

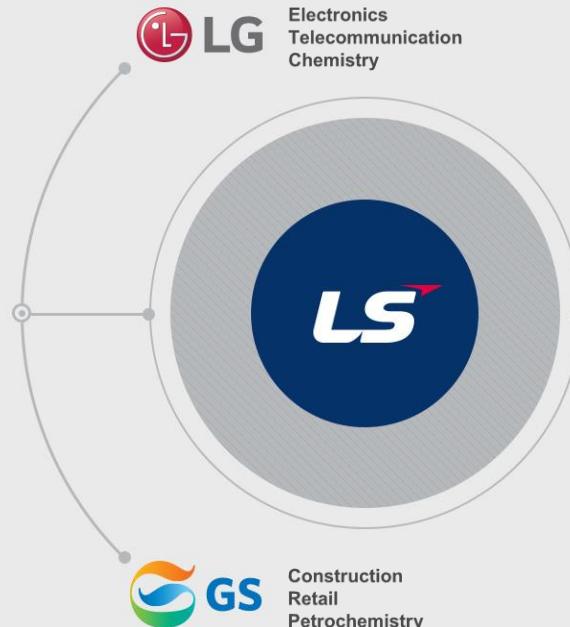


FUTUREING SMART ENERGY

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LS Group is a conglomerate based in South Korea. It spun off from LG Group in 2003. LS is leading in the field of electric power, automation, machinery, materials and energy.



- **LS** Cable & System [1962]
- **LS** Mtron [2008]
- **LS** - Nikko Copper [1936]
- **LS ELECTRIC** [1974]
- **yesco** [1981]
- **GAON** [1947]
- **E1** [1984]

LS Group

EMPLOYEES 12,700

AFFILIATES 48

SALES 22.9 B USD

TOTAL ASSET 22.6 B USD



EMPLOYEES 3,500

SALES 1.9 B USD

OPERATION
INCOME 150 M USD

* Financial figures in 2019

LS ELECTRIC is the pioneer of electric power system, automation, and green energy industry in South Korea.



Company Name LS ELECTRIC CO., LTD.

Founded 1974

Employees 3,500

Total Assets 2,170 (In millions of USD, 2019)

Headquarters LS Tower, LS-ro 127, Dongan-gu, Anyang-si, Gyeonggi-do, Korea

Seoul office LS Yongsan Tower, Hangang-daero 92, Yongsan-gu, Seoul, Korea

Plants 4 in Korea, 2 in China and 1 in Vietnam

Global Manufacturing Footprint

Global manufacturing footprints and top-notch R&D centers allows LS ELECTRIC to produce global top level products with unparalleled cost competitiveness

R&D centers, South Korea

- ⦿ Convergence Technology R&D Center
- ⦿ Electro Technology R&D Center
- ⦿ Automation R&D Center
- ⦿ Power Testing&Technology Institute





Power Distribution Solution



▶ Switchgear

- MV / LV Switchgear
- Busway

▶ Transformer

- Mold Transformers, Oil Transformers

▶ Medium Voltage

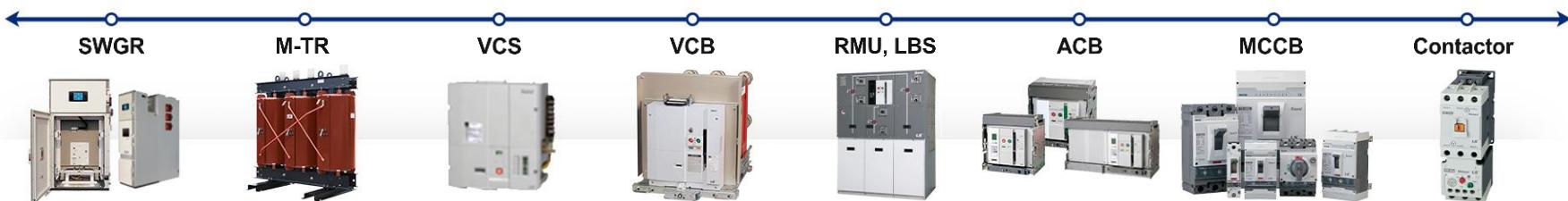
- Vacuum Circuit Breakers (VCB)
- Ring Main Units (RMU), Load Break Switches (LBS)

▶ Low Voltage

- Air Circuit Breakers (ACB)
- Molded Case Circuit Breakers (MCCB)
- Magnetic Contactors (MC)

▶ Measurement / Relay

- Smart Meter, Advanced Metering Infrastructure
- Digital Protection & Measurement Device



- 7.2~36kV
- 630~4,000A
- Up to 50kA
- IEC 62271-200

- 3.3~36kV
- Up to 20MVA
- IEC 60726

- AC 3.3kV~6.6kV
- Up to 400A
- Up to 40kA
- IEC 62271-106

- AC 7.2~40.5kV
- Up to 4,000A
- Up to 50kA
- IEC 62271-100

- 12/17.5/24kV
- 630A
- 21kA (3s)
- IEC 62271-1~200

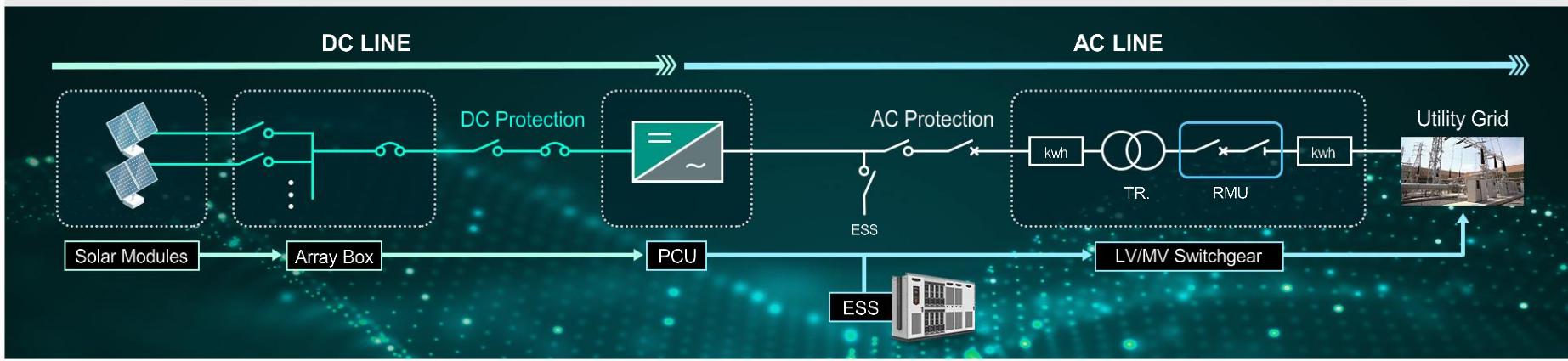
- AC 690V
- Up to 6,300A
- Up to 150kA
- IEC 60947-2

- AC 690V
- Up to 1,600A
- IEC 60947-2

- Up to AC 1,000V
- Up to 2,650A
- UL 508
- IEC 60947-4-1

LS ELECTRIC is growing into a major player in the DC market based on the successful reference of the PV, Wind, BESS field throughout Europe.

DC



DDH / DDV

- Ue=DC750~1,500V
- In=800~4,000AF
- Icw=100kA/1s



Compact DDH,DDV

- Ue=DC750~1,500V
- In=800~1,600AF
- Icw=50kA/1s



ADH / ADV

- Ue=DC750~1,500V
- In=800~3,200AF
- Icu=60kA(1,500V/dc)
- Icw=65kA/1s



TD100-TS800 DC

- Ue=DC500~1,500V
- In=16~800A
- Icu=40kA



GPR010~H500-A

- Ue=DC450~1,500V
- In=10~500A
- Uimp=4~8kV



BK63H DC

- Ue=DC250~1,000V
- In=1~63A
- Icu=10kA



BK20S-DC1500

- Un=DC110~1,500V
- Up≤1.0~4.5kV
- Imax=40kA

“Great Company Prospering for 100 years”

Our goal is to go beyond global standard through constant quality improvement and innovation.



Top 100 Global Innovator
for 10 consecutive years
[2021]

| R&D Campus_Anyang



R&D Campus is consistently developing differentiated technologies and software in new business sectors as a future growth engine. We sharpen our competitive edge by developing next generation platform, to provide total energy solution service.

| Electronic Power R&D Center_Cheongju



R&D Center is the main laboratory for electrical power solution business of LS ELECTRIC. Our focus is to lead smart energy & smart factory industry from transformation to distribution, which is the core business value of LS ELECTRIC.



