Implementation Of Ultracapacitor Based Stop-Start System Using Micro-Hybrid Technology In Three-Wheeler

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Abstract: Implementation of automatic Start/stop (SS) technology in a traveler vehicle is a financially savvy approach to enhance fuel economy (FE) and decrease outflows without influencing consumer acknowledgment. In urban ranges, where a great part of the vehicle driving time is spent sitting at stop lights or in traffic, the engine can be closed down when the vehicle is halted to spare fuel. The engine is rapidly and discreetly restarted as the driver requests torque for quickening. This working technique is regularly used in full hybrid electric vehicles that have intense electric systems; however, is ending up more well known in micro-hybrid vehicles that utilizes customary starter/battery configurations. In this paper the system has implemented in a Three-Wheeler where the regenerative braking and Stop-Start system of the Micro Hybrid system is operated by Ultracapacitor along with Traditional battery. The feasibility analysis of the vehicle is also discussed in this paper.

Keywords*:* Micro-hybrid; Ultracapacitor; Three-Wheeler; Fuel Economy; Environment Friendly Vehicle.

1. Introduction:

A Micro Hybrid vehicle what's known as a "Start-Stop system" where a regenerative braking mechanism stops the burning engine when the vehicle pulls a stop and again restarts it when the driver accelerates. This is the simplest type of Hybrid system where a battery is used for the Start-Stop and regenerative braking system. In this paper an Ultracapacitor is proposed along with Battery.Ultracapacitors offers instantaneous power bursts during periods of peak power demand. Ultracapacitors can store and release energy with high electric power very quickly and effectively in comparison to batteries, which are better suitable for store large amounts of energy, but should be charged and discharged at low electric power levels to avoid unwanted aging. More producers are picking ultracapacitors to control start-stop applications, particularly when quick restarts are required, and for keeping up the auto's supply voltage. The voltage can be diminished altogether in light of the fact that regular restarts tend to deplete the battery. With their high power density, ultracapacitors can guarantee energy is conveyed rapidly, considering autos to restart immediately without a pause in vehicle operation.Figure-1 shows an ultracapacitor which is used in Micro-Hybrid system. Table-1 shows characteristics difference of ultracapacitor, electrostatic capacitor and battery.

Device name	Discharge time(s)	Charge time (s)	Specific energy(KW/kg)	Specific power(W/kg)	Efficiency (%)	Serve life
Ultracapacitor	1-30	1-30	1-10	1000-2000	0.9-0.95	>10000
Electrostatic capacitor	10^{-6}-10^{-3}	10-6-10-3	<.01	>10000	1.0	unlimited
Battery	(0.3-3)hr	(1-5)hr	20-100	50-200	0.7-.085	500-2000

Table.1: *Characteristics of ultracapacitor, electrostatic capacitor and battery [1]*

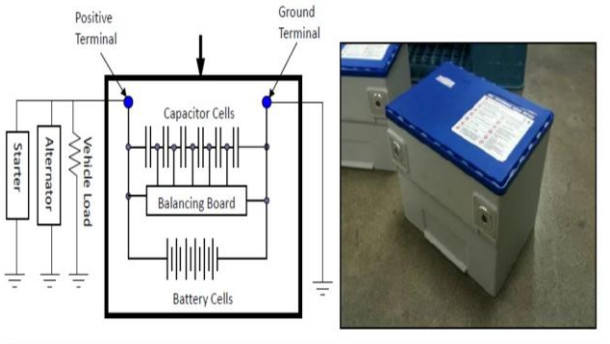

Figure-1:*Ultracapacitor/battery hybrid. (Maxwell Technologies)*

2. Ultracapacitors in Hybrid Three-Wheeled Vehicles:

Ultracapacitors essentially enhance control administration in hybrid electric vehicles. In addition, ultracapacitors diminish outflows,enhance fuel-proficiency and electrical drive abilities. Utilizing ultracapacitors permits the HEV to recover and reuse braking energy. Contrasted with ordinary diesel engines the decrease of fuel utilization is evaluated to be higher than half. Decrease in particulate discharges is 90% or considerably more, and in addition the diminishment of nitrogen oxide outflows by approximately 50%. [2]

