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16 MHz STM8S 8-bit MCU, up to 8 Kbytes Flash, 1 Kbyte RAM, 640 bytes EEPROM, 10-bit ADC, 2 timers, UART, SPI, I²C

Datasheet - production data

Features

Core

- 16 MHz advanced STM8 core with Harvard architecture and 3-stage pipeline
- Extended instruction set

Memories

- Program memory: 8 Kbyte Flash; data retention 20 years at 55 °C after 10 kcycle
- Data memory: 640 byte true data EEPROM; endurance 300 kcycle
- RAM: 1 Kbyte

Clock, reset and supply management

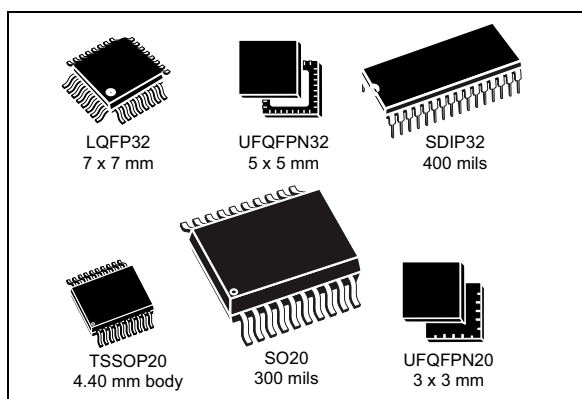
- 2.95 to 5.5 V operating voltage
- Flexible clock control, 4 master clock sources
 - Low power crystal resonator oscillator
 - External clock input
 - Internal, user-trimmable 16 MHz RC
 - Internal low-power 128 kHz RC
- Clock security system with clock monitor
- Power management:
 - Low-power modes (wait, active-halt, halt)
 - Switch-off peripheral clocks individually
- Permanently active, low-consumption power-on and power-down reset

Interrupt management

- Nested interrupt controller with 32 interrupts
- Up to 28 external interrupts on 7 vectors

Timers

- Advanced control timer: 16-bit, 4 CAPCOM channels, 3 complementary outputs, dead-time insertion and flexible synchronization



- 16-bit general purpose timer, with 3 CAPCOM channels (IC, OC or PWM)
- 8-bit basic timer with 8-bit prescaler
- Auto wake-up timer
- Window watchdog and independent watchdog timers

Communication interfaces

- UART with clock output for synchronous operation, SmartCard, IrDA, LIN master mode
- SPI interface up to 8 Mbit/s
- I²C interface up to 400 kbit/s

Analog to digital converter (ADC)

- 10-bit, ± 1 LSB ADC with up to 7 multiplexed channels + 1 internal channel, scan mode and analog watchdog
- Internal reference voltage measurement

I/Os

- Up to 28 I/Os on a 32-pin package including 21 high sink outputs
- Highly robust I/O design, immune against current injection

Unique ID

- 96-bit unique key for each device

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1 Introduction

This datasheet contains the description of the device features, pinout, electrical characteristics, mechanical data and ordering information.

- For complete information on the STM8S microcontroller memory, registers and peripherals, please refer to the STM8S microcontroller family reference manual (RM0016).
- For information on programming, erasing and protection of the internal Flash memory please refer to the STM8S Flash programming manual (PM0051).
- For information on the debug and SWIM (single wire interface module) refer to the STM8 SWIM communication protocol and debug module user manual (UM0470).
- For information on the STM8 core, please refer to the STM8 CPU programming manual (PM0044).

2 Description

The STM8S903K3/F3 access line 8-bit microcontrollers offer 8 Kbyte Flash program memory, plus integrated true data EEPROM. The STM8S microcontroller family reference manual (RM0016) refers to devices in this family as low-density. They provide the following benefits: performance, robustness, and reduced system cost.

Device performance and robustness are ensured by advanced core and peripherals made in a state-of-the-art technology, a 16 MHz clock frequency, robust I/Os, independent watchdogs with separate clock source, and a clock security system.

The system cost is reduced thanks to an integrated true data EEPROM for up to 300 k write/erase cycles and a high system integration level with internal clock oscillators, watchdog and brown-out reset.

Full documentation is offered as well as a wide choice of development tools.

