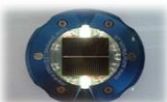




Ultracapacitor Application Guide



Fields of Application

Function	Industrial			Transportation			Energy	Others
Recuperation of braking & Energy/Power boost								 Amusement ride
								
Emergency Power							 Windmill	
								
Peak assist & Board net stabilization							 Grid	 Audio
								 Military
Short-term Energy Storage							 Solar	 Tool

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

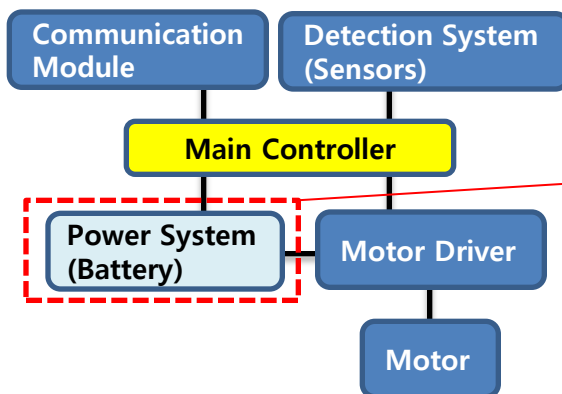
Short-term ES

AGV(Automated Guided Vehicle)



Conventional System

<System Example>

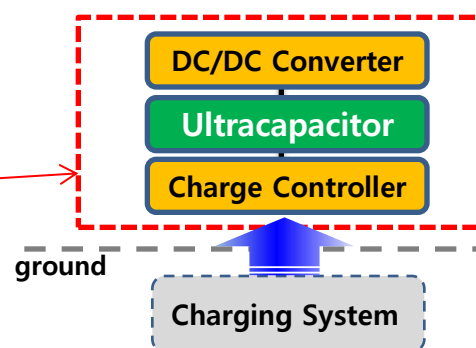


Customer needs

- Reduce battery replacements
 - Reduce Man/hour input & time loss caused by battery replacement.
- Eliminate back-up AGV and continuous operation
- Save battery costs

UC Power System

<Power System>



Benefit of AGV powered by UC

- Productivity improvement by eliminating battery replacement
- Fast charging (seconds ~ minutes)
- Regenerative Braking (Energy Saving)
- Long life (without Maintenance Expense)
 - Long life cycle(over 500k ~ 1M cycles)
- Wide operation temp. range (-40~65°C)
- Environmentally Friendly

Recommended UC Example

C-type & Lug type Cell

- LSUC 2.7V C-type 3000F
- LSUC 2.8V Lug type 350F & 600F



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUC 002R8L 0350F	350F	2.8V	3.2mΩ
LSUC 002R8L 0600F	600F	2.8V	3.2mΩ
LSUC 002R7C 3000F	3000F	2.7V	0.23mΩ

Module

- LSUM 380V 2F
- LSUM 48V 166F
- Customized Configuration



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUM 0380R8L 002F	2F	380.8V	650mΩ
LSUM 048R6C 0166F	166F	48.6V	5mΩ

