(54) Title: AN ARRANGEMENT FOR ATTENUATING ELECTROMAGNETIC INTERFERENCE

Abstract

The invention relates to an arrangement for attenuating electromagnetic interference propagating through a connector (11) in an electronic device positioned in a metal housing (1, 2). The inner space of the grounded metal housing (1, 2) is divided into at least three separate, substantially radiation-proof compartments (7, 9, 10) by metal partition walls (4, 6, 8) and/or metal foils (21) provided in a printed circuit board (3). The connector (11) is positioned in the first compartment (9) in the outer wall of the housing, and the electronic circuits which cause interference or are sensitive to it are substantially positioned in the third compartment (10). Each connection wire (13a, 13b, 13c) from the connector passes into the second compartment (7) from the first compartment through a respective first wire hole (18) provided in the grounded metal foil (21) of the printed circuit board (3), and then into the third compartment (10) from the second compartment through a respective second wire hole (19) provided in the grounded metal foil (21) of the printed circuit board (3).
An arrangement for attenuating electromagnetic interference.

Field of the Invention

The invention relates to an arrangement for attenuating electromagnetic interference propagating through a connector in an electronic device within a conductive housing.

Background of the Invention

One typical problem with electronic devices, especially radio devices or devices containing high-frequency digital clock signals, is the electromagnetic interference to their environment. Especially in devices processing low-power baseband signals, interference from the environment may cause severe problems in the operation of the device and impair the performance. The most common way of preventing the propagation of external electromagnetic interference into the device or the propagation of interference caused by the device into the environment is to position the electronic device in a fully closed grounded conductive housing, such as a metal housing. In most cases, however, electronic devices are interconnected by connectors and cables through which electromagnetic interference can propagate into and out of the metal housing. In an attempt to attenuate interference propagating through connectors and connection wires, various interference filters have been used, which are positioned at points where the connection wires pass through the metal housing. As each connection wire needs a separate interference filter, the number of the filters and the space required by them increase with increasing number of connection
wires. At the same time there is a substantial increase in the cost of the device.

Disclosure of the Invention

The object of the present invention is to enable the filtering of electromagnetic interference propagating through a connector in an electronic device positioned in a conductive housing in a simpler way and with a smaller space requirement.

This is achieved by means of an arrangement according to the invention wherein the inner space of the grounded conductive housing is divided into at least three separate, substantially radiation-proof compartments by means of conductive partition walls, and that the connector is positioned in the first compartment in the outer wall of the housing, and electronic circuits which cause interference or are sensitive to it are substantially positioned in the third compartment, and that each connection wire from the connector passes into the second compartment from the first compartment through a respective first wire hole provided in the partition wall between the first and the second compartment, and then into the third compartment from the second compartment through a respective second wire hole provided in the partition wall between the second and the third compartment.

The basic idea of the invention is that the partition walls of the conductive housing, wiring on the printed circuit board and possibly a few filtering capacitors are utilized to filter and separate the electromagnetic interference. The connector is positioned in the first, substantially radiation-proof compartment, within which any direct interference entering through the connector is
trapped. Each one of the connection wires is passed through a respective wire hole provided in a ground plane (such as a partition wall or the metal foil of the printed circuit board) into the second, substantially radiation-proof compartment and further through another wire hole in the ground plane to the third radiation-proof compartment, in which most of the circuits of the electronic device are positioned. The through-hole in the ground plane acts as a kind of filter which attenuates interference induced in the connection wire passing through the hole. The portion of the interference which nevertheless has leaked to the second compartment from the first compartment is trapped in the second radiation-proof compartment. The second wire hole between the second and the third compartment prevents the propagation of the interference through the wire into the third compartment. In addition, a filtering capacitor may be provided in the second compartment adjacent to each wire hole to further filter any interference that has entered the second compartment. The arrangement according to the invention also prevents the propagation of the interference caused by the electronic circuits from the third compartment to the first compartment and further to the environment of the device. If the contact pins of the connector are intended to be inserted through the printed circuit board and to be soldered to the printed circuit board, a fourth radiation-proof compartment may be provided on the opposite side of the printed circuit board adjacent to the contact pins. This compartment traps any interference leaked to the opposite side of the printed circuit board via the contact pins.

The arrangement according to the invention enables a more effective attenuation of electro-
magnetic interference propagating through a connector and connection wires by means of the interference separation and filtering structures formed by the structures of the housing and the printed circuit board. The invention is advantageous especially when there are plenty of connection lines, as it enables an effective filtration of interferences in each line simply and with a small space requirement.

Brief Description of the Drawings

The invention will now be described in greater detail by means of an example with reference to the attached figure, which shows a partial sectional side view of an electronic device according to the invention.

