

# **DWM1001 Firmware User Guide**

**Based on DWM1001-DEV board**

**Version 1.3**

**This document is subject to change without notice**

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**Caution!** ESD sensitive device.

Precaution should be used when handling the device in order to prevent permanent damage

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  - (c) The **Decawave DRTLS Gateway Application** which supplies a gateway function (on a Raspberry Pi ®) routing DRTLS location and sensor data traffic onto an IP based network (e.g. LAN), and consists of the following components:
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    - DRTLS Gateway Proxy
    - DRTLS Gateway MQTT Broker
    - DRTLS Gateway Web Manager
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# 1 INTRODUCTION

## 1.1 Overview

The development of real-time positioning network using UWB technology is not a trivial project. The intention of DWM1001 is to simplify the development of UWB RTLS by providing a complete solution in a single module.

The DWM1001 module comes pre-loaded with embedded firmware which provides two-way ranging (TWR) real time location system (RTLS) functionality and networking. The module can be configured and controlled via its API, which can be accessed through a number of different interfaces allowing flexibility to the product designer. The details of the API are described in document [2]. Additionally, Decawave also provides the module firmware in the form of libraries and source code along with a build environment so that user can customise the operation and/or add their own functions.

This document describes what is included in the DWM1001 firmware and how these various elements cooperate together, and explains how users can add their own customisations. The aim of this user guide is to help the users with their development based on the DWM1001-DEV board. After reading this guide developers should be able to compile, build and run the DWM1001 firmware, including custom modifications.

## 1.2 What's included in the firmware release

Each DWM1001 firmware release includes:

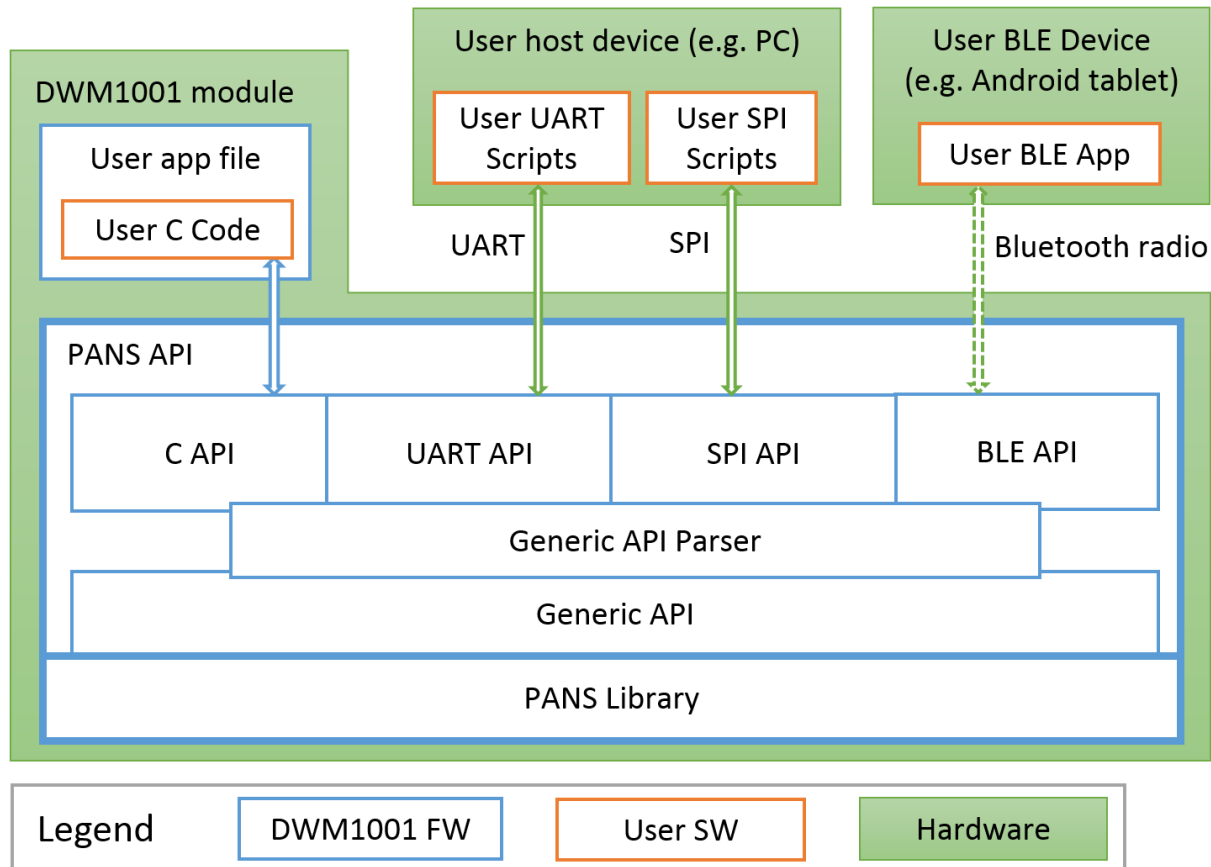
- 1) The pre-compiled DWM1001 Firmware, including the firmware Positioning and Networking stack (PANS) library for on-board development, is provided in the DWM1001 on-board package. The firmware and library architecture and its basic partitioning are described in Section 2.
- 2) Firmware tool chain, described in Section 3. The detailed steps to prepare the necessary tool chain, download the firmware user application package, and compile/build/flash their own application are introduced.
- 3) Simple examples demonstrating how to use the DWM1001 APIs. These are described in Section 4.



## 2 FIRMWARE OVERVIEW

### 2.1 High-Level Architecture

The firmware embedded in the DWM1001 module basically provides two types of functions: the PANS API and the PANS library which provides lower level functions. The PANS API, includes the Generic API, (these include different API sets for different interfaces and the corresponding parser, which acts as the translator between the user APIs (C, UART, SPI and BLE) and the PANS library). Figure 1 shows the architecture and components of the DWM1001 firmware.



**Figure 1 High-Level Architecture of DWM1001 Firmware vs. User Software**

As can be seen in Figure 1, apart from using the DWM1001 module itself, the DWM1001 module can be physically connected to external controlling hardware, either wired or wirelessly over Bluetooth radio. The PANS API provides the users with four sets of API to call the PANS library functions through different interfaces:

- **User C code:** an on-board user space, allowing to include an application-specific code in the user application file provided in the DWM1001 firmware, using the firmware development tool chain provided by Decawave, see Section 4.2.
- **SPI:** using a host device (e.g. PC) to communicate with the DWM1001 module using TLV (Type-Length-Value format, detailed in [2]) format requests and responses through SPI bus, for configuration and data transmission.
- **UART:** using a host device (e.g. PC) to communicate the DWM1001 module through UART bus, for configuration and data transmission. Two modes of communications

are provided over the UART interface: UART Generic mode using TLV format requests and responses; and UART Shell mode using terminal prompt commands.

- **BLE:** using a Bluetooth Low Energy (BLE) device (e.g. Android tablet) to control and configure through Bluetooth radio.

All these API sets provide the same set of generic functions calls, namely the Generic API. The Generic API Parser acts as the translator between the four API sets and the Generic API. When an API command is called from any of the above API Interfaces, the command goes through the Generic API Parser which translates the API command into Generic API function calls. If the API command needs a return message, the DWM1001 responds through the same interface.

