

1. General description

The XL9535 are 24-pin CMOS devices that provide 16 bits of General Purpose parallel Input/Output (GPIO) expansion for I²C-bus/SMBus applications and was developed to enhance the NXP Semiconductors family of I²C-bus I/O expanders. The improvements include higher drive capability, 5 V I/O tolerance, lower supply current, individual I/O configuration, and smaller packaging. I/O expanders provide a simple solution when additional I/O is needed for ACPI power switches, sensors, push buttons, LEDs, fans, etc.

The XL9535 consist of two 8-bit Configuration (Input or Output selection), Input, Output and Polarity Inversion (active HIGH or active LOW operation) registers. The system master can enable the I/Os as either inputs or outputs by writing to the I/O configuration bits. The data for each input or output is kept in the corresponding Input or Output register. The polarity of the read register can be inverted with the Polarity Inversion register. All registers can be read by the system master. Although pin-to-pin and I²C-bus address compatible with the 8575, software changes are required due to the enhancements and are discussed in *Application Note AN469*.

The XL9535 is identical to the XL9555 except for the removal of the internal I/O pull-up resistor which greatly reduces power consumption when the I/Os are held LOW.

The XL9535 open-drain interrupt output is activated when any input state differs from its corresponding Input Port register state and is used to indicate to the system master that an input state has changed. The power-on reset sets the registers to their default values and initializes the device state machine.

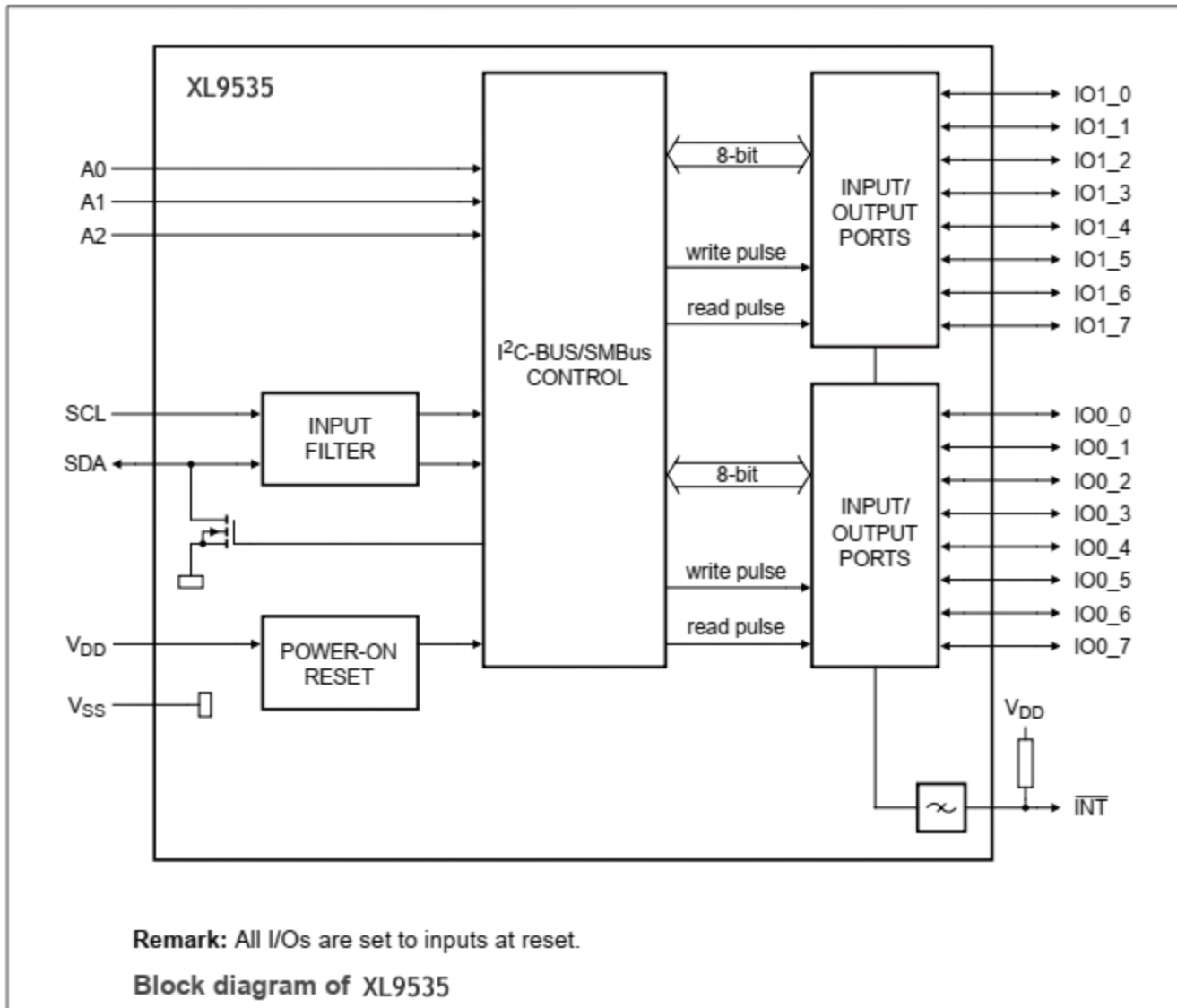
Three hardware pins (A0, A1, A2) vary the fixed I²C-bus address and allow up to eight devices to share the same I²C-bus/SMBus. The fixed I²C-bus address of the XL9535 are the same as the XL9555 allowing up to eight of these devices in any combination to share the same I²C-bus/SMBus.

2. Features

- Operating power supply voltage range of 2.3 V to 5.5 V
- 5 V tolerant I/Os
- Polarity Inversion register
- Active LOW interrupt output
- Low standby current
- Noise filter on SCL/SDA inputs

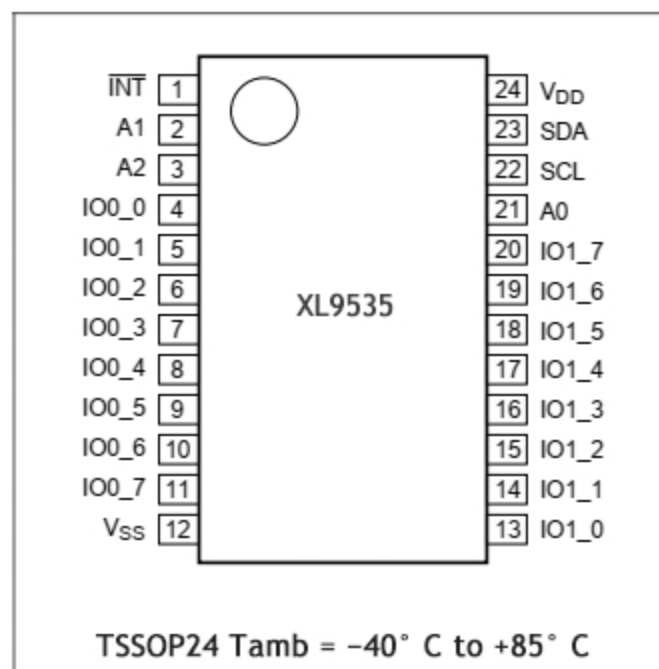
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3. Block diagram



4. Pinning information

4.1 Pinning



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4.2 Pin description

Pin description

Symbol	Pin		Description
	SO24, TSSOP24	HVQFN24, HWQFN24	
$\overline{\text{INT}}$	1	22	interrupt output (open-drain)
A1	2	23	address input 1
A2	3	24	address input 2
IO0_0	4	1	port 0 input/output ^[2]
IO0_1	5	2	
IO0_2	6	3	
IO0_3	7	4	
IO0_4	8	5	
IO0_5	9	6	
IO0_6	10	7	
IO0_7	11	8	
V _{SS}	12	9 ^[1]	supply ground
IO1_0	13	10	port 1 input/output ^[2]
IO1_1	14	11	
IO1_2	15	12	
IO1_3	16	13	
IO1_4	17	14	
IO1_5	18	15	
IO1_6	19	16	
IO1_7	20	17	
A0	21	18	address input 0
SCL	22	19	serial clock line
SDA	23	20	serial data line
V _{DD}	24	21	supply voltage

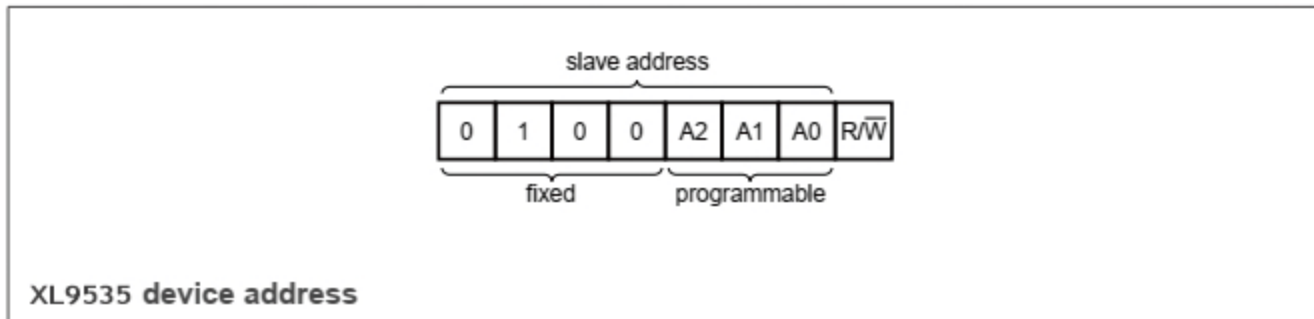
[1] HVQFN24 and HWQFN24 package die supply ground is connected to both the V_{SS} pin and the exposed center pad. The V_{SS} pin must be connected to supply ground for proper device operation. For enhanced thermal, electrical, and board-level performance, the exposed pad needs to be soldered to the board using a corresponding thermal pad on the board, and for proper heat conduction through the board thermal vias need to be incorporated in the PCB in the thermal pad region.

