

# PCA9600

## Dual Bidirectional Bus Buffer

Rev. 6.2 — 18 August 2025

Product data sheet



### Document information

Information	Content
Keywords	PCA9600, I <sup>2</sup> C-bus, bidirectional, buffer
Abstract	The PCA9600 device is designed to isolate I <sup>2</sup> C-bus capacitance, allowing long buses to be driven in point-to-point or multipoint applications of up to 4000 pF.



## 1 General description

The PCA9600 device is designed to isolate I<sup>2</sup>C-bus capacitance, allowing long buses to be driven in point-to-point or multipoint applications of up to 4000 pF. The PCA9600 is a higher-speed version of the P82B96. It creates a non-latching, bidirectional, logic interface between a normal I<sup>2</sup>C-bus and a range of other higher capacitance or different voltage bus configurations. It can operate at speeds up to at least 1 MHz, and the high drive side is compatible with the Fast-mode Plus (Fm+) specifications.

The PCA9600 features temperature-stabilized logic voltage levels at its SX/SY interface making it suitable for interfacing with buses that have non I<sup>2</sup>C-bus-compliant logic levels such as SMBus, PMBus, or with microprocessors that use those same TTL logic levels.

The separation of the bidirectional I<sup>2</sup>C-bus signals into unidirectional TX and RX signals enables the SDA and SCL signals to be transmitted via balanced transmission lines (twisted pairs), or with galvanic isolation using opto or magnetic coupling. The TX and RX signals can be connected together to provide a normal bidirectional signal.

## 2 Features and benefits

- Bidirectional data transfer of I<sup>2</sup>C-bus signals
- Isolates capacitance allowing 400 pF on SX/SY side and 4000 pF on TX/TY side
- TX/TY outputs have 60 mA sink capability for driving low-impedance or high-capacitive buses
- 1 MHz operation on up to 20 meters of wire (for more detail, *Sending I2C-bus signals via long communications cables* (document [AN10658](#)))
- Supply voltage range of 2.5 V to 15 V with I<sup>2</sup>C-bus logic levels on SX/SY side independent of supply voltage
- Splits I<sup>2</sup>C-bus signal into pairs of forward/reverse TX/RX, TY/RX signals for interface with opto-electrical isolators and similar devices that need unidirectional input and output signal paths
- Low power supply current
- ESD protection exceeds 3500 V HBM per JESD22-A114 and 1000 V CDM per JESD22-C101
- Latch-up testing is done to JEDEC Standard JESD78, which exceeds 100 mA
- Packages offered: SO8 and TSSOP8 (MSOP8)

## 3 Applications

- Interface between I<sup>2</sup>C-buses operating at different logic levels (for example, 5 V, 3 V, or 15 V)
- Interface between I<sup>2</sup>C-bus and SMBus (350  $\mu$ A) standard or Fm+ standard
- Simple conversion of I<sup>2</sup>C-bus SDA or SCL signals to multi-drop differential bus hardware, for example, via compatible PCA82C250
- Interfaces with opto-couplers to provide opto-isolation between I<sup>2</sup>C-bus nodes up to 1 MHz
- Long-distance point-to-point or multipoint architectures

## 4 Ordering information

[Table 1](#) describes the ordering information for PCA9600.

Table 1. Ordering information

Type number	Topside marking	Package		
		Name	Description	Version
PCA9600D	PCA9600	SO8	Plastic small outline package; 8 leads; body width 3.9 mm	SOT96-1

Table 1. Ordering information...continued

Type number	Topside marking	Package		
		Name	Description	Version
PCA9600DP	9600	TSSOP8	Plastic thin shrink small outline package; 8 leads; body width 3 mm	SOT505-1

4.1 Ordering options

Table 2 describes the ordering options for PCA9600.

Table 2. Ordering options

Type number	Orderable part number	Package	Packing method <sup>[1]</sup>	Minimum order quantity	Temperature
PCA9600D	PCA9600D,118	SO8	REEL 13" Q1/T1 *STANDARD MARK SMD	2500	T <sub>amb</sub> = -40 °C to +85 °C
PCA9600DP	PCA9600DP,118	TSSOP8	REEL 13" Q1/T1 *STANDARD MARK SMD	2500	T <sub>amb</sub> = -40 °C to +85 °C
	PCA9600DPZ <sup>[2]</sup>	TSSOP8	REEL 13" Q1/T1 SSB <sup>[3]</sup>	2500	T <sub>amb</sub> = -40 °C to +85 °C

[1] Standard packing quantities and other packaging data are available at [www.nxp.com/packages](http://www.nxp.com/packages)  
[2] Orderable part number PCA9600DPZ is a drop-in alternate for PCA9600DP,118.  
[3] This packing method uses a static shielding bag (SSB) solution. Material must be kept in a sealed bag between uses.

5 Block diagram

Figure 1 shows the labeled block diagram of PCA9600.

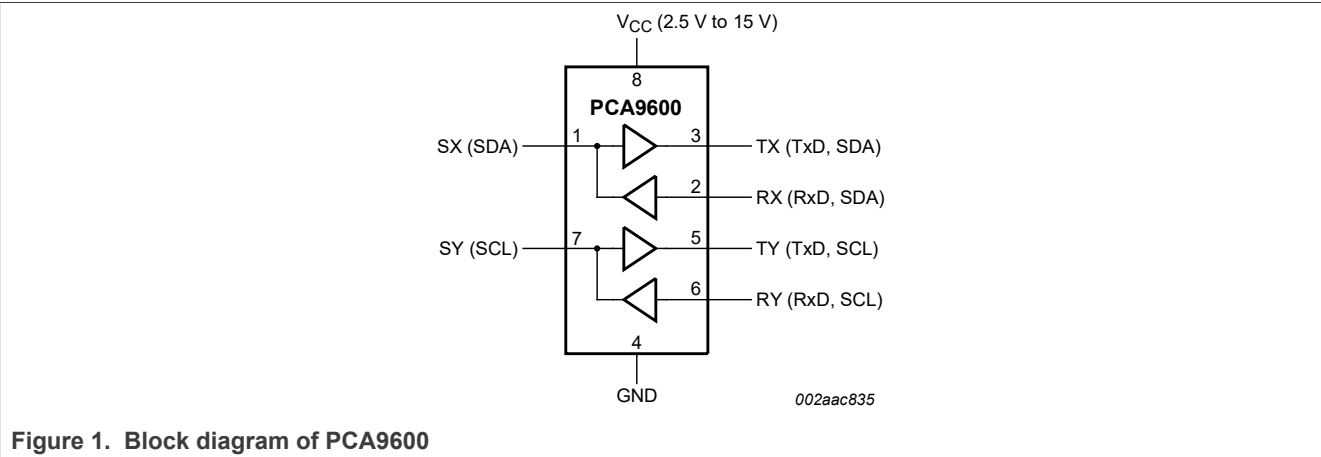


Figure 1. Block diagram of PCA9600

6 Pinning information

This section provides the pin configuration and description of PCA9600.

6.1 Pinning

Figure 2 and Figure 3 show the pin configuration of PCA9600.

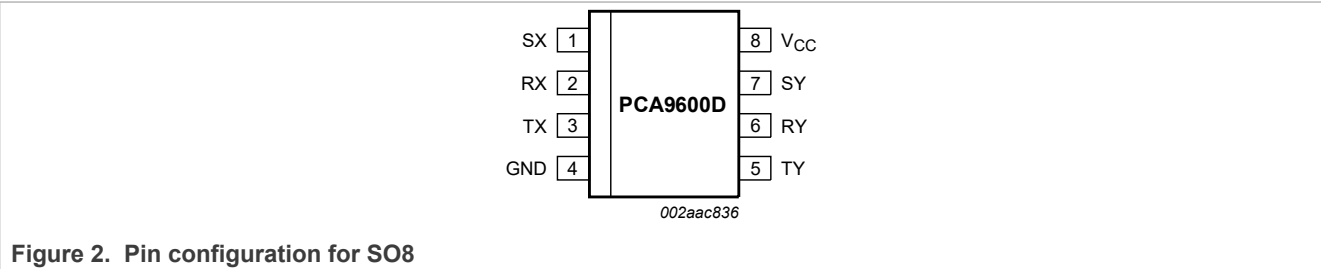


Figure 2. Pin configuration for SO8

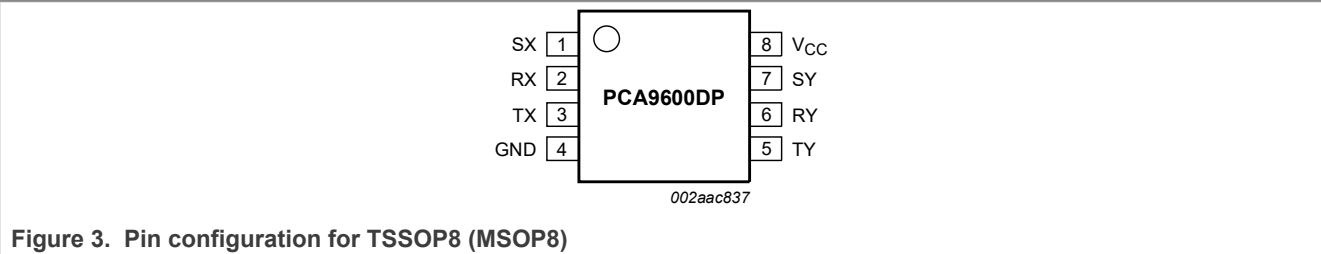


Figure 3. Pin configuration for TSSOP8 (MSOP8)

6.2 Pin description

Table 3 provides detailed description of various pins on PCA9600.

Table 3. Pin description

Symbol	Pin	Description
SX	1	I <sup>2</sup> C-bus (SDA or SCL)
RX	2	Receive signal
TX	3	Transmit signal
GND	4	Negative supply voltage
TY	5	Transmit signal
RY	6	Receive signal
SY	7	I <sup>2</sup> C-bus (SDA or SCL)
VCC	8	Positive supply voltage

7 Functional description

Refer to Figure 1.

The PCA9600 has two identical buffers allowing buffering of SDA and SCL I<sup>2</sup>C-bus signals. Each buffer is made up of two logic signal paths, a forward path from the I<sup>2</sup>C-bus interface, pins SX and SY, which drive the buffered bus, and a reverse signal path from the buffered bus input, pins RX and RY to drive the I<sup>2</sup>C-bus interface. These paths:

- sense the voltage state of I<sup>2</sup>C-bus pins SX (and SY) and transmit this state to pin TX (and TY respectively), and
- sense the state of pins RX and RY and pull the I<sup>2</sup>C-bus pin LOW whenever pin RX or pin RY is LOW.

The rest of this discussion addresses only the 'X' side of the buffer; the 'Y' side is identical.

The I<sup>2</sup>C-bus pin SX is specified to allow interfacing with Fast-mode, Fm+, and TTL-based systems.

