



E-Learning, DC Non-Motoric Applications

# DCS800 Lift Magnet Supply

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Welcome to the lift magnet supply training module for the DCS800.

# Objectives

## **This training module covers:**

- Examples of different magnet types
- Single magnet configuration in current control
- Multi magnets configuration in voltage control
- Battery backup and battery charging
- Overvoltage protection
- Functions of the lift magnet supply application
- Additional technical information

## **This training module covers:**

- Examples of different magnet types
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- Additional technical information

# Lift Magnet Supply Magnet Types



## Wide range of applications:

- Metal plants for lifting rods and coils
- Iron scrap cranes and iron rod and bar handling cranes

Use of magnetic force for the iron goods

## Industrial electric lifting magnets for:

- lifting
- holding
- handling

loads with ferromagnetic properties.

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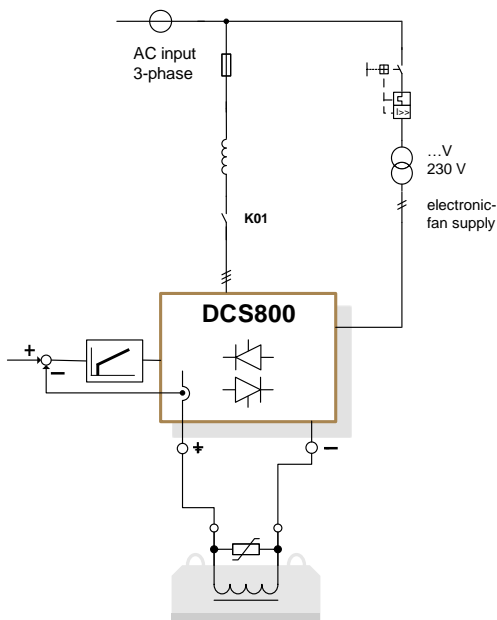
This slide provides an overview of the lift magnet types.

Many cranes lift ferrous material by using a magnet instead of a hook. Today, new cranes, like small tower cranes or overhead bridge cranes in electric overhead travelling systems, are equipped with AC drives and a thyristor-based DC supply for the lift magnet. Lift magnets are used for a wide range of applications.

They are also used in metal plants for lifting rods and coils. Iron scrap cranes and iron rod and bar handling cranes use magnetic force for the iron goods. Industrial electric lifting magnets, mains fed and battery fed, are used in electric and electromechanical devices and equipment with a magnetic field generated by an electrical current creating sufficient force for lifting, holding and handling loads with ferromagnetic properties.

# Lift Magnet Supply

## Single magnet configuration in current control mode



### Configuration requirements:

- Converter operates in current control to increase and decrease the magnetic force dynamically
- MOV in parallel of the magnet for overvoltage protection
- Full connected AC voltage utilized

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This slide shows a single magnet configuration.

The converter operates in current control.

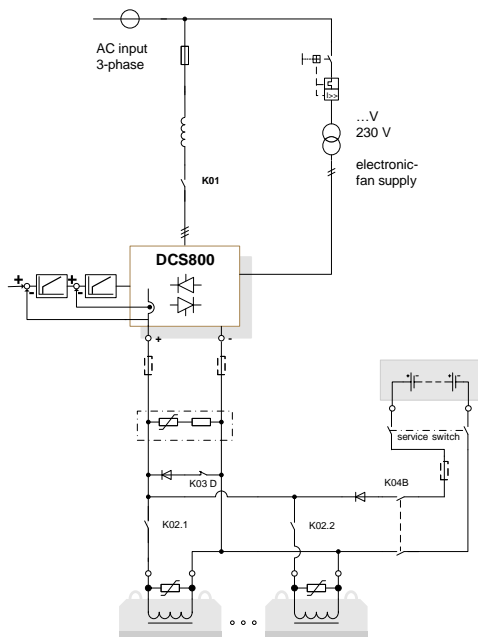
The magnetic force can be dynamically increased and decreased using pure current control.

There is a metal oxide varistor [in short MOV] directly in parallel to the magnet for overvoltage protection.

Note that for dynamic control, the full voltage range of the connected AC voltage is utilized.

