NEXUS Technologies

Proposal for a

Smart House with Power Line Communication Network

Project Team: Pranil Reddy
Kia Filsoof
Yalda Hakki
Kevan Thompson
Michael Kubanski

Contact Person: Kevan Thompson
kjthomps@sfu.ca

Submitted to: Dr. Andrew Rawicz – ENSC 440
Steve Whitmore – ENSC 305
School of Engineering Science
Simon Fraser University

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Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Project Proposals for an Implementation of a Smart House using Power Line Communication

Dear Dr. Rawicz:

The attached document, *Proposal for an Implementation of a Smart House using Power Line Communication* , outlines our project for ENSC 440 (Capstone Engineering Science Project). We intend to develop and implement a programmable power line modulation system to control household objects, through the structures existing power grid.

The purpose of this proposal is to provide a system overview and design considerations of our proposed product, Prometheus. We will also discuss potential sources of funding, outline a budget and the project organization and timeline. Finally we will provide market analysis for similar products and compare our system's market potential.

The Nexus team consists of five intellectual, highly motivated, and talented fourth-year engineering students: Kia Filsoof, Pranil Reddy, Yalda Hakki, Mike Kubanski and Kevan Thompson. If you have any questions or concerns about our proposal, please feel free to contact me by phone at (604) 910-5747 or by e-mail at kjthomps@sfu.ca

Sincerely,

Kevan Thompson

Kevan Thompson
Chief Executive Officer
Nexus Technology

Enclosure: *Proposal for a Mobile Paging Car Security System*

EXECUTIVE SUMMARY

In this day and age, communication is a very integral part of our society, and we rely more and more on it with new advances in technology every year. The Internet is a very popular medium for communication of ideas and information between people, but also for communication between devices, allowing for control of a device remotely. It is limited though as not everything can be hooked up directly to the Internet in a feasible and cost effective manner, for example, home appliances.

Control over home appliances, and more generally, control over a home or any other building remotely, has the potential to ease most peoples' hectic lives. Instead of having to physically get home and put on dinner after a long day of work, the alternative would be to connect to your home online, set the oven temperature and turn it on given that dinner was prepared ahead of time. What if you left for a vacation and forgot to turn off the lights? The ability to check on your house online would be very convenient.

This proposal is for a smart home system where anyone could connect to their home online, and control, configure, and check on different devices at home. The proposed solution to the problem of not being able to hook up appliances to the Internet is to create a network of devices connected by the power lines in a building. A central controller connected to the Internet would be connected to different electronics within a building through power line modulation, and could for example communicate with a toaster oven plugged into a wall socket. A user could then have control over this appliance from over the Internet with the click of a button through this controller.

Nexus Technologies consists of five engineering students with strengths in computing, electronics, and systems design. Each member has skills and experience in many areas including: analog/digital communication, software/hardware design, real time and embedded systems, and circuit design. Everyone contributes different strengths, resulting in a diverse team capable of working on a complicated system incorporating different areas of engineering.

This project will consists of the research, design, implementation, and testing of a prototype system over a 4 month period. The scheduled completion of this project is set for April 19, 2010. The first half of this project will consist of designing and documenting the proposed project, while the second half of the project will focus on the implementation and testing of the prototype. The projected cost of the prototype system is approximately $300.00.

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1.   INTRODUCTION

With the addition of the Prometheus to your house, you now have the ability to control your appliances from anywhere in the world using the Internet. With Just a click of a mouse, you are now able to switch your house lights you forgot to turn off when leaving the house.

The objective of our project is to establish a working control system which will use power modulation to communicate and control home appliances. This project in particular, is aimed to be used within a house to control appliances such as light bulbs, coffee makers, and toasters. The major advantage of our product from similar devices on the market is that we are aiming to add extensive security to the already existing power modulation communication protocol. Moreover, many existing products have non-intuitive user interface, causing the user experience to be rather unpleasant. With the design of Prometheus, we are aiming to provide simple and innovative user interaction with the product.

After extensive research, power modulation has been successfully chosen as the method of communication for this control system for number of reasons. One of the major advantages with power modulation is that it utilizes the existing structure's electrical grid for communication purposes. This feature of power modulation allows the overall cost of the system to drop by a noticeable amount.

