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Model Predictive and Genetic Algorithm (GA) – Based Optimization of Residential Temperature Control in The Presence of Time-Varying Electricity Prices

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ABSTRACT:

This paper presents an optimal control algorithm for residential temperature regulation. The combination of concepts from system identification, model-predictive control, and genetic algorithms result in an optimization methodology capable of achieving an acceptable compromise between comfort and cost in the presence of constant as well as time-varying electricity prices. Simulation results demonstrate that the proposed approach has the potential to achieve substantial energy savings and cost reductions while maintaining acceptable comfort levels with minimal consumer participation. There is no existing method is available for device control based on temperature and also cost effective time-varying Electricity prices. Thus the way we go for the proposed system. In the proposed system, microcontroller is connected with Zigbee, temperature sensor and LCD. In this outside and inside temperature are monitored depends upon the outside temperature the inside temperature is automatically controlled. For temperature control we use either fan or AC this device is choose depends upon the time varying electricity price for example, if pick time means switch on the fan or else if normal time means switch on the AC. The device selection depends upon the control section.

Index-Terms:
ARM7 controller, LCD, ZIGBEE module, Temperature sensor, Loads, Transistors.

INTRODUCTION:

The increasing demand for electricity, diminishing supplies of fossil fuels, concerns for the effect of greenhouse gas emissions on climate change, etc., render the current model for generation and consumption of electricity unsustainable.

Furthermore, electric energy market deregulation, variable electricity generation costs, power system congestion, and other factors have prompted an increasing trend to charge a time varying price for electricity at the residential level. Several time-differentiated pricing models have been proposed: real-time pricing (RTP), day-ahead pricing, time-of-use pricing, etc.

Theoretically, allowing the price of electricity to fluctuate could serve as an incentive for consumers to reduce electric energy consumption at peak times when the energy is expensive to produce and deliver. Such reductions could, in turn, alleviate power system congestion, as well as provide economic and environmental benefits for society as a whole. Several studies have been conducted to evaluate these potential benefits. The aforementioned pricing models have one common denominator: They rely on active customer participation as well as on their ability to make intelligent decisions concerning their energy consumption patterns.

Recent studies have shown that most users find many barriers to respond to time-varying prices. Understandably, not all users will have the time, desire, knowledge, etc., to assume this responsibility. Under this framework, technologies capable of aiding consumers to automatically improve their energy consumption patterns become paramount. Such technologies would not only provide tangible economic gains but would also promote sustainable societal consumption of electricity with minimal additional effort from consumers.

II. RELATED WORK:
2.1 TRANSMITTER SECTION:

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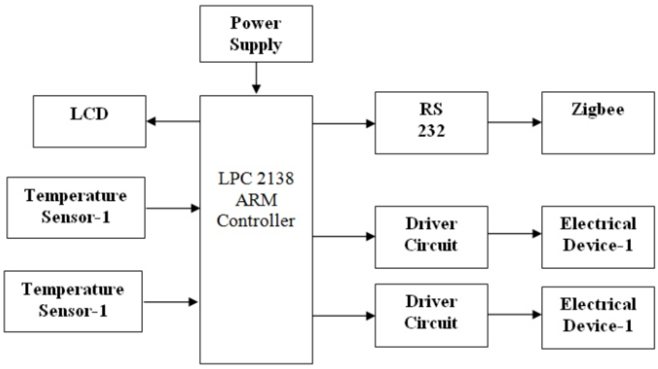

Figure-1: Transmitter Block Diagram

2.2 COLLECTING SECTION:

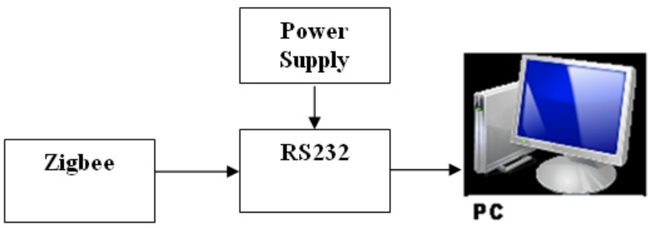

Figure-2: Receiver section

2.3 ARM7 PROCESSOR:

ARM is a 32-bit RISC processor architecture developed by the ARM Corporation. ARM processors possess a unique combination of features that makes ARM the most popular embedded architecture today. First, ARM cores are very simple compared to most other general-purpose processors, which means that they can be manufactured using a comparatively small number of transistors, leaving plenty of space on the chip for application specific macro cells. A typical ARM chip can contain several peripheral controllers, a digital signal processor, and some amount of on-chip memory, along with an ARM core. Second, both ARM ISA and pipeline design are aimed at minimizing energy consumption — a critical requirement in mobile embedded systems. Third, the ARM architecture is highly modular: the only mandatory component of an ARM processor is the integer pipeline.

