GE
Industrial Solutions

Flywheel UPS Systems, 50-1000 kVA

using TLE or SG Series UPS

Incorporating VYCON Flywheel Technology

Growing Need for Flywheel UPS Systems

Popular Market Segments

Numerous applications for critical power UPS Systems require short duration backup time, as many mission-critical loads now have other design means to provide long duration power outage support thru various hardware and spatial software redundancies. Applications and markets that embrace Flywheel UPS technology include:

- Datacenters – Cloud, Colocation, Enterprise
- Medical Imaging
- Broadcast
- Transportation
- Industrial Critical Process
- Gambling/Casinos

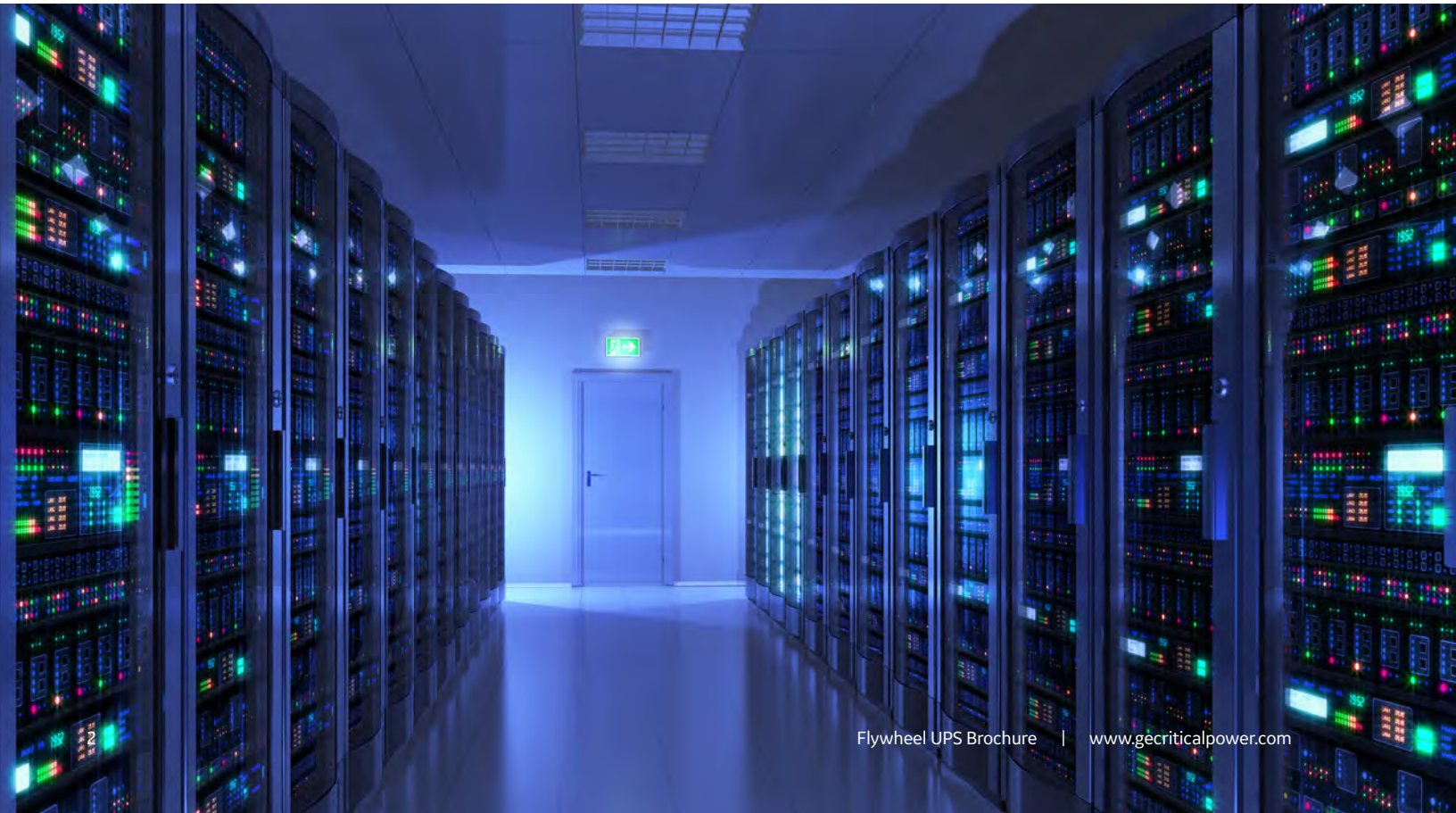
UPS Module


UPS Flywheel

Key Drivers

There are various drivers that make Flywheels an attractive energy storage device in GE UPS Systems, including:

- Low Total Cost of Ownership
- High Efficiency
- Small Footprint
- Limited Ambient Cooling Needs
- Simple & Reduced Maintenance Costs
- Simple Installation
- Expandable up to (6) Flywheels in Parallel for increased runtime
- Green, Sustainable Product
- 20 Year Life



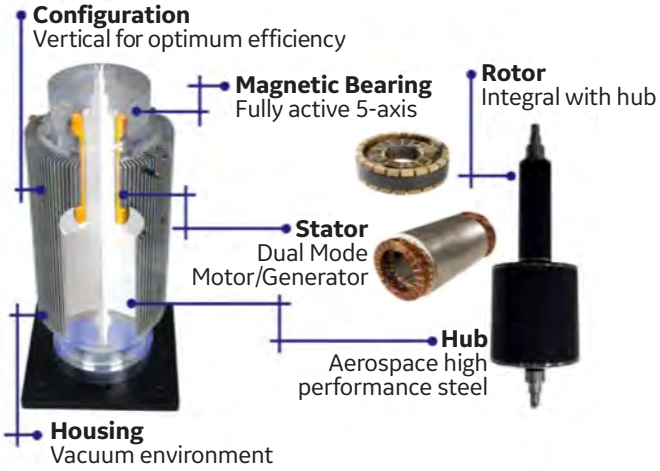
Flywheel Overview

Summary

The flywheel, using VYCON technology, stores kinetic energy in the form of a rotating mass and is designed for hi power, short time discharge applications. The technology includes a high speed motor generator and active magnetic bearings that are used to levitate and sustain the rotor during operation. The flywheel assembly includes a superior control system that provides information on system performance. This innovative technology allows the flywheel to charge and discharge at high rates for countless cycles, providing much superior operation over conventional battery use.

How the Flywheel Works

The flywheel energy storage system works like a dynamic battery that stores energy by spinning a mass around an axis. Electrical input spins the flywheel hub up to a high speed and a standby charge keeps the unit spinning until its called upon to release its energy. The energy is proportional to its mass and speed squared. Thus, doubling the mass will double the energy capacity, but doubling the rotational speed will quadruple the energy capacity, thus giving our flywheel a competitive advantage.



GE UPS Systems Compatible with Flywheel Technology

TLE Series UPS

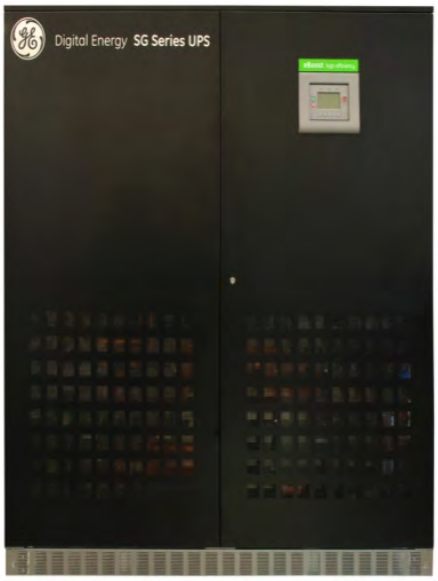
This UPS product is a transformerless topology, providing premium protection via online double conversion technology. The primary target for this product is Datacenter/IT applications. The TLE Series key statistics are:

- 50 thru 1000kVA ; UL Listed, 480/277V, 60Hz
- 40 thru 800kVA ; CE Listed, 400/230V, 50Hz
- Unity (1.0) Output Power Factor
- High OnLine Efficiency up to 97%
- Ecomode option, raising Efficiency up to 99%
- 3-Level IGBT Design
- Small Footprint
- Parallel up to 6 UPS Modules
- **Parallel up to 6 Flywheels on a UPS Module**

SG Series UPS

This UPS product is a transformer-based topology, providing premium protection via online double conversion technology. The UPS module utilizes an internal output zig-zag isolation transformer that is superior for output load balancing and high crest factor loads. The primary target for this product is numerous Critical Process applications. The SG Series key statistics are:

- 50 thru 300kVA ; UL Listed, 480/277V, 60Hz
- 60 thru 600kVA ; CE Listed, 400/230V, 50Hz
- Output Power Factor (0.80 & 0.90 models)
- Good OnLine Efficiency up to 95%
- Ecomode option, raising Efficiency up to 99%
- 2-Level IGBT Design
- Small Footprint
- Parallel up to 6 UPS Modules
- **Parallel up to 6 Flywheels on a UPS Module**



See GE TLE and SG Series Brochures for more technical details on the UPS modules

UPS Module Data

TLE UPS MODULES, 480/277V 3PHASE 4 WIRE, UL LISTED, 60HZ											
Module kVA	50*	80*	100*	120*	150*	225	250	400	500	750	1000
Width (in)	24	24	24	24	24	44	44	64	64	118	144
Depth (in)	34	34	34	34	34	34	34	34	34	34	34
Height (in)	65	65	65	65	65	75	75	75	75	75	75
Weight (lbs)	992	992	992	1146	1146	1323	1323	2756	2746	4520	4520
Efficiency - Dbl Conv	Up to 96%					Up to 97%					
Efficiency - EcoMode	Up to 99%										

* 50-150kVA TLE 60Hz modules available in Q1 2017

TLE UPS MODULES, 400/230V 3PHASE 4 WIRE, CE LISTED, 50HZ										
Module kVA	60	80	100	120	160	200	320	400	600	800
Width (mm)	600	600	600	600	820	820	1420	1420	3020	3420
Depth (mm)	855	855	855	855	865	865	865	865	865	865
Height (mm)	1630	1630	1630	1630	1905	1905	1905	1905	1905	1905
Weight (kg)	450	450	520	520	500	500	950	950	2400	2800
Efficiency - Dbl Conv	Up to 96%				Up to 97%					
Efficiency - EcoMode	Up to 99%									

SG UPS MODULES, 480/277V 3PHASE 4 WIRE, UL LISTED, 60HZ							
Module kVA	50	80	100	120	150	225	300
Width (in)	27	27	47	47	47	65	65
Depth (in)	32	32	32	32	32	32	32
Height (in)	71	71	71	71	71	71	71
Weight (lbs)	1257	1489	1929	2006	2160	3086	3086
Efficiency - Dbl Conv	Up to 93%						
Efficiency - EcoMode	Not Available					Up to 99%	

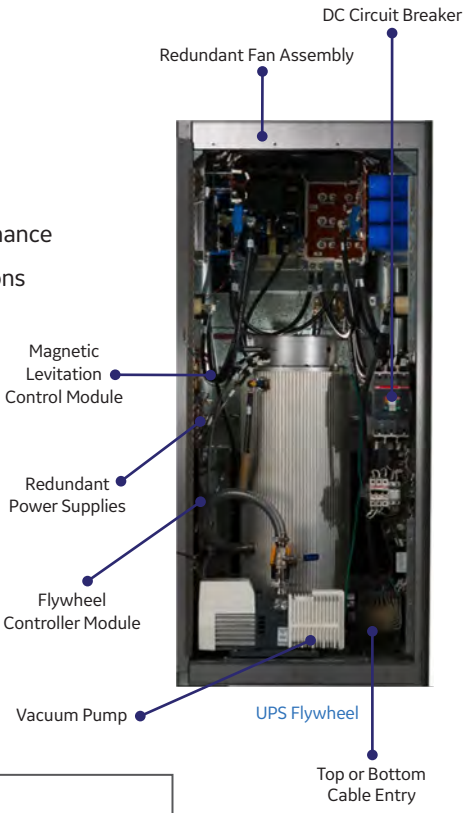
SG UPS MODULES, 400/230V 3PHASE 4 WIRE, CE LISTED, 50HZ											
Module kVA	60	80	100	120	160	200	250	300	400	500	600
Width (mm)	650	650	835	850	900	1300	1300	1300	1800	1800	1950
Depth (mm)	850	850	850	850	850	850	850	850	950	950	950
Height (mm)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Weight (kg)	550	630	860	860	1050	1220	1470	1560	2190	2470	2950
Efficiency - Dbl Conv	Up to 94%										
Efficiency - EcoMode	Not Available				Up to 99%						

Notes:
1. UPS Modules are available in smaller kVA ratings than noted, but 50kVA is smallest rating GE is using with Flywheel energy storage.
2. Physical sizes and weights are subject to change.
3. For additional technical detail on UPS modules, see module brochure and product technical data sheets.

