TeKCEM

Available patents relating to crosstalk reduction in high-speed links

(January 2015)

- ❒ Definitions
- ❒ Suggested applications of our inventions
- ❒ Introduction to modal signaling and the ZXtalk method
- ❒ Presentation of the ZXtalk-B patent portfolio
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- ❒ Presentation of the ZXnoise-B patent portfolio

Definitions

❒ *Multichannel link* (in this document): link providing several channels, without resorting to time domain, frequency domain or code domain multiplexing.

❒ *Internal crosstalk*: the detrimental phenomenon by which a signal sent on one of the channels produces noise on another channel.

❒ *External crosstalk*: crosstalk between one or more channels of the link and some other circuit.

❒ *Single-ended link*: a link in which a transmission conductor (TC) is allocated to each channel, the return current flowing in GND or VCC, etc.

❒ *Differential link*: uses two TCs per channel, to obtain some crosstalk reduction.

Suggested applications of our inventions

❒ We use ZXtalk method and ZXnoise method to designate two different schemes for the reduction of crosstalk and echo in multichannel links.

❒ Our inventions are meant to replace or enhance multiple differential or single-ended links.

❒ Multiple differential links for board-to-board and on-board links are expensive:

- ◆ large number of leads (pins, solder balls, etc) in ICs;
- ◆ large footprint on each PCB layer;
- ◆ this market being driven by standards, adoption of innovation is difficult;
- ◆ the "ZXtalk on differential pair" is an easy (backward compatible) step;
- ◆ standards are not an issue in some cases.

❒ Multiple differential links are also expensive in the case of chip-to-chip links inside MCMs and SiPs: here a single manufacturer can use the ZXnoise and/or ZXtalk methods to reduce costs.

❒ TSV used for 3-D integration are expensive: pseudo-differential signaling can be used to reduce costs.

❒ High-performance proprietary interfaces may use the ZXtalk and ZXnoise methods.

❒ Multiconductor cables and flexible circuits are also an important market for our technologies, in particular:

- ◆ links used in mobile device hinge structures;
- ◆ top-side chip-to-chip bridges proposed by Intel (see for instance the paper entitled "A 47 x 10Gb/s 1.4mW/gb/s parallel interface in 45nm CMOS", *IEEE Journal of Solid-State Circuits*, vol. 45, No. 12, Dec. 2010).

Introduction to modal signaling and the ZXtalk method

❒ In modal signaling, for each of the *m* transmission channels, we use a modal voltage or a modal current instead of a natural voltage or a natural current.

❒ A differential link implements modal signaling, for $m = 1$.

❒ The *ZXtalk method* uses modal signaling and at least one matched termination, i.e., for *n* TCs, a $(n + 1)$-terminal linear circuit having an impedance matrix close to $\mathbf{Z}_C$.

❒ The ZXtalk method is based on a sound theory. It is used to remove internal crosstalk and echo in a multichannel link.

❒ Two types of ZXtalk method:

- ◆ The general ZXtalk method is appropriate for a small number of channels;
- ◆ The special ZXtalk method is appropriate for any number of channels and the highest speed.

❒ Rambus has disclosed its first implementations of the ZXtalk method, in

[A] Q. Lin, H.-C. Lee, J. Kim, B.S. Leibowitz, J.L. Zerbe, J. Ren, *Signaling with superimposed differential-monde and common-mode signals*, United States patents US 8,279,976.

[B] J. Zerbe, *et al*, "A 5 Gb/s Link With Matched Source Synchronous and Common-Mode Clocking Techniques", *IEEE J. Solid-State Circuits*, Vol. 46, No. 4, pp. 974-985, April 2011.

[C] J. Ren, D. Oh, R. Kollipara, B. Tsang, Y. Lu, J. Zerbe, Q. Lin, "System Design Considerations for a 5 Gb/s Source-Synchronous Link with Common-Mode Clocking", *Proc. IEEE 20th Conference on Electrical Performance of Electronic Packaging and Systems, EPEPS 2011*, San Jose, pp. 143-146, Oct. 23-26, 2011.

❒ Intel is also working in this direction, using the approach described in

[D] Y. Choi, H. Braunisch, K. Aygün, P.D. Franzon, "Analysis of inter-bundle crosstalk in multimode signaling for high-density interconnects", *Proc 58th IEEE Electronic Components and Technology Conference (ECTC)*, pp. 664-668, May 27-30, 2008.

[E] H. Braunisch, K. Aygün, *Multimode signaling on decoupled input/output and power channels*, United States patents US 8,450,201, US 7,989,946 and US 7,816,779.

[F] Y. Choi, H. Braunisch, K. Aygun, P.D. Franzon, "Multimode transceiver for high-density interconnects: measurement and validation", *Proc 60th IEEE Electronic Components and Technology Conference, ECTC 2010*, pp. 1733-1738, June 2010.

❒ The technical background of the ZXtalk method is explained in § 14 and § 15 of the Seminar 32 of Excem.

❒ Inventions on the ZXtalk method (essential patents shown in red):

ZXtalk method	Link	
	Not pseudo-differential	Pseudo-differential (ZXnoise + ZXtalk)
General	P26, P27, P47, P39, P40, P42	P39, P40, P43, P48, P42, P45, P46
Special	P28, P47 P30, P36, P39, P40, P41, P42	P39, P40, P44, P48 P30, P36, P41, P42, P45, P46

❒ The following inventions are no more available for sale:

- ◆ P26 was sold to Rambus, Inc. in 2005;
- ◆ P27 and P28 were sold in 2006 and assigned to ZXtalk Assets, LLC;
- ◆ P30 and P41 were sold in 2012 and assigned to Apple, Inc.

❒ The others are for sale in January 2015, more information available here .

Presentation of the ZXtalk-B patent portfolio

Title of the Patent Family — ZXtalk-B patent portfolio	Family
Multichannel interfacing device having a termination circuit	P40
Multichannel interfacing device having a balancing circuit	P42
Method for transmission using a non-uniform interconnection	P47
Balanced-input current-sensing differential amplifier	P49

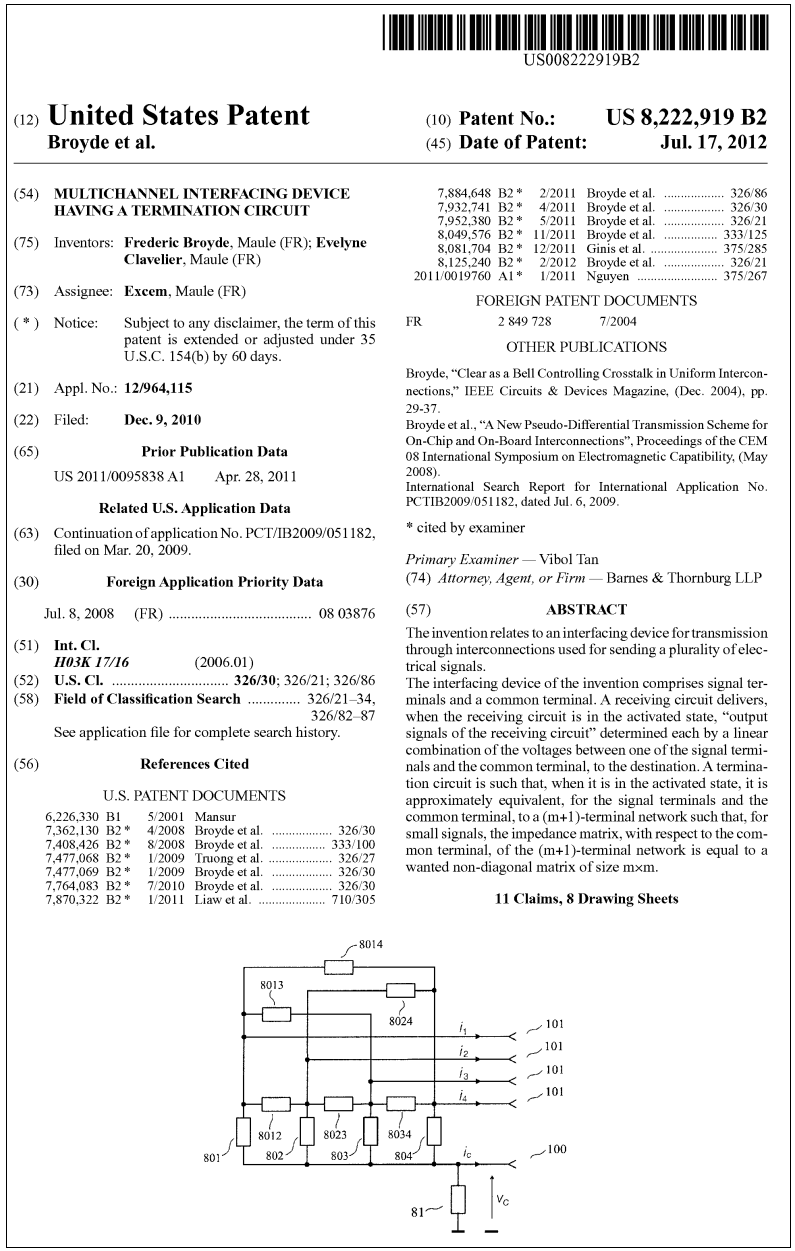
❒ Patent family P40:

Multichannel interfacing device having a termination circuit

◆ it can be applied to the ZXtalk method, to reduce common-mode coupling at the far end (see Seminar 32, 3rd ed., p. 104);

◆ this is a floating termination circuit, dubbed “type 3” termination circuit (see Seminar 32, 3rd ed., p. 124);

◆ it can be used to combine the ZXtalk and ZXnoise methods, to obtain reduced internal and external crosstalk.



US008222919B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 8,222,919 B2**
(45) **Date of Patent: Jul. 17, 2012**

(54) **MULTICHANNEL INTERFACING DEVICE HAVING A TERMINATION CIRCUIT**

(75) Inventors: **Frederic Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **Excem**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 60 days.

(21) Appl. No.: **12/964,115**

(22) Filed: **Dec. 9, 2010**

(65) **Prior Publication Data**

US 2011/0095838 A1 Apr. 28, 2011

Related U.S. Application Data

(63) Continuation of application No. PCT/IB2009/051182, filed on Mar. 20, 2009.

(30) **Foreign Application Priority Data**

Jul. 8, 2008 (FR) 08 03876

(51) **Int. Cl.**
H03K 17/16 (2006.01)

(52) **U.S. Cl.** **326/30**; 326/21; 326/86

(58) **Field of Classification Search** 326/21–34, 326/82–87

See application file for complete search history.

