Design of Energy Savings in Metropolitan Railway Substations and Communication Based Train Control

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Abstract: Reduction in energy consumption has become a global concern and the EU is committed to reducing its overall emissions to at least 20%. Traffic operation has a significant impact on energy consumption in metro lines and thus it is important to analyze and minimize it. Trains equipped with automatic train operation (ATO) systems are operated between stations according to the speed commands they receive from speed profile. These commands define a particular speed profile and running time. The design of speed profiles usually takes into account running times, but not energy consumption criteria. In order to reduce the energy consumption Regenerative braking is used to recoup some of the energy that is lost while the vehicle is stopping. And another main objective of this paper is to design communications-based train control (CBTC). The trains and signal are fitted with a GPS receiver, a microcontroller and a RF transceiver. The GPS receiver continuously receives the location of the train and transmits to signal. According to that information the signal will decide when to allow another train. This is used to improve the train operation and control and it will reduce the manual work. **In the design process, energy consumption can also be considered in order to design the speed profile that minimizes the consumption.**

Keywords: Regenerative brake, ATO, CBTC, windmill.

1. Introduction

Energy efficiency in railway systems is nowadays a key topic being studied in order to reduce energy consumption and costs since it has become a global concern. In particular, traffic operation has an important impact on energy consumption and different strategies can be applied to optimize the traffic regulation. Metro lines equipped with Automatic Train Operation systems (ATO) use preprogrammed speed commands to drive the trains corresponding to a set of alternative ATO speed profiles per interstation with different running times. Traffic regulation systems performance and total energy consumption strongly depend on the offline design of these ATO speed commands. Depending on the required running time, the regulation system online selects the ATO speed profile to be executed between two stations. Up to 40% of the consumed energy could be fed back to electrical network and however, measurements show only 19% of recuperation. The amount of recovered energy depends on service frequency, train power profiles, electric network configuration, rolling stock, line voltage, track profile and length of feed sections, and train auxiliary power. It is possible to install energy storage devices on the train or at substations to reduce energy consumption accompanied with reduction of power peaks, and voltage stabilization. Feeding back the regenerative energy to storage devices at substations leads to transmission losses. These losses are avoided placing the device on-board vehicles but the train mass is increased and additional space is needed in the vehicle. These devices can be flywheels, which have large dimensions and are usually rejected on-board for safety reasons, batteries which have a limited number of load cycles, and super capacitors. The main objective of this paper is to design the optimal ATO speed profiles taking into account the regenerative energy and the total net energy consumption in substations.

2. Problem:

In existing paper, the net energy consumption of a train is evaluated at substations instead of pantograph by means of a network energy model. Here the regenerative energy is considered when ATO speed profiles are designed. In short, the installation of power inverters or on-board energy storage devices in the case study would provide energy savings in scenarios with low density traffic but advantages are not obtained in dense traffic scenarios. To avoid this problem we are going to regenerate the energy from the wind turbine and regenerative braking. Communications-based train control (CBTC) is designed to reduce the manual operation so the delay due to this will be reduced.

3. Objective:

Energy demand is increasing now-a-days. Due to the energy crisis, a number of energy plans have been proposed. This paper is motivated by the problem of reducing the energy consumption in metropolitan railway lines. Many metropolitan lines are highly automated, being driven by ATO systems, and energy can be regenerated when trains are braking. The configuration of these automatic driving equipments can be optimized to reduce energy consumption considering also the regenerative energy with no impact on the quality of transport service offered to passengers. Thus, this paper is focused on the improvement of automatic driving energy-efficiency.

4. Block Diagram:

4.1 Regenerative Braking module:

The spring arrangement consists of two plates, two springs and the break wire. The break wire is connected to the brake pedal of the vehicle and another end of the break wires are connected to the rack and pinion arrangement. The rack and pinion arrangement is coupled to the gear arrangement the gear is coupled with a dynamo shaft. while we apply the brake through the brake pedal the wire pull the spring rack arrangements due to this the spring start to compressed and while we release the brake pedal the spring elongates during this compress and elongation movements the rack and pinion moves forward and reverse due to this the gear arrangement rotated in clockwise and in anticlockwise direction with the help of rack and pinion. The pinion gear will rotates the dynamo and generate the power from the dynamo and send the output signal directly to the control unit. The power generated from the dynamo is AC the control unit converts into DC and stored to the battery. Using this equipment we can easily generate the power supply. This equipment is mainly used in all types of four wheeler vehicles in automobile.

