
ATA8352 Software Application Development Application Note

Introduction

This application note describes the following topics for the ATA8352:

1. Software development and application software for the ATA8352 Ultra-Wideband (UWB) demo kit.
2. Evaluation software to test the operating modes of the ATA8352 device.
3. Software porting for other MCUs.

The user can control the device and port this application software to any other 8-bit, 16-bit or 32-bit MCU by using the Serial Peripheral Interface (SPI).

Notes:

- The development environment for the SAM C21 32-bit Cortex-M0 MCUs is Microchip Studio (formerly Atmel Studio). The user can download Microchip Studio from the [Microchip](#) website.
- This document is software guidance for the device version 7.0 and later.

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1. Quick References

1.1 Reference Documentation

For further details, refer to the following:

1. www.microchip.com
2. *ATA8352 Impulse-Radio Ultra-Wideband (IR_UWB) Transceiver Data Sheet*
3. *ATA8352 Impulse-Radio Ultra-Wideband (IR_UWB) Transceiver User's Guide*
4. *AN_42698_AT13526 : ASF Manual (ATSAM C21)*
5. *TD0A Demo Software for ATA8352 UWB Demo Kit*
6. *DS-TWR Demo Software for ATA8352 UWB Demo Kit*
7. *Demo Software for ATA8352 UWB Demo Kit*
8. *Evaluation Software for ATA8352 Demo Kit*
9. *ATA8352 TD0A Application Note*

1.2 Acronyms/Abbreviations

Table 1-1. Acronyms/Abbreviations

Acronyms	Abbreviations
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
FLL	Frequency Lock Loop
DS-TWR	Double-Sided Two-Way-Ranging
PR	Prover
RF	Radio Frequency
SMA	Sub Miniature version A
SSID	Secure Session Identifier
SWD	Serial Wire Debugger
USB	Universal Serial Bus
UWB	Ultra-Wide Band
VR	Verifier
XTAL	External Crystal
ToA	Time of Arrival
TD0A	Time Difference of Arrival
MCU	Microcontroller Unit
SW	Software
HW	Hardware
RX	Receiver
TX	Transmitter

.....continued

Acronyms	Abbreviations
DGI	Data Gateway Interface

2. Development Environment

Microchip Studio is the development environment for the SAM MCUs. The following hardware platforms are available for the UWB device:

1. A demo kit with the SAM C21 XplainedPro evaluation boards (see [Figure 3-1](#) and [Figure 3-2](#)). This demo kit uses an ATSAMC21J18A MCU (256-kByte Flash, 32-kByte SRAM, LIN, CAN-FD).
2. A support package with the ATAUWB-EK1 development board for SAM MCUs. This support package uses a ATSAMC21E16A MCU (64-kByte Flash, 8-kByte SRAM, LIN, CAN-FD).

3. Demo Kit Software Application

The ATA8352 device is a low-power Ultra-Wide-Band (UWB) transceiver with an integrated security layer for secure distance bounding, ranging, localization and point-to-point data communication.

The *ATA8352 Impulse-Radio Ultra-Wideband (IR_UWB) Transceiver Data Sheet* and *ATA8352 Impulse-Radio Ultra-Wideband (IR_UWB) Transceiver User's Guide* describe this distance bounding application using Verifier and Prover modes and the data communication with RX and TX modes. The *ATA8352 TDoA Application Note* describes ranging and localization applications. The TDoA mode uses the data communication with RX and TX modes together with the capability of the device to capture timestamps during transmission and reception. These timestamps will be used for ranging measurements in TDoA and TWS applications. For more information, refer to *TDoA Demo Software for ATA8352 UWB Demo Kit* and *DS-TWR Demo Software for ATA8352 UWB Demo Kit*.

The demo kit for the UWB ATA8352 device includes two UWB nodes using an XplainedPro SAM C21 MCU board with an attached UWB ATA8352 Break-out board Xplained Pro. One board acts as a Prover device, shown in [Figure 3-1](#), and the other as a Verifier device, shown in [Figure 3-2](#). The difference between the nodes is that the Verifier node includes an OLED board to display the measurement results. For more details, refer to the *ATA8352 Impulse-Radio Ultra-Wideband (IR-UWB) Transceiver User's Guide*.

