



Vhodno izhodne naprave

Laboratorijska vaja 4 - VP 3
STM32-CubeIDE projekt, VComPort,
GPIO (LED, tipka), PWM (LED, brenčač)

VIN projekt - VP3: STM32-CubeIDE projekt, VComPort, GPIO (LED, tipka), PWM (LED, brenčač)

- STM32F4, STM32H7 Discovery board in ostale platforme
- STM32 CubeIDE
- Osnovni projekt CubeIDE in CubeMX
 - CubeMX
 - USB VComPort (STM32F4)
 - GPIO – nivoji programiranja
 - GPIO – tipka, LED diode
 - GPIO – PWM, LED diode

VIN projekt - VP3: STM32-CubeIDE projekt, VComPort, GPIO (LED, tipka), PWM (LED, brenčač)

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 - GPIO – tipka, LED diode
 - GPIO – PWM, LED diode

VIN Projekt – Osnovna platforma

STM32F407 ST Discovery

STM Discovery F4 (Cortex M4)

- STM32F407VGT6 microcontroller featuring 32-bit Arm® Cortex®-M4 with FPU core, 1-Mbyte Flash memory and 192-Kbyte RAM in an LQFP100 package

•USB OTG FS

•ST MEMS 3-axis accelerometer

•ST-MEMS audio sensor omni-directional digital microphone

•Audio DAC with integrated class D speaker driver

•User and reset push-buttons

•Eight LEDs:

- LD1 (red/green) for USB communication
- LD2 (red) for 3.3 V power on
- Four user LEDs, LD3 (orange), LD4 (green), LD5 (red) and LD6 (blue)

•Board connectors:

- USB with Micro-AB
- Stereo headphone output jack
- 2.54 mm pitch extension header for all LQFP100 I/Os for quick connection to prototyping board and easy probing

•External application power supply: 3 V and 5 V

STM32



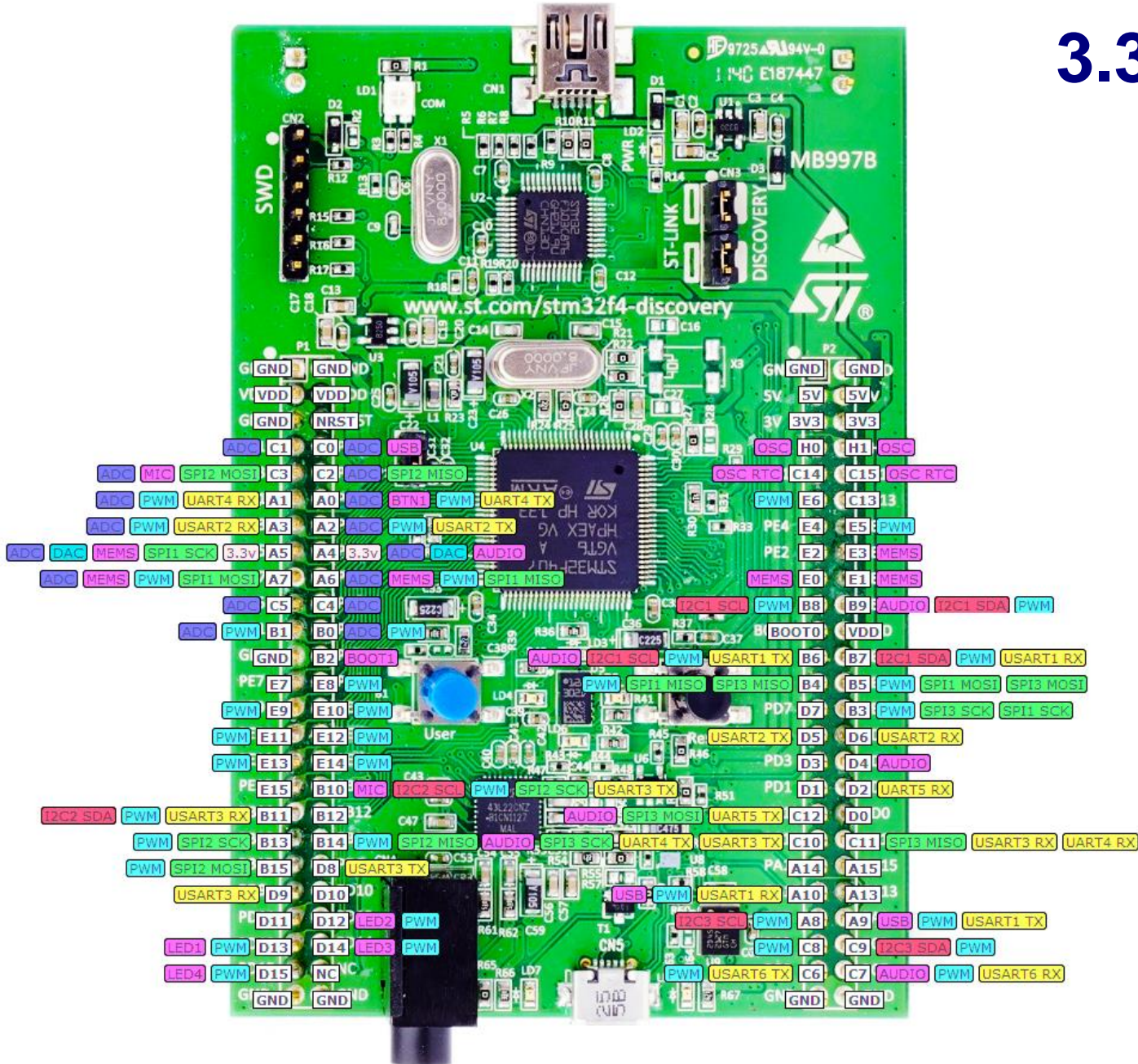
STM32F4DISCOVERY

3.3V !!!

P1

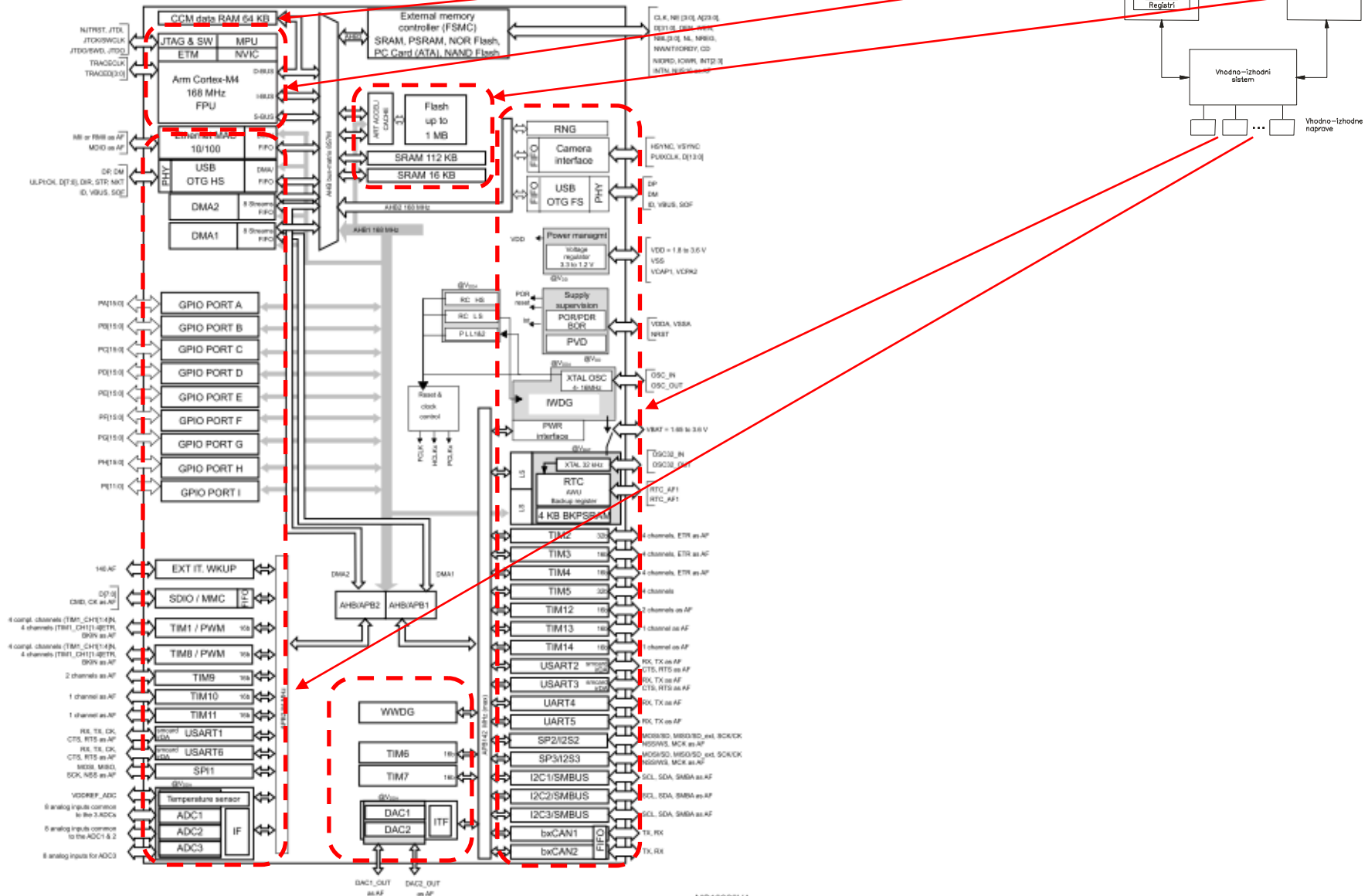
P2

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STM32F407VG



Delo na STM32F4 razvojnem sistemu

Priključitev :

- **Mini USB** priklp na **krajši stranici**, svetila rdeči **LED** diodi

Poseben začetni projekt za STM32F4 (e-učilnica) :

- **dodajanje vsebine (main.c):**

```
CubelDEWorkspace - STM32_USB_Key_LED/Core/Src/main.c - STM32CubelDE
File Edit Source Refactor Navigate Search Project Run Window Help
Project Explorer x
  Delo
  Node_V4 (in node_v4)
  Sluzba
  CAN_IEX_Module
  CAN_IEX_Module_bak
  H7-BSP-LCD-OS
  ORLab-STM32
  ORLab-STM32H7
  ORLab-STM32H7_bak
  RALab-STM32H7
  STM32_USB_Key_AdvDebug
  STM32_USB_Key_FreeRTOS_AdvDebug
  STM32CubelDE_Adv_Debug
  STM32F4_Discovery_VIN_Projects
    Audio_playback_and_record
    Buzzer_PWM_Demo
    CAN_IEX_Module_Base
    CAN_IEX_Sniffer
    Initial_Breadboard_VIN
    ...
main.c x
103
104 /* Infinite loop */
105 /* USER CODE BEGIN WHILE */
106 while (1)
107 {
108
109     HAL_GPIO_TogglePin(GPIOA, GPIO_PIN_12);
110     HAL_GPIO_TogglePin(GPIOA, GPIO_PIN_13);
111     HAL_GPIO_TogglePin(GPIOA, GPIO_PIN_14);
112
113     KeyState = HAL_GPIO_ReadPin(GPIOA, GPIO_PIN_0);
114     HAL_GPIO_WritePin(GPIOA, GPIO_PIN_15, KeyState);
115
116
117     snprintf(SendBuffer, BUFSIZE, "Hello World [%d]: Key:%d\r\n", Counter++, KeyState);
118     CDC_Transmit_FS(SendBuffer, strlen(SendBuffer));
119
120     /* USER CODE END WHILE */
121
122     /* USER CODE BEGIN 3 */
123     HAL_Delay(1000);
124 }
125 /* USER CODE END 3 */
126 }
127
```



**Mikro USB
VCom-port**

STM32 CubelDE, STM32F4 (izbrana dokumentacij

----- Razvojni sistem -----

- STM32 CubelDE
- ORLab-STM32 - GitHub repozitorij
- User Manual Discovery kit stm32f407vg Uploaded 8/11/21, 12:58
- DataSheet_stm32f407vg Uploaded 8/11/21, 12:56
- Reference Manual rm0090-stm32f407417 Uploaded 8/11/21, 12:57
- Programming_Manual_pm0214-stm32-cortexm4-mcus-and-mpu
- Arm Cortex-M4 Processor Datasheet Short Uploaded 29/10/21, 15:00
- Cortex-M arhitektura, zbirnik -----
- ARM Cortex-M for Beginners ARM 2017 Uploaded 29/10/21, 14:50

