Power Line Communication: Application in a Tether Based Underwater Vehicle

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Abstract (200words)

This paper describes the potential usage and application of the Power Line Communication (PLC) in a tether based underwater vehicle as the alternative module in establishing the communication line. The common application for PLC is to establish the networking between multiple network peripherals only by using the power line. This method reduces the number of communication cables in a network, and indirectly reduces the cable cost. The Power Line Communication module has been applied and tested in the new model of Remotely Operated Vehicle (ROV) developed by members of Robotics Research Group of Universiti Sains Malaysia(URRG) in 2008.

Keywords

Power Line Communication, Remotely Operated Vehicle,

Surface computer, Single board computer, Power line

Introduction

A tether based underwater vehicles required them to be supervisory controlled. For short distance underwater vehicle like shallow water ROV, it may require the likes of shielded copper cores as the communication cable. For a deep submerging ROV or any tethered underwater platform, which a very reliable cable must be used to prevent any data loss. For long distance application like this, the best option is to use the optical fiber cable, which is known as a very reliable and convenient element in having unaltered and noise-free data transmission. This kind of cable requires more space to be spared. Power Line Communication (PLC) is a solution where the number cables can be reduced without losing the reliability of the communication connection. PLC gives advantage in having both power and communication on a single power line. Electrical power lines are usually classified into three classes of voltage networks [Ferreira] which are; high voltage (>100kV), medium voltage (1-100 kV) and low voltage (<1kV). Because there are increase demand for sending digital voices, videos and internet data, PLC technology does provides high speed networking capabilities [Yousuf & El-Shafei].CSMA/CA protocol is normally use in Homeplug standards with low voltage networks. This is a collision avoidance technique where each device listens to the signal level to determine when the channel is idle. In overall, the data rate is improved compared to other methods because lees retransmission is occurred.

Application

The Power Line Communication (PLC) has been applied and tested in the Mini Remotely Operated Vehicle developed by members of URRG. The PLC becomes the communication module to interconnect two computers; the onboard single board computers and the surface control computer using Local Area Network (LAN) and TCP/IP protocol. Both computers are using the Window XP operating system, with 2 pairs of PLC modem are being used. The power cable connecting the surface control station to the mini ROV is powered by continuous 240Vac, 50Hz from a generator. The PLC modem is an Ethernet Homeplug AV adaptor from Aztech with the data rate capacity of 200mbps from a point to point. It utilizes the CSMA/CA and TDMA protocols with 10/100base T-LAN port interface. The power cable is composed of two cores AWG 13 stranded copper wires length at 100m. Given below is the specification description of the Homeplug AV that has been used in the project.

Table 1: PLC Modem Specification

Model	Aztech 200mbps Homeplug AV Ethernet adaptor
Standards	Powerline : Homeplug Ethernet: IEEE 802.3 Auto MDI/X
Protocols	CSMA/CA & TDMA
Data transfer rate	200mbps over powerline
Modulation	Powerline: QFDM Symbol Modulation, DQPSK, DBPSK, ROBO Carrier Modulation
Range	Powerline: 200 meter point to point
Security	Powerline:128-bit AES description
Indicator LEDs	1.Power 2.Powerline Link/activity 3.Ethernet Link/activity
External Interfaces	10/100Base T LAN port
Dimension	92(H0x66(W)x45(D) mm
Weight	160g
Power consumption	5.5W, 0.08A
Temperature	Operating: 0-40 degree celcius Non-operating: -2570 degree celcius
Environment	Non-condensing: 30% to 80% humidity
Operating systems	Windows XP, Vista