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

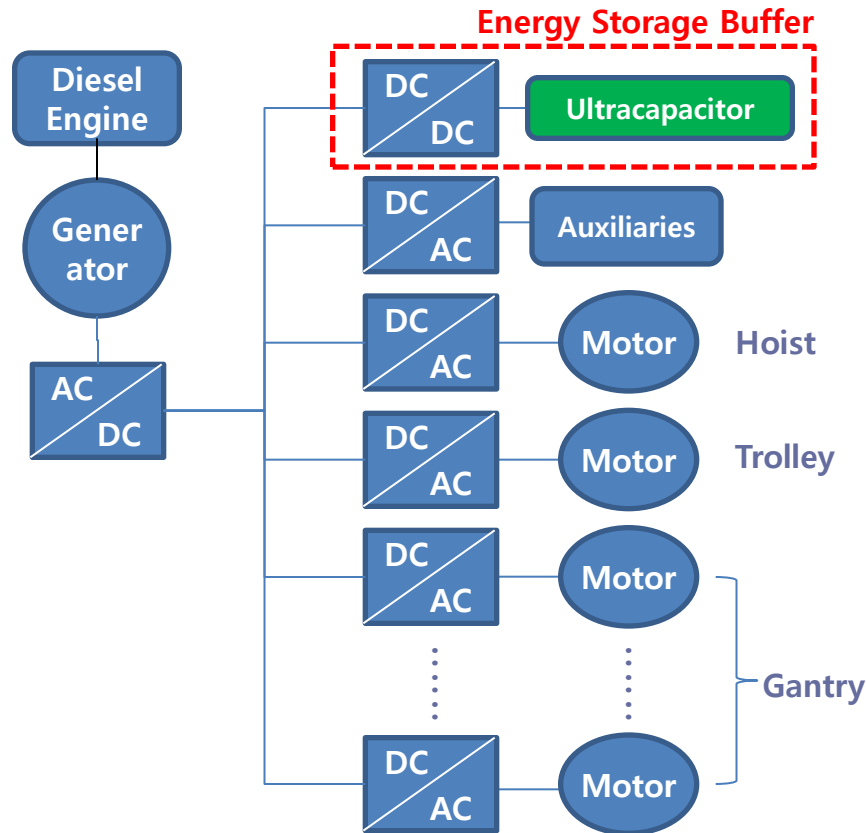
Short-term ES

Hybrid RTG(Rubber Tyred Gantry) Crane



Hybrid RTG Crane System

<Example of System Diagram>



Features and Recommended UC Example

Benefit of Hybrid RTG Crane

- Regenerative energy recovery and storage (for peak load demand)
- → Fuel Saving and Emission Reduction
- Stabilizing voltage fluctuation
- Reducing load onto the grid (minimize voltage drop)
- Low Maintenance costs
- Fast charging, tolerance of huge currents (charging & discharging)
- Environmentally friendly

Recommended Cell & Module

- LSUC 2.7V 3000F/2.85V 3400F



Part. No	Capacitance	V _{Rated}	ESR(DC)	Dimension
LSUC 002R7C 3000F	3000F	2.7V	0.23mΩ	Φ60*L138mm
LSUC 002R85C 3400F	3400F	2.85V	0.23mΩ	Φ60*L138mm

- LSUM 129.6V 62F
- System Configuration based customers' needs



Part. No	Capacitance	V _{Rated}	ESR(DC)	Dimension
LSUM 129R6C 0062F	62F	129.6V	13.2mΩ	720*405*226mm

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

Short-term ES

Excavator



Hybrid Excavator System

<Outline of Hybrid System>

- Recover energy when turning slows down
- Powers electric swing motor



Swing motor to turn the upper structure

Inverter

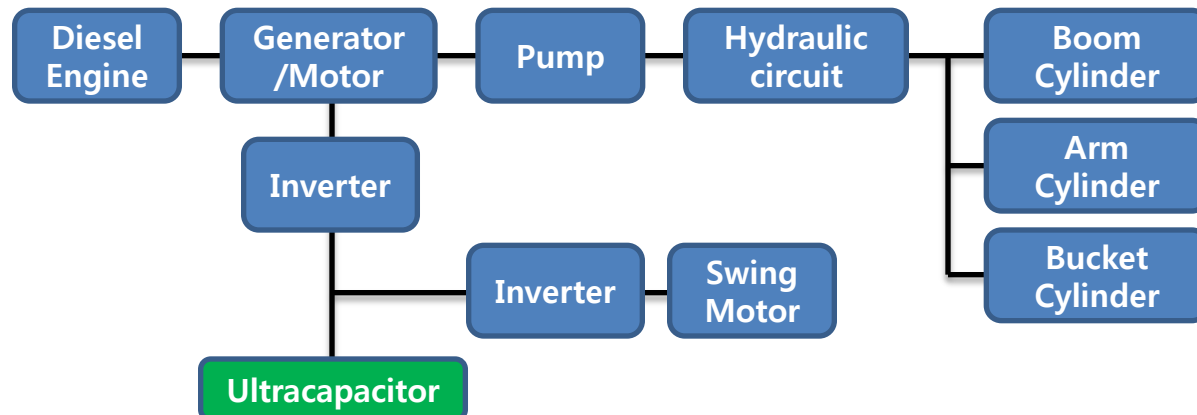
Ultracapacitor



Generator motor

- Electric power assistance during engine acceleration

<Example of System Diagram>



Features and Recommended UC Example

Benefit of Hybrid System

- Reduce load onto engine by utilizing regenerative energy (30% fuel costs saving)
- Peak power assist
- Reduce CO₂ Emission
- Meeting low-carbon regulations

Recommended Cell & Module

- LSUC 2.7V C-type 3000F
- LSUC 2.85V C-type 3400F



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUC 002R7C 3000F	3000F	2.7V	0.23mΩ
LSUC 002R85C 3400F	3400F	2.85V	0.23mΩ

- LSUM 129.6V 62F
- System Configuration based on customers' needs



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUM 129R6C 0062F	62F	129.6V	13.2mΩ

