DWM1001 FIRMWARE APPLICATION PROGRAMMING INTERFACE (API) GUIDE

USING API FUNCTIONS TO CONFIGURE AND PROGRAMME DWM1001 MODULE

This document is subject to change without notice

TABLE OF CONTENTS

List of Tables

List of Figures

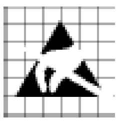
DOCUMENT INFORMATION

Disclaimer

Decawave reserves the right to change product specifications without notice. As far as possible changes to functionality and specifications will be issued in product specific errata sheets or in new versions of this document. Customers are advised to check the Decawave website for the most recent updates on this product

LIFE SUPPORT POLICY

Decawave products are not authorized for use in safety-critical applications (such as life support) where a failure of the Decawave product would reasonably be expected to cause severe personal injury or death. Decawave customers using or selling Decawave products in such a manner do so entirely at their own risk and agree to fully indemnify Decawave and its representatives against any damages arising out of the use of Decawave products in such safety-critical applications.



Caution! ESD sensitive device.

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

DISCLAIMER

(1) This Disclaimer applies to the software provided by Decawave Ltd. ("Decawave") in support of its DWM1001 module product ("Module") all as set out at clause 3 herein ("Decawave Software").

(2) Decawave Software is provided in two ways as follows: -
(a) pre-loaded onto the Module at time of manufacture by Decawave ("Firmware");
(b) supplied separately by Decawave ("Software Bundle").

(3) Decawave Software consists of the following components (a) to (d) inclusive:

(a) The **Decawave Positioning and Networking Stack** ("PANS"), available as a library accompanied by source code that allows a level of user customisation. The PANS software is pre-installed and runs on the Module as supplied, and enables mobile "tags", fixed "anchors" and "gateways" that together deliver the DWM1001 Two-Way-Ranging Real Time Location System ("DRTLS") Network.

(b) The **Decawave DRTLS Manager** which is an Android™ application for configuration of DRTLS nodes (nodes based on the Module) over Bluetooth™.

(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:

- DRTLS Gateway Linux Kernel Module
- DRTLS Gateway Daemon
- DRTLS Gateway MQTT Broker
- DRTLS Gateway Web Manager

(d) **Example Host API functions**, also designed to run on a Raspberry Pi, which show how to drive the Module from an external host microprocessor.

(4) The following third party components are used by Decawave Software and are incorporated in the Firmware or included in the Software Bundle as the case may be: -

(a) The PANS software incorporates the Nordic SoftDevice S132-SD-v3 version 3.0.0 (production) which is included in the Firmware and is also included in the Software Bundle;

(b) The PANS software uses the eCos RTOS which is included in the Software Bundle. The eCos RTOS is provided under the terms of an open source licence which may be found at: http://ecos.sourceware.org/license-overview.html;

(c) The PANS software uses an open source CRC-32 function from FreeBSD which is included in the Software Bundle. This CRC-32 function is provided under the terms of the BSD licence which may be found at: https://github.com/freebsd/freebsd/blob/386ddae58459341ec567604707805814a2128a57/COPYRIGHT;

(d) The Decawave DRTLS Manager application uses open source software which is provided as source code in the Software Bundle. This open source software is provided under the terms of the Apache Licence v2.0 which may be found at http://www.apache.org/licenses/LICENSE-2.0;

(e) The Decawave DRTLS Gateway Application uses the following third party components: -

(i) The Linux Kernel which is provided as source code in the Software Bundle. The Linux Kernel is provided under the terms of the GPLv2 licence which may be found at: https://www.gnu.org/licenses/old-licenses/gpl-2.0.en.html and as such the DWM1001 driver component of the DRTLS Gateway Application is provided under the same license terms;

(ii) The three.js JavaScript library, the downloadable version of which is available here https://threejs.org/, is provided under the terms of the MIT Licence which may be found at https://opensource.org/licenses/MIT.

Items (a), (b), (c), (d) and (e) in this section 4 are collectively referred to as the "Third Party Software"

(5) Decawave Software incorporates source code licensed to Decawave by Leaps s.r.o., a supplier to Decawave, which is included in the Firmware and the Software Bundle in binary and/or source code forms as the case may be, under the terms of a license agreement entered into between Decawave and Leaps s.r.o.

(6) Decawave hereby grants you a free, non-exclusive, non-transferable, worldwide license without the right to sub-license to design, make, have made, market, sell, have sold or otherwise dispose of products incorporating Decawave Software, to modify Decawave Software or incorporate Decawave Software in other software and to design, make, have made, market, sell, have sold or otherwise dispose of products incorporating such modified or incorporated software PROVIDED ALWAYS that the use by you of Third Party Software as supplied by Decawave is subject to the terms and conditions of the respective license agreements as set out at clause 4 herein AND PROVIDED ALWAYS that Decawave Software is used only in systems and products based on Decawave semiconductor products. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER DECAWAVE INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY THIRD PARTY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT, IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which Decawave semiconductor products or Decawave Software are used.

(7) Downloading, accepting delivery of or using Decawave Software indicates your agreement to the terms of (i) the license grated at clause 6 herein, (ii) the terms of this Disclaimer and (iii) the terms attaching to the Third Party Software. If you do not agree with all of these terms do not download, accept delivery of or use Decawave Software.

(8) Decawave Software is solely intended to assist you in developing systems that incorporate Decawave semiconductor products. You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in

designing your systems and products. THE DECISION TO USE DECAWAVE SOFTWARE IN WHOLE OR IN PART IN YOUR SYSTEMS AND PRODUCTS RESTS ENTIRELY WITH YOU AND DECAWAVE ACCEPTS NO LIABILTY WHATSOEVER FOR SUCH DECISION.

(9) DECAWAVE SOFTWARE IS PROVIDED "AS IS". DECAWAVE MAKES NO WARRANTIES OR REPRESENTATIONS WITH REGARD TO DECAWAVE SOFTWARE OR USE OF DECAWAVE SOFTWARE, EXPRESS, IMPLIED OR STATUTORY, INCLUDING ACCURACY OR COMPLETENESS. DECAWAVE DISCLAIMS ANY WARRANTY OF TITLE AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS WITH REGARD TO DECAWAVE SOFTWARE OR THE USE THEREOF.

(10) DECAWAVE SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY THIRD PARTY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON DECAWAVE SOFTWARE OR THE USE OF DECAWAVE SOFTWARE. IN NO EVENT SHALL DECAWAVE BE LIABLE FOR ANY ACTUAL, SPECIAL, INCIDENTAL, CONSEQUENTIAL OR INDIRECT DAMAGES, HOWEVER CAUSED, INCLUDING WITHOUT LIMITATION TO THE GENERALITY OF THE FOREGOING, LOSS OF ANTICIPATED PROFITS, GOODWILL, REPUTATION, BUSINESS RECEIPTS OR CONTRACTS, COSTS OF PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION), LOSSES OR EXPENSES RESULTING FROM THIRD PARTY CLAIMS. THESE LIMITATIONS WILL APPLY REGARDLESS OF THE FORM OF ACTION, WHETHER UNDER STATUTE, IN CONTRACT OR TORT INCLUDING NEGLIGENCE OR ANY OTHER FORM OF ACTION AND WHETHER OR NOT DECAWAVE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, ARISING IN ANY WAY OUT OF DECAWAVE SOFTWARE OR THE USE OF DECAWAVE SOFTWARE.

(11) You acknowledge and agree that you are solely responsible for compliance with all legal, regulatory and safety-related requirements concerning your products, and any use of Decawave Software in your applications, notwithstanding any applications-related information or support that may be provided by Decawave.

(12) Decawave reserves the right to make corrections, enhancements, improvements and other changes to its software, including Decawave Software, at any time.

Mailing address: Decawave Ltd.,
Adelaide Chambers,
Peter Street,
Dublin D08 T6YA
IRELAND.

1 INTRODUCTION AND OVERVIEW

1.1 DWM1001 module and the firmware

The DWM1001 module is a radio transceiver module integrating the Nordic Semiconductor nRF52 MCU and Decawave's DW1000 IC. The nRF52 MCU, which has Bluetooth v4.2 protocol stack implemented [1], is acting as the main processor of the DWM1001 module. The DW1000 IC part, which has the UWB physical layer defined in IEEE 802.15.4-2011 standard [2], is acting as the UWB radio module controlled by the nRF52 MCU.

Decawave provides a pre-built firmware library, the "Positioning and Networking stack" (PANS) library, in the DWM1001 module which runs on the nRF52 MCU. The firmware provides the Application Programming Interface (API) for users to use their own host devices to communicate with the DWM1001 module, namely the PANS API. The PANS API essentially is a set of functions providing a means to communicate with the nRF52 MCU to drive the module through the PANS library on application level without having to deal with the details of accessing the DW1000 IC part and other peripherals directly through its SPI/I2C interface register set. The detailed information of the firmware is introduced in the DWM1001 Firmware User Guide [3].

1.2 API and its guide

The PANS APIs are a set of functions. Each individual API function may be accessed through various communication interfaces providing flexibility to developers in using the DWM1001 module and integrating it into their systems. The API accesses mainly come in as two types:

1) External access API: via UART, SPI and BLE.
2) Integrated access API: via on-board user app (C code).

The detailed introduction to the flow with examples of how the API can be used is introduced in [3].

This document, "*DWM1001 API Guide*", specifies the PANS API functions themselves, providing descriptions of each of the API functions in detail in terms of its parameters, functionality and utility. Users can use the PANS API to configure each individual DWM1001 module. To setup a location system with multiple DWM1001 modules, users should refer to the DWM1001 System Guide [4].

This document relates to: `"DWM1001 PANS Library Version 1.1.5"`

2 GENERAL API DESCRIPTIONS

2.1 External Interface usage

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.

2.2 Low power mode wake-up mechanism

As provided in the PANS library, the DWM1001 module can work in a low power mode. In the low power mode, the module puts the API related threads into "sleep" state when the API is not currently being communicated by host devices. In this case, the host device needs to wake up the module through external interfaces before the real communication can start.

For UART interface, the host device needs to send a single byte first to wake up the module.

For SPI interface, putting the chip select pin to low level wakes up the module, i.e. no extra transmission is needed.

After the API transmission has finished, the host device needs to put the module back to "sleep" state to save power, as introduced in section 4.3.8 and section 5.4.

2.3 TLV format

TLV format, the Type-Length-Value encoding, is used in the DWM1001 module API. Data in TLV format always begins with the type byte, followed by the length byte, and then followed by a variable number of value bytes [0 to 253] as specified by the length byte. Table 1 shows an example of TLV format data, in which the type byte is 0x28, the length byte is 0x02, and as declared by the length byte, the value field is of two bytes: 0x0D and 0x01.

In DWM1001 firmware, both SPI and UART APIs use TLV format for data transmission. Users should refer to the type list for the meaning of type bytes (see Section 6). And for each specific command or response, the value field is of different length to provide the corresponding information.

Table 1 TLV format data example

TLV request			
Type	**Length**	**Value**	
		gpio_idx	**gpio_value**
0x28	0x02	0x0d	0x01

2.4 DWM1001 threads

In the DWM1001 firmware system, there are many threads, including SPI, BLE, UART, Generic API, User App and other threads. Each thread deals with specific tasks:

The SPI, BLE and UART threads control the data transmission with external devices. They don't parse the requests they've received. All received requests are sent to the Generic API thread.

The Generic API thread is a parser of the received requests. It judges whether the incoming request is valid. If valid, the firmware goes on to prepare the corresponding data as response; if invalid, the firmware uses error message as response. Then the Generic API thread runs the call_back() function which sends the prepared response message back to the thread where the request comes from.

The on-board user application thread is an independent thread for the users to add their own functionalities. The entrance is provided in the dwm\example\ folder in the DWM1001 on-board package. An example project is given in dwm\example\dwm-simple\ folder.

2.5 API via BLE interface

This is described in DWM1001-Bletooth-API document.

2.6 API via SPI interface

2.6.1 DWM1001 SPI overview

DWM1001 SPI interface uses TLV format data. Users can use an external host device in SPI master mode to connect to the DWM1001 module SPI interface which operates in slave mode. The maximum SPI clock frequency is 8 MHz. (This is maximum supported by the nRF52 MCU)

In the DWM1001 SPI schemes, host device communicates with the DWM1001 through TLV requests. A full TLV request communication flow includes the following steps:

1) Host device sends TLV request;
2) DWM1001 prepares response;
3) Host device reads the length of total response;
4) Host device reads data response;

Because SPI uses full duplex communication, when the host device (as the SPI master) writes x bytes, it actually sends x bytes to the DWM1001 module (as the slave), and receives x bytes dummy in the same time. Similarly for reading, the host device sends x bytes of dummy, and receives x bytes data back as response. In the DWM1001 SPI scheme, the dummy bytes are octets of value 0xFF.

