A METHOD OF IDENTIFYING TRANSFER FUNCTION FOR NETWORK BY USE OF M-SEQUENCE CORRELATION

Eiji NISHIYAMA and Kenshi KUWANAMI
Department of Information and Communication, Kumamoto National College of Technology, Suya 2659-2, Nishigoshi-cho, Kumamoto, 861-1102, Japan

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Abstract: Monitoring a communication line is significant for broadband, mobile phone and so on. In this paper, we propose a new method for detecting a fault point of communication line by use of M-sequence correlation technique. In this method, detecting signal is used as one or plural M-sequences (same characteristic polynomial, including normal and reverse mark, synchronized). At receiving tap, we make same sequence with the input one and take crosscorrelation function between M-sequence and the received signal. We can get transfer functions of plural paths between inputs and a output tap separated from different of delay times on the crosscorrelation function, and from these transfer functions, so fault point is occurred when we compare them.

1 INTRODUCTION

Communication network which is used in telephone, broadband, LAN and so on requires to maintain completely and quickly. A communication agency is supervising telephone, CATV or radio-wave lines and so on.

In case of that a person wants to use internet, the person use dial up, ADSL and FTTH. He lived in old style building, it has connected optical FTTH line on the gateway of the building and branches the line for many user and use the old style telephone line, VDSL or ADSL in the building as it was.

It has a cost advantage that it is not necessary to be laid a new (metal or fiber) line. In general, the metal lines of old building or cables in a city are very complex. It has short cut open or down cause of secular progress, flood and animals. It is very hard work for agency or the building owner to investigate finding the fault point of the lines.

In this paper, we proposed a new method for supervisory of communication line using M-sequences and a correlation technique. That is the M-sequence are put at one or several input points. And we take crosscorrelation function between same M-sequence and received signal, on the function, there exists some peak appeared points shifted and figured depend on path length and transfer function from input(s) to receiving point. We compare the parameter originated from the crosscorrelation function when fault occurred with in usual time.

2 PRINCIPLE OF MEASUREMENT

We will describe the fundamental method for finding the fault point of network by using M-sequence.

2.1 Measurement of transit function of path

Let us assume a Communication network which has one input and output tap line, respectively as shown in Fig.1. And the transit function between input a and output b is defined by g_{ab}, so the output signal appears as

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$$y(t) = \int g_{ab}(\tau)u(t-\tau-k_{ab})d\tau$$
$$= g_{ab} * u(t-k_{ab}) \qquad 1)$$

where $\boldsymbol{k_{ab}}$ indicated an arriving time from $\boldsymbol{a}$ to $\boldsymbol{b}$ and (*) is indicated by convolution integral of $\boldsymbol{g_{ab}}$ and $\boldsymbol{u(t-k_{ab})}$.
We use M-sequence as input $u(t)$, and take crosscorrelation function between g_{ab} and $u(t-k_{ab})$, so the function can be written by

$$\phi_{ab}(n) = g_{ab} * \delta(k_{ab}-n) \qquad 2)$$

{Note, in this paper; we assumed a reflective wave would not be appeared.}

Figure 1: One input and output line

Here, n is defined by shift time and $\delta(k_{ab}-n)$ is delta function which appears at k_{ab} shift time on the crosscorrelation function. Simultaneously, the transit function can be estimated start at k_{ab} on the crosscorrelation function.

2.2 Measurement of transit functions of plural paths

As same consideration with former sub-section, we define a simple network circuit as shown in Fig. 2. It has 4 taps such as a, b, c, and d, and they are set far places each other. a, b is assumed signal as input, and c, d are set receiving taps, respectively. Then

$$y_c(n) = g_{abc} * u_a(n-k_{abc}) + g_{adc} * u_a(n-k_{adc})$$
$$+ g_{bc} * u_a(n-k_{bc}) + g_{badc} * u_a(n-k_{badc}). \quad 3)$$

output signal $y_c(t)$ is displayed as

Here, g_{abc} and k_{abc} are transfer function and delay time of the paths of a-b-c and a-d-c, respectively, note that g_{abc}, g_{bc}, g_{badc}, k_{abc}, k_{bc} and k_{badc} also have to be named.