Other options which were available to us for implementing the Prometheus device were to use either wireless or Ethernet for means of communication. As for the wireless method, even though it does not require any wiring, it would still add unnecessary complexity to the design of the system, causing the price to increase. Similarly, as for the Ethernet method, the cost would increase due to the cabling required.

This proposal will provide the design overview and considerations of the Prometheus project. Similar design solutions and existing methods, along with the proposed solution's implementation and financial requirements will be discussed. Moreover, the project's tentative schedule is provided within a Gantt and a milestone chart.

2.   SYSTEM OVERVIEW

The Prometheus general block diagram in Figure 1 shows off the basic functionality of our product. The user can easily control a desired device remotely in the building from the Internet. The building controller determines what device the user intends to control by the data received and sends control signals to the Power Line Communication Modem (PLCM). The control signals are processed by the PLCM and sent through the electrical grid, the control signal are, then, recovered from the electrical grid by a PLCM located in the room and used to control the required device.
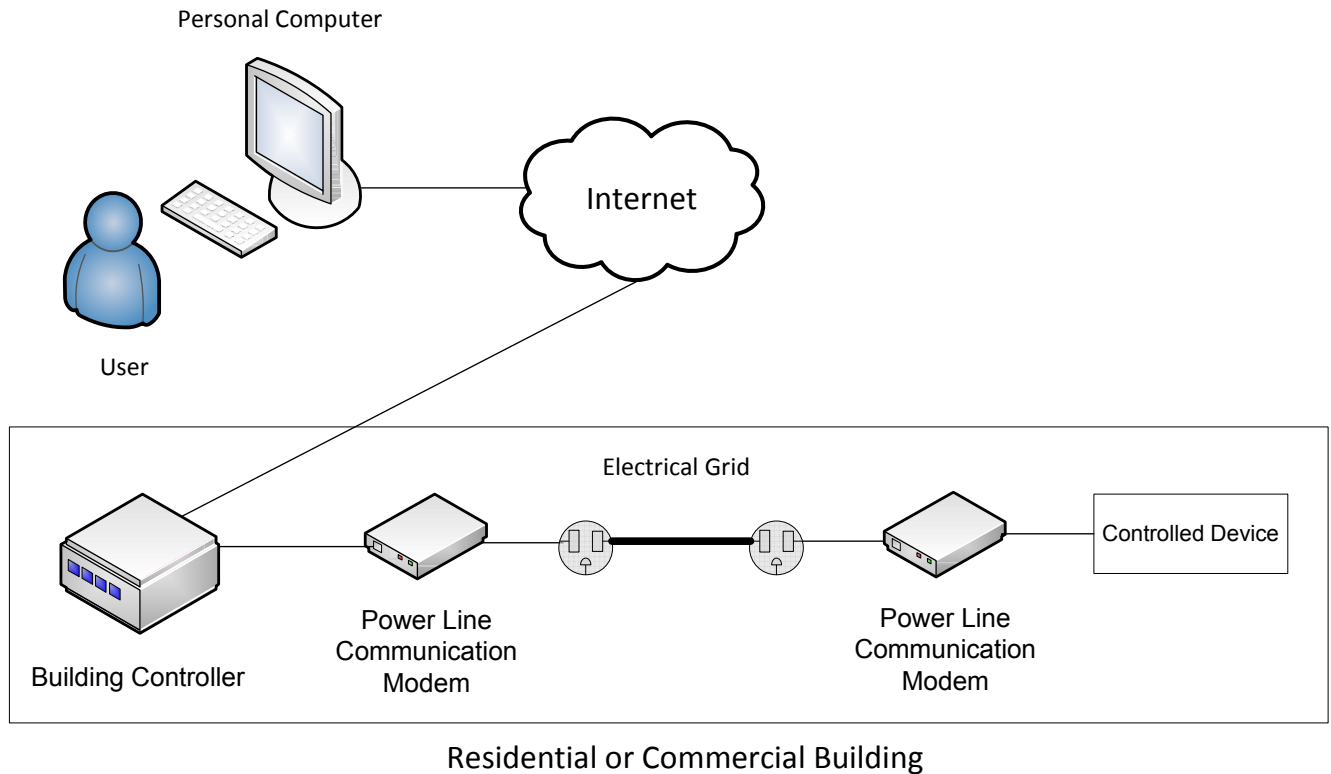
Personal Computer

Internet

User

Electrical Grid

Controlled Device

Building Controller

Power Line
Communication
Modem

Power Line
Communication
Modem

Residential or Commercial Building

Figure 1. Conceptual Overview

3. POSSIBLE DESIGN SOLUTIONS

There are many possible ways for different devices to communicate with each other, each with its pros and cons. An important consideration is whether or not using a specific way of communicating will increase the cost of the smart home system, along with the cost of appliances and other devices used in the system. Some possible design solutions for the smart home are listed below, though they do have drawbacks and, thus, are not the proposed solution.

