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Solar Tracking Motivated Tricycle for Physically Challenged People

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Abstract: In this, primary objective of the ability of tricycle has been improved by using a solar tracking energy system, enhanced converter and employing DC motor to drive tricycle. An intelligent speed controller based on fuzzy logic was developed to increase comfort of physical challenged people. One of the best inventions in the medical field that helped both the aged and the disabled people is the mobility vehicle. A prototype solar tracking array fitted with photovoltaic panels it is to utilize adjusts solar collecting positions dynamically to attain maximum power collection. All these improvements were implemented by using of a MSP430F5438 microcontroller due to its low cost and better-quality performance.
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Key words: Solar tracking energy system, Fuzzy logic, DC motor, Tricycle, Microcontroller.

INTRODUCTION

Since the oil crises of the 1970's, fuel economy has been one of the dominant issues in automobile performance. Achieving the lowest possible fuel consumption helps to save natural resources and is more economical for consumers. It also translates directly into lower emissions. Often in contrast with these requirements, customers continue to demand increasing comfort and performance. In general, there are methodologies that can be employed to reduce the fuel consumption of an automobile. But actually first electric vehicles of the 1830s used non-rechargeable batteries. Half a century was to elapse before batteries had developed sufficiently to be used in commercial electric vehicles. By the end of the 19th century, with mass production of rechargeable batteries, electric vehicles became fairly widely used. Indeed if performance was required, the electric cars were preferred to their internal combustion or steam powered rivals. The electric vehicle was relatively reliable and started instantly, whereas internal combustion engine vehicles were at the time unreliable, smelly and needed to be manually cranked to start. The other main contender, the steam engine vehicle, needed lighting and the thermal efficiency of the engines was relatively low.

This substitute power supply is always achieving greater popularity especially since the realization of fossil fuels shortcomings. Renewable energy in the form of electrical energy has been in use to some measure as long as 75 or 100 years ago. Sources such as Solar, Wind, Hydro and Geothermal have all been utilized with varying levels of success. The most widely used are hydro and wind power, with solar power being moderately used worldwide.

The concept of the solar charged battery electric vehicle is essentially simple and is shown in Fig. 1. The vehicle consists of an electric battery for energy storage, an electric motor, and a controller. The battery is normally recharged from mains electricity via a solar arrays and a battery charging unit that can either be carried onboard or fitted at the charging point. The controller will normally control the power supplied to the motor, and hence the vehicle speed, in forward and reverse.

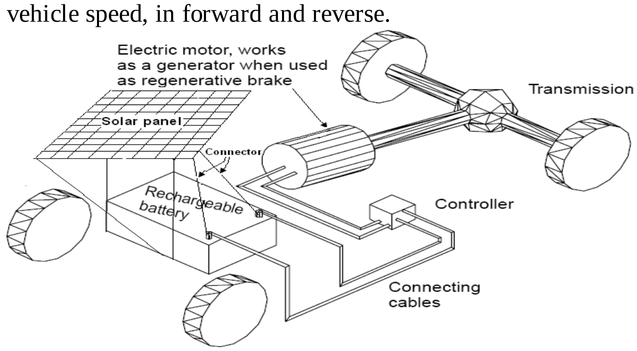

Fig. 1: Concept of the rechargeable battery electric vehicle.

According to the Indian census results of the year 2001the total number of people with disabilities is more than 100 million. The majority of this group is physically disabled people. Physically disabled or in other words, orthopaedic disabled people constitute more than 50% of the total as per 2001 census. The wheelchair is a fundamental vehicle for orthopaedic disabled and old people to survive. With the recent technological developments, the wheelchairs, which are driven by an electrical motor, provide comfort to the disabled person to move easily without a requirement of any extra force. The type of electric vehicle used is the basic reason which determines the comfort and distance without charging. These vehicles have the similar characteristics with electrical cars.

