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Wireless Charging of Electric Vehicle While Moving with dual input Sources

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Abstract: *This project presents a novel localization method for electric vehicles (EVs) charging through wireless power transmission (WPT) and solar based charging. With the proposed technique, the wireless charging system can self-determine the most efficient coil to transmit power at the EV's position based on the proximity sensors activated by its wheels. To ensure optimal charging, our approach involves measurement of the transfer efficiency of individual transmission coil to determine the most efficient one to be used. This not only improves the charging performance, but also minimizes energy losses by autonomously activating only the coils with the highest transfer efficiencies. The results show that with the proposed system it is possible to detect the coil with maximum transmitting efficiency without the use of actual power transmission and comparison of the measured efficiency. This project also proves that with the proposed charger set-up, the position of the receiver coil can be detected almost instantly and get charge while moving in the road. This indeed saves energy and boosts the charging time. Here we also introduce the solar panel in the top of the EV which indeed saves energy and boosts the charging time in day time. The vehicle battery voltage and current data can be monitoring continuously and updated in online.*

Keywords: *wireless power transmission, car charging, electrical vehicle, efficiency, charging pad, sensor network, smart charger.*

1. INTRODUCTION

During recent years, the electrification sector of transport, like trains, electric vehicles became one of the most attractive fields. In particular, the electric vehicle is increasingly attracting the attentions of industry and due of environmental issues and economic considerations. In 2016, the UK alone had more than 30 million cars registered and driven on the roads. The vehicle licensing statistics shows that in 2016, around 3.3 million cars were registered for the first time and 42,000 of the vehicles were ultra-low emission vehicles (ULEVs) It has also been predicted that by 2030, about 60% of all new vehicles sales in the UK will be electric vehicles (EVs) regarded as one of the most promising alternatives to the fossil fuel vehicles. Statistics indicate that in July 2018, 162,000 plug-in EVs (PEVs) were used on the roads. Furthermore, the number of electric cars models and brands available in the UK market have also grown rapidly during the recent years. The wireless charging of electric vehicles is based on the inductive power transfer between two mutually coupled coils, one is "primary" connected to charging station with solar and main supply and the other "secondary" connected to the battery of E-vehicle. The advantages provided by the wireless charging are in terms of safety and comfort, as the driver can avoid danger by using power cord and he needs to park the vehicle without the need of plug-in operation to start charging the battery. The WPT can also occur in reverse direction, so that the power could again be send from the vehicle battery to the grid in times of need. Thus, the wireless power transfer also fit for bi-directional power flow. This paper mainly keen on the concepts of wirelessly charging the electric vehicle. The wired charging can be mainly four types and all are explained. The charging can be done through pv-wind grid connected system. The use of solar and wind is pollution free and ecofriendly in use. We focus on the Wireless Power Transfer solution which uses magnetic resonant coupling between the primary ground coil and the secondary vehicle coil side. Using these techniques, power transfer can be fast and efficient of over 80% are possible. By eliminating the use of wiring, the Wireless Power Transfer simplifies the charging process. For a static WPT system, the driver's just need to park their car and the charging system will operate. For a dynamic WPT system, EV could be powered while driving in normal traffic; this makes it run forever without a stop. In recent years, the dynamic wireless power transfer received focus and is expected to extend the cruising distance of EVs.

objective

- This method can effectively realize by installing photovoltaic (PV) systems along the inter-urban routes and in rural areas. The power will be transferred from photovoltaic generator to the EVs via wireless power transfer systems.
- The energy availability, environment conservation and many other reasons, the electrification of vehicles has been carried out for many years.
- The electric vehicles (EVs) are considered as a solution for the environmental problem. However, large scale adoption of electric vehicle faces the range anxiety.
- The required system storage has to be with high energy and power density, affordable cost, long cycle life time, good safety and reliability; all these items complicate the design of the battery.
- Also the transmission efficiency has significantly improved over the years. Currently, efficiency of the WPT system can reach up to 96%.

2. LITERATURE SURVEY

The electric vehicles (EVs) are considered as a solution for the environmental problem. However, large scale adoption of electric vehicle faces the range anxiety. The required system storage has to be with high energy and power density, affordable cost, long cycle life time, good safety and reliability, all these items complicate the design of the batter. While researches keep optimizing battery technologies, the growing EVs markets demand more efficient and reliable system to recharge the battery. Such charging techniques can allow car manufacturers to reduce battery capacities (up to 20%); making the EVs more affordable. In this paper, we focus on the Wireless Power Transfer solution which uses magnetic resonant coupling between the primary ground coil and the secondary vehicle coil side. Using these techniques, power transfer can be fast and efficient of over 80% are possible. By eliminating the use of wiring, the Wireless Power Transfer simplifies the charging process. For a static WPT system, the driver's just need to park their car and the charging system will operate. For a dynamic WPT system, EV could be powered while driving in normal traffic; this makes it run forever without a stop. In recent years, the dynamic wireless power transfer received focus and is expected to extend the cruising distance of EVs. Firstly, the alternating power is converted to a direct current (DC) using AC to DC converter. Then the DC power is converted to high frequency AC power to drive the transmitting coil through a compensation network. Secondly, the primary and the secondary coil, the high frequency current in the primary side coil generates an alternating magnetic field, which induces an AC voltages on the receiving coil. By resonating with the secondary compensation network, the transferred power and efficiency are significantly improved. For high power applications, the power provided is not enough due to the losses between the transmitter and receiver. Leakage inductances between the coils lead to poor power transfer efficiency at the coils. The leakage inductance between the coils can be minimized by applying reactive current compensation between the coils. Compensation capacitor is used to improve power transfer capability and efficiency, and reduce requirement of power capacity. There are four basic resonant topologies of WPT system.