Lastni viri :

https://github.com/LAPSYLAB/STM32F4_Discovery_VIN_Projects

https://github.com/LAPSYLAB/STM32F4_Docs_and_Examples

<https://github.com/LAPSYLAB/ORLab-STM32>

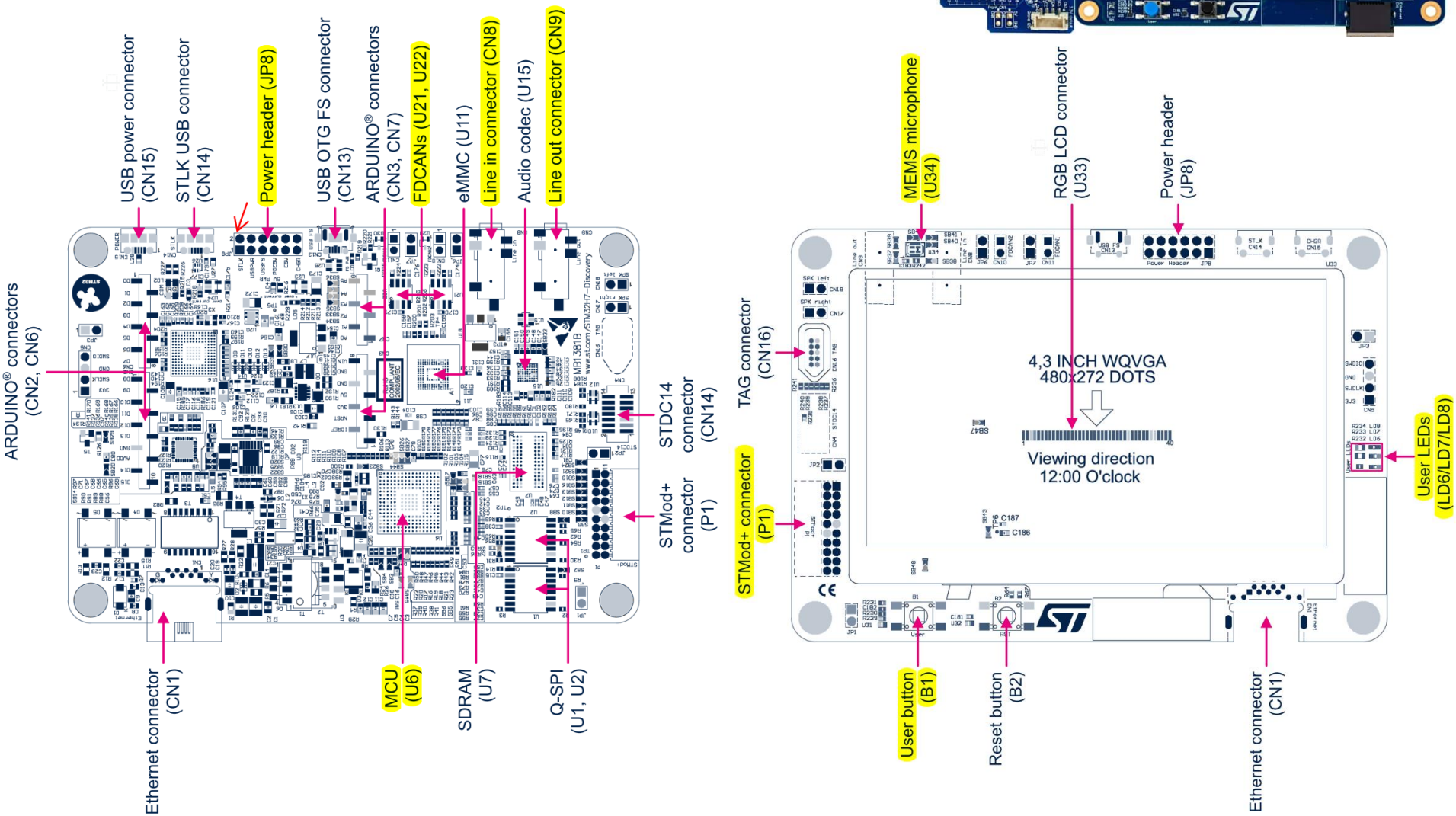
STM32H750B-DK Discovery razvojni sistem

- Arm® Cortex® core-based microcontroller with 128 Kbytes (STM32H750XBH6) of Flash memory and 1 Mbyte of RAM, in TFBGA240+25 package
- 4.3" RGB interface LCD with touch panel connector
- Ethernet compliant with IEEE-802.3-2002, and POE
- USB OTG FS with Micro-AB connector
- SAI audio codec
- One ST-MEMS digital microphone
- 2 x 512-Mbit Quad-SPI NOR Flash memory
- 128-Mbit SDRAM
- 4-Gbyte on-board eMMC
- 1 user and reset push-button
- Fanout daughterboard
- 2 x FDCANs
- Board connectors:
 - USB FS Micro-AB connectors
 - ST-LINK Micro-B USB connector
 - USB power Micro-B connector
 - Ethernet RJ45
 - Stereo headset jack including analog microphone input
 - Audio header for external speakers
 - Arduino™ Uno V3 expansion connectors
 - STMod+

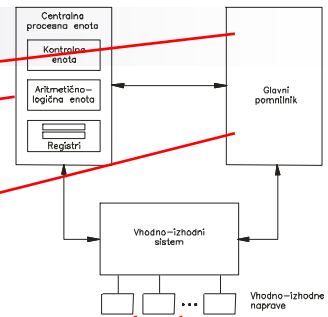
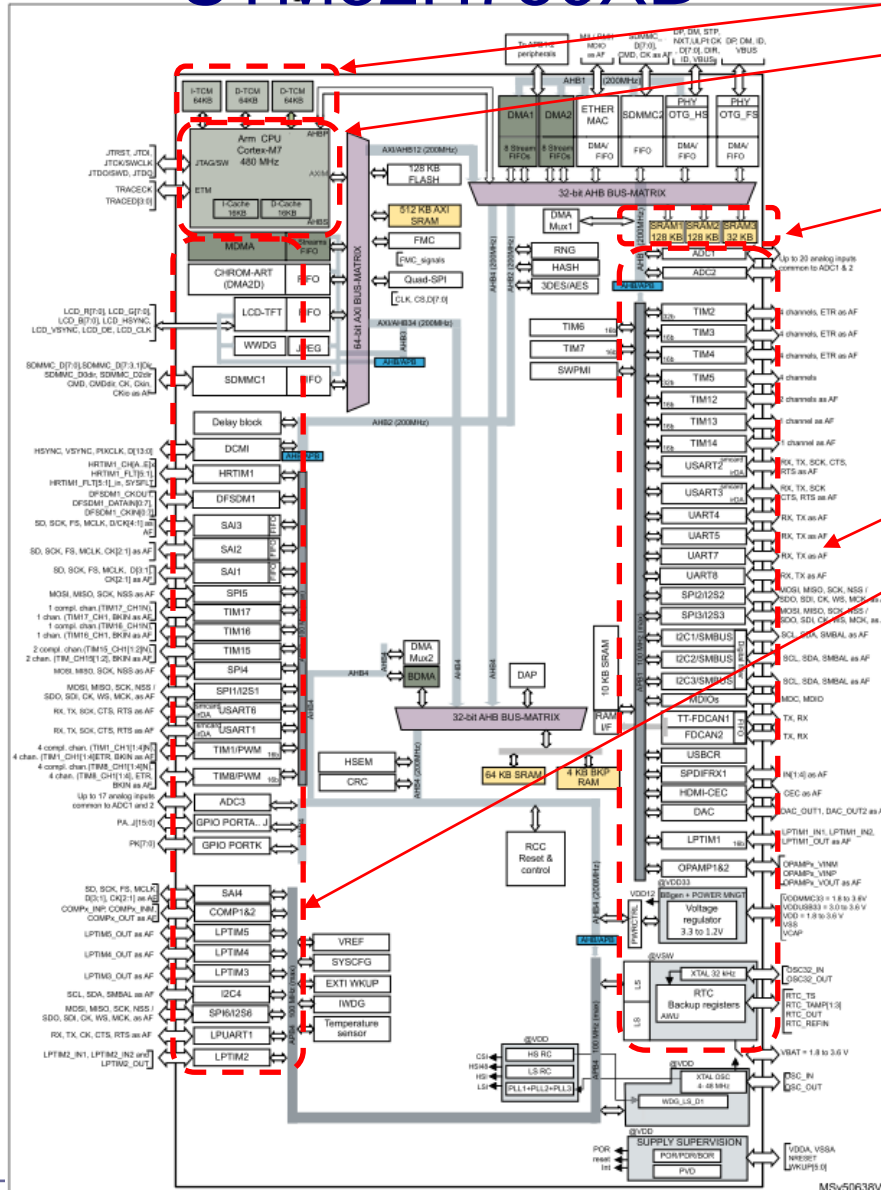


<https://www.st.com/en/evaluation-tools/stm32h750b-dk.html>

STM32H750B-DK Discovery razvojni sistem



STM32H750XB



Delo na STM32H7 razvojnem sistemu

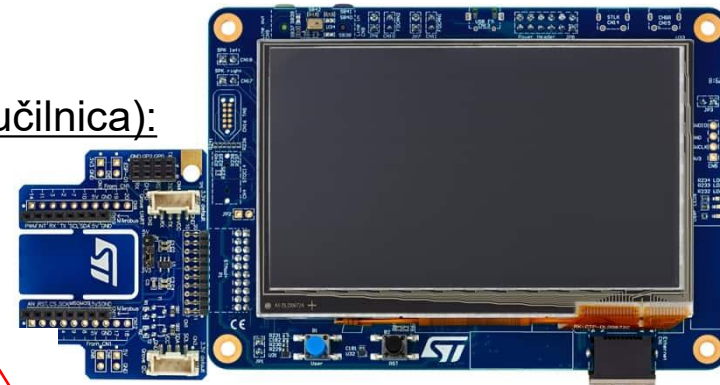
Priključitev :

- **Mikro USB** priklp na **daljši stranici** (srednji !!!)

Poseben začetni projekt (github) in info za STM32H7 (e-učilnica):

- **dodajanje vsebine (main.c):**

Mikro USB priklp na daljši stranici (srednji !!!) ↓



```
CubeIDEWorkspace - Sluzba/ORLab-STM32H7/STM32H750B-DK_C_Basic/Core/Src/main.c - STM32CubeIDE
File Edit Source Refactor Navigate Search Project Run Window Help
Project Explorer
CubelDE_Workspace
Delo
Node_V4 (in node_v4)
Sluzba
  CAN_IEX_Module
  CAN_IEX_Module_bak
  H7-BSP-LCD-OS
  ORLab-STM32
  ORLab-STM32H7
    Docs
    DWT_Cycles_Measurements
    GPIO_LEDs
    STM32H750B-DK_C_Basic
      Core
        Inc
        Src
main.c
131
132  /* Infinite loop */
133  /* USER CODE BEGIN WHILE */
134  while (1)
135  {
136      HAL_GPIO_TogglePin(GPIOI, GPIO_PIN_13);
137      HAL_GPIO_TogglePin(GPIOJ, GPIO_PIN_2);
138
139      /* USER CODE END WHILE */
140
141      /* USER CODE BEGIN 3 */
142      snprintf (SendBuffer,BUFSIZE,"USART3:%d secs\r\n",Cnt);
143      HAL_UART_Transmit(&uart3,SendBuffer,strlen(SendBuffer),1).
144
145      HAL_Delay(1000);
146      Cnt++;
147  }
148  /* USER CODE END 3 */
149 }
150
```

----- Razvojni sistem STM32H750-DK -----

- STM32H750B-DK Discovery kit with STM32H750XB MCU
- ORLab-STM32H7 - GitHub repozitorij
- User Manual Discovery kit stm32h750xb Uploaded 11/11/22, 10.15
- DataSheet_stm32h750xb Uploaded 11/11/22, 10.16
- Reference Manual rm0433-stm32h750xb Uploaded 11/11/22, 10.17
- Programming_Manual_pm0253-stm32h750xb Uploaded 11/11/22, 10.17
- Errata_es0396-stm32h750xb Uploaded 11/11/22, 10.19

Lastni viri :

<https://github.com/LAPSyLAB/STM32H7> Discovery VIN Projects

<https://github.com/LAPSyLAB/ORLab-STM32H7>

ARM Cortex M – ISA

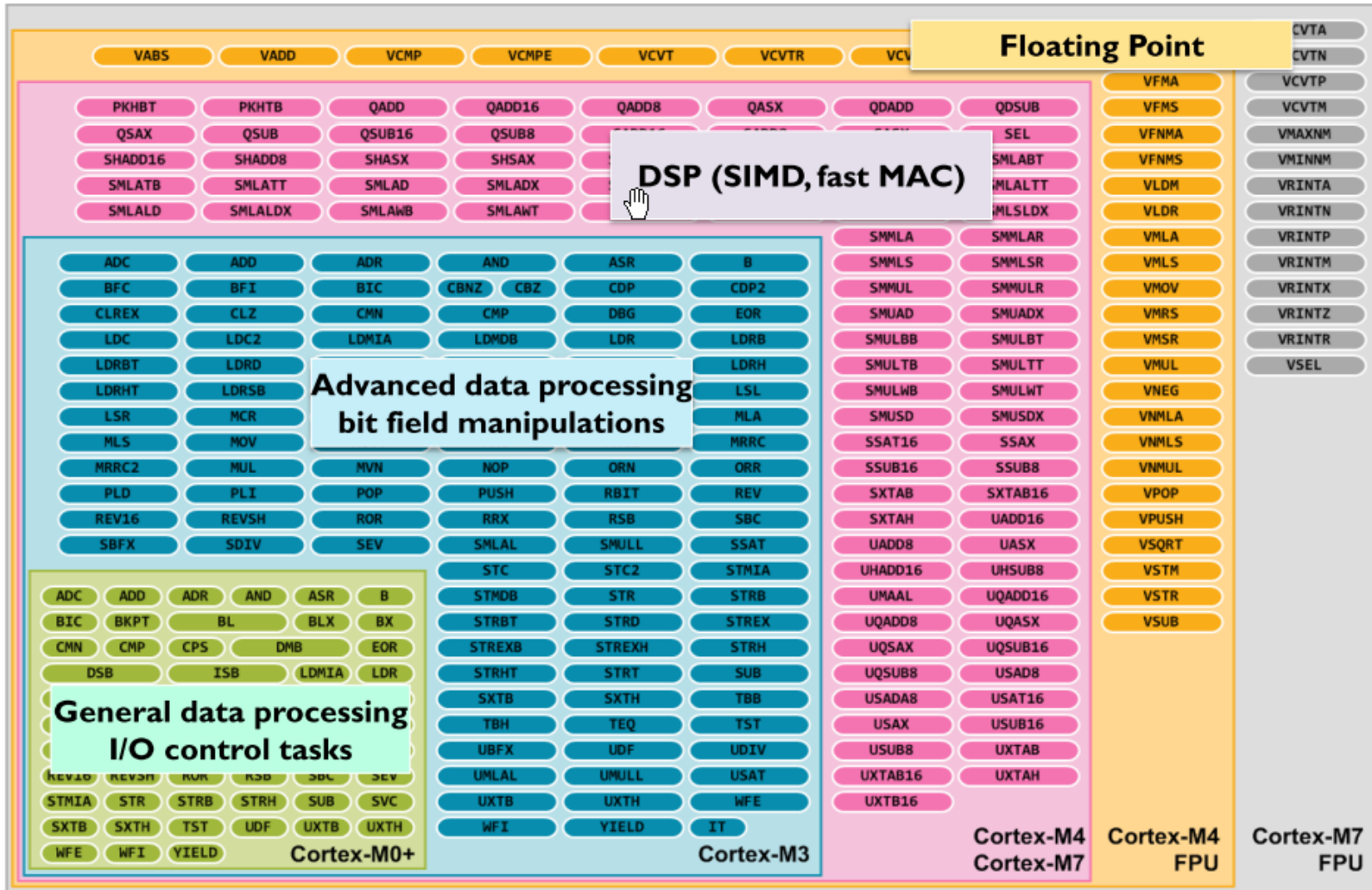
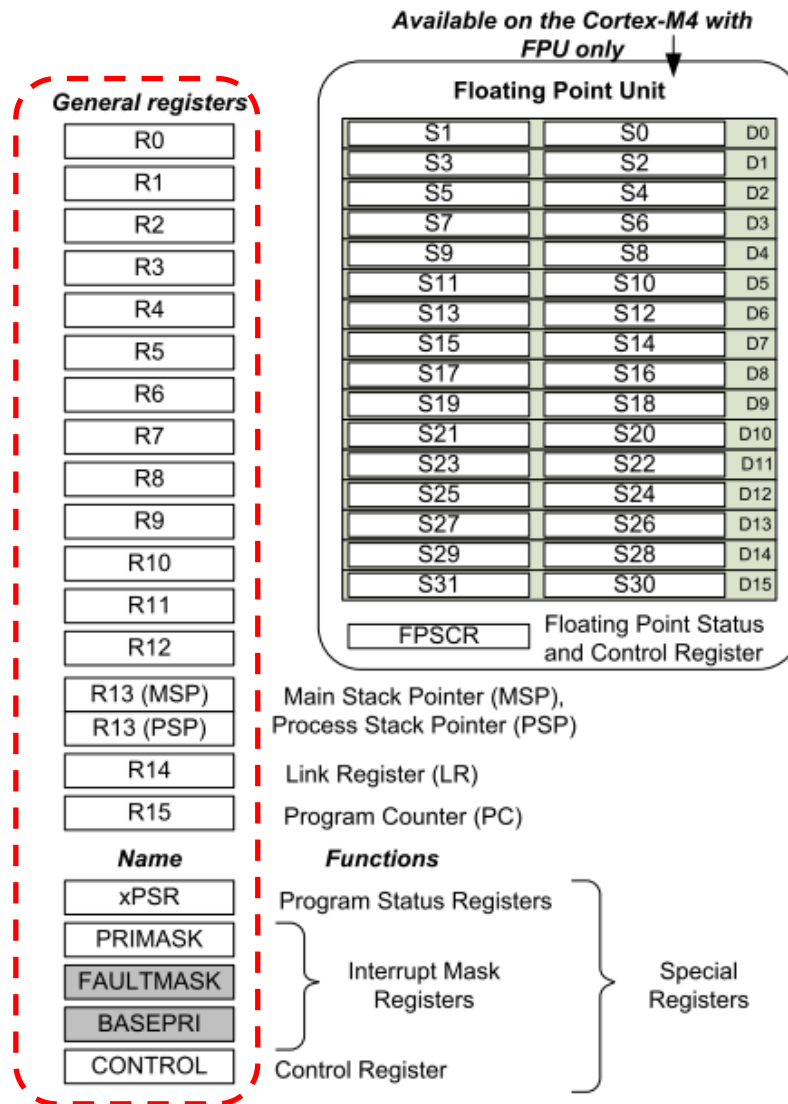