STATE –OF-THE-ARTS

Mechatronics Application to Solar Tracking motivated wheelchair has driven the growth of this technology to levels of practical application. The advances in manufacturing and growing markets demand has lowered the cost of solar cells to one-seventh of the production cost during 1980 (Wolcott, 2002). Nansen said, "worldwide output of solar cells has increased fifty-fold since 1978 (p. 92)." Meisen said," IIASA/UNDP have offered a radically different scenario that shows renewable energy, especially solar, becoming a major market share by 2050 (p. 117)." Aronson has identified the following "categories of solar power systems."

As our current utility systems are based on the burning of carbon fuels environmentalists are studying the effects on the environment. Energy utilities Mechatronics Application to Solar Tracking produce greenhouse gasses. As energy demand rises, the production of greenhouse gasses will also rise. Nuclear power is another alternative that is harmful to the environment. Nansen (1995) said:

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"Nuclear power uses a delectable resource and also leaves in its wake toxic nuclear waste." "Hydroelectric power is generated by a wonderful renewable source, but there are few rivers left in the world to dam and there is a growing concern over the impact dams have on the fish population (p. 7)." From Nansen's statement we see the implications of hydroelectric power and how its effects the ecosystem in rivers. Rose and Pinkerton emphasize the pollution caused by coal and nuclear power. Rose and Pinkerton (1981): "Solar cells have no known adverse environmental impacts during operation.

Ibrahim Sefa, Mehmet Demirtas, and Ilhami Colak (2009) designed a single axis sun tracking system in Turkey. The sun tracking system developed by Sefa and others included a serial communication interface based on RS222 to monitor whole processes on a computer and record the data. Feedback data was recorded by two photoresistors. The solar cell was aligned at a fixed 41° facing south (Sefa, et al., 2009). A microcontroller observed and controlled the east-west rotation of the tracker by means of 24V 50W dc motor (Sefa, et al., 2009). The results of the measured energy showed an increase up to 46.46% of collected solar energy (Sefa, et al., 2009). Yusuf Oner, Engin Cetin, Harun Kemal Ozturk, and Ahmet Yilanci (2009) developed a solar tracker utilizing the application of a spherical motor. The motor contains a rotor containing a four pole magnet surrounded by eight individually energized stator poles (Oner, et al., 2009). With the magnet in the middle direction is controlled by the surrounding stator poles (Oner, et al., 2009). This design allows for three degrees of freedom. The degrees of freedom being forward and back tilt, a left and right lateral tilt, and rotation along a z-axis.

SYSTEM BLOCK DIAGRAM FOR SOLAR TRACKING

The system architecture of the proposed solar tracking control system using microcontroller MSB430F643 the sun light fed to the solar panel will feed the boost converter directly which stores the electrical energy temporarily in an inductor and then charges the battery. The battery then feeds the load during sunlight hours as well as nighttimes. The boost converter is to be operated by a digital controller. The digital controller will be based upon a microcontroller that monitors the voltage and current levels coming from the solar cell and controls the boost converter accordingly. Finally, the charge sensor will keep track of the charge of the battery in order to not overcharge the battery, which may damage some types of batteries. While not shown, all active components such as the digital controller will be getting its power from the solar cell is shown in fig. 2.

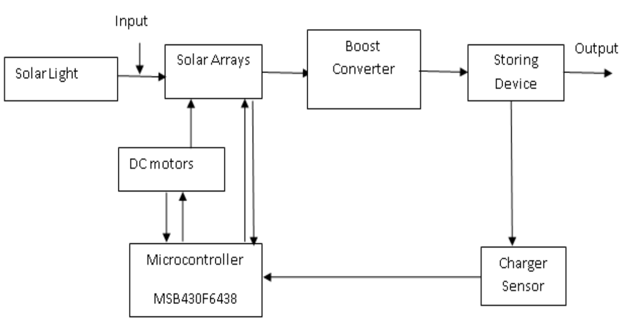

Fig.2: System architecture of the solar tracking system.

