Lithium Ion Cells For Satellites– Power Optimized

GS Yuasa has manufactured space qualified lithium ion cells since 1998. GS Yuasa lithium ion cells have provided orbital vehicles more than 1,350,000 Wh of combined energy storage capacity without failure or anomaly.

More than 65 space missions have relied on GS Yuasa lithium ion cells. Customers include: Orbital Sciences Corporation, Johns Hopkins University APL, Space Systems Loral, Thales Alenia Space, and JAXA & ISRO.

LSE Gen III: Power Type Cells Optimized for LEO Missions

The Gen III family of Li-ion cells retains the same physical configurations and manufacturing processes that have been proven through GS Yuasa's industry leading spaceflight heritage. These cells benefit from minor and well-understood adjustments to the Gen II heritage chemistry to deliver outstanding reliability, performance and service life.

Features

- Excellent discharge characteristics
- Excellent cycle life
- High energy density
- Predictable capacity retention
- Excellent calendar life
- Hermetically sealed
- Anodized aluminum case and cover
- Wound prismatic construction

LSE Gen III Overview:

- Evolution of the Gen II chemistry
- Same physical construction as Gen II
- Same manufacturing process as Gen II
- Uses GEN II heritage components

LSE Gen III Enhancements:

- Higher average discharge voltages
- Reduced DCR growth
- Increased capacity
- Improved capacity retention

Cell Specifications		LSE51	LSE102	LSE134
Chemistry		Lithium Cobalt Oxide		
Cell Capacity				
Capacity (Ah)	Nameplate	51	102	134
	BOL	57	114	148
Energy (Wh)	Nameplate	189	377	496
	BOL	211	422	548
Energy Density at BOL (Wh/L)		289	337	349
Specific Energy at BOL (Wh/kg)		139	152	155
Cell Electrical Specifications				
Nominal Voltage (V)		3.7	3.7	3.7
End of Charge (V)		4.1	4.1	4.1
End of Discharge (V)		2.75	2.75	2.75
Max. Continuous Charge Current (A)		25.5	50	67
Max. Continuous Discharge Current (A)		76.5	150	134
Max. Pulse Discharge Current (A) (5 seconds)		153	300	402
Cell Mechanical Properties				
Dimensions (mm)	Width	130	130	130
	Thickness	50	50	50
	Height *	131	216	271
	Weight (kg)	1.52	2.77	3.53
	Volume (L)	0.73	1.25	1.57
Temperature range (°C)				
	Charge	10 ~ 35	10 ~ 35	10 ~ 35
	Discharge	-10 ~ 35	-10 ~ 35	-10 ~ 35
	Storage	-10 ~ 10	-10 ~ 10	-10 ~ 10

* Excluding terminals.

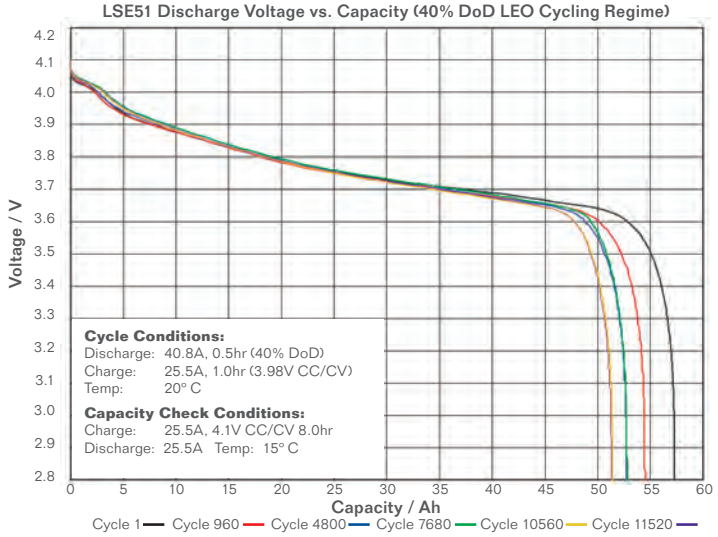
For information on other specialty cell sizes please contact GYLP.

Cell design details and specifications are subject to change without notice.