[2] XL9535 I/Os are totem pole, whereas the I/Os on XL9535 are open-drain.

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5. Functional description

5.1 Device address



5.2 Registers

5.2.1 Command byte

The command byte is the first byte to follow the address byte during a write transmission. It is used as a pointer to determine which of the following registers will be written or read.

Command byte

Command	Register
0	Input port 0
1	Input port 1
2	Output port 0
3	Output port 1
4	Polarity Inversion port 0
5	Polarity Inversion port 1
6	Configuration port 0
7	Configuration port 1

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5.2.2 Registers 0 and 1: Input port registers

This register is an input-only port. It reflects the incoming logic levels of the pins, regardless of whether the pin is defined as an input or an output by Register 3. Writes to this register have no effect.

The default value 'X' is determined by the externally applied logic level.

Input port 0 Register

Bit	7	6	5	4	3	2	1	0
Symbol	I0.7	I0.6	I0.5	I0.4	I0.3	I0.2	I0.1	I0.0
Default	X	X	X	X	X	X	X	X

Input port 1 register

Bit	7	6	5	4	3	2	1	0
Symbol	I1.7	I1.6	I1.5	I1.4	I1.3	I1.2	I1.1	I1.0
Default	X	X	X	X	X	X	X	X

5.2.3 Registers 2 and 3: Output port registers

This register is an output-only port. It reflects the outgoing logic levels of the pins defined as outputs by Registers 6 and 7. Bit values in this register have no effect on pins defined as inputs. In turn, reads from this register reflect the value that is in the flip-flop controlling the output selection, **not** the actual pin value.

Output port 0 register

Bit	7	6	5	4	3	2	1	0
Symbol	O0.7	O0.6	O0.5	O0.4	O0.3	O0.2	O0.1	O0.0
Default	1	1	1	1	1	1	1	1

Output port 1 register

Bit	7	6	5	4	3	2	1	0
Symbol	O1.7	O1.6	O1.5	O1.4	O1.3	O1.2	O1.1	O1.0
Default	1	1	1	1	1	1	1	1

5.2.4 Registers 4 and 5: Polarity Inversion registers

This register allows the user to invert the polarity of the Input port register data. If a bit in this register is set (written with '1'), the Input port data polarity is inverted. If a bit in this register is cleared (written with a '0'), the Input port data polarity is retained.

Polarity Inversion port 0 register

Bit	7	6	5	4	3	2	1	0
Symbol	N0.7	N0.6	N0.5	N0.4	N0.3	N0.2	N0.1	N0.0
Default	0	0	0	0	0	0	0	0

Polarity Inversion port 1 register

Bit	7	6	5	4	3	2	1	0
Symbol	N1.7	N1.6	N1.5	N1.4	N1.3	N1.2	N1.1	N1.0
Default	0	0	0	0	0	0	0	0

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5.2.5 Registers 6 and 7: Configuration registers

This register configures the directions of the I/O pins. If a bit in this register is set (written with '1'), the corresponding port pin is enabled as an input with high-impedance output driver. If a bit in this register is cleared (written with '0'), the corresponding port pin is enabled as an output. At reset, the device's ports are inputs.

Configuration port 0 register

Bit	7	6	5	4	3	2	1	0
Symbol	C0.7	C0.6	C0.5	C0.4	C0.3	C0.2	C0.1	C0.0
Default	1	1	1	1	1	1	1	1

Configuration port 1 register

Bit	7	6	5	4	3	2	1	0
Symbol	C1.7	C1.6	C1.5	C1.4	C1.3	C1.2	C1.1	C1.0
Default	1	1	1	1	1	1	1	1

5.3 Power-on reset

When power is applied to V_{DD} , an internal power-on reset holds the XL9535 in a reset condition until V_{DD} has reached V_{POR} . At that point, the reset condition is released and the XL9535 registers and SMBus state machine will initialize to their default states. Thereafter, V_{DD} must be lowered below 0.2 V to reset the device.

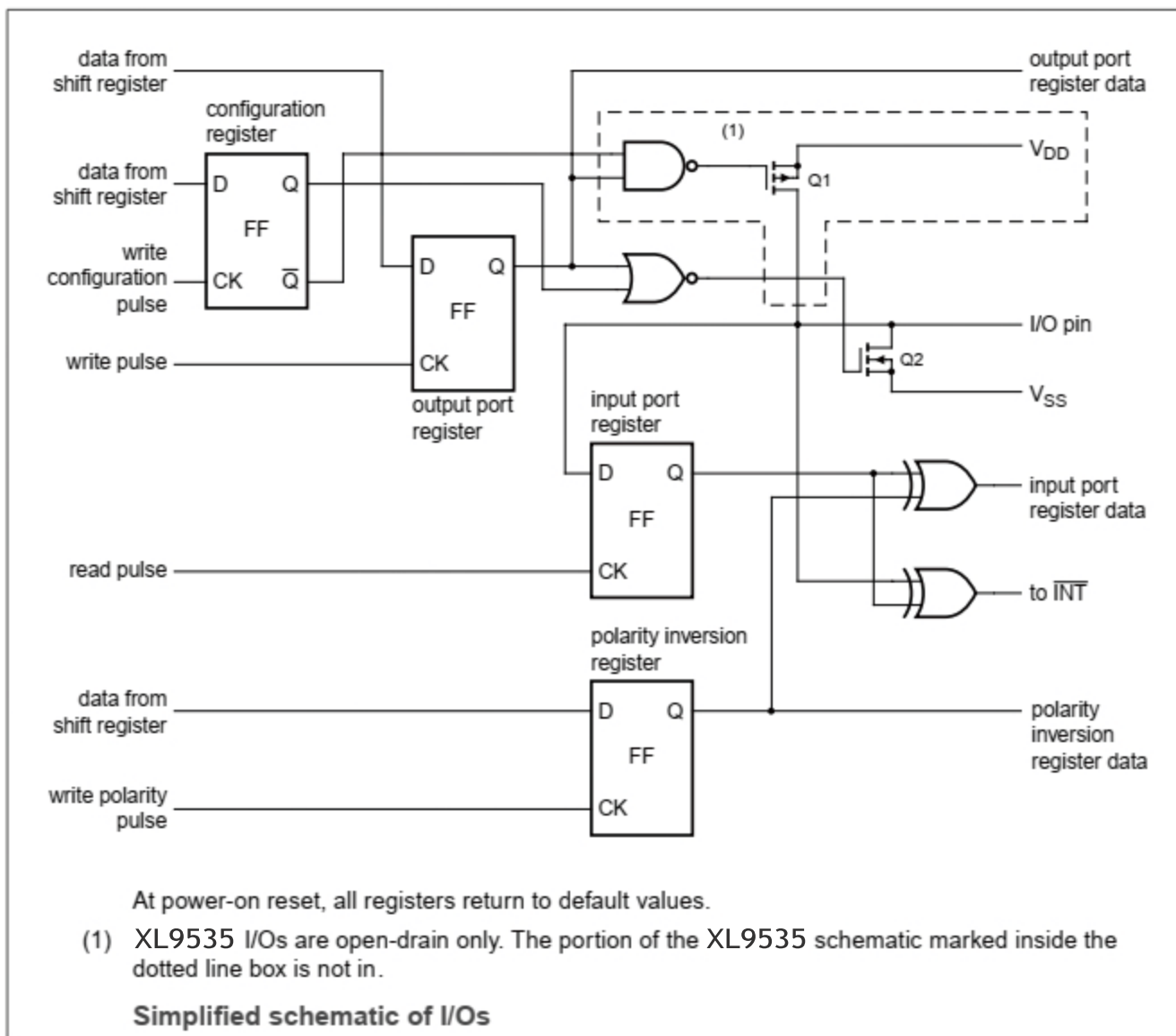
For a power reset cycle, V_{DD} must be lowered below 0.2 V and then restored to the operating voltage.

