(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(54) Title: TRANSMISSION DEVICE
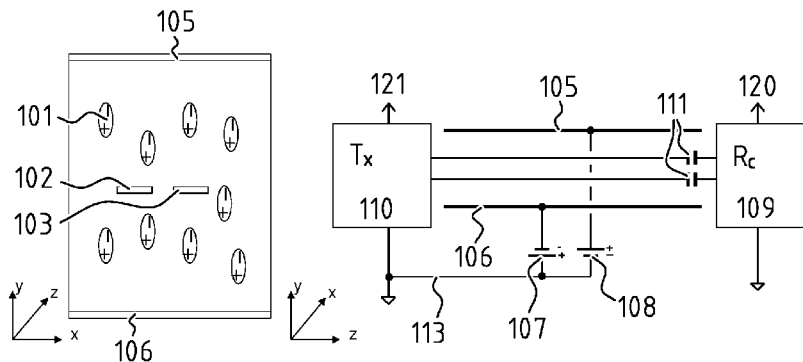
FIG. 2

(57) Abstract: Transmission device comprising at least one electric conductor for the transmission of an AC signal and a dielectric material at least partly surrounding the at least one conductor, said dielectric material comprising dipoles, further comprising a dipole orienting system adapted to orient said dipoles and to force said dipoles in a saturation regime in order to limit the movement of the dipoles when the at least one electric conductor conducts an AC signal.

Transmission device

<u>Technical field</u>

Embodiments of the invention relate to transmission devices,
also called interconnects, in which electrical signals are
transmitted over one or more conductors which are at least
partially surrounded by a dielectric material.

<u>Background</u>

Interconnects typically aim to convey a large amount of
information between the end points by means of modulation of
an electric and/or magnetic field. In order for the
modulated signal to be transmitted in an undistorted
fashion, the interconnect must possess sufficient bandwidth,
i.e. all frequencies composing the signal must preferably
experience a low and equal attenuation. As the speed of
interconnects is increased to the gigabit per second (Gbps)
and multi-Gbps speed, the required bandwidth of the
interconnect is also increased.

<u>Summary</u>

The object of embodiments of the invention is to provide an
improved transmission device having an increased bandwidth
whilst keeping the cost and power consumption limited.

According to an aspect of embodiments the transmission
device comprises at least one electric conductor for the
transmission of an alternating current (AC) signal and a
dielectric material at least partly surrounding the at least
one conductor. The dielectric material comprises electrical
dipoles. The movement of such dipoles typically affects the
conductivity of the conductor at high frequencies. The
device further comprises a dipole orienting system adapted

to orient said dipoles and to force said dipoles in a
saturation regime in order to limit the movement of the
dipoles when the at least one electric conductor conducts an
AC signal. Such embodiments have the advantage that by

5   biasing the dipoles in the saturation regime the dipole
movement due to signal variation becomes negligible.
Consequently, the conductivity of the dielectric is
decreased, leading to a decrease in dielectric loss of the
material, and to an increased bandwidth of the transmission

10   device.

For orienting the dipoles, according to embodiments a high
electric field is applied. However, according to other
embodiments, the device may be cooled, at least locally, to

15   a low temperature for which the movement of the dipoles is
limited. The dipole mobility is an inverse function of the
dielectric relaxation time which strongly depends on the
temperature. E.g. for a typical printed circuit board
material, the dielectric material of the device is

20   preferably cooled to a temperature below -50 degrees
Celsius. According to yet other embodiments the orientation
of the dipoles may be fixed using a magnetic
field/radiation.

25   According to an embodiment using a high electric field, the
dipole orienting system comprises at least one electrode for
applying an electric field over the dielectric material
using at least one voltage source. In that way, in
operation, the at least one voltage source can cause the

30   electric field to force the dipoles into the saturation
regime. The voltage source and the location of the at least
one electrode is preferably such that an electric field
obtained in the dielectric material is higher than 1 kV/cm,

preferably higher than 2 kV/cm, more preferably higher than 10 kV/cm. It is noted that the required value for the electric field depends on the type of dielectric material, but for typical printed circuit board (PCB) materials the

5   above values are preferred.

According to a preferred embodiment the device comprises at least two conductors coupled to each other through the dielectric material. Especially for this type of

10 interconnects the invention is useful because this type of interconnects is typically used on a PCB containing a relatively high amount of dipoles if it is desirable to keep the cost low. Also for PCB's the presence of dipoles typically improves the adherence to the copper of the

15 conductors, and therefore it is preferable to have a dielectric material containing dipoles.

According to a typical embodiment the transmission device further comprises a transmitter and a receiver, wherein the

20 at least one conductor extends between the transmitter and the receiver. According to a possible embodiment thereof the transmitter, the receiver and an electrode of the at least one electrode are connected to a voltage reference, typically a ground reference, and the at least one voltage

25 source is applying a voltage between the voltage reference, typically the ground reference, and the at least one conductor. According to another variant the transmitter and the receiver are connected to a voltage reference, typically a ground reference, and each voltage source is applying a

30 voltage between an electrode of the at least one electrode and the voltage reference, typically the ground reference.

