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(54) **Title**: SENSOR DEVICE AS WELL AS METHOD FOR PROXIMITY AND TOUCH DETECTION

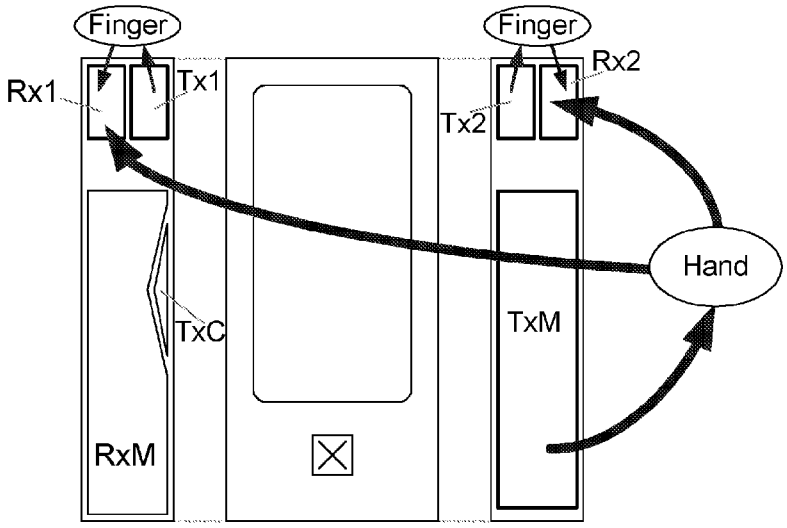

Fig. 1

(57) **Abstract**: The invention provides a sensor device with a first electrode structure and a second electrode structure, the first electrode structure comprising a transmitting electrode, a compensation electrode and a reception electrode and the second electrode structure comprising a field transmission electrode and at least one field sensing electrode. The first electrode structure is adapted to detect a gripping of an electric hand-held device, whereas the second electrode structure is adapted to detect an approach of a finger to the second electrode structure, for example of the hand gripping the hand-held device.

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Sensor device as well as method for proximity and touch detection

Field of the invention

The invention relates to a sensor device which can be arranged at an electric hand-held device and which is adapted to detect as to whether the electric hand-held device is gripped by a hand and as to whether the electric hand-held device is approached by a hand. Moreover the invention relates to a method for the proximity and touch detection with a sensor device according to the invention. Moreover the invention concerns a hand-held device with a sensor device according to the invention. The hand-held device can be for example a mobile phone, a computer mouse, a remote control, an input means for a game console, a mobile computer or similar.

State of the art and background of the invention

On an electric device, for example an electrical hand-held device, always means for operating the electric device are needed. In case of an electric hand-held device, for example a mobile phone, it is usual, to handle it with one or several fingers.

It is known to provide sensing devices for operating electric hand-actuated devices, the operation of which is evaluated with the help of an evaluation circuit coupled with the electric sensing devices. Besides the use from electric sensors it is also known to detect the operation of an electric hand-held device by means of capacitive proximity sensors, in which to a detected event a device function is assigned, which is executed.

Here the disadvantage is however that the detection of a finger movement or the release of a switching event by a finger strongly depends on the hand gripping the hand-held device. In case of unfavourable position of the hand on the electric hand-held device, the hand can influence the capacitive environment of the capacitive proximity sensors in such a way that an approach of a finger at the capacitive proximity sensor can no longer reliably be detected by it. This can entail that the electric hand-held device cannot be operated anymore.

Object of the invention

The invention therefore is based on the problem to provide solutions which allow to detect an operation of an electric hand-held device on a capacitive basis, especially guaranteeing a reliable detection of an operation process independent of the fact if the electric hand-held device is gripped by a hand or not.

Solution according to the invention

According to the invention, this object is achieved by a sensor device as well as a method according to the independent claims. Advantageous embodiments and improvements of the invention are referred to in the respective dependent claims.

According to this a sensor device is provided that comprises

- at least one first electrode structure which comprises at least one transmitting electrode, at least one compensation electrode and at least one reception electrode,
- at least one second electrode structure which comprises at least one field transmitting electrode and at least one field sensing electrode and
- at least one signal transmitter for supplying the at least one transmitting electrode, the at least one compensation electrode, and the at least one field transmitting electrode with an electric alternating signal,

in which

- the at least one transmitting electrode, the at least one compensation electrode and the at least one reception electrode are arranged in such a way in relation to each other that a first alternating electrical field emitted at the at least one transmitting electrode and a second alternating electrical field emitted at the at least one compensation electrode can be coupled into the at least one reception electrode, and
- the at least one field transmitting electrode and the at least one field sensing electrode are arranged in such a way in relation to each other that a third alternating electrical field emitted at the at least one field transmitting electrode can be coupled into the at least one field sensing electrode.

With the first electrode structure and the second electrode structure of the sensor device according to the invention, substantially two observation areas are defined, so that e. g. in case of a mobile phone a grip of the mobile phone by a hand can be detected (with the first electrode structure) and at the same time or afterwards also an approach to the mobile phone (with the second electrode structure), e. g. of a finger of the hand gripping the mobile phone. At the same time this avoids that several sensor devices have to be provided for detecting the grip of a hand-held device by a hand and for detecting the operation of the hand-held device, which reduces construction efforts considerably.

The transmitting electrode and the compensation electrode are arranged relatively to the reception electrode in such a way that the alternating electric field emitted at the transmitting electrode and coupled into the reception electrode is almost deleted by the alternating electric field emitted at the compensation electrode and coupled into the reception electrode. This is the case when the transmitting electrode, the compensation electrode and the reception electrode are not covered by a hand. When the transmitting electrode, the compensation electrode and the reception electrode are covered by a hand, the capacitive coupling between the transmitting electrode and the reception electrode increases (by the hand), so that the

effect of the alternating electric field emitted at the compensation electrode on the alternating electric field emitted at the transmitting electrode is reduced.

The field transmitting electrode and the field sensing electrode are also arranged in such a way towards each other that the electric alternating field emitted at the field transmitting electrode couples into the field sensing electrode. If an object, for example a finger approaches the field transmitting electrode and the field sensing electrode, the capacitive coupling between the field transmitting electrode and the field sensing electrode increases.

Preferably the first electrode structure and the second electrode structure are arranged towards each other in such a way, e. g. on a hand-held device, that in case of a grip of the hand-held device, for example by a hand, substantially only the electrodes of the first electrode structure are covered. The electrodes of the second electrode structure can be covered by a finger of the hand gripping the hand-held device. If over the hand gripping the hand-held device the electric alternating field emitted at the transmitting electrode all the same couples into the field sensing electrode of the second electrode structure, a further approach to the second electrode structure by a finger entails an increase of the capacitive coupling between the field transmitting electrode and the field sensing electrode, so that the approach to the second electrode structure can be detected. If on the other hand the increase of the capacitive coupling compared to the capacitive coupling between the transmitting electrode and the field sensing electrode is very small, the sensor device according to the invention can be operated in two different operating modes described below.

The arrangement according to the invention of the electrodes of the two electrode structures in relation to each other also avoids that the capacitive environment of the second electrode structure is influenced by a hand gripping the hand-held device in such a way that a reliable detection of an approach of a finger to the second electrode structure cannot be reliably detected anymore.

The at least one compensation electrode and the at least one field transmitting electrode can be galvanically coupled. For supplying the compensation electrode or the field transmitting electrode with an electric alternating signal thus no separate signal generators have to be provided. The production effort can thus be reduced considerably.

The sensor device can be operated in a first mode of operation and in a second mode of operation. In the first mode of operation the at least one transmitting electrode, the at least one compensation electrode and the at least one field transmitting electrode can be supplied with an electric alternating signal and in the second mode of operation only the at least one field transmitting electrode can be supplied with the electric alternating signal.

It has proved advantageous to supply, in the first mode of operation, the at least one transmitting electrode with a first electric alternating signal and to supply the at least one compensation electrode with a second electric alternating signal, in which the first electric alternating signal is phase-shifted with respect to the second electric alternating signal. Preferably the second electric alternating signal has a lower amplitude than the first electric alternating signal.

