**TECNICA-MENTE 2019 – CICLO SUPERIOR**

ESCUELA DE EDUCACIÓN SECUNDARIA TECNICA Nº: 9 Antonio José Rodríguez.

DISTRITO: Lanús.

REGIÓN: 2.

TÍTULO DEL PROYECTO: Sistema Auxiliar para Personas con Limitaciones Motrices.

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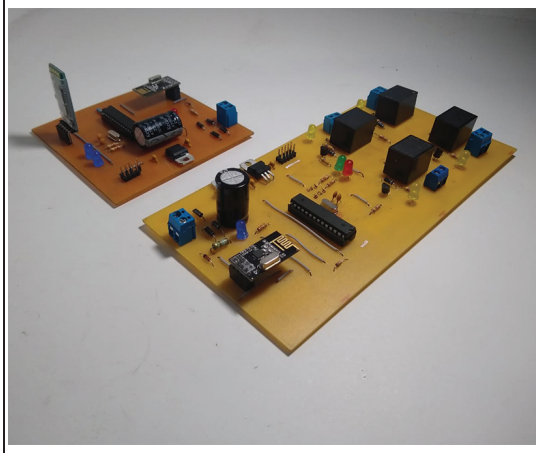
## 1. Objetivo del Proyecto

Las relaciones cercanas con personas de capacidades limitadas nos llevaron a plantearnos la idea de implementar una ayuda para mejorar su calidad de vida a partir de nuestros conocimientos como técnicos electrónicos. A principio de año, junto a nuestros profesores, ideamos un servicial sistema para beneficiarlos; al cual luego lo bautizamos **S**istema **A**uxiliar para **P**ersonas con **L**imitaciones **M**otrices **(SAPLM).**

El objetivo que quisiéramos alcanzar consta en facilitar su vida cotidiana a través de la simplificación de los mandos y controles de sistemas tanto eléctricos como electromecánicos hogareños sin la necesidad de un tercero que lo asista en estas tareas, como podría ser desde un simple encendido de luces hasta regular la calefacción mediante un simple comando por voz procesado por teléfono celular.



Placa principal (Izquierda)
Placa de mandos de potencia (Derecha)

## 2. Descripción del Proyecto

Este sistema se compone en primera instancia de un teléfono móvil Android, el cual el paciente dispone en todo momento, en este se reciben y procesan los comandos de voz mediante la aplicación diseñada, programada y desarrollada por nosotros. Ésta aplicación fue desarrollada en Android Studio, el programa oficial de Android para desarrollo de aplicaciones móviles, y programada en lenguaje Java. Ésta integra dos librerías las cuales resuelven el reconocimiento de voz, pocket-sphinx y la API oficial de Google destinada a este propósito.

Estos comandos luego de ser procesados en la aplicación se envían mediante Bluetooth a lo que nosotros denominamos la placa principal o maestra. La cual, inmediatamente a través de un sistema de radiofrecuencia, retransmite el comando recibido a la placa de mando correspondiente. Estas llamadas placas de mando son aquellas que interactuar directamente con el dispositivo o maquinaria a controlar, reciben un simple comando mediante el sistema de radiofrecuencia enviado desde la placa central y cumplen la orden.

Concretamente en nuestro proyecto se exponen dos placas de mando, una al cual la llamamos “Placa de mandos de potencia” y a la otra “Placa de mandos motrices”. Ambas se componen esencialmente del modulo de radiofrecuencia junto a un microcontrolador de 8 bits de la familia AVR y de todos los elementos para la regulación del voltaje. La “Placa de mandos de potencia” dispone de 4 contactos electromecánicos los cuales controlaran elementos simples, como una estufa, ventilador, luz, velador u otros. En cuanto a la “Placa de mandos motrices” esta dispone de dos drivers para motores paso a paso los cuales manejaran una camilla y una cortina.

El proyecto está planteado de manera extensible de manera que soporte la adición de nuevas placas de mando al sistema ya planteado; luego de una correspondiente actualización del firmware de la placa principal.

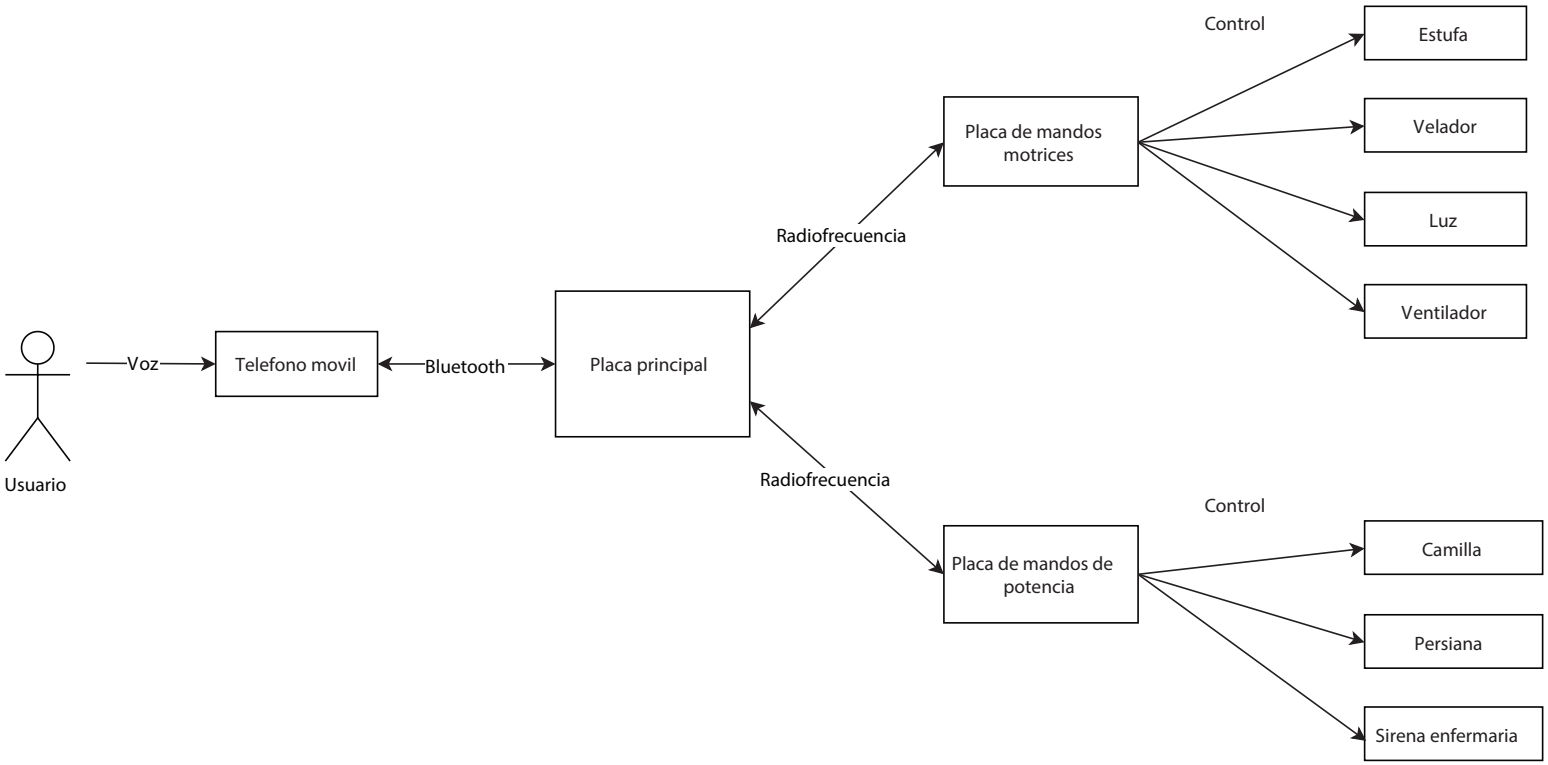
## 3. ESTADO DE DESARROLLO DEL PROYECTO:

Luego de cuatro meses de desarrollo nos encontramos con una firme base del proyecto ya armada. Largas tardes y noches resultaron en una aplicación capaz de recibir comandos de voz con una exactitud competente y de transmitirlos mediante el protocolo Bluetooth. Los firmware de las placas ya están asentados.

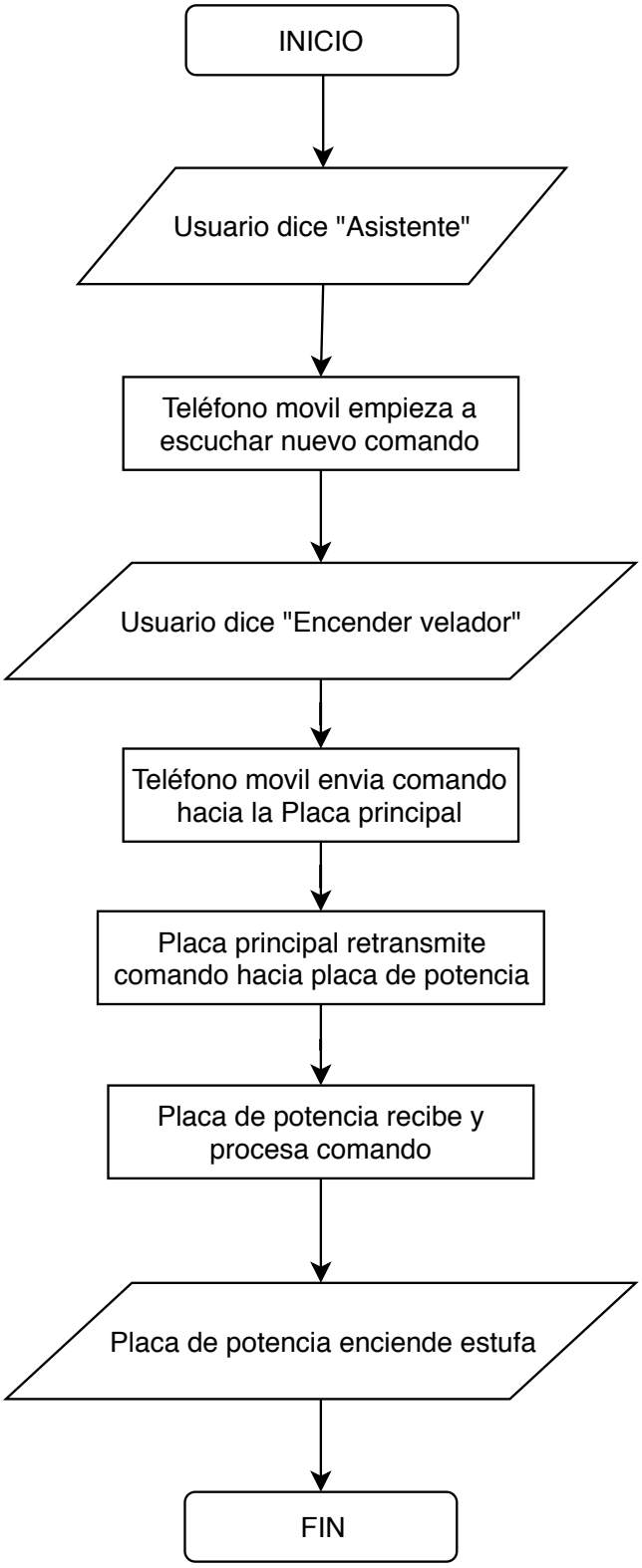
Todas las placas se encuentran diseñadas pero por el momento solo construimos dos de ellas, las cuales funcionan a la perfección . La placa principal sufrió un rediseño luego de que en una jornada de trabajo caigamos en la cuenta de que esta tenía una configuración de conexiones errónea. Se decidió construir primero la “Placa de mandos de potencia” debido a su simpleza, esta no trajo dificultades al armado y sus modificaciones fueron mínimas luego de ser completada.

