

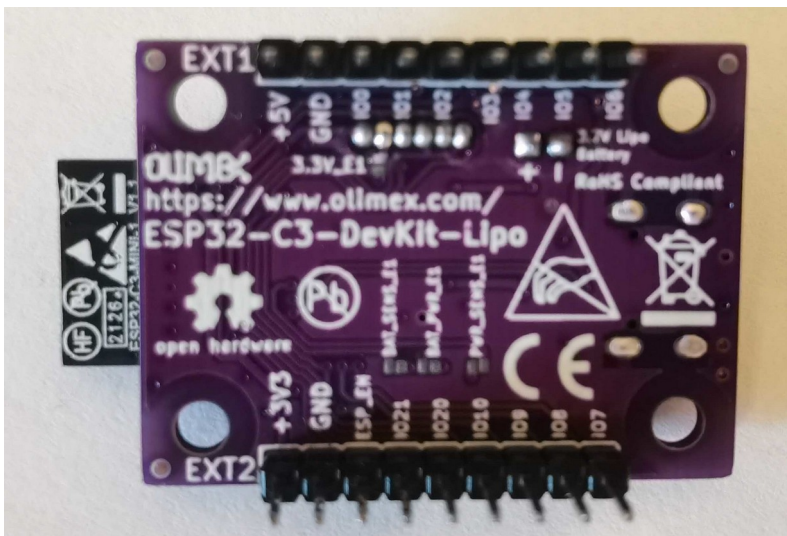
RISC-V v0.3

Въведение в програмирането на RISC-V

Techniverse, София
Октомври, 2022



* със съдействието на olimex.com



OLIMEX

Цял ден работилници и музика на открито.

TECHNIVERSE

Маймунарица, парк Борисова Градина, София, България
Начален час 10:00. Вход Свободен.

02
ОКТ
2022

С поглед към
технологии за
мобилност от

DIGITAL
LIGHTS

информационни технологии и приложения
3D, AI, графика
Софтуер
Инженерна среда - IoT, сензори, хардуер и software
Творчество и изкуство

спомогнато от:

4 0 4 1 X

План на работилницата

- За RISC-V накратко
- RISC-V ISA – основи
- ESP32-C3 модул
- Настройка на среда/IDE, необходими инструменти
- Първи стъпки – “Hello, world”
- blinky – дебъгване през JTAG, openocd, gdb
- RISC-V assembly
- Примерна задача - работа с Bluetooth библиотеката/модула

