The Delta Tandem Kinetic Battery Concept

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- **The system charges and discharges two flywheels in tandem.**
- **The speeds of the flywheels are kept at a constant difference delta**
- **It consumes and generates AC power without inverters.**
- **The components are standard technology, their use is unique.**
- **The process is called Torque Amplification**

Figure 1

Introduction

The Delta Tandem Kinetic Battery is a charge/discharge concept for storing electrical energy on two flywheels. The two flywheels act in tandem at a constant difference called Delta, hence Delta Tandem.

This system takes a constant speed input from two motors and converts to a constant acceleration of two flywheels. It also takes a constant deceleration from two flywheels and converts that to a constant speed driving two generators. Its components are standard technology assembled and operated in a unique way.

The system is comprised of three basic components, motor/generators, flywheels and planetary systems. It charges and discharges using AC power eliminating the need for invertors.

Torque Amplification

The term Torque Amplifier was first introduced in a transmission patent that had two transmissions charging and discharging two dynamically connected flywheels. Then it was realized that torque amplification it could be controlled without the transmissions.

Torque Amplification is the process that converts a constant speed input from two motors into a continuous acceleration of two flywheels. It discharges two flywheels converting the continuous deceleration into a constant speed output that generates electricity.

This conversion requires two flywheels to operate at a constant difference called delta. For example if flywheel A is 14,000 RPMs and flywheel B is 15,800 RPMs, their delta difference is 1,800 RPMs. The underlying principal of the Torque Amplifier is that the difference in speeds is maintained while the flywheels are slowing down or speeding up in tandem. So if flywheel A is at 10,000 RPMs, then flywheel B would 11,800 which is flywheel A plus delta. This delta difference is the constant speed for driving an input/output device.

The Basic System

Figure 2 is the basic diagram of the of the Delta Tandem Kinetic Battery concept. There are two flywheels connected to two planetary systems. These planetary systems are dynamically connected, but not directly connected. The planetary systems are the conduits for the flow of torsion between the motor/generators and flywheels.

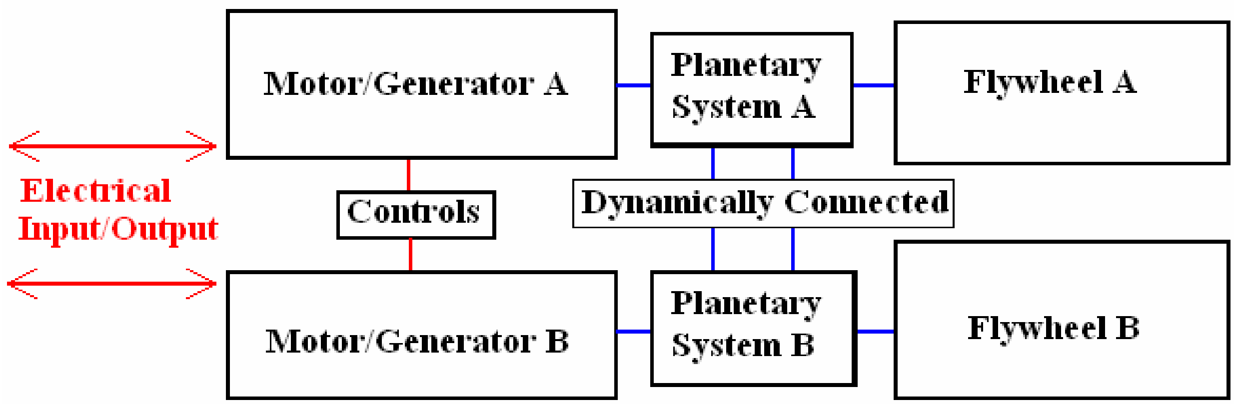


Figure 2

Each planetary system has two inputs that drive one output. They are configured so two flywheels of equal speeds will not produce any output. The flywheels have to be unequal in order for their difference to produce an output. It has to be maintained to produce a constant speed.

Maintaining the flywheel differences is done by controlling the motor/generators. While charging, if a difference is detected in Flywheel A being faster than it should be, then more torque needs to be drawn from Motor B and a corresponding less torque from Motor A until the difference between the flywheels is reestablished. While discharging, if Flywheel A is faster than it should be, then more load has to be produced by Generator A and less to Generator B until the flywheels are at their desired differences.

The planetary systems are connected in a 70%-30% distribution, meaning 70% of Flywheel A is drawn from Motor A and 30% is drawn from Motor B. This connection provides the two inputs. By producing more torsion in one motor and less in the other, both flywheels are still being charged, just one more than the other which is how they are brought back into their constant difference delta.