The at least one transmitting electrode, the at least one compensation electrode and the at least one field transmitting electrode can be supplied with the electric alternating signal in a multiplex method (time-division multiplex method and/or frequency multiplex method and/or code multiplex method).

The sensor device can further include an evaluating device, which can be coupled with the first electrode structure and the second electrode structure, wherein the evaluating device is adapted to evaluate a first electrical signal tapped at the at least one reception electrode and a second electrical signal tapped at the at least one field sensing electrode. The evaluating device advantageously includes a mi-

crocontroller.

It is advantageous if the evaluating device includes an amplifying circuit to which the first electric signal and the second electric signal can be fed, the amplification of the amplifying circuit being preferably adjustable.

The first electric signal and the second electric signal can preferably be fed to the amplifying circuit in a time-division multiplex method, the amplification of the amplifying circuit being adjustable depending on the signal supplied.

Moreover a method for approach and contact detection is provided by the invention, which includes the following steps:
- supplying at least one transmitting electrode, at least one compensation electrode and at least one field transmitting electrode with an electric alternating signal, so that an alternating electrical field emitted at the at least one transmitting electrode and a second alternating electrical field emitted at the at least one compensation electrode can be coupled into the at least one reception electrode, and a third alternating electrical field emitted at the at least one field transmitting electrode can be coupled into the at least one field sensing electrode, and
- evaluating a first electrical alternating signal tapped at the least one reception electrode and of a second electrical signal tapped at the least one field sensing electrode.

In a first mode of operation the at least one transmitting electrode, the at least one compensation electrode and the at least one field transmitting electrode can be supplied with the electric alternating signal and in a second mode of operation only at least one field transmitting electrode can be supplied with the electric alternating signal.

The electrodes to which an electrical alternating signal is supplied can be supplied with the electric alternating signal according to a multiplex method and the first

electric signal and the second electric signal can be tapped in a multiplex method.

The at least one transmitting electrode can be supplied with a first electric alternating signal and the at least one compensation electrode can be supplied with a second electric alternating signal, the first electric alternating signal being phase-shifted with respect to the second electric alternating signal.

Moreover the invention provides a hand-held device which comprises a sensor device according to the invention. The hand-held device can be an electrical hand-held device, especially a computer mouse, mobile phone, remote control, input or control means for game consoles, minicomputer or similar.

Short description of the figures

Further features and characteristics of the invention as well as concrete embodiments of the invention result from the following description in connection with the drawing. The figures show:

Fig. 1 a first usage scenario with two electrode structures according to the invention on one electric hand-held device, which is gripped by a hand;

Fig. 2 a second usage scenario with two electrode structures according to the invention on one electric hand-held device, which is gripped by a hand;

Fig. 3 a third usage scenario with two electrode structures according to the invention on one electric hand-held device, which is not gripped by a hand;

Fig. 4 a fourth usage scenario with two electrode structures according to the invention on one electric hand-held device, which is not gripped by a hand;

Fig. 5 the influence of a hand gripping an electrical hand-held device on the signal level at a field sensing electrode with an approached finger on the one hand and without an approached finger on the other hand;

Fig. 6 a block diagram of a first embodiment of a sensor device according to the invention;

Fig. 7 a block diagram of a second embodiment of a sensor device according to the invention;

Fig. 8 a block diagram of a third embodiment of the sensor device according to the invention, wherein the second electrode structure comprises several areas;

Fig. 9 a block diagram of a fourth embodiment of a sensor device according to the invention with several areas of the second electrode structure;

Fig. 10 a block diagram of a fifth embodiment of a sensor device according to the invention with a plurality of areas of the second electrode structure, in which with the plurality of areas a slide control and/or a multiple button system can be realized;

Fig. 11 a block diagram of a sixth embodiment of the sensor device according to the invention, wherein the second electrode structure comprises a plurality of areas with which a slide control and/or a multiple button system can be realized; and

Fig. 12 a principle representation of a sensor device according to the invention for realizing a slide control and a rotary regulator, in which the sensor resolution can be increased in case of a fixed number of transmission channels.

Detailed description of the invention

Fig. 1 shows an electrical hand-held device, for example a mobile phone, on which a first electrode structure and a second electrode structure are arranged. The first electrode structure includes a transmitting electrode TxM, a compensation electrode TxC and a reception electrode RxM. The second electrode structure includes two electrode pairs Rx1, Tx1 or Rx2; Tx2.

The first electrode structure is provided for detecting the grip of the electric hand-

held device by a hand. The second electrode structure or the two electrode pairs Rx1, Tx1 and Rx2, Tx2 are provided for detecting the approach of a finger to the respective electrode pair. The electrodes Tx1, Tx2 (field transmission electrodes) are operated as transmission electrodes, at which an alternating electrical field can be irradiated. The electrodes Rx1 and Rx2 (field sensing electrodes) are operated as reception electrodes, into which the alternating electrical field irradiated by the respective field transmitting electrode Tx1, Tx2 can be coupled, as soon as the finger has come sufficiently near to the respective electrode pair. The coupling is done by means of the approaching the finger to the respective electrode pair.

At the transmitting electrode TxM also an alternating electrical field can be emitted, which can be coupled in case of a grip of the electric hand-held device by a hand over the hand into the reception electrode RxM. At the compensation electrode TxC an alternating electrical field is emitted, which can be coupled into the reception electrode RxM. If the hand-held device is not gripped by a hand, the alternating electric field emitted at the transmitting electrode TxM is almost deleted by the alternating electric field emitted at the compensation electrode TxC, so that the electric current in the reception electrode RxM is very small.

Preferably the phasing of the alternating electric field emitted at the compensation electrode TxC is different from the phasing of the alternating electric field emitted at the transmitting electrode TxM. Preferably the alternating electric field emitted at the compensation electrode TxC presents a phase shift of about 180° as to the electric alternating field emitted at the transmitting electrode TxM.

If the electric hand-held device is gripped by a hand, a strong electric coupling between the transmitting electrode TxM over the hand to the field sensing electrodes Rx1 or Rx2 results. In case of an approach of a finger to the electrode pairs Tx1, Rx1 or Tx2, Rx2 moreover the alternating electric field emitted at the respective field transmitting electrode Tx1 or Tx2 is coupled over the finger into the respective field sensing electrode Rx1 or Rx2. The coupling over the finger entails

a level rise of the electric current flowing in the respective field sensing electrode Rx1 or Rx2, which is indicative for the approach of a finger to the respective electrode pair Rx1, Tx1 or Rx2, Tx2.

As also the alternating electric field emitted by the transmitting electrode TxM over the hand couples into the field sensing electrodes Rx1 or Rx2, an unfavourable grip of the electric hand-held device by a hand may entail that the portion of the alternating electric field coupled over the hand into the field sensing electrodes Rx1 and Rx2 is quite bigger than the portion of the alternating electric field coupled over the finger into the field sensing electrodes Rx1 or Rx2, which is emitted at the respective field transmitting electrode Tx1 or Tx2. This may entail that in a hand-held device which is gripped by a hand, the level rise of the current flowing in the field sensing electrodes Rx1 or Rx2 in case of an approach of a finger to the respective electrode pair Rx1, Tx1 or Rx2, Tx2 is only very small, which my entail that an approach to the respective electrode pair may not be reliably detected.

In order to avoid this it is advantageous, at first to detect the grip of the electric hand-held device by a hand with the help of the first electrode structure TxM, TxC, RxM and, after successful detection to deactivate at least the transmitting electrode TxM, so that after successful detection of the grip by a hand at the transmitting electrode TxM no alternating electrical field is emitted anymore which could be coupled over the hand into the field sensing electrodes Rx1 or Rx2.

