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SELF-POWERED PROCESSORS

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ABSTRACT

In this paper, we have explained how to recycle the processor generated heat, convert it into electric signal and use it as a standby power source. It is a novel approach towards the power saving technique because nowadays power saving is vital in energy saving and waste utilization. This proposed technique has been simulated with the help of MULTISIM. As the temperature of SMD processor IC increases, the generated heat energy usually goes waste. It is possible to recycle that generated heat into suitable power with the help of LM35 (a precision centigrade temperature sensor) circuit design. Thus resultant voltage can be utilized back to power the processor and thus we can save energy.

Key words*: Energy recycle, LM3 and energy conservation technique.*

INTRODUCTION

Energy recovery is any technique of minimizing the input of energy to an overall system by the exchange of energy from one sub-system with another. The energy can be in any form in the subsystem, but most energy recovery systems exchange thermal energy in either sensible or latent form as energy conservation is one of the top concern of electronic design industry, fabrication industry or any other sub-field of science and technology. Energy conservation is done by adopting low power technology and avoiding or reducing the energy/power losses. Heat dissipation is an unavoidable by-product of all electronic devices and circuits. In general, the temperature of the device or component will depend on the thermal resistance from the component to the environment, and the heat dissipated by the component. To ensure that the component temperature does not overheat the device, an efficient heat transfer path has to be provided. In order to avoid loss of energy in the form of heat, it can be recycled and used. In this paper we have discussed a technique to recycle the heat sink and utilize it as supply to the processor. In this technique the increase in the temperature of the processor IC is sensed by a temperature sensor, LM35 and suitable circuit design to convert it into equivalent voltage. This voltage is in turn provided back to the processor in terms of supply.

Heat recycling is one of the many approaches towards energy conservation. Many suggestions or ideas have been considered for recycling the heat. Most of them think of a transducer, to be precise a temperature sensor. There is one approach which is useful in a large industry where lot of heat is dissipated due to different equipments or due to large quantity of equipments. ABB has come up with a heat recovery system which converts the heat that was previously wasted into electricity; efficiently, economically and CO2-free [2]. This technology allows waste air or stack gases with temperatures starting from only 150°C to be economically used. Some of its main features are as follows:

• Lower operation costs through own power generation
• CO2-free power generation – a clear competitive and image advantage
• More independence from rising energy prices
• Plant operation with proven technology at low risk
• Fast installation through professional planning and execution
• Low capital expenditures due to standard components.
•High profits are guaranteed due to minimum maintenance costs.

Another related work is 'Heat recovery from heat treatment furnace[3,4]; the sources can be heat in flue gases, heat in vapour streams, convective and radiant heat lost from exterior of equipment etc. Typical methods of recovering heat in industrial applications include direct heat recovery to the process itself, recuperators, regenerators, and waste heat boilers [3]. In many applications– especially with low-temperature waste heat streams, such as automotive applications – the economic benefits of waste heat recovery do not justify the cost of the recovery systems. The above works are industry-oriented and can be successfully implemented in plants. The amounts of heat generated in ICs are very low and the above techniques cannot be used for the utilization of heat energy. We have come out with a new technique that makes use of LM35 sensor and the heat energy is utilized effectively.

Types of transducers: This section is devoted to give an overview on various types of temperature transducers. A temperature transducer or sensor converts a change in temperature to an equivalent change in voltage, current, resistance depending on the type of transducer used. Few of the temperature transducers are:

(i)RTD: Resistance Temperature Detector uses the change in electrical resistance of conductor to determine the temperature. A metal with a high value of resistivity should be used for RTDs. Platinum is commonly used as it can withstand high temperatures and maintain excellent stability.

(ii)Thermistor: Thermistor is a special kind of resistor whose resistance varies with the variation in temperature. This is not a linear device. Thermistor differs from RTDs is that the material used in a thermistor is generally a ceramic or polymer, while RTDs use pure metals. The temperature response is also different; RTDs are useful over larger temperature ranges, while thermistors typically achieve a higher precision within a limited temperature range.

(iii) Thermocouple: Thermocouple works on the principle of Seebeck effect, that is the output voltage is directly proportional to the difference in temperature between two junctions when a small current passes through it. This principle is used to convert heat energy to electrical energy at the junction of two conductors. Many experiments involving a thermocouple as the sensor for heat recycling have been conducted. But the output of the thermocouple is usually in mV range; reutilization of this voltage is not of much use.

(iv) LM35: LM35[1] is a precision centigrade temperature sensor. This is a linear device.

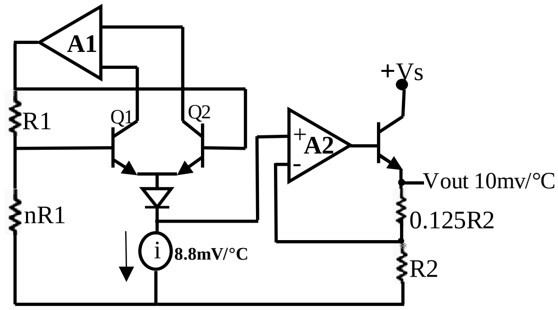
We have chosen LM35 as the transducer out of the above four as LM35 is a linear device and doesn't require calibration, whereas RTD is linear for short temperature spans but less sensitive, thermistor and thermocouple requires calibration as they are nonlinear devices. The use of LM35 would make the measurement of temperature slightly calculative than the thermistor method but makes the prototyping easy [5]. In addition to this thermocouple requires reference junction compensation which increases the circuit area and they follow temperature changes with a small time lag and are suitable for recording rapid changes in temperature. The next subsection gives details about LM35.

