A Method for Fault detecting on Power Transmission Network by use of M-sequence Correlation

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Abstract: Monitoring a power transmission line is significant for power electric companies. In this paper, we propose a new method for detecting an fault point of power transmission 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 re verse mark, synchronized). In receiving point, we make same sequence with the input one and take crosscorrelation fun ction between M-sequence and the received signal. We can see transfer fanctions of plural paths between inputs and a o utput taps separated from different of delay times on the crosscorrelation function, and from these transfer fanctions, so we compare them when fault occurred with in usual.
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Keywords: Power transmission line, M-sequence, fault detect, cross correlation function, characteristic polynomial

1. INTRODUCTION

Supervisory control of the power system including distributed generations such as fuel cells micro-turbines, etc., requires to detect faults of power transmission line, details. As conventional method, a electric power company is supervising power transmission lines using power system monitoring system. A fault on a power transmission line would occurred, in order to find the abnormal point, the company turn on or off several times, therefore worker's danger is pointed out.In this paper, we proposed a new method for supervisory of power transmission line using plural M-sequences and a correlation technique.

That is, the M-sequence are put at several input points. And making same M-sequence at the receiving point. 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 inputs to receiving point. We compare the parameter originated from the crosscorrelation function when fault occurred with in usual time. . Nissan and Hitachi have patents but on computer network and is needed complex inquiry system and plural sensors.

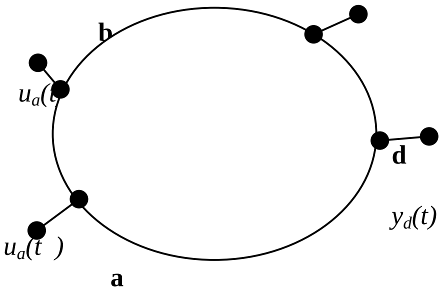


Fig. 1 Example of linear network circuit

2. PRINCIPLE OF MEASUREMENT

2.1 Measurement of transit functions of plural paths

Let's define a simple network circuit as shown in Fig. 1. It has 4 taps such as **a, b, c**, and **d**, and they set far places each other. **a** and **b** assume signal input taps and **c** and **d** are receiving taps. Input signal $u_a(t)$ flows to **c** via 2 paths **a-b-c** and **a-d-c**, and output signal $y_c(t)$ is displayed as

$$y_d(t) = \int g_{abc}(\tau) u_a(t-\tau-k_{abc}) d\tau + \int g_{adc}(\tau) u_a(t-\tau-k_{adc}) d\tau. \quad 1)$$

Here, $g_{abc}(\tau)$ means transfer fanction (linear impulseresp onse) between **a-b-c**, and k_{abc} means transmit delay for **a-b-c** and so on.

$$y_c(t) = g_{abc} * u_a(k_{abc}) + g_{adc} * u_a(k_{adc}) \quad 2)$$

In this paper, equation 1) is if it writes simply, Here, we take crosscorrelation function between u_a and y_c, here, n indicates

$$\phi_{ac}(n) = \overline{u_a \cdot \{g_{abc} * u_a(k_{abc}-n) + g_{adc} * u_a(k_{adc}-n)\}} \quad 3)$$

phase shifts. If pseudo-random M-sequence is used, transfer function of the path is obtained as next equation[1].

$$\phi_{ac}(n) = g_{abc} * \delta_a(k_{abc}-n) + g_{adc} * \delta_a(k_{adc}-n) \quad 4)$$

$\delta(k_{xyz}-n)$ shows delta function which appears at phase k_{xyz}.

So, we can measure transfer function of each paths taking crosscorrelation function between an input M-sequence and an output of path. Figure 2 shows typical crosscorrelation function between $u_a(t)$ and $y_c(t)$ if distance between **a–c** is near. In this figure, horizontal and vertical axis show delay time n and amplitude of correlation, respectively. And we can see the first term of equation [4] appears at n=20 and the second term appears at n=23. In general, a correlation peak point appears depend on length of path.

