ADVANCED & VERSATILE LITHIUM POLYMER BATTERY SOLUTION FOR MILITARY APPLICATION

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KOKAM IN BRIEF

As a globally acknowledged battery manufacturer and battery solution provider, Kokam has developed customer-centered, reliable, safe, high performing, and eco-friendly solution for the past 28 years.

Kokam manufactures over 30 different types of Lithium Ion batteries for variety of military applications such as Fighter Jets, Armed Fighting & Support Vehicles, Mobile Energy Storage Systems (ESS), and Portable Devices. Kokam battery has pioneered applications in Unmanned Aviation and Ground Vehicles (UAV & UGV), and Unmanned Underwater Vehicles (UUV). With 28 years of field experience, Kokam has installed over 650 MWh of batteries around the world. Kokam’s technology has been proven to be high performing, reliable, durable, and safe.

Kokam’s Mobile ESS provides sufficient energy for various devices in the battlefield. Compared to the conventional diesel generator, it releases less noise and heat, allowing for more efficient energy supply.

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A LITHIUM ION BATTERY THAT MEETS YOUR APPLICATION’S NEEDS

UAV / DRONE / FIGHTER JET:
UAVs are controlled from ground-based stations. Such advanced vehicles require advanced sensory, communication and power components to ensure a safe and reliable flight. Installing high tech components into a relatively small UAV is often impractical. However compact features of Lithium Ion battery allows additional space within the UAVs, which could be used to accommodate various components. The Lithium Ion battery is the most safe and quiet power source for UAV’s.

ARMED FIGHTING & SUPPORT VEHICLE:
High energy density, high power and light weight Lithium Ion battery improves the mobility of wheeled vehicles. More military transport, combat, and unmanned vehicles are turning toward fully electrical or hybrid systems where the battery becomes the primary source of power propulsion.

UUV / TORPEDO / SUBMARINE:
Lithium Ion battery is the best source of power for UUV, Torpedo and Submarine. Its compact design brings higher efficiency and strengthens reliability for diverse marine application.

MOBILE ESS:
Kokam’s Mobile ESS provides sufficient energy for various devices in the battlefield. Compared to the conventional diesel generator, it releases less noise and heat, allowing for more efficient energy supply.

PORTABLE DEVICE / COMMUNICATION TOWER:
Batteries are installed in various types of military communication equipments, providing reliable power under harsh conditions at critical times. The same technology is used for emergency power support in telecom stations and control facilities.
KOKAM LITHIUM ION CELL

“TRANSCEND THE LIMITATIONS WITH THE FUSION OF SUPERIOR CELL CHEMISTRY”

Kokam sets about to solve the limitations associated with conventional Lithium Ion Battery technology, including cycle and calendar life, safety, recharge time, power delivery, and ability to operate in extreme temperatures. The performance and features of this technology surpass other existing battery capabilities in the market space today.

<table>
<thead>
<tr>
<th></th>
<th>HIGH POWER</th>
<th>HIGH ENERGY DENSITY</th>
<th>OPERATING TEMPERATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 C-rate</td>
<td>260 Wh/kg</td>
<td>-30 ~ 60 degC</td>
</tr>
</tbody>
</table>

HIGH ENERGY NMC (NICKEL MANGANESE COBALT)

Advantages
- High energy density (~ 260Wh/kg): Up to 2.8MWh of batteries can be stored in a 40ft container
- High efficiency of more than 96% at 0.5C
- Competitive Price: The NMC cells have a comparative advantage in terms of price, considering its superior performance, reliability and safety features.

HIGH POWER NMC

Advantages
- High C-rate up to 100 C-rate level
- High C-rate discharge performance for uses in laser weapon, torpedo, etc.
- Improved performance without safety or cycle life trade off

LITHIUM TITANATE (LTO)

Advantages
- Operating temperature: -30 ~ 60 degC.
- High specific power: 4 C-rate continuous and 8 C-rate peak charge & discharge operation
- High round trip efficiency (RTE) >95%.
- Long cycle life: 20,000 cycles @ 80% DoD, 1C charge & discharge operating conditions.
- Extremely Safe: A thermal runaway event is significantly less likely to occur in LTO cells. LTO cells can also be re-operated after an event of an over-discharge, unlike conventional graphite based Li-Ion cells. This feature enables the user to operate the battery cells under extreme environmental and usage conditions.
- Advantages of the LTO cells: Anode side of ordinary Li-Ion cells are made up of graphite, the anode side of the LTO cell is composed of Lithium Titanate, which has stronger chemical structure than graphite.