Figure 3-1. UWB Prover Node

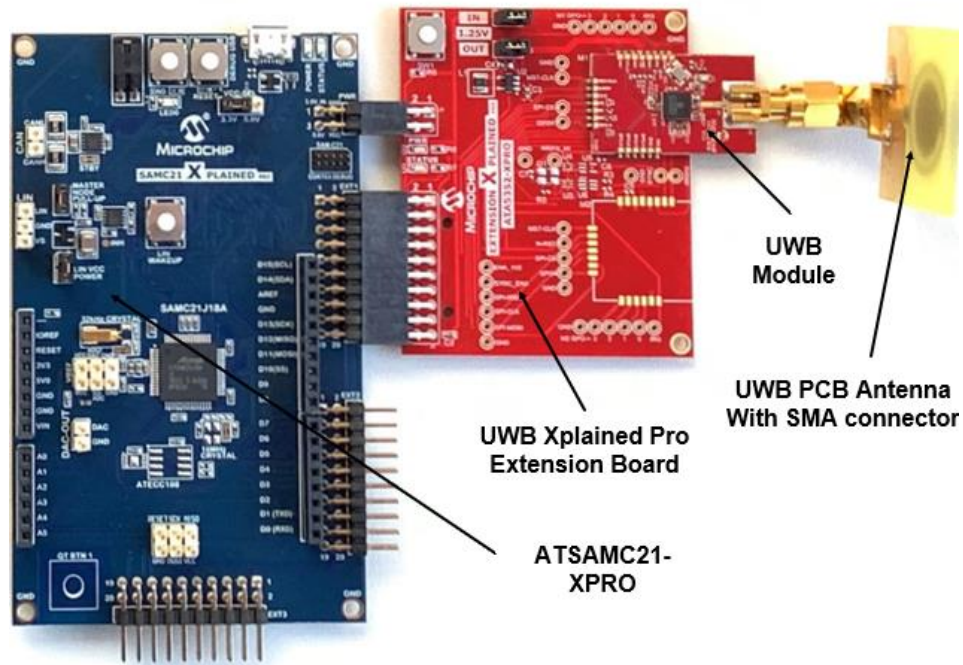
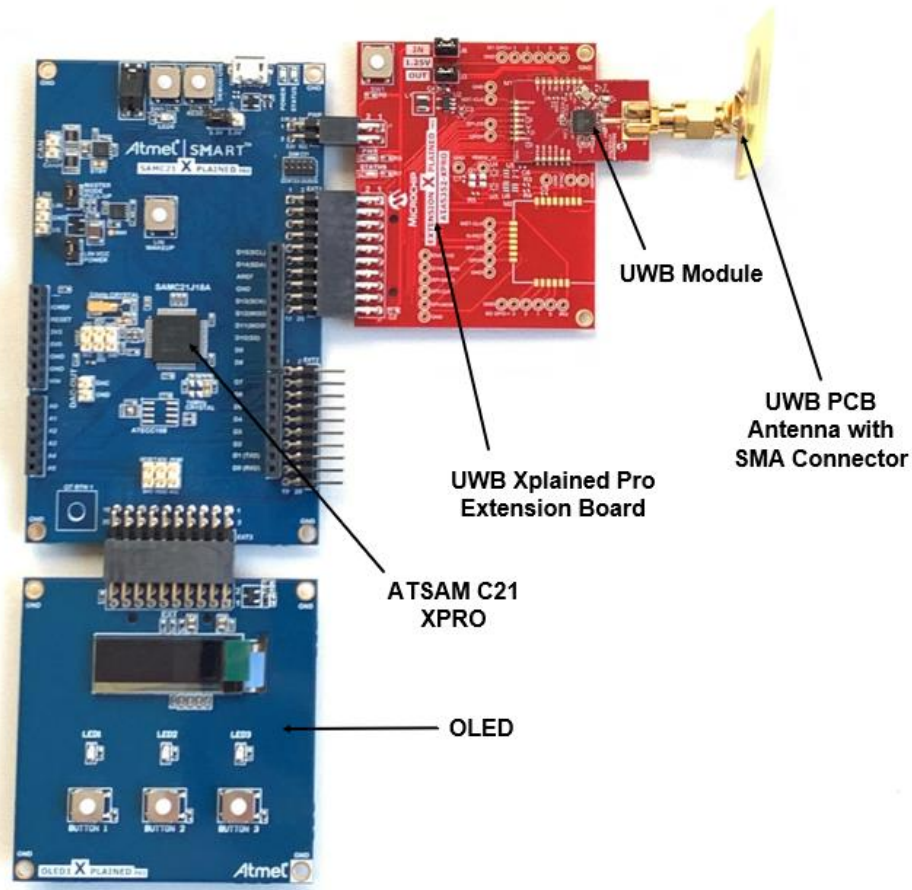
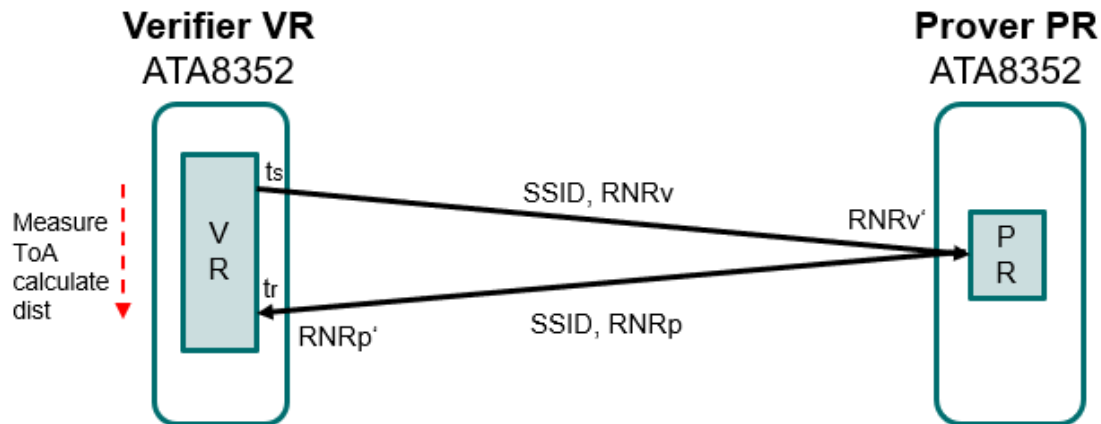


