open source watch Documentation

Release 1.0.0

jj

Jan 14, 2020

CONTENTS

Note : You may at any time read the book, store it in your ereaders

CHAPTER

ONE

AUTHOR:

Jan Jansen najnesnaj@yahoo.com

CHAPTER

TWO

LICENSE:

All the software is subject to the Apache 2.0 license (same as zephyr), which is very liberal.

CHAPTER

THREE

ZEPHYR FOR THE PINTIME SMARTWATCH

```
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

FOUR

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
```

Note : in order to get the display st7789 Picture-Perfect, you might need a zephyr patch

have a look at : https://github.com/zephyrproject-rtos/zephyr/pull/20570/files You will find them in this repo under patches-zephyr.

CHAPTER

FIVE

ZEPHYR ON THE PINETIME SMARTWATCH

5.1 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

SIX

READING OUT THE BUTTON ON THE WATCH

```
The pinetime does have a button.
I do not have a segger debugging probe.
A way around this, it to put a value in memory at a fixed location.
With openocd you can peek at this memory location.
```

6.1 Building and Running

In this repo under samples you will find an adapted basic/button program. (copy this to the samples/basic directory)

```
west build -p -b pinetime samples/basic/button
```

Note: #define MY_REGISTER (*(volatile uint8_t*)0x2000F000)

in the program you can set values: MY_REGISTER=(read button value);

this way you know till whether the code executes

---

a way to set port 15 high (hard-coded of course :))

```
gpio_pin_configure(gpiob, 15,GPIO_DIR_OUT); //push button out
gpio_pin_write(gpiob, 15, &button_out); //set port high
```

```
#telnet 127.0.0.1 4444
```

Peeking

```
once your telnet sessions started:
Trying 127.0.0.1...
Connected to 127.0.0.1.
Escape character is '^]'.
Open On-Chip Debugger
>mdw 0x2000F000 0x1
0x2000f000: 00000100 (switch pushed)
```

Note::

The watch has a button out port (15) and buttin in port (13). You have to set the out-port high. Took me a while to figure this out...

CHAPTER

SEVEN

BLUETOOTH (BLE) EXAMPLE

7.1 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.

7.2 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

7.3 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

EIGHT

ST7789 DISPLAY

8.1 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 While connecting 5V, do not connect 3.3V

```
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

```
$  west build -p -b pinetime samples/display/st7789v
```

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

NINE

GFX LIBRARY SAMPLE

9.1 Overview

This sample is built on top of the ST7789 display sample (*st7789 display*), extending it with the Adafruit GFX Library. The library was ported from Arduino and has the same functionality and API. See `src/main.cpp` for examples on the GFX API usage.

See *st7789 display* for more details on working with the display itself.

9.2 Usage

Add the gfx sample from this repo into your project:

```
$ cp samples/gui/gfx ~/zephyrproject/zephyr/samples/gui/
```

Note: In order to make the library work the sample is built with C++ support. This is achieved by having the following line in the sample's *prj.conf* configuration:

```
CONFIG_CPLUSPLUS=y
```

Build & flash the sample:

```
$  west build -p -b pinetime samples/gui/gfx
$  west flash
```

If all goes well, you should see a looping graphical test: drawing lines, rectangles, triangles etc.

CHAPTER

TEN

LITTLEVGL BASIC SAMPLE

10.1 Overview

This sample application displays “Hello World” in the center of the screen and a counter at the bottom which increments every second.

LittlevGL is a free and open-source graphics library providing everything you need to create embedded GUI with easy-to-use graphical elements, beautiful visual effects and low memory footprint.

10.2 Requirements

definitions can be found under the boards sub-directory

- pinetime.conf
- pinetime.overlay

The program has been modified to light up the background leds. Might be unnecessary... can be found in this repo

```
Matching labels are necessary!
pinetime.conf:CONFIG_LVGL_DISPLAY_DEV_NAME="DISPLAY"
pinetime.overlay:               label = "DISPLAY"; (spi definition)
```

10.3 Building and Running

Make sure you copied the board definitions.

