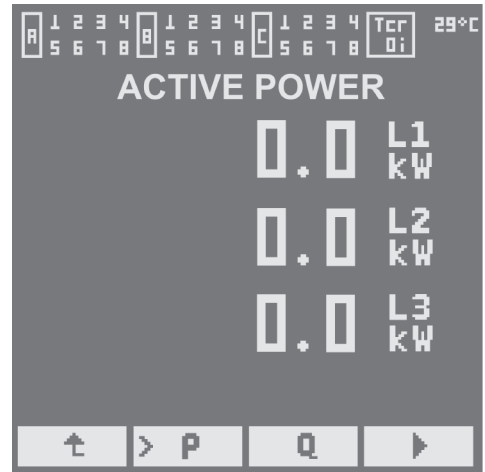
5.1.5 Q (Reactive Power) Page

The reactive power values for each phase in kVAr are displayed on the page. If the reactive power value is positive it means that the system is inductive, whereas if the value is negative, it means that capacitive reactive power is generated.

REACTIVE POWER

0.0 L1 kVAR

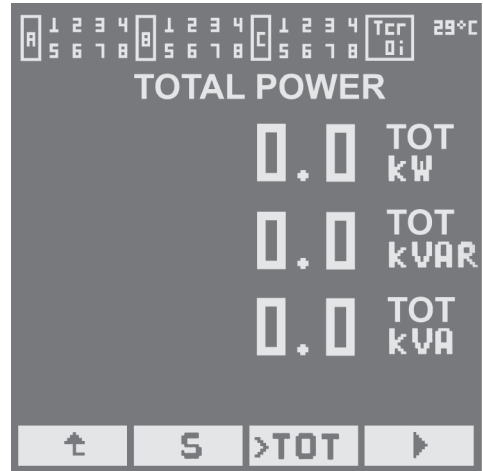0.0 L2 kVAR

0.0 L3 kVAR

↑ P > Q ▶

5.1.6 S (Apparent Power) Page

The apparent power values for each phase in kVA are displayed on the page.

APPARENT POWER

0.0 L1 kVA

0.0 L2 kVA

0.0 L3 kVA

↑ > S TOT ▶
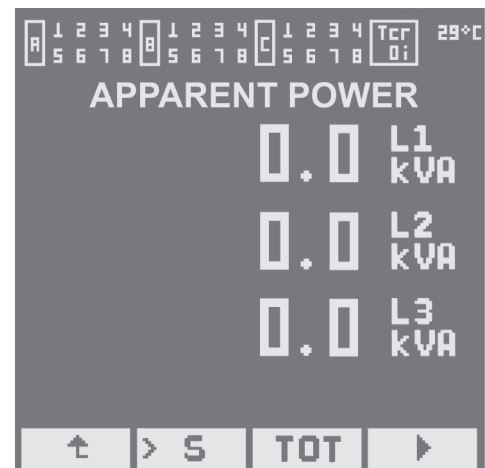
5.1 Measurement Menu

5.1.7 TOT (Total Power) Page

In this page, total active power (kW), total re-active power (kVA) and the total apparent power (kVA) values can be monitored respectively.

5.1.8 PF (Power Factor) Page

On this page the power factor (cosφ) values of each phase can be monitored. If the power factor is negative, the system is capacitive, vice versa if the value is positive than the system is inductive.
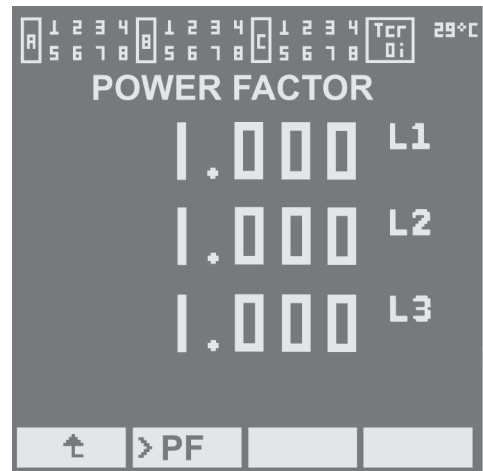
5.1.9 FRQ (Frequency) Page

The mains frequency (Hz) can be monitored on this page.

