

ADVANCED COMMUNICATIONS & SENSING

SX1508B/SX1509B

World's Lowest Voltage Level Shifting GPIO with LED Driver and Keypad Engine

GENERAL DESCRIPTION

The SX1508B and SX1509B are complete ultra low voltage General Purpose parallel Input/Output (GPIO) expanders ideal for low power handheld battery powered equipment. This family of GPIOs comes in 8-, 16-channel configuration and allows easy serial expansion of I/O through a standard 400kHz I²C interface. GPIO devices can provide additional control and monitoring when the microcontroller or chipset has insufficient I/O ports, or in systems where serial communication and control from a remote location is advantageous.

These devices can also act as a level shifter to connect a microcontroller running at one voltage level to a component running at a different voltage level, thus eliminating the need for extra level translating circuits. The core is operating as low as 1.425V while the dual I/O banks can operate between 1.2V and 3.6V independent of the core voltage and each other (5.5V tolerant).

The SX1508B and SX1509B feature a fully programmable LED Driver with internal oscillator for enhanced lighting control such as intensity (via 256-step PWM), blinking and breathing (fade in/out) make them highly versatile for a wide range of LED applications.

In addition, keypad applications are also supported with an on-chip scanning engine that enables continuous keypad monitoring up to 64 keys without any additional host interaction reducing bus activity.

The SX1508B and SX1509B have the ability to generate mask-programmable interrupts based on a falling/rising edge of any of its GPIO lines. A dedicated pin (NINT) indicates to a host controller that a state change occurred on one or more of the lines. Each GPIO is programmable via a bank of 8-bit configuration registers that include data, direction, pull-up/pull-down, interrupt mask and interrupt registers. These I/O expanders feature small footprint packages and are rated from -40°C to +85°C temperature range.

ORDERING INFORMATION

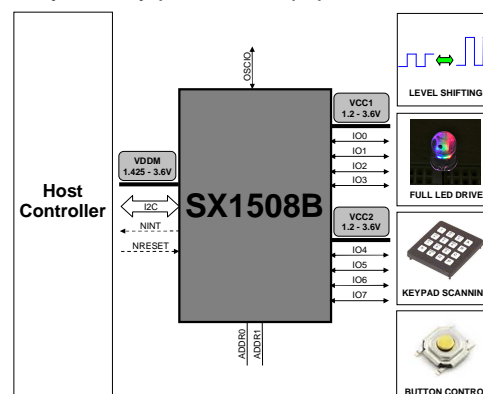
| Part Number | I/Os | Package | Marking |
|---------------|------|----------------|---------|
| SX1508BIULTRT | 8 | QFN-UT-20 | GAA2 |
| SX1509BIULTRT | 16 | QFN-UT-28 | GBA3 |
| SX1508BEVK | 8 | Evaluation Kit | - |
| SX1509BEVK | 16 | Evaluation Kit | - |

KEY PRODUCT FEATURES

- 1.2V to 3.6V Low Operating Voltage with Dual Independent I/O Rails (VCC1, VCC2)
 - Enable Direct Level Shifting Between I/O Banks and Host Controller
- 5.5V Tolerant I/Os, Up to 15mA Output Sink on All I/Os (No Total Sink Current Limit)
- Integrated LED Driver for Enhanced Lighting
 - Intensity Control (256-step PWM)
 - Blink Control (224 On/Off values)
 - Breathing Control (224 Fade In/Out values)
- On-Chip Keypad Scanning Engine
 - Support Up to 8x8 Matrix (64 Keys)
 - Configurable Input Debouncer
- 8/16 Channels of True Bi-directional Style I/O
 - Programmable Pull-up/Pull-down
 - Push/Pull or Open-drain outputs
 - Programmable Polarity
- Open Drain Active Low Interrupt Output (NINT)
 - Bit Maskable
 - Programmable Edge Sensitivity
- Built-in Clock Management (Internal 2MHz Oscillator/External Clock Input, 7 clock values)
 - OSCIO can be Configured as GPO
- 400kHz I²C Compatible Slave Interface
- 4 User-Selectable I²C Slave Addresses
- Power-On Reset and Reset Input (NRESET)
- Ultra Low Current Consumption: 1uA Typ
- -40°C to +85°C Operating Temperature Range
- Up to 2kV HBM ESD Protection
- Small Footprint Packages
- Pb & Halogen Free, RoHS/WEEE compliant

TYPICAL APPLICATIONS

- Cell phones, PDAs, MP3 players
- Digital camera, Notebooks, GPS Units
- Any battery powered equipment



ADVANCED COMMUNICATIONS & SENSING

Table of Contents

| | |
|--|-----------|
| GENERAL DESCRIPTION | 1 |
| ORDERING INFORMATION..... | 1 |
| KEY PRODUCT FEATURES..... | 1 |
| TYPICAL APPLICATIONS | 1 |
| 1 PIN DESCRIPTION | 4 |
| 1.1 SX1508B 8-channel I ² C GPIO with LED Driver and Keypad Engine | 4 |
| 1.2 SX1509B 16-channel I ² C GPIO with LED Driver and Keypad Engine | 5 |
| 1.3 I/Os Feature Summary | 6 |
| 2 ELECTRICAL CHARACTERISTICS..... | 7 |
| 2.1 Absolute Maximum Ratings | 7 |
| 2.2 Electrical Specifications | 7 |
| 3 TYPICAL OPERATING CHARACTERISTICS | 10 |
| 4 BLOCK DETAILED DESCRIPTION | 11 |
| 4.1 SX1508B 8-channel I ² C GPIO with LED Driver and Keypad Engine | 11 |
| 4.2 SX1509B 16-channel I ² C GPIO with LED Driver and Keypad Engine | 11 |
| 4.3 Reset | 12 |
| 4.3.1 Hardware (NRESET) | 12 |
| 4.3.2 Software (RegReset) | 12 |
| 4.4 2-Wire Interface (I ² C) | 12 |
| 4.4.1 WRITE | 13 |
| 4.4.2 READ | 13 |
| 4.5 I/O Banks | 14 |
| 4.5.1 Input Debouncer | 14 |
| 4.5.2 Keypad Scanning Engine | 14 |
| 4.5.3 Level Shifter | 15 |
| 4.5.4 Polarity Inverter | 16 |
| 4.6 Interrupt (NINT) | 16 |
| 4.7 Clock Management | 17 |
| 4.8 LED Driver | 17 |
| 4.8.1 Overview | 17 |
| 4.8.2 Static Mode | 18 |
| 4.8.3 Single Shot Mode | 18 |
| 4.8.4 Blink Mode | 19 |
| 4.8.5 LED Driver Modes | 19 |
| 4.8.6 Synchronization of LED Drivers across several ICs | 20 |
| 4.8.7 Tutorial | 20 |
| 5 CONFIGURATION REGISTERS..... | 22 |
| 5.1 SX1508B 8-channel GPIO with LED Driver and Keypad Engine | 22 |
| 5.2 SX1509B 16-channel GPIO with LED Driver and Keypad Engine | 26 |
| 6 APPLICATION INFORMATION | 32 |
| 6.1 Typical Application Circuit | 32 |
| 6.2 Typical LED Connection | 32 |
| 7 PACKAGING INFORMATION | 33 |
| 7.1 QFN-UT 20-pin Outline Drawing | 33 |
| 7.2 QFN-UT 20-pin Land Pattern | 33 |

ADVANCED COMMUNICATIONS & SENSING

| | | |
|-----|-------------------------------|----|
| 7.3 | QFN-UT 28-pin Outline Drawing | 34 |
| 7.4 | QFN-UT 28-pin Land Pattern | 34 |
| 8 | SOLDERING PROFILE | 35 |
| 9 | MARKING INFORMATION | 36 |

ADVANCED COMMUNICATIONS & SENSING

1 PIN DESCRIPTION

1.1 SX1508B 8-channel I²C GPIO with LED Driver and Keypad Engine

| Pin | Symbol | Type | Description |
|-----|--------|---------|---|
| 1 | NRESET | DI | Active low reset input |
| 2 | SDA | DIO | I ² C serial data line |
| 3 | SCL | DI | I ² C serial clock line |
| 4 | ADDR0 | DI | Address input bit 0, connect to VDDM or GND |
| 5 | I/O[0] | DIO (*) | I/O[0], at power-on configured as an input LED driver : Intensity control (PWM) |
| 6 | I/O[1] | DIO (*) | I/O[1], at power-on configured as an input LED driver : Intensity control (PWM) |
| 7 | VCC1 | P | Supply voltage for Bank A I/O[3-0] |
| 8 | GND | P | Ground Pin |
| 9 | I/O[2] | DIO (*) | I/O[2], at power-on configured as an input LED driver : Intensity control (PWM), Blinking |
| 10 | I/O[3] | DIO (*) | I/O[3], at power-on configured as an input LED driver : Intensity control (PWM), Blinking, Breathing (Fade In/Out) |
| 11 | NINT | DO | Active low interrupt output |
| 12 | ADDR1 | DI | Address input bit 1, connect to VDDM or GND |
| 13 | OSCIO | DIO (*) | Oscillator input/output, can also be used as GPO |
| 14 | VDDM | P | Main supply voltage |
| 15 | I/O[4] | DIO (*) | I/O[4], at power-on configured as an input LED driver : Intensity control (PWM) |
| 16 | I/O[5] | DIO (*) | I/O[5], at power-on configured as an input LED driver : Intensity control (PWM) |
| 17 | VCC2 | P | Supply voltage for Bank B I/O[7-4] |
| 18 | GND | P | Ground Pin |
| 19 | I/O[6] | DIO (*) | I/O[6], at power-on configured as an input LED driver : Intensity control (PWM), Blinking |
| 20 | I/O[7] | DIO (*) | I/O[7], at power-on configured as an input LED driver : Intensity control (PWM), Blinking, Breathing (Fade In/Out) |

D/I/O/P: Digital/Input/Output/Power

(*) This pin is programmable through the I²C interface

Table 1 – SX1508B Pin Description

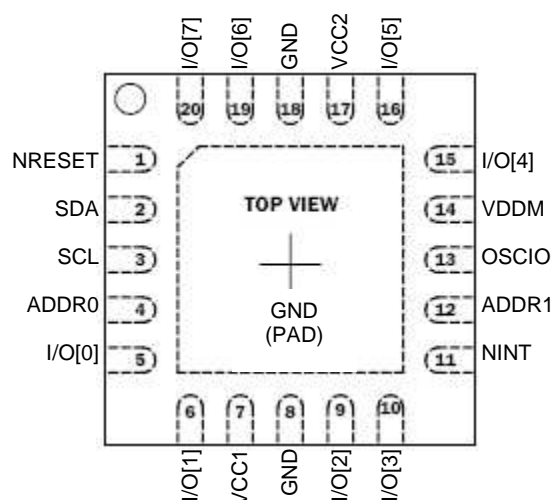


Figure 1 – SX1508B QFN-UT-20 Pinout

ADVANCED COMMUNICATIONS & SENSING

1.2 SX1509B 16-channel I²C GPIO with LED Driver and Keypad Engine

| Pin | Symbol | Type | Description |
|-----|---------|---------|--|
| 1 | I/O[2] | DIO (*) | I/O[2], at power-on configured as an input LED driver : Intensity control (PWM), Blinking |
| 2 | I/O[3] | DIO (*) | I/O[3], at power-on configured as an input LED driver : Intensity control (PWM), Blinking |
| 3 | GND | P | Ground Pin |
| 4 | VCC1 | P | Supply voltage for Bank A I/O[7-0] |
| 5 | I/O[4] | DIO (*) | I/O[4], at power-on configured as an input LED driver : Intensity control (PWM), Blinking, Breathing (Fade In/Out) |
| 6 | I/O[5] | DIO (*) | I/O[5], at power-on configured as an input LED driver : Intensity control (PWM), Blinking, Breathing (Fade In/Out) |
| 7 | I/O[6] | DIO (*) | I/O[6], at power-on configured as an input LED driver : Intensity control (PWM), Blinking, Breathing (Fade In/Out) |
| 8 | I/O[7] | DIO (*) | I/O[7], at power-on configured as an input LED driver : Intensity control (PWM), Blinking, Breathing (Fade In/Out) |
| 9 | NINT | DO | Active low interrupt output |
| 10 | ADDR1 | DI | Address input bit 1, connect to VDDM or GND |
| 11 | OSCIO | DIO (*) | Oscillator input/output, can also be used as GPO |
| 12 | VDDM | P | Main supply voltage |
| 13 | I/O[8] | DIO (*) | I/O[8], at power-on configured as an input LED driver : Intensity control (PWM), Blinking |
| 14 | I/O[9] | DIO (*) | I/O[9], at power-on configured as an input LED driver : Intensity control (PWM), Blinking |
| 15 | I/O[10] | DIO (*) | I/O[10], at power-on configured as an input LED driver : Intensity control (PWM), Blinking |
| 16 | I/O[11] | DIO (*) | I/O[11], at power-on configured as an input LED driver : Intensity control (PWM), Blinking |
| 17 | GND | P | Ground Pin |
| 18 | VCC2 | P | Supply voltage for Bank B I/O[15-8] |
| 19 | I/O[12] | DIO (*) | I/O[12], at power-on configured as an input LED driver : Intensity control (PWM), Blinking, Breathing (Fade In/Out) |
| 20 | I/O[13] | DIO (*) | I/O[13], at power-on configured as an input LED driver : Intensity control (PWM), Blinking, Breathing (Fade In/Out) |
| 21 | I/O[14] | DIO (*) | I/O[14], at power-on configured as an input LED driver : Intensity control (PWM), Blinking, Breathing (Fade In/Out) |
| 22 | I/O[15] | DIO (*) | I/O[15], at power-on configured as an input LED driver : Intensity control (PWM), Blinking, Breathing (Fade In/Out) |
| 23 | NRESET | DI | Active low reset input |
| 24 | SDA | DIO | I ² C serial data line |
| 25 | SCL | DI | I ² C serial clock line |
| 26 | ADDR0 | DI | Address input bit 0, connect to VDDM or GND |
| 27 | I/O[0] | DIO (*) | I/O[0], at power-on configured as an input LED driver : Intensity control (PWM), Blinking |
| 28 | I/O[1] | DIO (*) | I/O[1], at power-on configured as an input LED driver : Intensity control (PWM), Blinking |

(*) This pin is programmable through the I²C interface

Table 2 – SX1509B Pin Description

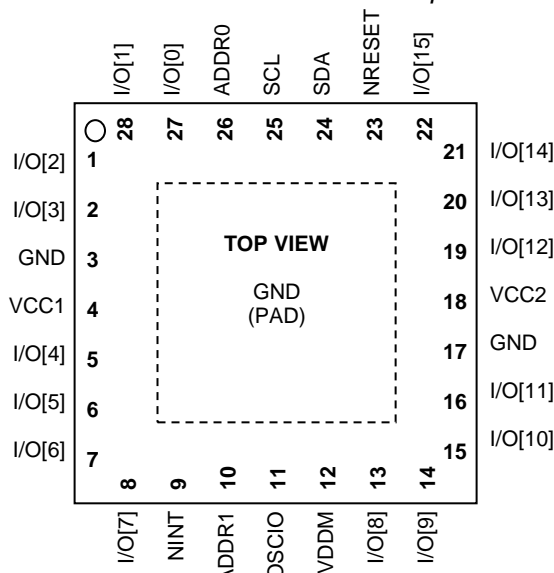


Figure 2 – SX1509B QFN-UT-28 Pinout

ADVANCED COMMUNICATIONS & SENSING

1.3 I/Os Feature Summary

| I/O | SX1508B | | | | | SX1509B | | | | |
|-----|------------|-------|---------|--------|------|------------|-------|---------|--------|------|
| | LED Driver | | | Keypad | | LED Driver | | | Keypad | |
| | PWM | Blink | Breathe | Row | Col. | PWM | Blink | Breathe | Row | Col. |
| 0 | √ | | | √ | | √ | √ | | √ | |
| 1 | √ | | | √ | | √ | √ | | √ | |
| 2 | √ | √ | | √ | | √ | √ | | √ | |
| 3 | √ | √ | √ | √ | | √ | √ | | √ | |
| 4 | √ | | | | √ | √ | √ | √ | √ | |
| 5 | √ | | | | √ | √ | √ | √ | √ | |
| 6 | √ | √ | | | √ | √ | √ | √ | √ | |
| 7 | √ | √ | √ | | √ | √ | √ | √ | √ | |
| 8 | | | | | | √ | √ | | | √ |
| 9 | | | | | | √ | √ | | | √ |
| 10 | | | | | | √ | √ | | | √ |
| 11 | | | | | | √ | √ | | | √ |
| 12 | | | | | | √ | √ | √ | | √ |
| 13 | | | | | | √ | √ | √ | | √ |
| 14 | | | | | | √ | √ | √ | | √ |
| 15 | | | | | | √ | √ | √ | | √ |

Table 3 – I/Os Feature Summary

Please note that in addition to table above, all I/Os feature bank-to-bank and bank-to-host level shifting.

