Special Explanation on Regenerative Braking

💡 **Selection of braking resistors is just a click away**

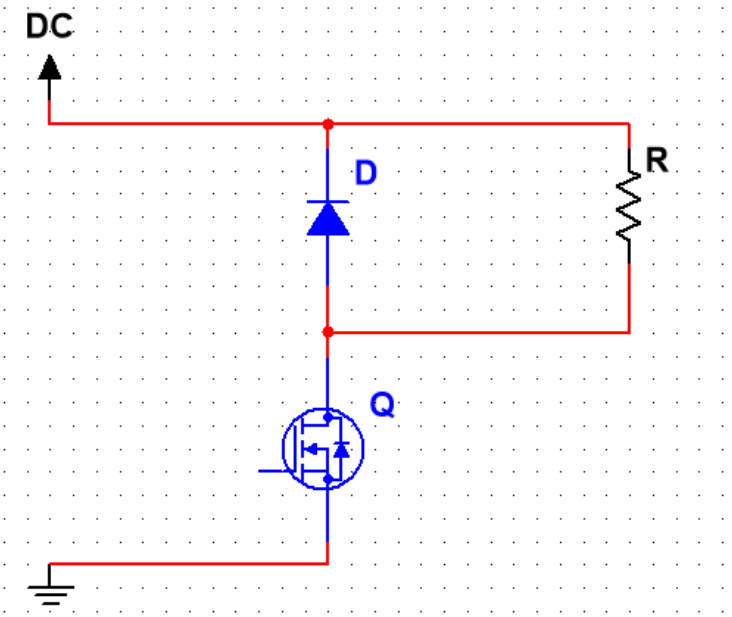
1. Regenerative discharge function

When the energy generated by the motor is transmitted back to the drive, the DC bus voltage becomes too high, which may lead to situations such as drive error reporting and the motor failing to operate normally. At this time, a braking resistor must be connected to dissipate the energy; otherwise, the servo drive will be damaged.

Our products that support the regenerative discharge function can be directly connected to the regenerative braking resistor. Products that do not support the regenerative discharge function need to be connected to the regenerative discharge unit, that is, connected to the braking resistor through the braking module. For detailed reference, please refer to the wiring example of the braking resistor .

💡 To check whether the regenerative braking function is supported, please refer to the corresponding product specification - Hardware Function Specification Table.

2. Selection of Braking Resistors



Diagram, schematic diagram of the discharge circuit

Q is the discharge switch, typically a MOSFET; D is the freewheeling diode, and R is the discharge resistor, which is used to form a current loop in DR when Q is turned off.

- **Resistance Value**

As can be seen from the above figure, the performance of Q determines the maximum discharge current.

$R_{min} = \frac{V_{dc_{max}}}{I_{q_{max}}}$, which is the minimum resistance.

Since the current flowing through the bleeder resistor must be greater than or equal to the system input current, it can also be set to the actual continuous current of the device.

- **Resistance Power**

Since the energy absorbed by the resistor mainly comes from the energy received by the system, the maximum power of the resistor is the actual power consumption of the device.

2.1 Reference for Selection and Calculation of Braking Resistors

1. Determine the reciprocating motion period T (s)	
2. Determine the load-to-motor inertia ratio N1 (N)	
3. Calculate the energy Eo (J) generated by the motion of the load end	Line: $E_0 = \frac{1}{2}mv^2$, where: **m**: mover mass (kg), **v**: maximum motor speed (m/s). Rotation: $E_0 = \frac{1}{2}mr^2\omega^2 = \frac{1}{2}J\omega^2$, where:

	J: Load inertia ($kg \cdot m^2$), **ω**: Angular velocity $\omega = \frac{2\pi n}{60}$ (n is the maximum motor speed in rpm).
4. Calculate the energy E1 (J) generated by the motion at the motor shaft end	$E_1 = (N+1)E_0$
5. Calculate the required braking resistor power Pa (W)	$P_a = \frac{2(E_1 - E_c)}{T}$, where: **Ec**: The capacitance of the drive power line can absorb energy, $E_c = \frac{1}{2}C(U_{max}^2 - U^2)$,**C** is the power line capacitance (μF),**Umax** is the maximum voltage of the drive (V),**U** is the rated voltage of the drive (V).
6. When actually used, it can be derated by 70%, then the actual power of the braking resistor Pb (W)	$P_b = \frac{P_a}{0.3}$

The energy absorption capacity of the capacitor in the power cord of our company's drive can be referred to in the following table:

Drive Specifications	Power line capacitor C	The line capacitance can absorb energy Ec
Below 10 Arms (excluding 10 Arms)	50 μF	0.018 J
10 Arms	150 μF	0.054 J
20 Arms	470 μF	0.169 J

2.2 Recommended Selection

For example:

Assume that the rated current of the low-voltage rotating motor is 20 Arms, the motor power is 750 W, the moment of inertia is 1.5×10^-4 kg·m^2, the load inertia is 4 times that of the motor inertia, and the maximum speed is 4000 rpm.

