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RESEARCH ARTICLE

Charging our Electrical Devices in Anywhere and at any time

Lam Kai Shun Carson

Department of Mathematics, University of Hong Kong, Pokfulam, Hong Kong

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ABSTRACT

Being able to charge electronic devices anywhere is a modern-day problem. That said, "Made in China" external charging devices can solve this problem to some extent. However, these devices are often poor quality and can be a fire hazard. To address this issue, the author suggests using an electromagnetic (EM) spread spectrum, which is highly related to harvesting electrical energy from clean, renewable energy sources, and then transmitted to charge all types of electrical devices. By applying this author's proposed probability-random variables assignment — each type of EM wave is associated with a special channel with a centralized management information system (MIS) controlled in the background. Such design can avoid EM-wave interference and encourage a delicate (or special) channel for energy transmitting. Hence, it can solve electrical devices charging problem or one may get the device charged anywhere and anytime. Furthermore, with a professional electronic circuit design, together with meta-materials coated on the surface of a set antenna block, 90–100% of harvested renewable-clean energy might be transmitted. There is an alternative way of charging by using inductive coils; however, there are some defects in such case. Further advance is the introduction of EM wormhole which can shield human beings from the influence of magnetic flux outside the tunnel during charging.

Key words: Electrical device, Electromagnetic, Energy

BACKGROUND

In our modern world, energy has always been a problem of our human beings. This is because fossil fuel usually causes pollution. Clean energy sources such as wind and solar are still in the developing stages although they are expected to replace fossil one. My proposal aims to study how one can convert those clean energy sources into electrical energy and then charging our usual electrical devices through common electro-magnetic (EM) waves wirelessly such as either Wi-Fi, Bluetooth or infra-red. My theoretical framework for the research is stated as follows:

Research Framework

Consider the following imaginary statistical experiment that is often used when teaching statistics:

Address for correspondence:
Lam Kai Shun Carson
E-mail: h9361977@connect.hku.hk

One should first toss three (or more) coins together in front of the participants, such that heads are on the front and tails are on back. The participants are then required to list all possible outcomes after tossing the coins.

In general, the set of all feasible results (outcomes) would be:

S = {HHH, HHT, THH, HTT, THT, TTH, TTT} (suppose one will obtain such expected result). There are also other combinations and permutations of heads and tails when each of them are assigned with a number. Hence, the outcome space is not just unique.

Finally, the participants must count the number of tails for each possible outcome and then list them on a table, as seen below:

Possible Outcomes (s_i)	HHH	HHT	HTH	THH
No. of tails obtained t_i	0	1	1	1
	HTT	HTT	TTH	TTT
	2	2	2	3

(Obviously, the above table is NOT just the only one; there are lots of possible outcomes different ways of mapping tails. Instead of using tails, one may use no of heads for the mapping as an example.)