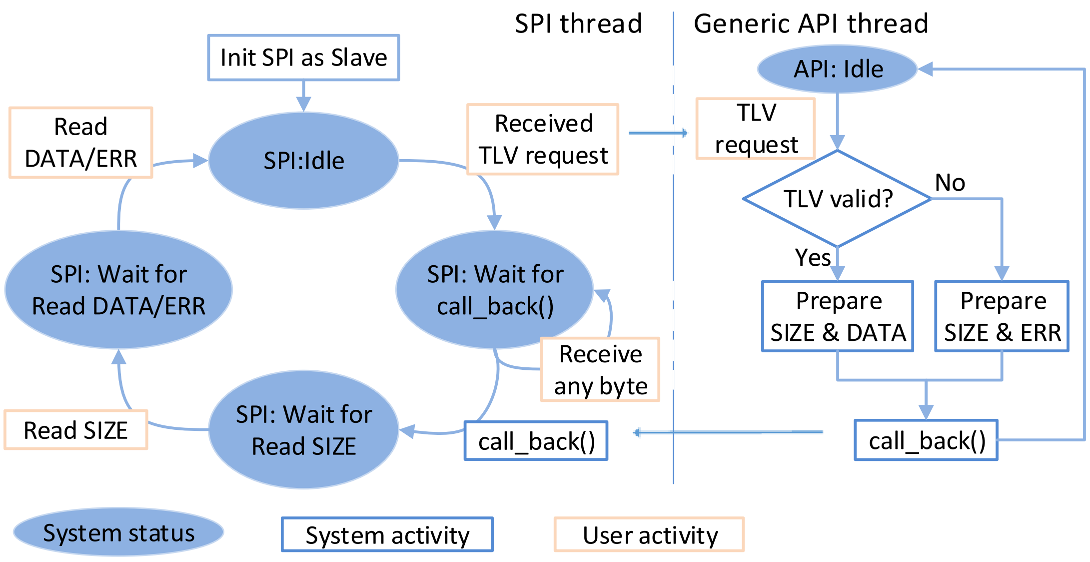


Figure 1 DWM1001 SPI work flow

As shown in Figure 1, the DWM1001 SPI thread transfers between four states in serial. Each state will transfer to its next corresponding state on certain events.

- **SPI: Idle**: the state after initialization and after each successful data transmission/response. In this state, any received data is assumed to be a TLV request. Thus, on receiving any data, the SPI thread in the firmware passes the received data to the Generic API. The Generic API parses the TLV requests and prepares the return data.
    - Waiting for event: receiving TLV requests.
    - Action on event – if Type==0xFF:
        - No action, stay in SPI: Idle. See Section 2.6.5 for more details.
    - Action on event – if Type≠0xFF :
        - Send received TLV request to Generic API thread.
        - Transfer to "SPI: Wait for call_back".
- **SPI: Wait for call_back**: the DWM1001 SPI is waiting for the Generic API to parse the TLV request and prepare the response. Any data from the host side will be ignored and returned with 0x00 in this state.
    - Waiting for event: call_back() function being called by the Generic API.
    - Action on event:
        - Toggle data ready pin HIGH – detailed in Section 2.6.4.
        - Transfer to "SPI: Wait for READ SIZE".
- **SPI: Wait for Read SIZE**: the DWM1001 SPI has prepared the SIZE byte as response, which is only one byte non-zero data indicating the size of data or error message to be responded, and is waiting for the host device to read the SIZE byte.
    - Waiting for event: host device reads one byte.
    - Action on event:
        - Respond with the SIZE byte.
        - Transfer to "SPI: Wait for READ DATA/ERR".
- **SPI: Wait for Read DATA/ERR**: the DWM1001 SPI has prepared SIZE bytes of data or error message as response to the TLV request, and is waiting for the host device to read it.
    - Waiting for event: host device reads any number of bytes.

- Action on event:
  - Respond with DATA/ERR.
  - Toggle data ready pin LOW – detailed in Section 2.6.4.
  - Transfer to “SPI: Idle”.

In DWM1001, starting from “SPI: Idle”, traversing all four states listed above and returning to “SPI: Idle” indicates a full TLV request communication flow. The user should have received the response data or error message by the end of the communication flow.

A few different usages and examples are illustrated in the following sub-sections.

2.6.2 SPI Scheme: normal TLV communication

Figure 2 shows the normal communication flow of a host device writing/reading information to/from the DWM1001 module:

1) Host device sends the request in TLV format.
2) Host device reads the SIZE byte, indicating the number of bytes ready to be read.
    a. On receiving SIZE= 0, meaning the response is not ready yet, repeat step 2).
    b. On receiving SIZE > 0, meaning the response is ready, go to step 3)
3) Host device reads SIZE bytes data response in TLV format.

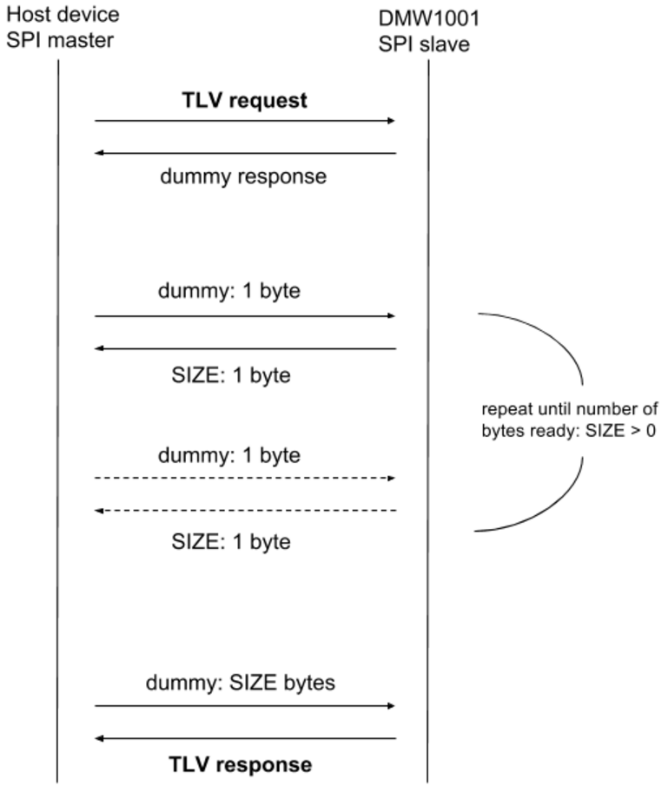


Figure 2 SPI scheme: normal TLV communication

2.6.3 SPI Example: normal TLV communication - dwm_gpio_cfg_output

Figure 3 illustrates an example of host device writing the dwm_gpio_cfg_output TLV request to set pin 13 level HIGH ([0x28, 0x02, 0x0D, 0x01] in byte array, detailed in Section 4.3.14) and reading the response from the DWM1001 module.

The communication flow of the transmission and response includes:

1) Host device writes the dwm_gpio_cfg_output command to set pin 13 level HIGH in TLV format, 4 bytes in total:
   Type = 0x28, length = 0x02, value = 0x0D 0x01.
2) Host device reads the SIZE byte, and receives SIZE = 0: the response is not ready yet. Repeat to read the SIZE byte.
3) Host device reads the SIZE byte again, and receives SIZE = 3: the response is ready. Proceed to read 3 bytes response data.
4) Host device reads the 3-byte TLV format data:
   Type = 0x40, Length = 0x01, value = 0x00,
   where Type = 0x40 indicates this is a return message (see Section 6), Length = 0x01 indicates that there is one byte following as data, value = 0x00 indicates the TLV request is parsed correctly.

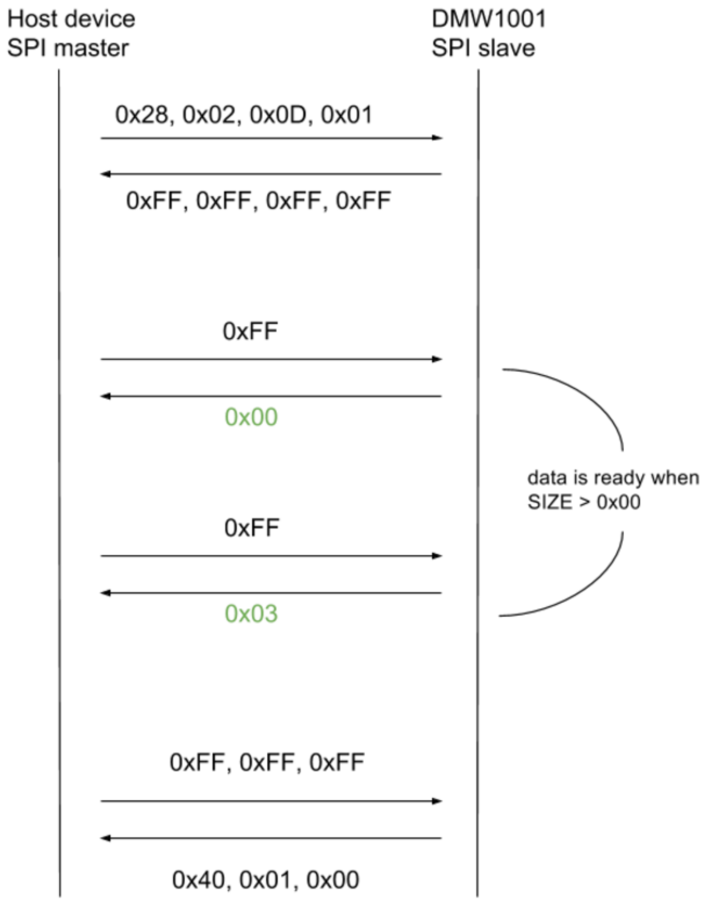


Figure 3 SPI example: normal TLV communication

2.6.4 SPI Scheme: TLV communication using data ready pin

Similar to the scheme described in Section 2.6.2, users can setup the data ready pin (GPIO P0.26) from the DWM1001 to indicate when data is ready, instead of the master polling multiple times to check the response status. When the data ready function is setup, the data ready pin will be set to LOW level when there's no data to be read; when the response SIZE and data is ready to be read, the data ready pin will be set to HIGH level during states "SPI: Wait for Read SIZE" and "SPI: Wait for Read DATA/ERR". Thus, the users can use the data ready pin either as an interrupt or as a status pin.

To setup data ready pin for SPI scheme, users need to use dwm_int_cfg TLV request through SPI Scheme: normal TLV communication introduced in Section 2.6.2. The detail of dwm_int_cfg request is introduced in Section 4.3.14.

The communication flow of this scheme is illustrated in Figure 4.

1) Setup the SPI interrupt.
2) Host device writes the request in TLV format.
3) Host device waits until the data ready pin on DWM1001 to go HIGH.
4) Host device reads the SIZE byte.
5) Host device reads SIZE bytes data response in TLV format

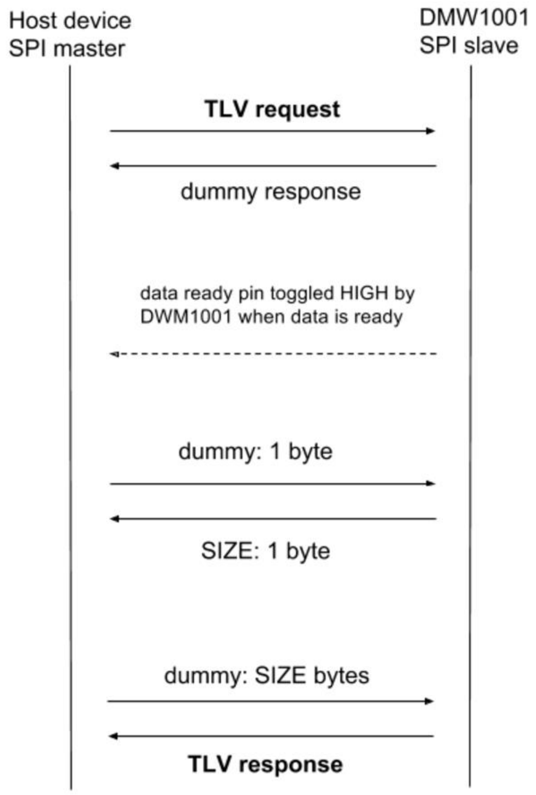


Figure 4 SPI scheme: TLV communication using data ready pin

As can be seen from the steps, this scheme is using the data ready pin on the DWM1001 to indicate the host device when the response data is ready. This makes the host device less busy in reading SIZE byte.

