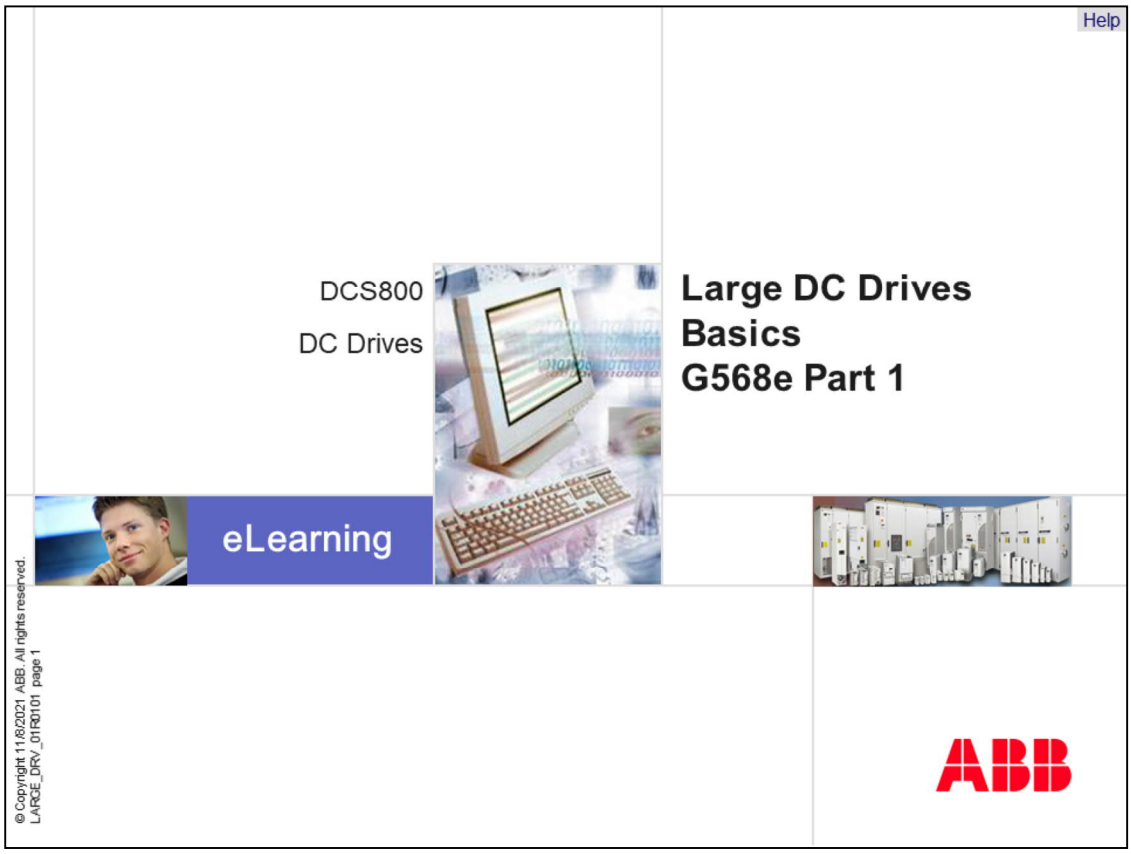
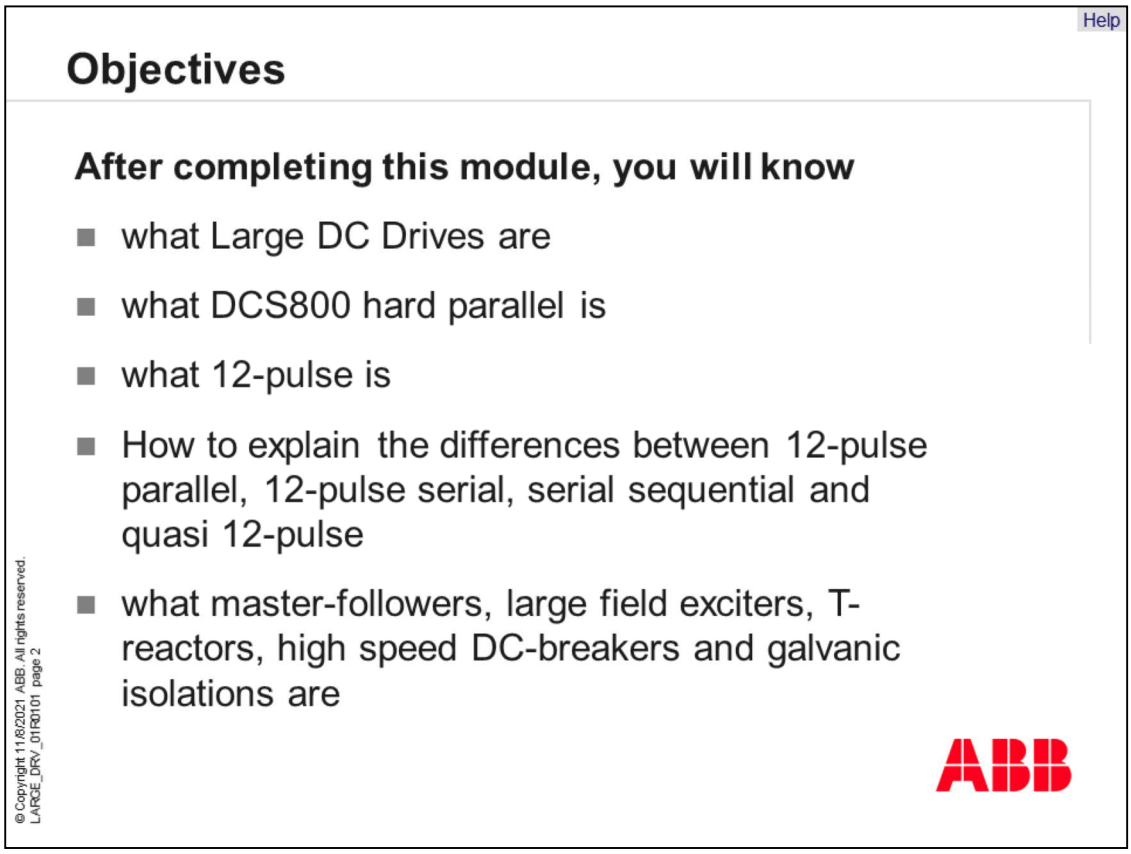


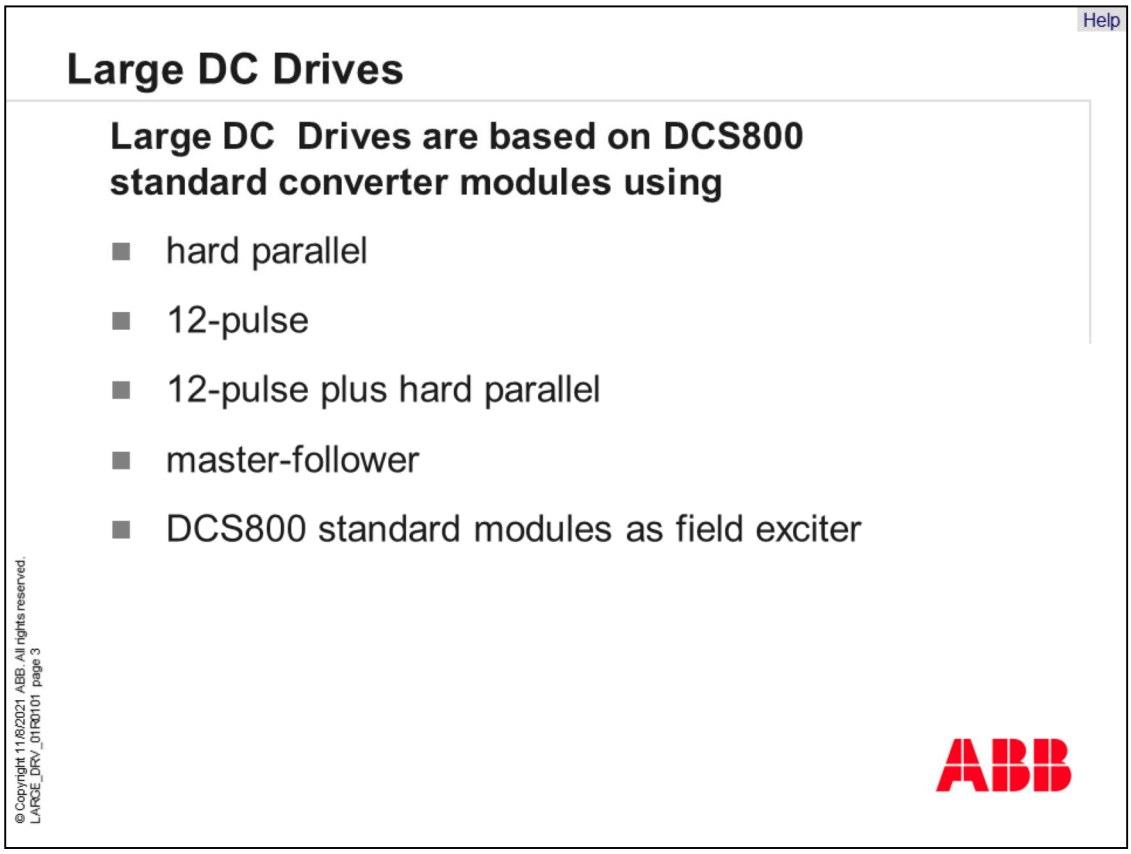
Welcome to the Large DC Drives Basic training module for the DCS800, ABB DC Drives.

