ADF P200 Hardware Manual

COMSYS
Creating Value through Power Quality™

Safety notes

Read these instructions carefully and look at the equipment to become familiar with the product before trying to install, operate or maintain it. The following special messages may appear throughout this manual to warn of potential hazards or to call attention to that which clarifies or simplifies a procedure:

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or loss of life, property damage, or economic loss.

NOTE Provides additional information to clarify or simplify a procedure.

ATTENTION: Only qualified electrical personnel familiar with the construction and operation of this equipment and the hazards involved should install, adjust, operate, or service this equipment. Read and understand this manual and other applicable manuals in their entirety before proceeding. Failure to observe this precaution could result in severe bodily injury or loss of life.

ATTENTION: The product contains DC bus capacitors which retain hazardous voltages in excess of 1000 V after input power has been disconnected. After disconnecting input power, wait at least sixty (60) minutes for the DC bus capacitors to discharge and then check the voltage with a voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. Failure to observe this precaution could result in severe bodily injury or loss of life.

ATTENTION: This product may have been modified from factory in order for the auxiliary power to be supplied externally. After disconnecting main fuses, the external auxiliary power must also be disconnected.

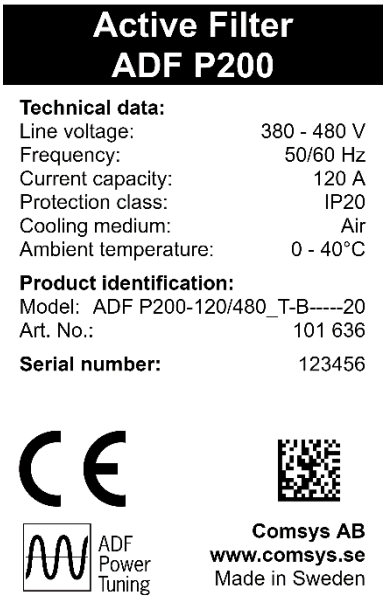
ATTENTION: Before manipulating current transformers, make sure that the secondary is short-circuited. Never open the secondary of a loaded current transformer. You must always wear isolating gloves and eye-protection when working on electrical installations. Also make sure that all local safety regulations are fulfilled.

ATTENTION: Only qualified personnel or other trained personnel who understand the potential hazards involved may make service, updates, troubleshooting, repair or similar work to the product. Any such activities not made corrects may result in uncontrolled operation. Failure to observe this precaution could result in damage to equipment and bodily injury. Although reasonable care has been taken to provide accurate and authoritative information in this document, no responsibility is assumed by **Comsys** for any consequences arising out of the use of this material.

The information in this document is subject to change without notice.

Product identification

The product identification label is found at the front of the ADF. Remember to check that your supply is compatible with the technical data stated on the label before installing and commissioning the Active Filter.



This manual applies to products listed in the table below:

Table 1: Applicable ADF P200 models

Product line	Models	Current rating	Voltage
ADF P200 Air cooled, 3 wire	ADF P200-120/415	120 A_{RMS}	208 – 415 V
	ADF P200-120/480	120 A_{RMS}	380 – 480 V

Standards

These products are CE compliant, which means that the product is in conformity with the European Community low voltage directives 2014/35/EU and 93/68/EEC and it bears the CE label.

The following standards apply:

Table 2: Standards

Standards	
Electromagnetic compatibility	EN 61000-6-2, EN 61800-5-1
Electrical design and safety	EN 50178 / VDE0160
Protection class	IP20 according to IEC 60529 IP21 according to IEC 60529 (Option)
Approval marking	2014/35/EU, 93/68/EEC, 2011/65/EU

Document revision

Table 3: Document revision

Revision	Date	History:	Status:
A0	2010-12-08	ORIGINAL	LIMITED RELEASE
D01	2012-08-02	MAJOR UPDATE	RELEASED
REV03	2018-06-21	NEW ADF P200 DESIGN, IP21 included	RELEASED

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1 Overview

1.1 Content

This manual describes the hardware, installation and maintenance topics of the Comsys ADF P200 series of active filters.

1.2 Organization of manual

The ADF P200 manual is organized in two parts, namely:

1. ADF P200 Hardware Manual, doc no 1 199 178 (this document)
2. ADF P200 User Manual, doc no 1 199 248

The Hardware Manual covers hardware related issues, such as installation, cable selection, CT configuration, preventive maintenance, and troubleshooting.

The user manual covers issues which are governed by the installed software in the system such as operation, initial configuration and commissioning. Hence, when the system is updated, a new User Manual is supplied.

1.3 Related documentation

- ADF P200 User Manual; doc no 1 199 248
- ADF P200 Circuit diagram

2 Active Filter Overview

2.1 Introduction to the Technology

Comsys offers a new generation of high performance power quality products for industrial, utility and commercial applications based on active filter technology, which removes the losses and restores the natural wave shape of the current.

2.1.1 The Problem: Poor Power Quality

Transients, harmonics, voltage variations (including flicker) and unbalance puts the power grid, machines, motors and computer equipment under considerable stress resulting in disturbances, production stops, waste of energy and reduced lifetime. These terms, among others, constitute power quality.

A large part of the equipment connected to the power grid creates disturbances, voltage variations and undesired harmonics that pollute the grid. This pollution generates losses, disturbances, productions stops and reduces expected lifetime of cabling, transformers and other installed equipment as a cause of the excess load.

This leads to decreased capacity in the electrical network, less effective electrical power consumption and energy losses that transforms into both technical and economic costs.

2.1.2 The Solution: Active Filters

Traditionally fixed, electro-mechanical and semiconductor controlled filters and/or compensators have been used to limit or minimize power quality problems in the network.

They operate mainly on a fixed or stepped basis using passive elements. All these solutions suffer from the same drawbacks – they add losses, are installation specific and have no ability to adapt to or follow dynamic load changes.

The Active Dynamic Filter (ADF) eliminates loss creating behaviors such as harmonics, flicker, voltage variations, resonances and reactive energy using a highly dynamic, step less digitally controlled compensation and filtering approach. By continuously monitoring the network and injecting exactly the right amount of compensation current – at exactly the right time – the most efficient and accurate solution to any power quality problem can be achieved.

This approach enables the current waveform to be restored instantaneously, the current consumption to be lowered and changes in load or installation conditions to be fully compensated at all times.

2.1.3 Common applications which can benefit from Active Filters

- Harmonic/reactive power suppression in 3-phase systems
- Industrial production machines (e.g. mills, presses)
- Variable speed drive systems (AC drives, DC drives)
- Electrical welding systems
- Plastic machinery (extruders, injection molders, film treatment machines)
- Power generation systems and UPS equipment
- Electrolytic processes
- Induction heating

2.1.4 How Active Filters Work

An active filter is basically a very advanced computer controlled current generator with the ability to produce any shape or form of current with little or no delay.

A simplified diagram of the operating principle is shown in Figure 1. The system is connected in parallel with the load requiring compensation.

Currents and voltage delivered from the network are measured and analyzed, to determine if disturbances such as e.g. reactive displacement and/or harmonics are present.

The system injects compensation currents which is the exact opposite of the e.g. harmonics and/or reactive displacement to cancel out the undesired behavior of the load.

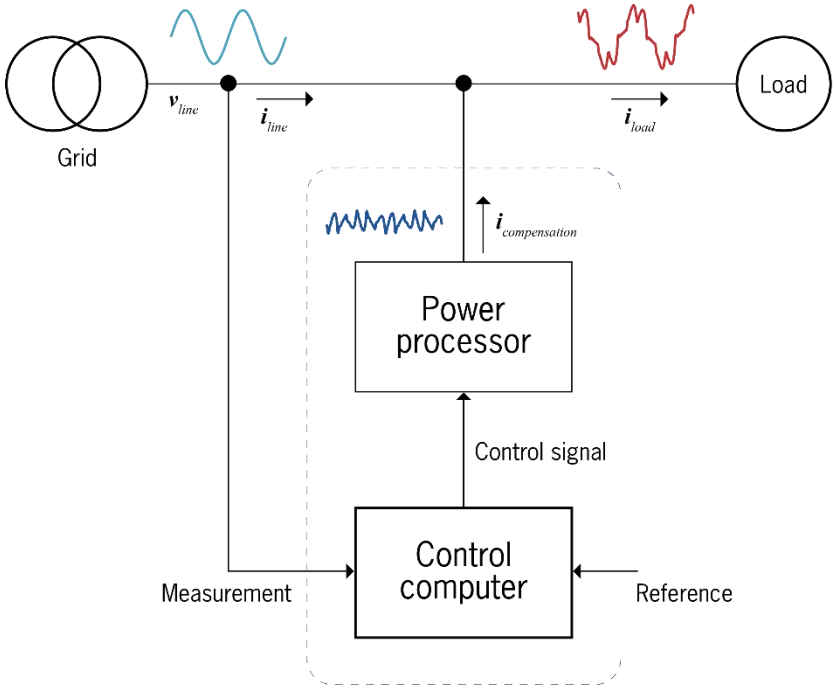

Figure 1: Basic operating principle

The Figure 2 shows how the current consumed by an electrical load may look like prior to and during compensation. Before compensation, the current consists of several harmonics in addition to the fundamental, which are apparent from the current's deformed waveform. After injection of the compensation current, the load current's natural sinusoidal waveform is restored and the loss creating behaviors have been eliminated.