5.1 Measurement Menu

5.1.10 HRM (Harmonic Spectrum) Page

This sub-section consist a total of six pages for each three-phase voltage and current harmonic spectrum separately:

V1H, I1H, V2H, I2H, V3H, I3H.

The corresponding current or voltage harmonics can be monitored up to 17th harmonic. The effective value of the relevant current or voltage is seen on the left side just above the spectrum while on the right side, the harmonic percentage % value of the selected harmonic by the cursor located at the bottom is monitored. Sliding the cursor with arrows to left or right, the percentage of all the components can be seen in the spectrum.
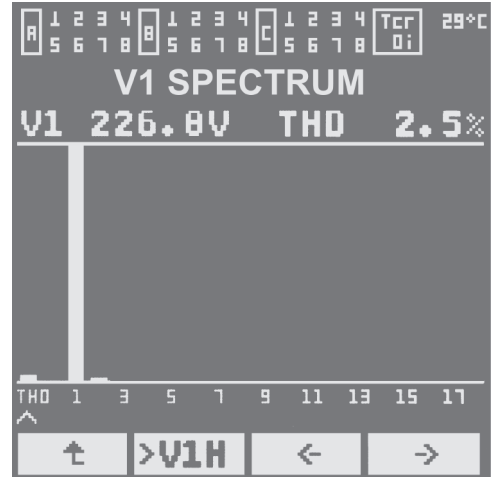
5.1.11 WVF (Wavefom) Page

This sub-section consist a total of six pages for each three-phase voltage and current waveform separately:

V1D, I1D, V2D, I2D, V3D, I3D.

On the screen, one period of corresponding current and voltage can be monitored. At the bottom of the screen the effective (rms) value of the corresponding current or voltage is displayed.
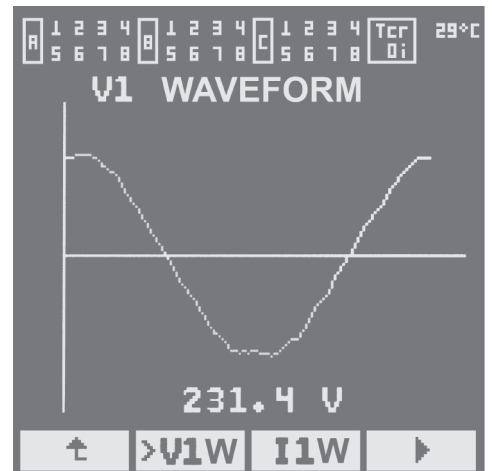
5.1.12 MNT (Switching Count) Page

On this page, the switching times of each of the 24 steps can be monitored. Section consists of four sub-pages. Sliding the cursor by the help of the arrow keys, the requested page can be reached and the number of switching steps can be displayed.
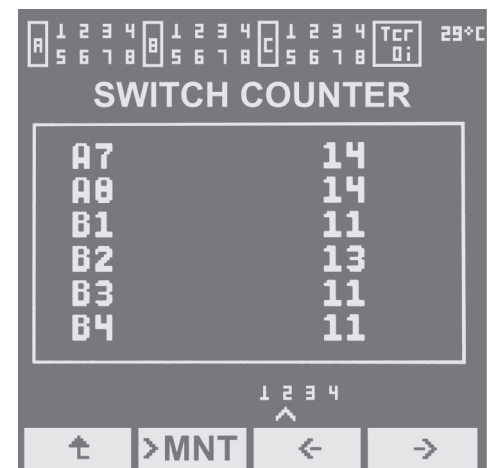
5.2 Setup (STP) Menu

The setup menu consists of ten sub-menus. The sub-menus are password protected. When the user enters the STP menu, it is wanted to enter the four digit password. The default password is 0000. After entering the correct password the user can reach the sub-menus of CT, BNK, AUT, TRG, DLY, COM, PRT, PSW, TST and MSC. The following part describes the function and the usage of the sub-menus in detail.