If you need help navigating this module, please click the Help button in the top right-hand corner. To view the presenter notes as text, please click the Notes button in the bottom right corner.



After completing this module, you will know

- what Large DC Drives are
- what DCS800 hard parallel is,
- what 12-pulse is,
- how to explain the differences between 12-pulse parallel, 12-pulse serial, serial sequential and quasi 12-pulse, and
- what master-followers, large field exciters, T-reactors, high speed DC-breakers and galvanic isolations are.



Large DC Drives are used to drive the mechanics of very large installations for example mill stands, mine hoists, etc.

The range of standard ABB converter modules is from 20 A to 5200 A with supply voltages from 230 VAC to 1000 VAC. It is possible to increase the power and torque of several different applications.

The power and current can be increased by connecting several converter modules in hard parallel.

The power and current can be increased by connecting two converter modules in 12-pulse parallel.

The power and voltage can be increased by connecting two converter modules in 12-pulse serial.

The power can also be increased by combining both hard parallel and 12-pulse.

It is also possible to increase the power by using two or more motors. An example of this is that the motors are mounted on one shaft. All drives are controlled by one master. This configuration is called master-follower.

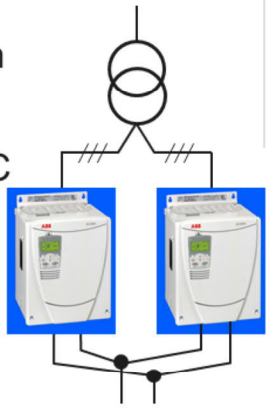
Standard ABB field exciters supply a maximum field current of 60 A. Large motors need higher field currents. Standard DCS800 converter modules are used to supply field currents up to 520 A.

Help

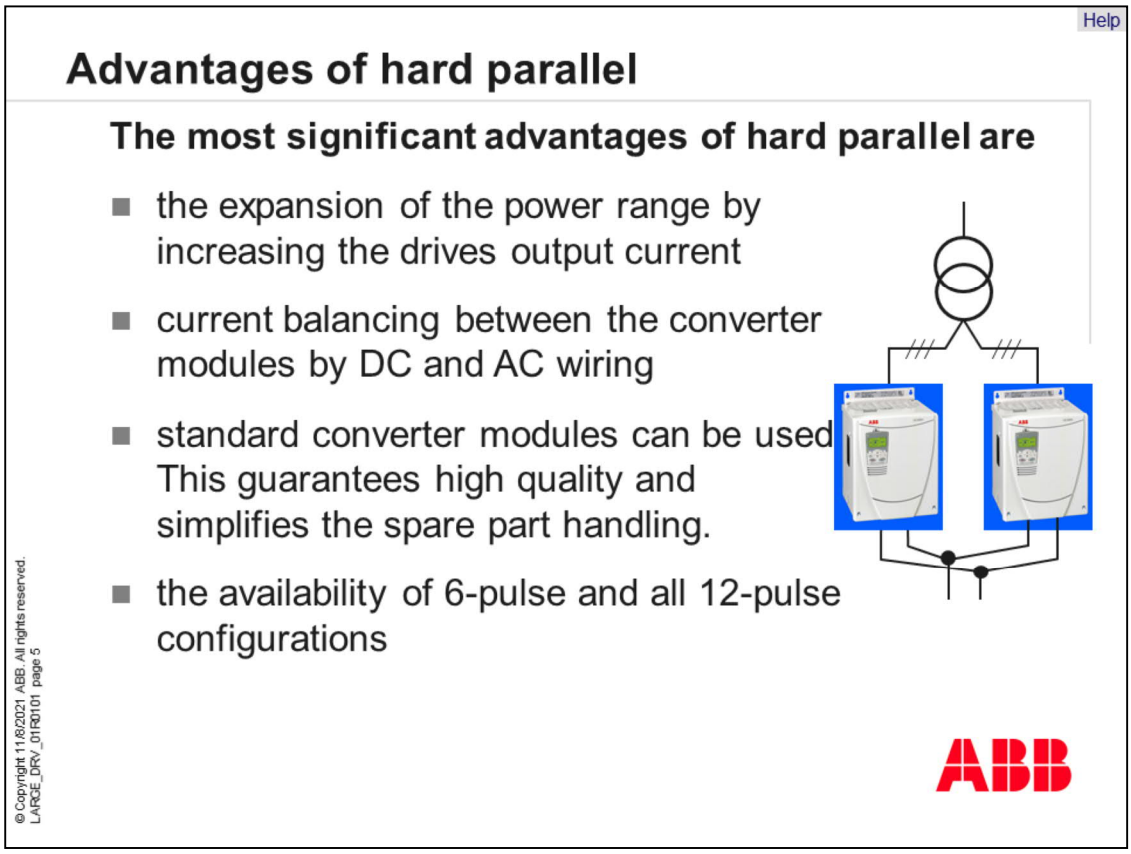
What is hard parallel?

The characteristics are

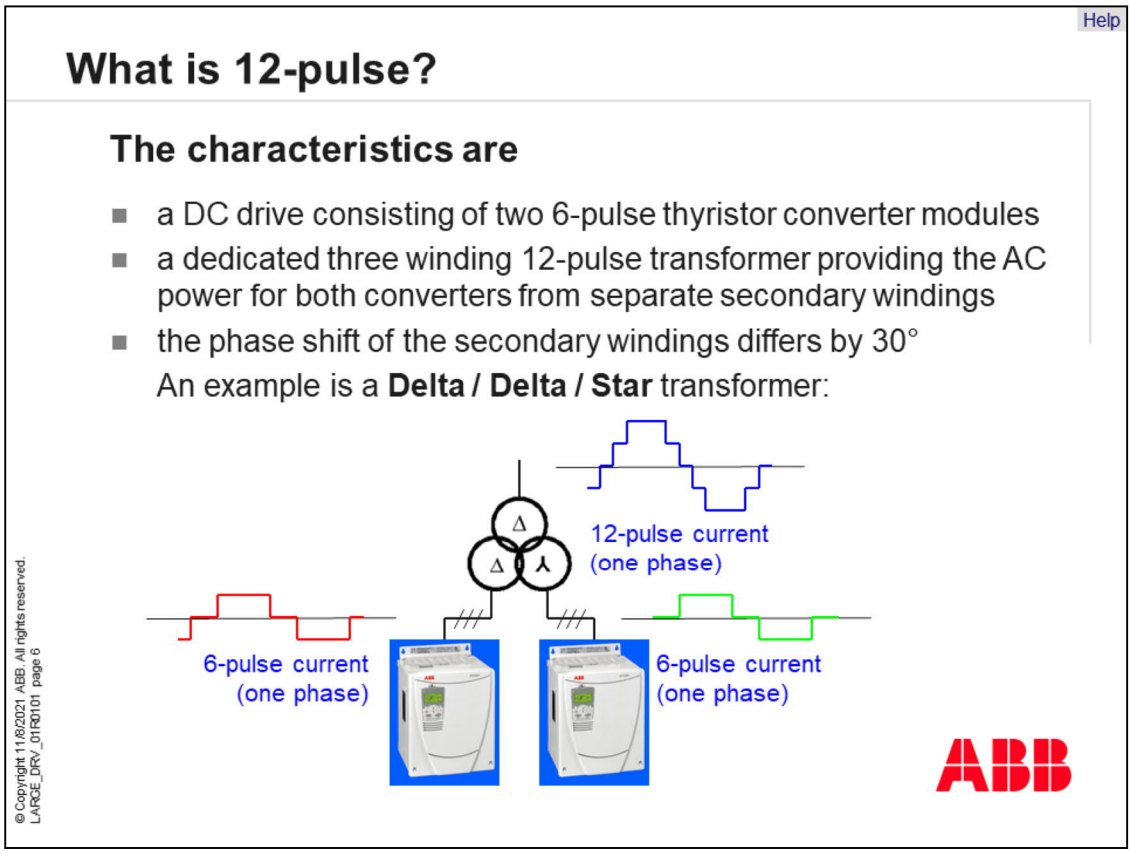
- a DC drive consisting of two to four thyristor converter modules connected in parallel
- a dedicated transformer providing the AC power for all converters from one single secondary winding
- all converter modules are controlled by one paralleling master
- current balancing between the converter modules is done by wiring