- A driver with a rated current of 20 Arms and a rated voltage of 48 VDC should be selected;
- Energy generated by the movement of the motor shaft end

$$E_1 = (N+1)E_0 = \frac{1}{2}(N+1)J(\frac{2\pi n}{60})^2 = \frac{n^2(N+1)J}{182}$$

$$= \frac{4000^2 * (4+1) * 1.5 * 10^{-4}}{182} = 65.9J$$

- Since E1 = 65.9J > Ec = 0.169J, a braking resistor needs to be added. Referring to the table below, the braking resistor should be selected with a minimum resistance value of 3R and a maximum power of 20Arms * 48V = 960W.

> For recommended braking resistors, please refer to the 零配件选型参考 document.

Please refer to the following table,

1. Brake resistor resistance = Drive rated voltage÷Motor rated current (ohm)
2. Brake resistor power = rated power of the motor * 50%, Note: This recommendation can be adopted in 80% of cases.

It is worth noting thatfor motors with a large rated current, the actual equivalent power is not necessarily large, which is related tothe actual motion cycleand the scenario. The actual rated current and actual operating power of the system should be used as the basis for model selection.**Generally, after selecting the resistance value, the resistance power is adjusted according to the actual heating situation.**

📌
1. If the discharge effect is not obvious and overpressure continues to be reported: continue to decrease the resistance value of the braking resistor. However, it cannot be less than the minimum resistance value specified by the product; otherwise, the discharge tube will burn out. The minimum resistance values corresponding to different models vary, and you can consult if you have any questions.
2. If the discharge resistor heats up significantly: increase the power of the discharge resistor until it meets the ambient operating temperature. Theoretically, the higher the power, the better; the lower the temperature rise, the higher the safety, but it will also be more expensive and the volume will increase.

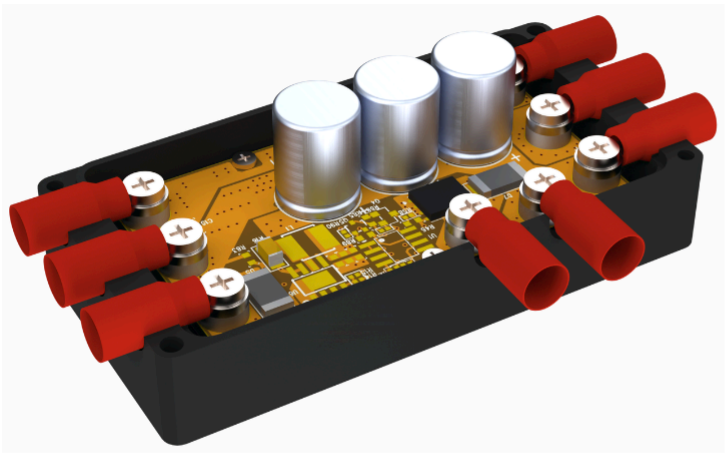
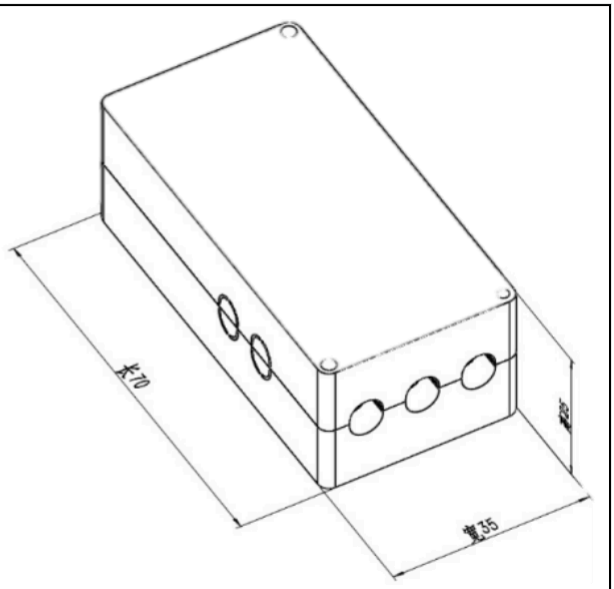
Motor rated current (A)	Motor Power (W)	Drive rated voltage (V)	Recommended Resistance (ohm) Note: The resistance value of the braking resistor should be selected to be at least ⩾ 3Ω	Regenerative Resistor Power (W) Note: It is recommended to be half of the motor power, and can be appropriately increased based on the usage in the on-site scenario.
1	50	48	50	25
3	100	48	18	50
6	200	48	10	100
10	400	48	5	200
14	500	48	4	250
20	750	48	3	375
20	1000	48	3	500