5.2.1 CT (Current TR Ratio) Page

Current transformer ratio is entered with the arrow keys (←,↑,↓). When enter (↵) button is pressed, the value on the screen will be saved and the menu will be exited.

5.2.2 BNK (Bank Set) Page

Each 24 output step of the relay can be programmed to desired configuration. The status of a step (EN=Enabled, DS=Disabled, ON=Fixed ON) can be set from the column just right of the step. The ON means the step will remain switched continiously, while DS identifies the unused output steps. Only the EN marked steps will be automatically controlled by the relay.

The type of the step (three phase capacitor or reactor, single phase capacitor or reactor) can be chosen from the next column:
3PC : Three phase capacitor
L1C : Capacitor connected to L1 phase
L2C : Capacitor connected to L2 phase
L3C : Capacitor connected to L3 phase
3PI : Three phase shunt reactor
L1I : Reactor connected to L1 phase
L2I : Reactor connected to L2 phase
L3I : Reactor connected to L3 phase

From the left column the reactive power of each step in kVAr can be set. The corresponding values for each of the 24 steps can be reached and changed using the right (►) and down (▼) cursor.

If automatic comissioning is used, the bank types and powers found by relay comes to the screen. Error due to measuring and instant load changes are possible. It is recommended to correct the values for a healthy control. When enter (↵) button is pressed, the value on the screen will be saved and the menu will be exited.
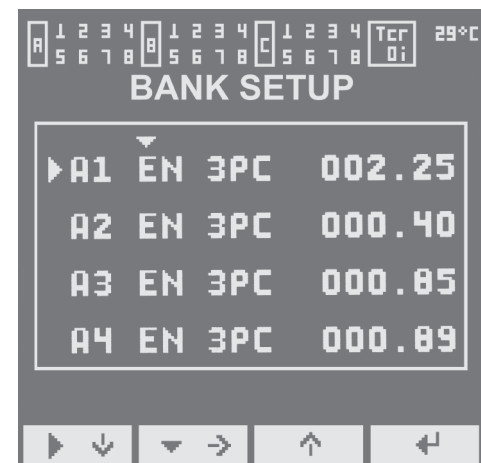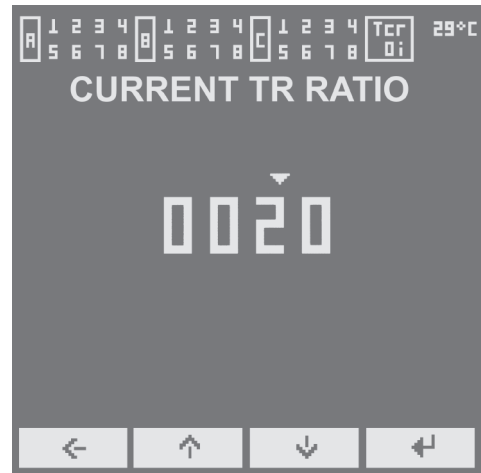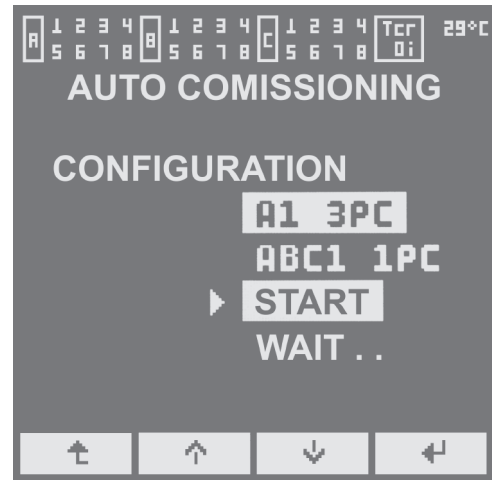
5.2 Setup (STP) Menu

