Study on Energy-saving Method of Microwave Monitoring for Detecting Human Physical Body and Shielding Interference from Regular Motion Objects

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Abstract. This paper explores a method of detecting human body by microwave that avoids the interference of regular motion. It can accurately detect the presence of human body in the presence of interference of regular moving objects, and is applied to the energy-saving control of power sockets to achieve energy-saving control. This method can also be used in water-saving control. This method solves problems related to resource waste in public buildings, especially problems in classrooms and offices in colleges and universities where there are everlasting lights and air-conditioning and no people where other waste problems, which improves the level of scientific management, and saves a lot of energy. It can not only solve the problem of energy saving and control, but also realize the safety utilization of power of the device. According to the statistics, it can be guaranteed that there are more than 30% saving energy with low input. This method makes great contributions to environmental protection and social security. This method can be further promoted to be applied to any control system which requires accurate human physical body detection and shielding interference from regular motion object, which will be progressively integrated into building clusters and municipal facility. It can also achieve data sharing, information interaction and centralized control of energy of the whole city.

Keywords: detecting human body by microwave, energy-saving control environmental protection, shielding interference.

1. Introduction
With the enormous social development technological development, believing in improving life quality is one of the important points. The living and office environment with more comforts are needed, which there are higher requirements for temperature, humidity and light intensity inside the buildings. Therefore, the type and number of electrical equipment in the building are increased continually. Meanwhile, the energy consumption is also increased. The present day buildings have become the third largest consumer of fossil energy after industry and agriculture [1]. It is common that equipment is still under operation or standby when the building is unoccupied. Studies show that more than half of the total building energy is typically consumed during the non-working hours mainly due to occupancy related actions (e.g. equipment and lighting after-hours usage) and can be reduced through behavioural changes [2-5]. For example, the power consumption of standby water fountains is more than ten 13.7 billion kWh per a year in whole china, causing waste of energy. In addition, equipment under standby state, such as television, will automatically turn on when they are interfered by receiving strong external signal, resulting in equipment operation under unmanned situation. With
regard to equipment of high risk under automatic operation without human control, it will cause a catastrophic accidents.

This article presents an energy-saving method by using microwave monitoring to detect physical body from to regular motion objects and to shields their interference from two aspects of energy saving and safety utilization of power. The main innovation of this method is that it will distinguish non-human regular motion objects, which will prevent fans and robots of regular operation to be mistakenly recognized as physical body by sensor, resulting in automatic running of equipment. This method is used in practical application, on the premise that the comfort is ensured as well as there are interferences from regular moving objects, which will realize that the electrical equipment will be turned on when people comes and when people has been on operation. The equipment will be turned off automatically when there is no human and no need operation of device over a certain period of time, avoiding the standby state of equipment. It can not only solve the problem of energy saving and control, but also realize the safety utilization of power of the device. According to the statistics, it can be guaranteed that there are more than 30% saving energy with low input. This method solves problems related to resource waste in public buildings, especially problems in classrooms and offices in colleges and universities where there are ever-lasting lights air-conditioning and no people there other waste problems, which improves the level of scientific management, and saves a lot of energy, and makes great contributions to environmental protection and social security.

2. Microwave Monitoring Method for Detecting Physical Body and Shielding Interference from Regular Motion Objects

This method can be used to realize intelligent power-saving control of the operation of electrical equipment such as lighting and air conditioning by detecting whether there are human indoors and the shielding interference of regularly moving objects, which solves the problem that similar equipment cannot shield interference from regular moving objects and cannot accurately detect the human physical body. It is well promoted and applied in field of energy saving control.

The microwave monitoring method for shielding interference and recognizing physical body from regular motion objects as follows:

Step 1: Use the microwave detector to collect the signals of regularly moving objects;

Step 2: De-frequency encode the feature code of the collected signals and encode the characteristic code;

Step 3: When there is a physical body, the periodic feature wave will be disrupted and the decoding fails. At this time, it can be determined that there is a physical body there. If no physical body, the periodic feature waves will appear and the decoding is successful. At this time, it is determined that it is the interference, and the interference of regular objects will be shielded.

As for step one, it should be performed that regular objects are set at a certain rotating speed to keep uniform motion. Then, signals under this situation will be collected.

For every regularly moving object, it will perform periodic motion with a certain form, and the microwave detector will generate a waveform of a certain shape. The features of each signal will be analyzed. When the rotating speed of regular moving object such as the fan is different, the shapes of waveforms generated are the same, but frequencies are different.