5.4 I/O port

When an I/O is configured as an input on XL9535, FETs Q1 and Q2 are off, creating a high impedance input. The input voltage may be raised above V_{DD} to a maximum of 5.5 V. In the case of XL9535, FET Q1 has been removed and the open-drain FET Q2 will function the same as XL9535.

If the I/O is configured as an output, then on XL9535 either Q1 or Q2 is on, depending on the state of the Output Port register. Care should be exercised if an external voltage is applied to an I/O configured as an output because of the low-impedance path that exists between the pin and either V_{DD} or V_{SS} .

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5.5 Bus transactions

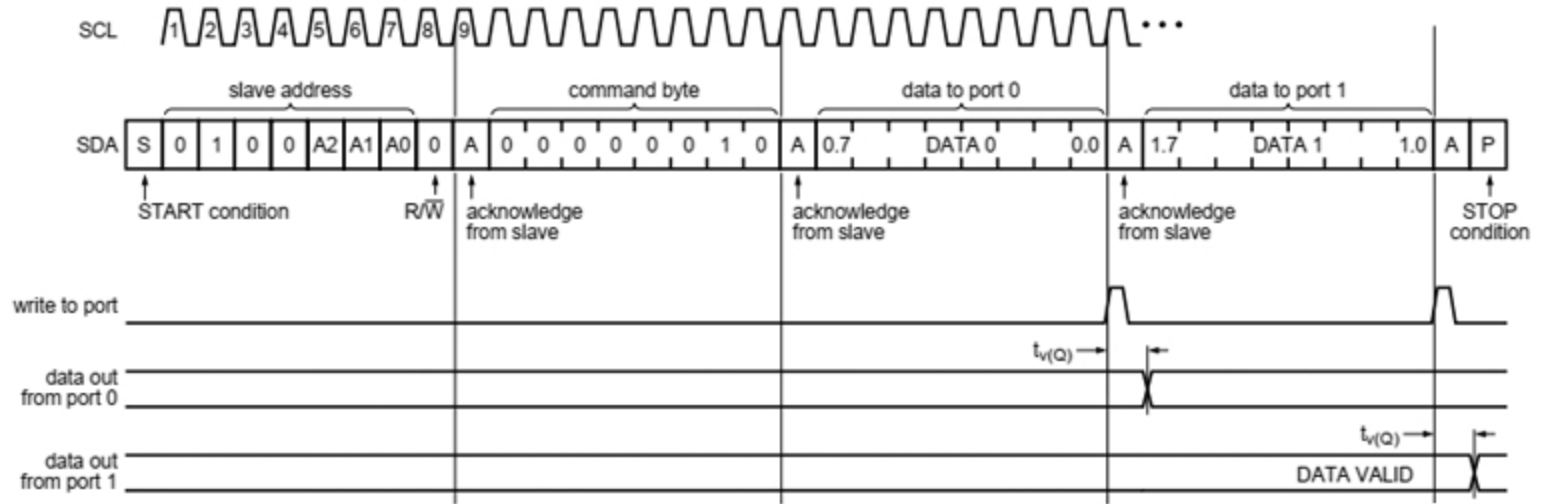
5.5.1 Writing to the port registers

Data is transmitted to the XL9535 by sending the device address and setting the least significant bit to a logic 0.

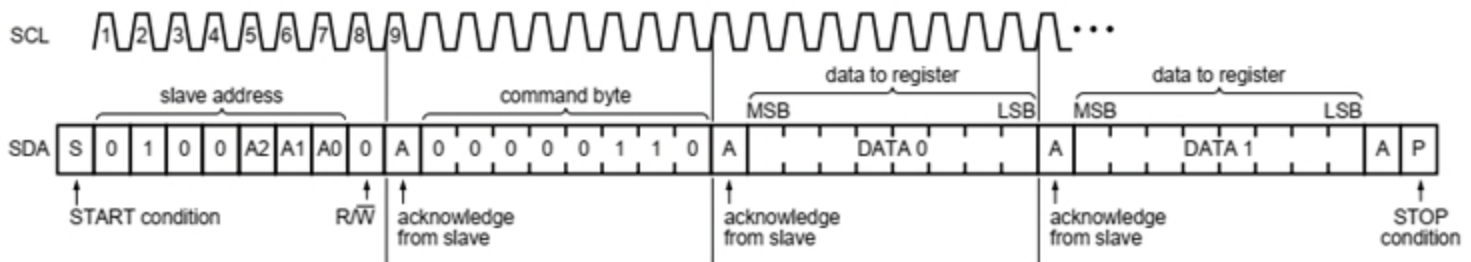
The command byte is sent after the address and determines which register will receive the data following the command byte.

The eight registers within the XL9535 are configured to operate as four register pairs. The four pairs are Input Ports, Output Ports, Polarity Inversion Ports, and Configuration Ports. After sending data to one register, the next data byte will be sent to the other register in the pair. For example, if the first byte is sent to Output Port 1 (register 3), then the next byte will be stored in Output Port 0 (register 2). There is no limitation on the number of data bytes sent in one write transmission. In this way, each 8-bit register may be updated independently of the other registers.

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Write to Output Port registers



Write to Configuration registers

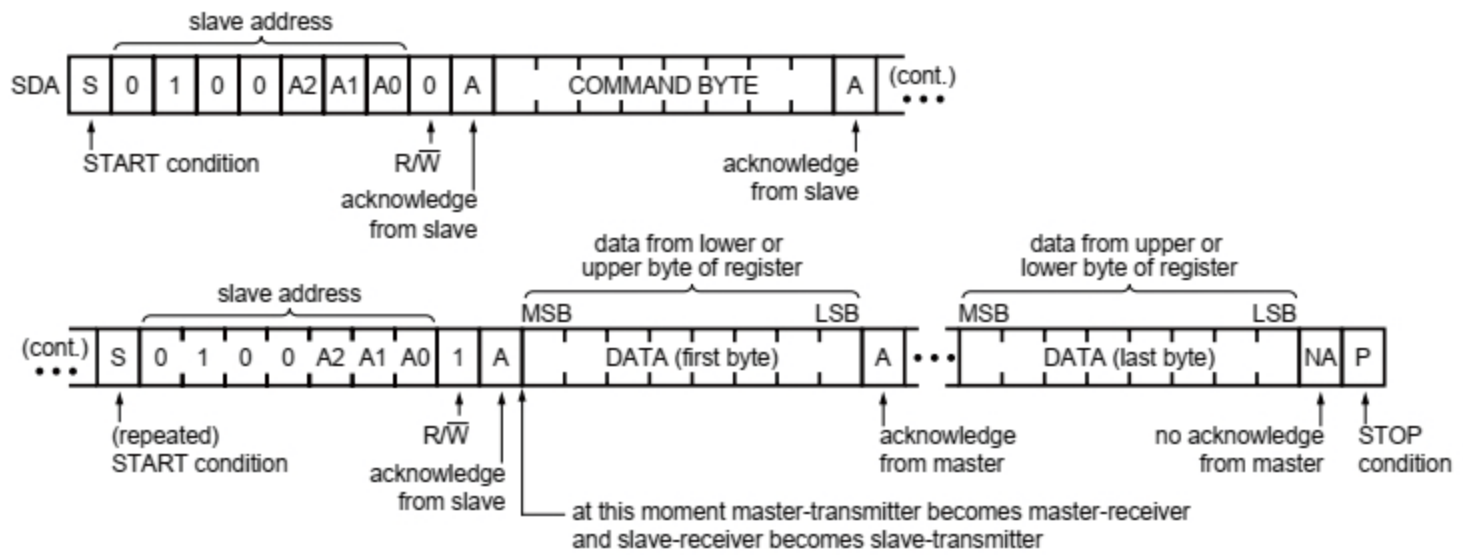
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6.5.2 Reading the port registers

In order to read data from the XL9535, the bus master must first send the XL9535 address with the least significant bit set to a logic 0.

The command byte is sent after the address and determines which register will be accessed. After a restart, the device address is sent again, but this time the least significant bit is set to a logic 1. Data from the register defined by the command byte will then be sent by the XL9535.