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8,125,240	B2 *	2/2012	Broyde et al.	326/21
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Broyde et al., “A New Pseudo-Differential Transmission Scheme for On-Chip and On-Board Interconnections”, Proceedings of the CEM 08 International Symposium on Electromagnetic Capatibility, (May 2008).

International Search Report for International Application No. PCTIB2009/051182, dated Jul. 6, 2009.

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Primary Examiner — Vibol Tan
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

The invention relates to an interfacing device for transmission through interconnections used for sending a plurality of electrical signals.

The interfacing device of the invention comprises signal terminals and a common terminal. A receiving circuit delivers, when the receiving circuit is in the activated state, “output signals of the receiving circuit” determined each by a linear combination of the voltages between one of the signal terminals and the common terminal, to the destination. A termination circuit is such that, when it is in the activated state, it is approximately equivalent, for the signal terminals and the common terminal, to a (m+1)-terminal network such that, for small signals, the impedance matrix, with respect to the common terminal, of the (m+1)-terminal network is equal to a wanted non-diagonal matrix of size m×m.

11 Claims, 8 Drawing Sheets

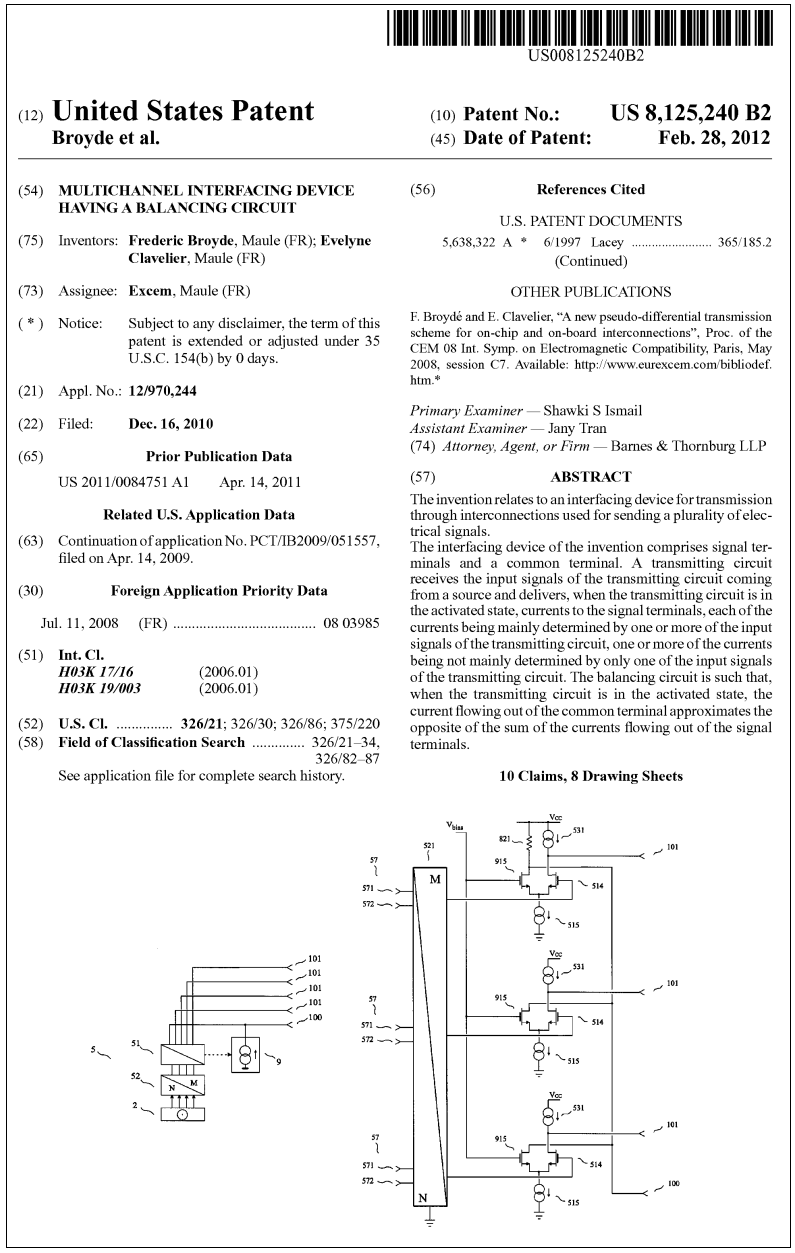
❒ Patent family P42:

Multichannel interfacing device having a balancing circuit

◆ can be applied to the ZXtalk method, to reduce common-mode coupling at the near end (see Seminar 32, 3rd ed., p. 103);

◆ this is a TX circuit producing linear combinations of input signals and a constant common mode current (see Seminar 32, 3rd ed., p. 118);

◆ can be used to combine the ZXtalk and ZXnoise methods, to reduce common-mode coupling at the near end.



US008125240B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 8,125,240 B2**
(45) **Date of Patent: Feb. 28, 2012**

(54) **MULTICHANNEL INTERFACING DEVICE HAVING A BALANCING CIRCUIT**

(75) Inventors: **Frederic Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **Excem**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **12/970,244**

(22) Filed: **Dec. 16, 2010**

(65) **Prior Publication Data**

US 2011/0084751 A1 Apr. 14, 2011

Related U.S. Application Data

(63) Continuation of application No. PCT/IB2009/051557, filed on Apr. 14, 2009.

(30) **Foreign Application Priority Data**

Jul. 11, 2008 (FR) 08 03985

(51) **Int. Cl.**
H03K 17/16 (2006.01)
H03K 19/003 (2006.01)

(52) **U.S. Cl.** **326/21**; 326/30; 326/86; 375/220
(58) **Field of Classification Search** 326/21–34, 326/82–87
See application file for complete search history.

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Primary Examiner — Shawki S Ismail
Assistant Examiner — Jany Tran
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

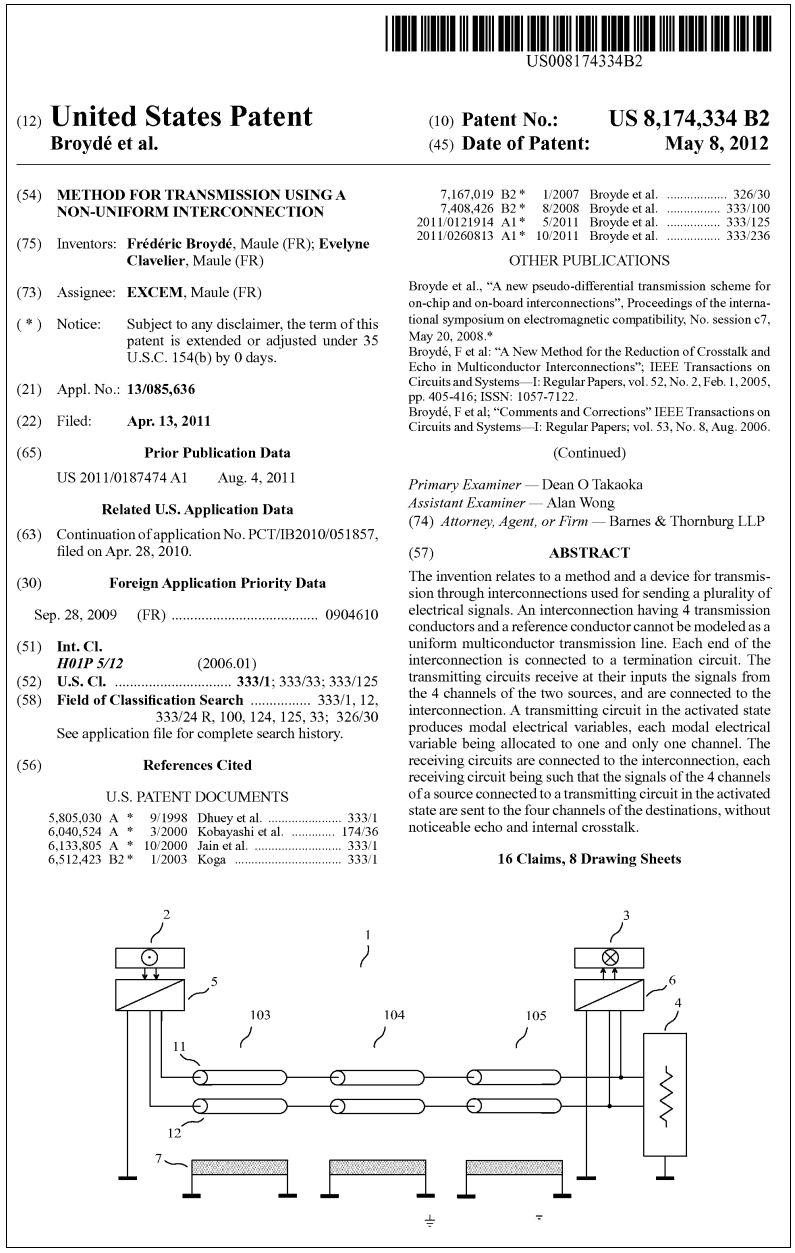
The invention relates to an interfacing device for transmission through interconnections used for sending a plurality of electrical signals.
The interfacing device of the invention comprises signal terminals and a common terminal. A transmitting circuit receives the input signals of the transmitting circuit coming from a source and delivers, when the transmitting circuit is in the activated state, currents to the signal terminals, each of the currents being mainly determined by one or more of the input signals of the transmitting circuit, one or more of the currents being not mainly determined by only one of the input signals of the transmitting circuit. The balancing circuit is such that, when the transmitting circuit is in the activated state, the current flowing out of the common terminal approximates the opposite of the sum of the currents flowing out of the signal terminals.

10 Claims, 8 Drawing Sheets

❒ Patent family P47:

Method for transmission using a non-uniform interconnection

- ◆ it is necessary for expanding the ZXtalk method to an interconnection which cannot be modeled as a uniform multiconductor transmission line;
- ◆ such an interconnection may for instance extend from a first chip to a second chip;
- ◆ it might be needed to implement the invention of Rambus disclosed in US patent 8,279,676.



US008174334B2

(12) **United States Patent**
Broydé et al.

(10) **Patent No.: US 8,174,334 B2**
(45) **Date of Patent: May 8, 2012**

(54) **METHOD FOR TRANSMISSION USING A NON-UNIFORM INTERCONNECTION**

(75) Inventors: **Frédéric Broydé**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **EXCEM**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/085,636**

(22) Filed: **Apr. 13, 2011**

(65) **Prior Publication Data**

US 2011/0187474 A1 Aug. 4, 2011

Related U.S. Application Data

(63) Continuation of application No. PCT/IB2010/051857, filed on Apr. 28, 2010.