Preferred Embodiment of the Invention

In the figure, the electrically conductive housing of the electronic device comprises a top portion 1 and a bottom portion 2 supporting a printed circuit board 3. As used in this patent application, the term conductive housing refers to any housing made of an electrically conductive material or coated or laminated with such a material. The housing is preferably of metal.

The bottom portion 2 of the housing comprises two conductive partition walls 4 and 6 projecting upward from the bottom. The upper edges of the partition walls 4 and 6 preferably make contact substantially over their entire length with grounded metal foils 24 and 22, respectively, positioned on the underside of the printed circuit board 3 at corresponding points. An end wall 25 of the bottom portion 2 of the housing, the partition wall 4 and the printed circuit board 3 define therebetween a
separate compartment 5 within the housing. Correspondingly, the partition wall 4, the partition wall 6 and the printed circuit board 3 define therebetween a second separate closed compartment 7 within the housing, which compartment is separated from the compartment 5 by the partition wall 4. A conductive partition wall 8 extends between the top portion 1 of the housing and the printed circuit board 3, and the lower edge of the partition wall preferably makes contact over its entire length with a grounded metal foil 23 positioned on the upper surface of the printed circuit board 3 at a corresponding point. The end wall 25 of the top portion 1 of the housing, the partition wall 8 and the printed circuit board 3 define therebetween a separate closed compartment 9 within the housing. Correspondingly, a compartment 10 separate from the other compartments 5, 7 and 9 is defined on the other side of the partition wall 8.

The printed circuit board 3 is preferably a multi-layer printed circuit board within which a substantially integral grounded metal foil 21 is provided at least within areas separating the compartments 5, 7, 9 and 10, so that the grounded metal parts of the housing and the grounded metal foil 21 separate the compartments from each other in a substantially radiation-proof manner at least in view of the electromagnetic interference. The metal foils 22, 23 and 24 of the printed circuit board 3 enable the radiation-proof junctions of the printed circuit board and the respective partition walls 6, 8 and 4.

A connector 11 is positioned in the end wall 25 of the top portion 1 of the housing in the compartment 9 in such a way that a proper counter connector can be attached to it from outside the housing. The rear portion of the connector 11 in the
compartment 9 is provided with contact pins 12. The pins are soldered to the printed circuit board 3 and they extend through holes formed in the printed circuit board into the compartment 5 positioned below the printed circuit board at the corresponding point. Connection wires 13 for the transmission of connecting signals are connected to at least some of the contact pins 12. Direct interference radiation caused by interference induced in the contact pins 12 and the connection wires 13 through the connector 11 is trapped within the radiation-proof compartment 9. Correspondingly, interference radiation caused by the contact pins 12 below the printed circuit board 3 remains in the radiation-proof compartment 5. The connection wires 13 are passed from the connector 11 in the compartment 9 into the compartment 7 through a respective number of wire holes 18 provided in the printed circuit board 3 and its grounded metal foil 21, which separate the compartments 9 and 7. Each connection wire 13 passing through the respective wire hole 18 in the grounded metal foil acts as a kind of filter which attenuates the interference signal induced in the wire 13 before it reaches the compartment 7. Direct interference radiation caused by the connection wires 13 in the compartment 7 is trapped within the radiation-proof compartment 7. From the compartment 7 the connection wires 13 are passed into the radiation-proof compartment 10 above the printed circuit board 3 through a respective number of wire holes 19 provided in the printed circuit board 3 and its grounded metal foil 21, which separate the compartments 7 and 10. Again each connection wire passing through the respective wire hole 19 in the grounded metal foil 21 acts as a filter which further filters the interference signal.
possibly still present in the wire 13 so that the baseband connecting signal applied to the compartment 10 is substantially free from interference. All or most of the components in the electronic device which cause electromagnetic interference or are sensitive to it are positioned in the compartment 10 or subsequent compartments.

In the compartment 7, a filtering capacitor C1 or C2 may be connected to at least one of the connection wires 13 adjacent to at least one of the wire holes 18 or 19, respectively. The capacitors further filter the interference signal induced in the wire 13. The capacitors C1 and C2 may be realized by the metal foils of the printed circuit board.

The arrangement according to the invention also prevents the escape of the electromagnetic interference possibly caused by the electronic device positioned in the housing from the compartment 10 to the connection wire 13 and to the outside of the housing through the connector 11.

Even though the connection wires 13 are shown as separate wires in the figures, they may alternatively be formed of strip lines and through-holes provided in the printed circuit board.

The structure of the housing can be modified e.g. by passing the connection wires 13 from one compartment to another through wire holes provided in the grounded partition wall separating them. The partition walls can be realized as parts integral with the housing or as separate wall elements to be attached to the printed circuit board and/or to the housing.

