

SYSTEM AND METHOD FOR SUPPRESSING A BACK ELECTROMOTIVE FORCE

Field of Invention

5 The present invention relates to a system and method for suppressing a back electromotive force. The system and method are particularly relevant, but not limited to suppress or reduce the back electromotive force generated by a rotational motor drive in a vehicle.

Background Art

10 The following discussion of the background to the invention is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general knowledge of the person skilled in the art in any jurisdiction as at the priority date of the invention.

15 During the last few decades, environmental impact of the petroleum-based transportation infrastructure, along with the fear of 'peak oil' occurrence, has led to interest in an electric transportation infrastructure. Electric vehicles differ from fossil fuel-powered vehicles in that the electricity they consume can be generated from a wide range of sources, including fossil fuels, nuclear power, and renewable sources such as tidal power, solar power, wind power or any combination of those.

20 Conventional electric vehicles include one or more electric motor drives as a power source. The motor drive includes at least one of engine, transmission, drive shaft, differential gear and drive wheel. The motor drive generates power and delivers it to land (e.g. road surface), water or air. Some electric vehicles use $n \times$ (n is greater than or equal to 1) split AC/DC motor drive(s) for propulsion. However, such AC/DC motor drive
25 may be inefficient due to presence of a counter-electromotive force known as back electromotive force or back EMF.

Such back EMF are typically induced due to current passing through one or more electric motor coils, and act against the applied voltage, leading to reduction of current

flowing through the one or more electric motor coils and therefore resulting in inefficiency.

In light of the above drawbacks, alternatives such as hydraulic motors which include power steering motor, hydraulic fluid motor or inverter hydraulic cooling motor are proposed. The hydraulic motors may circulate fluids driven by AC/DC which generate a magnetic field. However, the hydraulic motors may risk leaking fluid which would result in potential damage or an unclean working environment.

As such, there exists a need for controlling the force, i.e. back EMF, induced in the motor drive running on AC/DC alternating source and generating magnetic flux variation, in order to increase the efficiency of performance of the motor drive and extend output range of the electric vehicle without increasing battery's capacity.

Summary of the Invention

The present invention seeks to provide a back EMF suppression system and method that addresses the aforementioned need at least in part.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Furthermore, throughout the specification, unless the context requires otherwise, the word "include" or variations such as "includes" or "including", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

In accordance with an aspect of the present invention, there is a system for suppressing a back electromotive force (EMF) comprising: a motor drive operable to generate a rotational force and the back EMF which counteracts the rotational force; and a thruster device operable to compute variations in phase, time and/or frequency waveforms of the motor drive and the thruster device, and shift the phase, time and/or frequency waveform of the thruster device using the computed variations, wherein the thruster

device is operable to generate a voltage on the shifted phase, time and/or frequency waveform to suppress the back EMF.

Preferably, the thruster device is operable to shift the phase, time and/or frequency waveform of the thruster device to synchronize with the phase, time and/or frequency waveform of the motor drive.

Preferably, the thruster device is operable to generate a current on the shifted phase, time and/or frequency waveform flows in an opposing direction to the eddy current, thereby the eddy current is suppressed.

Preferably, the thruster device comprises: at least one inductor and at least one capacitor operable to generate the voltage; and a controller operable to vary inductance of the inductor and capacitance of the capacitor based on the shifted phase, time and/or frequency waveform.

Preferably, the thruster device further comprises a thruster sensor operable to detect the variations in the phase, time and/or frequency waveforms of the motor drive and the thruster device.

Preferably, the controller is operable to apply Einstein's Unified Field Theory using a differential voltage, a differential current, and shift of the phase, time and/or frequency waveform as five-dimensional elements, to suppress the back EMF.

Preferably, the controller comprises an algorithm firmware.

Preferably, the capacitor comprises a high voltage inductive dual capacitor.

Preferably, the system further comprising at least one supercapacitor operable to be used as a backup energy discharge on a vehicle, while the back EMF is suppressed by the voltage generated by the thruster device.

Preferably, the system further comprising an energy management controller operable to charge the supercapacitor to use as the backup energy discharge.

Preferably, the thruster device is operable to compute the variations based on a Genetic Algorithm.

In accordance with another aspect of the present invention, there is a method for suppressing a back electromotive force (EMF) comprising: generating, by a motor drive, a rotational force and the back EMF which counteracts the rotational force; computing, by a thruster device, variations in phase, time and/or frequency waveforms of the motor drive and the thruster device; shifting, by the thruster device, the phase, time and/or frequency waveform of the thruster device using the computed variations; and generating, by the thruster device, a voltage on the shifted phase, time and/or frequency waveform to suppress the back EMF.

Preferably, the thruster device is operable to shift the phase, time and/or frequency waveform of the thruster device to synchronize with the phase, time and/or frequency waveform of the motor drive.

Preferably, the thruster device is operable to generate a current on the shifted phase, time and/or frequency waveform flows in an opposing direction to the eddy current, thereby the eddy current is suppressed.

Preferably, the thruster device comprises: at least one inductor and at least one capacitor operable to generate the voltage; and a controller operable to vary inductance of the inductor and capacitance of the capacitor based on the shifted phase, time and/or frequency waveform.

Preferably, the thruster device further comprises a thruster sensor operable to detect the variations in the phase, time and/or frequency waveforms of the motor drive and the thruster device.

Preferably, the controller is operable to apply Einstein's Unified Field Theory using a differential voltage, a differential current, and shift of the phase, time and/or frequency waveform as five-dimensional elements, to suppress the back EMF.

Preferably, the controller comprises an algorithm firmware.

Preferably, the capacitor comprises a high voltage inductive dual capacitor.

Preferably, at least one supercapacitor is operable to be used as a backup energy discharge on a vehicle, while the back EMF is suppressed by the voltage generated by the thruster device.

5 Preferably, an energy management controller is operable to charge the supercapacitor to use as the backup energy discharge.

Preferably, the thruster device is operable to compute the variations based on a Genetic Algorithm.

10 In accordance with another aspect of the present invention, there is a supercapacitor charge system for a vehicle comprising: at least one supercapacitor; a stabilization and equalization controller operable to dampen a noise voltage; a charge balancing controller operable to suppress an overcharge of the at least one supercapacitor; and an energy management controller operable to control charge and discharge of the at least one supercapacitor for an energy distribution and operable to manage the energy distribution by interfacing with the stabilization and equalization controller and the
15 charge balancing controller, and wherein the energy management controller is operable to detect a charge amount and determine whether to charge or stop charging based on the charge amount.

Preferably, the at least one supercapacitor is diffused with graphene onto an active carbon film.

20 Preferably, diffusing of the graphene into an activated carbon anode is to lower a resistance of an electrical series resistors (ESR).

Preferably, the at least one supercapacitor is integrated with the charge balancing controller.

25 Preferably, the supercapacitor charge system further comprises a storage medium operable to store buffer energy.

Preferably, the storage medium includes a lithium iron phosphate medium.

Preferably, the stabilization and equalization controller is operable to dampen the noise voltage which comes from at least one of the following: an alternator, a generator, a magneto and an ignition system.

5 Preferably, the stabilization and equalization controller comprises a plurality of capacitors and a resistor.

Preferably, the charge balancing controller comprises, in series between each cell, a light emitting diode (LED) and a Zener diode.

Preferably, the LED lights up when the corresponding supercapacitor is fully charged up.

10 Preferably, the supercapacitor charge system further comprises a kinetic energy recovery system (KERS) connected as an external media and operable to capture a kinetic energy under braking.

Preferably, the energy management controller is operable to manage the energy distribution by interfacing with the KERS.

15 Preferably, the KERS is operable to convert the kinetic energy to an electrical energy and transfer the converted energy in at least one of the supercapacitor and the storage medium.

Preferably, the KERS is operable to power up the supercapacitor charge system so that the supercapacitor charge system can supply power to the vehicle.

20 Preferably, the supercapacitor charge system further comprises an external charger connected as an external media and including an induction coil motor.

Preferably, the external charger includes at least one of the following: an alternator, a generator and a charger.

Preferably, the alternator is operable to power up the supercapacitor charge system so that the supercapacitor charge system can supply power to the vehicle.

25 Preferably, the energy management controller is operable to control charge and discharge of the storage medium for the energy distribution.

Preferably, the energy management controller is operable to discharge the storage medium in order to charge the at least one supercapacitor.

5 Preferably, the energy management controller is operable to determine to charge one of the supercapacitor and the storage medium if the charge amount is below a predetermined amount.

Preferably, the energy management controller is operable to be synchronized with the stabilization and equalization controller.

10 Preferably, the energy management controller is operable to compute a Fourier transform line integration formulation at a pre-set interval to optimize the charge and discharge of the at least one supercapacitor and the storage medium.

Preferably, the energy management controller is operable to compute the Fourier transform line integration formulation at every 11ns.

15 Preferably, the energy management controller is operable to compute a numerical integration formulation to optimize the charge and discharge of the at least one supercapacitor and the storage medium.

Preferably, the energy management controller comprises a plurality of capacitors, a plurality of registers, a diode, an inductor and an algorithm firmware modem.

Preferably, the algorithm firmware modem is a programmable chip and is operable to support electronic components.

20 Preferably, the algorithm firmware modem is operable to trigger different charge and discharge output quantum level in a real dynamic mode in order to manage the energy distribution.

25 Preferably, if the vehicle is a car, the storage medium provides a first initial charge to the supercapacitor, and the alternator provides power to the supercapacitor to run the car.

Preferably, if the vehicle is a forklift, the charger charges the storage medium, and the storage medium provides power to the supercapacitor to run the forklift.

In accordance with another aspect of the present invention, there is a supercapacitor charge method of a supercapacitor charge system for a vehicle comprising: dampening a noise voltage at a stabilization and equalization controller; suppressing, at a charge balancing controller, an overcharge of at least one supercapacitor; controlling, at an energy management controller, charge and discharge of the at least one supercapacitor for an energy distribution; and managing, at the energy management controller, the energy distribution by interfacing with the stabilization and equalization controller and the charge balancing controller, and wherein the energy management controller is operable to detect a charge amount and determine whether to charge or stop charging based on the charge amount.

Preferably, the at least one supercapacitor is diffused with graphene onto an active carbon film.

Preferably, diffusing of the graphene into an activated carbon anode is to lower a resistance of an electrical series resistors (ESR).