# Lift Magnet Supply

## Multi magnet configuration in voltage control



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### Configuration requirements:

- 2 or more magnets in parallel
- Converter operates in voltage control to prevent the possible overloading of the individual magnet
- Overvoltage protection with a combination of components
- Minimum one magnet should be connected before DCS800 will be enabled
- Prevention of switching off magnets with DCS800 in RUN state
- Battery backup for emergency

This slide shows a configuration of 2 magnets in parallel.

The 2 magnets are connected to one DCS800.

The converter operates in voltage control, which is the preferred operation when magnets are connected in parallel.

This prevents possible overloading of the individual magnet.

Overvoltage protection is ensured via a MOV directly in parallel to each magnet and additionally with a MOV-resistor combination plus a freewheeling diode in parallel of both magnets.

At least one magnet must be connected before the DCS800 is enabled.

Additional magnets can be added while the DCS800 is enabled.

Switching off magnets while the DCS800 is enabled must be prevented to avoid high inductance switch off effects.

Furthermore, care has to be taken that the required contactor, K01 on the AC supply side, stays ON.

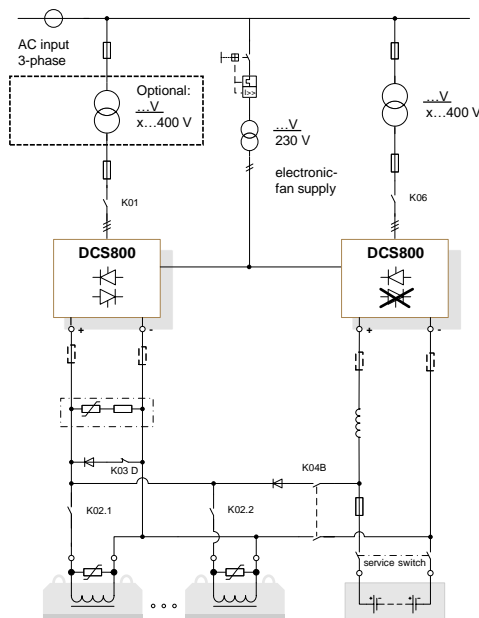
With pure and simple voltage control, increasing and decreasing the current and thus the magnetic force, the operation proceeds more slowly.

Depending on the requirements, a combination of both, current and voltage control, is desirable.

The battery backup for emergency cases will be explained on the next slide.

# Lift Magnet Supply

## Battery backup and battery charging



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### Battery backup:

- To prevent load falling down in case of AC mains problems
- DC fuses open a short circuit between DCS800 magnet supply and battery
- Additional diode decouples the battery backup from DCS800 magnet supply and K04B to be released in emergency

### Battery charging:

- Charging by a second DCS800
- Battery decoupled from the DCS800 magnet supply branch by a contactor
- Use transformer for electrical isolation



How can the concept of battery backup and battery charging be realized for the DCS800 lift magnet supply?

For safety reasons a battery backup is necessary, if the load is not to drop should there be problems with the AC mains.

The DC fuses open a short circuit with a battery in case of two blown thyristors in the DCS800 to avoid the loss of magnet supply.

An additional diode decouples the battery backup from the DCS800 magnet supply.

DCS800 and battery supply should not work continuously together.

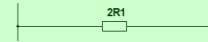
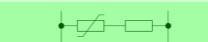
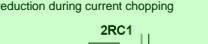
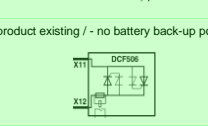
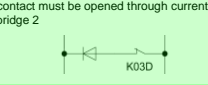

Thus K04B has to be used for releasing the battery backup in emergency cases.

The battery can be charged by a second DCS800 with the battery decoupled by contactor K04B from the magnet supply branch.

The built-in contactor K06 is controlled by the second DCS800 for charging the battery.

The use of a transformer is important for electrical isolation.

