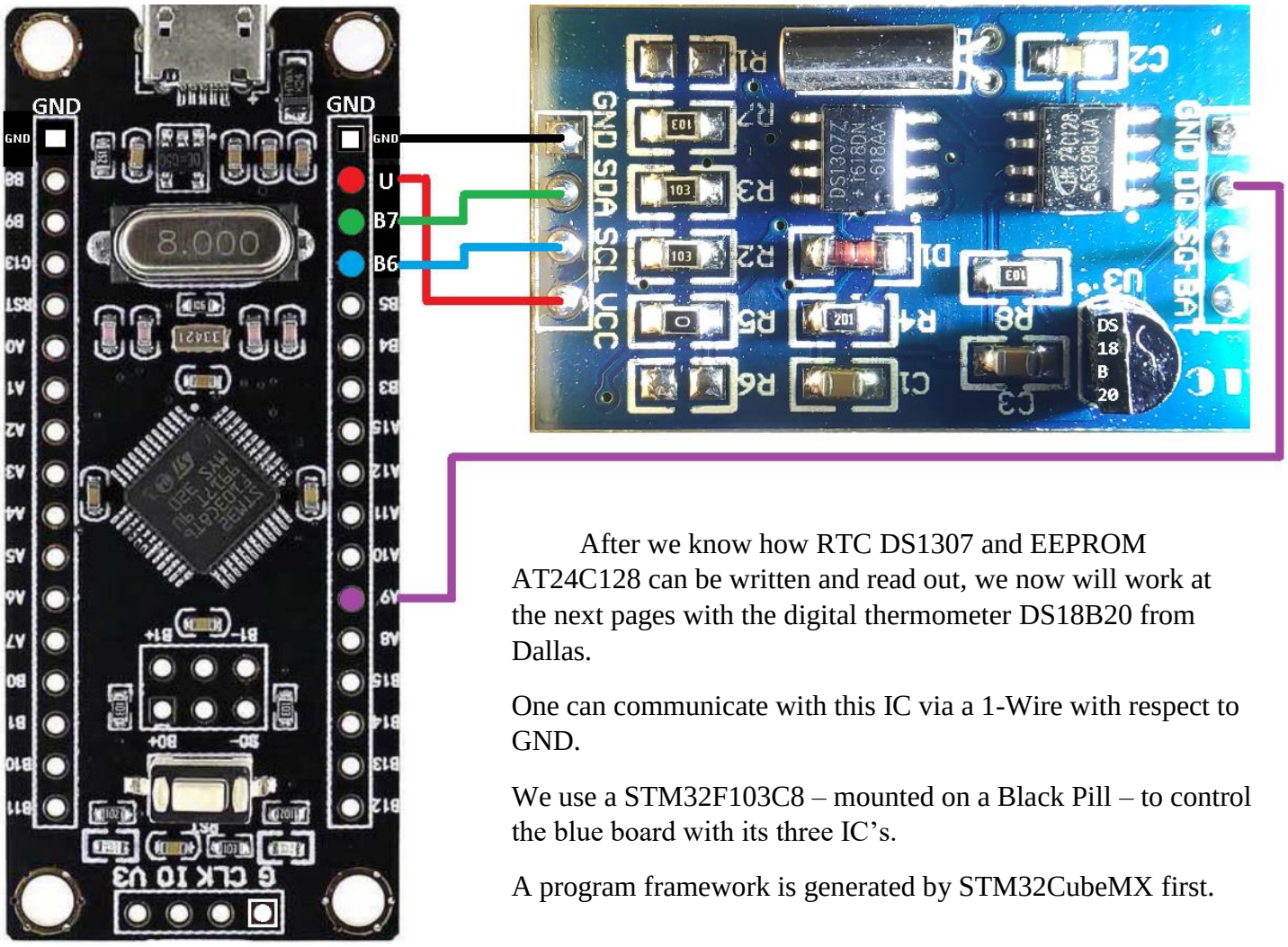
STM32CubeMX, ONE WIRE and DS18B20

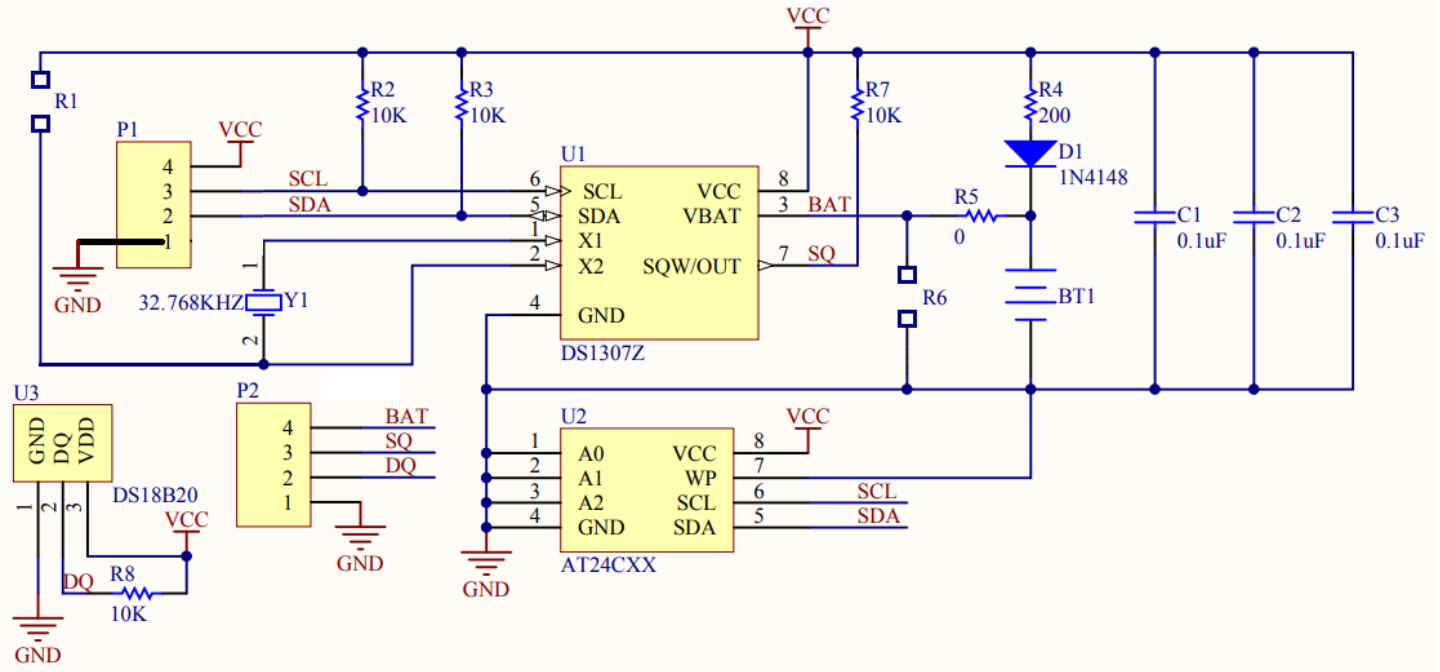


After we know how RTC DS1307 and EEPROM AT24C128 can be written and read out, we now will work at the next pages with the digital thermometer DS18B20 from Dallas.

One can communicate with this IC via a 1-Wire with respect to GND.

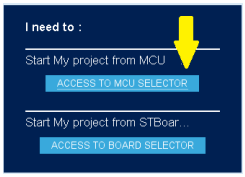
We use a STM32F103C8 – mounted on a Black Pill – to control the blue board with its three IC's.

A program framework is generated by STM32CubeMX first.



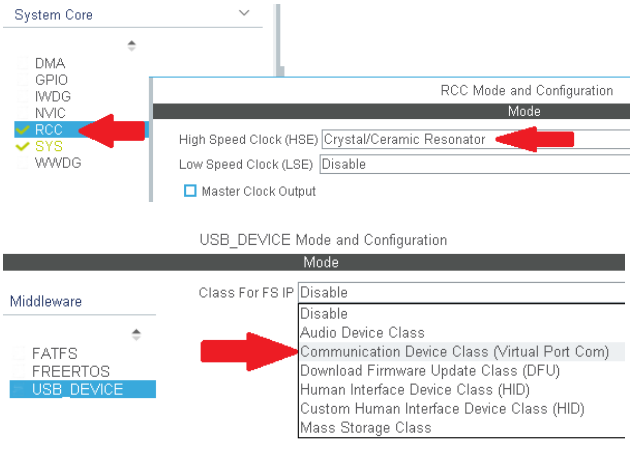
The Black Pill is on the lower side connected with a ST Link V2 programmer for STM8 and STM32.
The upper USB connector of the Black Pill is used to transfer all of the DS18B20 data to a terminal program.

