Peripheral Interface Controller based the Display Unit of Remote Display System

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Abstract— This paper expresses about how to construct the peripheral interface controller (PIC) based the display unit of the remote display system. The remote display system can be used to display the token number that is to know the people. It is also intended for use in clinic, hospitals, bank, and etc. In this research, the peripheral interface controller based remote display system is used for displaying the number and the character. The remote display system consists of two portions: display unit and console unit. The display unit of remote display system contains the display controller, three seven-segment Light Emitting Diode (LEDs), Diode matrix, Category display LEDs and DSUB9 connector. The display controller is controlled by the microcontroller PIC16F873. It controls to display the token numbers. And then it can control at the diode matrix to display the three kinds of character such as A, B, and C. The three numbers of seven-segment LEDs will display the token number from one to 999. The diode matrix helps to display the category display LEDs. The category display LEDs will display one kind of characters. In the research work, the category display LEDs can be displayed only three kinds of characters. For the display unit, the DSUB9 connector applies the data that is from the console unit of the remote display system. In this research work, the display unit works as the receiver the console unit works as the transmitter in remote display system. This paper explains about the design, construction, testing and result of a remote display system.

Index Terms— Diode Matrix, Display Unit, Light Emitting Diode, Peripheral Interface Controller, Remote Display System.

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1 INTRODUCTION

THIS display system is very useful in many applications. To advertise, to express the number, the remote display system can be used. Because of the token number can be expressed by using the display system. The token number may be used in banks, financial institutions, clinics and etc. The display unit of the remote display system can be controlled by the microcontroller PIC16F873. The token number is displayed by the large-sized seven- segment Light Emitting Diodes (LEDs). The category display LED can be expressed the three characters. This research consists of two modules; one for the construction of hardware circuit (including interfacing circuit and LED matrix circuit) and other for how to control the process by using peripheral interface controller (PIC). In this research, the hardware controlling program is Assembly programming language. The circuit components consist of resistors, transistors, Integrated Circuit (ICs), LEDs and other accessories. The remote display system consists of two parts. They are console unit and display unit. The display unit is used to display the numbers. That number is needed to know the people. That numbers may be the token number for using many public places. For examples, the token number may be used in the banks and financial institutions, calling the patients one by one at the clinics, calling the candidates at the interviewing and etc. There are many ways to display the number.

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2 RELATED WORKS

2.1 PC Basted Token Number Display

An increasing number of banks are computerizing their operations. For actual field use, the display with target LED arrays must be replaced. No other hardware is needed, except the displays and the buffers. The absence of any seven segment decoder chip like 7447 is to be noticed. Because of all the decoding is done entirely by software. Time division multiplexing is another important concept. The four numbers of seven-segment displays share a common data bus. The PC places the first digit on the data bus, and enables only the first seven-segment unit. After a delay of one millisecond, the digit is replaced by the next digit, but this time only the second display unit is enabled. After displaying all the four digits in this way, the first unit is enabling again. The cycle repeats itself over and over. Another feature provided by the software is the ability to suppress leading zeros. Number five is displayed as 5, rather than as 0005. This is usually done by the hardware using the so called 'ripple blanking' facility of the decoder chips. Finally, the computer emits a musical sound whenever there is a change in the displayed number, to attract attention. A regulated 5-volt power supply is recommended [1].

2.2 Digital Bank Token Number Display

Electronic bank token number display systems are quite popular with bank and financial institutions nowadays. These can be used by general practitioners in their clinics to call the patients one by one, and by interviewing committees to call the candidates. In most applications, there

are two sets of displays, a small one kept inside the cabin of the person controlling it, and a large one kept outside for visitors. There is a keyboard for teller to enter token numbers. The large size plasma devices and TTL chips are being used in the constructing of bank token display [2]. In digital bank token number display system, the display device circuit is used to control both the common cathode LED and common anode plasma displays. A well regulated transistorized circuit provides power to TTL chips as well as to high voltage plasma displays.

2.3 Improvement of Display Unit

The digit display part of the display unit is made to light up by 1 digit to suppress an electric current. The lighting-up time of one digit becomes 1/3 and the light falls. When little flow of the electric current occurs, the color patches occurs to the displaying. The display data is hold by the latch register (74LS 273). The 74LS273 which is D-type flip-flop (D-FF) as the latch register to hold the display of the LED is used. The eight D-FFs are housed in one piece of IC. One 74LS273 is used to control one seven-segment LED. It inputs the data to D terminal to make hold. First, the data for the 100th is outputted to RB6 from RB0 and it is inputted to all the latch registers. Next, RA0 is made H and only the CK of the latch register (IC five) for the 100th is made H level. By this, a 100th digit is displayed in LED1.