```
west build -p -b pinetime samples/gui/lvgl
```

modifying the font size :

west build -t menuconfig goto additional libraries / lvgl gui library (look for fonts, and adapt according to your need)

west build

10.4 Todo

- Create a button
- touchscreen activation (problem cause zephyr does not support this yet)

- lvgl supports lv_canvas_rotate(canvas, &imd_dsc, angle, x, y, pivot_x, pivot_y) should be cool for a clock, chrono…

10.5 References

https://docs.littlevgl.com/en/html/index.html

LittlevGL Web Page: https://littlevgl.com/

CHAPTER

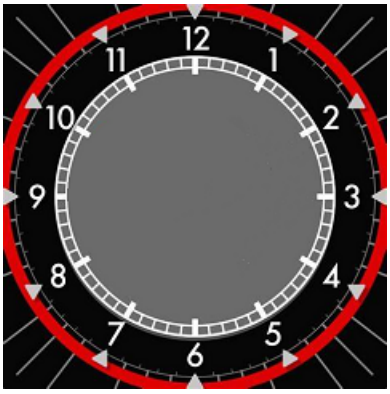
ELEVEN

LITTLEVGL CLOCK SAMPLE

11.1 Overview

This sample application displays a “clockbackground” in the center of the screen.

LittlevGL is a free and open-source graphics library providing everything you need to create embedded GUI with easy-to-use graphical elements, beautiful visual effects and low memory footprint.



11.2 Requirements

Make sure the prj.conf contains the following :

```
CONFIG_LVGL=y
CONFIG_LVGL_OBJ_IMAGE=y
```

LitlevGL uses a “c” file to store the image. You need to convert a jpg, or png image to this c file. There is an online tool : https://littlevgl.com/image-to-c-array

11.3 Building and Running

copy the samples/gui/clock from this repository to the zephyr one.

```
west build -p -b pinetime samples/gui/clock
```

11.4 Todo

- create an internal clock (and adjustment mechanism, eg. bluetooth cts)
- lvgl supports lv_canvas_rotate(canvas, &imd_dsc, angle, x, y, pivot_x, pivot_y) should be cool for a clock, chrono...

11.5 References

https://docs.littlevgl.com/en/html/index.html

LittlevGL Web Page: https://littlevgl.com/

CHAPTER

TWELVE

PLACING A BUTTON ON THE SCREEN

12.1 Building and Running

In this repo under samples you will find an adapted gui/clock program. A button from the LVGL library is placed on the screen.

Later on when the touch-screen driver is ready, we'll be able to manipulate it.

```
Make sure that prj.conf file in clock directory contains the following:
```

Note: CONFIG_LVGL_OBJ_CONTAINER=y CONFIG_LVGL_OBJ_BUTTON=y

```

```

problem the canvas heigh*width eats up RAM and exceeds once > 40

CHAPTER

THIRTEEN

REAL TIME CLOCK

13.1 Overview

This sample application “clock” uses the RTC0 timer. It uses the counter driver.

13.2 Requirements

Make sure the prj.conf contains the following :

```
CONFIG_COUNTER=y
```

You need the Kconfig file, which contains :

```
config COUNTER_RTC0
        bool
        default y if SOC_FAMILY_NRF
```

13.3 Building and Running

copy the samples/gui/clock from this repository to the zephyr one.

```
west build -p -b pinetime samples/gui/clock
```

13.4 Todo

- time of day clock
- setting the time

13.5 References

CHAPTER

FOURTEEN

SERIAL NOR FLASH

```
west build -p -b pinetime samples/drivers/spi_flash -DCONF=prj.conf
```

14.1 Overview

This sample application should unlock the serial nor flash memory. This can be very usefull to store e.g. background for the watch.

compilation problematic ....

/root/zephyrproject/zephyr/samples/drivers/spi_flash/src/main.c:17:22: error: 'DT_INST_0_JEDEC_SPI_NOR_LABEL' undeclared (first use in this function); did you mean 'DT_INST_0_NORDIC_NRF_RTC_LABEL'?

Turns out this is some problem with the board definition file.

I found it to be very useful to consult the generated dts file. Here you can check if everything is present.

Guess the dts-file has to be well intended.(structured)

```
vi /root/zephyrproject/zephyr/build/zephyr/include/generated/generated_dts_board.conf
```

14.2 Requirements

complement the pinetime.dts file with the following (under spi) #define JEDEC_ID_MACRONIX_MX25L64 0xC22017