2.2 Correlation from two paths and how to find path which fault occurs.

In Figure 1, An another input tap **b** is used and we put $u_b(t)$ that is reverse mark M-sequence of $u_a(t)$, then the crosscorrelation function between $u_a(t)$ and $y_c(t)$ is obtained as

$$\phi_{ac}(n) = g_{abc} * \delta(k_{abc}-n) + g_{adc} * \delta(k_{adc}-n) - A_{b1}\cdot g_{bc} * \delta(k_{bc}-n) - A_{b2}\cdot g_{badc} * \delta(k_{badc}-n). \quad 5)$$

Equation (5) contains 4 terms depend on the inputs and the paths. Note the first term and third term, we say the procedure of this method, again.

1) the phase of $u_b(t)$ should be shifted 0 to k_{bc}-k_{abc} ,
2) and an amplitude of $u_b(t)$ will be adjusted amplitude k_{bx},

We should to note the constants k_{bc}, k_{abc} and A_{bc} as usual. And if a fault of the line occurred, so the constants should be calculated once again, and compared with usual values, then we can find the point having fault.

3. SIMULATION

3.1 Target circuit and M-sequence

We tried a theoretical simulation to confirm effectiveness of the proposed method. Figure 3 shows an example linear network circuit. Here **a** and **b** are defined input taps, and **c** and **d** are signal receiving taps, respectively. Transfer fanctions 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

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

And, transfer delays are

n=14 for k_{ab}= k_{bc}= k_{cd} 8)
n=28 for k_{da} 9)

We use 10 degree M-sequence having characteristic polynomial ($x^{10}+x^8+x^5+x^2+1=0$) as $u_a(t)$ and -$u_b(t)$, then $u_a(t)$ is called "basis M-sequence".