Fig. 2 shows an electrical hand-held device with a first electrode structure and a second electrode structure, in which the electric hand-held device is gripped by a hand. In the example shown in Fig. 2 the transmitting electrode TxM of the first electrode structure is inactive, whereas the compensation electrode TxC of the first electrode structure is active, so that at it an alternating electrical field is emitted. As the compensation electrode TxC is small if compared to the transmitting electrode TxM, the alternating electric field emitted at the compensation electrode

TxC only has a very small effect on the electric current flowing in the field sensing electrodes Rx1 or Rx2. In order to detect with certainty the approach of a finger to the electrode pairs Tx1, Rx1 or Tx2, Rx2, the compensation electrode TxC must not be deactivated.

Fig. 3 shows an electrical hand-held device with a first electrode structure and a second electrode structure, in which the electric hand-held device is not gripped by a hand. The hand here is only approaching the hand-held device. Like in Fig. 1 here too the transmitting electrode TxM of the first electrode structure is active, i. e. at the transmitting electrode TxM an alternating electrical field is emitted. As however the electric hand-held device is not gripped by the hand, the capacitive coupling of the transmitting electrode TxM over the hand to the field sensing electrodes Rx1 or Rx2 is only very small.

A finger approaching the electrode pairs Rx1, Tx1 or Rx2, Tx2 here again entails that the alternating electric field emitted at the respective field transmitting electrode Tx1 or Tx2 couples in over the finger into the field sensing electrode Rx1 or Rx2. The alternating electric field coupled into the respective field sensing electrode Rx1 or Rx2 over the finger entails in the respective field sensing electrode a significant level rise of the electric current flowing in the respective field sensing electrode. As the capacitive coupling between the transmitting electrode TxM and the field sensing electrodes Rx1 or Rx2 is very small, this capacitive coupling has only a small effect on the level rise of the current flowing in the respective field sensing electrode. An approach of a finger to the electrode pairs Rx1, Tx1 or Rx2, Tx2 can thus precisely be detected even in case of active transmitting electrode TxM.

Fig. 4 shows an electrical hand-held device with a first electrode structure and a second electrode structure, in which the electric hand-held device is not gripped by a hand and in which the compensation electrode TxC is active, whereas the transmitting electrode TxM is inactive. Like in Fig. 3 the hand-held device is ap-

proached here too. As already explained in regard to Fig. 2, the alternating electric field emitted at the compensation electrode TxC, which compared to the transmitting electrode TxM is small, and coupled over the hand into the field sensing electrode Rx1 or Rx2, has almost no effect on the electric current flowing in the respective field sensing electrode Rx1 or Rx2. The approach of a finger to the electrode pairs Rx1, Tx1 or Rx2, Tx2 can therefore precisely be ascertained.

Fig. 5 shows two diagrams which show the influence of the hand once in case of an approaching finger and once without approaching finger on the signal level of the current flowing in the field sensing electrode Rx1 or Rx2.

The continuous line shows the level depending on the hand, when the transmitting electrode TxM is active. As can be recognized here, in case of active transmitting electrode TxM the area of the hand has a strong effect on the signal level in the field sensing electrode Rx1 and Rx2. The influence of the hand in case of active transmitting electrode TxM on the signal level is great, independent of the fact if a finger is near the second electrode structure.

The dotted line shows the influence of a gripping hand on the signal level in the field sensing electrode Rx1 or Rx2, when the compensation electrode TxC is active, whereas the transmitting electrode TxM is inactive. As can be seen, the area of the hand hardly influences the signal level in the field sensing electrodes Rx1 or Rx2 when the compensation electrode TxC is active whereas the transmitting electrode TxM is inactive.

Fig. 6 shows a block diagram of a first embodiment of the sensor device according to the invention. The evaluating device includes a multiplexer MPX, an amplifier AMP, a microcontroller µC and two signal generators G1 and G2. The field sensing electrodes Rx1, Rx2 and the reception electrode RxM are coupled with the multiplexer MPX. The signals tapped at the field sensing electrodes Rx1, Rx2 and at the reception electrode RxM are fed over the multiplexer MPX in the time-

division multiplex method to the amplifier AMP or to the microcontroller μC. Alternatively the measured signals can be fed each time to different amplifiers, the respective amplified signal being fed to the microcontroller μC.

The amplifier AMP is preferably adjustable in its amplification during operation, so that the amplification can be optimized for the respective signal fed to the amplifier AMP depending on the position of the multiplexer MPX.

The signal generator G1 generates an electrical alternating signal, which is supplied to the field transmission electrodes Tx1, Tx2 and the compensation electrode TxC. The electric alternating signal generated by the signal generator G1 is set in such a way that in the first mode of operation, in which the gripping of a handheld device by a hand is detected, it acts as a compensation signal, as described referring to Fig. 1.

The electric alternating signal generated by the signal generator G1 is in the first mode of operation preferably phase-shifted with respect to the electric alternating signal generated by the second signal generator G2, which is supplied to the transmitting electrode TxM. Particularly preferably the electric alternating signal generated by the signal generator G1 presents a phase shift of around 180° with respect to the electric alternating signal from the second signal generator G2. Moreover it is advantageous if the electric alternating signal provided by the signal generator G1 is slightly dampened, so that the alternating electric field emitted by the transmitting electrode TxM is not completely deleted by the alternating electric field emitted by the compensation electrode TxC.

The field transmission electrodes Tx1, Tx2 in the embodiment shown in Fig. 6 are galvanically coupled with the compensation electrode TxC. In this way the production expenditure for producing the sensor device according to the invention is kept low, because for the operation of the compensation electrode TxC no own signal generator needs to be provided.

After the detection of the gripping of the hand-held device by a hand, the sensor device is operated in a second mode of operation, in which an approach to the electrode pairs Rx1, Tx1 or Rx2, Tx2 by a finger is detected. If for example a finger approaches the electrode pair Tx1, Rx1, the alternating electric field emitted at the field transmitting electrode Tx1 is coupled over the finger into the field sensing electrode Rx1. The alternating electric field coupled into the field sensing electrode Rx1 entails a level change of the electric current flowing in the field sensing electrode Rx1. The electric current flowing in the field sensing electrode Rx1 or the level change of the electric current flowing in the field sensing electrode Rx1 is indicative for an approaching finger to the electrode pair Rx1, Tx1.

If the sensor device is in the second mode of operation, the second signal generator G2 is preferably deactivated, so that no coupling of an alternating electric field emitted by the transmitting electrode TxM over the hand into the field sensing electrodes Rx1 or Rx2 is possible. In this way the influence of a hand gripping the electric hand-held device on the detection of an approach of a finger to the electrode pairs Rx1, Tx1 or Rx2, Tx2 is almost completely eliminated.

As an alternative to deactivating the second signal generator G2 in the second mode of operation, also the phase of the signal provided by the first signal generator G1 or by the second signal generator G2 can be modified, so that the signals of the signals provided by the signal generators G1 and G2 are substantially in phase. This alternative is advantageous above all if the electrodes Tx1, Tx2 and TxM in substance have the same electrode surface or when the electrode surface of the electrodes Tx1 and Tx2 is greater than the electrode surface of the electrode TxM.

Fig. 7 shows a block diagram of a second embodiment of the sensor device according to the invention. In this embodiment for each transmitting electrode TxM, Tx1, Tx2 and TxC an own signal generator G1, G2, G3 or G4 is provided. The receiving electrodes or field sensing electrodes RxM or Rx1 and Rx2 are here

parallelly operated. The signal generators G1, G2, G3 or G4 are activated sequentially, so that at every moment in time exactly one signal generator is active. The signal generators G1, G2, G3 or G4 can also be parallelly operated, preferably every signal generator providing an electric alternating signal with a different frequency, i. e. the signal generators are operated in the frequency multiplex method. The evaluating device or the microcontroller μC can split the RxM signal tapped at the receiving electrodes or field sensing electrodes Rx1 and Rx2 into its frequency components.