5.2.3 AUT (Automatic Commisioning) Page

In the case of the phase order and direction of the voltage and current connections not matching, DVC-24 is capable to detect and correct the misorder. For this process to be succesful, two options are possible for the bank configuration. A three phase capacitive load should be connected to A1 output or the second alternative, single phase capacitors must be connected to A1,B1 and C1 outputs, each one is connected to different phase. (order is not important)

The Process of Automatic Comissioning

1. According to the output configuration choose the correct configuration suitable for your system. "A1 3PC" means that three-phase capacitor is connected to the A1 output, "ABC1 1PC" means that three single phase capacitors are connected to the A1, B1 and C1 outputs. To select one of two, use up or down arrows to move right cursor (►) and press enter (↵).
2. After the selection is done, come to "START" line and press enter (↵). Wait until this process ends.
Relay will switch the A1 output or A1,B1,C1 outputs accroding to chosen configuration. After that all the steps will be switched in the order.
3. If the phase connections are sensed and determined in a healthy way, "OK" message will appear. On the other hand if recognition is not successful due to rapid load changes, step faults etc. an "ERROR" message will appear on the screen.
4. Exit the page using exit (↰) button.

5.2 Setup (STP) Menu

5.2.4 TRG (Target Set) Page

Compensation control can be made with one of the three different methods by DVC-24: cos(φ) method, reference VAR method, transformer compensation.

Cos(φ) method

Controller targets to keep the system in desired cos (φ) value. Cos (φ) can be defined as capacitive or inductive, as well as two different cos (φ) targets can be defined. The first target is the normal operating value while the second one activates with the ON position of the digital input via an external signal.

Reference VAR method

Controller targets to keep the system in desired reference value. Reference (kVAr) can be defined as capacitive or inductive, as well as two different references targets can be defined. The first target is the normal operating value while the second one activates with the ON position of the digital input via an external signal.

Transformer Compensation

The transformer nominal power and %Usc values are entered to controller. Controller, considering the loading, estimates the reactive power consumption of the transformer and tries to compensate it.

The Process of Target Selection

1. From the main menu select and enter STP menu, enter the password correctly.

2. Using the arrow keys select and enter TRG menu.

3. To select one of the three modes , use up or down arrows to move right cursor (►) and press enter (↵).

4. After the selection is done, come to "SET" line and press enter (↵).

5. In the opened page, siliding the right (►) and down (▼) cursors, and using the (↑) for changing the digits, set the desired parameters.

Target Cos(φ) should be chosen between 0 and 1. Reference VAR unit is kVAr. In both pages "C" stands for capacitive and "I" stands for inductive.

6. Press enter to save values and return to previous page.

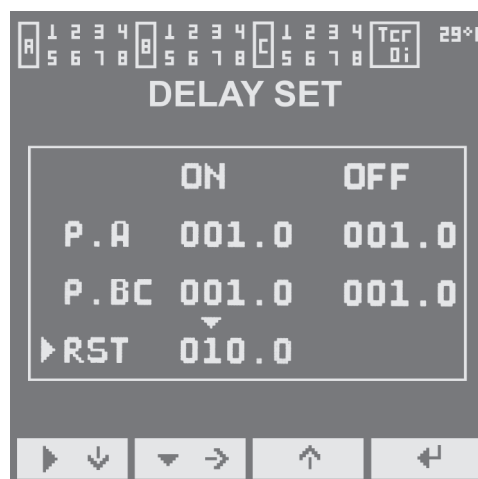7. Exit the page using exit (⌐) button.
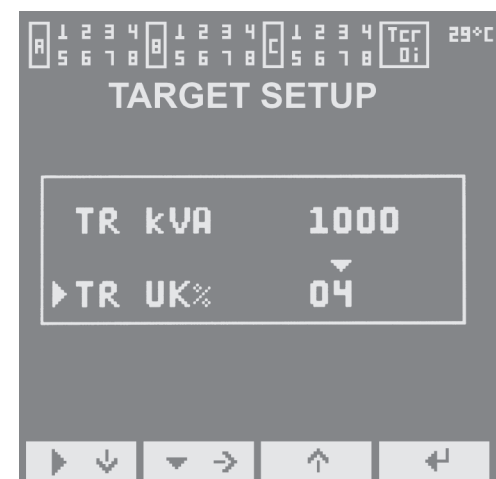
5.2 Setup (STP) Menu