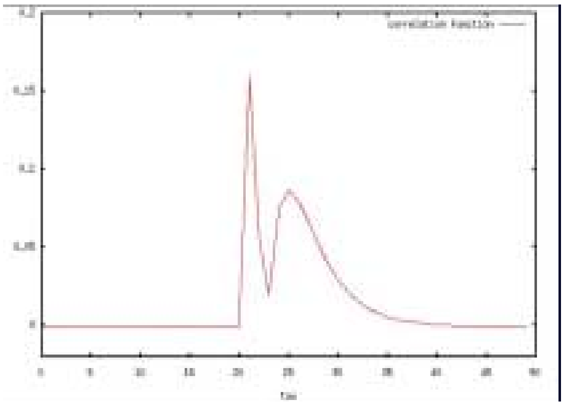


Fig.2 An example of crosscorrelation function

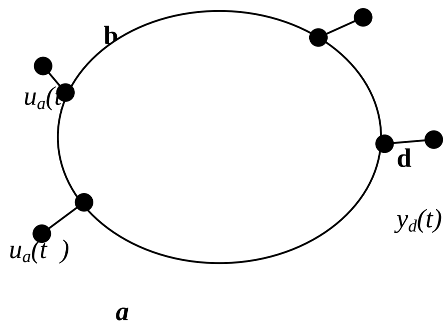


Fig. 3 Example of linear network circuit

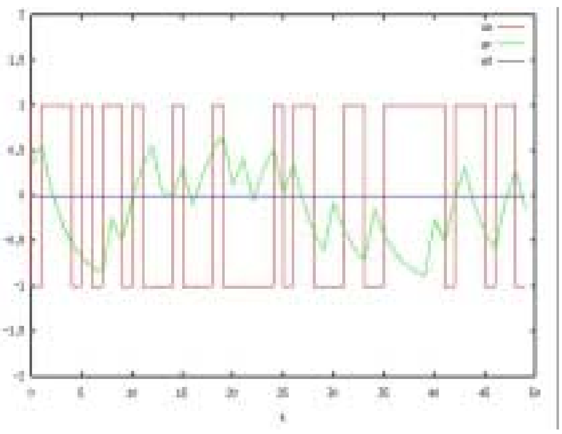


Fig. 4 $u_a(t)$, $y_c(t)$ andand

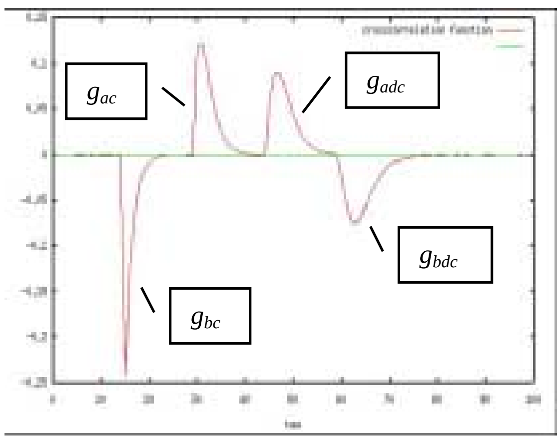


Fig. 5 Crosscorrelation between $u_a(t)$ and $y_c(t)$

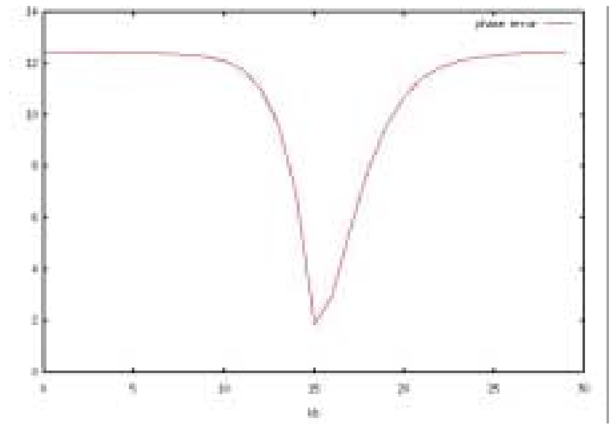


Fig. 6 Shift error value

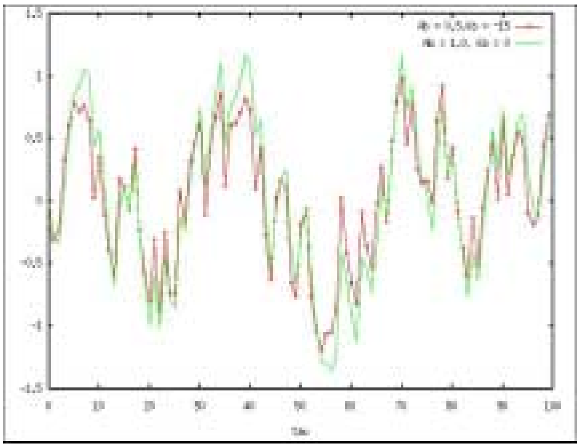


Fig. 7 Output waveform

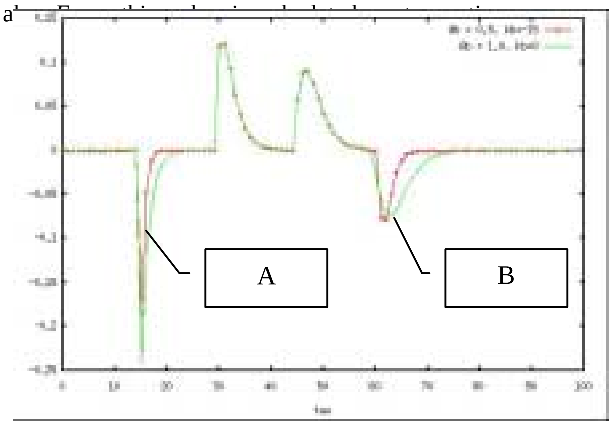


Fig. 8-a C.C.F using for path b-c

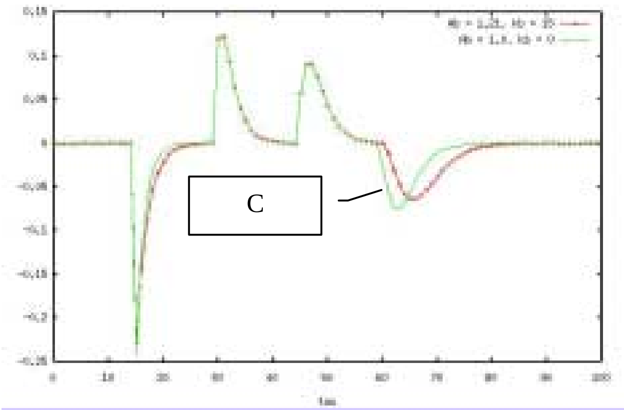


Fig. 8-b C.C.F for path b-a-d-c

3.2 Crosscorrelation function

Figure 4 shows $u_a(t)$, $y_c(t)$ and $y_d(t)$, here horizontal and vertical axis are time and amplitude, respectively. Note, the network circuit is completely symmetry, then $y_d(t)$ is not appeared. And $y_c(t)$ has 14 time delay comparing with $u_a(t)$.

Figure 5 indicates crosscorrelation function between $u_a(t)$ and $y_c(t)$. 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 $u_a(t)$ 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 $u_a(t)$. And it has also third (+ correlation, n=42, originated from $u_a(t)$, path **a-d-c**) and fourth (- correlation, n=54, from $u_b(t)$, path **b-d-c**).

3.3 Getting parameters