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The transmission device preferably comprises a PCB, and the dielectric material is formed by the dielectric material of the PCB. The at least one conductor may be located on an outer side of the PCB or may be embedded in the PCB. The at

5   least one electrode may be located on an outer side of the PCB or may be embedded in the PCB.

Preferably the at least one conductor is part of any one of the following: a differential pair microstrip, a strip line,

10 a shielded or unshielded twisted pair, a coaxial cable.

According to another aspect the dipole orienting system comprises one electrode and a supply voltage circuit for applying a voltage difference between the electrode and the

15 at least one conductor such that an electric field is created in the dielectric material, said at least voltage difference being such that the electric field forces the dipoles in the saturation regime. According to a variant thereof the dipole orienting system comprises a first and a

20 second electrode, located at opposite sides of the at least one conductor, and a supply voltage circuit for applying a voltage difference between the first and the second electrode such that an electric field is created in the dielectric material, said voltage difference being such that

25 the electric field forces the dipoles in the saturation regime.

According to preferred embodiments each electrode and each conductor take the form of a metal strip. Further each

30 electrode preferably has a width which is larger than the width of a conductor, and the at least one electrode and at least one conductor are preferably arranged parallel to each other.

Brief description of the figures

The accompanying drawings are used to illustrate presently
preferred non-limiting exemplary embodiments of devices. The

5   above and other advantages of the features and objects will
become more apparent and the invention will be better
understood from the following detailed description when read
in conjunction with the accompanying drawings, in which:
Figures 1A-C illustrate schematically the principles of

10   embodiments;
Figure 2 illustrates a first embodiment of a transmission
device;
Figure 3 illustrates a second embodiment of a transmission
device;

15   Figure 4 illustrates a third embodiment of a transmission
device;
Figure 5 illustrates a fourth embodiment of a transmission
device; and
Figure 6 illustrates a fifth embodiment of a transmission

20   device.

The transmission of high-frequency signal components is
generally limited by the frequency-dependent losses of the
transmission system consisting of conductor losses and

25   dielectric losses. Typically, conductor losses dominate at
low frequency, while dielectric losses dominate at higher
frequencies (>~1 GHz). Both loss components are typically
defined per length of interconnect, which means that the
speed has to be traded off if longer transmission distance

30   is required. The problem of frequency-dependent losses has
been addressed in a number of ways, each of them leading to
an increase in overall system cost. The most typical
solutions are:

- lowering the serial interconnect rate and introducing multiple parallel interconnects, resulting in an additional cost of transceivers and conductors, and an increase in power consumption;

5   - employing more expensive low-loss materials;

- shortening the interconnect length and using repeaters, resulting in an additional cost of the repeaters, as well as in an increase of the power consumption;

- using advanced modulation formats, such as pulse-amplitude

10   modulation with 4 levels instead non-return to zero, however requiring a more sophisticated transceiver, and resulting in an increase of the cost and the power consumption.

- applying pre-emphasis at the transmitter and/or equalization at the receiver to compensate the frequency

15   dependant losses, requiring more sophisticated transceivers.

The generic concept of embodiments is to solve the aforementioned problem by reducing the loss component affecting the high frequencies of the signal. In embodiments

20   we propose the concept of reducing the dielectric loss through material loss tangent modification.

The signal and return path in an interconnect forms a capacitor. An ideal capacitor with air as the dielectric has

25   an infinite direct current (DC) resistance. The current through an ideal capacitor is given by:

$$I = C_0 \frac{dV}{dt} = C_0 \omega V_0 \cos(\omega t)$$

30   where:

I = the current through the capacitor

V = the applied voltage which is assumed to be a sine wave given by V0 sin(wt);

C0 = the capacitance of the capacitor

ω = the angular frequency, in radians/sec

5 V0 = the amplitude of the voltage sine wave applied across the capacitor.

If the ideal capacitor were to be filled with an insulator with a dielectric constant of εr, the capacitance would
10 increase to C = εr × C0. However, real dielectric materials have resistivity associated with them. The mechanism for flow of alternating current (AC) in a dielectric is by the re-orientation of permanent electric dipoles in the material. When a voltage is applied across a capacitor, an
15 electric field is generated. This field will cause some randomly oriented dipoles in the dielectric to align with the field. The motion of the negative end of the dipole toward the positive electrode and the positive end of the dipole to the negative electrode looks like a transient
20 current through the material. If the voltage applied is a sine wave, the dipoles will be rotated sinusoidally back and forth. This motion gives rise to an AC current. The higher the sine-wave frequency, the faster the charges will rotate back and forth and the higher the current. Consequently, the
25 higher the current, the lower the bulk resistivity will be at that frequency. The resistivity of the material is decreasing with increasing frequency. If the movements of the dipoles are able to follow the externally applied field and move the same distance for the same applied field, the
30 current they create, and the bulk conductivity of the material, will increase linearly with frequency. Their conductivity is constant from DC until some frequency is reached and then it begins to increase and continues

increasing, proportional to the frequency. At frequencies
above this transition frequency, where the motion of dipoles
plays a significant role, there can be a very high-leakage
current through a real capacitor. This current will be in

