Advanced Universal Remote Controller for Home Automation and Security

Taewan Kim, Hakjoon Lee, and Yunmo Chung

Abstract — *There has been inconvenience in controlling each digital home appliance which requires its own remote controller. In this paper, we present an advanced universal remote controller (URC) with the total solution for home automation and security. All kinds of home appliances can be controlled with the URC, which can be also connected to a PC dealing with Internet as well. To use the URC, we need several receivers with wired or wireless communication methods to be connected to all appliances. The receivers have many channels and IDs to control many appliances at the same time and to support multi-zone services. In addition, we propose a PC-based interface for end-users to use the URC conveniently. With the proposed URC, we can easily construct a ubiquitous home automation and security environment with the total solution. Furthermore, this solution can be applied to the automated control of all kinds of appliances installed within buildings for companies, schools, hospitals, and so on.*

Index Terms — **Digital Appliance, Universal Remote Controller, Home Automation and Security, Total Solution.**

I. INTRODUCTION

With the increasing use and popularity of remote controllers, they have been regarded as one of the best inventions in the 21st century because of the convenience and easiness to use. Recently, the wide usage of remote controllers with digital technology has been rapidly extended to customer devices such as car keys, air conditioners, and game controllers, as well as home appliances such as TVs, DVD players, game controllers, and audios/videos. In addition, remote controllers have been developed for home automation such as lighting and temperature control, door management, and security. Nobody can imagine the convenient and state-of-the-art life without the use of remote controllers because we cannot use each function given for an appliance without them.

Traditionally, since each appliance has required its own remote controller, a user might have had inconvenience to take care of remote controllers as many as the number of appliances. To solve this problem, URCs have been developed in [1 - 3]. The existing URCs, however, have some weak points such as inconvenient user interfaces, restricted control to dedicated appliance, and direct connection of an RF to IR(Radio Frequency to Infrared Ray) receiver to the appliance.

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This connection method restricts the number of appliances with the same characteristics.

In this paper, we present an advanced URC which can control various appliances with convenient user interfaces to overcome the problems mentioned above. That is to say, a user-suitable touch panel technique has been considered as a user-friendly interface to give various services to a user at home. After installing the URC at home, the user can easily control all appliances with various connecting methods. Since the proposed URC has an IR learning function, it is also possible for the URC to control the appliances which don't know their own IR codes. Also the user makes various scenario modes with a PC-user interface as well as the URC itself. The scenario modes make it possible to control many appliances by one button. For instance, the button "movie macro" can make the theater environment by just turning off lights, closing electrical curtains, and turning on a DVD player. Moreover, it might be possible that the powerful scenario mode can be widely used in business offices or school classes.

For more convenient control in connection with a URC, a user can control a home automation system by the PC which is connected to the Internet. In addition, the URC proposed in this paper is also applicable to building automation, security service, parking management, and so on.

The proposed technique to control various appliances with the URC has been designed and implemented by means of various receivers to connect all appliances. For example, it is possible to control audio and video devices with IR signal control, lighting devices and AV switches with RS232/RS485, electric motorized screens and elevation with relay contact control [4]. Receivers are very closely placed between a URC and their appliances for efficient wired or wireless communications. In addition, the URC-based system can be also controlled by a cellular phone with a TCP/IP route.

II. PROPOSED HOME AUTOMATION AND SECURITY SYSTEM

A. Entire system architecture

The goal of the scheme proposed in this paper is to make a user control appliances and equipments easy to be used everywhere all the time. For example, a user in a room can control all the appliances installed in other rooms as well as the room itself. That is, any designated room is able to be controlled by a URC.

Fig. 1 shows an example of the schemes of the home automation and security system proposed in this paper. Under the control of a URC, which can be a wall mountable touch pad or a mobile touch pad, there are three kinds of receivers such as RF to IR-RS232, RF to IR-RELAY, and LAN to Multi-Converter. Various appliances like TVs, DVDs, and

Projectors are connected through suitable receivers with either wired or wireless type. An Internet connection receiver, LAN to Multi-Converter, takes care of CCTV/Door cameras, lobby or guard phones, and other security systems.

