open source watch Documentation

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jj

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CONTENTS

```
this document describes the installation of zephyr RTOS on the PineTime smartwatch.

https://wiki.pine64.org/index.php/PineTime

It should be applicable on other nordic nrf52832 based watches (Desay D6....).
```

```
the approach in this manual is to get quick results :
    - minimal effort install
    - try out the samples
    - inspire you to modify and enhance
```

suggestion :

- install zephyr, https://docs.zephyrproject.org
- copy the board definition
- try some examples
- try out bluetooth
- try out the display

CHAPTER ONE

ABOUT

I got a pinetime development kit very early.

I would like to thank the folks from https://www.pine64.org/.

I like to hack stuff, and I like the idea behind Open Source.

The smartwatches I hacked, contained microcontrollers from Nordic Semiconductor.

A lot of resources exist for this breed.

It is an Arm based, 32bit microcontroller with a lot of flash and RAM memory.

In fact it is a small computer on your wrist, with a battery and screen, and capable of bluetooth 4+ wireless communication.

```
A word of warning: this is work in progress.
You're likely to have a better skillset then me.
You are invited to add the missing pieces and to improve what's already there.
```

1.1 Todo

list with suggestions:

- better graphics
- watchdog
- DFU (update over bluetooth)
- acceleration sensor
- heart rate sensor
- fun stuff
- useless stuff, but somehow cool
- applications, e.g. calculator, cycle computer, step counter, heart attack predictor . . .

1.2 Fast track

In this repository you can find modified directories, which you can copy to the zephyrproject directory:

- pinetime (board definition -> boards/arm)
- st7789v (example -> samples/display)

- blinky (example -> samples/basic)

CHAPTER

TWO

INSTALL ZEPHYR

https://docs.zephyrproject.org/latest/getting_started/index.html

the documentation describes an installation process under Ubuntu/macOS/Windows

I picked Debian (which is not listed) . . . . and soon afterwards ran into trouble

this behaviour is known as : stuborn or stupid, but I remain convinced it could work

But even after following the rules, I got a problem with the `dtc (device tree compiler)`

- I solved this by creating a link from the development-tools to /usr/bin/dtc (here you need to make sure you got a very recent one)

```
cd  /root/zephyr-sdk-0.10.3/sysroots/x86_64-pokysdk-linux/usr/bin/
mv dtc dtc-orig
ln -s /usr/bin/dtc dtc
```

CHAPTER

THREE

ZEPHYR ON THE PINETIME SMARTWATCH

3.1 Blinky example

Note: I think you need to connect the 5V, just connecting the SWD cable (3.3V) is likely not enough to light up the leds

```
The watch does not contain a led as such, but it has background leds for the LCD.

Once lit, you can barely see it, cause the screen is black.
```

```
copy the board definition for the pinetime to the zephyrproject directory
$ cp (this repo)pinetime  ~/zephyrproject/zephyr/boards/arm/pinetime

replace the blinky sample with the one in this repo
$ cp (this repo)blinky  ~/zephyrproject/zephyr/samples/basic
```

have a look at the pinetime.dts file, here you see the definition of the background leds.

```
gpios = <&gpio0 14 GPIO_INT_ACTIVE_LOW>;
gpios = <&gpio0 22 GPIO_INT_ACTIVE_LOW>;
gpios = <&gpio0 23 GPIO_INT_ACTIVE_LOW>;
```

building an image, which can be found under the build directory

```
$ west build -p -b pinetime samples/basic/blinky
```

once the compilation is completed you can upload the firmware ~/zephyrproject/zephyr/build/zephyr/zephyr.bin

CHAPTER

FOUR

BLUETOOTH (BLE) EXAMPLE

4.1 Eddy Stone

Note: compile the provided example, so a build directory gets created

```
$ west build -p -b pinetime samples/bluetooth/eddystone
```

```
this builds an image, which can be found under the build directory
```

I use linux with a bluetoothadapter 4.0. You need bluez.

```
#bluetoothctl
[bluetooth]#scan on
```

And your Eddy Stone should be visible.