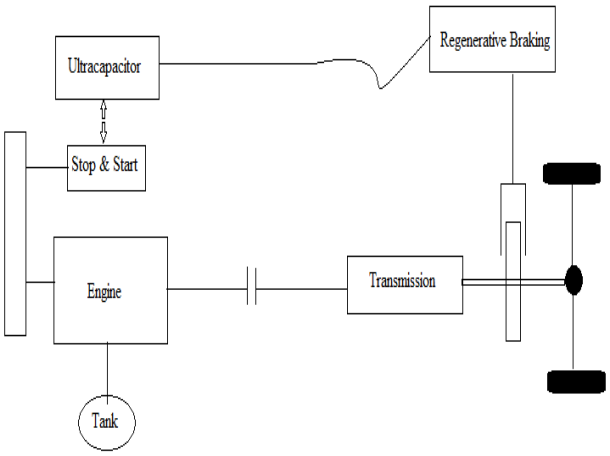

Figure-2: *Micro-Hybrid system architecture (ultracapacitor+start-stop+regenerative braking)*

The systems contrast by the power necessity for the energy storage system. Here the battery is exposed in general. On the off chance that these pinnacles are secured by an optional power source, the battery can be down-sized and its lifetime emphatically be expanded, in this manner lessening cost. The ultracapacitor innovation protects the battery, as it enables the battery to deal with the energy necessities while the capacitors handle the high power prerequisites. Figure-2 shows Micro-Hybrid system architecture. Hybrid energy storage system [3, 4] in view of Ultracapacitors is normal for quick charge and release speed, fast response to fluctuant stack current. At the point when stack vacillates, Ultracapacitors will bear the greater part of load current, so the present move through battery is little, under this condition, not only does energy consumed on resistance of battery is diminished, yet additionally expands battery service life. IF the output power is the same, contrasted with battery alone, hybrid energy storage system can diminish the equipped capacity of battery storage system alone.

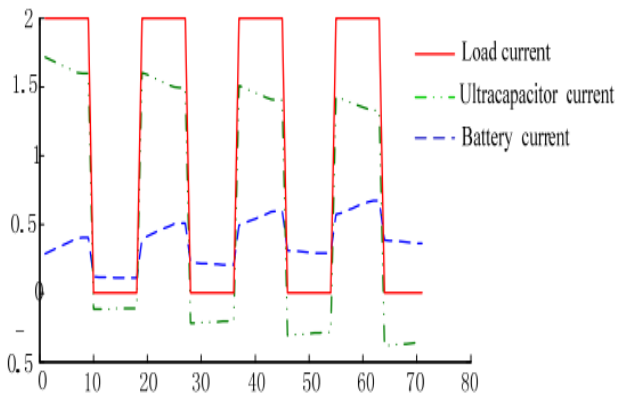

Figure-3: Current of battery, Ultracapacitor and load [5]

3. Feasibility analysis for using Ultracapacitor with battery in Micro-hybrid system:

3.1 Cost analysis:

12V Starter Battery price (typically used in Micro hybrid system) 60USD. A typical Micro Hybrid in a three wheeler requires 3 to 4 time replacement in total lifetime of a three-wheeler. Total lifetime of a three-wheeler approximately 15 to 20 years. If a ultracapacitor is installed in the system then battery life extends more than double [5] Cost of installment of an ultracapacitor is approximately 130 USD. So, in a typical vehicle in a whole lifetime 3 times battery replacement cost =180 USD IF an Ultracapacitor is installed then it requires 1 time battery replacement in total lifetime. So, total cost of 1 time battery replacement and ultracapacitor installation= 190 USD which is approximately equal to 3 times battery replacement cost. So, the installation of ultracapacitor doesn't require extra cost. The below Results shows how ultracapacitor extends battery life (start-stop test results) [6] (CAP-XX CONFIDENTIAL 2013)

1. New European drive cycle at 23°C : Battery alone-failed after 44000 starts Battery+ultracapacitor – Ran for 120000 starts
2. Japanese charge acceptance Test at 23°C: Battery alone-Failed after 981 starts Battery+ultracapacitor-Ran for 9553 starts.
3. Modified new European drive cycle at -18°c: Battery alone – Failed after 1 start-stop cycle Battery + ultracapacitor- Failed after 4500 start-stop cycle

4. Feasibility analysis for using ultra capacitor based micro hybridized three-wheeler in Bangladesh:

4.1 Cost analysis & payback time:

Micro hybrid system installment cost approximately 300 to 400 USD [7] Autorickshaw (three-WHEELER) runs at 30 Km/h & per day runtime 4 hours (estimated) in Bangladesh. Fuel consumption 30 km/l. 1 liter diesel costs 100 taka = 1.23 USD. For 4 hour runtime costs = 4.92 USD. For using Start-Stop system Fuel economy gains in the range of 5 to 10 percent [7]. (Taking, 6%), so per day amount of fuel saved =.24 liter .which costs approximately .2952 USD. So, payback time = micro hybrid system installment cost/per day saving= 1186 days =3.24 years.