5.2.5 DLY (Delay Set) Page

The ON and OFF times of port A and ports B, C can be adjusted seperately. This option can be helpful for hybrid applications where contactors are connected to port A, while thyristor switches are connected to port B and C.
The ON delay is defined as the time required to switch on a step just after it was switched off. On the other hand the OFF delay is defined as the time required to switch off a step just after it is switche on.
RST (Reset) delay is defined as the time required the controller to work when it is powered. On the other hand reset time determines the time of re-working of the controller after a fault condition is removed.

```
┌A┐1 2 3 4┌B┐1 2 3 4┌C┐1 2 3 4┌Tcr┐ 29°C
└─┘5 6 7 8└─┘5 6 7 8└─┘5 6 7 8└─Oi┘
            DELAY SET
  ┌──────────────────────────────┐
  │          ON        OFF        │
  │   P.A   001.0     001.0       │
  │   P.BC  001.0     001.0       │
  │           ▼                   │
  │ ▶RST    010.0                 │
  └──────────────────────────────┘
   ▶  ↓    ▼  →      ↑        ↵
```

5.2.6 COM (Communication Set) Page

This page is for modbus configured devices. Modbus adress, baud rate and parity can be set using this page.

```
┌A┐1 2 3 4┌B┐1 2 3 4┌C┐1 2 3 4┌Tcr┐ 29°C
└─┘5 6 7 8└─┘5 6 7 8└─┘5 6 7 8└─Oi┘
          COMMUNICATION
  ┌MODBUS RTU────────────────────┐
  │ ▶ADDRESS     001              │
  │  BAUD RATE  9600              │
  │  PARITY      ODD              │
  │  DATA BIT    8                │
  │  STOP BIT    1                │
  └──────────────────────────────┘
   ▶  ↓    ↑        ↓        ↵
```

5.2 Setup (STP) Menu

5.2.7 PRT (Protection Set) Page

DVC-24 has over voltage (VMAX), low voltage (VMIN), over current (IMAX), total harmonic distortion (THDV) and temperature (TMAX) protections. For protections to be active, EN (enable) option must be selected instead of DIS (disable) option in the first column. The limit values of the protections can be set from the second column. The controllers function in case of fault condition can be selected from the right column. Here;

0 : Steps are switched off at fault condition

1 : Digital output of relay is activated at fault condition

01: Both steps are switched off and digital output is activated at fault condition.

If more than one fault function is defined as "1", in this case digital output is activated even in one fault condition.

Fan Control

The digital output of DVC-24 can be configured to control a fan.

1. From main menu enter STP menu and enter the password.

2. Using arrow buttons come to PRT menu and press Enter (↵).

3. Slide the right cursor (►) down by down arrow button and come to second page where FAN is located.

4. Sliding the down (▼) cursor enable (EN) the FAN from the first column, set the FAN ON temperature in the second column and FAN OFF temperature at the third column using (↑) button. FAN ON must be a higher value than FAN OFF.

5. Save the values pressing Enter (↵).

5.2 Setup (STP) Menu

5.2.8 PSW (Password Set) Page

The DVC-24 setup pages are password protected for the use of authorized people. The password can be changed from STP menu.

The Procedure of Changing Password

1. From main menu enter STP menu and enter the password.

2. Using arrow buttons come to PSW menu and press Enter (↵).

3. Sliding the down corsor (▼) and using (↑) button for changing digits enter the old password.

4. Slide the right cursor (►) down to new password section and enter the new password.

5. Save the new password pressing Enter (↵).The digital output of DVC-24 can be configured to control a fan.

5.2.9 TST (Bank Test) Page

The controllers outputs can be tested seperately. The TST section consist of three pages, each one is for one port.

