ADF P200 User Manual 2.0

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 1000V 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.

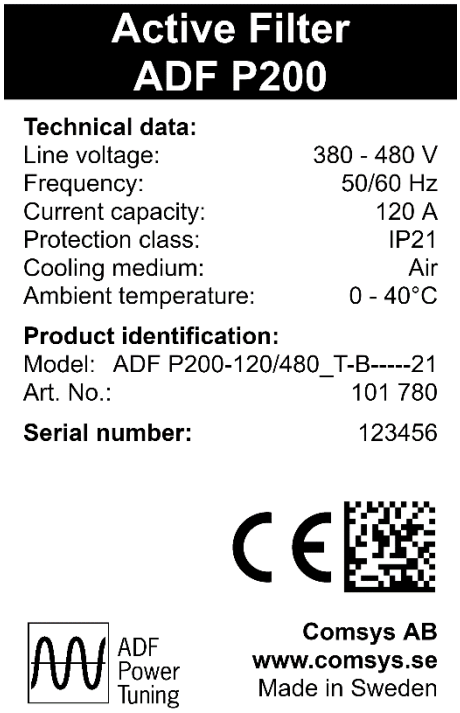
ATTENTION: Before manipulating current transformers, make sure that the secondary is short-circuited. Never open the secondary of a loaded current transformer. You must always wear isolating gloves and eye-protection when working on electrical installations. Also make sure that all local safety regulations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

ATTENTION: Only qualified personnel or other trained personnel who understand the potential hazards involved may make modifications to the product. Any modifications 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 on the front of the cabinet. 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 products

Product Line	Models	Current rating	Voltage
ADF P200 Air cooled, 3 wire	ADF P200-120/4xx	120 A_{RMS}	208 – 480 V

Standards

These products are CE compliant, which means that the products are 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	2012-01-16	ORIGINAL	RELEASED
A1	2012-06-11	REVISED	RELEASED
REV02	2018-06-20	REVISED FOR RELEASE 2.0	RELEASED

Contents

List of figures

List of tables

1 Overview

1.1 Content

This manual describes the user interface and operation modes of the Comsys ADF P200 series of Active Filters. The user can choose to use either the Human Machine Interface (HMI-Basic) interface found at the cabinet door or the Web User Interface (WUI).

The manual assumes knowledge of the ADF P200 products from reading the ADF P200 Hardware Manuals.

ATTENTION: The Hardware Manual must be studied carefully before following the commissioning procedure. It describes the physical installation of the system and how it should be inspected prior to the first start-up.

1.2 Organization of manuals

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

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

In case of system integration, a modified Hardware Manual by the integrator might exist. Otherwise the ADF P200 Hardware Manual (doc no 1 199 178) can be used in combination with this ADF P200 User Manual.

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 Hardware Manual, doc no 1 199 178
- ADF P200 Circuit diagram

1.4 Manual structure

This manual starts out with a brief feature overview of the system described in general terms.

The *Feature Overview* describes the capabilities of the ADF P200 in general.

The *Operation* chapter describes the operating states and principle of the ADF P200.

Next is a description of the *Commissioning procedure*, consisting of an installation inspection, system setup and automated diagnostic tests.

The *Web User Interface* (WUI), also referred to as the *ADF Dashboard*, is then introduced. This is the interface for commissioning, configuration and troubleshooting.

Appendix A describes the *System Settings*.

Appendix B describes the *Error codes*.

Appendix C describes the *Operating principle* of the ADF P200.

2 Feature overview

This section gives an overview of the ADF P200 compensation settings. The settings can be changed using the WUI interface described in later sections of this manual. For an overview of the power principles of the ADF P200 unit, please refer to the overview section in the Hardware Manual.

2.1 General

The ADF P200 has two sets of compensation settings. One Sensorless control set and one Current control set. Typically, only one of the sets is active.

If the compensation power of the system is not enough to fulfill the requested settings, the system will scale down power factor correction and harmonics in equal amounts.

By default, all compensation settings are disabled and should be configured as a part of system commissioning.

2.2 Power Factor Compensation – PFC

The ADF P200 can be configured in static and dynamic PFC mode.

In static mode, the system will produce a fixed amount of reactive power.

In dynamic mode, the system will try to maintain a fixed power factor of 1 in the grid.

2.3 Harmonics

The ADF P200 can be configured to dampen or eliminate either voltage or current harmonics. In voltage mode (sensorless) it is also possible to dampen grid resonances.

When working in sensorless mode the filter perform compensation based only on the grid voltage. Current transformers are therefore not required in this mode.

In current mode the ADF P200 compensate harmonics measured using current transformers.

In both sensorless and current mode, the filter can and will compensate both harmonics and interharmonics.

3 Operation

This section provides an overview of the operating states of the ADF P200.

3.1 Operating states

When the ADF P200 have been turned on the system can be in seven possible states. The possible states and transitions between the states are shown in Figure 1.

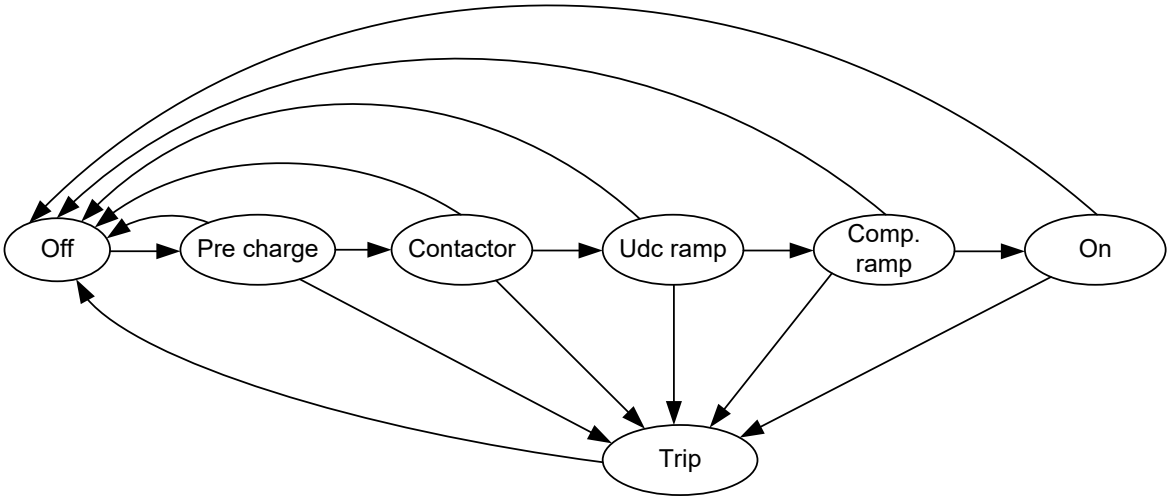


Figure 1: System states

State: Off (0)

This is the initial system state when the system is turned on or when the system has been stopped.

State: Pre charge (1)

In this state the DC-bus is charged to allow the system to start. When the dc-bus is charged the system will automatically move to the next state.

State: Contactor (2)

In this state the main contactor and the capacitor contactor is closed.

State: Udc ramp (3)

In this state the voltage of the DC-bus is ramped to its working level.

State: Compensation ramp (4)

In this state the amount of compensation is increased from zero to the configured level.

State: On (5)

In this state the system is running and is performing the compensation selected by the user.

State: Trip (6)

This is the system error state. If any problems have been detected during any of the other states, the system will jump to this state.

3.2 Automatic restart

The filter trips automatically if certain conditions are met that exhibit a danger for the filters integrity.

The filter enters the trip state immediately after sensing the error condition.

A trip counter is maintained by the filter and is incremented by one when a trip condition is detected. If the trip counter is less than 10 the system will automatically jump to the off state after a wait period of 10 seconds.

After the system has jumped to the off state the system will try to restart using the normal startup sequence. When the trip counter reaches 10, no more restarts will be attempted, and the filter will stay in the trip state until the system is restarted.