Alternatively also only one signal generator can be provided, which is coupled with the transmission electrodes TxM, Tx1, Tx2 or TxC by means of a multiplexer. In the first mode of operation of the sensor device however the signal generators G2 and G4 are parallelly operated, in order to detect a gripping of an electric hand-held device by a hand. In the first mode of operation the electric alternating signal generated by the signal generator G4 is equally preferably phase-shifted with respect to the electric alternating signal generated by the signal generator G2.

In the second mode of operation of the sensor device preferably only the signal generators G1 and G3 are operated. The signal generators G2 and G4 are inactive in the second mode of operation.

Fig. 8 shows a block diagram of the sensor device according to the invention, in which the second electrode structure comprises several areas, with which a so-called slide control can be realized. Each area has an electrode pair consisting of a field transmitting electrode and a field sensing electrode. The operation mode of the sensor device here corresponds substantially to the operation mode as described referring to Fig. 6. The single areas of the second electrode structure, i. e. the electrode pairs Tx1, Rx1 or Tx2, Rx2 are arranged here however side by side, so that the movement of a finger along the single areas can be detected. Because of the temporal sequence of the activation of the single areas by a finger moving over the areas, the direction of the finger movement can be detected. Of course

also more than the two areas shown in Fig. 8 can be provided.

Fig. 9 shows a block diagram of the sensor device according to the invention with several areas of the second electrode structure, in which, unlike the sensor device shown in Fig. 8, the field sensing electrodes Rx1 and Rx2 are parallelly operated, whereas the field transmission electrodes Tx1, Tx2 are supplied with an electric alternating signal by means of a multiplexer in sequential sequence.

Fig. 10 shows a block diagram of a sensor device according to the invention with a plurality of areas of the second electrode structure, in which with the plurality of areas a slide control or a multiple button system can be realized.

The field transmission electrodes Tx1, Tx2 to Txn are supplied each time with an electric alternating signal, which each time is provided by a signal generator G1, G2 to G. The field sensing electrodes Rx1, Rx2 to Rxn and RxM are parallelly operated, while in the second mode of operation each time only one signal generator G1, G2 to G3 is active. For the operation of the sensor device in the first mode of operation the signal generators G1, G2 to G are parallelly operated, so that the field transmission electrodes Tx1, Tx2 to Txn form a large transmitting electrode TxM which serves as transmitting electrode for the detection of the gripping of a hand-held device by a hand.

According to the embodiment shown in Fig. 10 of the sensor device according to the invention, the field transmission electrodes Tx1 to Txn are both used as transmission electrodes for the second mode of operation and as transmission electrodes for the first mode of operation. In this way the construction expenditure can be reduced considerably. Another reduction of construction expenditure can be reached by providing only one signal generator for the operation of the field transmission electrodes Tx1 to Txn, which in the time-division multiplex method is coupled with the field transmission electrodes Tx1 to Txn, in which for the operation of the field transmission electrodes Tx1 to Txn in the first mode of opera-

tion all the field transmission electrodes are coupled with the signal generator.

Fig. 11 shows a block diagram of the sensor device according to the invention, wherein the second electrode structure comprises a plurality of areas, with which a slide control and/or a multiple button system can be realized. The field transmission electrodes Tx1 to Txn are operated here parallelly, i.e. supplied with an electric alternating signal of a single signal generator G1, whereas the field sensing electrodes Rx1 to Rxn are coupled in the time-division multiplex method with the amplifier AMP or with the microcontroller μC.

For the operation of the sensor device in the first mode of operation the field sensing electrodes Rx1 to Rxn can be parallelly operated, so that the field sensing electrodes Rx1 to Rxn form a large reception electrode RxM for the detection of the gripping of a hand-held device by a hand. For the operation of the sensor device in the first mode of operation an additional compensation electrode TxC can be provided (in Fig. 11 not shown). Alternatively also the field transmission electrodes Tx1 to Txn can be operated in the first mode of operation as compensation electrode. In case of the operation of the field transmission electrodes Tx1 to Txn as compensation electrode in the first mode of operation, the electric alternating signal generated by the signal generator G1 has a phase that is different from that of the electric alternating signal generated by the signal generator G2.

According to the embodiment shown in Fig. 11 of the sensor device according to the invention, the field transmission electrodes Tx1 to Txn and the field sensing electrodes Rx1 to Rxn are both used in the first mode of operation for detecting a grip and in the second mode of operation for detecting the approach of a finger to an electrode pair. In such a way the construction expenditure for the production of corresponding electrode surfaces on an electric hand-held device can be maintained low.

Fig. 12 shows a principle representation of the sensor device according to the in-

vention for realization of a slide control or a rotary regulator, in which the sensor resolution can be increased in case of a fixed number of transmission channels.

The slide control or rotary regulator presents each four different transmission electrodes Tx1 to Tx4 and a common reception electrode Rx. Because of the spatial arrangement of the transmission electrodes Tx1 to Tx4 in relation to each other, as shown in Fig. 12, the direction of a finger moving in relation to the transmission electrodes can be detected. A localization is however not possible, since a transmitting electrode is at the same time active at several places. For example in the rotary regulator shown in Fig. 12 the transmitting electrode Tx1 is active both on top and at the bottom and on the left and on the right at the same time. A distinction as to which of the four transmission electrodes Tx1 a finger is approaching, cannot be made here.

A localization can be however reached for example by providing for the slide control eight different transmission electrodes and for the rotary regulator 16 different transmission electrodes. Alternatively the electrodes can also be operated in a time-division multiplex method. For example the electrodes shown in the slide control Tx1 in a time-division multiplex method can be supplied with the electric alternating signal of the signal generator G1, so that each time only one of the two transmission electrodes Tx1 is active at a moment.

CLAIMS

1. Sensor device, comprising
   - at least one first electrode structure (TxM, TxC, RxM), which comprises at least one transmitting electrode (TxM), at least one compensation electrode (TxC) and at least one reception electrode (RxM),
   - at least one second electrode structure (Tx1, Rx1), which comprises at least one field transmission electrode (Tx1) and at least one field sensing electrode (Rx1), and
   - at least one signal transmitter (G) for supplying the at least one transmitting electrode (TxM), the at least one compensation electrode (TxC) and the at least one field transmission electrode (Tx1) with an electric alternating signal,

   in which
   - the at least one transmitting electrode (TxM), the at least one compensation electrode (TxC) and the at least one reception electrode (RxM) are arranged in such a way in relation to each other, that a first alternating electrical field (WS) emitted at the at least one transmitting electrode (TxM) and a second alternating electrical field (WK) emitted at the at least one compensation electrode (TxC) are coupleable into the at least one reception electrode (RxM), and
   - the at least one field transmission electrode (Tx1) and the at least one field sensing electrode (Rx1) are arranged in such a way in relation to each other that a third alternating electrical field (WF) emitted at the at least one field transmission electrode (Tx1) is coupleable into the at least one field sensing electrode (Rx1).

2. Sensor device according to claim 1, wherein the at least one compensation electrode (TxC) and the at least one field transmission electrode (Tx1) are galvanically coupled.

3. Sensor device according to one of the preceding claims, wherein the sensor device can be operated in a first mode of operation and in a second mode of operation, wherein in the first mode of operation the at least one transmitting electrode (TxM), the at least one compensation electrode (TxC) and the at least one field transmission electrode (Tx1) can be supplied with the electric alternating signal and in the second mode of operation only the at least one field transmission electrode (Tx1) can be supplied with the electric alternating signal.

4. Sensor device according to claim 3, wherein in the first mode of operation the at least one transmitting electrode (TxM) can be supplied with a first electric alternating signal and the at least one compensation electrode (TxC) can be supplied with a second electric alternating signal, whereby the first electric alternating signal is phase-shifted with respect to the second electric alternating signal.

5. Sensor device according to one of the preceding claims, wherein the at least one transmitting electrode (TxM), the at least one compensation electrode (TxC) and the at least a field transmission electrode (Tx1) are supplied with the electric alternating signal in a multiplex operation.