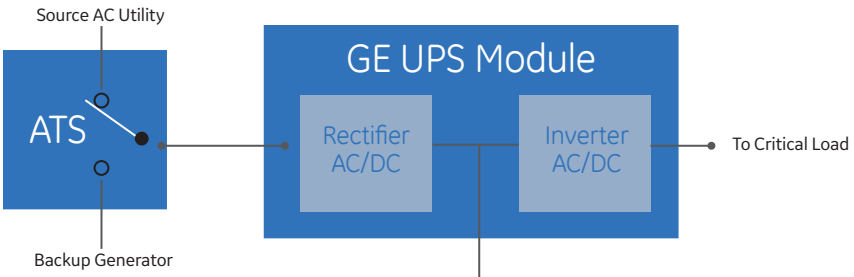
Flywheel Features & Applications

Key Flywheel Features

- **Hi-Speed Motor** Generator for hi efficiency, hi power density & hi temperature operation
- **Magnetic Levitation System** for no lubrication, no bearing replacement, and no maintenance
- **Smart Monitoring System** for real time data, advanced warnings, remote communications
- **Proven/Tested**, with over 1000 systems installed and over 13 million discharge cycles



Block Diagram



Continuous Power Application

- Battery Free Operation
- Ride through to Generator Start
- Highest reliability
- Parallel the flywheels for capacity, longer runtimes or redundancy

Glitch Protection Application

- Battery Free Operation
- Resolves 98% of all power events
- High Operating Temperature
- Small footprint

Battery Hardening Application

- Flywheel first line of defense for all but long duration outages
- Provides energy storage redundancy
- Can extend battery life due to reduced battery cycling

Flywheel Data

POWER/DURATION RATINGS	
Max Power	300 kW
Max Energy Storage	Standard Flywheel: 4000kW seconds
	Enhanced Flywheel: 6000kW seconds
Runtimes	See tables near end of brochure
Rotational Speed	Standard Flywheel: 36,750-24,500 RPM
	Enhanced Flywheel: 36,750-14,000 RPM

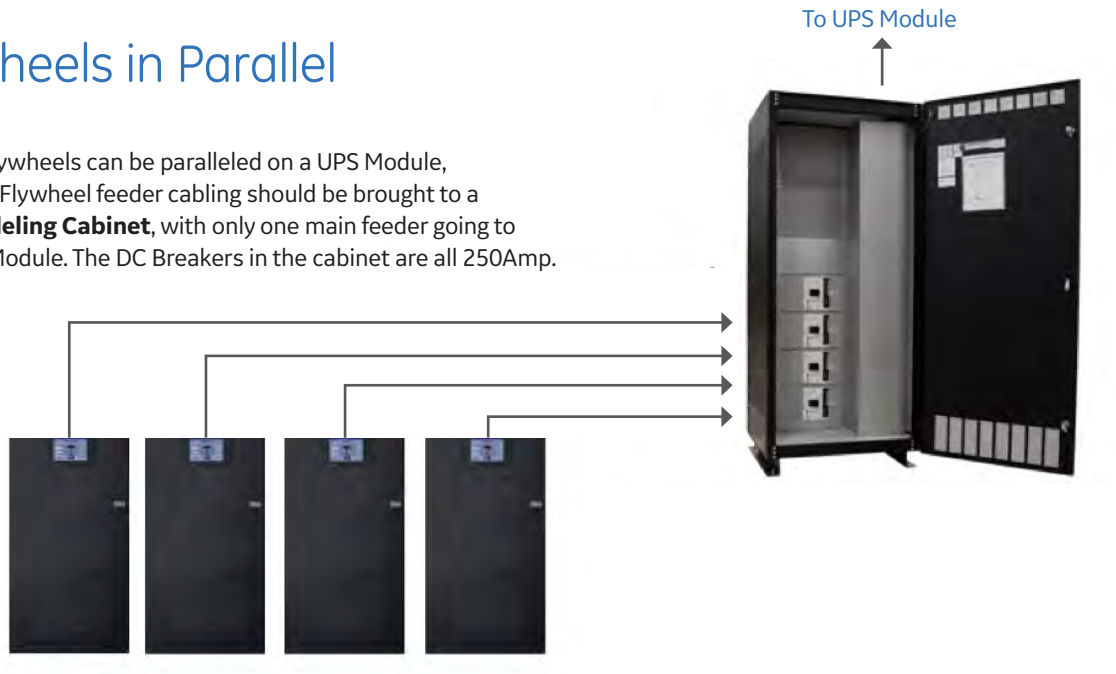
OUPUT	
Voltage Discharge (Vdc)	400-520 adjustable
Operating Temp	14 degr F to 104 degr F (-10 degr C to 40 degr C)
Humidity	90% non-condensing
Max Altitude	5,000 ft (1524 m) without derating
Audible Noise	< 68 dBA at 3.3ft (1M)

