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Research Article

Implementation of Free-Air Hand Motion Signatures Based control for Home Entertainment

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Abstract

Gesture based (Non-contact) operation of electrical appliances is becoming increasingly desired technology. Various kinds of domestic appliances are used in households, industries and offices. These devices are mostly controlled by human hand with manual switches. This work is focusing on study of electric field (E-field) for advanced proximity sensing which are distorted through hand movements in detecting movements. While compared to the other systems this technology can be employed unobtrusively, work through various materials and do not have a high computational burden also. It allows realization of new user interface applications by detection, tracking and classification of the user's hand or finger motion in free space.

Keywords: *ARM, Gesture Pad, RF module*

1. Introduction

Biometric systems allow the identification and verification of an individual on the basis of physical or behavioral traits. Although systems based on physical information are considered reliable, emerging systems that utilize dynamic characteristics, e.g., motion, offer increased security, intuitiveness, and usability. Researchers have developed such systems based on gait full body motion, mouse movements and typing rhythm , and hand-gestures. The inspiration for using hand signature-gestures for identification comes from the large bulk of work on handwriting and signature-based identification systems . Signature-gestures are considered more secure than written-signatures (that are considered easy to forge). It has been found that even when a forger watches the execution of a signature-gesture, she/he will have difficulty in imitating it .Gesture-based identification systems can be divided into touch and non-touch-based systems. Touch-based systems (see or Android's nine point pattern identification) require direct contact between the user and the capture device, dictating a specific motion plane. In such systems, determining signature start and end (gesture spotting) is straightforward, and feedback to the user regarding the shape of the executed signature-gesture is readily available. Non-touch-based systems facilitate systems require gesture spotting, which is difficult, and even when feedback is available it is remote and inherently planar. Due to the reduced quality of the feedback, within-subject variability in non-touch-based systems is expected to be higher than in touch-based systems or written signatures. Finally, while it is possible to use the, typically well-practiced, written signature as the motion signature-gesture, this possibility may be cumbersome, since written signatures generally translate into long motion trajectories with small strokes, which are susceptible to recognition errors.

Non-touch-based systems can be further divided into encumbered (requiring wearing/holding assistive devices) and non encumbered systems. In encumbered systems extracting a gesture trajectory is straightforward, and the difficulty of gesture spotting is greatly alleviated, especially in comparison to non encumbered systems. Several researchers, have developed encumbered user verification (identity authentication) and user identification systems for hand-held accelerometers. Gesture based (Non-contact) operation of electrical appliances is becoming increasingly desired technology.

Portable Sensor based touch less solutions become more popular after the recent success of touch screen technology. Presently Gestures are not often used to control domestic appliances in a modern infrastructure. This project discuss on the current use of gestures in domestic appliances and possible usage for various other domains. In recent years, several remote hand-gesture control systems for home-media systems have become commercially available. Such systems aim to augment the living-room media experience and enhance user enjoyment. In this regard,

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scenarios that call for user identification include interface customization (i.e., facilitating a personalized gesture vocabulary), content adaptation, and parental control. Traditionally, TV-remote content adaptation and parental control are facilitated by the use of numerical passwords. Various kinds of domestic appliances are used in households, industries and offices.

These devices are mostly controlled by human hand with manual switches. The overview of products is given with varying input methods. A perfect example is the television control by hand gesture. This idea made it possible to switch channel, change the volume with the use of hand gestures. Present technologies available to recognize gestures in free air which uses Common methods include cameras, depth sensors or capacitive systems. This work is focusing on study of electric field (E-field) for advanced proximity sensing which are distorted through hand movements in detecting movements. While compared to the other systems this technology can be employed unobtrusively, work through various materials and do not have a high computational burden also. It allows realization of new user interface applications by detection, tracking and classification of the user's hand or finger motion in free space.

