RF 模块 MD-Si4432-PHY
说明书

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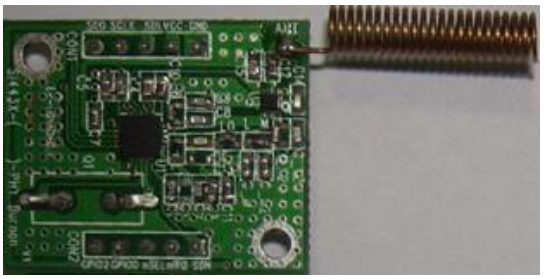
简述

本模块采用了 Silicon Labs 的 Si4432 作为无线收发芯片，是一块完整的、体积小巧的、低功耗无线收发模块。模块集成了芯片所需的外围器件，用户通过提供的数字 I/O 口，控制芯片内部寄存器，实现对无线数据发送、接收、RF 参数设置等功能。

基本特征:



- 完整的 FSK，GFSK,OOK 收发器
- MD-Si4432-433M-PHY，MD-Si4432-470M-PHY
  - 工作频率范围 433~470MHz
  - 发射功率典型 17dBm
  - 接收灵敏度-115 dBm@9.6Kbps
  - 空旷通讯距离 800 米以上@9.6Kbps
- 传输速率最大 128Kbps
- FSK 频偏可编程(1~160KHz)
- 接收带宽可编程(10.6~230.4KHz)
- 只需使用 5 个 I/O 口（SDI,SDO,SCK,NSEL,NIRQ)即可工作
- SPI 兼容的控制接口
- 低功耗任务周期模式,自带唤醒定时器，低关断电流（10nA）
- 1.8~3.6V 电源供电
- 低的接收电流(典型 18.5mA)
- 发射电流(典型 60mA)
- 内置温度传感器与 8 位 ADC
- 集成电压调节器
- 针对窄带系统，内置晶体负载电容微调电路，方便生产调试。

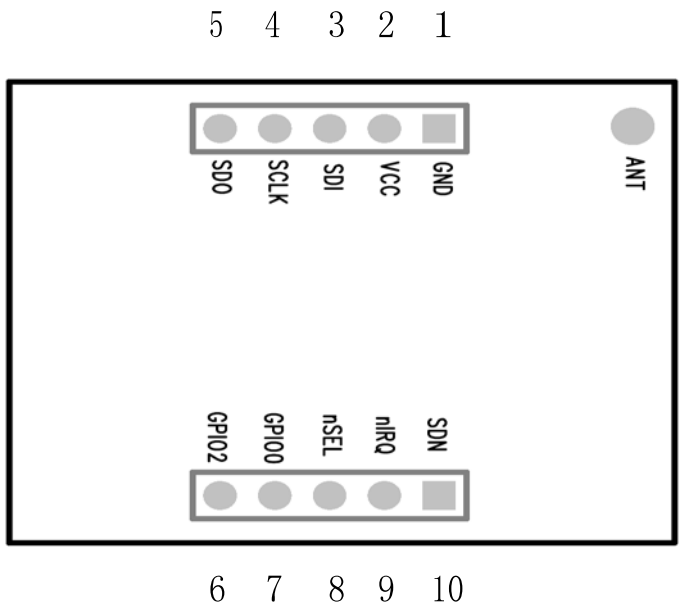
主要用途:

家居自动化和安防门禁系统
无线抄表
车辆防盗
无线传感器
远程无线数据传输
远程工业遥控，遥测

引脚说明:

引脚	定义	类型	说明
1	GND	S	电源地
2	VCC	S	供电电压
3	SDI	DI	SPI 串口数据输入
4	SCLK	DI	SPI 串口时钟输入
5	SDO	DO	SPI 串口数据输出
6	GPIO2	DO	中断请求输出/数字信号控制/接收数据输出（禁止 FIFO 模式）
7	GPIO0	DO	中断请求输出/数字信号控制/接收数据输出（禁止 FIFO 模式）
8	nSEL	DO	SPI 片选输入(低电平有效)
9	nIRQ	DO	中断请求输出(低电平有效)
10	SDN	DI	芯片关断模式输入(高电平有效)