INPUT	
Voltage (Vdc)	400-600
Recharge Rate	15-50 Amps adjustable

PHYSICALS	
Height	73.7 in (1872mm)
Width	30.0 in (762mm)
Depth	30.0 in (762mm)
Weight	1810 lbs (822kg)

Flywheels in Parallel

Up to 6 Flywheels can be paralleled on a UPS Module, but each Flywheel feeder cabling should be brought to a **DC Paralleling Cabinet**, with only one main feeder going to the UPS Module. The DC Breakers in the cabinet are all 250Amp.



DC PARALLELING CABINET		
	For 2-3 Flywheels	For 4-6 Flywheels
Bus Size	800A MLO	1600A MLO
Size w x dp x hi	24" x 33" x 71"	24" x 33" x 71"
	609mm x 838mm x 1803mm	609mm x 838mm x 1803mm
Weight (est)	500 lbs	600 lbs
	227 kg	272 kg

Flywheels vs. Battery Energy Storage

UPS Battery Plants will have Supplemental & Ongoing Costs

While the capital cost of a VRLA battery plant can be less than a flywheel solution, there are other costs associated to a UPS battery installation, such as:

- Temperature controlled room
- Spill containment system
- Fire code approvals/permits
- Independent monitoring systems
- Hazardous waste disposal costs
- Occasional replacement battery jars between years 3 and 5 (VRLA)
- Full replacement battery plants every 5 years (VRLA)

CATEGORY	FLYWHEEL	LEAD ACID BATTERY
Maintenance	Minimal (Annual)	Frequent (Quarterly)
HVAC Costs	None	High
MTBF	> 50,000 Hrs	> 2,200 Hrs
Life Expectancy	20 Yrs	4-5 Years (VRLA)
Install Cost	Low	Med to High
Hazardous Materials	None	Lead & Acid
Toxic Emissions	None	Hydrogen
Footprint	Small	Med to Large
Diagnostics & Monitoring	Accurate	Speculative
Disposal Requirements	None	Yes
Fire Hazard Permits	None	Often

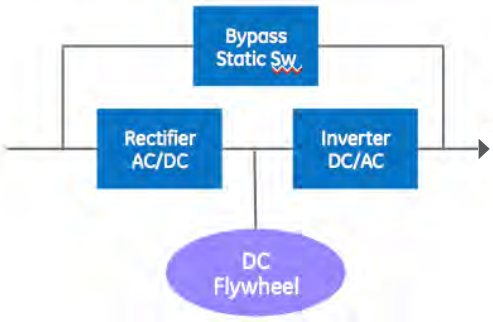
Carbon Footprint Reduction of Flywheels vs Battery Plants

Utilizing Flywheel energy storage systems reduces the carbon footprint as compared to 5 minute Battery Plant by an astounding 95%.

	VRLA BATTERY PLANT	GE FLYWHEEL
Embedded Carbon Emmissions (CO_2/kg)	1.14	2.70
Energy Storage for 1MW UPS	6 Cabinets/Strings	4x300kw Flywheels
Total Energy Storage Weight (kg)	14,693	1,297
Total Embedded Carbon (kg CO_2)	16,750	5,502
15 Year Energy Storage Replacement	3 Times	0 Times
Total 15 Year Lifecycle Embedded Carbon (kg CO_2)	67,000	3,502