6. Sensor device according to one of the preceding claims, further comprising an evaluating device, which can be coupled with the first electrode structure and the second electrode structure, and wherein the evaluating device is adapted to evaluate a first electrical signal tapped at the at least one reception electrode (RxM) and a second electrical signal tapped at the at least one field sensing electrode (Rx1), preferably by means of a microcontroller.

7. Sensor device according to claim 6, wherein the evaluating device includes an amplifying circuit (AMP), to which the first electric signal and the second electric signal can be fed, wherein the amplification of the amplifying circuit (AMP) is preferably adjustable.

8. Sensor device according to claim 7, wherein the first electric signal and the second electric signal can be fed in a time division multiplex method to the amplifying circuit (AMP), and wherein the amplification of the amplifying circuit (AMP) is adjustable depending on the fed signal.

9. Method for the approach and contact detection, comprising the following steps:
   - supplying at least one transmitting electrode (TxM), at least one compensation electrode (TxC) and at least one field transmission electrode (Tx1) with an electric alternating signal, so that a first alternating electrical field (WS) emitted at the at least one transmitting electrode (TxM) and a second alternating electrical field (WK) emitted at the at least one compensation electrode (TxC) can be coupled into the at least one reception electrode (RxM) and a third alternating electrical field (WF) emitted at the at least one field transmission electrode (Tx1) can be coupled into the at least one field sensing electrode (Rx1), and
   - evaluation of a first electrical signal tapped at the least one reception electrode (RxM) and of a second electrical signal tapped at the least one field sensing electrode (Rx1).

10. Method according to claim 9, wherein in a first mode of operation the at least one transmitting electrode (TxM), the at least one compensation electrode (TxC) and the at least one field transmission electrode (Tx1) are supplied with the electric alternating signal and in the second mode of operation only the at least one field transmission electrode (Tx1) is supplied with the electric

alternating signal.

11. Method according to claim 9 or 10, wherein the electrodes (TxM, TxC, Tx1) are supplied with the electric alternating signal according to a multiplex method and the first electric signal and the second electric signal are tapped in a multiplex method.

12. Method according to one of claims 9 to 11, wherein the at least one transmitting electrode (TxM) is supplied with a first electric alternating signal and the at least one compensation electrode (TxC) is supplied with a second electric alternating signal, whereby the first electric alternating signal is phase-shifted with respect to the second electric alternating signal.

13. Hand-held device having a sensor device according to one of the claims 1 to 8.

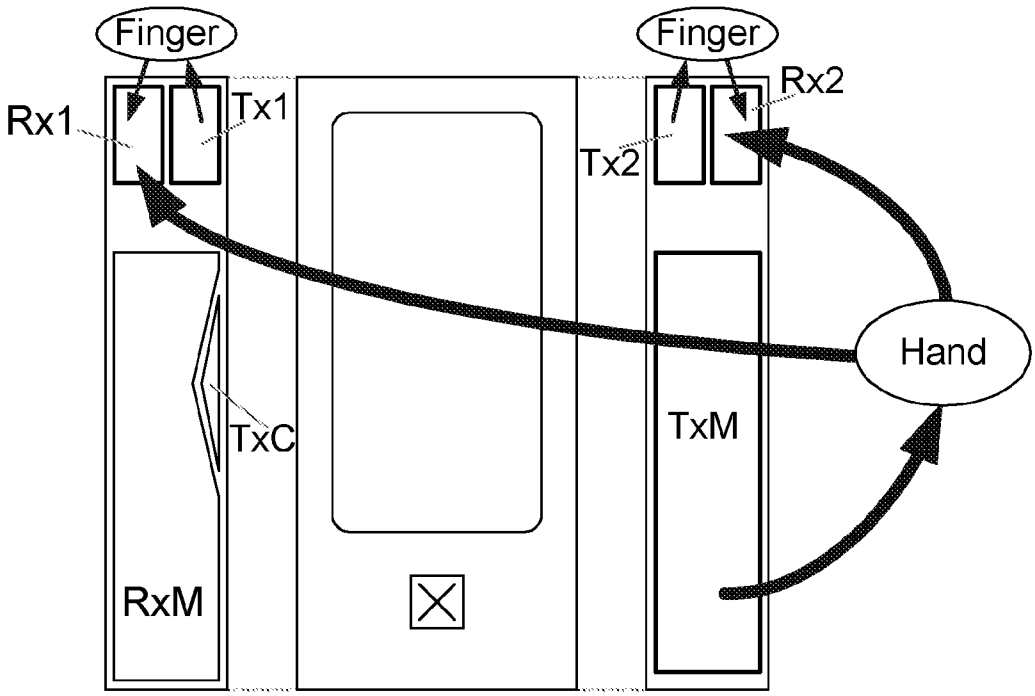
Finger
Finger
Rx1
Tx1
Tx2
Rx2
Hand
TxC
TxM
RxM

Fig. 1

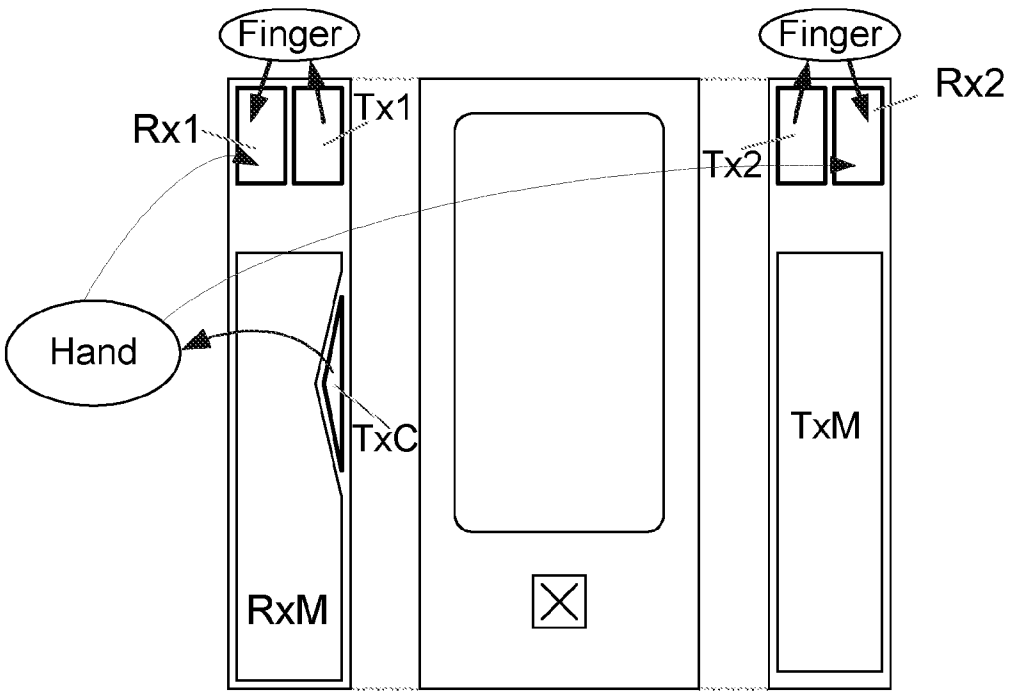
Finger
Finger
Rx1
Tx1
Tx2
Rx2
Hand
TxC
TxM
RxM