```
&spi0 {
  compatible = "nordic,nrf-spi";
  status = "okay";
  sck-pin = <2>;
  mosi-pin = <3>;
  miso-pin = <4>;
  cs-gpios = <&gpio0 27 0>,<&gpio0 5 0>;
  st7789v@0 {
          compatible = "sitronix,st7789v";
          label = "DISPLAY";
          spi-max-frequency = <8000000>;
          reg = <0>;
          cmd-data-gpios = <&gpio0 18 0>;
          reset-gpios = <&gpio0 26 0>;
          width = <240>;
```

(continues on next page)

(continued from previous page)

```
          height = <240>;
          x-offset = <0>;
          y-offset = <0>;
          vcom = <0x19>;
          gctrl = <0x35>;
          vrhs = <0x12>;
          vdvs = <0x20>;
          mdac = <0x00>;
          gamma = <0x01>;
          colmod = <0x05>;
          lcm = <0x2c>;
          porch-param = [0c 0c 00 33 33];
          cmd2en-param = [5a 69 02 01];
          pwctrl1-param = [a4 a1];
          pvgam-param = [D0 04 0D 11 13 2B 3F 54 4C 18 0D 0B 1F 23];
          nvgam-param = [D0 04 0C 11 13 2C 3F 44 51 2F 1F 1F 20 23];
          ram-param = [00 F0];
          rgb-param = [CD 08 14];

  };

  mx25r64: mx25r6435f@1 {
          compatible = "jedec,spi-nor";
          reg = <1>;
          spi-max-frequency = <1000000>;
          label = "MX25R64";
          jedec-id = [0b 40 16];
          size = <67108864>;
          has-be32k;
  };
```

14.3 Building and Running

```
west build -p -b pinetime samples/drivers/spi_flash
```

14.4 Todo

- detect ID memory : it is not the macronix one as suggestion on the pinetime website

I found the following : jedec-id = [0b 40 16]; (OK: can execute sample program)

- create working board definition (OK: see above)

14.5 References

http://files.pine64.org/doc/datasheet/pinetime/MX25L6433F,%203V,%2064Mb,%20v1.6.pdf

CHAPTER

FIFTEEN

SENSORS ON THE I2C BUS

0x18: Accelerometer: BMA423-DS000 https://github.com/BoschSensortec/BMA423-Sensor-API

0x44: Heart Rate Sensor: HRS3300_Heart

0x15: Touch Controller: Hynitron CST816S Touch Controller

CHAPTER

SIXTEEN

CONFIGURING I2C

16.1 board level definitions

```
under boards/arm/pinetime are the board definitions
- pinetime.dts
- pinetime_defconfig


The sensors in the pintime use the I2C bus.

&i2c1 {
        compatible = "nordic,nrf-twi";
        status = "okay";
        sda-pin = <6>;
        scl-pin = <7>;

      };
```

16.2 development trajectory

The final goal is to use the accel-sensor in the watch (BMA423), which does not exist yet. In order to minimize the effort:

- we'll use something that looks like it (ADXL372), because there exists an example.
- next we adapt it to use the existing BMA280 sensor (under drivers/sensor)
- finally we create a driver for the BMA423, based upon the BMA280

16.3 defining an I2C sensor

```
under samples/sensor/axl372 we create : "pinetime.overlay"
&i2c1 {
    status = "okay";
    clock-frequency = <I2C_BITRATE_STANDARD>;
    adxl372@18 {
                compatible = "adi,adxl372";
                reg = <0x18>;
                label = "ADXL372";
```

(continues on next page)

(continued from previous page)

```
                int1-gpios = <&gpio0 8 0>;
                };
    };
```

note: this gets somehow merged with the board definition pinetime.dts

```
In the "prj.conf" file we define the sensor

CONFIG_STDOUT_CONSOLE=y
CONFIG_LOG=y
CONFIG_I2C=y
CONFIG_SENSOR=y
CONFIG_ADXL372=y
CONFIG_ADXL372_I2C=y
CONFIG_SENSOR_LOG_LEVEL_WRN=y
```

note: this gets somehow merged with the board definition pinetime_defconfig

16.4 compiling the sample