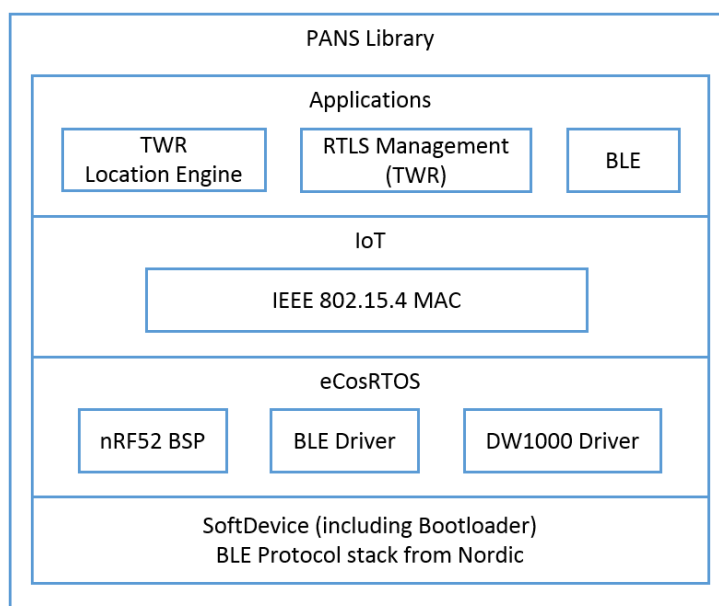
The use of C code, UART and SPI APIs are detailed with simple examples in Section 4. More detailed information is provided in the API document [2].

Note1: The external interfaces, including the UART, the SPI and the BLE, are used by the external APIs in the PANS library for Host connection. The on-board user application through C code API cannot make use of the external interfaces due to compatibility reasons.

Note2: Decawave does not provide the library source code, or support any use of the PANS library except through the PANS API which is described in the API Document [2]

## 2.2 Overview of the PANS Library

Figure 2 illustrates the architecture of the PANS Library in detail. From bottom up the main components are the SoftDevice and the BLE Protocol stack from Nordic Semiconductor, eCos RTOS system with embedded drivers of the components, IoT layer protocols and the applications layer. Section 2.3 gives a brief introduction to each of the components in the library and the operations on the application layer.



**Figure 2 DWM1001 Firmware LibraryComponents**

## 2.3 Components and operations of the PANS Library

The PANS library includes a few firmware components to drive the DWM1001 module. Some operations are implemented based on these components to perform the positioning and networking function.

### 2.3.1 SoftDevice and BLE driver

SoftDevice is a Nordic Semiconductor feature-rich library for BLE. The SoftDevice employed on the DWM1001 is the S132, a concurrent multi-link SoftDevice for Central, Peripheral, Broadcaster and Observer roles in BLE applications. The BLE driver / library is included in the S132 SoftDevice, providing the DWM001 with BLE features to create complex network topologies, communication and firmware update over-the-air [1].

### 2.3.2 eCos RTOS and BSP

eCos RTOS is a free open source real-time operating system. The eCos system provides very good run-time performance and the board support package (BSP) for the DWM1001 hardware platform. It includes all the necessary drivers for the module components (i.e. accelerometer, BLE & DW1000).

### 2.3.3 DW1000 driver

Decawave's DW1000 API driver. For details please see DW1000 Software API Guide [2].

### 2.3.4 Stationary indication

An accelerometer component LIS2DH12TR of slave address 0x19 as an I2C peripheral device is implemented on the DWM1001 module, i.e. the read and write address are 0x33 and 0x32 respectively. This accelerometer provides a simple "stationary" indication function. The DWM1001-based tag can be configured to use *Responsive* or Low-Power mode. It will be in *Low-Power* mode when stationary, and will enter *Responsive* mode when moving. The real-time accelerometer data is accessible through provided Shell API command and I2C functions in the C code API, see [2] for detailed information.

### 2.3.5 PANS Network operation

The PANS networking stack, allows discovery, joining and leaving. The UWB frames are sent according to 802.15.4 standard frame formats. The MAC layer functionality implemented on the DWM1001 module, as described in DWM1001 System Overview document [3], controls the mechanism for joining, leaving, installation, commissioning of nodes and associated two-way ranging protocol and data transfer. A number of different use cases e.g. follow-me, large-scale asset-tracking, navigation, home network are supported.

### 2.3.6 Commissioning

DRTLs can be commissioned with Decawave RTLS Manager Android application. After power on, new nodes will advertise over Bluetooth. Decawave RTLS Manager application is used to connect to the node and configure it (e.g. its role as anchor or tag; its x,y,z coordinates if it is an anchor and other attributes).

### **2.3.7 RTLS Management**

The RTLS Management application supports configuration of DWM1001 modules as tags and anchors which will participate in TWR. The tags will range to nearby anchors and use internal location engine to calculate position. The full implementation is detailed in the DWM1001 System Overview document [3].

### **2.3.8 TWR solver / Location Engine**

The TWR solver / Location Engine in the tags calculates tag's x, y and z coordinates is implemented on the DWM1001 module. TWR results between the tag and the relative anchors are sent to the solver for the calculation of tag's position. The TWR results are accessible through the APIs. The internal location engine can be disabled and user customised location calculation performed instead, e.g. adding extra filtering of change LE/solver algorithms.

### 3 FIRMWARE TOOL CHAIN

#### 3.1 Tool Chain Overview

The Virtual Box image is now deprecated and the recommended methodology for firmware development is to use Segger Embedded Studio.

The Decawave firmware tool chain includes the following parts:

- Segger Embedded Studio and the GNU ARM Embedded Toolchain 5.4 2016q3
- DWM1001 on-board package.

Segger Embedded Studio is ideal for DWM1001 development as it offers a free commercial use license for the nrf51-52 Nordic Semiconductors MCU.

<https://www.segger.com/news/segger-embedded-studio-ide-now-free-for-nordic-sdk-users/>

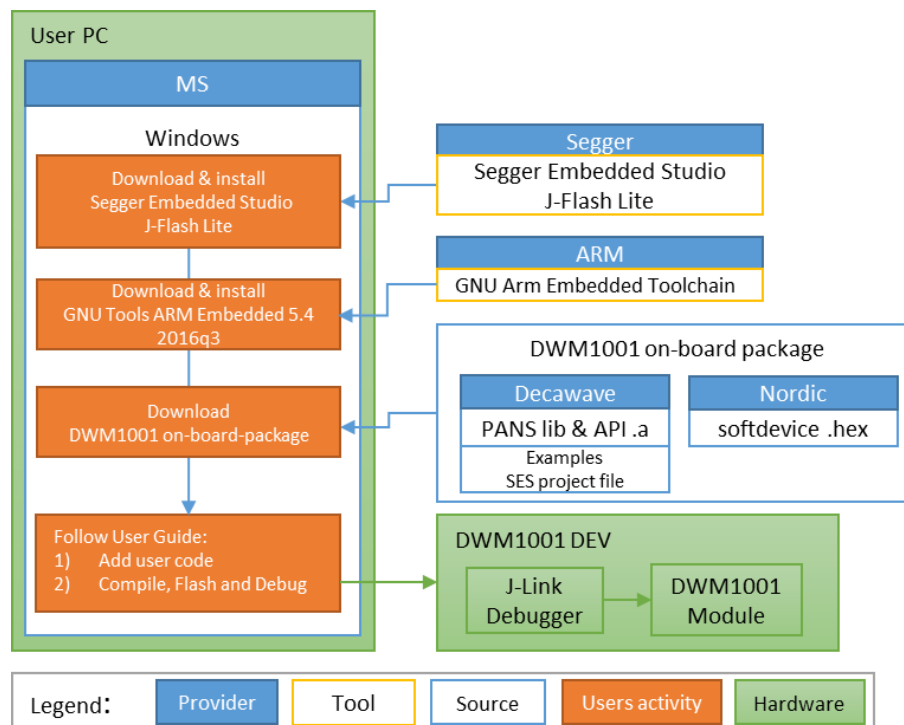
The tool chain can be used for developing a new application with added functionalities which will reside in the DWM1001 module and will run on top of the PANS library and the main module functionality.