Figure 3-2. UWB Verifier Node



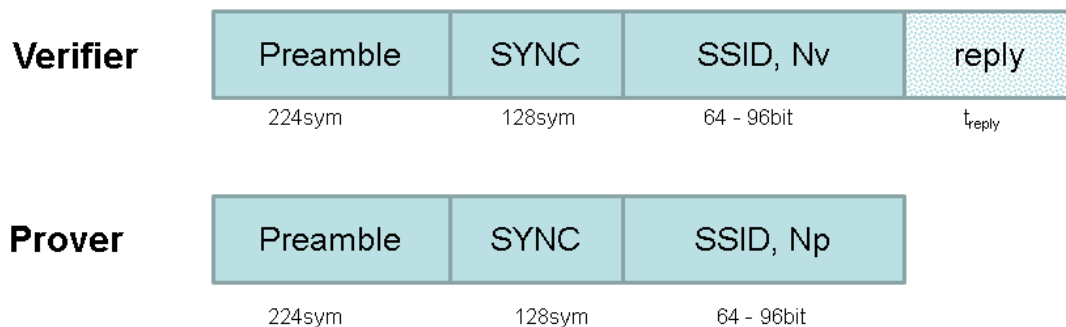
The following figure illustrates how to perform the distance bounding measurement. The Verifier node initiates the distance measurement and the Prover node responds to the signal. The ATA8352 hardware automatically triggers the measurement; in other words, when the data telegram transmission starts. The Verifier starts in the Verifier mode, initiates transmission and starts the measurement. The Prover node starts in the Prover mode, listens to the incoming data telegrams with a predefined SSID header and responds to the Verifier. The devices automatically switch the modes from transmitter to receiver (Verifier) and receiver to transmitter (Prover) after the first data telegram. Once the Verifier node receives the Prover response, the ATA8352 calculates the distance and displays the results on the OLED. The device repeats the measurement after 0.5s and displays on the OLED.

Figure 3-3. Distance Bounding Measurement



The following figure illustrates the data telegrams used during the measurement including the turnaround time (t_{reply}) to switch the receiver and transmitter modes.