3. EXISTING SYSTEM & PROPOSED SYSTEM

Existing System:

- This existing system presents a novel method to improve the performance of the dynamic wireless recharge system.

- In this system, receiver coils have been added to maximize charging power by offering a dynamic mathematical model that can describe and measure source-to-vehicle power transmission even though it is in motion.
- In the mathematical model, all physical parameters describing the model were presented and discussed.

Advantages*:*

- The power loss can be overcome in the proposed system by detecting the vehicle using sensor that time only activate the coils to Transferring the power .

4. HARDWARE REQUIERMENTS & SPECIFICATION

The high-performance, low-power Atmel 8-bit ATMEL 16A RISC-based microcontroller combines 16KB ISP flash memory, 1KB SRAM, 512B EEPROM, an 8-channel/10-bit A/D converter (TQFP and QFN/MLF), and debug WIRE for on-chip debugging. The device supports a throughput of 20 MIPS at 20 MHz and operates between 2.7-5.5 volts.By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

Architectural Overview:

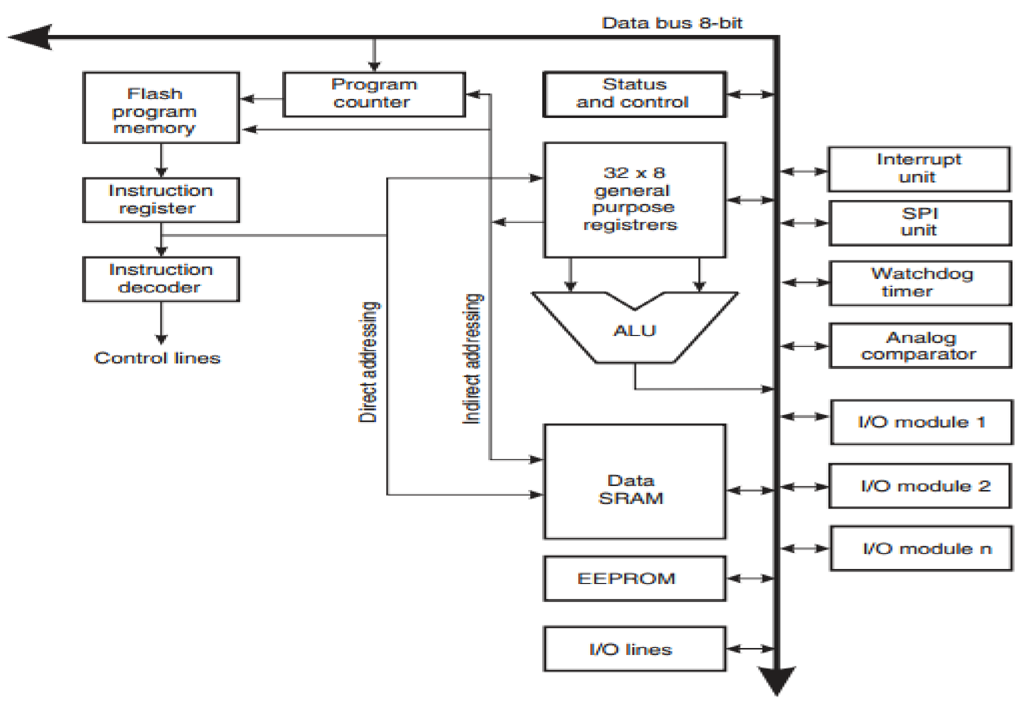

Figure.1 Architectural Overview of Atmel 16bit

In order to maximize performance and parallelism, the ATMEL 16 BIT uses a Harvard architecture – with separate memories and buses for program and data. Instructions in the program memory are executed with a single level pipelining. While one instruction is being executed, the next instruction is pre-fetched from the program memory. This concept enables instructions to be executed in every clock cycle. The program memory is In-System Reprogrammable Flash memory.

The ALU supports arithmetic and logic operations between registers or between a constant and a register. Single register operations can also be executed in the ALU. After an arithmetic operation, the Status Register is updated to reflect information about the result of the operation. Program flow is provided by conditional and unconditional jump and call instructions, able to directly address the whole address space. Most ATMEL 16BIT instructions have a single 16-bit word format. Every program memory address contains a 16-bit or 32-bit instruction. Program Flash memory space is divided in two sections, the Boot Program section and the Application Program section. Both sections have dedicated Lock bits for write and read/write protection. The SPM instruction that writes into the Application Flash memory section must reside in the Boot Program section. The memory spaces in the ATMEL 16BIT architecture are all linear and regular memory maps. A flexible interrupt module has its control registers in the I/O space with an additional Global Interrupt Enable bit in the Status Register. All interrupts have a separate Interrupt Vector in the Interrupt Vector table. The interrupts have priority in accordance with their Interrupt Vector position. The lower the Interrupt Vector address, the higher the priority. The I/O memory space contains 64 addresses for CPU peripheral functions as Control Registers, SPI, and other I/O functions. The I/O Memory can be accessed directly, or as the Data Space locations following those of the Register File, 0x20 - 0x5F. In addition, the ATmega48/88/168 has Extended I/O space from 0x60 - 0xFF in SRAM where only the ST/STS/STD and LD/LDS/LDD instructions can be used.