MODEL ELECTRICAL MOTOR DRIVES WHEELCHAIR

The electrical motor drives the wheels of the wheelchair. The power for electrical motor is obtained from the batteries. However, the wheelchair requires more power when claiming to hill or accelerating. These assistant power sources are used for short-term power supply during acceleration or uphill driving. Therefore, an auxiliary power supply is required A second battery or a super capacitor in addition to main battery can be used as an auxiliary power supply source.

In the circuit, crystal with 40 MHZ attached MSP430F5438 microcontroller has been used for controlling. Sensation of two phase currents at the same time is enough for running BLDCM [1]. While BLDCM is rotating with the rating speed of 800 rpm the frequency of the position information is 18067 Hz. The period of this signal is 38.25° sec. For a stable operation the rotating speed of the controller should be shorter than this period. A 12 bit A/D conversion has been used in order to prevent missing the signals from the position sensor of the controller and accordingly instable operation of the motor.

The switching frequency is 15 kHz 1RP 250 type MOSFETs have been used as switching component. Resistance and plastic case roundup diode with the speed of IXYSI 20-60 has been used as a protection circuit. In order to minimize the fluctuation of momentum produced in BLDCM, a low transitive LC passive filter has been located on the output of switching component [2]. The inductance of the filter bobbin is 10 mH and the value of the capacitor is 250 V, 470 µF. An extra diode with the same value has been added between the coil and the switch in order to avoid damaging the switching component by the reverse emf while cutting off due to the remnant energy.

Dynamic model of BLDCM with boost converter: Fig. 3 and 4 shows schematic step up chopper circuit with BLDCM. The dynamic performance of the system is by sets of differential equations. The first set governs the system performance when the step up chopper MOSFET is off. The off period of the boost chopper is related frequency, as follows:

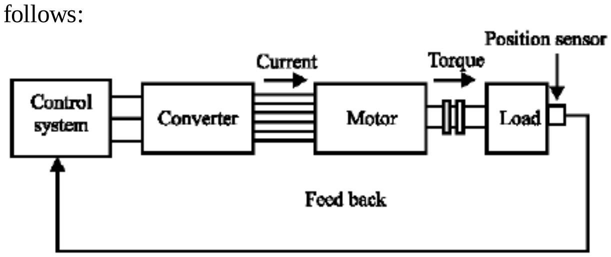

Fig. 3: Block diagram of BLDM control system.

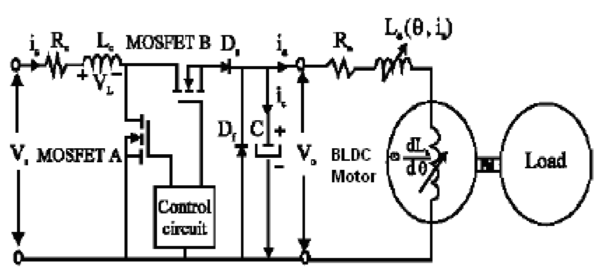

Fig 4: Circuit of BLDCM with boost converter.

$T_{off} = (1 - \xi)/f$ ---------- (1)

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Where ξ is the duty cycle of the chopper, f is the switching frequency of the chopper, and it is equal to 1/T and the last T is switching period of the chopper.

$did/dt = 1/L * vd - R/L * id + \omega * iq$

$dIq/dt = 1/L * vq - R/L * iq - \omega * id - \lambda * \omega /L$

$d\omega /dt = 1/J * (Te - F \omega - Tm)$ where $Te = 1.5 *\lambda * iq$

L motor inductance

R resistance of the stator windings

vd, id voltage and current in d-direction

vq, iq voltage in q-direction

ω angular velocity of the rotor

λ amplitude of the flux induced by the magnets of the rotor in the stator phases

J inertia of rotor and load

F viscous friction of the model

Te electromagnetic torque

Tm mechanical torque

The fourth element is a trivial calculation in that $d\theta/dt = w$ and is calculated outside of the single-cycle timed loop. The three assumptions made in the development of this set of differential equation are 1) Lq = LD (the d and q inductances are equal), 2) P =1 (the number of pole pairs in the model is 1) which also means that 3) $\omega d = \omega r$ (the mechanical angular velocity and electrical angular velocity are equal).