Block Diagram

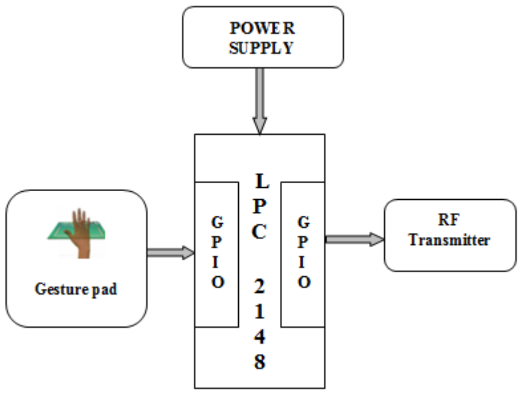

Fig.1: Block diagram

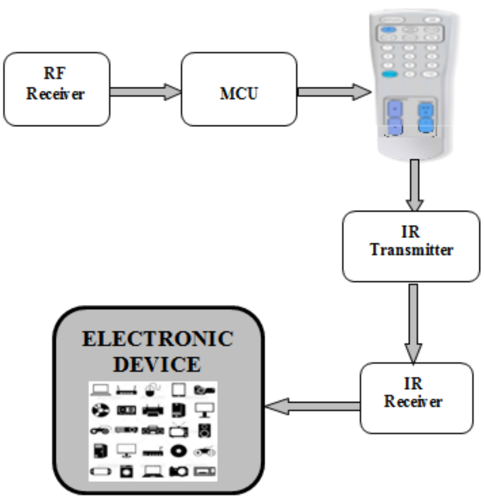

Fig.2: Device section

2. Design and Implementation

The objective of the project is to control a device based on free air hand gesture motion technology. This process is going to be done with a hand gesture pad interfaced with a microcontroller. Hand gesture pad will works based on electric field variation.

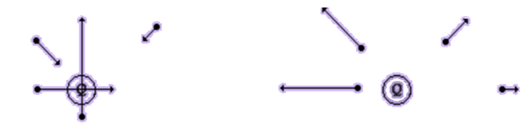

Fig.3: E-Field Vectors for locations around a negative (on left) and a positive (on right) source charge

The magnitude or strength of an electric field in the space surrounding a source charge is related directly to the quantity of charge on the source charge and inversely to the distance from the source charge. The direction of the electric field is always directed in the direction that a positive test charge would be pushed or pulled if placed in the space surrounding the source charge. Since electric field is a vector quantity, it can be represented by a vector arrow. For any given location, the arrows point in the direction of the electric field and their length is proportional to the strength of the electric field at that location. Such vector arrows are shown in the diagram below. From the theory, it is confirmed that an e field generate based on a source charge. These positive charges will be received by a negative source. So, In the gesture pad , the electrodes will acts as positive charge receivers. These positive charges will be converted into the digital value by the signal processing IC, present inside the Gesture Pad kit and continuously will be checked by the threshold values. If any value crosses the threshold value set inside the Gesture Pad, it will generate the digital outputs. For the device control application we are going to work with four digital outputs. The output of the hand gesture is connected to general purpose input and output pins. In port 1, we have to configure four pins as input pins and we have to read the status of those pins through IOPIN register. These gesture output pins are active high. So, if there is any state change in the IO pin, then as per the program it will enable an appropriate RFID pin.The first output of the hand gesture board is connected to the port 1 of 16^{th} pin. Second output to the port 1 of 17^{th} and third output to the port 1 of 18^{th} pin fourth output of the hand gesture board is connected to the port 1 of 19^{th} pin. RF transmitter is connected to the 24^{th}, 25^{th}, 26^{th} and 27^{th} pin of the ARM microcontroller. Based on the input received in the GPIO pins from the hand gesture, the RF transmitter pin connected to the ARM microcontroller will be high. RF transmitter receives serial data and transmits to the receiver through an antenna which is connected to the 4^{th} pin of the transmitter. The transmitted data is in 12 bit format containing 8 address bit and four data bit. The encoder will convert the 4 bit parallel data given to pins D0 – D3 to serial data and will be available at D_{OUT}.

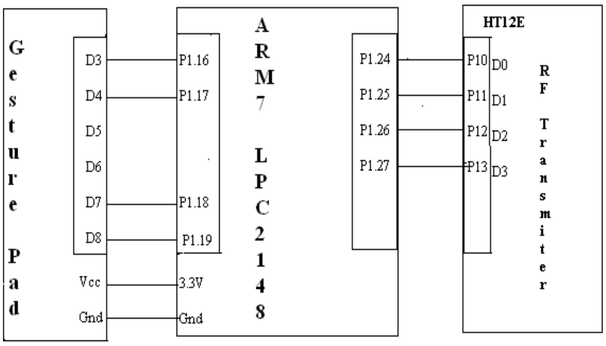

Fig 4: Pin connections of Gesture pad section

This output serial data is given to RF Transmitter. Status of these Address pins should match with status of address pins in the receiver for the transmission of the data. Data will be transmitted only when the Transmit Enable pin (TE) is LOW. It operates at a specific frequency of 433MHz.RF Receiver receives the data transmitted through RF Transmitter. Decoder will convert the received serial data to 4 bit parallel data D0 – D3. The status of these address pins in the decoder should match with status of address pin in the encoder of the transmitter for the reception of data. In that RF receiver is input to the ARM controller and device is act as a output to the controller.