ADVANCED COMMUNICATIONS & SENSING

2 ELECTRICAL CHARACTERISTICS

2.1 Absolute Maximum Ratings

Stress above the limits listed in the following table may cause permanent failure. Exposure to absolute ratings for extended time periods may affect device reliability. The limiting values are in accordance with the Absolute Maximum Rating System (IEC 134). All voltages are referenced to ground (GND).

| Symbol | Description | Min | Max | Unit |
|--------------------|---|--------|------|------|
| V_{\max_VDDM} | Main supply voltage | - 0.4 | 3.7 | V |
| V_{\max_VCC1-2} | Digital I/O pin supply voltage | - 0.4 | 3.7 | V |
| V_{ES_HBM} | Electrostatic handling HBM model ⁽¹⁾ (SX1508B) | - | 2000 | V |
| | Electrostatic handling HBM model ⁽¹⁾ (SX1509B) | - | 1500 | |
| V_{ES_CDM} | Electrostatic handling CDM model | - | 1000 | V |
| V_{ES_MM} | Electrostatic handling MM model (SX1508B) | - | 200 | V |
| | Electrostatic handling MM model (SX1509B) | - | 150 | |
| T_A | Operating ambient temperature range | -40 | +85 | °C |
| T_C | Junction temperature range | -40 | +125 | °C |
| T_{STG} | Storage temperature range | -55 | +150 | °C |
| I_{lat} | Latchup-free input pin current ⁽²⁾ | +/-100 | - | mA |

(1) Tested according to JESD22-A114A

(2) Static latch-up values are valid at maximum temperature according to JEDEC 78 specification

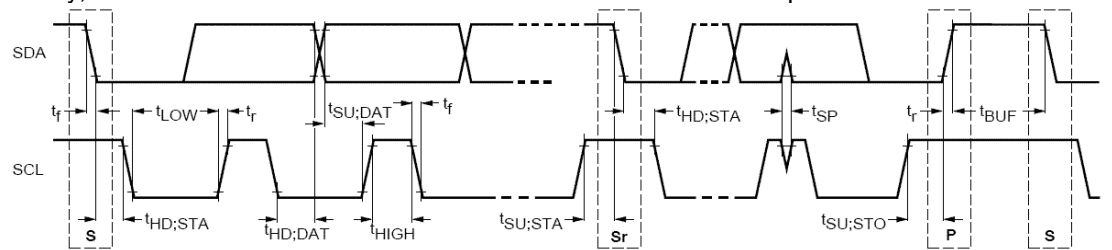
Table 4 - Absolute Maximum Ratings

2.2 Electrical Specifications

Table below assumes default registers values, unless otherwise specified. Typical values are given for $T_A = +25^\circ\text{C}$, $VDDM=VCC1=VCC2=3.3\text{V}$.

| Symbol | Description | Conditions | Min | Typ | Max | Unit |
|---------------------------|---|---------------------------------|----------------|-----|----------------|---------------|
| Supply | | | | | | |
| VDDM | Main supply voltage | | 1.425 | - | 3.6 | V |
| VCC1,2 | I/O banks supply voltage | | 1.2 | - | 3.6 | V |
| IDD | Main supply current (SX1508B, $I^2\text{C}$ inactive) | Oscillator OFF | - | 1 | 5 | μA |
| | | Internal osc. (2MHz) | - | 175 | 235 | |
| | | External osc. (32kHz) | - | 10 | - | |
| | Main supply current (SX1509B, $I^2\text{C}$ inactive) | Oscillator OFF | - | 1 | 5 | μA |
| | | Internal osc. (2MHz) | - | 365 | 460 | |
| | | External osc. (32kHz) | - | 10 | - | |
| ICC1,2 | I/O banks supply current ⁽¹⁾ | | - | 1 | 2 | μA |
| I/Os set as Input | | | | | | |
| VIH | High level input voltage | $VCC1,2 \geq 2\text{V}$ | $0.7^* VCC1,2$ | - | $5.5^{(8)}$ | V |
| | | $VCC1,2 < 2\text{V}$ | $0.8^* VCC1,2$ | - | $5.5^{(8)}$ | |
| VIL | Low level input voltage | $VCC1,2 \geq 2\text{V}$ | -0.4 | - | $0.3^* VCC1,2$ | V |
| | | $VCC1,2 < 2\text{V}$ | -0.4 | - | $0.2^* VCC1,2$ | |
| ILEAK | Input leakage current | Assuming no active pull-up/down | -1 | - | 1 | μA |
| CI | Input capacitance | - | - | - | 10 | pF |
| I/Os set as Output | | | | | | |
| VOH | High level output voltage | - | $VCC1,2 - 0.3$ | - | $VCC1,2$ | V |
| VOL | Low level output voltage | - | -0.4 | - | 0.3 | V |
| IOH | High level output source current | $VCC1,2 \geq 2\text{V}$ | - | - | $8^{(2)}$ | mA |
| | | $VCC1,2 < 2\text{V}$ | - | - | $2^{(2)}$ | |
| IOL | Low level output sink current | $VCC1,2 \geq 2\text{V}$ | - | - | $15^{(2)}$ | mA |
| | | $VCC1,2 < 2\text{V}$ | - | - | $8^{(2)}$ | |

ADVANCED COMMUNICATIONS & SENSING

| Symbol | Description | Conditions | Min | Typ | Max | Unit |
|--|----------------------------------|----------------------------------|----------|--------|---------------------|------|
| t _{PV} | Output data valid timing | Cf. Figure 8 | - | - | 425 | ns |
| NINT (Output) | | | | | | |
| VOL | Low level output voltage | - | -0.4 | - | 0.3 | V |
| IOL _M | Low level output sink current | VDDM >= 2V | - | - | 8 | mA |
| | | VDDM < 2V | - | - | 4 | |
| t _{IV} | Interrupt valid timing | From input data change | - | - | 4 | μs |
| t _{IR} | Interrupt reset timing | From RegInterruptSource clearing | - | - | 4 | μs |
| NRESET (Input) | | | | | | |
| VIH _{MR} | High level input voltage | VDDM >= 2V | 0.7*VDDM | - | VDDM _{max} | V |
| | | VDDM < 2V | 0.8*VDDM | - | VDDM _{max} | |
| VIL _M | Low level input voltage | VDDM >= 2V | -0.4 | - | 0.3*VDDM | V |
| | | VDDM < 2V | -0.4 | - | 0.2*VDDM | |
| ILEAK | Input leakage current | - | -1 | - | 1 | μA |
| CI | Input capacitance | - | - | - | 10 | pF |
| VPOR | Power-On-Reset voltage | Cf. Figure 6 | - | 0.8 | - | V |
| VDROPH | High brown-out voltage | Cf. Figure 6 | - | VDDM-1 | - | V |
| VDROPL | Low brown-out voltage | Cf. Figure 6 | - | 0.2 | - | V |
| t _{RESET} | Reset time | Cf. Figure 6 | - | - | 2.5 | ms |
| t _{PULSE} | Reset pulse from host uC | Cf. Figure 6 | 200 | - | - | ns |
| ADDR0, ADDR1 (Inputs) | | | | | | |
| VIH _{MA} | High level input voltage | VDDM >= 2V | 0.7*VDDM | - | VDDM+0.3 | V |
| | | VDDM < 2V | 0.8*VDDM | - | VDDM+0.3 | |
| VIL _M | Low level input voltage | VDDM >= 2V | -0.4 | - | 0.3*VDDM | V |
| | | VDDM < 2V | -0.4 | - | 0.2*VDDM | |
| ILEAK | Input leakage current | - | -1 | - | 1 | μA |
| CI | Input capacitance | - | - | - | 10 | pF |
| OSCIO (Input/Output) | | | | | | |
| VIH _{MO} | High level input voltage | VDDM >= 2V | 0.7*VDDM | - | VDDM+0.3 | V |
| | | 1.425V <= VDDM < 2V | 0.8*VDDM | - | VDDM+0.3 | |
| | | VDDM < 1.425V | 0.9*VDDM | - | VDDM+0.3 | |
| VIL _{MO} | Low level input voltage | VDDM >= 2V | -0.4 | - | 0.3*VDDM | V |
| | | 1.425V <= VDDM < 2V | -0.4 | - | 0.2*VDDM | |
| | | VDDM < 1.425V | -0.4 | - | 0.1*VDDM | |
| ILEAK | Input leakage current | - | -1 | - | 1 | μA |
| CI | Input capacitance | - | - | - | 10 | pF |
| VOH _M | High level output voltage | - | VDDM-0.3 | - | VDDM | V |
| VOL | Low level output voltage | - | -0.4 | - | 0.3 | V |
| IOH _M | High level output source current | VDDM >= 2V | - | - | 8 | mA |
| | | VDDM < 2V | - | - | 2 | |
| IOL _M | Low level output sink current | VDDM >= 2V | - | - | 8 | mA |
| | | VDDM < 2V | - | - | 4 | |
| SCL (Input) and SDA (Input/Output) ⁽³⁾ | | | | | | |
| Interface complies with slave F/S mode I ² C interface as described by Philips I ² C specification version 2.1 dated January, 2000. Please refer to that document for more detailed I ² C specifications. | | | | | | |
|  | | | | | | |
| VOL | Low level output voltage | - | -0.4 | - | 0.3 | V |
| IOL _M | Low level output sink current | VDDM >= 2V | - | - | 8 | mA |
| | | VDDM < 2V | - | - | 4 | |
| VIH _{MR} | High level input voltage | VDDM >= 2V | 0.7*VDDM | - | VDDM _{max} | V |
| | | VDDM < 2V | 0.8*VDDM | - | VDDM _{max} | |
| VIL _M | Low level input voltage | VDDM >= 2V | -0.4 | - | 0.3*VDDM | V |
| | | VDDM < 2V | -0.4 | - | 0.2*VDDM | |

ADVANCED COMMUNICATIONS & SENSING

| Symbol | Description | Conditions | Min | Typ | Max | Unit |
|----------------------|---|---|--------------------|-----------|--------------------|------------|
| f_{SCL} | SCL clock frequency | - | - | - | 400 | kHz |
| $t_{HD:STA}$ | Hold time (repeated) START condition | - | 0.6 | - | - | μ s |
| t_{LOW} | LOW period of the SCL clock | - | 1.3 | - | - | μ s |
| t_{HIGH} | HIGH period of the SCL clock | - | 0.6 | - | - | μ s |
| $t_{SU:STA}$ | Set-up time for a repeated START condition | - | 0.6 | - | - | μ s |
| $t_{HD:DAT}$ | Data hold time | - | 0 ⁽⁴⁾ | - | 0.9 ⁽⁵⁾ | μ s |
| $t_{SU:DAT}$ | Data set-up time | - | 100 ⁽⁶⁾ | - | - | ns |
| t_r | Rise time of both SDA and SCL | - | $20+0.1C_b^{(7)}$ | - | 300 | ns |
| t_f | Fall time of both SDA and SCL | - | $20+0.1C_b^{(7)}$ | - | 300 | ns |
| $t_{SU:STO}$ | Set-up time for STOP condition | - | 0.6 | - | - | μ s |
| t_{BUF} | Bus free time between a STOP and START condition | - | 1.3 | - | - | μ s |
| C_b | Capacitive load for each bus line | - | - | - | 400 | pF |
| V_{nL} | Noise margin at the LOW level for each connected device (including hysteresis) | - | - | 0.1* VDDM | - | V |
| V_{nH} | Noise margin at the HIGH level for each connected device (including hysteresis) | - | - | 0.2* VDDM | - | V |
| t_{SP} | Pulse width of spikes suppressed by the input filter | - | - | - | 50 | ns |
| Miscellaneous | | | | | | |
| RPULL | Programmable pull-up/down resistors for IO[0-7] | - | - | 42 | - | k Ω |
| f_{OSC} | Oscillator frequency | Internal | 1.3 | 2 | 2.6 | MHz |
| | | External from OSCIN (40-60% duty cycle) | - | - | 2.6 | |

(1) Assuming no load connected to outputs and inputs fixed to VCC1,2 or GND.

(2) Can be increased by tying together and driving simultaneously several I/Os.

(3) All values referred to $V_{IHMR\ min}$ and $V_{ILM\ max}$ levels.

(4) A device must internally provide a hold time of at least 300ns for the SDA signal (referred to $V_{IHMR\ min}$) to bridge the undefined region of the falling edge of SCL.

(5) The maximum $t_{HD:DAT}$ has only to be met if the device does not stretch the LOW period (t_{LOW}) of the SCL signal.

(6) A Fast-mode I²C-bus device can be used in a Standard-mode I²C-bus system, but the requirement $t_{SU:DAT} \geq 250$ ns must then be met. This will automatically be the case if the device does not stretch the LOW period of the SCL signal.

If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line $t_r\ max + t_{SU:DAT} = 1000 + 250 = 1250$ ns (according to the Standard-mode I²C-bus specification) before the SCL line is released.

(7) C_b = total capacitance of one bus line in pF. If mixed with Hs-mode devices, faster fall-times are allowed.

(8) With RegHighInput bit enabled (VCCx min = 1.65V), else 3.6V (VCCx min = 1.2V)