If u_b would be used same M-sequence with u_a, , thus, the crosscorrelation function via a and c taps is indicated by

$$\phi_{ac}(n) = g_{abc} * \delta(n-k_{abc}) + g_{adc} * \delta(n-k_{adc})$$
$$+ g_{bc} * \delta(n-k_{bc}) + g_{badc} * \delta(n-k_{badc}). \qquad 4)$$

We see in Equation 4), each term of this equation has to be overlapped. It is a reason that the M-sequence clock speed is too late comparison with the light speed, so almost correlation function have overlapped. In general, we can not analyze the transfer functions from plural input system in this method.

In order to get each functions, this is the idea of the study, we use $\boldsymbol{b}$ shift of $\boldsymbol{u_a}$ in $\boldsymbol{u_b}$ which satisfies enough delay compare with transfer time of via $\boldsymbol{a}$ to $\boldsymbol{b}$.
At this time, the crosscorrelation function via a to c is calculated by

$$\phi_{ac}(n) = g_{abc} * \delta(n-k_{abc}) + g_{adc} * \delta(n-k_{adc})$$
$$+ g_{bc} * \delta(n-b-k_{bc}) + g_{badc} * \delta(n-b-k_{badc}). \qquad 5)$$

Then, this crosscorrelation function can show all of path information from $\boldsymbol{a}$ to $\boldsymbol{b}$.
Additionally, in general, in order to easy understanding, shift b should be used delay time comparison with u_a, and u_b also used reverse mark of u_a.

3 COMPUTER SIMULATION

3.1 Target circuit and M-sequence

We tried a theoretical simulation to confirm effectiveness of the proposed method. Fig. 2 shows an example network circuit. Here a and b are defined input taps, and c and d are signal receiving taps, respectively. Transfer functions of path a-b, b-c, c-d are assumed,

$$g_{ab}(\tau) = g_{bc}(\tau) = g_{cd}(\tau) = \frac{1}{1+3s} \qquad 6)$$

,respectively, and path d-a is

$$g_{da}(\tau) = \frac{1}{1+3s} \bullet \frac{1}{1+3s}. \qquad 7)$$

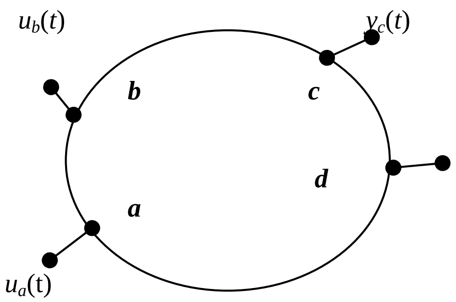

Figure 2: A network having 2 inputs

And, transfer delays are

$$n=14 \quad \text{for} \quad \boldsymbol{k_{ab}= k_{bc}= k_{cd}} \qquad 8)$$

$$n=28 \quad \text{for} \quad \boldsymbol{k_{da}} \qquad 9)$$

We use 10 degree M-sequence having characteristic polynomial ($x^{10}+x^8+x^5+x^2+1=0$) as $\boldsymbol{u_a(t)}$ and $\boldsymbol{u_b(t)}$.

3.2 Crosscorrelation function

Figure 3 indicates crosscorrelation function between $\boldsymbol{u_a(t)}$ and $\boldsymbol{y_c(t)}$. There exists much information of the each path. The first peak has minus correlation, and n is the smallest delay shift, and this amplitude is also the largest and this peak figures shape, therefore, the first peak is originated input $\boldsymbol{u_a(t)}$ and ***b-c*** by these reasons. The second (***n***=28) one has plus peak and larger from the third peak (***n***=42), we can estimate that transferring path is ***a-b-c*** and input $\boldsymbol{u_a(t)}$. And it has also third (+ correlation, ***n***=42, originated from $\boldsymbol{u_a(t)}$, path ***a-d-c***) and fourth (- correlation, ***n***=54, from $\boldsymbol{u_b(t)}$, path ***b-d-c***).