Surface control station & generator

PLC

Surface

……………………………………………………………

Underwater

PLC
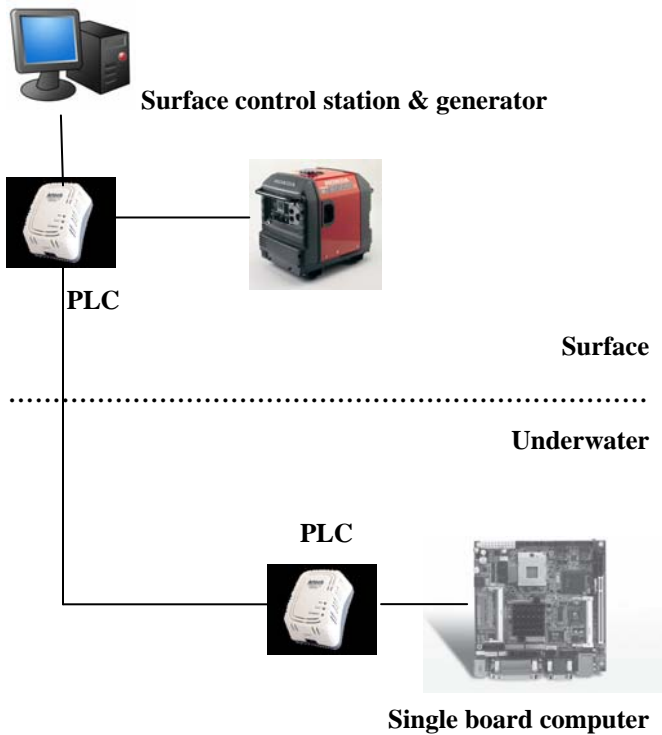
Single board computer

Figure1: PLC Interconnection

Steps to establish TCP/IP connection between two computers using Windows XP operating system

1. Switch on supplied power to the PLC and computers. Make sure the PLC shares the same power line

2. The Homeplug Ethernet adaptor pair will find each other soon after the power is switched on. The LED indicators will flash giving indication that the network link is established.

3. In Window, go to Control Panel-Network Connections to configure the TCP/IP properties..

4. Enter TCP/IP properties, and configure the IP address, Subnet Mask and Default gateway.

5. Make sure the IP addresses for both computers are in the same domain.

Communication & Control Algorithm

Power Line Communication is used to receive and transmit three types of data, which are:

1. Control command form the surface

2. Video signal from the vehicle

3. Sensor data from the vehicle

It is important to have a very reliable and secure network communication to prevent any data loss and providing a real time control.

For the programming, SIMULINK toolbox from MATLAB is used for executing control command and establishing the communication channel between the computers and the motor driver's communication module.

For the surface computer, a joystick is used to supervisory control the vehicle movements. The control algorithm is set such that the joystick is sending bit signal every time the toggle and button are being moved. The bit by bit signals are sent to the on-board computer using UDP (user datagram protocol).

Figure 2: Surface Master Program
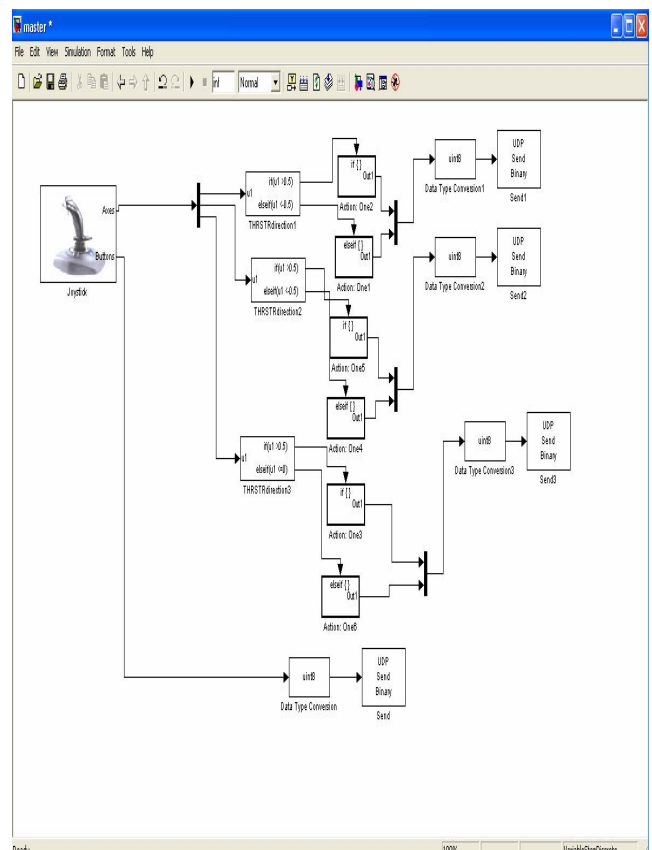
While, in the ROV, the program code is ready to receive the data if the communication channel has been established and afterwards compiles the bit signal into a set of 4 bits binary. The 4 bits data are sending to the motor driver communication module through the parallel port to initiate and execute the specific command for each thruster.
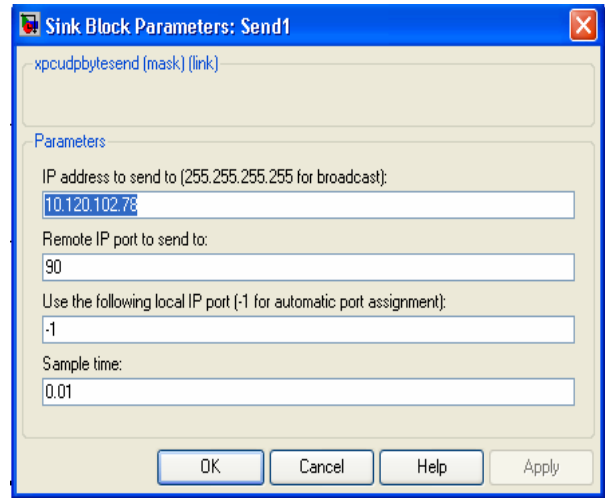
Figure 3:On-board Receive Data Slave Program