3.1 Networked Devices over Ethernet

One of the most common ways of networking devices is through an Ethernet network. This method of communication would consist of running Ethernet cables from devices to a central hub/switch or router, and having them communicate over a local network with a central server which would be connected to the Internet. This method of setting up a smart home system would be very expensive for many reasons. All devices to be connected to the system would require network capability and increased processing power, increasing their cost substantially. The network would also be difficult to set up in terms of running Ethernet cables throughout a house, and also in terms of expanding the system, as every new device would require a cable to be run from it to a network hub, switch, or router.

3.2 Networked Devices over Wireless

Using wireless communication to setup a wireless network removes the problem of having to run cables to each device, and if a wireless router is used, many devices could be connected to the network, and adding additional devices would be trivial. The problem still remaining, and an important one, is that adding a wireless adapter will increase the cost and complexity of appliances that are on the smart home network. An example of this is the simple task of turning a light on or off, which with wireless networking would require a wireless adapter along with a microcontroller to process packets and control a light switch. There is a substantial increase in cost and complexity of even the simplest of devices.

4. PROPOSED DESIGN SOLUTION

Our proposed solution is to create a network of microcontrollers which will communicate over a Power Line Communication Network (PLCN). This solution will have a high performance microcontroller which will act as a Master, to a series of low powered Slave microcontrollers. The Master microcontroller will communicate to the Slave microcontrollers over a PLCN. This network will save costs by combining the power and communications lines into a single entity. In addition it is also user friendly since the user will only need to plug in a single cable.

The user will select devices to be activated or deactivate by a password protected website which they will be able to access from any computer connected to the Internet. This website will be stored on the Master microcontroller, which will act as a web server. When a user has finished selecting devices the Master microcontroller will then send the data to the appropriate Slave microcontroller which will then turn on or off the device.

For this project we will attempt to control several simple devices such as lamps, or a coffee machine. If more time, and funding was available, we would attempt to create more complicated devices to control such as a smart oven, which would have configurable temperatures, and timing.

5.   SOURCES OF INFORMATION

Various sources of information will be used in order to obtain theoretical information and complete this project. These sources of information are available in libraries and on the Internet. Professors in the SFU School of Engineering Science will also be invaluable sources of information for our project.

The Internet will be a great source of information. Electronic periodicals, journals, manufacturers' component data sheets, and different past engineering projects from SFU and other universities can be found on the Internet. Existing related prototypes can also be found on the Internet.

Textbooks and research journals regarding our project topic may be found in the SFU library, which will be much appreciated. Also, we can have access to several electronic journals and textbooks through the SFU library's website.

Although the above sources of information are crucial for the successful completion of our project, it is necessary for us to consult with professional individuals in the fields of communication, electronics, and computers to benefit from their expertise. For that, we are fortunate to have several faculty members at SFU involved in these areas of interest whom can provide us with valuable resources through different stages of our project. We can also benefit from consulting with graduate students. Any contribution from faculty members and graduate students will be clearly referenced in all project documents.