Preferably, the at least one supercapacitor is integrated with the charge balancing controller.

Preferably, the supercapacitor charge system further comprises a storage medium operable to store buffer energy.

Preferably, the storage medium includes a lithium iron phosphate medium.

Preferably, the stabilization and equalization controller is operable to dampen the noise voltage which comes from at least one of the following: an alternator, a generator, a magneto and an ignition system.

Preferably, the stabilization and equalization controller comprises a plurality of capacitors and a resistor.

Preferably, the charge balancing controller comprises, in series between each cell, a light emitting diode (LED) and a Zener diode.

Preferably, the LED lights up when the corresponding supercapacitor is fully charged up.

Preferably, the supercapacitor charge method further comprises a kinetic energy recovery system (KERS) connected as an external media and operable to capture a kinetic energy under braking.

5 Preferably, the energy management controller is operable to manage the energy distribution by interfacing with the KERS.

Preferably, the KERS is operable to convert the kinetic energy to an electrical energy and transfer the converted energy in at least one of the supercapacitor and the storage medium.

10 Preferably, the KERS is operable to power up the supercapacitor charge system so that the supercapacitor charge system can supply power to the vehicle.

Preferably, the supercapacitor charge method further comprises an external charger connected as an external media and including an induction coil motor.

Preferably, the external charger includes at least one of the following: an alternator, a generator and a charger.

15 Preferably, the alternator is operable to power up the supercapacitor charge system so that the supercapacitor charge system can supply power to the vehicle.

Preferably, the energy management controller is operable to control charge and discharge of the storage medium for the energy distribution.

20 Preferably, the energy management controller is operable to discharge the storage medium in order to charge the at least one supercapacitor.

Preferably, the energy management controller is operable to determine to charge one of the supercapacitor and the storage medium if the charge amount is below a predetermined amount.

25 Preferably, the energy management controller is operable to be synchronized with the stabilization and equalization controller.

Preferably, the energy management controller is operable to compute a Fourier transform line integration formulation at a pre-set interval to optimize the charge and discharge of the at least one supercapacitor and the storage medium.

5 Preferably, the energy management controller is operable to compute the Fourier transform line integration formulation at every 11ns.

Preferably, the energy management controller is operable to compute a numerical integration formulation to optimize the charge and discharge of the at least one supercapacitor and the storage medium.

10 Preferably, the energy management controller comprises a plurality of capacitors, a plurality of registers, a diode, an inductor and an algorithm firmware modem.

Preferably, the algorithm firmware modem is a programmable chip and is operable to support electronic components.

15 Preferably, the algorithm firmware modem is operable to trigger different charge and discharge output quantum level in a real dynamic mode in order to manage the energy distribution.

Preferably, if the vehicle is a car, the storage medium provides a first initial charge to the supercapacitor, and the alternator provides power to the supercapacitor to run the car.

20 Preferably, if the vehicle is a forklift, the charger charges the storage medium, and the storage medium provides power to the supercapacitor to run the forklift.

Other aspects of the invention will become apparent to those of ordinary skill in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures or by combining the various aspects of invention as described above.

25 **Brief Description of the Drawings**

The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 illustrates perspective views of a thruster device for suppressing back EMF in an electric vehicle in accordance with an embodiment of the invention.

Fig. 2 illustrates a schematic diagram showing the thruster device in accordance with an embodiment of the invention.

5 Fig. 3 illustrates a graph showing voltage-current relationship of a circuit consisting an inductor.

Fig. 4 illustrates a graph showing voltage-current relationship of a circuit consisting a capacitor.

Fig. 5 is a block diagram and a graph illustrating the delay effect of a system.

10 Fig. 6 illustrates an example of principle of operation based on the Lorentz force.

Fig. 7 illustrates a block diagram of a system for controlling force in accordance with an embodiment of the invention.

Fig. 8 illustrates a thruster device quantum cell in accordance with an embodiment of the invention.

15 Fig. 9 illustrates a block diagram of a supercapacitor charge system in accordance with another embodiment of the invention.

Fig. 10 illustrates a flow diagram of a supercapacitor charge method in accordance with another embodiment of the invention.

20 Fig. 11 illustrates a schematic diagram of a supercapacitor charge system in accordance with another embodiment of the invention.

Fig. 12 illustrates a table showing values of circuitry component illustrated in Fig. 11 in accordance with another embodiment of the invention.

Fig. 13 illustrates an example of a supercapacitor charge system in accordance with another embodiment of the invention.

25 Fig. 14 illustrates a modular layout of a supercapacitor charge system in accordance with another embodiment of the invention.

Figs. 15 and 16 illustrate examples of a practical application of a supercapacitor charge system in accordance with another embodiment of the invention.

Fig. 17 illustrates a table showing advantages of a supercapacitor charge system in accordance with another embodiment of the invention compared with conventional
5 batteries.

Figs. 18 to 21 illustrate line graphs showing torque and power output from the supercapacitor charge system and method compared with a conventional battery.

Fig. 22 illustrates line graphs showing air fuel ratio and power output from the supercapacitor charge system and method compared with a conventional battery.

10 **Description of Embodiments of the Invention**

An electric vehicle may include, but not be limited to, at least one of the following vehicle: road vehicle, rail vehicle, vessel, electric aircraft and electric spacecraft. The electric vehicle includes an electric motor drive as an element of a powertrain to generate power and deliver it to the road surface, water or air.

15 Fig. 1 illustrates perspective views of a thruster device for suppressing back EMF in an electric vehicle in accordance with an embodiment of the invention. Fig. 2 illustrates a schematic diagram showing the thruster device in accordance with an embodiment of the invention.

Referring to Figs. 1 and 2, the thruster device 130 (also referred to as “kinetic induction
20 thruster”) comprises a hardware circuitry including at least one inductor 131, at least one capacitor 132 (also referred to as “condenser”), a controller 133, and other circuit elements such as a resistor. In some embodiments, the thruster device 130 may be implemented in the form of an integrated circuit chip and/or in other forms of electrical circuits.

25 The inductor 131 may be a wire wound inductor. In some embodiments, the inductor 131 includes a magnetic induction ferrite core to induce voltage and current amplitude to be high enough for the capacitor 132. For example, the capacitor 132 may be a high voltage inductive dual capacitor. The high voltage may include, but not be limited to

400-500 volts. In some embodiments, the hardware circuitry includes one dual capacitor. Alternatively, the hardware circuitry includes two single capacitors 132 as shown in Fig. 1 and 2.

The controller 133, for example a microprocessor controller, may include an algorithm firmware 134 implemented in a memory block/unit on the microprocessor controller. The algorithm firmware 134 of the controller 133 is operable, when executed, to compute a variation in phase, time and/or frequency waveform of the thruster device 130. The algorithm firmware 134 is further operable to compute a variation in phase, time and/or frequency waveform of the motor drive 110. The variations may be dynamic, as the computation is conducted every 2-3 nanoseconds (nsec) and varies in duration since the computation is real time based on the differential computation. Thereafter, the algorithm firmware 134 is operable to shift the phase, time and/or frequency waveform of the thruster device 130 using the computed variations, to synchronize with the phase, time and/or frequency waveform of the motor drive 110.

In some embodiments, the algorithm firmware 134 computes the dynamic variations in real-time as a motor shaft or a rotor slice through a magnetic coupling field of the motor drive 110. In some embodiments, the variations in the phase, time and/or frequency waveforms may be computed every 2-3 nanoseconds (nsec) for synchronization before discharge, in order to suppress the opposing back EMF in the motor drive 110. The motor drive's 110 rotational momentum is optimized as the algorithm firmware 134 continuously suppresses the back EMF and eddy current to enhance the rotation newton force of the motor drive 110.

Fig. 3 illustrates a graph showing voltage-current relationship of a circuit consisting an inductor and Fig. 4 illustrates a graph showing voltage-current relationship of a circuit consisting a capacitor.

The inductor 131 and capacitor 132 included in the hardware circuitry may act as reactive components, in which voltage and current are out of phase with each other. As shown in Fig. 3, in the inductor 131, the voltage leads the current by 90° ($\Phi = 90^\circ$). As shown in Fig. 4, in the capacitor 132, the voltage lags the current by 90° ($\Phi = -90^\circ$). A

circuit containing inductors and/or capacitors is referred to as a reactive circuit, which is classified into inductive circuit ($X_L > X_C$) or capacitive circuit ($X_C > X_L$).

Genetic Algorithm (GA) Formulation utilized in this embodiment of the invention

5 An algorithm formulation for computation of the variations in the phase, time and/or frequency waveforms is based on an optimization algorithm, such as a heuristic optimization algorithm. In some embodiments, genetic algorithm is deployed as described below (in equations (9) to (23)). The algorithm firmware 134 of the controller 133 may sense the feedback frequency from the motor drive 110, operate or execute a set of mathematical formula/equations, and vary the inductance of the inductor 131 and
10 capacitance of the capacitor 132 contained in the hardware circuitry with the resultant of the shift of the phase, time and/or frequency waveform. The algorithm formulation may be computed/executed and refreshed every 3-4 nanoseconds (nsec) to generate the high opposition discharge voltage. The discharge voltage is generated in a dynamic real time mode. The generated discharge voltage is used to suppress the back EMF.

15 One step in applying the genetic algorithm is to determine or select the objective function performance indices of phase and time delay that are used to evaluate fitness of each chromosome.

The performance indices used in this computation include at least one of Mean of the Squared Error ("MSE"), Integral of Time multiplied by Absolute Error ("ITAE"), Integral of
20 Absolute phase magnitude of the Error ("IAE"), and Integral of the Squared Error ("ISE"). Further, the Integral of Time multiplied by the Squared Error ("ITSE") may be used to minimize the error signal $E(s)$ and compare them to find the most suitable one. $E(s)$ is an error signal in phase domain.

In some embodiments, the performance indices of MSE, ITAE, IAE and ISE are
25 calculated based on the following mathematical expression in equations (1) to (4):

$$MSE = \frac{1}{t} \int_0^{\tau} (e(t))^2 dt \quad (1)$$

$$ITAE = \int_0^{\tau} t|e(t)|dt \quad (2)$$

$$IAE = \int_0^{\tau} |e(t)|dt \quad (3)$$

$$ISE = \int_0^{\tau} e(t)^2 dt \quad (4)$$

where $e(t)$ is the error signal in time domain.

