AN3313

A Wireless Cubicle Doorbell

Introduction

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Getting someone's attention in their office can be difficult if they are focused on work tasks (virtual meetings, training videos, etc.) and not focused on the entrance to their office. To ease the difficulty of getting someone's attention, a Cubicle Doorbell was developed utilizing the PIC16F18075 microcontroller from Microchip Technology.

This application note will explain the creation of this Cubicle Doorbell for an office setting. The doorbell system uses the PIC microcontroller's EUSART module to establish a data pipe to send data between two modules, one at the door and one at the desk.

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1. Application Overview

The Cubicle Doorbell utilizes the micorocontrollers's EUSART peripherals to establish a connection between two MikroElektronika RN4678 Bluetooth® Click™ modules (based on Microchip's RN4678 Dual Mode Bluetooth module). These modules facilitate the transfer of data which occurs when the doorbell button is pressed. When the button is pressed, the door module sends a signal via a Bluetooth connection to the desk module to alert the person inside the cubicle that someone is at the door and trying to get their attention.

The following components were used in this application:

- PIC16F18075 Microcontroller (2)
- MikroElektronika Cap Touch Click Board (Product ID: MIKROE-2888)
- Adafruit® NeoPixel® 8 x 5050 RGB LED Stick (Product ID: 1426)
- MikroElektronika RN4678 Bluetooth Click Module (2) (Product ID: MIKROE-2545)
- Microchip MPLAB® IDE v6.00
- Microchip XC8 Compiler v2.31
- Microchip MPLAB Code Configurator (Melody) v5.1.0
- MPLAB PICkit™ 4 In-Circuit Debugger (PG164140)

1.1 Cap Touch Click Board

The Cap Touch Click Board processes a touch into an electrical signal by using the Microchip AT42QT1010 Single-Key capacitive touch controller operating in Low Power mode. When the chip detects a button press, the Fast Detect Integrator is enabled until an output signal is sent. The output signal is sent after four successive detections using the detect integrator. The output signal is sent to the Click board's INT pin, and is also used to power an on-board LED though a MOSFET.

For more information about the AT42QT1010 touch controller, please visit the AT42QT1010 capacitive touch controller product page.

1.2 NeoPixel Stick

The Adafruit NeoPixel Stick contains eight WS2812 RGB LEDs and their integrated driver modules connected in series. Each LED has a power pin (5VDC), a ground pin (GND), a data in pin (DIN), and a data out pin (DOUT). Each LED needs data to be sent in the correct timing to display a color. The WS2812 LEDs have a very strict timing specification since it only uses one data line. The timing specification defines three types of sequences that can be sent. These sequences include a high code sequence, a low code sequence, and a reset sequence. Each sequence starts with the pin going high, then going low. Table 1-1 has the specific timing specifications for each sequence.

Table 1-1. WS2812 Timing Specifications

Type of Sequence	Time of Pin High	Time of Pin Low
High Code	580 ns~1 µs	580 ns~1 µs
Low Code	220 ns~380 ns	580 ns~1 µs
Reset	0s	>280 µs

1.3 RN4678 Bluetooth Click Module

The RN4678 Bluetooth Click module allows for the communication between the two different doorbell modules (desk and door). The communication is configured by sending a series of commands to the Bluetooth Click module. By default, the Click module uses flow control UART to send commands to it. Flow control UART uses four pins in total: two for data transfer and two for checking if data can be sent. The two data transfer pins are the typical TX and RX lines used within the basic form of UART. The two other pins are the Clear To Send (CTS) and the Request To Send

($\overline{\text{RTS}}$) pins. These pins can affect the flow of a message being sent across the TX/RX data pins by pausing and resuming the data transfer. For data to be sent, the $\overline{\text{RTS}}$ pin must be asserted by the transmitting device.

In addition to the flow control UART, the RN4678 Bluetooth Click module can operate in two different modes. The first (and default) mode is the Data mode, in which the Click module operates as a data pipe. The data pipe allows a UART signal to be sent and received by each module.