If you have a smartphone, you can download the nrf utilities app from nordic.

4.2 Ble Peripheral

this example is a demo of the services under bluetooth

first build the image

```
$  west build -p -b pinetime samples/bluetooth/peripheral -D CONF_FILE="prj.conf"
```

the image, can be found under the build directory, and has to be flashed to the pinetime

with linux you can have a look using bluetoothctl

```
#bluetoothctl
[bluetooth]#scan on


[NEW] Device 60:7C:9E:92:50:C1 Zephyr Peripheral Sample Long
once you see your device
[blueooth]#connect 60:7C:9E:92:50:C1 (the device mac address as displayed)

then you can already see the services
```

same thing with the app from nordic, you could try to connect and display value of e.g. heart rate

4.3 using Python to read out bluetoothservices

In this repo you will find a python script : readbat.py In order to use it you need bluez on linux and the python *bluepy* module.

It can be used in conjunction with the peripheral bluetooth demo. It just reads out the battery level, and prints it.

```
import binascii
from bluepy.btle import UUID, Peripheral

temp_uuid = UUID(0x2A19)

p = Peripheral("60:7C:9E:92:50:C1", "random")

try:
   ch = p.getCharacteristics(uuid=temp_uuid)[0]
   print binascii.b2a_hex(ch.read())
finally:
    p.disconnect()
```

CHAPTER

FIVE

ST7789 DISPLAY

5.1 Display example

Note: I think you need to connect the 5V, just connecting the SWD cable (3.3V) is likely not enough to light up the leds

```
The watch has background leds for the LCD.

They need to be on (LOW) to visualize the display.
```

```
replace the display sample with the one in this repo
$ cp (this repo)st7789  ~/zephyrproject/zephyr/samples/display
```

building an image, which can be found under the build directory the pinetime.overlay contains the definitions for the screen like resolution, and SPI-port data

```
$  west build -p -b pinetime samples/display/st7789v -DDTC_OVERLAY="pinetime.overlay"
```

once the compilation is completed you can upload the firmware ~/zephyrproject/zephyr/build/zephyr/zephyr.bin

if all goes well, you should see some coloured squares on your screen

CHAPTER

SIX

MENUCONFIG

6.1 Zephyr is like linux

Note: to get a feel, compile a program, for example

```
west build -p -b pinetime samples/bluetooth/peripheral -D CONF_FILE="prj.conf"
```

`the pinetime contains an external 32Kz crystal` now you can have a look in the configurationfile (and modify if needed)

```
$ west build -t menuconfig
```

```
    Modules  --->
    Board Selection (nRF52832-MDK)  --->
    Board Options  --->
    SoC/CPU/Configuration Selection (Nordic Semiconductor nRF52 series MCU)  --->
    Hardware Configuration  --->
    ARM Options  --->
    Architecture (ARM architecture)  --->
    General Architecture Options  --->
[ ] Floating point  ----
    General Kernel Options  --->
    Device Drivers  ---> **************SELECT THIS ONE***************************
    C Library  --->
    Additional libraries  --->
[*] Bluetooth  --->
[ ] Console subsystem/support routines [EXPERIMENTAL]  ----
[ ] C++ support for the application  ----
    System Monitoring Options  --->
    Debugging Options  --->
[ ] Disk Interface  ----
    File Systems  --->
-*- Logging  --->
    Management  --->
    Networking  --->
```

```
[ ] IEEE 802.15.4 drivers options  ----
(UART_0) Device Name of UART Device for UART Console
[*] Console drivers  --->
[ ] Net loopback driver  ----
[*] Serial Drivers  --->
    Interrupt Controllers  --->
    Timer Drivers  --->
```