6.   BUDGET AND FUNDING

Table 1 demonstrates the overall estimated required budget for completion of the Prometheus project. It has been decided to use the TS 7200 Arm Processor as the main microcontroller unit due to its versatility such as a fast CPU, Ethernet interfacing capabilities, enough memory, and etc. The cost of the Power Modulation Modem includes all the electronics required for communication through the power line. Controlled Appliances cost covers the cost of the devices meant to be controlled such as light bulbs, coffee maker, and a toaster. The cost of the interfacing to the appliances, such as each device's unique microcontroller, control circuitry, and connectors is covered under the Appliance Interfacing section. Moreover, the cost of the chassis of the control system is also considered. Lastly, a 15% contingency plan is included in case any of the costs have been underestimated.
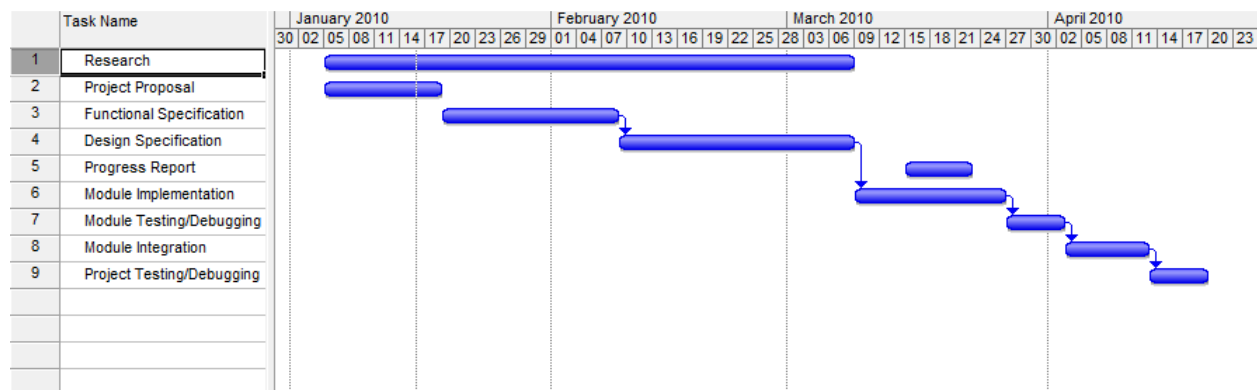
Table 1. Overall Project Budget Estimation

Equipment	Estimated Cost
Arm Processor (TS 7200)	$120.00
Power Modulation Modem	$70.00
Controlled Appliances	$20.00
Appliance Interfacing	$30.00
System Chassis	$22.00
15% Contingency Plan	$38.00
Total Cost	**$300.00**

Funding is a critical factor to ensure our project completion. Various sources of funding have been considered in order to assist us with the cost of the Prometheus design. The team has already applied for funding from the Engineering Science Student Endowment Fund. However, in case the cost of the project exceeds our estimation, other sources have also been considered. For instance, the School of Engineering Science and the Wighton Development Fund are other possible funding solutions. The reason we think we might be able to obtain funds for our project from the Wighton Development Fund is that we believe our project has the potential to become marketable and can be considered as a project benefiting the society. Appliance control will be very comforting and easy with the Prometheus as it allows users, such as elderly people, to control appliances spread around their home from anywhere in the world using the Internet. Lastly, since our project is focused on power modulation, British Columbia Transmission Corporation and BC Hydro may also be interested in contributing to our project financially. Finally, free samples can also be ordered from electronics distributors, such as Texas Instruments.

7. SCHEDULE

Below in, Figure 2, is a tentative schedule for the completion of tasks within the proposed project. This is a general schedule as detailed milestones will be developed later in the design process. Figure 3 below is a milestone chart showing the deadlines for the project milestones over a 4 month period.