The scale of controlling the system needs to happen when the difference between the flywheels is in the order of one RPMs or less. At thousands of RPMs any difference adds up quickly. This smallest difference is the smallest remedy that can be applied. This will be an ongoing computer controlled process. It should always be in a small scale so the corrective measures in the motor/generators are also very small.

The controlling issue is not a function of how fast power is drawn. The overall system should be able to handle charging at 10 amps and discharging at 100 amps while maintaining delta control.

The Planetary Systems

Figure 3 is a diagram of a planetary system front and side views. There is a sun gear in the center with planetary gears around it that are held in place by a surrounding ring gear. The planet gears are mounted on a planet carrier. When the planets gears are stationary, the planet carrier is stationary. When the planet gears are in orbit, the planet carrier rotates. A Torque Amplifier configuration has the ring gear and the sun gear as the two inputs. These inputs cause the planet gears to turn. If the inputs are equal, then the planet gears are stationary. If they are unequal, then the planets orbit the sun gear and drive the planet carrier shaft.

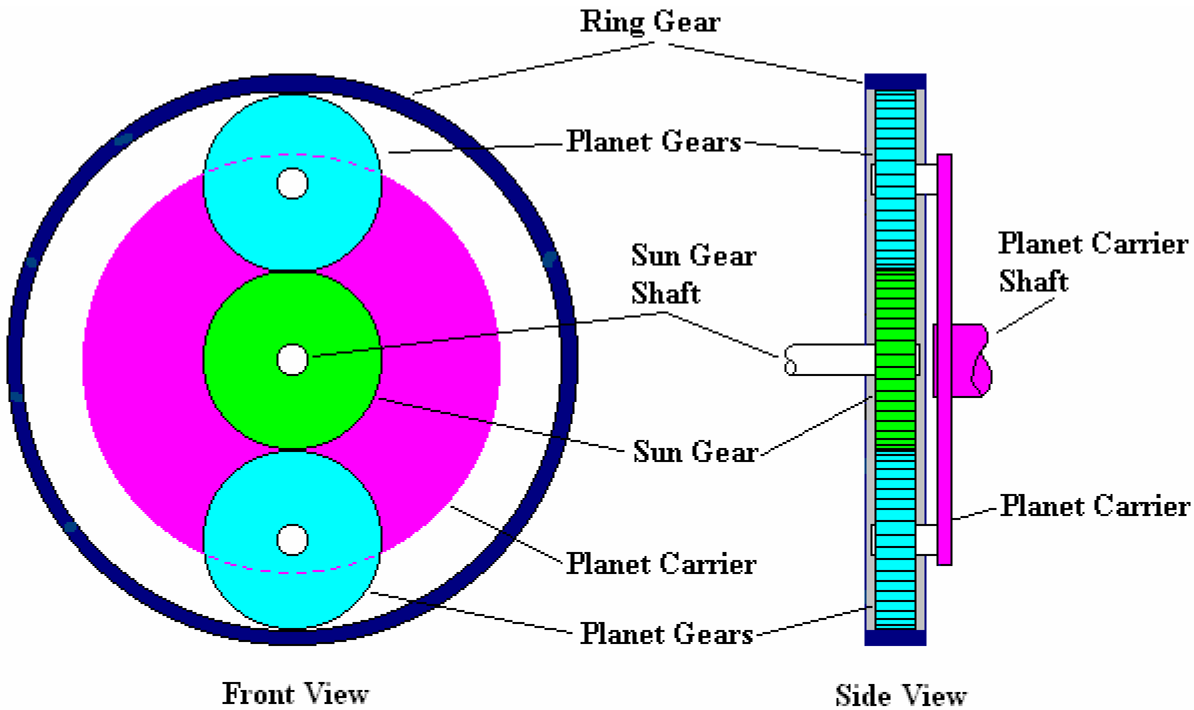


Figure 3

Figure 4 is a diagram of a torque amplification assembly. This is called an internal configuration because the transfer gears A and B are inside the ring gears. With the internal configuration the flywheels turn in opposite directions. These flywheels are dynamically connected, but not directly connected. This is achieved using the two planetary systems diagramed in Figures 3. Flywheel shaft A drives the sun gear A of planetary system A and the transfer gear for ring gear B. Flywheel shaft B drives the sun gear B of planetary system B and the transfer gear B for ring gear A. So, on one planetary system: the sun gear is driven by one flywheel and the ring gear by the other flywheel and the planet gears are driven by both. When the flywheels are equal, the planet gears sit and spin. When the flywheels are at a delta difference, the planet gears orbit the sun gear at a constant rate.

The ring gear in Figure 4 is three times the diameter of the planet gears. The delta difference of 1,800 RPMs means the planet gear rotates 1,800 RPMs inside the ring gear. Since the ring gear is three times bigger, the orbit of the planet gear is at a one third ratio or 600 RPMs. This orbit is the rotation of the planet carrier.