Voltage And Current Sensor:

Sensors are basically a device which can sense or identify and react to certain types of electrical or some optical signals. Implementation of Voltage and Current Sensor and current sensor techniques has become an excellent choice to the conventional current and voltage measurement methods.

Advantages of Sensors over Conventional Measuring Techniques

- Small in weight and size.
- Personnel safety is high.
- Degree of accuracy is very high.
- It is non-saturable.
- Wide dynamic range.
- Eco-friendly.
- It is possible to combine both the voltage and current measurement into a single physical device with small and compact dimensions.

In this article, we can discuss in detail about Voltage and Current Sensor. A Voltage and Current Sensor can in fact determine, monitor and can measure the supply of voltage. It can measure AC level or/and DC voltage level. The input to the Voltage and Current Sensor is the voltage itself and the output can be analog voltage signals, switches, audible signals, analog current level, frequency or even frequency modulated outputs. That is, some Voltage and Current Sensors can provide sine or pulse trains as output and others can produce Amplitude Modulation, Pulse Width Modulation or Frequency Modulation outputs.

In Voltage and Current Sensors, the measurement is based on the voltage divider. Mainly two types are of Voltage and Current Sensors are available- Capacitive type Voltage and Current Sensor and Resistive type Voltage and Current Sensor.

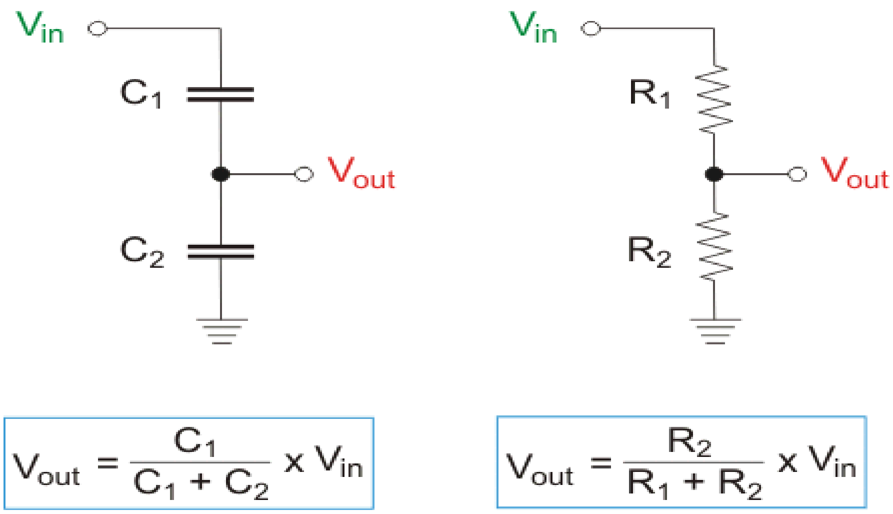

Figure 2. Voltage and Current Sensor circuit

Charging Circuit:

Here is a tried and tested sample circuit of a Li-Ion battery charger that can be used to charge any 3.7V Li-Ion battery using a 5VDC (USB, Solar Panel…) power supply. At the heart of the circuit is one microchip MCP73831, available in SOT-23-5 package. MCP73831 is a highly advanced linear charge management controller for use in space-limited, cost-sensitive applications. This IC employs a constant current/constant voltage charge algorithm with selectable preconditioning and charge termination.

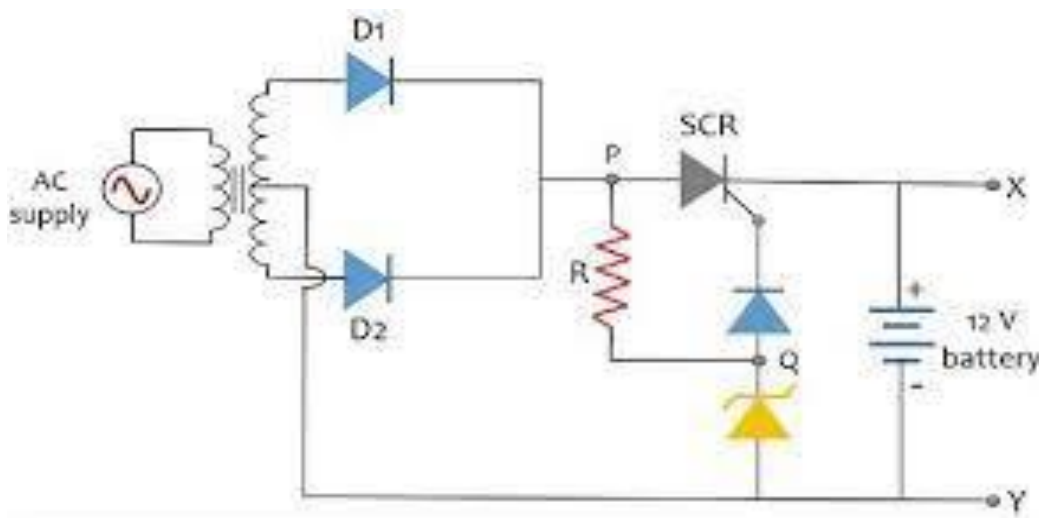

FIGURE 3. charging circuit

MCP73831

Lithium-ion batteries have become popular for portable electronics because they boast the highest energy density of any commercial battery technology. Benefits include thousands of recharges and no occurrence of the “memory effect” that infested early NiCd rechargeable cells. However, Li-ion batteries need to be charged following a carefully controlled constant current/constant voltage (CV-CC) pattern that is unique to this cell chemistry. Overcharging and careless handling of a Li-ion cell can cause permanent damage, or instability and potential danger!

