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Smart Station for Electrical Vehicle using Pantograph

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Abstract: *Electric vehicles (EVs) are being considered as a viable solution for ecological and economic concerns such as global warming, glasshouse gas emissions, and fossil fuel resources reduction. In such vehicles, wireless charging has become an emerging challenge. Currently, the widely used method to charge EVs is plug-in charging of Evs but it has serious disadvantages such as proper maintenance, getting shocked while connecting the charger etc. The alternative method that can be utilized to convey energy to the electric vehicle is by using 'PANTOGRAPH'. With numerous advantages, electric vehicle technology has experienced various difficulties like battery charging, expanding electric charges, and accessibility of charging stations, and battery life assessment. The smart charging system for EVs is proposed in this project. Vehicle detection at the charging station is detected employing an ultrasonic sensor. The charging system after sensing the vehicle battery voltage is described in the later section. The proposed system provides a highly efficient, cheaper, and environment-friendly solution for charging EVs.*

Keywords: Electrical Vehicle, Charging Station, Pantograph, Microcontroller, Automation, Ultrasonic Sensor;

I. INTRODUCTION

Transportation vehicles are a large contributor of the carbon dioxide emissions to the atmosphere. Electric Vehicles (EVs) are a promising solution to reduce the CO2 emissions which, however, requires the right electric power production mix for the largest impact. The increase in the electric power consumption caused by the EV charging demand could be matched by the growing share of Renewable Energy Sources (RES) in the power production. EVs are becoming a popular sustainable mean of transportation and the expansion of EV units due to the stochastic nature of charging behavior and increasing share of RES creates additional challenges to the stability in the power systems. Modeling of EV charging fleets allows understanding EV charging capacity and demand response (DR) potential of EV in the power systems. This article focuses on modeling of daily EV charging profiles for buildings with various number of chargers and daily events. The Report presents a modeling approach based on the charger occupancy data from the local charging sites. The approach allows one to simulate load profiles and to find how many chargers are necessary to suffice the approximate demand of EV charging from the traffic characteristics, such as arrival time, duration of charging, and maximum charging power. Additionally, to better understand the potential impact of demand response, the modeling approach allows one to compare charging profiles, while adjusting the maximum power consumption of chargers. The transport sector is responsible for almost a quarter of worldwide total CO2 emissions, while about three quarters of these emissions are attributable to cars and trucks. According to the IEA report, car ownership, trucking activity, and air travel would increase substantially by 2050 [1]. Appropriately, the IEA expects the energy use to increase by 70%, and greenhouse gas emissions to increase by 50%, if no new policies are introduced [2]. Besides promoting the climate change, the increasing number of combustion engine vehicles adds to the problem of airborne particle pollution. According to WHO report, it already affects the health of more than 90% of the world's population [3].Thus, one of the challenges is to enable mobility without accelerating the climate change and prevent adding up to the already existing pollution problem [4]. Due to absence of emission during operation, Electric Vehicles (EVs) have become a promising technology that offers practical reduction of the CO2 emissions and air pollution if the increased power demand necessary to charge EVs is sustainable. To successfully implement the solution and maximize the technological advantage, it requires a multilevel approach that involves car manufacturers, car owners, building owners, and power system authorities to collaborate. EV deployment has been growing rapidly over the past ten years. The global stock of EV passenger vehicles passed 5 million in 2018, with an increase of 63% since 2017, and the rising trend continues. At the same time, there is also a growing trend of installation of EV charging points. Charging infrastructure follows the EV trend. In 2018, according to IEA in the global EV outlook, the number of charging points was estimated to be 5.2 million, which is 44% more than in 2017, where 90% were in the private sector [5].

A large number of Electric Vehicles (EVs) and the growing trend in installation of EV charging points may create more challenges for electrical power system. The EV charging patterns are stochastic due to uncertainties in the travel behavior of each individual driver and charging preferences. Coupled with increasing share of Renewable Energy Sources (RES) in the generation mix and their intermittent nature, large-scale EV charging can lead to grid overloading, especially during the peak loading hours [6–8]. With well-designed incentives for EV users and charging service providers, EVs may be used as flexible loads that help to mitigate the load variations and peak demand in the power system [8].

