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ANEXOS

Dispositivo IoT para la monitorización de parámetros fisiológicos

IoT device for monitoring physiological parameters

242.21.29

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1. CÓDIGO FUENTE

1.1. LIBRERÍA DEL SENSOR MAX30205 EN C.

Archivo MAX30205.h de la librería creada para el sensor MAX30205 en C:

```
#ifndef __MAX30205_H_
#define __MAX30205_H_

#define MAX30205_ADDRESS        0x90  //Dirreccion de 8 bit

#define MAX30205_TEMPERATURE    0x00
#define MAX30205_CONFIGURATION  0x01
#define MAX30205_THYST          0x02
#define MAX30205_TOS            0x03


  union MAX_Configuration{
        uint8_t all;
        struct BitField_s{
              uint8_t shutdown    : 1;
              uint8_t comp_int    : 1;
              uint8_t os_polarity : 1;
              uint8_t fault_queue : 2;
              uint8_t data_format : 1;
              uint8_t timeout     : 1;
              uint8_t one_shot    : 1;
         }bits;
  } max_Configuration_u;


  float MAX_temperature;
  uint8_t MAX_sensorAddress;
  void  MAX_shutdown(void);
  void  MAX_begin(void);
  float MAX_getTemperature(void);
  uint16_t MAX_readConfiguration(void);

  void MAX_writeRegister(uint8_t subAddress, uint16_t value);
  void MAX_readRegister(uint8_t subAddress, uint16_t *value);

#endif
```

Archivo MAX30205.c de la librería creada para el sensor MAX30205 en C:

```
#include "main.h"
#include "MAX30205.h"

uint8_t MAX_sensorAddress = MAX30205_ADDRESS;


float MAX_getTemperature(void){
      max_Configuration_u.bits.shutdown = 1;
      max_Configuration_u.bits.one_shot = 1;

      uint16_t local_config = (0x00FF & max_Configuration_u.all);
      MAX_writeRegister(MAX30205_CONFIGURATION, local_config);

      HAL_Delay(60);      //50 ms de conversión según datasheet

      uint16_t readRaw;
      MAX_readRegister(MAX30205_TEMPERATURE, &readRaw);
     MAX_temperature = readRaw * 0.00390625;

      return  MAX_temperature;
}



uint16_t MAX_readConfiguration(void){
    uint16_t data;
    MAX_readRegister(MAX30205_CONFIGURATION , &data);

    return data;
}



void MAX_shutdown(void){
  uint16_t reg;
  MAX_readRegister(MAX30205_CONFIGURATION, &reg);
  MAX_writeRegister(MAX30205_CONFIGURATION, reg | 0x80);
}



void MAX_begin(void){
      max_Configuration_u.bits.shutdown = 1;
      max_Configuration_u.bits.comp_int = 0;
```

```
      max_Configuration_u.bits.os_polarity = 0;
      max_Configuration_u.bits.fault_queue = 0;
      max_Configuration_u.bits.data_format = 0;
      max_Configuration_u.bits.timeout = 1;
      max_Configuration_u.bits.one_shot = 1;

      uint16_t local_config = (0x00FF & max_Configuration_u.all);
      MAX_writeRegister(MAX30205_CONFIGURATION, local_config);
}


void MAX_writeRegister(uint8_t subAddress, uint16_t value) {
  uint8_t hi = ((value >> 8) & 0xFF);
  uint8_t lo = (value & 0xFF);
  uint8_t cmdData[3] = {subAddress, hi, lo};

  HAL_I2C_Master_Transmit(&hi2c1, MAX_sensorAddress, cmdData, 3,
100);
}


void MAX_readRegister(uint8_t subAddress, uint16_t *value) {
      uint8_t data[2];
      uint8_t cmdData[1] = {subAddress};

      HAL_I2C_Master_Transmit(&hi2c1, MAX_sensorAddress, cmdData,
1, 100);
      HAL_I2C_Master_Receive(&hi2c1, MAX_sensorAddress, data, 2,
500);

      *value = ((uint16_t)data[0] << 8) | data[1];

}
```