- 5 In some embodiments, ITSE is calculated based on the following mathematical expression in equation (5):

$$ITSE = \int_0^{\tau} te(t)^2 dt \quad (5)$$

where $e(t)$ is the error signal in time domain.

- 10 The fitness of the chromosomes is calculated based on the following mathematical expression in equation (6):

$$fitness\ value = \frac{1}{performance\ index} \quad (6)$$

The performance indices of phase and time can be defined in the genetic MSE integral equation which can compute the fitness value. The time delay formulation may equate to the time delay effect 'T' and the phase formulation may equate to the phase shift ' δ_0 '.

- 15 It is appreciable that in some embodiments, the fitness value may include a weighted sum or weighted average of the aforementioned performance indices. In these embodiments, the genetic algorithm seeks to achieve a compromise between the various performance indices in accordance with assigned 'weights' where possible.

Fig. 5 is a block diagram and a graph illustrating the delay effect of a system. This may be a time delay or time shift.

Time delay or time shift in motor control system may be referred to time-interval between events that start in one point with its output in another point within the system.

- 5 Time delay is also recognized as transport lag, dead time and time lag. Since delay reduces stability of minimum phase systems, stability of the system may be analysed with time delay. Fig. 5 shows the delay effect in the system which causes time shift at the system's output.

10 The relationship between $f(t)$ and $f(t-T)$ is calculated based on the following mathematical expression in equation (7):

$$\ell[f(t-T)u(t-T)] = \int_0^{\infty} f(t-T)u(t-T)e^{-st} dt \quad (7)$$

where t is the initiated time for the motor, T is the designated delay time lag and $u(t)$ is unit step. The integral $\int$ is the correlation formulation for differential in time delay interval.

Let $\tau = t - T$,

$$\int_0^{\infty} f(t-T)u(t-T)e^{-st} dt = \int_{-T}^{\infty} f(\tau)u(\tau)e^{-s(\tau+T)} d\tau$$

assume $f(t) = 0$ for $t < 0$,

$$\begin{aligned} \int_{-T}^{\infty} f(\tau)u(\tau)e^{-s(\tau+T)} d\tau &= \int_0^{\infty} f(\tau)u(\tau)e^{-s(\tau+T)} d\tau \\ &= \int_0^{\infty} f(\tau)e^{-s\tau}e^{-Ts} d\tau \\ &= e^{-Ts} \int_0^{\infty} f(\tau)e^{-s\tau} d\tau \\ &= e^{-Ts} F(s) \end{aligned}$$

In order to perform a tuning process using the genetic algorithm, the delay with Direct Frequency Response ("DFR") series may be approximated. The tuning process

minimises the error signal $e(t)$ using a second order DFR series. The DFR series is selected for use as it has been shown that this series has the smallest average error among the others series. In addition, within the DFR series itself the first order DFR has a wider error margin and the second order DFR reduces the error margin sufficiently. It may be appreciated that the third or subsequent order DFR can also be used.

For simulation purpose, the second order DFR series may be used to circumvent unnecessary complexity, because as the order of the series increases, not only does the computational requirements increase leading to increased time in calculations, but the overall system stability may be compromised as new poles and zeros associated with higher order series may have error(s) and destabilize the system.

The DFR series is calculated based on the following mathematical expression in equation (8):

$$\text{DFR series : } e^{-s\tau} \approx \frac{1 - 0.49s\tau + 0.0954s^2\tau^2}{1 + 0.49s\tau + 0.0954s^2\tau^2} \quad (8)$$

Where $e^{-s\tau}$ is an error signal, S is $\vec{S} = (\sin \delta_0, \dots, \sin \delta_{m-1})^T$ and T is a time delay shift. The frequency is dependent on the time delay and the phase interference is defined as δ_0 .

Genetic Algorithm of Phase Reconstruction in Phase-shifting Interference Patterns

A genetic reconstruction algorithm may be proposed, which is obtained by using a phase-shifting technique with an arbitrary number of phase shifts between intensity measurements of the rotational DC motor drive. The genetic algorithm entirely describes the structure of known phase-shifting algorithms and permits the construction of new ones with an arbitrary number of phase shifts.

Phase-shifting interference pattern methodology has been used in interference systems in recent years. Widespread use of the methodology has resulted from the simplicity of specifying the values of phase shifts, the low complexity of the algorithms, and the high

precision that they may achieve. At the same time, the layouts of interference pattern may be easily modified.

A large number of expressions for phase reconstruction with an arbitrary number of phase shifts are known. The earliest algorithms used decoding equations with three or four shifts. With an increased amount of available computational power, it became possible to use algorithms with a larger number of shifts. Thus an algorithm using 15 phase shifts was introduced, and an algorithm using 101 phase shifts was implemented.

The equations used for the phase reconstruction are derived by solving trigonometric equations. An analysis of formulas for phase reconstruction with an arbitrary number of the phase shifts is given, but the number of shifts should be constant. The genetic algorithm allows the structure of known algorithms to be determined and the construction of new algorithms with an unlimited number of arbitrary, and not always constant, phase shifts.

The phase-shifting interference pattern methodology is based on the capture of several interference patterns while the phase of the reference wave continues to follow the specified values. At different phase shifts, the intensity of the interference patterns with phase shift δ_i may be represented based on the following mathematical expression in equation (9):

$$I_i(x, y) = A(x, y) + B(x, y) \cos(\phi(x, y) + \delta_i) \quad (9)$$

where $A(x, y)$ and $B(x, y)$ are the average signal amplitude of the interference pattern and the amplitude of the interference pattern in the point (x, y) respectively, $i = 0, 1, 2, \dots, m - 1$, m is the number of phase shifts, and $\delta_0 = 0$. I is the intensity of the interferogram (electromagnetic wave).

The algorithms obtained at m different values are referred to as m -point algorithms. There are algorithms that work for different numbers of phase shifts. Many of the possible implementations arose from an interest in determining a genetic scheme for the algorithms. A genetic scheme allows evaluation of the pros and cons of a specific variant and determining the methodology of the algorithm construction.

The equation (9) may be represented in vector form as the following mathematical expression in equation (10):

$$\vec{I} = \vec{A} + (B \cos \phi) \vec{C} - (B \sin \phi) \vec{S} \quad (10)$$

where $\vec{I}$ is the set of intensities for different phase shifts δ_i at each point of the interference patterns $I_i(x, y)$, $\vec{A} = A \cdot (1, \dots, 1)^T$ is an m -dimensional vector, $\vec{C} = (\cos \delta_0, \dots, \cos \delta_{m-1})^T$, $\vec{S} = (\sin \delta_0, \dots, \sin \delta_{m-1})^T$, ϕ is a phase angle, and the size of the vector is determined by the number of phase shifts.

The equation (10) may be written as the following mathematical expression in equations (11) and (12):

$$\vec{I} \cdot \vec{C}^\perp = \vec{A} \cdot \vec{C}^\perp + (B \cdot \cos \phi) \vec{C} \cdot \vec{C}^\perp - (B \cdot \sin \phi) \vec{S} \cdot \vec{C}^\perp \quad (11)$$

$$\vec{I} \cdot \vec{S}^\perp = \vec{A} \cdot \vec{S}^\perp + (B \cdot \cos \phi) \vec{C} \cdot \vec{S}^\perp - (B \cdot \sin \phi) \vec{S} \cdot \vec{S}^\perp. \quad (12)$$

To extract the quadrature components $\sin \phi$ and $\cos \phi$, a property of the dot product for orthogonal vectors ($a \cdot a^\perp = 0$) may be used. Let $\vec{C}^\perp$ be the result of the cross product $\vec{A}$ and $\vec{C}$, $\vec{C}^\perp = \vec{C} \times \vec{A}$, and $\vec{S}^\perp$ be the result of the cross product $\vec{A}$ and $\vec{S}$, $\vec{S}^\perp = \vec{S} \times \vec{A}$. Taking into account that $\vec{S}^\perp$ is orthogonal to $\vec{A}$ and $\vec{S}$, and the mentioned property of the dot product, the following mathematical expression in equations (13) and (14) are obtained:

$$\vec{I} \cdot \vec{C}^\perp = - (B \cdot \sin \phi) \vec{S} \cdot \vec{C}^\perp \quad (13)$$

$$\vec{I} \cdot \vec{S}^\perp = (B \cdot \cos \phi) \vec{C} \cdot \vec{S}^\perp; \quad (14)$$

Considering the properties of the dot product and the cross-product $c(b \times a) = -b(c \times a)$ in the case of the noncyclic permutation of the vectors, the following mathematical expression in equation (15) is obtained:

$$(\vec{S} \cdot \vec{C}^\perp) = \vec{S}(\vec{C} \times \vec{A}) = -\vec{C}(\vec{S} \times \vec{A}) = -(\vec{C} \cdot \vec{S}^\perp). \quad (15)$$

Then, a reconstruction formula may be represented in the vector form as the following mathematical expression in equation (16):

$$\frac{\sin \phi}{\cos \phi} = \frac{\vec{I}^\perp \cdot \vec{C}}{\vec{I}^\perp \cdot \vec{S}}, \quad \phi = \arctan \left(\frac{\vec{I}^\perp \cdot \vec{C}}{\vec{I}^\perp \cdot \vec{S}} \right), \quad (16)$$

- 5 Because in this case only the vector $\vec{I}^\perp$ is calculated. For the case of three shifts as the following mathematical expression in equation (17):

$$\vec{I}^\perp = \vec{I} \times \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} = M \cdot \vec{I} = \begin{bmatrix} 0 & 1 & -1 \\ -1 & 0 & 1 \\ 1 & -1 & 0 \end{bmatrix} \cdot \vec{I} = \begin{bmatrix} I_2 - I_3 \\ I_3 - I_1 \\ I_1 - I_2 \end{bmatrix}, \quad (17)$$

where M is a matrix, which calculates the cross-product of the vectors. Then, the following mathematical expression in equation (18) is obtained:

$$10 \quad \phi = \arctan \frac{(I_2 - I_3) \cos \delta_1 + (I_3 - I_1) \cos \delta_2 + (I_1 - I_2) \cos \delta_3}{(I_3 - I_2) \sin \delta_1 + (I_1 - I_3) \sin \delta_2 + (I_2 - I_1) \sin \delta_3} \quad (18)$$