Figure 2. Tentative Schedule

2010			
January	February	March	April
18th	8th 16th	8th 22nd	2nd 19th

Project Proposal

Functional Specification

Progress Report 2

Module Integration and Testing + Project Completion

Progress Report 1

Design Specification
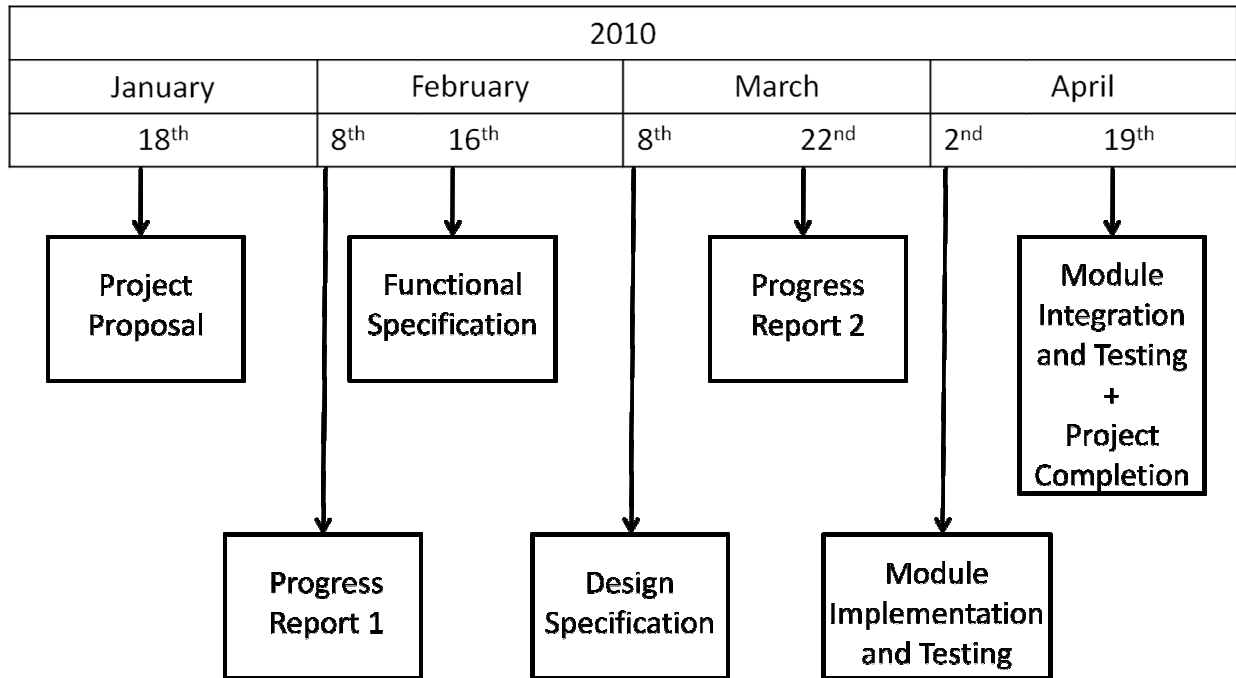
Module Implementation and Testing

Figure 3. Milestone Chart

8. TEAM ORGANIZATION

Nexus Technologies is a design and manufacturing company based in Burnaby, BC, which was founded in December 2009. The company's current major project is the research, development, marketing and manufacturing of the Prometheus device. The company consists of five colleagues from Simon Fraser University's Engineering Science department.

Members of Nexus include five experienced undergraduate engineering students in their final years of studies. Kevan Thompson, the Chief Executive Officer (CEO), is in charge of the overall management and organization of the company. Pranil Reddy, the Chief Financial Officer (CFO), overlooks and manage the company's financial conditions, such as financial risks, financial planning, and record-keeping. Yalda Hakki, the Chief Operations Officer (COO), carries out the management of the company's everyday technical activities. Mike Kubanski, the Chief Technology Officer (CTO) is in charge of the research carried out to successfully complete the current project at hand. Kia Filsoof, the Chief Marketing Officer (CMO), is responsible for the marketing side of the company.

Due to the small population of the company, each member is still heavily involved within all aspects of the company, despite their title. This holds mainly for the research and development side as it is the most time and effort consuming. Each member within the company has his/her own unique strong points when it comes down to design of the project. Any major software and processor design issues is handled by Kevan Thompson, due to his specialization in computer engineering. Pranil Reddy's knowledge of mechanical engineering and the SolidWorks software is helpful when it comes to the

mechanical side of the project such as chassis design. Yalda Hakki has completed various courses on signal processing and communications, and hence, most design issues in these areas are handled by her. Mike Kubanski's strong points lie within area of physics as he has completed numerous courses in this field such as quantum mechanics. Kia Filsoof's main area of specialization is in electronics circuit design, and, therefore, any issues in this area are addressed to him.

To ensure great communication and no misunderstandings between group members, continuous in-person meetings are held within the company to discuss the progress of the project. There are no times specified for these meetings; they are just held as soon as the need for one is arisen. Minutes at each meeting is recorded to have written proof of the agreements and conclusions made at the end of each meeting, and to make it easier for referring back to ideas raised in the past.

It is guaranteed that the members at Nexus have great group dynamics between one another, due to the reason that they all have had previous teamwork experience with each other. The team is very efficient in deciding whom to choose for a specific task as they all are very familiar to one another's strengths and weaknesses.

9. COMPANY PROFILE

Kevan Thompson – Chief Executive Officer (CEO)

Kevan is a fourth year computer engineering student at Simon Frasier University, but also has an honors diploma from the British Columbia Institute of Technology in Electrical and Computer Engineering Technology: Computer Control option. He has completed two co-op work terms, with Icron Technologies, and General Electric Canada respectively. His skills including coding in C/C++, Java, and VHDL, FPGA design, and working with embedded systems.