Fig. 2

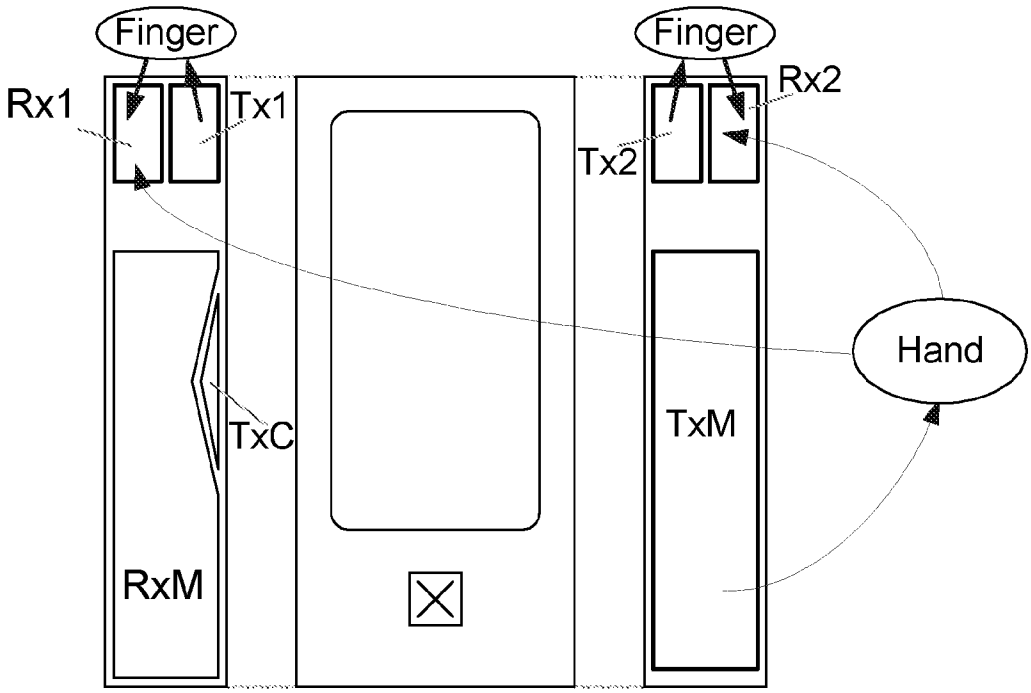
Finger
Finger
Rx1
Tx1
Rx2
Tx2
Hand
TxC
TxM
RxM

Fig. 3

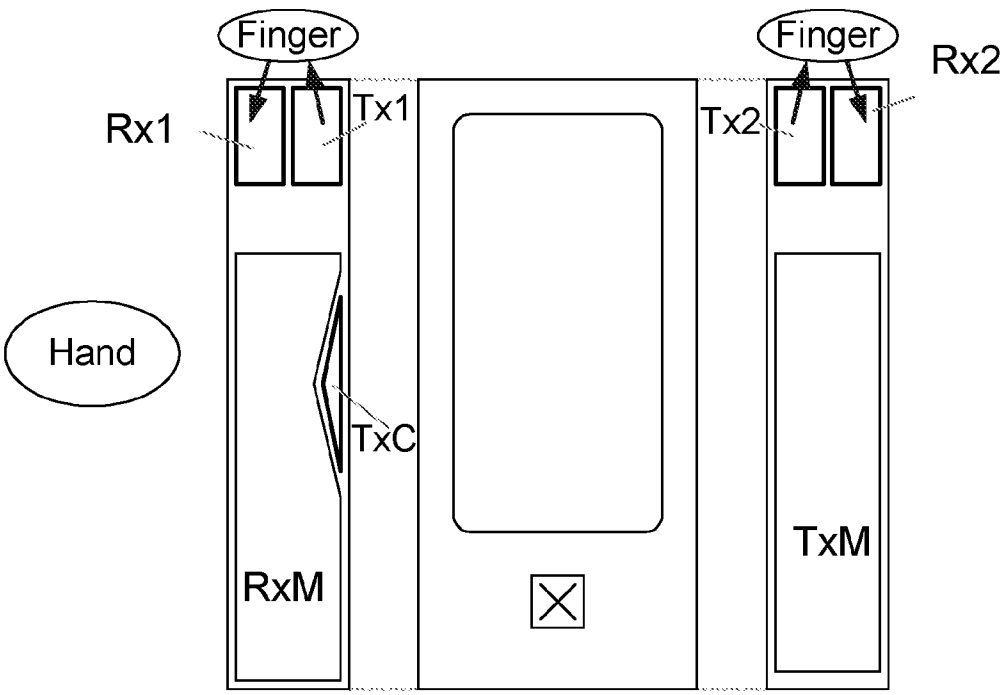
Finger
Finger
Rx2
Rx1
Tx1
Tx2
Hand
TxC
TxM
RxM

Fig. 4

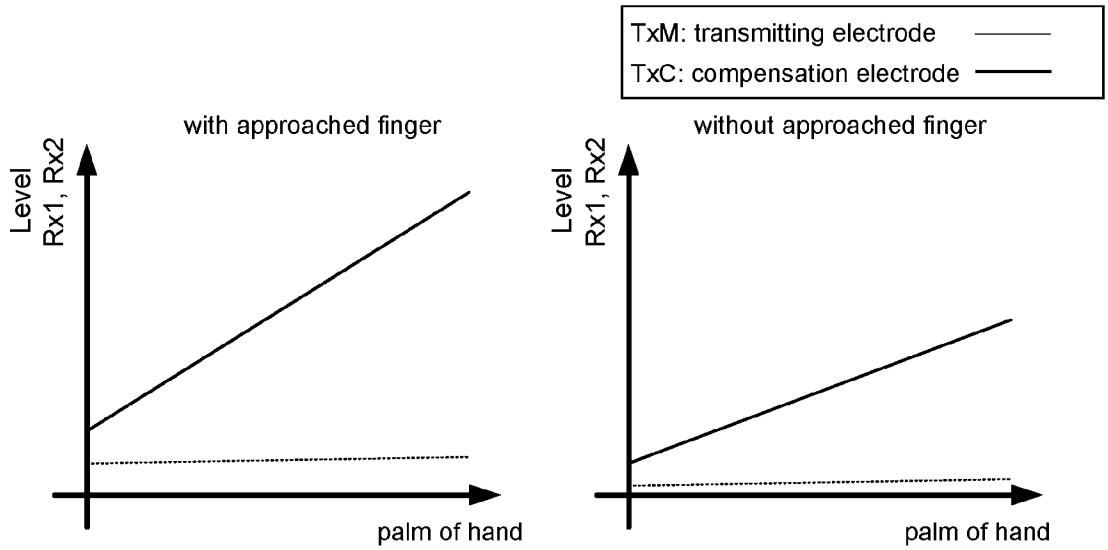
TxM: transmitting electrode
TxC: compensation electrode
with approached finger
without approached finger
Level
Rx1, Rx2
palm of hand
Level
Rx1, Rx2
palm of hand

Fig. 5

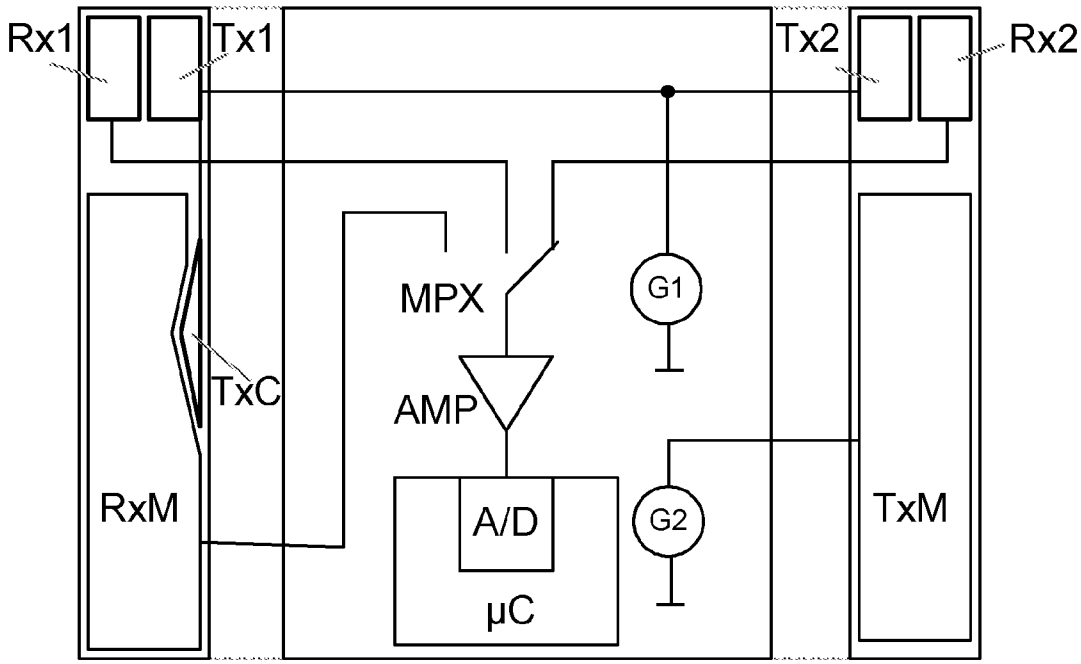
Rx1
Tx1
Tx2
Rx2
MPX
G1
AMP
TxC
RxM
A/D
G2
TxM
µC