In the given environment, a user can control appliances in a direct fashion as well as an indirect way through various receivers and Internet. A user can monitor the outside situation through a door camera or a CCTV installed at home to check visitors. Additionally, various services are possible like a Wi-Fi telephone, a gas security system, a fire alarm system, and a home security system if they are connected to a URC system.
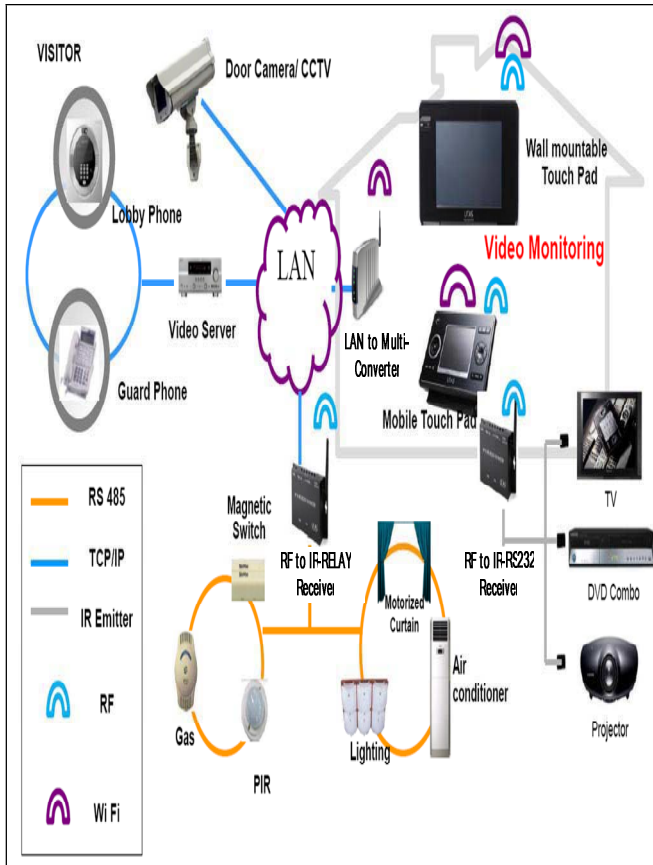

Fig. 1. Proposed home automation and security system

B. Basic control techniques using receivers

In the system proposed in this paper, there are three kinds of receivers as mentioned above, which are constructed with RF signal based on IEEE802.15.4 [5], [6] especially ZigBee protocol. The RF to IR-RS232 receiver shown in Fig. 2 is used for a lighting control system which uses IR and UART communication protocols. In the figure, the RF to IR-RS232 receiver gets control signals from the URC with RF protocol, and then converts the RF signals to RS232 signals. The RS485 converter is used to send the converted RS232 signals further to several places for efficient lighting control at home. Meanwhile, the RF to IR-Relay receiver in Fig. 3 and Fig. 4 can be connected to electronic appliances like electric motorized screens, curtains and windows. The RF to IR-Relay receiver connected to the URC uses RF signals and controls appliances using AC and DC motors together.
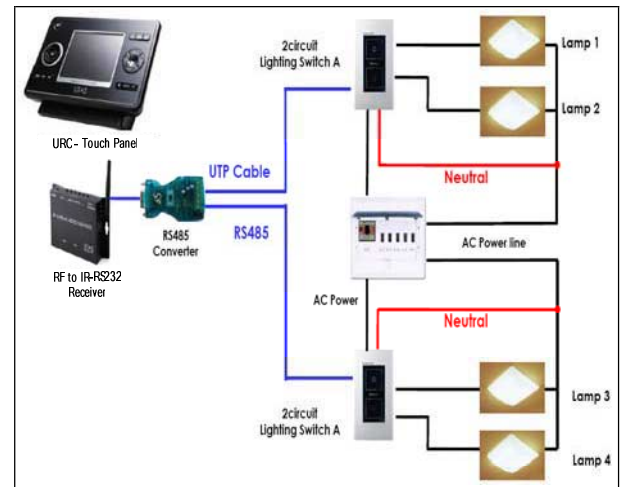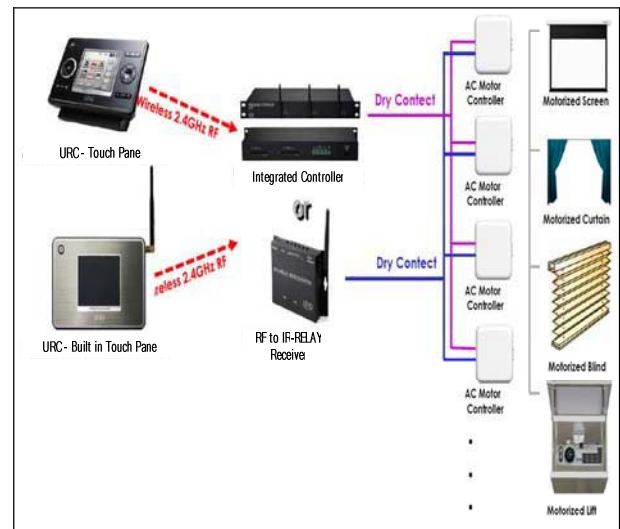