Figure 3: Instruction Set support in the Cortex-M processors

ARM Cortex M – Programski model



STEVAL-MKSBOX1V1 SensorTile.box razvojni sistem

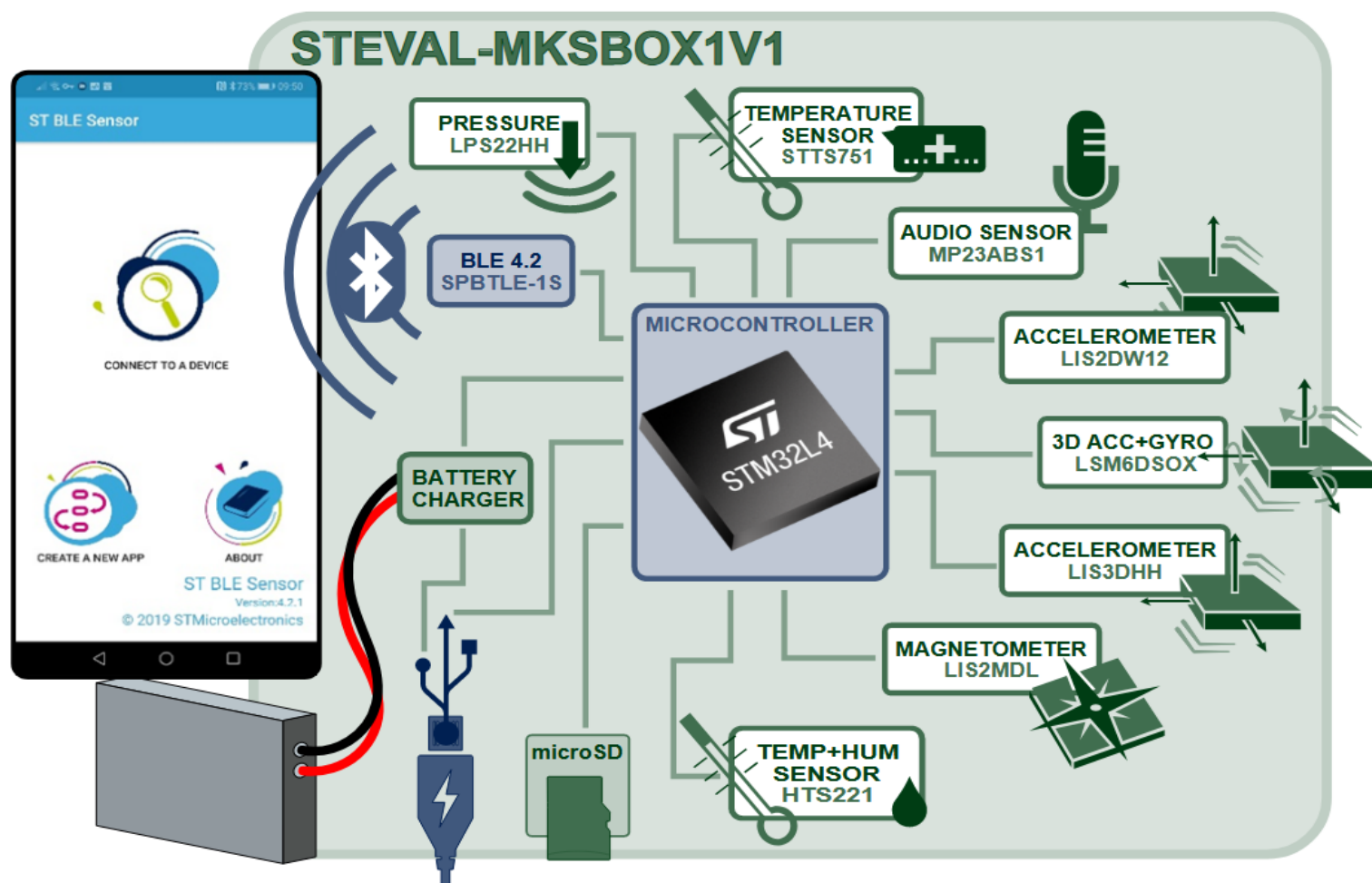
All features

- Easy-to-use app with immediate functionality for the following motion and environmental sensor applications:
 - Pedometer optimized for belt positioning
 - Baby crying detection with Cloud AI learning
 - Barometer / environmental monitoring
 - Vehicle / goods tracking
 - Vibration monitoring
 - Compass and inclinometer
 - Sensor data logger
- Expert Mode with additional sensor app parameter settings
- Compact board with the following high precision sensors:
 - Digital temperature sensor (STTS751)
 - 6-axis inertial measurement unit (LSM6DSOX)
 - 3-axis accelerometers (LIS2DW12 and LIS3DHH)
 - 3-axis magnetometer (LIS2MDL)
 - Altimeter / pressure sensor (LPS22HH)
 - Microphone / audio sensor (MP23ABS1)
 - Humidity sensor (HTS221)
- Ultra-low-power ARM Cortex-M4 microcontroller with DSP and FPU (STM32L4R9)
- Bluetooth application processor v5.2 (BlueNRG-M2) which replaces the SPBTLE-1S Bluetooth Smart connectivity v4.2 module of the board previous batches



<https://www.st.com/en/evaluation-tools/stm32h750b-dk.html>

STEVAL-MKSBOX1V1 SensorTile.box razvojni sistem

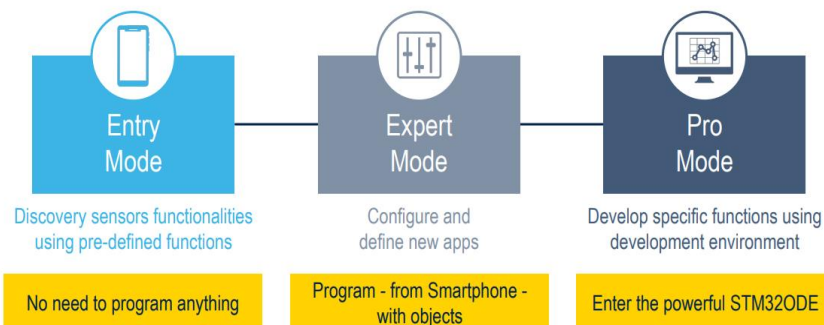


<https://www.st.com/en/evaluation-tools/stm32h750b-dk.html>

STEVAL-MKSBOX1V1 SensorTile.box razvojni sistem

The IoT made easy

SensorTile.box has 3 operational modes



KAJ VSE OMOGOČA APLIKACIJA?

V realnem času s pomočjo senzorjev zaznava stanje v okolju, risanje grafov na podlagi podatkov, shranjevanje podatkov v oblak - cloud logging.



VGRAJENE APLIKACIJE

Primeri vgrajenih aplikacij, dostopnih v Entry Mode načinu aplikacije STE BLE Sensor:

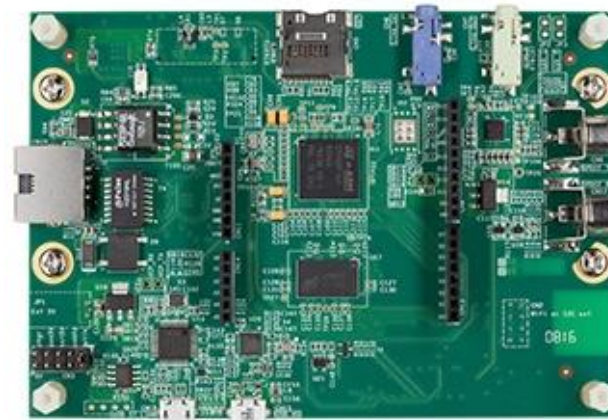
- Preprosta aplikacija za štetje korakov s pomočjo merilnika pospeška
- Zaznavanje otroškega joka
 - zaznavanje otroškega joka preko mikrofona, prižig LED diode/opozorilo na aplikaciji, ko je jok zaznan
- Barometriška aplikacija
 - omogoča dodatno ponastavljanje senzorjev za temperaturo, tlak in vlago, prejete meritve prikaže grafično v obliki
- Sledenje prevažanim dobrinam, stanje v vozilu
 - s primernimi tipali (npr. merilnik vlage) merimo pogoje, katerim bi bili potencialno izpostavljeni izdelki, prevažani v nekem vozilu
- Vibration monitoring
 - določimo neko sprejemljivo meritev tresljajev, ki jih zaznamo z merilnikom pospeška - o morebitnih odstopanjih obvestimo uporabnika in zabeležimo dogodek
- Compass and inclinometer
 - beleženje sprememb v orientaciji SensorTile.box-a tekom časa, grafični prikaz meritev (npr. spremembe v smeri neba, naklon)



<https://www.st.com/en/evaluation-tools/stm32h750b-dk.html>

STM Discovery F7 (Cortex M7)

- STM32F769NIH6 microcontroller featuring 2 Mbytes of Flash memory and 512+16+4 Kbytes of RAM, in BGA216 package
- On-board ST-LINK/V2-1 supporting USB reenumeration capability
- USB ST-LINK functions: virtual COM port, mass storage, debug port
- 4" capacitive touch LCD display with MIPI® DSI connector (on STM32F769I-DISCO only)
- SAI audio codec
- Two audio line jacks, one for input and one for output
- Stereo speaker outputs
- Four ST MEMS microphones on DFSDM inputs
- Two SPDIF RCA input and output connectors
- Two push-buttons (user and reset)
- 512-Mbit Quad-SPI Flash memory
- 128-Mbit SDRAM
- Connector for microSD card
- Wi-Fi or Ext-EEP daughterboard connector
- USB OTG HS with Micro-AB connector
- Ethernet connector compliant with IEEE-802.3-2002
- Arduino™ Uno V3 connectors



STM32



<https://www.st.com/en/evaluation-tools/32f769idiscovery.html>

ST Discovery STM32MP157C

STM Discovery MP1 (2xCortex A7 + 1xCortex M4)

- STM32MP157 Arm®-based **dual Cortex®-A7 32 bits + Cortex®-M4 32 bits MPU** in TFBGA361 package
- 4-Gbit DDR3L, 16 bits, 533 MHz
- 1-Gbps Ethernet (RGMII) compliant with IEEE-802.3ab
- USB OTG HS
- Audio codec
- 4 user LEDs
- 2 user and reset push-buttons, 1 wake-up button
- 5 V / 3 A USB Type-CTM power supply input (not provided)
- Board connectors:
 - Ethernet RJ454 × USB Host Type-AUSB Type-CTM DRPMIPI DSISMHDMI@Stereo headset jack including analog microphone inputmicroSDTM cardGPIC expansion connector (Raspberry Pi® shields capability)
- ARDUINO® Uno V3 expansion connectors
- STM32CubeMP1 and full mainline **open-source Linux® STM32** MPU OpenSTLinux Distribution (such as STM32MP1Starter) software and examples
- 4" **TFT 480 × 800 pixels** with LED backlight, MIPI DSISM interface, and capacitive **touch panel**
- Wi-Fi® 802.11b/g/n**
- Bluetooth® Low Energy 4.1**

STM32MP1

STM32



VIN projekt - VP3: STM32-CubeIDE projekt, VComPort, GPIO (LED, tipka), PWM (LED, brenčač)

- STM32F4, STM32H7 Discovery board in ostale platforme

■ STM32 CubeIDE

- Osnovni projekt CubeIDE in CubeMX
 - CubeMX
 - USB VComPort (STM32F4)
 - GPIO – nivoji programiranja
 - GPIO – tipka, LED diode
 - GPIO – PWM, LED diode

Mikro USB priključek na daljši stranici (srednji !!!) ↓

Delo na STM32 razvojnih sistemih

Priključitev :