```
west build -p -b pinetime samples/sensor/adxl372 -DCONF=prj.conf
```

CHAPTER

SEVENTEEN

DRIVERS

CHAPTER

EIGHTEEN

SAMPLES AND DEMOS

18.1 Basic Samples

18.1.1 Blinky Application

Overview

The Blinky example shows how to configure GPIO pins as outputs which can also be used to drive LEDs on the hardware usually delivered as "User LEDs" on many of the supported boards in Zephyr.

Requirements

The demo assumes that an LED is connected to one of GPIO lines. The sample code is configured to work on boards that have defined the led0 alias in their board devicetree description file. Doing so will generate these variables:

- DT_ALIAS_LED0_GPIOS_CONTROLLER
- DT_ALIAS_LED0_GPIOS_PIN

Building and Running

This samples does not output anything to the console. It can be built and flashed to a board as follows:

After flashing the image to the board, the user LED on the board should start to blink.

18.1.2 Button demo

Overview

A simple button demo showcasing the use of GPIO input with interrupts.

Requirements

The demo assumes that a push button is connected to one of GPIO lines. The sample code is configured to work on boards with user defined buttons and that have defined the SW0_* variables.

To use this sample, you will require a board that defines the user switch in its header file. The `board.h` must define the following variables:

- SW0_GPIO_NAME (or DT_ALIAS_SW0_GPIOS_CONTROLLER)

- DT_ALIAS_SW0_GPIOS_PIN

Alternatively, this could also be done by defining 'sw0' alias in the board devicetree description file.

Building and Running

This sample can be built for multiple boards, in this example we will build it for the nucleo_f103rb board:

After startup, the program looks up a predefined GPIO device, and configures the pin in input mode, enabling interrupt generation on falling edge. During each iteration of the main loop, the state of GPIO line is monitored and printed to the serial console. When the input button gets pressed, the interrupt handler will print an information about this event along with its timestamp.

18.1.3 Touchscreen IRQ

Overview

The touchscreen generates an interrupt when touched.

Requirements

A counter that keeps track of the number of times touched.

This value is stored at a fixed location in memory, because I have a simple test setup.

Building and Running

18.1.4 Touchpoints

Overview

When touched the touchscreen triggers an interrupt, it's address 0x15 becomes visable.

Requirements

Cach the interrupts and act upon it.

Only the first touchpoint is usable.

But a sequence of 64 has to be read.

Building and Running

the purpose is just testing howto read the touchpoints of the touchscreen

18.2 Sensor Samples

18.2.1 BMA280: Three Axis High-g I2C/SPI Accelerometer

Description

This sample application produces slightly different outputs based on the chosen driver configuration mode:

- In **Measuring Mode with trigger support**, the acceleration on all three axis is printed in m/s^2 at the sampling rate (ODR).
- In **Polled Measuring Mode**, the instantaneous acceleration is polled every 2 seconds.
- In **Max Peak Detect Mode**, the device returns only the over-threshold peak acceleration between two consecutive sample fetches or trigger events. (In most high-g applications, a single 3-axis acceleration sample at the peak of an impact event contains sufficient information about the event, and the full acceleration history is not required.) Instead of printing the acceleration on all three axis, the sample application calculates the vector magnitude (root sum squared) and displays the result in g's rather than in m/s^2, together with an bar graph.

References

- BMA280: http://www.analog.com/bma280

Wiring

This sample uses the BMA280 sensor controlled either using the I2C or SPI interface. Connect supply **VDD**, **VS** and **GND**. The supply voltage can be in the 1.6V to 3.5V range.

I2C mode

Connect Interface: **SDA**, **SCL** and optionally connect the **INT1** to a interrupt capable GPIO. It is a requirement that **SCLK** must be connected to **GND** in I2C mode. Depending on the baseboard used, the **SDA** and **SCL** lines require Pull-Up resistors. With the **MISO** pin low, the I2C address for the device is 0x1D, and an alternate I2C address of 0x53 can be chosen by pulling the **MISO** pin high.

I2C Address:

- **0x1D**: if MISO is pulled low
- **0x53**: if MISO is pulled high

Note: When sharing an SDA bus, the BMA280 Silicon Revision < 3 may prevent communication with other devices on that bus.

SPI mode

Connect Interface: **SCLK**, **MISO**, **MOSI** and **/CS** and optionally connect the **INT1** to a interrupt capable GPIO.

Building and Running

This project outputs sensor data to the console. It requires an BMA280 sensor. It should work with any platform featuring a I2C/SPI peripheral interface. It does not work on QEMU. In this example below the nrf52_pca10040 board is used.

Sample Output: Max Peak Detect Mode