# Lift Magnet Supply Overvoltage Protection

OV1 (possibilities)	Overvoltage ... + reduction / - losses due to heating
▪ Resistor	
▪ MOV + resistor	+ reduction 
▪ RC snubber	+ reduction during current chopping 
▪ DCF506	+ product existing / - no battery back-up possible 
Diode + contact	+ prevent OV through current bridge 1 - contact must be opened through current bridge 2 
MOV (Metal Oxid Varistor)	directly in parallel of each magnet 

## Used overvoltage components:

- Damping through pure ohmic resistor
- Damping through varistor and resistor
- RC element to avoid electric arc at switches → Spark Quenching
- DCF506 as standard overvoltage protection
- Damping through diodes and zener diodes
- Damping through varistors only  
→ Voltage dependent resistors

This slide deals with the topic of overvoltage protection.

A magnet is a large inductance which means that great attention must be paid to the protection concept.

A DC electromagnet has an inductance that causes, especially with larger magnets, high negative switch-off voltages.

This might lead to the disruption of the electric isolation and cause sensible electronic components of the customers electronic control interface to be destroyed.

There are measures which have to be taken into account to dampen the voltage spikes. But damping the switch-off peak is always a compromise between the fall time of the armature and the lifetime of the electronic and switches in the periphery.

## Damping through ohmic Resistor helps with the following:

A parallel resistor limits the switch-off voltage.

Thus the fall time of the armature current and the electric energy demand increases.

The switch-off voltage decreases if the parallel resistor is reduced.

## Overvoltage protection with standard DCF506:

The overvoltage protection activates a free-wheeling circuit between connectors F+ and F- if an overvoltage occurs. The DCF506 consists of a trigger unit and a free-wheeling thyristor.

It also consists of a relay output to indicate a free-wheeling condition to the magnet converter. When the free-wheeling function is triggered, it will continue until the DC current is less than 0.5 A. During this time the relay contacts are closed.

## Damping through diodes and zener diodes helps with the following:

To prevent trouble it is recommended to use a diode for decoupling.

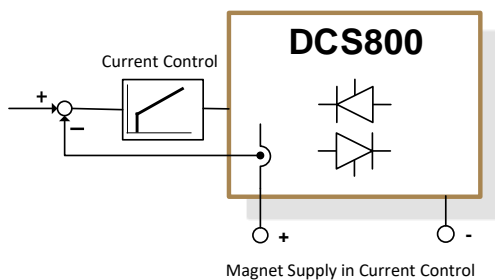
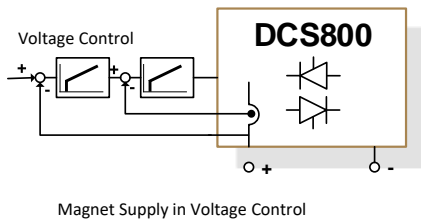
With closed contactors of the diode the current bridge 2 has to be blocked.

# Lift Magnet Supply

## DCS800 DEABBMagBat 3.0 Application Functions

### Operation Mode Magnetization:

- Voltage and current control



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The application program **DEABBMagBat V3.0** with advance and function extension for lift magnet supply with DCS800 is available from the DC factory, adapts to all different control concepts and handles the original relay logic.

This application program was developed in order to cover the scope of required solutions.

This slide shows the operation mode magnetization in both voltage and current control.

The advantages and disadvantages of current and voltage control were already explained in the previous slides.

Magnetic force can be dynamically increased and decreased using pure **current control** by using the full voltage range.

But a longer pure current control can overheat the magnet. Magnets in parallel prefer **voltage control**.

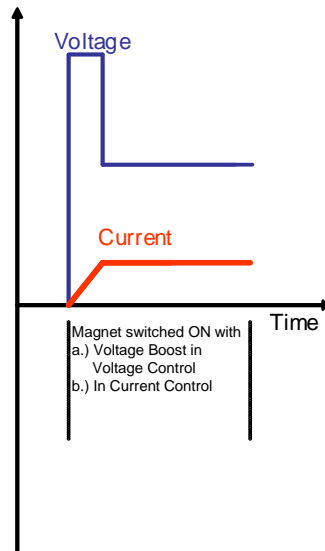
This will prevent possible overloading of the individual magnet.

Depending on the requirements, a combination of current and voltage control can be realized with that application program.



# Lift Magnet Supply

## DCS800 DEABBMagBat 3.0 Application Functions



- Switch ON Boost:
- Voltage and current control
- During Switch ON of the magnet
- Help to reach the magnetization reference as quickly as possible
- In current control with dynamic of higher input voltage
- In voltage control with a voltage boost
- Input voltage must not be higher than the isolation voltage of the magnet

This slide shows how the magnet current reference can be reached as quick as possible after starting the command of the converter.