When the filter is in the on state the trip counter is decremented by one every minute.

3.3 Starting and stopping

The filter can be started and stopped remotely using Input 1. It is also possible to start and stop the system using the ADF Dashboard described in section 5.

3.3.1 Automatic start

The filter can be configured to automatically start when it is powered on.

4 Commissioning procedure

4.1 First step

Before start of the commissioning, make sure that:

- The electrical supply is disconnected
- AUX transformer is set to the right grid voltage

4.2 Routine inspection

A routine inspection of the unit is required before attempting operation of the ADF P200 for the first time

- Inspect the unit for physical damage.
- Inspect ground connection.
- Inspect mains connection. Verify that all screws are tightened with the correct torque.
- Inspect current transformers (if used). Make sure that the current transformers and the connection to the ADF P200 meets the requirements in the Hardware Manual.
- Inspect the optional error relay connection.
- Inspect the optional start signal connection.
- Inspect the selected fuses.
- Inspect optional fuses or circuit breakers of the mains connection to the ADF P200.
- Inspect the air evacuation of the ADF P200 setup location.
- Ensure that all physical distances are kept.

4.3 Connect electrical supply and check voltage installation

The circuit breaker at the electrical supply should now be closed and the mains connection should be checked. Check that the phase rotation is correct (**L1 → L2 → L3 → L1**) and that the voltage is in the permissible range of 208 - 480V.

4.4 CT installation check (if used)

If current transformers are used, then inspect the connection of the current transformers. Carefully control that the current transformers are connected to the correct phase wise pairs in conjunction with the main power connection.

- Inspect the orientation of the current transformers. S1 should be oriented closest to the supply; S2 should be oriented closest to the load.
- Ensure that the current transformers are connected in open loop configuration.
- Ensure that each CT is individually connected to protective earth, and that all CTs are grounded in the exact same way.
- Inspect the phase rotation of the current transformers.
- Ensure that any short circuit of the secondary of the current transformers has been removed.

4.5 Power up the ADF

When all the previous inspections have been performed successfully the ADF P200 can be powered on by the HMI-Basic with a short click on the button. Power is now supplied to the control computer and it is possible to access the ADF Dashboard described in section 5.

4.6 Perform final system configuration

With the system and installation-specific configuration now verified, it’s time to configure compensation settings. Please see Section 5.4 for instructions.

After everything has been configured, please verify the system performance using a power quality instrument. Adjust the compensation settings if needed. The commissioning is now finished.

5 ADF Dashboard (Web User Interface)

5.1 Introduction

The *ADF Dashboard* is the *Web User Interface* (WUI) of the ADF P200 series.

Through the dashboard it is possible to:

- Start and stop the system
- Commission the system (e.g., changing system setup parameters)
- Change compensation settings (e.g., harmonic compensation, reactive compensation, etc.)
- Change curve settings
- Change system settings (e.g. digital in and out, time/date, TCP/IP networking, etc.)
- Update the software image on the control computer

5.1.1 ADF Dashboard versions

This manual covers ADF P200 software revision 2.0.x. The software revision and build date can be displayed by opening the *About window*.

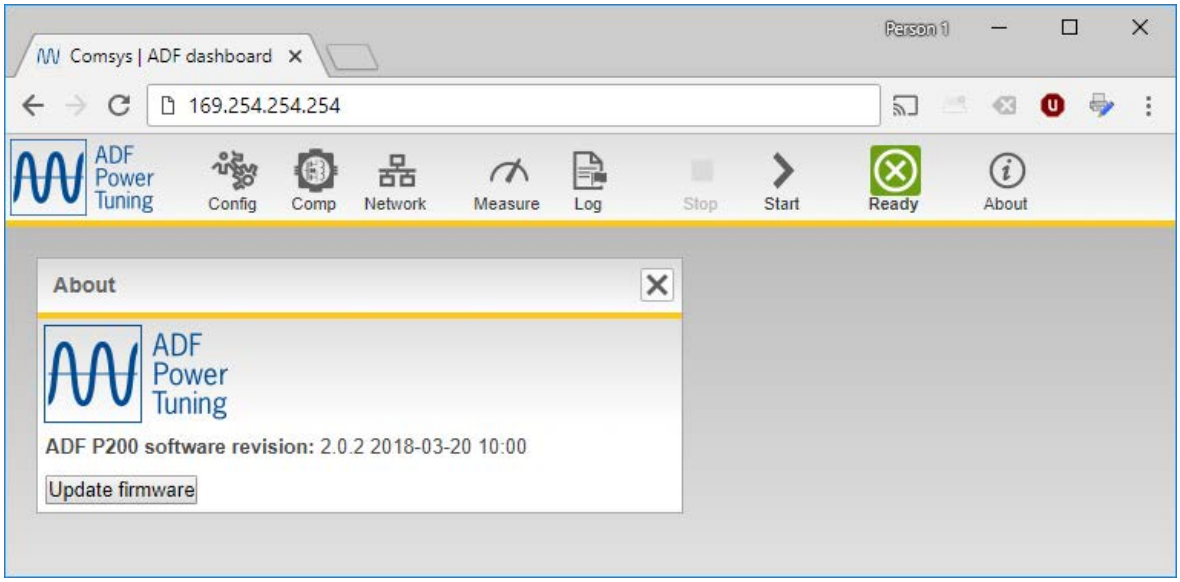


Figure 2: Overview of the ADF Dashboard showing the About window

NOTE When contacting customer support, please note the software revision.

5.1.2 Web browser compatibility

The ADF Dashboard uses advanced functionality and therefore requires a recent web browser such as Google Chrome, Mozilla Firefox or Microsoft Edge.

5.1.3 Connecting to the ADF

The physical connection is made using an ethernet cable. The location of the X21 (LAN) socket in the ADF P200 is shown in Figure 3 below:

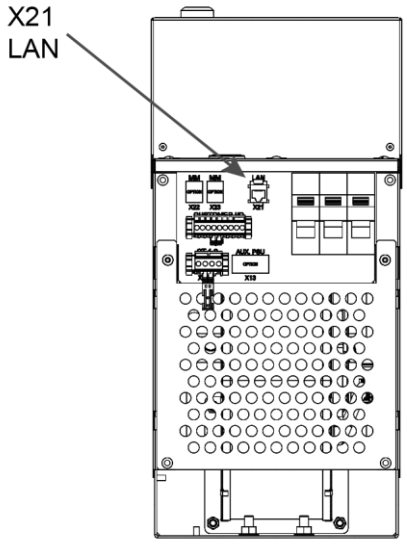


Figure 3: RJ45 socket (X21) on ADF P200 bottom plate

For commissioning and maintenance work it is preferable to connect to the ADF directly from a laptop via an ethernet cable. For permanent supervision, the ADF should be permanently connected to the local area network.

By default, the system is configured to use a Link-local IP address. This makes direct connection to the ADF very simple as it requires no configuration on the client PC. The client PC must be set to obtain an IP address automatically.

Connect the RJ45 cable to the ADF and power up the system using the HMI-B. Now connect the other end of the RJ45 cable to the client PC and open a web browser. Note that the process of address assignment may take up to two minutes. Point the web browser to the default address http://169.254.254.254/ and you will be presented with the web-user-interface.

ATTENTION: Do not connect the Ethernet cable while the system is running or energized. Refer to Hardware Manual on how to prepare the system for maintenance.

ATTENTION: The ADF should under no circumstance be connected directly to the internet. Always connect it behind a firewall to maintain good network security.

NOTE The default network settings are intended for direct connection between ADF and a client PC. The IP address must be changed if the ADF is to be connected to a network.

5.1.4 Default network settings

The default ADF network settings are as follows:

Table 4: Default IP settings

Setting	Default value
Address Mode	Static IP
IP address	169.254.254.254
Subnet Mask	255.255.0.0
Gateway address	0.0.0.0

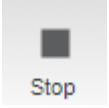
5.2 Overview of the ADF dashboard (WUI)

5.2.1 Toolbar

The main toolbar gives access to all functions in the Dashboard. Settings and measurement buttons open corresponding windows which control settings and overview measurements.