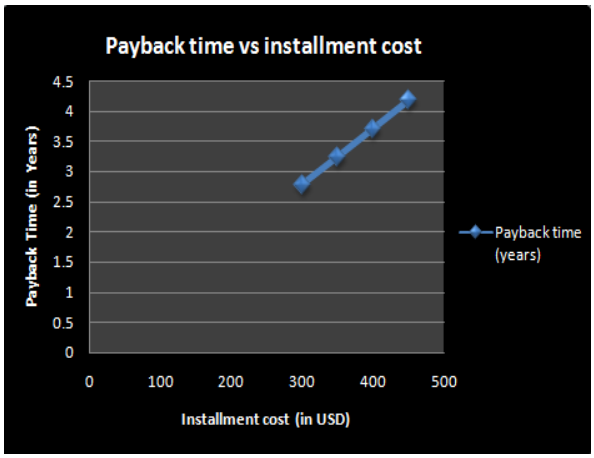

Figure-4: *Payback time depending on installment cost*

4.2 Environmental impact:

Assuming that the autorickshaw runs approximately 120 km/day with a fuel consumption of 30 km/l.Then the fuel consumption is 4 liter per day.so,the corresponding CO_2 emission = 4 l/day. 2.5 kg/l= 10 kg per day. The system would save 6% fuel (estimated).So, per day fuel saving .24 liter. In Dhaka city the number of autorickshaw is approximately 5000.so, total amount of fuel saving in Dhaka city would be =1200 liter/day and the corresponding CO_2 emission will reduce by= 3000 kg/day CO_2 reduction cost in Asian market = 29.5 USD/1000kg.so, per day will be saved = 88.5 USD and annually it would 32,302.5 USD.

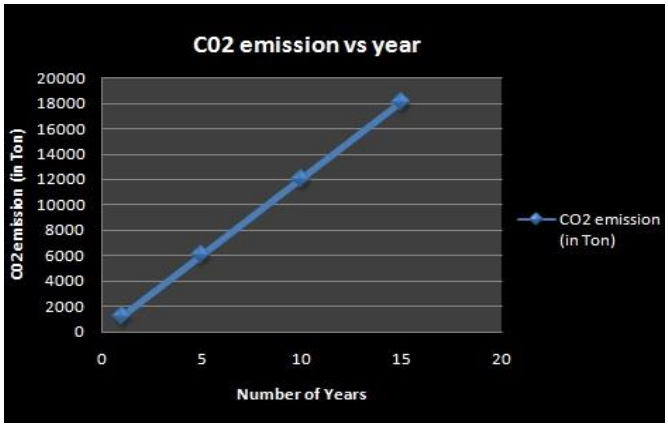

Figure-5: *CO_2 emission rate in terms of year.*

5. Advantage of proposed mechanism:

1. Fuel consumption is decreased by up to 5% to 10% in city driving.
2. CO2 emissions are decreased by up to 5% to 10% in city driving; nearly the same as the pickup from efficiency.
3. Within 350 milliseconds the engine restarts inside in complete silence.
4. Wipe out engines commotion and vibrations when the vehicle is at a transitory Standstill, which speaks to 35% of city driving time.
5. Execution cost is not high (for the most part in go $300-$400)
6. The engine restarts automatically [8].

6. Conclusion:

More than 50% cars from 2013 are using start-stop technology of micro hybrid system. If an ultracapacitor is used along with battery in micro hybrid system and it is used in three-wheelers then it will not only reduce fuel consumption but also CO_2 emission in huge amount. In Asian cities like Bangladesh, India, Japan etc. millions of autorickshaw runs on the road per day. If all the autorickshaw are taken under this system then a huge amount of money can be saved. All the mentioned advantage is provided by the system without compromising vehicle efficiency and consumers comfort.

Acknowledgement:

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