#### 3.2 Content in the tool chain

The figure 3 shows the tool chain used in the DWM1001 firmware development.

The GNU ARM Embedded Toolchain (arm-none-eabi-gcc version 5.4.1 for cross-compatibility) and Segger Embedded Studio (SES) must be installed by user.

The distributed DWM1001 on-board package contains the user app source files and the libraries needed to compile and build the DWM1001 user firmware. A SES project is also provided for each example.



**Figure 3: Tool chain and source components in DWM1001 firmware development**

### 3.2.1 Hardware part of toolchain

As illustrated in green color in Figure 3, a PC with Microsoft Windows OS and a DWM1001-DEV board are required as the hardware. The DWM1001-DEV board provides the DWM1001 module as the target and a J-Link debugger.

### 3.2.2 Software part of toolchain

In order to perform user application development for dwm1001, the following software must be downloaded and installed on the windows computer. We recommend to use the default installation path.

- Segger Embedded Studio v4.12  
<https://www.segger.com/downloads/embedded-studio>

Default installation path:

C:\Program Files\SEGGER\SEGGER Embedded Studio for ARM 4.12

- Segger J-Flash Lite (J-Link software suite)  
<https://www.segger.com/downloads/jlink/#J-LinkSoftwareAndDocumentationPack>

Default installation path:

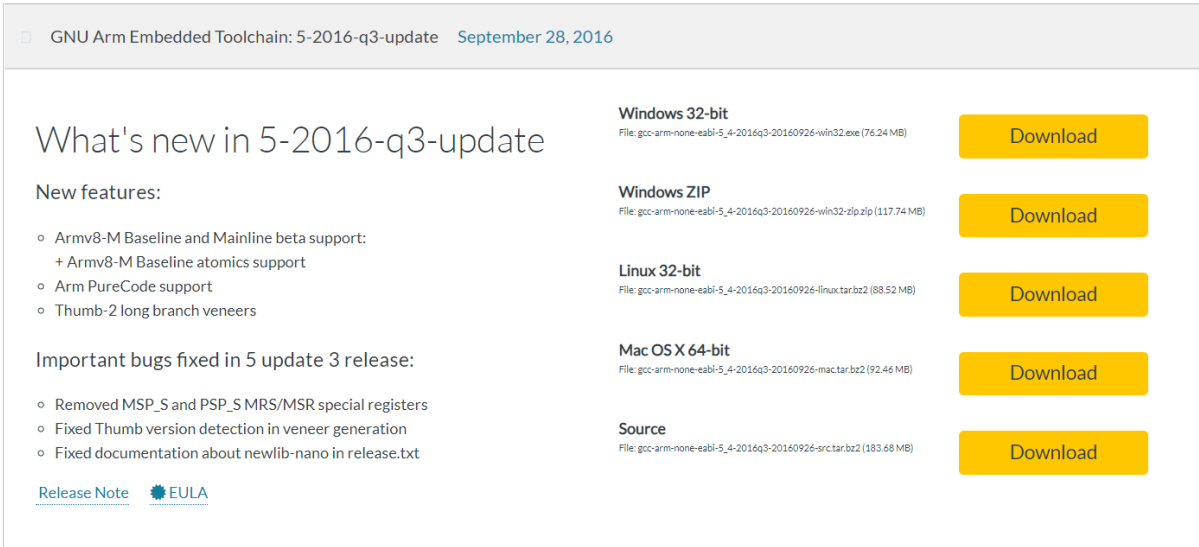
C:\Program Files (x86)\SEGGER\JLink\_V622g

- GNU ARM Embedded Toolchain 5.4 2016q3  
<https://developer.arm.com/open-source/gnu-toolchain/gnu-rm/downloads>

Default installation path:

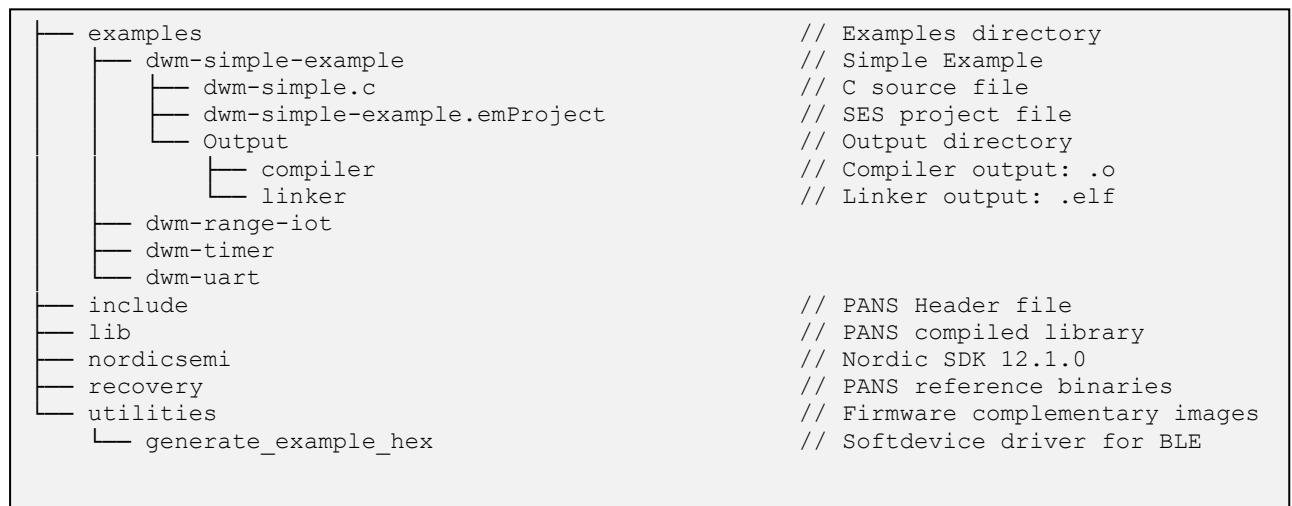
C:\Program Files (x86)\GNU Tools ARM Embedded\5.4 2016q3\bin

*For cross-compatibility with the compiled PANS library, please ensure the version of the GNU ARM Embedded Toolchain corresponds to 5.4 2016q3 - Figure 4*



**Figure 4: Version of GNU ARM Embedded Toolchain to download**

### 3.2.3 Example application package for DWM1001



**Figure 5: DWM1001 on-board-package structure**

The DWM1001 on-board package is provided for download on Decawave website [5].

