TRIOL

AK06

VARIABLE SPEED DRIVE FOR ESP APPLICATIONS

DESIGN MANUAL

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Dear customer

Thank you for purchasing Triol Variable Speed Drive (VSD), the key to your successful artificial lift strategy.

We are sure that our variable speed drive technologies allow you to improve operations and adjust production.

VSD is complete with the following manuals:

- Design Manual;
- Operation Manual;
- Quickstart Manual;
- Programming Manual;
- Troubleshooting Manual;
- Approvals/Standards.

<u>IMPORTANT</u>: The list may be extended with the additional documents (The Factory Acceptance Testing (FAT) and others) depending on the VSD line.

<u>NOTE</u>: Quickstart manual includes only the necessary basic steps to start VSD with an induction motor at a well site during pre-commissioning: set-up VSD to motor and transformer, no-load test and test a VSD with step-up transformer. During commissioning shell be set-up protections, operation and starting modes in accordance to a field standards or well design. Explanation of VSD controller settings are given in the Programming manual. Procedures of starting/stop, recommendations for settings, connection of external equipment (such as downhole sensors, analog/digital input/outputs sensors are given in the Operation manual. In case of any problems or failures please use Troubleshooting manual. Design manual includes technical specifications, a set of dimensional drawings and electrical diagrams for Variable Speed Drives Triol AK06. The list of all kinds of user manuals is discussed at the placing an order stage. E-documents version for the product is available on the official Triol Corporation website.

https://triolcorp.us/documents/

Design Manual AT.654252.411 ver. 1.0.

The manual applies to the commercially available Variable Speed Drives Triol AK06 series.

Contents

Specification

Input	
Power supply, V	• 3x380 ± 15% / 3x480 (-15% … + 10%); • 50% continuously with reduced output power; • 65% up to 500 ms (with a decrease of output power)
Input frequency, Hz	50/60 (-5% … + 5%)
Rectifier type	6, 12, 18, 24 pulse available for request
Output	
Rated output current, A	From 100 up to 3000
Rated full power, kVA	From 83 up to 2494
Overcurrent characteristics	• 120% of rated value for 60 sec; • 150% of rated value for 60 sec with derating of continuous output current (integral time-current characteristic)
Output frequency	• 1.5 - 80 Hz, in asynchronous motor control mode; • 1.5 - 200 Hz, in permanent magnet motor control mode; • up to 600 Hz, in high-speed PMM control mode (option)
PWM frequency	Up to 8 kHz depending on VSD type
Efficiency	96 %
Change of frequency task increment	0,1 Hz
Control type	• scalar control: based on the characteristic voltage / frequency V/Hz (for asynchronous motors); • vector control in an open-loop system without speed feedback (for PMM); • cosine mode control (for PMM)
Speed maintenance accuracy (static)	+/- 10% of rated speed in open-loop system
Acceleration and deceleration rates	• linear, from 0.1 Hz / s; • program mode with adjustable time of reaching given frequency
Design	
Enclosure	• type Nema 4 (4X for request), double layer polymer coating, RAL 9016; • junction box for power connections with clamping terminals; • separate section for down hole sensor installation; • mechanical blocks on doors; • lugs for luck on the breaker handle; • double roof for sun protection; • sand shield for protection main cooling system
Cooling type	Type of cooling Air-to-air heat exchanger for cooling of power compartment, air forced to cool the winding elements of the power circuit
Internal	• modular construction; • separate power and control units; • air dryer in power section; • built-in DC bus Choke; • built-in Sine wave filter (THD level <5%)
HMI (for request)	• UMKA07 controller with LCD-TFT 7 inch display, touch screen; • UMKA03 controller with LCD-TFT 7 inch monochrome display, push-button control
Drive Status Indicator Lights	• “Running”, “Standby”, “Stop”, “Backspin”
Insulation	• galvanic isolation between power and user circuits; • insulation resistance > 5 MOhm

Control connections	
Analog input	• 2 by default, optional extension +8 or more • programmable 4..20 mA, 0..5 mA, 0..10 V (frequency reference / multifunction analog input)
Digital input	• 2 by default, optional extension +4 or more • 24 V, input resistance: 4 kOhm
Analog outputs	Option, 4 or more programmable 4..20 mA, 0..5 mA, 0..10 V
Relay Outputs	Option, 8
Communication port	Modbus
Physical interface	• 2-wire RS-485/232 for Modbus by default; • Ethernet (optional) - for communication with ACS/automated control system; • wire RS-485/232 for Modbus - for communication with a surface telemetry unit
Operator control voltage (option)	• 10 V DC, +/- 2% current not more than 30 mA; • 24 V, 300 mA; • 110/220 V, 10A for connecting of third-party consumers
Environmental conditions	
Operating temperature	• -4°F (-20 °C) ... +140°F (+60 °C); • -4°F (-20 °C) ... +131°F (+55 °C) for UL listed VSD's
Storege temperature	-40°F (-40°C) ... +158°F (+70 °C)
Relative humidity	100 %.
Max. altitude	3281 ft (1000 m).
Vibration load	0.5g (5 m/s^2).
Impact load	3g (30 m/s^2).
Standards	
EN 61439-1:2011, EN 61000-6-4:2007, EN 61000-6-2:2005; RETIE; UL 61800-5-1 (for request)	

Rated VSD power and overall dimensions

Rated current (output current), Amps	Rated power, kVA	Full output power, kVA (with SWF)	Cabinet	Width, mm (inch)	Depth, mm (inch)	Height, mm (inch)	Mass (max), kg (lb)
100	83	75	№1	1350 (53.15)	1210 (47.64)	1955 (76.97)	540 (1190)
160	133	120					
250	208	187					
300	249	224	№2	1350 (53.15)	1110 (43.7)	2000 (78.74)	600 (1323)
360	299	269					
400	333	299					
420	349	314					
515	428	385	№3	1670 (65.75)	1210 (47.64)	2000 (78.74)	830 (1830)
590	491	441					
630	524	471					
675	561	505					
800	665	599	№4	1690 (66.54)	1210 (47.64)	2000 (78.74)	975 (2150)
900	748	673	№5	2130 (83.86)	1250 (49.21)	2180 (85.83)	1650 (3638)
1000	831	748					
1200	998	898					
1400	1164	1048					
1600	1330	1197					
*Up to 3000 Amps VSD's available on tandem drives **Power for 480V supply voltage							

Variable Speed Drive protection and blocks

- switch off an Electrical Submersible Motor in case of deviation of the mains power supply voltage, if this deviation leads to an unacceptable current overload with the possibility of reclosing after voltage recovery;
- switch off an Electrical Submersible Motor at underload (protection against supply disruption);
- switch off an Electrical Submersible Motor at overload in accordance with the programmable ampere - second characteristic;
- switch off an Electrical Submersible Motor for overcurrent protection (overcurrent protection);
- switch off an Electrical Submersible Motor at unacceptable reduction in the insulation resistance of the Cable-motor system;
- switch off an Electrical Submersible Motor due to unacceptably low output frequency of the electric drive;
- switch off an Electrical Submersible Motor when the protection of the power tongs of the electric drive is triggered;
- switch off an Electrical Submersible Motor in case of power modules overheating;
- switch off an the Electrical Submersible Motor when the specified parameters of the telemetry system are exceeded;
- switch off an Electrical Submersible Motor at an unacceptable pressure in the pipeline (according to the signals of the contact pressure gauge);
- switch off an Electrical Submersible Motor in case the door of the power compartment of the cabinet is open.
- VSD protection against voltage transients and surges by using MOV`s on each phase;
- circuit breaker emergency switching off in case of critical alarm (optional).

Variable Speed Drive functionality

VSD Triol AK06 series provides the following functions but not limited to these:

- operation of the electric motor in the modes - “Manual” (without the possibility of automatic re-activation of the ESM after the protection trips), “Automatic” with the possibility of automatic re-activation of the ESM and “Automatic” in accordance with the specified time program;
- braking of a motor in the presence of turbine rotation, with the subsequent start;
- current optimization mode when the specified motor speed is reached;
- gas lock algorithm;
- built-in backspin control unit;
- “Catch on the fly” function;
- built-in insulation monitoring system of the submersible part of the installation;
- operation on the assigned time program with separately programmable times of the on and off state of the ESM;
- automatic change of the output frequency according to the specified time program;
- smooth acceleration and deceleration of the ESM at a given rate;
- reversing the motor;
- operation of the motor in a field weakening mode when rotational speed is higher than nominal (only for asynchronous motors);
- automatic start of the electric motor with an adjustable time delay when energizing the supply voltage;
- automatic keeping of a given value of the technological parameter (pressure, current);
- motor start modes: start with buildup, inching start (can be used to uncouple the submersible unit), smooth start with synchronization. Wedging occurs to ensure maximum motor torque at low speed;
- continuous monitoring of the insulation resistance of the “Cable - ESM” system with the disconnection of the ESM at unacceptable reduction of insulation;
- ability to operate with reduced insulation resistance of the Cable-ESM system with high-speed disconnection at overload;

- measurement and display on the built-in liquid crystal display of current parameters of the electric drive and submersible installation;
- ability to control the motor remotely, control parameters, view and change protection settings via a telemetry system by means of RS485 and / or Ethernet interface;
- support of the all types telemetry systems (can be add for request);
- recording the data about the reasons for enabling and disabling the ESM, as well as recording the current parameters of operation to the built-in non-volatile memory;
- registration of settings change and displaying of a report in the event log with indication of the date and time of setting change;
- outdoor light alarm of installation status (operation, standby, shutdown);
- ability to control the motor by means of submersible device (sensor);
- ability to configure on-site: protection against overload and underload, unacceptable values of the mains voltage and the DC link of the electric drive protection, current imbalance protection, long-term operation at a low frequency protection, overheating of the power switches chiller protection, operation beyond the limits of telemetry system protection;
- ability to display information about VSD doors open through the telemetry system at the control room;
- continuous monitoring of three phases power supply voltage availability, disconnection or prohibition of switching on of the motor if one of the phases is missing

Options

Built-in options

Option	Description
Ethernet	SCADA connection interface
8 analog inputs 4...20 mA, 0...10 V, 0...5 mA	Additional modules for control connections
4 analog outputs 4...20 mA, 0...10 V, 0...5 mA, 4 digital inputs 24VDC	
8 digital inputs 24 VDC 8 relay outputs	
8 relay outputs 110/220VAC, 5A	
Duplex Ethernet port	For adjusting the monitoring and control system
GPS Modem	
User output 24V	Supply for external costumer connections
Socket 220V, 10A	
Socket 110V, 10A	
User output terminal 110V, (500 VA)	
Transformer 415V	For VSD supply voltage 415V -15% +10%
Transformer 440V	For VSD supply voltage 415V -15% +10%
Power socket 3x380V, 60 Apms	For costumer equipment connection
Power socket 3x480V, 60 Apms	
UPS 500 VA	Backup power supply
UPS 1500 VA	
Space heaters	Internal space heaters for arctic conditions or high humidity environment
Motor heaters supply	Output power supply for surface motor heaters
Energy meter	Input power measuring system *Note: available for 6, 12 pulse input only*
Input current transformers	Input CT's for costumer energy meter connection
Analog thermal sensor rectifier	Additional control and protections
Enclosure Inside thermal control sensor	
Enclosure Inside humidity control sensor	
DC bus current sensor	
Amperchart recorder	Amperchart recorder with sheet charts
Breaking switch	For PCP application *Note: option available not for all lines and power range*
Breaking resistors	
Output contactor	
MCCB with firing coil	Switching off the power supply by relay external signal
MCCB with electric drive	For remote MCCB controlling
Input Fuse	Additional control protections
High Voltage Fuse	
1 ns responsible time surge suppression	
Transient Voltage Surge Suppressor	

