CERN-ICEC-STFC-hosted Workshop on Innovative, Robust and Affordable Medical Linear Accelerators for Challenging Environments

Personal overview of special issues of the robust/reliable medical accelerator.

I. Syratchev, CERN

25-27 October 2017
CERN
Europe/Zurich timezone

Boundary conditions, limitations and recommendations:

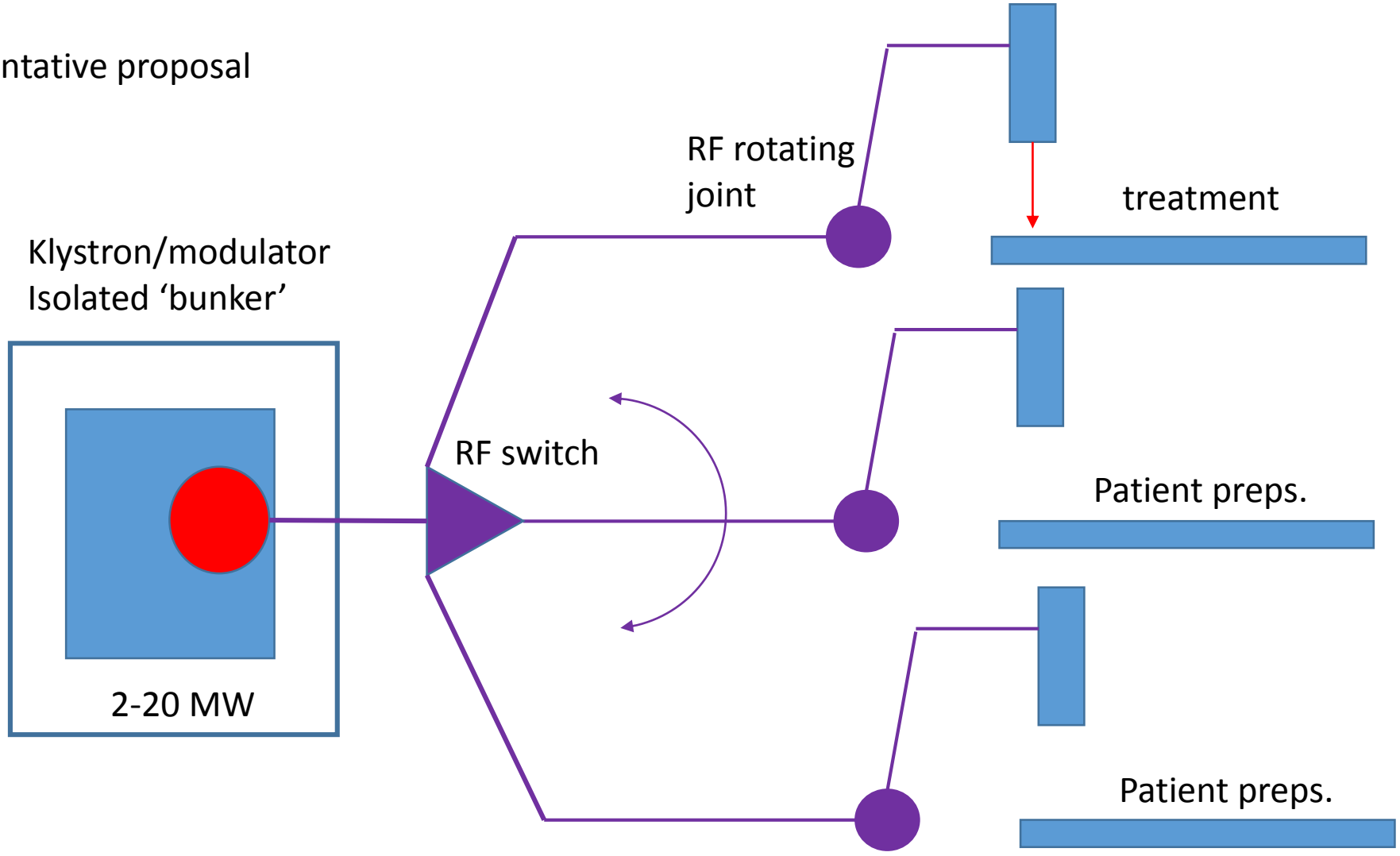
- Limited personal (number and qualification)
- Environmental conditions (climate and power supply)
- Logistic and maintenance
- Patient needs multiple treatments

→ Centralized facility

- Do not invent new things!!!. Use exiting technology. But try to choose the one with cutting-edge performance.
- Do not put cost minimisation as a priority to stat with. It could come naturally through system optimisation, that might be specific for every region.