From the block diagram, following equations could be written:

$$e(j) = \omega_\delta^*(j) - \omega_\delta(j) \quad (1)$$

$$ce(j) = e(j) - e(j-1) \quad (2)$$

where, e(j) is value of error at time k, ce(j) is change of error at time (j-1), is the reference radial speed at time j, ω_δ (j) is actual speed at j and e(j–1) is error at time j-1. Consequently, the control signal which will be sent to BLDC motor could be stated as follows:

$$U_{(j)} = U_{(j-1)} + PKdu(j) \quad (3)$$

Where, $u_{(j-1)}$ is the previous controller output value and PK is integral constants (Akpolat, 2005).

SYSTEM BLOCK DIAGRAM

The tracking device is composed of two same LDR (Light dependent resistor) light sensitive resistors, which detect light intensity from eastern, western, southern, and northern directions, respectively. In every direction, there is a LDR light sensitive resistor with an elevating angle 90^0 to face a light source. The two sensors are separated each one. One is using LDR light sensitive resistors to be an eastward-eastward direction sensor for comparing the light intensity of eastward and westward directions. When the eastward-westward direction sensor receives different light intensity, the system will obtain the signal according to the output voltages of the eastward-westward direction sensors. As shown in the fig. 5.

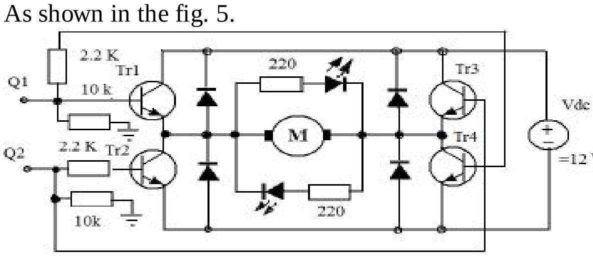

Fig.5: Motor driver circuit for solar altitude direction.

A voltage type analog/digital converter (ADC0804) can read different output voltages of the sensor and decide which direction has larger light intensity than the other direction. Then, the system will drive the stepping motors to make the solar panel turn to the decided direction. When the output voltages of the eastward-westward direction sensor are equal, i.e., the difference between the outputs of the eastward-westward direction sensors is zero. Then, the motor voltage is also zero. This means that the tracking process is completed in the eastward-westward direction. Similarly for another southern-northern direction sensor, it can be analyzed by the same methodology to track the sun in the Southern-northern direction.

Motor driver circuit: This experiment is conducted by the main source of power or motor which functions both altitude and azimuth directions. Two 12 volt direct circuit motors are employed in the device. The motor test from head gear indicates that the motor speed is at 8 rpm. This part is split into two significant parts which are the altitude part and azimuth part. The motor structure is as displayed in the Fig. 6.

Fig. 6: Print circuit board of motor driver circuit.

Solar trackers may be solo axis or double axis. Solo axis trackers usually use a polar mount for maximum solar efficiency. Single axis trackers will usually have a manual altitude (axis tilt) adjustment on a second axis which is adjusted on regular intervals throughout the year. Compared to a fixed amount, a single axis tracker increases annual output by approximately 30% and a double axis tracker an extra 6% shown in the fig.7. A tracking device is more expensive than a fixed mounting rack. It requires a modifiable vertical that can withhold larger wind pressure during storms. It can either be equipped with an electric drive.

Fig.7: Solar tracking panel.

THE FUZZY LOGIC CONTROLLER OF BLDC MOTOR

Fig. 8 shows the block diagram of a solar wheelchair system with BLDCM. The system is composed of solar panel, battery, boost converter used for increasing the voltage level, 2 phases classical converters for driving BLDCM, position

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sensor, 2 items of current sensor and the MSP430F5438 microcontroller (Chappell *eta!.*, 1984).