Fig. 2. Lighting control system
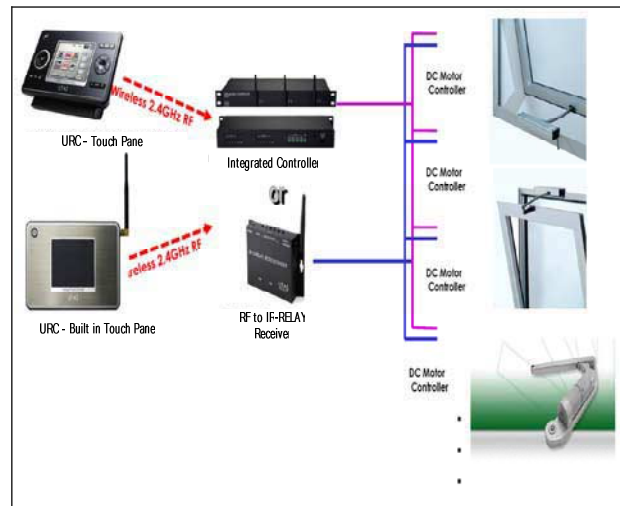

Fig. 3. Motorized shade control system

Fig. 4. Motorized windows operator with DC motor

C. Advanced control methods using Receivers

It is possible to expand the proposed system to several rooms (or zones) with different appliances as shown in Fig. 5 by means of advanced control system with a TCP/IP-based

network. Each room has a LAN to Multi-Converter to support TCP/IP protocols. An integrated controller at each zone in Fig. 5 has three kinds of receivers as mentioned above to transfer control signals from users to appliances in the zone. Based on the scheme, we can control the all the appliances in the system with both a URC and a Manager PC through TCP/IP communication everywhere. This advanced control methods can be applied to several cases such as conference rooms, hotels, and schools.
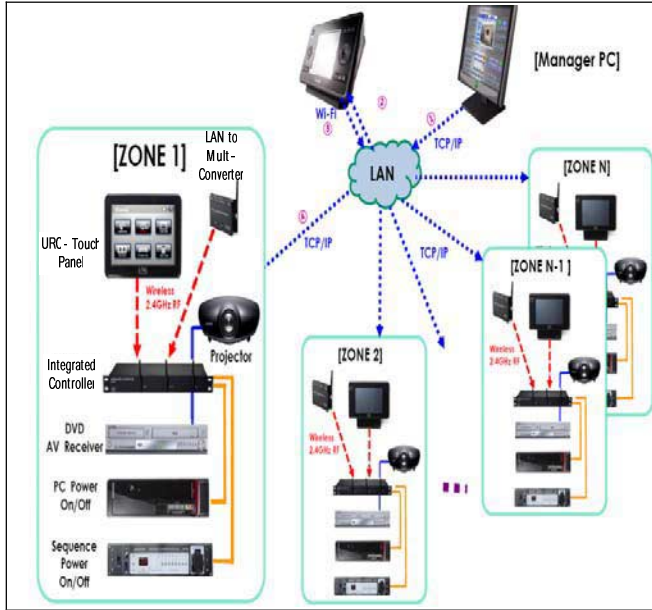

Fig. 5. Advanced control system with network

D. Proposed URC Features

1. IR Learning

A URC has an IR code library to be installed with a wide selection of code-sets for domestic and foreign brands of IR devices, and it also provides a convenient code-sets auto-scan function to help a user find code-sets and register devices. Since it is impossible to have all of IR codes for the URC, the URC supports an IR learning function which directly saves unknown IR codes through appliances.