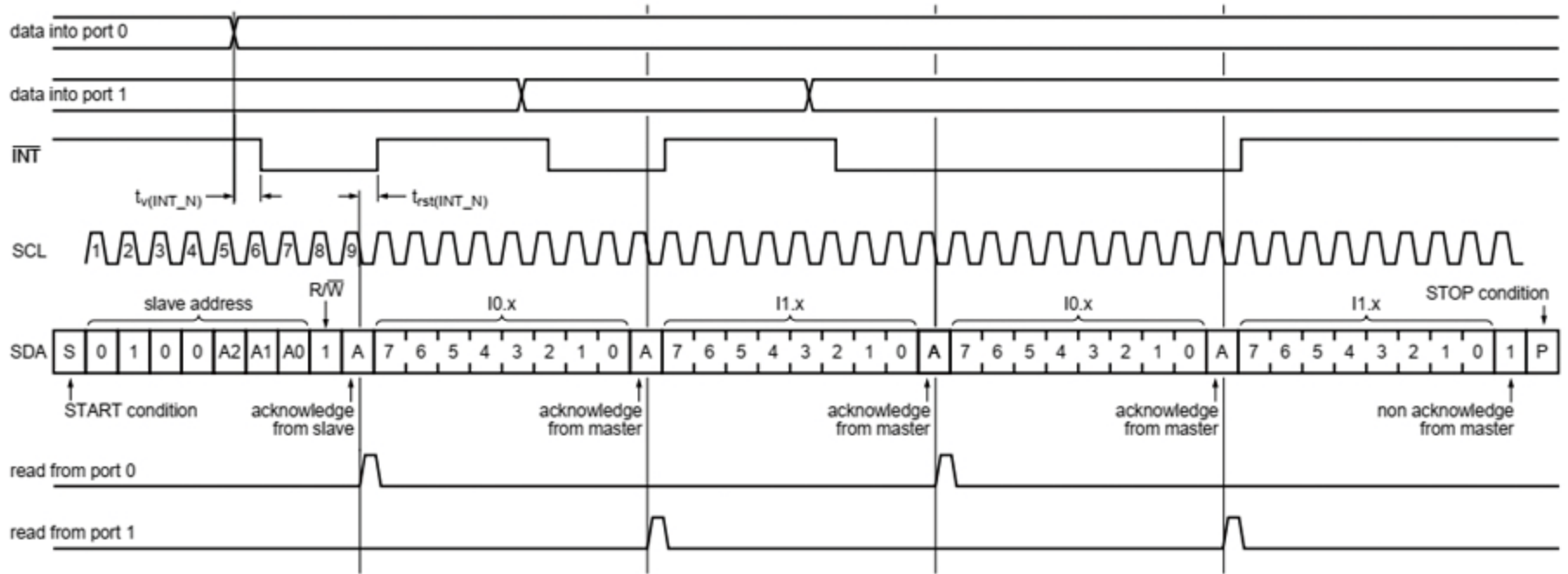
Data is clocked into the register on the falling edge of the acknowledge clock pulse. After the first byte is read, additional bytes may be read but the data will now reflect the information in the other register in the pair. For example, if you read Input Port 1, then the next byte read would be Input Port 0. There is no limitation on the number of data bytes received in one read transmission but the final byte received, the bus master must not acknowledge the data.



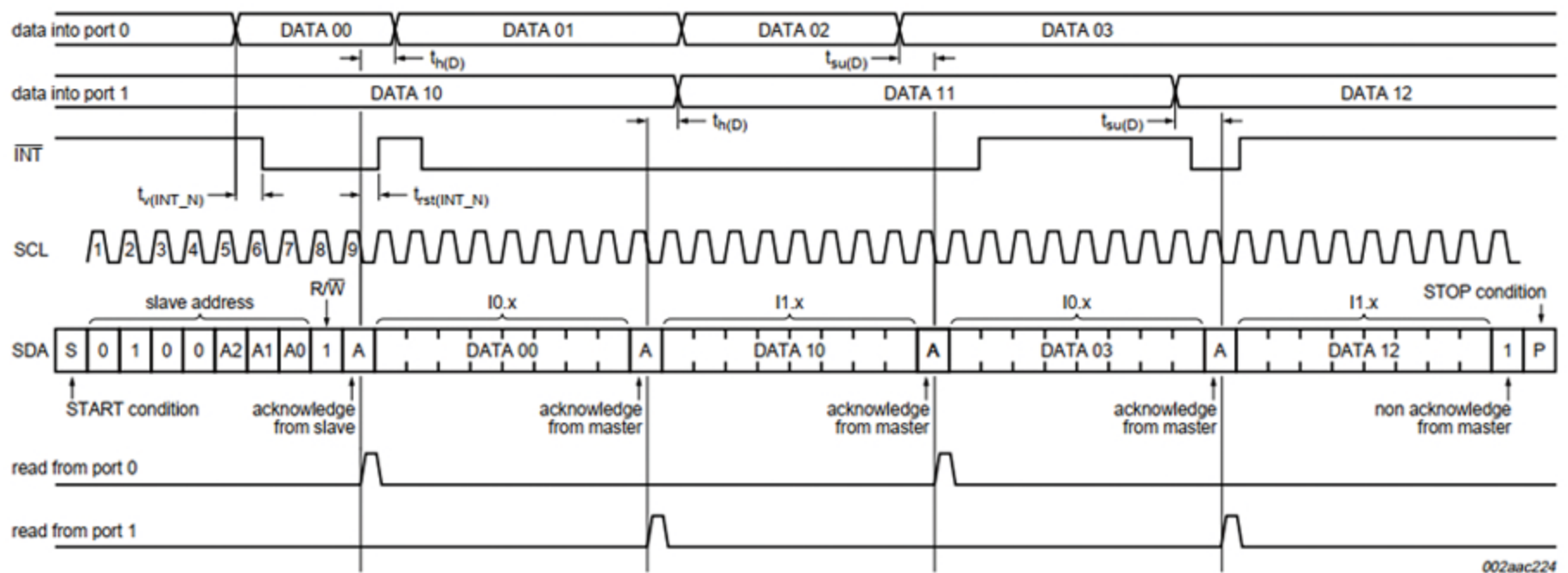
Remark: Transfer can be stopped at any time by a STOP condition.

Read from register

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Remark: Transfer of data can be stopped at any moment by a STOP condition. When this occurs, data present at the latest acknowledge phase is valid (output mode). It is assumed that the command byte has previously been set to '00' (read Input Port register).



Remark: Transfer of data can be stopped at any moment by a STOP condition. When this occurs, data present at the latest acknowledge phase is valid (output mode). It is assumed that the command byte has previously been set to '00' (read Input Port register).

Read Input Port register, scenario 2

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5.5.3 Interrupt output

The open-drain interrupt output is activated when one of the port pins change state and the pin is configured as an input. The interrupt is deactivated when the input returns to its previous state or the Input Port register is read. A pin configured as an output cannot cause an interrupt. Since each 8-bit port is read independently, the interrupt caused by Port 0 will not be cleared by a read of Port 1 or the other way around.

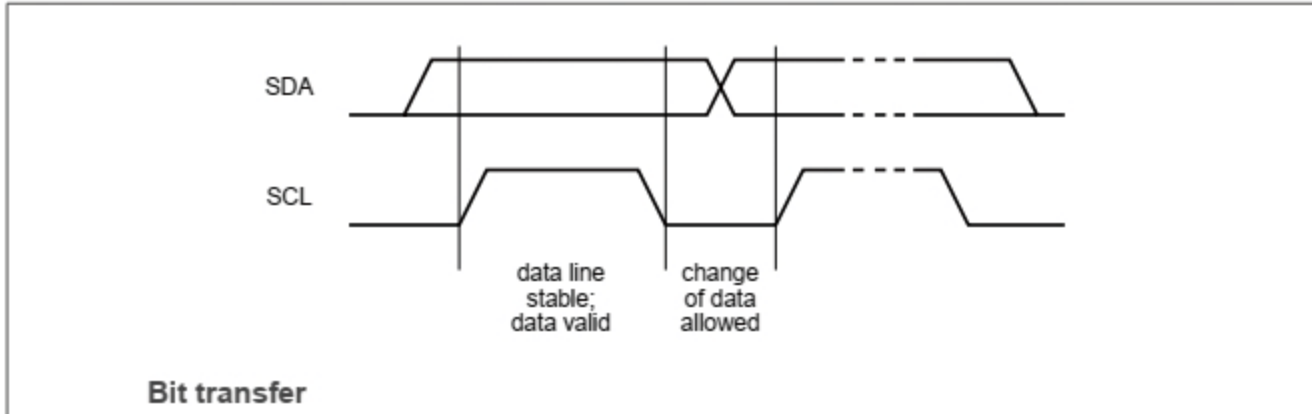
Remark: Changing an I/O from an output to an input may cause a false interrupt to occur if the state of the pin does not match the contents of the Input Port register.