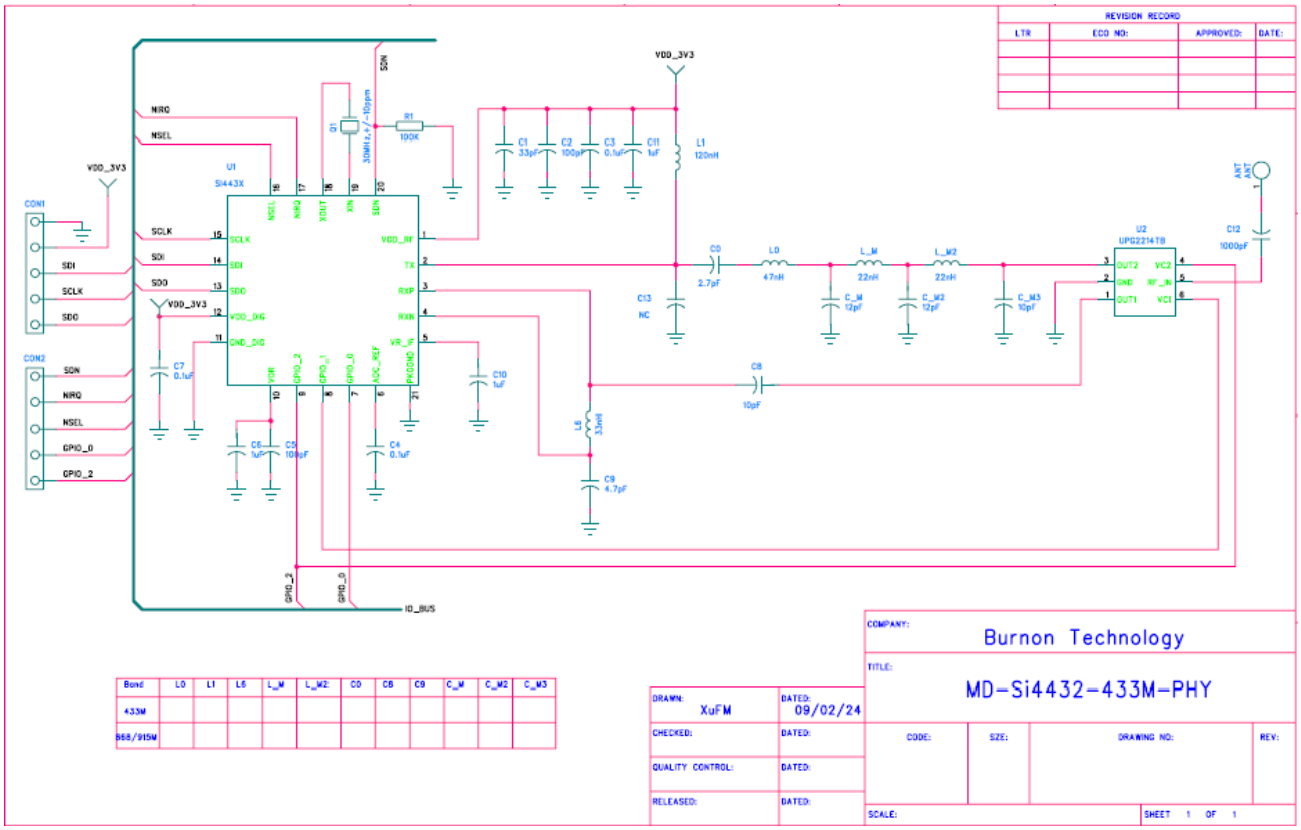
注:D=数字,A=模拟,S=供电,I=输入，O=输出,IO=输入/输出

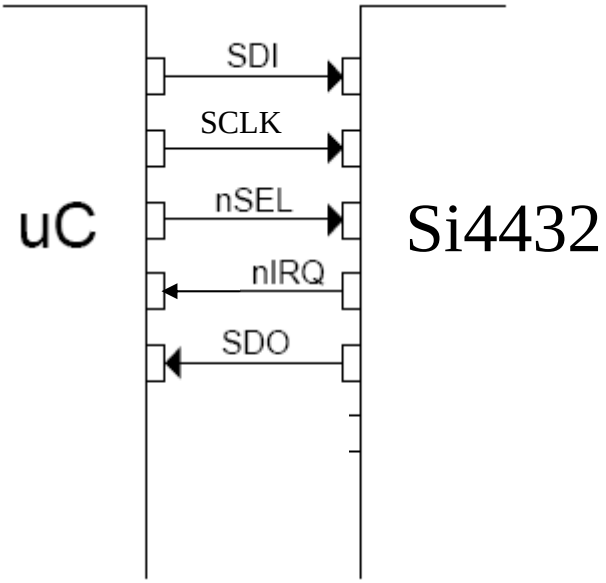


控制原理及方法：

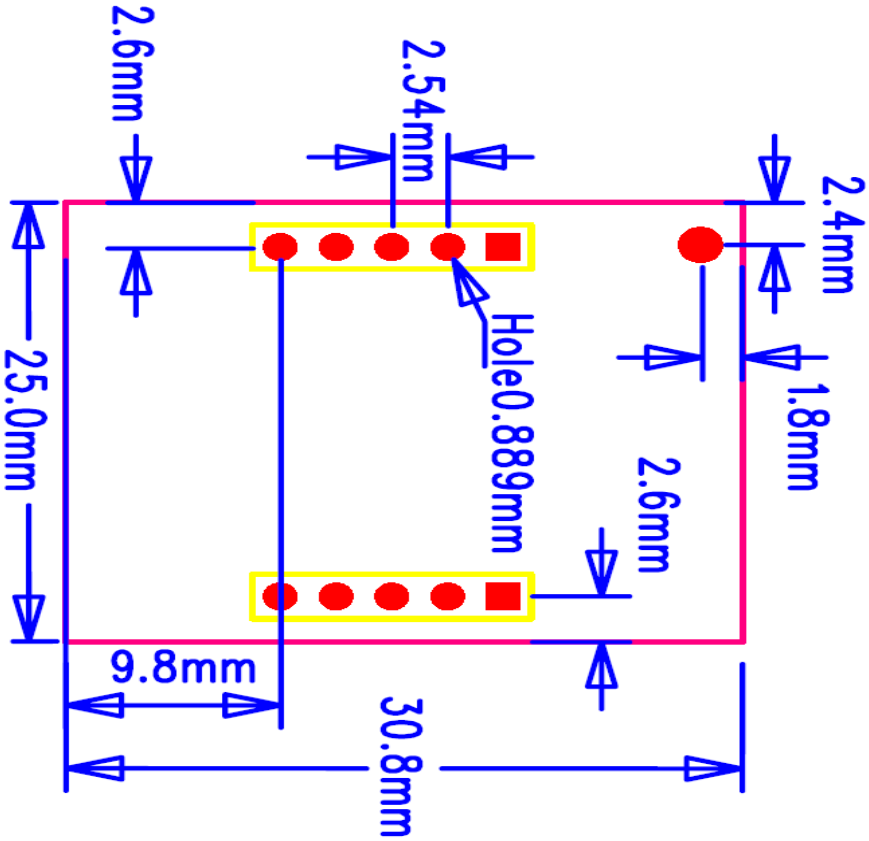
本模块是基于 Silicon Labs 的 Si4432 芯片开发出来的，是将 Si4432 及其正常工作必须的外围元器件集合在一起的一个模块，故模块的控制原理及方法等请参考 Si4432 的数据手册。