The connector 11 may be of any known type or be any other structure suitable for the purpose. Typically, it may be a multi-pin connector to be
attached to the printed circuit board, such as a D connector.

The figure and the description related to it are only intended to illustrate the invention. In its details, the arrangement according to the invention may vary within the scope of the attached claims.
Claims:

1. An arrangement for attenuating electromagnetic interference propagating through a connector (11) in an electronic device positioned in a conductive housing (1, 2), characterized in that the inner space of the grounded conductive housing (1, 2) is divided into at least three separate, substantially radiation-proof compartments (7, 9, 10) by means of conductive partition walls (3, 4, 6, 8), and that the connector (11) is positioned in the first compartment (9) in the outer wall of the housing, and electronic circuits which cause interference or are sensitive to it are substantially positioned in the third compartment (10), and that each connection wire (13a, 13b, 13c) from the connector (11) passes into the second compartment (7) from the first compartment through a respective first wire hole (18) provided in the partition wall (3) between the first and the second compartment, and then into the third compartment (10) from the second compartment (7) through a respective second wire hole (19) provided in the partition wall (3) between the second and the third compartment.

2. An arrangement according to claim 1, characterized in that at least one of said conductive partition walls comprises a grounded metal foil provided in a printed circuit board (3).

3. An arrangement according to claim 1 or 2, characterized in that a filtering capacitor (C1) is connected to at least one of the connection wires (13a, 13b, 13c) in the second compartment (7) adjacent to the first wire hole (18).

4. An arrangement according to claim 1, 2 or 3, characterized in that a filtering
capacitor (C2) is connected to at least one of the connection wires (13a, 13b, 13c) in the second compartment (7) adjacent to the second wire hole (19).

5. An arrangement according to claim 1, 2, 3 or 4, characterized in that the conductive housing comprises a top portion (1) and a bottom portion (2) supporting the printed circuit board (3), and that said first (9) and third (10) compartment are positioned on one side of the printed circuit board (3) and separated by the partition wall (8), and said second compartment (7) is positioned on the opposite side of the printed circuit board (3), the printed circuit board (3) comprising a substantially integral grounded metal foil (21) at least within the area of said compartments (7, 9, 10).

6. An arrangement according to claim 5, characterized in that the connector (11) in the first compartment (9) comprises contact pins (12) soldered to and extending through the printed circuit board (3), respective connection wires (13a) being connected to at least some of the contact pins in the first compartment, and that a fourth substantially radiation-proof compartment (5) is positioned on the opposite side of the printed circuit board (3) adjacent to the contact pins (12) of the connector (11), said compartment being separated from said second compartment (7) by the partition wall (4) of the housing.

7. An arrangement according to claim 5 or 6, characterized in that the top edges of the partition walls (4, 6, 8) separating said compartments (5, 7, 9, 10) make contact over their entire length with grounded metal foils (22, 23, 24) provided on the surfaces of the printed circuit board (3) at respective points.
8. An arrangement according to claim 2, characterized in that the printed circuit board (3) is a multi-layer circuit board within which a substantially integral, grounded metal foil (21) is provided at least within areas where the printed circuit board separates said radiation-proof compartments (5, 7, 9, 10).

9. An arrangement according to claim 2, characterized in that said connection wires (13a, 13b, 13c) comprise strip lines and through-holes formed in the printed circuit board.

10. An arrangement according to claim 1, characterized in that said connection wires transmit baseband signals.
INTERNATIONAL SEARCH REPORT

International Application No PCT/FI 92/00065

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all)¹

According to International Patent Classification (IPC) or to both National Classification and IPC

IPCS: H 05 K 9/00

II. FIELDS SEARCHED

Minimum Documentation Searched²

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Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched³

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT⁴

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<td>CH, A5, 654162 (R. DÖRING) 31 January 1986, see page 2, line 54 - line 61; page 5, line 35 - line 38</td>
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<td>X</td>
<td>GB, A, 2101811 (RACAL-DANA INSTRUMENTS LIMITED) 19 January 1983, see page 2, line 53 - line 56</td>
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<td>A</td>
<td>US, A, 4370700 (A.L. DUDDLES ET AL) 25 January 1983, see column 3, line 39 - line 44</td>
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* Special categories of cited documents:¹⁰
*A* document defining the general state of the art which is not considered to be of particular relevance
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*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

*¹* document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search 23rd June 1992

Date of Mailing of this International Search Report 1992-06-24

International Searching Authority

SWEEDISH PATENT OFFICE

Signature of Authorized Officer

HARRIET EKDAHL
ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. PCT/FI 92/00065

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDF file on 29/05/92.
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