6. Characteristics of the I²C-bus

The I²C-bus is for 2-way, 2-line communication between different ICs or modules. The two lines are a serial data line (SDA) and a serial clock line (SCL). Both lines must be connected to a positive supply via a pull-up resistor when connected to the output stages of a device. Data transfer may be initiated only when the bus is not busy.

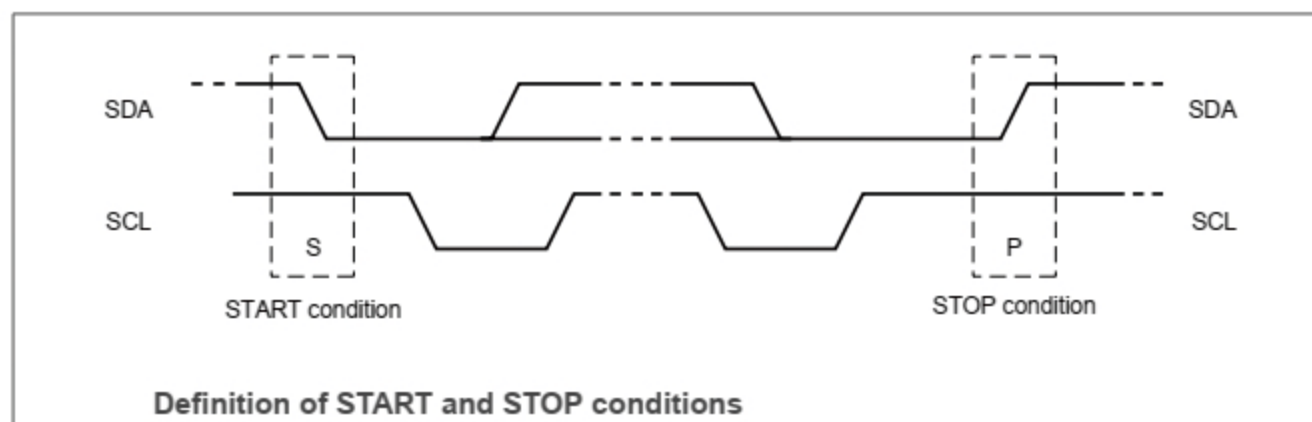
6.1 Bit transfer

One data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the HIGH period of the clock pulse as changes in the data line at this time will be interpreted as control signals.



6.1.1 START and STOP conditions

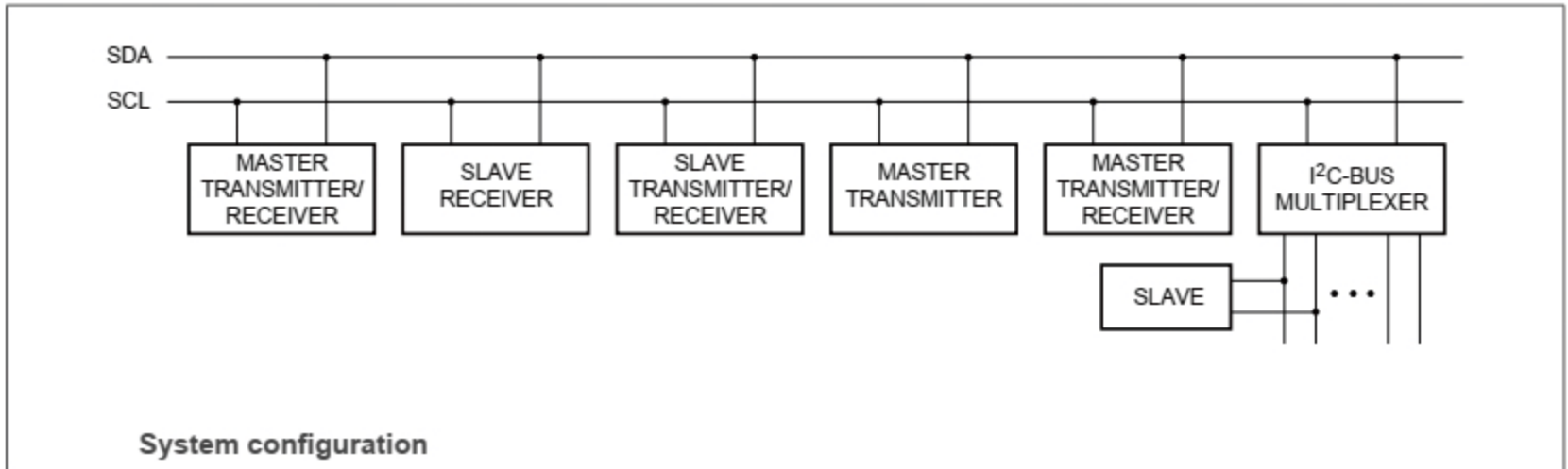
Both data and clock lines remain HIGH when the bus is not busy. A HIGH-to-LOW transition of the data line while the clock is HIGH is defined as the START condition (S). A LOW-to-HIGH transition of the data line while the clock is HIGH is defined as the STOP condition (P).



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6.2 System configuration

A device generating a message is a 'transmitter'; a device receiving is the 'receiver'. The device that controls the message is the 'master' and the devices which are controlled by the master are the 'slaves'.

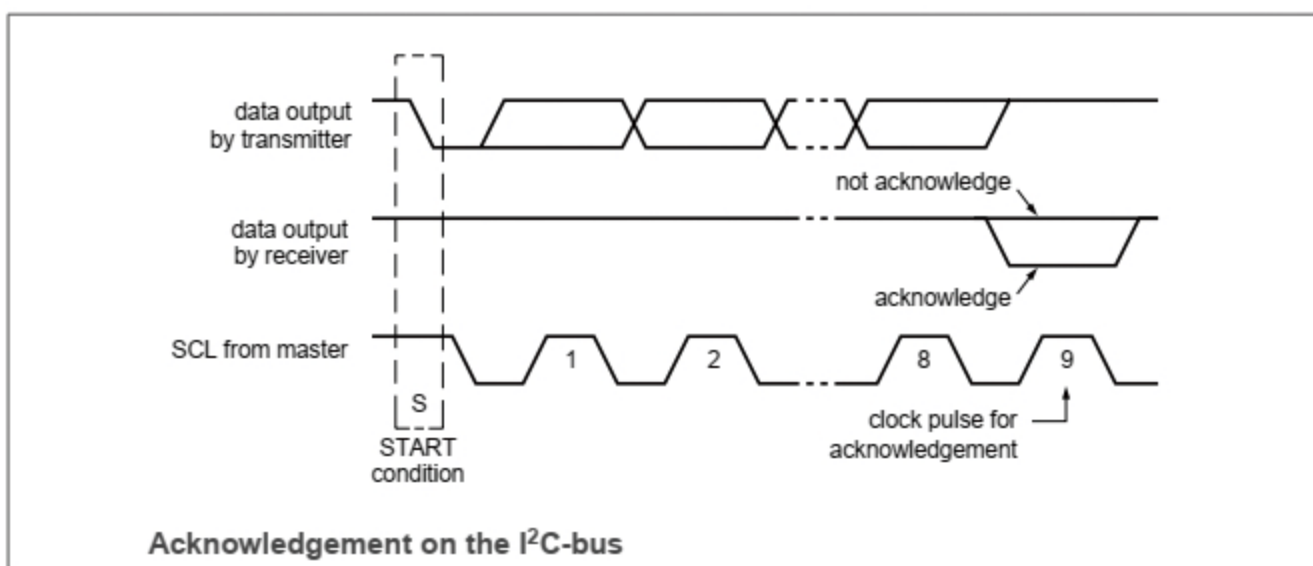


6.3 Acknowledge

The number of data bytes transferred between the START and the STOP conditions from transmitter to receiver is not limited. Each byte of eight bits is followed by one acknowledge bit. The acknowledge bit is a HIGH level put on the bus by the transmitter, whereas the master generates an extra acknowledge related clock pulse.