Decode the feature code and encode the features. When someone is present, the periodic feature wave will be disrupted and the decoding fails. At this time, it can be determined that someone enters the room, so that the human physical body can be accurately detected.

If no one enters the room, periodic feature waves will appear and the decoding is successful. At this time, it is determined that it is the interference, then the interference of regular objects will be shielded. Based on the above characteristics, reverse thinking could be adopted for determination. Namely, the decoding failure can be regarded as a signal of normal human movement. The successful decoding will be eliminated as an interference signal.

By using the energy-saving method of microwave monitoring for shielding interference and recognizing physical body from regular motion objects, in a set space such as a classroom, when using
the method of interference shielding above to monitor the regular objects where there are no human, the electric lights and air conditioners will be cut off to achieve the effect of energy saving.

3. Application of the Detection Method in Practical Engineering

When the detection method is applied to the intelligent power strip, it can automatically detect whether there are someone in the room, and it can automatically cut power off after a certain delay when there is no one, to avoid energy consumption in the standby state of the device, and to eliminate hidden safety hazards of electrical equipment.

The application of microwave detectors for detecting physical body and shielding the interference from regular moving objects is used in intelligent power strip. The schematic diagram is shown below.

![Figure 1. Schematic diagram between modules.](image)

The input end of the rectifier module is connected to an external power line, and the output end is connected to a regulator circuit. The output end of the regulator circuit is respectively connected to a USB interface, a microwave induction module, an amplifier circuit and a single-chip computer. The voltage output by the regulator circuit will provide power supply to the microwave induction module, amplifier circuit and single chip computer.

The output end of the microwave induction module is connected to the input end of the amplifier circuit. The signal sensed by the microwave induction module, after amplification processing by amplifier circuit, will be input single-chip computer. The input terminal of single-chip is respectively connected to the display screen magnetic latching relay. The input end of magnetic latching relay is directly connected to the external power supply. The single-chip computer will control the display of the display screen and the operation of the magnetic latching relay.

The control circuit also includes a signal collection module that collects signals input by an external power supply. The collected current and voltage signals are sent to the single-chip computer by the signal collection module for processing. The voltage, current, and power information are displayed on the display screen in real time. In addition, when the power exceeds the set power of the power strip, the single chip computer will control the magnetic latching relay to be disconnected, so that the power strip is powered off.

There are touch sense buttons are set on the base or the upper shell of power strip. They are used manually controlling the power of the strip. The touch sense button is connected with a single chip computer inside the control circuit. The single chip computer will control magnetic latching relay to achieve the controlling of the on-off of strip.

The external power supply is connected to the rectifier module in the internal control circuit through the power cord to rectify the AC to DC. The output of the rectifier module is connected to a voltage stabilizing circuit to obtain DC voltage at certain value, which will provide power supply to
the microwave induction module, amplifier circuit and single chip computer. At the same time, the output end of the voltage-stabilizing circuit charges the electronic device through the USB interface.

The signal sensed by the microwave induction module, after amplification processing by amplifier circuit, will be input single-chip computer for sampling. The single-chip computer can judge whether there are someone according to the sampled signals. When detecting no one there, the single-chip computer will control operation of the magnetic latching relay. Thereby, the power strip is powered off.

The application model adopts the inclined surface design. The microwave induction module is arranged on the inclined surface, which increases the induction range of the microwave induction module and improves the sensitivity. This kind of power strip can automatically power off when no one is sensed, thereby reducing power consumption under standby state and improving safety at the same time. The power strip is equipped with a USB interface which is convenient for charging electronic products without charging converter. This kind of design can detect the current, voltage and power conditions. When the set power is exceeded, the single-chip computer controls the magnetic latching relay, and the power strip is automatically powered off to ensure that the power strip works in the normal working mode.

As shown in figure 1, the control circuit includes the rectifier module. The input end of the rectifier module is connected to an external power line, the output end is connected to the voltage stabilizing circuit, and the output end of the voltage stabilizing circuit is respectively connected to a USB interface 6, a microwave induction module 10, an amplifying circuit and a single-chip computer. The voltage stabilizing circuit will provide power supply for a microwave induction module 10 and an amplifying circuit and a single chip.

The output end of the microwave induction module 10 is connected to the input end of the amplifying circuit. The signal sensed by the microwave induction module 10, after amplification processing by amplifier circuit, will be input single-chip computer. The output end of the single-chip computer is respectively connected to the display screen 11 and the magnetic latching relay to control the display of the display screen 11 and the action of the magnetic latching relay. Using the magnetic latching relay makes the control circuit more reliable during operation while reducing power consumption.

