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A Novel Embedded Based Power Management System

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Abstract: ***Power management is the key factor in distribution automation system. We propose a novel embedded system that captures the load power requirement and then send it to a console master computer where software designed in matlab handles the load requirement according to user defined constraints.***

Keywords: Embedded system, distribution automation , graphical user interface , current sensor

1. Introduction

An embedded system is a computer system with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints. It is *embedded* as part of a complete device often including hardware and mechanical parts. Embedded systems control many devices in common use today [1].

Examples of properties typical of embedded computers when compared with general-purpose ones are low power consumption, small size, rugged operating ranges, and low per-unit cost. This comes at the price of limited processing resources, which make them significantly more difficult to program and to interface with. However, by building intelligence mechanisms on the top of the hardware, taking advantage of possible existing sensors and the existence of a network of embedded units, one can both optimally manage available resources at the unit and network levels as well as provide augmented functionalities, well beyond those available [4]. For example, intelligent techniques can be designed to manage power consumption of embedded systems [5].

Modern embedded systems are often based on microcontrollers (i.e. CPUs with integrated memory or peripheral interfaces) but ordinary microprocessors (using external chips for memory and peripheral interface circuits) are also still common, especially in more complex systems. In either case, the processor(s) used may be types ranging from general purpose to those specialised in certain class of computations, or even custom designed for the application at hand. A common standard class of dedicated processors is the digital signal processor (DSP)[19].

Since the embedded system is dedicated to specific tasks, design engineers can optimize it to reduce the size and cost of the product and increase the reliability and performance. Some embedded systems are mass-produced, benefiting fromeconomies of scale.

Power management for computer systems has traditionally focused on regulating the power consumption in static modes such as *sleep* and *suspend*. These are de-activating states, often requiring a user action to re-activate the system. There are usually significant latencies and overheads for entering and exiting these states, and in desktop and server systems a firmware layer typically supports these modes [20].

Dynamic power management refers to power management schemes implemented while programs are running [**1**]. Many architectures provide the equivalent of a *halt* instruction that reduces CPU power during idle periods. The operating system and device drivers may also manage power of peripheral devices, for example spinning down disks during
periods of inactivity. Highly integrated processors with on-board peripherals often include software-controlled clock management capabilities to reduce power consumed by inactive peripherals and peripheral controllers. The memory subsystem also provides a profitable area for dynamic power management, either through the memory controller implementation or through software-based schemes[15].

Recent advances in processor design techniques have led to the development of systems that support very dynamic power management strategies based on dynamic voltage and frequency scaling. Since CPU power consumption typically decreases with the cube of voltage while frequencies scale linearly with voltage, significant opportunities exist for tuning the power-performance tradeoff to the needs of the application. Processors such as the Transmit Crusoe, Intel Strong and Scale processors, and the recently announced IBM PowerP 405LP allow dynamic voltage and frequency scaling of the processor core in support of these ynamic power management strategies. Aside from the Transmit system, all of the processors named above are highly integrated system-on-a-chip (SOC) rocessors designed for embedded applications. The applications of these processors typically do not include a traditional BIOS, therefore control of the dynamic power state of the system must be implemented in the operating system[12].

The need to save power and distribution automation

Distribution automation spans a broad field of applications from product automation to distribution plants. For all these applications, there are numerous challenges to be faced like reduced time-to-market, reduced costs, increased variability and expectations concerning higher quality. Domain engineering has been developed for software and offers a good approach for meeting these requirements, since it is based on reusability. Unfortunately, the adoption of this approach to distribution automation systems is not possible without major changes. Distribution automation possesses distinguishing characteristics, which require deeper research and new methodologies, in order to enable a systematic reuse. A new approach, based on the domain engineering approach applied for software, is being currently developed. The new approach considers the characteristics of distribution automation by taking not only software into account, but also hardware and the knowledge necessary to develop new distribution automation systems.