Figure 5 is color coded to show relative rotation direction. If the light and dark blues are clockwise, the light and dark green are counter-clockwise. The dark colors of the ring gear reflect a different speed.

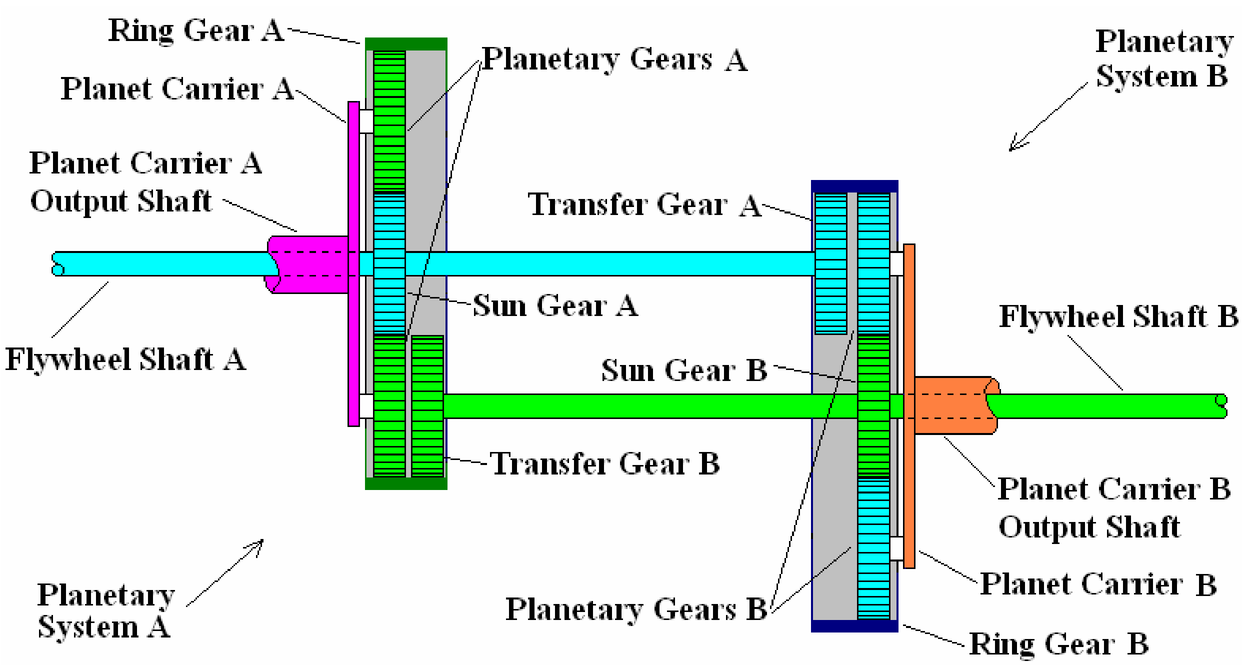


Figure 4

The actual speeds of the two flywheels do not effect the planet carrier rotation, the delta difference between them does. This delta can be kept constant while the flywheels increase or decrease in rotation by thousands of RPMs. This is the operational window of the torque amplifier.

Figure 5 is an extension of Figure 4 adding the motor/generators to the planet carrier shaft while the flywheel shaft passes through them. The color codes demonstrate the different directions of the motor/generators

