MULTIPHYSICS SIMULATIONS OF AN ENERGY EFFICIENT IOT-BASED SMART HOME

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ABSTRACT

The concept of “automated home/smart home” was first introduced over 80 years ago and has been facing different technical limitations since then. Recently, service providers and home appliance manufacturers have launched a new initiative to bring the concept of smart homes to reality. This Smart Home initiative allows subscribers to remotely manage and monitor different home devices from anywhere via smart phones or over the web with no physical distance limitations. With the ongoing development of mass-deployed broadband internet connectivity and wireless technology, the concept of a Smart Home has become a reality where all devices are integrated and interconnected via through the wireless network. These “smart” devices have the potential to share information with each other given the permanent availability to access the broadband internet connection. Hence, the Smart Home Technology has become part of Internet of Things (IoT), the wireless sharing of information.

A new challenge is now present in the design process of a Smart Home. In today’s world the Smart Home is not enough to the environmentally-conscious user, but energy efficiency is a key. The future of Smart Homes is to be coupled with energy efficiency to yield an energy efficient IoT-based Smart Home. The IoT provides a strong tool that not only connects wireless communication devices but wireless sensors for heating/cooling or any needed utility within the house to better manage energy usage as well as enhance the living experience in modern homes.

In this work, a house model is analyzed to demonstrate the comprehensive simulation studies on consumed energy reduction for lighting as well as home cooling and heating. With ANSYS software, various Multiphysics simulations were carried out on the kitchen room portion of the house. Camera/motion sensor were used as part of the home security system and were coupled with the home light and HVAC control system to remotely switch on/off the lights and turn on/off the heating/cooling system when a person enters or leaves the room. The camera/motion sensor is to send signals to the home security system and energy control unit when motion is detected within the room or movement throughout the house. Integration of the different smart technologies is also studied including smartwatch communication with home control unit as an example of customizing the Smart Home for the user-based experience.

ANSYS software allows engineers to perform different types of analysis including detailed human models to ensure high design fidelity. The electromagnetic fields generated from different antennas located in the home energy control unit, security/motion sensors/cameras, LED light bulbs, and the actuator for HVAC duct dampers are modeled in ANSYS HFSS. The coupling/RF interference between these antennas within their RF circuitries are simulated using ANSYS DELCROSS EMIT. Signal integrity is examined to ensure IoT-enabled devices can communicate seamlessly to execute an energy saving protocol. The protocol turns on the LED light bulb and an actuator to open the HVAC duct damper when an occupant enters the kitchen area and gets sensed by the security/motion sensor/camera. ANSYS FLUENT is utilized to perform a CFD analysis of the transient flow after opening the HVAC damper plate along with the flow and temperature distributions in the area. Evolution of flow and temperature in the area as a function of time after damper opening is determined. A detailed thermal study of the internal components of the LED light bulb in ANSYS ICEPAK shows the temperature distribution in the light bulb. The CFD results show how the energy saving protocol manages temperature in the area and inside the critical components for cooling and lighting. They also provide insight to optimize the home control unit operations. The simulation strategies addressed in this work can be utilized to create a virtual smart model of an IoT-enabled smart home and the fundamental elements. Such computational methodologies can be extended to other home parts and buildings such as warehouses, commercial buildings, stadiums, and shopping malls.