💡 Note:

- It is recommended to use aluminum shell resistors.
- Please install the external braking resistor on non-combustible materials such as metal.
- For products that do not support the regenerative braking function, do not directly connect the external braking resistor to the positive and negative poles of the busbar, otherwise it may cause the device to explode and lead to a fire.

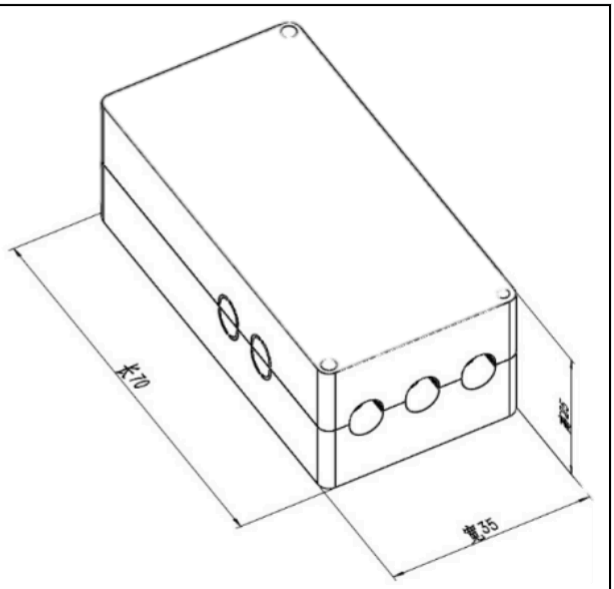
3. Selection of Brake Module

3.1 RM Discharge Module

	
RM 泄放模块外观图	尺寸: 70mm*35mm*25mm (长*宽*高) (不包括制动电阻)

Product Model	RM-48A01
Input Voltage	20-60VDC
Bleeding Voltage Threshold	On threshold 52.5VDC, off threshold 50.5VDC
Power Range	0-1KW
Rated Current	20Arms
Peak Current	50Arms
Compatible Drive Type	XActant DC Drive
Other	Available for connecting a braking resistor
Dimensions (Length * Width * Height)	70mm*35mm*25mm (excluding braking resistor)

3.2 CM Capacitor Module

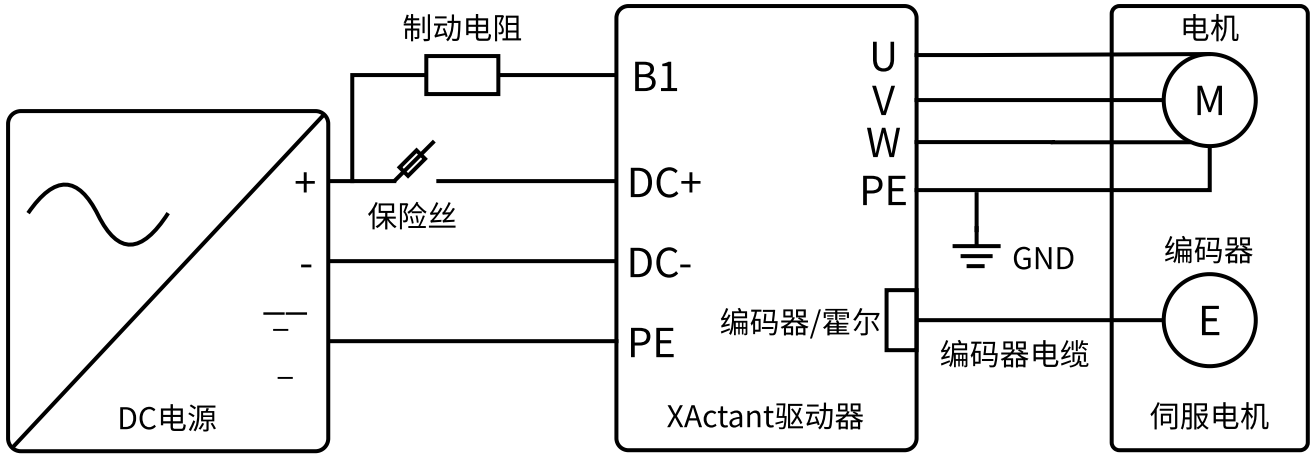
	
CM 电容模块外观图	尺寸: 60mm*35mm*25mm (长*宽*高)