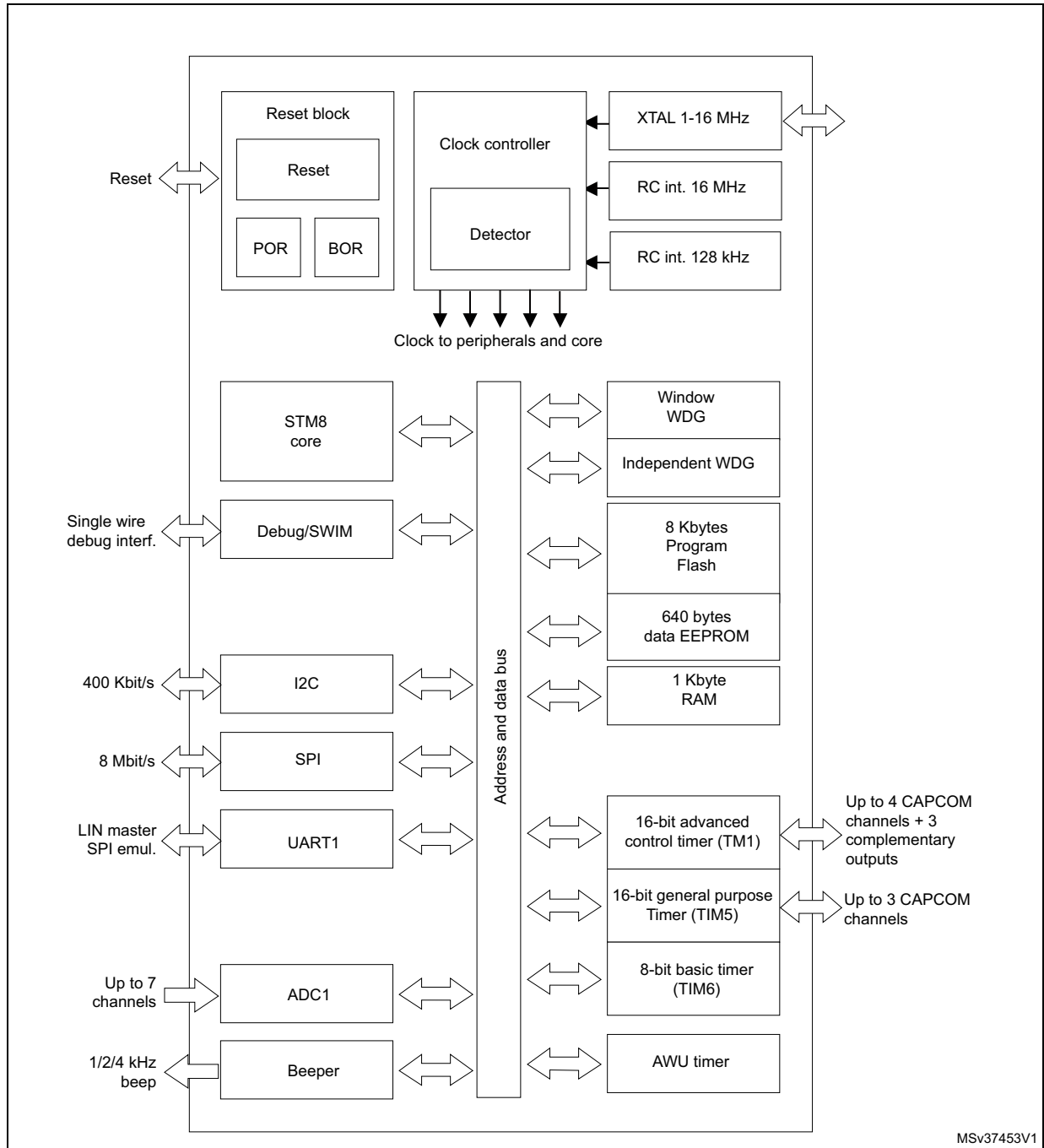
Table 1. STM8S903K3/F3 access line features

Device	STM8S903K3	STM8S903F3
Pin count	32	20
Maximum number of GPIOs (I/Os)	28 ⁽¹⁾	16 ⁽²⁾
Ext. interrupt pins	28	16
Timer CAPCOM channels	7	
Timer complementary outputs	3	2
A/D converter channels	7	5
High sink I/Os	21	12
Low density Flash program memory (bytes)	8K	
Data EEPROM (bytes)	640 ⁽³⁾	
RAM (bytes)	1K	
Peripheral set	Multipurpose timer (TIM1), SPI, I2C, UART window WDG, independent WDG, ADC, PWM timer (TIM5), 8-bit timer (TIM6)	

1. Including 21 high-sink outputs
2. Including 12 high-sink outputs
3. No read-while-write (RWW) capability.

3 Block diagram

Figure 1. STM8S903K3/F3 block diagram



MSv37453V1

4 Product overview

The following section provides an overview of the basic features of the device functional modules and peripherals.

For more detailed information please refer to the corresponding family reference manual (RM0016).

4.1 Central processing unit STM8

The 8-bit STM8 core is designed for code efficiency and performance.

It contains 6 internal registers which are directly addressable in each execution context, 20 addressing modes including indexed indirect and relative addressing and 80 instructions.

Architecture and registers

- Harvard architecture,
- 3-stage pipeline,
- 32-bit wide program memory bus - single cycle fetching for most instructions,
- X and Y 16-bit index registers - enabling indexed addressing modes with or without offset and read-modify-write type data manipulations,
- 8-bit accumulator,
- 24-bit program counter - 16-Mbyte linear memory space,
- 16-bit stack pointer - access to a 64 K-level stack,
- 8-bit condition code register - 7 condition flags for the result of the last instruction.