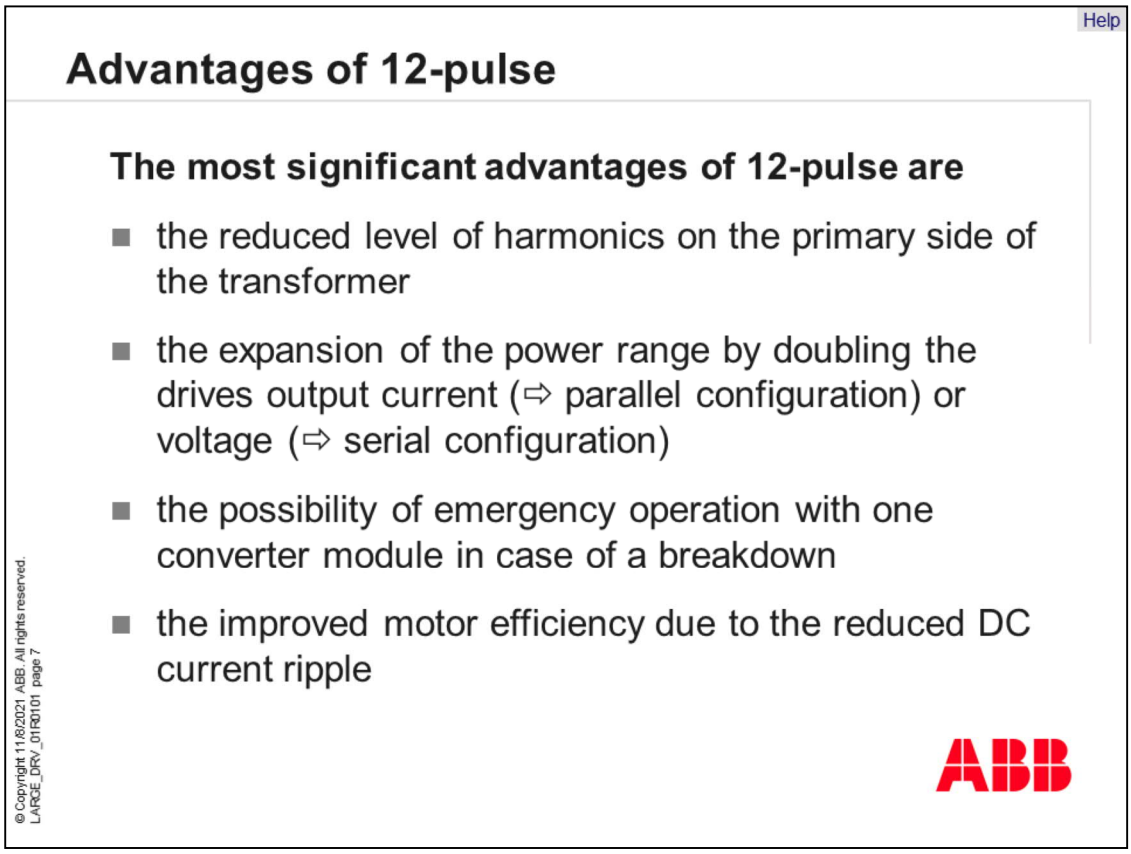
- A hard parallel DC Drive consists of two to four thyristor converter modules. The mains and the DC are connected in parallel.
- All modules are connected to a dedicated transformer. The only function of the transformer is to supply all of the converter modules, thus the name dedicated transformer.
- All converter modules are controlled by one paralleling master. Special hardware is used for this hard parallel master-slave communication.
- The current balancing between the converter modules is done by the DC and AC wiring. On the AC side, split and symmetrical cables, at least 3 m in length, have to be used. On the DC side, split cables of at least 3 m have to be used.



- Up to four converter modules can be connected in parallel. Thus, the power can be doubled, tripled or quadrupled by simply increasing the current.
- The current balancing between the converter modules is done by the DC and AC wiring. The AC wiring of each converter module is split on the secondary side of the transformer. All cables have to have the same length and must be routed symmetrically. The cables for DC wiring have to have the same length. No symmetrical routing is needed.
- The advantage of this design is the use of standard converter modules from the series production. Selected thyristors are not necessary anymore. This increases the quality, because converter modules from the series production can be used. Also, the spare part handling is easier, since standard spare parts can be used.
- Hard parallel is available for 6-pulse, 12-pulse parallel, 12-pulse serial, serial sequential and quasi 12-pulse.