The function of the power transmission system is restored, which leads to saved energy, lower disturbances or in short – improved power quality and significantly lowered costs in electrical installations.

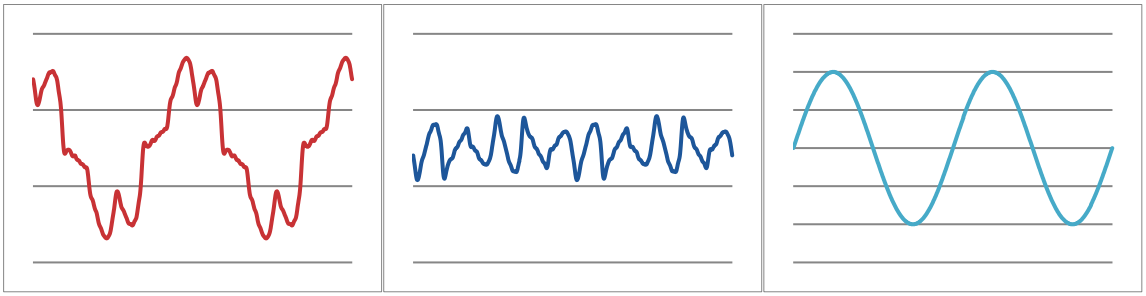

Figure 2: Uncompensated load current (left), Compensation current (middle), Compensated net current (right)

2.2 System Overview

The Active Filter ADF P200 is a stand-alone and modular high power active power filter. It can be installed inside a machine as OEM, inside a cabinet in system integration or directly on the wall. Several ADF P200 units can work in parallel.

2.2.1 Features

General features:

- Compact design in ready-to-use wall mounted enclosure
- High performance and reliability
- Advanced digital control and low response time

- Several units can be operated in parallel for higher power ratings
- Suitable for embedded solutions
- Non-overloadable and insensitive to changes in network or load conditions
- Easy installation, commissioning and maintenance

2.2.2 Main components overview

This section describes the major components of the ADF P200 Active Filter.

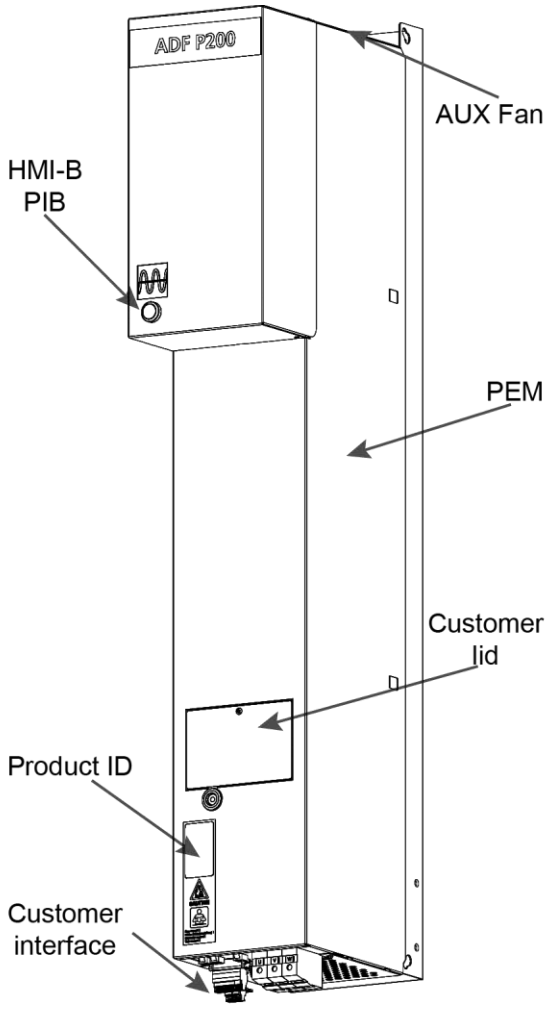

Figure 3: ADF P200 external overview with HMI

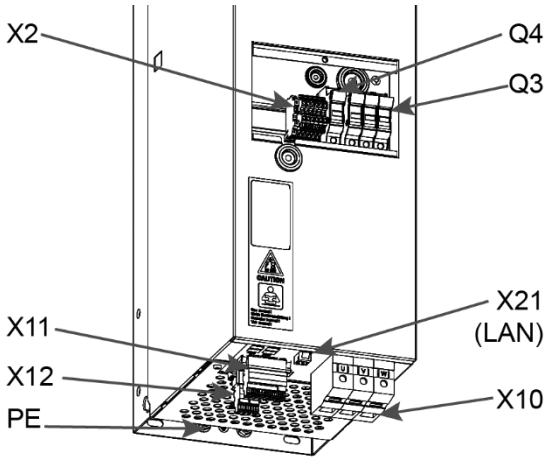

Figure 4: ADF P200 with removed Customer lid

2.2.2.1 PIB - Power Indication Button (HMI-3 Basic)

Basic operations like start and stop, can be performed on the PIB. The button also shows basic operation information on an indication light, integrated in the button.

The ADF is powered ON by pressing this button short and powered OFF by pressing the button for two seconds.

Table 4: PIB color coding

Color	Description	Button action
Solid red	System in trip	None
Fading yellow	Pre-charge / all other states	Stop system
Fading green	System is stopped	Start system
Solid green	System is running	Stop system
None	System is powered off	Boot system

2.2.2.2 Power Electronics Module (PEM)

The largest part of the ADF P200 is the Power Electronics Module that generates the compensation currents. The power processor contains power electronics such as IGBT modules, IGBT driver electronics, EMC-filter, DC-storage, cooling fans and line filtering components.

2.2.2.3 Customer interface

The Customer interface is the main I/O used to connect the ADF P200.

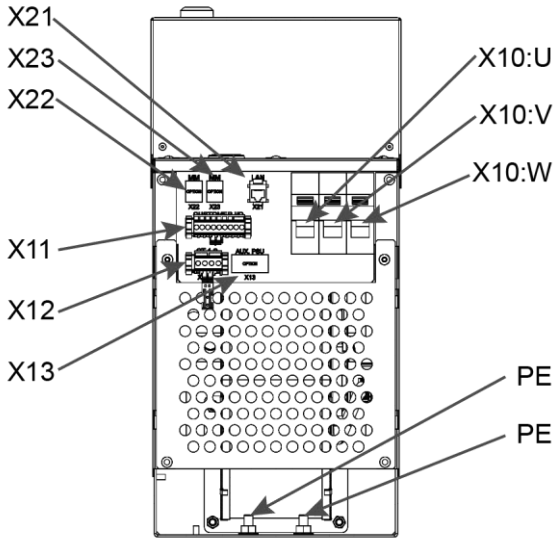

Figure 5: Customer Electrical Interface of ADF P200

2.2.2.4 Customer lid

The customer lid is a cover giving access to some important fuses and terminals needed during commissioning.

2.2.2.5 Auxiliary fuse block (Q3) (under customer lid)

Auxiliary fuse block (Q3), located inside the unit behind the customer lid, protects voltage measurement circuits, pre-charging circuits and auxiliary power systems in the Active Filter.

2.2.2.6 230 V fuse block (Q4) (under customer lid)

Auxiliary fuse block (Q4), located inside the unit behind the customer lid, auxiliary power systems in the Active Filter.

2.2.2.7 Auxiliary voltage selection (X2) (under customer lid)

The internal auxiliary transformer, used to generate 230 V, can be selected to different input voltages depending on the grids nominal voltage. The selection can be made on terminal X2. See section 5.3.8 for more information.

2.2.2.8 AUX fan

24 V driven fan to increase airflow through the AUX part of the system.

2.2.2.9 Power connection terminals (X10)

Used for connection of mains to the system. See section 5.3.2 for detailed connection information. The terminals are placed in the bottom section of the Control Module.

2.2.2.10 Earth connection (PE)

Main protective earth connection. See section 5.3.3 for more information.

2.2.2.11 User signal interface (X11)

The user signal interface terminals, X11, are used for interface to external devices via alarm outputs and digital inputs. See section 5.3.4 for more information on how to connect digital inputs and outputs.