- Intelligent components breakdown of entire system is mandatory. Do not use industrial experience /recommendation and not try to put all in one.
- Optimisation of every component should be targeted fpr reduction of cost, operation and maintenance as an integrated value (facility operates for decades).
- The optimised facility could appear not as compact (and not cheaper) as the one you can find on the market. BUT it will fit your needs best!

Tentative proposal



Maximize facility put through in the most economic way.

New kid in the block

JSC "Vacuum device's basic technologies"
Moscow, 117342, Vvedenskogo str., 3, k.1,
Russian Federation, tel. +7 (495) 578-05-46
www.vdbtc.com

VDBT

Sales Agent:
NELSON Created AB
www.nelsoncreated.com

NELSON

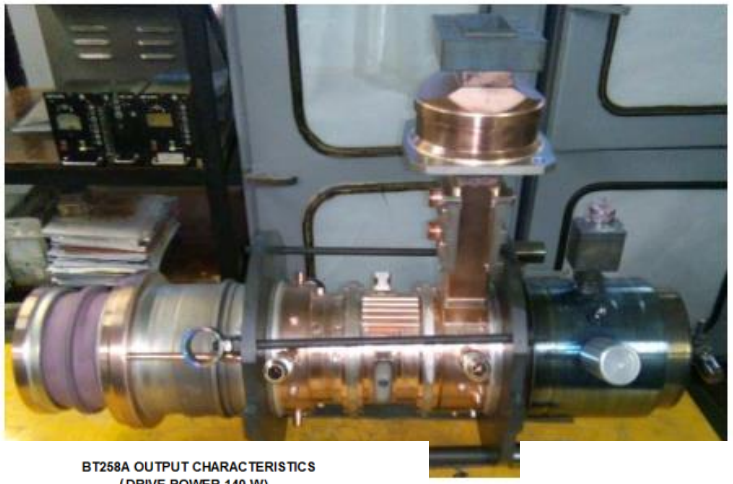
TECHNICAL SPECIFICATION
#10258-01
Multi-beam S-band Klystron type BT258A

0.72m long
92 kg (incl. PPM solenoid)
No oil tank.
Positioning: arbitrary (rotation possible)

VDBT

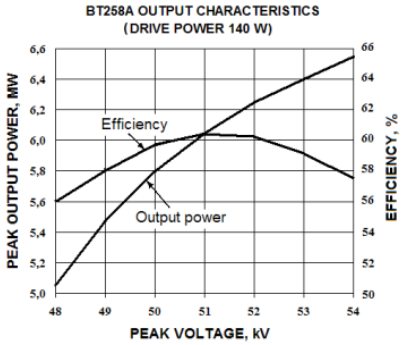
The company was created for the development and manufacture of precision microwave vacuum-electron-tube devices (VETD).
The main product areas being manufactured are:
- Linear electron accelerators.
- Vacuum-tube radar devices.
- Multi-beam high power klystrons (MBK).

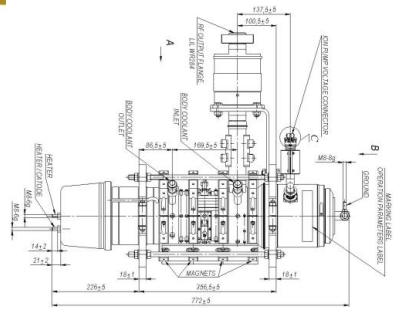
BT258A Data sheet



TYPICAL OPERATION
(Example)

		Units
Frequency	2998.5	MHz
Heater Voltage	21	V
Heater Current	25	A
Peak Beam Voltage	50	kV
Peak Cathode Current	200	A
Peak RF Drive Power	150	W
Peak RF Output Power	6	MW
Efficiency	60	%
Gain	46	dB
Pulse Width (Beam Voltage)	7	μs
Pulse Width (RF Output Power)	5	μs
Pulse Repetition Rate	200	pps





CETC NELSON

VE2116 S-Band 5.5MW
Fast Tuned Magnetron

VE2116 is mainly used for mid-power linear accelerators. It is a mature and reliable product in China. It can replace the MG6028、MG6370 pulse magnetron perfectly for the medical application.