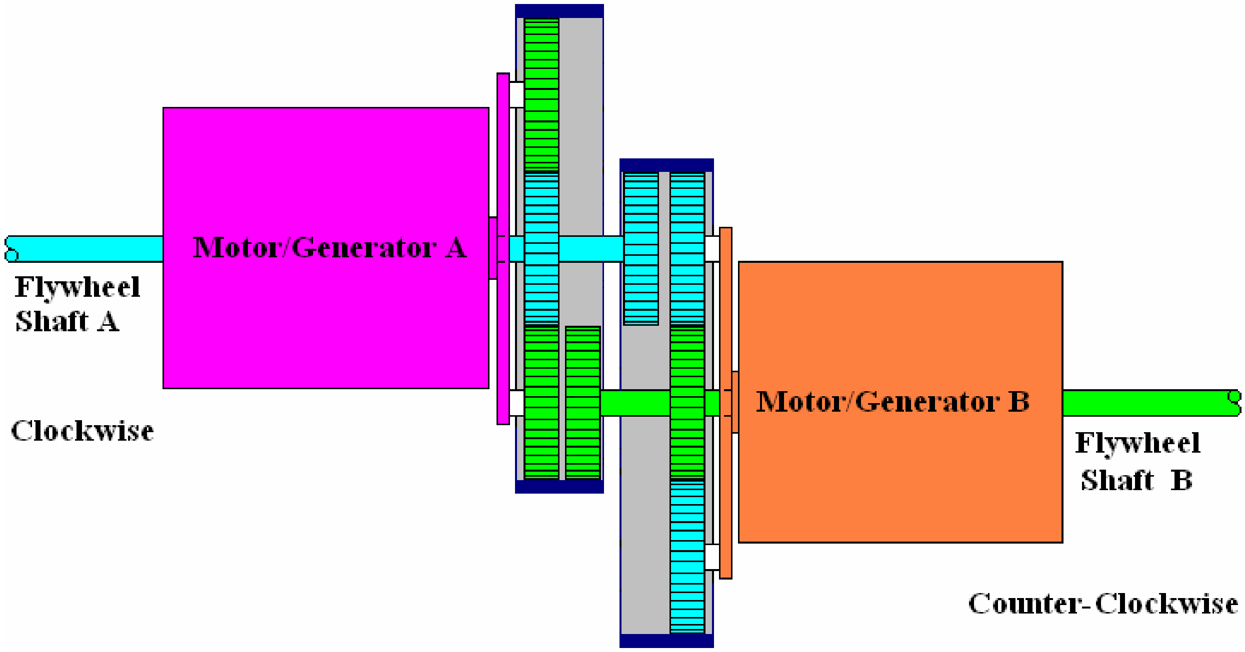


Figure 5

How Does It Work

The rotation of the planet gears is the same as the flywheels. The sun gear has been shown as the same size as a planet gear and it is on the flywheel shaft, so it drives planet gears the same speed. The ring gear is driven by the transfer gear which is also the same size as a planet gear. Because the transfer gear and the planet gears are connect by the same ring gear, the transfer and planet gear speeds are equal. The rotation of the transfer gear is the same as the flywheel. If both flywheels are equal speeds the planet gear would sit and spin in one location. When the speeds of the flywheels are different, then the transfer and sun gears are different. The planet gears absorb that difference by going into orbit around the sun gear. This orbit is transferred to the rotation of the planet carrier and carrier shaft to the motor/generator.

This is a closed system. Pushing this orbit, pushes the planet gears whose teeth push on the sun and ring gear teeth, which in turn pushes the rotation of the flywheels, thus adding to it. The reverse would be pulling on this orbit and it would the flywheels to slow down. These components create a single collective unit between the motor/generator and the flywheels.

The speeds of the flywheels can be increased or decreased, the delta difference does not. Whether pushing, pulling, or no load, the orbit stays the same. What does change is the torsional load. Since this is a closed system, when both generators induce a load, that torsion is pulled directly through that collective unit from both flywheels. When both motors push torsion out, it passes through the collective units to increase the speeds of both flywheels.

Control

The delta difference has to be kept constant. That requires monitoring for variations and remedying any detected. This is done electrically through the motor/generator. In Figure 4, planetary system A is referenced to flywheel shaft A. This is because motor/generator A drives the sun gear in planetary system A. Though both planetary systems are dynamically connected, there actual power distribution is more like 70% / 30%. From flywheel shaft A, 70% of the torsion goes through sun gear A and 30% goes through transfer gear B. The distribution will always be unequal due to more leverage, mass and moving parts on one path then the other. The benefit is more energy can be redirected to one planetary system than the other.

When the delta difference between the flywheels drifts 0.01% or smaller with flywheel A going slightly slower, then the power on motor A can be increased a small percentage while the power on motor B is reduced an equally small percent. The effect is to increase the amount of energy to flywheel A enough to bring the difference back in line. The same applies as generators. As the flywheels are discharging, if flywheel A has slowed down more then flywheel B, then more drag can to be shifted to flywheel B by increasing the load on generator B and decreasing it on generator A until the difference is back at delta.

The spread sheet in Figure 6 shows the calculations of the difference between two flywheels. The Flywheel A is at 14,000 RPMs clockwise and Flywheel B is 15,800 counter-clockwise. Their relative difference is 1,800 RPMs. Through the Torque Amplifier this difference produces an output of 600 RPMs clockwise from Planet carrier A and 600 RPMs counter-clockwise denoted as negative numbers on Planet Carrier B.