Refer to the Figure 5 for the detailed content of the DWM1001 on-board package. Its main components are the DWM1001 PANS library, the firmware binaries such as NRF softdevice and bootloader, and the user application examples.

In DWM1001 firmware, the eCos library and other third-party software constitute the PANS library as introduced in Section 2.2. These source files are not provided in the on-board package.

The nordic semiconductor SDK for nrf52832 is also provided as users may need it for application development. Note that the sdk version used within PANS is: SDK v 12.1.0

### 3.3 Guides to flash the DWM1001 with factory image

DWM1001 comes with pre-flashed factory image of firmware. This image is provided in the DWM1001 on-board package: /dwm/recovery/DWM1001\_PANS\_R2.0.hex. The necessary steps to flash the factory image on the DWM1001-DEV board are described below.

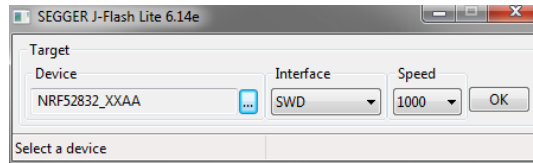
The J-Flash Light tool can be used to flash the factory image through the DWM1001-DEV over a few different platforms.


- 1) Connect the module with a micro USB data cable, shown in Figure 6.

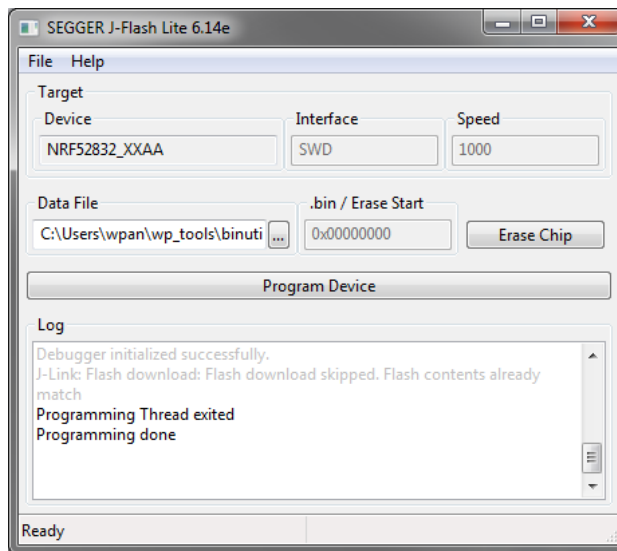


**Figure 6 DWM1001 DEV board – micro USB connection**

- 2) Flash the image DWM1001 module
  - a. Open J-Flash Lite
  - b. Choose nrf52832\_XXAA as Device and SWD as interface, use default speed 1000. Click “OK”.



- c. Click “Erase Chip” to do a full chip erase.
    - d. In Data File, click  and browse to the hex file provided in the DWM1001 on-board package (/dwm/recovery/DWM1001\_PANS\_R2.0.hex) to flash, click “Program Device”.



The LEDs on the boards should be active once the flash update completes.



## 4 USER APPLICATION EXAMPLES

### 4.1 Overview

As illustrated in Figure 1, DWM1001 provides many ways to use its API functions. Examples that show the use of the APIs are listed in this section. In C code, UART Shell, UART Generic, and SPI, examples of getting the location of the node through the API are presented. The API document [2] provides more detailed information.

A tool to open serial port between host device and the DWM1001 module over UART is needed in the firmware development. In Windows, PuTTY can be used; in Linux with a Raspberry Pi for example, minicom can be used. The UART baud rate on the DWM1001 module is 115200 bps and the configuration is 8N1.

### 4.2 “C code API” user application example

“C code API” example is an application, which is running as part of the on-board firmware, utilizing a system resources of built-in to the module Cortex M4F microcontroller. The application is running as a thread application in multi-thread environment, driving by included to the PANS library eCos real-time operation system.

#### 4.2.1 Firmware image partitioning

The flash size of the MCU (nRF52832) used on the DWM1001 module is 512KB from address 0 to 0x80000. The partitioning of the flash is illustrated as in Figure 7.

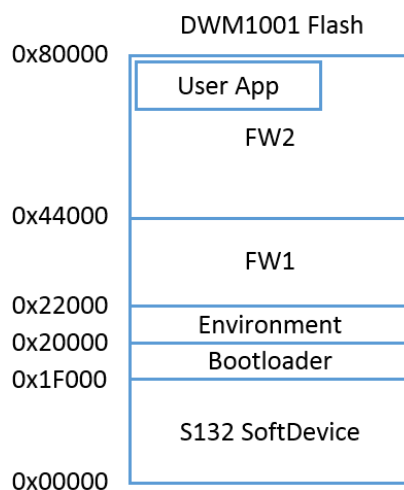


Figure 7 DWM1001 Flash Address Map

The DWM1001 firmware includes the following parts: Nordic S132 Softdevice, Bootloader, Environment, FW1 and FW2:

- **Softdevice**, of size 124KB starting from address 0, provides Bluetooth low energy central and peripheral protocol stack solution.
- **Bootloader**, of size 4KB start from address 0x1F000, is a firmware manager controlling the choice of FW1 and FW2 during booting/reseting.
- **Environment**, of size 8KB start from address 0x20000, is a flash section reserved for the firmware to store user configuration information. Doing power off/on, reset or firmware re-flash will not clear the Environment section in the flash. To clear the

environment section, a full-erase operation introduced in Section 3.3 is needed. Or alternatively, the “frst” shell command introduced in the PANS API [2] can be used.

- **FW1**, of size 136KB starting from address 0x22000, is a piece of firmware for the over-the-air (OTA) firmware update.
- **FW2**, size of up to 240KB starting from address 0x44000, is the firmware image that includes the full PANS library and the c code user application, where the user application is acting as an independent thread in the firmware and can occupy up to 3KB RAM and 60KB Flash. When rebuilding/reflashing the user application firmware, the whole FW2 is being operated.

## 4.2.2 Compiling/debugging user application in the firmware

To add user customized features, the user customized code needs to be added to the application files and the whole project needs to be re-built. A simple example of making a C code user application is given in examples/dwm-simple/dwm-simple.c. The dwm-simple example can be edited, compiled and debugged with Segger Embedded Studio.