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

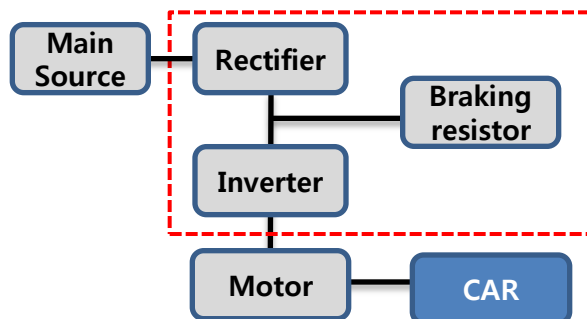
Short-term ES

Elevator



Conventional Elevator

<System Example>

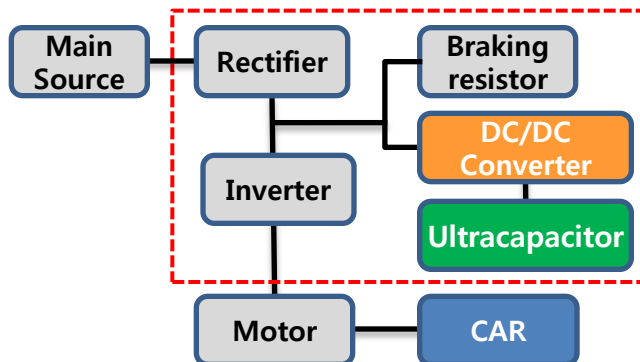


Customer needs

- Improve energy efficiency
 - Braking Resistor (waste) → regenerating energy → Improve Efficiency
 - eliminate over-heating caused by braking resistor
- Safety concerns (power off/shut down)
 - Emergency power back up

UC Regeneration System Elevator

<System Example>



Benefit of Regen Elevator

- Improve energy efficiency
 - utilize the feature of huge currents operation
 - Reduce peak loading
- Emergency power back up or emergency lighting

Recommend UC Example

Lug type Cell

- LSUC 2.8V 320F & 350F



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUC 002R8L 0320F	320F	2.8V	2mΩ
LSUC 002R8L 0350F	350F	2.8V	3.2mΩ

Module

- LSUM 168V 5F
- Customized configuration



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUM 168R0L 0005F	5F	168V	240mΩ

- LSUM 48V 166F



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUM 048R6C 0166F DC	166F	48.6V	5mΩ
LSUM 048R6C 0166F YJ	166F	48.6V	5mΩ

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

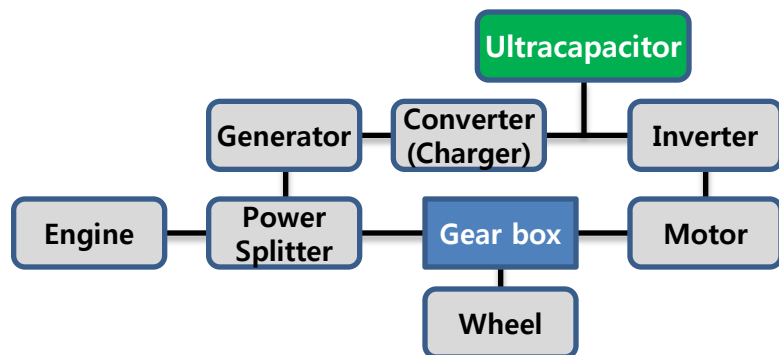
Peak assist

Short-term ES

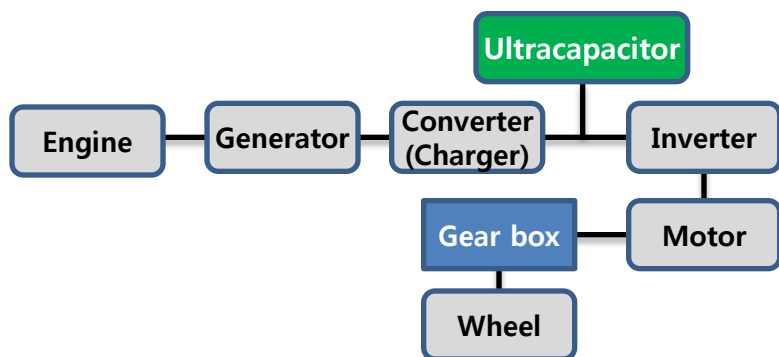
Hybrid Bus



Hybrid Bus System



<Series Parallel Hybrid>



<Series Hybrid>

Recommended UC Example

Customer needs

- Environmentally friendly vehicle
 - Low emission, low carbon, and fuel efficiency
 - To cover a segment that is not fit for EV (electric vehicle)
 - long charging hours and charging stations required
 - Low maintenance costs

Benefit of UC powered Hybrid bus

- Low emission, low carbon, and fuel efficiency
- Low ESR and fast charging (seconds to minutes)
- Long life cycles (one million cycles)
 - Maintenance free

Wide operation temperature (-40°C~65°C)



Cell & Module

- LSUC 2.7V C-type 3000F / LSUC 2.85V C-type 3400F
- LSUM 129.6V 62F / LSUM 48V 166F
- Customization (400~750V)