The logic threshold voltage levels at SX on this I<sup>2</sup>C-bus are independent of the IC supply voltage  $V_{CC}$ . The maximum I<sup>2</sup>C-bus supply voltage is 15 V.

When interfacing with Fast-mode systems, the SX pin is guaranteed to sink the normal 3 mA with a  $V_{OL}$  of 0.74 V maximum. This characteristic guarantees compliance with the Fast-mode I<sup>2</sup>C-bus specification for all I<sup>2</sup>C-bus voltages greater than 3 V, as well as compliance with SMBus or other systems that use TTL switching levels.

SX is guaranteed to sink an external 3 mA in addition to its internally sourced pullup of typically 300  $\mu$ A (maximum 1 mA at -40 °C). When selecting the pullup for the bus at SX, the sink capability of other connected drivers must be taken into account. Most TTL devices are specified to sink at least 4 mA so that the pullup is limited to 3 mA by the requirement to ensure the 0.8 V TTL LOW.

For Fast-mode I<sup>2</sup>C-bus operation, the other connected I<sup>2</sup>C-bus parts can have the minimum sink capability of 3 mA. SX sources typically 300  $\mu$ A (maximum 1 mA at -40 °C), which forms part of the external driver loading. When selecting the pullup, it is necessary to subtract the SX pin pullup current. So, worst-case at -40 °C, the allowed pullup can be limited (by external drivers) to 2 mA.

When the interface at SX is an Fm+ bus with a voltage greater than 4 V, its higher specified sink capability can be used. PCA9600 has a guaranteed sink capability of 7 mA at  $V_{OL} = 1$  V maximum. This 1 V complies with the bus LOW requirement ( $0.25V_{bus}$ ) of any Fm+ bus operating at 4 V or greater. Since the other connected Fm+ devices have a drive capability greater than 20 mA, the pullup can be selected for 7 mA sink current at  $V_{OL} = 1$  V. For a nominal 5 V bus (5.5 V maximum), the allowed pullup is  $(5.5 \text{ V} - 1 \text{ V}) / 7 \text{ mA} = 643 \text{ } \Omega$ . With 680  $\Omega$  pullup, the Fm+ rise time of 120 ns maximum can be met with total bus loading up to 200 pF.

The logic level on RX is determined from the power supply voltage  $V_{CC}$  of the chip. Logic LOW is below 40 % of  $V_{CC}$ , and logic HIGH is above 55 % of  $V_{CC}$  (with a typical switching threshold slightly below half  $V_{CC}$ ).

TX is an open-collector output without ESD protection diodes to  $V_{CC}$ . It can be connected via a pullup resistor to a supply voltage in excess of  $V_{CC}$ , as long as the 15 V rating is not exceeded. It has a larger current sinking capability than a normal I<sup>2</sup>C-bus device, being able to sink a static current of greater than 30 mA, and typical 100 mA dynamic pulldown capability as well.

A logic LOW is transmitted to TX when the voltage at I<sup>2</sup>C-bus pin SX is below 0.425 V. A logic LOW at RX causes I<sup>2</sup>C-bus pin SX to be pulled to a logic LOW level in accordance with I<sup>2</sup>C-bus requirements (maximum 1.5 V in 5 V applications) but not low enough to be looped back to the TX output and cause the buffer to latch LOW.

The LOW level that this chip can achieve on the I<sup>2</sup>C-bus by a LOW at RX is typically 0.64 V when sinking 1 mA.

If the supply voltage  $V_{CC}$  fails, then neither the I<sup>2</sup>C-bus nor the TX output is held LOW. Their open-collector configuration allows them to be pulled up to the rated maximum of 15 V even without  $V_{CC}$  present. The input configuration on SX and RX also presents no loading of external signals when  $V_{CC}$  is not present.

The effective input capacitance of any signal pin, measured by its effect on bus rise times, is less than 10 pF for all bus voltages and supply voltages including  $V_{CC} = 0$  V.

**Remark:** Two or more SX or SY I/Os must not be interconnected. The PCA9600 design does not support this configuration. Bidirectional I<sup>2</sup>C-bus signals do not allow any direction control pin. Instead, slightly different logic LOW voltage levels are used at SX/SY to avoid latching of this buffer. A 'regular I<sup>2</sup>C-bus LOW' applied at the RX/RX of a PCA9600 propagates to SX/SY as a 'buffered LOW' with a slightly higher voltage level. If this special 'buffered LOW' is applied to the SX/SY of another PCA9600, that second PCA9600 does not recognize

it as a 'regular I<sup>2</sup>C-bus LOW' and does not propagate it to its TX/TY output. The SX/SY side of PCA9600 cannot be connected to similar buffers that rely on special logic thresholds for their operation, for example P82B96, PCA9511A, PCA9515A, 'B' side of PCA9517, and so on. The SX/SY side is only intended for, and compatible with, the normal I<sup>2</sup>C-bus logic voltage levels of an I<sup>2</sup>C-bus controller and target chips, or even TX/RX signals of a second PCA9600 or P82B96 if required. The TX/RX and TY/RX I/O pins use the standard I<sup>2</sup>C-bus logic voltage levels of all I<sup>2</sup>C-bus parts. There are **no** restrictions on the interconnection of the TX/RX and TY/RX I/O pins to other PCA9600s, for example in a star or multipoint configuration with the TX/RX and TY/RX I/O pins on the common bus and the SX/SY side connected to the line card target devices. For more details, see *Sending I<sup>2</sup>C-bus signals via long communication cables* (document [AN10658](#)).

The PCA9600 is a direct upgrade of the P82B96 with the significant differences summarized in [Table 4](#).

**Table 4. PCA9600 versus P82B96**

Detail	PCA9600	P82B96
Supply voltage (V <sub>CC</sub> ) range:	2.5 V to 15 V	2 V to 15 V
Maximum operating bus voltage (independent of V <sub>CC</sub> ):	15 V	15 V
Typical operating supply current:	5 mA	1 mA
Typical LOW-level input voltage on I <sup>2</sup> C-bus (SX/SY side):	0.5 V over -40 °C to +85 °C	0.65 V at 25 °C
LOW-level output voltage on I <sup>2</sup> C-bus (SX/SY side; 3 mA sink):	0.74 V (max.) over -40 °C to +85 °C	0.88 V (typ.) at 25 °C
LOW-level output voltage on Fm+ I <sup>2</sup> C-bus (SX/SY side; 7 mA sink):	1 V (max.)	N/A
Temperature coefficient of V <sub>IL</sub> / V <sub>OL</sub> :	0 mV/°C	-2 mV/°C
Logic voltage levels on SX/SY bus (independent of V <sub>CC</sub> ):	Compatible with I <sup>2</sup> C-bus and similar buses using TTL levels (SMBus, and so on)	Compatible with I <sup>2</sup> C-bus and similar buses using TTL levels (SMBus, and so on)
Typical propagation delays:	< 100 ns	< 200 ns
TX/RX switching specifications (I <sup>2</sup> C-bus compliant):	Yes, all classes including 1 MHz Fm+	Yes, all classes including Fm+
RX logic levels with tighter control than I <sup>2</sup> C-bus limit of 30 % to 70 %:	Yes, 40 % to 55 % (48 % nominal)	Yes, 42 % to 58 % (50 % nominal)
Maximum bus speed:	> 1 MHz	> 400 kHz
ESD rating HBM per JESD22-A114:	> 3500 V	> 3500 V
Package:	SO8, TSSOP8 (MSOP8)	SO8, TSSOP8 (MSOP8)

When the device driving the PCA9600 is an I<sup>2</sup>C-bus compatible device, then the PCA9600 is an improvement on the P82B96 as shown in [Table 4](#). There are always exceptions however, and if the device driving the bus buffer is not I<sup>2</sup>C-bus compatible (for example, you must use the micro already in the system and bit-bang using two GPIO pins), then here are some considerations that would point to using the P82B96 instead:

- When the pullup must be the weakest one possible. The spec is 200 µA for P82B96, but it typically works even below that. And if designing for a temperature range -40 °C up to +60 °C, then the driver when sinking 200 µA only needs to drive a guaranteed low of 0.55 V. For the PCA9600, over that same temperature range and when sinking 1.3 mA (at -40 °C), the device driving the bus buffer must provide the required low of 0.425 V.
- When the lower operating temperature range is restricted (say 0 °C). The P82B96 larger SX voltage levels then make a better **typical** match with the driver, even when the supply is as low as 3.3 V.

For an I<sup>2</sup>C-bus compliant driver on 3.3 V, the P82B96 is required to guarantee a bus low that is below 0.83 V. P82B96 guarantees that with a 200  $\mu$ A pullup.

- When the operating temperature range is restricted at both limits. An I<sup>2</sup>C driver's typical output is well below 0.4 V and the P82B96 typically requires 0.6 V input even at +60 °C so that there is a reasonable margin. The PCA9600 requires a typical input low of 0.5 V so that its typical margin is smaller. At 0 °C, the driver requires a typical input low of 1.16 V and P82B96 provides 0.75 V. Again, the typical margin is already big and even though PCA9600 is better, providing 0.7 V, the difference is not big.

## 8 Limiting values

[Table 5](#) describes the limiting values of PCA9600.

**Table 5. Limiting values**

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

*Voltages with respect to pin GND.*

Symbol	Parameter	Conditions	Note	Min	Max	Unit
V <sub>CC</sub>	Supply voltage	V <sub>CC</sub> to GND		-0.3	+18	V
V <sub>I2C-bus</sub>	I <sup>2</sup> C-bus voltage	SX and SY; I <sup>2</sup> C-bus SDA or SCL		-0.3	+18	V
V <sub>O</sub>	Output voltage	TX and TY; buffered output	[1]	-0.3	+18	V
V <sub>I</sub>	Input voltage	RX and RY; receive input	[1]	-0.3	+18	V
I <sub>I2C-bus</sub>	I <sup>2</sup> C-bus current	SX and SY; I <sup>2</sup> C-bus SDA or SCL		-	250	mA
P <sub>tot</sub>	Total power dissipation			-	300	mW
T <sub>j</sub>	Junction temperature	Operating range		-40	+125	°C
T <sub>stg</sub>	Storage temperature			-55	+125	°C
T <sub>amb</sub>	Ambient temperature	Operating		-40	+85	°C

[1] See [Section 10.2](#).

## 9 Characteristics

[Table 6](#) describes the characteristics of PCA9600.