Option	Description
Doors electric blocking	Additional safety protection
Emergency stop button to breaking the main circuit	
Common Mode Filter	Decreasing PWM high frequency radiation
Custom branding	Customer decals, plate and marking
Cable glands	Cable glands *Note: type of cable glands in package per order*
Potentiometer (frequency setting)	Frequency settings
Auto/Manual switch	Operation mode switching
Outside Led lightening	Outside Led lightening
*Bypass for capacitor PHF	Additional protection
*Twin passive harmonic filter	Operation in range of load from 25% up to 100%
*Input Passive harmonic filter for 50Hz supply frequency	To integrated in not typical power grid
*Adaptable Input Passive harmonic filter	For 50Hz and 60Hz supply frequency
*Options available for VSD AK06 line CP and LH only	

Separate options for order in package

Option	Description
Right-through module (500 ms sag)	Power right-through module to operation with power sags. Time of operation during the voltage interrupt can be increase be two or more parallel modules
General backup KIT for 10* VSD's *Note: options for 25 and 100 VSD `s available*	Universal back up KIT with general units for all power range VSD (deference in depended from VSD line)
Particular backup KIT for 10* VSD's *Note: options for 25 and 100 VSD `s available*	Backup KIT with power modules for each rated power VSD
Breaking resistors	For PCP application *Note: option available not for all lines and power range*
Output contactor	
Step-up transformer	Step-up transformer for ESP application

Installing and connection

When installing the VSD, it is necessary to leave the intake of air, the space at the sides - at least 200 mm (8 in) in, from above and from the rear – 500 mm (20 in). Input and output of power circuits and control circuits in the VSD must be made through cable bushings. Cable bushings are installed on the underside of the cabinet distribution box. Interface cables must be kept separate from power cables. For noise sensitive circuits it is necessary to use a shielded cable, or stranded wires in metal hose. The cable shield (protective sleeve) must be grounded. Ground the cabinet. The grounding should be carried out with a wire of at least 16 mm^2. It is recommended to use copper wiring, designed for working at the temperature of 75 ° C.

All 12 pulse VSD can be connected like a 6 pulse.

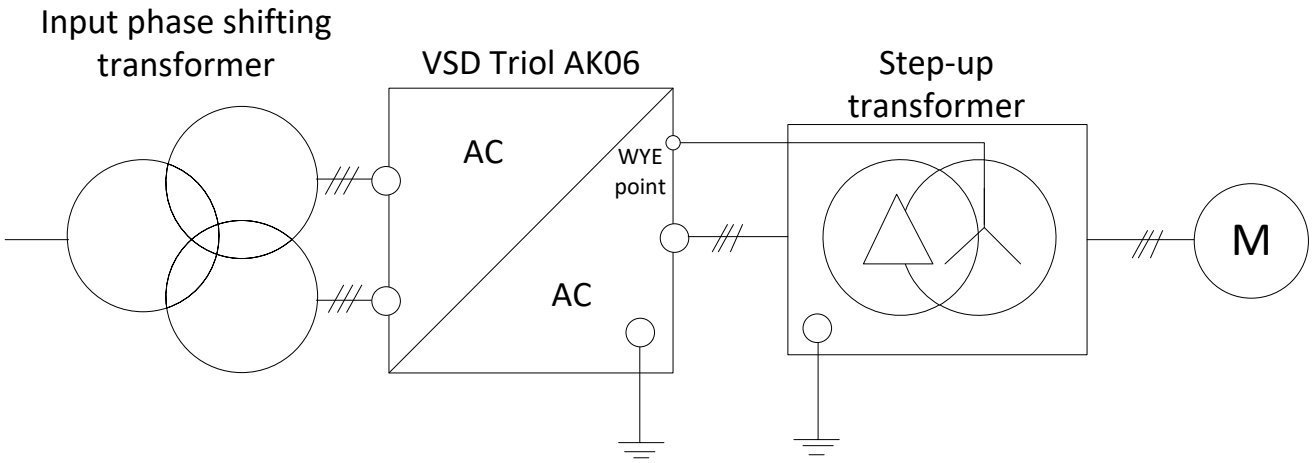


Figure 1 – 12 pulse VSD connection

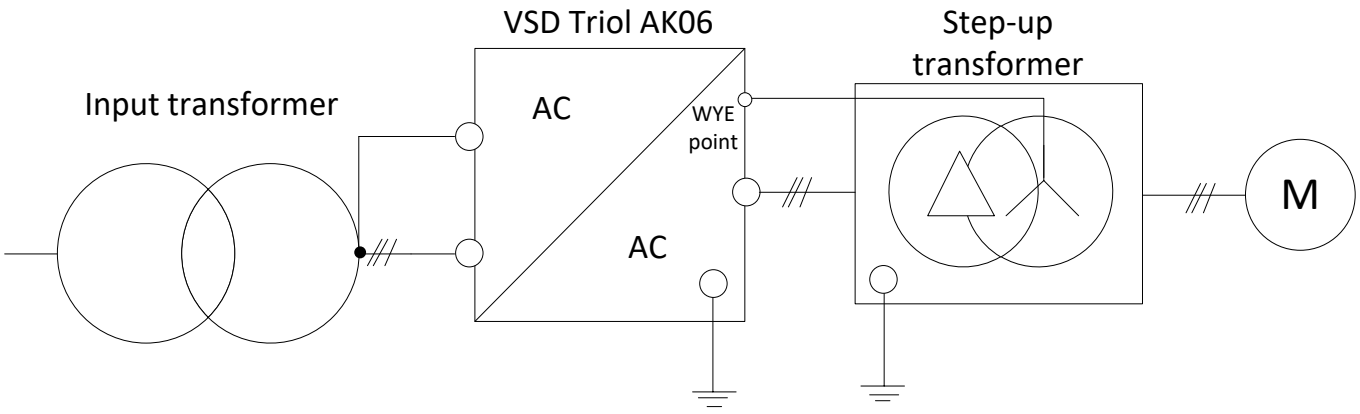


Figure 1.1 – 12 pulse VSD connection like a 6 pulse

The common point to 6 pulse scheme power connection can be make in VSD junction box. Install the jumper from a power cable between the phases of the same name.

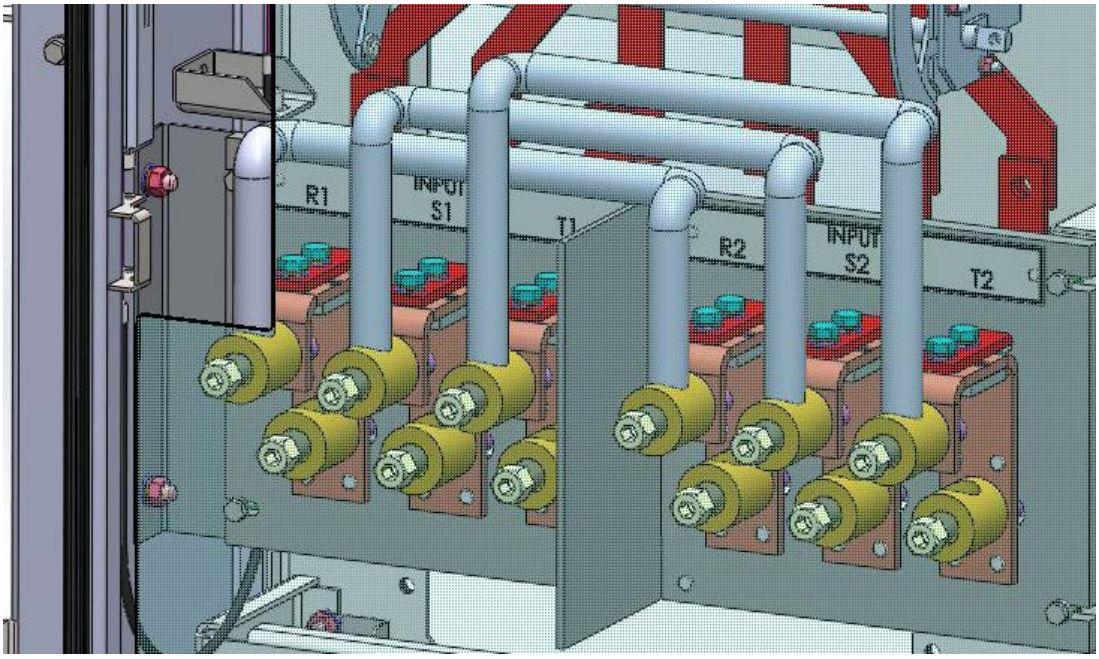


Figure 2 – input power terminals with common input to 6 pulse connections

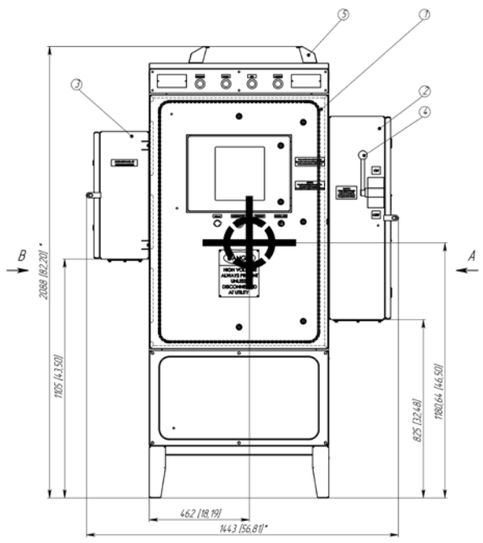
On the bottom of junction box installed the input panel. For entering the cable make a whole in the panel and install the cable glands. Recommended place of drilling shows on the general drawings.