Figure 4: The ADF Dashboard toolbar

Table 5: Toolbar tools

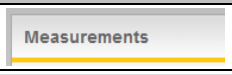
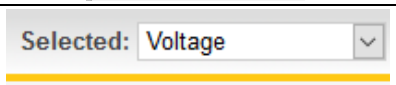
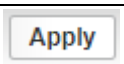
Element	Symbol	Function
Settings group		
Configuration settings		Opens the *Configuration settings window*. This window controls basic settings like time and date, and language.
Compensation settings		Opens the *Compensation settings window*. This window controls the function of the ADF, allowing configuration of the different modes of compensation.
Network settings		Opens the *Network settings window*. The window allows configuration of the TCP/IP.
Monitoring group		
Measure		Opens the *Measurement window*. This window displays measurement data and relay statuses.
Log		Opens the *Log window*. The log window is used to download the trend log in .tar format.
Controls group		
Stop		Stop operation of the ADF. The system will still be on, but not compensating.
Start		Start operation of the ADF. The system will start compensating the load.
Status group		
Status		The system is pre-charging its DC-link.
		The system is stopped and ready to start.
		The system is running.
		The system has tripped on an alarm and is stopped.

About group		
About		Opens the about window. The about window shows the revision and build date of the software currently running on the control computer. From here the software updater can be reached.

5.2.2 Windows

The windows in the *ADF Dashboard* can be moved around like windows on an ordinary desktop operating system.

Table 6: Managing windows

Element	Symbol	Function
Window title		Move window. Click and hold the window title to move the window.
Window drop down menu		Drop down the menu to select the desired view.
Apply		Click the button to apply the settings without closing the window.
OK		Click the button to apply the settings and close the window.
Close window		Click the button to close the window.

ATTENTION: If the ADF is connected to a network where it may be remotely started, the ethernet cable should be unplugged during local operation to prevent unintended remote starts of the system.

5.3 Network settings

The network settings are controlled in the network settings dialog box reached by clicking the 'Network' button on the tool bar of the dashboard. The system allows for configuration of both static IP addresses and dynamic IP addresses.

5.3.1 Default IP settings

The default IP settings are shown in the picture below.

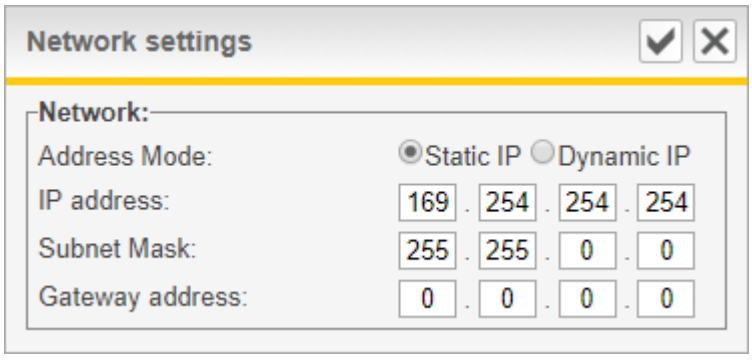


Figure 5: Default network settings in the Network settings window

5.3.2 Setting the IP address manually

By selecting 'Static IP' in the network settings window the system will use a static IP address.

When the system is used in 'Static IP' mode the IP address, subnet mask, broadcast address and gateway address must be entered.

ATTENTION: Be careful not to enter an already used IP address in the dialog box since this will cause trouble accessing the dashboard and the other computer using the same IP address.

Should a taken IP accidentally be entered, disconnect the control computer from the network and connect directly from a laptop to the control computer to change the settings again.

There is no way to recover a wrongly entered IP-address.

5.3.3 Dynamic IP and network settings

By selecting dynamic IP the network settings of the system will be will be configured automatically by querying the local DHCP server.

In this addressing mode it is not possible to change the IP address, subnet mask, broadcast and gateway address settings because the network settings are provided by the local DHCP server.

ATTENTION: When using the dynamic IP address mode of the system the local DHCP server MUST be configured to provide the system with a known address prior to changing the networking settings.

5.4 Configuration using the WUI

5.4.1 Configuration settings

In the configuration settings window it is possible to change the autostart settings, the time and date of the system and the language used in the WUI.

It is important to configure the correct time and date as this information is used in the system log files.

If the language setting is changed the WUI will automatically be reloaded to use the new settings. This process may close currently opened windows.

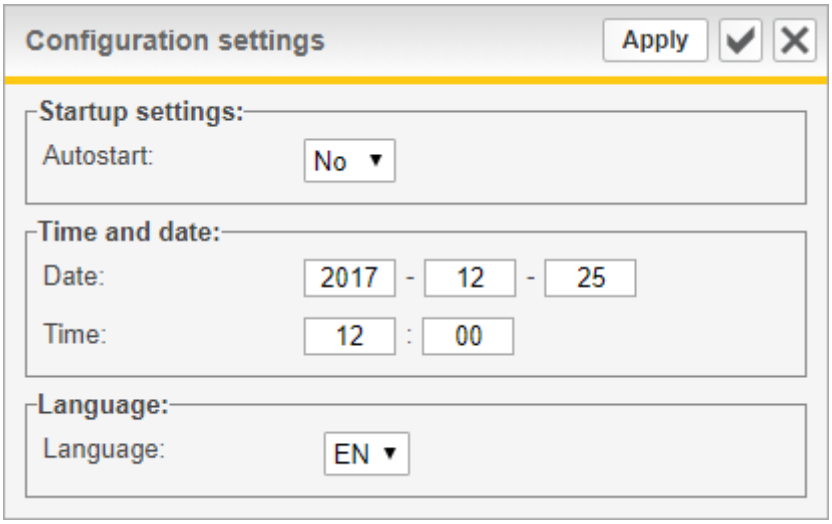


Figure 6: The ADF Dashboard configuration settings window

5.4.2 Compensation settings

In the compensation settings window it is possible to change the ratio of compensation done by the ADF P200.

For compensation of current and voltage harmonics it is possible to select between 0 – 100 % compensation. A value of 0 % means no compensation and a value of 100 % equals full compensation. Note that the value indicates the degree used of the set curve (section 5.5).

For current and voltage harmonics it is also possible to select that the compensation control ratio should be configured using the potentiometers on the control board. The preferred method of changing the current and voltage compensation control ratios it to use the WUI.

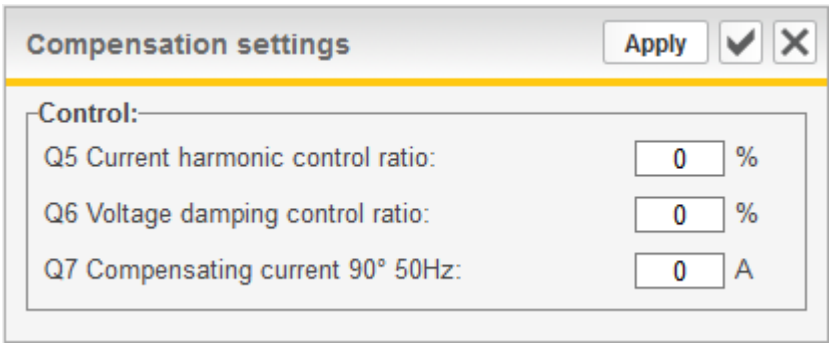


Figure 7: The ADF Dashboard compensation settings window, showing drop down menu

It is also possible to set the amount of static reactive power that the system will produce. It is possible to enter both positive and negative values. Negative values produce inductive reactive power and positive values will produce capacitive reactive power. A setting of -11 A will compensate the reactive power consumed by the internal capacitor in the LC circuit.

5.4.3 Starting and stopping

Starting and stopping the ADF unit is performed by pushing the start or stop button in the tool bar.

5.4.4 Trend log

In the trend log window it is possible to download the trend log saved by the system. The downloaded file is a tar archive that contains one log file for each day the system has been turned on.