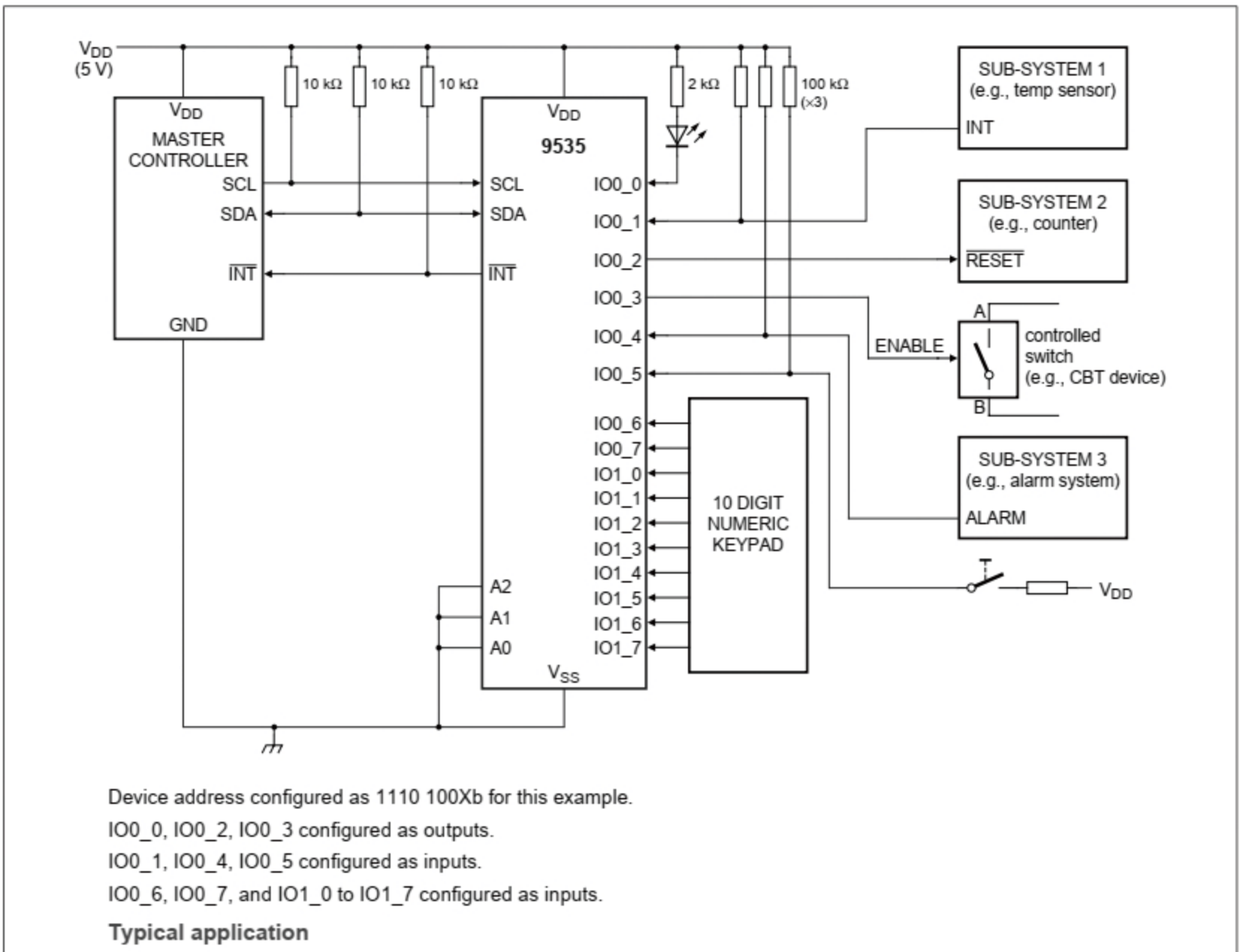
A slave receiver which is addressed must generate an acknowledge after the reception of each byte. Also a master must generate an acknowledge after the reception of each byte that has been clocked out of the slave transmitter. The device that acknowledges has to pull down the SDA line during the acknowledge clock pulse, so that the SDA line is stable LOW during the HIGH period of the acknowledge related clock pulse; set-up time and hold time must be taken into account.

A master receiver must signal an end of data to the transmitter by not generating an acknowledge on the last byte that has been clocked out of the slave. In this event, the transmitter must leave the data line HIGH to enable the master to generate a STOP condition.



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7. Application design-in information



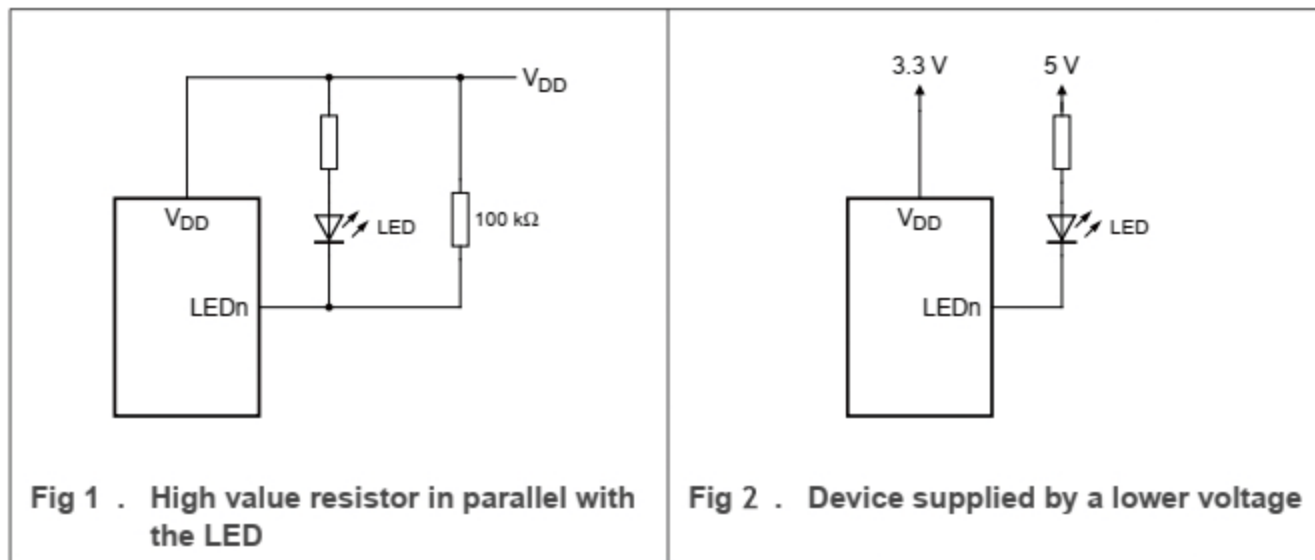
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7.1 Minimizing I_{DD} when the I/Os are used to control LEDs

When the XL9535 I/Os are used to control LEDs, they are normally connected to V_{DD} through a resistor. Since the LED acts as a diode, when the LED is off the I/O V_I is about 1.2 V less than V_{DD} . The supply current, I_{DD} , increases as V_I becomes lower than V_{DD} .

Designs needing to minimize current consumption, such as battery power applications, should consider maintaining the I/O pins greater than or equal to V_{DD} when the LED is off. [Figure 1](#) shows a high value resistor in parallel with the LED. [Figure 2](#) shows V_{DD} less than the LED supply voltage by at least 1.2 V. Both of these methods maintain the I/O V_I at or above V_{DD} and prevents additional supply current consumption when the LED is off.

This concern does not occur in the case of PCA9535C because the I/O pins are open-drain.



8. Limiting values

Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DD}	supply voltage		-0.5	+6.0	V
$V_{I/O}$	voltage on an input/output pin		$V_{SS} - 0.5$	6	V
I_O	output current	on an I/O pin	-	±50	mA
I_I	input current		-	±20	mA
I_{DD}	supply current		-	160	mA
I_{SS}	ground supply current		-	200	mA
P_{tot}	total power dissipation		-	200	mW
T_{stg}	storage temperature		-65	+150	°C
T_{amb}	ambient temperature	operating	-40	+85	°C