Con ambas placas en marcha y una aplicación funcional el sistema esta listo para ser utilizado en situaciones simplonas como prender una estufa o luz; sin embargo no lo son para alguien con capacidades diferentes.

# Diagrama de bloques



# Diagrama de flujo para encender una estufa



# CODIGO DE FUENTE PLACA DE POTENCIA

```
 1
 2  #define F_CPU 16000000UL
 3
 4  #define bit_get(p,m) ((p) & (m))
 5  #define bit_set(p,m) ((p) |= (m))
 6  #define bit_clear(p,m) ((p) &= ~(m))
 7  #define bit_flip(p,m) ((p) ^= (m))
 8  #define bit_write(c,p,m) (c ? bit_set(p,m) : bit_clear(p,m))
 9  #define BIT(x) (0x01 << (x))
10  #define LONGBIT(x) ((unsigned long)0x00000001 << (x))
11
12  #include "nrf24.h"
13  #include "Command_Handler.h"
14
15  #include <avr/io.h>
16  #include <string.h>
17  #include <stdlib.h>
18  #include <util/delay.h>
19
20  bool initRF();
21  void initIO();
22  void faultyRF_Alarm();
23
24  int main(void)
25  {
26      initIO();
27      initRF();
28
29      while (1)
30      {
31          if(nrf24_dataReady())
32          {
33              bit_clear(PORTB, BIT(0));
34
35              nrf24_getData(command_buffer);
36
37              bit_set(PORTD, BIT(7));
38              _delay_ms(500);
39              commandType currentCommand;
40              bool success = decomposeCommand(command_buffer, &currentCommand,
                  parameter);
41              if (success) { currentCommand.handlerFunction(); }
42              bit_clear(PORTD, BIT(7));
43          }
44
45          if (nrf24_checkAvailability()==false) { while(initRF()==false); }
46      }
47  }
48
49  void initIO(){
50      /*
51          Input/Output pin initialization
```

```
52          1 : OUTPUT | 0 : INPUT | 0b76543210 Bit order
53          ATTACHMENTS
54              RELAY 0     : PD3               |   OUTPUT
55              RELAY 1     : PD2               |   OUTPUT
56              RELAY 2     : PD6               |   OUTPUT
57              RELAY 3     : PD5               |   OUTPUT
58              RED LED     : PD7               |   OUTPUT
59              GREEN LED   : PB0               |   OUTPUT
60          nRF24L01
61              CE   : PC0                      |   OUTPUT
62              CSN  : PC1                      |   OUTPUT
63              MISO : PD0 (MSPIM MISO ATMEGA)  |   INPUT
64              MOSI : PD1 (MSPIM MOSI ATMEGA)  |   OUTPUT
65              SCK  : PD4 (MSPIM XCK)          |   OUTPUT
66      */
67      DDRD = 0b11111110;
68      DDRB = 0b00101001;
69      DDRC = 0b11011111;
70
71      PORTD = 0b00000000;
72      PORTC = 0b00000000;
73      PORTB = 0b00000000;
74  }
75
76  bool initRF(){
77      uint8_t tx_address[5] = {0xD7,0xD7,0xD7,0xD7,0xD7};
78      uint8_t rx_address[5] = {0xE7,0xE7,0xE7,0xE7,0xE7};
79
80      initliazeMemory();
81
82      /* Power down module */
83      nrf24_powerDown();
84
85      nrf24_init();
86
87      /* Channel #112 , payload length: 32 */
88      nrf24_config(112,32);
89
90      /* Check module configuration */
91      if (nrf24_checkConfig()==false) { faultyRF_Alarm(); return false; }
92
93      /* Set the device addresses */
94      nrf24_tx_address(tx_address);
95      nrf24_rx_address(rx_address);
96
97      /* Power up in receive mode */
98      nrf24_powerUpRx();
99
100     return true;
101 }
102
103 void faultyRF_Alarm(){
```

```
104     bit_clear(PORTD, BIT(7));
105     for (uint8_t x = 0; x < 6; x++)
106     {
107         bit_flip(PORTD, BIT(7));
108         _delay_ms(125);
109 
110     }
111 }
112 
113 
114 
115 
```

```
1
2
3  #ifndef COMMAND_HANDLER_H_
4  #define COMMAND_HANDLER_H_
5
6  #include <stdbool.h>
7  #include <stdint.h>
8
9  #ifndef nullptr
10 #define nullptr ((void *)0)
11 #endif
12
13 #ifndef F_CPU
14 #define F_CPU               16000000UL
15 #endif
16
17 #define AVAILABLE_COMMANDS 6
18 #define COMMAND_BUFFER_SIZE 32
19 #define PARAMETER_BUFFER_SIZE 28
20
21 #ifndef BIT_MANIPULATION_MACRO
22 #define BIT_MANIPULATION_MACRO 1
23 #define bit_get(p,m) ((p) & (m))
24 #define bit_set(p,m) ((p) |= (m))
25 #define bit_clear(p,m) ((p) &= ~(m))
26 #define bit_flip(p,m) ((p) ^= (m))
27 #define bit_write(c,p,m) (c ? bit_set(p,m) : bit_clear(p,m))
28 #define BIT(x) (0x01 << (x))
29 #define LONGBIT(x) ((unsigned long)0x00000001 << (x))
30 #endif
31
32 typedef struct commandType {
33     const char *commandBase;
34     uint8_t nParameters;
35     void (*handlerFunction)();
36 } commandType;
37
38 void *parameter[3];
39 uint8_t *command_buffer;
40 extern bool initliazeMemory();
41 bool memoryInitialized;
42 extern void TURN_RELAY_ON_HANDLE(), TURN_RELAY_OFF_HANDLE(),
     BUILT_IN_LED_TEST_HANDLER(), TURN_EVERYTHING_ON_HANDLER(),
     TURN_EVERYTHING_OFF_HANDLER(), CALL_NURSE_HANDLE();
43
44 extern void composeCommand(void* output_buffer, commandType* commandT, void**
     inputParameter);
45 extern bool decomposeCommand(void* input_buffer, commandType* commandT, void**
     outputParameter);
46
47
48 #endif /* COMMAND_HANDLER_H_ */
```

```
1
2  #include "Command_Handler.h"
3  #include "nrf24.h"
4  #include <stdbool.h>
5  #include <string.h>
6  #include <stdlib.h>
7  #include <stdint.h>
8  #include <avr/io.h>
9  #include <util/delay.h>
10
11
12 const commandType availableCommand[AVAILABLE_COMMANDS] = {
13     { .commandBase = "TURN_RELAY_ON", .nParameters = 1, .handlerFunction =
       &TURN_RELAY_ON_HANDLE},
14     { .commandBase = "TURN_RELAY_OFF", .nParameters = 1, .handlerFunction =
       &TURN_RELAY_OFF_HANDLE},
15     { .commandBase = "BUILT_IN_LED_TEST", .nParameters = 0, .handlerFunction =
       &BUILT_IN_LED_TEST_HANDLER},
16     { .commandBase = "TURN_EVERYTHING_ON", .nParameters = 0, .handlerFunction =
       &TURN_EVERYTHING_ON_HANDLER},
17     { .commandBase = "TURN_EVERYTHING_OFF", .nParameters = 0, .handlerFunction =
       &TURN_EVERYTHING_OFF_HANDLER},
18     { .commandBase = "CALL_NURSE", .nParameters = 0, .handlerFunction =
       &CALL_NURSE_HANDLE}
19 };
20
21 bool initliazeMemory(){
22     if(memoryInitialized) return false;
23     parameter[0] = (void*)calloc(28,1);
24     parameter[1] = (void*)calloc(28,1);
25     parameter[2] = (void*)calloc(28,1);
26     command_buffer = (uint8_t*)calloc(32,1);
27     if(parameter[0]==nullptr||parameter[1]==nullptr||parameter[2]==nullptr||
       command_buffer==nullptr) return false;
28     memoryInitialized = true;
29     return true;
30 }
31
32
33 void composeCommand(void* output_buffer, commandType* commandT, void**
     inputParameter){
34     strcpy(output_buffer, commandT->commandBase);
35     char* startParamPTR = (char*)(output_buffer+strlen(commandT->commandBase));
36     char* endParamPTR = (char*)(startParamPTR+1+strlen(*inputParameter));
37
38     for (uint8_t index = 0; index < commandT->nParameters; index++){
39         *startParamPTR='[';
40         strcpy(startParamPTR+1, *inputParameter);
41         *endParamPTR=']';
42         startParamPTR=(endParamPTR+1);
43         if (index!=(commandT->nParameters-1)){
44             inputParameter++;
```

```
45              uint8_t len = strlen(*inputParameter);
46              endParamPTR = (char*)(startParamPTR+len+1);
47          }
48      }
49      *startParamPTR='\0';
50  }
51
52  bool decomposeCommand(void* input_buffer, commandType* commandT, void**
      outputParameter){
53
54      for (uint8_t index = 0; index < AVAILABLE_COMMANDS; index++){
55          if (memmem(input_buffer, COMMAND_BUFFER_SIZE, availableCommand
              [index].commandBase, strlen(availableCommand[index].commandBase))!
              =nullptr)
56          {
57              *commandT = availableCommand[index]; break;
58          }
59          else if (index==(AVAILABLE_COMMANDS-1)) { return false;}
60      }
61
62      for (uint8_t x = 0; x < commandT->nParameters; x++){
63          uint8_t* startNumPTR = memchr(input_buffer, '[', COMMAND_BUFFER_SIZE);
64          uint8_t* endNumPTR = memchr(input_buffer, ']', COMMAND_BUFFER_SIZE);
65          if (startNumPTR==nullptr||endNumPTR==nullptr) { if(x==0) return false;
              break; }
66          (*startNumPTR) = 0x20;
67          (*endNumPTR) = 0x20;
68          startNumPTR++;
69          uint32_t bytes = ((endNumPTR)) - ((startNumPTR));
70          if (bytes>PARAMETER_BUFFER_SIZE) return false;
71          memcpy(outputParameter[x], startNumPTR, bytes);
72      }
73
74      return true;
75  }
76
77  void TURN_RELAY_ON_HANDLE() {
78      uint8_t relayIndex =  atoi(parameter[0]);
79      switch (relayIndex) {
80          case 0:
81          bit_set(PORTD, BIT(3));
82          break;
83          case 1:
84          bit_set(PORTD, BIT(2));