The log files contained in the tar archive are standard comma separated values files. These files can be opened in for example Microsoft Excel.

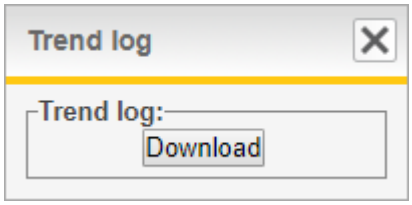


Figure 8: The ADF Dashboard event log window

5.4.5 Measurements

The measurement window shows internal and external measurements done by the system. For a description of the measurements refer to Table 6 in Appendix B.

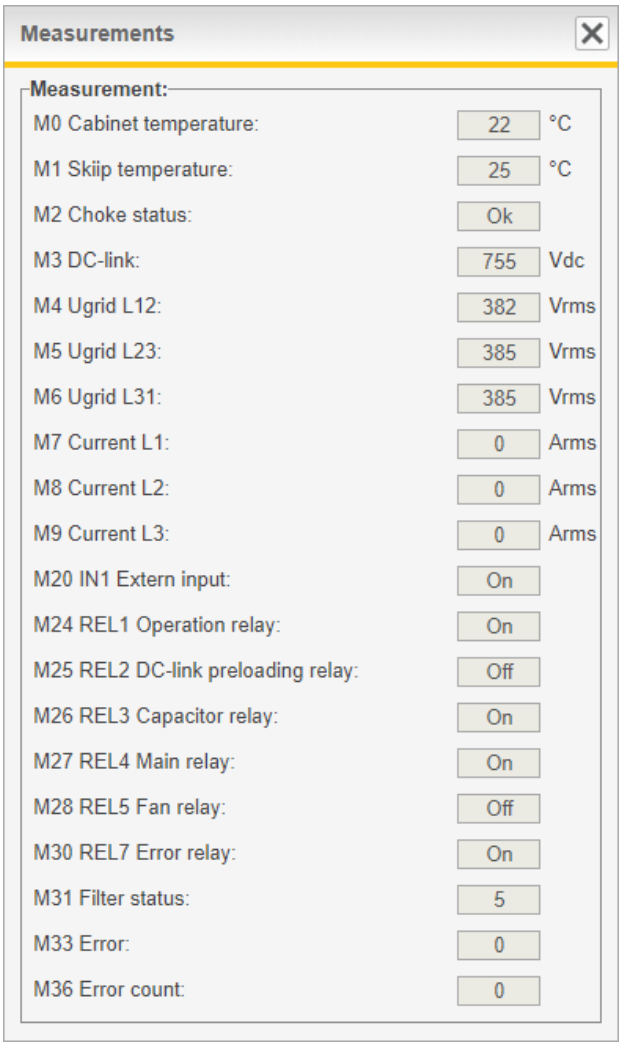


Figure 9: The ADF Dashboard network measurement window

5.5 Curve settings

The compensation settings of the ADF P200 are governed by defining transfer function curves. The curves define the reaction of the ADF P200 in terms of amplitude as function of frequency. Please see Appendix C for further information.

> **ATTENTION:** Changing the curve settings should only be performed by personnel who are proficient in Power Quality and System Theory.

In order to access the settings, the text '#filter' must be added to the URL in the web browser. The figure below demonstrates this:

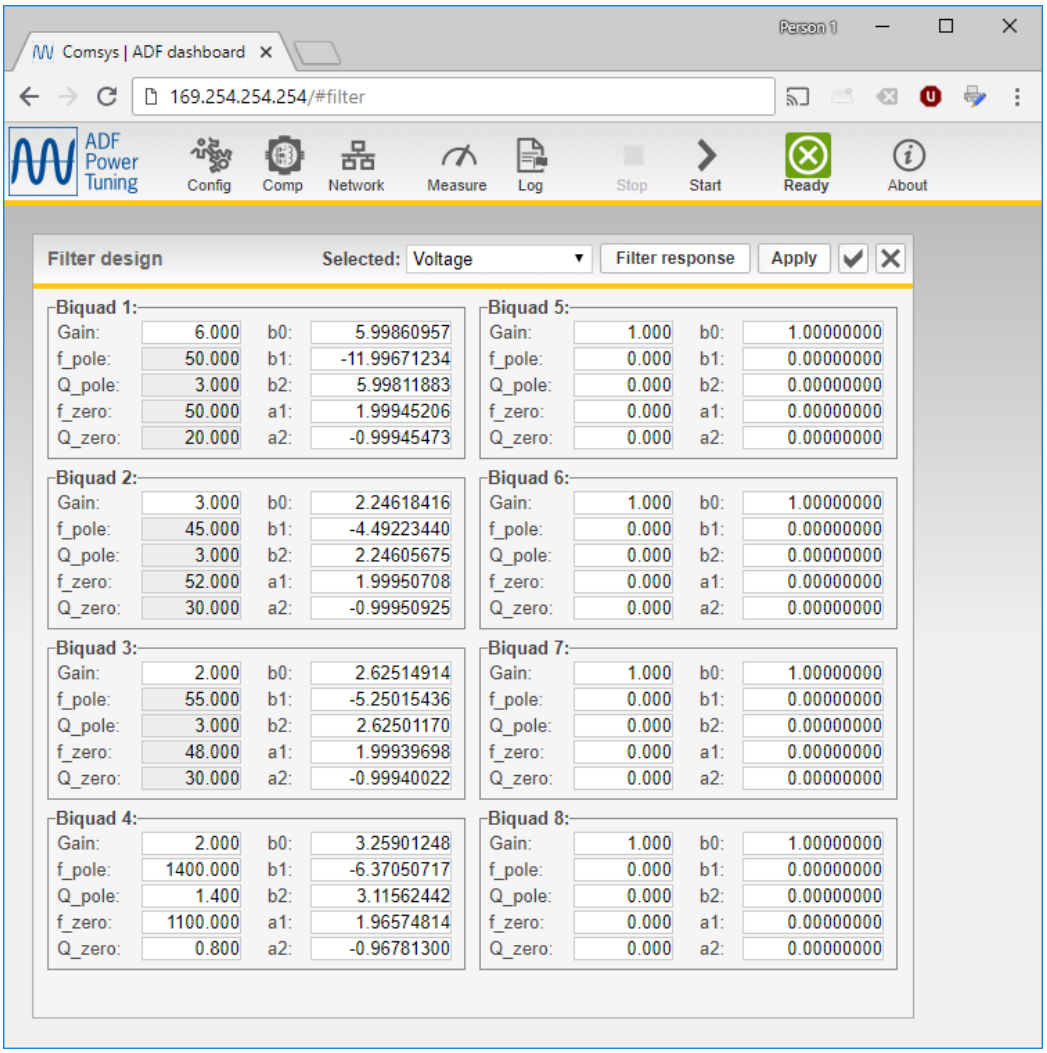


Figure 10: Filter design window

Note the address of 'http://169.254.254.254/#filter'. In some cases, after entering the filter string the web page must be refreshed. The window allows the user to edit the filter curve. Use the pull-down menu to select if the voltage or the current curve is edited:

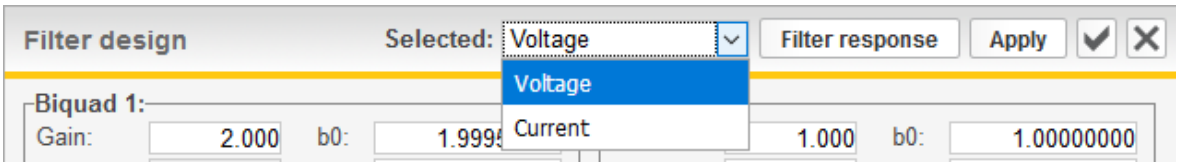


Figure 11: Selecting which curve to edit

In order to edit the curve, add poles and zeros (defining the biquads). In the dialog box crop shown below, the Gain, pole frequency, pole Q, zero frequency, and zero Q can be edited. The coefficients b_0, b_1, b_2, a_1 and a_2 are calculated.