The second mode is Command mode, in which the specific configuration of the Bluetooth connection can be modified. The only way to enter the Command Mode is by sending a `'$$$'` command over UART to the specific Bluetooth Click mode. From Command mode, the configurations can be changed using ASCII commands.

For more information and a complete list of commands for the RN4678 Bluetooth module, please visit the RN4678 Bluetooth module product page.

2. Building the System

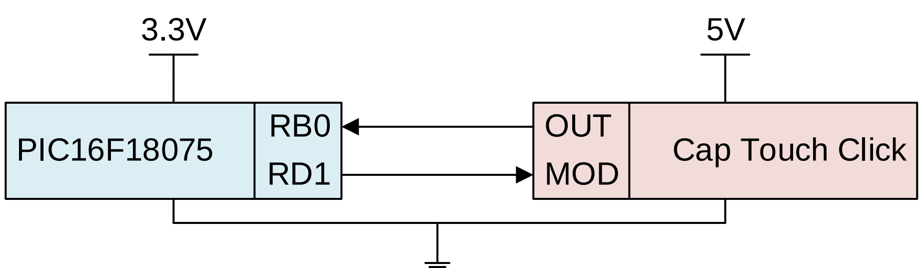
To function as a complete system, the doorbell application requires multiple parts – the Bluetooth Click modules, the Cap Touch Click board and the NeoPixel LED Stick – to work together as a whole. This section of the application note discusses each part of the system in the order in which they were created, to allow the reader to understand how they fit together and create the application. Once the reader understands this, they will be able to adapt it as needed.

The microcontrollers and hardware modules described in this section have been assembled by direct wiring on a breadboard prototyping system. The development of appropriate circuit boards and casing for the final application is left up to the reader.

2.1 Part One: Cap Touch Click Board

The Cap Touch Click board connects via the OUT pin to any of the microcontroller's input pins. In this application, RB0 is selected as the input pin. The MOD pin on the Click board determines the mode of operation; it is connected to the PIC's RD1 pin. The Cap Touch Click board shares the ground, both pins, with the PIC, but not the 3.3V power. Figure 2-1 shows the connections made between the Cap Touch Click board and the PIC16F18075 microcontroller for the door module.

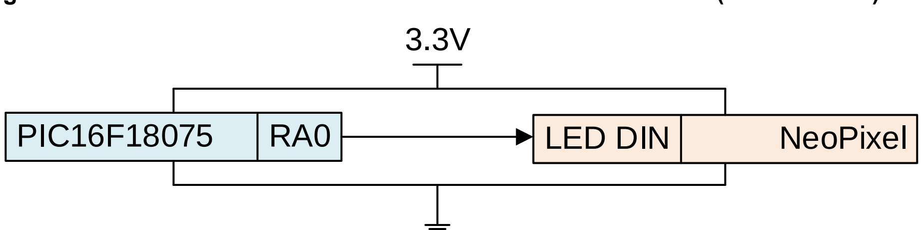
Figure 2-1. Cap Touch Click Board to PIC16F18075 Connections (Door Module)



2.2 Part Two: NeoPixel Stick

The Adafruit NeoPixel LED Stick connects via the DIN pin to any of the PIC microcontroller's output pins. In this application, RA0 is selected as the output. The NeoPixel Stick shares both the 3.3V power and the ground, both pins, with the microcontroller. The timing described in section 1.2. NeoPixel Stick can be achieved by using the 16 MHz clock. Figure 2-2 shows the connections between the NeoPixel Stick and the PIC16F18075 microcontroller for the desk module.