### 4.2.2.1 Segger Embedded Studio tool chain path setup

Open the “examples/dwm-simple/dwm-simple.emProject” file with Segger Embedded Studio. The project should be loaded as in

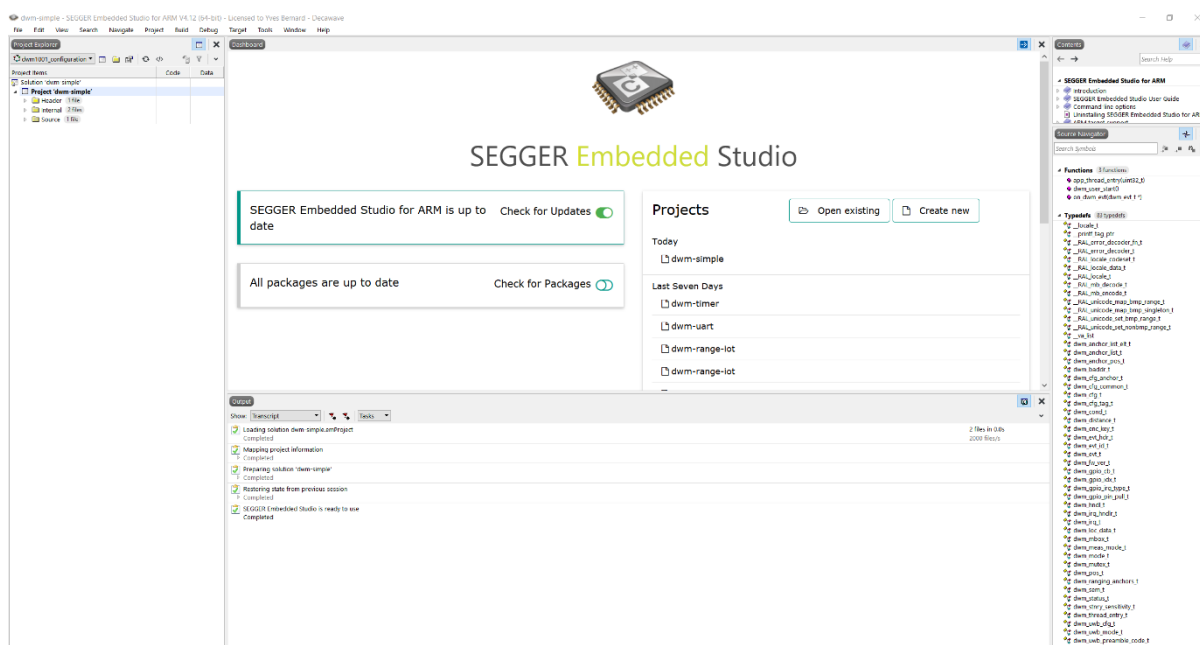


Figure 8: Segger Embedded Studio on project opening

PANS was initially developed and compiled GNU ARM Embedded Toolchain 5.4 2016q3. It is required to use the exact same version to avoid any retro-compatibility issues.

The first step consists in setting the compiler tool chain to the external GCC compiler installed previously as per section 3.2.2.

1. Right click on the solution name in the project item section, on the left of the main SES window. The solution name is at the top of the project structure: dwm-simple. See Figure 9.

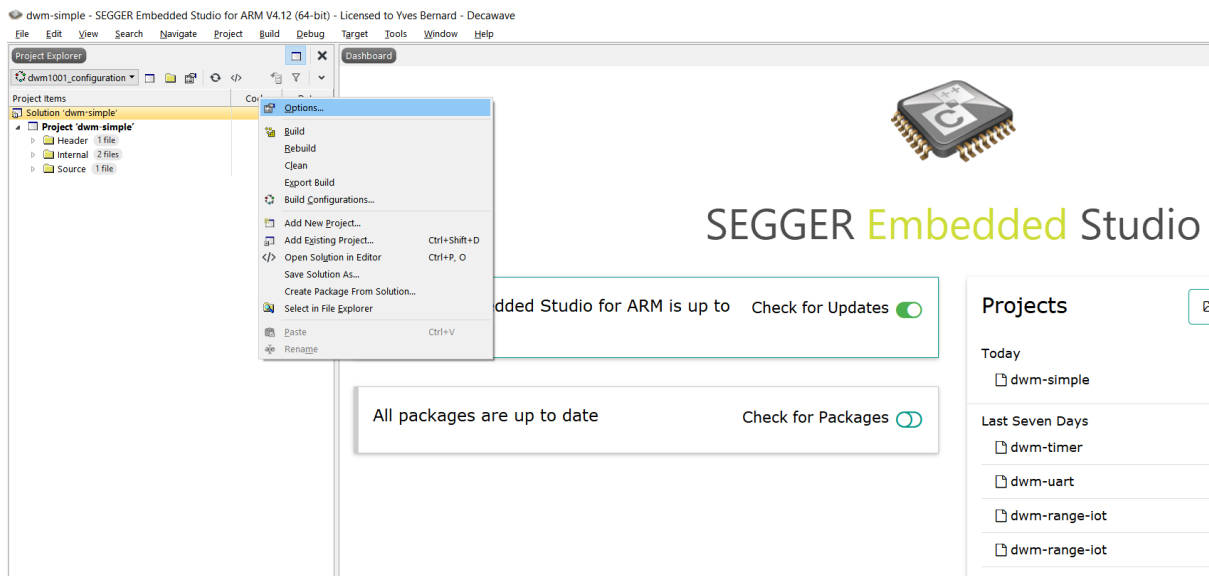


Figure 9: SES - Opening solution configuration menu

2. Click on “option” within the opening menu
3. Set the variable “Tool Chain Directory” to the path of the bin directory of the GNU Arm Embedded Toolchain previously installed. The Figure 10 shows the setting for the default install path.

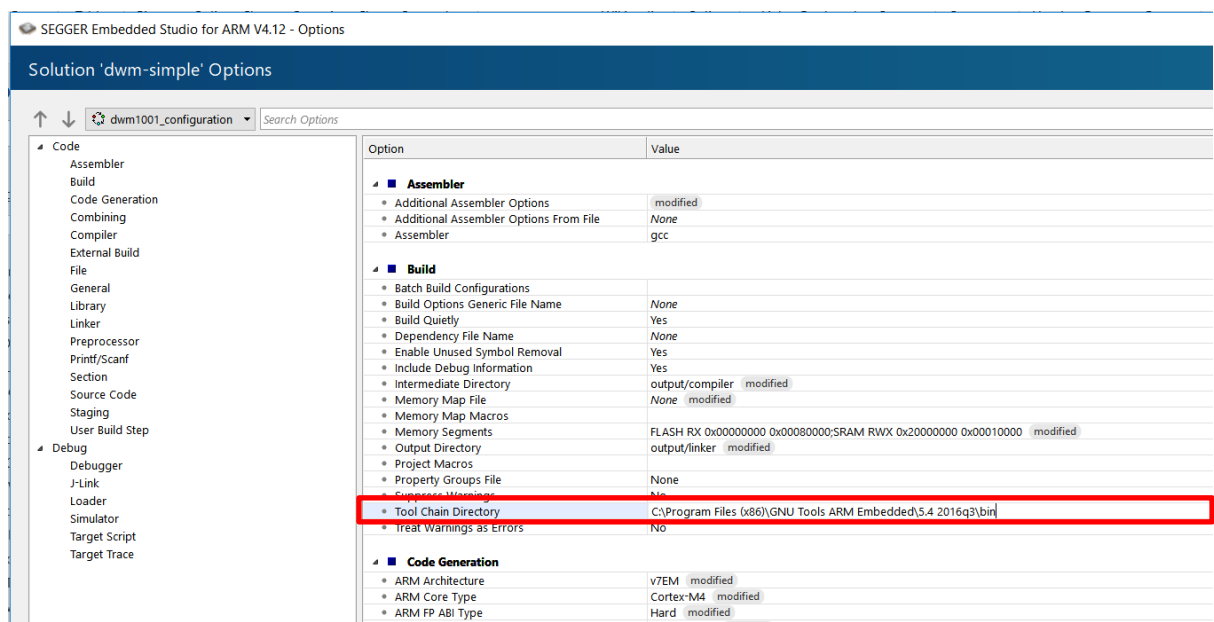


Figure 10: SES - Configuration of GNU ARM Embedded Toolchain install path

4. installation path. Click on ok to save the new value.

