Getting started with STM32F10xxx hardware development

Introduction

This document is addressed to system designers who need a hardware implementation overview of the development board features, such as power supply, clock management, reset control, boot mode settings, and debug management.

It shows how to use the low-density value line, low-density, medium-density value line, medium-density, high-density, XL-density and connectivity line STM32F10xxx products (the full list is detailed in Table 1), and describes the minimum hardware resources required to develop an application. Detailed reference design schematics are also provided, with the description of the main components, interfaces, and modes.

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<table>
<thead>
<tr>
<th>Type</th>
<th>Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontrollers</td>
<td>STM32F100 Value Line</td>
</tr>
<tr>
<td></td>
<td>STM32F101</td>
</tr>
<tr>
<td></td>
<td>STM32F102</td>
</tr>
<tr>
<td></td>
<td>STM32F103</td>
</tr>
<tr>
<td></td>
<td>STM32F105/107</td>
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1 General information

This document applies to STM32F10xxx microcontrollers, based on Arm® Cortex® cores.

Note: Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

Glossary

Low-density value line devices are STM32F100xx microcontrollers where the flash memory density ranges between 16 and 32 Kbytes.

Low-density devices are STM32F101xx, STM32F102xx and STM32F103xx microcontrollers where the flash memory density ranges between 16 and 32 Kbytes.

Medium-density value line devices are STM32F100xx microcontrollers where the flash memory density ranges between 64 and 128 Kbytes.

Medium-density devices are STM32F100xx, STM32F101xx, STM32F102xx and STM32F103xx microcontrollers where the flash memory density ranges between 64 and 128 Kbytes.

High-density value line devices are STM32F100xx microcontrollers where the flash memory density ranges between 256 and 512 Kbytes.

High-density devices are STM32F101xx and STM32F103xx microcontrollers where the flash memory density ranges between 256 and 512 Kbytes.

XL-density devices are STM32F101xx and STM32F103xx microcontrollers where the flash memory density ranges between 768 Kbytes and 1 Mbyte.

Connectivity line devices are STM32F105xx and STM32F107xx microcontrollers.
2 Power supplies

2.1 Introduction

The device requires a 2.0 to 3.6 V operating voltage supply ($V_{DD}$). An embedded regulator is used to supply the internal 1.8 V digital power.

The real-time clock (RTC) and backup registers can be powered from the $V_{BAT}$ voltage when the main $V_{DD}$ supply is powered off.

*Figure 1. Power supply overview*

Note: $V_{DDA}$ and $V_{SSA}$ must be connected, respectively, to $V_{DD}$ and $V_{SS}$.

2.1.1 Independent A/D converter supply and reference voltage

To improve the conversion accuracy, the ADC has an independent power supply that can be filtered separately, and shielded from noise on the PCB:

- the ADC voltage supply input is available on a separate $V_{DDA}$ pin
- an isolated supply ground connection is provided on the $V_{SSA}$ pin

When available (depending on package), $V_{REF-}$ must be tied to $V_{SSA}$.

**On 100- and 144-pin packages**

To ensure a better accuracy on low-voltage inputs, the user can connect a separate external reference voltage ADC input on $V_{REF+}$. The voltage on $V_{REF+}$ can range from 2.4 V to $V_{DDA}$. 
On packages with 64 pins or less
The VREF+ and VREF- pins are not available, they are internally connected to the ADC voltage supply (VDDA) and ground (VSSA).

2.1.2 Battery backup
To retain the content of the Backup registers when VDD is turned off, the VBAT pin can be connected to an optional standby voltage supplied by a battery or another source.

The VBAT pin also powers the RTC unit, allowing the RTC to operate even when the main digital supply (VDD) is turned off. The switch to the VBAT supply is controlled by the power down reset (PDR) circuitry embedded in the Reset block.

If no external battery is used in the application, it is highly recommended to connect VBAT externally to VDD.

2.1.3 Voltage regulator
The voltage regulator is always enabled after reset. It works in three different modes, depending on the application modes:
• in Run mode, the regulator supplies full power to the 1.8 V domain (core, memories and digital peripherals)
• in Stop mode, the regulator supplies low power to the 1.8 V domain, preserving the contents of the registers and SRAM
• in Standby mode, the regulator is powered off. The contents of the registers and SRAM are lost except for those concerned with the Standby circuitry and the Backup domain.

2.2 Power supply schemes
The circuit is powered by a stabilized power supply, VDD.
• The VDD pins must be connected to VDD with external decoupling capacitors (one 100 nF ceramic capacitor for each VDD pin, plus one tantalum or ceramic capacitor (min. 4.7 µF, typ.10 µF).
• The VBAT pin can be connected to the external battery (1.8 V < VBAT < 3.6 V). If no external battery is used, it is recommended to connect this pin to VDD with a 100 nF external ceramic decoupling capacitor.
• The VDDA pin must be connected to two external decoupling capacitors (100 nF ceramic + 1 µF tantalum or ceramic).
• The VREF+ pin can be connected to the VDDA external power supply. If a separate, external reference voltage is applied on VREF+, a 100 nF and a 1 µF capacitors must be connected on this pin. In all cases, VREF+ must be kept between 2.4 V and VDDA.
• Additional precautions can be taken to filter analog noise:
  – VDDA can be connected to VDD through a ferrite bead.
  – The VREF+ pin can be connected to VDDA through a resistor (typ. 47 Ω).

Caution: If the ADC is used, the VDD range is limited to 2.4 to 3.6 V (when the ADC is not used, the VDD range is 2.0 to 3.6 V).
2.3 Reset and power supply supervisor

2.3.1 Power on reset (POR) / power down reset (PDR)

The device has an integrated POR/PDR circuitry that allows proper operation starting from 2 V.

The device remains in the Reset mode as long as $V_{DD}$ is below a specified threshold, $V_{POR/PDR}$, without the need for an external reset circuit. For more details concerning the power on/power down reset threshold, refer to the electrical characteristics in the low-density, medium-density, high-density, XL-density, and connectivity line STM32F10xxx datasheets.
2.3.2 Programmable voltage detector (PVD)

You can use the PVD to monitor the \(V_{DD}\) power supply by comparing it to a threshold selected by the PLS[2:0] bits in the Power control register (PWR_CR).

The PVD is enabled by setting the PVDE bit.

A PVDO flag is available, in the Power control/status register (PWR_CSR), to indicate whether \(V_{DD}\) is higher or lower than the PVD threshold. This event is internally connected to EXTI Line16 and can generate an interrupt if enabled through the EXTI registers. The PVD output interrupt can be generated when \(V_{DD}\) drops below the PVD threshold and/or when \(V_{DD}\) rises above the PVD threshold depending on the EXTI Line16 rising/falling edge configuration. As an example the service routine can perform emergency shutdown tasks.

![Figure 4. PVD thresholds](image)

2.3.3 System reset

A system reset sets all registers to their reset values except for the reset flags in the clock controller CSR register and the registers in the Backup domain (see Figure 1).

A system reset is generated when one of the following events occurs:
1. A low level on the NRST pin (external reset)
2. Window watchdog end-of-count condition (WWDG reset)
3. Independent watchdog end-of-count condition (IWDG reset)
4. A software reset (SW reset)
5. Low-power management reset

The reset source can be identified by checking the reset flags in the Control/Status register, RCC_CSR.
The STM32F1xx does not require an external reset circuit to power-up correctly. Only a pull-down capacitor is recommended to improve EMS performance by protecting the device against parasitic resets. See Figure 5.

Charging and discharging a pull-down capacitor through an internal resistor increases the device power consumption. The capacitor recommended value (100 nF) can be reduced to 10 nF to limit this power consumption.

Figure 5. Simplified diagram of the reset circuit
3 Clocks

Three different clock sources can be used to drive the system clock (SYSCLK):
- HSI oscillator clock (high-speed internal clock signal)
- HSE oscillator clock (high-speed external clock signal)
- PLL clock

The devices have two secondary clock sources:
- 40 kHz low-speed internal RC (LSI RC), driving the independent watchdog and, optionally, the RTC used for Auto-wakeup from the Stop/Standby modes.
- 32.768 kHz low-speed external crystal (LSE crystal), optionally driving the real-time clock (RTCCLK)

Each clock source can be switched on or off independently when it is not used, to optimize the power consumption.

Refer to the reference manuals for the description of the clock tree:
- RM0008 for STM32F101xx, STM32F102xx, STM32F103xx and STM32F105xx/107xx microcontrollers
- RM0041 for STM32F100xx value line microcontrollers

3.1 HSE OSC clock

The high-speed external clock signal (HSE) can be generated from two clock sources:
- HSE external crystal/ceramic resonator (see Figure 7)
- HSE user external clock (see Figure 6)

1. The value of $R_{EXT}$ depends upon the crystal characteristics. Typical value is in the range of 5 to 6 $R_S$ (resonator series resistance).

2. Load capacitance $C_L$ has the following formula: $C_L = C_{L1} \times C_{L2} / (C_{L1} + C_{L2}) + C_{stray}$, where $C_{stray}$ is the pin capacitance and board or trace PCB-related capacitance. Typically, it is between 2 and 7 pF. Refer to Section 6 to minimize its value.
3.1.1 **External source (HSE bypass)**

In this mode, an external clock source must be provided. It can have a frequency of up to:

- 24 MHz for STM32F100xx value line devices
- 25 MHz for STM32F101xx, STM32F102xx and STM32F103xx devices
- 50 MHz for connectivity line devices

The external clock signal (square, sine or triangle) with a duty cycle of about 50%, has to drive the OSC_IN pin while the OSC_OUT pin must be left in the high impedance state (see [Figure 7](#) and [Figure 6](#)).

3.1.2 **External crystal/ceramic resonator (HSE crystal)**

The external oscillator frequency ranges from:

- 4 to 16 MHz on STM32F101xx, STM32F102xx and STM32F103xx devices
- 4 to 24 MHz for STM32F100xx value line devices
- 3 to 25 MHz on connectivity line devices

The external oscillator has the advantage of producing a very accurate rate on the main clock. The associated hardware configuration is shown in [Figure 7](#).

The resonator and the load capacitors have to be connected as close as possible to the oscillator pins in order to minimize output distortion and startup stabilization time. The load capacitance values must be adjusted according to the selected oscillator.

For $C_{L1}$ and $C_{L2}$ it is recommended to use high-quality ceramic capacitors in the 5 pF-to-25 pF range (typ.), designed for high-frequency applications and selected to meet the requirements of the crystal or resonator. $C_{L1}$ and $C_{L2}$ are usually the same value. The crystal manufacturer typically specifies a load capacitance that is the series combination of $C_{L1}$ and $C_{L2}$. The PCB and MCU pin capacitances must be included when sizing $C_{L1}$ and $C_{L2}$ (10 pF can be used as a rough estimate of the combined pin and board capacitance).

Refer to the electrical characteristics sections in the datasheet for more details.
3.2 LSE OSC clock

The low-speed external clock signal (LSE) can be generated from two possible clock sources:

- LSE external crystal/ceramic resonator (see Figure 9)
- LSE user external clock (see Figure 8)

### Figure 8. External clock

<table>
<thead>
<tr>
<th>OSC32_IN</th>
<th>OSC32_OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### Figure 9. Crystal/ceramic resonators

<table>
<thead>
<tr>
<th>STM32F10xxx</th>
<th>OSC32_IN</th>
<th>OSC32_OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Note:**

1. **“External clock” figure:**
   
   To avoid exceeding the maximum value of $C_{L1}$ and $C_{L2}$ (15 pF), it is strongly recommended to use a resonator with a load capacitance $C_L \leq 7$ pF. Never use a resonator with a load capacitance of 12.5 pF.

2. **“External clock” and “crystal/ceramic resonators” figures:**
   
   OSC32_IN and OSC32_OUT pins can be used also as GPIO, but it is recommended not to use them as both RTC and GPIO pins in the same application.

3. **“Crystal/ceramic resonators” figure:**
   
   The value of $R_{EXT}$ depends on the crystal characteristics. A 0 Ω resistor works, but it is not optimal. Typical value is in the range of 5 to 6 $R_S$ (resonator series resistance). To fine tune $R_S$ value refer to AN2867 - Oscillator design guide for ST microcontrollers.

### 3.2.1 External source (LSE bypass)

In this mode, an external clock source must be provided. It can have a frequency up to 1 MHz. The external clock signal (square, sine or triangle) with a duty cycle of about 50% must drive the OSC32_IN pin, while the OSC32_OUT pin must be left high impedance (see Figure 9 and Figure 8).

### 3.2.2 External crystal/ceramic resonator (LSE crystal)

The LSE crystal is a 32.768 kHz low-speed external crystal or ceramic resonator. It has the advantage of providing a low-power, but highly accurate clock source to the real-time clock peripheral (RTC) for clock/calendar or other timing functions.

The resonator and the load capacitors have to be connected as close as possible to the oscillator pins in order to minimize output distortion and startup stabilization time. The load capacitance values must be adjusted according to the selected oscillator.
3.3 Clock security system (CSS)

The clock security system can be activated by software. In this case, the clock detector is enabled after the HSE oscillator startup delay, and disabled when this oscillator is stopped.

- If a failure is detected on the HSE oscillator clock, the oscillator is automatically disabled. A clock failure event is sent to the break input of the TIM1 advanced control timer and an interrupt is generated to inform the software about the failure (clock security system interrupt CSSI), allowing the MCU to perform rescue operations. The CSSI is linked to the Cortex-M3 NMI (non-maskable interrupt) exception vector.

- If the HSE oscillator is used directly or indirectly as the system clock (indirectly means that it is used as the PLL input clock, and the PLL clock is used as the system clock), a detected failure causes a switch of the system clock to the HSI oscillator and the disabling of the external HSE oscillator. If the HSE oscillator clock (divided or not) is the clock entry of the PLL used as system clock when the failure occurs, the PLL is disabled too.

For details, see the STM32F10xxx (RM0008) and STM32F100xx (RM0041) reference manuals available from the STMicroelectronics website www.st.com.
4 Boot configuration

4.1 Boot mode selection

In the STM32F10xxx, three different boot modes can be selected by means of the BOOT[1:0] pins, as shown in Table 2.

<table>
<thead>
<tr>
<th>BOOT mode selection pins</th>
<th>Boot mode</th>
<th>Aliasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>x 0</td>
<td>Main flash memory</td>
<td>Main flash memory is selected as boot space</td>
</tr>
<tr>
<td>0 1</td>
<td>System memory</td>
<td>System memory is selected as boot space</td>
</tr>
<tr>
<td>1 1</td>
<td>Embedded SRAM</td>
<td>Embedded SRAM is selected as boot space</td>
</tr>
</tbody>
</table>

The values on the BOOT pins are latched on the fourth rising edge of SYSCLK after a reset. It is up to the user to set the BOOT1 and BOOT0 pins after reset to select the required boot mode.

The BOOT pins are also resampled when exiting the Standby mode. Consequently, they must be kept in the required Boot mode configuration in the Standby mode. After this startup delay has elapsed, the CPU fetches the top-of-stack value from address 0x0000 0000, and starts code execution from the boot memory, starting from 0x0000 0004.

4.2 Boot pin connection

Figure 10 shows the external connection required to select the boot memory of the STM32F10xxx.

Figure 10. Boot mode selection implementation example

1. Resistor values are given only as a typical example.
4.3 Embedded boot loader mode

The Embedded boot loader mode is used to reprogram the flash memory using one of the available serial interfaces:

- In low-density, low-density value line, medium-density, medium-density value line, and high-density devices, the boot loader is activated through the USART1 interface. For further details refer to AN2606.
- In XL-density devices, the boot loader is activated through the USART1 or USART2 (remapped) interface. For further details refer to AN2606.
- In connectivity line devices the boot loader can be activated through one of the following interfaces: USART1, USART2 (remapped), CAN2 (remapped) or USB OTG FS in Device mode (DFU: device firmware upgrade). The USART peripheral operates with the internal 8 MHz oscillator (HSI). The CAN and USB OTG FS, however, can only function if an external 8 MHz, 14.7456 MHz or 25 MHz clock (HSE) is present. For further details, refer to AN2662.

This embedded boot loader is located in the System memory and is programmed by ST during production.
5 Debug management

5.1 Introduction

The Host/Target interface is the hardware equipment that connects the host to the application board. This interface is made of three components: a hardware debug tool, a JTAG or SW connector and a cable connecting the host to the debug tool.

*Figure 11* shows the connection of the host to the evaluation board (STM3210B-EVAL, STM3210C-EVAL, STM32100B-EVAL or STM3210E-EVAL). The Value line evaluation board (STM32100B-EVAL or STM32100E-EVAL) embeds the debug tools (ST-LINK). Consequently, it can be directly connected to the PC through a USB cable.

*Figure 11. Host-to-board connection*

5.2 SWJ debug port (serial wire and JTAG)

The STM32F10xxx core integrates the serial wire/JTAG debug port (SWJ-DP). It is an Arm® standard CoreSight™ debug port that combines a JTAG-DP (5-pin) interface and a SW-DP (2-pin) interface.

- The JTAG debug port (JTAG-DP) provides a 5-pin standard JTAG interface to the AHP-AP port
- The serial wire debug port (SW-DP) provides a 2-pin (clock + data) interface to the AHP-AP port

In the SWJ-DP, the two JTAG pins of the SW-DP are multiplexed with some of the five JTAG pins of the JTAG-DP.

5.3 Pinout and debug port pins

The STM32F10xxx MCU is offered in various packages with different numbers of available pins. As a result, some functionality related to the pin availability may differ from one package to another.

5.3.1 SWJ debug port pins

Five pins are used as outputs for the SWJ-DP as *alternate functions* of general-purpose I/Os (GPIOs). These pins, shown in *Table 3*, are available on all packages.
5.3.2 Flexible SWJ-DP pin assignment

After reset (SYSRESETn or PORESETn), all five pins used for the SWJ-DP are assigned as dedicated pins immediately usable by the debugger host (note that the trace outputs are not assigned except if explicitly programmed by the debugger host).

However, the STM32F10xxx MCU implements a register to disable some part or all of the SWJ-DP port, and so releases the associated pins for general-purpose I/Os usage. This register is mapped on an APB bridge connected to the Cortex-M3 system bus. This register is programmed by the user software program and not by the debugger host.

<table>
<thead>
<tr>
<th>SWJ-DP pin name</th>
<th>JTAG debug port</th>
<th>SW debug port</th>
<th>Pin assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type</td>
<td>Description</td>
<td>Type</td>
</tr>
<tr>
<td>JTMS/SWDIO</td>
<td>I</td>
<td>JTAG test mode selection</td>
<td>I/O</td>
</tr>
<tr>
<td>JTCK/SWCLK</td>
<td>I</td>
<td>JTAG test clock</td>
<td>I</td>
</tr>
<tr>
<td>JTDI</td>
<td>I</td>
<td>JTAG test data input</td>
<td>-</td>
</tr>
<tr>
<td>JTDO/TRACESWO</td>
<td>O</td>
<td>JTAG test data output</td>
<td>-</td>
</tr>
<tr>
<td>JNTRST</td>
<td>I</td>
<td>JTAG test nReset</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4. SWJ I/O pin availability

<table>
<thead>
<tr>
<th>Available Debug ports</th>
<th>SWJ I/O pin assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PA13 / JTMS/ SWDIO</td>
</tr>
<tr>
<td>Full SWJ (JTAG-DP + SW-DP) - reset state</td>
<td>X</td>
</tr>
<tr>
<td>Full SWJ (JTAG-DP + SW-DP) but without JNTRST</td>
<td>X</td>
</tr>
<tr>
<td>JTAG-DP disabled and SW-DP enabled</td>
<td>X</td>
</tr>
<tr>
<td>JTAG-DP disabled and SW-DP disabled</td>
<td>Released</td>
</tr>
</tbody>
</table>

Table 4 shows the different possibilities to release some pins.

For more details, see the STM32F10xxx (RM0008) and STM32F100xx (RM0041) reference manuals, available from the STMicroelectronics website www.st.com.
5.3.3 Internal pull-up and pull-down resistors on JTAG pins

The JTAG input pins must not be floating since they are directly connected to flip-flops to control the debug mode features. Special care must be taken with the SWCLK/TCK pin that is directly connected to the clock of some of these flip-flops.

To avoid any uncontrolled I/O levels, the STM32F10xxx embeds internal pull-up and pull-down resistors on JTAG input pins:

- JNTRST: Internal pull-up
- JTDI: Internal pull-up
- JTMS/SWDIO: Internal pull-up
- TCK/SWCLK: Internal pull-down

Once a JTAG I/O is released by the user software, the GPIO controller takes control again. The reset states of the GPIO control registers put the I/Os in the equivalent state:

- JNTRST: Input pull-up
- JTDI: Input pull-up
- JTMS/SWDIO: Input pull-up
- JTCK/SWCLK: Input pull-down
- JTDO: Input floating

The software can then use these I/Os as standard GPIOs.

Note: The JTAG IEEE standard recommends to add pull-up resistors on TDI, TMS and nTRST, but there is no special recommendation for TCK. However, for the STM32F10xxx, an integrated pull-down resistor is used for JTCK. Having embedded pull-up and pull-down resistors removes the need for external resistors.

5.3.4 SWJ debug port connection with standard JTAG connector

Figure 12 shows the connection between the STM32F10xxx and a standard JTAG connector.
6  Recommendations

6.1  Printed circuit board

For technical reasons, it is best to use a multilayer printed circuit board (PCB) with a separate layer dedicated to ground (V_{SS}) and another dedicated to the V_{DD} supply. This provides good decoupling and a good shielding effect. For many applications, economical reasons prohibit the use of this type of board. In this case, the major requirement is to ensure a good structure for ground and for the power supply.

6.2  Component position

A preliminary layout of the PCB must separate the different circuits according to their EMI contribution in order to reduce cross-coupling on the PCB, that is noisy, high-current circuits, low-voltage circuits, and digital components.

6.3  Ground and power supply (V_{SS}, V_{DD})

Every block (noisy, low-level sensitive, digital, etc.) must be grounded individually, and all ground returns must be to a single point. Loops must be avoided or have a minimum area. The power supply must be implemented close to the ground line to minimize the area of the supply loop. This is due to the fact that the supply loop acts as an antenna, and is therefore the main transmitter and receiver of EMI. All component-free PCB areas must be filled with additional grounding to create a kind of shielding (especially when using single-layer PCBs).

6.4  Decoupling

All power supply and ground pins must be properly connected to the power supplies. These connections, including pads, tracks and vias must have as low an impedance as possible. This is typically achieved with thick track widths and, preferably, the use of dedicated power supply planes in multilayer PCBs.

In addition, each power supply pair must be decoupled with filtering ceramic capacitors C (100 nF) and a chemical capacitor C of about 10 µF connected in parallel on the STM32F10xxx device. These capacitors need to be placed as close as possible to, or below, the appropriate pins on the underside of the PCB. Typical values are 10 nF to 100 nF, but exact values depend on the application needs. Figure 13 shows the typical layout of such a V_{DD}/V_{SS} pair.
6.5 Other signals

When designing an application, the EMC performance can be improved by closely studying:

- Signals for which a temporary disturbance affects the running process permanently (the case of interrupts and handshaking strobe signals, and not the case for LED commands).
  
  For these signals, a surrounding ground trace, shorter lengths and the absence of noisy and sensitive traces nearby (crosstalk effect) improve EMC performance.
  
  For digital signals, the best possible electrical margin must be reached for the two logical states and slow Schmitt triggers are recommended to eliminate parasitic states.

- Noisy signals (such as clocks)

- Sensitive signals (such as those with high impedance)

6.6 Unused I/Os and features

All microcontrollers are designed for a variety of applications and often a particular application does not use 100% of the MCU resources.

To increase EMC performance, unused clocks, counters or I/Os, must not be left free, e.g. I/Os must be set to “0” or “1” (pull-up or pull-down to the unused I/O pins), and unused features must be “frozen” or disabled.
7 Reference design

7.1 Description

The reference design shown in Figure 14, is based on the STM32F103ZE(T6), a highly integrated microcontroller running at 72 MHz, that combines the new Cortex™-M3 32-bit RISC CPU core with 512 Kbytes of embedded flash memory and up to 64 Kbytes of high-speed SRAM.

This reference design can be tailored to any other STM32F10xxx device with different package, using the pins correspondence given in Table 7.

7.1.1 Clock

Two clock sources are used for the microcontroller:

- LSE: X1– 32.768 kHz crystal for the embedded RTC
- HSE: X2– 8 MHz crystal for the STM32F10xxx microcontroller

Refer to Section 3.

7.1.2 Reset

The reset signal in Figure 14 is active low. The reset sources include:

- Reset button (B1)
- Debugging tools via the connector CN1

Refer to Section 2.3.

7.1.3 Boot mode

The boot option is configured by setting switches SW2 (Boot 0) and SW1 (Boot 1). Refer to Section 4.

Note: In low-power mode (more specially in Standby mode) the boot mode is mandatory to be able to connect to tools (boot the device from the SRAM).

7.1.4 SWJ interface

The reference design shows the connection between the STM32F10xxx and a standard JTAG connector. Refer to Section 5.

Note: It is recommended to connect the reset pins so as to be able to reset the application from the tools.

7.1.5 Power supply

Refer to Section 2.
## 7.2 Component references

### Table 5. Mandatory components

<table>
<thead>
<tr>
<th>Id</th>
<th>Name</th>
<th>Reference</th>
<th>Quantity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Microcontroller</td>
<td>STM32F103ZE(T6)</td>
<td>1</td>
<td>144-pin package</td>
</tr>
<tr>
<td>2</td>
<td>Capacitors</td>
<td>100 nF</td>
<td>11</td>
<td>Ceramic capacitors (decoupling capacitors)</td>
</tr>
<tr>
<td>3</td>
<td>Capacitor</td>
<td>10 µF</td>
<td>1</td>
<td>Ceramic capacitor (decoupling capacitor)</td>
</tr>
</tbody>
</table>

### Table 6. Optional components

<table>
<thead>
<tr>
<th>Id</th>
<th>Name</th>
<th>Reference</th>
<th>Quantity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Resistor</td>
<td>10 kΩ</td>
<td>5</td>
<td>Pull-up and pull-down for JTAG and Boot mode.</td>
</tr>
<tr>
<td>2</td>
<td>Resistor</td>
<td>390Ω</td>
<td>1</td>
<td>Used for HSE: the value depends on the crystal characteristics. This resistor value is given only as a typical example.</td>
</tr>
<tr>
<td>3</td>
<td>Resistor</td>
<td>0Ω</td>
<td>1</td>
<td>Used for LSE: the value depends on the crystal characteristics. This resistor value is given only as a typical example.</td>
</tr>
<tr>
<td>4</td>
<td>Capacitor</td>
<td>100 nF</td>
<td>3</td>
<td>Ceramic capacitor</td>
</tr>
<tr>
<td>5</td>
<td>Capacitor</td>
<td>1µF</td>
<td>2</td>
<td>Used for VDDA and VREF.</td>
</tr>
<tr>
<td>6</td>
<td>Capacitor</td>
<td>10 pF</td>
<td>2</td>
<td>Used for LSE: the value depends on the crystal characteristics.</td>
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<td>7</td>
<td>Capacitor</td>
<td>20 pF</td>
<td>2</td>
<td>Used for HSE: the value depends on the crystal characteristics.</td>
</tr>
<tr>
<td>8</td>
<td>Quartz</td>
<td>8 MHz</td>
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<tr>
<td>9</td>
<td>Quartz</td>
<td>32 kHz</td>
<td>1</td>
<td>Used for LSE</td>
</tr>
<tr>
<td>10</td>
<td>JTAG connector</td>
<td>HE10</td>
<td>1</td>
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</tr>
<tr>
<td>11</td>
<td>Battery</td>
<td>3V3</td>
<td>1</td>
<td>If no external battery is used in the application, it is recommended to connect VBAT externally to VDD</td>
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<tr>
<td>12</td>
<td>Switch</td>
<td>3V3</td>
<td>2</td>
<td>Used to select the correct boot mode.</td>
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<tr>
<td>13</td>
<td>Push-button</td>
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</table>
1. If no external battery is used in the application, it is recommended to connect $V_{BAT}$ externally to $V_{DD}$.

2. To be able to reset the device from the tools this resistor must be kept.
### Table 7. Reference connection for all packages

<table>
<thead>
<tr>
<th>Pin name</th>
<th>Pin number for LQFP packages</th>
<th>Pin number for BGA packages</th>
<th>Pin number for VFQFPN package</th>
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### 8 Revision history

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<thead>
<tr>
<th>Date</th>
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<td>12-Jul-2007</td>
<td>1</td>
<td>Initial release.</td>
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<tr>
<td>23-May-2008</td>
<td>2</td>
<td>Application note also applicable to High-density devices. Figure 1: Power supply overview, Figure 2: Power supply scheme and Figure 6: Clock overview updated. Low-speed internal RC frequency modified in Section 3: Clocks on page 12. VREF+ voltage range modified. Table 7: Reference connection for all packages on page 26 added. Small text changes.</td>
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<tr>
<td>23-Jun-2009</td>
<td>3</td>
<td>Connectivity line STM32F10xxx and Glossary added. Section 2.2: Power supply schemes and Figure 2: Power supply scheme updated. Figure 5: Simplified diagram of the reset circuit updated. Section 2.3 Clock-out capability section removed. Section 4.1: Boot mode selection and Section 4.3: Embedded boot loader mode updated. When no external battery is used, it is recommended to externally connect the VBAT pin to VDD. PA14 updated in Table 8: Document revision history. Small text changes. STM3210C-EVAL evaluation board added in Section 5.</td>
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<tr>
<td>01-Mar-2010</td>
<td>4</td>
<td>This application note also applies to STM32F100xx low- and medium-density value line products: – low- and medium-density value line devices added to Introduction – Section 3.1.1: External source (HSE bypass) and Section 3.1.2: External crystal/ceramic resonator (HSE crystal) updated – reference to line’s evaluation board added to Section 5.1: Introduction Table 5: Simplified diagram of the reset circuit updated.</td>
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<tr>
<td>19-Oct-2010</td>
<td>5</td>
<td>Modified Section 3.2.1: External source (LSE bypass) Updated for high-density value line devices.</td>
</tr>
<tr>
<td>14-Apr-2011</td>
<td>6</td>
<td>Updated VDDA and VREF schematics in Figure 14: STM32F103ZE(T6) microcontroller reference schematic and Table 6: Optional components.</td>
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<tr>
<td>18-Nov-2011</td>
<td>7</td>
<td>Updated to include XL-density devices.</td>
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<tr>
<td>09-Dec-2022</td>
<td>8</td>
<td>Added Table 1: Applicable products and Section 1: General information. Updated Figure 3: Power on reset/power down reset waveform, Figure 4: PVD thresholds, and Figure 5: Simplified diagram of the reset circuit. Minor text edits across the whole document.</td>
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