The present Report is prepared for a special issue on the subject of load modeling in power systems, where the general theme is modeling of loads in the context that includes analysis and control of existing electricity supply networks and future “smart grids”, at all voltage levels and in a variety of applications. Applications include measurement-based and component-based load modeling approaches, modeling and representation of aggregate loads and evaluation of their impact, load modeling in related “smart grid” applications, e.g., demand-side management and demand–response schemes, functionalities, and services. This report presents a modeling approach that allows one to use EV charger occupancy data for simulation of load power profiles. In the context of analysis and control of existing electricity supply networks, the current approach allows one to extend the existing modeling methods by creating seconds resolution load profiles of EV charging infrastructure, while utilizing the data straight from the service provider and mapping the possible expectations of load profiles during the demand-side management and demand response events. It is used to model various charging scenarios, e.g., with an increasing charging demand in the future it helps finding the necessary number of chargers and the peak load with the corresponding number of daily events, or use it on historical data obtainable from the local service provider. This is important to the building owner, as it is necessary to understand the approximate charger demand and peak power demand to be able to carry out a decision on, e.g., upgrading the charging infrastructure. Simulating scenarios of using EVs as a flexible load form litigation of load variation and load peaks by reducing or increasing the maximum charging load in the charging infrastructure allows one to showcase the pros of EVs as a flexible load and a necessity of a robust charging infrastructure, which implicates larger levels of EV penetration. Object-oriented design of the simulation tool allows one to incorporate real data, zoom in, and find possible bottlenecks in the availability of the service on standalone chargers. Aggregators and flexibility service providers want to understand the implications of adjusting the available charging power on the probability of having enough available procurement for delivery in DR events. It is beneficial to prepare a set of scenarios before creating a pilot to have expectations about the aggregate load and individual or collective response. The remainder of the article is organized as follows. Section 2 describes the types of EVs, relevant for modeling parameters, field EV charging data, and the modeling approach of the EV charging power. Section 3 presents the modeling results. Section 4 discusses the implications of utilizing the modeling approach for creating scenarios of EV profiles during the demand response (DR) events. It also discusses the bottlenecks for extending the research, as well as the future research directions. Section 5 provides the link to the source code for possible updates and documentation.

II. LITERATURE SURVEY

The basis of an electrified highway or e-Highway is an intelligent currentcollector combined with a hybrid drive system, where the eHighway trucks collect power from the overhead cables. The Electric highway is a technique where large trucks or vehicles, hybrids with dynamic pantographs on their bottom, attached or coupled to the overheadpower cables so as to get electricity from the powergrid. The Trolley bus is one of the electric buses with the main power source ofthe network catenary/overhead line with trolley pole as the point ofcontact. DWPT (Dynamic wireless power transfer) using three charging configurationsat three levels of EV densities without regenerative braking were compared. The results revealed that the sectional loop and long loop charging configurations offered the greatest benefits.

Previous research supports the importance of conducting EV modelling, investigating EVs and the related impact on the electric power system. Reference [9] proposes an optimization model for determining the capacity of RES, while utilizing

EVs with other sources to capture fluctuations of RES. Reference [10] utilizes Support Vector Regression (SVR) approach to create a charging load forecasting model based on various historical data. Reference [11] describes a model that forecasts the daily load profile of EV charging stations in commercial building premises. Reference [12] models power profiles using a variation auto-encoder. The research emphasizes that peak load will rise due to uncontrolled charging of EVs [13–16]. If it is possible to impact the charging behaviour, using different charging strategies, this flexible capacity could be used to keep the grid stable with an increased amount of variable renewable energy. With higher penetration of EVs, their batteries in an aggregate become a flexible capacity in the power system [8]. This is an opportunity to use them as individual and flexible loads which may be considered for grid-support to mitigate load variation and load peaks. Reference [17] describes how various EV charging strategies can help to reduce the peak demand and improve system load factor. If there are well-designed incentives for EV users to take part in grid-support, the value of driving an EV and having EVs in the electrical system increases. The opportunity of using EVs as grid ancillary services was studied in [18–22]. While modelling approaches in the literature