2. RF control

A URC can separately control many appliances with the same IR frequency. An individual ID is granted for each device or each remote control button in order to prevent unwanted devices to operate if there are several identical devices. There are total 16 RFIDs whose names are composed of numbers from 0 to 9, and alphabets from A to F. Channels are used to prevent frequency interception in case of using a product with RF control method nearby.

3. Wi-Fi-based control and monitoring

Fig.6 shows a door control and monitoring system based on Wi-Fi protocol. The URC touch panel is connected to wireless TCP/IP switcher through the Wi-Fi protocol, and both door camera and lock are also connected to the switcher through corresponding converters. When a visitor pushes a door bell, a

captured image of the visitor with a door camera can be displayed and identified on the portable URC in a real-time mode. In other words, the image through the video server in responding to the door bell is sent to the URC by Wi-Fi networks, and then a user decides the order to open the door. More detailed diagram for Wi-Fi-based door control and monitoring is shown in Fig. 7.
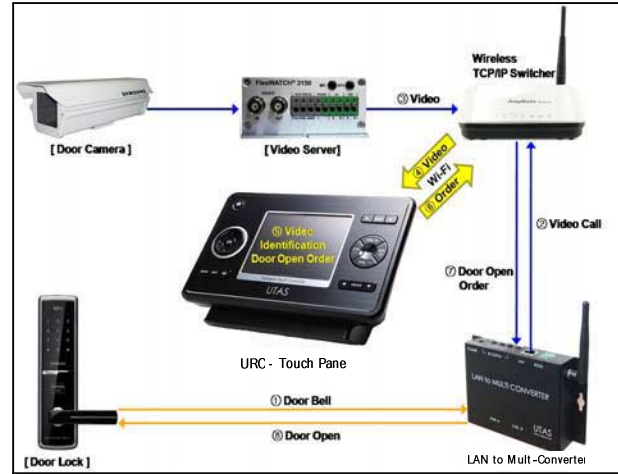

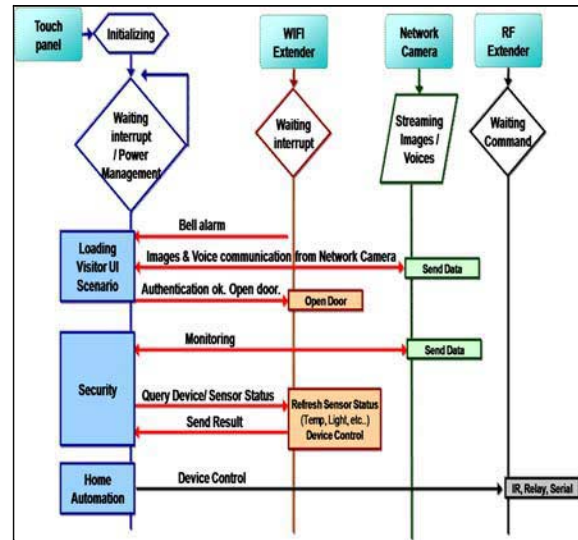**Fig. 6. Wi-Fi-based door control and monitoring system**