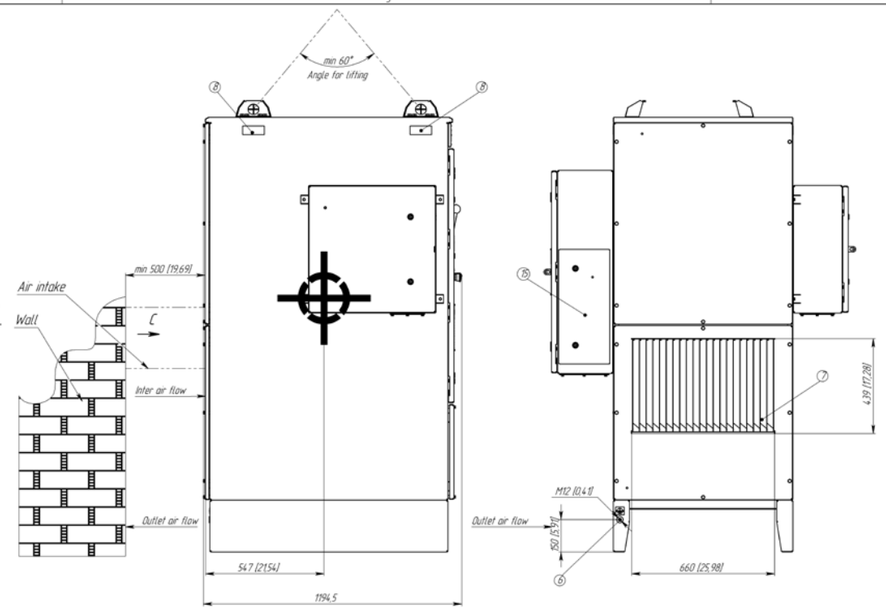
Recommended power connections cable gauge

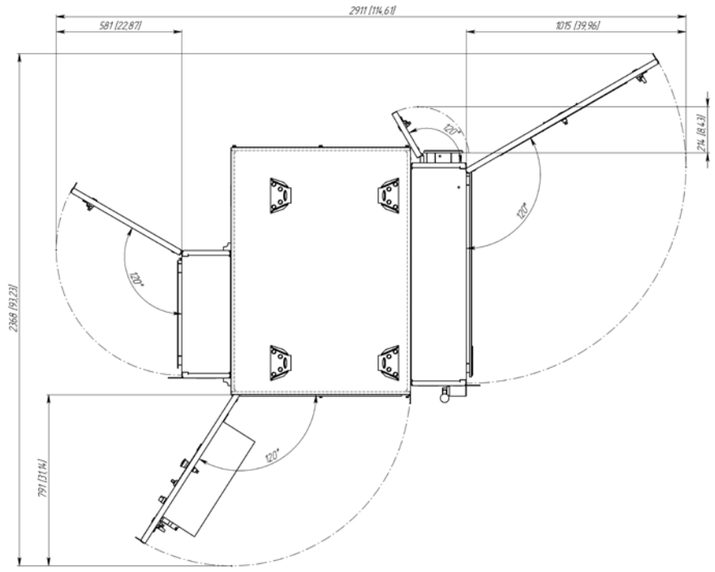
№	VSD rated current	Input 12 pulse (6 phase)		Output (3 phase)	
		Terminals per phase, pcs	Recommended cable cross section, AWG/kcmil (mm²)	Terminals per phase, pcs	Recommended cable cross section, AWG/kcmil (mm²)
1	100	1	AWG 4 (25)	2	AWG 1 (50)
2	160		AWG 4 (20)		AWG 1 (50)
3	250		AWG 2 (35)		AWG 2/0 (70)
4	300	2	AWG 2 (35)	2	AWG 2/0 (70)
5	360		AWG 1 (50)		AWG 3/0 (95)
6	400		AWG 1 (50)		AWG 3/0 (95)
7	420		AWG 1 (50)		AWG 3/0 (95)
8	515	2	AWG 2/0 (70)	4	MCM 300 (150)
9	590		AWG 2/0 (70)		MCM 400 (185)
10	630		AWG 3/0 (95)		MCM 400 (185)
11	675		AWG 3/0 (95)		MCM 400 (185)
12	800	3	AWG 3/0 (95)	6	MCM 400 (185)
13	900	2	AWG 4/0 (120)	4	MCM 500 (240)
14	1000		AWG 4/0 (120)		MCM 500 (240)
15	1200		MCM 300 (150)		MCM 750 (300)
16	1400		MCM 300 (150)		MCM 750 (300)
17	1600		MCM 400 (185)		MCM 800 (400)
Note: to connection like a 6 pulse VSD increase the cable cross section in two times					

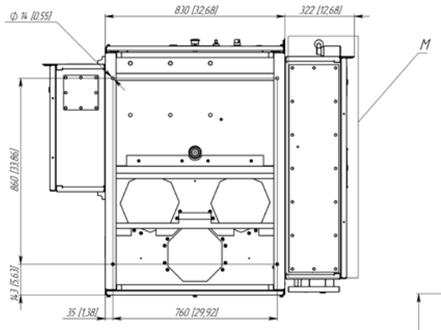
Signal connections terminals

Connection	Max cable gouge (mm²)
Terminal block of external connection	AWG 11 (6)
Extension unit (I/O module)	AWG 14 (2)
WYE-point terminal	AWG 15 (50)



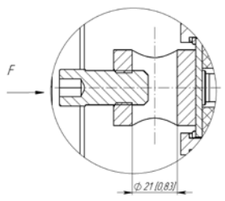






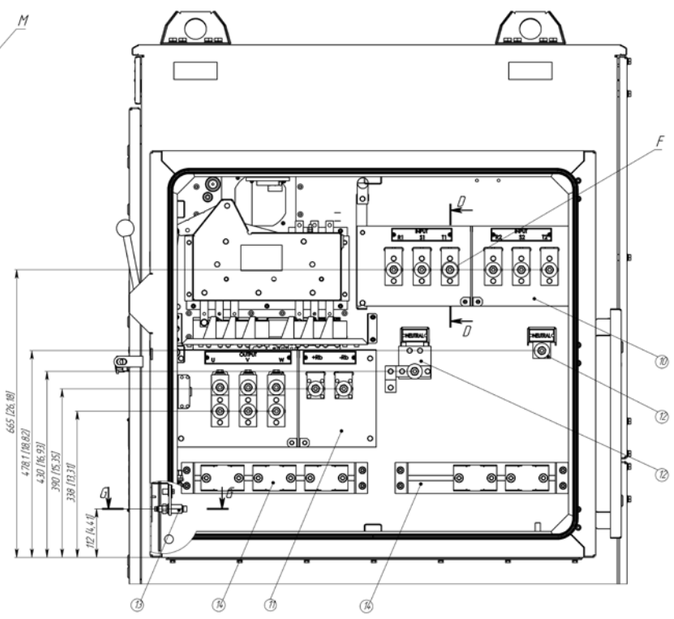
D–D (1 : 1)

Input / output / neutral terminal



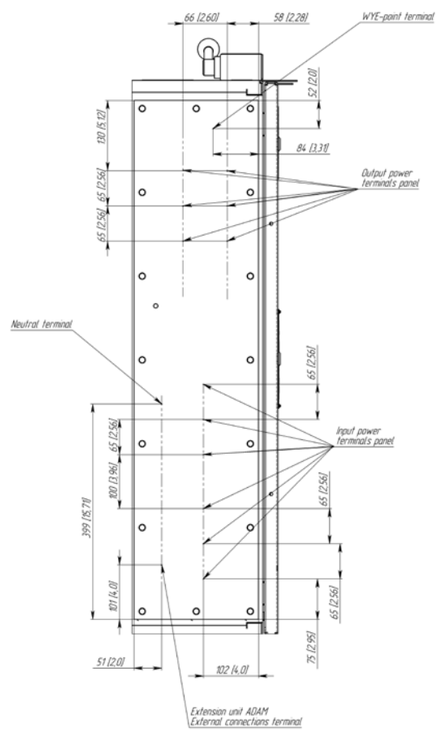
A (1 : 5)

Power connection junction box



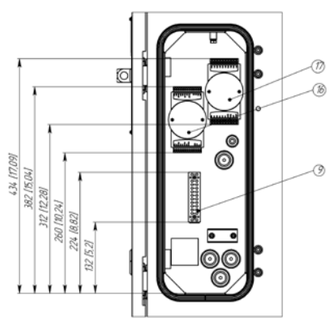
M (1 : 4)

Drilling place

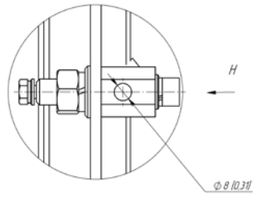


C (1 : 4)

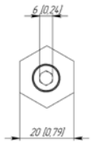
External connection unit



G–G (1 : 1)



H–H (1 : 1)



F (1 : 1)

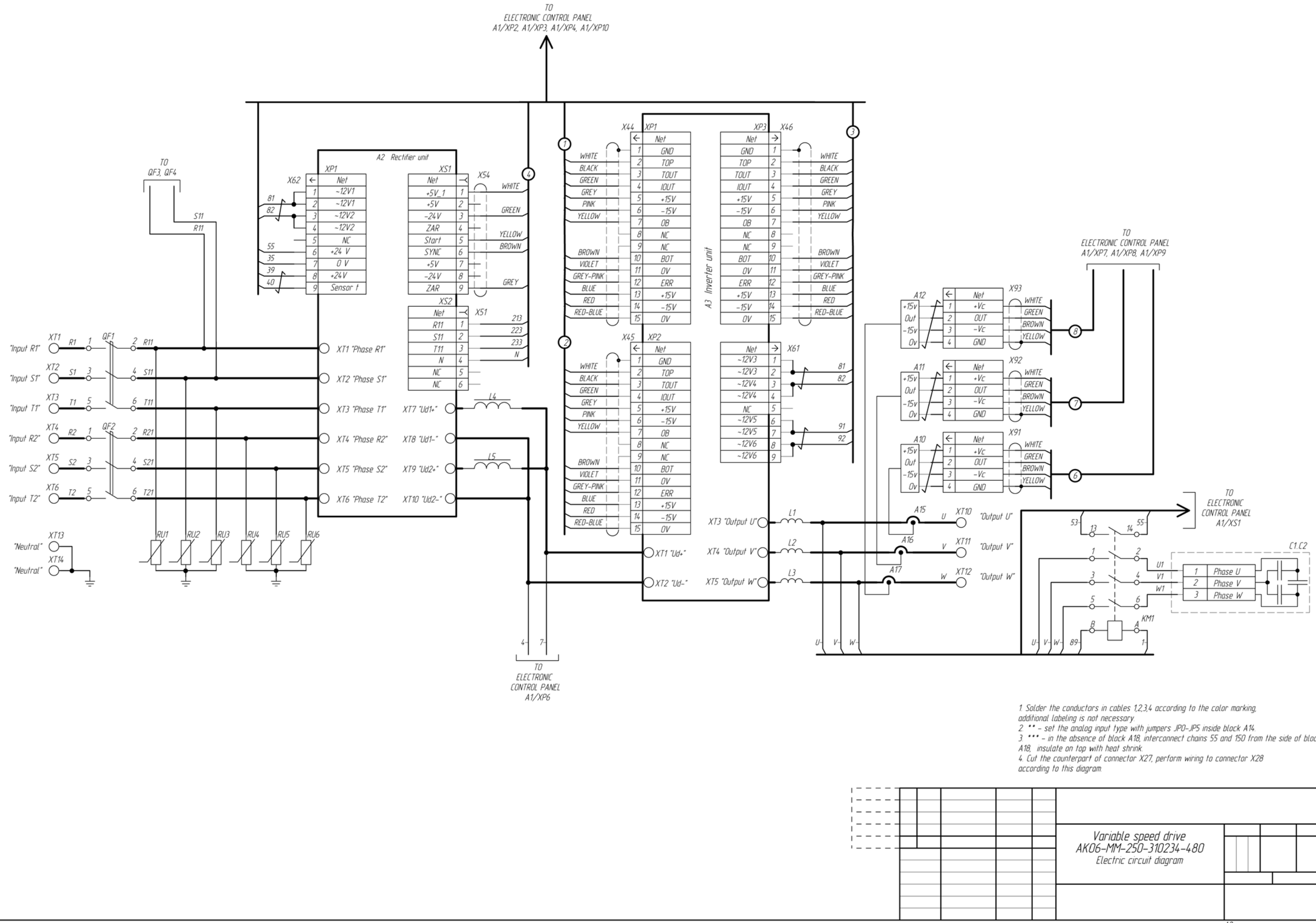
* Dimensions for reference
** Installed as directed in order
Dimensions in mm [in]

Общая таблица		
№	Description	Notation
1	Electronic control compartment	
2	Power connection junction box	
3	Sensor installation section	
4	Main circuit breaker handle	
5	Lifting lugs	
6	Grounding terminal	
7	Inter air flow panel with sand protection	
8	Marking plate	
9	Terminal block of external connections	Max. cable diameter 11 AWG (8.19 MCM)
10	Input power terminals panel	Max. cable diameter 8/0 AWG (619.69 MCM)
11	Output power terminals panel	Max. cable diameter 8/0 AWG (619.69 MCM)
12	Neutral terminal	Max. cable diameter 8/0 AWG (619.69 MCM)
13	WYE-point terminal	Max. cable diameter 0 AWG (105.54 MCM)
14	Cable clamp	
15	External connection unit	
16	Extension unit ADAM**	Max. cable diameter 14 AWG (4.1 MCM)
17	Extension unit ADAM**	Max. cable diameter 14 AWG (4.1 MCM)

Varible speed driver
AK06-UD-160..250

~60 kg
~895 lb

1:10



1. Solder the conductors in cables 1,2,3,4 according to the color marking, additional labeling is not necessary.
2. ** – set the analog input type with jumpers JP0–JP5 inside block A14.
3. *** – in the absence of block A18, interconnect chains 55 and 150 from the side of block A18, insulate on top with heat shrink.
4. Cut the counterpart of connector X27, perform wiring to connector X28 according to this diagram.

