ACS 1000
medium-voltage drives
for speed and torque control of
315 to 5000 kW / 400 to 6700 hp
squirrel cage induction motors

Technical Catalog

61449744

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Table of Contents

Chapter 1 - Overview

Introduction

This Technical Catalog describes the main electrical, mechanical and environmental features of the ACS 1000 – a new type of medium-voltage AC drive. In addition, the Catalog looks at the various options available for the drive and offers advice on selecting a motor and drive combination. It also provides useful installation tips.

The Standard Solution

The ACS 1000 is a standard, medium-voltage AC drive, rated from 315 to 5000 kW (400 to 6700 hp) for motor voltages 2.3, 3.3 and 4.0 kV.

The drive has been designed as a standard product rather than an engineered drive. It is, therefore, a core product from ABB, forming part of the company's ACS family. As such, the drive uses standard components, software tools and design principles as employed in the low voltage ACS range. This vastly increases the reliability of the drive and offers users a consistent addition to the extensive ACS product portfolio.

As a standard solution the ACS 1000 has many of the benefits associated with engineered drives built-in. This meets the most common system specifications with minimal engineering. In addition, because the drive is pre-engineered, shorter delivery times to end-users are possible.

About 85% of all medium-voltage drives are applied in standard applications such as fans, pumps, conveyors and compressors, where the customized engineering content is minimal. The ACS 1000 is ideally suitable for retrofit applications, where only a small portion of the world's motors are fitted with drives.

Industries, which can benefit from this approach, include petrochemicals, mining, water, pulp & paper, cement and power generation.

Key Technology

Two main technology features distinguish the ACS 1000 from other types in the market. Firstly, the motor control platform is based on Direct Torque Control (DTC) which achieves the ultimate torque and speed performance.

DTC allows the speed of any standard squirrel cage induction motor to be controlled without the need for expensive and delicate encoders or tachogenerator feedback devices.

Secondly, and for the first time in any AC drive, a new power semiconductor switching device is utilized. Known as IGCT (Insulated Gate Commutated Thyristor), the device provides an intrinsically less complex, more efficient, and reliable drive. This is achieved by fast switching and inherently low losses which mean less cooling equipment is needed.

IGCTs do not require snubbers and allow power bridge implementation with fewer power devices than conventional medium-voltage drives. While reliability is improved, the physical size of the ACS 1000 is compact.

Technical Benefits

The technology described above brings many more practical benefits to the ACS 1000, as described within this Catalog.

For instance, the use of IGCTs together with active feedback control of an LC filter results in a sinusoidal output voltage. This proves useful in retrofit applications, as the drive is compatible with existing squirrel cage motors without the need to derate. There are no undue voltage rises stressing the motor insulation and voltage reflections are eliminated on long cable runs.

Meanwhile, DTC avoids any torque pulsations, which can be damaging to loads and their associated mechanical connections.

The ACS 1000 is available for use with a separately mounted input isolation transformer (standard) or alternatively with an integrated dry-type transformer for air-cooled versions. This provides installation flexibility and allows for the use of oil filled transformers which are typically mounted outdoors.

The ACS 1000 meets all common standards including IEC, EN, NEMA, ANSI, UL, CSA, VDE and BS. In addition, ABB has undertaken much development work to ensure that the 12-pulse configuration adequately meets the requirements of the world's harmonics standards, such as IEEE 519-1992.

The ACS 1000 features a selection of pre-programmed application macros for configuration of inputs, outputs, signal processing and other parameters. The macros conform to those used by the low voltage ACS range.

2.3 kV Motors

Drives rated 2.3 kV have output ratings based on horsepower. Equivalent kilowatt ratings are approximate and are listed for reference only.

Table 2-1 ACS 1000 ratings for 2.3 kV motors, 60 Hz and 50 Hz supply

Motor Voltage (kV)	ACS 1000 Type	Type of Cooling	Max. Cont. Power (kVA) of ACS 1000	Motor Power** (HP) (rated)	Motor Power** (kW) (equivalent)	Rated Output Current (A)	Frame Size
2.3	ACS1012-A1-A0-00	Air	400	400	_	100	A1
2.3	ACS1012-A1-B0-00	Air	400	450	315	100	A1
2.3	ACS1012-A1-C0-00	Air	450	500	355	113	A1
2.3	ACS1012-A1-D0-00	Air	550	600	450	138	A1
2.3	ACS1012-A1-E0-00	Air	650	700	500	163	A1
2.3	ACS1012-A1-F0-00	Air	750	800	560	188	A1
2.3	ACS1012-A1-G0-00	Air	800	900	630	201	A1
2.3	ACS1012-A1-H0-00	Air	900	1000	710	226	A1
2.3	ACS1012-A2-J0-00	Air	1150	1250	900	289	A2
2.3	ACS1012-A2-K0-00	Air	1350	1500	1120	339	A2
2.3	ACS1012-A3-L0-00	Air	1550	1750	1250	389	A3
2.3	ACS1012-A3-M0-00	Air	1800	2000	1400	452	A3
2.3	ACS1012-A3-N0-00	Air	2000	2250	1600	502	A3
2.3	ACS1012-W1-P0-00	Water	2300	2500	1800	577	W1
2.3	ACS1012-W1-Q0-00	Water	2700	3000	2250	678	W1
2.3	ACS1012-W2-R0-00	Water	3100	3500	2500	778	W2
2.3	ACS1012-W2-S0-00	Water	3600	4000	2800	904	W2

** *The power ratings apply to typical 4 pole motors. For those motors the frequency converter has a built-in overloadability of 10%. When selecting the frequency converter it should be observed that the rated current of the ACS 1000 must be higher than or equal to the rated motor current in order to achieve the rated motor power given in the table.*

***Note**: The load capacity (current and power) decreases if the installation site altitude exceeds 2000 m above sea level (6600 ft.), or if the ambient temperature exceeds 40 °C (104 °F) (units with enclosure class IP21), or, in the case of water cooled units, if the cooling water temperature exceeds 27 °C (81 °F). For the derating factors, see Appendix B - Technical Data.*

3.3 kV Motors

Drives rated 3.3 kV have output ratings based on kilowatts. Equivalent horsepower ratings are approximate and are listed for reference only.

Table 2-2 ACS 1000 ratings for 3.3 kV motors, 50 Hz and 60 Hz supply

Motor Voltage (kV)	ACS 1000 Type	Type of Cooling	Max. Cont. Power (kVA) of ACS 1000	Motor Power** (kW) (rated)	Motor Power** (HP) (equivalent)	Rated Output Current (A)	Frame Size
3.3	ACS1013-A1-A0-00	Air	400	315	450	70	A1
3.3	ACS1013-A1-B0-00	Air	450	355	500	79	A1
3.3	ACS1013-A1-C0-00	Air	500	400	550	87	A1
3.3	ACS1013-A1-D0-00	Air	550	450	600	96	A1
3.3	ACS1013-A1-E0-00	Air	600	500	700	105	A1
3.3	ACS1013-A1-F0-00	Air	700	560	750	122	A1
3.3	ACS1013-A1-G0-00	Air	750	630	800	131	A1
3.3	ACS1013-A1-H0-00	Air	850	710	900	149	A1
3.3	ACS1013-A2-J0-00	Air	950	800	1000	166	A2
3.3	ACS1013-A2-K0-00	Air	1100	900	1250	192	A2
3.3	ACS1013-A2-L0-00	Air	1200	1000	1350	210	A2
3.3	ACS1013-A2-M0-00	Air	1350	1120	1500	236	A2
3.3	ACS1013-A2-N0-00	Air	1500	1250	1650	262	A2
3.3	ACS1013-A2-P0-00	Air	1700	1400	1750	297	A2
3.3	ACS1013-A3-Q0-00	Air	1900	1600	2000	332	A3
3.3	ACS1013-A3-R0-00	Air	2150	1800	2250	376	A3
3.3	ACS1013-W1-S0-00	Water	2400	2000	2500	420	W1
3.3	ACS1013-W1-T0-00	Water	2700	2250	3000	472	W1
3.3	ACS1013-W1-U0-00	Water	3000	2500	3350	525	W1
3.3	ACS1013-W2-V0-00	Water	3350	2800	3500	586	W2
3.3	ACS1013-W2-W0-00	Water	3750	3150	4000	656	W2
3.3	ACS1013-W2-X0-00	Water	4250	3550	4500	744	W2
3.3	ACS1013-W2-Y0-00	Water	4750	4000	5000	831	W2
3.3	ACS1013-W3-Z0-00	Water	5350	4500	6000	936	W3
3.3	ACS1013-W3-10-00	Water	5950	5000	6700	1041	W3

*** The power ratings apply to typical 4 pole motors. For those motors the frequency converter has a built-in overloadability of 10%. When selecting the frequency converter it should be observed that the rated current of the ACS 1000 must be higher than or equal to the rated motor current in order to achieve the rated motor power given in the table.*

***Note**: The load capacity (current and power) decreases if the installation site altitude exceeds 2000 m above sea level (6600 ft.), or if the ambient temperature exceeds 40 °C (104 °F) (units with enclosure class IP21), or, in the case of water cooled units, if the cooling water temperature exceeds 27 °C (81 °F). For the derating factors, see Appendix B - Technical Data.*

4.0 kV Motors

Drives rated 4.0 kV have output ratings based on horsepower. Equivalent kilowatt ratings are approximate and are listed for reference only.

Table 2-3 ACS 1000 ratings for 4.0 kV motors, 60 Hz and 50 Hz supply

Motor Voltage (kV)	ACS 1000 Type	Type of Cooling	Max. Cont. Power (kVA) of ACS 1000	Motor Power** (HP) (rated)	Motor Power** (kW) (equivalent)	Rated Output Current (A)	Frame Size
4.0	ACS1014-A1-A0-00	Air	400	400	_	58	A1
4.0	ACS1014-A1-B0-00	Air	400	450	315	58	A1
4.0	ACS1014-A1-C0-00	Air	450	500	355	65	A1
4.0	ACS1014-A1-D0-00	Air	550	600	450	79	A1
4.0	ACS1014-A1-E0-00	Air	650	700	500	94	A1
4.0	ACS1014-A1-F0-00	Air	750	800	560	108	A1
4.0	ACS1014-A1-G0-00	Air	800	900	630	115	A1
4.0	ACS1014-A1-H0-00	Air	900	1000	710	130	A1
4.0	ACS1014-A2-J0-00	Air	1150	1250	900	166	A2
4.0	ACS1014-A2-K0-00	Air	1350	1500	1120	195	A2
4.0	ACS1014-A3-L0-00	Air	1550	1750	1250	224	A3
4.0	ACS1014-A3-M0-00	Air	1800	2000	1400	260	A3
4.0	ACS1014-A3-N0-00	Air	2000	2250	1600	289	A3
4.0	ACS1014-W1-P0-00	Water	2300	2500	1800	332	W1
4.0	ACS1014-W1-Q0-00	Water	2700	3000	2250	390	W1
4.0	ACS1014-W2-R0-00	Water	3100	3500	2500	447	W2
4.0	ACS1014-W2-S0-00	Water	3600	4000	2800	520	W2
4.0	ACS1014-W2-T0-00	Water	4000	4500	3150	577	W2
4.0	ACS1014-W2-U0-00	Water	4500	5000	3550	650	W2
4.0	ACS1014-W3-V0-00	Water	4900	5500	4000	707	W3
4.0	ACS1014-W3-W0-00	Water	5300	6000	4500	765	W3
4.0	ACS1014-W3-X0-00	Water	5800	6700	5000	837	W3

*** The power ratings apply to typical 4 pole motors. For those motors the frequency converter has a built-in overloadability of 10%. When selecting the frequency converter it should be observed that the rated current of the ACS 1000 must be higher than or equal to the rated motor current in order to achieve the rated motor power given in the table.*

***Note**: The load capacity (current and power) decreases if the installation site altitude exceeds 2000 m above sea level (6600 ft.), or if the ambient temperature exceeds 40 °C (104 °F) (units with enclosure class IP21), or, in the case of water cooled units, if the cooling water temperature exceeds 27 °C (81 °F). For the derating factors, see Appendix B - Technical Data.*

IGCT Power Semiconductors

ABB researched and designed the Integrated Gate Commutated Thyristor (IGCT) specifically for the medium voltage market. IGCTs provide high speed switching like IGBTs (Insulated Gate Bipolar Transistors) and at the same time provide high voltage blocking and low loss conduction like GTOs (Gate Turn-Off Thyristors). The result is a fast, low loss device that can be used at medium voltage levels without resorting to series topologies. It transcends both of the older technologies from which it evolved. IGCTs also provide other benefits:

- Freewheeling diode is integrated into the same package
- Snubber circuits are not required
- Gating circuitry is packaged with the power device
- High reliability (low total parts count)
- High power density (combination of low total parts count and low power losses)
- Safe from catastrophic failures

All of these features combine to provide a medium voltage power switching device with the best combination of performance, reliability, efficiency, and space effectiveness available in the market today.

Fuseless Design

The ACS 1000 features a fuseless protected medium voltage drive. The patented design uses the new power semiconductor switching device, IGCT, for circuit protection.

The IGCT, which is placed between the DC link and the rectifier, can, unlike conventional fuses, directly isolate the inverter of the drive system from the power supply side. It achieves this within 25 microseconds, making it 1000 times faster than the operational performance of fuses.

Using the IGCT as integrated protection leads to a lower parts count within the drive system, which makes the ACS 1000 a more reliable drive.

The reason why IGCTs are capable of performing a protection function, unlike other power semiconductor devices, lies in their low onstate losses and their ability to turn off at high speed at medium voltage levels.

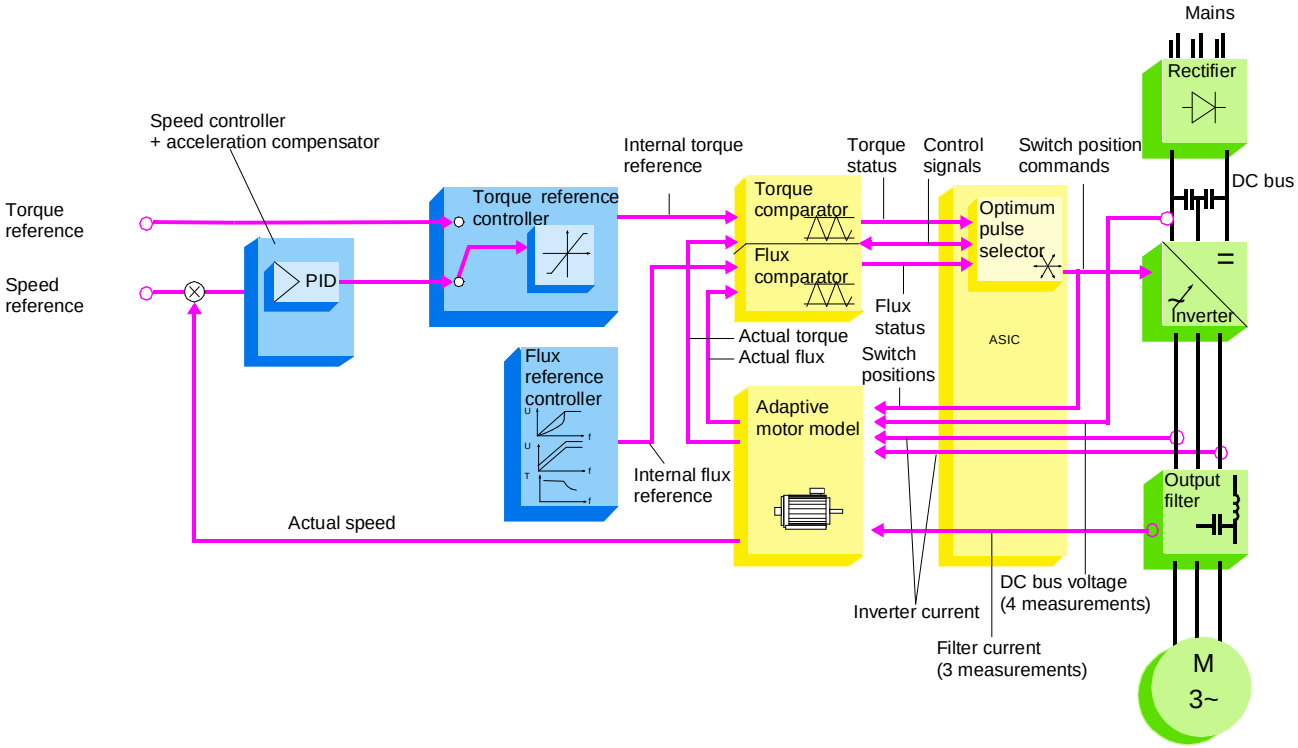
Direct Torque Control

Direct Torque Control (DTC) is a unique motor control method for AC Drives. The inverter switching is directly controlled according to the motor core variables flux and torque.