85          break;
86          case 2:
87          bit_set(PORTD, BIT(6));
88          break;
89          case 3:
90          bit_set(PORTD, BIT(5));
91          break;
92      }
```

```
 93  }
 94
 95  void TURN_RELAY_OFF_HANDLE() {
 96      uint8_t relayIndex =  atoi(parameter[0]);
 97      switch (relayIndex) {
 98          case 0:
 99          bit_clear(PORTD, BIT(3));
100          break;
101          case 1:
102          bit_clear(PORTD, BIT(2));
103          break;
104          case 2:
105          bit_clear(PORTD, BIT(6));
106          break;
107          case 3:
108          bit_clear(PORTD, BIT(5));
109          break;
110      }
111  }
112
113  void BUILT_IN_LED_TEST_HANDLER(){
114      for (uint8_t x = 0; x < 8; x++) {
115          bit_flip(PORTD, BIT(7));
116          bit_flip(PORTB, BIT(0));
117          _delay_ms(250);
118      }
119      bit_clear(PORTD, BIT(7));
120      bit_clear(PORTB, BIT(0));
121  }
122
123  void TURN_EVERYTHING_ON_HANDLER(){
124      bit_set(PORTD, BIT(3));
125      bit_set(PORTD, BIT(2));
126      bit_set(PORTD, BIT(6));
127      bit_set(PORTD, BIT(5));
128  }
129
130  void TURN_EVERYTHING_OFF_HANDLER(){
131      bit_clear(PORTD, BIT(3));
132      bit_clear(PORTD, BIT(2));
133      bit_clear(PORTD, BIT(6));
134      bit_clear(PORTD, BIT(5));
135  }
136
137  void CALL_NURSE_HANDLE(){
138      bit_set(PORTD, BIT(5));
139      _delay_ms(500);
140      bit_clear(PORTD, BIT(5));
141      _delay_ms(500);
142      bit_set(PORTD, BIT(5));
143      _delay_ms(500);
144      bit_clear(PORTD, BIT(5));
```

```
145     _delay_ms(500);
146     bit_set(PORTD, BIT(5));
147     _delay_ms(500);
148     bit_clear(PORTD, BIT(5));
149 }
150
```

```
1  #ifndef NRF24
2  #define NRF24
3
4  #include "nRF24L01_Definitions.h"
5  #include <stdint.h>
6  #include <stdbool.h>
7  #include <util/delay.h>
8
9  #define LOW 0
10 #define HIGH 1
11
12 #define nrf24_ADDR_LEN 5
13 #define nrf24_CONFIG ((1<<EN_CRC)|(0<<CRCO))
14
15 #define NRF24_TRANSMISSON_OK 0
16 #define NRF24_MESSAGE_LOST   1
17
18 void    nrf24_init();
19 void    nrf24_rx_address(uint8_t* adr);
20 void    nrf24_tx_address(uint8_t* adr);
21 void    nrf24_config(uint8_t channel, uint8_t pay_length);
22 bool    nrf24_checkRegister(uint8_t reg, uint8_t desiredValue, uint8_t len);
23 bool    nrf24_checkConfig();
24 bool    nrf24_checkAvailability();
25
26
27 uint8_t nrf24_dataReady();
28 uint8_t nrf24_isSending();
29 uint8_t nrf24_getStatus();
30 uint8_t nrf24_rxFifoEmpty();
31
32 void    nrf24_send(uint8_t* value);
33 void    nrf24_getData(uint8_t* data);
34
35 uint8_t nrf24_payloadLength();
36
37 uint8_t nrf24_lastMessageStatus();
38 uint8_t nrf24_retransmissionCount();
39
40 uint8_t nrf24_payload_length();
41
42 void    nrf24_powerUpRx();
43 void    nrf24_powerUpTx();
44 void    nrf24_powerDown();
45
46 uint8_t spi_transfer(uint8_t tx);
47 void    nrf24_transmitSync(uint8_t* dataout,uint8_t len);
48 void    nrf24_transferSync(uint8_t* dataout,uint8_t* datain,uint8_t len);
49 void    nrf24_configRegister(uint8_t reg, uint8_t value);
50 void    nrf24_readRegister(uint8_t reg, uint8_t* value, uint8_t len);
51 void    nrf24_writeRegister(uint8_t reg, uint8_t* value, uint8_t len);
52
```

```
53  extern void nrf24_setupPins();
54
55  extern void nrf24_ce_digitalWrite(uint8_t state);
56
57  extern void nrf24_csn_digitalWrite(uint8_t state);
58
59  extern void nrf24_sck_digitalWrite(uint8_t state);
60
61  extern void nrf24_mosi_digitalWrite(uint8_t state);
62
63  extern uint8_t nrf24_miso_digitalRead();
64
65  #endif
66
```

```
 1
 2  #define UCPHA0 1
 3  #define F_CPU 8000000UL
 4  #define BAUD_RATE 9600UL
 5  #define UBRR_VALUE ((F_CPU)/(2UL*BAUD_RATE))-1
 6
 7  #include "nrf24.h"
 8  #include <avr/io.h>
 9
10  uint8_t payload_len;
11  uint8_t selectedChannel;
12
13  void nrf24_init()
14  {
15      nrf24_setupPins();
16      nrf24_ce_digitalWrite(LOW);
17      nrf24_csn_digitalWrite(HIGH);
18  }
19
20  void nrf24_config(uint8_t channel, uint8_t pay_length)
21  {
22      /* Use static payload length ... */
23      payload_len = pay_length;
24      selectedChannel = channel;
25      // Set RF channel
26      nrf24_configRegister(RF_CH,channel);
27      // Set length of incoming payload
28      nrf24_configRegister(RX_PW_P0, 0x00); // Auto-ACK pipe ...
29      nrf24_configRegister(RX_PW_P1, payload_len); // Data payload pipe
30      nrf24_configRegister(RX_PW_P2, 0x00); // Pipe not used
31      nrf24_configRegister(RX_PW_P3, 0x00); // Pipe not used
32      nrf24_configRegister(RX_PW_P4, 0x00); // Pipe not used
33      nrf24_configRegister(RX_PW_P5, 0x00); // Pipe not used
34      // 1 Mbps, TX gain: 0dbm
35      nrf24_configRegister(RF_SETUP, (0<<RF_DR)|((0x03)<<RF_PWR));
36      // CRC enable, 1 byte CRC length
37      nrf24_configRegister(CONFIG,nrf24_CONFIG);
38      // Auto Acknowledgment
39      nrf24_configRegister(EN_AA,(1<<ENAA_P0)|(1<<ENAA_P1)|(0<<ENAA_P2)|
          (0<<ENAA_P3)|(0<<ENAA_P4)|(0<<ENAA_P5));
40      // Enable RX addresses
41      nrf24_configRegister(EN_RXADDR,(1<<ERX_P0)|(1<<ERX_P1)|(0<<ERX_P2)|
          (0<<ERX_P3)|(0<<ERX_P4)|(0<<ERX_P5));
42      // Auto retransmit delay: 1000 us and Up to 15 retransmit trials
43      nrf24_configRegister(SETUP_RETR,(0x04<<ARD)|(0x0F<<ARC));
44      // Dynamic length configurations: No dynamic length
45      nrf24_configRegister(DYNPD,(0<<DPL_P0)|(0<<DPL_P1)|(0<<DPL_P2)|(0<<DPL_P3)|
          (0<<DPL_P4)|(0<<DPL_P5));
46
47  }
48
49  bool nrf24_checkConfig(){
```

```
50      // Check all registers
51      if (nrf24_checkRegister(RF_CH, selectedChannel,1)==false) return false;
52      if (nrf24_checkRegister(RX_PW_P0, 0x00,1)==false) return false;
53      if (nrf24_checkRegister(RX_PW_P1, payload_len,1)==false) return false;
54      if (nrf24_checkRegister(RX_PW_P2, 0x00,1)==false) return false;
55      if (nrf24_checkRegister(RX_PW_P3, 0x00,1)==false) return false;
56      if (nrf24_checkRegister(RX_PW_P4, 0x00,1)==false) return false;
57      if (nrf24_checkRegister(RX_PW_P5, 0x00,1)==false) return false;
58      if (nrf24_checkRegister(RF_SETUP, (0<<RF_DR)|((0x03)<<RF_PWR),1)==false)
          return false;
59      if (nrf24_checkRegister(CONFIG,nrf24_CONFIG,1)==false) return false;
60      if (nrf24_checkRegister(EN_AA,(1<<ENAA_P0)|(1<<ENAA_P1)|(0<<ENAA_P2)|
          (0<<ENAA_P3)|(0<<ENAA_P4)|(0<<ENAA_P5),1)==false) return false;
61      if (nrf24_checkRegister(SETUP_RETR,(0x04<<ARD)|(0x0F<<ARC),1)==false) return
          false;
62      if (nrf24_checkRegister(DYNPD,(0<<DPL_P0)|(0<<DPL_P1)|(0<<DPL_P2)|
          (0<<DPL_P3)|(0<<DPL_P4)|(0<<DPL_P5),1)==false) return false;
63
64      return true;
65  }
66
67  bool nrf24_checkAvailability(){
68      if (nrf24_checkRegister(RF_CH, selectedChannel,1)==true) { return true; }
          else { return false;}
69  }
70
71
72
73  /* Set the RX address */
74  void nrf24_rx_address(uint8_t * adr)
75  {
76      nrf24_ce_digitalWrite(LOW);
77      nrf24_writeRegister(RX_ADDR_P1,adr,nrf24_ADDR_LEN);
78      nrf24_ce_digitalWrite(HIGH);
79  }
80
81  /* Returns the payload length */
82  uint8_t nrf24_payload_length()
83  {
84      return payload_len;
85  }
86
87  /* Set the TX address */
88  void nrf24_tx_address(uint8_t* adr)
89  {
90      /* RX_ADDR_P0 must be set to the sending addr for auto ack to work. */
91      nrf24_writeRegister(RX_ADDR_P0,adr,nrf24_ADDR_LEN);
92      nrf24_writeRegister(TX_ADDR,adr,nrf24_ADDR_LEN);
93  }
94
95  /* Checks if data is available for reading */
96  /* Returns 1 if data is ready ... */
```

```
 97  uint8_t nrf24_dataReady()
 98  {
 99      // See note in getData() function - just checking RX_DR isn't good enough
100      uint8_t status = nrf24_getStatus();
101
102      // We can short circuit on RX_DR, but if it's not set, we still need
103      // to check the FIFO for any pending packets
104      if ( status & (1 << RX_DR) )
105      {
106          return 1;
107      }
108
109      return !nrf24_rxFifoEmpty();;
110  }
111
112  /* Checks if receive FIFO is empty or not */
113  uint8_t nrf24_rxFifoEmpty()
114  {
115      uint8_t fifoStatus;
116
117      nrf24_readRegister(FIFO_STATUS,&fifoStatus,1);
118
119      return (fifoStatus & (1 << RX_EMPTY));
120  }
121
122  /* Returns the length of data waiting in the RX fifo */
123  uint8_t nrf24_payloadLength()
124  {
125      uint8_t status;
126      nrf24_csn_digitalWrite(LOW);
127      spi_transfer(R_RX_PL_WID);
128      status = spi_transfer(0x00);
129      nrf24_csn_digitalWrite(HIGH);
130      return status;
131  }
132
133  /* Reads payload bytes into data array */
134  void nrf24_getData(uint8_t* data)