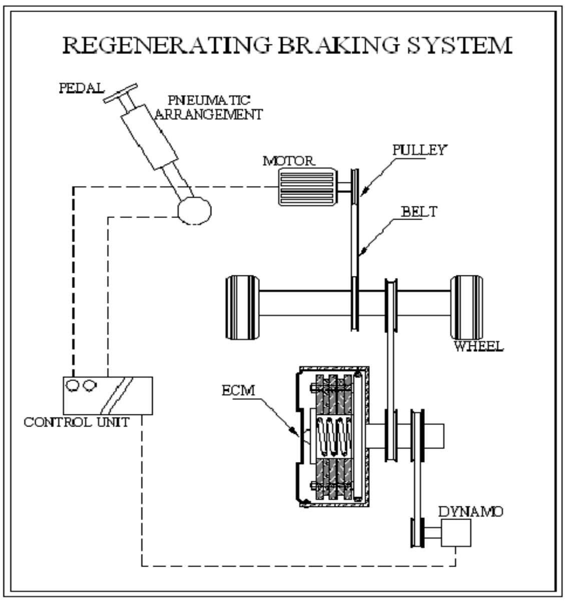


Fig 1

4.2 Windmill module:

The wind turbine device generates energy without any interference of the normal train operation – the device is installed between railway tracks, and is partially buried underground. As the train passes over the device, the wind generated from the train spins the turbine inside the wind turbine to generate electricity.

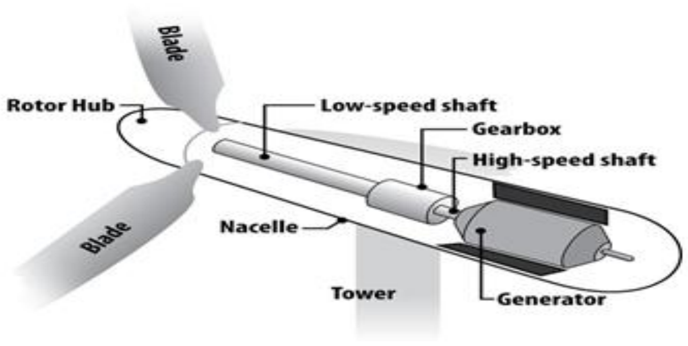


Fig 2

In this Wind mill arrangement is the mechanical arrangements which are easily rotated. The rotating speed is depends upon the wind strength. The wind mill arrangement is coupled with the dynamo. So whenever the wind mill is rotated due to wind, the electric power is generated in the dynamo. In this the motor is fixed to rotate the wind mill arrangement. And the electric power is store in the battery.