The measured motor current and DC link voltage are inputs to an adaptive motor model which produces exact actual values of torque and flux every 25 microseconds. Motor torque and flux comparators compare actual values to the reference values produced by the torque and flux reference controllers. Depending on the outputs from the hysteresis controllers, the pulse selector directly determines the optimum inverter switch positions.

Typical performance figures for the speed and torque control are given in *Chapter 7 - Standard Functions*.

Figure 3-1 DTC block diagram.



How Does DTC Differ from PWM Flux Vector Drives?

In DTC, every switching is determined separately based on the values of flux and torque, rather than switching in a predetermined pattern as in conventional PWM flux vector drives.

DTC	Flux Vector
Switching based on core motor variables Flux and Torque	Switching based on separate control of magnetising and torque producing components of current
Shaft speed and position not required	Mechanical speed is essential. Requires shaft speed and position (either measured or estimated)
Each inverter switching is determined separately (every 25 µs).	Inverter switching based on average references to a PWM modulator. This results in delays in response and wasted switchings.
Torque Step Rise Time (open loop) is less than 10 msec.	Torque Step Rise Time Closed Loop 10 to 20 msec. Sensorless 100 to 200 msec.

For more information on DTC, please refer to the *Technical Guide No. 1 Direct Torque Control* (3AFY 58056685 R0025).

Input Stage

The ACS 1000 features a 12-pulse diode rectifier input stage. This is adequate for most networks and normally meets the harmonic requirements demanded by standards such as IEEE 519.

For networks that are more demanding, the ACS 1000 can be supplied optionally in a 24-pulse configuration for air cooled types.

Output Stage

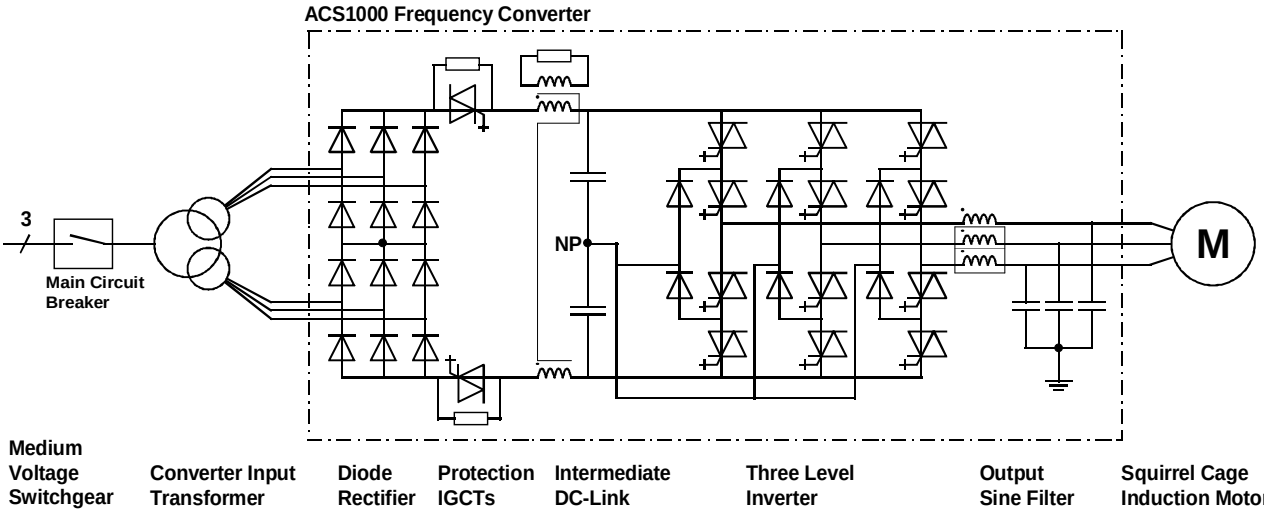
As a standard the ACS 1000 is equipped with a low pass LC sine filter in its output stage. Current feedback is used to actively control filter operation. The low pass frequency is designed to be well below the lowest switching frequency used by the inverter output stage. This greatly enhances the purity of both the voltage and current waveforms applied to the motor. This in turn provides many important benefits:

- Harmonic heating is virtually eliminated. The drive may be used to supply standard medium voltage motors (existing or new) without applying thermal derating factors.
- Voltage reflection and the associated occurrence of voltage doubling at the motor input terminals is no longer an issue (the causal high frequency content doesn't exist). Therefore, any standard medium voltage winding insulation system (existing or new) is compatible.
- Motor cables of any length may be utilized without concern (normal voltage drop issues as found in any electrical installation still apply).
- Motor bearing failures attributable to capacitively coupled high frequency current are no longer an issue (the causal high frequency common mode voltage is eliminated).
- Motor insulation is not subjected to the common mode voltage typical for other drive topologies.

Elementary Diagram

The diagram below shows the basic electrical connections of the drive system.

Figure 3-2 Elementary Diagram - ACS 1000



Cabinet Design

The riveted cabinet construction of the ACS 1000 provides extremely effective protection against electromagnetic emissions compared to traditional bolted frames. In addition, this construction technique provides an extremely solid, yet flexible and self-supporting framework which avoids the need for additional skeletal support.

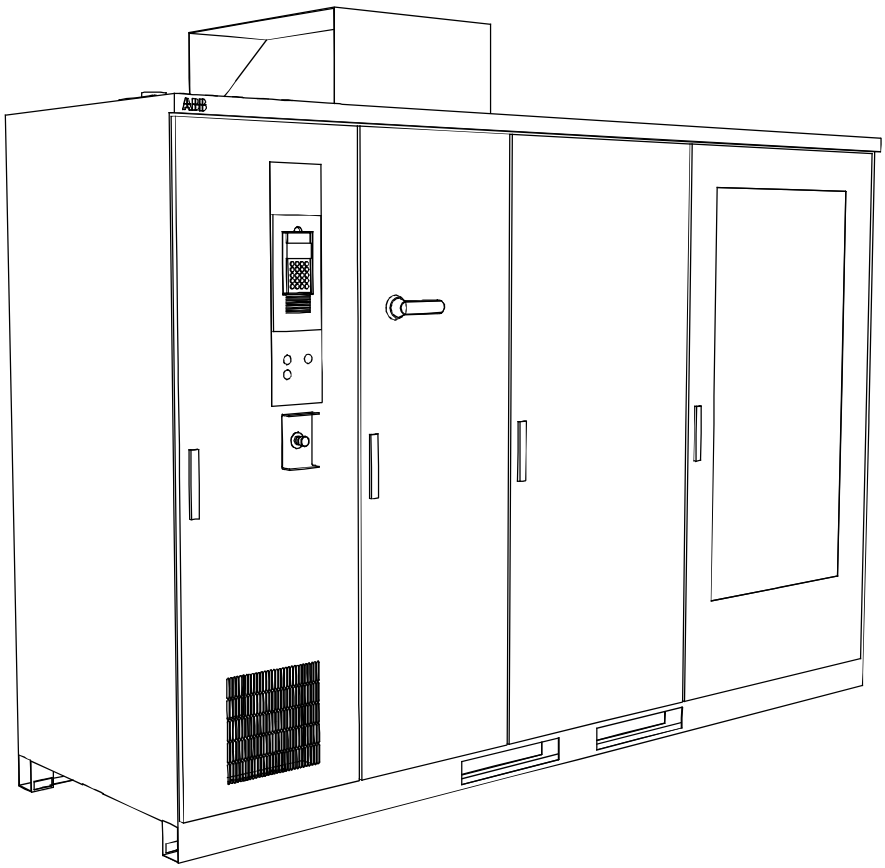
The design fulfils the requirements of international standards like UL 347A.

EMC (Electromagnetic Compatibility) has been achieved by minimizing the spacing between the rivets and avoiding the use of paint on the cabinet's inside walls. Paint tends to reduce the effectiveness of metallic bonding which is paramount to successful EMC.

Accordingly, only the front of the ACS 1000 cabinet is painted while all other walls are galvanized. The cabinet can be entirely painted outside as an option.

EMC performance is further enhanced by the use of metal cable channels, which are an integral part of the folded cabinet construction.

Figure 4-1 The ACS 1000. Air Cooled Type



Cabinet Sections

The ACS 1000 is designed with the inverter unit as one complete section including output filter capacitors and DC link capacitor. This section experiences maximum air flow which is advantageous for the temperature sensitive capacitors. Construction allows easy exchange of IGCTs using a special tool.

The middle section houses the cooling fan, the rectifier stack, protection IGCTs and filter reactor. The construction is such that the fan can be exchanged easily.

The third section includes control equipment and also provides space devoted exclusively to cable termination. All control equipment with the exception of one I/O card is located on the front of a swing frame. The remaining I/O card and any optional I/O cards are located behind and to the right of the swing frame. Customer signal terminals are also located in this area. I/O cards have screw-type terminals on which cables totaling 2.5 mm^2 (AWG12) may be connected. See *Figure 4-2* and *Figure 4-3*.

Behind the swing frame and a protective separation door is the drive's power terminal section. To provide adequate access to this section, the swing frame can be opened through more than 120°.

The design is such that the swing frame can be opened without dangerously exposing the power terminals.

The standard ACS 1000 cabinet is rated IP21. Higher IP ratings are optionally available.

The ACS 1000 cabinet system provides the flexibility to add cabinet sections to the drive at any time. Sections can be added in widths of 600, 800 and 1000 mm (resp. 24, 32 and 39 Inches).

Figure 4-2 Control section view.

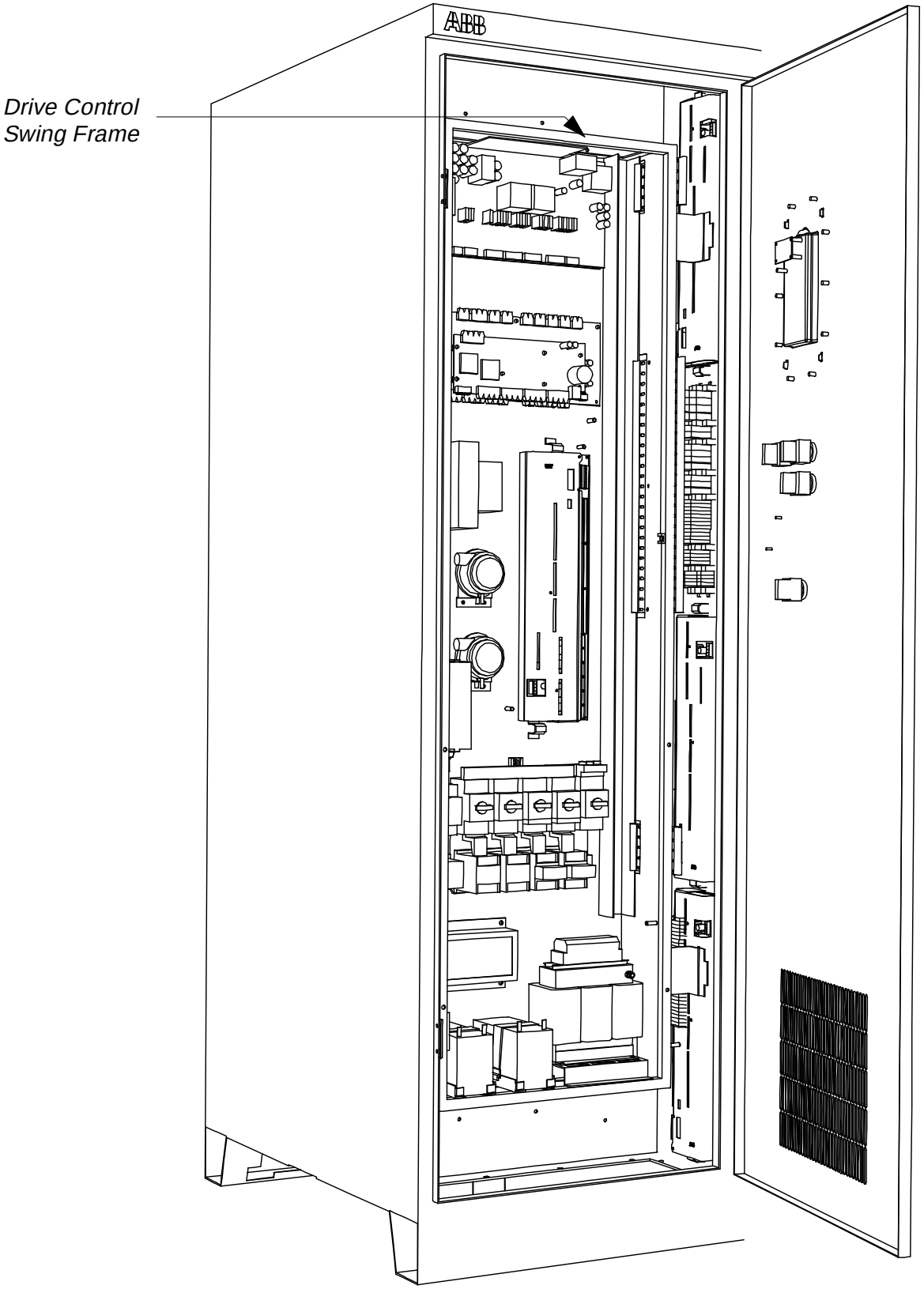
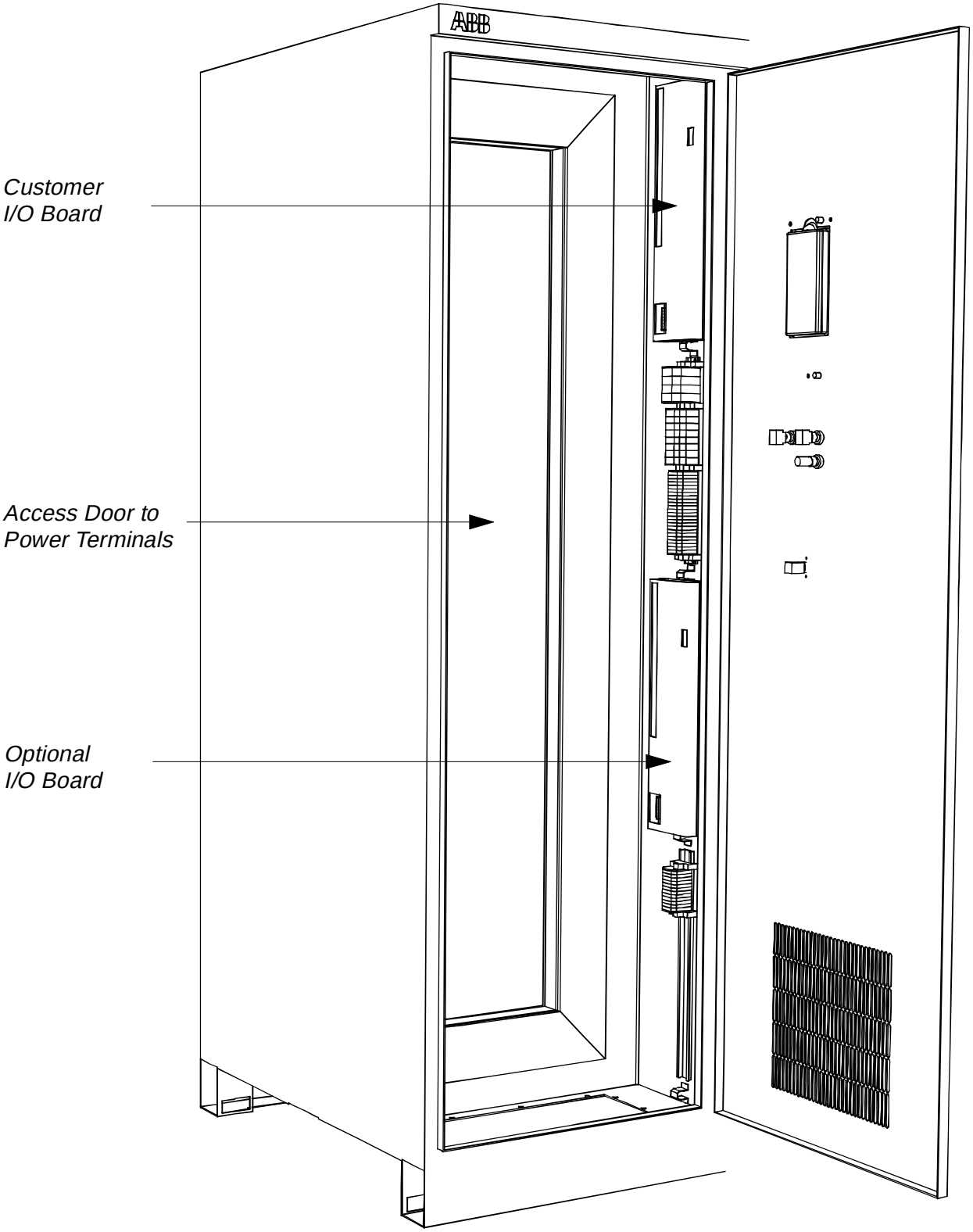


Figure 4-3 Control section view, shows the swing frame removed. The I/O boards, signal terminals and auxiliary terminals can also be seen. The door covering power terminals in the rear section of the cubicle is closed.