13

13th largest testing capacity lab in the world [2019]Short circuit test capacity :
2,000MVA**Resolute investment for development & competitiveness**22.5 million USD investment plan
for the 2nd short circuit generator**Global standard activities with IEC**

IEC TC : Technical Committee activities

**Rigorous performance test for credibility of products****MV/LV (~36kV)**

MV test & Direct test for short-circuit generator

Ultra high voltage (~170kV)

Composite test

Credibility test considering real-use situation

EMC, environment/proof test

**Perusing global reputation with international certificate associations**

* KOLAS : Korea Laboratory Accreditation Scheme

* ILAC-MRA : International Laboratory Accreditation Cooperation - Mutual Recognition Arrangement

| Global expansion through more than 20 overseas branches and subsidiaries



Overseas Subsidiaries

Chicago(USA), Tokyo(Japan), Dubai(U.A.E),
Hanoi(Vietnam), Wuxi/Dalian(China),
Amsterdam(Netherland)

Overseas Branches

Irvine(USA), Moscow(Russia), Tokyo(Japan),
Bangkok(Thailand), Hochiminh(Vietnam), Jakarta(Indonesia)
Shanghai/Beijing/Guangzhou/Qingdao/Chengdu/Shenyang/Jinan(China)

Presence Internationally

77 Countries

DC Solution | DC Relay Business & Reference

History

LSE's capability for developing and manufacturing automotive components for xEV is derived from the business experience over 40 years and domestic market share of 70% in magnetic contactor & circuit breaker.

Automation Equipment & Systems



- Programmable Logic Controller
- Inverter
- Process Automation
- Railway System
- Intelligent Transport System
- Power IT Solution
- Power Photovoltaic System

Electric Equipment & Systems



- Low Voltage
- Medium Voltage
- Protection & Measurement
- Transformer
- Gas Insulated Switchgear
- Low & Medium Switchgear
- Power Equipment Diagnosis, Preventive, Maintenance
- Bus Duct System

Automotive Component Products

HIGH VOLTAGE EV RELAY



EV Relay (Standard)

BATTERY DISCONNECT UNIT



Industrial Products

ESS BPU

PCS

PV Inverter

EV charger



1000V/1500V Relay

DC Solution | DC Relay Main function

I Main function

The main function of LS ELECTRIC DC Relay is stable supply of electric power and cut-off.

This prevents the failure of blocking the short circuit current of capacitor, motor or the wiring within short time.

Hermetically sealed with mixed gas, it provides compact solution with low operating sound.

I GER? GPR?

I GER Green Electric Vehicle Relay

I GPR Green Power Relay



DC Solution | DC Relay Structure

Features



Compact Design

Achieved compact size by filling with hydrogen and nitrogen gas to improve the breaking performance.



Proven Safety

High value of short circuit current withstanding.



Superior Reliability

Excellent performance with electrical and mechanical endurances.

Structure

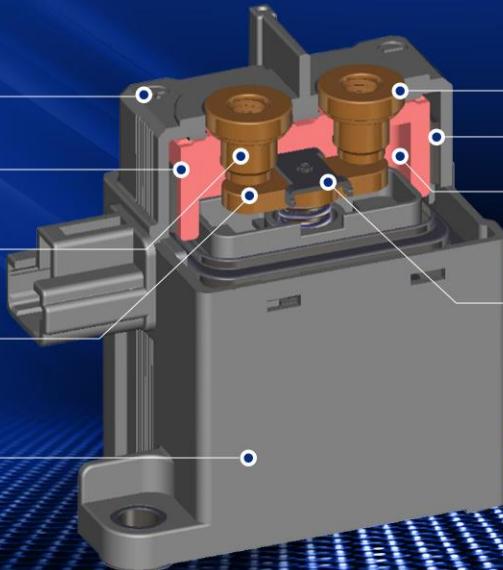
Housing

Arc Chamber

Fixed Contact

Movable Contact

Actuator



Main contact

Magnet & Holder

H2 Mixed Gas

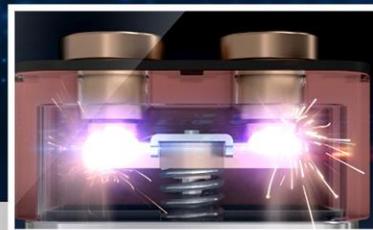
Short circuit
Improving Design

DC Solution | DC Relay Arc Quenching Method

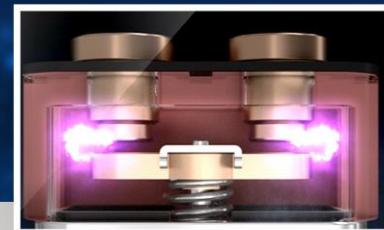
Due to magnetic field by permanent magnet, the arc can move toward the arc chamber by Fleming's left-hand law.

Arc quenching sequence

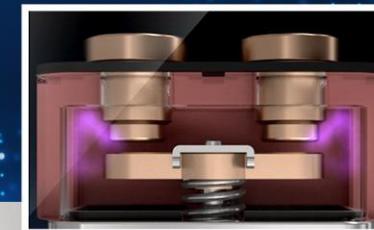
Arc Ignition



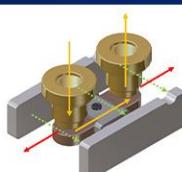
Arc Elongation



Arc Quenching



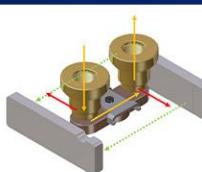
Unidirectional



Magnetic field
Current direction
Arc direction

If current flow to reverse direction, arc direction will be reverse direction.

Bidirectional



Magnetic field
Current direction
Arc direction

Control the arc direction with magnet location

DC Solution | LS Electric DC Relay Portfolio

	10A/20A	40AF	150AF	250AF	400AF	600AF~
450V	10A	40A 75A	100A 150A 200A	250A	300A('21) ※ Short-Circuit Capacity & Bi-directional Load	400A ※ Short-Circuit Capacity & Bi-directional Load
750V/800V			150A	250A('21)	400A('21)	
1000V	10A	40A	100A 150A 200A	250A ※ Short-Circuit Capacity & Bi-directional Load	400A ※ Short-Circuit Capacity & Bi-directional Load	500A('21) ※ Short-Circuit Capacity & Bi-directional Load 600A ('22)
1500V					500A(w/aux) ※ Bi-directional Load	800A(w/aux,'23) ※ Bi-directional Load
PCB Type		60A ※ Bi-directional Load	150A	20A/40A('21)		

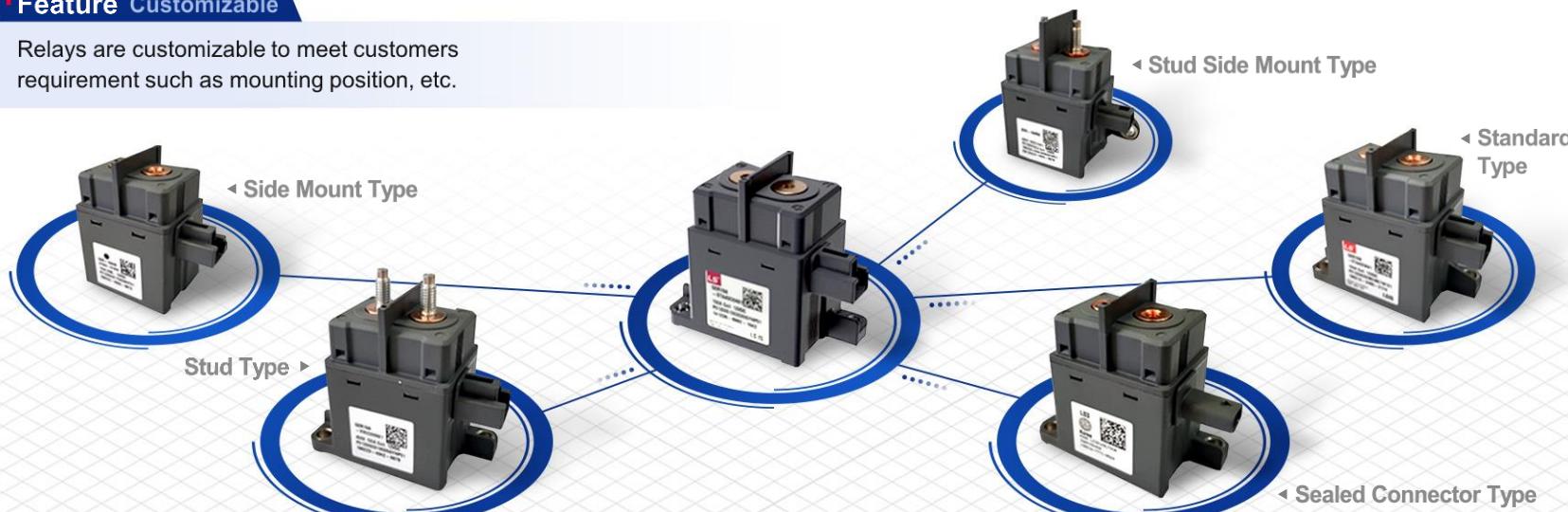
● Year of production ready

DC Solution | DC Relay Customizing Option

- ▶ DC Relay standard is BM type(Bottom Mounting), But we can provide SM type(Side Mounting) for customer height issue.
- ▶ If customer want to increase torque, We can provide stud type contact shape.

