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RECYCLING OF ENERGY BY THE UTILIZATION OF A PIEZOELECTRIC CRYSTAL AND MICROCONTROLLER

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Abstract. With the increasing demand for utilization of energy resources, there has been a deflation in the availability of resources and there have been many methods of recycling of energy resources .This paper discusses about the concept of recycling of energy by the piezoelectric crystals. End of the circuit is connected to a battery. The battery is charged completely so that energy can be recycled i.e. electrical energy can be converted into mechanical energy and vice versa, when there is a power failure and in these situations there is a reduction in electricity(by switching off the supply) expenditures. The design consists of a piezo ignitor, a stack actuator, audio amplifier, microcontroller, a pyroelectric crystal, A/D converter, voltage divider and a sound sensor. The mechanical energy produced by the device such as fan which is to be operated is given to the piezo ignitor .The piezo ignitor converts the given mechanical input to electrical energy. One part of the electrical energy produced by the piezo ignitor is given to an audio amplifier and the other part is given to a battery by the voltage divider. The heat generated by the ignitor is sent over to the pyroelectric crystal where it is converted into voltage. When the voltage produced is in the range of acceptable operating limit of the microcontroller, it is directly given to the controller. If the heat generated is more than the critical value in the pyroelectric crystal, then a voltage divider is used to reduce the voltage and send the necessary voltage with which the microcontroller can operate without any problem. The other part of the voltage which is divided by the voltage divider is given in parallel connection to the voltage given out from the ignitor crystal .The added voltage is given to the battery. If the voltage coming from the pyroelectric crystal is below the critical value, then a part of the voltage coming from the piezo ignitor is added with the voltage coming from the pyroelectric crystal and is given to the microcontroller. Audio amplifier detects the noise from the operating device and the noise signal in the amplifier is amplified to a particular gain value which is in turn sent to the sound sensor. If the gain is too high and if it exceeds a critical value, it would damage the entire ignitor so the sound sensor senses the level of gain and sends it to the microcontroller .The microcontroller adjusts the gain of the amplifier accordingly so that it does not cause any damage to the ignitor. Proper input to the sound amplifier comes from the microcontroller after necessary programming. Then the final value is given to the piezo ignitor. All these processes in the design occurs only after the battery is fully charged .When the battery is completely charged, the supply gets cut off automatically from the device and finally the device operates by the use of battery. This method and design is very useful in home appliances or any other devices where disturbance or noise occurs. This would be a very significant and a useful technology in future for efficient recycling of energy if it is put to proper use.

Keywords: piezo ignitor, pyroelectric crystal, LM386 audio amplifier, ATMEGA16 microcontroller, battery, sound sensor.

1. Recycling of energy

Energy recycling is the energy recovery process of utilizing energy that would normally be wasted, by converting it into electric energy or thermal energy. There are various forms of recycling of energy which have existed so far. This paper introduces a new concept of energy recycling using the piezoelectric crystal and a microcontroller.

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2. Components of design

- Piezo Ignitor
- LM386 Audio amplifier
- ATMEGA16 microcontroller
- Pyroelectric crystal
- Sound sensor
- Battery

2.1. Piezo ignitor

Piezo ignition is a type of ignition that is used in portable camping stoves, gas grills and some lighters. It consists of a small, springloaded hammer which, when a button is pressed, hits a crystal of PZT or quartz crystal. Quartz is piezoelectric, which means that it creates a voltage when deformed. The volume of the ceramic element and the amount of stress exerted on the element are key factors in converting mechanical input to electrical energy. In squeeze-type piezoelectric fuel ignitors a static mechanical energy input – very low frequency, relative to the resonance frequency of the ceramic generates the electrical energy for ignition. In the impact ignition design a spring-loaded hammer delivers a dynamic input to the ceramic element. The pressure wave generated when the hammer strikes the element once is reflected multiple times in both the element and the hammer, in accord with the elastic and acoustical properties of the ceramic and the hammer. Until the flashover at the spark gap, stress varies along the height of the ceramic element, and exact values for voltage must be calculated by integration over the height of the element.