Addressing

- 20 addressing modes,
- Indexed indirect addressing mode for look-up tables located anywhere in the address space,
- Stack pointer relative addressing mode for local variables and parameter passing.

Instruction set

- 80 instructions with 2-byte average instruction size,
- Standard data movement and logic/arithmetic functions,
- 8-bit by 8-bit multiplication,
- 16-bit by 8-bit and 16-bit by 16-bit division,
- Bit manipulation,
- Data transfer between stack and accumulator (push/pop) with direct stack access,
- Data transfer using the X and Y registers or direct memory-to-memory transfers.

4.2 Single wire interface module (SWIM) and debug module (DM)

The single wire interface module and debug module permits non-intrusive, real-time in-circuit debugging and fast memory programming.

SWIM

Single wire interface module for direct access to the debug module and memory programming. The interface can be activated in all device operation modes. The maximum data transmission speed is 145 bytes/ms.

Debug module

The non-intrusive debugging module features a performance close to a full-featured emulator. Beside memory and peripherals, also CPU operation can be monitored in real-time by means of shadow registers.

- R/W to RAM and peripheral registers in real-time
- R/W access to all resources by stalling the CPU
- Breakpoints on all program-memory instructions (software breakpoints)
- Two advanced breakpoints, 23 predefined configurations

4.3 Interrupt controller

- Nested interrupts with three software priority levels,
- 32 interrupt vectors with hardware priority,
- Up to 28 external interrupts on 7 vectors including TLI,
- Trap and reset interrupts

4.4 Flash program and data EEPROM memory

- 8 Kbyte of Flash program single voltage Flash memory,
- 640 byte true data EEPROM,
- User option byte area.

Write protection (WP)

Write protection of Flash program memory and data EEPROM is provided to avoid unintentional overwriting of memory that could result from a user software malfunction.

There are two levels of write protection. The first level is known as MASS (memory access security system). MASS is always enabled and protects the main Flash program memory, data EEPROM and option bytes.

To perform in-application programming (IAP), this write protection can be removed by writing a MASS key sequence in a control register. This allows the application to write to data EEPROM, modify the contents of main program memory or the device option bytes.

A second level of write protection, can be enabled to further protect a specific area of memory known as UBC (user boot code). Refer to the figure below.

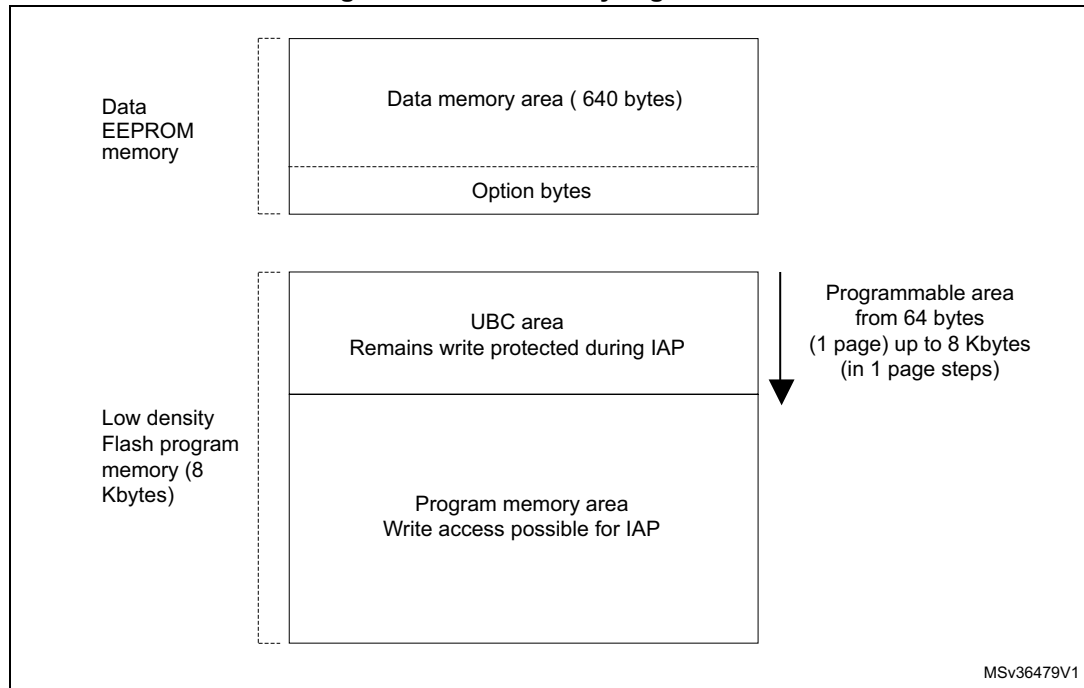
The size of the UBC is programmable through the UBC option byte, in increments of 1 page (64-byte block) by programming the UBC option byte in ICP mode.

This divides the program memory into two areas:

- Main program memory: up to 8 Kbyte minus UBC
- User-specific boot code (UBC): Configurable up to 8 Kbyte

The UBC area remains write-protected during in-application programming. This means that the MASS keys do not unlock the UBC area. It protects the memory used to store the boot program, specific code libraries, reset and interrupt vectors, the reset routine and usually the IAP and communication routines.

