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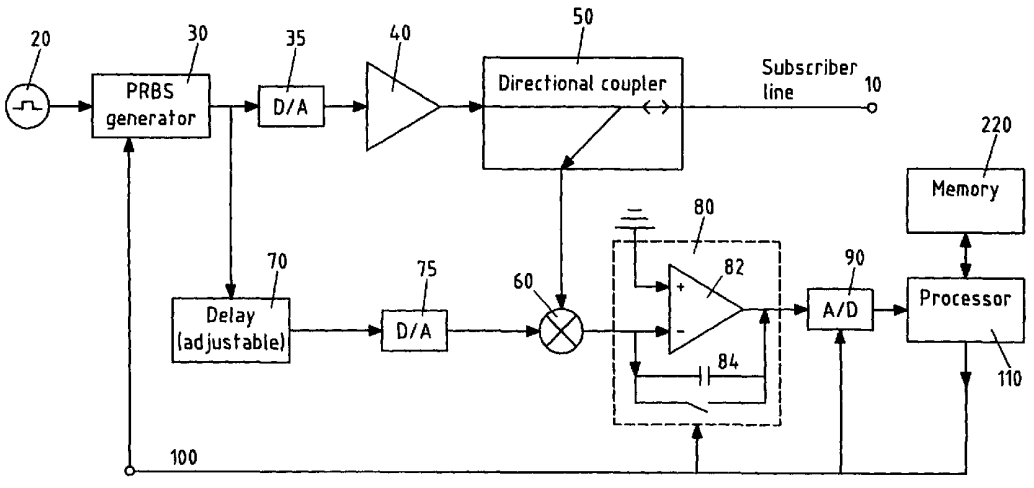
(54) Title: ELECTRONIC CIRCUIT AND METHOD FOR TESTING A LINE



(57) Abstract: The invention relates to an electronic circuit and method for testing a line (10). According to the invention the signal generator (20, 30) comprises a random bit series generating means for generating a spread spectrum test signal and the evaluating unit comprises means (60-90, 200-230) for calculating and evaluating the correlation function of the test signal and the reflected signal.

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Electronic circuit and method for testing a line

Field of the invention

The invention relates to an electronic circuit for testing a line, in particular a subscriber line for broadband data transmission.

Technical background of the invention

Such a circuit is known in the art and typically comprises a signal generator for generating a test signal, a coupler for coupling the signal generator to the line and for enabling a sending of said test signal to said line. The circuit further comprises an evaluating unit for receiving form said coupler a reflected signal being generated when said test signal is sent via said line.

The invention further relates to a corresponding method for testing lines.

In prior art in particular time domain reflectrometry was used for testing lines. According to that method a short pulse was sent to the line and a reflected signal of said short pulse was measured. Said reflected signal might be caused from any impedance discontinuities on the line. When evaluating said reflected signal, faults on the line can be located or the suitability of the line for a particular purpose can be predicted.

However, implementation of such traditional electronic circuits and methods is complicated and quite expensive. Moreover, the traditional systems are very sensitive to disturbances and noise on the line with the result that they operate only less accurate.

Object of the invention

Starting from that prior art it is the object of the invention to improve an electronic circuit and method for testing a line, in particular a subscriber line in that the system and method operates more accurate and implementation thereof is facilitated and made less expensive.

Summary of the invention

For the above defined system this object is solved in the way that the signal generator comprises a random bit series generating means for generating a spread spectrum test signal and that said evaluating unit comprises means for calculating and evaluating the correlation function of said test signal and said reflected signal.

The usage of such a test signal and such means allows the usage of low measurement frequencies with the result that the performance, the accuracy and the measurement range is improved, because the attenuation of the line is strongly frequency dependent.

Moreover, accuracy is increased because the system according to the invention is less sensitive to noise and other disturbances present on the line. Further,

implementation of the system is reasonably simple and cheap.

According to a first embodiment the random bit generating means is a pseudo random bit series PRBS generator implementation of which is quite simple.