(30) **Foreign Application Priority Data**

Sep. 28, 2009 (FR) 0904610

(51) **Int. Cl.**
H01P 5/12 (2006.01)

(52) **U.S. Cl.** **333/1**; 333/33; 333/125

(58) **Field of Classification Search** ..... 333/1, 12, 333/24 R, 100, 124, 125, 33; 326/30
See application file for complete search history.

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Broydé, F et al; "Comments and Corrections" IEEE Transactions on Circuits and Systems—I: Regular Papers; vol. 53, No. 8, Aug. 2006.

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Primary Examiner — Dean O Takaoka
Assistant Examiner — Alan Wong
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

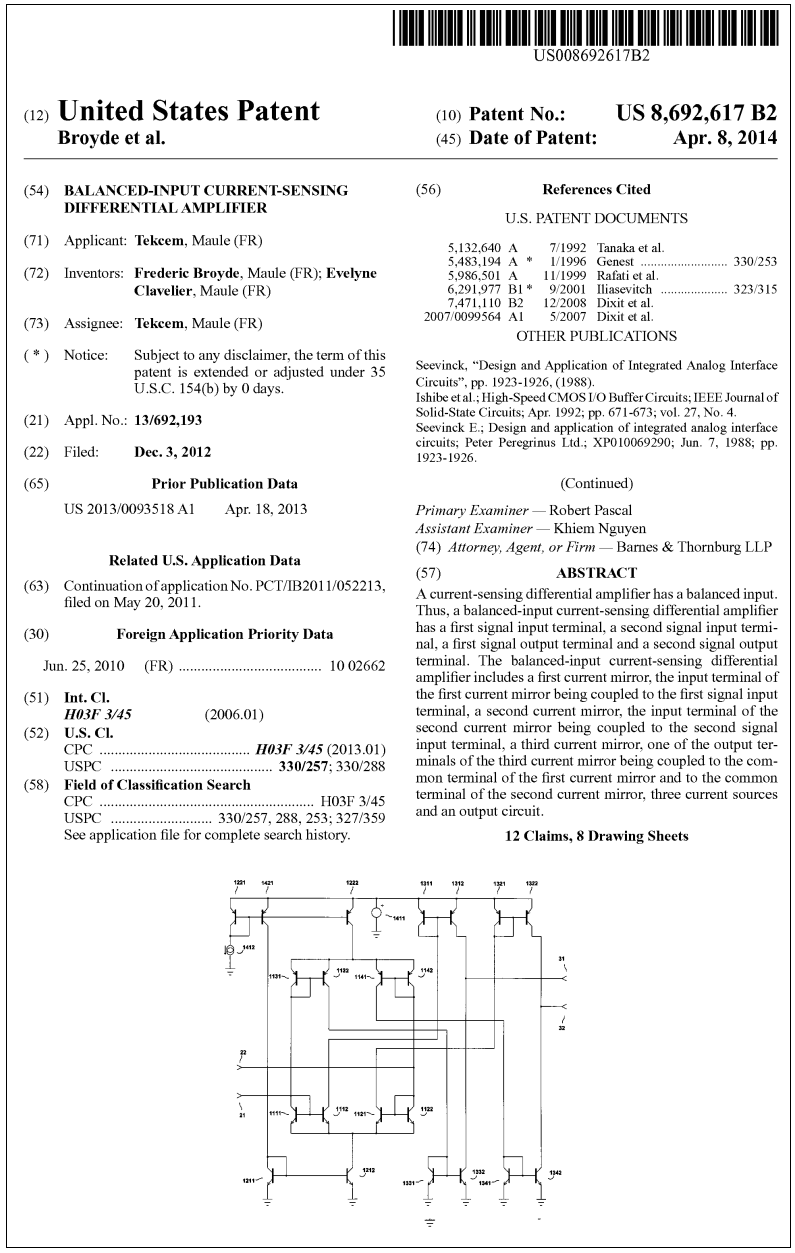
The invention relates to a method and a device for transmission through interconnections used for sending a plurality of electrical signals. An interconnection having 4 transmission conductors and a reference conductor cannot be modeled as a uniform multiconductor transmission line. Each end of the interconnection is connected to a termination circuit. The transmitting circuits receive at their inputs the signals from the 4 channels of the two sources, and are connected to the interconnection. A transmitting circuit in the activated state produces modal electrical variables, each modal electrical variable being allocated to one and only one channel. The receiving circuits are connected to the interconnection, each receiving circuit being such that the signals of the 4 channels of a source connected to a transmitting circuit in the activated state are sent to the four channels of the destinations, without noticeable echo and internal crosstalk.

16 Claims, 8 Drawing Sheets

❒ Patent family P49:

Balanced-input current-sensing differential amplifier

- ◆ it may be used as the input circuit of a line receiver for a differential link;
- ◆ it may be used as a subcircuit of the input circuit of a line receiver for a pseudo-differential link.



US008692617B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 8,692,617 B2**
(45) **Date of Patent: Apr. 8, 2014**

(54) **BALANCED-INPUT CURRENT-SENSING DIFFERENTIAL AMPLIFIER**

(71) Applicant: **Tekcem**, Maule (FR)

(72) Inventors: **Frederic Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **Tekcem**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/692,193**

(22) Filed: **Dec. 3, 2012**

(65) **Prior Publication Data**

US 2013/0093518 A1 Apr. 18, 2013

Related U.S. Application Data

(63) Continuation of application No. PCT/IB2011/052213, filed on May 20, 2011.

(30) **Foreign Application Priority Data**

Jun. 25, 2010 (FR) 10 02662

(51) **Int. Cl.**
H03F 3/45 (2006.01)

(52) **U.S. Cl.**
CPC ***H03F 3/45*** (2013.01)
USPC **330/257**; 330/288

(58) **Field of Classification Search**
CPC H03F 3/45
USPC 330/257, 288, 253; 327/359
See application file for complete search history.

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Seevinck E.; Design and application of integrated analog interface circuits; Peter Peregrinus Ltd.; XP010069290; Jun. 7, 1988; pp. 1923-1926.

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Primary Examiner — Robert Pascal
Assistant Examiner — Khiem Nguyen
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

A current-sensing differential amplifier has a balanced input. Thus, a balanced-input current-sensing differential amplifier has a first signal input terminal, a second signal input terminal, a first signal output terminal and a second signal output terminal. The balanced-input current-sensing differential amplifier includes a first current mirror, the input terminal of the first current mirror being coupled to the first signal input terminal, a second current mirror, the input terminal of the second current mirror being coupled to the second signal input terminal, a third current mirror, one of the output terminals of the third current mirror being coupled to the common terminal of the first current mirror and to the common terminal of the second current mirror, three current sources and an output circuit.

12 Claims, 8 Drawing Sheets

Introduction to pseudo-differential links and the ZXnoise method

❒ *Pseudo-differential link* (in this document): multichannel link using one TC per channel + a common conductor, to obtain a reduction of external crosstalk.

❒ A pseudo-differential link providing *m* channels uses only *m* + 1 conductors to obtain a reduction of external crosstalk in *m* channels.

❒ A differential link is a special case of a pseudo-differential link, for *m* = 1.

❒ *ZXnoise method*: pseudo-differential transmission scheme using a type 2 or type 3 termination circuit. The ZXnoise method is based on a sound theory.

❒ When type 3 termination circuits are used, the ZXnoise method is combined with the *ZXtalk method*.

❒ The technical background of the ZXnoise method is explained in § 16 of the Seminar 32 of Excem.

❒ Our portfolios have 15 inventions applicable to 12 different pseudo-differential transmission schemes (essential patents shown in red):

Termination circuit	Architecture of the PDL			
	VDCC (unidirectional)	SW circuit (bidirectional)	Unidirectional CCMC	Bidirectional CCMC
Type 0	Prior Art P39, P46, P49	P37 P39, P46, P49		
Type 1	Prior Art P39, P46, P49	P37 P39, P46, P49		
Type 2 (ZXnoise)	P35, P38, P48 P39, P41, P46, P49	P35, P37, P38, P48 P39, P41, P46, P49	P35, P36, P38, P48 P39, P41, P42, P46, P49	
Type 3 (ZXnoise+ZXtalk)	P39, P40, P43, P44, P48 P30, P41, P46, P49	P39, P40, P43, P44, P45 P48, P30, P41, P46, P49	P36, P39, P40, P42, P43, P44, P48 P30, P41, P46, P49	

❒ The inventions P30 and P41 were sold in 2012 and assigned to Apple, Inc.

❒ The others are for sale in January 2015, more information available here .

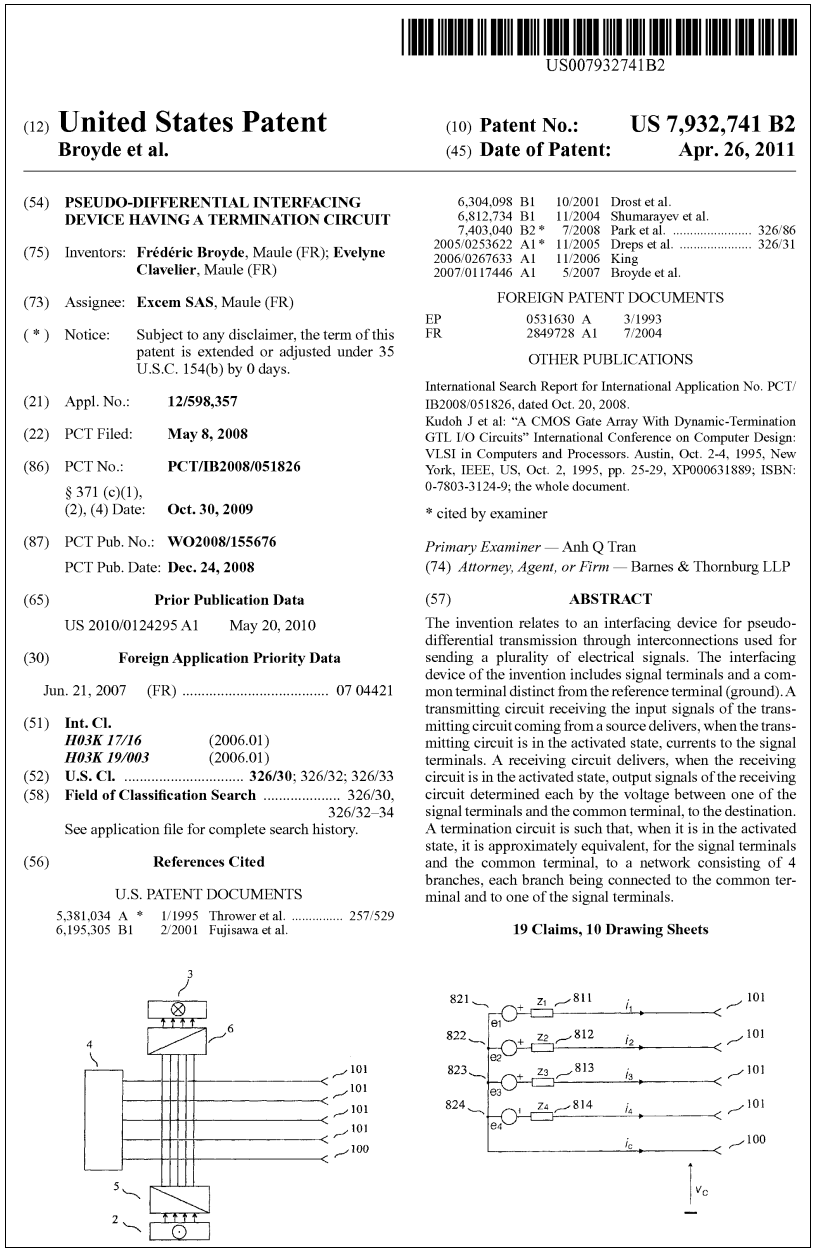
Presentation of the ZXnoise-A patent portfolio