Figure 4: On-board Slave Program IP address Configuration in Surface Master Program
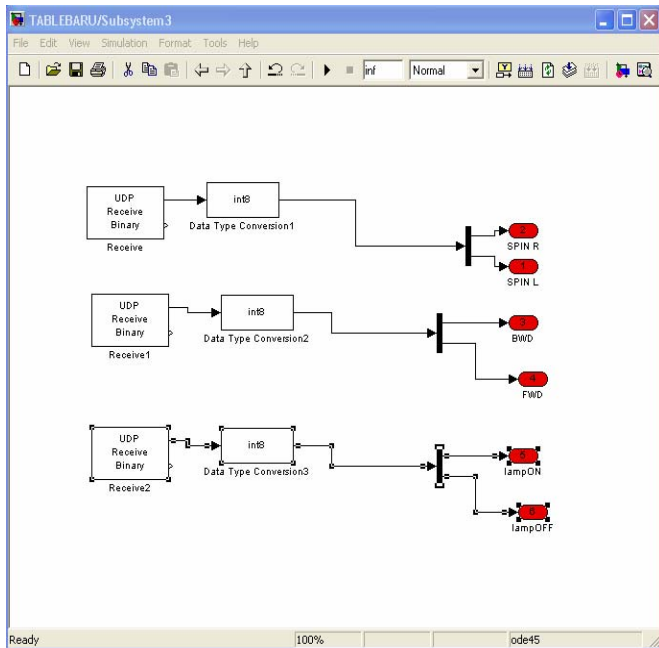
IP address and port is configured on the on-board computer in order the surface computer to recognize and transmit the bit signal to the right terminal. The same configuration needs to be configured on the surface computer to allow the on-board computer recognize the sender in order to establish the communication. For master-slave communication between the surface computer and the on-board computer, the details are as follows.

1. Surface computer

   IP address: 10.120.102.160

2. On-board computer

   IP address: 10.120.102.78

3. Port : 90-93

4. Number of PLC pair used : 1 pair

There is another pair of PLC is used for sensor and video streaming. In this part, the on-board computer is sending the bits signal and surface computer is receiving it. The detail for this communication is as follows:

1. On-board computer

   IP address: 220.120.102.168

2. Surface computer

   IP address: 220.120.102.70

3. Video software: CAMLAN shareware

The on-board computer has two ports LAN 10/100base, so it holds two IP addresses. On the surface, two computers are being used; each is configured with different IP address.

Further work

This was the first time using PLC technology as the communication module in a tethered underwater vehicle. Thus further study must be held towards using the PLC application in wide views of underwater technology. One lesson learned is how to improve the real time transmission using PLC because data processing must follow many network protocols, which create a delay in control, video streaming and data transmission. The PLC technology surely reduces the numbers of cable used but the number of network peripherals connected through a pair of PLC must be limited as too many loads will also produces delay and interference like the electromagnetic and the cable might not be able to supply sufficient power over the power line to carry the data transmission. The other part is to improve the software so that it is compatible and convenient to be use with PLC. SIMULINK is good software for control algorithm, but ideally it is good for software simulation but not for real time control programming. Running SIMULINK from MATLAB requires high specification of a computer in

which in other hand is not cost effective.

Conclusion

In this paper there were discussions about PLC technology and how it is being used in a tethered underwater vehicle. There are many applications that can apply the PLC technology. As long as the power line is in place, PLC technology proves to be very convenient technique to be adopted as the communication module.

Acknowledgement

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