Fig. 7. Wi-Fi-based control and monitoring diagram

III. IMPLEMENTAION

A. A URC Touch Panel Design

Fig. 8 and Fig. 9 show the front side and the rear side of the URC, respectively. The URC has additional external antennas as well as an embedded basic antenna. Transmitter-receivers with infrared rays are equipped on each URC. In addition, a USB port is provided for the URC to be connected to a PC which allows downloading the configuration data from the PC. It makes it possible to copy data between two URCs.
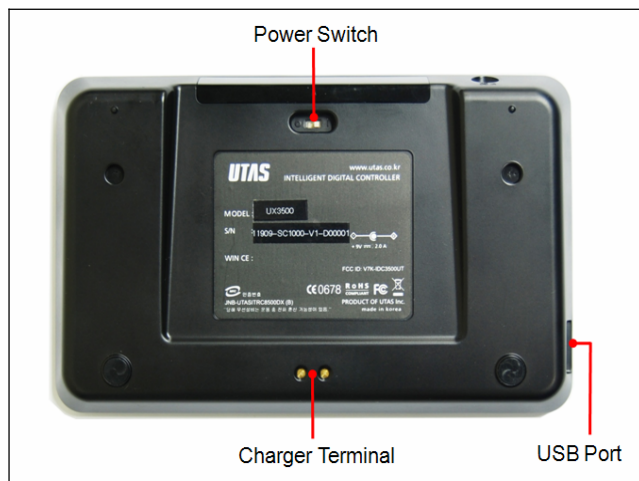
Fig. 8. The front of a URC

Fig. 9. The rear of a URC

Fig. 10 shows the implementation specifications of the URC proposed in this paper. There are an 32 RISC processor, a 3.5Inch TFT Touch panel LCD, a 64M NAND Flash memory and a 64M SDRAM, and WinCE .NET5.0 as an operating system. Also, respectively, the RF and IR ranges are 120m and 45m.

Section	URC - Touch Panel
CPU	32 bit RISC processor(206MHz)
LCD	3.5" TFT LCD (320 X 240 pixel)
Memory	64M NAND Flash 64M SDRAM
O.S	WinCE .NET 5.0
RF Range	120M (Max)
IR Range	45M (Max)
RF Freq.	2.4Ghz (Zigbee)
Size	160 X 99 X 17.0 240g
WiFi	Available
Channel	16
ID	16

Fig. 10. A URC specifications

B. User Interface of a URC

For the efficient control of the system with the URC proposed in this paper, the application program needs eligible software shown in Fig. 11 to display each function button. Whenever each button is pushed, a corresponding screen appears as one of the functions as shown in Fig. 12. The application program cannot only control each appliance separately, but also controls all the appliances by a scenario mode. For example, we can use a "movie" scenario mode to close an electric curtain, to turn off the light, and to turn on the DVD player by one button.

Fig. 11. Example of main screen of a URC

Fig. 12. Examples of detailed screens

C. Convenient User Interface based on a PC

A PC-based user interface application program is provided for a user to make the control program by the use of GUI easy. In addition, we can use basic design libraries to make our own interface very quickly. Also, our own system or button shape can be designed by the button action modification tap. After making the own controlling program, a user can download program data to a URC with a USB

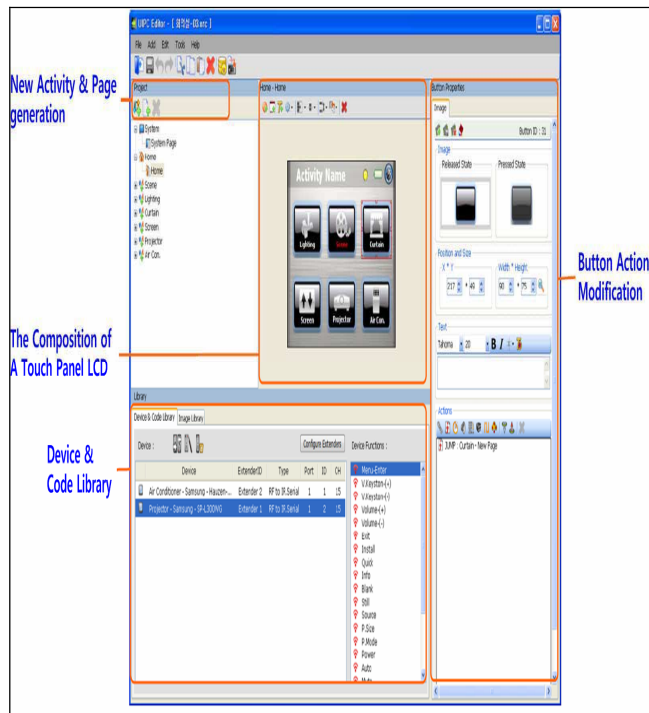port. Fig. 13 shows a touch panel edit screen mentioned above.