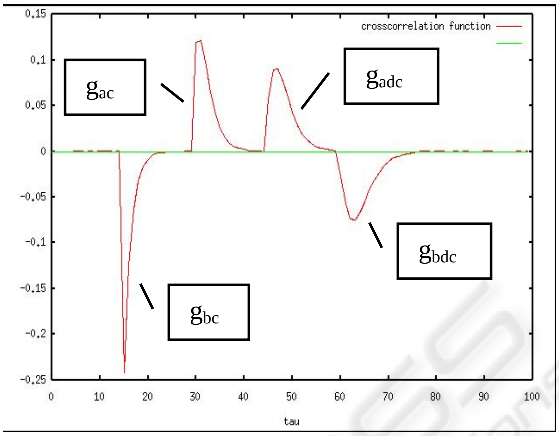

Figure 3: Crosscorrelation between $u_a(t)$ and $y_c(t)$

4. EXPERIMENT

We tried to confirm to the theory and computer simulation, then we carried out the four practical simulations using shield line, one is Loop type and the other hand is 3 kinds of Y-connect type circuits. The property of this circuit is shown Table 1. In order to be accuracy measuring, M-sequence is used 12 degree (length is 2^{12}-1=4095), and it clock frequency (chip speed) is selected by 2MHz (shield line property, it has LPF characteristics, it can not be passed upper of this frequency).

Table 1: Property of shield line simulation

M-sequence	$f_{(x)}=x^{12}+x^6+x^4+x+1$
Clock frequency (chip speed)	2MHz
Shield line impedance	75 ohm
Input voltage	8Vpp
Result of unit of *y* axis (Fig.6)	0.5micro second
$u_b(t)$	$u_a(t\text{-}50T)$

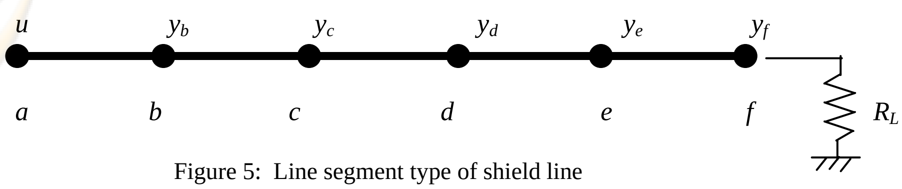

Figure 5: Line segment type of shield line

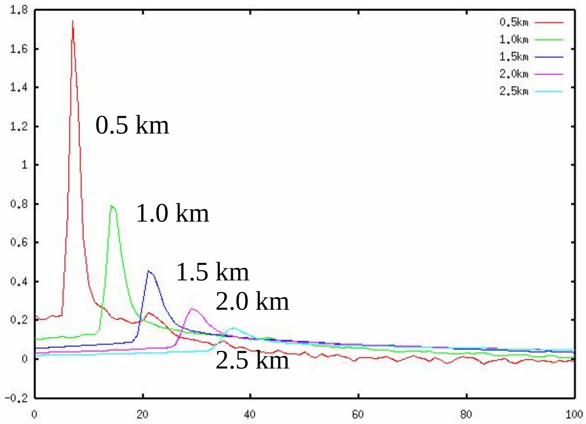

Figure 6: Crosscorrelation of line segment

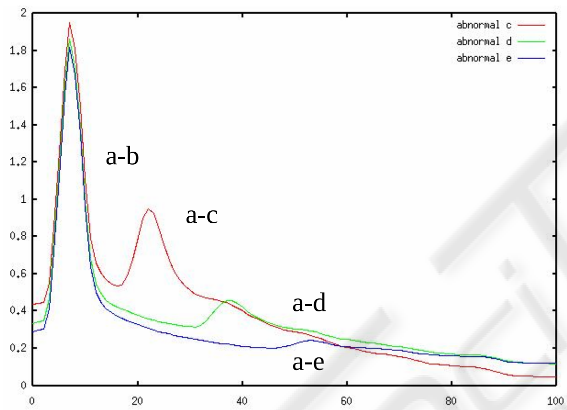

Figure 7: Crosscorrelation of line segment with reflective waves (without resistor)

4.1 Line Segment type

Figure 5 shows line segment type circuit, distance between each tap (***a-b***, ***b-c***,…., ***e-f***) is 0.5km. The shift time is 10micro second in 20 shift time.

The crosscorrelation function between taps (a-b, a-c, a-d,..) can be drawn in Fig. 6,. The peak of each tap can be occurred in this figure. The peak will be proportional apart from shift 0 comply with distance. And the figure of peak will be sharply according reverse of distance. Here we can not see reflective peak in order to be set the resistor same as characteristics resistance of the shield cable.