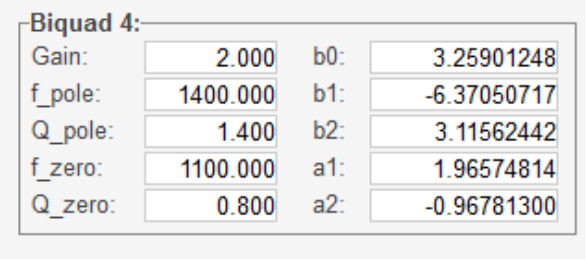


Figure 12: Defining a biquad

The figure above shows editing one biquad. All five values (Gain, f_pole, Q_pole, f_zero, Q_zero) must be entered to define one biquad. Further, for sensorless control, biquads 1-3 are predefined and cannot be changed as they define the notch function keeping the filter from compensating the fundamental frequency.

In order to preview the curve, click on 'Filter Response' in the window bar to toggle the view.

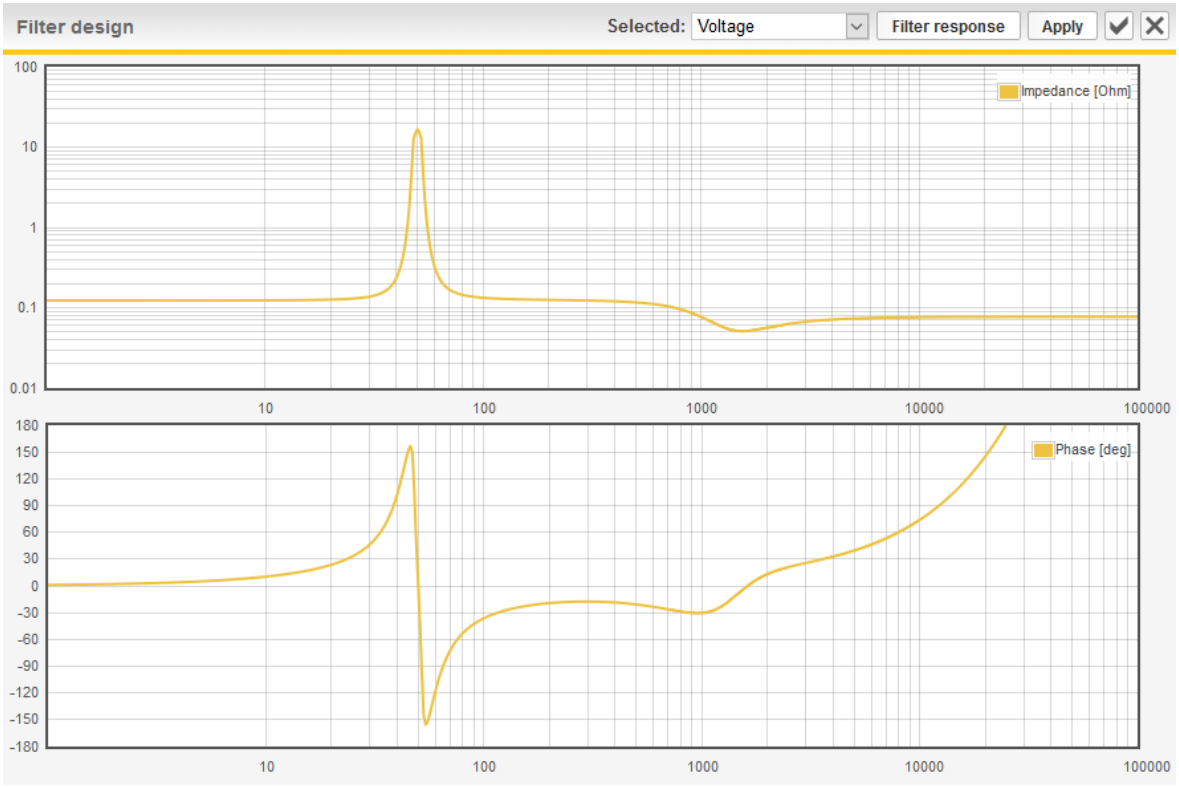


Figure 13 Transfer function example

The figure above shows the resulting transfer function for sensorless control from inserting the poles and zeros from the previous figure. This transfer function will not interact strongly with 5th and 7th harmonic (250 Hz and 350 Hz, respectively, in a 50 Hz grid), but will strongly dampen a resonance or harmonic behaviors around 1250 Hz (the dip in the impedance magnitude curve).

Holding the mouse of the curve will reveal detailed data:

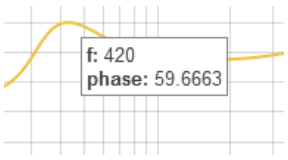


Figure 14: Curve mouseover function

The curve settings for current work in a similar way. The total current outputted at a certain frequency is a result of the curve, the network disturbance and the values Q5 (for current control) and Q6 (for sensorless control) in the compensation settings dialog box.

ATTENTION: In general, keeping phase shift within +-30 degrees will make the system stable.

System must be fine-tuned using a measurement instrument.

5.6 Advanced functions

5.6.1 Updating the ADF software

The ADF software can be upgraded via the WUI. The uploaded software image is checked against a checksum in order to prevent software binaries with error to be programmed in to the flash memory.

ATTENTION: Updating the ADF software will also reset all system settings to their default value. This includes compensation settings and network settings.

The software programmer is reached by clicking ‘Update firmware’ in the About window.