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9. Static characteristics

Static characteristics

$V_{DD} = 2.3\text{ V to }5.5\text{ V}$; $V_{SS} = 0\text{ V}$; $T_{amb} = -40\text{ }^{\circ}\text{C to }+85\text{ }^{\circ}\text{C}$; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Supplies						
V_{DD}	supply voltage		2.3	-	5.5	V
I_{DD}	supply current	Operating mode; $V_{DD} = 5.5\text{ V}$; no load; $f_{SCL} = 100\text{ kHz}$; I/O = inputs	-	135	200	μA
I_{stb}	standby current	Standby mode; $V_{DD} = 5.5\text{ V}$; no load; $V_I = V_{SS}$; $f_{SCL} = 0\text{ kHz}$; I/O = inputs	-	0.25	1	μA
		Standby mode; $V_{DD} = 5.5\text{ V}$; no load; $V_I = V_{DD}$; $f_{SCL} = 0\text{ kHz}$; I/O = inputs	-	0.25	1	μA
V_{POR}	power-on reset voltage ^[1]	no load; $V_I = V_{DD}$ or V_{SS}	-	1.5	1.65	V
Input SCL; input/output SDA						
V_{IL}	LOW-level input voltage		-0.5	-	+0.3 V_{DD}	V
V_{IH}	HIGH-level input voltage		0.7 V_{DD}	-	5.5	V
I_{OL}	LOW-level output current	$V_{OL} = 0.4\text{ V}$	3	-	-	mA
I_L	leakage current	$V_I = V_{DD} = V_{SS}$	-1	-	+1	μA
C_i	input capacitance	$V_I = V_{SS}$	-	6	10	pF
I/Os						
V_{IL}	LOW-level input voltage		-0.5	-	+0.3 V_{DD}	V
V_{IH}	HIGH-level input voltage		0.7 V_{DD}	-	5.5	V
I_{OL}	LOW-level output current	$V_{DD} = 2.3\text{ V to }5.5\text{ V}$; $V_{OL} = 0.5\text{ V}$	[2] 8	10	-	mA
		$V_{DD} = 2.3\text{ V to }5.5\text{ V}$; $V_{OL} = 0.7\text{ V}$	[2] 10	14	-	mA
V_{OH}	HIGH-level output voltage	XL9535 only				
		$I_{OH} = -8\text{ mA}$; $V_{DD} = 2.3\text{ V}$	[3] 1.8	-	-	V
		$I_{OH} = -10\text{ mA}$; $V_{DD} = 2.3\text{ V}$	[3] 1.7	-	-	V
		$I_{OH} = -8\text{ mA}$; $V_{DD} = 3.0\text{ V}$	[3] 2.6	-	-	V
		$I_{OH} = -10\text{ mA}$; $V_{DD} = 3.0\text{ V}$	[3] 2.5	-	-	V
		$I_{OH} = -8\text{ mA}$; $V_{DD} = 4.75\text{ V}$	[3] 4.1	-	-	V
I_{LIH}	HIGH-level input leakage current	$V_{DD} = 5.5\text{ V}$; $V_I = V_{DD}$	-	-	1	μA
		$V_{DD} = 5.5\text{ V}$; $V_I = V_{SS}$	-	-	-1	μA
I_{LIL}	LOW-level input leakage current	$V_{DD} = 5.5\text{ V}$; $V_I = V_{SS}$	-	-	-1	μA
C_i	input capacitance		-	3.7	5	pF
C_o	output capacitance		-	3.7	5	pF
Interrupt $\overline{\text{INT}}$						
I_{OL}	LOW-level output current	$V_{OL} = 0.4\text{ V}$	3	-	-	mA
Select inputs A0, A1, A2						
V_{IL}	LOW-level input voltage		-0.5	-	+0.3 V_{DD}	V
V_{IH}	HIGH-level input voltage		0.7 V_{DD}	-	5.5	V
I_{LI}	input leakage current		-1	-	+1	μA

[1] V_{DD} must be lowered to 0.2 V for at least 5 μs in order to reset part.

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- [2] Each I/O must be externally limited to a maximum of 25 mA and each octal (IO0_0 to IO0_7 and IO1_0 to IO1_7) must be limited to a maximum current of 100 mA for a device total of 200 mA.
- [3] The total current sourced by all I/Os must be limited to 160 mA. XL9535 does not source current and does not have the V_{OH} specification.

10. Dynamic characteristics

Dynamic characteristics

Symbol	Parameter	Conditions	Standard-mode I ² C-bus		Fast-mode I ² C-bus		Unit
			Min	Max	Min	Max	
f_{SCL}	SCL clock frequency		0	100	0	400	kHz
t_{BUF}	bus free time between a STOP and START condition		4.7	-	1.3	-	μ s
$t_{HD;STA}$	hold time (repeated) START condition		4.0	-	0.6	-	μ s
$t_{SU;STA}$	set-up time for a repeated START condition		4.7	-	0.6	-	μ s
$t_{SU;STO}$	set-up time for STOP condition		4.0	-	0.6	-	μ s
$t_{VD;ACK}$	data valid acknowledge time	[1]	0.3	3.45	0.1	0.9	μ s
$t_{HD;DAT}$	data hold time		0	-	0	-	ns
$t_{VD;DAT}$	data valid time	[2]	300	-	50	-	ns
$t_{SU;DAT}$	data set-up time		250	-	100	-	ns
t_{LOW}	LOW period of the SCL clock		4.7	-	1.3	-	μ s
t_{HIGH}	HIGH period of the SCL clock		4.0	-	0.6	-	μ s
t_f	fall time of both SDA and SCL signals		-	300	$20 + 0.1C_b^{[3]}$	300	ns
t_r	rise time of both SDA and SCL signals		-	1000	$20 + 0.1C_b^{[3]}$	300	ns
t_{SP}	pulse width of spikes that must be suppressed by the input filter		-	50	-	50	ns
Port timing							
$t_{V(Q)}$	data output valid time	[4]	-	200	-	200	ns
$t_{su(D)}$	data input set-up time		150	-	150	-	ns
$t_{h(D)}$	data input hold time		1	-	1	-	μ s
Interrupt timing							
$t_{V(INT_N)}$	valid time on pin \overline{INT}		-	4	-	4	μ s
$t_{rst(INT_N)}$	reset time on pin \overline{INT}		-	4	-	4	μ s

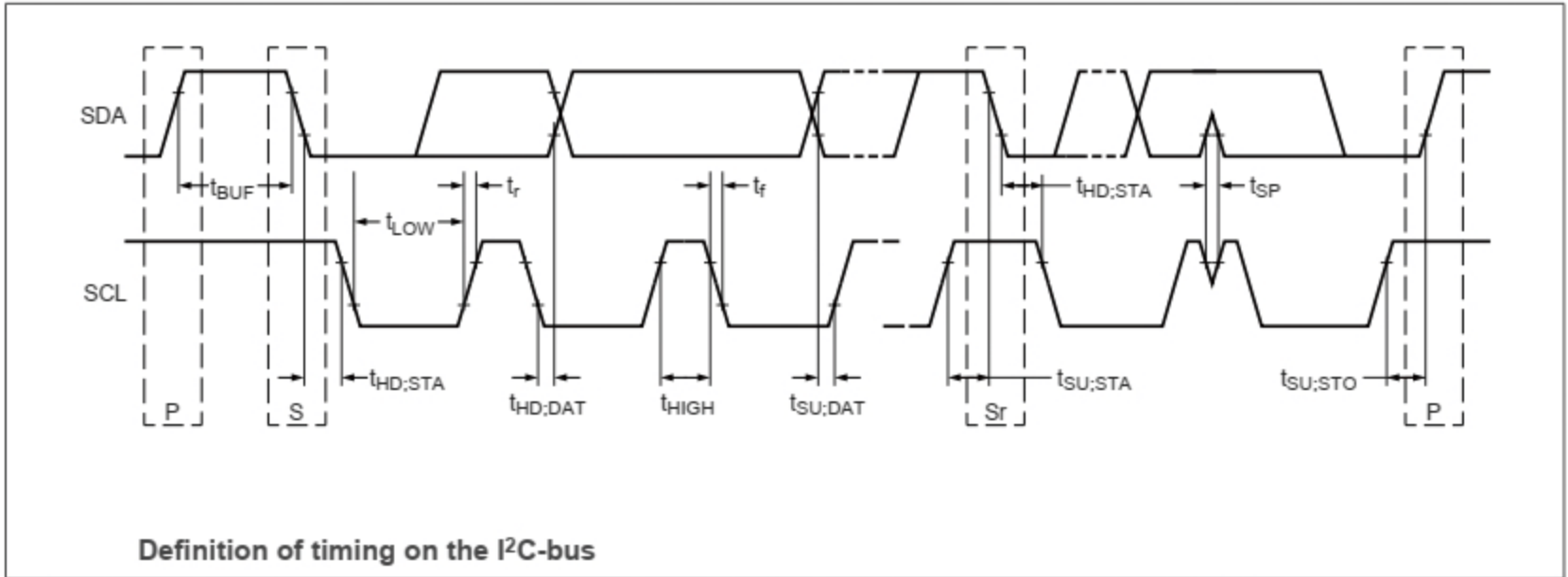
[1] $t_{VD;ACK}$ = time for acknowledgement signal from SCL LOW to SDA (out) LOW.

[2] $t_{VD;DAT}$ = minimum time for SDA data out to be valid following SCL LOW.