Pranil Reddy – Chief Financial Officer (CFO)

Pranil Reddy is a 4th year systems engineering student attending Simon Fraser University. Prior to attending Simon Fraser university Pranil obtained a DipIT in electrical and computer engineering technology program from British Columbia Institute of Technology. Pranil has extensive experience in SolidWorks for mechanical design and simulation making him a natural choice to manage the mechanical design components of the project. Pranil is also experienced with Surface Mount Devices (SMD), and printed circuit board design using Altium Designer. Additionally, Pranil has previous work as a Payroll Manager for CLS Catering Services makes him the ideal candidate to manage the company finances.

Yalda Hakki – Chief Operations Officer (COO)

Yalda is a 4th year electronics engineering student. She is proficient in math and physics. She has programming experience with C, C++, MATLAB, and assembly. She has also done a few projects using VHDL. Yalda has worked as a research assistant for Dr. Parvaneh Saeedi and gained experience in the field of image processing. She is, also, experienced using most electronics lab equipment, such as, oscilloscopes, power supplies, function generators, digital multi-meters, and spectrum analyzers. Yalda has also gained knowledge of basic project management principals through her previous co-op at BCTC.

Michael Kubanski – Chief Technology Officer

Mike is a fourth year engineering science student majoring in Electronics Engineering and minoring in Physics at Simon Fraser University with 2 Co-op semesters of work experience in real time and embedded system programming at Broadcom. He is experienced in programming in C/C++, Java, assembly, and object oriented programming in general. Mike has worked on software for both high level applications and low level drivers for real time systems. He also has experience in hardware design on FPGA's, along with circuit analysis and circuit design/implementation. Mike is academically strong and has a good understanding of the theoretical aspects in many other areas of engineering and physics.

Kia Filsoof – Chief Marketing Officer

Kia Filsoof is a 4th year engineering student, specializing in the field of electronics. Kia has previous co-op experience working as a Jr. Electronics Technologist at Analytic Systems, where he gained practical experience with assembling, testing and troubleshooting of electronic systems. Before coming to Simon Fraser University, Kia finished the two-year electrical and computer engineering technology program at BCIT. His main experience lies within the area of programming and electronic circuit designs.

10. CONCLUSION

The Prometheus system from Nexus Technologies will provide users will a practical low cost implementation of a smart home. Our smart home design will allow users to control a variety of devices from either a local computer, or a computer connected to the internet without having to connect any additional wires to the device other then power. This approach is a more cost effective solution then either Ethernet which requires the installation of additional wires throughout the user's home, or a wireless network which requires the installation of expensive of expensive wireless access points.

With our companies' diverse education and depth of knowledge combined with the more than sufficient funding which we have been able to acquire it is clear that our company will be able to complete the project on time and on budget. To further this goal we have clearly planned out the project in the Gantt chart shown above. There is no doubt in our minds that our product will be of the highest quality, and greatest reliability.

11. SOURCES AND REFERENCES

[1] "Powerline communication modem PLC-UART XBee," *SparkFun Electronics*. [Online]. Available: http://www.sparkfun.com/commerce/product_info.php?products_id=9080.[Accessed: Jan. 18, 2010].

 [2] "Power line communication," *Wikipedia,* Jan. 16, 2010. [Online]. Available: http://en.wikipedia.org/wiki/Power_line_communication.[Accessed: Jan. 18, 2010].

[3] "Power Line Communication Modem Solution form Texas Instruments," *Block Diagram(SBD),* 2010. [Online].Available: http://focus.ti.com/docs/solution/folders/print/502.html.[Accessed: Jan. 18, 2010].

[4] R. E. Redgate, A. R. Carson, M. T. Collins, K. Q. Lam, D. P. Ketron and D. L. Toland, "Information and Control Communication over Power Lines," US 6281784 B1, 08/28, 2001. Available: http://www.freepatentsonline.com/6281784.pdf.

12. GLOSSARY

CEO: Chief Executive Officer

CFO: Chief Financial Officer

CMO: Chief Marketing Officer

COO: Chief Operations Officer

CTO: Chief Technology Officer

PLCN: Power Line Communication Network

PLCM: Power Line Communication Modem