From the crosscorrelation function, we can get the shift and amplitude parameters.

Delay parameter Figure 6 shows delay shift and error v a

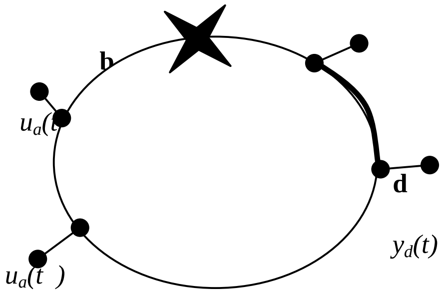
This value indicates the best shift delay of $u_b(t)$ a basis of $u_a(t)$. So we should use $u_b(t)$ shifted by 15, the crosscorrelation function will be minimum comparison with $u_a(t)$.

Remark amplitude See Fig. 4 once again, Path **b-c** has large peak amplitude comparing with **a-c**, so amplitude of $u_b(t)$ would be adjust small, we can obtain the smallest correlation of tap **c**. But we can not find the best estimating method for adjustment of amplitude, so in order to equal the correlation peak $g_{bc}(t)$ with $g_{abc}(t)$, amplitude parameter A_b that is just a ratio of amplitude of each peak. Figure 7-a, 7-b shows the crosscorrelation function using A_b=0.50 (for path **b-c**), A_b =1.21 (for path **b-a-d-c**), respectively, and you can see that the amplitude of peak is reduced.

3.4 Fault detection

We tried 2 type fault detection of the network circuit as shown in Fig. 8 using the detected parameters.

Network having break point An upper part of Fig. 8, path **b-c** is broken, and the crosscorrelation function of the situation is shown in Fig. 9-a. You can see the first and second peaks have lost, so we estimate the fault on the path **b-c**.