DC-DC BOOSTER

A boost converter is one of the simplest types of switch mode converter. As the name suggests, it takes an input voltage and boosts or increases it. All it consists of is an inductor, a semiconductor switch (these days it's a MOSFET, since you can get really nice ones these days), a diode and a capacitor. Also needed is a source of a periodic square wave. This can be something as simple as a 555 timer or even a dedicated SMPS IC like the famous MC34063A IC.

FIGURE 4. dc-dc booster

The biggest advantage boost converters offer is their high efficiency – some of them can even go up to 99%! In other words, 99% of the input energy is converted to useful output energy, only 1% is wasted.

DC-DC Conversion

A DC to DC converter takes the voltage from a DC source and converts the voltage of supply into another DC voltage level. They are used to increase or decrease the voltage level. This is commonly used automobiles, portable chargers and portable DVD players. Some devices need a certain amount of voltage to run the device. Too much of power can destroy the device or less power may not be able to run the device. The converter takes the power from the battery and cuts down the voltage level, similarly a converter step-up the voltage level. For example, it might be necessary to step down the power of a large battery of 24V to 12V to run a radio.

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Boost Converter Operation

There is yet another way of thinking about the operation of a boost converter.

We know that the energy stored in an inductor is given by:

½ x L x I2

Where L is the inductance of the coil and I is the maximum peak current.

So we store some energy in the inductor from the input and transfer that same energy to the output though at a higher voltage (power is conserved, obviously). This happens many thousands of times a second (depending on the oscillator frequency) and so the energy adds up in every cycle so you get a nice measurable and useful energy output, for example 10 Joules every second, i.e.10 watts.

As the equation tells us, the energy stored in the inductor is proportional to the inductance and also to the square of the peak current.

To increase output power our first thoughts might be to increase the size of the inductor. Of course, this will help, but not as much as we think! If we make the inductance larger, the maximum peak current that can be achieved in a given time decreases, or the time taken to reach that current increases(remember the basic equation V/L = dI/dt), so the overall output energy does not increase by a significant amount!

However, since energy is proportional to the square of the maximum current, increasing the current will lead to a larger increase in output energy!

So we understand that choosing the inductor is a fine balance between inductance and peak current.

With this knowledge we can being to understand the formal method of designing a boost converter.