2.2.2.12 Current transformer interface (X12)

Current transformer interface terminals, X12, are used for connecting current transformers. See section 5.3.4 for more information on how to connect current transformers (CT's).

2.2.2.13 LAN connection (X21)

LAN connection for interfacing the ADF Dashboard Web-User-Interface.

2.2.2.14 Multi-master interface (X22 & X23; not yet implemented)

MM-bus connections X22 and X23 for interconnecting the ADF P200 with ADF P100/300 systems is not yet implemented.

2.2.2.15 AUX PSU (X13)

The AUX PSU interface (X13) is not yet implemented.

3 Filter configuration

The ADF P200 filter is available in a variety of configurations. The product configuration is defined by the product string. The product string consists of the basic type of product, such as ADF P200-120/480, but also a list of factory built-in options. Please note that other options exist that are not immediately part of the product string, such as software licenses that do not have a hardware impact. The nomenclature of the product string is defined as below:

```
ADF PmodQ-cur/vol{-UL}_{OPTION STRING: ABCDEFGHIJ}
```

```
ADF P200-120/480_ABCDEFGHIJ
```

```
ADF P200-120/480_T-B-----20
```

All positions are always visible within the product string, except for ‘Q’ that is a qualifier that enables a certain type of product. When an option is enabled, it is lit up in the string.

Also note that the encapsulation class (ingress protection) is documented in the last two letters. 20 in this case means IP20. All relevant ADF P200 codes are listed in the table below:

Tabell 1: ADF P200 product string

Position	ADF	Active Dynamic Filter
Product Type (mod) and Qualifier (Q)		
ADF P200 **ADF P200**-120/480__T-B-----20	**P200**	3phase-3wire, air cooled, wall-mounted Active Dynamic Filter
Current Rating (cur)		
cur ADF P200-**120**/480__T-B-----20	**120**	120 A rating on ADF P200 in 415/480 V versions (IEC)
Voltage Level (vol)		
vol ADF P200-120/**480**_T-B-----20	**415**	Permissible voltage levels are: 215/230/245/385/400/415 V
	480	Permissible voltage levels are: 380/400/420/440/460/480 V
Options (ABCDEFGH)		
Grounding System (A)		
A ADF P200-120/480_**T**-B-----20	**T**	TN/TT grounding system (standard if not otherwise specified)
Reserved (unused) option code (B)		
B ADF P200-120/480_T-**B**-----20	**-**	**Currently not in use**
HMI (C)		
C ADF P200-120/480__T-**B**-----20	**B**	Basic HMI with PIB only (standard)
Reserved (unused) option codes (DEFGH)		
DEFGH ADF P200-120/480__T-B**-----**20	-	**Currently not in use**
Protection class (IJ)		
IJ ADF P200-120/480_T-B-----**20**	**20**	IP20 (IEC/CE systems only)
	21	IP21 (IEC/CE systems only)

4 Getting started

This section is intended to help you get through to operate the Active Filter with the least work on your part. Guidance and hints are provided. First it is important that you read and observe the safety notes in the beginning of this manual to help avoid damage to equipment, installation and persons.

4.1 Receiving and unpacking

On receiving the unit read notes in section 5.1. If the system is to be transported on site, please be sure to avoid excessive strains. In particular, no components must be bent, or isolating distances altered in the course of transportation or handling. No contact must be made with electronic components and contacts. Also note that all operations serving transport, installation and commissioning as well as maintenance must to be carried out by skilled technical personnel.

Active Filters contain electrostatic sensitive components which are liable to damage through improper use. Electric components must not be mechanically damaged or destroyed (potential health risks).

4.2 Installation

It is important to prepare the installation site prior to installing and connecting the Active Filter. In the section 5, important information such as location of terminals, cable size recommendations, ADF P200 over current protection and cooling air flow requirements are discussed. To maintain operation and long equipment life it is vital to keep environmental conditions in accordance with the specifications.

Current transformer (CT) selection is important for good performance. Read about CT selection and connection in section 5.3.5 and if possible use separate CTs, not shared with other equipment e.g. power quality meters.

Notice that the ADF P200 is in most cases run without current transformer in “Sensorless Control”. A operation with CT’s is also possible.

Good earth connection is also important to achieve best results and electrical safety as described in the section 5.3.3.

It is important that any materials or method for connection used is within limits with respects to local safety regulations. Also make sure that appropriate fuses are fitted in the mains connection.

4.3 Configuration and Commissioning

The Active Filter has extensive functionality built-in for several modes of operation.

The ADF P200 User Manual (1 199 248) details how to configure the software parameters for the ADF P200.

5 Installation

5.1 Unpacking the Active Filter

Each Active Filter is delivered in packaging suitable for transportation. Upon reception of the Active Filter, visually inspect that the packaging is in good condition. Verify that all below listed items are present in the package:

- ADF P200
- IP 21 roof (option)
- ADF P200 Hardware Manual, doc no 1 199 178 (this document)
- The ADF P200 User Manual (1 199 248)

ATTENTION: Before unpacking and installing the Active Filter please read through the following pages THOROUGHLY to make sure that it is handled in the right way.

The unit is heavy and weighs up to 101 kilograms / 223 lbs.

Do not attempt to move the unit before reading the lifting instruction and act accordingly.

Attempt to move the equipment without proper equipment and not according to instructions may result in damage of the equipment and injury.

5.1.1 Before unpacking and Installation/Commissioning

Before moving the Active Filter without its protective packaging please pay extra attention to the section in this document that handles lifting. During transport and storage and before commissioning, keep the system protected from dust and water ingression.

ATTENTION: Make sure to protect the Active Filter at all times, especially during installation since the product contains very sensitive power electronics.

5.1.2 Storage conditions

During storage of the unit, the unit should be kept within the following conditions. The conditions are acceptable only when the unit is kept in its shipping packaging.

Table 5: Maximum storage conditions

Maximum storage conditions (in protective shipment package)	
Temperature	-25 °C to 70 °C (-13 °F to 158 °F)
Relative humidity	Less than 95 %, non-condensing
Environmental conditions	Chemical class 3C3 Mechanical class 3S3

5.1.3 Transport conditions

During transport, the unit should be kept within the following conditions. The conditions are acceptable only when the unit is kept in its shipping packaging.

Table 6: Maximum transport conditions

Maximum transport conditions (in protective shipment package)	
Temperature	-25 °C to 70 °C (-13 °F to 158 °F)
Relative humidity	Less than 95 %, non-condensing
Environmental conditions	Chemical class 3C3 Mechanical class 3S3

5.1.4 Lifting the Active Filter in its box

The ADF P200 can be handled by forklifts and cranes as long as it is packaged in its protective packaging.

5.1.5 Lifting the Active Filter

The ADF P200 must be lifted and moved according to the instructions in this section.

Start by removing part of freight box in such a way that the ADF P200 is accessible from all sides and top when lying on its back. Only the part of the freight box under the ADF P200 back is then left. The ADF P200 is screwed to the pallet with two screw on the top and two at the bottom.

The Active Filter may only be lifted in the lifting ears on top and bottom of the Active Filter. This is only possible without the optional IP21 cover. The length of the straps must exceed 220 mm / 9” and be of the same length according to Figure 6. Protect the ADF P200 from scratching and other damages during lifting, by adding soft protective material between the ADF P200 and other objects.

The filter may also be manually lifted using special metal rods. Insert the metal rods in the lifting holes and manually lift the filter. The metal rods are not included. Generally round metal rod(s) can also be used.