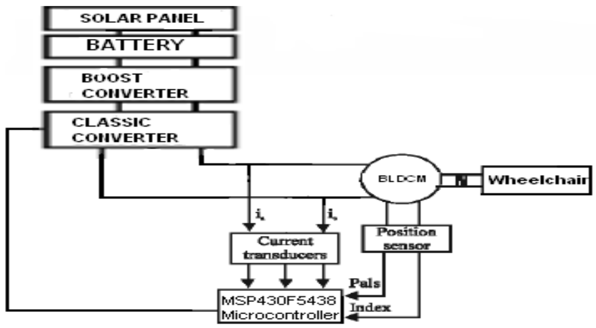

Fig. 8: shows the block diagram of a solar wheelchair system with BLDCM.

The speed of BLDCM was controlled by means of fuzzy logic. Fig.9 shows the view of BLDCM driver's completed design with the boost converter [5, 6, 7]. The error between reference speed and actual speed was assigned to be one of inputs of fuzzy logic controller while the change of error was second input to controller. The error and change error signal were scaled by 1/PE and 1/PK, respectively. Accordingly, seven linguistic variables, NB: Negative Big, NM: Negative Medium, NS: Negative Small, Zero, and PB: Positive Small, PM: Positive Medium and PB: Positive Big was created for error and change of error variable (Chen and Zan, 2006). The membership functions for error and change were shown in fig. 10 (a) and (b), respectively (De Azevedo *et al.*, 1995; Huh and Lee, 1995; Vijayan *et al.*, 2007).

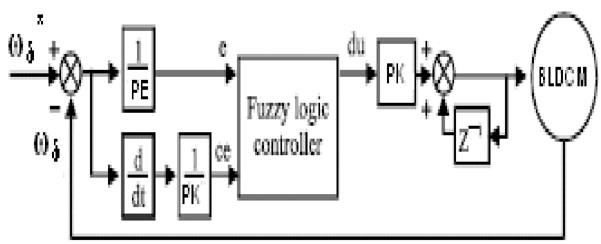

Fig. 9 Fuzzy logic controller system

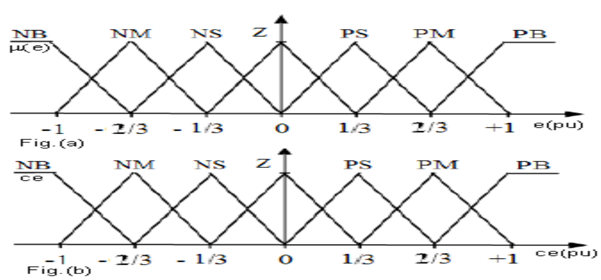

Fig. 10: (a) & (b) Membership functions of linguistic variables.

EXPERIMENTAL RESULTS

Fuzzy controller is utilized to verify the proposed technique; and it is easy to apply other control algorithms. Also the results can be obtained faster by using C language when compared to other methods. The differential equations of the BLDC motor are solved using the boost converted function of MATLAB for an accurate result. The simulation results are saved in a text file using the function of Fuzzy controller, and are presented through MATLAB. A flowchart of the simulation procedure is presented in Fig.11. After all of the values are initialized, the program loop, which contains the functions for setting up model equations and solving differential equations, is repeated until the final results are obtained. In the simulation procedure, model equations are set up using the proposed technique. The sampling time of the simulation and the motor specifications are presented in table I.

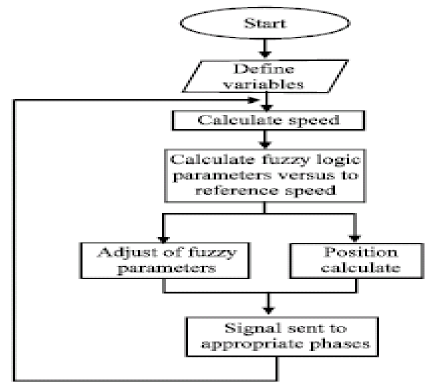

Fig. 11: Flow diagram of the solar tracking controller.