In the field of distribution automation, the requirements are very tight and security is prime concern. In addition to tightly constrained performance and security, the overall cost for automation must not interfere with the very basic business objective i.e. profit. With the improvement in science, several novel methods [1] are developing in the sector of automation. Some highly popular of them are LAN (Local Area Networking) [2], PLC [3] (Power line communication), ZigBee[4][5] , CAN (Control Area Network) etc

Electrical energy demand is ever increasing. Electric power is normally generated at 11-25kV in a power station. To transmit over long distances, it is then stepped-up to 400kV, 220kV or 132kV as necessary. Power is carried through a transmission network of high voltage lines. Usually, these lines run into hundreds of kilometers and deliver the power into a common power pool called the grid. The grid is connected to load centers (cities) through a sub-transmission network of normally 33kV (or sometimes 66kV) lines. These lines terminate into a 33kV (or 66kV) substation, where the voltage is stepped-down to 11kV for power distribution to load points through a distribution network of lines at 11kV and lower. Today over 21% of the total electrical energy generated in India is lost in transmission and distribution. The electrical power deficit in the country is currently about 18%. Clearly, reduction in distribution losses can reduce this deficit significantly. It is possible to bring down the distribution losses to a 6-8 % level in India with the help of newer technological options in the electrical power distribution sector which will enable better monitoring and control. The power network, which generally concerns the common man, is the distribution network of 11kV lines or feeders downstream of the 33kV substation. Each 11kV feeder which emanates from the 33kV substation branches further into several subsidiary 11kV feeders to carry power close to the load points (localities, industrial areas, villages, etc.,). At these load points, a transformer further reduces the voltage from 11kV to 415V to provide the last-mile connection through 415V feeders (also called as Low Tension (LT) feeders) to individual customers, either at 240V (as single-phase supply) or at 415V (as three-phase supply). A feeder could be either an overhead line or an underground cable. In urban areas, owing to the density of customers, the length of an 11kV feeder is generally up to 3 km. On the other hand, in rural areas, the feeder length is much larger (up to 20 km). A 415V feeder should normally be restricted to about 0.5-1.0 km. unduly long feeder‟s lead to low voltage at the consumer end.

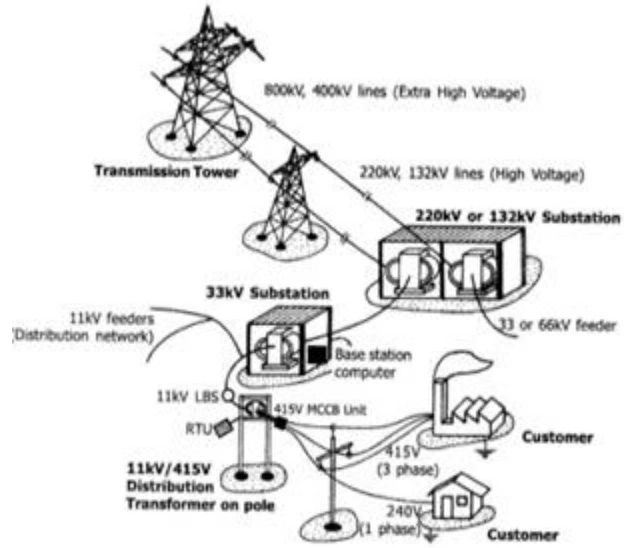

Figure 1: Typical Power Transmission and Distribution Scenario with DA components

2. Traditional Approach to Distribution Automation and Power Management

Distribution automation is normally deployed in distribution with the purpose of enhancing safety, comfort, communication and power saving with less human interaction. It usually consists of sensors and actuators. Sensor is used to collect data from the physical environment while actuators are meant to make decisions based on the information gathered by the sensors [3]. A network is also required for the purpose of establishing communication between sensors and actuators [4]. As the technologies become advances, the current automation system has been developed to be more flexible and adaptable to the changing scenario [5].

From the rapid advancement in technology, various type of information can be shared easily, efficiently, and effectively through networking. There are many communication networks such as local area network (LAN), power line communication, ZigBee and so on are suitable to be implemented as the smart home network. LAN generally provides high-bandwidth communication over inexpensive transmission media such as twisted pair, coaxial cable and fiber optic. However, a set of software protocols which is necessary to be implemented in the host computers to enable the LAN to transmit and receive the control data from one host or device to another via the transmission mediums of the network. The software protocols are the integral part which functions at various levels, starts from low level packet transport protocols to high-level application protocols [6].

Traditionally, power lines are only intended for conveying electrical power to devices and not designed for delivering high-frequency signals. Although the advancement of signal modulation and error control coding techniques have made power line communication (PLC) become possible [7], it is not suitable for signal transmission due to noise and interference in the power line channel. Consequently, power line signal transmission will encounter variety of characteristic impedances. ZigBee is the first industrial standard using wireless personal area network (WPAN) technology that provides short range, low power and low data rate communication, and also supports mesh networking and multihopping. However, ZigBee networks are primarily intended for low duty-cycle sensors especially for those active for less than 1% of the time [8], [9].