NMC + LFP+LTO (NANO)

Advantages
- Specially designed for defense & aerospace application
- This hybrid type cell has incorporated the advantages of NMC, LFP and LTO cells into one cell. It is suitable for extremely volatile and dynamic operational conditions. The high power, energy and safety features allow the NANO cells to be flexibly applied in various applications.
With its flexible and modular design, Kokam’s Battery Module can be customized to meet various technical needs.

Reliability of batteries in military, marine and aviation is vital to its performance. Kokam’s Lithium Polymer batteries are capable of operating over a wide temperature range, which is ideal for rugged military use. Kokam provides high-tech solution for various military applications ranging from small portable electronics to highly sophisticated machinery, ensuring that it is always prepared for the unexpected.

**SCALABLE, VALIDATED, READY FOR USE, HIGH-PERFORMANCE BATTERY SYSTEMS.**
- Freely scalable system design
- Extremely Compact & Light Weight Solution
- Easy to Scale-Up & Ready to connect
- Stable Temperature with Liquid Cooling System
- Thermal Management for Long Service Life
- Optimum Production System resulting in excellent Price Performance ratio
- Monitoring of Voltage and Temperature
- SOC/SOH analysis
- Voltage balancing between the modules

**LIQUID COOLED BATTERY SYSTEM**

1. Cell
2. Module
3. High-strength battery tray
4. Thermal insulation
5. Coolant connection
6. Coolant connector
7. Electric connectors
8. Main contactor box
9. High voltage connection
10. BMS
11. Safety control unit

**MEET VARIOUS NEEDS OF CUSTOMER’S TECHNICAL REQUIREMENT**
**COMMIT TO CUSTOMER’S SPECIFIC NEEDS**

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The high-power output feature is ideal not only as the main propulsion energy source but also as an aircraft backup power source, which can function in the event of a normal power system failure. The compactness of Kokam’s battery solution decreases the overall consumption of fuel – saving both cost and energy. Kokam has successfully designed and manufactured mission-critical battery solutions, which have been applied to a variety of solutions out in the field today.

In aviation, the reliable performance of batteries is imperative, being able to withstand frequent changes in temperature or other environmental conditions as well as being light-weight. Kokam products meet these requirements and are tested to be fully functional over a wide range of temperature, humidity and pressure.
Kokam designs and develops Lithium Polymer battery to meet the military requirements of high power and high energy density systems with less weight. They are applied for both armed fighting vehicles (Stryker / Cougar / M-series Tanks) and support vehicles (FMTV / HEMTT / HUMVEE). Today, Lithium Polymer batteries are not only designed for startup application, but also for independent power sources for other various applications in vehicles designed for military tactics, ground robotics and exploration vehicles for research markets. Together with our technical capabilities and system-level knowledge, we will keep innovating to meet customer’s requirements.


- High energy & high power density
- Maintenance free
- Certified & standardized for military applications
- Significant volume reduction
- Flexible packaging
- Longer calendar & cycle life

Safe and Quiet Power Source in Much Smaller and Lighter Size

- Freely scaleable system design
- Superior power and energy
- Extended battery service life
- Sustains high power in low temperatures
- Preserved from electrical and physical abuse
- Long maintenance free periods for lower costs in cycle life

Military battery needs are varied and demanding. But total reliability is key –

- To optimize the efficiency in military operation and training in extreme environment
- To provide sufficient energy for transportation

Kokam’s optimized systems achieve peak performance, enable long & reliable application life. The design and manufacturing of the primary & rechargeable batteries and charging accessories are custom built for precise requirements.
SAFETY CENTERED
- Intrinsic safety of cell chemistry
- Smart short circuit protection
- Heat and electric insulation packaging system

UNPRECEDEDENTED LONGEVITY
- More than a decade of life proven at sea
- Extremely lower capacity fading rate
- The world’s lowest internal resistance

PROVEN RELIABILITY
- More than a decade of fault-free recorded operation
- LBTS durance & abuse tested
- US MIL-STD certified

FULL CUSTOMIZATION SERVICE
- Chemical tuning for the best optimization
- Scalability of hardware and software
- Full in-house design and production
Advanced technology in Lithium Ion battery is enabling strategic advantages in marine applications. The battery has high energy density both in weight and volume, coupled with the capacity to rapidly charge and discharge, delivering immense amounts of power over many thousands of cycles with minimum degradation. Compared to the lead acid batteries, the Lithium Ion battery delivers higher amounts of stored energy and power.

Kokam is a world market in the field of Lithium Ion battery for maritime applications. Examples of large scale deployment of Kokam Lithium Ion battery include, electric propulsion of surface ships (100% battery powered ferries with displacement of up to 3000 tonnes); hybrid ship propulsion to reduce fuel consumption and boost peak power, thus reducing reliance on gas turbines and propulsion of diesel electric submarines with the strategic advantages of increased sub surface range, higher speed, and reduced surface charge time.