Consider a function f (which should be called as the random variable). Intuitively,
f maps all the possible outcomes (s_i) to the number of tails T_i
f_i: s_i| sot_i (i.e. no. of tails obtained as it takes values t = 0,1,2,3 … by HKU, Dr. K.T. Leung's lecture note 1993–1994).
or strictly speaking
f: Srictly spe, **R – Real Number**).
One may group the same random variables (with similar outcomes) to the home-used EM networks (such as wi-fi, RF, infra-red, and Bluetooth), respectively.
I.e. 0 → Bluetooth; 1 → Wi – Fi; 2 → infra-red; 3 → RF (Radio Frequency);
Together with an Information management system (including a password login each network individually).
In our home environment (can also be extended for street/telephone booth), there are lots of EM wave such as infra-red, Wi-Fi, and RF together with Bluetooth. By introducing a MIS (together with a password) to assign each EM wave with a suitable channel (as mentioned in the previous section), one can login into an individual network system once at a time without causing interference to each other. Upward a step, with the MIS and some meta-materials to the antenna, one can collect EM-wave (e.g., microwave). Although the received electronic signals may not be larger enough, if one can design a suitable rectifier circuit, it is feasible for us to employ the output D.C voltage to charge our electrical devices. That is one can convert the microwave energy backward to achieve our daily usage consumption.
The above plan is only feasible in theory. In practice, the induced current or voltage may be too low to charge any electrical device. To make the scheme possible, there should be a special/dedicated channel for the purpose of microwave to devices charging. Hence, the power output for charging devices and the power gained by these devices will be larger. Under my imaginary suggestion, there will be a combined way of collecting electricity from our nature resources such as solar and wind. These energies are then stored in charging batteries and will be used as a source for dedicated wife charging. In addition, these stored energies are then used in places such as our common street light and telephone booth which used as the source of dedicated Wi-Fi for charging to our usual electrical devices with higher power of electricity output once logged in. Then both the low voltage and current problem will have solved immediately once our government or telecommunication company is willing to investigate in a such unprecedented plan of proposed "microwave" charging project.
Therefore, the following is the expected procedure for charging an electrical device:
Step I: Clean Energy Source (Solar/wind energy, etc.) to charge batteries.
Step II: Charged Batteries as sources of energy for special EM wave channel.
Step III: Special EM wave channel sources in street light/telephone booth.
Step IV: Login street light/telephone booth for wireless charge electrical devices besides the charging procedure, there are also some practical questions concerning about the possibilities of my proposed charging scheme, thus here comes the three research questions:

1. What kind of EM waves will give the maximum current and voltage output that is best suited for wireless charging?
2. How can we achieve the maximum gain of both current and voltage from the rectifier circuit for electrical devices charging? What are those factors influenced?
3. What is the energy convenience and efficiency for this kind of wireless charging scheme when compared with traditional fossil or only clean energy scheme? Does the proposed schedule feasible for us to implement?

METHODOLOGY

The main objectives or research aim of this study is to investigate the feasibility of wireless charging to electrical devices through a dedicated or special channel of EM wave (come through street light/telephone booth) where the energy sources mainly from clean energy (such as solar/wind) to charge batteries. The core theory has been mentioned in the research framework section (tossing coin experiment) while the method of implementation can be employed through the EM wave meta material antenna (for receiving microwave only; other designs may be needed for different types of EM waves). The application domain is to use electronic circuit for the transportation of wireless induced current or voltage such that one is able to charge different kinds of electrical devices. The major methodologies that I used in this proposal are comparative, descriptive together with experimental one. It is because we want to compare people's past/present experience in the convenience and efficiency when using fossil fuels, unconverted clean energy and the suggested charging scheme. We also want to observe (as a means of collecting magnified current and voltage data) how well in descriptive way (what are those factors influence) will the electronic circuit provide a gain to both current and voltage. Finally, one will need to practically perform those experiments through isolating and controlling every relevant condition which determines the events investigated, so as to observe the effects when the conditions are manipulated. Then one can decide the feasibility of my proposed wireless charging scheme.

Indeed, one may categorize the research paradigms (or models) into quantitative and qualitative approach. For the quantitative one, it is usually referred to the testing of theories, establishing facts together with the showing causal or other relationships between variables. This will be achieved via statistical, mathematical, or computational techniques. For the qualitative one, it is used for the developing theories, exploring a topic, and developing a hypothesis. This can be realized through those scientific method of observation to obtain non-numerical data such as meanings, concepts of definitions characteristics, metaphors, symbols, and description of things and not to their counts or measures (Berg *et al*., 2012).[1] Therefore, both of the comparative and descriptive methodologies are of qualitative types while the experimental one is quantitative kind. This research is then a mixed method of study.

When one is concerning about data collecting procedures or research design, one needs to use a questionnaire for the comparison of different experience in energy type of usage. Hence, those non-essential characteristics of phenomena can be eliminated by looking at multiple instance of it. It can be conducted at a marco (revolutions) or a micro level (individual experiences). Actually, the questionnaire is a set of questions.