3 SOFTWARE IMPLEMENTATION OF DISPLAY UNIT

3.1 Receiver Operation in Display Unit

The display unit of the remote display system is based on the PIC16F873. And it uses the asynchronous communication of PIC16F873. In asynchronous communication, there are two operations: Transmitter operation, Receiver operation. Fig. 1 showed the schematic diagram of receiver operation of PIC16F873 in the display unit.
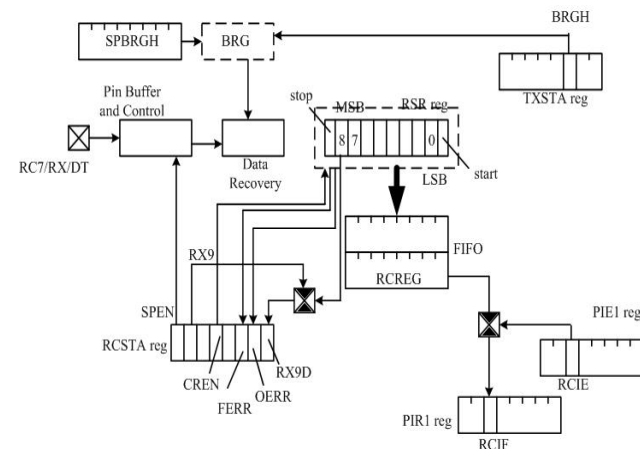

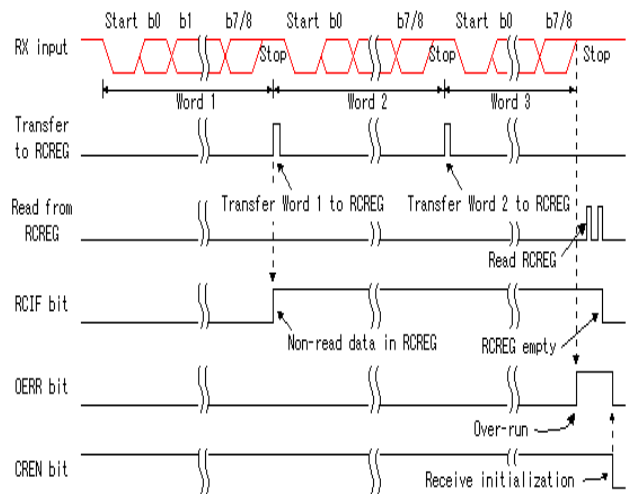Fig.1. Schematic diagram of receiver operation of display unit.

Fig. 2. Receive time chart of the receiver operation of display unit.

3.2 Software Flowchart and Processing of the Display Unit

The following flowchart shows the outline of the software processing of the display unit of the remote display system.
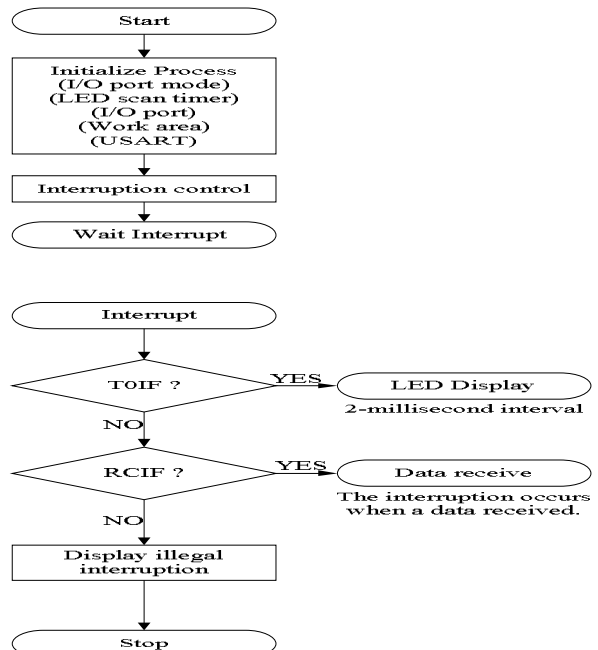

Fig. 3. Software flowchart for the display unit.