Part. No	Capacitance	V _{Rated}	ESR(DC)	Dimension
LSUC 002R7C 3000F	3000F	2.7V	0.23mΩ	Φ60*L138mm
LSUM 129R6C 0062F	62F	129.6V	13.2mΩ	720*405*226mm

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

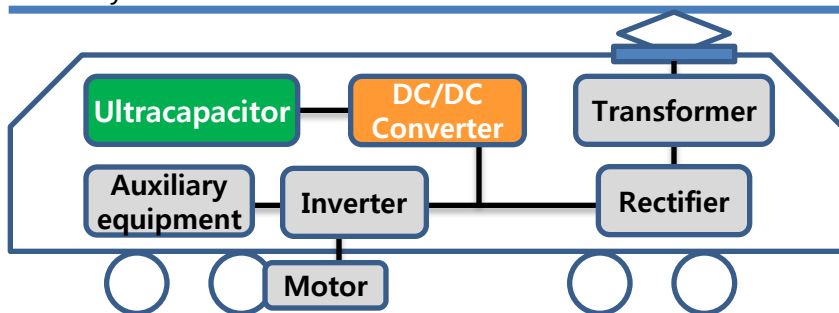
Short-term ES

Tram



Electric Tram System

Catenary



<Electric Tram System Example>

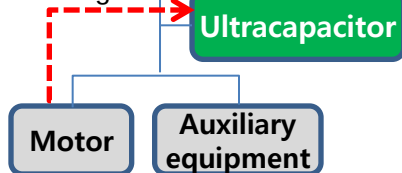
Catenary operation



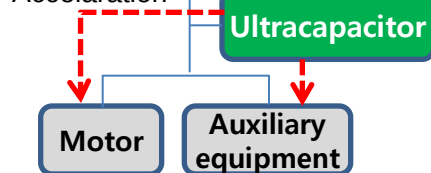
Catenary free operation



Braking



Acceleration



<Catenary (free) operation>

Recommended UC Example

Customer needs

- Energy saving and emission cutting
- No Catenary for aesthetic and safety concerns
- High power and energy density, fast charging
- Long life cycles

Benefit of UC Tram

- No Catenary life is needed
- Regenerative braking is possible (energy efficiency)
- Reduce loading onto the city grid
- Long life expectancy and maintenance free
- Extreme tolerance of the environment (-40°C~65°C)

Cell & Module

- LSUC 2.7V C-type 3000F / LSUC 2.85V C-type 3400F
- LSUM 129.6V 62F / LSUM 48V 166F
- Customer design (400~750V)



Part. No	Capacitance	V _{Rated}	ESR(DC)	Dimension
LSUC 002R7C 3000F	3000F	2.7V	0.23mΩ	Φ60*L138mm
LSUM 129R6C 0062F	62F	129.6V	13.2mΩ	720*405*226mm

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

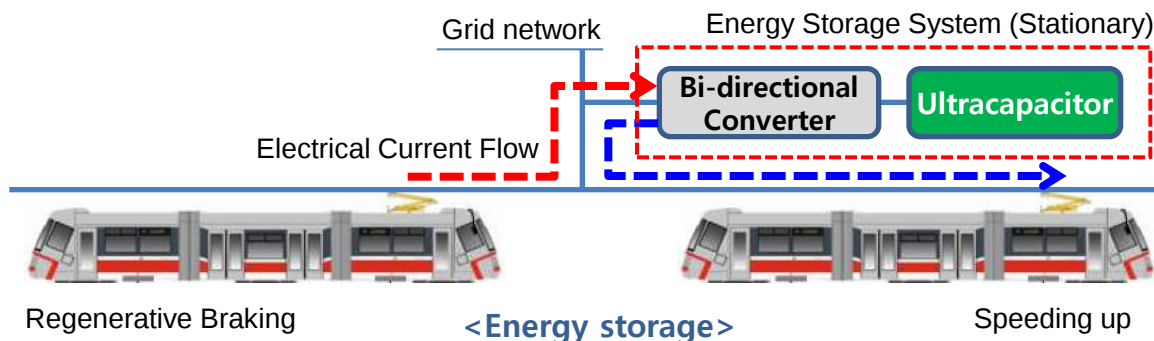
Short-term ES

Subway



Regenerative System for Subway

Resistor Chopper	Inverter	Energy storage
Energy Loss	- Power regeneration - Power generation & consumption have to occur at the same time	- Regenerative energy for the vehicle - Stored energy for just in time power supply



Recommended UC Example

Customer needs

- Energy Efficiency
- Reduce heat dissipation

Benefit of Regeneration System

- Energy Saving
- Energy Efficiency
 - System Stability
- Prevent Voltage Drop, Reduce peak loading

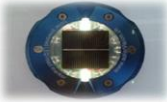
Cell & Module

- LSUC 2.7V C-type 3000F
- LSUC 2.85V C-type 3400F
- LSUM 48V 166F
- Customizaion (600V~ 1500V)