Feature Customizable

Relays are customizable to meet customers requirement such as mounting position, etc.



EV Solution | EV Business & Reference

Korea



LG Energy Solution

LG Electronics

- **BDU**
: EV, PHEV, HEV

- **DC Relay**
: Pre-charger, Main Relay,
DC Charger

EU



DAIMLER

BOSCH

China



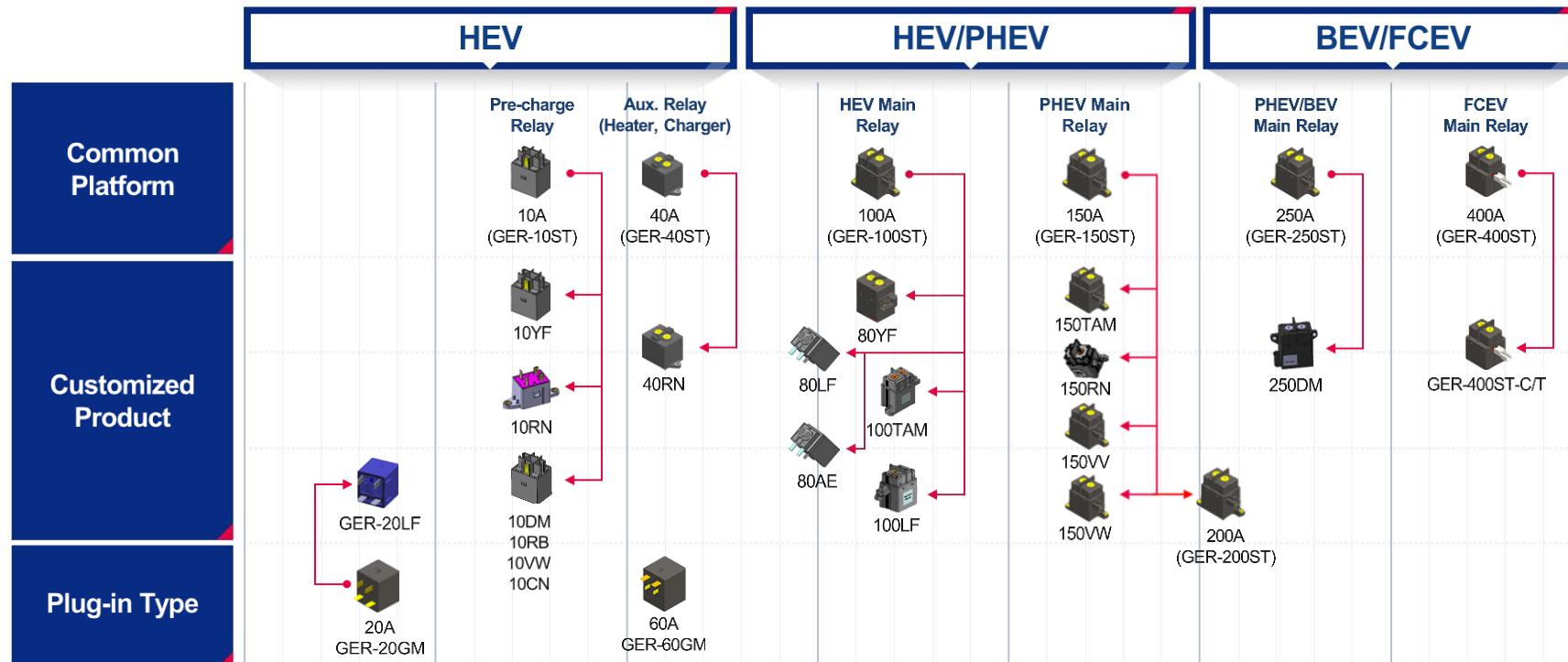
North America



- **DC Relay**
: Pre-charger, Main Relay,
DC Charger

- **BDU**
: HEV
- **DC Relay**
: Pre-charger, Main Relay,
DC Charger

EV Solution | Customized Product Line-up



Confidential

New Products | GER-M250ST G2

Now markets want to have more compact and high performance solution.

GER250(Standard Type)

Size : 61 x 78.5 x 45

Volume : 215cm³



Current Specification

- Rated Voltage : 450V
(Insulation Voltage : Up to 500V)
- Rated Current : 250A(100sq) at 85°C
- Short Circuit : 6kA with Fuse
- Unidirectional
- Status : Mass Production

Volume
29%
Decreased

GER-M250ST G2(Smaller Design)

Size : 56.7 x 63 x 42.7

Volume : 152cm³



Key Target Specification

- Rated Voltage : 800V
(Insulation Voltage : Up to 1000V)
- Rated Current : 250A(50sq)/**300A(75sq)** at 85°C
- Short Circuit : **10kA** without Fuse(**12kA** with Fuse)
- **Bidirectional**
- SOP : 2021 Q3

Confidential

New Products | GER-M400ST G2

Now markets want to have more compact and high performance solution.

GER400(Standard Type)

Size : 63 x 84 x 58

Volume : 307cm³



Current Specification

- Rated Voltage : 450V
(Insulation Voltage : Up to 500V)
- Rated Current : 400A(150sq) at 85°C
- Short Circuit : 7kA with Fuse
- Unidirectional
- Status : Mass Production

Volume
47%
Decreased

GER-M400ST G2(Smaller Design)

Size : 56.5 x 73 x 42.5

Volume : 175cm³



Key Target Specification

- Rated Voltage : 800V
(Insulation Voltage : Up to 1000V)
- Rated Current : 400A(120sq)/500A(150sq) at 85°C
- Short Circuit : 12kA without Fuse(18kA with Fuse)
- Bidirectional
- SOP : 2021 Q3