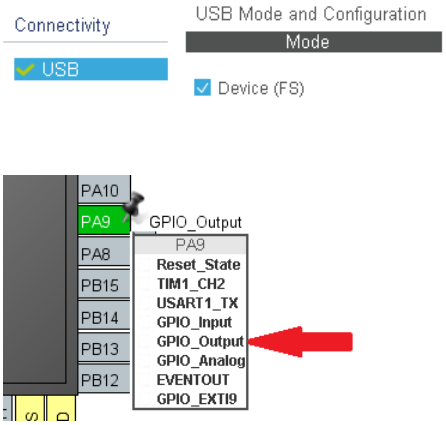
STM32CubeMX

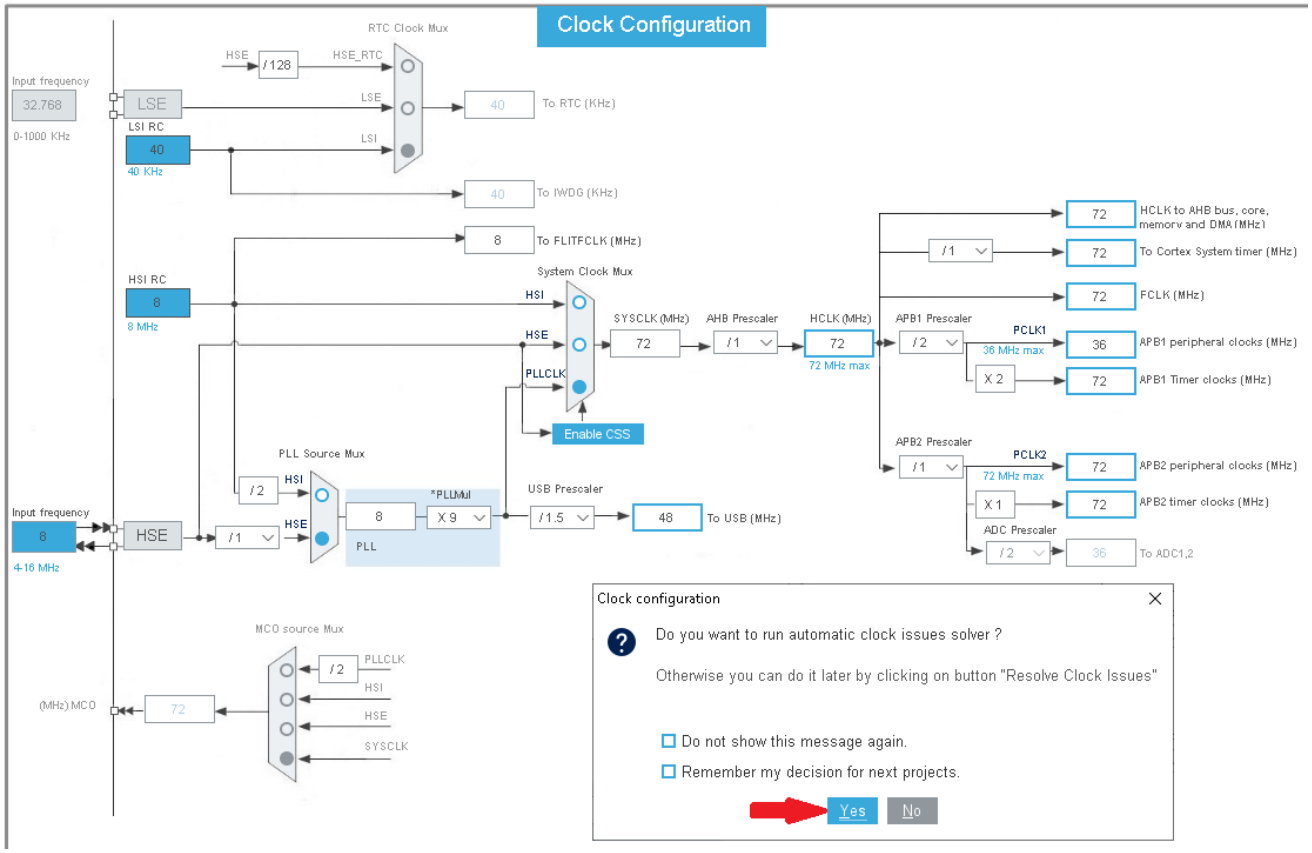
Launch STM32CubeMX,  select 

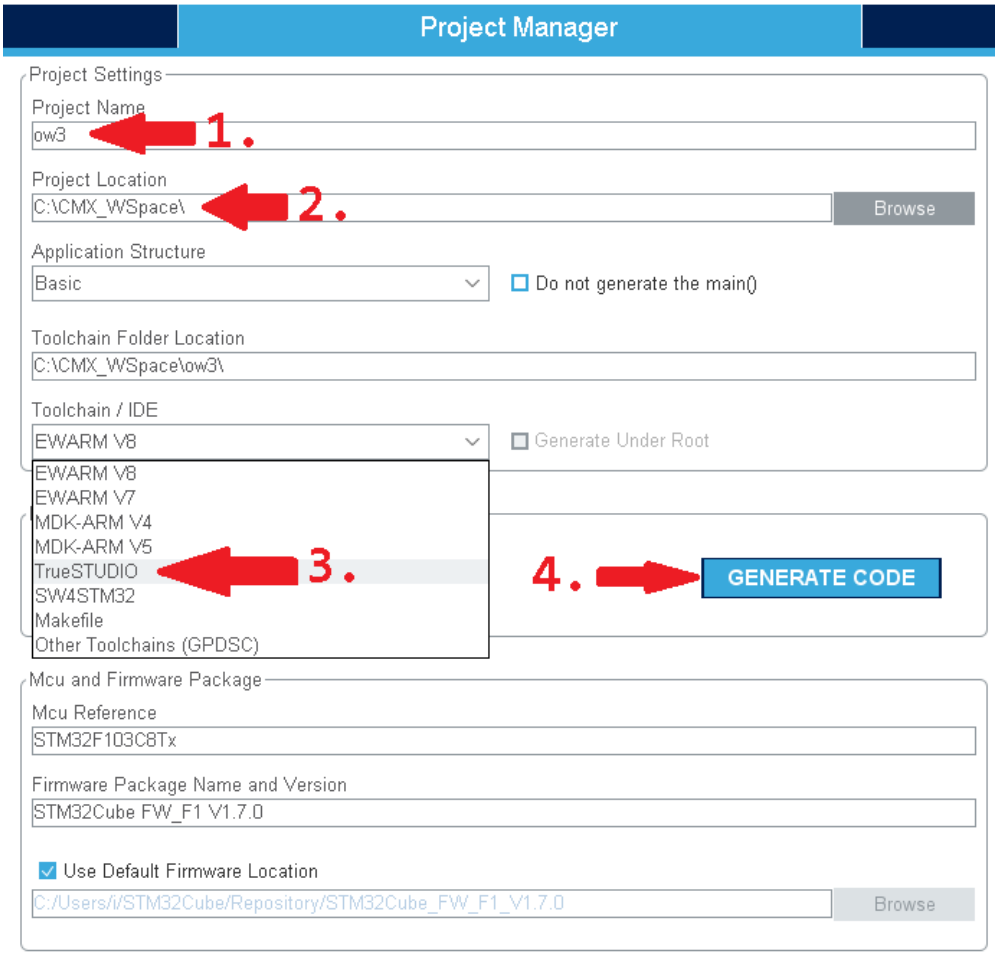
and 

Then do the following:

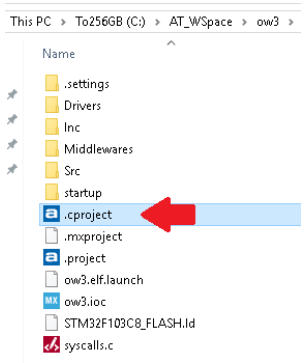





Clock Configuration
RTC Clock Mux
HSE
/128
HSE_RTC
LSE
LSI
Input frequency
32.768
0-1000 KHz
LSE
LSI RC
40
40 KHz
40
To RTC (KHz)
40
To IWDG (KHz)
8
To FLITFCLK (MHz)
System Clock Mux
HSI RC
8
8 MHz
HSI
HSE
PLLCLK
SYSCLK (MHz)
72
AHB Prescaler
/1
HCLK (MHz)
72
72 MHz max
Enable CSS
PLL Source Mux
/2
HSI
HSE
/1
*PLLMul
8
X 9
PLL
USB Prescaler
/1.5
48
To USB (MHz)
Input frequency
8
4-16 MHz
HSE
APB1 Prescaler
/2
PCLK1
36 MHz max
X 2
APB2 Prescaler
/1
PCLK2
72 MHz max
X 1
ADC Prescaler
/2
36
To ADC1,2
72
HCLK to AHB bus, core, memory and DMA (MHz)
/1
72
To Cortex System timer (MHz)
72
FCLK (MHz)
36
APB1 peripheral clocks (MHz)
72
APB1 Timer clocks (MHz)
72
APB2 peripheral clocks (MHz)
72
APB2 timer clocks (MHz)
MCO source Mux
/2
PLLCLK
HSI
HSE
SYSCLK
(MHz) MCO
72
Clock configuration
Do you want to run automatic clock issues solver ?
Otherwise you can do it later by clicking on button "Resolve Clock Issues"
Do not show this message again.
Remember my decision for next projects.
Yes
No


Project Manager
Project Settings
Project Name
ow3
1.
Project Location
C:\CMX_WSpace\
2.
Browse
Application Structure
Basic
Do not generate the main()
Toolchain Folder Location
C:\CMX_WSpace\ow3\
Toolchain / IDE
EWARM V8
Generate Under Root
EWARM V8
EWARM V7
MDK-ARM V4
MDK-ARM V5
TrueSTUDIO
SW4STM32
Makefile
Other Toolchains (GPDSC)
3.
4.
GENERATE CODE
Mcu and Firmware Package
Mcu Reference
STM32F103C8Tx
Firmware Package Name and Version
STM32Cube FW_F1 V1.7.0
Use Default Firmware Location
C:/Users/i/STM32Cube/Repository/STM32Cube_FW_F1_V1.7.0
Browse

Atollic TrueSTUDIO



Copy the project ow3 into the workspace of TrueSTUDIO,

select and activate

Inside TrueSTUDIO we do the following:

In main.c we change

```
static void MX_GPIO_Init(void)
{ . . .
HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_RESET);
. . .
GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_PP;
. . .
GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_LOW;
```

into

```
HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_SET);
GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_OD; //open drain
GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_HIGH;
```

so we will not forget it – for the moment it is not important.

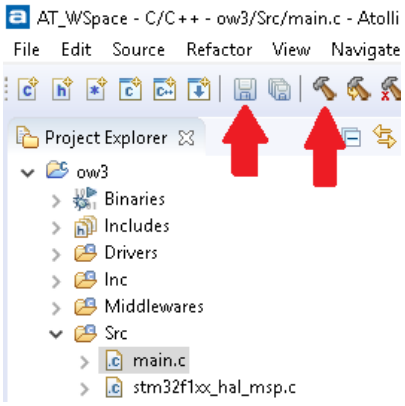
Test USB communication

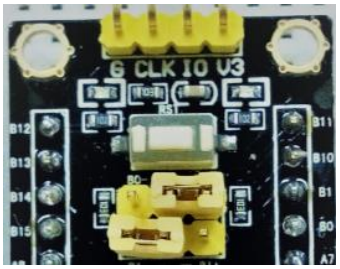
Include the gray highlighted C-code:

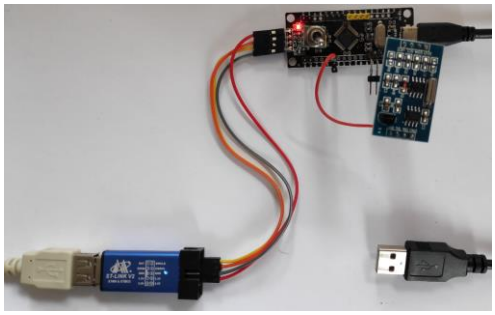
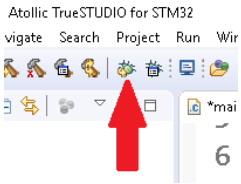
```
#include "main.h"
#include "usb_device.h"
#include "usbd_cdc_if.h"//By reason of: CDC_Transmit_FS(uint8_t*, uint16_t);
void SystemClock_Config(void);
static void MX_GPIO_Init(void);
void USB_Info(char*);
uint16_t slen(const char*);
void add_txt(char* , char* );
int main(void)
{
HAL_Init();
SystemClock_Config();
MX_GPIO_Init();
MX_USB_DEVICE_Init();
```

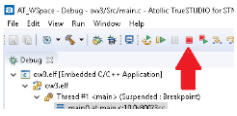
```
while (1){
    USB_Info("Hallo");
    HAL_Delay(1000);
}
}
uint16_t slen(const char* s) {
   uint16_t i;
   for (i = 0; s[i] != 0; i++);
   return i;//s[0] not 0 then i=1;
}
void add_txt(char* out, char* in) {
  while (*out != 0) out++;
  while (*in != 0) {
    *out++ = *in++;
  }
  *out = 0;
}
void USB_Info(char *str)
{
 char txt[64] = {};
 add_txt( txt, str);
 add_txt( txt, "\n\r");
 CDC_Transmit_FS((uint8_t *)txt, slen(txt));
}
void SystemClock_Config(void)
{
RCC_OscInitTypeDef RCC_OscInitStruct = {0};
RCC_ClkInitTypeDef RCC_ClkInitStruct = {0};
RCC_PeriphCLKInitTypeDef PeriphClkInit = {0};
RCC_OscInitStruct.OscillatorType = RCC_OSCILLATORTYPE_HSE;
RCC_OscInitStruct.HSEState = RCC_HSE_ON;
RCC_OscInitStruct.HSEPredivValue = RCC_HSE_PREDIV_DIV1;
RCC_OscInitStruct.HSIState = RCC_HSI_ON;
RCC_OscInitStruct.PLL.PLLState = RCC_PLL_ON;
RCC_OscInitStruct.PLL.PLLSource = RCC_PLLSOURCE_HSE;
RCC_OscInitStruct.PLL.PLLMUL = RCC_PLL_MUL9;
if (HAL_RCC_OscConfig(&RCC_OscInitStruct) != HAL_OK) Error_Handler();
RCC_ClkInitStruct.ClockType = RCC_CLOCKTYPE_HCLK|RCC_CLOCKTYPE_SYSCLK
|RCC_CLOCKTYPE_PCLK1|RCC_CLOCKTYPE_PCLK2;
RCC_ClkInitStruct.SYSCLKSource = RCC_SYSCLKSOURCE_PLLCLK;
RCC_ClkInitStruct.AHBCLKDivider = RCC_SYSCLK_DIV1;
RCC_ClkInitStruct.APB1CLKDivider = RCC_HCLK_DIV2;
RCC_ClkInitStruct.APB2CLKDivider = RCC_HCLK_DIV1;
if (HAL_RCC_ClockConfig(&RCC_ClkInitStruct, FLASH_LATENCY_2) != HAL_OK)
Error_Handler();
PeriphClkInit.PeriphClockSelection = RCC_PERIPHCLK_USB;
PeriphClkInit.UsbClockSelection = RCC_USBCLKSOURCE_PLL_DIV1_5;
if (HAL_RCCEx_PeriphCLKConfig(&PeriphClkInit) != HAL_OK) Error_Handler();
}
static void MX_GPIO_Init(void)
{
GPIO_InitTypeDef GPIO_InitStruct = {0};
```