H-Bridge Motor Control

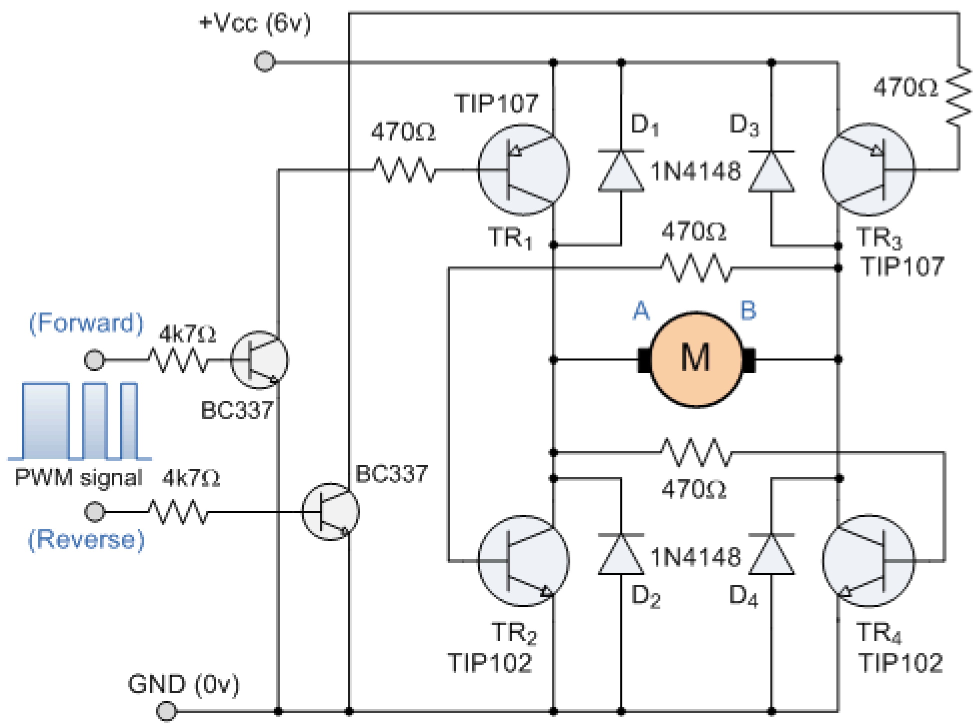


FIGURE 5. driver boardMOTOR CONTROL

The four transistors are connected together in a "H-bridge" configuration with the motor connected in the middle. To make the motor rotate in the forward direction, a high (logic "1″or +5V) signal is applied to the forward input, while no signal is applied to the reverse input (applying a voltage to both inputs at the same time is not allowed). The speed of the motor is controlled by using the pulse width modulating signal as before. Transistors TR1 and TR4 conduct. Current flows from terminal A through to terminal B (left-to-right direction) of the motor. To reverse the motor's direction a high signal is applied to the reverse input and transistors TR3 and TR2 conduct, allowing current to pass through the motor in the opposite direction from terminal B through to terminal A (right-to-left direction). The flywheel diodes, D1 to D4 across the transistors of the H-bridge motor control circuit help to protect the transistors from any induced back emf generated by the motor during braking. Any suitable PNP or NPN transistor can be used other than the ones above, but all the transistors should have high power ratings, if not use heatsinks.
While it is possible to construct the H-bridge motor control circuit from scratch using individual components, there are lots of IC's and "black boxes" available off-the-shelf to make motor speed control and design far easier and usually cheaper. Two H-bridge motor control IC's that are popular and easy to connect are the National Semiconductors LMD18200 and the Texas Instruments L293D motor-driver chips. Both are easy to use with in-built diodes, shorted circuit protection and are TTL and CMOS compatible.

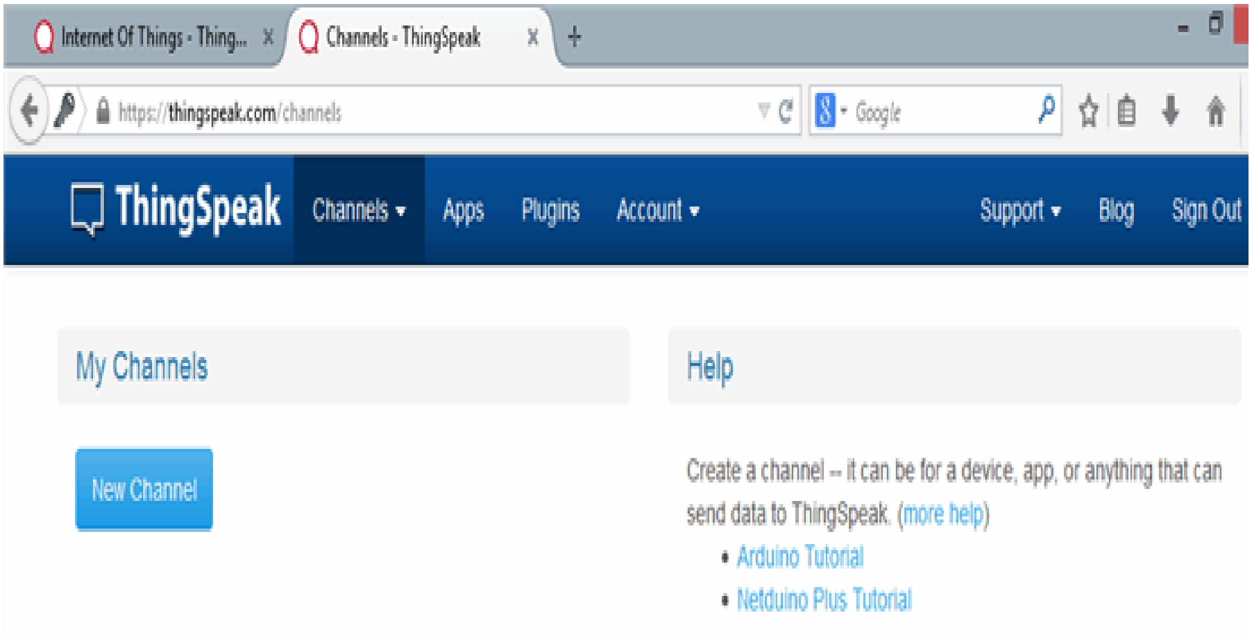
Thingspeak Web Page

Thing Speak is a platform providing various services exclusively targeted for building IoT applications. It offers the capabilities of real-time data collection, visualizing the collected data in the form of charts, ability to create plugins and apps for collaborating with web services, social network and other APIs. We will consider each of these features in detail below.
The core element of Thing Speak is a 'Thing Speak Channel'. A channel stores the data that we send to Thing Speak and comprises of the below elements:

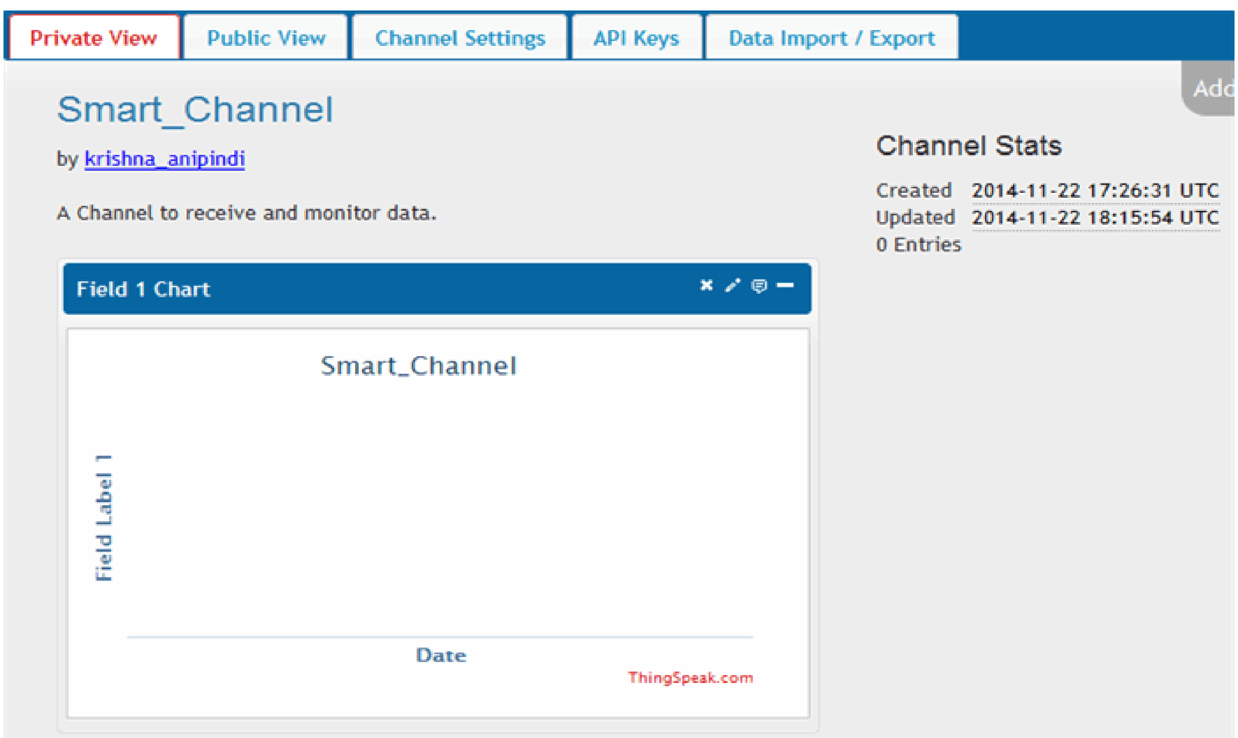
- 8 fields for storing data of any type - These can be used to store the data from a sensor or from an embedded device.
- 3 location fields - Can be used to store the latitude, longitude and the elevation. These are very useful for tracking a moving device.

- 1 status field - A short message to describe the data stored in the channel.

To use Thing Speak, we need to sign up and create a channel. Once we have a channel, we can send the data, allow Thing Speak to process it and also retrieve the same. Let us start exploring Thing Speak by signing up and setting up a channel.

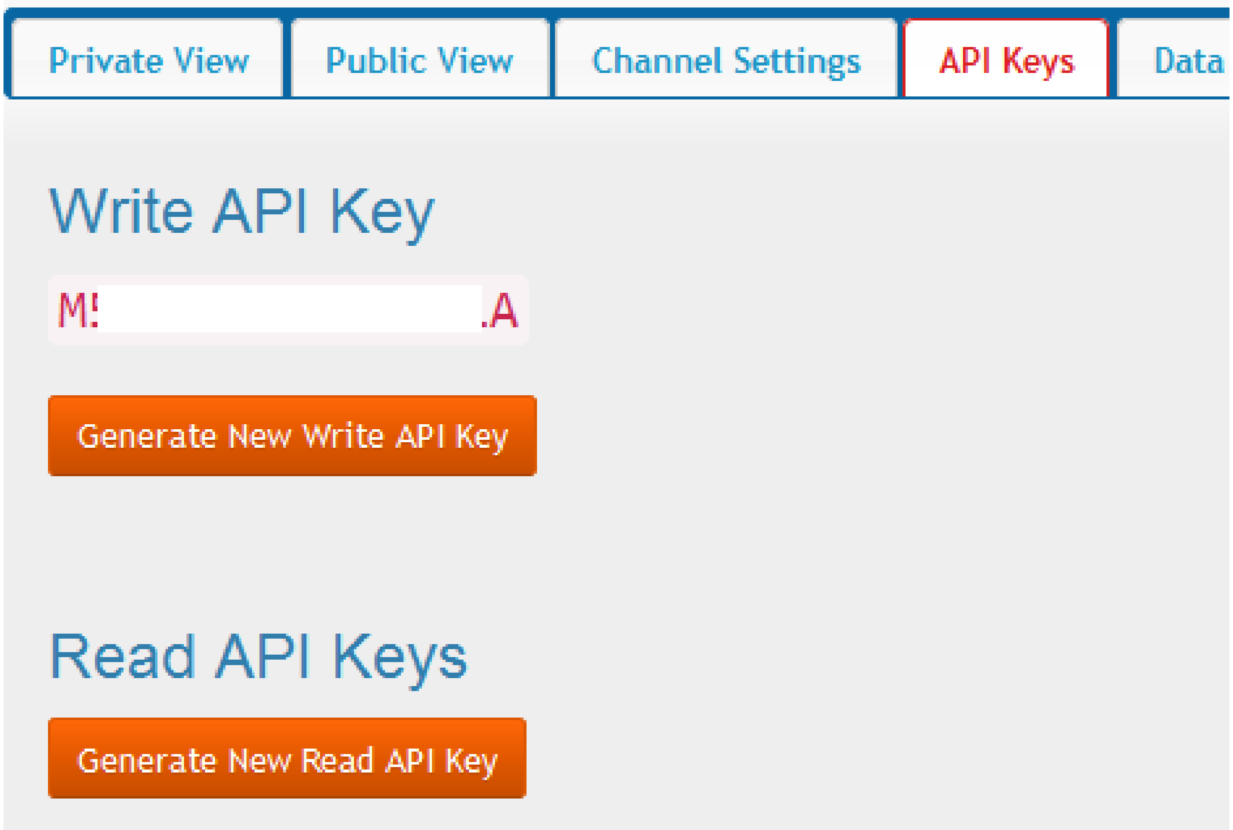


Go ahead and click on 'New Channel'. You should see a page like the below:



The Private View shows a chart corresponding to each of the fields that we have added. Now click on the 'Public View' tab. This should look exactly similar to the we see in the 'Private View' tab since our channel is public. In case your channel is not public ('make public' check box not checked in the 'channel settings' tab), the public view tab shows a message that 'This channel is not public'.