a

Fig. 9 The network circuit with fault

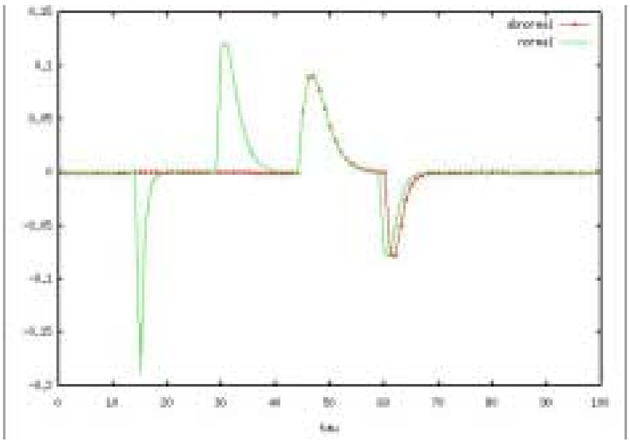


Fig. 10-a C.C.F. in case of cutting the line

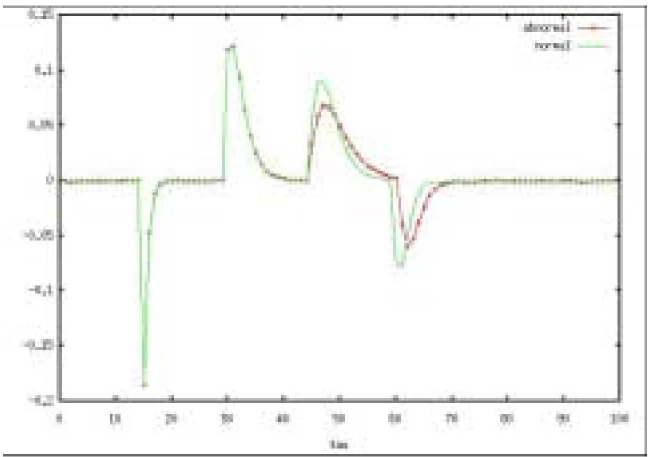


Fig. 10-b C.C.F in case of changed impedance changed impedance

Network impedance is changed A right side of

Fig. 8, network impedance is changed next

$$g_{cd}(\tau) = \frac{1}{1+3s} \bullet \frac{1}{1+3s}. \qquad 11)$$

transfer function,

The crosscorrelation function is shown in Fig. 9-b, here third and fourth peaks are blunted and constant becomes Ab=1.5. then we can find the impedance of path **c-d** is changed.

5. PRACTICAL EXPERIMENTS

We tried experiments for detecting the fault of power transmission line. Two type transmission line which are Line segment type and network type experiments are carried out. Here, 12 degree M-sequence having the characteristics polynomial 10123 (oct) is used. And clock frequency of M-sequence is 2 MHz.

4.1 Line segment type

Transmission status of segment Figure 11 shows line segment type transmission line which having 0.5km ~2.5km lengths with a 75 ohm loading resistance.

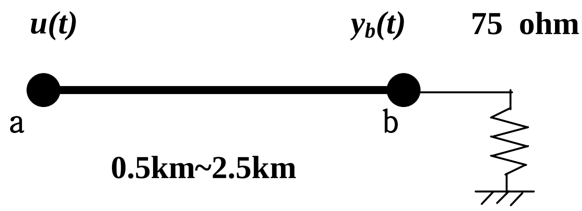


Fig. 11 Line segment type

An M-sequence ***u(t)*** is stimulated in **a** tap, and we get a received signal $y_b(t)$ in **b** tap. So a crosscorrelation function between ***u(t)*** and $y_b(t)$ is shown as Fig. 12.