It is advantageous that said means of the evaluating unit comprise an adjustable delay unit for adjustably delaying the spread spectrum test signal as generated by said PRBS generator, a second D/A converter for converting the delayed test signal into an analog delayed test signal, a mixer for multiplying the analog delayed spread spectrum test signal with the analog received reflected signal and an integrator for integrating the output signal of said mixer for variable delays of said spread spectrum test signal. Said components of said means advantageously enable an analog calculation of the correlation function of the reflected signal and the delayed test signal wherein the correlation function enables assessment of the similarity of the reflected signal and the delayed test signal. The similarity of these signals allows the location of faults on the tested line or the prediction of as to whether the line is suitable for a particular application, e.g. for broadband data transmission.

Alternatively to the embodiment of the evaluating unit described above the evaluating unit may comprise a second A/D converter for converting the analog reflected signal received from said coupler into a digital signal and a second processor for calculating the correlation function from said digitized reflected signal and the digital random bit series as generated by said signal generator. Advantageously said alternative embodiment of the

evaluating unit enables a digital calculation of the correlation function.

Preferably, the coupler is embodied as line-hybrid coupler comprising two parallel branches, each comprising a series connection of impedances wherein the spread spectrum test signal is input to said coupler in parallel to said branches and wherein the reflected signal is received between two connecting points defining the connection between two impedances of a series connection, respectively. The line is connected to the coupler via a transformer such that the input impedance of said transformer being loaded with the impedance of said line represents one of said coupler impedances.

Advantageously said coupler and in particular said line-hybrid coupler, enables a directional coupling of the electronic circuit to the line.

The object of the present invention is further solved by the method according to claim 9. The advantages of said method correspond to the advantages of the electronic circuit as mentioned above.

Listing of the figures

In the following several embodiments of the invention are described in more detail by referring to the accompanying figures, wherein:

Fig. 1 shows a first embodiment of the electronic circuit according to the invention;

Fig. 2 shows a second embodiment of the electronic circuit according to the invention;

Fig. 3 shows a third embodiment of the electronic circuit according to the invention; and

Fig. 4 shows a block diagram of a line hybrid coupler as used in any of the embodiments of the electronic circuit.

Detailed description of the embodiments of the invention

Fig. 1 shows a first embodiment of the electronic circuit according to the invention for testing a subscriber line 10. The electronic circuit comprises an adjustable clock generator 20 being coupled to a digital pseudo random bit series PRBS generator 30 for generating a PRBS-signal. The operation clock rate of the electronic circuit can be changed by changing the frequency of the clock generated by said adjustable clock generator 20.

The PRBS-signal represents a spread spectrum test signal. Said test signal is converted into an analog signal by a first digital to analog D/A converter 35 and amplified by an amplifier 40 before being output to a directional coupler 50.

The directional coupler 50 enables a sending of said analog amplified spread spectrum test signal to said subscriber line 10 and further enables the receive of the reflected signal from said spread spectrum test signal caused by impedance discontinuities on the subscriber line 10.

Said received reflected signal is mixed in a mixer 60 with said spread spectrum test signal, which has been adjustably delayed by an adjustable delay unit 70 and converted into an analog signal by a second D/A-converter 75.

The signal output by said mixer 60 is input to an integrator 80 for being integrated. The integrator 80 is preferably, but not necessarily realised by an operational amplifier 82 which is connected accordingly. According to Fig. 1 the output signal of the mixer 60 is input to the inverting input of said operational amplifier 82 whereas its non-inverting input is connected to ground. A capacitor 84 is connected between the inverting input of the operational amplifier 82 and its output in order to enable an operation of said operational amplifier as integrator.

With the help of the adjustable delay unit 70, the mixer 60 and the analog integrator 80 the correlation function between the delayed spread spectrum test signal and the reflected signal is calculated in an analog manner. The values of said correlation function are output by said integrator 80. An evaluation of said calculated correlation values provide information about the similarity of the received reflected signal and the delayed test signal and thus, about the location of faults on the subscriber line or the suitability of the subscriber line 10 for a particular desired application, e.g. for broadband data transmission (xDSL wherein DSL means Digital Subscriber Line).