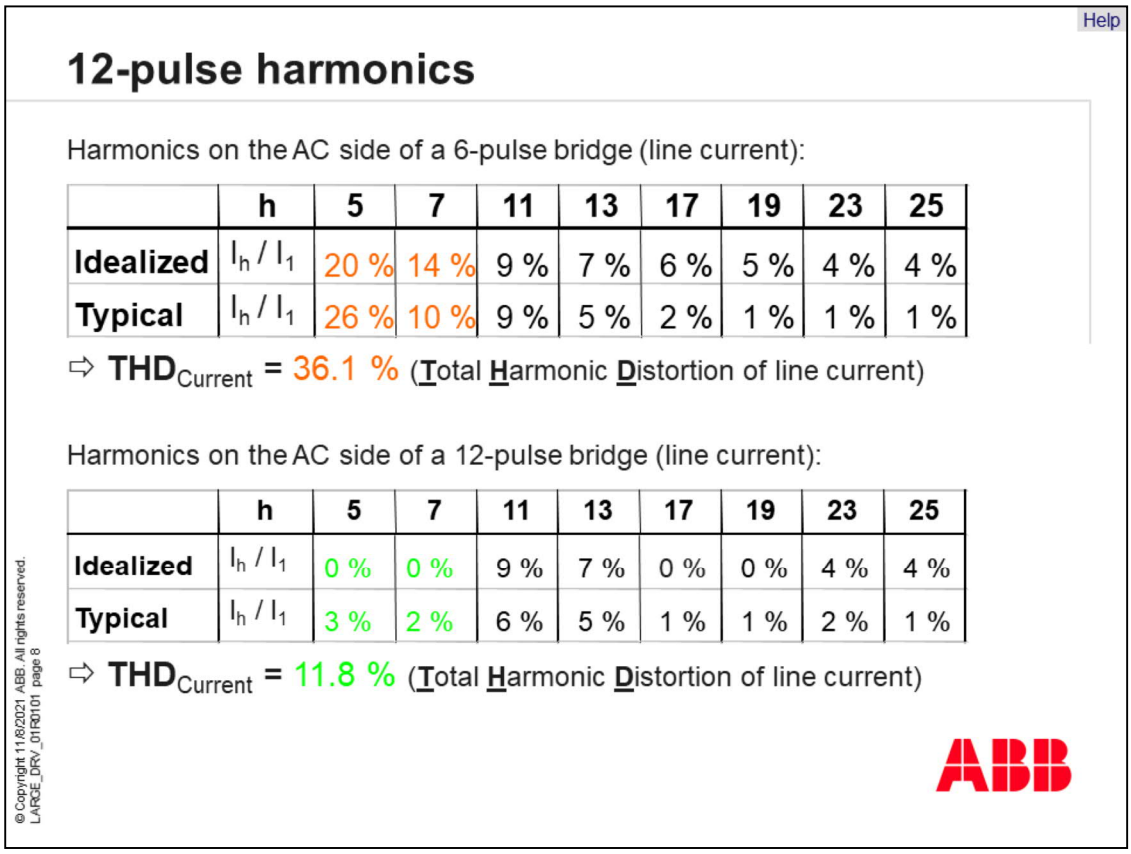


- A 12-pulse DC Drive consists of two 6-pulse thyristor converter modules.
- The modules are connected to a dedicated three winding transformer. A three winding transformer has one primary winding and two secondary windings. Each of the secondary windings only supplies one of the 6-pulse converter modules, thus the name dedicated transformer.
- The phase shift between the secondary windings must be 30° electrical to achieve 12-pulse. This is possible with one of the secondary windings being in delta configuration and the other one being in star configuration. Thus 12-pulses will be seen on the primary side of the dedicated transformer and the current ripple of the DC-current.
- An example is a **delta / delta / star** transformer.



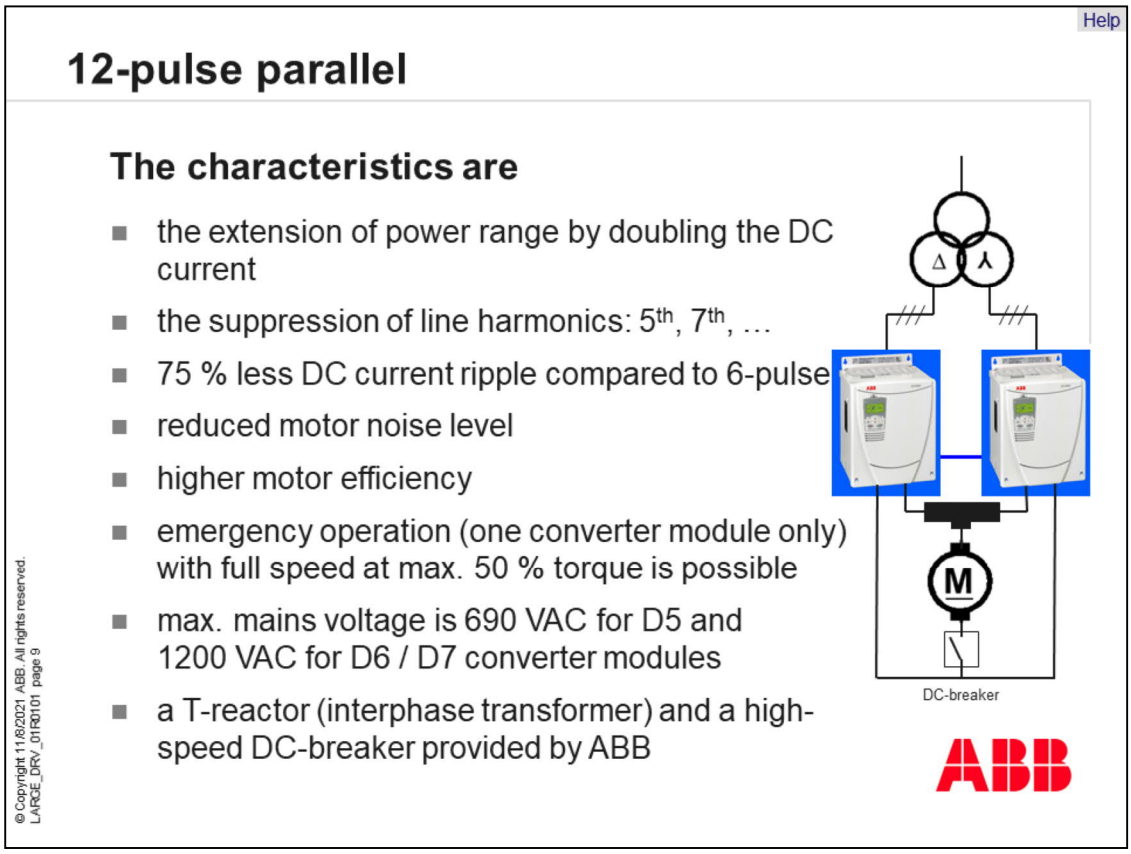
The advantages of 12-pulse are:

- the reduced level of harmonics on the primary side of the transformer. Primarily the 5th and 7th harmonics are much lower compared to 6-pulse configurations.
- the power range is increased by either doubling the drive´s output current or its voltage. The configuration is a 12-pulse parallel configuration if the output current is increased. It is a 12-pulse serial configuration, when the output voltage is increased.
- Since each 12-pulse drive consists of 2 converter modules it is possible to continue emergency operation with just one converter module.
- Compared to 6-pulse drives, the current ripple of 12-pulse drives is considerably lower. The motor efficiency increases due to the lower current ripple.



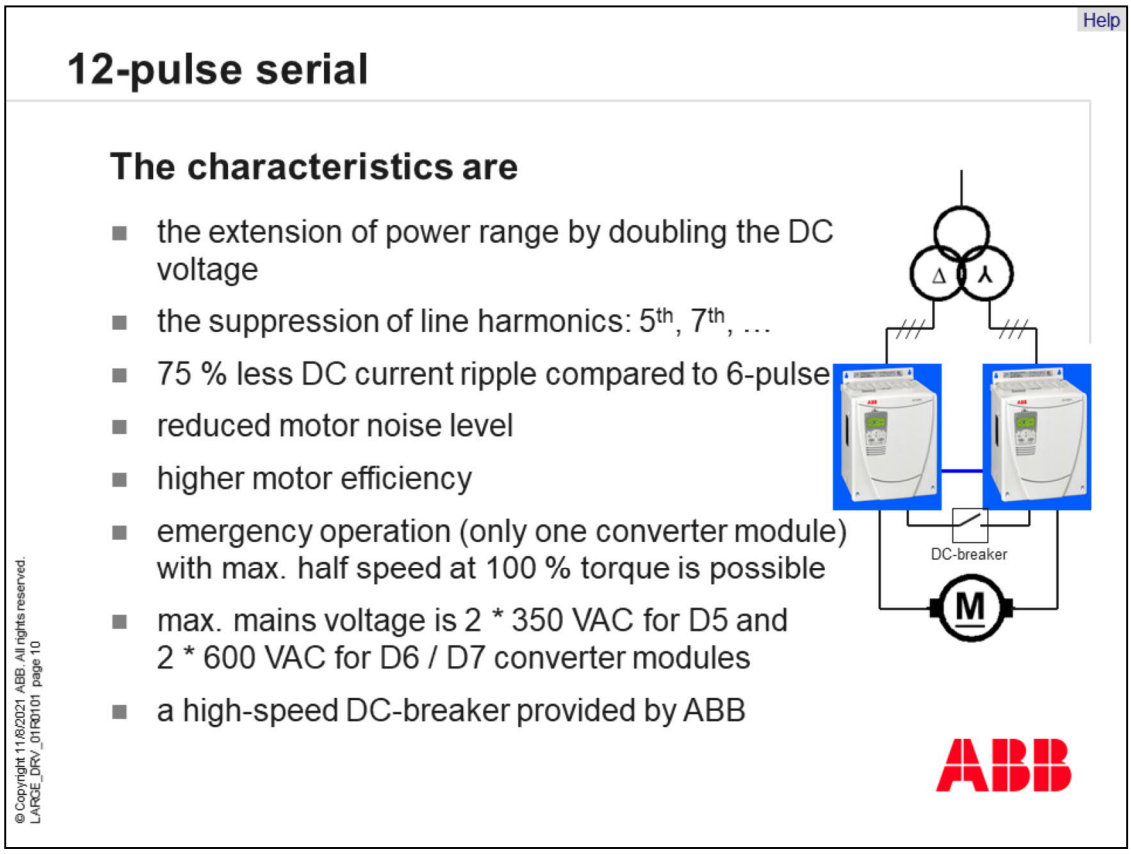
All drives interfere with other equipment, because they produce harmonics on the AC side. To filter these harmonics, additional hardware is needed. For large drives this equipment is very expensive.

