Modeling of the T.C.M.S. using Power Line Carrier in Railway

*Y. S. Song, S. G. Lee, S. K. Shin, S. H. Han

* KCR System Engineering Team, Conventional Rail Engineering Corps,
Korea Railroad Research Institute, Uiwang-city, Kyonggi-do, Korea
* (Tel : +82-31-460-5668 ; E-mail: adair@krri.re.kr)
(Tel : +82-31-460-5678; E-mail: sglee@krri.re.kr)
(Tel : +82-31-460-4537; E-mail: skshin@krri.re.kr)
(Tel : +81-31-460-5660; E-mail: shhan@krri.re.kr)

Abstract: Recently, many technologies of the P.L.C (Power Line Carrier) are introduced for an efficient communication. P.L.C communication sends information in the carrier signals by conduction over the power wire. An arc detector is proposed in this paper for the effective transmission. The Power Line Carrier has an advantage in low cost because it uses existent power line. It can be easily applied anywhere that a power line socket is available. But the P.L.C. is very noisy, because many electronic devices in generate electronic noise in modulated signals. This problem should be considered carefully in the design of the arc detector system using P.L.C in railway. The proposed system can be applied for monitoring the arc detector system and the arc locator system in railway. Hence the system will be able to exchange the arc information to be T.C.M.S. (Train Control Management System), bogies and even between a station and trains in railway and use to suspicion fire in train.

Keywords: : P.L.C.(Power Line Carrier), T.C.M.S(Train Control Management System), Arc detector, Arc locator

1. INTRODUCTION

With the development of information-technology, T.C.M.S. (Train Control Management System) has also been automated. T.C.M.S. enables train operation data to be exchanged among carbodys even between train and station. T.C.M.S. is a new research area utilized in train automation and auto train supervisor system. Usually can bus is preferred in protocol for Train communication system. Can bus is safer than others communication methods. But, Can bus system would be very expensive. And ID of can bus was have installed to utilized for device and sensor. Because it is used to two communication lines, hence can bus was dropped efficiency in circuit. However, PLC could have efficiency for circuit and efficiency for space by using electric power line communication communicating with existent electric power line in train communication. Also, it can connect a train bus several if power line communication was adjusts correctly standard of protocol in replace that it had to giant swing and to give each priority order. But it is difficult to set up in old train. There are various reasons for this:

1. Efficiency of wiring drops as can communication uses two fair lines. And LAN system is limited to some area that served with communication service.

2. The power line carrier (PLC) is a communication technique that existing power line to carry information. The PLC communication sends information in carrier signals by conduction over the power wire. Electric power line communication is

3. more effective because can apply ark detector in effective electric power line watch and each device inside along with communication and there is number of percent that it is means of communication in TCMS that it occurs newly in train industry that is trend. It is very expensive to establish in tilting train.

4. Power line communication that is used for groove network has excellent performance in speed and ID discrimination and encryption. But LAN is easy to hack. It has security problem. can bus is not able to monitoring for occurring ark in pantograph.

So I propose to use the power line network for T.C.M.S. P.L.C transmits information of high frequency to power line. Easy installation, low space, is important factors in designing T.C.M.S. Vehicle and vehicle appliances will be networked together, through some medium, for vehicle and arc detector.

I will use the power line network instead of an exclusive line for train data transferring. It can be easily set up anywhere in train that a power line is available.

My proposal is divided into three main tasks:

1. Modeling and simulation to define the train digital signal processing requirements for power line network in train.

2. System hardware and software design to implement a power line system capable of transmitting T.C.M.S.

Testing and evaluation of the sensors and main system in

train..