According to Fig. 1 the analog correlation values output by the integrator 80 are digitised by a first

analog/digital A/D converter 90 before being provided to a first processor 110 which serves for storing and reading out said correlation values in /from a memory 220.

The PRBS-generator 30, the integrator 80 as well as said first A/D converter 90 are connected to a reset line 100 for being reset by a reset signal being generated by said processor 110; in that way the processor 110 serves for controlling the generation of the correlation values which represent a measurement sequence. The integrator 80 is reset by shunting said capacitor 84.

Fig. 2 shows a second embodiment of the electronic circuit according to the invention. The subscriber line 10, the adjustable clock generator 20, the PRBS generator 30, the first D/A-converter 35, the amplifier 40, the directional coupler 50 and the memory 220 as well as the operations thereof correspond to the identical components and operations thereof as described for the first embodiment by referring to Fig 1.

However, the second embodiment differs from the first embodiment in that the correlation function is calculated digitally. For achieving that purpose the reflected analog test signal received from the directional coupler 50 is digitised by a second analog to digital converter 200 before being communicated to a second processor 210. The second processor is further connected to the output of said PRBS generator 30 for receiving the spread spectrum test signal which is a pseudo random bit series. The processor 210 calculates the correlation function form the digitised reflected signal and the test signal

and outputs the calculated correlation values to the memory 220.

Fig. 3 shows a third embodiment of the electronic circuit according to the invention. It only differs from the second embodiment as described by referring to Fig. 2 in that the second processor 210 is not connected to the output of said PRBS generator 30 but to the output of the amplifier 40. The amplifier 40 outputs the spread spectrum test signal in an analog form and thus a third A/D converter 230 is required for digitising the test signal before being input to said processor 210.

Fig. 4 shows a specific embodiment of the directional coupler as used in any of the embodiments of the electronic circuit according to the present invention. In said embodiment the directional coupler is embodied as a line hybrid coupler 500. The coupler 500 comprises two parallel branches each comprising a series connection of impedances 510, 520, 530 and 540. The impedance 530 is the input impedance of a transformer 550 being connected to the subscriber line 10. In Fig. 3 said subscriber line is represented by its line impedance 10'.

The spread spectrum test signal is input to said coupler 500 in parallel to said branches and the reflected signal is received between two connection points defined by the connections between the two impedances in said series connections, respectively.

CLAIMS

1. Electronic circuit for testing a line (10), in particular a subscriber line, the circuit comprising:

a signal generator (20, 30) for generating a test signal;

a coupler (50, 500) for coupling the signal generator (20, 30) to the line (10) and for enabling a sending of said test signal to said line (10), and

an evaluating unit (60-90, 200-230) being also connected to said coupler (50, 500) for receiving form said coupler a reflected signal generated when said test signal is transmitted via said line (10);

characterised in that

the signal generator (20, 30) comprises a random bit series generating means for generating a spread spectrum test signal; and

said evaluating unit comprises means (60-90, 200-230) for calculating and evaluating the correlation function of said test signal and said reflected signal.

2. The electronic circuit according to claim 1, **characterized in that** the random bit generating means is a pseudo random bit series (PRBS) generator (20, 30).

3. The electronic circuit according to claim 2, **characterised in that** said means (60-90) comprises:
an adjustable delay unit (70) for adjustably delaying the spread spectrum test signal as generated by said first PRBS generator (30);

a second D/A converter (75) for converting said digital delayed test signal into an analog delayed test signal;

a mixer (60) for multiplying the analog delayed spread spectrum test signal with the analog received reflected signal; and

an integrator (80) for integrating the output signal of said mixer (60) for variable delays of said spread spectrum test signal.