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUC 002R7C 3000F	3000F	2.7V	0.23mΩ
LSUM 048R6C 0166F	166F	48.6V	5mΩ

Fields of Application

Function	Industrial			Transportation			Energy	Others
Recuperation of braking & Energy/Power boost								
								
Emergency Power								
								
Peak assist & Board net stabilization								
								
Short-term Energy Storage								

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

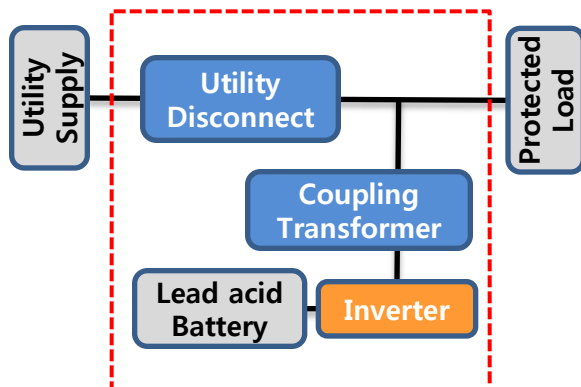
Short-term ES

UPS



Lead-acid Battery UPS

<System Example>

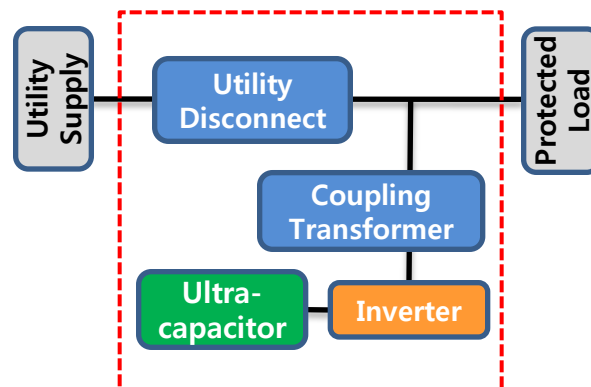


Customer needs

- Short time backup
- Against voltage sag
- Instant response for power disruption
- Long life cycle and high reliability
- Maintenance free

UC UPS

<System Example>



Benefit of UC UPS

- Fight sag/swell/dip
 - Instant response (m.s.)/bridging source
 - High power density / compact size
 - 10 years plus life cycle
 - Tolerance of the environment
- suitable for highly power-sensitive manufacturing

Recommend UC Example

C-type & Snap-in type Cell

- LSUC 2.7V C-type 3000F
- LSUC 2.8V snap-in type 100F & 120F



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUC 002R8S 0100F	100F	2.8V	9mΩ
LSUC 002R8S 0120F	120F	2.8V	9mΩ
LSUC 002R7C 3000F	3000F	2.7V	0.23mΩ

Module

- LSUM 51.3V 166F
- Customized Configuration



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUM 051R3C 0166F	166F	51.3V	5mΩ

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

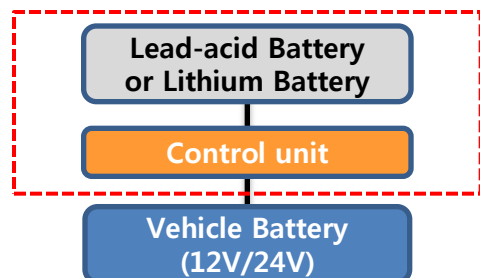
Short-term ES

Jump Starter



Battery Jump Starter

<System Example>

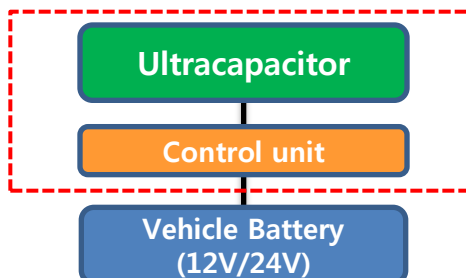


Customer Needs

- Shortened life time of battery due to frequent high power discharge during jump start
→ Needs long life battery
- Long charging time (several hours)
→ Needs short charging time
- Difficult to carry & used as it's too heavy
→ Needs light weight products

UC Jump Starter

<System Example>



Benefit of Ultracapacitor Jump Starter

- **Long life (over 500k ~ 1M cycles)** & No maintenance needed
 - **Full charge within a few seconds** with high current tolerance
 - Easy to carry with small & **light weight**
 - Wide operating temperature(-40°C~65°C)
 - Environment friendly
- ※ Control units : prevent short, reverse polarity connection alarm, overcharge protection, UC balancing circuit ...