Table 5 – Electrical Specifications

ADVANCED COMMUNICATIONS & SENSING

3 TYPICAL OPERATING CHARACTERISTICS

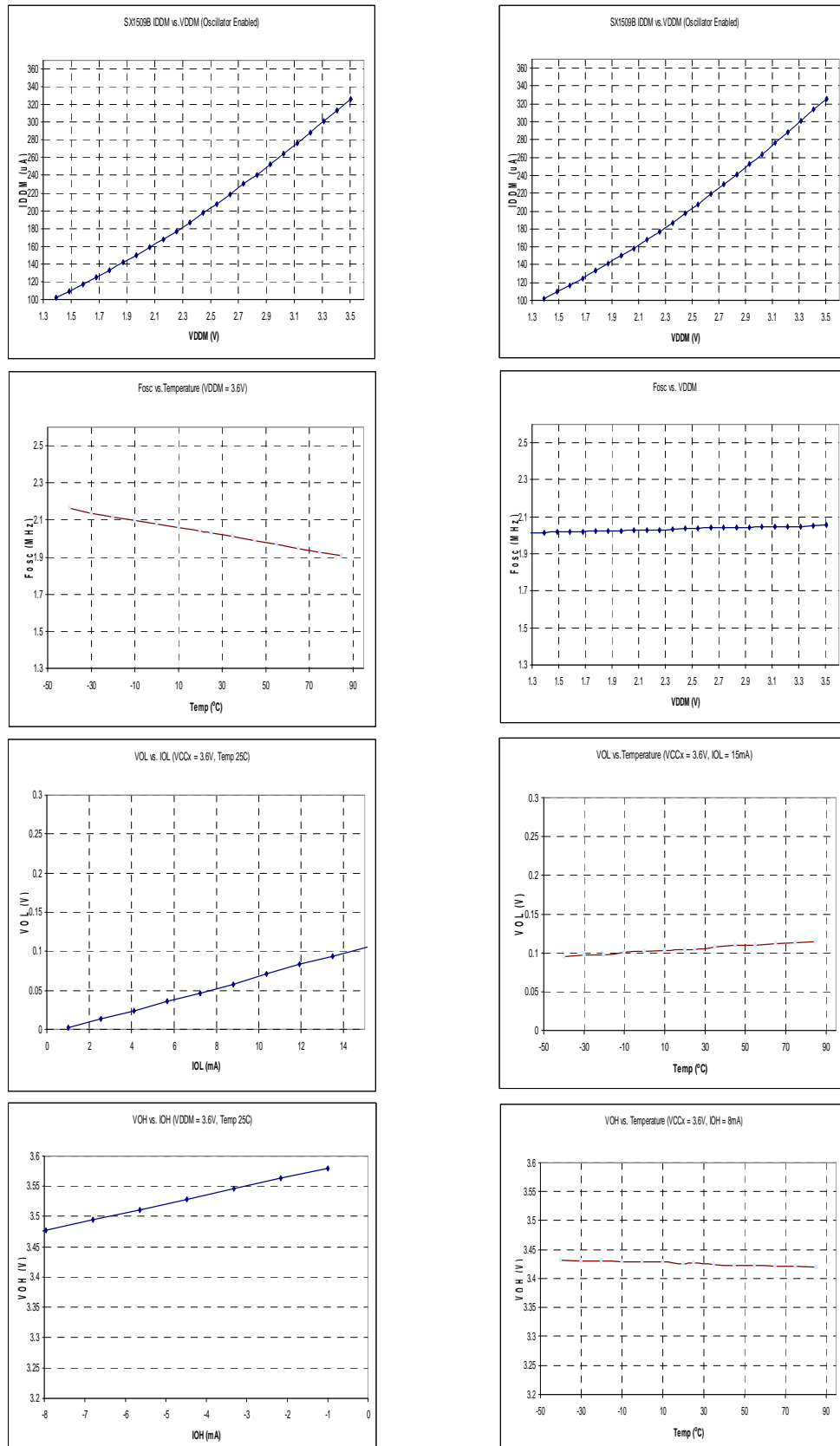


Figure 3 – Typical Operating Characteristics

ADVANCED COMMUNICATIONS & SENSING

4 BLOCK DETAILED DESCRIPTION

4.1 SX1508B 8-channel I²C GPIO with LED Driver and Keypad Engine

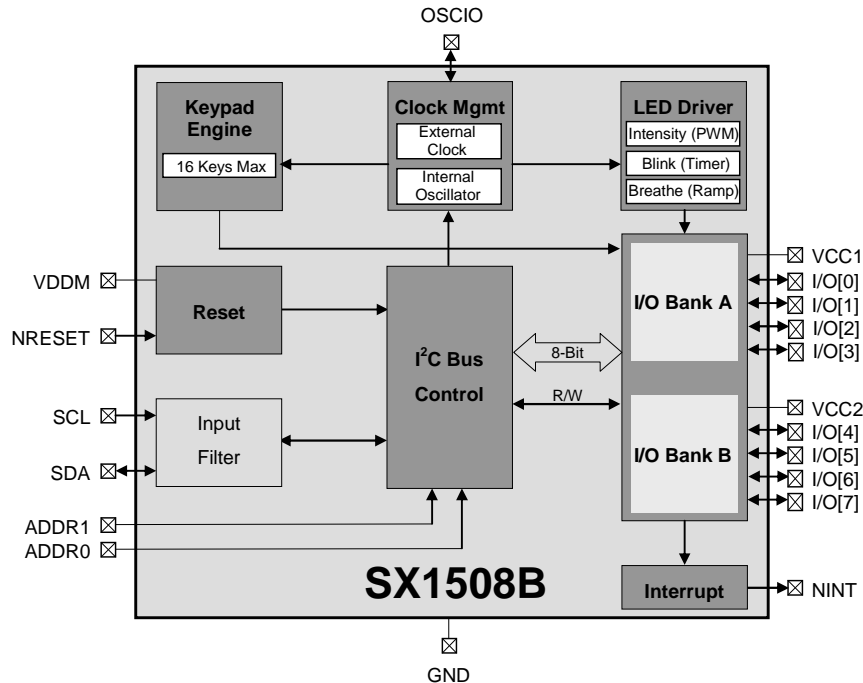


Figure 4 – 8-channel Low Voltage GPIO with LED Driver and Keypad Engine

4.2 SX1509B 16-channel I²C GPIO with LED Driver and Keypad Engine

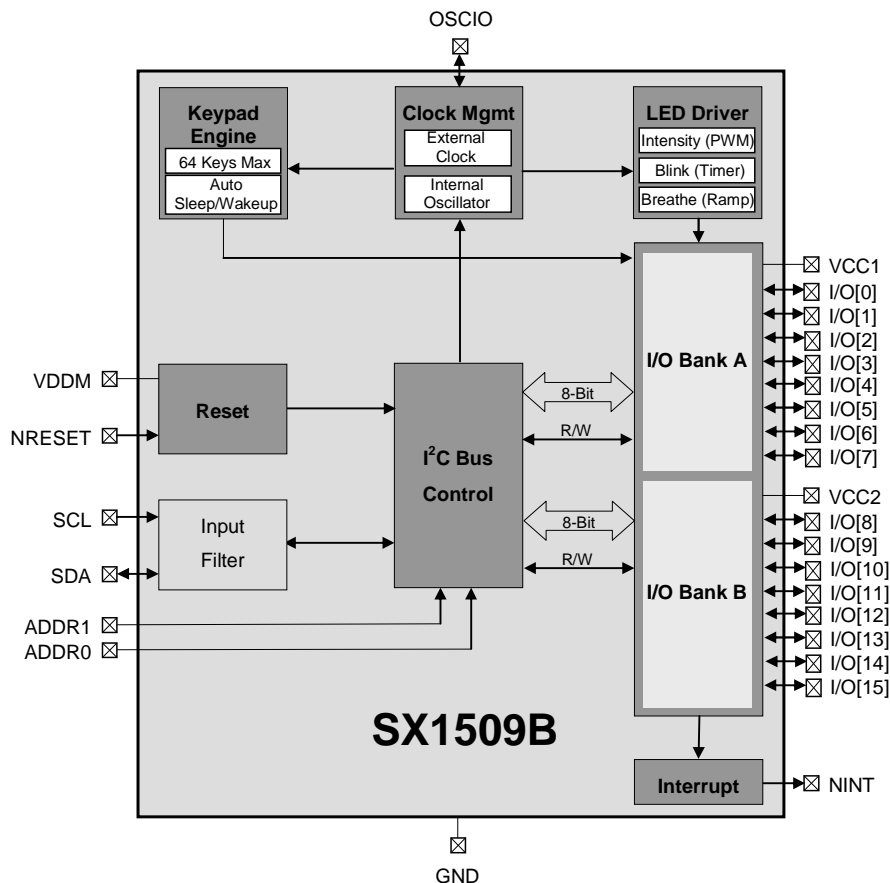


Figure 5 – 16-channel Low Voltage GPIO with LED Driver and Keypad Engine

ADVANCED COMMUNICATIONS & SENSING

4.3 Reset

4.3.1 Hardware (NRESET)

The SX1508B and SX1509B generate their own power on reset signal after a power supply is connected to the VDDM pin. NRESET input pin can be used to reset the chip anytime, it must be connected to VDDM (or greater) either directly (if not used), or via a resistor.

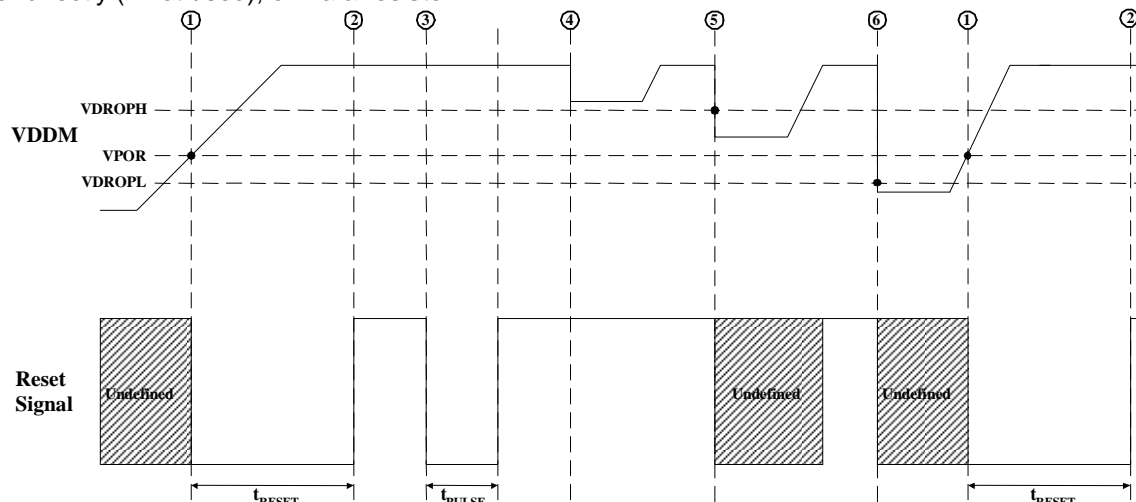


Figure 6 – Power-On / Brown-out Reset Conditions

1. Device behavior is undefined until VDDM rises above VPOR, at which point internal reset procedure is started.
2. After t_{RESET} , the reset procedure is completed.
3. In operation, the SX1508B and SX1509B may be reset (POR like or LED driver counters only depending on RegMisc setting) at anytime by an external device driving NRESET low for t_{PULSE} or longer. Chip can be accessed normally again after NRESET rising edge.
4. During a brown-out event, if VDDM drops above VDROP a reset will not occur.
5. During a brown-out event, if VDDM drops between VDROP and VDROPL a reset may occur.
6. During a brown-out event, if VDDM drops below VDROPL a reset will occur next time VPOR is crossed.

Please note that a brown-out event is defined as a transient event on VDDM. If VDDM is attached to a battery, then the gradual decay of the battery voltage will not be interpreted as a brown-out event. Please also note that a sharp rise in VDDM ($> 1\text{V}/\mu\text{s}$) may induce a circuit reset.

4.3.2 Software (RegReset)

Writing consecutively 0x12 and 0x34 to RegReset register will reset all registers to their default values.

4.4 2-Wire Interface (I²C)

The SX1508B and SX1509B 2-wire interface operates only in slave mode. In this configuration, the device has one or 4 possible devices addresses defined by ADDR[1:0] pins:

| Device | ADDR[1:0] | Address | Description |
|---------|-----------|----------------|--|
| SX1508B | 00 | 0x20 (0100000) | First address of the 2-wire interface |
| | 01 | 0x21 (0100001) | Second address of the 2-wire interface |
| | 10 | 0x22 (0100010) | Third address of the 2-wire interface |
| | 11 | 0x23 (0100011) | Fourth address of the 2-wire interface |
| SX1509B | 00 | 0x3E (0111110) | First address of the 2-wire interface |
| | 01 | 0x3F (0111111) | Second address of the 2-wire interface |
| | 10 | 0x70 (1110000) | Third address of the 2-wire interface |
| | 11 | 0x71 (1110001) | Fourth address of the 2-wire interface |

Table 6 - 2-Wire Interface Address

2 lines are used to exchange data between an external master host and the slave device:

- **SCL** : Serial **C**lock
- **SDA** : Serial **D**ata

ADVANCED COMMUNICATIONS & SENSING

The SX1508B and SX1509B are read-write slave-mode I²C devices and comply with the Philips I²C standard Version 2.1 dated January, 2000. The SX1508B and SX1509B have a few user-accessible internal 8-bits registers to set the various parameters of operation (Cf. §5 for detailed configuration registers description). The I²C interface has been designed for program flexibility, in that once the slave address has been sent to the SX1508B or SX1509B enabling it to be a slave transmitter/receiver, any register can be written or read independently of each other. The start and stop commands frame the data-packet and the repeat start condition is allowed if necessary.

Seven bit addressing is used and ten bit addressing is not allowed. Any general call address will be ignored by the SX1508B and SX1509B. The SX1508B and SX1509B are not CBUS compatible and can operate in standard mode (100kbit/s) or fast mode (400kbit/s).

4.4.1 WRITE

After the start condition [S], the slave address (SA) is sent, followed by an eighth bit ('0') indicating a Write. The slave then Acknowledges [A] that it is being addressed, and the Master sends an 8 bit Data Byte consisting of the slave Register Address (RA). The Slave Acknowledges [A] and the master sends the appropriate 8 bit Data Byte (WD0). Again the slave Acknowledges [A]. In case the master needs to write more data, a succeeding 8 bit Data Byte will follow (WD1), acknowledged by the slave [A]. This sequence will be repeated until the master terminates the transfer with the Stop condition [P].

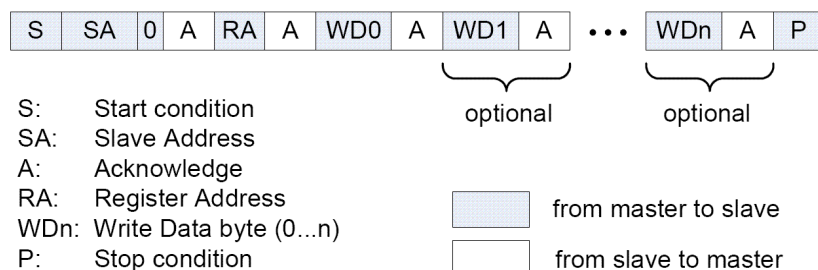


Figure 7 - 2-Wire Serial Interface, Write Operation

When successive register data (WD1...WDn) is supplied by the master, the register address can be automatically incremented or kept fixed depending on the setting programmed in RegMisc.

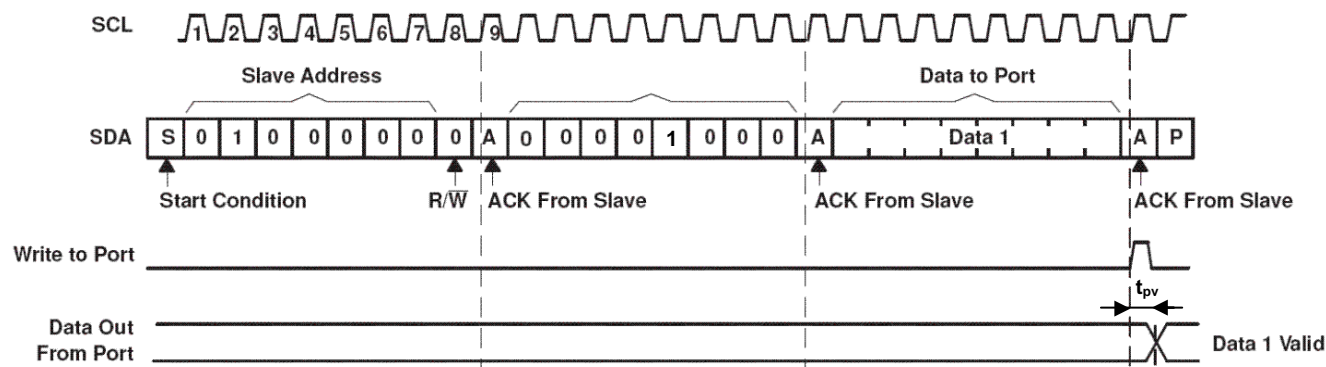


Figure 8 – Example: Write RegData Register

4.4.2 READ

After the start condition [S], the slave address (SA) is sent, followed by an eighth bit ('0') indicating a Write. The slave then Acknowledges [A] that it is being addressed, and the Master responds with an 8 bit Data consisting of the Register Address (RA). The slave Acknowledges [A] and the master sends the Repeated Start Condition [Sr]. Once again, the slave address (SA) is sent, followed by an eighth bit ('1') indicating a Read.

The slave responds with an Acknowledge [A] and the read Data byte (RD0). If the master needs to read more data it will acknowledge [A] and the slave will send the next read byte (RD1). This sequence can be repeated until the master terminates with a NACK [N] followed by a stop [P].

ADVANCED COMMUNICATIONS & SENSING

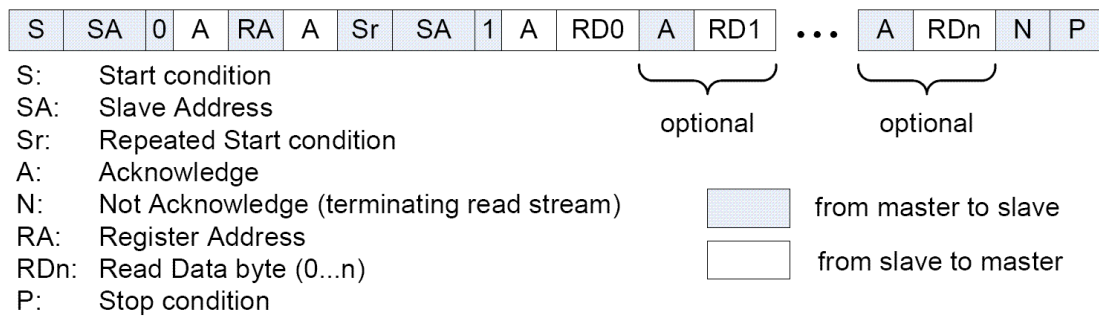


Figure 9 - 2-Wire Serial Interface, Read Operation

When successive register data (RD1...RDn) is read by the master, the register address will be automatically incremented or kept fixed depending on the setting programmed in RegMisc.

4.5 I/O Banks

4.5.1 Input Debouncer

Each input can be individually debounced by setting corresponding bits in RegDebounce register. At power up the debounce function is disabled. After enabling the debouncer, the change of the input value is accepted only if the input value is identical at two consecutive sampling times.

The debounce time common to all IOs can be set in RegDebounceConfig register from 0.5 to 64ms (fOSC = 2MHz).

4.5.2 Keypad Scanning Engine

SX1508B, and SX1509B integrate a fully programmable keypad scanning engine to implement keypad applications up to 8x8 matrix (i.e. 64 keys).

Please note that SX1509B also implements an Auto Sleep/Wakeup feature to save power consumption when no key has been pressed for a programmed time.

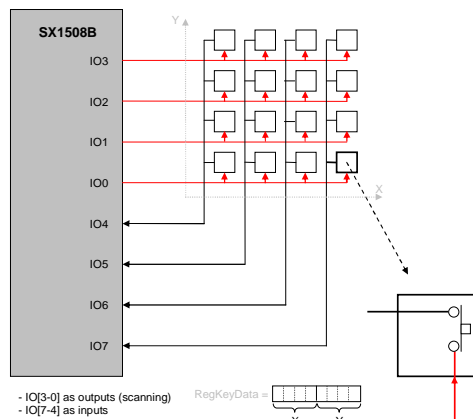


Figure 10 – 4x4 Keypad Connection to SX1508B

Following procedure should be implemented on the host controller for a 4x4 keypad:

1. Set RegDir to 0xF0 (IO[3:0] as outputs, IO[7:4] as inputs), set RegOpenDrain to 0x0F (IO[3:0] as open-drain outputs), set RegPullup to 0xF0 (pull-ups enabled on inputs IO[7:4]).
2. Enable and configure debouncing on IO[7:4] (RegDebounceEnable = 0xF0, Ex : RegDebounceConfig = 0x05)
3. Enable and configure keypad scanning engine (Ex : RegKeyConfig = 0x7D) This will start an infinite loop with the following sequence to IO[3:0]: ZZZ0, ZZ0Z, Z0ZZ, 0ZZZ. Make sure that scan interval is set to higher value than the debounce time.
4. When a key is pressed, NINT goes low, key scan is halted and the key coordinates are stored in RegKeyData:
 - The column data will be stored in RegKeyData[7:4] (Note: column indication is active low)

ADVANCED COMMUNICATIONS & SENSING

- The row data will be stored in RegKeyData[3:0] (Note: row indication is active low)
- When RegKeyData is read, this data along with the interrupt is automatically cleared (same behavior as reading RegData) and the key scan continues to the next row.

5. Restart from point 4.

This implementation allows the host to handle both single and multi-touches easily (fast AAAAAA sequence is a long press of key A, fast ABABABAB sequence is key A and key B pressed together, etc)

4.5.3 Level Shifter

Because of their 5.5V tolerant I/O banks with independent supply voltages between 1.2V and 3.6V, the SX1508B and SX1509B can perform level shifting of signals from one I/O bank to another **without uC activity** by programming the corresponding configuration register bits accordingly in RegLevelShifter (and RegDir). This can save significant BOM cost in a final application where only a few signals need to be level-shifted (no need for an additional external level shifter IC).