Title of the Patent Family — ZXnoise-A patent portfolio	Family
Pseudo-differential interfacing device having a termination circuit	P35
Pseudo-differential interfacing device having a balancing circuit	P36
Pseudo-differential interfacing device having a switching circuit	P37
Method and device for pseudo-differential transmission	P38

❒ Patent family P35:

Pseudo-differential interfacing device having a termination circuit

- ◆ this interface includes a floating termination circuit, dubbed “type 2” termination circuit (see Seminar 32, 3rd ed., p. 123);
- ◆ this interface can be used to improve any single-ended parallel link;
- ◆ this is the simplest interface for the ZXnoise method: it reduces reflections and external crosstalk.



US007932741B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 7,932,741 B2**
(45) **Date of Patent: Apr. 26, 2011**

(54) **PSEUDO-DIFFERENTIAL INTERFACING DEVICE HAVING A TERMINATION CIRCUIT**

(75) Inventors: **Frédéric Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **Excem SAS**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **12/598,357**

(22) PCT Filed: **May 8, 2008**

(86) PCT No.: **PCT/IB2008/051826**
§ 371 (c)(1),
(2), (4) Date: **Oct. 30, 2009**

(87) PCT Pub. No.: **WO2008/155676**
PCT Pub. Date: **Dec. 24, 2008**

(65) **Prior Publication Data**
US 2010/0124295 A1 May 20, 2010

(30) **Foreign Application Priority Data**
Jun. 21, 2007 (FR) 07 04421

(51) **Int. Cl.**
H03K 17/16 (2006.01)
H03K 19/003 (2006.01)

(52) **U.S. Cl.** **326/30**; 326/32; 326/33

(58) **Field of Classification Search** 326/30, 326/32–34
See application file for complete search history.

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Kudoh J et al: “A CMOS Gate Array With Dynamic-Termination GTL I/O Circuits” International Conference on Computer Design: VLSI in Computers and Processors. Austin, Oct. 2-4, 1995, New York, IEEE, US, Oct. 2, 1995, pp. 25-29, XP000631889; ISBN: 0-7803-3124-9; the whole document.

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Primary Examiner — Anh Q Tran
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

The invention relates to an interfacing device for pseudo-differential transmission through interconnections used for sending a plurality of electrical signals. The interfacing device of the invention includes signal terminals and a common terminal distinct from the reference terminal (ground). A transmitting circuit receiving the input signals of the transmitting circuit coming from a source delivers, when the transmitting circuit is in the activated state, currents to the signal terminals. A receiving circuit delivers, when the receiving circuit is in the activated state, output signals of the receiving circuit determined each by the voltage between one of the signal terminals and the common terminal, to the destination. A termination circuit is such that, when it is in the activated state, it is approximately equivalent, for the signal terminals and the common terminal, to a network consisting of 4 branches, each branch being connected to the common terminal and to one of the signal terminals.

19 Claims, 10 Drawing Sheets

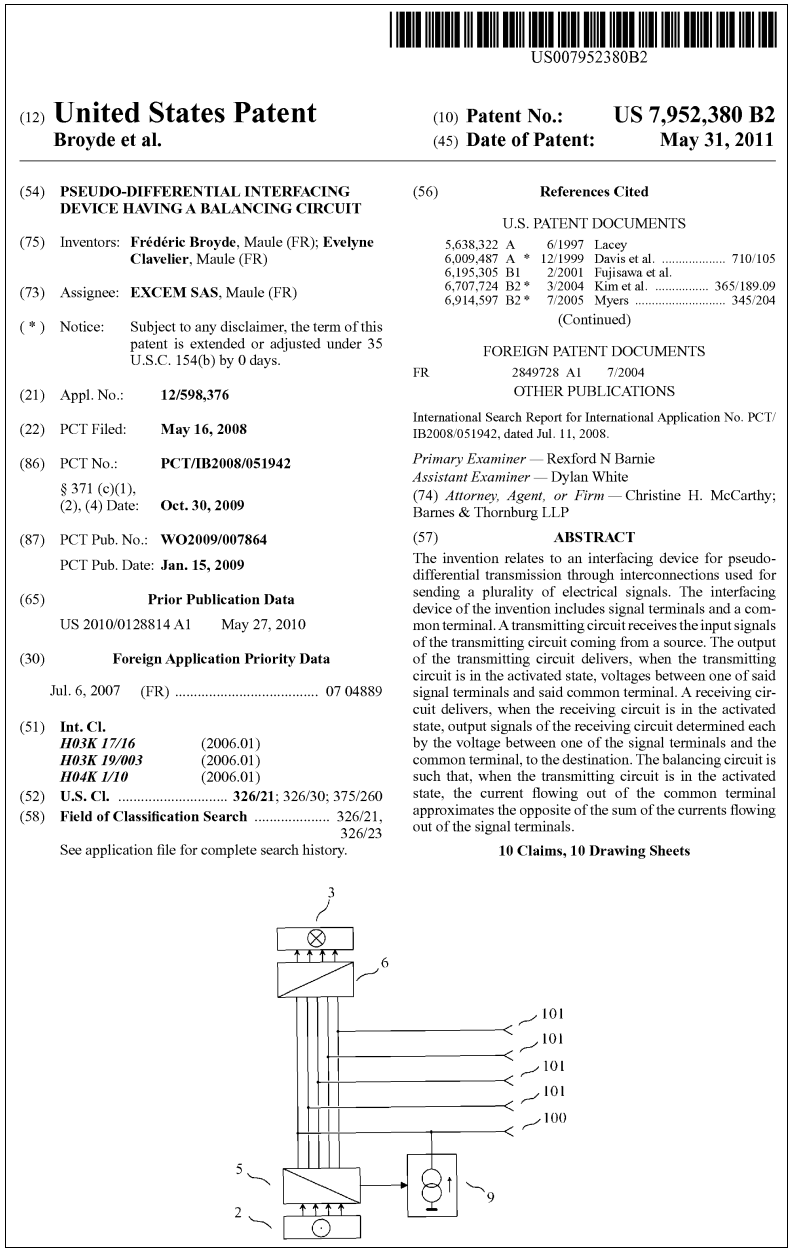
❒ Patent family P36:

Pseudo-differential interfacing device having a balancing circuit

◆ this is a transmitting circuit producing a constant common mode current to reduce SSO noise (see Seminar 32, 3rd ed., p. 118);

◆ this interface can be used to improve any single-ended parallel link;

◆ it can be used in the ZXnoise method (see Seminar 32, 3rd ed., p. 119 and 120).



US007952380B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 7,952,380 B2**
(45) **Date of Patent: May 31, 2011**

(54) **PSEUDO-DIFFERENTIAL INTERFACING DEVICE HAVING A BALANCING CIRCUIT**

(75) Inventors: **Frédéric Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **EXCEM SAS**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **12/598,376**

(22) PCT Filed: **May 16, 2008**

(86) PCT No.: **PCT/IB2008/051942**
§ 371 (c)(1),
(2), (4) Date: **Oct. 30, 2009**

(87) PCT Pub. No.: **WO2009/007864**
PCT Pub. Date: **Jan. 15, 2009**

(65) **Prior Publication Data**
US 2010/0128814 A1 May 27, 2010

(30) **Foreign Application Priority Data**
Jul. 6, 2007 (FR) 07 04889

(51) **Int. Cl.**
H03K 17/16 (2006.01)
H03K 19/003 (2006.01)
H04K 1/10 (2006.01)

(52) **U.S. Cl.** **326/21**; 326/30; 375/260

(58) **Field of Classification Search** 326/21, 326/23
See application file for complete search history.

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Primary Examiner — Rexford N Barnie
Assistant Examiner — Dylan White
(74) *Attorney, Agent, or Firm* — Christine H. McCarthy; Barnes & Thornburg LLP

(57) **ABSTRACT**

The invention relates to an interfacing device for pseudo-differential transmission through interconnections used for sending a plurality of electrical signals. The interfacing device of the invention includes signal terminals and a common terminal. A transmitting circuit receives the input signals of the transmitting circuit coming from a source. The output of the transmitting circuit delivers, when the transmitting circuit is in the activated state, voltages between one of said signal terminals and said common terminal. A receiving circuit delivers, when the receiving circuit is in the activated state, output signals of the receiving circuit determined each by the voltage between one of the signal terminals and the common terminal, to the destination. The balancing circuit is such that, when the transmitting circuit is in the activated state, the current flowing out of the common terminal approximates the opposite of the sum of the currents flowing out of the signal terminals.