If $\delta_1 = \pi/4$, $\delta_2 = 3\pi/4$, and $\delta_3 = 5\pi/4$, the following mathematical expression in equation (19) is obtained:

$$\phi = \arctan \frac{I_3 - I_2}{I_1 - I_2}. \quad (19)$$

- 15 The m-dimensional matrix M ($m \geq 3$) may be presented as the following mathematical expression in equation (20):

$$M = \begin{bmatrix} 0 & 1 & 0 & \cdots & 0 & -1 \\ -1 & 0 & 1 & \cdots & 0 & 0 \\ 0 & -1 & 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & 0 & 1 \\ 1 & 0 & 0 & \cdots & -1 & 0 \end{bmatrix}_{m \times m} . \quad (20)$$

and for the case of four shifts as the following mathematical expression in equation (21):

$$\vec{I}^\perp = \begin{bmatrix} 0 & 1 & 0 & -1 \\ -1 & 0 & 1 & 0 \\ 0 & -1 & 0 & 1 \\ 1 & 0 & -1 & 0 \end{bmatrix} \cdot \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} I_2 - I_4 \\ -I_1 + I_3 \\ -I_2 + I_4 \\ I_1 - I_3 \end{bmatrix} . \quad (21)$$

If $\delta_1 = 0$, $\delta_2 = \pi/2$, $\delta_3 = \pi$, and $\delta_4 = 3\pi/2$, the following mathematical expression in equations (22) and (23) are obtained:

$$\phi = \arctan \frac{I_4 - I_2}{I_1 - I_3} . \quad (22)$$

$$\phi = \arctan \frac{\sum_{i=0}^{m-1} [(I_{\text{mod}(i+1,m)} - I_{\text{mod}(m+i-1,m)}) \cdot (\delta_i)]}{\sum_{i=0}^{m-1} [(I_{\text{mod}(i+1,m)} - I_{\text{mod}(m+i-1,m)}) \cdot \sin(\delta_i)]} , \quad (23)$$

where $\text{mod}(i, m)$ is the remainder when i is divided by m .

The phase angle ϕ correlates to the phase shift δ_1 , and the above equations (10) to (23) correlates to $\vec{C} = (\cos \delta_0, \dots, \cos \delta_{m-1})^T$ and $\vec{S} = (\sin \delta_0, \dots, \sin \delta_{m-1})^T$ where T is the time delay.

Fig. 6 illustrates an example of principle of operation based on the Lorentz force.

Electrical machines such as motors and generators are based on the Lorentz force and the principle of operation is shown in Fig. 6 in which a single turn coil carrying electrical current rotates in a magnetic field between the two poles of a magnet.

For multiple turn coils, the effective current is NI (Ampere Turns) where N is the number of turns in the coil.

If the coil is supplied with a current the machine acts as a motor. If the coil is rotated mechanically, current is induced in the coil and the machine thus acts as a generator.

- 5 It may be appreciated that from the phase angle ϕ , classified information on direct motor torque power control formulation is used. The formulation may be written as the following mathematical expression in equations (24):

$$P = V(t)V(T)[\phi(t) - \phi(T)]/X \quad (24)$$

10 where P is motor torque power coefficient, $V(t)$ is voltage potential magnitude at initial point, $V(T)$ is voltage potential magnitude at designated time delay, $\phi(t)$ is phase angle at initial point, $\phi(T)$ is phase angle at designated time delay, and X is motor magnetizing impedance or reactance.

15 It may be appreciated that a numerical software model, for example MATLAB or Simulink, may be used to compute the voltage potential magnitude of the synchronous motor and the back EMF induced.

Fig. 7 illustrates a block diagram of a system 100 for suppressing back EMF in an electric vehicle in accordance with an example of the invention.

20 The system 100 comprises a motor drive 110 and a thruster device 130. The system 100 may further comprise an energy management controller 120, a stabilization and equalization controller 140 and at least one supercapacitor 150.

25 The motor drive 110 may include, but not be limited to an electric motor drive. The motor drive 110 may comprise at least one of direct current ("DC") motor drive and alternating current ("AC") motor drive. In some embodiments, the motor drive 110 may comprise a combination of AC and DC motor drive arrangement, such as, but not limited to, split AC/DC motor drives configuration. The motor drive 110 may convert electrical energy into mechanical energy. The motor drive 110 may operate through an interaction between the motor drive's magnetic field and winding currents to generate rotary force or torque.

The motor drive 110 may have coils of wire turning inside a magnetic field, and the coil turning inside the magnetic field induces the back EMF during rotation of the motor drive 110. The back EMF is a voltage that opposes the change in current which induced it. The back EMF may decrease an efficiency of the motor drive 110 since the back EMF acts against the applied voltage that causes the motor drive 110 to spin or rotate.

In addition, eddy current may be induced in the magnetic field. The eddy current is a loop of electrical current induced within a conductor by a changing magnetic field in the conductor due to Faraday's Law of induction. The eddy current generates resistive losses that transform some forms of energy, such as kinetic energy, into heat. In this regard, the eddy current may decrease the efficiency of the motor drive 110.

The energy management controller 120 may comprise an algorithm firmware 121, for example kinematics algorithm firmware. The energy management controller 120 may control charge and discharge of the supercapacitor 150 and the thruster device 130. To control them, the energy management controller 120 is interfaced with the supercapacitor 150 and the thruster device 130.

The thruster device 130 may comprise a controller 133, for example a microprocessor controller. The controller 133 may include an algorithm firmware 134. As described above, the controller 133 may control the thruster device 130 to suppress the back EMF.

The algorithm firmware 134 computes variations in phase, time and/or frequency waveforms of the motor drive 110 and the thruster device 130, and shift the phase, time and/or frequency waveform of the thruster device 130 using the computed variations, to synchronize with the phase, time and/or frequency waveform of the motor drive 110. Further, the algorithm firmware 134 generates a voltage on the shifted phase, time and/or frequency waveform, to suppress the back EMF.

In some embodiments, the controller 133 may utilize a concept of Einstein's Unified Field Theory. The electromagnetism is generated by the motor drive 110, applied AC in solenoid coil and/or AC step up transformer. According to the Einstein's Unified Field Theory, the electromagnetism and earth gravitational magnetic field are different manifestations of a single fundamental field which is governed by five-dimensional

approach. The five-dimensional elements for the five-dimensional approach may comprise a differential voltage, a differential current, and shift of the phase, time and/or frequency waveform.

For example, the algorithm firmware 134 may compute the variation in the phase, time and/or frequency waveform of the thruster device 130 as per the motor shaft magnetic slicethrough the magnetic fields in accordance with the Einstein's Unified Field Theory. In some embodiments, the variation in the frequency oscillation feedback determines the variation in the phase and time waveform.

The thruster device 130 may further comprise a thruster sensor. The thruster sensor may be incorporated in the hardware circuitry. The thruster sensor may sense the variation in applied voltage, current and frequency fluctuation. The thruster sensor may also detect variations in phase, time and/or frequency waveforms of the motor drive 110 and the thruster device 130. The controller 133 then computes the variations in phase, time and/or frequency waveforms of the motor drive 110 and the thruster device 130 based on the detection by the thruster sensor.

Momentarily suppressive high discharge voltage is generated from the dual capacitor 132 of the thruster device 130 to counteract the opposing back EMF induced. In some embodiments, the thruster device 130 may be controlled by the controller 133 installed with the algorithm firmware 134. The thruster device 130 may utilise the phase, time and/or frequency shift parameters which are calculated by the controller 133. The thruster device 130 may synchronize with the phase waveform, time waveform and frequency waveform of the rotational motor drive 110 using the phase, time and/or frequency shift parameters.

Thereafter, the thruster device 130 may generate a voltage. The voltage may be a dynamic voltage. The voltage may be a dynamic high amplitude voltage on the shifted phase, time and/or frequency waveform of the thruster device 130. Further, the thruster device 130 may generate a current. The current may be a dynamic current on the shifted phase, time and/or frequency waveform flows in an opposing direction to the eddy current.

Since the dynamic voltage is on the shifted phase, time and/or frequency waveform of the thruster device 130 which are synchronous with the phase, time and/or frequency waveform of the motor drive 110, the dynamic voltage can suppress the back EMF induced by the rotational motor drive 110 which counteracts the rotational force of the motor drive 110. In addition, since the dynamic current is on the shifted phase, time and/or frequency waveform of the thruster device 130 which are synchronous with the phase, time and/or frequency waveform of the motor drive 110, the eddy current which counteracts the rotational force of the motor drive 110 can be suppressed.

In another embodiment, the energy management controller 120 may control the supercapacitor 150 to be used as a secondary or backup energy discharge on a vehicle engine load, while the back EMF is suppressed by the dynamic voltage generated from the thruster device 130. The algorithm firmware 121 of the energy management controller 120 may precisely charge up and electronically balance the graphene supercapacitor for backup energy.

The number of the supercapacitors 150 may be six (6). Meanwhile, the number of the supercapacitors 150 may depend on a type of the vehicle. In one embodiment, where output power requirement is higher, the number of supercapacitors 150 may be more than six (6). In another embodiment, the number of supercapacitor 150 may be less than six (6).

The supercapacitor 150 may be doped with graphene. In some embodiments, doping is achieved by diffusing the supercapacitor 150 with graphene. For example, the supercapacitor 150 is diffused with 3% to 10% of fine graphene mesh material onto an active carbon film. It is understood that the embodiments are not limited to the above range and the above mesh material, as such, other range of graphene diffusion such as 1% to 15%, 2% to 8% may be possible.

Graphene is, basically, a single atomic layer of graphite. The graphene is an allotrope of carbon that is made up of very tightly bonded carbon atoms organized into a hexagonal lattice. The graphene has the Sp^2 hybridisation and thin atomic thickness (0.345nm). These properties are what enable the graphene to break records in terms of strength, electricity and heat conduction. In this regard, the graphene diffused supercapacitor 150

has a high energy storage capability due to a high porosity of graphene nanostructure to achieve a high surface area for a high energy density storage. In addition, the graphene diffused supercapacitor 150 has a low temperature operation and is capable of delivering energy down to -40°C with minimum effect on efficiency.

