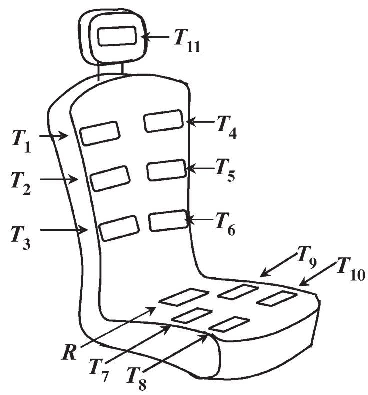

Fig. 1. Automobile seat equipped with the proposed structure of capacitive sensing electrodes. Electrode R in the sitting area is the common receiver, while electrodes $T_1, T_2, \ldots, T_{11}$ are transmitters.

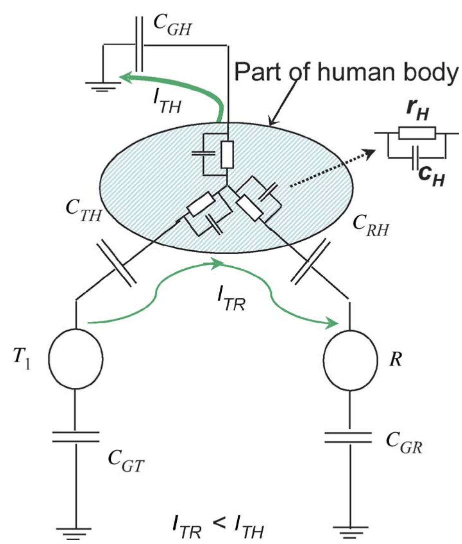

Fig. 2. Equivalent circuit showing the shielding effect by a human body. In shielding mode, current $I_{\rm TH}$ increases as the human body enters the vicinity of the sensor. Hence, the signal received by R is reduced.

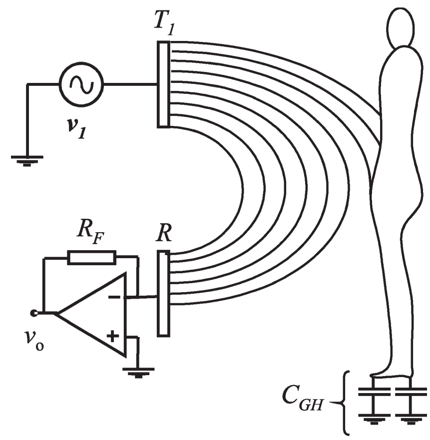

Fig. 3. Pictorial representation of the shielding of electric field lines due to the presence of a human in the far sensor vicinity. For clarity, the electric field lines from transmitter to ground are not shown. Similarly, the distributed capacitances between the human body and ground are represented by a lumped capacitance $C_{\rm GH}$.

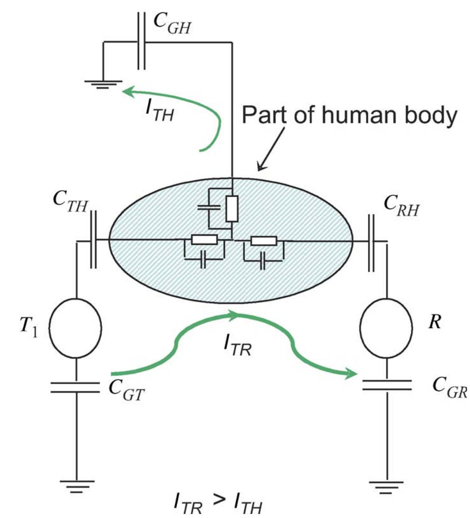

Fig. 4. Capacitances $C_{\rm TH}$ and $C_{\rm RH}$ are larger than $C_{\rm GH}$ when the human body is very close to the sensor vicinity. Under this condition, the coupling effect is more dominant than the shielding effect.

electrode R is placed in the sitting area of the seat, as shown in Fig. 1. A conducting sheet is placed below the receiver and kept at circuit ground potential. An insulating layer is provided between the conductive sheet and the receiver electrode R. The conducting sheet shields the electric field lines that will otherwise reach R mainly through the seat material and structure, thus resulting in a large offset capacitance. An electrical equivalent circuit of the sensor system with a human body in the vicinity of the sensor electrodes is shown in Fig. 2. For simplicity, only one transmitter T_1 and the receiver R are used to explain the principle of operation. There are capacitances $C_{\rm TH}$ between the transmitter T_1 and the human body, $C_{\rm RH}$ between the receiver and the human body, and $C_{\rm GH}$ between the human body and ground. There are also capacitances $C_{\rm GT}$ and $C_{\rm GR}$ from the transmitter and receiver to ground, respectively. The part of the human body that is in the sensor vicinity is represented in the equivalent circuit with a parallel combination of a resistance r_H and a capacitance c_H [11], as shown in Fig. 2.

Let us consider that the transmitter is kept at an electric potential and the receiver is at circuit ground potential. Then, there will be electric field lines emanating from the transmitter to the receiver. Consider, as shown in Fig. 3, that only a small portion of the sensing volume is now occupied by the human body. In such a case, the human body shields some of the electric field lines as shown in Fig. 3. Consequently, the signal received by R and, hence, the output signal v_0 will be reduced compared to a vacant condition. In this mode, the capacitances $C_{\rm TH}$ and $C_{\rm RH}$ will be low in value as compared with $C_{\rm GH}$. Thus, as in Fig. 2, a significant part of the transmitted current $I_{\rm TH}$ will flow to the ground through the human body. Consequently, the displacement current $I_{\rm TR}$ that flows between the transmitter and receiver will be reduced. The receiver signal will gradually be reduced as the human body enters more into sensor vicinity. This continues as long as $C_{\rm TH}$ and $C_{\rm RH}$ are lower in value than $C_{\rm GH}$. This is called the shielding mode of operation. On the other hand, when the human body comes very close or is between the transmitter and receiver (refer to Fig. 4), $C_{\rm TH}$ and $C_{\rm RH}$ become much larger than $C_{\rm GH}$, and hence, $I_{\rm TH}$ will be much lower compared with $I_{\rm TR}$. Thus, the $I_{\rm TR}$ from