An alternative to achieve a lower level of harmonics is the 12-pulse configuration. The 12-pulse configuration reduces the level of harmonics on the primary side of the transformer. Primarily the 5th and 7th harmonics are much lower compared to 6-pulse configurations. The total harmonic distortion is reduced by two thirds from over 36 % to fewer than 12 %.



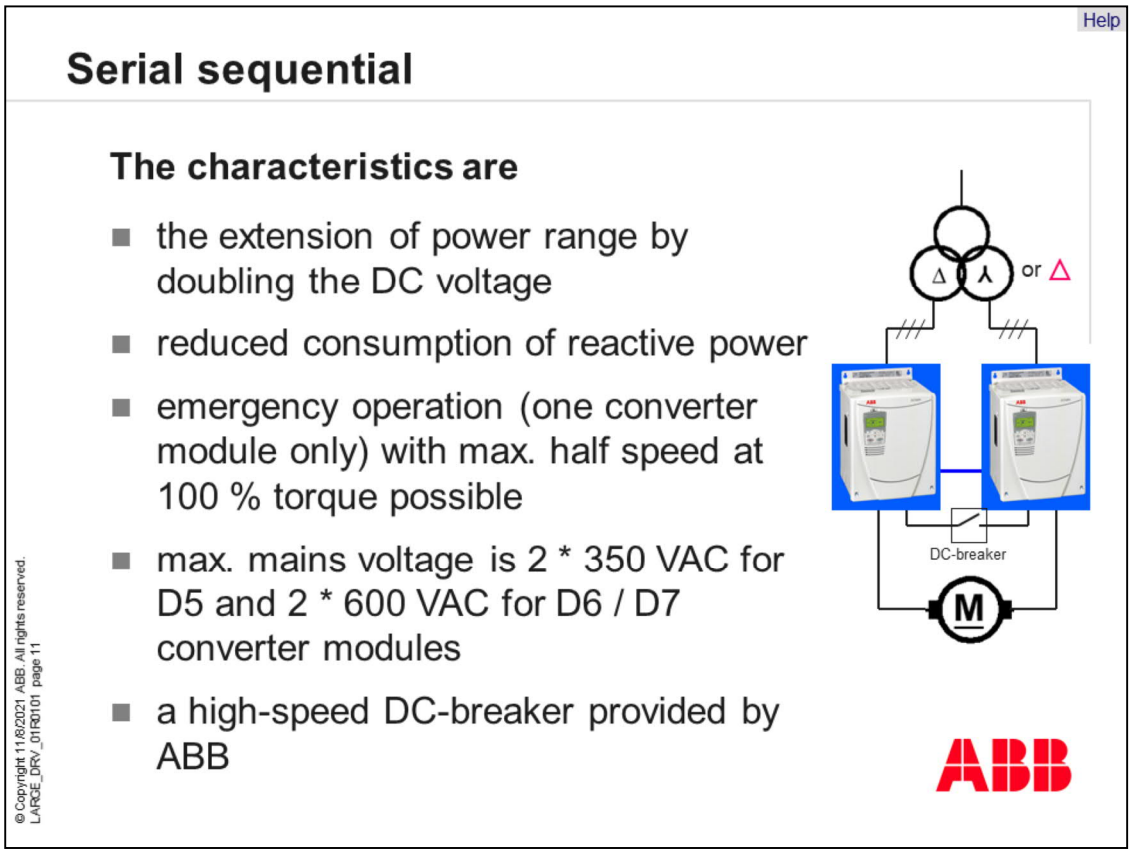
The characteristics of 12-pulse parallel are:

- two converter modules connected in parallel. Each converter module provides 50 % of the motor current. Thus, the power range is extended by doubling the DC current.
- The total harmonic distortion is reduced by two thirds by nearly eliminating the 5th and 7th harmonics.
- Compared to 6-pulse drives the current ripple of 12-pulse parallel drives is about 75 % lower. This reduces the motor noise level and increases the efficiency of the motor due to lower losses. This is an advantage especially for old motors which do not have sheeted bodies.
- Since each 12-pulse parallel drive consists of 2 converter modules, it is possible to continue emergency operation with only one converter. This converter module still supplies 100 % of the motor voltage but only 50 % of the motor current. Thus, it is possible to reach full speed with 50 % torque.
- The maximum mains voltage is 690 VAC for D5 converter modules and 1200 VAC for D6 and D7 converter modules.
- ABB also provides customized T-reactors and high-speed DC-breakers. The T-reactors are used to suppress currents flowing between two converter modules. The ones provided by ABB are much smaller than smoothing reactors and therefore much lower in cost. The high-speed DC-breakers will trip in case of overcurrent. They are built in to protect expensive motors against high currents, e.g., flash-over at the commutator.



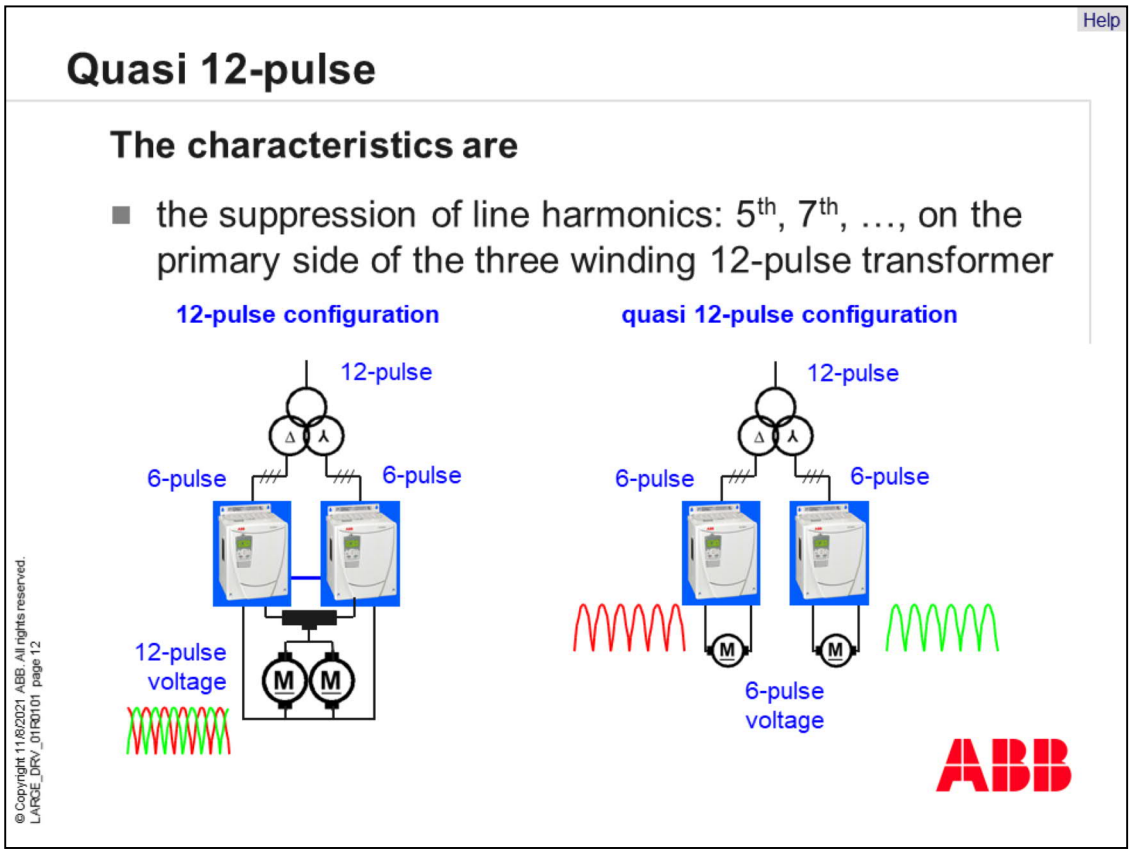
The characteristics of 12-pulse serial are:

- two converter modules connected in serial. Each converter module provides 50 % of the motor voltage. Thus, the power range is extended by doubling the DC voltage.
- The total harmonic distortion is reduced by two thirds by nearly eliminating the 5th and 7th harmonics.
- Compared to 6-pulse drives the current ripple of a12-pulse parallel drive is about 75 % lower. This reduces the motor noise level and increases the efficiency of the motor due to lower losses. This is an advantage especially for old motors which do not have sheeted bodies.
- Since each 12-pulse serial drive consists of 2 converter modules, it is possible to continue emergency operation with only one converter. This converter module still supplies 100 % of the motor current but only 50 % of the motor voltage. Thus, half speed with a maximum of 100 % torque is possible.
- The maximum mains voltage is 2 * 350 VAC for D5 converter modules and 2 * 600 VAC for D6 and D7 converter modules.
- ABB also provides high speed DC-breakers. The high-speed DC-breakers will trip in case of overcurrent. They are built in to protect expensive motors against high currents e.g., flash over at the commutator.