GENERAL DATA

	Min	Max	
Frequency range	2852	2861	MHz
Peak output power（nominal）	—	5.5	MW
Heater voltage	12	13.5	V
Heater current	12.5	14	A
Cathode pre-heating time （minimum）	6	—	Min
Magnetic field	120	164	mT
Anode voltage(peak)	34	55	kV
Anode current(peak)	—	260	A
Duty cycle	—	0.003	
Pulse duration			
at 5.0 MW peak.....	—	3	μs at 2.5 MW
peak.....	—	5	μs at 1.0 MW
peak.....	—	5.5	μs
Rate of rise of voltage pulse	100	150	kV/μs
VSWR at the output coupler	—	1.3:1	
Anode water outlet temperature	—	70	℃
Pressuring of waveguide	—	448	kPa

Anode voltage (kV)	34.4	42.2	46	48.9	51.7	52.7
Anode current(mean) (mA)	95	115	117	120	105	111
Anode current(peak) (A)	175	214	220	224	245	260
Output power(mean)（kW）	1.02	1.64	1.89	2.16	2.15	2.35
Output power(peak)（MW）	2	3.2	3.7	4.2	5	5.5

Efficiency 33% 40%

OPERATING ENVIRONMENT

Magnet ..... Electromagnet
Isolator ..... Isolator is needed
Power output .... Output through a No. 10 waveguide
Cooling ..... Water and air forced cooling
The magnetron must be protected from the load by an isolator or circulator.

Length 48 cm.
Weight with electromagnet (?)

Personal recommendation:

RF PEAK POWER: 2.5 – 5 MW
PULSE VOLTAGE: 40 – 75 kV
PULSE CURRENT: 30 – 250 A
MODULATOR PEAK: 14 MW X0.6 = 8.4MW
MODULATOR AVG.: 16 kW
MAINS (1 / 3 PHASE): 3
COOLING: Water

http://scandinovasystems.com/

CLIC – Note – 1071

DESIGN AND HIGH POWER MEASUREMENTS OF A 3 GHZ ROTARY JOINT FOR MEDICAL APPLICATIONS

Alberto Degiovanni[1,2*], Stefano Benedetti[1,2], Marco Garlasché[1,2], Jorge Giner-Navarro[1], Paolo Magagnin[1,2], Gerard McMonagle[1], Igor Syratchev[1], Walter Wuensch[1]

[1] CERN/Switzerland
[2] TERA Foundation/Italy
* now at A.D.A.M. SA/Switzerland

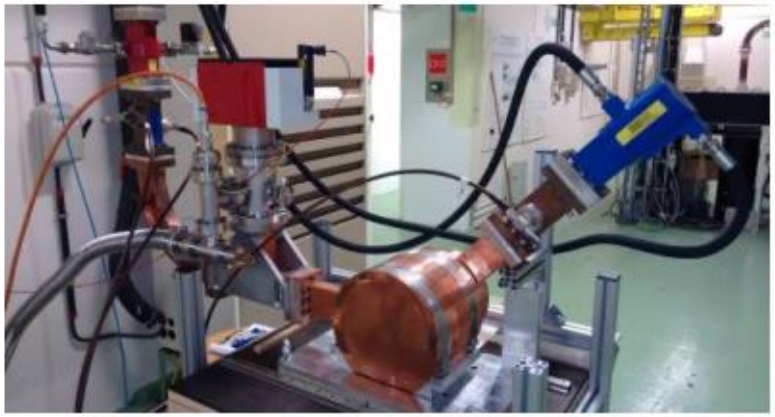
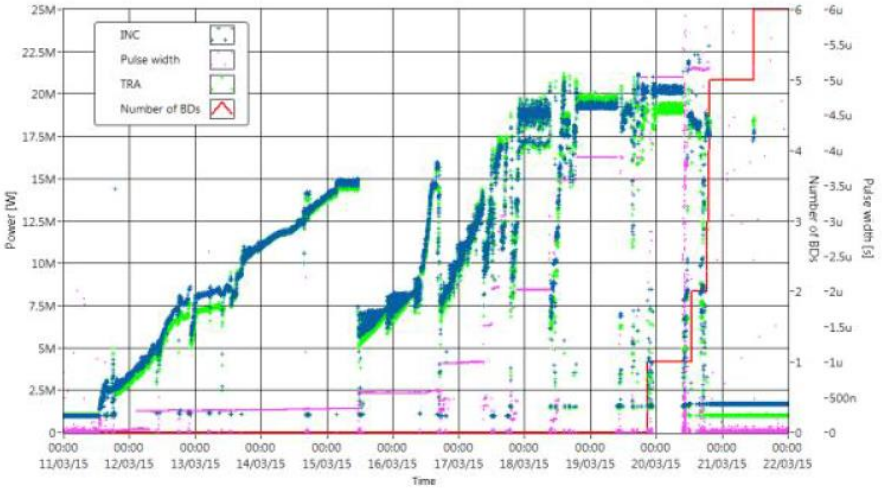