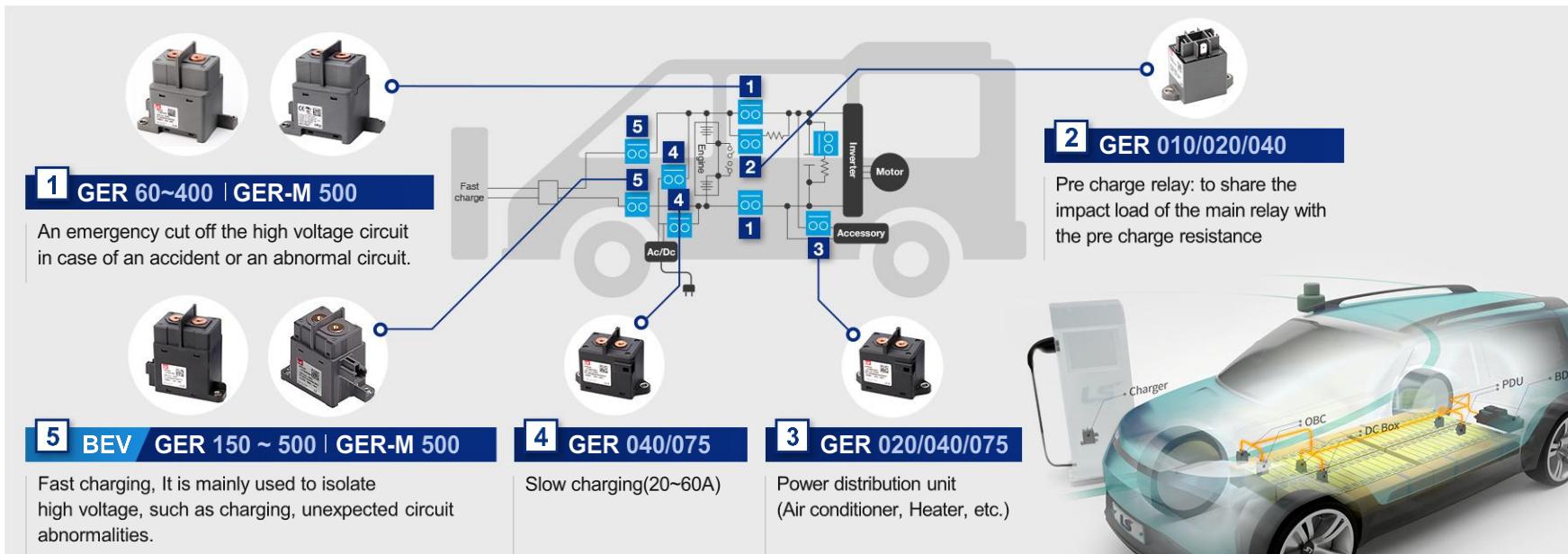
Confidential

New Products | Target Specification

MODEL		GER-M250ST G2	GER-M400ST G2
Pole (P)		1	1
Operation Voltage (Ue)		DC800V	DC800V
Rate Insulation (Ui)		DC1000V	DC1000V
Rate Impulse Withstand Voltage (Uimp)		4kV	4kV
Contact	Conventional thermal current (Ith)	250A (85°C, 50mm ²) / 300A (85°C, 75mm ²)	400A(85°C, 120mm ²) / 500A(85°C, 150mm ²)
	Contact Resistance (Voltage Drop)	0.02V @ 20A	0.02V @ 20A
Coil	Rated Voltage (@ 20°C)	12VDC	12VDC
	Pick-up Voltage (@ 20°C)	Max. 9VDC	Max. 9VDC
	Drop-out Voltage (@ 20°C)	Min. 1.2VDC	Min. 1.2VDC
	Coil Resistance (@ 20°C)	20.2Ω	33Ω
	Power Consumption (@ 20°C)	7W	TBD(PWM)
	Max. Allowable Voltage	16VDC	16VDC
	Operating Time	Max. 50ms	Max. 30ms
	Release Time	Max. 30ms	Max. 10ms
	Insulation Strength	Min. 100MΩ (@500VDC)	Min. 100MΩ (@500VDC)
	Dielectric Strength	2500Vrms/min	2500Vrms/min
Shock	Functional	ON: 196m/s ² (20G) OFF : 147m/s ² (15G)	ON: 196m/s ² (20G) OFF : 98m/s ² (10G)
	Destructive	490m/s ² (50G)	490m/s ² (50G)
Vibration	Functional	10 to 1000 Hz @1.0G	10 to 1000 Hz @1.0G
	Destructive	10 to 200Hz in increments of 10 @Min. 4.5G	10 to 200Hz in increments of 10 @Min. 4.5G
Expected Life	Mechanical	Min. 200,000 Cycles (3600Cycles/h)	Min. 200,000 Cycles (3600Cycles/h)
	Electrical(Rate Operational Current, Ie)	500Vdc 250A, 100 Cycles	500Vdc 400A,100 Cycles
	Short-Circuit Current (With FUSE)	12,000A,2ms	18,000A,2ms
	Short time Withstand Current (Without FUSE)	10,000A,2ms	12,000A,2ms
	Max. Cut-off Current	1,800A at DC500V (1 cycle) 800A at DC800V (1 cycle)	2,000A at DC500V (1 cycle)TBD 1,800A at DC800V (1 cycle)TBD
	Ambient Operating Temp	-40 ~ 85°C	-40 ~ 85°C
	Ambient Operating Humidity	5-95% R.H.	5-95% R.H.
	Weight	Approx. 390g	Approx. 450g
SIZE	W X H X D (mm)	56.7 x 63 x 42.7	56.5 x 73 x 42.5

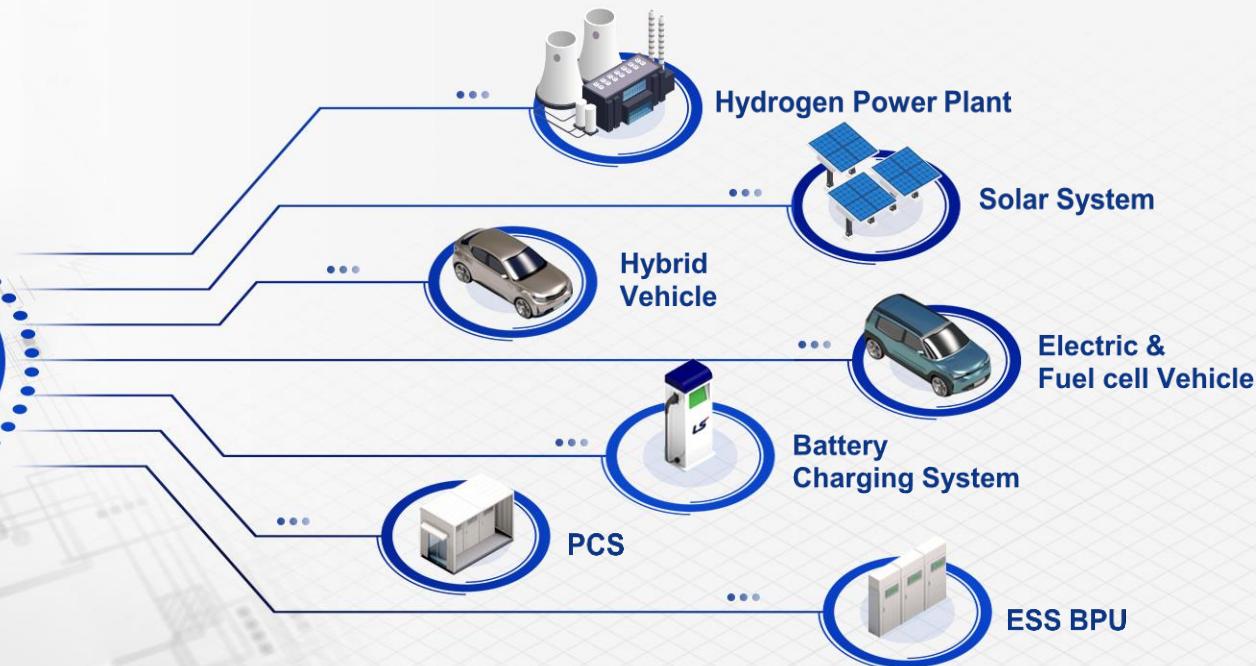
EV Solution | EV Relay Application

The location of the relay applied inside the vehicle is as follows. The use of each application is slightly different depending on where it is applied. The quantity may increase or decrease depending on the customer's battery and circuit configuration.