Now click on the 'API Keys' tab. You should see a screen similar to the below. The write API key is used for sending data to the channel and the read API key(s) is used to read the channel data. When we create a channel, by default, a write API key is generated. We generate read API keys by clicking the 'Generate New Read API Key' button under this tab. You can also add a note corresponding to each of the read API keys.



Introducing Ip Addresses

An IP address is a number that uniquely identifies every host on an IP network. IP addresses operate at the Network layer of the TCP/IP protocol stack, so they are independent of lower-level Data Link layer MAC addresses, such as Ethernet MAC addresses.

IP addresses are 32-bit binary numbers, which means that theoretically, a maximum of something in the neighborhood of 4 billion unique host addresses can exist throughout the Internet. You'd think that would be enough, but TCP/IP places certain restrictions on how IP addresses are allocated. These restrictions severely limit the total number of usable IP addresses. Many experts predict that we will run out of IP addresses as soon as next year. However, new techniques for working with IP addresses have helped to alleviate this problem, and a standard for 128-bit IP addresses has been adopted, though it still is not yet in widespread use.

Networks and hosts

IP stands for Internet protocol, and its primary purpose is to enable communications between networks. As a result, a 32-bit IP address actually consists of two parts:

- The network ID (or network address): Identifies the network on which a host computer can be found
- The host ID (or host address): Identifies a specific device on the network indicated by the network ID

Most of the complexity of working with IP addresses has to do with figuring out which part of the complete 32-bit IP address is the network ID and which part is the host ID, as described in the following sections.

As describe the details of how host IDs are assigned, you may notice that two host addresses seem to be unaccounted for. For example, the Class C addressing scheme, which uses eight bits for the host ID, allows only 254 hosts - not the 256 hosts you'd expect. That's because host 0 (the host ID is all zeros) is always reserved to represent the network itself. The host ID can't be 255 (the host ID is all ones) because that host ID is reserved for use as a broadcast request that's intended for all hosts on the network.
IP addresses are usually represented in a format known as dotted-decimal notation. In dotted-decimal notation, each group of eight bits - an octet - is represented by its decimal equivalent. For example, consider the following binary IP address:
11000000101010001000100000011100
To convert this value to dotted-decimal notation, first divide it into four octets, as follows:
11000000 10101000 10001000 00011100
Then, convert each of the octets to its decimal equivalent:
11000000 10101000 10001000 00011100
192 168 136 28
11000000101010001000100000011100
To convert this value to dotted-decimal notation, first divide it into four octets, as follows:
11000000 10101000 10001000 00011100
Then, convert each of the octets to its decimal equivalent:
11000000 10101000 10001000 00011100
192 168 136 28

Classifying IP Addresses When the original designers of the IP protocol created the IP addressing scheme, they could have assigned an arbitrary number of IP address bits for the network ID. The remaining bits would then be used for the host ID. For example, suppose that the designers decided that half of the address (16 bits) would be used for the network, and the remaining 16 bits would be used for the host ID. The result of that scheme would be that the Internet could have a total of 65,536 networks, and each of those networks could have 65,536 hosts.
In the early days of the Internet, this scheme probably seemed like several orders of magnitude more than would ever be needed. However, the IP designers realized from the start that few networks would actually have tens of thousands of hosts. Suppose that a network of 1,000 computers joins the Internet and is assigned one of these hypothetical network IDs. Because that network will use only 1,000 of its 65,536 host addresses, more than 64,000 IP addresses would be wasted.
As a solution to this problem, the idea of IP address classes was introduced. The IP protocol defines five different address classes: A, B, C, D, and E. Each of the first three classes, A-C, uses a different size for the network ID and host ID portion of the address. Class D is for a special type of address called a multicast address. Class E is an experimental address class that isn't used.
The first four bits of the IP address are used to determine into which class a particular address fits, as follows:

- If the first bit is zero, the address is a Class A address.
- If the first bit is one and if the second bit is zero, the address is a Class B address.
- If the first two bits are both one and if the third bit is zero, the address is a Class C address.
- If the first three bits are all one and if the fourth bit is zero, the address is a Class D address.
- If the first four bits are all one, the address is a Class E address.

Because Class D and E addresses are reserved for special purposes, focus the rest of the discussion here on Class A, B, and C addresses. Table-3 summarizes the details of each address class.

5. CONCLUSION

This project control method based on the primary voltage estimation using only vehicle-side information to simplify ground facilities on a dynamic WPT system. Experiments verified that the primary voltage estimation was achieved and the power control using the equilibrium point calculation based on the primary voltage estimation is effective for the dynamic WPT system, which can be simplified and not be required to regulate the road-side voltage. We also implemented the charging system with solar input source. The solar panel is added in the top of the vehicle for charging the battery in day time and which will help us in alternating way.Due to their suitability for EVs charging application in both power and range level.The basic principle of each technology is explained. The latest development and research are summarized.