3. Circuit Diagram

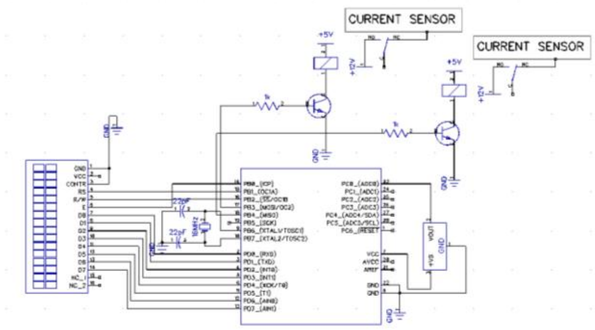

Figure 2: Circuit diagram of the overall system

The heart of the circuit is ATMEGA 328 microcontroller system . It gets the data from the current sensor and then sends the data to the matlab environment where the data is processed and then matlab after processing the data sends the signal to the microcontroller which then takes appropriate actions.

4. Current Sensor

The Winson WCS2202 provides economical and precise solution for both DC and AC current sensing in industrial, commercial and communications systems. The unique package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, over-current fault detection and any intelligent power management system etc… The WCS2202 consists of a precise, low-temperature drift linear hall sensor IC with temperature compensation and AC to DC rectifier circuit and a current path with 8.3 mΩ typical internal conductor resistance. This extremely low resistance can effectively reduce power loss, operating temperature and increase the reliability greatly. Applied current flowing through this conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional rectified DC voltage. The terminals of the conductive path are electrically 1,000V isolated from the sensor leads. This allow the WCS2202 current sensor to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques and make system more competitive in cost.

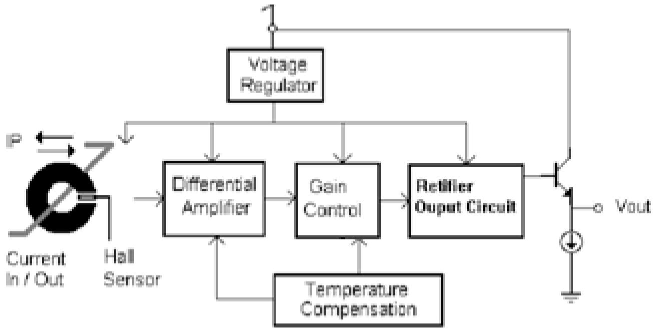

Figure 3: Functional block diagram of WCS2202

MATLAB GUI

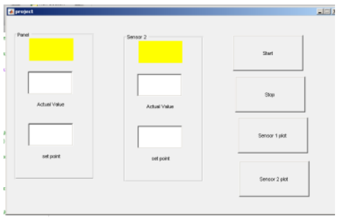

Figure 4: Matlab based graphical user interface

The figure above shows the matlab based graphical user interface in which there are controls which enables the user to set a limiting point for current sensors and then after starting the communication the microcontroller takes action accordingly . Also the system continuously logs the data from the sensor and the graph could be printed at any time . The sample graph for a particular instance is as shown below

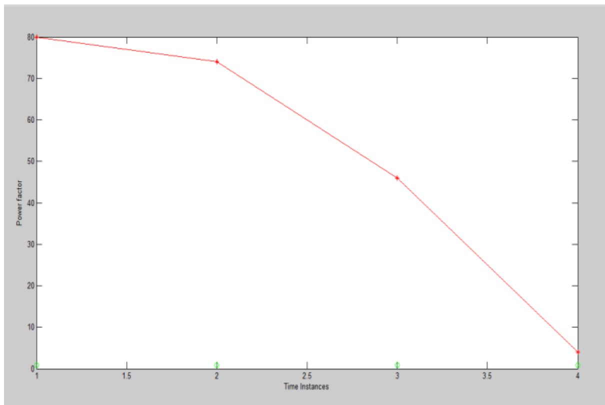

Figure 5: Values for current sensor 1

5. Conclusion

In this project the primary purpose was to develop a system working on matlab and embedded system which would control various physical nodes in the form of sensors and feedback mechanism. Based on the simulation results, the proposed system has the capability of controlling physical nodes in any scenario and have wide practical usages.

Several benefits of the project that had made the work useful for modern industry are GUI,ease of operation, graphical results and low cost.Moreover embedded system itself provides high electrical immunity to the signals as compared to traditional electronic systems. This perfected system enables the user to control a plethora of physical nodes by a click of a button.

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