In the label definition, the frequently used commands are assigned. The data area is automatically assigned from 20h by CBLOCK directive. ENDC is used for the ending of assignment. The label 'data-h' is used for the area which stores 100th data. Similarly, the label 'data-t' is assigned for the area which stores 10th data, 'data-u' for the area which stores first data. And 'cdisp-p' is used for

the area which stores a category display scan position. 'ddisp-p' is to store a seven-segment LED display scan position. 'rcv-p' is the area which counts a received data. And 'r-category' is the workarea to use for the change of the received category data. When making the power ON of the PIC, the instruction is executed from zero address of the program memory. When there is interruption processing, processing is began for the address4. And then it makes each processing jump with the GOTO instruction. The initialization processing is done after turning on. In this processing, all ports of the PORTA are set output mode. And all ports of PORTB are also set to output mode and are used for the segment control of the seven-segment LED. RC0, RC1, RC2, RC3 are set to output mode for the scan of the category display. RC7 pin of PIC16F873 is the only input mode and to receive the transferred data form the console unit.

For the USART, the most of the registers about the setting of a USART are in bank1. Therefore, it is necessary to be careful of the bank designation. The designation of the asynchronous serial communication with 9600bps transmission speed is done. This receiving interrupting occurs when the data is received in the receiving buffer. When the initialization of the USART ends, the receiving operation is immediately done. When the initialization of interruption will start, Global Interrupt Enable bit (GIE), Peripheral Interrupt Enable bit (PEIE), and Timer0 Overflow Interrupt Flag bit (T0IF) are set. To use the interruption of transmission complete, PEIE must to set. The initialization processing is ended. Then, it waits for the interruption only.

As the main processing, it repeats the execution of the same address. In the interruption process subroutine, two kinds of interruptions are used. They are interruption by the time-out of TMR0 and the interruption when the data is received. The interruption of TMR0 is identified by the T0IF bit of the INTCON register and the data receive interruption is identified by the RCIF bit of the PIR1 register.. The RETFIE instruction is executed at end of the interruption processing. It becomes the interruption possible condition.

3.3 Software Flowchart and Processing of LED Control

The interruption occurs every two milliseconds with TMR0. The interruption flag of T0IF should be cleared first. If T0IF bit is not cleared, the interruption occurs without waiting the desired time. Therefore, the setting of the timer value of TMR0 is needed. As for the control of the category display, one row is done every time it interrupts in the two milliseconds. The specification of the row is done by the portC. As for the seven-segment LED control, a three digit figure is displayed by the seven-segment LED. The one digit is controlled every two milliseconds about these LEDs. The digit specification of seven-segments is done by RA0, RA1, and RA2. And RA3, RA4, RA5 of the PIC16F873 is used for the category display

specification. For displaying the seven-segment LEDs, RA0, RA1, RA2 must be rewritten while d\saving this value.

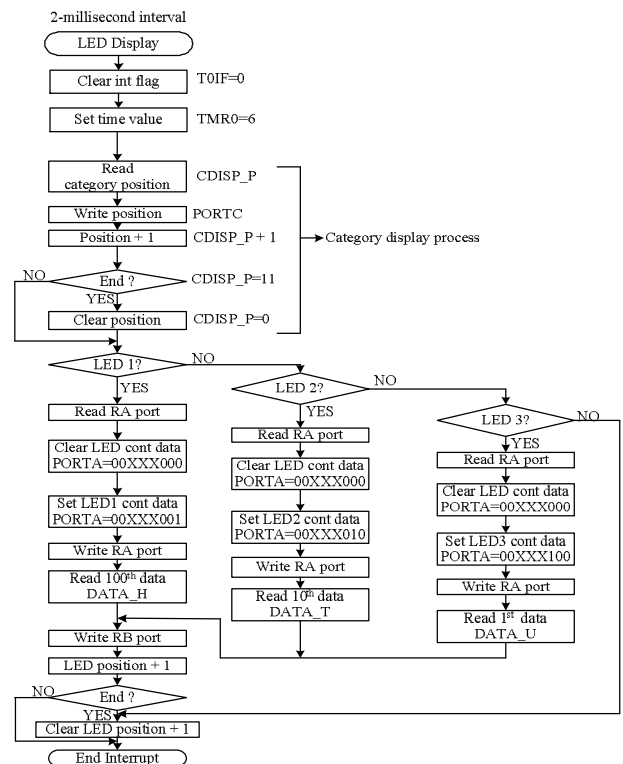The following flowchart shows the LED control process.

