# UM1009
# User manual

## STM32L152-EVAL demonstration firmware

## Introduction

This user manual describes the demonstration firmware running on the STM32L152-EVAL evaluation board, which can be used to evaluate the capabilities of the STM32L152VB(T6) microcontroller and on-board peripherals.

This demo contains many applications that can be easily reused, such as RTC calendar, file system FAT implementation on SD Card, Wave player with STM32 DAC peripheral, automatic measure of the power consumption in several operating modes, temperature sensor interfacing and TFT LCD.

The STM32L152-EVAL board is delivered with the demonstration programmed in the internal Flash memory, and all the files needed by the demonstration are programmed in the MicroSD card. The demonstration is executed at each reset (board power-up, external reset, etc.).

In case the STM32L152-EVAL board was not factory-programmed or the demonstration application was erased, the Bootloader, IAP or USB DFU can be used to program this file. For more details, refer to *Section 3: STM32L152-EVAL demonstration package* and *Section 4: STM32L152-EVAL demonstration programming*.

*Note: Before you execute the demonstration, make sure that all EVAL board jumpers are well configured. For more details, refer to Section 1.10.7: STM32L152-EVAL board jumper configuration.*

This demonstration firmware and other such firmware are available for download from the STMicroelectronics website: *www.st.com*.

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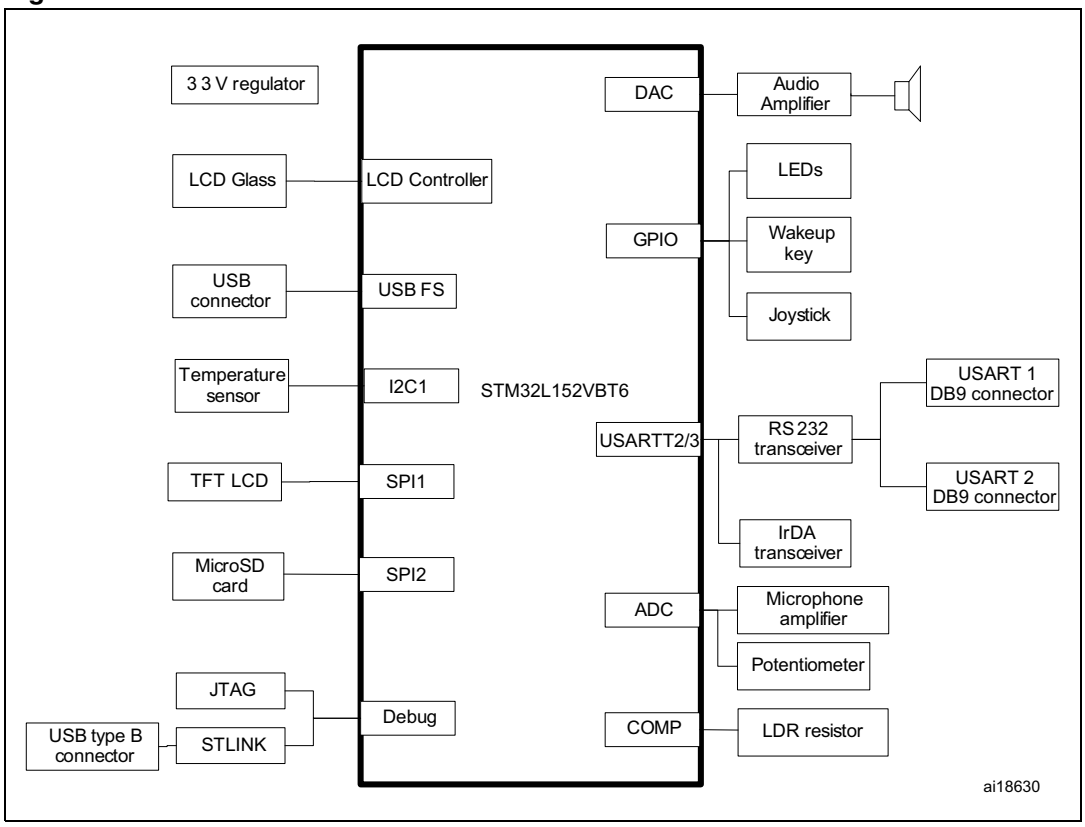
# 1 Functional description

The STM32L152VB(T6) microcontroller evaluation board provides a development and demonstration platform for STM32L152-based applications. It is designed to allow the user to try out the major functions of the STM32L152VB(T6) microcontroller.

*Figure 1* summarizes the main functional blocks of the evaluation board.

**Figure 1. Evaluation board overview**




## 1.1 Power control

The evaluation board can be powered from an external 5 V supply or from the USB connector or ST-Link connector. All other required voltages are provided by on-board voltage regulators.

## 1.2 Clocking

Two clock sources are available on the STM32L152-EVAL evaluation board:

- 32 kHz crystal for embedded RTC and glass LCD
- 8 MHz crystal for the STM32L152VB main clock system

## 1.3 Reset control

The reset can be generated by hardware or software:

- Reset button: activates the RESET input when pressed
- JTAG reset

## 1.4 Debug JTAG interface

Software debug is done via the standard ARM® JTAG connection: 20-pin IDC (insulation displacement connector) for connection to the standard ARM host interface.

## 1.5 Serial wire debugger interface

The Serial Wire Debug Port (SWD-DP) provides a 2-pin (clock + data) interface to the AHP-AP port.

## 1.6 Embedded ST-LINK

An embedded ST-LINK is integrated on the board as an embedded in-circuit debugger and programmer for the STM32L152VB MCU.

## 1.7 Display devices

### 1.7.1 LCD

A color LCD module is mounted on the STM32L152-EVAL board. It is interfaced through the embedded SPI peripheral.

### 1.7.2 LCD Glass

An LCD Glass module is mounted on the STM32L152-EVAL board. It is interfaced through the embedded LCD Glass peripheral.

### 1.7.3 LEDs

Four general-purpose LEDs are available. They are used as a display.

## 1.8 Interfaces

### 1.8.1 RS232

The STM32L152 evaluation board (STM32L152-EVAL) provides two on-board RS-232 serial ports. Both RS232 ports(USART2 and USART3) are accessed via DB9 connectors.

## 1.9 IrDA

The STM32L152-EVAL evaluation board supports IrDA communication. The interface is mounted on USART2.

## 1.10 Miscellaneous peripherals

### 1.10.1 Joystick

Four-direction joystick with a selection key.

### 1.10.2 Push-buttons

The STM32L152 evaluation board (STM32L152-EVAL) provides only one push-button (key). This key can be used as user push-button, tamper push-button or wakeup push-button (to wake up the processor from a low-power mode).

### 1.10.3 12-bit analog-to-digital converter (ADC)

Varistor: ADC channel (ADC1_IN18) connected to an on-board variable resistor. The variable resistor provides a voltage in the range of 0 V to 3.3 V.

Moreover, a BNC connector is available for analog input and is connected on-board to the ADC channel (ADC1_IN05).

### 1.10.4 Audio

The STM32L152-EVAL evaluation board implements a dedicated audio amplifier to be interfaced with the STM32 DAC peripheral. For the audio output, a speaker and an audio jack are available on the board and connected to the DAC.

### 1.10.5 Storage memories

The STM32L152-EVAL evaluation board has a MicroSD card connector connected to the SPI2 peripheral.

### 1.10.6 Temperature sensor

The STM32L152-EVAL evaluation board includes an $I^2C$ temperature sensor connected to the I2C1 peripheral.

### 1.10.7 STM32L152-EVAL board jumper configuration

To be able to run the STM32L152-EVAL demo correctly, configure the following STM32L152-EVAL board jumpers as follows:

- JP2 uSD: fitted
- JP4: fitted in IDD position
- JP5: fitted in RS232 position
- JP7, JP8: fitted in LCD 1<->2 position
- JP9: fitted in CTS position
- JP10: fitted in LDR position
- JP11 I2C_SMB: fitted
- JP12: fitted in PSU position
- JP13: fitted in VDD <->3.3 V position
- JP14: fitted
- JP16: not fitted
- JP18 (LED3), JP19 (LED4): fitted

# 2 Running the demonstration

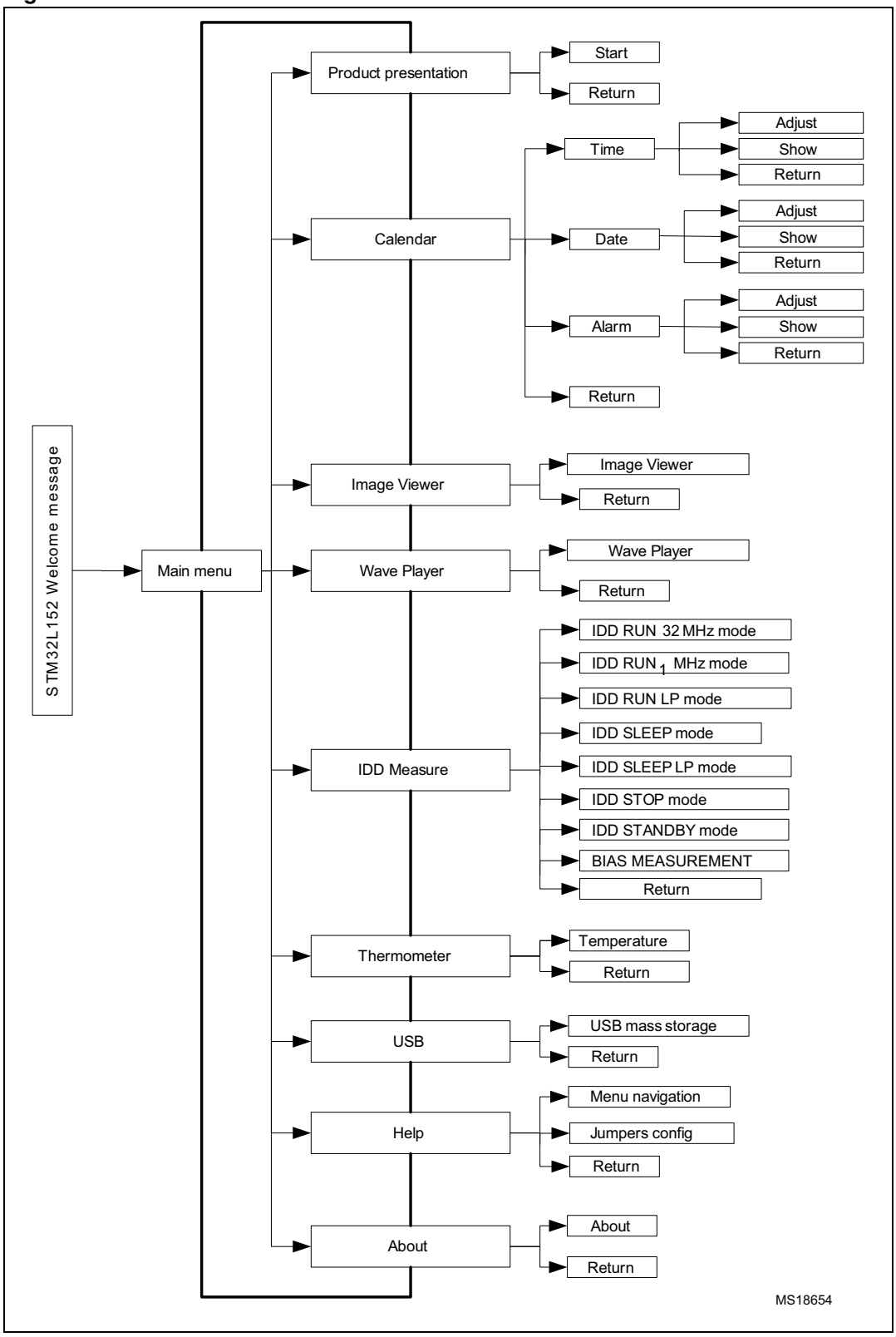
## 2.1 Menu

*Figure 2* shows the menu system of the STM32L152 demonstration. The main menu is shown on the left-hand side. The UP, DOWN, RIGHT and LEFT joystick directions allow the user to navigate between items in the main menu and the submenus. To enter a submenu, press the SEL push-button.

The SEL push-button designates the action of vertically pressing the top of the joystick, as opposed to moving it horizontally UP, DOWN, RIGHT or LEFT.

To exit a submenu, select the Return menu and press SEL.

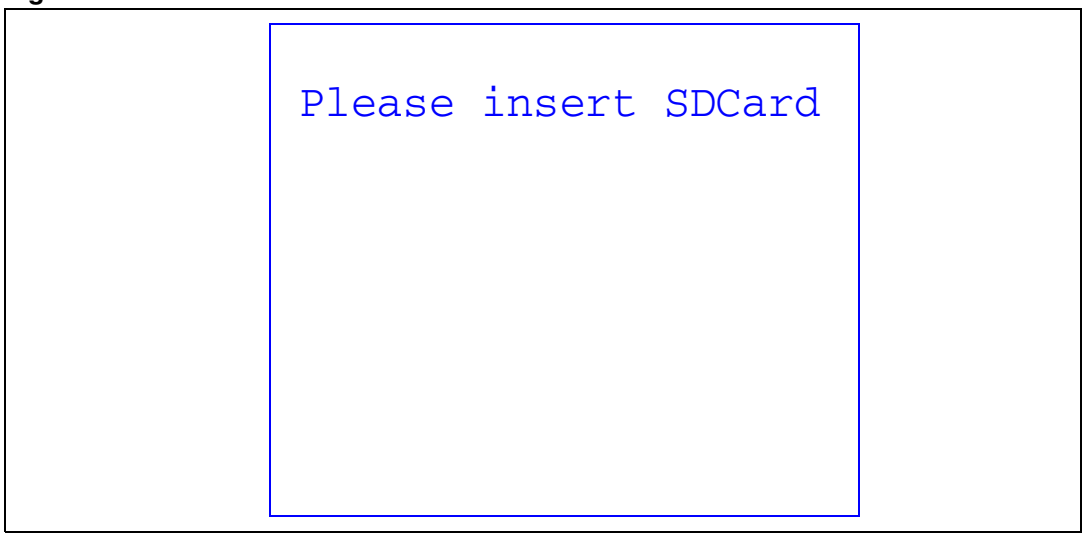
**Figure 2. Structure of the demonstration menus**



### 2.1.1 Demo startup

After a board reset, at demo startup, the system checks if an SD card memory is already present in connector CN4. If no card is detected, the demo does not start and the message shown in *Figure 3.* is displayed on the LCD screen.

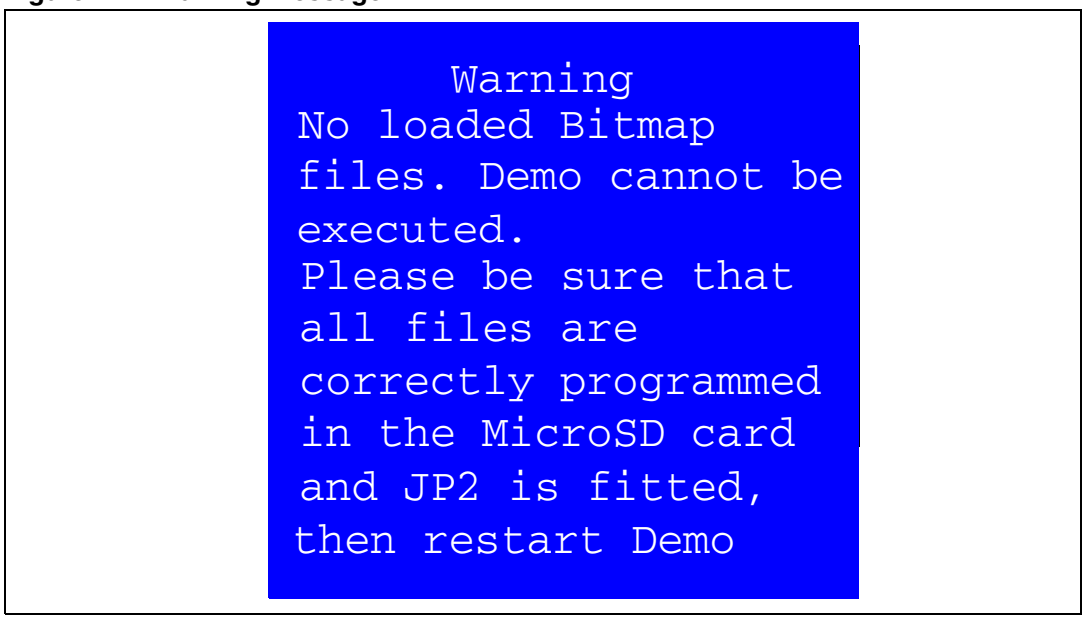
**Figure 3. SD card check**




The demo continues only if an SD card is inserted.

Then, the demo graphic icons and bitmap files are checked in the MicroSD card (see *Section 2.3.5: External memory organization*). All the icons have to be correctly programmed in the MicroSD card for the demo to start. If an icon is missing, the demo does not start and the message shown in *Figure 4* is displayed on the LCD screen.

**Figure 4. Warning message**




However, if the icons are correctly loaded into the SD Card memory, the welcome screen is displayed and the ST logo appears on the LCD (see *Figure 5*).