Industrial Solution | DC Relay Application

Feature Applications

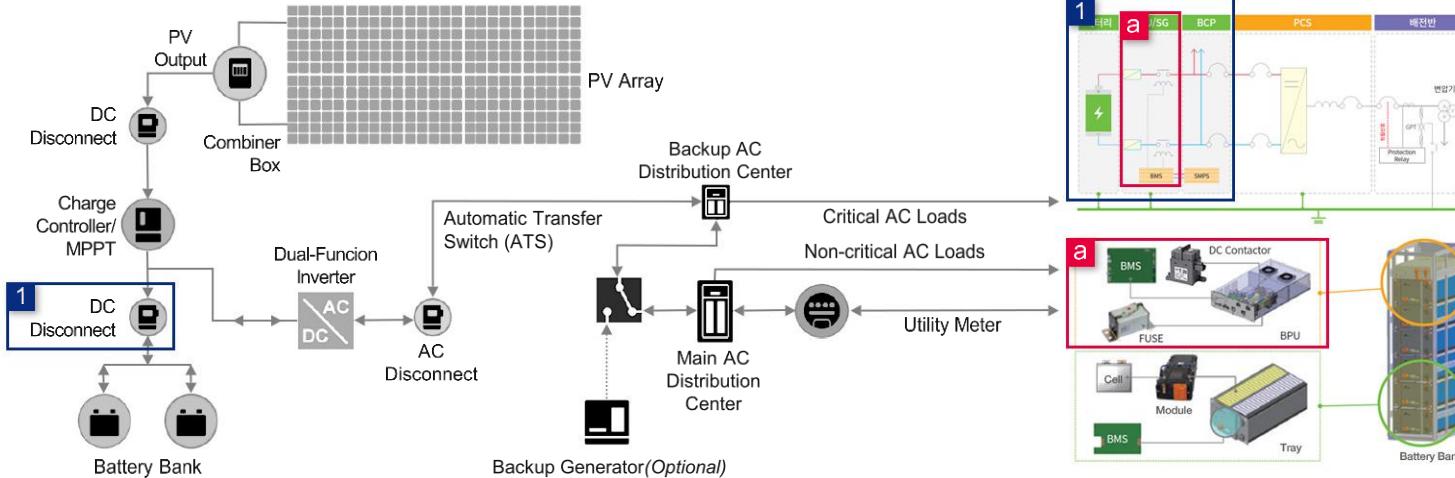


Industrial Solution | DC Relay Application

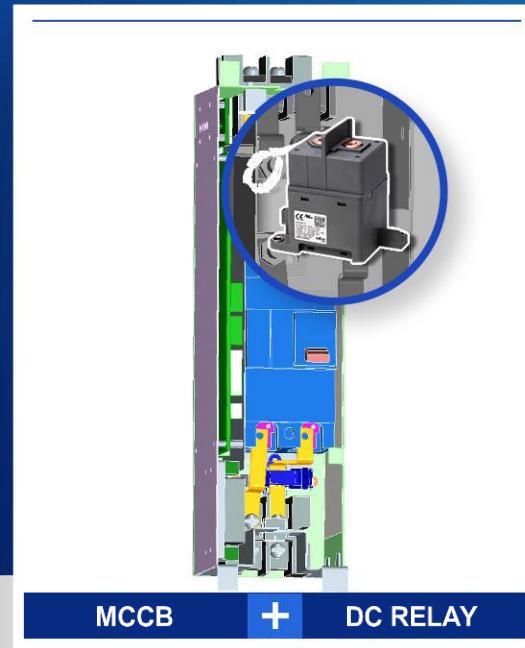
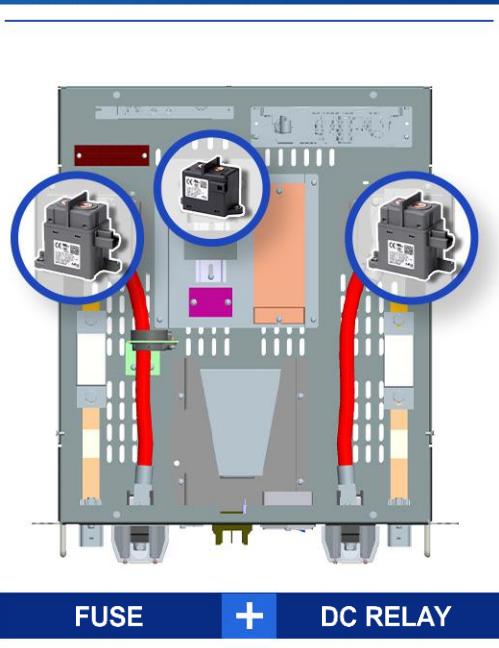
DC RELAY+FUSE Combination

- Series connected inside the BPU for battery protection.
- The main function of DC Relay is current flow with bi-directional and withstanding short circuit current until fuse blow.

TYPICAL DC-COUPLED PV GRID-TIED SYSTEM WITH BATTERY BACKUP



Industrial Solution | DC Relay Application

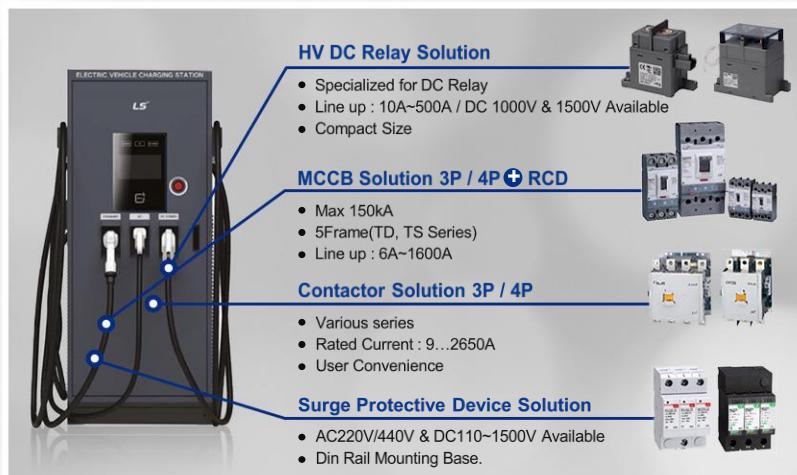


Industrial Reference 01 EV Charger

Application : EV-Charger (LS Electric)

Products : 1500Vdc Bi-directional DC Relay(500A)
1000Vdc DC Relay(400A)
AC Circuit Breaker(250AF)

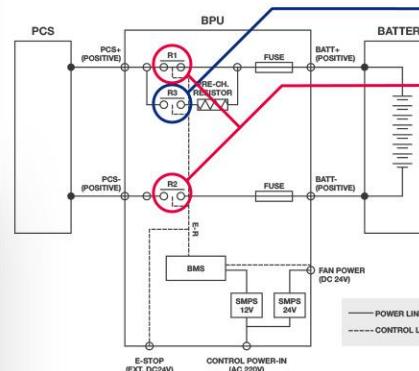
Note : DC Relays for Fast DC Charger(100kw)



Industrial Reference 02 ESS BPU

Application : ESS BPU (Battery Protection Unit)

Circuit Diagram

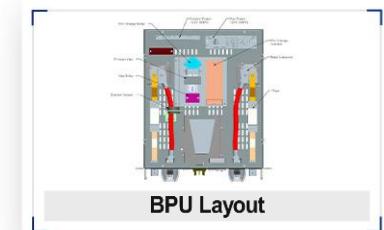


Pre-Charge Relay (DC1500V, 20A)

- To reduce Inrush by voltage difference.

Main Relay (DC1500V, 90A)

- Switching between the PCS and Battery.



BPU Layout

BPU Environment

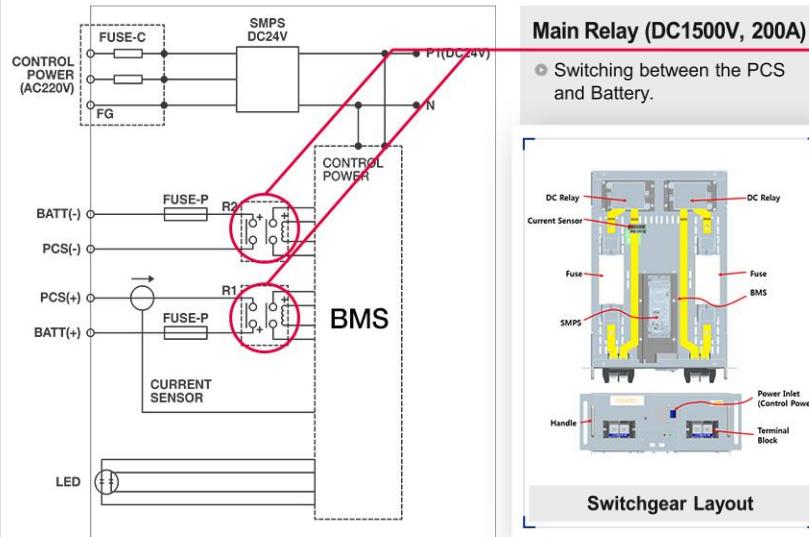
List	Condition	Diagram
Operating Temperature Range	-5~40°C	
Recommended Operating Temperature	23 ± 5°C	
storage temperature	-20~70°C	
Operating Humidity	<85%	
Operating Altitude	1,000 METERS	
Pollution Degree	2	

Industrial Reference 03 ESS Switchgear

Application

ESS Switchgear

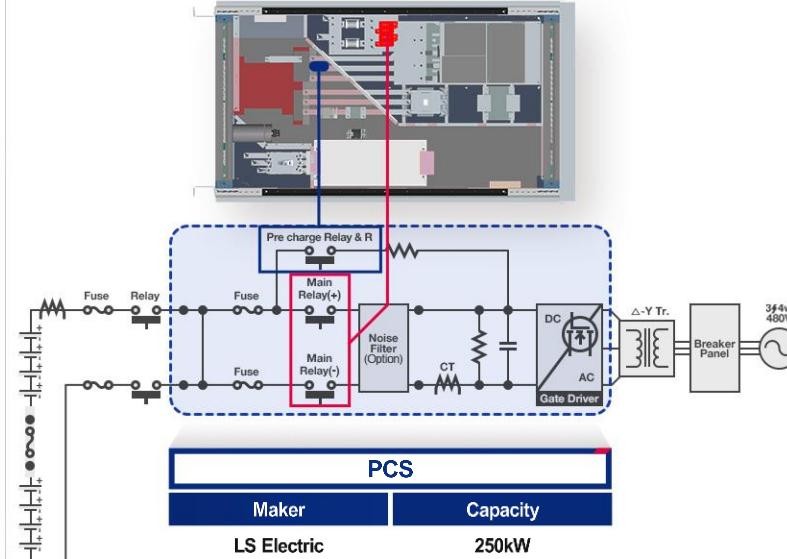
Circuit Diagram



Industrial Reference 04 ESS PCS

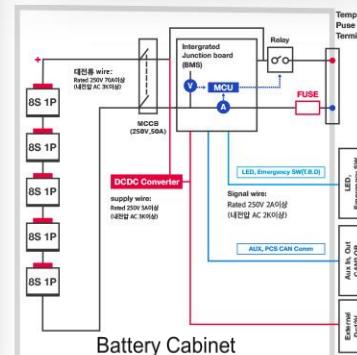
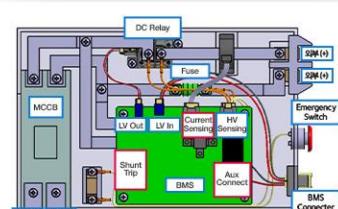
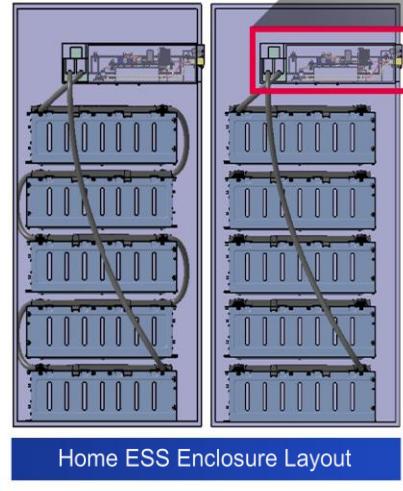
ESS PCS : Applied DC Relay for Main & Pre-Charge Circuit