5   phase with the voltage and will look like a resistor. At
higher frequencies, the leakage resistance will go down and
the power dissipated will go up causing the dielectric to
heat up. At low frequency, the leakage resistance of a
dielectric material is constant and a bulk conductivity is

10   used to describe the electrical properties of the material.
This bulk conductivity is related to the density and
mobility of ions in the material. At high frequency, the
conductivity increases with frequency due to the increasing
motion of the dipoles. The more dipoles there are in the

15   material that can rotate, the higher the bulk conductivity
of the material. Also, the farther the dipoles can move with
an applied field, the higher the conductivity. To describe
this property material dissipation factor is defined as:

20     $$\sigma = 2\pi\varepsilon_0\varepsilon_r \tan(\delta)$$

where:
σ = the bulk AC conductivity of the dielectric;
f = the sine-wave frequency, in Hz;

25   ε_0 = the permittivity of free space, $8.89 \times 10-14$ F/cm;
ε_r = the relative dielectric constant, dimensionless;
$\tan(\delta)$ = the dissipation of the material, dimensionless;

The dissipation factor, written as the tangent of the loss

30   angle, $\tan(\delta)$, and also abbreviated as Df, is a measure of
the number of dipoles in the material and how far each of
them can rotate in the applied field:

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$$\tan(\delta) \sim n * p * \Theta_{max}$$

where:

tan(δ) = the dissipation factor, Df;

n = the number density of dipoles in the dielectric;

p = the dipole moment, a measure of the charge and
separation of each dipole;

Θ_{max} = how far the dipoles rotate in the applied field

As the frequency increases, the dipoles move the same
distance, but faster, so the current increases and the
conductivity increases.

The current through a real capacitor, with an applied sine-
wave voltage, can be described by two components. One
component of the current is out of phase with the voltage
and contributes to the current through an ideal lossless
capacitor. The other current component is in phase with the
applied-voltage wave and looks like the current passing
through an ideal resistor, contributing to loss. To describe
these out-of-phase and in-phase components, a formalism can
be established based on complex numbers. The current through
capacitor is described as

$$I = C\frac{dV}{dt} = i\omega\varepsilon_r C_0 V$$

The complex dielectric constant can be defined as:

$$\varepsilon_r = \varepsilon_r' - i\varepsilon_r''$$

where:

ε_r = the complex dielectric constant;

$\varepsilon_{r'}$ = the real part of the complex dielectric constant;

ε_{r}″ = the imaginary part of the complex dielectric constant.
Therefore the current through a lossy capacitor becomes

$$I = i\omega\varepsilon_r C_0 V = i\omega\varepsilon_r' C_0 V + \omega\varepsilon_r'' C_0 V$$

The tangent of the loss angle is the ratio of the imaginary
to the real component of the dielectric constant:

$$\tan(\delta) = \frac{\varepsilon_r''}{\varepsilon_r'}$$

As a result, the resistance contributing to leakage current
in AC regime can be described as

$$R_{leak} = \frac{1}{\omega\tan(\delta)C}$$

And the bulk-AC conductivity of the material becomes:

$$\sigma = \varepsilon_0\varepsilon_r'\omega\tan(\delta)$$

where:
σ = the bulk-AC conductivity of the dielectric material;
ε_0 = the permittivity of free space = 8.89 × 10-14 F/cm;
ε_{r}′ = the real part of the dielectric constant;
tan(δ) = the dissipation factor of the dielectric;
δ = the loss angle of the dielectric;
ω = angular frequency = 2 × π × f, with f = the sine-wave
frequency.

From the above derivation the conductance of the dielectric
is proportional to the mobility of dipoles and reducing this
mobility will affect the loss. As the electric field

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strength is increased, the degree of polarization keeps
increasing. For a certain value of the dielectric field, all
electric dipoles align themselves. The dielectric material
in such a state is said to be saturated. The movement of
5   dipoles is governed by the varying electric field due to
transmitted signal. However, the field generated by the
signal is typically limited to tens of V/cm. If an
additional external field is applied with a field value
forcing the dipoles in the saturation regime, dipole
10   movement due to signal variation will be negligible or
significantly reduced compared to typical prior art devices.
Consequently, conductivity of the dielectric would be
increased, leading to a decrease in dielectric loss of the
material.
15

According to embodiments such an external electric field is
applied between two metal plates located above and below the
interconnect PCB with a DC voltage applied between the
plates. The voltage necessary to induce the required
20   electric field is chosen to be high enough to saturate
dipole polarization yet low enough not to exceed the
breakdown voltage of the PCB material, and is preferably in
range from 1 kV to 10 kV, but this value will be dependent
on the material that is being used as a dielectric. This
25   concept of embodiments is generally applicable to
conductors, e.g. a differential pair microstrip or stripline
on PCB, or a shielded/unshielded twisted pair, embedded
inside or on the top surface of any type of dielectric
material where DC voltage can be induced between one or more
30   signal conductors and the return path, or between the signal
conductors.