Fig. 6

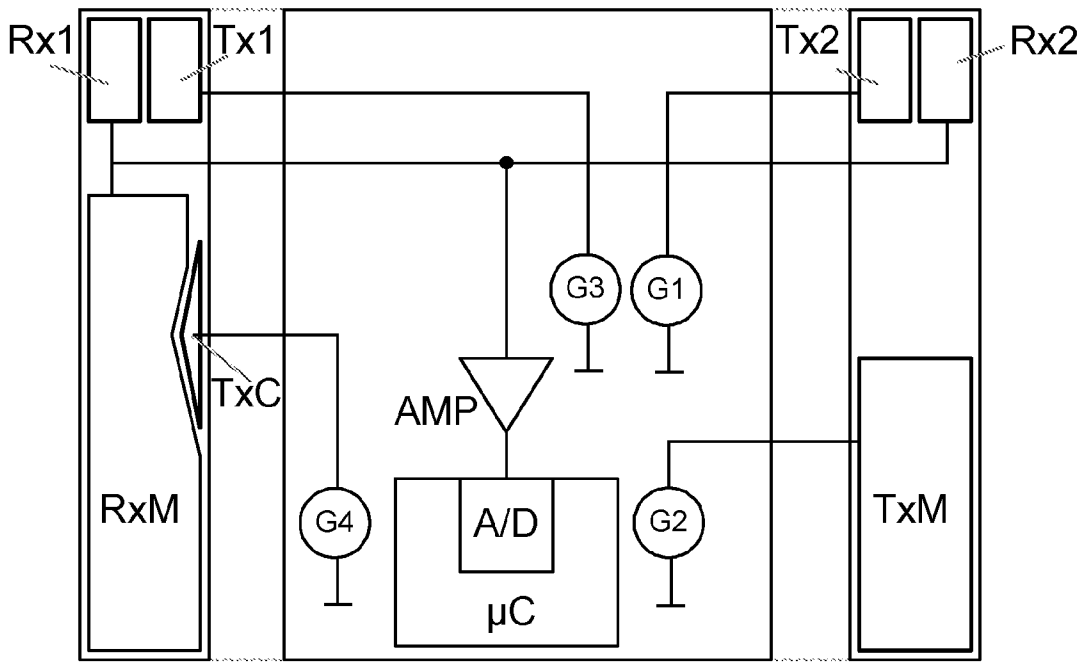
Rx1
Tx1
Tx2
Rx2
G3
G1
TxC
AMP
RxM
G4
A/D
G2
TxM
µC

Fig. 7

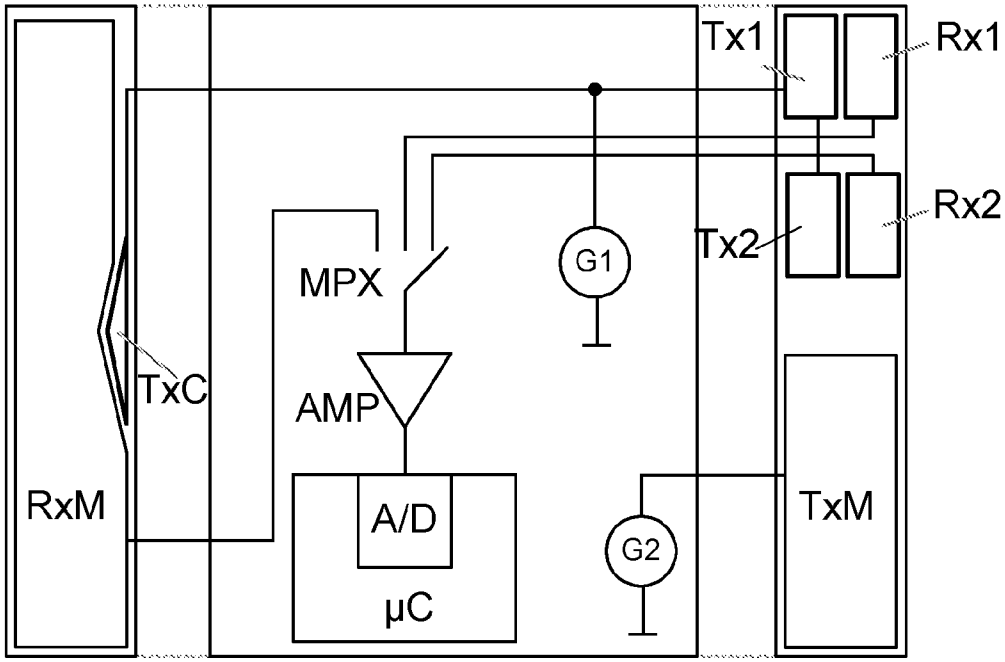
Tx1
Rx1
Rx2
Tx2
G1
MPX
TxC
AMP
RxM
A/D
µC
G2
TxM

Fig. 8

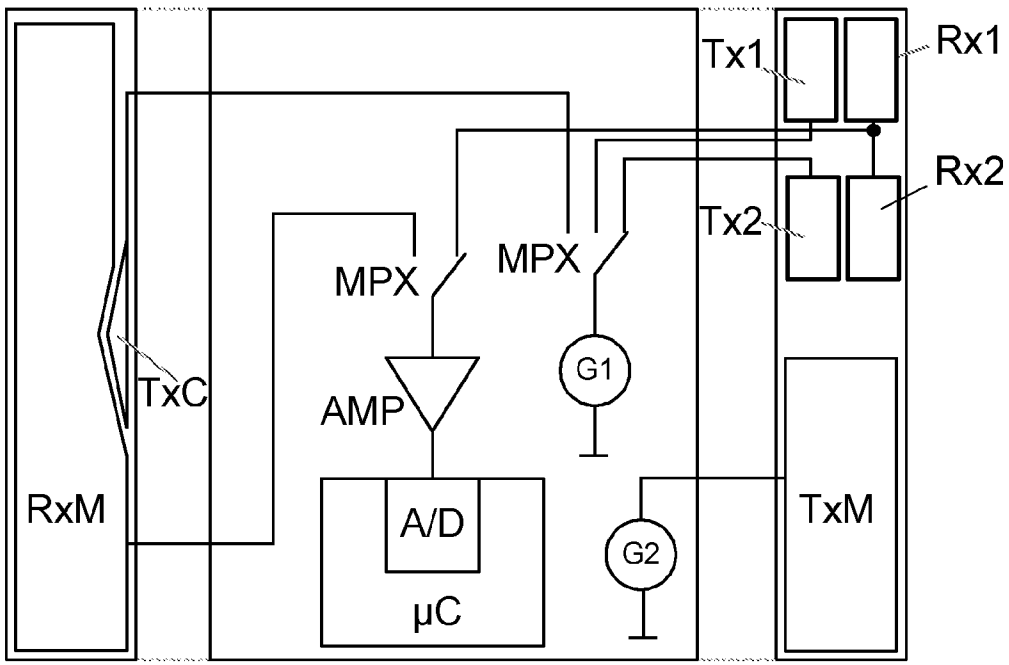
Tx1
Rx1
Rx2
Tx2
MPX
MPX
G1
TxC
AMP
RxM
A/D
µC
G2
TxM