Qualitative information will be gathered from a particular population (most likely to be randomly selected electrical device users and student researcher as testers). Those responses will not be aggregated for analysis. The questionnaire items will have four response categories such as "agree a lot," "agree a little," "disagree a little," and "disagree a lot" (Lam, 2018).[2] The major questions for normal users will focus in their experience of energy using - fossil, traditional clean energy and the present wireless charging where one will particularly study in their convenience of usage. While for those testers, the energy efficiency of the above three form of charging will also be questioned. I note that testers are those student researchers who will be answered in the energy efficiency questionnaire part's questions as the questionnaire is divided into two parts; one for ordinary user to question about convenience, the other is for student researchers (or testers) who will answer in the matters of energy efficiency. This is for the comparative research design.

For the descriptive research design, observations will be performed as a means of collecting qualitative data which attempt to examine those normal situations. One will also try to predict the outcome when the same circumstances happened. These observations will be written or recorded for the subsequently analyzed. However, biased questions may result the distorted data in interviews, questionnaire and selective observation of events. In this study, observation is used to investigate what those factors that are influencing electric current is wirelessly transferred from past experienced mathematical data together with interviews to expert researchers.[3] In fact, interviews offer a way for researchers to understand the relationships behind wireless current transportation and those influencing factors (Seidman, 1998).[4] Furthermore, interviews are also well- known as a tool for understanding the reasons behind the gain and factors. I remark that Cool and Xie (2000)[5] used interviews as a supplementary way to survey and document choices. Hence, both relationships and reasons will be found between those investigated variables.

Finally, there will be the practical experiment design with each factor being controlled individually to study the wireless transportation of received current from the electronic circuit. Causes and effects of their relationships will be the most interesting thing for me to research. Thus, correlation and ex post facto is implemented. Quantitative data will be collected in each of the cases. Actually, there are four types of experimental design. The first one is "Pre-experimental" where one will have made unreliable assumption without sufficient control over variables. The second one is "True experimental" where there will be a rigorous test in the similarity of groups before one is trying to test the influence of a variable to a sample of them when those circumstances are controlled. The third one is "Quasi- experimental" where only the shortcomings are identified without fulfilling all conditions of true experimental design. The last one is "Correlation and ex post facto" where correlation is used for the finding of cause and effect relationships between two sets of data; ex post facto is a reverse experimentation. It is employed to interpret the cause of phenomenon by observing its effects.

Outcomes and Values

The expected outcome of my research is that: It is feasible for us to make modifications to our street light and telephone booth for the wireless charging of electrical devices through a special EM wave channel from clean energy source's charged batteries. Although the energy efficiency may not be the best among fossil fuel and traditional clean energy, the proposed charging scheme is more convenient (where one can charge the electrical devices whenever he/she finds the street light/ telephone booth) and safer (when compared with explosive external China made charging batteries). In addition, those common electronic symbols are employed to represent the rectifier circuit. Thus, it will easier for one to design, test and make amendments to it such that one can maximize the current and voltage obtained for wireless charging electrical devices whenever necessary. One of my design's advantages is that the device will only need an EM wave receiving antenna and rectifier circuit without buying and redesigning any new electrical devices. The most significant value of the scheme is one can charge any electrical devices anywhere in the world without carrying any other extra charging devices when the (modified or smart) street light or telephone booth exists for logging in with the known password.

Limitations and Advantages over Other charging

There are also limitations to the above proposed charging scheme. First of all, the energy efficiency (about 37% of conversion, from Duke University, microwave experiment) may not be as good as expected. It is hard to convert all energy during the transmission between EM wave source and receiver since microwave signal propagates in all directions and the power will drop when the source sphere is extending larger (N.B. maximum power may be gained at the pole of it. [Ali *et al*., 2015]).[6] Obviously, there must be energy lost during transmission so there may be a need to redesign the antenna.

Furthermore, it may be hard to unify all standard of street light/telephone booth around our world's different countries. Hence, it is required to memories various passwords which leads to the danger of lost. Finally, too strong EM wave power may cause harmful effect to our human life's healthy.