2. METHOD

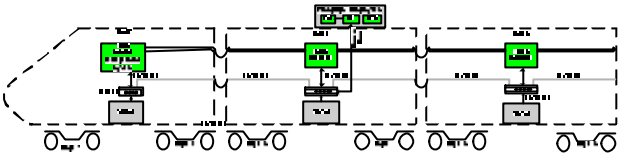


Fig. 1 Diagram of the T.C.M.S. using P.L.C

Diagram of the T.C.M.S is shown in Fig. 1. There are many information data in various places in the train such as train information, trip information those prescripts to vehicle, a sensor's sensitive and data for train. All of these train data are connected to sensors that in turn are connected to a vehicle computer by the power line network. The train computer collects the data on the train operation under trip, and transfers the data to T.C.M.S. operated by the power line network. The power line network is very noisy, because many appliances emit radio waves as electronic noise. These include servo motor sets, tilting actuator, auto door, etc. It uses the spectrum spreading method to reduce noise.

3. Background

3.1 Communication theory

The Spectrum spreading (SS) method is multiplied with a special signal in original signal; a special signal was called the PN (Pseudorandom Noise) signal and spread to a wider band. It has Correlating the modulated signal and PN signal, when demodulating can restore the original signal.

The autocorrelation function of a real-valued power signal x (t) is defined as

$$Rx(t) = \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} x(t)x(t+t)dt$$

For $-\infty < t < \infty$ (1)

When the power signal, x (t), is periodic with period T0, the time average in equation (1) may be taken over a signal period, T0, and the autocorrelation function can be expressed as follows:

$$Rx(t) = \lim_{T\to\infty} \frac{1}{T_0} \int_{-T_0/2}^{T_0/2} x(t)x(t+t)dt$$

For $-\infty < t < \infty$ (2)

The autocorrelation function Rx ( ) of a periodic waveform x (t), when period T0, was given in Equation (3) and is shown below in normalized form.

$$R_x(t) = \frac{1}{K}\left(\frac{1}{T_0}\right)\int_{-T_0/2}^{T_0/2} x(t)x(t+t)dt$$

For $-\infty < t < \infty$ (3)

Where

$$K = \frac{1}{T_0}\int_{-T_0/2}^{T_0/2} x^2(t)dt$$

When x (t) is a periodic pulse waveform representing a PN code, I refer to each fundamental pulse as a PN code symbol or chip.

4. SYSTEM

4.1 Control part

The control part has two functions that one is control Power line Modem, the other is data communication in system.

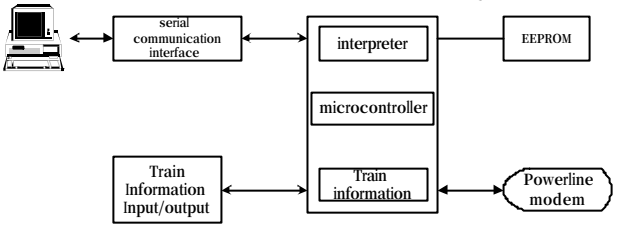


Fig. 2 Control part

4.2 Power Line communication

Greatly, communications department for power line communication can divide by Power Line modem, Line Driver, Line Interface.

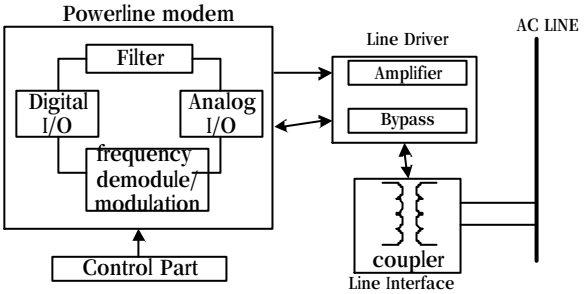


Fig. 3 Communication part

Function of power line modem is thing which does send-receive data through power line. Transmission of a message command came from control part is received and analyzed in digital I/O department and Driver Circuit is decided to use Amplifier.

4.3 Power Line Impedance

It is important that how much is impedance of in power line communication. We have to know biographical special quality

of power line because power line interface, coupling, can be properly. According to CENELEC regulation, power line impedance model is likely to Fig 4.