Door Locks

All doors are hinged and locked using carriage key locks.

The power section of the drive (multiple doors) includes an electromechanical interlock system that functions in conjunction with the safety grounding switch and electrical interlocks from the main circuit breaker (external). This interlock system insures that none of the power cabinets can be opened until the main source of power is disconnected, the safety grounding switch is closed and the DC link capacitors are discharged. Additionally the same interlock system insures that power cannot be initialized to the drive unless the doors are closed and the safety grounding switch has been opened.

The control section can always be opened.

Lifting Arrangements

The cabinets are fitted with lifting lugs as standard. Channels are provided at the base of the unit for lifting by forklift vehicles.

Standard Color

The standard color is RAL 7035 (light grey). Other colors are available on request.

Options

The air intake will, as an option, have an air filter in front of the air intake for extremely dusty environment. The filter can be changed from the outside insuring that the drive remains in operation.

Redundant cooling fans are also available as an option. These are mounted on top of the converter unit.

Overview

The ACS 1000 can be controlled from several control locations:

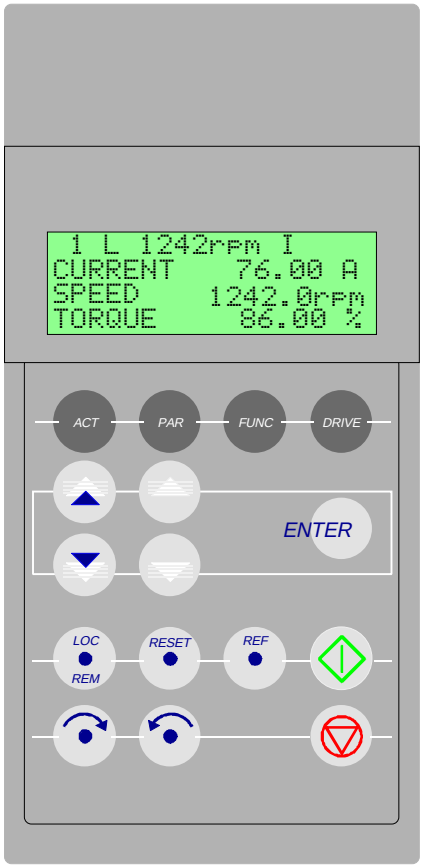
- The detachable CDP 312 Control Panel mounted on the ACS 1000 front door of the control section.
- External control devices, e.g. a supervisory control system, that connect to the analog and digital I/O terminals on the Standard I/O Boards.
- Fieldbus adapter modules.
- PC Tools (Drives Window and Drive Link) hooked up via a PC adapter to the ACS 1000 control board.

Optional analog and digital I/O extension modules can be used to provide extended transformer and motor protection, protection for external cooling equipment (e.g. fans, chillers), on-line synchronization logic, and other customer requirements as needed.

CDP 312 Control Panel

The Control Panel is the basic user interface for monitoring, adjusting parameters and controlling the ACS 1000 operation.

Figure 5-1 CDP 312 Control Panel.



Enclosure class IP54 when attached to the Control Panel Mounting Platform

Control Panel Display

Multilingual Alphanumeric Display (4 lines x 20 characters)
Plain text messages in 10 available languages

Depending on the selected Application Software, four specific languages are loaded in the ACS 1000.

Control Panel Keypad

Control Panel Mode Selection keys

Double Up Arrow, Up Arrow, Enter, Double Down Arrow, Down Arrow keys

Local/Remote, Reset, Reference and Start keys

Forward, Reverse and Stop keys

Using the panel it is possible to

- enter start-up data into the drive
- control the drive with a reference signal and with Start, Stop and Direction commands
- display actual values (three values can be read simultaneously)
- display and adjust parameters
- display information on the most recent forty fault events
- upload and download complete parameter settings from one drive to another (this greatly simplifies the start-up procedure of several identical drives).

Standard I/O

There are a number of analog and digital I/Os, already available as standard, which is sufficient for most applications. Besides those various, already pre-programmed I/Os, optional I/Os are also available to offer a wide range of signal interfaces. Standard I/Os are marked in the following tables by a dot (●). Signal names beginning with slash (/) indicate signals which are true when low.

All analog and digital I/Os are floating, galvanically isolated with the following ratings:

Analog Input	(AI):	0..20 mA / 4..20 mA or 0..10 V / 2..10 V, scalable by parameter setting
Analog Output	(AO):	0..20 mA / 4..20 mA, scalable by parameter setting
Digital Input	(DI):	Opto-coupled, rated for 22..250 VAC or 22..150 VDC
Relay Output	(RO):	With switch-over contact (SPDT), rated for 250 VAC, 2 A.

Table 5-1 I/O Signals: Remote Control Interface

Type	Signal Name	Remarks	Standard
DI	STANDARD INPUT 1	see *Chapter 6*	●
DI	STANDARD INPUT 2	see *Chapter 6*	●
DI	STANDARD INPUT 3	see *Chapter 6*	●
DI	STANDARD INPUT 4	see *Chapter 6*	●
DI	STANDARD INPUT 5	see *Chapter 6*	●
DI	STANDARD INPUT 6	see *Chapter 6*	●

DI	DISABLE LOCAL	Remote input to disable the possibility for a local/remote switch-over from the CDP 312 Control Panel
DI	REM ORD ON-LINE	Remote request for closing the Main Circuit Breaker
DI	REM ORD OFF-LINE	Remote request for opening the Main Circuit Breaker
DI	REMOTE RESET	Remote Fault Reset (only certain faults can be reset remotely)
RO	DRIVE READY	Status Output “Drive Ready” (i.e. MCB closed, DC link charged, no lockout active)
RO	DRIVE RUNNING	Status Output “Drive Running”
RO	DRIVE ALARM	Status Output “Drive Alarm”
RO	DRIVE TRIP	Status Output “Drive Tripped”
RO	LOCAL MODE	Local Mode Operation Status Indication
AI	REF VALUE 1	see

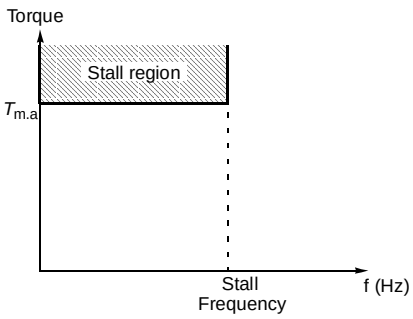
The values for alarm and trip levels must be set in either case.

Motor Stall

The ACS 1000 protects the motor if a stall condition is detected. The supervision limits for stall frequency (speed) and stall time can be set by the user. The user can also select whether the stall function is enabled and whether the drive responds with an alarm or a trip when a stall is detected.

The protection is activated if all of the following conditions are fulfilled simultaneously:

Figure 7-4 Stall region of the Motor



1 The output frequency is below the set stall frequency.

2 The drive is in torque limit. The torque limit level can be set by the user. The torque limit level is a basic setup parameter that sets maximum drive output torque and although it indirectly effects operation of motor stall protection, it should not be considered a motor stall parameter.

3 The frequency and torque levels from conditions 1 and 2 have been present for a period longer than the set stall time.

Underload

Loss of motor load may indicate a process malfunction. ACS 1000 provides an Underload function to protect the machinery and process in such a serious fault condition. This supervision function checks whether the motor load is above the specified load curve. 5 different load curves can be selected by the customer.

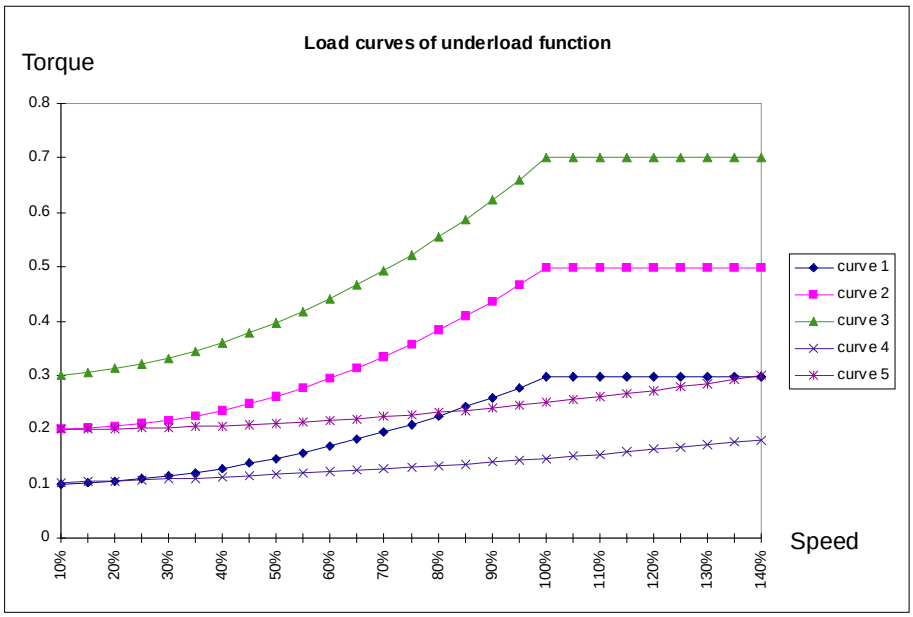
The supervision limits: Underload curve and Underload time can be chosen as well as the drive response to the underload condition (alarm / trip indication & stop the drive / no reaction).

The protection is activated if all the following conditions are fulfilled at the same time:

1 The motor load is below the Underload curve selected by the user (five options, see *Figure 7-5*).

2 The motor load has been below the selected Underload curve longer than the time set by the user (Underload time).

Figure 7-5 Load curves for Underload function



Overspeed Motor speed as determined by DTC is monitored. If motor speed exceeds the maximum permitted motor speed (user adjustable) a trip is initiated. In addition, an input for connection of an external motor overspeed trip is available. A converter trip is also initiated if the external motor overspeed trip is activated (signal active when low).

Undervoltage In order to detect a loss of the net supply, the levels of the positive and negative DC link voltage levels are supervised. If these voltage levels drop below 70% of their nominal levels an undervoltage alarm is initiated and power loss ride through is activated (provided it is selected). If the DC link voltage levels drop below 65% of their nominal levels an undervoltage trip is initiated.

Preprogrammed Protection Functions

Motor Phase Loss The Phase Loss function monitors the status of the motor cable connections. The function is useful especially during motor starting: the ACS 1000 detects if any of the motor phases are not connected and refuses to start.

The Phase Loss function also supervises the motor connection status during normal operation. The motor operating frequency must be above a minimum level in order for this feature to function. Should a motor phase loss be detected a trip is initiated.

Overvoltage The levels of the positive and negative DC link voltage are supervised to detect if an improper overvoltage condition develops. If these voltage levels rise above 130% of their nominal levels an overvoltage trip is initiated. On rare occurrences a combination of conditions can result in the

motor entering a self excitation mode that can cause the DC link voltage to continue to rise despite the fact that a trip has been implemented. If this condition occurs, and if the DC link voltage levels rise above 135% of their nominal levels, a second overvoltage trip is initiated that causes the inner 6 IGCTs to be gated simultaneously such that the motor windings are effectively shunted together. This eliminates the self excitation voltage that is causing the DC link voltage levels to rise. To provide ultimate reliability the second overvoltage trip is implemented both in software and redundantly in hardware (140%).

Short Circuit in the Rectifier Bridge

A short circuit in the rectifier bridge is detected by supervising the DC link voltage. If a short circuit is detected a trip is initiated and the drive is disconnected from the supply voltage.

Charging Fault

The intermediate DC link voltage is supervised while charging. If the voltage does not reach a certain level after a pre-set time a trip will be initiated.

Supply Phase Loss

If the voltage ripple in the intermediate dc link rises above a pre-set level, a supply phase may be lost. A trip is initiated.

Overcurrent

The overcurrent trip limit for the ACS 1000 is 2.2 times nominal inverter current. If this level is exceeded a trip is initiated.

Loadability of the Inverter

In order to insure that the inverter section does not exceed normal temperature limits, the current load of the inverter is supervised. If a current/time overload is detected a trip is initiated.

Short Circuit of the Inverter

The inverter is monitored to insure that a short circuit condition does not exist. If a short circuit is detected a trip is initiated.

Operating System

The operating system of the microprocessor board supervises different functions within the control software and will initiate a trip if a malfunction is detected. Such faults are displayed as “Control SW fault”. Should one of these faults be initiated during operation, the system should be restarted.

Measurement Loss

In order to guarantee proper operation of the protection functions included in the converter, all communications between the control boards are checked cyclically.

On the ADCVI board (analog digital conversion for voltage and current) analog signals are converted into digital signals. The digital signals are then transmitted via PPCC (fiber-optic bus system) to the interface board which is the main interface to the converter control.

On the interface board the status of the communication is supervised. If a fault is sensed a trip is initiated.

Battery Test

In order to guarantee correct fault indications and proper trip sequencing in the event that the auxiliary power source feeding the drive is lost, the ACS 1000 is equipped with a battery to supply redundant DC control

power. While the converter is in operation the charge on the battery is checked periodically by applying a known load and measuring the resultant voltage drop. If the battery is determined to be deficient in its ability to supply power, a fault message is displayed and either a normal stop or an alarm is initiated (user selectable).

Communication Fault Except for the measurement boards all other links are realized by DDCS. If one of these links is missing a trip is initiated.

ID Run Fault An identification run is done during commissioning. The commissioning engineer enters nominal data for the identification of the system parameters. If the data has not been entered correctly and therefore the system parameters cannot be determined, a trip is initiated.

In this case the entered data needs to be corrected and the identification run has to be repeated.

Other Protection Functions

External Motor Protection Trip If the customer uses an external motor protection relay it can be connected to a pre-defined protection input of the ACS 1000. The motor protection input is integrated into the tripping loop by a normally closed (NC) contact.

External Transformer Protection Trip If the customer uses an external transformer protection relay it can be connected to a pre-defined protection input of the ACS 1000. The transformer protection input is integrated into the tripping loop by a normally closed (NC) contact.

Process Stop A process stop button or relay can be connected to a pre-defined input of the ACS 1000. The physical process stop input must be normally closed during normal running. If the process stop input opens the drive control initiates a stop order. The type of stop (emergency, ramp, or coast) is parameter selectable.

External Emergency Off If the customer wants to use an External Emergency Off button it can be connected to a pre-defined protection input of the ACS 1000. The External Emergency Off input is integrated into the tripping loop by a normally closed (NC) contact.