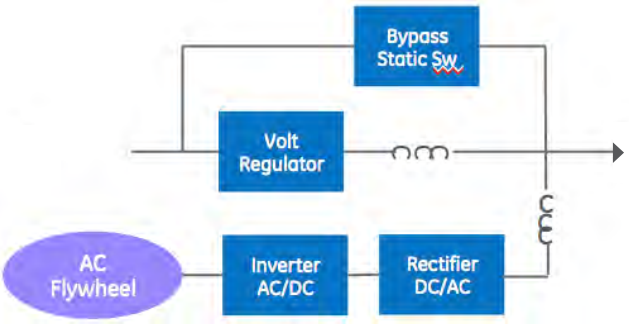
Flywheel UPS Design Comparisons

GE Flywheel UPS Design



- Double Conversion UPS
- Wide Input Voltage/Frequency tolerance
- Input PF remains very high (0.99)
- System Efficiency 96-97%
- Inverter & Bypass always in phase
- Add flywheels only for added runtime
- Add batteries in combo with flywheel

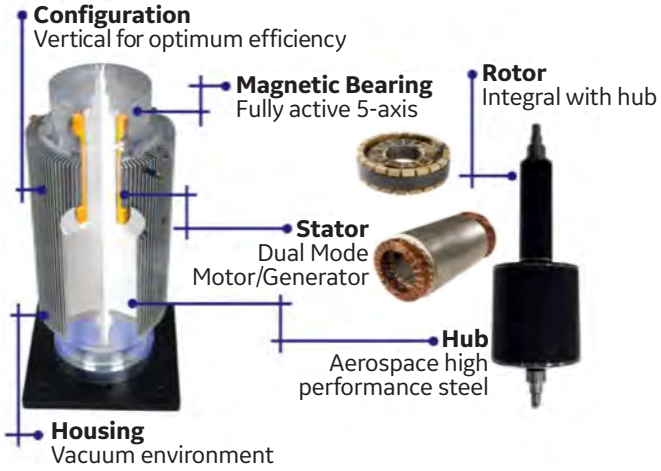
Sample Competitor's Flywheel UPS



- Line Interactive UPS
- Narrow Input Voltage/Frequency tolerance
- Input PF varies with % Load & Input Voltage
- System Efficiency 95-96%
- Inductor can put Regulator & Bypass out of phase
- Add UPS modules & flywheels for added runtime
- Cannot add batteries to system

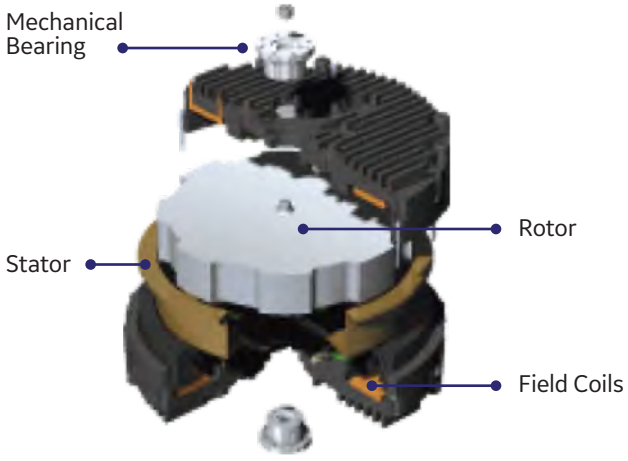
Core Flywheel Design Comparisons

GE High Speed Flywheel



- No Bearing Replacement
- No External Power Source to generate rotor field
- High Speed, Low Mass design

Sample Competitor's Low Speed Flywheel



- Bearing Replacement every 3-4 years, 8hrs work, $8-10K+ cost
- External Power Source required to generate rotor field
- Low Speed, Low Mass design

Flywheel Runtime Charts – for TLE Series UPS w/ Enhanced Flywheel

Enhanced Flywheel Backup Time: TLE UPS, 480V 60Hz

GE UPS MODELS	50kVA*	80kVA*	100kVA*	120kVA*	150kVA*	225kVA	250kVA	400kVA	500kVA	750kVA	1000kVA
UPS kW	50	80	100	120	150	225	250	400	500	750	1000
# of Flywheels	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
1	113	72	57	45	33	19	16				
2		140	111	92	75	48	43	22	15		
3						75	68	40	28	15	
4							87	55	42	24	15
5								69	55	33	22
6										42	28

* Denoted TLE kVA module ratings available in 2017

Enhanced Flywheel Backup Time: TLE UPS, 400V 50Hz

GE UPS MODELS	60KVA	80KVA	100kVA	120KVA	160KVA	200KVA	320KVA	400KVA	600KVA	800KVA
kW	60	80	100	120	160	200	320	400	600	800
# of Flywheels	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
1	94	72	57	45	32	23				
2		140	111	92	71	56	31	22		
3					103	83	51	40	22	13
4							69	55	33	22
5								69	45	30
6									55	39

Notes:
1. Runtimes in seconds.