```
Waiting for a threshold event
 23.94 g: ########################
Waiting for a threshold event
 38.01 g: ######################################
Waiting for a threshold event
 51.40 g: ###################################################
Waiting for a threshold event
 63.63 g: ################################################################
```

Sample Output: Measurement Mode

```
AX=      2.94 AY=     -5.88 AZ=      0.98 (m/s^2)
AX=     -4.90 AY=      6.86 AZ=     -1.96 (m/s^2)
AX=      2.94 AY=     -2.94 AZ=      8.83 (m/s^2)
AX=     -0.98 AY=     -6.86 AZ=     -0.98 (m/s^2)
AX=      6.86 AY=      2.94 AZ=      3.92 (m/s^2)
AX=     -0.98 AY=      4.90 AZ=     -3.92 (m/s^2)

<repeats endlessly>
```

18.2.2 CST816S HYNITRON TOUCHSCREEN

Description

References

Wiring

I2C mode

Building and Running

Sample Output: X & Y coordinates

Sample Output: Measurement Mode

```

```

18.2.3 MAX30101 Heart Rate Sensor

Overview

A sensor application that demonstrates how to poll data from the max30101 heart rate sensor.

Building and Running

This project configures the max30101 sensor on the hexiwear_k64 board to enable the green LED and measure the reflected light with a photodiode. The raw ADC data prints to the console. Further processing (not included in this sample) is required to extract a heart rate signal from the light measurement.

Sample Output