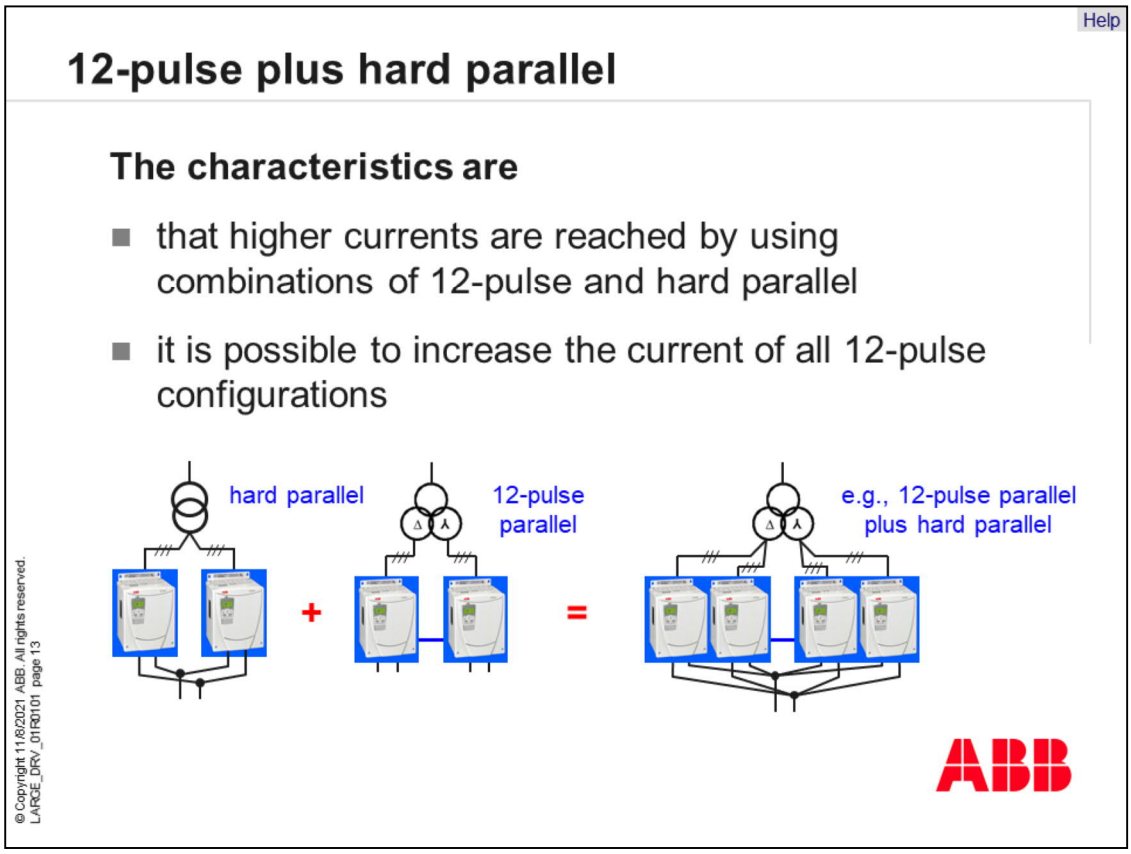
The characteristics of serial sequential are:

- two converter modules connected in serial. Each converter module provides 50 % of the motor voltage. Thus, the power range is extended by doubling the DC voltage.
- The 30° phase shift on the secondary side of the dedicated transformer is not necessary.
- Due to the sequential type of firing pulses, the consumption of reactive power is reduced. This is important for large drives using high torques at low speeds.
- Since each serial sequential drive consists of 2 converter modules, it is possible to continue emergency operation with only one converter. This converter module still supplies 100 % of the motor current but only 50 % of the motor voltage. Thus, half speed with a maximum of 100 % torque is possible.
- The maximum mains voltage is 2 * 350 VAC for D5 converter modules and 2 * 600 VAC for D6 and D7 converter modules.
- ABB also provides high speed DC-breakers. The high-speed DC-breakers will trip in case of overcurrent. They are built in to protect expensive motors against high currents e.g., flash-over at the commutator.



The characteristics of quasi 12-pulse are:

- the reduced level of harmonics on the primary side of the transformer. This is one of the most significant advantages of 12-pulse especially since 12-pulse is mainly used for large drives.
- In a 12-pulse configuration the harmonics are suppressed on the DC side of the converter at the motor and on the primary side of the dedicated transformer. 12-pulse on the DC side reduces the losses of the motor. 12-pulse on the primary side of the transformer reduces the harmonics.
- In a quasi 12-pulse configuration the harmonics are only suppressed on the primary side of the dedicated transformer. The DC motors run in normal 6-pulse configuration. Thus, less filtering and compensation hardware is needed on the high voltage side to suppress disturbances such as flickering.



To increase the power even higher, 12-pulse and hard parallel configurations can be combined. Hard parallel is available for 6-pulse, 12-pulse parallel, 12-pulse serial, serial sequential and quasi 12-pulse.

Help

Master-follower

The characteristics are

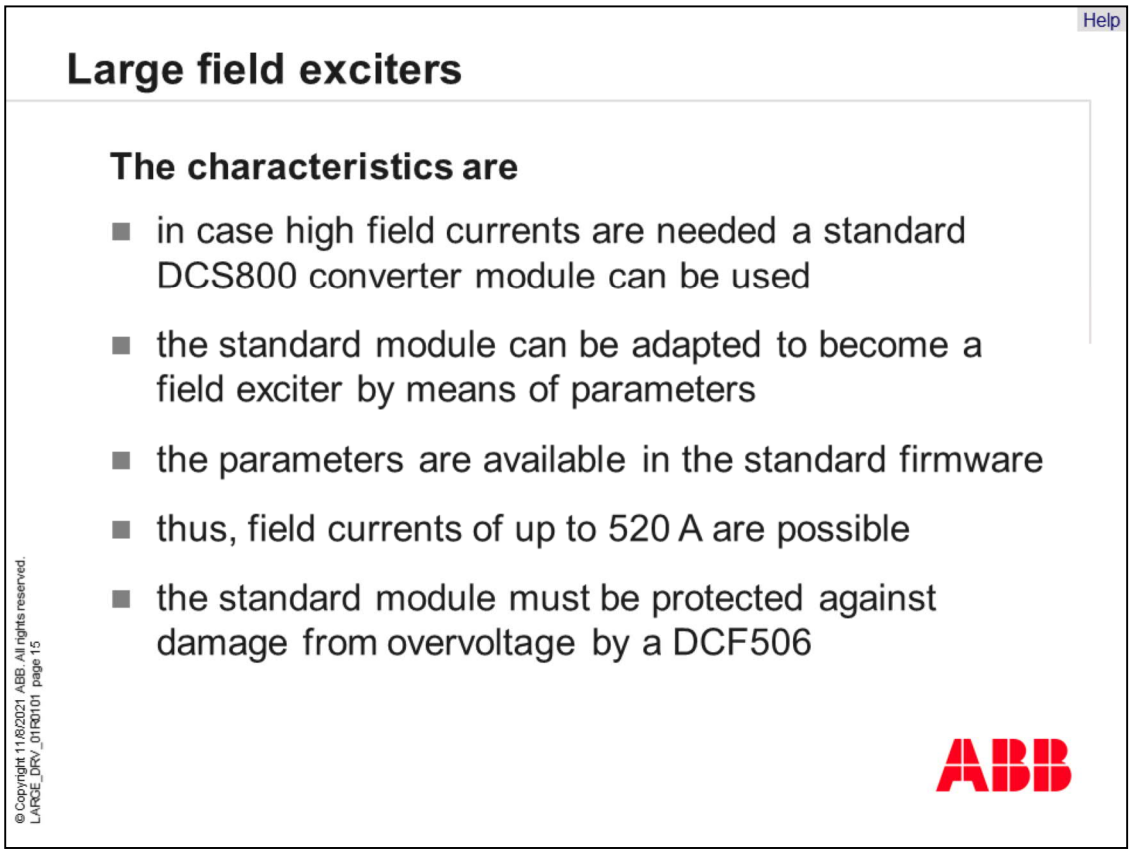
- no speed difference between the motors is possible
- the motors are coupled for example by shafts, gears, chains belts etc. (tandem motors)
- usually, the master is speed controlled
- the followers are torque or window controlled

ABB

To increase the power of an installation, it is also possible to use more than one motor. All of these motors are controlled by a configuration called master - follower.