135  {
136      /* Pull down chip select */
137      nrf24_csn_digitalWrite(LOW);
138
139      /* Send cmd to read rx payload */
140      spi_transfer( R_RX_PAYLOAD );
141
142      /* Read payload */
143      nrf24_transferSync(data,data,payload_len);
144
145      /* Pull up chip select */
146      nrf24_csn_digitalWrite(HIGH);
147
148      /* Reset status register */
```

```
149     nrf24_configRegister(STATUS,(1<<RX_DR));
150 }
151
152 /* Returns the number of retransmissions occured for the last message */
153 uint8_t nrf24_retransmissionCount()
154 {
155     uint8_t rv;
156     nrf24_readRegister(OBSERVE_TX,&rv,1);
157     rv = rv & 0x0F;
158     return rv;
159 }
160
161 // Sends a data package to the default address. Be sure to send the correct
162 // amount of bytes as configured as payload on the receiver.
163 void nrf24_send(uint8_t* value)
164 {
165     /* Go to Standby-I first */
166     nrf24_ce_digitalWrite(LOW);
167
168     /* Set to transmitter mode , Power up if needed */
169     nrf24_powerUpTx();
170
171     /* Do we really need to flush TX fifo each time ? */
172     #if 1
173     /* Pull down chip select */
174     nrf24_csn_digitalWrite(LOW);
175
176     /* Write cmd to flush transmit FIFO */
177     spi_transfer(FLUSH_TX);
178
179     /* Pull up chip select */
180     nrf24_csn_digitalWrite(HIGH);
181     #endif
182
183     /* Pull down chip select */
184     nrf24_csn_digitalWrite(LOW);
185
186     /* Write cmd to write payload */
187     spi_transfer(W_TX_PAYLOAD);
188
189     /* Write payload */
190     nrf24_transmitSync(value,payload_len);
191
192     /* Pull up chip select */
193     nrf24_csn_digitalWrite(HIGH);
194
195     /* Start the transmission */
196     nrf24_ce_digitalWrite(HIGH);
197 }
198
199 uint8_t nrf24_isSending()
200 {
```

```
201     uint8_t status;
202
203     /* read the current status */
204     status = nrf24_getStatus();
205
206     /* if sending successful (TX_DS) or max retries exceded (MAX_RT). */
207     if((status & ((1 << TX_DS)  | (1 << MAX_RT))))
208     {
209         return 0; /* false */
210     }
211
212     return 1; /* true */
213
214 }
215
216 uint8_t nrf24_getStatus()
217 {
218     uint8_t rv;
219     nrf24_csn_digitalWrite(LOW);
220     rv = spi_transfer(NOP);
221     nrf24_csn_digitalWrite(HIGH);
222     return rv;
223 }
224
225 uint8_t nrf24_lastMessageStatus()
226 {
227     uint8_t rv;
228
229     rv = nrf24_getStatus();
230
231     /* Transmission went OK */
232     if((rv & ((1 << TX_DS))))
233     {
234         return NRF24_TRANSMISSON_OK;
235     }
236     /* Maximum retransmission count is reached */
237     /* Last message probably went missing ... */
238     else if((rv & ((1 << MAX_RT))))
239     {
240         return NRF24_MESSAGE_LOST;
241     }
242     /* Probably still sending ... */
243     else
244     {
245         return 0xFF;
246     }
247 }
248
249 void nrf24_powerUpRx()
250 {
251     nrf24_csn_digitalWrite(LOW);
252     spi_transfer(FLUSH_RX);
```

```
253     nrf24_csn_digitalWrite(HIGH);
254
255     nrf24_configRegister(STATUS,(1<<RX_DR)|(1<<TX_DS)|(1<<MAX_RT));
256
257     nrf24_ce_digitalWrite(LOW);
258     nrf24_configRegister(CONFIG,nrf24_CONFIG|((1<<PWR_UP)|(1<<PRIM_RX)));
259     nrf24_ce_digitalWrite(HIGH);
260
261     _delay_ms(5);
262 }
263
264 void nrf24_powerUpTx()
265 {
266     nrf24_configRegister(STATUS,(1<<RX_DR)|(1<<TX_DS)|(1<<MAX_RT));
267
268     nrf24_configRegister(CONFIG,nrf24_CONFIG|((1<<PWR_UP)|(0<<PRIM_RX)));
269
270     _delay_ms(5);
271 }
272
273 void nrf24_powerDown()
274 {
275     nrf24_ce_digitalWrite(LOW);
276     nrf24_configRegister(CONFIG,nrf24_CONFIG);
277
278     _delay_ms(5);
279 }
280
281 uint8_t spi_transfer(uint8_t tx)
282 {
283     uint8_t i = 0;
284     uint8_t rx = 0;
285
286     nrf24_sck_digitalWrite(LOW);
287
288     for(i=0;i<8;i++)
289     {
290
291         if(tx & (1<<(7-i)))
292         {
293             nrf24_mosi_digitalWrite(HIGH);
294         }
295         else
296         {
297             nrf24_mosi_digitalWrite(LOW);
298         }
299
300         nrf24_sck_digitalWrite(HIGH);
301
302         rx = rx << 1;
303         if(nrf24_miso_digitalRead())
304         {
```

```
305             rx |= 0x01;
306         }
307
308         nrf24_sck_digitalWrite(LOW);
309
310     }
311
312     return rx;
313 }
314
315 /* send and receive multiple bytes over SPI */
316 void nrf24_transferSync(uint8_t* dataout,uint8_t* datain,uint8_t len)
317 {
318     uint8_t i;
319
320     for(i=0;i<len;i++)
321     {
322         datain[i] = spi_transfer(dataout[i]);
323     }
324
325 }
326
327 /* send multiple bytes over SPI */
328 void nrf24_transmitSync(uint8_t* dataout,uint8_t len)
329 {
330     uint8_t i;
331
332     for(i=0;i<len;i++)
333     {
334         spi_transfer(dataout[i]);
335     }
336
337 }
338
339 /* Clocks only one byte into the given nrf24 register */
340 void nrf24_configRegister(uint8_t reg, uint8_t value)
341 {
342     nrf24_csn_digitalWrite(LOW);
343     spi_transfer(W_REGISTER | (REGISTER_MASK & reg));
344     spi_transfer(value);
345     nrf24_csn_digitalWrite(HIGH);
346 }
347
348 /* Read single register from nrf24 */
349 void nrf24_readRegister(uint8_t reg, uint8_t* value, uint8_t len)
350 {
351     nrf24_csn_digitalWrite(LOW);
352     spi_transfer(R_REGISTER | (REGISTER_MASK & reg));
353     nrf24_transferSync(value,value,len);
354     nrf24_csn_digitalWrite(HIGH);
355 }
356
```

```
357 /* Write to a single register of nrf24 */
358 void nrf24_writeRegister(uint8_t reg, uint8_t* value, uint8_t len)
359 {
360     nrf24_csn_digitalWrite(LOW);
361     spi_transfer(W_REGISTER | (REGISTER_MASK & reg));
362     nrf24_transmitSync(value,len);
363     nrf24_csn_digitalWrite(HIGH);
364 }
365
366 /* Check single register from nrf24 */
367 bool nrf24_checkRegister(uint8_t reg, uint8_t desiredValue, uint8_t len)
368 {
369     uint8_t registerValue;
370     nrf24_readRegister(reg,&registerValue,len);
371     if (registerValue==desiredValue) { return true; } else { return false; }
372 }
373
374 #define RF_DDR  DDRD
375 #define RF_PORT PORTD
376 #define RF_PIN  PIND
377
378 #define CE_CSN_DDR  DDRC
379 #define CE_CSN_PORT PORTC
380 #define CE_CSN_PIN  PINC
381
382 #define MISO_BIT_POS    0
383 #define MOSI_BIT_POS    1
384 #define SCK_BIT_POS     4
385
386 #define CE_BIT_POS      0
387 #define CSN_BIT_POS     1
388
389 #define set_bit(reg,bit) reg |= (1<<bit)
390 #define clr_bit(reg,bit) reg &= ~(1<<bit)
391 #define check_bit(reg,bit) (reg&(1<<bit))
392
393 /* ---------------------------------------------------------------------------- */
394
395 void nrf24_setupPins()
396 {
397     set_bit(CE_CSN_DDR, CE_BIT_POS); // CE output
398     set_bit(CE_CSN_DDR, CSN_BIT_POS); // CSN output
399
400     clr_bit(RF_DDR, MISO_BIT_POS); // MISO input
401     set_bit(RF_DDR, MOSI_BIT_POS); // MOSI output
402     set_bit(RF_DDR, SCK_BIT_POS); // SCK output
403 }
404 /* ---------------------------------------------------------------------------- */
405 void nrf24_ce_digitalWrite(uint8_t state)
406 {
407     if(state)
408     {
```

```
409             set_bit(CE_CSN_PORT, CE_BIT_POS);
410         }
411         else
412         {
413             clr_bit(CE_CSN_PORT, CE_BIT_POS);
414         }
415     }
416     /* ------------------------------------------------------------------------ */
417     void nrf24_csn_digitalWrite(uint8_t state)
418     {
419         if(state)
420         {
421             set_bit(CE_CSN_PORT, CSN_BIT_POS);
422         }
423         else
424         {
425             clr_bit(CE_CSN_PORT, CSN_BIT_POS);
426         }
427     }
428     /* ------------------------------------------------------------------------ */
429     void nrf24_sck_digitalWrite(uint8_t state)
430     {
431         if(state)
432         {
433             set_bit(RF_PORT, SCK_BIT_POS);
434         }
435         else
436         {
437             clr_bit(RF_PORT, SCK_BIT_POS);
438         }
439     }
440     /* ------------------------------------------------------------------------ */
441     void nrf24_mosi_digitalWrite(uint8_t state)
442     {
443         if(state)
444         {
445             set_bit(RF_PORT, MOSI_BIT_POS);
446         }
447         else
448         {
449             clr_bit(RF_PORT, MOSI_BIT_POS);
450         }
451     }
452     /* ------------------------------------------------------------------------ */
453     uint8_t nrf24_miso_digitalRead()
454     {
455         return check_bit(RF_PIN, MISO_BIT_POS);
456     }
457     /* ------------------------------------------------------------------------ */
458
```

