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Determination Of Power Consumption Of An Embedded System

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Abstract
In this Paper, the energy consumption of microcontroller based embedded systems was analyzed. It involves calculation of power consumed by all the individual components of the embedded system. This is done by the implementation of appropriate measuring units corresponding to each component of the system. These measuring units determine the current consumed. From the current output, the power consumed by every component is estimated. In addition to this the overall power consumed by the system can also be determined by aggregating these values. The power values are displayed in the LabVIEW. Comparisons are carried out by replacing each component with an alternative version, identical features but different manufacturers, so that their behavior in a particular scenario can be analyzed.

Keyword: Wireless sensor Network, Power output, Microcontroller, Zigbee, Gas sensor

Introduction
The main objective of the project is to determine the energy consumption of embedded systems. Based on the characteristics of the components used, appropriate measurement instrumentation corresponding to each component must be designed. By implementing these measurement instrumentations, the current output and thus, the energy consumed by every component in the embedded system can be measured. From the results obtained, the power consumed by all the components are analyzed and the overall power consumed by the system was determined. Comparison can be taken , to know the e behavior of different types of the same component in the current scenario and determine the best suited model for the test system. The project involves design of an energy estimation model for microcontroller based embedded systems. The design of this model involves knowledge about all the software tasks occurring in the various devices part of the embedded system. Thus, all the software tasks are first profiled and their characteristics are analyzed. In order to measure the energy consumed by each of the devices, individual measurement units specifically designed for that device must be constructed. Using these independent measuring units, the current flowing and thus the power consumed by these devices can be measured. By aggregating these values, the overall power consumed by the embedded system can be determined. In order to implement this model, a test embedded system which performs Gas Monitoring using MQ Gas Sensor controlled using PIC16F877A and the concentration is displayed using an LCD Display and also transmitted using ZigBee. Thus using the designed model, we can measure the power consumed for all the operations performed in the embedded system.

Proposed Idea
A test monitoring system was considered, which performs gas monitoring using MQ gas sensor, controlling done by PIC16F877A and the concentration is displayed using an LCD display and also transmitted using ZigBee. Thus by this setup, the measurement was carried out for all the operations performed in the Embedded system.

The hardware setup for the Gas Monitoring Embedded System has the following components:

1. MQ5/MQ6 Gas Sensor
2. 16*2 LCD Display
3. PIC16F877A
4. ZigBee Transmitter

The following block diagram illustrates the overall idea of the project,

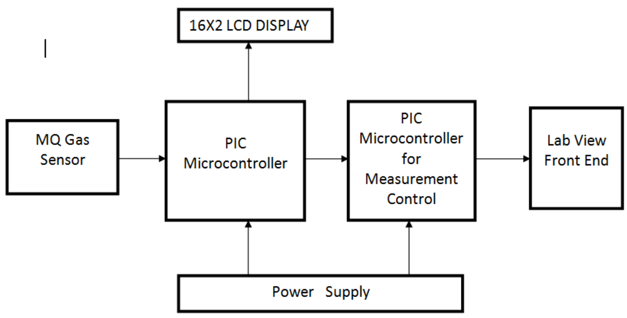

Fig.1. Block Diagram

The operation of the embedded system is as follows,

- The gas leakage is monitored continuously using MQ5/MQ6 Gas sensor and the analog output from the sensor is connected to pin AN0 of the microcontroller which corresponds to one of the 8 channels available for the internal ADC.

- The ADC converts the analog signal into corresponding digital value which is then processed by the microcontroller and scaled accordingly to obtain the concentration value.
- The final result is then sent to a LCD Display Unit which is connected to the Port B of the PIC Microcontroller.

The circuit such that certain components can be replaced by another counterpart which consumes power considerably different from the previous one. The following components can be varied as listed below,

- Gas Sensor
- LCD Display
- ZigBee Transmitter

The working of the measurement controlling PIC microcontroller is as follows,

- The current consumed by each of these units is measured using (resistive) current sensors which are connected to the analog inputs of the PIC microcontroller.
- These analog values are converted to the corresponding digital value using the internal ADC which is converted into the corresponding concentration value.
- The final result is then sent to a LCD Display Unit which is connected to the Port B of the PIC Microcontroller.

The power outputs for each of the components are displayed in LabVIEW in tabulated form by integrating the hardware unit using Serial RS232 to USB conversion. The circuit in such a way that each component can be replaced by another counterpart which consumes considerably different power. By considering more alternatives for each component in a circuit and their corresponding power consumption can also be analyzed.
By such analysis in each different scenario where the system can be implemented, the component with least power consumption for that specific application can be determined. By aggregating the values of power consumed by them, the overall power consumed by the embedded system can also be determined and hence power consumption can be minimized for the same embedded system in every different application.