4. The electronic circuit according to claim 1, **characterised in that** said means comprises:

a second analog to digital A/D converter (200) for converting the analog reflected signal received from said coupler (50, 500) into a digital signal; and

a second processor (210) for digitally calculating the correlation function of the digital spread spectrum test signal as output by said signal generator (20,30) and said digitized reflected signal.

5. The electronic circuit according to claim 1, **characterised in that** the coupler (500) comprises two parallel branches each comprising a series connection of impedances (510-540) wherein the spread spectrum test

signal is input to said coupler (500) in parallel to said branches and wherein the reflected signal is received between two connecting points defining the connection between two of said impedances connected in series, respectively, and wherein the line (10) is connected to the coupler (500) via a transformer (550) such that the input impedance of said transformer being loaded with said line represents one of said coupler impedances (530).

6. The electronic circuit according to claim 1, **characterised in that** the coupler (50) is a directional coupler.

7. Method for testing a line, especially a subscriber line, the method comprising the steps of:

generating a test signal,

sending said test signal to said line and receiving and evaluating a reflected signal being generated when the test signal is sent via the line,

characterised in that

the test signal is a spread spectrum test signal; and

the evaluating step includes the step of calculating and evaluating the correlation function of said test signal and said reflected signal.

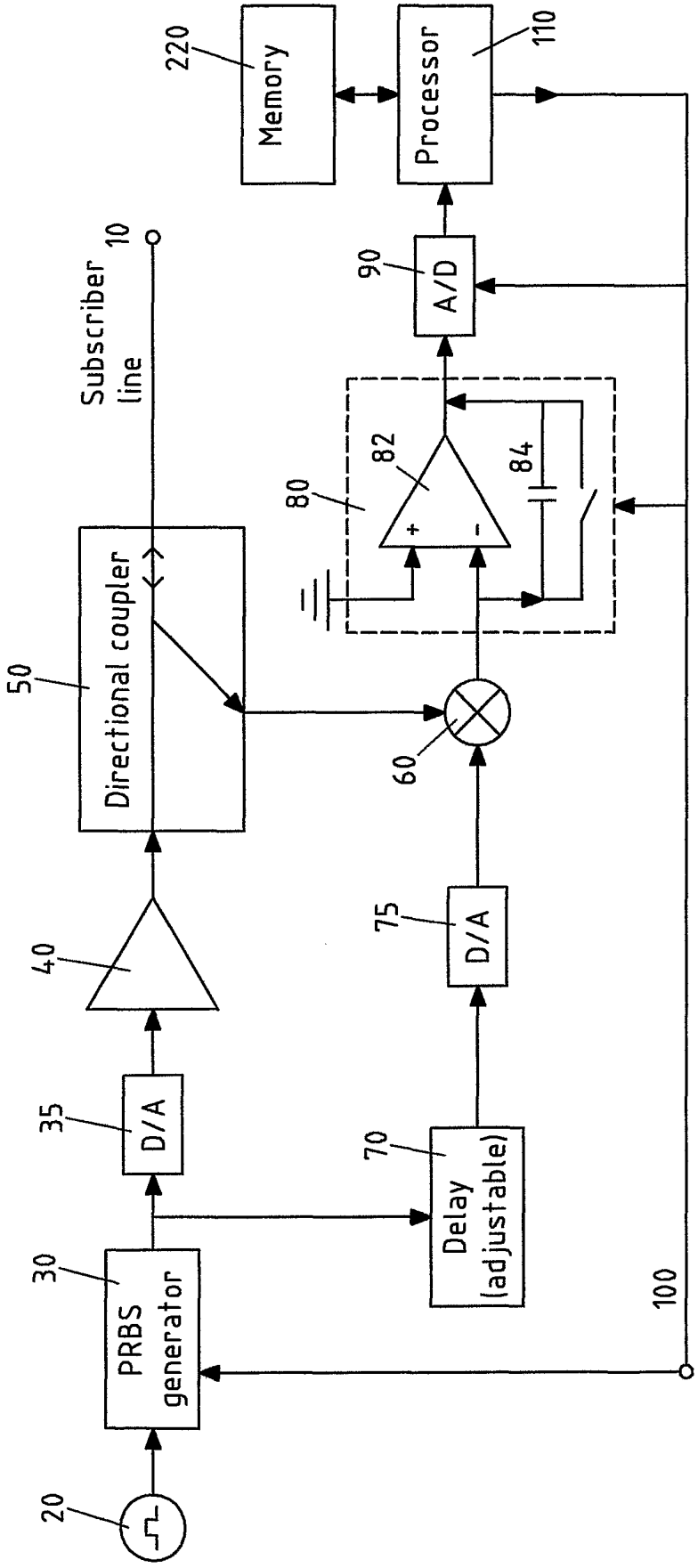
220
Memory
Processor
110
10
Subscriber line
90
A/D
80
82
84
+
-
50
Directional coupler
60
40
75
D/A
35
D/A
70
Delay (adjustable)
30
PRBS generator
100
20