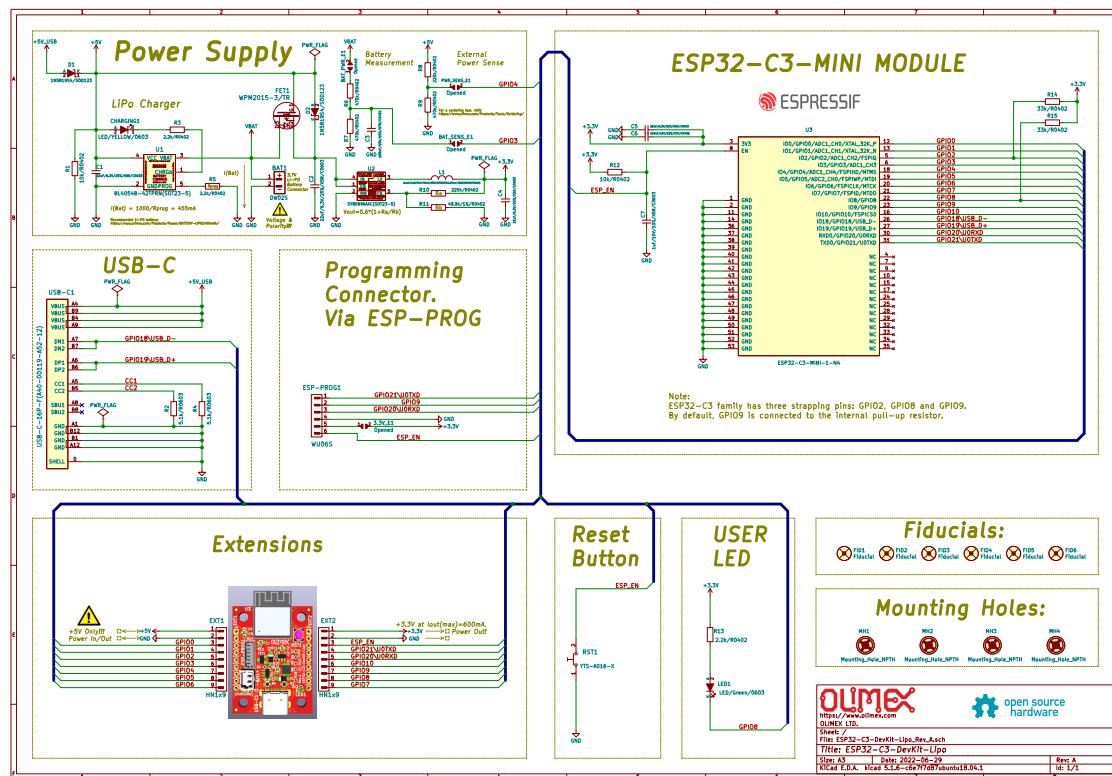


RISC-V & RISC-V ISA

- Open source процесорен дизайн, базиран на RISC архитектура; алтернатива на Intel и ARM
- **RISC-V ISA** – основи, privilege levels – machine, supervisor, user, hypervisor (TBD), harts (cores)- id 0
- Регистри с общо предназначение – x0-x31, load-store архитектура, CSR инструкции
- Работа с цели числа - ALU – branches, jumps, load, stores
- Незадължителни/стандартни разширения – умножение/деление на цели числа, атомични инструкции, числа с плаваща запетая (single-/double-precision)
- Допълнителни разширения – compressed instructions, etc



ESP32-C3-Devkit-Lipo



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ESP32-C3-Devkit-Lipo

- Спецификации/Datasheet
- RISC-V single-core, до 160 MHz, RV32IMC ISA
- JTAG интерфейс за дебъгване
- 400 KB onchip SRAM
- Embedded flash - външен, чрез SPI интерфейс
- RNG, secure boot, крипто-хардуерни акселератори – AEC128/256, HMAC



Документация, настройка на среда/IDE

- Arduino **IDE**
- <https://github.com/espressif/arduino-esp32>
- Espressif IoT Development Framework - manual installation
- <https://github.com/espressif/esp-idf>
- JTAG debugging -
<https://docs.espressif.com/projects/esp-idf/en/latest/esp32c3/api-guides/jtag-debugging/index.html>
- Терминален емулятор – cu, minicom, Teraterm, Putty, ...



“Hello, world”

```
$ git clone git@github.com:espressif/esp-idf.git ~/esp/  
$ cd ~/esp/esp-idf  
$ ./install.sh esp32  
$ . $HOME/esp/esp-idf/export.sh  
$ cd $IDF_PATH/examples/get-started/hello_world  
$ idf.py set-target esp32c3  
$ idf.py menuconfig  
$ idf.py build  
$ esptool.py -p /dev/cuaU0 -b 460800 --before default_reset --after hard_reset --chip esp32c3  
$ write_flash --flash_mode dio --flash_size detect --flash_freq 80m 0x0  
build/bootloader/bootloader.bin 0x8000 build/partition_table/partition-table.bin 0x10000  
build/hello-world.bin
```