Variable speed drive
AK06-MM-250-310234-480
Electric circuit diagram

A2

Discrete inputs-outputs

Analog inputs

Supply

"Watchdog"

Emergency stop

Operating modes

STOP

STANDBY

OPERATING

BACKSPIN

+ Contrast -

RS232 DME

RS485 DME

RS485 ACS

RS232 ACS

VSD control

A5 TEC power supply unit

Cabinet doors control

Electric latches

TO SHEET 1

A4

A1 Electronic control panel

"Connections of current sensor"

"Relay output"

"Connection os invertor panel, phase U"

"Connection os invertor panel, phase V"

"Connection os invertor panel, phase W"

"Connections of controller"

"Connections of high-voltage panel"

"Supply"

"Connections of rectifier 1"

"Connections of rectifier 2"

Braking

TO SHEET 3

TO SHEET 1

A2

TO SHEET 2

SA2

12	1	2	380
	3	4	480

X6

	Net	
14	~220 V	1
16	~24 V	2
1	N	3
480	~480V	4
380	~380V	5
22	~380V/~480V	6

T1

3	~480V
2	~380V
1	
7	~220 V
6	
5	~24 V
4	

KM2

55	A1 (+)	A2 (-)	18
	13 NO	14 NO	
	21 NC	22 NC	
24	1 L1	2 T1	25
	3 L2	4 T2	
29	5 L3	6 T3	30

KM3

55	A1 (+)	A2 (-)	235
	13 NO	14 NO	
	21 NC	22 NC	
14	1 L1	2 T1	89
	3 L2	4 T2	
	5 L3	6 T3	

DME supply
QF6

2	1	88
		14

Fan and TEC supply
QF5

2	1	8
		14

Transformer supply
QF4

S11	2	4	22
R11	1	3	12

VSD supply
QF3

S11	2	4	23
R11	1	3	13

R11

S11

Extension unit

A13 *ADAM-4017+

XT2		XT1		
	Net	Net		
11	Vin0–	Vin5+	1	
12	Vin0+	Vin5–	2	
13	Vin1–	Vin6+	3	
14	Vin1+	Vin6–	4	
15	Vin2–	Vin7+	5	
16	Vin2+	Vin7–	6	
17	Vin3–	(Y) DATA+	7	170
18	Vin3+	(G) DATA–	8	171
19	Vin4–	(R) +VS	9	55
20	Vin4+	(B) GND	10	35

A14 ADAM-4024 *, **

XT2		XT1		
	Net	Net		
14	DI 0	I OUT 1+	1	
15	DI 1	I OUT 1–	2	
16	DI 2	V OUT 1	3	
17	DI 3	GND	4	
18	COM	V OUT 0	5	
19	NA	I OUT 0–	6	
20	I OUT 3+	I OUT 0+	7	
21	I OUT 3–	NA	8	
22	V OUT 3	INIT+	9	
23	GND	(Y) DATA+	10	170
24	V OUT 2	(G) DATA–	11	171
25	I OUT 2–	(R) +VS	12	55
26	I OUT 2+	(B) GND	13	35

X26

Terminal block of external connections

	Net	
1	ESM on	511
2	ESM all	512
3	ESM off	510
4	+24V	77
5	Press gauge	79
6	NC	
7	Ain 1	704
8	Ain 2	705
9	Ain COM	706
10	ACS RS485 A+	153
11	ACS RS485 B–	154
12	ACS RS GND	152

X25

Digital DME RS-232 connection

	Net	
1	DME RS458 A+	192
2	DME RS485 B–	194
3	DME RS GND	196
4	DME TXD	146
5	DME RXD	147
6	DME GND	145
7	NC	
8	NC	
9	NC	
10	NC	
11	~220 V	88
12	~220 V	1

DME supply

XT15 "WYE-POINT" 165

XT16 "WYE-POINT" 165

A7

XT1

1	L	88
2	N	1
3	GND	
4	-V	
5	+V	

A8

XT1

L	1	88
N	2	1
GND	3	
-V	4	
+V	5	

A18 *, **

Braking key control

XP1 X8*

Net		
+24 HBPH	1	55
"+" locks	2	150
0V	3	35
NC	4	
NC	5	
NC	6	
NC	7	
NC	8	
NC	9	

XS1 X9*

Net		
~12V-2	1	BROWN
~12V-1	2	WHITE
NC	3	
NC	4	GREY
IN7	5	GREEN
W7	6	PINK
+5V	7	YELLOW
0V	8	
~12V-2	9	
~12V-1	10	
NC	11	
NC	12	
IN7	13	
W7	14	
+5V	15	

XT1:1 "+Rb" 7 XT18*"+Rb"

High voltage circuits connection XT1:2 "Rg" 5 XT17*"-Rb"

XT1:3 "- Ud" 4

XT1:4 "+ Ud" 7

5

Power compartment cooling

M2 X11 M3 X12 M4 X13 M5 X14

Net	+24 V	-24 V
1	2	

15 25

"Power modules cooling"