Voltage or current control can be used.

In current control, the magnet current can be ramped up dynamically depending on the amount of input voltage.

The higher the input voltage the higher the dynamic of the current controller.

In voltage control, the magnet current can be ramped up depending on a voltage boost.

The voltage boost is a voltage reference value which is higher than the demanded voltage reference to ramp up the magnet current dynamically.

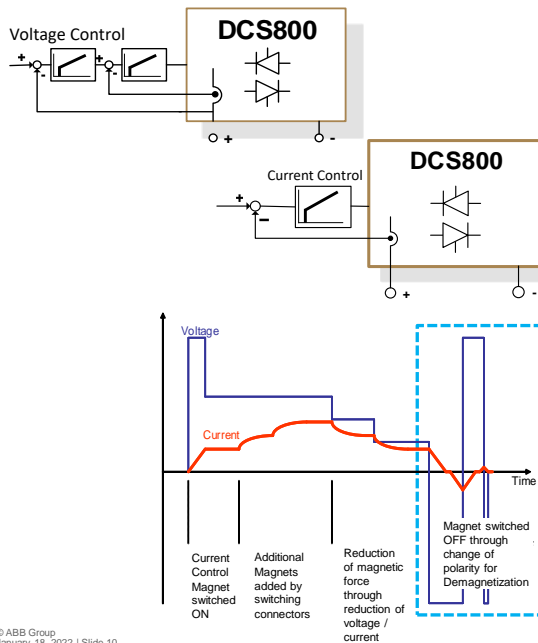
After reaching the magnet current reference the voltage reference is switched to the demanded voltage reference.

The maximum voltage boost is equal to the input voltage.

Precautions have to be taken not to supply the converter with a higher input voltage than the specified isolation voltage of the magnet.

# Lift Magnet Supply

## DCS800 DEABBMagBat 3.0 Application Functions



- Operation Mode Demagnetization:
- Voltage and current control
- Release of light weight loads
- Erase the residual force created by physical remanence
- Decreasing or alternating magnet current

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Magnets create a residual force even if the input current of the magnet is zero.

This is called physical remanence of magnets.

The operation mode of demagnetization is explained on this slide.

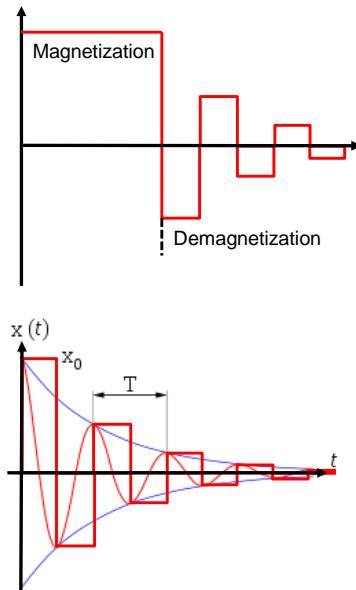
The release of light weight loads is done by demagnetization.

Decreasing or alternating (positive and negative) magnet current will erase the residual force.

A 4-quadrant converter which can supply current in both directions is required for this operation.

# Lift Magnet Supply

## DCS800 DEABBMagBat 3.1 Application Functions



- Operation Mode  
Degaussing of Magnets by Pulsing:
- Like Demagnetizing Mode
- Goal is the complete erasement of the residual force created by physical remanence
- Decreasing and alternating magnet current
- To be defined:
  - 1.) Number of current pulses
  - 2.) Amplitude and pulse width
  - 3.) Degaussing time period
- Following a damped oscillation curve
 
$$x(t) = x_0 * e^{-\zeta t} * \cos(\omega t)$$

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There are requirements of erasing the remanence of magnets completely.

The operation mode which is called degaussing by pulsing is explained on this slide.