Gas Sensors

The MQ series of gas sensors use a small heater inside with an electro-chemical sensor. They are sensitive for a range of gases and are mostly used indoors at room temperature. They can be calibrated more using a known concentration of a particular gas. Some sensors use 5V for the heater, others need 2V. The heater cannot be connected directly to an output-pin of the microcontroller, since the current involved is very high. The sensors that use 5V for the internal heater get warm. They can easily get 50 or 60 degrees Celsius.
After the "burn-in time", the heater needs to be on for about 3 minutes before the readings become stable. The sensor also needs a load-resistor at the output to ground. The value can range from 2k to 47k Ohm. The lower the value, the lower the sensitivity. If only one specific gas is measured, the load-resistor can be calibrated by applying a know concentration of that gas. If the sensor is used to measure any gas (like in an air quality detector) the load-resistor could be set for a value of about 1V output with clean air.
MQ5 Gas Sensor module is useful for gas leakage detection. It can detect LPG, natural gas etc. Because it has a fast response time once it has pre-heated, measurements are almost instantaneous. The sensitivity can be adjusted by the potentiometer.

LabVIEW

LabVIEW contains a comprehensive set of tools for acquiring, analyzing, displaying, and storing data, as well as tools to help you troubleshoot code you write. In LabVIEW, you build a user interface, or front panel, with controls and indicators. Controls are knobs, push buttons, dials, and other input mechanisms. Indicators are graphs, LEDs, and other output displays. After you build the user interface, you add code using VIs and structures to control the front panel objects. The block diagram contains this code. You can use LabVIEW to communicate with hardware such as data acquisition, vision, and motion control devices, as well as GPIB, PXI, VXI, RS232, and RS485 instruments.
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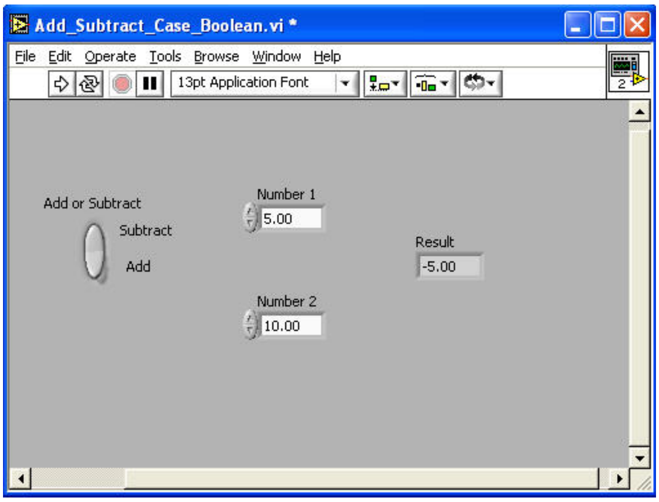

Fig .2. Lab VIEW Front Panel

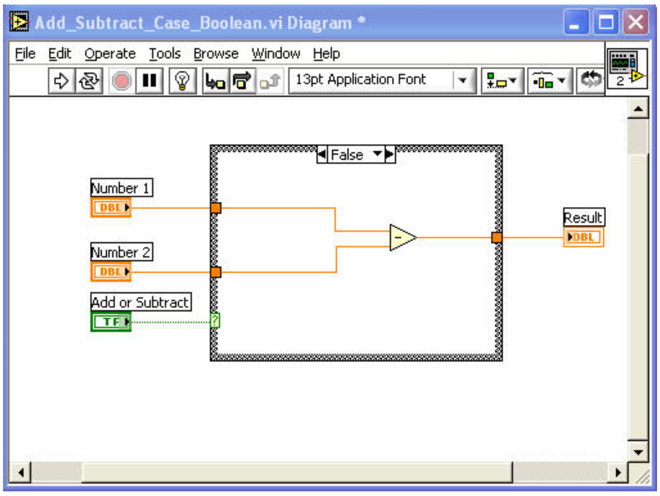

Fig .3. Lab VIEW Back end Panel

Results And Discussions

As stated in the introduction, the main objective of the project is to determine the Energy consumption of embedded systems. This process involves knowledge about all the software tasks occurring in the various devices part of the embedded system. Thus, all the software tasks have been profiled and their characteristics are analyzed. In order to measure the energy consumed by each of the devices, individual measurement units specifically designed for that device must be constructed. The various components have been studied and based on their characteristics, specific current measuring instrumentations have been used. By implementing measurement instrumentations, the current output and thus, the energy consumed by every component in the embedded system has been measured. The overall power consumption has also been obtained by aggregating these individual values. This is used to compare the behavior of different types of the same component in the current scenario and determine the best suited model for the test system. In order to implement this model, we have considered a test embedded system which performs Gas Monitoring using MQ Gas Sensor controlled using PIC16F877A and the concentration is displayed using an LCD Display and also transmitted using ZigBee. In addition to measuring the power, we have implemented methods to perform comparison. The hardware setup is such that each component can be replaced by another counterpart which consumes considerably different power. By considering more alternatives for each component in a circuit and their corresponding power consumption can also be analyzed. By such analysis in each different scenario where the system can be implemented, the component with least power consumption for that specific application can be determined. By aggregating the values of, the overall power consumed by the embedded system can also be determined and hence power consumption can be minimized for the same embedded system in every different application.