4.3 ATO Speed Profile

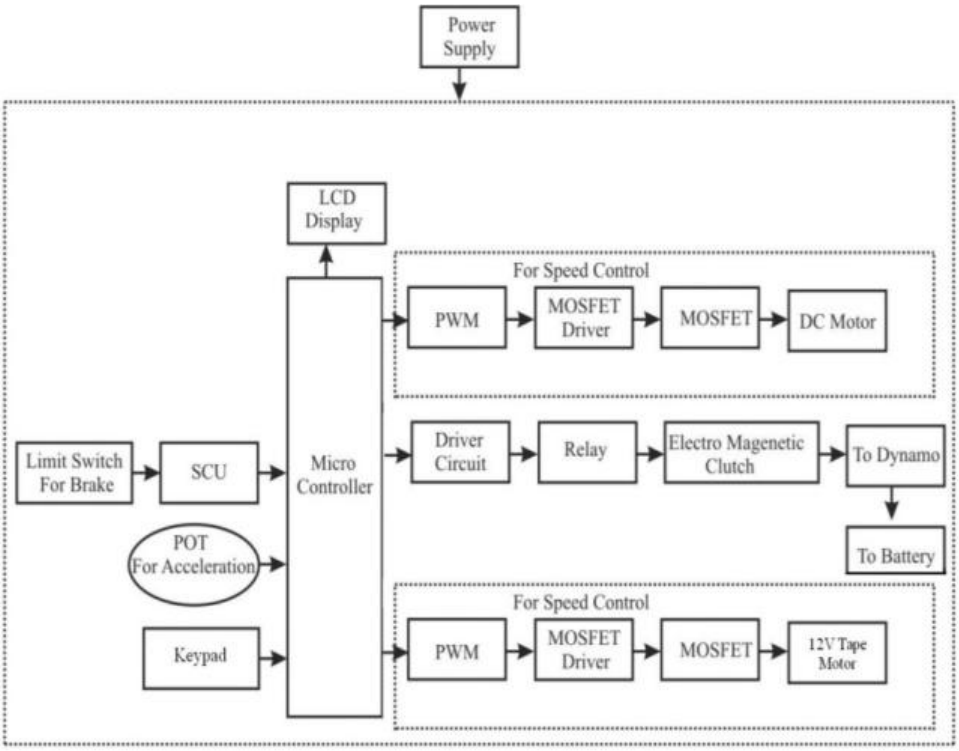
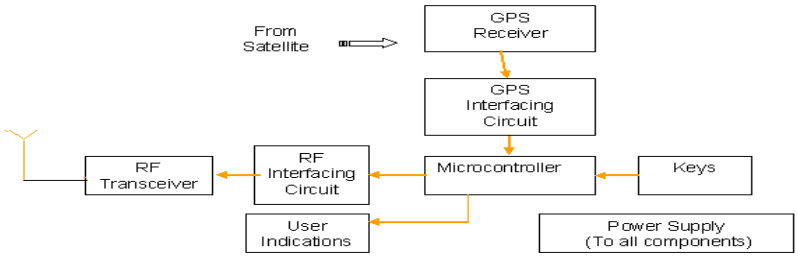


Fig 3

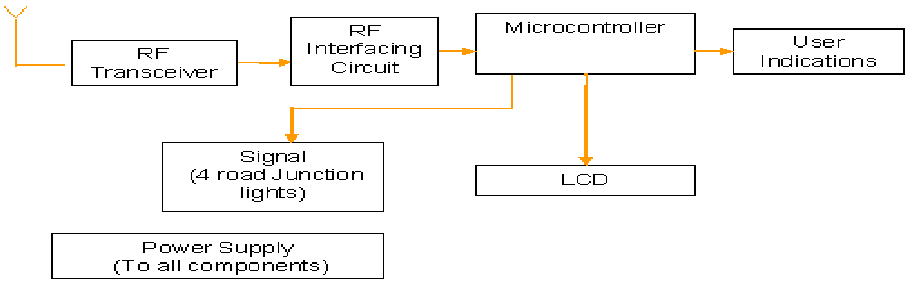
The chain is used to drive to couple the wheel with the electromagnetic clutch. The electromagnetic clutch is also coupled with a dynamo, by which electrical power generation is possible. The wheel is mounted on a shaft. The motor coupled with the wheel just rotates at a certain speed. A POT is arranged such that the speed of the motor can be controlled. When we apply the brake, it presses the limit switch and supply to the motor is stopped and it is provided to the clutch. The POT is arranged with the accelerator pedal .When the clutch starts to work the electric power supply is generated since the dynamo is coupled with the EMC (electromagnetic clutch). The generated electric power can be stored in the battery and it can be used to run the motor.

4.4 CBTC

4.4.1 Train module:



4.4.2 Signal module:



Communication Based Train Control (CBTC) is an automated control system for railways that ensures the safe operation of rail vehicles using RF data communication. Both train and signal modules fitted with GPS receiver, microcontroller, RF transceiver. Train keeps on transmitting its location information to the signal module through RF transceiver. It gets the location information from GPS and transmits it through the Zigbee transceiver. It receives information about the train and compares it with its own location. With the help of this comparison, the signal module can decide whether it will allow another train or not.

5. Result:

Fig 4. Regenerative braking

6. Conclusion

The braking arrangement can be installed in four wheelers. Windmill can be implemented anywhere but at a certain height from the ground level. From this the net energy consumption at substations will be reduced.

7. References

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