5 The system 100 comprises a stabilization and equalization circuitry relating to the stabilization and equalization controller 140. In some embodiments, the stabilization and equalization circuitry may be integrated with the algorithm firmware 121 of the energy management controller 120. The energy management controller 120 therefore may use an algorithm to manage the energy distribution by interfacing with the stabilization and
10 equalization controller 140. The energy management controller 120 may be synchronized with the stabilization and equalization controller 140 for the transient noise suppression, voltage spikes suppression, frequency stabilization and/or balancing of the overall energy distribution. In this way, the stabilization and equalization controller 140 is operable to dampen the noise voltage for the voltage stabilization of the overall
15 energy distribution.

Fig. 8 illustrates a system in accordance with an embodiment of the invention.

As shown in Fig. 8, the system 100 may be assembled as a thruster device quantum cell.

Although not shown, design improvement may be done on the inductor windings on
20 customized ferrite core composite materials impregnated with graphite. The variance of the inductance can be altered by the ferrite core composite materials impregnated with different concentration level of graphite.

It may be appreciated that the one or more components of the system 100 described in Figs. 1 to 8 may be replaced with and/or combined with one or more components of a
25 supercapacitor charge system 200 described in Figs. 9 to 22.

Fig. 9 illustrates a block diagram of a supercapacitor charge system 200 for a vehicle in accordance with another embodiment of the invention.

The embodiment seeks to replace a non-environmental friendly battery of a vehicle with an environmental friendly battery. In addition, the embodiment seeks to optimize the control of charge and discharge cycles of the environmental friendly battery.

5 The supercapacitor charge system 200 may be a subset of a high kinetic discharge system. The supercapacitor charge system 200 includes at least one supercapacitor 210 as an immediate main energy peripheral reservoir, a stabilization and equalization controller 230, a charge balancing controller 240 and an energy management controller 250.

10 Although not shown, the supercapacitor charge system 200 may include six (6) supercapacitors 210. Meanwhile, the number of the supercapacitor 210 may depend on a type of vehicle. Although not shown, the supercapacitor 210 is integrated with the charge balancing controller 240. In various embodiments, where output power requirement is higher, the number of supercapacitors 210 may be more than six. In other embodiments, the number of supercapacitors 210 may be less than six.

15 A capacitor is an energy storage medium similar to an electrochemical battery. A supercapacitor is a high-capacity capacitor with capacitance values much higher than a typical capacitor of the same size. The supercapacitor 210, also known as an ultra-capacitor, is therefore suitable as a replacement for electrochemical batteries in industrial and commercial applications. To be suitable for such industrial and
20 commercial applications, control of the supercapacitor 210 has to be managed precisely. In particular, the charge and discharge cycle is managed by the energy management controller 250.

The supercapacitor 210 may be doped with graphene. In some embodiments, doping is achieved by diffusing the supercapacitor 210 with graphene. For example, the
25 supercapacitor 210 is diffused with 3% to 10% of fine graphene mesh material onto an active carbon film. It is understood that the embodiments are not limited to the above range and the above mesh material, as such, other range of graphene diffusion such as 1% to 15%, 2% to 8% may be possible.

Graphene is, basically, a single atomic layer of graphite. The graphene is an allotrope of carbon that is made up of very tightly bonded carbon atoms organized into a hexagonal lattice. The graphene has the Sp^2 hybridisation and very thin atomic thickness (0.345nm). These properties are what enable the graphene to break records in terms of strength, electricity and heat conduction. In this regard, the graphene diffused supercapacitor 210 has a high energy storage capability due to a high porosity of graphene nanostructure to achieve a high surface area for a high energy density storage. In addition, the graphene diffused supercapacitor 210 has a low temperature operation and is capable of delivering energy down to -40°C with minimum effect on efficiency.

As an example, the doping of the graphene mesh into an activated carbon anode is able to alter an electrical property, in particular lowering the resistance of an electrical series resistors ('ESR') so that electron holes pairs mobility charge carriers in an electrolyte embedded region of the supercapacitor 210 can travel at high velocity rate. Such a feature provides fast charge and discharge through an absorption and release of an ion composition. In other words, due to extremely low resistivity properties of the graphene, it is allowed to discharge onto any external load and the storage medium 220 as a buffer energy storage to top up the graphene diffused supercapacitor 210 which has rapid charge capabilities.

The supercapacitor charge system 200 further includes a storage medium 220 as a buffer energy reservoir. The storage medium 220 may be a redox battery. One example of the storage medium 220 is a lithium iron phosphate (LiFePO_4) medium and one example of the buffer energy is electrical energy. It is understood that the storage medium 220 is not limited to the lithium iron phosphate medium but can include other forms of batteries suitable for use in the start-up and provision of electrical energy or other energy to a vehicle. In addition, it is understood that the buffer energy is not limited to the electrical energy but can include other forms of energy such as chemical energy.

The functions of the storage medium 220 and an external charger 270 can vary depending on the type of vehicle. For example, where the supercapacitor charge

system 200 is installed in a car, the main source of an input charge comes from the external charger 270, for example alternator. The storage medium 220, for example lithium iron phosphate medium, provides a first initial charge to the supercapacitor 210.

5 In another embodiment where the supercapacitor charge system 200 is installed in a forklift, the external charger 270, for example charger, charges the storage medium 220, for example lithium iron phosphate medium, and the storage medium 220 may be the main source to provide electrical power to the supercapacitor 210 to run the forklift.

The energy management controller 250 controls charge and discharge of the supercapacitor 210 and the storage medium 220 for an energy distribution. To control
10 them, the energy management controller 250 is interfaced with the supercapacitor 210 and the storage medium 220.

In some embodiments, the energy management controller 250 is operable to discharge the storage medium 220 in order to charge the supercapacitor 210 having rapid charge capability. In addition, the energy management controller 250 detects a charge amount
15 and determine whether to charge or stop charging based on the charge amount. The charge amount includes at least one of a charge amount of the storage medium 220 and a charge amount of the supercapacitor 210.

For example, the energy management controller 250 may detect a charge amount of the storage medium 220. If the charge amount is below a predetermined amount, the
20 energy management controller 250 operates to charge the storage medium 220. Meanwhile, if the charge amount is above or equal the predetermined amount, the energy management controller 250 operates to stop charging the storage medium 220.

Hence, the energy management controller 250 has a sequential mapping self-charge capability that recharges one of the reservoirs, for example the storage medium 220,
25 when the voltage potential drops by a predetermined amount, for example 10% of its maximum voltage storage capacity. Hence, the supercapacitor charge system 200 creates a high efficient power retention and has a self-diagnostic feature.

For another example, the energy management controller 250 may detect a charge amount of the supercapacitor 210. If the charge amount is below a predetermined

amount, the energy management controller 250 operates to charge the supercapacitor 210. Meanwhile, if the charge amount is above or equal the predetermined amount, the energy management controller 250 operates to stop charging the supercapacitor 210.

5 The discharge and charge of the storage medium 220 may occur periodically and therefore forms a charge-discharge cycle of the storage medium 220. The process of charge and discharge of the supercapacitor 210 may occur periodically and therefore forms a charge-discharge cycle of the supercapacitor 210.

10 The energy management controller 250 is operable to compute a Fourier transform line integration formulation for a voltage differential optimization to transform input variables to output. In some embodiments, the energy management controller 250 computes a Fast Fourier transform ('FFT') which optimize the complex integrated input composite signals from the vehicle electrical load factor and vehicle EMS (Engine Management System) by computing an n-by-n matrix. The matrix may be implemented as a Discrete Fourier transform ('DFT') matrix. DFT is the resultant interpolation of multiplying an input
15 vector x of n numbers by the n-by-n matrix F_n to get an output vector y of n numbers governed by a formulation $y = F_n \cdot x$. In some embodiments, n is a variable polynomial integer and may be predetermined by one or more firmware macro subroutines whenever the algorithm firmware modem 251 refreshes at pre-set interval (for example, every 11ns), and x is a coefficient value. In some embodiments, the integrated input
20 composite signals comprise at least one of the following signals: vehicle engine cranking load signals, super turbo electrical load signals, compressor load signals and fan and fuel pump load signals.

In some embodiments, a super turbo hardware driven technology is activated above a predetermined number of revolutions per minute (for example 2000 rpm) where one or
25 more turbochargers are activated or initialized. The super turbo hardware driven technology is driven by increasing engine exhaust velocity and providing considerable kick in on power band. The turbochargers provide immediate instantaneous power and compensation for lag or delay associated with the turbochargers at low rpm. Therefore, the turbochargers require electrical power drain from the vehicle battery reservoir.

In some embodiments, the energy management controller 250 may compute the Fourier transform line integration formulation at a pre-set interval, for example every 11ns, to optimize the charge and discharge of discrete quantum energy onto a vehicle engine load 280. For computing the Fourier transform line integration formulation, the energy management controller 250 includes one or more sensors for sensing and capturing input variables and database for storing at least one of the input variables and output variables. It is to be appreciated that the one or more sensors may include hard and/or soft sensors. Therefore, the sensing of the input variables or parameters are done by the energy management controller 250's sensing, specifically the algorithm firmware modem's 251 sensing. The energy management controller 250 transforms the rows and columns, calculates the number of signal points, does a bit reversal, computes the Fast Fourier transform, and scales for forward transform.

In some embodiments, the input variables may comprise composite signals of a vehicle electrical controller unit ('ECU') and voltage differential and current differential composite signals detected by the one or more sensors which may include volt-meters, amp-meters or electrical power meters working in tandem with soft sensors to obtain any resulting voltage differential and current differential signals. These input variables are then processed by the Fourier transform algorithm which synchronizes the frequency variance and phase shift. In some embodiments, the Fourier transform algorithm may be a Fast Fourier transform. In other embodiments, the Fourier transform algorithm uses Line Vector Integration for voltage and current optimization. The output variables may be manipulated through sequential integration for stabilization, balancing, noise suppression, back electromagnetic field (hereinafter referred to as 'EMF') and electromagnetic interference (hereinafter referred to as 'EMI') filtration.

In this way, the energy management controller 250 may compute one or more normalization curves for comparison with the reference voltage signal for a voltage differential optimization at every 11ns. Although not shown, the energy management controller 250 may utilize a master reference clock for the cross-reference.

The Fourier transform is an algorithm utilized for signal processing, image processing, and data compression. The Fourier transform can be described as multiplying an input

vector x of n numbers by a particular n -by- n matrix F_n , called a discrete Fourier transform (hereinafter referred to as a 'DFT') matrix, to get an output vector y of n numbers: $y = F_n \cdot x$. This is one of the simplest way to describe the Fourier transform and shows that a straightforward implementation with 2 nested loops would cost $2n^2$ operations. The importance of the Fourier transform is that it performs this matrix-vector in just $O(n \log n)$ steps using divide-and-conquer. Furthermore, it is possible to compute x from y , i.e. compute $x = F_n^{-1} \cdot y$, using nearly the same algorithm. Practical uses of the Fourier transform require both multiplying by F_n and F_n^{-1} .