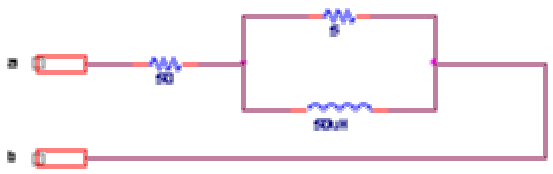


Fig. 4 .Power line model circuit

4.4 Power Line Interface

Power Line Interface is connected power line and Line Driver interval that have impedance of Fig4. Transformer acts role that separate power line and Modem circuit, support receipt signal with power line, isolate 60Hz signal from power line. And it is filtering harmonic from receipt signal. Fig. 5 is interface that embody in this research.

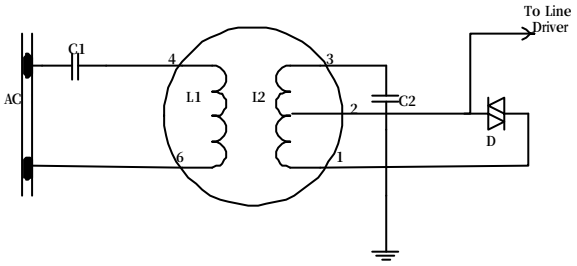


Fig. 5 Power Line Interface

4.5 Train information transmission part

Train treatment information transmission department digitalizes signal that obtain through A/D converter after reading information of arc detector, A.T.O (Auto Train Operation), A.T.S (Automatic Train Supervision), A.T.P.(Auto Train Protection), Etc. and vehicle information transmission part the information from train automation equipment to main computer(TCMS) though power line.

This Train information transmission part can divide analog signal input part that is linked with A.T.O equipment and A/D converter volume that make digital signal from analog input. To digitalize Analog signal that measure from real time signal of ATC, usually used single ADC IC. Generally it is necessary to signal filter circuit is removes interior noise and waveform capital punishment circuit such as amplifier that properly change size of signal. Fig6 is completed system

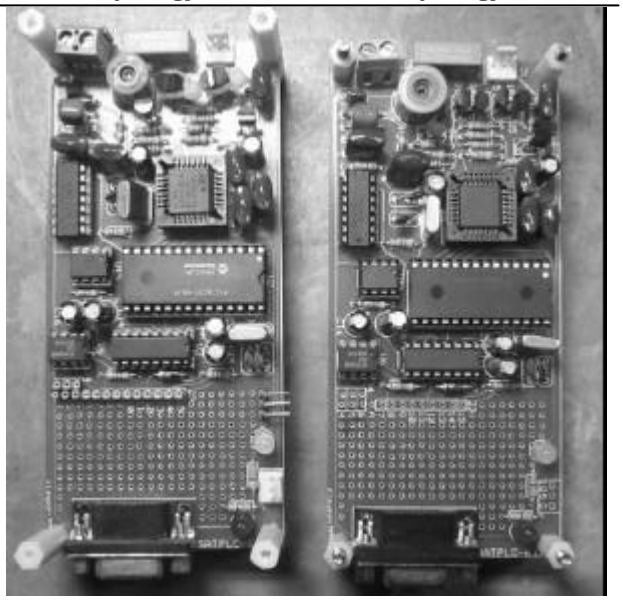
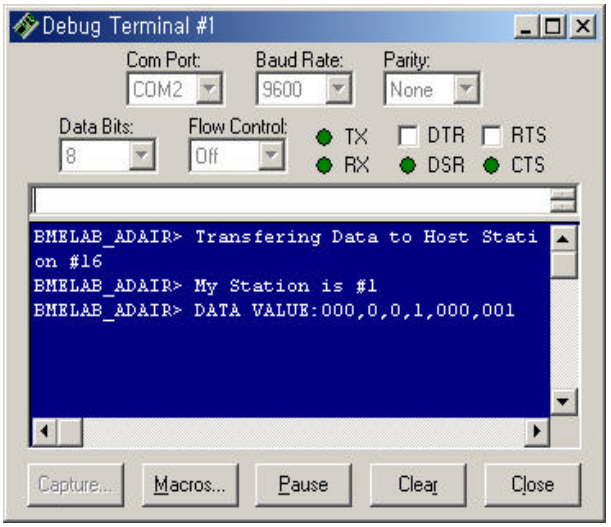