```
GREEN=5731
GREEN=5750
GREEN=5748
GREEN=5741
GREEN=5735
GREEN=5737
GREEN=5736
GREEN=5748
```

<repeats endlessly>

18.3 Driver Samples

The following samples demonstrate how to use various drivers supported by Zephyr.

18.3.1 I2C Scanner sample

Overview

This sample sends I2C messages without any data (i.e. stop condition after sending just the address). If there is an ACK for the address, it prints the address as `FOUND`.

> **Warning:** As there is no standard I2C detection command, this sample uses arbitrary SMBus commands (namely SMBus quick write and SMBus receive byte) to probe for devices. This sample program can confuse your I2C bus, cause data loss, and is known to corrupt the Atmel AT24RF08 EEPROM found on many IBM Thinkpad laptops. See also the i2cdetect man page

Building and Running

18.3.2 I2C Scanner sample

Overview

This sample sends I2C messages without any data (i.e. stop condition after sending just the address). If there is an ACK for the address, it prints the address as `FOUND`.

Warning: As there is no standard I2C detection command, this sample uses arbitrary SMBus commands (namely SMBus quick write and SMBus receive byte) to probe for devices. This sample program can confuse your I2C bus, cause data loss, and is known to corrupt the Atmel AT24RF08 EEPROM found on many IBM Thinkpad laptops. See also the i2cdetect man page

Building and Running

18.4 Display Samples

18.4.1 ST7789V Display driver

make sure this patch is applied : https://github.com/zephyrproject-rtos/zephyr/pull/20570/files

Overview

This sample will draw some basic rectangles onto the display. The rectangle colors and positions are chosen so that you can check the orientation of the LCD and correct RGB bit order. The rectangles are drawn in clockwise order, from top left corner: Red, Green, Blue, grey. The shade of grey changes from black through to white. (if the grey looks too green or red at any point then the LCD may be endian swapped).

Note: The display driver rotates the display so that the 'natural' LCD orientation is effectively 270 degrees clockwise of the default display controller orientation.

Building and Running

The sample has a board overlay for a nrf52832 based board with the following pin assignments:

nRF52832 Pin	LCD module signal
P0.03	SPI_SCK
P0.05	SPI_MOSI
P0.26	SPI_MISO
P0.27	CS
P0.25	DATA/CMD
P0.02	RESET

You might need to alter these according to your specific board/LCD configuration.

For nrf52_pca10040, build this sample application with the following commands:

See nrf52_pca10040 on how to flash the build.

References

- ST7789V datasheet

18.5 GUI Samples

18.5.1 LittlevGL Basic Sample

Overview

This sample application displays “Hello World” in the center of the screen and a counter at the bottom which increments every second.

Requirements

Display shield and a board which provides a configuration for Arduino connectors, for example:

- adafruit_2_8_tft_touch_v2 and nrf52840_pca10056
- ssd1306_128x64_shield and frdm_k64f

or a simulated display environment in a native Posix application:

- native_posix
- SDL2[1]

or

- mimxrt1050_evk
- RK043FN02H-CT[2]

or

- mimxrt1060_evk
- RK043FN02H-CT[2]

Building and Running

Example building for nrf52840_pca10056:

Example building for native_posix:

References

18.5.2 Adafruit GFX Library on ST7789V Display

[1] https://www.libsdl.org

[2] https://www.nxp.com/products/processors-and-microcontrollers/arm-based-processors-and-mcus/i.mx-applications-processors/i.mx-rt-series/4.3-lcd-panel:RK043FN02H-CT

Overview

This is a sample C++ firmware running Adafruit GFX Library on a ST7789V display. The library is ported from Arduino.

18.5.3 LittlevGL Basic Sample

Overview

This sample application displays "Hello World" in the center of the screen and a counter at the bottom which increments every second.

Requirements

Pinetime watch definitions can be found under the boards sub-directory

- pinetime.conf
- pinetime.overlay

Building and Running

west build -p -b pinetime samples/gui/lvgl

References

18.5.4 BMA280: Three Axis High-g I2C/SPI Accelerometer

Description

This sample application produces slightly different outputs based on the chosen driver configuration mode:

- In **Measuring Mode with trigger support**, the acceleration on all three axis is printed in m/s^2 at the sampling rate (ODR).
- In **Polled Measuring Mode**, the instantaneous acceleration is polled every 2 seconds.
- In **Max Peak Detect Mode**, the device returns only the over-threshold peak acceleration between two consecutive sample fetches or trigger events. (In most high-g applications, a single 3-axis acceleration sample at the peak of an impact event contains sufficient information about the event, and the full acceleration history is not required.) Instead of printing the acceleration on all three axis, the sample application calculates the vector magnitude (root sum squared) and displays the result in g's rather than in m/s^2, together with an bar graph.

References

- BMA280: http://www.analog.com/bma280

Wiring

This sample uses the BMA280 sensor controlled either using the I2C or SPI interface. Connect supply **VDD**, **VS** and **GND**. The supply voltage can be in the 1.6V to 3.5V range.

I2C mode

Connect Interface: **SDA**, **SCL** and optionally connect the **INT1** to a interrupt capable GPIO. It is a requirement that **SCLK** must be connected to **GND** in I2C mode. Depending on the baseboard used, the **SDA** and **SCL** lines require Pull-Up resistors. With the **MISO** pin low, the I2C address for the device is 0x1D, and an alternate I2C address of 0x53 can be chosen by pulling the **MISO** pin high.

I2C Address:

- **0x1D**: if MISO is pulled low
- **0x53**: if MISO is pulled high

Note: When sharing an SDA bus, the BMA280 Silicon Revision < 3 may prevent communication with other devices on that bus.

SPI mode

Connect Interface: **SCLK**, **MISO**, **MOSI** and **/CS** and optionally connect the **INT1** to a interrupt capable GPIO.

Building and Running

This project outputs sensor data to the console. It requires an BMA280 sensor. It should work with any platform featuring a I2C/SPI peripheral interface. It does not work on QEMU. In this example below the nrf52_pca10040 board is used.

Sample Output: Max Peak Detect Mode

```
Waiting for a threshold event
 23.94 g: ########################
Waiting for a threshold event
 38.01 g: ######################################
Waiting for a threshold event
 51.40 g: ####################################################
Waiting for a threshold event
 63.63 g: ################################################################
```

Sample Output: Measurement Mode

```
AX=      2.94 AY=     -5.88 AZ=      0.98 (m/s^2)
AX=     -4.90 AY=      6.86 AZ=     -1.96 (m/s^2)
AX=      2.94 AY=     -2.94 AZ=      8.83 (m/s^2)
AX=     -0.98 AY=     -6.86 AZ=     -0.98 (m/s^2)
AX=      6.86 AY=      2.94 AZ=      3.92 (m/s^2)
AX=     -0.98 AY=      4.90 AZ=     -3.92 (m/s^2)