# CODIGO DE FUENTE PLACA PRINCIPAL

```c
#define F_CPU                   16000000UL

#include <avr/io.h>
#include <util/delay.h>
#include <avr/interrupt.h>
#include <stdlib.h>
#include <string.h>
#include <stdbool.h>
#include <stdint.h>

#include "UART_Bluetooth.h"
#include "nrf24.h"

void initIO();
void initRF();
char messageTest[] = "UART TESTING COMMANDS! \n";

int main(void)
{
    sei();  // Interrupts on
    initBluetoothUart();
    initIO();
    initRF();
    setupReceiveMode();
    while (1)
    {
        while(!commandAvailable);
        processReceivedLine();
        setupReceiveMode();
    }
}


void initIO(){
    /*
        Input/Output pin initialization
        1 : OUTPUT | 0 : INPUT | 0b76543210 Bit order
        HC-05
            TX          : PD0 (RX ATMEGA)   |   INPUT
            RX          : PD1 (TX ATMEGA)   |   OUTPUT
            KEY/ENABLE  : PD2               |   OUTPUT
            STATE       : PC5               |   INPUT
        nRF24L01
            CE   : PC0                      |   OUTPUT
            CSN  : PC1                      |   OUTPUT
            MISO : PD0 (MSPIM MISO ATMEGA)  |   INPUT
            MOSI : PD1 (MSPIM MOSI ATMEGA)  |   OUTPUT
            SCK  : PD4 (MSPIM XCK)          |   OUTPUT
    */
    DDRD = 0b11111110;
    DDRB = 0b00101001;
    DDRC = 0b11011111;
```

```
53      bit_clear(PORTD, BIT(2));
54  }
55
56  void initRF(){
57      uint8_t tx_address[5] = {0xE7,0xE7,0xE7,0xE7,0xE7};
58      uint8_t rx_address[5] = {0xD7,0xD7,0xD7,0xD7,0xD7};
59
60      nrf24_init();
61
62      /* Channel #112 , payload length: 32 */
63      nrf24_config(112,32);
64
65      /* Set the device addresses */
66      nrf24_tx_address(tx_address);
67      nrf24_rx_address(rx_address);
68  }
69
70
71
72
73
```

```
1
2
3  #ifndef COMMAND_HANDLER_H_
4  #define COMMAND_HANDLER_H_
5
6  #ifndef nullptr
7  #define nullptr ((void *)0)
8  #endif
9
10 #ifndef F_CPU
11 #define F_CPU               16000000UL
12 #endif
13
14 #include <stdbool.h>
15 #include <stdint.h>
16 #include <stdio.h>
17 #include <string.h>
18 #include <stdlib.h>
19 #include <avr/io.h>
20 #include <util/delay.h>
21
22 #define AVAILABLE_COMMANDS 11
23 #define COMMAND_BUFFER_SIZE 32
24 #define PARAMETER_BUFFER_SIZE 28
25
26 #ifndef BIT_MANIPULATION_MACRO
27 #define BIT_MANIPULATION_MACRO 1
28 #define bit_get(p,m) ((p) & (m))
29 #define bit_set(p,m) ((p) |= (m))
30 #define bit_clear(p,m) ((p) &= ~(m))
31 #define bit_flip(p,m) ((p) ^= (m))
32 #define bit_write(c,p,m) (c ? bit_set(p,m) : bit_clear(p,m))
33 #define BIT(x) (0x01 << (x))
34 #define LONGBIT(x) ((unsigned long)0x00000001 << (x))
35 #endif
36
37 typedef struct commandType {
38     const char *commandBase;
39     uint8_t nParameters;
40     void (*handlerFunction)();
41 } commandType;
42
43 void *parameter[3];
44 uint8_t *command_buffer;
45 extern bool initliazeMemory();
46 bool memoryInitialized;
47 extern void ROTATE_FORWARDS_HANDLE(), ROTATE_BACKWARDS_HANDLE(),                  ↵
     TURN_LED_ON_HANDLE(), TURN_LED_OFF_HANDLE(), TURN_RELAY_ON_HANDLE(),          ↵
     TURN_RELAY_OFF_HANDLE();
48 extern void UART_TEST_HANDLER(), BUILT_IN_LED_TEST_HANDLER(),                   ↵
     TURN_EVERYTHING_ON_HANDLE(), TURN_EVERYTHING_OFF_HANDLE(), CALL_NURSE_HANDLE();
49
```

```
50  extern void composeCommand(void* output_buffer, commandType* commandT, void**
      inputParameter);
51  extern bool decomposeCommand(void* input_buffer, commandType* commandT, void**
      outputParameter);
52
53
54  #endif /* COMMAND_HANDLER_H_ */
```

```c

#include "Command_Handler.h"
#include "UART_Bluetooth.h"
#include "nrf24.h"


const commandType availableCommand[AVAILABLE_COMMANDS] = {
    { .commandBase = "ROTATE_FORWARDS", .nParameters = 3, .handlerFunction = &ROTATE_FORWARDS_HANDLE},
    { .commandBase = "ROTATE_BACKWARDS", .nParameters = 1, .handlerFunction = &ROTATE_BACKWARDS_HANDLE},
    { .commandBase = "TURN_LED_ON", .nParameters = 1, .handlerFunction = &TURN_LED_ON_HANDLE},
    { .commandBase = "TURN_LED_OFF", .nParameters = 1, .handlerFunction = &TURN_LED_OFF_HANDLE},
    { .commandBase = "TURN_RELAY_ON", .nParameters = 1, .handlerFunction = &TURN_RELAY_ON_HANDLE},
    { .commandBase = "TURN_RELAY_OFF", .nParameters = 1, .handlerFunction = &TURN_RELAY_OFF_HANDLE},
    { .commandBase = "UART_TEST", .nParameters = 0, .handlerFunction = &UART_TEST_HANDLER},
    { .commandBase = "BUILT_IN_LED_TEST", .nParameters = 0, .handlerFunction = &BUILT_IN_LED_TEST_HANDLER},
    { .commandBase = "TURN_EVERYTHING_ON", .nParameters = 0, .handlerFunction = &TURN_EVERYTHING_ON_HANDLE},
    { .commandBase = "TURN_EVERYTHING_OFF", .nParameters = 0, .handlerFunction = &TURN_EVERYTHING_OFF_HANDLE},
    { .commandBase = "CALL_NURSE", .nParameters = 0, .handlerFunction = &CALL_NURSE_HANDLE}
};

bool initliazeMemory(){
    if(memoryInitialized) return false;
    parameter[0] = (void*)calloc(28,1);
    parameter[1] = (void*)calloc(28,1);
    parameter[2] = (void*)calloc(28,1);
    command_buffer = (uint8_t*)calloc(32,1);
    if(parameter[0]==nullptr||parameter[1]==nullptr||parameter[2]==nullptr||command_buffer==nullptr) return false;
    memoryInitialized = true;
    return true;
}


void composeCommand(void* output_buffer, commandType* commandT, void** inputParameter){
    strcpy(output_buffer, commandT->commandBase);
    char* startParamPTR = (char*)(output_buffer+strlen(commandT->commandBase));
    char* endParamPTR = (char*)(startParamPTR+1+strlen(*inputParameter));

    for (uint8_t index = 0; index < commandT->nParameters; index++){
        *startParamPTR='[';
```

```
40          strcpy(startParamPTR+1, *inputParameter);
41          *endParamPTR=']';
42          startParamPTR=(endParamPTR+1);
43          if (index!=(commandT->nParameters-1)){
44              inputParameter++;
45              uint8_t len = strlen(*inputParameter);
46              endParamPTR = (char*)(startParamPTR+len+1);
47          }
48      }
49      *startParamPTR='\0';
50  }
51
52  bool decomposeCommand(void* input_buffer, commandType* commandT, void**
      outputParameter){
53
54      for (uint8_t index = 0; index < AVAILABLE_COMMANDS; index++){
55          if (memmem(input_buffer, COMMAND_BUFFER_SIZE, availableCommand
              [index].commandBase, strlen(availableCommand[index].commandBase))!
              =nullptr)
56          {
57              *commandT = availableCommand[index]; break;
58          }
59          else if (index==(AVAILABLE_COMMANDS-1)) { return false;}
60      }
61
62      for (uint8_t x = 0; x < commandT->nParameters; x++){
63          uint8_t* startNumPTR = memchr(input_buffer, '[', COMMAND_BUFFER_SIZE);