- Applied DC Relay & Fuse instead of DC Circuit Breaker
- Product : GPR-400 2ea & GPR-40 1ea
- Main Relay requirement : DC850V 400A(Overload :600A 1min)



Industrial Reference 05 Home ESS BPU

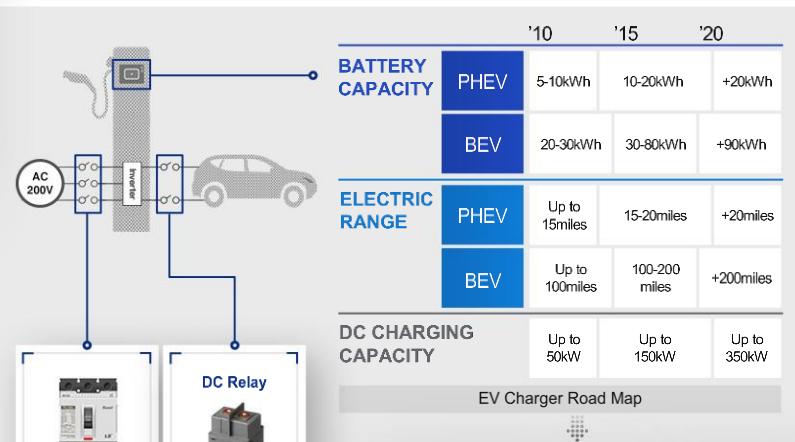
DC RELAY + MCCB Combination



Industrial Reference 06 EV Charger

DC RELAY + MCCB Combination

- AC System : MCCB
- DC System : DC Relay



Item	Capacity (kW)	Charging time (0%~80%)	Location	
			Slow	Normal
Fast	Over 50	Under 30min	Charging station	Charging station
Normal	23	Under 1hour	Resident area, Public office	Resident area, Public office
Slow	7	4-5hours	Apartment	Apartment

Fast Charger Layout

BDU(Battery Disconnect Unit) | Development Process

A

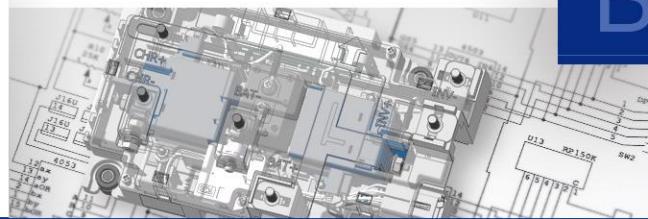
Product Requirement



CUSTOMER
ORDER TYPE

B

Build-to-Print



- ▶ Product & Process Design
- ▶ Simulation
- ▶ Component Sourcing
- ▶ Prototype & Pilot
- ▶ Validation Testing
- ▶ Production Launch
- ▶ Feedback Assessment & Corrective Action

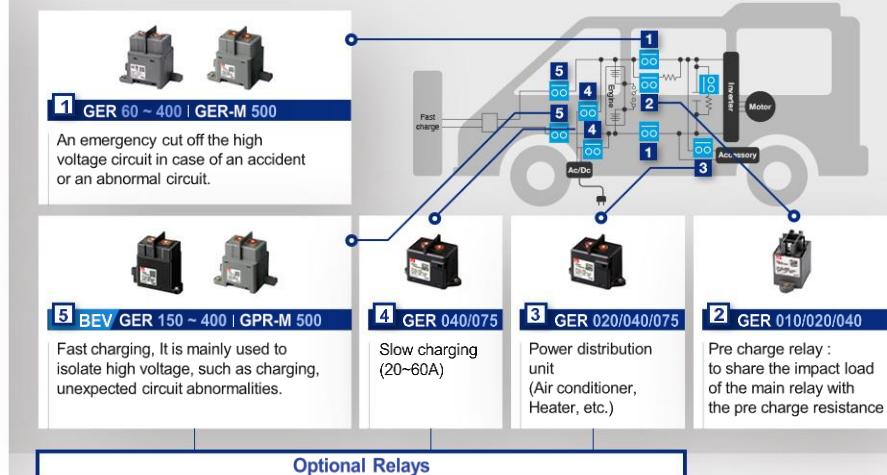
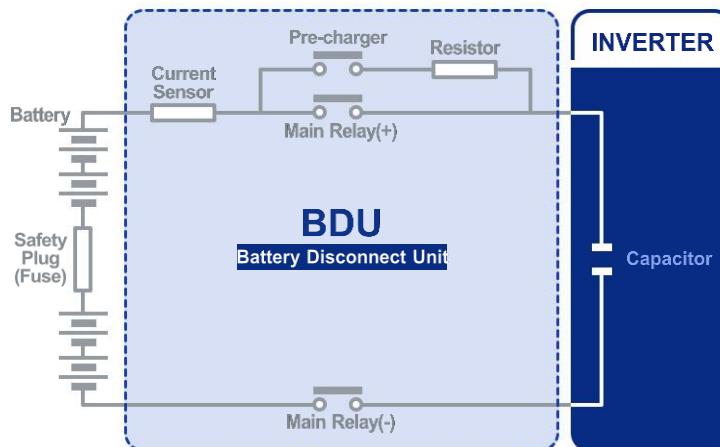
LS ELECTRIC

- ▶ Process Design to Meet Build-to-Print
- ▶ Prototype & Pilot
- ▶ Validation Testing
- ▶ Production Launch
- ▶ Feedback Assessment & Corrective Action

BDU(Battery Disconnect Unit) | Function & Diagram

Function and Feature

BDU(Battery Disconnect Unit) is a EV component designed to distribute high voltage electric power to various automotive parts and to disconnect electric power when the emergency situation happens. safety cut off the current between the high-voltage battery and the rest unit of the vehicle, thus reducing or eliminating the flow of current and risk of electric shock or fire.



BDU(Battery Disconnect Unit) | Main Components

Main Relay

- Connect and disconnect traction battery from entire electric drivetrain



Current Sensor

- Measure current flow into & out of battery
- Translate flow into variable duty cycle signal
- Send duty cycle signal to BCM to indicate current flow



Pre-charge Relay

- Protect main relay from excess inrush current
- Charge capacitor of power inverter



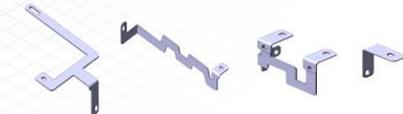
Pre-charge Resistor

- Reduce inrush current during changing capacitor.



Busbar

- Designed for reinforced safety for use in a high-voltage environment.



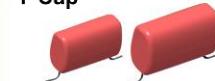
Optional

Fuse



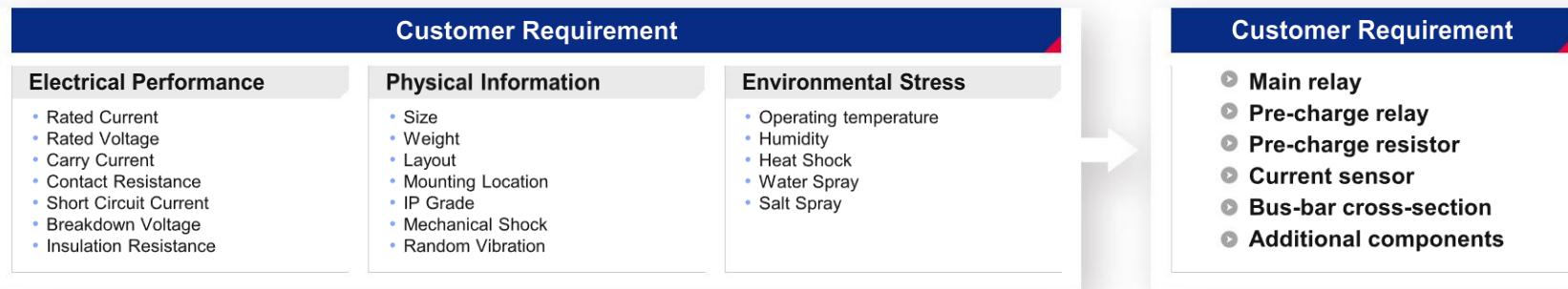
Disconnect HV system
from emergencies situation

Y-Cap

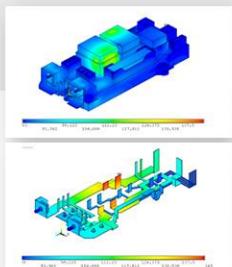


Reduce ripple noise for
HV system

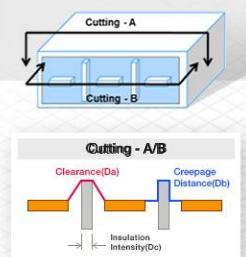
BDU(Battery Disconnect Unit) | Design Process