As with all technology deployments, safe operation requires a fully engineered solution. In addition, selecting the most suitable technology for each application is imperative for a successful deployment.

For example, the propelling characteristic of a torpedo is remarkably different compared to that of a submarine. Kokam offers customized cells that are best suitable for specific applications.

Kokam ensures the safety of the cells by selecting the appropriate chemical ingredients and adopting rigorous quality management procedures. That is why Kokam has over 10 years of incident-free deployment of Lithium Ion cells in marine applications such as the UUVs, submarines, and torpedoes.
Kokam’s Mobile ESS assures successful military operation by effectively using the limited space, improving the condition of driving & transportation in the battlefield. We also provide our customers a simple inspection & repair procedure to optimize military operation and training.

 PORTABLE DEVICE & MOBILE ENERGY STORAGE SYSTEM

- Rechargeable Lithium Polymer battery for portable electronic devices
- Wide operating temperature range
- High energy density
- High power
- Operational life greater than 300 cycles to 80% capacity at 100% DoD
- Flexible output voltage
- Robust molded plastic case
- Strong endurance against extreme environmental conditions

- Operational in -20°C to +60°C
- More than 8,000 Cycles (80% DOD)
- 95% Charge/Discharge efficiency
- Strong endurance against vibration and physical impact
- Applied anti-swing & low noise technology
Kokam’s Indoor and Outdoor Type Rack (KRI/KRO) is composed of Kokam’s standard battery modules which can be configured to have capacity ranging from 60-130kWh upon a customer’s request. The KRI/KRO racks can be installed in various locations such as military bases, communication towers offices, hospitals, utilities, data centers and offices.

- Energy capacity of hundreds of kWh
- Outdoor type rack follows the NEMA3R
- Weatherproof capability
- Extreme environments

Kokam’s UPS battery can be configured to have a capacity ranging from 5kWh to 10MWh and be tailored to suit the customer’s desired specifications.
Kokam UPS (KUPS) provides perfect protection in a number of applications including medical, telecom, and data centers. During an outage, KUPS immediately provides battery back-up power to protect mission-critical information and systems.

- Higher energy density and lighter weight allow integration of batteries and UPS within a factory-tested single container, providing faster and more reliable field installation and start-up
- Provides 4 to 8 times longer cycle life and high power density than lead-acid battery
- No degradation with shallow cycles
- No open-circuit failure mode
- No hydrogen generation
- Integrated monitoring of individual cell's voltages and temperatures

### VRLA VS. Kokam Li-Ion

- **X 8 Times (8C-rate)**
- **20~22.5°C (COOLING SYSTEM NEEDED)**
- **-25~45°C (NO ADDITIONAL COOLING SYSTEM)**
- **5 : 1**

### Customization of parallel cabinet & rack connections

Kokam UPS series provides a modular, easily scalable solution.

<table>
<thead>
<tr>
<th>Model</th>
<th>10S</th>
<th>12S</th>
<th>12S</th>
<th>132S</th>
<th>140S</th>
<th>154S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed Capacity (kWh)</td>
<td>27.7</td>
<td>30.5</td>
<td>33.3</td>
<td>38.6</td>
<td>38.8</td>
<td>42.7</td>
</tr>
<tr>
<td>Module Configuration</td>
<td>20S1P x 5</td>
<td>22S1P x 5</td>
<td>20S1P x 6</td>
<td>22S1P x 6</td>
<td>20S1P x 7</td>
<td>22S1P x 7</td>
</tr>
<tr>
<td>Float Voltage (Vdc)</td>
<td>400–400</td>
<td>450–440</td>
<td>491–480</td>
<td>540–528</td>
<td>573–456</td>
<td>630–616</td>
</tr>
<tr>
<td>Continuous Discharge Power (kW, 5min)</td>
<td>222</td>
<td>244</td>
<td>266</td>
<td>293</td>
<td>310</td>
<td>342</td>
</tr>
<tr>
<td>Peak Discharge Power (kW, 1min)</td>
<td>277</td>
<td>305</td>
<td>333</td>
<td>366</td>
<td>388</td>
<td>427</td>
</tr>
<tr>
<td>Battery Capacity (Ah)</td>
<td></td>
<td></td>
<td></td>
<td>75 Ah</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Discharge Current (A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>870 A</td>
<td></td>
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<tr>
<td>UL Certification</td>
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<td></td>
<td></td>
<td></td>
<td>UL1973, UL1642, UN38.3</td>
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</tbody>
</table>

- For larger battery capacity, each rack is scalable as connected in parallel
- 3-wire connection is available on request

### 40% Less Footprint & 5 times Lighter

Small footprint allows for more flexibility in installation and transportation. Kokam UPS takes up 40% less footprint than VRLA.