The Fourier transform can also be described as evaluating a polynomial with coefficients in x at a special set of n points, to get n polynomial values in y . This polynomial evaluation-interpretation is used to derive an $O(n \log n)$ algorithm. The inverse operation is referred to as interpolation: given the values of the polynomial y , find its coefficients x . To pursue the signal processing interpretation mentioned above, imagine measuring a spectrum of signal wavelength with a set of notes. Each note has a characteristic frequency (for example, middle A is 440 cycles per second). Digitizing this wavelength spectrum will produce a sequence of numbers that represent this set of notes, by measuring the spaced sampling times $t_1, t_2, \dots, t_i$, where $t_i = i \cdot \Delta t$, Δt is the interval between consecutive samples, and $1/\Delta t$ is called as the sampling frequency. If there were only the single and pure middle A frequency, then the sequence of numbers representing these notes would form a sine curve, $x_i = d \cdot \sin(2 \cdot \pi \cdot t_i \cdot 440)$. As an example, suppose $1/\Delta t = 45056$ per second (or 45056 Hertz), which is a reasonable 1 sampling frequency for the signal note. The scalar d is the maximum amplitude of the curve, which depends on the signal strength and optimization.

In general, the energy management controller 250 is operable to utilize a numerical integration formulation in conjunction with or in alternative to the Fourier transform line integration formulation. In some embodiments, the energy management controller 250 is operable to utilize the numerical integration formulation and the Fourier transform line integration formulation.

The energy management controller 250 is operable to utilize the numerical integration formulation by evaluating an integrand to obtain an approximation to an integral. The

energy management controller 250 evaluates the integrand at a finite set of points (referred to as integration points). A weighted sum of the evaluated integrand is used to approximate the integral. The integration points and weights may depend on the utilized method (for example, the numeric integration method) and the accuracy required from the approximation.

The numerical integration method relates an approximation error as a function of the number of evaluations of the integrand. As the number of evaluations of the integrand is reduced, the number of arithmetic operations may be reduced, and therefore total round-off errors may be reduced. In this regard, the numerical integration method may increase accuracy for optimization of the charge and discharge of discrete quantum energy onto a vehicle engine load 280.

In some embodiments, the integral over infinite intervals between region of a and b is calculated based on the following mathematical expression in equation (25):

$$\int_{-\infty}^{+\infty} f(x) dx = \int_{-1}^{+1} f\left(\frac{t}{1-t^2}\right) \frac{1+t^2}{(1-t^2)^2} dt, \quad (25)$$

wherein a and b are integration points, f(x) is integrand, x is polynomials interpolation function, and t is infinite time interval.

In other embodiments, the integral is calculated for semi-infinite intervals based on the following mathematical expressions in equations (26) and (27):

$$\int_a^{+\infty} f(x) dx = \int_0^1 f\left(a + \frac{t}{1-t}\right) \frac{dt}{(1-t)^2} \quad (26)$$

$$\int_{-\infty}^a f(x) dx = \int_0^1 f\left(a - \frac{1-t}{t}\right) \frac{dt}{t^2} \quad (27)$$

wherein a is integration point, f(x) is integrand, x is polynomials interpolation function, and t is infinite time interval.

The EMF and/or EMI are reduced by a feedback ferrite loop coil which is interfaced or arranged in data communication to be controlled by the firmware algorithm modem 251.

In some embodiments, the firmware algorithm modem 251 may compute a statistical

extrapolation to manipulate the EMI Induction. The EMI is also referred to as RFI (Radio Frequency Interference) under the radio frequency spectrum, and is a disturbance generated by an external source, for example a vehicle compressor, fan motor, alternator, fuel pump motor or water pump motor, that affects an electrical circuit by
5 electromagnetic induction, electrostatic coupling or conduction.

In some embodiments, the firmware algorithm modem 251 utilizes a macro command to compute the EMI or RFI based on the following mathematical expression in equation (28) for EMI susceptibility:

$$V_i = \frac{2AEFB}{300S} \quad (28)$$

10 wherein V_i is voltage induced into the loop, A is loop area in square meter, E is field strength in volts per meter, F is frequency in megahertz, B is bandwidth factor (in case of in band, B is 1; in case of out of band, B is circuit attenuation), and S is shielding (ratio) protecting circuit.

Meanwhile, the oscillation of the supercapacitor 210 causes an induced frequency.
15 Further, a noise voltage comes from at least one of an external charger 270, for example an alternator, a generator, a magneto and an ignition system such as capacitor discharge ignition (hereinafter referred to as a 'CDI') of the vehicle. The transient noise and/or voltage spikes need to be reduced, dampened, or mitigated in order to reduce engine vibration(s) and provide a desirable output with good power quality.

20 The supercapacitor charge system 200 comprises a voltage balance circuitry relating to the charge balancing controller 240 and a stabilization and equalization circuitry relating to the stabilization and equalization controller 230. In some embodiments, the voltage balance circuitry and/or the stabilization and equalization circuitry may be integrated with the firmware algorithm modem 251 of the energy management controller 250. The
25 energy management controller 250 therefore may use an algorithm to manage the energy distribution by interfacing with the stabilization and equalization controller 230 and the charge balancing controller 240. The energy management controller 250 may be synchronized with the stabilization and equalization controller 230 and the charge balancing controller 240 for the transient noise suppression, voltage spikes suppression,

frequency stabilization and/or balancing of the overall energy distribution. In this way, the stabilization and equalization controller 230 is operable to dampen the noise voltage for the voltage stabilization of the overall energy distribution.

Also, the charge balancing controller 240 is operable to suppress an overcharge of the supercapacitor 210. Hence, the supercapacitor charge system 200 is allowed to improve a performance such as power to torque ratio, improve a quality of a lighting system of the vehicle, improve a quality of a sound system of the vehicle, extend life of the supercapacitor 210 and the storage medium 220, and/or enable fuel savings. The supercapacitor charge system 200 further includes a kinetic energy recovery system (hereinafter referred to as a 'KERS') 260 and an external charger 270.

The KERS 260 is an automotive system for recovering a moving vehicle's kinetic energy under braking. The recovered energy is stored in a reservoir, for example a flywheel or high voltage batteries, for later use under acceleration. In some embodiments, the KERS 260 is connected with the supercapacitor charge system 200 as an external media. The energy management controller 250 manages the energy distribution by interfacing with the KERS 260.

In some embodiments, the KERS 260 is operable to capture kinetic energy under braking of the vehicle. The KERS 260 converts the captured kinetic energy to electrical energy by a traction motor and transfers the converted energy in at least one of the supercapacitor 210 and the storage medium 220 so that the kinetic energy generated under braking can be reused in the supercapacitor 210 and the storage medium 220 (i.e. regenerative braking). Also, the KERS 260 is operable to power up the supercapacitor charge system 200 so that the supercapacitor charge system 200 can supply power to the vehicle. As a result, in an embodiment, the vehicle is able to start. In other embodiments, electronic devices of the vehicle, for example navigation device and black box, are able to operate.

For example, the access time (for example, transient rise and fall time in 3 to 4ns) of the firmware algorithm modem's 251 computation is a guard band to capture the KERS 260 electrical energy generated by the traction motor in less than 5ns. Therefore, most of

(for example, 90 to 95%) KERS's 260 kinetic energy is channelled to the supercapacitor charge system 200 to charge up the supercapacitor charge system 200.

The external charger 270 is also connected with the supercapacitor charge system 200 as an external media. The energy management controller 250 manages the energy distribution by interfacing with the external charger 270.

The external charger 270 includes an induction coil motor which an electromagnetic induced potential energy is created when a rotor core is spinning inside stator core windings. The external charger 270 is operable to power up the supercapacitor charge system 200 so that the supercapacitor charge system 200 can supply power to the vehicle. The external charger 270 includes at least one of an alternator, a generator and a charger. The type of the external charger 270 can vary depending on the type of vehicle.

In some embodiments, the external charger 270 is arranged to interface with the vehicle roof top solar panel. The firmware algorithm modem 251 in the energy management controller 250 comprises logic implemented to operate as a solar auto charger unit for optimizing the charging rate of the lithium iron phosphate medium and the supercapacitor charge system 200, and to prevent the lithium iron phosphate medium and the supercapacitor charge system 200 from overcharging as there is a max current limitation level set in the firmware algorithm modem's 251 upper current control limits.

Fig. 10 illustrates a flow diagram of a supercapacitor charge method in accordance with another embodiment of the invention.

Firstly, the energy management controller 250 interfaces with the supercapacitor 210 and the storage medium 220 (S310). The energy management controller 250 is operable to control charge and discharge of the supercapacitor 210 and the storage medium 220 for an energy distribution. Although not shown, the energy management controller 250 may control the supercapacitor 210 and the storage medium 220 separately. Meanwhile, the energy management controller 250 may control the supercapacitor 210 and the storage medium 220 at the same time.

The energy management controller 250 includes an algorithm firmware modem 251 which is a programmable chip and is operable to support electronic components of the supercapacitor charge system 200. A user is able to enter a command into the algorithm firmware modem 251 via a user interface (not shown).

- 5 For example, the user is able to enter the command so that the energy management controller 250 can start to charge the storage medium 220 when the charge amount is below a predetermined amount. Then, the energy management controller 250 is able to operate according to the command.

10 For another example, the user is able to enter the command so that the energy management controller 250 can start to charge the supercapacitor 210 when the charge amount is below a predetermined amount. Then, the energy management controller 250 is able to operate according to the command. Meanwhile, although not shown, the 'predetermined amount' may be present without the user's command.

15 The energy management controller 250 detects the charge amount (S320). The energy management controller 250 may monitor the power, for example the charge amount. The charge amount includes at least one of a charge amount of the storage medium 220 and a charge amount of the supercapacitor 210.

After that, the energy management controller 250 determines whether to charge or stop charging based on the charge amount (S330).