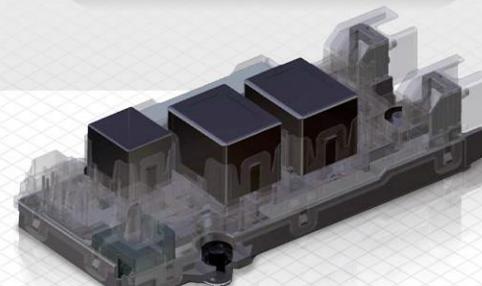
I Thermal Analysis



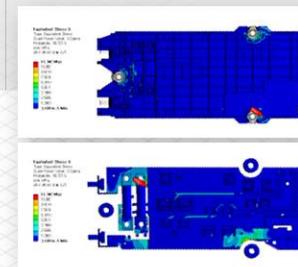
I Insulation Design



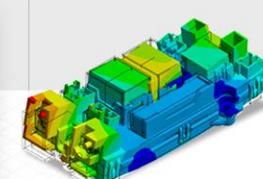
DESIGN



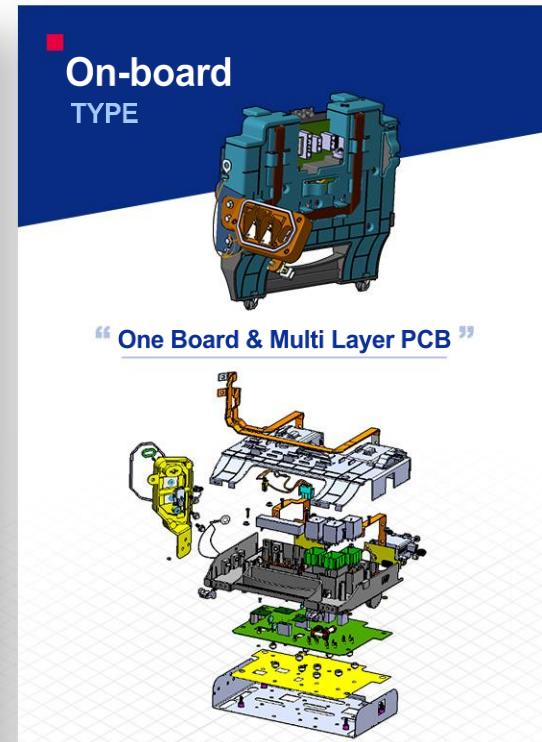
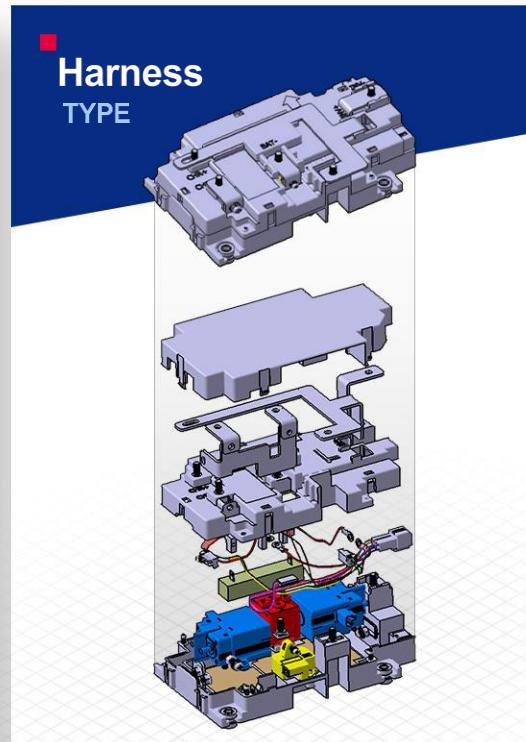
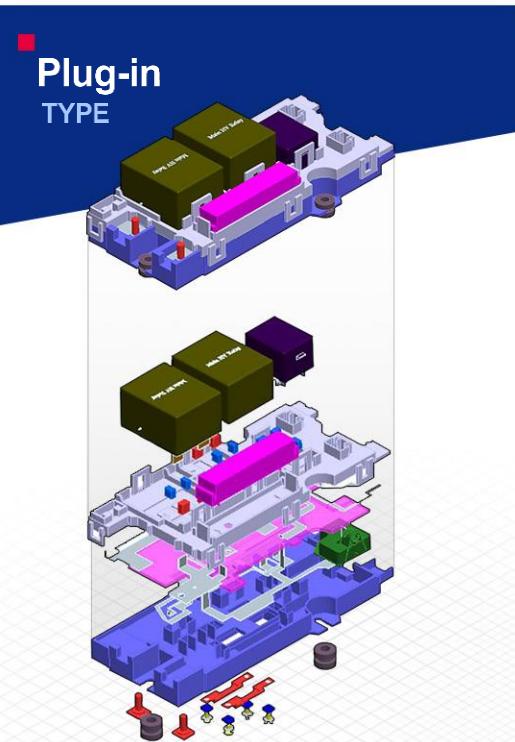
I Random Vibration Analysis



I Modal Analysis



BDU(Battery Disconnect Unit) | Installation Type



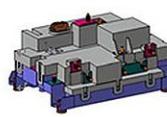
BDU(Battery Disconnect Unit) | Design Reference



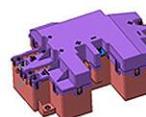
G Company



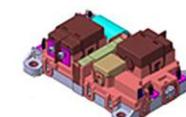
G Company



V Company



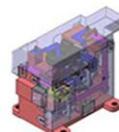
F Company



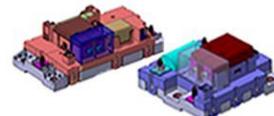
150A BDU Platform



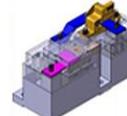
H Company



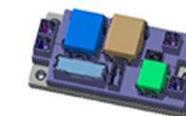
L Company



N Company



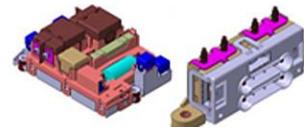
L Company



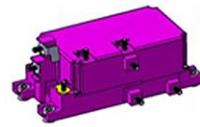
H Company



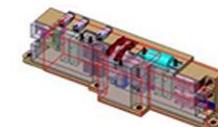
R Company



H Company

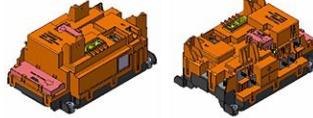
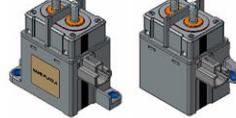
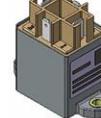
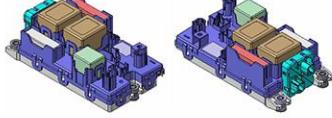
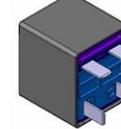
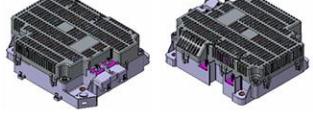
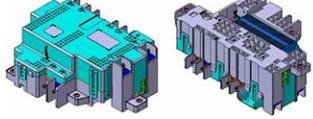