2. Runtimes are based on UPS with 540VDC float voltage for ratings 160kVA and higher; 432VDC for ratings less than 160kVA.

3. DC-AC efficiencies (battery to output) are based on battery power data at rated power factor from UPS Technical Data Sheets.

4. Runtimes take into account the minimum 2sec rectifier walk-in time.

Flywheel Runtime Charts – for TLE Series UPS w/ Standard Flywheel

Standard Flywheel Backup Time: TLE UPS, 480V 60Hz

GE UPS MODELS	50kVA*	80kVA*	100kVA*	120kVA*	150kVA*	225kVA	250kVA	400kVA	500kVA	750kVA	1000kVA
kW	50	80	100	120	150	225	250	400	500	750	1000
# of Flywheels	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
1	71	44	35	29	22	15	12				
2		87	70	58	46	32	28	16	12		
3						48	43	26	21	12	
4							58	35	28	18	12
5								45	35	23	16
6										28	20

* Denoted TLE kVA module ratings available in 2017

Standard Flywheel Backup Time: TLE UPS, 480V 50Hz

GE UPS MODELS	60KVA	80KVA	100kVA	120KVA	160KVA	200KVA	320KVA	400KVA	600KVA	800KVA
kW	60	80	100	120	160	200	320	400	600	800
# of Flywheels	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
1	59	44	35	29	23	17				
2		87	70	58	46	36	22	16		
3					69	55	33	26	16	10
4							45	35	23	16
5								45	29	21
6									35	26

Notes:
1. Runtimes in seconds.

2. Runtimes are based on UPS with 540VDC float voltage for ratings 160kVA and higher; 432VDC for ratings less than 160kVA.

3. DC-AC efficiencies (battery to output) are based on battery power data at rated power factor from UPS Technical Data Sheets.

4. Runtimes take into account the minimum 2sec rectifier walk-in time.

Flywheel Runtime Charts – for SG Series UPS w/Enhanced Flywheel

Enhanced Flywheel Backup Time: SG UPS, 480V 60Hz

GE UPS MODELS	50KVA	80KVA	100kVA	120KVA	150KVA	225KVA	300KVA
kW	40	64	80	96	120	202	270
# of Flywheels	↓	↓	↓	↓	↓	↓	↓
1	142	88	71	59	45	22	
2		174	139	115	91	54	39
3						81	62
4							80
5							
6							

Enhanced Flywheel Backup Time: SG UPS, 400V 50Hz

GE UPS MODELS	60KVA	80KVA	100kVA	120KVA	160KVA	200KVA	250KVA	300KVA	400KVA	500KVA	600KVA
kW	54	72	90	108	128	180	225	270	360	450	540
# of Flywheels	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
1	103	79	63	51	35	25	17				
2		155	123	101	77	62	48	38	24	17	
3					114	91	74	62	44	32	24
4							96	80	61	47	37
5									76	61	49
6											61

Notes:
1. Runtimes in seconds.
2. Runtimes are based on UPS with 540VDC float voltage for ratings 160kVA and higher ; 432VDC for ratings less than 160kVA.
3. DC-AC efficiencies (battery to output) are based on battery power data at rated power factor from UPS Technical Data Sheets.
4. Runtimes take into account the minimum 2sec rectifier walk-in time.

Flywheel Runtime Charts – for SG Series UPS w/Standard Flywheel

Standard Flywheel Backup Time: SG UPS, 480V 60Hz

GE UPS MODELS	50KVA	80KVA	100kVA	120KVA	150KVA	225KVA	300KVA
kW	40	64	80	96	120	202	270
# of Flywheels	↓	↓	↓	↓	↓	↓	↓
1	94	58	46	38	30	16	
2		115	92	76	60	35	26
3						53	40
4							53
5							
6							

Standard Flywheel Backup Time: SG UPS, 400V 50Hz

GE UPS MODELS	60KVA	80KVA	100kVA	120KVA	160KVA	200KVA	250KVA	300KVA	400KVA	500KVA	600KVA
kW	54	72	90	108	128	160	225	270	360	450	540
# of Flywheels	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
1	65	48	37	32	23	18	14				
2		97	77	64	48	38	30	24	18	13	
3					72	57	45	37	27	21	17
4							60	50	37	29	24
5									47	37	30
6											37

Notes:
1. Runtimes in seconds.