20 For example, if the charge amount is below the predetermined amount, the energy management controller 250 operates to charge storage medium 220. Then, the storage medium 220 is charged (S340). For another example, if the charge amount is below the predetermined amount, the energy management controller 250 operates to charge the supercapacitor 210. Then, the supercapacitor 210 is charged (S340).

25 On the other hand, if the charge amount is above or equal the predetermined amount, the energy management controller 250 operates to stop charging. Although not shown, the energy management controller 250 continues to monitor the power.

Although not shown, as one of the supercapacitor 210 and the storage medium 220 is charged, another one of the supercapacitor 210 and the storage medium 220 may be discharged.

Hence, the energy management controller 250 has a sequential mapping self-charge capability, creates a high efficient power retention and has a self-diagnostic feature.

Meanwhile, the energy management controller 250 interfaces with the stabilization and equalization controller 230 and the charge balancing controller 240 (S350). The energy management controller 250 may be synchronized with the stabilization and equalization controller 230 and the charge balancing controller 240 for managing the energy distribution.

The stabilization and equalization controller 230 dampens a noise voltage (S360) for the voltage stabilization of the overall energy distribution. Further, the charge balancing controller 240 suppresses an overcharge of the supercapacitor 210 (S370). Thus, the supercapacitor charge system 200 is allowed to improve a performance such as not only power to torque ratio but also output horse power, improve a quality of the vehicle system, and enable fuel savings.

The energy management controller 250 may operate a first group of the steps (S310 to S340) with a second group of the steps (S350 to S370) concurrently. On the other hand, the energy management controller 250 may operate the first group of the steps and the second group of the steps in sequential order. For example, the energy management controller 250 may operate the first group of the steps, and then operate the second group of the steps.

Fig. 11 illustrates a schematic diagram of a supercapacitor charge system 200 in accordance with another embodiment of the invention. Specifically, Fig. 11 depicts the schematic diagram of the supercapacitor charge system 200 which comprises a voltage balance circuitry relating to the charge balancing controller 240, a stabilization and equalization circuitry relating to the stabilization and equalization controller 230 and an energy management firmware circuitry relating to the energy management controller 250.

Fig. 12 illustrates a table showing values of circuitry component illustrated in Fig. 11 in accordance with another embodiment of the invention.

The supercapacitors 210 (UC1 to UC7) are in the voltage balancing circuitry. The voltage balancing circuitry comprises, in series between each cell, a light emitting diode (hereinafter referred to as an 'LED') and a Zener diode. Specifically, the LED and the Zener diode are wired in series between each supercapacitor 210.

For example, the maximum volt value of the supercapacitor 210 may be 2.7V, but is not limited to this value. These electrical components cause any voltage above 2.7V to dump through the Zener diode and the LED causing the LED to light up and causing the supercapacitor 210 to be drained until it reaches 2.7V. While charging, once all the LEDs light up, it is an indication that all the supercapacitors 210 are fully charged up and balanced.

The stabilization and equalization circuitry comprises a plurality of capacitors and a resistor. The stabilization and equalization circuitry works as a damper for the noise voltage suppression. For example, the algorithm will capture the transient noise interference signals from the engine load (like the compressor noise, fan motor noise or alternator noise), and generate a similar amplitude composite counteract opposing signal for noise cancellation. In some embodiments, the stabilization and equalization circuitry comprises low-pass, high-pass or band-pass filters to filter the high and low frequency noise signals and voltage spikes.

Each customized capacitor is selected to reduce the amount of noise voltage that is different. The smaller the value of its capacitance, the higher the frequency to be suppressed from the electrical system. The algorithm firmware module 251 of the energy management firmware 250 utilizes a macro subroutine command to vary the capacitances and voltage of the circuitry for the electrical stabilization and balancing of the vehicle.

Generally defects and/or the noise voltage come from at least one of the external charger 270, for example an alternator, the generator, the magneto and the ignition system such as the CDI of the vehicle. The noise voltage needs to be improved or

mitigated in order to reduce engine vibration(s) and provide a desirable output with good power quality.

The energy management firmware circuitry comprises a plurality of capacitors, a plurality of registers, a diode, an inductor and the algorithm firmware modem 251. The algorithm firmware modem 251 is a programmable chip, and acts as a programmable charge and discharge quantum energy controller, a flyback and a forward converter comparator. Specifically, the flyback and the forward converter comparator are featured in the feedback loop of the mapping signal integration where the firmware computes the normalization curves for comparison with the reference voltage signal for a voltage differential optimization at every 11ns.

The algorithm firmware modem 251 has a wide input voltage range, for example 9V to 20V, with a programmable operating speed of 20MHz oscillator clock input and 200ns instruction cycle. It is understood that the input voltage range can vary depending on the type of vehicle. The programmable modem includes programmable code protection and pulse width modulation ('PWM') high endurance protection mode to provide associated protection circuitry consisting current/thermal limiting and under voltage lockout.

The algorithm firmware modem 251 has software selectable frequency range of 32 kHz to 8MHz. Also, the algorithm firmware modem 251 has an internal on-chip oscillator that requires no external components, soft start mode to reduce in-rush current during start-up and current mode control for improved rejection of input voltage and output load transients.

By in circuit programming the modem chip, the algorithm firmware modem 251 can trigger different charge or discharge output quantum level in real dynamic mode for efficient energy management of the KERS 260 and the external charger 270 charging of the supercapacitor 210 and the storage medium 220.

Fig. 13 illustrates an example of a supercapacitor charge system 200 in accordance with another embodiment of the invention.

As shown in Fig. 13 (a) and (b), each component is assembled as the supercapacitor charge system 200. The supercapacitor charge system 200 comprises the

supercapacitor 210 as an immediate main energy peripheral reservoir, the stabilization and equalization controller 230, the charge balancing controller 240 and the energy management controller 250. The supercapacitor charge system 200 may further comprise the KERS 260 and the external charger 270, for example an alternator. The
5 supercapacitor charge system 200 may further include a storage medium 220. One example of the storage medium 220 is a lithium iron phosphate (LiFePO_4) medium.

The functions of the storage medium 220 and an external charger 270 can vary depending on the type of vehicle, for example car and forklift, as shown in Fig. 13 (a) and (b).

10 Fig. 13 (a) shows a supercapacitor charge system 200 for installation in a car. In this embodiment, the main source of an electrical input comes from the external charger 270, for example alternator. The storage medium 220, for example lithium iron phosphate medium, provides a first initial charge to the supercapacitor 210. In this embodiment, the supercapacitor charge system 200 may be disconnected from the storage medium
15 220 since the electrical energy (for example, petrol or diesel) is provided to the supercapacitor charge system 200.

Fig. 13 (b) shows a supercapacitor charge system 200 for installation in a forklift. In this embodiment, the external charger 270, for example charger, charges the storage medium 220, for example lithium iron phosphate medium, and the storage medium 220
20 provides electrical power to the supercapacitor 210. In other words, the storage medium 220 may be a main source to provide the electrical power to the supercapacitor 210 to run the forklift. In this embodiment, the supercapacitor charge system 200 may depend on the storage medium 220 in order to obtain the electrical energy.

Fig. 14 illustrates a modular layout of a supercapacitor charge system 200 in
25 accordance with another embodiment of the invention.

The supercapacitor charge system 200 comprises the supercapacitor 210 as an immediate main energy peripheral reservoir, the storage medium 220 as a buffer energy reservoir, the stabilization and equalization controller 230, the charge balancing

controller 240 and the energy management controller 250. As shown in Fig. 14, the supercapacitor 210 may be integrated with the charge balancing controller 240.

The supercapacitor charge system 200 may further comprise the KERS 260 and the external charger 270, for example alternator, as external media.

- 5 The KERS 260 basically includes an electrical traction motor that converts the mechanical kinetic energy during braking into the electrical energy and transfers the regenerative energy into the storage medium like the vehicle battery reservoir. The KERS 260 has been used in the motor sports formula in 2013. One of the reasons that not all vehicles use the KERS 260 is that the KERS 260 raises the vehicle's centre of gravity and reduces the amount of ballast that is available to balance the vehicle so that
10 it is more predictable when turning.

As described above, the KERS 260 converts the kinetic energy to an electrical energy by a traction motor and transfers the converted energy in at least one of the supercapacitor 210 and the storage medium 220 so that the discrete kinetic energy can
15 be reused in the supercapacitor 210 and the storage medium 220. Also, the KERS 260 is operable to power up the supercapacitor charge system 200 so that the supercapacitor charge system 200 can supply power to the vehicle.

The external charger 270 includes an induction coil motor which an electromagnetic induced potential energy is created when a rotor core is spinning inside stator core
20 windings. The external charger 270 is operable to power up the supercapacitor charge system 200 so that the supercapacitor charge system 200 can supply power to the vehicle.

The energy management controller 250 manages the energy distribution by interfacing with the KERS 260 and the external charger 270. Specifically, the algorithm firmware
25 spectrum bandwidth (upper and lower guard band bandwidth) of the algorithm firmware modem 251 is customized to capture the electrical energy generated by the traction motor of the KERS 260.

As described above, the energy management controller 250 further manages the energy distribution by interfacing with the stabilization and equalization controller 230

and the charge balancing controller 240. The energy management controller 250 basically controls charge and discharge of the supercapacitor 210 and the storage medium 220.

Figs. 15 and 16 illustrate examples of a practical application of a supercapacitor charge system 200 in accordance with another embodiment of the invention.

Fig. 15 shows examples of a practical application of a supercapacitor charge system 200 installed in a car, the car comprising a 2.4L engine.

As shown in Fig. 15 (a) and (b), the supercapacitor charge system 200 can ignite the 2.4L engine vehicle instantaneously. As shown in Fig. 15 (c) and (d), the supercapacitor charge system 200 can be installed in the 4X wheel drive vehicle for igniting. As shown in Fig. 15 (e) and (f), the supercapacitor charge system 200 can also be installed in the battery compartment of a 328i vehicle replacing the toxic battery, for example lead acid battery. As shown in Fig. 15 (g), the supercapacitor charge system 200 can also be installed in the battery compartment of a 523i vehicle to replace the conventional lead acid battery.

Fig. 16 shows examples of a practical application of a supercapacitor charge system 200 installed in a forklift.

As shown in Fig. 16 (a), (b) and (c), the external charger 270, for example charger, charges the storage medium 220, for example lithium iron phosphate medium, and the storage medium 220 may be a main source to provide electrical power to the supercapacitor 210. Thereafter, the supercapacitor charge system 200 can supply electrical power to the forklift DC electric motor to run the forklift. Although not shown, the supercapacitor charge system 200 can also supply electrical power to the electric fishing boat starter DC motor and can be powered up by a solar energy panel replacing diesel utilization.