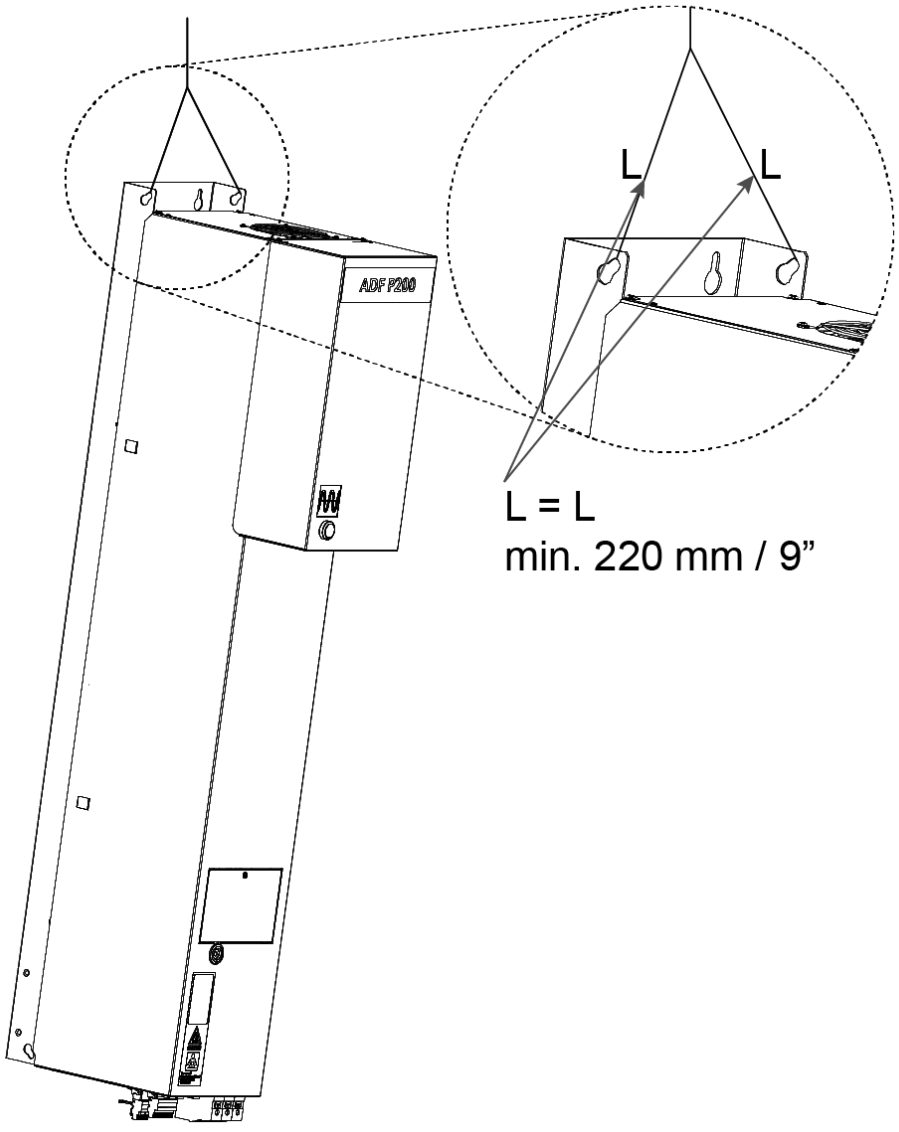

Figure 6: Correct lifting of the Active Filter

If moving the Active Filter with for example a fork lift, it may only be moved lying down on its back, not on its sides nor standing.

5.1.6 Wall mounting and preservation of the Active Filter

Make sure the wall and the fastening bolts can support the weight (up to 101 kg / 223 lbs.) of the Active Filter. Start with fastening the screws on the top (use M10 with flat head) in the wall as suggested by the footprint in Figure 7. Leave space between the head of the screw and the wall for the back side of the Active Filter to be fitted.

Lift the Active Filter into place over the keyholes, push it flat to the wall and lower it in place. Tighten the screws. The screws in the bottom can then be mounted.

The bottom screw holes are extended to long holes for backwards compatibility. For backwards compatibility a hole distance of 178 mm / 7” exists. Current systems have a hole distance of 156 mm / 6.14” (same as in the top of the system).

Comsys suggests using the 156 mm / 6.14” distance.

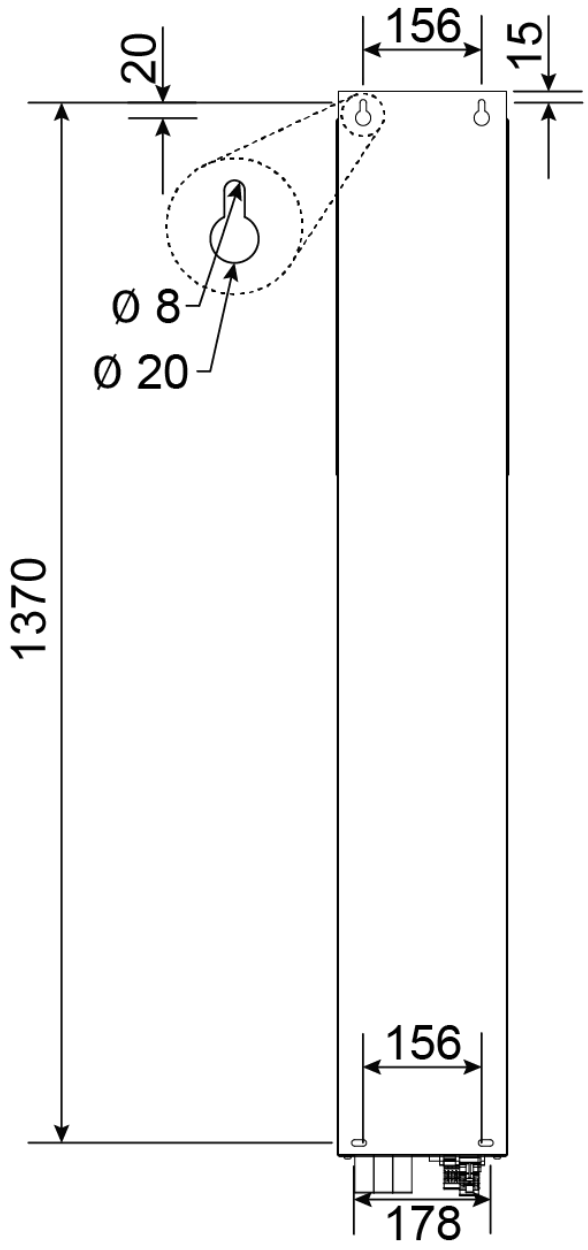

Figure 7: Footprint for wall mounting the Active Filter (in mm)

After the Active Filter has been mounted on the wall, and before commissioning, protect the system from dust and other harmful particles.

5.1.7 Mounting IP21 roof (optional)

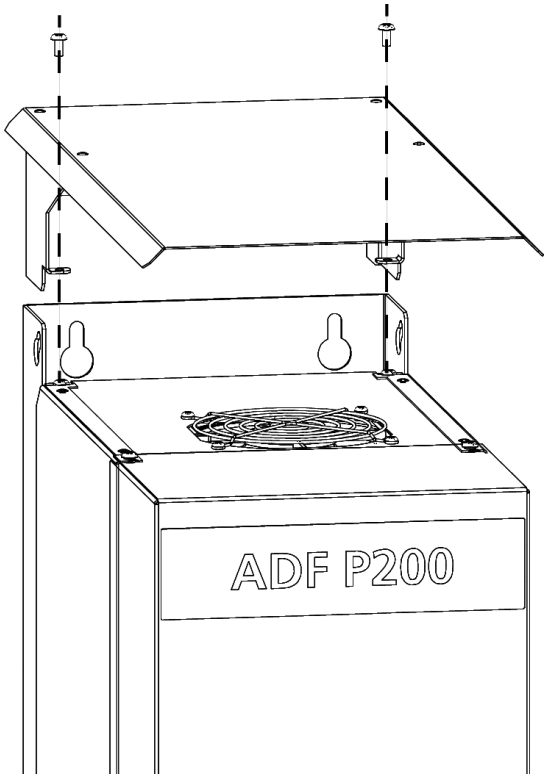

Figure 8: Mounting IP21 roof

The ADF P200 is available with an IP21 option. This option is not mounted when shipping.

To mount the IP21 roof, two screws (size 3 hex-screw) in top back of the ADF P200 needs to be removed. The IP21 roof must be put on top and the screws then needs to be put back, holding the roof in place.

5.2 Environmental conditions

5.2.1 Operating conditions

The unit is suitable for indoor operation only. If the unit is operated within the below limits, full power may be utilized. During more demanding conditions, the unit will be derated when approaching full power.

The unit must be placed in a well-ventilated area. For cooling air flow requirements, see section 5.2.3.

Table 7: Maximum operating environmental conditions

Maximum operating environmental conditions	
Temperature	0 °C to 50 °C, derating applies above 40 °C 32 °F to 122 °F, derating applies above 104 °F
Relative humidity	Less than 95 %, non-condensing
Altitude	1000 m (3300 ft) Derating may be required at higher altitude. For more details, see “Appendix D Power derating”
Environmental conditions	Chemical class 3C2 Mechanical class 3S2

ATTENTION: Make sure that the unit is installed in an environment without conductive or corrosive dust. If conductive or corrosive dust is present extra precautions must be taken. Contact your COMSYS representative.

5.2.2 Physical conditions

There should be a minimum of 100 mm / 4” clearance to the ceiling above the roof of the unit in order not to obstruct cooling air flow.

In front of the unit, there should be a minimum clearance of 400 mm / 16” to allow removal of cover. However, make sure to enable service access, for example it must be possible to physically access the unit from the front. Also, in front of the unit, there should be a minimum clearance of 100 mm / 4” to avoid restriction of air intake, assuming no external restrictions for air flow, for example if the ADF P200 is placed in a cabinet.

