Capacitive Touch Buttons & Sliders for Consumer Electrical Application with Wireless 2.4 GHz 802.11b Wireless Communication

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***Abstract*—In this day and age, communication is a very integral part of our society. For communication with electrical appliances, these device allowing to control of appliances remotely and by a finger touch. Touch sensors have been around for years, but recent advances in mixed signal programmable devices are making capacitance-based touch sensors a practical and value-added alternative to mechanical switches in a wide range of consumer products. Control over home appliances, and more generally, control over a devices or any appliances by finger touch.**

***Index Terms*—Capacitive touch, CSM, Mtouch, SSR, CAN, Ethernet, WiFi.**

I. Introduction

CAPACITIVE sensing is becoming more prevalent and in demand for consumer applications. Several techniques for capacitive sensing are currently present in industry. Many are based on measuring a frequency or duty cycle which is changed by the introduction of additional capacitance from a persons finger to ground. Some other methods use charge balancing or rise and fall time measurements. This solution measures frequency using a free-running RC oscillator.
While capacitive sensing has been around for more than 50 years, it is becoming increasingly easier to implement and more popular. A classic example of a capacitive switch is the Touch Lamp. The Touch Lamp has been around for a long time, and it is a simple, capacitive switch that turns a light bulb on, off or dims it. New technology allows much more sophisticated control of touch buttons. A key to this has been micro controllers with mixed signal peripherals. They provide the ability to perform capacitive sensing, decision making, responsive actions and other duties pertinent to the system as well. Capacitive Touch Electrical Switches March 05, 2012

II. Proposed Design Solution

Our proposed solution is to create a Capacitive Touch pads for Consumer Electrical Application with several communication methods. This solution will have a high performance PIC Micro-Controller which will act as a master, to a series of low powered sub IC for I/O expansion and LED controlling. The master micro controller will communicate to the sub sections over a I^2C bus. This network will save costs by combining the power and communication lines into a single entity. In addition, it also consists of a very friendly user interface. This I^2C bus helps to decrease the length of the PCB wires because it uses the bus structure.
The inter-networking is done by IEEE standards Ethernet and WiFi. And the switch board interconnection is done by Controller Area Network. The user will select devices to be activated or deactivated by capacitive touch switches, which they will be also able to access from any computer connected to the LAN or WiFi. This communication program will be stored on the another micro controller, which will collect data from CAN bus and convert it in to Ethernet. When a user has finished selecting devices the Ethernet micro controller will then send the data to the CAN bus and device micro controller which will decide the actions on the output.
For this project we attempt to control several simple devices such as lamps, fan and power plugs. If more time and funding were available, we would attempt to control more complex devices such as a door camera and take out values of current measurement, faulty indications.

III. System Overview

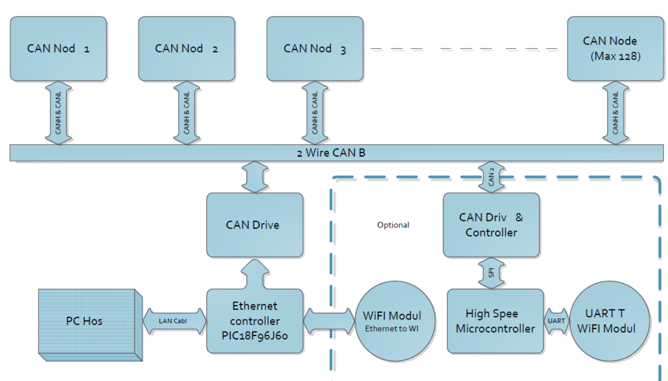

Fig. 1. System overview, CAN and Ethernet bus connections

The Prometheus general block diagram in Figure 3.1 shows the basic functionality of our product. The user can easily control a desired device remotely in the building from the host PC. The building Ethernet controller determines what device the user intends to control by the data received and sends control signals to the control area network (CAN). The control signals are propagated through the CAN bus and the CAN nodes will use the CAN messages to control the home appliances.The touch control have the maximum priority and Ethernet can send forced turn-off message through the CAN

Manuscript created on March 5, 2012.

bus. We are mainly using CAN bus because it's bus topology structure will reduce wiring cost. We need less data rate for this application. So the 1 Mbps speed of CAN is much better option. And the message based signalling will help the system to force turn off, turn on, activating emergency lights etc..