**Table 6. Characteristics**

*T<sub>amb</sub> = -40 °C to +85 °C unless otherwise specified; voltages are specified with respect to GND with V<sub>CC</sub> = 2.5 V to 15 V unless otherwise specified. Typical values are measured at V<sub>CC</sub> = 5 V and T<sub>amb</sub> = 25 °C.*

Symbol	Parameter	Conditions	Note	Min	Typ	Max	Unit
<b>Power supply</b>							
V <sub>CC</sub>	Supply voltage	Operating		2.5	-	15	V
I <sub>CC</sub>	Supply current	V <sub>CC</sub> = 5 V; buses HIGH		-	5.2	6.75	mA
		V <sub>CC</sub> = 15 V; buses HIGH		-	5.5	7.3	mA
$\Delta$ I <sub>CC</sub>	Additional supply current	Per TX/TY, output driven LOW; V <sub>CC</sub> = 5.5 V		-	1.4	3.0	mA
<b>Bus pullup (load) voltages and currents</b>							

Table 6. Characteristics...continued

$T_{amb}$  = -40 °C to +85 °C unless otherwise specified; voltages are specified with respect to GND with  $V_{CC}$  = 2.5 V to 15 V unless otherwise specified. Typical values are measured at  $V_{CC}$  = 5 V and  $T_{amb}$  = 25 °C.

Symbol	Parameter	Conditions	Note	Min	Typ	Max	Unit
Pins SX and SY; I <sup>2</sup> C-bus							
$V_I$	Input voltage	Open-collector; RX and RY HIGH		-	-	15	V
$V_O$	Output voltage	Open-collector; RX and RY HIGH		-	-	15	V
$I_O$	Output current	Static; $V_{SX} = V_{SY} = 0.4$ V	[1]	0.3	-	2	mA
$I_{O(sink)}$	Output sink current	Dynamic; $V_{SX} = V_{SY} = 1$ V; RX and RY LOW		7	15	-	mA
$I_L$	Leakage current	$V_{SX} = V_{SY} = 15$ V; RX and RY HIGH		-	-	10	μA
Pins TX and TY							
$V_O$	Output voltage	Open-collector		-	-	15	V
$I_{load}$	Load current	Maximum recommended on buffered bus; $V_{TX} = V_{TY} = 0.4$ V; SX and SY LOW on I <sup>2</sup> C-bus = 0.4 V		-	-	30	mA
$I_O$	Output current	From buffered bus; $V_{TX} = V_{TY} = 1$ V; SX and SY LOW on I <sup>2</sup> C-bus = 0.4 V		60	130	-	mA
$I_L$	Leakage current	On buffered bus; $V_{TX} = V_{TY} = V_{CC} = 15$ V; SX and SY HIGH		-	-	10	μA
Input currents							
$I_I$	Input current	From I <sup>2</sup> C-bus on SX and SY					
		RX and RY HIGH or LOW; SX and SY LOW ≤ 1 V	[1]	-	-0.3	-1	mA
		RX and RY HIGH; SX and SY HIGH > 1.4 V	[1]	-	-	10	μA
		From buffered bus on RX and RY; SX and SY HIGH or LOW; $V_{RX} = V_{RY} = 0.4$ V	[2]	-	-1.5	-10	μA
$I_L$	Leakage current	On buffered bus input on RX and RY; $V_{RX} = V_{RY} = 15$ V		-	-	10	μA
Output logic LOW level							
Pins SX and SY							
$V_{OL}$	LOW-level output voltage	On Standard-mode or Fast-mode I <sup>2</sup> C-bus					
		$I_{SX} = I_{SY} = 3$ mA; <a href="#">Figure 6</a>		-	0.7	0.74	V



Table 6. Characteristics...continued

$T_{amb}$  = -40 °C to +85 °C unless otherwise specified; voltages are specified with respect to GND with  $V_{CC}$  = 2.5 V to 15 V unless otherwise specified. Typical values are measured at  $V_{CC}$  = 5 V and  $T_{amb}$  = 25 °C.

Symbol	Parameter	Conditions	Note	Min	Typ	Max	Unit
		$I_{SX} = I_{SY} = 0.3 \text{ mA}$ ; <a href="#">Figure 5</a>		-	0.6	0.65	V
		On 5 V Fm+ I <sup>2</sup> C-bus					
		$I_{SX} = I_{SY} = 7 \text{ mA}$		-	-	1	V
$\Delta V/\Delta T$	Voltage variation with the temperature	$I_{SX} = I_{SY} = 0.3 \text{ mA}$ to 3 mA		-	0	-	%/K
<b>Input logic switching threshold voltages</b>							
Pins SX and SY							
$V_{IL}$	LOW-level input voltage	On normal I <sup>2</sup> C-bus; <a href="#">Figure 7</a>	[3]	-	-	425	mV
$V_{th(IH)}$	HIGH-level input threshold voltage	On normal I <sup>2</sup> C-bus; <a href="#">Figure 8</a>		580	-	-	mV
$\Delta V/\Delta T$	Voltage variation with the temperature			-	0	-	%/K
Pins RX and RY							
$V_{IH}$	HIGH-level input voltage	Fraction of applied $V_{CC}$		$0.55V_{CC}$	-	-	V
$V_{th(i)}$	Input threshold voltage	Fraction of applied $V_{CC}$		-	$0.48V_{CC}$	-	V
$V_{IL}$	LOW-level input voltage	Fraction of applied $V_{CC}$		-	-	$0.4V_{CC}$	V
<b>Logic level threshold difference</b>							
$\Delta V$	Voltage difference	SX and SY; SX output LOW at 0.3 mA to SX input HIGH maximum	[4]	50	-	-	mV
<b>Thermal resistance</b>							
$R_{th(j-pcb)}$	Thermal resistance from junction to printed-circuit board	SOT96-1 (SO8); average lead temperature at board interface		-	127	-	K/W
<b>Bus release on <math>V_{CC}</math> failure</b>							
$V_{CC}$	Supply voltage	SX, SY, TX, and TY; voltage at which all buses are to be released at 25 °C		-	-	1	V
$\Delta V/\Delta T$	Voltage variation with the temperature	<a href="#">Figure 9</a>		-	-4	-	%/K
<b>Buffer response time</b> <sup>[5]</sup>							
$V_{CC}$ = 5 V; pin TX pullup resistor = 160 $\Omega$ ; pin SX pullup resistor = 2.2 k $\Omega$ ; no capacitive load							
$t_d$	Delay time	$V_{SX}$ to $V_{TX}$ , $V_{SY}$ to $V_{TY}$ ; on <b>falling</b> input between $V_{SX}$ = input switching threshold, and $V_{TX}$ output falling to 50 % $V_{CC}$		-	50	-	ns

Table 6. Characteristics...continued

$T_{amb}$  = -40 °C to +85 °C unless otherwise specified; voltages are specified with respect to GND with  $V_{CC}$  = 2.5 V to 15 V unless otherwise specified. Typical values are measured at  $V_{CC}$  = 5 V and  $T_{amb}$  = 25 °C.

Symbol	Parameter	Conditions	Note	Min	Typ	Max	Unit
		$V_{SX}$ to $V_{TX}$ , $V_{SY}$ to $V_{TY}$ ; on <b>rising</b> input between $V_{SX}$ = input switching threshold, and $V_{TX}$ output reaching 50 % $V_{CC}$		-	60	-	ns
		$V_{RX}$ to $V_{SX}$ , $V_{RY}$ to $V_{SY}$ ; on <b>falling</b> input between $V_{RX}$ = input switching threshold, and $V_{SX}$ output falling to 50 % $V_{CC}$		-	100	-	ns
		$V_{RX}$ to $V_{SX}$ , $V_{RY}$ to $V_{SY}$ ; on <b>rising</b> input between $V_{RX}$ = input switching threshold, and $V_{SX}$ output reaching 50 % $V_{CC}$		-	95	-	ns
Input capacitance							
$C_i$	Input capacitance	Effective input capacitance of any signal pin measured by incremental bus rise times; guaranteed by design, not production tested		-	-	10	pF

- [1] This bus pullup current specification is intended to assist the design of the bus pullup resistor. It is not a specification of the sink capability (see  $V_{OL}$  under sub-section "Output logic LOW level"). The maximum static sink current for a Standard/Fast-mode I<sup>2</sup>C-bus is 3 mA and PCA9600 is guaranteed to sink 3 mA at SX/SY when its pins are holding the bus LOW. However, when an external device pulls the SX/SY pins below 1.4 V, the PCA9600 can source a current between 0 mA and 1 mA maximum. When that other external device is driving LOW, it pulls the bus connected to SX or SY down to, or below, the 0.4 V level referenced in the I<sup>2</sup>C-bus specification and in these test conditions. Then, that device must be able to sink up to 1 mA coming from SX/SY plus the usual pullup current. Therefore, the external pullup used at SX/SY must be limited to 2 mA. The typical and maximum currents sourced by SX/SY as a function of junction temperature are shown in [Figure 10](#), and the equivalent circuit at the SX/SY interface is shown in [Figure 4](#).
- [2] Valid over temperature for  $V_{CC} \leq 5$  V. At higher  $V_{CC}$ , this current can increase to maximum -20  $\mu$ A at  $V_{CC} = 15$  V.
- [3] The input logic threshold is independent of the supply voltage.
- [4] The minimum value requirement for pullup current, 0.3 mA, guarantees that the minimum value for  $V_{SX}$  output LOW always exceeds the maximum  $V_{SX}$  input HIGH level to eliminate any possibility of latching. The specified difference is guaranteed by design within any IC. While the tolerances on absolute levels allow a small probability, the LOW from one SX output is recognized by an SX input of another PCA9600 having no consequences for normal applications. In any design, the SX pins of different ICs should never be linked because the resulting system would be very susceptible to induced noise and would not support all I<sup>2</sup>C-bus operating modes.
- [5] The fall time of  $V_{TX}$  from 5 V to 2.5 V in the test is approximately 10 ns.  
The fall time of  $V_{SX}$  from 5 V to 2.5 V in the test is approximately 20 ns.  
The rise time of  $V_{TX}$  from 0 V to 2.5 V in the test is approximately 15 ns.  
The rise time of  $V_{SX}$  from 0.7 V to 2.5 V in the test is approximately 25 ns.