If the unit is placed inside an enclosed cabinet, the door is not considered a restriction. However, consider that cooling air must not be restricted see section 5.2.3.

The base of the ADF P200 is the main income for the cooling air. There must be a minimal clearance to floor of at least 200 mm / 8” to allow for a good air flow. Also make sure that mains and signal cables have space for bending and connecting. There is no minimal clearance sideways however consider that the unit can become warm under operation.

Local regulations may impose stricter demands.

5.2.3 Cooling air flow requirements

The cooling air flow requirements are dependent on operating conditions and load cycles. The following table states the maximum demanded air flow from each ADF P200:

Table 8: Minimum air flow requirements

Model	Maximum air flow	Maximum losses
ADF P200-120/415 ADF P200-120/480	600 m^3/h	1200 W

It is crucial that the Active Filter can utilize the needed air flow during maximum operating conditions. The cooling air may not exceed 50 °C / 122 °F under any circumstances. Derating applies above 40 °C / 104 °F.

ATTENTION: Make sure that the ambient temperature is below 50 °C / 122 °F under all circumstances.

Make sure that the air drawn into the unit does not contain corrosive or conductive gases of any kind. Make sure that the physical mounting guidelines are followed and that no obstruction lower the air flow. Take care of the hot air emitted from the unit in a proper way.

Failure to observe these guidelines may result in premature aging or failure of the equipment.

The Active Filter contains internal fans that will ensure that the air flow reaches the needed capacity during maximum operating conditions. The emitted hot air must be taken care of by the room housing the unit. Hot air is emitted from the top of the unit according to the figure below.

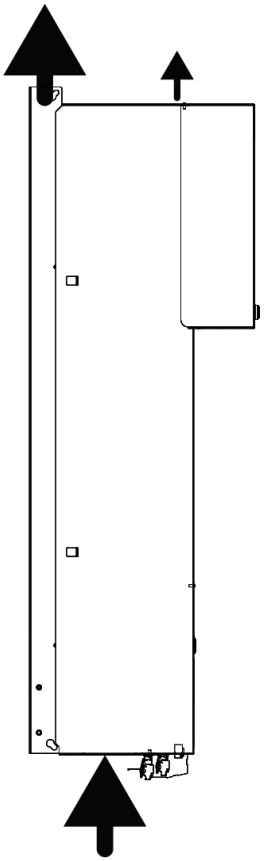

Figure 9: Air flow in ADF P200

5.3 Connection of the Active Filter

The Active Filter has three main connector terminals, X10 for the power interface, X11 for external user functionality signals and X12 for CTs, as seen in Figure 5. They are located at the underside of the unit.

5.3.1 Overview connection terminals of the ADF P200

In Figure 5 the connection area and the terminal names for the ADF P200 products can be seen.

5.3.2 Power connection terminals (X10)

The mains power connection is made at terminals X10 (see Figure 5), found in the bottom of the unit. X10 accepts a wide range of different cable types (copper or aluminum, solid or stranded with or without ferrule and ferrule with or without plastic sleeve) up to 95 mm^2.

Table 9: ADF Power connection data

ADF Power connection data	
Conductor cross section solid min.	25 mm^2
Conductor cross section solid max.	95 mm^2
Conductor cross section stranded min.	35 mm^2
Conductor cross section stranded max.	95 mm^2
Conductor cross section AWG min.	4
Conductor cross section AWG max.	4/0
Stripping length	27 mm / 1”

ADF P200 systems have one terminal each for U, V and W (L1, L2 and L3).

Mount the cabling using the appropriate accessories. Use a torque of 15 – 20 Nm.

ATTENTION: After running the Active Filter, wait at least 60 minutes after opening the main feeding circuit to guarantee that there is no residual voltage on the DC capacitors. Failure to observe these guidelines may result in injury or loss of life.

ATTENTION: Note that the Active Filter is fed from an external point. Only in this point, like a MCB or fuse disconnector, it is possible to open the main feeding to the Active Filter.

ATTENTION: The active filter must be connected via either fuses or a circuit breaker that can be operated by the user and are suitable for the short circuit power in the feeding network. Since there is no main fuse or breaker in the ADF P200, the only way to make the system fully de-energized is to open the fuse or breaker feeding X10.

5.3.2.1 Selection of power cable size

In order to guarantee that the cables are not overheated some derating has to be introduced. This is due to the skin effect caused by the harmonics. A derating factor of x 1.5 is suggested, as well as a maximum cable inductance of 2 µH in case of Sensorless operation.

Table 10: Recommended cable sizes

Intended unit max current	Derating factor
120 A_{RMS}	x 1.5
Cable inductance	< 2 µH

ATTENTION: The dimensions given in Table 10 only take the skin effect into consideration due to the load current being mostly harmonics. Local regulations must be observed and followed and other installation conditions which may affect the sizing of the cables, number of parallel conductors, distance and layout between conductors, and such parameters. Consult your cable manufacturer for the appropriate cable. The above guidelines are only recommendations with no warranty of suitability.

5.3.2.2 Main fuse selection

The switchgear feeding the unit must provide a breaker or fusing capable of interrupting the short circuit power. The unit must be protected for over current at least according to the nominal current rating of the model installed. Note that current in many cases will be purely harmonic.

Local regulations may impose further demands on external fusing and/or external circuit breakers.

ATTENTION: Note that the fuses may have to be derated due to the load characteristics if for example the unit is used for harmonics only. Consult with the fuse supplier.

NOTE Comsys recommend the use of fast fuses (semiconductor type) for protecting the ADF P200. With semiconductor fuses, the damage in a short circuit condition is reduced, meaning lower repair cost. Note that in this case cable protection must also be considered.

5.3.3 Protective earth (PE) connection

Connect the protective earth to the PE screw stud (see Figure 5; lower back of the cabinet). Connecting points are two M8 bolds. A cable area of at least 16 mm^2 / AWG5 is recommended. Tighten the connection with a torque of 20 Nm.

ATTENTION: The protective earth connection must be connected to PE in the installation and NOT to the N-conductor.

5.3.4 User signal interface (X11)

The external interface terminal block X11 (see section 2.2.2.3) is the connection for digital inputs, digital outputs and alarm output.

Table 11: External interface terminal X11

Terminal No	Description
X11:1	Alarm relay NO
X11:2	Alarm relay COM
X11:3	Alarm relay NC
X11:4	Digital IN1, 24 V_{DC} (Start/Stop function)
X11:5	Digital IN COM GND
X11:6	RESERVED
X11:7	Operation relay NO
X11:8	Operation relay COM
X11:9	PE

The digital outputs Alarm relay and Operation relay are of the following specification:

- Switches 5 A at 250 V_{AC} / 30 V_{DC}, resistive load

Table 12: ADF X11 connection data

ADF CT connection data	
Conductor cross section solid min.	0.14 mm^2 / AWG 26
Conductor cross section solid max.	6 mm^2 / AWG 10
Conductor cross section stranded min.	0.14 mm^2 / AWG 26
Conductor cross section stranded max.	6 mm^2 / AWG 10
Stripping length	9 mm / 3/8”
Torque	0.6 – 0.8 Nm

5.3.6 Current transformer terminals (X12)

Current transformers are connected to terminal block X12:1 – X12:4 in the bottom of the unit. Current transformers are used on Phase 1 and Phase 2.

CT's are needed in only a few types of installations. Typically, the ADF P200 is installed Sensorless without the use of current transformer.

The terminal block X12 provides a short circuit possibility for the incoming cable. The short circuit needs to be removed before operating.

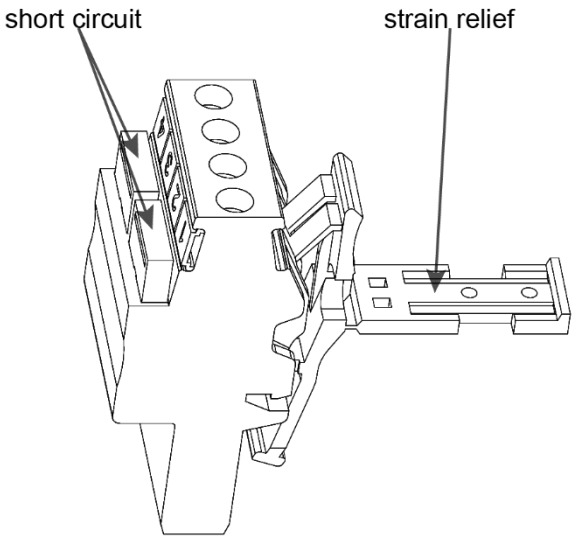

Figure 10: X12 terminals; with closed short circuit

Table 13: External interface terminals X12

Terminal No	Description
X12:1	S1 (k), Current transformer U (L1)
X12:2	S2 (l), Current transformer U (L1)
X12:3	S1 (k), Current transformer V (L2)
X12:4	S2 (l), Current transformer V (L2)

5.3.6.1 Selection of current transformers

The current transformers should fulfill the following specification:

Table 14: Current transformer (CT) specification

Current transformer specification	
Class	1.0 or better
Primary ratio	Exceeding the maximum load current including harmonics, reactive power, and transients
Secondary ratio	1 A
ADF total CT burden	1 VA
Symmetry	Two identical CTs must be used.