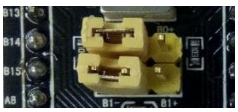
```
__HAL_RCC_GPIOD_CLK_ENABLE();
__HAL_RCC_GPIOA_CLK_ENABLE();
HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_SET);
GPIO_InitStruct.Pin = GPIO_PIN_9;
GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_OD;
GPIO_InitStruct.Pull = GPIO_NOPULL;
GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_HIGH;
HAL_GPIO_Init(GPIOA, &GPIO_InitStruct);
}
void Error_Handler(void){}
#ifdef  USE_FULL_ASSERT
void assert_failed(uint8_t *file, uint32_t line){}
#endif
```

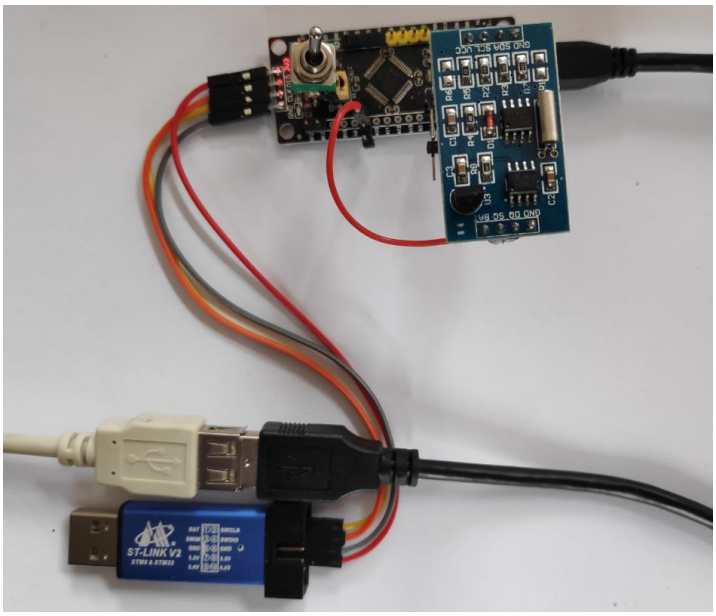
Save and build the project, 

put jumper into programming mode 

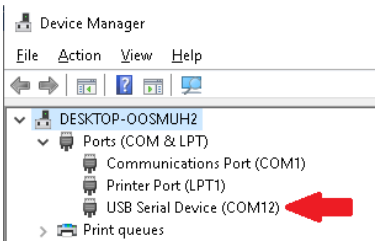
connect the programmer 
and press 

Once the program is flashed, terminate debugging 
and disconnect the ST-Link.

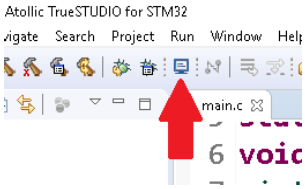
Put the jumper in RUN mode, 
and connect USB of Black Pill to the computer



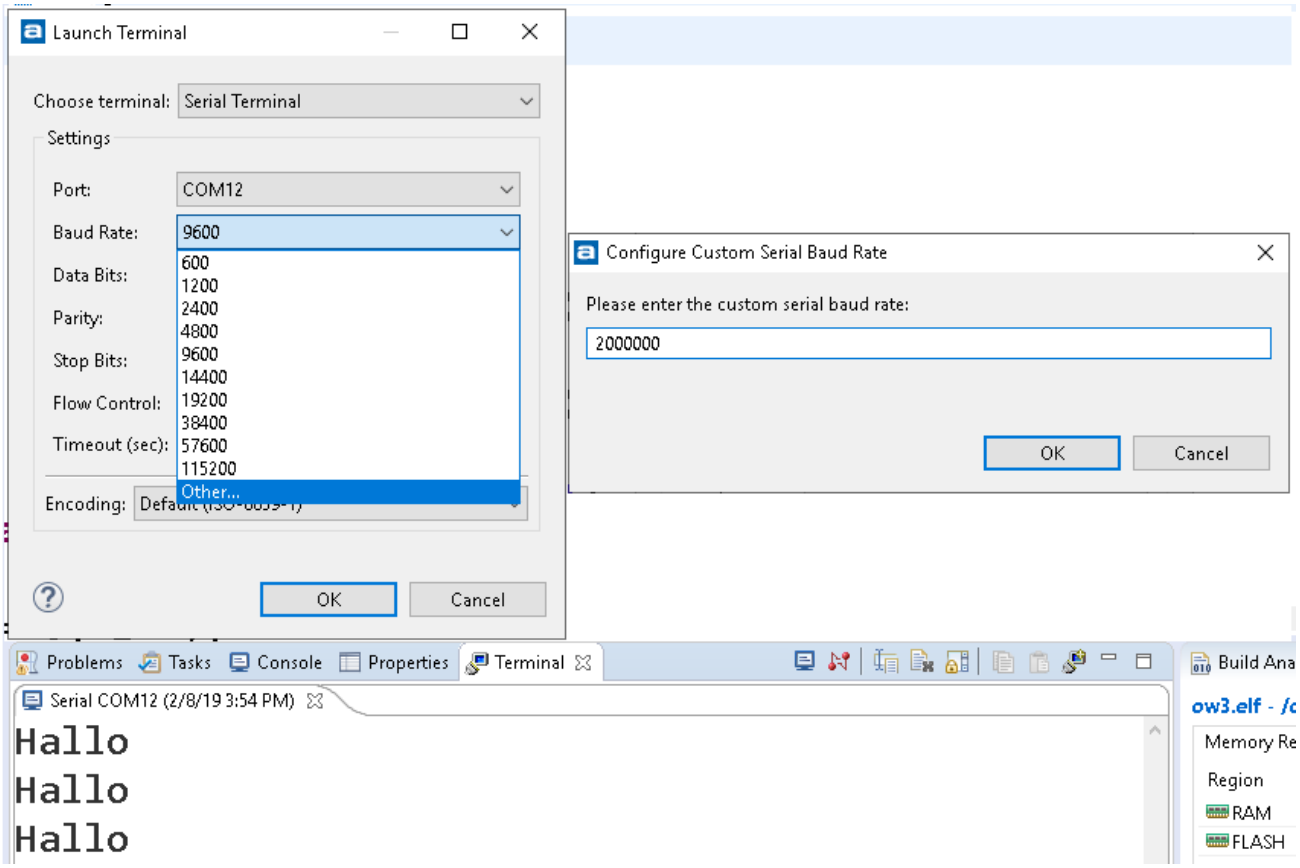
A new Comport appears



Start a terminal sheet

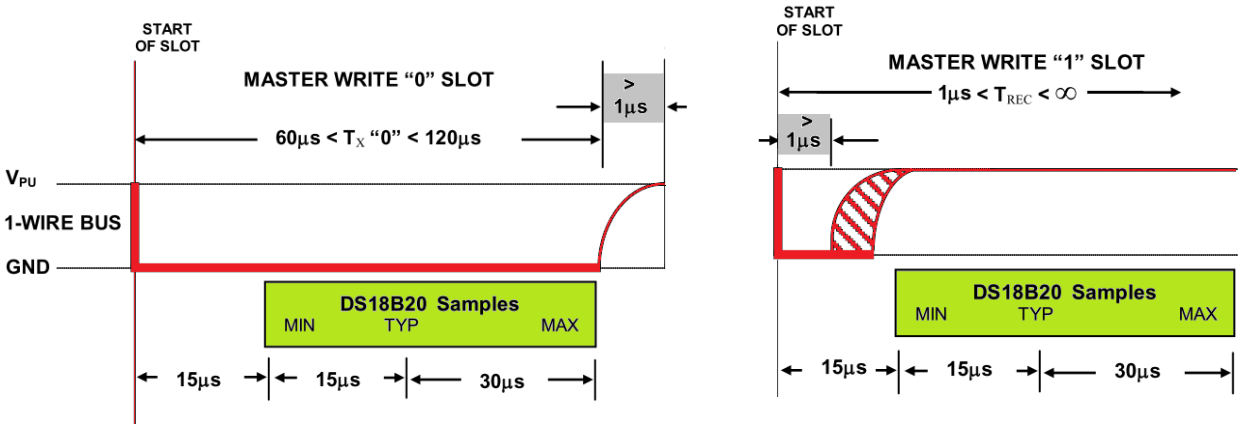


and connect with 2000000 bauds with – in my case COM12



ONE WIRE and DS18B20

All write time slots must be a minimum of $dt_{write} \geq 60\mu s$ in duration with a minimum of a $dt_{recover} \geq 1\mu s$ recovery time between individual write slots. To write a **ZERO** (GND_LOW) or a **ONE** (PULLUP_HIGH), use:




```
void LH_signal(uint32_t L_time, uint32_t H_time) {
   HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_RESET);
   delayus(L_time);//From pullup_HIGH to GND_LOW:---___
   HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_SET);
   delayus(H_time);//From GND_LOW to pullup_HIGH:___---
}

void write_bit(uint8_t bit) {
   if(bit == 0) LH_signal(60, 5);
   else LH_signal(5, 60);
}
```