Kinetic Storage System: Flywheels at 14,000 and -15,800 RPMs

Flywheel A	# of	Surface Speed			**Flywheel B**	# of	Surface Speed		
Clockwise	Teeth	Teeth/Min.	RPMs		**Counter-Clockwise**	Teeth	Teeth/Min.	RPMs	
Flywheel A				**14000**	Flywheel B				**-15800**
Sun gear	24	336000	14000		Sun gear	24	-379200	-15800	
Planet gear - sun	24	-336000	-14000		Planet gear - sun	24	379200	15800	
Ring - Planet	72	-336000	**-4666.7**		Ring - Planet	72	379200	**5266.7**	
Transfer Gear	24	-379200	-15800		Transfer Gear	24	336000	14000	
Internal Ring gear	72	-379200	**-5266.7**		Internal Ring gear	72	336000	**4666.7**	
Planet Carrier A Output	72	43200		**600.0**	Planet Carrier B Output	72	-43200		**-600.0**

Figure 6

This relative delta in RPMs is the difference in absolute values. Changing the relative difference in the flywheels changes the outputs of the planet carriers as shown in Figure 7. These differences equate to output differences of the planet carriers. That in turn affects output AC frequency. The colors match the color groups of the components in Figure 4 and Figure 5.

	Flywheel A Input	Flywheel B Input	Relative Difference	Planet Carrier A Output	Planet Carrier B Output	Frequency
1	14,000	-15,800	1,800	600.0	-600.0	60.00
2	13,001	-14,800	1,799	599.7	-599.7	59.97
3	12,001	-13,801	1,800	600.0	-600.0	60.00
4	11,001	12,802	1,801	600.3	-600.3	60.03
5	10,002	11,802	1,800	600.0	-600.0	60.00

Figure 7

Figure 7 shows the flywheels decreasing in speed at slightly uneven rates. In line 2 the relative delta of 1,799 RPMs equated to an output of 599.7 RPMs. This has to be corrected with slightly more load on generator B and a corresponding less amount on generator A. The correction was made gradually so by line 3 the outputs were at 600 RPMs again. Line 4 has a drift on the flywheel B side increasing the planet carrier output to 600.3. More load is directed to generator B and less to A and the output returned to 600 in line 5.

For an AC system this drift causes a net change in frequency. It has nothing to do with the amount of torque the flywheels have. It has everything to do with the different speeds of the flywheels.

Note that these corrections were done gradually. In practice, corrections need to be made on even smaller discrepancies for frequency control in stand alone applications. If the Torque Amplifier is connected to a Utility line then frequency is maintained and power levels are affected.

The clockwise and counter-clockwise rotation of the shafts is relative. Their connection to the motor/generator will be clockwise for the same power input/output off the same line. It is the orientation of the motor/generators that produces the clockwise, counter-clockwise difference. One is backwards to the other.

Another important consideration is the difference of scale. This is the comparison of the instant capacity of the motor/generator and the net load of the flywheels. In order to make fine tune adjustments through the motor/generators, the flywheels have to be large enough to respond to small changes. If the motor/generator is too large then the changes in the flywheel differences will not be easily controlled.

The Utilities Line diagramed in Figure 8 does not allow variance in the 60 Hz frequency. There are many generators on a utility line that drive that frequency. If Prime Mover A starts to experience a drop in its speed, its load drops and the volt-amp power output drops, but the frequency is maintained. If prime mover B starts to experience an increase in revolutions, its load increases increasing its volt-amp power output, thus holding the speed down to match the frequency.

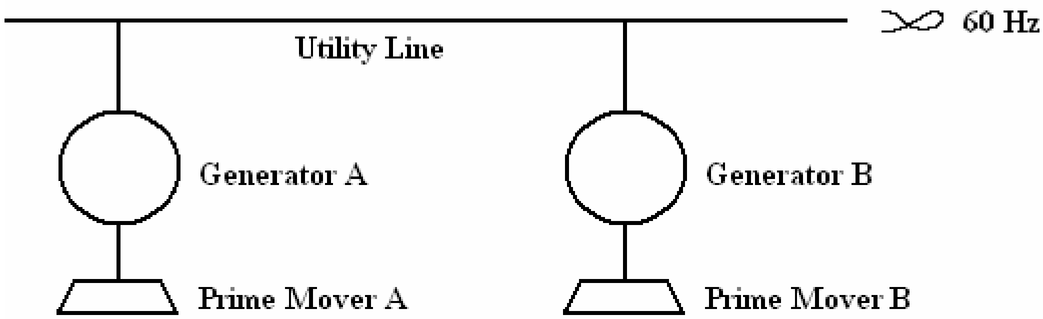


Figure 8

In normal generator operations the primer mover would have more fuel added, more steam let through, or more water let in to increase the torsion to adjust the power output volt-amps upwards. The Torque Amplifier is different. The output of the prime mover can not be adjusted. Also, normal variances in the flywheels do not correspond with their loads. The net amount of volt-amp power does not change.

When connected to a Utility, the frequency does not change, only the volt-amps. In order for the Torque Amplifier configuration to operate, the normal drift of the flywheels has to be corrected by changing the amount of amperage produced while maintaining the frequency and voltage. Currently, this is not how it is done. Controls for commercial generators do not vary their amperage, they vary their prime mover.