Recommended UC Example

Lug type cell

- 3V 380F~480F



12V system	480F 5series	remark
Peak power	3 kW	※ Recharge time : 7.2V ~ Vmax, charge at 50A ※ Weight : UC package only
Voltage (Vmax)	15 V	
Recharge Time	about 15 sec	
Weight	about 0.5 kg	

Cylindrical type cell

- 2.7V 1500F~3000F
- 2.85V 3400F



12V system	1500F 5series	3000F 5series
Peak power	27 kW	33 kW
Voltage (Vmax)	13.5 V	13.5 V
Recharge Time	about 40 sec	about 75 sec
Weight	about 2 kg	about 3 kg

24V system	3000F 10series	3400F 10series
Peak power	66 kW	73 kW
Voltage (Vmax)	27 V	28.5 V
Recharge Time	about 75 sec	about 95 sec
Weight	about 6 kg	about 6 kg

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

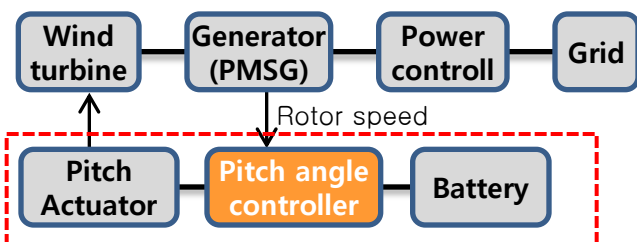
Short-term ES

Windmill



Battery pitch control

<System Example>

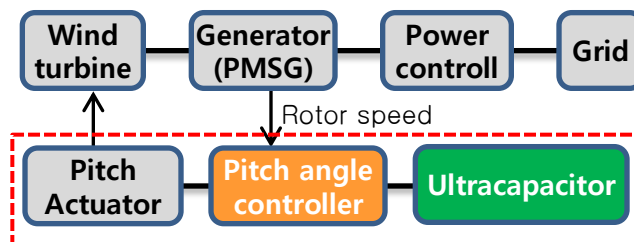


Customer needs

- Wind mill increases in size and number (on/off-shore) → Low maintenance costs(Reliability)
 - Battery needs to be replaced once in two or three years. Costs incurred by battery costs and man-hour inputs.
 - Vibration resistance is required for pitch control power module.
- Down-sizing the power supply module.

UC pitch control

<System Example>



Benefit of UC pitch control

- Reliability in 10 years life cycle
 - Reduce maintenance costs
- Lightening and downsizing the pitch control module, space saving
- Insensitive to environment temperature (-40°C~65°C)

Recommend UC Example

Lug type & C-type Cell

- LSUC 2.7V 3000F
- LSUC 2.8V 350F & 400F
- LSUC 3V 480F



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUC 002R8L 0350F	350F	2.8V	3.2mΩ
LSUC 002R8L 0400F	400F	2.8V	3mΩ
LSUC 003R0L 0480F	480F	3.0V	3mΩ
LSUC 002R7C 3000F	3000F	2.7V	0.23mΩ

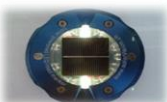
Module

- LSUM 16V 58F / LSUM 16V 500F
- LSUM 168V 5F
- customized configuration



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUM 016R8L 0058F	58F	16.8V	22mΩ
LSUM 016R2C 0500F	500F	16.2V	1.7mΩ
LSUM 168R0L 0005F	5.8F	168V	240mΩ

Fields of Application

Function	Industrial			Transportation			Energy	Others
Recuperation of braking & Energy/Power boost								 Amusement ride
								
Emergency Power								
								
Peak assist & Board net stabilization								 Audio
								
Short-term Energy Storage								 Tool

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

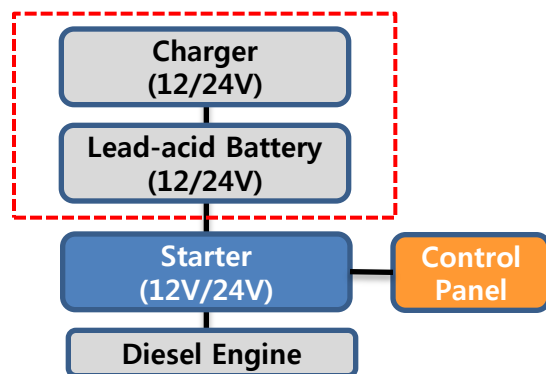
Short-term ES

Generator



Conventional System

<System Example>

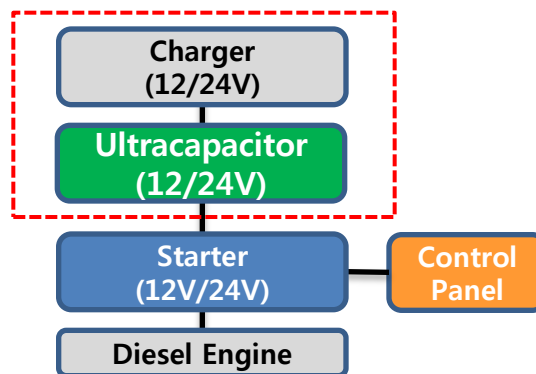


Customer Needs

- Acid Battery : periodical replacement is needed, sensitive to temperature
→ Reduce replacement and maintenance costs.
- Reliable engine cranking in all seasons