Table.1(a). Comparison Table

S.No	Location	ZigBee 1		MQ 5 Gas Sensor			LCD 1	
		Current (mA)	Power	Gas %	Current (mA)	Power	Current (mA)	Power
1	Filled Class Room	0.21	1.05	58.6	63.2	316	16.8	84
2	Chemistry Lab	0.26	1.3	70.3	75.5	377.5	16.6	83
3	Ground (Afternoon)	0.17	0.85	38.9	43.1	215.5	16.3	81.5
4	Ground (Night)	0.2	1	52	58.7	293.5	15.9	79.5
5	AC Hall	0.2	1	46.7	51.7	258.5	16.6	83
6	Kitchen	0.23	1.15	63	67.3	336.5	16.8	84
7	Industry	0.28	1.4	72.3	79.6	398	16.7	83.5

Table.1(b). Comparison Table

S.No	Location	ZigBee 2		MQ 6 Gas Sensor			LCD 2	
		Current (mA)	Power	Gas %	Current (mA)	Power	Current (mA)	Power
1	Filled Class Room	37.1	185.5	38.6	66.8	334	18.4	92
2	Chemistry Lab	40.6	203	66.3	78.2	391	18.9	94.5
3	Ground (Afternoon)	35.17	175.8	14	53.5	267.5	17.3	86.5
4	Ground (Night)	36.2	181	42.3	71.7	358.5	16.9	84.5
5	AC Hall	36.2	181	24.1	66.8	334	18.6	93
6	Kitchen	38.3	191.5	47.5	73.3	366.5	18.2	91
7	Industry	43.28	216.4	52.6	84.6	423	17.7	88.5

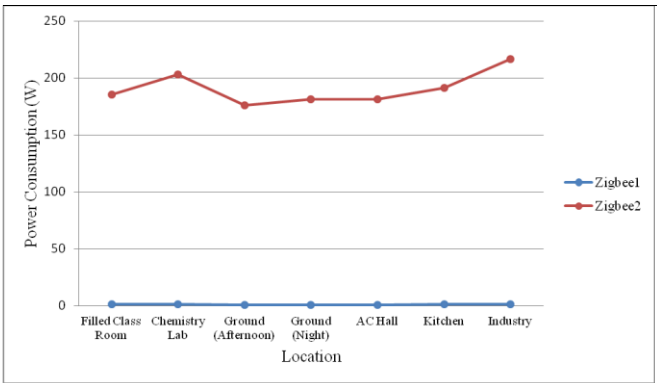

Fig.4. Plot for ZigBee Transmitter Power Consumption

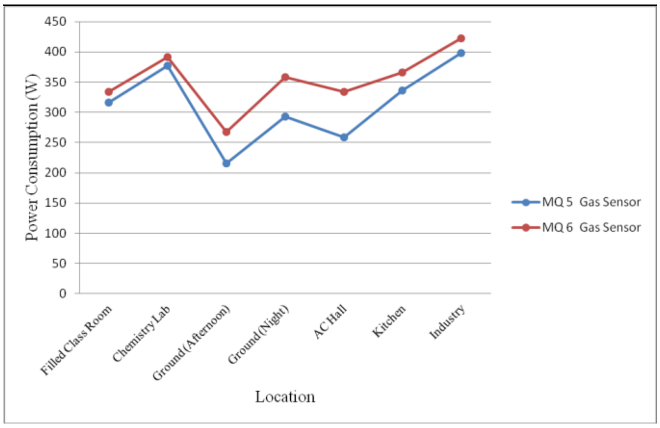

Fig.5. Plot for Gas Sensor Power Consumption

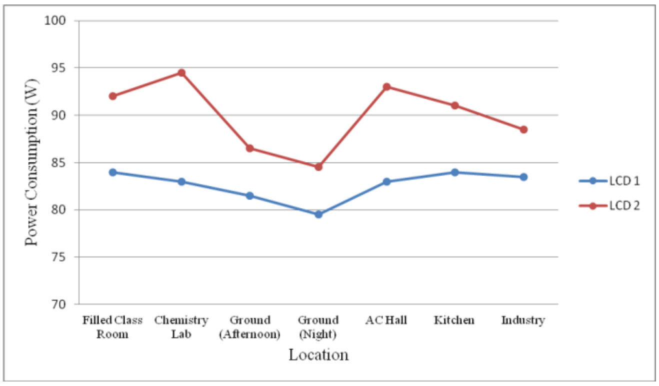

Fig.6. Plot for LCD Power Consumption

Conclusion

The hardware setup is such that each component can be replaced by another counterpart which consumes considerably different power. By considering more alternatives for each component in a circuit, their corresponding power consumption can also be analyzed. By performing such analysis for several different scenarios where the embedded system is to be implemented, the component with least power consumption for that specific application can be determined. By aggregating the values of power consumed by them, the overall power consumed by the embedded system can also be determined and hence power consumption can be minimized for the same embedded system in every different application. This project idea serves as a methodology of determining a low power consuming setup for an embedded system based on the scenario in which the system is implemented. It takes into consideration several aspects of the environment where portable embedded systems are used and helps to establish a configuration that helps minimize power consumption with respect to the application.

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