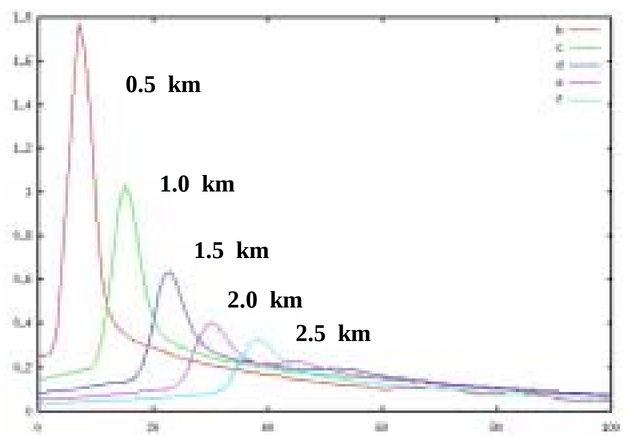


Fig. 12 CCF for line segment type

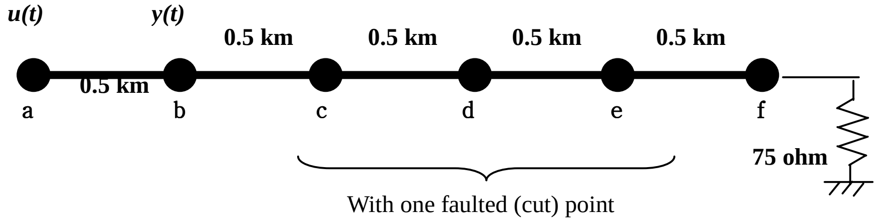


Fig. 13 Line segment type with having fault

In this figure, distance between input and output tap is clearly illustrates, and the amplitudes of peak can be also identified according lengths of line.

Segment type with fault Figure 13 shows line segment type power transmission line with one fault (cut) point and fault point is moved **c** to **e**. Here, we input M-sequence ***u(t)*** in a tap and received signal ***y(t)*** in **b** tap. We calculate crosscorrelation function between ***u(t)*** and ***y(t)*** is shown as Fig. 14. So fault point of line (**c**, **d**, or **e**) are clearly appear, we can estimate where a fault point would occurred.

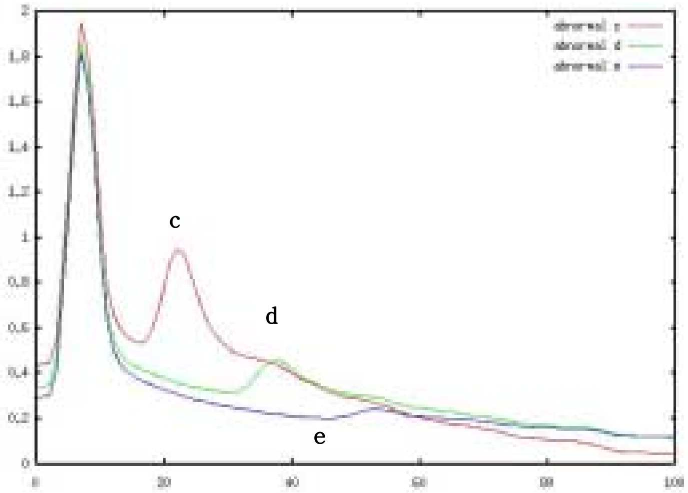


Fig. 13 CCF for line segment type with having fault

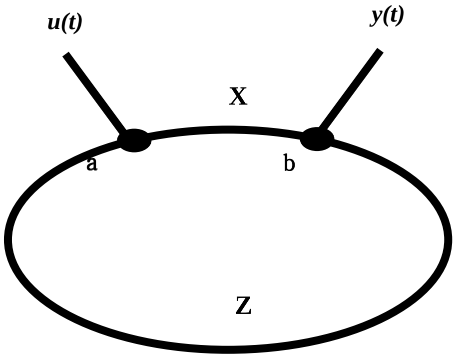


Fig. 14 Network type having one input

4.2 Network type

One input type network Figure 14 shows having network having one input type transmission system. We input M-sequence in **a** tap and received **b** tap, here X, Z shows length parameter is shown as Table 1. Figure 15 shows crosscorrelation function for one input network type system.
In this figure, a peak of **A** type is signal of ***u(t)*** arrived to **b** tap in the fastest delay. And parameter of **C** and **B** is as same as each other, because they are symmetry.