Figure 3-4. Data Telegrams



Use Microchip Studio for the development of the software application for the Prover and Verifier nodes, as shown in [Figure 3-5](#). The following shows the structure of the UWB application software:

- Prover application layer
 - main_prover
 - uwb_prover_app.c
 - uwb_prover_app.h
- Verifier application layer
 - main_verifier
 - uwb_verifier_app.c
 - uwb_verifier_app.h
- UWB driver functions (common for Prover and Verifier nodes)

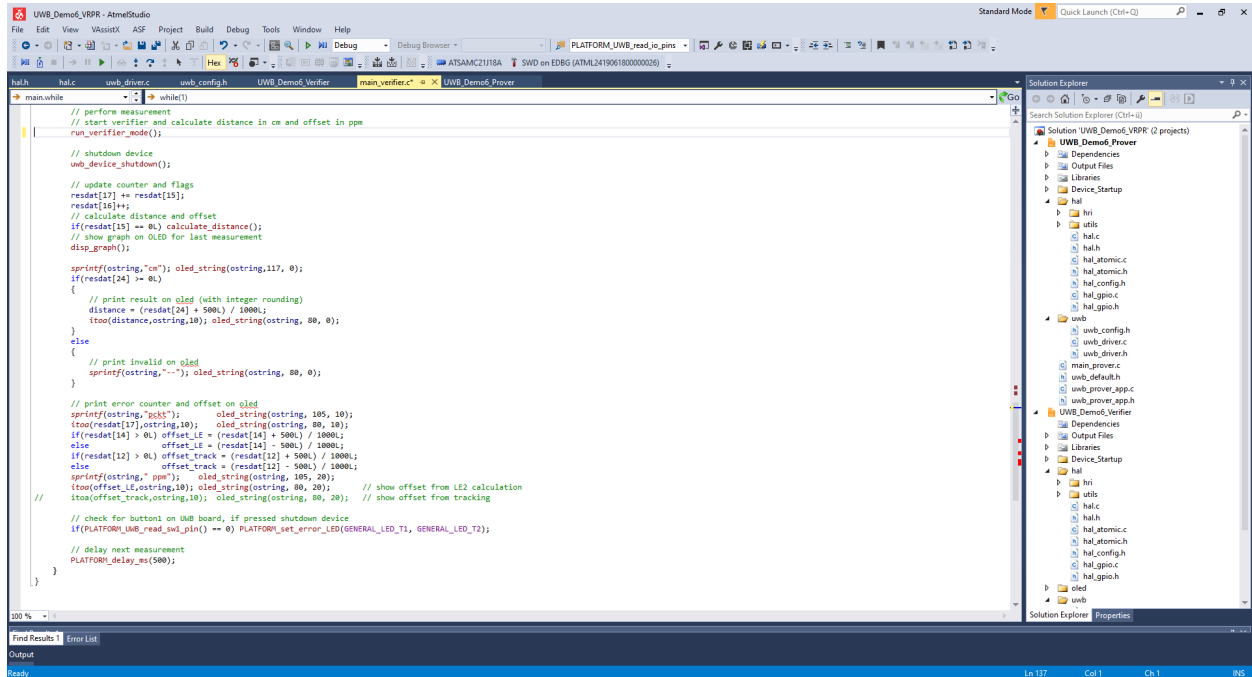
- uwb_driver.c
- uwb_driver.h
- uwb_config.h
- UWB default register settings (common for Prover and Verifier nodes)
 - uwb_default.h

The Hardware Abstraction Layer (HAL) is located in the following files:

- hal/hal.c
- hal/hal.h
- hal/hal_config.h

The software application also includes the basic functions (HAL) for the selected MCU. In other words, the user must modify these functions when porting the application to another MCU.

Figure 3-5. Microchip Studio Solution with Prover and Verifier Project



3.1 Verifier Application Flow

For the Verifier application, perform the following steps after the program starts:

1. Initialize the system and enable the 1.25V DC/DC converter.
2. Initialize the UWB device using the `uwb_device_init()` function:
 - 2.1. Release the nRESET signal.
 - 2.2. Copy the default SPI register data from the Flash/EEPROM into the SRAM working structure.
 - 2.3. Read the UWB device version number.
3. Check the UWB device version.
4. Set up the UWB device for the Prover or Verifier operating mode using the `uwb_setup_analog()` function:
 - 4.1. Load the SPI working structure into the SPI register of the ATA8352.
 - 4.2. Set up the PLL (and check the crystal operation).
 - 4.3. Set up the FLL for the RX function.
 - 4.4. Set up the FLL for the TX function.
 - 4.5. Configure the turnaround mode for the Prover or Verifier operation.

