

Arrangement of contact pairs of twin conductors and of
conductors of a multi-core cable for the purpose of
reducing crosstalk

5 The invention relates to an arrangement of
contact pairs of twin conductors and of conductors of a
multi-core cable for the purpose of reducing crosstalk.

 Because of magnetic and electric coupling
between two neighboring contact pairs, a contact pair
10 induces a current in neighboring contact pairs and
influences electric charges, thus producing crosstalk.

 Several approaches to a solution are conceivable
in principle for the purpose of reducing crosstalk.
Thus, for example, the individual contact pairs can be
15 shielded from one another. A disadvantage of this
solution is the increased outlay on production and the
costs associated therewith. Another possibility consists
in arranging the contact pairs at a large spacing from
one another and simultaneously choosing the spacing
20 between the contacts of a pair to be very small, since
the absolute values of the field strengths decrease with
increasing spacing. Such arrangements have the
disadvantage that they are very voluminous and run
counter to requirements for a compact design. It is also
25 known to compensate for existing crosstalk, but this is
very complicated technically and subject to physical
constraints.

 A further possibility is to arrange the contact
pairs in such a way that crosstalk is reduced because of
30 the field conditions. It has been proposed for this
purpose to arrange the contact pairs of twin conductors
relative to one another in such a way that the areas
defined by the contact pairs of a respective twin
conductor are perpendicular to one another. If, in this
35 case, certain symmetry conditions are observed by the
field distribution, a contact pair can be arranged on
the electric equipotential surfaces of its neighboring
contact pair, with the result that the contact pairs are
decoupled electrically and magnetically. The contact



pairs can be arranged in this case such that the areas defined by the contact pairs intersect. The effect of this is that the conductors are mutually interleaved in the region of connection to the transmission lines, which causes additional crosstalk. Consequently, arrangements are preferred in which the defined areas of the contact pairs do not intersect. The large space requirement and changing connecting planes are a disadvantage of the known arrangements with non-intersecting areas. Problems due to crosstalk which are similar in principle also occur in the case of multi-core cables.

It is therefore the object of the invention to create an arrangement of contact pairs of twin conductors and of conductors of a multi-core cable which are arranged in a compact and easily accessible fashion in conjunction with minimum crosstalk.

The solution to this problem is yielded by the features of patent claims 1 and 4. The arrangement of the contact pairs in such a way that the areas defined by them are parallel and the contact pairs are arranged on electric equipotential lines of their neighboring contact pairs renders possible the compact, easily accessible arrangement of the contact pairs with respect to one another in which the neighboring contact pairs are decoupled electrically and magnetically, with the result that crosstalk is avoided. The same holds for the multi-core cable, in which the respectively neighboring conductor pairs are arranged on an electric equipotential surface of a conductor pair. Further advantageous embodiments of the invention follow from the subclaims.

A simplified connection by machine of the twin conductors to following cables is possible owing to the design of the contact pairs with the same spacing in each case. In a further preferred embodiment, all the forward conductors and all the return conductors are arranged in one plane.



The invention is explained in more detail below with the aid of a preferred exemplary embodiment. In the figures:

5 Figure 1 shows a field distribution of a twin conductor,

Figure 2 shows a contact arrangement of a second parallel twin conductor in the field distribution of the first twin conductor,

10 Figure 3 shows a contact arrangement of a 4 x 2 connector, and

Figure 4 shows a diagrammatic representation for calculating the optimum angle.

Figure 1 represents the field distribution of a twin conductor 1, 2 with the magnetic field lines H and the electric field lines E. The magnetic crosstalk from the first twin conductor 1, 2 to the second twin conductor 3, 4 is directly proportional to the mutual inductance M of this arrangement. The mutual inductance is yielded by integrating the magnetic field strength H of the twin conductor 1, 2 over the area $F_{3,4}$, which is defined by the line conductor of the twin conductor 3, 4, as

$$M = \mu_0 \iint_{F_{3,4}} \vec{H}_{1,2}(x,y,z) d\vec{F},$$

25 it being the case that only the components of the magnetic field strength H which are perpendicular to the surface $F_{3,4}$ make a contribution to this scalar vector product. The surface integral represents the magnetic flux which passes through between the two
30 conductors 3, 4. This flux is equal to zero when the two conductors 3, 4 are situated on a common magnetic field line H. Influence charges which can flow off via the load impedance and thus generate crosstalk are
35 generated on the conductors 3, 4 by the electric field E of the twin conductor 1, 2. The electric field E of the twin conductor 1, 2 generates between the two conductors 3, 4 a potential difference of

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$$V_4 - V_3 = \int_{\text{Conductor 3}}^{\text{Conductor 4}} \vec{E} d\vec{r}.$$

5 This is a line integral on an electric field
line E from conductor 3 to conductor 4, the potential
difference being zero when the electric field strength
E is incident perpendicular to the area $F_{3,4}$ defined by
the conductors 3, 4. The vector electric field E can
also be described by the scalar potential, the poten-
10 tial lines extending perpendicular to the electric
field lines E. For the case of electric decoupling, it
is then necessary for the two conductors 3, 4 to be
arranged on an equipotential surface of the electric
potential. Since the electric and magnetic field lines
15 E and H are perpendicular to one another, the profile
of the potential lines is identical to the profile of
the magnetic field lines H. This means, in turn, that
in the case of line conductors an arrangement with
magnetic decoupling also has electric decoupling.
20 Because of the finite extent of the conductors, the
electric field E is distorted near the conductor, since
the surface constitutes an equipotential surface.
However, these deviations are negligible in the case of
larger spacings.