2.6.5 SPI error recovery mechanism

2.6.5.1 SPI data doesn't allow partial transmission

When reading data from the DWM1001 module, if the host device doesn't read all bytes of data in one transmission, the reading operation will still be considered as done. The rest of the response will be abandoned. For example, in "SPI: Wait for Read DATA/ERR" state, the DWM1001 module has prepared SIZE bytes of response data and expects the host device to read all SIZE bytes of the response. However, if the host device only reads part of the data, the DWM1001 module will drop the rest of the data, and transfers to the next state: "SPI: IDLE".

2.6.5.2 SPI state recovery: type_nop message

The DWM1001 SPI has a special Type value 0xFF, called type_nop. A TLV data message with type_nop means no operation. In "SPI: IDLE" state, when the DWM1001 SPI receives a message and finds the type byte is 0xFF, it will not perform any operation, including sending the TLV data message to the Generic API thread.

The type_nop is designed for error recovery. If the host device is not sure what state the DWM1001 SPI is in, it can make use of the SPI response and the non-partial transmission mechanism, and reset the DWM1001 SPI to "SPI: IDLE" state by sending three 0xFF dummy bytes, each in a single transmission. After the three transmissions, the response data from the DWM1001 SPI will become all dummy bytes of value 0xFF, indicating that the DWM1001 SPI is in "SPI: IDLE" state.

2.7 *API via UART interface*

2.7.1 DWM1001 UART overview

Users can use an external host device to connect to the DWM1001 module through UART interface at baud rate 115200. Figure 5 shows the work flow of the DWM1001 UART interface. In the UART Generic mode communication, the host device is acting as the initiator, while the DWM1001 module is the responder.

DWM1001 UART provides two modes: the UART Generic mode, commands introduced in Section 4, and the UART Shell mode, commands introduced in Section 5. The default mode of the DWM1001 UART is Generic mode. However, the two modes are transferrable:

Generic mode to Shell mode: press "Enter" twice or input two bytes [0x0D, 0x0D] within one second. If the module is in "sleep" state in low power mode as introduced in Section 2.2, an extra byte will be needed before the double "Enter". E.g. pressing "Enter" three times will wake up the module and transfer it to Shell mode.

Shell mode to Generic mode: users need to input "quit" command.

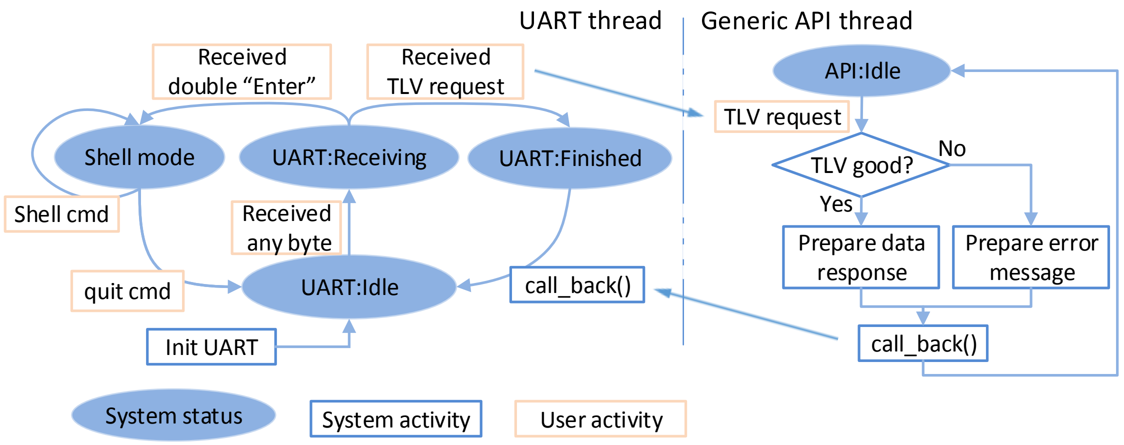


Figure 5 DWM1001 UART work flow

2.7.2 UART TLV Mode

UART TLV mode uses TLV format data. In this mode, host device and the DWM1001 module communicate using TLV requests/responses. A full TLV request communication flow includes the following steps:

1) Host device sends TLV request;
2) DWM1001 responds with TLV data.

On receiving any data, the UART starts a delay timer for the following data. If there is new data coming in within a delay period, specifically 25 clock cycles (25/32768 second ≈ 763 µs), the UART starts the delay timer and waits for new data. If there's no new data coming in within the delay period, the delay timer will expire. The UART then sends the received data to the Generic API thread and waits for it to return the response data or error message.

As shown in Figure 5, the DWM1001 UART TLV mode thread transfers between three states in serial: "UART: Idle", "UART: Receiving" and "UART: Finished". Each state will transfer to its next corresponding state on certain events.

- **UART: Idle**: is the state after initialization and after each successful TLV response. In this state, the UART is only expecting one byte as the start of the TLV request or the double "Enter" command.
    - Waiting for event: receiving TLV requests.
    - Action on event:
        - Start the delay timer.
        - Transfer to UART: Receiving.
- **UART: Receiving**: is the state waiting for end of the incoming request. On receiving any data in this state, the UART will refresh the delay timer. If the host device has finished sending bytes, the delay timer will expire.
    - Waiting for event: delay period timed out.
    - Action on event - if received request is double "Enter":
        - Transfer to UART Shell mode.
    - Action on event - if received request is not double "Enter":
        - Send received request to Generic API thread.
        - Transfer to UART: Finished.
- **UART: Finished**: is the state waiting for the Generic API thread to parse the incoming request and send the response data or error message back to UART thread.
    - Waiting for event: call_back() function called by the Generic API thread.
    - Action on event:
        - Send the response data or error message to host device.
        - Transfer to UART: Idle.

2.7.3 UART scheme: TLV mode communication

The UART communication in TLV mode is illustrated in Figure 6, steps described as below:

1) The host device sends a request in TLV format;
2) The DWM1001 module responds with a message in TLV format.

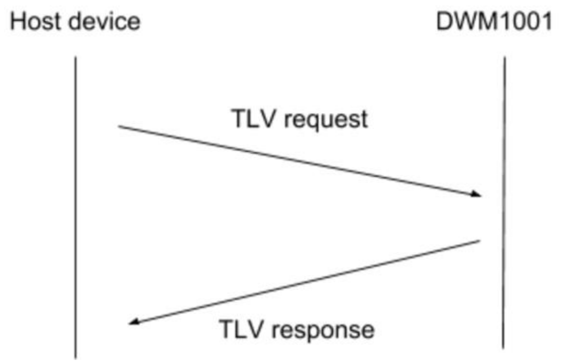


Figure 6 UART scheme: TLV mode communication

2.7.4 UART example: TLV mode communication

Figure 7 illustrates an example of host device sending the dwm_gpio_cfg_output command to set pin 13 level HIGH ([0x28, 0x02, 0x0D, 0x01] in byte array, detailed in Section 4.3.14) and receiving the response from the DWM1001 module using the UART API in TLV mode. The steps of the communication flow are:

1) The host device sends the dwm_gpio_cfg_output command in TLV format:
   Type = 0x28, Length = 0x02, Value = 0x0D 0x01.
2) The DWM1001 module responds in TLV format:
   Type = 0x40, Length = 0x01, value = 0x00,
   where Type = 0x40 indicates this is a return message (see Section 6), Length = 0x01 indicates that there is one byte following as data, value = 0x00 indicates the TLV request is parsed correctly.

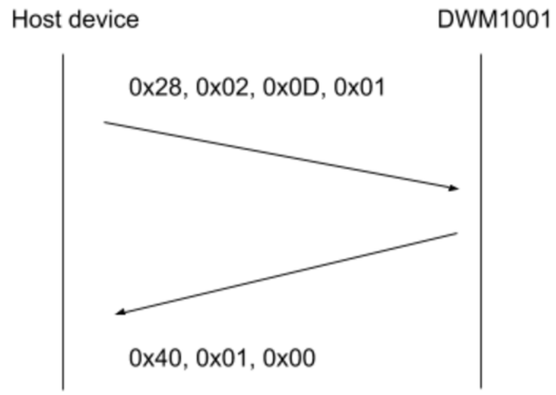


Figure 7 UART example: TLV mode communication

2.7.5 UART scheme: Shell mode communication

UART Shell mode provides prompt and uses Shell commands. The UART Shell mode intends to provide users with human readable access to the APIs, thus, all Shell commands are strings of letters followed by a character return, i.e. “Enter”. Users can input the string directly through keyboard and press “Enter” to send the Shell commands. DWM1001 UART stays in the Shell mode after each Shell commands except for the “quit” command.

As illustrated in Figure 8, a full Shell command communication flow includes the following steps:

1) Host device sends the Shell command + “Enter” to the DWM1001.
2) If there’s any message to respond, the DWM1001 sends the message to the host device.
3) If there’s nothing to respond, the DWM1001 doesn’t send anything and keeps quiet.

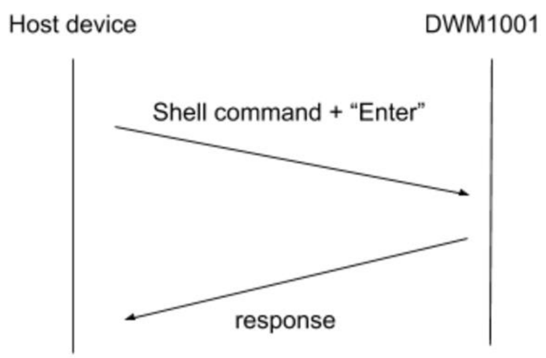


Figure 8 UART scheme: Shell mode communication

2.7.6 UART example: Shell Mode communication

Figure 9 illustrates an example of host device sending the "GPIO set" command using UART Shell to set pin 13 level HIGH ("gs 13" in byte array, followed by "Enter" key, detailed in Section 5.7). The steps of the communication flow are:

1) The host device sends the "GPIO set" command in Shell mode: "gs 13" + "Enter".
2) The DWM1001 responds the host with string "gpio13: 1".

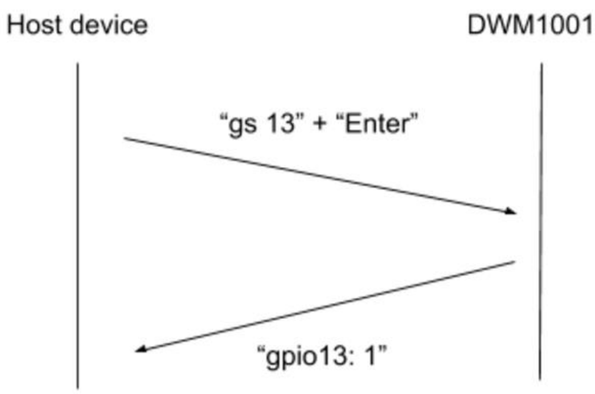


Figure 9 UART example: Shell mode communication

2.8 GPIO Scheme: DWM1001 notifies for status change

Rather than the host device initiating the SPI/UART communication, the DWM1001 module can send notifications of status change by toggling the dedicated GPIO pin (P0.26) to HIGH level, as illustrated in Figure 10. To enable this feature, host device needs to use the dwm_int_cfg command, detailed in Section 4.3.14. On detecting the HIGH level, host device can initiate a dwm_status_get command, detailed in Section 0, to get the status from the DWM1001 device. Both dwm_int_cfg and dwm_status_get commands can be sent through SPI or UART schemes introduced in the previous sections.

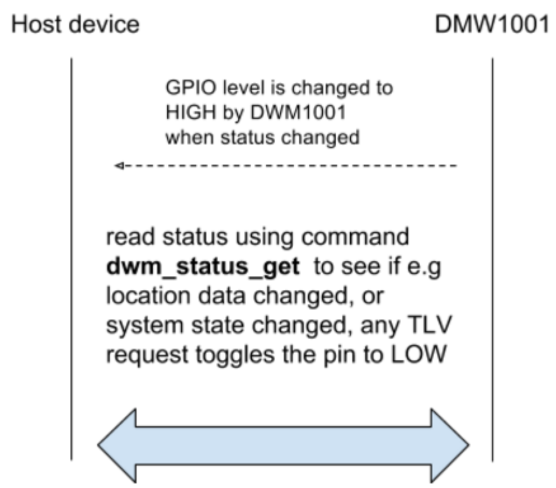


Figure 10 GPIO scheme: DWM1001 notifies host device of status change, using GPIO

This GPIO pin level change will be postponed if the status change happens during the SPI TLV request/response procedure described above to avoid conflict. In detail, when the SPI is in status: “SPI: Wait for call_back”, “SPI: Wait for Read SIZE” and “SPI: Wait for Read DATA/ERR”, the GPIO scheme will surrender the control of the GPIO pin. After the SPI communication when the SPI is in status “SPI: Idle”, the GPIO scheme will regain the control of the GPIO pin.

2.9 API for on-board C code developers

Decawave provides the DWM1001 source pack of the pre-built firmware. Users can add their own code and make use of the C code API functions in certain entry files provided in the source pack. In this way, users are able to add their own functions inside the module firmware and perhaps not need to add an external host controller device. The detail of adding such user code is provided in DWM1001 Firmware User Guide [3].