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```
-*- Entropy Drivers  --->
[*] GPIO Drivers  --->
[ ] Shared interrupt driver  ----
[ ] SPI hardware bus support  ----
[ ] I2C Drivers  ----
[ ] I2S bus drivers  ----
[ ] PWM (Pulse Width Modulation) Drivers  ----
[ ] Enable board pinmux driver  ----
[ ] ADC drivers  ----
[ ] Watchdog Support  ----
[*] Hardware clock controller support  ---> <<<<<<<<<<<<<<<<SELECT THIS ONE<<<<<<<<<<
[ ] Precision Time Protocol Clock driver support
[ ] IPM drivers  ----
    Max compiled-in log level for ipm (Info)  --->
[ ] Flash hardware support  ----
[ ] Sensor Drivers  ----
```

```
    Max compiled-in log level for clock control (Info)  --->
[*] NRF Clock controller support  ---> <<<<<<<<<<<<<<<<<<<<SELECT THIS ONE<<<<<<<<<<<
```

CHAPTER

SEVEN

HACKING THE PINETIME SMARTWATCH

```
The pinetime is preloaded with firmware.
This firmware is secured, you cannot peek into it.
```

Note: the pinetime has a swd interface to write firmware you need special hardware I use a stm-link which is very cheap(2$) You can also use the GPIO header of a raspberry pi / or orange pi (see my repo: https://github.com/najnesnaj/openocd)

To flash the software I use openocd : example for stm-link usb-stick

```
# openocd -s /usr/local/share/openocd/scripts -f interface/stlink.cfg -f target/nrf52.
↪cfg
```

example for the orange-pi GPIO header (or raspberry)

> # openocd -f /usr/local/share/openocd/scripts/interface/sysfsgpio-raspberrypi.cfg -c ‘transport select swd’
> -f /usr/local/share/openocd/scripts/target/nrf52.cfg -c ‘bindto 0.0.0.0’

once you started the openocd background server, you can connect to it using:

```
#telnet 127.0.0.1 4444
```

programming

```
once your telnet sessions started:
Trying 127.0.0.1...
Connected to 127.0.0.1.
Escape character is '^]'.
Open On-Chip Debugger
> program zephyr.bin

target halted due to debug-request, current mode: Thread
xPSR: 0x01000000 pc: 0x00001534 msp: 0x20004a10
** Programming Started **
auto erase enabled
using fast async flash loader. This is currently supported
only with ST-Link and CMSIS-DAP. If you have issues, add
"set WORKAREASIZE 0" before sourcing nrf51.cfg/nrf52.cfg to disable it
target halted due to breakpoint, current mode: Thread
xPSR: 0x61000000 pc: 0x2000001e msp: 0x20004a10
wrote 24576 bytes from file zephyr.bin in 1.703540s (14.088 KiB/s)
** Programming Finished **
```

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```
And finally execute a reset :
>reset
```

removing write protection see: *Howto flash your zephyr image*

CHAPTER

EIGHT

HOWTO FLASH YOUR ZEPHYR IMAGE

Once you completed your `west build`, your image is located under the build directory

```
$ cd ~/zephyrproject/zephyr/build/zephyr
here you can find zephyr.bin which you can flash
```

I have an orange pi (single board computer) in my network.

I copy the image using $scp -P 8888 zephyr.bin 192.168.0.77:/usr/src/pinetime (secure copy using my user defined port 8888 which is normally port 22)

Note: the PineTime watch is read/write protected executing the following : nrf52.dap apreg 1 0x0c shows 0x0

Mind you st-link does not allow you to execute that command, you need J-link. There is a workaround using the GPIO of a raspberry pi or a Orangepi. You have to reconfigure Openocd with the –enable-cmsis-dap option.

Unlock the chip by executing the command: > nrf52.dap apreg 1 0x04 0x01

CHAPTER NINE

HOWTO GENERATE PDF DOCUMENTS

sphinx cannot generate pdf directly, and needs latex

```
apt-get install latexmk
apt-get install texlive-fonts-recommended
apt-get install xzdec
apt-get install cmap
apt-get install texlive-latex-recommended
apt-get install texlive-latex-extra
```