Mechanical input	Diameter (mm)	Length (mm)	Density/ ρ(gm/cm3)	Dielectric constant/ξ	Electric capacity/ C(pF)	Coupling Factor/k 33	Piezoelectric voltage constant/G33(10-3 V-m/N)	Curie point TC/(◦C)	Operating temperature/(◦C)
Impact	2.7	5	7.7	750	8±2	≥0.68	40±2	≥310	<100
Impact	5	10	7.5	880	14±4	≥0.68	31±2	≥310	<120
Impact	7	15	7.7	2000	50±5	≥0.75	28±2	≥300	<120
Impact	6.27	15.88	7.7	2000	38±2	≥0.75	28±2	≥300	<120
Squeeze	6.35	15	7.6	1100	20±2	≥0.65	30±2	≥310	<120

Fig 1: standard specification

Note: Static Compressive Strength (kg/cm) >3000 for all standard ignitor elements

Force / Voltage: g33 * (force (N) * thickness of ceramic (m)) /surface area of ceramic (m2) = Volts

2.2. Microcontroller

ATMEGA16 microcontroller is used to adjust the proper gain and send it to the audio amplifier by necessary programming

Constraints Requirements

Speed Grades 0 - 16 MHz

Operating Voltages 4.5V - 5.5V

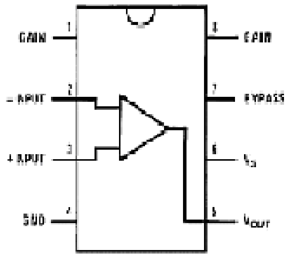
Active 1.1 mA

Idle Mode 0.35 mA

Power-down Mode < 1 A

8-bit Microcontroller with 16 K Bytes In system Programmable

2.3. LM386 Audio amplifier



The LM386 is a power amplifier designed for use in low voltage consumer applications. The gain is internally set to 20 to keep external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value from 20 to 200. The inputs are ground referenced while the output automatically biases to one-half the supply voltage. The quiescent power drain is only 24 milliwatts when operating from a 6 volt supply, making the LM386 ideal for battery operation.

Features

- Wide supply voltage range: 4V-12V or 5V-18V
- Low quiescent current drain: 4mA
- Voltage gains from 20 to 200
- Low distortion: 0.2% (AV = 20, VS = 6V, RL = 8Ohm, PO =125mW, f = 1kHz)

2.4. Pyroelectric crystal

Typical examples of pyroelectric crystals are tourmaline, lithium sulphate and monohydrate. Pyroelectric crystals can be regarded as having a built-in or permanent electric polarization. When the crystal is held at constant temperature, this polarization does not manifest itself because it is compensated by free charge carriers that have reached the surface of the crystal by conduction through the crystal and from the surroundings. However, when the temperature of the crystal is raised or lowered, the permanent polarization changes, and this change manifests itself as pyroelectricity. The magnitude of the pyroelectric effect depends upon whether the thermal expansion of the crystal is prevented by clamping or whether the crystal is mechanically unconstrained. In the clamped crystal, the primary pyroelectric effect is observed, whereas in the free crystal, a secondary pyroelectric effect is superposed upon the primary effect. The secondary effect may be regarded as the piezoelectric polarization arising from thermal expansion, and is generally much larger than the primary effect.

2.5. Sound sensor

The Sound sensor module is a simple microphone. Based on the power amplifier LM386 and the electret microphone, it can be used to detect the sound strength of the environment. The value of output can be adjusted by the potentiometer. It has a wide supply voltage range of 4V-12V ,a maximum current supply of 8mA ,low quiescent current drain of 4 mA and it is gain adjustable.

This module uses the LM386 power amplifier to strengthen the electronic signal produced by the electret microphone. When powered on, the SIG pin will output the signal regulated by LM386.The potentiometer at the output can be used to regulate the gain. The program below shows how to use the sound sensor to control the led. Connect the Sound sensor to analog port A0 and the LED to port 12.The potentiometer is used to regulate the gain of the output signal. The larger the potentiometer, the larger the output signal. If the sound of the environment is bigger than the threshold, then the Led will be turned on.

```
const int ledPin = 12; // the number of the LED pin
const int thresholdvalue=400;//The threshold to turn the led on
void setup() {pinMode(ledPin, OUTPUT);}
void loop() {
```

```
int sensorValue = analogRead(A0);//use A0 to read the electrical signal
if(sensorValue>thresholdvalue)
digitalWrite(ledPin,HIGH);//if the value read from A0 is larger than 400,then light the LED
 delay(200);
digitalWrite(ledPin,LOW);}
```

2.6. Battery

One end of the circuit is connected to a battery. The battery is charged completely so that it can recycle the electrical power by converting it into mechanical energy and vice versa, so that it can be used in case of power failure power failure and in situations where reduction in electricity(by switching off the supply) expenditures is needed. The entire process mentioned in the design occurs only after the battery is fully charged .When the battery is completely charged, the supply gets cut off automatically from the device and finally the device operates by the use of battery.

