

Contactor (EMR) or Solid State Relay (SSR)?

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To get the most out of the BMS and protect your electrical installation you need some heavy duty relays. They open or close the power circuits, can handle high current and are remotely commanded by the BMS.

In this article I look at the two main categories of heavy duty relays:

- **contactor or electro-mechanical relay (EMR)**
- **solid state relay (SSR)**



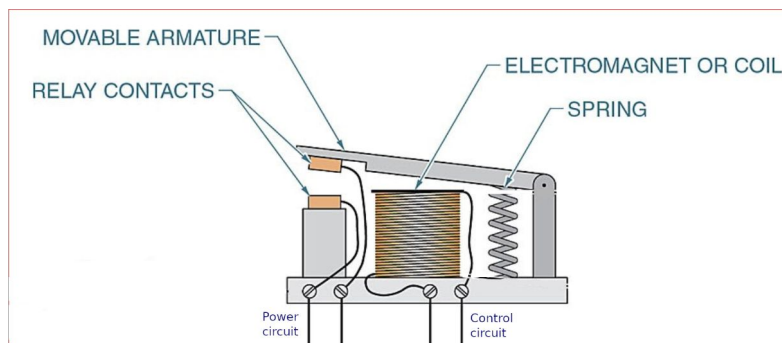
Typical use for heavy duty switching device are:

- main isolation of a battery bank
- disconnect one or more charge sources (the charge bus or individual chargers)
- disconnect one or more loads (the load bus or individual loads)
- parallel two battery banks

Disclaimer: all the products I mention in this article are just examples. I do not endorse nor recommend any specific product. I do not have any interest in the brand names I mention. The choice of a heavy duty switching device is yours based on their usage and the characteristics of your electrical installation. If in doubt, I strongly suggest that get advice from a professional.

CONTACTOR (EMR)

An electro-mechanical device where the contacts are closed or opened by a mechanical system



- the power circuit is closed by mechanical contacts
- when the control circuit is not powered, the spring keeps the contacts open
- powering the electromagnet (control circuit) closes the contacts

Important characteristics of contactors:

- voltage rating:
the voltage of the power circuit controlled by the SSR
- continuous rated current:
the maximum current that can safely flow through the power circuit - should be 20% above the normal maximum current you anticipate
- max braking current:
the maximum current the relay can interrupt without arcing (if arcing happens, the current is not interrupted) - should be greater than the rating of the fuse on the power circuit
- contact resistance:
the resistance introduced in the power circuit when the contacts are closed - the smaller, the better as the heat generated in the relay is proportional to that resistance (for example a resistance of 0.5 mOhm will produce 5 watts of heat with a 100 A current, and 20 watts with 200 A)
- coil power:
the power consumed by the control circuit after the relay is closed (more power is consumed during a short time to initially close the contacts) - it depends on the voltage and the conception of the control circuit (some have two coils or electronics to limit power once the contacts are closed)

Examples:



TE Connectivity
High current relay 150
cost: ~ 70 USD

continuous rated current	180 A @ 23°C
max braking current	300 A
contact resistance	0.7 mΩ
coil power	4 W (0.33A @ 12v)



TE Connectivity
IHVA200
price: ~ 100 USD

rated current	200 A
max braking capacity	2000 A
contact resistance	0.3 mΩ
coil power	5W (0.42A @ 12V)



AliExpress
SEV200ADXL
price: ~ 35 USD

continuous rated current	200 A
max braking current	???
contact resistance	> 0.8 mΩ
coil power	? 2 - 7 W



Blue Sea
ML-RBS 7713
price: ~220 USD

continuous rated current	500 A
max braking current	1450 A
contact resistance	???
coil power	0.16 W (0.013A @ 12V)



Gigavac
GX14
price: ~ 115 USD

continuous rated current	300 A
max braking current	600 A
contact resistance	0.15 to 0.3 mΩ
coil power	2.8 W (0.23A @ 12V)



Dongya
DH250L
price: ~40 USD

continuous rated current	250 A
max braking current	2000 A
contact resistance	0.3 mΩ
coil power	2.2 W (0.18A @ 12V)

What you need to check when selecting a contactor (EMR):

- diameter of power studs and distance / isolation between them (critical for high currents / big cables)
- some can only be mounted in one direction
- check the voltage of the control circuit to match your installation
- manual override (OFF / BMS / ON) - can also be done with a 3-way switch and some wiring on the control circuit
- presence of a circuit to suppress high voltage spikes (if not you will have to add a spike suppression diode in the control circuit)
- most contactors are mono-stable (they return to the open state when the control circuit is no longer powered), but some that are bi-stable (they stay in the last state even after the control circuit is no longer powered) - they have two control circuits (one to open and one to close) that are activated by an impulsion - the advantage is that they do not consume any power once switched in the desired state, but additional logic is required to control them (may not be the best choice for safety applications where you want the failure mode to be in the open state)

Benefits:

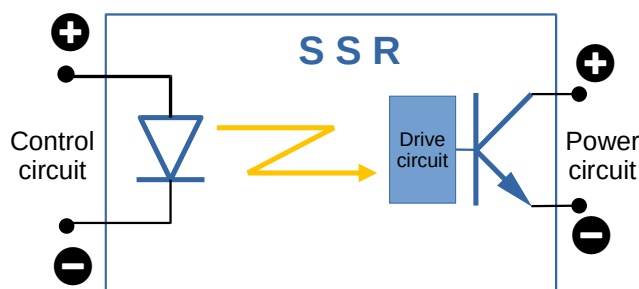
- low contact resistance (low heat dissipation)

Other installation considerations:

- if this is a main contactor that is activated most of (all) the time you need to consider the power consumption of the control circuit (0.42A corresponds to 10Ah per day) and select a contactor with low coil power
- the control circuit is inductive (coil) and an unacceptably high voltage spike can be produced in the control circuit when the device is de-energized - this may damage the controlling electronics and you should insert a protective device (diode) in the control circuit (some contactors are already equipped with such protective device and do not need external protection)
- an arc is produced when the contactor interrupts the current - they cannot be used in environment with flammable gas or where equipment is sensitive to electromagnetic interference (EMI)
- being mechanical devices you need to mount them only in a position approved by the manufacturer and they may be sensitive to shocks and vibrations leading to potential unreliable or erratic operation

SOLID STATE RELAY (SSR)

An electronic switching device that switches ON and OFF when an external voltage is applied across its control terminals.