25 The magnetic field H of the twin conductor 1, 2
is represented in Figure 2, the contact spacing of the
conductors 1, 2 being a. Possible arrangements of the
second twin conductor 3, 4, for which the contact
spacing is likewise a, are illustrated in Figure 2.
30 There is thus an infinite number of possible arrange-
ments of the twin conductors 3, 4, in which the area
 $F_{3,4}$ defined by the conductors 3, 4 is parallel to the
area $F_{1,2}$ and spacing of the contact pairs 1, 2 and 3, 4
is the same size in each case. Since the twin conductor
35 3, 4 is located on a magnetic field line H, the two
twin conductors 1, 2 and 3, 4 are decoupled both
electrically and magnetically.

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A contact arrangement for a 4×2 connector is represented in Figure 3. The spacing of the conductors of each twin conductor 1, 2 and 3, 4 and 5, 6 and 7, 8 is a in each case. In addition, the forward conductors 1, 3, 5, 7 and the return conductors 2, 4, 6, 8 lie in one plane in each case, the spacing from a return conductor 2, 4, 6 to the neighboring forward conductor 3, 5, 7 likewise being a . The angle α resulting therefrom can be calculated by calculating with the aid of Figure 4 as follows:

The forward conductor 3 describes around the return conductor 2 as a function of the angle $\alpha = 90^\circ + \beta$ a circle of radius $2A = a$ and a center displacement A . The circle equation for this circle K 1 is:

$$(X - A)^2 + Y^2 = (2A)^2.$$

Complete decoupling requires the conductors 3, 4 to lie on a magnetic field line which is described by a circle K 2 of radius $R^2 = M^2 - A^2$ and a center point M :

$$(X - M)^2 + Y^2 = M^2 - A^2$$

The point of intersection of the two circles K 1, K 2 is obtained by solving the system of equations

$$(X - A)^2 - (X - M)^2 = (2A)^2 - M^2 + A^2 \Rightarrow X = \frac{2 \cdot A^2}{M - A}$$

It follows from Figure 4 that for the center $M = X + A$, resulting in the following relationship for the X-coordinate of conductor 3:

$$x = \sqrt{2} \cdot A.$$

The angle β can be calculated from the X-coordinate of conductor 3 as:

This produces the desired angle $\alpha = \beta + 90^\circ$ at 101.95° .

$$\sin\beta = \frac{X-A}{2 \cdot A} = \frac{\sqrt{2}-1}{2} \Rightarrow \beta = 11.95^\circ$$

In the arrangement in accordance with Figure 3, the twin conductors 5, 6 and 7, 8 are no longer exactly on a magnetic field line of the twin conductor 1, 2, with the result that crosstalk is induced. However, because of the large spacing this crosstalk is very slight. It is possible using the same principle in accordance with Figure 3 to construct a multi-core cable, for example as a ribbon cable, in which the neighboring conductor pairs are arranged on an electric equipotential line of a conductor pair.

List of reference numerals

- | | | | |
|---|-------------------|---|----------------|
| 1 | Forward conductor | } | Twin conductor |
| 2 | Return conductor | | |
| 3 | Forward conductor | } | Twin conductor |
| 4 | Return conductor | | |
| 5 | Forward conductor | } | Twin conductor |
| 6 | Return conductor | | |

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5. Patent claims

1. An arrangement of contact pairs of twin conductors for the purpose of reducing crosstalk, wherein the contact pairs of the twin conductor (1, 2; 3, 4; 5, 6; 7, 8) are parallel to one another and define non-congruent areas, and the twin conductors (1, 2; 3, 4; 5, 6; 7, 8) are arranged on electric equipotential lines of their neighboring twin conductors (1, 2; 3, 4; 5, 6; 7, 8).
- 15 2. The arrangement as claimed in claim 1, wherein the contact pairs of the twin conductors (1, 2; 3, 4; 5, 6; 7, 8) have the same spacing a in each case.
3. The arrangement as claimed in claim 2, wherein all the forward conductors (1, 3, 5, 7) and all the return conductors (2, 4, 6, 8) of the arrangement are
20 arranged in one plane in each case.
4. A multi-core cable having a multiplicity of conductors, wherein the conductor pairs define mutually parallel, non-congruent areas, and the conductor pairs
25 are arranged on electric equipotential surfaces of their neighboring conductor pairs.

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