64          uint8_t* endNumPTR = memchr(input_buffer, ']', COMMAND_BUFFER_SIZE);
65          if (startNumPTR==nullptr||endNumPTR==nullptr) { if(x==0) return false;
              break; }
66          (*startNumPTR) = 0x20;
67          (*endNumPTR) = 0x20;
68          startNumPTR++;
69          uint32_t bytes = ((endNumPTR)) - ((startNumPTR));
70          if (bytes>PARAMETER_BUFFER_SIZE) return false;
71          memcpy(outputParameter[x], startNumPTR, bytes);
72      }
73
74      return true;
75  }
76
77  void ROTATE_FORWARDS_HANDLE() {}
78
79  void ROTATE_BACKWARDS_HANDLE() {}
80
81  void TURN_LED_ON_HANDLE() {}
82
83  void TURN_LED_OFF_HANDLE() {}
84
85  void TURN_RELAY_ON_HANDLE() {
86      composeCommand(command_buffer, &availableCommand[4], parameter);
87
```

```
 88      nrf24_send(command_buffer);
 89      while(nrf24_isSending());
 90
 91      uint8_t messageStatus = nrf24_lastMessageStatus();
 92      if(messageStatus == NRF24_TRANSMISSON_OK) { transmitMessageSync("Successful
           RF transmission! \n", 29); }
 93      else if(messageStatus == NRF24_MESSAGE_LOST) { transmitMessageSync("Failure
           on RF transmission! \n", 29); }
 94
 95      uint8_t retransmissionCount = nrf24_retransmissionCount();
 96      char* retransmissionString = malloc(32);
 97      sprintf(retransmissionString, "Retransmission count: %d \n",
           retransmissionCount);
 98      transmitMessageSync(retransmissionString, strlen(retransmissionString));
 99      free(retransmissionString);
100  }
101
102  void TURN_RELAY_OFF_HANDLE() {
103      composeCommand(command_buffer, &availableCommand[5], parameter);
104
105      nrf24_send(command_buffer);
106      while(nrf24_isSending());
107
108      uint8_t messageStatus = nrf24_lastMessageStatus();
109      if(messageStatus == NRF24_TRANSMISSON_OK) { transmitMessageSync("Successful
           RF transmission! \n", 29); }
110      else if(messageStatus == NRF24_MESSAGE_LOST) { transmitMessageSync("Failure
           on RF transmission! \n", 29); }
111
112      uint8_t retransmissionCount = nrf24_retransmissionCount();
113      char* retransmissionString = malloc(32);
114      sprintf(retransmissionString, "Retransmission count: %d \n",
           retransmissionCount);
115      transmitMessageSync(retransmissionString, strlen(retransmissionString));
116      free(retransmissionString);
117  }
118
119  void UART_TEST_HANDLER() {
120      transmitMessageSync("Successful UART transmission!\n", 30);
121  }
122
123  void BUILT_IN_LED_TEST_HANDLER(){
124      for (uint8_t x = 0; x < 8; x++) {
125          bit_flip(PORTD, BIT(7));
126          bit_flip(PORTB, BIT(0));
127          _delay_ms(250);
128      }
129      bit_clear(PORTD, BIT(7));
130      bit_clear(PORTB, BIT(0));
131  }
132
133  void TURN_EVERYTHING_ON_HANDLE(){
```

```
134     composeCommand(command_buffer, &availableCommand[8], parameter);
135
136     nrf24_send(command_buffer);
137     while(nrf24_isSending());
138
139     uint8_t messageStatus = nrf24_lastMessageStatus();
140     if(messageStatus == NRF24_TRANSMISSON_OK) { transmitMessageSync("Successful
          RF transmission! \n", 29); }
141     else if(messageStatus == NRF24_MESSAGE_LOST) { transmitMessageSync("Failure
          on RF transmission! \n", 29); }
142
143     uint8_t retransmissionCount = nrf24_retransmissionCount();
144     char* retransmissionString = malloc(32);
145     sprintf(retransmissionString, "Retransmission count: %d \n",
          retransmissionCount);
146     transmitMessageSync(retransmissionString, strlen(retransmissionString));
147     free(retransmissionString);
148 }
149
150 void TURN_EVERYTHING_OFF_HANDLE(){
151     composeCommand(command_buffer, &availableCommand[9], parameter);
152
153     nrf24_send(command_buffer);
154     while(nrf24_isSending());
155
156     uint8_t messageStatus = nrf24_lastMessageStatus();
157     if(messageStatus == NRF24_TRANSMISSON_OK) { transmitMessageSync("Successful
          RF transmission! \n", 29); }
158     else if(messageStatus == NRF24_MESSAGE_LOST) { transmitMessageSync("Failure
          on RF transmission! \n", 29); }
159
160     uint8_t retransmissionCount = nrf24_retransmissionCount();
161     char* retransmissionString = malloc(32);
162     sprintf(retransmissionString, "Retransmission count: %d \n",
          retransmissionCount);
163     transmitMessageSync(retransmissionString, strlen(retransmissionString));
164     free(retransmissionString);
165 }
166
167 void CALL_NURSE_HANDLE(){
168     composeCommand(command_buffer, &availableCommand[10], parameter);
169
170     nrf24_send(command_buffer);
171     while(nrf24_isSending());
172
173     uint8_t messageStatus = nrf24_lastMessageStatus();
174     if(messageStatus == NRF24_TRANSMISSON_OK) { transmitMessageSync("Successful
          RF transmission! \n", 29); }
175     else if(messageStatus == NRF24_MESSAGE_LOST) { transmitMessageSync("Failure
          on RF transmission! \n", 29); }
176
177     uint8_t retransmissionCount = nrf24_retransmissionCount();
```

```
178     char* retransmissionString = malloc(32);
179     sprintf(retransmissionString, "Retransmission count: %d \n",
          retransmissionCount);
180     transmitMessageSync(retransmissionString, strlen(retransmissionString));
181     free(retransmissionString);
182 }
183
184
```

```
#ifndef NRF24
#define NRF24

#include "nRF24L01_Definitions.h"
#include <stdint.h>

#define LOW 0
#define HIGH 1

#define nrf24_ADDR_LEN 5
#define nrf24_CONFIG ((1<<EN_CRC)|(0<<CRCO))

#define NRF24_TRANSMISSON_OK 0
#define NRF24_MESSAGE_LOST   1

void    nrf24_init();
void    nrf24_rx_address(uint8_t* adr);
void    nrf24_tx_address(uint8_t* adr);
void    nrf24_config(uint8_t channel, uint8_t pay_length);

uint8_t nrf24_dataReady();
uint8_t nrf24_isSending();
uint8_t nrf24_getStatus();
uint8_t nrf24_rxFifoEmpty();

void    nrf24_send(uint8_t* value);
void    nrf24_getData(uint8_t* data);

uint8_t nrf24_payloadLength();

uint8_t nrf24_lastMessageStatus();
uint8_t nrf24_retransmissionCount();

uint8_t nrf24_payload_length();

void    nrf24_powerUpRx();
void    nrf24_powerUpTx();
void    nrf24_powerDown();

uint8_t spi_transfer(uint8_t tx);
void    nrf24_transmitSync(uint8_t* dataout,uint8_t len);
void    nrf24_transferSync(uint8_t* dataout,uint8_t* datain,uint8_t len);
void    nrf24_configRegister(uint8_t reg, uint8_t value);
void    nrf24_readRegister(uint8_t reg, uint8_t* value, uint8_t len);
void    nrf24_writeRegister(uint8_t reg, uint8_t* value, uint8_t len);

extern void nrf24_setupPins();

extern void nrf24_ce_digitalWrite(uint8_t state);

extern void nrf24_csn_digitalWrite(uint8_t state);