- **Mini USB** priključek na **krajši stranici**, svetila rdeči **LED** diodi

STM32 CubeIDE

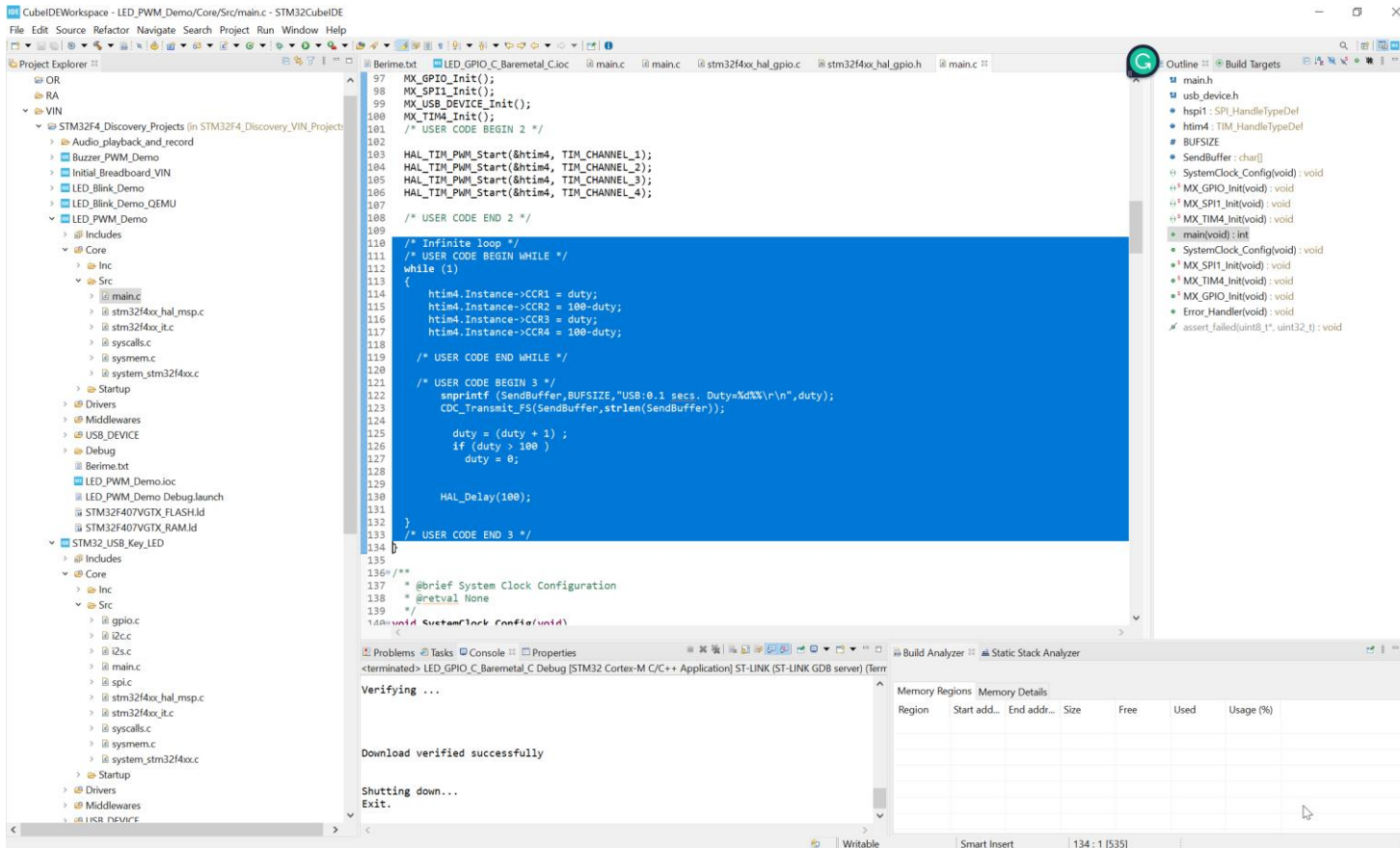
- <https://www.st.com/en/development-tools/stm32cubeide.html>



↓ **Mini USB**



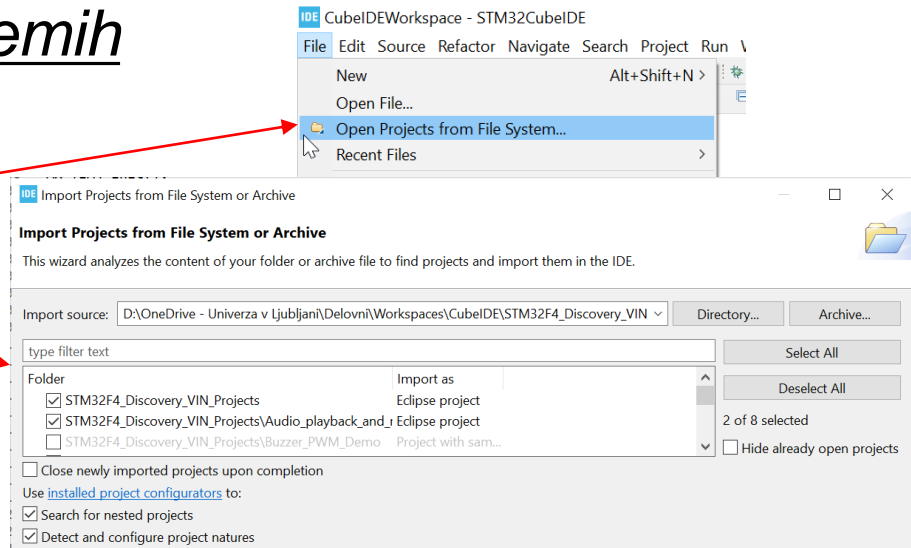
Mikro USB
VCom-port



Delo na STM32 razvojnih sistemih

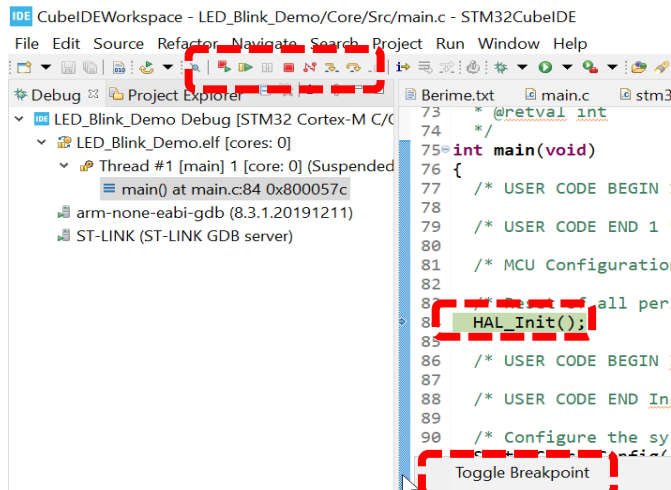
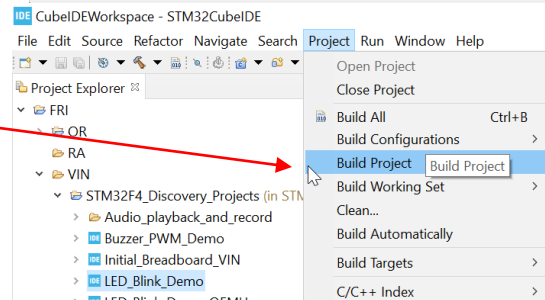
Vzpostavitev začetnega projekta :

- **Uvoz obstoječega**
 - Open projects from File System
 - Select project(s)
- **Nov projekt Cube MX ->**
(v nadaljevanju)



Prevajanje, zagon :

- Project -> Build Project
- Run -> Debug
- Step (Into,Over), Breakpoints



VIN projekt - VP3: STM32-CubeIDE projekt, VComPort, GPIO (LED, tipka), PWM (LED, brenčač)

- STM32F4, STM32H7 Discovery board in ostale platforme

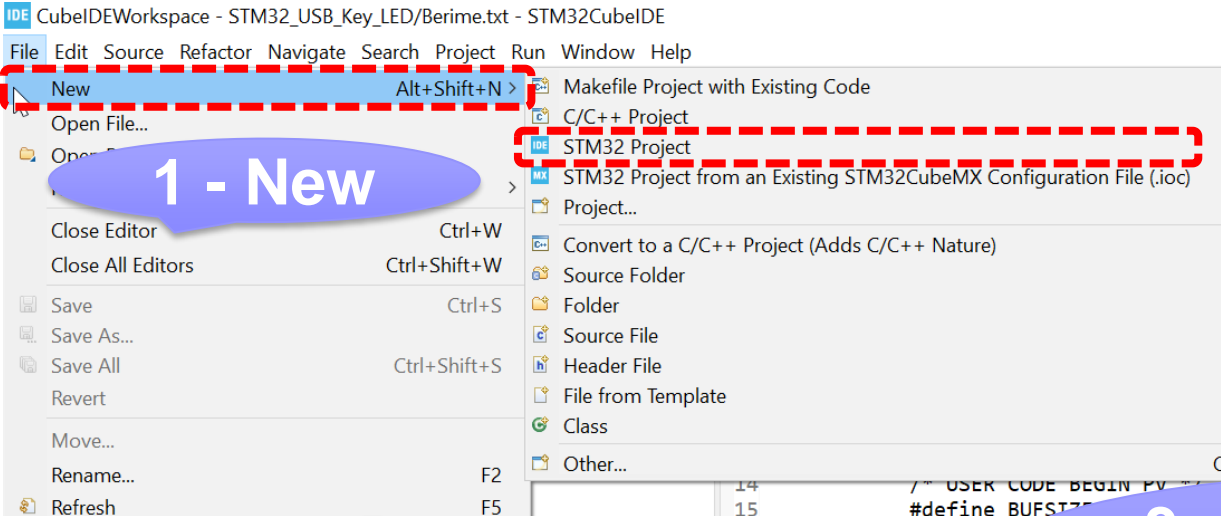
- STM32 CubeIDE

- Osnovni projekt CubeIDE in CubeMX

- CubeMX
- USB VComPort (STM32F4)
- GPIO – nivoji programiranja
- GPIO – tipka, LED diode
- GPIO – PWM, LED diode

CubeIDE – Vzpostavitev novega projekta

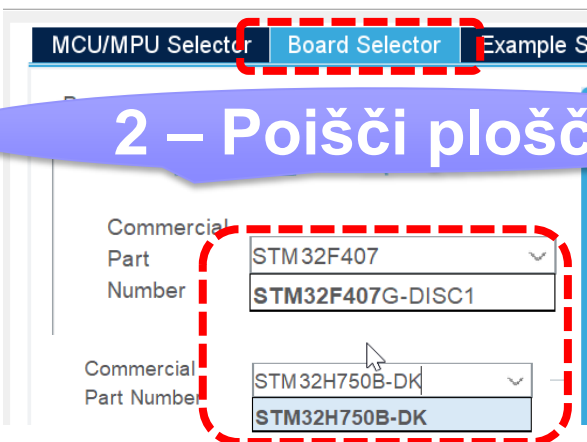
Nov projekt :



IDE STM32 Project

Target Selection

⚠ STM32 target or STM32Cube example selection is required



Konfiguracija : priključki, knjižnice STM32F4

STM32Cube MCU packages and embedded software packs

- Copy all used libraries into the project folder
- Copy only the necessary library files
- Add necessary library files as reference in the toolchain project configuration file

Generated files

- Generate peripheral initialization as a pair of '.c/.h' files per peripheral
- Backup previously generated files when re-generating
- Keep User Code when re-generating
- Delete previously generated files when not re-generated

HAL Settings

- Set all free pins as analog (to optimize the power consumption)
- Enable Full Assert

Template Settings

Select a template to generate customized code Settings...

Project Settings

Project Name
LED_GPIO_C_Baremetal_C

Project Location
D:\Delovni\CubeIDE\CubeIDEWorkspace

Application Structure
Advanced Do not generate the main()

Toolchain Folder Location
D:\Delovni\CubeIDE\CubeIDEWorkspace\LED_GPIO_C_Baremetal_C

Toolchain / IDE
STM32CubeIDE Generate Under Root

Linker Settings

Minimum Heap Size Minimum Stack Size

Thread-safe Settings

Cortex-MANS

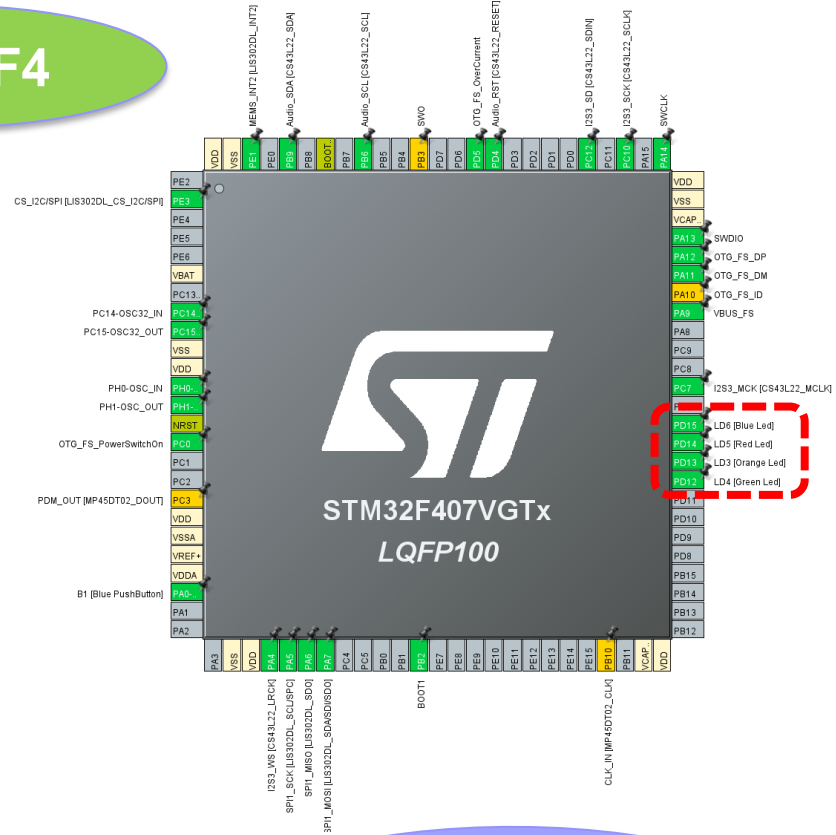
Enable multi-threaded support

Thread-safe Locking Strategy
Default - Mapping suitable strategy depending on RTOS selection