As shown in Figs 15 and 16, the vehicle is not limited to an automobile such as a gas engine vehicle and a hybrid or electric vehicle. The vehicle includes a marine electric boat, a heavy industrial vehicle such as a forklift and a truck, and other portable power

storage medium. In summary, the vehicle includes a ground vehicle, an underwater vehicle, and an aerial vehicle.

When the supercapacitor charge system 200 is fitted into the battery compartment of the vehicle combustion engine, replacing the non-environmental friendly battery, for example lead acid battery, completely, the vehicle engine can easily be ignited and the vehicle can received an instantaneous boost of energy delivered by the supercapacitor 210 and the user (driver) will feel the immediate sensation of the high acceleration response and performance efficiency of the vehicle.

Also there is an increase in the engine output torque and the sensitivity of shift gearing.

The supercapacitor charge system 200 also improves the vehicle ignition efficiency and lessens fuel consumption (for example, over 10% during highway driving). The stabilization and equalization controller 230 installed in the supercapacitor charge system 200 enhances the current output and reduces the engine vibration due to a sparkplug complete combustion. The supercapacitor charge system 200 increases the sensitivity and accuracy of signals of the vehicle electrical controller unit ('ECU') that is the vehicle computerised hardware controller hidden inside the dashboard of the vehicle. The supercapacitor charge system 200 increases the sensitivity and accuracy of sensors, and optimizes the fuel consumption, the output power and the vehicle handling safety.

Fig. 17 illustrates a table showing advantages of a supercapacitor charge system 200 in accordance with an embodiment of the invention compared with conventional batteries.

The supercapacitor charge system 200 has advantages over the lead acid battery and the lithium ion battery used in the vehicle.

As shown in Fig. 17, the supercapacitor charge system 200 can withstand extreme operating temperature, for example -40°C to 70°C, suitable for any vehicle in any weather condition. Further, the supercapacitor charge system 200 has a high life cycle from 5 to 50 years. The supercapacitor charge system 200 has fast charge and discharge rate, for example 30 seconds to be fully charged by the external charger 270 of the vehicle.

Also, the supercapacitor charge system 200 is environmental friendly. The supercapacitor charge system 200 does not contain any acidic chemicals, all dry and sealed components. For example, a diesel vehicle installed with the supercapacitor charge system 200 is able to reduce emissions such as CO (carbon monoxide), HC (hydrocarbons) and NO_x (nitrogen oxide) compared to a diesel vehicle installed with a conventional lead acid battery. In another example, a petrol vehicle installed with the supercapacitor charge system 200 is able to reduce the emissions such as CO, HC, NO_x and PN (particle number) compared to a petrol vehicle installed with the conventional lead acid battery. It is to be appreciated that the emissions reduction ratio in the petrol vehicle may be higher than the diesel vehicle.

Also, the supercapacitor charge system 200 has relatively lightweight compared to other conventional car battery systems. In addition, the algorithm firmware modem 251 of the energy management controller 250 is operable to have rapid responses to the vehicle's kinetic energy brake recovery system besides the external charger 270.

Moreover, the supercapacitor charge system 200 can induce the differential voltage gradient to the supercapacitor 210. The algorithm firmware modem 251 is custom-designed to have a sequential mapping self-charge capability that recharges the storage medium 220 when the voltage potential drops by a predetermined amount, for example 10% of its maximum voltage storage capacity. Hence, the supercapacitor charge system 200 creates a high efficient power retention and has a self-diagnostic feature.

Figs. 18 to 21 illustrate line graphs showing torque and power output from the supercapacitor charge system 200 and method compared with a conventional battery in various vehicles. Fig. 18 illustrates line graphs showing air fuel ratio and power output from the supercapacitor charge system 200 and method compared with the conventional battery. The x-axis of the line graphs is engine revolutions per minute (hereinafter referred to as 'RPM').

As an example, in Figs. 18 to 21, the supercapacitor charge system 200 and the conventional battery, for example lead acid battery, are installed in each of a coupe, a sedan, a minivan and a SUV. Figs. 18 (a), 19 (a), 20 (a) and 21 (a) show torque on a

flywheel along with the engine RPM in the supercapacitor charge system 200, while Figs. 18 (b), 19 (b), 20 (b) and 21 (b) show torque on a flywheel along with the engine RPM in the lead acid battery. Figs. 18 (c), 19 (c), 20 (c) and 21 (c) show power output, for example horsepower output, along with the engine RPM in the supercapacitor charge system 200, while Figs. 18 (d), 19 (d), 20 (d) and 21 (d) show horsepower output along with the engine RPM in the lead acid battery.

As an example, in Fig. 22, the supercapacitor charge system 200 and the lead acid battery are installed in the coupe. Fig. 22 (a) and (b) show air fuel ratio along with the engine RPM in each of the supercapacitor charge system 200 and the lead acid battery. Fig. 22 (c) and (d) show horsepower output along with the engine RPM in each of the supercapacitor charge system 200 and the lead acid battery.

According to the line graphs, overall, vehicles having the supercapacitor charge system 200 have higher torque, horsepower output and air fuel ratio compared to vehicles having the lead acid battery. The reasons are at least as follows:

- Optimization of voltage and current, and supply of them to current demand within nanoseconds

The energy management controller 250 of the supercapacitor charge system 200 computes the Fourier transform line integration formulation at a pre-set interval, for example every 11ns, to optimize voltage and current.

The energy management controller 250 of the supercapacitor charge system 200 computes the numerical integration formulation to optimize voltage and current.

- Reduced noise

The noise voltage comes from the external charger 270, for example an alternator, the generator, the magneto and the ignition system, of the vehicle.

The stabilization and equalization controller 230 of the supercapacitor charge system 200 dampens the noise voltage.

- Complete combustion

The supercapacitor charge system 200 discharges high current momentarily compared to the conventional battery, for example lead acid battery. Thus, the

supercapacitor charge system 200 allows better and more complete combustion of fuel in the chamber.

It should be appreciated by the person skilled in the art that variations and combinations of features described above, not being alternatives or substitutes, may be combined to
5 form yet further embodiments falling within the intended scope of the invention.

CLAIMS

1. A system for suppressing a back electromotive force (EMF) comprising:

a motor drive operable to generate a rotational force and the back EMF which counteracts the rotational force; and

5 a thruster device operable to compute variations in phase, time and/or frequency waveforms of the motor drive and the thruster device, and shift the phase, time and/or frequency waveform of the thruster device using the computed variations,

wherein the thruster device is operable to generate a voltage on the shifted phase, time and/or frequency waveform to suppress the back EMF.

10

2. The system according to claim 1, wherein the thruster device is operable to shift the phase, time and/or frequency waveform of the thruster device to synchronize with the phase, time and/or frequency waveform of the motor drive.

15 3. The system according to claim 1, wherein the thruster device is operable to generate a current on the shifted phase, time and/or frequency waveform flows in an opposing direction to the eddy current, thereby the eddy current is suppressed.

4. The system according to claim 2, wherein the thruster device comprises:

20 at least one inductor and at least one capacitor operable to generate the voltage; and

a controller operable to vary inductance of the inductor and capacitance of the capacitor based on the shifted phase, time and/or frequency waveform.

5. The system according to claim 4, wherein the thruster device further comprises a thruster sensor operable to detect the variations in the phase, time and/or frequency waveforms of the motor drive and the thruster device.
- 5 6. The system according to claim 4, wherein the controller comprises an algorithm firmware, the algorithm firmware is operable to apply Einstein's Unified Field Theory using a differential voltage, a differential current, and shift of the phase, time and/or frequency waveform as five-dimensional elements, to suppress the back EMF.
- 10 7. The system according to claim 4, wherein the capacitor comprises a high voltage inductive dual capacitor.
8. The system according to claim 1 further comprising at least one supercapacitor operable to be used as a backup energy discharge on a vehicle, while the back EMF is
15 suppressed by the voltage generated by the thruster device.
9. The system according to claim 8 further comprising an energy management controller operable to charge the supercapacitor to use as the backup energy discharge.
- 20 10. The system according to claim 1, wherein the thruster device is operable to compute the variations based on a Genetic Algorithm.
11. A method for suppressing a back electromotive force (EMF) comprising:
generating, by a motor driver, a rotational force and the back EMF which
25 counteracts the rotational force;

computing, by a thruster device, variations in phase, time and/or frequency waveforms of the motor drive and the thruster device;

shifting, by the thruster device, the phase, time and/or frequency waveform of the thruster device using the computed variations; and

5 generating, by the thruster device, a voltage on the shifted phase, time and/or frequency waveform to suppress the back EMF.

12. The method according to claim 11, wherein the thruster device is operable to shift the phase, time and/or frequency waveform of the thruster device to synchronize
10 with the phase, time and/or frequency waveform of the motor drive.

13. The method according to claim 11, wherein the thruster device is operable to generate a current on the shifted phase, time and/or frequency waveform flows in an opposing direction to the eddy current, thereby the eddy current is suppressed.

15

14. The method according to claim 12, wherein the thruster device comprises:
at least one inductor and at least one capacitor operable to generate the voltage;
and

a controller operable to vary inductance of the inductor and capacitance of the
20 capacitor based on the shifted phase, time and/or frequency waveform.

15. The method according to claim 14, wherein the thruster device further comprises a thruster sensor operable to detect the variations in the phase, time and/or frequency waveforms of the motor drive and the thruster device.

25

16. The method according to claim 14, wherein the controller comprises an algorithm firmware, the algorithm firmware is operable to apply Einstein's Unified Field Theory using a differential voltage, a differential current, and shift of the phase, time and/or frequency waveform as five-dimensional elements, to suppress the back EMF.

5

17. The method according to claim 14, wherein the capacitor comprises a high voltage inductive dual capacitor.

10 18. The method according to claim 11, wherein at least one supercapacitor is operable to be used as a backup energy discharge on a vehicle, while the back EMF is suppressed by the voltage generated by the thruster device.

19. The method according to claim 18, wherein an energy management controller is operable to charge the supercapacitor to use as the backup energy discharge.

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20. The method according to claim 11, wherein the thruster device is operable to compute the variations based on a Genetic Algorithm.