“Hello, world”

```
load:0x403ce000,len:0x8d4
load:0x403d0000,len:0x2d80
SHA-256 comparison failed:
Calculated: 139dfa699dc2f77262dbfef250ba481488507ff091ed7824dfc7cd2c4b6de5ec
Expected: 1a2ab6dad58992d862ebd46b49d917f5a411b8d48eb27b46d2aff5f0d69e47c6
Attempting to boot anyway...
entry 0x403ce000
I (42) boot: ESP-IDF v4.3.4-dirty 2nd stage bootloader
I (42) boot: compile time 14:41:42
I (42) boot: chip revision: 3
I (44) boot.esp32c3: SPI Speed      : 80MHz
I (49) boot.esp32c3: SPI Mode      : DIO
I (54) boot.esp32c3: SPI Flash Size : 4MB
I (59) boot: Enabling RNG early entropy source...
I (64) boot: Partition Table:
I (68) boot: ## Label            Usage            Type ST Offset   Length
I (75) boot:  0 nvs              WiFi data        01 02 00009000 00006000
I (82) boot:  1 phy init         RF data          01 01 0000f000 00001000
I (90) boot:  2 factory          factory app      00 00 00010000 00100000
I (97) boot: End of partition table
I (101) esp_image: segment 0: paddr=00010020 vaddr=3c020020 size=06448h ( 25672) map
I (114) esp_image: segment 1: paddr=00016470 vaddr=3fc8a000 size=01b20h (  6944) load
I (120) esp_image: segment 2: paddr=00017f98 vaddr=40380000 size=08080h ( 32896) load
I (133) esp_image: segment 3: paddr=00020020 vaddr=42000020 size=11930h ( 71984) map
I (147) esp_image: segment 4: paddr=00031958 vaddr=40380080 size=01f3ch ( 7996) load
I (149) esp_image: segment 5: paddr=0003389c vaddr=50000010 size=00010h (   16) load
I (156) boot: Loaded app from partition at offset 0x10000
I (159) boot: Disabling RNG early entropy source...
I (175) cpu_start: Pro cpu up.
I (184) cpu_start: Pro cpu start user code
I (184) cpu_start: cpu freq: 160000000
I (184) cpu_start: Application information:
I (187) cpu_start: Project name:      hello-world
I (192) cpu_start: App version:      v4.3.4-dirty
I (197) cpu_start: Compile time:      Oct  1 2022 14:41:54
I (203) cpu_start: ELF file SHA256:  7a48abd4ee7fc09d...
I (209) cpu_start: ESP-IDF:          v4.3.4-dirty
I (215) heap_init: Initializing. RAM available for dynamic allocation:
I (222) heap_init: At 3FC8C990 len 00033670 (205 KiB): DRAM
I (228) heap_init: At 3FCC0000 len 0001F060 (124 KiB): STACK/DRAM
I (235) heap_init: At 50000020 len 00001FE0 (7 KiB): RTCRAM
I (242) spi_flash: detected chip: generic
I (246) spi_flash: flash io: dio
I (250) sleep: Configure to isolate all GPIO pins in sleep state
I (257) sleep: Enable automatic switching of GPIO sleep configuration
I (264) cpu_start: Starting scheduler.
Hello world!
This is esp32c3 chip with 1 CPU core(s), WiFi/BLE, silicon revision 3, 4MB external flash
Minimum free heap size: 326848 bytes
Restarting in 10 seconds...
```

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Творчество и изкуство - музика, танци и театрални системи, ког

спомогнато от:



blinky

```
$ cd ../blink
$ idf.py set-target esp32c3
$ idf.py build
$ idf.py flash -p PORT [-b BAUD]
$ idf.py monitor

...
$ idf.py menuconfig — proper GPIO
$ idf.py build
```

```
bash-4.2$ sudo /home/syrinx/.espressif/python_env/idf4.3_py3.9_env/bin/python ../../components/esptool_py/esptool/esptool.py -p /dev/ttyU0 -b 460800 --ba
write_flash --flash_mode dio --flash_size detect --flash_freq 80m 0x0 build/bootloader/bootloader.bin 0x8000 build/partition_table/partition-table.bin 0x100
esptool.py v3.3.2-dev
Serial port /dev/ttyU0
Connecting...
Failed to get PID of a device on /dev/ttyU0, using standard reset sequence.
.....
A fatal error occurred: Failed to connect to ESP32-C3: Wrong boot mode detected (0xd)! The chip needs to be in download mode.
For troubleshooting steps visit: https://docs.espressif.com/projects/esptool/en/latest/troubleshooting.html
bash-4.2$
bash-4.2$ sudo /home/syrinx/.espressif/python_env/idf4.3_py3.9_env/bin/python ../../components/esptool_py/esptool/esptool.py -p /dev/ttyU0 -b 460800 --ba
write_flash --flash_mode dio --flash_size detect --flash_freq 80m 0x0 build/bootloader/bootloader.bin 0x8000 build/partition_table/partition-table.bin 0x100
esptool.py v3.3.2-dev
Serial port /dev/ttyU0
Connecting...
Failed to get PID of a device on /dev/ttyU0, using standard reset sequence.
..
Chip is ESP32-C3 (revision 3)
Features: Wi-Fi
Crystal is 40MHz
MAC: a0:76:4e:43:60:dc
Uploading stub...
Running stub...
Stub running...
Changing baud rate to 460800
Changed.
Configuring flash size...
Auto-detected Flash size: 4MB
Flash will be erased from 0x00000000 to 0x00004fff...
Flash will be erased from 0x00008000 to 0x00008fff...
Flash will be erased from 0x00010000 to 0x00034fff...
Flash params set to 0x022f
Compressed 20320 bytes to 12156...
Wrote 20320 bytes (12156 compressed) at 0x00000000 in 0.4 second.
Hash of data verified.
Compressed 3072 bytes to 103...
Wrote 3072 bytes (103 compressed) at 0x00008000 in 0.1 seconds (1
Hash of data verified.
Compressed 148928 bytes to 79337...
Wrote 148928 bytes (79337 compressed) at 0x00010000 in 2.1 second.
Hash of data verified.
Leaving...
Hard resetting via RTS pin...
```

Welcome to minicom 2.8

OPTIONS: I18n

Compiled on Aug 13 2022, 13:02:23.

Port /dev/cuaU0, 19:40:02

Press CTRL-A Z for help on special keys

20 size=06618h (26136) map

Turning off the LED

Turning on the LED

Turning off the LED

Turning on the LED

Turning off the LED

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Turning off the LED

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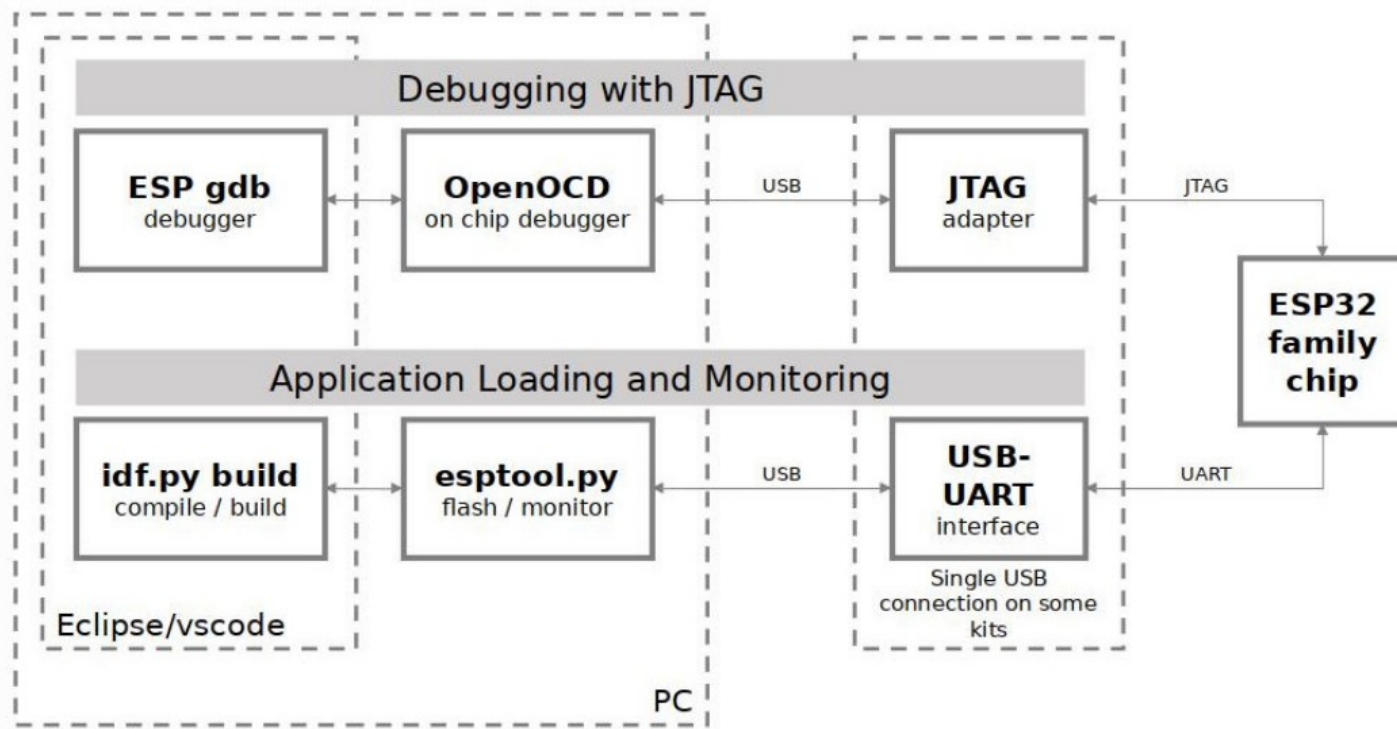