Fig. 4. Software flowchart for subroutine of LED control process.

Therefore, it makes data "0" except the category specification by the AND. By suing the AND, the result becomes "1" only when both data is "1". If the bit that fixing value in the instruction is "1", the contents don't change. When the bit that is fixing value is "0" always becomes "0". The digit specification data of the seven-segment LED is set to RA0-2. Now, the calculation of the OR is used. When either of the data is "1", the result becomes "1". If the contents of the bit that fixing value in the instruction is "0", the contents do not change. When the bit that is the fixing value is "1", the contents always becomes "1". When the digit specification is ended, the segment data will be to display. The segment data to display is written in the portB. It reads the content in the received data area of each of the digits and writes in the portB. It makes writing processing to the portB common and a processing step is reduced.

3.4 Software Flowchart for Data Receive Process

The following flowchart is the software flowchart for sub-
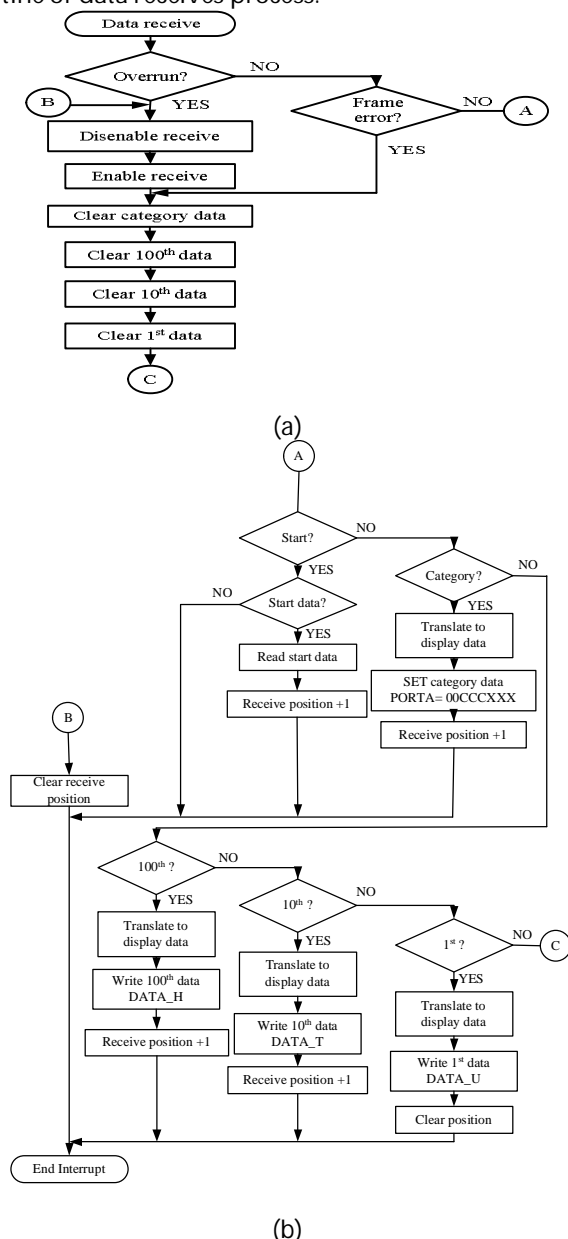
routine of data receives process.

(a)

(b)

Fig. 5. Software flowchart for subroutine of data receive process: (a) for checking the overrun rrror and frame error and (b) for checking the category and LED.

The data receive process makes the data receiving from the console unit. This process is started by the data receive interruption by the Receive Interrupt Flag (RCIF) bit of the PIR1 register. It is different from the other interruption display bit and to clear RCIF bit by the software is not necessary. It is cleared by the hardware in reading the data which was received to RCREG. When the data is received, the overrun error must be checked. If an overrun condition occurs, the Continuous Receive Enable (CREN) bit of Receive Status and Control Register (RCSTA) must be cleared. Then the CREN bit is set and

the received data is cleared. When the overrun occurs, it stops the receiver and it must be started once again. This process must be always done when the overrun occurs.