参考原理图及 MCU 连接示意图：

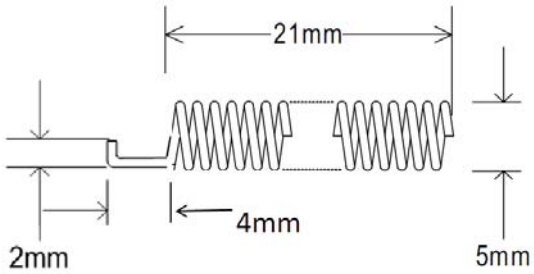




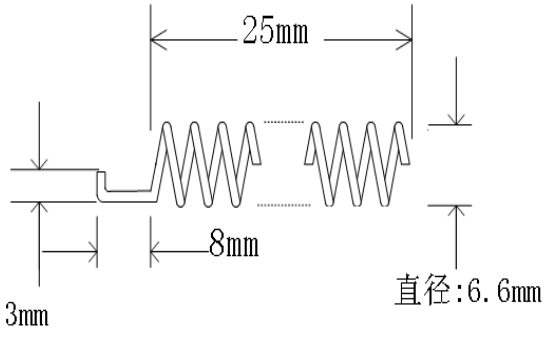
模块尺寸图：



天线信息：

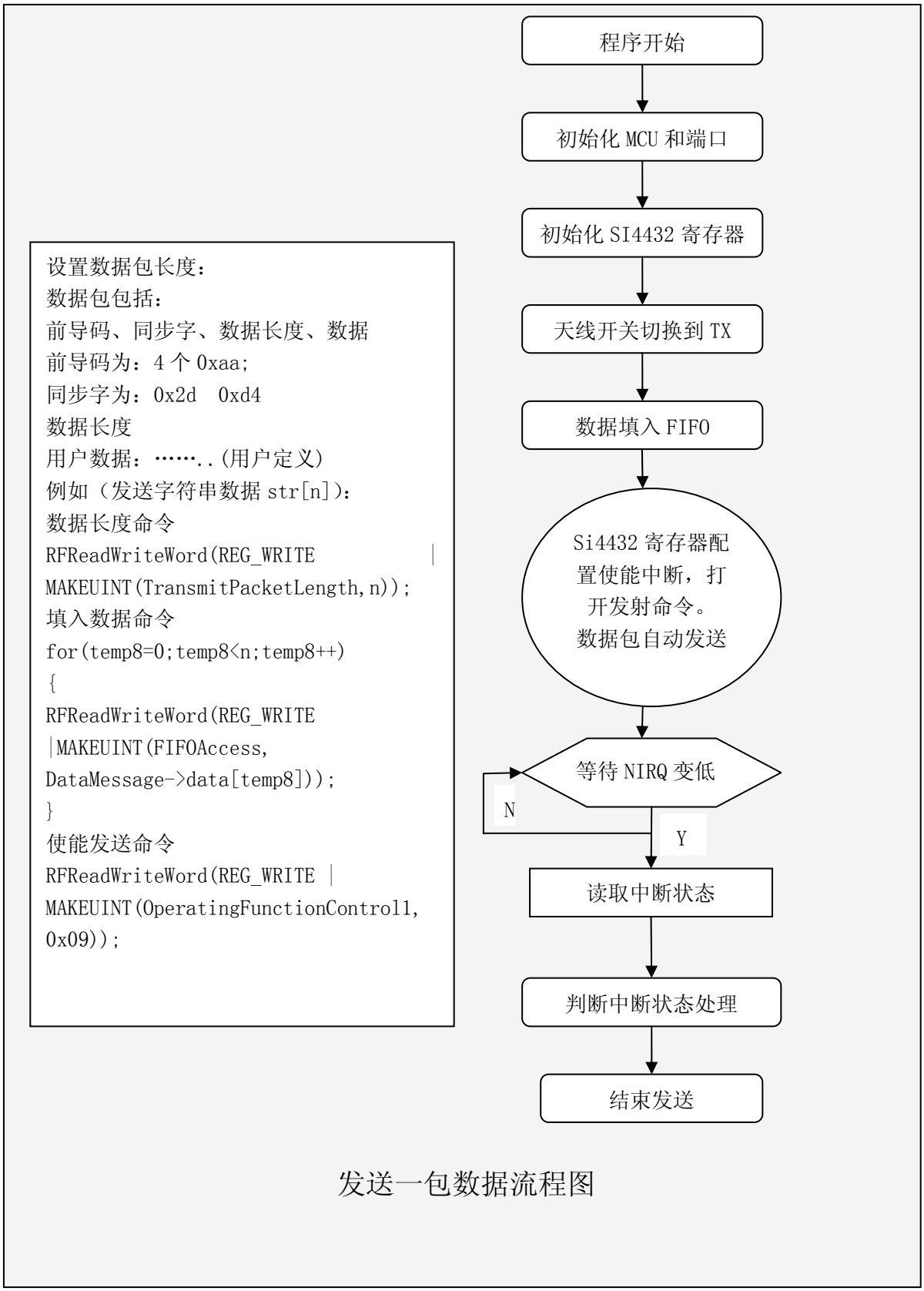


433MHz



470MHz

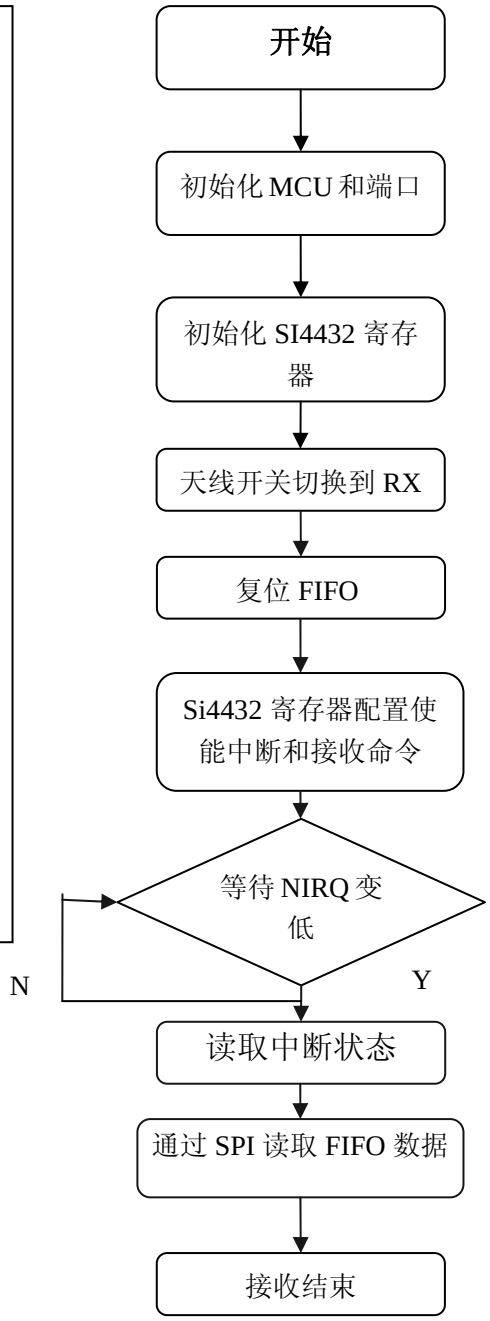
软件简单流程图：



发送一包数据流程图

1. 当接收的时候，芯片自动识别前导码和同步字，不需要干预；
2. 接收数据前，必须复位芯片 FIFO。
   例如（接收一个字符串放 buf[]），以’\0’做为结束符：

```
//clear FIFO
RFReadWriteWord(REG_WRITE
|MAKEUINT(OperatingFunction
Control2, 0x02));
RFReadWriteWord(REG_WRITE
|MAKEUINT(OperatingFunction
Control2, 0x00));
使能接收
RFReadWriteWord(REG_WRITE
|MAKEUINT(OperatingFunction
Control1 , 0x05));
While(NIRQ==0);
读取 FIFO 数据
RFGetBuffer(UCHAR * buff);
```