Product Model	CM-48A01
Input Voltage	20-60VDC
Bleeding Voltage Threshold	On threshold 52.5VDC, off threshold 50.5VDC
Power Range	0-1KW
Rated Current	20Arms
Peak Current	50Arms
Compatible Drive Type	XActant DC Drive
Other	Unable to connect braking resistor
Dimensions (Length * Width * Height)	70mm*35mm*25mm

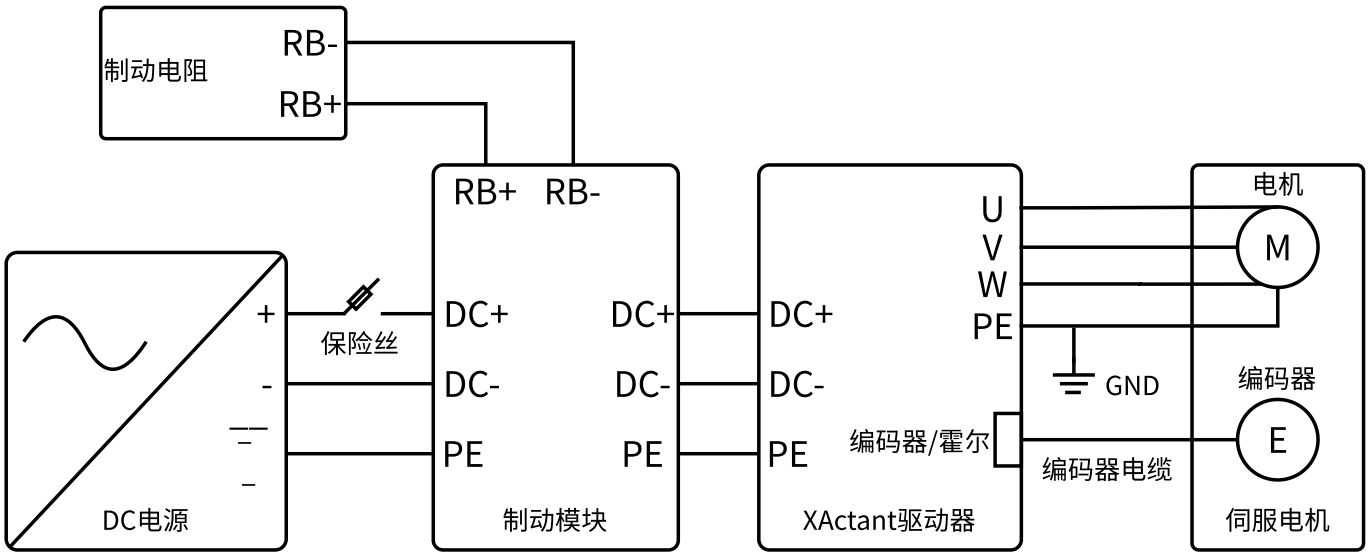
> Alternatively, select other suitable braking modules, ensuring that the voltage range, discharge current, power, etc., can cover the hardware specifications of the drive.

4. Wiring Example

1. Products that support the regenerative braking function have a regenerative braking interface (B1), allowing direct connection of a regenerative braking resistor between B1 and DC+, as shown in the figure below.



2. For products that do not support the regenerative braking function, a regenerative braking unit must be connected between DC+ and DC-, that is, a braking resistor is connected through a braking module, as shown in the figure below.



Note:

- It is recommended to use aluminum shell resistors.
- Please install the external braking resistor on non-combustible materials such as metal.
- For products that do not support the regenerative braking function, do not directly connect the external braking resistor to the positive and negative poles of the busbar, otherwise it may cause the drive to explode and start a fire. The braking resistor must be connected to the drive through the braking module.