A few points the C code users should note when using the on-board firmware:

1) User application is based on eCos RTOS and DWM libraries.
2) Files used for linking with the user applications:
    a. dwm.h - header file - wrapper for all header files necessary for building of the user application
    b. libdwm.a - static library
    c. extras.o, vectors.o, libtarget.a - eCos static library
    d. target_s132_fw1.ld - linker script for firmware section 1
    e. target_s132_fw2.ld - linker script for firmware section 2
3) The API provides functions and defines to the user application
    a. Common functions on operating systems like thread creation, memory allocation, access to interfaces (e.g. GPIO, SPI), synchronization (e.g. mutex, signal)
    b. Initialization, configuration and maintenance of the DWM communication stack
    c. Register of callbacks for incoming data and measurements

3 GENERIC API INFORMATION

3.1 Used terminology

Anchor: has a fixed location – as a reference point to locate Tags. The module may be configured to behave as an anchor node. An anchor initiator is an anchor with the initiator flag enabled as introduced in section 3.4.8. It is a special anchor node that initiates the whole network, see the system overview for more detail [4].

Tag: usually moving/changing location, determines its position dynamically with the help of the anchors. The module may be configured to behave as a tag node.

Gateway: knows about all nodes in the network, provides status information about network nodes (read/inspect), cache this information and provide it to gateway client, provides means to interact with network elements (a.k.a. interaction proxy).

Node: network node (anchor, tag, gateway...)

LE: location engine – position solver function (on the tag)

3.2 Little endian

The integers used in the PANS API are little endian, unless otherwise stated.

3.3 Firmware update

As introduced in the DWM1001 System Overview [4], the nodes will compare their firmware version to the network they want to join. If the firmware version is different, the nodes will try to update their firmware before joining. This firmware update function can be enabled/disabled in the configuration. Here lists the rules of the function that the nodes will follow.

Tag:

When enabled, the tag will always check the firmware version and try to synchronise its firmware version with the network by sending the update request to the nearby anchor nodes in the network before it starts ranging.

When disabled, the tag will start ranging without checking the firmware version. This can lead to version compatibility problems and must be dealt with very carefully.

Anchor:

When enabled, before joining the network, the anchor will check the firmware version and try to synchronise its firmware version with the network by sending the update request to the nearby anchor nodes. After having joined the network, the anchor will respond to nearby nodes' requests to update their firmware.

When disabled, before joining the network, the anchor will directly send the join request and will not check the firmware version. This can lead to version compatibility problems and must be dealt with very carefully. After having joined the network, the anchor will ignore the firmware update requests from the nearby nodes.

3.4 Frequently used TLV values

Below lists the data that are frequently used in the APIs, either as input parameters or output parameters. These parameters are of fixed size and some have their own value ranges.

3.4.1 err_code

1-byte error code, response information to the incoming requests.

err_code : 8-bit integer, valid values:
0 : OK
1 : unknown command or broken TLV frame
2 : internal error
3 : invalid parameter
4 : busy

3.4.2 position

13-byte position information of the node (anchor or tag).

position = x, y, z, qf : bytes 0-12, position coordinates and quality factor
x : bytes 0-3, 32-bit integer, in millimeters
y : bytes 4-7, 32-bit integer, in millimeters
z : bytes 8-11, 32-bit integer, in millimeters
qf : bytes 12, 8-bit integer, position quality factor in percent

3.4.3 gpio_idx

1-byte index of GPIO pins available to the user.

gpio_idx : 8-bit integer, valid values: 2, 8, 9, 10, 12, 13, 14, 15, 22, 23, 27, 30, 31.

Note: some GPIO pins are occupied by the PANS library and can only be accessed/controlled by through the APIs partially:

- When configured as tag and BLE function is enabled, GPIO2 is occupied.
- When LED function is enabled, GPIO 22, 30 and 31 are occupied.
- During the module reboot, the bootloader (as part of the firmware image) blinks twice the LEDs on GPIOs 22, 30 and 31 to indicate the module has restarted. Thus these GPIOs should be used with care during the first 1s of a reboot operation.

3.4.4 gpio_value

1-byte value of the GPIO pin.

gpio_value = 8-bit integer, valid values:

0 : set the I/O port pin to a LOW voltage, logic 0 value
1 : set the I/O port pin to a HIGH voltage, logic 1 value

3.4.5 gpio_pull

1-byte status of the GPIO pin as input.

gpio_pull = 8-bit integer, valid values:
0 : DWM_GPIO_PIN_NOPULL
1 : DWM_GPIO_PIN_PULLDOWN
3 : DWM_GPIO_PIN_PULLUP

3.4.6 fw_version

4-byte value representing the version number of the firmware.

fw_version = maj, min, patch, ver: bytes 0-3, firmware version
maj : byte 0, 8-bit number, MAJOR
min : byte 1, 8-bit number, MINOR
patch : byte 2, 8-bit number, PATCH
ver : byte 3, 8-bit number, **res** and **var**
res : byte 3, bits 4-7, 4-bit number, RESERVED
var : byte 3, bits 0-3, 4-bit number, VARIANT

3.4.7 cfg_tag

2 bytes, configuration of the tag, which contains common tag configuration parameters. Each bit represents different thing.

cfg_tag = accel_en, meas_mode, low_power_en, loc_engine_en, ble_en, uwb_mode, fw_upd_en: tag configuration information.
accel_en: accelerometer enable.
meas_mode: measurement mode. 0 - TWR; 1, 2, 3 - reserved.
low_power_en: low-power mode enable.
loc_engine_en: internal Location Engine enable. 0 means do not use internal Location Engine, 1 means internal Location Engine.
ble_en: Bluetooth enable.
uwb_mode: UWB operation mode: 0 - offline, 1 – passive, 2 – active.
fw_upd_en: Firmware update enable.

3.4.8 cfg_anchor

1 byte, configuration of the anchor, which contains common anchor configuration parameters. Each bit represents different thing.

cfg_anchor = initiator, bridge, ble_en, uwb_mode, fw_upd_en
initiator : Initiator role enable.
bridge : Bridge role enable.
ble_en : Bluetooth enable.
uwb_mode: UWB operation mode: 0 - offline, 1 – passive, 2 – active.
fw_upd_en : Firmware update enable.

3.4.9 cfg_node

2 bytes, configuration of the node, which contains common configuration parameters. Each bit represents different thing.

cfg_anchor = err_code, mode, initiator, bridge, low_power_en, meas_mode, loc_engine_en, ble_en, uwb_mode, fw_update_en
mode: 0 - tag, 1 - anchor.
initiator : Initiator role enable.
bridge : Bridge role enable.
accel_en: accelerometer enable.
meas_mode: measurement mode. 0 - TWR; 1, 2, 3 - reserved.
low_power_en: low-power mode enable.
loc_engine_en: internal Location Engine enable. 0 means do not use internal Location Engine, 1 means internal Location Engine is active.
ble_en: Bluetooth enable.
uwb_mode: UWB operation mode: 0 - offline, 1 – passive, 2 – active.
fw_upd_en: Firmware update enable.

4 API FUNCTION DESCRIPTIONS

4.1 List of API functions

The API functions for on-board user app (c code) and SPI/UART TLV commands are unified. Listed below in Table 2, in TLV type ascending order.

Table 2 API request function list

API function name	On-board user app available	SPI/UART TLV		Ref (Section)
		type	Length	
dwm_pos_set	y	0x01	0x0d	4.3.1
dwm_pos_get	y	0x02	0x00	4.3.2
dwm_upd_rate_set	y	0x03	0x02	4.3.3
dwm_upd_rate_get	y	0x04	0x00	4.3.4
dwm_cfg_tag_set	y	0x05	0x02	4.3.5
dwm_cfg_anchor_set	y	0x07	0x01	4.3.6
dwm_cfg_get	y	0x08	0x00	4.3.7
dwm_sleep	y	0x0a	0x00	4.3.8
dwm_loc_get	y	0x0c	0x00	4.3.9
dwm_baddr_set	y	0x0f	0x00	4.3.10
dwm_baddr_get	y	0x10	0x00	4.3.11
dwm_reset	y	0x14	0x00	4.3.12
dwm_ver_get	y	0x15	0x00	4.3.13
dwm_gpio_cfg_output	y	0x28	0x02	4.3.14
dwm_gpio_cfg_input	y	0x29	0x02	4.3.15
dwm_gpio_value_set	y	0x2a	0x02	4.3.16
dwm_gpio_value_get	y	0x2b	0x01	4.3.17
dwm_gpio_value_toggle	y	0x2c	0x01	4.3.18
dwm_status_get	n	0x32	0x00	4.3.19
dwm_int_cfg	n	0x34	0x02	4.3.20
dwm_gpio_irq_cfg	y	n/a	n/a	4.3.21
dwm_gpio_irq_dis	y	n/a	n/a	4.3.22
dwm_i2c_read	y	n/a	n/a	4.3.23
dwm_i2c_write	y	n/a	n/a	4.3.24
dwm_evt_cb_register	y	n/a	n/a	4.3.25

The definition and usage of the API functions are described below in individual sub-sections. In introducing each API function, all possible accesses are described, including c code, UART/SPI TLV.

Note: Some API functions are only provided in limited accesses.

Note: There are more TLV type than listed in Table 2. The TLV types that do not relate to API functions are not introduced here, e.g. the TLV response types. See Section 6 for the full TLV type list.

4.2 Usage of the APIs

Examples of how the UART Generic, SPI and C code API can be used is introduced in the DWM1001 Firmware User Guide [3]. The examples intend to give a brief view of the API usage and only include very simple API functions. The code in the source files of the examples can be changed to modify/add functionalities. The full list of API functions as shown in Table 2 can also be found in the included header files of the API source code packages. Table 3 lists the packages with examples of the corresponding APIs, the locations of the header files and the locations of the source files.

Table 3 API examples location

API	Package with examples	Header file location	Example source file location
C code	DWM1001 on-board package [5]	dwm\include\dwm.h	dwm\examples\dwm-simple\dwm-simple.c
UART Generic	DWM1001 Host API package [6]	include\dwm_api.h	examples\ex1_TWR_2Hosts\tag\tag_cfg.c
SPI	DWM1001 Host API package [6]	include\dwm_api.h	examples\ex1_TWR_2Hosts\tag\tag_cfg.c

4.3 Details of the API functions

The details of each API function listed in Table 2 are described in the below sub-sections.

4.3.1 dwm_pos_set

4.3.1.1 Description

This API function set the default position of the node. Default position is not used when in tag mode but is stored anyway so the module can be configured to anchor mode and use the value previously set by dwm_pos_set. This call does a write to internal flash in case of new value being set, hence should not be used frequently as can take, in worst case, hundreds of milliseconds.

Parameter			Description
Field	**Name**	**Size**	
Input	position	13-byte array	Position information, see Section 3.4.2
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.1.2 C code

Declaration:

```
int dwm_pos_set(dwm_pos_t* p_pos);
```

Example:

```
dwm_pos_t pos;
pos.qf = 100;
pos.x = 121;
pos.y = 50;
pos.z = 251;
dwm_pos_set(&pos);
```

4.3.1.3 SPI/UART Generic

Declaration:

TLV request		
Type	**Length**	**Value**
0x01	0x0D	position

Example:

TLV request					
Type	**Length**	**Value**			
		Position			
		32 bit value in little endian is x coordinate in millimeters	32 bit value in little endian is y coordinate in millimeters	32 bit value in little endian is z coordinate in millimeters	8 bit value is quality factor in percents (0-100)
0x01	0x0D	0x79 0x00 0x00 0x00 0x32 0x00 0x00 0x00 0xfb 0x00 0x00 0x00 0x64			

TLV response		
Type	**Length**	**Value**
		err_code
0x40	0x01	0x00

4.3.2 dwm_pos_get

4.3.2.1 Description

This API function obtain position of the node. If the current position of the node is not available, the default position previously set by dwm_pos_set will be returned.

Parameter			Description
Field	**Name**	**Size**	
Input	none		
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1
	position	13-byte array	position information, see Section 3.4.2

4.3.2.2 C code

Declaration:

```
int dwm_pos_set(dwm_pos_t* p_pos);
```

Example:

```
dwm_pos_t pos;
dwm_pos_get(&pos);
```

4.3.2.3 SPI/UART Generic

Declaration:

TLV request	
Type	**Length**
0x02	0x00

Example:

TLV request	
Type	**Length**
0x02	0x00

TLV response								
Type	**Length**	**Value**	**Type**	**Length**	**Value**			
		err_code			**Position**			
					32 bit value in little endian is x coordinate in millimeters	32 bit value in little endian is y coordinate in millimeters	32 bit value in little endian is z coordinate in millimeters	8 bit value is quality factor in percents (0-100)
0x40	0x01	0x00	0x41	0x0D	0x79 0x00 0x00 0x00 0x32 0x00 0x00 0x00 0xfb 0x00 0x00 0x00 0x64			

4.3.3 dwm_upd_rate_set

4.3.3.1 Description

This API function sets the update rate and the stationary update rate of the position in unit of 100 milliseconds. Stationary update rate must be greater or equal to normal update rate. This call does a write to the internal flash in case of new value being set, hence should not be used frequently as can take, in worst case, hundreds of milliseconds.