The torque amplifier will have to operate inside of the utility variances. When the frequency starts to increase, the utility line will increase the load. When the frequency starts to decrease the utility line will decrease the load. Because the two flywheels are the connected prime movers they should not have the load drop that the utility line would induce. It will affect both motor/generators equally, not just one side. That is why smaller variances need to be detected and remedied.

The External Configurations

The first torque amplifying assembly was called an internal configuration. It had the transfer gears A and B on the inside of the ring gear. The second torque amplifying assembly diagramed in Figured 8 has its transfer gears A and B are on the outside of the ring gears. This is called the external configuration.

In the external ring configuration both flywheels rotate in the same direction. This is denoted with the color green in the Figure 9. The motor/generators also both turn in the same direction as denoted with the lavender color. They are opposite the flywheels so if the flywheels are clockwise, the motor/generators will be counter-clockwise.

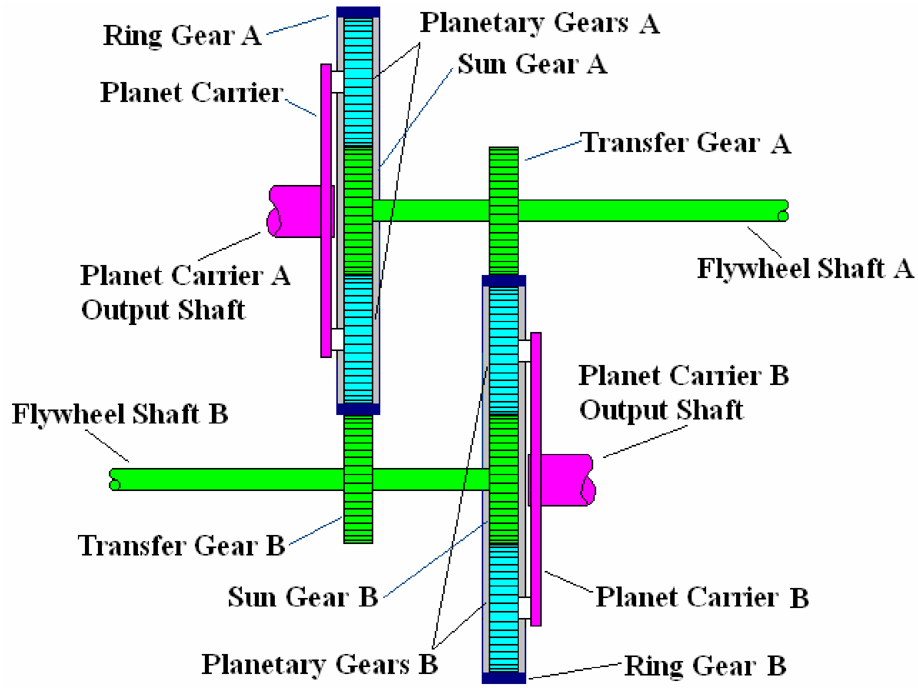
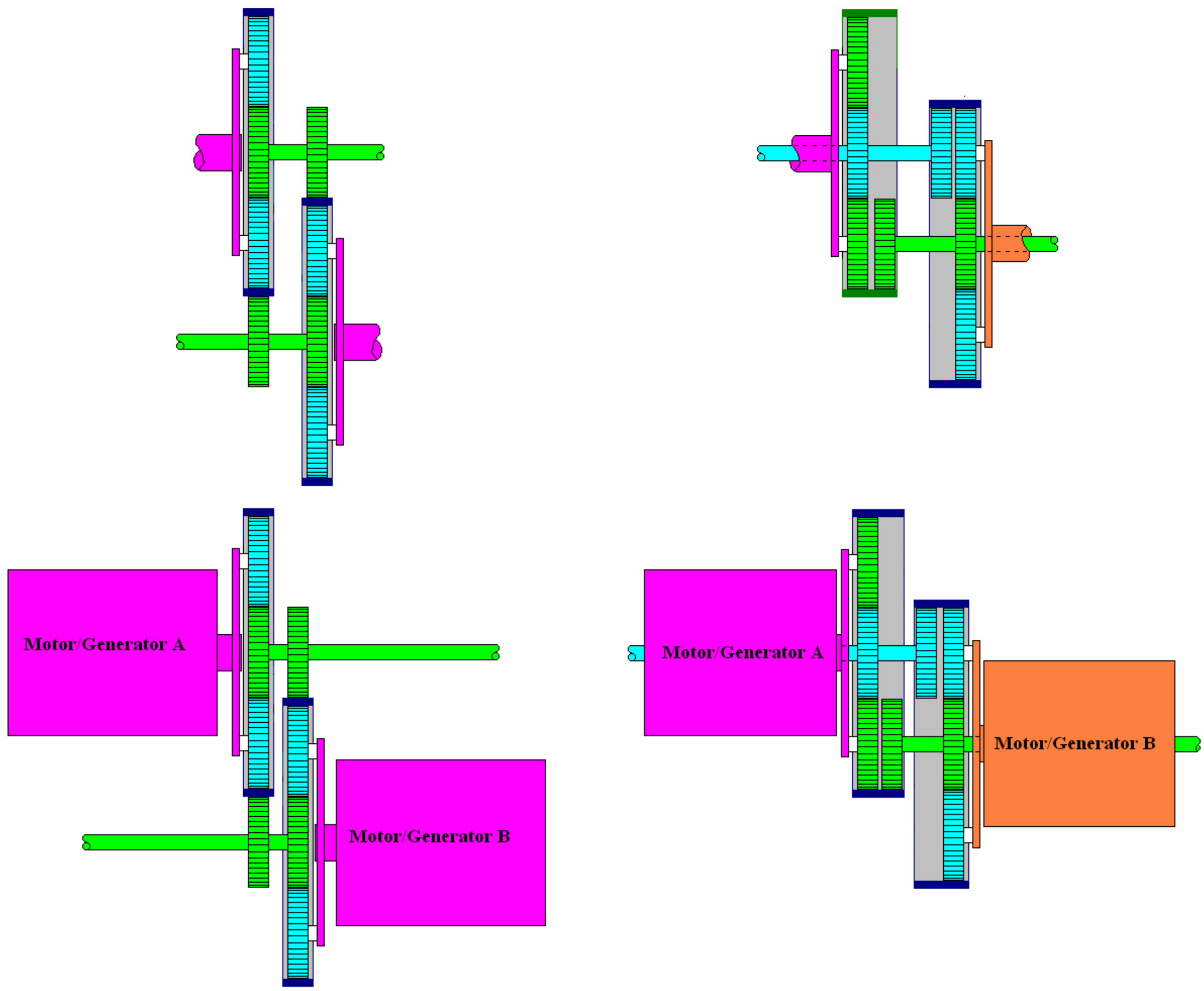