5. Regenerative Braking Instructions

> Servos have three braking methods: "electromagnetic braking", "regenerative braking", and "dynamic braking", which users may easily confuse in terms of their concepts and functions.
>
> 1. Electromagnetic braking locks the motor shaft through a mechanical device, similar to a clutch, and serves to maintain torque after the servo stops, also known as "brake holding". It is generally not recommended for use in the braking process. Its purpose is to prevent the vertical axis from falling when power is cut off or to maintain the axis position after power-down, and it is generally not used as a brake except in an emergency stop.
> 2. Regenerative braking refers to the process in which the servo motor feeds the energy generated during braking back to the DC bus through the inverter circuit and absorbs it via the resistor-capacitor circuit when decelerating or stopping. The purpose is to discharge the generated energy that the servo motor feeds back to the DC bus, ensuring that the DC bus remains within a safe voltage range, and requires the use of built-in or external power discharge resistors of the servo motor.
> 3. The dynamic brake consists of dynamic braking resistors, which shortens the mechanical feed distance of the servo motor through dynamic braking during faults, emergency stops, and power outages. The purpose is to quickly release the kinetic energy of the shaft and stop the shaft movement as soon as possible. There are resistors inside the servo to consume the braking energy, and small-power servos also simply use winding resistors.
>
> Differences among the three:
>
> 1. Regenerative braking only works when the servo is operating normally, and cannot brake the motor in cases such as malfunction, emergency stop, or power outage. Dynamic brakes and electromagnetic brakes do not require power to operate.
> 2. The operation of regenerative braking is automatically performed by the system, while the operation of dynamic brakes and electromagnetic braking requires external relay control.
> 3. Electromagnetic braking generally starts after SV OFF; otherwise, it may cause amplifier overload. Dynamic braking generally starts after SV OFF or main circuit power-off; otherwise, it may cause the dynamic braking resistor to overheat.
> 4. Electromagnetic braking is mostly used for braking, while dynamic braking is mostly used for emergency stops, but the position after dynamic braking cannot be controlled.

> Note: The information is sourced from the internet.

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6. Regenerative Energy

6.1 Renewable energy sources

When the servo decelerates the motor machine load, mechanical energy is converted into electrical energy and fed back to the drive. If the returned energy is not properly handled, it will cause the drive voltage to rise, resulting in overvoltage protection alarm at best and drive burnout at worst.

6.2 Regenerative energy handling method

6.2.1 Capacitor Storage

For AC servo drives, the capacitance is generally relatively large, with some ability to store energy. For low-voltage servo drives, the capacitance is relatively low.

1，电能： $E = 0.5C(U_{max}^2 - U^2)$ 。举例，C = 200μF，Umax = 55V，U = 48V，E = 0.072J。

2, Mechanical Energy: $E = \frac{1}{2}Jw^2$ 或者 $\frac{1}{2}mv^2$

Neglecting friction, when mechanical energy equals electrical energy, the capacitor storage can precisely store mechanical energy. For example, when the speed is 6000 RPM and J < 5.37E-7 kg*m^2, the capacitor can complete energy storage.

6.2.2 Resistance Release

When the energy that the capacitor is allowed to store is less than the mechanical energy, the voltage will continue to rise. The excess energy needs to be dissipated as heat through the resistor. At this time, the rate at which mechanical energy is converted into electrical energy depends on the control current and operating voltage of the driver, and this part of the energy power needs to be released (in many documents, it is also considered to first subtract the stored electrical energy, but if the mechanical energy is much greater than the stored electrical energy, the electric field energy is ignored).