Fig. 13. Touch panel LCD page edit screen

Fig. 14. External forms of receivers

RF Extender	IR	Serial	Relay	PowerRelay	Total Port
IR, RS232	4	1	1	0	0	0	6
Relay, RS232	0	0	1	0	5	0	6
RS232, RS485	0	0	4	1	0	0	5
Power Relay	0	0	0	0	0	5	5
RF Repeater	0	0	0	0	0	0	0

Fig. 15. The control port specification of RF receivers

D. Receiver Implementation

Fig. 14 shows the external forms of IR receivers, which are divided into an RF antenna part to receive signals from a URC and an addressable IR part to be connected to appliances. The RF to IR-RS232 receiver shown in Fig. 14(a) and the RF to IR-RELAY receiver shown in Fig. 14(b) have the similar shape but they have different connection techniques as described in Fig. 2 to Fig. 4.

These receivers consist of 2 rotary switches, an IR window with 4 IR LEDs, 4 infrared rays emitter cable connection ports (IR port), 1 Link port, 1 RS232 connection port, a +12V DC input, and an exterior 2.4GHz antenna.

The RF distance of these receivers is up to 120 meters in all directions in the case of using a 2dB exterior antenna in the visibility range standard. The control reception distance can be increased up to hundreds of meters if the exterior antenna is replaced with a very tall one. It is possible to send signals simultaneously through 4 IR ports and a front IR window. In other words, you can send individual signals to each IR port.

Fig. 15 shows the control port specifications of the RF receivers. The front IR window supports a moving distance of about 30 meters, and an IR device is also available for control without a separate cable. In addition, it is available to setup 16 channels (CH) in order to prevent frequency crossover, and it is designed to control multiple receivers with a touch panel integrated controller as 16 IDs are granted.

Working distance is up to 15 meters in the case of RS232 port. The long distance control of 1km is also possible by using RS422 or 485 converters.
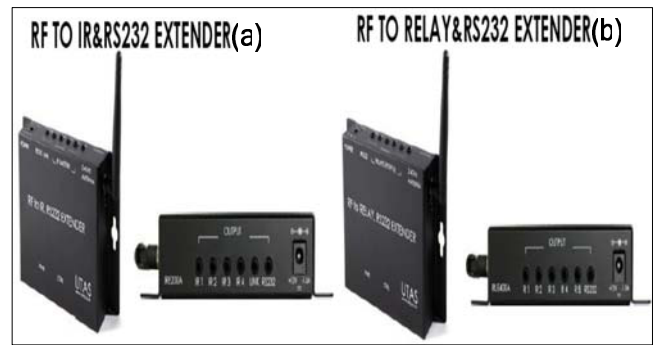
E. Application field

The proposed URC system can be applied to the automation and security of intelligent buildings for houses, schools, public institutes, and so on. Specifically, based on the smart URC, it is possible to control TVs, DVDs, projectors, lighting devices, electric motorized screens, electric motorized curtains, and others. In addition, by means of Wi-Fi and cameras, we can control a heating system unity, a security and disaster management, spatial resolution and simultaneous real-time control information.

In the case of using the URC in school buildings, audio and video systems can be efficiently controlled in each class based on separated or total management. The electric desk or board control in classes can be possible by a teacher. In the same way, conference and meeting rooms in companies or public institutes can be easily controlled by the URC system proposed in this paper.

IV. CONCLUSION

In this paper, we propose an advanced URC for home automation and security based on various controlling techniques such as several RF receivers, Wi-Fi, ZigBee protocol to control all kinds of appliances in the ubiquitous environment. As a further study, we consider the smart URC with direct connection to all kinds of smart phones which will be leading the digital technology and industries in the future.

V. ACKNOWLEDGMENT

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BIOGRAPHIES

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