MCB Control Fault All opening and closing commands to the Main Circuit Breaker (MCB) are supervised for time-out. Should the MCB not change its status within a pre-set time the MCB trip loop (signal active when low) is activated.

Other Features

Limits The ACS 1000 offers adjustable limits for speed, current (max.) and torque (max.) and protects itself against overvoltage.

Automatic Resets The ACS 1000 can automatically reset itself after certain faults. A user

selectable parameter determines whether this feature is implemented. When the feature is active, fault reset occurs within a few milliseconds after the fault is detected. The fault has no effect on the drive or process operation; however, it is annunciated as a fault on the drives panel. Faults which can be handled in this manner include:

- DC undervoltage
- Inverter overcurrent
- Switching frequency

A reset counter tracks the number of automatic resets that occur within a set time window. If an excessive number of automatic resets occur within this time window, a system fault trip is initiated and drive operation ceases.

Supervision

Programmable supervision is a unique feature of the ACS 1000 which allows the drive to monitor certain user selectable signals. A trigger level can be defined for each signal.

For example, the user may set two speed limits, one current limit, two torque limits, two reference limits and two actual value limits. The digital status of the active limit appears on the control panel display, and can also be supervised through relay outputs.

ACS 1000 Information

The ACS 1000 software version, test date, and serial number can be displayed.

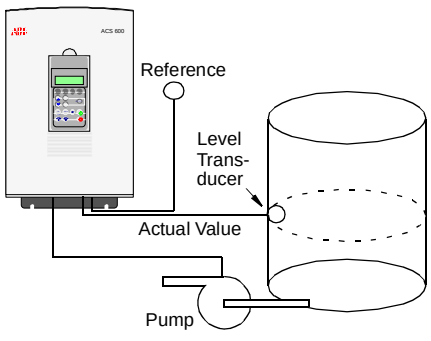
Parameter Lock

The user can prevent unwanted parameter adjustment by activating the Parameter Lock.

Built-in PID Controller

There is a built-in process PID Controller in the ACS 1000. The controller can be used to control process variables such as pressure, flow, or fluid level.

Instead of applying a speed reference to the ACS 1000, a process reference (setpoint) is applied via an analog input or the keypad. An actual value (process feedback) is brought back to the ACS 1000 through one of the analog inputs.



The internal PID controller of the ACS 1000 eliminates the need to provide, mount, and wire a separate PID controller.

Resonance Frequency Damping (RFD)

Mechanical resonance frequencies within the system can be damped by means of an integrated algorithm of the control software.

If this function is enabled the control software produces a cancellation signal at the resonance frequency which minimizes or eliminates the mechanical resonance.

PC Tools

Drives Window Drives Window consists of several independent parts: the User Interface, the Target Drivers, and the Communication Drivers. With this component structure, enhanced flexibility is achieved to enable working with several different types of products through different target and communication drivers. The look and feel of the Drives Window program remains the same even when the product changes.

User Interface The User Interface of Drives Window allows access to the main functions of the program. The program follows the common user interface guidelines for Windows programs.

Target Driver The Target Driver includes all of the target-dependent information. The program identifies the type of the target device and starts the corresponding target driver automatically during initialization. Different types of products can be worked with at the same time due to the component structure of Drives Window.

Communication Driver Drives Window can be used with different communication links. The types of communication drivers that can be used are defined by the target device. Only the hardware for connecting the PC to the communication link and the respective communication driver is needed.

Drives Window Functions Drives Window offers several functions for commissioning and monitoring ABB products. All the functions are available from the main Menubar or Toolbar of the program.

In Drives Window there are two special displays and six tools:

Special Displays	Tools
• System Configuration	• Signals and Parameters Tool
• Drives Panel	• Monitoring Tool
	• Data Logger Tool
	• Event Logger Tool
	• Fault Logger Tool
	• Application Tool

It is possible to work with several drives using several tools at the same time. Each time a tool is started a new tool window is created.

System Configuration Display The System Configuration display provides an overview of the system as well as the type and status of each product on the communication link(s). Included in the System Configuration display are also the previously saved files located on the hard disk of the computer. By double-clicking on a specific file, the corresponding Drives Window tool is started to display the

contents of the file.

Drives Panel The Drives Panel is used for controlling the operation of a selected drive within the system. Different drives can be controlled by changing the target drive selection. Commands available with the Drives Panel depend on the currently active target. Usually the following commands are available:

- Start and Stop
- Set speed reference
- Change reference direction (forward/reverse for AC-drives)
- Reset active fault
- Change control between Drives Window and external control location
- Step reference level

Signals and Parameters Tool The Signals and Parameters Tool is used for selecting signals, parameters, and application symbols used for monitoring. Parameter values can be set either off-line or on-line. Several Signal and Parameter Tool windows for one or multiple drives can be used at the same time. When started, either the whole Parameter table or only the group headings are loaded depending on the option set.

Monitoring Tool The Monitoring Tool is used for trending the actual values of the target graphically. The following functions are supported:

- Zoom-In and Zoom-Out
- Scaling of graphs
- Setting Sample Interval
- Setting length of the visible screen
- Triggering on specific conditions
- Scrolling Monitor History
- Adding a synchronized reference graph to the Monitor View System
- Saving Monitor View and History

Data Logger Tool The Data Logger Tool provides facilities for viewing the contents of the data loggers in the drive. The data can be displayed in either graphical or numerical form. The contents of different data loggers are displayed in separate windows. Data loggers are useful for exact measurements with rapid data point monitoring.

Event Logger Tool The contents of the event logger in the drive can be viewed and cleared by using the Event Logger Tool.

Fault Logger Tool The contents of the fault logger in the drive can be viewed and cleared using the Fault Logger Tool.

Drives Link Drives Link is designed to serve as a dynamic data exchange (DDE) tool between the Target Driver and most of the DDE supporting Windows applications such as MS Excel. The Drives Link does not need any other ABB tool to perform it's actions.

The Drives Link consists of several independent parts: the User Interface, the Target Driver, and the Communication Driver. With this component structure, enhanced flexibility is achieved to enable working with several different types of products through different target and communication drivers. The look and feel of the Drives Link program remains the same even when the product changes.

User Interface The User Interface of Drives Link allows access to the help file of the program. Usually the user interface has no function except the icon being visible at the bottom of the screen.

Target Driver The Target Driver includes all of the target-dependent information. The program identifies the type of the target device and starts the corresponding target driver automatically during initialization. Different types of products can be worked with at the same time due to the component structure of Drives Link.

Communication Driver The Drives Link can be used with different communication links. The types of communication drivers that can be used are defined by the target device. Only the hardware for connecting the PC to the communication link and the respective communication driver is needed.

Drives Link Functions The Drives Link provides the capability to monitor ABB products. For this purpose the following elements are available:

Downlink features	Uplink features
• Start/Stop	• Running, warning and fault status
• Fault Reset	• Reference
• Reference	• Parameters
• Parameters	• Control Location
• Control Location	

Support Tool The ACS 1000 Support Tool is a diagnostics tool which identifies faults and warnings based on the signal values from the converter. It provides expert knowledge for troubleshooting and servicing the converter. Actual pictures and step-by-step replacement procedures are available within the tool.

The ACS 1000 Support Tool is fully configurable for ABB drive products and/or projects. The user language can be customized, and special faults and warnings can be added based on experience.

In addition, the ACS 1000 Support Tool keeps a record of all service activities that have been performed on any part of the converter since start-up. Spare part numbers and contract information can be added to the tool.

The ACS 1000 Support Tool works on-line together with the Drives Window tool.

Environmental Requirements

Extended Ambient Temperature: 50 °C

Above 40 °C the converter output power must be derated by 1.5% per 1 °C and different filter capacitors, suitable for high operating temperatures, are supplied.

Vibration Absorbers

The vibration absorbers are base plates with springs which are bolted to the base frame of the converter.

Vibration absorbers are mainly used for marine applications like vessels and ferries or any other mobile installations where vibrations need to be damped.

If this option is required, please contact your ABB representative.

Altitude > 2000 m above Sea Level

For installations higher than 2000 m above sea level, the maximum output power is derated 1% for every additional 100 m.

The maximum possible altitude is limited to:

- 5500 m above sea level for 2.3 kV motor voltage
- 4000 m above sea level for 3.3 kV motor voltage
- 3000 m above sea level for 4.0 kV motor voltage.

For installations above these limits, please contact your local ABB representative.

Tinned Bus Bars

Under certain environmental conditions (e.g. salty air in combination with increased ambient temperature and high humidity) tinned bus bars can be chosen instead of the untreated copper ones (standard). This choice is relevant for all power and grounding bus bars of the converter.

Converter Enclosure

IP Class

The standard IP classes of the converter enclosure according to IEC 529 are:

- IP21 (for air cooled converters)
- IP31 (for water cooled converters)

The following converter enclosure classes are optional:

- *IP42 (for air cooled converters)*
- *IP54 (for water cooled converters)*

If this option is required, please contact your ABB representative.

Door Interlocking

The ACS 1000 is equipped with an electro-mechanical door interlocking system as standard.

Alternative optional interlocking:

- Kirk key interlocking

If this option is required, please contact your ABB representative.

Cabinet Color

The standard color of the ACS 1000 is RAL 7035, “Light Grey”. Other RAL colors are available optionally and must be specified explicitly within the order.

Cabinet Paint Finish

The standard converter has painted front doors. As an option the entire cabinet exterior can be painted. (see also *Cabinet Color*).

Input Section

Input Bridges

- 12-pulse diode rectifier (standard)

  This type is sufficient for most network conditions to fulfill the network harmonic requirements according to IEEE 519-1992.

  It is the ideal solution for a small converter footprint and if an outdoor transformer can be used.

- 24-pulse diode rectifier with integrated dry-type transformer *(available for air cooled converters by the end of 1998)*

  This type is recommended if superior network behavior is required.

  The 24-pulse diode rectifier is applicable if outdoor transformers are not required. In this case there is no need for an oil pit and no additional cabling between transformer and converter is needed which can substantially reduce construction and installation costs.

Extended Transformer Supervision Interface

In addition to the standard digital (hardwired) input “Transformer Protection Trip” (signal active when low) the following signals can be optionally included in the signal interface between the transformer and the ACS 1000.

- “Oil Temperature Alarm” (“Winding Temperature Alarm” for dry type transformers): digital input
- “Oil Temperature Trip” (“Winding Temperature Trip” for dry type transformers): digital input, initiates a converter trip
- “Oil Level Alarm”: digital input
- “Buchholz Alarm”: digital input
- “Buchholz Trip”: digital input, initiates a converter trip
- “Oil Temperature Actual Value” (“Winding Temperature Actual Value” for dry-type transformers):

  0..20 mA / 4..20 mA (or 0..10 V / 2..10 V) analog input, can be used alternatively to the above mentioned digital temperature alarm and trip

inputs. This analog signal is processed by the control system for alarm and trip initiation.

Line Unbalance Protection Relay

An optional signal input is available to connect a line unbalance protection relay for initiation of a converter trip.

Motor Side

Extended Motor Supervision Interface

In addition to the standard digital (hardwired) input “Motor Protection Trip” (signal active when low) the following signals can be optionally included in the signal interface between the motor and the ACS 1000.

- “Motor Cooling Alarm”: digital input
- “Motor Cooling Trip”: digital input, initiates a converter trip
- “Vibration Supervision Alarm”: digital input
- “Vibration Supervision Trip”: digital input, initiates a converter trip
- “Overspeed Trip”: digital input, initiates a converter trip
- “External Motor Protection Alarm”: digital input
- Bearing Temperature (DE) Actual Value
- Bearing Temperature (NDE) Actual Value

  0..20 mA / 4..20 mA (or 0..10 V / 2..10 V) analog inputs, which are processed by the control system for alarm and trip initiation.

Ex-Zone Signal Interface for Motor Measurements (Zener Barriers)

For motor installations in hazardous areas (Ex-Zone) all interface signals from the motor have to be connected to Zener Barriers mounted in the converter. This applies to the winding temperature and bearing temperature measurements as well as to all digital signals e.g. external motor protection alarm and trip and external overspeed trip.

If this option is required, please contact your ABB representative.

Pulse Encoder Interface Module (NTAC-01)

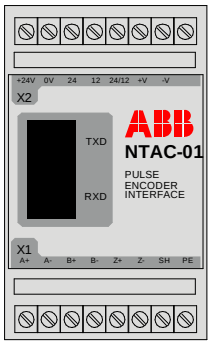
The Pulse Encoder Interface Module (NTAC-01) provides an interface for an incremental pulse encoder connection. By measuring the motor actual speed with a pulse encoder, the speed control accuracy can be improved. See the speed control performance figures in *Chapter 7 - Standard Functions*.

To achieve highest accuracy speed control, special attention should be paid to the pulse encoder resolution/signal accuracy. Requirements for the encoder:

- Supply voltage 12 VDC or 24 VDC (supplied by the module)
- Single ended or differential connection can be used
- Available signal channels: A, A inverted, B (90 electrical degrees phase shift to A), B inverted (Z (zero channel), Z inverted - optional)
- The encoder must give 2^n pulses per revolution. Recommended pulse train is 2048 pulses/revolution. Maximum signal frequency must not ex-

ceed 100 kHz.

Front view



Screw terminal block
for the power supply/source
connections

fiber optic connectors
for the ACS 1000 I/O link connection
RXD = Receiver
TXD = Transmitter

Screw terminal block
for pulse encoder connection

The NTAC-01 module is fed from the ACS 1000 internal control power supply.

A typical application for a pulse encoder would be a case where crawling at a speed < 1 Hz is required.

Braking Chopper

Effective motor braking and short deceleration times can be achieved by using resistor braking. For resistor braking, the ACS 1000 must be equipped with a braking chopper and a braking resistor.

Braking choppers are available for all ACS 1000 types. The choppers can be ordered factory-installed and/or as add-on kits.

The chopper control board supervises the system status and detects failures such as:

- braking resistor and resistor cable short circuits
- chopper short circuit
- chopper control card failure
- resistor overtemperature (optional)

The chopper control board has one digital input and one relay output. The input can be connected to a resistor-mounted temperature sensitive switch to protect the resistor against overtemperature. The relay output indicates the faults listed above.

If this option is required, please contact your ABB representative.

Braking Resistor

The braking resistor is available as an add-on kit for all ACS 1000 types. Resistors other than the standard resistors may be used provided the specified resistance value is not decreased, and the heat dissipation capacity of the resistor is sufficient for the application.

If this option is required, please contact your ABB representative.

Circuit Breaker for Motor Space Heater

A motor space heater can be connected directly to a single-phase auxiliary power circuit breaker installed in the converter. Based on the power rating of the heater used one of the following circuit breaker sizes must be chosen:

Table 8-1 Power ratings for different circuit breaker sizes

	Auxiliary Voltage (single phase)		
Circuit Breaker Rating	120 V	240 V	400 V
0.5 A	60 W	120 W	200 W
1.0 A	120 W	240 W	400 W
2.0 A	240 W	480 W	800 W
3.0 A	360 W	720 W	1200 W
4.0 A	480 W	960 W	1600 W
5.0 A	600 W	1200 W	2000 W
6.0 A	720 W	1440 W	2400 W

Motor Starter for Motor Cooling Fan / Pump

A motor cooling fan or pump can also be connected directly to an auxiliary motor starter installed in the converter. Based on the power rating of the cooling fan or pump used one of the following motor starter sizes must be chosen:

Table 8-2 Power ratings for different starter sizes

	Auxiliary Voltage (three phase)		
Overload Current Rating	400 V	480 V	575 V
2.5 - 4.0 A	750 W - 1500 W (1.0 - 2.0 hp)	1100 W - 2000 W (1.5 - 2.7 hp)	1200 W - 2600 W (1.6 - 3.5 hp)
4.0 - 6.3 A	1500 W - 2200 W (2.0 - 3.0 hp)	2000 W - 3000 W (2.7 - 4.0 hp)	2600 W - 3600 W (3.5 - 4.8 hp)
6.3 - 10.0 A	2200 W - 4000 W (3.0 - 5.4 hp)	3000 W - 4000 W (4.0 - 5.4 hp)	3600 W - 6000 W (4.8 - 8.0 hp)

Converter Cooling

Redundant Cooling Fans

Redundant cooling fans are located on top of the converter cabinet. The single fan (standard solution), on the other hand, is located inside; see *Figure 8-1*.