Figure 2. Flash memory organization



Read-out protection (ROP)

The read-out protection blocks reading and writing the Flash program memory and data EEPROM memory in ICP mode (and debug mode). Once the read-out protection is activated, any attempt to toggle its status triggers a global erase of the program and data memory. Even if no protection can be considered as totally unbreakable, the feature provides a very high level of protection for a general purpose microcontroller.

4.5 Clock controller

The clock controller distributes the system clock (fMASTER) coming from different oscillators to the core and the peripherals. It also manages clock gating for low power modes and ensures clock robustness.

Features

- **Clock prescaler:** to get the best compromise between speed and current consumption the clock frequency to the CPU and peripherals can be adjusted by a programmable prescaler.
- **Safe clock switching:** clock sources can be changed safely on the fly in run mode through a configuration register. The clock signal is not switched until the new clock source is ready. The design guarantees glitch-free switching.
- **Clock management:** to reduce power consumption, the clock controller can stop the clock to the core, individual peripherals or memory.
- **Master clock sources:** four different clock sources can be used to drive the master clock:
 - 1-16 MHz high-speed external crystal (HSE)
 - Up to 16 MHz high-speed user-external clock (HSE user-ext)
 - 16 MHz high-speed internal RC oscillator (HSI)
 - 128 kHz low-speed internal RC (LSI)
- **Startup clock:** After reset, the microcontroller restarts by default with an internal 2 MHz clock (HSI/8). The prescaler ratio and clock source can be changed by the application program as soon as the code execution starts.
- **Clock security system (CSS):** This feature can be enabled by software. If an HSE clock failure occurs, the internal RC (16 MHz/8) is automatically selected by the CSS and an interrupt can optionally be generated.
- **Configurable main clock output (CCO):** This outputs an external clock for use by the application.

Table 2. Peripheral clock gating bit assignments in CLK_PCKENR1/2 registers

Bit	Peripheral clock	Bit	Peripheral clock	Bit	Peripheral clock	Bit	Peripheral clock
PCKEN17	TIM1	PCKEN13	UART1	PCKEN27	Reserved	PCKEN23	ADC
PCKEN16	TIM5	PCKEN12	Reserved	PCKEN26	Reserved	PCKEN22	AWU
PCKEN15	Reserved	PCKEN11	SPI	PCKEN25	Reserved	PCKEN21	Reserved
PCKEN14	TIM6	PCKEN10	I2C	PCKEN24	Reserved	PCKEN20	Reserved

4.6 Power management

For efficient power management, the application can be put in one of four different low-power modes. You can configure each mode to obtain the best compromise between lowest power consumption, fastest start-up time and available wakeup sources.

- **Wait mode:** In this mode, the CPU is stopped, but peripherals are kept running. The wakeup is performed by an internal or external interrupt or reset.
- **Active halt mode with regulator on:** In this mode, the CPU and peripheral clocks are stopped. An internal wakeup is generated at programmable intervals by the auto wake up unit (AWU). The main voltage regulator is kept powered on, so current consumption is higher than in active halt mode with regulator off, but the wakeup time is faster. Wakeup is triggered by the internal AWU interrupt, external interrupt or reset.
- **Active halt mode with regulator off:** This mode is the same as active halt with regulator on, except that the main voltage regulator is powered off, so the wake up time is slower.
- **Halt mode:** In this mode the microcontroller uses the least power. The CPU and peripheral clocks are stopped, the main voltage regulator is powered off. Wakeup is triggered by external event or reset.

4.7 Watchdog timers

The watchdog system is based on two independent timers providing maximum security to the applications.

Activation of the watchdog timers is controlled by option bytes or by software. Once activated, the watchdogs cannot be disabled by the user program without performing a reset.

Window watchdog timer

The window watchdog is used to detect the occurrence of a software fault, usually generated by external interferences or by unexpected logical conditions, which cause the application program to abandon its normal sequence.

The window function can be used to trim the watchdog behavior to match the application perfectly.

The application software must refresh the counter before time-out and during a limited time window.

A reset is generated in two situations:

1. **Timeout:** At 16 MHz CPU clock the time-out period can be adjusted between 75 μ s up to 64 ms.
2. **Refresh out of window:** The downcounter is refreshed before its value is lower than the one stored in the window register.

Independent watchdog timer

The independent watchdog peripheral can be used to resolve processor malfunctions due to hardware or software failures.

It is clocked by the 128 kHz LSI internal RC clock source, and thus stays active even in case of a CPU clock failure

The IWDG time base spans from 60 μ s to 1 s.

4.8 Auto wakeup counter

- Used for auto wakeup from active halt mode,
- Clock source: Internal 128 kHz internal low frequency RC oscillator or external clock,
- LSI clock can be internally connected to TIM1 input capture channel 1 for calibration.

4.9 Beeper

The beeper function outputs a signal on the BEEP pin for sound generation. The signal is in the range of 1, 2 or 4 kHz.

The beeper output port is only available through the alternate function remap option bit AFR7.

4.10 TIM1 - 16-bit advanced control timer

This is a high-end timer designed for a wide range of control applications. With its complementary outputs, dead-time control and center-aligned PWM capability, the field of applications is extended to motor control, lighting and half-bridge driver

- 16-bit up, down and up/down autoreload counter with 16-bit prescaler
- Four independent capture/compare channels (CAPCOM) configurable as input capture, output compare, PWM generation (edge and center aligned mode) and single pulse mode output
- Synchronization module to control the timer with external signals or to synchronize with TIM5 or TIM6
- Break input to force the timer outputs into a defined state
- Three complementary outputs with adjustable dead time
- Encoder mode
- Interrupt sources: 3 x input capture/output compare, 1 x overflow/update, 1 x break
-

4.11 TIM5 - 16-bit general purpose timer

- 16-bit autoreload (AR) up-counter
- 15-bit prescaler adjustable to fixed power of 2 ratios 1...32768
- 3 individually configurable capture/compare channels
- PWM mode
- Interrupt sources: 3 x input capture/output compare, 1 x overflow/update
- Synchronization module to control the timer with external signals or to synchronize with TIM1 or TIM6

4.12 TIM6 - 8-bit basic timer

- 8-bit autoreload, adjustable prescaler ratio to any power of 2 from 1 to 128
- Clock source: CPU clock
- Interrupt source: 1 x overflow/update
- Synchronization module to control the timer with external signals or to synchronize with TIM1 or TIM5.

Table 3. TIM timer features

Timer	Counter size (bits)	Prescaler	Counting mode	CAPCOM channels	Complementary outputs	Ext. trigger	Timer synchronization/ chaining
TIM1	16	Any integer from 1 to 65536	Up/down	4	3	Yes	Yes
TIM5	16	Any power of 2 from 1 to 32768	Up	3	0	No	
TIM6	8	Any power of 2 from 1 to 128	Up	0	0	No	

4.13 Analog-to-digital converter (ADC1)

The STM8S903K3/F3 family products contain a 10-bit successive approximation A/D converter (ADC1) with up to 7 external and 1 internal multiplexed input channels and the following main features:

- Input voltage range: 0 to VDD
- Conversion time: 14 clock cycles
- Single and continuous and buffered continuous conversion modes
- Buffer size (n x 10 bits) where n = number of input channels
- Scan mode for single and continuous conversion of a sequence of channels
- Analog watchdog capability with programmable upper and lower thresholds
- Internal reference voltage on channel AIN7
- Analog watchdog interrupt
- External trigger input
- Trigger from TIM1 TRGO
- End of conversion (EOC) interrupt

Internal bandgap reference voltage

Channel AIN7 is internally connected to the internal bandgap reference voltage. The internal bandgap reference is constant and can be used for example to monitor V_{DD} . It is independent of variations in V_{DD} and ambient temperature T_A .

4.14 Communication interfaces

The following communication interfaces are implemented:

- UART1: Full feature UART, synchronous mode, SPI master mode, Smartcard mode, IrDA mode, single wire mode, LIN2.1 master capability
- SPI: Full and half-duplex, 8 Mbit/s
- I²C: Up to 400 kbit/s

4.14.1 UART1

Main features

- 1 Mbit/s full duplex SCI
- SPI emulation
- High precision baud rate generator
- Smartcard emulation
- IrDA SIR encoder decoder
- LIN master mode
- Single wire half duplex mode

Asynchronous communication (UART mode)

- Full duplex communication - NRZ standard format (mark/space)
- Programmable transmit and receive baud rates up to 1 Mbit/s (fCPU/16) and capable of following any standard baud rate regardless of the input frequency
- Separate enable bits for transmitter and receiver
- Two receiver wakeup modes:
 - Address bit (MSB)
 - Idle line (interrupt)
- Transmission error detection with interrupt generation
- Parity control

Synchronous communication

- Full duplex synchronous transfers
- SPI master operation
- 8-bit data communication
- Maximum speed: 1 Mbit/s at 16 MHz (fCPU/16)

LIN master mode

- Emission: Generates 13-bit synch. break frame
- Reception: Detects 11-bit break frame

4.14.2 SPI

- Maximum speed: 8 Mbit/s (fMASTER/2) both for master and slave
- Full duplex synchronous transfers
- Simplex synchronous transfers on two lines with a possible bidirectional data line
- Master or slave operation - selectable by hardware or software
- CRC calculation
- 1 byte Tx and Rx buffer
- Slave/master selection input pin

4.14.3 I²C

- I²C master features:
 - Clock generation
 - Start and stop generation
- I²C slave features:
 - Programmable I2C address detection
 - Stop bit detection
- Generation and detection of 7-bit/10-bit addressing and general call
- Supports different communication speeds:
 - Standard speed (up to 100 kHz)
 - Fast speed (up to 400 kHz)

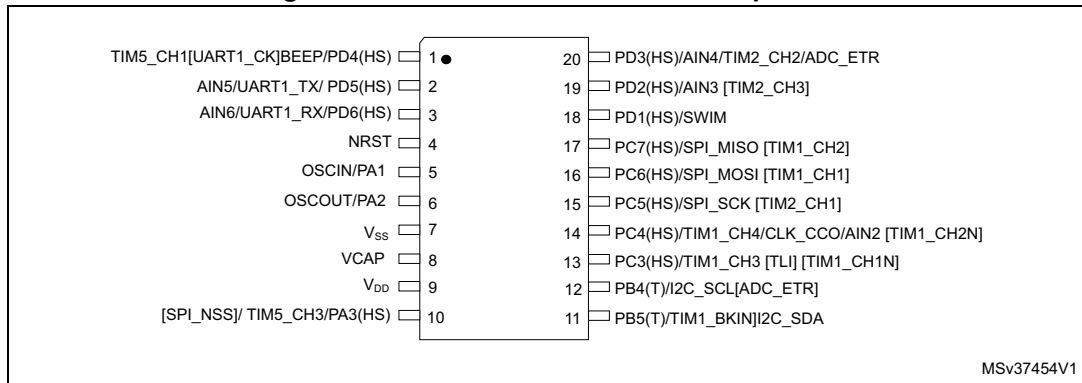
5 Pinouts and pin descriptions

Table 4. Legend/abbreviations for pinout tables

Type	I= Input, O = Output, S = Power supply	
Level	Input	CM = CMOS
	Output	HS = High sink
Output speed	O1 = Slow (up to 2 MHz) O2 = Fast (up to 10 MHz) O3 = Fast/slow programmability with slow as default state after reset O4 = Fast/slow programmability with fast as default state after reset	
Port and control configuration	Input	float = floating, wpu = weak pull-up
	Output	T = True open drain, OD = Open drain, PP = Push pull
Reset state	Bold X (pin state after internal reset release). Unless otherwise specified, the pin state is the same during the reset phase and after the internal reset release.	

5.1 STM8S903F3 TSSOP20/SO20 pinout

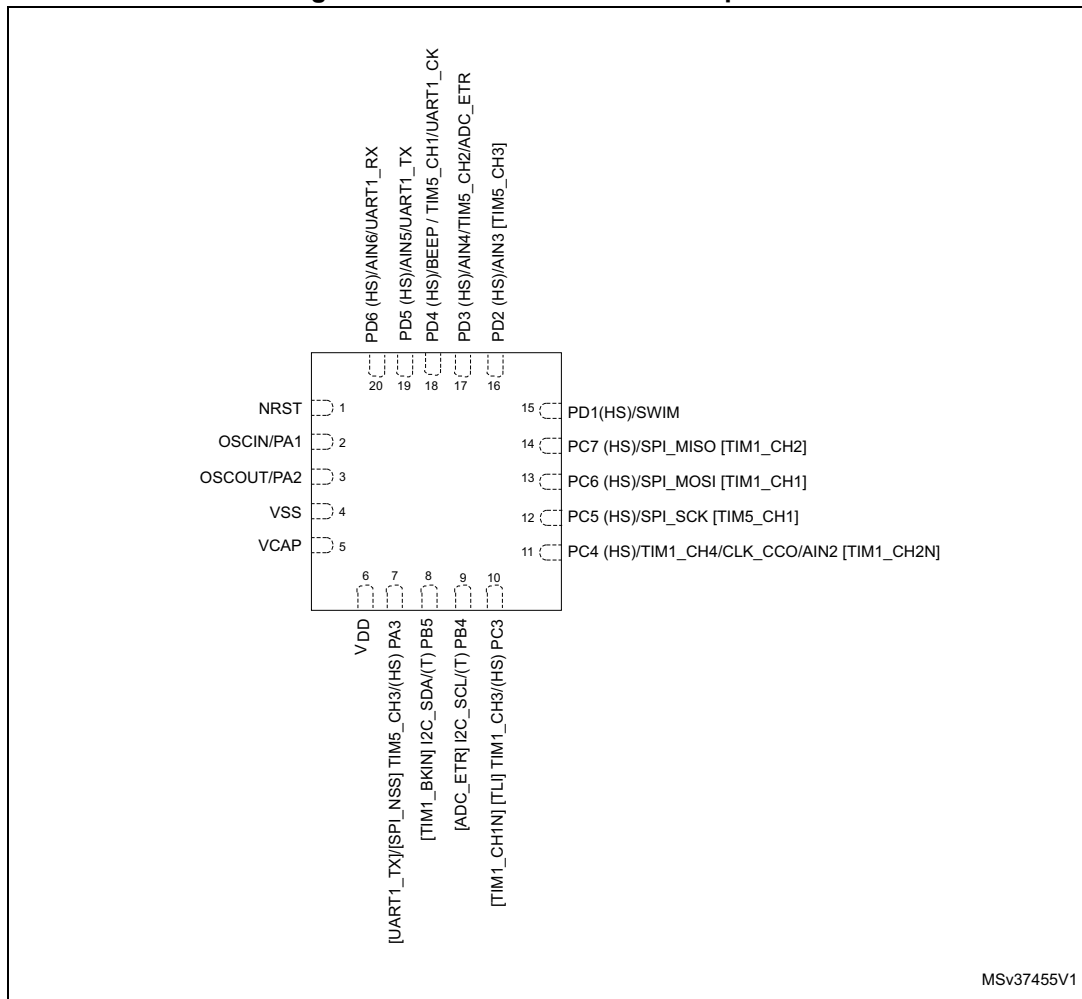
Figure 3. STM8S903F3 TSSOP20/SO20 pinout



1. HS high sink capability.
2. (T) True open drain (P-buffer and protection diode to V_{DD} not implemented).
3. [] alternate function remapping option (If the same alternate function is shown twice, it indicates an exclusive choice not a duplication of the function)

5.2 STM8S903F3 UFQFPN20 pinout

Figure 4. STM8S903F3 UFQFPN20 pinout



1. HS high sink capability.
2. (T) True open drain (P-buffer and protection diode to VDD not implemented).
3. [] alternate function remapping option (if the same alternate function is shown twice, it indicates an exclusive choice not a duplication of the function).

5.3 TSSOP20, SO20 and UFQFPN20 pin descriptions

Table 5. TSSOP20/SO20/UFQFPN20 pin descriptions

TSSOP20	UFQFPN20	Pin name	Type	Input			Output				Main function (after reset)	Default alternate function	Alternate function after remap [option bit]
				floating	wpu	Ext.	High sink ⁽¹⁾	Speed	OD	PP			
4	1	NRST	I/O	-	X	-	-	-	-	-	Reset	-	
5	2	PA1/ OSCIN ⁽²⁾	I/O	X	X	X	-	O1	X	X	Port A1	Resonator/crystal in	-
6	3	PA2/ OSCOUT	I/O	X	X	X	-	O1	X	X	Port A2	Resonator/crystal out	-
7	4	VSS	S	-	-	-	-	-	-	-	Digital ground	-	
8	5	VCAP	S	-	-	-	-	-	-	-	1.8 V regulator capacitor	-	
9	6	VDD	S	-	-	-	-	-	-	-	Digital power supply	-	
10	7	PA3/ TIM5_CH3 [SPI_NSS] [UART1_TX]	I/O	X	X	X	HS	O3	X	X	Port A3	Timer 52 channel 3	SPI master/ slave select [AFR1]/ UART1 data transmit [AFR1:0]
11	8	PB5/ I2C_SDA [TIM1_BKIN]	I/O	X	-	X	-	O1	T ⁽³⁾		Port B5	I2C data	Timer 1 - break input [AFR4]
12	9	PB4/ I2C_SCL [ADC_ETR]	I/O	X	-	X	-	O1	T ⁽³⁾		Port B4	I2C clock	ADC external trigger [AFR4]
13	10	PC3/ TIM1_CH3/TLI/ [TIM1_CH1N]	I/O	X	X	X	HS	O3	X	X	Port C3	Timer 1 - channel 3	Top level interrupt [AFR3] Timer 1 inverted channel 1 [AFR7]
14	11	PC4/ TIM1_CH4/ CLK_CCO/AIN2/ [TIM1_CH2N]	I/O	X	X	X	HS	O3	X	X	Port C4	Timer 1 - channel 4 /configurable clock output	Analog input 2 [AFR2]Timer 1 inverted channel 2 [AFR7]
15	12	PC5/SPI_SCK [TIM5_CH1]	I/O	X	X	X	HS	O3	X	X	Port C5	SPI clock	Timer 5 channel 1 [AFR0]
16	13	PC6/ SPI_MOSI [TIM1_CH1]	I/O	X	X	X	HS	O3	X	X	Port C6	PI master out/slave in	Timer 1 channel 1 [AFR0]
17	14	PC7/ SPI_MISO [TIM1_CH2]	I/O	X	X	X	HS	O3	X	X	Port C7	SPI master in/ slave out	Timer 1 channel 2[AFR0]
18	15	PD1/ SWIM ⁽⁴⁾	I/O	X	X	X	HS	O4	X	X	Port D1	SWIM data interface	-



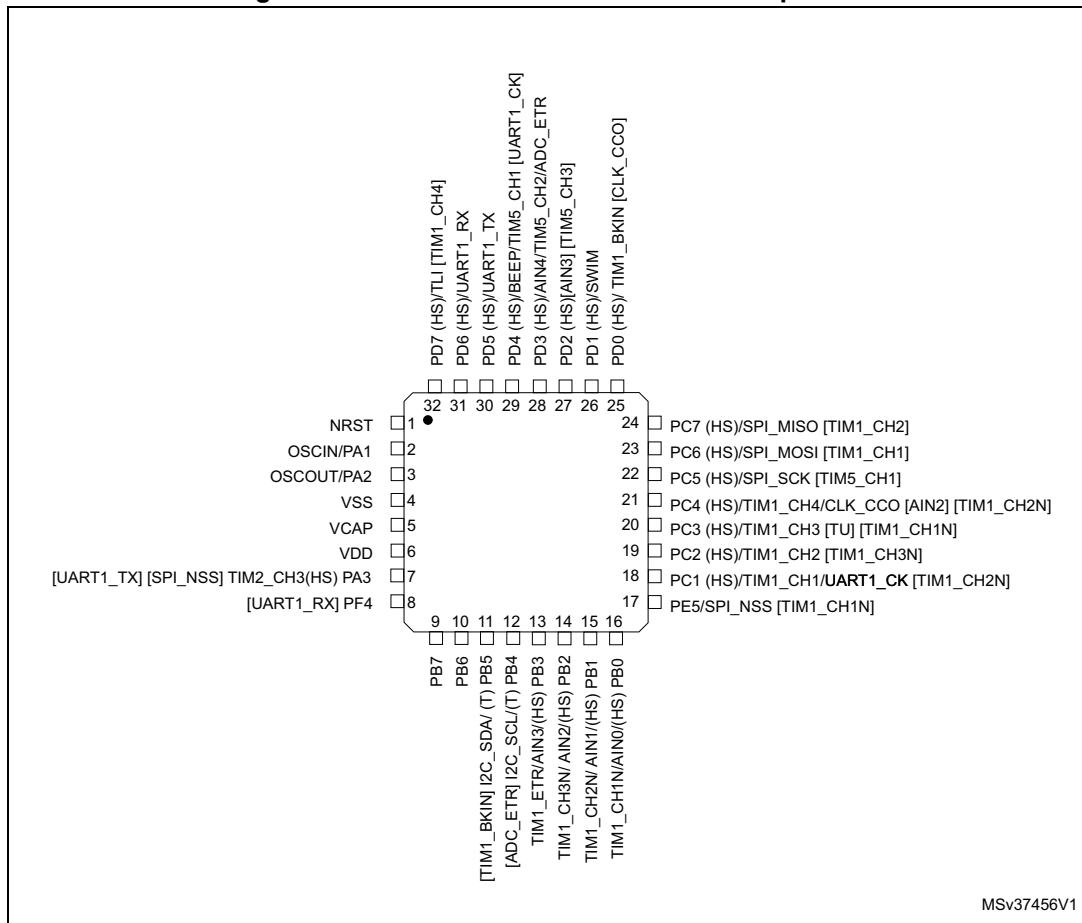
Table 5. TSSOP20/SO20/UFQFPN20 pin descriptions (continued)

TSSOP20	UFQFPN20	Pin name	Type	Input			Output				Main function (after reset)	Default alternate function	Alternate function after remap [option bit]
				floating	wpu	Ext.	High sink ⁽¹⁾	Speed	OD	PP			
19	16	PD2/AIN3/ [TIM5_CH3]	I/O	X	X	X	HS	O3	X	X	Port D2	-	Analog input 3 [AFR2] Timer 52 - channel 3 [AFR1]
20	17	PD3/ AIN4/ TIM5_CH2/ ADC_ETR	I/O	X	X	X	HS	O3	X	X	Port D3	Analog input 4 Timer 52 - channel 2/ADC external trigger	-
1	18	PD4/ TIM5_CH1/ BEEP [UART1_CK]	I/O	X	X	X	HS	O3	X	X	Port D4	Timer 5 - channel 1/BEEP output	UART clock [AFR2]
2	19	PD5/ AIN5/ UART1_TX	I/O	X	X	X	HS	O3	X	X	Port D5	Analog input 5/ UART1 data transmit	-
3	20	PD6/ AIN6/ UART1_RX	I/O	X	X	X	HS	O3	X	X	Port D6	Analog input 6/ UART1 data receive	-

1. I/O pins used simultaneously for high current source/sink must be uniformly spaced around the package. In addition, the total driven current must respect the absolute maximum ratings (see [Section 10.2: Absolute maximum ratings](#)).
2. When the MCU is in Halt/Active-halt mode, PA1 is automatically configured in input weak pull-up and cannot be used for waking up the device. In this mode, the output state of PA1 is not driven. It is recommended to use PA1 only in input mode if Halt/Active-halt is used in the application.
3. In the open-drain output column, 'T' defines a true open-drain I/O (P-buffer, weak pull-up, and protection diode to VDD are not implemented)
4. The PD1 pin is in input pull-up during the reset phase and after internal reset release.

5.4 STM8S903K3 UFQFPN32/LQFP32 and SDIP32 pinouts

Figure 5. STM8S903K3 UFQFPN32/LQFP32 pinout



1. (HS) high sink capability.
2. (T) True open drain (P-buffer and protection diode to V_{DD} not implemented).
3. [] alternate function remapping option (if the same alternate function is shown twice, it indicates an exclusive choice not a duplication of the function).