1. Click ‘Browse’ in the Software updater dialog box.

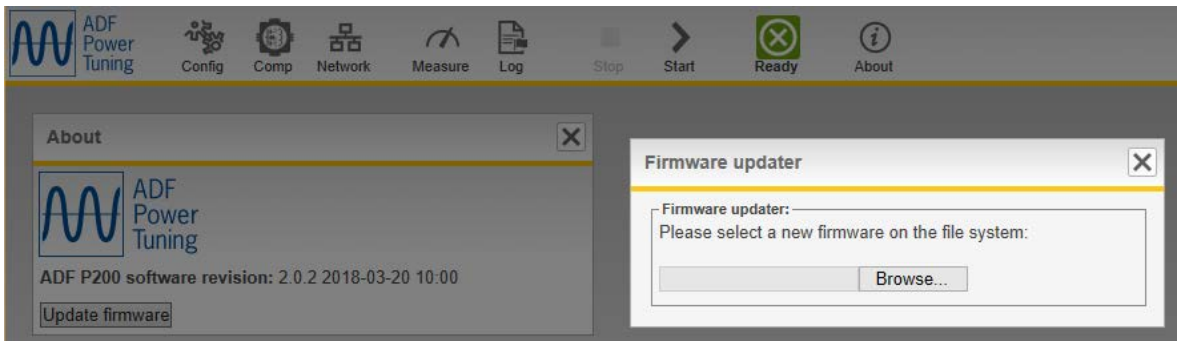


Figure 15: Software upgrade step 1

2. Navigate to the appropriate software image file supplied by Comsys.

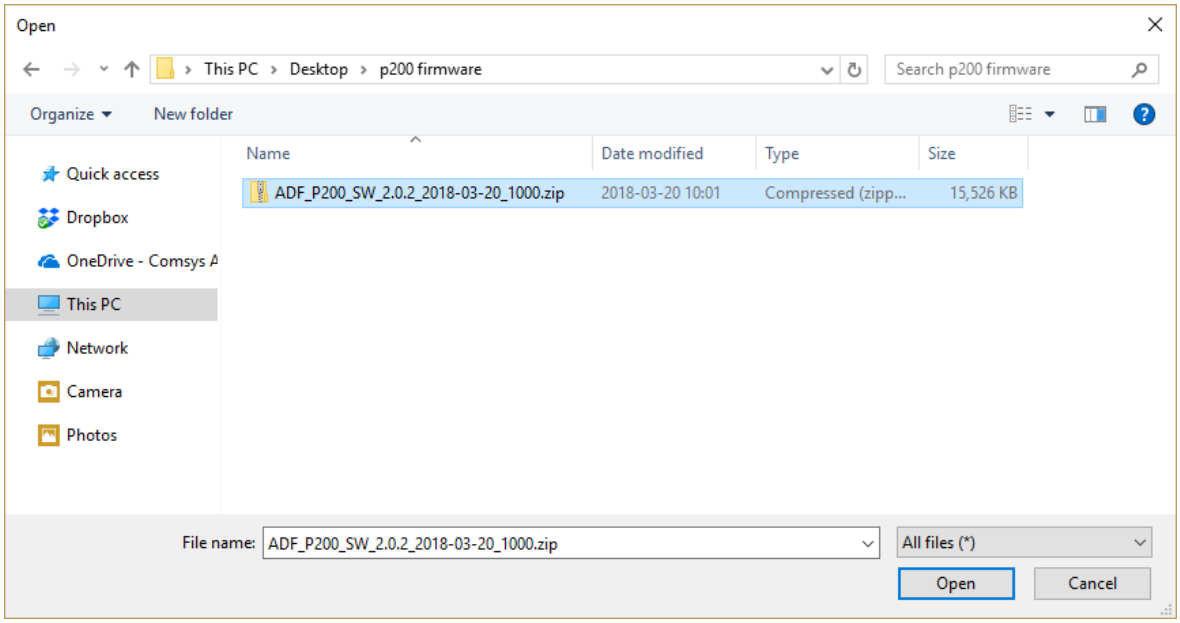


Figure 16: Software upgrade step 2

Click the open button to start the upload and firmware validation.

3. Wait for the firmware upload to finish

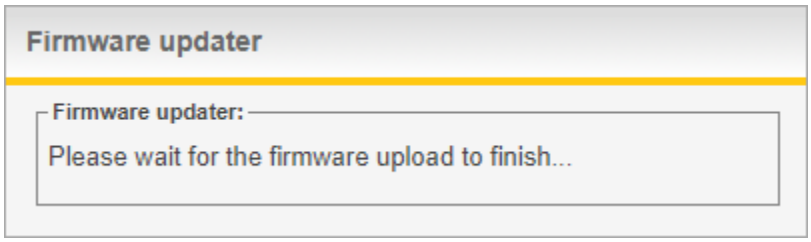


Figure 17: Software upgrade step 3

It takes approximately one minute for the upload and firmware validation to finish. Do not close the browser during this time.

3. Click 'Start update' to start the update.

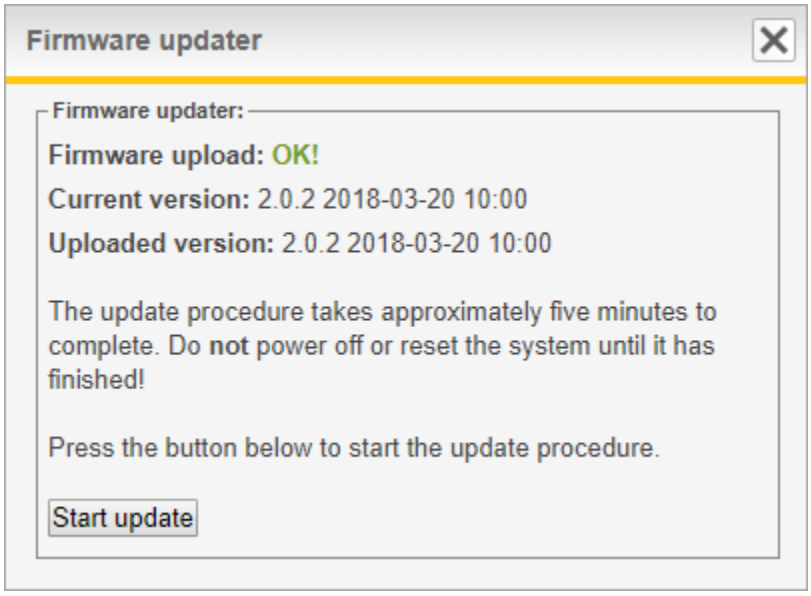


Figure 18: Software upgrade step 4

4. Wait for firmware update to finish.

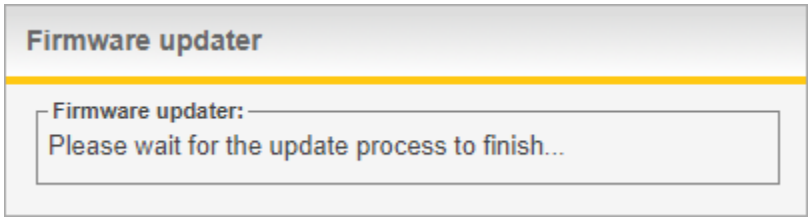


Figure 19: Software upgrade step 5

NOTE	Should contact with the ADF Dashboard be lost during the flashing procedure, wait 10 minutes and then restart the ADF.

5. Finish the flash procedure by reload the WUI.

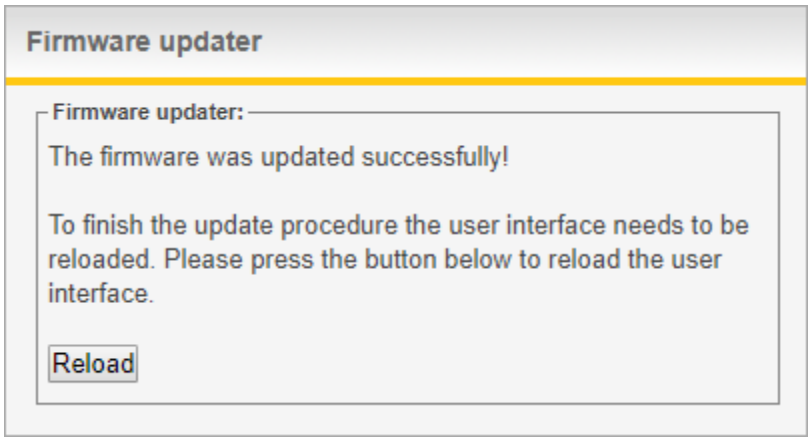


Figure 20: Software upgrade step 6

ATTENTION: It is imperative that the software image used is an approved Comsys software image suitable for the application at hand.

Using any other software image may cause malfunction and risk for the equipment as well as for personnel.

Warranty is void if non-official software images are used.

Appendix A System settings

Table 7: Configuration settings window

Parameter	Default	Description
Autostart	No	Enable/Disable the auto start function at system power on **No**: Autostart disabled **Yes**:Autostart enabled
Date	2000-01-01	ADF system date
Time	00:00	ADF system time
Language	EN	ADF Dashboard display language **EN**: English **DE**: German

Table 8: Compensation settings window

Parameter	Default	Description
Q5 Current harmonic control ratio	0 %	Degree of compensation of current harmonics **0%**: No compensation **100%**: Full compensation
Q6 Voltage damping control ratio	0 %	Degree of compensation of voltage harmonics **0%**: No compensation **100%**: Full compensation
Q7 Compensating current 90° 50Hz	0 A	Amount of static reactive current. Negative values correspond to an inductive current and positive values correspond to a capacitive current.

Table 9: Network settings window

Parameter	Default	Description
Address Mode	Static	Method used to acquire the network configuration settings. **Dynamic**: ADF will query the local DHCP server for network settings. **Static**: The system uses the network configuration settings entered in the networking window.
IP address	169.254.254.254	IP address used by the system when static address mode is used.
Subnet Mask	255.255.0.0	Subnet mask used by the system when static address mode is used
Gateway address	0.0.0.0	Gateway address used by the system when static address mode is used. This setting is currently not required.