#### 4.2.2.2 Segger Embedded Studio: Build and flash the user application

In order to build the project, open the “build” menu from the SES menu bar and click on “build dwm-simple” or press “F7”. The log for the build is displayed in the output windows. If the build is successful, the target mcu memory map is also displayed as information, with the occupied and remaining amount of flash/RAM memory. See Figure 11.

The “dwm-simple” example can easily be customized and recompiled by the user. Follow the instructions below to perform an initial PANS customization.

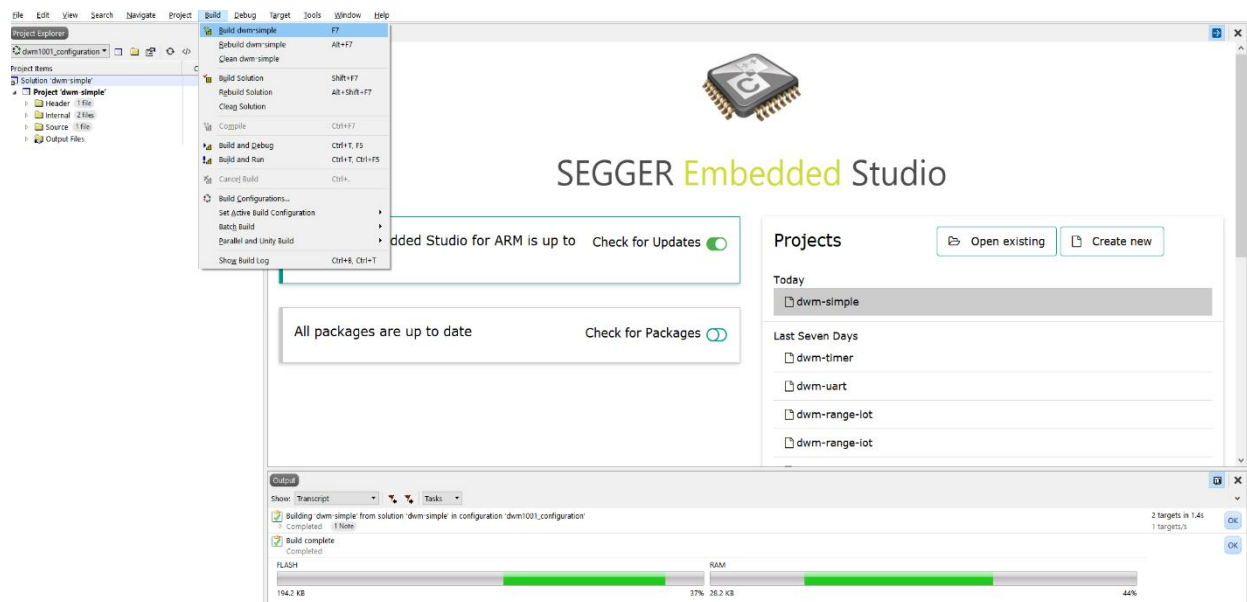


Figure 11: SES - Compiling the project

1. Within the dwm-simple.c file, find the function app\_thread\_entry

Within the app-thread-entry function:

2. Add the following to local variables:  
`dwm_pos_t pos;`
3. Find while(1) and add in the brace:  
`dwm_pos_get(&pos);`  
`printf("x=%ld, y=%ld, z=%ld, qf=%u \n", pos.x, pos.y, pos.z,`  
`pos.qf);`  
`printf("\t\t\t\t\t time=%lu \n", dwm_systime_us_get());`

Note: printf will send the message to through UART interface when Shell mode is enabled.  
Save.

Build the project and eliminate errors.

This change intends to read the position information in the device and print the message on the terminal. A system timer is added in the end of the message to indicate the message time.

The source file `dwm/examples/dwm-simple/dwm-simple.c` can be customized to add/modify functionalities. All available C code API functions are listed in header file `dwm/include/dwm.h`. More detailed information of the C code API is introduced in the DWM1001 API Guide [2].

The compiled example can be flashed on the target device directly from SES. Plug the DWM1001-Dev device over USB to the computer, and click on “target” from the menu bar. The option “Download dwm-simple” can be used to load the example.

The compilation output can be found in the `examples/dwm-simple/Output` directory. If the compilation is successful, then SES will create a compiled image:  
`/dwm-simple/Output/linker/dwm-simple_fw2.bin`

Please note that SES is only compiling and producing an image corresponding to FW2. If the user wishes to flash the full PANS library on a blank DWM1001 device, then the softdevice, bootloader and FW1 will have to be flashed before FW2 as per described in section 4.1.

In order to simplify this task and generate a unique hex file, a batch script is provided in the `/utilities` directory.

Open the `generate_example_hex.bat` file with a text editor and alter the following fields depending on the project you are currently modifying and compiling.

```
SET example_name="dwm-simple"  
SET fw2_path="..\examples\dwm-simple\Output\linker\dwm-  
simple_fw2.bin"
```

Save the file and execute the `generate_example_hex` file by double clicking on it.

A new image file combining the softdevice, bootloader, FW1 and customized FW2 will be created:  
`/dwm-simple/Output/dwm1001_dwm-simple.hex`.

This new file can be flashed using J-Lite as explained in section **Error! Reference source not found.**

#### 4.2.2.3 Segger Embedded Studio: Debug the user application

SES also supports debugging. In order to start the debugging mode, click on “Debug” from the menu bar or press F5.

Note that a DWM1001-Deb must be connected to the computer to start the debugging mode successfully. The device is automatically flashed with the latest compiled project when starting debugging.

As presented by Figure 12, SES has the default options and features usually offered by a debugger. With the center widget, the user can setup break points and run the application

through the code. The equivalent assembly program is displayed on left widget. On the top right widget, note that the default breakpoints list contains the ARM V7M exceptions.