Parameter			Description
Field	**Name**	**Size**	
Input	update_rate	16-bit integer	position publication interval in multiples of 100 milliseconds
	update_rate_stationary	16-bit integer	position publication interval when node is not moving in multiples of 100 milliseconds, maximum is 2 minutes, must be greater or equal to normal update_rate
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.3.2 C code

Declaration:

```
int dwm_upd_rate_set(uint16_t ur, uint16 urs);
```

Example:

```
dwm_upd_rate_set(10, 50); // update rate 1 second. 5 seconds stationary
```

4.3.3.3 SPI/UART Generic

Declaration:

TLV request			
Type	**Length**	**Value**	
0x03	0x04	update_rate	update_rate_stationary

Example:

TLV request			
Type	**Length**	**Value**	
		update_rate	**update_rate_stationary**
		16 bit value in little endian, which is update rate in multiples of 100 ms (e.g. 0x0A 0x00 means 10)	16 bit value in little endian, which is stationary update rate in multiples of 100 ms. E.g. 0x0A 0x00 means 5.0.
0x03	0x04	0x0A 0x00	0x32 0x00

TLV response		
Type	**Length**	**Value**
		err_code
0x40	0x01	0x00

4.3.4 dwm_upd_rate_get

4.3.4.1 Description

This API function gets position update rate.

Parameter			Description
Field	**Name**	**Size**	
Input	none		
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1
	update_rate	16-bit integer	position update interval in multiples of 100 milliseconds,
	update_rate_stationary	16-bit integer	Stationary position update interval in multiples of 100 milliseconds

4.3.4.2 C code

Declaration:

```
int dwm_upd_rate_get(uint16_t* p_ur, uint16_t* p_urs);
```

Example:

```
uint16_t ur, urs;
dwm_upd_rate_get(&ur, &urs);
```

4.3.4.3 SPI/UART Generic

Declaration:

TLV request	
Type	**Length**
0x04	0x00

Example:

TLV request	
Type	**Length**
0x04	0x00

TLV response						
Type	**Length**	**Value**	**Type**	**Length**	**Value**	
		err_code			**update_rate**, first 2 bytes, indicating the position update interval in multiples of 100 ms. E.g. 0x0A 0x00 means 1.0s interval.	**update_rate_stationary**, second 2 bytes, indicating the stationary position update interval in multiples of 100 ms. E.g. 0x32 0x00 means 5.0s interval.
0x40	0x01	0x00	0x45	0x04	0x0A 0x00	0x32 0x00

4.3.5 dwm_cfg_tag_set

4.3.5.1 Description

This API function configures the node as tag with given options. It automatically resets the DWM module. This call does a write to internal flash in case of new value being set, hence should not be used frequently as can take, in worst case, hundreds of milliseconds. Note that this function only sets the configuration parameters. To make effect of the settings, users should issue a reset command, see section 4.3.12 for more detail.

Parameter			Description
Field	**Name**	**Size**	
Input	cfg_tag	16-bit integer	2-byte, configuration of the tag, see Section 3.4.7
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.5.2 C code

Declaration:

```
int dwm_cfg_tag_set(dwm_cfg_tag_t* p_cfg);
```

Example:

```
dwm_cfg_tag_t cfg;

cfg.accel_en = 0;
cfg.low_power_en = 1;
cfg.meas_mode = DWM_MEAS_MODE_TWR;
cfg.loc_engine_en = 1;
cfg.common.ble_en = 1;
cfg.common.online = 1;
cfg.common.fw_update_en = 1;
cfg.common.uwb_mode = DWM_UWB_MODE_ACTIVE;
dwm_cfg_tag_set(&cfg);
```

4.3.5.3 SPI/UART Generic

Declaration:

TLV request		
Type	**Length**	**Value**
		(* BYTE 1 *) (bits 3-7) reserved (bit 2) accel_en (bits 0-1) meas_mode : 0 - TWR, 1-3 reserved (* BYTE 0 *) (bit 7) low_power_en (bit 6) loc_engine_en (bit 5) reserved (bit 4) led_en (bit 3) ble_en (bit 2) fw_update_en (bits 0-1) uwb_mode
0x05	0x02	cfg_tag

Example:

TLV request		
Type	**Length**	**Value**
		cfg_tag: low_power_en, loc_engine_en, ble_en, DWM_UWB_MODE_ACTIVE, fw_update_en
0x03	0x04	0xCC 0x00

TLV response

Type	Length	Value
		err_code
0x40	0x01	0x00

4.3.6 dwm_cfg_anchor_set

4.3.6.1 Description

This API function configures the node as tag with given options. It automatically resets the DWM module. This call does a write to internal flash in case of new value being set, hence should not be used frequently as can take, in worst case, hundreds of milliseconds. Note that this function only sets the configuration parameters. To make effect of the settings, users should issue a reset command, see section 4.3.12 for more detail.

Parameter			Description
Field	Name	Size	
Input	cfg_anchor	8-bit integer	1-byte, configuration of the tag, see Section 3.4.8
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.6.2 C code

Declaration:

```
int dwm_cfg_anchor_set(dwm_cfg_anchor_t* p_cfg)
```

Example:

```
dwm_cfg_anchor_t cfg;

cfg.initiator = 1;
cfg.bridge = 0;
cfg.common.ble_en = 1;
cfg.common.online = 1;
cfg.common.fw_update_en = 1;
cfg.common.uwb_mode = DWM_UWB_MODE_ACTIVE;
dwm_cfg_anchor_set(&cfg);
```

4.3.6.3 SPI/UART Generic

Declaration:

TLV request		
Type	Length	Value
		(bit 7) initiator (bit 6) bridge (bit 5) reserved (bit 4) led_en (bit 3) ble_en (bit 2) fw_update_en (bits 0-1) uwb_mode
0x07	0x01	cfg_anchor

Example:

TLV request		
Type	Length	Value
		cfg_anchor: initiator, ble_en, fw_update_en, UWB_MODE_ACTIVE
0x03	0x04	0x8E

TLV response		
Type	Length	Value
		err_code
0x40	0x01	0x00

4.3.7 dwm_cfg_get

4.3.7.1 Description

This API function obtains the configuration of the node.

Parameter			Description
Field	Name	Size	
Input	none		
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1
	cfg_node	16-bit integer	configuration of the node, see Section 3.4.9

4.3.7.2 C code

Declaration:

```
int dwm_cfg_get(dwm_cfg_t* p_cfg);
```

Example:

```
dwm_cfg_t cfg;

dwm_cfg_get(&cfg);

printf("mode %u \n", cfg.mode);
printf("initiator %u \n", cfg.initiator);
printf("bridge %u \n", cfg.bridge);
printf("motion detection enabled %u \n", cfg.accel_en);
printf("measurement mode %u \n", cfg.meas_mode);
printf("low power enabled %u \n", cfg.low_power_en);
printf("internal location engine enabled %u \n", cfg.loc_engine_en);
printf("LED enabled %u \n", cfg.common.led_en);
printf("BLE enabled %u \n", cfg.common.ble_en);
printf("firmware update enabled %u \n", cfg.common.fw_update_en);
printf("UWB mode %u \n", cfg.common.uwb_mode);
```

4.3.7.3 SPI/UART Generic

Declaration:

TLV request	
Type	Length
0x08	0x00

Example:

TLV request	
Type	Length
0x08	0x00

TLV response					
Type	Length	Value	Type	Length	Value
		err_code			**cfg_node**: (* BYTE 1 *) (bits 6-7) reserved (bit 5) mode : 0 - tag, 1 - anchor (bit 4) initiator (bit 3) bridge (bit 2) accel_en (bits 0-1) meas_mode : 0 - TWR, 1-3 not supported (* BYTE 0 *) (bit 7) low_power_en (bit 6) loc_engine_en (bit 5) reserved (bit 4) led_en (bit 3) ble_en (bit 2) fw_update_en

					(bits 0-1) uwb_mode
0x40	0x01	0x00	0x46	0x02	0x07 0x04

4.3.8 dwm_sleep

4.3.8.1 Description

This API function puts the module into sleep mode. Low power option must be enabled otherwise an error will be returned.

Parameter			Description
Field	Name	Size	
Input	none		
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.8.2 C code

Declaration:

```
int dwm_sleep(void);
```

Example:

```
dwm_sleep();
```

4.3.8.3 SPI/UART Generic

Declaration:

TLV request	
Type	Length
0x0A	0x00

Example:

TLV request	
Type	Length
0x0A	0x00

TLV response		
Type	Length	Value
		err_code
0x40	0x01	0x00

4.3.9 dwm_loc_get

4.3.9.1 Description

Get last distances to the anchors (tag is currently ranging to) and the associated position. The interrupt is triggered when all TWR measurements have completed and the LE has finished. If the LE is disabled, the distances will just be returned. This API works the same way in both Responsive and Low-Power tag modes.

Parameter			Description
Field	Name	Size	
Input	none		
Output	position	13-byte array	Position information of the current node, see Section 3.4.2
	dist.cnt	1-byte	Number of distances to the anchors, max 15.
	dist.addr	8-byte/2-byte	public UWB address in little endian. (1)
	dist.dist	4-byte	Distances to the anchors. (1)
	dist.qf	1-byte	Quality factor of distances to the anchors. (1)
	an_pos.cnt	1-byte	Number of anchor positions, max 15.
	an_pos	13-byte array	Anchor positions information, see Section 3.4.2. (2)

(1) This data can appear more than once according to the value of dist.cnt. This data is 8-byte long in C code API, 8-byte long in SPI/UART response for Anchor, and 2-byte long for SPI/UART response for Tag.

(2) This data can appear more than once according to the value of an_pos.cnt.

4.3.9.2 C code

Declaration:

```
int dwm_loc_get(dwm_loc_data_t* p_loc);
```

Example:

```
dwm_loc_data_t loc;
dwm_pos_t pos;
int rv, i;

loc.p_pos = &pos;
rv = dwm_loc_get(&loc);

if (0 == rv) {
        PRINT("[%ld,%ld,%ld,%u] ", loc.p_pos->x, loc.p_pos->y, loc.p_pos->z,
                        loc.p_pos->qf);

        for (i = 0; i < loc.anchors.dist.cnt; ++i) {
                PRINT("%u)", i);
                PRINT("0x%llx", loc.anchors.dist.addr[i]);
                if (i < loc.anchors.an_pos.cnt) {
                        PRINT("[%ld,%ld,%ld,%u]", loc.anchors.an_pos.pos[i].x,
                                loc.anchors.an_pos.pos[i].y,
                                loc.anchors.an_pos.pos[i].z,
                                loc.anchors.an_pos.pos[i].qf);
                }

                PRINT("=%lu,%u ", loc.anchors.dist.dist[i], loc.anchors.dist.qf[i]);
        }
        PRINT("\n");
} else {
        PRINT("err code: %d\n", rv);
}
```

4.3.9.3 SPI/UART Generic

Declaration:

TLV request	
Type	Length

0x0C	0x00

Example 1 (Tag node):

TLV request	
Type	**Length**
0x0C	0x00

TLV response											
Type	**Length**	**Value**	**Type**	**Length**	**Value**				**Type**	**Length**	**Value**
		err_code			**position**, 13 bytes						1 byte, number of distances encoded in the value
					4-byte x	4-byte y	4-byte z	1-byte quality factor			
0x40	0x01	0x00	0x41	0x0D	0x4b 0x0a 0x00 0x00 0x1f 0x04 0x00 0x00 0x9c 0x0e 0x00 0x00 0x64				0x49	0x51	0x04

TLV response (residue of the frame from previous table)								
Value								
2 bytes UWB address	4-byte distance	1-byte distance quality factor	position in standard 13 byte format	…	2 bytes UWB address	4-byte distance	1-byte distance quality factor	position in standard 13 byte format
position and distance AN1				AN2, AN3	position and distance AN4			

Example 2 (Anchor node):

TLV request	
Type	**Length**
0x0C	0x00

TLV response											
Type	**Length**	**Value**	**Type**	**Length**	**Value**				**Type**	**Length**	**Value**
		err_code			**position**, 13 bytes						1 byte, number of distances encoded in the value
					4-byte x	4-byte y	4-byte z	1-byte quality factor			
0x40	0x01	0x00	0x41	0x0D	0x4b 0x0a 0x00 0x00 0x1f 0x04 0x00 0x00 0x9c 0x0e 0x00 0x00 0x64				0x48	0xC4	0x0F

TLV response (residue of the frame from previous table)						
Value						
8 bytes UWB address	4-byte distance	1-byte distance quality factor	…	8 bytes UWB address	4-byte distance	1-byte distance quality factor
distance AN1			AN2, …, AN14	distance AN15		

4.3.10 dwm_baddr_set

4.3.10.1 Description

Sets the public Bluetooth address used by device. New address takes effect after reset. This call does a write to internal flash in case of new value being set, hence should not be used frequently as can take, in worst case, hundreds of milliseconds

Parameter			Description
Field	**Name**	**Size**	
Input	ble_addr	6-bytes	48-bit long public BluetoothE address in little endian.
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.10.2 C code

Declaration:

```
int dwm_baddr_set(dwm_baddr_t* p_baddr);
```

Example:

```
dwm_baddr_t baddr;

baddr.byte[0] = 1;
baddr.byte[1] = 2;
baddr.byte[2] = 3;
baddr.byte[3] = 4;
baddr.byte[4] = 5;
baddr.byte[5] = 6;
dwm_baddr_set(&baddr);
```

4.3.10.3 SPI/UART Generic

Declaration:

TLV request		
Type	**Length**	**Value**
0x0F	0x06	ble_addr

Example:

TLV request		
Type	**Length**	**Value**
		ble_addr, 6 bytes in little endian
0x0F	0x06	0x01 0x23 0x45 0x67 0x89 0xab

TLV response		
Type	**Length**	**Value**
		err_code
0x40	0x01	0x00

4.3.11 dwm_baddr_get

4.3.11.1 Description

Get Bluetooth address currently used by device.