Table 8 –Measurement window

Parameter	Description
M0 Cabinet temperature	Cabinet temperature measured as by the control computer
M1 Skiip temperature	Temperature of the semiconductor in the power processor
M2 Choke status	Temperature status of the main inductors
M3 DC-link	DC-link voltage
M4 Ugrid L12	Voltage between L1 and L2
M5 Ugrid L23	Voltage between L2 and L3
M6 Ugrid L31	Voltage between L3 and L1
M7 Current L1	ADF output current L1
M8 Current L2	ADF output current L2
M9 Current L3	ADF output current L3
M20 IN2 Extern input	Status of external run input
M24 REL1 Operation relay	Status of on signal
M25 REL2 DC-link preloading relay	Status of DC-link preloading relay
M26 REL3 Capacitor relay	Status of the AC capacitor relay
M27 REL4 Main relay	Status of main contactor relay
M28 REL5 Fan relay	Status of relay controlling the fan
M30 REL7 Error relay	Status of error output relay
M31 Filter status	Operating state of the ADF P200
M33 Error	System error code (see Appendix B)
M36 Error count	Current value of the system error counter

Appendix B Error codes

Table 10: Error codes

Code	State	Description
1	Pre charge	SKiiP over temperature
2	Pre charge	Cabinet over temperature
3	Pre charge	Choke over temperature
4	Pre charge	SKiiP error
5	Pre charge	DC-bus overvoltage
7	Pre charge	DC-bus precharging timeout
8	Contactor	SKiiP over temperature
9	Contactor	Cabinet over temperature
10	Contactor	Choke over temperature
11	Contactor	SKiiP error
12	Contactor	DC-bus overvoltage
13	Contactor	Timeout closing main relay
14	Udc ramp	SKiiP over temperature
15	Udc ramp	Cabinet over temperature
16	Udc ramp	Choke over temperature
17	Udc ramp	SKiiP error
18	Udc ramp	DC-bus overvoltage
19	Comp. ramp	SKiiP over temperature
20	Comp. ramp	Cabinet over temperature
21	Comp. ramp	Choke over temperature
22	Comp. ramp	SKiiP error
23	Comp. ramp	DC-bus overvoltage
24	Comp. ramp	DC-bus undervoltage
25	On	SKiiP over temperature
26	On	Cabinet over temperature
27	On	Choke over temperature
28	On	SKiiP error
29	On	DC-bus overvoltage
30	On	DC-bus undervoltage

Appendix C Operating principle

This appendix describes the operating principle of the ADF P200. The curve settings defines the transfer function of a set of 8 cascaded biquad filters. A separate curve can be defined for sensorless control and for current control simultaneously. Each biquad has the following transfer function:

$$H(z) = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2}}{1 + a_1 z^{-1} + a_2 z^{-2}}$$

Figure 21: Biquad transfer function

The global transfer function will define how the system compensates problems in the grid. In the figure below, a typical compensation curve is shown. Note that the notch at 50 Hz is mandatory in sensorless control, as the filter would otherwise try to compensate the fundamental frequency.

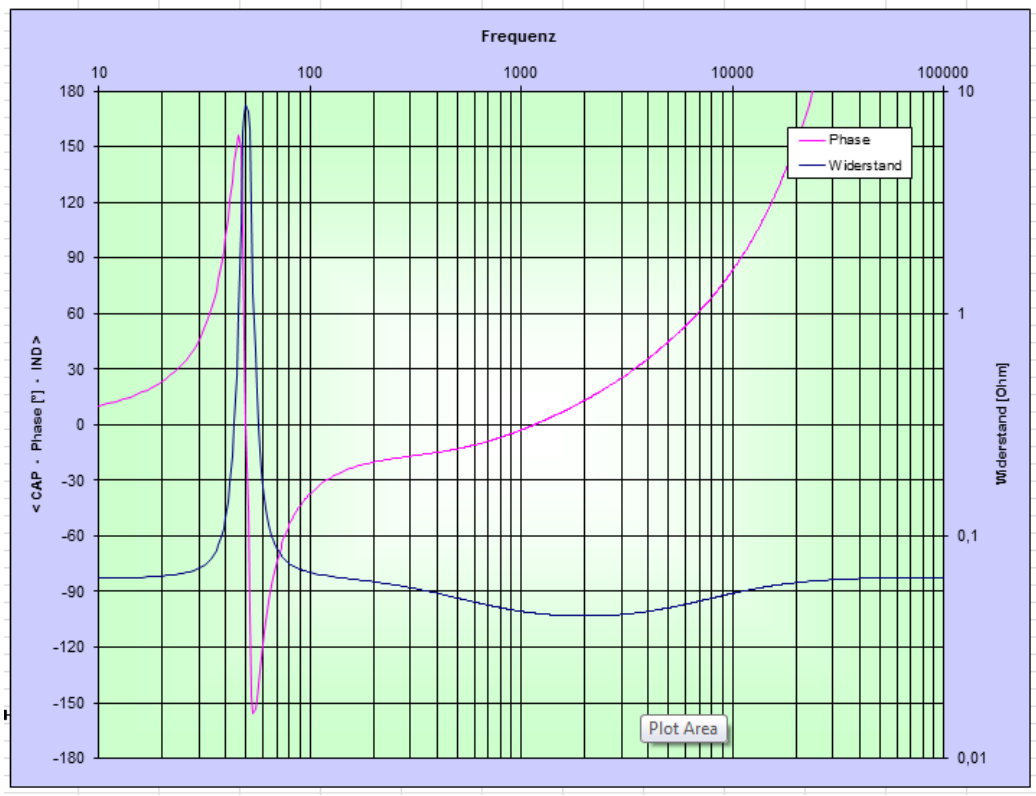


Figure 22: Typical sensorless response curve

For sensorless control, compensation current will be defined as I_{ADF} = Z*V, where Z is the complex transfer function impedance. For current control, the similar function is I_{ADF} = K*I_{NET}, where K is the transfer function for the current control. Note that the K curve is unit-less and normalized to a CT ration of 800/1.

Use the WUI to define the transfer functions. Note that the phase shift must be kept under control in order to keep the system stable during compensation.

For each biquad, take care to not put in too extreme values, as the coefficients will be out of range. For example, if higher amplification is needed, increase several of the gain values (in individual biquads).

The following guidelines should be followed:

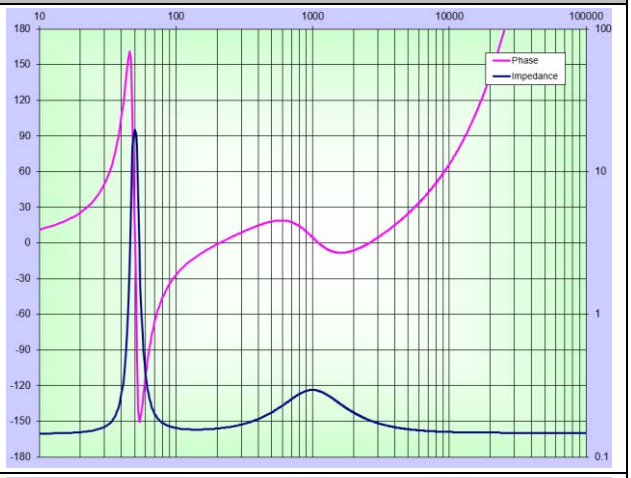
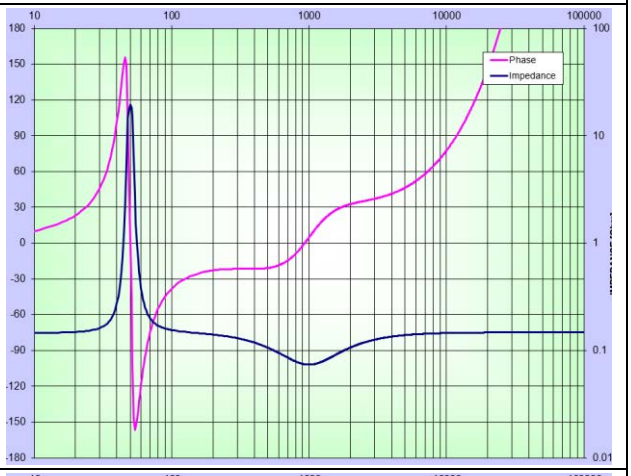
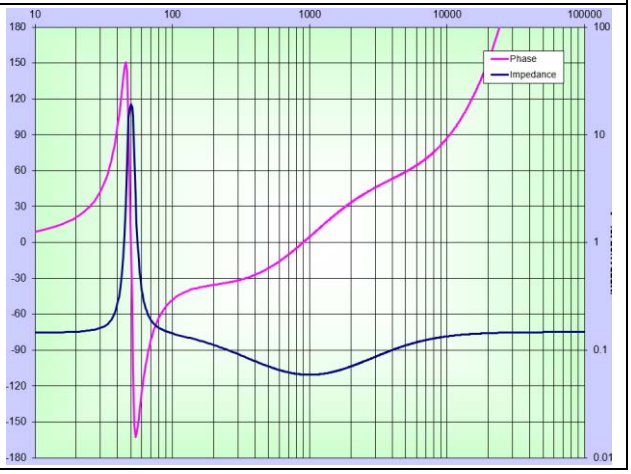
In general, the minimum impedance value that gives stable operation is between 20 – 40 mΩ. This value is dependent on both application and grid. In addition to this, in the area where the filter is actively working (the pass band), the impedance value should stay within ±30 degrees. In the example above, 30 degrees is passed at approximately 3.5 kHz.