It clears all display data after that to find that the overrun occurred in the process. After the overrun error is checked, the frame error is checked. The frame is from the start bit to the stop bit. When a stop bit is not detected after detecting a start bit, the frame error occurs. If a normal frame is received, the error passes away. When the frame error occurs, it clears display only. If the frame error occurs, the Framing Error (FERR) bit of the Receive Status and Control Register (RCSTA) register is set. And then the category data, 100th data, 10th data and 1st data are cleared. The received position is almost cleared. The interrupt is ended.

After the frame error is checked, the start process is checked. If the frame error does not occur, the start process may be occurred. The category, 100th, 10th and 1st data is sent sequentially from the console unit to the display unit. The information which shows the kind of the data isn't included in each data. The kind of the data is decided in order to receive. The console unit sends start data first and transmits category, 100th, 10th, and 1st data continuously in the order. In the receiving process, it waits for the start data first. If the start data bit is received it is read and the received position is set. Then, the received position is incremented and the interrupt is ended. When the data except the start data comes in the start data receiving position, the data is canceled and the incrementation of the receiving position is not done.

The category data is received behind the start data. After the start data is checked, the category data will be checked. The category data which is sent from the console unit is sent in the form to use in the console unit. The bit configuration and the bit contents of the data that is sent from the console unit to the display unit is different. In the received data, bit four-six is the data which shows a category. Bit six indicates "A", bit five indicates "B", and bit four indicates "C". And, "0" indicates lighting-up and "1" indicates going-out.

If the category data is received, it is checked to be 'A' firstly. As for the display unit, bit three-five indicates a category. Bit three corresponds to "A", bit four corresponds to "B" and bit five corresponds to "C". In the display unit, "0" indicates going-out and "1" indicates lighting-up. The difference is due to the difference of the hardware of each unit. In the number data receive process, the 100th data, the 10th data and the 1st data are received in the order following the category data. The form of the console unit and the form of the display unit are different about these data. The bit position is the same and the meaning is opposite to "0" and "1". In the console unit, '0' is lighting-up and '1' is going-out. In the display unit, "0" is going-out and "1" is lighting-up.

The Exclusion OR is used to reverse "0" and "1". According to Exclusive OR, "0" is output if being a value

with the same data and "1" is output when the value is different. The result may reverses when calculating in Exclusion OR with "1". When the received data is "01001111", the result of execution of Exclusion OR with "11111111" is "10110000". This is the value which reversed "0" and "1" of the received data. A translated value is written in the storage area which corresponds to each of the digits.

When the data receiving stops in the condition that the frame would be received, being normal. The receiving processing has the possibility to make a mistake in the kind of data. When the 100th data is receiving, the communication stopped. And then, when the start data from the console unit is receiving, it receives the start data as 10th data and category data as 1st data. Because it becomes start data waiting condition when 1st data is received, the 100th data, 10th data, and 1st data are canceled. So, the normal receiving is done.

4 HARDWARE IMPLEMENTATION OF DISPLAY UNIT OF REMOTE DISPLAY SYSTEM

The objective of the project is to design the display unit of the remote display system. The display unit is controlled by PIC16F873. The display unit is displayed the number and character that is transferred from the console unit of the remote display system. The display unit of the remote display system consists of three numbers of seven-segment LEDs, diode matrix, RS232C interface, PIC16F873, and four-to-sixteen decoder. The RS232 interface is used to connect between the display unit and the console unit of the remote display system. PIC16F873 controls the three numbers of seven-segment LEDs and diode matrix.

The remote display system consists two portions: Display Unit and Console Unit. This project is to design the display unit of the remote display system. PIC16F873 is used to control both the display unit and the console unit of the remote display system. PORTA of the PIC16F873 is used for output mode to display the number and alphabet. All of PORTB is to display the segments of the seven-segment LEDs. A +5V is used to power of the PIC and +12V is used to the seven-segment LEDs and diode matrix. The diode matrix is used to display three kinds of characters such as A, B, and C.

4.2 Design of Display Unit of the Remote Display System

The display unit of remote display system is controlled by the PIC16F873. There are LED selecting circuit and segment selecting circuit to display the numbers with three numbers of seven-segment LEDs. And there are the row selecting circuit and LED selecting circuit to display the three kinds of characters such as A, B, and C. The RS232 interface is used as the connector between the display unit and the console unit. There is a clock circuit to drive

the PIC16F873. Fig. 6 shows the circuit diagram of the display unit of the remote display system. In the portion of design of display unit of the remote display system, the following circuits are including: the seven-segment LED control circuit, the category display control circuit, the RS232C control circuit, PIC oscillator circuit and power circuit.