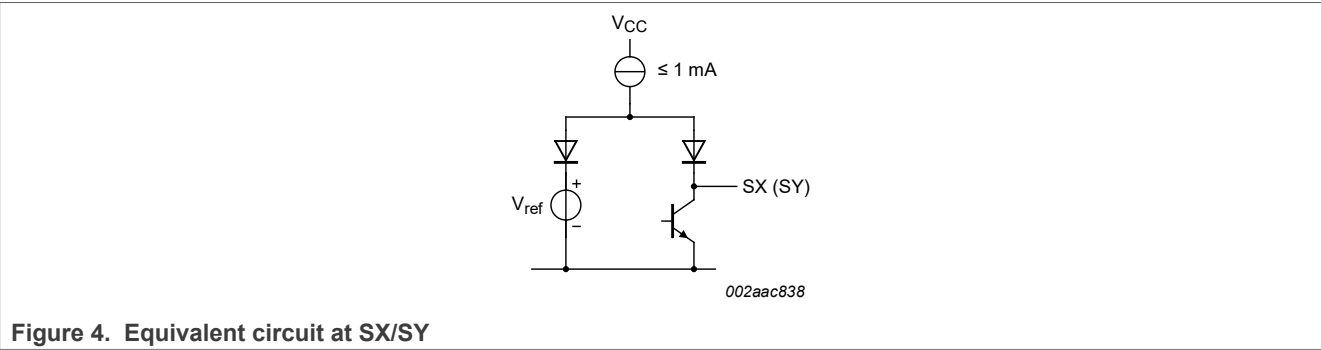
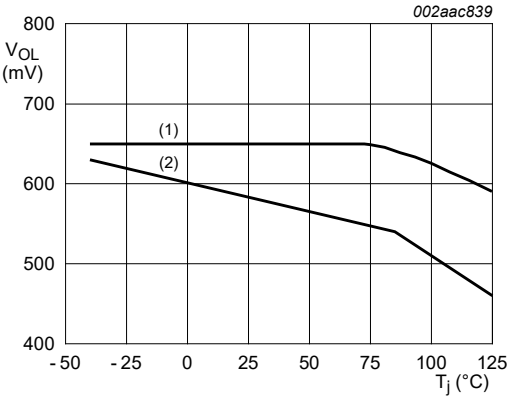


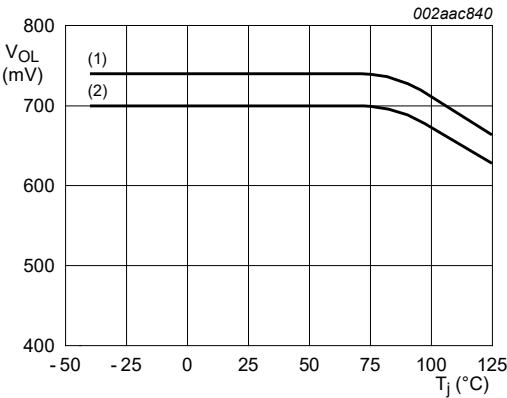
Figure 4. Equivalent circuit at SX/SY



$V_{OL}$  at SX typical and limits over temperature.

- 1. Maximum
- 2. Typical

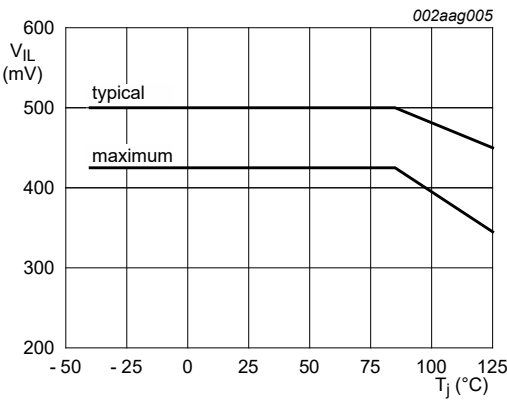
Figure 5.  $V_{OL}$  as a function of junction temperature ( $I_{OL} = 0.3\text{ mA}$ )



$V_{OL}$  at SX typical and limits over temperature.

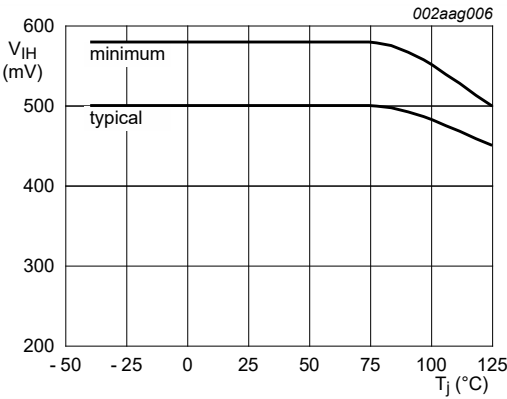
- 1. Maximum
- 2. Typical

Figure 6.  $V_{OL}$  as a function of junction temperature ( $I_{OL} = 3\text{ mA}$ )



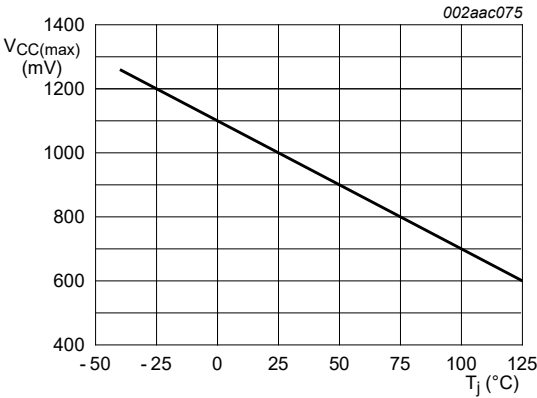
$V_{IL}$  at SX changes over the temperature range.

Figure 7.  $V_{IL}$  as a function of junction temperature; maximum and typical values



$V_{IH}$  at SX changes over the temperature range.

Figure 8.  $V_{IH}$  as a function of junction temperature; minimum and typical values



1. Maximum
2. Typical

Figure 9.  $V_{CC}$  bus release limit over temperature; maximum values

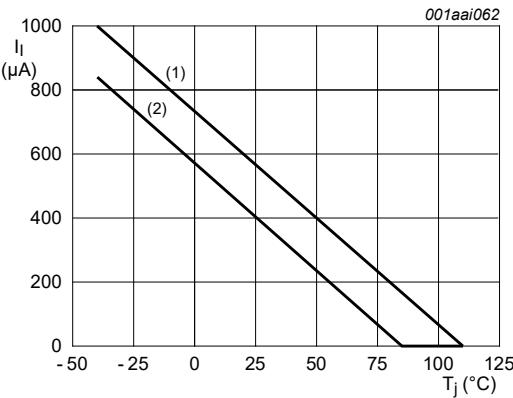
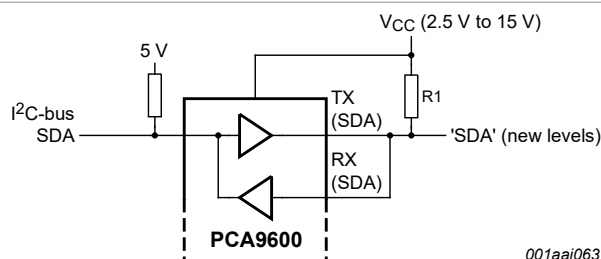


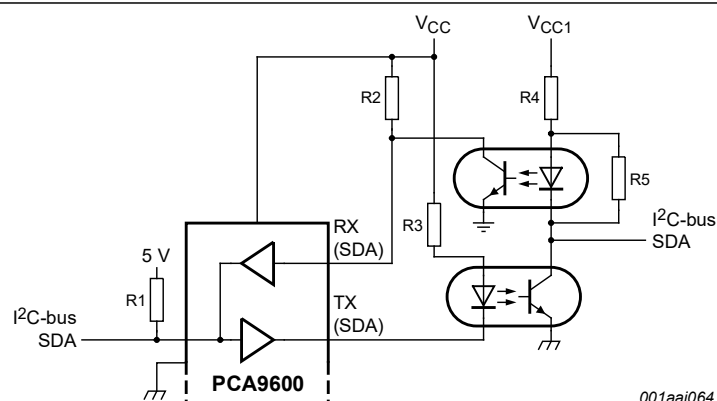
Figure 10. Current sourced out of SX/SY as a function of junction temperature if these pins are externally pulled to 0.4 V or lower

## 10 Application information

See the PCA9600 data sheet and application notes *Sending I<sup>2</sup>C-bus signals via long communication cables* (document [AN10658](#)) and *I<sup>2</sup>C / SMBus REPEATERS, HUBS AND EXPANDERS* (document [AN255](#)) for more detailed application information.

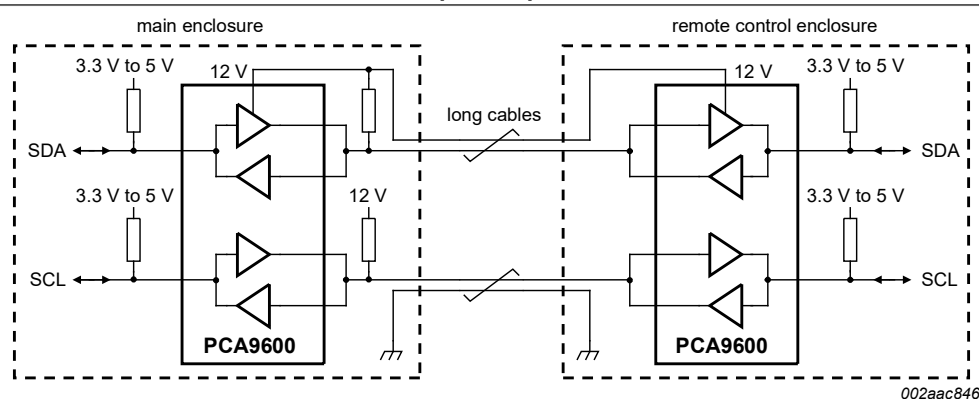


**Figure 11.** Interfacing a standard 3 mA I<sup>2</sup>C-bus or one with TTL levels (for example, SMBus) to higher voltage or higher current sink (for example, Fm+) devices



This simple example may be limited, if using lowest-cost couplers, to speeds as low as 5 kHz. Refer to application notes for schematics suitable for operation to 400 kHz or higher.