M1

X7

	Net	
8	L	1
1	N	2
GNYE	PE	3
29	10V	4
29	E1	5
30	D1	6

3

29 30 1 8

A9 Fan power supply unit

XT1

Net		
L	1	8
N	2	1
GND	3	1
-V	4	24
+V	7	15

Power compartment heating

EK1

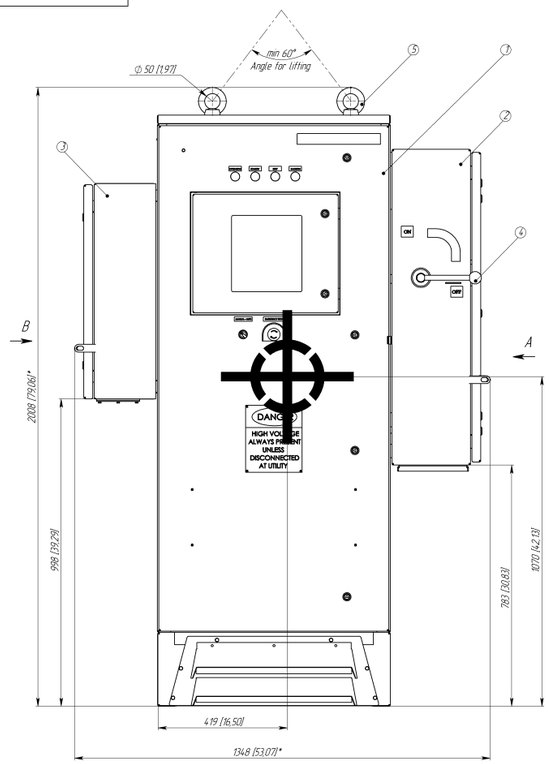
9 1

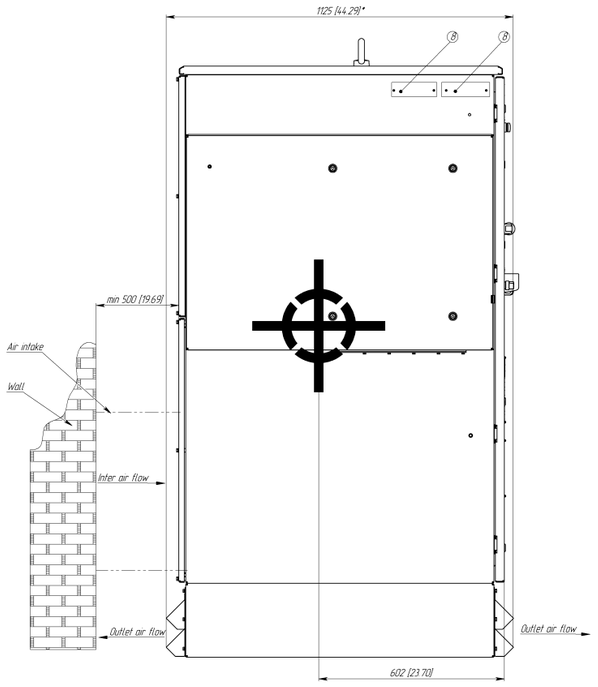
X15

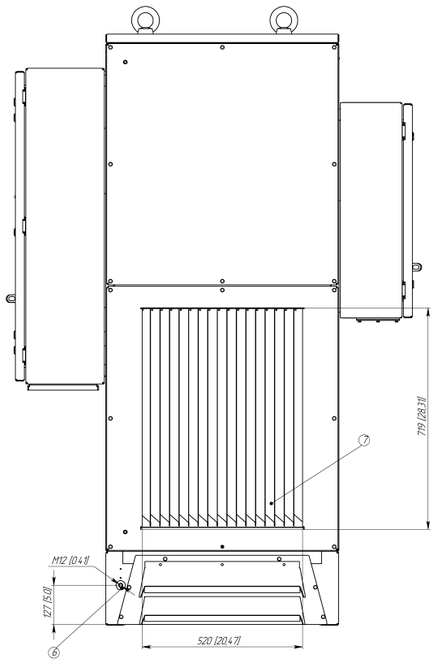
Net			
L	N	PE	
1	2	3	

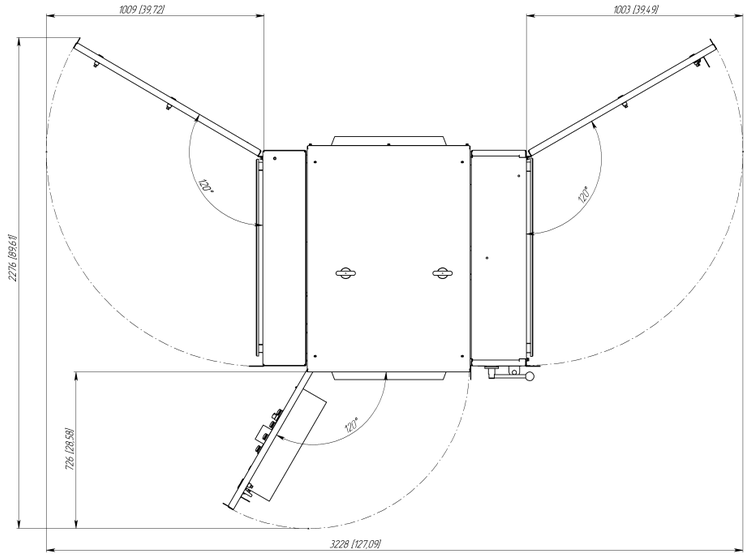
9 1

A3





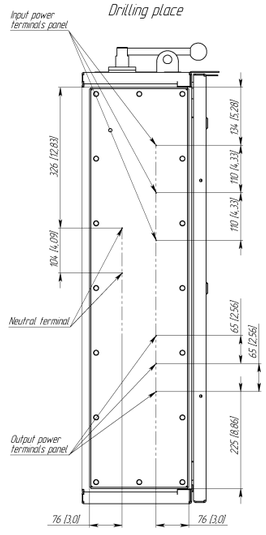




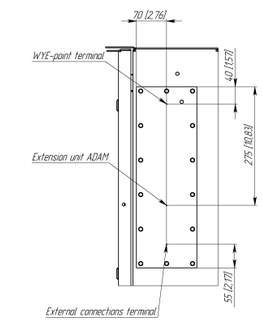
A (1 : 5)
Power connection junction box

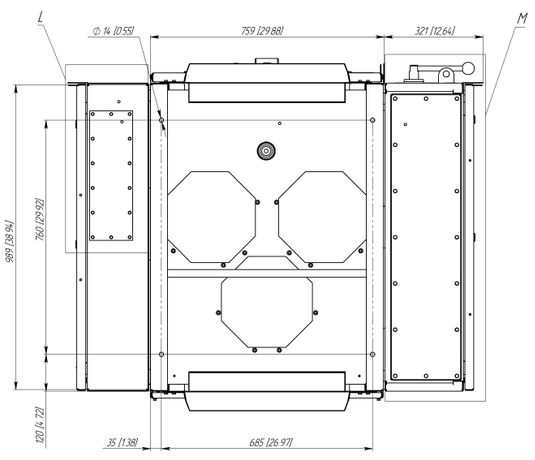
B (1 : 5)
Sensor instalation section and signal connection

M (1 : 5)
Drilling place

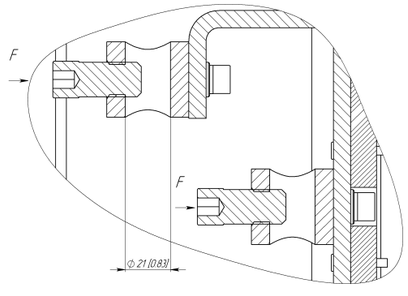


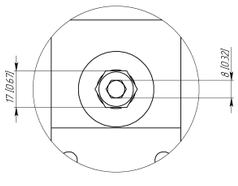
L (1 : 5)
Drilling place



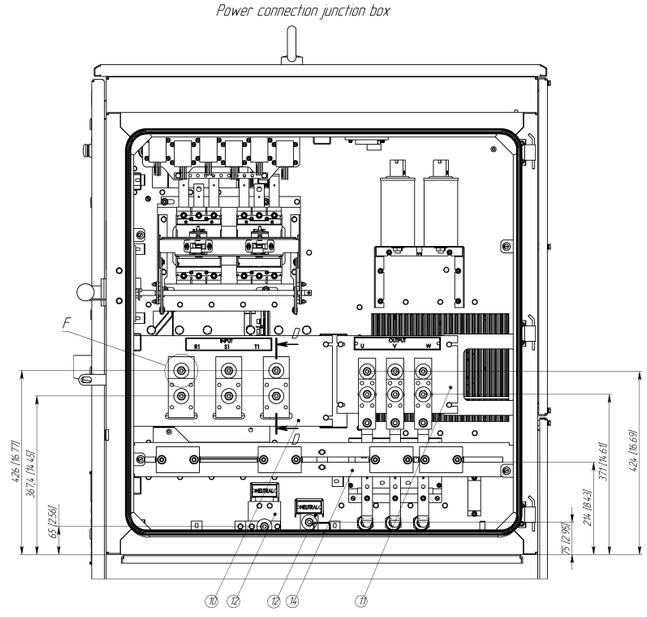


D-D (1 : 1)
Input/output/neutral terminal

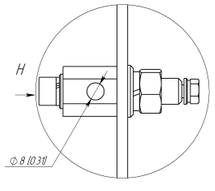




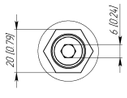
F (1 : 1)

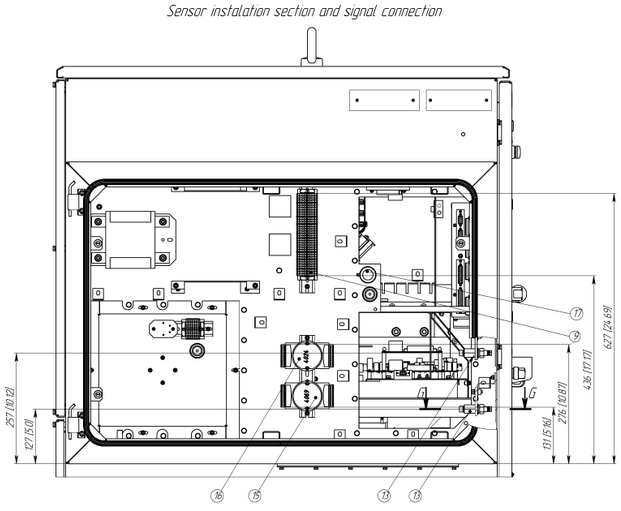


G-G (1 : 1)



H-H (1 : 1)





*. Dimensions for reference
** Installed as directed in order
Dimensions im mm [in]

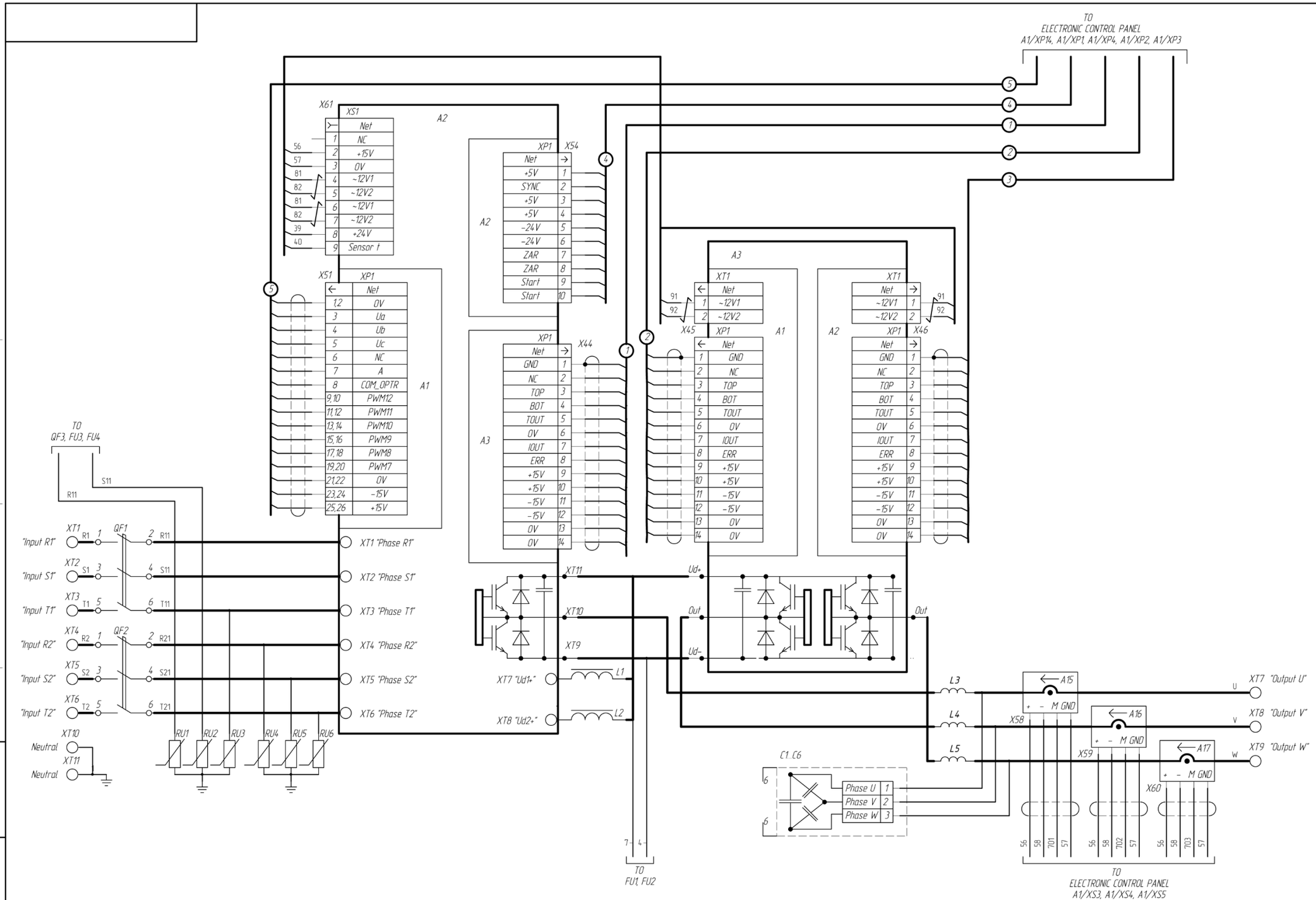
№	Description	Notation
1	Electronic control compartment	
2	Power connection junction box	
3	Sensor installation section and signal connection	
4	Main curcuit breaker handle	
5	Lifting lugs	
6	Grounding terminal	
7	Inter air flow panel with sand protection	
8	Marking plate	
9	Terminal block of external connections	Max. cable diameter 11 AWG (8.19 MCM)
10	Input power terminals panel	Max. cable diameter 8/0 AWG (619.69 MCM)
11	Output power terminals panel	Max. cable diameter 8/0 AWG (619.69 MCM)
12	Neutral terminal	Max. cable diameter 8/0 AWG (619.69 MCM)
13	WYE-point terminal	Max. cable diameter 0 AWG (105.54 MCM)
14	Cable clamp	
15	Extension unit ADAM**	Max. cable diameter 14 AWG (4.1 MCM)
16	Extension unit ADAM**	Max. cable diameter 14 AWG (4.1 MCM)
17	Ethernet connector**	

Varible speed driver
AK06-UD-360

706 kg
1556 lb

1:10

VERTICAL



Notes:
1. * – install the items as directed in the order.
2. ** – set the type of analog input with jumpers JP0–JP5 inside the block A9.