Note that the size of the CT is critical to the performance of the system when operating in current control. Using a very large CT in relation to the total load size will result in poor resolution and hence poor results.

ATTENTION: Current Transformers with 1 A secondary must be used. CTs with 5 A secondary will overload the measurement.

5.3.6.2 Recommended current transformer cable size

The recommended cable size used for connection of the current transformers is dependent of the output power of the current transformers and total length of the cables. A calculation of burden must be performed to guarantee that the burden of the CT is not exceeded. Table 18 shows the need required burden in relation to the cable size and length for some examples.

Table 15: Burden as function of cable size and length (total cable length, round trip)

	5 m	10 m	20 m	30 m	50 m	100 m	160 m
0.5 mm²	5.2 VA	9.4 VA	17.8 VA	26.2 VA	43.0 VA	85.0 VA	135.4 VA
0.8 mm²	3.8 VA	6.6 VA	12.2 VA	17.8 VA	29.0 VA	57.0 VA	90.6 VA
1.0 mm²	3.1 VA	5.2 VA	9.4 VA	13.6 VA	22.0 VA	43.0 VA	68.2 VA
1.5 mm²	2.4 VA	3.8 VA	6.6 VA	9.4 VA	15.0 VA	29.0 VA	45.8 VA
2.5 mm²	1.9 VA	2.7 VA	4.4 VA	6.1 VA	9.4 VA	17.8 VA	27.9 VA
4.0 mm²	1.6 VA	2.1 VA	3.1 VA	4.2 VA	6.3 VA	11.5 VA	17.8 VA
6.0 mm²	1.4 VA	1.7 VA	2.4 VA	3.1 VA	4.5 VA	8.0 VA	12.2 VA

Table 16: ADF CT connection data

ADF CT connection data	
Conductor cross section solid min.	0.14 mm^2 / AWG 26
Conductor cross section solid max.	6 mm^2 / AWG 10
Conductor cross section stranded min.	0.14 mm^2 / AWG 26
Conductor cross section stranded max.	6 mm^2 / AWG 10
Stripping length	9 mm
Torque	0.6 – 0.8 Nm

5.3.6.3 Location of current transformers

The following guidelines should be observed for proper operation:

Sensorless control is preferred. This means no CTs are used to monitor the load current. Compensation is based on the grid voltage. However, open loop control is also possible – meaning that CTs are placed downstream to the mains connection of the Active Filter unit.

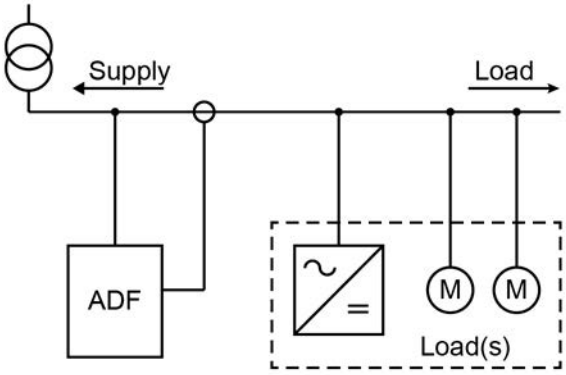

Figure 11: Current Transformer placement diagram – open loop

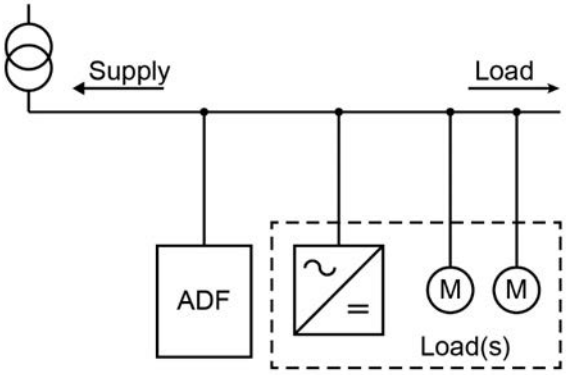

Figure 12: No current transformer in Sensorless Control

ATTENTION: Never open the circuit of a connected current transformer. During all connection work, short circuit the secondary of the current transformers.

Failure to short circuit the current transformers may cause dangerous voltages, arcs and destruction of the current transformers. When connection is complete, the short circuit must be removed.

5.3.6.4 Connection and wiring of current transformers

- The S1 (k) terminal of each CT must be oriented to the supply side. The S2 (l) of each CT must be oriented toward the load side.
- The CTs must be grouped properly phase wise with the corresponding mains connection. This means that the connected to phase L1 (U) on X12 must monitor the current corresponding to phase L1 (U) of the network line connection on X10.
- The phases must be connected in proper rotation. V must lag U, W must lag V and U must lag W.
- Either S1 (k) or S2 (l) must be individually connected to PE (Protective Earth). The connection must be performed identically for each CT.
- The connection is made to terminal block X12:1 through X12:4.

The wiring should be connected according to Table 17.

Table 17: CT connection table

Phase	Current transformer	Terminal block
U / Phase L1	S1 (k)	X12:1
	S2 (l)	X12:2
V / Phase L2	S1 (k)	X12:3
	S2 (l)	X12:4

In Figure 13, the correct connection of mains power and current transformers with correct grounding is illustrated. The example shows open loop operation on an ADF P200.

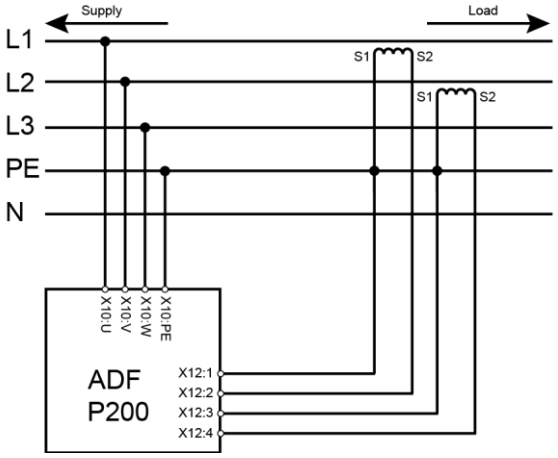

Figure 13: ADF P200 Current Transformer connection diagram – open loop

5.3.6.5 Connection of current transformers with paralleled systems

Figure 14 illustrates correct connection of two paralleled Active Filters, again in open loop operation with correct grounding:

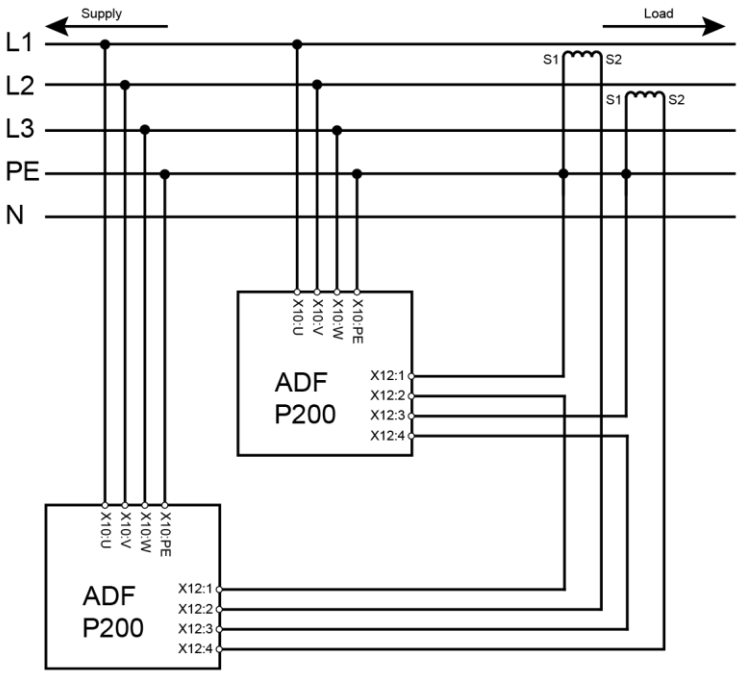

Figure 14: Current Transformer connection diagram – paralleled units

5.3.6.6 Use of summation current transformers

Summation current transformers can be used in certain configurations. Some examples of usable scenarios:

- When compensating loads, in open loop configuration, where the main CTs must be placed on two or more outgoing groups.