Figure 9

The flywheels still have a delta difference. The motor/generators still control the system by varying the source or load.

The internal configuration is believed to be more efficient then the external. First, internal teeth are more efficient then external teeth; they are going in the same direction and internal teeth have a longer tooth contact cycle. Second, the internal configuration has the flywheels in opposite directions and they push against each other. The motor/generators of the external configuration have to push and pull against their base.



External Configuration **Internal Configuration**

Figure 10

Figure 10 is a side by side comparison the external and internal configurations with the color codes showing their relative directions.

Connect to a Utility Line

Figure 11 is a suggested Delta Tandem Kinetic Battery configuration for connecting with a utility line. It is divided into electrical in red and mechanical in blue. The mechanical is completely standalone without any controls. It either has a constant mechanical input from the motors; a constant mechanical output to the generators; or is spinning in a no load state. In a standard grid system diagramed in figure 8 the adjustments to the primer mover maintain the constant power output. In the Delta Tandem, adjustments to the motor/generator control the constant delta difference that maintains the power output.

From the Utility lines are the breakers and electrical safety equipment that protects the incoming and the outgoing lines. The lines are split to the motor/generators. The control box has lines from the sensors on the flywheels that are used for detecting variances. The corrective action for these variances is to reduce the amperage of one motor/generator while increasing the other a small amount.

Between the motor/generators are the interconnected planetary systems. These convert the difference between the flywheels to a constant speed input/outputs.

At the bottom of the flywheels are the starter motors. This is a separate system to get the flywheels over the initial moment of inertia and up to an operational speed that can develop the constant difference delta for charging. The Kinetic Battery can be kept in constant operation, but it has to be started.