For the master - follower configuration it is mandatory, that all motors run at the same speed and no speed difference between the motors is possible. Thus, all motors are, for example, mounted on one shaft.

All drives are controlled by only one master. The other drives are followers and are either torque or window controlled.



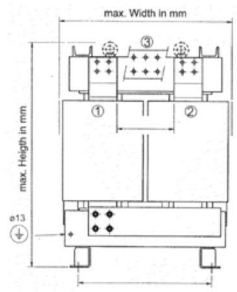
Standard ABB field exciters supply a maximum field current of 60 A. Large motors need higher field currents. To supply field currents up to 520 A, standard DCS800 converter modules are used. The standard converter module can be adapted to become a field exciter. This adaptation is done by means of parameters which are available in the standard firmware. So, to use a standard module as a field exciter, no hardware changes are needed in the converter module. Overvoltage protection is needed to protect the field circuit from damage.

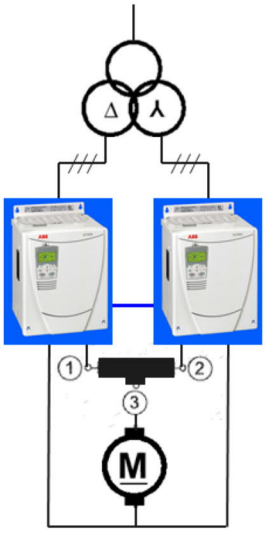
Help

T-reactors (interphase transformers)

The characteristics are

- used in 12-pulse parallel configurations
- customized T-reactors provided by ABB
- have a high overload capability
- smaller than air-core reactors





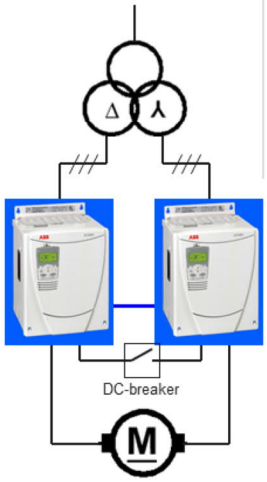
- T-reactors are only used in 12-pulse parallel configurations. The 30 ° phase shift between 12-pulse master and 12-pulse follower supply voltages generates an instantaneous voltage difference between the output voltages of both converters. The maximum amount of this difference is 50 % of the peak value of the supply voltage. The T-reactor absorbs this instantaneous voltage difference and provides the typical 12-pulse current to the DC-motor.
- ABB also provides customized T-reactors. The T-reactors are dimensioned depending on the line voltage and motor current.
- The T-reactors provided by ABB have a high overload capability and are much smaller than air-core reactors and are therefore much lower in cost.

Help

High speed DC-breakers

The characteristics are

- a high-speed DC-breaker that protects the DC-motor against overcurrents
- using fast magnetic trip coils
- features a trip relay (**On-Off** relay) which is controlled by the drive
- a special, fast trip relay is available



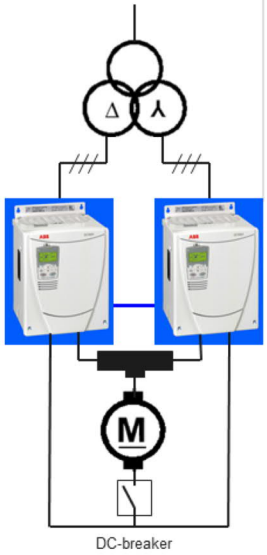
- High speed DC-breakers are able to extinguish excessively high DC currents immediately. Thus, the motor can be protected against overcurrents causing damages to it, for example flash over at the commutator. Usually the high-speed DC-breaker trips itself when an overcurrent occurs.
- This is done by means of a fast magnetic overcurrent trip coil.
- It is also possible to trip the high-speed DC-breaker with a trip command from the drive. This trip signal is generated by motor or drive overcurrents, mains under voltage and excessively high current rise.
- To reduce the delay time before the high-speed DC-breaker is opened after a trip command from the drive, fast tripping relays are available.