IV. Ethernet Controller

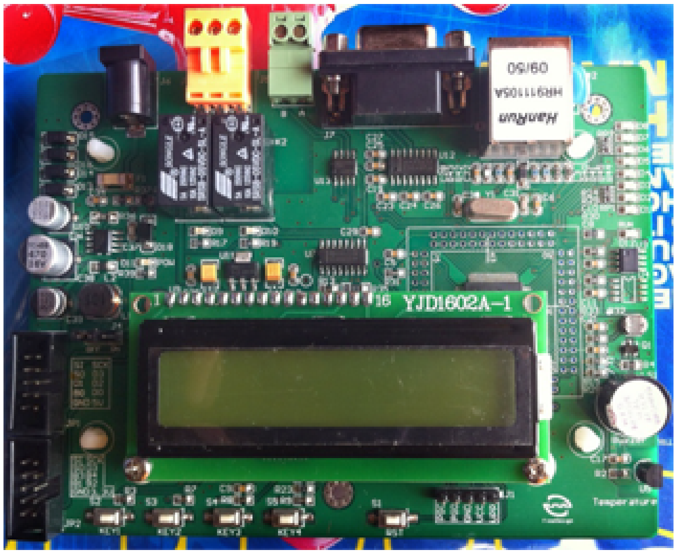

Fig. 2. Ethernet Development Board

Here master controller act as Ethernet controller. PIC18F96J60 is used for communicating with Ethernet and CAN. This will act as Ethernet to CAN translator. The default CAN messages are transmitted by this master controller. This master controller have inbuilt Ethernet controller and transmit/receiver. So by using this PIC controller we can reduce the system complex and power conception.
This development board also contains communication standards RS232/485 standards so we can easily troubleshoot the firmware. For testing purpose this development board includes LDR, temperature sensor, 8 led status indicators, buzzer, 16*2 LCD and 2 SPST relays.

V. Touch Pad Board

Capacitive touch board is etched on a 4 layer FR4 based PCB. These four layers are used to touch button, noise reducing ground, touch button connections and back light & status LED connection.
This touch board consist of 4 switches, one fan controller with 5 steps, 2 USB charging points, locking button, IR receiver and proximity pad. So by using this board we can control 3 lights, one fan with on-off switch. The back light LED are embedded on proximity pad because the CAP channel for proximity is used as ground connection to back light. The basic behind this selection : we need proximity when the device in sleep mode and we need back light at time device is off & proximity is not needed at that time. We included USB charger because at this time all the portable devices are charged using USB.

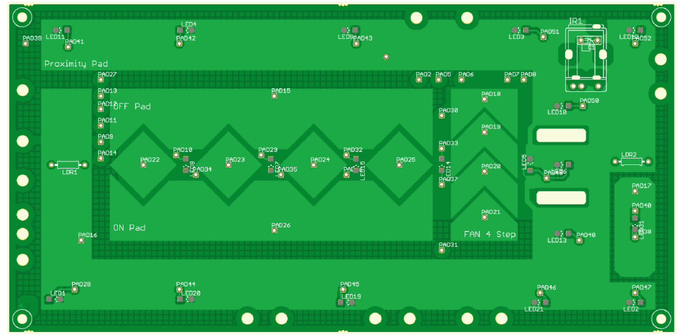

Fig. 3. Capacitive touch panel top view

eg : mobile phone, digital camera, ipod, iphone etc. IR sensor is used to control the device by using common remote and wireless firmware updation for device controller.

VI. Device Controller

The Microchip PIC micro controllers are used for controlling the capacitive touch pads and relays. For Capacitive sensing mainly three methods are used. Main characteristics difference are speed, power conception, sensitivity, and cost. The three methods are

1) CVD - Capacitive Voltage Division method
2) CSM - Capacitive sensing module method
3) CTMU - Charge Time Measurement Unit method

Capacitive Voltage Division: This method describes a new hardware sensing method called Capacitive Voltage Divider (CVD) which uses no external components. It requires only the ADC to perform capacitive touch sensing. The principle is simple, and can be applied to nearly any Micro Controller device with an ADC. So we can work out CVD in existing micro controller with ADC support. Beacuse it does not need external circuit it's implementation cost is less.

Capacitive Sensing Module: The CSM allows the user to design a capacitive sensing system without an external oscillator circuit. The CSM has its own software-controlled oscillator. It can also monitor up to 16 inputs. In a typical application, the CSM is directly attached to pads on a PCB and covered by an insulating material. When the insulating material above a pad is touched by the user?s fingertip, the capacitance of the pad increases, thus causing a frequency shift in the CSM. This module simplifies the software needed for capacitive sensing: it is only necessary to initialize a few registers and then set the appropriate method of measuring the change in frequency. It's very easy method for measurement of capacitive sensing. We need to check the value of timer to decide touch. It's also less expensive, but this is module is embedded in less no of controllers. PIC16F7xx controller have CSM module inbuilt.

Charge Time Measurement Unit: This method describes the use of Microchips Charge Time Measurement Unit (CTMU) for capacitive touch applications. The CTMU is an excellent peripheral for use in touch sensing applications. The CTMU is used in capacitive touch applications by applying the constant current source of the CTMU to the capacitive touch pad using the following equation: $I * T = C * V$