Fig.1

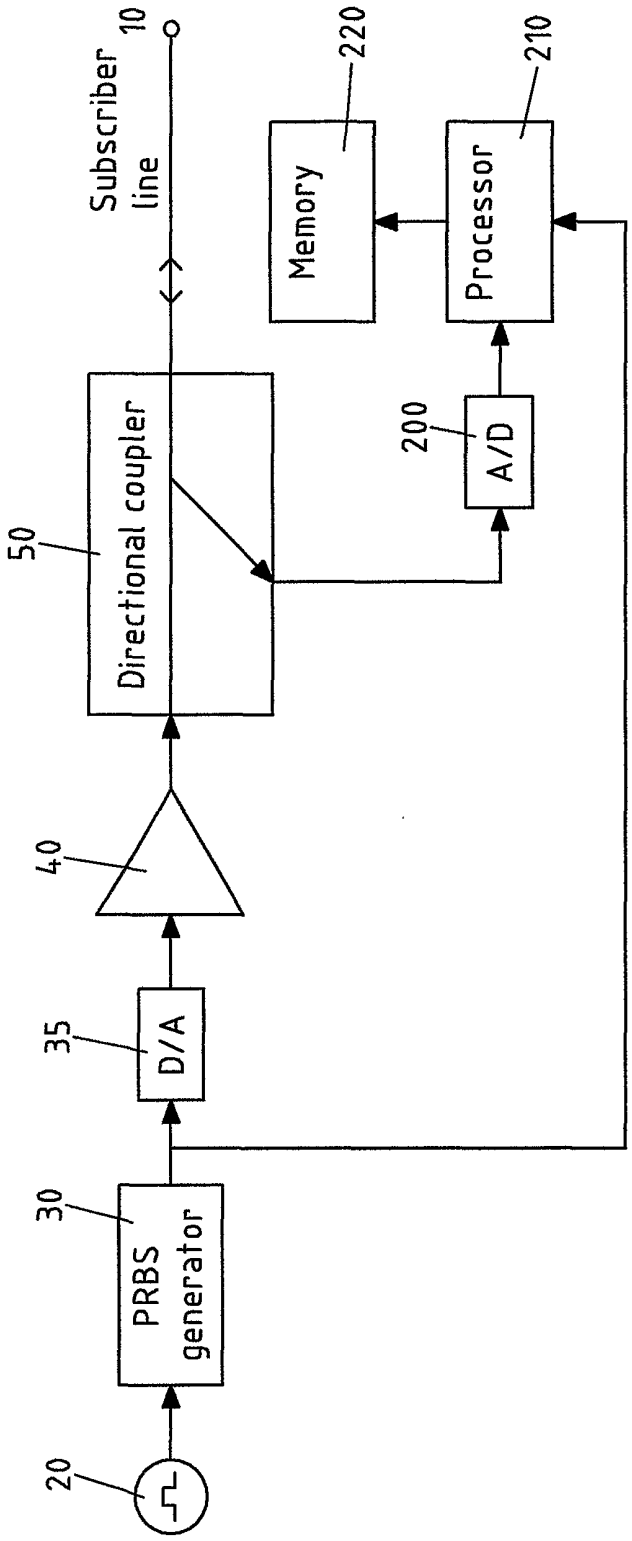
20
30
PRBS generator
35
D/A
40
50
Directional coupler
200
A/D
210
Processor
220
Memory
Subscriber line
10