LSE Gen III Cell Performance Characteristics

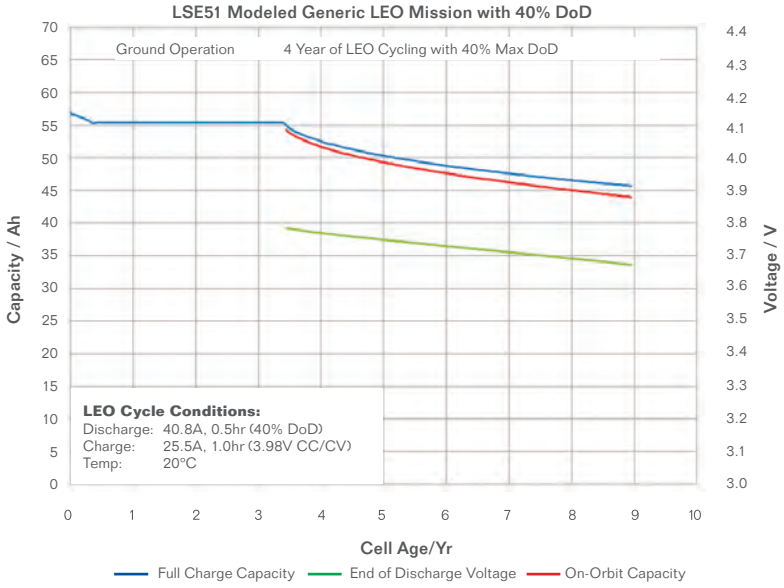
Gen III Chemistry Demonstrates:

1. Superior voltage stability
2. Excellent capacity retention through cycling
3. Suppressed DCR growth through cycling
4. Greater watt hour retention through cycling



Simulated LEO Mission

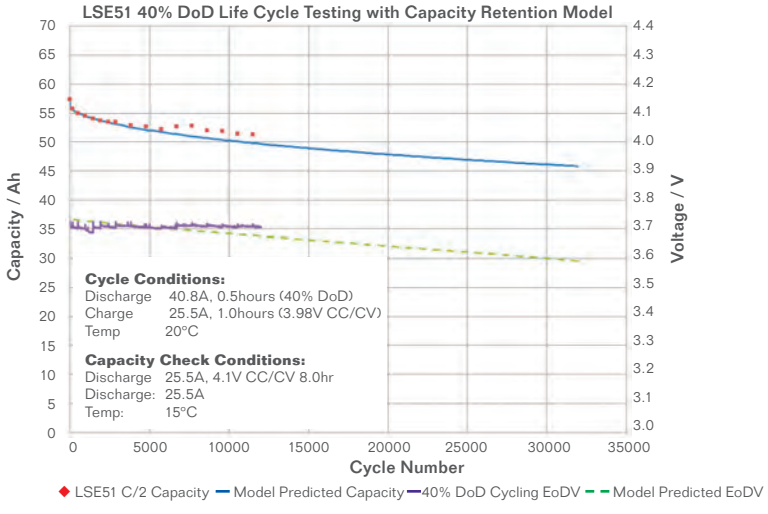
1. Modeling of cell performance both on the ground and in orbit is possible with GS Yuasa's advanced modeling software capabilities as demonstrated by the simulated 40% DoD LEO Mission with on-orbit cycling of 5.5 years.
2. Model predicts both full capacity and expected on-orbit capacity based on the actual time allowed on-orbit for charging.
3. Just as important for LEO missions, the End of Discharge Voltage is accurately predicted and can be used to determine when the battery will approach low bus voltage limits.



40% DoD Life Cycle Test and Model Validation

1. $LiCoO_2$ based cell technology has well-understood cycling parameters and ages predictably.
2. GS Yuasa's Life model can accurately predict capacity and EoDV retention.
3. GS Yuasa's life model has been validated against a database of more than 700 cell years of test data.

GS Yuasa's advanced life and performance modeling capability supports the selection of optimal cell and battery configuration for a given use case.



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GS YUASA LITHIUM POWER
QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
= ISO 9001:2008 AND EN/JISQ/AS9100:2009 =

Lithium Ion Cells For Satellites – Energy Optimized

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LSE Gen III: Energy Type Cells Ideal for GEO Missions

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LSE Gen III Enhancements:

- Increased capacity
- Improved capacity retention
- Higher average discharge voltages
- Reduced DCR growth

Cell Specifications		LSE110	LSE145	LSE190
Chemistry		Lithium Cobalt Oxide		
Space Qualified		Yes	Yes	Yes
Cell Capacity				
Capacity (Ah)	Nameplate	110	145	190
	BOL	122	161	205
Energy (Wh)	Nameplate	407	536	703
	BOL	451	595	758
Specific Energy at BOL (Wh/kg)		163	168	165
Energy Density at BOL (Wh/L)		334	348	373
Cell Electrical Specifications				
Nominal Voltage (V)		3.7	3.7	3.7
End of Charge (V)		4.1	4.1	4.1
End of Discharge (V)		2.75	2.75	2.75
Max. Continuous Charge Current (A)		55	72.5	95
Max. Continuous Discharge Current (A)		110	145	190
Max. Pulse Discharge Current (A) (5 seconds)		330	435	570
Cell Mechanical Properties				
Dimensions (mm)	Width	130	130	165
	Thickness	50	50	50
	Height *	208	263	263
	Weight (kg)	2.77	3.55	4.59
	Volume (L)	1.35	1.71	2.03
Temperature range (°C)				
	Charge	10 ~ 35	10 ~ 35	10 ~ 35
	Discharge	-10 ~ 35	-10 ~ 35	-10 ~ 35
	Storage	-10 ~ 10	-10 ~ 10	-10 ~ 10

* Excluding terminals.