6.1 A Comparison with charging through electric induction.

Theoretically, Maxwell equations tell us that if there is a time varying electric field, then a displacement current will be produced which is indeed proportional to the rate of change of the field. As a result, the induced current appears on the sender side will allow energy to be delivered among the space between different plates and hence act as role like a capacitor. When one is applying a load on the plates of the receiver side, there will be an induced electric charges moving between the side of the two plates. The result is mainly due to the time-varying displacement current moving around on the other side. This is known as "Capacitive Coupling." The aforementioned theory is widely used in our present daily mobile phone wireless charging. When one moves up a stair, one may create an EM wormhole (which is a virtual one but not the physical space-time wormhole) with meta-materials and induced current on the plates of the other sides of the coupled capacitor. It is true that the technique can also avoid EM interference but there are several disadvantages over my proposed one. They are:

1. Longer charging time: If one provides the same power for the charging, most devices take 15% longer (in general) to charge. From the following graph, one may observe that wired charging is much faster (or the charging rate is better) than wireless charging for mobile phone. Thus, this author suggests that it is wise for us to charge electric devices directly. In my design, the energy source is a clean one, and then it is transferred through EM waves (e.g., microwaves) to the receiver. The resultant electrical energy is charged directly to the electric devices. The whole process is faster.

2. More money is spending: It will increase the complexity of the charging process and manufacturing cost. This is because inductive charging needs drive electronics and coils in both sides of senders and receivers. This is practically known as resonance inductive charging. However, in my proposed design, it seems that only electronic circuits are required for receiving transmitted energy from the sender. The next part that connected to the devices is wired. It should be much simpler and cheaper
3. Poor mobility: In most cases, the present practical inductive pad's mobility is very poor. This is because people should place their phone statically on the induction pad without moving. However, for the wired charging, one may move the phone anywhere if the wire is long enough and even listen to the phone call. In my design, since the telephone booth and street light are all over any countries, it must be a convenient and safe method for charging outside homes
4. No common standard exists: Until recently, there is no common standard in the inductive charging standard. Different devices require different charging devices. Devices may need to fulfill multiple standards. However, wired charging standard has been unified for some times which is not same as wireless one. My design employs wired charging which does not have the problem of standard
5. Low efficiency: The efficiency of wired charging is much higher than the wireless one. Moreover, devices may get hotter during inductive charging. This may harm the battery. In my design, there will be a warning signal when the device is full charged through wire. This can prevent it from overheated or charged.

Miscellaneous for Receiver Electronic Circuits and Antenna Array Design

To achieve the maximum power harvesting, one should employ a set of Rectenna Array - Figure 1 (See *et al.*, 2017)[7] that coated by meta-material together with a matching circuit and resistance connections network rectifier - resistance compression network (RCN) (one of a similar case is shown in Figures 2 and 3) which should be designed by advanced design system (ADS) simulation software version 2017. The purpose of ADS is to design (by computation) a best and optimized power transfer circuit (Mouapi *et al.*).[8] This is because in the rectifier circuits, either when there is a small change in the output load or if there is a change in the input power, this will produce changes in the matching of the rectifying device. Indeed these inputting matching changes will cause a degradation on the whole circuit performance (Niotaki *et al.*).[9] That is all of the input energy in the port is transformed and transferred to the resistive load and hence can act ideally without the loss (Leitermann *et al.*) whenever an RCN is introduced. I note that before the matching circuit is added, the maximum energy conversion effciency is about 34% while when there is a matching; the conversion can be upgraded to 66.8% (Mouapi *et al.*, 2018).[8]

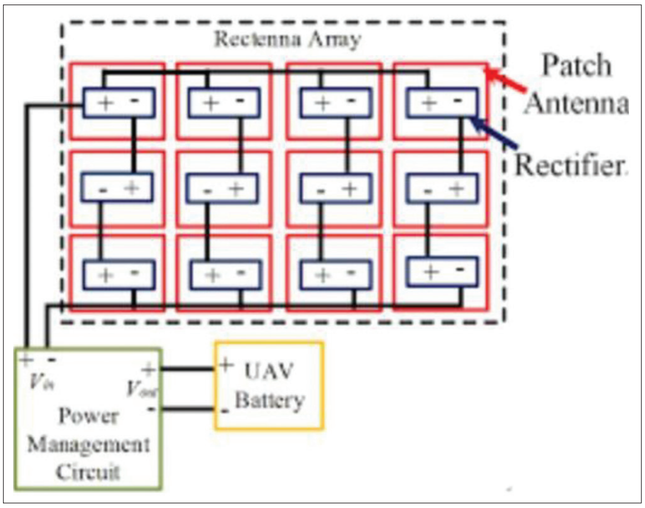

Figure 1: A set of array of patch antenna with rectifier (Rectenna array) - I suppose to add a set of matching circuit array in-between and the energy efficiency may be maximised more than 90% (K. Y. See, et al. 2017)[8]