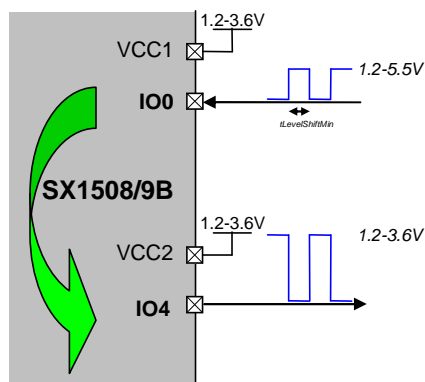


Figure 11 – Level Shifting Example

The minimum pulse width $t_{LevelShiftMin}$ which can be level shifted properly depends on VCCx and VDDM:

$$t_{LevelShiftMin} = \text{Input Delay} + \text{Core Delay} + \text{Output Delay}$$

Input/Core/Output delays vs VCCx/VDDM are given in figures below.

ADVANCED COMMUNICATIONS & SENSING

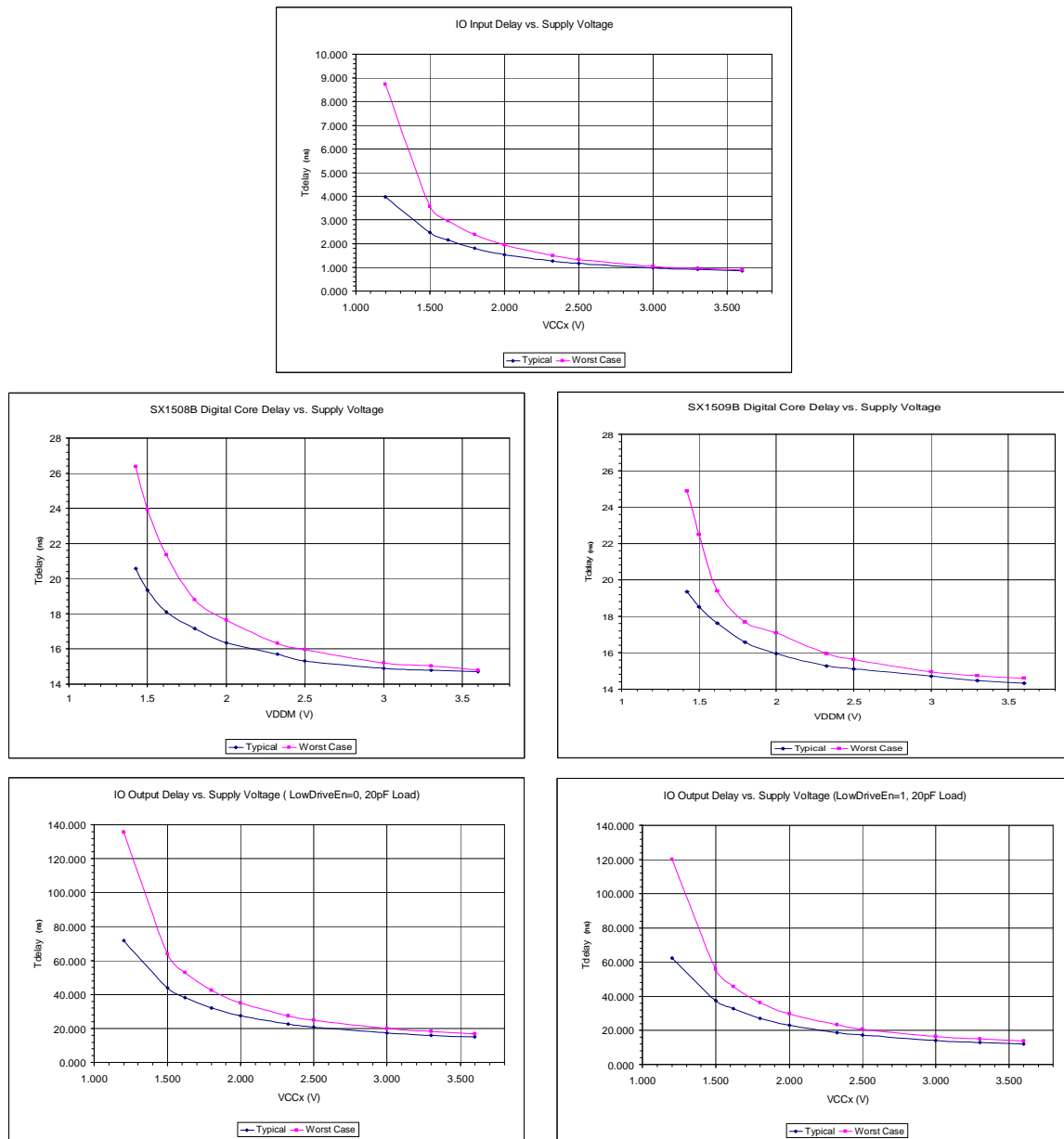


Figure 12 – Level Shifter Max Frequency Calculation Data

4.5.4 Polarity Inverter

Each IO's polarity can be individually inverted by setting corresponding bit in RegPolarity register. Please note that polarity inversion can also be combined with level shifting feature.

4.6 Interrupt (NINT)

At start-up, the transition detection logic is reset, and NINT is released to a high-impedance state. The interrupt mask register is set to 0xFF, disabling the interrupt output for transitions on all I/O ports. The transition flags are cleared to indicate no data changes.

An interrupt NINT can be generated on any programmed combination of I/Os rising and/or falling edges through the RegInterruptMask and RegSense registers.

If needed, the I/Os which triggered the interrupt can then be identified by reading RegInterruptSource register.

When NINT is low (i.e. interrupt occurred), it can be reset back high (i.e. cleared) by writing 0xFF in RegInterruptSource (this will also clear corresponding bits in RegEventStatus register).

The interrupt can also be cleared automatically when reading RegData register (Cf. RegMisc)

Example: We want to detect rising edge of I/O[1] on SX1508B (NINT will go low).

1. We enable interrupt on I/O[1] in RegInterruptMask

ADVANCED COMMUNICATIONS & SENSING

⇒ *RegInterruptMask* = "XXXXXX0X"

2. We set edge sense for I/O[1] in *RegSense*

⇒ *RegSenseLow* = "XXXX01XX"

Please note that independently from the "user defined" process described above the keypad engine, when enabled, also uses NINT to indicate a key press.

Hence we have NINT = "user defined condition occurred" OR "keypad engine condition occurred".

4.7 Clock Management

A main oscillator clock *fOSC* is needed by the LED driver, keypad engine and debounce features.

Clock management block is illustrated in figure below.

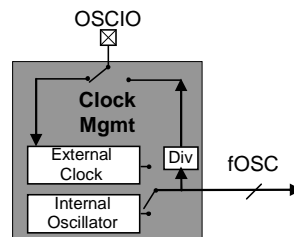


Figure 13 – Clock Management Overview

The block is configured in register *RegClock* (Cf §5 for more detailed information):

- Selection of internal clock source: none (OFF) or internal oscillator or external clock input from OSCIN.
- Definition of OSCIO pin function (OSCIN or OSCOUT)
- OSCOUT frequency setting (sub-multiple of *fOSC*)

Please note that if needed the OSCOUT feature can be used as an additional GPO (Cf. *RegClock*)

4.8 LED Driver

4.8.1 Overview

Every IO has its own independent LED driver (Cf §6.2 for typical LED connection), all IOs can perform intensity control (PWM) while some of them additionally include blinking and breathing features (Cf pin description §1)

The LED drivers of all I/Os share the same clock *ClkX* configurable in *RegMisc*[6:4]. Please note that for power consumption reasons *ClkX* is OFF by default.

Assuming *ClkX* is not OFF, LED driver for IO[X] is enabled when *RegLEDDriverEnable*[X] = 1 in which case it can operate in one of the three modes below:

- Static mode (all I/Os, with or without fade in/out)
- Single shot mode (blinking capable I/Os only, with or without fade in/out)
- Blink mode (blinking capable I/Os only, with or without fade in/out)

ADVANCED COMMUNICATIONS & SENSING

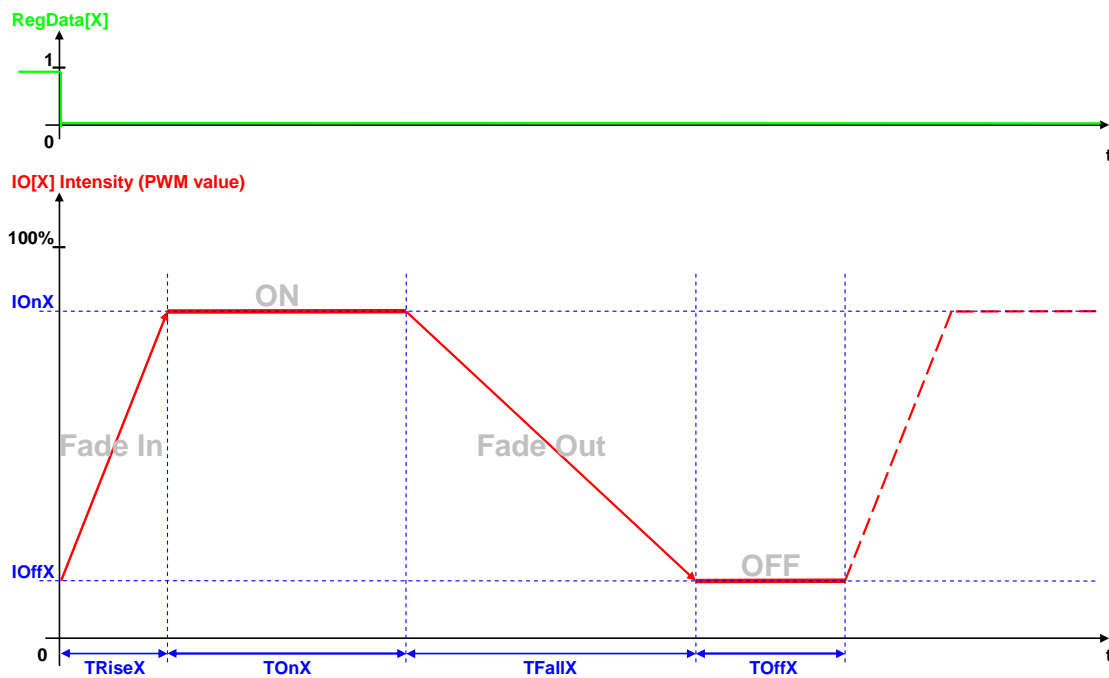


Figure 14 – LED Driver Overview

Each IO[X] has its own set of programmable registers (Cf §5 for more detailed information):

- **RegTOnX** (blinking capable I/Os only): TOnX, ON time of IO[X]
- **RegIOOnX** (all I/Os): IOnX, ON intensity of IO[X]
- **RegOffX** (blinking capable I/Os only): TOffX and IOOffX, OFF time and intensity of IO[X]
- **RegTRiseX** (breathing capable I/Os only): TRiseX, fade in time of IO[X]
- **RegTFallX** (breathing capable I/Os only): TFallX, fade out time of IO[X]

Please note that the LED driver mode is selectable for each IO bank between linear and logarithmic. (Cf §4.8.5)

All the figures assume normal IO polarity, for inverse polarity RegData control must be inverted (does not invert the polarity of the IO signal itself).

4.8.2 Static Mode

Only mode available for non blinking capable IOs (with Off intensity = 0), else invoked when TOnX = 0. If the I/O doesn't support fading the LED intensity will step directly to the IOnX/IOOffX value.

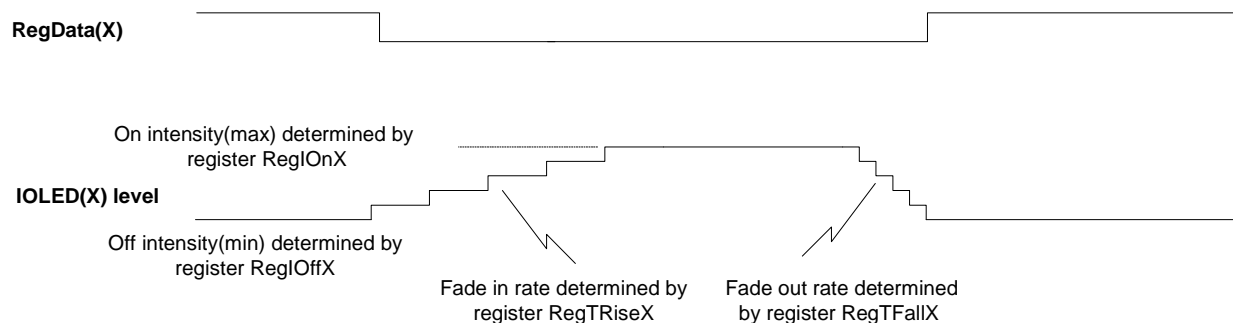


Figure 15 – LED Driver Static Mode

4.8.3 Single Shot Mode

Invoked when TOnX != 0 and TOffX = 0.

If the I/O doesn't support fading the LED intensity will step directly to the IOnX/IOOffX value.

ADVANCED COMMUNICATIONS & SENSING

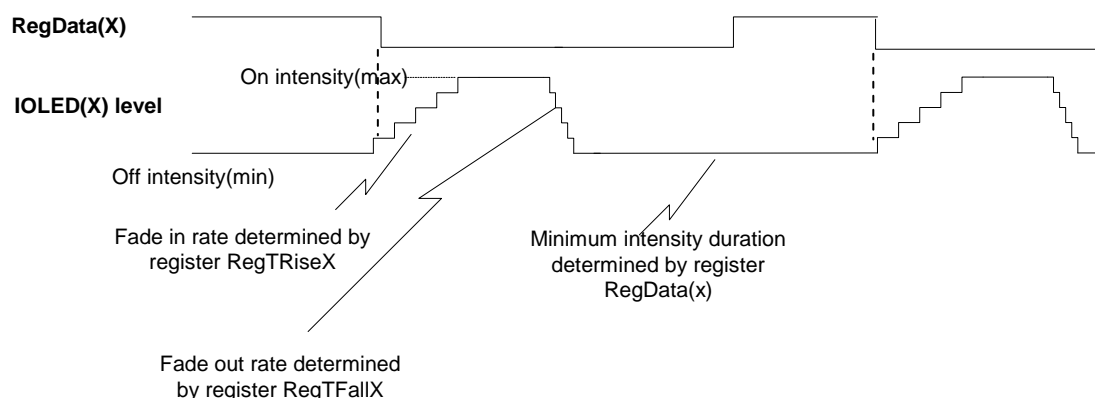


Figure 16 – LED Driver Single Shot Mode

4.8.4 Blink Mode

Invoked when TOnX != 0 and TOffX != 0.

If the I/O doesn't support fading the LED intensity will step directly to the IOnX/IOffX value.

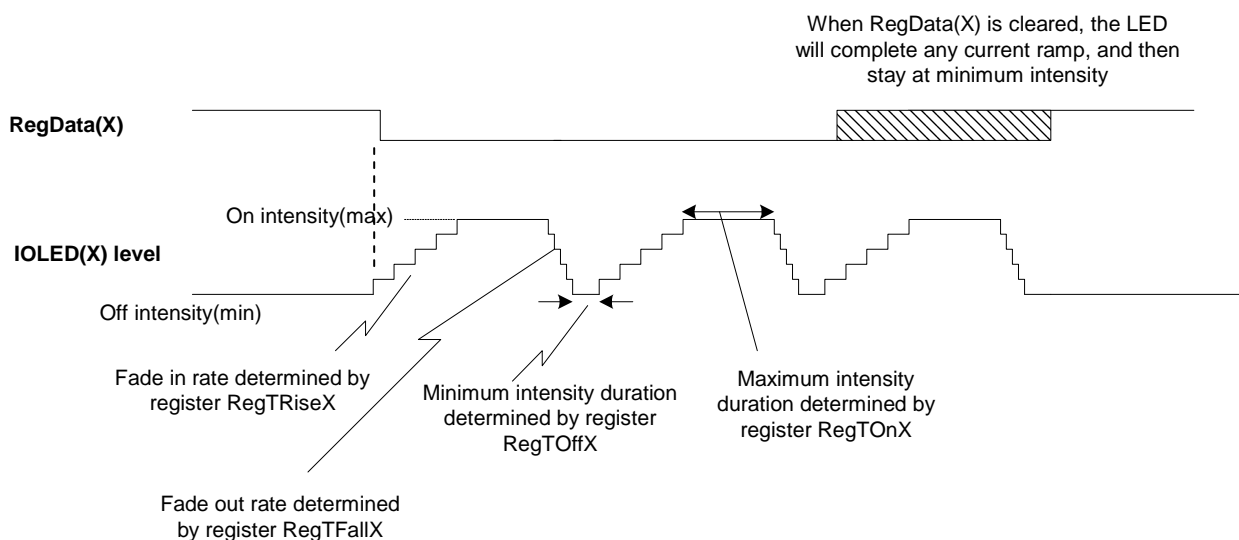


Figure 17 – LED Driver Blink Mode

4.8.5 LED Driver Modes

For each IO bank, the LED driver mode of fading capable IOs can be selected between linear or logarithmic in RegMisc.