This is illustrated in Figures 1A-C. Figure 1A shows a
typical set-up of conductors according to the prior art,
where the dipoles 1 in the dielectric material will move
with a varying electric field. In the embodiment of figure

5   1A the conductors comprise two signal traces 2 and two
return paths 3 embedded in a PCB 4. Figures 1B and 1C
illustrate two embodiments where a high electric field is
applied at least in the area of the dielectric substantially
between the signal traces 2 and the return path(s) 3. In the

10   embodiment of figure 1B the dipoles 1 are forced in the
saturation regime by a high electric field represented by
field lines 8. The high electric field is caused by a
voltage 7 which is applied between electrodes 5 and 6
located on a top side and a bottom side of the PCB 4, such

15   that the dipoles 1 are oriented vertically. In the
embodiment of figure 1C the dipoles 1 are forced in the
saturation regime by a high electric field between
electrodes 5 and 6 located on a left side and a right side
of the PCB 4, such that the dipoles 1 are oriented

20   horizontally. To that end a voltage source 7 applies an
appropriate voltage across the electrodes 5, 6. In both
embodiments the dipoles 1 are forced in the saturation
regime such that the dipole movement due to signal variation
becomes negligible, leading to a decrease in dielectric loss

25   without significantly increasing the cost or power
consumption of the set-up.

Figure 2 illustrates a first embodiment of a transmission
device of the invention in a configuration where the

30   electrodes 105, 106, also called polarizing planes, are
located above and below an edge-coupled differential pair
102, 103 extending between a receiver (Rx) 109 and a
transmitter (Tx) 110. The transmitter 110 is supplied with a

supply voltage 121, and the receiver is supplied with a
supply voltage 120. A positive voltage 108 with respect to
ground 113 is applied on the top electrode 105 and a
negative voltage 107 is applied with respect to ground 113

5   on the bottom electrode 106. In the illustrated embodiment
the distance between the top electrode 105 and the
conductors 102, 103 is substantially equal to the distance
between the bottom electrode 106 and the conductors, and the
value of the positive and negative voltage may also be

10   substantially equal, but the skilled person understands that
this may also not be the case. The ground reference is
preferably a ground reference to one of the transmitter 110
or receiver chip 109 supply rails, and typically the ground
of the transmitter or the receiver inputs are typically

15   AC-coupled through AC coupling capacitors 111.

Figure 3 illustrates a second embodiment of the invention in
a configuration where a single electrodes 205, also called
polarizing plane, is located below an edge-coupled

20   differential pair 202, 203 extending between a receiver 209
and a transmitter 210. The transmitter 210 is supplied with
a supply voltage 221, and the receiver is supplied with a
supply voltage 220. In this embodiment the differential pair
is located on top of a PCB 204 but the skilled person

25   understands that the conductors 202, 203 could also be
embedded in the PCB 204. The electrode 205 is embedded in
the PCB 204. A positive voltage 207 with respect to ground
213 is applied on the electrode 205, but the skilled person
understands that a negative voltage can be used as well. The

30   ground reference 213 is here also a ground reference to the
transmitter 210, and the receiver inputs are AC-coupled
through optional AC coupling capacitors 211. Further

optional capacitors 212 may be provided for restoring the
return path.

Figure 4 illustrates a third embodiment of the invention in

5   a configuration where two electrodes 305, 306 are located
above and below an edge-coupled differential pair 302, 303
extending between a receiver 309 and a transmitter 310. The
transmitter 310 and the receiver 309 are supplied with a
supply voltage 320. A positive polarizing voltage 308 with

10   respect to ground 313 is applied on a first trace 302 of the
differential pair and a negative polarizing voltage 307 is
applied with respect to ground 313 on a second trace 303 of
the differential pair. The electrodes 305 and 306 are
respectively connected to the supply voltage 320 of the

15   transmitter/receiver and to the ground 313. The ground
reference 313 is preferably also a ground reference to the
transmitter 310 and receiver chip 309. In this embodiment
both the transmitter outputs and the receiver inputs are
AC-coupled through AC coupling capacitors 311, preferably

20   high-breakdown voltage capacitors. The polarizing voltage
sources 307 and 308 may impact the impedance control of the
differential trace, but this can be avoided by adding high
impedance resistors 314. The skilled person will understand
that the third embodiment is also applicable to

25   shielded/unshielded twisted pair. The major advantage of
this third embodiment is that the polarizing planes 305 and
306 can be used as supply rail for active components and
still act as polarizing planes. The skilled person
understands that it is not necessary that both transmitter

30   and receiver are powered by the same supply rail voltage.