```

```
53  extern void nrf24_sck_digitalWrite(uint8_t state);
54
55  extern void nrf24_mosi_digitalWrite(uint8_t state);
56
57  extern uint8_t nrf24_miso_digitalRead();
58
59  #endif
60
```

```
 1
 2  #define UCPHA0 1
 3  #define F_CPU 8000000UL
 4  #define BAUD_RATE 9600UL
 5  #define UBRR_VALUE ((F_CPU)/(2UL*BAUD_RATE))-1
 6
 7  #include "nrf24.h"
 8  #include <avr/io.h>
 9
10  uint8_t payload_len;
11
12  void nrf24_init()
13  {
14      nrf24_setupPins();
15      nrf24_ce_digitalWrite(LOW);
16      nrf24_csn_digitalWrite(HIGH);
17  }
18
19  void nrf24_config(uint8_t channel, uint8_t pay_length)
20  {
21      /* Use static payload length ... */
22      payload_len = pay_length;
23
24      // Set RF channel
25      nrf24_configRegister(RF_CH,channel);
26
27      // Set length of incoming payload
28      nrf24_configRegister(RX_PW_P0, 0x00); // Auto-ACK pipe ...
29      nrf24_configRegister(RX_PW_P1, payload_len); // Data payload pipe
30      nrf24_configRegister(RX_PW_P2, 0x00); // Pipe not used
31      nrf24_configRegister(RX_PW_P3, 0x00); // Pipe not used
32      nrf24_configRegister(RX_PW_P4, 0x00); // Pipe not used
33      nrf24_configRegister(RX_PW_P5, 0x00); // Pipe not used
34
35      // 1 Mbps, TX gain: 0dbm
36      nrf24_configRegister(RF_SETUP, (0<<RF_DR)|((0x03)<<RF_PWR));
37
38      // CRC enable, 1 byte CRC length
39      nrf24_configRegister(CONFIG,nrf24_CONFIG);
40
41      // Auto Acknowledgment
42      nrf24_configRegister(EN_AA,(1<<ENAA_P0)|(1<<ENAA_P1)|(0<<ENAA_P2)|
          (0<<ENAA_P3)|(0<<ENAA_P4)|(0<<ENAA_P5));
43
44      // Enable RX addresses
45      nrf24_configRegister(EN_RXADDR,(1<<ERX_P0)|(1<<ERX_P1)|(0<<ERX_P2)|
          (0<<ERX_P3)|(0<<ERX_P4)|(0<<ERX_P5));
46
47      // Auto retransmit delay: 1000 us and Up to 15 retransmit trials
48      nrf24_configRegister(SETUP_RETR,(0x04<<ARD)|(0x0F<<ARC));
49
50      // Dynamic length configurations: No dynamic length
```

```
51      nrf24_configRegister(DYNPD,(0<<DPL_P0)|(0<<DPL_P1)|(0<<DPL_P2)|(0<<DPL_P3)|
          (0<<DPL_P4)|(0<<DPL_P5));
52
53      // Start listening
54      nrf24_powerUpRx();
55  }
56
57  /* Set the RX address */
58  void nrf24_rx_address(uint8_t * adr)
59  {
60      nrf24_ce_digitalWrite(LOW);
61      nrf24_writeRegister(RX_ADDR_P1,adr,nrf24_ADDR_LEN);
62      nrf24_ce_digitalWrite(HIGH);
63  }
64
65  /* Returns the payload length */
66  uint8_t nrf24_payload_length()
67  {
68      return payload_len;
69  }
70
71  /* Set the TX address */
72  void nrf24_tx_address(uint8_t* adr)
73  {
74      /* RX_ADDR_P0 must be set to the sending addr for auto ack to work. */
75      nrf24_writeRegister(RX_ADDR_P0,adr,nrf24_ADDR_LEN);
76      nrf24_writeRegister(TX_ADDR,adr,nrf24_ADDR_LEN);
77  }
78
79  /* Checks if data is available for reading */
80  /* Returns 1 if data is ready ... */
81  uint8_t nrf24_dataReady()
82  {
83      // See note in getData() function - just checking RX_DR isn't good enough
84      uint8_t status = nrf24_getStatus();
85
86      // We can short circuit on RX_DR, but if it's not set, we still need
87      // to check the FIFO for any pending packets
88      if ( status & (1 << RX_DR) )
89      {
90          return 1;
91      }
92
93      return !nrf24_rxFifoEmpty();;
94  }
95
96  /* Checks if receive FIFO is empty or not */
97  uint8_t nrf24_rxFifoEmpty()
98  {
99      uint8_t fifoStatus;
100
101     nrf24_readRegister(FIFO_STATUS,&fifoStatus,1);
```

```
102
103     return (fifoStatus & (1 << RX_EMPTY));
104 }
105
106 /* Returns the length of data waiting in the RX fifo */
107 uint8_t nrf24_payloadLength()
108 {
109     uint8_t status;
110     nrf24_csn_digitalWrite(LOW);
111     spi_transfer(R_RX_PL_WID);
112     status = spi_transfer(0x00);
113     nrf24_csn_digitalWrite(HIGH);
114     return status;
115 }
116
117 /* Reads payload bytes into data array */
118 void nrf24_getData(uint8_t* data)
119 {
120     /* Pull down chip select */
121     nrf24_csn_digitalWrite(LOW);
122
123     /* Send cmd to read rx payload */
124     spi_transfer( R_RX_PAYLOAD );
125
126     /* Read payload */
127     nrf24_transferSync(data,data,payload_len);
128
129     /* Pull up chip select */
130     nrf24_csn_digitalWrite(HIGH);
131
132     /* Reset status register */
133     nrf24_configRegister(STATUS,(1<<RX_DR));
134 }
135
136 /* Returns the number of retransmissions occured for the last message */
137 uint8_t nrf24_retransmissionCount()
138 {
139     uint8_t rv;
140     nrf24_readRegister(OBSERVE_TX,&rv,1);
141     rv = rv & 0x0F;
142     return rv;
143 }
144
145 // Sends a data package to the default address. Be sure to send the correct
146 // amount of bytes as configured as payload on the receiver.
147 void nrf24_send(uint8_t* value)
148 {
149     /* Go to Standby-I first */
150     nrf24_ce_digitalWrite(LOW);
151
152     /* Set to transmitter mode , Power up if needed */
153     nrf24_powerUpTx();
```

```
154
155     /* Do we really need to flush TX fifo each time ? */
156     #if 1
157         /* Pull down chip select */
158         nrf24_csn_digitalWrite(LOW);
159
160         /* Write cmd to flush transmit FIFO */
161         spi_transfer(FLUSH_TX);
162
163         /* Pull up chip select */
164         nrf24_csn_digitalWrite(HIGH);
165     #endif
166
167     /* Pull down chip select */
168     nrf24_csn_digitalWrite(LOW);
169
170     /* Write cmd to write payload */
171     spi_transfer(W_TX_PAYLOAD);
172
173     /* Write payload */
174     nrf24_transmitSync(value,payload_len);
175
176     /* Pull up chip select */
177     nrf24_csn_digitalWrite(HIGH);
178
179     /* Start the transmission */
180     nrf24_ce_digitalWrite(HIGH);
181 }
182
183 uint8_t nrf24_isSending()
184 {
185     uint8_t status;
186
187     /* read the current status */
188     status = nrf24_getStatus();
189
190     /* if sending successful (TX_DS) or max retries exceded (MAX_RT). */
191     if((status & ((1 << TX_DS)  | (1 << MAX_RT))))
192     {
193         return 0; /* false */
194     }
195
196     return 1; /* true */
197
198 }
199
200 uint8_t nrf24_getStatus()
201 {
202     uint8_t rv;
203     nrf24_csn_digitalWrite(LOW);
204     rv = spi_transfer(NOP);
205     nrf24_csn_digitalWrite(HIGH);
```

```
206     return rv;
207 }
208 
209 uint8_t nrf24_lastMessageStatus()
210 {
211     uint8_t rv;
212 
213     rv = nrf24_getStatus();
214 
215     /* Transmission went OK */
216     if((rv & ((1 << TX_DS))))
217     {
218         return NRF24_TRANSMISSON_OK;
219     }
220     /* Maximum retransmission count is reached */
221     /* Last message probably went missing ... */
222     else if((rv & ((1 << MAX_RT))))
223     {
224         return NRF24_MESSAGE_LOST;
225     }
226     /* Probably still sending ... */
227     else
228     {
229         return 0xFF;
230     }
231 }
232 
233 void nrf24_powerUpRx()
234 {
235     nrf24_csn_digitalWrite(LOW);
236     spi_transfer(FLUSH_RX);
237     nrf24_csn_digitalWrite(HIGH);
238 
239     nrf24_configRegister(STATUS,(1<<RX_DR)|(1<<TX_DS)|(1<<MAX_RT));
240 
241     nrf24_ce_digitalWrite(LOW);
242     nrf24_configRegister(CONFIG,nrf24_CONFIG|((1<<PWR_UP)|(1<<PRIM_RX)));
243     nrf24_ce_digitalWrite(HIGH);
244 }
245 
246 void nrf24_powerUpTx()
247 {
248     nrf24_configRegister(STATUS,(1<<RX_DR)|(1<<TX_DS)|(1<<MAX_RT));
249 
250     nrf24_configRegister(CONFIG,nrf24_CONFIG|((1<<PWR_UP)|(0<<PRIM_RX)));
251 }
252 
253 void nrf24_powerDown()
254 {
255     nrf24_ce_digitalWrite(LOW);
256     nrf24_configRegister(CONFIG,nrf24_CONFIG);
257 }
```

```
258
259 uint8_t spi_transfer(uint8_t tx)
260 {
261     uint8_t i = 0;
262     uint8_t rx = 0;
263
264     nrf24_sck_digitalWrite(LOW);
265
266     for(i=0;i<8;i++)
267     {
268
269         if(tx & (1<<(7-i)))
270         {
271             nrf24_mosi_digitalWrite(HIGH);
272         }
273         else
274         {
275             nrf24_mosi_digitalWrite(LOW);
276         }
277
278         nrf24_sck_digitalWrite(HIGH);
279
280         rx = rx << 1;