With this option continuous operation of the drive is guaranteed even if a fan failure occurs. A switch-over from the faulty to the stand-by device will take place automatically; see *Figure 8-2*. To replace the faulty unit the converter must be stopped. The replacement of a fan takes about 30 minutes.

If this option is required, please contact your ABB representative.

Figure 8-1 Cooling Fan inside the converter cabinet (standard)

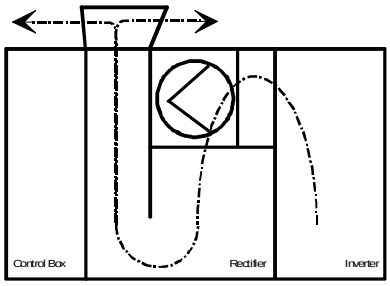
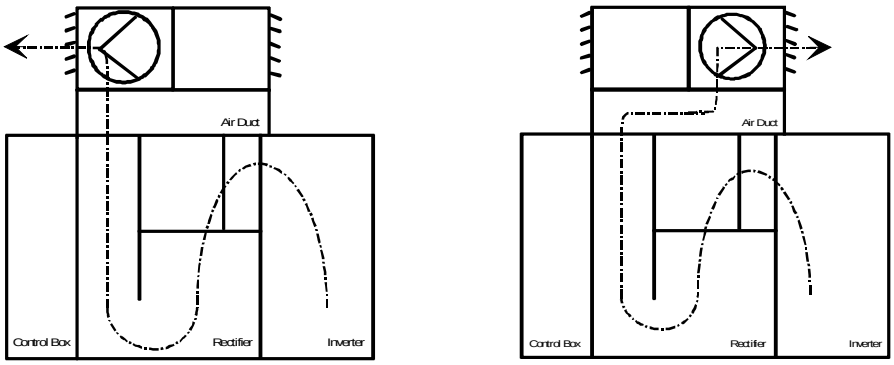


Figure 8-2 Cooling Fan arrangement for Redundant Cooling Fans (optional)



Space Heater for Tropicalized Version

A space heater is typically required in places/countries with high atmospheric humidity. It is switched on automatically when the converter is not in operation in order to prevent condensation.

The heater consists of three heating elements with a rated power of 150 W each.

Air Filter with Supervision

The optional mechanical air filter is mounted at the converter air intake and should be selected if the air contamination level exceeds IEC 721-3-3, Class 3C2 (for chemical gases) or IEC 721-3-3, Class 3S1 (for solid particles).

The air filter is supervised by measuring the pressure difference across the filter (with alarm indication). It can be exchanged while the converter is in operation.

Converter Isolators and Bypass

Converter Bypass

This option comprises the control logic and all required I/Os for a manual or motorized non-synchronized bypass switch.

Input Isolator

Used in addition to the main circuit breaker the input isolator provides the possibility to create guaranteed safe conditions for service and maintenance personnel. The six power cables between the transformer and the rectifier section are visually disconnected when the input isolator is in the open position.

The input isolator is located in an additional cabinet next to the converter.

If this option is required, please contact your ABB representative.

Output Isolator

The output isolator is normally provided in combination with a converter bypass and provides the possibility to isolate the converter completely from the motor. The three power cables between the motor and the converter are visually disconnected when the output isolator is in open position.

The output isolator is located in an additional cabinet next to the converter.

If this option is required, please contact your ABB representative.

Auxiliary & Control Interfaces

24 VDC to 120/240 VAC Converter

The operational voltage for digital inputs to the ACS 1000 can be increased from 24 VDC (standard) to either 120 VAC or 240 VAC depending on the user requirements. Typical examples are where greater cable distances or interference sources are present. The voltage from the DC/AC converter provides a safe supply (battery buffered) generated from the converter internal control power supply.

Fieldbus Adapter Modules

A fieldbus module may be used for controlling and monitoring the converter instead of using conventional hard-wired I/Os.

There are several fieldbus adapter modules available for the ACS 1000:

- Profibus DP
- Profibus FMS
- Modbus
- Modbus+
- Allen-Bradley Device Net
- ABB Advant Fieldbus 100
- ABB Procontic CS31

Other fieldbus adapters are planed.

The fieldbus connects to the adapter module via a twisted pair bus (RS 485) or via BNC connectors (for ABB AF100). The adapter communicates with the ACS 1000 control board via a fast (4 Mbit/s) duplex fiber optic link.

All fieldbus modules require 24 VDC power. In all cases power is supplied by the ACS 1000 internal control power supply (EPS).

Spare Terminals

As an option 30 spare signal terminals can be provided. This results in at least 20% spare terminals. These terminals are blank and do not connect to any internal converter wiring. A higher number of spare terminals is available upon special request.

Chapter 9 - Selecting Motor, Transformer and ACS 1000

Overview

The excellent performance of the ACS 1000 makes it suitable for most variable speed drive applications.

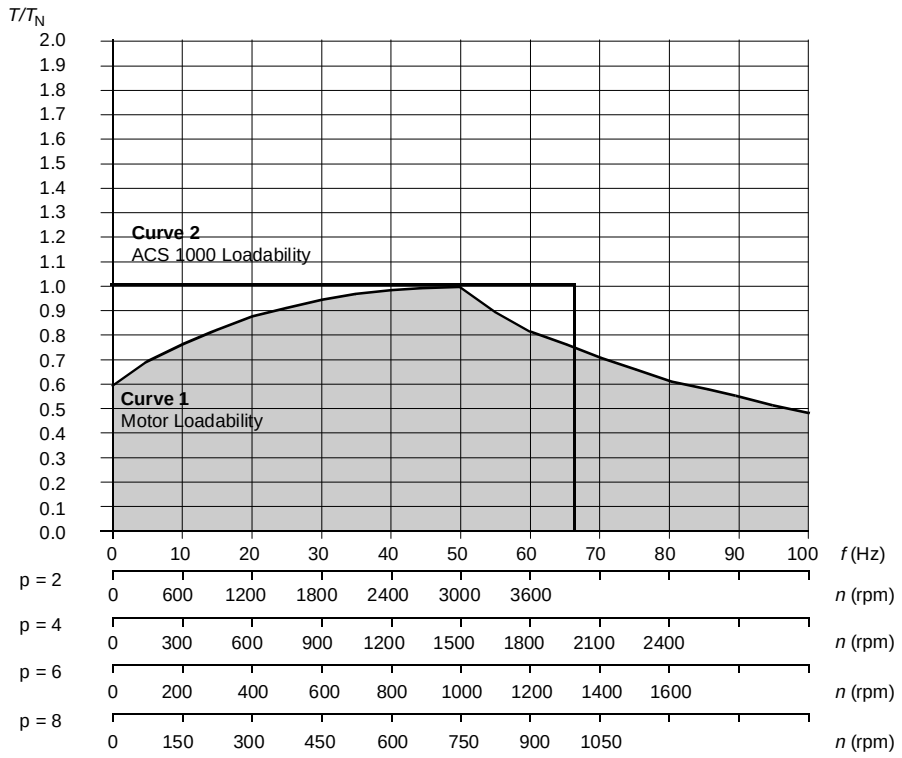
To dimension and configure an ACS 1000 drive system, the driven load has to be clearly specified and an appropriate motor must be selected. The driven load together with the selected motor basically determine the ACS 1000 frequency converter sizing as well as the size of the required converter input transformer.

Motor Selection

Load Capacity Curves

In the example below the motor rated frequency and the field weakening point are at 50 Hz.

Figure 9-1 **Curve 1**: Typical continuous load capacity curve of an IEC34 self-ventilated motor, controlled by the ACS 1000.
Curve 2: Load capacity of the ACS 1000, rated for normal use (i.e. 100% continuous, 110% for 1 min. every 10 min.).



p = number of poles
T = load torque
T_N = rated motor torque
n = speed
f = output frequency of ACS 1000

Selection Criteria Generally speaking the motor must be selected and sized as required by load requirements. Supplying an additional power margin to compensate for PWM inverter operation is not required with the ACS 1000 due to its sinusoidal output waveform.

After motor selection (or if an existing motor is being applied) the following parameters are relevant to converter and transformer selection:

- load characteristic (the most common characteristic is square torque; for other loads like constant torque or constant power applications, please contact your ABB representative)
- overloadability requirements
- motor voltage
- number of motor poles
- shaft power (nominal)
- shaft speed (nominal)
- rated current (nominal)
- motor efficiency
- motor power factor

Special attention must be paid to motor cooling in variable speed applications. If the motor is self-ventilated, long-time operation at low speeds will usually require some derating to compensate for the reduced cooling.

Depending on the mechanical configuration of the motor, load, gear-box and shaft there may be some critical speed points within the operating speed range of the drive. These have to be known in order to be avoided by making the appropriate critical speed settings in the ACS 1000 control (parameter setting). Special attention has to be paid to variable speed applications using two-pole motors, since there is usually a critical motor speed below its rated speed. For details see *Chapter 7 - Standard Functions*, *Critical Speed*.

Retrofit Due to its specific topology ACS 1000 can supply standard medium voltage motors (existing or new) without applying thermal derating factors. In addition, due to its sinusoidal output waveform, standard medium voltage winding insulation is sufficient.

To avoid risk of bearing currents and related consequential damages one motor bearing should be insulated (the one at the non-driven shaft end). This is actually a typical accessory even for most direct on-line operated motors. If, nevertheless, such a bearing is not available (e.g. for older existing motors), a grounding brush can be applied on either shaft end.

Even though from an electrical point of view no restrictions exist for variable speed operation with retrofit motors, attention should be paid to possible motor and load mechanical restrictions such as insufficient lubrication or reduced cooling at low speed, critical speed areas within the targeted operating range that need to be avoided, etc. Also the maximum (i.e. rated) speed of the motor should under no circumstance be increased

without authorization from the manufacturer of each drive train component concerned.

Torsional Excitation

Due to its sinusoidal output voltage and current waveforms and its superior control performance from DTC the ACS 1000 will not introduce any significant torsional excitations to the motor shaft. Therefore a torsional analysis for the sake of applying a frequency converter is not required.

ACS 1000 Selection

In general the ACS 1000 is selected according to the rated motor power (see exceptions following). The rating tables can be found in *Chapter 2 - ACS 1000 Types*. The rated output current of the ACS 1000 should be checked to insure that it is higher than, or equal to, the rated motor current. If a motor with 8 or more poles is used nominal motor current usually increases as compared to a motor with fewer poles. Based on the higher current requirements of the motor it may appear that the next larger inverter size will be required; however, for higher pole motors, the size of the output filter is also increased and this tends to decrease the draw on inverter current (due to improved power factor) and often offsets the increased motor current. Therefore, in such cases, please contact your ABB representative for further assistance before making a final drive size selection.

Derating from Special Ambient Conditions

For ambient operating temperatures above 40 °C (104 °F), cooling water temperatures above 27 °C (81 °F), or installation site altitudes above 2000 m above sea level (6600 ft.), the loadability of the drive decreases. For the derating factors see *Appendix B - Technical Data*.

Converter Output Filter

The standard converter output filter is appropriate for 2 to 6-pole motors. For higher pole numbers a different filter configuration sometimes is needed. The modular and flexible filter design allows the ACS 1000 to be configured for 2 to 20-pole motors.

Non Quadratic Load Applications

For constant torque or constant power applications a high overloadability (start-up torque) is usually required. This overloadability, together with possibly needed derating for low speed operation, requires some additional calculations for drive selection. To determine the appropriate ACS 1000 please contact your ABB representative.

Converter Input Transformer Selection

The input to the drive is fed from a main power transformer with multiple secondaries. The multiple secondaries are required in order to provide the necessary phase shift for 12 pulse operation. A secondary purpose for the transformer is to provide sufficient impedance to limit line harmonics to acceptable levels. For 12 pulse systems the secondary of the transformer has one star and one delta secondary winding. This creates the 30° phase shift between the two 3-phase windings that is necessary to facilitate 12-pulse input bridge operation.

Transformers may be oil-immersed or dry type. Based on installation requirements of the application the transformer may be located remote from the drive equipment or nearby. However, a maximum cable length between transformer and drive of 300 m (1000 ft.) shall not be exceeded.

Transformer Selection

The appropriate transformer size is selected according to the motor power rating. The motor and drive efficiency, power factor of the converter input bridge, and harmonic loading of the transformer must all be considered when determining the power rating of the transformer. For selection of an appropriate ABB converter transformer or for a generic transformer requirement specification, please contact your ABB representative.

PC Dimensioning and Configuration Tool

Instead of selecting the main components for the drive system by hand, the Dimensioning and Configuration Tool, ACS 1000 BidMaker (specially designed for the ACS 1000), can be used. The tool is designed to help an ABB sales representative select, dimension and configure the motor, transformer, and ACS 1000 drive.

Appendix A - Installation Guidelines

Ambient Conditions

See *Appendix B - Technical Data* for load capacity derating factors and other requirements related to ambient conditions. Derating may be necessary due to the presence of elevated levels in air temperature, altitude, or cooling water temperature. Sufficient air flow must be available. Other ambient factors such as relative humidity, air contamination, and shock and vibration must also be in compliance with stated maximum permissible levels.

Mounting

All units must be mounted in an upright position with adequate free space provided in accordance with *Table A-1*.

Table A-1 ACS 1000 free space requirements. Drive unit dimensions are shown in Appendix C - Dimensions and Weights. (Dimensions are given in mm with equivalent inches in parenthesis.)

ACS 1000 Type Code (1)	Above (2)	Below (2)	Left / Right	Front (5)	Back
ACS 101* A*	500 (20) **(3)(4)**	0 (0)	0 (0)	1000 (39.4)	0 (0)
ACS 101* W*	0 (0)	0 (0)	0 (0)	1000 (39.4)	0 (0)

Notes:

1 The * symbol indicates that any character may be present in this position. The final * symbol indicates that any character may be present in all subsequent positions.

2 Dimensions listed do not include space for cable entry which can be from above or from below.

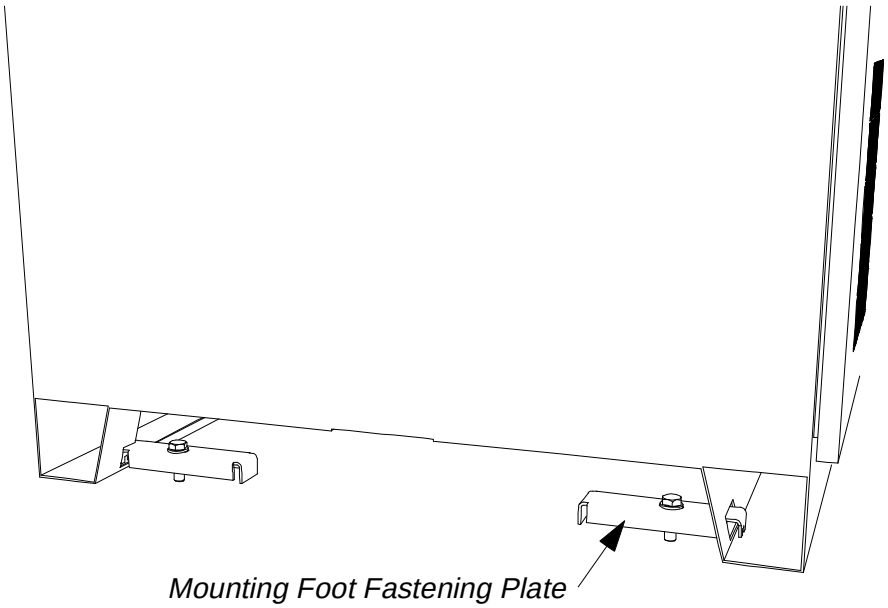
3 Dimensions listed are above the blower hood.

4 This is a general recommendation to insure proper air flow; actual site conditions may allow this dimension to decrease or force it to increase.

5 Dimensions listed indicate maximum necessary door swing area. Additional space may be needed to meet local code requirements.