The outputs can be made ON or OFF selecting the step by sliding down corsor (▼), right cursor (►) and using (↑) button.

For relay to stop automatic control, select and activate the "HOLD" section on the bottom left. This will protect relay to work in test mode. If HOLD section is left activated and the user exits TST menu, the relay will not maintain autocontrol.

5.2 Setup (STP) Menu

5.2.8 MSC (Miscellaneous Set) Page

Some settings which are not defined in others are collected in this page. Current order, current direction, DSP reset, and language can be set from this page.

Current Order and Current Direction Set

If the automatic commissioning fails to determine the current order and direction, the right connection can be defined manually. Refer to the tables, to choose the right connection.

| Voltage Order		A	B	C
	0	A	B	C
	1	A	C	B
Current Order	2	B	A	C
	3	B	C	A
	4	C	A	B
	5	C	B	A

Example: referring to voltage inputs, if current B is entered instead of A and current A is entered instead of B, from the table current order must be selected 2.

| Current Directions			
0	k-l	k-l	k-l
1	l-k	k-l	k-l
2	k-l	l-k	k-l
3	k-l	k-l	l-k
4	l-k	l-k	k-l
5	k-l	l-k	l-k
6	l-k	k-l	l-k
7	l-k	l-k	l-k

Example: if A and C currents directions are true (from k to l) and phase B is reversed (from l to k) than current direction must be selected as 2

If RESET DSP is enabled, VLLmax, VLNmax and Idmnd values will be reset.

Two language options are available: English and Turkish.