接收一包数据流程图

软件参考例程：

SI4432_RF.H

```
#ifndef _IA4432_RF_H_
#define  _IA4432_RF_H_
#include "mcudef.h"
#include "macrodefine.h"

//ISP  define
#define SdiIn()    (MISO_DIR=1)
#define SdiSet()    (MISO_PIN=1)
#define SdiClr()    (MISO_PIN=0)
#define SdiData()   (MISO_PIN)

#define  SdoOut()   (MOSI_DIR=0)
#define  SdoSet()   (MOSI_PIN=1)
#define  SdoClr()    (MOSI_PIN=0)
#define  SdoData()   (MOSI_PIN)

#define  SckOut()   (SCK_DIR=0)
#define  SckSet()    (SCK_PIN=1)
#define   SckClr()    (SCK_PIN=0)

#define  nIrqIn()        (RF_NIRQ_DIR=1)
#define  nIrqSet()        (RF_NIRQ_PIN=1)
#define  nIrqData()    (RF_NIRQ_PIN)

#define  nSelOut()       (RF_NSEL_DIR=0)
#define  nSelSet()         (RF_NSEL_PIN=1
#define  nSelClr()      (RF_NSEL_PIN=0)

typedef struct _HEADER
{
    UCHAR header3;
    UCHAR header2;
    UCHAR header1;
    UCHAR header0;
    UCHAR  enabled_headers;
} HEADER;
//数据包格式，用户自行定义
typedef   struct    _MESSAGE
{
    HEADER    header;
```



```
    UCHAR    length;
    UCHAR  *data;
} MESSAGE;
        /* ====================================== *
                *          D E F I N I T I O N S         *
                *          芯片寄存器定义                *
        * ====================================== */
/*definitions for the GPIO Configuration 0,1,2 registers*/
//These functions can be multiplex out to the GPIO pins
#define   GPIO_NPOR                  (0x00)    //only on GPIO0
#define   GPIO_POR                   (0x00)    //only on GPIO1
#define   GPIO_UCLK                  (0x00)    //only on GPIO2
#define   GPIO_WUT                   (0x01)
#define   GPIO_LBD                   (0x02)
#define   GPIO_DIN                   (0x03)
#define   GPIO_IT_FALLING                (0x04)
#define   GPIO_IT_RISING                 (0x05)
#define GPIO_IT_STATE                (0x06)
#define   GPIO_ADC                   (0x07)
#define   GPIO_ATB_IN_N              (0x08)
#define   GPIO_ATB_IN_P              (0x09)
#define GPIO_DOUT                    (0x0A)
#define   GPIO_DTB                   (0x0B)
#define   GPIO_ATB_OUT_N                 (0x0C)
#define   GPIO_ATB_OUT_P                 (0x0D)
#define   GPIO_REF                   (0x0E)
#define GPIO_TX_CLK                      (0x0F)
#define GPIO_TX_DATA_IN              (0x10)
#define GPIO_EXT_RETX                (0x11)
#define GPIO_TX_STATE                (0x12)
#define GPIO_TX_FIFO_AFULL           (0x13)
#define GPIO_RX_DATA                 (0x14)
#define GPIO_RX_STATE                (0x15)
#define GPIO_RX_FIFO_AFULL           (0x16)
#define GPIO_ANT1_SWITCH             (0x17)
#define GPIO_ANT2_SWITCH             (0x18)
#define GPIO_VALID_PREA              (0x19)
#define GPIO_INVALID_PREA            (0x1A)
#define GPIO_SYNCH_WORD_DET          (0x1B)
#define GPIO_CCA                     (0x1C)
#define GPIO_VDD                     (0x1D)
#define GPIO_GND                     (0x1F)

//Register setting default values
#define   RF_MCU_LF_CLK              (0)
```

```
#define   RF_MCU_CLOCK_TAIL           (0)
#define   RF_MCU_CLK_RATE                   (0)

//definitions for register usage
#define   REG_READ                    (0x0000)
#define   REG_WRITE                   (0x8000)
/*definitions for the Modulation Mode Control 2 register*/
//definitions for the TX CLK
#define   TX_CLK_OFF                        (0x00)
#define   TX_CLK_ON_GPIO              (0x40)
#define   TX_CLK_ON_SCK               (0x80)
#define TX_CLK_ON_nIRQ                (0xC0)
//definitions for the Modulation source
#define MOD_DIRECT_VIA_GPIO      (0x00)
#define MOD_DIRECT_VIA_SDI            (0x10)
#define MOD_FIFO                      (0x20)
#define MOD_PN9                           (0x30)
#define MOD_INVERT_TX                 (0x08)
//definition for the modulation type
#define MOD_TYPE_CW                   (0x00)
#define MOD_TYPE_OOK                  (0x01)
#define MOD_TYPE_FSK                  (0x02)
#define MOD_TYPE_GFSK                 (0x03)
/*definitions for the Data Access Control register*/
//definitions for the packet handler
#define TX_PACKET_HANDLER_DIS         (0x00)
#define TX_PACKET_HANDLER_EN          (0x08)
#define RX_PACKET_HANDLER_DIS         (0x00)
#define RX_PACKET_HANDLER_EN          (0x80)
#define LSB_FIRST                     (0x40)
#define MSB_FIRST                     (0x00)
#define CRC_DIS                           (0x00)
#define CRC_CCITT                     (0x04)
#define CRC_16                            (0x05)
#define CRC_IEC16                     (0x06)
#define CRC_BIACHEVA                  (0x07)
#define CRC_DATA_ONLY                 (0x20)
#define AUTO_PHASE_DETECT_MANCH       (0x10)

/*definitions for the TX Power register*/
#define RF_FULL_POWER                 (0x07)
typedef enum _RF_REG_MAP                        //4 定义 32 内部寄存器地址
{
  DeviceType                                    = 0x00,
  DeviceVersion                                     = 0x01,
```



```
DeviceStatus                                = 0x02,
InterruptStatus1                            = 0x03,
InterruptStatus2                            = 0x04,
InterruptEnable1                            = 0x05,
InterruptEnable2                            = 0x06,
OperatingFunctionControl1                   = 0x07,
OperatingFunctionControl2                   = 0x08,
CrystalOscillatorLoadCapacitance            = 0x09,
MicrocontrollerOutputClock                  = 0x0A,
GPIO0Configuration                          = 0x0B,
GPIO1Configuration                          = 0x0C,
GPIO2Configuration                          = 0x0D,
IOPortConfiguration                         = 0x0E,
ADCConfiguration                            = 0x0F,
ADCSensorAmplifierOffset                    = 0x10,
ADCValue                                    = 0x11,
TemperatureSensorControl                    = 0x12,
TemperatureValueOffset                      = 0x13,
WakeUpTimerPeriod1                          = 0x14,
WakeUpTimerPeriod2                          = 0x15,
WakeUpTimerPeriod3                          = 0x16,
WakeUpTimerValue1                           = 0x17,
WakeUpTimerValue2                           = 0x18,
LowDutyCycleModeDuration                    = 0x19,
LowBatteryDetectorThreshold                 = 0x1A,
BatteryVoltageLevel                         = 0x1B,
IFFilterBandwidth                           = 0x1C,
AFCLoopGearshiftOverride                    = 0x1D,
AFCTimingControl                            = 0x1E,
ClockRecoveryGearshiftOverride              = 0x1F,
ClockRecoveryOversamplingRatio              = 0x20,
ClockRecoveryOffset2                        = 0x21,
ClockRecoveryOffset1                        = 0x22,
ClockRecoveryOffset0                        = 0x23,
ClockRecoveryTimingLoopGain1                = 0x24,
ClockRecoveryTimingLoopGain0                = 0x25,
ReceivedSignalStrengthIndicator             = 0x26,
RSSIThresholdForClearChannelIndicator   = 0x27,
AntennaDiversityRegister1                   = 0x28,
AntennaDiversityRegister2                   = 0x29,
DataAccessControl                           = 0x30,
EZmacStatus                                 = 0x31,
HeaderControl1                              = 0x32,
HeaderControl2                              = 0x33,
PreambleLength                              = 0x34,
```

```
PreambleDetectionControl                = 0x35,
SyncWord3                               = 0x36,
SyncWord2                               = 0x37,
SyncWord1                               = 0x38,
SyncWord0                               = 0x39,
TransmitHeader3                         = 0x3A,
TransmitHeader2                         = 0x3B,
TransmitHeader1                         = 0x3C,
TransmitHeader0                         = 0x3D,
TransmitPacketLength                    = 0x3E,
CheckHeader3                                = 0x3F,
CheckHeader2                                = 0x40,
CheckHeader1                                = 0x41,
CheckHeader0                                = 0x42,
HeaderEnable3                           = 0x43,
HeaderEnable2                           = 0x44,
HeaderEnable1                           = 0x45,
HeaderEnable0                           = 0x46,
ReceivedHeader3                         = 0x47,
ReceivedHeader2                         = 0x48,
ReceivedHeader1                         = 0x49,
ReceivedHeader0                         = 0x4A,
ReceivedPacketLength                    = 0x4B,
AnalogTestBus                           = 0x50,
DigitalTestBus                          = 0x51,
TXRampControl                           = 0x52,
PLLTuneTime                                 = 0x53,
CalibrationControl                      = 0x55,
ModemTest                               = 0x56,
ChargepumpTest                          = 0x57,
ChargepumpCurrentTrimming_Override      = 0x58,
DividerCurrentTrimming                      = 0x59,
VCOCurrentTrimming                      = 0x5A,
VCOCalibration_Override                 = 0x5B,
SynthesizerTest                         = 0x5C,
BlockEnableOverride1                    = 0x5D,
BlockEnableOverride2                    = 0x5E,
BlockEnableOverride3                    = 0x5F,
ChannelFilterCoefficientAddress         = 0x60,
ChannelFilterCoefficientValue           = 0x61,
CrystalOscillator_ControlTest           = 0x62,
RCOscillatorCoarseCalibration_Override  = 0x63,
RCOscillatorFineCalibration_Override        = 0x64,
LDOControlOverride                      = 0x65,
DeltasigmaADCTuning1                    = 0x67,
```

```
  DeltasigmaADCTuning2                  = 0x68,
  AGCOverride1                          = 0x69,
  AGCOverride2                          = 0x6A,
  GFSKFIRFilterCoefficientAddress       = 0x6B,
  GFSKFIRFilterCoefficientValue         = 0x6C,
  TXPower                               = 0x6D,
  TXDataRate1                           = 0x6E,
  TXDataRate0                           = 0x6F,
  ModulationModeControl1                = 0x70,
  ModulationModeControl2                = 0x71,
  FrequencyDeviation                    = 0x72,
  FrequencyOffset                       = 0x73,
  FrequencyChannelControl               = 0x74,
  FrequencyBandSelect                   = 0x75,
  NominalCarrierFrequency1              = 0x76,
  NominalCarrierFrequency0              = 0x77,
  FrequencyHoppingChannelSelect         = 0x79,
  FrequencyHoppingStepSize              = 0x7A,
  TXFIFOControl1                        = 0x7C,
  TXFIFOControl2                        = 0x7D,
  RXFIFOControl                         = 0x7E,
  FIFOAccess                            = 0x7F,
} RF_REG_MAP;

extern MESSAGE    gcMessage;

void   RfPortInit(void);                    //初始化 spi 端口
BOOL  RfChipInit(void);                    //芯片初始化
UINT  RFReadWriteWord(UINT cmd);           //读写寄存器
void RFIdle(void);                          //进入准备状态
void  RFSleep(void);                       //进入睡眠状态
void  RFTransmitByte(UCHAR data);          //发送一个字节
void RFTransmitMessage(MESSAGE *DataMessage);      //发送一个数据结构
void RFReceiveReady(void);//start receive                 //接收准备
void RFWakeUp(void);                       //睡眠唤醒
void RFGetBuffer(UCHAR * buff);             //读取 fifo 数据
UCHAR RFGetStringMun(UCHAR *str);
#endif
```