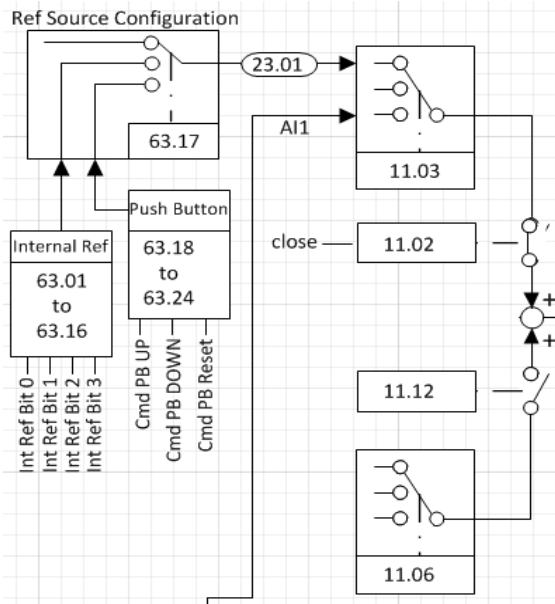
Decreasing and alternating the magnet current erases the residual force.

The number of alternating current pulses, the amplitude and the pulse width of each current pulse as well as the complete degaussing time has to be defined and to be set up. The reversal time delay for the change of the thyristor bridge also has to be considered.

The degaussing procedure in simplified terms can be shown with a damped harmonic oscillation curve.

# Lift Magnet Supply

## DCS800 DEABBMagBat 3.0 Application Functions



- Reference Selection:
- Voltage and current setpoints
- Analog Inputs (U + I)
- Push Button continuously like MotPot-Function with inputs for Up, Down and Reset Button (U)
- Push Button stepwise with discrete reference steps via inputs for Up, Down and Reset Button (U)
- Internal fixed references  
16 fixed values selectable with 4 Bits out of a table (next slide)

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The different reference sources of the application are looked at on this slide.

Voltage and current reference sources can be selected over analog inputs.

Reference sources which can be selected additionally in voltage control are:

### - Push Button Continuously

which is like a MotPot-Function with command buttons for Up, Down and Reset.

### - Push Button Stepwise

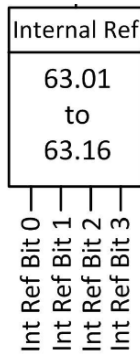
which is realized with discrete reference steps via command buttons for Up, Down and Reset

### - Internal Fixed References

which are reference sources offering 16 fixed values selectable with 4 Bits out of a table from the next slide.

# Lift Magnet Supply

## DCS800 DEABBMagBat 3.0 Application Functions



Bit 3	Bit 2	Bit 1	Bit 0	Fixed Setpoint
0	0	0	0	1
0	0	0	1	2
0	0	1	0	3
0	0	1	1	4
0	1	0	0	5
0	1	0	1	6
0	1	1	0	7
0	1	1	1	8
1	0	0	0	9
1	0	0	1	10
1	0	1	0	11
1	0	1	1	12
1	1	0	0	13
1	1	0	1	14
1	1	1	0	15
1	1	1	1	16

- Internal fixed references:
- 16 different voltage references (U)
- Selectable by 4 Bits via MagnetMCW (7.10) or 4 digital inputs

This slide shows the table for the internal fixed references.

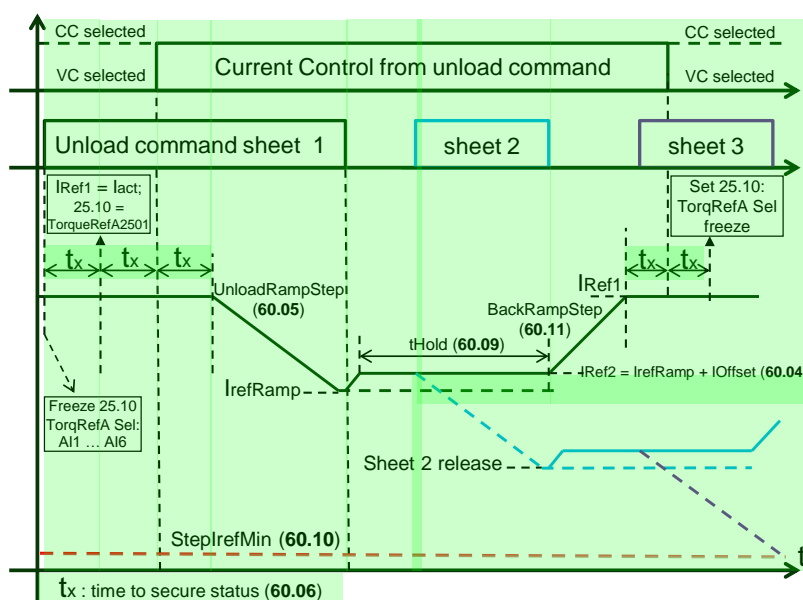
16 different voltage references can be defined in the parameters 63.01 to 63.16