Fig.6. Proposed circuit diagram of the display unit of the remote display system.

4.2.1 Seven-segment LED Control Circuit

In the display unit of the remote display system, there are three number of seven-segment LEDs. It is the I/O port number limitation with PIC and to make an electricity consumption little. Only the circuit which displays 100th data is drawn in the Figure 4.2. The circuit for 10th and 1st is similar too. TR27 and TR26 are the circuit which selects a controlled LED. The drive voltage of the large-sized LED to be using this time is 12V. The drive voltage for one LED is about 2V. As for one segment, five LEDs are connected in series. So, the drive voltage of one segment becomes from 10V to 14V. The LED which was used this time is an anode common type and the anode termin-

al which applies + voltage is common to all the segments. Because an LED selecting circuit is put in the side of the + voltage, PNP type is used for the control transistor. When using NPN-type transistor for this circuit, the emitter of the transistor is connected with the anode terminal of the LED. In the case, the electric current control for the base becomes difficult.
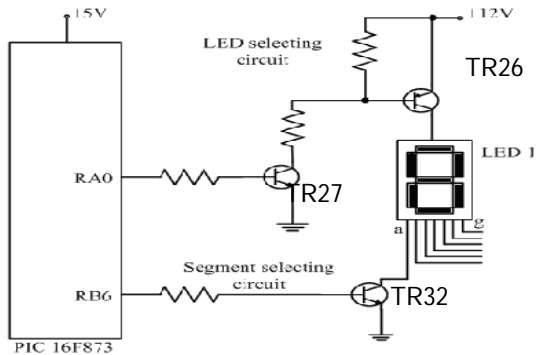

Fig. 7. Schematic diagram of 7-segment LED control circuit.

    The TR27 is used for the output of PIC. This is because the voltage which is applied to the I/O port of PIC is limited to +5V. When making TR26 ON, it makes the base voltage of TR26 less than +12V (About11V). The electric current flows through the base with this. When making TR26 OFF, it makes base voltage +12V. So, about +12V voltage is applied to the base of TR26. The base of TR26 can not be directly driven by PIC. When making RA0 of PIC 0V (0 conditions), TR27 becomes OFF. Therefore, the base electric current of TR26 does not flow and TR26 becomes OFF too. That is, LED1 does not light up. When making RA0 of PIC +5V (1 condition), the base electric current flows through TR27 and TR27 becomes ON. When TR27 becomes ON, the electric current flows through the base of TR26 and TR26 becomes ON condition. By this, +12V are applied on the anode of the LED and the LED becomes the condition about which it is possible to light up.

The segment selecting circuit drives a lit segment. A segment selecting circuit is put between the LED and the grounding. So, the transistor for the control can be directly driven by PIC. In the left figure, a circuit for the "a" segment is drawn. The other segment control circuit is similar too. When making RB6 of PIC 0V (0 conditions), TR32 becomes OFF. Therefore, the electric current does not flow through the "a" segment of the LED and the "a" segment does not light up. The base electric current flows through the base of TR32 when RB6 of PIC is +5V (1 condition). With this, the electric current flows through the "a" segment and the "a" segment lights up. In this research, the common cathode seven-segment LED is used. So, the LED selecting circuit used only one NPN transistor for each seven-segment LED. For the segment selecting circuit, one PNP transistor and one NPN transistor

are used. At the LED selecting circuit, that transistor is directly controlled by the portA of PIC. If the port A of PIC is 0V (0 condition), the transistor will be off and the LED does not light-up. When the portA of PIC is 5V (1 condition), the base electric current flows through the transistor. And the electric current through the LED and the LED will be light-up.

At the segment selecting circuit, the NPN transistor becomes off when the portB of PIC is making 0V (0 condition). So, the base electric current of PNP transistor does not flow and the PNP transistor will off. The electric current does not through the segment of seven-segment LED and the segment does not light-up. If the portB of the PIC is 5V (1 condition), the NPN transistor will be on. The electric current flows through the base of the PNP transistor and that transistor will be on condition. And the electric current flows through the segments and the segment lights up. The PNP transistor is not directly by the PIC.