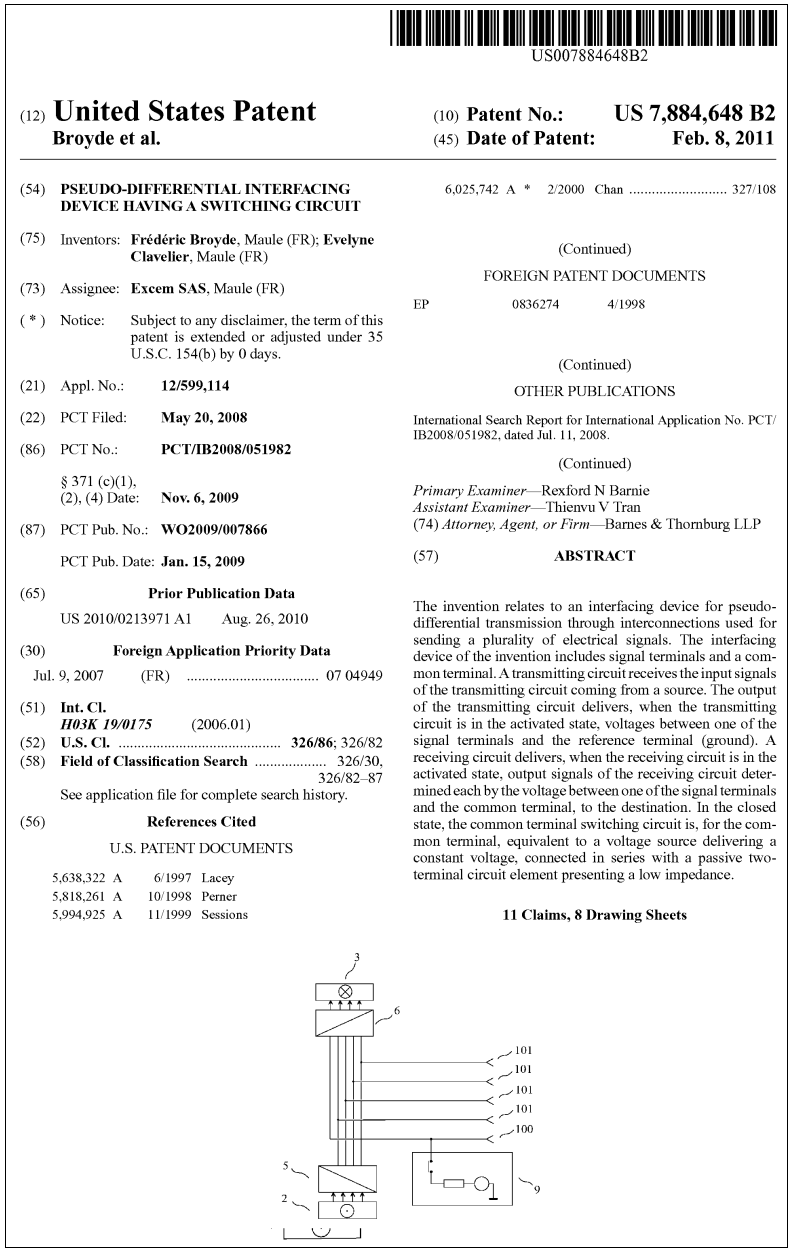
10 Claims, 10 Drawing Sheets

❒ Patent family P37:

Pseudo-differential interfacing device having a switching circuit

◆ this patent family can be applied to any bidirectional pseudo-differential link;

◆ in particular, it can be used in the ZXnoise method, for bidirectional transmission (see Seminar 32, 3rd ed., p. 117).



US007884648B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 7,884,648 B2**
(45) **Date of Patent: Feb. 8, 2011**

(54) **PSEUDO-DIFFERENTIAL INTERFACING DEVICE HAVING A SWITCHING CIRCUIT**

(75) Inventors: **Frédéric Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **Excem SAS**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **12/599,114**

(22) PCT Filed: **May 20, 2008**

(86) PCT No.: **PCT/IB2008/051982**

§ 371 (c)(1),
(2), (4) Date: **Nov. 6, 2009**

(87) PCT Pub. No.: **WO2009/007866**

PCT Pub. Date: **Jan. 15, 2009**

(65) **Prior Publication Data**

US 2010/0213971 A1 Aug. 26, 2010

(30) **Foreign Application Priority Data**

Jul. 9, 2007 (FR) 07 04949

(51) **Int. Cl.**
H03K 19/0175 (2006.01)

(52) **U.S. Cl.** **326/86**; 326/82

(58) **Field of Classification Search** 326/30, 326/82–87

See application file for complete search history.

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Primary Examiner—Rexford N Barnie
Assistant Examiner—Thienvu V Tran
(74) *Attorney, Agent, or Firm*—Barnes & Thornburg LLP

(57) **ABSTRACT**

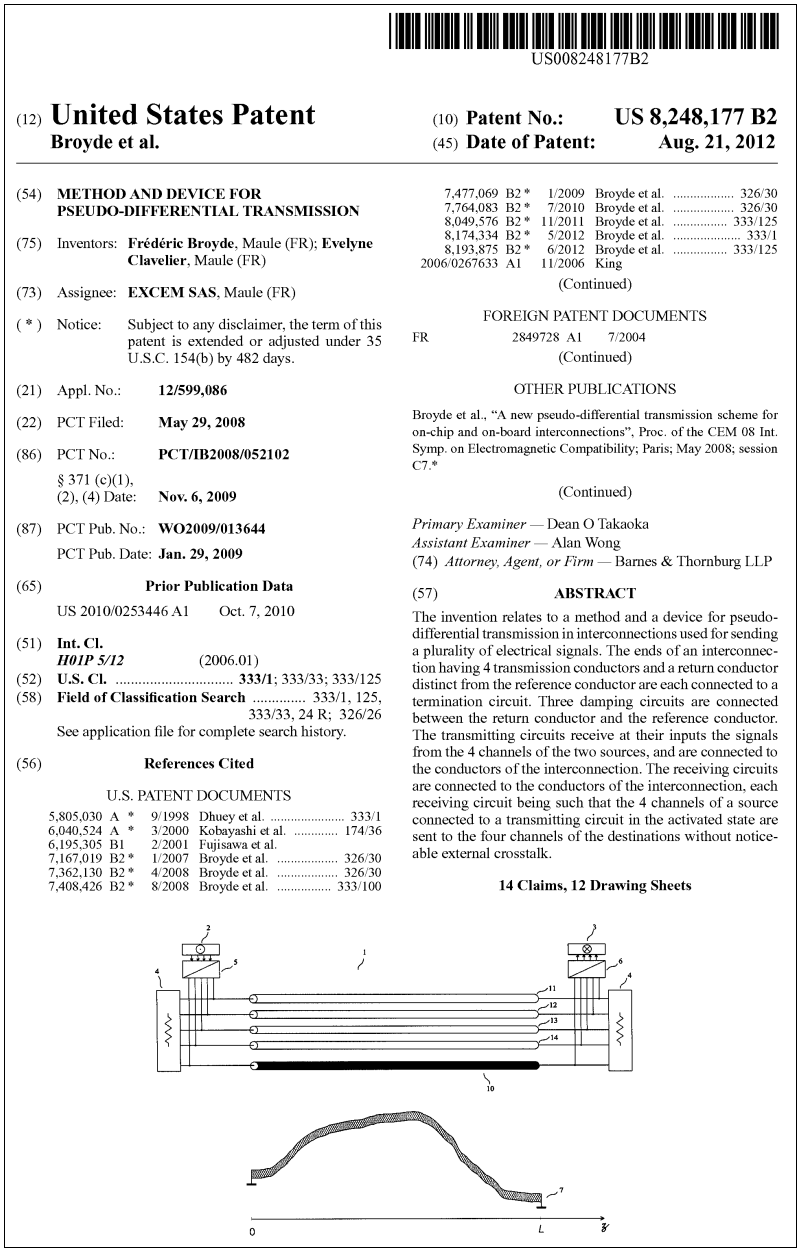
The invention relates to an interfacing device for pseudo-differential transmission through interconnections used for sending a plurality of electrical signals. The interfacing device of the invention includes signal terminals and a common terminal. A transmitting circuit receives the input signals of the transmitting circuit coming from a source. The output of the transmitting circuit delivers, when the transmitting circuit is in the activated state, voltages between one of the signal terminals and the reference terminal (ground). A receiving circuit delivers, when the receiving circuit is in the activated state, output signals of the receiving circuit determined each by the voltage between one of the signal terminals and the common terminal, to the destination. In the closed state, the common terminal switching circuit is, for the common terminal, equivalent to a voltage source delivering a constant voltage, connected in series with a passive two-terminal circuit element presenting a low impedance.

11 Claims, 8 Drawing Sheets

❒ Patent family P38:

Method and device for pseudo-differential transmission

This patent family discloses the structure of a link using the ZXnoise method, which necessarily implements P35, and which may implement P36 or P37.



US008248177B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 8,248,177 B2**
(45) **Date of Patent: Aug. 21, 2012**

(54) **METHOD AND DEVICE FOR PSEUDO-DIFFERENTIAL TRANSMISSION**

(75) Inventors: **Frédéric Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **EXCEM SAS**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 482 days.

(21) Appl. No.: **12/599,086**

(22) PCT Filed: **May 29, 2008**

(86) PCT No.: **PCT/IB2008/052102**
§ 371 (e)(1),
(2), (4) Date: **Nov. 6, 2009**

(87) PCT Pub. No.: **WO2009/013644**
PCT Pub. Date: **Jan. 29, 2009**

(65) **Prior Publication Data**
US 2010/0253446 A1 Oct. 7, 2010

(51) **Int. Cl.**
H01P 5/12 (2006.01)

(52) **U.S. Cl.** **333/1**; 333/33; 333/125

(58) **Field of Classification Search** ..... 333/1, 125, 333/33, 24 R; 326/26
See application file for complete search history.

(56) **References Cited**

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(Continued)

Primary Examiner — Dean O Takaoka
Assistant Examiner — Alan Wong
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

The invention relates to a method and a device for pseudo-differential transmission in interconnections used for sending a plurality of electrical signals. The ends of an interconnection having 4 transmission conductors and a return conductor distinct from the reference conductor are each connected to a termination circuit. Three damping circuits are connected between the return conductor and the reference conductor. The transmitting circuits receive at their inputs the signals from the 4 channels of the two sources, and are connected to the conductors of the interconnection. The receiving circuits are connected to the conductors of the interconnection, each receiving circuit being such that the 4 channels of a source connected to a transmitting circuit in the activated state are sent to the four channels of the destinations without noticeable external crosstalk.