In all cases, when using summation CT's, the ratio must be selected so that full signal corresponds to 1 A on the secondary of the summation transformer going into the X12 terminal block.

5.3.7 Local area network (X21)

The RJ45 LAN socket allows connection to the control computer and is used for configuration and monitoring of the ADF via a standard Ethernet network or directly from a PC. Please see the User Manual for more information on how to connect to the ADF.

For fixed installations, Comsys suggests using a shielded Ethernet cable.

5.3.8 Auxiliary Transformer Setup (X2)

The ADF P200 includes an auxiliary transformer which supplies internal circuits with 230 V. Two different transformers are used for different voltages according to the order ADF type. The auxiliary transformer is hidden, however Terminal X2 makes it possible to select the different voltages. X2 is located behind the customer lid.

Table 18: Voltage range 208 – 415 V (ADF P200-120/**415**)

Nominal Primary	+15 V (X2:1)	0 V (X2:2)	-15 V (X2:3)	230 V (X2:4)	400 V (X2:5)	PARKING (X2:6)
215 V			N	L		
230 V		N		L		
245 V	N			L		
385 V			N		L	
400 V		N			L	
415 V	N				L	
deactivated		N				L

Table 19: Voltage range 380 – 480 V (ADF P200-120/**480**)

Nominal Primary	+20 V (X2:1)	0 V (X2:2)	-20 V (X2:3)	400 V (X2:4)	460 V (X2:5)	PARKING (X2:6)
380 V			N	L		
400 V		N		L		
420 V	N			L		
440 V			N		L	
460 V		N			L	
480 V	N				L	
deactivated		N				L

The transformer primary is in deactivated position when the unit is delivered from factory. Thus, it is necessary to select the proper primary winding in order to supply 230 V to the internal circuits. Please select a tap that is closest to the operating voltage of your system.

The connection is made by connecting the loose wire to the appropriate terminal.

ATTENTION: Do not use a primary voltage that differs more than 10 per cent from the nominal voltage. In case such a primary voltage must be used, order a custom transformer from Comsys AB. Please refer to the table above.

ATTENTION: Selecting a too low voltage will result in overheating of some components. In worst case selecting a too low voltage will cause fire.

5.3.9 Auxiliary fuse / 230 V fuse selection (Q3 / Q4)

The Active Filter has internal fuse blocks for protection of the auxiliary power circuit as well as the 230 V circuits located behind the customer lid. The fuse types are defined in the below table.

Table 20: Auxiliary fuse / 230 V fuse selection

Product line 480 V, IEC	Fuse type	Brand example
ADF P200	Ferrule fuse link, 10x38, aM, 500V_{AC}, 10A	Cooper Bussman CBC10M10

ATTENTION: Warranty is void if the wrong fuse type is used.

6 Maintenance

The following chapter covers routine maintenance of all ADF P200 variants.

The ADF P200 is fully serviceable from the front, bottom and top after removing all covers. All internal parts can be changed without dismounting the entire unit if for example mounted on a wall.

Every 6 months, a routine inspection is performed. In most cases, no components are exchanged during biannual inspection.

NOTE Warranty is void if maintenance is not performed according to schedule.

ATTENTION: All maintenance must be performed by trained and qualified personnel.

Make sure no voltage is present in main circuit, auxiliary power system, AC voltage measurement circuits and power capacitors.

Follow the guidelines for preparing the ADF P200 for maintenance before attempting to perform any work in this section.

ADF P200 consists of electronics sensitive to electrostatic voltage.

When tightening electrical or mechanical connections be sure to apply the correct torque.

Before attempting any maintenance, the ADF P200 must be shut down by disconnecting the mains in the customer switchgear or similar, followed by taking appropriate safety measures.

6.1 Biannual inspection

The following items are included in the maintenance procedure:

- Visual inspection
- Cleaning
- Cooling system
- Cover inspection
- Electrical connections

6.1.1 Removal of covers

To be able to perform inspections the covers must be removed.

Remove the small white cover mounted on the top by losing the screws and pull cover down. Make sure to disconnect the HMI cable.

Remove the main cover by loosen the mounting screws on the top and remove the screws on the bottom, then lift it off.

6.1.2 Visual inspection

The cover must be removed. A visual inspection must be performed of all the system. Check for any of the following items:

- Dust
- Condensation
- Abnormal smell, discoloration, soot or swelling of components
- Cracks in plastic covers
- Inspect DC capacitors for signs of overheating; be aware of swollen capacitors and signs of overheating. Such capacitors must be replaced.
- Inspect line filter AC capacitors, check for signs of damage.
- Inspect internal contactors; check for sign of damage such as soot or other discolor.

- Inspect internal cables for signs of insulation wear due to poor routing.

Pay particular attention to presence of conductive dust.

6.1.3 Cleaning

All dust must be removed. The best way of doing this is to use pressurized air (from a compressor system).

ATTENTION: The equipment is sensitive to ESD. Avoid cleaning the system with any method which may cause build-up of ESD; such as vacuum cleaning, using cloths, etc.

Dust build-up may cause unreliability and component failure in the worst case.

6.1.4 Electrical connection

Visually inspect all electrical connections. Check for signs of heated cable terminations and damaged insulation.

Check the torque on mains connections and PE.

6.1.5 Change and inspection of internal fuse

Inspect the auxiliary fuses (Q3 and Q4) located behind the customer lid.

6.1.6 Cooling system

The ADF P200 has one main fan as well as one auxiliary fan. The main fan is located in the bottom, with the air outlet on the top of the unit. The auxiliary fan is located in the top of the unit.

After restarting the unit; check that no noise indicating fans wear is audible. Also check that the air flow is strong by putting the hand over the air outlets.

Appendix A Technical Specifications

A.1 Technical Data – ADF P200

Table 21: Technical specifications ADF P200

Model	ADF P200-120/4x0
Rated power *	83 / 100 kVA
Compensation current capacity at 50/60 Hz	120 A_{RMS}
System voltage ± 10 %	208 – 480 V
Nominal frequency	50/60 Hz ± 5 %
Number of phases	3 phase 3 wire
Connection type	3 phase without neutral (TN, TT)
Harmonic compensation	curve selectable harmonics, interhamonics compensation up to 5 kHz (100^{th} order)
Filter efficiency	better than 97 %
Current compensation of cos φ	up to 1.0
Expandability	ADF P200 units can be used in parallel
Response time	< 20 µs
Power dissipation	< 1200 W
Maximum air flow requirement	600 m^3/h
Noise level	< 60 dB(A)
Environment	0 to 95 % RH non-condensing, max altitude 1000 m without derating
Operating temperature	0 to 50 °C, up to 40 °C without derating
Dimensions	230 x 1400 x 470 mm (W x H x D)
Weight	101 kg.
Cabinet color	RAL 7035 (light grey) RAL 5017 (traffic blue)
Protection class	IP20, IP21** according to IEC 60529
Environmental conditions	chemical 3C3, mechanical 3S3
Electromagnetic compatibility	EN 55011, Class B
Certificates	CE