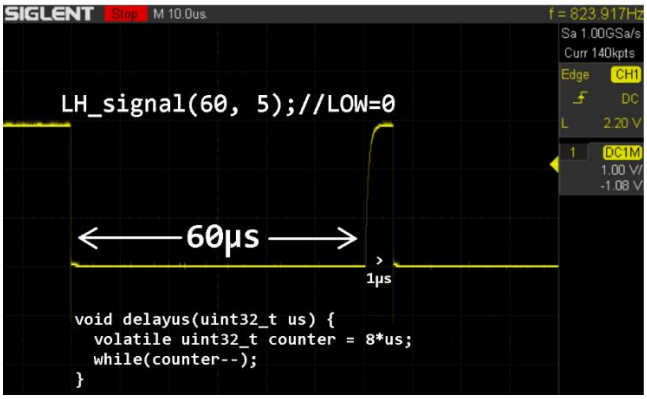
together with a DELAY procedure for microseconds:

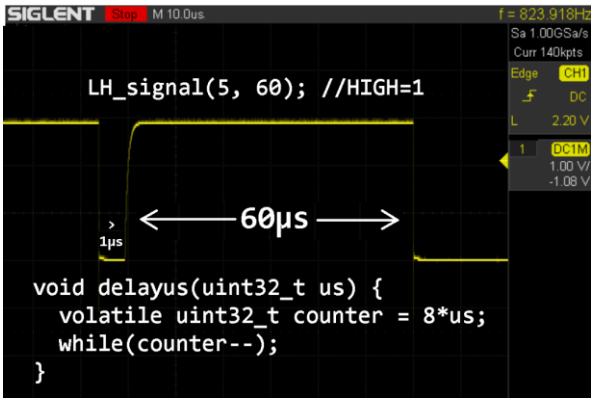
```
void delayus(uint32_t us) {
  volatile uint32_t counter = 8*us;
  while(counter--);
}
```

Oscilloscope pictures for a Black Pill with a STM32F103, f = 72MHz, prove the result. You will get these pictures with a little blue highlighted trick:

```
void LH_show_signal(uint32_t L_time, uint32_t H_time) {
   HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_RESET);
   delayus(L_time);//From pullup_HIGH to GND_LOW:---___
   HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_SET);
   delayus(H_time);//From GND_LOW to pullup_HIGH:___---
   HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_RESET);
   HAL_Delay(1);
   HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_SET);
   HAL_Delay(1);
}
```

```
int main(void) {
  …
  while (1){
     LH_show_signal(5, 60);//HIGH=1
     //LH_show_signal(60, 5);//LOW=0
  }
}
```



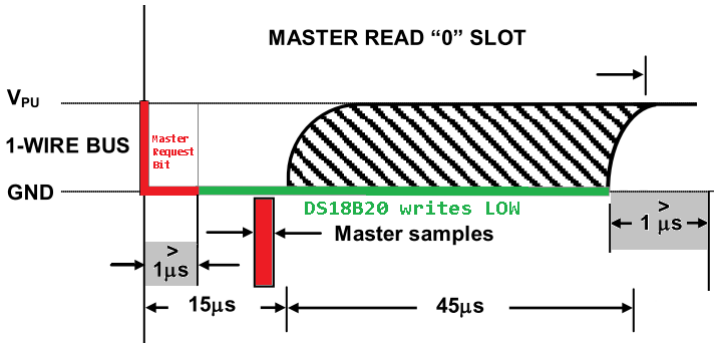


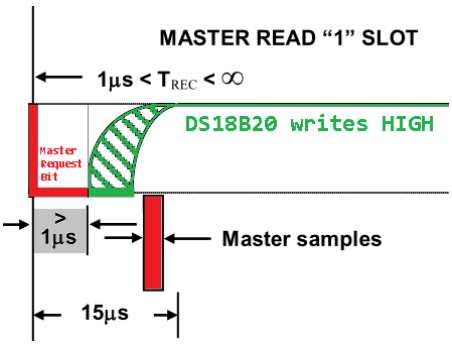
To write and read, we need procedures to flip between OUTPUT and INPUT mode:

```
static void A9_as_OUTPUT(void)
{
 GPIO_InitTypeDef GPIO_InitStruct = {0};
 HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_SET);
 GPIO_InitStruct.Pin = GPIO_PIN_9;
 GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_OD;
 GPIO_InitStruct.Pull = GPIO_NOPULL;
 GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_HIGH;
 HAL_GPIO_Init(GPIOA, &GPIO_InitStruct);
}
```

```
static void A9_as_INPUT(void)
{
 GPIO_InitTypeDef GPIO_InitStruct = {0};
 HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_SET);
 GPIO_InitStruct.Pin = GPIO_PIN_9;
 GPIO_InitStruct.Mode = GPIO_MODE_INPUT;
 GPIO_InitStruct.Pull = GPIO_NOPULL;
 HAL_GPIO_Init(GPIOA, &GPIO_InitStruct);
}
```

Let's put the STM32 in READ mode, to read a **ZERO** (GND_LOW) or a **ONE** (PULLUP_HIGH):

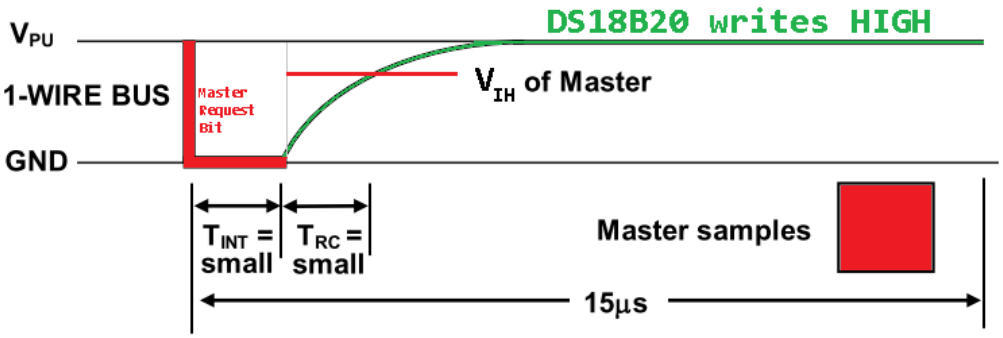




Our code is:

```
uint8_t read_bit(void) {
   uint8_t bit = 0;
   LH_signal(1, 10);
   A9_as_INPUT();
   bit = (HAL_GPIO_ReadPin(GPIOA, GPIO_PIN_9) ? 1 : 0);
   delayus(40);
   A9_as_OUTPUT();
   return bit;
}
```

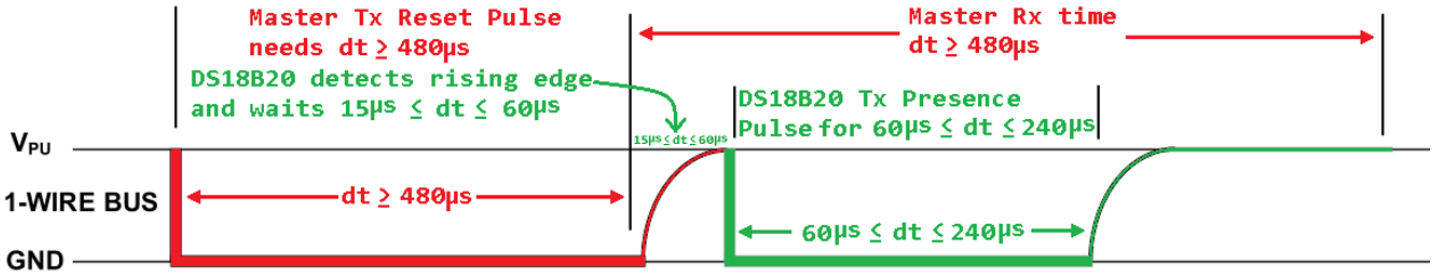
Figure 16. Recommended Master Read 1 Timing



Power-On and Reset

After power-on we need a reset. “If the bus is held low for more than 480µs, all DS18B20 on the bus will be reset.” With the green part **GND_LOW**, a DS18B20 signals that it is present.