Figure 6: Setup of the high power test of the RJ in CTF2 at CERN.

Proven technology. Certified at CERN.

Tested up to 20 MW at 50 Hz with 5 µsec pulses



Transmitted RF pulses power profiles at different angles

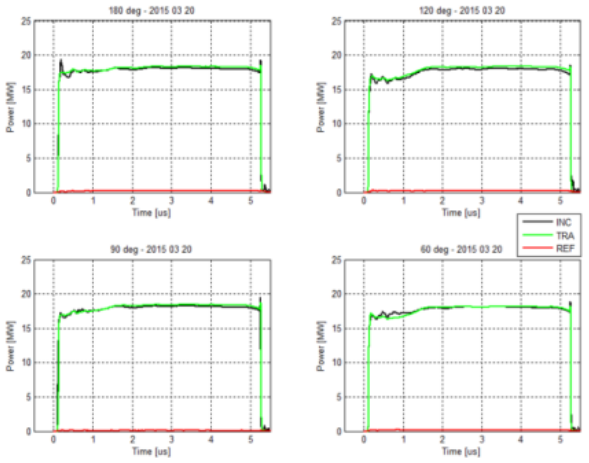


Figure 9: RF pulse profiles taken at different angles of the RJ.

High gradient linac for proton therapy

S. Benedetti,* A. Grudiev, and A. Latina
CERN, CH-1211 Geneva-23, Switzerland
(Received 23 January 2017; published 13 April 2017)

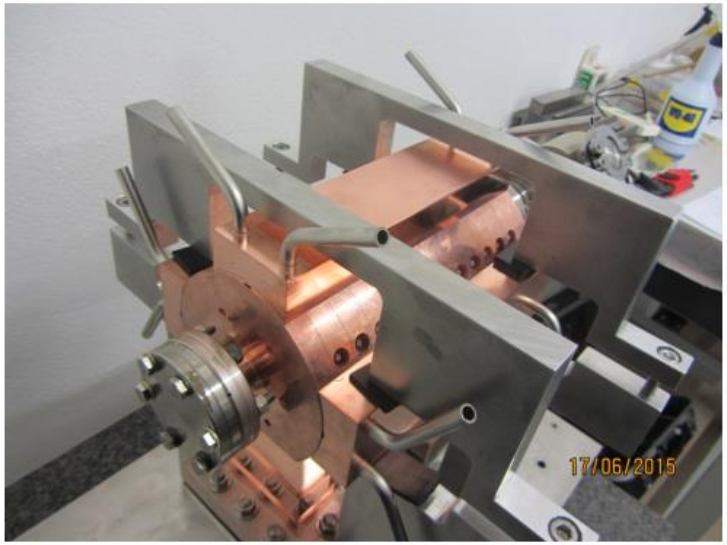
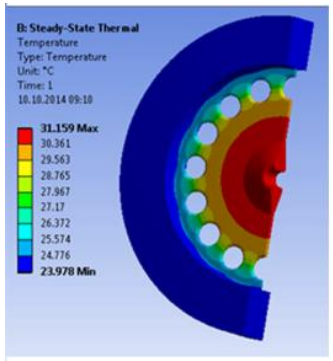
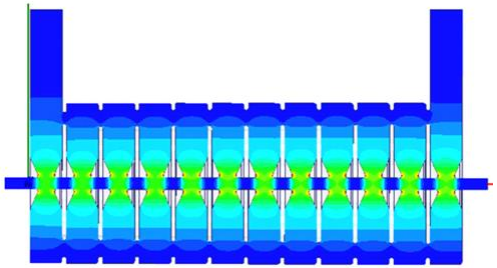


FIG. 13. The 3 GHz BTW prototype.