<repeats endlessly>
```

18.5.5 LittlevGL Basic Sample

Overview

This sample application displays “Hello World” in the center of the screen and a counter at the bottom which increments every second.

Requirements

Pinetime watch definitions can be found under the boards sub-directory

- pinetime.conf
- pinetime.overlay

Building and Running

west build -p -b pinetime samples/gui/lvgl

References

CHAPTER

NINETEEN

MENUCONFIG

19.1 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  --->
```

(continues on next page)

(continued from previous page)

```
-*- 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

TWENTY

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 be able 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. (my repo: https://github.com/najnesnaj/openocd is adapted for the orange pi)

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 **
```

(continues on next page)

(continued from previous page)

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

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

CHAPTER

TWENTYONE

DEBUGGING THE PINETIME SMARTWATCH

```
The pinetime does not have a serial port.
I do not have a segger debugging probe.
A way around this, it to put a value in memory at a fixed location.
With openocd you can peek at this memory location.
```

Note: #define MY_REGISTER (*(volatile uint8_t*)0x2000F000)

in the program you can set values: MY_REGISTER=1; MY_REGISTER=8;

this way you know till where the code executes

```
#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
>mdw 0x2000F000 0x1

the last byte shows the value of your program trace value
```

CHAPTER

TWENTYTWO

TROUBLESHOOTING DRIVERS

Drivers, like the one for the accel sensor BMA421 or the touchscreen CST816S, can deal with interrupts.

Adapting existing drivers did not get me the desired quick results.

Even after analysing the behaviour, setting values at each function step, did not get me any further.

22.1 Overview

The drivers can use interrupts.

In the settings/config one can choose between OWN_THREAD and GLOBAL_THREAD.

This affect the behaviour of how threads are handled.

The tread-handling and interrupt-handling occurs in the driver itself.

An interrupt is handled immediatly, the processing is offloaded to the threading.

22.2 Example

- You touch the touchscreen
- the touchscreen generates an interrupt
- the driver handles the interrupt
- a thread is created by the interrupt
- the threadhandling read the I2C-bus

22.3 Requirements

In order to create a working driver, I took it apart :

(split a complex problem into simple problems)

22.3.1 a sample to detect interrupt

samples/basic/testirq

Each time the touchscreen gets touched, it increases a counter.

22.3.2 a sample to scan the I2C-BUS

(*scanning the I2C_1 port*),

22.3.3 a sample to read the I2C-BUS

samples/basic/touched It is based on the Hynitron touchscreen code. Mass reading 63 bytes was not possible.

I did add a write of 1 to register 0x00.

22.3.4 a samples to handle semaphores

samples/basic/testsemaphore

CHAPTER

TWENTYTHREE

SCANNING THE I2C_1 PORT

```
The pinetime does not have a serial port.
I do not have a segger debugging probe.
A way around this, it to put a value in memory at a fixed location.
With openocd you can peek at this memory location.
```

23.1 Building and Running

In this repo under samples you will find an adapted i2c scanner program.

```
west build -p -b pinetime samples/drivers/i2c_scanner
```

Note: #define MY_REGISTER (*(volatile uint8_t*)0x2000F000)

in the program you can set values: MY_REGISTER=1; MY_REGISTER=8;

this way you know till where the code executes

```
#telnet 127.0.0.1 4444
```

Peeking

```
once your telnet sessions started:
Trying 127.0.0.1...
Connected to 127.0.0.1.
Escape character is '^]'.
Open On-Chip Debugger
>mdw 0x2000F000 0x1
0x2000f000: 00c24418
```

Note::

this corresponds to 0x18, 0x44 and 0xC2 (which is endvalue of scanner, so it does not detect touchscreen, which should be touched first. . . .)

CHAPTER

TWENTYFOUR

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

TWENTYFIVE

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
```

CHAPTER

TWENTYSIX

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.
```

26.1 Todo

list with suggestions:

- better graphics (lvgl using images and rotating stuff)
- NOR flash (here one can store data)
- 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 . . .

26.2 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)