3. Working of model

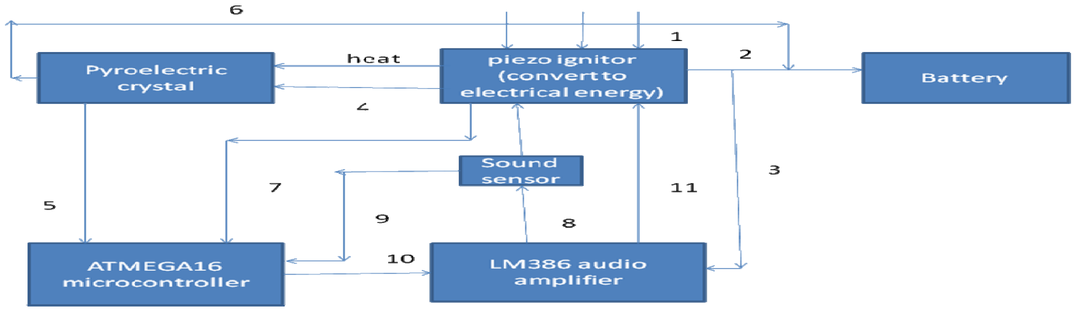


Fig 2: working of the model

The mechanical energy produced by the device which is to be operated is given to the piezo ignitor. The piezo ignitor converts the given mechanical input to electrical energy.

1. One part of the electrical energy produced is given to the battery for charging.

2. The other part of the electrical energy is given to the LM386 audio amplifier by the voltage divider.

3. The heat generated by the ignitor is sent over to the pyroelectric crystal where it is converted into voltage.

4. When the voltage produced is in the range of acceptable operating limit of the microcontroller, it is directly given to the controller.

5. If the heat generated is more than the critical value in the pyroelectric crystal, then a voltage divider is used to reduce the voltage and send the necessary voltage which the microcontroller can operate without any problem. The other part of the voltage which is divided by the voltage divider is given in parallel connection to the voltage given out from the ignitor crystal .The added voltage is given to the battery

6. If the voltage coming from the pyro electric crystal is below the critical value ,then a part of the voltage coming from the piezo ignitor is added with the voltage coming from the pyroelectric crystal and is given to the microcontroller.

7. The noise signal in the amplifier is amplified to a particular gain value and sent to the sound sensor.The gain of the audio amplifier must be between (20-200)

8. If the gain is too high and if it exceeds a critical value, it would damage the entire ignitor. So the sound sensor senses the level of gain and sends it to the microcontroller.

9. The microcontroller adjusts the gain of the amplifier accordingly that it does not cause damage to the ignitor. Proper input to the sound amplifier comes from the microcontroller after necessary programming.

10. Then the final value is given to the piezo ignitor.

All these process in the design occurs only after the battery is fully charged .When the battery is completely charged, the supply gets cut off automatically from the device and finally the device operates by the use of battery.

3.1. Coding to adjust amplifier gain

```
#include <mega16.h>
void main(void)
{
unsigned int k,c, h;
DDRA=0x00;
DDRC=0xFF;//piezo crystal output
DDRD=0x00; //POWER OUTPUT to device
DDRB=0xFF;//audio amplifier output
k =PINA // BATTERY INPUT
if(k=0xFF)
{PORTD=k;
}
Else
{
while (k<0xFF)
{
k=PINC;
h=0xab;//value needed
c=PINB;
if(c!=h) //adjusting gain of audio amplifier
{DDRB=h}
}
PORTD=k;
}
}
```

3.2. Application

This method of recycling can be used in many home appliances such as fans etc, it is also used in devices which produce noise and vibration while they are operating.

3.3. Advantages

- This method gives rise to efficient recycling of energy.
- There is no loss in energy
- It can be used in situations in case of power failure or any emergency conditions
- This method reduces electricity expenditures.

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