focus on modelling average hourly power profiles, modelling the demand-side management and demand response events requires minutes or even seconds resolution. For example, the technical requirements for participation in the frequency containment reserve in Finland require the activation time of the reserve from sub-minute values to 3 min, depending on the type of the reserve [23]. Taking into consideration that aggregated EV load is an intermittent and a stochastic source of flexibility, new data-driven modelling approaches require smaller resolution for modelling of power profiles

III. PROPOSED SYSTEM

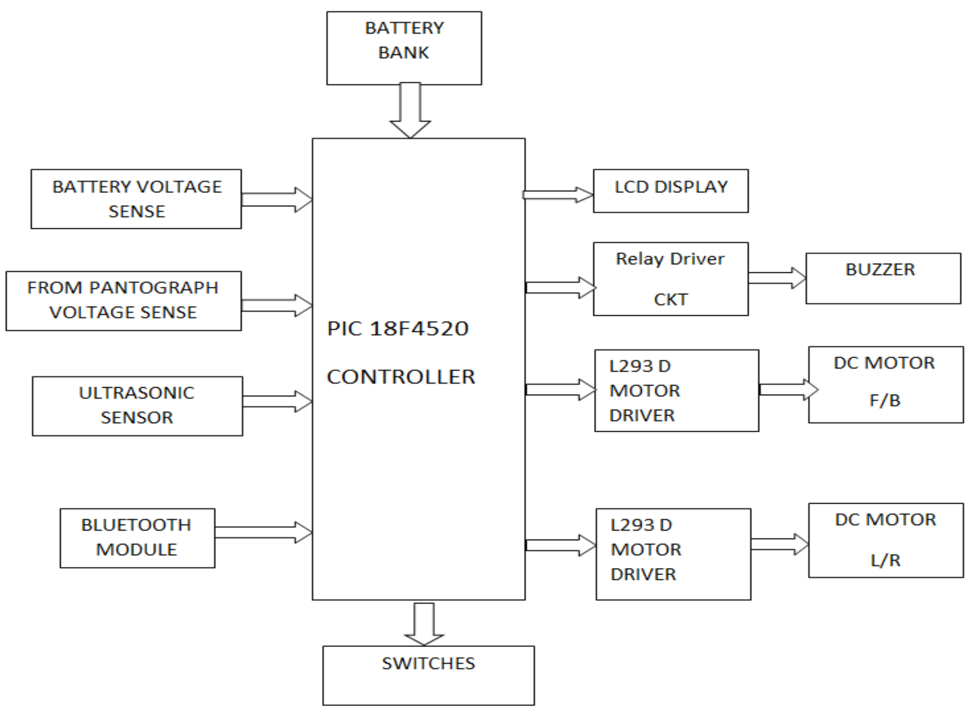

Fig. 1. Block Diagram (Vehicle unit)

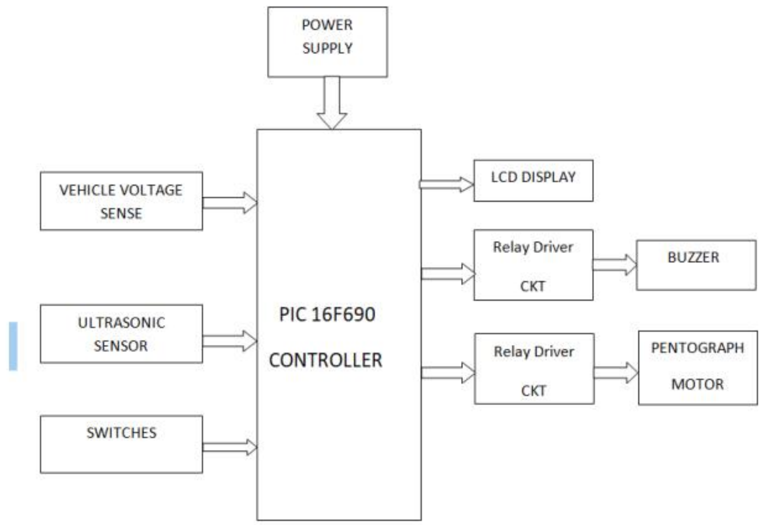

Fig. 2. Block Diagram (Charging Station unit)