Figure 2-2. Adafruit NeoPixel Stick to PIC16F18075 Connections (Desk Module)

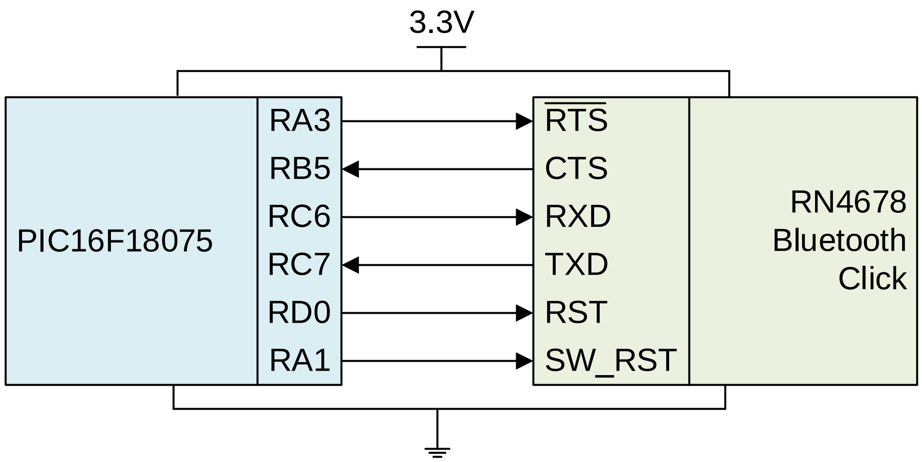


2.3 Part Three: Bluetooth Click Module

The RN4678 Bluetooth Click module connects to the PIC through the $\overline{\text{RTS}}$, CTS, RXD, TXD, RST, and SW_RST pins. The CTS and TXD pins are configured as input pins while the $\overline{\text{RTS}}$, RXD, RST, and SW_RST pins are configured as output pins. The Click module shares the 3.3V power line and the ground pins, both pins, with the PIC.

Figure 2-3 shows the connections made between the RN4678 Bluetooth Click module and the PIC for both the desk and door modules.

Figure 2-3. RN4678 Bluetooth Click Module to PIC Connections (Door and Desk Modules)



2.4 The Full System

By combining one instance of Parts One and Three, we can create the complete Door module (Figure 2-4). Similarly, by combining one instance each of Parts Two and Three, we can create the complete Desk module (Figure 2-5).

Figure 2-4. Complete Door Module

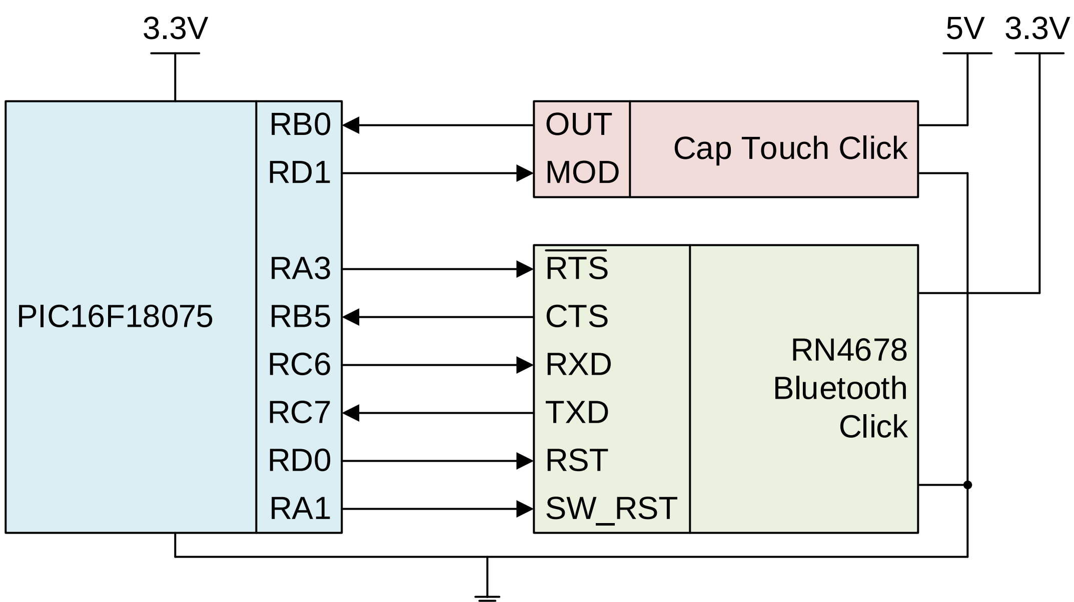
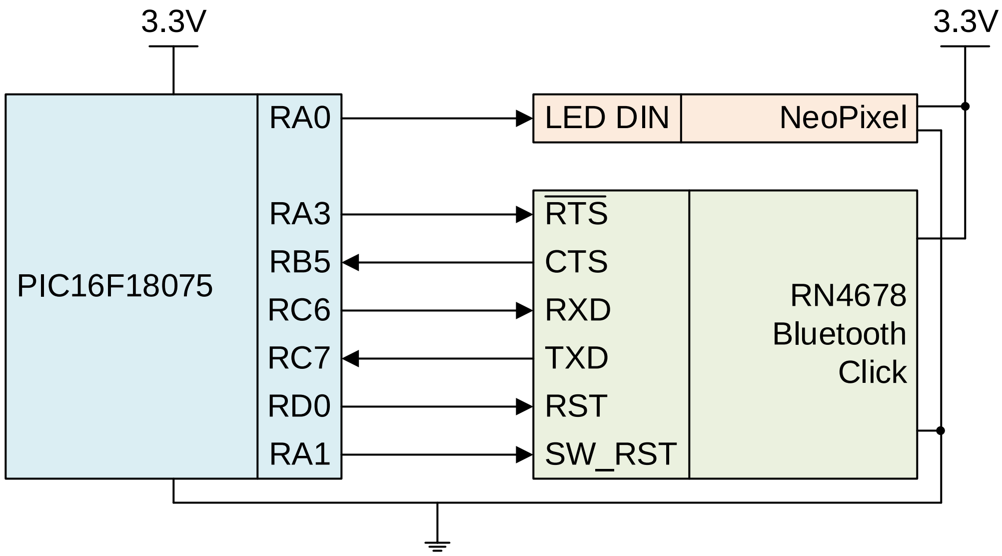