5. Execute the Verifier mode within an endless loop using the `run_verifier_mode()` function:
 - 5.1. Switch ON the 1.25V DC/DC converter.
 - 5.2. Set up the UWB device for the Prover/Verifier operating mode using the `uwb_setup_analog()` function.
 - 5.3. Initialize the Verifier operation using the `init_verifier_mode()`.
 - 5.3.1. Load the SSID data into the device SRAM.
 - 5.3.2. Configure the IRQ mask of the device.
 - 5.3.3. Clear the data buffer.
 - 5.4. Load the RNR data into the device FIFO.
 - 5.5. Enable the Verifier mode.
 - 5.6. Wait until the IRQ pin is active.
 - 5.7. Read the IRQ register of the device to clear the interrupt.
 - 5.8. Read the data buffer with measurement data and check if it is a valid value.
6. Shut down the device using the `uwb_device_shutdown()` function:
 - 6.1. Apply the nRESET signal.
 - 6.2. Disable the 1.25V DC/DC converter.
7. Calculate the distance `calculate_distance()`.
8. Display the output data on the OLED board (LE and MaxIDX/MaxV as a graph and distance and packet error as a value).

3.2 Prover Application Flow

For the Prover application, perform the following steps after the program starts:

1. Initialize the system and enable the 1.25V DC/DC converter.
2. Initialize the UWB device using the `uwb_device_init()` function.
 - 2.1. Release the nRESET signal.
 - 2.2. Copy the default SPI register data from the Flash/EEPROM into the SRAM working structure.
 - 2.3. Read the UWB device version number.
3. Check the UWB device version.
4. Set up the UWB device for the Prover or Verifier operating mode using the `uwb_setup_analog()` function:
 - 4.1. Load the SPI working structure into the SPI register of the ATA8352.
 - 4.2. Set up the PLL (and check the crystal operation).
 - 4.3. Set up the FLL for the RX function.
 - 4.4. Set up the FLL for the TX function.
 - 4.5. Configure the turnaround mode for the Prover or Verifier operation.
5. Initialize the Prover operation using the `init_prover_mode()` function:
 - 5.1. Load the SSID data into the device SRAM.
 - 5.2. Configure the IRQ mask of the device.
 - 5.3. Clear the data buffer.
6. Execute the Prover mode within an endless loop using `run_prover_mode()` function:
 - 6.1. Load the RNR data into the device SRAM.
 - 6.2. Read the IRQ register of the device to clear the interrupt signal.
 - 6.3. Clear the data buffer.
 - 6.4. Wait until the IRQ pin is active.
 - 6.5. Read the IRQ register of the device to clear the interrupt signal.
 - 6.6. Clear the data buffer.

3.3 Evaluation Application

The user can test the ATA8352 device operating modes using an evaluation application. This evaluation application uses the demo kit setup, as shown in [Figure 3-1](#) or [Figure 3-2](#), with a USB connection to the PC and a PC Terminal application program (TeraTerm or similar setup with 115.2 kBaud, 8-bit data, 1 stop bit). The test application shows a test menu in the PC Terminal window (see the following figure).

Figure 3-6. Evaluation Application

```
***** ATA8352_V6/7 Evaluation (c)2020 Microchip V1.2 *****

Initial trimming of XTAL @ 4.0MHz:
xtrim_freq_val<7:0> = 139

Initial trimming of FLL RX @ 3000MHz:
fllrx_bias min. FLL RX freq.
  15      2622MHz (4244MHz)
  14      2724MHz (4402MHz)
  13      2842MHz (4606MHz)
  12      3004MHz (4866MHz)
  11      3220MHz (5209MHz)
  10      3535MHz (5666MHz)
   9      4024MHz (6264MHz)
   8      3512MHz (145MHz)
FLL RX trim = 12
FLL RX tune = 7
----- Settings V60_00 -----
Parameter: RX=6512MHz[886], TX=6489MHz[824], TX_div=4, TX_tune=5, RX_tune=4
          Range: RX=5516...7457MHz TX=5071...7993
          TX_PA=(15:8, 15:8, 15:8, 15:8) XTAL_TRIM=-31(139)ppm
          Symbol-to-Bit=16:1 Preamble=224 Postamble=160 SSID=yes accuracy=s
td

Select OP-Mode or Parameter:
  0=PR  1=VR  2=PRo  3=VRo  4=PRs  5=VRs  6=PRso  7=VRso
  A=RX  B=TX  C=RXo  D=TXo
  E=Debug F=PA-test(TX) G=PA-test(TXo) R=reset
  H=Preamble J=SSID K=Symbol_map L=Accuracy
  M=TX_RX_freq. N=TXPA_level P=XTAL_trim
>
```

The evaluation application switches the device into different operating modes until the user aborts the mode by making an entry (typically the letter 'q'). During evaluation of the modes, the PC Terminal application displays the result data. The following table describes the operating modes or parameters that the user can select.