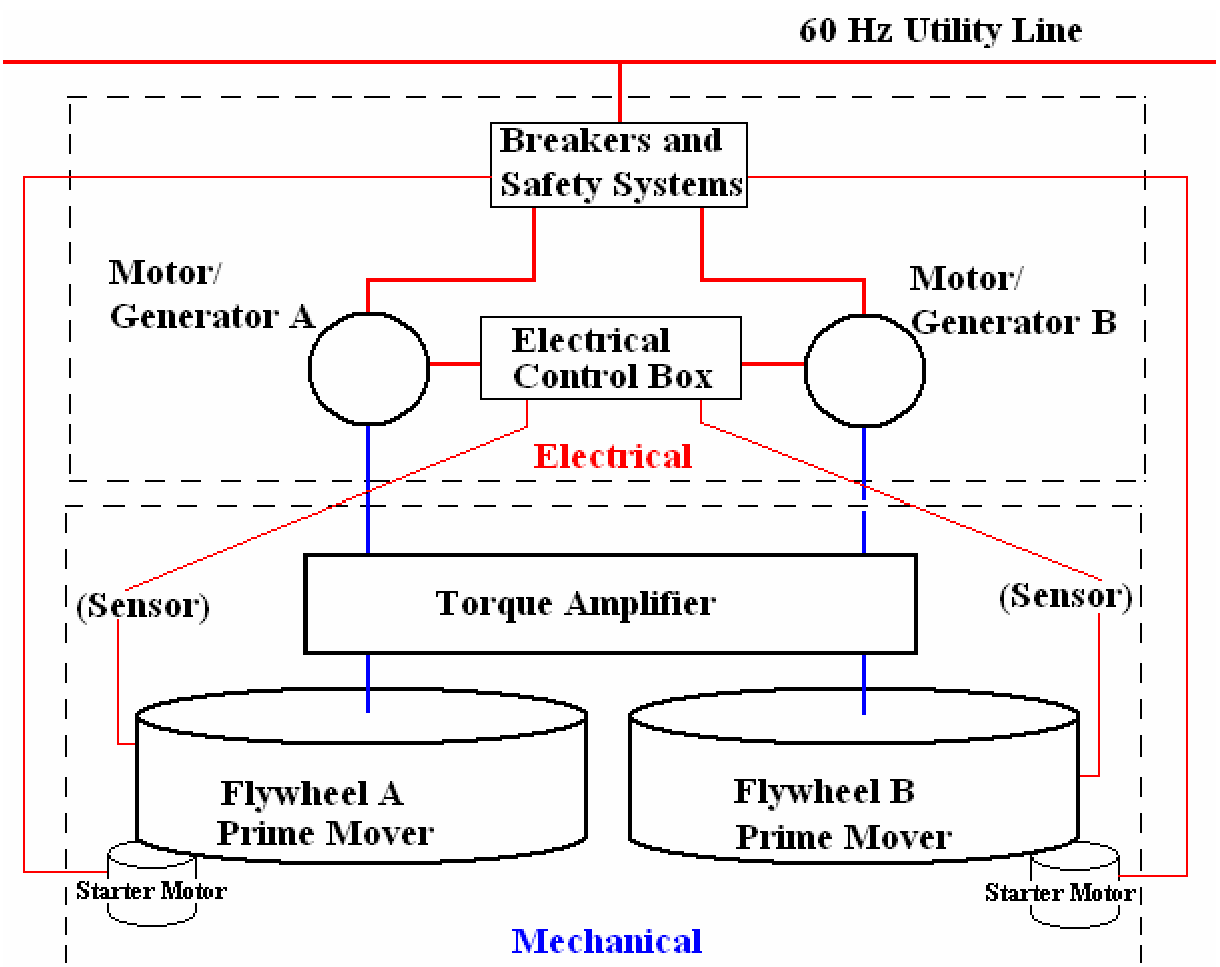


Figure 10

This is just one example of how the Delta Tandem Kinetic Battery assembly can be configured to be connected to a utility power supply. As a stand alone unit the controls can be simpler.

What differentiates the Delta Tandem Kinetic Battery from other flywheel storage system is the elimination of inverters. The electrical energy does not have to be converted from AC to DC to charge and DC to AC to discharge. That is two energy transfer states that are eliminated. This system is also simple. With the exception of unique power controls, the components are off-the-shelf parts: standard motor/generators, standard gear technology and wide range of flywheels on the current market.

The down side is the mechanical planetary systems: They will always induce drag and loss of efficiency. They have to be made from materials with the highest strength to weight ratios in order for them to have the least amount of mass.

The charge/discharge cycle is short term. Its operation will generate heat as a constant loss. Its value is when the cost of the power offsets the cost of it operational losses.

Markets:

The market with the largest impact would be peak shaving. The daily demand rate a company is charged for is their peak demand. The application of the Kinetic Battery is to provide an instant power supply when there is a sudden demand spike. An example may be from the initial start of a large motor that induces a high demand. This may include overcoming the inertia of the load that the motor is attached to. It can be any device or group of devices that causes a high short-term demand spike.

The Kinetic Battery can be used for load leveling: That is charging and discharging at different rates for optimal use. That covers a broad range. It could be taking in wind and solar power at intermittent rates and output at a constant rate. Or it could run a bank of elevators the have large, sudden demands, then flatten out. This would require charging at a constant rate and discharging at different rates. It could apply to any collections of machinery that includes high initial load demands.

This system can be used for power factor correction.

An Uninterruptible Power Supply or power conditioning configuration may include separate motors and generators.