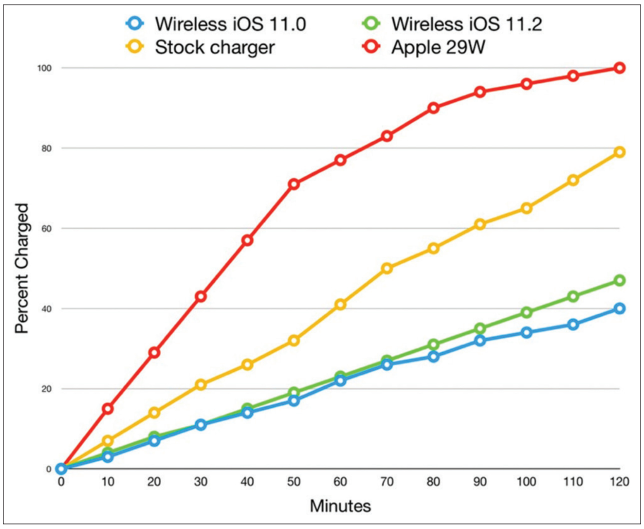

Figure 2: A comparison between the wired and wireless charging rate

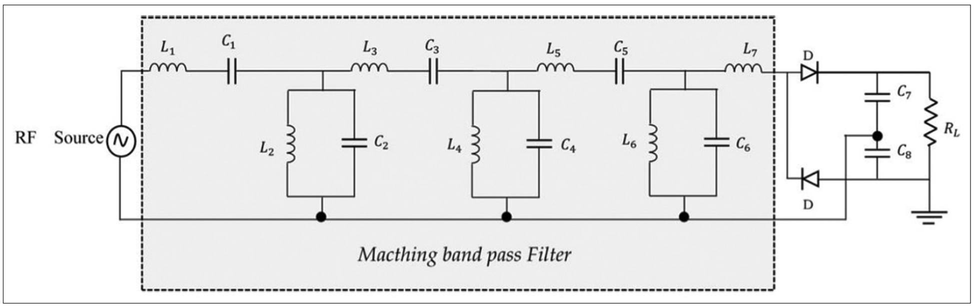

Figure 3: Rectifier with matching circuit Mouapi. A, et al. 2017)[10]

Next, to the matching or resistance connections network, there is a rectifier circuit that usually consists of Schottky diodes. It is well-known that the sensitivity of the circuit to convert the harvested RF signals into a DC signal is directly related to the sensitivity of the used rectifying diode (Chang). Hence, I suggest that one needs to further design one's own matching and a rectifier circuit for this project such that it will best fit those requirement (where one of a similar case study is shown in Figure 2).

Theoretically and under my imagination, using a set of rectenna array together with the suitable meta-materials coated on their surface which connected with matching circuits and rectifier circuits, one may expect to receive nearly 90–100% of transmitted (microwave) energy. This author suggests the actual result should be experimented or obtained in the laboratory first by establishing a similar testing model before the practical implementation.

Finally, this author remarks that the proposed idea can be extended to a mini-electrical power station for charging electric transportations devices. Indeed, the station may replace our present oil stations in the future. This can reduce the air pollution in most of the highly commercial and densely populated cities such as Hong Kong, New York, and London as most of the oil cars will soon be diminished.