Variable speed drive
AK06-MM-360-310274-480
Electric circuit diagram

A2

XP11	→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Net	~12V_2	~12V_2	~12V_1	~12V_1	NC	NC	NC	NC	NC	IN7	IN7	W7	W7	+5V	+5V	0V	0V

Braking

"Relay output"

A1

TO SHEET1

A5 XT1		
	1	L
	2	N
	3	GND
	4	-V
	5	+V

DC voltage measurement
FU1
FU2

VSD power supply
QF3

Fan and TEC power supply
QF4

DME power supply
QF5

Transformer power supply
FU3
FU4

X1		
Net		1
"-"		2
NC		3
"+"		4

A6

X2		
Net		1
		2
NC		3

SF1

X3		
Net		1
		2
NC		3

SF2

X4		
Net		1
		2
NC		3

SF3

A13

XT1	
Net	1
-Ud	2

XT2	
Net	1
+Ud	2

XT3	
Net	1
+24V_OUT	2
0V	

XT4	
Net	1
+24V_BPH	2
0V	

SA2

X5		
Net		1
L1_1		2
NC		3
UP		4
DOWN		5
N		6

T1: brown, blue, red, white, black

Cooling system control

KM1: A1 (+), A2 (-), 13 NO, 14 NO, 21 NC, 22 NC, 1 L1, 2 T1, 3 L2, 4 T2, 5 L3, 6 T3

Cooling of power modules

M1

X6		
Net		1
L		2
N		3
PE		4
+10V		5
Speed		6
Din1		7

BN, BU, GNYE, RD, YE, GN

Cooling of main cabinet

M2: black, blue, brown, y/g, PE

X7: Net, N, L, C, GND

C7

XT14: PE, PE

X48 XP14	Rectifier 1 connection
X53 XP1	Rectifier 2 connection
X41 XP4	"Inverter panel connection, phase U"
X42 XP2	"Inverter panel connection, phase V"
X43 XP3	"Inverter panel connection, phase W"

Cabinet doors control

X57 XS5		
Net		1
NC		2
NC		3
+15 V		4
-15 V		5
shield		6
OUT_A		7
0 V		8
NC		9

Current sensor connection (W)

X52 XS2		
Net		1
+24 V		2
GND		3
+15 V		4
0 V		5
-15 V		6
-12 V-1		7
-12 V-2		8
-12 V-3		9
-12 V-4		10
-12 V-5		11
-12 V-6		12
+24V_HOT		13
Ready		14
NC		15
NC		16

"Supply"

XS1 X47		
Net		1
ESM on		2
ESM COM		3
ESM off		4
Backspin		5
NC		6
NC		7
380/480		8
KSF		9
FAN		10
+24 V_Din		11
Din2		12
NC		13
NC		14
NC		15
NC		16
NC		17
NC		18
NC		19
NC		20
NC		21
+24 V		22
Sensor t		23
GND		24
GND		25

XP1 X49		
Net		1
+ 24 V		2
0 V		3
RS485_A		4
RS485_B		5
F_TURB		6
+RIS-U/10		7
-RIS-U/10		8
RIS-COM		9
RIS-I		10

Controller connection

XP2 X50		
Net		1
-Ud		2
+Ud		3
AC1		4
AC2		5
N		6
U		7
V		8
NC		9
NC		10
NC		11
NC		12
NC		13
NC		14
NC		15
NC		16

High-voltage panel connection

XS3 Current sensor connection (U): Net, NC, NC, NC, +15 V, -15 V, shield, OUT_A, 0 V, NC — X55

XS4 Current sensor connection (V): Net, NC, NC, NC, +15 V, -15 V, shield, OUT_A, 0 V, NC — X56

XT1 "WYE-POINT"

X33 XP5		
Net		1
RXD_UC8		2
RTS_UC8		3
RS485A_2_UC8		4
0V_U8		5
RS485B_2_UC8		6
0V_U3		7
TXD_UC8		8
CTS_UC8		9
RS485B_UC8		10
RS485A_UC8		11
RS485A_3		12
RS485B_3		13

X35 XP14		
Net		1
DIN1		2
DIN5		3
DIN3		4
0V_DIN		5
DOUT0		6
DOUT2		7
DOUT4		8
DOUT5		9
DIN0		10
DIN4		11
DIN2		12
+24V_DIN		13
DOUT1		14
DOUT3		15
+24V_DOUT		16
0V_DOUT		17

Discrete inputs-outputs

A

XS1		
Net		1
+5 V		2
DM		3
DP		4
0V		5

USB

A4

XP4 X37		
Net		1
RXD_UC1		2
RTS_UC1		3
RS485B_UC1		4
0V_U1		5
RS485A_2		6
TXD_UC1		7
CTS_UC1		8
RS485A_UC1		9
0V_U2		10
RS485B_2		11

IO_RS485A, IO_RS485B

XP12 X36		
Net		1
CUR_SENS		2
+3.3 V_2		3
VOLT_SENS		4
NC		5
		6
0V_1		7
0V_1		8
NC		9
+24V_HOT		10
Ready		11
+24 VS_IN		12
GND		13
CUR_A		14
CUR_B		15
CUR_C		16
ZER_CUR		17
		18
AIN11		19
AIN10		20
0V_DIN6..9		21
DIN7		22
DIN6		23
DIN9		24
DIN8		25

Supply

Analog inputs

XT1 X38		
Net		1
TX+		2
TX-		3
RX+		4
		5
RX-		6
		7
		8

Ethernet

X8		
Net		1
+24V		2
-24V		

X27	
Net	1
+5 V	2
DM	3
DP	4
0V	5
Screen	

Emergency stop SB1

Operating modes SA1

STOP HL1, STANDBY HL2, OPERATING HL3, BACKSPIN HL4

TO SHEET 3

A2

A14

XT1

L	1
N	2
GND	3
–V	4
+V	5

88
1
PE
–24_V
+24_V

A9 *, ** ADAM-4017+

XT1		XT2	
Net		Net	
Vin5+	1	Vin0–	11
Vin5–	2	Vin0+	12
Vin6+	3	Vin1–	13
Vin6–	4	Vin1+	14
Vin7+	5	Vin2–	15
Vin7–	6	Vin2+	16
(Y) DATA+	7	Vin3–	17
(G) DATA–	8	Vin3+	18
(R) +VS	9	Vin4–	19
(B) GND	10	Vin4+	20

IO_RS485A
IO_RS485B
+24_V
–24_V

A10* ADAM-4024

XT1		XT2	
Net		Net	
I OUT 1+	1	DI 0	14
I OUT 1–	2	DI 1	15
V OUT 1	3	DI 2	16
GND	4	DI 3	17
V OUT 0	5	COM	18
I OUT 0–	6	NA	19
I OUT 0+	7	I OUT 3+	20
NA	8	I OUT 3–	21
INIT+	9	V OUT 3	22
(Y) DATA+	10	GND	23
(G) DATA–	11	V OUT 2	24
(R) +VS	12	I OUT 2–	25
(B) GND	13	I OUT 2+	26

IO_RS485A
IO_RS485B
+24_V
–24_V

A11 * ADAM-4024

XT1		XT2	
Net		Net	
I OUT 1+	1	DI 0	14
I OUT 1–	2	DI 1	15
V OUT 1	3	DI 2	16
GND	4	DI 3	17
V OUT 0	5	COM	18
I OUT 0–	6	NA	19
I OUT 0+	7	I OUT 3+	20
NA	8	I OUT 3–	21
INIT+	9	V OUT 3	22
(Y) DATA+	10	GND	23
(G) DATA–	11	V OUT 2	24
(R) +VS	12	I OUT 2–	25
(B) GND	13	I OUT 2+	26

A12 * ADAM-4069

XT2		XT1	
Net		Net	
RL0 NO	14	RL5 NO	1
RL0 COM	15	RL5 COM	2
RL0 NC	16	RL6 NO	3
RL1 NO	17	RL6 COM	4
RL1 COM	18	RL7 NO	5
RL1 NC	19	RL7 COM	6
RL2 NO	20	RL7 NC	7
RL2 COM	21	NC	8
RL2 NC	22	NC	9
RL3 COM	23	(Y) DATA+	10
RL3 NO	24	(G) DATA–	11
RL4 COM	25	(R) +VS	12
RL4 NO	26	(B) GND	13

IO_RS485A
IO_RS485B
+24_V
–24_V

165 XT15 "WYE – POINT"
65 XT16 "WYE – POINT_DME"
65 XT17 "WYE – POINT_DME"

T2
H1 X1
H2
H3
H4 X2
1– 88 ~110_V 1–

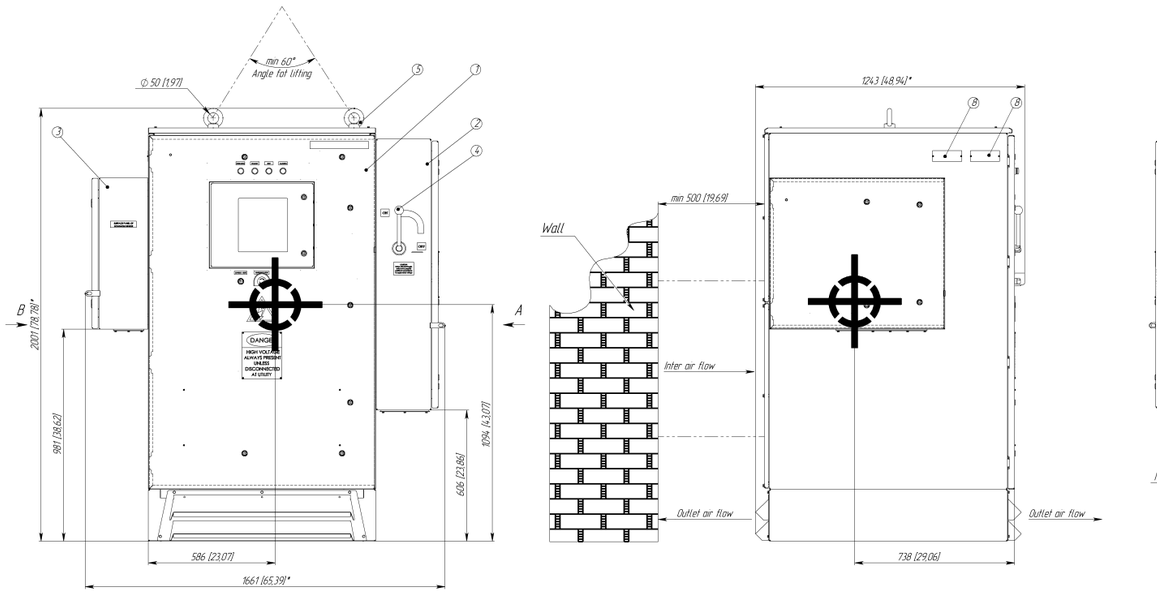
TO SHEET2

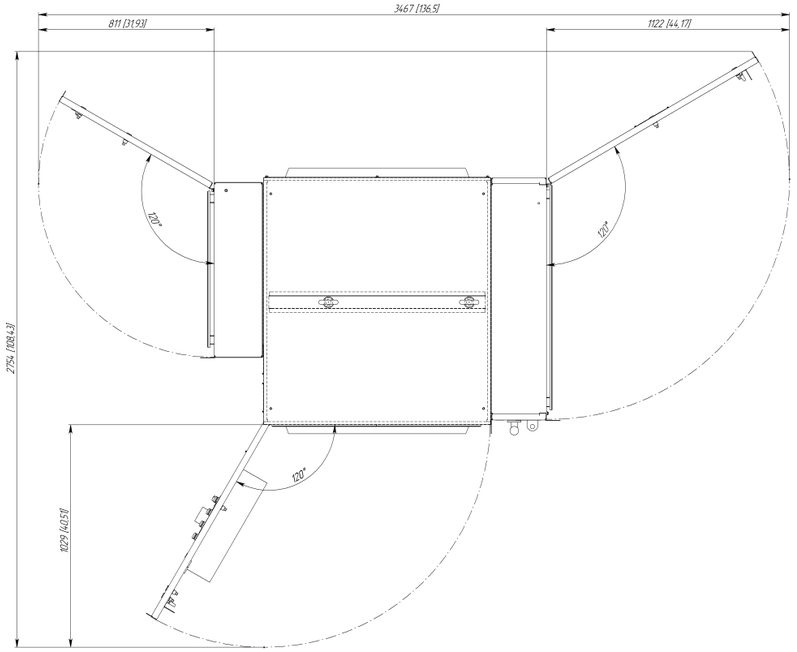
X26

	Net	
510	ESM on	1
512	ESM com.	2
511	ESM off	3
77	+24 V	4
79	Din1	5
	NC	6
	NC	7
704	Ain. 1	8
705	Ain. 2	9
706	Ain. com.	10
153	ACS RS485 A+	11
154	ACS RS485 B–	12
152	ACS RS GND	13
	ACS TXD	14
	ACS RXD	15
	ACS GND	16
192	DME RS485 A+	17
194	DME RS485 B–	18
196	DME RS GND	19
146	DME TXD	20
147	DME RXD	21
145	DME GND	22
IO_RS485A	ADAM RS485 A+	23
IO_RS485B	ADAM RS485 B–	24
	ADAM RS GND	25
+24_V	+24 V	26
+24_V	+24 V	27
+24_V	+24 V	28
–24_V	0V	29
–24_V	0V	30
–24_V	0V	31
~110_V	~110V	32
1	~110V	33
88	~220V	34
1	~220V	35