Parameter			Description
Field	Name	Size	
Input	none		
Output	ble_addr	6-bytes	48-bit long public Bluetooth address in little endian.

4.3.11.2 C code

Declaration:

```
int dwm_baddr_get(dwm_baddr_t* p_baddr);
```

Example:

```
dwm_baddr_t baddr;
int i;

if (DWM_OK == dwm_baddr_get(&baddr)) {
        printf("addr=");
        for (i = DWM_BLE_ADDR_LEN - 1; i >= 0; --i) {
                printf("%02x%s", baddr.byte[i], (i > 0) ? ":" : "");
        }
        printf("\n");
} else {
        printf("FAILED");
}
```

4.3.11.3 SPI/UART Generic

Declaration:

TLV request	
Type	Length
0x10	0x00

Example:

TLV request	
Type	Length
0x10	0x00

TLV response					
Type	Length	Value	Type	Length	Value
		err_code			**ble_addr**, 6 bytes in little endian
0x40	0x01	0x00	0x5F	0x06	0x01 0x23 0x45 0x67 0x89 0xab

4.3.12 dwm_reset

4.3.12.1 Description

This API function reboots the module.

Parameter			Description
Field	**Name**	**Size**	
Input	none		
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.12.2 C code

Declaration:

```
int dwm_reset(void);
```

Example:

```
dwm_reset();
```

4.3.12.3 SPI/UART Generic

Declaration:

TLV request	
Type	**Length**
0x14	0x00

Example:

TLV request	
Type	**Length**
0x14	0x00

TLV response		
Type	**Length**	**Value**
		err_code
0x40	0x01	0x00

4.3.13 dwm_ver_get

4.3.13.1 Description

This API function obtains the firmware version of the module.

Parameter			Description
Field	**Name**	**Size**	
Input	none		
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1
	fw_version	4-byte array	firmware version, see Section 3.4.6
	cfg_version	4-byte array	configuration version, 32-bits integer
	hw_version	4-byte array	hardware version, 32-bits integer

4.3.13.2 C code

Declaration:

```
int dwm_ver_get(dwm_ver_t* p_ver);
```

Example:

```
dwm_ver_t ver;
dwm_ver_get(&ver);
```

4.3.13.3 SPI/UART Generic

Declaration:

TLV request	
Type	**Length**
0x15	0x00

Example:

TLV request	
Type	**Length**
0x15	0x00

TLV response								
Type	**Length**	**Value**	**Type**	**Length**	**Value**	**Type**	**Length**	**Value**
		err_code			**fw_version**: maj = 1 min = 2 patch = 5 var = 1			**cfg_version**
0x40	0x01	0x00	0x50	0x04	0x01 0x05 0x02 0x01	0x51	0x04	0x00 0x07 0x01 0x00

TLV response (residue of the frame from previous table)		
Type	**Length**	**Value**
		hw_version
0x52	0x04	0x2a 0x00 0xca 0xde

4.3.14 dwm_gpio_cfg_output

4.3.14.1 Description

This API function configures a specified GPIO pin as an output and also sets its value to 1 or 0, giving a high or low digital logic output value.

Note: During the module reboot, the bootloader (as part of the firmware image) blinks twice the LEDs on GPIOs 22, 30 and 31 to indicate the module has restarted. Thus these GPIOs should be used with care during the first 1s of a reboot operation.

Parameter			**Description**
Field	**Name**	**Size**	
Input	gpio_idx	8-bit integer	GPIO number, see Section 3.4.3 for valid values
	gpio_value	8-bit integer	0 or 1
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.14.2 C code

Declaration:

```
int dwm_gpio_cfg_output(dwm_gpio_idx_t idx, bool value);
```

Example:

```
dwm_gpio_cfg_output(DWM_GPIO_IDX_13, 1); // set pin 13 as output and to 1 (high voltage)
```

4.3.14.3 SPI/UART Generic

Declaration:

TLV request			
Type	**Length**	**Value**	
0x28	0x02	gpio_idx	gpio_value

Example:

TLV request			
Type	**Length**	**Value**	
		gpio_idx	**gpio_value**
0x28	0x02	0x0d	0x01

TLV response		
Type	**Length**	**Value**
		err_code
0x40	0x01	0x00

4.3.15 dwm_gpio_cfg_input

4.3.15.1 Description

This API function configure GPIO pin as input.

Note: During the module reboot, the bootloader (as part of the firmware image) blinks twice the LEDs on GPIOs 22, 30 and 31 to indicate the module has restarted. Thus these GPIOs should be used with care during the first 1s of a reboot operation.

Parameter			**Description**
Field	**Name**	**Size**	
Input	gpio_idx	8-bit integer	GPIO number, see Section 3.4.3 for valid values.
	gpio_pull	8-bit integer	GPIO pull status, see Section 3.4.53.4.3 for valid values.
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.15.2 C code

Declaration:

```
int dwm_gpio_cfg_input(dwm_gpio_idx_t idx, dwm_gpio_pin_pull_t pull_mode);
```

Example:

```
dwm_gpio_cfg_input(DWM_GPIO_IDX_13, DWM_GPIO_PIN_PULLUP);
```

4.3.15.3 SPI/UART Generic

Declaration:

TLV request			
Type	**Length**	**Value**	
0x29	0x02	gpio_idx	gpio_pull

Example:

TLV request			
Type	**Length**	**Value**	
		gpio_idx	**gpio_pull,** 0 -no pull 1 -pull down 3 -pull up
0x29	0x02	0x0D	0x01

TLV response		
Type	**Length**	**Value**
		err_code
0x40	0x01	0x00

4.3.16 dwm_gpio_value_set

4.3.16.1 Description

This API function sets the value of the GPIO pin to high or low.

Note: During the module reboot, the bootloader (as part of the firmware image) blinks twice the LEDs on GPIOs 22, 30 and 31 to indicate the module has restarted. Thus these GPIOs should be used with care during the first 1s of a reboot operation.

Parameter			Description
Field	**Name**	**Size**	
Input	gpio_idx	8-bit integer	GPIO number, see Section 3.4.3 for valid values.
	gpio_value	8-bit integer	GPIO value, see Section 0 for valid values.
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.16.2 C code

Declaration:

```
int dwm_gpio_value_set(dwm_gpio_idx_t idx, bool value);
```

Example:

```
dwm_gpio_value_set(DWM_GPIO_IDX_13, 1);
```

4.3.16.3 SPI/UART Generic

Declaration:

TLV request			
Type	**Length**	**Value**	
0x2a	0x02	gpio_idx	gpio_value

Example:

TLV request			
Type	**Length**	**Value**	
		gpio_idx	**gpio_value,** 0 - low 1 - high
0x2a	0x02	0x0D	0x01

TLV response		
Type	**Length**	**Value**
		err_code
0x40	0x01	0x00

4.3.17 dwm_gpio_value_get

4.3.17.1 Description

This API function reads the value of the GPIO pin.

Parameter			Description
Field	Name	Size	
Input	gpio_idx	8-bit integer	GPIO number, see Section 3.4.3 for valid values.
Output	gpio_value	8-bit integer	GPIO value, see Section 0 for valid values.

4.3.17.2 C code

Declaration:

```
int dwm_gpio_value_get(dwm_gpio_idx_t idx, bool* p_value);
```

Example:

```
uint8_t value;
dwm_gpio_value_get(DWM_GPIO_IDX_13, &value);
printf("DWM_GPIO_IDX_13 value = %u\n", value);
```

4.3.17.3 SPI/UART Generic

Declaration:

TLV request		
Type	Length	Value
0x2b	0x01	gpio_idx

Example:

TLV request		
Type	Length	Value
		gpio_idx
0x2b	0x01	0x0D

TLV response					
Type	Length	Value	Type	Length	Value
		err_code			gpio_value
0x40	0x01	0x00	0x55	0x01	0x01

4.3.18 dwm_gpio_value_toggle

4.3.18.1 Description

This API function toggles the value of the GPIO pin.

Note: During the module reboot, the bootloader (as part of the firmware image) blinks twice the LEDs on GPIOs 22, 30 and 31 to indicate the module has restarted. Thus these GPIOs should be used with care during the first 1s of a reboot operation.

Parameter			Description
Field	**Name**	**Size**	
Input	gpio_idx	8-bit integer	GPIO number, see Section 3.4.3 for valid values.
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.18.2 C code

Declaration:

```
int dwm_gpio_value_toggle(dwm_gpio_idx_t idx);
```

Example:

```
dwm_gpio_value_toggle(DWM_GPIO_IDX_13);
```

4.3.18.3 SPI/UART Generic

Declaration:

TLV request		
Type	**Length**	**Value**
0x2c	0x01	gpio_idx

Example:

TLV request		
Type	**Length**	**Value**
		gpio_idx
0x2c	0x01	0x0D

TLV response		
Type	**Length**	**Value**
		err_code
0x40	0x01	0x00

4.3.19 dwm_status_get

4.3.19.1 Description

This API function reads the system status: Location Data Ready. Location Data is the calculated result of the LE. When the tag finished TWR with the 4 anchors, the derived distance to the LE for position calculation. When this calculation is done, the Location Data Ready flag will be turn on. When the data is acquired by any API function, the flag will turn off until next calculation is done.

Parameter			**Description**
Field	**Name**	**Size**	
Input	none		
Output	status	8-bit integer	Bit0: loc_ready = '0' | '1' (* new location data are ready *) Bit1: uwbmac_joined = '0' | '1' (* node is connected to UWB network *)

4.3.19.2 C code

Declaration:

```
int dwm_status_get(dwm_status_t* p_status);
```

Example:

```
dwm_status_t status;
int rv;

rv = dwm_status_get(&status);
if (rv == DWM_OK) {
        printf("New location data: %d\n", status.loc_data);
        printf("UWB network joined: %d\n", status.uwbmac_joined);
} else {
        printf("error\n");
}
```

4.3.19.3 SPI/UART Generic

Declaration:

TLV request	
Type	**Length**
0x32	0x00

Example:

TLV request	
Type	**Length**
0x32	0x00

TLV response					
Type	**Length**	**Value**	**Type**	**Length**	**Value**
		err_code			**loc_ready**: yes **uwbmac_joined**: no
0x40	0x01	0x00	0x5A	0x01	0x01

4.3.20 dwm_int_cfg

4.3.20.1 Description

This API function enable interrupt generation for various events. Interrupts/events are communicated to the user by setting of dedicated GPIO pin (pin 19: READY), user can than read the status (dwm_status_get) and react according to the new status. The status is cleared when read. This call is available only on UART/SPI interfaces. This call does a write to internal flash in case of new value being set, hence should not be used frequently as can take, in worst case, hundreds of milliseconds.

Parameter			Description
Field	Name	Size	
Input	none		
Output	data_ready_flag	8-bit integer	Bit 0: loc_ready. Interrupt is generated when location data are ready, 0=disable, 1=enable. Bit 1: spi_data_ready. Interrupt is generated when new SPI response data is available. 0=disable, 1=enable.