Further Advances in Wireless Charging

In the future, may we hope that there will be advances in the application of EM wormhole. It is actually not the physical wormhole that proposed in our cosmological theories for shortening the distance travelling in the universe. As this author may suggest in the research, the energy sender and the receiver antenna parts can establish an EM wormhole in between with suitable meta-material installed.[10] Hence, those magnetic sensitive apparatuses from outside can be shielded in between them. One more important thing is that we can manipulate how well the magnetic sensitive apparatus being exposed to the internal EM waves or even the permissibility of the man-made EM wormhole. This is because one may create the EM wormhole through controlling the amount of meta-material used externally on the surface of the shielded tunnel. Therefore, another application of the magnetic wormhole is: One may place a moving magnetic device (as the source) long distance away from the receiver side's conductor with the immediate part being magnetic wormhole shielded. An electric current will then be induced on the receiver side relative to an electrical load installed. Or electrical devices can be charged through magnetic resonance from long distance automatically. Thus, people are freeing from the claustrophobic environment of the magnetic resonance machine (or the source of resonance).

Conversely, one may imagine a thought experiment, instead of a transport vehicle's outside being shielded from magnetic flux, the vehicle's inside is shielded, and people are seating in it. Then, the magnetic resonance charging can be occurred outside the vehicle without cause any harmful effect to the human tissues. Hence, such vehicle can be charged wirelessly whenever and where-ever necessary. But the inside or the outside vehicle shielded experiments is actually a kind of philosophy with the practical possibilities.

CONCLUSION

To conclude, one may apply the concept of random matrix to the different range of the electromagnetic wave spectrum within various channels. From these EM wave channels, we — human beings may upgrade our telephone booth into a multimedia centre together with the novelly wireless Butterfly charging method for energy harvesting. Practically, one may employ the business information management system for these various channels with different functions.

Hence, the problem of charging small sized electronic appliances will be solved completely instead of using low quantity China made external charging device. To go a further step, researcher may apply the same technique with suitable meta-material coatings and creating the electromagnetic wormhole, then the transportation vehicles may also be charged externally in any-where and at any place without causing any harmful effects to those people seating inside.[11] That is also the contribution of the present paper to the wireless charging research field. Last but not least, the wireless Butterfly charging method is indeed a philosophy which is out of the scope of my present paper's discussion.

REFERENCES

1. Berg BL, Lune H. Qualitative Research Methods for the Social Sciences. 8th ed. Boston: Pearson; 2012. p. 3.
2. Lam KS. A Quantum Look into Education. Beau Bassin, Mauritius: Scholar's; 2018.
3. Shinohara N. Wireless Power Transfer: Theory, Technology, and Applications. London: Institution of Engineering and Technology; 2018. p. 112.
4. Seidman I. Interviewing as Qualitative Research: A Guide for Researchers in Education and the Social Sciences. 3rd ed. New York: Teachers College Press; 2006.
5. Cool C, Xie H. Patterns of Information Use, Avoidance and Evaluation in a Corporate Engineering Environment. Vol. 37. United States: Proceedings of American Society of Information Science Annual Meeting; 2000. p. 462-72.
6. Ali EM, Yahaya NZ, Nallagownden P. Design and development of harvester RECTENNA at GSM band for battery charging applications. J Eng Appl Sci 2015;10:10206-12.
7. See KY, Koh WJ, Li KR. Design of 2.45 GHZ Microwave Wireless Power Transfer System for Battery Charging Applications; Progress in Electro-Magnetics Research Symposium-Fall (Piers-Fall), Singapore; 2017.
8. Mouapi NH. A New Approach to Design Autonomous Wireless Señor Node Based on RF Energy Harvesting System; 2018. Available from: https://www.mdpi.com/1424-8220/18/1/133.
9. Niotaki K, Georgiadis A, Collado A, Tentzeris M. Solar/Electromagnetic Energy Harvesting and Wireless Power Transmission. Vol. 102. United States: Proceedings of the IEEE; 2014.
10. Hawkes AM, Katko AR, Cummer AS. A microwave metamaterial with integrated power harvesting functionality. Appl Phys Lett 2013;103:163901.
11. Han Y, Leitermann O, Jackson DA, Rivas JM, Perreault DJ. Resistance compression networks for radio-frequency power conversion. IEEE Trans Power Electron 2006;22:41-53.