Transmission of Information Using the Human Body

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ABSTRACT

The paper is focused on the transmission of information concerned using conductive properties of the human body as a transmission channel. A physically separated transmitter and receiver can be placed on various parts of the human body. Individual system parts perform data communication with one another. In British and American literature, this principle is referred to as **P**ersonal **A**rea **N**etwork (**PAN)**. The paper outlines some practical PAN applications and its current status in global usage. The conclusion of the paper describes the design of an information system that the authors have practically implemented and tested. The principle used of data transmission through the human body can be implemented in several specific applications.

Keywords: Personal Area Network, Wearable Interfaces, Skin Communication.

1. PERSONAL AREA NETWORK – PAN

Use of the properties of the human body for signal or data transmission was proposed in 1995. The PAN concept is based on the fact that the contemporary electronic equipment used by users consists, in principle, of a microcontroller, a display, a keyboard, a microphone input and headset output, a battery and many other common hardware circuits. These circuits are rather redundant and jointly consume considerable amounts of battery power. Nowadays, separately carried equipment usually communicates over a metallic line, infrared, WiFi, ZigBee or Bluetooth ports. The data or signals are transmitted at a distance of several tens of centimetres or units of metres. Therefore, an experiment was conducted to provide one person with all electronic equipment as part of a PAN and to have simultaneously one system consisting of, for example, one common keyboard, one microcontroller, one headset, one display, etc. The electric properties of the human body can be used for data transmission among such devices, so that the body itself functions as a transmission channel.

At present, there are three basic types of configurations for communication using the human body that are shown in Fig. 1.

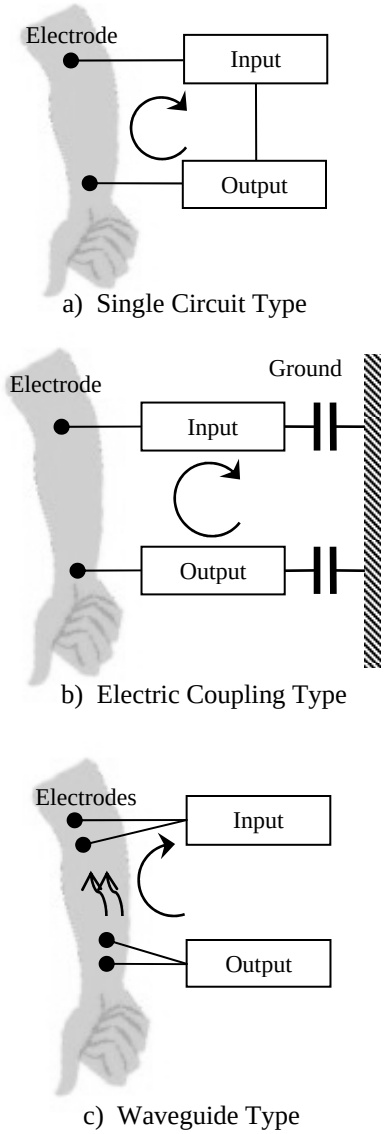


Fig.1: Principle of communication using the human body

In fact, the transmitting/receiving electrodes or pairs of transmitter/receiver electrodes need not be conductively-connected to the surface of the body: the capacitance coupling is often sufficient.
The principle of communication using a *single circuit* is not used in practice, because the input and the output are electrically connected by means of one branch. *Electrostatic coupling* ensures that the signal or data are transmitted between the transmitter and the receiver - assuming that a suitable capacitance coupling is available to provide earthing between the input and output circuits.
If such capacitance coupling is not available, a *waveguide-type* PAN can be substituted, where each transmitter and receiver are equipped with a pair of electrodes, and one of the electrodes functions as a common earthing. [2-12]
However, for any further development of PAN, the existing patent protection will have to be taken into account, including the use of conductivity characteristics of human body for both the transmission of data and supply voltage.

2. INFORMATION SYSTEM USING THE PAN PRINCIPLE

Many conference papers describe experiments made regarding PAN, the vast majority of which have focused on the principle of electrostatic coupling. The main protagonists in this field include various electronics companies that have participated in the development of PAN type equipment designed to transmit an audio signal from a music platform to wireless headsets.
However, research has been suspended, primarily because of signal losses or interference in the transmission path encountered in situations where people held hands or came into bodily contact during equipment use, or where the concentration of people was high, e.g. on public transporting means of mass transportation, etc. However, there are applications where the above negative property of the equipment does not matter and is indeed often beneficial. This, for example, relates to persons with vision impairment. In this case, it is required to easily obtain information content or information content in another language for foreign visitors.
The use of the PAN principle for a person with vision impairment has led to the design of equipment that can be relatively easily implemented in various information boards or other information systems permanently installed in state administration buildings, galleries, zoological or botanical gardens, etc.
For a block diagram of the information system refer to Fig. 3. The information system is divided into two basic, independently operating parts, i.e. into the transmitter and receiver of the information system.