Terminal block of external connections

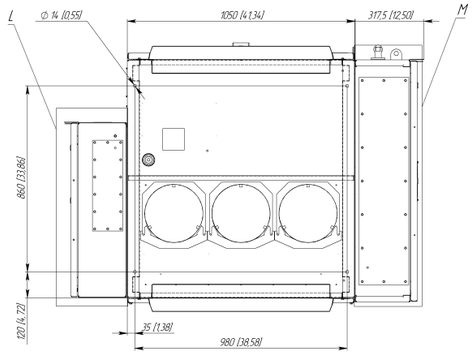
A3

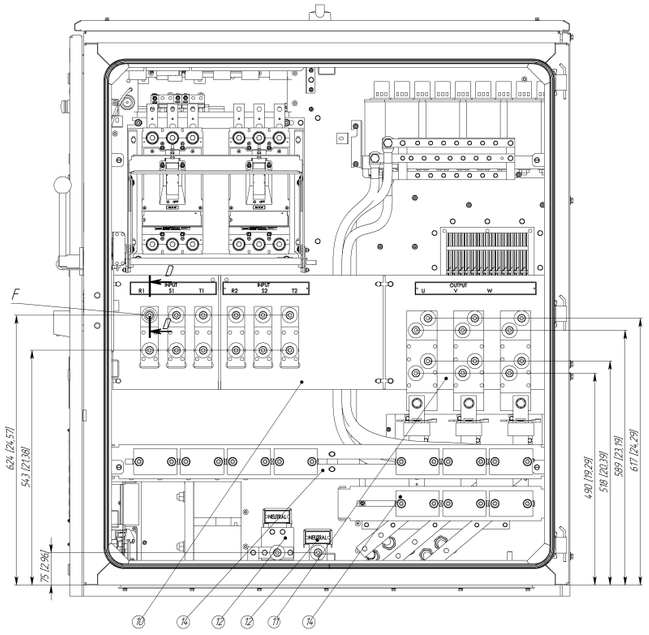


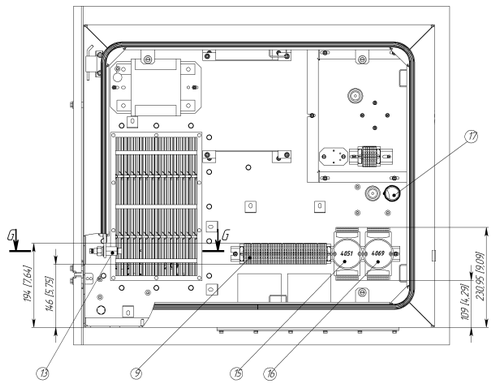


A (1 : 5)
Power connection junction box

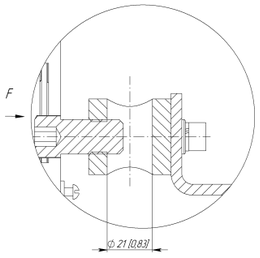
B (1 : 5)
Sensor instalation section and signal connection





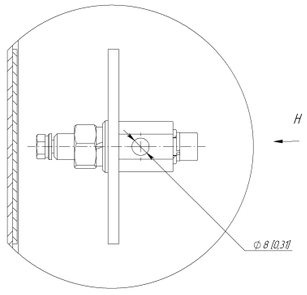


D–D (1 : 1)
Input/output/neutral terminal

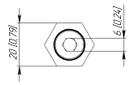


F (1 : 1)

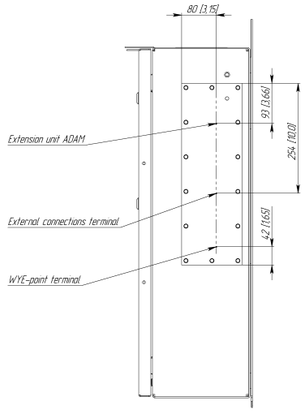
G–G (1 : 1)



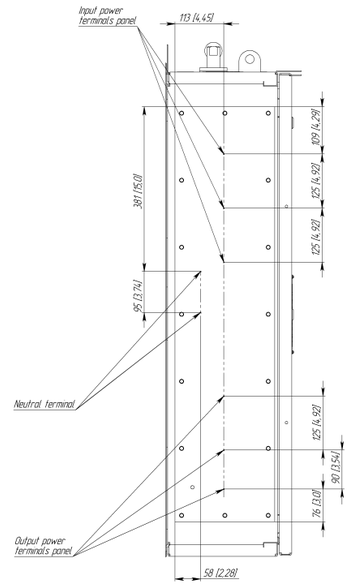
H–H (1 : 1)



L (1 : 5)
Drinling place



M (1 : 5)
Drinling place



* Dimensions for reference
** Installed as directed in order
Dimensions in mm [in]

№	Description	Notation
1	Electronic control compartment	
2	Power connection junction box	
3	Sensor installation section and signal connection	
4	Main curcuit breaker handle	
5	Lifting lugs	
6	Grounding terminal	
7	Inter air flow panel with sand protection	
8	Marking plate	
9	Terminal block of external connections	Max. cable diameter 11 AWG (8.19 MCM)
10	Input power terminals panel	Max. cable diameter 8/0 AWG (619.69 MCM)
11	Output power terminals panel	Max. cable diameter 8/0 AWG (619.69 MCM)
12	Neutral terminal	Max. cable diameter 8/0 AWG (619.69 MCM)
13	WYE-point terminal	Max. cable diameter 0 AWG (105.54 MCM)
14	Cable clamp	
15	Extension unit ADAM**	Max. cable diameter 14 AWG (4.1 MCM)
16	Extension unit ADAM**	Max. cable diameter 14 AWG (4.1 MCM)
17	Ethernet connector**	

Varible speed driver
AK06-UD-515.675

8.33 kg
18.35 lb

1:10

VERTICAL

TO
ELECTRONIC CONTROL PANEL
A1/XP14, A1/XP1, A1/XP4, A1/XP2, A1/XP3

5 4 7 2 3

A2 XS1 X61

Net		
NC	1	56
+15V	2	57
0V	3	81
-12V1	4	82
-12V2	5	81
-12V1	6	82
-12V2	7	39
+24V	8	40
Sensor t	9	

A1 X51 XP1

←	Net
1,2	0V
3	Ua
4	Ub
5	Uc
6	NC
7	A
8	COM_OPTR
9,10	PWM12
11,12	PWM11
13,14	PWM10
15,16	PWM9
17,18	PWM8
19,20	PWM7
21,22	0V
23,24	-15V
25,26	+15V

A2 XP1 X54

Net	→	
+5V	1	4
SYNC	2	
+5V	3	
+5V	4	
-24V	5	
-24V	6	
ZAR	7	
ZAR	8	
Start	9	
Start	10	

A3 XP2 X62

Net	→	
NC	1	71
NC	2	72
NC	3	
-12V1	4	
-12V2	5	
-12V1	6	
-12V2	7	
NC	8	
NC	9	

A3 XP1 X44

Net	→	
GND	1	1
NC	2	
TOP	3	
BOT	4	
TOUT	5	
0V	6	
IOUT	7	
ERR	8	
+15V	9	
+15V	10	
-15V	11	
-15V	12	
0V	13	
0V	14	

A7 XP2 X63

Net	→	
NC	1	81
NC	2	82
NC	3	
-12V1	4	
-12V2	5	
-12V1	6	
-12V2	7	
NC	8	
NC	9	

A7 XP1 X45

Net	→	
GND	1	1
NC	2	
TOP	3	
BOT	4	
TOUT	5	
0V	6	
IOUT	7	
ERR	8	
+15V	9	
+15V	10	
-15V	11	
-15V	12	
0V	13	
0V	14	

A8 XP2 X64

Net	→	
NC	1	91
NC	2	92
NC	3	
-12V1	4	
-12V2	5	
-12V1	6	
-12V2	7	
NC	8	
NC	9	

A8 XP1 X46

Net	→	
GND	1	1
NC	2	
TOP	3	
BOT	4	
TOUT	5	
0V	6	
IOUT	7	
ERR	8	
+15V	9	
+15V	10	
-15V	11	
-15V	12	
0V	13	
0V	14	

TO
QF3, FU3, FU4

S11
R11

"Input R1" XT1 R1 1 QF1 2 R11 XT1 "Phase R1"
"Input S1" XT2 S1 3 4 S11 XT2 "Phase S1"
"Input T1" XT3 T1 5 6 T11 XT3 "Phase T1"
"Input R2" XT4 R2 1 QF2 2 R21 XT4 "Phase R2"
"Input S2" XT5 S2 3 4 S21 XT5 "Phase S2"
"Input T2" XT6 T2 5 6 T21 XT6 "Phase T2"

XT7 "Ud1+"
XT8 "Ud2+"
XT9 "Ud-"

XT10 Neutral
XT11 Neutral

RU1 RU2 RU3 RU4 RU5 RU6

L1
L2
L3
L4
L5

Ud+
Ud-
Out

R4 R5

4 7
TO
FU1, FU2

XT7 "Output U"
XT8 "Output V"
XT9 "Output W"