14 Claims, 12 Drawing Sheets

Presentation of the ZXnoise-B patent portfolio

Title of the Patent Family — ZXnoise-B patent portfolio	Family
Pseudo-differential receiving circuit	P39
Method for pseudo-differential transmission using modal electrical variables	P43
Method for pseudo-differential transmission using natural electrical variables	P44
Multichannel interfacing device having a switching circuit	P45
Transmission device using a plurality of elementary return conductors	P46
Method for pseudo-differential transmission using a non-uniform interconnection	P48

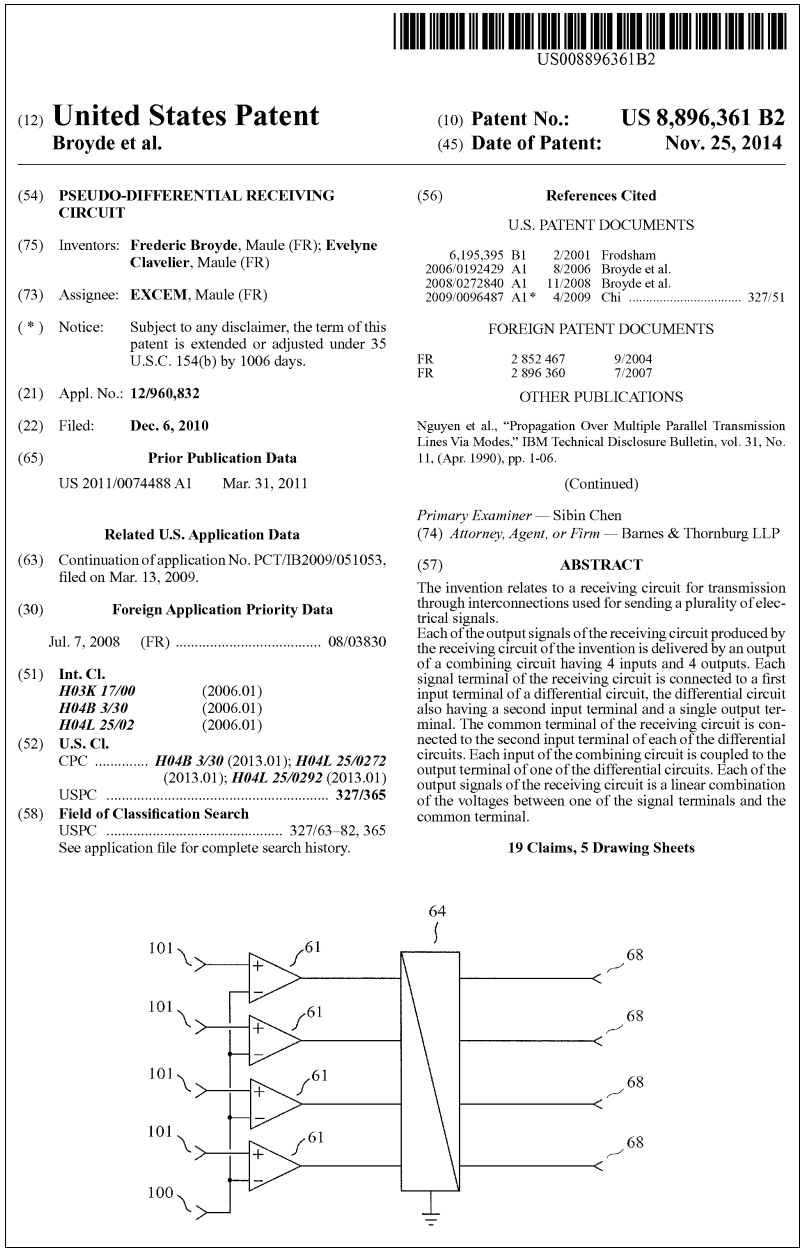
❒ Patent family P39:

Pseudo-differential receiving circuit

◆ this is a pseudo-differential receiving circuit, which performs linear combinations of received signals;

◆ it can be used to improve any pseudo-differential link, including links using the ZXnoise method;

◆ it can be used to combine the ZXtalk and ZXnoise methods, to obtain reduced internal and external crosstalk.



US008896361B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 8,896,361 B2**
(45) **Date of Patent: Nov. 25, 2014**

(54) **PSEUDO-DIFFERENTIAL RECEIVING CIRCUIT**

(75) Inventors: **Frederic Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **EXCEM**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1006 days.

(21) Appl. No.: **12/960,832**

(22) Filed: **Dec. 6, 2010**

(65) **Prior Publication Data**

US 2011/0074488 A1 Mar. 31, 2011

Related U.S. Application Data

(63) Continuation of application No. PCT/IB2009/051053, filed on Mar. 13, 2009.

(30) **Foreign Application Priority Data**

Jul. 7, 2008 (FR) 08/03830

(51) **Int. Cl.**
H03K 17/00 (2006.01)
H04B 3/30 (2006.01)
H04L 25/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H04B 3/30*** (2013.01); ***H04L 25/0272*** (2013.01); ***H04L 25/0292*** (2013.01)
USPC **327/365**

(58) **Field of Classification Search**
USPC 327/63–82, 365
See application file for complete search history.

(56) **References Cited**

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(Continued)

Primary Examiner — Sibin Chen
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

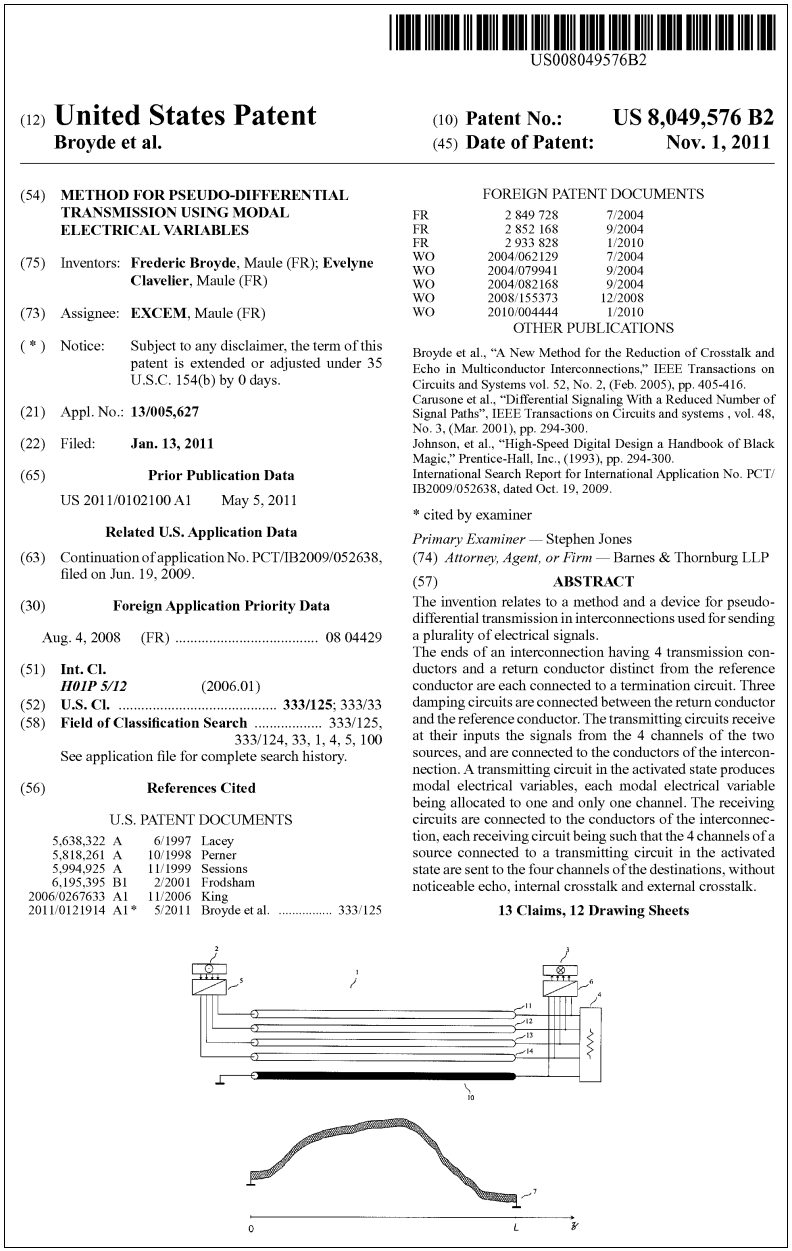
The invention relates to a receiving circuit for transmission through interconnections used for sending a plurality of electrical signals.
Each of the output signals of the receiving circuit produced by the receiving circuit of the invention is delivered by an output of a combining circuit having 4 inputs and 4 outputs. Each signal terminal of the receiving circuit is connected to a first input terminal of a differential circuit, the differential circuit also having a second input terminal and a single output terminal. The common terminal of the receiving circuit is connected to the second input terminal of each of the differential circuits. Each input of the combining circuit is coupled to the output terminal of one of the differential circuits. Each of the output signals of the receiving circuit is a linear combination of the voltages between one of the signal terminals and the common terminal.

19 Claims, 5 Drawing Sheets

❒ Patent family P43:

Method for pseudo-differential transmission using modal electrical variables

This patent family discloses the structure of a link combining the ZXnoise method and the general ZXtalk method.



US008049576B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 8,049,576 B2**
(45) **Date of Patent: Nov. 1, 2011**

(54) **METHOD FOR PSEUDO-DIFFERENTIAL TRANSMISSION USING MODAL ELECTRICAL VARIABLES**

(75) Inventors: **Frederic Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **EXCEM**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/005,627**

(22) Filed: **Jan. 13, 2011**

(65) **Prior Publication Data**

US 2011/0102100 A1 May 5, 2011

Related U.S. Application Data

(63) Continuation of application No. PCT/IB2009/052638, filed on Jun. 19, 2009.

(30) **Foreign Application Priority Data**

Aug. 4, 2008 (FR) 08 04429

(51) **Int. Cl.**
H01P 5/12 (2006.01)

(52) **U.S. Cl.** **333/125**; 333/33

(58) **Field of Classification Search** 333/125, 333/124, 33, 1, 4, 5, 100
See application file for complete search history.

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2006/0267633	A1	11/2006	King	
2011/0121914	A1 *	5/2011	Broyde et al.	333/125

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Johnson, et al., "High-Speed Digital Design a Handbook of Black Magic," Prentice-Hall, Inc., (1993), pp. 294-300.
International Search Report for International Application No. PCT/IB2009/052638, dated Oct. 19, 2009.