Help

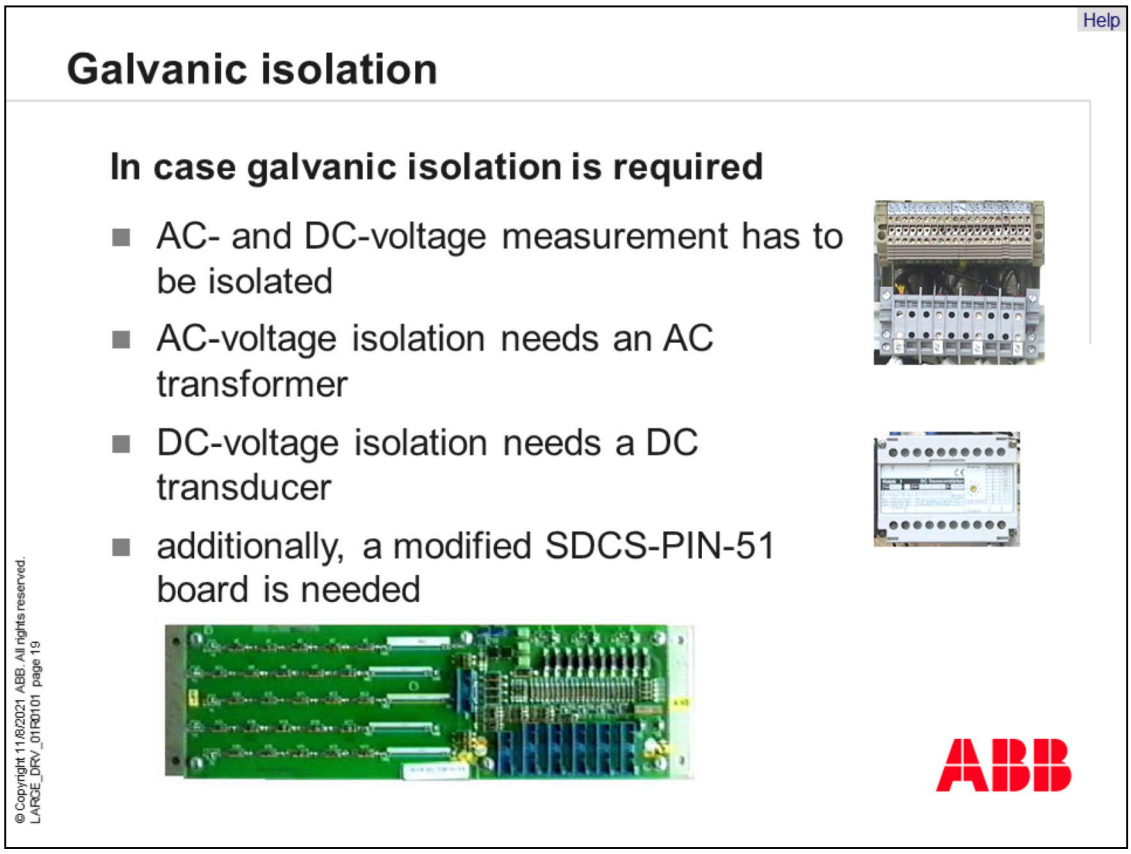
High speed DC-breakers

The characteristics are

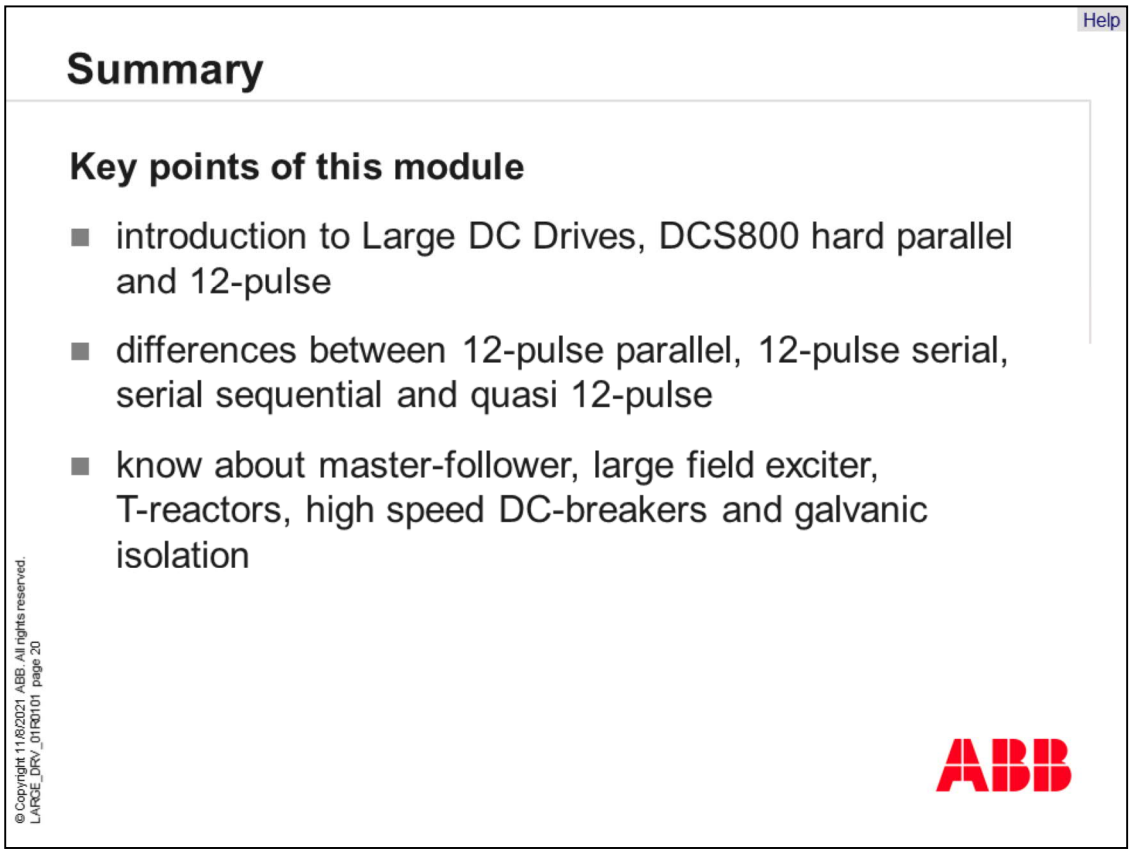
- resetable overcurrent trips
- higher availability
- strongly recommended for drives without AC breakers
- high speed DC-breakers are provided by ABB
- ABB integrates high speed DC-breakers into drive cabinets



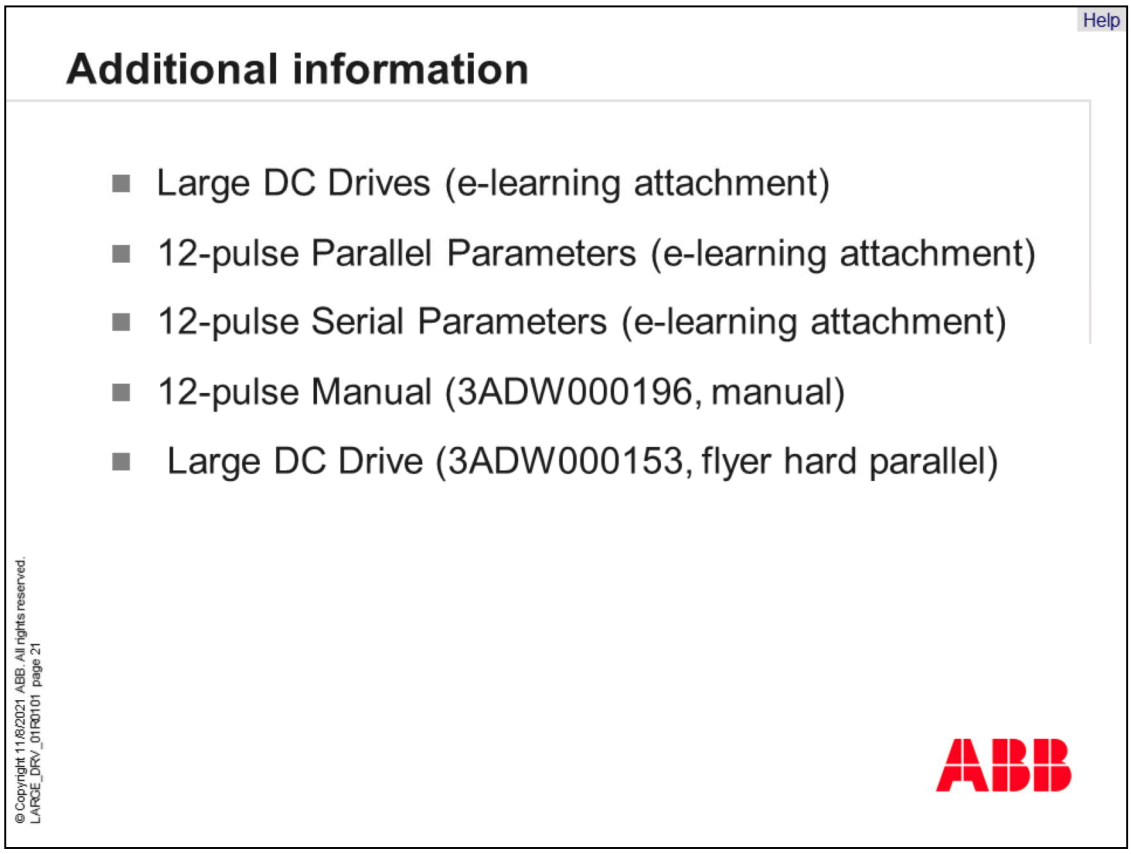
- When using high speed DC-breakers, overcurrent trip become resettable, because the high-speed DC-breaker trips before other parts in the system - for example the fuse - become damaged.
- Thus, the availability of the whole drive increases.
- High speed DC-breakers are strongly recommended when using drives without AC breakers to ensure that the DC motors are protected against damage from overcurrent.
- ABB also provides high speed DC-breakers and integrates them into the drive's lineup.



- Usually the DC- and AC-voltage is measured via high ohmic resistors with a scaling of 1 MOhm per 100 V.
- Galvanic isolation is used to isolate the DC- and AC-voltage measurement circuits of the converter modules from dangerously high DC- and AC-voltages. Galvanic insulation is usually needed when either the supply voltage or the motor voltage is greater than 690 V.
- Galvanic isolation is used in both 6-pulse and 12-pulse systems.
- Only the AC- and DC-voltage measurement has to be galvanically isolated, because the current measurement is already isolated via current transformers - CTs for short.
- To isolate the AC-voltage measurement, a special isolation transformer for all three phases is needed.
- The DC-voltage measurement is isolated by means of a DC-DC transducer.
- The transformer and the DC-DC transducer are provided by ABB.
- To complete the galvanic isolation of the voltage measurement circuit, a modified SDCS-PIN-51 board is needed. Thus, galvanic isolation is only possible for converter sizes D5, D6 and D7.



Now you know what Large DC Drives using DCS800 hard parallel and 12-pulse are. Also, the differences between the different kinds of 12-pulse configurations should be clear. You should also know about master-follower, large field exciters, T-reactors, high speed DC-breakers and galvanic isolation.



Here are some related documents for further training and additional references.

Thank you for your attention. You may now go ahead and move on to the next unit.