U V W
/2 /1
W2 W1
TA1 TA2 TA3
R1 R2 R3
U1 V1 W1
57
701 702 703

C1..C9
9 9

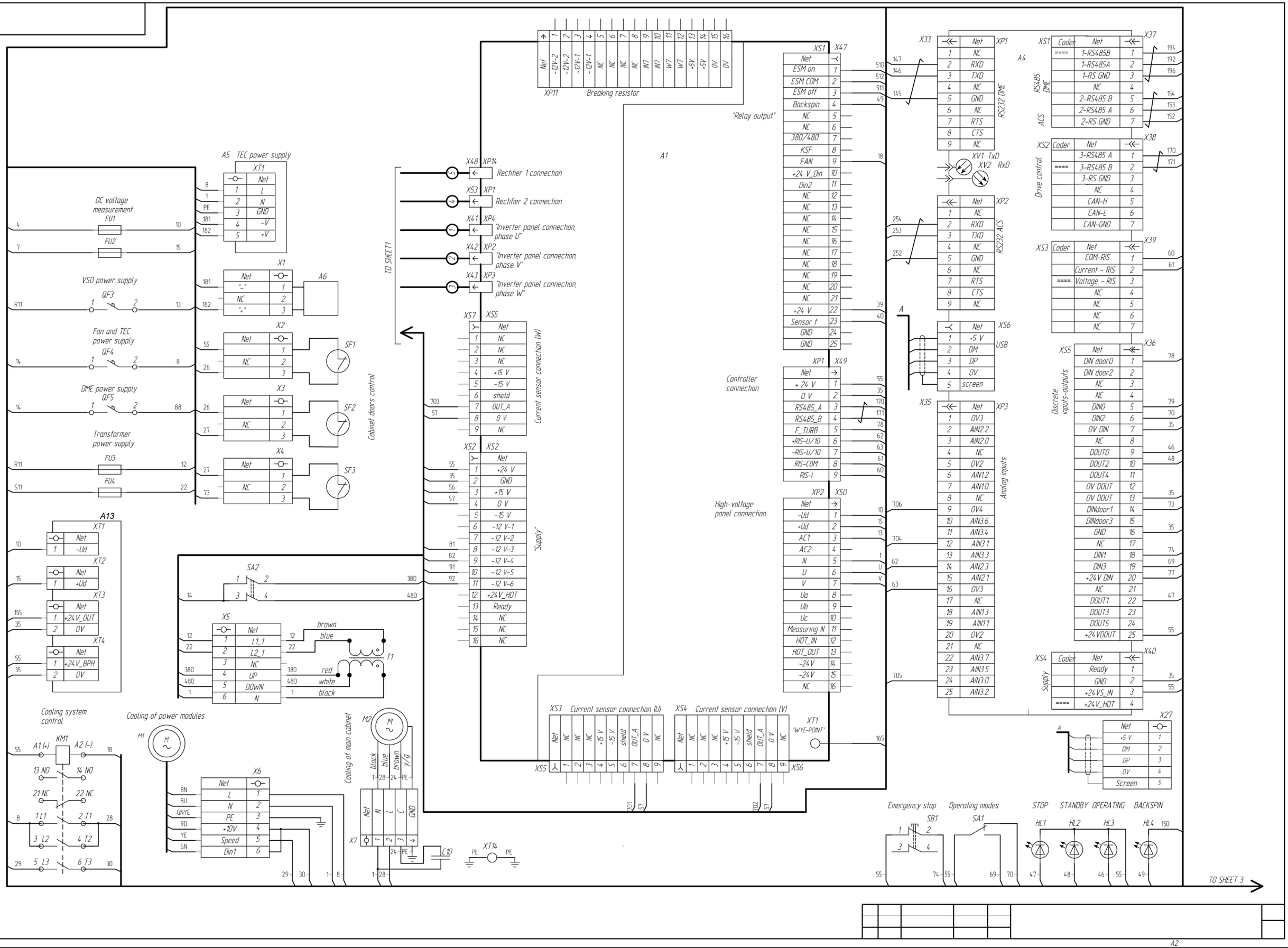
Phase U	1
Phase V	2
Phase W	3

U1 V1 W1
XT21 XT22 XT23
U1 V1 W1

TO
ELECTRONIC CONTROL PANEL
A1/XS3, A1/XS4, A1/XS5

Variable speed drive
AK06-MM-675-310274-480
Electric circuit diagram

A2


A5 TEC power supply
XT1
Net
L
N
GND
-V
+V
DC voltage measurement
FU1
FU2
VSD power supply
QF3
Fan and TEC power supply
QF4
DME power supply
QF5
Transformer power supply
FU3
FU4
X1
A6
X2
SF1
X3
SF2
X4
SF3
A13
XT1 Net -Ud
XT2 Net +Ud
XT3 Net +24V_OUT 0V
XT4 Net +24V_BPH 0V
SA2
X5
L1_1
L2_1
NC
UP
DOWN
N
brown
blue
red
white
black
T1
Cooling system control
KM1
A1 (+)
A2 (-)
13 NO
14 NO
21 NC
22 NC
1 L1
2 T1
3 L2
4 T2
5 L3
6 T3
Cooling of power modules
M1
X6
BN L
BU N
GNYE PE
RD +10V
YE Speed
GN Din1
Cooling of main cabinet
M2
black blue brown y/g
X7 Net N L L GND
C10
XT14
TO SHEET1
Cabinet doors control
X48 XP14 Rectifier 1 connection
X53 XP1 Rectifier 2 connection
X41 XP4 "Inverter panel connection, phase U"
X42 XP2 "Inverter panel connection, phase V"
X43 XP3 "Inverter panel connection, phase W"
X57 XS5
Current sensor connection (W)
NC +15 V -15 V shield OUT_A 0 V NC
X52 XS2
"Supply"
+24 V GND +15 V 0 V -15 V ~12 V-1 ~12 V-2 ~12 V-3 ~12 V-4 ~12 V-5 ~12 V-6 +24V_HOT Ready NC NC
XP11 Breaking resistor
Net -12V-2 -12V-2 -12V-1 -12V-1 NC NC NC NC W7 W7 W7 +5V +5V 0V 0V
A1
"Relay output"
XS1 X47
Net ESM on ESM COM ESM off Backspin NC NC 380/480 KSF FAN +24 V_Din Din2 NC NC NC NC NC NC NC NC NC NC +24 V Sensor t GND GND
Controller connection
XP1 X49
Net +24 V 0 V RS485_A RS485_B F_TURB +RIS-U/10 -RIS-U/10 RIS-COM RIS-I
High-voltage panel connection
XP2 X50
Net -Ud +Ud AC1 AC2 N U V Ua Ub Uc Measuring N HOT_IN HOT_OUT ~24V ~24V NC
XS3 Current sensor connection (U)
XS4 Current sensor connection (V)
Net NC NC NC +15 V -15 V shield OUT_A 0 V NC
XT1 "WYE-POINT"
X55 X56
A4
X33 XP1 Net NC RXD TXD NC GND NC RTS CTS NC
RS232 DME
XV1 TxD XV2 RxD
X34 XP2 Net NC RXD TXD NC GND NC RTS CTS NC
RS232 ACS
A
X35 XP3 Net OV3 AIN2.2 AIN2.0 NC OV2 AIN1.2 AIN1.0 NC OV4 AIN3.6 AIN3.4 AIN3.1 AIN3.3 AIN2.3 AIN2.1 OV3 NC AIN1.3 AIN1.1 OV2 NC AIN3.7 AIN3.5 AIN3.0 AIN3.2
Analog inputs
X36 XS6 +5 V DM DP 0V screen
USB
XS1 Coder Net X37
RS485 DME
1-RS485B 1-RS485A 1-RS GND NC 2-RS485 B 2-RS485 A 2-RS GND
ACS
XS2 Coder Net X38
Drive control
3-RS485 A 3-RS485 B 3-RS GND NC CAN-H CAN-L CAN-GND
XS3 Coder Net X39
COM-RIS Current - RIS Voltage - RIS NC NC NC
XS5 Net X36
Discrete inputs-outputs
DIN door0 DIN door2 NC NC DIN0 DIN2 0V DIN NC DOUT0 DOUT2 DOUT4 0V DOUT 0V DOUT DINdoor1 DINdoor3 GND NC DIN1 DIN3 +24V DIN NC DOUT1 DOUT3 DOUT5 +24VDOUT
XS4 Coder Net X40
Supply
Ready GND +24VS_IN +24V_HOT
X27 Net +5 V DM DP 0V Screen
Emergency stop SB1
Operating modes SA1
STOP HL1 STANDBY HL2 OPERATING HL3 BACKSPIN HL4
TO SHEET 3
A2

A14

XT1

L	1
N	2
GND	3
-V	4
+V	5

88
1
PE
-24_V
+24_V

A9 *, ** ADAM-4017+

XT1		XT2	
	Net	Net	
1	Vin5+	Vin0-	11
2	Vin5-	Vin0+	12
3	Vin6+	Vin1-	13
4	Vin6-	Vin1+	14
5	Vin7+	Vin2-	15
6	Vin7-	Vin2+	16
7	(Y) DATA+	Vin3-	17
8	(G) DATA-	Vin3+	18
9	(R) +VS	Vin4-	19
10	(B) GND	Vin4+	20

170
171
+24_V
-24_V

A10* ADAM-4024

XT1		XT2	
	Net	Net	
1	I OUT 1+	DI 0	14
2	I OUT 1-	DI 1	15
3	V OUT 1	DI 2	16
4	GND	DI 3	17
5	V OUT 0	COM	18
6	I OUT 0-	NA	19
7	I OUT 0+	I OUT 3+	20
8	NA	I OUT 3-	21
9	INIT+	V OUT 3	22
10	(Y) DATA+	GND	23
11	(G) DATA-	V OUT 2	24
12	(R) +VS	I OUT 2-	25
13	(B) GND	I OUT 2+	26

170
171
+24_V
-24_V

A11 * ADAM-4024

XT1		XT2	
	Net	Net	
1	I OUT 1+	DI 0	14
2	I OUT 1-	DI 1	15
3	V OUT 1	DI 2	16
4	GND	DI 3	17
5	V OUT 0	COM	18
6	I OUT 0-	NA	19
7	I OUT 0+	I OUT 3+	20
8	NA	I OUT 3-	21
9	INIT+	V OUT 3	22
10	(Y) DATA+	GND	23
11	(G) DATA-	V OUT 2	24
12	(R) +VS	I OUT 2-	25
13	(B) GND	I OUT 2+	26

170
171
+24_V
-24_V

A12 * ADAM-4069

XT2		XT1	
	Net	Net	
14	RL0 NO	RL5 NO	1
15	RL0 COM	RL5 COM	2
16	RL0 NC	RL6 NO	3
17	RL1 NO	RL6 COM	4
18	RL1 COM	RL7 NO	5
19	RL1 NC	RL7 COM	6
20	RL2 NO	RL7 NC	7
21	RL2 COM	NC	8
22	RL2 NC	NC	9
23	RL3 COM	(Y) DATA+	10
24	RL3 NO	(G) DATA-	11
25	RL4 COM	(R) +VS	12
26	RL4 NO	(B) GND	13

170
171
+24_V
-24_V

165 XT15 "WYE - POINT"
65 XT16 "WYE - POINT_DME"
65 XT17 "WYE - POINT_DME"

T2
H1 X1
H2
H3
H4 X2
1 88 ~110_V 1

TO SHEET2

X26

510	Net	
512	ESM on	1
511	ESM com.	2
	ESM off	3
77	+24 V	4
79	Din1	5
	NC	6
	NC	7
704	Ain. 1	8
705	Ain. 2	9
706	Ain. com.	10
153	ACS RS485 A+	11
154	ACS RS485 B-	12
152	ACS RS GND	13
	ACS TXD	14
	ACS RXD	15
	ACS GND	16
192	DME RS485 A+	17
194	DME RS485 B-	18
196	DME RS GND	19
146	DME TXD	20
147	DME RXD	21
145	DME GND	22
170	ADAM RS485 A+	23
171	ADAM RS485 B-	24
	ADAM RS GND	25
+24_V	+24V	26
+24_V	+24V	27
+24_V	+24V	28
-24_V	0V	29
-24_V	0V	30
-24_V	0V	31
~110_V	~110V	32
1	~110V	33
88	~220V	34
1	~220V	35

Terminal block of external connections

A3