Figure 5 illustrates a fourth embodiment of the invention in
a configuration where a single electrode 405 is located

below an edge-coupled differential pair 402, 403 extending
between a receiver 409 and a transmitter 410. In this
embodiment the differential pair is located on top of the
PCB 404 but the skilled person understands that the

5   conductors 402, 403 could also be embedded in the PCB 404.
Similar, a skilled person understands that the polarizing
plane 405 may be at the surface of PCB 404. A negative
voltage 407 with respect to ground is applied on the signal
traces 402, 403, and the electrode 405 is grounded 413.

10   Resistors 414 are used to put the polarizing voltage 407 on
the differential transmission lines 402, 403 without
shorting them to each other. The skilled person understands
that also a positive voltage can be used for 407. The ground
reference 413 is here also a ground reference to the

15   transmitter 410 and the receiver 409. In this embodiment
both the transmitter outputs and the receiver inputs are
AC-coupled through AC coupling capacitors 411, preferably
high-breakdown voltage capacitors. The polarizing voltage
source 407 and polarizing resistors 414 may impact the

20   impedance control of the differential trace, but this can be
avoided by using high impedance resistors 414.

Figure 6 illustrates a fifth embodiment of a transmission
device comprising a coaxial cable with a central conductor

25   502 which is surrounded by a dielectric material 504
containing dipoles 501. The dielectric material 504 is
surrounded by an outer electrode 505. The coaxial cable is
used between a transmitter 510 and a receiver 509. A voltage
507 is applied to the central conductor 502, whilst the

30   outer electrode 505 is connected to ground 513. Also in
this embodiment the dipoles 501 are forced in the saturation
regime such that the dipole movement due to signal variation
on the central conductor 502 becomes negligible, leading to

a decrease in dielectric loss without significantly
increasing the cost or power consumption of the device.
Optional AC-coupling capacitors 511 are provided for the
coupling with the transmitter 510 and receiver 509. The

5   skilled person understands that the polarizing voltage may
be applied to the outer conductor 505 instead of to the
inner conductor 502. In this case the optional AC-coupling
capacitors are typically relocated to the outer conductor.

10 Whilst the principles of the invention have been set out
above in connection with specific embodiments, it is to be
understood that this description is merely made by way of
example and not as a limitation of the scope of protection
which is determined by the appended claims.

15

Claims

1. Transmission device comprising at least one electric
conductor for the transmission of an AC signal and a

5   dielectric material at least partly surrounding the at least
one conductor, said dielectric material comprising dipoles,
further comprising a dipole orienting system adapted to
orient said dipoles and to force said dipoles in a
saturation regime in order to limit the movement of the

10 dipoles when the at least one electric conductor conducts an
AC signal.

2. Transmission device of claim 1, wherein the dipole
orienting system comprises at least one electrode for

15 applying an electric field using at least one voltage
source, said at least one electrode being located such that
the electric field is created in the dielectric material,
such that, in operation, said at least one voltage source
causes the electric field to force the dipoles in the

20 saturation regime.

3. Transmission device of claim 2, wherein the voltage
source and the location of the at least one electrode is
such that an electric field in the dielectric material is

25 obtained that is higher than 1 kV/cm.

4. Transmission device of any one of the previous claims,
wherein the at least one conductor comprises two conductors
electrically coupled to each other through the dielectric

30 material.

5. Transmission device of any one of the previous claims,
further comprising a transmitter and a receiver, the at

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least one conductor extending between the transmitter and the receiver.

6. Transmission device of claim 2 or 3 and 5, wherein the transmitter, the receiver and an electrode of the at least one electrode are connected to a voltage reference, and the at least one voltage source is applying a voltage between the voltage reference, and the at least one conductor.

7. Transmission device of claim 2 or 3 and 5, wherein the transmitter and the receiver are connected to a voltage reference, and each voltage source is applying a voltage between an electrode of the at least one electrode and the voltage reference.

8. Transmission device of any one of the previous claims, wherein the device comprises a PCB and the dielectric material is part of the PCB.

9. Transmission device of claim 8, wherein the at least one conductor is located on an outer side of the PCB or is embedded in the PCB.

10. Transmission device of claim 8 or 9, wherein the at least one electrode is located on an outer side of the PCB or is embedded in the PCB.

11. Transmission device of any one of the previous claims, wherein the at least one conductor is part of any one of the following: a differential pair microstrip, a strip line, a shielded or unshielded twisted pair, a coaxial cable.

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12. Transmission device of any one of the previous claims, wherein the dipole orienting system comprises one electrode and a supply voltage circuit for applying a voltage difference between the electrode and the at least one

5   conductor such that an electric field is created in the dielectric material, said at least voltage difference being such that the electric field forces the dipoles in the saturation regime.

10 13. Transmission device of any one of the claims 1-11, wherein the dipole orienting system comprises a first and a second electrode, located at opposite sides of the at least one conductor, and a supply voltage circuit for applying a voltage difference between the first and the second

15 electrode such that an electric field is created in the dielectric material, said voltage difference being such that the electric field forces the dipoles in the saturation regime.