**Figure 5. ST logo**

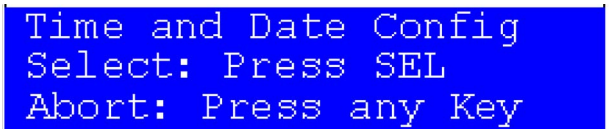
Then, after 1 second, an STM32 presentation slide is displayed on the LCD screen.

**Figure 6. STM32L presentation slide**

When the board is powered up for the first time, the user is prompted to set the time, year, month and day. The user may choose to ignore it by pressing any key except for the SEL push-button to abort the configuration sequence. To set the time and date, the user must press SEL and follow the setting sequence.

The message shown in *Figure 7* appears on the LCD screen.

**Figure 7. Time and date configuration**

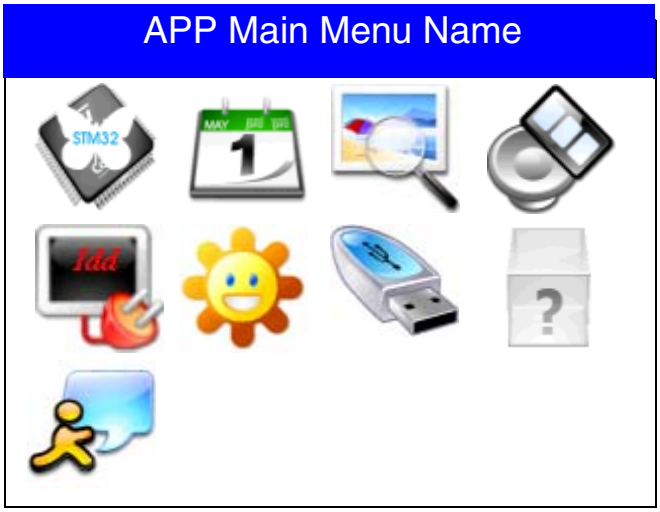



*Note: 1 If the user chooses to configure the time and date, the Time Adjust and Date Adjust menus are displayed. Otherwise, the main menu is displayed and the user can set the time parameters in the Calendar menu. To set the time/date, use the joystick UP/DOWN and SEL push-buttons.*

*2 If the time configuration has already been done, then the number of elapsed days (higher than 1 day) from the last time the demo board was powered up appears on the LCD screen. It is soon followed by the current date.*

Once the time/date have been set, the main menu appears. The main menu is displayed in the form of a set of icons. It shows all the submenus in the same screen. You can navigate using the UP, DOWN, RIGHT and LEFT joystick directions to select the required submenu. To enter a submenu, press the SEL joystick push-button, and the new submenu corresponding to the selected icon is displayed.

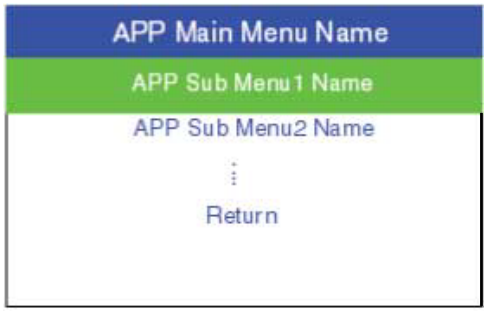
**Figure 8. Main menu**




*Note: The icons shown in Figure 8 are taken from http://commons.wikimedia.org/wiki/Crystal_Clear.*

Once a submenu has been selected, the name of the application is listed at the top of the display and all the corresponding submenus are listed below as shown in *Figure 9*.

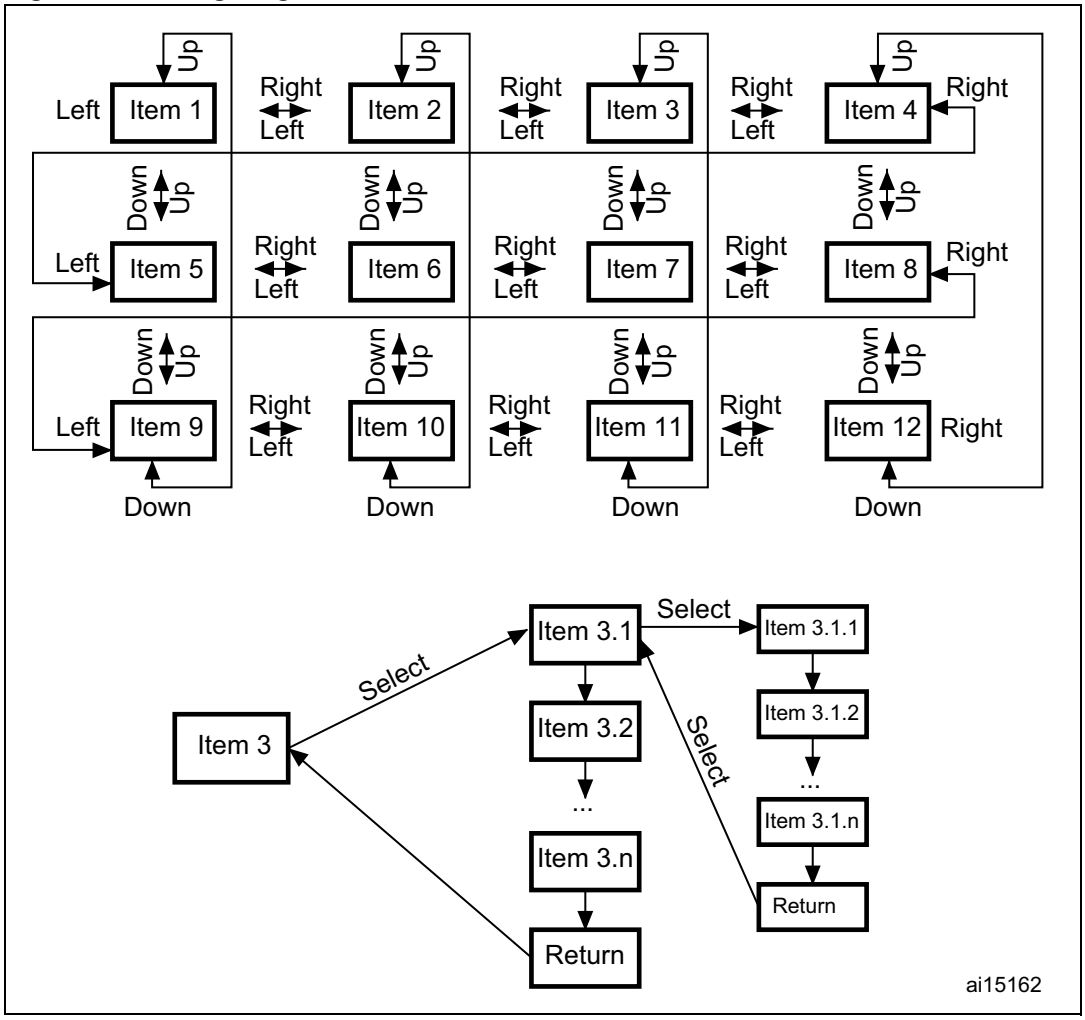
**Figure 9. Corresponding submenus**



### 2.1.2 Navigation

The demonstration menu is based on circular navigation, submenu selection, item selection and back navigation as described in *Figure 10*.

**Figure 10. Navigating in the demonstration menus**




The user navigates using the joystick push-buttons located on the evaluation board: RIGHT, LEFT, SEL, UP and DOWN.

- The UP, DOWN, RIGHT and LEFT push-buttons are used to perform circular navigation in the main menu and the current menu items.
- The SEL push-button selects the current item.
- The UP and DOWN push-buttons are used for vertical navigation in the submenus.
- To return to the upper menu, go to the Return line and press SEL.

## 2.2 Clock sources

### 2.2.1 Clock control

The STM32L152VB's internal clocks are derived from the HSE (clocked by the external 8 MHz crystal).

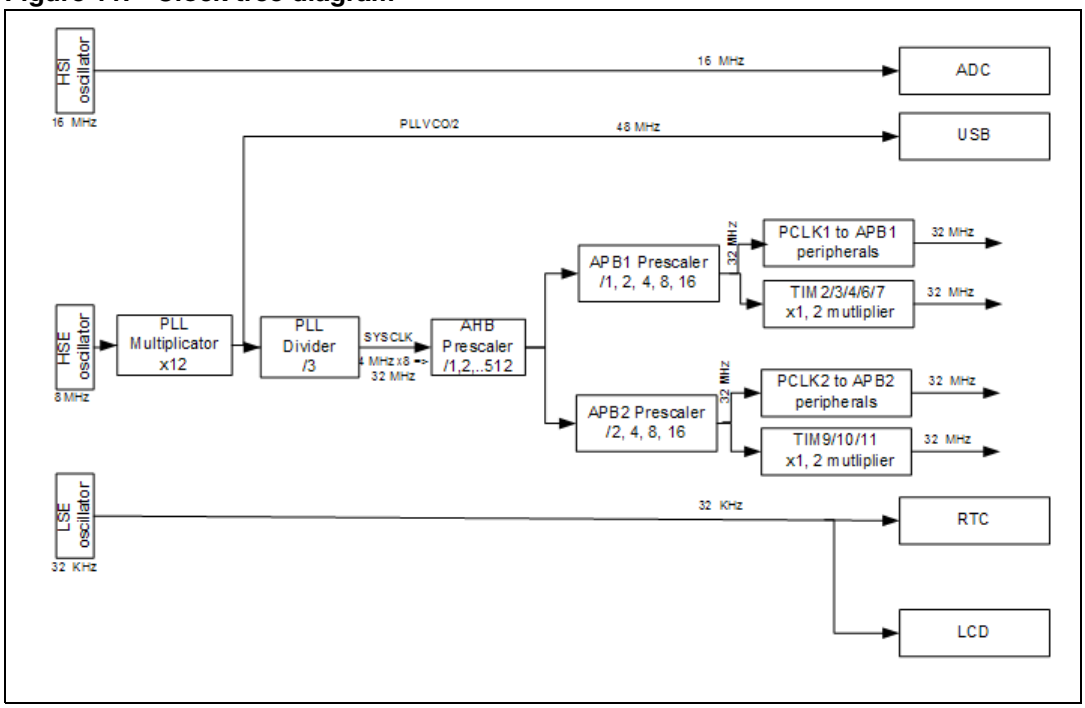
In this demo application, the various system clocks are configured as follows:

- System clock is set to 32 MHz: the PLL is used as the system clock source: 32 MHz (1 wait state, Flash memory prefetch buffer enabled).
- HCLK frequency is set to 32 MHz.
- Timer clock (TIMCLK) is set to 32 MHz.
- USB clock is set to 48 MHz.
- ADC clock is set to 16 MHz.
- PCLK1 is set to 32 MHz.
- PCLK2 is set to 32 MHz.

Only the RTC is clocked by a 32 kHz external oscillator.

*Figure 11* illustrates the clock tree organization for this demo.

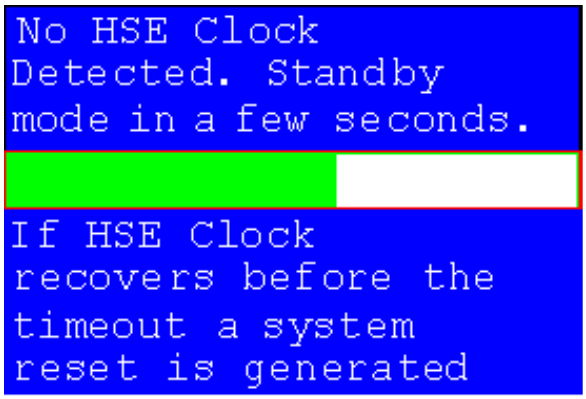
**Figure 11. Clock tree diagram**



### 2.2.2 Clock failure

At any demo level, if no clock is present on OSC_IN (broken or disconnected crystal), the message shown in *Figure 12* is displayed on the LCD screen.

**Figure 12. No HSE clock detected**

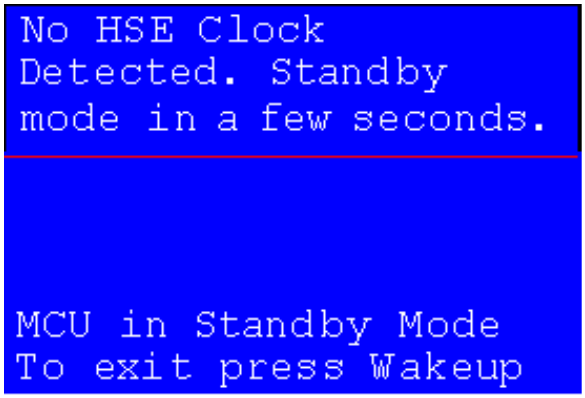



If the 8 MHz crystal is not reconnected in the next few seconds, the MCU enters Standby mode. If the 8 MHz crystal is reconnected within a few seconds, a system reset is generated.

*Note: The clock security system (CSS) feeds the MCU with the MSI OSC used as an emergency clock if no clock is detected.*

When a timeout occurs, the MCU enters Standby mode and the message shown in *Figure 13* is displayed on the LCD screen.

**Figure 13. Standby mode entered**




*Note: The demo does not restart as long as the 8 MHz crystal is not present.*

*Connecting the 8 MHz crystal after reset may not restart the demo correctly. The crystal must be connected before starting the demo.*

## 2.3 STM32L152VB(T6) resources

### 2.3.1 Peripherals

All used peripherals are described in *Table 1*.

**Table 1. STM32L152VB(T6) demo peripherals**

| Used peripherals | Application |
|---|---|
| I2C1 | Temperature sensor |
| LCD | LCD glass control |
| EXTI | Menu navigation + joystick + push-button + IDD measure |
| GPIO | All applications + LEDs |
| NVIC | All applications using interrupts |
| PWR | IDD measure |
| RCC | All applications + Demo kernel |
| RTC | Calendar |
| SPI2 | Color LCD |
| SysTick | Generate 10 ms time base |
| TIM1 | LED toggling |
| DMA1 | Wave Player |
| TIM6 | Wave Player |
| DAC | Wave Player |
| SPI1 | MSD + SPI Flash |
| ADC1 | IDD measure |
| USB | USB mass storage |
| COMP | LCD Glass contrast adjust |

### 2.3.2 Interrupts

*Table 2* shows all the enabled interrupts.

**Table 2. STM32L152VB(T6) demo interrupts**

| Interrupts | Priority | Used for |
|---|---|---|
| SysTick | Preemption: 0<br>SubPriority: 0 | System timing |
| PVD | Preemption: 0<br>SubPriority: 0 | Adapt the System Clock to voltage range |
| RTC Wake-Up | Preemption: 1<br>SubPriority: 1 | Calendar, date update |
| NMI | Preemption(fixed): -2 | CSS interrupt |
| EXTI0 | Preemption: 0<br>SubPriority: 0 | Wake-Up button |
| EXTI9_5 | Preemption: 3<br>SubPriority: 2 | Menu navigation |
| EXTI15_10 | Preemption: 2<br>SubPriority: 2 | Menu navigation |
| I2C1 Error | Preemption: 0<br>SubPriority: 0 | SMBus Alert interrupt |
| TIM6_UP | Preemption: 0<br>SubPriority: 1 | Sampling rate |
| TIM2_UP | Preemption: 1<br>SubPriority: 1 | LED toggling |
| RTCAlarm | Preemption: 1<br>SubPriority: 1 | Alarm generation |
| COMP | Preemption: 2<br>SubPriority: 1 | LCD Glass contrast adjust |
| USB | Preemption: 0<br>SubPriority: 0 | USB sub-Demo |

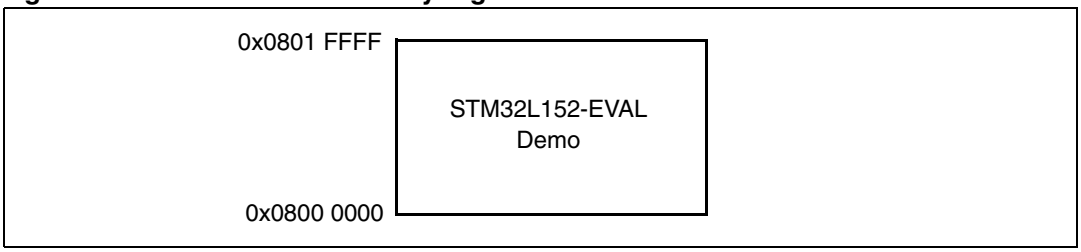
### 2.3.3 External interrupts

**Table 3. STM32L152VB(T6) demo external interrupts**

| External interrupts | Used for |
|---|---|
| EXTI line 8 | Joystick SEL (interrupt mode, falling edge) |
| EXTI line 9 | Joystick UP (interrupt mode, falling edge) |
| EXTI line 10 | Joystick DOWN (interrupt mode, falling edge) |
| EXTI line 13 | User Button (interrupt mode, falling edge) |
| EXTI line 17 | RTC Alarm (interrupt mode, rising edge) |
| EXTI line 20 | RTC wake up (interrupt mode, rising edge) |
| EXTI line 22 | Comparator (interrupt mode, rising and falling edge) |

### 2.3.4 Internal memory size

**Figure 14. Internal Flash memory organization**



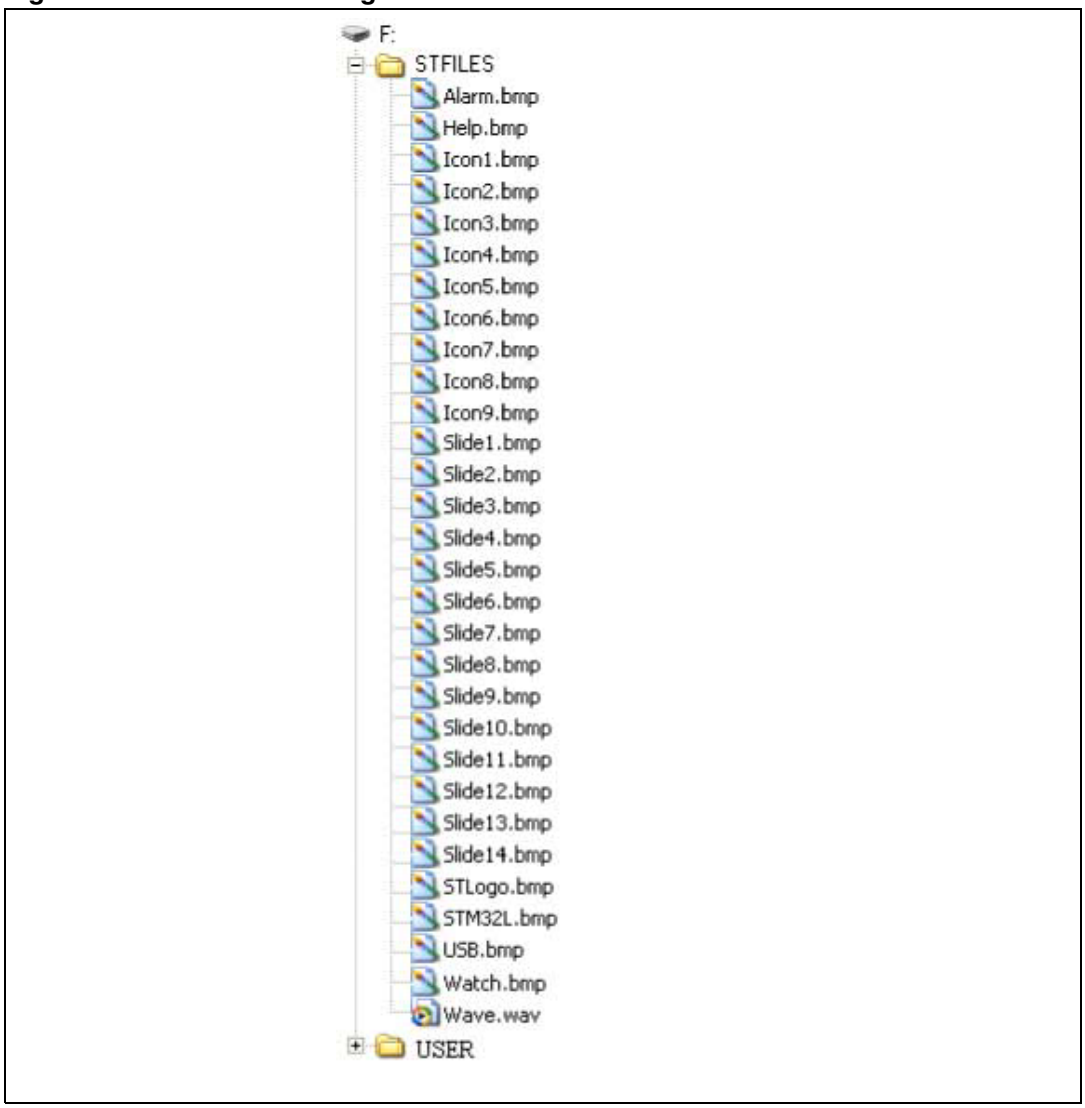

### 2.3.5 External memory organization

The STM32L152-EVAL demo is based on an embedded free FAT file system, FatFs. The file system is needed to read all media information from the on-board MicroSD card memory. The SD card memory is organized in two subdirectories:

- STFILES: this directory contains all the required demo media files (icons, wave and slides). User files located in this folder cannot be handled by demo; only default files are managed.
- USER: this is a user folder. The user can add his/her own files here to be played inside the demo menus (pictures and waves). This folder is used only by the Image Viewer and Wave Player submenus. For more details on the various files properties, please refer to *Section 2.4.3: Image Viewer submenu* and *Section 2.4.4: Wave Player submenu*.

*Note: The STFILES directory and its internal files are mandatory for demo startup. FatFs is a generic FAT file system module for small embedded systems. The FatFs is written in compliance with ANSI C and completely separated from the disk I/O layer. For more details, refer to the following link: http://elm-chan.org/fsw/ff/00index_e.htmltml.*

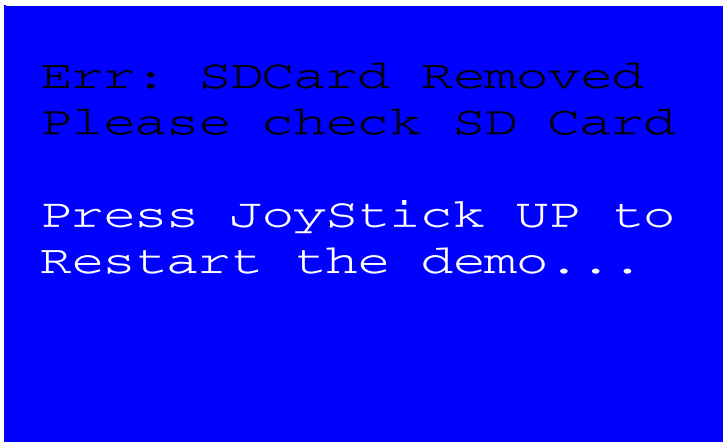
**Figure 15. MicroSD card organization**




*Note: The user can add his/her 16-bit bitmap images (320x240) and wave files in the USER folder.*

*At any demo level, if the SD card is removed, the demo stops and the message shown in Figure 16 is displayed on the LCD screen.*

**Figure 16. SD card removal**




## 2.4 Demo applications

The following section provides a detailed description of each part of the demonstration.

*Note: In the demonstration, the core runs at HCLK = 32 MHz.*

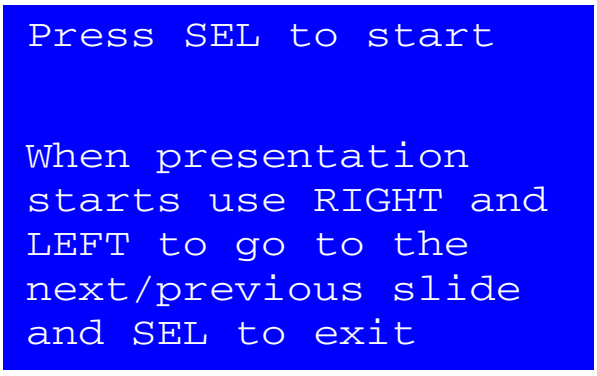
*Four LEDs (LD1, LD2, LD3 and LD4) flash throughout the demonstration at a frequency depending on the core clock.*

### 2.4.1 Product presentation

This part of the demo is dedicated to the listing of all the embedded STM32L152VB(T6) peripherals and features. This presentation of the microcontroller is made with a set of slides accompanied by a speech. Each slide is associated with a dedicated speech. When the user starts the product presentation, the first slide appears and the corresponding speech starts. Once the speech is finished, the second slide is displayed accompanied by its speech, and so on until the last slide.

When the Product presentation menu is selected, the message shown in *Figure 17* is displayed on the LCD screen.

**Figure 17. Product presentation is ready to start**



### Product presentation slides

The set of slides is composed of 14 slides listing all features and advantages of the STM32L152VB(T6). *Figure 18* and *Figure 19* show the first and last slides, respectively.

**Figure 18. First presentation slide**

**Figure 19. Last presentation slide**

### Product presentation speech

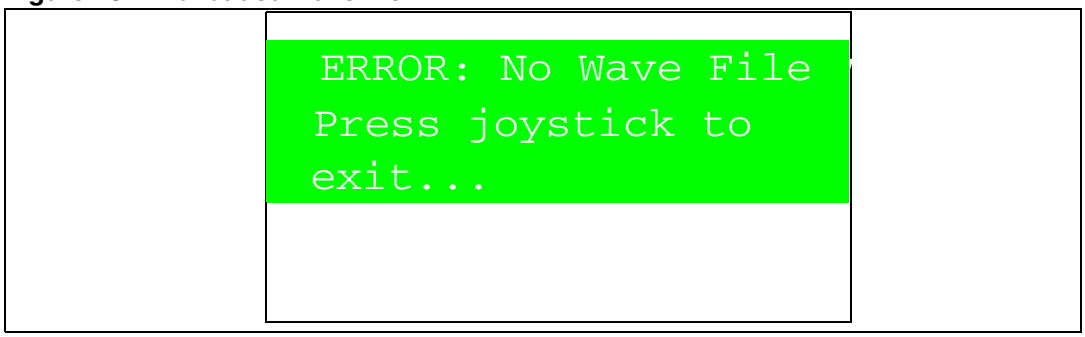
The STM32L152VB microcontroller has one embedded DAC peripheral that can be used for audio communication. An external audio amplifier is implemented on the evaluation board in order to allow speech audio files to be played through the embedded speaker or headphone.

The properties of the product presentation speech wave file are the following:

- Playing time: 6 min 16 s
- File size: 3,014,752 bytes
- Format tag: PCM
- Channels: Mono
- Sample rate: 8 kHz
- Bits per sample: 8 bits

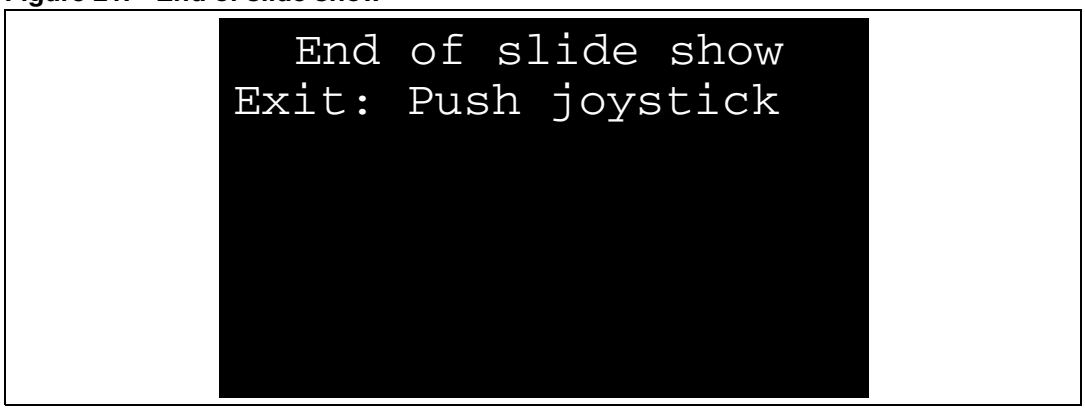
*Note: If the wave file of the promotion presentation speech is not loaded in the dedicated memory, the message shown in Figure 20 is displayed on the LCD screen.*

**Figure 20. No loaded wave file**




To stop the product presentation slide show and speech, press the SEL push-button. The message shown in *Figure 21* is displayed.

**Figure 21. End of slide show**



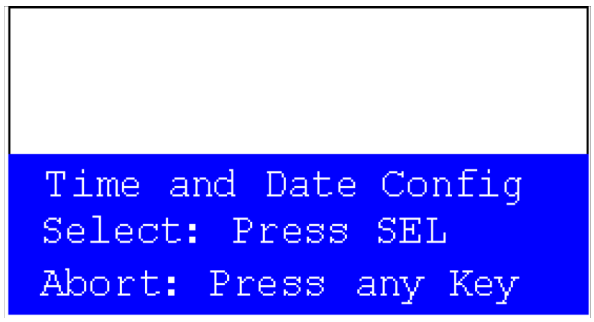

At the end of the product presentation, or if the presentation was stopped, simply press any joystick key to exit and return to the Product presentation submenu.

### 2.4.2 Calendar

The STM32L15x features a real-time clock (RTC) which is an independent BCD timer/counter. The RTC provides a time-of-day clock/calendar, two programmable alarm interrupts, and a periodic programmable wakeup flag with interrupt capability.

This submenu is used to configure the time, date and alarm. In any submenu, if the time and date parameters have not yet been configured, the message shown in *Figure 22* is displayed on the LCD screen.

**Figure 22. Setting the time and date**



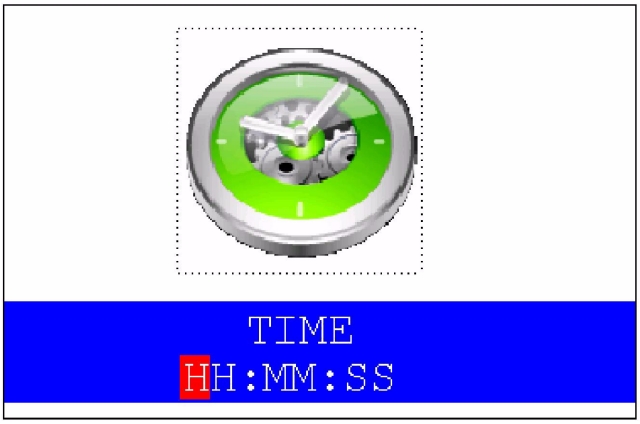

The user can choose to set or not the time, year, month and day. Press any key (except for SEL) to ignore the prompt and abort the configuration sequence. Press SEL and follow the setting sequence to set the time and date.

### Time submenu

This submenu is divided into two items that allow the user to display or set the current time.

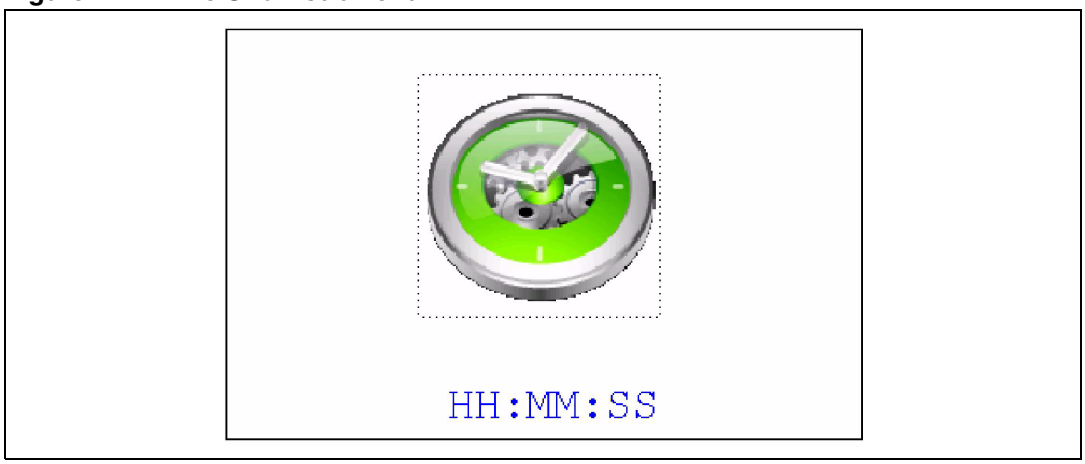
- **Time Adjust:** after the evaluation board is powered up, select this submenu to change the default time (00:00:00) to the current time. Once Time Adjust has been selected, the first digit of the hour field can be changed. Press the UP button to display the current value plus one. Press the DOWN button to display the previous digit value. After setting the digit value, press SEL, and the cursor automatically jumps to the next digit. When all the time digits have been set, the Time submenu appears. Some digit values are limited to a range of values depending on the field (hour, minutes or seconds). The following message (with the default time or the current time) is displayed on the LCD when this submenu is selected.

**Figure 23. Time Adjust submenu**



- **Time Show:** this item displays the current time. If time and date have not been configured before, a message is displayed, prompting the user to set the time and date or to exit to the upper submenu. When this submenu is selected, the message shown in *Figure 24* appears on the LCD. In the example, the time has not been set yet.

**Figure 24. Time Show submenu**




To exit the Time Show submenu, press the SEL push-button. To exit the Time submenu, select the Return line and press the SEL push-button.

### Date submenu

This submenu is divided into two items that allow the user to display or set the current date.

- **Date Adjust:** select this item after each power-up in order to set the current date. If the time and date have not been configured before, a message is displayed, prompting the user to set the time and date or to exit to the upper submenu.

  The user is requested to set the current date to be stored in the application memory. The date is displayed as Year, Month, Week Nbr, Day Nbr (number of the day in the year) with the selected day shown in the month. There is no default date since the user has to set the date at least once.

  Once the submenu has been selected, the user starts by setting the Year, then the Month and the day of the selected month. The Month and the Year are selected using the UP or DOWN push-button. For the day, the UP, DOWN, RIGHT and LEFT push-buttons can be used. Press the UP push-button to display the current value plus one; press the DOWN push-button to display the previous value. To confirm the selected month, press the SEL push-button. The display then jumps to the year configuration. The same procedure is applicable for the year configuration.

  After configuring the day, press the SEL push-button to store the entered value and exit to the Date submenu. The current date value is then shown and you can change the setting if required. The messages shown in *Figure 25*, *Figure 26* and *Figure 27* are successively displayed on the LCD when this submenu is selected.

**Figure 25. Setting the year**

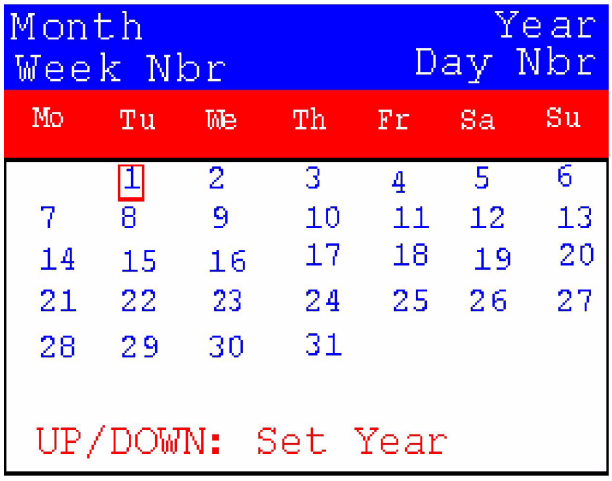



**Figure 26. Setting the month**

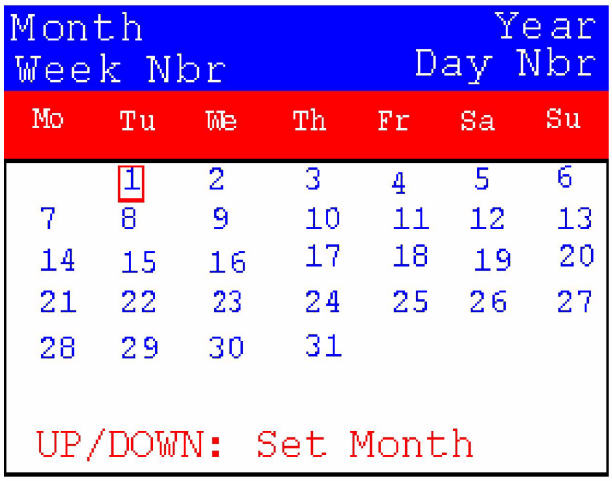
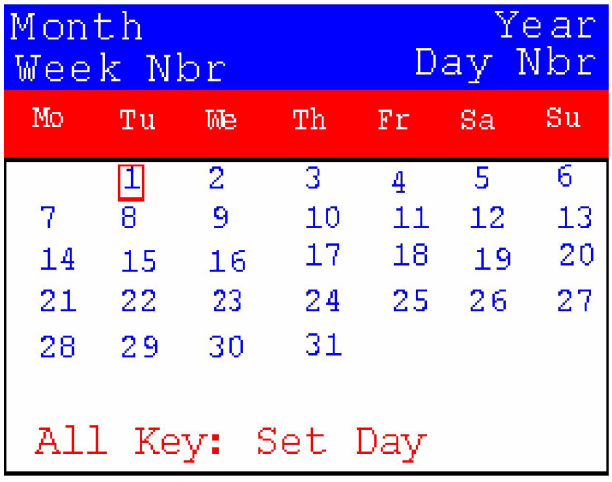
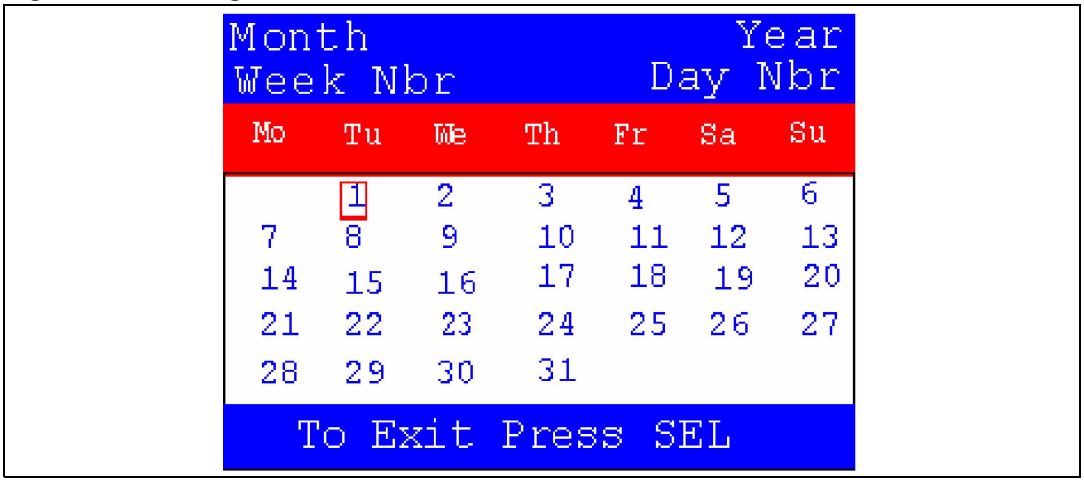



**Figure 27. Setting the day of the month**



- **Date Show:** this item displays the current date. If the time and date have not been configured before, a message is displayed, prompting the user to set the time and date or to exit to the upper submenu. The message shown in *Figure 28* is displayed on the LCD when the submenu is selected (with the date already configured).

**Figure 28. Exiting the Date Show submenu**



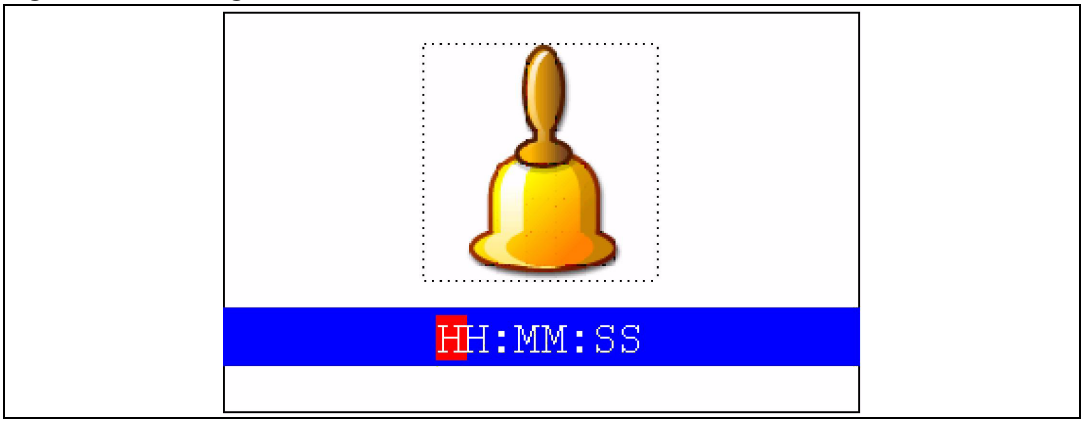

To exit this submenu, press the SEL push-button. To exit the Date submenu, select the Return line and press the SEL push-button.

### Alarm submenu

Using this submenu, the user can configure the alarm activation time. When the alarm time value is reached, all the LEDs (LED1 to LED4) start flashing together, and so for 30 seconds. This submenu is divided into two items that allow the user to display or set the current alarm.

- **Alarm Adjust:** the alarm time activation is set in the same way as the time is set in the Time Adjust submenu. The following messages are successively displayed on the LCD when this submenu is selected:

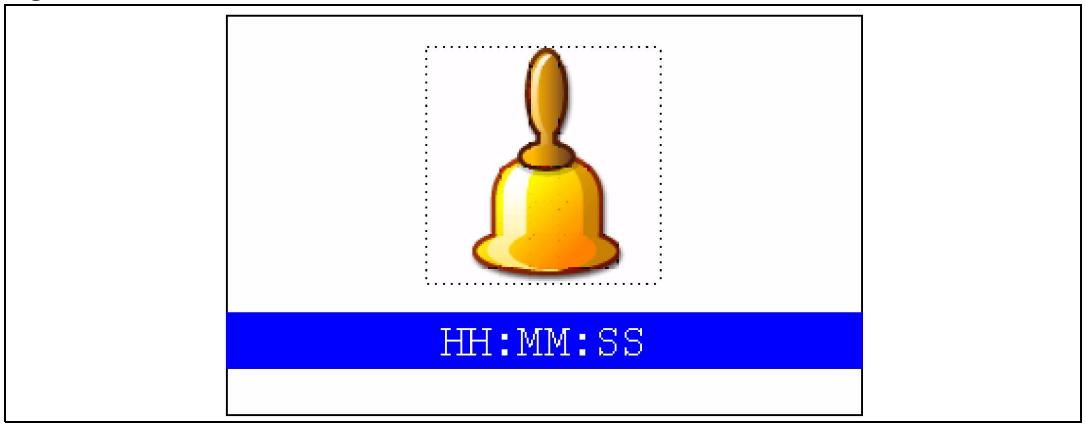
**Figure 29. Setting the alarm activation time**




- **Alarm Show:** this item displays the current alarm time. The default Alarm activation time displayed after power-up and before setting in the Alarm Adjust submenu is 00:00:00. If the time and date have not been configured before, a message shown in

*Figure 31* is displayed. Pressing SEL takes you back to the Alarm submenu. The message shown in *Figure 30* is displayed on the LCD when this submenu is selected.

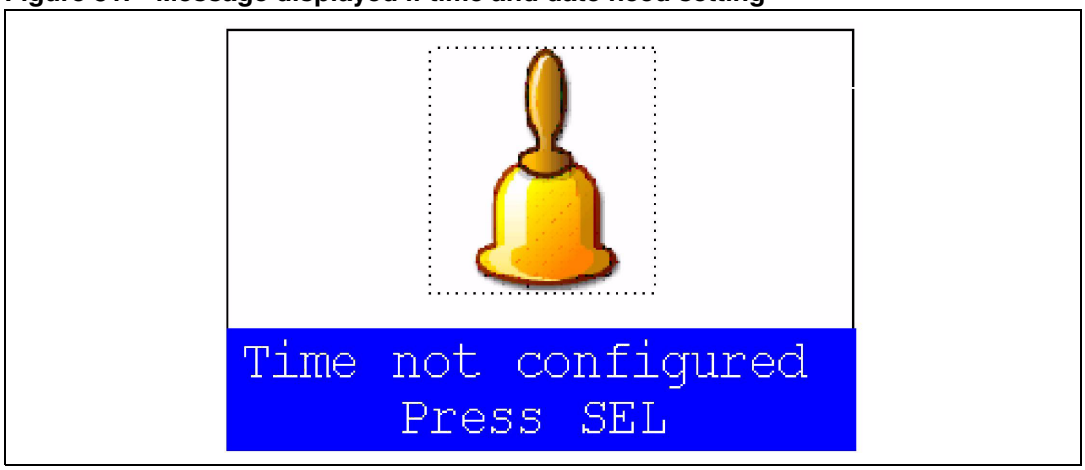
**Figure 30. Alarm Show submenu**




To exit the Alarm Show submenu, press the SEL push-button. To exit the Alarm submenu, select the Return line and press the SEL push-button.

*Note: In the Alarm Adjust and Alarm Show menus, if the time and date have not yet been configured, the message shown in Figure 31 is displayed on the LCD screen.*

**Figure 31. Message displayed if time and date need setting**




*Note: When the Calendar is configured, the following messages are displayed respectively in an infinite loop on LCD Glass STM32L, Time and Date.*

*The LCD Glass contrast is adjusted according to the brightness detected using the LDR resistor connected to COMP2.*

### 2.4.3 Image Viewer submenu

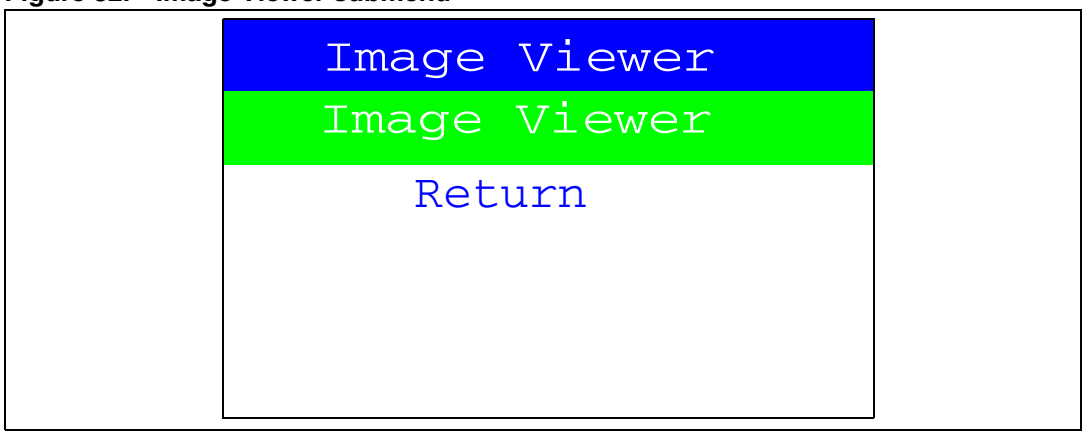
The Image Viewer submenu is used to demonstrate the LCD control performance using the embedded SPI interface. The application is a successive display of stored images.

This application reads all bitmap pictures from the USER directory (see *Section 4.1: Programming the media files* and displays only the .BMP files having the following format:

- Bit depth: 16 bits (RGB)
- Size: 240x320

Select Image Viewer to display the submenu as shown in *Figure 32*.

**Figure 32. Image Viewer submenu**




When Image Viewer is selected, the first image is displayed as shown in *Figure 33.*

**Figure 33. STM32 Image Viewer**

Use RIGHT and LEFT to go to the next/previous image stored in the USER folder on the MicroSD card. If the SEL push-button is pressed, the Image Viewer is stopped and the submenu shown in *Figure 32* is displayed.

The supported image size is 240x320. The maximum number of images that can be read from the MicroSD card is 25 images, selected in alphabetic order.

### 2.4.4 Wave Player submenu

The STM32L152VB(T6) microcontroller has an embedded DAC which can be used to generate output signals.

In this demo, any wave file stored under the USER folder in the MicroSD card can be opened using the file system FatFs and transferred to the internal SRAM by block (512 bytes) using the DMA and the SPI interface. Timer 6 (TIM6) triggers the DAC to generate the wave signal. The voice sampling period is read from the Wave File Header. An audio amplifier is connected to the DAC interface to play the stored wave files. For more details on the STM32 DAC capabilities, please refer to application note AN3126 *Audio and waveform generation using the DAC in STM32 microcontroller families*. This application illustrates all STM32 DAC features and modes using dedicated examples and lists the configuration steps for each mode.

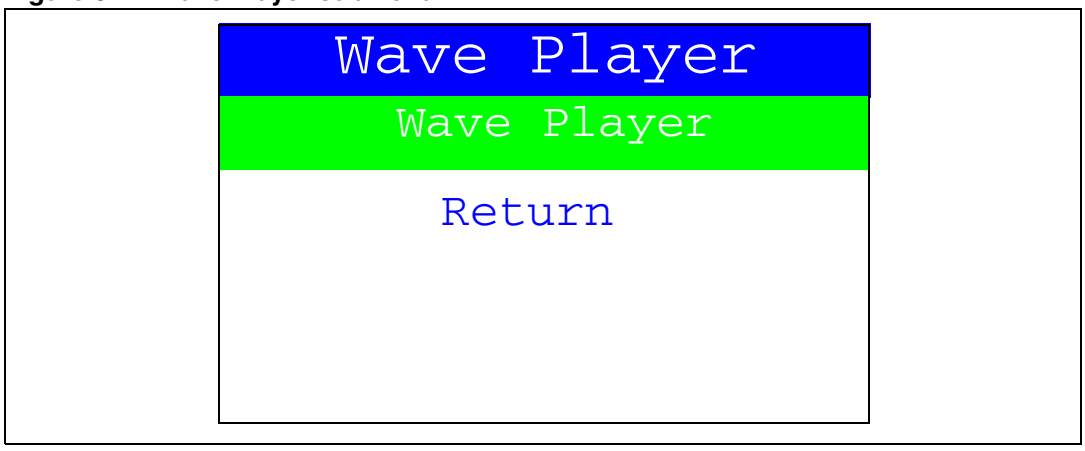
This application reads all wave files from the USER directory (see *Section 4.1: Programming the media files* and displays only the .WAV files having the following format:

- Audio format: PCM (an uncompressed wave data format in which each value represents the amplitude of the signal at the time of sampling)
- Sample rate: 8000, 11025, 22050 or 44100 Hz
- Bits per sample: 8 bits (audio sample data values are in the range [0-255])
- Number of channels: 1 (mono)

The maximum number of wave files that can be read from the MicroSD card is 25 files selected by alphabetic order.

Select Wave Player to display the submenu shown in *Figure 34*.

**Figure 34. Wave Player submenu**




When Wave Player is selected again, the wave player interface is displayed as shown in *Figure 35*

**Figure 35. Wave Player interface**

*Figure 35* lists the active push-buttons and their functions. For example, at start-up, press the SEL joystick push-button to play the file through the embedded speaker, and press the DOWN push-button to exit the Wave Player submenu.

Once the play command is activated, the submenu shown in *Figure 36* is displayed.

**Figure 36. Wave Player Playing submenu**

The progress bar and the volume bar are displayed at the bottom of the Wave Player Playing submenu. The progress bar is updated every ~1% of the audio file duration, and the volume bar is updated each time the volume level is changed.

At this application level:

- Press the SEL push-button to pause the audio stream.
- Press the LEFT push-button to decrement the audio stream.
- Press the RIGHT push-button to increment the audio stream.
- Press the DOWN push-button to exit the Wave Player submenu.

When the audio stream is paused, the menu in *Figure 37* is displayed.

**Figure 37. Pause submenu**

To resume playing, press the SEL push-button, and the menu shown in *Figure 36* is displayed.

When the audio stream is stopped, the stream position is reset and the menu shown in *Figure 35* is displayed.

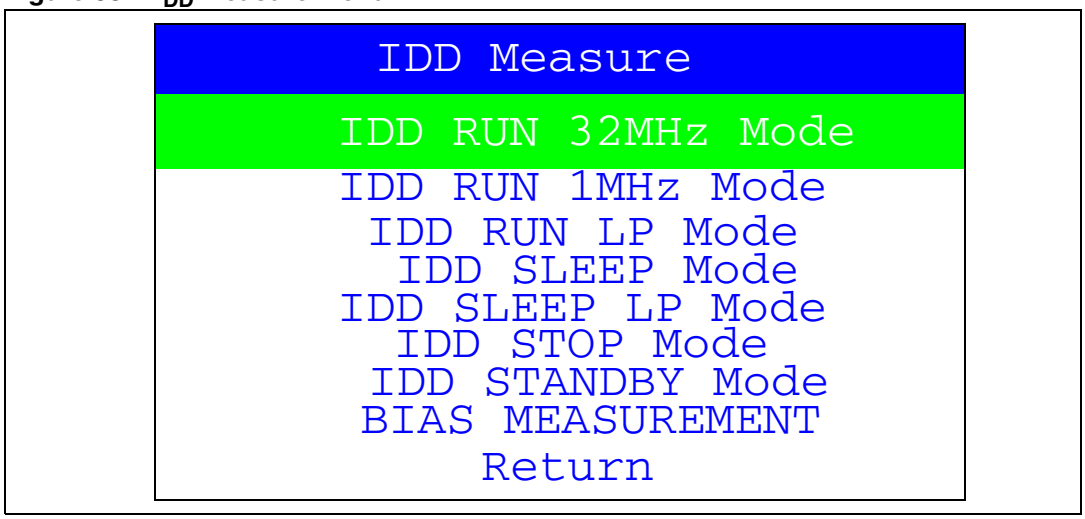
*Note: The audio files provided within this package are based on a free music download from www.DanoSongs.com website.*

### 2.4.5 IDD Measure

The STM32L152VB(T6) microcontroller provides several operating modes reducing power consumption. The purpose of this menu is to use the ADC peripheral features to measure the $I_{DD}$ current in Run 32MHz, Run 1MHz, Run LP, Sleep, Sleep LP, Stop, Standby modes and to measure the Bias current using the $I_{DD}$ measurement circuit available on the STM32L152VB-EVAL board.

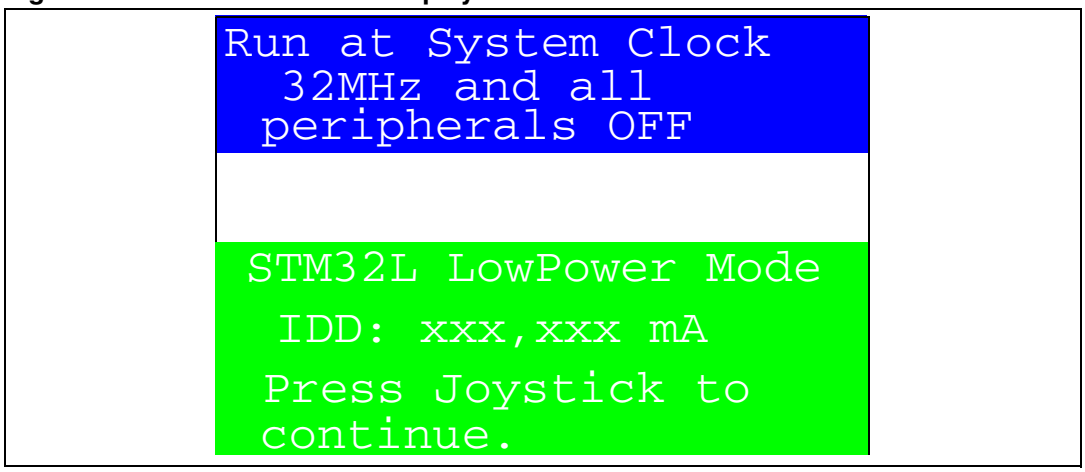
Select the IDD Measure menu by pressing SEL from the main menu. The message shown in *Figure 38* is then displayed on the LCD screen.

**Figure 38. $I_{DD}$ Measure menu**




- If the IDD RUN 32MHz Mode submenu is selected, the RUN message is displayed on the LCD Glass and the message shown in *Figure 39* is displayed on the LCD screen.

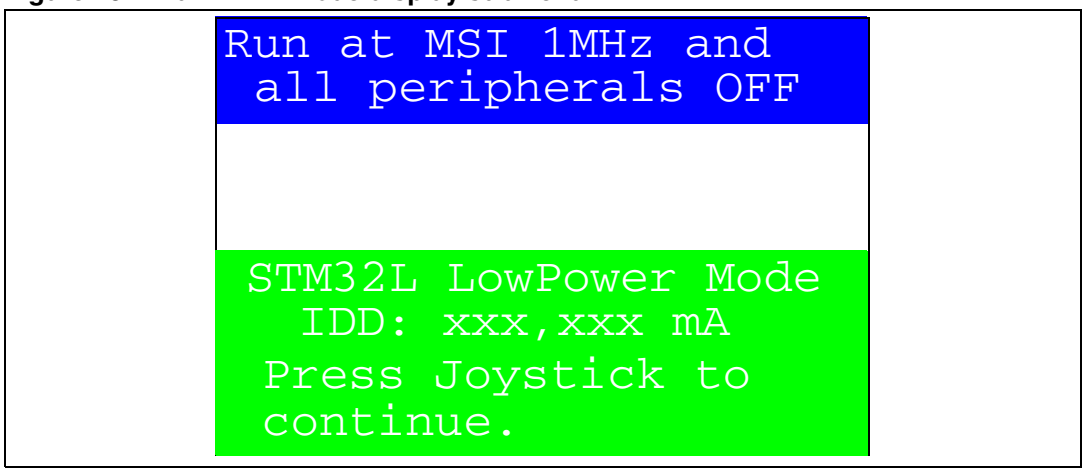
**Figure 39. Run 32MHz Mode display submenu**




The $I_{DD}$ value is displayed on the LCD screen until the joystick push-button is pressed. Once the joystick push-button is pressed, the MCU exits the IDD RUN 32MHz Mode submenu, the STM32L message is displayed on LCD Glass and the message shown in *Figure 38* is displayed on the LCD screen.

- If the IDD RUN 1MHz Mode submenu is selected, the STM32L message is displayed on the LCD Glass and the message shown in *Figure 40* is displayed on the LCD screen.

**Figure 40. Run 1MHz Mode display submenu**

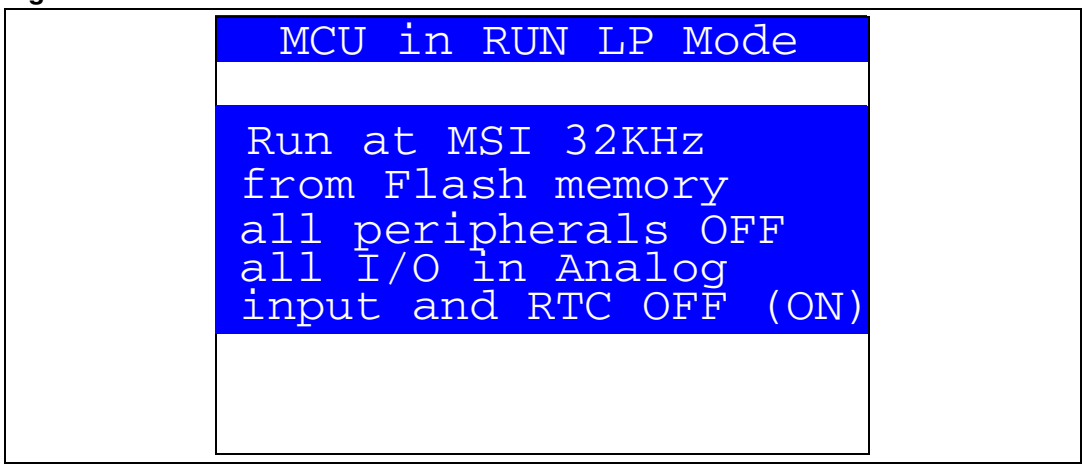



The $I_{DD}$ value is displayed on the LCD screen until the joystick push-button is pressed. Once the joystick push-button is pressed, the MCU exits the IDD RUN 1MHz Mode submenu, the STM32L message is displayed on the LCD Glass and the message shown in *Figure 38* is displayed on the LCD screen.

- If the IDD RUN LP Mode submenu is selected, the RUN LP message is displayed on the LCD Glass and the message shown in *Figure 41* is displayed on the LCD screen. Press SEL push-button to keep RTC peripheral ON during RUN LP mode, else press any other key push-button to stop RTC during this mode. Once pressed, the message shown in *Figure 42* is displayed on the LCD. The MCU enters the Run LP mode and waits for the rising edge on PA0 that can be generated by the external counter to exit the MCU from Run LP.

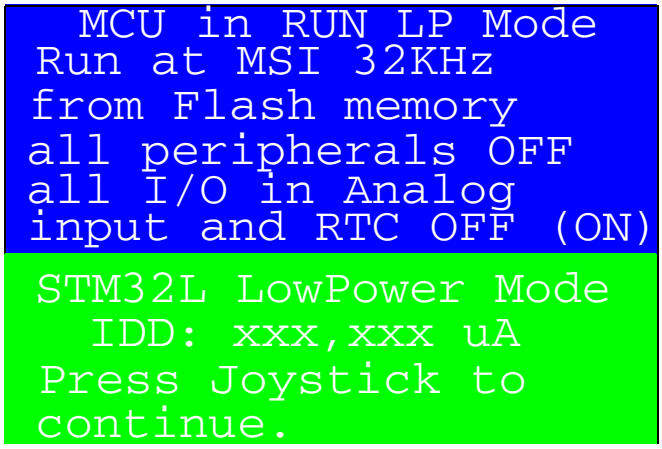
**Figure 41. RTC ON or OFF Selection submenu**

**Figure 42. Enter Run LP Mode submenu**




When the external rising edge is generated on PA0, the MCU exits the Run LP Mode, the STM32L message is displayed on the LCD Glass and the message shown in *Figure 43* is displayed on the LCD screen.

**Figure 43. Run LP Mode display submenu**

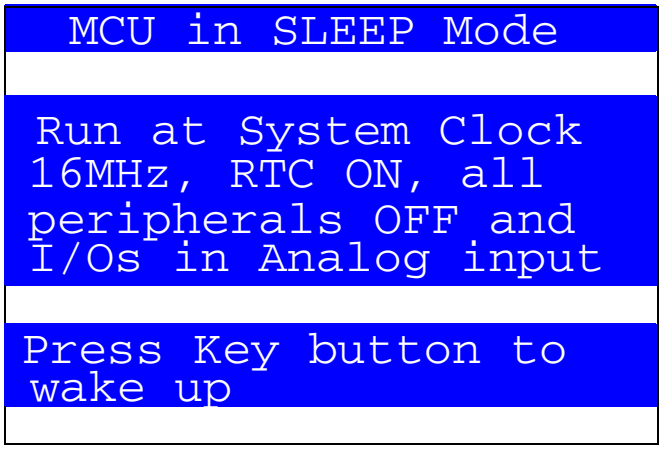



Once the joystick push-button has been pressed, the MCU exits the IDD RUN LP Mode submenu and the message shown in *Figure 38* is displayed on the LCD screen.

*Note: After executing the Run LP Mode submenu, if the RTC is OFF, you have to re-configure the time, date and alarm (Refer to Calendar menu).*

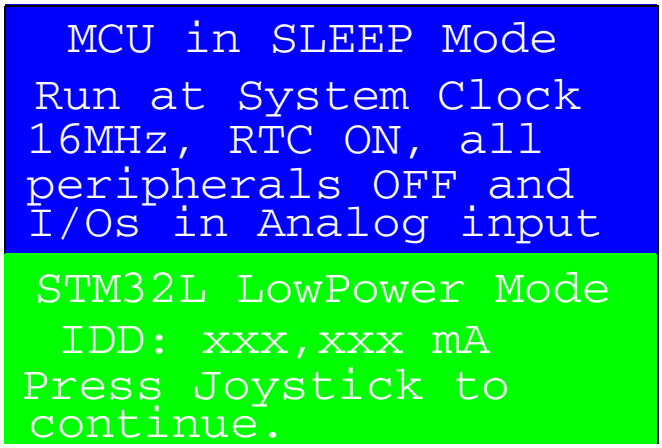
- If the IDD SLEEP Mode submenu is selected, the SLEEP message is displayed on the LCD Glass and the message shown in *Figure 44* is displayed on the LCD screen. The MCU enters the SLEEP mode and waits for the rising edge on PA0 (push-button) to exit the SLEEP mode.

**Figure 44. Enter Sleep Mode submenu**




When the user generates the external rising edge on PA0 by pressing the push-button, the MCU exits the SLEEP mode, the STM32L message is displayed on the LCD Glass and the IDD is displayed on the LCD screen as shown in *Figure 45*.

**Figure 45. Sleep Mode display submenu**




Once the joystick push-button has been pressed, the MCU exits the IDD Sleep Mode submenu and the message shown in *Figure 38* is displayed on the LCD screen.

*Note: When Sleep mode is entered, the system clock is configured to run at 16 MHz, all peripherals are OFF, all I/Os are configured as analog inputs, the ultralow power feature is enabled, and the FLASH memory is in power-down.*

- If the IDD SLEEP LP Mode submenu is selected, the message shown in *Figure 46* is displayed. Press SEL push-button to keep RTC peripheral ON during SLEEP LP mode else press any other key push-button to stop RTC during this mode. Once pressed, the message shown in *Figure 47* is displayed on the LCD.

**Figure 46. RTC ON or OFF Selection submenu**

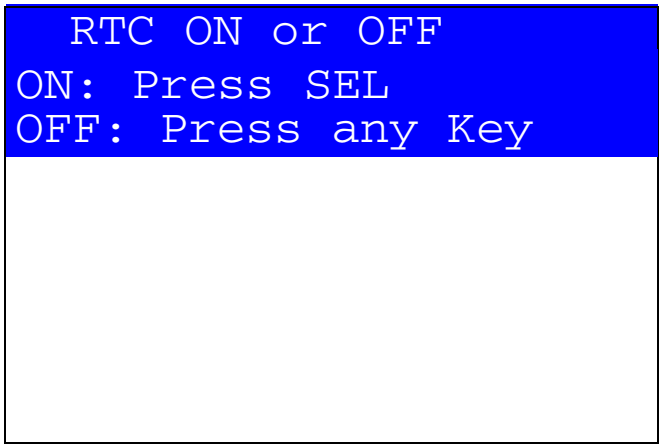
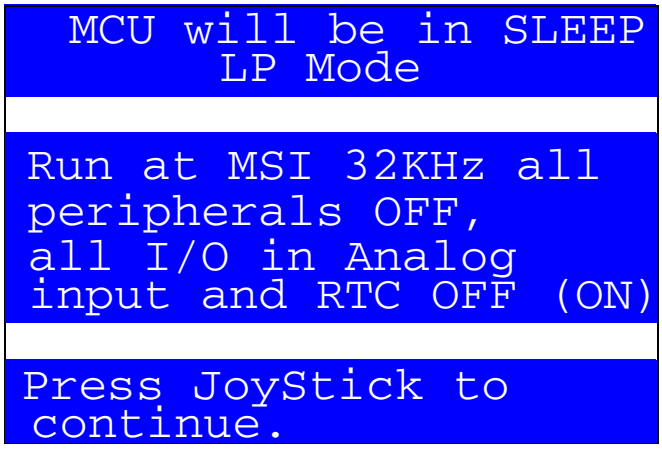


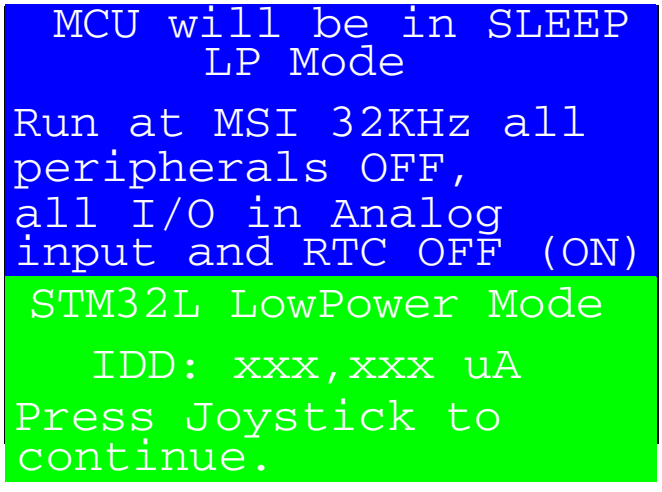
**Figure 47. Enter Sleep LP Mode submenu**




Once the joystick push-button has been pressed, the MCU enters the Sleep LP mode and waits for the rising edge on PA0 that can be generated by the external counter to exit the MCU from SLEEP LP mode.

When the external rising edge is generated on PA0, the MCU exits the Sleep LP Mode and the message shown in *Figure 48* is displayed on the LCD screen.

**Figure 48. Sleep LP Mode display submenu**




Once the joystick push-button has been pressed, the MCU exits the IDD Sleep LP Mode submenu and the message shown in *Figure 38* is displayed on the LCD screen.

*Note: When Sleep mode is entered, the system clock is configured to run at MSI 32 KHz, all peripherals are OFF, all I/Os are configured as analog inputs, the RTC is set to OFF, the ultralow power feature is enabled, and the FLASH memory is in power-down.*

*After executing the Sleep LP Mode submenu, if the RTC is OFF, you have to re-configure the time, date and alarm (Refer to Calendar menu).*

- If the IDD STOP Mode submenu is selected, the STOP message is displayed on the LCD Glass and the message shown in *Figure 49* is displayed on the LCD screen. Press SEL push-button to keep RTC peripheral ON during STOP mode else press any other key push-button to stop RTC during this mode. Once pressed, the message shown in *Figure 50* is displayed on the LCD.

**Figure 49. RTC ON or OFF Selection submenu**

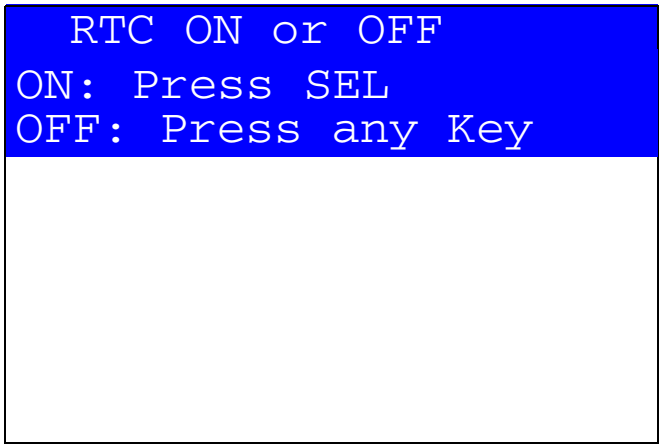
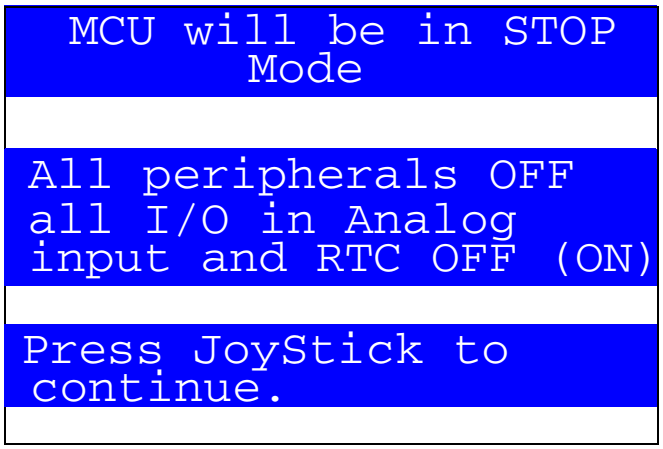


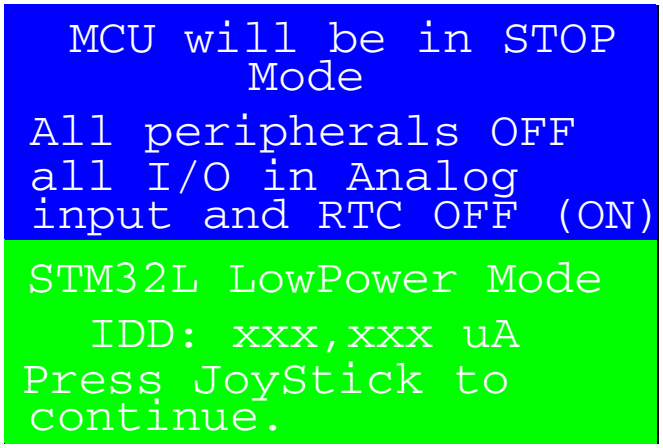

**Figure 50. Enter Stop Mode submenu**




Once the joystick push-button has been pressed, the MCU enters the Stop mode and waits for the rising edge on PA0 that can be generated by the external counter to exit the MCU from Stop mode.

When the external rising edge is generated on PA0, the MCU exits the Stop mode, the STM32L message is displayed on the LCD Glass and the message shown in *Figure 51* is displayed on the LCD screen.

**Figure 51. Stop Mode display submenu**




Once the joystick push-button has been pressed, the MCU exits the IDD Stop Mode submenu and the message shown in *Figure 38* is displayed on the LCD screen.

*Note: When Stop mode is entered: all peripherals are OFF, all I/Os are configured as analog inputs and the RTC is OFF.*

*After executing the Stop Mode submenu, if the RTC is OFF, you have to re-configure the time, date and alarm (Refer to Calendar menu).*

- If the IDD STANDBY Mode submenu is selected, the STANDBY message is displayed on the LCD Glass and the message shown in *Figure 52* is displayed on the LCD screen. Press SEL push-button to keep RTC peripheral ON during STANDBY mode else press any other key push-button to stop RTC during this mode. Once pressed, the message shown in *Figure 52* is displayed on the LCD.

**Figure 52. RTC ON or OFF Selection submenu**

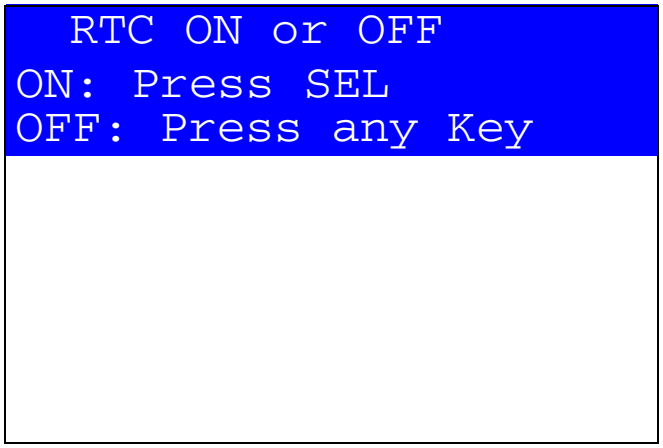
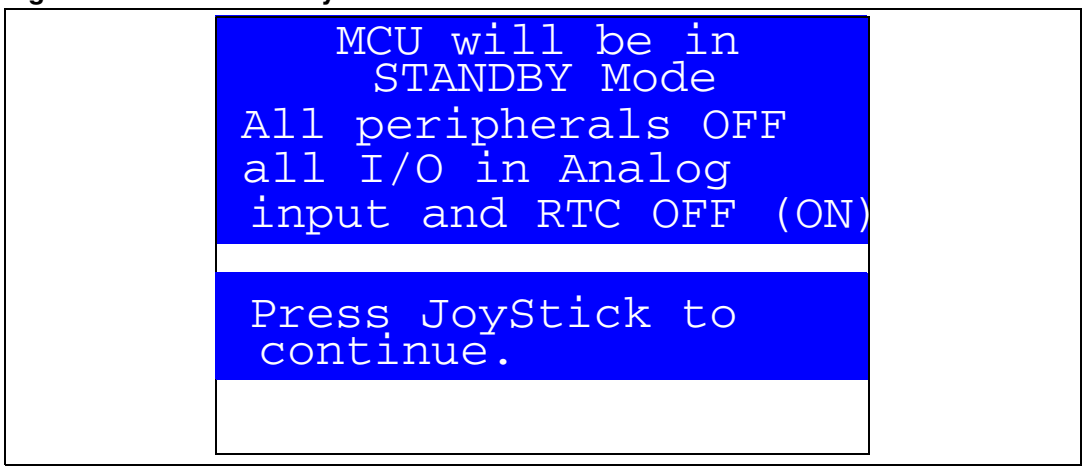


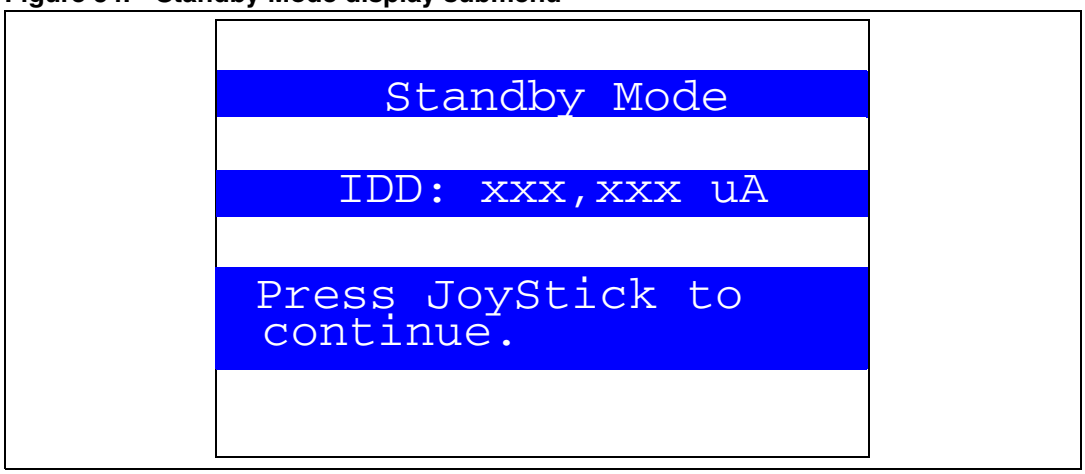
**Figure 53. Enter Standby Mode submenu**




Once the joystick push-button has been pressed, the MCU enters the Standby mode and waits for the rising edge on PA0 that can be generated by the external counter to exit the MCU from STANDBY mode.

When the external rising edge is generated on PA0, the MCU exits the Standby mode, the system reset is generated and the message shown in *Figure 54* is displayed on the LCD screen.

**Figure 54. Standby Mode display submenu**

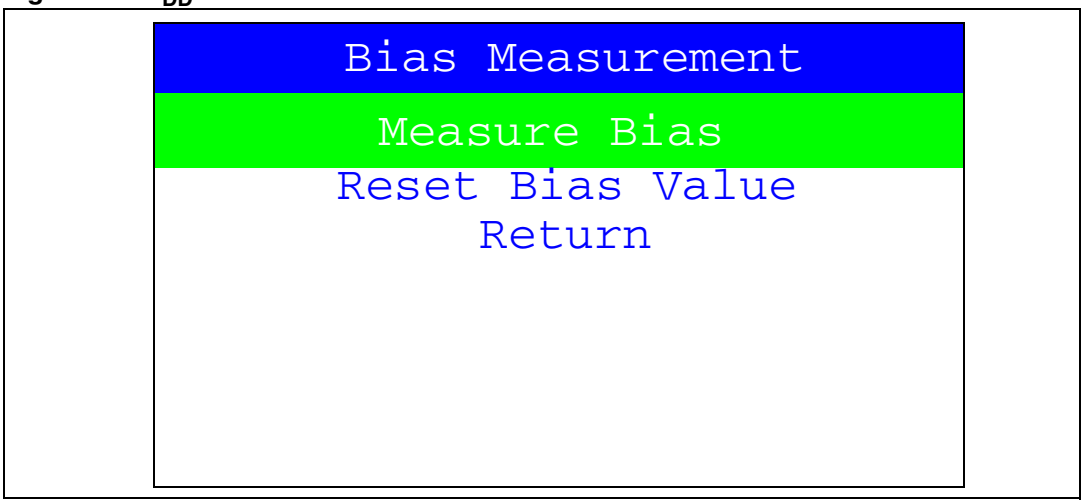



Once the joystick push-button has been pressed, the MCU continues the initialization as illustrated in *Section 2.1.1: Demo startup*.

- Bias Measurement: In Low power mode the bias current of operational amplifier input is not negligible compared to IDD current (typical Ibias is ~240 nA). To obtain a reliable MCU IDD measurement it is possible to subtract the bias current from the IDD low power measurement since this current is not sinked by the MCU.

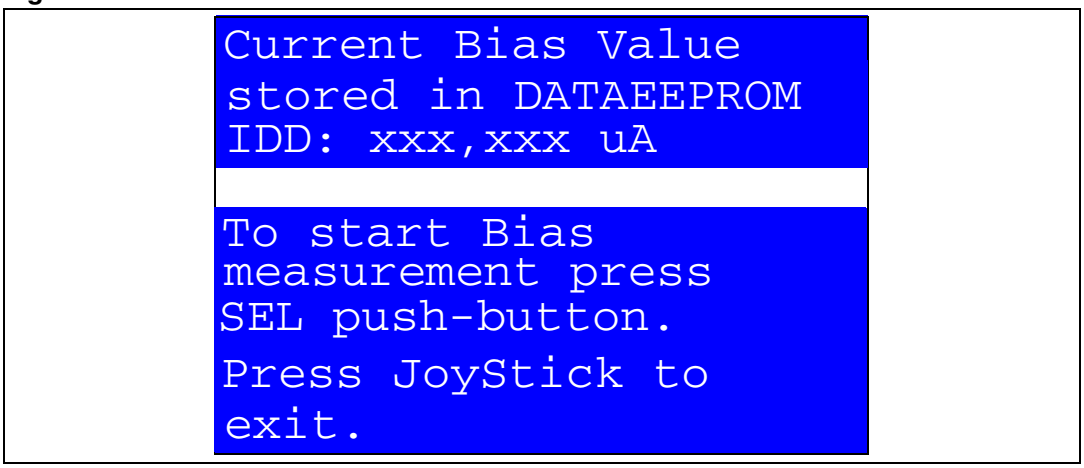
Select the Bias Measurement menu by pressing SEL from the IDD Measure menu. The message shown in *Figure 55* is then displayed on the LCD screen.

**Figure 55. $I_{DD}$ Bias Measurement menu**




- If the Measure Bias Mode submenu is selected, the BIAS message is displayed on the LCD Glass and the message shown in *Figure 56* is displayed on the LCD screen.

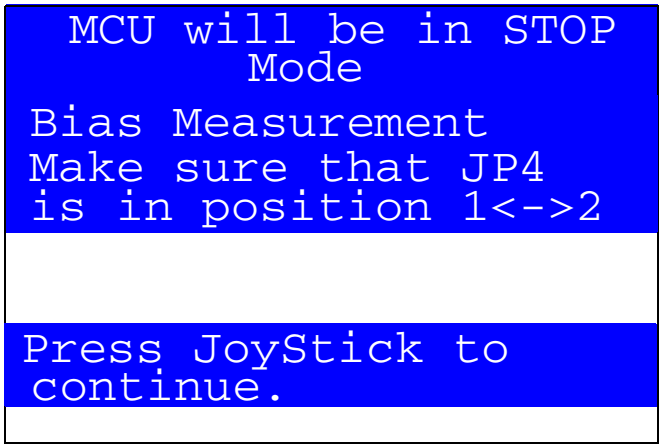
**Figure 56. Measure Bias submenu**




If the joystick push-button has been pressed, the MCU exits the Measure Bias submenu and the message shown in *Figure 55* is displayed on the LCD screen.

If the SEL push-button has been pressed, the MCU starts the Measure Bias submenu and the message shown in *Figure 57* is displayed on the LCD screen.

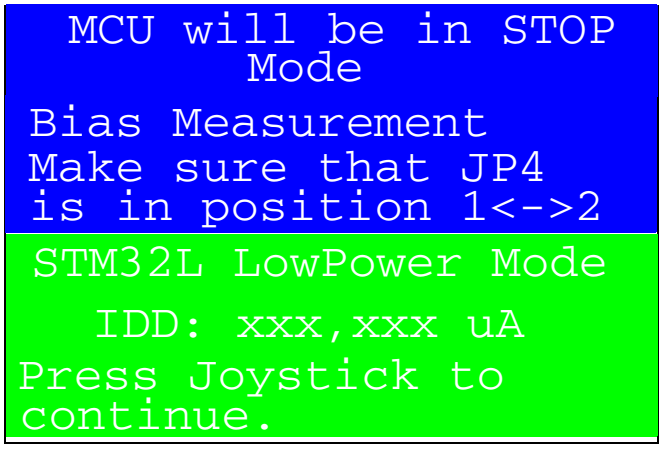
**Figure 57. Measure Bias Mode (Procedure Start) submenu**




Once the joystick push-button has been pressed, the MCU enters the Stop mode and waits for the rising edge on PA0 that can be generated by the external counter to exit the MCU from Stop mode.

When the external rising edge is generated on PA0, the MCU exits the Stop mode, the STM32L message is displayed on the LCD Glass and the message shown in *Figure 58* is displayed on the LCD screen.

**Figure 58. Stop Mode display submenu**

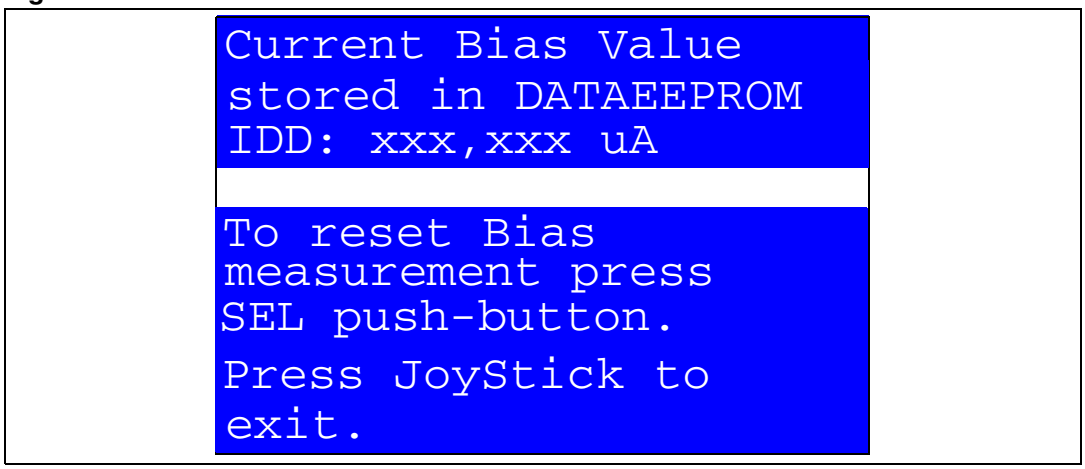



Once the joystick push-button has been pressed, the MCU exits the Bias Measure submenu and the message shown in *Figure 55* is displayed on the LCD screen.

The measured Bias value is stored in the internal DATA EEPROM memory. This value will be used with Low Power modes current measurement.

- If the Reset Bias Value submenu is selected, the BIAS message is displayed on the LCD Glass and the message shown in *Figure 59* is displayed on the LCD screen.

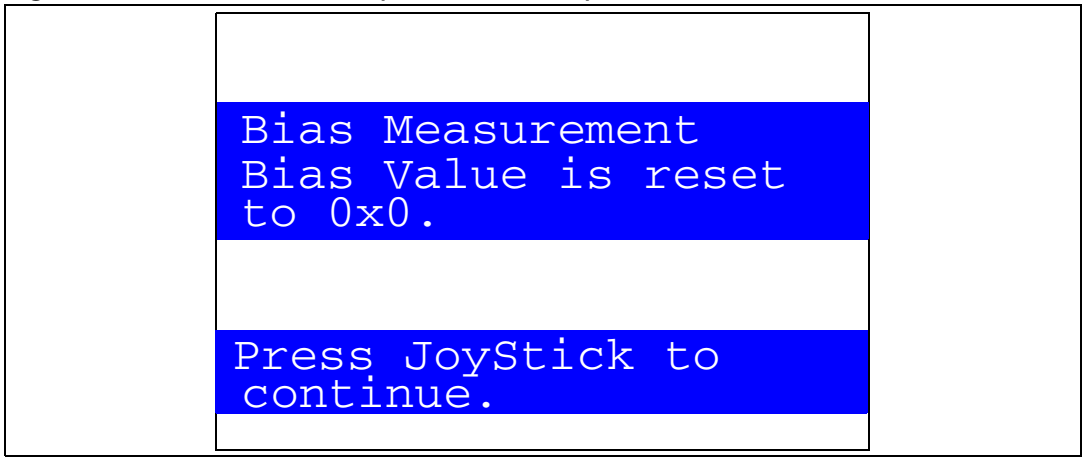
**Figure 59. Reset Bias Value submenu**




If the joystick push-button has been pressed, the MCU exits the Reset Bias Value submenu and the message shown in *Figure 55* is displayed on the LCD screen.

If the SEL push-button has been pressed, the MCU starts the Reset Bias Value submenu and the message shown in *Figure 60* is displayed on the LCD screen.

**Figure 60. Reset Bias Value (Procedure Start) submenu**



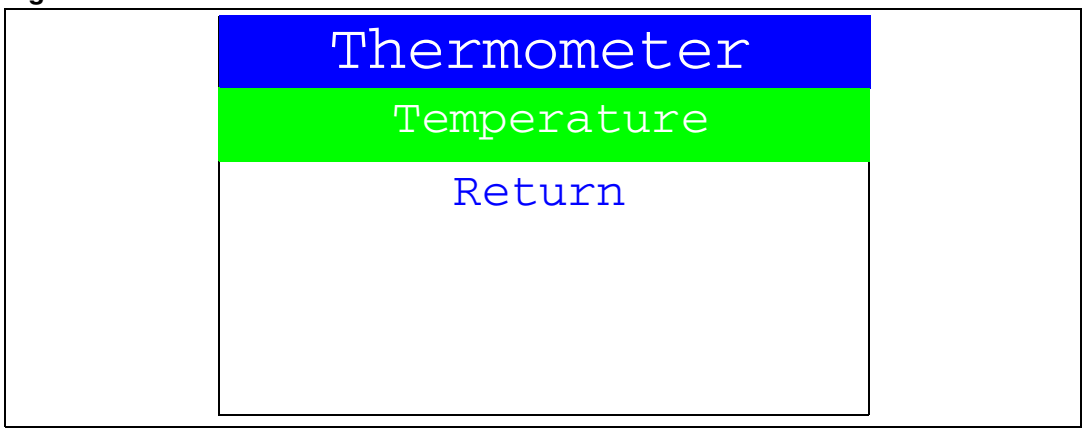

Once the joystick push-button has been pressed, the MCU exits the Reset Bias Value submenu and the message shown in *Figure 55* is displayed on the LCD screen.

### 2.4.6 Thermometer

The STM32L152VB(T6) microcontroller has two embedded $I^2C$ peripherals that can be connected to any device supporting the $I^2C$ protocol including System management bus (SMBus) mode. An STLM75 (or a compatible device) $I^2C$ temperature sensor is mounted on the STM32L152-EVAL board and used to capture the external temperature (-55°C to +125°C).

When the Thermometer submenu is selected, the message shown in *Figure 61* is displayed on the LCD.

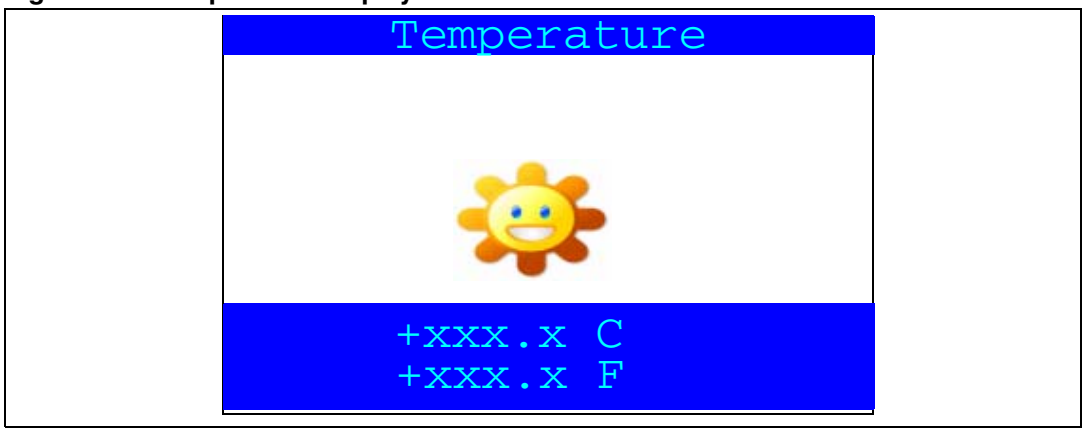
**Figure 61. Thermometer submenu selected**




Once the Temperature submenu has been selected by pressing the SEL push-button, the temperature value is displayed in Celsius and Fahrenheit as shown in *Figure 62*.

Press any key to return to the Thermometer submenu.

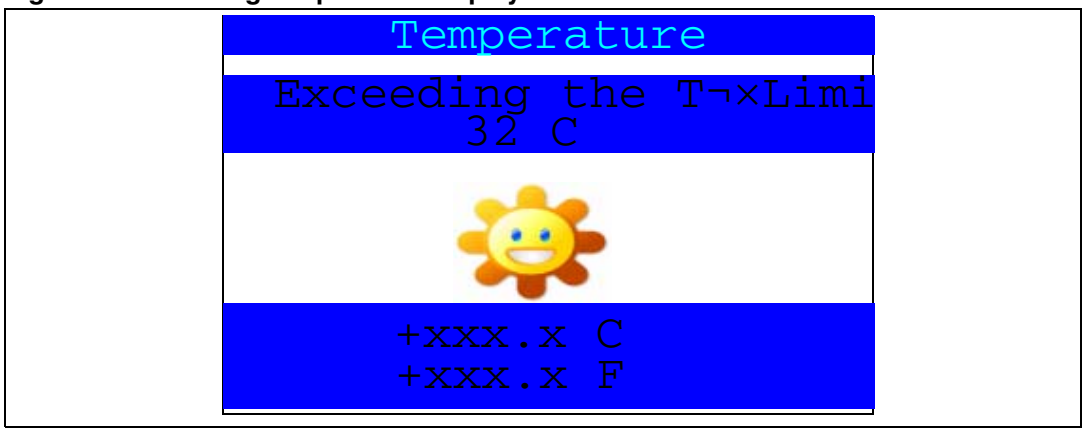
**Figure 62. Temperature display**




The temperature variations can be easily monitored using the STM32 I2C SMBus feature. This is managed by the SMBus Alert, which generates a dedicated interrupt informing the system that the temperature is out of the selected ranges. This can be very useful when a higher temperature needs an emergency action, as is the case in critical systems (motor control, medical...).

If the temperature exceeds the over-limit high (TEMPERATURE_TOS: Over Limit Temperature) the SMBus alert interrupt is generated and the warning message shown in *Figure 63* is displayed on the LCD screen.

**Figure 63. Warning temperature display**




The messages shown in *Figure 62* are displayed on the LCD screen when the temperature goes under the over-limit low (TEMPERATURE_THYS: Hysteresis Temperature).

The user can configure the TOS and THYS using dedicated define values in the code. By default, the STM32L152-EVAL demo sets them to (see menu.c file):

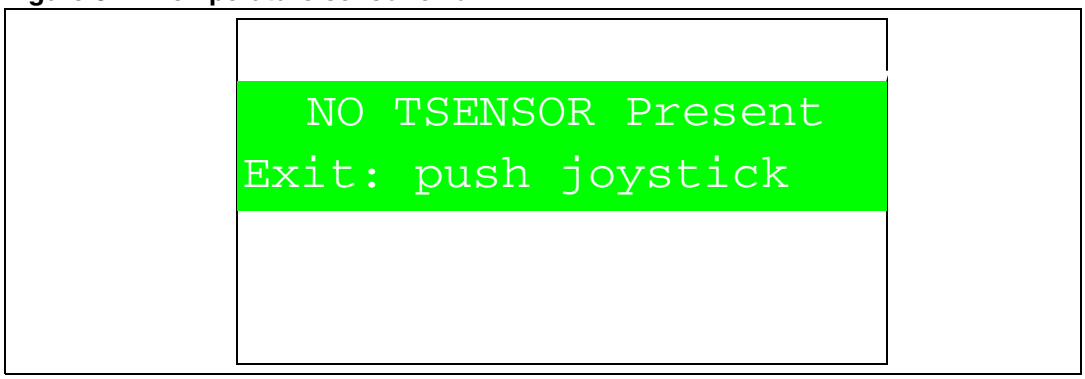
```
#define TEMPERATURE_THYS 31

#define TEMPERATURE_TOS 32
```

Press any key to return to the Thermometer submenu.

*Note: Any hardware trouble with the temperature sensor is detected by a test. In such case, the message shown in Figure 64 is displayed.*

**Figure 64. Temperature sensor error**

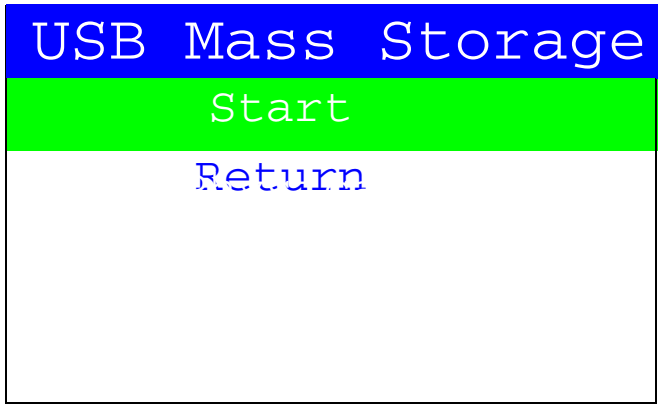



## 2.4.7 USB Mass Storage Submenu

The STM32L152VB(T6) microcontroller features a USB (universal serial bus) that provides a full-speed interface to a USB host PC.

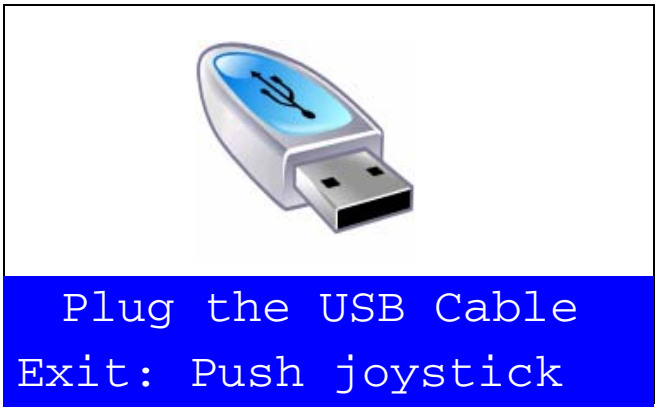
The USB Mass Storage submenu is used to configure the USB interface for communication with the PC and to run the mass storage demo using an MSD card.

**Figure 65. USB Mass Storage submenu**




If the SEL push-button is pressed when Start is selected, the message shown in *Figure 66* appears on the LCD screen until the cable is plugged in.

**Figure 66. USB Mass Storage submenu selected**




To return to the previous submenu, the user must connect a USB cable between the USB connector type B (CN1) and the PC. If the user connects a cable or presses any joystick push-button, the message shown in *Figure 67* is displayed on the LCD.

**Figure 67. USB cable connected**

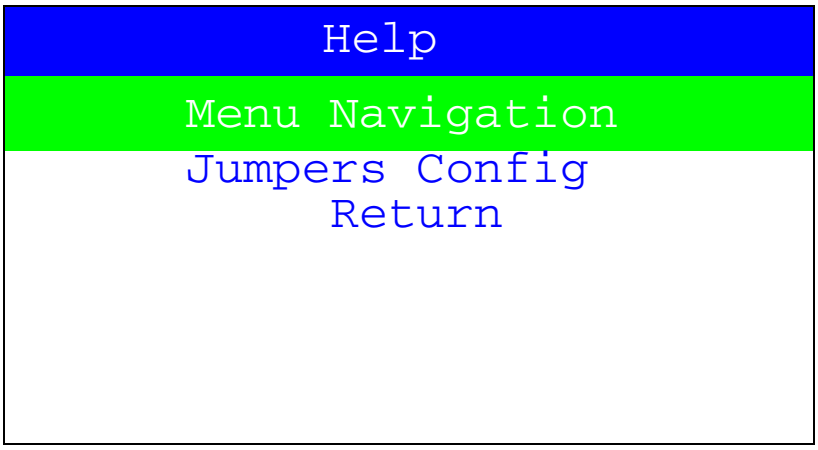
Once the cable has been connected, the PC recognizes the board as a mass storage device and consequently opens a window to show the contents of the MSD mounted on the STM32L152-EVAL board. The user can transfer files between the MSD and the PC.

### 2.4.8 Help

This submenu can help the user to configure the jumpers on the STM32L152-EVAL evaluation board and to navigate between the menus and submenus available in the firmware demo.

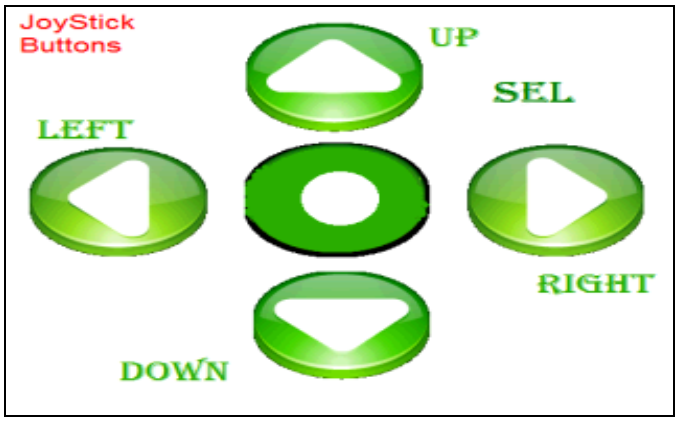
Select the Help menu by pressing SEL from the main menu. The message shown in *Figure 68* is then displayed on the LCD screen.

**Figure 68. Help menu**



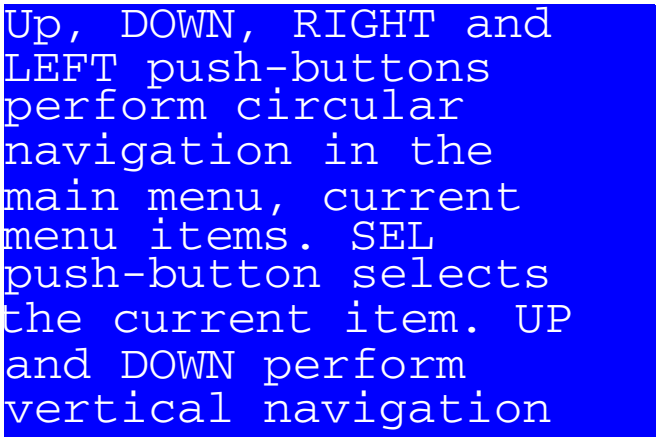

- If the Menu Navigation submenu is selected, the message shown in *Figure 69* is displayed.

**Figure 69. Navigation menu-1**




When any joystick button is pressed, the second navigation interface is displayed as shown in *Figure 70.*

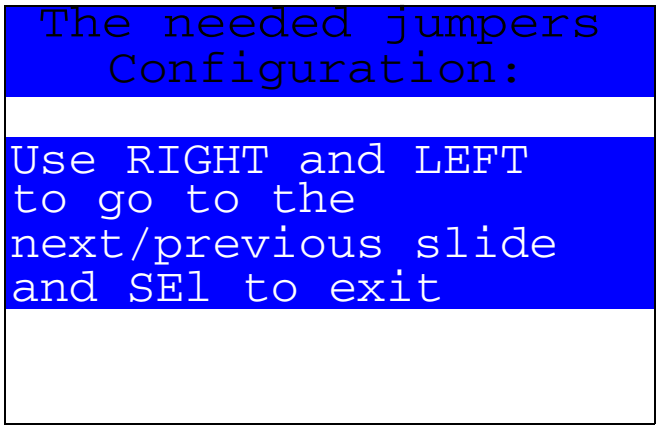
**Figure 70. Navigation menu-2**




Once the joystick push-button has been pressed again, the MCU exits the navigation submenu and the message shown in *Figure 68* is displayed on the LCD screen.

- If the Jumpers config submenu is selected, the message shown in *Figure 71* is displayed.

**Figure 71. Jumpers config menu-1**




Press RIGHT and LEFT to go to the next/previous slide and SEl to exit. The following messages shown in *Figure 72*, *Figure 73, Figure 74* and *Figure 75* are displayed sequentially on the LCD screen.

Figure 72. Jumpers config menu-2

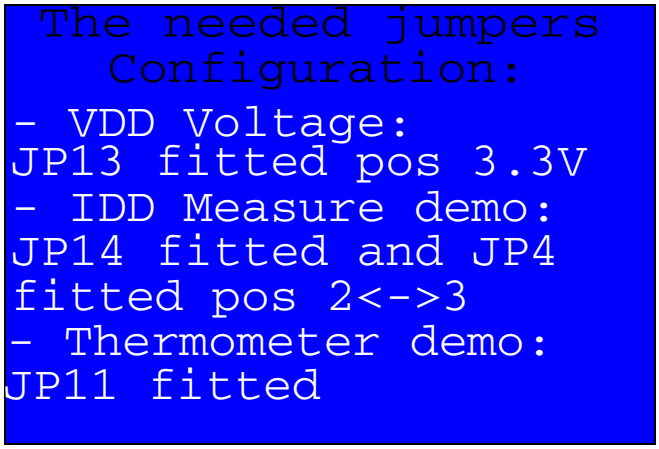



Figure 73. Jumpers config menu-3

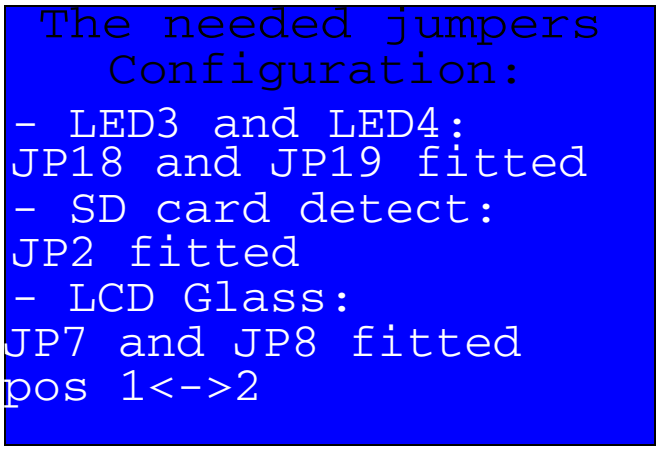


**Figure 74. Jumpers config menu-4**

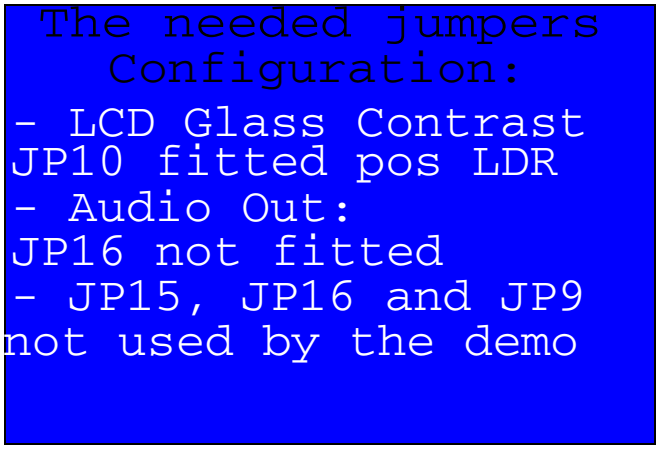
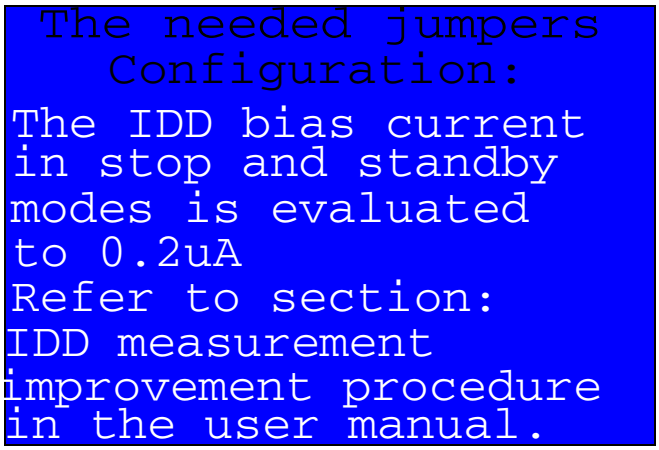



**Figure 75. Jumpers config menu-5**

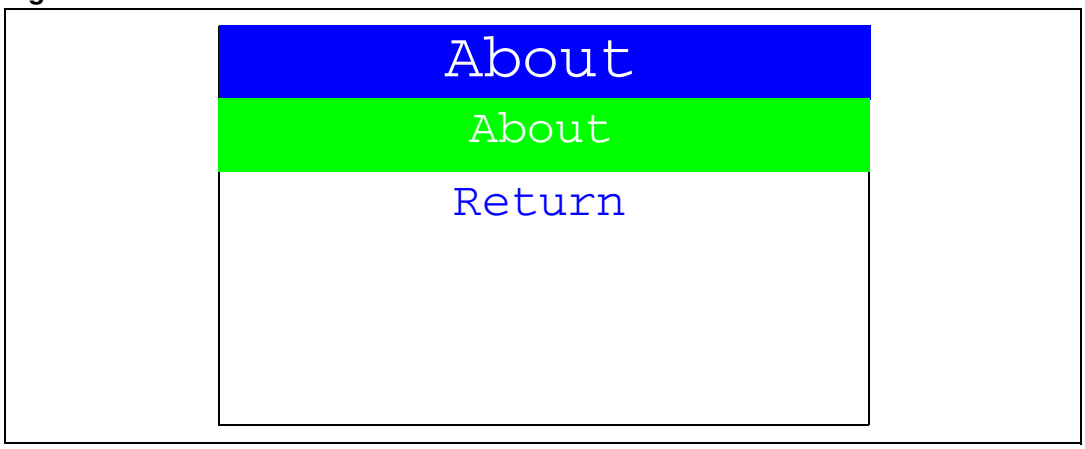



Once the SEL joystick push-button has been pressed, the MCU exits the Jumpers config submenu and the message shown in *Figure 68* is displayed on the LCD screen.

### 2.4.9 About submenu

This submenu shows the version of the STM32L152VB(T6) demo firmware. When the About submenu is selected, the message shown in *Figure 76* is displayed on the LCD screen.

**Figure 76. About submenu**

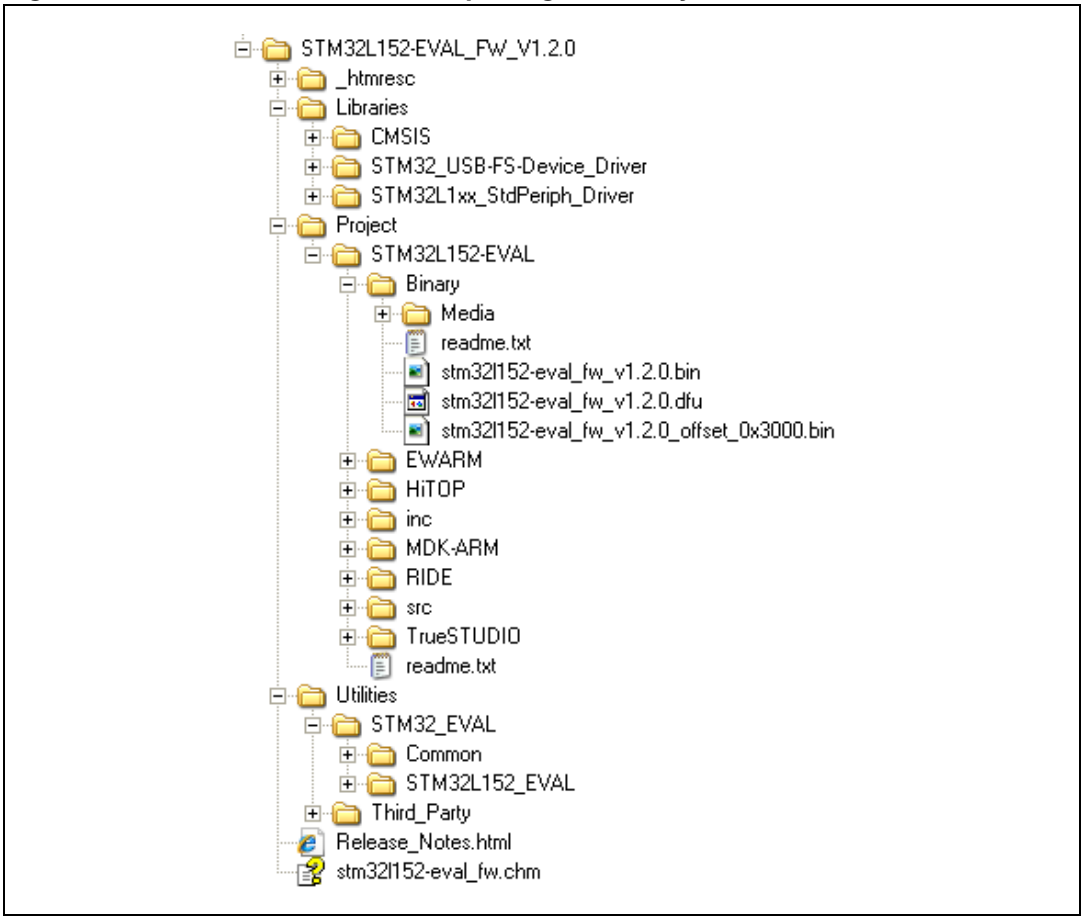



Pressing SEL then displays a message showing the STM32L152-EVAL demo version on the LCD screen.

# 3 STM32L152-EVAL demonstration package

The STM32L152-EVAL demonstration is supplied in one single zip file. The extraction of the zip file generates one folder, STM32L152-EVAL_FW_VX.Y.Z, which contains the subfolders shown in *Figure 77* and described below.

**Figure 77. STM32L152-EVAL demo package directory tree**




1. **Libraries**: contains all the subdirectories and files that make up the core of the STM32L1xx Standard Peripheral library V1.1.0:

   **CMSIS**

   – CMSIS\Include: contains the Cortex-Mx files

   – CMSIS\Device\ST\STM32L1xx: contains the STM32L1xx CMSIS layer files

   **STM32L1xx_Stdperiph_Driver**

   – *inc* subfolder contains the Standard Peripheral library header files

   – *src* subfolder contains the Standard Peripheral library source files

   **STM32_USB-FS-Device_Driver**

   – *inc* subfolder contains the USB Full Speed Peripheral library header files

   – *src* subfolder contains the USB Full Speed Peripheral library source files

2. **Project**

   **STM32L152-EVAL**

   – Binary: contains the binary image of the demonstration that can be used to program the binary image to the internal Flash memory using IAP, plus the media files required to run the demo (Binary\Media)
   – EWARM: contains preconfigured projects for the EWARM toolchain
   – MDK-ARM: contains preconfigured projects for the MDK-ARM toolchain
   – RIDE: contains preconfigured projects for the RIDE toolchain
   – TrueSTUDIO: contains preconfigured projects for the Atollic toolchain
   – HiTOP: contains preconfigured projects for the HiTOP toolchain
   – inc: contains the Demo header files
   – src: contains the Demo source files

3. **Utilities**

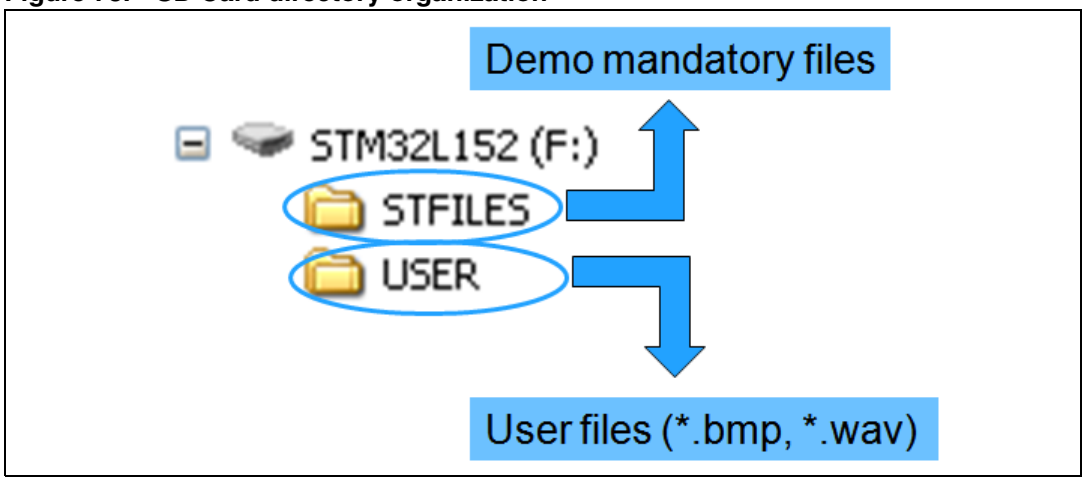
   – STM32L152-EVAL: contains the LCD, and other STM32L152-EVAL board-related drivers

# 4 STM32L152-EVAL demonstration programming

## 4.1 Programming the media files

The STM32L152-EVAL board comes with a MicroSD card memory pre-programmed with Audio and Image resources used by the demonstration. However, you can load your own image (*.bmp) and audio (*.wav) files in the USER directory, respectively, providing that these file formats are supported by the demonstration. For more details, please refer to *Section 2.4.3: Image Viewer submenu* and *Section 2.4.4: Wave Player submenu*.

**Figure 78. SD Card directory organization**




The default content of the media files (STFILES and USER directories) can be retrieved from the Binary\Media folder. So, if the user wants to reprogramm the MicroSD card, he can copy the content of the Binary\Media folder to his/her own SD memory.

## 4.2 Programming the demo

You can program the demonstration using four methods.

### 4.2.1 Using Bootloader

To program the demonstration's binary image into the internal Flash memory, you have to use the stm32l152_eval_fw_v1.2.0.bin file located under Project\STM32L152-EVAL\Binary with embedded Bootloader. For more details, please refer to Bootloader application note AN2606 *STM32™ microcontroller system memory boot mode*.

### 4.2.2 Using IAP

To program the demonstration's binary image into the internal Flash memory, you have to use the stm32l152-eval_fw_v1.2.0_offset_0x3000.bin file located under Project\STM32L152-EVAL\Binary with IAP over USART. For more details, please refer to IAP application note AN3310 *STM32L1xx in-application programming using the USART*.

### 4.2.3 Using USB DFU

To program the demonstration's binary image into the internal Flash memory, you have to use the stm32l152-eval_fw_v1.2.0.dfu file located under Project\STM32L152-EVAL\Binary with USB DFU. For more details, please refer to user manual UM0424 *STM32 USB-FS-Device development kit*.

### 4.2.4 Using preconfigured projects

- Select the folder corresponding to your preferred toolchain (MDK-ARM, EWARM, RIDE, HiTOP or TrueSTUDIO).
- Open the STM32L152_EVAL project and rebuild all sources.
- Load the project image through your debugger.
- Restart the evaluation board (press B1: reset button).

# 5 Revision history

Table 4. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 07-Apr-2011 | 1 | Initial release. |
| 31-Jan-2012 | 2 | *Chapter 2.4.5: IDD Measure* updated. |

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