1.2. CÓDIGO DE APLICACIÓN LORAWAN

```
/* USER CODE BEGIN Header */
/**
  ******************************************************************
  * @file    lora_app.c
  * @author  MCD Application Team
  * @brief   Application of the LRWAN Middleware
  ******************************************************************
  * @attention
```

```
  *
  * Copyright (c) 2022 STMicroelectronics.
  * All rights reserved.
  *
  * This software is licensed under terms that can be found in the
LICENSE file
  * in the root directory of this software component.
  * If no LICENSE file comes with this software, it is provided AS-IS.
  *
  ******************************************************************
  */
/* USER CODE END Header */

/* Includes ------------------------------------------------------------
--------*/
#include "platform.h"
#include "Region.h" /* Needed for LORAWAN_DEFAULT_DATA_RATE */
#include "sys_app.h"
#include "lora_app.h"
#include "stm32_seq.h"
#include "stm32_timer.h"
#include "utilities_def.h"
#include "lora_app_version.h"
#include "lorawan_version.h"
#include "subghz_phy_version.h"
#include "lora_info.h"
#include "LmHandler.h"
#include "stm32_lpm.h"
#include "adc_if.h"
#include "sys_conf.h"
#include "CayenneLpp.h"
#include "sys_sensors.h"

/* USER CODE BEGIN Includes */

#include <stdio.h>
#include "MAX30205.h"

/* USER CODE END Includes */

/* External variables ---------------------------------------------------
---------*/
/* USER CODE BEGIN EV */


int8_t snr_recibido = 0;            //Para enviar los parámetros
int8_t rssi_recibido = 0;


/* USER CODE END EV */
```

```
/* Private typedef -----------------------------------------------------
--------*/
/**
  * @brief LoRa State Machine states
  */
typedef enum TxEventType_e
{
  /**
    * @brief Appdata Transmission issue based on timer every
TxDutyCycleTime
    */
  TX_ON_TIMER,
  /**
    * @brief Appdata Transmission external event plugged on
OnSendEvent( )
    */
  TX_ON_EVENT
  /* USER CODE BEGIN TxEventType_t */

  /* USER CODE END TxEventType_t */
} TxEventType_t;

/* USER CODE BEGIN PTD */

/* USER CODE END PTD */

/* Private define ------------------------------------------------------
--------*/
/* USER CODE BEGIN PD */

/* USER CODE END PD */

/* Private macro -------------------------------------------------------
--------*/
/* USER CODE BEGIN PM */

/* USER CODE END PM */

/* Private function prototypes -----------------------------------------
--------*/
/**
  * @brief  LoRa End Node send request
  */
static void SendTxData(void);

/**
  * @brief  TX timer callback function
  * @param  context ptr of timer context
  */
static void OnTxTimerEvent(void *context);

/**
```

```
  * @brief  join event callback function