Figure 2-5. Complete Desk Module



3. Programming the System

3.1 System-Wide Programming

3.1.1 Pin Setup

There are a total of nine pins that need to be configured for both the desk and door modules. However, both modules do not share all the same pins. The RA0 pin is specific to the desk module while the RB0 pin is specific to the door module. Pins RC6 and RC7 are connected internally through Peripheral Pin Select (PPS) to be the TX1 and RX1 pins, respectively. Please refer to Table 3-1 to see what parameters are enabled or disabled for each pin for this application. Example 3-1 and Example 3-2 show the pin setup code and PPS setup code, respectively, for both the desk and door modules.

Table 3-1. Pin Setup

Pin Name	Function	Start High	Analog	Output	WPU	OD
RA0(1)	NeoPixel Stick – Data pin	-	-	X	-	-
RA1	RN4678 Click Module – SW_RST	-	-	X	-	-
RA3	RN4678 Click Module – $\overline{\text{RTS}}$	-	-	-	-	-
RB0(2)	Cap Touch Click Board – Data pin	-	-	-	-	-
RB5	RN4678 Click Module – CTS	-	-	X	-	-
RC6	RN4678 Click Module – RXD	-	X	X	-	-
RC7	RN4678 Click Module – TXD	-	-	-	-	-
RD0	RN4678 Click Module – RST	X	X	X	-	-
RD1	Cap Touch Click Board – Mode Pin	-	X	X	-	-

Notes:
1. Pin RA0 is only for the desk module.
2. Pin RB0 is only for the door module.