| Lin. | Log. | Lin. | Log. | Lin. | Log. | Lin. | Log. | Lin. | Log. | Lin. | Log. | Lin. | Log. | Lin. | Log. |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 0 | 0 | 32 | 4 | 64 | 13 | 96 | 28 | 128 | 53 | 160 | 88 | 192 | 135 | 224 | 198 |
| 1 | 0 | 33 | 4 | 65 | 13 | 97 | 28 | 129 | 53 | 161 | 88 | 193 | 135 | 225 | 198 |
| 2 | 0 | 34 | 4 | 66 | 13 | 98 | 30 | 130 | 53 | 162 | 88 | 194 | 135 | 226 | 198 |
| 3 | 0 | 35 | 4 | 67 | 13 | 99 | 30 | 131 | 53 | 163 | 88 | 195 | 135 | 227 | 198 |
| 4 | 0 | 36 | 5 | 68 | 14 | 100 | 31 | 132 | 56 | 164 | 93 | 196 | 142 | 228 | 207 |
| 5 | 0 | 37 | 5 | 69 | 14 | 101 | 31 | 133 | 56 | 165 | 93 | 197 | 142 | 229 | 207 |
| 6 | 0 | 38 | 5 | 70 | 14 | 102 | 32 | 134 | 56 | 166 | 93 | 198 | 142 | 230 | 207 |
| 7 | 0 | 39 | 5 | 71 | 14 | 103 | 32 | 135 | 56 | 167 | 93 | 199 | 142 | 231 | 207 |
| 8 | 1 | 40 | 6 | 72 | 16 | 104 | 34 | 136 | 60 | 168 | 98 | 200 | 150 | 232 | 216 |
| 9 | 1 | 41 | 6 | 73 | 16 | 105 | 34 | 137 | 60 | 169 | 98 | 201 | 150 | 233 | 216 |
| 10 | 1 | 42 | 6 | 74 | 17 | 106 | 35 | 138 | 60 | 170 | 98 | 202 | 150 | 234 | 216 |
| 11 | 1 | 43 | 6 | 75 | 17 | 107 | 35 | 139 | 60 | 171 | 98 | 203 | 150 | 235 | 216 |
| 12 | 1 | 44 | 7 | 76 | 18 | 108 | 36 | 140 | 65 | 172 | 104 | 204 | 157 | 236 | 225 |

ADVANCED COMMUNICATIONS & SENSING

| | | | | | | | | | | | | | | | |
|----|---|----|----|----|----|-----|----|-----|----|-----|-----|-----|-----|-----|-----|
| 13 | 1 | 45 | 7 | 77 | 18 | 109 | 36 | 141 | 65 | 173 | 104 | 205 | 157 | 237 | 225 |
| 14 | 1 | 46 | 7 | 78 | 19 | 110 | 38 | 142 | 65 | 174 | 104 | 206 | 157 | 238 | 225 |
| 15 | 1 | 47 | 7 | 79 | 19 | 111 | 38 | 143 | 65 | 175 | 104 | 207 | 157 | 239 | 225 |
| 16 | 2 | 48 | 8 | 80 | 20 | 112 | 39 | 144 | 69 | 176 | 110 | 208 | 165 | 240 | 235 |
| 17 | 2 | 49 | 8 | 81 | 20 | 113 | 39 | 145 | 69 | 177 | 110 | 209 | 165 | 241 | 235 |
| 18 | 2 | 50 | 8 | 82 | 21 | 114 | 41 | 146 | 69 | 178 | 110 | 210 | 165 | 242 | 235 |
| 19 | 2 | 51 | 8 | 83 | 21 | 115 | 41 | 147 | 69 | 179 | 110 | 211 | 165 | 243 | 235 |
| 20 | 2 | 52 | 9 | 84 | 22 | 116 | 42 | 148 | 73 | 180 | 116 | 212 | 172 | 244 | 245 |
| 21 | 2 | 53 | 9 | 85 | 22 | 117 | 42 | 149 | 73 | 181 | 116 | 213 | 172 | 245 | 245 |
| 22 | 2 | 54 | 9 | 86 | 23 | 118 | 44 | 150 | 73 | 182 | 116 | 214 | 172 | 246 | 245 |
| 23 | 2 | 55 | 9 | 87 | 23 | 119 | 44 | 151 | 73 | 183 | 116 | 215 | 172 | 247 | 245 |
| 24 | 3 | 56 | 10 | 88 | 24 | 120 | 46 | 152 | 78 | 184 | 122 | 216 | 181 | 248 | 255 |
| 25 | 3 | 57 | 10 | 89 | 24 | 121 | 46 | 153 | 78 | 185 | 122 | 217 | 181 | 249 | 255 |
| 26 | 3 | 58 | 10 | 90 | 25 | 122 | 46 | 154 | 78 | 186 | 122 | 218 | 181 | 250 | 255 |
| 27 | 3 | 59 | 10 | 91 | 25 | 123 | 46 | 155 | 78 | 187 | 122 | 219 | 181 | 251 | 255 |
| 28 | 3 | 60 | 11 | 92 | 26 | 124 | 49 | 156 | 83 | 188 | 129 | 220 | 189 | 252 | 255 |
| 29 | 3 | 61 | 11 | 93 | 26 | 125 | 49 | 157 | 83 | 189 | 129 | 221 | 189 | 253 | 255 |
| 30 | 3 | 62 | 12 | 94 | 27 | 126 | 49 | 158 | 83 | 190 | 129 | 222 | 189 | 254 | 255 |
| 31 | 3 | 63 | 12 | 95 | 27 | 127 | 49 | 159 | 83 | 191 | 129 | 223 | 189 | 255 | 255 |

Table 7 – LED Driver Linear vs Logarithmic Function (I)

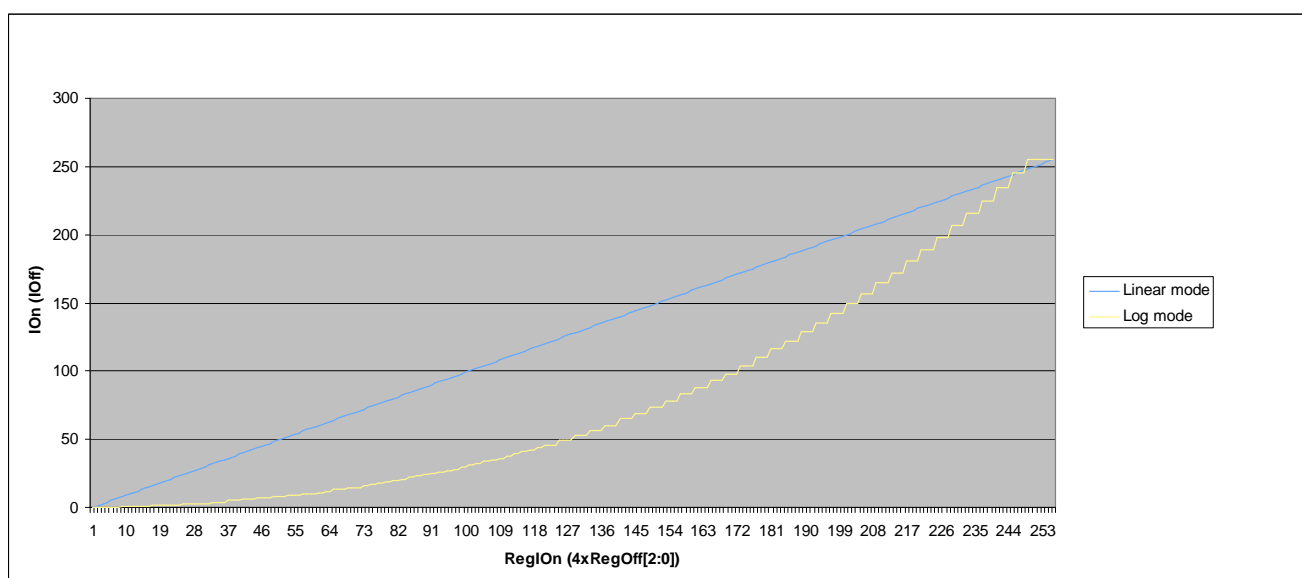


Figure 18 – LED Driver Linear vs Logarithmic Function (II)

4.8.6 Synchronization of LED Drivers across several ICs

When several GPIO expanders are used in the same application it may be useful that their LEDs drivers are synchronous for coherent global operation.

In this case all ICs should share their fOSC through their OSCIO pins and have their reset connected together.

When RegMisc of each IC is set accordingly, NRESET signal can then be used to reset all devices' internal counters (but not the register settings) and allow synchronous LED operation (blinking, fading) across multiple devices.

4.8.7 Tutorial

Below are the steps required to use the LED driver with the typical LED connection described §6.2:

- Disable input buffer (RegInputDisable)
- Disable pull-up (RegPullUp)

ADVANCED COMMUNICATIONS & SENSING

- Enable open drain (RegOpenDrain)
- Set direction to output (RegDir) – by default RegData is set high => LED OFF
- Enable oscillator (RegClock)
- Configure LED driver clock and mode if relevant (RegMisc)
- Enable LED driver operation (RegLEDDriverEnable)
- Configure LED driver parameters (RegTOn, RegIOn, RegOff, RegTRise, RegTFall)
- Set RegData bit low => LED driver started

ADVANCED COMMUNICATIONS & SENSING

5 CONFIGURATION REGISTERS

5.1 SX1508B 8-channel GPIO with LED Driver and Keypad Engine

| Address | Name | Description | Default |
|--|--------------------|--|-----------|
| Device and IO Banks | | | |
| 0x00 | RegInputDisable | Input buffer disable register | 0000 0000 |
| 0x01 | RegLongSlew | Output buffer long slew register | 0000 0000 |
| 0x02 | RegLowDrive | Output buffer low drive register | 0000 0000 |
| 0x03 | RegPullUp | Pull-up register | 0000 0000 |
| 0x04 | RegPullDown | Pull-down register | 0000 0000 |
| 0x05 | RegOpenDrain | Open drain register | 0000 0000 |
| 0x06 | RegPolarity | Polarity register | 0000 0000 |
| 0x07 | RegDir | Direction register | 1111 1111 |
| 0x08 | RegData | Data register | 1111 1111 |
| 0x09 | RegInterruptMask | Interrupt mask register | 1111 1111 |
| 0x0A | RegSenseHigh | Sense register for I/O[7:4] | 0000 0000 |
| 0x0B | RegSenseLow | Sense register for I/O[3:0] | 0000 0000 |
| 0x0C | RegInterruptSource | Interrupt source register | 0000 0000 |
| 0x0D | RegEventStatus | Event status register | 0000 0000 |
| 0x0E | RegLevelShifter | Level shifter register | 0000 0000 |
| 0x0F | RegClock | Clock management register | 0000 0000 |
| 0x10 | RegMisc | Miscellaneous device settings register | 0000 0000 |
| 0x11 | RegLEDDriverEnable | LED driver enable register | 0000 0000 |
| Debounce and Keypad Engine | | | |
| 0x12 | RegDebounceConfig | Debounce configuration register | 0000 0000 |
| 0x13 | RegDebounceEnable | Debounce enable register | 0000 0000 |
| 0x14 | RegKeyConfig | Key scan configuration register | 0000 0000 |
| 0x15 | RegKeyData | Key value | 1111 1111 |
| LED Driver (PWM, blinking, breathing) | | | |
| 0x16 | RegIOOn0 | ON intensity register for I/O[0] | 1111 1111 |
| 0x17 | RegIOOn1 | ON intensity register for I/O[1] | 1111 1111 |
| 0x18 | RegTOOn2 | ON time register for I/O[2] | 0000 0000 |
| 0x19 | RegIOOn2 | ON intensity register for I/O[2] | 1111 1111 |
| 0x1A | RegOff2 | OFF time/intensity register for I/O[2] | 0000 0000 |
| 0x1B | RegTOOn3 | ON time register for I/O[3] | 0000 0000 |
| 0x1C | RegIOOn3 | ON intensity register for I/O[3] | 1111 1111 |
| 0x1D | RegOff3 | OFF time/intensity register for I/O[3] | 0000 0000 |
| 0x1E | RegTRise3 | Fade in register for I/O[3] | 0000 0000 |
| 0x1F | RegTFall3 | Fade out register for I/O[3] | 0000 0000 |
| 0x20 | RegIOOn4 | ON intensity register for I/O[4] | 1111 1111 |
| 0x21 | RegIOOn5 | ON intensity register for I/O[5] | 1111 1111 |
| 0x22 | RegTOOn6 | ON time register for I/O[6] | 0000 0000 |
| 0x23 | RegIOOn6 | ON intensity register for I/O[6] | 1111 1111 |
| 0x24 | RegOff6 | OFF time/intensity register for I/O[6] | 0000 0000 |
| 0x25 | RegTOOn7 | ON time register for I/O[7] | 0000 0000 |
| 0x26 | RegIOOn7 | ON intensity register for I/O[7] | 1111 1111 |
| 0x27 | RegOff7 | OFF time/intensity register for I/O[7] | 0000 0000 |
| 0x28 | RegTRise7 | Fade in register for I/O[7] | 0000 0000 |
| 0x29 | RegTFall7 | Fade out register for I/O[7] | 0000 0000 |
| Miscellaneous | | | |
| 0x2A | RegHighInput | High input enable register | 0000 0000 |
| Software Reset | | | |
| 0x7D | RegReset | Software reset register | 0000 0000 |
| Test (not to be written) | | | |
| 0x7E | RegTest1 | Test register | 0000 0000 |
| 0x7F | RegTest2 | Test register | 0000 0000 |

Bits set as output take '1' as default value.

Table 8 – SX1508B Configuration Registers Overview

ADVANCED COMMUNICATIONS & SENSING

| Addr | Name | Default | Bits | Description |
|------|--------------------|---------|------|--|
| 0x00 | RegInputDisable | 0x00 | 7:0 | Disables the input buffer of each IO 0 : Input buffer is enabled (input actually being used) 1 : Input buffer is disabled (input actually not being used or LED connection) |
| 0x01 | RegLongSlew | 0x00 | 7:0 | Enables increased slew rate of the output buffer of each [output-configured] IO 0 : Increased slew rate is disabled 1 : Increased slew rate is enabled |
| 0x02 | RegLowDrive | 0x00 | 7:0 | Enables reduced drive of the output buffer of each [output-configured] IO 0 : Reduced drive is disabled 1 : Reduced drive is enabled. IOL specifications are divided by 2. |
| 0x03 | RegPullUp | 0x00 | 7:0 | Enables the pull-up for each IO 0 : Pull-up is disabled 1 : Pull-up is enabled |
| 0x04 | RegPullDown | 0x00 | 7:0 | Enables the pull-down for each IO 0 : Pull-down is disabled 1 : Pull-down is enabled |
| 0x05 | RegOpenDrain | 0x00 | 7:0 | Enables open drain operation for each [output-configured] IO 0 : Regular push-pull operation 1 : Open drain operation |
| 0x06 | RegPolarity | 0x00 | 7:0 | Enables polarity inversion for each IO 0 : Normal polarity : RegData[x] = IO[x] 1 : Inverted polarity : RegData[x] = !IO[x] (for both input and output configured IOs) |
| 0x07 | RegDir | 0xFF | 7:0 | Configures direction for each IO. 0 : IO is configured as an output 1 : IO is configured as an input |
| 0x08 | RegData | 0xFF | 7:0 | Write: Data to be output to the output-configured IOs Read: Data seen at the IOs, independent of the direction configured. |
| 0x09 | RegInterruptMask | 0xFF | 7:0 | Configures which [input-configured] IO will trigger an interrupt on NINT pin 0 : An event on this IO will trigger an interrupt 1 : An event on this IO will NOT trigger an interrupt |
| 0x0A | RegSenseHigh | 0x00 | 7:6 | Edge sensitivity of RegData[7] |
| | | | 5:4 | Edge sensitivity of RegData[6] |
| | | | 3:2 | Edge sensitivity of RegData[5] |
| | | | 1:0 | Edge sensitivity of RegData[4] |
| 0x0B | RegSenseLow | 0x00 | 7:6 | Edge sensitivity of RegData[3] |
| | | | 5:4 | Edge sensitivity of RegData[2] |
| | | | 3:2 | Edge sensitivity of RegData[1] |
| | | | 1:0 | Edge sensitivity of RegData[0] |
| 0x0C | RegInterruptSource | 0x00 | 7:0 | Interrupt source (from IOs set in RegInterruptMask) 0 : No interrupt has been triggered by this IO 1 : An interrupt has been triggered by this IO (an event as configured in relevant RegSense register occurred). Writing '1' clears the bit in RegInterruptSource and in RegEventStatus When all bits are cleared, NINT signal goes back high. |
| 0x0D | RegEventStatus | 0x00 | 7:0 | Event status of all IOs. 0 : No event has occurred on this IO 1 : An event has occurred on this IO (an edge as configured in relevant RegSense register occurred). Writing '1' clears the bit in RegEventStatus and in RegInterruptSource if relevant. If the edge sensitivity of the IO is changed, the bit(s) will be cleared automatically |
| 0x0E | RegLevelShifter | 0x00 | 7:6 | Level shifter mode for IO[3] (Bank A) and IO[7] (Bank B) |
| | | | 5:4 | Level shifter mode for IO[2] (Bank A) and IO[6] (Bank B) |
| | | | 3:2 | Level shifter mode for IO[1] (Bank A) and IO[5] (Bank B) |
| | | | 1:0 | Level shifter mode for IO[0] (Bank A) and IO[4] (Bank B) |
| 0x0F | RegClock | 0x00 | 7 | Unused |
| | | | 6:5 | Oscillator frequency (fOSC) source 00 : OFF. LED driver, keypad engine and debounce features are disabled. 01 : External clock input (OSCIN) 10 : Internal 2MHz oscillator 11 : Reserved |
| | | | 4 | OSCIO pin function (Cf. §4.7) 0 : OSCIO is an input (OSCIN) 1 : OSCIO is an output (OSCOOUT) |
| | | | 3:0 | Frequency of the signal output on OSCOUT pin: 0x0 : 0Hz, permanent "0" logical level (GPO) 0xF : 0Hz, permanent "1" logical level (GPO) Else : fOSCOOUT = fOSC/(2^(RegClock[3:0]-1)) |
| 0x10 | RegMisc | 0x00 | 7 | LED Driver mode for Bank B 's fading capable IOs (IO7) 0 : Linear 1 : Logarithmic |