**Figure 12.** Galvanic isolation of I<sup>2</sup>C-bus nodes via opto-couplers



**Figure 13.** Long-distance I<sup>2</sup>C-bus communication

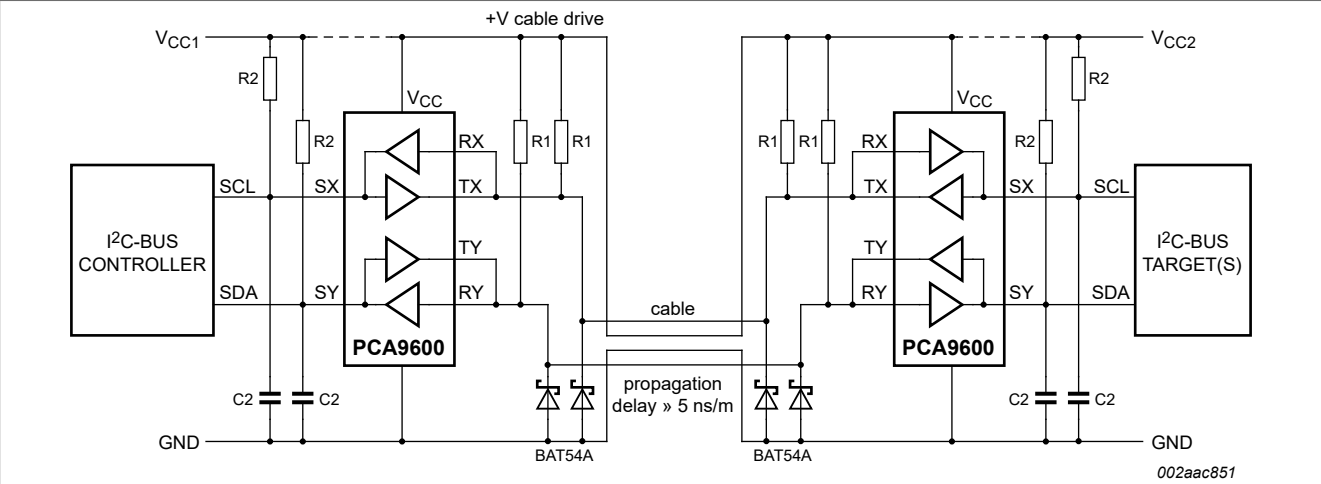


Figure 14. Driving ribbon or flat telephone cables

Table 7. Examples of bus capability

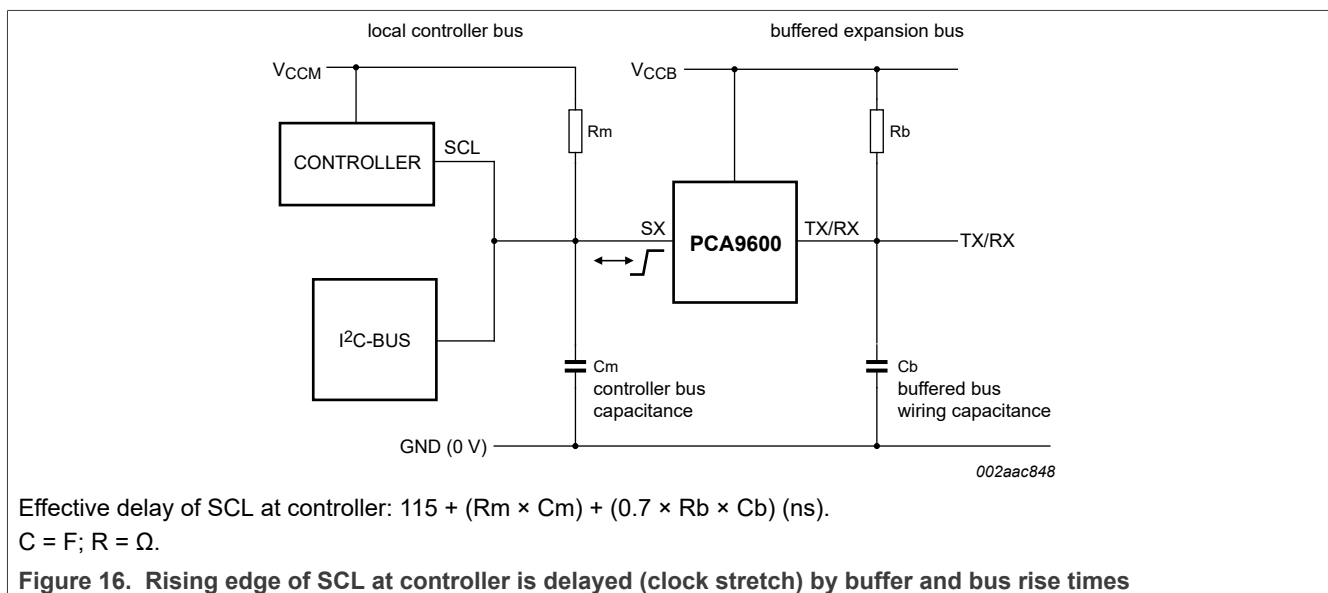
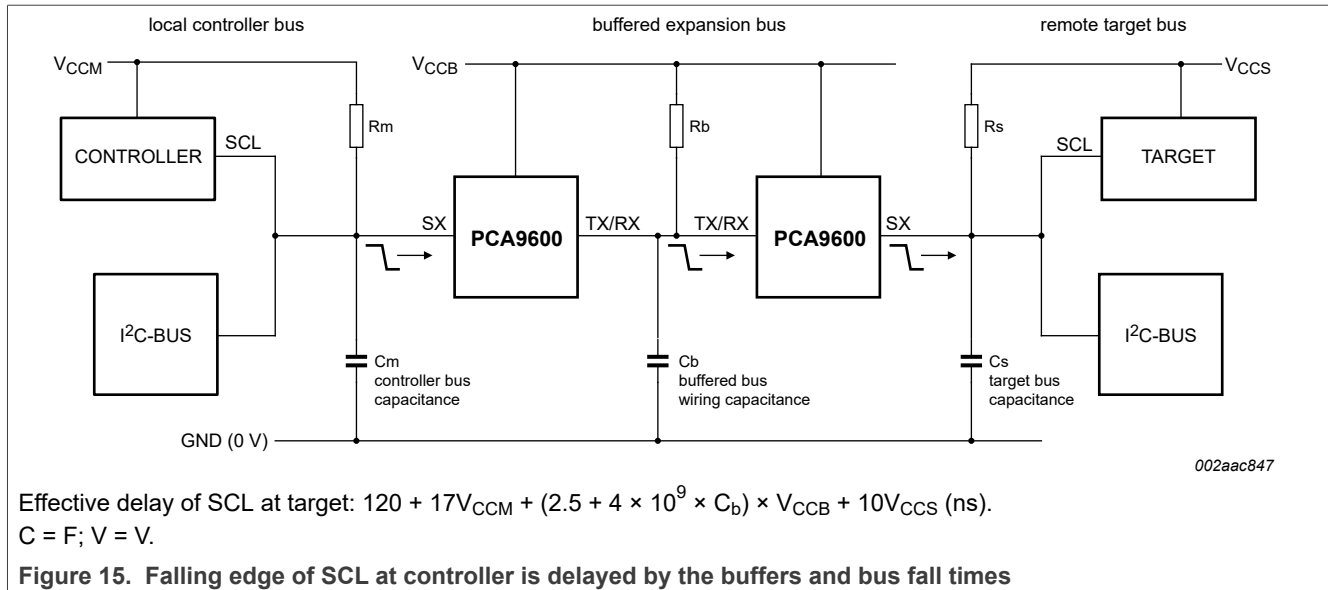
Refer to [Figure 14](#).

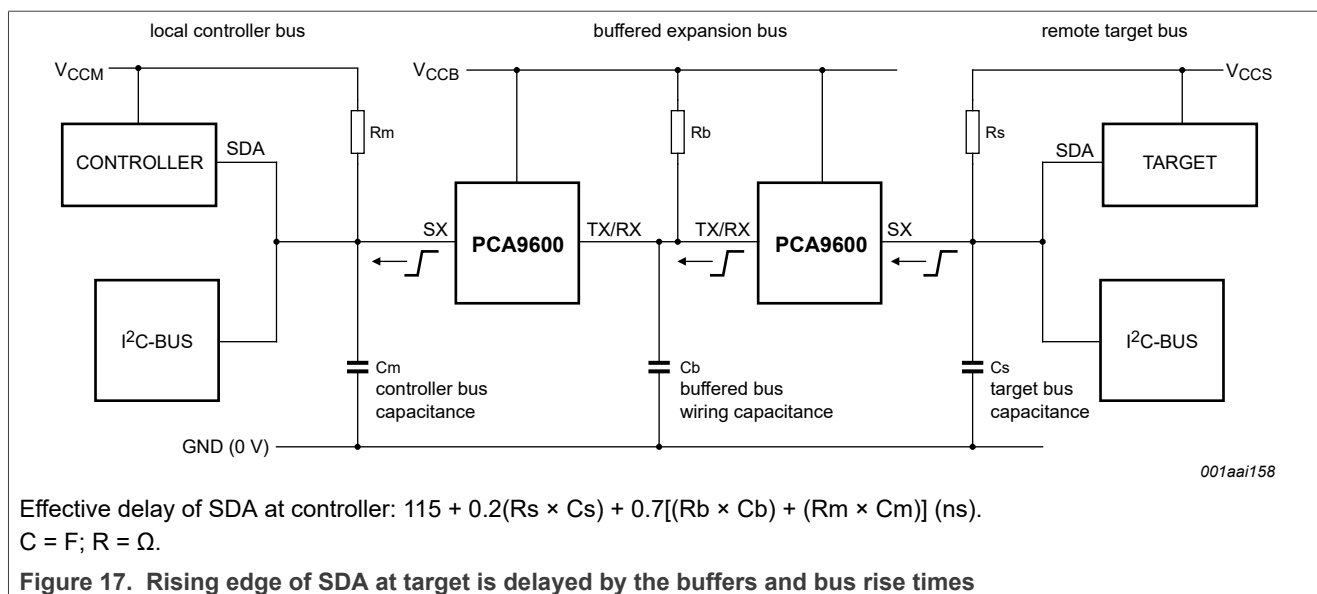
V <sub>CC1</sub> (V)	+V cable (V)	V <sub>CC2</sub> (V)	R1 (Ω)	R2 (kΩ)	C2 (pF)	Cable length (m)	Cable capacitance	Cable delay	Set controller nominal SCL		Effective bus clock speed (kHz)	Max. target response delay
									HIGH period (ns)	LOW period (ns)		
5	12	5	750	2.2	400	250	NA (delay based)	1.25 μs	600	3850	125	Normal specification 400 kHz parts
5	12	5	750	2.2	220	100	NA (delay based)	500 ns	600	2450	195	Normal specification 400 kHz parts
3.3	5	3.3	330	1	220	25	1 nF	125 ns	260	770	620	Meets Fm+ specification
3.3	5	3.3	330	1	100	3	120 pF	15 ns	260	720	690	Meets Fm+ specification

For more examples of faster alternatives for driving over longer cables such as Cat5 communication cable, see *Sending I<sup>2</sup>C-bus signals via long communication cables* (document [AN10658](#)). Communication at 1 MHz frequency is possible over short cables and at frequency more than 400 kHz is possible over 50 m of cable.

10.1 Calculating system delays and bus clock frequency

[Figure 15](#), [Figure 16](#), and [Figure 17](#) show that the PCA9600 used to drive extended bus wiring with relatively large capacitances linking two I<sup>2</sup>C-bus nodes.





These figures include simplified expressions for making the relevant timing calculations for 3.3 V or 5 V operation. Because the buffers and the wiring introduce timing delays, it can be necessary to decrease the nominal SCL frequency. In most cases, the actual bus frequency is lower than the nominal master timing due to bitwise stretching of the clock periods.

The delay factors involved in the calculation of the allowed bus speed are:

**A:** The propagation delay of the controller signal through the buffers and wiring to the target. The important delay is that of the falling edge of SCL because this edge 'requests' the data or acknowledge from a target. See [Figure 15](#).

**B:** The effective stretching of the nominal LOW period of SCL at the controller caused by the buffer and bus rise times. See [Figure 16](#).

**C:** The propagation delay of the target's response signal through the buffers and wiring back to the controller. The important delay is that of a rising edge in the SDA signal. Rising edges are always slower and are therefore delayed by a longer time than falling edges. (The rising edges are limited by the passive pullup while falling edges are actively driven); see [Figure 17](#).