Initialization Timing



You can test this – if you want – with:

```
void get_presence(void) {
   uint8_t flag = 1;
   LH_signal(500, 0);
   A9_as_INPUT();
   delayus(60);//look for GND_LOW = DS18B20 exists, and set flag = 1
   flag = (HAL_GPIO_ReadPin(GPIOA, GPIO_PIN_9) ? 0 : 1); //not ?1:0
   A9_as_OUTPUT();
   delayus(400);
   if(flag) USB_Info("DS18B20 present");
   else USB_Info("DS18B20 not present");
   HAL_Delay(1000);
}
```

```
int main(void) {
  …
  while (1){
     get_presence();
  }
}
```

Otherwise – there is only one working DS18B20 – use for a RESET:

```
void reset(void) {
   LH_signal(500, 500);
}
```

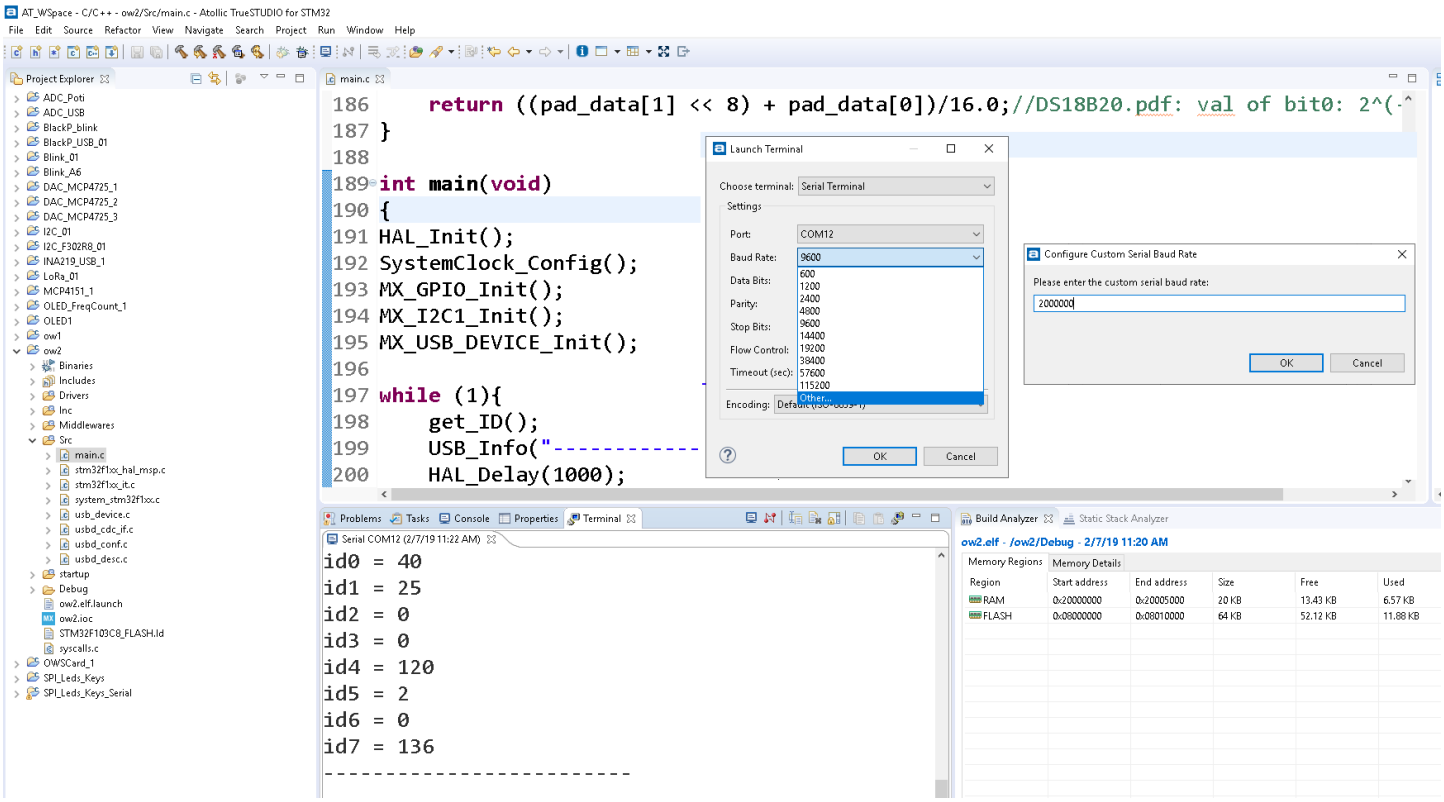
64-BIT Lasered ID

“Each DS18B20 contains a unique 64-bit code stored in ROM. The least significant 8 bits of the ROM code contain the DS18B20’s 1-Wire family code: 28h. The next 48 bits contain a unique serial number. The most significant 8 bits contain a cyclic redundancy check (CRC) byte that is calculated from the first 56 bits of the ROM code.”

You can read the 8 byte ID with these lines of code:

```
void get_ID(void) {
    uint8_t id_data[] = {0,0,0,0,0,0,0,0};//8 Byte
    reset();
    write_byte(0x33);//Read ROM [33h] command
    for (uint8_t i = 0; i < 8; i++)
        id_data[i] = read_byte();//id_data[0] = 40 = 0x28
    for (uint8_t i = 0; i < 8; i++){
        USB_Info_tutu("id", i, " = ", id_data[i]);
        HAL_Delay(200);
    }
}
```

```
int main(void) {
  …
  while (1){
    get_ID();
    USB_Info("------------------------");
    HAL_Delay(1000);
  }
}
```



Read Temperature

“After the Convert T command the DS18B20 will respond by transmitting 0 while the temperature conversion is in progress and 1 when the conversion is done.”

	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
LS BYTE	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}
	BIT 15	**BIT 14**	**BIT 13**	**BIT 12**	**BIT 11**	**BIT 10**	**BIT 9**	**BIT 8**
MS BYTE	S = SIGN = 0 for T ≥ 0	S = SIGN = 0 for T ≥ 0	S = SIGN = 0 for T ≥ 0	S = SIGN = 0 for T ≥ 0	S = SIGN = 0 for T ≥ 0	2^6	2^5	2^4

The reset value of resolution is 12 bit. At first we are not interressed in negative temperatures. If we factor out $2^{-4} = \frac{1}{16}$, we get usual register bit values, and the temperature is given by: **T = (MS << 8) + LS) / 16.0;**

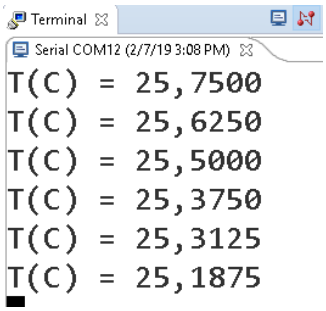
During the conversion we have to wait until the 1-wire is again in PULLUP_HIGH.