ADVANCED COMMUNICATIONS & SENSING

| | | | | |
|------|--------------------|------|-----|---|
| | | | 6:4 | Frequency of the LED Driver clock ClkX of all IOs: 0 : OFF. LED driver functionality is disabled for all IOs. Else : $ClkX = fOSC / (2^{(RegMisc[6:4]-1)})$ |
| | | | 3 | LED Driver mode for Bank A 's fading capable IOs (IO3) 0: Linear 1: Logarithmic |
| | | | 2 | NRESET pin function when externally forced low (Cf. §4.3.1 and §4.8.5). 0: Equivalent to POR 1: Reset PWM/Blink/Fade counters (not user programmed values) This bit is can only be reset manually or by POR, not by NRESET. |
| | | | 1 | Auto-increment register address (Cf. §4.4) 0: ON. When several consecutive data are read/written, register address is incremented. 1: OFF. When several consecutive data are read/written, register address is kept fixed. |
| | | | 0 | Autoclear NINT on RegData read (Cf. §4.6) 0: ON. RegInterruptSource is also automatically cleared when RegData is read. 1: OFF. RegInterruptSource must be manually cleared, either directly or via RegEventStatus. |
| 0x11 | RegLEDDriverEnable | 0x00 | 7:0 | Enables LED Driver for each [output-configured] IO 0 : LED Driver is disabled 1 : LED Driver is enabled |
| 0x12 | RegDebounceConfig | 0x00 | 7:3 | Unused |
| | | | 2:0 | Debounce time (Cf. §4.5.1) 000: 0.5ms x 2MHz/fOSC 001: 1ms x 2MHz/fOSC 010: 2ms x 2MHz/fOSC 011: 4ms x 2MHz/fOSC 100: 8ms x 2MHz/fOSC 101: 16ms x 2MHz/fOSC 110: 32ms x 2MHz/fOSC 111: 64ms x 2MHz/fOSC |
| 0x13 | RegDebounceEnable | 0x00 | 7:0 | Enables debouncing for each [input-configured] IO 0 : Debouncing is disabled 1 : Debouncing is enabled |
| 0x14 | RegKeyConfig | 0x00 | 7 | Unused |
| | | | 6:5 | Number of rows (outputs) + key scan enable 00 : Key scan OFF 01 : 2 rows – IO[0:1] 10 : 3 rows – IO[0:2] 11 : 4 rows – IO[0:3] |
| | | | 4:3 | Number of columns (inputs) 00 : 1 column – IO[4] 01 : 2 columns – IO[4:5] 10 : 3 columns – IO[4:6] 11 : 4 columns – IO[4:7] |
| | | | 2:0 | Scan time per row (must be set above debounce time). 000 : 1ms x 2MHz/fOSC 001 : 2ms x 2MHz/fOSC 010 : 4ms x 2MHz/fOSC 011 : 8ms x 2MHz/fOSC 100 : 16ms x 2MHz/fOSC 101 : 32ms x 2MHz/fOSC 110 : 64ms x 2MHz/fOSC 111 : 128ms x 2MHz/fOSC |
| 0x15 | RegKeyData | 0xFF | 7:0 | Key which generated NINT (active low) Ex: RegKeyData=11011110 => key [IO5;IO0] has been pressed and generated NINT When read it is automatically cleared together with NINT and key scan continues. |
| 0xXX | RegTOnX | 0x00 | 7:5 | Unused |
| | | | 4:0 | ON Time of IO[X]: 0 : Infinite (Static mode, TOn directly controlled by RegData, Cf §4.8.2) 1 - 15 : $TOnX = 64 * RegTOnX * (255/ClkX)$ 16 - 31 : $TOnX = 512 * RegTOnX * (255/ClkX)$ |
| 0xXX | RegIonX | 0xFF | 7:0 | ON Intensity of IO[X] - Linear mode : $IonX = RegIonX$ - Logarithmic mode (fading capable IOs only) : $IonX = f(RegIonX)$, Cf §4.8.5 |
| 0xXX | RegOffX | 0x00 | 7:3 | OFF Time of IO[X]: 0 : Infinite (Single shot mode, TOff directly controlled by RegData, Cf §4.8.3) 1 - 15 : $TOffX = 64 * RegOffX[7:3] * (255/ClkX)$ 16 - 31 : $TOffX = 512 * RegOffX[7:3] * (255/ClkX)$ |
| | | | 2:0 | OFF Intensity of IO[X] - Linear mode : $IOffX = 4 * RegOff[2:0]$ - Logarithmic mode (fading capable IOs only) : $IOffX = f(4 * RegOffX[2:0])$, Cf §4.8.5 |
| 0xXX | RegTRiseX | 0x00 | 7:5 | Unused |
| | | | 4:0 | Fade In setting of IO[X] 0 : OFF 1 - 15 : $TRiseX = (RegIonX - (4 * RegOffX[2:0])) * RegTRiseX * (255/ClkX)$ 16 - 31 : $TRiseX = 16 * (RegIonX - (4 * RegOffX[2:0])) * RegTRiseX * (255/ClkX)$ |

ADVANCED COMMUNICATIONS & SENSING

| | | | | |
|------|---------------------|------|-----|--|
| 0xXX | RegTFallX | 0x00 | 7:5 | Unused |
| | | | 4:0 | Fade Out setting of IO[X] 0 : OFF 1 - 15 : $TFallX = (RegIOOnX - (4 \times RegOffX[2:0])) * RegTFallX * (255/ClkX)$ 16 - 31 : $TFallX = 16 * (RegIOOnX - (4 \times RegOffX[2:0])) * RegTFallX * (255/ClkX)$ |
| 0x2A | RegHighInput | 0x00 | 7:0 | Enables high input mode for each [input-configured] IO 0 : OFF. VIH max = 3.6V and VCCx min = 1.2V 1 : ON. VIH max = 5.5V and VCCx min = 1.65V |
| 0x7D | RegReset | 0x00 | 7:0 | Software reset register Writing consecutively 0x12 and 0x34 will reset the device (same as POR). Always reads 0. |

Table 9 – SX1508B Configuration Registers Description

ADVANCED COMMUNICATIONS & SENSING

5.2 SX1509B 16-channel GPIO with LED Driver and Keypad Engine

| Address | Name | Description | Default |
|--|---------------------|---|-----------|
| Device and IO Banks | | | |
| 0x00 | RegInputDisableB | Input buffer disable register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x01 | RegInputDisableA | Input buffer disable register - I/O[7-0] (Bank A) | 0000 0000 |
| 0x02 | RegLongSlewB | Output buffer long slew register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x03 | RegLongSlewA | Output buffer long slew register - I/O[7-0] (Bank A) | 0000 0000 |
| 0x04 | RegLowDriveB | Output buffer low drive register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x05 | RegLowDriveA | Output buffer low drive register - I/O[7-0] (Bank A) | 0000 0000 |
| 0x06 | RegPullUpB | Pull-up register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x07 | RegPullUpA | Pull-up register - I/O[7-0] (Bank A) | 0000 0000 |
| 0x08 | RegPullDownB | Pull-down register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x09 | RegPullDownA | Pull-down register - I/O[7-0] (Bank A) | 0000 0000 |
| 0x0A | RegOpenDrainB | Open drain register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x0B | RegOpenDrainA | Open drain register - I/O[7-0] (Bank A) | 0000 0000 |
| 0x0C | RegPolarityB | Polarity register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x0D | RegPolarityA | Polarity register - I/O[7-0] (Bank A) | 0000 0000 |
| 0x0E | RegDirB | Direction register - I/O[15-8] (Bank B) | 1111 1111 |
| 0x0F | RegDirA | Direction register - I/O[7-0] (Bank A) | 1111 1111 |
| 0x10 | RegDataB | Data register - I/O[15-8] (Bank B) | 1111 1111 |
| 0x11 | RegDataA | Data register - I/O[7-0] (Bank A) | 1111 1111 |
| 0x12 | RegInterruptMaskB | Interrupt mask register - I/O[15-8] (Bank B) | 1111 1111 |
| 0x13 | RegInterruptMaskA | Interrupt mask register - I/O[7-0] (Bank A) | 1111 1111 |
| 0x14 | RegSenseHighB | Sense register for I/O[15:12] | 0000 0000 |
| 0x15 | RegSenseLowB | Sense register for I/O[11:8] | 0000 0000 |
| 0x16 | RegSenseHighA | Sense register for I/O[7:4] | 0000 0000 |
| 0x17 | RegSenseLowA | Sense register for I/O[3:0] | 0000 0000 |
| 0x18 | RegInterruptSourceB | Interrupt source register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x19 | RegInterruptSourceA | Interrupt source register - I/O[7-0] (Bank A) | 0000 0000 |
| 0x1A | RegEventStatusB | Event status register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x1B | RegEventStatusA | Event status register - I/O[7-0] (Bank A) | 0000 0000 |
| 0x1C | RegLevelShifter1 | Level shifter register | 0000 0000 |
| 0x1D | RegLevelShifter2 | Level shifter register | 0000 0000 |
| 0x1E | RegClock | Clock management register | 0000 0000 |
| 0x1F | RegMisc | Miscellaneous device settings register | 0000 0000 |
| 0x20 | RegLEDDriverEnableB | LED driver enable register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x21 | RegLEDDriverEnableA | LED driver enable register - I/O[7-0] (Bank A) | 0000 0000 |
| Debounce and Keypad Engine | | | |
| 0x22 | RegDebounceConfig | Debounce configuration register | 0000 0000 |
| 0x23 | RegDebounceEnableB | Debounce enable register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x24 | RegDebounceEnableA | Debounce enable register - I/O[7-0] (Bank A) | 0000 0000 |
| 0x25 | RegKeyConfig1 | Key scan configuration register | 0000 0000 |
| 0x26 | RegKeyConfig2 | Key scan configuration register | 0000 0000 |
| 0x27 | RegKeyData1 | Key value (column) | 1111 1111 |
| 0x28 | RegKeyData2 | Key value (row) | 1111 1111 |
| LED Driver (PWM, blinking, breathing) | | | |
| 0x29 | RegTON0 | ON time register for I/O[0] | 0000 0000 |
| 0x2A | RegION0 | ON intensity register for I/O[0] | 1111 1111 |
| 0x2B | RegOff0 | OFF time/intensity register for I/O[0] | 0000 0000 |
| 0x2C | RegTON1 | ON time register for I/O[1] | 0000 0000 |
| 0x2D | RegION1 | ON intensity register for I/O[1] | 1111 1111 |
| 0x2E | RegOff1 | OFF time/intensity register for I/O[1] | 0000 0000 |
| 0x2F | RegTON2 | ON time register for I/O[2] | 0000 0000 |
| 0x30 | RegION2 | ON intensity register for I/O[2] | 1111 1111 |
| 0x31 | RegOff2 | OFF time/intensity register for I/O[2] | 0000 0000 |
| 0x32 | RegTON3 | ON time register for I/O[3] | 0000 0000 |
| 0x33 | RegION3 | ON intensity register for I/O[3] | 1111 1111 |
| 0x34 | RegOff3 | OFF time/intensity register for I/O[3] | 0000 0000 |
| 0x35 | RegTON4 | ON time register for I/O[4] | 0000 0000 |
| 0x36 | RegION4 | ON intensity register for I/O[4] | 1111 1111 |
| 0x37 | RegOff4 | OFF time/intensity register for I/O[4] | 0000 0000 |
| 0x38 | RegTRise4 | Fade in register for I/O[4] | 0000 0000 |

ADVANCED COMMUNICATIONS & SENSING

| Address | Name | Description | Default |
|---------------------------------|---------------|---|-----------|
| 0x39 | RegTFall4 | Fade out register for I/O[4] | 0000 0000 |
| 0x3A | RegTOn5 | ON time register for I/O[5] | 0000 0000 |
| 0x3B | RegIOn5 | ON intensity register for I/O[5] | 1111 1111 |
| 0x3C | RegOff5 | OFF time/intensity register for I/O[5] | 0000 0000 |
| 0x3D | RegTRise5 | Fade in register for I/O[5] | 0000 0000 |
| 0x3E | RegTFall5 | Fade out register for I/O[5] | 0000 0000 |
| 0x3F | RegTOn6 | ON time register for I/O[6] | 0000 0000 |
| 0x40 | RegIOn6 | ON intensity register for I/O[6] | 1111 1111 |
| 0x41 | RegOff6 | OFF time/intensity register for I/O[6] | 0000 0000 |
| 0x42 | RegTRise6 | Fade in register for I/O[6] | 0000 0000 |
| 0x43 | RegTFall6 | Fade out register for I/O[6] | 0000 0000 |
| 0x44 | RegTOn7 | ON time register for I/O[7] | 0000 0000 |
| 0x45 | RegIOn7 | ON intensity register for I/O[7] | 1111 1111 |
| 0x46 | RegOff7 | OFF time/intensity register for I/O[7] | 0000 0000 |
| 0x47 | RegTRise7 | Fade in register for I/O[7] | 0000 0000 |
| 0x48 | RegTFall7 | Fade out register for I/O[7] | 0000 0000 |
| 0x49 | RegTOn8 | ON time register for I/O[8] | 0000 0000 |
| 0x4A | RegIOn8 | ON intensity register for I/O[8] | 1111 1111 |
| 0x4B | RegOff8 | OFF time/intensity register for I/O[8] | 0000 0000 |
| 0x4C | RegTOn9 | ON time register for I/O[9] | 0000 0000 |
| 0x4D | RegIOn9 | ON intensity register for I/O[9] | 1111 1111 |
| 0x4E | RegOff9 | OFF time/intensity register for I/O[9] | 0000 0000 |
| 0x4F | RegTOn10 | ON time register for I/O[10] | 0000 0000 |
| 0x50 | RegIOn10 | ON intensity register for I/O[10] | 1111 1111 |
| 0x51 | RegOff10 | OFF time/intensity register for I/O[10] | 0000 0000 |
| 0x52 | RegTOn11 | ON time register for I/O[11] | 0000 0000 |
| 0x53 | RegIOn11 | ON intensity register for I/O[11] | 1111 1111 |
| 0x54 | RegOff11 | OFF time/intensity register for I/O[11] | 0000 0000 |
| 0x55 | RegTOn12 | ON time register for I/O[12] | 0000 0000 |
| 0x56 | RegIOn12 | ON intensity register for I/O[12] | 1111 1111 |
| 0x57 | RegOff12 | OFF time/intensity register for I/O[12] | 0000 0000 |
| 0x58 | RegTRise12 | Fade in register for I/O[12] | 0000 0000 |
| 0x59 | RegTFall12 | Fade out register for I/O[12] | 0000 0000 |
| 0x5A | RegTOn13 | ON time register for I/O[13] | 0000 0000 |
| 0x5B | RegIOn13 | ON intensity register for I/O[13] | 1111 1111 |
| 0x5C | RegOff13 | OFF time/intensity register for I/O[13] | 0000 0000 |
| 0x5D | RegTRise13 | Fade in register for I/O[13] | 0000 0000 |
| 0x5E | RegTFall13 | Fade out register for I/O[13] | 0000 0000 |
| 0x5F | RegTOn14 | ON time register for I/O[14] | 0000 0000 |
| 0x60 | RegIOn14 | ON intensity register for I/O[14] | 1111 1111 |
| 0x61 | RegOff14 | OFF time/intensity register for I/O[14] | 0000 0000 |
| 0x62 | RegTRise14 | Fade in register for I/O[14] | 0000 0000 |
| 0x63 | RegTFall14 | Fade out register for I/O[14] | 0000 0000 |
| 0x64 | RegTOn15 | ON time register for I/O[15] | 0000 0000 |
| 0x65 | RegIOn15 | ON intensity register for I/O[15] | 1111 1111 |
| 0x66 | RegOff15 | OFF time/intensity register for I/O[15] | 0000 0000 |
| 0x67 | RegTRise15 | Fade in register for I/O[15] | 0000 0000 |
| 0x68 | RegTFall15 | Fade out register for I/O[15] | 0000 0000 |
| Miscellaneous | | | |
| 0x69 | RegHighInputB | High input enable register - I/O[15-8] (Bank B) | 0000 0000 |
| 0x6A | RegHighInputA | High input enable register - I/O[7-0] (Bank A) | 0000 0000 |
| Software Reset | | | |
| 0x7D | RegReset | Software reset register | 0000 0000 |
| Test (not to be written) | | | |
| 0x7E | RegTest1 | Test register | 0000 0000 |
| 0x7F | RegTest2 | Test register | 0000 0000 |

Bits set as output take "1" as default value.