and selected by 4 Bits via the Magnet Main Control Word in parameter 7.10

or configured to 4 digital inputs.

# Lift Magnet Supply

## DCS800 DEABBMagBat 3.0 Application Functions



Operation Mode: Step by step sheet release

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If the load is a stack of sheet metal, the operator can unload the crane sheet by sheet by slowly reducing the magnetic force.

The converter switches to current control and can simply reduce the output current.

With the corresponding configuration the application can leave this mode and return to the previous procedure or remain at the actual current value until the converter is disabled.

This is a big advantage compared to traditional diode magnet supplies.

If the function button **StepbyStepRelease** is pressed the following procedure starts:

The DCS800 is in voltage or current control when the function button is pressed.

The actual current value is set as reference current value **IRef1** for internal use.

In voltage control, the control mode is switched over to current control.

The current reference is ramped down within the ramp time called "UnloadRampStep" in parameter **60.05** and is always limited at the minimum allowed current reference "StepIrefMin" in parameter **60.10**.

With the release of the function button the application proceeds with taking the actual current reference "IrefRamp" and starts to ramp it up within the ramp time defined with BackRampStep in parameter **60.11** to increase the magnet current reference by a current offset up to an internal secure current reference **IRef2** and to avoid further sheets being released.

The following equation is applied:  $IRef2 = IrefRamp + Ioffset$  in parameter **60.04**.

**Configuration I:** If the hold time selection HoldTimeSel in parameter **60.08** is set to "Enabled" then 2 different procedures are possible for HoldTimeDelay in parameter **60.09**:

# Lift Magnet Supply

## DCS800 DEABBMagBat 3.0 Application Functions



### Transport Mode:

- Mode with the highest priority
- Transportation of the load over a certain distance safely
- Converter works in voltage control
- Reference value is fixed to the rated magnet voltage
- Highest magnetic force to prevent load from falling down
- Overrides each other command in the application

In this slide we examine the Transport mode.

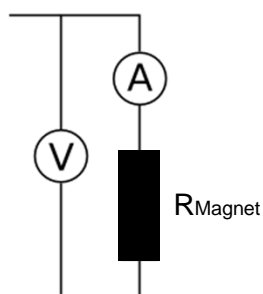
Transport mode is defined as the mode with the highest priority and has to ensure the transportation of the load over a certain distance safely.

The converter works in voltage control and the reference value is fixed to the rated magnet voltage to ensure the highest magnetic force and to prevent the load from falling down.

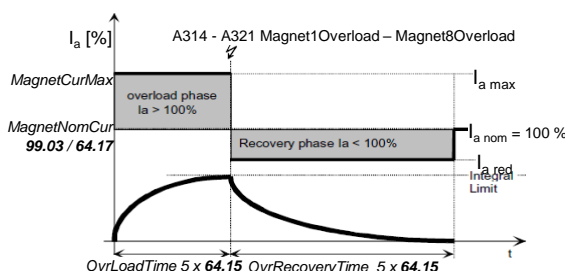
The transport mode command overrides every other command in the application.

# Lift Magnet Supply

## DCS800 DEABBMagBat 3.0 Application Functions



- Monitoring Functions:
- 1: Magnet resistance monitoring
  - Thermal protection of the magnet
  - Calculated by ohmic law
  - Thresholds for hot and cold resistance alarms



- 2: Magnet I<sup>2</sup>t-Function
  - Up to 8 magnets independently
  - Thresholds for thermal Alarms

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This slide covers the monitoring functions of the Lift Magnet Supply Application.

Magnet Resistance Monitoring was developed for thermal protection of the magnet.