L Company



L Company

BDU(Battery Disconnect Unit) | Mass Production

	BDU	Main Relay	Pre-charge Relay
01 V*			
02 G*			
03 R*			
04 S*			

I Main Relay

- GER-150VVBM : 1EA
- GER-150VVSM : 1EA

I Pre-charge Relay

- GER-10ST : 1EA

I Main Relay

- GER-60GM : 2EA

I Pre-charge Relay

- GER-20GM : 1EA

I Main Relay

- GER-150RN : 2EA

I Pre-charge Relay

- GER-20GM : 1EA

I Main Relay

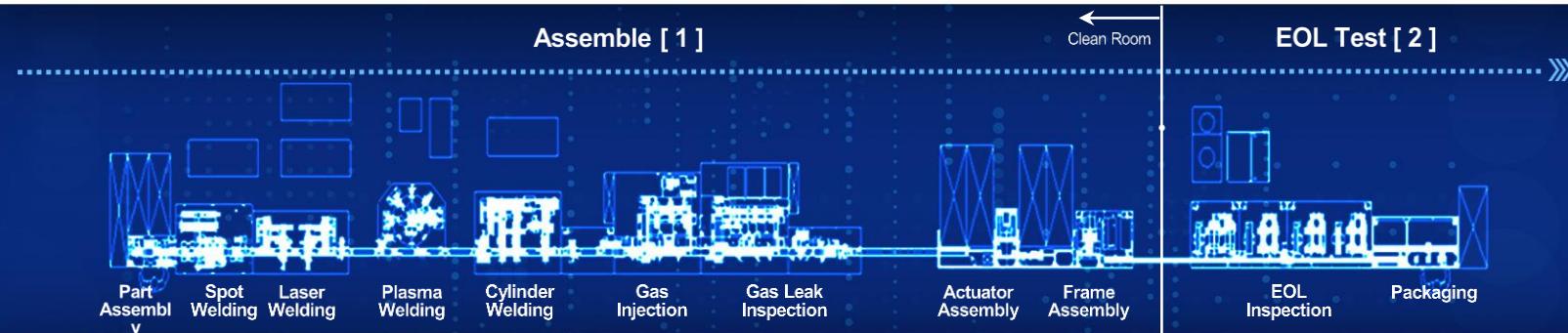
- GER-150SI : 2EA

I Pre-charge Relay

- GER-40ST : 1EA

Facility | Manufacturing Process | DC Relay

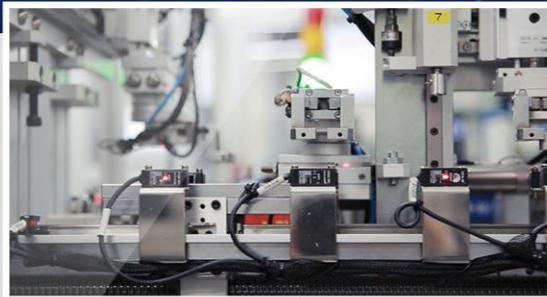
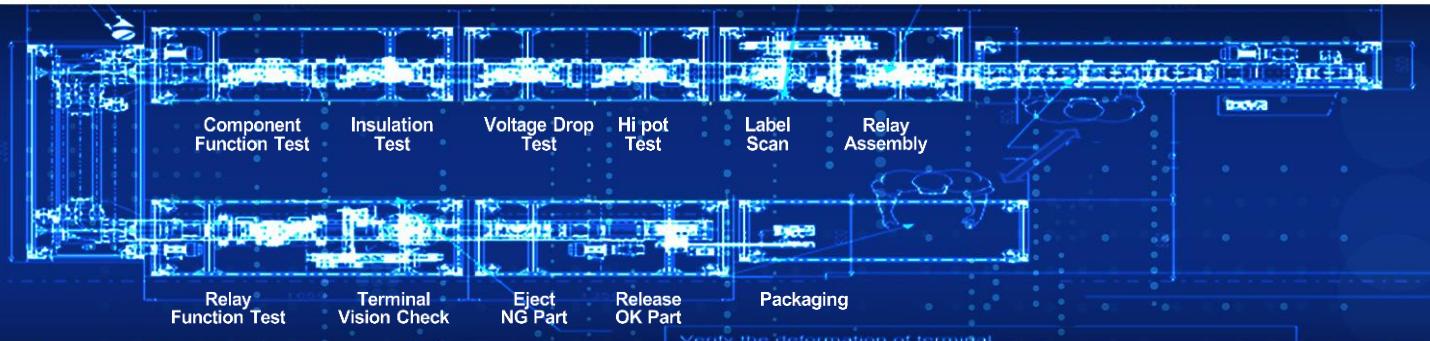
Process Flow of Relay Line Concept : Assemble [1] & EOL Test [2]



#	Process	Characteristics	Method
1	Assemble	Part of Relay Assembly Status	<ul style="list-style-type: none">➢ Laser welding, Plasma Welding➢ Gas injection & Leak Test➢ Parts Assembly
2	EOL test	Electrical Performance	<ul style="list-style-type: none">➢ Conditioning➢ Contact Resistance➢ Operation test➢ Withstanding voltage & insulation test

Facility | Manufacturing Process | BDU

Process Flow of BDU Line Concept : Assemble & EOL Test



#	Process	Characteristics	Method
1	Assemble	Component of BDU Assembly Status	<ul style="list-style-type: none">➢ Relay assembly status check➢ Torque, Angle and Rundown angle check➢ Data record in the Label(Traceability)
2	EOL test	Electrical Performance	<ul style="list-style-type: none">➢ Withstanding voltage & Insulation test➢ Component Function test➢ Operation(Current Flow) test➢ Terminal vision check test

Facility | Manufacturing Process | Capacity

DC Relay



BDU(Battery Disconnect Unit)



Production Status

| Main Relay Capa : 2,937K | P/C Relay Capa : 915K [Unit : ea/shift]

Description	Capacity	
	Month (2 Shift)	Annual (240days/year)
Pre-charge Relay Line(10A ~ 20A)	In Cheong-ju Korea	76,245
Main Relay Line (40A ~ 400A)		140,880
Aux Type Relay Line (400A ~ 500A)		12,977
BDU Line		16,440
China 10A~ 300A Line	In Wuxi China	90,952

Quality Control | Quality Certificates



IATF 16949



CB Certification



UL Certification



CCC Certification

OFFICIAL QUALIFICATION

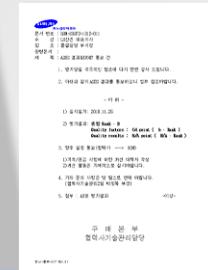


UL(Test Lab, PT&T)



KOLAS(Test Lab, PT&T)

Quality Control | Quality Certificates



SQ(HKMC)

SQ(LGES)

ASES (Renault)

Audit (VW)

CUSTOMER QUALIFICATION

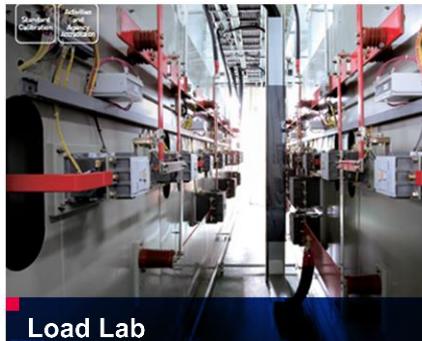


Audit (Bosch)

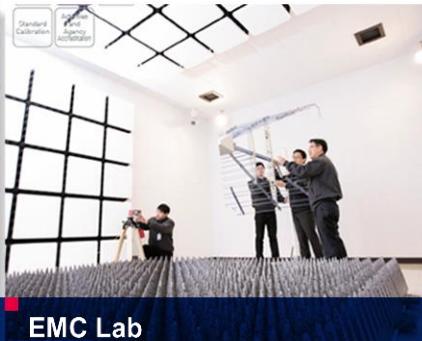
Audit (Daimler)

GM supplier Quality
Excellence AwardDaimler Plaque of Supplier
Performance Appreciation

Quality Control | LS Electric Test Lab



Load Lab



EMC Lab



Environmental Lab



DC Relay Lab



Agency Accreditation



KOLAS Testing



KOLAS Calibration



UL



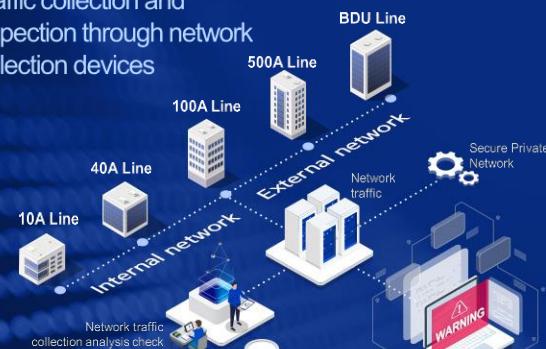
ASTA



Quality Control | Smart Factory | Best practice

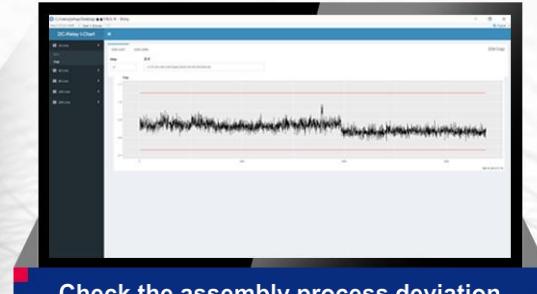
By establishing a DC relay process quality monitoring system, process data can be grasped in real time.

Traffic collection and inspection through network collection devices

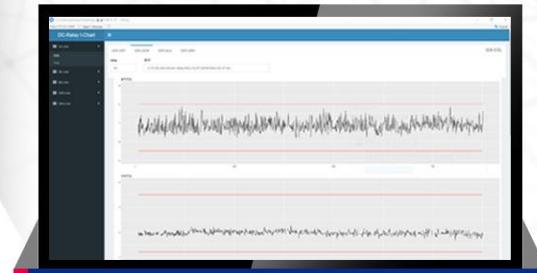


+ Build a system to check the data output during the process in real time

- Data output from the construction type can be checked in real time.
- The trend of process data for the production line can be grasped at once
- Real-time grasp of changes in assembly standards and EOL data caused by part deviations



Check the assembly process deviation



Check the inspection process deviation

FUTURING SMART ENERGY