Network having two input type Figure 14 shows one input network transmission system. We input M-sequence in **a** tap and received **b** tap. Here X, Z shows length parameters are shown as Table 1. Figure 15 shows crosscorrelation function for one input network type system having two inputs and one output, and Figure 17 shows its crosscorrelation function. The first and second peak of the function is caused by tap **b** and **a**, respectively. Third and forth peak should be reverse direction transfer of the network.

Table 1 Parameters of network type line (one input)

	X	Z
A	0.5 km	2.0 km
B	1.0 km	1.5 km
C	1.5 km	0.5 km

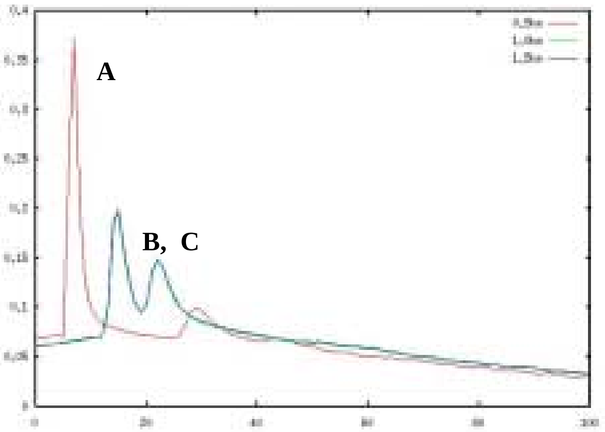


Fig. 15 CCF for Network type having one input

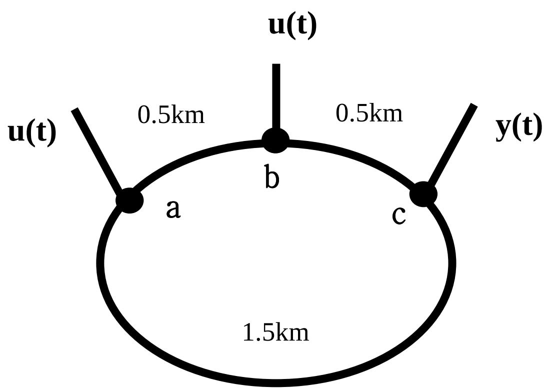


Fig. 16 Network type having two inputs

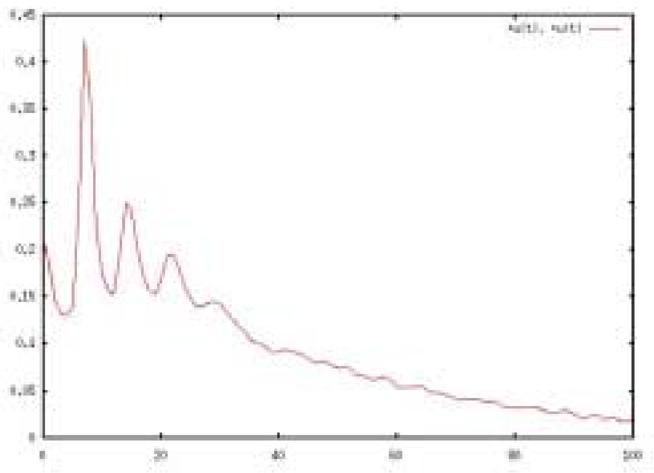


Fig. 17 CCF for network type having two inputs

5. CONCLUSION

An estimation of fault detecting for a power transmission line using of M-sequence is proposed.
This method;

One or plural M-sequence (same characteristic polynomial, and they take synchronization, which signs normal and reverse sequences) are provided and is put taps of power transmission line. And take a crosscorrelation function between the input sequence and received signal. Note the different delay parameter between the each input and received signal, and calculate an amplitude parameter that compared between inputs and estimate amplitudes.
If the network would be faulted, the constants change other values.

We tried the simulation confirming an effectiveness of the method for the fault detecting of a linear example network. In these results, we have detected of abnormal points.

ACKNOWLEDGMENTS

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