VII. CAN Bus Structure

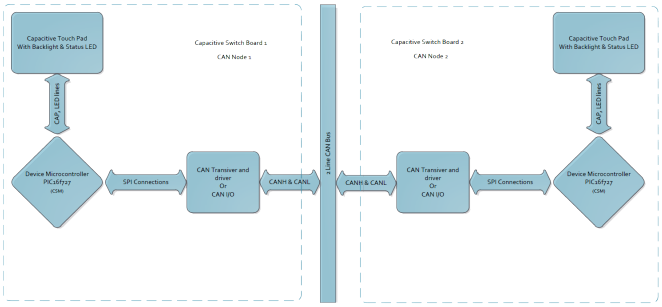

Fig. 4. CAN bus structure

Fig 7.1 shows the overall CAN bus structure of the system. Two type of nodes are commonly used. CAN I/O baser node and CAN driver based node. CAN driver node are used where high capacity is needed. And CAN i/o is used analogue input, digital input, digital output & PWM output. Fig shows 2 nodes, each node have it's own driver, Micro controller and Touch panel. Commonly each nodes send the status of that section periodically or at any status change. We selected Microchip CAN IC's because it have better availability and programming support. MiKroC is the best C based tool to develop PIC based devices. CAN transceivers are always needed for level conversion to the standard CAN voltage. And CAN I/O or driver are next connecting part. The IC's used for this bus structure are MCP2551 (CAN Transceiver), MCP2515 (CAN Controller) & MCP25055 (CAN I/O). Some of the 18f series PIC also supports inbuilt CAN controller.

VIII. Use of IEEE Standards

We mainly uses 3 main communication protocols in this project. The main two protocols are IEEE based.

1) 10BASE-T standalone Ethernet IEEE 802.3i
This is main communication used in this project. We made use of this standard to aid us towards achieving data transmission from Host PC to master controller. This standard is provided with many useful guidelines regarding wiring, host pc software selection, noise considerations, and channel losses which were very useful in regards to completion of our project. Also it's a widely using protocol in local area networking. So we can easly place master controller any where in the Ethernet bus by using a simple Ethernet switch.
2) WiFi 2.4 GHz IEEE 802.11b
This communication is used to convert the Ethernet protocol to wireless where the we can't do wiring by the construction effect of the building or another environmental conditions. Two type of method are used to implement the WiFi to our project. First method is to convert the Ethernet to WiFi by Hotspots and second is by serial to WiFi module. WiFi is globally accepted network, we can control master controller or the entire network by wifi enabled tablets and smart phones.
3) CAN Network ISO standard (ISO 11898)
This is used to interconnection between the device controller and master controller. This network have a best feature that it's bus structure. By using the bus structure, we can add nodes by simple parallel connection from the 2 wire bus. One main important thing is it need terminating resistance on each end.

IX. Current State of the Project

The Prometheus system can currently control home electrical devices through a finger touch on the Touch based Switch Board. A user can log onto a PC hosted by the master controller with Ethernet communication, which will send control signals through the Control Area Network to the corresponding device controller. The master controller and device controllers each consist of one CAN bus which allows for their transmitting and receiving of data over the bus.

Currently the Master Controller uses a PIC18F96J60 with Ethernet and CAN controller. The master controller can use an CAN to Ethernet interface with a static process which runs the network. This static process, called master controller, sends and receives data from the CAN bus and also reads and send data to Ethernet network. Currently this network is only configured to operate with a maximum of three CAN Node controllers. Each device controller must connect to the CAN network, and will then receive message from bus. In order to communicate with the device controllers, the master controller uses an CAN interface in combination with GPIO. The GPIO is needed to turn on or off the CAN controller of master controller.

The device controller consists of a PIC micro controller connected to the CAN through an SPI and an external device control circuitry used to control devices connected to 230 VAC power line. The device controller takes successive reading from the capacitive touch inputs and it uses special algorithms for decoding. The PIC drives an output pin high to turn a device on, and holds it low when the device is off. When the pin is driven high, it powers the optoisolator LED, which drives the other side of isolator. This in turn provides just enough base current to switch a gate triggered TRIAC. This closes the device circuit and allows the 230 VAC source to power the device.

X. Conclusion

In less than 4 months, through close collaboration between team members, we were able to carry out extensive research and design to develop a functional prototype incorporating the majority of functional specifications promised in a timely manner. Our product is currently capable of controlling the on/off state of any electrical equipment within a building by finger touch and Host PC. Data communication over the CAN bus has been successfully achieved, and consists of minimal error. The micro controllers installed within our system provide extensive communication protocol and security within the system to account for any possible errors.

One of the critical improvements which can be made to our system towards having it ready for market, and we would like to produce it in industrial manner. This device will allow for more safety, easier touch based operation and controllability of our system by the user. The intended final enclosure is to be made of thin glass outer shell and it help us to create a pleasant look and more dielectricity for touch. And the back side of this enclosure have a de-attachable relay modules.

Another improvement to our overall system would be to reduce the overall power consumption of our system implementing smart home techniques, leading to a less costly and more attractive premium device. All of the master micro controller, device controller, CAN and Ethernet modules include circuitry which can be optimized more towards increasing the systems efficiency and reliability.

Lastly, our final product will need to be capable of controlling more complex devices. Currently, our system can only control the on/off state and simple speed controlling of the corresponding electrical devices. As for future improvements, we are aiming to interact further with the internal circuitry of more complex devices. For example, we could use our system to control the overall operation of an automatic fan, light such as controlling its temperature and ambient light.

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