A.1 Dimensions

144

144

136

60

Dynamic VAr Controller

D24

FACTOR1

136
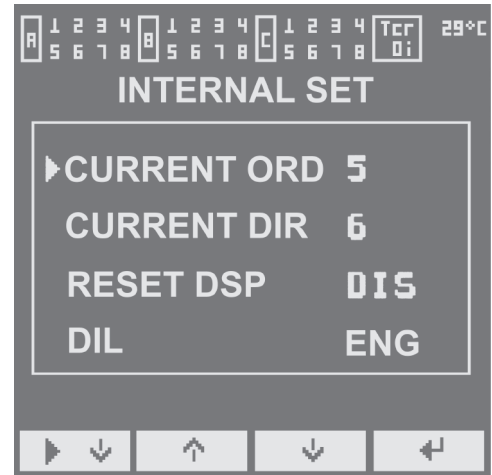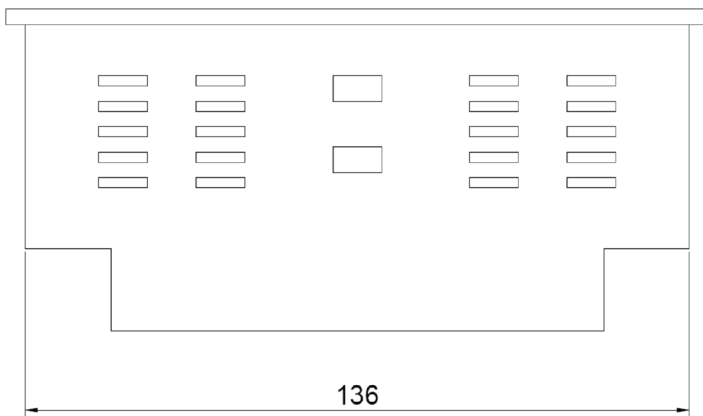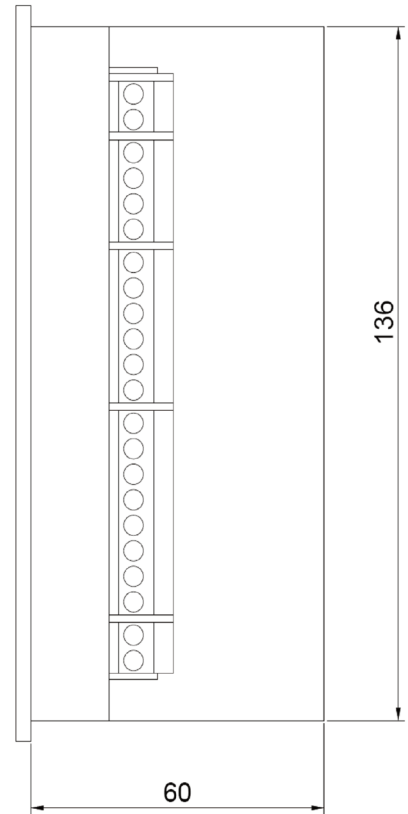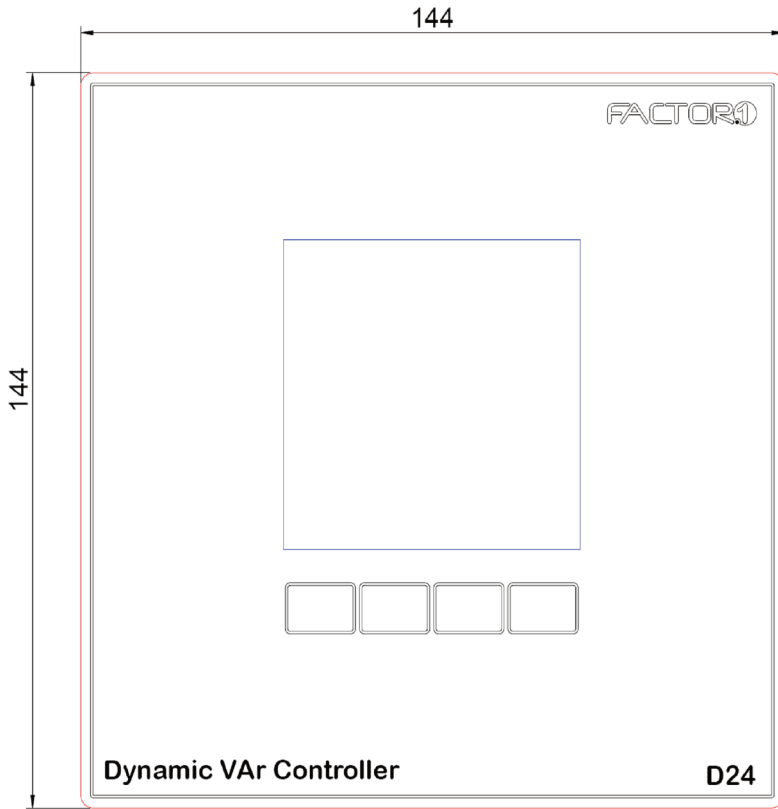
A.2 Technical Data

Measurement System

DSP based, three phase unbalanced systems, single phase systems

Operating Voltage

230V AC +/- 20%.

Operating Frequency

50Hz

Power Consumption

10 VA max.

Step Outputs

	DVC 24 11-201	DVC 24 11-202	DVC 24 11-203
Output Types and Number	24 Transistor	24 Triac	8 Triac 16 Transistor
Contact Position	Normally Open		
Output Current	50mA DC	1A AC	50mA DC (PortB-C) 1A AC (PortA)

Digital or Fan Control Output

- Triac

- Normally Open

- Max.1A AC.

Operating Modes

- Cos(φ) control (Inductive, Capacitive)

- Reference VAR control (Inductive, Capacitive)

- Transformer Compensation

Step Design

Free

Display

160x160 graphical LCD

Display Area

62x62mm

Saving Function

All programmed parameters and modes are permanently stored in memory.

Operating Temperature

between 0° C and 70° C

Storage Temperature

between -10° C and 85° C

Mounting

Perpendicular to the panel

Dimensions

Front panel 144 x 144 mm (HxW)

Total 145 x 145 x 67 mm (HxWxD).

Weight

0.760 kg (Package Excluded).

Connector

For directly inserting of single wire connectors (connector diameter 5 mm for cross sectional area 0,5 - 2,5 mm²)

Relative Humudity

Max. %95, noncondensed