REFERENCES

[1]. Y. Hori, "Future vehicle driven by electricity and control-research on four-wheel-motored "UOT electric March II"," IEEE Transactions on Industrial Electronics, vol. 51, no. 5, pp. 954-962, Oct. 2019

[2]. M. Yilmaz, V. T. Buyukdegirmenci, and P. T. Krein, "General design requirements and analysis of roadbed inductive power transfer system for dynamic electric vehicle charging," in Proc.2018 IEEE Transportation Electrification Conference and Expo, 2018 pp. 1-6.

[3]. S. Raabe and G. A. Covic, "Practical design considerations for contactless power transfer quadrature pick-ups," IEEE Transactions on Industrial Electronics, vol. 60, no.1, pp.400-409, Jan. 2017.

[4]. K. Throngnumchai, A. Hanamura, Y. Naruse, and K. Takeda, "Design and evaluation of a wireless power transfer system with road embedded transmitter coils for dynamic charging of electric vehicles," in Proc.The 27th International Electric Vehicle Symposium and Exhibition, 2017pp. 1-5.

[5]. S. Lee, B. Choi, and C. T. Rim, "Dynamics characterization of the inductive power transfer system for online electric vehicles by Laplace phasor transform," IEEE Transactions on Power Electronics, vol. 28, no. 12, pp. 5902-5909, Dec. 2018.

[6]. J. Shin, S. Shin, Y. Kim, S. Ahn, S. Lee, G. Jung, S. Jeon, and D. Cho, "Design and implementation of shaped magnetic-resonance-based wireless power transfer system for roadway-powered moving electric vehicles," IEEE Transactions on Industrial Electronics, vol. 61, no. 3, pp. 1179- 1192, Mar. 2019

[7]. G. R. Nagendra, L. Chen, G. A. Covic, and J. T. Boys, "Detection of EVs on IPT highways," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 2, no. 3, pp. 584-597, Sep. 2016.

[8]. K. Lee, Z. Pantic, and S. M. Lukic, "Reflexive field containment in dynamic inductive power transfer systems," IEEE Transactions on power Electronics, vol. 29, no. 9, pp. 4592-4602, Sep. 2017.

[9]. A. Kurs, A. Karalis, R. Moffatt, J. D. Joannopoulos, P. Fisher, and M. Soljacic, "Wireless power transfer via strongly coupled magnetic resonance," Science Express on 7 June 2007, vol. 317, no. 5834, pp. 83-86, Jun. 2017.

[10]. T. Imura, T. Uchida, and Y. Hori, "Flexibility of contactless power transfer using magnetic resonance coupling to air gap and misalignment for EV," World Electric Vehicle Association Journal, vol. 3, pp. 1-10, 2019.

[11]. M. Kato, T. Imura, and Y. Hori, "New characteristics analysis considering transmission distance and load variation in wireless power transfer via magnetic resonant coupling," in Proc. IEEE 34th International Telecommunications Energy Conference, 2018, pp. 1-5.

[12]. S. Li and C. C. Mi, "Wireless power transfer for electric vehicle applications," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. PP, no. 99, pp. 1-14, Apr. 2019.

[13]. Y. Moriwaki, T. Imura, and Y. Hori, "Basic study on reduction of reflected power using DC/DC converters in wireless power transfer system via magnetic resonant coupling," in Proc. IEEE 33rd International Telecommunications Energy Conference, 2018, pp. 1-5.

[14]. K. Iimura, N. Hoshi, and J. Haruna, "Experimental discussion on inductive type contactless power transfer system with boost or buck converter connected to rectifier," in Proc. IEEE 7thInternational Power Electronics and Motion Control Conference, 2020 , vol. 4, pp. 2652-2657.

[15]. K. Takuzaki and N. Hoshi, "Consideration of operating condition of secondary-side converter of inductive power transfer system for obtaining high resonant circuit efficiency," IEE Japan Transactions on Industry Applications, vol. 132, no. 10, pp. 966-975, Oct. 2017. (in Japanese)

[16]. H. Ishihara, F. Moritsuka, H. Kudo, S. Obayashi, T. Itakura, A. Matsushita, H. Mochikawa, and S. Otaka, "A voltage ratio-based efficiency control method for 3 kW wireless power transmission," in Proc. The 29th Annual IEEE Applied Power Electronics Conference and Exposition, 2018, pp. 1312-1316.

[17]. M. Kato, T. Imura, and Y. Hori, "Study on maximize efficiency by secondary side control using DC-DC converter in wireless power transfer via magnetic resonant coupling," in Proc. The 27th International Electric Vehicle Symposium and Exhibition, 2017, pp. 1-5.

[18]. T. Imura and Y. Hori, "Maximizing air gap and efficiency of magnetic resonant coupling for wireless power transfer using equivalent circuit and Neumann formula," IEEE Transactions on Industrial Electronics, vol. 58, no. 10, pp. 4746-4752, Oct. 2018.

[19]. D. Gunji, T. Imura, and H. Fujimoto, "Fundamental research of power conversion circuit control for wireless in-wheel motor using magnetic resonance coupling," in Proc. 40th Annual Conference of the IEEE Industrial Electronics Society, 2017, pp. 3004-3009.

[20]. D. Takei, H. Fujimoto, and Y. Hori, "Load current feedforward control of boost converter for downsizing output filter capacitor," in Proc. 40th Annual Conference of the IEEE Industrial Electronics Society, 2018, pp. 1581-1586.