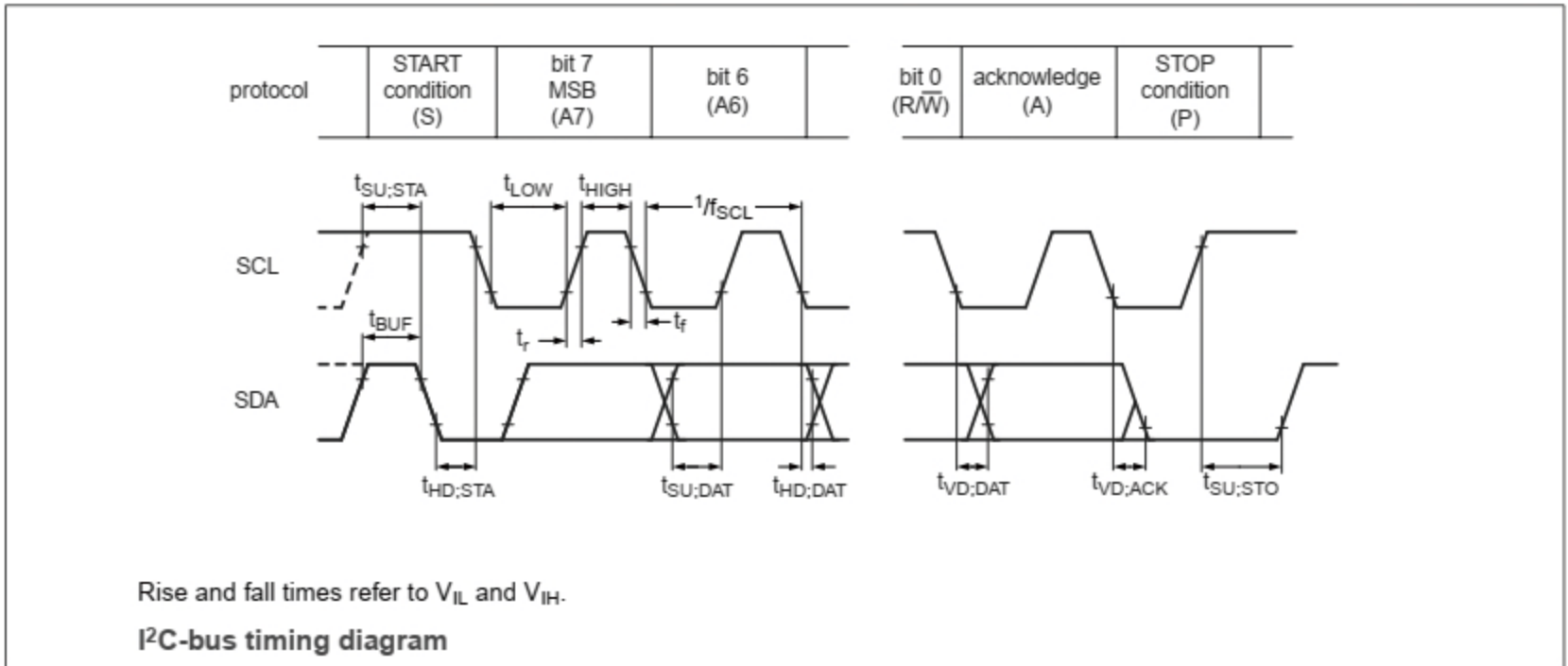
[3] C_b = total capacitance of one bus line in pF.

[4] $t_{V(Q)}$ measured from $0.7V_{DD}$ on SCL to 50 % I/O output (XL9535). For XL9535, use load circuit and measure from $0.7V_{DD}$ on SCL to 30 % I/O output.

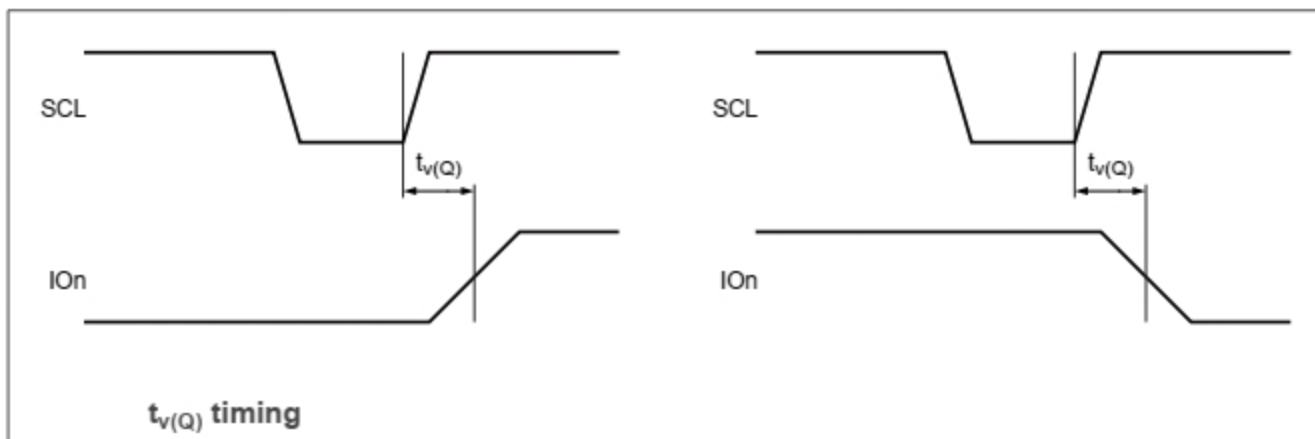
XL9535 TSSOP24



Definition of timing on the I²C-bus



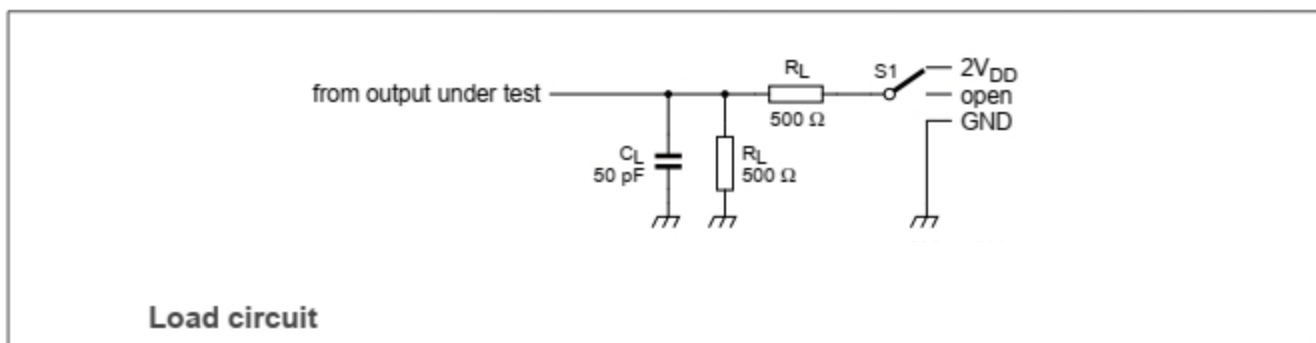
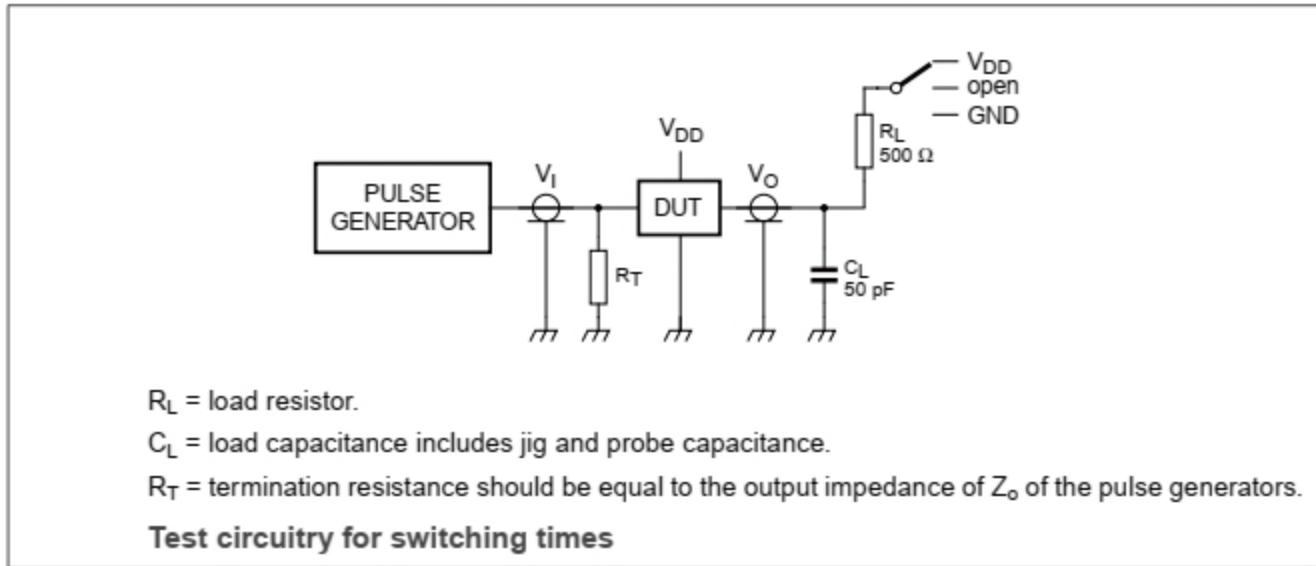
I²C-bus timing diagram



$t_{V(Q)}$ timing

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11. Test information



以上信息仅供参考. 如需帮助联系客服人员。谢谢 XINLUDA