Fig.2

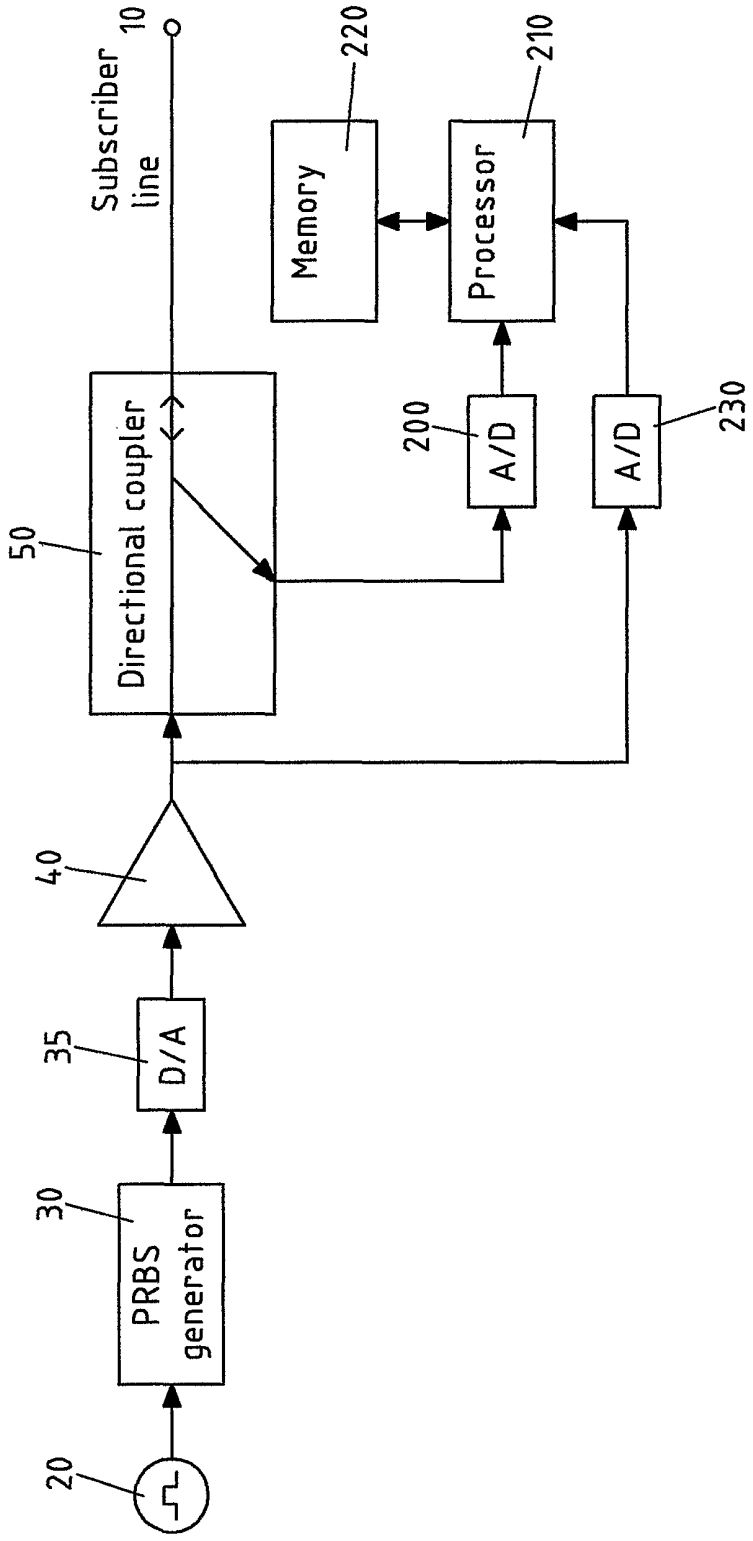
Subscriber line
10
Memory
220
Processor
210
Directional coupler
50
A/D
200
A/D
230
40
D/A
35
PRBS generator
30
20