The cabinet should be mounted with M12 hardware using the mounting foot fastening plates provided as shown in *Figure A-1*. These clamps can be installed either by accessing them from the ends of the cabinet structure or via the access plates that are provided inside the cabinet.

Figure A-1 Cabinet Mounting



Mains Connection

The connection from the mains supply to the ACS 1000 drive consists of six basic elements:

- Main Circuit Breaker / Controller
- Instrumentation and Protection Equipment
- Cable (transformer primary)
- Transformer
- Cable (transformer secondary)
- Cable Termination - ACS 1000

Each of these elements is discussed separately. For all items there is an implicit assumption that all applicable local electrical codes will be followed. If any specific instruction as stated appears to be in conflict with local code requirements, please contact your local ABB representative for further assistance.

Main Circuit Breaker / Controller

The main circuit breaker / controller can be either a vacuum circuit breaker or vacuum controller (medium voltage starter). In either case it should carry basic voltage and current ratings in accordance with the rated primary voltage and current levels of the transformer which is supplied. In addition to the basic electrical characteristics it must also meet specific drive requirements (some items require proper coordination with the instrumentation and protection equipment):

- Tolerate transformer inrush currents without tripping
- Clear transformer secondary short circuits within 100 ms
- Close in response to a Close Command
- Open within 60 ms in response to an Open Command (signal active

when high)

- Open within 60 ms in response to an Trip Command (signal active when low)
- Provide a status output which indicates MCB Closed
- Provide a status output which indicates MCB Open
- Provide a status output which indicates MCB Not Available (vacuum circuit breaker in Test position or vacuum controller disconnect switch in Open position)

A diagram of a vacuum circuit breaker solution is shown in *Figure A-2*. A diagram of a vacuum controller solution is shown in *Figure A-3*.

Figure A-2 Mains Connections — Vacuum Circuit Breaker

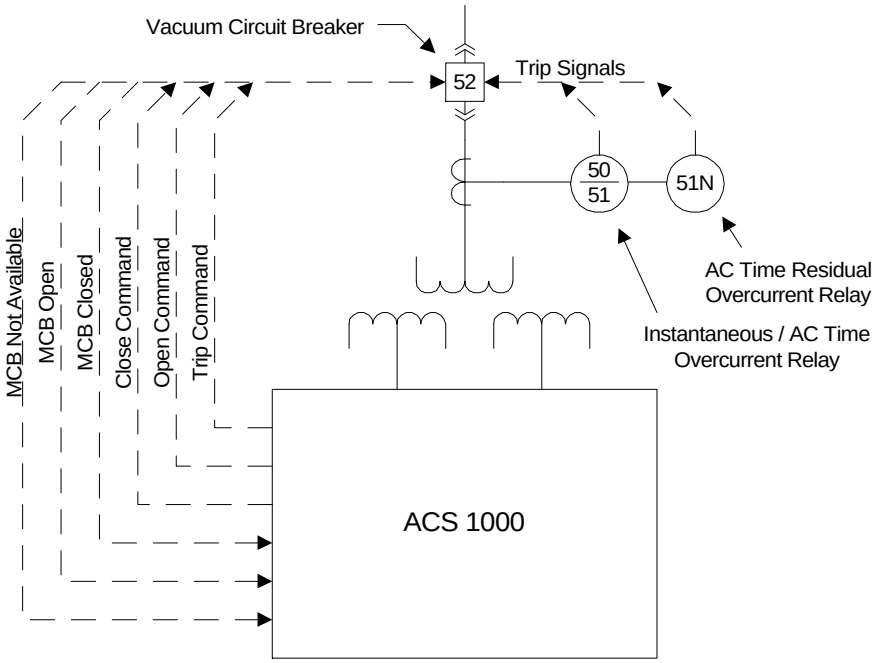
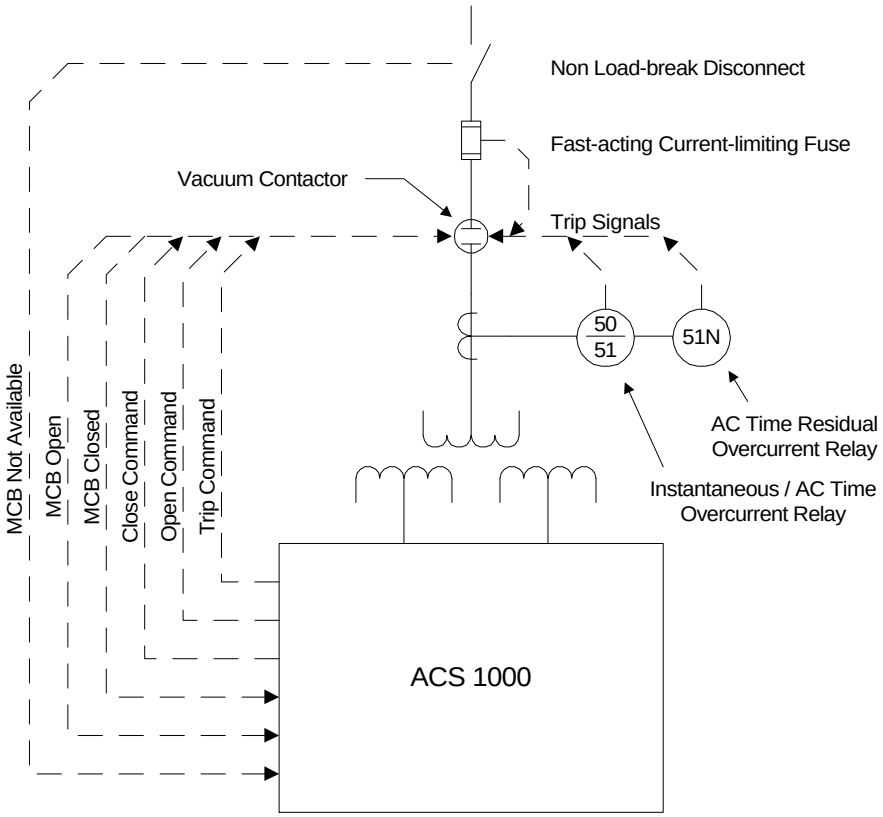


Figure A-3 Mains Connections — Vacuum Controller



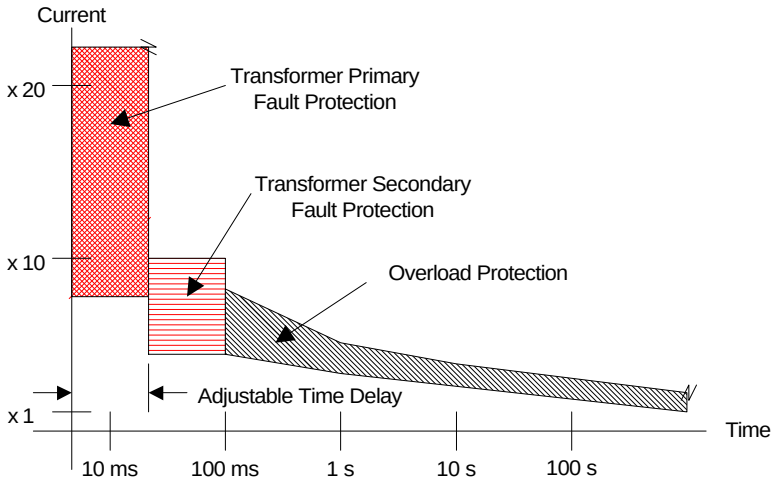
Instrumentation and Protection Equipment

Appropriate current transformers and protection relaying must provide protection for the transformer and the transformer primary cables. The intended approach for protection is shown in *Figure A-4*. As shown in the figure the protection can be considered to consist of three areas. The first area identified as Transformer Primary Fault Protection is an instantaneous trip area that protects against short circuits in the transformer primary windings or in the cables supplying the transformer primary. The lower level of the trip threshold should be adjusted high enough to insure that nuisance tripping does not occur due to transformer inrush currents. The second area identified as Transformer Secondary Fault Protection is a short delay trip area that protects against short circuits in the transformer secondary windings, the cables from the transformer secondaries to the ACS 1000, or in the input rectifier stages of the ACS 1000. The short time delay provided should be adjustable and should be set long enough to insure that the protection does not trip due to transformer inrush current. The trip level should be adjusted low enough to insure that tripping will occur within 100 ms (including MCB delay time) even when transformers with high input impedance are applied. The final area identified as Overload Protection should provide long term overload protection with an inverse time characteristic. This area is intended to protect the transformer and cables from long term overload conditions.

The protection described can be provided with individual protection relays or with a single microprocessor based unit. Required current transformers

should be sized in accordance with the rated current levels of the transformer. Basic protection configuration and connection should be as previously shown in *Figure A-2* and *Figure A-3*.

Figure A-4 Sample Protection Scheme



Cable (Transformer Primary)

The cable from the circuit breaker to the transformer primary has no special requirements. It should carry a voltage rating consistent with the voltage present in the primary circuit. The ampacity rating should be consistent with the size of the transformer being supplied and the protection settings of the protection equipment. Derating of cable ampacity in accordance with maximum expected ambient temperature, raceway fill factors, and any other factors required by local electrical codes should be applied. Installation should be in compliance with standard industry practice for medium voltage equipment.

If required by local electrical code an equipment safety ground wire should be supplied either separately or by including it in the 3 conductor cable. The ampacity of this conductor should be in accordance with the code.

Transformer

All ACS 1000 drives must be supplied from an isolation transformer with multiple phase shifted secondary windings designed in accordance with the pulse number of the input bridge (12 or 24). This transformer may be supplied from ABB with the ACS 1000 or may be supplied through another source in accordance with the specification provided by ABB. The design of the transformer must take into account user line conditions (voltage, short circuit capacity, existing harmonics, etc.) to insure compliance with harmonic standards invoked by the specification. Transformer quality is critical with respect to effecting proper limitation of harmonic currents and voltages. For more information concerning the transformer consult the documentation supplied with the order or reference the transformer specification which was provided when the order was placed.

Cable (Transformer Secondary)

The cables from the transformer secondaries to the ACS 1000 main power input buses are exposed to common mode voltages resulting from normal

inverter operation of the ACS 1000. For this reason it is required that cable rated 5 kV or higher be utilized for all transformer secondary cabling regardless of the transformer secondary voltage rating (1327, 1903, or 2305 VAC). Maximum installed cable length should not exceed 300 meters (1000 feet). In order to insure compliance with EMC requirements, and to provide a low impedance high frequency path through which the common mode currents can flow, a cable with 3 individually shielded conductors is recommended. Shields should be terminated and grounded in as short a distance as possible at both ends. The ACS 1000 includes a vertical ground bus within the cable termination compartment in order to facilitate this.

Non-shielded 3 conductor cable with a continuous corrugated aluminum armor may be used as an alternate to the individually shielded 3 conductor cable described above. Steel armored or interlocked aluminum armored cable should not be used. Connectors with 360° electrical contact to the armor should be used to terminate the cable ends to ground.

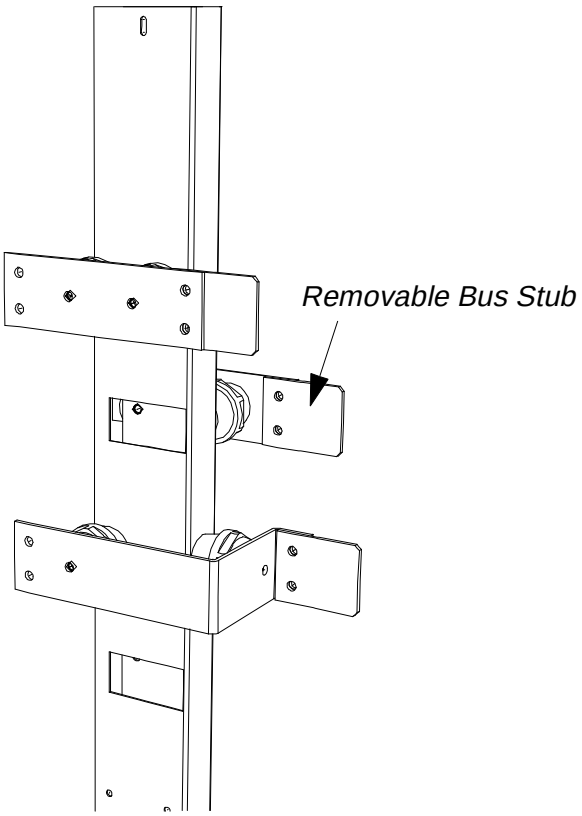
The ampacity rating of the cable should be consistent with 125% of the rated current of the ACS 1000 being supplied (allows for harmonic content) and the protection settings of the protection equipment. Derating of cable ampacity in accordance with maximum expected ambient temperature, raceway fill factors, and any other factors required by local electrical codes should be applied. Installation should be in compliance with standard industry practice for medium voltage equipment.

If required by local electrical code an equipment safety ground wire should be supplied either separately or by including it in the 3 conductor cable. The ampacity of this conductor should be in accordance with the code.

Cable Termination - ACS 1000

Access to the power termination section of the ACS 1000 is through the control cabinet on the left end of the drive. A bolted access door is located behind the control swing frame. Once the access door is opened all power terminations are readily available. As an aid to interfacing the main power connections removable bus stubs are included. *Figure A-5* shows the removable bus stubs mounted to sections of the internal bus system. The stubs are provided without holes. They are intended to be removed and then drilled or punched to match the user’s connection requirements.

Figure A-5 Internal Bus System with Removable Bus Stubs



Motor Connections

The cable from the ACS 1000 to the motor has no special requirements. It can be any length provided that voltage drop is taken into consideration. It should carry a voltage rating consistent with the voltage present in the motor circuit. The ampacity rating should be consistent with the size of the motor being supplied and the overload settings of the motor protection software as input to the ACS 1000. Derating of cable ampacity in accordance with maximum expected ambient temperature, raceway fill factors, and any other factors required by local electrical codes should be applied. Installation should be in compliance with standard industry practice for medium voltage equipment.

If required by local electrical code an equipment safety ground wire should be supplied either separately or by including it in the 3 conductor cable. The ampacity of this conductor should be in accordance with the code.

Motor cables are terminated within the ACS 1000 in the same manor that transformer secondary cables are terminated. See *Cable Termination - ACS 1000* above for further details.

Equipment Grounding

It is recommended that the ACS 1000 ground bus in the bottom of the cabinet be connected to the plant ground bus using a 240 mm^2 (500 MCM) cable.

Control Cables

Control cables should be provided in accordance with *Table A-2*. Cable shields should be terminated on the ACS 1000 end only. Either single or

multiple twisted pair cables may be used. Control cables should not be run with power cables. In air a minimum spacing of 300 mm (12 in.) should be maintained between control and power cables. Where control cables and power cables must pass closer than this they should be physically oriented to cross at 90° with respect to each other.

Table A-2 Control Cable Requirements

Signal Type	General Cable Type	Cross-Section (I/O Termination)
Analog In	Twisted pair(s) - Overall Shield	0.5 to 2.5 mm^2
Analog Out	Twisted pair(s) - Overall Shield	0.5 to 2.5 mm^2
Digital In	Twisted pair(s)	0.5 to 2.5 mm^2
Digital Out	Twisted pair(s)	0.5 to 2.5 mm^2

Transformer Mains Connection

Primary Side Voltage:

On the primary side of the converter input transformer any medium voltage level can be applied.

Secondary / Rectifier Input Voltage (no load):

1327 VAC, 6 phase ± 10% for 2.3 kV motors
1903 VAC, 6 phase ± 10% for 3.3 kV motors
2305 VAC, 6 phase ± 10% for 4.0 kV motors

Safe operation down to -25% with reduced output power.

Phase shift between the two transformer secondary windings: 30°

Frequency: 50..60 Hz

Imbalance: Max. ± 3% of nominal phase to phase input voltage

Fundamental Power Factor (cos φ_1): > 0.97

Total Power Factor (cos φ_T): > 0.95

Maximum Recommended Transformer Cable Length: 300 m (1000 ft.)