UC Generator Starting System

<System Example>



Benefit of UC Generator Starting

- Long life (over 500k ~ 1M cycles) and Maintenance free
- Instant high power output
- Suitable for all sizes (15kW~2MW)
- Reliable cranking in all environments (-40°C~65°C)
- No pollutants inside (eco-friendly)

Recommended UC Example

Cylindrical type cell

- 2.7V 3000F
- 2.85V 3400F



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUC 002R7C 3000F	3000F	2.7V	0.23mΩ
LSUC 02R85C 3400F	3400F	2.85V	0.23mΩ

Module

Module sizing based on engine size



12V system	3000F 5series	3400F 5series
Peak power	33 kW	36.5 kW
Voltage (Vmax)	13.5 V	14.25 V
Recharge Time	about 75 sec	about 95 sec
Weight	about 3 kg	about 3 kg
24V system	3000F 10series	3400F 10series
Peak power	66 kW	73 kW
Voltage (Vmax)	27 V	28.5 V
Recharge Time	about 75 sec	about 95 sec
Weight	about 6 kg	about 6 kg

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

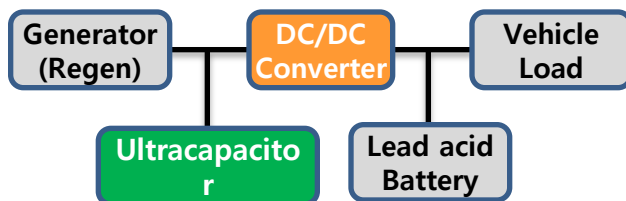
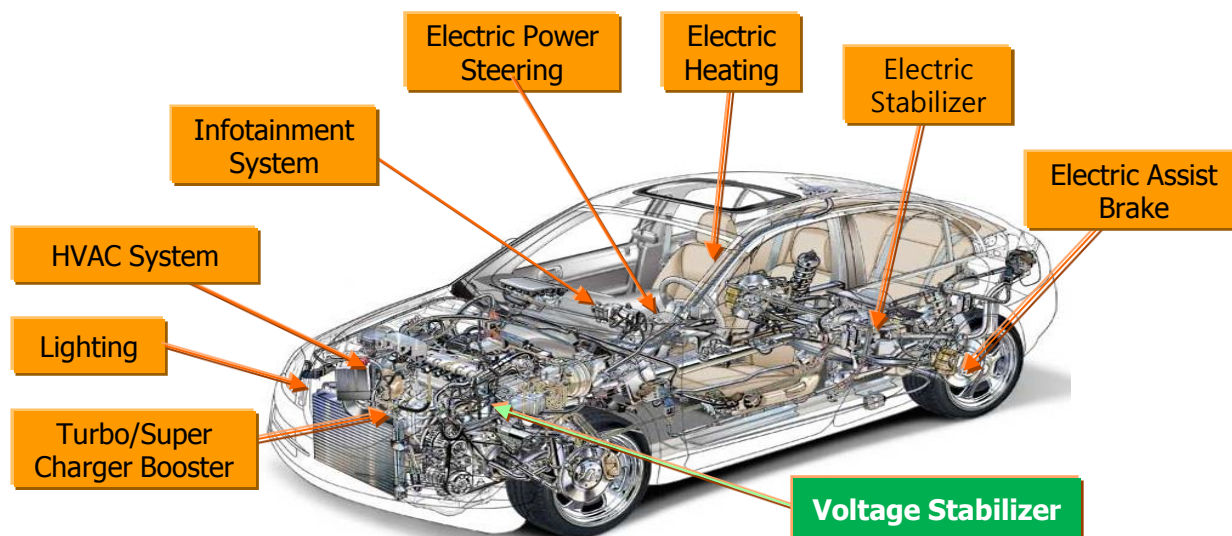
Peak assist

Short-term ES

Car



Vehicle Electric System



<UC based Voltage Stabilizer>

- ◆ Provide power & stable loads for electric system
- ◆ Increase reliability of system
- ◆ Reduce size & extend life of battery

Recommended UC Example

Radial type & Lug type Cell

- LSUC 3V 380F, 430F, 480F
- LSUC 2.7V 650F, 1200F



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUC 003R0L 0380F	380F	3.0V	3.2mΩ
LSUC 003R0L 0430F	430F	3.0V	3mΩ
LSUC 003R0L 0480F	480F	3.0V	3mΩ
LSUC 002R7C 0650F	650F	2.7V	0.57mΩ
LSUC 002R7C 1200F	1200F	2.7V	0.33mΩ