III. HARDWARE IMPLEMENTATION:
3.1 ZIGBEE MODULE:

ZigBee is a low-cost, low-power, wireless mesh networking proprietary standard.

The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries, and the mesh networking provides high reliability and larger range. The ZigBee Alliance, the standards body that defines ZigBee, also publishes application profiles that allow multiple OEM vendors to create interoperable products. The protocols build on recent algorithmic research (Ad-hoc On-demand Distance Vector, neuRFon) to automatically construct a low-speed ad-hoc network of nodes. In most large network instances, the network will be a cluster of clusters. It can also form a mesh or a single cluster. The current profiles derived from the ZigBee protocols support beacon and non-beacon enabled networks.

3.2 TEMPERATURE SENSOR:

LM35 series sensors are precision integrated-circuit temperature sensors whose output voltage is linearly proportional to the Celsius temperature. The LM35 requires no external calibration since it is internally calibrated. . The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air.

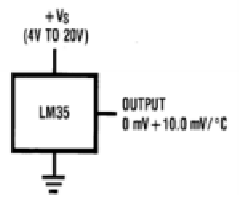

Figure-3: Temperature sensor

3.3 LIQUID CRYSTAL DISPLAY:

The LCD panel's Enable and Register Select is connected to the Control Port. The Control Port is an open collector / open drain output. While most Parallel Ports have internal pull-up resistors, there are a few which don't. Therefore by incorporating the two 10K external pull up resistors, the circuit is more portable for a wider range of computers, some of which may have no internal pull up resistors.

We make no effort to place the Data bus into reverse direction. Therefore we hard wire the R/W line of the LCD panel, into write mode. This will cause no bus conflicts on the data lines. As a result we cannot read back the LCD's internal Busy Flag which tells us if the LCD has accepted and finished processing the last instruction. This problem is overcome by inserting known delays into our program. The 10k Potentiometer controls the contrast of the LCD panel. Nothing fancy here. As with all the examples, I've left the power supply out. You can use a bench power supply set to 5v or use a onboard +5 regulator. Remember a few de-coupling capacitors, especially if you have trouble with the circuit working properly.

Figure-4: Liquid crystal display

IV. RESULTS:

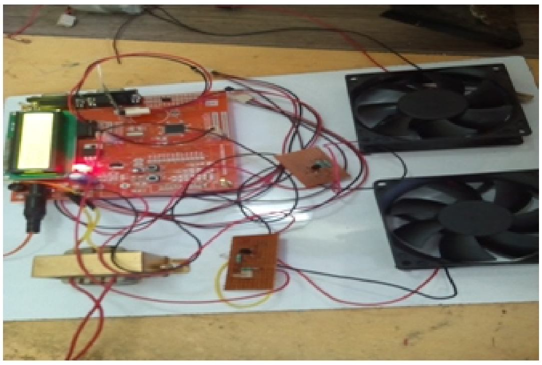

Figure-5: Hardware output

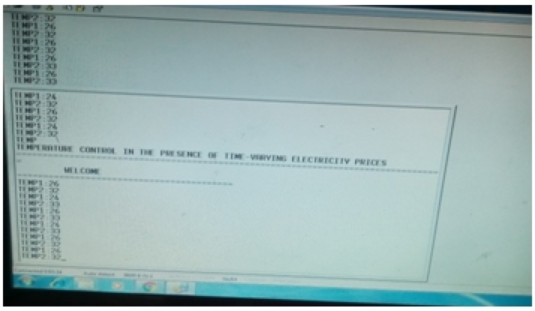

Figure-6: Output on PC

V. CONCLUSION:

Home automation technologies will be paramount to modify the energy consumption patterns of residential customers.

To achieve widespread utilization, such technologies must be capable of providing tangible economic incentives to customers. This paper has presented the development of an optimal control algorithm for optimization of the temperature regulation system in residential buildings. Concepts from system identification, model-predictive control, and GAs were incorporated into one routine capable of achieving an acceptable compromise between comfort and cost in the presence of time-varying electricity prices. Simulations showed that the optimization routine has the potential to increase comfort while minimizing costs and energy consumption by helping users shift their energy consumption to off-peak times when energy is cheaper. Also, the flexibility of the routine to accommodate different user preferences was demonstrated using two different settings: one that emphasized monetary costs and one that emphasized comfort.

Future work will focus on evaluating the proposed mechanism in real residential buildings. It is likely that more powerful and flexible system identification mechanisms will be necessary to cope with the higher complexity of real buildings. However, the system identification effort does not change the core of the optimization routine presented in this paper, and therefore, the proposed methodology is general enough to be applied in real world buildings. Higher returns might be attainable if consumer behavior is also included in the optimization algorithm, since the higher tolerance for temperature deviations from room to room has not been exploited at this point. Forecasting algorithms for energy price, solar irradiance, and outside temperature are currently being pursued to improve the results presented here.

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