20 14. Transmission device of claim 12 or 13, wherein each electrode and each conductor takes the form of a metal strip, each electrode having a width which is larger than the width of a conductor, said at least one electrode and at least one conductor being arranged parallel to each other.

25
    15. Transmission device of any one of the previous claims, wherein each conductor takes the form of a strip.
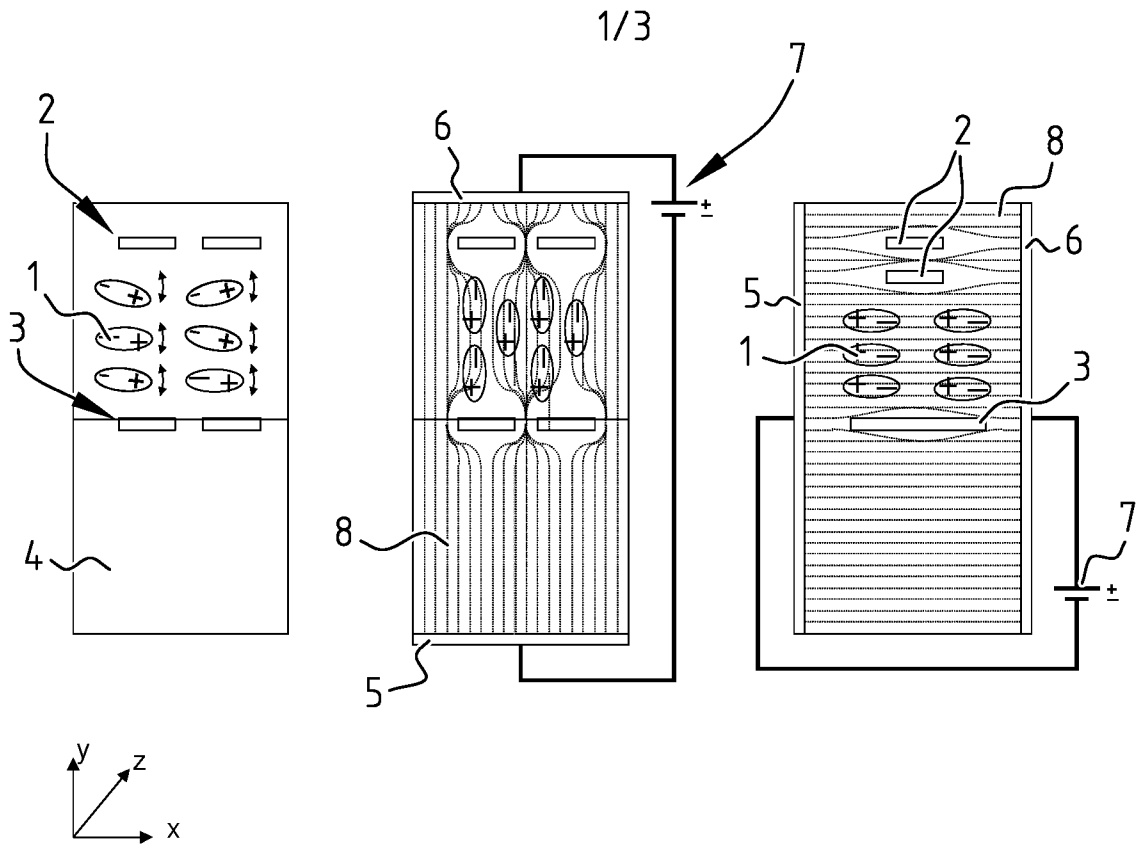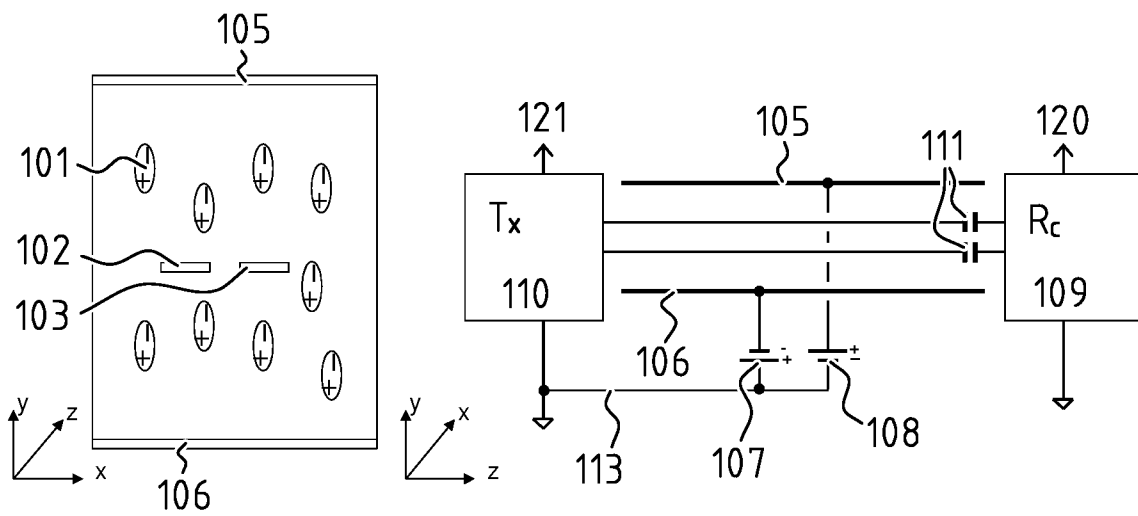
FIG. 1A   FIG. 1B   FIG. 1C
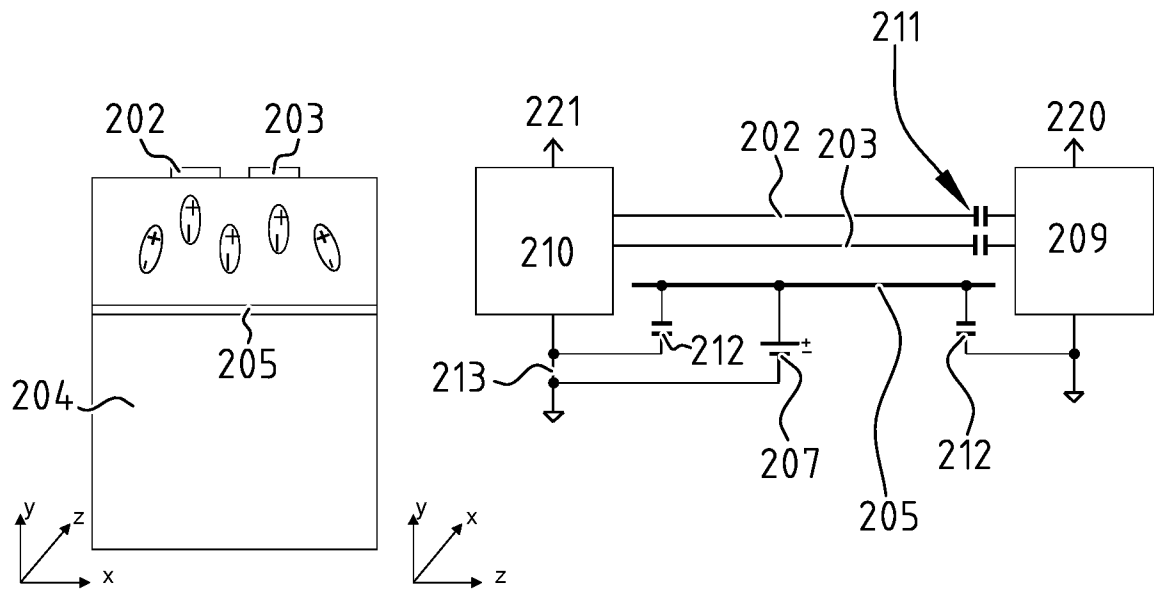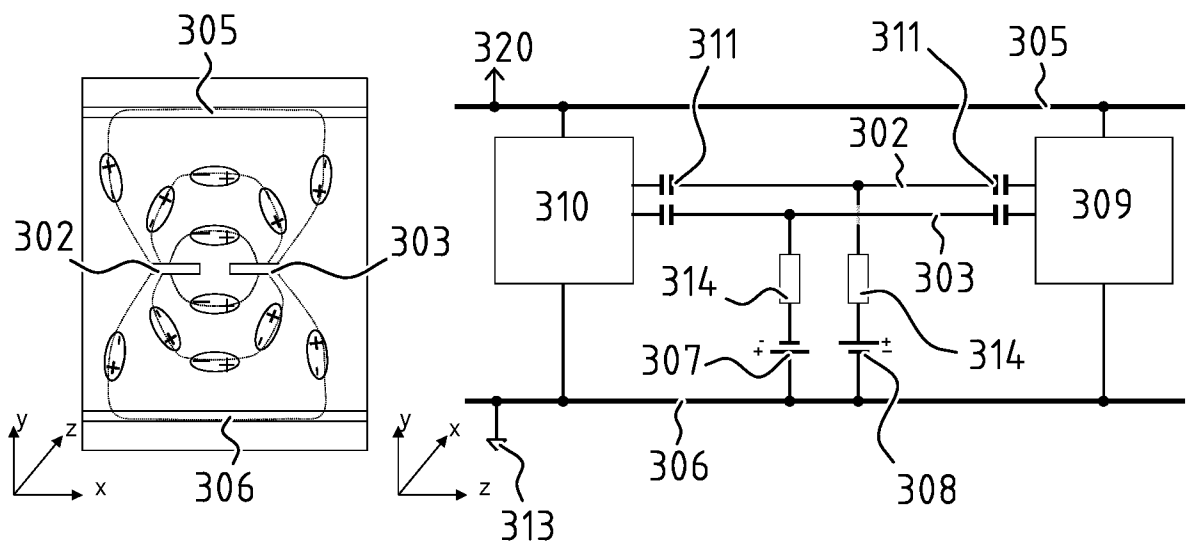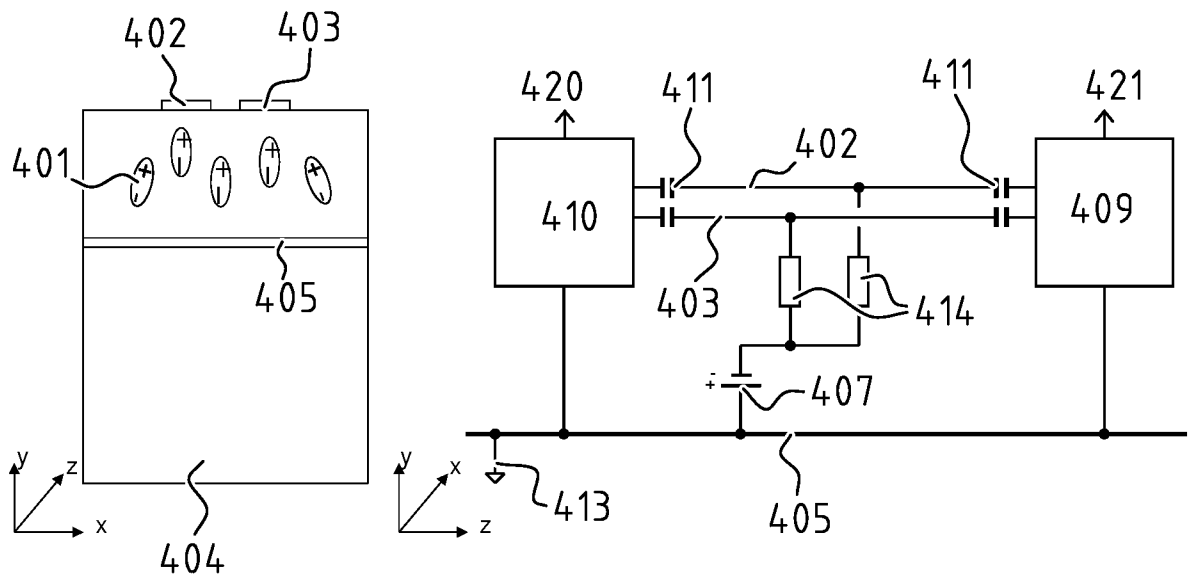