To calculate the actual magnet resistance value in parameter 64.12, the filtered values of actual voltage and actual current are used.

Alarms can be activated while the magnet resistance monitoring is permanently working with the converter in ReadyRef state with parameter 8.01 Bit 2 = TRUE.

IF parameter 8.01 Bit 2 = FALSE then the actual resistor value showed in parameter 64.12 = 0.

A compare function with the Resistance Limit Down (cold resistance – tolerance in mΩ) and the Resistance Limit Up (warm resistance + tolerance in mΩ) is implemented as well as a hysteresis function for debouncing. There are 2 parameters available for assigning the warning signals.

With the Magnet I<sup>2</sup>t-Function the overload capacity of the magnet will be calculated as square of the current and the time in seconds.

I<sup>2</sup>t is used to calculate heat generation in the magnet to protect it from thermal damage or failures in case of excess heat generation.

In the magnet supply application up to 8 magnets can be monitored with I<sup>2</sup>t accumulators independently.

The amount of installed and used magnets in the applications has to be configured with the Number Of Magnets in parameter 64.17.

The thermal time constant T of the magnets can be configured in parameter 64.15 in seconds.

Based on that thermal time constant T the calculation over an exponential charging and discharging curve can be realized.

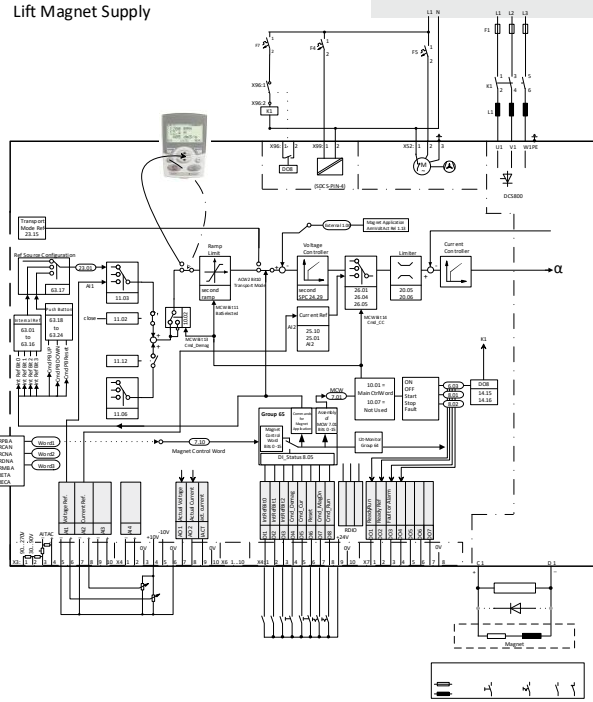
The set and reset level for overload alarm events can be configured for each of the 8 magnets separately.

Active overload warning events are also monitored in the Magnet Overload Status Word.



# Lift Magnet Supply DCS800 DEABBMagBat 3.0 Application Overview

Lift Magnet Supply



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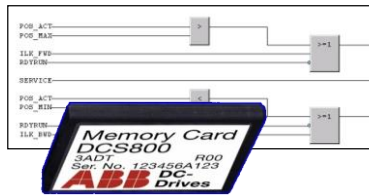


An overview sheet for the DCS800 converter with terminal connection and application parameters is available with the package.

# Lift Magnet Supply

## Additional Technical Information

### IEC 61131 Programming



- Ready Programmed SDCS-MEM-8:
- 1: Documentation:  
DCS800 Lift Magnet Supply e a
- 2: ID code 3ADW000430R0101
- 3: Ready programmed SDCS-MEM-8
- 4: Expert IEC 61131 Programming template  
and SCDS-MEM-8
- 5: Software: from V3.0 upward

The DCS800 function is handled by the additional parameter groups 60-69.

The DCS800 lift magnet supply application V 3.0 is available  
as a ready programmed  
SDCS-MEM-8 or as an expert template with SDCS-MEM-8.

# Summary

## Key points of this module are:

- Examples of different magnet types
- Single magnet configuration in current control
- Multi magnets configuration in voltage control
- Battery backup and battery charging
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- Functions of the lift magnet supply application
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