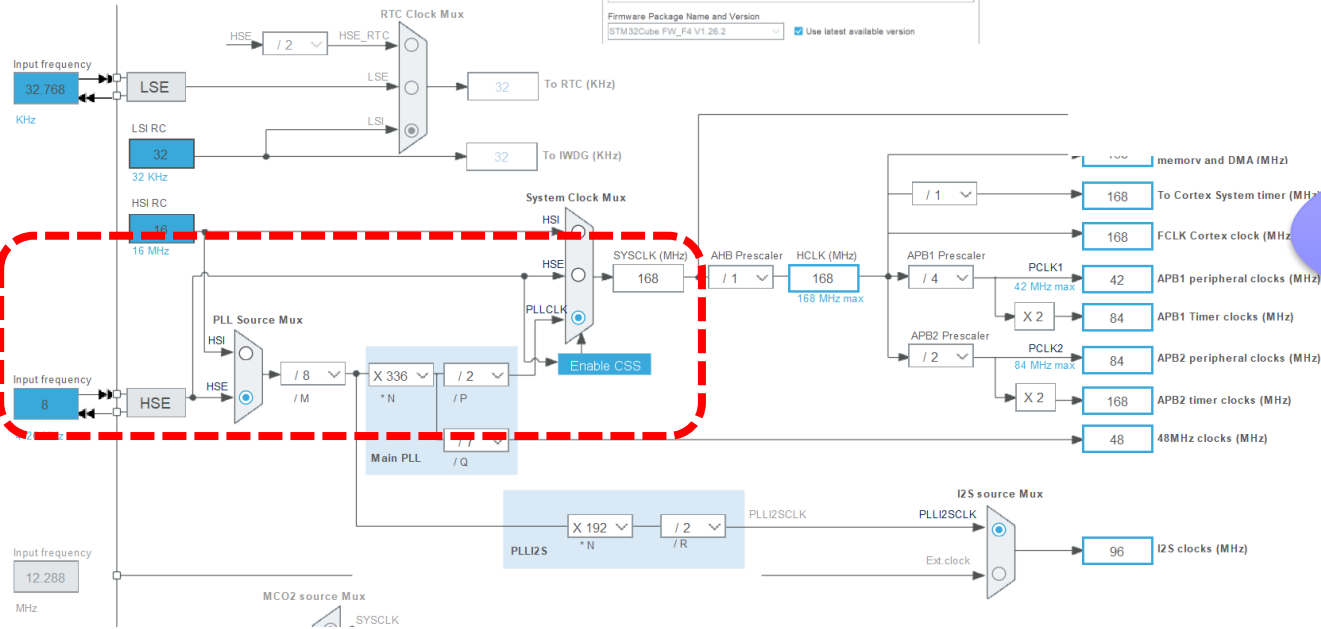
McU and Firmware Package

McU Reference
STM32F407VGTx

Firmware Package Name and Version
STM32Cube_FW_F4_V1.26.2 Use latest available version



4 – Preveri nastavitve



Osnovni projekt CubeIDE – USB Virtual COM Port

Konfiguracija : USB Device, CDC Class = Virtual COM Port

The image shows two screenshots of the STM32CubeIDE configuration interface. The left screenshot shows the 'Pinout & Configuration' window with the 'Mode' dropdown set to 'Device_Only' and 'USB_OTG_FS' checked in the 'Connectivity' list. A blue callout bubble labeled '5 - USB Device' points to the 'Device_Only' mode. The right screenshot shows the 'USB_DEVICE Mode and Configuration' window with 'Communication Device Class (Virtual Port Com)' selected in the 'Class For FS IP' dropdown. A blue callout bubble labeled '6 - VCP „Virt. COM Port“' points to this selection. A blue arrow points from the left screenshot to the right one.

5 – USB Device

6 – VCP „Virt. COM Port“

STM32F4

Osnovni projekt CubeIDE – USB Virtual COM Port

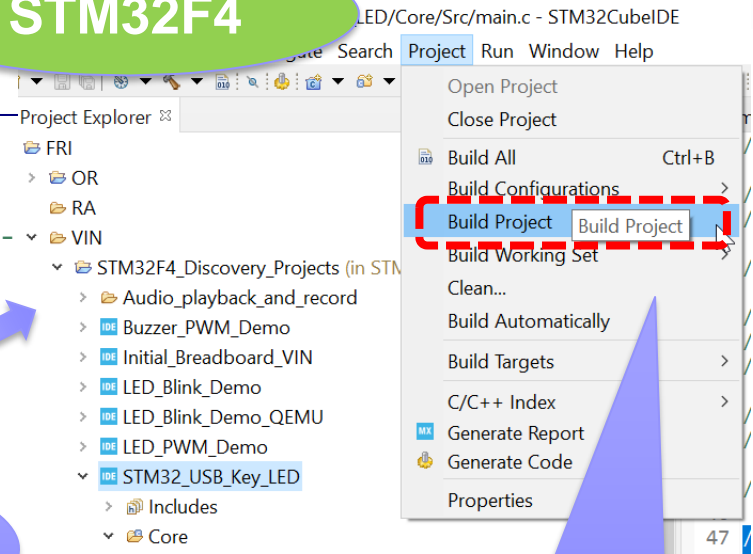
Program : za pošiljanje po USB Virtual COM Port

```
/* Private variables -----  
  
/* USER CODE BEGIN PV */  
#define    BUFSIZE 256  
char      SendBuffer[BUFSIZE];  
int       Counter;  
/* USER CODE END PV */
```

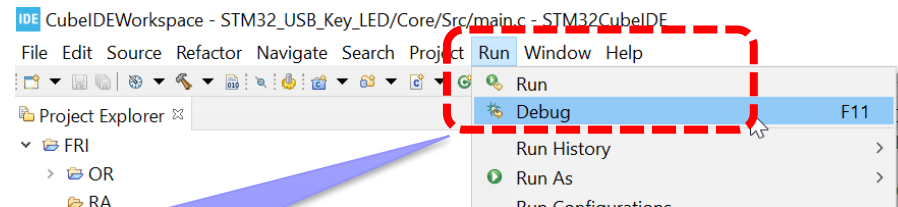
7 – USB
VCP koda

```
/* Infinite loop */  
/* USER CODE BEGIN WHILE */  
while (1)  
{  
    snprintf(SendBuffer, BUFSIZE, "Hello World [%d]\r\n", Counter++);  
    CDC_Transmit_FS(SendBuffer, strlen(SendBuffer));  
/* USER CODE END WHILE */  
  
/* USER CODE BEGIN 3 */  
    HAL_Delay(1000);  
}  
/* USER CODE END 3 */
```

9 – Debug
project

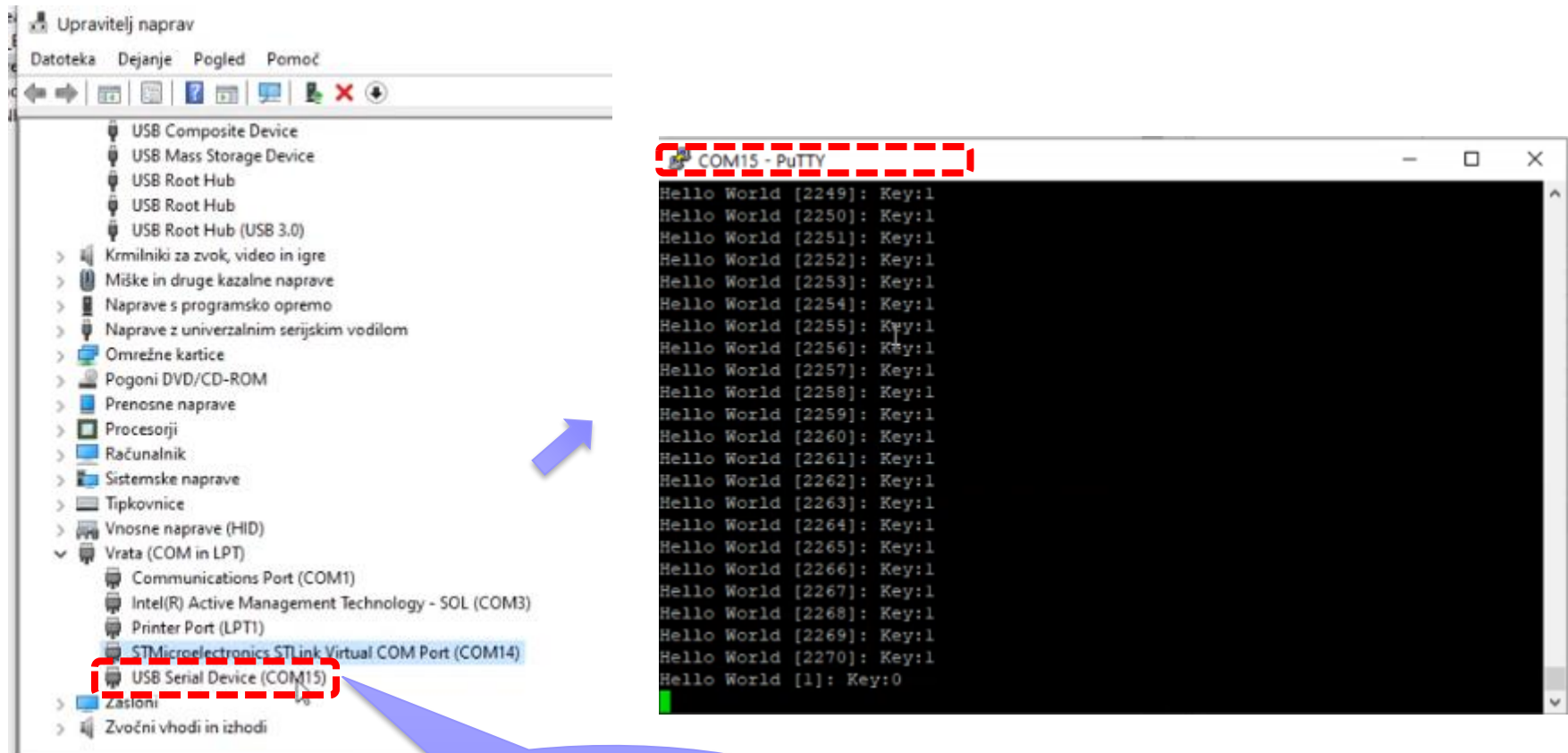


8 – Build
project



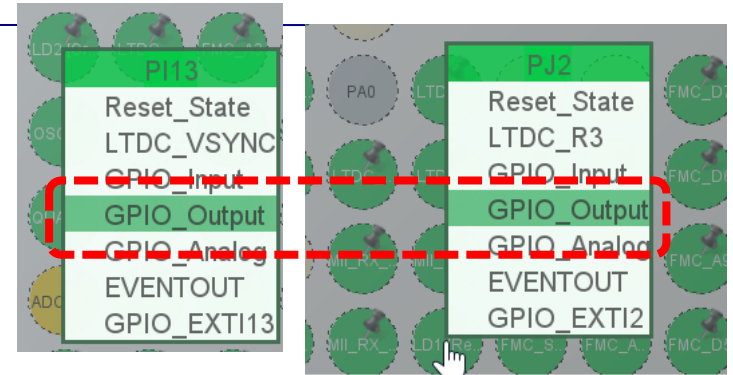
Osnovni projekt CubeIDE – USB Virtual COM Port

Program : sprejem na PC strani (povezava z Micro-USB kablom)



10 – Test
project

Konfiguracija : priključki, knjižnice STM32H7



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- Delete previously generated files when not re-generated

HAL Settings

- Set all free pins as analog (to optimize the power consumption)
- Enable Full Assert

Template Settings

Select a template to generate customized code Settings...

Project Settings

Project Name: LED_GPIO_C_Baremetal_C

Project Location: D:\Delovni\CubeIDE\CubeIDEWorkspace

Application Structure: Advanced Do not generate the main()

Toolchain Folder Location: D:\Delovni\CubeIDE\CubeIDEWorkspace\LED_GPIO_C_Baremetal_C

Toolchain / IDE: STM32CubeIDE Generate Under Root

Linker Settings

Minimum Heap Size: 0x200

Minimum Stack Size: 0x400

Thread-safe Settings

Cortex-MANS

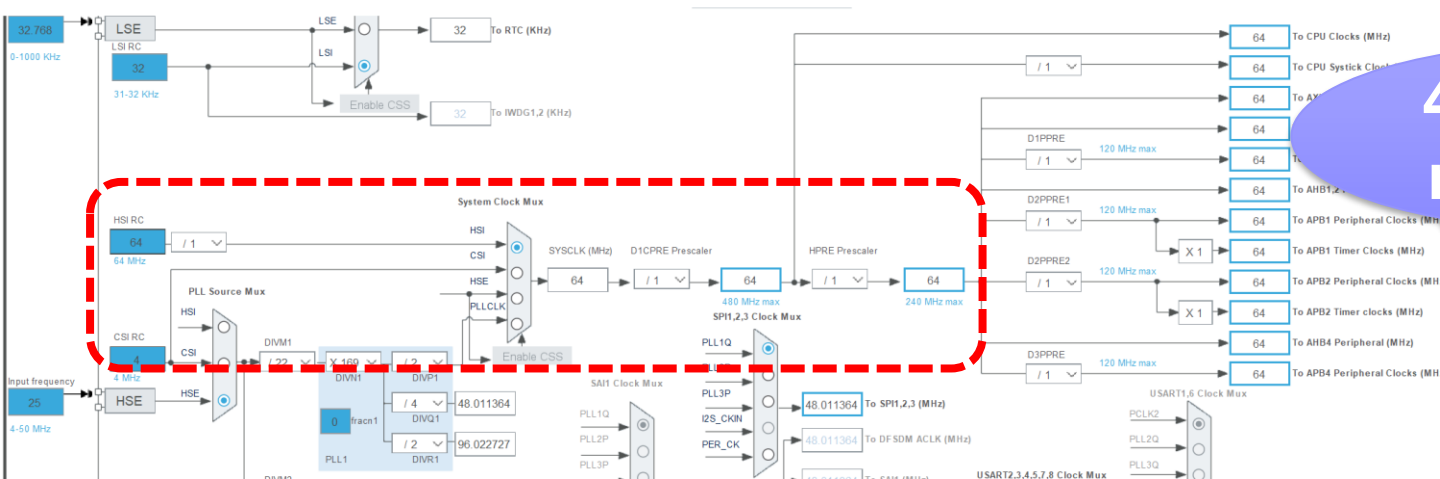
- Enable multi-threaded support

Thread-safe Locking Strategy: Default - Mapping suitable strategy depending on RTOS selection