We do that in C-code with:

```
void A9_wait_for_1(uint32_t time) {
   A9_as_INPUT();
   delayus(time);
   while(HAL_GPIO_ReadPin(GPIOA, GPIO_PIN_9) == 0);
   A9_as_OUTPUT();
}
```

MASTER MODE	DATA (LSB FIRST)	COMMENTS
Tx	Reset	Master issues reset pulse.
Tx	CCh	Master issues Skip ROM command.
Tx	44h	Master issues Convert T and DS18B20 goes GND_LOW
Rx	wait / ready — Duration of conversion	When done DS18B20 goes PULLUP_HIGH
Tx	Reset	Master issues reset pulse.
Tx	CCh	Master issues Skip ROM command.
Tx	BEh	Master issues Read Scratchpad command.
Rx	9 data bytes	Master reads entire scratchpad including CRC.

```
float get_temperature(void) {
    uint8_t pad_data[] = {0,0,0,0,0,0,0,0,0};//9 Byte
   reset();
   write_byte(0xCC);//Skip ROM [CCh]
   write_byte(0x44);//Convert Temperature [44h]
   A9_wait_for_1(20);
   reset();
   write_byte(0xCC);//Skip ROM [CCh]
   write_byte(0xBE);//Read Scratchpad [BEh]
   for (uint8_t i = 0; i < 9; i++)
     pad_data[i] = read_byte();
    //factor out 1/16 and remember 1/16 != 1/16.0
   return ((pad_data[1] << 8) + pad_data[0])/16.0;
    //DS18B20.pdf: val of bit0: 2^(-4) = 1/16
}
```




```
int main(void) {
    …
    while (1){
        USB_Info_tf("T(C) = ", get_temperature());
        HAL_Delay(500);
    }
}
```

In the presence of multiple DS18B20, the ID helps us to distinguish and address them. Our chip has the ID sequence – see above: 40 25 0 0 120 2 0 136

Instead of a Skip ROM [CCh] we can send this ID to communicate with our DS18B20:

```
void send_ID(void) {
    uint8_t id_data[] = {40,25,0,0,120,2,0,136};//8 Byte ID
    reset();
    write_byte(0x55);//Match ROM [55h]
    for (uint8_t i = 0; i < 8; i++)
        write_byte(id_data[i]);//id_data[0] = 40 = 0x28
}
```

```
float get_temperature_with_ID(void) {
    uint8_t pad_data[] = {0,0,0,0,0,0,0,0,0};//9 Byte
   reset();
   send_ID();
   write_byte(0x44);//Convert Temperature [44h]
   A9_wait_for_1(20);
   reset();
   send_ID();
   write_byte(0xBE);//Read Scratchpad [BEh]
   for (uint8_t i = 0; i < 9; i++)
     pad_data[i] = read_byte();//factor out 1/16 and remember 1/16 != 1/16.0
   return ((pad_data[1] << 8) + pad_data[0])/16.0;//DS18B20.pdf: val of bit0: 2^(-4) = 1/16
}
```

Try the C-code with a correct and a wrong ID and note the difference in your terminal window.

```
int main(void) {
    …
    while (1){
        USB_Info_tf("T(C) = ", get_temperature_with_ID());
        HAL_Delay(500);
    }
}
```

Negative Temperatures

In case of negative temperatures you have to take into account: “The temperature data is stored as a 16-bit sign-extended **two’s complement number** in the temperature register”, which means that a temperature value of

T = +10.125°C = 0000 0000 1010 0010 has, as a negative value, the expression:

T = –10.125°C = 1111 1111 0101 1101 + 1 = 1111 1111 0101 1110

Steps from + → – : take the complement of all 16 bits and add 1 to get the negative value.

Steps from – → + : subtract 1 and take the complement of all 16 bits to get the positive value.

~ (1111 1111 0101 1110 – 1) = 0000 0000 1010 0010

```
float get_temperature(void) {
    uint8_t pad_data[] = {0,0,0,0,0,0,0,0,0};//9 Byte
   reset();
   write_byte(0xCC);//Skip ROM [CCh]
   write_byte(0x44);//Convert Temperature [44h]
   A9_wait_for_1(20);
   reset();
   write_byte(0xCC);//Skip ROM [CCh]
   write_byte(0xBE);//Read Scratchpad [BEh]
   for (uint8_t i = 0; i < 9; i++)
     pad_data[i] = read_byte();//factor out 1/16 and remember 1/16 != 1/16.0
   uint16_t x = (pad_data[1] << 8) + pad_data[0];
   if ((pad_data[1] >> 7) == 1 ){
        x = x - 1; x = ~x; //subtract 1 and take complement
        return  x / -16.0;
   } else  return x / 16.0;
}
```