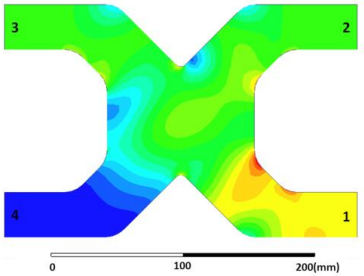




Currently structure is running at CERN at 56 MV/m with 25MW, 1 µsec (flat) input power.

Structure equipped with 3dB hybrid for RF power recirculation.

Compact hybrid:



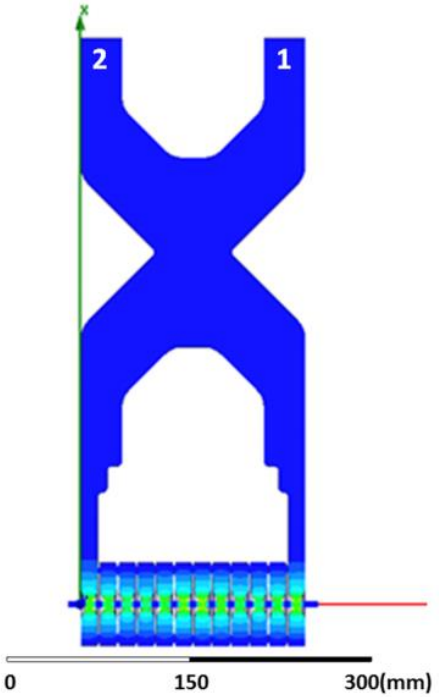


FIG. 17. Complex mag electric field distribution in BTW structure connected to the 3 db hybrid.

TW structure with re-circulation delivers similar impedance as in SW structure, but do not reflect the power during transient time – no needs for RF circulator:

saes group making innovation happen, together

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Home > Products & Functions > Products > Vacuum Pumps > NEXTORR PUMPS

NEXTORR PUMPS

The NEXTorr® product line has global Intellectual Property Rights coverage with patents already granted in the US (8,287,247), Europe (2,409,034), Japan (5,372,239), China (102356236)

The NEXTorr® pump **combines** in a synergic design **NEG and ion pumping technologies**.

A getter cartridge acts as the main UHV pumps, while a small Sputter Ion Pump (SIP) removes inert gases, not pumped by the NEG.

Thanks to the NEG large pumping capacity for active gases (water, carbon oxides, nitrogen etc.) and the integrated design, the NEXTorr pump is **10 to 50 times smaller and lighter than a SIP featuring similar nominal speed**.

This is shown in in the figure below which compares a NEXTorr D 100 with a 100 l/s SIP.

Highlights

- High pumping speed and capacity for all active gases
- Pumping speed for noble gases and methane
- Constant pumping speed in UHV-XHV
- Minimal power requirement during operations
- Extremely compact and light pump
- Reduced magnetic interference
- Oil free and vibration free
- Able to measure pressure lower than 10^{-9} mbar

https://www.saesgetters.com/products/nextorr-pumps

Maintains pumping speed in the case of electrical power cuts. Needs reactivations after vacuum intervention.

Use local industrial chillers (inexpensive!) with closed water circuit where possible:

water-cooled water chiller 1HP-200HP

US $1-3000 / Set

1 Set (Min. Order)

Dongguan Zillion Refrigeration M...

Powerful **chiller** price malaysia

US $2000-4000 / Set

1 Set (Min. Order)

Anhui Kaifeng Plastic Machinery...

Used and fully working Condition and **water** and air

US $500-700 / Set

1 Set (Min. Order)

Guangzhou Tyrone Plastic Machi...

Japan Daikin compressor **water cooled chiller** from

US $1200-9900 / Set

1 Set (Min. Order)

Foshan Creator Machinery Co., L...