S No.	Parameter	Ratings
1	BLDC Motor	1 phase
2	Motor Speed	300 RPM
3	β, Coefficient of Friction	0.0012
4	J, Momentum of Inertia	0.00027
5	DC Voltage	24V
6	Watts	95W
7	Current	1.75A
8	Sampling time, $T_{sampling}$	2.5µsec

In the simulation and the implementation, the common transfer velocity and the transfer angle are set as 0-5° and 15°, respectively. The speed of BLDCM is controlled by speed feedback and fuzzy logic method [3, 4]. Fig. 12 and 13 show the view of the disabled tricycle. Fig. 13 shows the view of the disabled vehicle in the field which is wholly installed, operative and working with solar system. The differential expressions in the dynamic equations are presented by 4° Runga Kutta Method and by using the programming language of C. The obtained data is represented graphically.

Fig.12: The solar tracking disables people tricycle.

Fig.13: The solar tracking tricycle and internal arrangements.

Fig. 14 shows the view of a phase current on a digital oscilloscope. The saved current views in the simulation and the implementation is seemed to be very similar. From here, we can say that the motor dynamic equations and the modelling are almost real.

Fig.14: A phase current on oscilloscope.

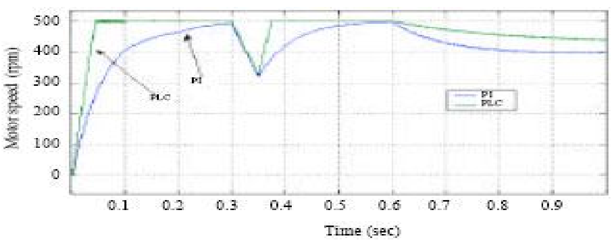

Fig.15: Velocity up curves against to time of the wheelchair

Fig. 15 shows velocity up curves against to time of the wheelchair on an uneven road after the first movement of the vehicle on a bumpy road.

A. Increase of Velocity of a Disabled Solar Tracking Tricycle

In this study, ICP Accelerometer is belonging to Piezotronics Company; DAQ 6036 E Card belonging to National Instrument Company and BNC2110 Connector. Fig. 16 shows the increase of velocity of the vehicle at the speed-up moment sec^{-2}.

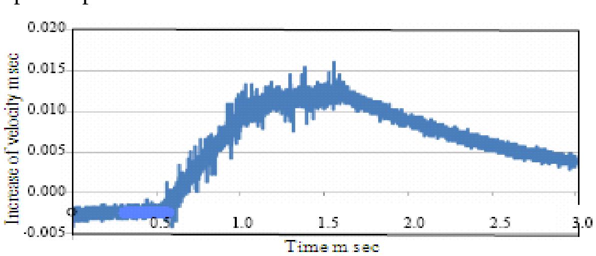

Fig. 16: Increase of velocity of the wheelchair at the accelerate moment.

CONCLUSION

The main objective of this paper aptitude and in general show of wheelchairs for disabled community has been improved by using a solar energy source and employing BLDCM to drive solar tracking tricycle. Accordingly, disabled community will able to use their solar tracking tricycle for long distance without disturbing about arrangement batteries. In addition, their traveling comfort was increased by means of proposed intelligent speed controller and accelerometer used. It has been shown that all these improvements could be done by using a modest price MSP430F5438 microcontroller. The major disadvantage of the in general method is that its show depends on solar tracking system, which is unmanageable up-and-down/wind direction. As an outcome, the show of Bio-medical equipment use for disabled community has been increased.

(A) Future Work

We are proposing to design a hybrid solar tracking tricycle/vehicle has two or more power sources, and there are a large number of possible variations. The most common types of hybrid wheelchair/vehicle combine an internal combustion engine with a solar charge battery and an electric motor and generator.

In the hybrid the vehicle is driven by one or more electric motors supplied either from the solar tracking tricycle through battery, or from the IC engine driven generator unit, or from both. However, in either case the driving force comes entirely from the electric motor or motors.

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