Table 10 – SX1509B Configuration Registers Overview

ADVANCED COMMUNICATIONS & SENSING

| Addr | Name | Default | Bits | Description | |
|------|-------------------|---------|------|--|---|
| 0x00 | RegInputDisableB | 0x00 | 7:0 | Disables the input buffer of each IO 0 : Input buffer is enabled (input actually being used) 1 : Input buffer is disabled (input actually not being used or LED connection) | |
| 0x01 | RegInputDisableA | 0x00 | 7:0 | Disables the input buffer of each IO 0 : Input buffer is enabled (input actually being used) 1 : Input buffer is disabled (input actually not being used, LED connection) | |
| 0x02 | RegLongSlewB | 0x00 | 7:0 | Enables increased slew rate of the output buffer of each [output-configured] IO 0 : Increased slew rate is disabled 1 : Increased slew rate is enabled | |
| 0x03 | RegLongSlewA | 0x00 | 7:0 | Enables increased slew rate of the output buffer of each [output-configured] IO 0 : Increased slew rate is disabled 1 : Increased slew rate is enabled | |
| 0x04 | RegLowDriveB | 0x00 | 7:0 | Enables reduced drive of the output buffer of each [output-configured] IO 0 : Reduced drive is disabled 1 : Reduced drive is enabled. IOL specifications are divided by 2. | |
| 0x05 | RegLowDriveA | 0x00 | 7:0 | Enables reduced drive of the output buffer of each [output-configured] IO 0 : Reduced drive is disabled 1 : Reduced drive is enabled. IOL specifications are divided by 2. | |
| 0x06 | RegPullUpB | 0x00 | 7:0 | Enables the pull-up for each IO 0 : Pull-up is disabled 1 : Pull-up is enabled | |
| 0x07 | RegPullUpA | 0x00 | 7:0 | Enables the pull-up for each IO 0 : Pull-up is disabled 1 : Pull-up is enabled | |
| 0x08 | RegPullDownB | 0x00 | 7:0 | Enables the pull-down for each IO 0 : Pull-down is disabled 1 : Pull-down is enabled | |
| 0x09 | RegPullDownA | 0x00 | 7:0 | Enables the pull-down for each IO 0 : Pull-down is disabled 1 : Pull-down is enabled | |
| 0x0A | RegOpenDrainB | 0x00 | 7:0 | Enables open drain operation for each [output-configured] IO 0 : Regular push-pull operation 1 : Open drain operation | |
| 0x0B | RegOpenDrainA | 0x00 | 7:0 | Enables open drain operation for each [output-configured] IO 0 : Regular push-pull operation 1 : Open drain operation | |
| 0x0C | RegPolarityB | 0x00 | 7:0 | Enables polarity inversion for each IO 0 : Normal polarity : RegData[x] = IO[x] 1 : Inverted polarity : RegData[x] = !IO[x] (for both input and output configured IOs) | |
| 0x0D | RegPolarityA | 0x00 | 7:0 | Enables polarity inversion for each IO 0 : Normal polarity : RegData[x] = IO[x] 1 : Inverted polarity : RegData[x] = !IO[x] (for both input and output configured IOs) | |
| 0x0E | RegDirB | 0xFF | 7:0 | Configures direction for each IO. 0 : IO is configured as an output 1 : IO is configured as an input | |
| 0x0F | RegDirA | 0xFF | 7:0 | Configures direction for each IO. 0 : IO is configured as an output 1 : IO is configured as an input | |
| 0x10 | RegDataB | 0xFF | 7:0 | Write: Data to be output to the output-configured IOs Read: Data seen at the IOs, independent of the direction configured. | |
| 0x11 | RegDataA | 0xFF | 7:0 | Write: Data to be output to the output-configured IOs Read: Data seen at the IOs, independent of the direction configured. | |
| 0x12 | RegInterruptMaskB | 0xFF | 7:0 | Configures which [input-configured] IO will trigger an interrupt on NINT pin 0 : An event on this IO will trigger an interrupt 1 : An event on this IO will NOT trigger an interrupt | |
| 0x13 | RegInterruptMaskA | 0xFF | 7:0 | Configures which [input-configured] IO will trigger an interrupt on NINT pin 0 : An event on this IO will trigger an interrupt 1 : An event on this IO will NOT trigger an interrupt | |
| 0x14 | RegSenseHighB | 0x00 | 7:6 | Edge sensitivity of RegData[15] | 00 : None 01 : Rising 10 : Falling 11 : Both |
| | | | 5:4 | Edge sensitivity of RegData[14] | |
| | | | 3:2 | Edge sensitivity of RegData[13] | |
| | | | 1:0 | Edge sensitivity of RegData[12] | |
| 0x15 | RegSenseLowB | 0x00 | 7:6 | Edge sensitivity of RegData[11] | 00 : None 01 : Rising 10 : Falling 11 : Both |
| | | | 5:4 | Edge sensitivity of RegData[10] | |
| | | | 3:2 | Edge sensitivity of RegData[9] | |
| | | | 1:0 | Edge sensitivity of RegData[8] | |
| 0x16 | RegSenseHighA | 0x00 | 7:6 | Edge sensitivity of RegData[7] | 00 : None 01 : Rising 10 : Falling 11 : Both |
| | | | 5:4 | Edge sensitivity of RegData[6] | |
| | | | 3:2 | Edge sensitivity of RegData[5] | |
| | | | 1:0 | Edge sensitivity of RegData[4] | |
| 0x17 | RegSenseLowA | 0x00 | 7:6 | Edge sensitivity of RegData[3] | 00 : None |

ADVANCED COMMUNICATIONS & SENSING

| | | | | | |
|------|---------------------|------|-----|--|---------------|
| | | | 5:4 | Edge sensitivity of RegData[2] | |
| | | | 3:2 | Edge sensitivity of RegData[1] | |
| | | | 1:0 | Edge sensitivity of RegData[0] | |
| 0x18 | RegInterruptSourceB | 0x00 | 7:0 | Interrupt source (from IOs set in RegInterruptMask) 0 : No interrupt has been triggered by this IO 1 : An interrupt has been triggered by this IO (an event as configured in relevant RegSense register occurred). Writing '1' clears the bit in RegInterruptSource and in RegEventStatus When all bits are cleared, NINT signal goes back high. | |
| 0x19 | RegInterruptSourceA | 0x00 | 7:0 | Interrupt source (from IOs set in RegInterruptMask) 0 : No interrupt has been triggered by this IO 1 : An interrupt has been triggered by this IO (an event as configured in relevant RegSense register occurred). Writing '1' clears the bit in RegInterruptSource and in RegEventStatus When all bits are cleared, NINT signal goes back high. | |
| 0x1A | RegEventStatusB | 0x00 | 7:0 | Event status of all IOs. 0 : No event has occurred on this IO 1 : An event has occurred on this IO (an edge as configured in relevant RegSense register occurred). Writing '1' clears the bit in RegEventStatus and in RegInterruptSource if relevant. If the edge sensitivity of the IO is changed, the bit(s) will be cleared automatically | |
| 0x1B | RegEventStatusA | 0x00 | 7:0 | Event status of all IOs. 0 : No event has occurred on this IO 1 : An event has occurred on this IO (an edge as configured in relevant RegSense register occurred). Writing '1' clears the bit in RegEventStatus and in RegInterruptSource if relevant. If the edge sensitivity of the IO is changed, the bit(s) will be cleared automatically | |
| 0x1C | RegLevelShifter1 | 0x00 | 7:6 | Level shifter mode for IO[7] (Bank A) and IO[15] (Bank B) | 00 : OFF |
| | | | 5:4 | Level shifter mode for IO[6] (Bank A) and IO[14] (Bank B) | 01 : A->B |
| | | | 3:2 | Level shifter mode for IO[5] (Bank A) and IO[13] (Bank B) | 10 : B->A |
| | | | 1:0 | Level shifter mode for IO[4] (Bank A) and IO[12] (Bank B) | 11 : Reserved |
| 0x1D | RegLevelShifter2 | 0x00 | 7:6 | Level shifter mode for IO[3] (Bank A) and IO[11] (Bank B) | 00 : OFF |
| | | | 5:4 | Level shifter mode for IO[2] (Bank A) and IO[10] (Bank B) | 01 : A->B |
| | | | 3:2 | Level shifter mode for IO[1] (Bank A) and IO[9] (Bank B) | 10 : B->A |
| | | | 1:0 | Level shifter mode for IO[0] (Bank A) and IO[8] (Bank B) | 11 : Reserved |
| 0x1E | RegClock | 0x00 | 7 | Unused | |
| | | | 6:5 | Oscillator frequency (fOSC) source 00 : OFF. LED driver, keypad engine and debounce features are disabled. 01 : External clock input (OSCIN) 10 : Internal 2MHz oscillator 11 : Reserved | |
| | | | 4 | OSCIO pin function (Cf. §4.7) 0 : OSCIO is an input (OSCIN) 1 : OSCIO is an output (OSCOU) | |
| | | | 3:0 | Frequency of the signal output on OSCOUT pin: 0x0 : 0Hz, permanent "0" logical level (GPO) 0xF : 0Hz, permanent "1" logical level (GPO) Else : fOSCOU = fOSC/(2^(RegClock[3:0]-1)) | |
| 0x1F | RegMisc | 0x00 | 7 | LED Driver mode for Bank B's fading capable IOs (IO15-12) 0: Linear 1: Logarithmic | |
| | | | 6:4 | Frequency of the LED Driver clock ClkX of all IOs: 0 : OFF. LED driver functionality is disabled for all IOs. Else : ClkX = fOSC/(2^(RegMisc[6:4]-1)) | |
| | | | 3 | LED Driver mode for Bank A's fading capable IOs (IO7-4) 0: Linear 1: Logarithmic | |
| | | | 2 | NRESET pin function when externally forced low (Cf. §4.3.1 and §4.8.5) 0: Equivalent to POR 1: Reset PWM/Blink/Fade counters (not user programmed values) This bit is can only be reset manually or by POR, not by NRESET. | |
| | | | 1 | Auto-increment register address (Cf. §4.4) 0: ON. When several consecutive data are read/written, register address is incremented. 1: OFF. When several consecutive data are read/written, register address is kept fixed. | |
| | | | 0 | Autoclear NINT on RegData read (Cf. §4.6) 0: ON. RegInterruptSourceA/B is also automatically cleared when RegDataA/B is read. 1: OFF. RegInterruptSourceA/B must be manually cleared, either directly or via RegEventStatusA/B. | |
| 0x20 | RegLEDDriverEnableB | 0x00 | 7:0 | Enables LED Driver for each [output-configured] IO 0 : LED Driver is disabled 1 : LED Driver is enabled | |

ADVANCED COMMUNICATIONS & SENSING

| | | | | |
|------|---------------------|------|-----|---|
| 0x21 | RegLEDDriverEnableA | 0x00 | 7:0 | Enables LED Driver for each [output-configured] IO 0 : LED Driver is disabled 1 : LED Driver is enabled |
| 0x22 | RegDebounceConfig | 0x00 | 7:3 | Unused |
| | | | 2:0 | Debounce time (Cf. §4.5.1) 000: 0.5ms x 2MHz/fOSC 001: 1ms x 2MHz/fOSC 010: 2ms x 2MHz/fOSC 011: 4ms x 2MHz/fOSC 100: 8ms x 2MHz/fOSC 101: 16ms x 2MHz/fOSC 110: 32ms x 2MHz/fOSC 111: 64ms x 2MHz/fOSC |
| 0x23 | RegDebounceEnableB | 0x00 | 7:0 | Enables debouncing for each [input-configured] IO 0 : Debouncing is disabled 1 : Debouncing is enabled |
| 0x24 | RegDebounceEnableA | 0x00 | 7:0 | Enables debouncing for each [input-configured] IO 0 : Debouncing is disabled 1 : Debouncing is enabled |
| 0x25 | RegKeyConfig1 | 0x00 | 7 | Reserved |
| | | | 6:4 | Auto Sleep time (no key press within this time will set keypad engine to sleep) 000 : OFF 001 : 128ms x 2MHz/fOSC 010 : 256ms x 2MHz/fOSC 011 : 512ms x 2MHz/fOSC 100 : 1sec x 2MHz/fOSC 101 : 2sec x 2MHz/fOSC 110 : 4sec x 2MHz/fOSC 111 : 8sec x 2MHz/fOSC |
| | | | 3 | Unused |
| 0x26 | RegKeyConfig2 | 0x00 | 2:0 | Scan time per row (must be set above debounce time). 000 : 1ms x 2MHz/fOSC 001 : 2ms x 2MHz/fOSC 010 : 4ms x 2MHz/fOSC 011 : 8ms x 2MHz/fOSC 100 : 16ms x 2MHz/fOSC 101 : 32ms x 2MHz/fOSC 110 : 64ms x 2MHz/fOSC 111 : 128ms x 2MHz/fOSC |
| | | | 7:6 | Unused |
| 0x26 | RegKeyConfig2 | 0x00 | 5:3 | Number of rows (outputs) + key scan enable 000 : Key scan OFF 001 : 2 rows – IO[0:1] 010 : 3 rows – IO[0:2] 011 : 4 rows – IO[0:3] 100 : 5 rows – IO[0:4] 101 : 6 rows – IO[0:5] 110 : 7 rows – IO[0:6] 111 : 8 rows – IO[0:7] |
| | | | 2:0 | Number of columns (inputs) 000 : 1 column – IO[8] 001 : 2 columns – IO[8:9] 010 : 3 columns – IO[8:10] 011 : 4 columns – IO[8:11] 100 : 5 columns – IO[8:12] 101 : 6 columns – IO[8:13] 110 : 7 columns – IO[8:14] 111 : 8 columns – IO[8:15] |
| 0x27 | RegKeyData1 | 0xFF | 7:0 | Column which generated NINT (active low) Ex: RegKeyData1=11011111 => IO13 has generated NINT The register is automatically cleared when RegKeyData2 is read. |
| 0x28 | RegKeyData2 | 0xFF | 7:0 | Row which generated NINT (active low) Ex: RegKeyData2=11111110 => IO0 has generated NINT When the register is read both RegKeyData1 & RegKeyData2 are automatically cleared together with NINT and key scan continues. |
| 0xXX | RegTOX | 0x00 | 7:5 | Unused |
| | | | 4:0 | ON Time of IO[X]: 0 : Infinite (Static mode, TOn directly controlled by RegData, Cf §4.8.2) 1 - 15 : TOnX = 64 * RegTOX * (255/ClkX) 16 - 31 : TOnX = 512 * RegTOX * (255/ClkX) |
| 0xXX | RegIOX | 0xFF | 7:0 | ON Intensity of IO[X] - Linear mode : IOX = RegIOX - Logarithmic mode (fading capable IOs only) : IOX = f(RegIOX) , Cf §4.8.5 |

ADVANCED COMMUNICATIONS & SENSING

| | | | | |
|------|----------------------|------|-----|--|
| 0xXX | RegOffX | 0x00 | 7:3 | OFF Time of IO[X]: 0 : Infinite (Single shot mode, TOff directly controlled by RegData, Cf §4.8.3) 1 - 15 : TOffX = $64 * \text{RegOffX}[7:3] * (255/\text{ClkX})$ 16 - 31 : TOffX = $512 * \text{RegOffX}[7:3] * (255/\text{ClkX})$ |
| | | | 2:0 | OFF Intensity of IO[X] - Linear mode : IOffX = $4 * \text{RegOff}[2:0]$ - Logarithmic mode (fading capable IOs only) : IOffX = $f(4 * \text{RegOffX}[2:0])$, Cf §4.8.5 |
| 0xXX | RegTRiseX | 0x00 | 7:5 | Unused |
| | | | 4:0 | Fade In setting of IO[X] 0 : OFF 1 - 15 : TRiseX = $(\text{RegOnX} - (4 * \text{RegOffX}[2:0])) * \text{RegTRiseX} * (255/\text{ClkX})$ 16 - 31 : TRiseX = $16 * (\text{RegOnX} - (4 * \text{RegOffX}[2:0])) * \text{RegTRiseX} * (255/\text{ClkX})$ |
| 0xXX | RegTFallX | 0x00 | 7:5 | Unused |
| | | | 4:0 | Fade Out setting of IO[X] 0 : OFF 1 - 15 : TFallX = $(\text{RegOnX} - (4 * \text{RegOffX}[2:0])) * \text{RegTFallX} * (255/\text{ClkX})$ 16 - 31 : TFallX = $16 * (\text{RegOnX} - (4 * \text{RegOffX}[2:0])) * \text{RegTFallX} * (255/\text{ClkX})$ |
| 0x69 | RegHighInputB | 0x00 | 7:0 | Enables high input mode for each [input-configured] IO 0 : OFF. VIH max = 3.6V and VCCx min = 1.2V 1 : ON. VIH max = 5.5V and VCCx min = 1.65V |
| 0x6A | RegHighInputA | 0x00 | 7:0 | Enables high input mode for each [input-configured] IO 0 : OFF. VIH max = 3.6V and VCCx min = 1.2V 1 : ON. VIH max = 5.5V and VCCx min = 1.65V |
| 0x7D | RegReset | 0x00 | 7:0 | Software reset register Writing consecutively 0x12 and 0x34 will reset the device (same as POR). Always reads 0. |

Table 11 – SX1509B Configuration Registers Description

ADVANCED COMMUNICATIONS & SENSING

6 APPLICATION INFORMATION

6.1 Typical Application Circuit

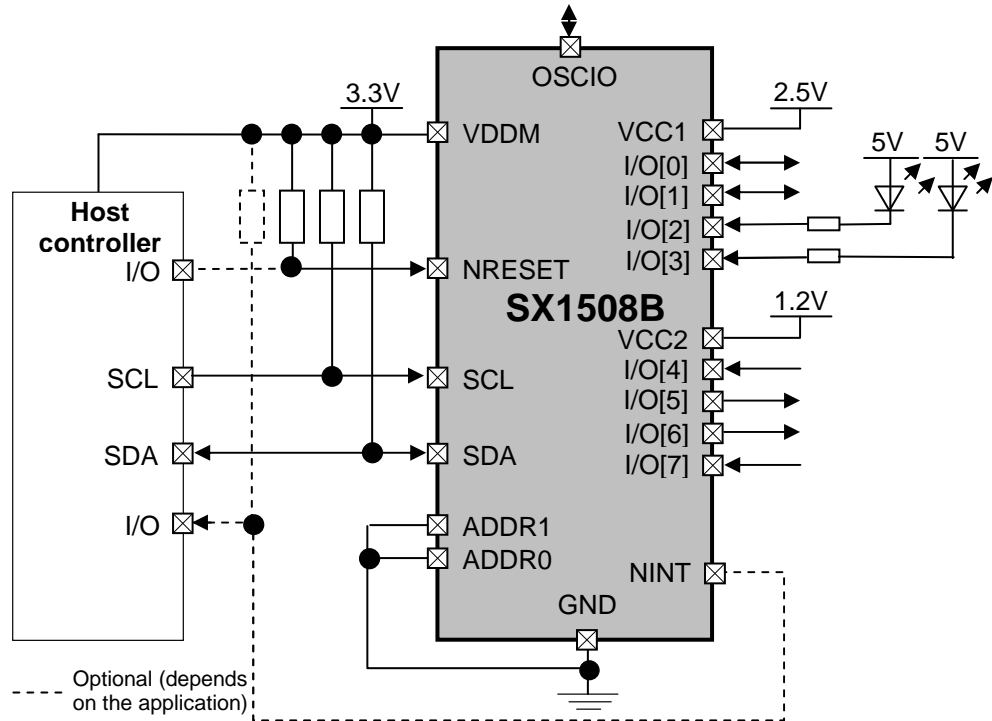


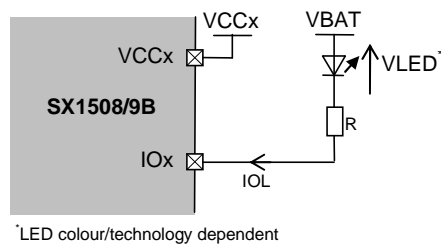
Figure 19 - Typical Application Schematic

6.2 Typical LED Connection

Typical LED Connection is described below. The LED is usually connected to a high voltage (VBAT) to take advantage of the high sink current of the I/O and to accommodate high LED threshold voltages (VLED).