Figure 7 shows Crosscorrelation of line segment with reflective waves (without resistor), so you can see the reflective peak in the largest one at 20 shift time. We can estimate the wave come from neighbour tap of b.

4.2 Line segment type with cut point

Figure 8 shows Line segment type and it has one cut point, the input stimulate in a and output signal will be received in b when the accident (cut at c, d, or f). In order to avoid of reflecting wave, so resistor is set.

Figure 9 shows crosscorrelation function between tap a and b, in this figure, the first peak of each wave are same shift time and absolute caused of direct distance of a to b.

Cut point in c, we can see the reflecting wave came from 23-7=16 from the point.

Cut point in d, we estimate approximate twice shift time 38-7=31 comparison cut point c.

Cut point in e, as same approximate 3rd time 55-7=48.

We consider that the peak of reflecting wave is appeared in the time shift proportioned with the distance.

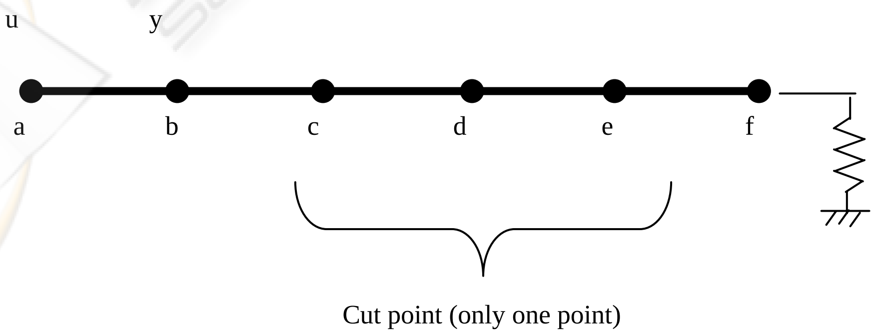

Figure 8: Line segment type with cut point

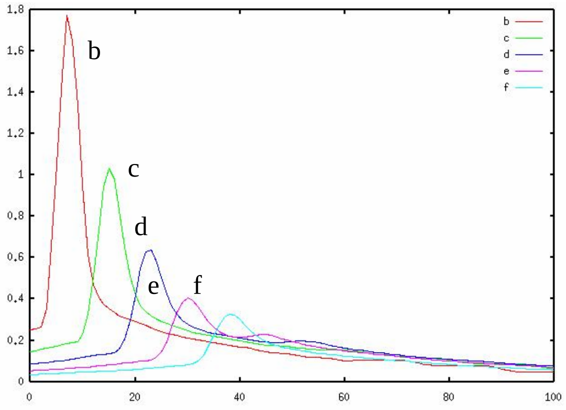

Figure 9: Crosscorrelation of line segment Line with cut point

4.3 Line segment type with 2 inputs

Figure 10 shows line segment type with 2 inputs circuit. We input 2 stimulates at **a** and **f** 50 shifted by **a**. and receiving wave is gotten at b,c,d,e or f.

Figure 11 shows crosscorrelation function of line segment type with 2 inputs circuit. It is easy to understand to see the information, the wave which has first peak is obtained in tap b. it is the nearest from **a** and farthest point from **f**, therefore it has largest at 7 and smallest peak at 80 shift point. Also the second arrived peak has second and second smallest peaks.

So, we will able to estimate direction and distance, if we stimulate 2 M-sequences for one circuit.

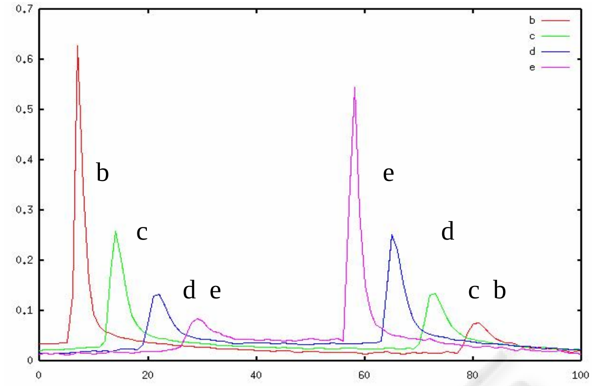

Figure 11: Crosscorrelation of line segment type with cut point

4.4 Loop circuit of shield line

Figure 12 shows Loop circuit the shield line simulation. Distance between a-b and b-c is set also 0.5km and a-c is 1.5km, respectively. Here, we use $u_b = -u_a(t\text{-}50T)$.