281         if(nrf24_miso_digitalRead())
282         {
283             rx |= 0x01;
284         }
285
286         nrf24_sck_digitalWrite(LOW);
287
288     }
289
290     return rx;
291 }
292
293 /* send and receive multiple bytes over SPI */
294 void nrf24_transferSync(uint8_t* dataout,uint8_t* datain,uint8_t len)
295 {
296     uint8_t i;
297
298     for(i=0;i<len;i++)
299     {
300         datain[i] = spi_transfer(dataout[i]);
301     }
302
303 }
304
305 /* send multiple bytes over SPI */
306 void nrf24_transmitSync(uint8_t* dataout,uint8_t len)
307 {
308     uint8_t i;
309
```

```
310     for(i=0;i<len;i++)
311     {
312         spi_transfer(dataout[i]);
313     }
314 
315 }
316 
317 /* Clocks only one byte into the given nrf24 register */
318 void nrf24_configRegister(uint8_t reg, uint8_t value)
319 {
320     nrf24_csn_digitalWrite(LOW);
321     spi_transfer(W_REGISTER | (REGISTER_MASK & reg));
322     spi_transfer(value);
323     nrf24_csn_digitalWrite(HIGH);
324 }
325 
326 /* Read single register from nrf24 */
327 void nrf24_readRegister(uint8_t reg, uint8_t* value, uint8_t len)
328 {
329     nrf24_csn_digitalWrite(LOW);
330     spi_transfer(R_REGISTER | (REGISTER_MASK & reg));
331     nrf24_transferSync(value,value,len);
332     nrf24_csn_digitalWrite(HIGH);
333 }
334 
335 /* Write to a single register of nrf24 */
336 void nrf24_writeRegister(uint8_t reg, uint8_t* value, uint8_t len)
337 {
338     nrf24_csn_digitalWrite(LOW);
339     spi_transfer(W_REGISTER | (REGISTER_MASK & reg));
340     nrf24_transmitSync(value,len);
341     nrf24_csn_digitalWrite(HIGH);
342 }
343 
344 #define RF_DDR  DDRC
345 #define RF_PORT PORTC
346 #define RF_PIN  PINC
347 
348 #define set_bit(reg,bit) reg |= (1<<bit)
349 #define clr_bit(reg,bit) reg &= ~(1<<bit)
350 #define check_bit(reg,bit) (reg&(1<<bit))
351 
352 /* ------------------------------------------------------------------------ */
353 
354 void nrf24_setupPins()
355 {
356     set_bit(RF_DDR,0); // CE output
357     set_bit(RF_DDR,1); // CSN output
358     set_bit(RF_DDR,2); // SCK output
359     set_bit(RF_DDR,3); // MOSI output
360     clr_bit(RF_DDR,4); // MISO input
361 }
```

```
362 /* ------------------------------------------------------------------------ */
363 void nrf24_ce_digitalWrite(uint8_t state)
364 {
365     if(state)
366     {
367         set_bit(RF_PORT,0);
368     }
369     else
370     {
371         clr_bit(RF_PORT,0);
372     }
373 }
374 /* ------------------------------------------------------------------------ */
375 void nrf24_csn_digitalWrite(uint8_t state)
376 {
377     if(state)
378     {
379         set_bit(RF_PORT,1);
380     }
381     else
382     {
383         clr_bit(RF_PORT,1);
384     }
385 }
386 /* ------------------------------------------------------------------------ */
387 void nrf24_sck_digitalWrite(uint8_t state)
388 {
389     if(state)
390     {
391         set_bit(RF_PORT,2);
392     }
393     else
394     {
395         clr_bit(RF_PORT,2);
396     }
397 }
398 /* ------------------------------------------------------------------------ */
399 void nrf24_mosi_digitalWrite(uint8_t state)
400 {
401     if(state)
402     {
403         set_bit(RF_PORT,3);
404     }
405     else
406     {
407         clr_bit(RF_PORT,3);
408     }
409 }
410 /* ------------------------------------------------------------------------ */
411 uint8_t nrf24_miso_digitalRead()
412 {
413     return check_bit(RF_PIN,4);
```

```
414  }
415  /* ---------------------------------------------------------------------------- */
416
```

```
1
2
3  #ifndef UART_BLUETOOTH_H_
4  #define UART_BLUETOOTH_H_
5
6
7  #include <stdbool.h>
8  #include <stdint.h>
9
10 #ifndef F_CPU
11 #define F_CPU           16000000UL
12 #endif
13
14 #ifndef BAUD
15 #define BAUD            9600
16 #endif
17
18 #ifndef BRC
19 #define BRC             F_CPU/8/BAUD-1
20 #endif
21
22 #ifndef nullptr
23 #define nullptr         nullptr ((void*)0)
24 #endif
25
26 #define uartBufferSize          32
27 #define uartEndMsgChar          '$'
28 #define uartCarriageReturnChar  '/'
29
30 #ifndef BIT_MANIPULATION_MACRO
31 #define BIT_MANIPULATION_MACRO 1
32 #define bit_get(p,m) ((p) & (m))
33 #define bit_set(p,m) ((p) |= (m))
34 #define bit_clear(p,m) ((p) &= ~(m))
35 #define bit_flip(p,m) ((p) ^= (m))
36 #define bit_write(c,p,m) (c ? bit_set(p,m) : bit_clear(p,m))
37 #define BIT(x) (0x01 << (x))
38 #define LONGBIT(x) ((unsigned long)0x00000001 << (x))
39 #endif
40
41
42 extern bool commandAvailable;
43
44 extern void initBluetoothUart();
45 extern void transmitMessage(uint8_t* message, uint8_t length);
46 extern void transmitMessageSync(uint8_t* message, uint8_t length);
47 extern bool transmissionState();
48 extern void setupReceiveMode();
49 extern void processReceivedLine();
50 extern void disableUART();
51
52
```

```
53
54  #endif /* UART_BLUETOOTH_H_ */
```

```
 1
 2
 3  #include "UART_Bluetooth.h"
 4  #include <avr/io.h>
 5  #include <avr/interrupt.h>
 6  #include "Command_Handler.h"
 7  #include <stdlib.h>
 8  #include <string.h>
 9
10  uint8_t* uartBufferPos;
11  uint8_t* uartTxMessageEnd;
12  bool commandAvailable;
13
14  void initBluetoothUart(){
15      // UART Initialization : 8-bit : No parity bit : 1 stop bit
16      UBRR0H = (BRC >> 8); UBRR0L =  BRC;             // UART BAUDRATE
17      UCSR0A |= (1 << U2X0);                          // DOUBLE UART SPEED
18      UCSR0C |= (1 << UCSZ01) | (1 << UCSZ00);        // 8-BIT CHARACTER SIZE
19
20      // Setup UART buffer
21      initliazeMemory();
22      uartBufferPos = command_buffer;
23  }
24
25  void transmitMessage(uint8_t* message, uint8_t length){
26      while (!(UCSR0A & (1<<UDRE0)));
27      uartBufferPos = command_buffer;
28      uartTxMessageEnd = (command_buffer+length);
29      memcpy(command_buffer, message, length);
30      UCSR0A |= (1<<TXC0) | (1<<RXC0);
31      UCSR0B |= (1<<TXEN0) | (1<<TXCIE0);
32      UCSR0B &=~(1<<RXEN0) &~(1<<RXCIE0);
33
34      uartBufferPos++;
35      UDR0 = *(command_buffer);
36  }
37
38  void transmitMessageSync(uint8_t* message, uint8_t length){
39      while (!(UCSR0A & (1<<UDRE0)));
40      uartBufferPos = command_buffer;
41      uartTxMessageEnd = (command_buffer+length);
42      memcpy(command_buffer, message, length);
43      UCSR0A |= (1<<TXC0) | (1<<RXC0);
44      UCSR0B |= (1<<TXEN0) | (1<<TXCIE0);
45      UCSR0B &=~(1<<RXEN0) &~(1<<RXCIE0);
46
47      uartBufferPos++;
48      UDR0 = *(command_buffer);
49
50      while (transmissionState());
51
52  }
```

```
53
54  bool transmissionState(){
55      // True : Currently transmitting | False : Transmission finished
56      if (uartBufferPos!=uartTxMessageEnd)
57      {
58          return true;
59      }
60      else
61      {
62          return false;
63      }
64  }
65
66
67  void setupReceiveMode(){
68      while (!(UCSR0A & (1<<UDRE0)));
69      uartBufferPos = command_buffer;
70
71      UCSR0A |= (1<<RXC0) | (1<<TXC0);
72      UCSR0B &=~(1<<TXEN0) &~(1<<TXCIE0);
73      UCSR0B |= (1<<RXEN0) | (1<<RXCIE0);
74  }
75
76  void processReceivedLine(){
77      commandAvailable = false;
78
79      commandType currentCommand;
80      bool success = decomposeCommand(command_buffer, &currentCommand, parameter);
81      if(success) currentCommand.handlerFunction();
82  }
83
84  void disableUART(){
85      UCSR0B &=~(1<<TXEN0) &~(1<<TXCIE0);
86      UCSR0B &=~(1<<RXEN0) &~(1<<RXCIE0);
87  }
88
89  ISR(USART_TX_vect){
90      if (uartBufferPos!=uartTxMessageEnd){
91          UDR0 = *uartBufferPos;
92          uartBufferPos++;
93      }
94  }
95
96  ISR(USART_RX_vect){
97      if(uartBufferPos!=(command_buffer+uartBufferSize)) {
98          *uartBufferPos=UDR0;
99          if (*uartBufferPos!=uartEndMsgChar) {
100             if(*uartBufferPos!=uartCarriageReturnChar) {uartBufferPos++;} else
                  { uartBufferPos = command_buffer; }
101         }
102         else { disableUART(); commandAvailable = true; }
103     } else {uartBufferPos = command_buffer;}
```

```
104  }
```