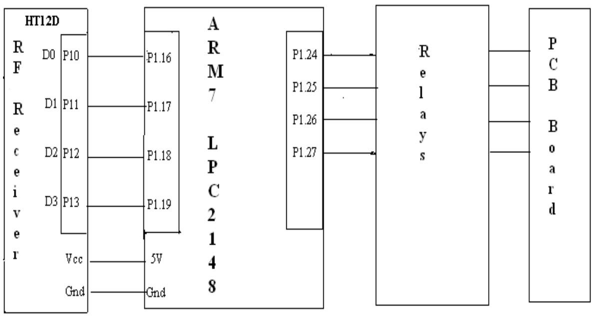

Fig.5: Pin connections of Device section

The RF receiver pin is connected to the ARM microcontroller in the GPIO ports. RF receiver contains four data pins are connected to 16th, 17th, 18th and 19th pin of microcontroller. Based on the input received to the controller from the RF transmitter, the device connected to the controller will be operated. The device is connected to the 24th, 25th, 26th and 27th of the ARM microcontroller. Based on the RF receiver data and flag, the device will be performing operation.

3. System Hardware

A. ARM Processor

The ARM7 family includes the ARM7TDMI, ARM7TDMI-S, ARM720T, and ARM7EJ-S processors. The ARM7TDMI core is the industry's most widely used 32-bit embedded RISC microprocessor solution. Optimized for cost and power-sensitive applications, the ARM7TDMI solution provides the low power consumption, small size, and high performance needed in portable, embedded applications.

The ARM7TDMI core uses a three-stage pipeline to increase the flow of instructions to the processor. This allows multiple simultaneous operations to take place and continuous operation of the processing and memory systems. As the processor is having a high speed it is easy to make the communication between the RF module and the Image acquisition module LPC2148 Microcontroller Architecture. The ARM7TDMI-S is a general purpose 32-bit microprocessor, which offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those of micro programmed Complex Instruction Set Computers (CISC). This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective processor core. Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory. The ARM7TDMI-S processor also employs a unique architectural strategy known as Thumb, which makes it ideally suited to high-volume applications with memory restrictions, or applications where code density is an issue. The key idea behind Thumb is that of a super-reduced instruction set. Essentially, the ARM7TDMI-S processor has two instruction sets:

- The standard 32-bit ARM set.
- A 16-bit Thumb set.

Operating modes

The ARM7TDMI core has seven modes of operation:

- User mode is the usual program execution state
- Interrupt (IRQ) mode is used for general purpose interrupt handling
- Supervisor mode is a protected mode for the operating system
- Abort mode is entered after a data or instruction pre fetch abort

The interrupt setting of ARM supports the DHLS to response to the interrupt coming from the server section.

B. Gesture Pad

This gesture pad Utilizes Electrical Near Field (E-field) sensing for advanced proximity sensing. E-Field is generated by electrical charges.

The magnitude or strength of an electric field in the space surrounding a source charge is related directly to the quantity of charge on the source charge and inversely to the distance from the source charge.

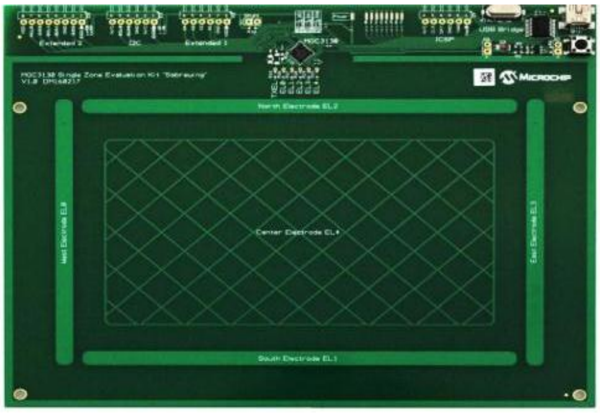

Fig.6: Gesture Pad Outlook

The direction of the electric field is always directed in the direction that a positive test charge would be pushed or pulled if placed in the space surrounding the source charge. The gesture Pad consists of five electrodes. The transmitter electrode transmits the charge from the source. The remaining five electrodes receives those positive charge. If a hand interrupted in the E-Field then the amount of negative ions falling on the Rx electrode will change. This makes a signal variation inside the MGC3130 processor and it will generate a digital output. Field distortion translated into 3D hand tracking and gestures. Very low power consumption since nearly no energy is transported.