The crosscorrelation function signal between *a* and *c* is shown as Figure 13. In this figure, first and second peak (appeared at 16 and 22) came from a tap via upper path and lower path, respectively. Third and forth peak came from b tap via upper and lower path, respectively. The third peak is larger than first and second peak. The nearest point from receiving point is c. The transfer time to c of upper path of b is the fastest, however, it appears shift time at the shift M-sequence shift delay plus differential phase 50.

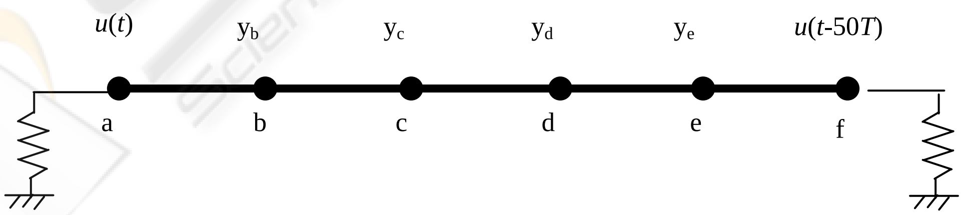

Figure 10: Line segment type with 2 inputs

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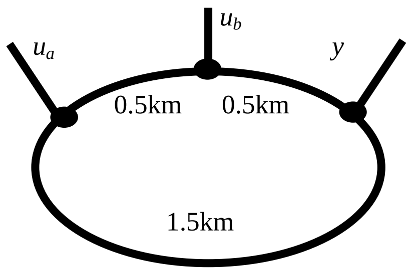

Figure 12: Loop type

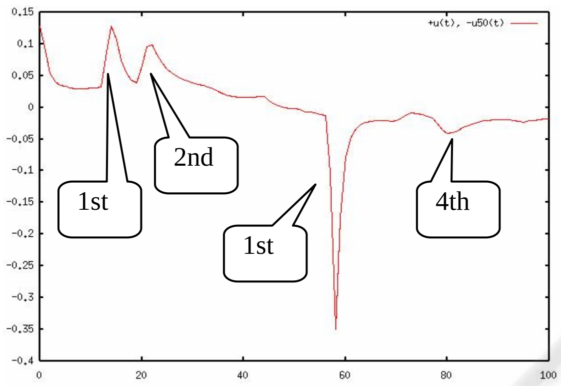

Figure 13: A result of loop type

5 CONCLUSIONS

We proposed a new method for identification of transfer function of line and network is used communication lines. In this method we input an or plural M-sequence(s) which is a kind of pseudo-random sequence and get receiving signal after flowing networks. And the crosscorrelation function between M-sequence and receiving signal is calculated. So we get the transfer function depend on the paths of input and receiving taps.

We carried out computer simulations and experiments to confirm the effectiveness of the method. The results of the simulations and experiments, we can identify the transfer functions which are matched with theoretical consideration.

REFERENCES

E. Nishiyama and K. Kuwanami : “Fault Detection for Power Transmission Line by Use of M-sequence Correlation” Proc. IEEE/PES Transmission and Distribution Conference and Exhibition 2002: Asia Pacific held in Yokohama, Japan, ,pp.465-469 (2002).

E. Nishiyama, K. Owakii, and K. Kuwanami: “ Fault Detection for Network by use of Plural M-sequences”, Proc. ICCAS 2002 held in Jeonbuk, Korea, pp. 1339-1342 (2002).

E. Nishiyama and K. Kuwanami: “Presentation of a Fault detecting Method for Power Transmission Line using M-sequence”, Proc. ICCAS held in Cheju, Korea, pp.533-535 (2001).

Kashiwagi, “M-sequence and its application,” *shokodo, Japan*, 1996.

IEE, “ Electrical Engineering Handbook, “ IEE 1986.