4.2.2 Category Display Control Circuit

In the display unit, the category is displayed with the diode matrix. Fig. 8 shows the category display control circuit. That consists of the row selecting circuit and the LED selecting circuit. A circuit like seven segments is used about the drive circuit for the category display. A category character is one character but is displayed by the LED matrix. An LED matrix is composed of 11 lines to the direction of the side (Row) and is composed of 13 lines to the longitudinal (Column). Alighting-up control is done every row. The row selecting circuit controls to pass an electric current to the LED of the row which was specified by PIC. Because there are 11 rows, the direct control by PIC is difficult. It is to limit the number of the I/O ports. A control signal is developed from the four-bit signal of PIC to 11 signals by the decoder IC. The operation of the row selecting circuit is similar to the case of seven segments.
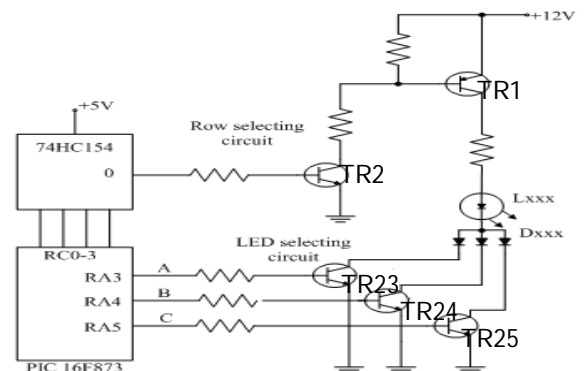

Fig. 8. Schematic diagram of the category display control Circuit.

The LED selecting circuit is the circuit which drives a lit LED in the selected row. The character to display with the circuit this time is three kinds. The kind of the character is controlled by RA3, RA4 and RA5 of PIC. The LED which

is lit up every character is different. When seeing from the LED, there are one which lights up by all character, one which lights up only in case of specific character and so on. It is the diode of the LED selecting circuit that is controlling this. In case of the circuit of the figure on the left, the case of the LED which lights up by all character is shown. When making an LED light up only when TR1 is ON, it makes a diode only the one which is connected with the collector of TR23. It decides a displaying character pattern in the LED matrix and it decides the combination of these diodes every LED.

4.2.3. RS232C Control Circuit

The RS232C interface is used for the information transfer between the console unit and the display unit. This interface is used for an interface with the modem. About ±9V is used for signal voltage on the connection cable with the console unit and the long distance transmission is possible comparatively. In the standard, the cable with about 15m length can be used. Actually, it is possible to use for more distance. It depends on the condition of the cable. The +5V signal of PIC16F873 can be directly transmitted without using the RS232C interface if being a short distance. The purpose that this IC is used this time is to attempt to use the RS232C device and to secure a distance. The ADM232AAN has the DC-DC converter which makes the voltage of ±10V with +5V power. The external circuit is very simple.

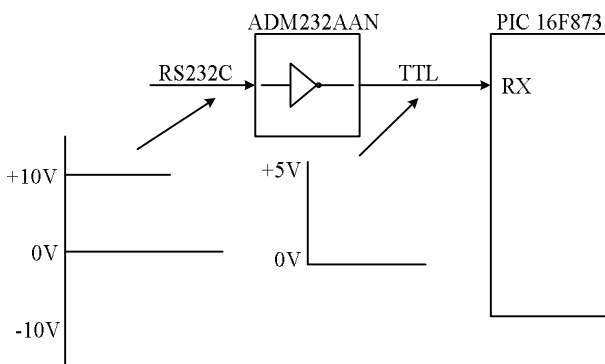Fig. 9. Schematic diagram of the RS232C control circuit.

4.2.4 PIC Oscillator Circuit

To make do the operation of PIC, a clock generator is needed. An oscillation had within PIC, so, it puts a vibrator outside only. As the vibrator, the crystal oscillator can be used because of the precision oscillation. However, at the circuit this time, a ceramic vibrator (Resonator) is used because it does not need the precision oscillation. The maximum clock frequency of PIC16F873 is upto 20MHz. However, at the equipment this time, because it does not need high-speed operation, the oscillation frequency is 4MHz. A transmission speed is calculated by 4MHz. So, when using this equipment at the clock frequency which is not 4MHz, reconsideration is needed.
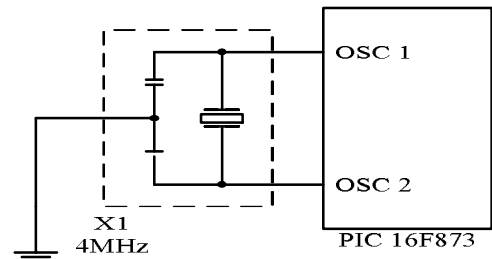