A.4 Dimensions – ADF P200

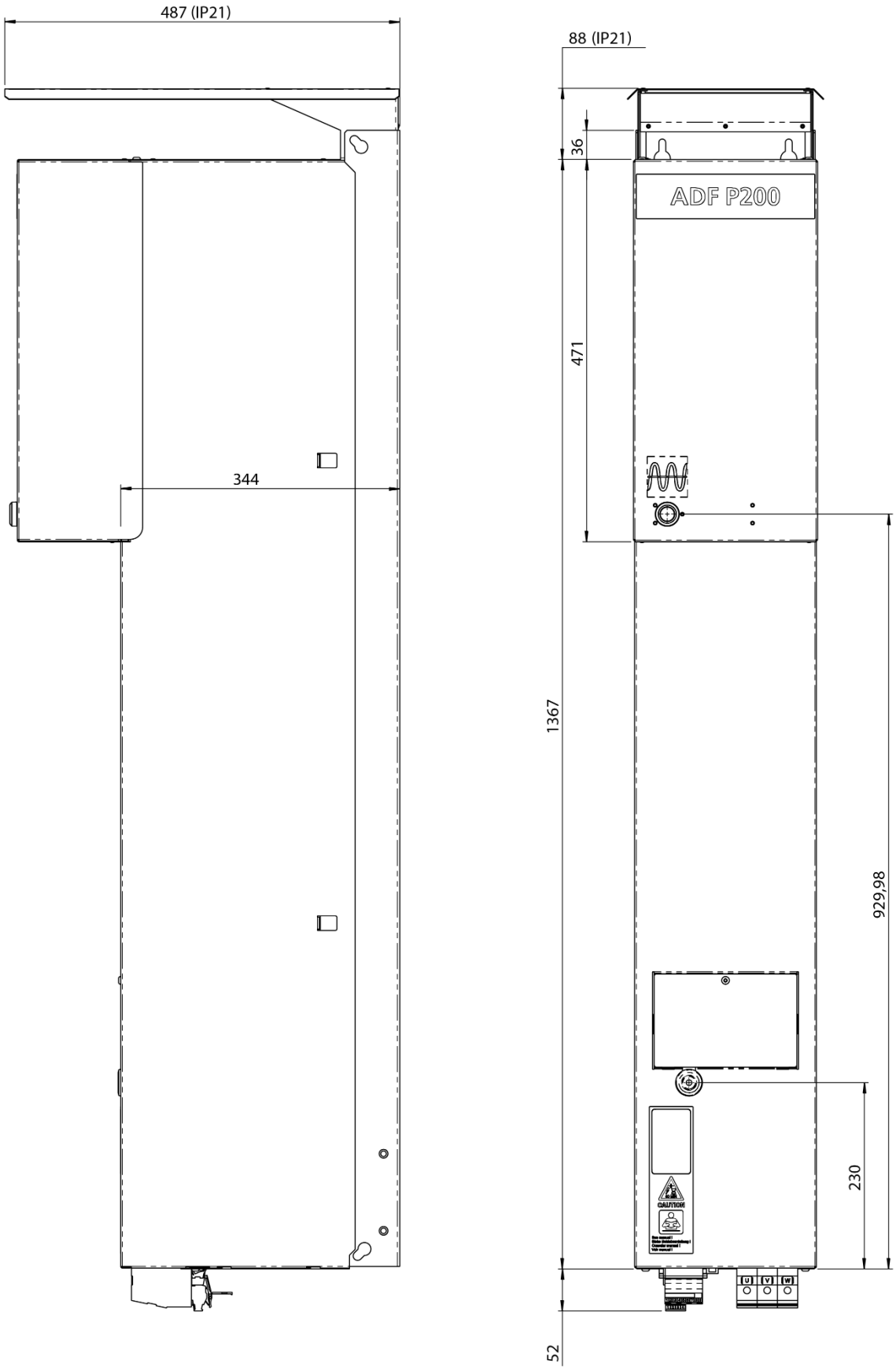

Figure 15: Dimensions ADF P200 (in mm)

Appendix B Compatibility with passive compensation

Capacitor banks are often used in various configurations to lower the reactive power in an installation. It is a recognized problem that the impedance of capacitors falls with rising frequency and hence capacitors act as a sink for harmonics.

It is **not recommended** to use Active Filter units in conjunction with direct connected passive compensation without series reactors. Detuned capacitor banks are easier to integrate with Active Filters.

In all cases, the capacitor bank should be connected prior to the current measurement used for the Active Filter, as illustrated in Figure 16 below. When using the Active Filter in conjunction with detuned capacitor banks, it is strongly recommended to configure the Active Filter for closed loop current measurement.

The passive compensation **must** be placed upstream to the Active Filter.

Note that the Active Filter unit's current transformers (CTs) are placed prior to the load, but after the passive compensation, viewing from the supply side.

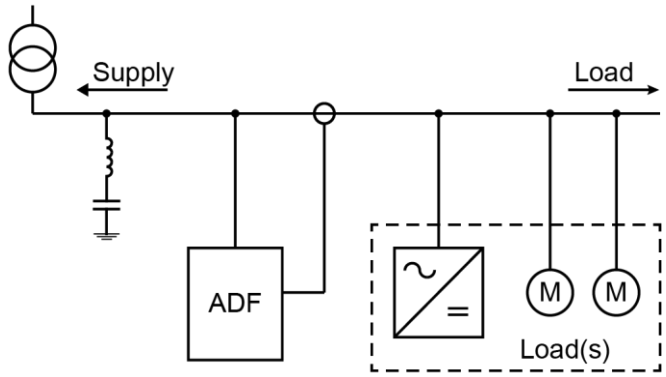

Figure 16: Connection of an Active Filter unit, passive compensation, and location of CTs.

ATTENTION: Failure to observe the orientation guidelines above will significantly shorten the lifetime of the passive compensation, lower the efficiency of both the Active Filter unit and the passive compensation, and may cause unpredictable results.

Appendix C Harmonics derating

The current rating of Active Filter units is specified at the system frequency (50 or 60 Hz). This is sufficient in all normal applications since higher harmonics are lower in amplitude in most cases. For special applications, requiring very high harmonic current in high harmonic orders, special care must be taken. A rating of 120 A_{RMS} does not imply that the unit can output 120 A_{RMS} @ 1250 Hz (25th harmonic in a 50 Hz system).

The following guidelines are useful for determining the maximum allowable higher harmonic current during normal operation of COMSYS Active Filters.

C.1 Single harmonic maximum current

The following guidelines are established for maximum continuous current only when the unit is running at maximum rated ambient temperature. During dynamic operation with lower ambient temperature than the maximally allowed, burst currents may be significantly higher. In the same fashion, in continuous operation at temperatures higher than the maximum allowed, the unit automatically derates the output to not shorten component lifetime.

The following table can be used to determine the maximum individual current, as percentage of the rated maximum compensation current:

Table 22: Maximum current output on single harmonics

h	Output (%)	h	Output (%)	H	Output (%)
1	100 %	19	60 %	37	40 %
3	100 %	21	55 %	39	35 %
5	100 %	23	55 %	41	35 %
7	100 %	25	50 %	43	35 %
9	90 %	27	45 %	45	30 %
11	80 %	29	45 %	47	30 %
13	75 %	31	40 %	49	30 %
15	70 %	33	40 %		
17	65 %	35	40 %		

In the given table, h is the harmonic order. For a unit rated at 120 A_{RMS}, the maximum current of the 23rd harmonic is consequently 66 A_{RMS}.

C.2 Determining the thermal limit

Given that each harmonic current is within the limits outlined above, the total limit of the system as a whole can be determined as follows. First, calculate the individual contribution of each harmonic:

$$I_{h,contrib} = I_h / OUT(\%,h)$$

where h is the harmonic order and Ih is the corresponding current. Finally, add the individual harmonic contributions as a root sum:

$$I_{total} = SQRT(I_{3,contrib}^2 + I_{5,contrib}^2 + \ldots + I_{49,contrib}^2 + I_{reactive,contrib}^2)$$

The answer is the amount of unit current rating needed to be able to compensate the load. Eventual reactive current can be added in the formula above as $I_{reactive,contrib}$.

Example:

A load needs 85 A_{RMS} at the 5th harmonic and 50 A_{RMS} at 7th harmonic. The individual contributions are $I_{5,contrib}$ = 85 A_{RMS} / 100 % = 85 A_{RMS} for fifth harmonic and $I_{7,contrib}$ = 50 A_{RMS} / 100 % = 50 A_{RMS} for the seventh harmonic. The RMS sum of the two components are 98.6 A_{RMS}. Thus, a 100 A unit will be sufficient to compensate the load. Adding an 11th harmonic of 35 A_{RMS} adds an equivalent contribution of 43.8 A_{RMS} yielding a total needed capacity of 107.8 A_{RMS} which will work in an 120 A unit in continuous operation at maximum allowed ambient temperature.

C.3 Summary

In most cases the above guidelines are sufficient to establish the needed Active Filter size to fully compensate the desired harmonics. Since the exact calculations are complex the guidelines established in this document can be considered safe limits.

For detailed calculations or custom solutions, please contact your Comsys ADF supplier.

The formulas and guidelines are valid for all ADF P200 Active Filters systems up to the 49th harmonic.

Appendix D Power derating

D.1 Altitude derating

The current rating of the ADF units is specified up to an altitude of 1000 m / 3281 ft.. At higher altitudes the current rating will be reduced.

When using an ADF P200 on altitudes above 1000 m / 3281 ft, the maximum output will be derated according to the following:

Altitude derating [%] = (h – 1000) / 100 (h = height in meter)

Altitude derating [%] = (h – 3281) / 328 (h = height in feet)

For example, at an altitude of 1500 m, the derating will be 5 %. In this case the compensation capacity of an ADF P200-120/480 will be derated from120 A_{RMS} to 114 A_{RMS}.

D.2 Overtemperature derating

The ADF P200 loses 1.5 % of output current per degree Celsius over 40 °C. At 50 °C, the output current is reduced 15 %.

The system will trip at 55 °C. Temperature derating is automatic and only uses sensors present in the ADF P200 system.

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