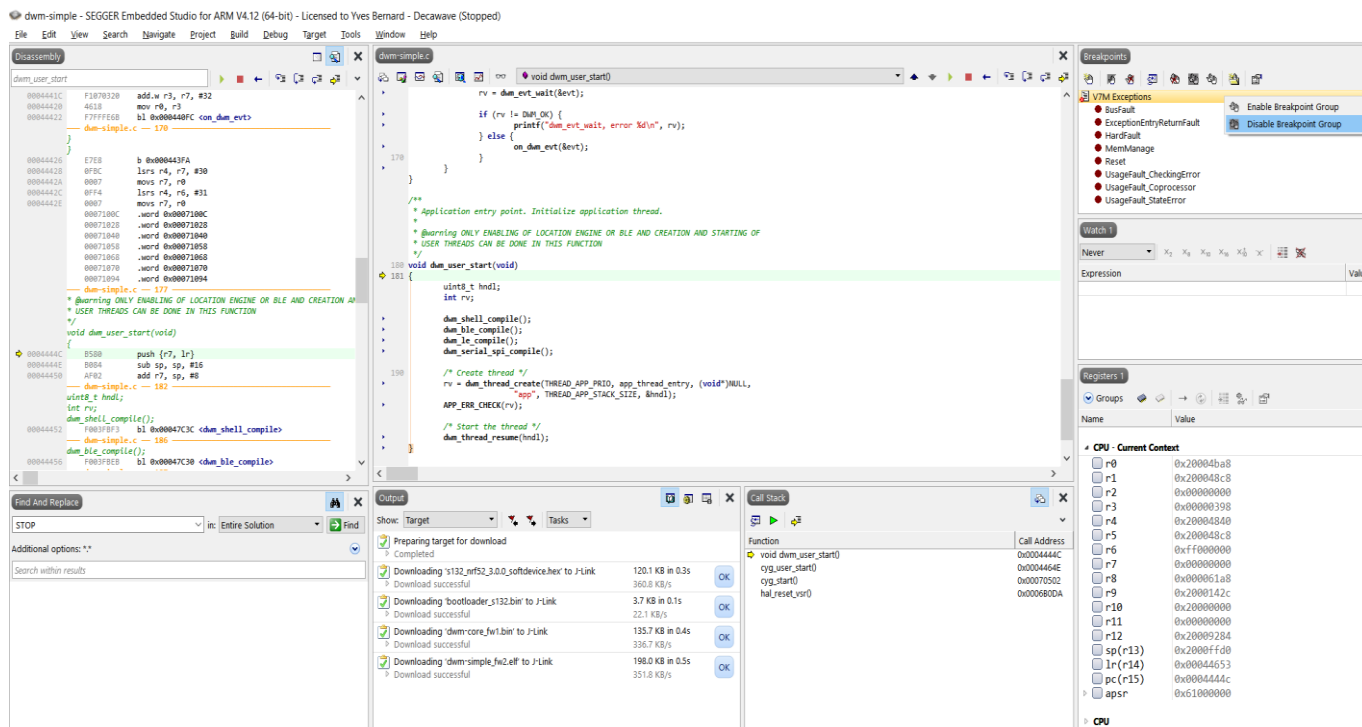


Figure 12: SES - Debugging window

We recommend to disable the V7M exceptions as they will be automatically triggered within the compiled library and will interfere with the user application debugging. In order to disable them, right click on “V7M exception” as shown on Figure 12.

Note1: A few compilation options are provided in the `dwm_user_start()` function, with function names of `dwm_XXXX_compile()`, where XXXX is the component name. Disabling these functions can disable the corresponding components in the DWM1001 firmware.

Note2: It is possible to use breakpoints to debug the firmware. However, the user has to be very careful because the nRF52 softdevice interrupts are of highest priority, and if there is BLE activity its interrupts will conflict with user interrupt, thus the BLE should either be disabled or its interrupts masked. Disabling function `dwm_ble_compile()` can disable the BLE compilation so as to void BLE operations during debugging. The function can be re-enabled after debugging.

Note3: SWO debug printf is not supported on the DWM1001 DEV board.

### 4.3 UART applications example

The PANS library provides API functions through UART interface. The connection and simple examples are introduced here.

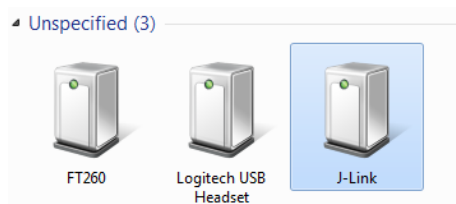
#### 4.3.1 UART connection

The DWM1001 DEV board provides UART access through both the USB connector and the pins on the external connector. Both accesses are introduced here.

##### 4.3.1.1 UART connection through COM port over USB

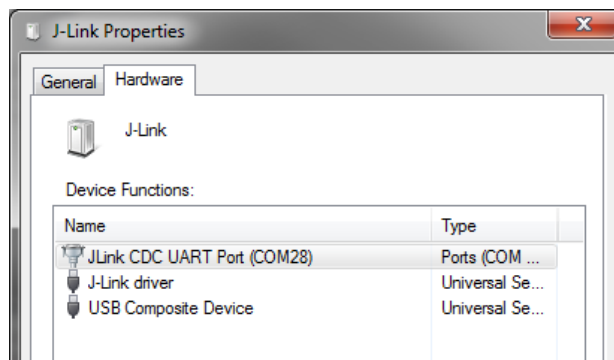
The UART connection can be setup simply through a USB data cable as shown in Figure 6. To find the device name of the DWM1001 DEV board in the Windows system:

- 1) Open Device and Printers,
- 2) Find the device J-Link:



**Figure 13 J-Link Device in Windows**

- 3) Double click the J-Link icon, go to Hardware tab and find the COM port with number as the device name (e.g. in Figure 14 below J-Link is device name is COM28).



**Figure 14: DWM1001 Device COM port over J-Link**

In different Linux systems, the UART devices may show different names.

##### 4.3.1.2 UART connection through external connector Tx and Rx pins

Other than using USB cable to connect, the external header pins provided on J10 of the DWM1001 DEV board also provides the UART interface. Table 1 shows the pins needed in the UART connection.

**Table 1 UART pin connections**

Pin to use in DWM1001 DEV		Pin to be connected to
Connector J10	Function	
Pin 6	GND	GND
Pin 8	RXD	TXD
Pin 10	TXD	RXD



For Raspberry Pi 3 using header pins connection, the device name is `/dev/serial0`.

The connection between the DWM1001 DEV board and a Raspberry Pi 3 (model B) is shown in Figure 15.



**Figure 15: Connecting DWM1001 to Raspberry Pi 3 over header pins**

Note: Pins on J10 of the DWM1001 DEV board are compatible with Raspberry Pi 3 connector J8 header pins 1-26.

### 4.3.2 UART examples

UART interface is accessible through two mode, the Shell mode and the Generic mode. Both Generic mode and Shell mode can be used to communicate with the DWM1001 module through the UART connection. The default mode of the DWM1001 UART is Generic mode. The two modes are transferrable:

Generic mode to Shell mode: presses “Enter” twice within one second, or input two bytes [0x0D, 0x0D] within one second.

Shell mode to Generic mode: input “quit” command.

For more information of the two UART API modes, please refer to DWM1001 API Guide [2].

#### 4.3.2.1 UART Shell mode example

On a raspberry pi, in order to connect to the device, perform the following:

- `minicom -D /dev/serial0`

When seeing “Device or resource busy”, try multiple times until it works.

If the connection over UART is successful, “Welcome to minicom” message will show on the terminal. Now hit “Enter” key twice within one second to enter UART shell mode. “dwm>” should present in the terminal when this is all done.