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Primary Examiner — Stephen Jones
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

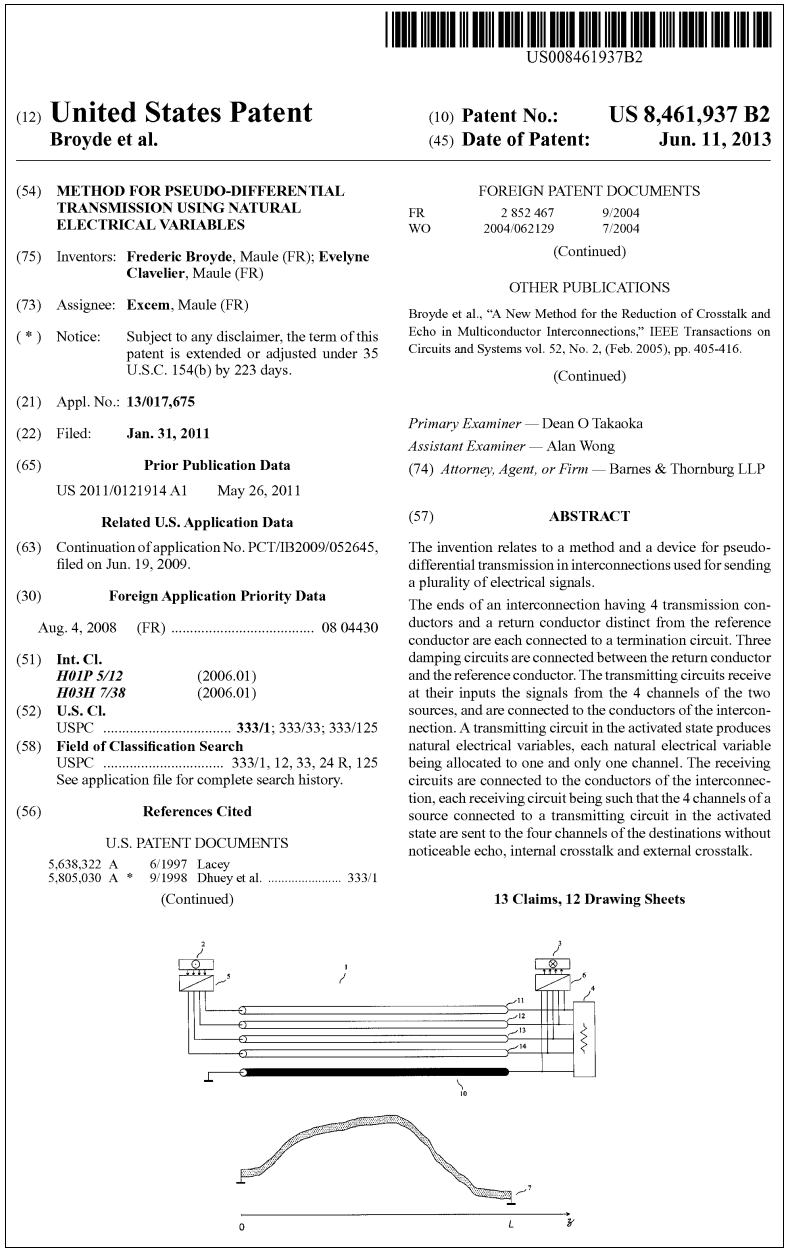
The invention relates to a method and a device for pseudo-differential transmission in interconnections used for sending a plurality of electrical signals.
The ends of an interconnection having 4 transmission conductors and a return conductor distinct from the reference conductor are each connected to a termination circuit. Three damping circuits are connected between the return conductor and the reference conductor. The transmitting circuits receive at their inputs the signals from the 4 channels of the two sources, and are connected to the conductors of the interconnection. A transmitting circuit in the activated state produces modal electrical variables, each modal electrical variable being allocated to one and only one channel. The receiving circuits are connected to the conductors of the interconnection, each receiving circuit being such that the 4 channels of a source connected to a transmitting circuit in the activated state are sent to the four channels of the destinations, without noticeable echo, internal crosstalk and external crosstalk.

13 Claims, 12 Drawing Sheets

❒ Patent family P44:

Method for pseudo-differential transmission using natural electrical variables

This patent family discloses the structure of a link combining the ZXnoise method and the special ZXtalk method.



US008461937B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 8,461,937 B2**
(45) **Date of Patent: Jun. 11, 2013**

(54) **METHOD FOR PSEUDO-DIFFERENTIAL TRANSMISSION USING NATURAL ELECTRICAL VARIABLES**

(75) Inventors: **Frederic Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **Excem**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 223 days.

(21) Appl. No.: **13/017,675**

(22) Filed: **Jan. 31, 2011**

(65) **Prior Publication Data**

US 2011/0121914 A1 May 26, 2011

Related U.S. Application Data

(63) Continuation of application No. PCT/IB2009/052645, filed on Jun. 19, 2009.

(30) **Foreign Application Priority Data**

Aug. 4, 2008 (FR) 08 04430

(51) **Int. Cl.**
H01P 5/12 (2006.01)
H03H 7/38 (2006.01)

(52) **U.S. Cl.**
USPC **333/1**; 333/33; 333/125

(58) **Field of Classification Search**
USPC ..... 333/1, 12, 33, 24 R, 125
See application file for complete search history.

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Broyde et al., "A New Method for the Reduction of Crosstalk and Echo in Multiconductor Interconnections," IEEE Transactions on Circuits and Systems vol. 52, No. 2, (Feb. 2005), pp. 405-416.
(Continued)

Primary Examiner — Dean O Takaoka
Assistant Examiner — Alan Wong
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

The invention relates to a method and a device for pseudo-differential transmission in interconnections used for sending a plurality of electrical signals.

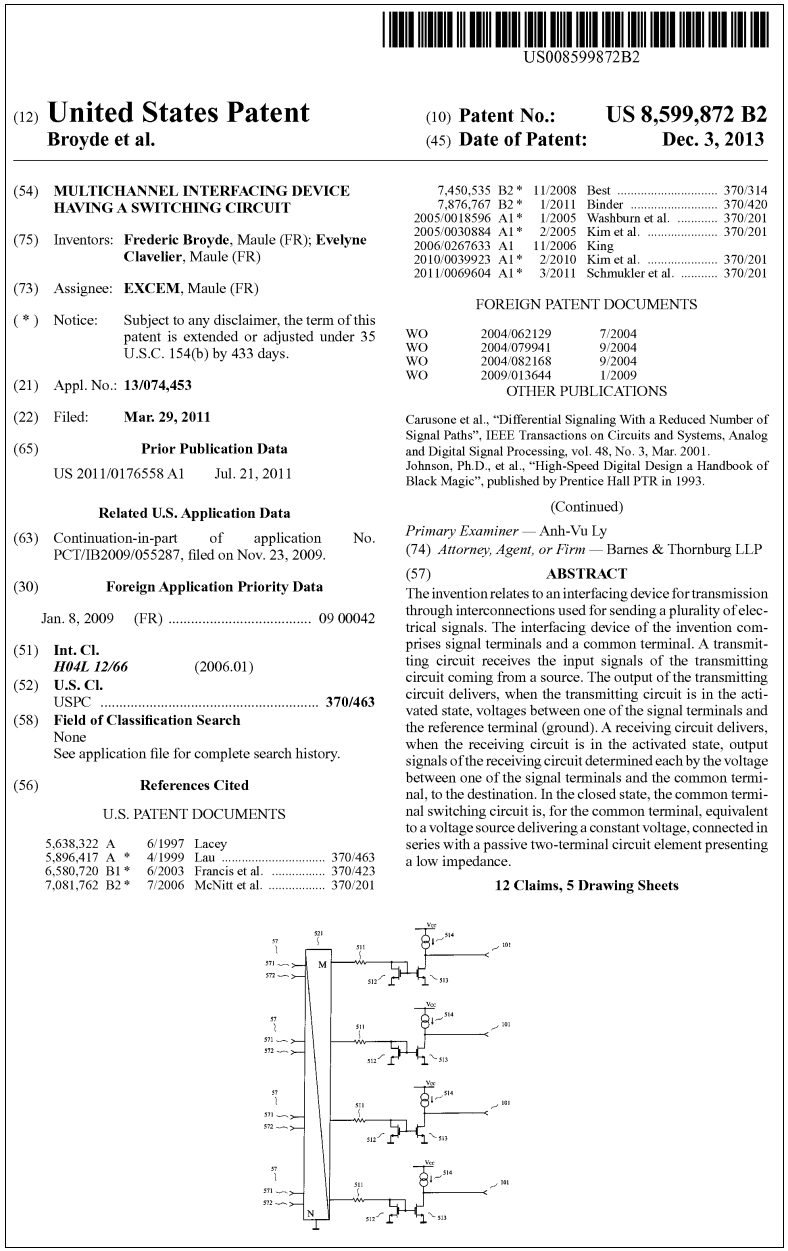
The ends of an interconnection having 4 transmission conductors and a return conductor distinct from the reference conductor are each connected to a termination circuit. Three damping circuits are connected between the return conductor and the reference conductor. The transmitting circuits receive at their inputs the signals from the 4 channels of the two sources, and are connected to the conductors of the interconnection. A transmitting circuit in the activated state produces natural electrical variables, each natural electrical variable being allocated to one and only one channel. The receiving circuits are connected to the conductors of the interconnection, each receiving circuit being such that the 4 channels of a source connected to a transmitting circuit in the activated state are sent to the four channels of the destinations without noticeable echo, internal crosstalk and external crosstalk.

13 Claims, 12 Drawing Sheets

❒ Patent family P45:

Multichannel interfacing device having a switching circuit

This patent family can be used in a link combining the ZXnoise and ZXtalk methods, for bidirectional transmission (see Seminar 32, 3rd ed., p. 117).



US008599872B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 8,599,872 B2**
(45) **Date of Patent: Dec. 3, 2013**

(54) **MULTICHANNEL INTERFACING DEVICE HAVING A SWITCHING CIRCUIT**

(75) Inventors: **Frederic Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **EXCEM**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 433 days.

(21) Appl. No.: **13/074,453**

(22) Filed: **Mar. 29, 2011**

(65) **Prior Publication Data**

US 2011/0176558 A1 Jul. 21, 2011

Related U.S. Application Data

(63) Continuation-in-part of application No. PCT/IB2009/055287, filed on Nov. 23, 2009.

(30) **Foreign Application Priority Data**

Jan. 8, 2009 (FR) 09 00042

(51) **Int. Cl.**
H04L 12/66 (2006.01)

(52) **U.S. Cl.**
USPC **370/463**

(58) **Field of Classification Search**
None
See application file for complete search history.