Please note that in this configuration the IO must be programmed as open drain output (RegOpenDrain) with no pull-up (RegPullUp) and input buffer must be disabled (RegInputBufferDisable).

VCCx can take any value without compromising LED operation.



*LED colour/technology dependent

Figure 20 – Typical LED Operation

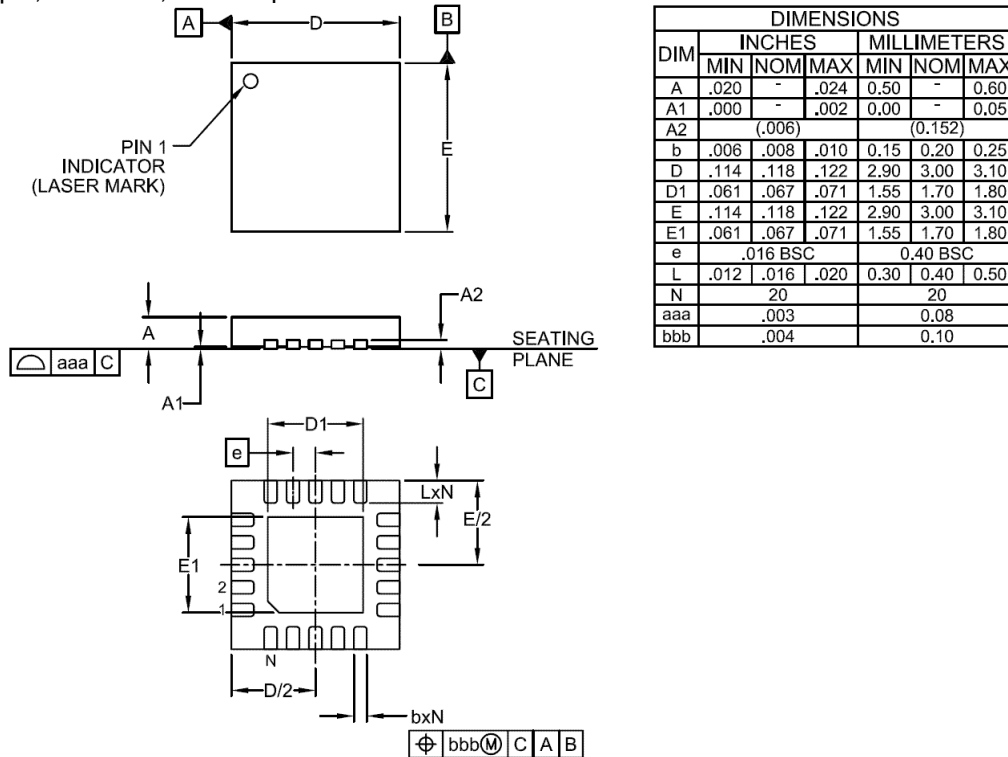
Serial R must be calculated for IOL not to exceed its max spec (Cf. Table 5) else VOL will increase.

ADVANCED COMMUNICATIONS & SENSING

7 PACKAGING INFORMATION

7.1 QFN-UT 20-pin Outline Drawing

QFN-UT 20-pin, 3 x 3 mm, 0.4 mm pitch

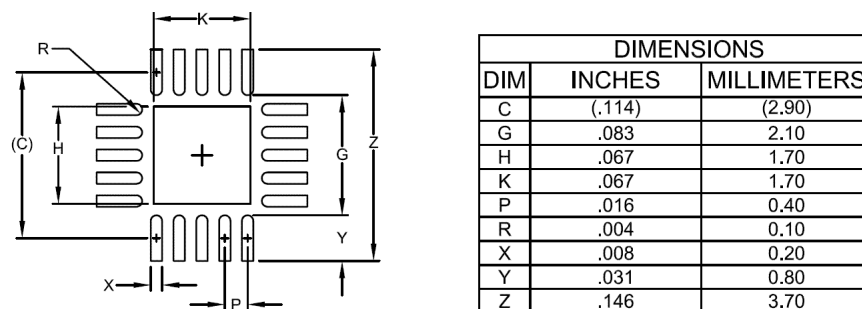


NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
3. DAP IS 1.90 x 1.90mm.

Figure 21 - QFN-UT 20-pin Outline Drawing

7.2 QFN-UT 20-pin Land Pattern



NOTES:

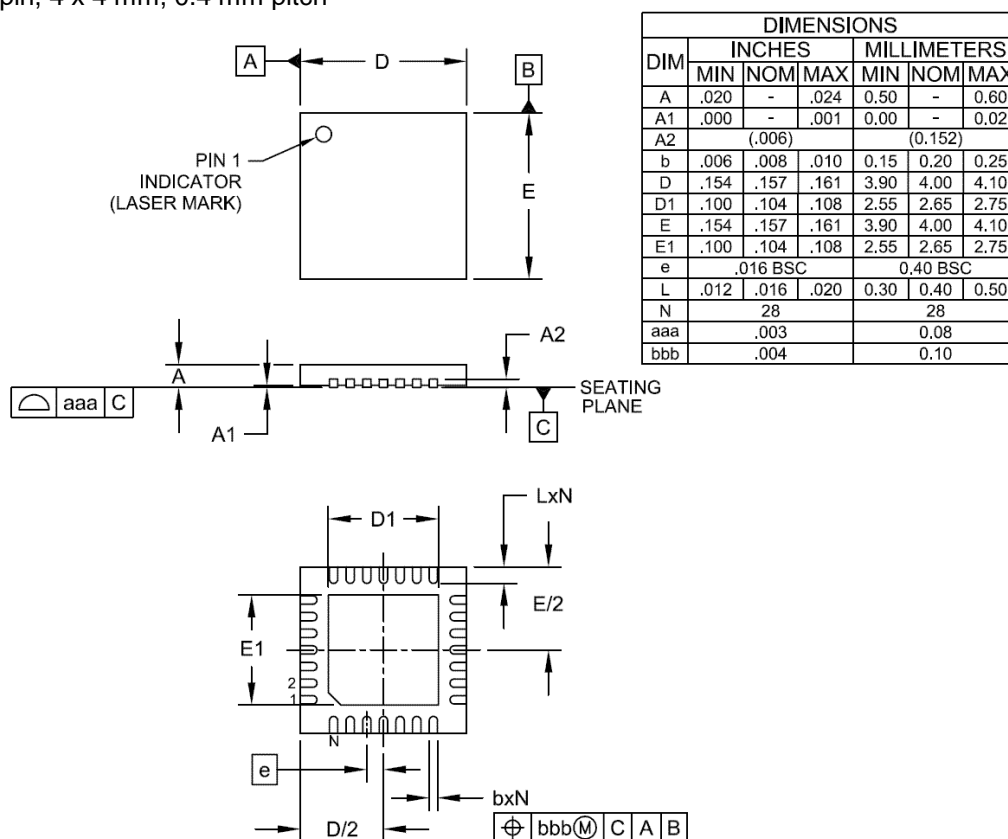
1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.
3. THERMAL VIAS IN THE LAND PATTERN OF THE EXPOSED PAD SHALL BE CONNECTED TO A SYSTEM GROUND PLANE. FAILURE TO DO SO MAY COMPROMISE THE THERMAL AND/OR FUNCTIONAL PERFORMANCE OF THE DEVICE.

Figure 22 - QFN-UT 20-pin Land Pattern

ADVANCED COMMUNICATIONS & SENSING

7.3 QFN-UT 28-pin Outline Drawing

QFN-UT 28-pin, 4 x 4 mm, 0.4 mm pitch

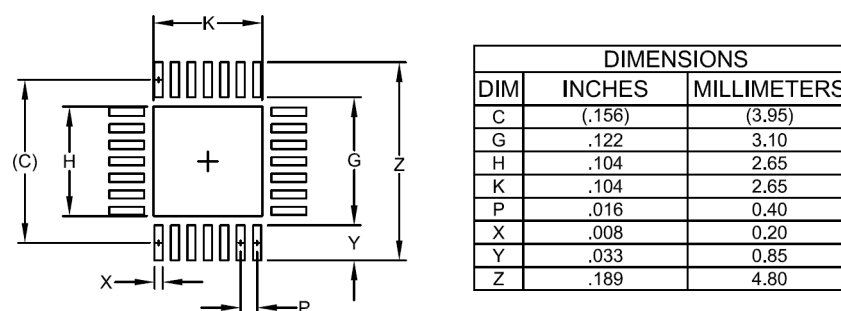


NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

Figure 23 - QFN-UT 28-pin Outline Drawing

7.4 QFN-UT 28-pin Land Pattern



NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.
3. THERMAL VIAS IN THE LAND PATTERN OF THE EXPOSED PAD SHALL BE CONNECTED TO A SYSTEM GROUND PLANE. FAILURE TO DO SO MAY COMPROMISE THE THERMAL AND/OR FUNCTIONAL PERFORMANCE OF THE DEVICE.
4. SQUARE PACKAGE-DIMENSIONS APPLY IN BOTH X AND Y DIRECTIONS.

Figure 24 - QFN-UT 28-pin Land Pattern

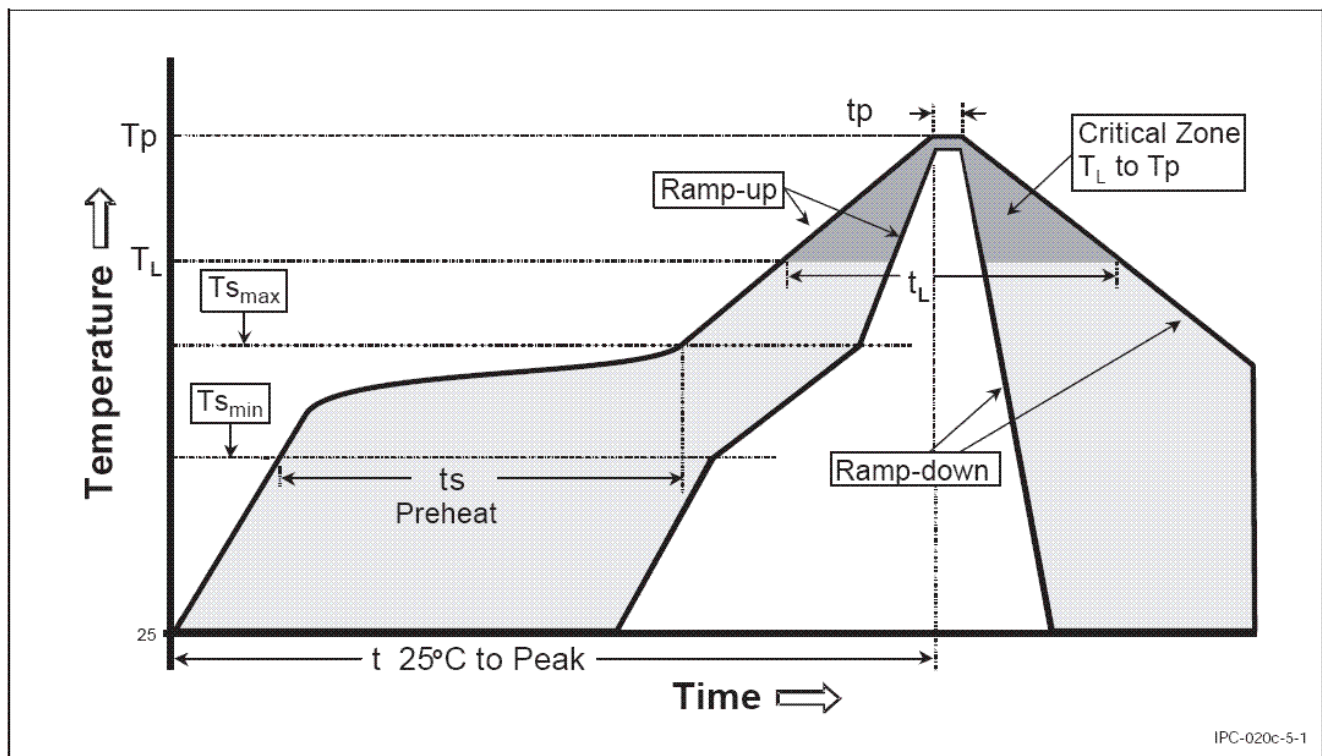
ADVANCED COMMUNICATIONS & SENSING

8 SOLDERING PROFILE

The soldering reflow profile for the SX1508B and SX1509B is described in the standard IPC/JEDEC J-STD-020C. For detailed information please go to <http://www.jedec.org/download/search/jstd020c.pdf>

| Profile Feature | Sn-Pb Eutectic Assembly | Pb-Free Assembly |
|---|-------------------------|------------------|
| Average Ramp-Up Rate ($T_{s_{max}}$ to T_p) | 3 °C/second max. | 3° C/second max. |
| Preheat | | |
| – Temperature Min ($T_{s_{min}}$) | 100 °C | 150 °C |
| – Temperature Max ($T_{s_{max}}$) | 150 °C | 200 °C |
| – Time ($t_{s_{min}}$ to $t_{s_{max}}$) | 60-120 seconds | 60-180 seconds |
| Time maintained above: | | |
| – Temperature (T_L) | 183 °C | 217 °C |
| – Time (t_L) | 60-150 seconds | 60-150 seconds |
| Peak/Classification Temperature (T_p) | See Table 4.1 | See Table 4.2 |
| Time within 5 °C of actual Peak Temperature (t_p) | 10-30 seconds | 20-40 seconds |
| Ramp-Down Rate | 6 °C/second max. | 6 °C/second max. |
| Time 25 °C to Peak Temperature | 6 minutes max. | 8 minutes max. |

Note 1: All temperatures refer to topside of the package, measured on the package body surface.



ADVANCED COMMUNICATIONS & SENSING**9 MARKING INFORMATION**

yyww = Date Code
xxxx = Semtech Lot No.

Figure 26 – SX1508B Marking Information



yyww = Date Code
xxxxx = Semtech Lot No.
xxxxx

Figure 27 – SX1509B Marking Information

ADVANCED COMMUNICATIONS & SENSING

© Semtech 2011

All rights reserved. Reproduction in whole or in part is prohibited without the prior written consent of the copyright owner. The information presented in this document does not form part of any quotation or contract, is believed to be accurate and reliable and may be changed without notice. No liability will be accepted by the publisher for any consequence of its use. Publication thereof does not convey nor imply any license under patent or other industrial or intellectual property rights. Semtech assumes no responsibility or liability whatsoever for any failure or unexpected operation resulting from misuse, neglect improper installation, repair or improper handling or unusual physical or electrical stress including, but not limited to, exposure to parameters beyond the specified maximum ratings or operation outside the specified range.

SEMTECH PRODUCTS ARE NOT DESIGNED, INTENDED, AUTHORIZED OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT APPLICATIONS, DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF SEMTECH PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE UNDERTAKEN SOLELY AT THE CUSTOMER'S OWN RISK. Should a customer purchase or use Semtech products for any such unauthorized application, the customer shall indemnify and hold Semtech and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs damages and attorney fees which could arise.

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

Contact Information

Semtech Corporation
Advanced Communications and Sensing Products Division
200 Flynn Road, Camarillo, CA 93012
Phone: (805) 498-2111 Fax: (805) 498-3804

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Semtech:](#)

[SX1509BIULTRT](#) [SX1508BIULTRT](#)