The timing requirement in any I<sup>2</sup>C-bus system is that a target's data response (which is provided in response to a falling edge of SCL) must be received at the controller before the end of the corresponding LOW period of SCL as appears on the bus wiring at the controller. Since all targets will, as a minimum, satisfy the worst case timing requirements of their speed class (Fast-mode, Fm+, and so on), they must provide their response, allowing for the set-up time within the minimum allowed clock LOW period, for example, 450 ns (max.) for Fm+ parts. In systems that introduce additional delays, it can be necessary to extend the minimum clock LOW period to accommodate the 'effective' delay of the target's response. The effective delay of the target's response equals the total delays in SCL falling edge from the controller reaching the target (see [Figure 15](#)) minus the effective delay (stretch) of the SCL rising edge (see [Figure 16](#)) plus total delays in the target's response data, carried on SDA, reaching the controller (see [Figure 17](#)).

The microcontroller must be programmed to produce a nominal SCL LOW period as follows:

$$SCL_{LOW} \geq (slaveresponsedelaytovaliddataonitsSDA + A - B + C + dataset-uptime) ns$$

The actual LOW period becomes the programmed value + the stretching time B. When this actual LOW period is then less than the specified minimum, the specified minimum should be used.

#### Example 1:



It is required to connect an Fm+ target with  $R_s \times C_s$  product of 100 ns to a 5 V Fast-mode system also having 100 ns  $R_m \times C_m$  using two PCA9600's to buffer a 5 V bus with 4 nF loading and 160  $\Omega$  pullup.

Calculate the allowed bus speed:

$$\text{Delay A} = 120 + 85 + (2.5 + [4 \times 4]) \times 5 + 50 = 347.5 \text{ ns}$$

$$\text{Delay B} = 115 + 100 + 70 = 285 \text{ ns}$$

$$\text{Delay C} = 115 + 20 + 0.7(100 + 100) = 275 \text{ ns}$$

The maximum Fm+ target response delay must be < 450 ns so the programmed LOW period is calculated as:

$$\text{LOW} \geq 450 + 347.5 - 285 + 275 + 100 = 887.5 \text{ ns}$$

The actual LOW period is  $887.5 + 285 = 1173 \text{ ns}$ , which is below the Fast-mode minimum, so the programmed LOW period must be increased to  $(1300 - 285) = 1015 \text{ ns}$ , so the actual LOW equals the 1300 ns requirement and this shows that this Fast-mode system can be safely run to its limit of 400 kHz.

### Example 2:

It is required to buffer a controller with Fm+ speed capability, but only 3 mA sink capability, to an Fm+ bus. All the system operates at 3.3 V. The controller  $R_m \times C_m$  product is 50 ns. Only one PCA9600 is used. The Fm+ bus becomes the buffered bus. The Fm+ bus has 200 pF loading and 150  $\Omega$  pullup, so its  $R_b \times C_b$  product is 30 ns. The Fm+ target has a specified data valid time  $t_{VD,DAT}$  maximum of 300 ns.

Calculate the allowed maximum system bus speed. (Note that the fixed values in the delay equations represent the internal propagation delays of the PCA9600. Only one PCA9600 is used here, so those fixed values used below are taken from the characteristics.)

The delays are:

$$\text{Delay A} = 40 + 56 + (2.5 + [4 \times 0.2]) \times 3.3 = 107 \text{ ns}$$

$$\text{Delay B} = 115 + 50 + 21 = 186 \text{ ns}$$

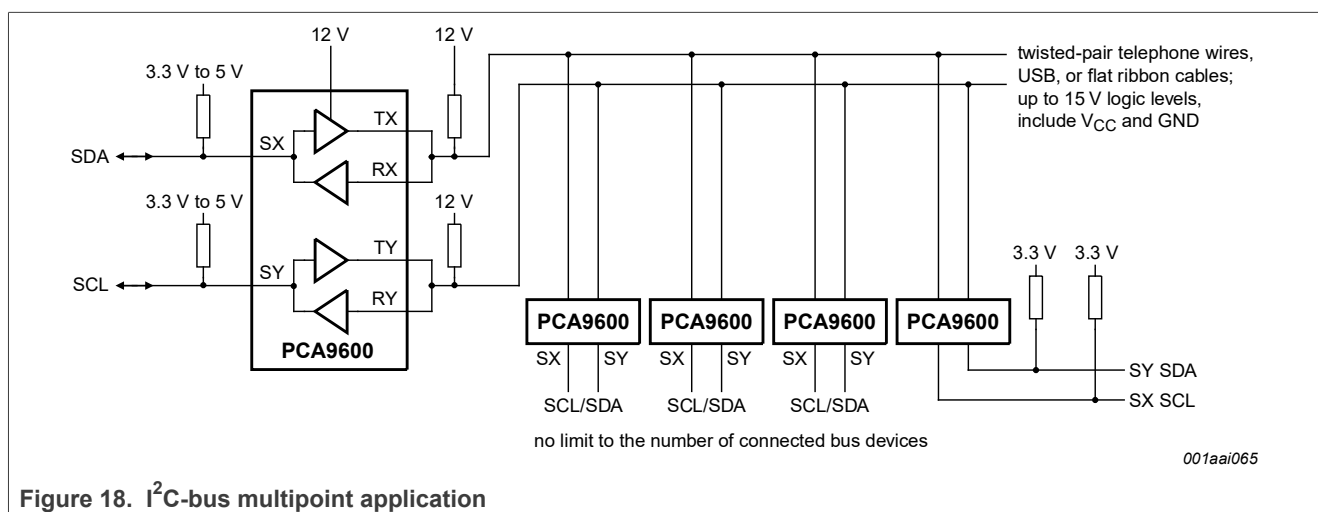
$$\text{Delay C} = 70 + 0.7(50 + 30) = 126 \text{ ns}$$

The programmed LOW period is calculated as:

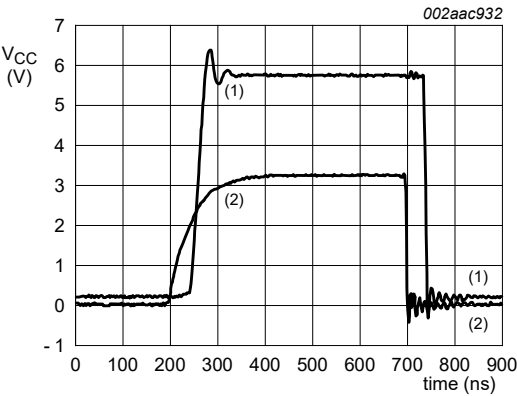
$$\text{SCL LOW} \geq 300 + 117 - 186 + 126 + 50 = 407 \text{ ns}$$

The actual LOW period is  $407 + 126 = 533 \text{ ns}$ , which exceeds the minimum Fm+ 500 ns requirement. This system requires the bus LOW period, and therefore cycle time, to be increased by 33 ns so the system must run slightly below the 1 MHz limit.

The possible maximum speed has a cycle period of 1033 ns or 968 kHz.

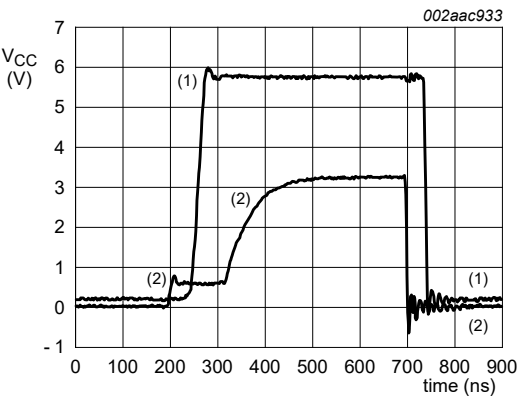


There is an Excel calculator, which makes it easy to determine the maximum I<sup>2</sup>C-bus clock speed when using the PCA9600. The calculator and instructions can be found at [www.nxp.com/clockspeedcalculator](http://www.nxp.com/clockspeedcalculator).



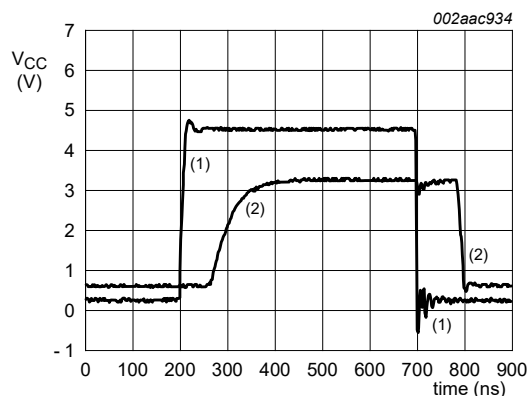
- 1. TX output
- 2. SX input

Figure 19. Propagation SX to TX with  $V_{RX} = V_{CC} = 3.3\text{ V}$  (SX pullup to 3.3 V; TX pullup to 5.7 V)



- 1. TX/RX output
- 2. SX input

Figure 20. Propagation SX to TX with RX tied to TX;  $V_{CC} = 3.3\text{ V}$  (SX pullup to 3.3 V; TX pullup to 5.7 V)



1. RX input
2. SX output

Figure 21. Propagation RX to SX (SX pullup to 3.3 V;  $V_{CC} = 3.3$  V; RX pullup to 4.6 V)

## 10.2 Negative undershoot below absolute minimum value

The reason why the IC pin reverse voltage on pins TX and RX in [Table 5](#) is specified at such a low value, -0.3 V, is **not** that applying larger voltages is likely to cause damage but that it is expected that, in normal applications, there is no reason why larger DC voltages are applied. This 'absolute maximum' specification is intended to be a DC or continuous ratings and the nominal DC I<sup>2</sup>C-bus voltage LOW usually does not even reach 0 V. Inside PCA9600 at every pin, there is a large protective diode connected to the GND pin and that diode starts to conduct when the pin voltage is more than about -0.55 V with respect to GND at 25 °C ambient.

[Figure 22](#) shows the measured characteristic for one of those diodes inside PCA9600. The plot was made using a curve tracer that applies 50 Hz mains voltage via a series resistor, so the pulse durations are long duration (several milliseconds) and are reaching peaks of over 2 A when more than -1.5 V is applied. The IC becomes hot during this testing but it was not damaged. Whenever there is current flowing in any of these diodes, it is **possible** that there can be faulty operation of any IC. For that reason, we put a specification on the negative voltage that is allowed to be applied. It is selected so that, at the highest allowed junction temperature, there is a big safety factor that guarantees the diode does not conduct and then we do not need to make any 100 % production tests to guarantee the published specification.