Module

- Customized configuration as per vehicle
- Low ESR type for high power demand
- → 2.7V 650F 6S
- 3.0V 480F 5~10S

12V system	480F 5series	650F 6series
Capacitance	80F	108F
Voltage (Vmax)	15 V	16.8 V
Operating Temp.	-40~65°C	-40~65°C
Weight	about 0.5kg	about 1.2kg

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

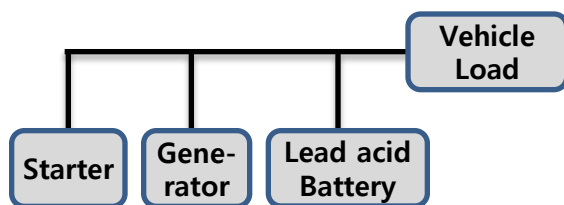
Short-term ES

Start-Stop



Conventional System

<System Example>

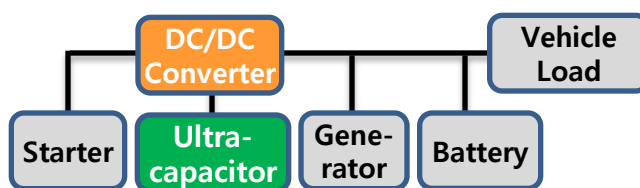


Customer needs

- Frequent Engine Start and Restart at low temperature
- Stable voltage even with Start/Stop System
- Fuel saving and low emission

UC Starting System

<System Example>



Benefit of UC Starting Vehicle

- Meeting frequent engine restart
- Instant start and restart (high power)
- Insensitive to environment (-40°C~65°C)
- Reduce loading onto battery, protecting battery
- Eliminate engine idle running (5~15% fuel saving)

Recommend UC Example

Cylindrical type Cell

- LSUC 3.0V 380F/430F/480F
- LSUC 2.7V C-type 1200F
- LSUC 2.7V C-type 1500F



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUC 003R0L 0380F	380F	3.0V	3.2mΩ
LSUC 003R0L 0430F	430F	3.0V	3mΩ
LSUC 003R0L 0480F	480F	3.0V	3mΩ
LSUC 002R7L 1200F	1200F	2.7V	0.33mΩ
LSUC 002R7L 1500F	1500F	2.7V	0.28mΩ

Module

- LSUC 2.7V 1200F~1500F
 - 12V : 5~6S
 - 24V :10S
- LSUM 16.2V 250F AG
 - Customized configuration



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUM 016R2C 0250F AG	250F	16.2V	2mΩ

Industrial

Transportation

Energy

Others

Regeneration

Emergency Power

Peak assist

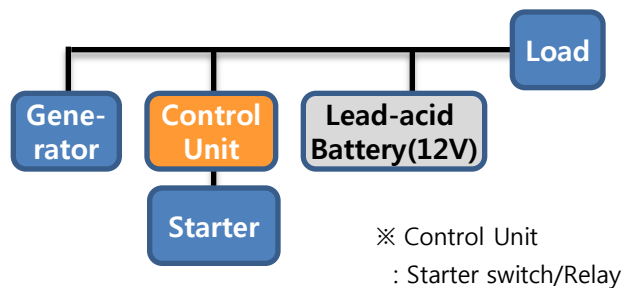
Short-term ES

Motorbike



Conventional System

<System Example>

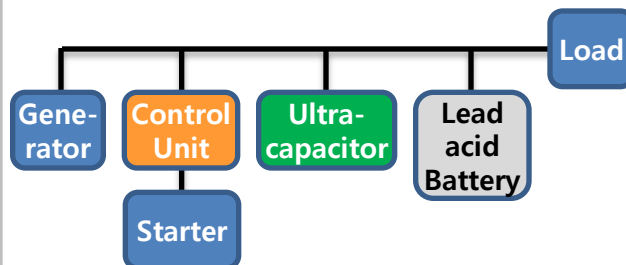


Customer needs

- Extend life for battery
 - reduce battery's wear and tear
- High power output
- Reliable engine starting at all temperature

Hybrid battery(battery + UC)

<System Example>



Benefit of Hybrid battery

- High power output/reduce battery loading
- Reduce battery size (costs)
- Long life cycle (over 500k)
- Wide operation temp. (-40°C~65°C)
- Compatibles with Acid battery (in parallel or series connection)

Recommended UC Example

Radial type cell

- 2.8V 100F



Part. No	Capacitance	V _{Rated}	ESR(DC)
LSUC 002R8S 0100F	100F	2.8V	9mΩ

Module

- Configuration as per power demand
- Acid ⇒ compact acid+ UC module

12V system	100F 6series
Capacitance	16.6F
Voltage (Vmax)	15 V
Operating Temp.	-40~65°C
Weight	about 140 g