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Primary Examiner — Anh-Vu Ly
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

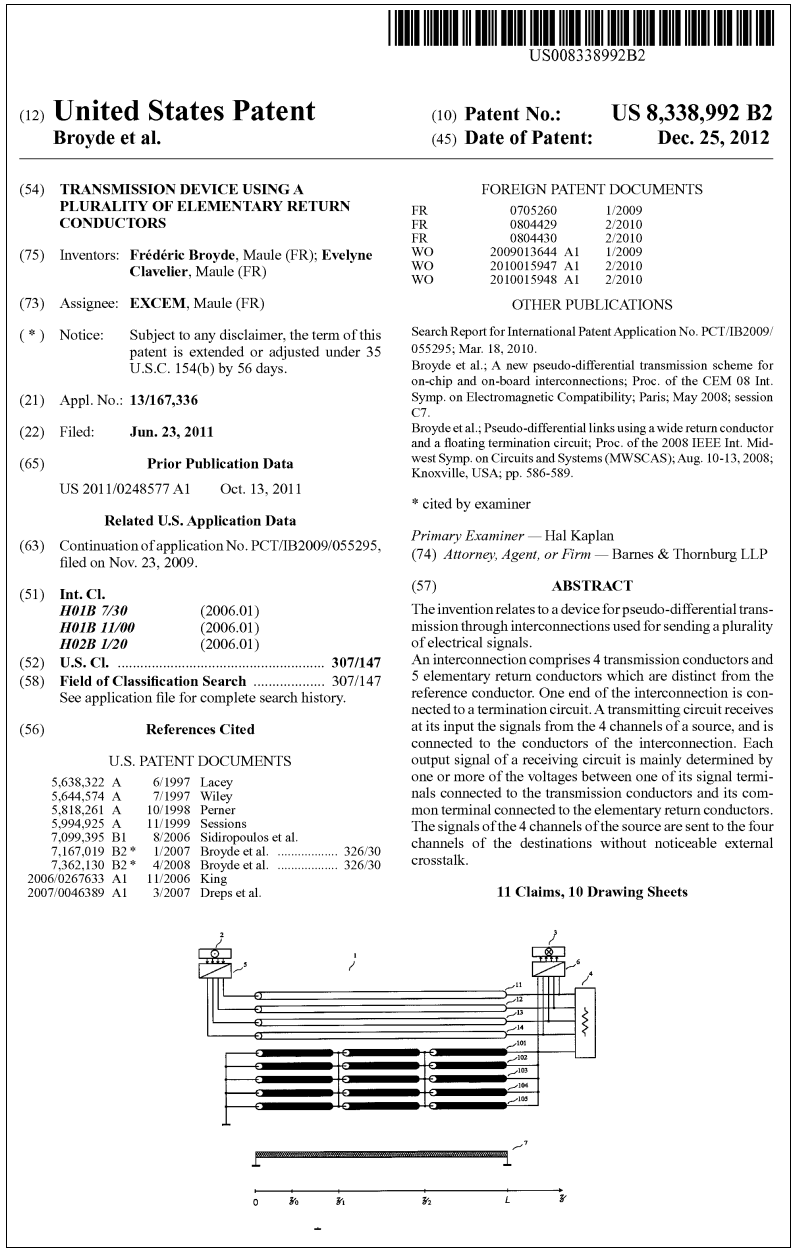
The invention relates to an interfacing device for transmission through interconnections used for sending a plurality of electrical signals. The interfacing device of the invention comprises signal terminals and a common terminal. A transmitting circuit receives the input signals of the transmitting circuit coming from a source. The output of the transmitting circuit delivers, when the transmitting circuit is in the activated state, voltages between one of the signal terminals and the reference terminal (ground). A receiving circuit delivers, when the receiving circuit is in the activated state, output signals of the receiving circuit determined each by the voltage between one of the signal terminals and the common terminal, to the destination. In the closed state, the common terminal switching circuit is, for the common terminal, equivalent to a voltage source delivering a constant voltage, connected in series with a passive two-terminal circuit element presenting a low impedance.

12 Claims, 5 Drawing Sheets

❒ Patent family P46:

Transmission device using a plurality of elementary return conductors

This patent family discloses practical low-cost interconnection structures for the ZXnoise method.



US008338992B2

(12) **United States Patent**
Broyde et al.

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(45) **Date of Patent: Dec. 25, 2012**

(54) **TRANSMISSION DEVICE USING A PLURALITY OF ELEMENTARY RETURN CONDUCTORS**

(75) Inventors: **Frédéric Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **EXCEM**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 56 days.

(21) Appl. No.: **13/167,336**

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(65) **Prior Publication Data**

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Related U.S. Application Data

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H01B 7/30 (2006.01)
H01B 11/00 (2006.01)
H02B 1/20 (2006.01)

(52) **U.S. Cl.** **307/147**

(58) **Field of Classification Search** 307/147
See application file for complete search history.

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Primary Examiner — Hal Kaplan
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

The invention relates to a device for pseudo-differential transmission through interconnections used for sending a plurality of electrical signals.
An interconnection comprises 4 transmission conductors and 5 elementary return conductors which are distinct from the reference conductor. One end of the interconnection is connected to a termination circuit. A transmitting circuit receives at its input the signals from the 4 channels of a source, and is connected to the conductors of the interconnection. Each output signal of a receiving circuit is mainly determined by one or more of the voltages between one of its signal terminals connected to the transmission conductors and its common terminal connected to the elementary return conductors. The signals of the 4 channels of the source are sent to the four channels of the destinations without noticeable external crosstalk.

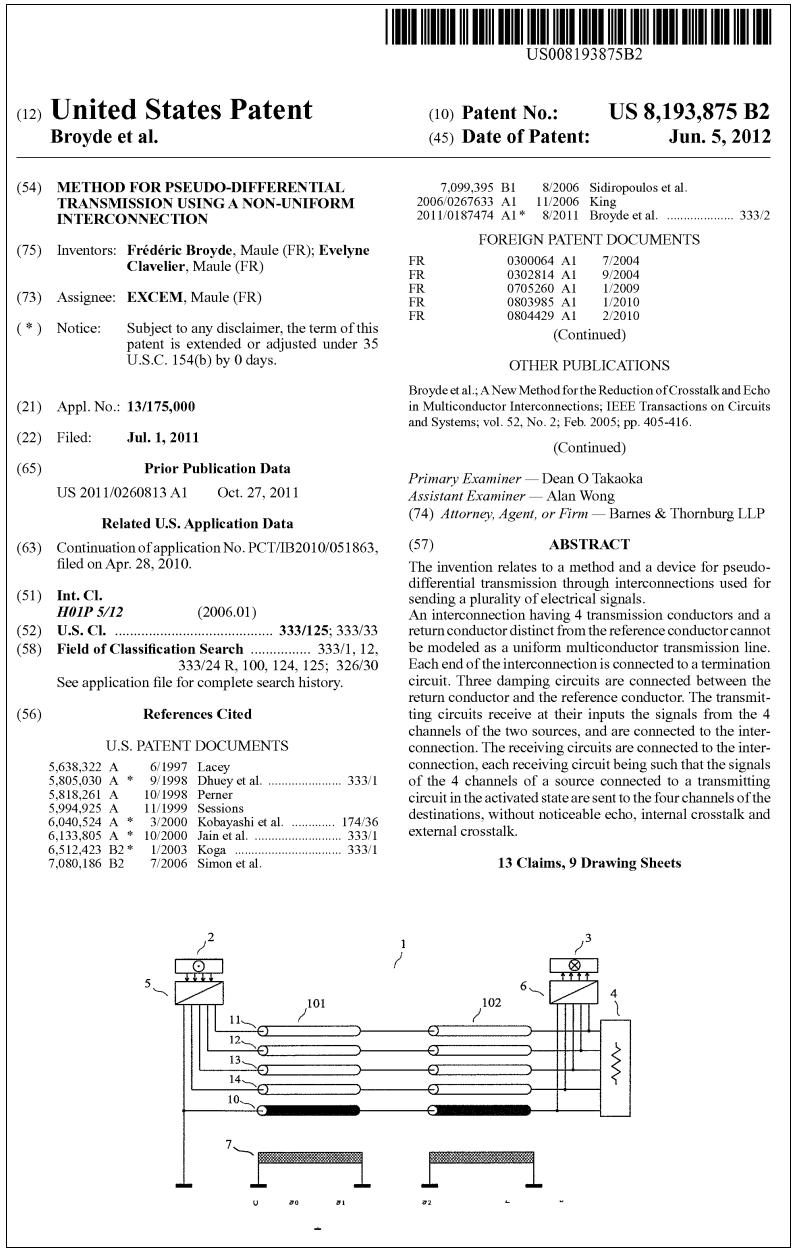
11 Claims, 10 Drawing Sheets

❒ Patent family P48:

Method for pseudo-differential transmission using a non-uniform interconnection

◆ this method is necessary for expanding the ZXnoise method to an interconnection which cannot be modeled as a uniform multi-conductor transmission line;

◆ such an interconnection may for instance extend from a first chip to a second chip.



US008193875B2

(12) **United States Patent**
Broyde et al.

(10) **Patent No.: US 8,193,875 B2**
(45) **Date of Patent: Jun. 5, 2012**

(54) **METHOD FOR PSEUDO-DIFFERENTIAL TRANSMISSION USING A NON-UNIFORM INTERCONNECTION**

(75) Inventors: **Frédéric Broyde**, Maule (FR); **Evelyne Clavelier**, Maule (FR)

(73) Assignee: **EXCEM**, Maule (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/175,000**

(22) Filed: **Jul. 1, 2011**

(65) **Prior Publication Data**

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Related U.S. Application Data

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H01P 5/12 (2006.01)

(52) **U.S. Cl.** **333/125**; 333/33

(58) **Field of Classification Search** ..... 333/1, 12, 333/24 R, 100, 124, 125; 326/30
See application file for complete search history.

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Primary Examiner — Dean O Takaoka
Assistant Examiner — Alan Wong
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

The invention relates to a method and a device for pseudo-differential transmission through interconnections used for sending a plurality of electrical signals.
An interconnection having 4 transmission conductors and a return conductor distinct from the reference conductor cannot be modeled as a uniform multiconductor transmission line. Each end of the interconnection is connected to a termination circuit. Three damping circuits are connected between the return conductor and the reference conductor. The transmitting circuits receive at their inputs the signals from the 4 channels of the two sources, and are connected to the interconnection. The receiving circuits are connected to the interconnection, each receiving circuit being such that the signals of the 4 channels of a source connected to a transmitting circuit in the activated state are sent to the four channels of the destinations, without noticeable echo, internal crosstalk and external crosstalk.

13 Claims, 9 Drawing Sheets