FIG. 2

FIG. 3

FIG. 4

FIG. 5
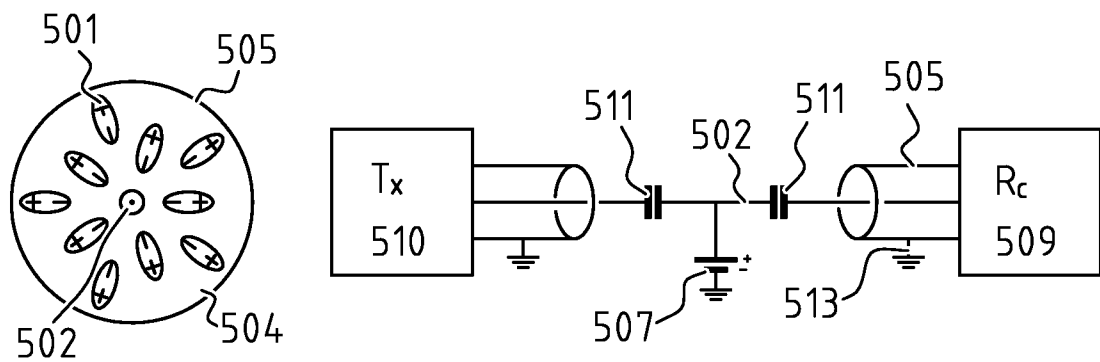
FIG. 6

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01P3/08   H05K1/02
ADD.

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)

H01P   H05K

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/122409 A1 (CAMBRIDGE ENTPR LTD [GB]; CROSSLAND WILLIAM ALDEN [GB]; COLLINGS NEIL) 1 November 2007 (2007-11-01) page 1, line 4 - line 5 page 3, line 6 - page 6, line 30 figures 1, 2, 5, 6 -----	1,2,4-15
X	EP 1 128 459 A2 (STANLEY ELECTRIC CO LTD [JP]) 29 August 2001 (2001-08-29) column 1, line 5 - line 22 column 3, line 9 - line 13 column 5, line 43 - column 7, line 58 column 10, line 34 - column 12, line 25 figures 1-7 ----- -/--	1-7, 11-15

X	Further documents are listed in the continuation of Box C.		X	See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 April 2014	08/04/2014

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, Fax: (+31-70) 340-3016	Köppe, Maro

Form PCT/ISA/210 (second sheet) (April 2005)

1

C(Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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