- 8 Total Rack System Wt. 13,000 Lbs.
- 10 Total Rack System Wt. 66,000 Lbs.

### Comparison of Battery Models

- **Lithium Ion (NMC)**
  - 8 (20S1P x 5) Racks + connection cabinet = 280"W x 25"D = 48.6 ft²
  - 2,250 kW / 48.6 ft² = 46.3 kW/ft²

- **VRLA**
  - 10 (20S1P x 7) Cabinets + connection cabinet = 400"W x 30"D = 83.3 ft²
  - 2,250 kW / 83.3 ft² = 27.0 kW/ft²
**SPECIFICATION**

HIGH-PERFORMANCE CONTAINERIZED STORAGE SOLUTION

**Utility-Scale**
- > 1MWh applications
- Integration of renewable
- Ensuring power quality
- Frequency regulation
- Microgrids

**Point Of Interconnection (POI)**
- Public Grid
- Power Conversion System (PCS)
- Power Plant Controller (PPC)
- Inverter
- Wind
- PV

**ENERGY STORAGE SYSTEM INTEGRATED RENEWABLE ENERGY**

<table>
<thead>
<tr>
<th>Model</th>
<th>KCE-3774</th>
<th>KCE-2664</th>
<th>KCE-1351</th>
<th>KCE-675</th>
<th>KCE-5860</th>
<th>KCE-2730</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed Energy (MWh)</td>
<td>3.77</td>
<td>2.66</td>
<td>1.35</td>
<td>0.67</td>
<td>5.47</td>
<td>2.73</td>
</tr>
<tr>
<td>Max Power (Continuous)</td>
<td>15.10</td>
<td>10.66</td>
<td>5.41</td>
<td>2.70</td>
<td>10.94</td>
<td>5.46</td>
</tr>
<tr>
<td>DC Efficiency</td>
<td>&gt;95% [C/2 rate]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC Voltage</td>
<td>640 ~ 1,100V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approx. Dimensions (ft)</td>
<td>53‘</td>
<td>40‘</td>
<td>40‘</td>
<td>20‘</td>
<td>40‘</td>
<td>20‘</td>
</tr>
<tr>
<td>Ambient Operating Temperature Range</td>
<td>-30 ~ 50°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enclosure details</td>
<td>Designed to satisfy IP54 per IEC 60529 standard</td>
<td></td>
<td></td>
<td></td>
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</table>

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INSTALLED 205MW ENERGY STORAGE SYSTEM

REFERENCE
Alinta Newman Power Station Project
KEPCO Frequency Regulation Project
Data Center UPS Project in U.S
Data Center UPS Project in Texas
Data Center UPS Project in Singapore
Telecommunication Center UPS in Australia
Distributed ESS Project
PowerCor Utility in Australia
Garden Island Micro Grid Project
Gasado Island Micro Grid Project (KEPCO)
Korea Industrial Building Project
Distributed ESS Project
San Diego Gas & Electric
Daegu Demand Response Project
Kansas City Power & Light Green Impact Zone Smart Grid
Eumseong Hyundai Heavy Industry Factory
KORAIL Station (x 2 units)
Duke Energy
Seoul National Park Peak Shaving Project

- 30MW / 11MWh
- 36MW / 13MWh
- 24MW / 9MWh
- 16MW / 6MWh
- 16MW / 5MWh
- 15MW / 2.4MWh
- 9MW / 1.7MWh
- 8MW / 1.5MWh
- 3MW / 472kWh
- 2MW / 4MWh
- 2MW / 2.2MWh
- 2MW / 555Wh
- 1.5MW / 3.2MWh
- 1MW / 6.6MWh
- 1MW / 2.6MWh
- 1MW / 2.3MWh
- 1MW / 1.5MWh
- 1MW / 1.0MWh
- 1MW / 1.0MWh
- 1MW / 530kWh
- 250kW / 800kWh
- 250kW / 310kWh
Great Power for Everyone

Kokam’s high-performance lithium polymer battery technology delivers high power and energy density combined with excellent safety performance and cycle life.

**ENERGY:**
Higher usable energy means greater battery utilization and lower cost

**POWER:**
Superior power by weight or volume in a cost effective solution

**CYCLE:**
Excellent calendar and cycle life with consistent performance over extended use

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DISCOVERY BEYOND TECHNOLOGY

POWERFUL & COMPLETE BATTERY SYSTEM SOLUTION

battery@kokam.com