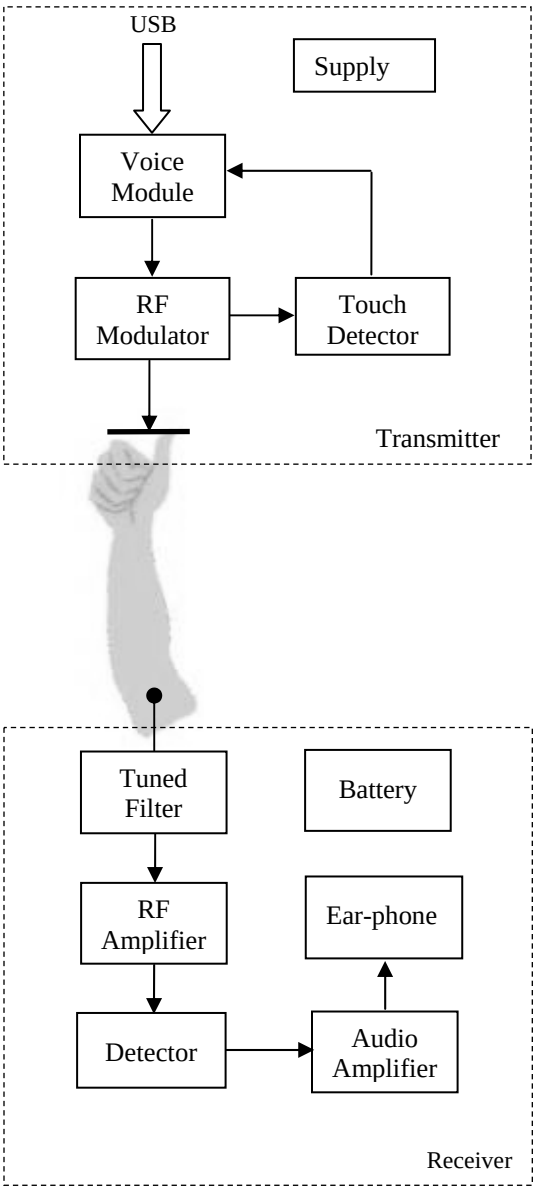


Fig.2: Block diagram of information system

The information content of data is saved via a USB interface in an acoustic module in WAV format. Sampling frequency is 16 kHz, and the data feature a 16-bit resolution.
The acoustic module converts the saved data to an audio signal using a D/A converter and a class D amplifier. In the HF modulator input are a low-pass filter to limit the frequency band of the audio signal above 7 kHz, and a modulator to create a modulated carrier frequency of 204.8 kHz through the audio signal.
The carrier frequency value of 204.8 kHz has mainly been selected for the following three reasons:

- signal attenuation between the touch area of the transmitter and receiver due to conductivity characteristics of human body is less than 50dB,
- in the given frequency band, a relatively small quantity of computer switch-mode power sources and other sources are in operation which might cause a severe interference,
- the touch area size is many times smaller than the wavelength of carrier frequency, and thus any unnecessary radiation of the HF signal to the environment does not occur.

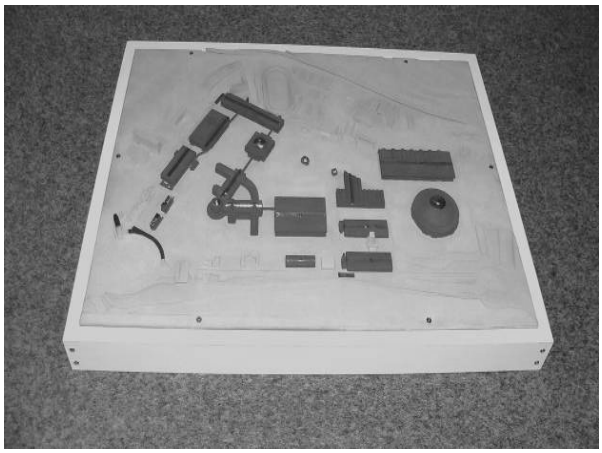
A touch on the area will result in a slight decrease in the output signal magnitude. The touch detector evaluates this change and generates a starting signal to the acoustic module. This ensures that the information content from the acoustic module will be generated from its beginning, i.e. from the moment the area is touched. The entire information system transmitter is supplied by a galvanically separated 12 V power source.

The receiver of the information system consists of a headset sleeve with a contact area located on its holding clip. This contact area touches the auricle skin. The signal is led via the band-pass filter and impedance matching to the HF amplifier, which also includes circuits for automatic sensitivity equalization (ASE). In addition, there is a detector and LF amplifier to amplify the demodulated signal to a sufficient level. The entire receiver of the information system is supplied by two NiMh batteries equipped with circuits for charging.

Fig. 3 shows a photograph of the practical application of the information system. The information system receiver is depicted as a 3D relief model. The surface of significant objects is coated with electrically conductive paint; inside the model, each such object is connected to a separate acoustic module containing the saved information to be reproduced to the user. Each message can even be several tens of minutes in length.

A person with vision impairment analyzes the 3D scene by touch and obtains a comprehensive representation of the layout of objects. Their subsequent orientation in the environment will thus be easier and more comfortable. The recording of data onto acoustic modules in another language is very easy, and the model can be used by foreign visitors to assist their orientation in the given environment. Fig. 3 shows a photograph of the receiver with standard earphone and an auricle clip. All receiver electronics are placed in a separate box with clip to be attached to the clothing.

To enable orientation in an unknown environment, it is not necessary to create a 3D relief model. The information system receiver can, for example, be installed in a door. The contact area is then located on the door handle. Having touched the door handle, the person equipped with the information system receiver receives information as to what authority, member of staff or departmental office is situated behind the given door. It is easy to install such information system on e.g. handrails, at stopping points on public transport systems, entrance doors of buildings or on exhibits. [7]



a) The relief model of an exhibition trade centre

b) The receiver module

c) The practical application [13]

Fig.3: Photograph of the information system

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3. CONCLUSION

The paper has shown that the PAN principle can further be developed and that there are several possibilities for its practical application. In the period to come, it is necessary to focus on the complete digitalization of the entire system, and thus to ensure, in particular, the easy selection of the language for the information content.
Future results achieved in this area will be disclosed on a regular basis. The information system shown in Fig. 3 is protected by the Industrial Property Office.
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