Example 3-1. Pin Setup Code – Door and Desk Module

```
/**
 LATx registers
 */
 LATA = 0x0;
 LATB = 0x0;
 LATC = 0x0;
 LATD = 0x0;
 LATE = 0x0;

 /**
 TRISx registers
 */
 TRISA = 0xFC;
 TRISB = 0xDF;
 TRISC = 0xBF;
 TRISD = 0xFC;
 TRISE = 0xF;

 /**
 ANSELx registers
 */
 ANSELA = 0xFF;
 ANSELB = 0xFF;
 ANSELC = 0xFF;
```

```
ANSELD = 0xFF;
ANSELE = 0x7;

/**
WPUx registers
*/
WPUA = 0x0;
WPUB = 0x0;
WPUC = 0x0;
WPUD = 0x0;
WPUE = 0x0;


/**
ODx registers
*/

ODCONA = 0x0;
ODCONB = 0x0;
ODCONC = 0x0;
ODCOND = 0x0;
ODCONE = 0x0;
/**
SLRCONx registers
*/
SLRCONA = 0xFF;
SLRCONB = 0xFF;
SLRCONC = 0xFF;
SLRCOND = 0xFF;
SLRCONE = 0x7;
/**
INLVLx registers
*/
INLVLA = 0xFF;
INLVLB = 0xFF;
INLVLC = 0xFF;
INLVLD = 0xFF;
INLVLE = 0xF;
```

Example 3-2. PPS Setup Code – Door and Desk Module

```
RC6PPS = 0x0E;  //RC6->EUSART1:TX1;
RX1PPS = 0x17;  //RC7->EUSART1:RX1;
```

3.1.2 Clock

Both the door and desk modules in this application require a high-frequency clock to run the RN4678 Bluetooth Click module at the required baud rate, and to meet the strict timing requirements of the NeoPixel LED Stick. Using the microcontrollers's HFINTOSC clock at 16 MHz meets these requirements. All other clock settings use their default values. See Example 3-3 for the setup code for the clock.

Example 3-3. Clock Initialization Code

```
//SOSCPWR Low power;
OSCCON3 = 0x00;
// HFOEN disabled; MFOEN disabled; LFOEN disabled;
// SOSCEN disabled; ADOEN disabled;
OSCEN = 0x00;
// HFFRQ 16_MHz;
OSCFRQ = 0x04;
// TUN undefined;
OSCTUNE = 0x00;
// ACTEN disabled; ACTUD enabled; ACTLOCK Not locked; ACTORS In range;
ACTCON = 0x00;
```

3.1.3 EUSART

Both the door and desk modules use the microcontroller's EUSART to communicate with the Bluetooth Click modules. Both the microcontrollers and the Bluetooth Click modules must be configured in the same way for the communication to be successful.

For this to occur, set the EUSART parameters as follows:

- EUSART module enabled
- EUSART Transmit and Receive enabled
- EUSART Asynchronous mode enabled
- baud rate of 115200
- 8-bit transmission and reception
- data polarity is non-inverted
- EUSART interrupts disabled

See Example 3-4 for the full setup code for the EUSART.

Example 3-4. EUSART Initialization Code

```
    // ABDEN disabled; WUE disabled; BRG16 16bit_generator; SCKP Non-Inverted;
    BAUD1CON = 0x48;

    // ADDEN disabled; CREN enabled; SREN disabled; RX9 8-bit; SPEN enabled;
    RC1STA = 0x90;

    // TX9D 0x0; BRGH hi_speed; SENDB sync_break_complete; SYNC asynchronous;
TXEN enabled; TX9 8-bit; CSRC client;
    TX1STA = 0x26;

    // SPBRGL 33;
    SP1BRGL = 0x21;

    // SPBRGH 0;
    SP1BRGH = 0x00;
```

3.2 Cap Touch Click Board Functions

The Cap Touch Click board is primarily used in the main WHILE loop in the programming for this application. There are two IF-ELSE statements that are used by the Click board:

- One IF-ELSE statement, located in the code for the door module, sends a signal over the EUSART when the sensor on the Cap Touch Click board is pressed.
- The other IF-ELSE statement, in the code for the desk module, is used to receive the signal that was sent from the EUSART. This signal then triggers the Adafruit NeoPixel Stick to blink on and off.

3.3 NeoPixel Stick Functions

The Adafruit NeoPixel Stick uses a custom-written set of six foundational functions that allow the NeoPixel Stick to turn on or off all its LEDs at the correct time. While there are other types of LED programming solutions, this one is primarily based on software as opposed to hardware.