Inverter Output / Motor Connection

Nominal Output Voltage (U_{Nom}): 2.3 kV, 3.3 kV, 4.0 kV

Voltage (U_{Out}): 0..U_{Nom}, 3-phase, sinusoidal, symmetrical

Frequency:

for U_{Nom} = 2.3 kV: 0..66 Hz
for U_{Nom} = 3.3 kV: 0..55 Hz (optionally 66 Hz)
for U_{Nom} = 4.0 kV: 0..66 Hz

Frequency Resolution: 0.01 Hz

Short Term Overload Capacity (1 min/10 min): 110% of rated current

Field Weakening Point: 45..66 Hz

Switching Frequency: 1 kHz (3-level inverter operating at 2 x 500 Hz)

Maximum Recommended Motor Cable Length: unlimited (the only limitation is given by the voltage drop over the cable)

Acceleration Time: 0..1800 s

Deceleration Time: 0..1800 s

Efficiency: Approximately 98% at nominal power level

Auxiliary Supply

Auxiliary Voltage Level:

400 VAC, 50 or 60 Hz, 3 phase ± 10% or
480 VAC, 60 Hz, 3 phase ± 10% or
575 VAC, 60 Hz, 3 phase ± 10%.

Auxiliary Power Consumption: approximately 7.3 kW

An uninterruptible power supply (UPS) is not required since ACS 1000 is equipped with an internal UPS for controls.

Ambient Conditions

Operational

Air Temperature: 0..+40 °C (32..104 °F). If the ambient temperature is higher than +40 °C (+104 °F), the output capacity of the ACS 1000 decreases. The maximum output current is calculated by multiplying the current given in the rating table by the derating factor.

Derating factor for enclosure class IP21:

- Above +40 °C (+104 °F), the rated output current is decreased 1.5 % for every additional 1 °C up to +50 °C (+122 °F).

  Example:. If the ambient temperature is 50 °C the derating factor is 100% - 1.5 %/°C · 10 °C = 85%. The maximum output current is then 85% of the rated value.

Relative Humidity: 5..95%, no condensation allowed. Maximum allowed relative humidity is 60% in the presence of corrosive gases.

Contamination Levels (boards without coating):
Chemical gases: IEC 721-3-3, Class 3C2
Solid particles: IEC 721-3-3, Class 3S2

Installation Site Altitude: Nominal output power at 0..2000 m (0..6600 ft.) above sea level. At sites over 2000 m (6600 ft.) above sea level, the maximum output power is derated 1% for every additional 100 m (330 ft.). If the installation site is higher than 3000 m (9900 ft.) above sea level, please contact your local ABB distributor or office for further information.

Vibration: Max. 0.3 mm (2..9 Hz), max. 1 m/s^2 (2..200 Hz) sinusoidal (IEC 721-3-3)

Transportation and Storage

Temperature: -40..+70 °C (-40..+158 °F).

Relative Humidity: Less than 95%, no condensation allowed.

Vibration (Storage): Max. 0.3 mm (2..9 Hz), max. 1 m/s^2 (2..200 Hz) sinusoidal (IEC 721-3-1)

Vibration (Transportation): Max. 3.5 mm (2..9 Hz), max. 10 m/s^2 (2..200 Hz); 15 m/s^2 (200..500 Hz)
sinusoidal (IEC 721-3-2 / 2M2)

Shock (Storage and Transportation): Max. 100 m/s^2, 11 ms (IEC 721-3-2 / 2M2)
Spectrum I

Cooling

Power Losses: <1% of nominal output power

Cooling Method: Air cooling with internal fan or water cooled closed loop

system

Protection Functions

The drive provides many protection, fault and alarm functions including:

- Motor temperature monitoring
- Motor stall
- Underload
- Overspeed
- Undervoltage
- Battery condition monitoring
- Motor phase loss
- Overvoltage
- Short circuit in the rectifier bridge
- Charging fault
- Supply phase loss
- Overcurrent
- Short circuit of the inverter
- Measurement loss
- Communication fault

Analog Inputs

Floating, galvanically isolated Inputs:

- **Signal Level:** 0..20 mA / 4..20 mA or 0..10 V / 2..10 V, individually configurable
- **Input Resistance:** R_{in} = 100 Ω for current input
  R_{in} = 210 kΩ for voltage input

Isolation Voltage: 350 VAC

Common Mode Rejection Ratio: ≥ 70 dB at 50 Hz

Resolution: 0.1% (10 bit)

Accuracy: ± 0.25% (Full Scale Range) at 25 °C (±50 mV offset).

Protection: up to 250 VAC/DC

Input Updating Time: 100 ms (with standard application software)

Terminal Block Size: Cables 0.5..2.5 mm^2 (up to AWG12)

Analog Outputs

Floating, galvanically isolated Current Outputs:

Signal Level: 0..20 mA / 4.. 20 mA

Resolution: 0.1% (10 bit)

Accuracy: ± 0.25% (Full Scale Range) at 25 °C.

Maximum Load Resistance: 250 Ω

Output Updating Time: 250 ms (with standard application software)

Terminal Block Size: Cables 0.5..2.5 mm^2 (up to AWG12)

Digital Inputs

Floating, galvanically isolated Inputs:

Signal Level: 22..250 VAC / 22..150 VDC

Logical Thresholds: < 16 VAC/DC ≙ "0", > 20 VAC/DC ≙ "1"

Input Current: at 24 V: 13 mA, at 250 V: 10 mA

Filtering Time Constant: 20 ms

Isolation: Individually isolated

Isolation Test Voltage: 500 VAC, 1 minute

Input Updating Time: 250 ms (with standard application software)

Terminal Block Size: Cables 0.5..2.5 mm^2 (up to AWG12)

An internal or external 120 VAC or 240 VAC supply can be used instead of the internal 24 VDC supply.

Relay Outputs

Switching Capacity:

AC: 6 A switching, 4 A steady state up to 250 V
DC: at 24 V: 6 A, at 48 V: 1A, at 120 V: 0.3 A

Contacts: Encapsulated Contacts

Isolation Test Voltage: 4 kVAC, 1 minute

Output Updating Time: 250 ms (with standard application software)

Terminal Block Size: Cables 0.5..2.5 mm^2 (up to AWG12)

Auxiliary Power Output

Voltage: 24 VDC ± 10%

Maximum Current: 2x180 mA

Protection: Short circuit proof

Terminal Block Size: Cables 0.5..2.5 mm^2 (up to AWG12)

This voltage can be used for the ACS 1000 digital inputs and / or to supply external measurement transmitters for analog inputs.

DDCS Fiber Optic Link

A high speed, DDCS protocol fiber optic serial data bus.

Connectors: A pair of fiber optic connectors (transmitter and receiver)

Fiber Optic Cable: Plastic core optic fiber, Ø 1 mm (0.04 in.), max. length 10 m (33 ft.), minimum bend radius 25 mm (1 in.) (short-term) or 35 mm (1.4 in.) (long-term)

Enclosures

Enclosure Classes:

IP21 (for air cooled converters)
IP31 (for water cooled converters)

optional:
IP42 (for air cooled converters)
IP54 (for water cooled converters)

Application Macros

FACTORY for basic industrial applications

HAND/AUTO for local and remote operation

PID CONTROL for closed loop processes

TORQUE CONTROL for processes that require torque control

SEQUENTIAL CONTROL for operation at preset constant speeds

USER MACRO 1 & 2 for user's own customized parameter settings.

Appendix C - Dimensions and Weights

Dimensions and weights of the ACS 1000 frequency converter range are given in *Table C-1* to *Table C-3*. Those dimensions and weights do not include any converter options.

Table C-1 Dimensions and Weights of the ACS 1000 converter, Motor Voltage 2.3 kV

Motor voltage (kV)	ACS 1000 Type	Type of cooling	Dimensions and weights							
			Length		Depth		Height		Weight**	
			(mm)	(ft/in)	(mm)	(ft/in)	(mm)	(ft/in)	(kg)	(lbs)
2.3	**ACS1012-A1-A0-00**	Air								
2.3	**ACS1012-A1-B0-00**	Air								
2.3	**ACS1012-A1-C0-00**	Air								
2.3	**ACS1012-A1-D0-00**	Air								
2.3	**ACS1012-A1-E0-00**	Air								
2.3	**ACS1012-A1-F0-00**	Air								
2.3	**ACS1012-A1-G0-00**	Air								
2.3	**ACS1012-A1-H0-00**	Air							**1600**	3530
2.3	**ACS1012-A2-J0-00**	Air								
2.3	**ACS1012-A2-K0-00**	Air							**1750**	3860
2.3	**ACS1012-A3-L0-00**	Air								
2.3	**ACS1012-A3-M0-00**	Air								
2.3	**ACS1012-A3-N0-00**	Air	**3000**	9' 10"	**900**	3' 0"	**2000 ***	6' 7" *	**2000**	4410
2.3	**ACS1012-W1-P0-00**	Water								
2.3	**ACS1012-W1-Q0-00**	Water	**4000**	13' 2"	**900**	3' 0"	**2000**	6' 7"	**3000**	6620
2.3	**ACS1012-W2-R0-00**	Water								
2.3	**ACS1012-W2-S0-00**	Water	**4500**	14' 9"	**900**	3' 0"	**2000**	6' 7"	**3200**	7060

* without air-exhaust cover

** approximate values

Table C-2 Dimensions and Weights of the ACS 1000 converter, Motor Voltage 3.3 kV

Motor voltage (kV)	ACS 1000 Type	Type of cooling	Dimensions and weights							
			Length		Depth		Height		Weight**	
			(mm)	(ft/in)	(mm)	(ft/in)	(mm)	(ft/in)	(kg)	(lbs)
3.3	**ACS1013-A1-A0-00**	Air								
3.3	**ACS1013-A1-B0-00**	Air								
3.3	**ACS1013-A1-C0-00**	Air								
3.3	**ACS1013-A1-D0-00**	Air								
3.3	**ACS1013-A1-E0-00**	Air								
3.3	**ACS1013-A1-F0-00**	Air								
3.3	**ACS1013-A1-G0-00**	Air								
3.3	**ACS1013-A1-H0-00**	Air							**1600**	3530
3.3	**ACS1013-A2-J0-00**	Air								
3.3	**ACS1013-A2-K0-00**	Air								
3.3	**ACS1013-A2-L0-00**	Air								
3.3	**ACS1013-A2-M0-00**	Air								
3.3	**ACS1013-A2-N0-00**	Air								
3.3	**ACS1013-A2-P0-00**	Air							**1750**	3860
3.3	**ACS1013-A3-Q0-00**	Air								
3.3	**ACS1013-A3-R0-00**	Air	**3000**	9' 10''	**900**	3' 0''	**2000 ***	6' 7'' *	**2000**	4410
3.3	**ACS1013-W1-S0-00**	Water								
3.3	**ACS1013-W1-T0-00**	Water								
3.3	**ACS1013-W1-U0-00**	Water	**4000**	13' 2''	**900**	3' 0''	**2000**	6' 7''	**3000**	6620
3.3	**ACS1013-W2-V0-00**	Water								
3.3	**ACS1013-W2-W0-00**	Water								
3.3	**ACS1013-W2-X0-00**	Water								
3.3	**ACS1013-W2-Y0-00**	Water								
3.3	**ACS1013-W3-Z0-00**	Water								
3.3	**ACS1013-W3-10-00**	Water	**4500**	14' 9''	**900**	3' 0''	**2000**	6' 7''	**3400**	7500

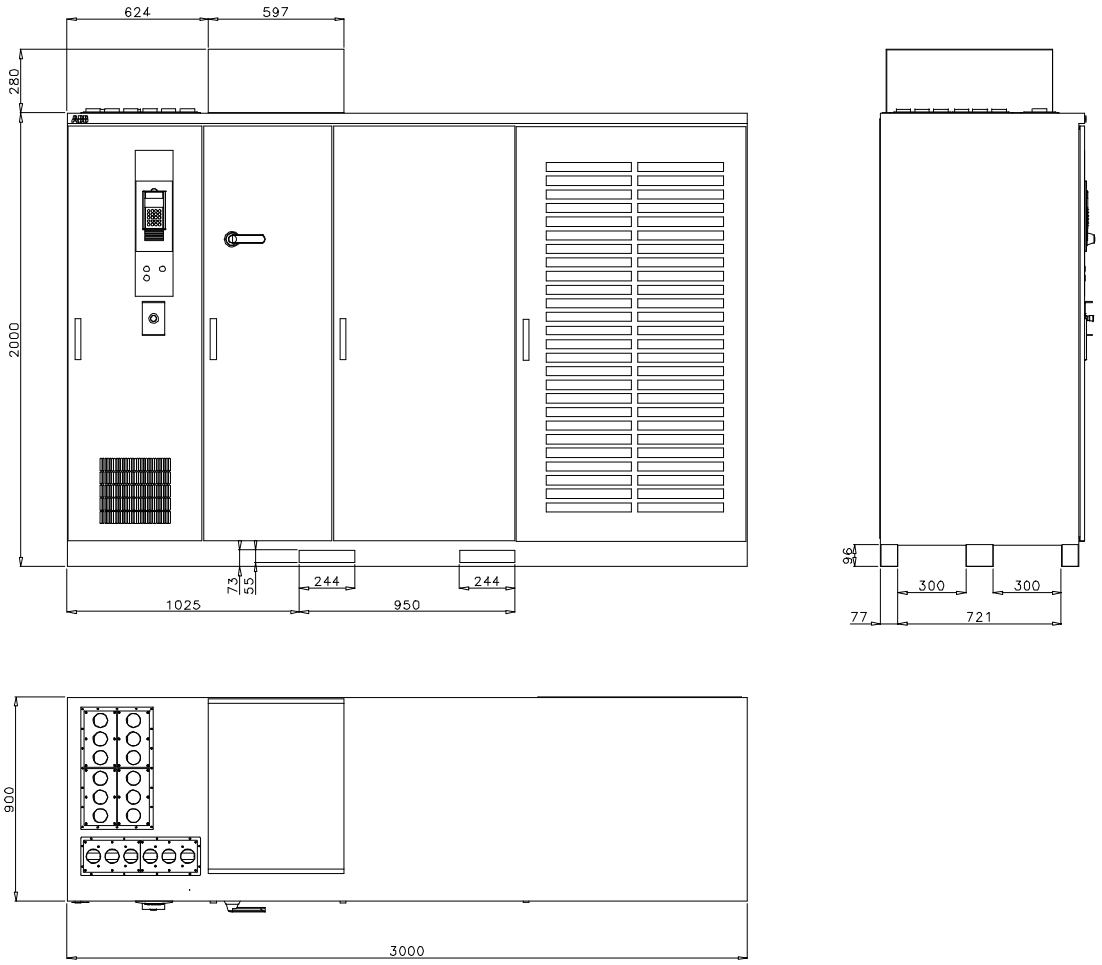
* without air-exhaust cover
** approximate values

Table C-3 Dimensions and Weights of the ACS 1000 converter, Motor Voltage 4.16 kV

Motor voltage (kV)	ACS 1000 Type	Type of cooling	Dimensions and weights							
			Length		Depth		Height		Weight**	
			(mm)	(ft/in)	(mm)	(ft/in)	(mm)	(ft/in)	(kg)	(lbs)
4.0	**ACS1014-A1-A0-00**	Air								
4.0	**ACS1014-A1-B0-00**	Air								
4.0	**ACS1014-A1-C0-00**	Air								
4.0	**ACS1014-A1-D0-00**	Air								
4.0	**ACS1014-A1-E0-00**	Air								
4.0	**ACS1014-A1-F0-00**	Air								
4.0	**ACS1014-A1-G0-00**	Air								
4.0	**ACS1014-A1-H0-00**	Air							**1600**	3530
4.0	**ACS1014-A2-J0-00**	Air								
4.0	**ACS1014-A2-K0-00**	Air							**1750**	3860
4.0	**ACS1014-A3-L0-00**	Air								
4.0	**ACS1014-A3-M0-00**	Air								
4.0	**ACS1014-A3-N0-00**	Air	**3000**	9' 10''	**900**	3' 0''	**2000 ***	6' 7'' *	**2000**	4410
4.0	**ACS1014-W1-P0-00**	Water								
4.0	**ACS1014-W1-Q0-00**	Water	**4000**	13' 2''	**900**	3' 0''	**2000**	6' 7''	**3000**	6620
4.0	**ACS1014-W2-R0-00**	Water								
4.0	**ACS1014-W2-S0-00**	Water								
4.0	**ACS1014-W2-T0-00**	Water								
4.0	**ACS1014-W2-U0-00**	Water							**3200**	7060
4.0	**ACS1014-W3-V0-00**	Water								
4.0	**ACS1014-W3-W0-00**	Water								
4.0	**ACS1014-W3-X0-00**	Water	**4500**	14' 9''	**900**	3' 0''	**2000**	6' 7''	**3400**	7500

* without air-exhaust cover
** approximate values

Figure C-1 Dimensions of the ACS 1000, Air Cooled Type (all values in mm)



Appendix D - CE Marking

CE Marking

The ACS 1000 frequency converter is marked with a CE symbol. The CE marking indicates that the ACS 1000 complies with the essential requirements of relevant EU Directives.