Fig.3

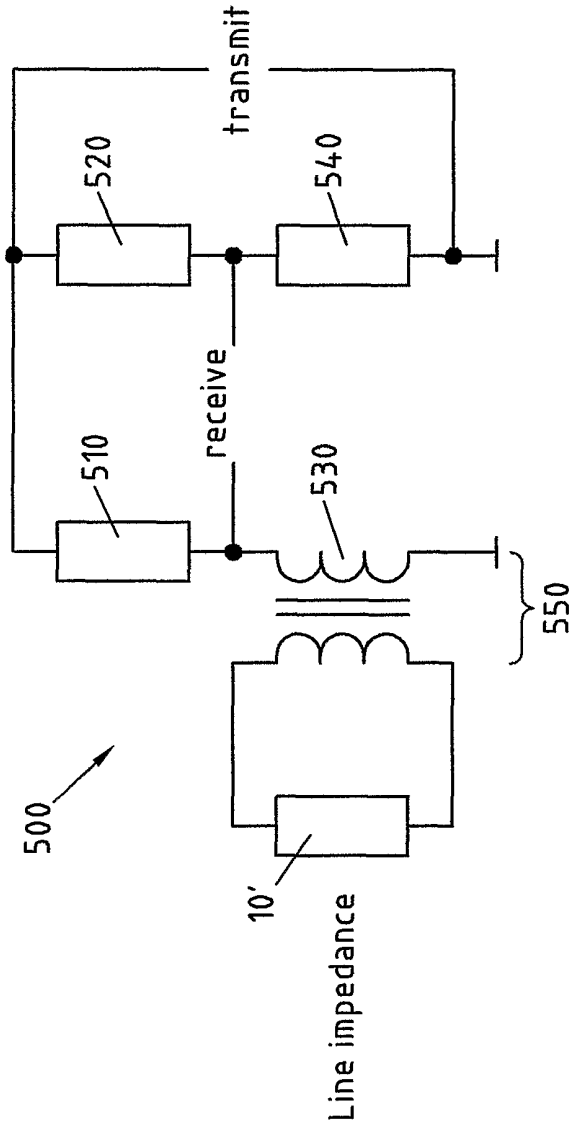

Fig.4

INTERNATIONAL SEARCH REPORT

In application No
PCT/EP 00/09309

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01R31/11

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01R H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 38023 A (TRILITHIC INC ;RITTMAN DANIEL E (US)) 29 July 1999 (1999-07-29) abstract; claims 1,12; figures 5-7 page 5, line 17 - line 27 page 9, line 1 - line 20 page 11, line 6 - line 16	1,2,6,7
X	US 4 041 381 A (HWA LIM CHING) 9 August 1977 (1977-08-09) abstract; figure 1 column 1, line 6 -column 2, line 22 column 4, line 50 -column 5, line 61	1,2,6,7
A	US 4 649 335 A (LASSAUX JEAN ET AL) 10 March 1987 (1987-03-10) abstract; figure 1	1,7

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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Date of the actual completion of the international search	Date of mailing of the international search report
15 June 2001	27/06/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Fritz, S

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	WO 92 11710 A (BRITISH TELECOMM) 9 July 1992 (1992-07-09) abstract; claims 1,18; figure 1 page 2, paragraph 2 -page 3, paragraph 3 page 4, paragraph 4 -page 5, last paragraph page 7, last paragraph -page 9, paragraph 1 page 11, last paragraph	1,2,6,7
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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter Application No
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