4.3.20.2 C code

This command is not available for on-board user application. It is used only available on external interfaces (UART/SPI).

4.3.20.3 SPI/UART Generic

Declaration:

TLV request		
Type	Length	Value
0x34	0x00	data_ready_flag

Example:

TLV request		
Type	Length	Value
		data_ready_flag, bit 0: loc_ready bit 1: spi_data_ready
0x34	0x01	0x03

TLV response		
Type	Length	Value
		err_code
0x40	0x01	0x00

4.3.21 dwm_gpio_irq_cfg

4.3.21.1 Description

This API function registers GPIO pin interrupt call back functions.

Parameter			Description
Field	Name	Size	
Input	gpio_idx	8-bit integer	GPIO number, see Section 3.4.3 for valid values.
	Irq_type	8-bit integer	interrupt type, 1 = rising, 2 = falling, 3 = both.
	p_cb	Function pointer	Pointer to the callback function on the interrupt.
	p_data	Data pointer	Pointer to data passed to the callback function.
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.21.2 C code

Declaration:

```
int dwm_gpio_irq_cfg(dwm_gpio_idx_t idx, dwm_gpio_irq_type_t irq_type, dwm_gpio_cb_t* p_cb,
void* p_data);
```

Example:

```
void gpio_cb(void* p_data)
{
        /* callback routine */
}

dwm_gpio_irq_cfg(DWM_GPIO_IDX_13, DWM_IRQ_TYPE_EDGE_RISING, &gpio_cb, NULL);
```

4.3.21.3 SPI/UART Generic

This command is not available on external interfaces (UART/SPI).

4.3.22 dwm_gpio_irq_dis

4.3.22.1 Description

This API function disables GPIO pin interrupt on the selected pin.

Parameter			Description
Field	**Name**	**Size**	
Input	gpio_idx	8-bit integer	GPIO number, see Section 3.4.3 for valid values.
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.22.2 C code

Declaration:

```
int dwm_gpio_irq_dis(dwm_gpio_idx_t idx);
```

Example:

```
dwm_gpio_irq_dis(DWM_GPIO_IDX_13);
```

4.3.22.3 SPI/UART Generic

This command is not available on external interfaces (UART/SPI).

4.3.23 dwm_i2c_read

4.3.23.1 Description

This API function read data from I2C slave.

Parameter			Description
Field	**Name**	**Size**	
Input	addr	8-bit integer	Address of a slave device (only 7 LSB)
	p_data	8-bit integer	Pointer to a receive data buffer
	len	8-bit integer	Number of bytes to be received
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.23.2 C code

Declaration:

```
int dwm_i2c_read(uint8_t addr, uint8_t* p_data, uint8_t len);
```

Example:

```
uint8_t data[2];
const uint8_t addr = 0x33; // some address of the slave device

dwm_i2c_read(addr, data, 2);
```

4.3.23.3 SPI/UART Generic

This command is not available on external interfaces (UART/SPI).

4.3.24 dwm_i2c_write

4.3.24.1 Description

This API function writes data to I2C slave.

Parameter			Description
Field	**Name**	**Size**	
Input	addr	8-bit integer	Address of a slave device (only 7 LSB)
	p_data	8-bit integer	Pointer to a receive data buffer
	len	8-bit integer	Number of bytes to be received
	no_stop	8-bit integer	0 or 1. If set to 1, the stop condition is not generated on the bus after the transfer has completed (allowing for a repeated start in the next transfer)
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

4.3.24.2 C code

Declaration:

```
int dwm_i2c_write(uint8_t addr, uint8_t* p_data, uint8_t len, bool no_stop);
```

Example:

```
uint8_t data[2];
const uint8_t addr = 1; // some address of the slave device

data[0] = 0xAA;
data[1] = 0xBB;
dwm_i2c_write(addr, data, 2, true);
```

4.3.24.3 SPI/UART Generic

This command is not available on external interfaces (UART/SPI).

4.3.25 dwm_evt_cb_register

4.3.25.1 Description

This API function registers event callback function. The callback function is called in case of any event that is intended for the user application. The user application decides whether to process the event and the data passed as input or if it ignores the event. This function applies only to on-board c code user application. Cannot be used with SPI or UART interface.

Parameter			**Description**
Field	**Name**	**Size**	
Input	p_cb	Function pointer	Pointer to the callback function on the event, input and output described below.
	p_data	Data pointer	Pointer to data passed to the callback function.
Output	err_code	8-bit integer	0, 1 or 2, see Section 3.4.1

Input and output data of event callback function. Input data is passed to the user in the callback function. The user can get data for actual event using event_id, see example in subsection 4.3.25.2.

Parameter			**Description**
Field	**Name**	**Size**	
Input	**event_id**	8-bit integer	Event ID to indicate the type of current event. 0 : new location data event, 1 : accelerometer event
	loc_data	location data	Location data available in new location data event. cnt, 8-bit integer: number of distances to the anchors. addr, 64-bit integer: UWB address/id of the particular anchor. distance, 32-bit integer: distance to particular anchor in millimetres. pqf, 8-bit integer: quality factor.
Output	none		

4.3.25.2 C code

Declaration:

```
void dwm_evt_cb_register(dwm_evt_cb_t* p_cb, void* p_data);
```

Example:

```
void on_dwm_evt(dwm_evt_t* p_evt, void* p_data)
{
        int i;

        switch (p_evt->header.id) {
        case DWM_EVT_NEW_LOC_DATA:
                printf("\nt:%lu ", dwm_systime_us_get());
                /* process the data here */
                if (0 == p_evt->data.loc.p_pos) {
                        /* location engine is turned off */
                } else {
                        printf("[%ld,%ld,%ld,%u] ", p_evt->data.loc.p_pos->x,
                                        p_evt->data.loc.p_pos->y, p_evt->data.loc.p_pos->z,
                                        p_evt->data.loc.p_pos->qf);
                }

                for (i = 0; i < p_evt->data.loc.anchors.dist.cnt; ++i) {
                        printf("%u)", i);

                        printf("0x%llx", p_evt->data.loc.anchors.dist.addr[i]);
                        if (i < p_evt->data.loc.anchors.an_pos.cnt) {
                                printf("[%ld,%ld,%ld,%u]",
                                                p_evt->data.loc.anchors.an_pos.pos[i].x,
                                                p_evt->data.loc.anchors.an_pos.pos[i].y,
                                                p_evt->data.loc.anchors.an_pos.pos[i].z,
```

```
                                                p_evt->data.loc.anchors.an_pos.pos[i].qf);
                        }

                        printf("=%lu,%u ", p_evt->data.loc.anchors.dist.dist[i],
                                       p_evt->data.loc.anchors.dist.qf[i]);
                }
                printf("\n");
                break;

        default:
                break;
        }
}

…

int* p_user_data;
p_user_data = (int*)malloc(100);
dwm_evt_cb_register(on_dwm_evt, p_user_data);
…
/* if no user data are required */
dwm_evt_cb_register(on_dwm_evt, NULL);
```

4.3.25.3 SPI/UART Generic

This command is not available on external interfaces (UART/SPI).

5 SHELL COMMANDS

5.1 Usage of UART Shell Mode

Shell mode shares UART interface with Generic mode. DWM1001 starts by default in UART Generic mode after reset. The Shell mode can be switched to by pressing ENTER twice within 1 second. The Generic mode can be switched to by executing command "quit" when in Shell mode. Shell mode and Generic mode can be switched back and forth.

Enter the Shell command and press "Enter" to execute the command. Press "Enter" without any command in Shell mode to repeat the last command. The following sub-sections provides overview of the Shell commands.

5.2 ?

Displays help.

Example:

```
dwm> ?
Usage: <command> [arg0] [arg1]
Build-in commands:

** Command group: Base **
?: this help
help: this help
quit: quit

** Command group: GPIO **
gc: GPIO clear
gg: GPIO get
gs: GPIO set
gt: GPIO toggle

** Command group: SYS **
f: Show free memory on the heap
ps: Show running threads
pms: Show PM tasks
reset: Reboot the system
si: System info
ut: Show device uptime
frst: Factory reset

** Command group: SENS **
twi: General purpose TWI read
aid: Read ACC device ID
av: Read ACC values

** Command group: LE **
les: Show meas. and pos.
lec: Show meas. and pos. in CSV
lep: Show pos. in CSV
```

** Command group: UWBMAC **
nmg: Get node mode
nmp: Set mode to PN (passive)
nmo: Set mode to PN (off)
nma: Set mode to AN
nmi: Set mode to AIN
nmt: Set mode to TN
nmtl: Set mode to TN-LP
bpc: Toggle BW/TxPWR comp
la: Show AN list
stg: Get stats
stc: Clear stats

** Command group: API **
tlv: Send TLV frame
aurs: Set upd rate
aurg: Get upd rate
apg: Get pos
aps: Set pos
acas: Set anchor config
acts: Set tag config

** Tips **
Press Enter to repeat the last command

5.3 help

Displays help, same as command “?”.

Example:
dwm> help
… /*same output as command ? */

5.4 quit

Quit shell and switch UART into API mode.

Example:
dwm> quit
/* press enter twice to switch to shell mode again*/

5.5 gc

Clears GPIO pin. See section 3.4.3 for valid GPIO number.

Example:
dwm> gc
Usage: gc <pin>
dwm> gc 13
gpio13: 0

5.6 gg

Reads GPIO pin level. See section 3.4.3 for valid GPIO number.

Example:
dwm> gg
Usage: gg <pin>
dwm> gg 13
gpio13: 0

5.7 gs

Sets GPIO as output and sets its value. See section 3.4.3 for valid GPIO number.

Example:
dwm> gs
Usage: gs <pin>
dwm> gs 13
gpio13: 1

5.8 gt

Toggles GPIO pin (must be output). See section 3.4.3 for valid GPIO number.

Example:
dwm> gt
Usage: gt <pin>
dwm> gt 13
gpio13: 0

5.9 f

Show free memory on the heap.

Example:
dwm> f
[000014.560 INF] mem: free=3888 alloc=9184 tot=13072

5.10 ps

Show info about running threads.

Example:
```
dwm> ps
ID NAME             PRIO STACK  USED
 1 idle              31   512   304
 2 ser               13   768   360
 3 svc               15  1024   512
 4 uwb                5  2560   760
 5 api               10  2048  1180
 6 sd                 6  1024   352
 7 ble                7  1024   392
 8 le                14  2048   688
```

9 pm 17 512 304
10 sh 16 2048 1096

5.11 pms

Show power managements tasks. IDL means that task is idle. USE means that task is allocated in the power management.

Example:
dwm> pms

ID	NAME	USE	IDL	ALM
0	ble	1	0	0
1	le	1	1	0
2	sh	1	0	0
3	--	0	0	0
4	--	0	0	0

5.12 reset

Reboot the system.

Example:
dwm> reset
/* node resets and boots in binary mode */

5.13 ut

Show device uptime.

Example:
dwm> ut
[000003.680 INF] uptime: 00:07:49.210 0 days (469210 ms)

5.14 frst

Factory reset.

Example:
dwm> frst

5.15 twi

General purpose I2C/TWI read.

Example: use twi to read accelerometer id. This should return the same value as using "aid" command. See section 5.16.
dwm> twi
Usage: twi <addr> <reg> [bytes to read (1 or 2)]
dwm> twi 0x33 0x0f 1
twi: addr=0x33, reg[0x0f]=0x33

5.16 aid

Read ACC device ID

Example:
dwm> aid
acc: 0x33

5.17 av

Read ACC values.

Example:
dwm> av
acc: x = 240, y = -3792, z = 16240
dwm> av
acc: x = 32, y = -3504, z = 15872
dwm> av
acc: x = 160, y = -3600, z = 16144

5.18 les

Show distances to ranging anchors and the position if location engine is enabled. Sending this command multiple times will turn on/off this functionality.

Example:
dwm> les
1151[5.00,8.00,2.25]=6.48 0CA8[0.00,8.00,2.25]=6.51 111C[5.00,0.00,2.25]=3.18
1150[0.00,0.00,2.25]=3.16 le_us=2576 est[2.57,1.98,1.68,100]

5.19 lec

Show distances to ranging anchors and the position if location engine is enabled in CSV format. Sending this command multiple times will turn on/off this functionality.

Example:
dwm> lec
DIST,4,AN0,1151,5.00,8.00,2.25,6.44,AN1,0CA8,0.00,8.00,2.25,6.50,AN2,111C,5.00,0.00,2.25,3.24,A
N3,1150,0.00,0.00,2.25,3.19,POS,2.55,2.01,1.71,98

5.20 lep

Show position in CSV format. Sending this command multiple times will turn on/off this functionality.