The CE marking is mainly for the benefit of authorities throughout the common European market.

Low Voltage Directive

73/23 EEC modified by 93/68 EEC.

This directive concerns all electrical equipment with nominal voltage levels from 50..1000 VAC and 75..1500 VDC.

The aim of the directive is to protect against electrical, mechanical, fire and radiation hazards. It tries to insure that safe products are placed on the market.

Compliance with the Low Voltage Directive

The ACS 1000 fully complies with the Low Voltage Directive as far as enclosure, auxiliary supply and I/O ports are concerned. The Declaration of Conformity will be enclosed in the ACS 1000 delivery.

The Low Voltage Directive is not applicable for the medium-voltage section of the ACS 1000. However, the medium-voltage section fulfills the requirements of the standard EN 50178 (Electronic equipment for use in power installations).

Machinery Directive

89/392 EEC modified by 91/368; 93/44 and 93/68 EEC.

This directive concerns all combinations of mechanically joined components, where at least one part is moving.

Compliance with the Machinery Directive

On its own, the ACS 1000 does not have a functional value to the user: It always needs its motor coupled to the driven load before it can function effectively.

Therefore, the Machinery Directive is not applicable for the ACS 1000.

EMC Directive

89/336 EEC modified by 91/263; 92/31; and 93/68 EEC.

EMC stands for **E**lectro**m**agnetic **C**ompatibility. It is the ability of electrical/electronic equipment to operate without problems within an electromag-

netic environment. Likewise, the equipment must not disturb or interfere with any other neighboring product or system.

Emissions The source of high-frequency emission of frequency converters is fast switching of IGCTs and control electronics. The high-frequency emission can propagate by conduction and radiation.

Immunity Electrical equipment should be immune to high-frequency and low-frequency phenomena. High-frequency phenomena include electrostatic discharge (ESD), fast transient burst, radiating electromagnetic field, conducting radio frequency disturbance and electrical surge. Typical low frequency phenomena are mains voltage harmonics, notches and imbalance.

Compliance with the EMC Directive The EMC Directive applies to the ACS 1000 as far as the enclosure, the auxiliary supply and the I/O ports are concerned. The Declaration of Conformity for industrial environment signed by ABB is enclosed in the ACS 1000 delivery. The two standards, EN 50081-2 (emissions) and EN 50082-2 (immunity) have been applied.

As far as the medium-voltage ports are concerned the EMC Directive is not applicable. The standard IEC 1800-3: Adjustable speed electrical power drive systems - Part 3: EMC product standard including specific test methods, states: “For supply voltages higher than 1000 VAC rms, EMC requirements result from agreement between manufacturer / supplier and user.”

In order to make sure that the whole system is electromagnetically compatible within its surrounding the installation regulations have to be strictly observed. Following the grounding regulations, instructions for cable entries as well as for cable laying is extremely important.

The ACS 1000 is installed with screened control and main power supply cables that are specified in *Appendix A - Installation Guidelines*.

The installation of the ACS 1000 shall be performed as described in the *ACS 1000 User’s Manual*.

Appendix E - Applicable Codes and Standards

The ACS 1000 complies with the following codes and standards:

- IEC 22B/88/CD:1995-06 — Draft revision of IEC 146-2: Self-commutated convertors including direct DC convertors and IEC 146-3: Semiconductors direct DC convertors DC chopper convertors.
- IEC 146-1-1: 1991 — Semiconductor convertors
- IEC 529: 1989 — Degrees for protection provided by enclosures (IP-Code)
- IEC 664-1: 1992 — Insulation coordination for equipment within low-voltage systems
- IEC 721-3-1 A1 1991 — Classification of environmental conditions Part 3: Storage
- IEC 721-3-2 A2:1993 — Classification of environmental conditions Part 3: Transportation
- IEC 721-3-3 A1: 1995 — Classification of environmental conditions Part 3: Stationary use at weatherprotected locations
- IEC 1000-4-2 — Electrostatic discharge (ESD)
  - contact discharge 4 kV
  - air discharge 8 kV
- IEC 1000-4-4 — Fast Transient (Burst)
  - Aux-Supply Power-Ports: 2 kV, 5 kHz
  - Signal-Ports: 2 kV, 5 kHz
- IEC 1000-4-5 — Surge
  - Aux-Supply Power Ports
    - Line to Line 2 kV
    - Line to Earth 4 kV
  - Signal-Ports 1 kV
- EN 50081-2: 1993 — Electromagnetic compatibility (EMC) generic emission standard part 2: Industrial environment
- EN 50082-2: 1995 — Electromagnetic compatibility (EMC) generic immunity standard part 2: Industrial environment
- prEN 50178: 1996 — Electronic equipment for use in power installations; Final Draft

• EN55011:1991; A2:1996	Suppression of Radio disturbances caused by electrical appliances and systems - aux-Supply Power-Ports conducted emission 0.15 - 30 MHz Class A
• ENV 50141	Radio frequency common mode - Aux-Supply Power-Ports - Signal-Ports AM 0.15 - 80 MHz 10 V (rms)
• UL 347: 1993	High Voltage Industrial Control Equipment
• UL 347A	Medium Voltage Power Conversion Equipment Proposed first edition of the standard
• UL 508C: 1994	Power Conversion Equipment

Appendix F - ACS 1000 Type Code Sheet

Example: ACS1014-A1-BH-00-F210-1T0A-0C10-0142-000C0

1 [A]

Product Category

A = AC Drive

2/3 [C][S]

Product Type

CS = Standard xx = OEM

4 [1]

ACS Product Family

1 = ACS 1000

5 [0]

Not used

6 [1]

Input Bridge

0 = 6-Pulse Rectifier 1 = 12 Pulse Rectifier 4 = 24-Pulse Rect. with Integrated Transformer
3 = 12-Pulse Rect. with integrated Transformer 2 = 24 Pulse Rectifier 5 = Regenerative

7 [ ] -

Voltage Rating

2 = 2.3 kV 3 = 3.3 kV 4 = 4.16 kV 6 = 6 kV 7 = Higher Voltage w. Step-up Transformer

8/9 [ ][ ] -

Frame Size

A1, A2 and A3 for air cooled converters W1, W2 and W3 for water cooled converters

10 [ ]

Sub-Frame Size ***See Option Sheet***

See ACS 1000 rating tables

11 [ ] -

Heavy Duty Use and Extended Ambient Temperature

0 = None H = Heavy Duty Use E = Extended Ambient Temperature
B = Heavy Duty Use and Extended Ambient Temperature

12 [0]

Maximum Output Frequency

0 = 66 Hz for 2.3kV and 4.0kV, resp. 55 Hz for 3.3kV (Standard) x = Other options will follow later

13 [0] -

Field Weakening

0 = Standard x = Other options will follow later

14/15 [F][ ]

Output Filter Choke

Output Filters are motor specifically selected

16/17 [ ][ ] -

Output Filter Capacitor

Output Filters are motor specifically selected

18 [ ]

Auxiliary Voltage Rating (indicated values +/- 10%)

1 = 400 VAC / 50 Hz 2 = 480 VAC / 60 Hz 3 = 575 VAC / 60 Hz 4 = 400 VAC / 60 Hz

19 [ ]

Pulse Encoder Interface / Positioning Module

0 = None T = Pulse Encoder Interface P = Positioning Module

20 [ ]

Additional I/O Boards ***See Option Sheet***

0 = None x = Option module included

21 [ ] -

Fieldbus Adapter Modules ***See Option Sheet***

0 = None x = Fieldbus adapter module included

22 [0] **Additional Environmental Requirements** *See Option Sheet*
0 = None x = Environmental requirements included

23 [ ] **Bus bars**
C = Copper Bus Bars (standard) T = Tinned Bus Bars N = Nickeled Bus Bars

24 [1] **Enclosure Class**
1 = IP 21 (air cooled standard) 3 = IP 31 (water cooled standard)
4 = IP 42 (for air cooled conv. only) 5 = IP 54 (for air cooled and water cooled conv.)

25 [0] - **Input and Output Options** *See Option Sheet*
0 = None x = Input and Output Options included

26 [0] **Bypass** *See Option Sheet*
0 = None x = Bypass Option included

27 [ ] **Motor Space Heater** *See Option Sheet*
0 = None x = Auxiliary Circuit Breaker included

28 [ ] **Motor Cooling Fan/Pump** *See Option Sheet*
0 = None x = Auxiliary Motor Starter included

29 [ ] - **Converter Cooling** *See Option Sheet*
0 = None x = Converter Cooling Options included

30 [0] **Glycol for internal water cooling circuit**
0 = None 1 = 10% Glycol 2 = 20% Glycol 3 = ...

31 [0] **Water / Air Heat Exchanger for water cooled converter**
0 = None x = Water / air heat exchanger for water cooled converter

32 [0] **Resistor Braking Equipment**
0 = None x = Braking chopper incl. braking resistor for 67% braking power

33 [ ] **Other Options** *See Option Sheet*
0 = Electro-mechanical Interlocking (Standard) x = Other Options included

34 [ ] - **Colors** *See Option Sheet*
0 = RAL 7035 light grey (Standard) x = Color options included

35/36 [ ][ ] **Language of Labels**
EN = English (Standard)
NL = Dutch DE = German PT = Portuguese
FI = Finish IT = Italian ES = Spanish
FR = French NW = Norwegian SE = Swedish

[ ] Not Available at the time of printing

Option Sheet

Type Code Pos. 10 Sub Frame Sizes

Motor power ratings

2.3 kV	Power in HP	3.3 kV	Power in kW	4.0 kV	Power in HP
A	400	**A**	315	**A**	400
B	450	**B**	355	**B**	450
C	500	**C**	400	**C**	500
D	600	**D**	450	**D**	600
E	700	**E**	500	**E**	700
F	800	**F**	560	**F**	800
G	900	**G**	630	**G**	900
H	1000	**H**	710	**H**	1000
J	1250	**J**	800	**J**	1250
K	1500	**K**	900	**K**	1500
L	1750	**L**	1000	**L**	1750
M	2000	**M**	1120	**M**	2000
N	2250	**N**	1250	**N**	2250
P	2500	**P**	1400	**P**	2500
Q	3000	**Q**	1600	**Q**	3000
R	3500	**R**	1800	**R**	3500
S	4000	**S**	2000	**S**	4000
		T	2250	**T**	4500
		U	2500	**U**	5000
		V	2800	**V**	5500
		W	3150	**W**	6000
		X	3550	**X**	6500
		Y	4000		
		Z	4500		
		1	5000		

Type Code Pos. 20 Additional I/O-Boards

Available options:

1 IOEC-Board 3 (implements External Transformer/Motor Protection and Input Voltage Imbalance Supervision)

2 IOEC-Board 4 (to be selected if any of Pos. 25, any of Pos. 26, Pos. 31 or Pos. 32 is choosen)

3 Optional Voltage Converter (DC/AC) 120 VAC

4 Optional Voltage Converter (DC/AC) 240 VAC

Available combinations:

Type Code	Combination	Type Code	Combination	Type Code	Combination
A	1	**E**	1 + 2	**J**	2 + 4
B	2	**F**	1 + 3	**K**	1 + 2 + 3
C	3	**G**	1 + 4	**L**	1 + 2 + 4
D	4	**H**	2 + 3		

Type Code Pos. 21 Fieldbus adapter modules

A	Profibus DP	**L**	Mitsubishi
B	Profibus FMS	**M**	Allen-Bradley DF1
C	Interbus-S	**N**	Allen-Bradley Datahighway
D	Modbus	**P**	Allen-Bradley Datahighway plus
E	Modbus+	**R**	Allen-Bradley Ethernet
G	ABB Advant Fieldbus 100	**S**	ABB SAMI Protocol
H	Allen-Bradley DeviceNet	**T**	ABB Procontrol P
J	ABB Procontic CS31	**U**	CAN Bus

Type Code Pos. 22	Additional Environmental Requirements
1	Vibration absorbing carpet
2	Ex-Zone signal interface for all motor measurements (Zener Barriers)
3	Coated printed circuit boards
4	1 and 2
5	1 and 3
6	2 and 3
7	1 and 2 and 3

Type Code Pos. 25	Input and Output Options
1	Input Isolator complete with additional cubicle, manually operated
2	Output Isolator complete with additional cubicle, manually operated
3	1 and 2 in common additional cubicle

Type Code Pos. 26	Bypass
I	Non synchronised Converter Bypass Control, only necessary Software and I/Os
M	Non synchronised Converter Bypass complete incl. all Software, I/Os and manual Bypass Switches
A	Non synchronised Converter Bypass complete incl. all Software, I/Os and automatic Bypass Switches
S	Synchronised Converter Bypass Control, only necessary Software, I/Os and Synchrotact
T	Synchronised Converter Bypass complete incl. all Software, I/Os, Synchrotact and Bypass Switches

Type Code Pos. 27	Motor Space Heater (single phase supply)
1	Circuit Breaker for a motor space heater (0.5 A)
2	Circuit Breaker for a motor space heater (1.0 A)
3	Circuit Breaker for a motor space heater (2.0 A)
4	Circuit Breaker for a motor space heater (3.0 A)
5	Circuit Breaker for a motor space heater (4.0 A)
6	Circuit Breaker for a motor space heater (6.0 A)

Type Code Pos. 28	Motor Cooling Fan/Pump (three phase supply)
1	Motor Starter for a cooling fan/pump (2.5 - 4.0 A)
2	Motor Starter for a cooling fan/pump (4.0 - 6.3 A)
3	Motor Starter for a cooling fan/pump (6.3 - 10.0 A)

Type Code Pos. 29 Converter Cooling

Available options:

For air cooled converters

1 Redundant cooling fan for air cooled converter
2 Converter space heater for tropicalized version
3 Air filter with supervision

Available combinations:

Type Code	Combination	Type Code	Combination
A	1	**D**	3
B	2	**E**	1 + 3
C	1 + 2	**F**	2 + 3
		G	1 + 2 + 3

Type Code Pos. 29 Continued

For water cooled converters

1 Redundant cooling pump for water cooled converters
2 Converter space heater for tropicalized version
3 Incoming cooling water temperature > 27° up to max. 38°C
4 Salt water resistant cooling unit for water cooled converters
5 Pressurised cubicle with water cooling

Available combinations:

Type Code	Combination	Type Code	Combination	Type Code	Combination
A	1	**H**	A + 4	**R**	D + 5
B	2	**J**	A + 5	**S**	E + 4
C	3	**K**	B + 4	**T**	E + 5
D	1 + 2	**L**	B + 5	**U**	F + 4
E	1 + 3	**M**	C + 4	**V**	F + 5
F	2 + 3	**N**	C + 5	**W**	G + 4
G	1 + 2 + 3	**P**	D + 4	**X**	G + 5

Type Code Pos. 33 Other Options

Available Options

0 Electro-mechanical Interlocking of cubicle doors (failsafe) (Standard)
1 not used
2 KIRK-key cubicle interlocking system
3 20% Spare Terminals

Available combinations:

Type Code	Combination	Type Code	Combination	Type Code	Combination
0	0	**B**	2	**D**	3 + 1
A	1	**C**	3 + 0	**E**	3 + 2

Type Code Pos. 34 Colors

0	RAL 7035 light grey (Standard)
1	Other RAL color
2	External surfaces of the whole cubicle painted in RAL 7035
3	External surfaces of the whole cubicle painted in another RAL color