The `onePulse()` function does not have any inputs and sends a `1` in the correct timing to the LED DIN pin. Likewise, the `zeroPulse()` function does not have any inputs and sends a `0` in the correct timing to the LED DIN pin.

The `LED_send_byte(K)` function uses an unsigned character (char) K as an input. This input, which is a byte of data, utilizes a series of IF-ELSE statements to send the correct `1` or `0` sequence that corresponds to each bit in the K byte.

The LED_Array(R,G,B) function uses three unsigned chars R, G, and B as inputs. Each of these inputs need to be a byte long since it contains the value of the red, green, or blue component of the LED. This function also sends the data in the correct order for the NeoPixel Stick to understand which is green, then red, then blue.

The RED() function has no inputs and sends the color red to all 8 LEDs on the LED Strip. This function can be renamed to other colors and be adapted to any other color.

The OFF() function has no inputs and turns all of the LEDs off. Additional custom functions can be created to cause a blink feature by using the RED() function and/or adapted functions, the OFF() function, and the __delay_ms(x) line of code, where x specifies the delay in milliseconds.

An example blink function, named RED_BLINK_500ms, is shown in Example 3-5.

Example 3-5. Blink Code Example

```
    //All 8 LEDs blink Red and then turn off at a 500 ms interval
void RED_BLINK_500ms()
{
        RED();
        __delay_ms(500);
        OFF();
        __delay_ms(500);
}
```

3.4 Bluetooth Click Module Functions

The RN4678 Bluetooth Click module uses a custom written set of seven functions that setup, control, and communicate with the RN4678 Bluetooth Click modules.

The BT_initialConditions() function sets the base state for the SW_RST, the RST, and CTS pins.

The BT_initialize() function switches the SW_RST, the RST, and the CTS pins to the active state with the correct timing between the commands.

The BT_enterCommandMode() sends the '$$$' that puts the RN4678 Bluetooth Click into Command Mode.

The BT_scan() function sends the correct command to scan for other RN4678 Bluetooth Clicks and waits for that scan to complete (about 20 seconds).

The BT_connect() function sends the correct command to connect to the RN4678 Bluetooth Click door module and uses the correct timing to ensure that the connection is made.

Notes:

1. The BT_scan() and BT_connect() functions are used only in the desk module's code since they initiate the Bluetooth connection.
2. This connection uses the specific MAC address for the modules that are used in this application. The MAC address will need to be changed for other RN4678 Bluetooth Click modules that may be used in the application.

3.5 Other Bluetooth Setting Changes

The RN4678 Bluetooth Click module has many different settings that are not described within this application note. For any additional setting changes, follow these steps:

1. Make sure that all of the Bluetooth Click pins are connected to the microcontroller.
2. Disconnect the TXD and RXD connections between the microcontroller and the Bluetooth Click module.
3. Using a USB to UART device, connect the TXD and RXD pins from the Bluetooth Click module to that device.
4. Now follow the instructions provided in the *RN4678 Bluetooth Dual Mode Module Command Reference User's Guide* for changing any of the settings. The Command Guide (DS50002506) can be found on the RN4678 Bluetooth module product page.

3.6 The Complete Code Project

The complete application code for the wireless cubicle doorbell, along with instructions on how to program your hardware, can be found on this Github page linked below.

AN3313: PIC16F18075 Wireless Cubicle Doorbell Firmware
Click to browse repositories

4. Conclusion

Starting with two PIC microcontrollers and a handful of other Microchip components, we have shown how to integrate everything into a wireless doorbell system. This application note describes the complete signal flow and hardware implementation – from the capacitive touch sensor, through the microcontroller's EUSART, across a data pipe implemented over a wireless Bluetooth connection, through a second EUSART and finally to an LED light stick. It also describes the simple software macros built into the application code that allow the user to fully use the RN4678 Bluetooth module and the NeoPixel LED Stick. If there is one drawback, it may be that when the wireless cubicle doorbell is fully implemented, it may be much harder to ignore the coworkers who come to your cubicle door.

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