For the PCA9600, in specific applications, there is always transient overshoot and ringing on the wiring that can cause these diodes to conduct. Therefore, we designed the IC to withstand those transients and as a part of the qualification procedure, we made tests using DC currents to more than twice the normal bus sink currents, to be sure that the IC is not affected by those currents. For example, the TX/TY and RX/RX pins were tested to at least -80 mA, which, from [Figure 22](#), would be more than -0.8 V. The correct functioning of the PCA9600 is not affected even by those large currents. The Absolute Maximum (DC) ratings are not intended to apply to transients but to steady state conditions. This explains why you never see any problems in practice even if, during transients, more than -0.3 V is applied to the bus interface pins of PCA9600.

[Figure 22](#) also explains how the general Absolute Maximum DC specification was selected. The current at 25 °C is near zero at -0.55 V. The PCA9600 is allowed to operate with +125 °C junction and that would cause this diode voltage to decrease by  $100 \times 2 \text{ mV} = 200 \text{ mV}$ . So, for zero current we must specify -0.35 V and we publish -0.3 V just to have some extra margin.

**Remark:** Do not be concerned about the **transients** generated on the wiring by a PCA9600 in normal applications and that is input to the TX/RX or TY/RX pins of another PCA9600. This fact is because not all ICs that can be driven by PCA9600 are designed to tolerate negative transients. In [Section 10.2.1](#), we show that they can be managed if required.

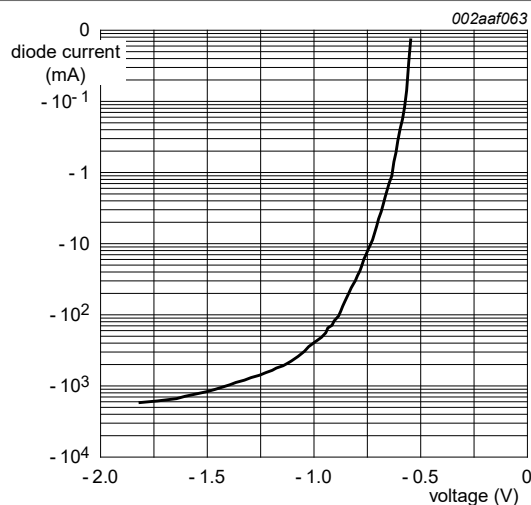


Figure 22. Diode characteristic curve

### 10.2.1 Example with questions and answers

**Question:** On a falling edge of TX, we measure undershoot at -800 mV at the linked TX, RX pins of the PCA9600 that is generating the LOW, but the PCA9600 data sheet specifies minimum -0.3 V. Does this mean that we violate the data sheet absolute value?

**Answer:** For PCA9600, the -0.3 V Absolute Maximum rating is not intended to apply to transients, it is a DC rating. As shown in [Figure 23](#), there is no theoretical reason for any undershoot at the IC that is driving the bus LOW and no significant undershoot must be observed when using reasonable care with the ground connection of the scope. It is more likely that the undershoot observed at a driving PCA9600 is caused by local stray inductance and capacitance in the circuit and by the oscilloscope connections. As shown, undershoot is generated by PCB traces, wiring, or cables driven by a PCA9600 because the allowed value of the I<sup>2</sup>C-bus pullup resistor generally is larger than that required to correctly terminate the wiring. In this example, with no IC connected at the end of the wiring, the undershoot is about 2 V.

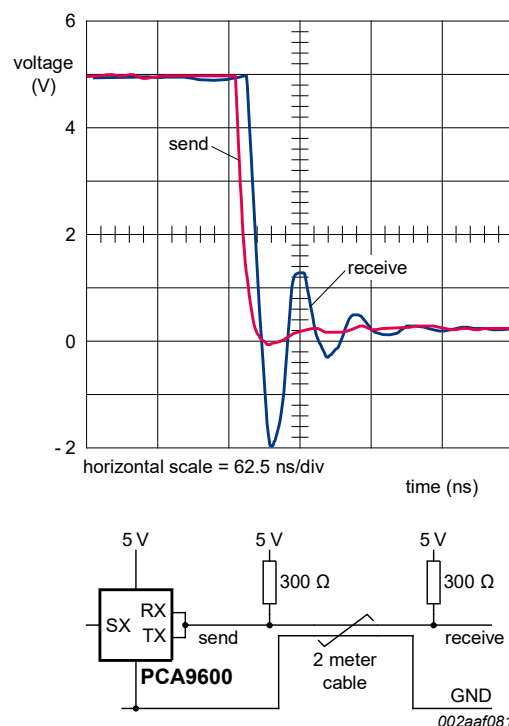


Figure 23. Transients generated by the bus wiring

**Question:** We have 2 meters of cable in a bus that joins the TX/RX sides of two PCA9600 devices. When one TX drives LOW, the other PCA9600 TX/RX is driven to -0.8 V for over 50 ns. What is the expected value and the theoretically allowed value of undershoot?

**Answer:** Because the cable joining the two PCA9600s is a 'transmission line' that has a characteristic impedance around 100  $\Omega$  and it is terminated by pullup resistors that are larger than that characteristic impedance, there is always a negative undershoot generated. The duration of the undershoot is a function of the cable length and the input impedance of the connected IC. As shown in [Figure 24](#), the transient undershoot is limited, by the diodes inside PCA9600, to around -0.8 V and that does not cause problems for PCA9600. Those transients are **not** passed inside the IC to the SX/SY side of the IC.

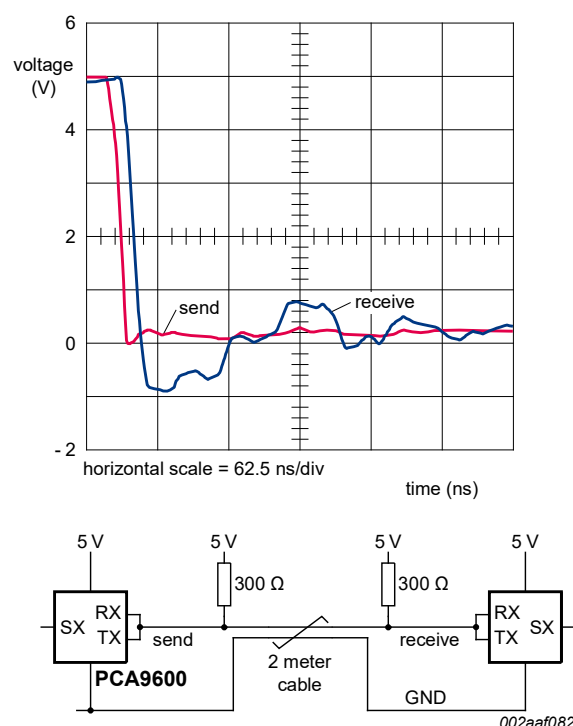


Figure 24. Wiring transients limited by the diodes in PCA9600

**Question:** If we input 800 mV undershoot at TX, RX pins, what kind of problem is expected?

**Answer:** When that undershoot is generated by another PCA9600 and is simply the result of the system wiring, then there are no problems.

**Question:** Do we have any functional problem or reliability problem?

**Answer:** No.

**Question:** If we add 100  $\Omega$  to 200  $\Omega$  at the signal line, the overshoot becomes slightly smaller. Is this a good idea?

**Answer:** No, it is not necessary to add any resistance. When the logic signal generated by TX or TY of PCA9600 drives long traces or wiring with ICs other than PCA9600 being driven, then adding a Schottky diode (BAT54A) as shown in [Figure 25](#) clamps the wiring undershoot to a value that does not cause conduction of the IC's internal diodes.