  * @param  joinParams status of join
  */
static void OnJoinRequest(LmHandlerJoinParams_t *joinParams);

/**
  * @brief  tx event callback function
  * @param  params status of last Tx
  */
static void OnTxData(LmHandlerTxParams_t *params);

/**
  * @brief callback when LoRa application has received a frame
  * @param appData data received in the last Rx
  * @param params status of last Rx
  */
static void OnRxData(LmHandlerAppData_t *appData, LmHandlerRxParams_t
*params);

/*!
 * Will be called each time a Radio IRQ is handled by the MAC layer
 *
 */
static void OnMacProcessNotify(void);

/* USER CODE BEGIN PFP */

/* USER CODE END PFP */

/* Private variables ---------------------------------------------------
--------*/
static ActivationType_t ActivationType =
LORAWAN_DEFAULT_ACTIVATION_TYPE;

/**
  * @brief LoRaWAN handler Callbacks
  */
static LmHandlerCallbacks_t LmHandlerCallbacks =
{
  .GetBatteryLevel =           GetBatteryLevel,
  .GetTemperature =            GetTemperatureLevel,
  .GetUniqueId =               GetUniqueId,
  .GetDevAddr =                GetDevAddr,
  .OnMacProcess =              OnMacProcessNotify,
  .OnJoinRequest =             OnJoinRequest,
  .OnTxData =                  OnTxData,
  .OnRxData =                  OnRxData
};

/**
  * @brief LoRaWAN handler parameters
  */
```

```
static LmHandlerParams_t LmHandlerParams =
{
  .ActiveRegion =             ACTIVE_REGION,
  .DefaultClass =             LORAWAN_DEFAULT_CLASS,
  .AdrEnable =                LORAWAN_ADR_STATE,
  .TxDatarate =               LORAWAN_DEFAULT_DATA_RATE,
  .PingPeriodicity =          LORAWAN_DEFAULT_PING_SLOT_PERIODICITY
};

/**
  * @brief Type of Event to generate application Tx
  */
static TxEventType_t EventType = TX_ON_TIMER;

/**
  * @brief Timer to handle the application Tx
  */
static UTIL_TIMER_Object_t TxTimer;

/* USER CODE BEGIN PV */

static uint8_t AppDataBuffer[LORAWAN_APP_DATA_BUFFER_MAX_SIZE];
static LmHandlerAppData_t AppData = { 0, 0, AppDataBuffer };

/* USER CODE END PV */

/* Exported functions ---------------------------------------------
---------*/
/* USER CODE BEGIN EF */

/* USER CODE END EF */

void LoRaWAN_Init(void)
{
  /* USER CODE BEGIN LoRaWAN_Init_1 */

  /* USER CODE END LoRaWAN_Init_1 */

  UTIL_SEQ_RegTask((1 << CFG_SEQ_Task_LmHandlerProcess), UTIL_SEQ_RFU,
LmHandlerProcess);
  UTIL_SEQ_RegTask((1 << CFG_SEQ_Task_LoRaSendOnTxTimerOrButtonEvent),
UTIL_SEQ_RFU, SendTxData);
  /* Init Info table used by LmHandler*/
  LoraInfo_Init();

  /* Init the Lora Stack*/
  LmHandlerInit(&LmHandlerCallbacks);

  LmHandlerConfigure(&LmHandlerParams);

  /* USER CODE BEGIN LoRaWAN_Init_2 */
  /* USER CODE END LoRaWAN_Init_2 */
```