Finally, the entire main.c file. The yellow highlighted code is not from STM32CubeMX

```
#include "main.h"
#include "usb_device.h"
#include "usbd_cdc_if.h"//By reason of: CDC_Transmit_FS(uint8_t*, uint16_t);
void SystemClock_Config(void);
static void MX_GPIO_Init(void);

uint16_t slen(const char*);
void add_txt(char* , char* );
char* my_utoa(unsigned, char*);
char* my_ftoa(float, char*);
void USB_Info(char*);
void USB_Info_tu(char*, unsigned);
void USB_Info_tutu(char*, unsigned, char*, unsigned);
void USB_Info_tf(char*, float);

void delayus(uint32_t us) {
  volatile uint32_t counter = 8*us;
  while(counter--);
}

void LH_signal(uint32_t L_time, uint32_t H_time) {
    HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_RESET);
    delayus(L_time);//From pullup_HIGH to GND_LOW:---___
    HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_SET);
    delayus(H_time);//From GND_LOW to pullup_HIGH:___---
}

void write_bit(uint8_t bit) {
    if(bit == 0) LH_signal(60, 5);
    else LH_signal(5, 60);
}

void write_byte(uint8_t data) {
    for (uint8_t i = 0; i < 8; i++)
        write_bit(data >> i & 1);
}

static void A9_as_INPUT(void)
{
  GPIO_InitTypeDef GPIO_InitStruct = {0};
  HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_SET);
  GPIO_InitStruct.Pin = GPIO_PIN_9;
  GPIO_InitStruct.Mode = GPIO_MODE_INPUT;
  GPIO_InitStruct.Pull = GPIO_NOPULL;
  HAL_GPIO_Init(GPIOA, &GPIO_InitStruct);
}

static void A9_as_OUTPUT(void)
{
  GPIO_InitTypeDef GPIO_InitStruct = {0};
```

```
  HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_SET);
  GPIO_InitStruct.Pin = GPIO_PIN_9;
  GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_OD;
  GPIO_InitStruct.Pull = GPIO_NOPULL;
  GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_HIGH;
  HAL_GPIO_Init(GPIOA, &GPIO_InitStruct);
}

uint8_t read_bit(void) {
    uint8_t bit = 0;
    LH_signal(1, 10);
    A9_as_INPUT();
    bit = (HAL_GPIO_ReadPin(GPIOA, GPIO_PIN_9) ? 1 : 0);
    delayus(40);
    A9_as_OUTPUT();
    return bit;
}

uint8_t read_byte(void) {
    uint8_t data = 0;
    for (uint8_t i = 0; i < 8; i++)
        data += read_bit() << i;
    return data;
}

void A9_wait_for_1(uint32_t time) {
    A9_as_INPUT();
    delayus(time);
    while(HAL_GPIO_ReadPin(GPIOA, GPIO_PIN_9) == 0);
    A9_as_OUTPUT();
}

void reset(void) {
    LH_signal(500, 500);
}

void get_presence(void) {
    uint8_t flag = 1;
    LH_signal(500, 0);
    A9_as_INPUT();
    delayus(60);//look for GND_LOW = DS18B20 exists
    flag = (HAL_GPIO_ReadPin(GPIOA, GPIO_PIN_9) ? 0 : 1);//not ?1:0
    A9_as_OUTPUT();
    delayus(400);
    if(flag) USB_Info("DS18B20 present");
    else USB_Info("DS18B20 not present");
    HAL_Delay(1000);
}

float get_temperature(void) {
    uint8_t pad_data[] = {0,0,0,0,0,0,0,0,0};//9 Byte
    reset();
```

```
   write_byte(0xCC);//Skip ROM [CCh]
   write_byte(0x44);//Convert Temperature [44h]
   A9_wait_for_1(20);
   reset();
   write_byte(0xCC);//Skip ROM [CCh]
   write_byte(0xBE);//Read Scratchpad [BEh]
   for (uint8_t i = 0; i < 9; i++)
     pad_data[i] = read_byte();//factor out 1/16 and remember 1/16 != 1/16.0
   uint16_t x = (pad_data[1] << 8) + pad_data[0];
   if ((pad_data[1] >> 7) == 1 ){
    x -= 1; x = ~x;
       return  x / -16.0;
   } else  return x / 16.0;
}

void get_scratchpad(void) {
    uint8_t pad_data[] = {0,0,0,0,0,0,0,0,0};//9 Byte
    reset();
   write_byte(0xCC);//Skip ROM [CCh]
   write_byte(0x44);//Convert Temperature [44h]
   A9_wait_for_1(20);
   reset();
   write_byte(0xCC);//Skip ROM [CCh]
   write_byte(0xBE);//Read Scratchpad [BEh]
   for (uint8_t i = 0; i < 9; i++)
     pad_data[i] = read_byte();//factor out 1/16 and remember 1/16 != 1/16.0
   for (uint8_t i = 0; i < 9; i++){
     USB_Info_tutu("pad", i, " = ", pad_data[i]);
     HAL_Delay(200);
    }
}

void get_ID(void) {
    uint8_t id_data[] = {0,0,0,0,0,0,0,0};//8 Byte
   reset();
   write_byte(0x33);//Read ROM [33h]
   for (uint8_t i = 0; i < 8; i++)
     id_data[i] = read_byte();//id_data[0] = 40 = 0x28
    for (uint8_t i = 0; i < 8; i++){
        USB_Info_tutu("id", i, " = ", id_data[i]);
     HAL_Delay(200);
    }
}

void send_ID(void) {
    uint8_t id_data[] = {40,25,0,0,120,2,0,136};//8 Byte ID
   reset();
   write_byte(0x55);//Match ROM [55h]
   for (uint8_t i = 0; i < 8; i++)
     write_byte(id_data[i]);//id_data[0] = 40 = 0x28
}
```

```
float get_temperature_with_ID(void) {
    uint8_t pad_data[] = {0,0,0,0,0,0,0,0,0};//9 Byte
   reset();
   send_ID();
   write_byte(0x44);//Convert Temperature [44h]
   A9_wait_for_1(20);
   reset();
   send_ID();
   write_byte(0xBE);//Read Scratchpad [BEh]
   for (uint8_t i = 0; i < 9; i++)
     pad_data[i] = read_byte();//factor out 1/16 and remember 1/16 != 1/16.0
   return ((pad_data[1] << 8) + pad_data[0])/16.0;//DS18B20.pdf: val of bit0: 2^(-4) = 1/16
}

int main(void)
{
HAL_Init();
SystemClock_Config();
MX_GPIO_Init();
MX_USB_DEVICE_Init();
while (1){
    USB_Info_tf("T(C) = ", get_temperature());
    HAL_Delay(500);
}
}

uint16_t slen(const char* s) {
   uint16_t i;
   for (i = 0; s[i] != 0; i++);
   return i;//s[0] not 0 then i=1;
}
void add_txt(char* out, char* in) {
  while (*out != 0) out++;
  while (*in != 0) {
    *out++ = *in++;
  }
  *out = 0;
}
char* my_utoa(unsigned val, char *str)
{
 //static char  buffer[10];
 char*   cp = str;
 unsigned v;
 char c;
 v = val;
 do {
   v /= 10;
   cp++;
 } while(v != 0);
 *cp-- = 0;
 do {
   c = val % 10;
```

```
    val /= 10;
    c += '0';
    *cp-- = c;
  } while(val != 0);
  return  cp;
}
char *my_ftoa(float val, char *str)
{
  char *cp; cp=str;
  int v, v0, rest, rest0;
  char c;
  if(val < 0){     //   cp=0
      val = -val;  //cp[0   ][1   ][2][3][4][5][6][7][8][9]
      *cp++ = '-'; //  [0: -] cp=1
  }
  v0 = (int)val; v=v0;
  //rest0=(int)((val-(int)val)*100000000); rest = rest0;
  rest0=(int)((val-(int)val)*10000); rest = rest0;
  do {
    v /= 10;
    cp++;
  } while(v != 0);
  do {
    rest /= 10;
    cp++;
  } while(rest != 0);
  cp++; //wegen ','
  *cp-- = 0;
  do {
    c = rest0 % 10;
    rest0 /= 10;
    c += '0';
    *cp-- = c;
  } while(rest0 != 0);
  *cp-- = ',';
  do {
    c = v0 % 10;
    v0 /= 10;
    c += '0';
    *cp-- = c;
  } while(v0 != 0);
  return  cp;
}
void USB_Info(char *str)
{
  char txt[64] = {};
  add_txt( txt, str);
  add_txt( txt, "\n\r");
  CDC_Transmit_FS((uint8_t *)txt, slen(txt));
}
void USB_Info_tu(char* t1, unsigned u1)
{
```

```
  char txt[64] = {}, h[32] = {};
  add_txt(txt, t1);
  my_utoa(u1, h);
  add_txt(txt, h);
  add_txt(txt, "\n\r");
  CDC_Transmit_FS((uint8_t *)txt, slen(txt));
}
void USB_Info_tutu(char* t1, unsigned u1, char* t2, unsigned u2)
{
  char txt[64] = {}, h[32] = {};
  add_txt(txt, t1);
  my_utoa(u1, h);
  add_txt(txt, h);
  add_txt(txt, t2);
    my_utoa(u2, h);
    add_txt(txt, h);
  add_txt(txt, "\n\r");
  CDC_Transmit_FS((uint8_t *)txt, slen(txt));
}
void USB_Info_tf(char* t1, float u1)
{
  char txt[64] = {}, h[32] = {};
  add_txt(txt, t1);
  my_ftoa(u1, h);
  add_txt(txt, h);
  add_txt(txt, "\n\r");
  CDC_Transmit_FS((uint8_t *)txt, slen(txt));
}

void SystemClock_Config(void)
{
RCC_OscInitTypeDef RCC_OscInitStruct = {0};
RCC_ClkInitTypeDef RCC_ClkInitStruct = {0};
RCC_PeriphCLKInitTypeDef PeriphClkInit = {0};
RCC_OscInitStruct.OscillatorType = RCC_OSCILLATORTYPE_HSE;
RCC_OscInitStruct.HSEState = RCC_HSE_ON;
RCC_OscInitStruct.HSEPredivValue = RCC_HSE_PREDIV_DIV1;
RCC_OscInitStruct.HSIState = RCC_HSI_ON;
RCC_OscInitStruct.PLL.PLLState = RCC_PLL_ON;
RCC_OscInitStruct.PLL.PLLSource = RCC_PLLSOURCE_HSE;
RCC_OscInitStruct.PLL.PLLMUL = RCC_PLL_MUL9;
if (HAL_RCC_OscConfig(&RCC_OscInitStruct) != HAL_OK) Error_Handler();
RCC_ClkInitStruct.ClockType = RCC_CLOCKTYPE_HCLK|RCC_CLOCKTYPE_SYSCLK
|RCC_CLOCKTYPE_PCLK1|RCC_CLOCKTYPE_PCLK2;
RCC_ClkInitStruct.SYSCLKSource = RCC_SYSCLKSOURCE_PLLCLK;
RCC_ClkInitStruct.AHBCLKDivider = RCC_SYSCLK_DIV1;
RCC_ClkInitStruct.APB1CLKDivider = RCC_HCLK_DIV2;
RCC_ClkInitStruct.APB2CLKDivider = RCC_HCLK_DIV1;
if (HAL_RCC_ClockConfig(&RCC_ClkInitStruct, FLASH_LATENCY_2) != HAL_OK)
Error_Handler();
PeriphClkInit.PeriphClockSelection = RCC_PERIPHCLK_USB;
PeriphClkInit.UsbClockSelection = RCC_USBCLKSOURCE_PLL_DIV1_5;
```

```
if (HAL_RCCEx_PeriphCLKConfig(&PeriphClkInit) != HAL_OK) Error_Handler();
}
static void MX_GPIO_Init(void)
{
GPIO_InitTypeDef GPIO_InitStruct = {0};
__HAL_RCC_GPIOD_CLK_ENABLE();
__HAL_RCC_GPIOA_CLK_ENABLE();
HAL_GPIO_WritePin(GPIOA, GPIO_PIN_9, GPIO_PIN_SET);
GPIO_InitStruct.Pin = GPIO_PIN_9;
GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_OD;
GPIO_InitStruct.Pull = GPIO_NOPULL;
GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_HIGH;
HAL_GPIO_Init(GPIOA, &GPIO_InitStruct);
}
void Error_Handler(void){}
#ifdef  USE_FULL_ASSERT
void assert_failed(uint8_t *file, uint32_t line){}
#endif
```

… have fun with STM32!

edgarmarx@t-online.de