blinky – read the docs

idf.py menuconfig → GPIO 8



blinky – JTAG debugging



JTAG debugging - overview diagram

blinky

```
bash-4.2$ cd $HOME/Arduino/hardware/espressif/esp32/tools/riscv32-esp-elf/bin/  
bash-4.2$ ./riscv32-esp-elf-gdb
```

Debugging demo - openocd
настройки, работа с gdb – принт
на някои регистри, модификация
на приложението да принти
mstatus, mtvec, mepc, mcause,
mhartid, etc, machine timers

```
bash-4.2$  
bash-4.2$  
bash-4.2$ cd $HOME/.espressif/tools/openocd-esp32/v0.11.0-esp32-20220706/openocd-esp32/share/openocd/scripts  
bash-4.2$ sudo ../../bin/openocd -f board/esp32c3-builtin.cfg  
Open On-Chip Debugger v0.11.0-esp32-20220706 (2022-07-06 15:48)  
Licensed under GNU GPL v2  
For bug reports, read  
    http://openocd.org/doc/doxygen/bugs.html  
Warn : Could not determine executable path, using configured BINDIR.  
Info : only one transport option; autoselect 'jtag'  
Info : esp_usb_jtag: VID set to 0x303a and PID to 0x1001  
Info : esp_usb_jtag: capabilities descriptor set to 0x2000  
Warn : Transport 'jtag' was already selected  
Info : Listening on port 6666 for tcl connections  
Info : Listening on port 4444 for telnet connections  
Info : esp_usb_jtag: serial (40:76:de:43:60:dc)  
Info : esp_usb_jtag: Device found. Base speed 40000KHz, div range 1 to 255  
Info : clock speed 40000 KHz  
Info : JTAG tap: esp32c3.cpu tap/device found: 0x00005c25 (mfg: 0x612 (Espressif Systems), part: 0x0005, ver: 0x0)  
Info : datacount=2 progbufsize=16  
Info : Examined RISC-V core; found 1 harts  
Info : hart 0: XLEN=32, misa=0x40101104  
Info : starting gdb server for esp32c3 on 3333  
Info : Listening on port 3333 for gdb connections  
Info : accepting 'gdb' connection on tcp/3333  
Memory protection is enabled. Reset target to disable it...  
Info : JTAG tap: esp32c3.cpu tap/device found: 0x00005c25 (mfg: 0x612 (Espressif Systems), part: 0x0005, ver: 0x0)  
Info : Reset cause (3) - (Software core reset)  
Warn : No symbols for FreeRTOS!  
Info : [esp32c3] Found 8 triggers  
Info : Flash mapping 0: 0x10020 -> 0x3c020020, 25 KB  
Info : Flash mapping 1: 0x20020 -> 0x42000020, 73 KB  
Info : Auto-detected flash bank 'esp32c3.flash' size 4096 KB  
Info : Using flash bank 'esp32c3.flash' size 4096 KB  
Info : Flash mapping 0: 0x10020 -> 0x3c020020, 25 KB  
Info : Flash mapping 1: 0x20020 -> 0x42000020, 73 KB  
Info : Using flash bank 'esp32c3.iron' size 76 KB  
Info : Flash mapping 0: 0x10020 -> 0x3c020020, 25 KB  
Info : Flash mapping 1: 0x20020 -> 0x42000020, 73 KB  
Info : Using flash bank 'esp32c3.drom' size 28 KB  
Warn : negative reply, retrying  
Warn : negative reply, retrying  
Warn : Prefer GDB command "target extended-remote :3333" instead of "target remote :3333"
```