Fig. 6 in the proposed system

5. Evaluation

To evaluate the power line network system, I will measure the transfer time and noise by loading. I will construct a power line network in a train in which many measurement devices and sensors were already installed. I will select one computer as the base, and installed a power line network adapter to this vehicle. This vehicle was located in the TCMS. In addition, I prepared a notebook computer, a power line adapter and a palm. I measure the transfer time at the various locations in the vehicle. I will transmit 8-byte packets from measurement location to base, and measure the turnaround time 100 times. Furthermore, I will repeat the measurements 3 times, and obtain the average turnaround time. Next to add a load to the network in train; I will plug in the AC power source for the arc detector, temperature sensor, ATO, and various equipments.



6. Discussion

I expect that the transfer rate depend on where the device was installed, and the nose loading examining will show that the transfer rate also depend on the level of noise.

Table 1 .Network system, which are suitable for TCMS system

Name	Speed (bps)	Cost
CAN Bus	1M	Low
IEEE-802.11	11M	Moderate
Bluetooth	1M	Moderate
Power line	100k	Low

Furthermore, packet loss will be considerable, and sometimes communication was not possible. The network adapter will appear to work using TCP/IP; however, it actually works using a passive token-ring protocol. The transfer rate is fix to maximum 300Kbps when there is only one pair of adapters. However, sometimes the data correction process will perform by the network adapter causes a delay. The delay will be considered to have result from the influence of the noise from impulse that it occurs to turn on or off institute in train. The data compression methods use to respond to delays in communication must be applied to synchronize all of the data, especially in the case of real-time transferring. The data must be available via the communication protocol Internet anywhere in the railway. However, the security of communication line can be protected by spectrum spreading method. In addition, the security of the data must be considered, and the data therefore should be encrypted. Also this system could do fire alarm. This system could watch electricity fire caused ARK, because it utilizes communication line by power line.

7. Conclusion

I propose a TCMS system using the power line network. I will evaluate this system experimentally because the power line system influenced by electronic noise. We will show that the transfer rate varies even when it is fixed. I expect that this network system should be an effective TCMS for tilting train. Network such as IEEE 802.1 has enough speed and capacity to transmit multimedia data of large size. But Ethernet is expensive of its setting the prices. Radio wave network such as IEEE-802.11 or Blue- tooth System has big capacity and rapid speed and it is unnecessary to fixed line. However Radio wave network occur interference and bottleneck between train tilting system and actuator in train control field. So I think that PLN using spectrum spread is good method in TCMS. But it is necessary to examination about power and noise problem.

REFERENCES

[1] *Bernard Sklar*, Digital Communication fundamental and applications, Prentice-hall, 1988

[2] *Woodward, B., Istepanian, R.S.H., Richards, C.I*: Finite-State Analysis of the CAN bus, International Symposium on High Assurance Systems Engineering, Volume: 5 Issue: 1 , Mar. 2001 Page(s): 13 -15

[3] IEEE Standard for Communications Protocol Aboard Trains (IEEE Std 1473-1999).

[4] Hook, J., Burnham, K.: Communications on the power line, Passenger Car Electrical Architecture (Ref. No. 2000/088) IEE Seminar, 2000 Page(s): 7/1 -7/6

[5] Shwehdi, M.H., Khan, A.Z.:A power line data communication interface using spread spectrum technology in home automation, Power Delivery, IEEE Transactions on, Volume: 11 Issue: 3, July 1996 Page(s): 1232 1237