SI4432_RF.C

```
#include "ia4432_rf.h"
//************************************************************
//函数名:VOID RfPortInit(VOID)
//功能:初始化 spi 端口设置
```

```
//************************************************************
void RfPortInit(void)
{
       SckOut();
     SckClr();
     SdiSet();
     SdiIn();
     SdoSet();
     SdoOut();
     nSelOut();
     nSelSet();
     nIrqSet();
      nIrqIn();
}
//************************************************************
//函数名:BOOL  RfChipInit(VOID)
//功能:芯片初始化
//参数:    无
//************************************************************
BOOL RfChipInit(void)
{
     UCHAR  setting=1;
     UCHAR  temp;
     //release all IT flag to set IRQ high
     ItStatus1 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus1 << 8));
     ItStatus2 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus2 << 8));
     //SW reset    -> wait for POR interrupt   复位成功则 nirq 会拉 low
     RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl1, 0x80));          //4 复位所有 spi 寄存器
     while(RF_NIRQ_PIN);
     //check the status of the POR
     if( RF_NIRQ_PIN == 0x00 )
     {//POR performedcorrectly
          //disable XTAL
          RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl1, 0x00));
          //set RF stack stateh
     }
     else
     {//POR error
          return FALSE;
     }
     //release all IT flag
     ItStatus1 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus1 << 8));
     ItStatus2 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus2 << 8));
     //disable all ITs, except 'ichiprdy'
     RFReadWriteWord(REG_WRITE | MAKEUINT(InterruptEnable1, 0x00));
```



```
RFReadWriteWord(REG_WRITE | MAKEUINT(InterruptEnable2, 0x02));
// TXPower
RFReadWriteWord(REG_WRITE|MAKEUINT(TXPower,0x03));
//crystal load cap.
RFReadWriteWord(REG_WRITE | MAKEUINT(CrystalOscillatorLoadCapacitance, 0x7f)); //lzc  72
//set VCO current trimming
RFReadWriteWord(REG_WRITE | MAKEUINT(VCOCurrentTrimming, 0x7f));
RFReadWriteWord(REG_WRITE | MAKEUINT(CrystalOscillator_ControlTest, 0x00));
// Set TX Ramp Control
RFReadWriteWord(REG_WRITE | MAKEUINT(TXRampControl, 0x7f));
//disable AFC
RFReadWriteWord(REG_WRITE | MAKEUINT(AFCLoopGearshiftOverride, 0x40)); //0902190x80
RFReadWriteWord(REG_WRITE | MAKEUINT(AFCTimingControl, 0x08));
//set 10kHz offset at high band -> it helps to tune the XTAL to the correct frequency by the cap bank
RFReadWriteWord(REG_WRITE |MAKEUINT( FrequencyOffset, 0x00));
RFReadWriteWord(REG_WRITE |MAKEUINT( FrequencyChannelControl, 0x00));
//reset digital testbus, disable scan test\
RFReadWriteWord(REG_WRITE | MAKEUINT(DigitalTestBus, 0x00));
//select nothing to the Analog Testbus
RFReadWriteWord(REG_WRITE | MAKEUINT(AnalogTestBus, 0x0b));
//start the crystal oscillator
RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl1, 0x01));
while(RF_NIRQ_PIN==0);
//set frequency band
RFReadWriteWord(REG_WRITE | MAKEUINT(FrequencyBandSelect,0x57));//470MHZ
//set frequency
RFReadWriteWord(REG_WRITE | MAKEUINT(NominalCarrierFrequency1, 0x4a));//0x4a));
RFReadWriteWord(REG_WRITE | MAKEUINT(NominalCarrierFrequency0, 0x00));//0x00));
//bug in revX: if txhdlen[2:0] is not 0, the length handled wrong way during RX!    设置前导
//set lower byte
RFReadWriteWord(REG_WRITE | MAKEUINT(PreambleLength, 0x08));    //4  4*16nit  = 8byte
RFReadWriteWord(REG_WRITE | MAKEUINT(PreambleDetectionControl, 0x20));
//synch word
RFReadWriteWord(REG_WRITE | MAKEUINT(HeaderControl2, 0x02));
RFReadWriteWord(REG_WRITE | MAKEUINT(SyncWord3,0x2d));
RFReadWriteWord(REG_WRITE | MAKEUINT(SyncWord2,0xd4));
//set RF chip for FIFO operation
//Modulation mode
RFReadWriteWord(REG_WRITE | MAKEUINT(ModulationModeControl1, 0x2c));
RFReadWriteWord(REG_WRITE | MAKEUINT(ModulationModeControl2, ( TX_CLK_ON_GPIO|MOD_FIFO | MOD_TYPE_FSK)));
      //lzc
//enable packet handler & CRC16
 RFReadWriteWord(REG_WRITE | MAKEUINT(DataAccessControl, (RX_PACKET_HANDLER_EN | TX_PACKET_HANDLER_EN |
CRC_16)));
```

```
    //set the registers according the selected RF settings
    RFReadWriteWord(REG_WRITE | MAKEUINT(IFFilterBandwidth, RfSettings[setting][0]));
    RFReadWriteWord(REG_WRITE | MAKEUINT(ClockRecoveryOversamplingRatio, RfSettings[setting][1]));
    RFReadWriteWord(REG_WRITE | MAKEUINT(ClockRecoveryOffset2, RfSettings[setting][2]));
    RFReadWriteWord(REG_WRITE | MAKEUINT(ClockRecoveryOffset1, RfSettings[setting][3]));
    RFReadWriteWord(REG_WRITE | MAKEUINT(ClockRecoveryOffset0, RfSettings[setting][4]));
    RFReadWriteWord(REG_WRITE | MAKEUINT(ClockRecoveryTimingLoopGain1, RfSettings[setting][5]));
    RFReadWriteWord(REG_WRITE | MAKEUINT(ClockRecoveryTimingLoopGain0, RfSettings[setting][6]));
    RFReadWriteWord(REG_WRITE | MAKEUINT(TXDataRate1, RfSettings[setting][7]));
    RFReadWriteWord(REG_WRITE | MAKEUINT(TXDataRate0, RfSettings[setting][8]));
    RFReadWriteWord(REG_WRITE | MAKEUINT(FrequencyDeviation, RfSettings[setting][9]));
    //automatic Gain Control (ONLY FOR revX2)
    RFReadWriteWord(REG_WRITE | MAKEUINT(AGCOverride1, 0x20));
    RFReadWriteWord(REG_WRITE | MAKEUINT(AGCOverride2, 0x0b));
    //override ADC refernce voltage to 0.8V
    RFReadWriteWord(REG_WRITE | MAKEUINT(DeltasigmaADCTuning2, 0x03));
    return TRUE;
}
//*************************************************************
//函数名:void  RFSleep(void)
//功能:使能睡眠
//参数:    无
//*************************************************************
void  RFSleep(void)
{
    //stop the crystal oscillator
    UCHAR temp8;
    //stop the crystal oscillator
    temp8 = (UCHAR)(0x00FF & RFReadWriteWord(OperatingFunctionControl1 << 8));
    temp8 &= 0xFE;
    RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl1, temp8));
}
//*************************************************************
//函数名:void  RFWakeUp(void)
//功能:唤醒
//参数:    无
//*************************************************************
void RFWakeUp(void)
{
    //start the crystal oscillator
    RFReadWriteWord(REG_WRITE |MAKEUINT( OperatingFunctionControl1, 0x01));
}
//*************************************************************
//函数名:void RFIdle(void)
//功能:  准备模式
```



```
//参数:    无
//*************************************************************
void RFIdle(void)                    //4 准备模式
{
     //switch off everything except XTAL
     RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl1, 0x01));
      //clear  interrupt
     RFReadWriteWord(REG_WRITE | MAKEUINT(InterruptEnable1, 0x00));
     RFReadWriteWord(REG_WRITE | MAKEUINT(InterruptEnable2, 0x00));
    //release all IT flag
     ItStatus1 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus1 << 8));
     ItStatus2 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus2 << 8));
}
//*************************************************************
//函数名:void  RFTransmitByte(UCHAR data)
//功能:  发送一个字节
//参数:    无
//*************************************************************
void  RFTransmitByte(UCHAR data)
{
     //release all IT flag
     ItStatus1 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus1 << 8));
     ItStatus2 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus2 << 8));
     if(ItStatus1&0x04==0x00)               //4 发送完毕中断标志位置位
     {
          //clear FIFO
          RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl2, 0x01));
          RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl2, 0x00));
           //set packet content
          RFReadWriteWord(REG_WRITE | MAKEUINT(TransmitPacketLength, 0x01));
          //set data
          RFReadWriteWord(REG_WRITE | MAKEUINT(FIFOAccess, data));
          //enable transmitter
          RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl1, 0x09));
          //enable the wanted ITs
          RFReadWriteWord(REG_WRITE | MAKEUINT(InterruptEnable1, 0x04));        //发送完中断允许
          RFReadWriteWord(REG_WRITE | MAKEUINT(InterruptEnable2, 0x00));
     }
      while(RF_NIRQ_PIN==1);
     ItStatus1 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus1 << 8));
     ItStatus2 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus2 << 8));
}
//*************************************************************
//函数名:void RFTransmitMessage(MESSAGE *DataMessage)
//功能:  发送一个数据结构
```

```
//参数:  MESSAGE 结构体
//*************************************************************
void RFTransmitMessage(MESSAGE *DataMessage)
{
      UCHAR  temp8;
     //gpio  control
      RFReadWriteWord(REG_WRITE | MAKEUINT(GPIO1Configuration, 0xca));  //0x03
      RFReadWriteWord(REG_WRITE | MAKEUINT(GPIO2Configuration, 0xca));  //0x23
      RFReadWriteWord(REG_WRITE | MAKEUINT(IOPortConfiguration, 0x02));  //0x02
      Delay(100);
     //release all IT flag
     ItStatus1 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus1 << 8));
     ItStatus2 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus2 << 8));
     //clear FIFO
     temp8=(UCHAR)(0x00FF & RFReadWriteWord(OperatingFunctionControl2<<8));//
     RFReadWriteWord( OperatingFunctionControl2 );
     temp8 |= 0x03;
     RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl2, temp8));
     temp8 &= 0xFc;
     RFReadWriteWord(REG_WRITE |MAKEUINT( OperatingFunctionControl2, temp8));
     //set headers and filters
     //bug in revX: if txhdlen[2:0] is not 0, the length handled wrong way during RX!
     temp8 =(UCHAR)(0x00FF & RFReadWriteWord(HeaderControl2 << 8));
     temp8 &= 0x07;
     RFReadWriteWord(REG_WRITE | MAKEUINT(HeaderControl2 , temp8));
    //set packet content
     RFReadWriteWord(REG_WRITE | MAKEUINT(TransmitPacketLength, DataMessage->length));
     //set data
       for(temp8=0;temp8<DataMessage->length;temp8++)
         {
            RFReadWriteWord(REG_WRITE | MAKEUINT(FIFOAccess, DataMessage->data[temp8]));
          }
     //enable transmitter
     RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl1, 0x09));
     //enable the wanted ITs
     RFReadWriteWord(REG_WRITE | MAKEUINT(InterruptEnable1, 0x04));      //发送完中断允许
     RFReadWriteWord(REG_WRITE | MAKEUINT(InterruptEnable2, 0x00));
     ItStatus1 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus1 << 8));
     ItStatus2 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus2 << 8));
}
//*************************************************************
//函数名:void RFReceiveReady(void)
//功能: 进入接收数据状态
//参数:    无
//*************************************************************
```



```
void RFReceiveReady(void)
{
       UCHAR temp8;
//-------------------------------------------------------------------------
//GPIO0 - RX_CLK
//gpio  control
RFReadWriteWord(REG_WRITE | MAKEUINT(GPIO1Configuration, 0xca));  //0x03
RFReadWriteWord(REG_WRITE | MAKEUINT(GPIO2Configuration, 0xca));  //0x23
RFReadWriteWord(REG_WRITE | MAKEUINT(IOPortConfiguration, 0x04));  //0x04
//-------------------------------------------------------------------------
//clear FIFO
RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl2, 0x02));
RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl2, 0x00));
//restart ADC   mcp6004
RFReadWriteWord(REG_WRITE |MAKEUINT( HeaderControl1 , 0x8c));
temp8 =(UCHAR)(0x00FF & RFReadWriteWord(HeaderControl2 << 8));
 temp8 &= 0x07;
RFReadWriteWord(REG_WRITE | MAKEUINT(HeaderControl2 , temp8));
RFReadWriteWord(REG_WRITE | MAKEUINT(DeltasigmaADCTuning1, 0x80));
RFReadWriteWord(REG_WRITE | MAKEUINT(DeltasigmaADCTuning1, 0x00));
//enable receiver chain
temp8 = (UCHAR)(0x00FF & RFReadWriteWord(OperatingFunctionControl1 << 8));
     temp8 |= 0x05;
     RFReadWriteWord(REG_WRITE | MAKEUINT(OperatingFunctionControl1 , temp8));
     //enable the wanted ITs
     RFReadWriteWord(REG_WRITE | MAKEUINT(InterruptEnable1, 0x02));
     RFReadWriteWord(REG_WRITE | MAKEUINT(InterruptEnable1, 0x03));
     RFReadWriteWord(REG_WRITE |MAKEUINT( InterruptEnable2, 0x00));
     ItStatus1 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus1 << 8));
     ItStatus2 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus2 << 8));
}
//*************************************************************
//函数名:void RFGetBuffer(UCHAR * buff)
//功能: 对取 buff 数据
//参数:    字符串指针
//*************************************************************
void RFGetBuffer(UCHAR * buff)
{
     UCHAR k,J;
     k=  (UCHAR)(0x00FF & RFReadWriteWord(ReceivedPacketLength << 8)) ;          //读取数据长度
     for(J=0;J<k;J++)
     {
          buff[J] = (UCHAR)(0x00FF & RFReadWriteWord(FIFOAccess << 8));           //读取 fifo 数据
     }
     buff[J] =0x00;
```

```
}
//*************************************************************
//函数名:UCHAR RFGetStringMun(UCHAR *str)
//功能: 提取字符串长度
//参数: 字符串指针
//*************************************************************
UCHAR RFGetStringMun(UCHAR *str)
{
        UCHAR  temp;
        for(temp=0;str[temp]!='\0';temp++);
       return temp;
}
//*************************************************************
//函数名:UINT RFReadWriteWord(UINT cmd)
//功能: //SPI  数据读写
//参数:    无
//*************************************************************
UINT RFReadWriteWord(UINT cmd)
{
      UCHAR ri;
      UINT temp;
      temp =0;
      SckClr();                          //拉低时钟线
      nSelClr();                        //片选
      for(ri=0;ri<16;ri++)              //16 位数据
          {
            SckClr();                    //拉低时钟线
         if(0x8000&cmd)               //取出一位数据
              {
                 SdoSet();
          }
          else
              {
                 SdoClr();
          }
//      Delay(8);
         SckSet();                      //上升沿打入数据
         cmd<<=1;                   //左移一位数据
         temp <<=1;
              if(SdiData())
              {
                temp |= 0x0001;
              }
       }
     SckClr();                        //****************注意必须恢复原来的引脚状态************
```