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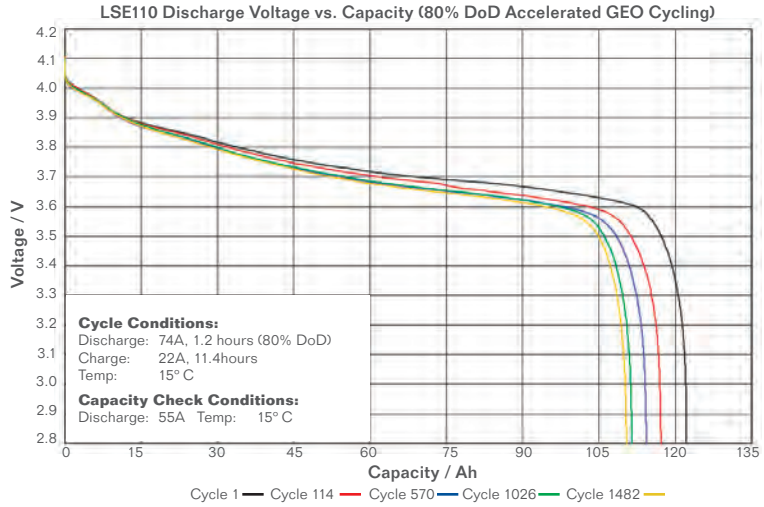

80% DoD Life Cycle Test and Model Validation

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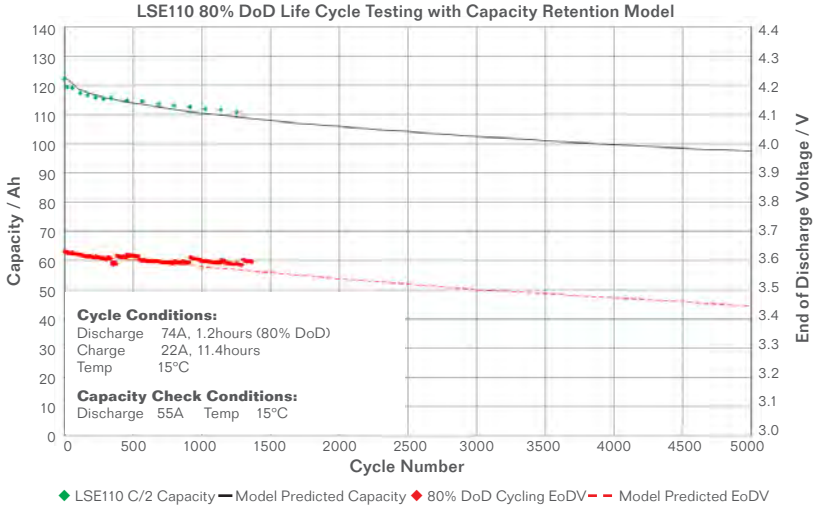
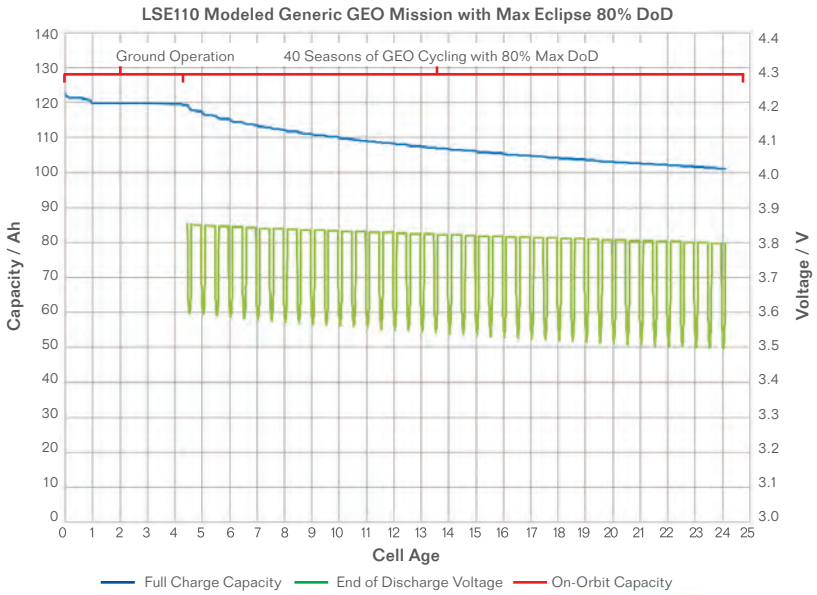


Simulated GEO Mission

1. Modeling of cell performance in profiles with frequently changing orbital parameters is possible with GS Yuasa's advanced modeling software as demonstrated by the simulated 40 season GEO mission.

GS Yuasa's advanced life and performance modeling capability supports the selection of optimal cell and battery configuration for a given use case.



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