Fig. 10. Schematic Diagram of the PIC Clock Circuit

4.2.5 Power Circuit

The power to operate the display unit is supplied from the console unit through the cable. The DC +12V is made with AC +220V by the switching power circuit. The supplied voltage from the console unit is +12V. The +12V can be used for the LED displaying. The power of PIC needs the +5V. A three-terminal regulator is used for the voltage change from +12V to +5V. The +5V is used for PIC16F873 and decoder IC. The regulator can be used as the 100mA type regulator.
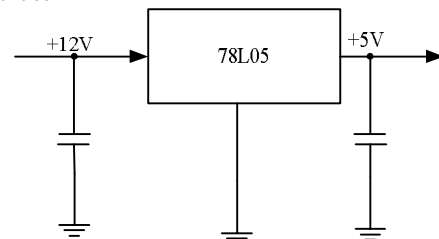

Fig. 11. Schematic Diagram of the Power Circuit

4.3 Test and Result of the Display Unit of the Remote Display System

The peripheral interface controller based the remote display system is shown in Fig. 12. The step-down transformer is used to change from the AC 220V to the 12V. The Fig. 12 is the figure that is before the power supply is off and the data is not being sent from the console unit to the display unit of the remote display system.
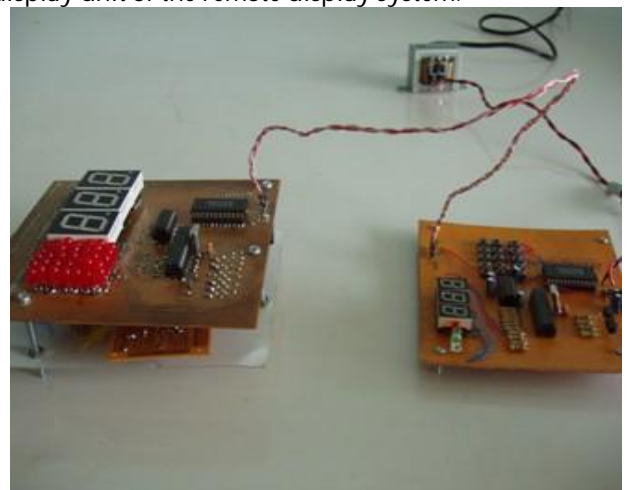

Fig. 12. The PIC based remote display system.

When the number 450 and the character A is sent from the console unit, the data that is sent from the console unit is shown in Fig. 13.

Fig. 13. Testing the receiving data both console unit and display unit in remote display system.

The Fig. 14 shows the display portion of the remote display system.

Fig. 14. The display unit with the data receiving process.

The supply voltage of the display unit is supplied from the console unit of the remote display system. Fig. 15 shows the testing of received voltage level at the display unit.

Fig. 15. Testing the received voltage level at the display unit.

4 CONCLUSION

This research describes about the display unit of the remote display system. The peripheral interface controller based remote display system can be used to inform the people. In this project, the display unit is constructed, one of the nearest, most versatile and most useful LED array, to view alphabetic character and numeric characters. In this research, the three kinds of characters and the three digits numbers are displayed. The PIC16F873 controls the numbers and the characters. The display unit of peripheral interface controller based remote display system is designed to construct using with the devices which can buy easily in the market, easy to use and familiar with a person who interested in electronics field. This system is designed for English language capital letters and numbers. This thesis is not only applied for the educational aid for the beginner to learn the design, programming and development of the applications which use the PIC but also applied for displaying the number in many fields such as clinic, bank and financial institutions, interviewing committees to call the candidates and etc.

As further extension, the remote display system is used 15m length between the console unit and the display unit in this research. For more distance, the various kinds of RS232 interface can be used. In large area of display, it can be used the largest size of seven-segment LED. By this way, the resolution of the display is smooth. Instead of LED, LCD can be used in this research. In this research, the digit display part of the display unit is made to light up by one digit to suppress an electric current. It can be made to light up the digits at the same time. It can be used to hold the display data by latch register (74LS273). The latch register is placed between the peripheral interface controller and the segment selecting circuit. The remote display system can be widely used in many fields that need to give information to users or partners. To develop the display technique and devices, people should

study this technology. The development of this project intended the display unit of the remote display system to be used in various fields.

ACKNOWLEDGMENT

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