The article presents a modelling approach which produces power profiles and impact of DR events on the peak power consumption of an aggregate of EV chargers. The approach is based on deriving parameters from distributions of the arrival time and the duration of charging, depending on the day type. In the contrast to the majority of the studies about EV charging power this data does not include prior knowledge about the state of charge (SOC) of the vehicle. Due to the present communication protocols between EVs and chargers, this parameter is not communicated during charging between the EV and the charging station. Thus, it is unavailable in the most datasets. In the presence of the described parameters, it is not as relevant to the objective of modelling power consumption profiles of aggregated chargers.

3.1 PIC 18f4520 Microcontroller

It is an 8-bit enhanced flash PIC microcontroller that comes with nanoWatt technology and is based on RISC architecture. Many electronic applications house this controller and cover wide areas ranging from home appliances, industrial automation, security system and end-user products. This microcontroller has made a renowned place in the market and becomes a major concern for university students for designing their projects, setting them free from the use of a plethora of components for a specific purpose, as this controller comes with inbuilt peripheral with the ability to perform multiple functions on a single chip.

- Data Memory up to 4k bytesn Data register map - with 12-bit address bus 000-FFF
- Divided into 256-byte banks
- There are total of F banks
- Half of bank 0 and half ofbank 15 form a virtual (oraccess) bank that is accessibleno matter which bank isselected – this selection isdone via 8-bit
- Program memory is 16-bits wide accessed through a separate program data bus and address bus inside the PIC18.
- Program memory stores the program and also static data in the system.
- On-chip External
- On-chip program memory is either PROM or EEPROM.
- The PROM version is called OTP (one-time programmable) (PIC18C) The EEPROM version is called Flash memory (PIC18F).

Maximum size for program memory is 2M n Program memory addresses are 21-bit address starting at location 0x000000

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Fig 3. PIC18F4520

3.2 PIC16f690 Microcontroller

The PIC16F range of microcontrollers from Microchip are 8-bit MCUs that incorporate Microchip's PIC® architecture into a variety of pin and package options, from space efficient 14-pin devices to feature-rich 64-pin devices. Devices with Baseline, Mid-Range or Enhanced Mid-Range architecture are available with numerous different peripheral combinations, giving designers flexibility and choice for their applications.

The PIC16F631/677/685/687/689/690 family of microcontrollers is based upon Microchip's Mid-range core with an 8 level deep hardware stack and 35 instructions. These MCUs provide up to 5 MIPS, up to 7 Kbytes program memory, up to 256 bytes RAM and Data EEPROM of up to 256 bytes. On board is a configurable oscillator factory calibrated to ±1% accuracy.