Example:
dwm> lep
POS,2.57,2.00,1.67,97

5.21 si

System info

Example:
dwm> si
[000077.340 INF] cfg:
[000077.340 INF] >fw1=x00022000
[000077.340 INF] board=DM1_A1
[000077.340 INF] cfg_ver=x00010500
[000077.350 INF] fw_ver=x01010200
[000077.350 INF] hw_ver=xDE410100
[000077.350 INF] opt=x03C10900
[000077.360 INF] fw_size[0]=x0001F000
[000077.360 INF] fw_size[1]=x0002F000
[000077.360 INF] fw_size[2]=x0002F000
[000077.370 INF] fw_csum[0]=x9445F89E
[000077.370 INF] fw_csum[1]=xF49DBF2A
[000077.370 INF] fw_csum[2]=xEB65F61F
[000077.380 INF] opt: LEDS LP UWB0 BLE I2C SPI UART
[000077.380 INF] mcu: temp=29.2 hfclk=rc:on lfclk=xtal:on
[000077.390 INF] uptime: 00:01:17.390 0 days (77390 ms)
[000077.390 INF] mem: free=2128 alloc=7224 tot=9352
[000077.400 INF] uwb: ch5 prf64 plen128 pac8 txcode9 rxcode9 sfd0 baud1
[000077.410 INF] uwb: tx_pwr=xC0/x25456585 125:250:500:norm[ms]=17:14:]
[000077.410 INF] uwb0: lna=0 xtaltrim=15 tx_delay=16472 rx_delay=16472
[000077.420 INF] uwb0: ID dev=xDECA0130 part=x1000113B lot=x10205EE9
[000077.430 INF] uwb0: panid=x0000 addr=xDECA7B1782D0113B
[000077.430 INF] mode: tn (act,twr,lp,nole)
[000077.440 INF] uwbmac: disconnected
[000077.440 INF] tn: upd_per=100000 upd_per_stat=100000 us
[000077.440 INF] tn: cnt=0 rtc:hrclk:devt dri=0.000000:0.000000:0.00000

5.22 nmg

Get node mode info.

Example:
dwm> nmg
mode: tn (act,twr,np,nole)

5.23 nmo

Enable passive offline option and resets the node.

Example:
dwm> nmo

/* press enter twice to switch to shell mode after reset*/
DWM1001 TWR Real Time Location System

Copyright : 2016-2017 LEAPS and Decawave
License : Please visit https://decawave.com/dwm1001_license
Compiled : Jul 3 2017 12:33:40

Help : ? or help

dwm> nmg
mode: tn (off,twr,np,nole)

5.24 nmp

Enable active offline option and resets the node.

Example:
dwm> nmp
/* press enter twice to switch to shell mode after reset*/
DWM1001 TWR Real Time Location System

Copyright : 2016-2017 LEAPS and Decawave
License : Please visit https://decawave.com/dwm1001_license
Compiled : Jul 3 2017 12:33:40

Help : ? or help

dwm> nmg
mode: tn (pasv,twr,np,nole)

5.25 nma

Configures node to as anchor, active and reset the node.

Example:
dwm> nma
/* press Enter twice */

DWM1001 TWR Real Time Location System

Copyright : 2016-2017 LEAPS and Decawave

License : Please visit https://decawave.com/dwm1001_license
Compiled : Jul 3 2017 12:33:40

Help : ? or help

dwm> nmg
mode: an (act,-,-)

5.26 nmi

Configures node to as anchor - initiator, active and reset the node.

Example:
dwm> nmi
/* press enter twice */

DWM1001 TWR Real Time Location System

Copyright : 2016-2017 LEAPS and Decawave
License : Please visit https://decawave.com/dwm1001_license
Compiled : Jul 3 2017 12:33:40

Help : ? or help

dwm> nmg
mode: ain (act,real,-)

5.27 nmt

Configures node to as tag, active and reset the node.

Example:
dwm> nmt
/* press enter twice */
DWM1001 TWR Real Time Location System

Copyright : 2016-2017 LEAPS and Decawave
License : Please visit https://decawave.com/dwm1001_license
Compiled : Jul 3 2017 12:33:40

Help : ? or help

dwm> nmg
mode: tn (act,twr,np,le)

5.28 nmtl

Configures node to as tag, active, low power and resets the node.

Example:
dwm> nmtl
/* press enter twice */
DWM1001 TWR Real Time Location System

Copyright : 2016-2017 LEAPS and Decawave
License : Please visit https://decawave.com/dwm1001_license
Compiled : Jul 3 2017 12:33:40

Help : ? or help

dwm> nmg
mode: tn (act,twr,lp,le)

5.29 bpc

Toggle UWB bandwidth / tx power compensation.

Example:
dwm> bpc
BW/TxPwr comp off
dwm> bpc
BW/TxPwr comp on

5.30 la

Show anchor list.

Example:
dwm> la
[003452.590 INF] AN: cnt=4 seq=x03
[003452.590 INF] 0) id=DECA5419E2E01151 seat=0 idl=0 seens=0 col=0 cl=000F nbr=000F fl=4002 opt=03C1B046 hw=DE41010
0 fw=01010101 fwc=7B033F01
[003452.600 INF] 1) id=DECA78A55EB00CA8 seat=1 idl=1 seens=119 col=0 cl=000F nbr=0000 fl=0000 opt=03C1B042 hw=DE410

100 fw=01010101 fwc=7B033F01
[003452.620 INF]   2) id=DECAFCED8D50111C seat=2 idl=1 seens=103 col=0 cl=000F nbr=0000 fl=0000 opt=03C1B042 hw=DE410
100 fw=01010101 fwc=7B033F01
[003452.640 INF]   3) id=DECA51421A901150 seat=3 idl=0 seens=81 col=0 cl=000F nbr=0000 fl=0000 opt=03C1B042 hw=DE4101
00 fw=01010101 fwc=7B033F01

5.31 stg

Displays statistics.

Example:

```
dwm> stg
uptime: 0
memfree: 0
mcu_temp: 0
rtc_drift: 0.000000
ble_con_ok: 0
ble_dis_ok: 0
ble_err: 0
uwb0_intr: 0
uwb0_rst: 0
rx_ok: 56454
rx_err: 0
tx_err: 0
tx_errx: 0
bcn_tx_ok: 1661
bcn_tx_err: 0
bcn_rx_ok: 0
alma_tx_ok: 51
alma_tx_err: 0
alma_rx_ok: 0
cl_tx_ok: 0
cl_tx_err: 0
cl_rx_ok: 0
cl_coll: 0
fwup_tx_ok: 0
fwup_tx_err: 0
fwup_rx_ok: 0
svc_tx_ok: 0
svc_tx_err: 0
svc_rx_ok: 0
clk_sync: 0
twr_ok: 0
twr_err: 0
```

res[0]: 0
res[1]: 0
res[2]: 0
res[3]: 0
res[4]: 0
res[5]: 0
res[6]: 0
res[7]: 0
tot_err: 0

5.32 stc

Clears statistics.

Example:
dwm> stc

5.33 tlv

Parses given TLV frame. See Section 4 for valid TLV commands.

Example: read node configuration
dwm> tlv 8 0
OUTPUT FRAME:
40 01 00 46 02 b0 00

Example: toggles GPIO pin 13
dwm> tlv 44 1 13
OUTPUT FRAME:
40 01 00

5.34 aurs

Set position update rate. See section 4.3.3 for more detail.

Example:
dwm> aurs
Usage aurs <ur> <urs>
dwm> aurs 10 20
err code: 0

5.35 aurg

Get position update rate. See section 4.3.4 for more detail.

Example:
dwm> aurg
err code: 0, upd rate: 10, 20(stat)

5.36 apg

Get position of the node. See section 3.4.2 for more detail.

Example:
dwm> apg
x:100 y:120 z:2500 qf:100

5.37 aps

Set position of the node. See section 3.4.2 for more detail.

Example:
dwm> aps
Usage aps <x> <y> <z>
dwm> aps 100 120 2500
err code: 0

5.38 acas

Configures node as anchor with given options. See section 3.4.8 for more detail. Note that this command only sets the configuration parameters. To make effect of the settings, users should issue s reset command, see section 5.12 for more detail.

Example:
dwm> acas
Usage acas <inr> <bridge> <leds> <ble> <uwb> <fw_upd>
dwm> acas 0 0 1 1 2 0
err code: 0

5.39 acts

Configures node as tag with given options. See section 3.4.7 for more detail. Note that this command only sets the configuration parameters. To make effect of the settings, users should issue s reset command, see section 5.12 for more detail.

Example:
dwm> acts
Usage acts <meas_mode> <accel_en> <low_pwr> <loc_en> <leds> <ble> <uwb> <fw_upd>
dwm> acts 0 1 0 1 1 0 0 0
err code: 0

6 APPENDIX A – TLV TYPE LIST

Table 4 DWM1001 TLV type list

Type		Comment
Name	Value	
TYPE_CMD_POS_SET	1	Request: set position coordinates XYZ
TYPE_CMD_POS_GET	2	Request: get position coordinates XYZ
TYPE_CMD_UR_SET	3	Request: set position update rate
TYPE_CMD_UR_GET	4	Request: get position update rate
TYPE_CMD_CFG_TN_SET	5	Request: set configuration for the tag
TYPE_CMD_CFG_AN_SET	7	Request: set configuration for the anchor
TYPE_CMD_CFG_GET	8	Request: get configuration data
TYPE_CMD_CFG_SAVE	9	Request: save configuration data
TYPE_CMD_SLEEP	10	Request: sleep
TYPE_CMD_LOC_GET	12	Request: location get
TYPE_CMD_BLE_ADDR_SET	15	Request: BLE address set
TYPE_CMD_BLE_ADDR_GET	16	Request: BLE address get
TYPE_CMD_RESET	20	Request: reset
TYPE_CMD_VER_GET	21	Request: get FW version
TYPE_CMD_GPIO_CFG_OUTPUT	40	Request: configure output pin and set
TYPE_CMD_GPIO_CFG_INPUT	41	Request: configure input pin
TYPE_CMD_GPIO_VAL_SET	42	Request: set pin value
TYPE_CMD_GPIO_VAL_GET	43	Request: get pin value
TYPE_CMD_GPIO_VAL_TOGGLE	44	Request: toggle pin value
TYPE_CMD_STATUS_GET	50	Request: get status
TYPE_CMD_INT_CFG	52	Request: configure interrupts
TYPE_RET_VAL	64	Response: the previous request is ok or error
TYPE_POS_XYZ	65	Response: position coordinates x,y,z
TYPE_POS_X	66	Response: position coordinate x
TYPE_POS_Y	67	Response: position coordinate y
TYPE_POS_Z	68	Response: position coordinate z
TYPE_UR	69	Response: update rate
TYPE_CFG	70	Response: configuration data
TYPE_DIST	72	Response: distances
TYPE_RNG_AN_POS_DIST	73	Response: ranging anchor distances and positions
TYPE_FW_VER	80	Response: firmware version
TYPE_CFG_VER	81	Response: configuration version
TYPE_HW_VER	82	Response: hardware version
TYPE_PIN_VAL	85	Response: pin value
TYPE_STATUS	90	Response: status
TYPE_CMD_N_POS_SET	128	Request: nested command set position
TYPE_CMD_N_LOC_GET	130	Request: nested command location get
TYPE_DUMMY	0	Reserved for SPI dummy byte

7 APPENDIX B – BIBLIOGRAPHY

1. nRF5 Getting Started, available from www.nordicsemi.com
2. IEEE 802.15.4-2011 or “IEEE Std 802.15.4™-2011” (Revision of IEEE Std 802.15.4-2006). IEEE Standard for Local and metropolitan area networks— Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs). IEEE Computer Society Sponsored by the LAN/MAN Standards Committee. Available from http://standards.ieee.org/
3. DWM1001 Firmware User Guide, available from www.decawave.com
4. DWM1001 System Overview, available from www.decawave.com
5. DWM1001 on-board package, available from www.decawave.com
6. DWM1001 Host API package, available from www.decawave.com

8 DOCUMENT HISTORY

Table 5: Document History

Revision	Date	Description
1.0	18-Dec-2017	Initial release.

9 ABOUT DECAWAVE

Decawave is a pioneering fabless semiconductor company whose flagship product, the DW1000, is a complete, single chip CMOS Ultra-Wideband IC based on the IEEE 802.15.4 standard UWB PHY. This device is the first in a family of parts.

The resulting silicon has a wide range of standards-based applications for both Real Time Location Systems (RTLS) and Ultra Low Power Wireless Transceivers in areas as diverse as manufacturing, healthcare, lighting, security, transport, and inventory and supply-chain management.

For further information on this or any other Decawave product contact a sales representative as follows: -

Decawave Ltd,
Adelaide Chambers,
Peter Street,
Dublin 8,
D08 T6YA,
Ireland.

mailto:sales@decawave.com
http://www.decawave.com/