Professional **industrial chiller** with **japan**

US $1-100000 / Piece

1 Piece (Min. Order)

Shanghai Jingyao Industrial Co.,...

XC-03ACI Portable Exquisite 2.5kw **Japan Water Chiller**

US $100-5000 / Set

1 Set (Min. Order)

Ningbo Haichen Servo Info & Tec...

93KW Air **coole Industrial chiller** with R22 or R404a

1 Piece (Min. Order)

Taizhou Best Refrigeration Equip...

Industrial Water Cooled Screw **Chiller** Price

US $3600-3990 / Set

1 Set (Min. Order)

Shijiazhuang Haidier Machinery...

Industrial Water cooled chiller for plastic injection

1 Set (Min. Order)

Dongguan Mitex Automation Ma...

High quality **industrial** air **cooled water chiller** for oil

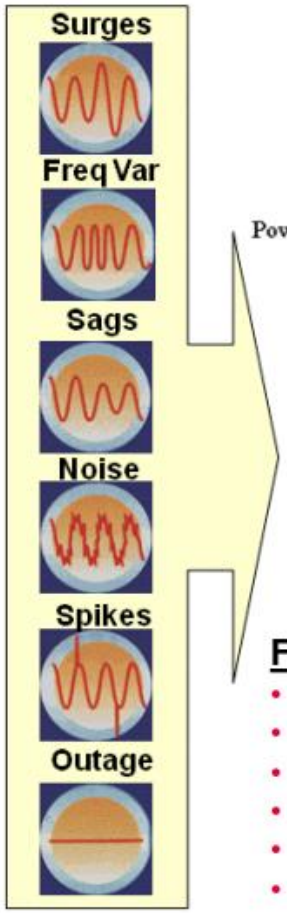
US $1000-5000 / Set

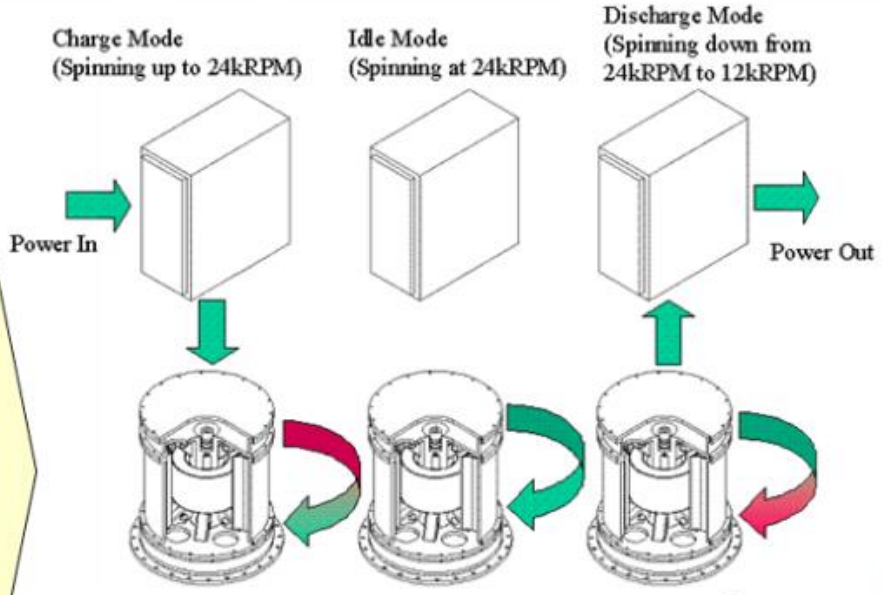
1 Set (Min. Order)

Zhangjiagang City Constant Tem...

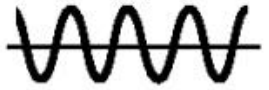
https://www.uaf.edu/files/acep/BoeingFlywheelOverview_06_20_2012.pdf

Flywheel Electricity Systems

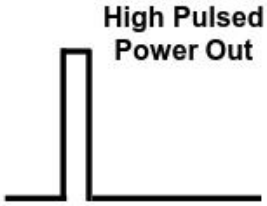




Uninterrupted Regulated (Load Leveled) Power Out



High Pulsed Power Out



Flywheel Functions

- Standby Power Source
- Power Quality
- Load Leveling
- Peak Shaving
- Reactive Power Support
- Voltage Support