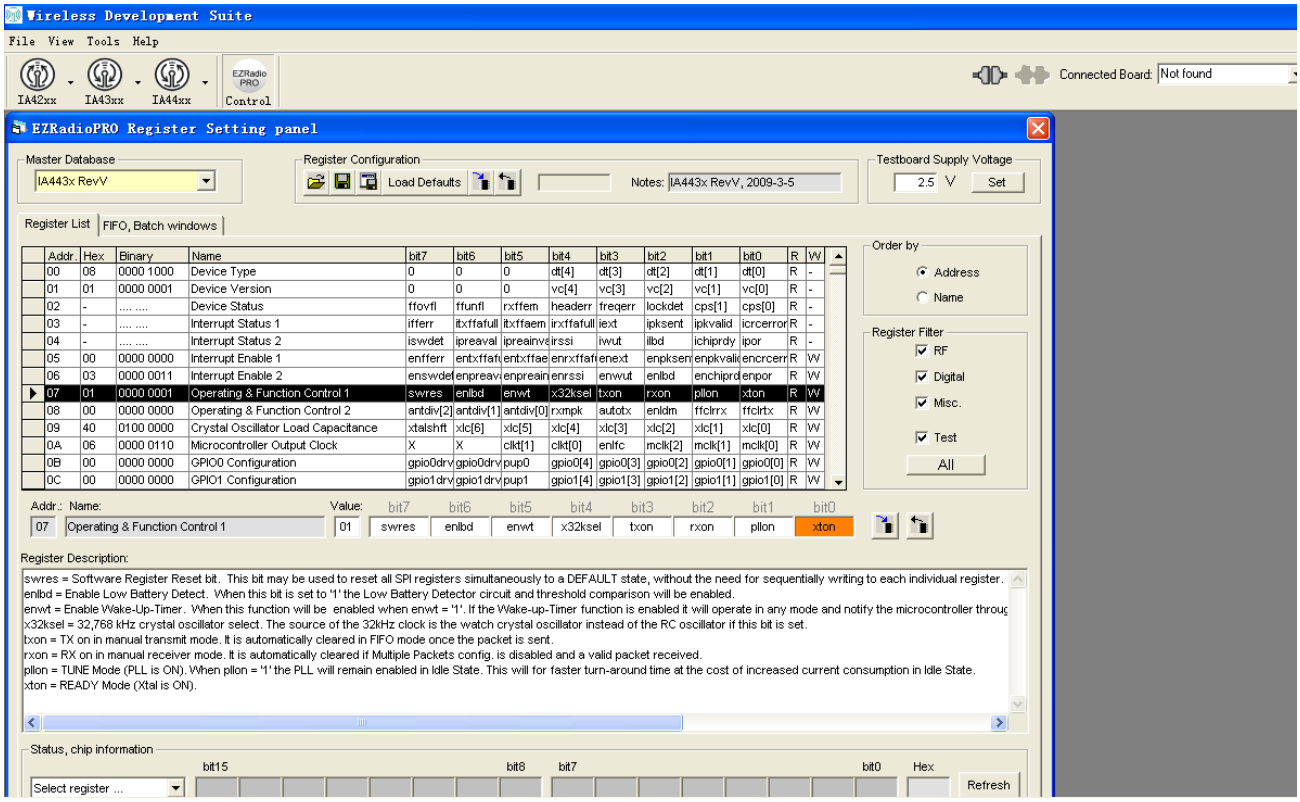


```
    nSelSet();
    return temp;
}
```