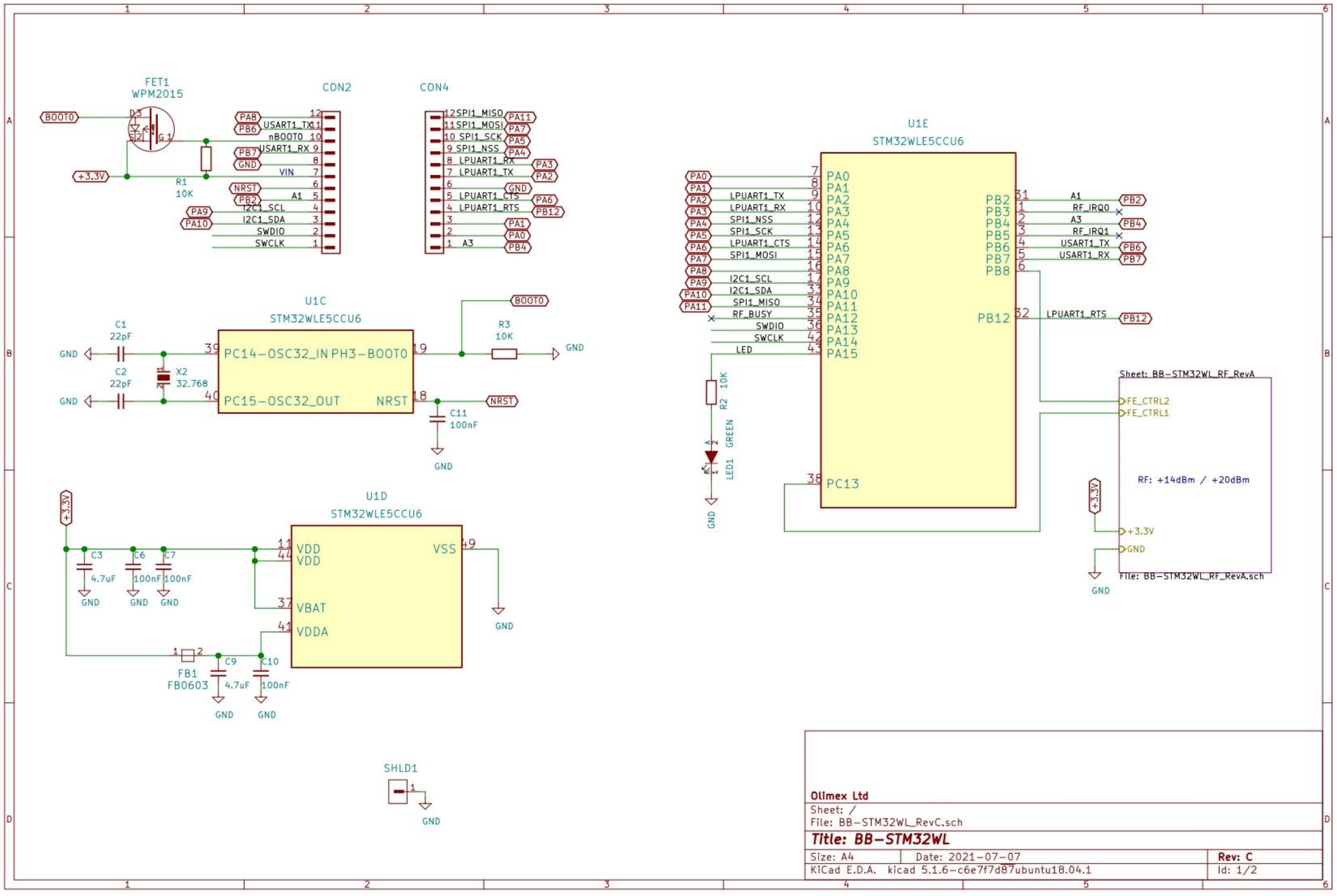
```
  LmHandlerJoin(ActivationType);

  if (EventType == TX_ON_TIMER)
  {
    /* send every time timer elapses */
    UTIL_TIMER_Create(&TxTimer,  0xFFFFFFFFU, UTIL_TIMER_ONESHOT,
OnTxTimerEvent, NULL);
    UTIL_TIMER_SetPeriod(&TxTimer,  APP_TX_DUTYCYCLE);
    UTIL_TIMER_Start(&TxTimer);
  }
  else
  {
    /* USER CODE BEGIN LoRaWAN_Init_3 */
    /* USER CODE END LoRaWAN_Init_3 */
  }

  /* USER CODE BEGIN LoRaWAN_Init_Last */

  /* USER CODE END LoRaWAN_Init_Last */
}

/* USER CODE BEGIN PB_Callbacks */

/* USER CODE END PB_Callbacks */

/* Private functions ---------------------------------------------
--------*/
/* USER CODE BEGIN PrFD */

/* USER CODE END PrFD */

static void OnRxData(LmHandlerAppData_t *appData, LmHandlerRxParams_t
*params)
{
  /* USER CODE BEGIN OnRxData_1 */

      if(appData->Port == LORAWAN_USER_APP_PORT){
            if(appData->Buffer[0] == 'X'){
                  snr_recibido = params->Snr;
                  rssi_recibido = params->Rssi;
            }
      }

  /* USER CODE END OnRxData_1 */
}

static void SendTxData(void)
{
  /* USER CODE BEGIN SendTxData_1 */

      float temperatura = 0;
```