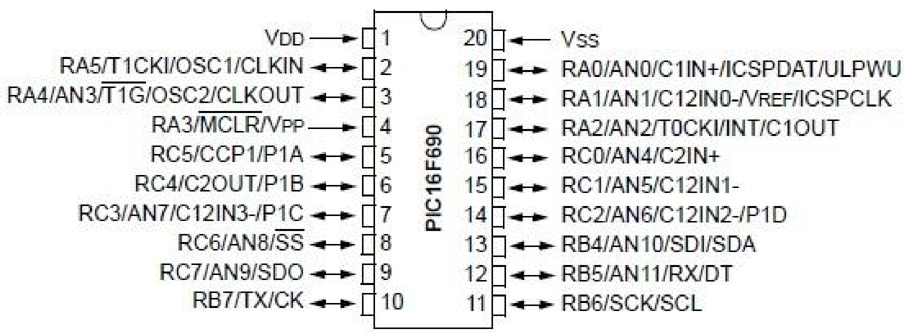

Fig. 4. PIC 16f690 microcontroller

3.3 Bluetooth Module (HC05)

- It is used for many applications like wireless headset, game controllers, wireless mouse, wireless keyboard and many more consumer applications.
- It has range up to <100m which depends upon transmitter and receiver, atmosphere, geographic & urban conditions.
- It is IEEE 802.15.1 standardized protocol, through which one can build wireless Personal Area Network (PAN). It uses frequency-hopping spread spectrum (FHSS) radio technology to send data over air.
- It uses serial communication to communicate with devices. It communicates with microcontroller using serial port (USART).
- HC-05 Bluetooth Module
- HC-05 is a Bluetooth module which is designed for wireless communication. This module can be used in a master or slave configuration

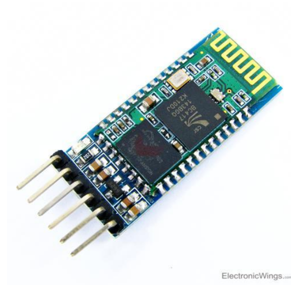

Fig 5. Bluetooth Module

3.4 LCD Display

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

.A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD.

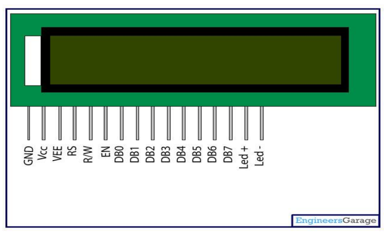

Fig. 6. LCD Display

3.5 DC Gear Motor

DC Motor – 10RPM – 12Volts geared motors are generally a simple DC motor with a gearbox attached to it. This can be used in all-terrain robots and variety of robotic applications. These motors have a 3 mm threaded drill hole in the middle of the shaft thus making it simple to connect it to the wheels or any other mechanical assembly. 10 RPM 12V DC geared motors widely used for robotics applications. Very easy to use and available in standard size. Also, you don't have to spend a lot of money to control motors with an Arduino or compatible board. The most popular L298N H-bridge module with onboard voltage regulator motor driver can be used with this motor that has a voltage of between 5 and 35V DC or you can choose the most precise motor diver module from the wide range available in our Motor divers' category as per your specific requirements. Nut and threads on the shaft to easily connect and internally threaded shaft for easily connecting it to the wheel. DC Geared motors with robust metal gearbox for heavy-duty applications, available in the wide RPM range and ideally suited for robotics and industrial applications. Very easy to use and available in standard size. Nut and threads on the shaft to easily connect and internally threaded shaft for easily connecting it to the wheel

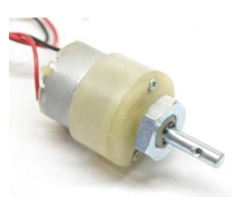

Fig. 7. DC gear Motor

3.6 Ultrasonic sensor

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules include ultrasonic transmitters, receiver and control circuit. The basic principle of work:

- Using IO trigger for at least 10us high level signal,
- The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
- IF the signal back, through high level, time of high output IO duration is the time from sending ultrasonic to returning.

Test distance = (high level time×velocity of sound (340M/S) / 2,

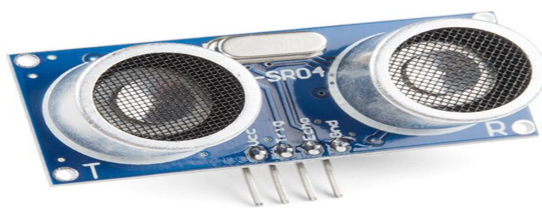

Fig. 8. Ultrasonic Sensor

This paper describes work that has been developed in order to provide a conceptual system to assist and manage Electrical Vehicles (EV) charging process. This proposed Smart EV Charging System uses Vehicle-to-Grid (V2G) technology, in order to connect not only Electric Vehicles, but also renewable energy sources, to Smart Grids (SG). The new paradigm of Electrical Markets (EM), with deregulation of electricity production and use, is also explored in this developed system, in order to optimize the prices of selling or buying electrical energy, to or from the electrical network.

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