Fig. 9

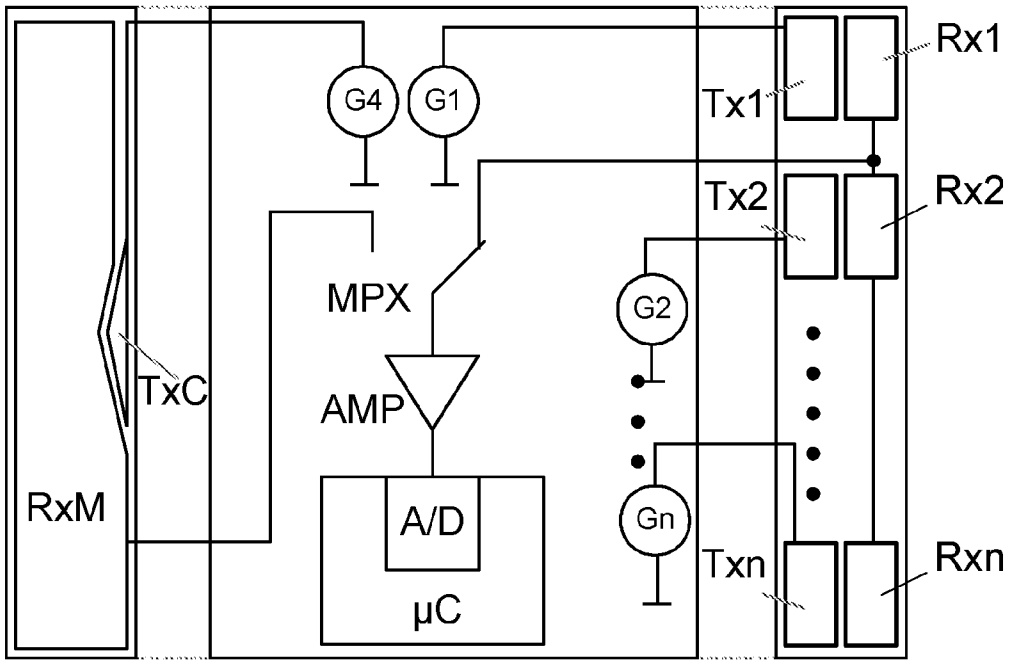
Rx1
G4
G1
Tx1
Tx2
Rx2
MPX
G2
TxC
AMP
RxM
A/D
Gn
Txn
Rxn
µC

Fig. 10

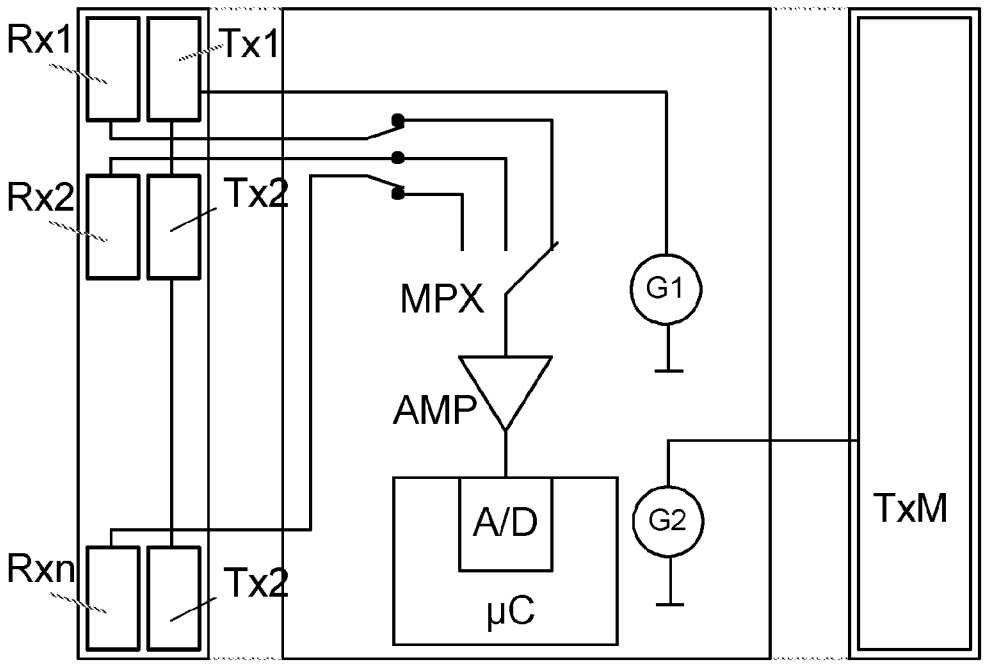
Rx1
Tx1
Rx2
Tx2
MPX
G1
AMP
A/D
G2
TxM
Rxn
Tx2
µC

Fig. 11

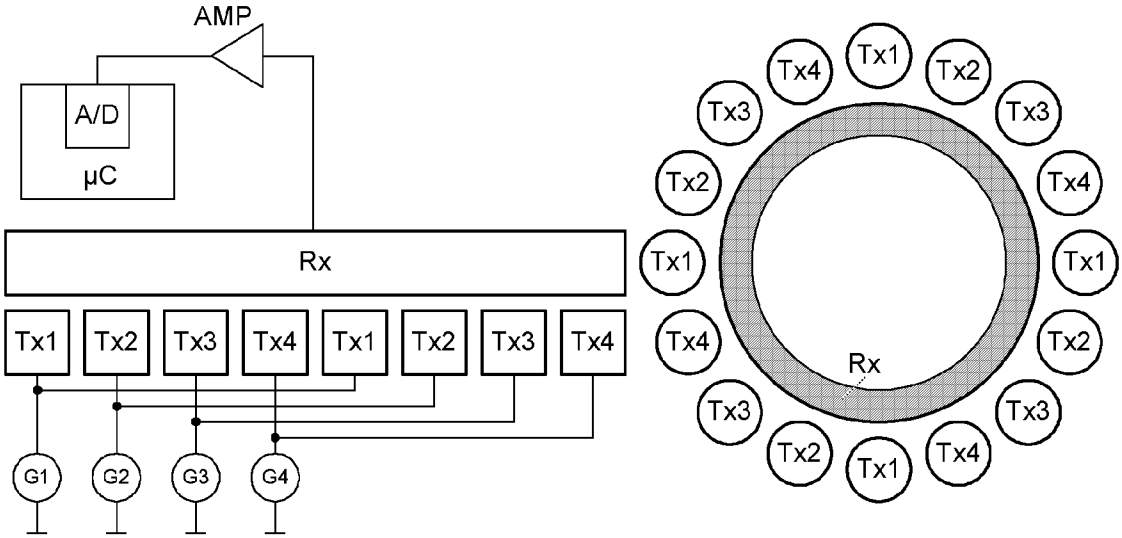
AMP
A/D
µC
Rx
Tx1
Tx2
Tx3
Tx4
Tx1
Tx2
Tx3
Tx4
G1
G2
G3
G4
Tx1
Tx2
Tx3
Tx4
Tx3
Tx2
Tx4
Tx1
Tx1
Tx4
Tx2
Rx
Tx3
Tx3
Tx2
Tx1
Tx4

Fig. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/065064

A. CLASSIFICATION OF SUBJECT MATTER
INV. H03K17/955 H03K17/96
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)
H03K

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/025003 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]; SOMERS PETRUS L M [NL]) 9 March 2006 (2006-03-09) page 4, line 16 - line 34; figures 3,5	1-13
A	US 6 859 141 B1 (VAN SCHYNDEL ANDRE J [CA] ET AL) 22 February 2005 (2005-02-22) figures 1-3B	1-13
A	US 6 051 981 A (GERSHENFELD NEIL [US] ET AL) 18 April 2000 (2000-04-18) figures 1A, 6A	1,9
A	EP 1 093 225 A2 (IFM ELECTRONIC GMBH [DE]) 18 April 2001 (2001-04-18) figure 2	1,9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"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
5 January 2012	13/01/2012

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	Mesplede, Delphine

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/065064

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		EP 1093225 A2	18-04-2001
		US 6664661 B1	16-12-2003