Table 3-1. Operating Mode Description

Parameter	Operating Mode (OP-Mode)	Description
0	PR mode	Prover mode with 4-byte SSID and 4-byte RNR data
1	VR mode	Verifier mode with 4-byte SSID and 4-byte RNR data
2	PRo mode	Prover offset mode with 4-byte SSID and 4-byte RNR data
3	VRo mode	Verifier offset mode with 4-byte SSID and 4-byte RNR data
4	PRs mode	Prover secure mode with 4-byte SSID and 4-byte RNR data
5	VRs mode	Verifier secure mode with 4-byte SSID and 4-byte RNR data
6	PRso mode	Prover offset secure mode with 4-byte SSID and 4-byte RNR data
7	VRso mode	Verifier offset secure mode with 4-byte SSID and 4-byte RNR data

.....continued

Parameter	Operating Mode (OP-Mode)	Description
A	RX mode	RX mode with 8-byte data
B	TX mode	TX mode with 8-byte data
C	RXo mode	RX offset mode with 8-byte data
D	TXo mode	TX offset mode with 8-byte data
E	DEBUG	Reads debug data ToA and debug data accumulator
F	PA_Test	TX power test mode (1 ms RMS mode)
G	PA-Testo	TX power test offset mode (1 ms RMS mode)
H	Short_Preamble	Transmits telegram with short preamble
J	Skip_SSID	Transmits telegram without SSID
K	Symbol_Map	Displays symbol map
M	TX_RX Freq.	Changes RF channel between 6.52, 7.04, 7.56 and 7.987 GHz
N	TX PA.	Changes TX level between 0 and 15
P	XTAL trim	Changes crystal trimming
R	RESET	Sets default configuration

4. Software Porting for Other MCUs

The UWB application software runs with a few basic functions that are specific to the target MCU. The user can change the Hardware Abstraction Layer (HAL) to port the application software to other MCUs if an SPI peripheral is available.

Note: The software implementations do not use Interrupt Request (IRQ) event processing and use polling to perform all I/O level checks.

The following table describes the HAL functions of the UWB software.

Table 4-1. HAL Target MCU Functions

Required Functions	Description
<code>void PLATFORM_delay_ms(uint16_t ms)</code>	Delay function (time in ms)
<code>void PLATFORM_delay_us(uint16_t us)</code>	Delay function (time in μ s)
<code>void PLATFORM_UWB_init(void)</code>	Initialization of I/O pins, SPI peripheral and power registers
<code>void PLATFORM_UWB_RST_N_set(uint8_t pinLevel)</code>	Enables or disables the reset signal
<code>void PLATFORM_set_V12(uint8_t pinLevel)</code>	Enables or disables 1.25V DC/DC converter
<code>uint8_t PLATFORM_UWB_read_irq_pin(void)</code>	Reads the IRQ signal
<code>uint8_t PLATFORM_UWB_read_io_pins(void)</code>	Reads the General Purpose Input/Output (GPIO) pins
<code>void PLATFORM_UWB_SPI_writeBytes(uint8_t *data, uint16_t length)</code>	Writes data bytes through the SPI peripheral
<code>uint8_t *PLATFORM_UWB_SPI_writeReadBytes(uint8_t *data, uint16_t length)</code>	Writes and reads data bytes via the SPI peripheral
Optional Functions	Description
<code>uint8_t PLATFORM_getchar(void)</code>	Reads character from the Debug port (UART peripheral)
<code>void PLATFORM_putchar(uint8_t data)</code>	Writes character to the Debug port (UART peripheral)
<code>void PLATFORM_set_LED(uint8_t pinLevel)</code>	Sets LED ON or OFF (optional)
<code>void PLATFORM_set_error_LED(uint16_t t1, uint16_t t2)</code>	Sets LED into the Blink mode
<code>uint8_t PLATFORM_UWB_read_sw1_pin(void)</code>	Reads SW1 button status

The user can locate these functions in the `hal.c` and `hal.h` files. These files also include other functions required to set up a target MCU.

The `uwb_default.h` contains a structure with the default SPI register values for the ATA8352 device. The user must locate this structure in the nonvolatile memory, such as flash or EEPROM.

The `uwb_driver.c` file includes a `uwb_init_default_register()` function to load these values into a working copy located in the SRAM, which is modified during the application flow.

5. Document Revision History

Revision	Date	Section	Description
A	01/2021	Document	Initial Revision

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