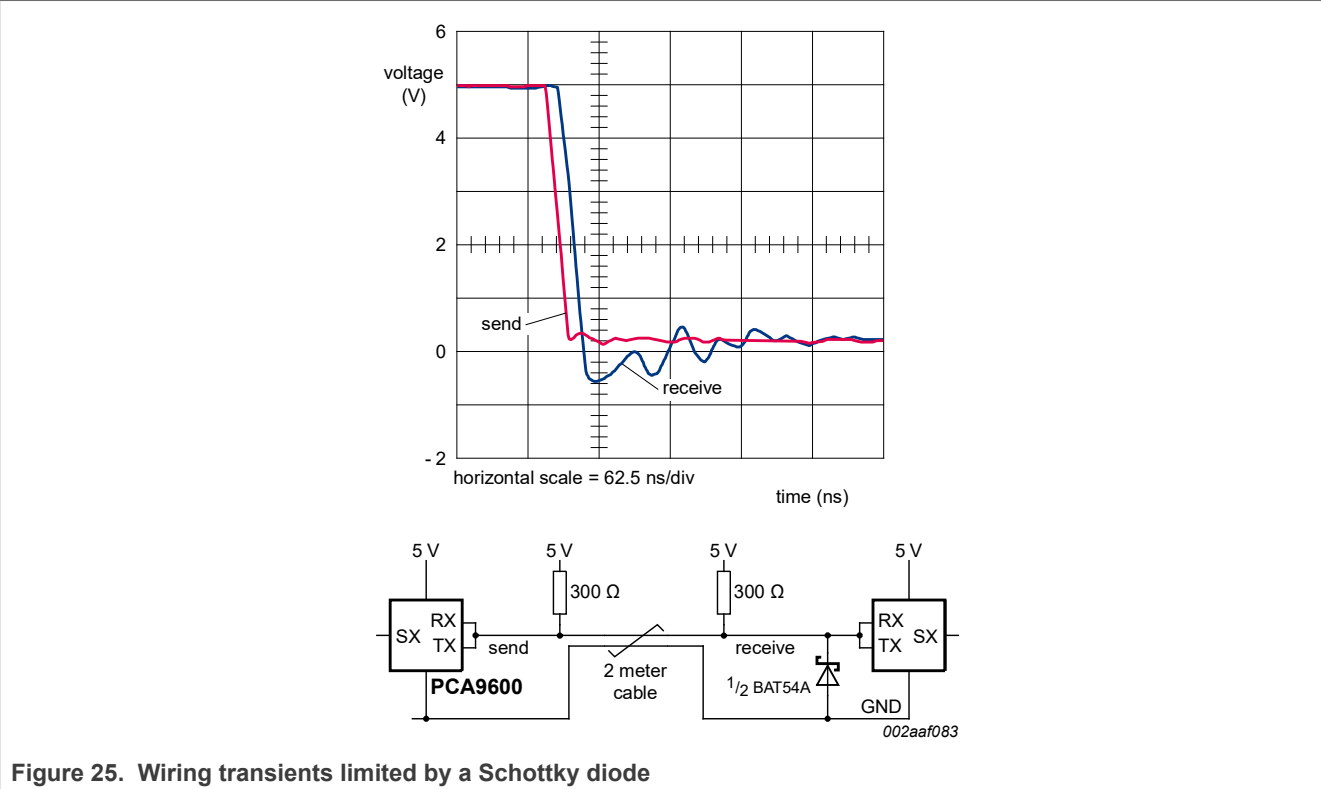


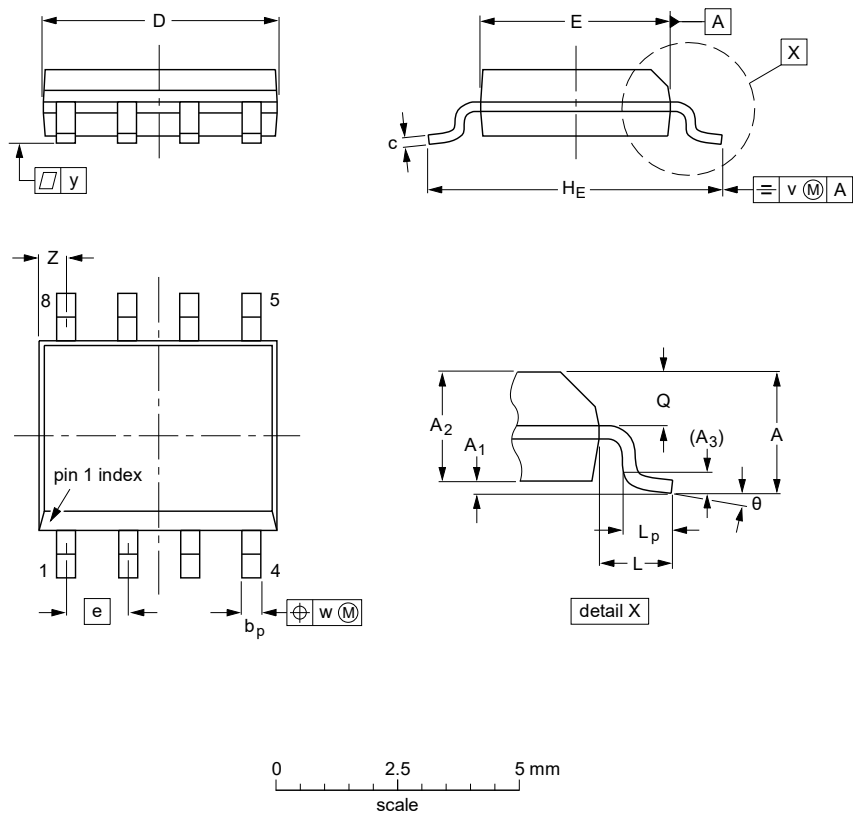
Figure 25. Wiring transients limited by a Schottky diode

## 11 Package outline

Figure 26 and Figure 27 show the package outline for PCA9600.

SO8: plastic small outline package; 8 leads; body width 3.9 mm

SOT96-1



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A <sub>max.</sub>	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(2)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	Q	v	w	y	Z <sup>(1)</sup>	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.20 0.19	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

Notes

- 1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.
- 2. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

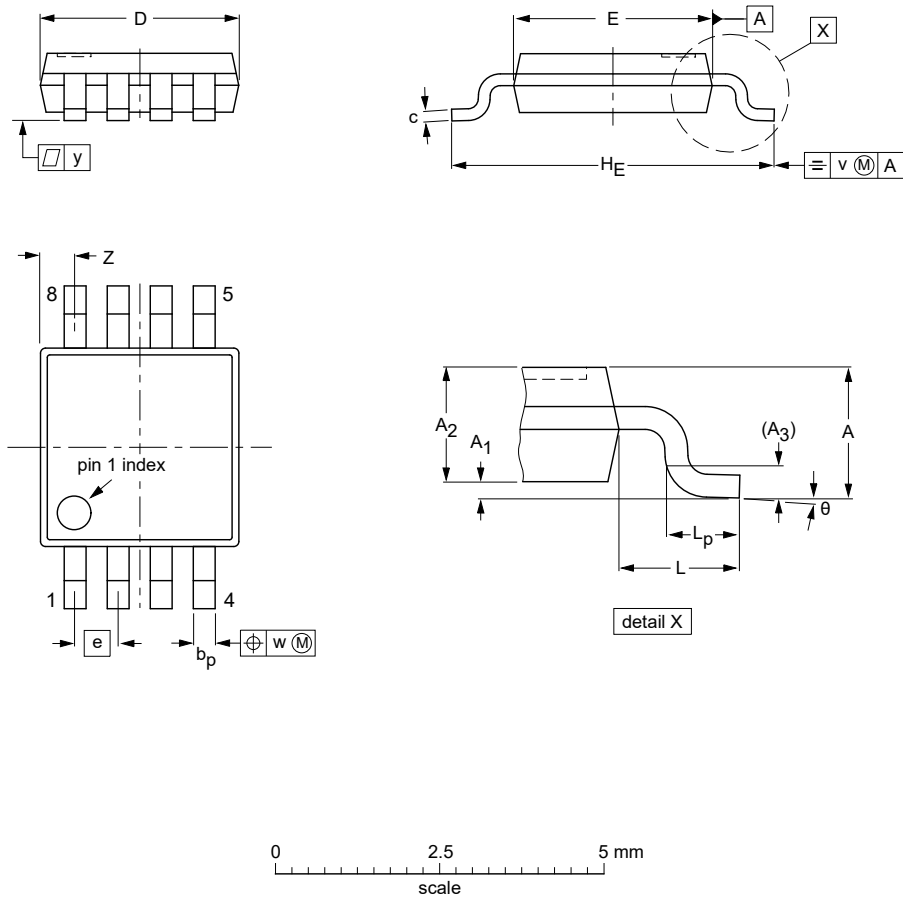
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT96-1	076E03	MS-012				99-12-27 03-02-18

Figure 26. Package outline SOT96-1 (SO8)



TSSOP8: plastic thin shrink small outline package; 8 leads; body width 3 mm

SOT505-1



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(2)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	v	w	y	Z <sup>(1)</sup>	θ
mm	1.1	0.15 0.05	0.95 0.80	0.25	0.45 0.25	0.28 0.15	3.1 2.9	3.1 2.9	0.65	5.1 4.7	0.94	0.7 0.4	0.1	0.1	0.1	0.70 0.35	6° 0°

Notes

- 1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
- 2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT505-1						<del>99-04-09</del> 03-02-18

Figure 27. Package outline SOT505-1 (TSSOP8)

## 12 Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 "Surface mount reflow soldering description"*.

### 12.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

### 12.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

### 12.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

### 12.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see [Figure 28](#)) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board

- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with [Table 8](#) and [Table 9](#)

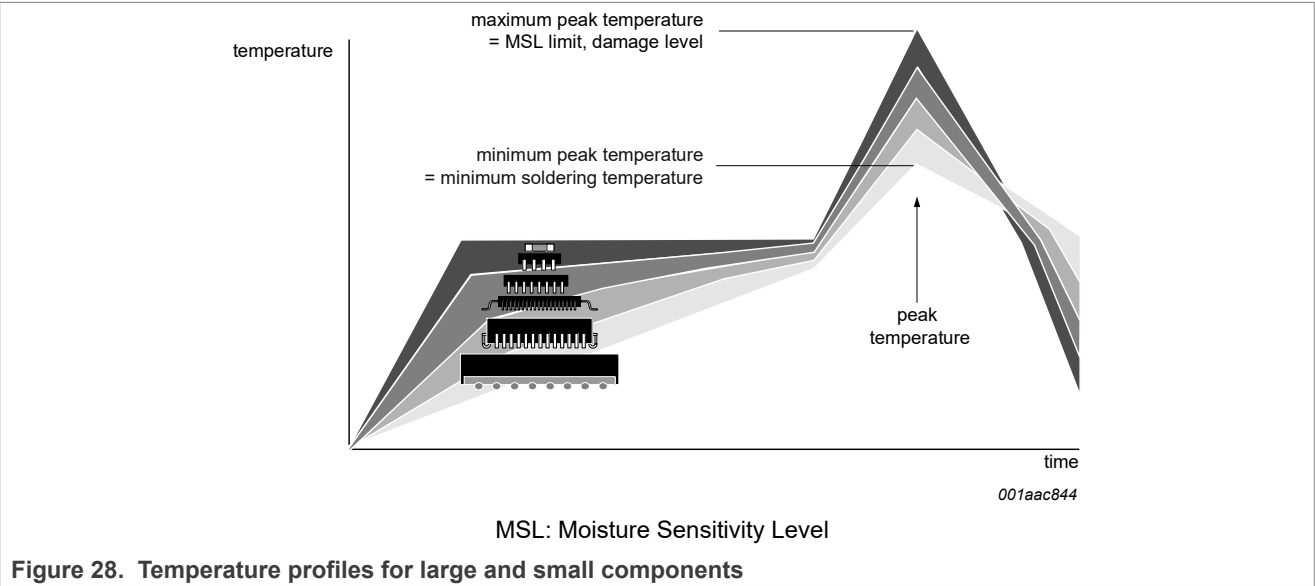
Table 8. SnPb eutectic process (from J-STD-020D)

Package thickness (mm)	Package reflow temperature (°C)	
	Volume (mm³)	
	< 350	≥ 350
< 2.5	235	220
≥ 2.5	220	220

Table 9. Lead-free process (from J-STD-020D)

Package thickness (mm)	Package reflow temperature (°C)		
	Volume (mm³)		
	< 350	350 to 2000	> 2000
< 1.6	260	260	260
1.6 to 2.5	260	250	245
> 2.5	250	245	245

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.  
Studies have shown that small packages reach higher temperatures during reflow soldering, see [Figure 28](#).



For further information on temperature profiles, refer to Application Note *AN10365 “Surface mount reflow soldering description”*.

## 13 Acronyms

This section lists the acronyms used in this document.

Table 10. Acronyms

Acronym	Description
CDM	Charged-device model
ESD	Electrostatic discharge
HBM	Human body model
I <sup>2</sup> C-bus	Inter-Integrated Circuit bus
I/O	Input/output
IC	Integrated circuit
PMBus	Power Management Bus
SMBus	System Management Bus
TTL	Transistor-transistor logic
SDA	Serial data line
SCL	Serial clock line
PCB	Printed circuit board

## 14 Revision history

[Table 11](#) summarizes revisions to this document.

Table 11. Revision history

Document ID	Release date	Description
PCA9600 v.6.2	18 August 2025	Updated per CIN# 202507032I: <ul style="list-style-type: none"><li>• Changed value from 1400 V to 1000 V in <a href="#">Section 2</a></li><li>• Made some editorial changes</li></ul>
PCA9600 v.6.1	20 December 2021	<ul style="list-style-type: none"><li>• Added orderable part number PCA9600DPZ</li><li>• Product data sheet</li></ul>
PCA9600 v.6.0	25 September 2015	Product data sheet
PCA9600 v.5.0	05 May 2011	Product data sheet
PCA9600 v.4.0	11 November 2009	Product data sheet
PCA9600 v.3.0	03 September 2009	Product data sheet
PCA9600 v.2.0	13 August 2008	Product data sheet
PCA9600 v.1.0	02 June 2008	Product data sheet

## Legal information

### Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

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[2] The term 'short data sheet' is explained in section "Definitions".

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