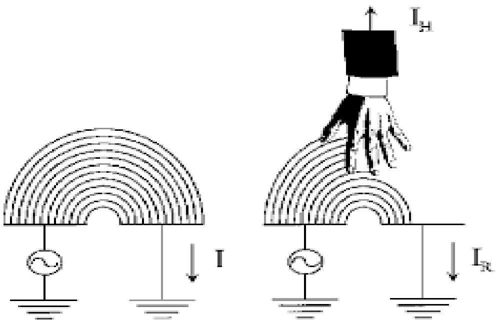

Fig.7: Gesture pad E-Field distortion

Theory of operation: electrical near-field (e-field) sensing

Microchip's Gest IC is a 3D sensor technology which utilizes an electric field (E-field) for advanced proximity sensing. It allows realization of new user interface applications by detection, tracking and classification of a user's hand or finger motion in free space. E-fields are generated by electrical charges and propagate three-dimensionally around the surface, carrying the electrical charge. Applying direct voltages (DC) to an electrode results in a constant electric field. Applying alternating voltages (AC) makes the charges vary over time and thus, the field. When the charge varies sinusoidal with frequency f, the resulting electromagnetic wave is characterized by wavelength λ = c/f, where c is the wave propagation velocity — in vacuum, the speed of light. In cases where the wavelength is much larger than the electrode geometry, the magnetic component is practically zero and no wave propagation takes place. The result is uasi - static electrical near field that can be used for sensing conductive objects such as the human body.

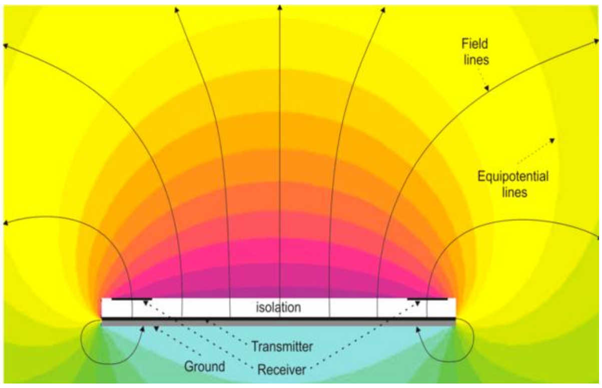

Fig.8: Equipotential lines of an undistorted E-field

Microchip's Gest IC technology uses transmit (Tx) frequencies in the range of 100 kHz which reflects a wavelength of about three kilometers. With electrode geometries of typically less than fourteen by fourteen centimeters, this wavelength is much larger in comparison.

In case a person's hand or finger intrudes the electrical field, the field becomes distorted. The field lines are drawn to the hand due to the conductivity of the human body itself and shunted to ground. The three dimensional electric field decreases locally. Microchip's Gest IC technology uses a minimum number of four receiver (Rx) electrodes to detect the E-field variations at different positions to measure the origin of the electric field distortion from the varying signals received. The information is used to calculate the position, track movements and to classify movement patterns (gestures). The simulation results in Figure 1-1 and Figure 1-2 show the influence of an earth-grounded body to the electric field. The proximity of the body causes a compression of the equipotential lines and shifts the Rx electrode signal levels to a lower potential which can be measured.

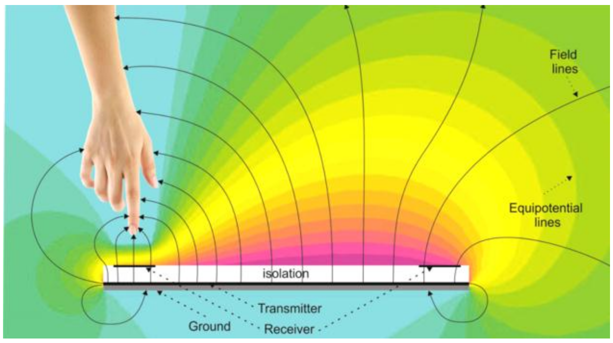

Fig.9: Equipotential lines of a distorted E-field

Gesture Pad Features

- Frame shape electrodes
- 1x Transmitter electrode Tx
- 4–5x Receiving electrodes Rx
- 2-Layer stack-up
- Optional GND layer
- Microchip MGC3130 MCU
- I^2C™ to USB bridge (PIC)
- USB powered

C. Wireless communication

RF communication

Radio Frequency: Any frequency within the electromagnetic spectrum associated with radio wave propagation. When an RF current is supplied to an antenna, an electromagnetic field is created that then is able to propagate through space. Many wireless technologies are based on RF field propagation

RF Transmitter: The TWS-434 extremely small, and are excellent for applications requiring short-range RF remote controls. The TWS-434 modules do not incorporate internal encoding. If simple control or status signals such as button presses or switch closures want to send, consider using an encoder and decoder IC set that takes care of all encoding, error checking, and decoding functions The transmitter output is up to 8mW at 433.92MHz with a range of approximately 400 foot (open area) outdoors. Indoors, the range is approximately 200 foot, and will go through most walls. The TWS-434 transmitter accepts both linear and digital inputs can operate from 1.5 to 12 Volts-DC, and makes building a miniature hand-held RF transmitter very easy.