MAIN.C

```
#include "mian.h"
//*************************************************************
//函数名:VOID MAIN(VOID)
//参数:    无
//返回值:无
//*************************************************************
UCHAR  DataBuff[20];
//寄存器配置
const UCHAR RfSettings[9][11] =      //revX2
{
//    IFBW, COSR, CRO2, CRO1, CRO0, CTG1, CTG0, TDR1, TDR0, FDEV, B_TIME
    {0x17, 0x41, 0x60, 0x27, 0x52, 0x00, 0x32, 0x00, 0x9D, 0x39, 209},    //DR2400BPS_DEV36KHZ
    {0x08, 0x41, 0x60, 0x27, 0x52, 0x00, 0x0f, 0x01, 0x3B, 0x48, 105},    //DR4800BPS_DEV45KHZ
    {0x16, 0xd0, 0x00, 0x9a, 0x49, 0x00, 0x7b, 0x0c, 0xcd, 0x28, 53 },    //DR9.6KBPS_DEV40KHZ_MOD8
    {0x04, 0x90, 0x20, 0x51, 0xec, 0x02, 0x11, 0x02, 0x8F, 0x40, 50 },    //DR10KBPS_DEV40KHZ_MOD8//
    {0x04, 0xC8, 0x00, 0xA3, 0xD7, 0x00, 0x42, 0x05, 0x1F, 0x40, 25 },    //DR20K0PS_DEV40KHZ_MOD4
    {0x05, 0x64, 0x01, 0x47, 0xae, 0x05, 0x0A, 0x0A, 0x3D, 0x40, 13  },    //DR40KBPS_DEV40KHZ_MOD2
    {0x05, 0x50, 0x01, 0x99, 0x9a, 0x06, 0x68, 0x0C, 0xCD, 0x28, 10  },    //DR50KBPS_DEV25KHZ_MOD1
    {0x81, 0x78, 0x01, 0x11, 0x11, 0x01, 0x0a, 0x19, 0x9A, 0x50, 5   },    //DR 100KBPS_ DEV100KHZ_MOD1
    {0x82, 0x60, 0x01, 0x55, 0x55, 0x02, 0x2a, 0x20, 0x00, 0x64, 4   },    //DR125KBPS_DEV62KHZ5_MOD1
};
```