2. Runtimes are based on UPS with 540VDC float voltage for ratings 160kVA and higher ; 432VDC for ratings less than 160kVA.

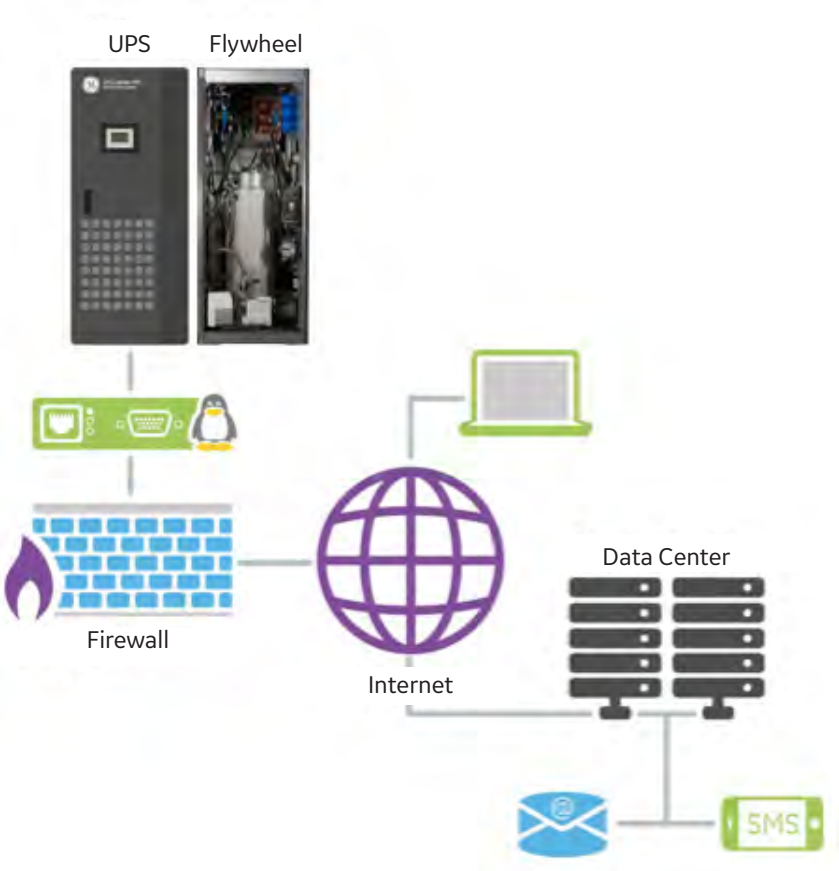
3. DC-AC efficiencies (battery to output) are based on battery power data at rated power factor from UPS Technical Data Sheets.

4. Runtimes take into account the minimum 2sec rectifier walk-in time.

iUPSGuard Diagnostic Monitoring

GE's iUPSGuard is a cloud-based remote monitoring solution, providing UPS & Flywheel status monitoring and alarm notification. iUPSGuard notifies personnel of critical alarms and events via email or SMS, allowing a user of GE technician to make timely decisions and/or repairs. Features include:

- 7x24x365 monitoring of Flywheel UPS
- Highly secure and efficient data transmission, SSL encrypted with unidirectional communication
- Communicate through various channels and monitors thru web/SNMP card
- Detailed reporting system providing valuable information on operating conditions and trends over time
- Predictive algorithms to anticipate issues



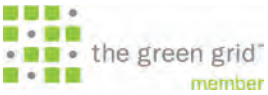
UPS Services

The Flywheel UPS protects your critical load. Our Service protects your UPS investment.

GE offers a complete range of services to proactively reduce downtime and meet your service level needs. You can rely on GE's service organization to support all your critical infrastructure support needs, including:

- 7x24x365 Service
- Product Training
- Maintenance Contracts
- Preventative Maintenance
- Spare Part Kits
- Part Replacements
- Technical Site Support
- Startup Services
- Integration Test Support
- Equipment Rentals

Certifications

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