About LM35: The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the temperature[1]. The LM35 does not require any external calibration or trimming to provide typical accuracies of $\pm 1/4°C$ at room temperature and $\pm 3/4°C$ over a full -55 to $+150°C$ temperature range. The internal structure of LM35 is as shown in figure (1).

Few important features are:

Calibrated directly in ° Celsius (Centigrade)
Linear + 10.0 mV/°C scale factor
0.5°C guaranteed accuracy (at +25°C)
Rated for full $-55°$ to $+150°C$ range
Suitable for remote applications
Low cost due to wafer-level trimming
Operates from 4 to 30 volts
Less than 60 μA current drain
Low self-heating, 0.08°C in still air
Nonlinearity only $\pm 1/4°C$ typical
Low impedance output, 0.1 Ω for 1 mA load.

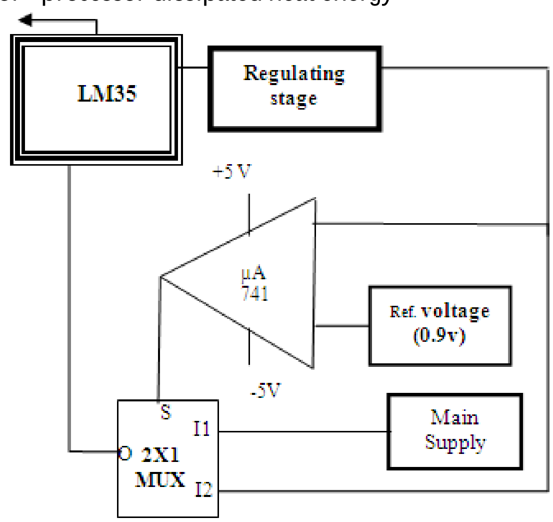
Figure 1. Internal structure of LM35



The typical applications of LM35 are as basic centigrade sensor and as Full grade temperature sensor.

Block diagram description of recycling of dissipated heat energy form processor (Figure 2).

Figure 2. Block diagram representation of recycling of processor dissipated heat energy



The heat dissipated in the processor can be recycled and used back as the supply voltage to the processor. This technique is realized using LM35 (a precision centigrade temperature sensor) and additional circuitry which includes a 0.9V zener diode, comparator, reference supply of 0.9V and 2x1 multiplexer. The above block diagram depicts the circuitry arrangement to achieve this energy conservation technique. As the processor heats up, its temperature increases. This increase in the temperature is sensed by LM35 which is placed above the processor. LM35 is a linear sensing device, thus it provides an equivalent voltage corresponding to the increase in temperature. A 0.9V zener diode is place in parallel with the output of LM35. Then a comparator is placed with one of its input given to the zener diode and the other input to a reference voltage of 0.9V. The output of the comparator is given as the select line of a 2x1 MUX. One input of the MUX is connected to the zener diode and the second input is given to the main supply. The output of the MUX is provided back to the processor at the power supply point.

Initially, when processor temperature results in a voltage less than 0.9V, the comparator gives the output as one (as different voltages are provided at the inputs of comparator) thus the input1 of the MUX, which is connected to the main supply, is provided as output of MUX which is in turn given to the processor. As the temperature of processor IC increases, the output voltage of LM35 increases proportionally. When the output voltage reaches 0.9V, the 0.9V zener diode acts as a 0.9V constant power supply thus providing a constant 0.9V to one of the comparator input. The comparator compares this voltage with the reference voltage (which is 0.9V) and provides the output to the select line of the MUX. The comparator output is 0 as both the inputs of comparator are equal and thus input2 of the MUX, which is connected to zener diode, is given as output of the MUX. Thus a constant 0.9V is provided as supply to the processor. Thus energy is conserved.

Each circuit in the additional circuitry involved to adapt this technique is realised using CMOS technology because our aim is to save the power. A 0.9V zener diode is used. The 2x1 Multiplexer is also made use of, to switch between the sources according to the sensor output.

RESULTS

Once executing the fundamental circuit, shown in figure (3), the following observations were tabulated (Table 1).

Table 1. Circuit output voltage in different temperature

Temperature(°C)	Output Voltage (in V)
25	0.251
30	0.321
35	0.381
40	0.438
45	0.489
50	0.558
55	0.616
60	0.696
65	0.743
70	0.821
75	0.901

The technique involves the realization of LM35, a comparator, a reference voltage of 0.9V, 2x1 MUX and a 0.9V zener diode. In future this whole circuitry can be fabricated as a single chip. Later this chip can be placed near the processor chip.Even better result can be obtained if this is placed inside the processor itself.

Application

This technique is useful to self-power a processor. This technique can also be implemented for a television, refrigerators (with slight modification in the additional circuitry). We can even apply this technique on any other IC which generates heat like power supply IC µm7805. For example in a mother board there are several ICs, if we combine all the IC energies, we can generate more power and this can be used to power any device on the mother board. Additional components like a battery can also be added in the circuitry, with minor modifications, in order to store the energy produced by LM35 and reuse it whenever required.

CONCLUSION

The heat produced by the processor is used to power-up the processor itself with the idea that the temperature transducer used to convert the heat to electrical voltage will generate enough power. However it is undesirable for any processor to heat up more than a prescribed limit. In such cases emergency is noticed and the cooling system starts to operate. It is noticed that a processor can work without any external power, if the heat produced by it is at a certain optimum value. The heat generated in turn depends on the amount of processing it does and also on the duration for which it has been processing. It is very rare for a processor to generate a constant degree of heat throughout. However with some more effort if we make sure that when the heat generated attains a minimum value after the processor start-up, from there, the processor can run on the self-generated power. So it can be observed that in such cases, the requirement of external power is only during the start-up and for some duration until the processor is able to generate enough power for it to operate solely on it. This eco-friendly design approach towards self-generating power can be incorporated in many applications with some modifications.

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