The control circuit also includes a signal acquisition module. The input end of the signal acquisition module is connected to the external power line. The output end is connected to the magnetic latching relay and the single-chip computer. The collected current and voltage signals collected by the signal acquisition module are sent the to the single-chip computer for processing. At the same time, the voltage, current, and power information are displayed on the display screen in real time. In addition, when the power exceeds the set power of the power strip, the single chip computer will control the magnetic latching relay to be disconnected, so that the power strip is powered off.

The external power supply is connected to the rectifier module in the internal control circuit through the power cord to rectify the AC to DC. The output of the rectifier module is connected to a voltage stabilizing circuit to obtain DC voltage at certain value, which will provide power supply to the microwave induction module, amplifier circuit and single chip computer. At the same time, the output end of the voltage-stabilizing circuit charges the electronic device through the USB interface 6.

The signal sensed by the microwave induction module, after amplification processing by amplifier circuit, will be input single-chip computer for sampling. The single-chip computer can judge whether there are someone according to the sampled signals. When detecting no one there, the single-chip computer will control operation of the magnetic latching relay. Thereby, the power strip is powered off.
Figure 2. Structure diagram of intelligent power strip with USB interface (base included).

As shown in figure 2, it is the intelligent power strip with USB interface (base included). The upper part of the strip base 1 is equipped with an upper shell 2. The upper shell 2 includes four sides: a front side 4, a back side, a left side 3, and a right side 5. The upper shell 2 also includes an upper plane 12. The four sides of the upper plane 12 are respectively connected to the front side 4, the back side, the left side 3 and the right side 6. The left side 3 and the right side 5 are all inclined surfaces.

There are three sockets 9 are respectively arranged on the left side 3 and the right side 4 of the upper shell 2 of the power strip. In addition, there are conductor pieces connected to the internal control circuit inside the socket 9.

The base 1 of power strip is provided with two USB interfaces 6, and the USB interface 6 is connected to the internal control circuit of the strip. The input end of the control circuit is connected to the power line, and the power line is connected to the control circuit from the power line inlet 7. The output terminal of the control circuit is connected to the conductor piece in the socket 9. The output terminal of the control circuit is also connected to the display screen 11 and the USB interface 6 is left behind.

A microwave induction module 10 is respectively arranged on the left side 3, right side 5 and upper plane 12 of the upper shell 2 of the power strip. The microwave induction module 10 is connected to an internal control circuit.

A touch sense button 8 ia arranged on the upper shell 2 of the power strip. They are used manually controlling the power of the strip. The touch sense button 8 is connected with the single chip computer inside the control circuit. The single chip computer will control magnetic latching relay to achieve the controlling of the on-off of strip.

This power strip and sensor are used in schools, enterprises and institutions, large public buildings, parks and other different occasions. They could be connected to the energy detection and control platform as an Internet of Things node. The power consumption equipment will have centralized and optimized controls by monitoring platform to achieve the purpose of energy saving. When they are used in buildings of energy saving, it can save energy by 30%. In addition, this power strip can also protect electrical equipment from strong interference signals under the standby state.

4. Conclusion

This paper explores a method of detecting human physical body by microwave monitoring to shield interference of regular motion objects. It can accurately detect the presence of human physical body under interference of regular moving objects, which is applied in the energy-saving control of power strip to achieve energy-saving. This method can also be used in water-saving control to have a real-time monitoring of personnel information in the water-using room. When the water meter is still running (leakage or valve is not closed) without human there, the monitoring system will give a command to close the solenoid valve, and uses mobile phone messages to sound the alarm, which can solve the phenomenon of water running, dripping and leakage. This method can be further promoted.
to be applied to any control system which requires accurate human physical body detection and shielding interference from regular motion object, which will be progressively integrated into building clusters and municipal facilities. It can also achieve data sharing, information interaction and centralized control of energy of the whole city.

References
[1] Chel A 2018 Geetanjali kaushik *Alexandria Engineering Journal* 57: 655–669.
[2] Webber C A, Roberson J A, McWhinney M C, Brown R E, Pinckard M J 2006 After-hours power status of office equipment in the USA *Energy* 31: 2823-2838.
[3] Masoso O T, Grobler L J 2010 The dark side of occupants’ behaviour on building energy use *Energy and Buildings* 42: 173-177(2010)
[4] Meier A 2006 Operating buildings during temporary electricity shortages *Energy and Buildings* 38: 1296-1301.
[5] Staats H, Van Leeuwen E and Wit A 2000 A longitudinal study of informational interventions to save energy in an office building *J. Appl. Behav. Anal.* 33: 101-104.