McU and Firmware Package

McU Reference: STM32F407GTX

Firmware Package Name and Version: STM32Cube_FW_F4_V1.26.2 Use latest available version



4 – Preveri nastavitve

STM32H7

Osnovni projekt CubeIDE – USB Virtual COM Port

Program : za pošiljanje po USB Virtual COM Port (USART3)

```
/* Private variables ----- */

/* USER CODE BEGIN PV */
#define    BUFSIZE 256
char    SendBuffer[BUFSIZE];
int    Counter;
/* USER CODE END PV */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
    /* USER CODE END WHILE */

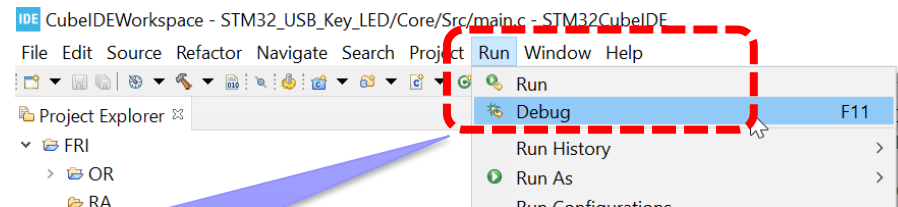
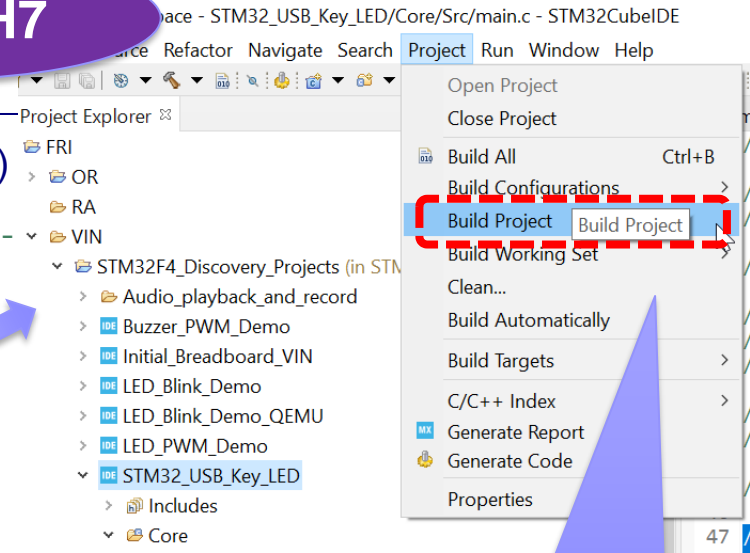
    /* USER CODE BEGIN 3 */
    snprintf (SendBuffer, BUFSIZE, "USART3:%d secs\r\n", Counter);
    HAL_UART_Transmit(&huart3, SendBuffer, strlen(SendBuffer), 1);

    HAL_Delay(1000);
    Counter++;
}
/* USER CODE END 3 */
```

5 – USB
UART koda

6 – Build
project

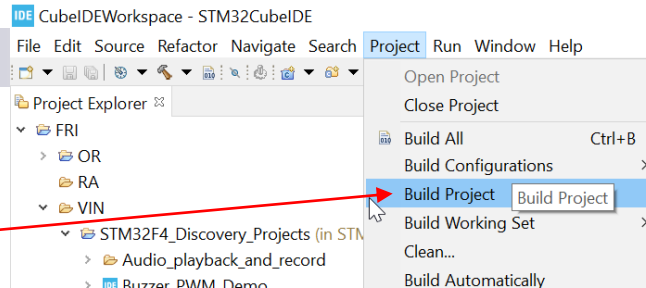
7 – Debug
project



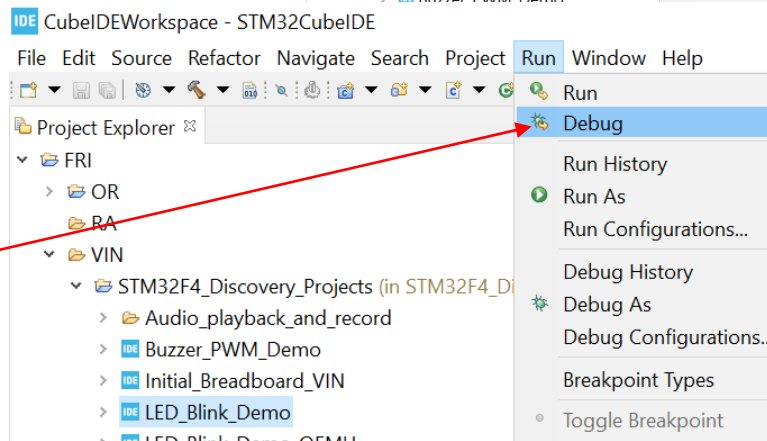
CubelIDE – Zagon, debug

Prevajanje, zagon :

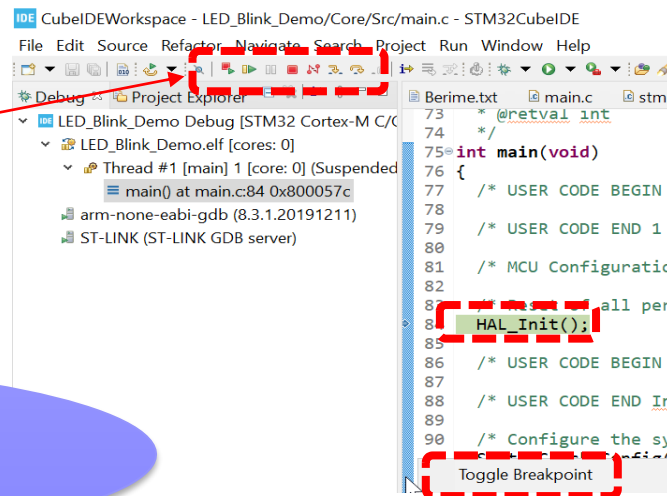
- Project -> Build Project



- Run -> Debug



- Step (Into,Over), Breakpoints



Build <-> Debug
project, ...

Baremetal - zbirnik

Baremetal - C

HAL - C

```
INIT_IO:
push {r5, r6, lr}
// Enable GPIO Peripheral Clock (bit 3 in AHBIENR register)
ldr r6, =RCC_AHB1ENR // Load peripheral clock reg address to r6
ldr r5, [r6] // Read its content to r5
orr r5, 0x00000008 // Set bit 3 to enable GPIO clock
str r5, [r6] // Store result in peripheral clock register

// Make GPIO Pin12 as output pin (bits 25:24 in MODER register)
ldr r6, =GPIO_BASE // Load GPIO BASE address to r6
ldr r5, [r6,#GPIO_MODER] // Read GPIO_MODER content to r5
and r5, 0x00FFFFFF // Clear bits 31-24 for P12-15
orr r5, 0x55000000 // Write 01 to bits 31-24 for P12-15
str r5, [r6] // Store result in GPIO MODER register
pop {r5, r6, pc}
```

```
LED_ON:
push {r5, r6, lr}
// Set GPIO Pins to 1 (through BSSR register)
ldr r6, =GPIO_BASE // Load GPIO BASE address to r6
mov r5, #LEDS_ON
str r5, [r6,#GPIO_BSSR] // Write to BSSR register
pop {r5, r6, pc}
```

```
LED_OFF:
push {r5, r6, lr}
// Set GPIO Pins to 0 (through BSSR register)
ldr r6, =GPIO_BASE // Load GPIO BASE address to r6
mov r5, #LEDS_OFF
str r5, [r6,#GPIO_BSSR] // Write to BSSR register
pop {r5, r6, pc}
```

https://github.com/LAPSYLAB/ORLab-STM32/tree/main/GPIO_LEDs

RA, OR

https://github.com/LAPSYLAB/STM32F4_Discovery_VIN_Projects/tree/main/LED_GPIO_C_Baremetal_C

VIN

https://github.com/LAPSYLAB/STM32F4_Discovery_VIN_Projects/tree/main/LED_Blink_Demo

```
/* USER CODE BEGIN 2 */

RCC->AHB1ENR |= 0x08;
// Enable clock for GPIO
GPIO->MODER |= 0x01000000; //
MODE Register: bit 12 == out

/* USER CODE END 2 */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
GPIO->ODR ^= 0x1000; //
Toggle PD12

/* USER CODE END WHILE */

/* USER CODE BEGIN 3 */
for (int i=0; i<0x1000000; i++) {};
// waste some time
}
/* USER CODE END 3 */
```

```
/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
HAL_GPIO_TogglePin(GPIO, GPIO_PIN_12);

/* USER CODE END WHILE */

/* USER CODE BEGIN 3 */
HAL_Delay(1000);
}
/* USER CODE END 3 */

void HAL_GPIO_TogglePin(GPIO_TypeDef* GPIOx,
uint16_t GPIO_Pin)
{
uint32_t odr;

/* Check the parameters */
assert_param(IS_GPIO_PIN(GPIO_Pin));

/* get current Output Data Register value
*/
odr = GPIOx->ODR;

/* Set selected pins that were at low
level, and reset ones that were high */
GPIOx->BSRR = ((odr & GPIO_Pin) <<
GPIO_NUMBER) | (~odr & GPIO_Pin);
}
```

Delo na STM32F4 razvojnem sistemu

Priključitev :

- **Mini USB** prikllop na **krajši stranici**, svetila rdeči **LED** diodi

Poseben začetni projekt za STM32F4 (e-učilnica) :

- **dodajanje vsebine (main.c):**

```

103
104 /* Infinite loop */
105 /* USER CODE BEGIN WHILE */
106 while (1)
107 {
108
109     HAL_GPIO_TogglePin(GPIOD, GPIO_PIN_12);
110     HAL_GPIO_TogglePin(GPIOD, GPIO_PIN_13);
111     HAL_GPIO_TogglePin(GPIOD, GPIO_PIN_14);
112
113     KeyState = HAL_GPIO_ReadPin(GPIOA, GPIO_PIN_0);
114     HAL_GPIO_WritePin(GPIOD, GPIO_PIN_15, KeyState);
115
116
117     snprintf(SendBuffer, BUFSIZE, "Hello World [%d]: Key:%d\r\n", Counter++, KeyState);
118     CDC_Transmit_FS(SendBuffer, strlen(SendBuffer));
119
120     /* USER CODE END WHILE */
121
122     /* USER CODE BEGIN 3 */
123     HAL_Delay(1000);
124 }
125 /* USER CODE END 3 */
126 }
127
    
```

STM32F4



Mikro USB
VCom-port

STM32 CubeIDE, STM32F4 (izbrana dokumentacij

----- Razvojni sistem -----

- STM32 CubeIDE
 - ORLab-STM32 - GitHub repozitorij
 - User Manual Discovery kit stm32f407vg Uploaded 8/11/21, 12.58
 - DataSheet_stm32f407vg Uploaded 8/11/21, 12.56
 - Reference Manual rm0090-stm32f407417 Uploaded 8/11/21, 12.57
 - Programming_Manual_pm0214-stm32-cortexm4-mcus-and-mpu
 - Arm Cortex-M4 Processor Datasheet Short Uploaded 29/10/21, 15.00
- Cortex-M arhitektura, zbirnik -----
- ARM Cortex-M for Beginners ARM 2017 Uploaded 29/10/21, 14.50

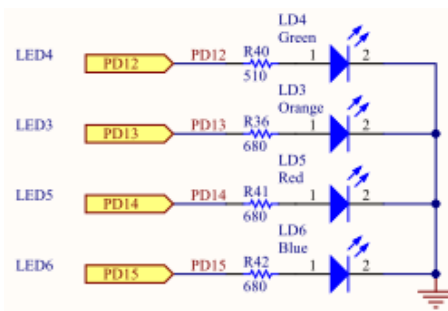
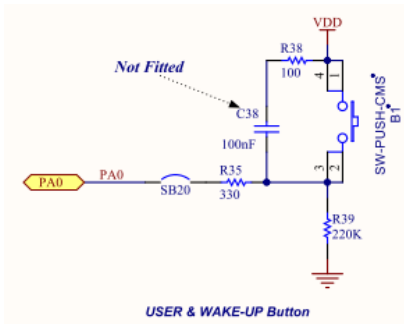
Lastni viri :

[https://github.com/LAPSYLAB/STM32F4 Discovery VIN Projects](https://github.com/LAPSYLAB/STM32F4_Discovery_VIN_Projects)