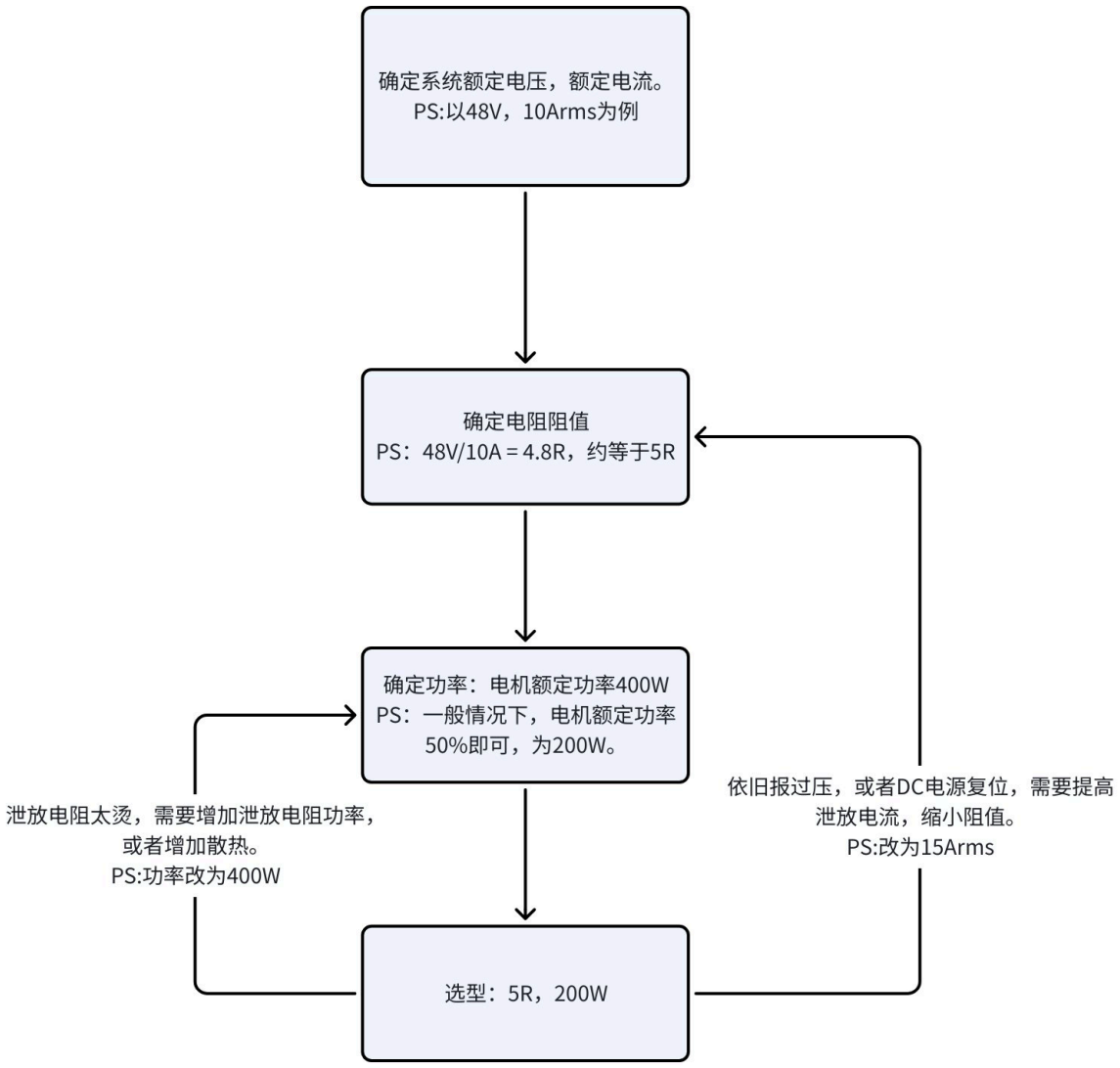
Taking the usage scenario as an example: with a maximum withstand voltage of 58V and a rated current of 10A (if overload is enabled, for example, 2 times overload, then 2*10A), the braking resistor R = U/I = 58/20A = 2.9R. The power of the braking resistor is P = UI = 58*20 = 1160W. Generally, the rated current is sufficient, and overload is not required.

When selecting a bleed module, the maximum current needs to be considered. Additionally, the brake resistor power is related to the actual mechanical energy and deceleration time. The theoretical maximum value calculated here, i.e., when the mechanical energy is very large and braking is performed at the overload factor, is not the optimal solution under actual conditions; it is only an extremesafety solution, while leaving a certain redundancy of 10% - 20% in the resistor power. That is, 1160W * 10% - 20% = 1276 - 1392W, and the redundancy depends on the resistor's heat dissipation method.

6.2.3 Grid Feed-in

For high power, such as 1MW, the cost of electrical energy storage is too high, and releasing energy through resistance is too wasteful. Therefore, energy can be fed back to the power grid in a more economical way for energy recovery.

7. Selection SOP



Diagram, Selection Process of Bleeder Resistors

7.1 Parameters of the bleeder resistor:

a. Resistance value, the reverse current during deceleration affects the resistance value of the discharge resistor. Especially during 3x overload deceleration, the regenerative energy is huge, and the corresponding discharge resistor also needs to be reduced.

b. Power depends on the magnitude of regenerative energy.