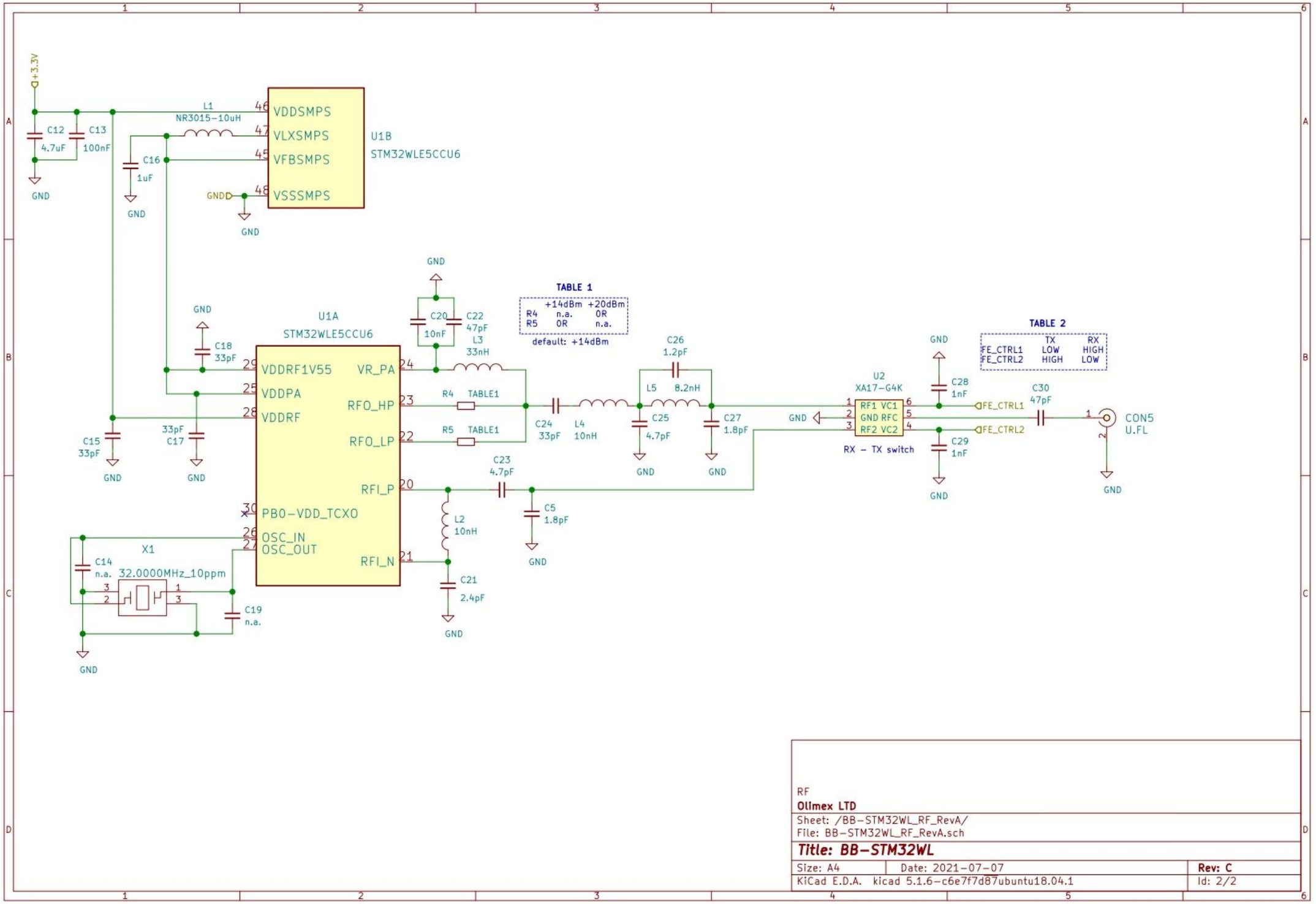
```
      UTIL_TIMER_Time_t nextTxIn = 0;

      temperatura = MAX_getTemperature();

      AppData.Port = LORAWAN_USER_APP_PORT;
      AppData.BufferSize = snprintf((char *) AppData.Buffer,
LORAWAN_APP_DATA_BUFFER_MAX_SIZE, "%.2f;%d:%d", temperatura,
snr_recibido, rssi_recibido);

      LmHandlerSend(&AppData, LORAWAN_DEFAULT_CONFIRMED_MSG_STATE,
nextTxIn, false);

  /* USER CODE END SendTxData_1 */
}

static void OnTxTimerEvent(void *context)
{
  /* USER CODE BEGIN OnTxTimerEvent_1 */

  /* USER CODE END OnTxTimerEvent_1 */
  UTIL_SEQ_SetTask((1 << CFG_SEQ_Task_LoRaSendOnTxTimerOrButtonEvent),
CFG_SEQ_Prio_0);

  /*Wait for next tx slot*/
  UTIL_TIMER_Start(&TxTimer);
  /* USER CODE BEGIN OnTxTimerEvent_2 */

  /* USER CODE END OnTxTimerEvent_2 */
}

/* USER CODE BEGIN PrFD_LedEvents */

/* USER CODE END PrFD_LedEvents */

static void OnTxData(LmHandlerTxParams_t *params)
{
  /* USER CODE BEGIN OnTxData_1 */
  /* USER CODE END OnTxData_1 */
}

static void OnJoinRequest(LmHandlerJoinParams_t *joinParams)
{
  /* USER CODE BEGIN OnJoinRequest_1 */
  /* USER CODE END OnJoinRequest_1 */
}

static void OnMacProcessNotify(void)
{
  /* USER CODE BEGIN OnMacProcessNotify_1 */

  /* USER CODE END OnMacProcessNotify_1 */
```

```
  UTIL_SEQ_SetTask((1 << CFG_SEQ_Task_LmHandlerProcess),
CFG_SEQ_Prio_0);

  /* USER CODE BEGIN OnMacProcessNotify_2 */

  /* USER CODE END OnMacProcessNotify_2 */
}
```