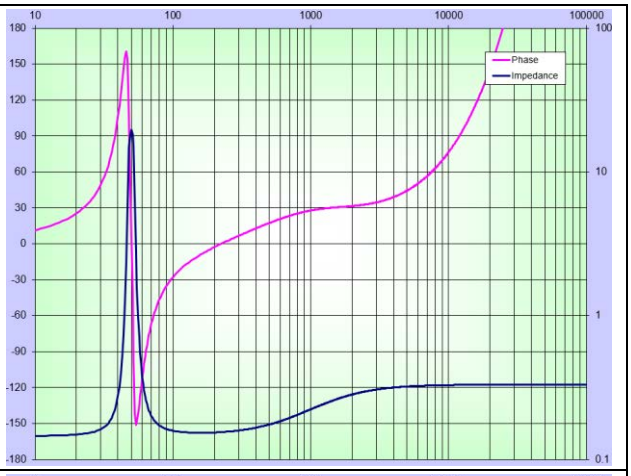
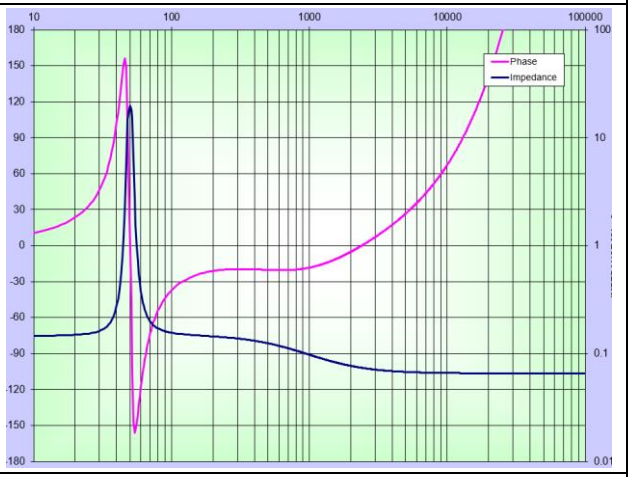
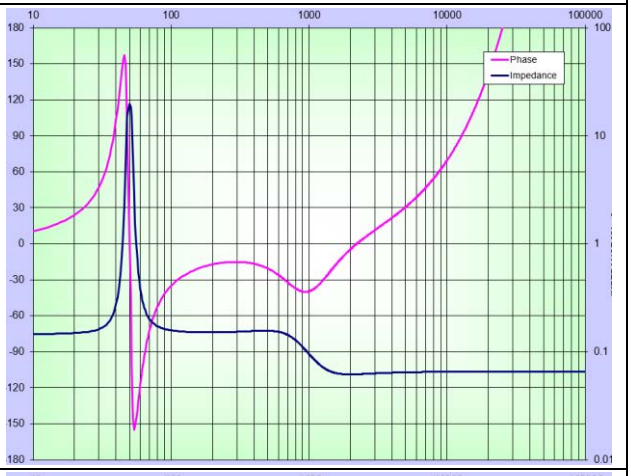
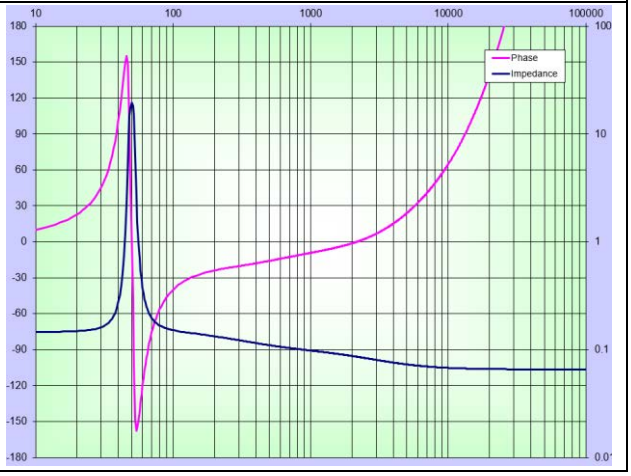
Due to the nature of the operation of the filter, a flat (default) curve will automatically compensate resonances the most as these occur at the frequencies with maximum impedance magnitude, and the change in impedance will be the highest where the ratio $\frac{Z_{grid}}{Z_{ADF}}$ is the highest. Due to this, in sensorless operation, the lower the impedance, the higher the damping.

For each biquad, the pole frequency determines when the curve bends up with increasing frequency, and the zero determines when the curve bends down. The Q value will determine the behavious of the knee/dip/peak: a low q-value gives a wideband response with a low change in amplitude, while a high Q-value gives a narrow-band response with a large change in amplitude.

The following table investigates this systematically in a couple of examples. In all examples below, the blue is the magnitude, and the purple is the phase shift.

Table 11: Sensorless response curve examples

Parameters	Graph
f_{pole} = 1000 Q_{pole} = 0.5 f_{zero} = 1000 Q_{zero} = 1 Frequency is the same. Q value of pole is higher than zero, so the impedance is higher, providing *less* damping at 1000 Hz.	
f_{pole} = 1000 Q_{pole} = 1 f_{zero} = 1000 Q_{zero} = 0.5 Inverting position of Q-values inverts graph – now the damping is *higher* at 1000 Hz as the impedance magnitude is lower.	
f_{pole} = 1000 Q_{pole} = 0.5 f_{zero} = 1000 Q_{zero} = 0.2 Lowering both Q-values provides a more wide-band response.	

f_{pole} = 800 Q_{pole} = 0.5 f_{zero} = 1200 Q_{zero} = 0.5 In this example, Q-values are identical, but the pole frequency is lower than the zero frequency. This provides a positive step with rising frequency. This is useful for reducing damping at high frequencies.	
f_{pole} = 1200 Q_{pole} = 0.5 f_{zero} = 800 Q_{zero} = 0.5 Reversing the positions of the frequencies, with the zero at a lower frequency of than the pole, reverses the direction of the step. This increase damping at higher frequencies.	
f_{pole} = 1200 Q_{pole} = 1 f_{zero} = 800 Q_{zero} = 1 From the example above, increasing Q-values makes the transition sharper. Note that the phase shift now exceeds -30 degrees in the transition area. This might lead to an unstable behavior.	
f_{pole} = 1200 Q_{pole} = 0.3 f_{zero} = 800 Q_{zero} = 0.3 Finally, instead reducing the Q-values give a very slowly changing slope with a corresponding flat phase shift response.	

Comsys AB
Fältspatvägen 4
SE-224 78 LUND
Sweden

+46 10 209 68 00
info@comsys.se
adfpowertuning.com

Partner: