ATA8520E

Single-Chip SIGFOX RF Transceiver

DATASHEET COMPLETE

Features

- Fully integrated, single-chip RF transceiver (SIGFOX™ compliant)
- System-on-chip solution including SIGFOX related protocol handling for modem operation
- AVR® microcontroller core with embedded firmware, SIGFOX, protocol stack and ID/PAC
- Supports up- and downlink operation, i.e., transmit and receive of data telegrams with SIGFOX base stations in EU and US
- The device has to be configured before the first usage
- Operating frequencies:
  - EU: uplink 868.0MHz to 868.6MHz, downlink 869.4MHz to 869.65MHz
  - US: uplink and downlink 902MHz to 906MHz
- Low current consumption:
  - 32.7mA (EU) / 16.7mA(US) during transmit and
  - 10.4mA (EU) / 10.5mA (US) during receive operation
- Typical OFF mode current: 5nA (maximum 600nA at V_S = +3.6V and T = +85°C)
- Data rate:
  - EU: 100bit/s with DBPSK modulation for uplink and 600bit/s with GFSK modulation for downlink
  - US: 600bit/s with DBPSK modulation for uplink and 600bit/s with GFSK modulation for downlink
- SPI interface for data access and transceiver configuration and control
- Event signal indicates the status of the IC to an external microcontroller
- Power-up (typical 10ms (EU), 30ms (US) from OFF mode to idle mode)
- Supply voltage ranges 1.9V to 3.6V and 2.4V to 5.5V (SIGFOX compliant supply range 3V ±5% and 3.3V to 5.5V)
- Temperature range –40°C to +85°C
- ESD protection at all pins (±4kV HBM, ±200V MM, ±750V FCDM)
- Small 5×5mm QFN32 package/pitch 0.5mm

Applications

SIGFOX™ compatible modem for long-range, low-power and low-cost applications using the SIGFOX network

- Home and building automation
- Alarm and security systems
- Smart environment and industrial
- Smart parking
- Tracking
- Metering

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1. General Description

1.1. Introduction

The Atmel® ATA8520E is a highly integrated, low-power RF transceiver with an integrated AVR® microcontroller for applications using the wide area SIGFOX™ network

The Atmel ATA8520E is partitioned into three sections: an RF front end, a digital baseband and the low-power 8-bit AVR microcontroller. The product is designed for the EU ISM frequency band in the range of 868.0MHz to 868.6MHz and 869.4MHz to 869.65MHz and for the US ISM frequency band in the range of 902.0MHz to 906.0MHz. The external part count is kept to a minimum due to the very high level of integration in this device. By combining outstanding RF performance with highly sophisticated baseband signal processing, robust wireless communication can be easily achieved. The transmit path uses a closed loop fractional-N modulator.

The SPI interface enables external control and device configuration.

1.2. System Overview

Figure 1-1. Circuit Overview

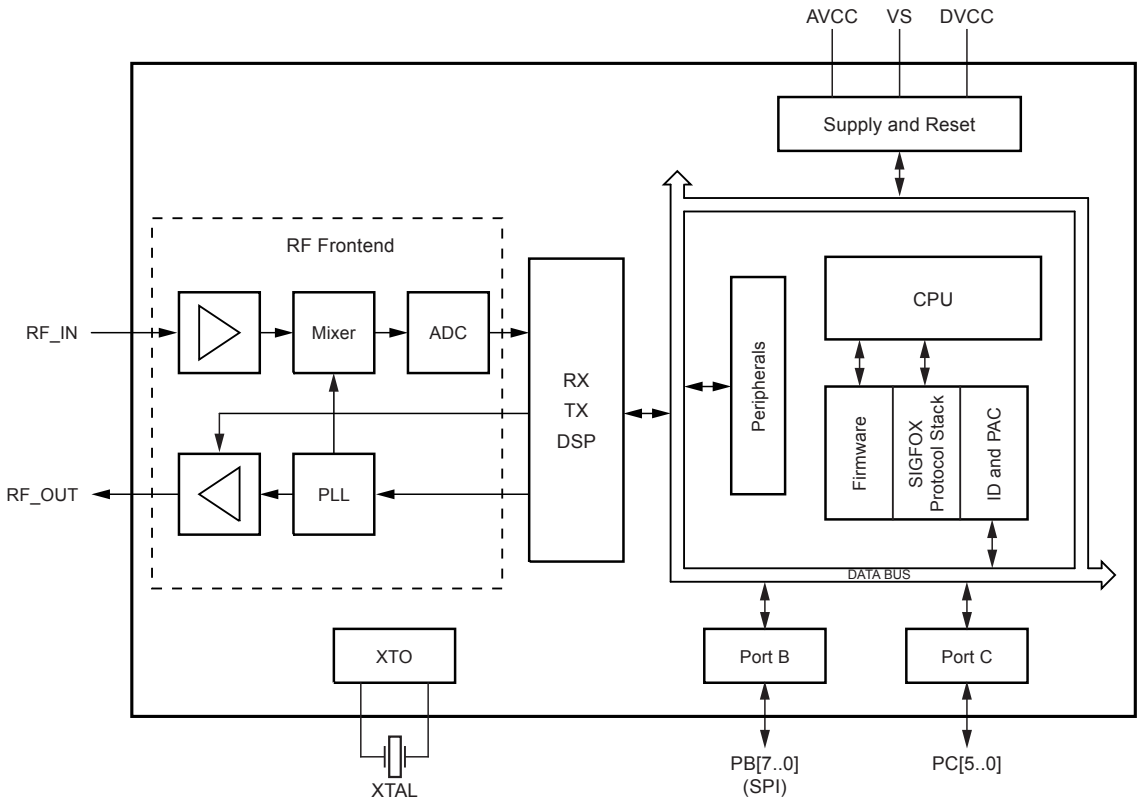


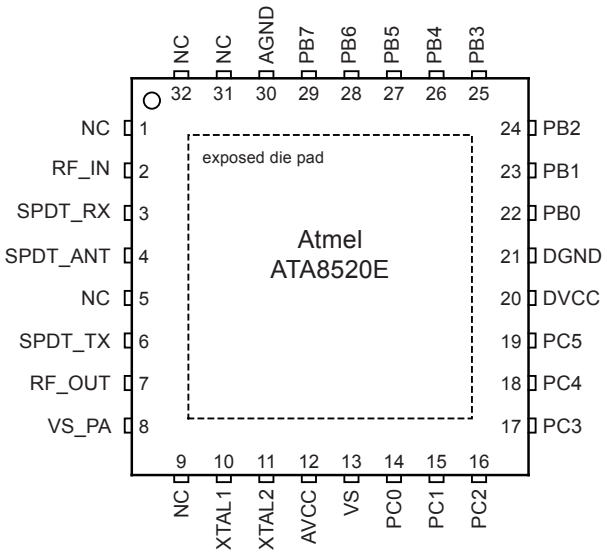
Figure 1-1 shows an overview of the main functional blocks of the Atmel® ATA8520E. External control of the Atmel ATA8520E is performed through the SPI pins SCK, MOSI, MISO, and NSS. The functionality of the device is defined by the internal firmware and processed by the AVR®. SPI commands are used to control the device and to start the data telegram transmission. The end of the telegram transmission is signaled to an external microcontroller on pin 28 (PB6/EVENT).

It is important to note that all PWRON and NPWRON pins (PC1..5, PB4, PB7) are active in OFF mode. This means that even if the Atmel ATA8520E is in OFF mode and the DVCC voltage is switched off, the power management circuitry within the Atmel ATA8520E biases these pins with VS.

The AVR microcontroller ports can be used as button inputs, LED drivers, EVENT pin, general purpose digital inputs, or wake-up inputs, etc. Functionality of these ports is already implemented in the firmware.

1.3. Pinning

Figure 1-2. Pin Diagram



Note: The exposed die pad is connected to the internal die.

Table 1-1. Pin Description

Pin No.	Pin Name	Type	Description
1	NC	–	Connected to GND
2	RF_IN	Analog	Receiver input
3	SPDT_RX	Analog	Rx switch output (damped signal output)
4	SPDT_ANT	Analog	Antenna input (downlink) and output (uplink) of the SPDT switch
5	NC		Leave open
6	SPDT_TX	Analog	TX mode input of the SPDT switch
7	RF_OUT	Analog	Power amplifier output
8	VS_PA	Analog	Power amplifier supply. 3V supply: connect to VS. 5V supply: connect to C2. Use SPI command “Write System Configuration” (0x11) to enable 5V supply mode.
9	NC	–	Connected to GND
10	XTAL1	Analog	Crystal oscillator pin 1 (input)

Pin No.	Pin Name	Type	Description	
11	XTAL2	Analog	Crystal oscillator pin 2 (output)	
12	AVCC	Analog	RF front-end supply regulator output	
13	VS	Analog	Main supply voltage input	
14	PC0	Digital	Main	: NRESET (low active)
15	PC1	Digital	Main Alternate	: AVR Port C1 : NPWRON1 (low active)
16	PC2	Digital	Main Alternate	: AVR Port C2 : NPWRON2 (low active)
17	PC3	Digital	Main Alternate	: AVR Port C3 : NPWRON3 (low active)
18	PC4	Digital	Main Alternate	: AVR Port C4 : NPWRON4 (low active)
19	PC5	Digital	Main Alternate	: AVR Port C5 : NPWRON5 (low active)
20	DVCC	–	Digital supply voltage regulator output	
21	DGND	–	Digital ground	
22	PB0	Digital	Main	: control front-end module; ='1' enable, ='0' disable
23	PB1	Digital	Main	: SCK
24	PB2	Digital	Main	: MOSI (SPI master out Slave in)
25	PB3	Digital	Main	: MISO (SPI master in Slave out)
26	PB4	Digital	Main	: PWRON
27	PB5	Digital	Main	: NSS (low active)
28	PB6	Digital	Main	: EVENT (low active)
29	PB7	Digital	Main Alternate	: ='1' TX active, ='0' RX active : NPWRON6 (low active)
30	AGND	–	Analog ground	
31	NC	–	Connected to GND	
32	NC	–	Connected to GND	
	GND	–	Ground/backplane on exposed die pad	

1.4. Applications

This section provides application examples for the two supply modes for the Atmel® ATA8520E device.

1.4.1. 3V Application Example

Figure 1-3. 3V Application with External Microcontroller

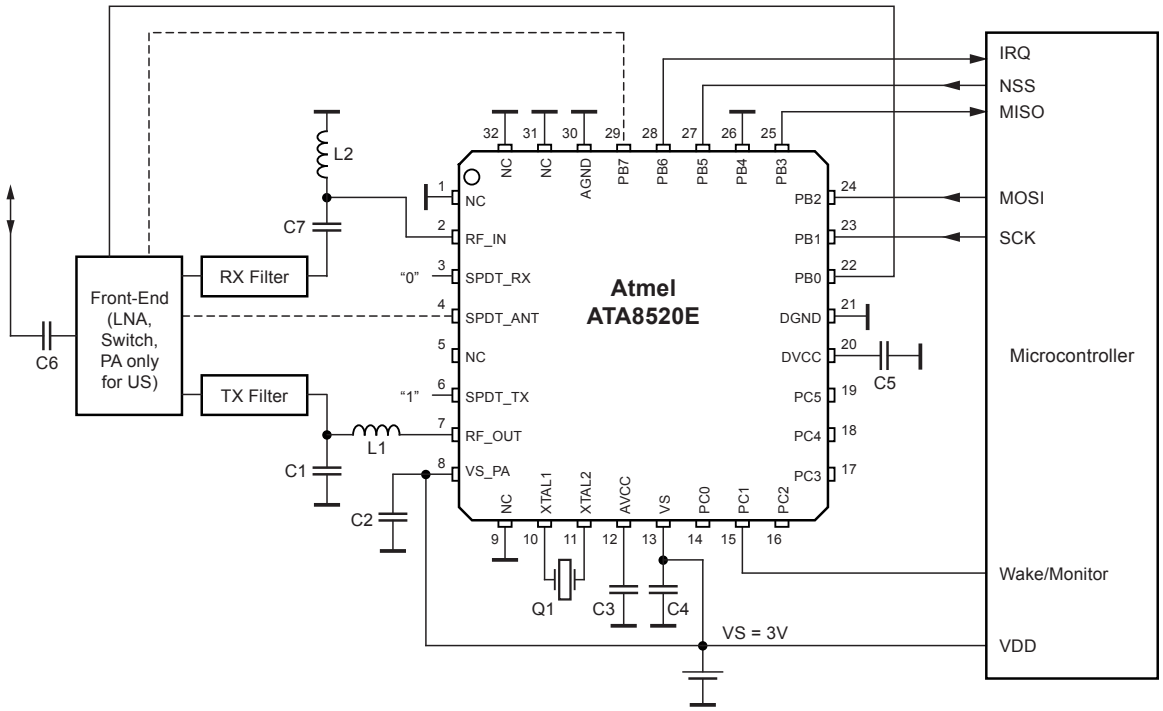


Figure 1-3 shows a typical application circuit with an external host microcontroller operating from a 3V battery. The Atmel® ATA8520E stays in OFFMode until NPWRON1 (PC1) is used to wake it up. In OFFMode the Atmel ATA8520E draws typically less than 5nA at 25°C.

In OFFMode all Atmel ATA8520E AVR® ports PB0..PB7 and PC0..PC5 are switched to input. PC0..PC5 and PB7 have internal pull-up resistors ensuring that the voltage at these ports is VS. PB0..PB6 are tri-state inputs and require additional consideration. PB1, PB2, and PB5 have defined voltages since they are connected to the output of the external microcontroller. PB4 is connected to ground to avoid unwanted power-ups. PB0, PB3 and PB6 do not require external circuitry since the internal circuit avoids transverse currents in OFFMode. The external microcontroller has to tolerate the floating inputs. Otherwise additional pull-down resistors are required on these floating lines.

Typically, the Atmel ATA8520E wake-up is done by pulling NPWRON1 (pin 15) to ground.

RF_OUT is matched with C1/L1 for 50Ω antenna connection and RF_IN with the components C7/L2. The front-end module (FEM) typically includes an antenna switch, an LNA for the receive direction and an optional PA for the transmit connection in one device. The RX and TX filters are additional to increase out-of-band jamming immunity in receive direction and to reduce spurious emissions in transmit direction. For these filters SAW components are typically used. The pins PB0 and PB7 can be used to control the FEM or the unused internal SPDT switch which is controlled by the Atmel ATA8520E for transmit and receive operation.

Together with the fractional-N PLL within the Atmel ATA8520E, an external crystal is used to set the Tx and Rx frequency. Accurate load capacitors for this crystal are integrated to reduce the system part count and cost. Only four supply blocking capacitors are needed to decouple the different supply voltages AVCC, DVCC, VS, and VS_PA of the Atmel ATA8520E. The exposed die pad is the RF and analog ground of the Atmel ATA8520E. It is connected directly to AGND via a fused lead. The Atmel ATA8520E is controlled using specific SPI commands via the SPI interface.

1.4.2. 5V Application Example

Figure 1-4. 5V Application with External Microcontroller

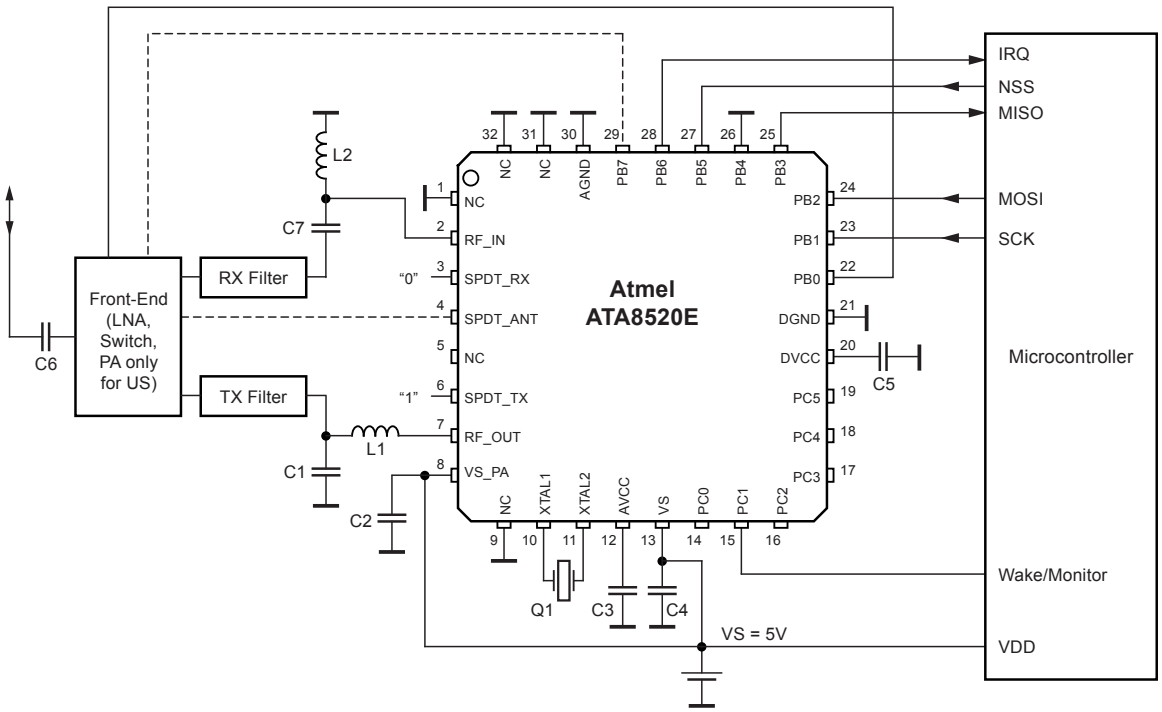


Figure 1-4 shows a typical application circuit with an external host microcontroller operating from a 5V supply. This application differs from the 3V supply mode that VS is not connected to VS_PA. Instead an internal LDO must be activated using the SPI command “Write System Configuration” (0x11) after powering the device and before transmitting a data telegram.

The front-end module (FEM) is controlled by the Atmel® ATA8520E device using the port pins PB7 and PB0 as described in section System and Pin Configuration (Table 2-7): In addition there is an internal switch which can be used to control the direction of the FEM. As shown in Figure 1-3 and Figure 1-4 the pins SPDT_RX, SPDT_TX and SPDT_ANT can be used by applying logical levels “0” and “1” to the pins. Please consider that the voltage levels at these pins are restricted as defined in section Absolute Maximum Ratings and section Supply Voltages and Current Consumption.

1.4.3. 5V Application for Uplink only

Figure 1-5. 5V Application for Uplink only

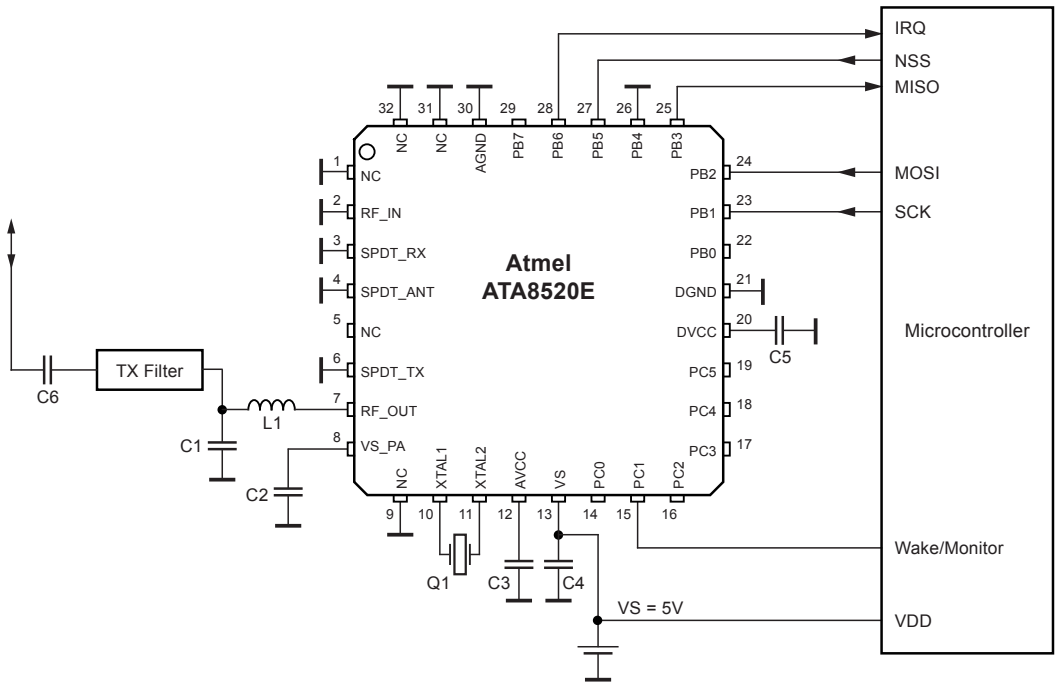


Figure 1-5 shows a 5V application with external microcontroller for uplink only. The downlink (receiving) part is not used together with the front-end module and the RX filter. For the TX filter an SAW filter can be used or a simple LC filter to suppress unwanted spurious and harmonic emissions.

2. System Functional Description

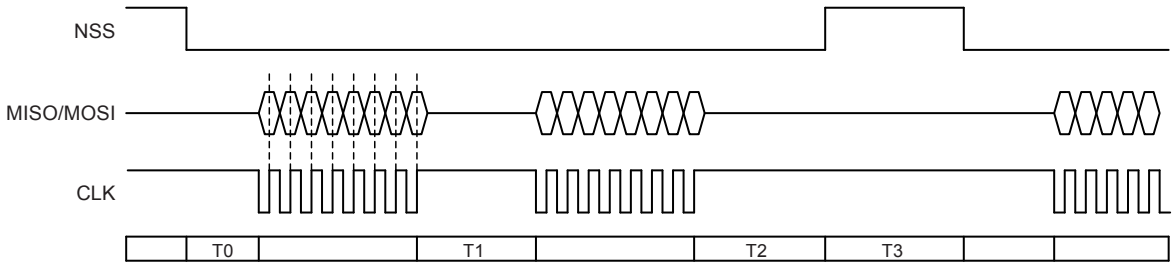
2.1. SPI Command Interface

The SPI command interface requires a timing setup as described in the following section and provides a set of commands to control the operation of the Atmel® ATA8520E device. The SPI transmission occurs with MSB first.

2.1.1. SPI Timing

The SPI communication requires a special timing to prevent data corruption. The SPI peripheral uses a SCK frequency of up to 125kHz for the bit transmission and requires timing delays between the CS signals and the start and stop of the SPI communication as shown in Figure 2-1.

Figure 2-1. SPI Timing Parameters



T0 ≥ 65µs, T1 ≥ 40µs, T2 ≥ 100µs, T3 ≥ 50µs, SPI CLK ≤ 125kHz (SPI Mode 0: CPOL = CPHA = 0)

2.1.2. SPI Command Set

The following SPI commands are available to control the Atmel® ATA8520E operation from a host microcontroller.

2.1.2.1. System Reset

This command uses the system internal WDT to do a complete hardware reset of the Atmel® ATA8520E. Resetting the device takes approximately 12ms (EU), 31ms (US). Afterwards the system restarts and generates an event on the EVENT signal after this time. This event will be cleared with the “Get Status” SPI command (0x0A).

Master		System Reset (0x01)
ATA8520E		Dummy

2.1.2.2. I/O Init

The I/O lines of port C can be used as additional I/O lines for an application. The port C I/O Init command defines the internal data direction register of output port PORTC (DDRC). Pin PC0 is used as NRESET signal and will always be an input pin, i.e., bit 0 will be written as 0 to be an input pin.

Master		I/O Init (0x02)	DDRC content
ATA8520E		Dummy	Dummy

2.1.2.3. I/O Write

The I/O write command writes directly to the output port register PORTC to set the I/O pins. Pin PC0 is used as NRESET signal and will always be an input pin with enabled pull-up, i.e., bit 0 will be written as 1 to enable the internal pull-up resistor.

Master		I/O Init (0x03)	PORTC content
ATA8520E		Dummy	Dummy

2.1.2.4. I/O Read

The I/O read command reads the status of the I/O pins directly from the input port register PINC. Pin PC0 is used as NRESET signal and will always be read as 1.

Master		I/O Read (0x04)	Dummy	Dummy
ATA8520E		Dummy	Dummy	PINC content

2.1.2.5. OFF Mode

The OFF mode command puts the Atmel® ATA8520E into off mode. To wake up the Atmel ATA8520E device, one of the power on lines has to be activated, i.e., set PWRON line to high or NPWRONx line to low. To switch the device into OFF mode the power on lines have to be de-activated before otherwise the device will remain in the on state.

Master		OFF Mode (0x05)
ATA8520E		Dummy

2.1.2.6. Atmel Version

The Atmel® version command reads the version information including a major and a minor version number.

Master		Atmel Version (0x06)	Dummy	Dummy	Dummy
ATA8520E		Dummy	Dummy	MajorVers	MinorVers

2.1.2.7. Write TX Buffer

The write TX buffer command fills the TX buffer to be sent with the next SIGFOX™ ATA8520E data frame with payload data of up to 12 bytes. The buffer can hold any number of bytes ranging from 0 to 12 bytes and are not buffered, i.e., a new SPI command will override the previous data.

Master		Write TX Buffer (0x07)	RF TX Num bytes	RF TX Bytes 0	.....	RF TX Num bytes-1
ATA8520E		Dummy	Dummy	Dummy		Dummy

2.1.2.8. Enable Special Mode

This command will only be used during testing of the system and not during regular operation in a SIGFOX™ network. This commands enables the execution of the following SPI command:

- Firmware tests 0x18

Master		Enable Mode (0x08)
ATA8520E		Dummy

2.1.2.9. SIGFOX Version

The SIGFOX™ version reads the SIGFOX library version information as a text string with N = 11 characters.

Master		SIGFOX Version (0x09)	Dummy	Dummy	.....	Dummy
ATA8520E		Dummy	Dummy	SFX Verinfo[0]		SFX Verinfo[N]

2.1.2.10. Get Status

The get status command reads the internal status of the device. Issuing this command clears the systems event line (PB6) and the status bytes. The event line is set to low when:

a. System is ready after power-up or reset

b. Finishes the transmit/receive operation

c. Finishes a temperature and supply measurement

d. Finishes the EEPROM write operation.

e. Test mode is finished.

The following status information is read after the event line is activated, i.e., polling using the Get Status command is not necessary:

Hardware SSM status (internal only)

Atmel® status:

- Bit6: System ready to operate (system ready event)
- Bit5: Frame sent (frame ready event)
- Bit4 to Bit1: Error code
  - 0000: no error
  - 0001: command error / not supported
  - 0010: generic error
  - 0011: frequency error
  - 0100: usage error
  - 0101: opening error
  - 0110: closing error
  - 0111: send error
- Bit0: PA on/off indication

SIGFOX™ status:

- 0x00: no error
- 0x30: TX data length > 12 byte
- 0x3E: Time-out for downlink message
- 0x4E: Time-out for bit downlink
- All other codes: Only for internal

SIGFOX status2:

- 0x00: no error
- 0x10: initialization error
- 0x18: error during send
- 0x40: error in RF frequency
- 0x68: error during wait for data frame

The SSM status is used for internal testing only. The SIGFOX status/status2 information may also generate other error codes which are used for internal only. The Atmel status information can be used for detection of issues with the application, i.e., bit6 is set after initialization of the device (reset or power-on) and bit5 is set after a telegram has been sent.

Master		Get Status (0x0A)	Dummy	Dummy	Dummy	Dummy	Dummy
ATA8520E		Dummy	Dummy	SSM status	Atmel status	SIGFOX status	SIGFOX status2

2.1.2.11. Send Single Bit

This command sends a data bit (0=0x00/1=0x01) within a SIGFOX™ RF frame as specified by SIGFOX. An event on the EVENT signal is generated when finished. This command will only be used during testing of the system and not during regular operation in a SIGFOX network.

Master		Send Bit (0x0B)	Bit Status (0/1)
ATA8520E		Dummy	Dummy

2.1.2.12. Send Out-Of-Band

This command triggers the out-of-band data transmission (as defined by SIGFOX™). It will generate an event on the EVENT signal when finished. This command will only be used during testing of the system and not during regular operation in a SIGFOX network.

Master		Send OOB (0x0c)
ATA8520E		Dummy

2.1.2.13. Send Frame

The send frame command triggers the start of a frame transmit process. The payload data has to be written into the TX buffer before using the write TX buffer command. The transmit operation will take ~7 seconds in EU mode and ~2 seconds in US mode and will generate an event on the EVENT signal when finished.

Master		Send Frame (0x0D)
ATA8520E		Dummy

2.1.2.14. Send/Receive Frame

The send/receive frame command triggers the start of a frame transmit process followed by a receive process. The payload data has to be written into the TX buffer before using the write TX buffer command. The transmit and receive operation will take up to 50 seconds and will generate an event on the EVENT signal when finished. The received data bytes can be read with the SPI command (0x10).

Master		Send/Receive Frame (0x0E)
ATA8520E		Dummy

2.1.2.15. Get PAC

The get PAC command will read the 16 byte PAC information which is used for the device registration process at the SIGFOX™ backend. Only the 8 lower bytes (0) .. (7) are used.

Master		Get PAC (0x0F)	Dummy	Dummy	.....	Dummy
ATA8520E		Dummy	Dummy	PAC ID[0]		PAC ID[15]

2.1.2.16. Read RX Buffer

This command triggers the read out of the received data packet. The packet length is always 8 bytes.

Master		Read RX Buffer (0x10)	Dummy	Dummy	.....	Dummy
ATA8520E		Dummy	Dummy	RX Byte 0		RX Byte 7

2.1.2.17. Store System Configuration

The Store System Configuration command writes the configuration data for the port C and the system configuration into the internal EEPROM. This changes will be applied by performing a system reset. An event on the EVENT signal is generated when finished. EDDRC register defines the data direction for the port C pins (0: input, 1: output). EPORTC register defines the output level for an output pin and enables a pull-up resistor for input pins when set. SysConf is used to configure the supply voltage and the up-/downlink operation (see section System and Pin Configuration). The parameter repeat defines the number of frames to be send for the SPI command Send/Receive Frame (0x0E). Possible values for the parameter repeat are

- 0x00: send 1 frame
- 0x01: send 2 frame
- 0x02: send 3 frame (default)

Master		Store Sys Conf (0x11)	EDDRC	EPORTC	repeat	SysConf
ATA8520E		Dummy	Dummy	Dummy	Dummy	Dummy

2.1.2.18. Get ID

The get ID command will read the 4 byte ID information which is used for the device registration process at the SIGFOX™ backend.

Master		Get ID (0x12)	Dummy	Dummy	.....	Dummy
ATA8520E		Dummy	Dummy	UID[3]		UID[0]

2.1.2.19. Read Supply Temperature

This command triggers the read out of the measured supply voltage in idle and active mode and the device temperature. To trigger a measurement the SPI command (0x14) has to be used. The return voltage level is in mV and the temperature value has to be calculated as T = TM/10 in °C. The voltage values are of type 16 bit unsigned integer (with high and low byte) while the temperature is a signed value.

Master		Read Supply Temperature (0x13)	Dummy	Dummy	Dummy	Dummy	Dummy	Dummy	Dummy
ATA8520E		Dummy	Dummy	VL idle	VH idle	VL active	VH active	TML	TMH

2.1.2.20. Start Measurement

This command triggers the measurement of the supply voltages and the temperature value. An event on the EVENT signal is triggered when finished which is cleared by reading the status with command 0x0A. Using this command will update the crystal calibration before any send command, i.e., it is recommended to adapt to changed ambient temperatures.

Master		Trigger Measurement (0x14)
ATA8520E		Dummy

2.1.2.21. Trigger Test Mode

This command triggers the uplink test procedure defined by SIGFOX™. An event on the EVENT signal is generated when finished. This command will only be used during testing of the system and not during regular operation in a SIGFOX network.

The command parameter are:

- TestMode: Test modes as defined by SIGFOX
- Configuration: configuration data for test modes as defined by SIGFOX

The following test modes are available:

Table 2-1. Trigger Test Modes

Test Mode	Configuration	Description
0	repeat: 0-255	Transmit random data frame without frequency hoping
1	repeat: 0-255	Transmit 3 random data frames with frequency hoping
2	repeat: 0-255	Test receive operation with SIGFOX tester
3	repeat: 0-255	Test receive operation in pure GFSK mode
4	repeat: 0-255	Test sensitivity with SIGFOX tester

Master		Trigger Test Mode (0x15)	Test Mode	Configuration
ATA8520E		Dummy	Dummy	Dummy

2.1.2.22. Send CW

This command triggers the transmission of a continuous carrier on the programmed RF frequency as defined by SIGFOX™. This command will only be used during testing of the system and not during regular operation in a SIGFOX network.

Master		Send CW (0x17)	On=0x11/Off=0x00
ATA8520E		Dummy	Dummy

2.1.2.23. Firmware Test

This command selects the firmware internal RX test mode. An event on the EVENT signal is generated when finished. This command will only be used during testing of the system and not during regular operation in a SIGFOX™ network.

This test mode will check for a data packet on the RX frequency with 600bps data rate and 0.8kHz FSK modulation with the following pattern (in hex):

Preamble	Frame ID	Data payload
AA AA	B2 27	31 32 33 34 35 36 37

It can be used to check the RX functionality and the sensitivity level of the hardware.

Master		Firmware Test (0x18)	0x06	0x09	0xFF	0xFF
ATA8520E		Dummy	Dummy	Dummy	Dummy	Dummy

2.1.2.24. Store Frequencies

This command store the RF frequencies for TX and RX in the internal EEPROM. The frequency values are 32-bit unsigned integer in [Hz]. An event on the EVENT signal is generated when finished. The system has to be reset to make the changes valid.

Master		Store Frequen-cies (0x1A)	freqTX [7..0]	freqTX [15..8]	freqTX [23..16]	freqTX [31..24]	freqRX [7..0]	freqRX [15..8]	freqRX [23..16]	freqRX [31..24]
ATA8520E		Dummy	Dummy	Dummy	Dummy	Dummy	Dummy	Dummy	Dummy	Dummy

2.1.2.25. Set TX Frequency

Set TX center frequency temporarily for testing purposes. This settings are lost after reset or when switching the device off. The frequency value is an unsigned 32-bit integer within the range [868.000.000Hz to 868.600.000Hz] and default value 868.130.000Hz for EU. The range for US is [902.000.000Hz to 906.000.000Hz] with default 902.200.000Hz. This command will only be used during testing of the system and not during regular operation in a SIGFOX™ network.

Master		TX Frequency (0x1B)	TX[31:24]	TX[23:16]	TX[15:8]	TX[7:0]
ATA8520E		Dummy	Dummy	Dummy	Dummy	Dummy

2.1.2.26. Set RX Frequency

Set RX center frequency temporarily for testing purposes. This settings are lost after reset or when switching the device off. The frequency value is an unsigned 32-bit integer within the range [869.400.000Hz to 869.650.000Hz] and default value 869.525.000Hz for EU. The range for US is [902.000.000Hz to 906.000.000Hz] with default 905.200.000Hz. This command will only be used during testing of the system and not during regular operation in a SIGFOX™ network.

Master		RX Frequency (0x1C)	RX[31:24]	RX[23:16]	RX[15:8]	RX[7:0]
ATA8520E		Dummy	Dummy	Dummy	Dummy	Dummy

2.1.2.27. Store Crystal Coefficients

This command stores a crystal coefficient for temperature compensation at position INDEX (range 0 to 22). The INDEX is related to a specific temperature value, i.e., index position 0 is for –48°C, index 1 for –40°C, index 2 for –32°C and so forth until index 22 for +128°C. The data value has to be in ppm and is interpreted as a signed value. The final table is composed with a step size of 8°C, starting at –48°C and ending at +128°C. The command will issue an event when finished.

Master		Store Crystal Coeff. (0x1D)	Index	Data
ATA8520E		Dummy	Dummy	Dummy

2.1.2.28. Trigger Read of Crystal Coefficient Table

This command triggers the read operation of the crystal coefficient table into a buffer area for the temperature range of –32°C to +88°C in steps of 8°C (16 coefficients) for verification purposes. The buffer read itself is then performed with command 0x20.

Master		Trigger Crystal Read (0x1E)
ATA8520E		Dummy

2.1.2.29. Trigger Read of System Configuration

This command triggers the read operation of the center frequencies for up- and downlink in Hz and the system configuration setting as used in command 0x11. The buffer read itself is then performed with command 0x20.

Master		Trigger Conf. Read (0x1F)
ATA8520E		Dummy

2.1.2.30. Read Configuration Buffer

This command returns the data read from EEPROM which has been triggered before by the following commands.

Read Crystal Coefficient Table

This command reads the crystal coefficients in ppm after issuing the trigger command 0x1E. The buffer area includes 16 signed data bytes to be read.

Master		Read Crystal Coeff. (0x20)	Dummy	Dummy	...	Dummy
ATA8520E		Dummy	Dummy	Coeff[2]		Coeff[17]

Read System Configuration

This command reads the center frequencies for up- and downlink in Hz as 32-bit unsigned value and the system configuration setting as used in command 0x11 after issuing the trigger command 0x1F. The buffer area includes 10 data bytes to be read.

Master		Read Crystal Coeff. (0x20)	Dummy	Dummy	Dummy	Dummy	Dummy	Dummy
ATA8520E		Dummy	Dummy	freqTX[7..0]	freqTX [15..8]	freqTX [23..16]	freqTX [31..24]	freqRX [7..0]

				Dummy	Dummy	Dummy	Dummy	Dummy
				freqRX [15..8]	freqRX [23..16]	freqRX [31..24]	repeat	Sys Config

Read Current FCC Channel Setting

This command reads the current FCC channel configuration stored in the EEPROM after issuing the trigger command 0x25. The buffer includes 1 FCC data byte with

Bit 7...4: =	1 if the current FCC Macro Channel is not the default SIGFOX channel
	0 otherwise
Bit 3...0: #	of free Micro Channel inside the current FCC Macro Channel

Master		Read Current FCC (0x20)	Dummy	Dummy
ATA8520E		Dummy	Dummy	FCC data

2.1.2.31. Enable Frequency Fixed Mode

This command will toggle between frequency hopping and fixed frequency for testing purposes. After applying a reset the frequency hopping mode is enabled per default. This command will only be used during testing of the system and not during regular operation in a SIGFOX™ network.

Master		Enable Fixed Frq. (0x21)
ATA8520E		Dummy

2.1.2.32. Store Channel Configuration

This command stores the channel configuration for the US mode operation in EEPROM. The following values have to be used for FCC compliance:

- MC1[0..3]: 0xFF, 0x01, 0x00, 0x00
- MC2[0..3]: 0x00, 0x00, 0x00, 0x00
- MC3[0..3]: 0x00, 0x00, 0x00, 0x00
- DC[0..1]: 0x01, 0x00

Master		Store Micro-chann. (0x22)	MC1[0]	MC1[1]	MC1[2]	MC1[3]	...	MC3[0]
ATA8520E		Dummy	Dummy	Dummy	Dummy	Dummy		Dummy

				MC3[1]	MC3[2]	MC3[3]	DC[0]	DC[1]
				Dummy	Dummy	Dummy	Dummy	Dummy

2.1.2.33. Reset Channel Usage

This command will reset the channel configuration of the US mode. It has to be applied before using any send or send/receive command (in US mode only). In addition it has to be ensured in the application software to use this command with a minimum delay of 20 seconds between consecutive calls to comply with FCC regulations.

Master		Reset Channel Usage (0x23)
ATA8520E		Dummy

2.1.2.34. Adjust RSSI - Value

This command will store a value which is automatically added to the measured RSSI level. This value is derived from the gain or loss of the external circuitry including the antenna. This corrected RSSI value will be used during frame sending to the SIGFOX™ network and is calculated as (value is of type signed 8-bit data):

RSSIsystem = RSSImeasured + Value

Master		Adjust RSSI(0x24)	Value
ATA8520E		Dummy	Dummy

2.1.2.35. Trigger Read of FCC Channel Configuration

This command triggers the read operation of the current FCC channel configuration setting for verification purposes. The buffer read itself is then performed with command 0x20.

Master		Trigger FCC Read (0x25)
ATA8520E		Dummy

2.1.3. Command Table Overview

This section gives an overview about the SPI commands and the separation into the

- application SPI commands used in application software
- configuration SPI commands used during end-of-line configuration
- test and maintenance SPI commands used for testing purposes

Table 2-2. Application SPI Commands

CMD	Index	Write Data	Read Data	Event
System reset	0x01	None	None	Yes
I/O Init	0x02	DDRC register setting	None	-
I/O Write	0x03	PORTC register setting	None	-
I/O Read	0x04	None	PINC register setting	-
OFF mode	0x05	None	None	-
Write TX buffer	0x07	Data written to TX buffer	None	-
Get status	0x0A	None	SSM / Atmel® FW / SIGFOX™ library	-
Send frame(1)	0x0D	None	None	Yes
Send/receive frame(1)	0x0E	None	None	Yes
Read RX buffer	0x10	None	RX buffer data	-
Read supply temperature	0x13	None	Vidle, Vactive, temperature	-
Trigger measurement	0x14	None	None	Yes
Reset channel usage	0x23	None	None	-

Note 1: These commands will be available after the initial configuration has been performed (see section Configuring US- and EU-Mode.

Table 2-3. Configuration SPI Commands

CMD	Index	Write Data	Read Data	Event
Get PAC	0x0F	None	PAC[0], PAC[1] …. PAC[15]	-
Store Sys Conf	0x11	DDRC, PORTC, SysConf	None	Yes
Get ID	0x12	None	ID[3] … ID[0]	-
Store frequencies	0x1A	TX and RX frequency	None	Yes
Store crystal coefficients	0x1D	Index/Data	None	Yes
Store channel configuration	0x22	Data	None	Yes
Adjust RSSI-value	0x24	Data	None	Yes

Table 2-4. Test and Maintenance SPI Commands

CMD	Index	Write Data	Read Data	Event
Atmel version	0x06	None	Major / minor	-
Enable special mode	0x08	None	None	-
SIGFOX version	0x09	None	Version L-H	-
Send bit(1)	0x0B	Bit status	None	Yes
Send out-of-band(1)	0x0C	None	None	Yes
Trigger test mode(1)	0x15	Test mode and configuration	None	Yes
Send CW(1)	0x17	On/off	None	-
Firmware test	0x18	Parameter	None	-
Set TX frequency	0x1B	TX frequency	None	-
Set RX frequency	0x1C	RX frequency	None	-
Trigger read of crystal coefficient table	0x1E	None	None	-
Trigger read of system configuration	0x1F	None	None	-
Read configuration buffer	0x20	None	Data	-
Enable frequency fixed mode	0x21	None	None	-
Trigger read of FCC channel configuration	0x25	None	None	-

Note 1: These commands will be available after the initial configuration has been performed (see section Configuring US- and EU-Mode.

Table 2-5. Parameter Memory Usage

Parameter	Size [Bit]	Description	SPI Command
Volatile Parameters			
DDRC	8	Set the data direction for the Port C pins [1..5]: :0 pin is an input :1 pin is an output	0x02
PORTC	8	Set the output level for the Port C pins [1..5]: :0 pin is low :1 pin is high	0x03
PINC	8	Read the signal level for the Port C pins [1..5]	0x04
TX buffer	12 × 8	Data payload for transmission	0x07
RX buffer	8 × 8	Data payload for reception	0x10
TX	32	Set TX frequency [Hz]	0x1B
RX	32	Set RX frequency [Hz]	0x1C
EEPROM Parameters			
PAC	16 × 8	Read the device registration key	0x0F
ID	32	Read the device ID	0x12
EDDRC	8	Set the data direction for the Port C pins [1..5]: :0 pin is an input :1 pin is an output	0x11
EPORTC	8	Set the output level for the Port C pins [1..5]: :0 pin is low :1 pin is high	0x11
Repeat	8	Set and read # of repetitions for the send/receive command 0x0E	0x11, 0x1F, 0x20
SysConf	8	Set and read system configuration as defined in section System and Pin Configuration	0x11, 0x1F, 0x20
freqTX	32	Set and read TX frequency [Hz]	0x1A, 0x1F, 0x20
freqRX	32	Set and read RX frequency [Hz]	0x1A, 0x1F, 0x20
Crystal Data	23 × 8	Set and read crystal coefficients for temperature compensation [ppm]	0x1D, 0x1E, 0x20
MC1, MC2, MC3, DC	14 × 8	Set channel configuration for US mode	0x22
RSSI Value	8	Set RSSI value to adjust RSSI level	0x24

2.1.4. System and Pin Configuration

This section specifies the system configuration settings used in the SPI command (0x11). This system configuration has to be set after the system issues a system ready event and before using any other SPI command. The settings are stored in the internal EEPROM and will be applied after a system reset. This settings are typically applied at the EOL testing in the factory. Table 2-6 summarizes the configuration settings.

Table 2-6. System Configuration

Function	Bit No.	Settings
None	7 to 6	:00 (default)
None	5 to 4	:11 (default)
Supply voltage	3	:0, 5V supply :1, 3V supply (default)
RX/TX select	2	:0, up-/downlink enabled :1, uplink only enabled (default)
EU/US select	1	:0 US mode
		:1 EU mode
None	0	:1 (default)

For an additional front-end module, which includes an antenna switch, a low-noise amplifier for downlink operation and a power amplifier for uplink operation, two control signals are available at the port pins PB0 and PB7. These pins are controlled by the Atmel® ATA8520E device during transmission and reception of a RF data telegram. Table 2-7 summarizes the function of these pins.

Table 2-7. FEM Control Pins

Function/Pin	PB0	PB7
FEM disabled	0	X
Uplink active	1	1
Downlink active	1	0

In case the internal SPDT switch is not used for RF control this switch can be used in addition to control an external FEM. During uplink operation the path between pins SPDT_ANT and SPDT_TX is closed and for downlink operation the path between pins SPDT_ANT and SPDT_RX is closed.

2.1.5. Configuring US- and EU-Mode

The Atmel® device ATA8520E can be configured to operate in US- or in EU-mode and can be switched between these modes. To select the operating mode the settings shown in Table 2-8 have to be set.

Table 2-8. US- and EU-Mode Settings

Mode	TX Frequency	RX Frequency	Configuration (Bit 1 in Table 2-6)
EU	868130000Hz	869525000Hz	1
US	902200000Hz	905200000Hz	0

To select the frequency use the SPI command sequence:

1. SPI cmd: (0x1A) (TX-freq.) (RX-freq.)
2. wait for EVENT signal and read status with SPI cmd: (0x0A)

To select the mode bit use the SPI cmd sequence:

1. SPI cmd: (0x11) (DDRC) (PORTC) (0x02) (systemConfig)
2. wait for EVENT signal and read status with SPI cmd: (0x0A)

Finally a System Reset with SPI command (0x01) will reset the device and apply the settings.

Caution: The device is delivered without mode configuration per default. Before the first usage a configuration is required with the SPI commands described before. In addition to the frequency and region settings the supply mode should be set with SPI command (0x11). When using the device with 5V supply it has to be ensured that before using the RF transmit operation the 5V supply mode is configured!

For the US mode the channel usage has to be initialized before the first RF command, i.e., the channel configuration has to be stored in EEPROM:

1. SPI cmd: (0x22) (default data)
2. wait for EVENT signal and read status with SPI cmd: (0x0A)
3. System Reset with SPI command (0x01) will reset the device and apply the settings
4. SPI cmd: (0x23)

The SPI cmd (0x23) shall be applied after each wake-up/reset of the device but must keep a 20s wait period before consecutive calls (due to FCC regulations).

When receiving a downstream data packet with 8 bytes the RSSI value is reported with byte no. 8. This RSSI value is determined at device pin level and need adjustment for the system level when using an external LNA. This offset value can be set with SPI cmd (0x24).

2.2. Operating Modes Overview

This section gives an overview of the operating modes supported by the Atmel® ATA8520E.

After connecting the supply voltage to the VS pin, the Atmel ATA8520E always starts in OFF mode. All internal circuits are disconnected from the power supply. Therefore, no SPI communication is supported. The Atmel ATA8520E can be woken up by activating the PWRON pin or one of the NPWRONx pins. This triggers the power-on sequence which will set the event line PB6 to low. After the system initialization the Atmel ATA8520E reaches the IDLE Mode.

The idle mode is the basic system mode supporting SPI communication and transitions to the other operating modes.

The transmit mode (TX Mode) starts the data transmission using the payload data which has to be previously written into the TX buffer with the SPI command “Write TX Buffer”. The data transmission is started with the SPI command “Send Frame”. After transmitting the data frame, the end of the transmission is indicated when the event pin PB6 switches to low and the device enters the idle mode again.

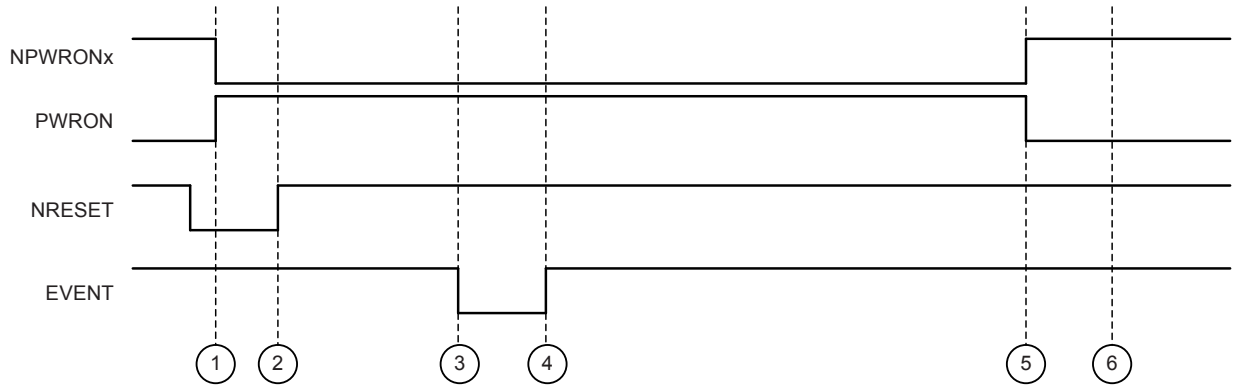
Reading the device status with the “Get Status” SPI command clears the PB6 event line, setting it to high level again.

The transmit/receive mode (TX/RX Mode) will send at first a data telegram in uplink direction and then enter receive mode for downlink direction. The downlink request is captured by the SIGFOX™ backend and processed. After transmission of the uplink frame the device will wait for 20 seconds before entering the receive mode. This receive mode will take up to 30 seconds and will end with an event on pin PB6. This event is cleared when reading the device status with the SPI command “Get Status”. If no error occurs during the downlink operation (Atmel status error code = 0000), the received data telegram of 8 bytes can be read with the SPI command “Read RX Buffer”.

2.2.1. Power-up Sequence

This section describes the power-up sequence for the device as described in Figure 2-2. The device is usually in OFF mode were the signals NPWRONx, PWRON and NRESET are inactive but VS is supplied with power. Switching the NRESET signal active or sending the SPI command System Reset (0x01) will have no effect in OFF mode. Switching one of the power-on pins active will wake-up the device and an internal power-on reset is performed. In addition the external NRESET line can be used to keep the device in reset state when waking-up the device. The minimum activation time for the NPWRONx, PWRON and NRESET signals is 10µs.

Figure 2-2. Power-up Sequence



After applying the reset signal NRESET one of the power-up signals NPWRON1...6 or PWRON is applied at timing point T1. At timing point T2 (~10µs after T1) the external reset signal is removed and the device starts its internal power-up sequence. This internal sequence is finished at timing point T3 (~10ms after T2 in EU mode and ~30ms after T2 in US mode) and is signaled with the event line. Reading the device status with the SPI command (0x0A) “Get status” will clear the event line at timing point T4. The device is now in idle mode and operational even if the NPWRONx and PWRON signals are deactivated (the start-up time between T2 and T3 for the first power-up and the first send or send/receive command after the configuration will take longer as the typical time due to internal initialization steps).

To shutdown the device into OFF mode the power-up signals NPWRON1...6 or PWRON have to be deactivated at first (shown in timing point T5). The shutdown into OFF mode is then performed by sending the SPI command (0x05) “OFF mode” to the device.

2.2.2. Power-down Sequence

The device can be switched into an OFF mode with very low power consumption (5nA at 25°C) using the SPI command 0x05. Before using this command a potential pending event has to be cleared by reading the status information with SPI command 0x0A. This ensures the correct updating of internal status information before power-down. In addition the PWRON and NPWRONx pins have to be released to prevent the wake-up of the device. If one of the power-on pins is active the device will not switch into OFF mode.

2.2.3. Application Example

The software to control the device and to transmit only a data frame (without reception) has to perform the following steps:

1. Initialize device as shown in Figure 2-2 for the power-up sequence
2. Check for the startup event and read the device status with SPI command (0x0A) “Get status” to clear this event
3. Load the transmit buffer with up to 12 bytes using the SPI command (0x07) “Write TX Buffer”
4. Start the data transmit with SPI command (0x0D) “Send Frame”
5. Wait until the event signal appears (this takes about 7-8 seconds in EU mode and 2-3 seconds in US mode)
6. Read the device status with SPI command (0x0A) “Get status” to clear this event
7. Switch off the power-on signals as shown in Figure 2-2
8. Send the SPI command (0x05) “OFF mode” to the shutdown the device

The software to control the device and to transmit and receive a data frame has to perform the following steps:

1. Initialize device as shown in Figure 2-2 for the power-up sequence
2. Check for the startup event and read the device status with SPI command (0x0A) “Get status” to clear this event
3. Load the transmit buffer with up to 12 bytes using the SPI command (0x07) “Write TX Buffer”
4. Start the data transmit with SPI command (0x0E) “Send/Receive Frame”
5. Wait until the event signal appears (this takes about 20-50 seconds)
6. Read the device status with SPI command (0x0A) “Get status” to clear this event
7. Read the receive buffer with SPI command (0x10) “Read RX Buffer” for the 8 data bytes
8. Process received data, etc.
9. Switch off the power-on signals as shown in Figure 2-2
10. Send the SPI command (0x05) “OFF mode” to the shutdown the device

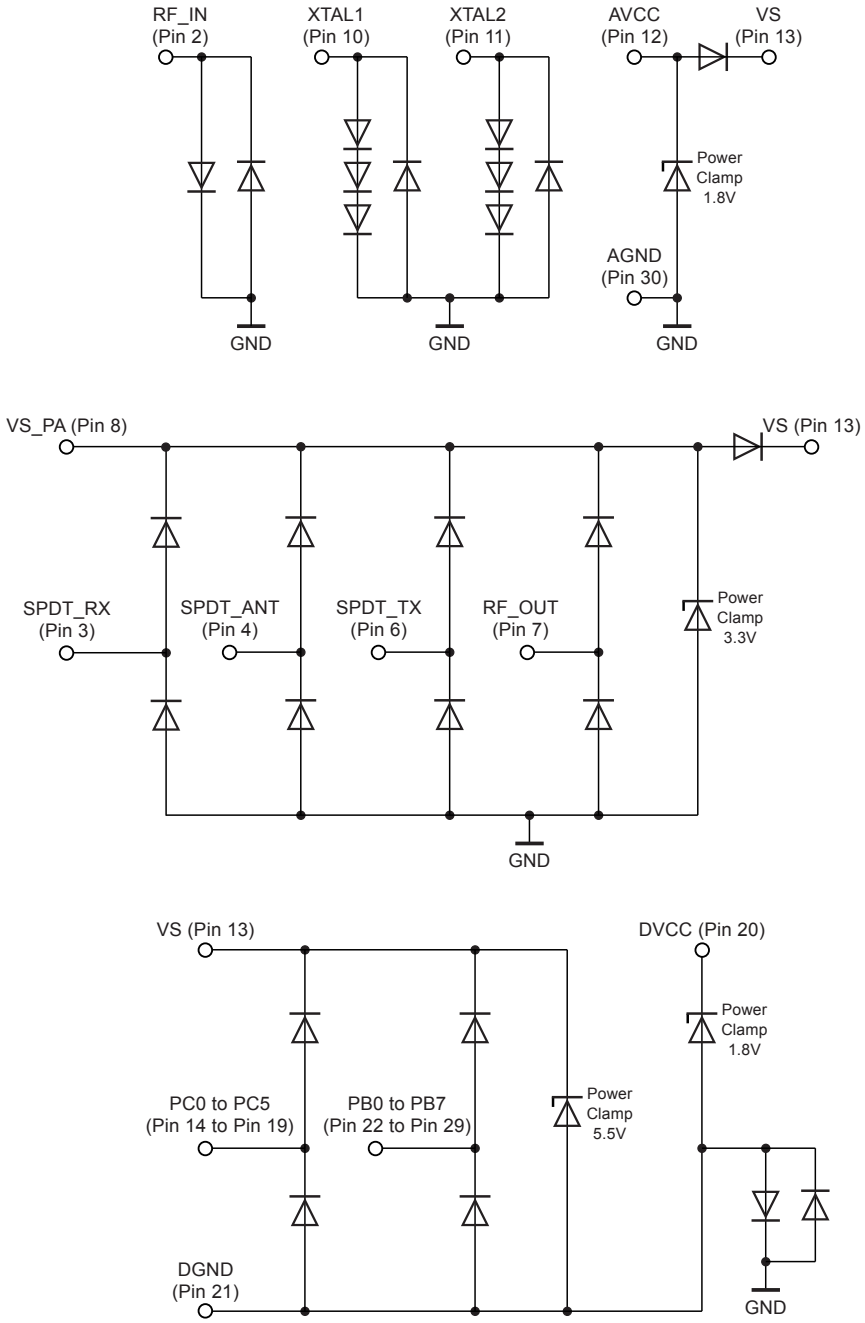
For the SPI communication it is important to keep the timing as shown in Figure 2-1. With the SPI commands (0x0F) „Get PAC” and (0x12) „Get ID” the SIGFOX™ registration information can be read to register the device in the SIGFOX cloud.

3. Electrical Characteristics

3.1. ESD Protection Circuits

GND is the exposed die pad of the Atmel® which is internally connected to AGND (pin 30). All Zener diodes shown in Figure 3-1 (marked as power clamps) are realized with dynamic clamping circuits and not physical Zener diodes. Therefore, DC currents are not clamped to the shown voltages.

Figure 3-1. Atmel ESD Protection Circuit



3.2. Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameters	Symbol	Min.	Max.	Unit
Junction temperature	Tj		+150	°C
Storage temperature	Tstg	–55	+125	°C
Ambient temperature	Tamb	–40	+85	°C
Supply voltage	V_{VS}	–0.3	+6.0	V
Supply voltage PA (1.9 to 3.6V application)	V_{VS_PA}	–0.3	+4.0	V
ESD (human body model) all pins	HBM	–4	+4	kV
ESD (machine model) all pins	MM	–200	+200	V
ESD (field induced charged device model) all pins	FCDM	–750	+750	V
Maximum peak voltage at pin 4 (SPDT_ANT)(1)	SPDTANT	–0.3	VS_PA(2) + 0.3	V
Maximum peak voltage at pin 6 (SPDT_TX)(1)	SPDTTX	–0.3	VS_PA(2) + 0.3	V

Note:

1. The customer application needs to be properly designed.
2. VS_PA is the voltage applied to pin 8.

3.3. Thermal Resistance

Parameters	Symbol	Value	Unit
Thermal resistance, junction ambient, soldered in compliance with JEDEC	R_{th_JA}	35	K/W

3.4. Supply Voltages and Current Consumption

All parameters refer to GND (backplane) and are valid for T_{amb} = –40°C to +85°C, V_{VS} = 1.9V to 3.6V across all process tolerances unless otherwise specified. Typical values are given at V_{VS} = 3V, T_{amb} = 25°C, and for a typical process unless otherwise specified. Crystal oscillator frequency f_{XTO} = 24.305MHz.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
1.00	Supply voltage range VS	3V application	13	V_{VS}	1.9	3.0	3.6	V	A
		5V application	13	V_{VS}	2.4	5.0	5.5	V	A
1.01	Supply voltage for SIGFOX™ compliance	3V application	13	V_{VS}	2.9	3.0	3.1	V	
		5V application	13	V_{VS}	3.3	5.0	5.5	V	
1.05	Supply voltage rise time		13	V_{VS_rise}			1	V/µs	D
1.10	Supply voltage range VS_PA	3V application	8	V_{VS_PA}	1.9	3	3.6	V	A
		5V application	8	V_{VS_PA}		3		V	A
		SIGFOX compliant	8	V_{VS_PA}		3		V	
1.20	OFF mode current consumption	T_{amb} = 25°C T_{amb} = 85°C	8, 13	$I_{OFFMode\_3V}$		5	150 600	nA nA	B B
1.30	Idle mode current consumption	Temperature range –40°C to +65°C	13	$I_{IdleMode}$		50	90	µA	B
1.80	RX mode current consumption	f_{RF} = 869.5MHz f_{RF} = 905.2MHz	13	I_{RXMode}		10.4 10.5	14.6 14.7	mA	A
2.00	TX mode current consumption	Pout = +14dBm f_{RF} = 868.3MHz f_{RF} = 902.2MHz	(7), 8, 13	I_{TXMode}		32.7 33.5	45 46	mA	B
2.05	SIGFOX TX mode current consumption	T_{amb} = 25°C, 3V application EU US	(7), 8, 13	$I_{SIGFOX\ Mode}$		31.8 16.7	40.1 21.0	mA mA	B B
2.06	SIGFOX TX mode current consumption	T_{amb} = 85°C, 3V application	(7), 8, 13	$I_{SIGFOX\ Mode}$		32.7	41.1	mA	B

Pin numbers in brackets mean they are measured matched to 50Ω on the application board.

*) Type means: A = 100% tested, B = 100% correlation tested, C = characterized on samples, D = design parameter

3.5. RF Receive Characteristics

All parameters refer to GND (backplane) and are valid for T_{amb} = –40°C to +85°C, V_{VS} = 1.9V to 3.6V across all process tolerances unless otherwise specified. Typical values are given at V_{VS} = 3V, T_{amb} = 25°C, and for a typical process unless otherwise specified. Crystal oscillator frequency f_{XTO} = 24.305MHz.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
4.50	Frequency range EU US	Defined by SIGFOX™ protocol	(2)	f_{RX}	 869.40 902.0		 869.65 906.0	MHz	
4.90	Sensitivity level	FSK at 25kHz IF bandwidth T_{amb} = 25°C 0.75Kbit/s ±0.75kHz	17, 19	SFSK	–1.5dB	–121.5	+1.5dB	dBm	B
7.30	Blocking	FSK at 25kHz IF bandwidth, T_{amb} = 25°C 2.4Kbit/s ±2.4kHz	(2)	fdist. ≥ 50kHz fdist. ≥ 100kHz fdist. ≥ 225kHz fdist. ≥ 450kHz fdist. ≥ 1MHz fdist. ≥ 4MHz fdist.>10MHz		34 40 52 58 67 75 75		dBc	C C C C C C C
7.70	Image rejection	Large disturber applied before useful signal	(2)	IM_{RED}	38	47		dB	A
7.80	Blocking $3f_{LO}$, $5f_{LO}$	$3 \times f_{LO} - f_{IF}$ $5 \times f_{LO} + f_{IF}$	(2)	BL_{NfLO}		39 45		dB	C C
8.50	Input impedance	Measured on application board, RC parallel equivalent circuit	2	Z_{in}	–20%	340 1.4	+20%	Ω pF	C
8.70	SPDT switch RX insertion loss	Sensitivity matching RF_IN with SPDT to 50Ω compared to matching RF_IN directly to 50Ω	(3, 4)	IL_{Switch_RX}		1.0	1.4	dB	C
9.00	RSSI accuracy	P_{RFIN} = –70dBm	(2), 4	$RSSI_{ABS\_ACCU}$	–5.5		+5.5	dB	B
9.20	RSSI resolution	DSP property	(2), 4	$RSSI_{RES}$		0.5		dB/ value	D

Pin numbers in brackets mean they are measured matched to 50Ω on the application board.

*) Type means: A = 100% tested, B = 100% correlation tested, C = characterized on samples, D = design parameter

3.6. RF Transmit Characteristics

All parameters refer to GND (backplane) and are valid for T_{amb} = –40°C to +85°C, V_{VS} = 1.9V to 3.6V across all process tolerances unless otherwise specified. Typical values are given at V_{VS} = 3V, T_{amb} = 25°C, and for a typical process unless otherwise specified. Crystal oscillator frequency f_{XTO} = 24.305MHz.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
10.00	Output power range	T_{amb} = 25°C EU US	(7)	P_{Range}			+14.5 +9.5	dBm dBm	B C
10.01	Output power for SIGFOX™ compliance	T_{amb} = 25°C, V_{VS} = 2.9V to 3.1V, 3V application (for 5V applications see no. 11.50) EU US	(7)	P_{SIGFOX}	13.5 9.2	13.8 9.5	14.0 9.7	dBm dBm	C C
10.02	Output power for SIGFOX compliance	T_{amb} = –45°C to +85°C, V_{VS} = 3.0V, 3V application (for 5V applications see no. 11.50) EU US	(7)	P_{SIGFOX}	13.1 8.9	13.8 9.5	14.7 10.1	dBm dBm	C C
10.05	Frequency range EU US	Defined by SIGFOX protocol	(7)	f_{TX}	868.0 902.0		868.6 906.0	MHz	
11.00	Output power at 14dBm	T_{amb} = 25°C using 14dBm matching	(7)	P_{out_14dBm}	–1.5dB	14	+1.5dB	dBm	B
11.10	Output 2nd harmonic at 14dBm	T_{amb} = 25°C using 14dBm matching	(7)	$HM2_{14dBm}$		–24		dBc	C
11.20	Output 3rd harmonic at 14dBm	T_{amb} = 25°C using 14dBm matching	(7)	$HM3_{14dBm}$		–50		dBc	C
11.50	Output power change full temperature and supply voltage range	For 13.8dBm V_{VS_PA} = 3.0V +-0.3V P = P_{out} + ΔP	(7)	$\Delta P_{TambVs2}$	–3.5		+2	dB	C C
11.60	Spurious emission	at $\pm f_{XTO}$ at $\pm f_{AVR}$ (f_{XTO} / 4) at $\pm f_{CLK\_OUT}$ (f_{XTO}/6)	(7)	SP_{TX}		–72 –85 –78	–60 –60 –60	dBc	B C C
12.40	SPDT insertion loss TX	Transmitted power using matching RF_OUT with SPDT to 50Ω compared to matching RF_OUT directly to 50Ω	(4, 6)	IL_{Switch_TX}		0.7	1.2	dB	C
12.45	Maximum peak voltage on SPDT_ANT (pin 4)		4	$V_{PEAK\_SPDT\_ANT}$	–0.3		VS_PA + 0.3	V	D

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
12.50	Maximum peak voltage on SPDT_TX (pin 6)		6	$V_{PEAK\_SPDT\_TX}$	–0.3		VS_PA + 0.3	V	D
Pin numbers in brackets mean they are measured matched to 50Ω on the application board. *) Type means: A = 100% tested, B = 100% correlation tested, C = characterized on samples, D = design parameter									

3.7. RF Transmit Characteristics

All parameters refer to GND (backplane) and are valid for T_{amb} = –40°C to +85°C, V_{VS} = 1.9V to 3.6V over all process tolerances, quartz parameters C_m = 4fF and C_0 = 1pF unless otherwise specified. Typical values are given at V_{VS} = 3V, T_{amb} = 25°C, and for a typical process unless otherwise specified. Crystal oscillator frequency f_{XTO} = 24.305MHz.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
13.30	XTO frequency range		10, 11	f_{xto}		24.305		MHz	C
13.35	XTO frequency for SIGFOX™ compliance	KDS: 1C324305AB0B NDK: NX3225SA EXS00A-CS08559	10, 11	f_{SIGFOX_XTO}		24.305		MHz	
13.40	XTO pulling due to internal capacitance and XTO tolerance	C_m = 4fF, T_{amb} = 25°C	10, 11	ΔF_{XTO1}	–10		+10	ppm	B
13.50	XTO pulling due to temperature and supply voltage	C_m = 4fF T_{amb} = –40°C to +85°C	10, 11	ΔF_{XTO2}	–4		+4	ppm	B
13.60	Maximum C_0 of XTAL	XTAL parameter	10, 11	C_{0_max}		1	2	pF	D
13.70	XTAL, C_m motional capacitance	XTAL parameter	10, 11	C_m		4	10	fF	D
13.90	XTAL, real part of XTO impedance at start-up	C_m = 4fF, C_0 = 1pF	10, 11	R_{e_start}	1100			Ω	B
14.00	XTAL, maximum R_m after start-up	XTAL parameter	10, 11	R_{m_max}	110			Ω	D
14.10	Internal load capacitors	Including ESD and package capacitance. XTAL has to be specified for 7.5pF load capacitance (incl. 1pF PCB capacitance per pin)	10, 11	C_{L1}, C_{L2}	13.3	14	14.7	pF	B
Pin numbers in brackets mean they are measured matched to 50Ω on the application board. *) Type means: A = 100% tested, B = 100% correlation tested, C = characterized on samples, D = design parameter									

3.8. I/O Characteristics for Ports PB0 to PB7 and PC0 to PC5

All parameters refer to GND (backplane) and are valid for T_{amb} = –40°C to +85°C, V_{VS} = 1.9V to 3.6V over all process tolerances unless otherwise specified. Typical values are given at V_{VS} = 3V, T_{amb} = 25°C, and for a typical process unless otherwise specified. Crystal oscillator frequency f_{XTO} = 24.305MHz.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
15.00	Input low voltage	PC0 to PC5 PB0 to PB7	14-19 22-29	V_{IL}	–0.3		0.2 × V_{VS}	V	A
15.05	Input low leakage current I/O pin	PC0 to PC5 PB0 to PB7	14-19 22-29	I_{IL}			–1	µA	A
15.10	Input high voltage	PC0 to PC5 PB0 to PB7	14-19 22-29	V_{IH}	0.8 × V_{VS}		V_{VS} + 0.3	V	A
15.15	Input high leakage current I/O pin	PC0 to PC5 PB0 to PB7	14-19 22-29	I_{IH}			1	µA	A
15.20	Output low voltage	I_{OL} = 0.2mA	14-19 22-29	V_{OL_3V}			0.1 × V_{VS}	V	A
15.30	Output high voltage	I_{OH} = –0.2mA	14-19 22-29	V_{OH_3V}	0.9 × V_{VS}			V	A
15.40	I/O pin pull-up resistor	OFF mode: see port B and port C	14-19 22-29	R_{PU}	30	50	70	kΩ	A
16.10	I/O pin output delay time (rising edge)	C_{Load} = 10pF	14-19 22-29	$T_{del\_rise\_3V}$	13.6	17.5	22.4	ns	D
16.20	I/O pin rise time (0.1 × V_{VS} to 0.9 × V_{VS})	C_{Load} = 10pF	14-19 22-29	T_{rise_3V}	20.7	23.9	28.4	ns	D
16.30	I/O pin slew rate (rising edge)	C_{Load} = 10pF	14-19 22-29	$T_{sr\_rise\_3V}$	0.115	0.100	0.084	V/ns	D
16.40	I/O pin output delay time (falling edge)	C_{Load} = 10pF	14-19 22-29	$T_{del\_fall\_3V}$	13.7	17.4	22.7	ns	D
16.50	I/O pin fall time (0.9 × V_{VS} to 0.1 × V_{VS})	C_{Load} = 10pF	14-19 22-29	T_{fall_3V}	16.2	19.2	22.5	ns	D
16.60	I/O pin slew rate (falling edge)	C_{Load} = 10pF	14-19 22-29	$T_{sr\_fall\_3V}$	0.148	0.125	0.106	V/ns	D

*) Type means: A = 100% tested at voltage and temperature limits, B = 100% correlation tested, C = characterized on samples, D = design parameter

3.9. Hardware Timings

All parameters refer to GND (backplane) and are valid for T_{amb} = –40°C to +85°C, V_{VS} =1.9V to 3.6V over all process tolerances. Typical values are given at V_{VS} = 3V, T_{amb} = 25°C, and for a typical process unless otherwise specified. Crystal oscillator frequency f_{XTO} = 24.305MHz.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
17.50	Startup time EU(1)	PWRON = '1' or NPWRON = '0' to EVENT generation	13, 20	$T_{STARTUP\_EU}$		10		ms	C
	Startup time US(1)	PWRON = '1' or NPWRON = '0' to EVENT generation	13, 20	$T_{STARTUP\_US}$		30		ms	C

*) Type means: A = 100% tested at voltage and temperature limits, B = 100% correlation tested, C = characterized on samples, D = design parameter

Note: The start-up time after the configuration and before the first send or send/receive command is typically longer (in the range of some 100ms) due to internal system initialization steps.

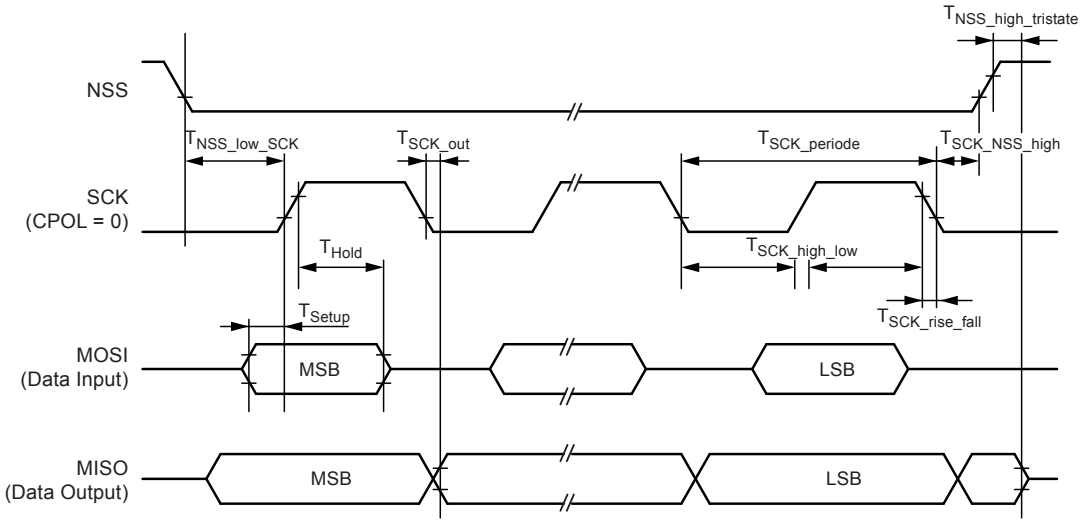
3.10. Hardware SPI Timing Characteristics

Timing shown for CPHA=0 and CPOL=0 in Figure 3-2, timing is valid for all CPHA and CPOL configurations. See also sction SPI Command Interface for functional SPI description and for firmware limitations on SPI data transfer. All parameters refer to GND (backplane) and are valid for T_{amb} = –40°C to +85°C, V_{VS} = 1.9V to 3.6V (3V application) and 4.5V to 5.5V (5V application) over all process tolerances. Typical values are given at V_{VS} = 5V, T_{amb} = 25°C, and for a typical process unless otherwise specified. Crystal oscillator frequency f_{XTO} = 24.305MHz.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
49.10	SCK cycle time		23	T_{SCK_period}	8			µs	D
49.20	SCK high or low time		23	$T_{SCK\_high\_low}$	330			ns	D
49.30	SCK rise or fall time		23	$T_{SCK\_rise\_fall}$			100	ns	D
49.40	MOSI setup time to active edge of SCK		23, 24	T_{Setup}	80			ns	D
49.50	MOSI hold time to active edge of SCK		23, 24	T_{Hold}	245			ns	D
49.60	Time period active edge of SCK to data out at MISO	C_{LOAD_MISO} = 10pF	23, 25	T_{SCK_out}			250	ns	D
49.70	Time period SCK inactive to NSS high		23, 27	$T_{SCK\_NSS\_high}$	100			µs	D
49.80	Time period NSS high to MISO tristate	C_{LOAD_MISO} = 10pF	25, 27	$T_{NSS\_high\_tristate}$			250	ns	D
49.90	Time period NSS low to active edge SCK		23, 27	$T_{NSS\_low\_SCK}$	65			µs	D

*) Type means: A = 100% tested at voltage and temperature limits, B = 100% correlation tested, C = characterized on samples, D = design parameter

Figure 3-2. SPI Interface Timing Requirements

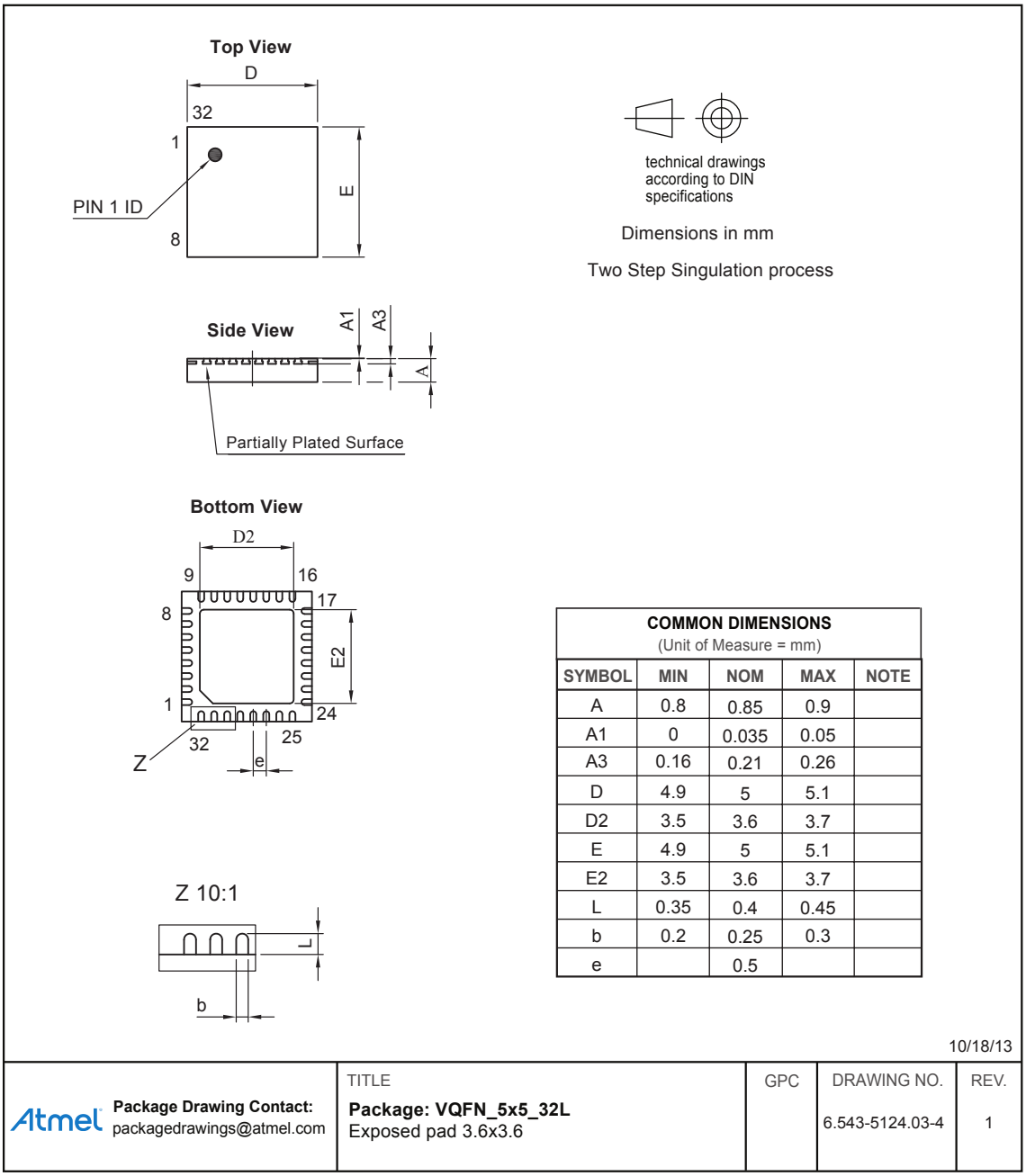


4. Ordering and Package Information

Table 4-1. Ordering Information

Extended Type Number	Package	Remarks
ATA8520E-GHQW	QFN32	5mm × 5mm, Pb-free, 6k, taped and reeled
ATA8520E-GHPW	QFN32	5mm × 5mm, Pb-free, 1.5k, taped and reeled

Figure 4-1. Package Information



COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	0.8	0.85	0.9	
A1	0	0.035	0.05	
A3	0.16	0.21	0.26	
D	4.9	5	5.1	
D2	3.5	3.6	3.7	
E	4.9	5	5.1	
E2	3.5	3.6	3.7	
L	0.35	0.4	0.45	
b	0.2	0.25	0.3	
e		0.5		

5. Disclaimer

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6. Revision History

Please note that the following page numbers referred to in this section refer to the specific revision mentioned, not to this document.

Revision No.	History
9409C-09/16	• Put datasheet in new template • Sections changed or added: 2.1.2.30. Read Configuration Buffer 2.1.2.35. Trigger Read of FCC Channel Configuration 3.7. RF Transmit Characteristics • Table changed: Table 2-4. Test and Maintenance SPI Commands • Ordering and Package Infomation changed
9409B-INDCO-08/16	• Section 2.1.5 “Configuring US- and EU-Mode” on page 20 updated

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Atmel Corporation 1600 Technology Drive, San Jose, CA 95110 USA **T:** (+1)(408) 441.0311 **F:** (+1)(408) 436.4200 | **www.atmel.com**