2. ESQUEMA ELECTRÓNICO

Esquema electrónico de la placa Olimex BB-STM32WL:




+3.3V
C12 4.7uF
C13 100nF
GND
L1 NR3015-10uH
C16 1uF
U1B STM32WLE5CCU6
VDDSMPS
VLXSMPS
VFBSMPS
VSSSMPS
GNDD
U1A STM32WLE5CCU6
VDDRF1V55
VDDPA
VDDRF
VR_PA
RFO_HP
RFO_LP
RFI_P
RFI_N
PB0-VDD_TCXO
OSC_IN
OSC_OUT
C18 33pF
C15 33pF
C17 33pF
C20 10nF
C22 47pF
L3 33nH
TABLE 1
+14dBm +20dBm
R4 n.a. 0R
R5 0R n.a.
default: +14dBm
R4 TABLE1
R5 TABLE1
C24 33pF
L4 10nH
C26 1.2pF
L5 8.2nH
C25 4.7pF
C27 1.8pF
C23 4.7pF
L2 10nH
C5 1.8pF
C21 2.4pF
X1
C14 n.a.
32.0000MHz_10ppm
C19 n.a.
U2 XA17-G4K
RF1 VC1
GND RFC
RF2 VC2
RX - TX switch
TABLE 2
TX RX
FE_CTRL1 LOW HIGH
FE_CTRL2 HIGH LOW
C28 1nF
C29 1nF
C30 47pF
FE_CTRL1
FE_CTRL2
CON5 U.FL
RF
Olimex LTD
Sheet: /BB-STM32WL_RF_RevA/
File: BB-STM32WL_RF_RevA.sch
Title: BB-STM32WL
Size: A4
Date: 2021-07-07
Rev: C
KiCad E.D.A. kicad 5.1.6-c6e7f7d87ubuntu18.04.1
Id: 2/2

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