To run the UART Shell command for `dwm_pos_get`, type “apg” followed by “Enter” key. The position of the module in the whole DRTLs will be printed out, see Figure 16. Type “?” followed by “Enter” key to get help information in UART Shell mode. More information of the UART Shell commands is introduced in the DWM1001 API Guide [2].



```
Welcome to minicom 2.7

OPTIONS: I18n
Compiled on Apr 22 2017, 09:14:19.
Port /dev/serial0, 15:17:54

Press CTRL-A Z for help on special keys

DWM1001 TWR Real Time Location System

Copyright : 2016-2019 LEAPS and Decawave
License   : Please visit https://decawave.com/dwm1001_license
Compiled  : Feb 11 2019 04:21:32

Help      : ? or help

dwm> si
[361018.670 INF] sys: fw2 fw_ver=x01030001 cfg_ver=x00010700
[361018.670 INF] uwb0: panid=x2607 addr=xDECA50F56E101AAC
[361018.680 INF] mode: bn (act, -)
[361018.690 INF] uwbmac: connected
[361018.690 INF] enc: off
[361018.690 INF] ble: addr=F3:15:F3:45:09:E8
dwm> █

CTRL-A Z for help | 115200 8N1 | NOR | Minicom 2.7 | VT102 | Offline | serial0
```

Figure 16: Connect to DWM1001 device through UART shell

#### 4.3.2.2 UART Generic mode example

A simple example to make use of the UART Generic API is given in the DWM1001 Host Api package [4]. The example runs on the Raspberry Pi platform:

- 1) Download the `dwm1001_host_api` package onto the Raspberry Pi 3 device.  
Navigate to folder `examples/ex1_TWR_2Hosts/tag/`
- 2) Use nano editor to edit Makefile:
  - nano Makefile
- 3) Change the configuration parameter `USE_INTERFACE` to use UART interface:  
`USE_INTERFACE = 0`
- 4) Press “Ctrl + o” and “Enter” to save. Press “Ctrl + x” to exit nano editor.
- 5) Use “make” command to build the example:
  - make
- 6) Run the executable:
  - `./tag_cfg`
- 7) Check `log.txt` file for the detail of UART data transmission.

```

pi@rpi-83:~/dwm1001_host_api/examples/ex1_TWR_2Hosts/tag $ ./tag_cfg
dwm_init(): dev0
Opening log file log.txt
    LMH_UARTRX_Init()...
    UART: Init start.
    UART: Init done.
Setting to tag: dev0.
dwm_cfg_tag_set(&cfg_tag): dev0.
Wait 2s for node to reset.
Comparing set vs. get: dev0.

Configuration succeeded.

Wait 1000 ms...
dwm_loc_get(&loc):
    [121,50,251,100]
Wait 1000 ms...
dwm_loc_get(&loc):
    [121,50,251,100]
Wait 1000 ms...
dwm_loc_get(&loc):
    [121,50,251,100]

```

**Figure 17: Run simple UART example on Raspberry Pi 3**

The simple UART Generic mode example project is designed specifically for Raspberry Pi platform. The source file `examples/ex1_TWR_2Hosts/tag/tag_cfg.c` can be changed to add/modify functionalities. All available UART API functions are listed in header file `include\dwm_api.h`. More detailed information of the UART Generic mode is introduced in the DWM1001 API Guide [2].

The code/makefile needs to be changed, to suit other platforms than Raspberry PI.

#### 4.4 SPI applications example

The DWM1001 module provides APIs over the SPI interface. The connection and a simple example are introduced here.

##### 4.4.1 SPI connection

To connect to the DWM1001 module over SPI, the SPI pins on external connector J10 on the DWM1001 DEV board can be used. Table 2 shows the pins needed in the SPI connection.

**Table 2 SPI pin connections**

Pin to use		Pin to be connected to
Pin number	Function	
Pin 19	MOSI	MOSI
Pin 21	MISO	MISO
Pin 23	SCLK	SCLK
Pin 25	GND	GND
Pin 24	CSN	CSN

The connection with Raspberry Pi 3 (model B) is shown in Figure 15.

Note: the connector J10 on the DWM1001 DEV board is compatible with Raspberry Pi 3

connector J8 header pins 1-26. Pin 4 from J10 provides 5V power from Raspberry Pi to the DWM1001 DEV board.

#### 4.4.2 SPI example

A simple example to make use of the SPI API is given in the DWM1001 Host API package [4]. The example can run on the Raspberry Pi platform:

- 1) Download the `dwm1001_host_api` package onto the Raspberry Pi 3 device.  
Navigate to folder `examples/ex1_TWR_2Hosts/tag/`
- 2) Use nano editor to edit Makefile:
  - nano Makefile
- 3) Change the configuration parameter `USE_INTERFACE` to use SPI interface:  
`USE_INTERFACE = 1`
- 4) Press “Ctrl + o” and “Enter” to save. Press “Ctrl + x” to exit nano editor.
- 5) Use “make” command to build the example:
  - make
- 6) Run the executable:
  - `./tag_cfg`
- 7) Check `log.txt` file for the detail of SPI data transmission.

```

pi@rpi-83:~/dwm1001_host_api/examples/ex1_TWR_2Hosts/tag $ ./tag_cfg
dwm_init(): dev0
Opening log file log.txt
  LMH_SPIRX_Init(): SPI dev0...
  SPI0: spi mode: 0
  SPI0: bits per word: 8
  SPI0: max speed: 8000000 Hz (8000 KHz)
  SPI0: Resetting DWM1001 to SPI:IDLE
  LMH: LMH_SPIRX_Init for SPI dev0 done.
Setting to tag: dev0.
dwm_cfg_tag_set(&cfg_tag): dev0.
Wait 2s for node to reset.
Comparing set vs. get: dev0.

Configuration succeeded.

Wait 1000 ms...
dwm_loc_get(&loc):
  [121,50,251,100]
Wait 1000 ms...
dwm_loc_get(&loc):
  [121,50,251,100]
Wait 1000 ms...
dwm_loc_get(&loc):
  [121,50,251,100]

```

**Figure 18: Run simple SPI example on Raspberry Pi 3**

The simple SPI example project is designed specifically for Raspberry Pi platform. The source file `examples/ex1_TWR_2Hosts/tag/tag_cfg.c` can be changed to add/modify functionalities. All available SPI API functions are listed in header file `include\dwm_api.h`. More detailed information of the SPI API is introduced in the DWM1001 API Guide [2].

The code/makefile needs to be changed to suit other platforms than Raspberry Pi.

## 5 REFERENCES

This document refers to the documents listed below. Note that References' format can be as the author chooses.

1. Nordic nRF52 series Softdevice introduction, available from [www.nordicsemi.com](http://www.nordicsemi.com)
2. DW1000 Software API Guide, available from [www.decawave.com](http://www.decawave.com)
3. DWM1001 System Overview, available from [www.decawave.com](http://www.decawave.com)
4. DWM1001 Host API source code package available from [www.decawave.com](http://www.decawave.com)
5. DWM1001 on-board source code package, available from [www.decawave.com](http://www.decawave.com)
6. DWM1001 Android application source package, available from [www.decawave.com](http://www.decawave.com)

## 6 DOCUMENT HISTORY

### 6.1 Revision History

Table 3: Document History

Revision	Date	Description
1.3	28-Mar-2019	Update for R2
1.2	07-Aug-2018	Logo Change
1.1	11-Jan-2018	Editorial changes
1.0	18-Dec-2017	Initial version

## 7 CHANGE LOG

### Revision 1.1

<b>Page</b>	<b>Change Description</b>
27	Remove unreleased documents from references
27	Repair url links for 2 references
10	Remove paragraph related to fig 2
10	Remove of renumber reference as references are removed or renumbered

### Revision 1.2

<b>Page</b>	<b>Change Description</b>
ALL	Update with new logo

## 8 FURTHER INFORMATION

Decawave develops semiconductors solutions, software, modules, reference designs - that enable real-time, ultra-accurate, ultra-reliable local area micro-location services. Decawave's technology enables an entirely new class of easy to implement, highly secure, intelligent location functionality and services for IoT and smart consumer products and applications.

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