- the power circuit is closed by an electronic switch (usually a MOSFET for DC applications)
- when the control circuit is not powered, the MOSFET does not conduct electricity
- powering the control circuit turns on a light emitting diode (led) - the generated light activates a drive circuit that makes that closes the electronic switch (the MOSFET becomes conductive)

Important characteristics of a SSR:

- voltage rating:
the voltage of the power circuit controlled by the SSR
- continuous rated current:
the maximum current that can safely flow through the power circuit - should be at least 20% above the normal maximum current you anticipate
- maximum surge current:
the maximum current that can flow through the power circuit for a very short time (should be well above the rating of the fuse protecting the power circuit)

- on-state resistance - R_{dson} (mOhm) / on-state voltage drop (V):
corresponds to the amount of energy the SSR will have to dissipate in the on state
- max off-state leakage current:
even in the off-state some current goes through the electronic switch (this could drain a battery over a long period)
- control voltage:
the voltage of the control circuit with the minimum turn-on voltage and the must turn-off voltage

Examples:



Crydom
HDC60D160
price: ~ 150 USD

voltage rating	7 - 48 VDC
continuous rated current	160 A
max surge current (10ms)	470 A
on-state resistance (Rdson)	3.5 mΩ (90W @ 160A)
max voltage drop	0.56 V
max off-state leak current	0.1 mA
control voltage	4.5 - 32 VDC



CG Instrument
(AliExpress)
SSR-200DD
price: ~ 15 USD

voltage rating	4 - 220 VDC
continuous rated current	200 A
max surge current (10ms)	???
on-state resistance (Rdson)	??? (see size of heat sink!)
max voltage drop	???
max off-state leak current	2 mA
control voltage	3 - 32 VDC



Kudom
KSJ30D100
price: ~ 55 USD

voltage rating	30 VDC
continuous rated current	100 A
max surge current (10ms)	260 A
on-state resistance (Rdson)	6 mΩ (60W @ 100A)
max voltage drop	0.6 V
max off-state leak current	0.1 mA
control voltage	4 - 32 VDC



Chargery
DCC-300HB
price: ~90 USD

voltage rating	100 VDC
continuous rated current	300 A
max surge current (2 s)	500 A
on-state resistance (Rdson)	0.8 mΩ (32W @ 200 A)
max voltage drop	80 mV @ 100 A
max off-state leak current	?
control voltage	12 V
bidirectional	yes

What you need to check when selecting a SSR:

- power stud diameter and distance / isolation between them (most seem to have 4mm studs which may not be suitable for power applications)
- power (heat) dissipation at operating current - this is wasted energy you cannot use

Benefits:

- control circuit consumes very little power (less than 20 mA)
- reliable - there are no moving parts (position insensitive, resistant to shock and vibration)
- no spark / electric arc

Other installation considerations:

- make sure you get a SSR designed for DC current (SSR for AC current have different switching principle and some may not open when used with DC current)
- although they are very reliable, when a SSR fails, it is often in the closed state, so that may not be suitable as a safety device for some installations
- SSR for DC current most often only work with current flowing one direction - check the SSR characteristics if using it to isolate a battery that is charged and discharged (Chargery DCC is bidirectional)
- most SSR dissipate a significant amount of energy and need to be mounted on a heat-sink or have internal fan:
 - in the examples above, the Chargery DCC has the lowest energy dissipation with about 32 watts when the current through it is 200 A (very low for a SSR)
 - the Crydom HDC60D160 with an on-state resistance of 3.5 mOhm dissipates 90W at 160A
 - the CG SSR-200D has no data about on-state resistance, or energy dissipation, but looking at the suggested heat-sink, it must be a lot!



- if a SSR is mounted in the same closed compartment as the battery, you want to be sure that the generated heat will not impact the battery temperature too much (lithium batteries age faster at high temperature)

THE FOUR QUESTIONS TO ASK YOURSELF:

- 1. Does polarity matter?**
 - some SSR are designed to work only with current flowing in one direction (OK to cut charge or load buses separately)
 - EMR are insensitive to current direction
- 2. Is power dissipation (heat) a concern?**
 - EMR dissipate very little power even with high current
 - some SSR will generate a lot of heat when the current increases and need to be mounted on a heat-sink - they may be more suited for lower current applications (or when high current is not frequent / does not last long)
- 3. Can you afford the power consumption of the control circuit?**
 - SSR's control circuit consumes very little power (20 mA or less)
 - some EMR's control circuit consumes from 0.3 to 0.5 A continuous @ 12V and much more for a brief moment when they are switched ON:

- you must validate that the control circuit can handle that current (if not, you need to add an intermediate low power relay to control them)
- power consumption can be 7 to 12 Ah per day – if the system is unattended for a long time you need a charge source (if you keep the solar panel in float all the time, make sure the float voltage is low as a lithium battery should not be kept fully charged)

4. Where is the device going to be mounted?

- SSR can be mounted in any direction, but low cost models often have very small posts
- some EMR can only be mounted in one position (check specifications)