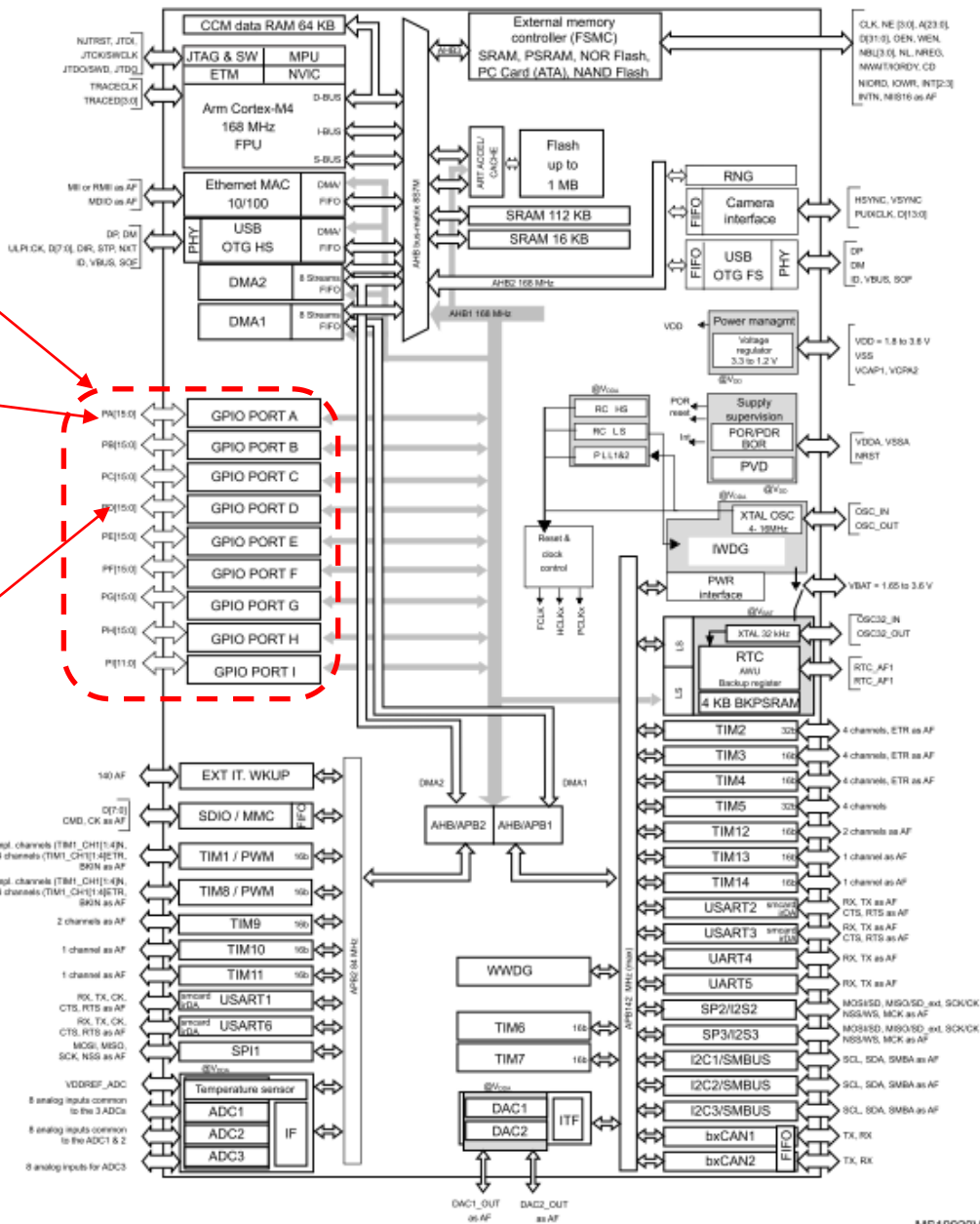
[https://github.com/LAPSYLAB/STM32F4 Docs and Examples](https://github.com/LAPSYLAB/STM32F4_Docs_and_Examples)

<https://github.com/LAPSYLAB/ORLab-STM32>

GPIO Krmilnik



STM32F4



MS19920V4



STM32F405/415, STM32F407/417, STM32F427/437 and
 STM32F429/439 advanced Arm[®]-based 32-bit MCUs

	General-purpose I/Os (GPIO)	267
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8.3	GPIO functional description	269
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8.3.3	I/O port control register	274
8.3.4	I/O port data register	274
8.3.5	I/O data bitwise hardware	274
8.3.6	GPIO locking mechanism	274
8.3.7	I/O alternate function	274

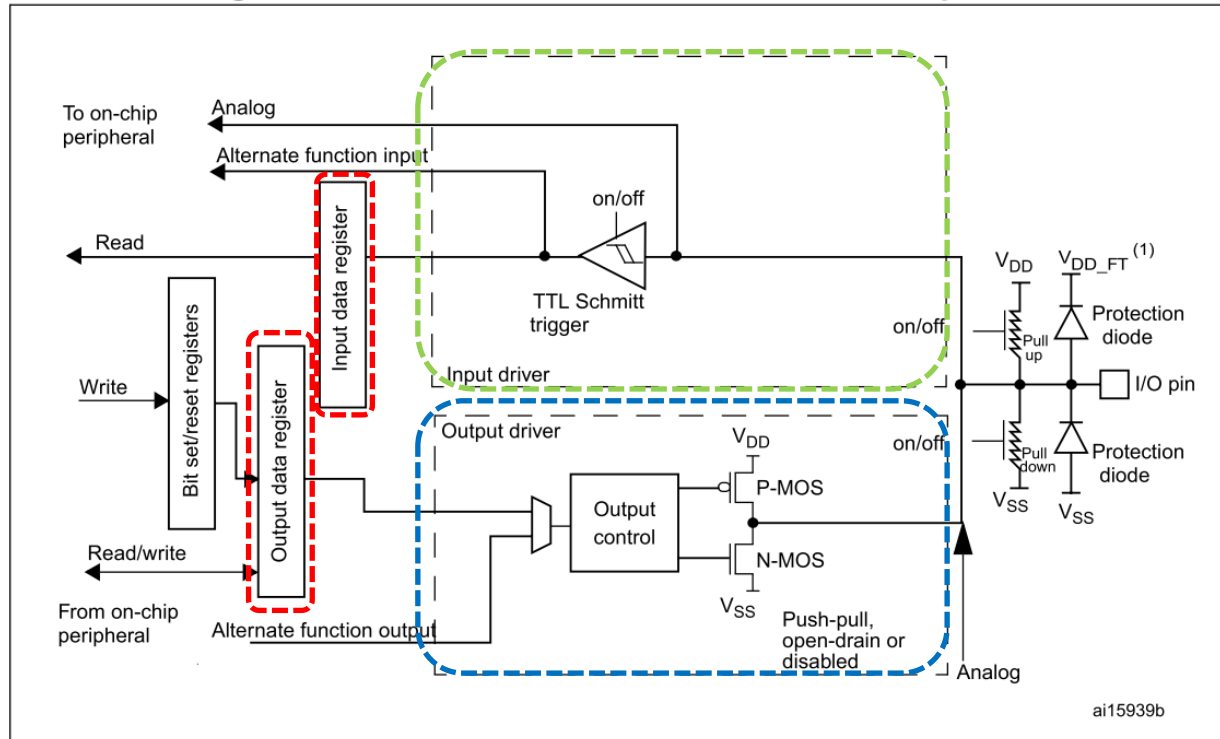
General-purpose I/Os (GPIO)

This section applies to the whole STM32F4xx family, unless otherwise specified.

8.1 GPIO introduction

Each general-purpose I/O port has four 32-bit configuration registers (GPIOx_MODER, GPIOx_OTYPER, GPIOx_OSPEEDR and GPIOx_PUPDR), two 32-bit data registers (GPIOx_IDR and GPIOx_ODR), a 32-bit set/reset register (GPIOx_BSRR), a 32-bit locking register (GPIOx_LCKR) and two 32-bit alternate function selection register (GPIOx_AFRH and GPIOx_AFRL).

Figure 25. Basic structure of a five-volt tolerant I/O port bit



Potrebni koraki za krmiljenje izhoda:

1. RCC_AHB1ENR(Peripheral Clock Register): $b_3=1$.. Port D Enable
2. **MODER (Mode Register): 01: General purpose output mode**
3. Default vrednosti že ustrezne v registrih :
OTYPER (Output TYPE Register): 0: Output push-pull (reset state)
OSPEEDR (Output SPEED Register): 00 – Low speed (reset state)
PUPDR (Pull Up/Down Register): 00 – No pull (reset state)
4. določi stanje izhoda s pisanjem v ODR ali BSRR (nastavljamo na 1/0)

Baremetal - zbirnik

```
INIT_IO:
push {r5, r6, lr}
// Enable GPIO Peripheral Clock (bit 3 in AHBIENR register)
ldr r6, =RCC_AHB1ENR // Load peripheral clock reg address to r6
ldr r5, [r6] // Read its content to r5
orr r5, 0x00000008 // Set bit 3 to enable GPIO clock
str r5, [r6] // Store result in peripheral clock register

// Make GPIO Pin12 as output pin (bits 25:24 in MODER register)
ldr r6, =GPIO_BASE // Load GPIO BASE address to r6
ldr r5, [r6,#GPIO_MODER] // Read GPIO_MODER content to r5
and r5, 0x00FFFFFF // Clear bits 31-24 for P12-15
orr r5, 0x55000000 // Write 01 to bits 31-24 for P12-15
str r5, [r6] // Store result in GPIO MODER register
pop {r5, r6, pc}
```

```
LED_ON:
push {r5, r6, lr}
// Set GPIO Pins to 1 (through BSSR register)
ldr r6, =GPIO_BASE // Load GPIO BASE address to r6
mov r5, #LEDS_ON
str r5, [r6,#GPIO_BSSR] // Write to BSSR register
pop {r5, r6, pc}
```

```
LED_OFF:
push {r5, r6, lr}
// Set GPIO Pins to 0 (through BSSR register)
ldr r6, =GPIO_BASE // Load GPIO BASE address to r6
mov r5, #LEDS_OFF
str r5, [r6,#GPIO_BSSR] // Write to BSSR register
pop {r5, r6, pc}
```

https://github.com/LAPSyLAB/ORLab-STM32/tree/main/GPIO_LEDs



https://github.com/LAPSyLAB/STM32F4_Discovery_VIN_Projects/tree/main/LED_GPIO_C_Baremetal_C

Potrebni koraki za krmiljenje izhoda:

1. **RCC_AHB1ENR** (Peripheral Clock Register): $b_3=1$.. Port D Enable
2. **MODER** (Mode Register): **01: General purpose output mode**
3. **Default vrednosti že ustrezne v registrih :**
OTYPER (Output TYPE Register): **0: Output push-pull** (reset state)
OSPEEDR (Output SPEED Register): **00 – Low speed** (reset state)
PUPDR (Pull Up/Down Register): **00 – No pull** (reset state)
4. določi **stanje izhoda s pisanjem v ODR** ali **BSRR** (nastavljamo na 1/0)



Baremetal - C

```
/* USER CODE BEGIN 2 */

RCC->AHB1ENR |= 0x08;
// Enable clock for GPIO
GPIO->MODER |= 0x01000000; //
MODE Register: bit 12 == out

/* USER CODE END 2 */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
    GPIO->ODR ^= 0x1000; //
    Toggle PD12

/* USER CODE END WHILE */

/* USER CODE BEGIN 3 */
for (int i=0; i<0x1000000; i++) {};
// waste some time
}
/* USER CODE END 3 */
```

HAL - C

```
/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
    HAL_GPIO_TogglePin(GPIO, GPIO_PIN_12);

/* USER CODE END WHILE */

/* USER CODE BEGIN 3 */
HAL_Delay(1000);
}
/* USER CODE END 3 */

void HAL_GPIO_TogglePin(GPIO_TypeDef* GPIOx,
uint16_t GPIO_Pin)
{
    uint32_t odr;

/* Check the parameters */
assert_param(IS_GPIO_PIN(GPIO_Pin));

/* get current Output Data Register value
*/
odr = GPIOx->ODR;

/* Set selected pins that were at low
level, and reset ones that were high */
GPIOx->BSRR = ((odr & GPIO_Pin) <<
GPIO_NUMBER) | (~odr & GPIO_Pin);
}
```

[https://github.com/LAPSyLAB/STM32F4_Discovery_VIN_Projects/tree/main/LED Blink Demo](https://github.com/LAPSyLAB/STM32F4_Discovery_VIN_Projects/tree/main/LED_Blink_Demo)

HAL - C

```

/* USER CODE BEGIN PV */
#define BUFSIZE 256
char SendBuffer[BUFSIZE];
int Counter;
int KeyState=0;

/* USER CODE END PV */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
    HAL_GPIO_TogglePin(GPIOD, GPIO_PIN_12);
    HAL_GPIO_TogglePin(GPIOD, GPIO_PIN_13);
    HAL_GPIO_TogglePin(GPIOD, GPIO_PIN_14);

    KeyState = HAL_GPIO_ReadPin(GPIOA, GPIO_PIN_0);
    HAL_GPIO_WritePin(GPIOD, GPIO_PIN_15, KeyState);

    snprintf(SendBuffer,BUFSIZE,"Hello World [%d]: Key:%d\r\n",Counter++,KeyState);
    CDC_Transmit_FS(SendBuffer,strlen(SendBuffer));

    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
    HAL_Delay(1000);
    }
/* USER CODE END 3 */

```

UM1725

User manual

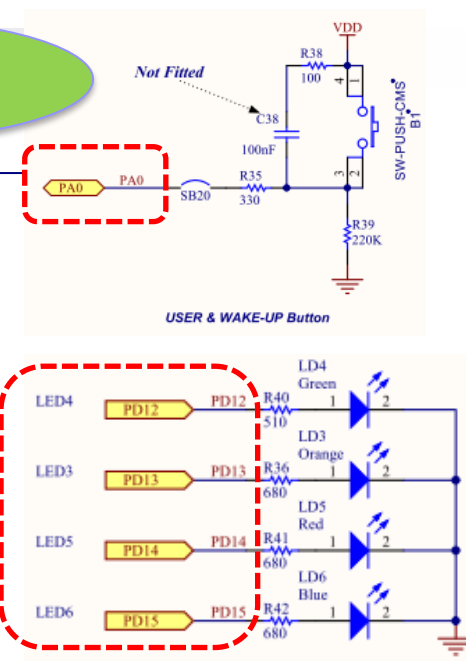
Description of STM32F4 HAL and low-layer drivers

31.2.4

IO operation functions

This section contains the following APIs:

- `HAL_GPIO_ReadPin()`
- `HAL_GPIO_WritePin()`
- `HAL_GPIO_TogglePin()`
- `HAL_GPIO_LockPin()`
- `HAL_GPIO_EXTI_IRQHandler()`
- `HAL_GPIO_EXTI_Callback()`



https://github.com/LAPSyLAB/STM32F4_Discovery_VIN_Projects/tree/main/STM32_USB_Key_LED

Delo na STM32H7 razvojnem sistemu

Priključitev :

- **Mikro USB** priklp na **daljši stranici** (**srednji !!!**)

Poseben začetni projekt (github) in info za STM32H7 (e-učilnica):