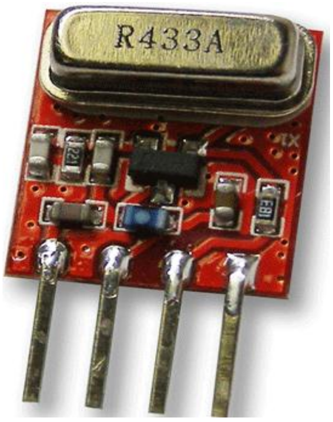

Fig.10: RF Transmitter

RF receiver: RWS-434: The receiver also operates at 433.92MHz, and has a sensitivity of 3uV. The WS-434 receiver operates from 4.5 to 5.5 volts-DC, and has both linear and digital outputs. 0V to Vcc data output is available on pins. This output is normally used to drive a digital decoder IC or a microprocessor which is performing the data decoding. The receiver's output will only transition when valid data is present. In instances, when no carrier is present the output will remain low.

The RWS-434 modules do not incorporate internal decoding. If you want to receive Simple control or status signals such as button presses or switch closes, you can use the encoder and decoder IC set described above. Decoders with momentary and latched outputs are available.

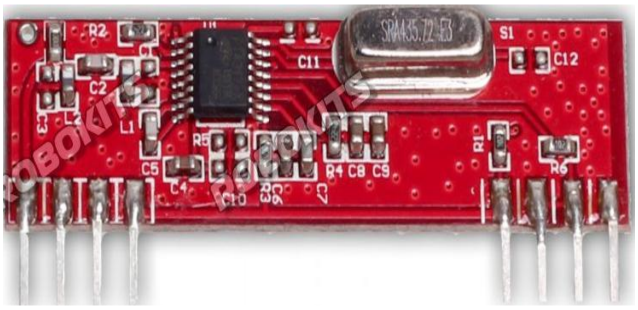

Fig.11: RF receiver

4. Experimental Results

In the gesture pad section, we have mainly three devices. They are 1) Gesture Pad, 2) ARM Board and 3) RF Transmitter.

The Gesture pad sense the gestures based on variations in electric field (E-field). When we give the gesture in front of gesture pad it sense the gesture and give the digital data as output. The ARM board sends the digital data of gesture pad to respected o/p pins based on program dumped in ARM processor. The RF transmitter gets the data from ARM processor and send it to another section i.e. Device section.

Fig.12: Gesture pad section

The Device section consists of three devices. They are 1) RF receiver, 2) ARM board and 3) PCB board of electronic device using in the project. The RF receiver gets the data from gesture board which was transmitted through RF transmitter. The data received from RF receiver is used to ground the switches in PCB board for controlling the electronic device. The PCB board is controlling the electronic device through IR communication.

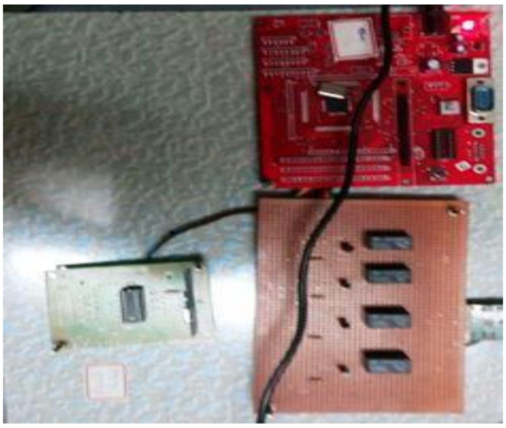

Fig.13: Device section

Fig.14: Electronic device

We used digital FM radio as electronic device for home entertainment. Its functions is basically controlled by PCB board through switches by pressing it. When we one switch the particular part in the board will be grounded. In the project, we ground respected part through program dumped in the ARM board.

Conclusion

This project has been done to control a device based on free air hand gesture motion technology. It uses the Hand gesture pad which works on a principle of e-field distortion. Hand gesture pad will works based on electric field variation. With this technology, any devices can be controlled from the user spot. It can able to bring a reliable assistance and security in electronics sector.

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