注：关于 Si4432 的寄存器配置帮助请登陆 www.silabs.com 下载文件 Si4432_Register_Settings_RevV-v13.xls
另外如果需要快速了解 Si4432 各个寄存器含义，请登陆 www.silabs.com 下载 WDS 软件（wireless development suit）
举例界面如下：




```
volatile UCHAR ItStatus1, ItStatus2, Rssi, ByteTime;
UCHAR  RFmodule;
UCHAR  String[]="TESTING ";
UCHAR  StringOk[]="OK";
MESSAGE    gcMessage;
volatile DEMO_STATES gcDEMO_STATES;
void main(void)
{
     UINT   count=0,count1=0,count2=0;
     UINT   ContTime;
     UCHAR con;
     UCHAR countbuf[3];
     gcDataMessage.length=8;
     gcDataMessage.data=String;
     RfPortInit();                          //初始化 spi 端口
     RfChipInit();                         //初始化 si4432 芯片
     Delay(1000);
while(1)
{
//*************************发送一个字符串*****************************************
    RFTransmitMessage(&gcDataMessage);          //发送数据

     while(nIrqData()==1);           //等待发送完毕
     if(nIrqData()==0)
          {
```



```
            //release all IT flag to set IRQ high        读取中断状态
            ItStatus1 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus1 << 8));
            ItStatus2 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus2 << 8));
            if( (ItStatus1 & 0x04) == 0x04 )      //    判断状态，发送完成中断?
              {
                 LED_ON();
              }
           }
     Delay_1ns(50000);
}
//*************************发送一个字符串*****************************************

//*************************接收一个字符串*****************************************
     RFReceiveReady();
     while(RF_NIRQ_PIN);   //等待 nirq 中断
     if(RF_NIRQ_PIN==0)
          {
            //release all IT flag to set IRQ high            读取中断状态
            ItStatus1 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus1 << 8));
            ItStatus2 = (UCHAR)(0x00FF & RFReadWriteWord(InterruptStatus2 << 8));
           if( (ItStatus1 & 0x02) == 0x02 )                              //判断是否是接收中断
              {
                //gcDEMO_STATES=sDemoStartReceive;
              RFGetBuffer(DataBuff);                                  //读取 FIFO 数据
              if(DataBuff[1]=='E')
              {
                   LED_ON();
              }
             }
          }
//*************************接收一个字符串*****************************************
}
}
```

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