- **dodajanje vsebine (main.c):**

Mikro USB priklp na daljši stranici
(srednji !!!) ↓



```
CubeIDEWorkspace - Sluzba/ORLab-STM32H7/STM32H750B-DK_C_Basic/Core/Src/main.c - STM32CubeIDE
File Edit Source Refactor Navigate Search Project Run Window Help
Project Explorer
CubelDE_Workspace
Delo
Node_V4 (in node_v4)
Sluzba
  CAN_IEX_Module
  CAN_IEX_Module_bak
  H7-BSP-LCD-OS
  ORLab-STM32
  ORLab-STM32H7
    Docs
    DWT_Cycles_Measurements
    GPIO_LEDs
    STM32H750B-DK_C_Basic
      Core
        Inc
        Src
main.c
131
132  /* Infinite loop */
133  /* USER CODE BEGIN WHILE */
134  while (1)
135  {
136      HAL_GPIO_TogglePin(GPIOI, GPIO_PIN_13);
137      HAL_GPIO_TogglePin(GPIOJ, GPIO_PIN_2);
138
139      /* USER CODE END WHILE */
140
141      /* USER CODE BEGIN 3 */
142      snprintf (SendBuffer,BUFSIZE,"USART3:%d secs\r\n",Cnt);
143      HAL_UART_Transmit(&huart3,SendBuffer,strlen(SendBuffer),1).
144
145      HAL_Delay(1000);
146      Cnt++;
147  }
148  /* USER CODE END 3 */
149 }
150
```

----- Razvojni sistem STM32H750-DK -----

- STM32H750B-DK Discovery kit with STM32H750XB MCU
- ORLab-STM32H7 - GitHub repozitorij
- User Manual Discovery kit stm32h750xb Uploaded 11/11/22, 10.15
- DataSheet_stm32h750xb Uploaded 11/11/22, 10.16
- Reference Manual rm0433-stm32h750xb Uploaded 11/11/22, 10.17
- Programming_Manual_pm0253-stm32h750xb Uploaded 11/11/22, 10.17
- Errata_es0396-stm32h750xb Uploaded 11/11/22, 10.19

Lastni viri :

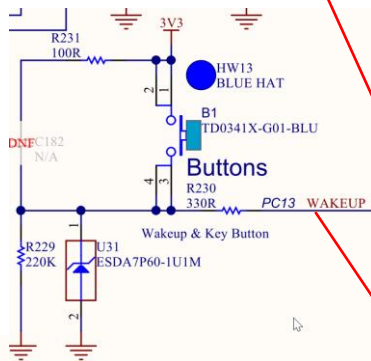
<https://github.com/LAPSyLAB/STM32H7> Discovery VIN Projects

<https://github.com/LAPSyLAB/ORLab-STM32H7>

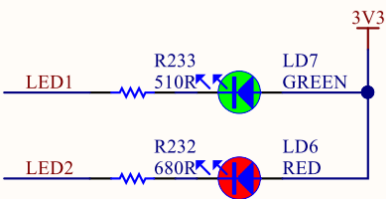
STM32H7

STM32H7

GPIO Krmilnik



LEDs

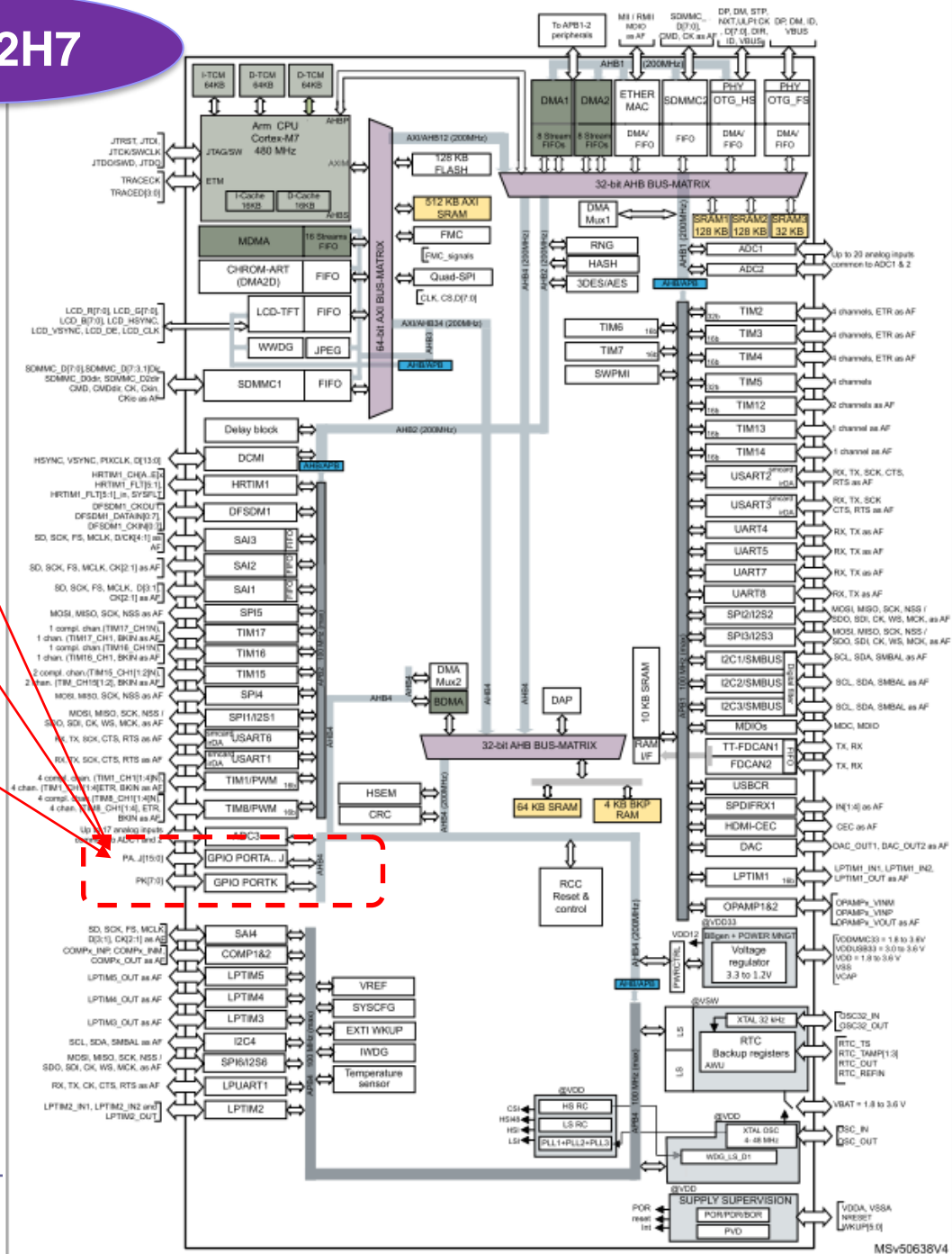


U6B STM32H750XBH6

T8	PG0	PI0	A16	LCD G5
U8	PG1	PI1	A15	LCD G6
H16	PG2	PI2	B15	ARD DI2
H15	PG3	PI3	C14	STMOD#8-MOSIs
H14	PG4	PI4	A4	SAI2 MCLKA
G14	PG5	PI5	A3	SAI2 SCKA
G15	PG6	PI6	A2	SAI2 SDA
F16	PG7	PI7	B3	SAI2 FSA
F15	PG8	PI8	E4	ARD D7
A10	PG9	PI9	E2	LCD VSYNC
A9	PG10	PI10	F3	MII RX ER
B9	PG11	PI11	F4	STMOD#18
C9	PG12	PI12	H1	LCD HSYNC
D9	PG13	PI13	H2	LED2
D8	PG14	PI14	H3	LCD CLK
D6	PG15	PI15	P5	LCD R0
F10	P6	LCD R2		
PI1	T6	LED1		
PI2	T16	LCD R4		

LED: rdeča PI13, zelena PJ2

VIN - LV





STM32H742, STM32H743/753 and STM32H750 Value line
advanced Arm[®]-based 32-bit MCUs



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11.1	Introduction	527
11.2	GPIO main features	527
11.3	GPIO functional description	530
11.3.1	General-purpose I/O (GPIO)	530
11.3.2	I/O pin alternate function multiplexer and mapping	530
11.3.3	I/O port control registers	531

11 General-purpose I/Os (GPIO)

11.1 Introduction

Each general-purpose I/O port has four 32-bit configuration registers (GPIOx_MODER, GPIOx_OTYPER, GPIOx_OSPEEDR and GPIOx_PUPDR), two 32-bit data registers (GPIOx_IDR and GPIOx_ODR) and a 32-bit set/reset register (GPIOx_BSRR). In addition all GPIOs have a 32-bit locking register (GPIOx_LCKR) and two 32-bit alternate function selection registers (GPIOx_AFRH and GPIOx_AFRL).

HAL - C

```

/* USER CODE BEGIN PV */
#define BUFSIZE 256
char SendBuffer[BUFSIZE];
int Counter;
int KeyState=0;

/* USER CODE END PV */

HAL_GPIO_WritePin(GPIOI, GPIO_PIN_13,1);

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
    HAL_GPIO_TogglePin(GPIOI, GPIO_PIN_13);

    KeyState = HAL_GPIO_ReadPin(GPIOC, GPIO_PIN_13);
    HAL_GPIO_WritePin(GPIOJ, GPIO_PIN_2, KeyState);

    sprintf(SendBuffer,BUFSIZE,"Hello World [%d]: Key:%d\r\n",Counter++,KeyState);
    HAL_UART_Transmit(&huart3,SendBuffer,strlen(SendBuffer),1);

    HAL_Delay(1000);
    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
}
/* USER CODE END 3 */

```

UM2217

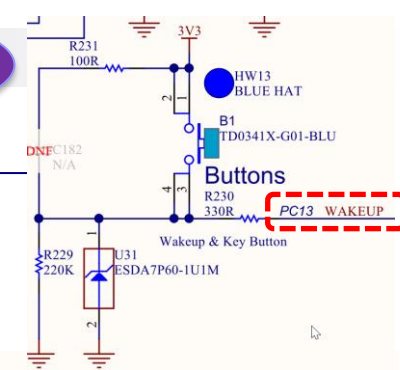
User manual

Description of STM32H7 HAL and low-layer drivers

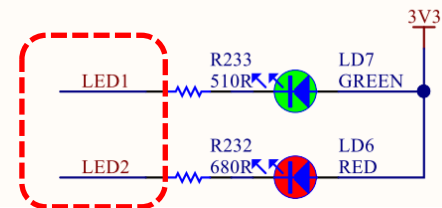
35.2.4 IO operation functions

This section contains the following APIs:

- HAL_GPIO_ReadPin()
- HAL_GPIO_WritePin()
- HAL_GPIO_TogglePin()
- HAL_GPIO_LockPin()
- HAL_GPIO_EXTI_IRQHandler()
- HAL_GPIO_EXTI_Callback()



LEDs



P111	H1	LCD HSYNC
P112	H2	LED2
P113	H3	LCD CLK
P114	P5	LCD R0
P115		

P30	P6	LCD R2
PJ1	T6	LED1
PJ2	T16	LCD R4

STM32F4 – PWM signali za LED diode (LED dimmer)

HAL - C

CubeMX :

1. New project -> STM32 Project -> Board -> 407DISC1
2. CubeMX: Spremeniti USB Host v USB Device :
Connectivity -> USB_OTG_FS -> Mode v Device Only
Middleware -> DEVICE_USB in Class Virtual Com Port
3. Spremeniti pine **PD12-PD15 (LED diode)** v **TIM4_CH1-4**
tim4 Vse kanale spremeniti na **PWM Generation CH1-4**

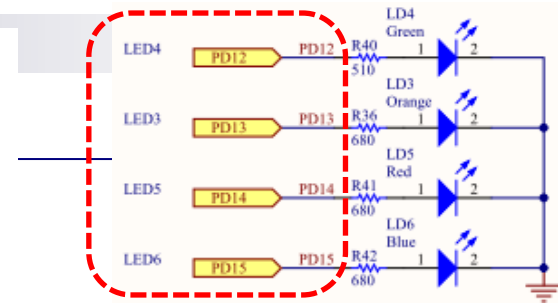
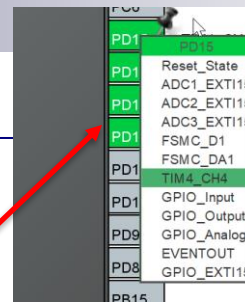
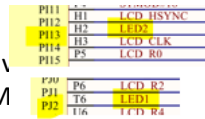
4. Clock :

Ura števca = 1 MHz

Prescaler (PSC - 16 bits value) Prescaler (PSC - 16 bits v must be between 0 and 65 535 = $84-1 = 83$ (clock 1M

Perioda štetja je 100 (duty cycle pa lahko 0-100)

Counter Period (AutoReload Register - 16 bits value) Counter Period (AutoReload Register - 16 bits value) = $100-1 = 99$




HAL - C

```

/* USER CODE BEGIN PV */
#define BUFSIZE 256
char SendBuffer[BUFSIZE];

/* USER CODE END PV */
/* USER CODE BEGIN 2 */

HAL_TIM_PWM_Start(&htim4, TIM_CHANNEL_1);
HAL_TIM_PWM_Start(&htim4, TIM_CHANNEL_2);
HAL_TIM_PWM_Start(&htim4, TIM_CHANNEL_3);
HAL_TIM_PWM_Start(&htim4, TIM_CHANNEL_4);

/* USER CODE END 2 */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
    htim4.Instance->CCR1 = duty;
    htim4.Instance->CCR2 = 100-duty;
    htim4.Instance->CCR3 = duty;
    htim4.Instance->CCR4 = 100-duty;

    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
    snprintf (SendBuffer, BUFSIZE, "USB:0.1 secs. Duty=%d%\r\n", duty);
    CDC_Transmit_FS(SendBuffer, strlen(SendBuffer));

    duty = (duty + 1) ;
    if (duty > 100 )
        duty = 0;

    HAL_Delay(100);
}
/* USER CODE END 3 */

```

CubeMX - dodatne spremembe osnovnega projekta :

1. New project -> STM32 Project -> Board -> 407DISC1
2. CubeMX: Spremeniti USB Host v USB Device :
Connectivity -> USB_OTG_FS -> Mode v Device Only
Middleware -> DEVICE_USB in Class Virtual Com Port
3. Spremeniti pine PD12-PD15 (LED diode) v TIM4_CH0-3
tim4 Vse kanale spreminiti na PWM Generation CH0-3
4. Clock :
Ura števca = 1 MHz
Prescaler (PSC - 16 bits value) Prescaler (PSC - 16 bits value) must
be between 0 and 65 535 = 84-1 = 83 (clock 1Mhz)
Perioda štetja je 100 (duty cycle pa lahko 0-100)
Counter Period (AutoReload Register - 16 bits value) Counter
Period (AutoReload Register - 16 bits value) = 100-1 = 99

https://github.com/LAPSYLAB/STM32F4_Discovery_VIN_Projects/tree/main/LED_PWM_Demo