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3D print, AI, графика

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6 0 4 1 A

blinky - using C- inline assembly

```
bash-4.2$ git diff
diff --git a/examples/get-started/blink/main/blink.c b/examples/get-started/blink/main/blink.c
index 8d41246e84..6fb3f72ab2 100644
--- a/examples/get-started/blink/main/blink.c
+++ b/examples/get-started/blink/main/blink.c
@@ -28,6 +28,17 @@ void app_main(void)
    gpio_reset_pin(BLINK_GPIO);
    /* Set the GPIO as a push/pull output */
    gpio_set_direction(BLINK_GPIO, GPIO_MODE_OUTPUT);

+   volatile uint32_t ulHartId, uVendorId, uArchId, uImpId = 0;
+   __asm volatile( "csrr %0, mhartid" : "=r"( ulHartId ) );
+   __asm volatile( "csrr %0, mvendorid" : "=r"( uVendorId ) );
+   __asm volatile( "csrr %0, marchid" : "=r"( uArchId ) );
+   __asm volatile( "csrr %0, mimpid" : "=r"( uImpId ) );
+
    printf("[blink] hart id %u, Vendor 0x%x, arch 0x%x, impl id 0x%x\n",
           ulHartId, uVendorId, uArchId, uImpId);

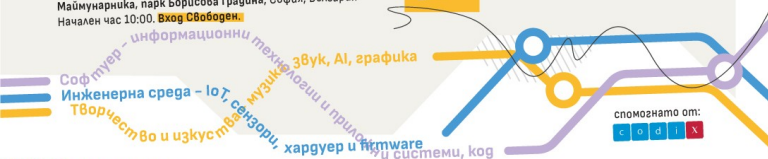
+   while(1) {
+       /* Blink off (output low) */
+       printf("Turning off the LED\n");
@@ -37,5 +48,7 @@ void app_main(void)
    printf("Turning on the LED\n");
    gpio_set_level(BLINK_GPIO, 1);
    vTaskDelay(1000 / portTICK_PERIOD_MS);
    printf("[blink] hart id %u, Vendor 0x%x, arch 0x%x, impl id 0x%x\n",
           ulHartId, uVendorId, uArchId, uImpId);
+   }
```

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example app

Task - Use bluetooth lib to scan for nearby devices, print to console
blink led for 10 secs, if unknown, move to known database

-

<https://docs.espressif.com/projects/esp-idf/en/latest/esp32c3/api-reference/bluetooth/index.html>

- Demo for ESP BLE Mesh Provisioner -

https://github.com/espressif/esp-idf/blob/master/examples/bluetooth/esp_ble_mesh/ble_mesh_provisioner/tutorial/BLE_Mesh_Provisioner_Example_Walkthrough.md



Благодаря!

Вашата обратна връзка е ценна –
shteryana@gmail.com, syrinx@freebsd.org



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